GOES-R SERIES PRODUCT DEFINITION AND USERS' GUIDE

(PUG)

VOLUME 1: MAIN
VOLUME 2: L0 PRODUCTS
VOLUME 3: LEVEL 1B PRODUCTS
VOLUME 4: GOES-R REBROADCAST (GRB)
VOLUME 5: LEVEL 2+ PRODUCTS
APPENDIX X: ISO SERIES METADATA

December 17, 2019

REVISION 2.2

U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Satellite and Information Service (NESDIS)
National Aeronautics and Space Administration (NASA)

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Signature on File____________________ **11/20/2017**
Jim Valenti Date
NOAA
GOES-R Ground Segment Project Manager

CHANGE RECORD

ISSUE	CCR #	DATE	PAGES AFFECTED	DESCRIPTION
Rev. 1.0	CCR-03240	03/02/2017	All	CDRL SE-16 under Government Control. Harris DCN 7035538 PUG GRB Vol 4 Rev E has been placed under Gov. GS control as GOES-R Series 416-R-PUG-GRB-0348 Vol 4 Rev 1.0.
Rev. 1.1	CCR-03332	10/27/2017	All	CDRL SE-16 under Government Control. Harris DCN 7035538 PUG GRB Vol 4 Rev F has been placed under Gov. GS control as GOES-R Series 416-R-PUG-GRB-0348 Vol 4 Rev 1.1.
Rev. 2.0	CCR-03461	11/01/2018	All	CDRL SE-16 under Government Control. Harris DCN 7035538 PUG GRB Vol 4 Rev G has been placed under Gov. GS control as GOES-R Series 416-R-PUG-GRB-0348 Vol 4 Rev 2.0.
Rev. 2.1	CCR-03511	08/08/2019	All	CDRL SE-16 under Government Control. Harris DCN 7035538 PUG GRB Vol 4 Rev G.1 and G.2 have been placed under Gov. GS control as GOES-R Series 416-R-PUG-GRB-0348 Vol 4 Rev 2.1. (Includes SW Baselines DO.07.01 and DO.07.02.)
Rev. 2.2	CCR-03554	12/17/2019	All	CDRL SE-16 under Government Control. Harris DCN 7035538 PUG GRB Vol 4 Rev H and H.1 have been placed under Gov. GS control as GOES-R Series 416-R-PUG-GRB-0348 Vol 4 Rev 2.2. ((Includes SW Baselines DO.08.00 and DO.08.01.00.)

The document version number identifies whether the document is a working copy, final, revision, or update, defined as follows:

- **Working copy or Draft:** a document not yet finalized or ready for distribution; sometimes called a draft. Use 0.1A, 0.1B, etc. for unpublished documents.
- **Final:** the first definitive edition of the document. The final is always identified as Version 1.0.
- **Revision:** an edition with minor changes from the previous edition, defined as changes affecting less than one-third of the pages in the document. The version numbers for revisions 1.1 through 1.9, 2.1 through 2.9, and so forth. After nine revisions, any other changes to the document are considered an update. A revision in draft, i.e. before being re-baselined, should be numbered as 1.1A, 1.1B, etc.
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PRODUCT DEFINITION AND USER'S GUIDE (PUG)

VOLUME 4: GOES-R REBROADCAST (GRB)

FOR

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE R SERIES (GOES-R) CORE GROUND SEGMENT

CONTRACT NO: DG133E-09-CN-0094

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CDRL SE-16

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PRODUCT DEFINITION AND USERS' GUIDE (PUG)

VOLUME 4: GOES-R REBROADCAST (GRB)

FOR
GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE R SERIES (GOES-R) CORE GROUND SEGMENT

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RECORD OF CHANGE

REVISION	DATE	DESCRIPTION
-	08 February 2011	Initial Release Pre-ECP5
-.1	25 August 2011	Interim Release includes ECP5 PTR-2871 Incorporate GSP comments & organize document structure into volumes PTR-2872 Update content for TBDs/Action Items PTR-2874 Incorporate monthly work-in-progress comments
A	06 February 2011	Pre-CDR Release PTR 3226 Update per BCN_046 ATP for BCR 049 Metadata Delivery PTR-3525 Incorporate GSP Comments (from Interim Release) PTR-3525 Incorporate GSP Comments (CDR Release) PTR-3526 Update Content for TBDs/Action Items (CDR Release)
A.1	19 March 2012	PTR-4138 Remove ITAR from Volume 4, GRB
B	26 July 2012	CDR+90 Release PTR-3239 SE-16 PUG – Update External File Naming Convention for New Static Metadata Files from Metadata BCR PTR-4138 Remove ITAR from Volume 4, GRB PTR-3576 Remove Reference to AWG Ancillary Data PTR-3409 Update Content for TBD-11, TBD-17 and TBD-20 PTR-4039 Update Content for TBDs/Action Items PTR-4203 PUG Update for SUVI Image Refresh and Snow Ice Metadata PTR-4298 GSP Comments Rev A PTR-4204 SE-16 PUG Feedback on PUG for L1b Volume 3 PTR-4845 SE-16 PUG Incorporate Peer Review Comments Deferred from Rev A (Note: Updated NcML files are from 6/12 for CMI and 6/11 for all others)
B.1	17 December 2012	Post-CDR Interim Release PTR-4841 SE-16 PUG - Deferred Comments from Release A PTR-4946 SE-16 PUG - Deferred Comments from PostCDR+90 Peer Review PTR-5318 SE-16 PUG: BCN_067 ATP for ECP007 RFP Amend 4

		PTR-5373 SE-16 PUG - Update PUG Vol 5 Product Algorithm Output Tables PTR-5403 Incorporate customer comments against Rev. B
B.2	20 May 2013	Post-CDR Interim Release PTR-6419 SE-16_Product Definition and User's Guide (PUG) Release Update Rev B.2 Update due to BCR75 PTR-6158 UMB_Delivery_SE-16_Product Definition and User's Guide (PUG) Release Update Rev B.2 PTR-6159 SE-16 PUG - Deferred Comments from Rev. B.1 Peer Review PTR-6837 SE-16 PUG Incorporate Customer Comments Against Rev B.1 PTR-6877 SE-16 Product Definition and User's Guide (PUG) - BCN_085 ATP for MAG SEISS L1b Changes
C	06 December 2013	Post-CDR Interim Release PTR-9218 Delivery_SE-16_Product Definition and User's Guide (PUG) Release Update Rev C 1) Other than the instrument overview and the ABI Fixed Grid paragraph, paragraphs 1 through the end of paragraph 7.1.3 have been completely revised with new and updated content. A Standard Coordinate data paragraph has been added to the ABI Fixed Grid paragraph. 2) Paragraphs 7.2 through the end of paragraph 8.4 have not been revised for this version of the PUG. 3) New appendices for the CCSDS APIDS, and product refresh rates and latencies have been included. 4) The subsequent version is identified where new content will be inserted into paragraphs that currently have headings and no content. PTR-7556 SE-16 PUG - Deferred GSP Comments from Rev. B.2 Review A subset of the deferred comments addressed related to the Radiances product, filename conventions, GRB content and format, and several miscellaneous topics. PTR-9027 SE-16 PUG - Evaluate Customer Comments Against Rev B.2 A subset of the deferred comments addressed related to the Radiances product, filename conventions, GRB content and format, and several miscellaneous topics.
C.1	05 December 2014	Post-CDR Interim Release Vol 1, Main:

		• Added FITS format section (SUVI) Vol 2, L0: • Minor editorial changes Vol 3, L1b: • Revised Space Weather and Solar instrument sections • Co-located Instrument Calibration Data with instrument section Vol 4, GRB: • Revised Space Weather and Solar instrument sections • Corrected APID list Vol 5, L2+: • Combined Volumes 5A and 5B • Added section for Latitude/Longitude grid (Radiation products) • Added Appendix for dynamic source data • Miscellaneous changes to CMI product Appendix X, ISO Series Metadata: • Revised L1b, L2+, Instrument Calibration Data sections PTR-12388 UMB_Delivery_SE-16_ Product Definition and User's Guide (PUG) Release Update Rev C.1 • Incorporates PTR-7028, PTR-7556, PTR-7557, PTR-7553, PTR-8055, PTR-8742, PTR-9027, PTR-9518, PTR-11701 • Combined Vol 5A and Vol 5B into a single volume • Rearranged major sections of the document (consolidated File Naming conventions, consolidated APID lists, etc.), for usability PTR-7028 Update Cumulative ERB/PCRB Changes in Next Rev of Document • ERB: delete the Rainfall Rate Coefficient Algorithm • PCRB: change GLM Lightning Event Peak L1b/GRB update • PCRB: change Radiation Grid from ABI Grid to Latitude/Longitude PTR-7556 Deferred Comments from Rev. B.2 Peer Review • Incorporate comments deferred from Revision B.2 Peer Review PTR-7753 SE-16: Updates to PUG Rev C for next Release • Fixed MAG L1b OMAS/GRB/PD periodicity PTR-8055

		SE-16 PUG BCR # 127 + BCR #129 + BCR 124 + BCN_120 ATP for NcML/Product Definition for non-ABI Sensors + BCN_149, BCR 115 Update GLM L2 NcML + BCR 119 + BCR #127 and 129 (IPS and Product Set 1 NcML Corrections) • BCR#127: incorporated IPS Product NcML corrections • BCR#129: incorporated IPS and Product Set 1 NcML corrections • BCR#124: changed SUVI, SEISS, MAG NcML • BCN_120: NcML/product definition for non-ABI instruments • BCN_149 / BCR#115: updated GLM L2+ NcML definition • BCR#119: changed SUVI GLM INR report design • ECP-9a: added aggregation criteria for Geomagnetic Field, Solar Flux: X-Ray products • BCR#212: incorporated Product Set 2 NcML corrections PTR-8742 SE-16 PUG - Scheduled Science Instrument Products definitions • Updated SUVI, EXIS, SEISS, MAG, GLM product definitions PTR-9027 SE-16 PUG - Evaluate Customer Comments Against Rev B.2 • Incorporated customer comments not previously addressed in PUG Rev C PTR-9518 SE-16 PUG, Evaluate Customer Comments from Rev C • Incorporated customer comments against PUG Rev C PTR-11701 SE-16 PUG - Update for BCR # 227, Non-ABI product Corrections Incorporated non-ABI Product NcML corrections
D	13 May 2015	PTR-7557 UMB_Delivery_SE-16_Product Definition and User's Guide (PUG) Release Update Rev D • Incorporate customer comments against PUG Rev C.1 PTR-13600 • SE-16 PUG - Miscellaneous Corrections Appendix X • New content – L0 and GRB Info ISO Series Metadata Vol 2, L0 • Restructured to be consistent with other volumes Vol 3, L1b • New content – dynamic and semi-static processing parameters Vol 4, GRB • New content – GRB Information

		Vol 5, L2+ • New content – dynamic and semi-static processing parameters
D.1	11 August 2015	PTR-14093 • Change 132.8 Angstroms wavelength to 131.2 Angstroms in SUVI documentation PTR-14107 • Update various L2 product lineage issues PTR-13638 • Update document for ECP-023 new CONUS center points PTR-14388 • WR 757: SE-16: CMI – Update PUG to change scaling of band 7 to a max brightness temp of 400K
D.2	24 March 2016	PUG release aligned with PC DO.03.00.00 software baseline. PTR-14663 • SE-16 PUG, Evaluate Customer Comments from Rev D PTR-15294 • SE-16 PUG, Add GRB-INFO-STATIC description PTR-15324 • SE-16 PUG - Misc. Updates to Sync with GS File Naming Conventions Additionally, the following changes have been made, in preparation for PC D0.04.00.00 (WR 813 / PTR-15605): • Changed yaw_flip_flag to allow 3 states (upright, neither, inverted) • Changed EXIS num_angle_pairs long_name
E	15 June 2016	PUG release aligned with PC DO.04.00.00 software baseline. PTR-16585 • SE-16 PUG - Miscellaneous Corrections PTR-16442 • WR 1949: GLM appears to have Timing Artifacts (PUG Update) PTR-15605 • WR 813: Space Weather products' enhancements requested by NCEI (SE-16 PUG)

		• Add SEISS MPS-LO energy bounds/levels to differential_flux_energy_band_label variable value PTR-15580 • WR 1697: SE-16 PUG - Rainfall Rate Product DQF Valid Range is Incorrect PTR-15194 • WR 1177: SE-16 Modify Product Definition User's Guide for expanded ABI L1b Radiance Limits
E.1	4 November 2016	PUG release aligned with PC DO.04.02.00 software baseline, except where otherwise noted. PTRDOC-15878 DO.05.00.00 • WR 1552: SE-16 PUG - ABI L1b Instrument Calibration Data - Number of detector rows discrepancy PTRDOC-16363 • WR 2261: SE-16 PUG - Provide documentation for CAL INR data file structures PTRDOC-16387 DO.05.00.00 • WR 2218: SE-16 PUG - There are no ABI CCR results in the PM Generated ABI INR Report PTRDOC-16397 DO.05.00.00 • WR 1937: SE-16 PUG - GLM L2+ product metadata errors PTRDOC-16639 DO.05.00.00 • WR 1698: SE-16 PUG - Sea Surface Temperature Fill Value incorrect PTRDOC-16911 DO.05.00.00 • WR 2961: SE-16 Update PUG to clarify Rainfall Rate metadata PTRDOC-16936 • WR 2566: SE-16 PUG - Add Derived Motion Winds PQI and Diagnostic Intermediate Products to the PUG PTRDOC-17008 • WR 2749: SE-16 PUG - Update PUG to reflect 2 minute EXIS L0 LZSS file aggregation time PTRDOC-17088 • WR 2874: SE-16 PUG - Correct File Names of Instrument Calibration Files Produced PTRDOC-17123 • WR 1739: SE-16 PUG - SUVI Instrument Calibration File Names

		PTRDOC-17254 • WR 2962: SE-16 PUG - CMI Coefficients update-ADR 143 PTRDOC-17416 • WR 3058: SE-16 PUG - SUVI scale factors in products do not match scale factors in the PUG PTRDOC-17661 • WR 3274: SE-16 PUG - Update to Align with XTCE Database v6.3.005A PTRDOC-17818 DO.06.00.00 • WR 2260: SE-16 PUG - Derived Motion Winds (DMW) Wind Direction: Incorrect Direction
E.2	30 March 2017	PUG release aligned with GOES-R Ground Segment Product Capabilities (PG, PD, PM) software baselines, as follows: DO.04.04.00: April 2017 DO.05.00.00: July 2017 DO.06.00.00: September 2017 (TBR) PTRDOC-17880 DO.05.00.00 Vol 5, Table 5.1.6.4-1. • WR 3383: SE-16 PUG - Changes for Expansion of CMI range to match DO.04 Rad-ADR 154 PTRDOC-17887 DO.04.04.00 Vol 3, Section 5.0.1; Vol 4, Section 7.0.1; Vol 5, Section 5.0.1 • WR 3483: SE-16 PUG - add explanation/instructions for converting 'seconds since epoch' to standard date/time PTRDOC-17995 DO.06.00.00 Vol 3, Table 5.3.2.5.1-11; Vol 4, Table 7.4.2.5.1-11. • WR 3438: SE-16 PUG - Fix Incorrect Flag Definition in EXIS Files - ADR 159 PTRDOC-18023 DO.06.00.00 Vol 5, Table 4.3.7-2. • WR 2291: SE-16 PUG - GRIP is not showing full SRB image on GOES WEST PTRDOC-18057 DO.05.00.00 Vol 3, Sections D.7, D.8 and D.9. • WR 3554: SE-16 PUG - Provide documentation for [CAL] INR data file structures (ABI, GLM, SUVI) PTRDOC-18090 DO.06.00.00 Vol 3, Section 5.1.4.1. • WR 3433: SE-16 PUG - Include pixels with under-saturated sample contributors in ABI Sample Outlier files PTRDOC-18144 DO.06.00.00 Vol 5, Table 5.1.7.6-2.

		• WR 3076: SE-16 PUG: DMW Output File is not CF Compliant-ADR 139 (PUG Changes) PTRDOC-18158 DO.06.00.00 Vol 3, Table 5.3.1.5-2; Vol 4, Table 7.4.1.5.2. • WR 3078: SE-16 PUG: EXIS - Add total number of valid SPS measurements used - ADR 148 PTRDOC-18191 DO.05.00.00 Vol 3, Table 5.3.1.5-2; Vol 4, Tables 7.4.1.5.1 and 7.4.1.5.2. • WR 3568: SE-16 PUG: Revise EXIS EUVS-C Cadence - ADR 183 (PUG Updates) PTRDOC-18225 DO.05.00.00 Vol 3, Sections D.4 and D.5. • WR 3324, 2989: SE-16 PUG - Update Documentation for MAG, SEISS CAL INR data file structures PTRDOC-18228 DO.06.00.00 Vol 3, Table 5.3.2.5-2; Vol 4, Table 7.4.2.5.2. • WR 3571: SE-16 PUG: Add SUVI roll angle to EXIS XRS - ADR 147 (PUG Changes) PTRDOC-18259 DO.06.00.00 Vol 5, Table 5.21.6-2. • WR 3222: SE-16 PUG - Land L2: FSC Metadata Issues-ADR 167 PTRDOC-18406 DO.06.00.00 Vol 3, Table 5.5.1.5-2; Vol 4, Tables 7.6.1.5.1 and 7.6.1.5.2. • WR 3429: SE-16 PUG - MAG Add IB and OB measurements in 4 coord frames-ADR 145 PTRDOC-18441 DO.04.04.00 Vol 3, Table 5.1.3.6.3-2; Vol 4, Table 7.1.3.6.1.1-2. • WR 3804: SE-16 PUG: Bad Radiance-to-Brightness-Temp Conversion Coeffs PTRDOC-18608 DO.04.04.00 Vol 5, Table A.2-1, Section E.1. • WR 1264: SE-16 PUG: Change DMW Intermediate Product Filename (Data Short Name) PTRDOC-18646 DO.05.00.00 Vol 3, Tables 5.3.1.5-2, 5.4.4.5-1, 5.4.4.5-2, 5.4.4.5.2-4 and 5.4.6.2-1; Vol 4, Tables 7.4.1.5.1, 7.4.1.5.2, 7.5.4.5.1, 7.5.4.5.1.2-4 and 7.5.4.5.2. • WR 3918: SE-16 PUG: Removing Hyphens in EXIS and SEIS Vars and Attrs-ADR 207
F	16 June 2017	PTRDOC-18154 DO.06.00.00 Vol 3, section 5.0.2; Vol 4, section 7.0.2; Vol 5, section 5.0.2

		• WR 3725: SE-16 PUG - Add description of unsigned integer processing PTRDOC-18519 DO.06.00.00 Vol 3, Table 5.3.1.5-2, Table 5.4.4.5-2; Vol 5, Table 5.10.6-2 • WR 3897: SE-16 PUG: Variable missing from XRS and SGPS files- ADR 211 PTRDOC-18813 DO.06.00.00 Vol 3, Table 5.2.1.5.1-2, section 5.2.1.5.2, Table 5.2.1.5.4-5, Table 5.3.1.5-2, Table 5.3.1.5.2-7, Table 5.3.2.5-2, Table 5.3.2.5.1-15, Table 5.4.1.5-2, Table 5.4.1.5.2-9, Table 5.4.2.5-2, Table 5.4.2.5.2-5, Table 5.4.3.5-2, Table 5.4.3.5.2-6, Table 5.4.4.5-2, Table 5.4.4.5.2-6, Table 5.5.1.5-2, Table 5.5.1.5.2-3; Vol 4, Table 7.3.1.5.1.2-8, Table 7.3.1.5.2, Table 7.4.1.5.1.2-7, Table 7.4.1.5.2, Table 7.4.2.5.1.1-15, Table 7.4.2.5.2, Table 7.5.1.5.1.2-9, Table 7.5.1.5.2, Table 7.5.2.5.1.2-5, Table 7.5.2.5.2, Table 7.5.3.5.1.2-6, Table 7.5.3.5.2, Table 7.5.4.5.1.2-6, Table 7.5.4.5.2, Table 7.6.1.5.1.2-3, Table 7.6.1.5.2 • WR 4164: SE-16 PUG: Space weather eclipse_flag flags do not capture all possible states PTRDOC-18819 DO.06.00.00 Vol 4, section 4.1, section 4.3 • WR 4139: SE-16 PUG: GRB Default Modem Configuration - QPSK PTRDOC-18879 DO.06.00.00 Vol 4, section 2.0, section 5.0, section 6.0, section 6.2.6.3, section 7.1.3.6, section 7.3.1.5 • WR 4179: SE-16 PUG: ABI L1b metadata sent prior to end of scene in GRB PTRDOC-18890 DO.06.00.00 Vol 4, Table A • WR 3511: SE-16 PUG: Add statement on CCSDS reserved APIDs to the PUG PTRDOC-18907 DO.06.00.00 Vol 3, section 5.3.1.1; Vol 4, section 7.4.1.1 • WR 3257: SE-16 PUG: Resolve Time Stamp Error in EXIS Files-ADR 158 PTRDOC-18910 DO.06.00.00 Vol 3, Table 5.3.1.5-2; Vol 4, Table 7.4.1.5.1, Table 7.4.1.5.2 • WR 4205: SE-16 PUG: EXIS EUVS long name corrections-ADR278 PTRDOC-18951 DO.06.00.00 Vol 3, Table 5.6.2.2-1 • WR 3407: SE-16 PUG: GLM Background Image Metadata Differences from PUG

		PTRDOC-18955 DO.06.00.00 Vol 1 – 5, Appendix X, several sections and tables • WR 4263: BCR_591 ATP for ECP-029, SE-16: ECP-029 - Update Product Users Guide (PUG) for Mode 6 functionality PTRDOC-19131 DO.07.00.00 Vol 3, Table 5.2.1.1-1, Table 5.2.1.5.3-1, Table 5.2.1.5.4-2, Table A.1; Vol 4, Table 7.3.1.1-1, Table 7.3.1.5.1.1-1, Table 7.3.1.5.1.2-2 • WR 4023: SE-16 PUG: SUVI short exposure time - Long term fix - ADR 199 PTRDOC-19350 DO.06.00.00 Vol 3, Table 5.3.1.5.2-3, Table 5.3.2.5.1-3; Vol 4, Table 7.4.1.5.1.2-3, Table 7.4.2.5.1.1-3 • WR 4540: SE-16 PUG: EUVS and EXIS Processing and Data Quality Flag Meanings
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1.0 SCOPE

The Product Definition and User's Guide (PUG) document provides product descriptions and formats for all data and products produced and made available to users by the Geostationary Operational Environmental Satellite R Series (GOES-R) Core Ground Segment (GS), developed under contract DG133E-09-CN-0094. This includes the Level 0 products, Level 1b products, GOES-R Rebroadcast (GRB), and Level 2+ products. This also includes ISO series metadata, instrument calibration data, and semi-static source data and algorithm packages.

The PUG is divided into five volumes. This volume, Volume 4: GRB, contains product and data descriptions, content and format information for data made available in the GRB. This volume also contains description, content and format information for the communications and application level protocols used in the GRB. Note that there is a separate standalone Appendix X containing detailed descriptions of the ISO series metadata associated with the Level 1b and Level 2+ products available in GRB.

1.1 Document Overview

The purpose of this volume is to describe the functional characteristics, and content and format of GOES-R Level 1b and Level 2+ products and data made available to users in GRB form, and enabling communications and application level protocols. The intent of providing this information is to allow users to exploit the products and data. This document also supports Government remote tele-training and public outreach requirements.

This GRB PUG volume includes the following sections:

- Instrument Overview
- GRB Overview
- Receiving GRB
- Common GRB Product and Data Characteristics
- GRB Product and Data Descriptions
- CCSDS Application Identifiers used in GRB
- GRB Refresh Rates and Latencies for Level 1b and Lightning Detection Products

2.0 GOES-R INSTRUMENT OVERVIEW

The six instruments on the GOES-R series satellites offer unique observations of the environment and consist of the Advanced Baseline Imager (ABI), Geostationary Lightning Mapper (GLM), Extreme Ultra-Violet and X-Ray Irradiance Sensors (EXIS), Solar Ultraviolet Imager (SUVI), Space Environment In-Situ Suite (SEISS), and Magnetometer.

The ABI instrument is a multi-spectral channel, two-axis scanning radiometer designed to provide radiometrically calibrated and geolocated observations of the Earth. ABI bands 1-6 measure solar reflected radiance at visible and near-infrared wavelengths, and bands 7-16 measure emitted radiance from the sources at infrared wavelengths. Data availability, radiometric quality, simultaneous data collection, coverage rates, scan flexibility, and minimizing data loss due to the sun, are prime capability requirements of the ABI system. The ABI scans the Earth using three standard geographic coverage regions: Full Disk, Continental United States (CONUS), and Mesoscale. The ABI utilizes the concepts of scenes and timelines in defining its scanner operations.

The Full Disk is defined as a circle, with a 17.4 degree angular diameter from the perspective of the ABI, centered at the instrument's nadir that reaches the Earth's limb. Overscan is required to deal with the non-ideal orbit and image motion compensation. CONUS is defined as a nadir-viewed rectangle 8.0215 x 4.8129 degrees, approximately 5000 E/W x 3000 North/South kilometers, in the geographic area of 10N-60N latitude and 60W-125W longitude; Mesoscale is defined as the equivalent of a 1.6043 x 1.6043 degree, approximately 1000 x 1000 kilometer region. Full Disk images are generated in ABI scanning Mode 3, Mode 6 and Mode 4, while Mesoscale and CONUS images are only generated in ABI scanning Mode 3 and Mode 6. Note that CONUS images are extracted from Full Disk images in Mode 4 for distribution to PDA.

The X-ray Sensor (XRS) and the Extreme Ultraviolet Sensor (EUVS) are packaged together in one instrument called the EXIS. EXIS is designed to be pointed at the sun to acquire space weather data at all times except for brief calibration and maintenance activities.

EUVS consists of three spherical grating spectrometer channels. The three channels denoted A, B and C, give coverage in the bands of 16-37 nm (1.4 nm resolution), 115-135 nm (1.3 nm resolution) and 275-285 nm (0.2 nm resolution). From these, a reconstruction of the full spectrum between 5 and 127 nm will be possible.

XRS: X-ray Sensor consists of three photodiode-based photometer channels, two active (A and B) and one inactive. Channel A covers 0.05-0.4 nm and channel B covers 0.1-0.8 nm. The "dark" diode channel allows background subtraction. All active channels view the sun through two Be filters. Each XRS channel consists of a low-sensitivity and a high-sensitivity detector whose responses overlap in order to span the required total dynamic range. The low-sensitivity detectors are quadrant photodiodes which view the sun through a small aperture, allowing X and Y position information to be extracted for bright, localized events such as solar flares.

The GLM instrument is a single-channel, near-infrared optical detector, used to detect, locate and measure the optical pulses associated with lightning over the Full Disk Earth. The instrument has sufficient spatial and temporal resolution to allow tracking of each lightning flash within a specific storm cell and calculation of the cell's optical center over time.

The Magnetometer instrument provides three orthogonal measurements of the geomagnetic field in space at a refresh rate of at least 0.5 seconds, a dynamic range of ±512 nT in each of the three orthogonal axes, and field measurements with a resolution of at least 0.016 nT per axis. The sampling rate of the product data is 10 Hz. This measurement data is used to map the space environment that controls charged particle dynamics in the outer region of the magnetosphere and provide information on the general level of geomagnetic activity, monitor current systems in space, and permit detection of magnetopause crossings, sudden storm commencements, and sub storms.

The SEISS instrument consists of a suite of sensors that monitors the proton, electron, and heavy ion fluxes at geosynchronous orbit. The information provided by the SEISS is critical for assessing the radiation hazard to astronauts and satellites. In addition to hazard assessment, the information from the SEISS can be used to warn of high flux events, mitigating any damage to radio communication. The SEISS instrument suite consists of the Energetic Heavy Ion Sensor (EHIS), the Magnetospheric Particle Sensor -High and Low (MPS-HI and MPS-LO), and the Solar and Galactic Proton Sensor (SGPS). There are two SGPSs in each suite, one looking east and one looking west.

The SUVI instrument is designed to provide a view of the solar corona, taking the Full Disk solar images at high cadence around the clock, except for brief periods during an eclipse, in the soft XUV to EUV wavelength range. Available combinations of exposures and filters allows the coverage of the entire dynamic range of solar XUV features, from coronal holes to X-class flares, as well as the estimate of temperature and solar emissions.

3.0 GRB OVERVIEW

The GOES-R ReBroadcast (GRB) is a 31 Mbps direct readout broadcast that replaces the 2.1 Mbps GOES VARiable (GVAR). The operational GOES-R satellites, nominally located at 75 and 137 degrees west longitude, and referred to as GOES-East and GOES-West, respectively, perform the remote sensing and

GRB function. The GOES-R series ground system receives downlinked raw instrument data from each GOES-R satellite, performs processing through Level 1b, and uplinks Level 1b and Level 2+ lightning detection product data in the form of the GRB. The GOES-R satellite provides a relay function and broadcasts the GRB data stream to earth terminals in the satellite's near hemispheric field of view. As is the case with the previous generation GOES system's direct broadcast service, the satellite that senses the data, receives and downlinks the processed data resulting from that sensing.

The product data and instrument source in the GRB data stream are defined in Table 3.0-1 GRB Products and Instrument Source Table.

Table 3.0-1 GRB Products and Instrument Source Table

Product	Instrument Source
Radiances	ABI
Lightning Detection	GLM
Level 1b SUVI Solar Imagery: EUV	SUVI
Solar Flux: X-Ray	EXIS: XRS
Solar Flux: EUV	EXIS: EUVS, XRS
Energetic Heavy Ions	SEISS: EHIS
Magnetospheric Electrons and Protons: Low Energy	SEISS: MPS-LO
Magnetospheric Electrons and Protons: Medium and High Energy	SEISS: MPS-HI
Solar and Galactic Protons	SEISS: SGPS
Geomagnetic Field	Magnetometer

These products are described, and their content and format are defined in paragraph 7.0.

A simplex link is used for GRB. A dual circular polarization is used to accommodate the 31 Mbps data rate within a frequency bandwidth constraint of 12 MHz using a standard downlink modulation at 1686.600 MHz (L-band). The GRB processed instrument data source is packetized compliant with Consultative Committee for Space Data Systems (CCSDS) Space Packet Protocol standard (CCSDS recommendation 133.0-B-1), and utilizes lossless data compression to fit within the allocated bandwidth. This Space Packet Protocol standard describes a protocol specifically designed for transfer of application data over a space-to-ground link, and includes a mandatory primary header, and an optional secondary header, which in the case of GRB, is always included. The primary header contains the Application Process Identifier (APID) field, which is used to distinguish the type of data in the packet.

Forward error correction (FEC) and Cyclic Redundancy Checks (CRC) are used to minimize risk of data loss due to link errors and allow for user verification of data integrity. In addition, a CCSDS space packet containing GRB data is constrained to 16,390 octets (i.e., bytes). This maximum packet size limits data corruption in the presence of uncorrectable link errors. The GRB packet size that is actually utilized may be much less than this maximum packet size (e.g., on the order of 1,500 octets (bytes)).

Radiance product data from the ABI is split by channel across the two polarizations, and the Level 1b product data from each of the other instruments and Lightning Detection product data are allocated to one of the polarizations to balance the load. The allocation of ABI channels, Level 1b product data from the other instruments, and GRB information is defined in Table 3.0-2, GRB Product LHCP/RHCP Allocation.

Table 3.0-2 GRB Product LHCP/RHCP Allocation

Left Hand Circular Polarization (LHCP)		Right Hand Circular Polarization (RHCP)	
Product: ABI channel	***ABI channel central wavelength (in um)***	***Product: ABI channel, if applicable***	***ABI channel central wavelength (in um)***
Radiance: channel 2	0.64	Radiance: channel 1	0.47
Radiance: channel 7	3.89	Radiance: channel 3	0.87
Radiance: channel 8	6.17	Radiance: channel 4	1.38
Radiance: channel 10	7.34	Radiance: channel 5	1.61
Radiance: channel 14	11.19	Radiance: channel 6	2.25
Radiance: channel 15	12.27	Radiance: channel 9	6.93
Radiance: channel 16	13.27	Radiance: channel 11	8.44
		Radiance: channel 12	9.61
		Radiance: channel 13	10.33
		Lightning Detection	
		Level 1b SUVI Solar Imagery: EUV	
		Solar Flux: X-Ray	
		Solar Flux: EUV	
		Energetic Heavy Ions	
		Magnetospheric Electrons and Protons: Low Energy	
		Magnetospheric Electrons and Protons: Medium and High Energy	
		Solar and Galactic Protons	
		Geomagnetic Field	
GRB Information		GRB Information	

The selection of these LHCP bands is designed to provide data aligned with, but not identical to, the current GVAR, with the addition of the 7.34 and 12.27 um bands that are not generated by the current GOES NOP Imager instrument. Allocating these channels within one polarization of the dual scheme allows users needing only the legacy spectral coverage to invest in a simpler and less-costly single polarity receive system.

In addition to the product data, the GRB data stream includes GRB information packets every five minutes. GRB information includes the following:

a) Operations schedules
b) Periodic data status informing users of process performance
c) Periodic state vectors for orbit knowledge
d) Operator messages

GRB information is included for both polarizations to support less-costly single polarity receive systems.

Space packets from each of the instruments, and instrument channels, in the case of the Radiances and Level 1b SUVI Solar Imagery: EUV, are interleaved in the GRB according to the allocations of product type for the two polarizations. Their insertion point into the GRB data stream is based on priority. This ensures that the data packets associated with specific products satisfy the latency requirements associated with the different product types. Idle (i.e., fill) packets are broadcast in the absence of data in the GRB's continuous fixed rate broadcast environment.

Lossless compression allows the full complement of Level 1b products, and the Level 2+ lightning detection product to be transferred over the 31 Mbps GRB link. The GOES-R ground system can configure either JPEG 2000 or SZIP compression for each type of data.

4.0 RECEIVING GRB

4.1 GRB Communications Overview

An earth terminal is required to receive the GRB from a GOES-R series satellite. This earth terminal consists of an antenna, and a suite of equipment to process RF signals into a digital data stream, and extract product data and metadata.

The GRB downlink is standards-based, making use of the following protocols:

- Digital Video Broadcasting; Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)
- Consultative Committee for Space Data Systems (CCSDS) Advanced Orbiting Systems (AOS) Space Data Link Protocol
- CCSDS Space Packet Protocol

The relationship among these protocol standards is shown in Figure 4.1, Relationship of Protocols Used in GRB.

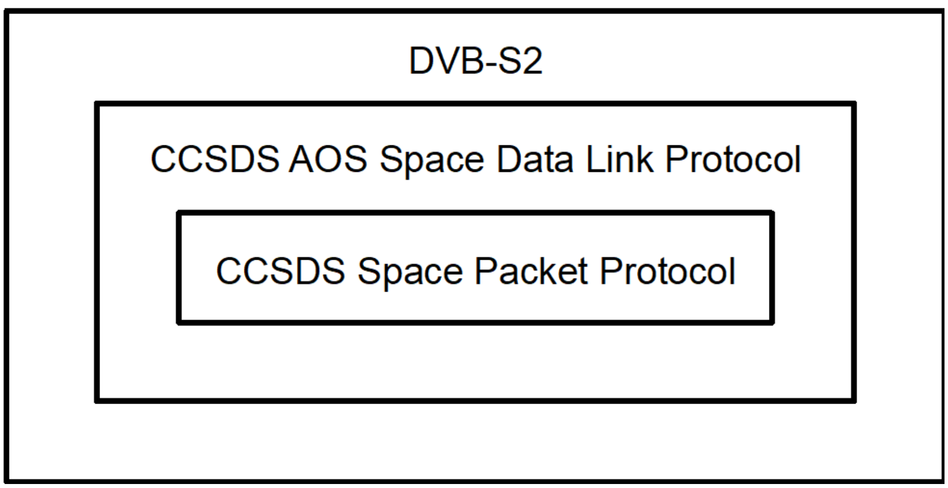


Figure 4.1 Relationships of Protocols Used in GRB

DVB-S2 is the outer frame of the GRB digital data stream. CCSDS AOS Space Data Link Protocol frames are extracted from the DVB-S2 frames, and CCSDS Space Packets are extracted from the CCSDS AOS Space Data Link Protocol frames.

The following paragraphs in this Receiving GRB section describe:

- Antenna system to receive GRB.
- DVB-S2 framing characteristics and configuration to demodulate the GRB signal and reconstruct the CCSDS AOS Space Data Link Protocol frames.
- CCSDS AOS space data link protocol framing characteristics and configuration to recovery the CCSDS Space Packets.
- CCSDS space packet protocol characteristics and configuration for GRB.

There are two possible types of modulation for GRB: Quadrature Phase Shift Keying (QPSK) and 8 level Phase Shift Keying (8PSK). Following launch and initial on-orbit testing of the GOES-R (now GOES-16) satellite, the decision was made to utilize Quadrature Phase Shift Keying (QPSK) as the default modulation type for GRB, rather than 8-level Phase Shift Keying (8PSK). This version of the PUG includes the GRB downlink data stream for both of these modulation types. These two modulation types are identified and defined in the DVB-S2 framing characteristics and configuration paragraph below.

4.2 Antenna System

Reception of the GRB data is accomplished by means of a fixed dish antenna with a dual left and right hand circular feed horn connected to two Low Noise Amplifiers (LNAs). The LNA outputs are connected to RF/IF down-converters. The RF/IF down-converters are connected to DVB-S2 capable receivers.

The GRB downlink signal from the satellite is at a center frequency of 1686.600 MHz and requires an antenna G/T of 15.2 dB/K for worst-case locations. This equate to a 4.5 meter dish with a system noise temperature of 120 K. Most CONUS locations are anticipated to have acceptable performance with a 3.8 meter dish.

4.3 DVB-S2 Framing Characteristics and Configuration for GRB

Off-the shelf DVB-S2 receivers are available to receive the IF outputs from the antenna system for each polarization. For each polarization, the DVB-S2 receiver extracts and outputs CCSDS Channel Access Data Units (CADUs) at a rate of 15.5 Megabits per second (Mbps).

The outer data protocol layer of the GRB link, as shown above in Figure 4.1, Relationship of Protocols Used in GRB, conforms to the DVB-S2 standard. The GOES-R GRB DVB-S2 data is transported using the single continuous generic stream format, and the Constant Coding and Modulation mode as defined in the standard.

There are two types of modulations that may be used for the GOES-R series GRB link operationally. They are as follows:

- QPSK with a symbol rate of 8.665938 Million symbols per second (Msps) with a rate 9/10 Forward Error Correction (FEC) coding.
- 8PSK with a symbol rate of 7.825768Msps with a rate 2/3 FEC coding.

Following launch and initial on-orbit testing of the GOES-R (now GOES-16) satellite, the decision was made to utilize Quadrature Phase Shift Keying (QPSK) as the default modulation type for GRB, rather than 8-level Phase Shift Keying (8PSK).

The FEC block length used for GRB is 64800 bits in length and uses Low Density Parity Check (LDPC) error correcting coding, Bose Chaudhuri Hocquenghem (BCH) error correction coding and randomization provided by the transport layer. The same GRB link protocol is used for both polarizations. For implementation details refer to the DVB-S2 standard. Note that a symbol is a waveform change representing an integer number of bits where the number of bits varies as a function of the type of modulation.

The subordinate paragraphs that follow summarize the physical and baseband framing protocol layers internal to DVB-S2, and specify the protocol parameter configuration selected for GRB.

The term "octet" is used in the subordinate DVB-S2 paragraphs and denotes 8 bits of information. To describe the DVB-S2 protocol parameter configuration requires the identification of specifically assigned binary values. The syntax used in the subordinate paragraphs is as follows:

- "0x" preceding values means hexadecimal notation.
- "0b" preceding values means binary notation.

The figures used here to describe the content of DVB-S2 frame and header structures, and fields use a left to right convention where the left most octet or bit in the left most field in the figure is received first. The DVB-S2 standard requires that the single and multiple octet fields in the structures described in this section are in Big Endian format. This convention is illustrated in Figure 4.3, DVB-S2 Octet Field Bit Ordering.

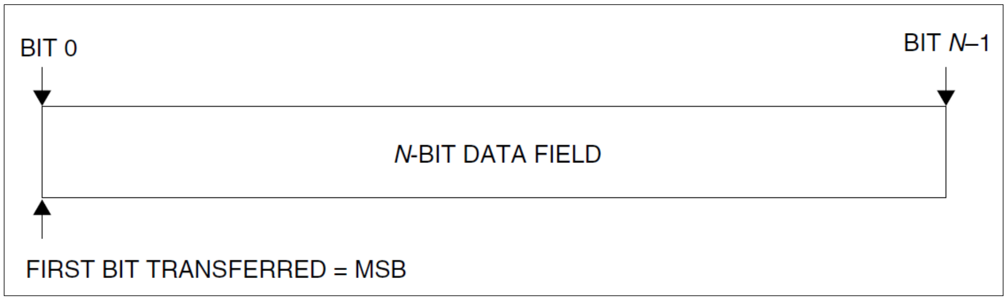


Figure 4.3 DVB-S2 Octet Field Bit Ordering

The first bit in the field transmitted is defined as "Bit 0". The last bit to be transmitted is 'Bit *N*–1', where *N* is a multiple of eight. "Bit 0" is the Most Significant Bit (MSB) of the data field. In addition, single bit and multiple bit subfields are described in the order in which the bits appear in the data stream.

4.3.1 Physical Layer Frame (PLFRAME)

The selected DVB-S2 physical layer frame configuration for the GRB downlink is shown in Figure 4.3.1, GRB DVB-S2 Physical Layer Framing.

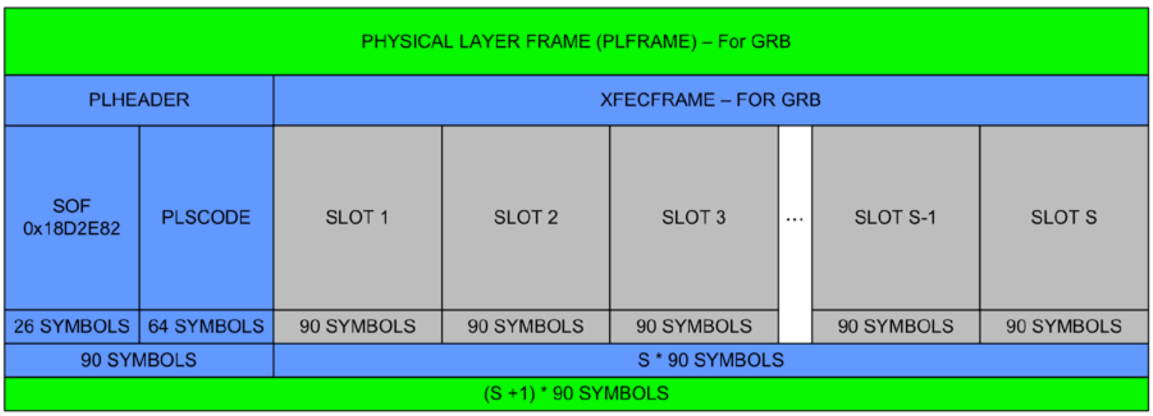


Figure 4.3.1 GRB DVB-S2 Physical Layer Framing

The PLFRAME contains a PLHEADER and XFECFRAME. The number of data slots in an XFECFRAME varies as a function of the selected modulation type for the GRB downlink. Refer to Table 4.3.1, XFECFRAME Data Slots for Modulation Type.

Table 4.3.1 XFECFRAME Data Slots for Modulation Type

GRB Modulation Type	Number of Data Slots
QPSK 9/10 FEC	360
8PSK 2/3 FEC	240

The XFECFRAME is 64800 bits for both the modulation types because a symbol carries 2 bits of information for QPSK, and 3 bits for 8PSK.

Prior to modulation for the downlink, each PLFRAME, excluding the PLHEADER are scrambled as detailed in paragraph 5.5.4 of the DVB-S2 standard. After scrambling, the signals are square root raised cosine filtered with a roll-off factor of $\alpha = 0.25$ as detailed in paragraph 5.5.4 of the DVB-S2 standard.

4.3.1.1 Physical Layer Header (PLHEADER)

The PLHEADER, which is defined above in Figure 4.3.1, GRB DVB-S2 Physical Layer Framing, contains 90 symbols of $\frac{\pi}{2}$ Binary Phase Shift Keying (BPSK) modulation regardless of the modulation type for the data. A symbol carries 1 bit of information for BPSK. The PLHEADER contains a 26 symbol Start of Frame (SOF) and 64 symbol PLSCODE field.

Start of Frame

The start of frame value is 0x18D2E82.

Physical Layering Signal Code (PLSCODE)

The PLSCODE field is a 7 bit value that is encoded into a 64 bit block using a first order Reed-Muller under a permutation error correction code as detailed in paragraph 5.5.2.4 of the DVB-S2 standard. The 7 bits are formed from a 5 bit modulation code (MODCOD) and a 2 bit type field (TYPE). Refer to Table 4.3.1.1, MODCOD Value for Modulation Type.

Table 4.3.1.1 MODCOD Value for Modulation Type

GRB Modulation Type	MODCOD Value
QPSK 9/10 FEC	0x0B
8PSK 2/3 FEC	0x0D

The TYPE value is 0x0 for normal 64800 bits and no pilots.

4.3.1.2 Physical Layer Data (XFECFRAME)

The detailed definition of the XFECFRAME, which is summarily illustrated above in Figure 4.3.1, GRB DVB-S2 Physical Layer Framing, varies as a function of the selected modulation type. Figure 4.3.1.2, GRB DVB-S2 XFECFRAME for QPSK and 8PSK, defines the XFECFRAME structure for QPSK and 8PSK. Refer to paragraph 5.3 of the DVB-S2 standard for additional details.

The XFECFRAME contains a Baseband Frame (BBFRAME), and two forward error correction blocks, BCHFEC and LDPCFEC. Figure 4.3.1, GRB DVB-S2 Physical Layer Framing, above is agnostic to the type of modulation, and the definition of the slots is generic. Once a type of modulation is selected, which is the case in Figure 4.3.1.2, the BBFRAME, BCHFEC, and LDPCFEC make use of these generic slots.

The forward error correction makes uses of both an inner and outer encoding. The inner encoding is applied to the BBFRAME and BCHFEC, and LDPC encoded as detailed in paragraph 5.3.2 of the DVB-S2 standard. For the 8PSK modulation type, the output of the LDPC encoder is bit interleaved as detailed in paragraph 5.3.3 of the DVB-S2 standard. The outer encoding is applied to the BBFRAME, and is BCH encoded as detailed in paragraph 5.3.1 of the DVB-S2 standard. The entire BBFRAME field is scrambled as detailed in paragraph 5.2.2 of the DVB-S2 standard.

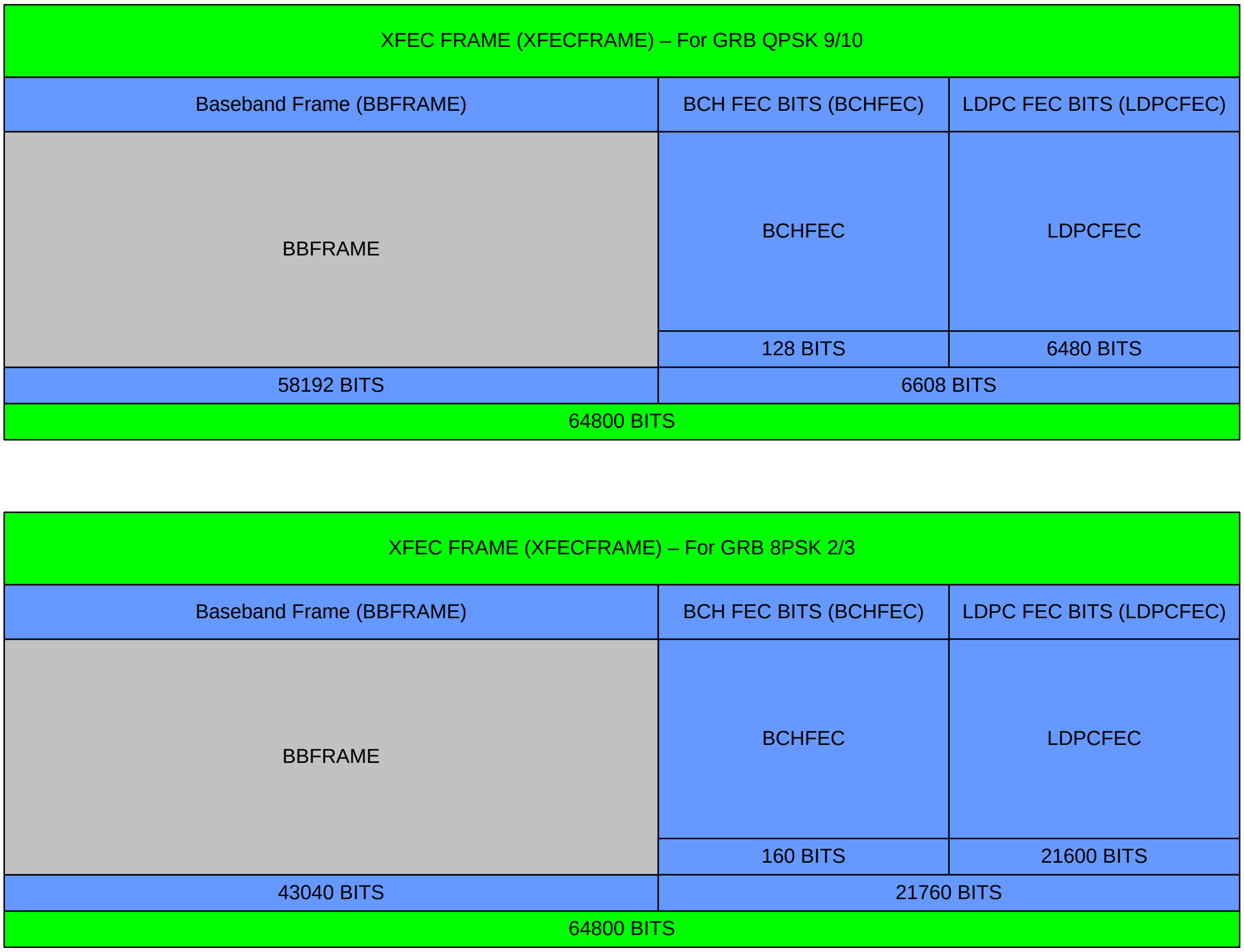


Figure 4.3.1.2 GRB DVB-S2 XFECFRAME for QPSK and 8PSK

4.3.2 Baseband Layer Frame (BBFRAME)

The BBFRAME, which is summarily illustrated above in Figure 4.3.1.2, GRB DVB-S2 XFECFRAME for QPSK and 8PSK, varies as a function of the selected modulation type. Figure 4.3.2, GRB DVB-S2 BBFRAME for QPSK and 8PSK, defines the BBFRAME structure for QPSK and 8PSK. Refer to paragraph 5.2 of the DVB-S2 standard for additional details.

The Baseband Frame (BBFRAME) contains a 10 octet Baseband Header (BBHEADER) and a user data field (DFL). In the event insufficient payload data is available for transmission, zero bits (i.e., 0b0) are appended to completely fill the DFL as detailed in paragraph 5.2 of the DVB-S2 standard.

BASEBAND FRAME (BBFRAME) – For GRB QPSK 9/10	
Baseband Header (BBHEADER)	DATA FIELD (DFL)
BBHEADER	DFL
80 BITS	58112 BITS
58192 BITS	

BASEBAND FRAME (BBFRAME) – For GRB 8PSK 2/3	
Baseband Header (BBHEADER)	DATA FIELD (DFL)
BBHEADER	DFL
80 BITS	42960 BITS
43040 BITS	

Figure 4.3.2 GRB DVB-S2 BBFRAME for QPSK and 8PSK

4.3.2.1 Baseband Header (BBHEADER)

The BBHEADER, which is summarily illustrated above in Figure 4.3.2, GRB DVB-S2 BBFRAME for QPSK and 8PSK, is shown in detail in Figure 4.3.2.1, GRB DVB-S2 Baseband Header (BBHEADER).

BASEBAND HEADER (BBHEADER) – For GRB					
MATYPE	UPL	DFL	SYNC	SYNCD	CRC-8
16 BITS	16 BITS	16 BITS	8 BITS	16 BITS	8 BITS
80 BITS					

Figure 4.3.2.1 GRB DVB-S2 Baseband Header (BBHEADER)

The BBHEADER contains six fields. These fields are summarized here with additional details in paragraph 5.1.6 of the DVB-S2 standard.

MATYPE

A 2 octet field defined in Table 4.3.2.1, MATYPE Subfields.

Table 4.3.2.1 MATYPE Subfields

Octet Number	Bits	MATYPE Subfield	Configured Value	Description
1	2	TS/GS	0b01	generic continuous
	1	SIS/MIS	0b1	single
	1	CCM/ACM	0b1	CCM
	1	ISSY	0b0	not active
	1	NPD	0b0	not active
	2	RO	0b01	roll-off = 0.25
2	16	Reserved	not applicable	not applicable

User Packet Length (UPL)

This 2 octet field contains the user packet length in bits. The UPL value is 0x0000 indicating continuous stream.

Data Field Length (DFL)

This 2 octet field contains the number of bit in the BBFRAME Data Field with payload data (0 to 58112).

SYNC

This 1 octet field is reserved for transport layer signaling.

SYNCD

This 1 octet field is reserved for future use.

CRC-8

This 1 octet field is the error detection code applied to the first nine octets of the BBHEADER. For additional details, refer to paragraph 5.1.4 of the DVB-S2 standard.

4.4 CCSDS AOS Space Data Link Protocol Framing Characteristics and Configuration for GRB

Off-the shelf front-end processing components are available to receive the outputs from a DVB-S2 receiver, and extract and output IP-encapsulated CCSDS space data packets at a rate of approximately 15.5 Mbps for each polarization.

As illustrated above in Figure 4.1, Relationship of Protocols Used in GRB, AOS space data link protocol framing is encapsulated within the DVB-S2 protocol framing. CADUs are inserted into the DVB-S2 Baseband Frame (BBFRAME) Data Field. CCSDS AOS Transfer Frames are inserted into CADUs. For GRB, the Packet Service is employed as defined in paragraph 3.3 of the CCSDS 732.0-B-2, AOS Space Data Link Protocol Blue Book. Note that the GRB implementation is a simplified, but compliant Packet Service implementation because there is only a single source of Space Packets. The following subordinate paragraphs summarize the framing protocol layers internal to the AOS Space Data Link Protocol, and specify its protocol parameter configuration selected for GRB.

The term "octet" is used in the subordinate AOS space data link protocol paragraphs and denotes 8 bits of information. To describe the AOS space data link protocol parameter configuration requires the identification of specifically assigned binary values. The syntax used in the subordinate paragraphs is as follows:

- "0x" preceding values means hexadecimal notation.
- "0b" preceding values means binary notation.

The figures used here to describe the content of CCSDS AOS space data link protocol structures, octets, and fields use a left to right convention where the left most octet or bit in the left most field in the figure is received first. The CCSDS AOS Space Data Link Protocol standard requires that protocol fields are in Big Endian format. This convention is illustrated in Figure 4.4, AOS Space Data Link Protocol Field Bit Ordering.

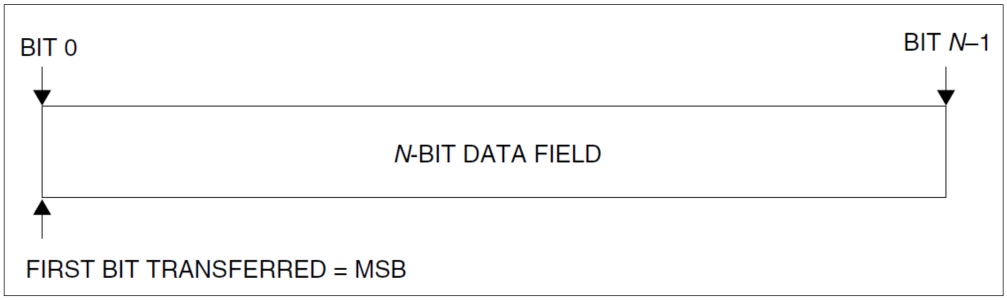


Figure 4.4 AOS Space Data Link Protocol Bit Ordering

The first bit in the field transmitted is defined as "Bit 0". The last bit to be transmitted is 'Bit *N*–1'. "Bit 0" is the Most Significant Bit (MSB) of the data field.

4.4.1 Channel Access Data Unit (CADU)

The CADU is not part of the AOS space data link protocol. Rather, they are a CCSDS space-ground communications construct that bridges media-specific communications services with the data transport services provided by the AOS space data link protocol. Refer to Figure 4.4.1, GRB CCSDS CADU.

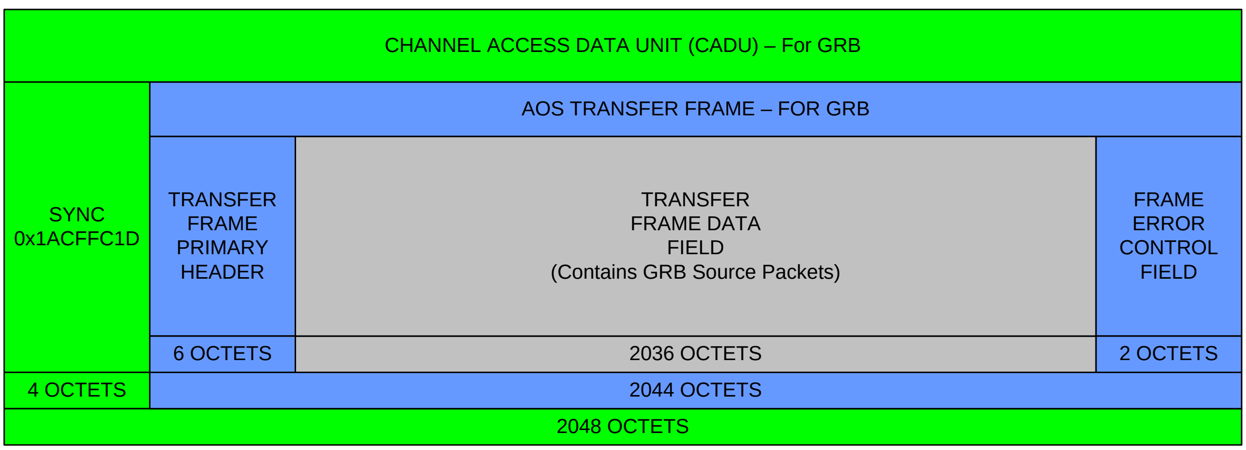


Figure 4.4.1 GRB CCSDS CADU

The CADU frame contains a SYNC marker field and an AOS Transfer Frame. The AOS Transfer Frame is defined in the following paragraph.

<u>SYNC</u>

This 4 octet field is the SYNC marker. The SYNC value is 0x1ACFFC1D.

4.4.2 AOS Transfer Frame

The AOS Transfer Frame is shown above in Figure 4.4.1, GRB CCSDS CADU. The AOS Transfer Frame used in GRB is defined as a CCSDS Version 2 Transfer Frame in accordance with paragraph 3.2.6 of the CCSDS 732.0-B-2, AOS Space Data Link Protocol Blue Book.

The AOS Transfer Frame contains the Transfer Frame Primary Header, Transfer Frame Data Field, and Frame Error Control Field. The Transfer Frame Primary Header and the Transfer Frame Data Field are defined in the subordinate paragraphs that follow.

<u>Frame Error Control Field</u>

This 2 octet field is as detailed in paragraph 4.1.6 of the CCSDS 732.0-B-2, AOS Space Data Link Protocol Blue Book.

4.4.2.1 Transfer Frame Primary Header

The fields in a Transfer Frame Primary Header are shown in Figure 4.4.2.1, Transfer Frame Primary Header.

<table>
<tr><th colspan="8">TRANSFER FRAME PRIMARY HEADER</th></tr>
<tr><td colspan="2">MASTER CHANNEL ID</td><td rowspan="2">VIRTUAL CHANNEL ID</td><td rowspan="2">VIRTUAL CHANNEL FRAME COUNT</td><td colspan="4">SIGNALING FIELD</td></tr>
<tr><td>TRANSFER FRAME VERSION NUMBER

00 = VERSION</td><td>SPACECRAFT ID</td><td>REPLAY FLAG</td><td>VIRTUAL CHANNEL FRAME COUNT USAGE FLAG</td><td>RSVD. SPARE</td><td>VIRTUAL CHANNEL FRAME COUNT CYCLE</td></tr>
<tr><td>2 BITS</td><td>8 BITS</td><td>6 BITS</td><td>24 BITS</td><td>1 BIT</td><td>1 BIT</td><td>2 BITS</td><td>4 BITS</td></tr>
<tr><td colspan="3">2 OCTETS</td><td>3 OCTETS</td><td colspan="4">1 OCTET</td></tr>
<tr><td colspan="8">6 OCTETS</td></tr>
</table>

Figure 4.4.2.1 Transfer Frame Primary Header

<u>Transfer Frame Version Number</u>

Bits 0–1 relative to the start of the Transfer Frame Primary Header contain the Transfer Frame Version Number. This two bit field designates the transfer frame as an AOS transfer frame in accordance with CCSDS 732.0-B-2, AOS Space Data Link Protocol Blue Book. The Transfer Frame Version Number value is 0b00 (binary zeroes).

<u>Spacecraft ID</u>

Bits 2-9 relative to the start of the Transfer Frame Primary Header contain the Spacecraft ID. This 8 bit field identifies the GOES-R series satellite data source for the GRB.

<u>Virtual Channel ID</u>

Bits 10-15 relative to the start of the Transfer Frame Primary Header contain the Virtual Channel ID. This 6 bit field identifies the polarization of the Transfer Frame. Table 4.4.2.1, Transfer Frame Virtual Channel IDs, identifies the values configured for this field.

Table 4.4.2.1 Transfer Frame Virtual Channel IDs

Virtual Channel ID Configured Values	Description
0b000101 (5)	Polarization 1 (RHCP)

0b000110 (6)	Polarization 2 (LHCP)
0b111111 (63)	Idle Frame

Virtual Channel Frame Count

Bits 16-39 relative to the start of the Transfer Frame Primary Header contain the Virtual Channel Frame Count. This 24 bit field is a count field that increments by one for each subsequent transfer frame with the same Virtual Channel ID. The Virtual Channel Frame Count rolls over modulo-16,777,216.

The purpose of this field is to provide individual accountability for each Virtual Channel, primarily to enable systematic Space Packet extraction from the Transfer Frame Data Field. If the Virtual Channel Frame Count is reset or a discontinuity occurs, the completeness of a sequence of Transfer Frames in the related Virtual Channel cannot be determined.

Replay Flag

Bit 40 relative to the start of the Transfer Frame Primary Header contains the Virtual Channel Frame Count. This 1 bit field is not applicable to the GRB downlink. The Replay Flag value is 0b0.

Virtual Channel Frame Count Usage Flag

Bit 41 relative to the start of the Transfer Frame Primary Header contains the Virtual Channel Frame Count Usage Flag. This 1 bit field indicates the Virtual Channel Cycle Count is used in the GRB downlink. The Virtual Channel Frame Count Usage Flag value is 0b1.

Reserved Spare

Bits 42-43 relative to the start of the Transfer Frame Primary Header is a spare 2 bit field. The Reserved Spare value is 0b00.

Virtual Channel Frame Count Cycle

Bits 44-47 relative to the start of the Transfer Frame Primary Header contains the Virtual Channel Frame Count Cycle. This 4 bit field increments by one for each roll-over of the Virtual Channel Frame Count. This field effectively extends the Virtual Channel Frame Count from 24 to 28 bits. The Virtual Channel Frame Count Cycle rolls over modulo-16.

4.4.2.2 Transfer Frame Data Field

The Transfer Frame Data Field is defined in Figure 4.4.2.2, Transfer Frame Data Field.

<table>
<tr><td colspan="5">TRANSFER FRAME DATA FIELD – For GRB</td></tr>
<tr><td colspan="2">M_PDU_HEADER</td><td colspan="3">M_PDU PACKET ZONE</td></tr>
<tr><td>RSVD SPARE</td><td>FIRST HEADER POINTER</td><td>END of SOURCE PKT (N)</td><td>SOURCE PACKET (N+1)</td><td>START of SOURCE PACKET (N+2)</td></tr>
<tr><td>5 BITS</td><td>11 BITS</td><td colspan="3">2034 OCTETS</td></tr>
<tr><td colspan="5">2036 OCTETS</td></tr>
</table>

Figure 4.4.2.2 Transfer Frame Data Field

The Transfer Frame Data Field contains the Multiplexing Protocol Data Unit (M_PDU) Header and M_PDU Packet Zone. The M_PDU Header and M_PDU Packet zone are defined in the subordinate paragraphs that follow.

4.4.2.2.1 M_PDU Header

The M_PDU Header is shown above in Figure 4.4.2.2, Transfer Frame Data Field.

Reserved Spare

Bits 0-4 relative to the start of the M_PDU Header is a spare 5 bit field. The Reserved Spare value is 0b00.

First Header Pointer

Bits 5-15 relative to the start of the Transfer Frame Data Field contain the First Header Pointer. This 11 bit field contains the octet offset to the location of the first octet of the first Space Packet that starts in the M_PDU Packet Zone. If no Space Packet starts in the M_PDU Packet Zone, the First Header Pointer value is 0b11111111111 (all 11 bits are set).

The purpose of the First Header Pointer is to facilitate delimiting of variable-length Space Packets contained within the M_PDU Packet Zone by pointing directly to the location of the first Space Packet starting in the M_PDU Packet Zone.

4.4.2.2.2 M_PDU Packet Zone

The M_PDU Packet Zone is shown above in Figure 4.4.2.2, Transfer Frame Data Field. The M_PDU Packet Zone contains CCSDS Space Packets, one after another, or fill data. There are cases where a single Space Packet spans several M_PDU Packet Zones because its size is approximately 2000 octets and, in the case of GRB, the maximum size of a Space Packet is approximately 16,000 octets. The GRB packet size that is actually utilized may be much less than this maximum packet size (e.g., on the order of 1,500 octets (bytes)).

For Space Packets containing fill data, the Application Identifier in the Packet Primary Header has a value of 0b11111111111 (all ones). The Packet Data Length in the Packet Primary Header contains the size of Space Packet containing fill data.

4.5 CCSDS Space Packet Protocol Characteristics and Configuration for GRB

The CCSDS Space Packet Protocol is defined in CCSDS 133.0-B-1 Space Packet Protocol Blue Book. The Space Packet Protocol provides a unidirectional data transfer service from a source user system application to one or more destination user system applications through one or more sub-networks.

The protocol data units employed by this protocol are Space Packets. They are variable in length and are transmitted at variable intervals. GRB Space Packets are constrained in size to 16,390 octets. The GRB packet size that is actually utilized may be much less than this maximum packet size (e.g., on the order of 1,500 octets (bytes)). Aside from a mandatory primary header that identifies the Packet, the internal data content of Space Packets is completely under the control of the GOES-R GRB assembly application.

Space Packet addressing, including the identification of the content of specific packets is achieved with the Application Process Identifier (APID) field in the packet's primary header. The Space Packet Protocol allows for an APID Qualifier, which is a naming domain. In the case of GRB, which handles only Space Packets associated with a single satellite, only the APID is needed for addressing.

The Space Packet Protocol provides the GRB assembly function with data transfer services. For GRB, the Packet Service is used. The Packet Service transfers Space Packets, pre-formatted by the GRB assembly function, through the sub-network defined in the previous paragraphs asynchronously.

The GRB Space Packet Service has the following characteristics:

- Unidirectional with users being in a receive-only configuration.
- Asynchronous with no predefined timing rules for the transfer of Packets beyond assurances that product latency requirements specified in Appendix B are satisfied.
- No guarantee of completeness, and no retransmission mechanism.
- No guarantee of the order of Packets.
- No guarantee that Packets are not duplicated.

- Integrity of Packet data assured.

Note that these characteristics are based on verbiage in the CCSDS Space Packet Protocol standard. The GOES-R series ground system uplinks GRB Space Packets in order and without duplication.

Also note that Packet data integrity is not part of the CCSDS Space Packet Protocol standard. For GRB, a 32 bit CRC is included in the Packet.

For GRB, the sending packet protocol entity, the GRB assembly function, generates protocol control information, and routes the Space Packets to the sub-network. The receiving packet protocol entity, the GRB user system application, validates and processes protocol control information included in the header to identify the data packet.

The structural components of the GRB Space Packet are shown in Figure 4.5-1, GRB Space Packet Structural Components.

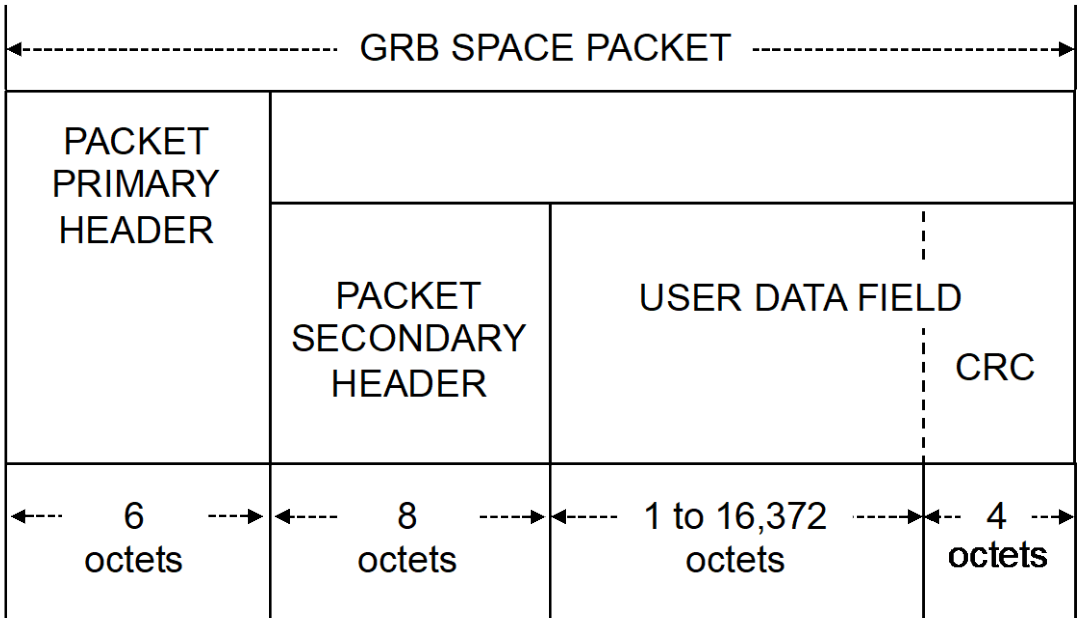


Figure 4.5-1 GRB Space Packet Structural Components

A GRB Space Packet includes the mandatory primary header, a standard secondary header, and a user data field where the last 4 octets are the CRC for the Packet. Note that spare bits in a Space Packet are permanently assigned a value of zero.

The term "octet" is used in the subordinate space packet protocol paragraphs and denotes 8 bits of information. The space packet protocol parameter configuration for GRB is defined below. The syntax used in the subordinate paragraphs is as follows:

- "0x" preceding values means hexadecimal notation.
- "0b" preceding values means binary notation.

The figures used here to describe the content of CCSDS space packet structures, octets, and fields use a left to right convention where the left most octet or bit in the left most field in the figure is received first. The CCSDS Space Packet Protocol standard requires that each of the fields in the primary and secondary header of the CCSDS packet are in Big Endian format. This convention is shown in Figure 4.5-2, Space Packet Primary and Secondary Header Bit Ordering.

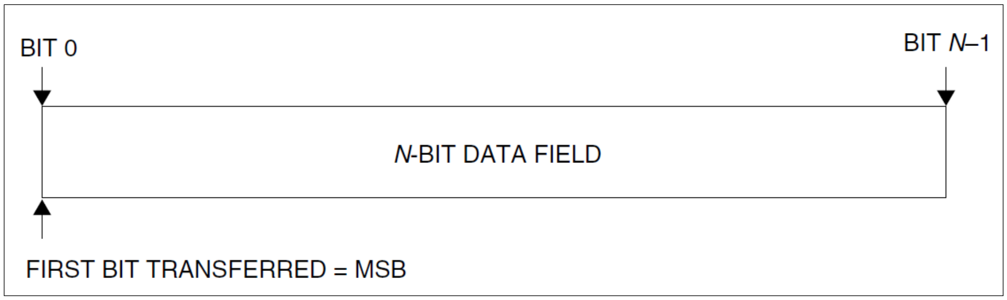


Figure 4.5-2 Space Packet Primary and Secondary Header Bit Ordering

The first bit in the field transmitted is defined as "Bit 0". The last bit to be transmitted is 'Bit *N*–1'. "Bit 0" is the Most Significant Bit (MSB) of the data field. In addition, the CRC field and the payload header fields in the user data field component of the GRB Space Packet are in Big Endian format. The remaining fields in the user data field component are in Little Endian format.

4.5.1 Primary Header Data Fields

Each GRB Space Packet has a mandatory and standard Primary Header. The Packet Primary Header fields are defined in Table 4.5.1, Space Packet Primary Header.

Table 4.5.1 Space Packet Primary Header

	Bits	Field	Summary Description
Packet Primary Header	3	Packet Version Number	CCSDS protocol version
	1	Packet Type	Indicates whether this is a telecommand or telemetry packet
	1	Secondary Header Flag	Indicates whether this packet has a secondary header (Set to 1 for all GRB Space Packets)
	11	Application Process Identifier (APID)	Identifies the specific data content of the packet
	2	Sequence Flags	Flags for data segmentation
	14	Packet Sequence Count	Counter that ascends sequentially for packets with the same APID
	16	Packet Data Length	Packet size information (in octets)

<u>Packet Version Number</u>

Bits 0–2 relative to the start of the GRB Space Packet contain the Packet Version Number. This 3 bit field is set to 0b000 and is used to identify this data as a CCSDS Space Packet. The packet version number field provides the capability to introduce other packet structures in the future. Setting this field to 0b000 indicates that version 1 of the CCSDS Space Packet structure is being used.

<u>Packet Type</u>

Bit 3 relative to the start of the Packet contains the Packet Type bit. This bit is used to distinguish between packets used for telemetry from packets that are used for telecommand. This bit is set to 0b0 for all GRB Space Packets, indicating that GRB data is telemetry.

<u>Secondary Header Flag</u>

Bit 4 relative to the start of the Packet contains the Secondary Header Flag. This flag is used to indicate the presence or absence of the Secondary Header within a Packet. This bit is set to 0b1 for all GRB Space Packets. All GRB Space Packets contain a secondary header.

Application Process Identifier

Bits 5–15 relative to the start of the Packet contain the Application Process Identifier (APID) for the GRB Space Packet. GRB APID values are used to uniquely identify the type of product data or metadata in a Space Packet. The APID values for specific types of GRB product data and metadata, and GRB information are defined in Appendix A. Note that APID values 0x7F8 through 0x7FF are not used in the GRB Space Packets, as these values are reserved for CCSDS internal use.

Sequence Flags

Bits 16–17 relative to the start of the GRB Space Packet contain the Sequence Flags. The Sequence Flags are set in the following manner:

- 0b00 if the GRB Space Packet contains a continuation of a payload data unit that is segmented across multiple Packets.
- 0b01 if the GRB Space Packet contains the first segment of payload data unit that is segmented across multiple GRB Space Packets.
- 0b10 if the GRB Space Packet contains the last segment of payload data unit that is segmented across multiple GRB Space Packets.
- 0b11 if the GRB Space Packet contains an unsegmented payload data unit.

Packet Sequence Count

Bits 18–31 relative to the start of the GRB Space Packet contain the Packet Sequence Count. The value of this 14 bit field increments by one for each subsequent Space Packet generated with the same APID. The Packet Sequence Count rolls over modulo-16,384.

There are several scenarios where a discontinuity in the sequence count for a specific APID may be detected by the user system application. They are as follows:

- Packet loss caused by a GRB link error or a transition to a backup component in the GOES-R system.
- Order of packets received not the same as order in which packets are generated.
- Duplicate packets.

Exception handling in user system applications should handle these scenarios. Packet Sequence Count and the secondary header time fields, Days Since the Epoch and Milliseconds of the Day, can be used to detect packet sequence anomalies. In the event a packet ordering anomaly is detected in the context of Packets containing an unsegmented or segmented payload data unit, which is split across multiple Packets, these header fields can be used by the user system application to preclude data loss.

Packet Data Length

Bits 32–47 relative to the start of the GRB Space Packet contain the Packet Data Length. This 16 bit field contains the size in octets of the Packet less the size of the Packet Primary Header plus one. Therefore, the Packet Data Length is equal to the size in octets of the GRB Space Packet minus 7.

4.5.2 Secondary Header Data Fields

Each GRB Space Packet has a standard Secondary Header. The Packet Secondary Header fields are defined in Table 4.5.2-1, Space Packet Secondary Header.

Table 4.5.2-1 Space Packet Secondary Header

	Bits	Field	Summary Description
Packet Secondary Header	16	Days Since the Epoch	Number of days since the start of the standard J2000 epoch (January 1, 2000 12:00:00 UTC) for packet creation time
	32	Milliseconds of the Day	Milliseconds since start of day (12:00:00 UTC) for packet creation time
	5	GRB Version	GRB version number
	5	GRB Payload Variant	Type of payload
	2	Assembler Identifier	GOES-R series ground system GRB assembly function hardware instance that generated the packet
	4	System Environment	GOES-R series ground system computing environment generating the packet

Days Since the Epoch

Bits 48-63 relative to the start of the GRB Space Packet contain the number of full days since the start of the standard J2000 epoch (January 1, 2000 12:00:00 UTC). This time is the creation time of the GRB Space Packet.

Millisecond of the Day

Bits 64-95 relative to the start of the GRB Space Packet contain the number of milliseconds since the start of the current day (12:00:00 UTC). This time is the creation time of the GRB Space Packet.

GRB Version

Bits 96-100 relative to the start of the GRB Space Packet contain the GRB version. This is currently set to 0b000 and changes in the event a new version of the GRB Space Packet is required.

GRB Payload Variant

Bits 101-103 relative to the start of the GRB Space Packet contain the type of the payload within the GRB Space Packet. The value associated with each type of payload is defined in the Table 4.5.2-2 GRB Payload Types.

Table 4.5.2-2 GRB Payload Types

Payload Type	Value
Generic Data	0
Reserved	1
Image Data	2
Image Data with Data Quality Flags	3

Assembler Identifier

Bits 104-107 relative to the start of the GRB Space Packet contain the GRB assembly function hardware instance, which generated the packet, by site and whether it is primary or backup. The value associated with each type of GRB assembly function hardware instance is defined in the Table 4.5.2-3 GRB Assembler Identifiers.

Table 4.5.2-3 GRB Assembler Identifiers

Assembler Identifier	Value
WCDAS primary	0
WCDAS backup	1
CBU primary	2
CBU backup	3

System Environment

Bits 108-111 relative to the start of the GRB Space Packet contain the GOES-R series ground system computing environment that generates the Packet. The value associated with each system computing environment is defined in the Table 4.5.2-4 GRB System Environments.

Table 4.5.2-4 GRB System Environments

Assembler Identifier	Value
Development	0
Integration and Test	1
Operational	2

Operational users should verify the system environment field indicates "operational".

4.5.3 Space Packet Checksum

The last 4 byte field in a GRB Space Packet is a CRC. This provides an application level data integrity measure for the Packet. The CRC is defined in International Organization for Standardization (ISO) 13239 High-Level Data Link Control (HDLC). The CRC is calculated based on the entire GRB Space Packet leading up to the CRC field. This includes the Packet's primary and secondary headers, and the payload data.

5.0 COMMON GRB PRODUCT AND DATA CHARACTERISTICS

The payload relative to the start of a GRB Space Packet begins in bit 112. The size of the GRB payload in octets is calculated by subtracting 11 from the Primary Header Packet Data Length. The GRB payload in a Packet is variable in size and has a maximum size of 16,372 octets. The GRB packet size that is actually utilized may be much less than this maximum packet size (e.g., on the order of 1,500 octets (bytes)). There are two distinct types of payloads:

- Image
- Generic

Table 5.0, GRB Payload Types identifies the payload type associated with each GRB product.

Table 5.0 GRB Payload Types

	GRB Payload Type	
GRB Product	**Product Data**	**Product Metadata**
Radiances	Image	Generic
Lightning Detection	Generic	Generic
Level 1b SUVI Solar Imagery: EUV	Image	Generic
Solar Flux: X-Ray	Generic	Generic
Solar Flux: EUV	Generic	Generic
Energetic Heavy Ions	Generic	Generic
Magnetospheric Electrons and Protons: Low Energy	Generic	Generic
Magnetospheric Electrons and Protons: Medium and High Energy	Generic	Generic
Solar and Galactic Protons	Generic	Generic

Geomagnetic Field	Generic	Generic
GRB Information Packet	Generic	n/a

The structure of GRB Space Packets for Image and Generic Payloads are different, and are described in the subordinate paragraphs that follow. Both types of payloads include both a header and data in each GRB Space Packet.

Product data and metadata are in separate GRB Space Packets. The Packet(s) containing product data are generated and inserted into the GRB data stream followed by Packets containing the product's metadata. It is recommended that GRB users delay the processing of the product 0.5 seconds after receipt of the product's metadata, in order to ensure that the final few product packets are received.

Product data is in binary form in the GRB Space Packets. Product metadata is in ASCII text-based XML, specifically netCDF Markup Language (NcML) form in the GRB Space Packets. Note that Little Endian bit ordering is used for GRB payload except for the payload header, which uses Big Endian.

The subordinate paragraphs that follow address the following topics related to the definition of the GRB data stream:

- Standards and conventions associated with GRB payload data.
- GRB Image Payload structure.
- GRB Generic Payload structure.

5.1 Standards and Conventions

The payload component of the GRB metadata packets contains a Generic Data payload header followed by an NcML product specification. This NcML product specification is an XML formatted embedded Unix text file without the end-of-file character.

In the case of the Radiances product, this is an NcML product specification that conforms to the Climate and Forecast (CF) Metadata Conventions. All the products in the GRB include the metadata to conform to Unidata's Attribute Conventions for Data Discovery (ACDD). In addition, values for static and dynamic product-level metadata variables and attributes are included in the NcML product specification.

Using NcML to store product metadata and the netCDF4 file specification for the product provides user system applications with the capability to generate netCDF product files from the GRB Space Packets containing the product data and metadata, and also allows user system applications to use widely available XML tools to extract product metadata fields.

Additional details on netCDF file format and conventions, the CF metadata conventions, and Unidata's ACDD is located in Volume 1 of the PUG.

5.2 GRB Image Payload

GRB Space Packets containing image payloads are used for the Radiances and Level 1b SUVI Solar Imagery: EUV products.

A Cartesian coordinate system framework is used to reference specific rows and columns of an image. The y-axis and x-axis are associated with rows and columns of pixels, respectively.

In the case of the Radiances product, the upper left corner pixel of the image corresponds to an X coordinate of 0 and a Y coordinate of 0. The value of X ascends sequentially from left to right across the image. The value of Y ascends sequentially from top to bottom of the image.

In the case of the Level 1b SUVI Solar Imagery: EUV, the lower left corner pixel of the image corresponds to an X coordinate of 0 and a Y coordinate of 0. The value of X ascends sequentially from left to right across the image. The value of Y ascends sequentially from bottom to top of the image.

In the case of image products sensed by the instrument is not natively rectangular, such as is the case with an ABI Full Disk, only the image region sensed by the instrument is included in the GRB data stream.

The Radiances and Level 1b SUVI Solar Imagery: EUV products both include a Data Quality Flag (DQF) for each image pixel. The data structure for the DQFs is identical to that used for the image data, a rectangular array using the same Cartesian coordinate system framework. The same Y and X coordinate values are used for an image pixel and its data quality flag.

Many GRB Space Packets are required to assemble the image products. As a result, the images are partitioned into blocks and fragments. Refer to Figure 5.2-1, GRB Image Data Structure.

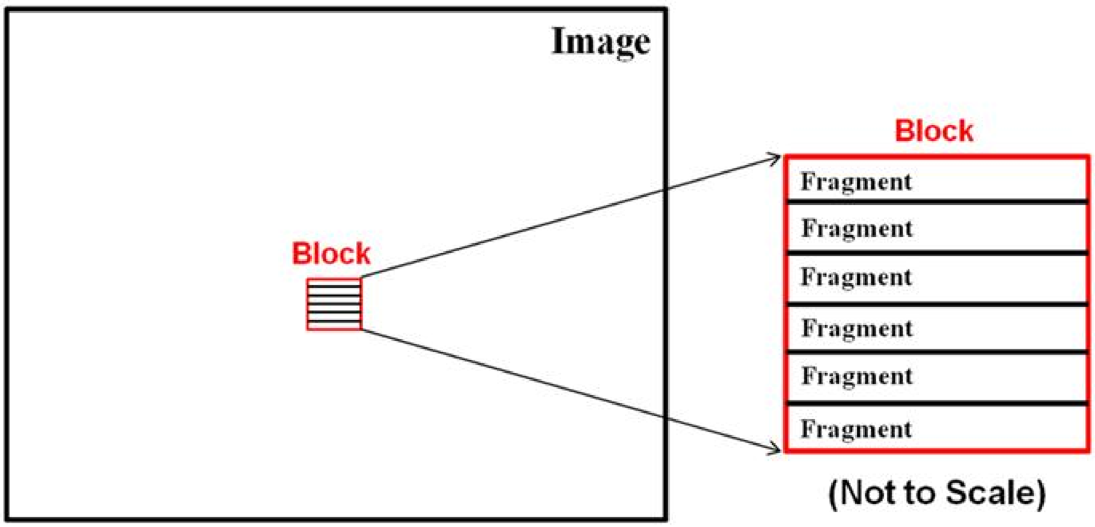


Figure 5.2-1 GRB Image Data Structure

The images are logically partitioned into blocks containing a number of rows and columns. Each row in a block has the same number of columns. Image Payload Header fields define the image block extents and its location in the product image. An image block is partitioned into image fragments. Each fragment has the same number of columns as its encapsulating block. Each fragment has a number of complete rows. Fragments are the unit of image transfer for GRB.

An image fragment and its corresponding DQF fragment, which has the same spatial extents, are interleaved in the GRB data stream. The combination of the image fragment and its corresponding DQF fragment is an Image Payload Data Unit.

An Image Payload Data Unit, after compression, is sized to fit in a single GRB Space Packet. It is possible that an Image Payload Data Unit does not fit into a single GRB Space Packet. This is a result of using a lossless compression algorithm where the compression yield varies as a function of the characteristics of the data in the fragment. The Packet Primary Header Sequence Flags field is used to identify this case.

An Image Payload contains an Image Payload Header followed by an Image Payload Data Unit. An Image Payload in a GRB Space Packet starts immediately after the Packet Secondary Header. An Image Payload may span packets. In this case, an Image Payload Header appears only in the first GRB Space Packet containing the Image Payload. The Image Payload Data starts immediately after the Packet Secondary Header in the subsequent packets required to assemble an Image Payload. The Sequence Flags field in the Packet Primary Header is used to indicate when an Image Payload spans Packets. Refer to Figure 5.2-2, GRB Image Payload Structural Components.

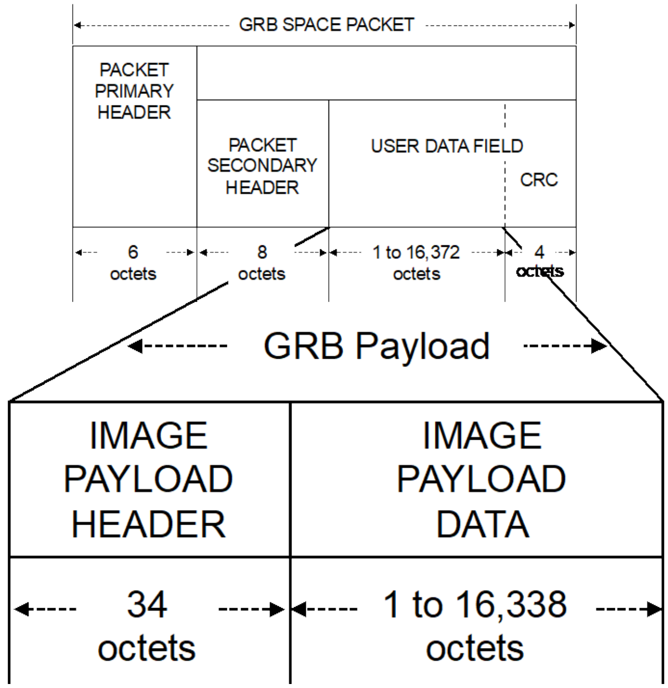


Figure 5.2-2 GRB Image Payload Structural Components

The Image Payload Data Unit, which may span packets, contains the image and DQF fragments. The Image Payload Header uses Big Endian bit ordering and is not compressed. The Image Payload Data Unit uses Little Endian bit ordering and is compressed. Although the Image Payload Data Unit can be up to 16,338 octets in length, the length is currently constrained to <1,500 octets. The Image Payload Header is defined in the subordinate paragraph that follows.

5.2.1 Image Payload Header Data Fields

The first GRB Space Packet used to assemble an Image Payload has an Image Payload Header. The Image Payload Header fields are defined in Table 5.2.1-1, Image Payload Header.

Table 5.2.1-1 Image Payload Header

	Bits	Field		Summary Description
Image Payload Header	8	Compression Algorithm		Compression algorithm used in image payload data
	32	Product Time	Seconds Since the Epoch	Number of seconds since the start of the standard J2000 epoch (January 1, 2000 12:00:00 UTC) for the first packet of data collected by the instrument
	32		Microsecond of the Second	Microseconds since the start of second for the first packet of data collected by the instrument
	16	Image Block Sequence Count		Counter that ascends sequentially for each block in an image product
	24	Row Offset within Image Block[1]		Number of rows in the current image block already assembled in previous packets

	Bits	Field	Summary Description
	32	Upper/Lower Left X Coordinate	For Radiances product, upper left X coordinate of image block in the image product For Level 1b SUVI Solar Imagery: EUV product, lower left X coordinate of image block in the image product
	32	Upper/Lower Left Y Coordinate	For Radiances product, upper left Y coordinate of image block in the image product For Level 1b SUVI Solar Imagery: EUV product, lower left Y coordinate of image block in the image product
	32	Image Block Height	Number of rows in the current image block being assembled
	32	Image Block Width	Number of columns in the current image block being assembled
	32	Octet Offset to DQF Fragment	Octet offset to the DQF fragment in the current packet

[1] An image block may span more than one packet. Rows in each packet will be complete (will always contain the number of columns equal to the Image Block Width) which is why no column offset is needed.

Compression Algorithm

Bits 0-7 relative to the start of the Image Payload Header contain the compression algorithm used for the Image Payload Data. The value associated with each compression algorithm is defined in the Table 5.2.1-2. GRB Compression Algorithms.

Table 5.2.1-2 GRB Compression Algorithms

Compression Algorithm	Value	Compression Options Used
No compression	0	
JPEG 2000	1	
SZIP	2	options_mask = SZ_RAW_OPTION_MASK | SZ_LSB_OPTION_MASK | SZ_NN_OPTION_MASK bits_per_pixel = 8 pixels_per_line = 8 blocks_per_scanline = 8

Image and DQF Fragments in a Packet use the same compression algorithm, but are compressed separately. This allows the Image and DQF Fragments to be extracted from the Packet separately.

Seconds Since the Epoch

Bits 8 to 39 relative to the start of the Image Payload Header contain the number of seconds since the start of the standard J2000 epoch (January 1, 2000 12:00:00 UTC). The sum of this time and the following header field, Microsecond of the Second, is the spacecraft time for the first packet of data collected by the instrument. This sum is referred to as the Product Time.

Microsecond of the Second

Bits 40-71 relative to the start of the Image Payload Header contain the number of microseconds since the start of the current second. The sum of this time and the previous header field, Seconds Since the Epoch, is the spacecraft time for the first packet of data collected by the instrument. This sum is referred to as the Product Time.

Image Block Sequence Count

Bits 72-87 relative to the start of the Image Payload Header is a count field that starts at zero and increments by one for each subsequent image block in an image product. Note that multiple GRB Space Packets are required to send a single image block.

Row Offset within Image Block

Bits 88-111 relative to the start of the Image Payload Header contain a row offset relative to the start of the image block associated with the image fragment in the current Packet's image payload. This is the number of rows of the image block already assembled in previous Packets.

Upper/Lower Left X Coordinate

Bits 113-143 relative to the start of the Image Payload Header contain the upper/lower left X coordinate (column number) of the current image block in the image product being assembled in the Packet.

Upper/Lower Left Y Coordinate

Bits 144-175 relative to the start of the Image Payload Header contain the upper/lower left Y coordinate (row number) of the current image block in the image product being assembled in the Packet.

Image Block Height

Bits 176-207 relative to the start of the Image Payload Header contain the number of rows associated with the current image block being assembled.

Image Block Width

Bits 208-239 relative to the start of the Image Payload Header contain the number of columns associated with the current image block being assembled.

Octet Offset to DQF Fragment

Bits 240-271 relative to the start of the Image Payload Header contain the octet offset from the start of the Image Payload Data Unit to the DQF Fragment. This octet offset may be associated with data that starts in a subsequent Packet.

5.3 GRB Generic Payload

GRB Space Packets with Generic Payloads are used for all data in the GRB data stream other than the Radiances and Level 1b SUVI Solar Imagery: EUV image data. This includes:

- Space and solar products other than Level 1b SUVI Solar Imagery: EUV.
- Lightning detection product.
- Metadata for all the products.
- GRB information packet.

The types of Generic Payload Data are as follows:

- Non-image product data.
- Product metadata.
- GRB Information Packet.

A Generic Payload contains a Generic Payload Header followed by a Generic Payload Data Unit. The data associated with an individual Solar Flux: X-Ray report, metadata for an ABI radiances image product, and a single GRB Information Packet are examples of Generic Payload Data Units. A Generic Payload in a GRB Space Packet starts immediately after the Packet Secondary Header. A Generic Payload may span packets. In this case, a Generic Payload Header appears only in the first GRB Space Packet containing the Generic Payload.

The Generic Payload Data starts immediately after the Packet Secondary Header in the subsequent packets associated with a Generic Payload. The Sequence Flags field in the Packet Primary Header is used to indicate when a Generic Payload Data Unit spans Packets. Refer to Figure 5.3, GRB Generic Payload Structural Components.

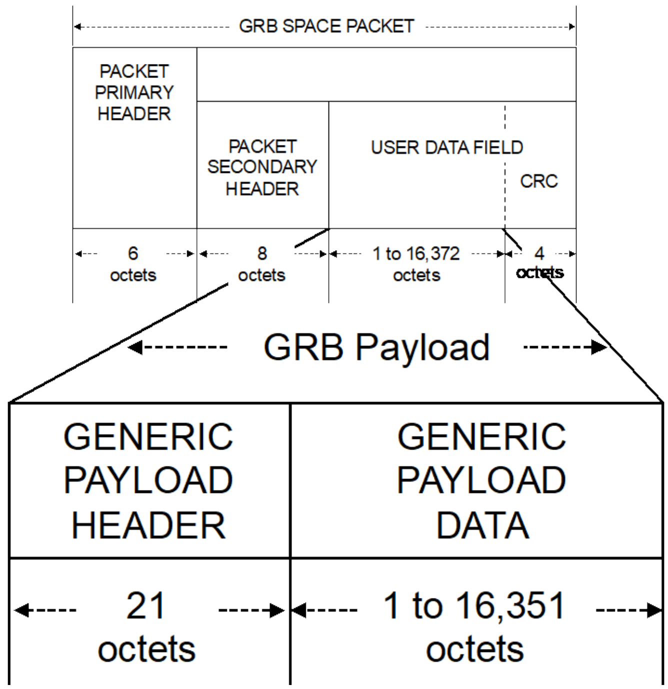


Figure 5.3 GRB Generic Payload Structural Components

The Generic Payload Header uses Big Endian bit ordering and is not compressed. The Generic Payload Data uses Little Endian bit ordering and the use of compression is configurable. Although the Generic Payload Data Unit can be up to 16,351 octets in length, the length is currently constrained to <1,500 octets.

The Generic Payload Header is defined in paragraph 5.3.1, Generic Payload Header Data Fields.

In the case of Generic Payloads containing non-image data, such as Solar Flux: X-Ray and Lightning Detection products, there are additional control fields contained within the Generic Payload Data Unit to simplify the extraction of constituent data. Refer to paragraph 5.3.2, Generic Payload Data Unit Control Fields for details.

Products consist of data and metadata. A product's data and metadata are transferred in separate Packets. A product's data and metadata are associated in the GRB data stream using the Product Time that is calculated by summing the Seconds Since the Epoch and Microseconds of the Second fields that exist in both the Image and Generic Payload Headers. The Product Time for a product's data and metadata are identical.

5.3.1 Generic Payload Header Data Fields

The first GRB Space Packet used to assemble a Generic Payload has a Generic Payload Header. The Generic Payload Header fields are defined in Table 5.3.1-1, Generic Payload Header.

Table 5.3.1-1 Generic Payload Header

	Bits	Field		Summary Description
Generic Payload Header	8	Compression Algorithm		Compression algorithm used in image payload data
	32	Product Time	Seconds Since the Epoch	Number of seconds since the start of the standard J2000 epoch (January 1, 2000 12:00:00 UTC)
	32		Microsecond of the Second	Microseconds since the start of second
	64	Reserved		
	32	Data Unit Sequence Count		Counter that ascends sequentially for each Generic Payload Data Unit in a product instance having the same APID

Compression Algorithm

Bits 0-7 relative to the start of the Generic Payload Header contain the compression algorithm used for the Generic Payload Data. The value associated with each compression algorithm is defined in the Table 5.3.1-2 GRB Compression Algorithms.

Table 5.3.1-2 GRB Compression Algorithms

Compression Algorithm	Value	Compression Options Used
No compression	0	
JPEG 2000	1	
SZIP	2	options_mask = SZ_RAW_OPTION_MASK | SZ_LSB_OPTION_MASK | SZ_NN_OPTION_MASK bits_per_pixel = 8 pixels_per_line = 8 blocks_per_scanline = 8

Seconds Since the Epoch

Bits 8 to 39 relative to the start of the Generic Payload Header contain the number of seconds since the start of the standard J2000 epoch (January 1, 2000 12:00:00 UTC). The sum of this time and the following header field, Microsecond of the Second, is the spacecraft time for the first packet of data collected by the instrument. This sum is referred to as the Product Time.

Microsecond of the Second

Bits 40-71 relative to the start of the Generic Payload Header contain the number of microseconds since the start of the current second. The sum of this time and the previous header field, Seconds Since the Epoch, is the spacecraft time for the first packet of data collected by the instrument. This sum is referred to as the Product Time.

Data Unit Sequence Count

Bits 136-167 relative to the start of the Generic Payload Header is a count field that starts at zero and increments by one for each subsequent Generic Payload Data Unit in a product.

5.3.2 Generic Payload Data Unit Control Fields

In the case of Generic Payloads containing non-image data, control fields are included in the Generic Payload Data Unit to simplify extraction. The composition of these control fields varies as a function of the following:

- Number of dimensions associated with the product's data fields.
- Use of data structures with multiple contiguous fields that repeat.

Number of dimensions associated with the product's data fields.

Refer to Table 5.3.2, Generic Payload Control Fields for Different Product Data Types.

Table 5.3.2 Generic Payload Control Fields for Different Product Data Types

Product Field Data Type	Embedded Control Information	Product Data Field Ordering
Scalar	None	n/a
One Dimensional: Fixed Number of Data Field Values	None	Array subscripts in ascending order.
One Dimensional: Variable Number of Data Field Values	Eight byte control field proceeds the repeating data field.	Array subscripts in ascending order.
Multi-Dimensional	Eight byte control fields precede the repeating data fields. One eight byte control field for each dimension. Order of control fields is least frequently changing dimension first (i.e., left-most subscript in netCDF variable declaration) and most frequently changing dimension last. Value of control field is the dimension size.	Most frequently changing array subscript (i.e., right-most subscript in netCDF variable declaration) first followed by next most frequently changing subscript, and so on.

For example, x (2,3) with a data type of short (i.e., 2 byte integer) in the Generic Payload Data Unit appears as follows:

	Control Fields		Data Fields					
Size	8 bytes	8 bytes	2 bytes	2 bytes	2 bytes	2 bytes	2 bytes	2 bytes
Value	2	3	x(0,0) value	x(0,1) value	x(0,2) value	x(1,0) value	x(1,1) value	x(1,2) value

Use of data structures with multiple contiguous fields that repeat.

In the case of the Lightning Detection product, multiple fields associated with the same flash, group, or event, are adjacent in the Generic Payload Data Unit. These adjacent fields are referred to as a data structure. These data structures repeat for each flash, group, or event. In this case, the control information identifies the number of data structures present in the Generic Payload Data Unit. For example, a Generic Payload Data Units with 200 individual and repeating data structures of 10 bytes each is as follows:

	Control Field	Repeating Data Structures			
Size	8 bytes	10 bytes	10 bytes	……	10 bytes
Value	200	values of fields for data structure # 1	values of fields for data structure # 2		values of fields for data structure # 200

The sets of data fields composing the flash, group, and event data structures are defined in the Lightning Detection product definition located in paragraph 7.0, GRB Product and Data Descriptions.

6.0 GRB PAYLOAD RECOVERY

The GRB data stream, which is composed of GRB Space Packets, is designed to provide the capability to display and exploit product data as GRB Space Packets are received, and also allows for the assembly of product files containing product data and metadata. The data and metadata associated with a product are sent in different Packets. The Packet(s) containing product data are sent first followed by the Packet containing the product's metadata. It is recommended that GRB users delay the processing of the product 0.5 seconds after receipt of the product's metadata, in order to ensure that the final few product packets are received.

The Application Process Identifier (APID) in the Space Packet Primary Header defined in Table 4.5.1 above distinguishes the type of information in specific packets. For all GRB products, unique APID values are assigned to the data and metadata packets. In the case of the Radiance product type, which has multiple types of images, Full Disk, CONUS, and mesoscale, generated in multiple modes, ABI modes 3, 4 and 6, and for 16 channels, unique product data and metadata APIDs are assigned to distinguish all combinations. Note that in the case of mesoscale images, the ABI sensor produces two unique mesoscale products, which typically are associated with two unique regions. Each mesoscale product is assigned a unique APID. Similarly, in the case of the Level 1b SUVI Solar Imagery: EUV product type, unique APIDs are assigned for images resulting from each of the six different central wavelengths. The Lightning Detection product is also a special case because flash, group, and event data are segregated into separate Packets, and unique APIDs are assigned to each. Refer to Appendix A for the APID values used for each product in the GRB data stream.

The association between a product's data and metadata Packets is achieved using the Product Time in the Image Payload Header defined in Table 5.2.1-1 and Generic Payload Header defined in Table 5.3.1-1. The Product Time is the same for all data and metadata Packets associated with a particular instance of a product.

Product metadata is stored in NcML format. NcML is an XML representation of the netCDF product files generated by the GOES-R ground station. The NcML metadata can be displayed and exploited by standard XML tools.

In the case of the Lightning Detection, Solar Flux: X-Ray, Magnetospheric Electrons and Protons: Low Energy, Magnetospheric Electrons and Protons: Medium and High Energy, Solar and Galactic Protons, and Geomagnetic Field products, a metadata Packet does not follow every observation data Packet. Rather, the metadata associated with a set of observations over a configured time interval is aggregated. It is recommended that GRB users delay the processing of the product 0.5 seconds after receipt of the product's metadata, in order to ensure that the final few product packets are received. Refer to Appendix B for GRB product and aggregated product refresh rates and latencies.

The subordinate paragraphs that follow define the algorithms to extract product data and metadata from GRB Space Packets with Image and Generic Payloads as defined above in Paragraphs 5.2 and 5.3, respectively. These algorithms assume that a single image product is being recovered. However, because products from the same and different instrument are interleaved in the GRB data stream, the user software application must have the ability to extract and assemble the data and metadata from multiple products simultaneously.

6.1 GRB Image Payload Recovery

The process for extracting an Image Payload from the GRB data stream is outlined in Figure 6.1, Image Payload Recovery.

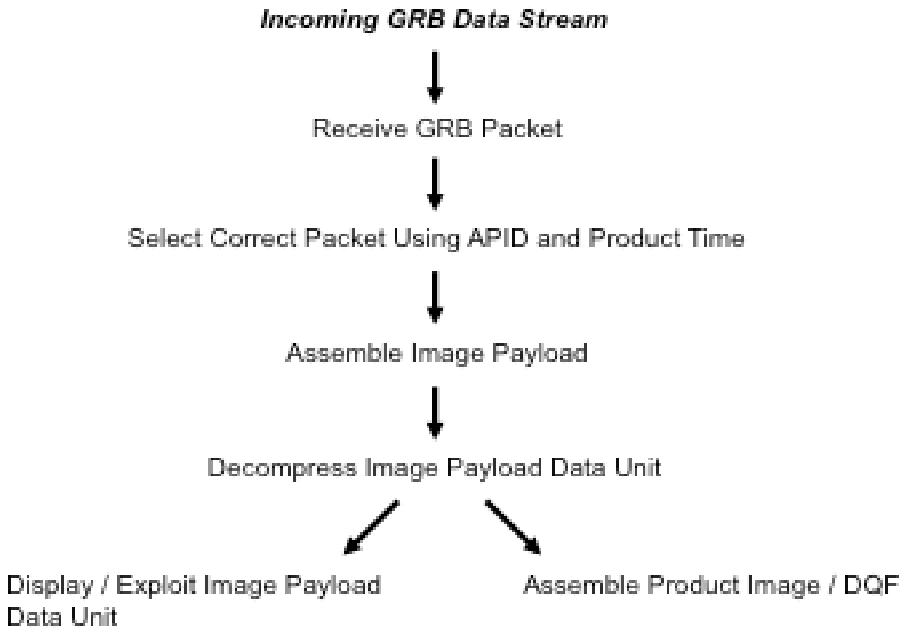


Figure 6.1 Image Payload Recovery

This algorithm is continuous, and extracts, decompresses, and assembles image and Data Quality Flag (DQF) fragments. The resulting fragments can be exploited immediately or used to construct the full image and DQF dataset. The algorithm accounts for the interleaving of Packets associated with other products in the data stream and handles the case where Packets are received out of order or duplicate Packets are received. Note that Packets are not transmitted out of order, but the receiving user system network and the user system's deployed communications protocol may allow this situation to occur.

The details of the image payload recovery algorithm are defined in the subordinate paragraphs that follow.

6.1.1 Receive GRB Space Packet

The GRB data stream is composed of three distinct protocol encapsulations, DVB-S2, CCSDS Space Data Link Protocol, and CCSDS Space Packets (i.e., GRB Space Packets) as show above in Figure 4.1, Relationship of Protocols Used in GRB. Extracting GRB Space Packets from the data stream requires the demodulation, execution of the forward error correction, and extraction and assembly in accordance with the characteristics and configuration of the DVB-S2 and CCSDS AOS Space Data Link framing defined above in paragraphs 4.3 and 4.4.

Once a GRB Space Packet has been extracted, the CRC algorithm should be performed and compared with the Space Packet Checksum in the Packet as defined above in paragraph 4.5.3 to verify the data integrity of the Packet. Should the CRC check fail, the packet should be discarded.

6.1.2 Select Correct Packet Using APID and Product Time

Packets from different products are interleaved in the GRB data stream. The APID in the Packet Primary Header and the Product Time in the Image Payload Header are used to identify Packets containing a specific instance of a product. Refer to Appendix A for the APID values used for each product in the GRB data stream.

The Product Time is the same for all Packets associated with a particular instance of a product.

6.1.3 Assemble Image Payload

A product image is logically partitioned into blocks containing a number of rows and columns. Each row in a block has the same number of columns. Image Payload Header fields define the image block extents and its location in the product image. An image block is partitioned into image fragments. Each fragment has the same number of columns as its encapsulating block. Each fragment has a number of complete rows. Fragments are the unit of image transfer for GRB.

The image fragment and its corresponding DQF fragments cover the same spatial extent and have the same number of rows and columns. An image fragment and its corresponding DQF fragment, which are collectively referred to as an Image Payload Data Unit, are adjacent in the GRB data stream, and packaged with an Image Payload Header into an Image Payload. An Image Payload can span GRB Space Packets as shown in Figure 6.1.3, GRB Space Packet to Image Payload Relationship.

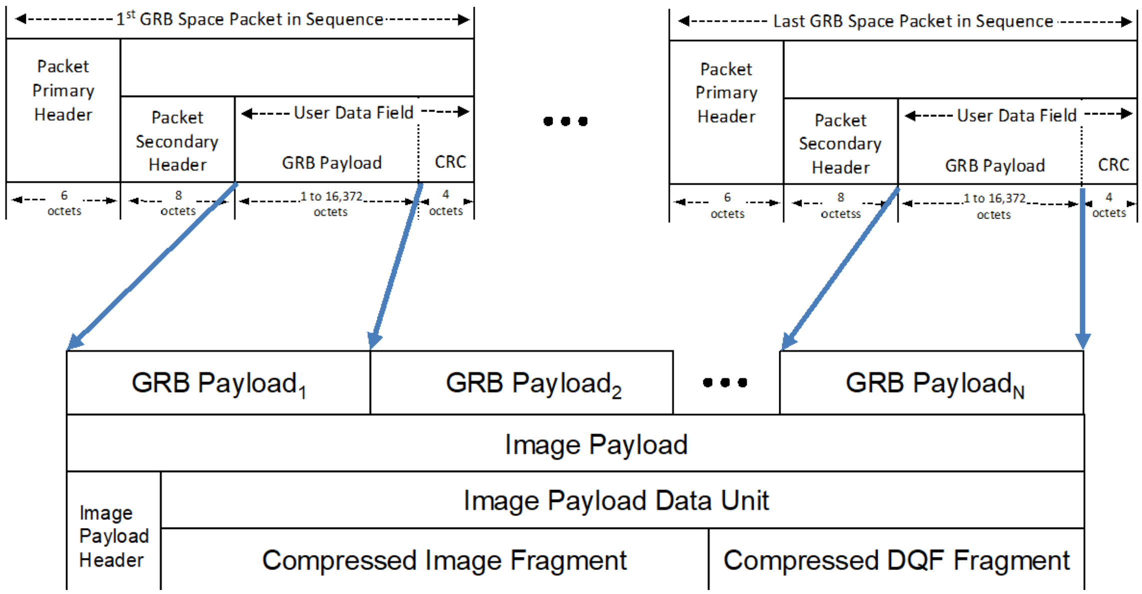


Figure 6.1.3 GRB Space Packet to Image Payload Relationship

The process for extracting and assembling the Image Payload is as follows:

1) Extract the Sequence Flags and Packet Sequence Count from the Packet Primary Header of the selected GRB Space Packets as they are received.

2) Collect the sequence of GRB Space Packets associated with an Image Payload until they all have been collected. The sequence is complete when the Sequence Flags and Packet Sequence Count in the Packet Primary Headers of the Packets indicate that all Packets in the sequence are present. In addition, the Packet Sequence Count should increment by one (modulo-16,384) for each Packet in the sequence. If any of the Packets in the sequence are missing, then all of the GRB Space Packets in this sequence should be discarded. Temporal windowing logic is required to handle Packets received out of order. It is only possible to decompress image and DQF fragments that have been completely received.

3) Duplicate Packets are detected using the Packet Sequence Count in the Packet Primary Header. Duplicate Packets should be discarded.

4) Extract the GRB Payload from each of the Packets associated with the Image Payload. The GRB Payload starts immediately after the Packet Secondary Header and ends at the start of the Space Packet Checksum (CRC). Concatenate each of the GRB Payloads in the order specified by the Packet Sequence Count. This creates the Image Payload shown in Figure 6.1.3.

5) The first 34 octets of the Image Payload are the Image Payload Header, which is defined above in paragraph 5.2.1. Extract the Octet Offset to DQF Fragment from the Image Payload Header.
6) Extract the image fragment from the Image Payload Data Unit. The image fragment is located in octets 0 through the value of Octet Offset to DQF Fragment - 1 in the Image Payload Data Unit.
7) Extract the DQF fragment from the Image Payload Data Unit. The DQF Image Fragment is located in octets defined by the value of Octet Offset to DQF Fragment to the end of the Image Payload Data Unit.

6.1.4 Decompress Image Payload Data Unit

The image and DQF fragments are both self-contained compressed image blocks. The compression algorithm used is defined in the Compression Algorithm in the Image Payload Header. The current compression algorithm for imagery in GRB is JPEG 2000. Off-the-shelf software libraries, such as Kakadu, are available to decompress the image and DQF fragments.

Note: When decompressing Image Payload Data that was compressed with SZIP compression (Compression Algorithm = 2), the first 4 octets of the Image Payload Data Unit represent the number of octets (bytes) of the payload data when it is uncompressed. Also, the Image Payload Data Unit must be decompressed using the same SZIP options that were used during the data compression. Refer to Table 5.2.1-2, GRB Compression Algorithms for the SZIP compression/decompression options to be used.

6.1.5 Display / Exploit Image Payload Data Unit

Displaying or exploiting an image fragment requires the knowledge needed to locate each pixel in the image fragment. In the case of the Radiances product, the product image's extents and coordinates needed to geo-locate the pixels in the image fragment are defined in paragraph 7.1.2, ABI Fixed Grid. The Radiances product image can also be displayed using a local reference frame provided by the x and y coordinates associated with the image fragment.

In the case of the Level 1b SUVI Solar Imagery: EUV product, the projection of the image, a gnomonic azimuthal projection that uses helioprojective-cartesian coordinates, is from the perspective of the GOES-R satellite. As a result, the product image can be displayed using a local reference frame provided by the x and y coordinates associated with the image fragment.

The size of a pixel is defined in the paragraph for the product in section 7, GRB Product and Data Descriptions.

Table 6.1.5 identifies the five fields within the Image Payload Header that are needed to position an image fragment in a display or image. The full definition of the Image Header is provided in Table 5.2.1-1.

Table 6.1.5 Positioning Fragment in Image

Image Payload Header Field	Processing Role
Image Block Sequence Count	Associates a fragment with its image block.
Upper/Lower Left X Coordinate and Upper/Lower Left Y Coordinate	Contains the product image's two dimensional array subscripts for the image block.
Row Offset within Image Block	Fragment's location relative to its encompassing image block.
Image Block Width	Number of columns in each row of the image block.

This information allows the fragment to be positioned in the product image. Note that the height and width of the fragment are also contained within JPEG 2000 compressed image block.

For the Radiances product, subscripts (0,0) are the most northwest corner of the image defined in paragraph 7.1.2, ABI Fixed Grid. The Upper/Lower Left X Coordinate and Upper/Lower Left Y Coordinate fields are subscripts (y,x) in the same full image space. An image block's constituent image fragment is loaded starting at subscripts (y + Row Offset of Image Fragment,x). The order of pixels in the image fragment is left to right, top to bottom row

The accompanying DQF fragment provides quality information for the pixels in the image fragment, and its location, extents, and element size can be similarly determined.

Product Time in the Image Payload Header is used to distinguish fragments from different product image instances.

6.1.6 Assemble Product Image / DQF

When the Product Time in the Image Payload Header contains a more recent time than the previous Image Payload Header Product Time and the Image Block Sequence Count in the Image Payload Header is zero, the start of a new product image has been received.

When a new product image has been detected, a two dimensional array of pixel values should be created for both the product image and DQF data. The values in the image and corresponding DQF data should be set to the product image's fill value and DQF's fill value, respectively. Loading the image and DQF data structure with fill value handles data loss scenarios.

Paragraph 6.1.5, Display / Exploit Image Payload, describes how to locate and insert image and DQF fragments in the product's image and DQF data.

The product's image and DQF data are complete when their two dimensional arrays have been fully populated. Different data loss scenarios are detected using the Image Block Height and Image Block Width for constituent fragment loss, and the Product Time in the Packet Primary Header in the event fragments associated with a subsequent product's image are received before all fragments from the current image are received. Temporal windowing logic is required to handle Packets received out of order.

6.2 GRB Generic Payload Recovery

The process for extracting a Generic Payload from the GRB data stream is outlined in Figure 6.2, Generic Payload Recovery.

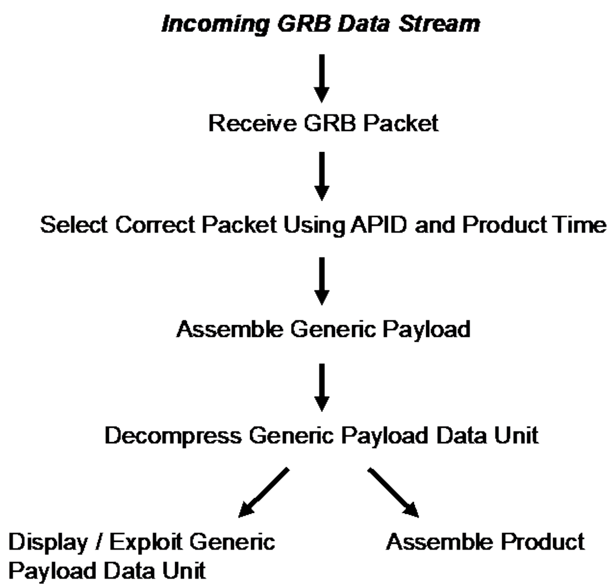


Figure 6.2 Generic Payload Recovery

This algorithm is continuous, and extracts, decompresses, and assembles Generic Payload Data Units. Products are assembled from Generic Payload Data Units, but the processing varies as a function of the type of Generic Payload Data Unit.

The algorithm accounts for the interleaving of Packets associated with other products in the data stream and handles the case where Packets are received out of order or duplicate packets are received. Note that Packets are not transmitted out of order, but the receiving user system network and the deployed communications protocol may allow this situation to occur.

The details of the generic payload recovery algorithm are defined in the subordinate paragraphs that follow.

6.2.1 Receive GRB Space Packet

This processing algorithm is identical to that specified in paragraph 6.1.1 for Image Payloads.

6.2.2 Select Correct Packet Using APID and Product Time

Packets from different products are interleaved in the GRB data stream. The APID in the Packet Primary Header and the Product Time in the Generic Payload Header are used to identify Packets containing a specific instance of a product. Refer to Appendix A for the APID values used for each product in the GRB data stream.

The Product Time is the same for all Packets associated with a particular instance of a product.

6.2.3 Assemble Generic Payload

This processing algorithm is identical to that specified in paragraph 6.1.3 for Image Payloads, except the Generic Payload Data Unit contains only a single compressed block. The compressed block can contain:

- Non-image product data.
- Product metadata.
- GRB Information Packet.

6.2.4 Decompress Generic Payload Data Unit

The Generic Payload Data Unit contains a single self-contained compressed block. The compression algorithm used is defined in the Compression Algorithm in the Generic Payload Header.

Note: When decompressing Generic Payload Data that was compressed with SZIP compression (Compression Algorithm = 2), the first 4 octets of the Generic Payload Data Unit represent the number of octets (bytes) of the payload data when it is uncompressed. Also, the Generic Payload Data Unit must be decompressed using the same SZIP options that were used during the data compression. Refer to Table 5.3.1-2, GRB Compression Algorithms for the SZIP compression/decompression options to be used.

6.2.5 Display / Exploit Generic Payload Data Unit

A decompressed Generic Payload Data Unit containing product metadata or GRB information can be directly displayed and exploited, as applicable, by a user system application. In the case of a Generic Payload Data Unit containing non-image product data, the user system application must account for the control fields defined in paragraph 5.3.2, Generic Payload Data Unit Control fields to display and exploit the data.

The content and format of the data is defined in the applicable Data Fields or Metadata Fields paragraph for the product in paragraph 7.0, GRB Product and Data Descriptions.

Product metadata is stored in NcML format. NcML is an XML representation of the netCDF product files generated by the GOES-R ground station. The NcML metadata can be displayed and exploited by standard XML tools.

6.2.6 Assemble Product

A different product assembly algorithm is required for:

- Product data contained in a single Generic Payload
- Product data contained in multiple Generic Payloads.
- Product metadata.
- GRB Information Packet.

The details of the different product assembly algorithms are defined in the subordinate paragraphs that follow.

6.2.6.1 Product Data Contained in a Single Generic Payload

A product's data can be extracted and assembled from a decompressed Generic Payload Data Unit by a user system application. The content and format of a product's data is defined in the applicable Data Fields paragraph for the product in paragraph 7.0, GRB Product and Data Descriptions.

6.2.6.2 Product Data Contained in Multiple Generic Payloads

When the Product Time in the Generic Payload Header contains a more recent time than has yet to be received and the Data Unit Sequence Count in the Generic Payload Header is zero, the start of a new product has been received.

When a new product has been detected, the data variable values as defined in the applicable Data Fields paragraph for the product in paragraph 7.0, GRB Product and Data Descriptions should be set to the respective data variables' fill value.

To load product data from the Generic Payload Data Unit, the Data Unit Sequence Count in the Generic Payload Header is used as the subscript into the destination product data variable. The content and format of a product's data is defined in the applicable Data Fields paragraph for the product in paragraph 7.0, GRB Product and Data Descriptions.

The product data is complete when the data variables have been fully populated. Different data loss scenarios are detected using the Product Time in the Packet Primary Header in the event data associated with a subsequent product is received before all the data from the current product is received. Temporal windowing logic is required to handle Packets received out of order. User system applications having stringent near real-time performance requirements may require the use of timers.

6.2.6.3 Product Metadata

A product's metadata appears in the GRB data stream after its data. The Product Time in the Image and Generic Payload Headers associate a product's metadata with its data. The content and format of a product's metadata is defined in the applicable Metadata Fields paragraph for the product in paragraph 7.0, GRB Product and Data Descriptions. The arrival and inclusion of a product's metadata into a file signals the end of the product assembly process. It is recommended that GRB users delay the processing of the product 0.5 seconds after receipt of the product's metadata, in order to ensure that the final few product packets are received. Temporal windowing logic is required to handle Packets received out of order.

6.2.6.4 GRB Information Packet

The GRB Information Packet is wholly contained in a single decompressed Generic Payload Data Unit, and can be directly displayed and exploited by a user system application. The content and format of a GRB Information Packet is defined in paragraph 7.7, GRB Information.

7.0 GRB PRODUCT AND DATA DESCRIPTIONS

This section of the document describes, and define the detailed content and format of the GOES-R Level 1b and Level 2+ products in the GRB.

The detailed descriptions of ISO series metadata for GOES-R Level 1b and Level 2+ products available in GRB are located in Appendix X, GOES-R ISO Series Metadata. This is a special standalone appendix to the PUG.

The Level 1b and Level 2+ products in the GRB data stream make use of flag variables. These products conform to the CF Metadata Conventions for flag variables. These flag variable conventions are described in the main volume of the PUG.

The Level 1b and Level 2+ products in the GRB data stream include a metadata field identifying the percentage of product data lost due to uncorrectable Level 0 data errors. This metadata field is not specifically discussed in the product description paragraphs.

There are two variable attributes that denote versions – product_version and algorithm_version. These attributes are independent of each other. Algorithm version will always increment when a new algorithm version is installed. Product version will also increment for a new algorithm, but may also increment due to a change to a product that is not an algorithm update.

Other than image data, tables are used to communicate the detailed content of product data and metadata. One table defines the product data in the file, and another table defines the product metadata. By default, in the product tables (see Table 7.4.1.5.1, for example), the values of variables are dynamic and the values of attributes are static. However, there are situations when an attribute value is selected from a list of valid values, has a fixed format, or is a dynamic value. Furthermore, there are situations where a variable or attribute value contains spatial coordinates, dimensioning information related to coverage areas and resolution, band dependent values, or flag values. For all these cases, ***bold italic*** text is used to convey how to properly interpret what the value of the variable or attribute should be.

7.0.1 Time Representation and Conversion

Products and data files described in this volume contain time and time-related variables that represent the seconds since J2000 (J2K) epoch (2000-01-01 12:00:00 UTC). Below are three methods that can be used to convert the "seconds since J2000 epoch" value into a standard calendar date and time. The following URL contains numerous other methods that are used in various computer languages (e.g., C, Perl, Python):

http://www.epochconverter.com.

Let "SSE" represent the value of "seconds since J2000 epoch".

Microsoft Excel conversion:

1. Enter into cell A1: =DATE(2000,1,1) + TIME(12,0,0)
2. Enter into cell A2: =SSE/24/3600
3. Enter into cell A3: =A2+A1
4. Change the format of cell A3 as desired (e.g., Format Cells > Number > Category:Date, Type:choose format)

IDL conversion:

1. epoch = julday(1,1,2000,12,0,0)
2. CALDAT, epoch + SSE, month, day, year, hour, minute, second

3. time_format = '(I04,"-",I02,"-",I02,"T",I02,":",I02,":",I02,"Z")'
4. print, year, month, day, hour, minute, second, FORMAT=time_format

Linux workstation conversion:

1. Add 946,728,000 to SSE (946,728,000 is the difference in seconds between J2000 epoch and the UNIX epoch (1/1/1970):
    a. SUM=$((946728000 + SSE))
2. Enter on the command line:
    a. date -u -d @${SUM}

    Note: this method may not work after January 19, 2038, which is the largest date the linux "date" command can support on some machines.

7.0.2 Unsigned Integer Processing

The classic model for netCDF (used by the GS) does not support unsigned integers larger than 8 bits. Many of the variables in GOES-R netCDF files are unsigned integers of 16-bit or 32-bit length. The following process is recommended to convert these unsigned integers:

1. Retrieve the variable data from the netCDF file.
2. For this variable, retrieve the attribute "_Unsigned".
3. If the "_Unsigned" attribute is set to "true" or "True", then cast the variable data to be unsigned.

The steps above must be completed before applying the scale_factor and add_offset values to convert from scaled integer to science units. Also, the valid_range and _FillValue attribute values are to be governed by the "_Unsigned" attribute.

7.1 ABI Level 1b Product

7.1.1 ABI Modes

There are three standard scanning modes for the ABI instrument: Mode 3, Mode 6 and Mode 4. Mode 4 consists of the observation of the Full Disk scene every five minutes. Mode 3 consists of one observation of the Full Disk scene of the earth, three observations of the continental United States (CONUS) scene, and thirty observations for each of two distinct mesoscale scenes every fifteen minutes, during nominal operations. Mode 6 consists of one observation of the full disk scene of the earth, two observations of the continental United States (CONUS) scene, and twenty observations for each of two distinct mesoscale scenes every ten minutes, during nominal operations. The CONUS scene coverage area is approximately 5000 km in the east-west direction by 3000 km in the north-south direction. The coverage area of a mesoscale scene is approximately 1000 km by 1000 km. In all of these modes, there are interleaved space, blackbody, and star looks to support radiometric and navigation accuracy requirements.

The detailed sensing timelines for the ABI in Mode 3, 4 and 6 are defined in Figure 7.1.1-1, 7.1.1-2 and Figure 7.1.1-3, respectively. Spacelooks needed for data calibration may occur after a Full Disk swath rather than before it depending on whether the spacelook occurs on the East or West side of the earth. Observations of the Full Disk (pink), CONUS (blue), and mesoscale (green) scenes, and the calibration looks (yellow: visible stars, red: infrared stars) are shown.

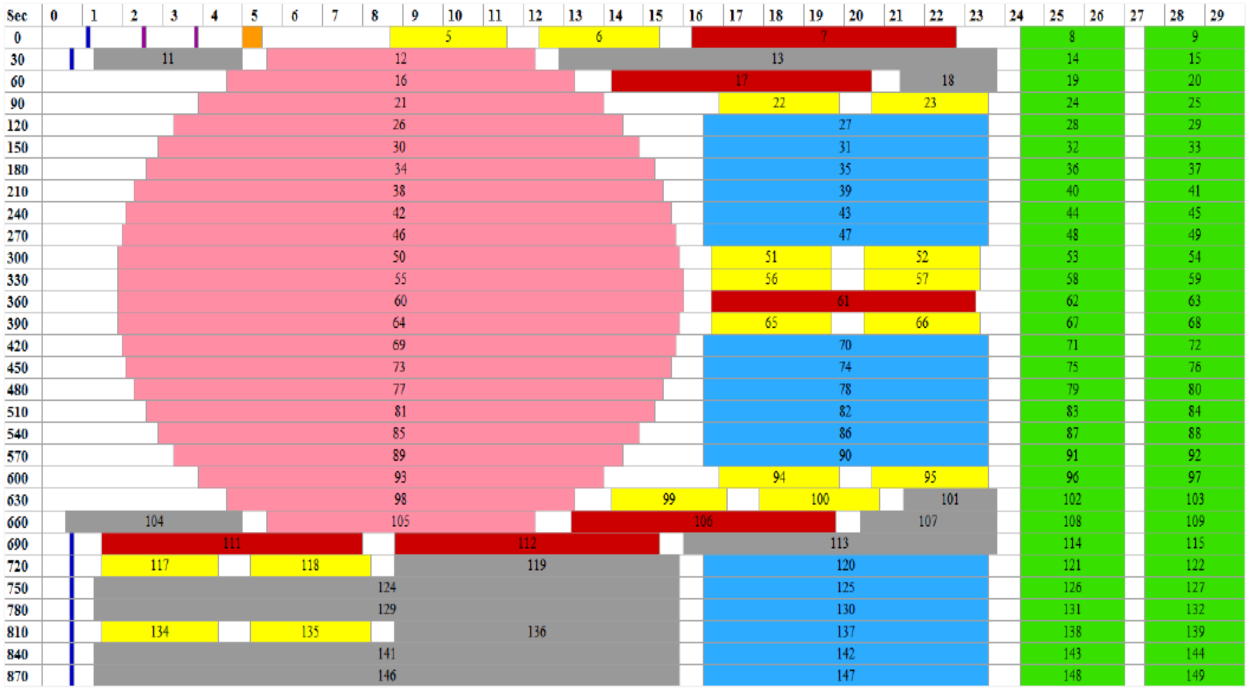


Figure 7.1.1-1 ABI Mode 3 Timeline

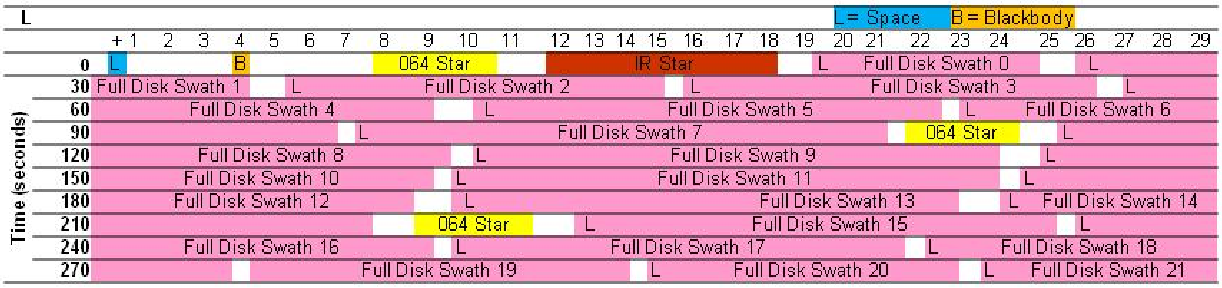


Figure 7.1.1-2 ABI Mode 4 Timeline

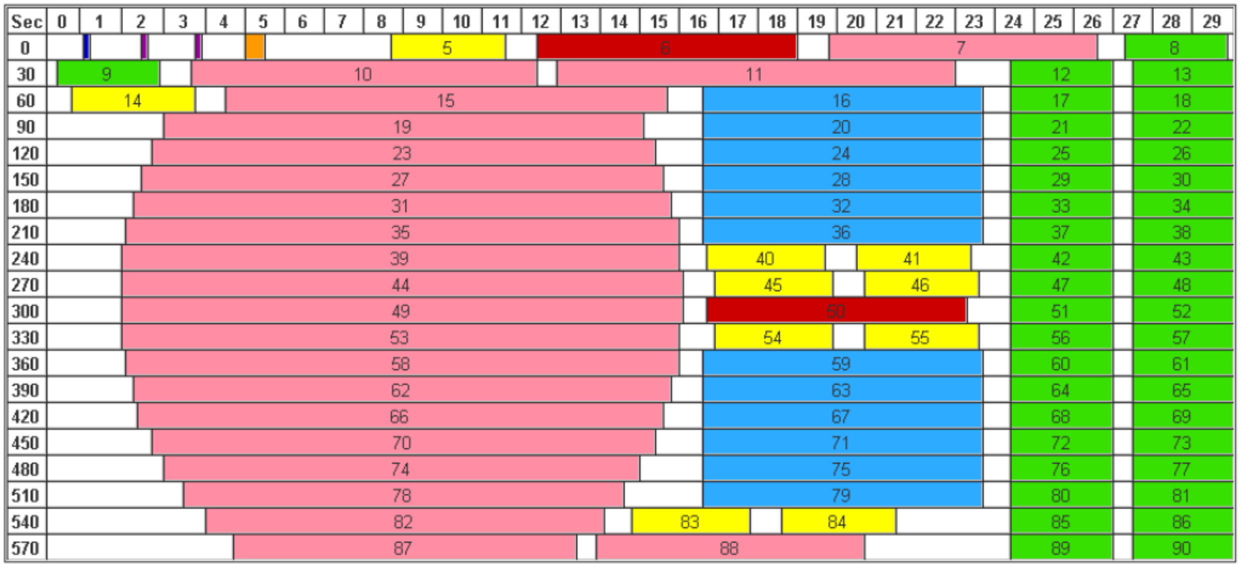


Figure 7.1.1-3 ABI Mode 6 Timeline

The Mode 3 fifteen minute timeline consists of 22 swaths to cover the Full Disk, 3 sets of 6 swaths to cover the CONUS 3 times, and 30 sets of 2 swaths to cover the Mesoscale regions 30 times. White space in the diagram represents periods of time when the instrument is not actively scanning or making calibration measurements. During Mode 4, the Full Disk is covered once with 22 swaths with the instrument actively scanning or making calibration measurements much of the time. The Mode 6 ten minute timeline consists of 22 swaths to cover the Full Disk, 2 sets of 6 swaths to cover the CONUS 2 times, and 20 sets of 2 swaths to cover the Mesoscale regions 20 times.

7.1.2 ABI Fixed Grid

The ABI fixed grid is the projection associated with the data in the ABI Level 1b Radiances products, and all the ABI Level 2+ products except for the Derived Motion Winds, Hurricane Intensity, Downward Shortwave Radiation: Surface, and Reflected Shortwave Radiation: Top-Of-Atmosphere products.

This paragraph includes the following subordinate paragraphs:

- Description
- Coordinate System
- Coverage Area Associated with the Full Disk, CONUS, and Mesoscale Images
- Horizontal Spatial Resolutions
- Data Point Coordinates
- Product Data Structures
- Standard Coordinate Data
- Navigation of Image Data
- Overlaying Data from Different Image Types

7.1.2.1 Description

The data points in the GOES-R ABI Level 1b and the ABI Level 2+ imagery products are on the ABI fixed grid. The ABI fixed grid is a projection based on the viewing perspective of the idealized location of a satellite in geosynchronous orbit. This allows the same data points in every product to be at the same location on the earth. All of the dynamics associated with an orbiting satellite are removed from the data to accomplish this. GOES-R ground system product processing functionality receives raw data from the ABI instrument and performs the processing required to place the data points on the ABI fixed grid.

The fixed grid is rectified to a GRS80 ellipsoid viewed from the idealized geostationary position. This defines the ellipsoid parameters to use when geo-referencing data points on the fixed grid. Data points are defined out to the edge of the earth's limb as defined by the GRS80 ellipsoid.

Data points at a particular horizontal spatial resolution on the fixed grid have the same angular separation from the satellite's viewing perspective in both east to west and north to south directions. Refer to Figure 7.1.2.1.

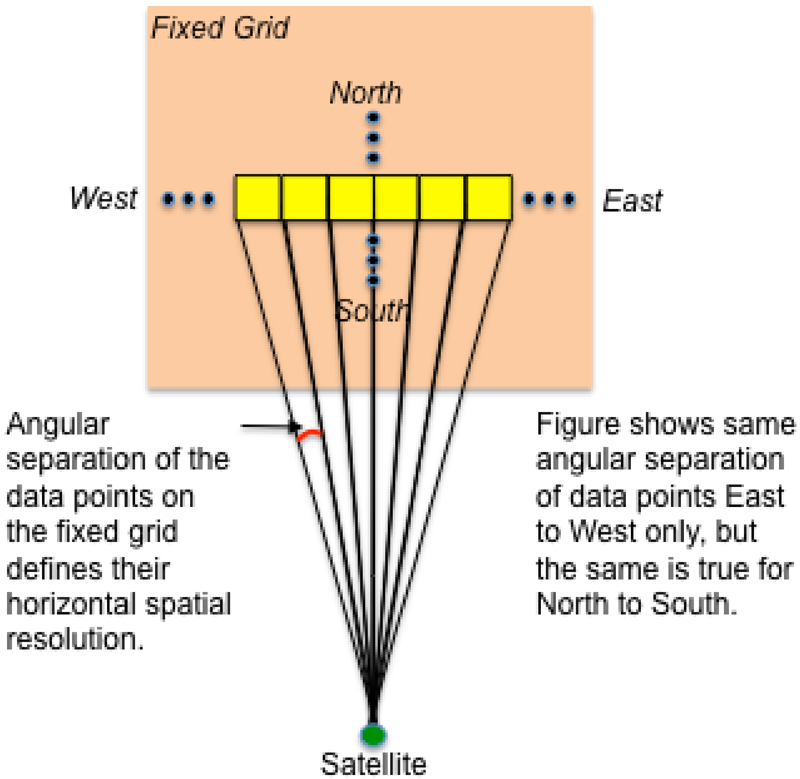


Figure 7.1.2.1 Data Points Have The Same Angular Separation On The Fixed Grid

The angular separation of the data points on the fixed grid provides the basis for the spatial resolution of the imagery data points, and is used to determine their coordinates. From the viewpoint of a right-hand coordinate system of the idealized geostationary satellite with the x-axis in the direction of the satellite velocity and the z-axis pointed at nadir, the north to south angle (i.e., N/S elevation angle) is determined by a rotation about the x-axis. The east to west angle (i.e., E/W scanning angle) is determined by a rotation about the rotated y-axis. Note that the earth surface area covered by a data point at a specific horizontal spatial resolution increases as the distance from the satellite's nadir increases.

7.1.2.2 Coordinate System

The ABI fixed grid is expressed in terms of the Cartesian coordinate system. The x axis represents the ABI E/W scan angle, i.e., the east-to-west direction. The y axis represents the ABI N/S scan angle, i.e., the north-to-south direction. The origin of the fixed grid represents the satellite sub-point which, by definition, is at the coordinate, (y = 0, x = 0). Refer to Figure 7.1.2.2-1, ABI Fixed Grid Coordinate System.

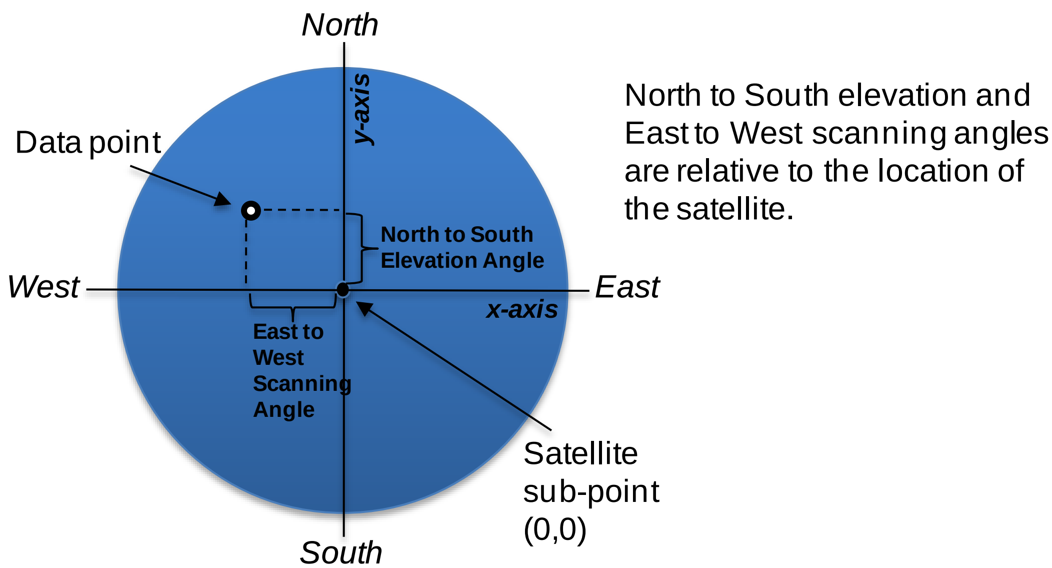


Figure 7.1.2.2-1 ABI Fixed Grid Coordinate System

The ABI native spatial resolutions are 0.5, 1.0, and 2.0 km at nadir. The radian is the standard unit of measure of the fixed grid. It is used to express the angular separation between imagery data points, which are 14, 28, and 56 microradians. For the ABI L2+ products that have reduced resolution (i.e., coarser distance between data points), the analogous spatial resolutions and angular separations apply. For example, ABI L2+ products with a spatial resolution of 10 km at nadir have data points with an angular separation of 280 microradians.

The ABI fixed grid coordinate system dictates that the ideal satellite sub-point is located at the corner of four imagery data points for the ABI native resolutions. Refer to Figure 7.1.2.2-2.

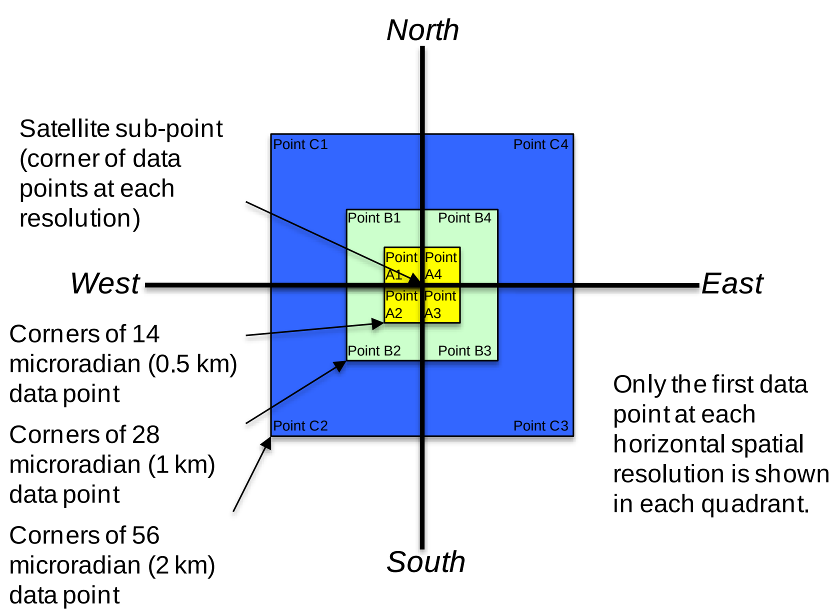


Figure 7.1.2.2-2 Fixed Grid Data Point Locations Relative to the Satellite Sub-Point

A 2 km data point subsumes four 1 km data points exactly. A 1 km data point subsumes four 0.5 km data points exactly. Refer to Figure 7.1.2.2-3. Note that for each of the Full Disk, CONUS, and mesoscale products, this relationship holds true when the lower resolution data is a multiple of the higher resolution data.

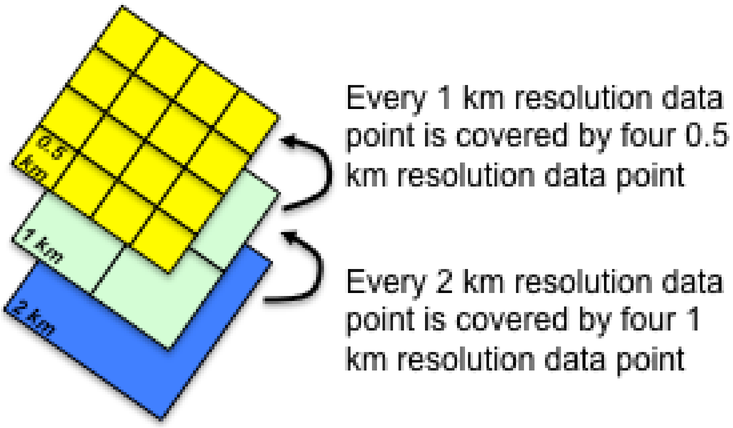


Figure 7.1.2.2-3 Relationship Between Data Points at Different Resolutions

ABI fixed grid imagery data points can be located on the earth. Knowing the (1) satellite sub-point longitude, (2) horizontal spatial resolution of the imagery data, (3) distance of the ideal geostationary satellite location from the earth, and (4) the selected earth model (GRS80) allows the location on the earth of each data point on the fixed grid to be determined.

7.1.2.3 Coverage Regions Associated with the Full Disk, CONUS, and Mesoscale Images

The coverage associated with the scenes sensed by the ABI is defined in terms of the viewing angle of the earth from the satellite perspective. Note that the term "scene" is used to communicate what the ABI instrument observes. The term, "image," is used to communicate the product data resulting from the scene. Refer to Figure 7.1.2.3.

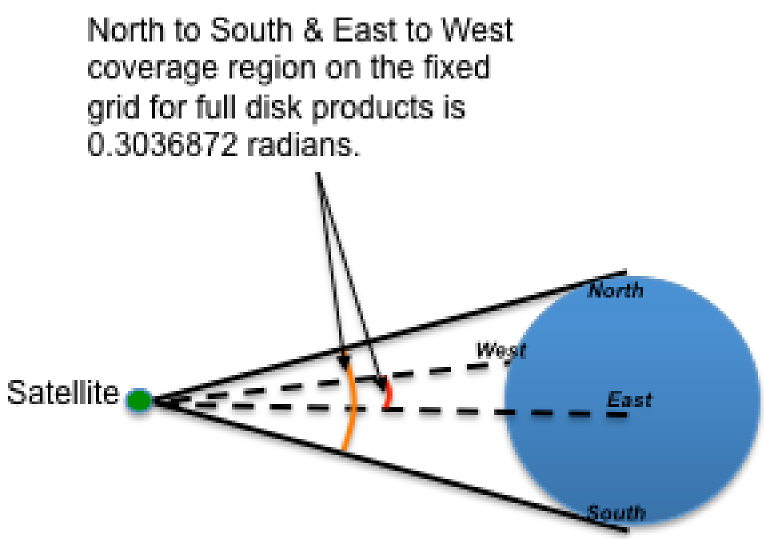


Figure 7.1.2.3 ABI Coverage Regions are Defined In Terms of Viewing Angle From The Satellite's Perspective

The coverage of the Full Disk L1b product consists of those pixels whose centers fall within the GRS80 Earth Ellipse. The maximum East to West and North to South extent of the GRS80 ellipse is shown in Table 7.1.2.3-1. Note that the center of the Full Disk image is the ABI fixed grid origin.

Table 7.1.2.3-1 Full Disk Image Coverage Region

East to West Coverage Extent	0.303704160 radians
North to South Coverage Extent	0.302701402 radians

Table 7.1.2.3-2 defines the coverage region for a CONUS image.

Table 7.1.2.3-2 CONUS Image Coverage Region

East to West Coverage Extent	0.14 radians
North to South Coverage Extent	0.084 radians

Table 7.1.2.3-3, Table 7.1.2.3-4 and Table 7.1.2.3-5 define the precise location of the center of the CONUS regions sensed by the ABI for the GOESEast, West and Test satellite orbital slots at 75.2 degrees, 137 and 89.5 degrees west longitude. The CONUS image center points are relative to the ABI fixed grid origin (75 degrees, 137 degrees and 89.5 degrees west longitude; 0 degrees latitude). The GOES-East data is resampled from the 75.2 west longitude orbital slot location to the ABI fixed grid origin. Note that a negative fixed grid coordinate indicates a data point that is either west or south of the ABI fixed grid origin.

Table 7.1.2.3-3 GOES-East CONUS Image Center

East to West Image Offset from ABI Fixed Grid Origin	-0.031360 radians
North to South Image Offset from ABI Fixed Grid Origin	0.086240 radians

Table 7.1.2.3-4 GOES-West CONUS Image Center

East to West Image Offset from ABI Fixed Grid Origin	0.000000 radians
North to South Image Offset from ABI Fixed Grid Origin	0.086240 radians

Table 7.1.2.3-5 GOES-Test CONUS Image Center

East to West Image Offset from ABI Fixed Grid Origin	-0.005040 radians
North to South Image Offset from ABI Fixed Grid Origin	0.084560 radians

Table 7.1.2.3-5 defines the coverage region for a mesoscale image. The mesoscale coverage region extents are relative to the center of the mesoscale image. The center of a mesoscale image is selected during operations based on weather conditions in the ABI's field of regard.

Table 7.1.2.3-5 Mesoscale Image Coverage Region

East to West Coverage Extent	0.028 radians
North to South Coverage Extent	0.028 radians

Note that the center of each CONUS image and mesoscale image is adjusted to the image corner that is nearest to the fixed grid data point.

7.1.2.4 Horizontal Spatial Resolutions

The GOES-R ground system outputs ABI Level 1b and ABI Level 2+ imagery products on the ABI fixed grid at several horizontal spatial resolutions. Table 7.1.2.4 identifies the set of horizontal spatial resolutions associated with the different types of products. Note that the horizontal spatial resolutions are specified in terms of resolution in kilometers at nadir, and angular resolution as defined above.

Table 7.1.2.4 Horizontal Spatial Resolution

ABI L1b/GRB	ABI L2+	Horizontal Spatial Resolution	
		At Nadir	Angular
applicable	*applicable*	0.5 km	14 μrad
		1.0 km	28 μrad
		2.0 km	56 μrad
not applicable		4.0 km	112 μrad
		10.0 km	280 μrad

7.1.2.5 Data Point Coordinates

An imagery data point on the ABI fixed grid is associated with an area on or above the surface of the earth. For example, a data point with a horizontal spatial resolution of 2 km at nadir is associated with a 4 square kilometer area. By convention, a data point is located at the center of this area with its coordinates expressed in terms of its angular resolution. For example, the center of a 2 km data point, which has an angular resolution of 56 microradians in both N/S elevation angle and E/W scanning angle, is 28 microradians from its edges. Refer to Figure 7.1.2.5.

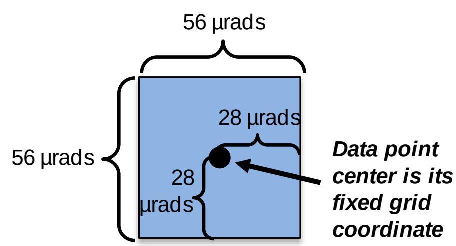


Figure 7.1.2.5 Example: Center of 2 km Data Point

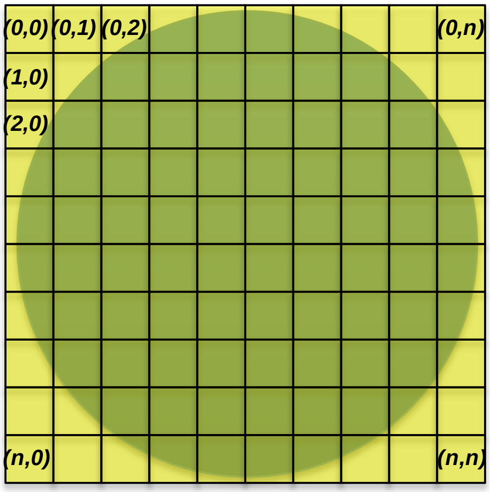
A data point is populated with observed data if its center is on-earth and in the ABI's field of regard. In the case of the lower resolution, non-native resolutions, 4 and 10 km, a data point is populated with observed data if the center of at least one constituent 2 km pixel is on-earth and in the ABI's field of regard.

7.1.2.6 Product Data Structures

In the preceding paragraphs that discussed the ABI fixed grid, the specification of its coordinate system, and the size and location of its data points have been defined. This paragraph defines how this information is captured in the ABI Level 1b and ABI Level 2+ imagery products.

The ABI Level 1b and ABI Level 2+ products are stored in netCDF version 4 product files. netCDF includes constructs to define scalar and multi-dimensional data, along with the associated metadata. netCDF variables are used to store scalar and multi-dimensional data. Metadata can be stored using either netCDF variables or attributes. The Climate and Forecast (CF) Metadata Conventions are applied to make the ABI Level 1b and ABI Level 2+ products self-describing. This standard includes requirements that allow the data to be located in space and time, as well as the semantics of the data to be captured in the product file.

For Full Disk products, the netCDF variables used to house the values for data points on the fixed grid define a rectangular region that encompasses the elliptical earth. Note that fill values are used for off-earth and missing data points. Refer to Figure 7.1.2.6-1.



- NetCDF variables provide storage for data point values on the fixed grid.
- Array element (0,0) of variable contains the data value for the most northwest data point.
- Array element (n, n) of variable contains the data value for the most southeast data point.

Figure 7.1.2.6-1 Storing Data Point Values For Full Disk Image in a Variable

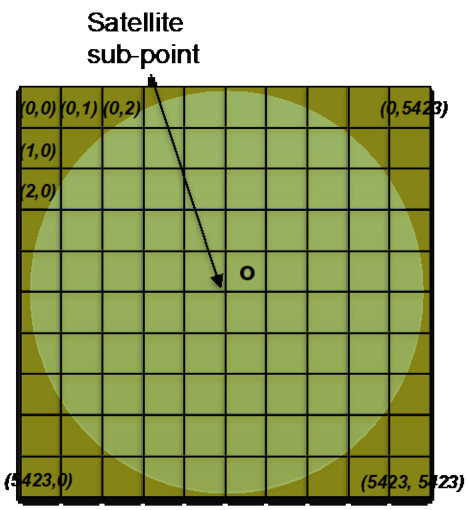
CONUS and mesoscale images are stored in a similar manner.

When netCDF values for data points are reported for single levels in the atmosphere, the variable has two dimensions, with array element value (0, 0) being the most northwest data point and array element value (n,n) being the most southeast data point. Note that the first element of an array element represents the fixed grid y-axis, while the second element represents the fixed grid x-axis, i.e., (n_y,n_x).

When netCDF data values are reported for multiple levels in the atmosphere, the data variable has three dimensions. The data variable subscripting is in the form (y, x, z) where z provides the dimension to store multiple values at the same location on the fixed grid.

In addition to the netCDF variables containing the data, there are coordinate variables in the product file. Coordinate variables, which are a CF metadata convention construct, provide the means to locate the data in space and time. Coordinate variables are required for the time, and the location along the y and x axes. The CF metadata conventions dictate that the coordinate variable names be the same as the corresponding dimension names. The values of data elements in the y and x coordinate variables are the ABI fixed grid coordinates - the N/S elevation angle and the E/W scanning elevation angle, respectively. Note that scaled integers as defined in the netCDF Users Guide are used for the y and x axis coordinate variables. The coordinate variable value in the product file is multiplied by the attached attribute scale_factor and then summed with the add_offset to obtain the ABI fixed grid coordinate in radians. The y and x coordinate variables are one-dimensional. The dimension of the y coordinate variable is the same as the y dimension in the data variable. The same is true for the x coordinate variable. This allows specific data points in the data variable to be associated with their ABI fixed grid coordinates. Refer to Figure 7.1.2.6-2.

In the GRB form of the ABI Level 1b Radiances product, the y- and x-coordinate variables, which are included in the Generic Payload containing the product metadata, are not populated. In this case, the y- and x-coordinate variables can be determined using the upper left y- and x-coordinates of the data points in the image, along with the image block height field and the image block width field contained in the Image Payload Header.



Full disk 2 km data variable is dimensioned 5424 x 5424.

The data variable array element for the data point marked with an "**o**" is (2711, 2712).

The x coordinate variable value for array element (2712) = 0.000028 radians.

The y coordinate variable value for array element (2711) =0.000028 radians.

The East to West scanning and North to South elevation angles of (0.000028, 0.000028) in the 2 km fixed grid coordinate system are used to determine the latitude and longitude of data point "**o**".

Figure 7.1.2.6-2 Relating a Data Point to Its ABI Fixed Grid Coordinates

Determining the latitude and longitude of data points using their ABI fixed grid coordinates is defined in paragraph 7.1.2.8, Navigation of Image Data that follows.

The dimensions of the data variables for ABI Level 1b and 2+ Full Disk, CONUS, and mesoscale products are defined in Table 7.1.2.6.

Table 7.1.2.6 ABI Product Data Variable Dimensions

Horizontal Spatial Resolution		Full Disk		CONUS Extraction from Full Disk		CONUS		Mesoscale	
km (nadir)	micro-radians	N/S (y-axis)	E/W (x-axis)	N/S (y-axis)	E/W (x-axis)	N/S (y-axis)	E/W (x-axis)	N/S (y-axis)	E/W (x-axis)
0.5	14	21696	21696	6000	10000	6000	10000	2000	2000
1.0	28	10848	10848	3000	5000	3000	5000	1000	1000
2.0	56	5424	5424	1500	2500	1500	2500	500	500
4.0	112	2712	2712	*not applicable*				250	250
10.0	280	1086	1086	300	500	300	500	100	100

There are two conventions associated with the dimensioning of variables for image data on the fixed grid. The first convention requires the dimensioning of the lowest native resolution data variables (2 km at nadir) completely covers the Full Disk, CONUS, and mesoscale images defined above. The second convention requires the higher native resolution data variables (i.e., 0.5, 1, and 2 km at nadir) and the lower non-native resolution data variables (i.e., 4 and 10 km at nadir) fully cover the region included in the native 2 km at nadir resolution data variables.

The selection of CONUS and mesoscale center points has an effect on the location of these region's pixels on the ABI fixed grid. For example, if the center point of a native CONUS image is not on the corner of a Full Disk 10 km pixel, the locations of its 10 km pixels are not the same as that in a CONUS image extracted from a mode 4 Full Disk image. It is advantageous to end users and their applications to select CONUS and mesoscale center points where pixels at the provided resolutions are at the same locations regardless of image type. This is accomplished by selecting CONUS and mesoscale center points using the least common denominator among the horizontal spatial resolutions (0.5, 1.0, 2.0. 4.0, and 10.0 km) for ABI fixed grid products. This constraint requires CONUS and mesoscale center points to be on the corner of Full Disk 20 km (i.e., 0.00056 radian) pixels.

7.1.2.7 Standard Coordinate Data

There are several netCDF variables and attributes in the ABI Level 1b and ABI Level 2+ products on the fixed grid that contain coordinate related information required to geo-locate data points and geo-reference metadata in the product, and provide support for data discovery. The standard coverage areas associated with Full Disk and CONUS products result in coordinate data values that do not change for a satellite operating at a particular slot. These standard and fixed coordinate data are identified and described in this paragraph.

Table 7.1.2.7-1 defines the variables and attributes that contain standard coordinate data.

Table 7.1.2.7-1 Variables and Attributes Containing Standard Coordinate Data

Variable / Attribute	Description
y -> add_offset x -> add_offset	Attribute add_offset of coordinate variables "y" and "x" contains the N/S elevation and E/W scanning angles for center, respectively, of the upper left (i.e., most northwest) data point in the image. This value varies with the location of the image for mesoscale.
y -> scale_factor x -> scale_factor	Attribute scale_factor of coordinate variables "x" and "y" contains the horizontal and vertical spatial resolution of the image.
y_image_center x_image_center	The y_image_center and x_image_center coordinate variables contain the N/S elevation and E/W scanning angles, respectively, of the center the image. These values vary with the location of the image for mesoscale.
y_image_bounds x_image_bounds	The y_image_bounds and x_image_bounds boundary variables contain the N/S elevation and E/W scanning angles of the north and south, and west and east, extents, respectively, of the image. These values vary with the location of the image for mesoscale.
geospatial_lat_lon_extent -> geospatial_lat_nadir geospatial_lat_lon_extent -> geospatial_lon_nadir geospatial_lat_lon_extent -> geospatial_lat_center geospatial_lat_lon_extent -> geospatial_lon_center geospatial_lat_lon_extent -> geospatial_northbound_latitude geospatial_lat_lon_extent -> geospatial_southbound_latitude geospatial_lat_lon_extent -> geospatial_westbound_longitude geospatial_lat_lon_extent -> geospatial_eastbound_longitude	This variable and its attributes contain the latitude and longitude of the satellite's nadir, center of the image, and north, south, west, and east extents of the image. Except for the satellite's nadir, these values vary with the location of the image for mesoscale.

Table 7.1.2.7-2 identifies the N/S elevation and E/W scanning angles of the center of the most northwest pixel in Full Disk and CONUS images (i.e., y and x coordinate variables' add_offsets), and the y and x coordinate variables' scale_factors.

Table 7.1.2.7-2 ABI Image Standard Upper Left Coordinates

		Horizontal Spatial Resolution				
		0.5 km (0.000014 radians)	**1.0 km (0.000028 radians)**	**2.0 km (0.000056 radians)**	**4.0 km (0.000112 radians)**	**10.0 km (0.000280 radians)**
Full Disk (all slots)	**add offset for y**	0.151865	0.151858	0.151844	0.151816	0.151900
	add offset for x	-0.151865	-0.151858	-0.151844	-0.151816	-0.151900
CONUS (GOES-East at -75.2 degrees east longitude)	**add offset for y**	0.128233	0.128226	0.128212		0.128100
	add offset for x	-0.101353	-0.101346	-0.101332		-0.101220
CONUS (GOES-West at -137 degrees east longitude)	**add offset for y**	0.128233	0.128226	0.128212	*not applicable*	0.128100
	add offset for x	-0.069993	-0.069986	-0.069972		-0.069860
CONUS (Test Slot at -89.5 degrees east longitude)	**add offset for y**	0.126553	0.126546	0.126532		0.126420
	add offset for x	-0.075033	-0.075026	-0.075012		-0.074900
Scale Factors for All Image Types	**scale factor for y**	-0.000014	-0.000028	-0.000056	-0.000112	-0.000280
	scale factor for x	0.000014	0.000028	0.000056	0.000112	0.000280

Note: GOES-East nominal satellite subpoint longitude is -75.2 degrees east. However, the image product data has been resampled to be centered at -75.0 degrees east longitude. The values in the table above are nominal values; the actual values are included in the product metadata.

Table 7.1.2.7-3 ABI Image Center (Fixed Grid Coordinates) identifies the N/S elevation and E/W scanning angles of the center of Full Disk and CONUS images (i.e., y_image_center and x_image_center coordinate variables).

Table 7.1.2.7-3 ABI Image Center (Fixed Grid Coordinates)

	y image center (N/S)	x image center (E/W)
Full Disk (all slots)	0.0	0.0
CONUS	0.086240	-0.031360

	y image center (N/S)	x image center (E/W)
(GOES-East at -75.2 degrees east longitude)		
CONUS (GOES-West at -137 degrees east longitude)	0.086240	0.000000
CONUS (Test Slot at -89.5 degrees east longitude)	0.084560	-0.005040

Note: GOES-East nominal satellite subpoint longitude is -75.2 degrees east. However, the image product data has been resampled to be centered at -75.0 degrees east longitude.

Table 7.1.2.7-4 identifies the N/S elevation angles of the N/S extents and E/W scanning angles of the E/W extents of Full Disk and CONUS images (i.e., y_image_bounds and x_image_bounds boundary variables).

Table 7.1.2.7-4 ABI Image N/S and E/W Extents (Fixed Grid Coordinates)

	y image bounds		x image bounds	
	North	South	West	East
Full Disk (all slots)	0.151872	-0.151872	-0.151872	0.151872
CONUS (GOES-East at -75.2 degrees east longitude)	0.128240	0.044240	-0.101360	0.038640
CONUS (GOES-West at -137 degrees east longitude)	0.128240	0.044240	-0.070000	0.070000
CONUS (Test Slot at -89.5 degrees east longitude)	0.126560	0.042560	-0.075040	0.064960

Note: GOES-East nominal satellite subpoint longitude is -75.2 degrees east. However, the image product data has been resampled to be centered at -75.0 degrees east longitude.

Table 7.1.2.7-5 identifies the latitude and longitude of the center and extents of Full Disk and CONUS images (i.e., geospatial_lat_lon_extent variable attributes).

Table 7.1.2.7-5 ABI Image Center and Extents (Lat/Lon Coordinates)

Latitude is degrees north Longitude is degrees east	Full Disk (GOES-East at -75.2 degrees east longitude)	Full Disk (GOES-West at -137 degrees east longitude)	Full Disk (GOES-Test Slot at -89.5 degrees east longitude)	CONUS (GOES-East at -75.2 degrees east longitude)	CONUS (GOES-West at -137 degrees east longitude)	CONUS (GOES-Test Slot at -89.5 degrees east longitude)
geospatial_lat_nadir	0.0	0.0	0.0	0.0	0.0	0.0
geospatial_lon_nadir	-75.0	-137.0	-89.5	-75.0	-137.0	-89.5
geospatial_lat_center	0.0	0.0	0.0	30.083003	29.967	29.294
geospatial_lon_center	-75.0	-137.0	-89.5	-87.096958	-137.000	-91.406
geospatial_northbound_latitude	81.3282	81.3282	81.3282	56.761450	53.500062	52.767707
geospatial_southbound_latitude	-81.3282	-81.3282	-81.3282	14.571340	14.571340	14.000162

geospatial_westbound_longitude	-156.2995	141.7005	-170.7995	-152.109282	175.623576	-140.616268
geospatial_eastbound_longitude	6.2995	-55.7005	-8.2005	-52.946879	-89.623576	-49.179291

Note: GOES-East nominal satellite subpoint longitude is -75.2 degrees east. However, the image product data has been resampled to be centered at -75.0 degrees east longitude.

7.1.2.8 Navigation of Image Data

This paragraph provides the equations needed to navigate data points on the ABI fixed grid to and from latitude and longitude. ABI fixed grid coordinates, N/S elevation angle and E/W scanning angle, coupled with the location of the satellite and the parameters associated with the selected earth model (GRS80) are used to determine the geodetic latitude/longitude coordinates. This paragraph also provides equations to determine the ABI fixed grid coordinates from the geodetic latitude/longitude coordinates.

All of the equations are based on the International System of Units (SI). These equations assume data points are lying on the GRS80 ellipsoid, and the location of data points on the ABI fixed grid is based on a geostationary satellite at the equator in an idealized orbit.

Table 7.1.2.8 defines the parameters required to navigate data points on the ABI fixed grid. The parameters are used in the equations in the following sections.

Table 7.1.2.8 Parameters Required to Navigate Data Points on ABI Fixed Grid

Parameter	netCDF Product File Attributes for the "goes_imager_projection" Variable	Attribute Value	Definition
r_{eq}	semi_major_axis	6378137 m	GRS80 semi-major axis of earth
$1/f$	inverse_flattening	298.257222096	Reciprocal of GRS80 flattening factor
r_{pol}	semi_minor_axis	6356752.31414 m	GRS80 semi-minor axis of earth = $(1-f)r_{eq}$
e	n/a	0.0818191910435	1st eccentricity = sqrt(f(2-f)) =sqrt((r_{eq}^2-r_{pol}^2)/r_{eq}^2)
n/a	perspective_point_height	35786023 m	Satellite height above ellipsoid
H	perspective_point_height + semi_major_axis	42164160 m	Satellite height from center of earth (m)
x	x	Input or Output Value rad	Fixed Grid E/W scanning angle (rad)
y	y	Input or Output Value rad	Fixed Grid N/S elevation angle (rad)
ϕ		Input or Output Value deg/rad	GRS80 geodetic latitude (deg/rad)
λ		Input or Output Value deg/rad	GRS80 longitude (deg/rad)
n/a	latitude_of_projection_origin	0 deg 0 rad	Satellite East latitude North
		0 deg 0 rad	Satellite West latitude North
		0 deg 0 rad	Satellite Test latitude North
	longitude_of_projection_origin	-75 deg -1.308996939 rad	Satellite East longitude East

Parameter	netCDF Product File Attributes for the "goes_imager_projection" Variable	Attribute Value	Definition
λ_0		-137 deg -2.39110107523 rad	Satellite West longitude East
		-89.5 deg -1.56206968053 rad	Satellite Test longitude East

Note: GOES-East nominal satellite subpoint longitude is -75.2 degrees east. However, the image product data has been resampled to be centered at -75.0 degrees east longitude.

Figure 7.1.2.8 provides an illustration of the coordinate frames and their relationships required for navigation. The equations in the following paragraphs are based on this figure.

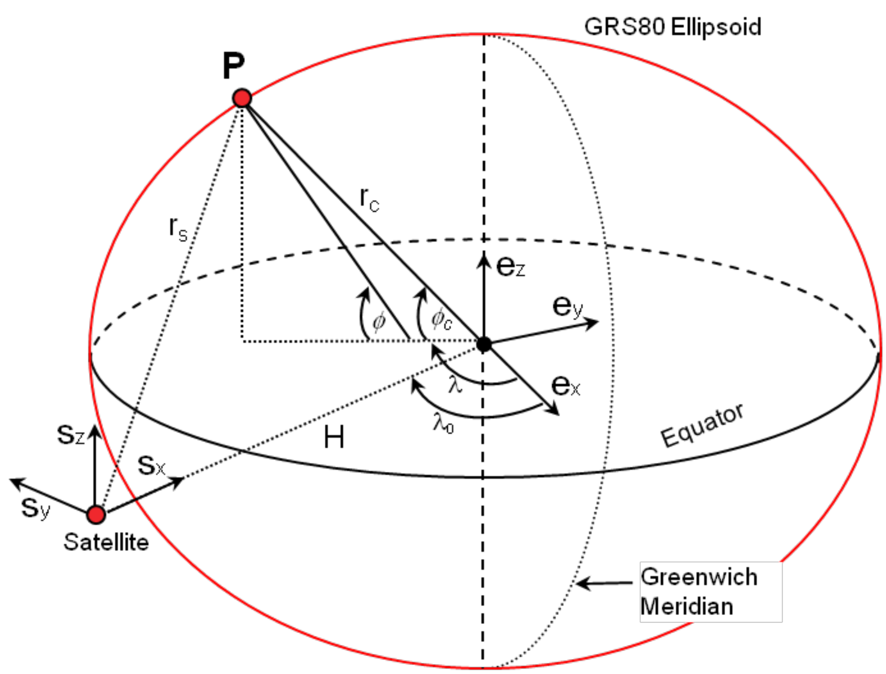


Figure 7.1.2.8 Coordinate Frames for ABI Fixed Grid Navigation

Two coordinate frames are described. The Earth Centered Fixed (ECF) coordinate frame rotates with the Earth. The origin is located at the center of the earth. The x-axis (e_x) passes through the Greenwich Meridian and the equator. The z-axis (e_z) passes through the North Pole. The y-axis (e_y) is defined as the cross product of the z-axis (e_z) with the x-axis (e_x) completing the right-handed coordinate system. The satellite coordinate frame has its origin located at the center of mass of the satellite. Its x-axis (s_x) is defined along the line from the satellite to the center of the earth and the z-axis (s_z) is parallel to the ECF z-axis (e_z) and points up. Again the y-axis (s_y) completes the right-handed coordinate system and is aligned with the equatorial axis. Two representations are shown for the latitude. The ϕ represents the geodetic latitude, and ϕ_C represents the geocentric latitude. Note that the geodetic latitude is measured at the equator, where the line is perpendicular or normal to the GRS80 ellipsoid at point P. The geodetic and geocentric longitudes λ are the same. Longitude is measured from the Greenwich meridian and is positive East and negative West. Note that the geostationary positions of the GOES-R satellites are both west of the Greenwich Meridian and therefore have negative longitudes as shown in the table immediately above.

Note that the open-source Unidata Geolocation Projection and Proj.4 Cartographic Projections software to perform these navigation functions will be available on the web at:

- http://www.unidata.ucar.edu/software/thredds/v4.3/netcdf-java/v4.2/javadoc/ucar/unidata/geoloc/Projection.html
- https://proj.org/usage/projections.html

7.1.2.8.1 Navigating from N/S Elevation Angle (y) and E/W Scanning Angle (x) to Geodetic Latitude (ϕ) and Longitude (λ)

Given a point P on the GRS80 ellipsoid with fixed grid coordinates (y,x) find the geodetic coordinates, (ϕ, λ).

The geodetic latitude (ϕ) and longitude (λ) are computed by the following equations

$$\begin{pmatrix}\phi \\ \lambda\end{pmatrix} = \begin{pmatrix} \arctan\left(\dfrac{r_{eq}^2}{r_{pol}^2}\dfrac{s_z}{\sqrt{(H-s_x)^2+s_y^2}}\right) \\ \lambda_0 - \arctan\left(\dfrac{s_y}{H-s_x}\right)\end{pmatrix}$$

For:

$x = \text{Fixed Grid E/W scan angle in radians}$

$y = \text{Fixed Grid N/S scan angle in radians}$

One computes S_x, S_y, S_z as follows:

$$a = \sin^2(x) + \cos^2(x)\left(\cos^2(y) + \frac{r_{eq}^2}{r_{pol}^2}\sin^2(y)\right)$$

$$b = -2H\cos(x)\cos(y)$$

$$c = H^2 - r_{eq}^2$$

$$r_s = \frac{-b-\sqrt{b^2-4ac}}{2a} \quad \text{distance from the satellite to point P}$$

$$s_x = r_s\cos(x)\cos(y)$$

$$s_y = -r_s\sin(x)$$

$$s_z = r_s\cos(x)\sin(y)$$

Example

This example is based on the GOES-East satellite for a point, P, in a 2 km CONUS product with fixed grid coordinates given by

$y(558) = 0.095340$ rad

$x(1539) = -0.024052$ rad

Note the variables and their subscripts used here are as defined in paragraph 7.1.2.6, Product Data Structures, above.

Values for the parameters used in the equations and their netCDF Product File Attribute Names described in the table immediately above are as follows:

r_{eq} = goes_imagery_projection:semi_major_axis = *6378137 (meters)*

$1/f$= goes_imagery_projection:inverse_flattening = *298.257222096*

r_{pol} = goes_imagery_projection:semi_minor_axis = *6356752.31414 (meters)*

$e = 0.0818191910435$

goes_imagery_projection:perspective_point_height = *35786023 (meters)*

H = goes_imagery_projection:perspective_point_height + goes_imagery_projection:semi_major_axis = *42164160 (meters)*

$x = x(1539) = -0.024052$

$y = y(558) = 0.095340$

λ_0 = goes_imagery_projection: longitude_of_projection_origin = -1.308996939

Based on these input values, the intermediate calculations in the above equations yield the following:

$a = 1.000061039$

$b = -83921070.03$

$c = 1.73714E+15$

$r_s = 37116295.87$

$s_x = 36937048.73$

$s_y = 892635.0779$

$s_z = 3532287.213$

Now using the values specified above and substituting into the equations for ϕ and λ, we obtain the following for the geodetic latitude and longitude:

$\phi = 0.590726971$ rad $= 33.846162$ deg

$\lambda = -1.478135612$ rad $= -84.690932$ deg

corresponding to the GOES-East satellite fixed grid coordinates of

$y(558) = 0.095340$ rad

$x(1539) = -0.024052$ rad

7.1.2.8.2 Navigating from Geodetic Latitude (ϕ) and Longitude (λ) to N/S Elevation Angle (y) and E/W Scanning Angle (x)

Given a point P on the GRS80 ellipsoid with geodetic (ϕ, λ) coordinates find the fixed grid (y, x) coordinates.

Note that if the following inequality is true, then the (ϕ, λ) location is not visible from the satellite and the elevation and scanning angles should not be computed.

$$H(H - s_x) < s_y^2 + \frac{r_{eq}^2}{r_{pol}^2} s_z^2$$

The N/S Elevation Angle (y) and E/W Scanning Angle (x) are computed by the following equations

$$\begin{pmatrix} y \\ x \end{pmatrix} = \begin{pmatrix} \arctan\left(\frac{s_z}{s_x}\right) \\ \arcsin\left(\frac{-s_y}{\sqrt{s_x^2 + s_y^2 + s_z^2}}\right) \end{pmatrix}$$

Where,

$$\phi = \text{GRS80 geodetic latitude in radians}$$

$$\lambda = \text{GRS80 longitude in radians}$$

$$\phi_C = \arctan\left(\frac{r_{pol}^2}{r_{eq}^2} \tan(\phi)\right) \quad \text{geocentric latitude}$$

$$r_C = \frac{r_{pol}}{\sqrt{1 - e^2 \cos^2(\phi_C)}} \quad \text{geocentric distance to the point on the ellipsoid}$$

$$\begin{pmatrix} s_x \\ s_y \\ s_z \end{pmatrix} = \begin{pmatrix} H - r_C \cos(\phi_C) \cdot \cos(\lambda - \lambda_0) \\ -r_C \cos(\phi_C) \cdot \sin(\lambda - \lambda_0) \\ r_C \sin(\phi_C) \end{pmatrix}$$

<u>Example</u>

This example verifies that the algorithm defined in paragraph 5.1.2.8.1 has an inverse. This example is based on the GOES-East satellite for a point, P, in a 2 km CONUS product with geodetic latitude and longitude given by

ϕ = 33.846162 deg = 0.590726966 rad

λ = -84.690932 deg = -1.47813561 rad

Values for the parameters used in the equations and their netCDF Product File Attribute Names described in the table immediately above are as follows:

r_{eq} = goes_imagery_projection:semi_major_axis = *6378137 (meters)*

1/f = goes_imagery_projection:inverse_flattening = *298.257222096*

r_{pol} = goes_imagery_projection:semi_minor_axis = *6356752.31414 (meters)*

e = 0.0818191910435

goes_imagery_projection:perspective_point_height = *35786023 (meters)*

H = goes_imagery_projection:perspective_point_height + goes_imagery_projection:semi_major_axis = *42164160 (meters)*

$\phi = 0.590726966$

$\lambda = -1.47813561$

λ_0 = goes_imagery_projection: longitude_of_projection_origin = -1.308996939

Based on these input values, the intermediate calculations in the above equations yield the following:

$\phi_C = 0.587623849$

$r_c = 6371541.614$

$s_x = 36937048.71$

$s_y = 892635.07$

$s_z = 3532287.186$

Now using the values specified above and substituting into the equations for y and x, we obtain the following for the fixed grid coordinates

$y = 0.095340$ rad

$x = -0.024052$ rad

corresponding to the GOES-East satellite geodetic latitude and longitude of

$\phi = 33.846162$ deg

$\lambda = -84.690932$ deg

7.1.2.9 Overlaying Data from Different Image Types

GOES-R ABI Level 1b and ABI Level 2+ product data users will need to overlay Full Disk, CONUS, and mesoscale products for data processing and display purposes.

The netCDF coordinate variables contain the ABI fixed grid coordinates, E/W scanning angle and N/S elevation angle that correspond to each point in the data variable. The ABI fixed grid coordinate values are relative to the origin of the fixed grid. However, the array subscripts for a netCDF product image data variable are relative to the most northwest data point in the image.

When the resolutions of the products are the same, the following equation allows one to map the data variable array subscripts from the product containing the geographically smaller region to the product containing the geographically larger region. Note that the data variable array element (0,0) corresponds to the most northwest data point in the image data.

$^{\wedge}Y_L = ({}^{FG}Y_L - {}^{FG}Y_S) / \alpha$

$^{\wedge}X_L = ({}^{FG}X_S - {}^{FG}X_L) / \alpha$

where,

${}^{FG}Y_S$ *fixed grid N/S elevation angle in radians for smaller region's northwest data point*

${}^{FG}X_S$ *fixed grid E/W scanning angle in radians for smaller region's northwest data point*

${}^{FG}Y_L$ *fixed grid N/S elevation angle in radians for larger region's northwest data point*

$^{FG}X_L$ *fixed grid E/W scanning angle in radians for larger region's northwest data point*

α *horizontal spatial resolution of the data in radians*

$^{\wedge}X_L$ *larger region's data variable x-axis subscript for smaller region's northwest data point*

$^{\wedge}Y_L$ *larger region's data variable y-axis subscript for smaller region's northwest data point*

In the case where the resolution of the products being overlaid is not the same, the same general thinking applies, except "α" needs to be the horizontal spatial resolution of the data in radians for the geographically larger product, and the application will need to deal with incongruities caused by the differing resolutions of the products.

Example

This example shows how a 2 km CONUS product can be overlaid on a 2 km Full Disk product from the GOES-East Fixed Grid at -75 degrees east longitude.

Table 7.1.2.9 captures the parameters required.

Table 7.1.2.9 Parameters for 2 km CONUS Product Overlay on 2 km Full Disk Product

Parameter Name	netCDF Product Variable / Attribute Name	Value (radians)
$^{FG}Y_{CONUS}$	CONUS coordinate variable y(0)	0.126588
$^{FG}X_{CONUS}$	CONUS coordinate variable x(0)	-0.110236
$^{FG}Y_{FullDisk}$	Full Disk coordinate variable y(0)	0.151844
$^{FG}X_{FullDisk}$	Full Disk coordinate variable x(0)	-0.151844
α	CONUS product file <*primary data variable*>:resolution	0.000056

Using the equations defined above:

$$^{\wedge}Y_{FullDisk} = (^{FG}Y_{FullDisk} - {}^{FG}Y_{CONUS}) / \alpha = (0.151844 - 0.126588) / 0.000056 = 451$$

$$^{\wedge}X_{FullDisk} = (^{FG}X_{CONUS} - {}^{FG}X_{FullDisk}) / \alpha = (-0.110236 - -0.151844) / 0.000056 = 743$$

Therefore:

(1) Full Disk location for coordinate variable y(451) and x(743) is same location as CONUS coordinate variable y(0) and x(0)

(2) <DataVariable> Full Disk (451,743) is same location as <DataVariable> CONUS (0,0)

7.1.3 Radiances Product

7.1.3.1 Description

The Radiances product contains an Earth-view radiometrically corrected and navigated image with pixel values identifying the radiance. The product includes data quality information that provides an assessment of the radiance data values for on-earth pixels, including an indication of good or degraded quality, or invalid, and the rationale.

Radiances product files are generated for each of the ABI's six reflective and ten emissive bands. Radiances product data is radiometrically corrected and navigated with image pixels being resampled to the ABI fixed grid.

The units of measure for the reflective band image pixel radiance values are "watts per square meter per steradian per micron". The units of measure for the emissive band image pixel radiance values are "milliwatts per square meter per steradian per reciprocal centimeter".

The reflective bands support the characterization of clouds, vegetation, snow/ice, and aerosols. The emissive bands support the characterization of the surface, clouds, water vapor, ozone, volcanic ash and dust based on emissive properties. Table 7.1.3.1-1, Applications of the Radiances Product, identifies the ABI bands and their central wavelength, native horizontal spatial resolution, and application for the product.

Table 7.1.3.1-1 Applications of the Radiances Product

ABI Band	Central Wavelength (um)	Native Resolution (km)	Primary Use
1	0.47	1	Daytime aerosol over land, coastal water mapping.
2	0.64	0.5	Daytime clouds, fog, insolation, winds.
3	0.87	1	Daytime vegetation, burn scar, aerosol over water, winds.
4	1.38	2	Daytime cirrus cloud.
5	1.61	1	Daytime cloud-top phase and particle size, snow.
6	2.25	2	Daytime land, cloud properties, particle size, vegetation, snow.
7	3.89	2	Surface and cloud, fog at night, fire, winds.
8	6.17	2	High-level atmospheric water vapor, winds, rainfall.
9	6.93	2	Midlevel atmospheric water vapor, winds, rainfall.
10	7.34	2	Lower-level water vapor, winds, and $SO_{2.}$
11	8.44	2	Total water for stability, cloud phase, dust SO_2, rainfall.
12	9.61	2	Total ozone, turbulence, winds.
13	10.33	2	Surface and clouds.
14	11.19	2	Imagery, sea surface temperature, clouds, rainfall.
15	12.27	2	Total water, volcanic ash, sea surface temperature.
16	13.27	2	Air temperature, cloud heights.

The Radiances product image is produced on the ABI fixed grid for Full Disk, CONUS, and Mesoscale coverage regions. The Radiances performance requirements are summarized in Table 7.1.3.1-2, Radiances Performance Requirements.

Table 7.1.3-1-2 Radiances Performance Requirements

	Measurement				Mapping
Region	**Range**	**Accuracy [1]**	**Precision [1]**	**Performance Conditions**	**Accuracy**
Full Disk, CONUS, & Mesoscale	180 to 320 K in brightness temperature units	(1) Bands 1, 2, 3, 5, 6: +/- 3% (one sigma) (2) Band 4: +/- 4% (one sigma) (3) All emissive bands (7-16): +/- 1 K (one-sigma)	(1) Bands 1, 2, 3, 5, 6: SNR = 300:1 (2) Band 4: SNR = 600:1 (3) Bands 7-15: NEDT = 0.1 K (4) Band 16: NEDT = 0.3 K	LZA ≤ 70 degrees [2] clear sky above clouds	1 km

[1] Specified accuracy and precision performance for reflective bands is for earth albedo measurements in scene of 100% albedo and, for emissive bands, is at a reference temperature of 300 K.
[2] Conditions for good quality prescribed by the algorithm do not include Local Zenith Angle (LZA) ≤ 70 degrees.

Metadata in the Radiances product provides statistical and other properties of the product image and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start, midpoint, and end time of the product image observation period.
- Solar radiance and irradiance values that vary as a function of the Earth-Sun distance, and planck constants used in support of cloud and moisture imagery generation.
- Number of good and conditionally usable, and missing pixels.
- Number of saturated and undersaturated pixels.
- Minimum, maximum, mean, and standard deviation of the radiance values in the product image.
- Star tracking information.
- Satellite's yaw flip configuration.

The minimum, maximum, mean, and standard deviation values are calculated using good and conditionally usable quality pixels. The percentages of pixels assigned to each data quality flag (DQF) value are also included in the product.

The Radiances product can be converted from radiances to reflectance factor or brightness temperature using information provided in the product. For the reflective bands, conversion from radiance L_ν to reflectance factor ρf_υ is computed as:

$$\rho f_\upsilon = \kappa L_\upsilon$$

where κ is the 'kappa factor'. The kappa factor $\kappa = ((\pi \cdot d^2)/E_{sun})$ represents the incident Lambertian-equivalent radiance, where d is the instantaneous Earth-Sun distance (in Astronomical Units) and E_{sun} is the solar irradiance in the respective bandpass (in $W/(m^2\ \mu m)$). The kappa factor is included in the product metadata as the variable "kappa0". The solar irradiance and Earth-Sun distance are also represented as variables "esun" and "earth_sun_distance_anomaly_in_AU", respectively.

Conversion from radiance to brightness temperature (*T*) is achieved for the emissive bands by applying the Planck function and the spectral bandpass correction:

$$T = [\ fk2\ /\ (alog((fk1\ /\ L_\nu) + 1)) - bc1\ ]\ /\ bc2$$

where fk1 and fk2 are coefficients of the Planck function derived from physical constants (i.e., the speed of light, the Boltzmann constant, and the Planck constant) and the bandpass central wavenumber, and bc1 and bc2 are the spectral response function offset and scale correction terms. These four coefficients are included in the product metadata as variables: "planck_fk1", "planck_fk2", "planck_bc1", and "planck_bc2".

The detailed description of the ISO series metadata for the Radiances product is located in the standalone Appendix X, ISO Series Metadata.

7.1.3.2 Dynamic Source Data

The Radiances product is derived using ABI Level 0 raw science telemetry, ABI engineering telemetry, and satellite ephemeris related telemetry. This data includes the sixteen bands, ABI bands 1 to 16, of observed scenes and instrument calibration data.

The primary sensor data used by the Radiances algorithm is identified in Table 7.1.3.2, Primary Sensor Data.

Table 7.1.3.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_ABI_L0_data

7.1.3.3 Semi-Static Source Data

There are six categories of semi-static source data employed in the ABI Level 1b ground processing algorithm:

- Coverage calibration parameters.
- Radiometric calibration parameters.
- Calibration target parameters.
- Geometric calibration parameters.
- Kalman filter calibration parameters
- Algorithm processing parameters

Semi-static source data files from the six categories above are contained in a single zip file. Some files fit into more than one category.

Coverage calibration parameters are those associated with the location of the ABI in geostationary orbit, global reference ellipsoid used to geolocate raw and resampled ABI imagery, ABI's field of regard, and instrument sensing rate. Specific types include:

- Earth polar and equatorial radius, and flattening.
- Extent and other physical and performance characteristics of the instrument's field of regard and field of view.

Radiometric calibration parameters are those associated with the instrument's radiometric observing characteristics, or its raw outputs. Specific types include:

- Band-specific lower and upper bounds of the radiances observed.
- East-west Line-of-Sight (LOS) offset of each band from field of view center.
- North-south and east-west mirror resistance factors, mirror temperature weights, and mirror reflectivity coefficients.
- Infrared observation data to engineering telemetry time synchronization parameters.
- Band-specific and detector-specific "Q" coefficients (i.e., quadratic term coefficients) used in the calculation of radiances.
- Emissive band-specific radiances as a function of brightness temperature.
- Reflective band normal scan start and end time intervals.

Calibration target parameters are those associated with the calibration performed by the instrument during operations including the infrared calibration (i.e., blackbody), and space, solar, and star looks. Specific types include:

- Band-specific initial and minimum number of space look samples to use for processing.
- Band-specific and detector-specific valid ranges of space look sample values used to calculate the mean count.
- Parameters used to determine space look outliers.
- Emissive band-specific initial and minimum number of Infrared Calibration Target (ICT) samples to use for processing.
- Emissive band-specific and detector-specific valid range of ICT sample values used to calculate the mean count.
- Parameters used to determine the ICT outliers.
- Platinum Resistance Thermometer (PRT) specific fixed low and high resistance values, and "A" and "B" coefficients used when calculating infrared calibration target temperatures.
- PRT specific temperature weight values used to determine the ICT weighted average temperature.
- Emissive band-specific emissivity values used to compute the effective ICT radiances.

- Reflective band-specific initial and minimum number of Solar Calibration Target (SCT) samples to use for processing.
- Reflective band-specific and detector-specific valid range of SCT sample values used to calculate the mean count.
- Parameters used to determine SCT outliers.
- Reflective band-specific and detector-specific coefficients used to relate to the Bi-directional Reflectance Distribution Function (BRDF).
- Instrument alignment angles and coefficients used to compute the solar incidence angle to the SCT.
- Parameters used to calculate the obliquity of the ecliptic, solar ephemerides, and geocentric apparent ecliptic latitude and longitude of the sun needed in support of SCT.
- Band-specific 100 percent albedo Lambertian scene, band-average spectral radiances with the sun at 1 Astronomical Unit (AU) from the earth needed in support of SCT.
- Parameters used to calculate the SCT effective radiances.
- Time interval parameters for space look, ICT, and SCT.
- Number of star look samples to use, and star look time interval parameters.
- Thresholds used to identify out-of-spec focal plane temperatures and flag occurrences in the radiance product data quality flag output.
- An enable flag for the calculation of radiance values based on inputs projected from previous space looks and gains, plus the associated focal plane temperature thresholds for the invoking of the correction.

Geometric calibration parameters are those associated with resampling, and the related geolocating of raw and resampled instrument data. Specific types include:

- Band-specific detector stack characteristic parameters, and detector selection map.
- Band-specific sample angular separation and timing parameters.
- Fixed grid pixel spacing parameters.
- Band-specific east-west and north-south swath characteristic parameters.
- Full disk, CONUS, and mesoscale scene dimensions.
- Band-specific and detector-specific valid range of space look sample values used to calculate the mean count.
- Scan and cross scene direction, which is roughly east-west and north-south direction, resampling kernel weighting functions.
- Band-specific eastward and northward LOS alignment offsets.
- Band-specific radiances valid range.
- Missing, saturated, under-saturated, minimum, and maximum pixel fill values.
- Valid pixel's contributing sample characteristic parameters.
- Band-dependent navigation sparseness parameters.
- Band-specific pixel bit depth, gain and bias values used when calculating scaled pixel values.
- Resampling threshold parameters.

Kalman filter calibration parameters are those associated with the Kalman filter used to support geolocation of raw samples and resampled pixels. Specific types include:

- Astronomical constants for earth-sun distance, earth, moon, and sun gravitation, earth reference ellipsoid parameters, earth rotation rate, and solar flux.
- Kalman filter control parameters.
- Orbit, attitude, and star look tolerance parameters.
- Angular rate, orbit, and star look threshold parameters.

- Star catalog parameters.

Algorithm processing parameters are those used during service initiation, the processing of science data and to format data in preparation for producing an end product. Specific types include:

- netCDF product templates
- Service configurations
- Look up tables

The filename conventions for the ABI Level 1b semi-static source data file are located in Appendix C.

7.1.3.4 Coordinates

The coordinates associated with data variables in the Radiances product are identified in Table 7.1.3.4, Radiances Product Coordinates.

Table 7.1.3.4 Radiances Product Coordinates

Radiances Product Data Quantity	Coordinates
radiances data radiances data quality flags	• Observation time period • N/S elevation and E/W scanning angles for pixel geo-location • Central wavelength and identifier of the ABI band
radiances pixel counts radiances minimum, maximum, mean, and standard deviation values	• Observation time period • N/S elevation and E/W scanning angle extents for image geo-location • Central wavelength and identifier of the ABI band
star look data solar irradiance (esun) inverse of the incoming top of atmosphere radiance (kappa0)	• Observation time period • Central wavelength and identifier of the ABI band
planck constants	• Central wavelength and identifier of the ABI band
Earth – sun distance anomaly	• Observation time period
data transmission error percentages	• Observation time period • N/S elevation and E/W scanning angle extents for image geo-location

7.1.3.5 Production Notes

The Radiances product is generated by ABI Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm decompresses and extracts the raw detector observation and calibration sample data from the CCSDS packets. The Level 1b algorithm radiometrically corrects the sample data, and navigates and resamples the radiometrically corrected sample data to the ABI fixed grid.

There are separate radiometric correction flows for the reflective and emissive bands. In both cases, the gains of the detectors are computed. The detector gain values are applied to the raw detector samples obtained during Earth scenes, star scenes, and lunar scans. For IR scenes, a configurable flag is set to enable calibration using a predictive correction algorithm that will project values of the most recent spacelook to the times of observations of the Infrared Calibration Target (ICT) for the calculation of the gains, and will project the spacelooks and gains to the times of observation of the Earth scene samples. This correction compensates for calibration drift and is needed only for GOES-17 during periods when focal plane temperatures exceed nominal operating temperatures (due to the issue with the loop heat pipe cooling assembly). Otherwise, the ABI instrument is stable and the latest space looks and gains are applied with no correction. Observations collected when focal plane temperatures exceed nominal values are also flagged in the sample data quality flag. Under some conditions, the cooling system anomaly can lead to saturated or missing data and are flagged accordingly by the calibration algorithm. Additional information on the GOES-17 cooling system anomaly can be found here:

https://www.goes-r.gov/users/GOES-17-ABI-Performance.html

The image navigation and registration algorithms are responsible for generating target star selection lists for uplink to the instrument, determining instrument line-of-sight, correcting the registration between focal plane module fields of view, and navigating and resampling sample data to the ABI fixed grid.

Resampling of the ABI Level 0 data to the fixed grid is driven by a "state" output by a Kalman Filter. This state contains all the information needed to determine the orientation of the line-of-sight for the ABI. In addition, the position of the spacecraft is needed to determine the Earth locations of the detector samples to allow resampling to the ABI fixed grid. The Kalman Filter state is updated whenever the ABI performs a star look and is propagated using spacecraft position and attitude rate telemetry from the spacecraft.

Resampling is an interpolation process that calculates the value of a pixel from a weighted sum of detector samples that are within ± 2 angular separation distances of the pixel location. The weight assigned to each detector sample is determined by its proximity to the selected pixel and the resampler kernel values. The proximity of a sample to a pixel is determined from the coordinates assigned during the navigation portion of the ground processing. Refer to Figure 7.1.3.5, ABI Level 1b Resampling Process.

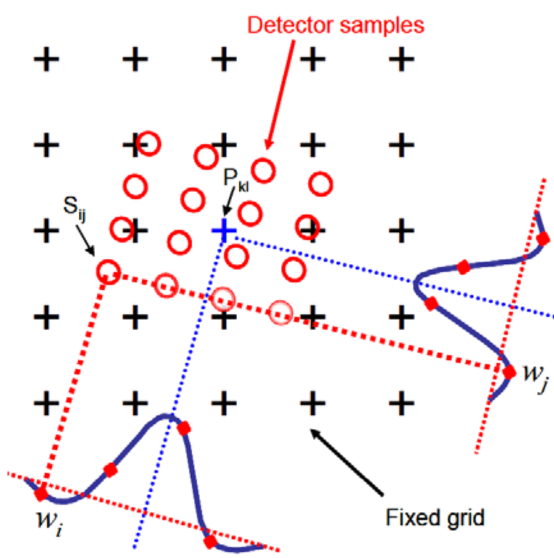


Figure 7.1.3.5 ABI Level 1b Resampling Process

The bit depth of the Radiances product, 10 to 14 bits, is band dependent, and is based on the bit depth of the downlinked samples from the ABI coupled with optimization considerations for GRB transmission. The bit depth for each of the sixteen bands is identified in Table 5.1.3.6.3-1, Radiances Product Quantity Characteristics.

A conditionally usable pixel means less than the full complement of sixteen radiometrically corrected data samples but at least twelve data samples are used in the formulation of the pixel value. Pixels can be either over-saturated or under-saturated. The valid range of pixel values are identified in in Table 7.1.3.6.3-1, Radiances Product Quantity Characteristics. Saturated pixels are assigned the minimum or maximum value in the valid range. The resampling algorithm identifies pixels affected by saturation, and outputs the radiometrically corrected sample data for the surrounding area in a sample outlier file for further analysis.

The ABI Level 1b data is processed in near real-time and transmitted over GRB before being assembled into a netCDF-4 product file that is distributed to PDA.

The Radiances algorithm intermediate data and diagnostic product files, which includes presampled radiometrically corrected and navigated radiance data, are available in the GOES-R ground system's Mission Management seven-day short term storage to support anomaly resolution and algorithm analysis. The final product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

The Radiances product is generated for each observation performed by the instrument. For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.1.3.6 Data Organization and Fields

A Radiances product image spans many GRB Space Packets. The Packets containing image data are sent first followed by the product's metadata. It is recommended that GRB users delay the processing of the product 0.5 seconds after receipt of the product's metadata, in order to ensure that the final few product packets are received. The APIDs used for each type of Radiances image and accompanying product metadata for the Full Disk, CONUS, mesoscale #1, and mesoscale #2 coverage regions, and ABI band are defined in Appendix A, CCSDS Application Identifiers.

The Radiances product data, which includes the binary radiances and DQF images use the GRB Image Payload format as defined above in Paragraph 5.2, GRB Image Payload.

The product metadata uses the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, and all variables other than the image and data quality flag variables.

The Radiances product data, specifically the radiances image data is scaled, making use of an unsigned 16 bit integer to store the data. The conventions used to specify the scaling information, specifically the data variable attributes scale_factor and add_offset, conform to the netCDF User's Guide (NUG) recommendations defined in the main volume of the PUG. In the event, the algorithm generates a data value less or greater than the valid range, the scaled value is assigned to be the minimum or maximum value in the valid range, respectively.

Generating a CF Metadata Convention compliant netCDF-4 Radiances product file from its GRB form requires population of the y and x coordinate variables with ascending integer values starting at zero.

The subordinate paragraphs that follow define the Radiances product image data, quantity characteristics, flag values and meanings, and metadata fields.

7.1.3.6.1 Image Data Fields

Once the product's radiance and DQF image fragments have been extracted from the packets, decompressed, and assembled into image blocks in accordance with the approach defined in Paragraph 6.1, GRB Image Payload Recovery, the radiance image pixels are 16 bits (short) unsigned scaled integers, and the DQF image pixels are 8 bit (byte) unsigned integers.

The units of measure after scaling for the Radiances product image pixels are defined in Table 7.1.3.6.1-1, Radiances Image Data Units.

Table 7.1.3.6.1-1 Radiances Image Data Units

ABI Band	Units
Bands 1-6 (reflectance bands)	W m-2 sr-1 um-1
Bands 7-16 (emissive bands)	mW m-2 sr-1 (cm-1)-1

7.1.3.6.1.1 Radiances Product Quantity Characteristics

Table 7.1.3.6.1.1-1 Radiances Product Quantity Characteristics

						Scaled Integer to Physical Quantity Conversion		Valid Range (packed - scaled integer form)		Valid Range (in units of physical quantity)	
ABI Channel (Band)	Central Wave-length (in µm)	Horizontal Spatial Resolution (in km at nadir)	Horizontal Spatial Resolution (in radians)	Fill Value (packed - scaled integer form)	Bit Depth	Scale Factor	Add Offset	Mini-mum	Maxi-mum	Minimum	Maximum
1	0.47	1.0	0.000028	1023	10	0.812106364	-25.93664701	0	1022	-25.93664701	804.03605737
2	0.64	0.5	0.000014	4095	12	0.158592367	-20.28991094	0	4094	-20.28991094	628.98723908
3	0.87	1.0	0.000028	1023	10	0.376912525	-12.03764377	0	1022	-12.03764377	373.16695681
4	1.38	2.0	0.000056	2047	11	0.070731082	-4.52236858	0	2046	-4.52236858	140.19342584
5	1.61	1.0	0.000028	1023	10	0.095800040	-3.05961376	0	1022	-3.05961376	94.84802665
6	2.25	2.0	0.000056	1023	10	0.030088475	-0.96095066	0	1022	-0.96095066	29.78947040
7	3.89	2.0	0.000056	16383	14	0.001564351	-0.03760000	0	16382	-0.03760000	25.58960000
8	6.17	2.0	0.000056	4095	12	0.007104763	-0.55860000	0	4094	-0.55860000	28.52830000
9	6.93	2.0	0.000056	2047	11	0.022539101	-0.82360000	0	2046	-0.82360000	45.29140000
10	7.34	2.0	0.000056	4095	12	0.020041280	-0.95610000	0	4094	-0.95610000	81.09290000
11	8.44	2.0	0.000056	4095	12	0.033357792	-1.30220000	0	4094	-1.30220000	135.26460000
12	9.61	2.0	0.000056	2047	11	0.054439980	-1.53940000	0	2046	-1.53940000	109.84480000
13	10.33	2.0	0.000056	4095	12	0.045728920	-1.64430000	0	4094	-1.64430000	185.56990000
14	11.19	2.0	0.000056	4095	12	0.049492208	-1.71870000	0	4094	-1.71870000	200.90240000
15	12.27	2.0	0.000056	4095	12	0.052774108	-1.75580000	0	4094	-1.75580000	214.30140000
16	13.27	2.0	0.000056	1023	10	0.176058513	-5.23920000	0	1022	-5.23920000	174.69260000

For the emissive channel radiances product, the planck constants required to convert the radiances to brightness temperature are defined in Table 7.1.3.6.1.1-2, Radiances to Brightness Temperature Planck Constants.
Scale factors are chosen in order to handle the minimum and maximum allowable values.

Table 7.1.3.6.1.1-2 Radiances to Brightness Temperature Planck Constants[1]

	Variable Names			
ABI Channel (Band)	planck_fk1	planck_fk2	planck_bc1	planck_bc2
7	2.02263e+05	3.69819e+03	0.43361	0.99939
8	5.06871e+04	2.33158e+03	1.55228	0.99667

	Variable Names			
ABI Channel (Band)	planck_fk1	planck_fk2	planck_bc1	planck_bc2
9	3.58283e+04	2.07695e+03	0.34427	0.99918
10	3.01740e+04	1.96138e+03	0.05651	0.99986
11	1.97799e+04	1.70383e+03	0.18733	0.99948
12	1.34321e+04	1.49761e+03	0.09102	0.99971
13	1.08033e+04	1.39274e+03	0.07550	0.99975
14	8.51022e+03	1.28627e+03	0.22516	0.99920
15	6.45462e+03	1.17303e+03	0.21702	0.99916
16	5.10127e+03	1.08453e+03	0.06266	0.99974

[1] The Planck constants in this table are example values, based on the ABI FM-1 instrument (on GOES-16). User applications should use the values in the product files because these values vary with each instance of the ABI instrument.

7.1.3.6.1.2 Radiances Product Flag Values and Meanings

Table 7.1.3.6.1.2 Radiances Product Data Quality Flag Values and Meanings

Data Quality Flags (DQF)	
Flag Value	Flag Meaning
0	good_pixel_qf
1	conditionally_usable_pixel_qf
2	out_of_range_pixel_qf
3	no_value_pixel_qf
4	focal_plane_temperature_threshold_exceeded_qf

7.1.3.6.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character).

The Radiances product metadata for bands 1-6 is defined in paragraph 7.1.3.6.2.1, Reflectance Band Radiance Product Metadata. The tables in these subordinate paragraphs. The Radiances product metadata for bands 7-16 is defined in paragraph 7.1.3.6.2.2, Emissive Band Radiance Product Metadata. The tables in these subordinate paragraphs define the physical content of the Radiances metadata in NcML format recovered from the GRB. The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Radiances product Data Fields paragraph for a logical depiction of the product metadata.

7.1.3.6.2.1 Radiances Product Reflective Bands Metadata

The Radiances product metadata for the reflective bands, ABI bands 1 to 6, is defined in Table 7.1.3.6.2.1, Radiances Product Reflective Bands Metadata.

Table 7.1.3.6.2.1 Radiances Product Reflective Bands Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf >
<dimension name="y" length="***see note [1]***" isUnlimited="false"/>
<dimension name="x" length="***see note [1]***" isUnlimited="false"/>
<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
<dimension name="number_of_image_bounds" length="2" isUnlimited="false"/>
<dimension name="band" length="1" isUnlimited="false"/>
<variable name="y" type="short" shape="y">
<attribute name="long_name" value="GOES-R fixed grid projection y-coordinate" type="string"/>
<attribute name="standard_name" value="projection_y_coordinate" type="string"/>
<attribute name="scale_factor" value="***see note [1]***" type="float"/>
<attribute name="add_offset" value="***see note [1]***" type="float"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="Y" type="string"/>
<values start="0" increment="1"></values>
</variable>
<variable name="x" type="short" shape="x">
<attribute name="long_name" value="GOES-R fixed grid projection x-coordinate" type="string"/>
<attribute name="standard_name" value="projection_x_coordinate" type="string"/>
<attribute name="scale_factor" value="***see note [1]***" type="float"/>
<attribute name="add_offset" value="***see note [1]***" type="float"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="X" type="string"/>
<values start="0" increment="1"></values>
</variable>
<variable name="t" type="double" shape="">
<attribute name="long_name" value="J2000 epoch mid-point between the start and end image scan in seconds" type="string"/>
<attribute name="standard_name" value="time" type="string"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<attribute name="axis" value="T" type="string"/>
<attribute name="bounds" value="time_bounds" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="time_bounds" type="double" shape="number_of_time_bounds">
<attribute name="long_name" value="Scan start and end times in seconds since epoch (2000-01-01 12:00:00)" type="string"/>
<values>***dynamic value dynamic value***</values>
</variable>
<variable name="band_wavelength" type="float" shape="band">
<attribute name="long_name" value="ABI band central wavelength" type="string"/>

<attribute name="standard_name" value="sensor_band_central_radiation_wavelength" type="string"/>
<attribute name="units" value="um" type="string"/>
<values>***see note [2]***</values>
</variable>
<variable name="band_id" type="byte" shape="band">
<attribute name="long_name" value="ABI channel number" type="string"/>
<attribute name="standard_name" value="sensor_band_identifier" type="string"/>
<attribute name="units" value="1" type="string"/>
<values>***see note [2]***</values>
</variable>
<variable name="y_image" type="float" shape="">
<attribute name="long_name" value="GOES-R fixed grid projection y-coordinate center of image" type="string"/>
<attribute name="standard_name" value="projection_y_coordinate" type="string"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="Y" type="string"/>
<attribute name="bounds" value="y_image_bounds" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="y_image_bounds" type="float" shape="number_of_image_bounds">
<attribute name="long_name" value="GOES-R fixed grid projection y-coordinate north/south extent of image" type="string"/>
<values>***see note [1] see note [1]***</values>
</variable>
<variable name="x_image" type="float" shape="">
<attribute name="long_name" value="GOES-R fixed grid projection x-coordinate center of image" type="string"/>
<attribute name="standard_name" value="projection_x_coordinate" type="string"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="X" type="string"/>
<attribute name="bounds" value="x_image_bounds" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="x_image_bounds" type="float" shape="number_of_image_bounds">
<attribute name="long_name" value="GOES-R fixed grid projection x-coordinate west/east extent of image" type="string"/>
<values>***see note [1] see note [1]***</values>
</variable>
<variable name="goes_imager_projection" type="int" shape="">
<attribute name="long_name" value="GOES-R ABI fixed grid projection" type="string"/>
<attribute name="grid_mapping_name" value="geostationary" type="string"/>
<attribute name="perspective_point_height" value="35786023." type="double"/>
<attribute name="semi_major_axis" value="6378137." type="double"/>

<attribute name="semi_minor_axis" value="6356752.31414" type="double"/>
<attribute name="inverse_flattening" value="298.2572221" type="double"/>
<attribute name="latitude_of_projection_origin" value="0.0" type="double"/>
<attribute name="longitude_of_projection_origin" value="***see note [1]***" type="double"/>
<attribute name="sweep_angle_axis" value="x" type="string"/>
</variable>
<variable name="Rad" type="short" shape="y x">
<attribute name="long_name" value="ABI L1b Radiances" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavelength" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="***see note [2]***" type="short"/>
<attribute name="sensor_band_bit_depth" value="***see note [2]***" type="byte"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="scale_factor" value="***see note [2]***" type="float"/>
<attribute name="add_offset" value="***see note [2]***" type="float"/>
<attribute name="units" value="W m-2 sr-1 um-1" type="string"/>
<attribute name="resolution" value="y: ***see note [2]*** rad x: ***see note [2]*** rad" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y x" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: point area: point" type="string"/>
<attribute name="ancillary_variables" value="DQF" type="string"/>
</variable>
<variable name="DQF" type="byte" shape="y x">
<attribute name="long_name" value="ABI L1b Radiances data quality flags" type="string"/>
<attribute name="standard_name" value="status_flag" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="255" type="byte"/>
<attribute name="valid_range" value="0 4" type="byte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y x" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: point area: point" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="byte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<attribute name="number_of_qf_values" value="5" type="byte"/>
<attribute name="percent_good_pixel_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_conditionally_usable_pixel_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_out_of_range_pixel_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_no_value_pixel_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_focal_plane_temperature_threshold_exceeded_qf" value="***dynamic value***" type="float"/>
</variable>

<variable name="focal_plane_temperature_threshold_exceeded_count" type="int" shape="">
<attribute name="long_name" value="number of pixels whose temperatures exceeded the threshold" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="maximum_focal_plane_temperature" type="float" shape="">
<attribute name="long_name" value="maximum focal plane temperature value" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range” value=”0 999.0” type=”float”/>
<attribute name="units" value="K" type="string"/>
</variable>
<variable name="focal_plane_temperature_threshold_increasing" type="float" shape="">
<attribute name="long_name" value="focal plane temperature threshold increasing bounds value" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range” value=”0 999.0” type=”float”/>
<attribute name="units" value="K" type="string"/>
</variable>
<variable name="focal_plane_temperature_threshold_decreasing" type="float" shape="">
<attribute name="long_name" value="focal plane temperature threshold decreasing bounds value" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range” value=”0 999.0” type=”float”/>
<attribute name="units" value="K" type="string"/>
</variable>
<variable name="valid_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of good and conditionally usable pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="missing_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of missing pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: missing ABI fixed grid pixels only)" type="string"/>

<values>***dynamic value***</values>
</variable>
<variable name="saturated_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of saturated pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: radiometrically saturated geolocated/not missing pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="undersaturated_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of undersaturated pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: radiometrically undersaturated geolocated/not missing pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="min_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="minimum radiance value of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavelength" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="units" value="W m-2 sr-1 um-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: minimum (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="max_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="maximum radiance value of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavelength" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="units" value="W m-2 sr-1 um-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>

<attribute name="cell_methods" value="t: sum area: maximum (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="mean_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="mean radiance value of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavelength" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="units" value="W m-2 sr-1 um-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: mean (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="std_dev_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="standard deviation of radiance values of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavelength" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-2 sr-1 um-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: standard_deviation (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<dimension name="num_star_looks" length="24" isUnlimited="false"/>
<variable name="t_star_look" type="double" shape="num_star_looks">
<attribute name="long_name" value="J2000 epoch time of star observed in seconds" type="string"/>
<attribute name="standard_name" value="time" type="string"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<attribute name="axis" value="T" type="string"/>
<values>***dynamic value dynamic value dynamic value dynamic value dynamic value dynamic value***</values>
</variable>
<variable name="band_wavelength_star_look" type="float" shape="num_star_looks">
<attribute name="long_name" value="ABI channel central wavelength associated with observed star" type="string"/>
<attribute name="standard_name" value="sensor_band_central_radiation_wavelength" type="string"/>
<attribute name="units" value="um" type="string"/>
<values>***dynamic value dynamic value dynamic value dynamic value dynamic value dynamic value***</values>
</variable>
<variable name="star_id" type="short" shape="num_star_looks">

<attribute name="long_name" type="string" value="ABI star catalog identifier associated with observed star"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="coordinates" value="band_id band_wavelength_star_look t_star_look" type="string"/>
<values>"***dynamic value***" "***dynamic value***" "***dynamic value***" "***dynamic value***" "***dynamic value***" "***dynamic value***"</values>
</variable>
<variable name="yaw_flip_flag" type="byte" shape="">
<attribute name="long_name" value="Flag indicating the spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="255" type="byte"/>
<attribute name="valid_range" value="0 1" type="byte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="t" type="string"/>
<attribute name="flag_values" value="0 1" type="byte"/>
<attribute name="flag_meanings" value="false true" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="esun" type="float" shape="">
<attribute name="long_name" value="bandpass-weighted solar irradiance at the mean Earth-Sun distance" type="string"/>
<attribute name="standard_name" value="toa_shortwave_irradiance_per_unit_wavelength" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-2 um-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t" type="string"/>
<attribute name="cell_methods" value="t: mean" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="kappa0" type="float" shape="">
<attribute name="long_name" value="Inverse of the incoming top of atmosphere radiance at current earth-sun distance (PI d2 esun-1)-1, where d is the ratio of instantaneous Earth-Sun distance divided by the mean Earth-Sun distance, esun is the bandpass-weighted solar irradiance and PI is a standard constant used to convert ABI L1b radiance to reflectance" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="(W m-2 um-1)-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t" type="string"/>
<attribute name="cell_methods" value="t: mean" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="planck_fk1" type="float" shape="">
<attribute name="long_name" value="wavenumber-dependent coefficient (2 h c2/ nu3) used in the ABI emissive band monochromatic brightness temperature computation, where nu =central wavenumber and h and c are standard constants" type="string"/>

<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>-999.0</values>
</variable>
<variable name="planck_fk2" type="float" shape="">
<attribute name="long_name" value="wavenumber-dependent coefficient (h c nu/b) used in the ABI emissive band monochromatic brightness temperature computation, where nu = central wavenumber and h, c, and b are standard constants" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="K" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>-999.0</values>
</variable>
<variable name="planck_bc1" type="float" shape="">
<attribute name="long_name" value="spectral bandpass correction offset for brightness temperature (B(nu) – bc_1)/bc_2 where B()=planck_function() and nu=wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="K" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>-999.0</values>
</variable>
<variable name="planck_bc2" type="float" shape="">
<attribute name="long_name" value="spectral bandpass correction scale factor for brightness temperature (B(nu) – bc_1)/bc_2 where B()=planck_function() and nu=wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>-999.0</values>
</variable>
<variable name="earth_sun_distance_anomaly_in_AU" shape="" type="float">
<attribute name="long_name" value="earth sun distance anomaly in astronomical units" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="ua" type="string"/>
<attribute name="coordinates" value="t" type="string"/>
<attribute name="cell_methods" value="t: mean" type="string"/>
<values>-999.0</values>
</variable>
<variable name="percent_uncorrectable_L0_errors" type="float" shape="">
<attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>

<attribute name="coordinates" value="t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (uncorrectable L0 errors only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="nominal_satellite_subpoint_lat" type="float" shape="">
<attribute name="long_name" value="nominal satellite subpoint latitude (platform latitude)" type="string"/>
<attribute name="standard_name" value="latitude" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="degrees_north" type="string"/>
<values>0.00</values>
</variable>
<variable name="nominal_satellite_subpoint_lon" type="float" shape="">
<attribute name="long_name" value="nominal satellite subpoint longitude (platform longitude)" type="string"/>
<attribute name="standard_name" value="longitude" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="degrees_east" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="nominal_satellite_height" type="float" shape="">
<attribute name="long_name" value="nominal satellite height above GRS 80 ellipsoid (platform altitude)" type="string"/>
<attribute name="standard_name" value="height_above_reference_ellipsoid" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="km" type="string"/>
<values>35786.023</values>
</variable>
<variable name="geospatial_lat_lon_extent" type="float" shape="">
<attribute name="long_name" value="geospatial latitude and longitude references" type="string"/>
<attribute name="geospatial_westbound_longitude" value="***see note [1]***" type="float"/>
<attribute name="geospatial_northbound_latitude" value="***see note [1]***" type="float"/>
<attribute name="geospatial_eastbound_longitude" value="***see note [1]***" type="float"/>
<attribute name="geospatial_southbound_latitude" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lat_center" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lon_center" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lat_nadir" value="0.0" type="float"/>
<attribute name="geospatial_lon_nadir" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lat_units" value="degrees_north" type="string"/>
<attribute name="geospatial_lon_units" value="degrees_east" type="string"/>
</variable>
<attribute name="dataset_name" value="***refer to filename conventions for L1b products in Appendix C.***" type="string"/>

<attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
<attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
<attribute name="project" value="GOES" type="string"/>
<attribute name="iso_series_metadata_id" value="a70be540-c38b-11e0-962b-0800200c9a66" type="string"/>
<attribute name="Conventions" value="CF-1.7" type="string"/>
<attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
<attribute name="standard_name_vocabulary" value="CF Standard Name Table (v25, 05 July 2013)" type="string"/>
<attribute name="title" value="ABI L1b Radiances" type="string"/>
<attribute name="summary" value="Single reflectance channel ABI L1b Radiance Products are digital maps of outgoing radiance values at the top of the atmosphere for visible and near-IR bands." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SPECTRAL/ENGINEERING > VISIBLE WAVELENGTHS > VISIBLE RADIANCE" type="string"/>
<attribute name="cdm_data_type" value="Image" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES R Series Advanced Baseline Imager" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument.***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="timeline_id" value="***possible values are ABI Mode 3, ABI Mode 4 and ABI Mode 6.***" type="string"/>
<attribute name="scene_id" value="***possible values are Full Disk, CONUS, and Mesoscale.***" type="string"/>
<attribute name="spatial_resolution" value="***possible values are 0.5km at nadir, 1km at nadir, and 2km at nadir.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data" type="string"/>
<attribute name="input_ABI_L0_data" value="***refer to filename conventions for L0 products in Appendix C.***" type="string"/>
</variable>
<variable name="processing_parm_version_container" type="int" shape="">

<attribute name="long_name" value="container for processing parameter filenames" type="string"/>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
</variable>
<variable name="algorithm_product_version_container" type="int" shape="">
<attribute name="long_name" value="container for algorithm package filename and product version" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
</variable>
</netcdf>

Note 1: Coverage region and horizontal spatial resolution related sizing and extent variable and attribute values are located in paragraph 7.1.2.6, Product Data Structures, and paragraph 7.1.2.7, Standard Coordinate Data, in the ABI Fixed Grid section.
Note 2: Radiance product quantity characteristics are located in paragraph 7.1.3.6.1.1, Radiances Product Quantity Characteristics.
Note “flags and meanings”: Flag values and meanings are located in paragraph 7.1.3.6.1.2, Radiances Product Flag Values and Meanings.

7.1.3.6.2.2 Radiances Product Emissive Band Metadata

The Radiances product metadata for the emissive bands, ABI bands 7 to 16, is defined in Table 7.1.3.6.2.2, Radiances Product Emissive Bands Metadata.

Table 7.1.3.6.2.2 Radiances Product Emissive Bands Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf >
<dimension name="y" length="***see note [1]***" isUnlimited="false"/>
<dimension name="x" length="***see note [1]***" isUnlimited="false"/>
<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
<dimension name="number_of_image_bounds" length="2" isUnlimited="false"/>
<dimension name="band" length="1" isUnlimited="false"/>
<variable name="y" type="short" shape="y">
<attribute name="long_name" value="GOES-R fixed grid projection y-coordinate" type="string"/>
<attribute name="standard_name" value="projection_y_coordinate" type="string"/>
<attribute name="scale_factor" value="***see note [1]***" type="float"/>
<attribute name="add_offset" value="***see note [1]***" type="float"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="Y" type="string"/>
<values start="0" increment="1"></values>
</variable>
<variable name="x" type="short" shape="x">
<attribute name="long_name" value="GOES-R fixed grid projection x-coordinate" type="string"/>
<attribute name="standard_name" value="projection_x_coordinate" type="string"/>
<attribute name="scale_factor" value="***see note [1]***" type="float"/>
<attribute name="add_offset" value="***see note [1]***" type="float"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="X" type="string"/>

<values start="0" increment="1"></values>
</variable>
<variable name="t" type="double" shape="">
<attribute name="long_name" value="J2000 epoch mid-point between the start and end image scan in seconds" type="string"/>
<attribute name="standard_name" value="time" type="string"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<attribute name="axis" value="T" type="string"/>
<attribute name="bounds" value="time_bounds" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="time_bounds" type="double" shape="number_of_time_bounds">
<attribute name="long_name" value="Scan start and end times in seconds since epoch (2000-01-01 12:00:00)" type="string"/>
<values>***dynamic value dynamic value***</values>
</variable>
<variable name="band_wavelength" type="float" shape="band">
<attribute name="long_name" value="ABI band central wavelength" type="string"/>
<attribute name="standard_name" value="sensor_band_central_radiation_wavelength" type="string"/>
<attribute name="units" value="um" type="string"/>
<values>***see note [2]***</values>
</variable>
<variable name="band_id" type="byte" shape="band">
<attribute name="long_name" value="ABI channel number" type="string"/>
<attribute name="standard_name" value="sensor_band_identifier" type="string"/>
<attribute name="units" value="1" type="string"/>
<values>***see note [2]***</values>
</variable>
<variable name="y_image" type="float" shape="">
<attribute name="long_name" value="GOES-R fixed grid projection y-coordinate center of image" type="string"/>
<attribute name="standard_name" value="projection_y_coordinate" type="string"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="Y" type="string"/>
<attribute name="bounds" value="y_image_bounds" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="y_image_bounds" type="float" shape="number_of_image_bounds">
<attribute name="long_name" value="GOES-R fixed grid projection y-coordinate north/south extent of image" type="string"/>
<values>***see note [1] see note [1]***</values>
</variable>
<variable name="x_image" type="float" shape="">
<attribute name="long_name" value="GOES-R fixed grid projection x-coordinate center of image" type="string"/>
<attribute name="standard_name" value="projection_x_coordinate" type="string"/>
<attribute name="units" value="rad" type="string"/>
<attribute name="axis" value="X" type="string"/>
<attribute name="bounds" value="x_image_bounds" type="string"/>
<values>***see note [1]***</values>

</variable>
<variable name="x_image_bounds" type="float" shape="number_of_image_bounds">
<attribute name="long_name" value="GOES-R fixed grid projection x-coordinate west/east extent of image" type="string"/>
<values>***see note [1] see note [1]***</values>
</variable>
<variable name="goes_imager_projection" type="int" shape="">
<attribute name="long_name" value="GOES-R ABI fixed grid projection" type="string"/>
<attribute name="grid_mapping_name" value="geostationary" type="string"/>
<attribute name="perspective_point_height" value="35786023." type="double"/>
<attribute name="semi_major_axis" value="6378137." type="double"/>
<attribute name="semi_minor_axis" value="6356752.31414" type="double"/>
<attribute name="inverse_flattening" value="298.2572221" type="double"/>
<attribute name="latitude_of_projection_origin" value="0.0" type="double"/>
<attribute name="longitude_of_projection_origin" value="***see note [1]***" type="double"/>
<attribute name="sweep_angle_axis" value="x" type="string"/>
</variable>
<variable name="Rad" type="short" shape="y x">
<attribute name="long_name" value="ABI L1b Radiances" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavenumber" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="***see note [2]***" type="short"/>
<attribute name="sensor_band_bit_depth" value="***see note [2]***" type="byte"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="scale_factor" value="***see note [2]***" type="float"/>
<attribute name="add_offset" value="***see note [2]***" type="float"/>
<attribute name="units" value="mW m-2 sr-1 (cm-1)-1" type="string"/>
<attribute name="resolution" value="y: ***see note [2]*** rad x: ***see note [2]*** rad" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y x" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: point area: point" type="string"/>
<attribute name="ancillary_variables" value="DQF" type="string"/>
</variable>
<variable name="DQF" type="byte" shape="y x">
<attribute name="long_name" value="ABI L1b Radiances data quality flags" type="string"/>
<attribute name="standard_name" value="status_flag" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="255" type="byte"/>
<attribute name="valid_range" value="0 4" type="byte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y x" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: point area: point" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="byte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<attribute name="number_of_qf_values" value="5" type="byte"/>
<attribute name="percent_good_pixel_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_conditionally_usable_pixel_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_out_of_range_pixel_qf" value="***dynamic value***" type="float"/>

<attribute name="percent_no_value_pixel_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_focal_plane_temperature_threshold_exceeded_qf" value="***dynamic value***" type="float"/>
</variable>
<variable name="focal_plane_temperature_threshold_exceeded_count" type="int" shape="">
<attribute name="long_name" value="number of pixels whose temperatures exceeded the threshold" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="maximum_focal_plane_temperature" type="float" shape="">
<attribute name="long_name" value="maximum focal plane temperature value" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range” value=”0 999.0” type=”float”/>
<attribute name="units" value="K" type="string"/>
</variable>
<variable name="focal_plane_temperature_threshold_increasing" type="float" shape="">
<attribute name="long_name" value="focal plane temperature threshold increasing bounds value" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range” value=”0 999.0” type=”float”/>
<attribute name="units" value="K" type="string"/>
</variable>
<variable name="focal_plane_temperature_threshold_decreasing" type="float" shape="">
<attribute name="long_name" value="focal plane temperature threshold decreasing bounds value" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range” value=”0 999.0” type=”float”/>
<attribute name="units" value="K" type="string"/>
</variable>
<variable name="valid_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of good and conditionally usable pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="missing_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of missing pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: missing ABI fixed grid pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>

<variable name="saturated_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of saturated pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: radiometrically saturated geolocated/not missing pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="undersaturated_pixel_count" type="int" shape="">
<attribute name="long_name" value="number of undersaturated pixels" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (interval: ***see note [2]*** rad comment: radiometrically undersaturated geolocated/not missing pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="min_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="minimum radiance value of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="units" value="mW m-2 sr-1 (cm-1)-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: minimum (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="max_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="maximum radiance value of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="units" value="mW m-2 sr-1 (cm-1)-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: maximum (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="mean_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="mean radiance value of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [2] see note [2]***" type="short"/>
<attribute name="units" value="mW m-2 sr-1 (cm-1)-1" type="string"/>

<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: mean (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="std_dev_radiance_value_of_valid_pixels" type="float" shape="">
<attribute name="long_name" value="standard deviation of radiance values of pixels" type="string"/>
<attribute name="standard_name" value="toa_outgoing_radiance_per_unit_wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="mW m-2 sr-1 (cm-1)-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: standard_deviation (interval: ***see note [2]*** rad comment: good and conditionally usable quality pixels only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<dimension name="num_star_looks" length="24" isUnlimited="false"/>
<variable name="t_star_look" type="double" shape="num_star_looks">
<attribute name="long_name" value="J2000 epoch time of star observed in seconds" type="string"/>
<attribute name="standard_name" value="time" type="string"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<attribute name="axis" value="T" type="string"/>
<values>***dynamic value dynamic value dynamic value dynamic value dynamic value dynamic value***</values>
</variable>
<variable name="band_wavelength_star_look" type="float" shape="num_star_looks">
<attribute name="long_name" value="ABI channel central wavelength associated with observed star" type="string"/>
<attribute name="standard_name" value="sensor_band_central_radiation_wavelength" type="string"/>
<attribute name="units" value="um" type="string"/>
<values>***dynamic value dynamic value dynamic value dynamic value dynamic value dynamic value***</values>
</variable>
<variable name="star_id" type="short" shape="num_star_looks">
<attribute name="long_name" type="string" value="ABI star catalog identifier associated with observed star"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="coordinates" value="band_id band_wavelength_star_look t_star_look" type="string"/>
<values>"***dynamic value***" "***dynamic value***" "***dynamic value***" "***dynamic value***" "***dynamic value***" "***dynamic value***"</values>
</variable>
<variable name="yaw_flip_flag" type="byte" shape="">
<attribute name="long_name" value="Flag indicating the spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="255" type="byte"/>
<attribute name="valid_range" value="0 1" type="byte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="t" type="string"/>
<attribute name="flag_values" value="0 1" type="byte"/>
<attribute name="flag_meanings" value="false true" type="string"/>

<values>***dynamic value***</values>
</variable>
<variable name="esun" type="float" shape="">
<attribute name="long_name" value="bandpass-weighted solar irradiance at the mean Earth-Sun distance" type="string"/>
<attribute name="standard_name" value="toa_shortwave_irradiance_per_unit_wavelength" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-2 um-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t" type="string"/>
<attribute name="cell_methods" value="t: mean" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="kappa0" type="float" shape="">
<attribute name="long_name" value="Inverse of the incoming top of atmosphere radiance at current earth-sun distance (PI d2 esun-1)-1, where d is the ratio of instantaneous Earth-Sun distance divided by the mean Earth-Sun distance, esun is the bandpass-weighted solar irradiance and PI is a standard constant used to convert ABI L1b radiance to reflectance" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="(W m-2 um-1)-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength t" type="string"/>
<attribute name="cell_methods" value="t: mean" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="planck_fk1" type="float" shape="">
<attribute name="long_name" value="wavenumber-dependent coefficient (2 h c2/ nu3) used in the ABI emissive band monochromatic brightness temperature computation, where nu =central wavenumber and h and c are standard constants" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>***see note [3]***</values>
</variable>
<variable name="planck_fk2" type="float" shape="">
<attribute name="long_name" value="wavenumber-dependent coefficient (h c nu/b) used in the ABI emissive band monochromatic brightness temperature computation, where nu = central wavenumber and h, c, and b are standard constants" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="K" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>***see note [3]***</values>
</variable>
<variable name="planck_bc1" type="float" shape="">
<attribute name="long_name" value="spectral bandpass correction offset for brightness temperature (B(nu) – bc_1)/bc_2 where B()=planck_function() and nu=wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="K" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>***see note [3]***</values>
</variable>
<variable name="planck_bc2" type="float" shape="">

<attribute name="long_name" value="spectral bandpass correction scale factor for brightness temperature (B(nu) – bc_1)/bc_2 where B()=planck_function() and nu=wavenumber" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="band_id band_wavelength" type="string"/>
<values>***see note [3]***</values>
</variable>
<variable name="earth_sun_distance_anomaly_in_AU" shape="" type="float">
<attribute name="long_name" value="earth sun distance anomaly in astronomical units" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="ua" type="string"/>
<attribute name="coordinates" value="t" type="string"/>
<attribute name="cell_methods" value="t: mean" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="percent_uncorrectable_L0_errors" type="float" shape="">
<attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
<attribute name="coordinates" value="t y_image x_image" type="string"/>
<attribute name="grid_mapping" value="goes_imager_projection" type="string"/>
<attribute name="cell_methods" value="t: sum area: sum (uncorrectable L0 errors only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="nominal_satellite_subpoint_lat" type="float" shape="">
<attribute name="long_name" value="nominal satellite subpoint latitude (platform latitude)" type="string"/>
<attribute name="standard_name" value="latitude" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="degrees_north" type="string"/>
<values>0.00</values>
</variable>
<variable name="nominal_satellite_subpoint_lon" type="float" shape="">
<attribute name="long_name" value="nominal satellite subpoint longitude (platform longitude)" type="string"/>
<attribute name="standard_name" value="longitude" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="degrees_east" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="nominal_satellite_height" type="float" shape="">
<attribute name="long_name" value="nominal satellite height above GRS 80 ellipsoid (platform altitude)" type="string"/>
<attribute name="standard_name" value="height_above_reference_ellipsoid" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="km" type="string"/>
<values>35786.023</values>
</variable>
<variable name="geospatial_lat_lon_extent" type="float" shape="">
<attribute name="long_name" value="geospatial latitude and longitude references" type="string"/>
<attribute name="geospatial_westbound_longitude" value="***see note [1]***" type="float"/>

<attribute name="geospatial_northbound_latitude" value="***see note [1]***" type="float"/>
<attribute name="geospatial_eastbound_longitude" value="***see note [1]***" type="float"/>
<attribute name="geospatial_southbound_latitude" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lat_center" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lon_center" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lat_nadir" value="0.0" type="float"/>
<attribute name="geospatial_lon_nadir" value="***see note [1]***" type="float"/>
<attribute name="geospatial_lat_units" value="degrees_north" type="string"/>
<attribute name="geospatial_lon_units" value="degrees_east" type="string"/>
</variable>
<attribute name="dataset_name" value="***refer to filename conventions for L1b products in Appendix C.***" type="string"/>
<attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
<attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
<attribute name="project" value="GOES" type="string"/>
<attribute name="iso_series_metadata_id" value="a70be540-c38b-11e0-962b-0800200c9a66" type="string"/>
<attribute name="Conventions" value="CF-1.7" type="string"/>
<attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
<attribute name="standard_name_vocabulary" value="CF Standard Name Table (v25, 05 July 2013)" type="string"/>
<attribute name="title" value="ABI L1b Radiances" type="string"/>
<attribute name="summary" value="Single emissive channel ABI L1b Radiance Products are digital maps of outgoing radiance values at the top of the atmosphere for IR bands." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SPECTRAL/ENGINEERING > INFRARED WAVELENGTHS > INFRARED RADIANCE" type="string"/>
<attribute name="cdm_data_type" value="Image" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES R Series Advanced Baseline Imager" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument.***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD”T”HH:MM:SS.s”Z”.***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="timeline_id" value="***possible values are ABI Mode 3, ABI Mode 4 and ABI Mode 6.***" type="string"/>
<attribute name="scene_id" value="***possible values are Full Disk, CONUS, and Mesoscale.***" type="string"/>
<attribute name="spatial_resolution" value="***possible values are 0.5km at nadir, 1km at nadir, and 2km at nadir.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD”T”HH:MM:SS.s”Z”.***" type="string"/>

<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data" type="string"/>
<attribute name="input_ABI_L0_data" value="***refer to filename conventions for L0 products in Appendix C.***" type="string"/>
</variable>
<variable name="processing_parm_version_container" type="int" shape="">
<attribute name="long_name" value="container for processing parameter filenames" type="string"/>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
</variable>
<variable name="algorithm_product_version_container" type="int" shape="">
<attribute name="long_name" value="container for algorithm package filename and product version" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
</variable>
</netcdf>

Note 1: Coverage region and horizontal spatial resolution related sizing and extent variable and attribute values are located in paragraph 7.1.2.6, Product Data Structures, and paragraph 7.1.2.7, Standard Coordinate Data, in the ABI Fixed Grid section.

Note 2: Radiance product quantity characteristics are located in paragraph 7.1.3.6.1.1, Radiances Product Quantity Characteristics.

Note 3: Planck constants are located in paragraph 7.1.3.6.1.1, Radiances Product Quantity Characteristics.
Note "flags and meanings": Flag values and meanings are located in paragraph 7.1.3.6.1.2, Radiances Product Flag Values and Meanings.

7.1.3.6.2.3 Radiances Product Block-Level Metadata (BLM)

The Radiances product block-level metadata is described in Table 7.1.3.6.2.3, Radiances Product Block-Level Metadata. The block-level metadata format is the same for all bands, and all ABI collection modes (e.g., Mode 3, Mode 4, Mode 6) and collection types (e.g., Full Disk, CONUS, Mesoscale). The block-level metadata is located in the GRB APIDs specified in Appendix A.1.

Table 7.1.3.6.2.3 Radiances Product Block-Level Metadata

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units[1]	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
theBandID	uint8	n/a	ABI band number (1-16)	1	1	0
theBlockID	uint8	n/a	block number within ABI scene (0-based)	1	1	1
theEarthToSunX_ECF	double	n/a	X-component of the earth-to-sun ECF position with respect to reference (nominal) GOES longitude.	km	8	2
theEarthToSunY_ECF	double	n/a	Y-component of the earth-to-sun ECF position with respect to reference (nominal) GOES longitude.	km	8	10
theEarthToSunZ_ECF	double	n/a	Z-component of the earth-to-sun ECF position with respect to reference (nominal) GOES longitude.	km	8	18
theEndTime	double	n/a	scene-and-band specific scan time for the last column of pixels in the L1b block. This value is calculated by the ABI L1b Resampling Algorithm based on scan mirror angle time stamps and band-specific focal plane offsets.	seconds since 2000-01-01 12:00:00	8	26
theFloatToShortOffset	double	n/a	add_offset for converting pixel value to short data type	1	8	34
theFloatToShortScale	double	n/a	scale_factor for converting pixel value to short data type	1	8	42
theImageBoundaryEastFG	double	n/a	Fixed Grid projection x-coordinate of the eastern edge of the easternmost pixel in the L1b image block	rad	8	50
theImageBoundaryEastPix	int32	n/a	Pixel index x-coordinate of the easternmost pixel in the L1b image block	1	4	58
theImageBoundaryNorthFG	double	n/a	Fixed Grid projection y-coordinate of the northern edge of the northernmost pixel in the L1b image block	rad	8	62
theImageBoundaryNorthPix	int32	n/a	Pixel index y-coordinate of the northernmost pixel in the L1b image block	1	4	70

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units[1]	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
theImageBoundarySouthFG	double	n/a	Fixed Grid projection y-coordinate of the southern edge of the southernmost pixel in the L1b image block	rad	8	74
theImageBoundarySouthPix	int32	n/a	Pixel index y-coordinate of the southernmost pixel in the L1b image block	1	4	82
theImageBoundaryWestFG	double	n/a	Fixed Grid projection x-coordinate of the western edge of the westernmost pixel in the L1b image block	rad	8	86
theImageBoundaryWestPix	int32	n/a	Pixel index x-coordinate of the westernmost pixel in the L1b image block	1	4	94
theImageCenterEWFG	double	n/a	Fixed Grid projection x-coordinate of the scene image center	rad	8	98
theImageCenterNSFG	double	n/a	Fixed Grid projection y-coordinate of the scene image center	rad	8	106
theInstrumentSerialNumber	uint8	n/a	ABI instrument number	1	1	114
theMaximumValidPixelRadiance	double	n/a	maximum value of valid pixel radiance	***see note [1]***	8	115
theMinimumValidPixelRadiance	double	n/a	minimum value of valid pixel radiance	***see note [1]***	8	123
theNominalLongitude	double	n/a	nominal satellite longitude	deg	8	131
theTotalNumberOfPixels	int32	n/a	total number of pixels in the block	1	4	139
theNumberOfGoodPixels	int32	n/a	total number of good pixels in the block	1	4	143
theNumberOfConditionalUsePixels	int32	n/a	total number of conditional use pixels in the block	1	4	147
theNumberOfMissingPixels	int32	n/a	total number of missing pixels in the block	1	4	151
theNumberOfOffEarthPixels	int32	n/a	total number of off earth pixels in the block	1	4	155
theNumberOfSaturatedSamplesHard	int32	n/a	number of pixels in the block that had radiances above the saturation limit	1	4	159
theNumberOfSaturatedSamplesSoft	int32	n/a	number of pixels in the block that had saturated sample contributors	1	4	163
theNumberOfUndersaturatedSamplesHard	int32	n/a	number of pixels in the block that had radiances below the undersaturation limit	1	4	167
theNumberOfUndersaturatedSamplesSoft	int32	n/a	number of pixels in the block that had undersaturated sample contributors	1	4	171

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units[1]	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
theRealSpaceCraftX_ECF	double	n/a	real (non-ideal) spacecraft X location in Earth Centered Fixed coordinates	km	8	175
theRealSpaceCraftY_ECF	double	n/a	real (non-ideal) spacecraft Y location in Earth Centered Fixed coordinates	km	8	183
theRealSpaceCraftZ_ECF	double	n/a	real (non-ideal) spacecraft Z location in Earth Centered Fixed coordinates	km	8	191
theSceneID	uint8	n/a	identifier of the scene	1	1	199
theStartTime	double	n/a	time of the beginning of the product instance (scene and band)	seconds since 2000-01-01 12:00:00	8	200
theSumOfSquaredValidPixelRadiances	double	n/a	sum of the squares of radiances of all good or conditional quality pixels in the block	1	8	208
theSumOfValidPixelRadiance	double	n/a	sum of the radiances of all good or conditional quality pixels in the block	1	8	216
theTimelineID	uint16	n/a	timeline ID	1	2	224
theYawFlipFlag	uint8	n/a	Flag indicating the spacecraft is operating in yaw flip configuration	1	1	226
theMaximumFocalPlaneTemperature	double	n/a	maximum focal plane temperature in the block	K	8	227
theNumberOfPixelsWithTDQF_Contributors	uint32	n/a	number of pixels with TDQF_contributors in the block	1	4	235

Note 1: The units for theMaximumValidPixelRadiance, theMinimumValidPixelRadiance variables are:
'W m-2 sr-1 um-1' for reflective bands, 'mW m-2 sr-1 (cm-1)-1' for emissive bands.

7.2 GLM Level 2+ Product

7.2.1 Lightning Detection Product

7.2.1.1 Description

The Lightning Detection product contains a list of lightning flashes, and their constituent groups and events. Refer to Figure 7.2.1.1-1, Lightning Detection Product Data Relationships.

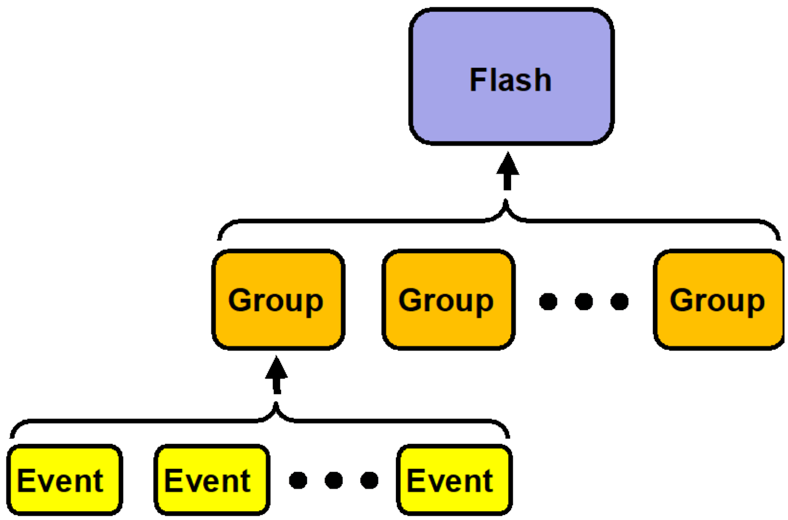


Figure 7.2.1.1-1 Lightning Detection Product Data Relationships

The definition of and relationship among flashes, groups, and events are governed by the following spatial and temporal characteristics:

- An event represents the signal detected from the cloud top associated with a lightning emission in an individual sensor pixel for a 2 ms integration period.
- A group represents the events detected in adjacent sensor pixels for the same integration period as an event.
- A flash represents a series of measurements constrained by temporal and spatial extent thresholds that are associated with one or more groups.

The parent, child relationship among specific flashes, groups, and events is stored in the product. Data for each flash includes an energy-weighted centroid latitude, longitude location, time span of occurrence, amount of radiant energy, and coverage area. Data for each group includes an energy-weighted centroid latitude, longitude location, mean time of occurrence, amount of radiant energy, and coverage area. Data for each event includes a latitude, longitude location, time of occurrence, and amount of radiant energy. The product includes data quality information for each flash and group, including an indication of good or degraded quality, and the rationale.

A Lightning Detection product contains a set of flashes, and its constituent groups and events for a nominally 20.5 second period, corresponding to a nominal twenty 1.024 second blocks.

The units of measure for the flash, group, and event radiant energy values are "joules". The units of measure for the flash and group coverage areas are "square kilometers".

The coverage area for the lightning detection product is defined in Table 7.2.1.1-1 Lighting Detection Product Field of View Center and Extents.

Table 7.2.1.1-1 Lightning Detection Product Field of View Center and Extents

latitude is degrees north longitude is degrees east	GOES-East	GOES-West	GOES-Test
nominal_satellite_subpoint_lat / lat_field_of_view (center)	0.0	0.0	0.0
nominal_satellite_subpoint_lon / lon_field_of_view (center)	-75.2	-137.0	-89.5
lat_field_of_view_bounds (1) (north)	66.56	66.56	66.56
lat_field_of_view_bounds (2) (south)	-66.56	-66.56	-66.56
lon_field_of_view_bounds (1) (west)	-141.56	-203.56	-156.06
lon_field_of_view_bounds (2) (east)	-8.44	-70.44	-22.94

Note that the field of view is not a rectangle in latitude, longitude space as implied with the field-of-view values in the table. The corners of the instrument field of view are rounded. See Figure 7.2.1.1-2, GLM Field of View (GOES-East).

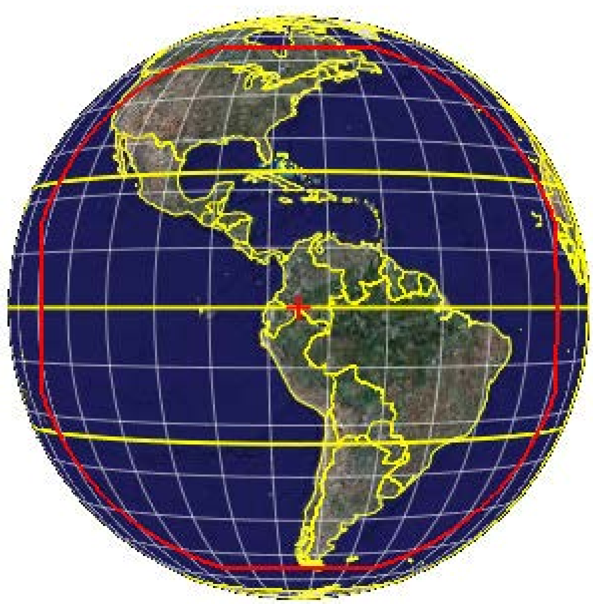


Figure 7.2.1.1-2 GLM Field of View (GOES-East)

The Lightning Detection performance requirements are summarized in Table 7.2.1.1-2, Lightning Detection Performance Requirements.

Table 7.2.1.1-2 Lightning Detection Performance Requirements

	Measurement				Mapping	
Region	**Range**	**Accuracy**	**Precision**	**Performance Conditions**	**Resolution**	**Accuracy**
GLM Instrument Field of View	Not specified	Flash probability of detection: 70% [1]	Flash false alarm rate: 5% [1]	LZA $\leq$ 65 degrees [2]	10 km (average)[3]	5 km

[1] Flash probability of detection and false alarm rate are computed as averages with equal weight given to all sensor pixels (i.e., potential events).
[2] Conditions for good quality prescribed by the algorithm do not include LZA ≤ 65 degrees.
[3] Actual event horizontal spatial resolution is 8 km at nadir, 14 km at the edge of the field of view. Requirement is 10 km (average across the field of view).

Metadata in the Lightning Detection product provides observation period, lightning detection statistics, and satellite state information. Specific metadata includes:

- Approximate start and end time of the observation period.
- Number of flashes, groups, and events.
- Satellite yaw flip configuration.

The percentages of pixels assigned to each flash and group DQF value are also included in the product.

The detailed description of the ISO series metadata for the Lightning Detection product is located in the standalone Appendix X, ISO Series Metadata.

7.2.1.2 Dynamic Source Data

The Lightning Detection product is derived using the GLM Level 0 raw science and engineering telemetry over an approximate 20.5 second period.

The primary sensor data used by the Lightning Detection algorithm is identified in Table 7.2.1.2, Primary Sensor Data.

Table 7.2.1.2-1 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_GLM_L0_data

7.2.1.3 Level 1b and Level 2+ Semi-Static Source Data

There are three categories of semi-static source data employed in the GLM Level 1b ground processing algorithm:

- Radiometric calibration parameters.
- Geometric calibration parameters.
- Algorithm processing parameters.

Semi-static source data files from the three categories above are contained in a single zip file, rolled up to the instrument level - all GLM semi-static parameter files are in one zip file. Some files fit into more than one category.

Radiometric calibration parameters are those associated with the instrument's radiometric observing characteristics, or its raw outputs. Specific types include:

- CCD sizing parameters.
- Background sizing parameters.
- Data formatter and RTEP to CCD subarray mapping table.
- 32 possible background levels of the five most significant bits of the 14-bit event background, which is used to index into the event energy calibration lookup table.
- CCD constants used to determine event pixel coordinates.
- GLM event real time event processor and data formatter to detector focal plane mapping.
- Masked region lookup table.
- Minimum count for valid lightning event cluster.

- Radiometric calibration lookup table as function of event RTEP count, background energy level, and pixel location in RTEP.
- Event pixel amplitude thresholds.

Geometric calibration parameters are those associated with the precise look angle and size of the instrument's field of view. Specific types include:

- CCD temperature, lens assembly, and bipod calibration coefficients.
- Lens assembly reference/nominal temperature and thermal coefficient.
- Reference and nominal effective focal length.
- Optical distortion and thermal expansion coefficients.
- CCD distortion coefficient matrix.
- Bipod reference locations, and temperature correction constants.
- FPGA configuration bias angles.
- Nominal lightning elevation above the geoid.
- Pixel size parameters.
- Maximum x, y, and radius of CCD field of view.
- Location, attitude, and attitude rate parameters.
- Earth reference ellipsoid parameters.

Algorithm processing parameters are those associated with configurable decision-making logic in the algorithm related to numerous filter behaviors, coherency filter factors and tuning parameters. Specific types include:

- Pixel padding, and time and probability factors used in the coherency filter.
- Event filter activation control switch.
- Contrast leakage, radiation track, and CCD frame transfer noise filter factors.
- Probability event is false as function of its amplitude and background.

There is one category of semi-static source data employed in the GOES-R GLM Lightning Cluster-Filter ground processing algorithm:

- Algorithm-specific parameters.

The algorithm-specific parameters represent parameters that are unique to the GLM Lightning Cluster-Filter algorithm. Some of these parameters may be tuned for the specific characteristics of the GLM instrument. These include:

- Spatial and temporal thresholds for the identification of groups and flashes.
- Maximum thresholds on group and flash durations and on group and flash child limits.
- Look-up table for pixel solid angle.
- Look-up table for pixel area.
- Scales and offsets applied to output group/flash energies and areas, to the event latitude and longitude, and to the event/group/flash times.

Following are the file names of algorithm parameters within the zip file. XML files are internally self-describing. Date qualifiers and other version-specific information have been removed from the file names.

- GLM_L0_NcML_Metadata_Template.xml
- glm_metadata_config.xml
- GLM_LSRLUT.bin
- AI_GLM-L2-GLMSemiStaticParams.bin

The filename conventions for the GLM Level 1b and Level 2+ semi-static source data file are located in Appendix C.

7.2.1.4 Coordinates

The coordinates associated with data variables in the Lightning Detection product are identified in Table 7.2.1.4, Lightning Detection Product Coordinates.

Table 7.2.1.4 Lightning Detection Product Coordinates

Lightning Detection Product Data Quantity	Coordinates
event energy data	• Event identifier • Observation time • Latitude and longitude for event • Wavelength range of data • Event to parent group mapping
group area data	• Group identifier • Observation time • Latitude and longitude for group centroid • Wavelength range of data • Group time threshold • Group to parent flash mapping (group area and group energy only) • Event to parent group mapping (group area and group energy only)
group energy data	
group data quality flags	
flash area data	• Flash identifier • Observation time period • Latitude and longitude for flash centroid • Wavelength range of data • Flash time threshold • Group to parent flash mapping (flash area and flash energy only)
flash energy data	
flash data quality flags	
event count	• Observation time period for product data • Latitude and longitude extents for field of view geo-location • Wavelength range of data
group count	
flash count	
percent_navigated_L1b_events	
data transmission error percentages	• Observation time period • Latitude and longitude extents for field of view geo-location

7.2.1.5 Production Notes

The Lightning Detection product is generated by the sequential execution of Level 0, Level 1b and Level 2+ ground processing algorithms. The Level 2+ algorithm is the GOES-R GLM Lightning Cluster-Filter algorithm. The Level 0 algorithm decompresses and extracts events and GLM background image data from the CCSDS packets.

The GLM instrument detects areas of potential lightning by capturing optical images of the Earth in its field of view, and identifying potential lightning events based on transient emissions from the tops of cloud. GLM Level 1b algorithm ground processing filters false lightning events using spatial and temporal thresholds and tracking tests. Each event remaining after filtering is radiometrically corrected, navigated to latitude, longitude coordinates, and time-tagged. The time-tag is corrected for light propagation time from cloud to satellite.

The Level 2+ Lightning Detection algorithm clusters the events into groups and flashes based on spatial and temporal threshold parameters. Events, groups, and flashes are related in a tree-like structure with each flash made up of a unique set of groups and each group made up of a unique set of events. Refer to Figure 7.2.1.1-1, Lightning Detection Product Data Relationships. For each group and flash, the centroid location is its optically-weighted position, the energy is the sum of its events’ energies, and its area is the sum of the areas covered by its events’ pixels. Flashes from cloud-to-ground lightning and intra-cloud lightning are not distinguished. The wavelength of the radiant energy sensed by the instrument is from 776.87 to 777.87 nm at half the maximum of the spectral response function.

The Level 1b and Level 2+ processing algorithms are executed at a cadence of once per second. The flashes for which processing has completed are included in the nominally 20.5 second products. This means that event, group, time stamp values may be prior to the nominally 20.5 second period associated with the particular product instance. These algorithms are designed subject to requirements for the maximum event, group, and flash rates to ensure that ground system processing operates at the data rate for lightning in the sensor’s field of view.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

For additional details on the Level 2+ Lightning Detection ground processing algorithm, and the expected performance, refer to the NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager Algorithm Theoretical Basis Document for the GLM Lightning Cluster-Filter Algorithm. This document is located at

https://www.goes-r.gov/products/baseline-lightning-detection.html

7.2.1.6 Data Organization and Fields

A Lightning Detection product spans many GRB Space Packets. A product, which contains a set of flashes and constituent groups and events for a nominal 20.5 second period, is transmitted over GRB in 1.024-second reports. These 1.024-second reports are composed of one or more flash, group, and event Packets, and can be exploited upon receipt. For a given report, the groups and events included fully complete the definition of the constituent flashes, and are only those associated with the report's flashes. As a result, the value of the time stamps for the groups and events may not be within the one second interval associated with the report. Nominally, a product metadata Packet is queued for transmission after the twentieth report has been queued for transmission.

The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data includes the flashes, groups, and events data. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, and coordinate variables other than the time variables for flashes, groups, and events.

The subordinate paragraphs that follow define the Lightning Detection product flash, group, and event data, flag values and meanings, and metadata fields.

7.2.1.6.1 Data Fields

7.2.1.6.1.1 Flash Data Fields

Table 7.2.1.6.1.1 Lightning Detection Product Flash Data

Data Name	Data Type	Shape	Description	Units	Byte Offset within Generic Payload Data Unit
number of flashes in Generic Payload Data Unit (numFlashes)	uint64	n/a	see Data Name	count	0
flash_id	uint16	24 byte structure containing flash data fields repeats numFlashes times	product-unique lightning flash identifier	1	8 + (flashIndex [1] – 1) * 24
flash_time_offset_of_first_event [2]	uint16		GLM L2+ Lightning Detection: time of occurrence of first constituent event in flash	seconds since product time [3]	10 + (flashIndex – 1) * 24
flash_time_offset_of_last_event [2]	uint16		GLM L2+ Lightning Detection: time of occurrence of last constituent event in flash	seconds since product time [3]	12 + (flashIndex – 1) * 24
flash_frame_time_offset_of_first_event [2]	uint16		GLM L2+ Lightning Detection: time of occurrence of first constituent event in flash	seconds since product time [3]	14 + (flashIndex – 1) * 24
flash_frame_time_offset_of_last_event [2]	uint16		GLM L2+ Lightning Detection: time of occurrence of last constituent event in flash	seconds since product time [3]	16 + (flashIndex – 1) * 24

Data Name	Data Type	Shape	Description	Units	Byte Offset within Generic Payload Data Unit
flash_lat	float		GLM L2+ Lightning Detection: flash centroid (mean constituent event latitude weighted by their energies) latitude coordinate	degrees_north	18 + (flashIndex – 1) * 24
flash_lon	float		GLM L2+ Lightning Detection: flash centroid (mean constituent event latitude weighted by their energies) longitude coordinate	degrees_east	22 + (flashIndex – 1) * 24
flash_area [2]	uint16		GLM L2+ Lightning Detection: flash area coverage (pixels containing at least one constituent event only)	km2	26 + (flashIndex – 1) * 24
flash_energy [2]	uint16		GLM L2+ Lightning Detection: flash radiant energy	J	28 + (flashIndex – 1) * 24
flash_quality_flag	uint16		GLM L2+ Lightning Detection: flash data quality flags	1	30 + (flashIndex – 1) * 24

[1] flashIndex = 1 to the number of flashes in the Generic Payload Data Unit (numFlashes).

[2] Values are scaled integers. The scale factor and offset values for this data are located in paragraph 7.2.1.6.2, Metadata Fields. Refer to the attributes scale_factor and add_offset for the variable with the data name used in the first column of this table.

[3] Time fields are seconds offsets from the product time. Product time is value of product_time variable in metadata Packet.

7.2.1.6.1.2 Group Data Fields

Table 7.2.1.6.1.2 Lightning Detection Product Group Data

Data Name	Data Type	Shape	Description	Units	Byte Offset within Generic Payload Data Unit
number of groups in Generic Payload Data Unit (numGroups)	uint64	n/a	see Data Name	count	0
group_id	uint32	28 byte structure containing group data fields repeats	product-unique lightning group identifier	1	8 + (groupIndex [1] – 1) * 28
group_time_offset [2]	uint16		GLM L2+ Lightning Detection: mean time of group's constituent events' times of occurrence	seconds since product time [3]	12 + (groupIndex – 1) * 28
group_frame_time_offset [2]	uint16		GLM L2+ Lightning Detection: mean time of group's constituent events' times of occurrence	seconds since product time [3]	14 + (groupIndex – 1) * 28

group_lat	float	numGroups times	GLM L2+ Lightning Detection: group centroid (mean constituent event latitude weighted by their energies) latitude coordinate	degrees_north	16 + (groupIndex – 1) * 28
group_lon	float		GLM L2+ Lightning Detection: group centroid (mean constituent event latitude weighted by their energies) longitude coordinate	degrees_east	20 + (groupIndex – 1) * 28
group_area [2]	uint16		GLM L2+ Lightning Detection: group area coverage (pixels containing at least one constituent event only)	km2	24 + (groupIndex – 1) * 28
group_energy [2]	uint16		GLM L2+ Lightning Detection: group radiant energy	J	26 + (groupIndex – 1) * 28
group_parent_flash_id	uint16		product-unique lightning flash identifier for one or more groups	1	28 + (groupIndex – 1) * 28
group_quality_flag	uint16		GLM L2+ Lightning Detection: group data quality flags	1	30 + (groupIndex – 1) * 28

[1] groupIndex = 1 to the number of groups in the Generic Payload Data Unit (numGroups).
[2] Values are scaled integers. The scale factor and offset values for this data are located in paragraph 7.2.1.6.2, Metadata Fields. Refer to the attributes scale_factor and add_offset for the variable with the data name used in the first column of this table.
[3] Time field is seconds offset from the product time. Product time is value of product_time variable in metadata Packet.

7.2.1.6.1.3 Event Data Fields

Table 7.2.1.6.1.3 Lightning Detection Product Event Data

Data Name	Data Type	Shape	Description	Units	Byte Offset within Generic Payload Data Unit
number of events in Generic Payload Data Unit (numEvents)	uint64	n/a	see Data Name	count	0
event_id	uint32	16 byte structure containing event data fields repeats numEvents times	product-unique lightning event identifier	1	8 + (eventIndex [1] – 1) * 16
event_time_offset	uint16		GLM L2+ Lightning Detection: event's time of occurrence	seconds since product time [3]	12 + (eventIndex – 1) * 16
event_lat [2]	uint16		GLM L2+ Lightning Detection: event latitude coordinate	degrees_north	14 + (eventIndex – 1) * 16
event_lon [2]	uint16		GLM L2+ Lightning Detection: event longitude coordinate	degrees_east	16 + (eventIndex – 1) * 16
event_energy [2]	uint16		GLM L2+ Lightning Detection: event radiant energy	J	18 + (eventIndex – 1) * 16

event_parent_group_id	uint32		product-unique lightning group identifier for one or more events	1	20 + (eventIndex – 1) * 16

[1] eventIndex = 1 to the number of events in the Generic Payload Data Unit (numEvents).
[2] Values are scaled integers. The scale factor and offset values for this data are located in paragraph 7.2.1.6.2, Metadata Fields. Refer to the attributes scale_factor and add_offset for the variable with the data name used in the first column of this table.
[3] Time field is seconds offset from the product time. Product time is value of product_time variable in metadata Packet.

7.2.1.6.1.4 Lightning Detection Flag Values and Meanings

Table 7.2.1.6.1.4-1 Lightning Detection Product Group Data Quality Flag Values and Meanings

Group Data Quality Flags (group_quality_flag)	
Flag Value	**Flag Meaning**
0	good_quality_qf
1	degraded_due_to_group_constituent_events_out_of_time_order_or_parent_flash_abnormal_qf
3	degraded_due_to_group_constituent_event_count_exceeds_threshold_qf
5	degraded_due_to_group_duration_exceeds_threshold_qf

Table 7.2.1.6.1.4-2 Lightning Detection Product Flash Data Quality Flag Values and Meanings

Flash Data Quality Flags (flash_quality_flag)	
Flag Value	**Flag Meaning**
0	good_quality_qf
1	degraded_due_to_flash_constituent_events_out_of_time_order_qf
3	degraded_due_to_flash_constituent_event_count_exceeds_threshold_qf
5	degraded_due_to_flash_duration_exceeds_threshold_qf

Table 7.2.1.6.1.4-3 Lightning Detection Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (yaw_flip_flag)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

7.2.1.6.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata

Packet. Refer to the Level 2+ PUG volume, specifically the Lightning Detection product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.2.1.6.2 Lightning Detection Product Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2 https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
<attribute name="featureType" value="point" type="string"/>
<dimension name="number_of_events" isUnlimited="true"/>
<dimension name="number_of_groups" isUnlimited="true"/>
<dimension name="number_of_flashes" isUnlimited="true"/>
<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
<dimension name="number_of_field_of_view_bounds" length="2" isUnlimited="false"/>
<dimension name="number_of_wavelength_bounds" length="2" isUnlimited="false"/>
<variable name="event_lat" type="short" shape="number_of_events">
<attribute name="long_name" value="GLM L2+ Lightning Detection: event latitude coordinate" type="string"/>
<attribute name="standard_name" value="latitude" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="scale_factor" value="0.00203128" type="float"/>
<attribute name="add_offset" value="-66.56" type="float"/>
<attribute name="units" value="degrees_north" type="string"/>
<attribute name="axis" value="Y" type="string"/>
</variable>
<variable name="event_lon" type="short" shape="number_of_events">
<attribute name="long_name" value="GLM L2+ Lightning Detection: event longitude coordinate" type="string"/>
<attribute name="standard_name" value="longitude" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="scale_factor" value="0.00203128" type="float"/>
<attribute name="add_offset" value="***see note [1]***" type="float"/>
<attribute name="units" value="degrees_east" type="string"/>

<attribute name="axis" value="X" type="string"/>
</variable>
<variable name="group_lat" type="float" shape="number_of_groups">
<attribute name="long_name" value="GLM L2+ Lightning Detection: group centroid (mean constituent event latitude weighted by their energies) latitude coordinate" type="string"/>
<attribute name="standard_name" value="latitude" type="string"/>
<attribute name="units" value="degrees_north" type="string"/>
<attribute name="axis" value="Y" type="string"/>
</variable>
<variable name="group_lon" type="float" shape="number_of_groups">
<attribute name="long_name" value="GLM L2+ Lightning Detection: group centroid (mean constituent event latitude weighted by their energies) longitude coordinate" type="string"/>
<attribute name="standard_name" value="longitude" type="string"/>
<attribute name="units" value="degrees_east" type="string"/>
<attribute name="axis" value="X" type="string"/>
</variable>
<variable name="flash_lat" type="float" shape="number_of_flashes">
<attribute name="long_name" value="GLM L2+ Lightning Detection: flash centroid (mean constituent event latitude weighted by their energies) latitude coordinate" type="string"/>
<attribute name="standard_name" value="latitude" type="string"/>
<attribute name="units" value="degrees_north" type="string"/>
<attribute name="axis" value="Y" type="string"/>
</variable>
<variable name="flash_lon" type="float" shape="number_of_flashes">
<attribute name="long_name" value="GLM L2+ Lightning Detection: flash centroid (mean constituent event latitude weighted by their energies) longitude coordinate" type="string"/>
<attribute name="standard_name" value="longitude" type="string"/>
<attribute name="units" value="degrees_east" type="string"/>
<attribute name="axis" value="X" type="string"/>
</variable>
<variable name="product_time" type="double" shape="">
<attribute name="long_name" value="start time of observations associated with product" type="string"/>

<attribute name="standard_name" value="time" type="string"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<attribute name="axis" value="T" type="string"/>
<attribute name="bounds" value="product_time_bounds" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="product_time_bounds" type="double" shape="number_of_time_bounds">
<attribute name="long_name" value="start and end time of observations associated with product" type="string"/>
<values>***dynamic value dynamic value***</values>
</variable>
<variable name="event_time_offset" type="short" shape="number_of_events">
<attribute name="long_name" value="GLM L2+ Lightning Detection: event’s time of occurrence" type="string"/>
<attribute name="standard_name" value="time" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="scale_factor" value="3.814756E-4" type="float"/>
<attribute name="add_offset" value="-5.0" type="float"/>
<attribute name="units" value="seconds since ***see note [2]***" type="string"/>
<attribute name="axis” value=”T” type=”string”/>
</variable>
<variable name="group_time_offset" type="short" shape="number_of_groups">
<attribute name="long_name" value="GLM L2+ Lightning Detection: mean time of group’s constituent events’ times of occurrence" type="string"/>
<attribute name="standard_name" value="time" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="scale_factor" value="3.814756E-4" type="float"/>
<attribute name="add_offset" value="-5.0" type="float"/>
<attribute name="units" value="seconds since ***see note [2]***" type="string"/>
<attribute name="axis” value=”T” type=”string”/>
</variable>
<variable name="flash_time_offset_of_first_event" type="short" shape="number_of_flashes">
<attribute name="long_name" value="GLM L2+ Lightning Detection: time of occurrence of first constituent event in flash" type="string"/>

```
    <attribute name="standard_name" value="time" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="scale_factor" value="3.814756E-4" type="float"/>
    <attribute name="add_offset" value="-5.0" type="float"/>
    <attribute name="units" value="seconds since see note [2]" type="string"/>
    <attribute name="axis" value="T" type="string"/>
  </variable>
  <variable name="flash_time_offset_of_last_event" type="short" shape="number_of_flashes">
    <attribute name="long_name" value="GLM L2+ Lightning Detection: time of occurrence of last constituent event in flash" type="string"/>
    <attribute name="standard_name" value="time" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="scale_factor" value="3.814756E-4" type="float"/>
    <attribute name="add_offset" value="-5.0" type="float"/>
    <attribute name="units" value="seconds since see note [2]" type="string"/>
  </variable>
  <variable name="group_frame_time_offset" type="short" shape="number_of_groups">
    <attribute name="long_name" value="GLM L2+ Lightning Detection: mean frame time of group's constituent events' times of occurrence"
type="string"/>
    <attribute name="standard_name" value="time" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="scale_factor" value="3.814756E-4" type="float"/>
    <attribute name="add_offset" value="-5.0" type="float"/>
    <attribute name="units" value="seconds since see note [2]" type="string"/>
    <attribute name="axis" value="T" type="string"/>
  </variable>
  <variable name="flash_frame_time_offset_of_first_event" type="short" shape="number_of_flashes">
    <attribute name="long_name" value="GLM L2+ Lightning Detection: frame time of occurrence of first constituent event in flash" type="string"/>
    <attribute name="standard_name" value="time" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="scale_factor" value="3.814756E-4" type="float"/>
```

<attribute name="add_offset" value="-5.0" type="float"/>
<attribute name="units" value="seconds since ***see note [2]***" type="string"/>
<attribute name="axis" value="T" type="string"/>
</variable>
<variable name="flash_frame_time_offset_of_last_event" type="short" shape="number_of_flashes">
<attribute name="long_name" value="GLM L2+ Lightning Detection: frame time of occurrence of last constituent event in flash" type="string"/>
<attribute name="standard_name" value="time" type="string"/>
<attribute name="scale_factor" value="3.814756E-4" type="float"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="add_offset" value="-5.0" type="float"/>
<attribute name="units" value="seconds since ***see note [2]***" type="string"/>
</variable>
<variable name="lightning_wavelength" type="float" shape="">
<attribute name="long_name" value="central wavelength for lightning data" type="string"/>
<attribute name="standard_name" value="sensor_band_central_radiation_wavelength" type="string"/>
<attribute name="units" value="nm" type="string"/>
<attribute name="bounds" value="lightning_wavelength_bounds" type="string"/>
<values>777.37</values>
</variable>
<variable name="lightning_wavelength_bounds" type="float" shape="number_of_wavelength_bounds">
<attribute name="long_name" value="wavelength range lightning data (full width at half the maximum of the response function)" type="string"/>
<values>776.87 777.87</values>
</variable>
<variable name="group_time_threshold" type="float" shape="">
<attribute name="long_name" value="lightning group maximum time difference among lightning events in a group" type="string"/>
<attribute name="units" value="s" type="string"/>
<values>0.0</values>
</variable>
<variable name="flash_time_threshold" type="float" shape="">
<attribute name="long_name" value="lightning flash maximum time difference among lightning events in a flash" type="string"/>

<attribute name="units" value="s" type="string"/>
<values>3.33</values>
</variable>
<variable name="lat_field_of_view" type="float" shape="">
<attribute name="long_name" value="latitude coordinate for center of field of view" type="string"/>
<attribute name="standard_name" value="latitude" type="string"/>
<attribute name="units" value="degrees_north" type="string"/>
<attribute name="axis" value="Y" type="string"/>
<attribute name="bounds" value="lat_field_of_view_bounds" type="string"/>
<values>0.0</values>
</variable>
<variable name="lat_field_of_view_bounds" type="float" shape="number_of_field_of_view_bounds">
<attribute name="long_name" value="latitude coordinates for north/south extent of field of view" type="string"/>
<values>66.56 -66.56</values>
</variable>
<variable name="lon_field_of_view" type="float" shape="">
<attribute name="long_name" value="longitude coordinate for center of field of view" type="string"/>
<attribute name="standard_name" value="longitude" type="string"/>
<attribute name="units" value="degrees_east" type="string"/>
<attribute name="axis" value="X" type="string"/>
<attribute name="bounds" value="lon_field_of_view_bounds" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="lon_field_of_view_bounds" type="float" shape="number_of_field_of_view_bounds">
<attribute name="long_name" value="longitude coordinates for west/east extent of field of view" type="string"/>
<values>***see note [1] see note [1]***</values>
</variable>
<variable name="event_id" type="int" shape="number_of_events">
<attribute name="long_name" value="product-unique lightning event identifier" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>

```
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="group_id" type="int" shape="number_of_groups">
    <attribute name="long_name" value="product-unique lightning group identifier" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="flash_id" type="short" shape="number_of_flashes">
    <attribute name="long_name" value="product-unique lightning flash identifier" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="event_parent_group_id" type="int" shape="number_of_events">
    <attribute name="long_name" value="product-unique lightning group identifier for one or more events" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="group_parent_flash_id" type="short" shape="number_of_groups">
    <attribute name="long_name" value="product-unique lightning flash identifier for one or more groups" type="string"/>
    <attribute name="_Unsigned" value="true" type="string"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="goes_lat_lon_projection" type="int" shape="">
    <attribute name="long_name" value="GOES-R latitude / longitude projection" type="string"/>
    <attribute name="grid_mapping_name" value="latitude_longitude" type="string"/>
    <attribute name="semi_major_axis" value="6378137." type="double"/>
    <attribute name="semi_minor_axis" value="6356752.31414" type="double"/>
    <attribute name="inverse_flattening" value="298.2572221" type="double"/>
    <attribute name="longitude_of_prime_meridian" value="0.0" type="double"/>
  </variable>
```

<variable name="event_energy" type="short" shape="number_of_events">
<attribute name="long_name" value="GLM L2+ Lightning Detection: event radiant energy" type="string"/>
<attribute name="standard_name" value="lightning_radiant_energy" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="scale_factor" value="1.52597e-15" type="float"/>
<attribute name="add_offset" value="0" type="float"/>
<attribute name="units" value="J" type="string"/>
<attribute name="coordinates" value="event_parent_group_id event_id lightning_wavelength event_time_offset event_lat event_lon" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum event_time_offset: point (sensor pixels have 2 ms integration time) area: sum (interval: 8 km comment: resolution of sensor data at nadir, filtered events only) where cloud" type="string"/>
</variable>
<variable name="group_area" type="short" shape="number_of_groups">
<attribute name="long_name" value="GLM L2+ Lightning Detection: group area coverage (pixels containing at least one constituent event only)" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="valid_range" value="0 65530" type="short"/>
<attribute name="scale_factor" value="0.152601862" type="float"/>
<attribute name="add_offset" value="0.0" type="float"/>
<attribute name="units" value="km2" type="string"/>
<attribute name="coordinates" value="group_parent_flash_id event_parent_group_id group_id lightning_wavelength group_time_threshold group_time_offset group_lat group_lon" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum group_time_offset: mean (times of occurrence of group's constituent events defined by variable event_parent_group_id) area: sum (interval: 8 km comment: resolution of sensor data at nadir, adjacent pixels only, including the diagonal, in sensor focal plane array) where cloud" type="string"/>
</variable>
<variable name="group_energy" type="short" shape="number_of_groups">
<attribute name="long_name" value="GLM L2+ Lightning Detection: group radiant energy" type="string"/>
<attribute name="standard_name" value="lightning_radiant_energy" type="string"/>

<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="valid_range" value="0 65530" type="short"/>
<attribute name="scale_factor" value="1.52597e-15" type="float"/>
<attribute name="add_offset" value="0" type="float"/>
<attribute name="units" value="J" type="string"/>
<attribute name="coordinates" value="group_parent_flash_id event_parent_group_id group_id lightning_wavelength group_time_threshold group_time_offset group_lat group_lon" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_measures" value="area: group_area" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum group_time_offset: mean (times of occurrence of group’s constituent events defined by variable event_parent_group_id) area: mean (centroid location of constituent events defined by variable event_parent_group_id weighted by their radiant energies) where cloud" type="string"/>
<attribute name="ancillary_variables" value="group_quality_flag" type="string"/>
</variable>
<variable name="group_quality_flag" type="short" shape="number_of_groups">
<attribute name="long_name" value="GLM L2+ Lightning Detection: group data quality flags" type="string"/>
<attribute name="standard_name" value="status_flag" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="valid_range" value="0 5" type="short"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="group_id lightning_wavelength group_time_threshold group_time_offset group_lat group_lon" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum group_time_offset: mean (times of occurrence of group’s constituent events defined by variable event_parent_group_id) area: mean (centroid location of constituent events defined by variable event_parent_group_id weighted by their radiant energies) where cloud" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="short"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<attribute name="number_of_qf_values" value="4" type="byte"/>
<attribute name="percent_good_quality_qf" value="***dynamic value***" type="float"/>

<attribute name="percent_degraded_due_to_group_constituent_events_out_of_time_order_or_parent_flash_abnormal_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_degraded_due_to_group_constituent_event_count_exceeds_threshold_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_degraded_due_to_group_duration_exceeds_threshold_qf" value="***dynamic value***" type="float"/>
</variable>
<variable name="flash_area" type="short" shape="number_of_flashes">
<attribute name="long_name" value="GLM L2+ Lightning Detection: flash area coverage (pixels containing at least one constituent event only)" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="valid_range" value="0 65530" type="short"/>
<attribute name="scale_factor" value="0.152601862" type="float"/>
<attribute name="add_offset" value="0.0" type="float"/>
<attribute name="units" value="km2" type="string"/>
<attribute name="coordinates" value="group_parent_flash_id flash_id lightning_wavelength flash_time_threshold flash_time_offset_of_first_event flash_time_offset_of_last_event flash_lat flash_lon" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum flash_time_offset_of_first_event: flash_time_offset_of_last_event: sum area: sum (interval: 8 km comment: resolution of sensor data at nadir, area of constituent groups' areas defined by variable group_parent_flash_id) where cloud" type="string"/>
</variable>
<variable name="flash_energy" type="short" shape="number_of_flashes">
<attribute name="long_name" value="GLM L2+ Lightning Detection: flash radiant energy" type="string"/>
<attribute name="standard_name" value="lightning_radiant_energy" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="valid_range" value="0 65530" type="short"/>
<attribute name="scale_factor" value="1.52597e-15" type="float"/>
<attribute name="add_offset" value="0" type="float"/>
<attribute name="units" value="J" type="string"/>
<attribute name="coordinates" value="group_parent_flash_id flash_id lightning_wavelength flash_time_threshold flash_time_offset_of_first_event flash_time_offset_of_last_event flash_lat flash_lon" type="string"/>

<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_measures" value="area: flash_area" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum flash_time_offset_of_first_event: flash_time_offset_of_last_event: sum area: mean (centroid location of constituent events defined by variables group_parent_flash_id and event_parent_group_id weighted by their radiant energies) where cloud" type="string"/>
<attribute name="ancillary_variables" value="flash_quality_flag" type="string"/>
</variable>
<variable name="flash_quality_flag" type="short" shape="number_of_flashes">
<attribute name="long_name" value="GLM L2+ Lightning Detection: flash data quality flags" type="string"/>
<attribute name="standard_name" value="status_flag" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="65535" type="short"/>
<attribute name="valid_range" value="0 5" type="short"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="flash_id lightning_wavelength flash_time_threshold flash_time_offset_of_first_event flash_time_offset_of_last_event flash_lat flash_lon" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum flash_time_offset_of_first_event: flash_time_offset_of_last_event: sum area: mean (centroid location of constituent events defined by variables group_parent_flash_id and event_parent_group_id weighted by their radiant energies) where cloud" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="short"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<attribute name="number_of_qf_values" value="4" type="byte"/>
<attribute name="percent_good_quality_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_degraded_due_to_flash_constituent_events_out_of_time_order_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_degraded_due_to_flash_constituent_event_count_exceeds_threshold_qf" value="***dynamic value***" type="float"/>
<attribute name="percent_degraded_due_to_flash_duration_exceeds_threshold_qf" value="***dynamic value***" type="float"/>
</variable>
<variable name="event_count" type="int" shape="">
<attribute name="long_name" value="number of lightning events in product" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="valid_range" value="1 630000" type="int"/>

<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="lightning_wavelength product_time lat_field_of_view lon_field_of_view" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum product_time: sum area: sum (filtered events only) where cloud" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="group_count" type="int" shape="">
<attribute name="long_name" value="number of lightning groups in product" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="valid_range" value="1 630000" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="lightning_wavelength product_time lat_field_of_view lon_field_of_view" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum product_time: sum area: sum where cloud" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="flash_count" type="int" shape="">
<attribute name="long_name" value="number of lightning flashes in product" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="valid_range" value="1 630000" type="int"/>
<attribute name="units" value="count" type="string"/>
<attribute name="coordinates" value="lightning_wavelength product_time lat_field_of_view lon_field_of_view" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum product_time: sum area: sum where cloud" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="percent_navigated_L1b_events" type="float" shape="">
<attribute name="long_name" value="after false event filtering, percent of lightning events navigated by instrument" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>

<attribute name="units" value="percent" type="string"/>
<attribute name="coordinates" value="lightning_wavelength product_time lat_field_of_view lon_field_of_view" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="lightning_wavelength: sum product_time: sum area: sum (filtered, and filtered and navigated lightning events only) where cloud" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="yaw_flip_flag" type="byte" shape="">
<attribute name="long_name" value="Flag indicating spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_Unsigned" value="true" type="string"/>
<attribute name="_FillValue" value="255" type="byte"/>
<attribute name="valid_range" value="0 2" type="byte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="coordinates" value="product_time" type="string"/>
<attribute name="cell_methods" value="product_time: sum" type="string"/>
<attribute name="flag_values" value="***see note [3]***" type="byte"/>
<attribute name="flag_meanings" value="***see note [3]***" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="percent_uncorrectable_L0_errors" type="float" shape="">
<attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
<attribute name="coordinates" value="product_time lat_field_of_view lon_field_of_view" type="string"/>
<attribute name="grid_mapping" value="goes_lat_lon_projection" type="string"/>
<attribute name="cell_methods" value="product_time: sum area: sum (uncorrectable L0 errors only)" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="nominal_satellite_subpoint_lat" type="float" shape="">

<attribute name="long_name" value="nominal satellite subpoint latitude (platform latitude)" type="string"/>
<attribute name="standard_name" value="latitude" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="degrees_north" type="string"/>
<values>0.00</values>
</variable>
<variable name="nominal_satellite_subpoint_lon" type="float" shape="">
<attribute name="long_name" value="nominal satellite subpoint longitude (platform longitude)" type="string"/>
<attribute name="standard_name" value="longitude" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="degrees_east" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="nominal_satellite_height" type="float" shape="">
<attribute name="long_name" value="nominal satellite height above GRS 80 ellipsoid (platform altitude)" type="string"/>
<attribute name="standard_name" value="height_above_reference_ellipsoid" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="km" type="string"/>
<values>35786.023</values>
</variable>
<attribute name="dataset_name" value="***refer to filename conventions for L2+ products in Appendix C.***" type="string"/>
<attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
<attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
<attribute name="project" value="GOES" type="string"/>
<attribute name="iso_series_metadata_id" value="f5816f53-fd6d-11e3-a3ac-0800200c9a66" type="string"/>
<attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
<attribute name="standard_name_vocabulary" value="CF Standard Name Table (v25, 05 July 2013)" type="string"/>
<attribute name="title" value="GLM L2 Lightning Detections: Events, Groups, and Flashes" type="string"/>

<attribute name="summary" value="The Lightning Detections: Events, Groups, and Flashes product consists of a hierarchy of earth-located lightning radiant energy measures including events, groups, and flashes. Lightning events are detected by the instrument. Lightning groups are a collection of one or more lightning events that satisfy temporal and spatial coincidence thresholds. Similarly, lightning flashes are a collection of one or more lightning groups that satisfy temporal and spatial coincidence thresholds. The product includes the relationship among lightning events, groups, and flashes, and the area coverage of lightning groups and flashes. The product also includes processing and data quality metadata, and satellite state and location information." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="ATMOSPHERE > ATMOSPHERIC ELECTRICITY > LIGHTNING, ATMOSPHERE > ATMOSPHERIC PHENOMENA > LIGHTNING" type="string"/>
<attribute name="cdm_data_type" value="Point" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES-R Series Geostationary Lightning Mapper" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument (sensor).***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L2" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="spatial_resolution" value="8km at nadir" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data" type="string"/>
<attribute name="input_GLM_L0_data" value="***refer to filename conventions for L0 products in Appendix C.***" type="string"/>
<attribute name="input_GLM_L1b_data" value="***refer to filename conventions for L1b products in Appendix C.***" type="string"/>
</variable>
<variable name="processing_parm_version_container" type="int" shape="">
<attribute name="long_name" value="container for processing parameter filenames" type="string"/>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
</variable>

<variable name="algorithm_product_version_container" type="int" shape="">
<attribute name="long_name" value="container for algorithm package filename and product version" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L2+ algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
</variable>
</netcdf>

Note 1: Coverage region extent variable and attribute values are located in Table 7.2.1.1-1, Lightning Detection Product Field of View Center and Extents. Note that the value of add_offset attribute for event_lon variable is the same as lon_field_of_view_bounds (1) in Table 7.2.1.1-1.
Note 2: Time value is product_time in format YYYY-MM-DD HH:MM:SS.sss (e.g., "seconds since 2016-10-05 13:12:44.839").
Note 3: "flags and meanings": Flag values and meanings are located in paragraph 7.2.1.6.1.4, Lightning Detection Product Flag Values and Meanings.

7.3 SUVI Level 1b Product

7.3.1 Level 1b SUVI Solar Imagery: Extreme Ultraviolet Product

7.3.1.1 Description

The Level 1b SUVI Solar Imagery: EUV product contains a radiometrically corrected 1280 x 1280 image of the sun with pixel values identifying the radiance. Pixels have a bit depth of sixteen bits: a fifteen bit image with ½ Digital Number (DN) resolution and; one bit for sign, which is needed to support radiometric correction, specifically dark frame current subtraction. The product includes data quality information that provides an assessment of the radiance data values for pixel in the SUVI's field of view, including an indication of good or degraded quality, or invalid, and the rationale.

Imaging of the sun is performed at six wavelengths. The solar features observed for each of the six wavelengths are identified in Table 7.3.1.1-1, Observed Solar Features.

Table 7.3.1.1-1 Observed Solar Features

	Wavelength (in Angstroms)					
Solar Feature	**93.9**	**131.2**	**171.1**	**195.1**	**284.2**	**303.8**
Filament						x
Coronal Hole					x	
Active Region Complexity			x	x		
Coronal Mass Ejection			x	x		
Flare Location and Morphology	x	x				
Quiet Region			x	x		x

Solar imagery product files are generated for fourteen types of solar images. Combinations of the six wavelengths, two exposure periods, and two types of exposures are the basis for the fourteen types of solar imagery. The science objective mnemonic and wavelengths enumerated in paragraph 7.3.1.5.3, Level 1b SUVI Solar Imagery: EUV Product Quantity Characteristics, define the fourteen solar imagery types.

The units of measure for the image pixel radiance values are "watts per square meter per steradian".

The Level 1b SUVI Solar Imagery: EUV product image is produced at 2.5 arcsecond resolution on a gnomonic azimuthal projection that uses helioprojective-cartesian coordinates. This projection is from the perspective of the observer.

The precise look angles of the angular zones relative to the GOES-R spacecraft body reference frame required for use and subsequent processing of this level 1b product data are available from the Product Distribution and Access system.

The Level 1b SUVI Solar Imagery: EUV performance requirements are summarized in Table 7.3.1.1-2, Level 1b SUVI Solar Imagery: EUV Performance Requirements.

Table 7.3.1.1-2 Level 1b SUVI Solar Imagery: EUV Performance Requirements

	Measurement			Mapping
Region	**Range**	**Accuracy**	**Precision**	**Accuracy**
solar disk	0.3 to 10^6 photons/cm^2/arcsec/s	+/- 40%	+/- 40%	+/- 2.5 arcsec

Metadata in the Level 1b SUVI Solar Imagery: EUV product provides statistical properties of the product image and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the product image observation period.
- Pixel location of center of sun, and diameter of the sun in pixels.

- Number of good quality pixels.
- Number of corrected, saturated, missing and spiking pixels.
- Sum of radiance and irradiance pixel values in the product image.
- Minimum, maximum, mean, and standard deviation of the radiance values in the product image.

The sum, minimum, maximum, mean, and standard deviation values are calculated using good and degraded quality pixels.

Metadata in the Level 1b SUVI Solar Imagery: EUV product provides instrument configuration and other information required for the generation of level 2 products, including:

- Type of solar imagery product.
- Satellite location and earth to sun distance.
- Eclipse of the sun indication.
- Satellite yaw flip configuration.
- Product image orientation.
- Angular offset of the solar north rotational pole and the solar equatorial plane.
- Uncertainty in pixels due to systematic errors.
- Wavelength-dependent telescope effective area and aperture selector setting.
- Forward and aft filter wheel settings and corresponding mnemonics.
- SUVI CCD readout configuration.
- SUVI CCD detector plate scale.
- Product image projection information.

Metadata in the Level 1b SUVI Solar Imagery: EUV product provides calibration processing and instrument performance information, including:

- Contamination flag to indicate if image was corrected for contamination.
- CCD signal to noise ratio, background noise, and temperature.
- Dark frames used for calibration.

The detailed description of the ISO series metadata for the Level 1b SUVI Solar Imagery: EUV product is located in the standalone Appendix X, ISO Series Metadata.

7.3.1.2 Dynamic Source Data

The Level 1b SUVI Solar Imagery: EUV product is derived using the SUVI Level 0 raw science telemetry, SUVI engineering telemetry, and satellite ephemeris related telemetry. This data includes fourteen types of images, as identified in paragraph 7.3.1.5.3, Level 1b SUVI Solar Imagery: EUV Product Quantity Characteristics.

The primary sensor data used by the Level 1b SUVI Solar Imagery: EUV algorithm is identified in Table 7.3.1.2, Primary Sensor Data.

Table 7.3.1.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_SUVI_L0_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.3.1.3 Level 1b Semi-Static Source Data

There are three categories of semi-static source data employed in the SUVI Level 1b ground processing algorithm:

- Radiometric calibration parameters and images.
- Geometric calibration parameters.
- Algorithm processing parameters.

Semi-static source data files from the three categories above are contained in a single zip file. Some files fit into more than one category.

Radiometric calibration parameters and images are those associated with the instrument's radiometric observing characteristics, or its raw outputs. Specific types include:

- Entrance and focal plane filter transmission factors.
- Data collection surface area.
- Wavelength-specific mirror reflectances.
- Wavelength-specific electron to photon and photon to energy conversion factors.
- Wavelength-specific quantum efficiencies.
- Wavelength-specific flat field images used to correct vignetting effects and variation in pixel response.
- Wavelength-specific coefficients used to determine signal loss.
- Solid angle at the SUVI detector pixel subtended by the telescope aperture.
- Per-pixel signal chain non-linearity correction tables as a function of Digital Number.
- Per-pixel electron to Digital Number gain table as a function of CCD temperature for readout amplifiers.
- Weighting factors and coefficients used to compute SUVI CCD temperatures.
- Temperature to gain mapping table.
- Signal to noise ratio, and Digital Number saturation threshold.
- Dark frame CCD temperature validation threshold.
- Bad CCD pixels and columns, and counts thereof.
- Contamination signal loss coefficients to correct the product image.

Geometric calibration parameters are those associated with the precise look angle and size of the instrument's field of view. Specific types include:

- Roll angle offset between the SUVI feet attached to the Sun Pointing Platform (SPP) and SUVI boresight.
- Guide telescope to SUVI telescope offsets in x and y axis directions.
- Wavelength-specific image shift in x and y axis directions caused by offset in corresponding mirror location.
- Correlation between the GT diode x and y axis readings to the sun center pixel location.
- Scale factor for converting pixels to arcseconds (i.e., plate scale).

Algorithm processing parameters are those associated with configurable decision-making logic in the algorithm related to data identification, data, time, and position thresholds, and conversion factors. Specific types include:

- CCSDS packet Application Process Identifiers (APIDs) for SUVI image data.
- Expected (i.e., commanded) image exposure times.
- Aperture selector encoder valid range.
- Exposure time conversion scale factors.
- Dark frame expiration threshold.
- Number of previous daily EUVS irradiances required for the SUVI-EXIS cross-calibration analysis.
- Exposure time threshold used when correcting image for dark current and bias.

- Filter wheel angle encoder limits and coefficients to convert encoder angle from Digital Number to engineering units.
- Number of rows and columns in leading and trailing edge overscan regions, and final image.
- Pixel buffer to avoid edge effects when calculating bias.
- Service configuration information
- netCDF product template
- Spike detection thresholds.

The filename conventions for the SUVI Level 1b semi-static source data file are located in Appendix C.

7.3.1.4 Production Notes

The Level 1b SUVI Solar Imagery: EUV product is generated by SUVI Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm decompresses and extracts the raw detector observation and calibration CCD sample data from the CCSDS packets. The Level 1b algorithm removes the overscan region, radiometrically corrects the CCD sample data, performs additional corrections to resolve CCD imperfections and degradations, and the effects of vignetting, and orients the image.

The fourteen types of solar images and dark frame calibration images are observed sequentially by the SUVI in the context of an imaging epoch.

The L1b algorithm executes and product data is generated only when the instrument is in the operational mode. The product is available in netCDF file format. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.3.1.5 Data Organization and Fields

A Level 1b SUVI Solar Imagery: EUV product image spans many GRB Space Packets. The Packets containing image data are sent first followed by the product's metadata. It is recommended that GRB users delay the processing of the product 0.5 seconds after receipt of the product's metadata, in order to ensure that the final few product packets are received. The APIDs used for each Level 1b SUVI Solar Imagery: EUV image band and accompanying product metadata are defined in Appendix A, CCSDS Application Identifiers.

The Level 1b SUVI Solar Imagery: EUV product data, which includes the binary radiances and DQF images, use the GRB Image Payload format as defined above in Paragraph 5.2, GRB Image Payload.

The product metadata uses the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, and all variables other than the image and data quality flag variables.

The subordinate paragraphs that follow define the Level 1b SUVI Solar Imagery: EUV product image data, quantity characteristics, flag values and meanings, and metadata fields.

7.3.1.5.1 Image Data Fields

Once the product's radiance and DQF image fragments have been extracted from the packets, decompressed, and assembled into image blocks in accordance with the approach defined in Paragraph 6.1, GRB Image Payload Recovery, the radiance image pixels are 16 bits (short) signed scaled integers, and the DQF image pixels are 8 bit (byte) unsigned integers.

7.3.1.5.1.1 Level 1b SUVI Solar Imagery: EUV Product Quantity Characteristics

The following table allows users to convert the integer-based SUVI L1b Solar Imagery data into physical units. These data are stored as radiance image pixels (16 bits). The conversion is accomplished by multiplying the pixel value by the appropriate Scale Factor then adding the Add Offset.

Table 7.3.1.5.1.1-1 Level 1b SUVI Solar Imagery: EUV Product Characteristics

		Scaled Integer to Physical Quantity Conversion[2]	
Science Objective Mnemonic[1]	**Wavelength (in angstrom)**	**Scale Factor**	**Add Offset**
Fe_XVIII_93.9A_short_flare_exposure	93.9	n/a	n/a
Fe_XVIII_93.9A_short_exposure	93.9	n/a	n/a
Fe_XVIII_93.9A_long_exposure	93.9	n/a	n/a
Fe_VIII_131.2A_short_flare_exposure	131.2	n/a	n/a
Fe_VIII_131.2A_short_exposure	131.2	n/a	n/a
Fe_VIII_131.2A_long_exposure	131.2	n/a	n/a
Fe_IX_171.1A_short_flare_exposure	171.1	n/a	n/a
Fe_IX_171.1A_long_exposure	171.1	n/a	n/a

		Scaled Integer to Physical Quantity Conversion[2]	
Science Objective Mnemonic[1]	**Wavelength (in angstrom)**	**Scale Factor**	**Add Offset**
Fe_XII_195.1A_short_flare_exposure	195.1	n/a	n/a
Fe_XII_195.1A_long_exposure	195.1	n/a	n/a
Fe_XV_284.2A_short_flare_exposure	284.2	n/a	n/a
Fe_XV_284.2A_long_exposure	284.2	n/a	n/a
He_II_303.8A_short_flare_exposure	303.8	n/a	n/a
He_II_303.8A_long_exposure	303.8	n/a	n/a

Note[1]: changes to the Science Objective Mnemonic are effective with build DO.07.00.00.

Note[2]: Scale Factor and Add Offset are dynamic values, effective with build DO.08.01.00. The Scale Factor and Add Offset dynamic values are contained in the scale_factor and add_offset attributes of the RAD variable in the netCDF file.

Table 7.3.1.5.1.1-2 Level 1b SUVI Solar Imagery: Filter Setting Mnemonics

Forward Filter Variable/Keyword Value (FILTPOS1)	Forward Filter Variable/Keyword Meaning (FILTER1)	Aft Filter Variable/Keyword Value (FILTPOS2)	Aft Filter Variable/Keyword Meaning (FILTER2)
0	thick_aluminum	0	thick_aluminum
1	open	1	fused_silica
2	thin_aluminum	2	open
3	thin_zirconium	3	thin_aluminum
4	thick_zirconium	4	thin_zirconium

7.3.1.5.1.2 Level 1b SUVI Solar Imagery: EUV Product Flag Values and Meanings

Table 7.3.1.5.1.2-1 Level 1b SUVI Solar Imagery: EUV Product Data Quality Flag Values and Meanings

Data Quality Flags (DQF)	
Flag Value	**Flag Meaning**
0	good_quality_qf
1	degraded_due_to_bad_pixel_correction_qf
2	degraded_due_to_bad_column_correction_qf
3	invalid_due_to_missing_L0_data_qf
4	potentially_degraded_due_to_pixel_spike_detected_qf

Table 7.3.1.5.1.2-2 Level 1b SUVI Solar Imagery: EUV Product Aperture Selector Position Flag Values and Meanings

Aperture Selector Settings (APSELPOS)	
Flag Value	**Flag Meaning**
0	93.9_angstrom
1	131.2_angstrom
2	171.1_angstrom
3	195.1_angstrom
4	284.2_angstrom
5	303.8_angstrom

Table 7.3.1.5.1.2-3 Level 1b SUVI Solar Imagery: EUV Product Forward Filter Position Flag Values and Meanings

Forward Filter Position Settings (FILTPOS1)	
Flag Value	**Flag Meaning**
0	thick_aluminum
1	open
2	thin_aluminum
3	thin_zirconium
4	thick_zirconium

Table 7.3.1.5.1.2-4 Level 1b SUVI Solar Imagery: EUV Product Aft Filter Position Flag Values and Meanings

Aft Filter Position Settings (FILTPOS2)	
Flag Value	**Flag Meaning**
0	thick_aluminum
1	fused_silica
2	open
3	thin_aluminum
4	thin_zirconium

Table 7.3.1.5.1.2-5 Level 1b SUVI Solar Imagery: EUV Product CCD Readout Flag Values and Meanings

CCD Readout Settings (CCD_READ)	
Flag Value	**Flag Meaning**
0	not_configured
1	left_readout_amplifier
2	right_readout_amplifier

Table 7.3.1.5.1.2-6 Level 1b SUVI Solar Imagery: EUV Product Contamination Correction State Flag Values and Meanings

Contamination Correction State Flags (CONT_FLG)	
Flag Value	**Flag Meaning**
0	true
1	false

Table 7.3.1.5.1.2-7 Level 1b SUVI Solar Imagery: EUV Product Eclipse Flag Values and Meanings

Eclipse Flags (ECLIPSE)	
Flag Value	**Flag Meaning**
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse
3	penumbra_following_full_eclipse

Table 7.3.1.5.1.2-8 Level 1b SUVI Solar Imagery: Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (YAW_FLIP)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

7.3.1.5.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Level 1b SUVI Solar Imagery: EUV product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.3.1.5.2 Level 1b SUVI Solar Imagery: EUV Product Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2 https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
<dimension name="NAXIS1" length="1280" isUnlimited="false"/>
<dimension name="NAXIS2" length="1280" isUnlimited="false"/>
<dimension name="detector_plate_scale_units_str_len" length="6" isUnlimited="false"/>
<dimension name="orientation_str_len" length="4" isUnlimited="false"/>
<dimension name="coord_ref_sys_str_len" length="25" isUnlimited="false"/>
<dimension name="coded_coord_ref_sys_str_len" length="8" isUnlimited="false"/>
<dimension name="time_sys_str_len" length="3" isUnlimited="false"/>
<dimension name="object_str_len" length="3" isUnlimited="false"/>
<dimension name="science_objective_str_len" length="38" isUnlimited="false"/>
<dimension name="wavelength_unit_str_len" length="8" isUnlimited="false"/>
<dimension name="filter_mnemonic_str_len" length="14" isUnlimited="false"/>
<variable name="IMSENUMB" type="uint" shape="">
<attribute name="long_name" value="serial number of the image; used to match ISP packet with corresponding Image Data Packets" type="string"/>
<attribute name="comment" value="Image Serial Number" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 4294967294" type="uint"/>
<attribute name="units" value="1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CRPIX1" type="float" shape="">
<attribute name="long_name" value="center of sun pixel, potentially fractional, in image along x-axis (1st axis). center of 1st pixel location = 1.0. provides alignment of image in solar projection" type="string"/>
<attribute name="comment" value="center of sun pixel in image along 1st axis" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.5 1280.5" type="float"/>
<attribute name="units" value="1" type="string"/>
<values>***dynamic value***</values>

</variable>
<variable name="CRPIX2" type="float" shape="">
<attribute name="long_name" value="center of sun pixel, potentially fractional, in image along y-axis (2nd axis). center of 1st pixel location = 1.0. provides alignment of image in solar projection" type="string"/>
<attribute name="comment" value="center of sun pixel in image along 2nd axis" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.5 1280.5" type="float"/>
<attribute name="units" value="1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CDELT1" type="float" shape="">
<attribute name="long_name" value="x-axis (1st axis) detector plate scale at the reference pixel in image" type="string"/>
<attribute name="comment" value="1st axis detector plate scale @ref pix" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="2.5 2.5" type="float"/>
<attribute name="units" value="arcsec" type="string"/>
<values>2.5</values>
</variable>
<variable name="CDELT2" type="float" shape="">
<attribute name="long_name" value="y-axis (2nd axis) detector plate scale at the reference pixel in image" type="string"/>
<attribute name="comment" value="2nd axis detector plate scale @ref pix" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="2.5 2.5" type="float"/>
<attribute name="units" value="arcsec" type="string"/>
<values>2.5</values>
</variable>
<variable name="DIAM_SUN" type="float" shape="">
<attribute name="long_name" value="sun diameter, potentially fractional, in pixels" type="string"/>
<attribute name="comment" value="sun diameter in pixels" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="752.0 780.0" type="float"/>
<attribute name="units" value="count" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CUNIT1" type="char" shape="detector_plate_scale_units_str_len">
<attribute name="long_name" value="x-axis (1st axis) detector plate scale units" type="string"/>
<attribute name="comment" value="1st axis detector plate scale units" type="string"/>
<values>arcsec</values>
</variable>

<variable name="CUNIT2" type="char" shape="detector_plate_scale_units_str_len">
<attribute name="long_name" value="y-axis (2nd axis) detector plate scale units" type="string"/>
<attribute name="comment" value="2nd axis detector plate scale units" type="string"/>
<values>arcsec</values>
</variable>
<variable name="ORIENT" type="char" shape="orientation_str_len">
<attribute name="long_name" value="orientation of image in array defined by string indicating side of sun corresponding to array origin corner (0,0) and that defined by x-axis (1st axis) maximum coordinate corner pixel. string contains 4 characters from set N, S, E, W and is a concatenation of the corner for (0,0) pixel and corner for the (0, x-axis maximum coordinate) pixel. solar direction is relative to an observer on earth" type="string"/>
<attribute name="comment" value="orientation of image" type="string"/>
<values>SESW</values>
</variable>
<variable name="CROTA" type="float" shape="">
<attribute name="long_name" value="angular offset of the solar north rotational pole in image with positive values measured clockwise" type="string"/>
<attribute name="comment" value="solar north pole angular offset" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 359.99999" type="float"/>
<attribute name="units" value="degree" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="SOLAR_B0" type="float" shape="">
<attribute name="long_name" value="angular offset of the solar equatorial plane relative to center of sun in image (positive values indicate solar equator is in lower half of image)" type="string"/>
<attribute name="comment" value="solar equator angular offset" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-7.23 7.23" type="float"/>
<attribute name="units" value="degree" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="PC1_1" type="float" shape="">
<attribute name="long_name" value="1st row, 1st col term in generalized 2x2 linear transformation matrix defining angular offset of the solar north rotational pole in image with positive values measured clockwise" type="string"/>
<attribute name="comment" value="1st row, 1st col 2D transformation matrix" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="PC1_2" type="float" shape="">

<attribute name="long_name" value="1st row, 2nd column term in generalized 2x2 linear transformation matrix defining angular offset of the solar north rotational pole in image with positive values measured clockwise" type="string"/>
<attribute name="comment" value="1st row, 2nd col 2D transformation matrix" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="PC2_1" type="float" shape="">
<attribute name="long_name" value="2nd row, 1st column term in generalized 2x2 linear transformation matrix defining angular offset of the solar north rotational pole in image with positive values measured clockwise" type="string"/>
<attribute name="comment" value="2nd row, 1st col 2D transformation matrix" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="PC2_2" type="float" shape="">
<attribute name="long_name" value="2nd row, 2nd column term in generalized 2x2 linear transformation matrix defining angular offset of the solar north rotational pole in image with positive values measured clockwise" type="string"/>
<attribute name="comment" value="2nd row, 2nd col 2D transformation matrix" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CSYER1" type="float" shape="">
<attribute name="long_name" value="uncertainty in coordinates due to systematic errors, specifically average guide telescope error signal reading in x-axis (1st axis) over image exposure time" type="string"/>
<attribute name="comment" value="1st axis systematic errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-100.0 100.0" type="float"/>
<attribute name="units" value="arcsec" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CSYER2" type="float" shape="">
<attribute name="long_name" value="uncertainty in coordinates due to systematic errors, specifically average guide telescope error signal reading in y-axis (2nd axis) over image exposure time" type="string"/>
<attribute name="comment" value="2nd axis systematic errors" type="string"/>

<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-100.0 100.0" type="float"/>
<attribute name="units" value="arcsec" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="WCSNAME" type="char" shape="coord_ref_sys_str_len">
<attribute name="long_name" value="solar image coordinate system type" type="string"/>
<attribute name="comment" value="solar image coordinate system type" type="string"/>
<values>Helioprojective-cartesian</values>
</variable>
<variable name="CTYPE1" type="char" shape="coded_coord_ref_sys_str_len">
<attribute name="long_name" value="HPLN is a helioprojective-cartesian coordinate system centered on observation location. LN indicates longitude varies as function of x-axis (1st axis). TAN is a gnomonic azimuthal projection used for CCD camera from observer perspective" type="string"/>
<attribute name="comment" value="1st axis coordinate system name" type="string"/>
<values>HPLN-TAN</values>
</variable>
<variable name="CTYPE2" type="char" shape="coded_coord_ref_sys_str_len">
<attribute name="long_name" value="HPLT is a helioprojective-cartesian coordinate system centered on observation location. LT indicates latitude varies as function of y-axis (2nd axis). TAN is a gnomonic azimuthal projection used for CCD camera from observer perspective" type="string"/>
<attribute name="comment" value="2nd axis coordinate system name" type="string"/>
<values>HPLT-TAN</values>
</variable>
<variable name="CRVAL1" type="float" shape="">
<attribute name="long_name" value="longitude at center of sun in image for projection HPLN-TAN" type="string"/>
<attribute name="comment" value="longitude of sun center for HPLN-TAN" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 0.0" type="float"/>
<attribute name="units" value="degree" type="string"/>
<values>0.0</values>
</variable>
<variable name="CRVAL2" type="float" shape="">
<attribute name="long_name" value="latitude at center of sun in image for projection HPLT-TAN" type="string"/>
<attribute name="comment" value="latitude of sun center for HPLT-TAN" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 0.0" type="float"/>
<attribute name="units" value="degree" type="string"/>
<values>0.0</values>
</variable>
<variable name="LONPOLE" type="float" shape="">

```xml
    <attribute name="long_name" value="native longitude of celestial north pole for sun projection" type="string"/>
    <attribute name="comment" value="longitude of celestial north pole" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="180.0 180.0" type="float"/>
    <attribute name="units" value="degree" type="string"/>
    <values>180.0</values>
  </variable>
  <variable name="TIMESYS" type="char" shape="time_sys_str_len">
    <attribute name="long_name" value="principal time system for time related keywords and data" type="string"/>
    <attribute name="comment" value="principal time system" type="string"/>
    <values>UTC</values>
  </variable>
  <variable name="DATE-OBS" type="double" shape="">
    <attribute name="long_name" value="J2000 epoch start time of observing sun at spacecraft in seconds" type="string"/>
    <attribute name="comment" value="sun observation start time on sat" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="double"/>
    <attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
    <values>dynamic value</values>
  </variable>
  <variable name="DATE-END" type="double" shape="">
    <attribute name="long_name" value="J2000 epoch end time of observing sun at spacecraft in seconds" type="string"/>
    <attribute name="comment" value="sun observation end time on sat" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="double"/>
    <attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
    <values>dynamic value</values>
  </variable>
  <variable name="CMD_EXP" type="float" shape="">
    <attribute name="long_name" value="commanded imaging exposure time" type="string"/>
    <attribute name="comment" value="commanded imaging exposure time" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="0.01 1.0" type="float"/>
    <attribute name="units" value="s" type="string"/>
    <values>dynamic value</values>
  </variable>
  <variable name="EXPTIME" type="float" shape="">
    <attribute name="long_name" value="actual imaging exposure time" type="string"/>
    <attribute name="comment" value="actual imaging exposure time" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
```

```
    &lt;attribute name="valid_range" value="0.008 1.02" type="float"/&gt;
    &lt;attribute name="units" value="s" type="string"/&gt;
    &lt;values&gt;dynamic value&lt;/values&gt;
  &lt;/variable&gt;
  &lt;variable name="OBSGEO-X" type="float" shape=""&gt;
    &lt;attribute name="long_name" value="observing platform ECEF X coordinate" type="string"/&gt;
    &lt;attribute name="comment" value="observing platform ECEF X coordinate" type="string"/&gt;
    &lt;attribute name="_FillValue" value="-99999999.0" type="float"/&gt;
    &lt;attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/&gt;
    &lt;attribute name="units" value="m" type="string"/&gt;
    &lt;values&gt;dynamic value&lt;/values&gt;
  &lt;/variable&gt;
  &lt;variable name="OBSGEO-Y" type="float" shape=""&gt;
    &lt;attribute name="long_name" value="observing platform ECEF Y coordinate" type="string"/&gt;
    &lt;attribute name="comment" value="observing platform ECEF Y coordinate" type="string"/&gt;
    &lt;attribute name="_FillValue" value="-99999999.0" type="float"/&gt;
    &lt;attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/&gt;
    &lt;attribute name="units" value="m" type="string"/&gt;
    &lt;values&gt;dynamic value&lt;/values&gt;
  &lt;/variable&gt;
  &lt;variable name="OBSGEO-Z" type="float" shape=""&gt;
    &lt;attribute name="long_name" value="observing platform ECEF Z coordinate" type="string"/&gt;
    &lt;attribute name="comment" value="observing platform ECEF Z coordinate" type="string"/&gt;
    &lt;attribute name="_FillValue" value="-99999999.0" type="float"/&gt;
    &lt;attribute name="valid_range" value="-7360.0 7360.0" type="float"/&gt;
    &lt;attribute name="units" value="m" type="string"/&gt;
    &lt;values&gt;dynamic value&lt;/values&gt;
  &lt;/variable&gt;
  &lt;variable name="DSUN_OBS" type="double" shape=""&gt;
    &lt;attribute name="long_name" value="distance to center of sun from observation location" type="string"/&gt;
    &lt;attribute name="comment" value="distance to center of sun" type="string"/&gt;
    &lt;attribute name="_FillValue" value="-999.0" type="double"/&gt;
    &lt;attribute name="valid_range" value="146000000000.0 152100000000.0" type="double"/&gt;
    &lt;attribute name="units" value="m" type="string"/&gt;
    &lt;values&gt;dynamic value&lt;/values&gt;
  &lt;/variable&gt;
  &lt;variable name="OBJECT" type="char" shape="object_str_len"&gt;
    &lt;attribute name="long_name" value="name of object being viewed" type="string"/&gt;
```

<attribute name="comment" value="object being viewed" type="string"/>
<values>SUN</values>
</variable>
<variable name="SCI_OBJ" type="char" shape="science_objective_str_len">
<attribute name="long_name" value="science objective of observation: image wavelength, exposure time and solar activity type" type="string"/>
<attribute name="comment" value="science objective of observation" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="WAVELNTH" type="float" shape="">
<attribute name="long_name" value="solar image wavelength" type="string"/>
<attribute name="comment" value="solar image wavelength" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="93.9 303.8" type="float"/>
<attribute name="units" value="angstrom" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="WAVEUNIT" type="char" shape="wavelength_unit_str_len">
<attribute name="long_name" value="solar image wavelength units" type="string"/>
<attribute name="comment" value="solar image wavelength units" type="string"/>
<values>Angstrom</values>
</variable>
<variable name="RAD" type="short" shape="NAXIS2 NAXIS1">
<attribute name="long_name" value="SUVI L1b Solar Imagery" type="string"/>
<attribute name="_FillValue" value="-32768" type="short"/>
<attribute name="sensor_bit_depth" value="14" type="byte"/>
<attribute name="valid_range" value="***see note [1]***" type="short"/>
<attribute name="scale_factor" value="***see note [1]***" type="float"/>
<attribute name="add_offset" value="***see note [1]***" type="float"/>
<attribute name="units" value="W m-2 sr-1" type="string"/>
</variable>
<variable name="DQF" type="ubyte" shape="NAXIS2 NAXIS1">
<attribute name="long_name" value="SUVI L1b Solar Imagery data quality flags" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 4" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="FITS_flag_values" value="***see note [flags and meanings]***" type="string"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>

</variable>
<variable name="GOOD_PIX" type="int" shape="">
<attribute name="long_name" value="number of good quality pixels in L1b solar image" type="string"/>
<attribute name="comment" value="number of good quality pixels in image" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="FIX_PIX" type="int" shape="">
<attribute name="long_name" value="number of pixels corrected in L1b solar image" type="string"/>
<attribute name="comment" value="number of corrected pixels in image" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="SAT_PIX" type="int" shape="">
<attribute name="long_name" value="number of saturated pixels in L1b solar image" type="string"/>
<attribute name="comment" value="number of saturated pixels in image" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="MISS_PIX" type="int" shape="">
<attribute name="long_name" value="number of missing pixels in L1b solar image" type="string"/>
<attribute name="comment" value="number of missing pixels in image" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="units" value="count" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="IMGTII" type="float" shape="">
<attribute name="long_name" value="sum of irradiance values of pixels in L1b solar image" type="string"/>
<attribute name="comment" value="total irradiance of image" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="IMGTIR" type="float" shape="">
<attribute name="long_name" value="sum of radiance values of pixels in L1b solar image" type="string"/>

<attribute name="comment" value="total radiance of image" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-2 sr-1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="IMG_MIN" type="float" shape="">
<attribute name="long_name" value="minimum radiance value of pixels in L1b solar image" type="string"/>
<attribute name="comment" value="minimum radiance in image" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [1] see note [1]***" type="float"/>
<attribute name="units" value="W m-2 sr-1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="IMG_MAX" type="float" shape="">
<attribute name="long_name" value="maximum radiance value of pixels in L1b solar image" type="string"/>
<attribute name="comment" value="maximum radiance in image" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [1] see note [1]***" type="float"/>
<attribute name="units" value="W m-2 sr-1" type="string"/>
<values>***dynamic value***</values>
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<variable name="IMG_MEAN" type="float" shape="">
<attribute name="long_name" value="mean radiance value of pixels in L1b solar image" type="string"/>
<attribute name="comment" value="mean radiance in image" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="***see note [1] see note [1]***" type="float"/>
<attribute name="units" value="W m-2 sr-1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="IMG_SDEV" type="float" shape="">
<attribute name="long_name" value="standard deviation of radiance values of pixels in L1b solar image" type="string"/>
<attribute name="comment" value="std dev of radiance in image" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="W m-2 sr-1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="EFF_AREA" type="float" shape="">
<attribute name="long_name" value="effective area of telescope (wavelength dependent)" type="string"/>

<attribute name="comment" value="effective telescope area" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0002 0.00045" type="float"/>
<attribute name="units" value="m2" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="APSELPOS" type="int" shape="">
<attribute name="long_name" value="aperture selector setting (wavelength dependent)" type="string"/>
<attribute name="comment" value="aperture selector setting" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="valid_range" value="0 5" type="int"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="int"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="FILTPOS1" type="int" shape="">
<attribute name="long_name" value="forward filter wheel setting" type="string"/>
<attribute name="comment" value="forward filter wheel setting" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="valid_range" value="0 4" type="int"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="int"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="FILTPOS2" type="int" shape="">
<attribute name="long_name" value="aft filter wheel setting" type="string"/>
<attribute name="comment" value="aft filter wheel setting" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>
<attribute name="valid_range" value="0 4" type="int"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="int"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="FILTER1" type="char" shape="filter_mnemonic_str_len">
<attribute name="long_name" value="forward filter setting mnemonic" type="string"/>

<attribute name="comment" value="forward filter setting mnemonic" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="FILTER2" type="char" shape="filter_mnemonic_str_len">
<attribute name="long_name" value="aft filter setting mnemonic" type="string"/>
<attribute name="comment" value="aft filter setting mnemonic" type="string"/>
<values>***see note [1]***</values>
</variable>
<variable name="YAW_FLIP" type="ubyte" shape="">
<attribute name="long_name" value="flags indicating whether spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="comment" value="0=upright 1=neither 2=inverted" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CCD_READ" type="ubyte" shape="">
<attribute name="long_name" value="flags indicating the CCD readout configuration" type="string"/>
<attribute name="comment" value="CCD cnfg: 0=no cnfg 1=left amp 2=right amp" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="ECLIPSE" type="ubyte" shape="">
<attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
<attribute name="comment" value="sun eclipse state" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<values>***dynamic value***</values>
</variable>

<variable name="CONTAMIN" type="float" shape="">
<attribute name="long_name" value="estimated contamination thickness value in angstroms used to correct image" type="string"/>
<attribute name="comment" value="contamination thickness in angstroms" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 999.0" type="float"/>
<attribute name="units" value="angstrom" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CONT_FLG" type="ubyte" shape="">
<attribute name="long_name" value="flags indicating whether contamination correction applied" type="string"/>
<attribute name="comment" value="contamination correction: 0=false 1=true" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-BKE" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of when last contamination bake-out ended" type="string"/>
<attribute name="comment" value="last contamination bake-out end time" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DER_SNR" type="float" shape="">
<attribute name="long_name" value="CCD signal to noise ratio for equivalent of 10 photons (wavelength dependent)" type="string"/>
<attribute name="comment" value="CCD signal to noise ratio" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 999.0" type="float"/>
<attribute name="units" value="W m-2 sr-1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="SAT_THR" type="float" shape="">
<attribute name="long_name" value="CCD saturation point (wavelength dependent)" type="string"/>
<attribute name="comment" value="CCD saturation point" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="2.0 40000.0" type="float"/>

<attribute name="units" value="W m-2 sr-1" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CCD_BIAS" type="float" shape="">
<attribute name="long_name" value="CCD background electronic noise estimated using mean value of digital numbers in overscan region" type="string"/>
<attribute name="comment" value="CCD background electronic noise" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 16383.0" type="float"/>
<attribute name="units" value="count" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CCD_TMP1" type="float" shape="">
<attribute name="long_name" value="camera temperature during exposure from one of two temperature sensors on the instrument" type="string"/>
<attribute name="comment" value="sensor 1 camera temperature" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-85.0 50.0" type="float"/>
<attribute name="units" value="degrees_C" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="CCD_TMP2" type="float" shape="">
<attribute name="long_name" value="camera temperature during exposure from one of two temperature sensors on the instrument" type="string"/>
<attribute name="comment" value="sensor 2 camera temperature" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-85.0 50.0" type="float"/>
<attribute name="units" value="degrees_C" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DFM" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of calculated median value dark frame used to calibrate image in seconds" type="string"/>
<attribute name="comment" value="median value dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="NDFRAMES" type="int" shape="">
<attribute name="long_name" value="number of source dark frames used to generate median value dark frame" type="string"/>
<attribute name="comment" value="number of source dark frames" type="string"/>
<attribute name="_FillValue" value="-1" type="int"/>

<attribute name="valid_range" value="1 10" type="int"/>
<attribute name="units" value="count" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF0" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="1st observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF1" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="2nd observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF2" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="3rd observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF3" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="4th observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF4" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>

<attribute name="comment" value="5th observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF5" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="6th observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF6" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="7th observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF7" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="8th observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF8" type="double" shape="">
<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="9th observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="DATE-DF9" type="double" shape="">

<attribute name="long_name" value="J2000 epoch time stamp of dark frame used to calculate median dark frame: 0-oldest 9-most recent in seconds" type="string"/>
<attribute name="comment" value="10th observed dark frame time stamp" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="SOLCURR1" type="ushort" shape="">
<attribute name="long_name" value="solar array current in DN for channels 1-4" type="string"/>
<attribute name="comment" value="solar array current chan 1-4 in DN" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
<values>65535</values>
</variable>
<variable name="SOLCURR2" type="ushort" shape="">
<attribute name="long_name" value="solar array current in DN for channels 5-8" type="string"/>
<attribute name="comment" value="solar array current chan 5-8 in DN" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
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</variable>
<variable name="SOLCURR3" type="ushort" shape="">
<attribute name="long_name" value="solar array current in DN for channels 9-12" type="string"/>
<attribute name="comment" value="solar array current chan 9-12 in DN" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
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</variable>
<variable name="SOLCURR4" type="ushort" shape="">
<attribute name="long_name" value="solar array current in DN for channels 13-16" type="string"/>
<attribute name="comment" value="solar array current chan 13-16 in DN" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
<values>65535</values>
</variable>

```
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  <attribute name="long_name" value="instrument response derived from LUT values, used to convert from instrument units to radiance" type="string"/>
  <attribute name="comment" value="instrument response, used to convert from instrument units to radiance" type="string"/>
  <attribute name="_FillValue" value="-999.0" type="float"/>
  <attribute name="valid_range" value=”0.01 1.0" type="float"/>
  <attribute name="units" value="count photon-1 cm-2" type="string"/>
  <values>dynamic value</values>
</variable>
<variable name="PHOT_ENG" type="float" shape="">
  <attribute name="long_name" value="photon energy, used in the calculation of radiance" type="string"/>
  <attribute name="comment" value="photon energy, used in the calculation of radiance" type="string"/>
  <attribute name="_FillValue" value="-999.0" type="float"/>
  <attribute name="valid_range" value="0.0 0.01" type="float"/>
  <attribute name="units" value="J" type="string"/>
  <values>dynamic value</values>
</variable>
<variable name="RSUN" type="float" shape="">
  <attribute name="long_name" value="solar angular radius in pixels" type="string"/>
  <attribute name="comment" value="solar angular radius in pixels" type="string"/>
  <attribute name="_FillValue" value="-999.0" type="float"/>
  <attribute name="valid_range" value="377.0 391.0" type="float"/>
  <attribute name="units" value="count" type="string"/>
  <values>dynamic value</values>
</variable>
<variable name="HGLT_OBS" type="float" shape="">
  <attribute name="long_name" value="Heliographic Stonyhurst Latitude of the sub-satellite point on the Sun, in degrees" type="string"/>
  <attribute name="comment" value="Heliographic Stonyhurst Latitude of the sub-satellite point on the Sun, in degrees" type="string"/>
  <attribute name="_FillValue" value="-999.0" type="float"/>
  <attribute name="valid_range" value="-8.0 8.0" type="float"/>
  <attribute name="units" value="degree" type="string"/>
  <values>dynamic value</values>
</variable>
<variable name="HGLN_OBS" type="float" shape="">
  <attribute name="long_name" value="Heliographic Stonyhurst Longitude of the sub-satellite point on the Sun, in degrees" type="string"/>
  <attribute name="comment" value="Heliographic Stonyhurst Longitude of the sub-satellite point on the Sun, in degrees" type="string"/>
  <attribute name="_FillValue" value="-999.0" type="float"/>
  <attribute name="valid_range" value="-1.0 1.0" type="float"/>
  <attribute name="units" value="degree" type="string"/>
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<values>***dynamic value***</values>
</variable>
<variable name="HEEX_OBS" type="float" shape="">
<attribute name="long_name" value="Heliocentric Earth Ecliptic X-axis coordinate of the space craft, in meters" type="string"/>
<attribute name="comment" value="Heliocentric Earth Ecliptic X-axis coordinate of the space craft, in meters" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="146000000000.0 153000000000.0" type="float"/>
<attribute name="units" value="m" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="HEEY_OBS" type="float" shape="">
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<attribute name="comment" value="Heliocentric Earth Ecliptic Y-axis coordinate of the space craft, in meters" type="string"/>
<attribute name="_FillValue" value="-1.00E+31" type="float"/>
<attribute name="valid_range" value="-150000000.0 150000000.0" type="float"/>
<attribute name="units" value="m" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="HEEZ_OBS" type="float" shape="">
<attribute name="long_name" value="Heliocentric Earth Ecliptic Z-axis coordinate of the space craft, in meters" type="string"/>
<attribute name="comment" value="Heliocentric Earth Ecliptic Z-axis coordinate of the space craft, in meters" type="string"/>
<attribute name="_FillValue" value="-1.00E+31" type="float"/>
<attribute name="valid_range" value="-150000000.0 150000000.0" type="float"/>
<attribute name="units" value="m" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="PCTL0ERR" type="float" shape="">
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<attribute name="comment" value="uncorrectable L0 error pct" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
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</variable>
<attribute name="dataset_name" value="***refer to filename conventions for L1b products in Appendix C.***" type="string"/>
<attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
<attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
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<attribute name="iso_series_metadata_id" value="f5816f57-fd6d-11e3-a3ac-0800200c9a66" type="string"/>
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<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
<attribute name="title" value="SUVI L1b Solar Imagery: EUV" type="string"/>
<attribute name="summary" value="SUVI L1b Solar Imagery: EUV Products are images of the sun at six wavelengths and multiple radiance level ranges spanning many orders of magnitude in support of viewing the sun during different types of solar activity. Different combinations of aperture positions, mirror coating, filters and exposure periods are used when imaging the sun. The product also contains processing and data quality metadata, satellite state and location information, and data required for the generation of level 2 products." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR IMAGERY, ATMOSPHERE > ATMOSPHERIC RADIATION > SOLAR RADIATION, SPECTRAL/ENGINEERING > ULTRAVIOLET WAVELENGTHS > ULTRAVIOLET RADIANCE, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > CORONA, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > CORONA HOLES, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > CORONAL MASS EJECTIONS, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR ACTIVE REGIONS, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR FLARES, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR PROMINENCES/SOLAR FILAMENTS, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR ULTRAVIOLET EMISSIONS, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SUNSPOTS" type="string"/>
<attribute name="cdm_data_type" value="Image" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES-R Series Solar Ultraviolet Imager" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument.***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
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<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
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<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data; not in use" type="string"/>
<attribute name="input_SUVI_L0_data" value="null" type="string"/>
</variable>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note 1: Science objective mnemonics, wavelengths, and valid range for the fourteen solar image types, and forward and after filter setting mnemonics are located in paragraph 7.3.1.5.1.1-1, Level 1b SUVI Solar Imagery: EUV Product Quantity Characteristics.
The dynamic values of scale factor and add offset are used together to provide simple data compression to store floating-point data as small integers in a product data file. When these attributes are present, the data is first scaled (i.e., multiplied) before the offset is added. In GOES-R netCDF product files, when scale factor and add offset are used for packing, the associated variable (containing the packed data) is of type short, whereas the unpacked values are intended to be of type float or double. The attributes scale_factor and add_offset are of the type intended for the unpacked data.

Note 2: "flags and meanings": Flag values and meanings are located in paragraph 7.3.1.5.1.2, Level 1b SUVI Solar Imagery: EUV Product Flag Values and Meanings.

7.4 EXIS Level 1b Products

7.4.1 Solar Flux: Extreme Ultraviolet Product

7.4.1.1 Description

The Solar Flux: EUV product contains a 23 bin solar irradiance spectrum proxy model that covers the wavelength range of 5 nm to 127 nm over successive 30 second observation intervals. The product includes processing and data quality information associated with the availability and characteristics of the observation data received from the EUVS and XRS, the generation of the spectrum proxy model, and whether geocorona absorption occurred during the 30 second observation interval. The definition of the spectrum proxy model wavelength bins is located in paragraph 7.4.1.5.1, Solar Flux: EUV Product Quantity Characteristics.

The units of measure for the solar irradiance spectrum proxy model values are "watts per square meter per nanometer".

The precise look angles of the angular zones relative to the GOES-R spacecraft body reference frame required for use and subsequent processing of this level 1b product data are available from the Product Distribution and Access system.

The Solar Flux: EUV performance requirements are summarized in Table 7.4.1.1, Solar Flux: EUV Performance Requirements.

Table 7.4.1.1 Solar Flux: EUV Performance Requirements

	Measurement			Mapping
Region	**Range**	**Accuracy**	**Precision**	**Uncertainty**
solar disk	1/2 solar minimum to 10 times solar maximum	20% at the specified minimum flux	20%	+/- 2 arcmin

Metadata in the Solar Flux: EUV product provides statistical and other properties of the observation and processed data and information required for the generation of level 2 products, and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the observation data in the product. The 30 second observation interval starts at the beginning of the wall clock minute or at the 30 second mark in the wall clock minute.
- Satellite location, spacecraft ACRF to J2000 ECI attitude quaternion, and earth to sun distance.
- Eclipse of the sun indication.
- Satellite yaw flip configuration.
- Mean Sun Positioning Sensor (SPS) dispersion and cross-dispersion angles over the 30 second observation interval.
- Wavelength ranges for each of the spectrum proxy model bins.
- Number of Solar Flux: X-Ray reports used, and EUVS-A, EUVS-B, and EUVS-C observations used in the generation of the spectrum proxy model.
- Number of good quality XRS-A, XRS-B, EUVS-A, and EUVS-B irradiance values, and Mg II core-to-wing ratio values used in the generation of the spectrum proxy model.
- Quality information for the Solar Flux: X-Ray, EUVS-A, EUVS-B, and EUVS-C L1b processing and data used in the generation of the spectrum proxy model.
- Mean XRS-A, XRS-B, EUVS-A, and EUVS-B irradiance values, and EXIS and NOAA Mg II core-to-wing ratio values over the 30 second observation interval.
- Mean XRS-A, XRS-B, EUVS-A, and EUVS-B irradiance values, and NOAA Mg II core-to-wing ratio values over the previous 24 hours.

- Mean temperature of the EUVS-A, EUVS-B, and EUVS-C detectors over the 30 second observation interval.

The detailed description of the ISO series metadata for the Solar Flux: EUV product is located in the standalone Appendix X, ISO Series Metadata.

7.4.1.2 Dynamic Source Data

The Solar Flux: EUV product is derived using EUVS Level 0 raw science telemetry, XRS Level 1b Solar Flux: X-Ray product data, EXIS engineering telemetry, and satellite ephemeris related telemetry.

The primary sensor data used by the Level 1b Solar Flux: EUV algorithm is identified in Table 7.4.1.2, Primary Sensor Data.

Table 7.4.1.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_EUVS_L0_data
L1b Products	input_XRS_L1b_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.4.1.3 Level 1b Semi-Static Source Data

There are three categories of semi-static source data employed in the EUVS Level 1b ground processing algorithm:

- Sensor calibration parameters.
- Solar calibration parameters.
- Model processing parameters.

Semi-static source data files from the three categories above are contained in a single zip file, rolled up to the instrument level - all EXIS semi-static parameter files are in one zip file. Some files fit into more than one category.

Sensor calibration parameters are used by the algorithms to calibrate the raw signals recorded by the instrument components into engineering units. The EUVS instrument is composed of three sensor subcomponents: EUVS-A, EUVS-B, and EUVS-C. In addition, EUVS-C is composed of two separate channels: EUVS-C1 and EUVS-C2. Specific types of sensor calibration parameters for the sensor subcomponents are defined in Table 7.4.1.3, EUVS Sensor Calibration Parameters. This table also specifies whether a parameter is applicable to all sensor subcomponents, associated with the parent instrument, or with one of the EUVS-C channel subcomponents.

Table 7.4.1.3 EUVS Sensor Calibration Parameters

Description of Parameter(s)	EUVS-A	EUVS-B	EUVS-C	EUVS-C1	EUVS-C2
Number of sensor photodiodes	x	x	x		
Number of diode layout table columns	x	x			
Number of sensor channels			x		
Number of solar emission lines	x	x			
Number of filter wheel positions for acceptable solar viewing	x	x		x	x
Number of days in the in-flight gain correction factor tables	x	x			

Description of Parameter(s)	EUVS-A	EUVS-B	EUVS-C	EUVS-C1	EUVS-C2
Number of samples in the linear gain correction factor tables	x	x	x		
Number of Digital Number samples in the temperature look-up tables	x	x	x		
Number of angles in the field of view correction factor tables	x	x			
Number of polynomial coefficients used to evaluate the flatfield and degradation corrections for each diode	x	x	x		
Number of polynomial coefficient used by the flatfield and degradation correction computations	x	x			
Number of Gaussian curve-fitting parameters			x		
Number of pixel modes requiring decoding			x		
Number of pixel modes indicating non-science data			x		
Number of flush-dead count pairs requiring addition of an extra time shift			x		
Processing intervals	x	x	x		
Time intervals for retaining previous raw dark diode signals	x	x			
Time interval for retaining previous masked dark diode signal averages			x		
Filter wheel absolute step numbers indicating that the filter position allows sunlight to detector	x	x		x	x
Absolute step number indicating that the door is closed	x	x	x		
Instrument invalid flag processing values	x	x	x		
Minimum and maximum bad dispersion and cross-dispersion angle thresholds	x	x	x		
Minimum and maximum degraded and warning dispersion and cross-dispersion angle thresholds	x	x			
Valid integration time threshold for processing	x	x			
Valid detector change count thresholds for processing	x	x	x		
Diode layout table mapping to ASIC and solar lines	x	x			
Sensor integration time calibration parameters	x	x	x		
Temperature calibration tables	x	x		x	x
Detector low and high temperature thresholds	x	x	x		
Mask identifying diodes used in the solar line processing	x	x			
Saturation threshold value for the solar line diode signals	x	x			
Minimum dark-corrected current amplitude threshold of solar line diodes	x	x			
Temperature-dependent pre-flight gain coefficients tables	x	x			
Time-dependent gain correction factor tables	x	x			
Amplitude-dependent signal linearity correction factor tables	x	x		x	x

Description of Parameter(s)	EUVS-A	EUVS-B	EUVS-C	EUVS-C1	EUVS-C2
Time-dependent flatfield correction coefficient tables	x	x		x	x
Time-dependent degradation correction coefficient tables	x	x			
Uncalibrated diode electrometer signal table	x	x			
Temperature-dependent diode thermal dark signal tables	x	x			
Dark diode weighting factors	x	x			
Diode dark current scaling factor tables	x	x			
Diode scattering light correction current tables	x	x		x	x
Diode order sorting correction current tables	x	x			
Split-diode identification table	x	x			
Filter-dependent diode sensor responsivity table	x				
Filter-independent diode sensor responsivity table		x			
Instrument field of view dispersion and cross-dispersion correction factor angle tables	x	x			
Instrument field of view dispersion and cross-dispersion correction factor tables	x	x			
Pixel mode identification parameters			x		
Diode signal offset for pixel decode mode			x		
Signal amplitude threshold for particle-filtering algorithm			x		
Active photodiode to blue wing, red wing, h-line, k-line, and masked region mappings				x	x
Low signal threshold value for the raw amplitudes of the photodiodes in the blue wing, red wing, h-line, and k-line regions				x	x
Saturation signal threshold value for the raw amplitudes of the photodiodes in the blue wing, red wing, h-line, and k-line regions				x	x
Diode dark flatfield correction tables				x	x
Diode dark signal offset tables				x	x
Diode red- and blue-wing weighting factor table				x	x
Initial Gaussian fitting parameters determining the Mg II h-line and k-line spectral peak regions			x		
Diode wavelength table for the Mg II h-line and k-line spectral peak regions			x		
Scale factors and offsets to convert the Mg II core-to-wing ratio from the EXIS resolution to the NOAA historical record			x		
Geocoronal absorption start and end time		x			

Solar calibration parameters are those associated with the distance, on a daily basis, between the earth and the sun.

Model processing parameters are those associated with the EUV spectrum proxy model. Specific types include:

- Number of wavelength bins in the EUV spectrum proxy model.
- Lower and upper limit for each of the wavelength bins in the EUV spectrum proxy model.
- Number of proxies used in EUV spectrum generation.
- EUV spectrum generation sensor data collection interval.
- Time intervals required to compute the averages for each of the trailing proxies.

- Minimum XRS-A, XRS-B, EUVS-A, and EUVS-B irradiance values used to calculate the slower time-average variability.
- Minimum EUVS-C NOAA Mg II core-to-wing ratio value used to calculate the slower time-average variability.
- Solar minimum irradiance amplitudes of each wavelength in the EUV spectrum proxy model.
- P and Q proxy exponent coefficients as a function of the sensor proxies.
- P and Q proxy amplitude coefficients as a function of the wavelength and sensor proxies for each of the seven cases.

The filename conventions for the EUVS Level 1b semi-static source data file are located in Appendix C.

7.4.1.4 Production Notes

The Solar Flux: EUV product is generated by EXIS Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm extracts the raw detector data from the CCSDS packets. The Level 1b algorithm uses the XRS-A and XRS-B irradiance values from the Solar Flux: X-Ray reports, and EUVS-A and EUVS-B observations, and the EUVS-C Mg II core-to-wing ratios from the 30 second observation interval. The algorithm calculates the Mg II core-to-wing ratio by determining the total irradiances for the h- and k-line spectra, and the blue and red wing regions from the entire medium ultraviolet spectrum measured by the EUVS-C, which is from 275-285 nm.

Rather than the product data being a calibrated form of the observation data from the sensor, it is a spectrum proxy model. This spectrum proxy model is generated at a 30 second cadence regardless of whether observation data is received by the ground system. In addition, the algorithm generates calibrated irradiance values for the three EUVS-A spectral emission lines and four EUVS-B spectral emission lines, and calibrated Mg II core-to-wing ratios for the EUVS-C measurements. However, the algorithm only includes the average values for these quantities over the 30 second observation interval.

The algorithm uses EUVS-A and EUVS-B dark diode values to estimate the in-situ radiation background. The algorithm uses the EUVS-C filtered signal values to remove contamination from large particles.

The L1b algorithm executes and product data is generated when the instrument is in any mode, but not when the satellite is in the on-orbit storage mode. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.4.1.5 Data Organization and Fields

A Solar Flux: EUV product spans two GRB Space Packets, one for the data and another for the metadata. The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, label variables, and product start and end time variable.

The subordinate paragraphs that follow define the Solar Flux: EUV product data, quantity characteristics, flag values and meanings, and metadata fields.

7.4.1.5.1 Data Fields

Table 7.4.1.5.1 Solar Flux: EUV Product Data

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
irradianceSpectrum control field(s)	uint64	number of control fields = 1	wavelength_bin = 23	1	8	0
irradianceSpectrum	float	wavelength_bin = 23	irradiance spectrum for wavelengths between 5 and 127 nm calculated using a proxy model based on inputs from XRS A and B channels, and EUVS A, B. and C channels	W m-2 nm-1	92	8
time	double	n/a	EUV spectrum observation center time	seconds	8	100
lowWavelength control field(s)	uint64	number of control fields = 1	wavelength_bin = 23	1	8	108
lowWavelength	float	wavelength_bin = 23	lower limit of each of wavelength bin, all 5nm in width except for the last 10 nm bin, used in EUV spectrum proxy model	nm	92	116
highWavelength control field(s)	uint64	number of control fields = 1	wavelength_bin = 23	1	8	208
highWavelength	float	wavelength_bin = 23	upper limit of each of wavelength bin, all 5nm in width except for the last 10 nm bin, used in EUV spectrum proxy model	nm	92	216
EUV_CaseNumber	ubyte	n/a	EUV spectrum product quality case number	1	1	308
qualityFlags	uint64	n/a	EUVS L1b processing and data quality flags	1	8	309

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
quaternion_Q0	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q0	1	4	317
quaternion_Q1	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q1	1	4	321
quaternion_Q2	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q2	1	4	325
quaternion_Q3	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q3	1	4	329
ECEF_X	float	n/a	spacecraft ECEF X coordinate	m	4	333
ECEF_Y	float	n/a	spacecraft ECEF Y coordinate	m	4	337
ECEF_Z	float	n/a	spacecraft ECEF Z coordinate	m	4	341
au_factor	float	n/a	earth to sun distance multiplicative correction factor to normalize to 1-AU at time of observation. not applied in EUVS L1b processing	1	4	345
SC_yaw_flip_flag	ubyte	n/a	flags indicating whether spacecraft is operating in yaw flip configuration	1	1	349
nXRS	ubyte	n/a	number of XRS L1b reports generated during time interval associated with EUV proxy spectrum model	count	1	350
nGoodXRSA	ubyte	n/a	number of calculated good quality XRS-A 0.05 to 0.4 nm irradiance values used in generation of EUV proxy spectrum model	count	1	351
nGoodXRSB	ubyte	n/a	number of calculated good quality XRS-B 0.1 to 0.8 nm irradiance values used in generation of EUV proxy spectrum model	count	1	352
nEUVSA	ubyte	n/a	number of EUVS-A observations (L0) processed during time interval associated with EUV proxy spectrum model	count	1	353
nGood256	ubyte	n/a	number of calculated good quality EUVS-A 25.6 nm irradiance values used in generation of EUV proxy spectrum model	count	1	354

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
nGood284	ubyte	n/a	number of calculated good quality EUVS-A 28.4 nm irradiance values used in generation of EUV proxy spectrum model	count	1	355
nGood304	ubyte	n/a	number of calculated good quality EUVS-A 30.4 nm irradiance values used in generation of EUV proxy spectrum model	count	1	356
nEUVSB	ubyte	n/a	number of EUVS-B observations (L0) processed during time interval associated with EUV proxy spectrum model	count	1	357
nGood1175	ubyte	n/a	number of calculated good quality EUVS-B 117.5 nm irradiance values used in generation of EUV proxy spectrum model	count	1	358
nGood1216	ubyte	n/a	number of calculated good quality EUVS-B 121.6 nm irradiance values used in generation of EUV proxy spectrum model	count	1	359
nGood1335	ubyte	n/a	number of calculated good quality EUVS-B 133.5 nm irradiance values used in generation of EUV proxy spectrum model	count	1	360
nGood1405	ubyte	n/a	number of calculated good quality EUVS-B 140.5 nm irradiance values used in generation of EUV proxy spectrum model	count	1	361
nEUVSC	ubyte	n/a	number of EUVS-C observations (L0) processed during time interval associated with EUV proxy spectrum model	count	1	362
nGoodMg	ubyte	n/a	number of calculated good quality Mg II core-to-wing ratio values used in generation of EUV proxy spectrum model	count	1	363
xrsQualityFlags control field(s)	uint64	number of control fields = 1	max_num_XRS_obs_spectrum_interval = 30	1	8	364
xrsQualityFlags	uint32	max_num_XRS_obs_spectrum_interval = 30	XRS L1b processing and data quality flags	1	120	372
euvsaQualityFlags control field(s)	uint64	number of control fields = 1	max_num_EUVS_A_obs_spectrum_interval = 30	1	8	492

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
euvsaQualityFlags	uint32	max_num_EUVS_A_obs_spectrum_interval = 30	EUVS-A L1b processing and data quality flags	1	120	500
euvsbQualityFlags control field(s)	uint64	number of control fields = 1	max_num_EUVS_B_obs_spectrum_interval = 30	1	8	620
euvsbQualityFlags	uint32	max_num_EUVS_B_obs_spectrum_interval = 30	EUVS-B L1b processing and data quality flags	1	120	628
euvsaAvgTemp	float	n/a	average temperature of EUVS-A detector during time interval associated with EUV proxy spectrum model	degrees_C	4	748
euvsbAvgTemp	float	n/a	average temperature of EUVS-B detector during time interval associated with EUV proxy spectrum model	degrees_C	4	752
euvsc1AvgTemp	float	n/a	average temperature of EUVS-C detector #1 during time interval associated with EUV proxy spectrum model	degrees_C	4	756
euvsc2AvgTemp	float	n/a	average temperature of EUVS-C detector #2 during time interval associated with EUV proxy spectrum model	degrees_C	4	760
avgIrradianceXRSA	float	n/a	average primary irradiance at wavelengths between 0.05 and 0.4 nm (XRS-A) during time interval associated with EUV proxy spectrum model	W m-2	4	764
avgIrradianceXRSB	float	n/a	average primary irradiance at wavelengths between 0.1 and 0.8 nm (XRS-B) during time interval associated with EUV proxy spectrum model	W m-2	4	768
avgIrradiance256	float	n/a	EUVS-A 25.6 nm average irradiance during time interval associated with EUV proxy spectrum model	W m-2	4	772
avgIrradiance284	float	n/a	EUVS-A 28.4 nm average irradiance during time interval associated with EUV proxy spectrum model	W m-2	4	776

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
avgIrradiance304	float	n/a	EUVS-A 30.4 nm average irradiance during time interval associated with EUV proxy spectrum model	W m-2	4	780
avgIrradiance1175	float	n/a	EUVS-B 117.5 nm average irradiance during time interval associated with EUV proxy spectrum model	W m-2	4	784
avgIrradiance1216	float	n/a	EUVS-B 121.6 nm average irradiance during time interval associated with EUV proxy spectrum model	W m-2	4	788
avgIrradiance1335	float	n/a	EUVS-B 133.5 nm average irradiance during time interval associated with EUV proxy spectrum model	W m-2	4	792
avgIrradiance1405	float	n/a	EUVS-B 140.5 nm average irradiance during time interval associated with EUV proxy spectrum model	W m-2	4	796
avgRatioMgExis	float	n/a	EUVS-C average EXIS Mg II core-to-wing ratio during time interval associated with EUV proxy spectrum model	1	4	800
avgRatioMgNoaa	float	n/a	EUVS-C average NOAA historical Mg II core-to-wing ratio during time interval associated with EUV proxy spectrum model	1	4	804
Reserved					4	808
Reserved					4	812
Reserved					4	816
Reserved					4	820
Reserved					4	824
Reserved					4	828
Reserved					4	832
Reserved					4	836
ObservationTimesEUVSAB control field(s)	uint64	number of control fields = 1	max_num_EUVS_A_obs_spectrum_interval = 30	1	8	840
ObservationTimesEUVSAB	double	max_num_EUVS_A_obs_spectrum_interval = 30	spectrum observation center time for 1 second high time resolution EUVS-A and EUVS-B measurements	seconds since 2000-01-01 12:00:00,	240	848

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
				neglecting leap seconds		
ObservationTimesEUVSC control field(s)	uint64	number of control fields = 1	max_num_EUVS_C_obs_spectrum_interval = 10	1	8	1088
ObservationTimesEUVSC	double	max_num_EUVS_C_obs_spectrum_interval = 10	spectrum observation center time for 1 second high time resolution EUVS-C measurement.	seconds since 2000-01-01 12:00:00, neglecting leap seconds	80	1096
CurrentsEUVSA control field(s)	uint64	number of control fields = 2	max_num_EUVS_A_obs_spectrum_interval = 30 num_currents_EUVSA = 24	1	16	1176
CurrentsEUVSA	float	max_num_EUVS_A_obs_spectrum_interval = 30, num_currents_EUVSA = 24	currents at observation time for each EUVS-A diode in telemetry order	ampere	2880	1192
CurrentsEUVSB control field(s)	uint64	number of control fields = 2	max_num_EUVS_B_obs_spectrum_interval = 30 num_currents_EUVSB = 24	1	16	4072
CurrentsEUVSB	float	max_num_EUVS_B_obs_spectrum_interval = 30, num_currents_EUVSB = 24	currents at observation time for each EUVS-B diode in telemetry order	ampere	2880	4088
SignalsEUVSC_hLine control field(s)	uint64	number of control fields = 2	max_num_EUVS_C_obs_spectrum_interval = 10 max_num_diodes_EUVSC_h_line = 10	1	16	6968
SignalsEUVSC_hLine	float	max_num_EUVS_C_obs_spectrum_interval = 10, max_num_diodes_EUVSC_h_line = 10	signals at observation time for the first 10 EUVSC diodes masked by the MgII h line mask in telemetry order	count	400	6984
SignalsEUVSC_kLine control field(s)	uint64	number of control fields = 2	max_num_EUVS_C_obs_spectrum_interval = 10 max_num_diodes_EUVSC_k_line = 10	1	16	7384
SignalsEUVSC_kLine	float	max_num_EUVS_C_obs_spectrum_interval = 10	signals at observation time for the first 10 EUVSC diodes masked by the MgII k line mask in telemetry order	count	400	7400

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
		max_num_diodes_EUVSC_k_line = 10				
IntegratedSignalsEUVSC_BlueWing control field(s)	uint64	number of control fields = 1	max_num_EUVS_C_obs_spectrum_interval = 10	1	8	7800
IntegratedSignalsEUVSC_BlueWing	float	max_num_EUVS_C_obs_spectrum_interval = 10	blue wing signal at observation time	count	40	7808
IntegratedSignalsEUVSC_RedWing control field(s)	uint64	number of control fields = 1	max_num_EUVS_C_obs_spectrum_interval = 10	1	8	7848
IntegratedSignalsEUVSC_RedWing	float	max_num_EUVS_C_obs_spectrum_interval = 10	red wing signal at observation time	count	40	7856
IntegratedSignalsEUVSC_DarkMask control field(s)	uint64	number of control fields = 1	max_num_EUVS_C_obs_spectrum_interval = 10	1	8	7896
IntegratedSignalsEUVSC_DarkMask	float	max_num_EUVS_C_obs_spectrum_interval = 10	dark signal at observation time	count	40	7904
Average_SPS_dispersion_angle	float	n/a	average dispersion direction pointing angle from SPS during time interval associated with EUV proxy spectrum model	degree	4	7944
Average_SPS_cross_dispersion_angle	float	n/a	average cross-dispersion direction pointing angle from SPS during time interval associated with EUV proxy spectrum model	degree	4	7948
solar_array_current control field(s)	uint64	number of control fields = 1	solar_array_current_channel_index = 4	1	8	7952
solar_array_current	ushort	solar_array_current_channel_index = 4	solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)	1	8	7960
SC_eclipse_flag	ubyte	n/a	flags indicating whether sun is obscured by earth as provided by spacecraft	1	1	7968
euvscIntegrationTime	float	N/A	EUVS-C Packet Integration Time in seconds.	seconds	4	7969
euvscQualityFlags control field(s)	uint64	number of control fields = 1	max_num_EUVS_C_obs_spectrum_interval = 10	1	8	7973
euvscQualityFlags	uint32	max_num_EUVS_C_obs_spectrum_interval =10	EUVS-C L1b processing and data quality flags	1	40	7981

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
Total_SPS_angles	ubyte	n/a	number of SPS measurements used to determine the Average_SPS_dispersion_angle and Average_SPS_cross_dispersion_angle values	count	1	8021
Total_valid_SPS_angle_pairs	ubyte	n/a	number of valid SPS measurements used during XRS L1b processing	count	1	8022
euvscActiveChannel	ubyte	N/A	indicates which EUVSC channel is active	1	1	8023

7.4.1.5.1.1 Solar Flux: EUV Product Quantity Characteristics

Table 7.4.1.5.1.1 Solar Flux: EUV Product Spectrum Proxy Model Wavelength Characteristics

Wavelength Bin (in nm)	Order in Product Data Structure	Product Label Variable Mnemonic
5 - 10	1	WaveBin-5_to_10nm
10 -15	2	WaveBin-10_to_15nm
15 - 20	3	WaveBin-15_to_20nm
20 - 25	4	WaveBin-20_to_25nm
25 - 30	5	WaveBin-25_to_30nm
30 - 35	6	WaveBin-30_to_35nm
35 - 40	7	WaveBin-35_to_40nm
40 - 45	8	WaveBin-40_to_45nm
45 - 50	9	WaveBin-45_to_50nm
50 - 55	10	WaveBin-50_to_55nm
55 - 60	11	WaveBin-55_to_60nm
60 - 65	12	WaveBin-60_to_65nm
65 - 70	13	WaveBin-65_to_70nm
70 - 75	14	WaveBin-70_to_75nm
75 - 80	15	WaveBin-75_to_80nm
80 - 85	16	WaveBin-80_to_85nm
85 - 90	17	WaveBin-85_to_90nm
90 - 95	18	WaveBin-90_to_95nm
95 - 100	19	WaveBin-95_to_100nm
100 - 105	20	WaveBin-100_to_105nm

105 - 110	21	WaveBin-105_to_110nm
110 - 115	22	WaveBin-110_to_115nm
117 - 127	23	WaveBin-117_to_127nm

7.4.1.5.1.2 Solar Flux: EUV Product Flag Values and Meanings

Table 7.4.1.5.1.2-1 Solar Flux: EUV Product EUVS L1b Processing and Data Quality Flag Values and Meanings

EUVS L1b Processing and Data Quality Flags (qualityFlags)		
Flag Mask	**Flag Value**	**Flag Meaning**
17592186044415	0	good_quality_qf
1	1	degraded_due_to_all_bad_sensor_pointing_qf
2	2	degraded_due_to_all_invalid_sensor_filter_position_qf
4	4	degraded_due_to_all_low_sensor_temperature_qf
8	8	degraded_due_to_all_high_sensor_temperature_qf
16	16	degraded_due_to_XRS-A_average_irradiance_near_zero_qf
32	32	degraded_due_to_XRS-B_average_irradiance_near_zero_qf
64	64	degraded_due_to_EUVS-A_25.6nm_average_irradiance_near_zero_qf
128	128	degraded_due_to_EUVS-A_28.4nm_average_irradiance_near_zero_qf
256	256	degraded_due_to_EUVS-A_30.4nm_average_irradiance_near_zero_qf
512	512	degraded_due_to_EUVS-B_117.5nm_average_irradiance_near_zero_qf
1024	1024	degraded_due_to_EUVS-B_121.6nm_average_irradiance_near_zero_qf
2048	2048	degraded_due_to_EUVS-B_133.5nm_average_irradiance_near_zero_qf
4096	4096	degraded_due_to_EUVS-B_140.5nm_average_irradiance_near_zero_qf
8192	8192	degraded_due_to_XRS-A_average_irradiance_at_saturation_qf
16384	16384	degraded_due_to_XRS-B_average_irradiance_at_saturation_qf
32768	32768	degraded_due_to_EUVS-A_25.6nm_average_irradiance_at_saturation_qf
65536	65536	degraded_due_to_EUVS-A_28.4nm_average_irradiance_at_saturation_qf
131072	131072	degraded_due_to_EUVS-A_30.4nm_average_irradiance_at_saturation_qf
262144	262144	degraded_due_to_EUVS-B_117.5nm_average_irradiance_at_saturation_qf
524288	524288	degraded_due_to_EUVS-B_121.6nm_average_irradiance_at_saturation_qf
1048576	1048576	degraded_due_to_EUVS-B_133.5nm_average_irradiance_at_saturation_qf
2097152	2097152	degraded_due_to_EUVS-B_140.5nm_average_irradiance_at_saturation_qf
4194304	4194304	degraded_due_to_truncation_of_all_XRS_integration_qf
8388608	8388608	degraded_due_to_truncation_of_all_EUVS-A_integration_qf
16777216	16777216	degraded_due_to_truncation_of_all_EUVS-B_integration_qf
33554432	33554432	degraded_due_to_truncation_of_all_EUVS-C_integration_qf
67108864	67108864	degraded_due_to_flatfield_LED_flash_during_sensor_integrations_qf
134217728	134217728	degraded_due_to_off_point_calibration_maneuver_received_from_ground_qf

EUVS L1b Processing and Data Quality Flags (qualityFlags)		
Flag Mask	**Flag Value**	**Flag Meaning**
268435456	268435456	degraded_due_to_planetary_transit_state_received_from_ground_qf
536870912	536870912	degraded_due_to_lunar_transit_state_received_from_ground_qf
1073741824	1073741824	degraded_due_to_eclipse_state_received_from_ground_qf
2147483648	2147483648	degraded_due_to_fov_state_not_received_from_ground_qf
4294967296	4294967296	degraded_due_to_all_invalid_XRS-A_L1b_report_qf
8589934592	8589934592	degraded_due_to_all_invalid_XRS-B_L1b_report_qf
17179869184	17179869184	degraded_due_to_all_invalid_EUVS-A_25.6nm_observation_qf
34359738368	34359738368	degraded_due_to_all_invalid_EUVS-A_28.4nm_observation_qf
68719476736	68719476736	degraded_due_to_all_invalid_EUVS-A_30.4nm_observation_qf
137438953472	137438953472	degraded_due_to_all_invalid_EUVS-B_117.5nm_observation_qf
274877906944	274877906944	degraded_due_to_all_invalid_EUVS-B_121.6nm_observation_qf
549755813888	549755813888	degraded_due_to_all_invalid_EUVS-B_133.5nm_observation_qf
1099511627776	1099511627776	degraded_due_to_all_invalid_EUVS-B_140.5nm_observation_qf
2199023255552	2199023255552	unused
4398046511104	4398046511104	unused
8796093022208	8796093022208	degraded_due_to_all_invalid_Mg_II_h-line_or_k-line_or_blue_wing_or_red_wing_spectral_region_observation_qf

Note: EUV spectrum quality flags are computed using only valid XRS, EUVS-A, EUVS-B and EUVS-C input data.

Table 7.4.1.5.1.2-2 Solar Flux: EUV Product Spectrum Product Quality Case Number Flag Values and Meanings

EUV Spectrum Product Quality Case Number Flags (EUV_CaseNumber)	
Flag Value	**Flag Meaning**
1	XRS_and_EUVS-A_and_EUVS-B_and_EUVS-C_and_no_geocorona
2	XRS_and_EUVS-A_and_EUVS-B_and_EUVS-C_and_geocorona
3	XRS_and_no_EUVS-A_and_no_EUVS-B_and_EUVS-C_and_no_geocorona
4	XRS_and_EUVS-A_and_EUVS-B_and_no_EUVS-C_and_no_geocorona
5	XRS_and_no_EUVS-A_and_EUVS-B_and_EUVS-C_and_no_geocorona
6	XRS_and_EUVS-A_and_no_EUVS-B_and_EUVS-C_and_no_geocorona
7	no_XRS_and_EUVS-A_and_EUVS-B_and_EUVS-C_and_no_geocorona
8	no_spectrum_due_to_missing_data

Table 7.4.1.5.1.2-3 Solar Flux: EUV Product XRS L1b Processing and Data Quality Flag Values and Meanings

XRS L1b Processing and Data Quality Flags (xrsQualityFlags)

Flag Mask	Flag Value	Flag Meaning
524287	0	good_quality_qf
1	1	invalid_due_to_out_of_range_XRS_pointing_qf
2	2	degraded_due_to_uncalibrated_range_XRS_pointing_qf
4	4	degraded_due_to_calibrated_but_exceeds_requirements_XRS_pointing_qf
8	8	invalid_due_to_XRS_L0_data_checksum_error_qf
16	16	degraded_due_to_low_XRS_A_and_B_temperature_qf
32	32	degraded_due_to_high_XRS_A_and_B_temperature_qf
64	64	degraded_due_to_XRS-A_solar_minimum_channel_signal_near_zero_qf
128	128	degraded_due_to_XRS-A_solar_maximum_channel_signal_near_zero_qf
256	256	degraded_due_to_XRS-B_solar_minimum_channel_signal_near_zero_qf
512	512	degraded_due_to_XRS-B_solar_maximum_channel_signal_near_zero_qf
1024	1024	degraded_due_to_XRS-A_solar_minimum_channel_signal_at_saturation_qf
2048	2048	degraded_due_to_XRS-A_solar_maximum_channel_signal_at_saturation_qf
4096	4096	degraded_due_to_XRS-B_solar_minimum_channel_signal_at_saturation_qf
8192	8192	degraded_due_to_XRS-B_solar_maximum_channel_signal_at_saturation_qf
16384	16384	degraded_due_to_flatfield_LED_flash_during_XRS_integration_qf
32768	32768	degraded_due_to_insufficient_number_of_integrations_after_XRS_reset_qf
65536	65536	degraded_due_to_non-nominal_XRS-A_irradiance_qf
131072	131072	degraded_due_to_non-nominal_XRS-B_irradiance_qf
262144	262144	degraded_due_to_out_of_valid_range_primary_XRS-B_to_XRS-A_irradiance_ratio_qf

Table 7.4.1.5.1.2-4 Solar Flux: EUV Product EUVS-A L1b Processing and Data Quality Flag Values and Meanings

EUVS-A L1b Processing and Data Quality Flags (euvsaQualityFlags)		
Flag Mask	**Flag Value**	**Flag Meaning**
262143	0	good_quality_qf
1	1	invalid_due_to_out_of_range_EUVS-A_pointing_qf
2	2	degraded_due_to_uncalibrated_range_EUVS-A_pointing_qf
4	4	degraded_due_to_calibrated_but_exceeds_requirements_EUVS-A_pointing_qf
8	8	invalid_due_to_EUVS-A_L0_data_checksum_error_qf
16	16	degraded_due_to_EUVS-A_25.6nm_signal_near_zero_qf
32	32	degraded_due_to_EUVS-A_25.6nm_signal_at_saturation_qf
64	64	degraded_due_to_EUVS-A_28.4nm_signal_near_zero_qf
128	128	degraded_due_to_EUVS-A_28.4nm_signal_at_saturation_qf
256	256	degraded_due_to_EUVS-A_30.4nm_signal_near_zero_qf
512	512	degraded_due_to_EUVS-A_30.4nm_signal_at_saturation_qf

EUVS-A L1b Processing and Data Quality Flags (euvsaQualityFlags)		
Flag Mask	**Flag Value**	**Flag Meaning**
1024	1024	degraded_due_to_low_EUVS-A_temperature_qf
2048	2048	degraded_due_to_high_EUVS-A_temperature_qf
4096	4096	degraded_due_to_flatfield_LED_flash_during_EUVS-A_integration_qf
8192	8192	invalid_due_to_invalid_EUVS-A_filter_position_qf
16384	16384	invalid_due_to_invalid_EUVS-A_door_position_qf
32768	32768	degraded_due_to_invalid_EUVS-A_25.6nm_observation_qf
65536	65536	degraded_due_to_invalid_EUVS-A_28.4nm_observation_qf
131072	131072	degraded_due_to_invalid_EUVS-A_30.4nm_observation_qf

Table 7.4.1.5.1.2-5 Solar Flux: EUV Product EUVS-B L1b Processing and Data Quality Flag Values and Meanings

EUVS-B L1b Processing and Data Quality Flags (euvsbQualityFlags)		
Flag Mask	**Flag Value**	**Flag Meaning**
4194303	0	good_quality_qf
1	1	invalid_due_to_out_of_range_EUVS-B_pointing_qf
2	2	degraded_due_to_uncalibrated_range_EUVS-B_pointing_qf
4	4	degraded_due_to_calibrated_but_exceeds_requirements_EUVS-B_pointing_qf
8	8	invalid_due_to_EUVS-B_L0_data_checksum_error_qf
16	16	degraded_due_to_EUVS-B_117.5nm_signal_near_zero_qf
32	32	degraded_due_to_EUVS-B_117.5nm_signal_at_saturation_qf
64	64	degraded_due_to_EUVS-B_121.6nm_signal_near_zero_qf
128	128	degraded_due_to_EUVS-B_121.6nm_signal_at_saturation_qf
256	256	degraded_due_to_EUVS-B_133.5nm_signal_near_zero_qf
512	512	degraded_due_to_EUVS-B_133.5nm_signal_at_saturation_qf
1024	1024	degraded_due_to_EUVS-B_140.5nm_signal_near_zero_qf
2048	2048	degraded_due_to_EUVS-B_140.5nm_signal_at_saturation_qf
4096	4096	degraded_due_to_low_EUVS-B_temperature_qf
8192	8192	degraded_due_to_high_EUVS-B_temperature_qf
16384	16384	degraded_due_to_flatfield_LED_flash_during_EUVS-B_integration_qf
32768	32768	invalid_due_to_invalid_EUVS-B_filter_position_qf
65536	65536	invalid_due_to_invalid_EUVS-B_door_position_qf
131072	131072	degraded_due_to_invalid_EUVS-B_117.5nm_observation_qf
262144	262144	degraded_due_to_invalid_EUVS-B_121.6nm_observation_qf
524288	524288	degraded_due_to_invalid_EUVS-B_133.5nm_observation_qf
1048576	1048576	degraded_due_to_invalid_EUVS-B_140.5nm_observation_qf

2097152	2097152	degraded_due_to_geocorona_condition_qf

Note: The geocorona flag (degraded_due_to_geocorona_condition_qf) is set based on evaluation of only valid EUVS-B input data.

Table 7.4.1.5.1.2-6 Solar Flux: EUV Product EUVS-C L1b Processing and Data Quality Flag Values and Meanings

EUVS-C L1b Processing and Data Quality Flags (euvscQualityFlags)		
Flag Mask	**Flag Value**	**Flag Meaning**
2097151	0	good_quality_qf
1	1	invalid_due_to_out_of_range_EUVS-C_pointing_qf
2	2	degraded_due_to_uncalibrated_range_EUVS-C_pointing_qf
4	4	degraded_due_to_calibrated_but_exceeds_requirements_EUVS-C_pointing_qf
8	8	invalid_due_to_EUVS-C_L0_data_checksum_error_qf
16	16	degraded_due_to_EUVS-C_blue_wing_spectral_region_signals_near_zero_qf
32	32	degraded_due_to_EUVS-C_blue_wing_spectral_region_signals_at_saturation_qf
64	64	degraded_due_to_EUVS-C_red_wing_spectral_region_signals_near_zero_qf
128	128	degraded_due_to_EUVS-C_red_wing_spectral_region_signals_at_saturation_qf
256	256	degraded_due_to_EUVS-C_h-line_spectral_region_signals_near_zero_qf
512	512	degraded_due_to_EUVS-C_h-line_spectral_region_signals_at_saturation_qf
1024	1024	degraded_due_to_EUVS-C_k-line_spectral_region_signals_near_zero_qf
2048	2048	degraded_due_to_EUVS-C_k-line_spectral_region_signals_at_saturation_qf
4096	4096	degraded_due_to_low_EUVS-C_temperature_qf
8192	8192	degraded_due_to_high_EUVS-C_temperature_qf
16384	16384	degraded_due_to_flatfield_LED_flash_during_EUVS-C_integration_qf
32768	32768	degraded_due_to_insufficient_number_of_integrations_after_EUVS-C_reset_qf
65536	65536	invalid_due_to_invalid_EUVS-C_filter_position_qf
131072	131072	invalid_due_to_invalid_EUVS-C_door_position_qf
262144	262144	degraded_due_to_invalid_EUVS-C_h-line_spectral_region_observation_qf
524288	524288	degraded_due_to_invalid_EUVS-C_k-line_spectral_region_observation_qf
1048576	1048576	degraded_due_to_invalid_EUVS-C_blue_wing_spectral_region_observation_qf
2097152	2097152	degraded_due_to_invalid_EUVS-C_red_wing_spectral_region_observation_qf
4194304	4194304	degraded_due_to_at_least_one_invalid_Mg_II_h-line_or_k-line_or_blue_wing_or_red_wing_spectral_region_observation_qf

Table 7.4.1.5.1.2-7 Solar Flux: EUV Product Eclipse Flag Values and Meanings

Eclipse Flags (SC_eclipse_flag)

Flag Value	Flag Meaning
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse
3	penumbra_following_full_eclipse

Table 7.4.1.5.1.2-8 Solar Flux: EUV Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (SC_yaw_flip_flag)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

Table 7.4.1.5.1.2-9 Solar Flux: EUV Product EUVS-C Active Channel Flag Values and Meanings

EUVS-C Active Channel Flag (euvscActiveChannel)	
Flag Value	**Flag Meaning**
0	active_channel_not_set
1	channel_1_active
2	channel_2_active

7.4.1.5.2 Metadata Fields

Once the product’s metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Solar Flux: EUV product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.4.1.5.2 Solar Flux: EUV Product Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2 https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
<dimension name="report_number" isUnlimited="true"/>
<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
<dimension name="max_num_XRS_obs_spectrum_interval" length="30" isUnlimited="false"/>
<dimension name="max_num_EUVS_A_obs_spectrum_interval" length="30" isUnlimited="false"/>
<dimension name="max_num_EUVS_B_obs_spectrum_interval" length="30" isUnlimited="false"/>
<dimension name="max_num_EUVS_C_obs_spectrum_interval" length=”10” isUnlimited="false"/>
<dimension name="wavelength_bin" length="23" isUnlimited="false"/>
<dimension name="solar_array_current_channel_index" length="4" isUnlimited="false"/>
<dimension name="wavelength_bin_str_len" length="20" isUnlimited="false"/>
<dimension name="solar_array_mnemonic_str_len" length="25" isUnlimited="false"/>
<dimension name="num_currents_EUVSA" length="24" isUnlimited="false"/>
<dimension name="num_currents_EUVSB" length="24" isUnlimited="false"/>
<dimension name="max_num_diodes_EUVSC_h_line" length="10" isUnlimited="false"/>
<dimension name="max_num_diodes_EUVSC_k_line" length="10" isUnlimited="false"/>
<dimension name="line_number" length="7" isUnlimited="false"/>
<variable name="ECEF_X" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ECEF X coordinate" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
<attribute name="units" value="m" type="string"/>
</variable>
<variable name="ECEF_Y" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ECEF Y coordinate" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>

```
    <attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="ECEF_Z" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF Z coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-7360.0 7360.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="quaternion_Q0" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q0" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q1" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q1" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q2" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q2" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q3" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q3" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="product_time" type="double" shape="number_of_time_bounds">
    <attribute name="long_name" value="start and end time of observations associated with product" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="double"/>
    <attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
    <values>dynamic value dynamic value</values>
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</variable>
<variable name="time" type="double" shape="report_number">
<attribute name="long_name" value="EUV spectrum observation center time" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="wavelength_bin_label" type="char" shape="wavelength_bin wavelength_bin_str_len">
<attribute name="long_name" value="labels for 23 wavelength bins associated with the EUV proxy spectrum model. labels are ordered the same as applicable data variables" type="string"/>
<values>WaveBin-5_to_10nm WaveBin-10_to_15nm WaveBin-15_to_20nm WaveBin-20_to_25nm WaveBin-25_to_30nm WaveBin-30_to_35nm WaveBin-35_to_40nm WaveBin-40_to_45nm WaveBin-45_to_50nm WaveBin-50_to_55nm WaveBin-55_to_60nm WaveBin-60_to_65nm WaveBin-65_to_70nm WaveBin-70_to_75nm WaveBin-75_to_80nm WaveBin-80_to_85nm WaveBin-85_to_90nm WaveBin-90_to_95nm WaveBin-95_to_100nm WaveBin-100_to_105nm WaveBin-105_to_110nm WaveBin-110_to_115nm WaveBin-117_to_127nm</values>
</variable>
<variable name="solar_array_current_channel_index_label" type="char" shape="solar_array_current_channel_index solar_array_mnemonic_str_len">
<attribute name="long_name" value="labels for four solar array current telemetry mnemonics. labels are ordered the same as applicable data variable" type="string"/>
<values>EPS_SA_CHAN_1_4_RETRN_I EPS_SA_CHAN_5_8_RETRN_I EPS_SA_CHAN_9_12_RETRN_I EPS_SA_CHAN_13_16_RETRN_I</values>
</variable>
<variable name="irradianceSpectrum" type="float" shape="report_number wavelength_bin">
<attribute name="long_name" value="irradiance spectrum for wavelengths between 5 and 127 nm calculated using a proxy model based on inputs from XRS A and B channels, and EUVS A, B. and C channels" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="W m-2 nm-1" type="string"/>
</variable>
<variable name="lowWavelength" type="float" shape="report_number wavelength_bin">
<attribute name="long_name" value="lower limit of each of wavelength bin, all 5nm in width except for the last 10 nm bin, used in EUV spectrum proxy model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="5.0 117.0" type="float"/>
<attribute name="units" value="nm" type="string"/>
</variable>
<variable name="highWavelength" type="float" shape="report_number wavelength_bin">
<attribute name="long_name" value="upper limit of each of wavelength bin, all 5nm in width except for the last 10 nm bin, used in EUV spectrum proxy model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="10.0 127.0" type="float"/>

<attribute name="units" value="nm" type="string"/>
</variable>
<variable name="EUV_CaseNumber" type="ubyte" shape="report_number">
<attribute name="long_name" value="EUV spectrum product quality case number" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="1 8" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="qualityFlags" type="ulong" shape="report_number">
<attribute name="long_name" value="EUVS L1b processing and data quality flags" type="string"/>
<attribute name="_FillValue" value="18446744073709551615" type="ulong"/>
<attribute name="valid_range" value="0 17592186044415" type="ulong"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ulong"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ulong"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="au_factor" type="float" shape="report_number">
<attribute name="long_name" value="earth to sun distance multiplicative correction factor to normalize to 1-AU at time of observation. not applied in EUVS L1b processing" type="string"/>
<attribute name="_FillValue" value="0.0" type="float"/>
<attribute name="valid_range" value="0.966 1.035" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="SC_yaw_flip_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
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<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="nXRS" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of XRS L1b reports generated during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>

<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGoodXRSA" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality XRS-A 0.05 to 0.4 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGoodXRSB" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality XRS-B 0.1 to 0.8 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nEUVSA" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of EUVS-A observations (L0) processed during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGood256" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality EUVS-A 25.6 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGood284" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality EUVS-A 28.4 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGood304" type="ubyte" shape="report_number">

<attribute name="long_name" value="number of calculated good quality EUVS-A 30.4 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nEUVSB" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of EUVS-B observations (L0) processed during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGood1175" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality EUVS-B 117.5 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGood1216" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality EUVS-B 121.6 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGood1335" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality EUVS-B 133.5 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGood1405" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality EUVS-B 140.5 nm irradiance values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 30" type="ubyte"/>

<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nEUVSC" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of EUVS-C observations (L0) processed during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 120" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="nGoodMg" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of calculated good quality Mg II core-to-wing ratio values used in generation of EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 120" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="xrsQualityFlags" type="uint" shape="report_number max_num_XRS_obs_spectrum_interval">
<attribute name="long_name" value="XRS L1b processing and data quality flags" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 524287" type="uint"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="euvsaQualityFlags" type="uint" shape="report_number max_num_EUVS_A_obs_spectrum_interval">
<attribute name="long_name" value="EUVS-A L1b processing and data quality flags" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 262143" type="uint"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="euvsbQualityFlags" type="uint" shape="report_number max_num_EUVS_B_obs_spectrum_interval">
<attribute name="long_name" value="EUVS-B L1b processing and data quality flags" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 4194303" type="uint"/>
<attribute name="units" value="1" type="string"/>

<attribute name="flag_masks" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="euvscQualityFlags" type="uint" shape="report_number max_num_EUVS_C_obs_spectrum_interval">
<attribute name="long_name" value="EUVS-C L1b processing and data quality flags" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 8388607." type="uint"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="euvsaAvgTemp" type="float" shape="report_number">
<attribute name="long_name" value="average temperature of EUVS-A detector during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-142.51690 933.17316" type="float"/>
<attribute name="units" value="degrees_C" type="string"/>
</variable>
<variable name="euvsbAvgTemp" type="float" shape="report_number">
<attribute name="long_name" value="average temperature of EUVS-B detector during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-142.51690 933.17316" type="float"/>
<attribute name="units" value="degrees_C" type="string"/>
</variable>
<variable name="euvsc1AvgTemp" type="float" shape="report_number">
<attribute name="long_name" value="average temperature of EUVS-C detector #1 during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-142.51690 933.17316" type="float"/>
<attribute name="units" value="degrees_C" type="string"/>
</variable>
<variable name="euvsc2AvgTemp" type="float" shape="report_number">
<attribute name="long_name" value="average temperature of EUVS-C detector #2 during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-142.51690 933.17316" type="float"/>

<attribute name="units" value="degrees_C" type="string"/>
</variable>
<variable name="avgIrradianceXRSA" type="float" shape="report_number">
<attribute name="long_name" value="average primary irradiance at wavelengths between 0.05 and 0.4 nm (XRS-A) during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 0.04" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
<attribute name="mask_of_xrsQualityFlags_excluded_from_average" value="65536" type="uint"/>
</variable>
<variable name="avgIrradianceXRSB" type="float" shape="report_number">
<attribute name="long_name" value="average primary irradiance at wavelengths between 0.1 and 0.8 nm (XRS-B) during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 0.03" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
<attribute name="mask_of_xrsQualityFlags_excluded_from_average" value="131072" type="uint"/>
</variable>
<variable name="avgIrradiance256" type="float" shape="report_number">
<attribute name="long_name" value="EUVS-A 25.6 nm average irradiance during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 2.0" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
<attribute name="mask_of_euvsaQualityFlags_excluded_from_average" value="32768" type="uint"/>
</variable>
<variable name="avgIrradiance284" type="float" shape="report_number">
<attribute name="long_name" value="EUVS-A 28.4 nm average irradiance during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 2.0" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
<attribute name="mask_of_euvsaQualityFlags_excluded_from_average" value="65536" type="uint"/>
</variable>
<variable name="avgIrradiance304" type="float" shape="report_number">
<attribute name="long_name" value="EUVS-A 30.4 nm average irradiance during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 3.0" type="float"/>

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      <attribute name="units" value="W m-2" type="string"/>
      <attribute name="mask_of_euvsaQualityFlags_excluded_from_average" value="131072" type="uint"/>
    </variable>
    <variable name="avgIrradiance1175" type="float" shape="report_number">
      <attribute name="long_name" value="EUVS-B 117.5 nm average irradiance during time interval associated with EUV proxy spectrum model"
type="string"/>
      <attribute name="_FillValue" value="-999.0" type="float"/>
      <attribute name="valid_range" value="0.0 1.0" type="float"/>
      <attribute name="units" value="W m-2" type="string"/>
      <attribute name="mask_of_euvsbQualityFlags_excluded_from_average" value="131072" type="uint"/>
    </variable>
    <variable name="avgIrradiance1216" type="float" shape="report_number">
      <attribute name="long_name" value="EUVS-B 121.6 nm average irradiance during time interval associated with EUV proxy spectrum model"
type="string"/>
      <attribute name="_FillValue" value="-999.0" type="float"/>
      <attribute name="valid_range" value="0.0 1.0" type="float"/>
      <attribute name="units" value="W m-2" type="string"/>
      <attribute name="mask_of_euvsbQualityFlags_excluded_from_average" value="262144" type="uint"/>
    </variable>
    <variable name="avgIrradiance1335" type="float" shape="report_number">
      <attribute name="long_name" value="EUVS-B 133.5 nm average irradiance during time interval associated with EUV proxy spectrum model"
type="string"/>
      <attribute name="_FillValue" value="-999.0" type="float"/>
      <attribute name="valid_range" value="0.0 1.0" type="float"/>
      <attribute name="units" value="W m-2" type="string"/>
      <attribute name="mask_of_euvsbQualityFlags_excluded_from_average" value="524288" type="uint"/>
    </variable>
    <variable name="avgIrradiance1405" type="float" shape="report_number">
      <attribute name="long_name" value="EUVS-B 140.5 nm average irradiance during time interval associated with EUV proxy spectrum model"
type="string"/>
      <attribute name="_FillValue" value="-999.0" type="float"/>
      <attribute name="valid_range" value="0.0 1.0" type="float"/>
      <attribute name="units" value="W m-2" type="string"/>
      <attribute name="mask_of_euvsbQualityFlags_excluded_from_average" value="1048576" type="uint"/>
    </variable>
    <variable name="avgRatioMgExis" type="float" shape="report_number">
      <attribute name="long_name" value="EUVS-C average EXIS Mg II core-to-wing ratio during time interval associated with EUV proxy spectrum model"
type="string"/>
      <attribute name="_FillValue" value="-999.0" type="float"/>
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<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<attribute name="mask_of_euvscQualityFlags_excluded_from_average" value="4194304" type="uint"/>
</variable>
<variable name="avgRatioMgNoaa" type="float" shape="report_number">
<attribute name="long_name" value="EUVS-C average NOAA historical Mg II core-to-wing ratio during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
<attribute name="mask_of_euvscQualityFlags_excluded_from_average" value="4194304" type="uint"/>
</variable>
<variable name="ObservationTimesEUVSAB" type="double" shape="report_number max_num_EUVS_A_obs_spectrum_interval">
<attribute name="long_name" value="spectrum observation center time for 1 second high time resolution EUVS-A and EUVS-B measurements" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="ObservationTimesEUVSC" type="double" shape="report_number max_num_EUVS_C_obs_spectrum_interval">
<attribute name="long_name" value="spectrum observation center time for 1 second high time resolution EUVS-C measurement" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="CurrentsEUVSA" type="float" shape="report_number max_num_EUVS_A_obs_spectrum_interval num_currents_EUVSA">
<attribute name="long_name" value="currents at observation time for each EUVS-A diode in telemetry order" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.000000001" type="float"/>
<attribute name="units" value="ampere" type="string"/>
</variable>
<variable name="CurrentsEUVSB" type="float" shape="report_number max_num_EUVS_B_obs_spectrum_interval num_currents_EUVSB">
<attribute name="long_name" value="currents at observation time for each EUVS-B diode in telemetry order" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.000000000001 0.000000001" type="float"/>
<attribute name="units" value="ampere" type="string"/>
</variable>
<variable name="SignalsEUVSC_hLine" type="float" shape="report_number max_num_EUVS_C_obs_spectrum_interval max_num_diodes_EUVSC_h_line">

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    <attribute name="long_name" value="signals at observation time for the first 10 EUVSC diodes masked by the MgII h line mask in telemetry order" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="0.0 40000.0" type="float"/>
    <attribute name="units" value="count" type="string"/>
  </variable>
  <variable name="SignalsEUVSC_kLine" type="float" shape="report_number max_num_EUVS_C_obs_spectrum_interval max_num_diodes_EUVSC_k_line">
    <attribute name="long_name" value="signals at observation time for the first 10 EUVSC diodes masked by the MgII k line mask in telemetry order" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="0.0 40000.0" type="float"/>
    <attribute name="units" value="count" type="string"/>
  </variable>
  <variable name="IntegratedSignalsEUVSC_BlueWing" type="float" shape="report_number max_num_EUVS_C_obs_spectrum_interval">
    <attribute name="long_name" value="blue wing signal at observation time" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="0.0 65534.0" type="float"/>
    <attribute name="units" value="count" type="string"/>
  </variable>
  <variable name="IntegratedSignalsEUVSC_RedWing" type="float" shape="report_number max_num_EUVS_C_obs_spectrum_interval">
    <attribute name="long_name" value="red wing signal at observation time" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="0.0 65534.0" type="float"/>
    <attribute name="units" value="count" type="string"/>
  </variable>
  <variable name="IntegratedSignalsEUVSC_DarkMask" type="float" shape="report_number max_num_EUVS_C_obs_spectrum_interval">
    <attribute name="long_name" value="dark signal at observation time" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="-100.0 100.0" type="float"/>
    <attribute name="units" value="count" type="string"/>
  </variable>
  <variable name="Average_SPS_dispersion_angle" type="float" shape="report_number">
    <attribute name="long_name" value="average dispersion direction pointing angle from SPS during time interval associated with EUV proxy spectrum model" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="-10.0 10.0" type="float"/>
    <attribute name="units" value="degree" type="string"/>
  </variable>
```

<variable name="Average_SPS_cross_dispersion_angle" type="float" shape="report_number">
<attribute name="long_name" value="average cross-dispersion direction pointing angle from SPS during time interval associated with EUV proxy spectrum model" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-10.0 10.0" type="float"/>
<attribute name="units" value="degree" type="string"/>
</variable>
<variable name="solar_array_current" type="ushort" shape="report_number solar_array_current_channel_index">
<attribute name="long_name" value="solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="SC_eclipse_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="euvscIntegrationTime" type="float" shape="report_number">
<attribute name="long_name" value="EUVS-C packet integration time, in seconds" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.25 64.0" type="float"/>
<attribute name="units" value="seconds" type="string"/>
</variable>
<variable name="Total_SPS_angles" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of SPS measurements used to determine the Average_SPS_dispersion_angle and Average_SPS_cross_dispersion_angle values" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 120" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="Total_valid_SPS_angle_pairs" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of valid SPS measurements used during XRS L1b processing" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 120" type="ubyte"/>
<attribute name="units" value="count" type="string"/>

</variable>
<variable name="euvscActiveChannel" type="ubyte" shape="report_number">
<attribute name="long_name" value="indicates which EUVSC channel is active" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="lowWavelengthLines" type="float" shape="report_number line_number">
<attribute name="long_name" value="lower edge of bandpass for line irradiances at 25.6, 28.4, 30.4, 117.5, 121.6. 133.5, and 140.5 nm" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="20.0 150.0" type="float"/>
<attribute name="units" value="nm" type="string"/>
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</variable>
<variable name="highWavelengthLines" type="float" shape="report_number line_number">
<attribute name="long_name" value="upper edge of bandpass for line irradiances at 25.6, 28.4, 30.4, 117.5, 121.6. 133.5, and 140.5 nm" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="20.0 150.0" type="float"/>
<attribute name="units" value="nm" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="percent_uncorrectable_L0_errors" type="float" shape="">
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<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
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</variable>
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<attribute name="project" value="GOES" type="string"/>
<attribute name="iso_series_metadata_id" value="f7087580-e5a8-11e3-ac10-0800200c9a66" type="string"/>
<attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>

<attribute name="title" value="EXIS XRS L1b Solar Flux: EUV" type="string"/>
<attribute name="summary" value="The Solar Flux: EUV product consists of a solar irradiance spectrum proxy model covering the wavelength range from 5 to 127 nm during a 30 second interval. To generate this proxy model, measurements are obtained from channels XRS-A and XRS-B, sensing wavelength ranges between 0.05 and 0.4 nm, and 0.1 and 0.8 nm, respectively. Measurement are also obtained from EUVS-A at wavelengths 25.6, 28.4, and 30.4 nm, EUVS-B at wavelengths 117.5, 121.6, 133.5, and 140.5 nm, and EUVS-C at the extreme ultraviolet h-line and k-line, blue wing, and red wing spectral regions. In addition, the product contains average irradiance and MG II core-to-wing ratio values, as applicable, from the contributing XRS and EUVS detectors over the time interval associated with EUV proxy spectrum model, and, in the case of EUVS measurements, the previous 24 hours. Furthermore, the product contains XRS and EUVS observation count statistics, processing and data quality metadata, satellite state and location information, and data required for the generation of level 2 products." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SPECTRAL/ENGINEERING > ULTRAVIOLET WAVELENGTHS > ULTRAVIOLET FLUX, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR IRRADIANCE, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR ULTRAVIOLET EMISSIONS" type="string"/>
<attribute name="cdm_data_type" value="Profile" type="string"/>
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<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES-R Series EXIS Extreme Ultraviolet Sensor" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument (sensor).***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data; not in use" type="string"/>
<attribute name="input_EUVS_L0_data" value="null" type="string"/>
<attribute name="input_XRS_L1b_data" value="null" type="string"/>
</variable>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note "flags and meanings": Flag values and meanings are located in paragraph 7.4.1.5.1.2, Solar Flux: EUV Product Flag Values and Meanings.

7.4.2 Solar Flux: X-Ray Product

7.4.2.1 Description

The Solar Flux: X-Ray product contains up to 30 irradiance values in the X-ray portion of the electromagnetic spectrum. Irradiance values are produced at one-second observation intervals, so each Solar Flux: X-Ray product spans 30 seconds. Two values are obtained from both the XRS-A and XRS-B sensors. XRS-A has a band pass of 0.05 to 0.4 nm, and XRS-B has a band pass of 0.1 to 0.8 nm. To span the full dynamic X-ray irradiance range over the eleven year solar cycle, the XRS-A and XRS-B include a solar minimum and a solar maximum detector. The resulting irradiance value from each detector is included in the product. Indication is provided of whether the irradiance value from the solar minimum or solar maximum detector is the primary irradiance value for each channel. The product includes processing and data quality information associated with the availability and characteristics of the observation data received from the XRS, the generation of the product irradiance values, and indications that the observation data may be invalid.

The units of measure for the solar irradiance values are "watts per square meter".

The precise look angles of the angular zones relative to the GOES-R spacecraft body reference frame required for use and subsequent processing of this level 1b product data are available from the Product Distribution and Access system.

The Solar Flux: X-Ray performance requirements are summarized in Table 7.4.2.1, Solar Flux: X-Ray Performance Requirements.

Table 7.4.2.1 Solar Flux: X-Ray Performance Requirements

	Measurement			Mapping
Region	**Range**	**Accuracy**	**Precision**	**Uncertainty**
solar disk	(1) XRS-A: 5 x 10^{-9} to 5 x 10^{-4} W/m^2 (2) XRS-B: 2 x 10^{-8} to 2 x 10^{-3} W/m^2	+/- 20% at 20 times the specified minimum flux	2%	+/- 2 arcmin

Metadata in the Solar Flux: X-Ray product provides statistical and other properties of the observation and processed data and information required for the generation of level 2 products, and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the observation data in the product.
- Time of each observation.
- Satellite location, spacecraft ACRF to J2000 ECI attitude quaternion, and earth to sun distance.
- Eclipse of the sun and other field of view related indications.
- Satellite yaw flip configuration.
- Mean SPS dispersion and cross-dispersion angles, and number of SPS observations associated with the XRS observation.
- Ratio between XRS-A and XRS-B irradiance values.
- Corrected current values for the XRS-A and XRS-B solar maximum detectors.
- EXIS and XRS component configuration information and settings.
- Temperature of the XRS-A and XRS-B ASICs, and Sun Positioning Sensor.
- XRS and SPS observation and integration times.

7.4.2.2 Dynamic Source Data

The Solar Flux: X-Ray product is derived using XRS Level 0 raw science telemetry, EXIS engineering telemetry, and satellite ephemeris related telemetry.

The primary sensor data used by the Level 1b Solar Flux: X-Ray algorithm is identified in Table 7.4.2.2, Primary Sensor Data.

Table 7.4.2.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_XRS_L0_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.4.2.3 Level 1b Semi-Static Source Data

There are two categories of semi-static source data employed in the XRS Level 1b ground processing algorithm:

- Sensor calibration parameters.
- Solar calibration parameters

Semi-static source data files from the two categories above are contained in a single zip file, rolled up to the instrument level - all EXIS semi-static parameter files are in one zip file. Some files fit into more than one category.

Sensor calibration parameters are those associated with the XRS and SPS sensors' radiometric and geometric observing characteristics, its raw outputs, and the subsequent calibration related processing. The XRS is composed of sensor subcomponents, XRS-A and XRS-B. Specific types of sensor calibration parameters for the sensors and sensor subcomponents are defined in Table 7.4.2.3, XRS Level 1b Algorithm Sensor Calibration Parameters.

Table 7.4.2.3 XRS Level 1b Algorithm Sensor Calibration Parameters

Description of Parameter(s)	XRS Sensor	XRS-A Channel	XRS-B Channel	SPS Sensor
Number of sensor diodes	x			x
Number of diode layout table columns	x			
Number of days in the in-flight gain correction factor table	x			x
Number of Digital Number samples in the temperature look-up tables	x			x
Number of angles in the field of view correction factor tables	x			x
Number of samples in the linear gain correction factor tables	x			x
Processing interval	x			
Dark diode history interval	x			
Instrument invalid flag processing values	x			x
Minimum and maximum bad dispersion and cross-dispersion angle thresholds	x			
Minimum and maximum degraded and warning dispersion and cross-dispersion angle thresholds	x			
Valid integration time threshold for processing	x			x

Valid detector change count thresholds for processing	x			x
Diode layout table mapping to ASIC and channel	x			x
Sensor integration time calibration parameters	x			x
Temperature calibration tables	x			x
Detector low and high temperature limits	x			x
Diode saturation threshold values		x	x	
Diode minimum dark-corrected current amplitude threshold values		x	x	
Temperature-dependent pre-flight gain coefficient tables	x			x
Time-dependent gain correction factor tables	x			x
Amplitude-dependent signal linearity correction factor tables	x			x
Uncalibrated diode electrometer signal table	x			x
Temperature-dependent diode thermal dark signal tables	x			x
Dark diode weighting factors	x			
Diode dark current scaling factor tables	x			
Channel responsivity tables		x	x	
Instrument field of view dispersion and cross-dispersion correction factor angle tables	x			
Instrument field of view dispersion and cross-dispersion correction factor tables		x	x	
Channel irradiance threshold for setting the primary channel flag		x	x	
Minimum total signal threshold for determining if the SPS sensor is operating within an acceptable range of pointing angles				x
Dispersion and cross-dispersion pointing angle tables				x
Parameter to convert normalized pointing values to pointing table indices				x

Solar calibration parameters are those associated with the distance, on a daily basis, between the earth and the sun.

The filename conventions for the XRS Level 1b semi-static source data file are located in Appendix C.

7.4.2.4 Production Notes

The Solar Flux: X-Ray product is generated by EXIS Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm extracts the raw detector observation data from the CCSDS packets. The Level 1b algorithm converts the raw data from the XRS-A and XRS-B detectors into electrical current. The Level 1b algorithm removes the effects of background radiation, and the detectors' thermal contributions, and converts the solar minimum and the solar maximum currents to irradiance values using the instrument responsivity and field of view correction data generated from the SPS pointing data. In addition, the primary irradiance values for XRS-A and XRS-B are determined.

The L1b algorithm executes and product data is generated when the instrument is in any mode, but not when the satellite is in the on-orbit storage mode. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.4.2.5 Data Organization and Fields

A Solar Flux: X-Ray product spans up to 31 GRB Space Packets, nominally 30 packets of 1 second data and one packet for the metadata. A product, which contains a set of irradiance and related data values for a 30 second period, is transmitted over GRB in one second reports. These one second reports can be exploited upon receipt. Nominally, a product metadata packet is queued for transmission after the thirtieth report has been queued for transmission.

The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, label variable, and product start and end time variable.

The subordinate paragraphs that follow define the Solar Flux: X-Ray product data, flag values and meanings, and metadata fields.

7.4.2.5.1 Data Fields

Table 7.4.2.5.1 Solar Flux: X-Ray Product Data

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
irradiance_xrsa1	float	n/a	irradiance at wavelengths between 0.05 and 0.4 nm calculated from XRS-A solar minimum channel (photodiode) based on a flat spectrum	W m-2	4	0
irradiance_xrsa2	float	n/a	irradiance at wavelengths between 0.05 and 0.4 nm calculated from XRS-A solar maximum channel (quadrant photodiode) based on a flat spectrum	W m-2	4	4
primary_xrsa	ubyte	n/a	flags indicating which of two XRS-A channels, solar minimum channel 1 or solar maximum channel 2, provides the primary irradiance value	1	1	8
irradiance_xrsb1	float	n/a	irradiance at wavelengths between 0.1 and 0.8 nm calculated from XRS-B solar minimum channel (photodiode) based on a flat spectrum	W m-2	4	9
irradiance_xrsb2	float	n/a	irradiance at wavelengths between 0.1 and 0.8 nm calculated from XRS-B solar maximum channel (quadrant photodiode) based on a flat spectrum	W m-2	4	13

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
primary_xrsb	ubyte	n/a	flags indicating which of two XRS-B channels, solar minimum channel 1 or solar maximum channel 2, provides the primary irradiance value	1	1	17
xrs_ratio	float	n/a	ratio calculated by XRS-A primary irradiance divided by XRS-B primary irradiance	1	4	18
corrected_current_xrsa_1	float	n/a	corrected current for 1st quadrant of XRS-A solar maximum channel's quadrant photodiode	A	4	22
corrected_current_xrsa_2	float	n/a	corrected current for 2nd quadrant of XRS-A solar maximum channel's quadrant photodiode	A	4	26
corrected_current_xrsa_3	float	n/a	corrected current for 3rd quadrant of XRS-A solar maximum channel's quadrant photodiode	A	4	30
corrected_current_xrsa_4	float	n/a	corrected current for 4th quadrant of XRS-A solar maximum channel's quadrant photodiode	A	4	34
corrected_current_xrsb_1	float	n/a	corrected current for 1st quadrant of XRS-B solar maximum channel's quadrant photodiode	A	4	38
corrected_current_xrsb_2	float	n/a	corrected current for 2nd quadrant of XRS-B solar maximum channel's quadrant photodiode	A	4	42
corrected_current_xrsb_3	float	n/a	corrected current for 3rd quadrant of XRS-B solar maximum channel's quadrant photodiode	A	4	46
corrected_current_xrsb_4	float	n/a	corrected current for 4th quadrant of XRS-B solar maximum channel's quadrant photodiode	A	4	50
dispersion_angle	float	n/a	average dispersion direction pointing angle from SPS during time interval associated with observation	degree	4	54
crossdispersion_angle	float	n/a	average cross-dispersion direction pointing angle from SPS during time interval associated with observation	degree	4	58
sc_power_side	ubyte	n/a	flags indicating which of two EXIS power boards, A or B, is active	1	1	62
exis_flight_model	ubyte	n/a	flags indicating EXIS flight model. also serves as serial number of instrument	1	1	63
exis_configuration_id	ushort	n/a	EXIS configuration identifier	1	2	64
xrs_runctrlmd	ubyte	n/a	flags indicating XRS internal gain calibration circuit and data retrieval indicator settings	1	1	66
integration_time	float	n/a	XRS integration time used to collect data associated with observation	s	4	67

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
exs_sl_pwr_ena	ubyte	n/a	flags indicating whether power to currently selected EXIS stimulus lamp is enabled	1	1	71
asic1_temperature	float	n/a	temperature of XRS ASIC board #1	degrees_C	4	72
asic2_temperature	float	n/a	temperature of XRS ASIC board #2	degrees_C	4	76
invalid_flags	ubyte	n/a	flags indicating observation data may be invalid	1	1	80
xrs_det_chg	uint32	n/a	count of XRS detector measurements since last sensor power-on or settings change	count	4	81
xrs_mode	ubyte	n/a	instrument (sensor) mode	1	1	85
sps_obs_time control field(s)	uint64	number of control fields = 1	sps_measurement_count = 4	1	8	86
sps_obs_time	double	sps_measurement _count = 4	time of observation for each SPS 4 Hz measurement	seconds since 2000-01-01 12:00:00, neglecting leap seconds	32	94
sps_int_time control field(s)	uint64	number of control fields = 1	sps_measurement_count = 4	1	8	126
sps_int_time	float	sps_measurement _count = 4	SPS integration time for each (4 Hz) SPS measurement	s	16	134
sps_temperature control field(s)	uint64	number of control fields = 1	sps_measurement_count = 4	1	8	150
sps_temperature	float	sps_measurement _count = 4	temperature of SPS detector for (4 Hz) each SPS measurement	degrees_C	16	158
sps_det_chg control field(s)	uint64	number of control fields = 1	n/a	1	8	174
sps_det_chg	uint32	sps_measurement _count = 4	counter, which resets after SPS power-on or setting change, indicating whether to disregard observation (conditions to disregard: .lt. configurable value after power on; .lt. configurable value after internal gain calibration)	count	16	182
num_angle_pairs	ushort	n/a	number of valid SPS measurements used during XRS L1b processing	count	2	198

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
yaw_flip_flag	ubyte	n/a	flags indicating whether spacecraft is operating in yaw flip configuration	1	1	200
au_factor	float	n/a	earth to sun distance multiplicative correction factor to normalize to 1-AU at time of observation. not applied in XRS L1b product processing	1	4	201
quality_flags	uint32	n/a	XRS L1b processing and data quality flags	1	4	205
time	double	n/a	XRS observation center time	seconds	8	209
packet_count	uint32	n/a	current count of XRS L0 primary header telemetry packets received since instrument start-up or reset	count	4	217
fov_unknown	ubyte	n/a	flags indicating whether instrument has received field-of-view information (eclipse, planetary and lunar transit, off-pointing calibration maneuver conditions) provided by ground system	1	1	221
fov_eclipse	ubyte	n/a	flags indicating whether sun being obscured by earth is imminent or in progress as provided by ground system	1	1	222
fov_lunar_transit	ubyte	n/a	flags indicating whether lunar transit across sun is imminent or in progress as provided by ground system	1	1	223
fov_planet_transit	ubyte	n/a	flags indicating whether planetary transit across sun is imminent or in progress as provided by ground system	1	1	224
fov_off_point	ubyte	n/a	flags indicating whether off-pointing calibration maneuver is imminent or in progress as provided by ground system	1	1	225
quaternion_q0	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q0	1	4	226
quaternion_q1	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q1	1	4	230
quaternion_q2	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q2	1	4	234
quaternion_q3	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q3	1	4	238
ecef_X	float	n/a	spacecraft ECEF X coordinate	m	4	242
ecef_Y	float	n/a	spacecraft ECEF Y coordinate	m	4	246
ecef_Z	float	n/a	spacecraft ECEF Z coordinate	m	4	250
solar_array_current control field(s)	uint64	number of control fields = 1	solar_array_current_channel_index = 4	1	8	254
solar_array_current	ushort	solar_array_current_channel_index = 4	solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)	1	8	262

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
SC_eclipse_flag	ubyte	n/a	flags indicating whether sun is obscured by earth as provided by spacecraft	1	1	270

7.4.2.5.1.1 Solar Flux: X-Ray Product Flag Values and Meanings

Table 7.4.2.5.1.1-1 Solar Flux: X-Ray Product XRS-A Primary Irradiance Flag Values and Meanings

XRS-A Primary Irradiance Flags (primary_xrsa)	
Flag Value	**Flag Meaning**
0	solar_minimum_channel_1_is_primary
1	solar_maximum_channel_2_is_primary

Table 7.4.2.5.1.1-2 Solar Flux: X-Ray Product XRS-B Primary Irradiance Flag Values and Meanings

XRS-B Primary Irradiance Flags (primary_xrsb)	
Flag Value	**Flag Meaning**
0	solar_minimum_channel_1_is_primary
1	solar_maximum_channel_2_is_primary

Table 7.4.2.5.1.1-3 Solar Flux: X-Ray Product XRS L1b Processing and Data Quality Flag Values and Meanings

XRS L1b Processing and Data Quality Flags (quality_flags)		
Flag Mask	**Flag Value**	**Flag Meaning**
524287	0	good_quality_qf
1	1	invalid_due_to_out_of_range_XRS_pointing_qf
2	2	degraded_due_to_uncalibrated_range_XRS_pointing_qf
4	4	degraded_due_to_calibrated_but_exceeds_requirements_XRS_pointing_qf
8	8	invalid_due_to_XRS_L0_data_checksum_error_qf
16	16	degraded_due_to_low_XRS_A_and_B_temperature_qf
32	32	degraded_due_to_high_XRS_A_and_B_temperature_qf
64	64	degraded_due_to_XRS-A_solar_minimum_channel_signal_near_zero_qf
128	128	degraded_due_to_XRS-A_solar_maximum_channel_signal_near_zero_qf

256	256	degraded_due_to_XRS-B_solar_minimum_channel_signal_near_zero_qf
512	512	degraded_due_to_XRS-B_solar_maximum_channel_signal_near_zero_qf
1024	1024	degraded_due_to_XRS-A_solar_minimum_channel_signal_at_saturation_qf
2048	2048	degraded_due_to_XRS-A_solar_maximum_channel_signal_at_saturation_qf
4096	4096	degraded_due_to_XRS-B_solar_minimum_channel_signal_at_saturation_qf
8192	8192	degraded_due_to_XRS-B_solar_maximum_channel_signal_at_saturation_qf
16384	16384	degraded_due_to_flatfield_LED_flash_during_XRS_integration_qf
32768	32768	degraded_due_to_insufficient_number_of_integrations_after_XRS_reset_qf
65536	65536	degraded_due_to_non-nominal_XRS-A_irradiance_qf
131072	131072	degraded_due_to_non-nominal_XRS-B_irradiance_qf
262144	262144	degraded_due_to_out_of_valid_range_primary_XRS-B_to_XRS-A_irradiance_ratio_qf

Table 7.4.2.5.1.1-4 Solar Flux: X-Ray Product Potentially Invalid Data Quality Flag Values and Meanings

Potentially Invalid Flags (invalid_flags)	
Flag Value	**Flag Meaning**
0	no_potentially_invalid_condition
1	potentially_invalid_due_to_XRS_integration_time_change
2	potentially_invalid_due_to_stimulus_lamp_power_change
4	EDAC_single_bit_error_detected_and_corrected
8	potentially_invalid_due_to_EDAC_multi_bit_error_detected

Table 7.4.2.5.1.1-5 Solar Flux: X-Ray Product Field of View Data Availability Flag Values and Meanings

Field of View Data Availability Flags (fov_unknown)	
Flag Value	**Flag Meaning**
0	known
1	unknown

Table 7.4.2.5.1.1-6 Solar Flux: X-Ray Product Eclipse in Field of View Flag Values and Meanings

Eclipse in Field of View Flags (fov_eclipse)	
Flag Value	**Flag Meaning**
0	false
1	true

Table 7.4.2.5.1.1-7 Solar Flux: X-Ray Product Lunar Transit in Field of View Flag Values and Meanings

Lunar Transit in Field of View Flags (fov_lunar_transit)	
Flag Value	**Flag Meaning**

0	false
1	true

Table 7.4.2.5.1.1-8 Solar Flux: X-Ray Product Planet Transit in Field of View Flag Values and Meanings

Planet Transit in Field of View Flags (fov_planet_transit)	
Flag Value	**Flag Meaning**
0	false
1	true

Table 7.4.2.5.1.1-9 Solar Flux: X-Ray Product Off-Pointing Field of View Flag Values and Meanings

Off-Pointing Field of View Flags (fov_off_point)	
Flag Value	**Flag Meaning**
0	false
1	true

Table 7.4.2.5.1.1-10 Solar Flux: X-Ray Product XRS Instrument Mode Flag Values and Meanings

XRS Instrument Mode Flags (xrs_mode)	
Flag Value	**Flag Meaning**
0	operational_mode
1	in-flight_calibration_mode
2	instrument_diagnostic_mode
3	failsafe_recovery_mode

Table 7.4.2.5.1.1-11 Solar Flux: X-Ray Product XRS Internal Settings Flag Values and Meanings

XRS Internal Settings Flags (xrs_runctrlmd)	
Flag Value	**Flag Meaning**
0	bad_data_no_mode
1	science_observation_in_progress
2	calibration_in_progress
3	bad_data_undetermined_mode

Table 7.4.2.5.1.1-12 Solar Flux: X-Ray Product EXIS Power Configuration Flag Values and Meanings

EXIS Power Configuration Flags (sc_power_side)	
Flag Value	**Flag Meaning**
0	EXIS_power_board_A_active
1	EXIS_power_board_B_active
2	EXIS_power_board_A_and_B_failure_type_1

3	EXIS_power_board_A_and_B_failure_type_2

Table 7.4.2.5.1.1-13 Solar Flux: X-Ray Product EXIS Stimulus Lamp Power Flag Values and Meanings

EXIS Stimulus Lamp Power Flags (exs_sl_pwr_ena)	
Flag Value	**Flag Meaning**
0	power_disabled
1	power_enabled

Table 7.4.2.5.1.1-14 Solar Flux: X-Ray Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (yaw_flip_flag)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

Table 7.4.2.5.1.1-15 Solar Flux: X-Ray Product Eclipse Flag Values and Meanings

Eclipse Flags (SC_eclipse_flag)	
Flag Value	**Flag Meaning**
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse
3	penumbra_following_full_eclipse

7.4.2.5.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Solar Flux: X-Ray product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.4.2.5.2 Solar Flux: X-Ray Product Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2 https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">

```xml
  <dimension name="report_number" isUnlimited="true"/>
  <dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
  <dimension name="sps_measurement_count" length="4" isUnlimited="false"/>
  <dimension name="solar_array_current_channel_index" length="4" isUnlimited="false"/>
  <dimension name="solar_array_mnemonic_str_len" length="25" isUnlimited="false"/>
  <variable name="ecef_X" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF X coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="ecef_Y" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF Y coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="ecef_Z" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF Z coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-7360.0 7360.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="quaternion_Q0" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q0" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q1" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q1" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q2" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q2" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
```

<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="quaternion_Q3" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q3" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="product_time" type="double" shape="number_of_time_bounds">
<attribute name="long_name" value="start and end time of observations associated with product" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
<values>***dynamic value dynamic value***</values>
</variable>
<variable name="time" type="double" shape="report_number">
<attribute name="long_name" value="XRS observation center time" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="solar_array_current_channel_index_label" type="char" shape="solar_array_current_channel_index solar_array_mnemonic_str_len">
<attribute name="long_name" value="labels for four solar array current telemetry mnemonics. labels are ordered the same as applicable data variable" type="string"/>
<values>EPS_SA_CHAN_1_4_RETRN_I EPS_SA_CHAN_5_8_RETRN_I EPS_SA_CHAN_9_12_RETRN_I EPS_SA_CHAN_13_16_RETRN_I</values>
</variable>
<variable name="irradiance_xrsa1" type="float" shape="report_number">
<attribute name="long_name" value="irradiance at wavelengths between 0.05 and 0.4 nm calculated from XRS-A solar minimum channel (photodiode) based on a flat spectrum" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000001 0.003" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
</variable>
<variable name="irradiance_xrsa2" type="float" shape="report_number">
<attribute name="long_name" value="irradiance at wavelengths between 0.05 and 0.4 nm calculated from XRS-A solar maximum channel (quadrant photodiode) based on a flat spectrum" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.0000005 0.2" type="float"/>
<attribute name="units" value="W m-2" type="string"/>

</variable>
<variable name="primary_xrsa" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating which of two XRS-A channels, solar minimum channel 1 or solar maximum channel 2, provides the primary irradiance value" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="irradiance_xrsb1" type="float" shape="report_number">
<attribute name="long_name" value="irradiance at wavelengths between 0.1 and 0.8 nm calculated from XRS-B solar minimum channel (photodiode) based on a flat spectrum" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000001 0.003" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
</variable>
<variable name="irradiance_xrsb2" type="float" shape="report_number">
<attribute name="long_name" value="irradiance at wavelengths between 0.1 and 0.8 nm calculated from XRS-B solar maximum channel (quadrant photodiode) based on a flat spectrum" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.0000005 0.2" type="float"/>
<attribute name="units" value="W m-2" type="string"/>
</variable>
<variable name="primary_xrsb" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating which of two XRS-B channels, solar minimum channel 1 or solar maximum channel 2, provides the primary irradiance value" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="xrs_ratio" type="float" shape="report_number">
<attribute name="long_name" value="ratio calculated by XRS-A primary irradiance divided by XRS-B primary irradiance" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 9999999.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>

<variable name="corrected_current_xrsa_1" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 1st quadrant of XRS-A solar maximum channel’s quadrant photodiode" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="corrected_current_xrsa_2" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 2nd quadrant of XRS-A solar maximum channel’s quadrant photodiode" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="corrected_current_xrsa_3" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 3rd quadrant of XRS-A solar maximum channel’s quadrant photodiode" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="corrected_current_xrsa_4" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 4th quadrant of XRS-A solar maximum channel’s quadrant photodiode" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="corrected_current_xrsb_1" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 1st quadrant of XRS-B solar maximum channel’s quadrant photodiode" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="corrected_current_xrsb_2" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 2nd quadrant of XRS-B solar maximum channel’s quadrant photodiode" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="corrected_current_xrsb_3" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 3rd quadrant of XRS-B solar maximum channel’s quadrant photodiode" type="string"/>

<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="corrected_current_xrsb_4" type="float" shape="report_number">
<attribute name="long_name" value="corrected current for 4th quadrant of XRS-B solar maximum channel's quadrant photodiode" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-0.000000000001 0.0000001" type="float"/>
<attribute name="units" value="A" type="string"/>
</variable>
<variable name="dispersion_angle" type="float" shape="report_number">
<attribute name="long_name" value="average dispersion direction pointing angle from SPS during time interval associated with observation" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-10.0 10.0" type="float"/>
<attribute name="units" value="degree" type="string"/>
</variable>
<variable name="crossdispersion_angle" type="float" shape="report_number">
<attribute name="long_name" value="average cross-dispersion direction pointing angle from SPS during time interval associated with observation" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-10.0 10.0" type="float"/>
<attribute name="units" value="degree" type="string"/>
</variable>
<variable name="sc_power_side" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating which of two EXIS power boards, A or B, is active" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="exis_flight_model" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating EXIS flight model. also serves as serial number of instrument" type="string"/>
<attribute name="_FillValue" value="0" type="ubyte"/>
<attribute name="valid_range" value="1 255" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="exis_configuration_id" type="ushort" shape="report_number">

<attribute name="long_name" value="EXIS configuration identifier" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="xrs_runctrlmd" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating XRS internal gain calibration circuit and data retrieval indicator settings" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="integration_time" type="float" shape="report_number">
<attribute name="long_name" value="XRS integration time used to collect data associated with observation" type="string"/>
<attribute name="_FillValue" value="0.0" type="float"/>
<attribute name="valid_range" value="0.239 63.989" type="float"/>
<attribute name="units" value="s" type="string"/>
</variable>
<variable name="exs_sl_pwr_ena" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether power to currently selected EXIS stimulus lamp is enabled" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="asic1_temperature" type="float" shape="report_number">
<attribute name="long_name" value="temperature of XRS ASIC board #1" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-142.51690 933.17316" type="float"/>
<attribute name="units" value="degrees_C" type="string"/>
</variable>
<variable name="asic2_temperature" type="float" shape="report_number">
<attribute name="long_name" value="temperature of XRS ASIC board #2" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-142.51690 933.17316" type="float"/>
<attribute name="units" value="degrees_C" type="string"/>

</variable>
<variable name="invalid_flags" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating observation data may be invalid" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 8" type="ibute"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="xrs_det_chg" type="uint" shape="report_number">
<attribute name="long_name" value="count of XRS detector measurements since last sensor power-on or settings change" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 65535" type="uint"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="xrs_mode" type="ubyte" shape="report_number">
<attribute name="long_name" value="instrument (sensor) mode" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubytebyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="sps_obs_time" type="double" shape="report_number sps_measurement_count">
<attribute name="long_name" value="time of observation for each SPS 4 Hz measurement" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="sps_int_time" type="float" shape="report_number sps_measurement_count">
<attribute name="long_name" value="SPS integration time for each (4 Hz) SPS measurement" type="string"/>
<attribute name="_FillValue" value="0.0" type="float"/>
<attribute name="valid_range" value="0.239 63.989" type="float"/>
<attribute name="units" value="s" type="string"/>
</variable>
<variable name="sps_temperature" type="float" shape="report_number sps_measurement_count">
<attribute name="long_name" value="temperature of SPS detector for (4 Hz) each SPS measurement" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-142.51690 933.17316" type="float"/>

<attribute name="units" value="degrees_C" type="string"/>
</variable>
<variable name="sps_det_chg" type="uint" shape="report_number sps_measurement_count">
<attribute name="long_name" value="counter, which resets after SPS power-on or setting change, indicating whether to disregard observation (conditions to disregard: .lt. configurable value after power on; .lt. configurable value after internal gain calibration)" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 65535" type="uinit"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="num_angle_pairs" type="ushort" shape="report_number">
<attribute name="long_name" value="number of valid SPS measurements used during XRS L1b processing" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 4" type="ushort"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="yaw_flip_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="au_factor" type="float" shape="report_number">
<attribute name="long_name" value="earth to sun distance multiplicative correction factor to normalize to 1-AU at time of observation. not applied in XRS L1b product processing" type="string"/>
<attribute name="_FillValue" value="0.0" type="float"/>
<attribute name="valid_range" value="0.966 1.035" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="quality_flags" type="uint" shape="report_number">
<attribute name="long_name" value="XRS L1b processing and data quality flags" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 524287" type="uint"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>

<variable name="packet_count" type="uint" shape="report_number">
<attribute name="long_name" value="current count of XRS L0 primary header telemetry packets received since instrument start-up or reset" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 16383" type="uint"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="fov_unknown" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether instrument has received field-of-view information (eclipse, planetary and lunar transit, off-pointing calibration maneuver conditions) provided by ground system" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="fov_eclipse" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether sun being obscured by earth is imminent or in progress as provided by ground system" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="fov_lunar_transit" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether lunar transit across sun is imminent or in progress as provided by ground system" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="fov_planet_transit" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether planetary transit across sun is imminent or in progress as provided by ground system" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>

<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="fov_off_point" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether off-pointing calibration maneuver is imminent or in progress as provided by ground system" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="solar_array_current" type="ushort" shape="report_number solar_array_current_channel_index">
<attribute name="long_name" value="solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="SC_eclipse_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="percent_uncorrectable_L0_errors" type="float" shape="">
<attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="SPP_to_Sun_roll_angle” type=”float” shape=””>
<attribute name="long_name" value="angular offset of the solar north rotational pole relative to SPP with positive values measured clockwise” type=”string”/>
<attribute name="comment” value=”does not include yaw flip; does not include solar P-angle” type=”string”/>
<attribute name="_FillValue” value=”-999.0” type=”float”/>

<attribute name="valid_range" value="0.0 359.99999" type="float"/>
<attribute name="units" value="degree" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="SPP_roll_angle_time" type="double" shape="">
<attribute name="long_name" value="time of SPP to Sun roll angle measurement" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
<values>***dynamic value***</values>
</variable>
<attribute name="dataset_name" value="***refer to filename conventions for L1b products in Appendix C.***" type="string"/>
<attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
<attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
<attribute name="project" value="GOES" type="string"/>
<attribute name="iso_series_metadata_id" value="f7087581-e5a8-11e3-ac10-0800200c9a66" type="string"/>
<attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
<attribute name="title" value="EXIS XRS L1b Solar Flux: X-Ray" type="string"/>
<attribute name="summary" value="The Solar Flux: X-Ray product consists of two irradiance measurements in the x-ray portion of the electromagnetic spectrum resulting from observing the sun. The two measurements are obtained from channels XRS-A and XRS-B. The XRS-A and XRS-B channels sense wavelength ranges between 0.05 and 0.4 nm, and 0.1 and 0.8 nm, respectively. To span the full dynamic x-ray irradiance range over the solar cycle, each channel includes a solar minimum photodiode and a solar maximum quadrant photodiode set, and the resulting irradiance value from each are included in the product. A flag indicates whether the irradiance value from the solar minimum or solar maximum photodiodes is the primary irradiance value for each channel. The product also includes a set of XRS state flags, processing and data quality metadata, satellite state and location information, and data required for the generation of level 2 products." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SPECTRAL/ENGINEERING > X-RAY > X-RAY FLUX, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR IRRADIANCE, SUN-EARTH INTERACTIONS > SOLAR ACTIVITY > SOLAR X-RAY EMISSIONS, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE FLUX > X-RAY FLUX" type="string"/>
<attribute name="cdm_data_type" value="Point" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES-R Series EXIS X-Ray Sensor" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument (sensor).***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>

<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data; not in use" type="string"/>
<attribute name="input_XRS_L0_data" value="null" type="string"/>
</variable>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note "flags and meanings": Flag values and meanings are located in paragraph 7.4.2.5.1.1, Solar Flux: X-Ray Product Flag Values and Meanings.

7.5 SEISS Level 1b Products

7.5.1 Energy Heavy Ions Product

7.5.1.1 Description

The Energetic Heavy Ions product contains heavy ion directional differential flux values measured in situ from geostationary orbit. The differential flux values are produced for the Hydrogen (H), Helium (He), Carbon-Nitrogen-Oxygen (CNO), Neon-Sulfur (Ne-S), and Chlorine-Nickel (Cl-Ni) mass groups, and the Beryllium to Copper (Be-Cu) elemental group over successive, valid one minute observation intervals within a five minute interval. For the Be-Cu group, differential flux values are generated for all elements in the periodic table from Be to Cu. The product includes data quality information that provides an assessment of the differential flux values, including an indication of good or degraded quality, or invalid, and the rationale.

For each mass group, heavy ion flux is reported in five energy bands for one angular zone. Similarly, for each element in the elemental group, heavy ion flux is reported in five energy bands for one angular zone. The five energy bands are evenly spaced logarithmically spanning from 10 to 200 MeV per nucleon for the H and He mass groups. The pre-flight nominal definition of the five energy bands for the H and He mass groups is located in paragraph 7.5.1.5.1, Energetic Heavy Ions Product Quantity Characteristics. For all the mass groups and the elemental group, the energy band bounds are dynamic and included in the product.

The one angular zone has a central look-angle that is anti-earthward and has a 60 degree conical field of view. The precise look angle of the angular zone relative to the GOES-R spacecraft body reference frame required for use and subsequent processing of this level 1b product data is available from the Product Distribution and Access system.

The units of measure for the directional differential flux values are "particles per second per square centimeter per steradian per (megaelectron volt per nucleon)".

The Energetic Heavy Ions performance requirements are summarized in Table 7.5.1.1, Energetic Heavy Ions Performance Requirements.

Table 7.5.1.1 Energetic Heavy Ions Performance Requirements

	Measurement			Mapping
Region	**Range**	**Accuracy**	**Precision**	**Uncertainty**
anti-earthward with a 60 degree field of view from perspective of GOES-R satellite	10 to 200 MeV/nuc for H and He. [1]	25%: when flux level above background > 10 times minimum flux 45%: when flux level above background is between minimum flux & 10 times minimum flux	flux values associated with 10 counts above background in the 5 minute observation interval	not applicable

[1] For ions heavier than He is species-dependent, corresponding approximately to the same stopping distance in silicon as He.

Metadata in the Energetic Heavy Ions product provides statistical and other properties of the observation and processed data and information required for the generation of level 2 products, and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the observation data in the product.
- Instrument data acquisition start and end times for the elemental flux, hardware coincident rate, and pulse height analysis event count measurements.
- Satellite location and spacecraft ACRF to J2000 ECI attitude quaternion.

- Eclipse of the sun indication.
- Satellite yaw flip configuration.
- Differential flux statistical errors, differential flux instrumental errors, and differential energy bounds for the H, He, CNO, Ne-S, and Cl-Ni mass groups and the Be-Cu elemental group for each data channel (i.e., energy band).
- Elemental flux, hardware coincident rate, and pulse height analysis event count observation, and engineering telemetry data availability information.
- Data validity information.
- High flux rate indication.
- Indications of sensor calibration and configuration changes.
- Instrument mode and serial number.

When the satellite is in on-orbit storage mode, the Energetic Heavy Ions product data format and content are the same.

The detailed description of the ISO series metadata for the Energetic Heavy Ions product is located in the standalone Appendix X, ISO Series Metadata.

7.5.1.2 Dynamic Source Data

The Energetic Heavy Ions product is derived using EHIS Level 0 raw science telemetry, SEISS engineering telemetry, and satellite ephemeris related telemetry.

The primary sensor data used by the Level 1b Energetic Heavy Ions algorithm is identified in Table 7.5.1.2, Primary Sensor Data.

Table 7.5.1.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_EHIS_L0_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.5.1.3 Level 1b Semi-Static Source Data

There are two categories of semi-static source data employed in the SEISS EHIS Level 1b ground processing algorithm:

- Sensor calibration parameters.
- Algorithm processing parameters.

One semi-static HDF5 source data file contains both categories above. This file is included with semi-static parameters for the other SEISS products in a single zip file.

Sensor calibration parameters are those associated with the sensor's observing characteristics, or its raw outputs. Specific types include:

- Hydrogen and Helium prime (i.e., high flux condition) and non-prime (i.e., low flux condition) geometric factors for each of the five energy bands, which are properties of the sensor used to convert the raw count rate to differential flux; additionally, the uncertainties in the geometric factors contribute to determining the instrumental error associated with the calculated differential flux values.
- Initial Hydrogen and Helium prime and non-prime energy band boundaries for each of the five energy bands, which are used to bin sensed raw count data, and calculate dynamic energy band

bounds; additionally, energy bandpass uncertainties contribute to determining the instrumental error associated with the calculated differentia flux values.

- Prime and non-prime deadtime correction factor profiles, which are used to calibrate the differential flux values.
- Proton-Contamination-to-Helium prime and non-prime contamination factors for each of the five bands, which are used to calibrate the differential flux values; uncertainties in the contamination factors contribute to determining the instrumental error associated with the calculated differential flux values.
- Heavy ion prime and non-prime geometric factors and their uncertainties for each of the five energy bands.
- Initial Elemental (i.e., for 26 elements from Be through Cu) prime and non-prime energy band boundaries and energy bandpass uncertainties for each of the five energy bands.
- Elemental peak positions and sigmas, in histogram units, which are used during maximum likelihood fitting of the histogram data.
- Sensor acquisition time intervals (3 seconds and 1 minute) and time correction (offset) parameters.

Algorithm processing parameters are those associated with configurable decision-making logic in the algorithm associated with tolerances, and iteration and convergence. Specific types include:

- Maximum number of attempts to find a stable set of fit parameters allowed by the Maximum Likelihood fitting procedure.
- Maximum distance (in peak sigmas) a particular histogram bin can be away from a particular element's peak position in order to be included in that element's Gaussian integral set.
- Change in Likelihood relative to the maximum Likelihood value which defines the 1-Sigma level.
- Tolerance to which two Likelihood values are considered the same.

The filename conventions for the EHIS Level 1b semi-static source data file are located in Appendix C.

7.5.1.4 Production Notes

The Energetic Heavy Ions product is generated by SEISS EHIS Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm extracts the raw detector data from the CCSDS packets. The Level 1b algorithm uses the in situ heavy ion count rate measurements from the Earth's geomagnetic environment to determine the directional differential flux values. The Level 1b algorithm corrects for instrument dead-time, removes out-of-band contamination, and converts count rates to directional differential flux values using sensor viewing geometry and area, and energy band characteristics.

The observation data is time stamped on the satellite with a known offset of one minute. This is adjusted by the Level 1b algorithm such that the time stamps reported in the Level 1b product metadata represent actual acquisition times, accurate to within 0.5 seconds. The acquisition times represent the start of a one second observation period.

Both instrument and statistical errors associated with the reported differential flux values are reported. For H and He, the statistical errors, σstat, are reported as symmetric errors; the lower and upper flux statistical limits are defined as flux – σstat and flux + σstat, respectively. In contrast to the H and He groups, statistical errors of the other group and elemental fluxes are reported as lower and upper bounds, $\sigma-$ and $\sigma+$, such that the lower and upper flux statistical limits are defined as flux – $\sigma-$ and flux + $\sigma+$, respectively.

The Level 1b algorithm generates valid product data from the combination of all one minute observation periods when the instrument is in the operational mode during a five minute period. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.5.1.5 Data Organization and Fields

An Energetic Heavy Ions product spans two GRB Space Packets, one for the data and another for the metadata. The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, label variables, and product start and end time variable.

The subordinate paragraphs that follow define the Energetic Heavy Ions product data, quantity characteristics, flag values and meanings, and metadata fields.

7.5.1.5.1 Data Fields

Table 7.5.1.5.1 Energetic Heavy Ions Product Data

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
H5MinuteDifferential Fluxes control field(s)	uint64	number of control fields = 1	energy = 5	1	8	0
H5MinuteDifferential Fluxes	float	energy = 5	Hydrogen (H) differential flux for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	8
H5MinuteDifferential FluxStatErrors control field(s)	uint64	number of control fields = 1	energy = 5	1	8	28
H5MinuteDifferential FluxStatErrors	float	energy = 5	Hydrogen (H) differential flux statistical errors for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	36
H5MinuteDifferential FluxInstErrors control field(s)	uint64	number of control fields = 1	energy = 5	1	8	56
H5MinuteDifferential FluxInstErrors	float	energy = 5	Hydrogen (H) differential flux instrumental errors for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	64
H5MinuteDifferential EnergyBounds control field(s)	uint64	number of control fields = 2	energy = 5 energy_bounds = 2	1	16	84

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
H5MinuteDifferential EnergyBounds	float	energy = 5 energy_bounds = 2	Hydrogen (H) differential flux dynamic energy bounds for each energy band	MeV	40	100
He5MinuteDifferentialFluxes control field(s)	uint64	number of control fields = 1	energy = 5	1	8	140
He5MinuteDifferentialFluxes	float	energy = 5	Helium (He) differential flux for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	148
He5MinuteDifferentialFluxStatErrors control field(s)	uint64	number of control fields = 1	energy = 5	1	8	168
He5MinuteDifferentialFluxStatErrors	float	energy = 5	Helium (He) differential flux statistical errors for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	176
He5MinuteDifferentialFluxInstErrors control field(s)	uint64	number of control fields = 1	energy = 5	1	8	196
He5MinuteDifferentialFluxInstErrors	float	energy = 5	Helium (He) differential flux instrumental errors for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	204
He5MinuteDifferentialEnergyBounds control field(s)	uint64	number of control fields = 2	energy = 5 energy_bounds = 2	1	16	224
He5MinuteDifferentialEnergyBounds	float	energy = 5 energy_bounds = 2	Helium (He) differential flux dynamic energy bounds for each energy band	MeV	40	240
CNO5MinuteDifferentialFluxes control field(s)	uint64	number of control fields = 1	energy = 5	1	8	280
CNO5MinuteDifferentialFluxes	float	energy = 5	Carbon-Nitrogen-Oxygen (CNO) mass group differential flux for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	288
CNO5MinuteDifferentialFluxStatErrorsBounds control field(s)	uint64	number of control fields = 2	energy = 5 error_bounds = 2	1	16	308
CNO5MinuteDifferentialFluxStatErrorsBounds	float	energy = 5 error_bounds = 2	Carbon-Nitrogen-Oxygen (CNO) mass group differential flux statistical error bounds for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	40	324

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
CNO5MinuteDifferentialEnergyBounds control field(s)	uint64	number of control fields = 2	energy = 5 energy_bounds = 2	1	16	364
CNO5MinuteDifferentialEnergyBounds	float	energy = 5 energy_bounds = 2	Carbon-Nitrogen-Oxygen (CNO) mass group differential flux dynamic energy bounds for each energy band	MeV	40	380
CNO5MinuteDifferentialFluxInstErrors control field(s)	uint64	number of control fields = 1	energy = 5	1	8	420
CNO5MinuteDifferentialFluxInstErrors	float	energy = 5	Carbon-Nitrogen-Oxygen (CNO) mass group differential flux instrumental errors for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	428
NeS5MinuteDifferentialFluxes control field(s)	uint64	number of control fields = 1	energy = 5	1	8	448
NeS5MinuteDifferentialFluxes	float	energy = 5	Neon-Sulfur (Ne-S) mass group differential flux for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	456
NeS5MinuteDifferentialFluxStatErrorsBounds control field(s)	uint64	number of control fields = 2	energy = 5 error_bounds = 2	1	16	476
NeS5MinuteDifferentialFluxStatErrorsBounds	float	energy = 5 error_bounds = 2	Neon-Sulfur (Ne-S) mass group differential flux statistical error bounds for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	40	492
NeS5MinuteDifferentialEnergyBounds control field(s)	uint64	number of control fields = 2	energy = 5 energy_bounds = 2	1	16	532
NeS5MinuteDifferentialEnergyBounds	float	energy = 5 energy_bounds = 2	Neon-Sulfur (Ne-S) mass group differential flux dynamic energy bounds for each energy band	MeV	40	548
NeS5MinuteDifferentialFluxInstErrors control field(s)	uint64	number of control fields = 1	energy = 5	1	8	588
NeS5MinuteDifferentialFluxInstErrors	float	energy = 5	Neon-Sulfur (Ne-S) mass group differential flux instrumental errors for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	596

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
ClNi5MinuteDifferentialFluxes control field(s)	uint64	number of control fields = 1	energy = 5	1	8	616
ClNi5MinuteDifferentialFluxes	float	energy = 5	Chlorine-Nickel (Cl-Ni) mass group differential flux for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	624
ClNi5MinuteDifferentialFluxStatErrorsBounds control field(s)	uint64	number of control fields = 2	energy = 5 error_bounds = 2	1	16	644
ClNi5MinuteDifferentialFluxStatErrorsBounds	float	energy = 5 error_bounds = 2	Chlorine-Nickel (Cl-Ni) mass group differential flux statistical error bounds for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	40	660
ClNi5MinuteDifferentialEnergyBounds control field(s)	uint64	number of control fields = 2	energy = 5 energy_bounds = 2	1	16	700
ClNi5MinuteDifferentialEnergyBounds	float	energy = 5 energy_bounds = 2	Chlorine-Nickel (Cl-Ni) mass group differential flux dynamic energy bounds for each energy band	MeV	40	716
ClNi5MinuteDifferentialFluxInstErrors control field(s)	uint64	number of control fields = 1	energy = 5	1	8	756
ClNi5MinuteDifferentialFluxInstErrors	float	energy = 5	Chlorine-Nickel (Cl-Ni) mass group differential flux instrumental errors for each energy band	cm-2 sr-1 s-1 (MeV nuc-1)-1	20	764
BeCu5MinuteDifferentialFluxes control field(s)	uint64	number of control fields = 2	energy = 5 element = 26	1	16	784
BeCu5MinuteDifferentialFluxes	float	energy = 5 element = 26	Beryllium to Copper (Be-Cu) differential flux for each element's energy bands	cm-2 sr-1 s-1 (MeV nuc-1)-1	520	800
BeCu5MinuteDifferentialFluxStatErrorsBounds control field(s)	uint64	number of control fields = 3	energy = 5 element = 26 error_bounds = 2	1	24	1320
BeCu5MinuteDifferentialFluxStatErrorsBounds	float	energy = 5 element = 26 error_bounds = 2	Beryllium to Copper (Be-Cu) flux statistical error bounds for each element's energy bands	cm-2 sr-1 s-1 (MeV nuc-1)-1	1040	1344

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
BeCu5MinuteDifferentialEnergyBounds control field(s)	uint64	number of control fields = 3	energy = 5 element = 26 energy_bounds = 2	1	24	2384
BeCu5MinuteDifferentialEnergyBounds	float	energy = 5 element = 26 energy_bounds = 2	Beryllium to Copper (Be-Cu) flux dynamic energy bounds for each element's energy bands	MeV	1040	2408
BeCu5MinuteDifferentialFluxInstErrors control field(s)	uint64	number of control fields = 2	energy = 5 element = 26	cm-2 sr-1 s-1 (MeV nuc-1)-1	16	3448
BeCu5MinuteDifferentialFluxInstErrors	float	energy = 5 element = 26	Beryllium to Copper (Be-Cu) (26) instrumental errors for each element's energy bands	cm-2 sr-1 s-1 (MeV nuc-1)-1	520	3464
H5MinuteDifferentialFluxDQFs control field(s)	uint64	number of control fields = 1	energy = 5	1	8	3984
H5MinuteDifferentialFluxDQFs	uint8	energy = 5	Hydrogen (H) differential flux data quality flag for each energy band	1	5	3992
He5MinuteDifferentialFluxDQFs control field(s)	uint64	number of control fields = 1	energy = 5	1	8	3997
He5MinuteDifferentialFluxDQFs	uint8	energy = 5	Helium (He) differential flux data quality flag for each energy band	1	5	4005
CNO5MinuteDifferentialFluxDQFs control field(s)	uint64	number of control fields = 1	energy = 5	1	8	4010
CNO5MinuteDifferentialFluxDQFs	uint8	energy = 5	Carbon-Nitrogen-Oxygen (CNO) mass group differential flux data quality flag for each energy band	1	5	4018
NeS5MinuteDifferentialFluxDQFs control field(s)	uint64	number of control fields = 1	energy = 5	1	8	4023
NeS5MinuteDifferentialFluxDQFs	uint8	energy = 5	Neon-Sulfur (Ne-S) mass group differential flux data quality flag for each energy band	1	5	4031
ClNi5MinuteDifferentialFluxDQFs control field(s)	uint64	number of control fields = 1	energy = 5	1	8	4036

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
ClNi5MinuteDifferentialFluxDQFs	uint8	energy = 5	Chlorine-Nickel (Cl-Ni) mass group differential flux data quality flag for each energy band	1	5	4044
BeCu5MinuteDifferentialFluxDQFs control field(s)	uint64	number of control fields = 2	energy = 5 element = 26	1	16	4049
BeCu5MinuteDifferentialFluxDQFs	uint8	energy = 5 element = 26	Beryllium to Copper (Be-Cu) (26) differential flux data quality flag for each element's energy bands	1	130	4065
Overall_Validity_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4195
Overall_Validity_Flag	uint8	minute_interval = 5	flags indicating viability of each one minute interval of data for L1b processing; reasons for a minute interval not being viable include missing L0 data, instrument in non-operational mode, and a science configuration change occurred	1	5	4203
Process_Together_Flag	uint8	n/a	flags indicating whether valid one minute intervals of data can be processed together. if the science configuration change flag indicates a configuration change for any of the one minute intervals, processing one minute intervals of data together is not possible. this affects the 5 minute flux calculations for all the elements and mass groups (H, He, CNO, Ne-S, Ni-Cl, and Be-Cu)	1	1	4208
L1a_EngData_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4209
L1a_EngData_Flag	uint8	minute_interval = 5	flags indicating availability of instrument engineering telemetry data (instrument mode and serial number)	1	5	4217
L1a_PECData_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4222

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
L1a_PECData_Flag	uint8	minute_interval = 5	flags indicating availability of instrument Pulse Height Analysis Event Count (PEC) science data	1	5	4230
L1a_HCRData_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4235
L1a_HCRData_Flag	uint8	minute_interval = 5	flags indicating availability of instrument Hardware Coincident Rate (HCR) science data	1	5	4243
L1a_ELFData_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4248
L1a_ELFData_Flag	uint8	minute_interval = 5	flags indicating availability of instrument elemental Flux (ELF) source science data	1	5	4256
HFR_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4261
HFR_Flag	uint8	minute_interval = 5	flags indicating presence of high flux rate conditions	1	5	4269
IFC_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4274
IFC_Flag	uint8	minute_interval = 5	flags indicating whether instrument is in In-Flight Calibration (IFC) mode	1	5	4282
SCC_Flag control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4287
SCC_Flag	uint8	minute_interval = 5	flags from instrument hardware indicating whether a science configuration change has occurred	1	5	4295
N_blocks	uint8	n/a	number of one minute blocks of EHIS L0 data used to create Energetic Heavy Ions product	count	1	4300
Instrument_Mode control field(s)	uint64	number of control fields = 1	minute_interval = 5	1	8	4301
Instrument_Mode	uint8	minute_interval = 5	instrument (sensor) mode	1	5	4309
Instrument_Serial_Number	uint8	n/a	SEISS EHIS instrument (sensor) serial number	1	1	4314
HCR_StartStop_Time control field(s)	uint64	number of control fields = 1	number_of_time_bounds = 2	1	8	4315

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
HCR_StartStop_Time	double	number_of_time_bounds = 2	instrument Hardware Coincident Rate (HCR) data acquisition start and stop times for observation period, accurate to within 0.5 seconds of onboard data acquisition start time, associated with product	seconds since 2000-01-01 12:00:00, neglecting leap seconds	16	4323
PEC_StartStopTime control field(s)	uint64	number of control fields = 1	number_of_time_bounds = 2	1	8	4339
PEC_StartStopTime	double	number_of_time_bounds = 2	instrument Pulse Height Analysis Event Count (PEC) data acquisition start and stop times for observation period, accurate to within 0.5 seconds of onboard data acquisition start time, associated with product	seconds since 2000-01-01 12:00:00, neglecting leap seconds	16	4347
ELF_StartStopTime control field(s)	uint64	number of control fields = 1	number_of_time_bounds = 2	1	8	4363
ELF_StartStopTime	double	number_of_time_bounds = 2	instrument Elemental Flux (ELF) data acquisition start and stop times for observation period, accurate to within 0.5 seconds of onboard data acquisition start time, associated with product. This is also the time of observation by sensor for each report	seconds since 2000-01-01 12:00:00, neglecting leap seconds	16	4371
quaternion_Q0	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q0	1	4	4387
quaternion_Q1	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q1	1	4	4391
quaternion_Q2	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q2	1	4	4395
quaternion_Q3	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q3	1	4	4399
ECEF_X	float	n/a	spacecraft ECEF X coordinate	m	4	4403
ECEF_Y	float	n/a	spacecraft ECEF Y coordinate	m	4	4407
ECEF_Z	float	n/a	spacecraft ECEF Z coordinate	m	4	4411
yaw_flip_flag	uint8	n/a	flags indicating whether spacecraft is operating in yaw flip configuration	m	1	4415

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
eclipse_flag	uint8	n/a	flags indicating whether sun is obscured by earth as provided by spacecraft	1	1	4416
solar_array_current control field(s)	uint64	number of control fields = 1	solar_array_current_channel_index = 4	1	8	4417
solar_array_current	uint16	solar_array_current_channel_index = 4	solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)	1	8	4425

7.5.1.5.1.1 Energy Heavy Ions Product Quantity Characteristics

Table 7.5.1.5.1.1-1 Energetic Heavy Ions Product H and He Mass Group Nominal Energy Band Characteristics

Energy Band (in MeV/nuc) [1]	Order in Product Data Structure	Product Label Variable Mnemonic
9 - 31	1	EnergyBand-1
31 - 43	2	EnergyBand-2
43 - 55	3	EnergyBand-3
55 - 110	4	EnergyBand-4
110 - 200	5	EnergyBand-5

[1] The energy band values in this table are pre-flight nominal values. The precise values for the non-prime and prime energy bands and their uncertainties used by the Level 1b algorithm are semi-static source data. These values are available from the Product Distribution and Access system. Additional details are located in paragraph 5.4.1.3, Level 1b Semi-Static Source Data. Note that the EHIS energy band limits are dynamic and included in the Energetic Heavy Ions product.

For the other mass groups and the elemental group, the energy band bounds are dynamic and included in the product.

Table 7.5.1.5.1.1-2 Energetic Heavy Ions Product Be-Cu Elemental Group Characteristics

Element (product label variable mnemonic in parenthesis)	Order in Product Data Structure	Element (periodical table symbol)	Order in Product Data Structure	Element (periodical table symbol)	Order in Product Data Structure
(Be)rylium	1	(Al)uminum	10	(Ti)tanium	19
(B)oron	2	(Si)licon	11	(V)anadium	20
(C)arbon	3	(P)hosphorus	12	(Cr) Chromium	21
(N)itrogen	4	(S)ulfur	13	(Mn) Manganese	22
(O)xygen	5	(Cl) Chlorine	14	(Fe) Iron	23
(F)luorine	6	(Ar)gon	15	(Co)balt	24

Element (product label variable mnemonic in parenthesis)	Order in Product Data Structure	Element (periodical table symbol)	Order in Product Data Structure	Element (periodical table symbol)	Order in Product Data Structure
(Ne)on	7	(K) Potassium	16	(Ni)ckel	25
(Na) Sodium	8	(Ca)lcium	17	(Cu) Copper	26
(Mg) Magnesium	9	(Sc)andium	18		

7.5.1.5.1.2 Energy Heavy Ions Product Flag Values and Meanings

Table 7.5.1.5.1.2-1 Energetic Heavy Ions Product H, He, CNO, Ne-S, Cl-Ni, & Be-Cu Group Flux Data Quality Flag Values and Meanings

Mass and Elemental Group Flux Data Quality Flags (H5MinuteDifferentialFluxDQFs, He5MinuteDifferentialFluxDQFs, CNO5MinuteDifferentialFluxDQFs, NeS5MinuteDifferentialFluxDQFs, ClNi5MinuteDifferentialFluxDQFs, & BeCu5MinuteDifferentialFluxDQFs)		
Flag Mask	**Flag Value**	**Flag Meaning**
63	0	good_quality_qf
1	1	invalid_due_to_missing_L0_data_or_not_operational_mode_qf
2	2	invalid_due_to_calibration_failed_qf
4	4	degraded_due_to_deadtime_correction_threshold_exceeded_qf [1]
8	8	degraded_due_to_out_of_band_contamination_level_threshold_exceeded_qf [2]
16	16	degraded_due_to_dynamic_error_threshold_exceeded_or_dynamic_error_not_calculable_qf [3]
32	32	degraded_due_to_dynamic_lower_error_bound_not_calculable_only_upper_limit_exists_qf

[1] Dead-time correction threshold is the limiting case where 25% of the raw counts are restored to account for dead-time. The data is considered degraded if the correction exceeds this threshold.
[2] Out-of-band contamination correction threshold is the limiting case of 0.33 for the ratio of the out-of-band contamination term to the valid raw counts for EHIS. Out-of-band contamination includes particles arriving at the detector that are the wrong species, look-direction, energy, or a combination of these deficiencies. The data is considered degraded if the ratio exceeds this threshold.
[3] Dynamic flux error threshold is the limiting case of 0.25 for the ratio of the flux uncertainty to the flux. The data is considered degraded if the ratio exceeds this threshold.

Table 7.5.1.5.1.2-2 Energetic Heavy Ions Product Elemental Flux, Hardware Coincident Rate, Pulse Count Height Analysis Event Count, and Engineering Telemetry Data Availability Flag Values and Meanings

Data Availability Flags (L1a_ELFData_Flag, L1a_HCRData_Flag, L1a_PECData_Flag, & L1a_EngData_Flag)	
Flag Value	**Flag Meaning**
0	all_data_available
1	some_data_available
2	all_data_missing

Table 7.5.1.5.1.2-3 Energetic Heavy Ions Product High Flux Rate Flag Values and Meanings

High Flux Rate Flags (HFR_Flag)	
Flag Value	**Flag Meaning**
0	no_high_flux_rate_conditions_exist_and_L1b_algorithm_uses_non_prime_rates_for_this_minute
1	high_flux_rate_conditions_exist_and_L1b_algorithm_uses_prime_rates_for_this_minute

Table 7.5.1.5.1.2-4 Energetic Heavy Ions Product Overall Validity Quality Flag Values and Meanings

Overall Validity Quality Flags (Overall_Validity_Flag)	
Flag Value	**Flag Meaning**
0	processing_not_viable
1	processing_viable

Table 7.5.1.5.1.2-5 Energetic Heavy Ions Product Process Together Flag Values and Meaning

Process Together Flags (Process_Together_Flag)	
Flag Value	**Flag Meaning**
0	multiple_minute_intervals_of_data_cannot_be_processed_together
1	multiple_minute_intervals_of_data_can_be_processed_together

Table 7.5.1.5.1.2-6 Energetic Heavy Ions Product In-Flight Calibration Flag Values and Meaning

In-Flight Calibration Flags (IFC_Flag)	
Flag Value	**Flag Meaning**
0	instrument_not_in_IFC_mode_data_suitable_for_L1b_algorithm
1	instrument_in_IFC_mode_data_not_suitable_for_L1b_algorithm

Table 7.5.1.5.1.2-7 Energetic Heavy Ions Product Science Configuration Change Flag Values and Meaning

Science Configuration Change Flags (SCC_Flag)	
Flag Value	**Flag Meaning**
0	no_science_configuration_change
1	science_configuration_change_occurred_accounted_for_in_L1b_algorithm

Table 7.5.1.5.1.2-8 Energetic Heavy Ions Product EHIS Instrument Mode Flag Values and Meaning

EHIS Instrument Mode Flags (Instrument_Mode)	
Flag Value	**Flag Meaning**
0	failsafe_recovery_mode
1	operational_mode
2	in-flight_calibration_mode
3	instrument_diagnostic_mode

Table 7.5.1.5.1.2-9 Energetic Heavy Ions Product Eclipse Flag Values and Meanings

Eclipse Flags (eclipse_flag)	
Flag Value	**Flag Meaning**
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse
3	penumbra_following_full_eclipse

Table 7.5.1.5.1.2-10 Energetic Heavy Ions Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (yaw_flip_flag)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

7.5.1.5.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Energetic Heavy Ions product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.5.1.5.2 Energetic Heavy Ions Product Metadata

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<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
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<dimension name="energy_bounds" length="2" isUnlimited="false"/>
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<dimension name="error_bounds" length="2" isUnlimited="false"/>
<dimension name="solar_array_current_channel_index" length="4" isUnlimited="false"/>
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<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
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<attribute name="_FillValue" value="-1.0e+31" type="double"/>
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</variable>
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```xml
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    <values>EPS_SA_CHAN_1_4_RETRN_I EPS_SA_CHAN_5_8_RETRN_I EPS_SA_CHAN_9_12_RETRN_I EPS_SA_CHAN_13_16_RETRN_I</values>
  </variable>
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    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
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    <attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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  </variable>
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  </variable>
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<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<variable name="He5MinuteDifferentialFluxStatErrors" type="float" shape="report_number energy">
<attribute name="long_name" value="Helium (He) differential flux statistical errors for each energy band" type="string"/>
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<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
</variable>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="MeV" type="string"/>
</variable>
<variable name="CNO5MinuteDifferentialFluxes" type="float" shape="report_number energy">
<attribute name="long_name" value="Carbon-Nitrogen-Oxygen (CNO) mass group differential flux for each energy band" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<variable name="CNO5MinuteDifferentialFluxStatErrorsBounds" type="float" shape="report_number energy error_bounds">
<attribute name="long_name" value="Carbon-Nitrogen-Oxygen (CNO) mass group differential flux statistical error bounds for each energy band" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
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</variable>
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<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
</variable>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="long_name" value="Neon-Sulfur (Ne-S) mass group differential flux instrumental errors for each energy band" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<variable name="ClNi5MinuteDifferentialFluxes" type="float" shape="report_number energy">
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<variable name="ClNi5MinuteDifferentialFluxStatErrorsBounds" type="float" shape="report_number energy error_bounds">

<attribute name="long_name" value="Chlorine-Nickel (Cl-Ni) mass group differential flux statistical error bounds for each energy band" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<attribute name="long_name" value="Chlorine-Nickel (Cl-Ni) mass group differential flux dynamic energy bounds for each energy band" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="units" value="MeV" type="string"/>
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<variable name="ClNi5MinuteDifferentialFluxInstErrors" type="float" shape="report_number energy">
<attribute name="long_name" value="Chlorine-Nickel (Cl-Ni) mass group differential flux instrumental errors for each energy band" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
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<attribute name="long_name" value="Beryllium to Copper (Be-Cu) differential flux for each element's energy bands" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<variable name="BeCu5MinuteDifferentialFluxStatErrorsBounds" type="float" shape="report_number energy element error_bounds">
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="units" value="MeV" type="string"/>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>

<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 (MeV nuc-1)-1" type="string"/>
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<variable name="H5MinuteDifferentialFluxDQFs" type="ubyte" shape="report_number energy">
<attribute name="long_name" value="Hydrogen (H) differential flux data quality flag for each energy band" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 60" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="He5MinuteDifferentialFluxDQFs" type="ubyte" shape="report_number energy">
<attribute name="long_name" value="Helium (He) differential flux data quality flag for each energy band" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 60" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="CNO5MinuteDifferentialFluxDQFs" type="ubyte" shape="report_number energy">
<attribute name="long_name" value="Carbon-Nitrogen-Oxygen (CNO) mass group differential flux data quality flag for each energy band" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 60" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<variable name="NeS5MinuteDifferentialFluxDQFs" type="ubyte" shape="report_number energy">
<attribute name="long_name" value="Neon-Sulfur (Ne-S) mass group differential flux data quality flag for each energy band" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 60" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>

</variable>
<variable name="ClNi5MinuteDifferentialFluxDQFs" type="ubyte" shape="report_number energy">
<attribute name="long_name" value="Chlorine-Nickel (Cl-Ni) mass group differential flux data quality flag for each energy band" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 60" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="BeCu5MinuteDifferentialFluxDQFs" type="ubyte" shape="report_number energy element">
<attribute name="long_name" value="Beryllium to Copper (Be-Cu) (26) differential flux data quality flag for each element's energy bands" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 60" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Overall_Validity_Flag" type="ubyte" shape="report_number minute_interval">
<attribute name="long_name" value="flags indicating viability of each one minute interval of data for L1b processing; reasons for a minute interval not being viable include missing L0 data, instrument in non-operational mode, and a science configuration change occurred" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Process_Together_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether valid one minute intervals of data can be processed together. if the science configuration change flag indicates a configuration change for any of the one minute intervals, processing one minute intervals of data together is not possible. this affects the 5 minute flux calculations for all the elements and mass groups (H, He, CNO, Ne-S, Ni-Cl, and Be-Cu)" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>

<variable name="L1a_EngData_Flag" type="ubyte" shape="report_number minute_interval">
<attribute name="long_name" value="flags indicating availability of instrument engineering telemetry data (instrument mode and serial number)" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1a_PECData_Flag" type="ubyte" shape="report_number minute_interval">
<attribute name="long_name" value="flags indicating availability of instrument Pulse Height Analysis Event Count (PEC) science data" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
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</variable>
<variable name="L1a_HCRData_Flag" type="ubyte" shape="report_number minute_interval">
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<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1a_ELFData_Flag" type="ubyte" shape="report_number minute_interval">
<attribute name="long_name" value="flags indicating availability of instrument elemental Flux (ELF) source science data" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<variable name="HFR_Flag" type="ubyte" shape="report_number minute_interval">
<attribute name="long_name" value="flags indicating presence of high flux rate conditions" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
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<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<variable name="IFC_Flag" type="ubyte" shape="report_number minute_interval">
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<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="SCC_Flag" type="ubyte" shape="report_number minute_interval">
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<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
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<variable name="N_blocks" type="ubyte" shape="report_number">
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<attribute name="_FillValue" value="0" type="ubyte"/>
<attribute name="valid_range" value="1 5" type="ubyte"/>
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</variable>
<variable name="Instrument_Mode" type="ubyte" shape="report_number minute_interval">
<attribute name="long_name" value="instrument (sensor) mode" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
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<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Instrument_Serial_Number" type="ubyte" shape="report_number">
<attribute name="long_name" value="SEISS EHIS instrument (sensor) serial number" type="string"/>
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<attribute name="valid_range" value="0 254" type="ubyte"/>
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<attribute name="long_name" value="flags from instrument hardware indicating whether a science configuration change has occurred" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="eclipse_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
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<attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
<values>***dynamic value***</values>
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<attribute name="title" value="SEISS EHIS L1b Energetic Heavy Ions" type="string"/>
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<attribute name="instrument_ID" value="***serial number of the instrument (sensor).***" type="string"/>
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<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note “flags and meanings”: Flag values and meanings are located in paragraph 7.5.1.5.1.2, Energetic Heavy Ions Product Flag Values and Meanings.

7.5.2 Magnetospheric Electrons and Protons: Low Energy Product

7.5.2.1 Description

The Magnetospheric Electrons and Protons: Low Energy product contains up to 30 successive sets of directional differential electron and ion flux values of relatively low energy measured in situ from geostationary orbit. Note that the MPS-LO sensor is unable to distinguish protons from other ions. As a result, ion fluxes are reported rather than proton fluxes. A set is a block of processed observation data containing differential flux values produced over a one second observation interval. The product includes data quality information that provides an assessment of the differential flux values, including an indication of good or degraded quality, or invalid, and the rationale.

Electron and ion differential flux are reported in fifteen energy bands for fourteen angular zones. The fifteen energy bands are evenly spaced logarithmically spanning from 30 eV to 30 keV. The fourteen angular zones, which have a central look angle that is anti-earthward, span a total angular range of 180 degrees in the north to south direction. Each zone, which has a rectangular frustum shaped field of view, is fifteen degrees in the north to south direction and five degree in the east to west direction. Although there are fourteen angular zones, there are only twelve unique look-angles with the two adjacent central angular zones measured twice. The definition of the pre-flight nominal fifteen energy bands and angular zones are located in paragraph 7.5.2.5.1, Magnetospheric Electrons and Protons: Low Energy Product Quantity Characteristics.

The units of measure for the directional differential flux values are "particles per second per square centimeter per steradian per kiloelectron volt".

The Magnetospheric Electrons and Protons: Low Energy performance requirements are summarized in Table 7.5.2.1, Magnetospheric Electrons and Protons: Low Energy Performance Requirements.

Table 7.5.2.1 Magnetospheric Electrons and Protons: Low Energy Performance Requirements

	Measurement			Mapping
Region	Range	Accuracy	Precision	Uncertainty
anti-earthward with a 180 degree north to south field of view from perspective of GOES-R satellite	30 eV to 30 keV	25%: when flux level above background > 10 times minimum flux 45%: when flux level above background is between minimum flux & 10 times minimum flux	flux values associated with 10 counts above background in the 5 minute observation interval	not applicable

Metadata in the Magnetospheric Electrons and Protons: Low Energy product provides statistical and other properties of the observation and processed data and information required for the generation of level 2 products, and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the observation data in the aggregated product (i.e., start time of the first observation and end time of the last).
- Time of each observation.
- Satellite location and spacecraft ACRF to J2000 ECI attitude quaternion.
- Eclipse of the sun indication.
- Satellite yaw flip configuration.
- Dynamic error estimate of differential flux for each zone's electron and ion data channels (i.e., energy bands).
- Electron and ion count observation, and engineering telemetry data availability information.
- Processing quality information.

- Instrument mode and serial number.

When the satellite is in on-orbit storage mode, the Magnetospheric Electrons and Protons: Low Energy product data format and content are the same except that the observation data is subsampled such that it is provided every one in three seconds.

The detailed description of the ISO series metadata for the Magnetospheric Electrons and Protons: Low Energy product is located in the standalone Appendix X, ISO Series Metadata.

7.5.2.2 Dynamic Source Data

The Magnetospheric Electrons and Protons: Low Energy product is derived using MPS-LO Level 0 raw science telemetry, SEISS engineering telemetry, and satellite ephemeris related telemetry.

The primary sensor data used by the Level 1b Magnetospheric Electrons and Protons: Low Energy algorithm is identified in Table 7.5.2.2, Primary Sensor Data.

Table 7.5.2.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_MPS-LO_L0_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.5.2.3 Level 1b Semi-Static Source Data

There are two categories of semi-static source data employed in the SEISS MPS-LO Level 1b ground processing algorithm:

- Sensor calibration parameters.
- Algorithm processing parameters.

One semi-static HDF5 source data file contains both categories above. This file is included with semi-static parameters for the other SEISS products in a single zip file.

Sensor calibration parameters are those associated with the sensor's observing characteristics, or its raw outputs. Specific types include:

- Ion and electron geometric factors for each of the fifteen energy steps and fourteen angular zones, which are properties of the sensor used to convert the raw count rate to differential flux; additionally, the uncertainties in the geometric factors contribute to determining the dynamic error estimate associated with the calculated differential flux values.
- Energy step boundaries, bandpasses, and central values for each of the fifteen energy steps. Note that these are currently not used by the L1b algorithm as energy-dependence has been folded into the geometric factors.
- Ion and electron deadtimes, which are used to calibrate the differential flux values.
- Fractional background removal coefficients as a function of two species (ion and electron), two sensor heads (R- and L-sensor heads) and four background zones (Ions/R, Ions/L, Electrons/R and Electrons/L).
- Overall scaling background removal coefficients as a function of species and sensor head.
- Sensor acquisition time interval.

Algorithm processing parameters are those associated with configurable decision-making logic in the algorithm. Specific types include:

- Data quality flag thresholds which define excessive threshold values for the dead-time correction, the out-of-band contamination correction and the fractional error on flux; these thresholds are used to calculate the data quality flag associated with each flux value.

The filename conventions for the MPS-LO Level 1b semi-static source data file are located in Appendix C.

7.5.2.4 Production Notes

The Magnetospheric Electrons and Protons: Low Energy product is generated by SEISS MPS-LO Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm extracts the raw detector observation data from the CCSDS packets. The Level 1b algorithm uses the in situ low energy electron and ion count rate measurements from the Earth's geomagnetic environment to determine the directional differential flux values. The Level 1b algorithm corrects for instrument dead-time, removes out-of-band contamination, and converts count rates to directional differential flux values using sensor viewing geometry and area, and energy band characteristics.

The flux uncertainties reported in the product are total uncertainties that include both instrument and statistical uncertainties.

The Level 1b algorithm generates valid product data only when the instrument is in the operational mode. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.5.2.5 Data Organization and Fields

A Magnetospheric Electrons and Protons: Low Energy product spans up to 31 GRB Space Packets, nominally 30 for the data and another for the metadata. A product, which contains a set of directional differential electron and ion flux and related data values for a 30 second period, is transmitted over GRB in one second reports. These one second reports can be exploited upon receipt. Nominally, a product metadata Packet is queued for transmission after the thirtieth report has been queued for transmission.

The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, label variables, and product start and end time variable.

The subordinate paragraphs that follow define the Magnetospheric Electrons and Protons: Low Energy product data, quantity characteristics, flag values and meanings, and metadata fields.

7.5.2.5.1 Data Fields

Table 7.5.2.5.1 Magnetospheric Electrons and Protons: Low Energy Product Data

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
DiffElectronFluxes control field(s)	uint64	number of control fields = 2	field_of_view = 14 differential_flux_energy_band = 15	1	16	0
DiffElectronFluxes	float	field_of_view = 14 differential_flux_energy_band = 15	differential electron flux at specific energy bands for each zone's primary electron data channels	cm-2 sr-1 s-1 keV-1	840	16
DiffElectronFluxDQFs control field(s)	uint64	number of control fields = 2	field_of_view = 14 differential_flux_energy_band = 15	1	16	856
DiffElectronFluxDQFs	uint8	field_of_view = 14 differential_flux_energy_band = 15	differential electron flux data quality flag at specific energy bands for each zone's primary electron data channels	1	210	872

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
DiffIonFluxes control field(s)	uint64	number of control fields = 2	field_of_view = 14 differential_flux_energy_band = 15	1	16	1082
DiffIonFluxes	float	field_of_view = 14 differential_flux_energy_band = 15	differential ion flux at specific energy bands for each zone's primary ion data channels	cm-2 sr-1 s-1 keV-1	840	1098
DiffIonFluxDQFs control field(s)	uint64	number of control fields = 2	field_of_view = 14 differential_flux_energy_band = 15	1	16	1938
DiffIonFluxDQFs	uint8	field_of_view = 14 differential_flux_energy_band = 15	differential ion flux data quality flag at specific energy bands for each zone's primary ion data channels	1	210	1954
DiffElectronUncertainties control field(s)	uint64	number of control fields = 2	field_of_view = 14 differential_flux_energy_band = 15	1	16	2164
DiffElectronUncertainties	float	field_of_view = 14 differential_flux_energy_band = 15	dynamic error estimate of differential electron flux at specific energy bands for each zone's primary electron data channels	cm-2 sr-1 s-1 keV-1	840	2180
DiffIonUncertainties control field(s)	uint64	number of control fields = 2	field_of_view = 14 differential_flux_energy_band = 15	1	16	3020
DiffIonUncertainties	float	field_of_view = 14 differential_flux_energy_band = 15	dynamic error estimate of differential ion flux at specific energy bands for each zone's primary ion data channels	cm-2 sr-1 s-1 keV-1	840	3036
L1a_EngData_Flag	uint8	n/a	flags indicating availability of instrument engineering telemetry data	1	1	3876
L1a_IonData_Flag	uint8	n/a	flags indicating availability of instrument ion count science data	1	1	3877

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
L1a_EleData_Flag	uint8	n/a	flags indicating availability of instrument electron count science data	1	1	3878
L1b_Processing_Flag	uint8	n/a	flags indicating status of L1b product processing	1	1	3879
N_blocks	uint8	n/a	number of one second blocks of MPS-LO data used to create Magnetospheric Electrons and Protons: Low Energy product reports	count	1	3880
Instrument_Mode	uint8	n/a	instrument (sensor) mode	1	1	3881
Instrument_Serial_Number	uint8	n/a	SEISS MPS-LO instrument (sensor) serial number	1	1	3882
L1a_SciData_TimeStamp	double	n/a	End time of one-second observation by sensor, accurate to within 0.5 seconds of onboard data acquisition start time, for each report. The MPS-LO one-second interval is subdivided into sixteen .0625s segments. The first 0.0625s interval is used for a voltage fly-back step, while the remaining 15 intervals correspond to 15 energy channels from highest to lowest (30 keV to 0.030 keV). Each energy-channel data acquisition interval is in fact slightly less than 1/16 of a second, as data is not collected during the first 0.001 of each 16th of a second to allow the triquadrisphere HV power supply to settle at the	seconds since 2000-01-01 12:00:00, neglecting leap seconds	8	3883

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
			new voltage setting. Thus the actual data collection interval for each energy channel is 0.0615s. In summary, the data collection intervals are 0.0635s to 0.125s for the 30 keV channel, 0.126s to 0.1875 for the 18 keV channel, etc. Note that data is collected from all angular look zones and four background zones during each energy-channel observation			
quaternion_Q0	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q0	1	4	3891
quaternion_Q1	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q1	1	4	3895
quaternion_Q2	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q2	1	4	3899
quaternion_Q3	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q3	1	4	3903
ECEF_X	float	n/a	spacecraft ECEF X coordinate	m	4	3907
ECEF_Y	float	n/a	spacecraft ECEF Y coordinate	m	4	3911
ECEF_Z	float	n/a	spacecraft ECEF Z coordinate	m	4	3915
yaw_flip_flag	uint8	n/a	flags indicating whether spacecraft is operating in yaw flip configuration	1	1	3919
eclipse_flag	uint8	n/a	flags indicating whether sun is obscured by earth as provided by spacecraft	1	1	3920
solar_array_current control field(s)	uint64	number of control fields = 1	solar_array_current_channel_index = 4	1	8	3921

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
solar_array_current	uint16	solar_array_current_channel_index = 4	solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)	1	8	3929

The designation of "primary" for the sensor data channels is used for the channels where the primary observation data is acquired to distinguish it from the channels collecting background data.

7.5.2.5.1.1 Magnetospheric Electrons and Protons: Low Energy Product Quantity Characteristics

Table 7.5.2.5.1.1-1 Magnetospheric Electrons and Protons: Low Energy Product Electron and Ion Energy Band Characteristics

Energy Band (central value in eV) [1] [2]	Order in Product Data Structure	Product Label Variable Mnemonic
30000	1	EnergyBand-1
18320	2	EnergyBand-2
11180	3	EnergyBand-3
6828	4	EnergyBand-4
4168	5	EnergyBand-5
2545	6	EnergyBand-6
1554	7	EnergyBand-7
949	8	EnergyBand-8
579	9	EnergyBand-9
354	10	EnergyBand-10
216	11	EnergyBand-11
132	12	EnergyBand-12
80	13	EnergyBand-13
49	14	EnergyBand-14
30	15	EnergyBand-15

[1] The nominal width of each energy band divided by its central energy value is a constant = 6.67%.
[2] The energy band values in this table are pre-flight nominal values. The precise values for the energy bands, and bandpasses allowing count rate to be converted to flux used by the Level 1b algorithm are semi-static source data. These values are available from the Product Distribution and Access system. Additional details are located in paragraph 7.5.2.3, Level 1b Semi-Static Source Data.

Table 7.5.2.5.1.1-2 Magnetospheric Electrons and Protons: Low Energy Product Electron and Ion Flux Angular Zone Characteristics

	Electron and Ion Zones	
Angular Zone Center Direction [1][2]	Order in Product Data Structure	Product Label Variable Mnemonic
82.5° North of Zenith	14	Zone-12
67.5° North of Zenith	13	Zone-11
52.5° North of Zenith	12	Zone-10
37.5° North of Zenith	11	Zone-9
22.5° North of Zenith	10	Zone-8
7.5° North of Zenith	9	Zone-7L
7.5° North of Zenith	7	Zone-7R
7.5° South of Zenith	8	Zone-6L
7.5° South of Zenith	6	Zone-6R
22.5° South of Zenith	5	Zone-5
37.5° South of Zenith	4	Zone-4
52.5° South of Zenith	3	Zone-3
67.5° South of Zenith	2	Zone-2
82.5° South of Zenith	1	Zone-1

[1] When satellite is in yaw flip configuration, angular zone direction is reversed.
[2] Each angular zone is nominally 15 degrees wide. The angular zone center angles in this table are pre-flight nominal central values. The root-mean-square-deviation of the measured look directions from the nominal look directions (given here) is approximately 2.5 degrees. The measured look angles are used in the Level 2 processing.

7.5.2.5.1.2 Magnetospheric Electrons and Protons: Low Energy Product Flag Values and Meanings

Table 7.5.2.5.1.2-1 Magnetospheric Electrons and Protons: Low Energy Product Electron and Ion Flux Data Quality Flag Values and Meanings

Flux Data Quality Flags (DiffElectronFluxDQFs & DiffIonFluxDQFs)		
Flag Mask	Flag Value	Flag Meaning
31	0	good_quality_qf
1	1	invalid_due_to_missing_L0_data_or_not_operational_mode_qf
2	2	invalid_due_to_calibration_failed_qf
4	4	degraded_due_to_deadtime_correction_threshold_exceeded_qf [1]

Flux Data Quality Flags (DiffElectronFluxDQFs & DiffIonFluxDQFs)		
Flag Mask	**Flag Value**	**Flag Meaning**
8	8	degraded_due_to_out_of_band_contamination_level_threshold_exceeded_qf [2]
16	16	degraded_due_to_dynamic_error_threshold_exceeded_qf [3]

[1] Dead-time correction threshold is the limiting case where 25% of the raw counts are restored to account for dead-time. The data is considered degraded if the correction exceeds this threshold.
[2] Out-of-band contamination correction threshold is the limiting case of 1.0 for the ratio of the out-of-band contamination term to the valid raw counts. Out-of-band contamination includes particles arriving at the detector that are the wrong species, look-direction, energy, or a combination of these deficiencies. The data is considered degraded if the ratio exceeds this threshold.
[3] Dynamic flux error threshold is the limiting case of 0.25 for the ratio of the flux uncertainty to the flux. The data is considered degraded if the ratio exceeds this threshold.

Table 7.5.2.5.1.2-2 Magnetospheric Electrons and Protons: Low Energy Product Electron and Ion Count, and Engineering Telemetry Data Availability Flag Values and Meanings

Data Availability Flags (L1a_EleData_Flag, L1a_IonData_Flag, & L1a_EngData_Flag)	
Flag Value	**Flag Meaning**
0	all_data_available
1	some_data_available
2	all_data_missing

Table 7.5.2.5.1.2-3 Magnetospheric Electrons and Protons: Low Energy Product MPS-LO L1b Processing Quality Flag Values and Meaning

MPS-LO L1b Processing Quality Flags (L1b_Processing_Flag)	
Flag Value	**Flag Meaning**
0	good_processing_qf
1	failed_processing_qf
2	processing_not_attempted_due_to_missing_L0_data_qf
3	processing_not_attempted_due_to_non_operational_mode_qf

Table 7.5.2.5.1.2-4 Magnetospheric Electrons and Protons: Low Energy Product MPS-LO Instrument Mode Flag Values and Meaning

MPS-LO Instrument Mode Flags (Instrument_Mode)	
Flag Value	**Flag Meaning**
0	no_mode_indicated
1	standby_operational_mode
2	operational_mode
3	instrument_diagnostic_mode
4	in-flight_calibration_mode

Table 7.5.2.5.1.2-5 Magnetospheric Electrons and Protons: Low Energy Product Eclipse Flag Values and Meanings

Eclipse Flags (eclipse_flag)	
Flag Value	**Flag Meaning**
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse
3	penumbra_following_full_eclipse

Table 7.5.2.5.1.2-6 Magnetospheric Electrons and Protons: Low Energy Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (yaw_flip_flag)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

7.5.2.5.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Magnetospheric Electrons and Protons: Low Energy product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.5.2.5.2 Magnetospheric Electrons and Protons: Low Energy Product Metadata

```xml
<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2
https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
  <dimension name="report_number" isUnlimited="true"/>
  <dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
  <dimension name="field_of_view" length="14" isUnlimited="false"/>
  <dimension name="differential_flux_energy_band" length="15" isUnlimited="false"/>
  <dimension name="solar_array_current_channel_index" length="4" isUnlimited="false"/>
  <dimension name="field_of_view_str_len" length="7" isUnlimited="false"/>
  <dimension name="differential_flux_energy_band_str_len" length="16" isUnlimited="false"/>
  <dimension name="solar_array_mnemonic_str_len" length="25" isUnlimited="false"/>
  <variable name="ECEF_X" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF X coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="ECEF_Y" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF Y coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="ECEF_Z" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF Z coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-7360.0 7360.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="quaternion_Q0" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q0" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q1" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q1" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
```

<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="quaternion_Q2" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q2" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="quaternion_Q3" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q3" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="product_time" type="double" shape="number_of_time_bounds">
<attribute name="long_name" value="start and end time of observations associated with product" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
<values>***dynamic value dynamic value***</values>
</variable>
<variable name="L1a_SciData_TimeStamp" type="double" shape="report_number">
<attribute name="long_name" value="End time of one-second observation by sensor, accurate to within 0.5 seconds of onboard data acquisition start time, for each report. The MPS-LO one-second interval is subdivided into sixteen .0625s segments. The first 0.0625s interval is used for a voltage fly-back step, while the remaining 15 intervals correspond to 15 energy channels from highest to lowest (30 keV to 0.030 keV). Each energy-channel data acquisition interval is in fact slightly less than 1/16 of a second, as data is not collected during the first 0.001 of each 16th of a second to allow the triquadrisphere HV power supply to settle at the new voltage setting. Thus the actual data collection interval for each energy channel is 0.0615s. In summary, the data collection intervals are 0.0635s to 0.125s for the 30 keV channel, 0.126s to 0.1875 for the 18 keV channel, etc. Note that data is collected from all angular look zones and four background zones during each energy-channel observation" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="field_of_view_label" type="char" shape="field_of_view field_of_view_str_len">
<attribute name="long_name" value="label for instrument's fourteen angular electron and ion sensing zones, each with 15 degree (solid) angular zone field of view ordered the same as applicable data variables" type="string"/>
<values>Zone-1 Zone-2 Zone-3 Zone-4 Zone-5 Zone-6R Zone-7R Zone-6L Zone-7L Zone-8 Zone-9 Zone-10 Zone-11 Zone-12</values>
</variable>
<variable name="differential_flux_energy_band_label" type="char" shape="differential_flux_energy_band differential_flux_energy_band_str_len">

<attribute name="long_name" value="labels for fifteen energy bands reported, which are evenly spaced logarithmically spanning from 30 keV to 30 eV. labels are ordered the same as applicable data variables" type="string"/>
<values> Band1_30.0keV Band2_18.2keV Band3_11.3keV Band4_6.588keV Band5_4.094keV Band6_2.49keV Band7_1.514keV Band8_0.926keV Band9_0.546keV Band10_0.346keV Band11_0.212keV Band12_0.13keV Band13_0.08keV Band14_0.049keV Band15_0.03keV</values>
</variable>
<variable name="solar_array_current_channel_index_label" type="char" shape="solar_array_current_channel_index solar_array_mnemonic_str_len">
<attribute name="long_name" value="labels for four solar array current telemetry mnemonics. labels are ordered the same as applicable data variable" type="string"/>
<values>EPS_SA_CHAN_1_4_RETRN_I EPS_SA_CHAN_5_8_RETRN_I EPS_SA_CHAN_9_12_RETRN_I EPS_SA_CHAN_13_16_RETRN_I</values>
</variable>
<variable name="DiffElectronFluxes" type="float" shape="report_number field_of_view differential_flux_energy_band">
<attribute name="long_name" value="differential electron flux at specific energy bands for each zone’s primary electron data channels" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="DiffElectronFluxDQFs" type="ubyte" shape="report_number field_of_view differential_flux_energy_band">
<attribute name="long_name" value="differential electron flux data quality flag at specific energy bands for each zone’s primary electron data channels" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="DiffIonFluxes" type="float" shape="report_number field_of_view differential_flux_energy_band">
<attribute name="long_name" value="differential ion flux at specific energy bands for each zone’s primary ion data channels" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="DiffIonFluxDQFs" type="ubyte" shape="report_number field_of_view differential_flux_energy_band">
<attribute name="long_name" value="differential ion flux data quality flag at specific energy bands for each zone’s primary ion data channels" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>

<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="DiffElectronUncertainties" type="float" shape="report_number field_of_view differential_flux_energy_band">
<attribute name="long_name" value="dynamic error estimate of differential electron flux at specific energy bands for each zone’s primary electron data channels" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="DiffIonUncertainties" type="float" shape="report_number field_of_view differential_flux_energy_band">
<attribute name="long_name" value="dynamic error estimate of differential ion flux at specific energy bands for each zone’s primary ion data channels" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="L1a_EngData_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating availability of instrument engineering telemetry data" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1a_IonData_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating availability of instrument ion count science data" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1a_EleData_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating availability of instrument electron count science data" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>

<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1b_Processing_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating status of L1b product processing" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="N_blocks" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of one second blocks of MPS-LO data used to create Magnetospheric Electrons and Protons: Low Energy product reports" type="string"/>
<attribute name="_FillValue" value="0" type="ubyte"/>
<attribute name="valid_range" value="1 1" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="Instrument_Mode" type="ubyte" shape="report_number">
<attribute name="long_name" value="instrument (sensor) mode" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 4" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Instrument_Serial_Number" type="ubyte" shape="report_number">
<attribute name="long_name" value="SEISS MPS-LO instrument (sensor) serial number" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 254" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="yaw_flip_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>

```
    </variable>
  <variable name="eclipse_flag" type="ubyte" shape="report_number">
    <attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
    <attribute name="_FillValue" value="255" type="ubyte"/>
    <attribute name="valid_range" value="0 3" type="ubyte"/>
    <attribute name="units" value="1" type="string"/>
    <attribute name="flag_values" value="see note [flags and meanings]" type="ubyte"/>
    <attribute name="flag_meanings" value="see note [flags and meanings]" type="string"/>
  </variable>
  <variable name="solar_array_current" type="ushort" shape="report_number solar_array_current_channel_index">
    <attribute name="long_name" value="solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)" type="string"/>
    <attribute name="_FillValue" value="65535" type="ushort"/>
    <attribute name="valid_range" value="0 65534" type="ushort"/>
    <attribute name="units" value="count" type="string"/>
  </variable>
  <variable name="percent_uncorrectable_L0_errors" type="float" shape="">
    <attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="0.0 1.0" type="float"/>
    <attribute name="units" value="percent" type="string"/>
    <values>dynamic value</values>
  </variable>
  <variable name="algorithm_dynamic_input_data_container" type="int" shape="">
    <attribute name="long_name" value="container for filenames of dynamic algorithm input data; not in use" type="string"/>
    <attribute name="input_MPS-LO_L0_data" value="null" type="string"/>
  </variable>
  <attribute name="dataset_name" value="refer to filename conventions for L1b products in Appendix C." type="string"/>
  <attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
  <attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National
Environmental Satellite, Data, and Information Services" type="string"/>
  <attribute name="project" value="GOES" type="string"/>
  <attribute name="iso_series_metadata_id" value="f7087583-e5a8-11e3-ac10-0800200c9a66" type="string"/>
  <attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
  <attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0"
type="string"/>
  <attribute name="title" value="SEISS MPS-L0 L1b Magnetospheric Electrons and Protons: Low Energy" type="string"/>
  <attribute name="summary" value="The GOES-R Magnetospheric Electrons and Protons: Low Energy Product consists of fluxes of relatively low energy
electrons and ions derived from in situ measurements of electron and ion count rates.  Differential electron and ion fluxes are reported at fifteen energy bands
in fourteen angular zones. The energy bands are evenly spaced logarithmically spanning from 30 eV to 30 keV. Collectively, the fourteen angular zones, each
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with a fifteen degree field-of-view, span a total angular range of 180 degrees in the Y-Z plane, with the central zones having an anti-earthward look-angle and are parallel to the minus Z-axis (in spacecraft body-reference-frame coordinates). Although there are fourteen angular zones, there are only twelve unique look-angles with the two adjacent central angular zones measured twice. With respect to the earth, the zones are arranged from north to south with the central zones pointing anti-earthward. The product also contains processing and data quality metadata, satellite state and location information, and data required for the generation of level 2 products." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SUN-EARTH INTERACTIONS > IONOSPHERE/MAGNETOSPHERE DYNAMICS > ELECTRIC FIELDS/ELECTRIC CURRENTS, SUN-EARTH INTERACTIONS > IONOSPHERE/MAGNETOSPHERE DYNAMICS > ION CHEMISTRY/IONIZATION, SUN-EARTH INTERACTIONS > IONOSPHERE/MAGNETOSPHERE DYNAMICS > SOLAR WIND, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE FLUX > ELECTRON FLUX, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE FLUX > ION FLUX" type="string"/>
<attribute name="cdm_data_type" value="Point" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES-R Series SEISS Magnetospheric Particle Sensor Low Energy Range (MPS-LO)" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument (sensor).***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note "flags and meanings": Flag values and meanings are located in paragraph 7.5.2.5.1.2, Magnetospheric Electrons and Protons: Low Energy Product Flag Values and Meanings.

7.5.3 Magnetospheric Electrons and Protons: Medium and High Energy Product

7.5.3.1 Description

The Magnetospheric Electrons and Protons: Medium and High Energy product contains up to 30 sets of directional differential electron and proton flux values and directional integral electron flux values of medium and high energy measured in situ from geostationary orbit. A set is a block of processed observation data containing differential and integral flux values produced over a one second observation interval. The product includes data quality information that provides an assessment of the differential and integral flux values, including an indication of good or degraded quality, or invalid, and the rationale.

Differential and integral electron flux are reported in eleven energy bands for five angular zones. Differential electron flux is reported in ten of the energy bands, which are evenly spaced logarithmically spanning from 50 keV to 4 MeV. Integral electron flux is reported in the eleventh band for energies greater than 2 MeV. Differential proton flux is reported in eleven energy bands for the same five angular zones. These eleven proton energy bands are evenly spaced logarithmically spanning from 80 keV to 12 MeV. The five angular zones, which have a central look angle that is anti-earthward, span a total angular range of 170 degrees in the north to south direction. Each zone has a 30 degree conical field of view. The definition of the pre-flight nominal energy bands and angular zones are located in paragraph 5.4.3.5.1, Magnetospheric Electrons and Protons: Medium and High Energy Product Quantity Characteristics.

The product also contains calibrated ionizing radiation dose values in two energy ranges measured in situ from geostationary orbit. The low and high energy ranges are from 50 keV to 1 MeV and 1 MeV to 10 MeV, respectively. Like the differential flux values, the ionizing radiation dose values are produced over successive one second observation intervals. The product includes data quality information that provides an assessment of the calibrated ionizing radiation dose values, including an indication of good or degraded quality, or invalid, and the rationale. Since no calibration data was provided by the instrument vendor, there is a significant uncertainty for radiation dose values when the data quality flag is set to good.

The units of measure for the directional differential flux values are "particles per second per square centimeter per steradian per kiloelectron volt". The units of measure for the directional integral flux values are "particles per second per square centimeter per steradian". The units of measure for the ionizing radiation dose values are "centigrays".

The Magnetospheric Electrons and Protons: Medium and High Energy performance requirements are summarized in Table 7.5.3.1, Magnetospheric Electrons and Protons: Medium and High Energy Performance Requirements.

Table 7.5.3.1 Magnetospheric Electrons and Protons: Medium and High Energy Performance Requirements

	Measurement [1]			Mapping
Region	**Range**	**Accuracy**	**Precision**	**Uncertainty**
anti-earthward with a 170 degree north to south field of view from perspective of GOES-R satellite	(1) electrons: 50 keV to 4 MeV & > 2 MeV (2) protons: 80 keV to 12 MeV	25%: when flux level above background > 10 times minimum flux 45%: when flux level above background is between minimum flux & 10 times minimum flux	flux values associated with 10 counts above background in the 5 minute observation interval	not applicable

[1] Performance requirements for ionizing radiation dose has not been specified.

Metadata in the Magnetospheric Electrons and Protons: Medium and High Energy product provides statistical and other properties of the observation and processed data and information required for the generation of level 2 products, and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the observation data in the product.
- Time of each observation.
- Satellite location and spacecraft ACRF to J2000 ECI attitude quaternion.
- Eclipse of the sun indication.
- Satellite yaw flip configuration.
- Dynamic error estimate of differential electron and proton flux, and integral electron flux for each zone's electron and proton data channels (i.e., energy bands).
- Electron and proton count observation, dosimeter count observation, and engineering telemetry data availability information.
- Processing quality information.
- Instrument mode and serial number.

When the satellite is in on-orbit storage mode, the Magnetospheric Electrons and Protons: Medium and High Energy product data format and content are the same except that the observation data is subsampled such that it is provided every one in three seconds.

The detailed description of the ISO series metadata for the Magnetospheric Electrons and Protons: Medium and High Energy product is located in the standalone Appendix X, ISO Series Metadata.

7.5.3.2 Dynamic Source Data

The Magnetospheric Electrons and Protons: Medium and High Energy product is derived using MPS-HI Level 0 raw science telemetry, SGPS Level 1b Solar and Galactic Protons product data, SEISS engineering telemetry, and satellite ephemeris related telemetry.

The primary sensor data used by the Level 1b Magnetospheric Electrons and Protons: Medium and High Energy algorithm is identified in Table 7.5.3.2, Primary Sensor Data.

Table 7.5.3.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_MPS-HI_L0_data
L1b Products	input_SGPS_L1b_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.5.3.3 Level 1b Semi-Static Source Data

There are two categories of semi-static source data employed in the SEISS MPS-HI Level 1b ground processing algorithm:

- Sensor calibration parameters.
- Algorithm processing parameters.

One semi-static HDF5 source data file contains both categories above. This file is included with semi-static parameters for the other SEISS products in a single zip file.

Sensor calibration parameters are those associated with the sensor's observing characteristics, or its raw outputs. Specific types include:

- Geometric factors for each of the five electron telescopes' one integral energy band, and for the five proton telescopes' eleven differential bands are properties of the sensor, which are used to convert the raw count rate to flux; additionally, the uncertainties in the geometric factors contribute to determining the dynamic error estimate associated with the calculated flux values.
- Energy band boundaries for each of the five electron telescopes' ten differential bands and five proton telecopes' eleven differential bands.
- Electron and proton deadtime correction factors (both digital and analog), which are used to calibrate the flux values.
- Electron inverse instrument matrices for each of the five electron telescopes, which are used to convert count rate to unfolded count rate for the electron energy bands.
- An uncertainty parameter, which is used to estimate the uncertainty in the determination of the instrument response matrix.
- Out of band weighting factors (alpha, beta, gamma) for the five electron telescopes' four electron energy bands, E9, E10, E10A and Ell, which are used to scale the SGPS-X flux data during contamination removal.
- High Linear Energy Transfer (HILET) dosimeter 1 and 2, and Low Linear Energy Transfer (LOLET) dosimeter 1 and 2 factors, which are used to convert raw dose to calibrated dose.
- Sensor acquisition time interval.

Algorithm processing parameters are those associated with configurable decision-making logic in the algorithm. Specific types include:

- Data quality flag thresholds, which define excessive threshold values for the dead-time correction, the out-of-band contamination correction, and the fractional error on flux; these thresholds are used to calculate the data quality flag associated with each flux value.

The filename conventions for the MPS-HI Level 1b semi-static source data file are located in Appendix C.

7.5.3.4 Production Notes

The Magnetospheric Electrons and Protons: Medium and High Energy product is generated by SEISS MPS-HI Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm extracts the raw detector and radiation dose observation data from the CCSDS packets. The Level 1b algorithm uses the in situ medium and high electron and proton count rate measurements from the Earth's geomagnetic environment to determine the directional differential and integral flux values. The Level 1b algorithm corrects for instrument dead-time, removes out-of-band contamination, and converts count rates to directional differential and integral flux values using sensor viewing geometry and area, and energy band characteristics. For the out-of-band contamination correction of the higher energy electron data channels, the Level 1b algorithm uses SGPS L1b telescope 3 directional differential proton flux values.

In addition, the Level 1b algorithm uses the in situ ionizing radiation dose values from a pair of Low Linear Energy Transfer (LOLET) and a pair of High Linear Energy Transfer (HILET) dosimeters to determine calibrated ionizing radiation dose values from each of the four dosimeters. Multiplicative factors are used to calibrate the raw ionizing radiation dose values.

The flux uncertainties reported in the product are total uncertainties that include both instrument and statistical uncertainties.

The Level 1b algorithm generates valid product data only when the instrument is in the operational mode. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.5.3.5 Data Organization and Fields

A Magnetospheric Electrons and Protons: Medium and High Energy product spans up to 31 GRB Space Packets, nominally 30 for the data and another for the metadata. A product, which contains a set of directional differential electron and proton flux and related data values for a 30 second period, is transmitted over GRB in one second reports. These one second reports can be exploited upon receipt. Nominally, a product metadata Packet is queued for transmission after the thirtieth report has been queued for transmission.

The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, label variables, and product start and end time variable.

The subordinate paragraphs that follow define the Magnetospheric Electrons and Protons: Medium and High Energy product data, quantity characteristics, flag values and meanings, and metadata fields.

7.5.3.5.1 Data Fields

Table 7.5.3.5.1 Magnetospheric Electrons and Protons: Medium and High Energy Product Data

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
DiffElectronFluxes control field(s)	uint64	number of control fields = 2	direction = 5 energy_electron = 10	1	16	0
DiffElectronFluxes	float	direction = 5 energy_electron = 10	differential electron flux at specific energy bands for each telescope's ten primary data channels	cm-2 sr-1 s-1 keV-1	200	16
IntgElectronFluxes control field(s)	uint64	number of control fields = 1	direction = 5	1	8	216
IntgElectronFluxes	float	direction = 5	integral electron flux at energy band > 2000 keV for each telescope's primary data channel E11	cm-2 sr-1 s-1	20	224
DiffProtonFluxes control field(s)	uint64	number of control fields = 2	direction = 5 energy_proton = 11	1	16	244
DiffProtonFluxes	float	direction = 5 energy_proton = 11	differential proton flux at specific energy bands for each telescope's eleven primary data channels	cm-2 sr-1 s-1 keV-1	220	260

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
DiffElectronUncertainties control field(s)	uint64	number of control fields = 2	direction = 5 energy_electron = 10	1	16	480
DiffElectronUncertainties	float	direction = 5 energy_electron = 10	dynamic error estimate of differential electron flux at specific energy bands for each telescope's ten primary data channels	cm-2 sr-1 s-1 keV-1	200	496
IntgElectronUncertainties control field(s)	uint64	number of control fields = 1	direction = 5	1	8	696
IntgElectronUncertainties	float	direction = 5	dynamic error estimate of integral electron flux at energy band > 2000 keV for each telescope's primary data channel E11	cm-2 sr-1 s-1	20	704
DiffProtonUncertainties control field(s)	uint64	number of control fields = 2	direction = 5 energy_proton = 11	1	16	724
DiffProtonUncertainties	float	direction = 5 energy_proton = 11	dynamic error estimate of differential proton flux at specific energy bands for each telescope's eleven primary data channels	cm-2 sr-1 s-1 keV-1	220	740
DiffElectronFluxDQFs control field(s)	uint64	number of control fields = 2	direction = 5 energy_electron = 10	1	16	960
DiffElectronFluxDQFs	uint8	direction = 5 energy_electron = 10	differential electron flux data quality flags at specific energy bands for each telescope's primary data channels	1	50	976
DiffProtonFluxDQFs control field(s)	uint64	number of control fields = 2	direction = 5 energy_proton = 11	1	16	1026
DiffProtonFluxDQFs	uint8	direction = 5 energy_proton = 11	differential proton flux data quality flags at specific energy bands for each telescope's primary data channels	1	55	1042
IntgElectronFluxDQFs control field(s)	uint64	number of control fields = 1	direction = 5	1	8	1097
IntgElectronFluxDQFs	uint8	direction = 5	integral electron flux data quality flags at energy band > 2000 keV for each telescope's primary data channel E11	1	5	1105

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
Dos1_HiLetDose	float	n/a	calibrated dose from High Linear Energy Transfer (HILET) dosimeter 1, which measures energy between 1 and 10 MeV	cGy	4	1110
Dos1_HiLetDqf	uint8	n/a	flags indicating calibrated measurement derived from HILET dosimeter 1	1	1	1114
Dos2_HiLetDose	float	n/a	calibrated dose from High Linear Energy Transfer (HILET) dosimeter 2, which measures energy between 1 and 10 MeV	cGy	4	1115
Dos2_HiLetDqf	uint8	n/a	flags indicating calibrated measurement derived from HILET dosimeter 2	1	1	1119
Dos1_LoLetDose	float	n/a	calibrated dose from Low Linear Energy Transfer (LOLET) dosimeter 1, which measures energy between 50 keV and 1 MeV	cGy	4	1120
Dos1_LoLetDqf	uint8	n/a	flags indicating calibrated measurement derived from LOLET dosimeter 1	1	1	1124
Dos2_LoLetDose	float	n/a	calibrated dose from Low Linear Energy Transfer (LOLET) dosimeter 2, which measures energy between 50 keV and 1 MeV	cGy	4	1125
Dos2_LoLetDqf	uint8	n/a	flags indicating calibrated measurement derived from LOLET dosimeter 2	1	1	1129
L1a_EngData_Flag	uint8	n/a	flags indicating availability of instrument engineering telemetry data	1	1	1130
L1a_ProtonData_Flag	uint8	n/a	flags indicating availability of instrument proton count science data	1	1	1131

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
L1a_EleData_Flag	uint8	n/a	flags indicating availability of instrument electron count science data	1	1	1132
L1a_DosData_Flag	uint8	n/a	flags indicating availability of instrument dosimeter count science data	1	1	1133
L1b_Processing_Flag	uint8	n/a	flags indicating status of L1b product processing	1	1	1134
N_blocks	uint8	n/a	number of one second blocks of MPS-HI data used to create Magnetospheric Electrons and Protons: Medium and High Energy product reports	count	1	1135
Instrument_Mode	uint8	n/a	instrument (sensor) mode	1	1	1136
Instrument_Serial_Number	uint8	n/a	SEISS MPS-HI instrument (sensor) serial number	1	1	1137
L1a_SciData_TimeStamp	double	n/a	End time of one-second observation by sensor, accurate to within 0.5 seconds of onboard data acquisition start time, for each report	seconds since 2000-01-01 12:00:00, neglecting leap seconds	8	1138
quaternion_Q0	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q0	1	4	1146
quaternion_Q1	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q1	1	4	1150
quaternion_Q2	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q2	1	4	1154
quaternion_Q3	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q3	1	4	1158
ECEF_X	float	n/a	spacecraft ECEF X coordinate	m	4	1162
ECEF_Y	float	n/a	spacecraft ECEF Y coordinate	m	4	1166
ECEF_Z	float	n/a	spacecraft ECEF Z coordinate	m	4	1170

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
yaw_flip_flag	uint8	n/a	flags indicating whether spacecraft is operating in yaw flip configuration	1	1	1174
eclipse_flag	uint8	n/a	flags indicating whether sun is obscured by earth as provided by spacecraft	1	1	1175
solar_array_current control field(s)	uint64	number of control fields = 1	solar_array_current_channel_index = 4	1	8	1176
solar_array_current	uint16	solar_array_current_channel_index = 4	solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)	1	8	1184

The designation of "primary" for the sensor data channels is used for the channels where the primary observation data is acquired to distinguish it from the channels collecting singles data.

7.5.3.5.1.1 Magnetospheric Electrons and Protons: Medium and High Energy Product Quantity Characteristics

Table 7.5.3.5.1.1-1 Magnetospheric Electrons and Protons: Medium and High Energy Product Electron Energy Band Characteristics

Energy Band (in keV)	Order in Product Data Structure	Product Label Variable Mnemonic
50 - 80	1	ElectronEnergyBand-1
80 - 140	2	ElectronEnergyBand-2
140 - 200	3	ElectronEnergyBand-3
200 - 300	4	ElectronEnergyBand-4
300 - 450	5	ElectronEnergyBand-5
450 - 700	6	ElectronEnergyBand-6
700 - 1100	7	ElectronEnergyBand-7
1100 - 1700	8	ElectronEnergyBand-8
1700 - 2600	9	ElectronEnergyBand-9
2600 - 4000	10	ElectronEnergyBand-10
> 4000	1	not applicable

[1] The energy band values in this table are pre-flight nominal values. The precise values for the electron energy bands used by the Level 1b algorithm are semi-static source data. These values are available from the Product Distribution and Access system. Additional details are located in paragraph 7.5.3.3, Level 1b Semi-Static Source Data.

Table 7.5.3.5.1.1-2 Magnetospheric Electrons and Protons: Medium and High Energy Product Proton Energy Band Characteristics

Energy Band (in keV) [1]	Order in Product Data Structure	Product Label Variable Mnemonic
80 - 115	1	ProtonEnergyBand-1
115 - 165	2	ProtonEnergyBand-2
165 - 235	3	ProtonEnergyBand-3
235 - 340	4	ProtonEnergyBand-4
340 - 500	5	ProtonEnergyBand-5
500 - 700	6	ProtonEnergyBand-6
700 - 1000	7	ProtonEnergyBand-7
1000 - 1900	8	ProtonEnergyBand-8
1900 - 3200	9	ProtonEnergyBand-9
3200 - 6500	10	ProtonEnergyBand-10
6500 - 10000	11	ProtonEnergyBand-11

[1] The energy band values in this table are pre-flight nominal values. The precise values for the proton energy bands used by the Level 1b algorithm are semi-static source data. These values are available from the Product Distribution and Access system. Additional details are located in paragraph 7.5.3.3, Level 1b Semi-Static Source Data.

Table 7.5.3.5.1.1-3 Magnetospheric Electrons and Protons: Medium and High Energy Product Proton Flux Angular Zone Characteristics

	Electron Telescopes		Proton Telescopes	
Angular Zone Direction [1]	Order in Product Data Structure	Product Label Variable Mnemonic	Order in Product Data Structure	Product Label Variable Mnemonic
70° North of Zenith	3	Telescope-3	1	Telescope-1
35° North of Zenith	1	Telescope-1	4	Telescope-4
Zenith (radially outward)	4	Telescope-4	2	Telescope-2
35° South of Zenith	2	Telescope-2	5	Telescope-5
70° South of Zenith	5	Telescope-5	3	Telescope-3

[1] When satellite is in yaw flip configuration, angular zone direction is reversed.

7.5.3.5.1.2 Magnetospheric Electrons and Protons: Medium and High Energy Product Flag Values and Meanings

Table 7.5.3.5.1.2-1 Magnetospheric Electrons and Protons: Medium and High Energy Product Electron and Proton Flux Data Quality Flag Values and Meanings

Electron and Proton Flux Data Quality Flags (DiffElectronFluxDQFs, IntgElectronFluxDQFs, & DiffProtonFluxDQFs)		
Flag Mask	**Flag Value**	**Flag Meaning**
31	0	good_quality_qf
1	1	invalid_due_to_missing_L0_data_or_not_operational_mode_qf
2	2	invalid_due_to_calibration_failed_qf
4	4	degraded_due_to_deadtime_correction_threshold_exceeded_qf [1]
8	8	degraded_due_to_out_of_band_contamination_level_threshold_exceeded_qf [2]
16	16	degraded_due_to_dynamic_error_threshold_exceeded_qf [3]

[1] Dead-time correction threshold is the limiting case where 25% of the raw counts are restored to account for dead-time. The data is considered degraded if the correction exceeds this threshold.
[2] Out-of-band contamination correction threshold is the limiting case of 1.0 for the ratio of the out-of-band contamination term to the valid raw counts. Out-of-band contamination includes particles arriving at the detector that are the wrong species, look-direction, energy, or a combination of these deficiencies. The data is considered degraded if the ratio exceeds this threshold.
[3] Dynamic flux error threshold is the limiting case of 0.25 for the ratio of the flux uncertainty to the flux. The data is considered degraded if the ratio exceeds this threshold.

Table 7.5.3.5.1.2-2 Magnetospheric Electrons and Protons: Medium and High Energy Product Radiation Dose Data Quality Flag Values and Meanings

Energy Radiation Dose Data Quality Flags (Dos1_HiLetDqf, Dos2_HiLetDqf, Dos1_LoLetDqf, & Dos2_LoLetDqf)	
Flag Value	**Flag Meaning**
0	good_quality_qf
1	invalid_due_to_missing_L0_data_or_not_operational_mode_qf

Table 7.5.3.5.1.2-3 Magnetospheric Electrons and Protons: Medium and High Energy Product Electron and Proton Count, Radiation Dose, and Engineering Telemetry Data Availability Flag Values and Meanings

Data Availability Flags (L1a_EleData_Flag, L1a_ProtonData_Flag, L1a_DosData_Flag, & L1a_EngData_Flag)	
Flag Value	**Flag Meaning**
0	all_data_available
1	some_data_available
2	all_data_missing

Table 7.5.3.5.1.2-4 Magnetospheric Electrons and Protons: Medium and High Energy Product MPS-HI L1b Processing Quality Flag Values and Meaning

MPS-HI L1b Processing Quality Flags (L1b_Processing_Flag)	
Flag Value	**Flag Meaning**
0	good_processing_qf
1	failed_processing_qf
2	processing_not_attempted_due_to_missing_L0_data_qf
3	processing_not_attempted_due_to_non_operational_mode_qf

Table 7.5.3.5.1.2-5 Magnetospheric Electrons and Protons: Medium and High Energy Product MPS-HI Instrument Mode Flag Values and Meaning

MPS-HI Instrument Mode Flags (Instrument_Mode)	
Flag Value	**Flag Meaning**
0	no_mode_indicated
1	standby_operational_mode
2	operational_mode
3	instrument_diagnostic_mode
4	in-flight_calibration_mode

Table 7.5.3.5.1.2-6 Magnetospheric Electrons and Protons: Medium and High Energy Product Eclipse Flag Values and Meanings

Eclipse Flags (eclipse_flag)	
Flag Value	**Flag Meaning**
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse

Eclipse Flags (eclipse_flag)	
Flag Value	**Flag Meaning**
3	penumbra_following_full_eclipse

Table 7.5.3.5.1.2-7 Magnetospheric Electrons and Protons: Medium and High Energy Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (yaw_flip_flag)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

7.5.3.5.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Magnetospheric Electrons and Protons: Medium and High Energy product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.5.3.5.2 Magnetospheric Electrons and Protons: Medium and High Energy Product Metadata

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<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2 https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
<dimension name="report_number" isUnlimited="true"/>
<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
<dimension name="direction" length="5" isUnlimited="false"/>
<dimension name="energy_electron" length="10" isUnlimited="false"/>
<dimension name="energy_proton" length="11" isUnlimited="false"/>
<dimension name="solar_array_current_channel_index" length="4" isUnlimited="false"/>
<dimension name="telescope_label_str_len" length="11" isUnlimited="false"/>
<dimension name="electron_energy_label_str_len" length="24" isUnlimited="false"/>
<dimension name="proton_energy_label_str_len" length="22" isUnlimited="false"/>

<dimension name="solar_array_mnemonic_str_len" length="25" isUnlimited="false"/>
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<attribute name="long_name" value="spacecraft ECEF X coordinate" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
<attribute name="units" value="m" type="string"/>
</variable>
<variable name="ECEF_Y" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ECEF Y coordinate" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
<attribute name="units" value="m" type="string"/>
</variable>
<variable name="ECEF_Z" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ECEF Z coordinate" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="units" value="m" type="string"/>
</variable>
<variable name="quaternion_Q0" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q0" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="quaternion_Q1" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q1" type="string"/>
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<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
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<variable name="quaternion_Q2" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q2" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="quaternion_Q3" type="float" shape="report_number">

<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q3" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-1.0 1.0" type="float"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="product_time" type="double" shape="number_of_time_bounds">
<attribute name="long_name" value="maximum and minimum CCSDS header time codes of observations associated with product" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
<values>***dynamic value dynamic value***</values>
</variable>
<variable name="L1a_SciData_TimeStamp" type="double" shape="report_number">
<attribute name="long_name" value="End time of one-second observation by sensor, accurate to within 0.5 seconds of onboard data acquisition start time, for each report" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="direction_label" type="char" shape="direction telescope_label_str_len">
<attribute name="long_name" value="labels for instrument's five paired identical electron and proton sensing telescopes, each with 30 degree (solid) angular zone fields of view. labels are ordered the same as applicable data variables" type="string"/>
<values>Telescope-1 Telescope-2 Telescope-3 Telescope-4 Telescope-5</values>
</variable>
<variable name="energy_electron_label" type="char" shape="energy_electron electron_energy_label_str_len">
<attribute name="long_name" value="labels for ten electron energy bands reported, which are evenly spaced logarithmically spanning from 50 keV to 4 MeV, labels are ordered the same as applicable data variables" type="string"/>
<values>ElectronEnergyBand-1 ElectronEnergyBand-2 ElectronEnergyBand-3 ElectronEnergyBand-4 ElectronEnergyBand-5 ElectronEnergyBand-6 ElectronEnergyBand-7 ElectronEnergyBand-8 ElectronEnergyBand-9 ElectronEnergyBand-10</values>
</variable>
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<values>ProtonEnergyBand-1 ProtonEnergyBand-2 ProtonEnergyBand-3 ProtonEnergyBand-4 ProtonEnergyBand-5 ProtonEnergyBand-6 ProtonEnergyBand-7 ProtonEnergyBand-8 ProtonEnergyBand-9 ProtonEnergyBand-10 ProtonEnergyBand-11</values>
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<attribute name="long_name" value="labels for four solar array current telemetry mnemonics. labels are ordered the same as applicable data variable" type="string"/>
<values>EPS_SA_CHAN_1_4_RETRN_I EPS_SA_CHAN_5_8_RETRN_I EPS_SA_CHAN_9_12_RETRN_I EPS_SA_CHAN_13_16_RETRN_I</values>

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  </variable>
  <variable name="DiffElectronFluxes" type="float" shape="report_number direction energy_electron">
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    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
    <attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
  </variable>
  <variable name="IntgElectronFluxes" type="float" shape="report_number direction">
    <attribute name="long_name" value="integral electron flux at energy band > 2000 keV for each telescope’s primary data channel E11" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
    <attribute name="units" value="cm-2 sr-1 s-1" type="string"/>
  </variable>
  <variable name="DiffProtonFluxes" type="float" shape="report_number direction energy_proton">
    <attribute name="long_name" value="differential proton flux at specific energy bands for each telescope’s eleven primary data channels" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
    <attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
    </variable>
  <variable name="DiffElectronUncertainties" type="float" shape="report_number direction energy_electron">
    <attribute name="long_name" value="dynamic error estimate of differential electron flux at specific energy bands for each telescope’s ten primary data channels" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
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  </variable>
  <variable name="IntgElectronUncertainties" type="float" shape="report_number direction">
    <attribute name="long_name" value="dynamic error estimate of integral electron flux at energy band > 2000 keV for each telescope’s primary data channel E11" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
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  </variable>
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    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
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</variable>
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<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
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<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<variable name="IntgElectronFluxDQFs" type="ubyte" shape="report_number direction">
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<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
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<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
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</variable>
<variable name="Dos1_HiLetDqf" type="ubyte" shape="report_number">

<attribute name="long_name" value="flags indicating calibrated measurement derived from HILET dosimeter 1" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
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<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Dos2_HiLetDose" type="float" shape="report_number">
<attribute name="long_name" value="calibrated dose from High Linear Energy Transfer (HILET) dosimeter 2, which measures energy between 1 and 10 MeV" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cGy" type="string"/>
</variable>
<variable name="Dos2_HiLetDqf" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating calibrated measurement derived from HILET dosimeter 2" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
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</variable>
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<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
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<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<attribute name="_FillValue" value="-1.0e+31" type="float"/>
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<attribute name="units" value="cGy" type="string"/>
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<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1a_EngData_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating availability of instrument engineering telemetry data" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
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</variable>
<variable name="L1a_ProtonData_Flag" type="ubyte" shape="report_number">
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<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
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<attribute name="long_name" value="flags indicating availability of instrument electron count science data" type="string"/>
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<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
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<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1b_Processing_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating status of L1b product processing" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="N_blocks" type="ubyte" shape="report_number">
<attribute name="long_name" value="number of one second blocks of MPS-HI data used to create Magnetospheric Electrons and Protons: Medium and High Energy product reports" type="string"/>
<attribute name="_FillValue" value="0" type="ubyte"/>
<attribute name="valid_range" value="1 1" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="Instrument_Mode" type="ubyte" shape="report_number">
<attribute name="long_name" value="instrument (sensor) mode" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 4" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Instrument_Serial_Number" type="ubyte" shape="report_number">
<attribute name="long_name" value="SEISS MPS-HI instrument (sensor) serial number" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 254" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="yaw_flip_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>

<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="eclipse_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="solar_array_current" type="ushort" shape="report_number solar_array_current_channel_index">
<attribute name="long_name" value="solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="percent_uncorrectable_L0_errors" type="float" shape="">
<attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data; not in use" type="string"/>
<attribute name="input_MPS-HI_L0_data" value="null" type="string"/>
<attribute name="input_SGPS_L1b_data" value="null" type="string"/>
</variable>
<attribute name="dataset_name" value="***refer to filename conventions for L1b products in Appendix C.***" type="string"/>
<attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
<attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
<attribute name="project" value="GOES" type="string"/>
<attribute name="iso_series_metadata_id" value="f7087584-e5a8-11e3-ac10-0800200c9a66" type="string"/>
<attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>

<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
<attribute name="title" value="SEISS MPS-HI L1b Magnetospheric Electrons and Protons: Medium and High Energy" type="string"/>
<attribute name="summary" value="The GOES-R Magnetospheric Electrons and Protons: Medium and High Energy Product consists of fluxes of medium and high energy electrons and protons derived from in situ measurements of electron and proton count rates. Differential and integral electron fluxes are reported at eleven energy bands in five angular zones. Ten of the energy bands are evenly spaced logarithmically spanning from 50 keV to 4 MeV with differential electron flux being reported. The eleventh energy band collects electrons with energies greater than 2 MeV with electron integral flux being reported. In addition, differential proton fluxes are reported at eleven energy bands in the same five angular zones. The eleven proton energy bands are evenly spaced logarithmically and range from 80 keV to 12 MeV. Collectively, the five angular zones, each with a 30 degree field-of-view, span a total angular range of 170 degrees in the Y-Z arranged north to south with the central zone having an anti-earthward look-angle and are parallel to the minus Z-axis (in spacecraft body-reference-frame coordinates). With respect to the earth, the zones are arranged from north to south with the central zone pointing anti-earthward. In addition, the product contains ionizing radiation doses in two energy ranges, 50 keV to 1 MeV and 1 MeV to 10 MeV, obtained from a pair of Low and High Linear Energy Transfer dosimeters, respectively. The product also contains processing and data quality metadata, satellite state and location information, and data required for the generation of level 2 products." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SUN-EARTH INTERACTIONS > IONOSPHERE/MAGNETOSPHERE DYNAMICS > ELECTRIC FIELDS/ELECTRIC CURRENTS, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE FLUX > ELECTRON FLUX, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE FLUX > PROTON FLUX, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE PROPERTIES > ENERGY DEPOSITION" type="string"/>
<attribute name="cdm_data_type" value="Point" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES-R Series SEISS Magnetospheric Particle Sensor High Energy Range (MPS-HI)" type="string"/>
<attribute name="instrument_ID" value="***serial number of the instrument (sensor).***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note "flags and meanings": Flag values and meanings are located in paragraph 7.5.3.5.1.2, Magnetospheric Electrons and Protons: Medium and High Energy Product Flag Values and Meanings.

7.5.4 Solar and Galactic Protons Product

7.5.4.1 Description

The Solar and Galactic Protons product contains up to 60 sets of directional differential and integral proton flux values of very high energy measured in situ from geostationary orbit. A set is a block of processed observation data containing differential and integral flux values produced over a one second observation interval. The product includes data quality information that provides an assessment of the differential and integral flux values, including an indication of good or degraded quality, or invalid, and the rationale.

Differential and integral proton flux are reported in fourteen energy bands for two angular zones. Differential proton flux is reported in thirteen of the energy bands, which span from 1 to 500 MeV. Integral proton flux is reported in the fourteenth band for energies greater than 500 MeV. The two angular zones have a westward and eastward central look angle. Separate sensor units support each of the two angular zones. The size of the conical fields-of-view for the energy bands vary. The definition of the pre-flight nominal energy bands, and the angular zones and size of their fields-of-view are located in paragraph 7.5.4.5.1, Solar and Galactic Protons Product Quantity Characteristics.

The precise look angles of the angular zones relative to the GOES-R spacecraft body reference frame required for use and subsequent processing of this level 1b product data are available from the Product Distribution and Access system.

The units of measure for the directional differential flux values are "particles per second per square centimeter per steradian per kiloelectron volt". The units of measure for the directional integral flux values are "particles per second per square centimeter per steradian".

The Solar and Galactic Protons performance requirements are summarized in Table 7.5.4.1, Solar and Galactic Protons Performance Requirements.

Table 7.5.4.1 Solar and Galactic Protons Performance Requirements

	Measurement			Mapping
Region	Range	Accuracy	Precision	Uncertainty
westward and eastward from perspective of GOES-R satellite with varying fields-of-view for different energy bands	1 to 500 MeV & > 500 MeV	25%: when flux level above background > 10 times minimum flux 45%: when flux level above background is between minimum flux & 10 times minimum flux	flux values associated with 10 counts above background in the 5 minute observation interval	not applicable

Metadata in the Solar and Galactic Protons product provides statistical and other properties of the observation and processed data and information required for the generation of level 2 products, and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the observation data in the product.
- Time of each observation.
- Satellite location and spacecraft ACRF to J2000 ECI attitude quaternion.
- Eclipse of the sun indication.
- Satellite yaw flip configuration.
- Dynamic error estimate of differential and integral proton flux for each zone's data channels (i.e., energy bands).
- Proton count observation and engineering telemetry data availability information.
- Processing quality information.
- On-board out-of-band contamination removal enabled indication.

- Instrument mode and serial number.

When the satellite is in on-orbit storage mode, the Solar and Galactic Protons product data format and content are the same except that the observation data is subsampled such that it is provided every one in three seconds.

The detailed description of the ISO series metadata for the Solar and Galactic Protons product is located in the standalone Appendix X, ISO Series Metadata.

7.5.4.2 Dynamic Source Data

The Solar and Galactic Protons product is derived using SGPS Level 0 raw science telemetry, SEISS engineering telemetry, and satellite ephemeris related telemetry.

The primary sensor data used by the Level 1b Solar and Galactic Protons algorithm is identified in Table 7.5.4.2, Primary Sensor Data.

Table 7.5.4.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_SGPS_L0_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.5.4.3 Level 1b Semi-Static Source Data

There are two categories of semi-static source data employed in the SEISS SGPS Level 1b ground processing algorithm:

- Sensor calibration parameters.
- Algorithm processing parameters.

One semi-static HDF5 source data file contains both categories above. This file is included with semi-static parameters for the other SEISS products in a single zip file.

Sensor calibration parameters are those associated with the sensor's observing characteristics, or its raw outputs. Specific types include:

- Geometric factors for each of the three telescopes' energy bands, which are properties of the sensor and used to convert the raw count rate to flux; additionally, the uncertainties in the geometric factors contribute to determining the dynamic error estimate associated with the calculated flux values.
- Energy band boundaries for each of the three telescopes' differential energy bands.
- Deadtime correction factor, which is used to calibrate the flux values.
- Out-of-band contamination removal overall scaling factors and weighting factors for those channels undergoing out-of-band contamination removal (i.e., P5, P8CF, P9F and P10).
- Sensor acquisition time interval.

There are separate parameter instances for the SGPS-X and SGPS+X units.

Algorithm processing parameters are those associated with configurable decision-making logic in the algorithm. Specific types include:

- Data quality flag thresholds, which define excessive threshold values for the dead-time correction, the out-of-band contamination correction and the fractional error on flux; these thresholds are used to calculate the data quality flag associated with each flux value.

The filename conventions for the SGPS Level 1b semi-static source data file are located in Appendix C.

7.5.4.4 Production Notes

The Solar and Galactic Protons product is generated by SEISS SGPS Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm extracts the raw detector observation data from the CCSDS packets. The Level 1b algorithm uses the in situ very high energy proton count rate measurements from the Earth's geomagnetic environment to determine the directional differential and integral flux values. The Level 1b algorithm corrects for instrument dead-time, removes out-of-band contamination, and converts count rates to directional differential and integral flux values using sensor viewing geometry and area, and energy band characteristics.

The flux uncertainties reported in the product are total uncertainties that include both instrument and statistical uncertainties.

The Level 1b algorithm generates valid product data only when the instrument is in the operational mode. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.5.4.5 Data Organization and Fields

A Solar and Galactic Protons product spans up to 61 GRB Space Packets, nominally 60 for the data and another for the metadata. A product, which contains a set of directional differential and integral proton flux and related data values for a 60 second period, is transmitted over GRB in one second reports. These one second reports can be exploited upon receipt. Nominally, a product metadata Packet is queued for transmission after the sixtieth report has been queued for transmission.

The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, label variables, and product start and end time variable.

The subordinate paragraphs that follow define the Solar and Galactic Protons product data, quantity characteristics, flag values and meanings, and metadata fields.

7.5.4.5.1 Data Fields

Table 7.5.4.5.1 Solar and Galactic Protons Product Data

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
T1_DifferentialProtonFluxes control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T1 = 6	1	16	0
T1_DifferentialProtonFluxes	float	sensor_unit = 2 energy_T1 = 6	differential proton flux at specific energy bands for telescope 1's primary proton data channels on each of the two sensor units	cm-2 sr-1 s-1 keV-1	48	16
T1_DifferentialProtonFluxUncertainties control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T1 = 6	1	16	64
T1_DifferentialProtonFluxUncertainties	float	sensor_unit = 2 energy_T1 = 6	dynamic error estimate of differential proton flux at specific energy bands for telescope 1's primary proton data channels on each of the two sensor units	cm-2 sr-1 s-1 keV-1	48	80
T1_DifferentialProtonFluxDQFs control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T1 = 6	1	16	128

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
T1_DifferentialProtonFluxDQFs	byte	sensor_unit = 2 energy_T1 = 6	differential proton flux data quality flag at specific energy bands for telescope 1's primary proton data channels on each of the two sensor units	1	12	144
T2_DifferentialProtonFluxes control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T2 = 2	1	16	156
T2_DifferentialProtonFluxes	float	sensor_unit = 2 energy_T2 = 2	differential proton flux at specific energy bands for telescope 2's primary proton data channels on each of the two sensor units	cm-2 sr-1 s-1 keV-1	16	172
T2_DifferentialProtonFluxUncertainties control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T2 = 2	1	16	188
T2_DifferentialProtonFluxUncertainties	float	sensor_unit = 2 energy_T2 = 2	dynamic error estimate of differential proton flux at specific energy bands for telescope 2's primary proton data channels on each of the two sensor units	cm-2 sr-1 s-1 keV-1	16	204
T2_DifferentialProtonFluxDQFs control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T2 = 2	1	16	220
T2_DifferentialProtonFluxDQFs	uint8	sensor_unit = 2 energy_T2 = 2	differential proton flux data quality flag at specific energy bands for telescope 2's primary proton data channels on each of the two sensor units	1	4	236
T3_DifferentialProtonFluxes control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T3 = 5	1	16	240
T3_DifferentialProtonFluxes	float	sensor_unit = 2 energy_T3 = 5	differential proton flux at specific energy bands for telescope 3's primary proton data channels on each of the two sensor units	cm-2 sr-1 s-1 keV-1	40	256
T3_DifferentialProtonFluxUncertainties control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T3 = 5	1	16	296

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
T3_DifferentialProtonFluxUncertainties	float	sensor_unit = 2 energy_T3 = 5	dynamic error estimate of differential proton flux at specific energy bands for telescope 3's primary proton data channels on each of the two sensor units	cm-2 sr-1 s-1 keV-1	40	312
T3_DifferentialProtonFluxDQFs control field(s)	uint64	number of control fields = 2	sensor_unit = 2 energy_T3 = 5	1	16	352
T3_DifferentialProtonFluxDQFs	uint8	sensor_unit = 2 energy_T3 = 5	differential proton flux data quality flag at specific energy bands for telescope 3's primary proton data channels on each of the two sensor units	1	10	368
T3P11_IntegralProtonFlux control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	378
T3P11_IntegralProtonFlux	float	sensor_unit = 2	integral proton flux at energy band > 500 MeV for telescope 3's primary integral data channel P11 on each of the two sensor units	cm-2 sr-1 s-1	8	386
T3P11_IntegralProtonFluxUncertainties control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	394
T3P11_IntegralProtonFluxUncertainties	float	sensor_unit = 2	dynamic error estimate of integral proton flux at energy band > 500 MeV for telescope 3's primary integral data channel P11 on each of the two sensor units	cm-2 sr-1 s-1	16	402
T3P11_IntegralProtonFluxDQFs control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	418
T3P11_IntegralProtonFluxDQFs	uint8	sensor_unit = 2	integral proton flux data quality flag at energy band > 500 MeV for telescope 3's primary integral data channel P11 on each of the two sensor units	1	2	426

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
L1a_EngData_Flag control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	428
L1a_EngData_Flag	uint8	sensor_unit = 2	flags indicating availability of instrument engineering telemetry data on each of the two sensor units	1	2	436
L1a_SciData_Flag control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	438
L1a_SciData_Flag	uint8	sensor_unit = 2	flags indicating availability of instrument proton count science data on each of the two sensor units	1	2	446
L1b_Processing_Flag	uint8	n/a	flags indicating status of L1b product processing	1	1	448
N_blocks control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	449
N_blocks	uint8	sensor_unit = 2	number of one second blocks of SGPS data used to create Solar and Galactic Protons product reports on each of the two sensor units	1	2	457
Instrument_Mode control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	459
Instrument_Mode	uint8	sensor_unit = 2	SGPS-X and SGPS+X instrument (sensor) mode	1	2	467
Instrument_Serial_Number control field(s)	uint8	number of control fields = 1	sensor_unit = 2	1	8	469
Instrument_Serial_Number	uint8	sensor_unit = 2	SEISS SGPS-X and SGPS+X instrument (sensor) serial number	1	2	477
Diff31_Logic_Flags control field(s)	uint64	number of control fields = 2	sensor_unit = 2 channel = 3	1	16	479
Diff31_Logic_Flags	uint8	sensor_unit = 2 channel = 3	flags indicating whether on-board out-of-band contamination removal is enabled for primary proton data channels P7, P8CF and	1	6	495

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
			P9F on each of the two sensor units			
L1a_SciData_TimeStamp control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	501
L1a_SciData_TimeStamp	double	sensor_unit = 2	End time of one-second observation by sensor, accurate to within 0.5 seconds of onboard data acquisition start time, for each report	seconds since 2000-01-01 12:00:00, neglecting leap seconds	16	509
quaternion_Q0	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q0	1	4	525
quaternion_Q1	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q1	1	4	529
quaternion_Q2	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q2	1	4	533
quaternion_Q3	float	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q3	1	4	537
ECEF_X	float	n/a	spacecraft ECEF X coordinate	m	4	541
ECEF_Y	float	n/a	spacecraft ECEF Y coordinate	m	4	545
ECEF_Z	float	n/a	spacecraft ECEF Z coordinate	m	4	549
yaw_flip_flag	uint8	n/a	flags indicating whether spacecraft is operating in yaw flip configuration	1	1	553
eclipse_flag	uint8	n/a	flags indicating whether sun is obscured by earth as provided by spacecraft	1	1	554
solar_array_current control field(s)	uint64	number of control fields = 1	solar_array_current_channel_index = 4	1	8	555
solar_array_current	uint16	solar_array_current_channel_index = 4	solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)	1	8	563

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
sgps_telemetry_time control field(s)	uint64	number of control fields = 1	sensor_unit = 2	1	8	571
sgps_telemetry_time	double	sensor_unit = 2	time of the SGPS-X and SGPS+X engineering telemetry packets containing the 4 sensor temperature values	seconds since 2000-01-01 12:00:00, neglecting leap seconds	16	579
sgps_sensor_temperature control field(s)	uint64	number of control fields = 2	sensor_unit = 2 temperature_number = 4	1	16	595
sgps_sensor_temperature	float	sensor_unit = 2 temperature_number = 4	SGPS-X and SGPS+X sensor unit temperatures, the first is from Telescope 3, the second is from the Low Voltage Regulator (LVR), the third is from the Baseplate and the fourth is from Telelscope 2	K	32	611

The designation of "primary" for the sensor data channels is used for the channels where the primary observation data is acquired to distinguish it from the channels collecting singles data.

7.5.4.5.1.1 Solar and Galactic Protons Product Quantity Characteristics

Table 7.5.4.5.1.1-1 Solar and Galactic Protons Product Field of View and Proton Energy Band Characteristics

Telescope [1]	Field of View [2] [3]	Energy Band (in MeV) [4]	Order in Product Data Structure	Product Label Variable Mnemonic
Telescope 1	*60 degrees*	1 - 1.9	1	EnergyBand-P1:1-1.9MeV
		1.9 - 2.3	2	EnergyBand-P2A:1.9-2.3MeV
		2.3 - 3.4	3	EnergyBand-P2B:2.3-3.4MeV
		3.4 - 6.5	4	EnergyBand-P3:3.4-6.5MeV
		6.5 - 12	5	EnergyBand-P4:6.5-12MeV
		12 - 25	6	EnergyBand-P5:12-25MeV
Telescope 2	*60 degrees*	25 - 40	1	EnergyBand-P6:25-40MeV
		40 - 80	2	EnergyBand-P7:40-80MeV
Telescope 3	*90 degrees*	83 - 99	1	EnergyBand-P8AF:83-99MeV

Telescope [1]	Field of View [2] [3]	Energy Band (in MeV) [4]	Order in Product Data Structure	Product Label Variable Mnemonic
		99 - 118	2	EnergyBand-P8BF:99-118MeV
		118 - 150	3	EnergyBand-P8CF:118-150MeV
		150 - 275	4	EnergyBand-P9F:150-275MeV
		275 - 500	5	EnergyBand-P10:275-500MeV
		> 500	1	not applicable

[1] Three telescopes, which have identical central look angles, collectively support the fourteen data channels (i.e., energy bands). Separate data structures are used to store the differential fluxes associated with each telescope.
[2] Field-of-view for the three telescopes is conical.
[3] The angular zone values in this table are pre-flight nominal values. The precise values for the look angles of the angular zones relative to the GOES-R spacecraft body reference frame required for use and subsequent processing of this level 1b product data are semi-static source data. These values are available from the Product Distribution and Access system. Additional details are located in paragraph 5.4.4.3, Level 1b Semi-Static Source Data.
[4] The energy band values in this table are pre-flight nominal values. The precise values for the energy bands used by the Level 1b algorithm are semi-static source data. These values are available from the Product Distribution and Access system. Additional details are located in paragraph 7.5.4.3, Level 1b Semi-Static Source Data.

Table 7.5.4.5.1.1-2 Solar and Galactic Protons Product Sensor Unit Characteristics

Angular Zone Direction [1]	Order in Product Data Structure	Product Label Variable Mnemonic
Westward	1	SGPS-X
Eastward	2	SGPS+X

[1] When satellite is in yaw flip configuration, angular zone direction for sensor units is reversed.

7.5.4.5.1.2 Solar and Galactic Protons Product Flag Values and Meanings

Table 7.5.4.5.1.2-1 Solar and Galactic Protons Product Proton Flux Data Quality Flag Values and Meanings

Proton Flux Data Quality Flags (T1_DifferentialProtonFluxDQFs, T2_DifferentialProtonFluxDQFs, T3_DifferentialProtonFluxDQFs, & T3_DifferentialProtonFluxDQFs)		
Flag Mask	**Flag Value**	**Flag Meaning**
31	0	good_quality_qf
1	1	invalid_due_to_missing_L0_data_or_not_operational_mode_qf
2	2	invalid_due_to_calibration_failed_qf
4	4	degraded_due_to_deadtime_correction_threshold_exceeded_qf [1]
8	8	degraded_due_to_out_of_band_contamination_level_threshold_exceeded_qf [2]
16	16	degraded_due_to_dynamic_error_threshold_exceeded_qf [3]

[1] Dead-time correction threshold is the limiting case where 25% of the raw counts are restored to account for dead-time. The data is considered degraded if the correction exceeds this threshold.
[2] Out-of-band contamination correction threshold is the limiting case of 1.0 for the ratio of the out-of-band contamination term to the valid raw counts. Out-of-band contamination includes particles arriving at the detector that are the wrong species, look-direction, energy, or a combination of these deficiencies. The data is considered degraded if the ratio exceeds this threshold.
[3] Dynamic flux error threshold is the limiting case of 0.25 for the ratio of the flux uncertainty to the flux. The data is considered degraded if the ratio exceeds this threshold.

Table 7.5.4.5.1.2-2 Solar and Galactic Protons Product Proton Count and Engineering Telemetry Data Availability Flag Values and Meanings

Data Availability Flags (L1a_SciData_Flag & L1a_EngData_Flag)	
Flag Value	**Flag Meaning**
0	all_data_available
1	some_data_available
2	all_data_missing

Table 7.5.4.5.1.2-3 Solar and Galactic Protons Product SGPS L1b Processing Quality Flag Values and Meaning

SGPS L1b Processing Quality Flags (L1b_Processing_Flag)	
Flag Value	**Flag Meaning**
0	good_processing_qf
1	failed_processing_qf
2	processing_not_attempted_due_to_missing_L0_data_qf
3	processing_not_attempted_due_to_non_operational_mode_qf

Table 7.5.4.5.1.2-4 Solar and Galactic Protons Product On-Board Contamination Removal Flag Values and Meaning

On-Board Contamination Removal Flags (Diff31_Logic_Flags)	
Flag Value	**Flag Meaning**
0	on_board_contamination_removal_disabled
1	on_board_contamination_removal_enabled

Table 7.5.4.5.1.2-5 Solar and Galactic Protons Product SGPS Instrument Mode Flag Values and Meaning

SGPS Instrument Mode Flags (Instrument_Mode)	
Flag Value	**Flag Meaning**
0	no_mode_indicated
1	standby_operational_mode
2	operational_mode
3	instrument_diagnostic_mode
4	in-flight_calibration_mode

Table 7.5.4.5.1.2-6 Solar and Galactic Protons Product Eclipse Flag Values and Meanings

Eclipse Flags (eclipse_flag)	
Flag Value	**Flag Meaning**
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse
3	penumbra_following_full_eclipse

Table 7.5.4.5.1.2-7 Solar and Galactic Protons Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (yaw_flip_flag)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

7.5.4.5.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Solar and Galactic Protons product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.5.4.5.2 Solar and Galactic Protons Product Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2 https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
<dimension name="report_number" isUnlimited="true"/>
<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
<dimension name="energy_T1" length="6" isUnlimited="false"/>
<dimension name="energy_T2" length="2" isUnlimited="false"/>
<dimension name="energy_T3" length="5" isUnlimited="false"/>
<dimension name="sensor_unit" length="2" isUnlimited="false"/>
<dimension name="channel" length="3" isUnlimited="false"/>
<dimension name="solar_array_current_channel_index" length="4" isUnlimited="false"/>
<dimension name="sensor_unit_str_len" length="6" isUnlimited="false"/>
<dimension name="energy_T1_str_len" length="25" isUnlimited="false"/>
<dimension name="energy_T2_str_len" length="22" isUnlimited="false"/>
<dimension name="energy_T3_str_len" length="26" isUnlimited="false"/>
<dimension name="channel_str_len" length="16" isUnlimited="false"/>
<dimension name="solar_array_mnemonic_str_len" length="25" isUnlimited="false"/>
<dimension name="temperature_number" length="4" isUnlimited="false"/>
<variable name="ECEF_X" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ECEF X coordinate" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
<attribute name="units" value="m" type="string"/>
</variable>
<variable name="ECEF_Y" type="float" shape="report_number">
<attribute name="long_name" value="spacecraft ECEF Y coordinate" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>

```
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="ECEF_Z" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ECEF Z coordinate" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-7360.0 7360.0" type="float"/>
    <attribute name="units" value="m" type="string"/>
  </variable>
  <variable name="quaternion_Q0" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q0" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q1" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q1" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q2" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q2" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="quaternion_Q3" type="float" shape="report_number">
    <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q3" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="float"/>
    <attribute name="valid_range" value="-1.0 1.0" type="float"/>
    <attribute name="units" value="1" type="string"/>
  </variable>
  <variable name="product_time" type="double" shape="number_of_time_bounds">
    <attribute name="long_name" value="maximum and minimum CCSDS header time codes of observations associated with product" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="double"/>
    <attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
    <values>dynamic value dynamic value</values>
  </variable>
```

```
  <variable name="L1a_SciData_TimeStamp" type="double" shape="report_number sensor_unit">
    <attribute name="long_name" value="End time of one-second observation by sensor, accurate to within 0.5 seconds of onboard data acquisition start time, for each report" type="string"/>
    <attribute name="_FillValue" value="-1.0e+31" type="double"/>
    <attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
  </variable>
  <variable name="sensor_unit_label" shape="sensor_unit sensor_unit_str_len" type="char">
    <attribute name="long_name" value="labels for the two Solar and Galactic Proton Sensor units nominally (i.e., no yaw flip) providing fields of view in the westward (-X) and eastward (+X) direction. labels are ordered the same as applicable data variables" type="string"/>
    <values>SGPS-X SGPS+X</values>
  </variable>
  <variable name="energy_T1_label" type="char" shape="energy_T1 energy_T1_str_len">
    <attribute name="long_name" value="labels for six energy bands reported from telescope 1 spanning from 1 to 25 MeV. labels are ordered the same as applicable data variables" type="string"/>
    <values>EnergyBand-P1:1-1.9MeV EnergyBand-P2A:1.9-2.3MeV EnergyBand-P2B:2.3-3.4MeV EnergyBand-P3:3.4-6.5MeV EnergyBand-P4:6.5-12MeV EnergyBand-P5:12-25MeV</values>
  </variable>
  <variable name="energy_T2_label" type="char" shape="energy_T2 energy_T2_str_len">
    <attribute name="long_name" value="labels for two energy bands reported from telescope 2 spanning from 25 to 80 MeV. labels are ordered the same as applicable data variables" type="string"/>
    <values>EnergyBand-P6:25-40MeV EnergyBand-P7:40-80MeV</values>
  </variable>
  <variable name="energy_T3_label" type="char" shape="energy_T3 energy_T3_str_len">
    <attribute name="long_name" value="labels for five energy bands reported from telescope 3 spanning from 80 to 500 MeV. labels are ordered the same as applicable data variables" type="string"/>
    <values>EnergyBand-P8AF:83-99MeV EnergyBand-P8BF:99-118MeV EnergyBand-P8CF:118-150MeV EnergyBand-P9F:150-275MeV EnergyBand-P10:275-500MeV</values>
  </variable>
  <variable name="Diff31_logic_channel_label" type="char" shape="channel channel_str_len">
    <attribute name="long_name" value="labels for three primary proton channels supporting on-board out-of-band contamination removal. labels are ordered the same as applicable data variable" type="string"/>
    <values>D3-D1_Logic:P7 D3-D1_Logic:P8CF D3-D1_Logic:P9F</values>
  </variable>
  <variable name="solar_array_current_channel_index_label" type="char" shape="solar_array_current_channel_index solar_array_mnemonic_str_len">
    <attribute name="long_name" value="labels for four solar array current telemetry mnemonics. labels are ordered the same as applicable data variable" type="string"/>
    <values>EPS_SA_CHAN_1_4_RETRN_I EPS_SA_CHAN_5_8_RETRN_I EPS_SA_CHAN_9_12_RETRN_I EPS_SA_CHAN_13_16_RETRN_I</values>
  </variable>
```

<variable name="T1_DifferentialProtonFluxes" type="float" shape="report_number sensor_unit energy_T1">
<attribute name="long_name" value="differential proton flux at specific energy bands for telescope 1’s primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="T1_DifferentialProtonFluxUncertainties" type="float" shape="report_number sensor_unit energy_T1">
<attribute name="long_name" value="dynamic error estimate of differential proton flux at specific energy bands for telescope 1’s primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="T1_DifferentialProtonFluxDQFs" type="ubyte" shape="report_number sensor_unit energy_T1">
<attribute name="long_name" value="differential proton flux data quality flag at specific energy bands for telescope 1’s primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="T2_DifferentialProtonFluxes" type="float" shape="report_number sensor_unit energy_T2">
<attribute name="long_name" value="differential proton flux at specific energy bands for telescope 2’s primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="T2_DifferentialProtonFluxUncertainties" type="float" shape="report_number sensor_unit energy_T2">
<attribute name="long_name" value="dynamic error estimate of differential proton flux at specific energy bands for telescope 2’s primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="T2_DifferentialProtonFluxDQFs" type="ubyte" shape="report_number sensor_unit energy_T2">

<attribute name="long_name" value="differential proton flux data quality flag at specific energy bands for telescope 2's primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="T3_DifferentialProtonFluxes" type="float" shape="report_number sensor_unit energy_T3">
<attribute name="long_name" value="differential proton flux at specific energy bands for telescope 3's primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="T3_DifferentialProtonFluxUncertainties" type="float" shape="report_number sensor_unit energy_T3">
<attribute name="long_name" value="dynamic error estimate of differential proton flux at specific energy bands for telescope 3's primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1 keV-1" type="string"/>
</variable>
<variable name="T3_DifferentialProtonFluxDQFs" type="ubyte" shape="report_number sensor_unit energy_T3">
<attribute name="long_name" value="differential proton flux data quality flag at specific energy bands for telescope 3's primary proton data channels on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="T3P11_IntegralProtonFlux" type="float" shape="report_number sensor_unit">
<attribute name="long_name" value="integral proton flux at energy band > 500 MeV for telescope 3's primary integral data channel P11 on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1" type="string"/>

</variable>
<variable name="T3P11_IntegralProtonFluxUncertainties" type="float" shape="report_number sensor_unit">
<attribute name="long_name" value="dynamic error estimate of integral proton flux at energy band > 500 MeV for telescope 3's primary integral data channel P11 on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="float"/>
<attribute name="valid_range" value="-9999999.0 9999999.0" type="float"/>
<attribute name="units" value="cm-2 sr-1 s-1" type="string"/>
</variable>
<variable name="T3P11_IntegralProtonFluxDQFs" type="ubyte" shape="report_number sensor_unit">
<attribute name="long_name" value="integral proton flux data quality flag at energy band > 500 MeV for telescope 3's primary integral data channel P11 on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 28" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1a_EngData_Flag" type="ubyte" shape="report_number sensor_unit">
<attribute name="long_name" value="flags indicating availability of instrument engineering telemetry data on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1a_SciData_Flag" type="ubyte" shape="report_number sensor_unit">
<attribute name="long_name" value="flags indicating availability of instrument proton count science data on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="L1b_Processing_Flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating status of L1b product processing" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>

<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="N_blocks" type="ubyte" shape="report_number sensor_unit">
<attribute name="long_name" value="number of one second blocks of SGPS data used to create Solar and Galactic Protons product reports on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="0" type="ubyte"/>
<attribute name="valid_range" value="1 1" type="ubyte"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="Instrument_Mode" type="ubyte" shape="report_number sensor_unit">
<attribute name="long_name" value="SGPS-X and SGPS+X instrument (sensor) mode" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 4" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Instrument_Serial_Number" type="ubyte" shape="report_number sensor_unit">
<attribute name="long_name" value="SEISS SGPS-X and SGPS+X instrument (sensor) serial number" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 254" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="Diff31_Logic_Flags" type="ubyte" shape="report_number sensor_unit channel">
<attribute name="long_name" value="flags indicating whether on-board out-of-band contamination removal is enabled for primary proton data channels P7, P8CF and P9F on each of the two sensor units" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 1" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="yaw_flip_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>

<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="eclipse_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="solar_array_current" type="ushort" shape="report_number solar_array_current_channel_index">
<attribute name="long_name" value="solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>
<attribute name="units" value="count" type="string"/>
</variable>
<variable name="sgps_telemetry_time" type="double" shape="report_number sensor_unit">
<attribute name="long_name" value="time of the SGPS-X and SGPS+X engineering telemetry packets containing the 4 sensor temperature values" type="string"/>
<attribute name="_FillValue" value="-1.00E+31" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="sgps_sensor_temperature" type="float" shape="report_number sensor_unit temperature_number">
<attribute name="long_name" value="SGPS-X and SGPS+X sensor unit temperatures, the first is from Telescope 3, the second is from the Low Voltage Regulator (LVR), the third is from the Baseplate and the fourth is from Telelscope 2" type="string"/>
<attribute name="_FillValue" value="-1.00E+31" type="float"/>
<attribute name="valid_range" value="0.0 1000.0" type="float"/>
<attribute name="units" value="K" type="string"/>
</variable>
<variable name="percent_uncorrectable_L0_errors" type="float" shape="">
<attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="0.0 1.0" type="float"/>
<attribute name="units" value="percent" type="string"/>
<values>***dynamic value***</values>
</variable>
<variable name="algorithm_dynamic_input_data_container" type="int" shape="">
<attribute name="long_name" value="container for filenames of dynamic algorithm input data; not in use" type="string"/>

<attribute name="input_SGPS_L0_data" value="null" type="string"/>
</variable>
<attribute name="dataset_name" value="***refer to filename conventions for L1b products in Appendix C.***" type="string"/>
<attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
<attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
<attribute name="project" value="GOES" type="string"/>
<attribute name="iso_series_metadata_id" value="67e28dc8-4a39-11e4-9e35-164230d1df67" type="string"/>
<attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
<attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
<attribute name="title" value="SEISS SGPS L1b Solar and Galactic Protons" type="string"/>
<attribute name="summary" value="The GOES-R Solar and Galactic Protons Product consists of fluxes of very high energy protons derived from in situ measurements of proton count rates. Differential proton fluxes are reported at thirteen energy bands spanning from 1 to 500 MeV, and one integral proton flux is reported for particles > 500 MeV. One angular zone, having a central westward or eastward look-angle, is observed by the three telescopes on each of two sensor units, one facing west (-X) and another facing east (+X). Each telescope provides for a subset of the reported energy bands. Telescope 1 and 2 have 60 degree fields-of-view, and telescope 3 has a 90 degree field-of-view. A yaw-flip reverses the direction observed by the two sensor units. The product also contains processing and data quality metadata, satellite state and location information, and data required for the generation of level 2 products." type="string"/>
<attribute name="license" value="Unclassified data. Access is restricted to approved users only." type="string"/>
<attribute name="keywords" value="SUN-EARTH INTERACTIONS > IONOSPHERE/MAGNETOSPHERE DYNAMICS > ELECTRIC FIELDS/ELECTRIC CURRENTS, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE FLUX > ALPHA PARTICLE FLUX, SUN-EARTH INTERACTIONS > SOLAR ENERGETIC PARTICLE FLUX > PROTON FLUX" type="string"/>
<attribute name="cdm_data_type" value="Point" type="string"/>
<attribute name="orbital_slot" value="***possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage.***" type="string"/>
<attribute name="platform_ID" value="***possible values are G16 and G17.***" type="string"/>
<attribute name="instrument_type" value="GOES-R Series SEISS Solar and Galactic Proton Sensor" type="string"/>
<attribute name="SGPS-X_instrument_ID" value="***serial number of the SGPS-X instrument (sensor).***" type="string"/>
<attribute name="SGPS+X_instrument_ID" value="***serial number of the SGPS+X instrument (sensor).***" type="string"/>
<attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>

<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note "flags and meanings": Flag values and meanings are located in paragraph 7.5.4.5.1.2, Solar and Galactic Protons Product Flag Values and Meanings.

7.6 Magnetometer Level 1b Product

7.6.1 Geomagnetic Field Product

7.6.1.1 Description

The Geomagnetic Field product contains up to 60 sets of Earth ambient magnetic field values measured in situ from geostationary orbit. A set is a block of processed observation data containing ten samples of the Earth's ambient magnetic field acquired at one-tenth of a second intervals produced over one second observation intervals. The Earth's ambient magnetic field is reported in four coordinate reference systems. The four coordinate reference systems are as follows:

- Earth Polar Normal (EPN).
- Earth-Centric Inertial (ECI).
- Spacecraft Body Reference Frame (BRF)
- Attitude Control Reference Frame (ACRF).

For the EPN, ECI, and BRF, the Earth's ambient magnetic field values are produced in three orthogonal directions along their axes. For the ACRF, a total ambient magnetic field value is produced. The product also contains compensated magnetic field values in the native magnetometer reference frames from the two magnetometers, inboard and outboard, on the satellite. The ambient and compensated magnetic field values are produced at ten hertz. The product includes processing and data quality information that provides an assessment of the level 1b processing and ambient magnetic field values, including an indication of good, potentially degraded, or degraded quality, or invalid, and the rationale.

Although the ambient and compensated magnetic field values, and data quality information are reported at ten hertz, product metadata other than magnetometer data acquisition status is reported for each set of values, which is over successive one second observation intervals.

The units of measure for the ambient and compensated magnetic field values are "nanoteslas".

The Geomagnetic Field performance requirements are summarized in Table 7.6.1.1, Geomagnetic Field Performance Requirements.

Table 7.6.1.1 Geomagnetic Field Performance Requirements

Measurement				Mapping
Region	**Range**	**Accuracy**	**Precision**	**Uncertainty**
GOES-R satellite in situ environment, three axes must be orthogonal to within +/- 0.5 degrees	-512 nT ≤ geomagnetic field ≤ 512 nT per axis (3-axis vector)	(1) 2.3nT (2) 4 nT at end of life	0.016 nT	+/- 1 degree

Metadata in the Geomagnetic Field product provides statistical and other properties of the observation and processed data and information required for the generation of level 2 products, and supports diagnosis of algorithm anomalies. Specific metadata includes:

- Start and end time of the observation data in the product.
- Time of each set of observations for both the inboard and outboard magnetometers.
- Satellite location.
- Spacecraft ACRF to J2000 ECI and J2000 ECI to spacecraft Orbital Reference Frame (ORF) attitude quaternions, and their time stamps.
- Eclipse of the sun indication.
- Satellite yaw flip configuration.
- Inboard and outboard magnetometer data acquisition status.
- Instrument mode and serial number.

When the satellite is in on-orbit storage mode, the Geomagnetic Field product data format and content are the same.

The detailed description of the ISO series metadata for the Geomagnetic Field product is located in the standalone Appendix X, ISO Series Metadata.

7.6.1.2 Dynamic Source Data

The Geomagnetic Field product is derived using MAG Level 0 raw science telemetry, MAG engineering telemetry, and satellite ephemeris related telemetry.

The primary sensor data used by the Level 1b Geomagnetic Field algorithm is identified in Table 5.4.1.2, Primary Sensor Data.

Table 7.6.1.2 Primary Sensor Data

Dynamic Data Category	Dynamic Data Type
L0 Products	input_MAG_L0_data

Refer to the Level 0 product volume of the PUG for a description of the Level 0 product dynamic source data.

7.6.1.3 Level 1b Semi-Static Source Data

There are four categories of semi-static source data employed in the MAG Level 1b ground processing algorithm:

- Factory calibration parameters.
- On-orbit calibration parameters.
- Sensor calibration parameters.
- Algorithm processing parameters.

One semi-static HDF5 source data file contains all four categories above and is included in a single MAG zip file.

Factory calibration parameters are those associated with sensor and electronic temperature dependent, and alignment corrections required that were determined pre-launch. Specific types include:

- Inboard and outboard sensor alignment correction vectors.
- Inboard and outboard sensor scale factor compensation constants used in support of correcting for temperature dependent effects when calculating the raw magnetic field measurements.
- Inboard and outboard sensor zero offset compensation constants used to calculate temperature dependent factory zero offsets for the raw magnetic field measurements.
- Sensor and electronic compensation reference temperatures.
- Inboard and outboard sensor temperature dependent scaling factors.

On-orbit calibration parameters are those that account for launch shift and in-flight drifts. These parameters are applied to the compensated (factory calibrated) magnetic field measurements. Specific types include:

- Inboard and outboard sensor alignment correction vectors.
- Inboard and outboard sensor scale factor adjustment parameters.
- Inboard and outboard sensor zero offset adjustment parameters.

Note that there are up to 30 sets of each of on-orbit calibration parameters available for use.

Sensor calibration parameters are those associated with magnetometer hardware, valid telemetry ranges, and coordinate transformation matrices. Specific types include:

- Attitude Control Reference Frame (ACRF) to Body Reference Frame (BRF) transformation matrix.
- Orbit Reference Frame (ORF) to Earth Polar Normal (EPN) transformation matrix
- Magnetometer boom base reference system (BOOM) to ACRF transformation matrix.
- Counts to voltage scale factor.
- Current source (Amps) used to correct sensor temperature.
- Sensor and electronic temperature conversion coefficients.
- Sensor and electronic temperature upper and lower limits.
- MFIB to BOOM and MFOB to BOOM transformation matrices. MFIB and MFOB frames are the calibrated orthogonal frames in which the inboard and outboard magnetometers provide their respective magnetic field measurements.
- Resistance (Ohms) of reference resistor.
- Voltage reference levels (1.25V and 3.75V)
- Arcjet correction coefficients, current thresholds, and voltage thresholds.
- Inboard shadow unit vectors and thresholds.

Algorithm processing parameters are those associated with the gradiometer model, and valid time and temperature thresholds. Specific types include:

- Butterworth filter coefficients.
- Engineering telemetry validity time window.
- Gradiometer Q-factors.
- Magnetometer measurement temperature upper and lower limits.

The filename conventions for the Magnetometer Level 1b semi-static source data file are located in Appendix C.

7.6.1.4 Production Notes

The Geomagnetic Field product is generated by MAG Level 0 and Level 1b ground processing algorithms. The Level 0 algorithm extracts the raw in situ detector data from the CCSDS packets. The Level 1b algorithm uses the extracted magnetic field measurements to determine the Earth's ambient magnetic field values in three coordinate reference systems, EPN, ECI, and BRF, and the total ambient field. The Level 1b algorithm time correlates measurements from the inboard and outboard magnetometers, applies factory and on-orbit calibration corrections, uses a gradiometer-based method to estimate the ambient magnetic field, and performs transformations to the required coordinate reference systems.

The L1b algorithm executes and product data is generated when the instrument is in the operational and diagnostic modes. The product files are available in the GOES-R ground system's two-day revolving storage to support anomaly resolution and algorithm analysis.

The L1b product corrected variables contain MAG observations that have been corrected for magnetic field contamination induced by spacecraft arcjet firings. Errors introduced by the firings in the ambient magnetic field measurement can be as high as ~20 nT. The arcjet correction algorithm, which is empirically-derived, has an uncertainty less than ~1 nT. A one-bit flag in the L1b product DQF (bit24=1: Flag Mask=16777216; Flag Value=16777216) variable identifies the occurrence of arcjet firings. The correction algorithm is invalid during arcjet power-up (turn on) or power-down (turn off) phases. However, the induced magnetic contamination also occurs during these phases and therefore a second bit in the DQF identifies when the correction is valid (bit 25=1: Flag Mask=33554432; Flag Value=33554432) or invalid (bit 25=0: Flag Mask=33554432; Flag Value=0). When the arcjet is not firing (bit 24=0), no correction is applied, and the values in the corrected variables are the same as the values in the uncorrected product variables. In this case, the arcjet correction bit defaults to valid (bit 25=1).

For product refresh rate and latency information, refer to Appendix B, Product Refresh Rates and Latencies.

7.6.1.5 Data Organization and Fields

A Geomagnetic Field product spans up to 61 GRB Space Packets, nominally 60 for the data and another for the metadata. A product, which contains a set of ambient magnetic field and related data values for a 60 second period, is transmitted over GRB in one second reports. These one second reports can be exploited upon receipt. Nominally, a product metadata Packet is queued for transmission after the sixtieth report has been queued for transmission.

The APIDs used for product data and metadata are defined in Appendix A, CCSDS Application Identifiers.

The product data and metadata use the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. The product data format is binary. The product metadata format is a text file based NcML product specification with values for the global and variable attributes, label variables, and product start and end time variable.

The subordinate paragraphs that follow define the Geomagnetic Field product data, quantity characteristics, flag values and meanings, and metadata fields.

7.6.1.5.1 Data Fields

Table 7.6.1.5.1 Geomagnetic Field Product Data

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
IB_data_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	0
IB_data_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected Inboard MAG field values in Inboard MAG frame	nT	120	16
OB_data_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	136
OB_data_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected Outboard MAG field values in Outboard MAG frame	nT	120	152
IB_mag_ACRF_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	272
IB_mag_ACRF_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected ACRF frame Inboard MAG field values	nT	120	288
OB_mag_ACRF_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	408

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
OB_mag_ACRF_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected ACRF frame Outboard MAG field values	nT	120	424
IB_mag_BRF_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	544
IB_mag_BRF_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected BRF frame Inboard MAG field values	nT	120	560
OB_mag_BRF_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	680
OB_mag_BRF_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected BRF frame Outboard MAG field values	nT	120	696
IB_mag_ECI_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	816
IB_mag_ECI_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected ECI frame Inboard MAG field values	nT	120	832
OB_mag_ECI_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	952
OB_mag_ECI_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected ECI frame Outboard MAG field values	nT	120	968
IB_mag_EPN_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	1088
IB_mag_EPN_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected EPN frame Inboard MAG field values	nT	120	1104
OB_mag_EPN_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	1224

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
OB_mag_EPN_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected EPN frame Outboard MAG field values	nT	120	1240
total_mag_ACRF_uncorrected control field(s)	uint64	number of control fields = 1	number_samples_per_report = 10	1	8	1360
total_mag_ACRF_uncorrected	float	number_samples_per_report = 10	Uncorrected ACRF frame Ambient MAG field total magnitude	nT	40	1368
amb_mag_BRF_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	1408
amb_mag_BRF_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected BRF frame Ambient MAG field	nT	120	1424
amb_mag_ECI_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	1544
amb_mag_ECI_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected ECI frame Ambient MAG field	nT	120	1560
amb_mag_EPN_uncorrected control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	1680
amb_mag_EPN_uncorrected	float	number_samples_per_report = 10 coordinate = 3	Uncorrected EPN frame Ambient MAG field	nT	120	1696
IB_data control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	1816
IB_data	float	number_samples_per_report = 10 coordinate = 3	compensated (temperature calibrated and misalignment corrected) magnetic field for x, y, and z direction in calibrated orthogonal reference frame for inboard magnetometer (MFIB)	nT	120	1832
OB_data control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	1952
OB_data	float	number_samples_per_report = 10 coordinate = 3	compensated (temperature calibrated and misalignment corrected) magnetic field for x, y, and z direction in	nT	120	1968

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
			calibrated orthogonal reference frame for outboard magnetometer (MFOB)			
IB_mag_ACRF control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	2088
IB_mag_ACRF	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (inboard magnetometer) for x, y, and z direction in spacecraft's Attitude Control Reference Frame (ACRF) (after factory and on-orbit calibration)	nT	120	2104
OB_mag_ACRF control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	2224
OB_mag_ACRF	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (outboard magnetometer) for x, y, and z direction in spacecraft's Attitude Control Reference Frame (ACRF) (after factory and on-orbit calibration)	nT	120	2240
IB_mag_BRF control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	2360
IB_mag_BRF	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (inboard magnetometer) for x, y, and z direction in spacecraft's Body Reference Frame (BRF) (after factory and on-orbit calibration)	nT	120	2376
OB_mag_BRF control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	2496
OB_mag_BRF	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (outboard magnetometer) for x, y, and z direction in spacecraft's Body Reference Frame (BRF) (after factory and on-orbit calibration)	nT	120	2512
IB_mag_ECI control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	2632
IB_mag_ECI	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (inboard magnetometer) for x, y, and z direction in J2000 Earth-Centered Inertial reference frame (ECI) (after factory and on-orbit calibration)	nT	120	2648

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
OB_mag_ECI control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	2768
OB_mag_ECI	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (outboard magnetometer) for x, y, and z direction in J2000 Earth-Centered Inertial reference frame (ECI) (after factory and on-orbit calibration)	nT	120	2784
IB_mag_EPN control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	2904
IB_mag_EPN	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (inboard magnetometer) for x, y, and z direction in Earth Polar Normal reference frame (EPN) (after factory and on-orbit calibration)	nT	120	2920
OB_mag_EPN control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10; coordinate = 3	1	16	3040
OB_mag_EPN	float	number_samples_per_report = 10 coordinate = 3	compensated magnetic field (outboard magnetometer) for x, y, and z direction in Earth Polar Normal reference frame (EPN) (after factory and on-orbit calibration)	nT	120	3056
total_mag_ACRF control field(s)	uint64	number of control fields = 1	number_samples_per_report = 10	1	8	3176
total_mag_ACRF	float	number_samples_per_report = 10	estimated total ambient magnetic field in spacecraft's Attitude Control Reference Frame	nT	40	3184
amb_mag_BRF control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	3224
amb_mag_BRF	float	number_samples_per_report = 10 coordinate = 3	estimated ambient magnetic field for x, y, and z direction in spacecraft's Body Reference Frame	nT	120	3240
amb_mag_ECI control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	3360
amb_mag_ECI	float	number_samples_per_report = 10 coordinate = 3	estimated ambient magnetic field for x, y, and z direction in J2000 Earth-Centered Inertial reference frame	nT	120	3376
amb_mag_EPN control field(s)	uint64	number of control fields = 2	number_samples_per_report = 10 coordinate = 3	1	16	3496

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
amb_mag_EPN	float	number_samples_per_report = 10 coordinate = 3	estimated ambient magnetic field for x, y, and z direction in Earth Polar Normal reference frame	nT	120	3512
DQF control field(s)	uint64	number of control fields = 1	number_samples_per_report = 10	1	8	3632
DQF	uint32	number_samples_per_report = 10	magnetometer L1b processing and data quality flags	1	40	3640
IB_status control field(s)	uint64	number of control fields = 1	number_samples_per_report = 10	1	8	3680
IB_status	uint16	number_samples_per_report = 10	inboard magnetometer status flags	1	20	3688
OB_status control field(s)	uint64	number of control fields = 1	number_samples_per_report = 10	1	8	3708
OB_status	uint16	number_samples_per_report = 10	outboard magnetometer status flags	1	20	3716
Instrument_ID	uint8	number_of_sensors = 2	magnetometer instrument (sensor) serial number	1	2	3736
yaw_flip	uint8	n/a	flags indicating whether spacecraft is operating in yaw flip configuration	1	1	3738
eclipse_flag	uint8	n/a	flags indicating whether sun is obscured by earth as provided by spacecraft	1	1	3739
IB_time control field(s)	uint64	number of control fields = 1	number_samples_per_report = 10	1	8	3740
IB_time	double	number_samples_per_report = 10	time of 10 Hz inboard magnetometer observations for each report	seconds since 2000-01-01 12:00:00, neglecting leap seconds	80	3748
OB_time control field(s)	uint64	number of control fields = 1	number_samples_per_report = 10	1	8	3828
OB_time	double	number_samples_per_report = 10	time of 10 Hz outboard magnetometer observations for each report	seconds since 2000-01-01 12:00:00, neglecting	80	3836

Data Name	Data Type	Shape, or Number of Control Fields	Description, or Rationale and Value(s) For Control Field(s)	Units	Size (in bytes)	Byte Offset from Start of Generic Payload Data Unit
				leap seconds		
attitude_quat_Q0	double	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q0	1	8	3916
attitude_quat_Q1	double	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q1	1	8	3924
attitude_quat_Q2	double	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q2	1	8	3932
attitude_quat_Q3	double	n/a	spacecraft ACRF to J2000 ECI attitude quaternion Q3	1	8	3940
ECEF_X	float	n/a	spacecraft ECEF X coordinate	m	4	3948
ECEF_Y	float	n/a	spacecraft ECEF Y coordinate	m	4	3952
ECEF_Z	float	n/a	spacecraft ECEF Z coordinate	m	4	3956
orbit_quat_Q0	double	n/a	J2000 ECI to spacecraft ORF orbit quaternion Q0	1	8	3960
orbit_quat_Q1	double	n/a	J2000 ECI to spacecraft ORF orbit quaternion Q1	1	8	3968
orbit_quat_Q2	double	n/a	J2000 ECI to spacecraft ORF orbit quaternion Q2	1	8	3976
orbit_quat_Q3	double	n/a	J2000 ECI to spacecraft ORF orbit quaternion Q3	1	8	3984
quat_timestamp	double	n/a	time of corresponding ACRF to J2000 ECI attitude and J2000 ECI to ORF orbit quaternions for each report	seconds since 2000-01-01 12:00:00, neglecting leap seconds	8	3992
solar_array_current control field(s)	uint64	number of control fields = 1	solar_array_current_channel_index = 4	1	8	4000
solar_array_current	uint16	solar_array_current_channel_index = 4	solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)	1	8	4008

7.6.1.5.1.1 Geomagnetic Field Product Quantity Characteristics

Table 7.6.1.5.1.1-1 Geomagnetic Field Product Coordinate Axis Characteristics

Coordinate Axis	Order in Product Data Structure	Product Label Variable Mnemonic
x-axis	1	x
y-axis	2	y
z-axis	3	z

Table 7.6.1.5.1.1-2 Geomagnetic Field Product Sensor Characteristics

Sensor	Order in Product Data Structure	Product Label Variable Mnemonic
Inboard Magnetometer	1	InboardMagnetometer
Outboard Magnetometer	2	OutboardMagnetometer

7.6.1.5.1.2 Geomagnetic Field Product Flag Values and Meanings

Table 7.6.1.5.1.2-1 Geomagnetic Field Processing and Data Quality Flag Values and Meanings

Processing and Data Quality Flags (DQF)		
Flag Mask	**Flag Value**	**Flag Meaning**
33554431	0	good_quality_qf
1	1	invalid_due_to_missing_L0_IB_and_OB_MAG_data_qf
2	2	degraded_due_to_IB_MAG_x-axis_potential_failure_or_off_state_or_IB_mag_potentially_in_maintenance_mode_qf
4	4	degraded_due_to_IB_MAG_y-axis_potential_failure_or_off_state_or_IB_mag_potentially_in_maintenance_mode_qf
8	8	degraded_due_to_IB_MAG_z-axis_potential_failure_or_off_state_or_IB_mag_potentially_in_maintenance_mode_qf
16	16	degraded_due_to_OB_MAG_x-axis_potential_failure_or_off_state_or_OB_mag_potentially_in_maintenance_mode_qf
32	32	degraded_due_to_OB_MAG_y-axis_potential_failure_or_off_state_or_OB_mag_potentially_in_maintenance_mode_qf
64	64	degraded_due_to_OB_MAG_z-axis_potential_failure_or_off_state_or_OB_mag_potentially_in_maintenance_mode_qf
128	128	degraded_due_to_IB_MAG_x-axis_magnetic_field_at_saturation_qf
256	256	degraded_due_to_IB_MAG_y-axis_magnetic_field_at_saturation_qf
512	512	degraded_due_to_IB_MAG_z-axis_magnetic_field_at_saturation_qf
1024	1024	degraded_due_to_OB_MAG_x-axis_magnetic_field_at_saturation_qf
2048	2048	degraded_due_to_OB_MAG_y-axis_magnetic_field_at_saturation_qf
4096	4096	degraded_due_to_OB_MAG_z-axis_magnetic_field_at_saturation_qf

Processing and Data Quality Flags (DQF)		
Flag Mask	**Flag Value**	**Flag Meaning**
8192	8192	degraded_due_to_MAG_calibration_maneuver_in_progress_qf
16384	16384	degraded_due_to_potentially_stale_MAG_engineering_data_qf
32768	32768	potentially_degraded_due_to_out_of_valid_range_IB_MAG_x-axis_thermistor_temperature_qf
65536	65536	potentially_degraded_due_to_out_of_valid_range_IB_MAG_y-axis_thermistor_temperature_qf
131072	131072	potentially_degraded_due_to_out_of_valid_range_IB_MAG_z-axis_thermistor_temperature_qf
262144	262144	potentially_degraded_due_to_out_of_valid_range_OB_MAG_x-axis_thermistor_temperature_qf
524288	524288	potentially_degraded_due_to_out_of_valid_range_OB_MAG_y-axis_thermistor_temperature_qf
1048576	1048576	potentially_degraded_due_to_out_of_valid_range_OB_MAG_z-axis_thermistor_temperature_qf
2097152	2097152	potentially_degraded_due_to_out_of_valid_range_IB_electronics_temperature_qf
4194304	4194304	potentially_degraded_due_to_out_of_valid_range_OB_electronics_temperature_qf
8388608	8388608	potentially_degraded_due_to_IB_MAG_in_shadow_qf
16777216	16777216	potentially_degraded_due_to_arcjet_firing_qf
33554432	33554432	valid_arcjet_correction_qf

Note: Flag Mask for Flag Value = 0 intentionally ignores highest order flag "bit"; therefore, the data quality is deemed to be "good", regardless of the value of the highest order "bit".

Table 7.6.1.5.1.2-2 Geomagnetic Field Product Inboard and Outboard Magnetometer Data Acquisition Status Flag Values and Meanings

Data Acquisition Status Flags (IB_status & OB_status)		
Flag Mask	**Flag Value**	**Flag Meaning**
1	0	operational_mode
1	1	instrument_diagnostic_mode
8190	0	good_status
2	2	x-axis_data_error
4	4	y-axis_data_error
8	8	z-axis_data_error
16	16	unrecoverable_RAM_error_detected_by_EDAC
32	32	uncorrected_EEPROM_page_0_embedded_software_image_error
64	64	uncorrected_EEPROM_page_1_embedded_software_image_error
128	128	uncorrected_EEPROM_page_2_embedded_software_image_error
256	256	uncorrected_EEPROM_page_3_embedded_software_image_error
512	512	uncorrected_EEPROM_page_0_calibration_factor_error
1024	1024	uncorrected_EEPROM_page_1_calibration_factor_error
2048	2048	uncorrected_EEPROM_page_2_calibration_factor_error

Data Acquisition Status Flags (IB_status & OB_status)		
Flag Mask	**Flag Value**	**Flag Meaning**
4096	4096	uncorrected_EEPROM_page_3_calibration_factor_error

Note: Instrument mode is embedded in the data acquisition status flags.

Table 7.6.1.5.1.2-3 Geomagnetic Field Product Eclipse Flag Values and Meanings

Eclipse Flags (eclipse_flag)	
Flag Value	**Flag Meaning**
0	no_eclipse
1	penumbra_preceding_full_eclipse
2	umbra_full_eclipse
3	penumbra_following_full_eclipse

Table 7.6.1.5.1.2-4 Geomagnetic Field Product Satellite Yaw Flip Flag Values and Meanings

Satellite Yaw Flip Flags (yaw_flip)	
Flag Value	**Flag Meaning**
0	upright
1	neither
2	inverted

7.6.1.5.2 Metadata Fields

Once the product's metadata has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the metadata is an NcML product specification in Unix text file format (less the end-of-file character). The order of global attributes, dimensions, and variables as they appear in the table below does not necessarily reflect their exact order in the GRB metadata Packet. Refer to the Level 1b PUG volume, specifically the Geomagnetic Field product Data Fields paragraph for a logical depiction of the product metadata.

Table 7.6.1.5.2 Geomagnetic Field Product Metadata

<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="https://hcp.harris.com/namespaces/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2 https://hcp.harris.com/schemas/netcdf/,DanaInfo=www.unidata.ucar.edu+ncml-2.2.xsd" xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">

```
<dimension name="report_number" isUnlimited="true"/>
<dimension name="number_of_time_bounds" length="2" isUnlimited="false"/>
<dimension name="number_samples_per_report" length="10" isUnlimited="false"/>
<dimension name="number_of_sensors" length="2" isUnlimited="false"/>
<dimension name="coordinate" length="3" isUnlimited="false"/>
<dimension name="solar_array_current_channel_index" length="4" isUnlimited="false"/>
<dimension name="sensor_str_len" length="20" isUnlimited="false"/>
<dimension name="coordinate_str_len" length="1" isUnlimited="false"/>
<dimension name="solar_array_mnemonic_str_len" length="25" isUnlimited="false"/>
<variable name="ECEF_X" type="float" shape="report_number">
  <attribute name="long_name" value="spacecraft ECEF X coordinate" type="string"/>
  <attribute name="_FillValue" value="-1.0e+31" type="float"/>
  <attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
  <attribute name="units" value="m" type="string"/>
</variable>
<variable name="ECEF_Y" type="float" shape="report_number">
  <attribute name="long_name" value="spacecraft ECEF Y coordinate" type="string"/>
  <attribute name="_FillValue" value="-1.0e+31" type="float"/>
  <attribute name="valid_range" value="-42171520.0 42171520.0" type="float"/>
  <attribute name="units" value="m" type="string"/>
</variable>
<variable name="ECEF_Z" type="float" shape="report_number">
  <attribute name="long_name" value="spacecraft ECEF Z coordinate" type="string"/>
  <attribute name="_FillValue" value="-1.0e+31" type="float"/>
  <attribute name="valid_range" value="-7360.0 7360.0" type="float"/>
  <attribute name="units" value="m" type="string"/>
</variable>
<variable name="attitude_quat_Q0" type="double" shape="report_number">
  <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q0" type="string"/>
  <attribute name="_FillValue" value="-1.0e+31" type="double"/>
  <attribute name="valid_range" value="-1.0 1.0" type="double"/>
  <attribute name="units" value="1" type="string"/>
</variable>
<variable name="attitude_quat_Q1" type="double" shape="report_number">
  <attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q1" type="string"/>
  <attribute name="_FillValue" value="-1.0e+31" type="double"/>
  <attribute name="valid_range" value="-1.0 1.0" type="double"/>
  <attribute name="units" value="1" type="string"/>
```

</variable>
<variable name="attitude_quat_Q2" type="double" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q2" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="double"/>
<attribute name="valid_range" value="-1.0 1.0" type="double"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="attitude_quat_Q3" type="double" shape="report_number">
<attribute name="long_name" value="spacecraft ACRF to J2000 ECI attitude quaternion Q3" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="double"/>
<attribute name="valid_range" value="-1.0 1.0" type="double"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="orbit_quat_Q0" type="double" shape="report_number">
<attribute name="long_name" value="J2000 ECI to spacecraft ORF orbit quaternion Q0" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="double"/>
<attribute name="valid_range" value="-1.0 1.0" type="double"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="orbit_quat_Q1" type="double" shape="report_number">
<attribute name="long_name" value="J2000 ECI to spacecraft ORF orbit quaternion Q1" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="double"/>
<attribute name="valid_range" value="-1.0 1.0" type="double"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="orbit_quat_Q2" type="double" shape="report_number">
<attribute name="long_name" value="J2000 ECI to spacecraft ORF orbit quaternion Q2" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="double"/>
<attribute name="valid_range" value="-1.0 1.0" type="double"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="orbit_quat_Q3" type="double" shape="report_number">
<attribute name="long_name" value="J2000 ECI to spacecraft ORF orbit quaternion Q3" type="string"/>
<attribute name="_FillValue" value="-1.0e+31" type="double"/>
<attribute name="valid_range" value="-1.0 1.0" type="double"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="product_time" type="double" shape="number_of_time_bounds">

<attribute name="long_name" value="start and end time of observations associated with product" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
<values>***dynamic value dynamic value***</values>
</variable>
<variable name="IB_time" type="double" shape="report_number number_samples_per_report">
<attribute name="long_name" value="time of 10 Hz inboard magnetometer observations for each report" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="OB_time" type="double" shape="report_number number_samples_per_report">
<attribute name="long_name" value="time of 10 Hz outboard magnetometer observations for each report" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="quat_timestamp" type="double" shape="report_number">
<attribute name="long_name" value="time of corresponding ACRF to J2000 ECI attitude and J2000 ECI to ORF orbit quaternions for each report" type="string"/>
<attribute name="_FillValue" value="-999.0" type="double"/>
<attribute name="units" value="seconds since 2000-01-01 12:00:00, neglecting leap seconds" type="string"/>
</variable>
<variable name="sensor_label" type="char" shape="number_of_sensors sensor_str_len">
<attribute name="long_name" value="labels for the two magnetometers on the satellite. labels are ordered the same as applicable data variable" type="string"/>
<values>InboardMagnetometer OutboardMagnetometer</values>
</variable>
<variable name="coordinate_label" type="char" shape="coordinate coordinate_str_len">
<attribute name="long_name" value="labels for the 3 orthogonal axes in a 3-D coordinate reference system. labels are ordered the same as applicable data variables" type="string"/>
<values>x y z</values>
</variable>
<variable name="solar_array_current_channel_index_label" type="char" shape="solar_array_current_channel_index solar_array_mnemonic_str_len">
<attribute name="long_name" value="labels for four solar array current telemetry mnemonics. labels are ordered the same as applicable data variable" type="string"/>
<values>EPS_SA_CHAN_1_4_RETRN_I EPS_SA_CHAN_5_8_RETRN_I EPS_SA_CHAN_9_12_RETRN_I EPS_SA_CHAN_13_16_RETRN_I</values>
</variable>
<variable name="IB_data_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected Inboard MAG field values in Inboard MAG frame" type="string"/>

<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_data_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected Outboard MAG field values in Outboard MAG frame" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_ACRF_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected ACRF frame Inboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_ACRF_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected ACRF frame Outboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_BRF_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected BRF frame Inboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_BRF_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected BRF frame Outboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_ECI_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected ECI frame Inboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>

<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_ECI_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected ECI frame Outboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_EPN_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected EPN frame Inboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_EPN_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected EPN frame Outboard MAG field values" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="total_mag_ACRF_uncorrected" type="float" shape="report_number number_samples_per_report">
<attribute name="long_name" value="Uncorrected ACRF frame Ambient MAG field total magnitude" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="amb_mag_BRF_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected BRF frame Ambient MAG field" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="amb_mag_ECI_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected ECI frame Ambient MAG field" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>

<variable name="amb_mag_EPN_uncorrected" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="Uncorrected EPN frame Ambient MAG field" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_data" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated (temperature calibrated and misalignment corrected) magnetic field for x, y, and z direction in calibrated orthogonal reference frame for inboard magnetometer (MFIB)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_data" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated (temperature calibrated and misalignment corrected) magnetic field for x, y, and z direction in calibrated orthogonal reference frame for outboard magnetometer (MFOB)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_ACRF" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (inboard magnetometer) for x, y, and z direction in spacecraft's Attitude Control Reference Frame (ACRF) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_ACRF" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (outboard magnetometer) for x, y, and z direction in spacecraft's Attitude Control Reference Frame (ACRF) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_BRF" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (inboard magnetometer) for x, y, and z direction in spacecraft's Body Reference Frame (BRF) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>

<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_BRF" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (outboard magnetometer) for x, y, and z direction in spacecraft’s Body Reference Frame (BRF) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_ECI" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (inboard magnetometer) for x, y, and z direction in J2000 Earth-Centered Inertial reference frame (ECI) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_ECI" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (outboard magnetometer) for x, y, and z direction in J2000 Earth-Centered Inertial reference frame (ECI) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="IB_mag_EPN" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (inboard magnetometer) for x, y, and z direction in Earth Polar Normal reference frame (EPN) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="OB_mag_EPN" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="compensated magnetic field (outboard magnetometer) for x, y, and z direction in Earth Polar Normal reference frame (EPN) (after factory and on-orbit calibration)" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="total_mag_ACRF" type="float" shape="report_number number_samples_per_report">
<attribute name="long_name" value="estimated total ambient magnetic field in spacecraft’s Attitude Control Reference Frame" type="string"/>

<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="amb_mag_BRF" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="estimated ambient magnetic field for x, y, and z direction in spacecraft's Body Reference Frame" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="amb_mag_ECI" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="estimated ambient magnetic field for x, y, and z direction in J2000 Earth-Centered Inertial reference frame" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="amb_mag_EPN" type="float" shape="report_number number_samples_per_report coordinate">
<attribute name="long_name" value="estimated ambient magnetic field for x, y, and z direction in Earth Polar Normal reference frame" type="string"/>
<attribute name="_FillValue" value="-999.0" type="float"/>
<attribute name="valid_range" value="-512.0 512.0" type="float"/>
<attribute name="units" value="nT" type="string"/>
</variable>
<variable name="DQF" type="uint" shape="report_number number_samples_per_report">
<attribute name="long_name" value="magnetometer L1b processing and data quality flags" type="string"/>
<attribute name="_FillValue" value="4294967295" type="uint"/>
<attribute name="valid_range" value="0 67108863" type="uint"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="33554431 1 2 4 8 16 32 64 128 256 512 1024 2048 4096 8192 16384 32768 65536 131072 262144 524288 1048576 2097152 4194304 8388608 16777216 33554432" type="uint"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="uint"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="IB_status" type="ushort" shape="report_number number_samples_per_report">
<attribute name="long_name" value="inboard magnetometer status flags" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 8191" type="ushort"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="1 1 8190 2 4 8 16 32 64 128 256 512 1024 2048 4096" type="ushort"/>

<attribute name="flag_values" value="***see note [flags and meanings]***" type="ushort"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="OB_status" type="ushort" shape="report_number number_samples_per_report">
<attribute name="long_name" value="outboard magnetometer status flags" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 8191" type="ushort"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_masks" value="1 1 8190 2 4 8 16 32 64 128 256 512 1024 2048 4096" type="ushort"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ushort"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="Instrument_ID" type="ubyte" shape="report_number number_of_sensors">
<attribute name="long_name" value="magnetometer instrument (sensor) serial number" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 254" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
</variable>
<variable name="yaw_flip" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether spacecraft is operating in yaw flip configuration" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 2" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="eclipse_flag" type="ubyte" shape="report_number">
<attribute name="long_name" value="flags indicating whether sun is obscured by earth as provided by spacecraft" type="string"/>
<attribute name="_FillValue" value="255" type="ubyte"/>
<attribute name="valid_range" value="0 3" type="ubyte"/>
<attribute name="units" value="1" type="string"/>
<attribute name="flag_values" value="***see note [flags and meanings]***" type="ubyte"/>
<attribute name="flag_meanings" value="***see note [flags and meanings]***" type="string"/>
</variable>
<variable name="solar_array_current" type="ushort" shape="report_number solar_array_current_channel_index">
<attribute name="long_name" value="solar array current in DN for 4 channel groups (1-4, 5-8, 9-12, 13-16)" type="string"/>
<attribute name="_FillValue" value="65535" type="ushort"/>
<attribute name="valid_range" value="0 65534" type="ushort"/>

```
    <attribute name="units" value="count" type="string"/>
  </variable>
  <variable name="percent_uncorrectable_L0_errors" type="float" shape="">
    <attribute name="long_name" value="percent data lost due to uncorrectable L0 errors" type="string"/>
    <attribute name="_FillValue" value="-999.0" type="float"/>
    <attribute name="valid_range" value="0.0 1.0" type="float"/>
    <attribute name="units" value="percent" type="string"/>
    <values>dynamic value</values>
  </variable>
  <variable name="algorithm_dynamic_input_data_container" type="int" shape="">
    <attribute name="long_name" value="container for filenames of dynamic algorithm input data; not in use" type="string"/>
    <attribute name="input_MAG_L0_data" value="null" type="string"/>
  </variable>
  <attribute name="dataset_name" value="refer to filename conventions for L1b products in Appendix C." type="string"/>
  <attribute name="naming_authority" value="gov.nesdis.noaa" type="string"/>
  <attribute name="institution" value="DOC/NOAA/NESDIS> U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Services" type="string"/>
  <attribute name="project" value="GOES" type="string"/>
  <attribute name="iso_series_metadata_id" value="f5816f50-fd6d-11e3-a3ac-0800200c9a66" type="string"/>
  <attribute name="Metadata_Conventions" value="Unidata Dataset Discovery v1.0" type="string"/>
  <attribute name="keywords_vocabulary" value="NASA Global Change Master Directory (GCMD) Earth Science Keywords, Version 7.0.0.0.0" type="string"/>
  <attribute name="title" value="Magnetometer L1b Geomagnetic Field" type="string"/>
  <attribute name="summary" value="The Geomagnetic Field product consists of the estimated ambient magnetic field in four coordinate reference frames, Earth Polar Normal, J2000 Earth-Centered Inertial, and the spacecraft's Body Reference Frame and Attitude Control Reference Frame. The product also includes the compensated (calibrated and misalignment corrected) magnetic field in the native reference frame for both the inboard and outboard magnetometers. Furthermore, the product includes inboard and outboard magnetometer status flags, processing and data quality metadata, satellite state and location information, and data required for the generation of level 2 products." type="string"/>
  <attribute name="license" value="Unclassified data.  Access is restricted to approved users only." type="string"/>
  <attribute name="keywords" value="SUN-EARTH INTERACTIONS > IONOSPHERE/MAGNETOSPHERE DYNAMICS > MAGNETIC FIELDS/MAGNETIC CURRENTS, SUN-EARTH INTERACTIONS > IONOSPHERE/MAGNETOSPHERE DYNAMICS > MAGNETIC STORMS" type="string"/>
  <attribute name="cdm_data_type" value="Point" type="string"/>
  <attribute name="orbital_slot" value="possible values are GOES-East, GOES-West, GOES-Test, and GOES-Storage." type="string"/>
  <attribute name="platform_ID" value="possible values are G16 and G17." type="string"/>
  <attribute name="instrument_type" value="GOES-R Series Magnetometer" type="string"/>
  <attribute name="inboard_MAG_instrument_ID" value="serial number of the inboard magnetometer." type="string"/>
  <attribute name="outboard_MAG_instrument_ID" value="serial number of the outboard magnetometer." type="string"/>
  <attribute name="processing_level" value="National Aeronautics and Space Administration (NASA) L1b" type="string"/>
```

<attribute name="date_created" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="production_site" value="***possible values are WCDAS and RBU.***" type="string"/>
<attribute name="production_environment" value="***possible values are OE, ITE, and DE.***" type="string"/>
<attribute name="production_data_source" value="***possible values are Realtime, Simulated, Playback, and Test.***" type="string"/>
<attribute name="time_coverage_start" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="time_coverage_end" value="***format is YYYY-MM-DD"T"HH:MM:SS.s"Z".***" type="string"/>
<attribute name="L1b_processing_parm_version" value="***refer to filename conventions for L1b processing parameters in Appendix C.***" type="string"/>
<attribute name="algorithm_version" value="***refer to filename conventions for L1b algorithm packages in Appendix C.***" type="string"/>
<attribute name="product_version" value="***format is vVVrRR where VV is major release # and RR is minor revision #.***" type="string"/>
<attribute name="LUT_Filenames" value="***A space-separated list of processing parameter files used in producing the product.***" type="string"/>
</netcdf>

Note “flags and meanings”: Flag values and meanings are located in paragraph 7.6.1.5.1.2, Geomagnetic Field Product Flag Values and Meanings.

7.7 GRB Information

GRB information (INFO) provides data related to the operations, and health and performance of the GOES-R series flight and ground system, and includes the following types of information:

- Satellite acquisition data
- Mission schedule
- Flight system status
- ABI Image Navigation and Registration (INR) performance data
- GLM INR performance data
- SUVI INR performance data
- Semi-static processing parameter file manifest

Each of these types of GRB INFO exists in separate GRB Space Packets. In addition, GRB INFO packets contain information associated with a single satellite, and the components of the ground system supporting its operation, product processing, and product distribution. The content of the GRB INFO packets contains only information that is relevant to the satellite performing the rebroadcast. The wall-clock time that the packets containing each GRB INFO type is rebroadcast varies, but it is assured that each type is rebroadcast every five minutes. While the GRB INFO packets are rebroadcast every five minutes, the content of the GRB INFO packets does not change at the same frequency. The interval in which the GRB INFO content is updated can vary for the different types of GRB INFO. This is discussed further in the subordinate paragraphs that describe and define each of the GRB INFO types.

A single APID, which is defined in Appendix A, CCSDS Application Identifiers, is used for GRB INFO packets. GRB INFO uses the GRB Generic Payload format as defined in Paragraph 5.3, GRB Generic Payload. GRB INFO control fields occur at the start of the Generic Payload Data Unit to distinguish the type of GRB INFO. Refer to Figure 7.7, Location of GRB INFO Control Fields.

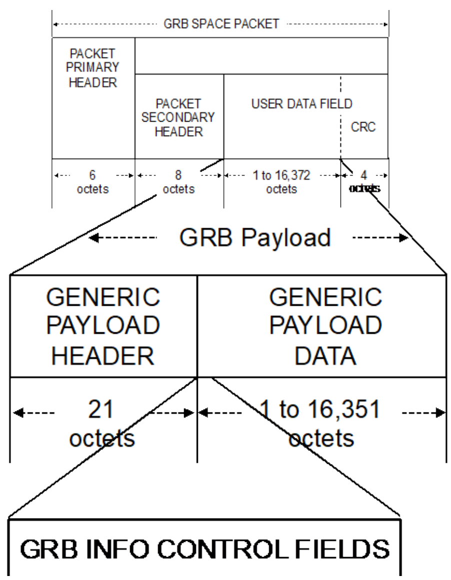

Figure 7.7 Location of GRB INFO Control Fields

The GRB INFO Control Fields are defined in Table 7.7, GRB INFO Control Fields.

Table 7.7 GRB INFO Control Fields

	Bits	Field		Summary Description
GRB INFO Control Fields	8	GRB INFO Identifier Size		Size in octets of the GRB INFO Identifier
	16	GRB INFO Identifier [1]	System Environment	Defines whether the file is created by the operational system or a test system. Also defines whether the data in the file is real-time, test, playback, or simulated data. Possible values are: "OR" = operational system real-time data "OT" = operational system test data "IR" = test system real-time data "IT" = test system test data "IP" = test system playback data "IS" = test system simulated data Note: Real-time data created by the operational system (i.e., "OR") support the operational mission.
	104 or 112		Data Short Name w/ underscore prefix	Identifies the type of GRB INFO. Possible values are: "_GRB-INFO-ACQ" = satellite acquisition data "_GRB-INFO-SCH" = mission schedule "_GRB-INFO-STAT" = flight system status "_GRB-INFO-NPRF" = ABI INR performance data "_GRB-INFO-GLMP" = GLM INR performance data "_GRB-INFO-SUVP" = SUVI INR performance data "_GRB-INFO-STATIC" = processing parameter file manifest
	24		Platform Identifier w/ underscore prefix	"_G16" = GOES-16 (R) "_G17" = GOES-17 (S)
	128		Rebroadcast Date & Time w/ underscore prefix	Date and time in the form of "_s" followed by "YYYYDDDHHMMSSs" Notes: ➢ YYYY = year: e.g., 2015 ➢ DDD = day of year: 001-366 ➢ HH = UTC hour of day: 00-23 ➢ MM = minute of hour: 00-59 SSs = second of minute: 00-59 (60 indicates leap second and third "s" is tenth of second)
	32		Extension	Fixed value of ".xml"

[1] The GRB INFO Identifier also serves as the filename of the constituent reconstituted XML document files sent to PDA.

The GRB INFO data immediately follows the GRB INFO Control Fields. The GRB INFO data format is a Unix text file based XML document (less the end-of-file character).

The XML documents for the different GRB INFO types conform to corresponding XML Schema Documents (XSDs). These XSDs can be used by GRB users to validate and perform application-specific processing on the embedded XML documents in the GRB INFO packets. The Uniform Resource Locators

(URLs) for the XSD files are located within the GRB INFO XML documents, and are identified in the subordinate paragraphs that follow. The URL for the directory where the GRB INFO XSD files exist is http://www.goes-r.gov/users/grb/schema/

The subordinate paragraphs that follow describe and define each type of GRB INFO. The last subparagraph contains tables that define the categorical values common to more than one type of GRB INFO.

The detailed description of the ISO series metadata for GRB INFO is located in the standalone Appendix X, ISO Series Metadata. The ISO series metadata identifier for GRB INFO is "d60ed140-3a8a-11e3-aa6e-0800200c9a66".

7.7.1 GRB INFO: Satellite Acquisition Data

7.7.1.1 Description

GRB INFO: Satellite Acquisition Data contains the latitude and longitude of the satellite sub-point at 30 minute intervals. This data is used by ground terminals to acquire and lock on the GRB RF downlink signal. Nominally, the satellite acquisition data is updated daily, and spans the subsequent seven day period. The frequency of update and time-span associated with the satellite acquisition data may change. Note that the more time that has passed since the generation of the satellite acquisition data, the greater the error in the satellite's predicted location.

7.7.1.2 Data Fields

Once the satellite acquisition data has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the data is an XML document in Unix text file format (less the end-of-file character). The order of XML elements and attributes within elements as they appear in the table below does not necessarily reflect their exact order in the XML document.

Table 7.7.1.2 GRB INFO: Satellite Acquisition Data

GRB INFO XML Document	Description (as required)
<?xml version="1.0" encoding="UTF-8"?> <SatAcquisition xmlns="urn:goes-r:grb_info:acquisition" xsi:schemaLocation="urn:goes-r:grb_info:acquisition ***<pathname to GOES-R GRB INFO XML schema definition files>***/GRB-INFO-ACQ_v01r00.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" MMSourceFilename="***dynamic value***">	XML document root element contains the applicable namespaces, URL for the satellite acquisition XML schema definition file, and the name of the XML document file populated from the GRB INFO packet. Note that the MMSourceFilename follows the same filename conventions as the GRB INFO Identifier defined in Table 7.7, GRB INFO Control Fields. The time stamp field in the MMSourceFilename is the effectivity start time of the GRB INFO data.
<ID>***categorical value***</ID>	Satellite number. Refer to Table 7.7.8.1, Satellite Numbers.

<Location>***categorical value***</Location>	Satellite orbital slot. Refer to Table 7.7.8.3, Satellite Orbital Slots.
<TBUS>	Legacy TIROS Bulletin United States (TBUS) designation.
<Label>***dynamic value***</Label>	Legacy TIROS Bulletin United States (TBUS) satellite-unique label.
The satellite acquisition records that follow nominally repeat 336 times (each record is associated with a 30 minute interval) with one instance of the fields for each record.	
<GeodeticSubpointState>	
<Epoch_GMT>***format is YYYY-MM-DD"T"HH:MM:SS.sss"Z"***</Epoch_GMT>	Time associated with satellite acquisition record.
<GeodeticSubpoint>	
<Latitude_deg>-***dynamic value***</Latitude_deg>	Floating point number in scientific notation for satellite data acquisition location in degrees north latitude.
<WestLongitude_deg>-***dynamic value***</WestLongitude_deg>	Floating point number in scientific notation for satellite data acquisition location in degrees west longitude.
</GeodeticSubpoint>	
</GeodeticSubpointState>	
End satellite acquisition record	
</TBUS>	
</SatAcquisition>	

7.7.2 GRB INFO: Mission Schedule

7.7.2.1 Description

GRB INFO: Mission Schedule contains a tailored set of scheduled O&M tasks that affect the ability of the GOES-R system to produce products, or the quality of the products. These tasks typically involve commanding the spacecraft or an instrument to perform an operation. The scheduled time frame associated with each task is included. This data indirectly provides GRB users with notification that product degradation and delivery interruptions will be occurring in the hours and days ahead due to planned satellite maintenance activities. Nominally, the mission schedule is updated daily, and spans the subsequent seven day period. The frequency of update and time-span associated with the mission schedule may change.

7.7.2.2 Data Fields

Once the mission schedule has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the data is an XML document in Unix text file format (less the end-of-file character). The order of XML elements and attributes within elements as they appear in the table below does not necessarily reflect their exact order in the XML document.

Table 7.7.2.2 GRB INFO: Mission Schedule

GRB INFO XML Document	Description (as required)
<?xml version="1.0" encoding="UTF-8"?>	

<MissionSchedule xmlns="urn:goes-r:grb_info:schedule" xsi:schemaLocation="urn:goes-r:grb_info:schedule ="<***pathname to GOES-R GRB INFO XML schema definition files***>/GRB-INFO-SCH_v01r00.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" TestingFile="***boolean value***" MMSourceFilename="***dynamic value***">	XML document root element contains the applicable namespaces, URL for the mission schedule XML schema definition file, and the name of the XML document file populated from the GRB INFO packet. Note that the MMSourceFilename follows the same filename conventions the GRB INFO Identifier as defined in Table 7.7, GRB INFO Control Fields. The time stamp field in the MMSourceFilename is the effectivity start time of the GRB INFO data. The TestingFile attribute is reserved for internal ground system use.
The mission schedule task records that follow repeat a variable number of times with one instance of the fields for each record.	
<Task>	
<UniqueID Value="***dynamic value***"/>	Unique string identifier for task. Identifier is unique across this instance of the mission schedule.
<TaskType Value="***dynamic value***"/>	User defined type of scheduling task.
<ProductTaskCategory Value="***categorical value*** "/>	Mission schedule task category. Refer to Table 7.7.8.5, Mission Schedule Task Categories.
<Duration ValueInMilliseconds="***dynamic value***"/>	Integer number of milliseconds to execute the task.
<ScheduleStart Value="***format is YYYY-MM-DD"T"HH:MM:SS***"/>	Scheduled start time for task execution.
<ScheduleEnd Value="***format is YYYY-MM-DD"T"HH:MM:SS***"/>	Scheduled end time for task execution.
<Satellite Value="***categorical value***"/>	Satellite number. Refer to Table 7.7.8.1, Satellite Numbers.
</Task>	
End mission schedule task record	
</MissionSchedule>	

7.7.3 GRB INFO: Flight System Status

7.7.3.1 Description

GRB INFO: Flight System Status contains a configurable set of parameters, and their values and status that summarize the health and performance of the flight system. Parameters associated with the (1) communications, (2) command and data handling, (3) guidance, navigation, and control, (4) electrical power, (5) propulsion, (6) mechanical, (7) thermal control, or (8) instrument satellite subsystems, or aggregates thereof may be included. Nominally, the flight system status is updated daily. The frequency of update associated with the flight system status may change.

7.7.3.2 Data Fields

Once the flight system status has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the data is an XML document in Unix text file format (less the end-of-file character). The order of XML elements and attributes within elements as they appear in the table below does not necessarily reflect their exact order in the XML document.

Table 7.7.3.2 GRB INFO: Flight System Status

GRB INFO XML Document	Description (as required)
<?xml version="1.0" encoding="UTF-8"?>	
<p:MMCompositeStatus xmlns="urn:goes-r:grb_info:status" xsi:schemaLocation="urn:goes-r:grb_info:status ***<pathname to GOES-R GRB INFO XML schema definition files***>/GRB-INFO-STAT_v01r00.xsd" xmlns:p="urn:goes-r:grb_info:status" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"	XML document root element contains the applicable namespaces, URL for the flight system status XML schema definition file, and the name of the XML document file populated from the GRB INFO packet. Note that the MMSourceFilename follows the same filename conventions the GRB INFO Identifier as defined in Table 7.7, GRB INFO Control Fields. The time stamp field in the MMSourceFilename is the effectivity start time of the GRB INFO data.
statusTimestamp=="***format is YYYY-MM-DD"T"HH:MM:SS***">	Flight system status report generation time.
<p:Satellite	
number="***dynamic value***"	Satellite number. Refer to Table 7.7.8.1, Satellite Numbers.
id="***dynamic value***">	Satellite identifier. Refer to Table 7.7.8.2, Satellite Identifiers.
The flight system status records that follow repeat a variable number of times with one instance of fields for each record.	
<p:Parameter	
name="***dynamic value***"	Identifier for the flight system health or performance status parameter.
description="***dynamic value***"	Description for the flight system health or performance status parameter.
value="***dynamic value***"	Value for the flight system health or performance status parameter.
alarmStatus="***categorical value***"/>	Flight system status indicator for status parameter. Refer to Table 7.7.8.6, System Status Indicators.

End flight system status record	
</p:Satellite>	
</p:MMCompositeStatus>	

7.7.4 GRB INFO: ABI INR Performance Data

7.7.4.1 Description

GRB INFO: ABI INR Performance Data contains statistics that summarize the ABI INR performance associated with the GOES-R system. In addition to monitoring INR performance of the ABI and overarching GOES-R system, this data is used by GRB users to assess the mapping accuracy of ABI Level 1b and Level 2+ product data. These statistics are calculated using ABI Level 1b Radiances product images and landmarks. The image to map, band to band (channel to channel) and within frame statistics derived using landmarks are available for those ABI bands that can see the earth's surface (i.e., ABI bands 1-3, 5-7, 11, and 13-16).

The individual band statistics are aggregates, specifically 3-sigma values (i.e., sum of the absolute value of the mean value and three times the standard deviation), using measurements taken from individual images over a configurable sliding time window. Nominally, this sliding time window is set to 24 hours with the ABI INR performance data being updated daily. The sliding time window and frequency of update associated with the ABI INR performance data may change. As a result, if the sliding time window is configured to minutes up to several hours, and the ABI INR performance data is updated at a similar frequency, it is possible that at certain times during the day, no statistics are reported for the reflective bands (i.e., ABI bands 1-6) due to their inability to operate effectively at night.

7.7.4.2 Data Fields

Once the ABI INR performance data has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the data is an XML document in Unix text file format (less the end-of-file character). The order of XML elements and attributes within elements as they appear in the table below does not necessarily reflect their exact order in the XML document.

Table 7.7.4.2 GRB INFO: ABI INR Performance Data

GRB INFO XML Document	Description (as required)
<?xml version="1.0" encoding="UTF-8"?>	
<ABI_INR_PerfData xmlns="urn:goes-r:grb_info:abi_inr_perf_data" xsi:schemaLocation="urn:goes-r:grb_info:abi_inr_perf_data **<*pathname to GOES-R GRB INFO XML schema definition files*>**/GRB-INFO-NPRF_v01r00.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" MMSourceFilename="***dynamic value***">	XML document root element contains the applicable namespaces, URL for the ABI INR performance data XML schema definition file, and the name of the XML document file populated from the GRB INFO packet. Note that the MMSourceFilename follows the same filename conventions as the GRB INFO Identifier defined in Table 7.7, GRB INFO Control Fields. The time stamp field in the MMSourceFilename is the effectivity start time of the GRB INFO data.

<ID>***categorical value***</ID>	Satellite number. Refer to Table 7.7.8.1, Satellite Numbers.
<Location>***categorical value***</Location>	Satellite orbital slot. Refer to Table 7.7.8.3, Satellite Orbital Slots.
<Site>***categorical value***</Site>	Ground system site where performance data generated. Refer to Table 7.7.8.4, Ground System Sites.
<Time_GMT>***format is YYYY-MM-DD"T"HH:MM:SS.sss"Z"***<//Time_GMT>	INR performance data report generation time.
The ABI INR performance records that follow repeat 16 times with one instance of fields for each of the 16 ABI bands [1]	
<AverageForBand>	
<Band>***categorical value***</Band>	Label designating a specific ABI band. Refer to Table 7.7.8.7, ABI Band Labels.
<EW_ImageToMapMeasure_microradians>***dynamic value***</EW_ImageToMapMeasure_microradians> [2]	Floating point number in scientific notation for the 3-sigma geolocation error in the ABI Level 1b Radiances product images' east/west direction. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
<NS_ImageToMapMeasure_microradians>***dynamic value***</NS_ImageToMapMeasure_microradians> [2]	Floating point number in scientific notation for the 3-sigma geolocation error in the ABI Level 1b Radiances product images' north/south direction. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
<WithinFrameMeasure_microradians>***dynamic value***</WithinFrameMeasure_microradians> [2]	Floating point number in scientific notation for the 3-sigma error in distance between pairs of selected locations in an ABI Level 1b Radiances product image. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
<EW_ImageToImageMeasure_microradians>***dynamic value***</EW_ImageToImageMeasure_microradians>	Floating point number in scientific notation for the 3-sigma east/west displacement error between successive ABI Level 1b Radiances product images. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
<NS_ImageToImageMeasure_microradians>***dynamic value***</NS_ImageToImageMeasure_microradians>	Floating point number in scientific notation for the 3-sigma north/south displacement error between

	successive ABI Level 1b Radiances product images. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
<EW_SwathToSwathMeasure_microradians>***dynamic value***</EW_SwathToSwathMeasure_microradians>	Floating point number in scientific notation for the 3-sigma east/west displacement error in the overlap region of adjacent swaths used in the assembly of ABI Level 1b Radiances product images. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
<NS_SwathToSwathMeasure_microradians>***dynamic value***</NS_SwathToSwathMeasure_microradians>	Floating point number in scientific notation for the 3-sigma north/south displacement error in the overlap region of adjacent swaths used in the assembly of ABI Level 1b Radiances product images. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
</AverageForBand>	
End ABI INR performance record for Individual Bands	
The ABI INR performance records that follow repeat 55 times with one instance of fields for each of the ground viewing band pairs [3]	
<AverageBetweenBands>	
<Band1>***categorical value***</Band1>	Label designating a specific ABI band. Refer to Table 7.7.8.7, ABI Band Labels.
<Band2>***categorical value***</Band2>	Label designating a specific ABI band. Refer to Table 7.7.8.7, ABI Band Labels.
<EW_BandToBandMeasure_microradians>***dynamic value***</EW_BandToBandMeasure_microradians>	Floating point number in scientific notation for the 3-sigma error in the image-to-map difference between band pairs in the east/west direction. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.
<NS_BandToBandMeasure_microradians>***dynamic value***</NS_BandToBandMeasure_microradians>	Floating point number in scientific notation for the 3-sigma error in the image-to-map difference between band pairs in the north/south direction. Error value is an angular offset from the perspective of the ideal location of the ABI in geostationary orbit. Units of measure are microradians.

</AverageBetweenBands>	
End ABI INR performance record for Between Viewing Band Pairs	
</ABI_INR_PerfData>	

[1] All of these statistics may not be reported for the ABI reflective bands 1 through 6.
[2] These statistics are not reported for ABI bands 4, 8, 9, 10, and 12.
[3] These statistics are reported for every possible ground viewing band (i.e., 1, 2, 3, 5, 6, 7, 11, 13, 14, 15, and 16) combination (55=11*10/2).

7.7.5 GRB INFO: GLM INR Performance Data

7.7.5.1 Description

GRB INFO: GLM INR Performance Data contains statistics that summarize the GLM INR performance associated with the GOES-R system. In addition to monitoring INR performance of the GLM and overarching GOES-R system, this data is used by GRB users to assess the mapping accuracy of the GLM Level 2+ Lightning Detection product data. These statistics are calculated using a background image observed by the GLM and downlinked periodically and landmarks.

The statistics are aggregates, specifically 3-sigma values (i.e., sum of mean value and three times the standard deviation), using measurements taken from individual images over a configurable sliding time window. Nominally, this sliding time window is set to 24 hours, and the GLM INR performance data is updated daily. The sliding time window and frequency of update associated with the GLM INR performance data may change. As a result, if the sliding time window is configured to minutes up to several hours, and the GLM INR performance data is updated at a similar frequency, it is possible that at certain times during the day, no statistics are reported because of the inability of the GLM to generate satisfactory background images at night.

7.7.5.2 Data Fields

Once the GLM INR performance data has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the data is an XML document in Unix text file format (less the end-of-file character). The order of XML elements and attributes within elements as they appear in the table below does not necessarily reflect their exact order in the XML document.

Table 7.7.5.2 GRB INFO: GLM INR Performance Data

GRB INFO XML Document	Description (as required)
<?xml version="1.0" encoding="UTF-8"?>	
<GLM_INR_PerfData xmlns="urn:goes-r:grb_info:glm_inr_perf_data" xsi:schemaLocation="urn:goes-r:grb_info:glm_inr_perf_data ***<pathname to GOES-R GRB INFO XML schema definition files>***/GRB-INFO-GLMP_v01r00.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" MMSourceFilename="***dynamic value***">	XML document root element contains the applicable namespaces, URL for the GLM INR performance data XML schema definition file, and the name of the XML document file populated from the GRB INFO packet. Note that the MMSourceFilename follows the same filename conventions as the GRB INFO Identifier as defined in Table 7.7, GRB INFO Control Fields. The time stamp field in the MMSourceFilename is the effectivity start time of the GRB INFO data.

<ID>***categorical value***</ID>	Satellite number. Refer to Table 7.7.8.1, Satellite Numbers.
<Location>***categorical value***</Location>	Satellite orbital slot. Refer to Table 7.7.8.3, Satellite Orbital Slots.
<Site>***categorical value***</Site>	Ground system site where performance data generated. Refer to Table 7.7.8.4, Ground System Sites.
<Time_GMT>***format is YYYY-MM-DD"T"HH:MM:SS.sss"Z"***<//Time_GMT>	INR performance data report generation time.
<EW_ImageToMapMeasure_microradians>***dynamic value***</EW_ImageToMapMeasure_microradians>	Floating point number in scientific notation for the 3-sigma east/west error in the geolocation information associated with the lightning detection product data. Note that this error is determined using an image observed and downlinked periodically by the GLM. Error value is an angular offset from the perspective of the ideal location of the GLM in geostationary orbit. Units of measure are microradians.
<NS_ImageToMapMeasure_microradians>***dynamic value***</NS_ImageToMapMeasure_microradians>	Floating point number in scientific notation for the 3-sigma north/south error in the geolocation information associated with the lightning detection product data. Note that this error is determined using an image observed and downlinked periodically by the GLM. Error value is an angular offset from the perspective of the ideal location of the GLM in geostationary orbit. Units of measure are microradians.
<GLM_INR_PerfData>	

7.7.6 GRB INFO: SUVI INR Performance Data

7.7.6.1 Description

GRB INFO: SUVI INR Performance Data contains statistics that summarize the SUVI INR performance associated with the GOES-R system. In addition to monitoring INR performance of the SUVI and overarching GOES-R system, this data is used by GRB users to assess the mapping accuracy of Level 1b SUVI Solar Imagery: EUV product data. These statistics are calculated using metadata fields in the SUVI Level 1b product that contain the location of the sun's center, which are based on information received from the Guide Telescope, and the SUVI Level 1b one second exposure 195.1 angstrom solar image, which is best for locating the edge of the solar disk.

The statistics are aggregates using measurements taken from individual images over a configurable fixed time window. Nominally, this fixed time window is set to 20 minutes, with the SUVI INR performance data being updated daily. The fixed time window and frequency of update associated with the SUVI INR performance data may change.

7.7.6.2 Data Fields

Once the SUVI INR performance data has been extracted from the packet and decompressed in accordance with the approach defined in paragraph 6.2, GRB Generic Payload Recovery, the data is an XML document in Unix text file format (less the end-of-file character). The order of XML elements and attributes within elements as they appear in the table below does not necessarily reflect their exact order in the XML document.

Table 7.7.6.2 GRB INFO: SUVI INR Performance Data

GRB INFO XML Document	Description (as required)
<?xml version="1.0" encoding="UTF-8"?>	
<SUVI_INR_PerfData xmlns="urn:goes-r:grb_info:suvi_inr_perf_data" xsi:schemaLocation="urn:goes-r:grb_info:suvi_inr_perf_data ***<pathname to GOES-R GRB INFO XML schema definition files>***/GRB-INFO-SUVP_v01r00.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" MMSourceFilename="***dynamic value***">	XML document root element contains the applicable namespaces, URL for the SUVI INR performance data XML schema definition file, and the name of the XML document file populated from the GRB INFO packet. Note that the MMSourceFilename follows the same filename conventions as the GRB INFO Identifier as defined in Table 7.7, GRB INFO Control Fields. The time stamp field in the MMSourceFilename is the effectivity start time of the GRB INFO data.
<ID>***categorical value***</ID>	Satellite number. Refer to Table 7.7.8.1, Satellite Numbers.
<Location>***categorical value***</Location>	Satellite orbital slot. Refer to Table 7.7.8.3, Satellite Orbital Slots.
<Site>***categorical value***</Site>	Ground system site where performance data generated. Refer to Table 7.7.8.4, Ground System Sites.
<Time_GMT>***format is YYYY-MM-DD"T"HH:MM:SS.sss"Z"***<//Time_GMT>	INR performance data report generation time.
<GT>	
<SUVI_X_GT_Minimum>***dynamic value***</SUVI_X_GT_Minimum>	Floating point number in scientific notation for the minimum x-axis coordinate (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Note that the value for the center of the first pixel in the image on the x-axis is 1.

<SUVI_X_GT_Maximum>***dynamic value***</SUVI_X_GT_Maximum>	Floating point number in scientific notation for the maximum x-axis coordinate (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Note that the value for the center of the first pixel in the image on the x-axis is 1.
<SUVI_X_GT_Mean>***dynamic value***</SUVI_X_GT_Mean>	Floating point number in scientific notation for the mean x-axis coordinate (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Note that the value for the center of the first pixel in the image on the x-axis is 1.
<SUVI_X_GT_Std_Dev>***dynamic value***</SUVI_X_GT_Std_Dev>	Floating point number in scientific notation for the standard deviation of the x-axis coordinates (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Units of measure are arcseconds.
<SUVI_Y_GT_Minimum>***dynamic value***</SUVI_Y_GT_Minimum>	Floating point number in scientific notation for the minimum y-axis coordinate (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Note that the value for the center of the first pixel in the image on the y-axis is 1.
<SUVI_Y_GT_Maximum>***dynamic value***</SUVI_Y_GT_Maximum>	Floating point number in scientific notation for the maximum y-axis coordinate (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Note that the value for the center of the first pixel in the image on the y-axis is 1.
<SUVI_Y_GT_Mean>***dynamic value***</SUVI_Y_GT_Mean>	Floating point number in scientific notation for the mean y-axis coordinate (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Note that the value for the center of

	the first pixel in the image on the y-axis is 1.
<SUVI_Y_GT_Std_Dev>***dynamic value***</SUVI_Y_GT_Std_Dev>	Floating point number in scientific notation for the standard deviation of the y-axis coordinates (i.e., pixel) for the center of the sun within the solar images acquired over an interval as determined by the guide telescope. Units of measure are arcseconds.
</GT>	
<EuclideanDistance>	
<SUVI_Image_Type>Fe_XII_195.1A_long_exposure</SUVI_Image_Type>	Fixed label designating the solar image type used to determine sun centering error statistics. The image type has a central wavelength of 195.1 angstrom and a long exposure period.
<SUVI_Sun_Center_Minimum>***dynamic value***</SUVI_Sun_Center_Minimum>	Floating point number in scientific notation for the minimum error between the center of the sun in the images acquired over an interval and the set of temporally coincident centers of the sun determined by the guide telescope in the two-dimensional Euclidean plane orthogonal to the viewing perspective of the imager. Units of measure are arcseconds.
<SUVI_Sun_Center_Maximum>***dynamic value***</SUVI_Sun_Center_Maximum>	Floating point number in scientific notation for the maximum error between the center of the sun in the images acquired over an interval and the set of temporally coincident centers of the sun determined by the guide telescope in the two-dimensional Euclidean plane orthogonal to the viewing perspective of the imager. Units of measure are arcseconds.
<SUVI_Sun_Center_Mean>***dynamic value***</SUVI_Sun_Center_Mean>	Floating point number in scientific notation for the mean error between the center of the sun in the images acquired over an interval and the set of temporally coincident centers of the sun determined by the guide telescope in the two-dimensional Euclidean plane orthogonal to the viewing perspective of the imager. Units of measure are arcseconds.

<SUVI_Sun_Center_Std_Dev>***dynamic value***</SUVI_Sun_Center_Std_Dev>	Floating point number in scientific notation for the standard deviation of the error between the center of the sun in the images acquired over an interval and the set of temporally coincident centers of the sun determined by the guide telescope in the two-dimensional Euclidean plane orthogonal to the viewing perspective of the imager. Units of measure are arcseconds.
</EuclideanDistance>	
</SUVI_INR_PerfData>	

7.7.7 GRB INFO: Semi-Static Processing Parameter File Manifest

7.7.7.1 Description

GRB INFO: STATIC contains a list of zip files. The zip files contain the current versions of semi-static processing parameter file names, one for each instrument. The file names are defined in the GOES-R File Naming Convention and listed in Appendix C – Filename Conventions.

7.7.7.2 Data Fields

The XML elements and attributes appear in the table below.

Table 7.7.7.2 GRB INFO: Semi-Static Processing Parameter File Manifest

GRB INFO XML Document	Description (as required)
<?xml version="1.0" encoding="UTF-8"?>	
<ProcParamsManifest xmlns="urn:goes-r:grb_info:static" xsi:schemaLocation="urn:goes-r:grb_info:static |***pathname to GOES-R GRB INFO XML schema definition files***|/GRB-INFO-STATIC_v01r00.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" PGSourceFilename="***dynamic value***">	XML document root element contains the applicable namespaces, URL for the STATIC processing parameters manifest data XML schema definition file, and the name of the XML document file populated from the GRB INFO packet. Note that the PGSourceFilename follows the same filename conventions as the GRB INFO Identifier as defined in Table 7.7, GRB INFO Control Fields. The time stamp field in the PGSourceFilename is the effectivity start time of the GRB INFO data.
<ID>***categorical value***</ID>	Satellite number. Refer to Table 7.7.8.1, Satellite Numbers.
<Location>***categorical value***</Location>	Satellite orbital slot. Refer to Table 7.7.8.3, Satellite Orbital Slots.

<Site>***categorical value***</Site>	Ground system site where performance data generated. Refer to Table 7.7.8.4, Ground System Sites.
<Time_GMT>***format is YYYY-MM-DD"T"HH:MM:SS.sss"Z"***<//Time_GMT>	Semi-static processing parameter manifest report generation time.
<FileManifest>***dynamic value1***</FileManifest> <FileManifest>***dynamic value2***</FileManifest> <FileManifest>***dynamic value3***</FileManifest> <FileManifest>***dynamic value4***</FileManifest> <FileManifest>***dynamic value5***</FileManifest> <FileManifest>***dynamic value6***</FileManifest>	String value – dataset name of the zip file. The zip file contains the list of processing parameter file names. This element repeats once for each instrument (6 occurrences).
<ProcParamsManifest>	

7.7.8 GRB INFO: Common Fields

The tables in this paragraph define the values for the fields have categorical values.

Table 7.7.8.1 Satellite Numbers

Satellite Number
GOES-16
GOES-17

Table 7.7.8.2 Satellite Identifiers

Satellite Identifier
GOES-R
GOES-S

Table 7.7.8.3 Satellite Orbital Slots

Satellite Orbital Slots
EAST
WEST
STORAGE
TEST

Table 7.7.8.4 Ground System Sites

Ground System Site
WCDAS
NSOF
RBU

Table 7.7.8.5 Mission Schedule Task Categories

Mission Schedule Task Category
MANEUVER
SPECIAL_OPERATION
IMAGING_CONFIG
CALIBRATION
OTHER

Table 7.7.8.6 System Status indicators

System Status Indicator	Meaning
GREEN	nominal condition
YELLOW	warning condition
RED	fault/failure condition

Table 7.7.8.7 ABI Band Labels

ABI Band	Label
1	VNIR_470_nm
2	VNIR_640_nm
3	VNIR_865_nm
4	VNIR_1378_nm
5	VNIR_1610_nm
6	VNIR_2250_nm
7	MWIR_3900_nm
8	MWIR_6185_nm
9	MWIR_6950_nm
10	MWIR_7340_nm
11	MWIR_8500_nm
12	LWIR_9610_nm
13	LWIR_10350_nm
14	LWIR_11200_nm
15	LWIR_12300_nm
16	LWIR_13300_nm

APPENDIX A CCSDS APPLICATION IDENTIFIERS (APIDS)

CCSDS Application Identifiers (APIDs) are in the Primary Header of each GRB Space Packet. The APID uniquely identifies the type of information contained in that CCSDS packet. The APID values are summarized in Table A.

APIDs marked as "Spare" are candidates for future expansion. For example, the ABI spare APIDs from (hexadecimal) 1B0 to 1CF and 284 to 2FF provide capacity for adding up to (decimal) 156 new APIDs.

APIDs marked as "Reserved for GS" are used by the internally by the Ground Segment for tracking and other administrative purposes.

Table A GRB Application Identifier (APID) Summary

Products	Data Type	APID (Hex)
	Spare	0 – 7F
Radiances	Full Disk Metadata (Mode 6)	80 - 8F
	Full Disk Radiance Image (Mode 6)	90 - 9F
	Continental United States Metadata (Mode 6)	A0 - AF
	Continental United States Radiance Image (Mode 6)	B0 - BF
	Mesoscale #1 Metadata (Mode 6)	C0 - CF
	Mesoscale #1 Radiance Image (Mode 6)	D0 - DF
	Mesoscale #2 Metadata (Mode 6)	E0 - EF
	Mesoscale #2 Radiance Image (Mode 6)	F0 - FF
	Full Disk Metadata (Mode 3)	100 - 10F
	Full Disk Radiance Image Data (Mode 3)	110 - 11F
	Continental United States Metadata (Mode 3)	120 - 12F
	Continental United States Radiance Image Data (Mode 3)	130 - 13F
	Mesoscale #1 Metadata (Mode 3)	140 - 14F
	Mesoscale #1 Radiance Image Data (Mode 3)	150 - 15F
	Mesoscale #2 Metadata (Mode 3)	160 - 16F
	Mesoscale #2 Radiance Image Data (Mode 3)	170 - 17F
	Full Disk Metadata (Mode 4)	180 - 18F
	Full Disk Radiance Image Data (Mode 4)	190 - 19F
	Continental United States Metadata (Extracted from Full Disk Mode 4)	1A0 - 1AF
	Spare	1B0 - 1CF
	Reserved for GS	1D0 - 283
	Spare	284 - 2FF
Lightning Detection	Lightning Detection Metadata	300
	Lightning Detection Data	301 - 303
	Spare	304 - 35F
	Reserved for GS	360
	Spare	361 - 37F
Solar Flux: EUV Solar Flux: X-Ray	EUV Metadata	380
	EUV Data	381
	X-Ray Metadata	382
	X-Ray Data	383
	Spare	384 - 3DF
	Reserved for GS	3E0 - 3E1
	Spare	3E2 - 3FF
Energetic Heavy Ions	Energetic Heavy Ions Metadata	400
	Energetic Heavy Ions Data	401

Products	Data Type	APID (Hex)
Magnetospheric Electrons and Protons: Low Energy	Spare	402 - 40F
	Magnetospheric Electrons and Protons: Low Energy Metadata	410
	Magnetospheric Electrons and Protons: Low Energy Data	411
	Spare	412 - 41F
Magnetospheric Electrons and Protons: Medium and High Energy	Magnetospheric Electrons and Protons: Medium and High Energy Metadata	420
	Magnetospheric Electrons and Protons: Medium and High Energy Data	421
	Spare	422 - 42F
Solar and Galactic Protons	Solar and Galactic Protons Metadata	430
	Solar and Galactic Protons Data	431
	Spare	432 - 44F
	Reserved for GS	450 - 45B
	Spare	45C - 47F
Solar Imagery: EUV	Solar Imagery: EUV Metadata	480 - 485
	Solar Imagery: EUV Data	486 - 48B
	Spare	48C - 4DF
	Reserved for GS	4E0 - 4E5
	Spare	4E6 - 4FF
Geomagnetic Field	Geomagnetic Field Metadata	500
	Geomagnetic Field Data	501
	Spare	502 - 55F
	Reserved for GS	560 - 562
	Spare	563 - 57F
GRB Information	GRB Information	580
	Spare	581 - 5FF
Radiances	Spare	600 - 6BF
	Radiances Block-Level Metadata (Mode 6)	6C0 - 6FF
	Radiances Block-Level Metadata (Modes 3 and 4)	700 - 74F
	Spare	750 -7DB
	Reserved for GS	7DC - 7E5
	Spare	7E6 - 7F7
Reserved	Reserved by CCSDS Standard	7F8 - 7FE
Reserved	Reserved for GS (active fill)	7FF

Tables in the subordinate paragraphs provide detailed APID information for the different types of products available in the GRB.

A.1 Radiances Product APIDs

Table A.1-1 GRB Application Identifier (APID) Details – Radiances

APID (Hex)	GRB APID Summary Name	Band
80	Full Disk Metadata (Mode 6)	1
81	Full Disk Metadata (Mode 6)	2
82	Full Disk Metadata (Mode 6)	3
83	Full Disk Metadata (Mode 6)	4
84	Full Disk Metadata (Mode 6)	5
85	Full Disk Metadata (Mode 6)	6
86	Full Disk Metadata (Mode 6)	7
87	Full Disk Metadata (Mode 6)	8
88	Full Disk Metadata (Mode 6)	9

APID (Hex)	GRB APID Summary Name	Band
89	Full Disk Metadata (Mode 6)	10
8A	Full Disk Metadata (Mode 6)	11
8B	Full Disk Metadata (Mode 6)	12
8C	Full Disk Metadata (Mode 6)	13
8D	Full Disk Metadata (Mode 6)	14
8E	Full Disk Metadata (Mode 6)	15
8F	Full Disk Metadata (Mode 6)	16
90	Full Disk Radiance Image Data (Mode 6)	1
91	Full Disk Radiance Image Data (Mode 6)	2
92	Full Disk Radiance Image Data (Mode 6)	3
93	Full Disk Radiance Image Data (Mode 6)	4
94	Full Disk Radiance Image Data (Mode 6)	5
95	Full Disk Radiance Image Data (Mode 6)	6
96	Full Disk Radiance Image Data (Mode 6)	7
97	Full Disk Radiance Image Data (Mode 6)	8
98	Full Disk Radiance Image Data (Mode 6)	9
99	Full Disk Radiance Image Data (Mode 6)	10
9A	Full Disk Radiance Image Data (Mode 6)	11
9B	Full Disk Radiance Image Data (Mode 6)	12
9C	Full Disk Radiance Image Data (Mode 6)	13
9D	Full Disk Radiance Image Data (Mode 6)	14
9E	Full Disk Radiance Image Data (Mode 6)	15
9F	Full Disk Radiance Image Data (Mode 6)	16
A0	Continental United States Metadata (Mode 6)	1
A1	Continental United States Metadata (Mode 6)	2
A2	Continental United States Metadata (Mode 6)	3
A3	Continental United States Metadata (Mode 6)	4
A4	Continental United States Metadata (Mode 6)	5
A5	Continental United States Metadata (Mode 6)	6
A6	Continental United States Metadata (Mode 6)	7
A7	Continental United States Metadata (Mode 6)	8
A8	Continental United States Metadata (Mode 6)	9
A9	Continental United States Metadata (Mode 6)	10
AA	Continental United States Metadata (Mode 6)	11
AB	Continental United States Metadata (Mode 6)	12
AC	Continental United States Metadata (Mode 6)	13
AD	Continental United States Metadata (Mode 6)	14
AE	Continental United States Metadata (Mode 6)	15
AF	Continental United States Metadata (Mode 6)	16
B0	Continental United States Radiance Image (Mode 6)	1
B1	Continental United States Radiance Image (Mode 6)	2
B2	Continental United States Radiance Image (Mode 6)	3
B3	Continental United States Radiance Image (Mode 6)	4
B4	Continental United States Radiance Image (Mode 6)	5
B5	Continental United States Radiance Image (Mode 6)	6
B6	Continental United States Radiance Image (Mode 6)	7
B7	Continental United States Radiance Image (Mode 6)	8
B8	Continental United States Radiance Image (Mode 6)	9
B9	Continental United States Radiance Image (Mode 6)	10

APID (Hex)	GRB APID Summary Name	Band
BA	Continental United States Radiance Image (Mode 6)	11
BB	Continental United States Radiance Image (Mode 6)	12
BC	Continental United States Radiance Image (Mode 6)	13
BD	Continental United States Radiance Image (Mode 6)	14
BE	Continental United States Radiance Image (Mode 6)	15
BF	Continental United States Radiance Image (Mode 6)	16
C0	Mesoscale #1 Metadata (Mode 6)	1
C1	Mesoscale #1 Metadata (Mode 6)	2
C2	Mesoscale #1 Metadata (Mode 6)	3
C3	Mesoscale #1 Metadata (Mode 6)	4
C4	Mesoscale #1 Metadata (Mode 6)	5
C5	Mesoscale #1 Metadata (Mode 6)	6
C6	Mesoscale #1 Metadata (Mode 6)	7
C7	Mesoscale #1 Metadata (Mode 6)	8
C8	Mesoscale #1 Metadata (Mode 6)	9
C9	Mesoscale #1 Metadata (Mode 6)	10
CA	Mesoscale #1 Metadata (Mode 6)	11
CB	Mesoscale #1 Metadata (Mode 6)	12
CC	Mesoscale #1 Metadata (Mode 6)	13
CD	Mesoscale #1 Metadata (Mode 6)	14
CE	Mesoscale #1 Metadata (Mode 6)	15
CF	Mesoscale #1 Metadata (Mode 6)	16
D0	Mesoscale #1 Radiance Image (Mode 6)	1
D1	Mesoscale #1 Radiance Image (Mode 6)	2
D2	Mesoscale #1 Radiance Image (Mode 6)	3
D3	Mesoscale #1 Radiance Image (Mode 6)	4
D4	Mesoscale #1 Radiance Image (Mode 6)	5
D5	Mesoscale #1 Radiance Image (Mode 6)	6
D6	Mesoscale #1 Radiance Image (Mode 6)	7
D7	Mesoscale #1 Radiance Image (Mode 6)	8
D8	Mesoscale #1 Radiance Image (Mode 6)	9
D9	Mesoscale #1 Radiance Image (Mode 6)	10
DA	Mesoscale #1 Radiance Image (Mode 6)	11
DB	Mesoscale #1 Radiance Image (Mode 6)	12
DC	Mesoscale #1 Radiance Image (Mode 6)	13
DD	Mesoscale #1 Radiance Image (Mode 6)	14
DE	Mesoscale #1 Radiance Image (Mode 6)	15
DF	Mesoscale #1 Radiance Image (Mode 6)	16
E0	Mesoscale #2 Metadata (Mode 6)	1
E1	Mesoscale #2 Metadata (Mode 6)	2
E2	Mesoscale #2 Metadata (Mode 6)	3
E3	Mesoscale #2 Metadata (Mode 6)	4
E4	Mesoscale #2 Metadata (Mode 6)	5
E5	Mesoscale #2 Metadata (Mode 6)	6
E6	Mesoscale #2 Metadata (Mode 6)	7
E7	Mesoscale #2 Metadata (Mode 6)	8
E8	Mesoscale #2 Metadata (Mode 6)	9
E9	Mesoscale #2 Metadata (Mode 6)	10
EA	Mesoscale #2 Metadata (Mode 6)	11

APID (Hex)	GRB APID Summary Name	Band
EB	Mesoscale #2 Metadata (Mode 6)	12
EC	Mesoscale #2 Metadata (Mode 6)	13
ED	Mesoscale #2 Metadata (Mode 6)	14
EE	Mesoscale #2 Metadata (Mode 6)	15
EF	Mesoscale #2 Metadata (Mode 6)	16
F0	Mesoscale #2 Radiance Image (Mode 6)	1
F1	Mesoscale #2 Radiance Image (Mode 6)	2
F2	Mesoscale #2 Radiance Image (Mode 6)	3
F3	Mesoscale #2 Radiance Image (Mode 6)	4
F4	Mesoscale #2 Radiance Image (Mode 6)	5
F5	Mesoscale #2 Radiance Image (Mode 6)	6
F6	Mesoscale #2 Radiance Image (Mode 6)	7
F7	Mesoscale #2 Radiance Image (Mode 6)	8
F8	Mesoscale #2 Radiance Image (Mode 6)	9
F9	Mesoscale #2 Radiance Image (Mode 6)	10
FA	Mesoscale #2 Radiance Image (Mode 6)	11
FB	Mesoscale #2 Radiance Image (Mode 6)	12
FC	Mesoscale #2 Radiance Image (Mode 6)	13
FD	Mesoscale #2 Radiance Image (Mode 6)	14
FE	Mesoscale #2 Radiance Image (Mode 6)	15
FF	Mesoscale #2 Radiance Image (Mode 6)	16
100	Full Disk Metadata (Mode 3)	1
101	Full Disk Metadata (Mode 3)	2
102	Full Disk Metadata (Mode 3)	3
103	Full Disk Metadata (Mode 3)	4
104	Full Disk Metadata (Mode 3)	5
105	Full Disk Metadata (Mode 3)	6
106	Full Disk Metadata (Mode 3)	7
107	Full Disk Metadata (Mode 3)	8
108	Full Disk Metadata (Mode 3)	9
109	Full Disk Metadata (Mode 3)	10
10A	Full Disk Metadata (Mode 3)	11
10B	Full Disk Metadata (Mode 3)	12
10C	Full Disk Metadata (Mode 3)	13
10D	Full Disk Metadata (Mode 3)	14
10E	Full Disk Metadata (Mode 3)	15
10F	Full Disk Metadata (Mode 3)	16
110	Full Disk Radiance Image Data (Mode 3)	1
111	Full Disk Radiance Image Data (Mode 3)	2
112	Full Disk Radiance Image Data (Mode 3)	3
113	Full Disk Radiance Image Data (Mode 3)	4
114	Full Disk Radiance Image Data (Mode 3)	5
115	Full Disk Radiance Image Data (Mode 3)	6
116	Full Disk Radiance Image Data (Mode 3)	7
117	Full Disk Radiance Image Data (Mode 3)	8
118	Full Disk Radiance Image Data (Mode 3)	9
119	Full Disk Radiance Image Data (Mode 3)	10
11A	Full Disk Radiance Image Data (Mode 3)	11
11B	Full Disk Radiance Image Data (Mode 3)	12

APID (Hex)	GRB APID Summary Name	Band
11C	Full Disk Radiance Image Data (Mode 3)	13
11D	Full Disk Radiance Image Data (Mode 3)	14
11E	Full Disk Radiance Image Data (Mode 3)	15
11F	Full Disk Radiance Image Data (Mode 3)	16
120	Continental United States Metadata (Mode 3)	1
121	Continental United States Metadata (Mode 3)	2
122	Continental United States Metadata (Mode 3)	3
123	Continental United States Metadata (Mode 3)	4
124	Continental United States Metadata (Mode 3)	5
125	Continental United States Metadata (Mode 3)	6
126	Continental United States Metadata (Mode 3)	7
127	Continental United States Metadata (Mode 3)	8
128	Continental United States Metadata (Mode 3)	9
129	Continental United States Metadata (Mode 3)	10
12A	Continental United States Metadata (Mode 3)	11
12B	Continental United States Metadata (Mode 3)	12
12C	Continental United States Metadata (Mode 3)	13
12D	Continental United States Metadata (Mode 3)	14
12E	Continental United States Metadata (Mode 3)	15
12F	Continental United States Metadata (Mode 3)	16
130	Continental United States Radiance Image (Mode 3)	1
131	Continental United States Radiance Image (Mode 3)	2
132	Continental United States Radiance Image (Mode 3)	3
133	Continental United States Radiance Image (Mode 3)	4
134	Continental United States Radiance Image (Mode 3)	5
135	Continental United States Radiance Image (Mode 3)	6
136	Continental United States Radiance Image (Mode 3)	7
137	Continental United States Radiance Image (Mode 3)	8
138	Continental United States Radiance Image (Mode 3)	9
139	Continental United States Radiance Image (Mode 3)	10
13A	Continental United States Radiance Image (Mode 3)	11
13B	Continental United States Radiance Image (Mode 3)	12
13C	Continental United States Radiance Image (Mode 3)	13
13D	Continental United States Radiance Image (Mode 3)	14
13E	Continental United States Radiance Image (Mode 3)	15
13F	Continental United States Radiance Image (Mode 3)	16
140	Mesoscale #1 Metadata (Mode 3)	1
141	Mesoscale #1 Metadata (Mode 3)	2
142	Mesoscale #1 Metadata (Mode 3)	3
143	Mesoscale #1 Metadata (Mode 3)	4
144	Mesoscale #1 Metadata (Mode 3)	5
145	Mesoscale #1 Metadata (Mode 3)	6
146	Mesoscale #1 Metadata (Mode 3)	7
147	Mesoscale #1 Metadata (Mode 3)	8
148	Mesoscale #1 Metadata (Mode 3)	9
149	Mesoscale #1 Metadata (Mode 3)	10
14A	Mesoscale #1 Metadata (Mode 3)	11
14B	Mesoscale #1 Metadata (Mode 3)	12
14C	Mesoscale #1 Metadata (Mode 3)	13

APID (Hex)	GRB APID Summary Name	Band
14D	Mesoscale #1 Metadata (Mode 3)	14
14E	Mesoscale #1 Metadata (Mode 3)	15
14F	Mesoscale #1 Metadata (Mode 3)	16
150	Mesoscale #1 Radiance Image (Mode 3)	1
151	Mesoscale #1 Radiance Image (Mode 3)	2
152	Mesoscale #1 Radiance Image (Mode 3)	3
153	Mesoscale #1 Radiance Image (Mode 3)	4
154	Mesoscale #1 Radiance Image (Mode 3)	5
155	Mesoscale #1 Radiance Image (Mode 3)	6
156	Mesoscale #1 Radiance Image (Mode 3)	7
157	Mesoscale #1 Radiance Image (Mode 3)	8
158	Mesoscale #1 Radiance Image (Mode 3)	9
159	Mesoscale #1 Radiance Image (Mode 3)	10
15A	Mesoscale #1 Radiance Image (Mode 3)	11
15B	Mesoscale #1 Radiance Image (Mode 3)	12
15C	Mesoscale #1 Radiance Image (Mode 3)	13
15D	Mesoscale #1 Radiance Image (Mode 3)	14
15E	Mesoscale #1 Radiance Image (Mode 3)	15
15F	Mesoscale #1 Radiance Image (Mode 3)	16
160	Mesoscale #2 Metadata (Mode 3)	1
161	Mesoscale #2 Metadata (Mode 3)	2
162	Mesoscale #2 Metadata (Mode 3)	3
163	Mesoscale #2 Metadata (Mode 3)	4
164	Mesoscale #2 Metadata (Mode 3)	5
165	Mesoscale #2 Metadata (Mode 3)	6
166	Mesoscale #2 Metadata (Mode 3)	7
167	Mesoscale #2 Metadata (Mode 3)	8
168	Mesoscale #2 Metadata (Mode 3)	9
169	Mesoscale #2 Metadata (Mode 3)	10
16A	Mesoscale #2 Metadata (Mode 3)	11
16B	Mesoscale #2 Metadata (Mode 3)	12
16C	Mesoscale #2 Metadata (Mode 3)	13
16D	Mesoscale #2 Metadata (Mode 3)	14
16E	Mesoscale #2 Metadata (Mode 3)	15
16F	Mesoscale #2 Metadata (Mode 3)	16
170	Mesoscale #2 Radiance Image (Mode 3)	1
171	Mesoscale #2 Radiance Image (Mode 3)	2
172	Mesoscale #2 Radiance Image (Mode 3)	3
173	Mesoscale #2 Radiance Image (Mode 3)	4
174	Mesoscale #2 Radiance Image (Mode 3)	5
175	Mesoscale #2 Radiance Image (Mode 3)	6
176	Mesoscale #2 Radiance Image (Mode 3)	7
177	Mesoscale #2 Radiance Image (Mode 3)	8
178	Mesoscale #2 Radiance Image (Mode 3)	9
179	Mesoscale #2 Radiance Image (Mode 3)	10
17A	Mesoscale #2 Radiance Image (Mode 3)	11
17B	Mesoscale #2 Radiance Image (Mode 3)	12
17C	Mesoscale #2 Radiance Image (Mode 3)	13
17D	Mesoscale #2 Radiance Image (Mode 3)	14

APID (Hex)	GRB APID Summary Name	Band
17E	Mesoscale #2 Radiance Image (Mode 3)	15
17F	Mesoscale #2 Radiance Image (Mode 3)	16
180	Full Disk Metadata (Mode 4)	1
181	Full Disk Metadata (Mode 4)	2
182	Full Disk Metadata (Mode 4)	3
183	Full Disk Metadata (Mode 4)	4
184	Full Disk Metadata (Mode 4)	5
185	Full Disk Metadata (Mode 4)	6
186	Full Disk Metadata (Mode 4)	7
187	Full Disk Metadata (Mode 4)	8
188	Full Disk Metadata (Mode 4)	9
189	Full Disk Metadata (Mode 4)	10
18A	Full Disk Metadata (Mode 4)	11
18B	Full Disk Metadata (Mode 4)	12
18C	Full Disk Metadata (Mode 4)	13
18D	Full Disk Metadata (Mode 4)	14
18E	Full Disk Metadata (Mode 4)	15
18F	Full Disk Metadata (Mode 4)	16
190	Full Disk Radiance Image Data (Mode 4)	1
191	Full Disk Radiance Image Data (Mode 4)	2
192	Full Disk Radiance Image Data (Mode 4)	3
193	Full Disk Radiance Image Data (Mode 4)	4
194	Full Disk Radiance Image Data (Mode 4)	5
195	Full Disk Radiance Image Data (Mode 4)	6
196	Full Disk Radiance Image Data (Mode 4)	7
197	Full Disk Radiance Image Data (Mode 4)	8
198	Full Disk Radiance Image Data (Mode 4)	9
199	Full Disk Radiance Image Data (Mode 4)	10
19A	Full Disk Radiance Image Data (Mode 4)	11
19B	Full Disk Radiance Image Data (Mode 4)	12
19C	Full Disk Radiance Image Data (Mode 4)	13
19D	Full Disk Radiance Image Data (Mode 4)	14
19E	Full Disk Radiance Image Data (Mode 4)	15
19F	Full Disk Radiance Image Data (Mode 4)	16
1A0	Continental United States Metadata (Extracted from Full Disk Mode 4)	1
1A1	Continental United States Metadata (Extracted from Full Disk Mode 4)	2
1A2	Continental United States Metadata (Extracted from Full Disk Mode 4)	3
1A3	Continental United States Metadata (Extracted from Full Disk Mode 4)	4
1A4	Continental United States Metadata (Extracted from Full Disk Mode 4)	5
1A5	Continental United States Metadata (Extracted from Full Disk Mode 4)	6
1A6	Continental United States Metadata (Extracted from Full Disk Mode 4)	7
1A7	Continental United States Metadata (Extracted from Full Disk Mode 4)	8
1A8	Continental United States Metadata (Extracted from Full Disk Mode 4)	9
1A9	Continental United States Metadata (Extracted from Full Disk Mode 4)	10
1AA	Continental United States Metadata (Extracted from Full Disk Mode 4)	11
1AB	Continental United States Metadata (Extracted from Full Disk Mode 4)	12
1AC	Continental United States Metadata (Extracted from Full Disk Mode 4)	13
1AD	Continental United States Metadata (Extracted from Full Disk Mode 4)	14
1AE	Continental United States Metadata (Extracted from Full Disk Mode 4)	15

APID (Hex)	GRB APID Summary Name	Band
1AF	Continental United States Metadata (Extracted from Full Disk Mode 4)	16

Table A.1-2 GRB Application Identifier (APID) Details – Radiances Block-Level Metadata

APID (Hex)	GRB APID Summary Name	Band
6C0	Full Disk Block-Level Metadata (Mode 6)	1
6C1	Continental United States Block-Level Metadata (Mode 6)	1
6C2	Mesoscale #1 Block-Level Metadata (Mode 6)	1
6C3	Mesoscale #2 Block-Level Metadata (Mode 6)	1
6C4	Full Disk Block-Level Metadata (Mode 6)	2
6C5	Continental United States Block-Level Metadata (Mode 6)	2
6C6	Mesoscale #1 Block-Level Metadata (Mode 6)	2
6C7	Mesoscale #2 Block-Level Metadata (Mode 6)	2
6C8	Full Disk Block-Level Metadata (Mode 6)	3
6C9	Continental United States Block-Level Metadata (Mode 6)	3
6CA	Mesoscale #1 Block-Level Metadata (Mode 6)	3
6CB	Mesoscale #2 Block-Level Metadata (Mode 6)	3
6CC	Full Disk Block-Level Metadata (Mode 6)	4
6CD	Continental United States Block-Level Metadata (Mode 6)	4
6CE	Mesoscale #1 Block-Level Metadata (Mode 6)	4
6CF	Mesoscale #2 Block-Level Metadata (Mode 6)	4
6D0	Full Disk Block-Level Metadata (Mode 6)	5
6D1	Continental United States Block-Level Metadata (Mode 6)	5
6D2	Mesoscale #1 Block-Level Metadata (Mode 6)	5
6D3	Mesoscale #2 Block-Level Metadata (Mode 6)	5
6D4	Full Disk Block-Level Metadata (Mode 6)	6
6D5	Continental United States Block-Level Metadata (Mode 6)	6
6D6	Mesoscale #1 Block-Level Metadata (Mode 6)	6
6D7	Mesoscale #2 Block-Level Metadata (Mode 6)	6
6D8	Full Disk Block-Level Metadata (Mode 6)	7
6D9	Continental United States Block-Level Metadata (Mode 6)	7
6DA	Mesoscale #1 Block-Level Metadata (Mode 6)	7
6DB	Mesoscale #2 Block-Level Metadata (Mode 6)	7
6DC	Full Disk Block-Level Metadata (Mode 6)	8
6DD	Continental United States Block-Level Metadata (Mode 6)	8
6DE	Mesoscale #1 Block-Level Metadata (Mode 6)	8
6DF	Mesoscale #2 Block-Level Metadata (Mode 6)	8
6E0	Full Disk Block-Level Metadata (Mode 6)	9
6E1	Continental United States Block-Level Metadata (Mode 6)	9
6E2	Mesoscale #1 Block-Level Metadata (Mode 6)	9
6E3	Mesoscale #2 Block-Level Metadata (Mode 6)	9
6E4	Full Disk Block-Level Metadata (Mode 6)	10
6E5	Continental United States Block-Level Metadata (Mode 6)	10
6E6	Mesoscale #1 Block-Level Metadata (Mode 6)	10
6E7	Mesoscale #2 Block-Level Metadata (Mode 6)	10
6E8	Full Disk Block-Level Metadata (Mode 6)	11

APID (Hex)	GRB APID Summary Name	Band
6E9	Continental United States Block-Level Metadata (Mode 6)	11
6EA	Mesoscale #1 Block-Level Metadata (Mode 6)	11
6EB	Mesoscale #2 Block-Level Metadata (Mode 6)	11
6EC	Full Disk Block-Level Metadata (Mode 6)	12
6ED	Continental United States Block-Level Metadata (Mode 6)	12
6EE	Mesoscale #1 Block-Level Metadata (Mode 6)	12
6EF	Mesoscale #2 Block-Level Metadata (Mode 6)	12
6F0	Full Disk Block-Level Metadata (Mode 6)	13
6F1	Continental United States Block-Level Metadata (Mode 6)	13
6F2	Mesoscale #1 Block-Level Metadata (Mode 6)	13
6F3	Mesoscale #2 Block-Level Metadata (Mode 6)	13
6F4	Full Disk Block-Level Metadata (Mode 6)	14
6F5	Continental United States Block-Level Metadata (Mode 6)	14
6F6	Mesoscale #1 Block-Level Metadata (Mode 6)	14
6F7	Mesoscale #2 Block-Level Metadata (Mode 6)	14
6F8	Full Disk Block-Level Metadata (Mode 6)	15
6F9	Continental United States Block-Level Metadata (Mode 6)	15
6FA	Mesoscale #1 Block-Level Metadata (Mode 6)	15
6FB	Mesoscale #2 Block-Level Metadata (Mode 6)	15
6FC	Full Disk Block-Level Metadata (Mode 6)	16
6FD	Continental United States Block-Level Metadata (Mode 6)	16
6FE	Mesoscale #1 Block-Level Metadata (Mode 6)	16
6FF	Mesoscale #2 Block-Level Metadata (Mode 6)	16
700	Full Disk Block-Level Metadata (Mode 4)	1
701	Full Disk Block-Level Metadata (Mode 3)	1
702	Continental United States Block-Level Metadata (Mode 3)	1
703	Mesoscale #1 Block-Level Metadata (Mode 3)	1
704	Mesoscale #2 Block-Level Metadata (Mode 3)	1
705	Full Disk Block-Level Metadata (Mode 4)	2
706	Full Disk Block-Level Metadata (Mode 3)	2
707	Continental United States Block-Level Metadata (Mode 3)	2
708	Mesoscale #1 Block-Level Metadata (Mode 3)	2
709	Mesoscale #2 Block-Level Metadata (Mode 3)	2
70A	Full Disk Block-Level Metadata (Mode 4)	3
70B	Full Disk Block-Level Metadata (Mode 3)	3
70C	Continental United States Block-Level Metadata (Mode 3)	3
70D	Mesoscale #1 Block-Level Metadata (Mode 3)	3
70E	Mesoscale #2 Block-Level Metadata (Mode 3)	3
70F	Full Disk Block-Level Metadata (Mode 4)	4
710	Full Disk Block-Level Metadata (Mode 3)	4
711	Continental United States Block-Level Metadata (Mode 3)	4
712	Mesoscale #1 Block-Level Metadata (Mode 3)	4
713	Mesoscale #2 Block-Level Metadata (Mode 3)	4
714	Full Disk Block-Level Metadata (Mode 4)	5
715	Full Disk Block-Level Metadata (Mode 3)	5
716	Continental United States Block-Level Metadata (Mode 3)	5
717	Mesoscale #1 Block-Level Metadata (Mode 3)	5
718	Mesoscale #2 Block-Level Metadata (Mode 3)	5
719	Full Disk Block-Level Metadata (Mode 4)	6

APID (Hex)	GRB APID Summary Name	Band
71A	Full Disk Block-Level Metadata (Mode 3)	6
71B	Continental United States Block-Level Metadata (Mode 3)	6
71C	Mesoscale #1 Block-Level Metadata (Mode 3)	6
71D	Mesoscale #2 Block-Level Metadata (Mode 3)	6
71E	Full Disk Block-Level Metadata (Mode 4)	7
71F	Full Disk Block-Level Metadata (Mode 3)	7
720	Continental United States Block-Level Metadata (Mode 3)	7
721	Mesoscale #1 Block-Level Metadata (Mode 3)	7
722	Mesoscale #2 Block-Level Metadata (Mode 3)	7
723	Full Disk Block-Level Metadata (Mode 4)	8
724	Full Disk Block-Level Metadata (Mode 3)	8
725	Continental United States Block-Level Metadata (Mode 3)	8
726	Mesoscale #1 Block-Level Metadata (Mode 3)	8
727	Mesoscale #2 Block-Level Metadata (Mode 3)	8
728	Full Disk Block-Level Metadata (Mode 4)	9
729	Full Disk Block-Level Metadata (Mode 3)	9
72A	Continental United States Block-Level Metadata (Mode 3)	9
72B	Mesoscale #1 Block-Level Metadata (Mode 3)	9
72C	Mesoscale #2 Block-Level Metadata (Mode 3)	9
72D	Full Disk Block-Level Metadata (Mode 4)	10
72E	Full Disk Block-Level Metadata (Mode 3)	10
72F	Continental United States Block-Level Metadata (Mode 3)	10
730	Mesoscale #1 Block-Level Metadata (Mode 3)	10
731	Mesoscale #2 Block-Level Metadata (Mode 3)	10
732	Full Disk Block-Level Metadata (Mode 4)	11
733	Full Disk Block-Level Metadata (Mode 3)	11
734	Continental United States Block-Level Metadata (Mode 3)	11
735	Mesoscale #1 Block-Level Metadata (Mode 3)	11
736	Mesoscale #2 Block-Level Metadata (Mode 3)	11
737	Full Disk Block-Level Metadata (Mode 4)	12
738	Full Disk Block-Level Metadata (Mode 3)	12
739	Continental United States Block-Level Metadata (Mode 3)	12
73A	Mesoscale #1 Block-Level Metadata (Mode 3)	12
73B	Mesoscale #2 Block-Level Metadata (Mode 3)	12
73C	Full Disk Block-Level Metadata (Mode 4)	13
73D	Full Disk Block-Level Metadata (Mode 3)	13
73E	Continental United States Block-Level Metadata (Mode 3)	13
73F	Mesoscale #1 Block-Level Metadata (Mode 3)	13
740	Mesoscale #2 Block-Level Metadata (Mode 3)	13
741	Full Disk Block-Level Metadata (Mode 4)	14
742	Full Disk Block-Level Metadata (Mode 3)	14
743	Continental United States Block-Level Metadata (Mode 3)	14
744	Mesoscale #1 Block-Level Metadata (Mode 3)	14
745	Mesoscale #2 Block-Level Metadata (Mode 3)	14
746	Full Disk Block-Level Metadata (Mode 4)	15
747	Full Disk Block-Level Metadata (Mode 3)	15
748	Continental United States Block-Level Metadata (Mode 3)	15
749	Mesoscale #1 Block-Level Metadata (Mode 3)	15
74A	Mesoscale #2 Block-Level Metadata (Mode 3)	15

APID (Hex)	GRB APID Summary Name	Band
74B	Full Disk Block-Level Metadata (Mode 4)	16
74C	Full Disk Block-Level Metadata (Mode 3)	16
74D	Continental United States Block-Level Metadata (Mode 3)	16
74E	Mesoscale #1 Block-Level Metadata (Mode 3)	16
74F	Mesoscale #2 Block-Level Metadata (Mode 3)	16

A.2 Lightning Detection Product APIDs

Table A.2 GRB Application Identifier (APID) Details – Lightning Detection

APID (Hex)	GRB APID Summary Name
300	Lightning Detection Metadata
301	Event Data
302	Flash Data
303	Group Data

A.3 Solar Flux: EUV and Solar Flux: X-Ray APIDs

Table A.3 GRB Application Identifier (APID) Details – Solar Flux: EUV, Solar Flux: X-Ray

APID (Hex)	GRB APID Summary Name
380	Solar Flux: EUV Metadata
381	Solar Flux: EUV Data
382	Solar Flux: X-Ray Metadata
383	Solar Flux: X-Ray Data

A.4 Energetic Heavy Ions, Magnetospheric Electrons and Protons: Low Energy, Magnetospheric Electrons and Protons: Medium and High Energy, and Solar and Galactic Protons APIDs

Table A.4 GRB Application Identifier (APID) Details – Energetic Heavy Ions, Magnetospheric Electrons and Protons: Low Energy, Magnetospheric Electrons and Protons: Medium and High Energy, and Solar and Galactic Protons

APID (Hex)	GRB APID Summary Name
400	Energetic Heavy Ions Metadata
401	Energetic Heavy Ions Data
410	Magnetospheric Electrons and Protons: Low Energy Metadata
411	Magnetospheric Electrons and Protons: Low Energy Data
420	Magnetospheric Electrons and Protons: Medium and High Energy Metadata
421	Magnetospheric Electrons and Protons: Medium and High Energy Data
430	Solar and Galactic Protons Metadata
431	Solar and Galactic Protons Data

A.5 Solar Imagery: EUV APIDs

Table A.5 GRB Application Identifier (APID) Details – Solar Imagery: EUV

APID (Hex)	GRB APID Summary Name	Band
480	Solar Imagery: EUV Metadata	Fe094
481	Solar Imagery: EUV Metadata	Fe132
482	Solar Imagery: EUV Metadata	Fe171
483	Solar Imagery: EUV Metadata	Fe195
484	Solar Imagery: EUV Metadata	Fe284
485	Solar Imagery: EUV Metadata	He304
486	Solar Imagery: EUV Data	Fe094
487	Solar Imagery: EUV Data	Fe132
488	Solar Imagery: EUV Data	Fe171
489	Solar Imagery: EUV Data	Fe195
48A	Solar Imagery: EUV Data	Fe284
48B	Solar Imagery: EUV Data	He304

A.6 Geomagnetic Field APIDs

Table A.6 GRB Application Identifier (APID) Details – Geomagnetic Field

APID (Hex)	GRB APID Summary Name
500	MAG Metadata
501	MAG Product Data

A.7 GRB Information APID

Table A.7 GRB Application Identifier (APID) Details – GRB Information

APID (Hex)	GRB APID Summary Name
580	GRB INFO File

APPENDIX B PRODUCT REFRESH RATES AND LATENCIES

This appendix contains the refresh rates and latencies associated with products and data in the GRB data stream.

The refresh rate is defined as the time between the completion of the n^{th} update of the product and the completion of the $(n+1)^{th}$ update of the same product for the user.

Vendor Allocated Ground Latency for GRB is defined as the time between the last packet of an observation at the intermediate frequency (IF) conversion and the arrival of the last bit at the input of the GRB uplink to the IF switch at WCDAS or CBU.

Refer to Table B, Product and Data Refresh Rates and Latencies.

Table B Product and Data Refresh Rates and Latencies

		Product Refresh Rate (ABI)			**Product Refresh Rate (other than ABI)**		**Vendor Allocated Ground Latency**
	Level 1b Product / Data	**Mode 3**	**Mode 4**	**Mode 6**	**Product Observations**	**Aggregated Product Metadata** *(note 1)*	
Radiances	Full Disk	15 min	5 min	10 min			*55 sec*
	CONUS	5 min		5 min			55 sec
	Mesoscale	0.5 min		0.5 min			28 sec
	Lightning Detection				sent in 1.024 sec blocks	nominally 20.5 sec	*16 sec*
	Solar Imagery: EUV				10 sec *(note 2)*		54 sec
	Solar Flux: X-Ray				1 sec	30 sec	1.8 sec
	Solar Flux: EUV				30 sec		28 sec
	Energetic Heavy Ions				5 min		267 sec
	Magnetospheric Electrons and Protons: Low Energy				1 sec	30 sec	51 sec
	Magnetospheric Electrons and Protons: Medium & High Energy				1 sec	30 sec	51 sec
	Solar and Galactic Protons				1 sec	60 sec	51 sec
	Geomagnetic Field				1 sec	60 sec	1.8 sec
	GRB Information				5 min		

Note 1: The Lightning Detection, Solar Flux: X-Ray, Magnetospheric Electrons and Protons: Low Energy, Magnetospheric Electrons and Protons: Medium and High Energy, Solar and Galactic Protons, and Geomagnetic Field products have metadata that is aggregated for a set of observations over the immediately preceding time interval.

Note 2: There is a four minute epoch associated with the entire sequence of solar images at different wavelengths and exposure periods. Four to six images are observed in any minute of this epoch. The best case refresh rate is 10 seconds.

The Radiances product latency values presented in this table are minimum performance requirements necessary to achieve end-product refresh rates.

APPENDIX C FILENAME CONVENTIONS

This appendix contains the convention for file names that contain semi-static L1b processing parameter files.

The main volume of the PUG contains a summary level description of the filename conventions used for all GOES-R product and data files. This appendix contains the detailed filename conventions for Level 1b products and data files defined in this volume of the PUG.

As discussed in the main volume of the PUG, filenames consist of a set of string fields delimited by an underscore or a period that are concatenated together. The content and format of several of the filename string fields are common across more than one of the Level 1b product and data filenames. Refer to Table C-1, Common Filename String Fields.

Table C-1 Common Filename String Fields

Common String Field	Description	Values and Meanings
System Environment	Defines whether the file is created by the operational system or a test system. Also defines whether the data in the file is real-time, test, playback, or simulated data.	"OR" = operational system real-time data "OT" = operational system test data "IR" = test system real-time data "IT" = test system test data "IP" = test system playback data "IS" = test system simulated data Note: Real-time data created by the operational system (i.e., "OR") support the operational mission. Default value is "OR".
Platform Identifier	Identifies the applicable GOES-R series satellite.	"G16" = GOES-16 (R) "G17" = GOES-17 (S) Default value is "Gnn"
Version	Version associated with the data file. Composed of a major version & minor revision number.	"v##r##" Notes: ➢ v = major version number: 01-99 ➢ r = minor revision number: 00-Z9

C.1 Level 1b Processing Parameter Filenames

Level 1b processing parameter filenames are assembled using filename string fields as follows:

<System Environment>_<DSN>_<Platform ID>_<Version>.<File Extension>

The string fields other than DSN and file extension are defined above in Table C-1, Common Filename String Fields. The DSN for Level 1b products include the following sub-fields:

- Instrument and processing level
- Processing parameter acronym

The file extension for L1b processing parameter filenames is ".zip".

The L1b processing parameter DSNs are:

- ABI-L1b-PARM
- EXIS-L1b-PARM
- MAG-L1b-PARM

- SEIS-L1b-PARM
- SUVI-L1b-PARM

C.2 Level 2 Processing Parameter Filenames

Level 2 processing parameter filenames are assembled using filename string fields as follows:

<System Environment>_<DSN>_<Platform ID>_<Version>.<File Extension>

The string fields other than DSN and file extension are defined above in Table C-1, Common Filename String Fields. The DSN for Level 2 products include the following sub-fields:

- Instrument and processing level
- Processing parameter acronym

The file extension for L2 processing parameter filenames is ".zip".

The L2 processing parameter DSNs are:

- GLM-L2-PARM