GOES-R AWG Radiation Budget Team: ABI Downward Shortwave Radiation-Surface (DSR) and Reflected Shortwave Radiation –TOA (RSR) Algorithm

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DSR/RSR Team

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Outline

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Executive Summary

- The ABI Shortwave Radiation Budget (SRB) Algorithm generates the Baseline products of Downward Shortwave Radiation at Surface (DSR) and Reflected Shortwave Radiation at TOA (RSR).
- Version 4 was delivered in March. Version 5 and ATBD (100%) is on track for a July and June delivery, respectively.
- A hybrid approach has been developed to either directly calculate or inversely retrieve shortwave radiation depending on the availability of ABI atmosphere and surface retrievals.
- Validation tools have been developed to validate DSR/RSR with ground/TOA shortwave flux measurements.
- Validation with proxy MODIS data shows the performance meets spec.

Algorithm Description

Algorithm Summary

- The ABI shortwave radiation budget algorithm retrieves DSR and RSR using two independent approaches depending on availability of inputs
  - » Direct Path is used when all inputs needed for describing the state of the atmosphere and surface are available from other ABI products
  - » Indirect Path is used otherwise
- In the Direct Path RSR and DSR are calculated from a full description of the atmosphere and surface in a forward RTM represented by a LUT – CERES heritage
- The Indirect Path estimates RSR from narrowband reflectances; DSR is retrieved by estimating the atmospheric transmission and absorption from RSR – GEWEX/SRB and GSIP heritage
- Retrievals are performed for all conditions (clear and cloudy) during daytime

Requirements

Product	Horizontal resolution	Accuracy	Precision	Latency
Downward Shortwave Radiation: Surface (DSR)	CONUS: 25 km Full disk: 50 km Mesoscale: 5 km	• 85 W/m^2 at high end of range (1000 W/m^2) • 65 W/m^2 at typical value / midpoint (350 W/m^2) • 110 W/m^2 at low end of range (100 W/m^2)	• 100 W/m^2 at high end of range (1000 W/m^2) • 130 W/m^2 at typical value / midpoint (350 W/m^2) • 100 W/m^2 at low end of range (100 W/m^2)	60 min
Reflected Shortwave Radiation (RSR)	CONUS, Full disk: 25 km	• 55 W/m^2 at high end of range (>500 W/m^2) • 45 W/m^2 at middle range (200-500 W/m^2) • 25 W/m^2 at low end of range (<200 W/m^2)	• 65 W/m^2 at high end of range (>500 W/m^2) • 65 W/m^2 at middle range (200-500 W/m^2) • 35 W/m^2 at low end of range (<200 W/m^2)	60 min

Qualifiers

- Daytime
- Solar elevation angle > 25 degrees
- Quantitative for Local zenith angle < 70 degrees, qualitative beyond

DSR/RSR Algorithm

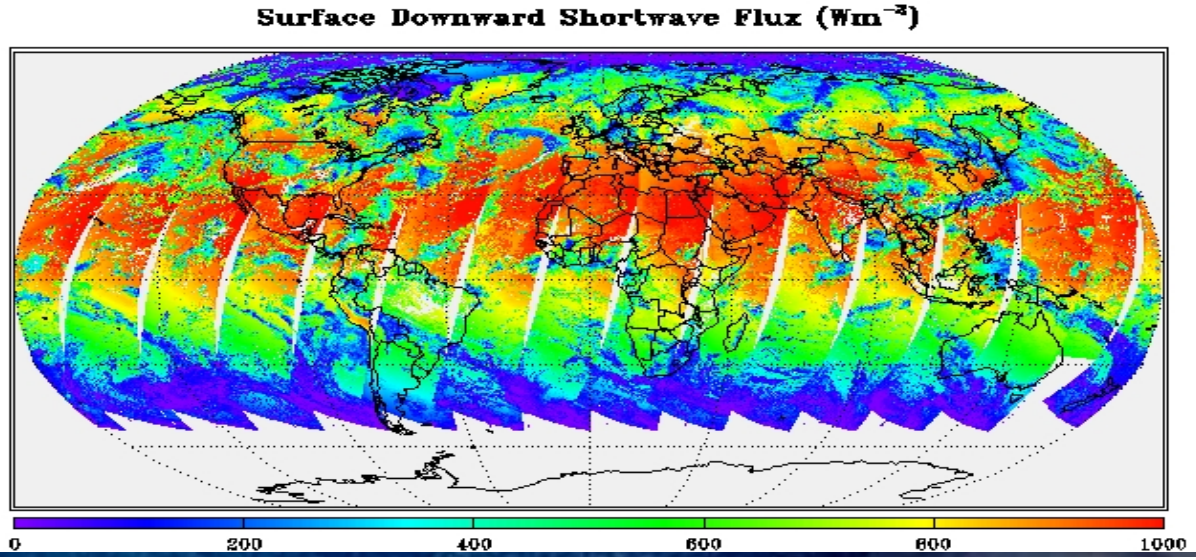
- The SRB algorithm includes direct and indirect retrieval paths:
  - » Direct path estimates DSR and RSR from LUT using inputs of
    - – cloud (fraction, optical depth, effective radius, height, phase)
    - – aerosol (optical depth, model)
    - – total gas amounts (precipitable water and ozone)
    - – surface albedo

    from ABI products directly
  - » Indirect path retrieves DSR and RSR from ABI shortwave reflectances
    - – RSR is obtained by estimating the TOA albedo from narrowband ABI reflectances using narrow-to-broadband conversions and angular distribution models
    - – DSR is obtained by estimating atmospheric transmission and absorption from RSR by matching RSR with like quantities calculated from the LUT

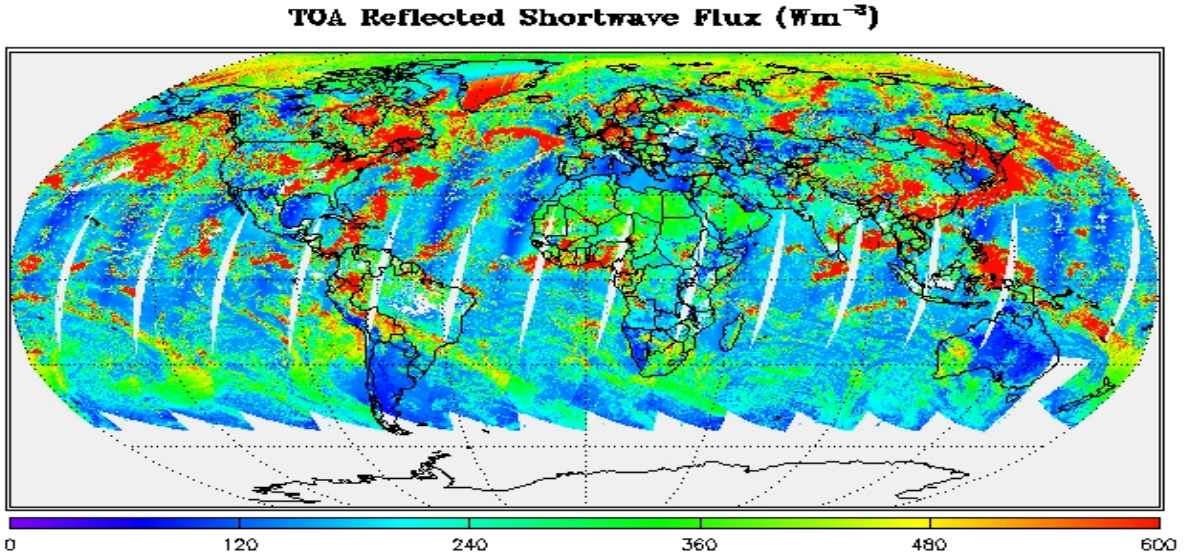
Example Output – MODIS input

DSR

06/11/2009



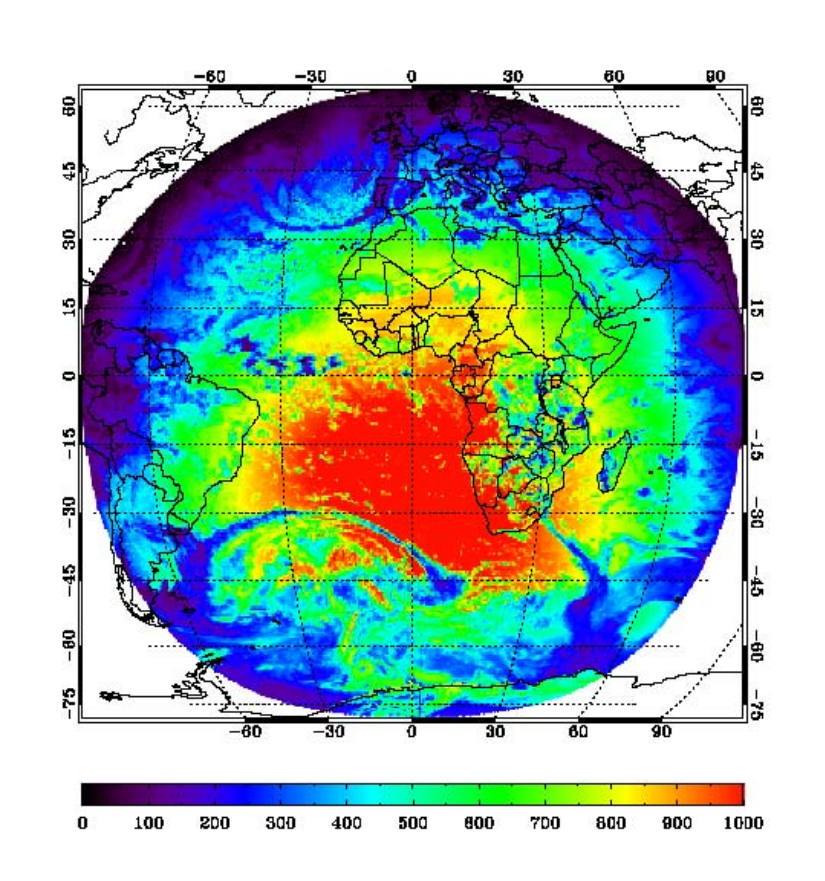
RSR



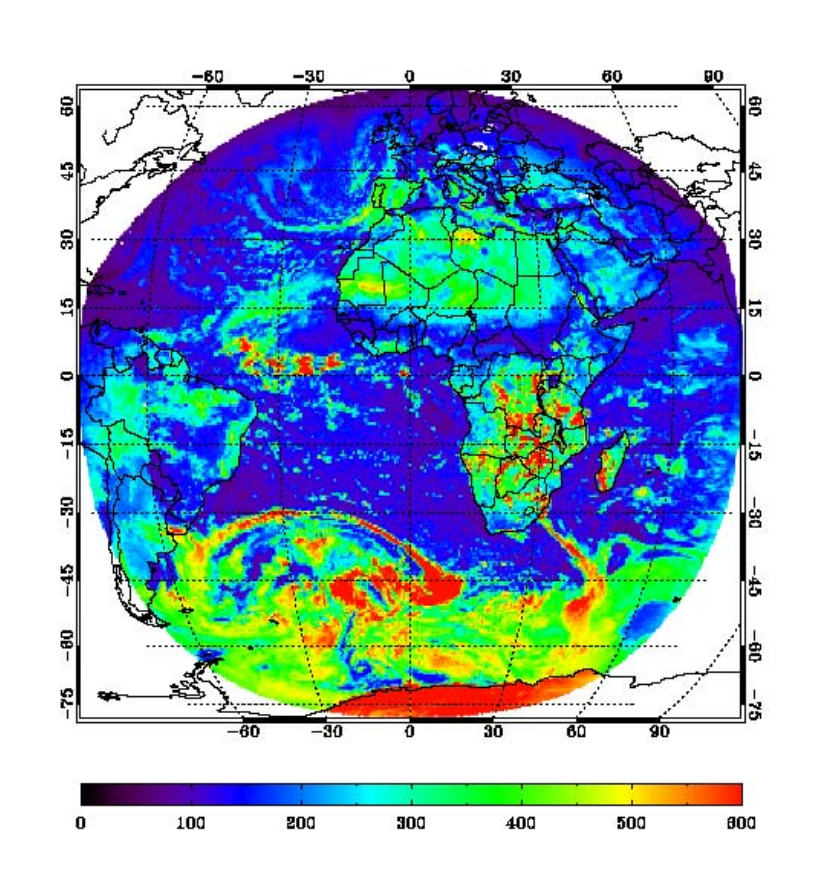
Example Output – SEVIRI input

01/15/2006 12Z

DSR



RSR



Algorithm Changes from 80% to 100%

- Incorporated view angle and azimuth angle dependence in the narrow-to-broadband conversion of TOA reflectance.
- Added a dedicated retrieval path to handle snow/ice scene type, which uses atmospheric transmittance retrieved from snow-free scene or the one corresponding to climatological aerosol optical depth.
- Added detailed quality flags indicating input quality, input sources, and retrieval pathways.

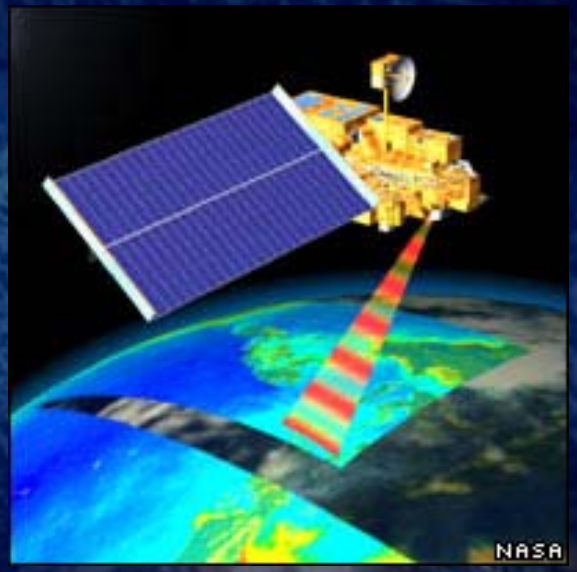
ADEB and IV&V Response Summary

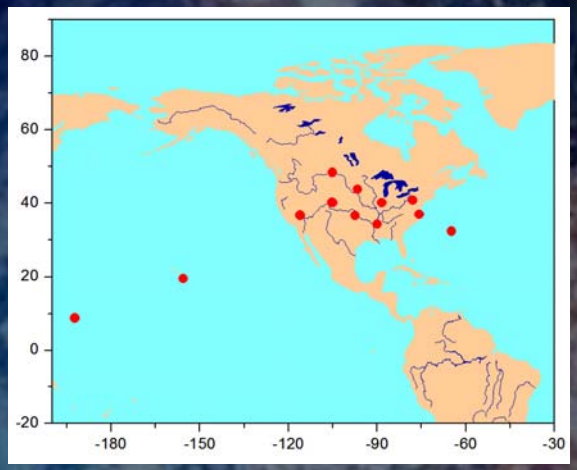
- All ATBD comments and clarification requests have been addressed
  - » added more details to ATBD to easy coding
  - » no need to code RTM for LUT; codes are freely available
  - » performance must be measured by the criteria (accuracy and precision) required by AWG
  - » sensitivity analysis was added to ATBD
  - » added details on generating the clear-composite field
  - » added view and solar zenith angle dependence to NTB
  - » performed analysis of spatial-scale dependence of errors
- No feedback required substantial modifications to the approach

Validation Approach

Validation Strategy

- **Use MODIS reflectances as proxy for ABI and retrieve DSR and RSR**
  - » Over 13 stations:
    - BON, DRA, FPK, GWN, PSU, SXF, TBL (SURFRAD); COV (COVE); E13 (ARM); BER, BOU, KWA, MLO (CMDL)
  - » Time period:
    - 2000.03 – 2009.12 (Terra); 2002.07 – 2009.12 (Aqua)
  - » Algorithm inputs:
    - Geometry and location;
    - Reflectance;
    - Surface elevation;
    - Cloud mask;
    - Cloud optical depth/size/height/phase;
    - Aerosol optical depth;
    - Ozone amount;
    - Total Precipitable Water;
    - Surface albedo
  - » Spatial resolution:
    - 50, 25 and 5 km
- **Appropriate statistics are calculated and compared to F&PS**
  - » bias, precision (and pdf)



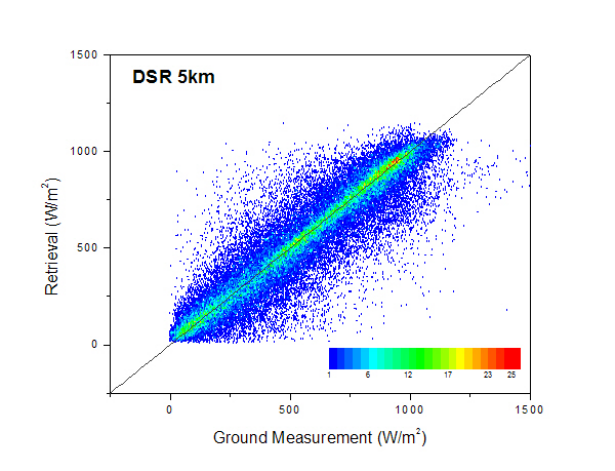


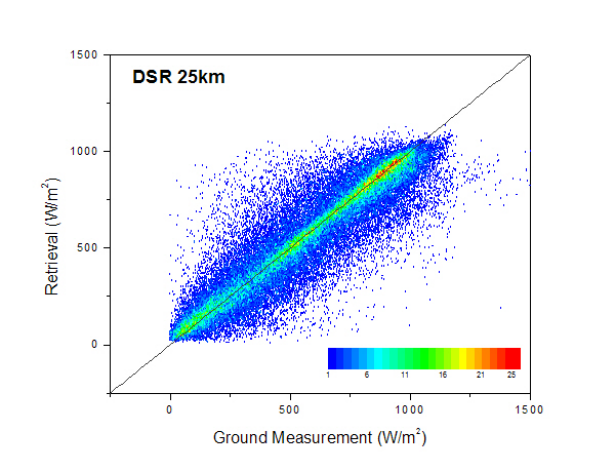
Validation Strategy – Reference Data

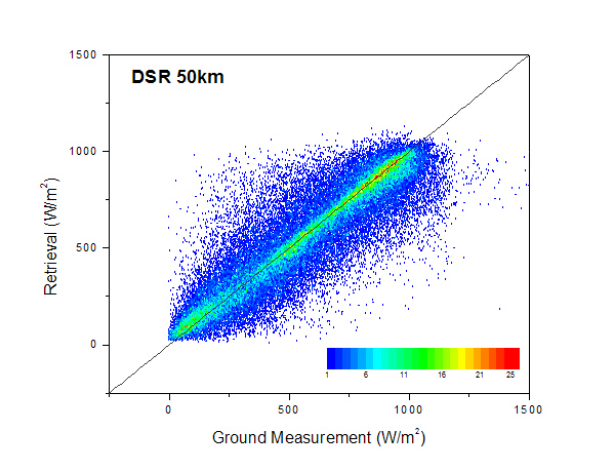
- **Ground measurements:**
  - » From the SURFRAD, COVE, ARM and CMDL networks.
- **TOA measurements:**
  - » CERES TOA broadband shortwave radiance converted to RSR by applying the angular distribution model (ADM)
- **Retrievals are matched up with reference data in space and time**
  - » Ground data are temporally averaged within 15-min window
  - » Spatially closest single CERES footprint (before 2006.06 for Terra and 2005.02 for Aqua)
  - » CERES footprints within an 18km circle centered on the ground stations (after 2006.06 for Terra and 2005.02 for Aqua).

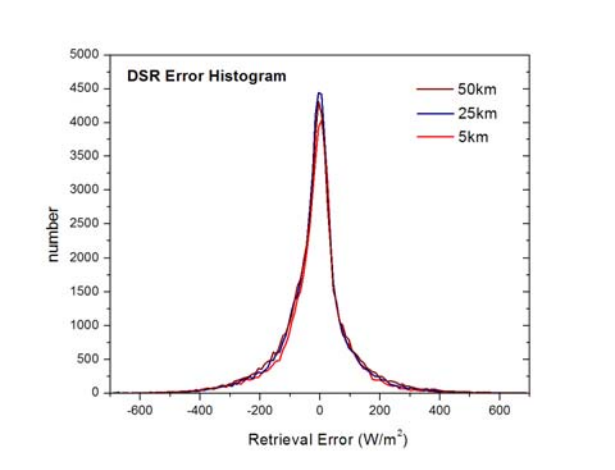
Validation Results

Offline Validation - DSR









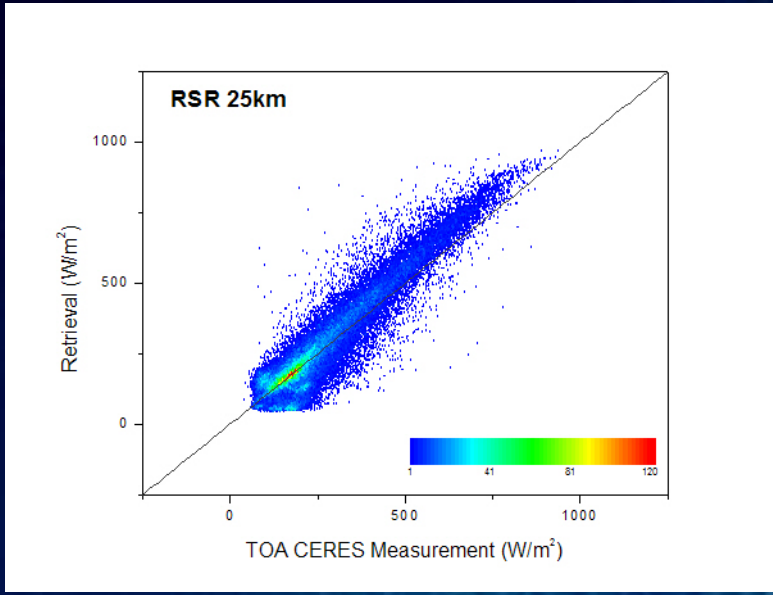
Based on 10 years of data over 13 sites:

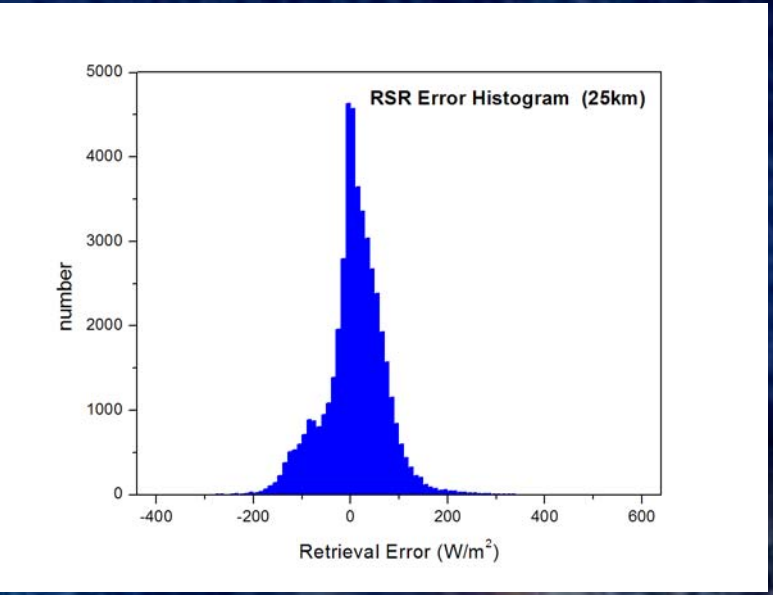
Similar performance of retrievals at the three spatial resolutions (5, 25, and 50 km):

overall accuracy: ~ -10 W/m^2

precision: ~ 100 W/m^2

Offline Validation - RSR





From 10 years of data
overall number of retrievals: 44046
accuracy: 11 W/m^2
precision: 59 W/m^2

Validation Summary

DSR	50km			25km			5km		
	Number of retrievals	Accuracy (W/m^2)	Precision (W/m^2)	Number of retrievals	Accuracy (W/m^2)	Precision (W/m^2)	Number of retrievals	Accuracy (W/m^2)	Precision (W/m^2)
Low (<200W/m^2)	8114	42 (110)	92 (100)	8059	32 (110)	84 (100)	7791	24 (110)	76 (100)
Medium [200, 500]	15529	44 (65)	98 (130)	15257	43 (65)	95 (130)	14692	46 (65)	97 (130)
High (>500W/m^2)	34447	25 (85)	89 (100)	34128	23 (85)	84 (100)	30840	16 (85)	82 (100)

RSR	25km		
	Number of retrievals	Accuracy (W/m^2)	Precision (W/m^2)
Low (<200W/m^2)	17166	6 (25)	33 (35)
Medium [200, 500]	20746	2 (45)	64 (65)
High (>500W/m^2)	4536	54 (55)	58 (65)

spec is in parenthesis

Summary

- The ABI SRB Algorithm provides current state-of-the-art radiation budget retrievals that utilizes the simultaneous atmosphere and surface retrievals and multi-channel measurements offered by ABI.
- The DSR and RSR products meet specifications using the collected 10-year validation data set.
- Version 5 code and the 100% ATBD will be delivered soon.