

NOAA's Joint Polar Satellite System Climate Sensors

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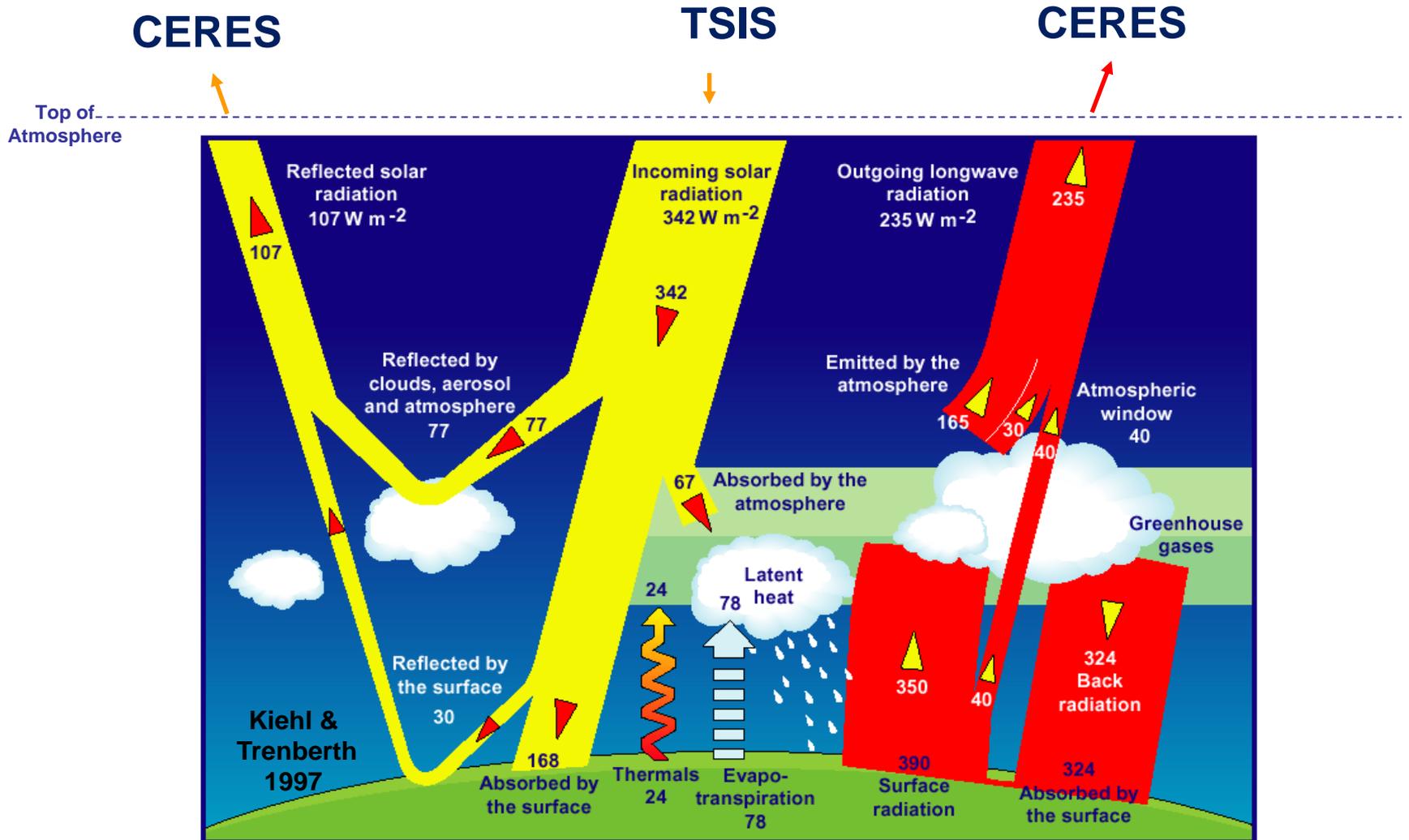
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Climate Sensors Overview

- The Climate Sensors for JPSS are:
 - The Total and Spectral solar Irradiance Sensor (TSIS)
 - The Clouds and Earth's Radiant Energy System (CERES)
- They support the Research to Operations transition for key Earth Radiation Budget measurements
 - Extending data continuity from beyond current NASA research missions
- Achieving this transition requires the coordination of three separate projects
 - The Climate Sensors Program to provide the space flight sensors
 - The JPSS Program to provide the host spacecraft, launch and mission operations
 - The National Climatic Data Center's Climate Data Record (NCDC CDR) project to incorporate the measurements into CDR and Climate Information Records (CIR) process

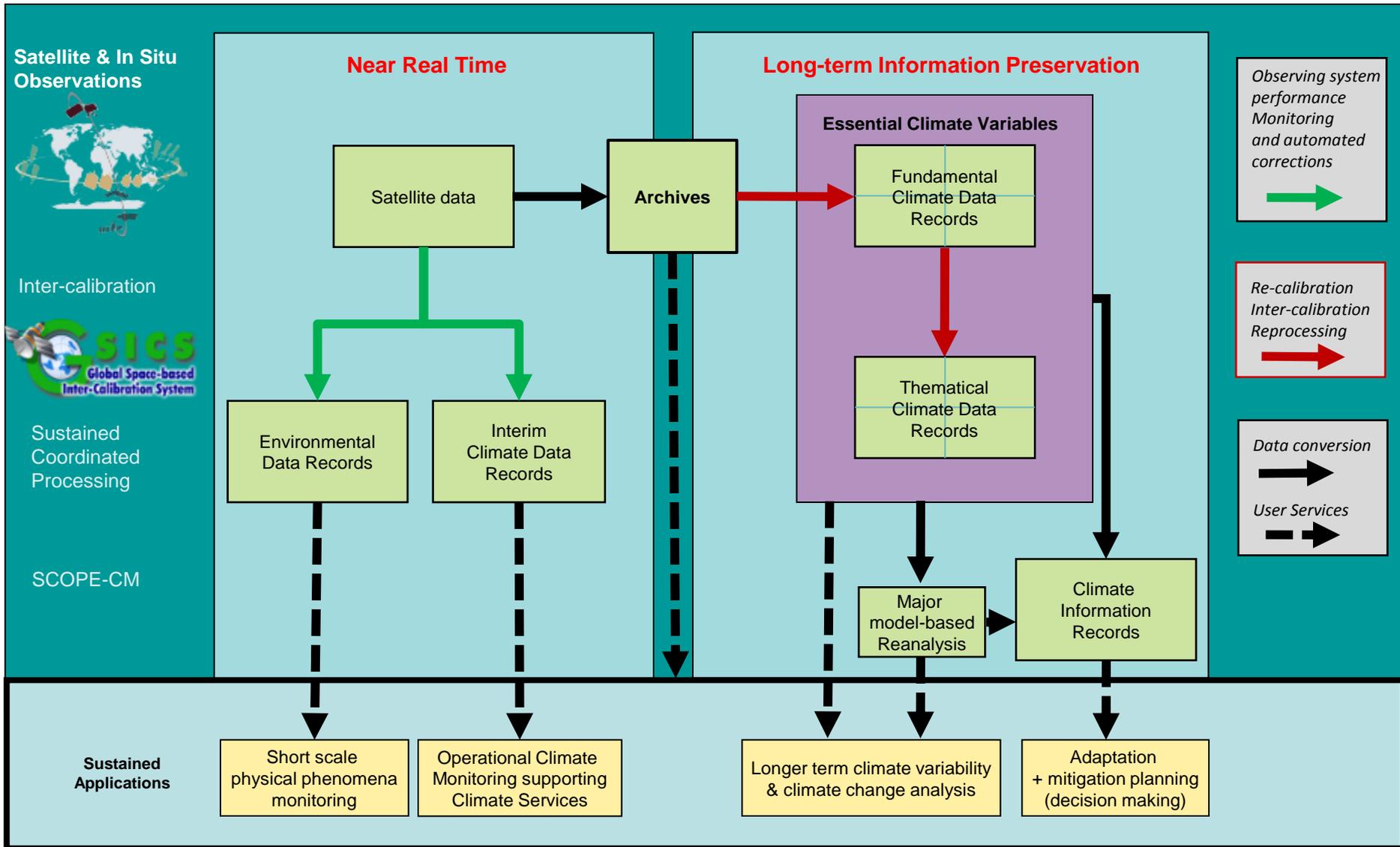


Earth Radiation Budget Components

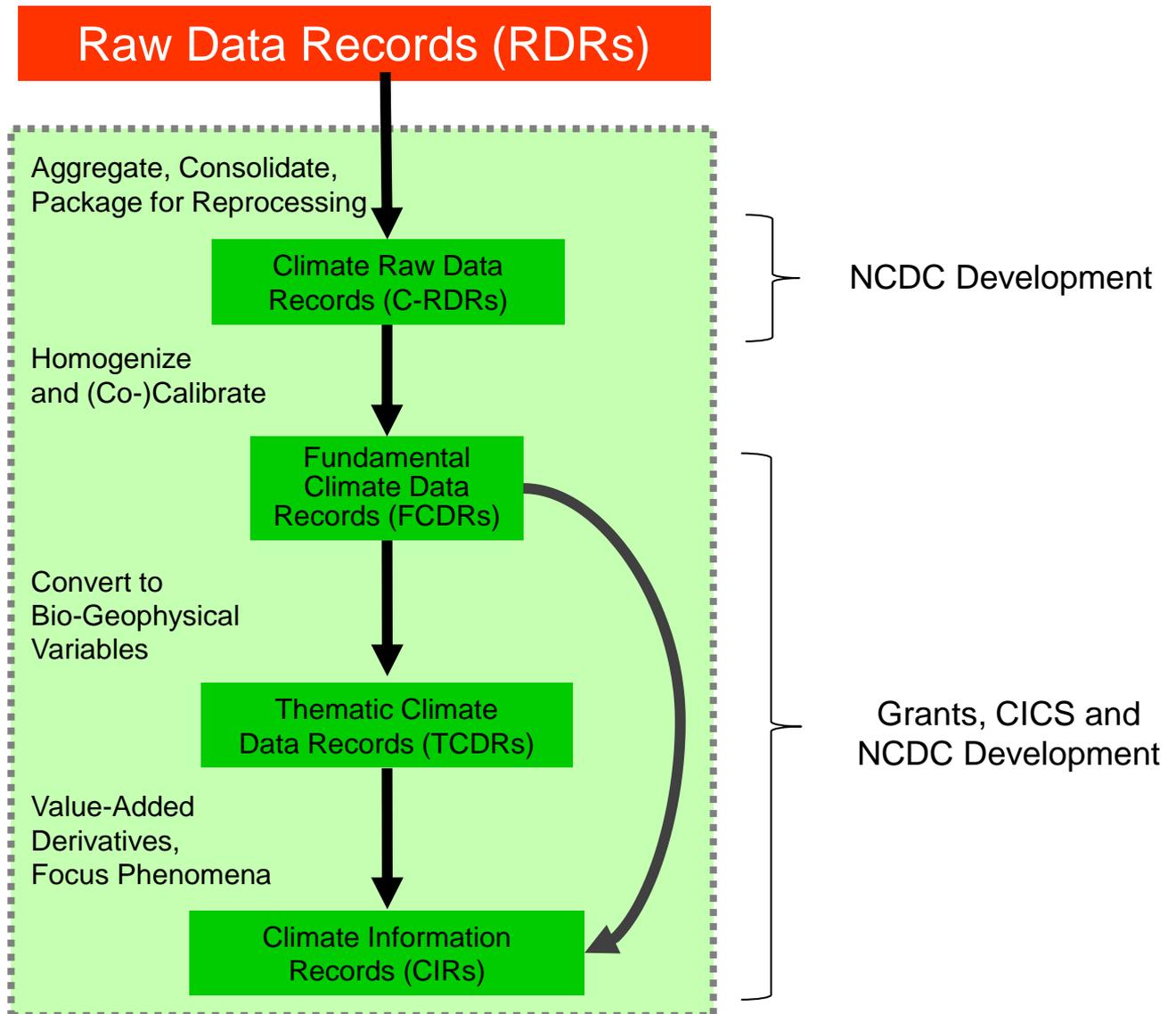


Sustained Climate Information Flow

(In Collaboration with GEO Climate Architecture & CEOS Working Group on Climate)

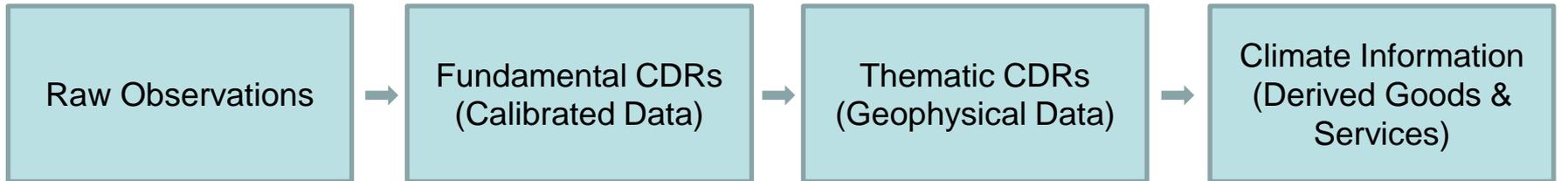


CDR Processing Flow Diagram



Example: CDRs Supporting Investment Decisions in Energy Sector

Collaboration of NOAA, NASA, Academia, Industry and NREL

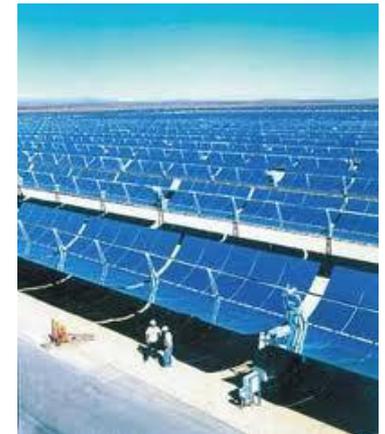
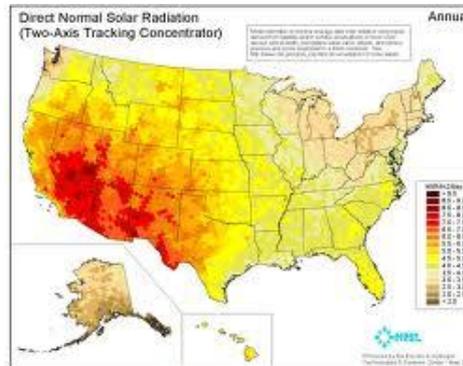
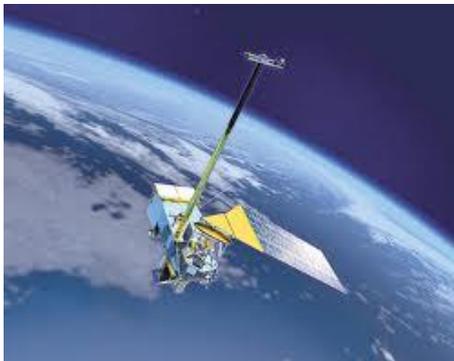


NOAA & NASA
raw satellite data

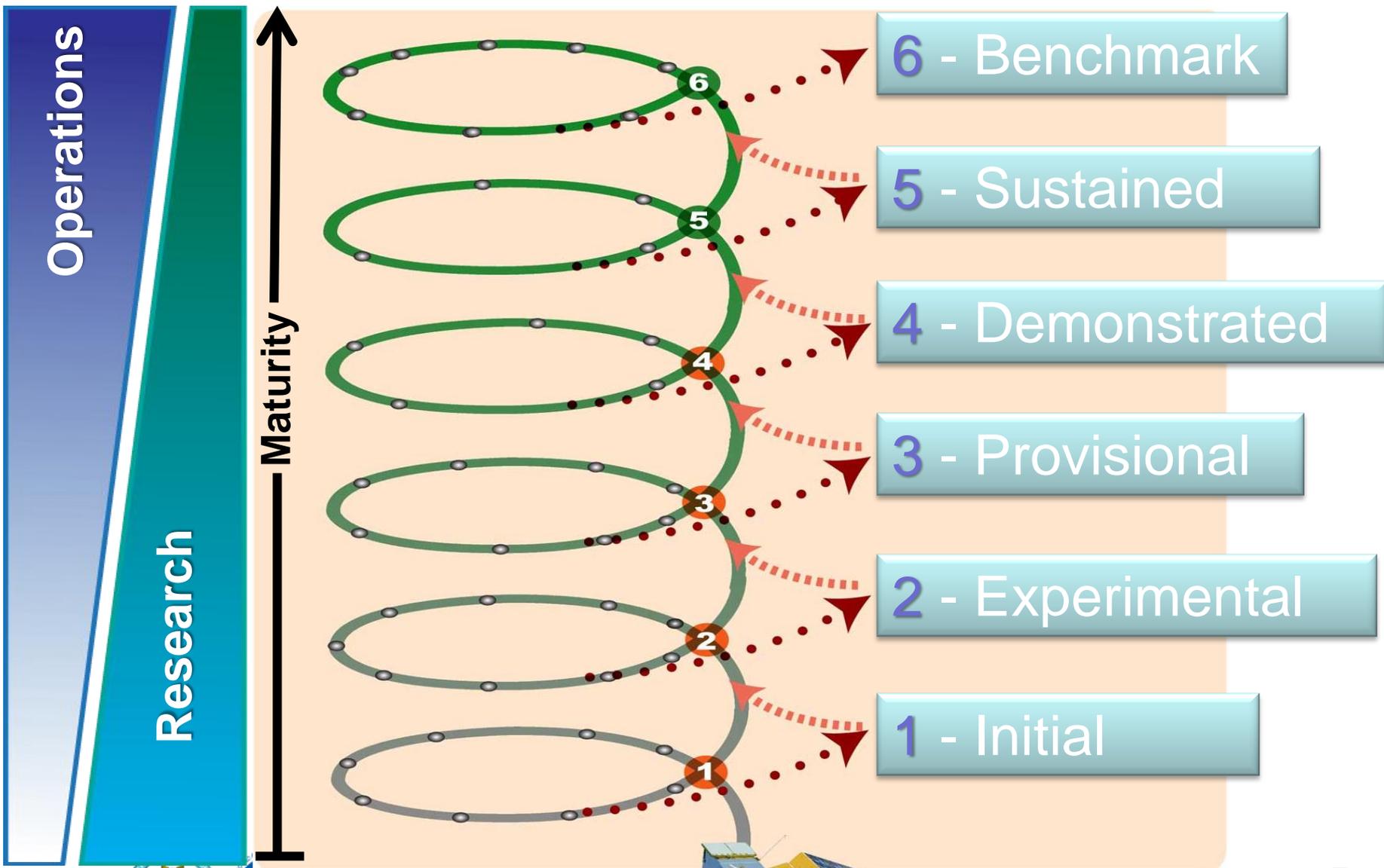
Merged and corrected
NOAA & NASA
data provide trustworthy
multi-decadal time series

Standards of the
renewable
energy community
applied

Siting information for major
solar energy farms



CDR Evolution



Moving from gray to green represents increasing understanding



Feedback Output

Maturity Matrix Indicates Product Quality

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none
2	Research Mission	Some changes expected	Research grade (extensive)	ATBD Version 1+	Uncertainty estimated for select locations/times	Data available but of unknown accuracy; caveats required for use.	Limited or ongoing
3	Research Missions	Minimal changes expected	Research grade (extensive); Meets international standards	Public ATBD; Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
4 (IOC)	Operational Mission	Minimal changes expected	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public ATBD; Draft Operational Algorithm Description (OAD); Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Source code released; Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
5	All relevant research and operational missions; unified and coherent record demonstrated across different sensors	Stable and reproducible	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Public ATBD, Operational Algorithm Description (OAD) and Validation Plan; Peer-reviewed algorithm, product and validation articles	Consistent uncertainties estimated over most environmental conditions by multiple investigators	Source code portable and released; Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators
6 (FOC)	All relevant research and operational missions; unified and coherent record over complete series; record is considered scientifically irrefutable following extensive scrutiny	Stable and reproducible; homogeneous and published error budget	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Product, algorithm, validation, processing and metadata described in peer-reviewed literature	Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation	Source code portable and released; Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators

JPSS Climate Sensor Status

- TSIS
 - Flight Model 1 (FM-1) is in integration
 - FM-1 Delivery is Dec 2012
 - TSIS cannot fit on JPSS-1, currently assessing alternatives

- CERES
 - CERES FM-5 was launched on NPP in October 2011
 - Instrument operating nominally, checkout continuing
 - CERES FM-6 is in final integration
 - Pre Environmental testing Review (PER) scheduled for Feb 2012
 - Delivery is scheduled for September 2012
 - FM-6 will be stored until required for JPSS-1 integration



TSIS Sensor Overview

Total and Spectral solar Irradiance Sensor (TSIS) is composed of two sensors

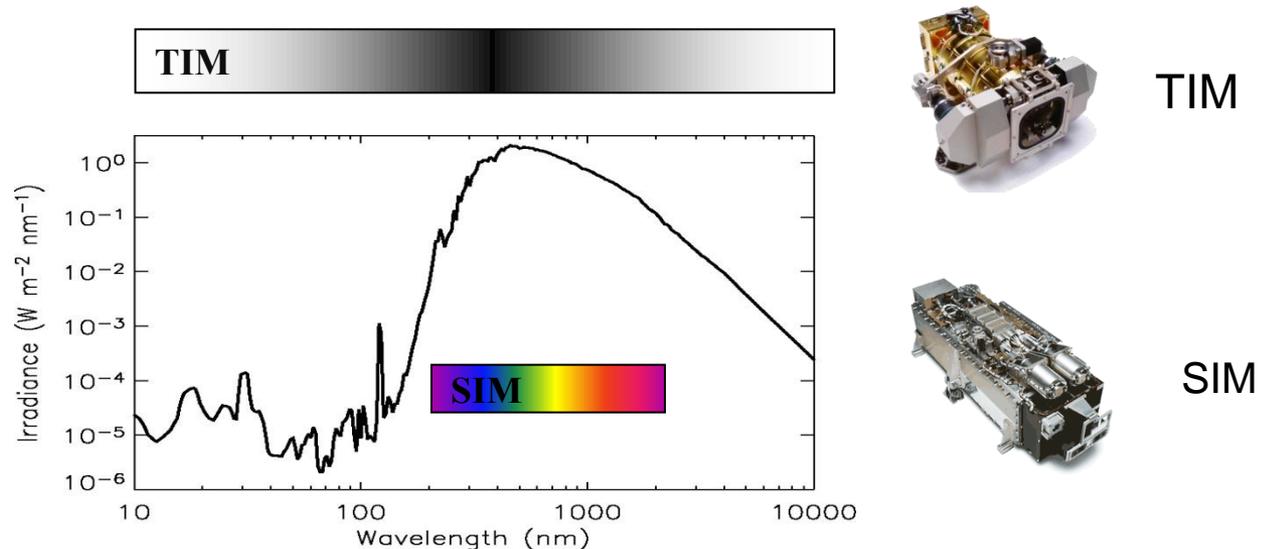
- Developed by the Laboratory for Atmospheric and Space Physics (LASP) under contract with NASA Goddard Space Flight Center (GSFC)

TIM continues the collection of Total Solar Irradiance (TSI) data following the SORCE missions to update the long-term climate record

- Sensor is an active cavity radiometer that monitors changes in TSI incident at the top of the Earth's atmosphere

SIM continues the collection of Solar Spectral Irradiance (SSI) data following the SORCE mission to update the long-term climate record

- - Sensor is a prism spectrometer that monitors changes in SSI as a function of wavelength

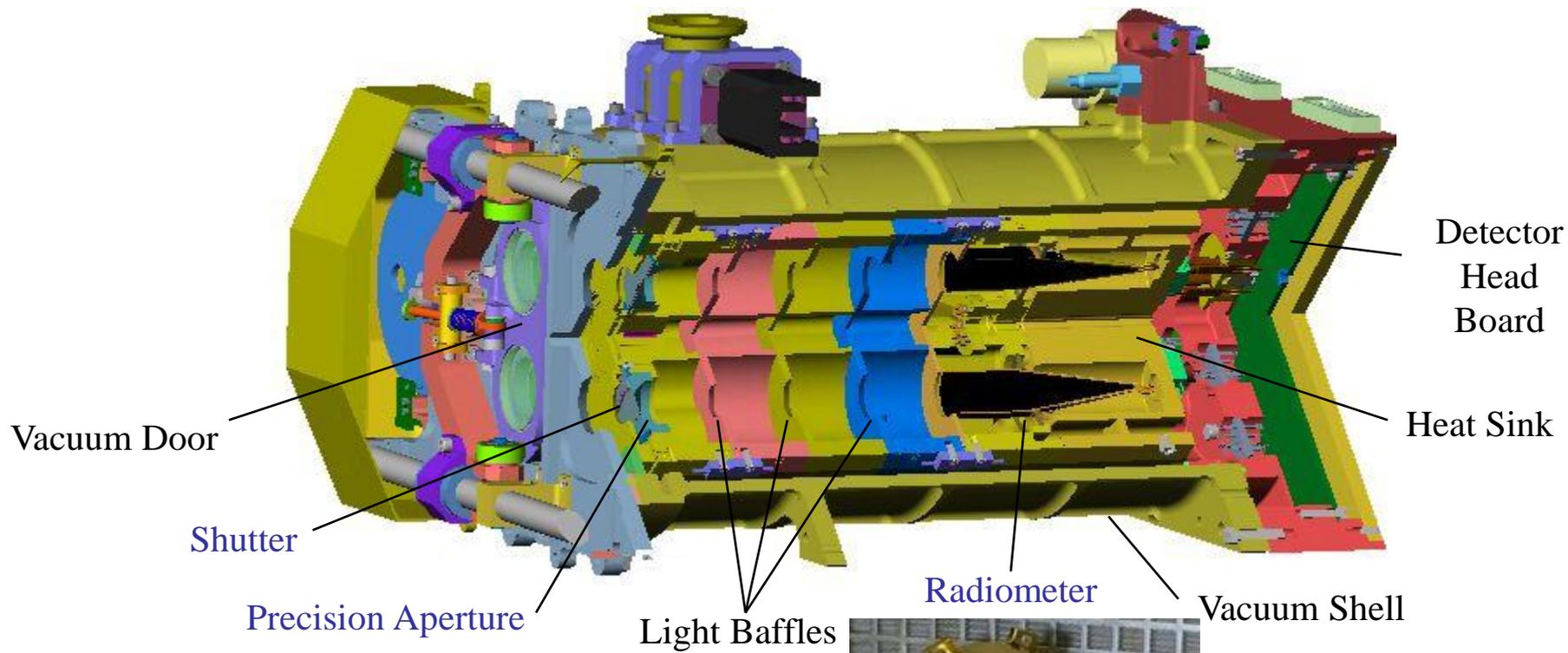


TSIS Top Level Requirements

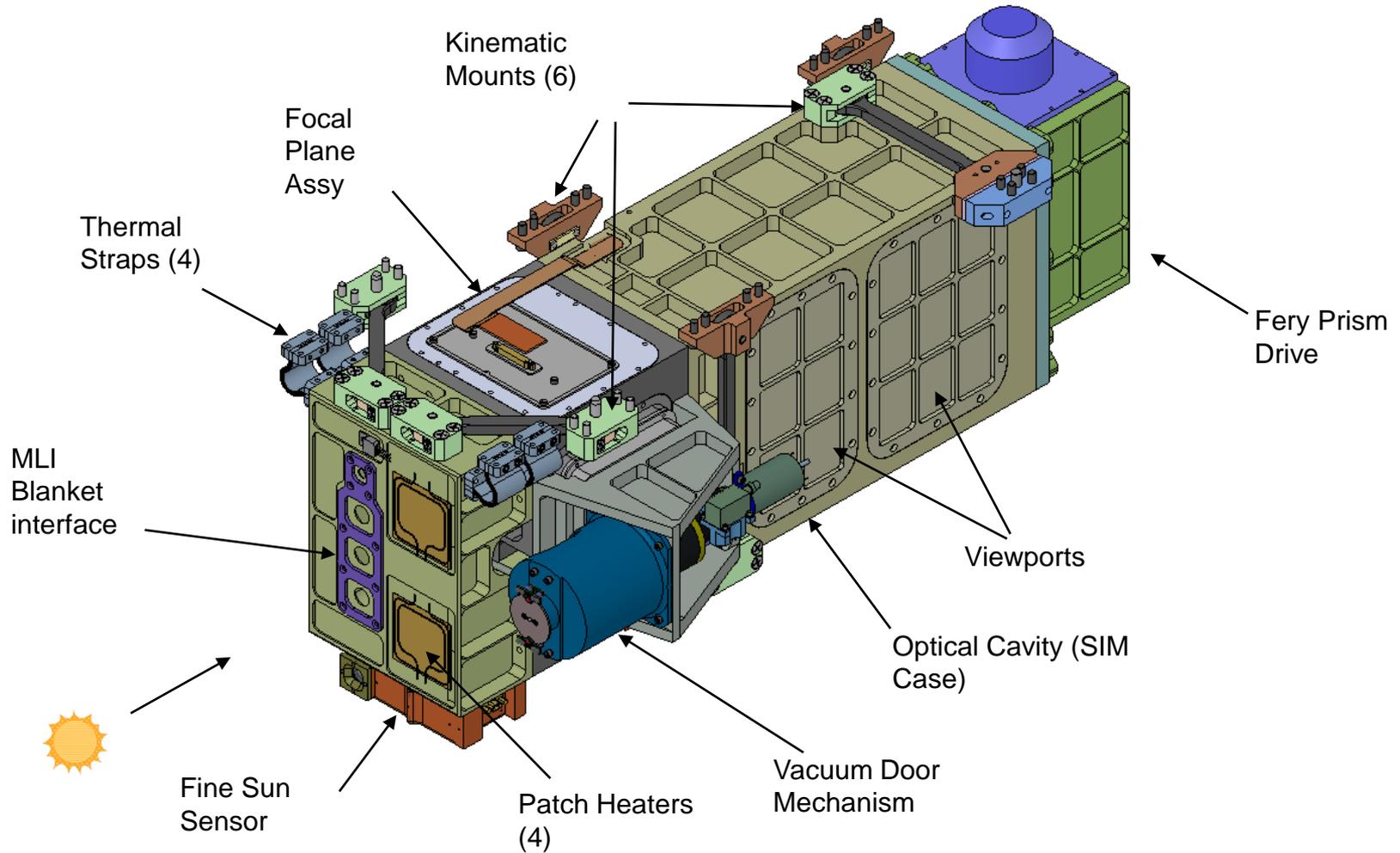
Level 1 Performance Requirement Parameter	TIM Requirement	SIM Requirement
Measured Spectrum	Total solar spectrum	200-2400 nm
Measurement Accuracy	0.01% with noise \leq 0.001%	0.2%
Measurement Stability (long term)	0.001% per year	0.05%/yr (<400 nm) 0.01%/yr (>400 nm)
Spectral Resolution	n/a	1 nm: (< 280 nm) 5 nm: (280 to 400 nm) 35nm: (>400 nm)
Reporting Frequency	4 six hourly averages per day	2 spectra per day
Data processing approach	Consistent with SORCE approach for continuity	Consistent with SORCE approach for continuity



Total Irradiance Monitor (TIM)



Spectral Irradiance Monitor (SIM)



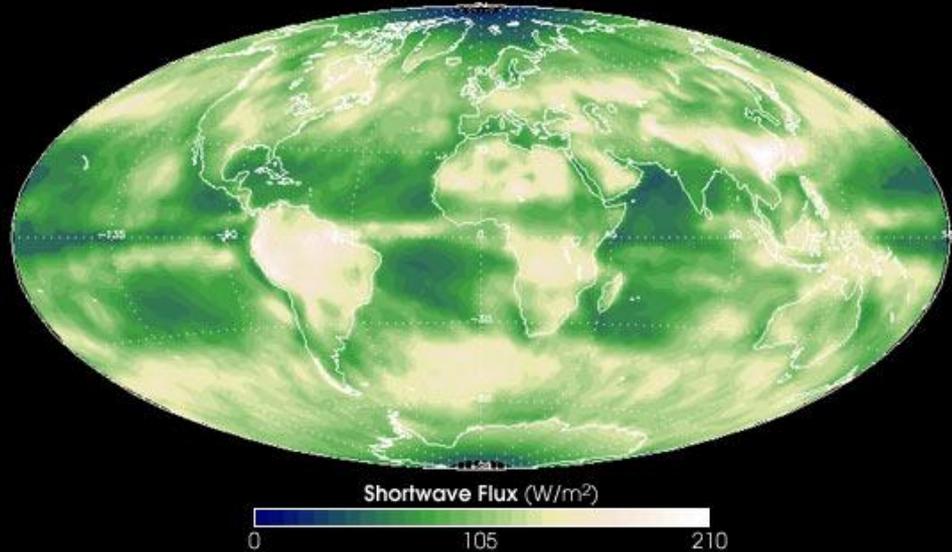
CERES FM6 Sensor Overview



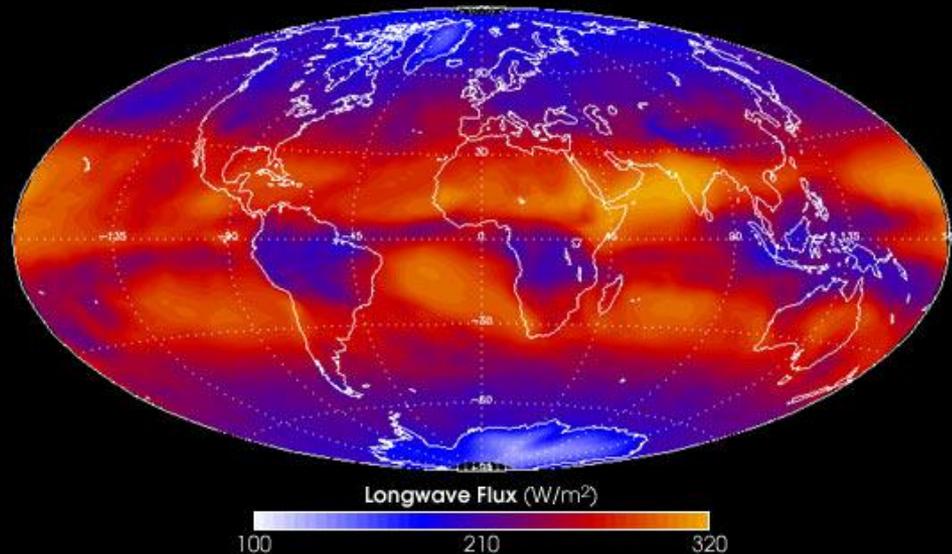
- Clouds and Earth's Radiant Energy System (CERES) is a broadband, multi-spectral scanning radiometer measuring the Earth Radiation Budget
 - Products include both solar-reflected and Earth-emitted radiation from the top of the atmosphere to the Earth's surface
 - Climate sensor providing better than 1.7% accuracy and supporting decadal timescales
- CERES operates continuously making Earth observations with periodic in-flight solar and internal calibrations traceable to their pre-flight ground calibrations
- CERES FM6 is manufactured by Northrop Grumman (NG), for flight on JPSS-1
- Instrument Operations, Data Processing and Science historically provided by NASA LaRC (EOS & NPP)
- NGAS working under contract to NASA LaRC
 - Build-to-Print and from spare parts
 - Minor modifications to accommodate the JPSS-1 interface, and improve calibration

Primary CERES Measurements

Reflected
Solar
Energy



Emitted
Thermal
Energy

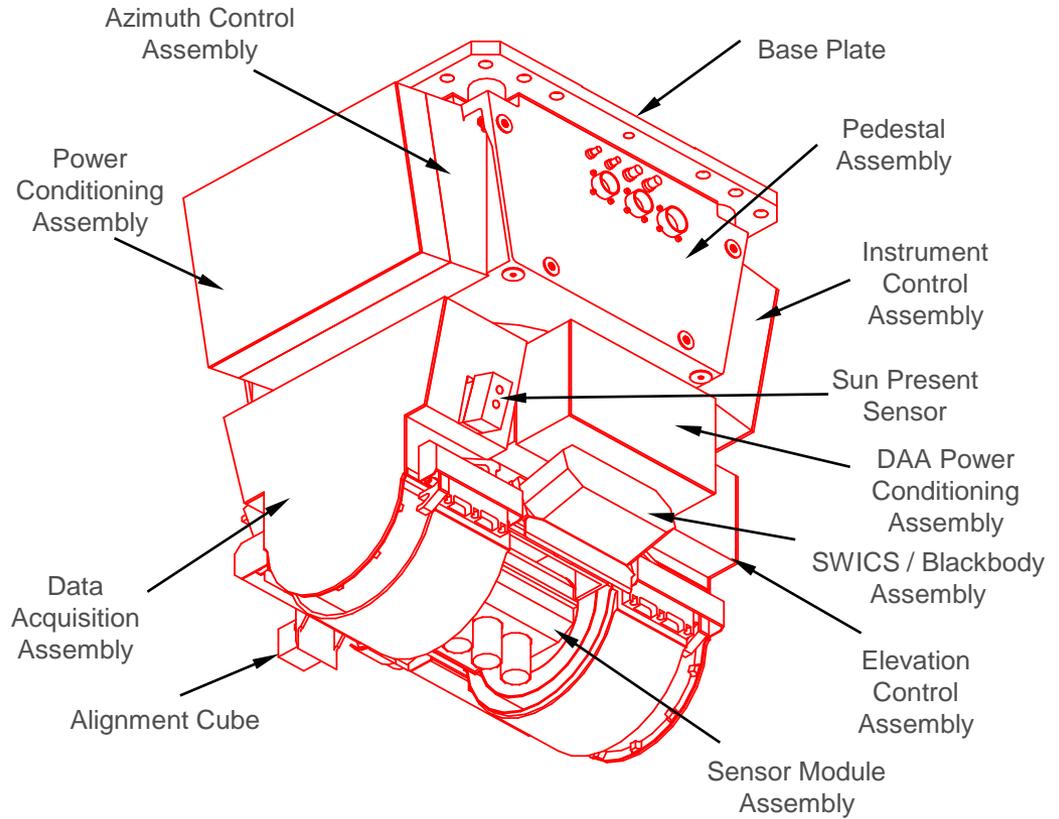


CERES FM6 Top Level Requirements

Performance Parameter	Level 1 Requirement
Total Channel Spectral Range	0.3 μm to $>50 \mu\text{m}$
Shortwave Channel Spectral Range	0.3 μm to 5.0 μm
Longwave Channel Spectral Range	5.0 μm to $>50 \mu\text{m}$
Total Channel Radiometric Accuracy	Larger of 0.7 $\text{W}/\text{m}^2\text{-sr}$ or 0.7%, 1σ
Shortwave Channel Radiometric Accuracy	Larger of 1.6 $\text{W}/\text{m}^2\text{-sr}$ or 1.7%, 1σ
Longwave Channel Radiometric Accuracy	$< 0.38 \text{ W}/\text{m}^2\text{-sr}$ or 0.5% 1σ
Total Channel Radiometric Precision	$< 0.2 \text{ W}/\text{m}^2\text{-sr} + 0.1\%$ of measured 3σ
Shortwave Channel Radiometric Precision	$< 0.3 \text{ W}/\text{m}^2\text{-sr} + 0.1\%$ of measured 3σ
Longwave Channel Radiometric Precision	$< 0.45 \text{ W}/\text{m}^2\text{-sr} + 0.1\%$ of measured 3σ
Total Channel Linearity	$< 1.5 \text{ W}/\text{m}^2\text{-sr}$
Shortwave Channel Linearity	$< 1.28 \text{ W}/\text{m}^2\text{-sr}$
Longwave Channel Linearity	$< 0.54 \text{ W}/\text{m}^2\text{-sr}$



CERES Instrument



Summary

- The TSIS and CERES FM6 Instruments are on track for delivery to JPSS
- These instruments will provide climate data continuity with existing missions
- JPSS is working with NCDC to define the data processing interfaces and flow to provide the underlying measurements to support the Climate Data and Information Record production

