

Science Data Processing and Distribution of Clouds and the Earth's Radiant Energy System (CERES) Data for the NPOESS Preparatory Project (NPP)

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Presentation Outline

CERES Overview

CERES FM-5 on NPP

CERES NPP Data Flow and Operations

CERES Processing Systems Design

Data Archival and Distribution

Future CERES Sensors



NPP Instruments



**VIIRS – Medium resolution
Visible & Infra-red Imager**

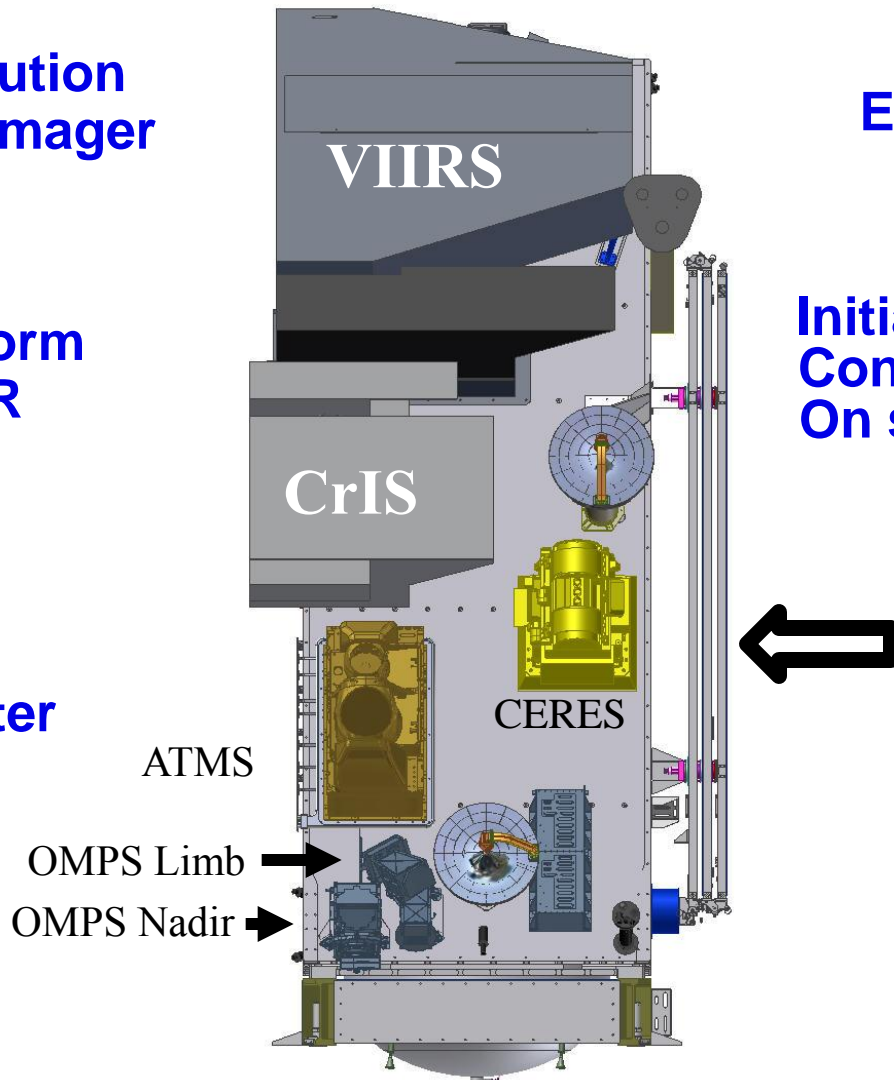
**CrIS – Fourier Transform
Spectrometer for IR
Temperature and
Moisture sounding**

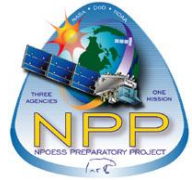
**ATMS – Microwave
sounding radiometer**

**OMPS – Total Ozone
Mapping and
Ozone Profile
measurements**

**CERES
Earth Radiation
Budget
measurements**

**Initial concept 2/07
Confirmed 2/08
On spacecraft 11/08**





CERES Flight Model 5



Three channel scanning radiometer.

Fluxes calculated at TOA

- Total (0.3 to >50 μm)
- Shortwave (0.3 to 5.0 μm)
- Window Bandpass (8 to 12 μm)

Operations, Data Processing, Products, and Science are a continuation of experience developed on:

- TRMM (1), EOS Terra (2), EOS Aqua (2)

Current Status: On NPP spacecraft

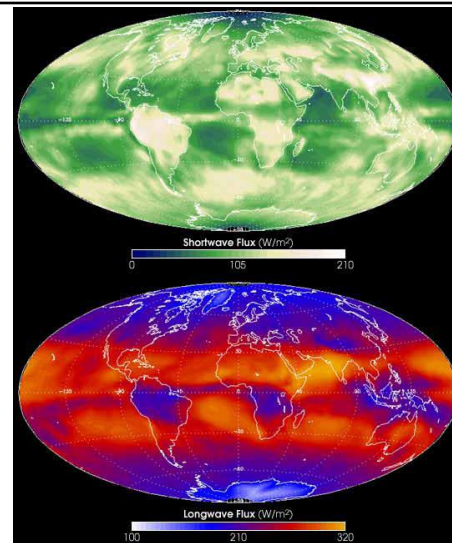
Margins

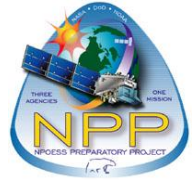
CERES	Spec	CBE
Mass - kg	50	50
Power (Avg.) - W	50	50
Power (Max) - W	75	75
Data Rate (Avg.) - Kbps	10	10
Data Rate (Max) - Kbps	10	10

Primary CERES Climate Data Records:

Reflected Solar Energy

Emitted Thermal Energy





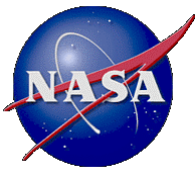
CERES Overview



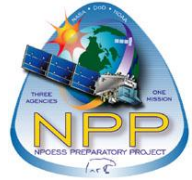
- **CERES is one of the highest priority scientific satellite instruments developed for NASA's Earth Observing System.**
- **CERES provides critical cloud and Earth radiation budget climate data records to support global climate change research.**
- **CERES is a three-channel scanning radiometer which measures reflected sunlight and emitted radiation between 0.3 and >100 μm .**
- **On-board calibration sources include a solar diffuser, a tungsten lamp system with a stability monitor, and a pair of blackbodies.**
- **CERES instruments were launched aboard the Tropical Rainfall Measuring Mission (TRMM) in November 1997 and on the EOS Terra and Aqua satellites in December 1999 and May 2002 respectively.**



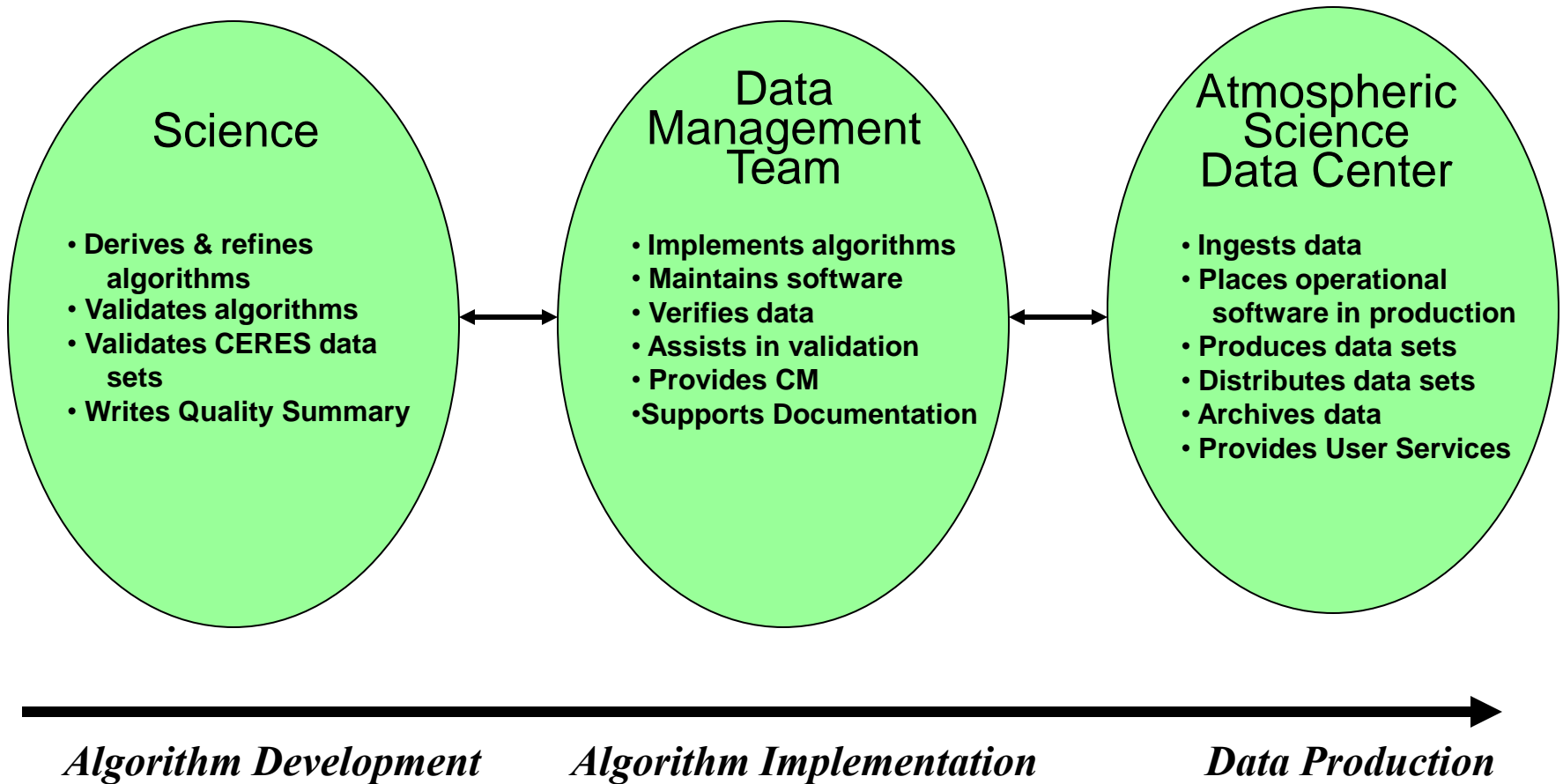
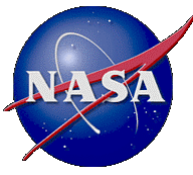
CERES Overview (cont.)



- **CERES products include both solar-reflected and Earth-emitted radiation from the top of the atmosphere to the Earth's surface.**
- **Cloud properties are determined using simultaneous measurements by other instruments such as the Moderate Resolution Imaging Spectroradiometer (MODIS).**
- **International Science Team based at Langley Research Center (LaRC) blends expertise in broadband radiometry, cloud and radiation remote sensing, and climate modeling.**
- **LaRC Science Computing Facility (SCF) used for scientific analysis, investigations and development of CERES data products.**
- **LaRC Atmospheric Science Data Center provides ingest, production, archival and distribution of CERES data products**



CERES Project Organization

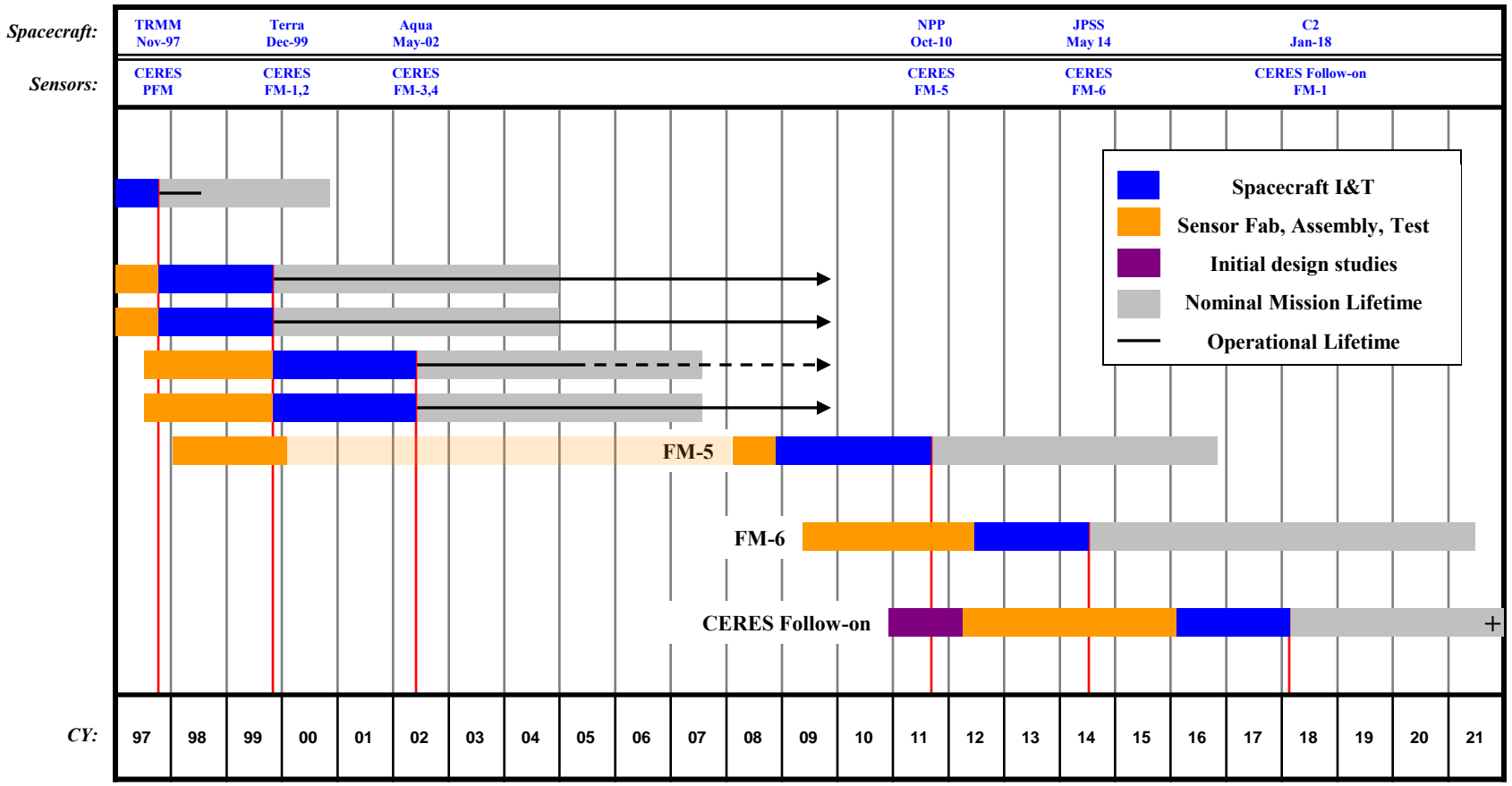


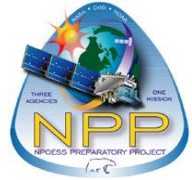


CERES Flight Schedule



Enabling Climate Data Record Continuity





CERES FM-5 on NPP



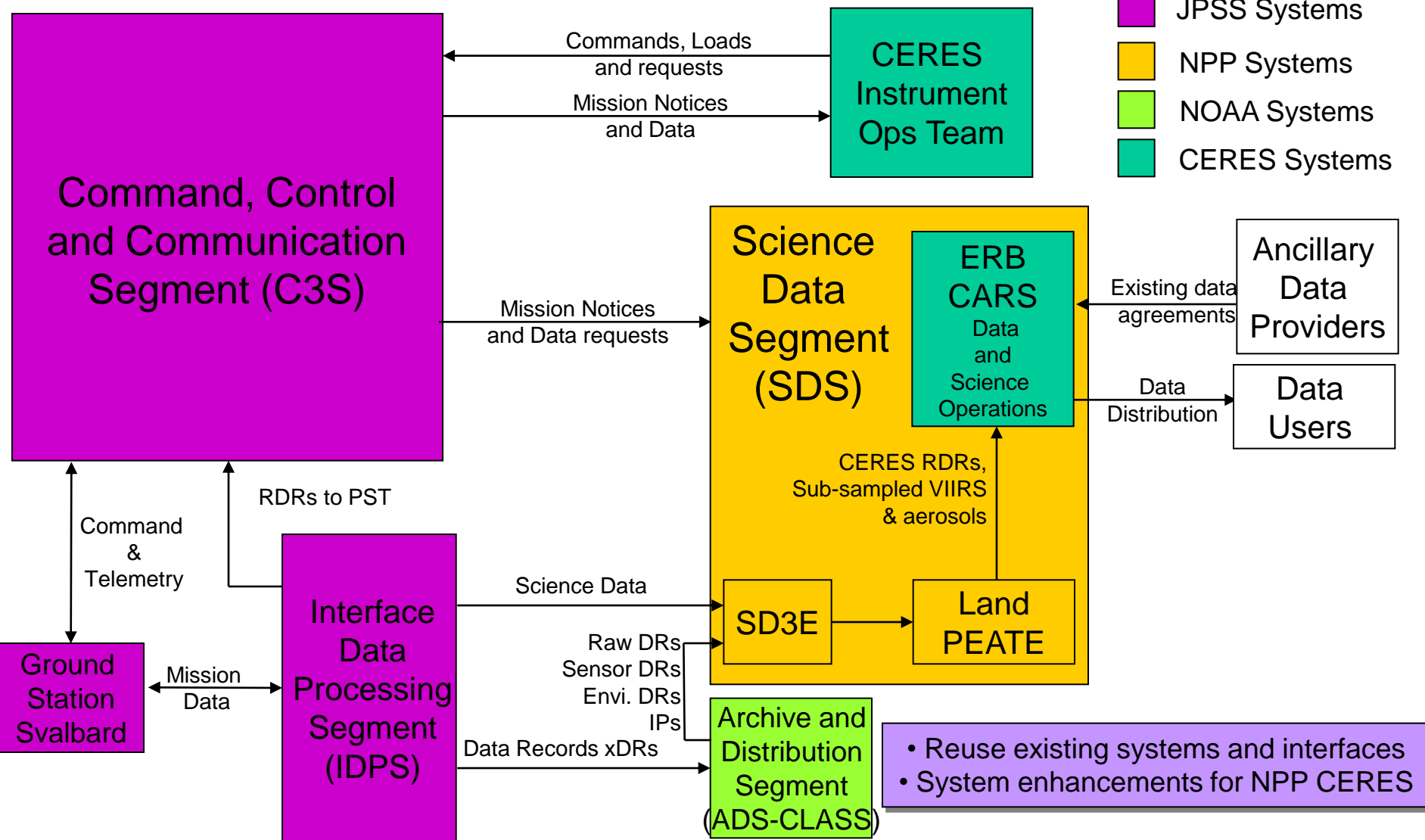
- **FM-5 is a NASA sensor manufactured by Northrop Grumman and provided to NPP by NASA.**
- **Instrument integration and test conducted from January to November, 2008.**
- **The Earth Radiation Budget Climate Analysis and Research System (ERB CARS) at LaRC is responsible for CERES instrument operation, data processing, and science analysis.**
- **ERB CARS is an element of the NPP Science Data Segment, and receives NPP data from the Land Product Evaluation and Test Element (PEATE) at GSFC.**



NPP CERES Operational Data Flow



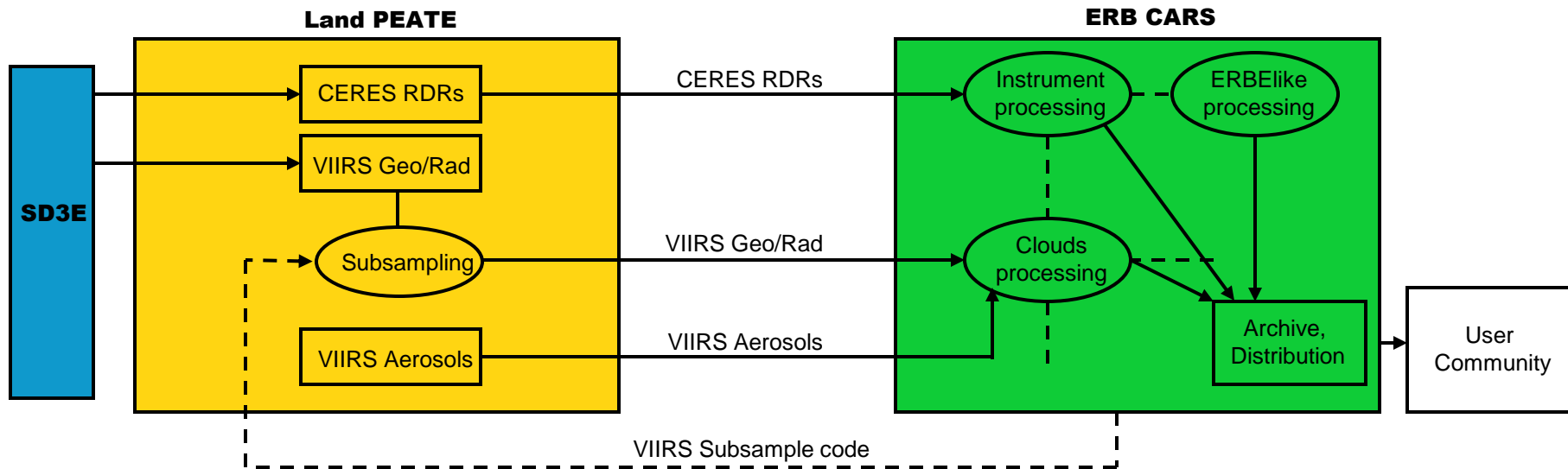
- JPSS Systems
- NPP Systems
- NOAA Systems
- CERES Systems



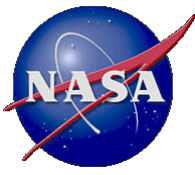
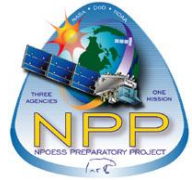
- Reuse existing systems and interfaces
- System enhancements for NPP CERES



CERES Data Flow

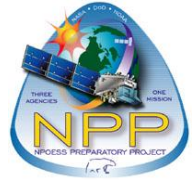


- 1- The Land PEATE receives CERES RDRs and VIIRS xDRs from the SD3E.
- 2- CERES RDRs are passed directly to ERB CARS, where they are processed by the Instrument subsystem to produce inputs to the ERBE-like and Cloud subsystems.
- 3- The Land PEATE produces MODIS-like VIIRS radiance/geolocation and aerosol files.
- 4- The Land PEATE subsamples the MODIS-like VIIRS radiance/geolocation data using software provided by CERES.
- 5- Land PEATE sends the subsampled VIIRS files and the MODIS-like VIIRS aerosol files to ERB CARS.
- 6- ERB CARS runs the downstream subsystems, beginning with Clouds, as data becomes available.
- 7- Climate-quality data products are archived and made available to the user community along with Data Quality Summaries and user support.

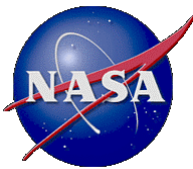


Relevant CERES NPP Issues

- **Imager input data required for Climate Data Records (CDRs) must be of climate quality and consistently calibrated over entire period.**
 - In NPP era, Land PEATE provides VIIRS aggregated radiance and geolocation files and sub-sampled data files using CERES provided code. Land PEATE also provides AOT files that correspond to sub-sampled radiance/geolocation.
 - For Terra/Aqua, MODAPS provides radiance, geolocation, and aerosol files from a collection that begins at covers open.
- **NPP CERES made use of already existing interfaces.**
 - Cost savings by using existing infrastructure.
 - Land PEATE already receiving simulated VIIRS data. Agreed to also obtain CERES Raw Data Records (RDRs).
 - Network between Land PEATE and ASDC exists for Terra/Aqua.



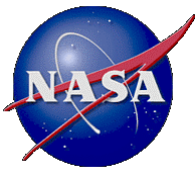
CERES Input Data



Type of Data	Parameter Description	Terra/Aqua Freq & Source	NPP Freq & Source	Comments
CERES L0 files	Instrument level 0 data	3/day; EDOS @ GSFC	~131/day; Land PEATE	In case of NPP, RDRs also contains spacecraft diary
Attitude	Attitude	12/day; GSFC Flight Dyn Facility	included in RDR	
Ephemeris	Ephemeris	12/day (Terra); GSFC Flight Dyn Facility 1/day (Aqua); same	included in RDR	
Imager Calibrated Data, Instantaneous	Imager Radiances & Geolocation Aerosols	288/day; MODAPS ~144/day; MODAPS	288/day; Land PEATE ~144/day; Land PEATE	CERES provided code to sub-sample radiance files at GSFC
Aerosol data	Aerosol (Coln) Optical thickness, type/size	1/day; MODAPS		For Terra/Aqua using MODIS MOD08 and MATCH. Plan to do same for NPP
Meteorological and Ozone data	3-D Met Data 2-D atmospheric data 2-D constants	4/day; GMAO 24/day; GMAO 1; GMAO		
Precipitable Water	2-D constants	2/day; Global Hydrology Resource Center (GHRC)		
Geostationary data	MCIDAS data from 5 geostationary satellites per month	120/day; University of Wisconsin Space Science and Engineering Center (SSEC)		Only every 3rd hour is used for production
SURFMAP(Snow/Ice)	Snow/Ice Map	4/day; NCEP/NESDIS		
SURFMAP(Snow/Ice)	Snow/Ice Map	1/day; NSIDC		

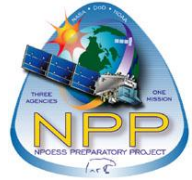


Science Data Processing Approach for CERES FM-5

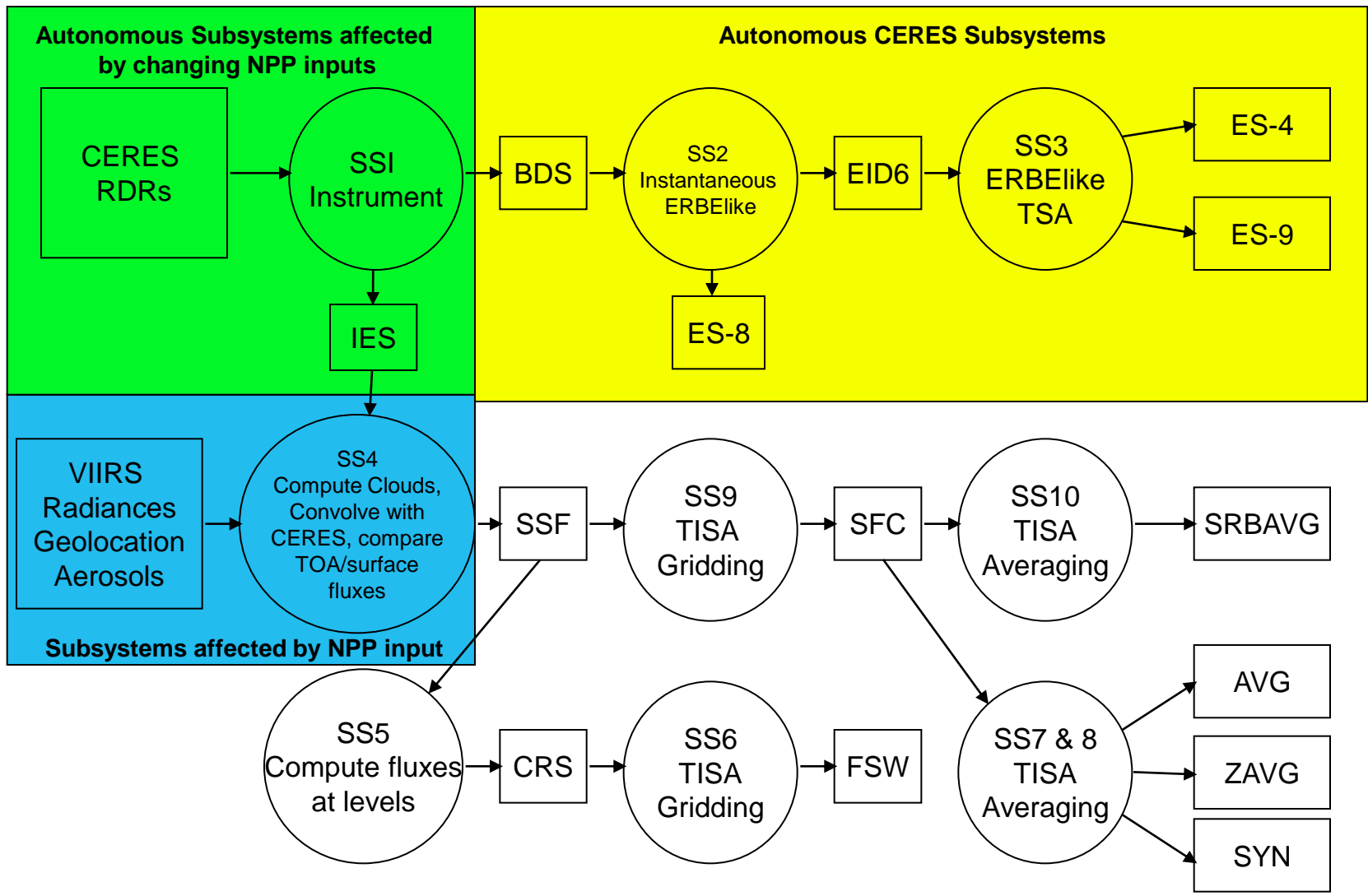


Processing is divided into 2 Streams:

- **Instrument and ERBE-like**
 - Autonomous stream, dependent only on CERES data
 - In production within 48 hours of power-on
 - Aids in establishing Instrument health
 - Critical for establishing CERES calibration/validation
 - Produces ERBE-like data sets
 - Data sets exist for CERES instruments on TRMM, Terra, and Aqua
 - Similar data sets exist for ERBE instruments on ERBS, NOAA-9 and NOAA-10
- **Fused data sets beginning with Cloud/Convolution/Inversion processing and the SSF**
 - Use inputs from imager and other data sources
 - Higher resolution imager data is Point Spread Function (PSF) weighted
 - Produces higher quality climate data
 - Data sets exist for CERES instruments on TRMM, Terra, and Aqua
 - Will not be in production immediately after covers open
 - Requirement is to ingest VIIRS radiance, geolocation, and aerosol data when it becomes available from Land PEATE



Simplified CERES Processing Flow

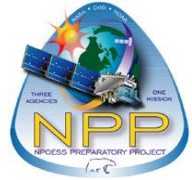




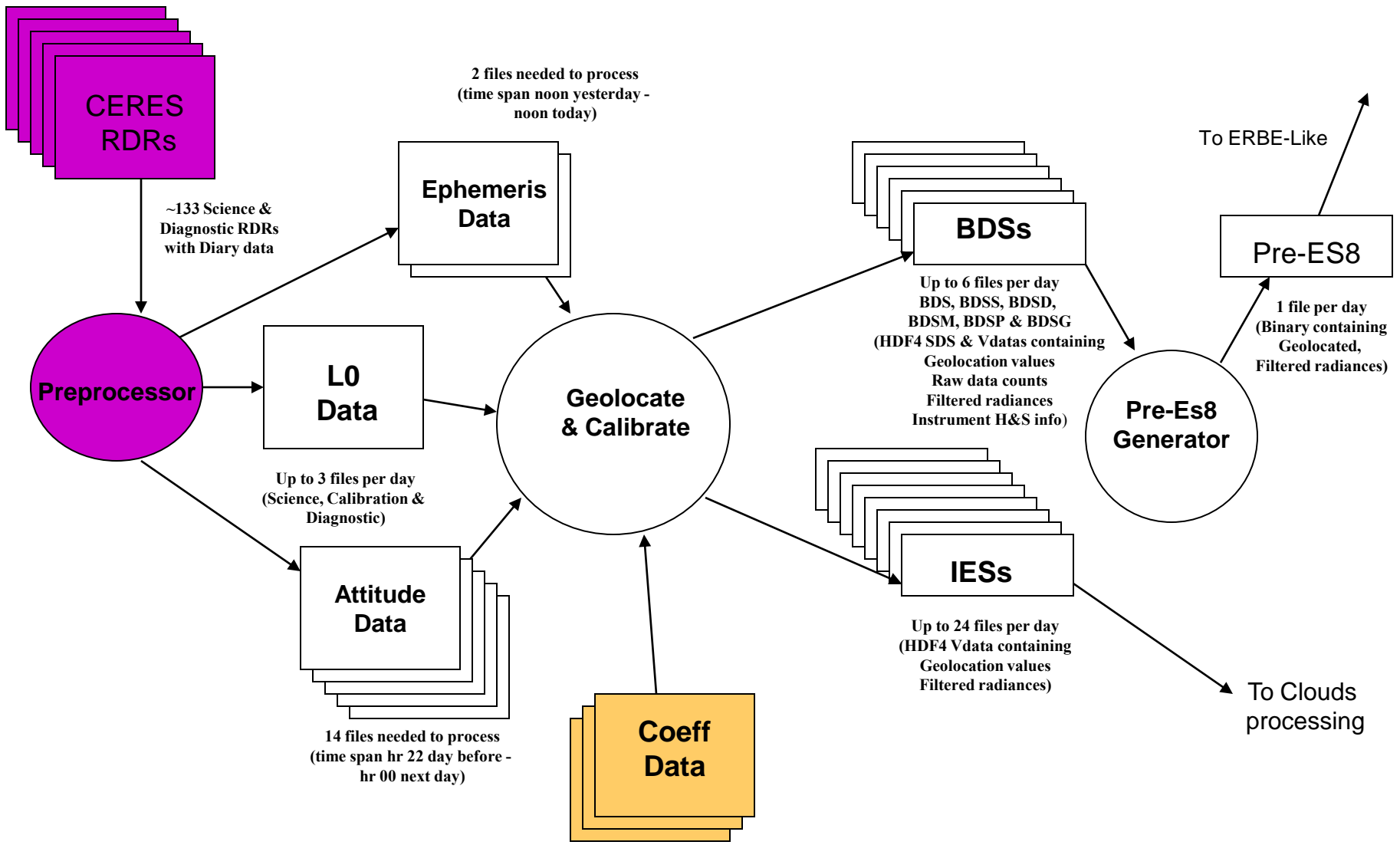
FM-5 Instrument Subsystem Design



- **Extensive reuse of existing software for instrument subsystem.**
 - Preprocessor will convert RDR raw data to format consistent with Terra and Aqua.
 - Creates 24-hr Level-0 and Toolkit compliant ephemeris and attitude data files
 - Proven operational system used for current CERES processing
- **Process incoming NPP Level-0 data is the first priority**
- **Other downstream processing subsystems were converted following successful testing of Level-0 processing.**



FM-5 Instrument Subsystem





FM-5 Clouds Subsystem Design



- **Use VIIRS sub-sampled calibrated radiance and aerosol products in place of MODIS data.**
- **VIIRS sub-setting code will run at the Land PEATE, and output sent to ERB CARS as input to CERES Clouds Subsystem.**

➤ **Input:**

NPP_VIAE (Radiances from Imaging “I” Channels)

NPP_VMAE (Radiances and geolocations from
Moderate-Resolution “M” Channels)

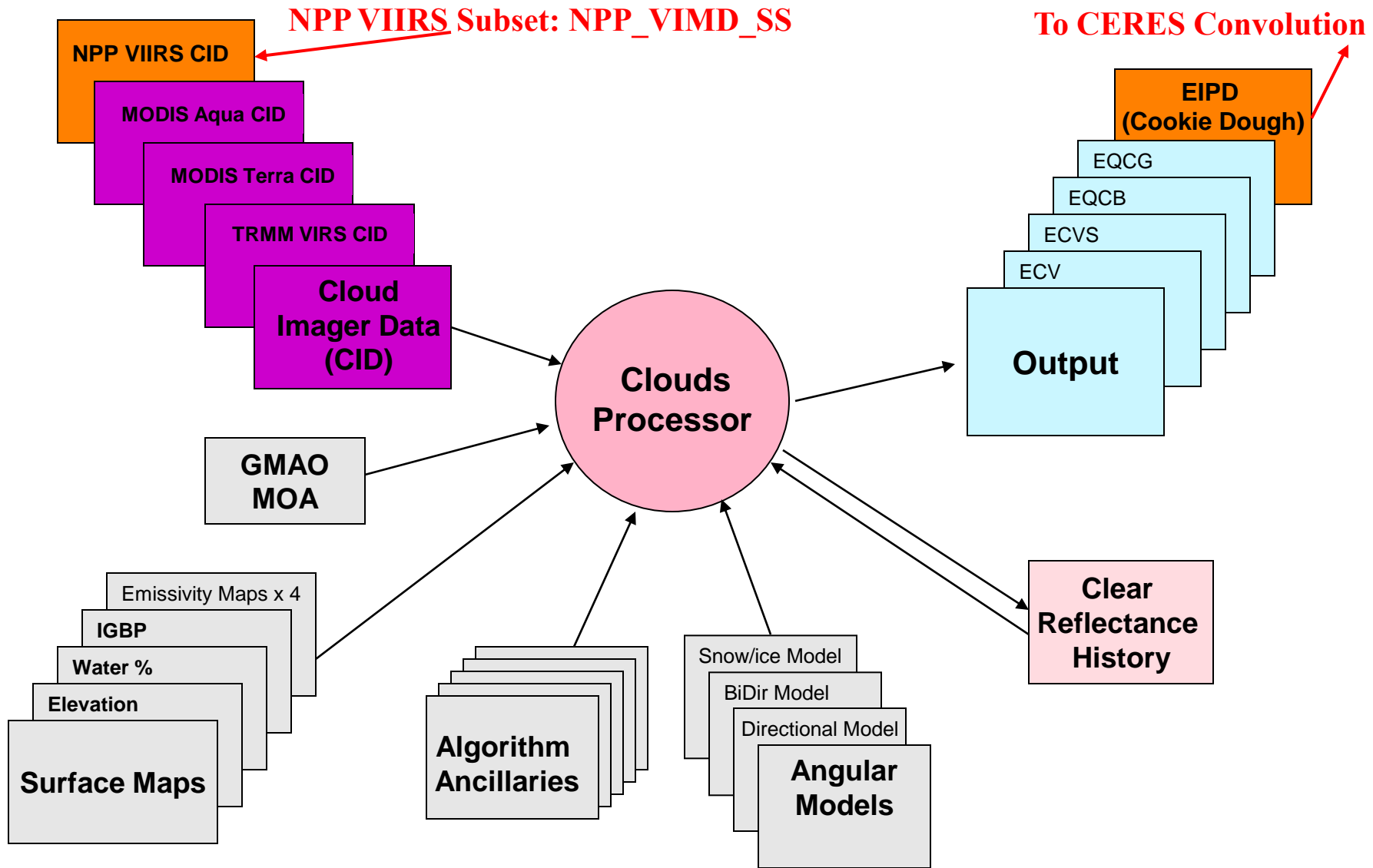
NPP_VDNE (Radiances and geolocations from Imaging
Day-Night Band (channel) “DNB”)

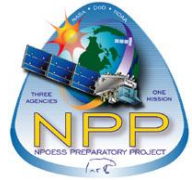
➤ **Output:**

NPP_VIMD_SS (Radiances and geolocations from all above
three Imaging, Moderate and DNB, but
sub-sampled and sub-channeled with
certain channels being averaged



FM-5 CERES Clouds Subsystem

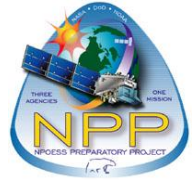




CERES Publicly Available Output Products



Data Product	Description
Level 4: Consistency between TOA global net flux and ocean heat storage.	
EBAF	CERES TOA fluxes, energy balanced and computed flux profiles for consistent cloud properties
Level 3: Spatial and temporally (daily, monthly, etc) averaged fluxes and cloud properties.	
SYN1deg	CERES observed and GEO-enhanced temporally interpolated TOA fluxes, MODIS/GEO clouds and MODIS aerosols and associated computed flux profiles for consistent cloud properties
SSF1deg	CERES observed temporally interpolated TOA flux, MODIS clouds and aerosols
ISCCP-D2like	CERES monthly cloud properties in a similar format to ISCCP
ES4/ES9	CERES observed TOA fluxes using original ERBE algorithms
FLASHFlux1deg	Near real-time SSF1deg product, not officially calibrated for publication
Level 2: CERES instantaneous footprint level fluxes and cloud properties.	
SSF	CERES observed TOA flux, MODIS clouds and aerosols and parameterized surface fluxes
CRS	Computed flux profiles from MODIS clouds and aerosols
ES8	CERES observed TOA fluxes using original ERBE algorithms
SSF-SSFM	Nadir view CERES-SSF/MODIS/MISR collocated parameters
C3M	Nadir view CERES-SSF/MODIS/CALIPSO/CloudSat collocated parameters
FLASHFlux	Near real-time SSF product, not officially calibrated for publication
Level 1B: CERES raw engineering and instantaneous filtered radiances.	
BDS	CERES geo-located and calibrated TOA filtered radiances.



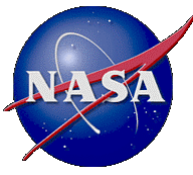
Atmospheric Science Data Center (ASDC)



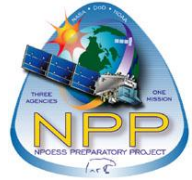
- **Ingesting and Archiving inputs for all Data Products**
 - Used by Production in Producing Data Products
 - Use by Science Team in analysis and algorithm refinement
- **Distribute CERES Data Products**
 - External Customers order data products via multiple services:
 - ASDC Order Tool, ESDIS ECHO, Subscription Services
 - CERES interactive subsetting tool
 - Plan to supply CLASS with subscription service as an offsite backup
- **Produce Data Products for CERES Science Team and community**
 - Accept delivery & test Production codes from DMT
 - Accept Production Requests from DMT
 - Run code consistently to produce expected data products
- **AMI - ASDC Modernization through Integration replace legacy ASDC/SCF systems (SGI, Sun, and Mac servers) with IBM processors.**



Future CERES Sensors



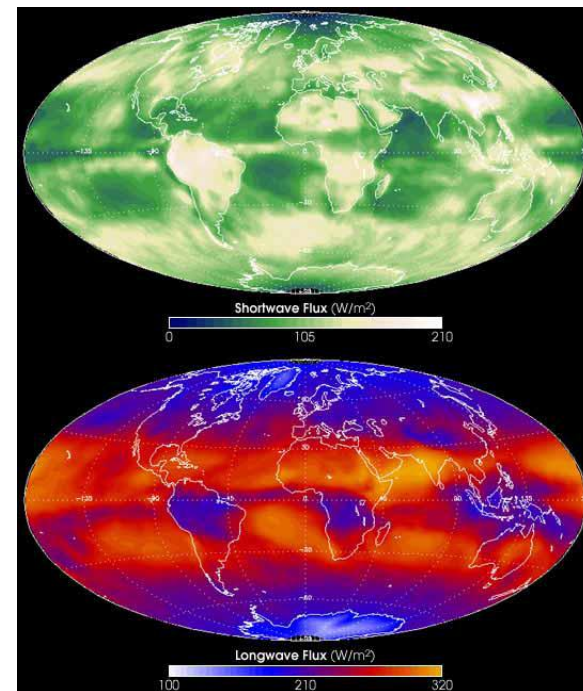
- **FM-6 on JPSS**
 - Authority To Proceed – 5/1/09
 - Being assembled from spare parts at Northrop Grumman.
 - Study phase and proposal for upgraded on-board calibration equipment design (Shortwave Internal Calibration Source (SWICS), Mirror Attenuator Mosaic (MAM)).
 - Scheduled to launch in 2014
- **CERES Follow-on**
 - New Design, new detectors
 - Platform, FOV TBD
 - Estimated to launch in 2018

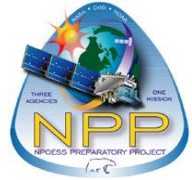


Summary

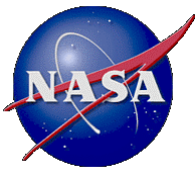


- **CERES is one of the highest priority scientific satellite instruments developed for NASA's Earth Observing System.**
- **LaRC has collected over 30 Instrument years of CERES data from TRMM, Terra, and Aqua and has processed over 90% of that data to date**
- **Extensive use of existing data processing software for FM5 maximizes efficiency and minimizes the risk of incompatible data sets.**
- **The inclusion of CERES FM-5 on NPP, and subsequently FM-6 on JPSS will ensure continuity of critical cloud and Earth radiation budget climate data records to support global climate change research.**

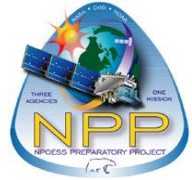




Data Access and Information



- **Ordering Data**
 - <http://science.larc.nasa.gov/ceres/>
 - <http://eosweb.larc.nasa.gov/>
 - <https://wist.echo.nasa.gov/api>
- **Subsetting for EBAF, SYN1deg, and SSF1deg are available**
 - Can subset by parameters or latitude/longitude
 - <http://ceres-tool.larc.nasa.gov/ord-tool/jsp/EBAFSelection.jsp>
- **Contacts for questions regarding production data products and their use**
 - E-mail: larc@eos.nasa.gov
 - Langley ASDC Customer Service
- **CERES News (e-mail)**
 - Subscribe from CERES Data Products webpage
 - All new public datasets are announced soon after public release

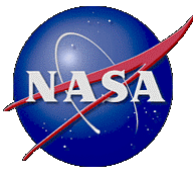


Backup Slides





CERES Processing Software



Subsystem Number	Subsystem Name	LOC (to nearest 1K)	Publicly Available Date Products	Product Frequency	Comments
	CERESlib	132K			All Satellites
1	Instrument/Pre-Processor	4K			NPP only
1	Instrument	110K	BDS	1/day	All Satellites
2	ERBElike/ Inversion	33K	ES-8	1/day	All Satellites
3	ERBElike/ TSA	16K	ES-9, ES-4	1/month	All Satellites
12	MOA	10K			Run monthly
4.1 – 4.4	Clouds	359K			All Satellites
4.5 – 4.6	Inversion	153K	SSF	1/hour	All Satellites
5	SARB	178K	CRS	1/hour	All Satellites
6 & 9	TISA-Gridding	43K	FSW, SFC, ISCCP-D2like-Day/Nit	60/month, 36/month, 1/month	All Satellites
11	GGEO	172K	ISCCP-D2like-GEO	1/month	Geostationary
7.2	Synoptic SARB	47K			All Satellites
7.1 & 8 10	TISA-Averaging	211K	SYN, AVG, ZAVG SRBAVG	1/day, 1/month, 1/month 5/month	All Satellites
	TOTAL LOC	1,468K			



ERB CARS Build Schedule



CERES Data Management System projected Build delivery schedule:

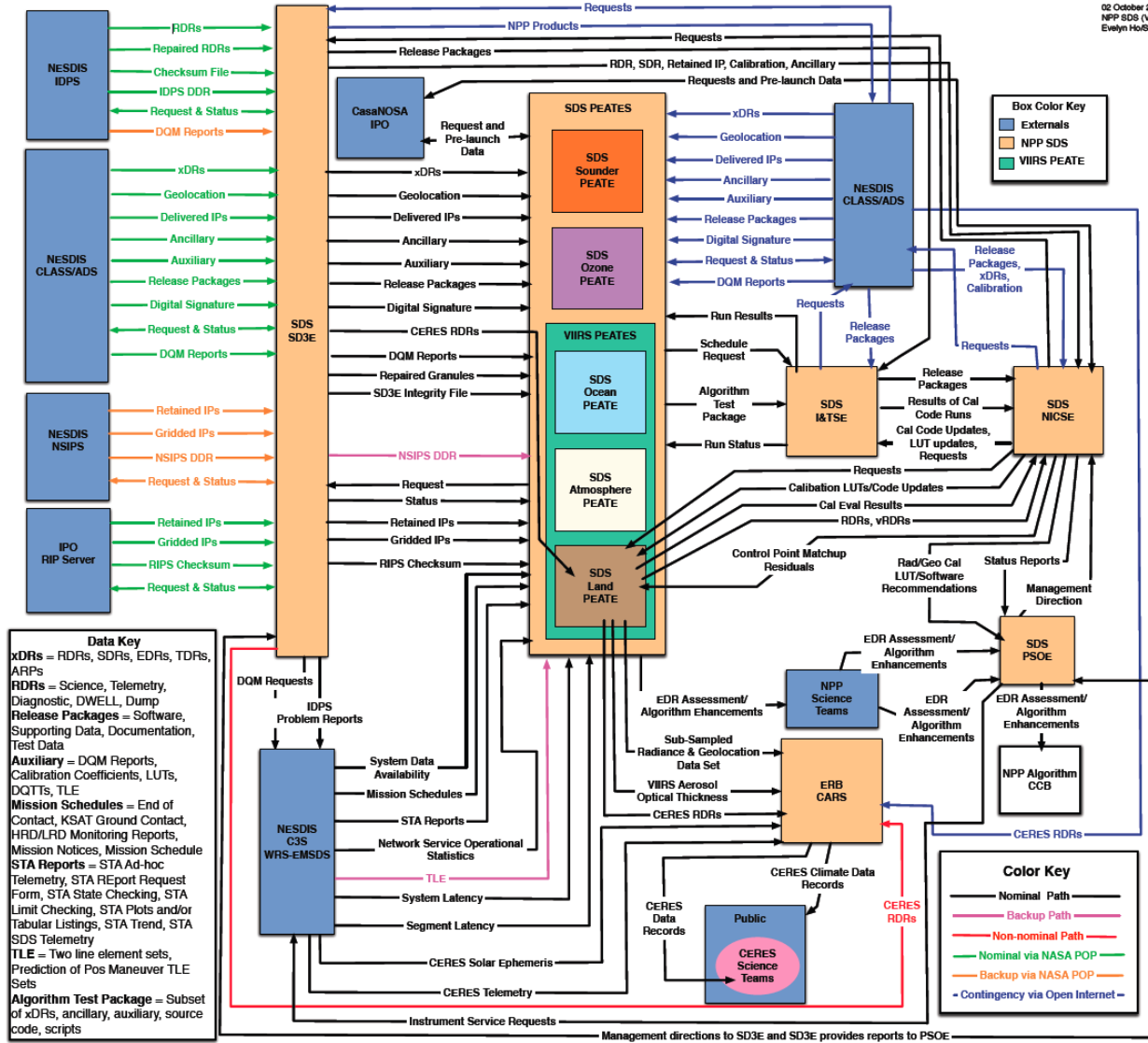
Build 1: Baseline Functionality - September 2009

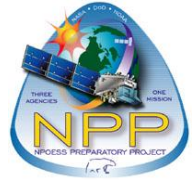
Build 2: Launch Ready Candidate, most technical requirements satisfied - September 2010

Build 3: "Soft" build for system compliance - December 2010

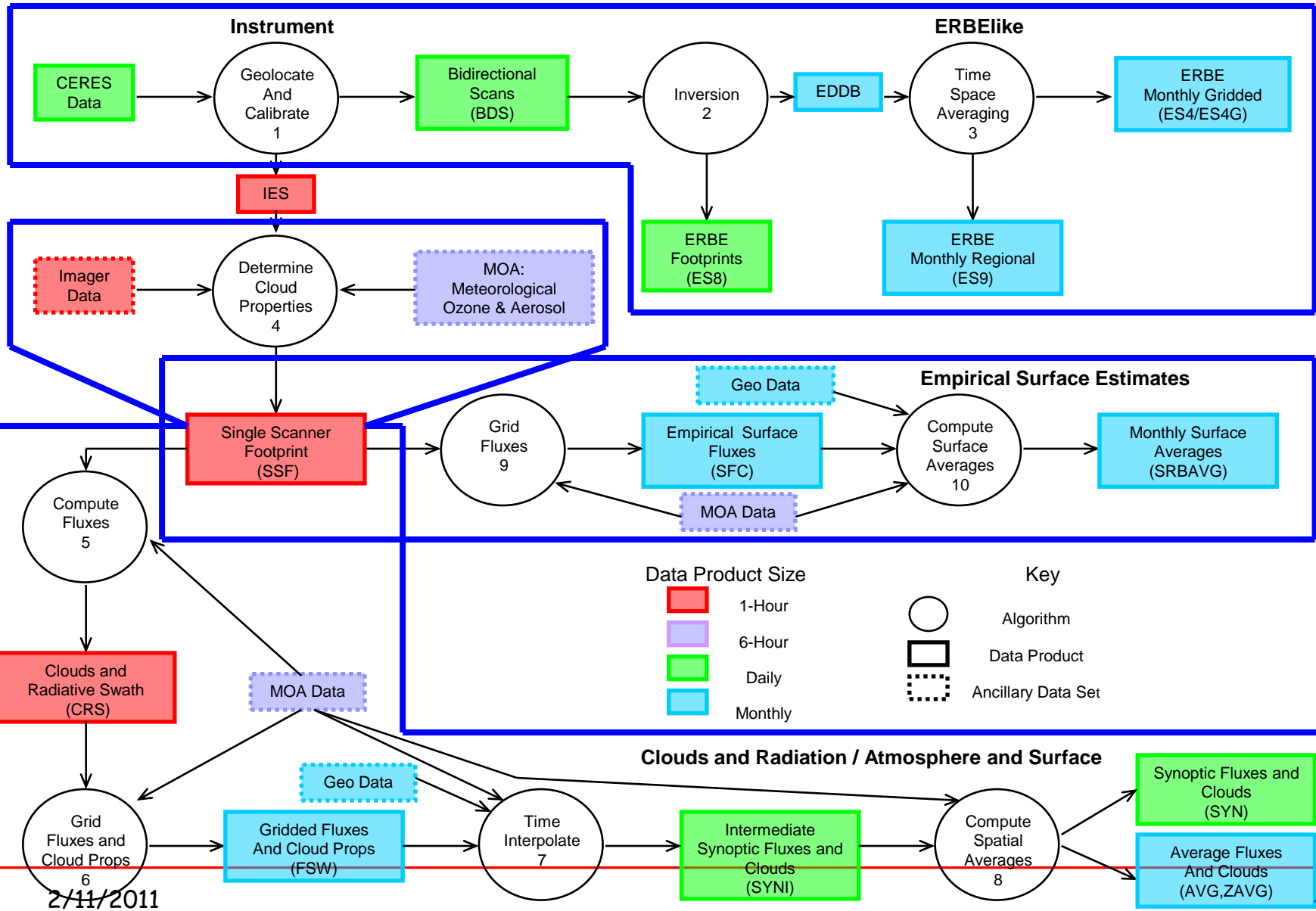
Build 4: Optional build to correct issues from NCT3 - May 2011

02 October 2009
NPP SDS (V4)
Evelyn Hurd/DOE



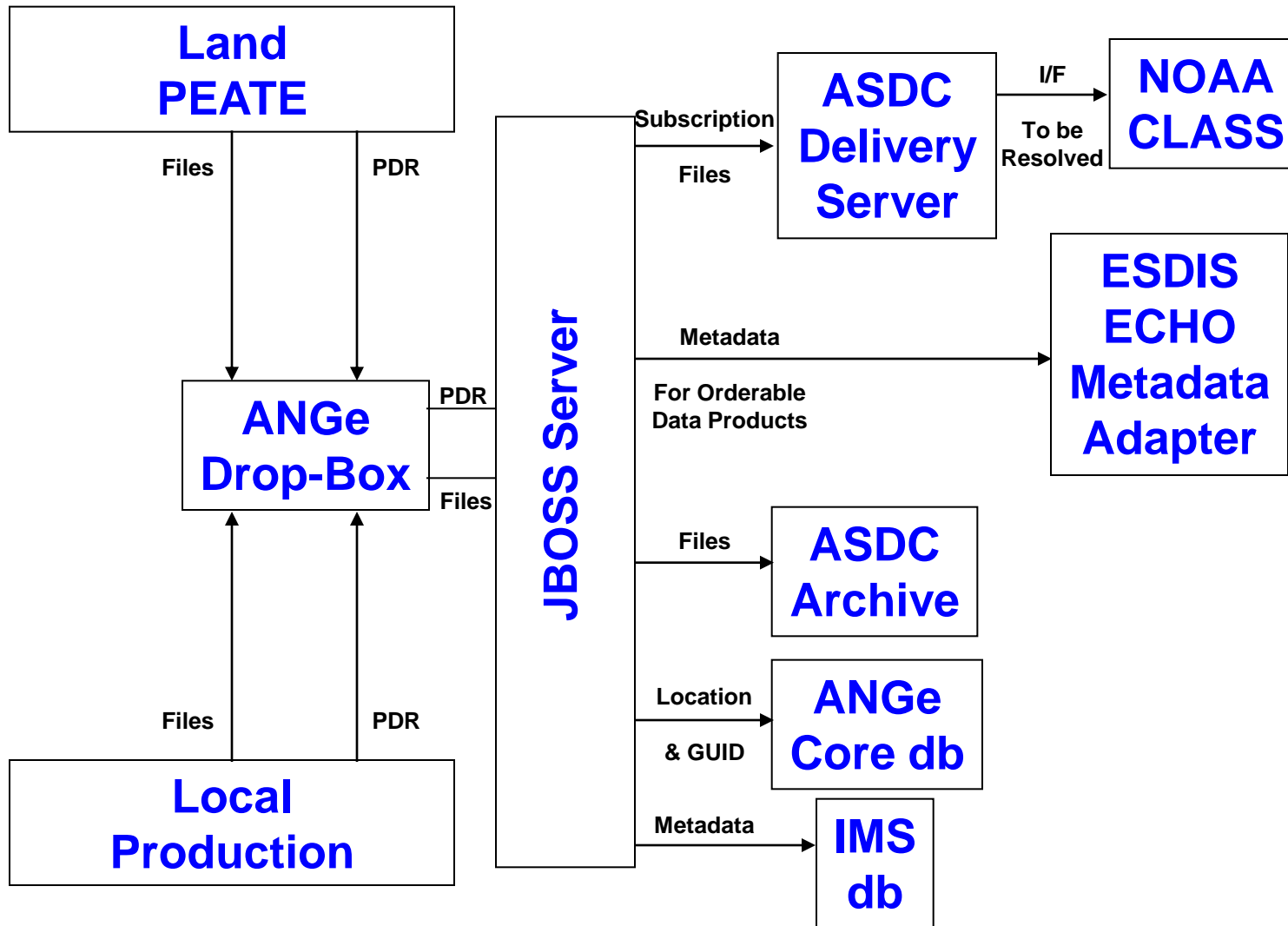


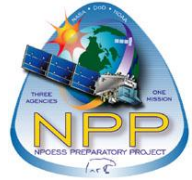
CERES Top Level Data Flow Diagram





ASDC Ingest Processes for NPP





ASDC & SCF Integrated Architecture



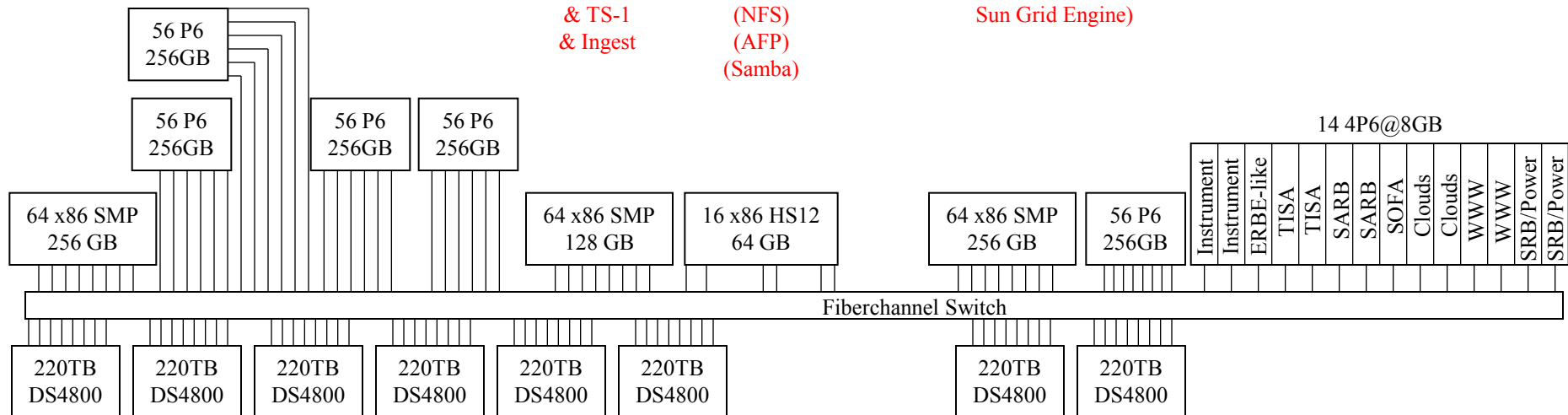
ASDC SDP Production

ASDC JBOSS Server & TS-1 & Ingest

Common SANhead (NFS) (AFP) (Samba)

SCF Cluster (Access through Sun Grid Engine)

SCF Customer Processors



ASDC Disk Archive (R/W Production) (R/O SCF)

SCF Disk Array

Archive	Common
	Drop-Box
	Delivery