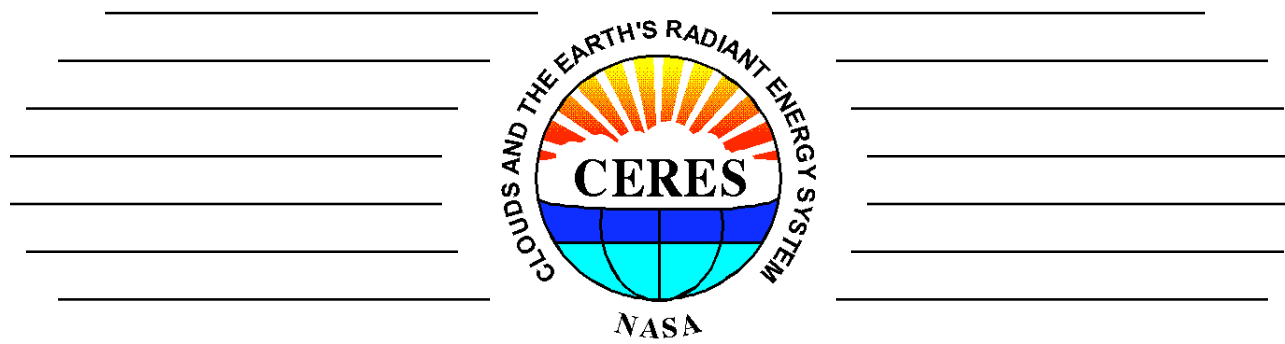




Update : CERES FM-5,6 & CERES II Terra/Aqua Edition3 Studies



Kory Priestley

CERES Science Team Meeting
Newport News, VA
May 6, 2008



NASA Langley Research Center

Atm**spheric**
SCIENCES

Instrument Working Group Personnel

Science

- Susan Thomas -
Phil Hess
Suzanne Maddock
Grant Matthews
Peter Szewczyk
Robert Wilson
(+1 tbd)

Data Management

- Denise Cooper -
- Dale Walikainen -
Lisa Coleman
Ashley Alford
Mohammad Naseer
Dianne Snyder
(+1 tbd)

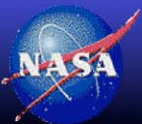
Mission Operations

- Bill Vogler -
James Bailey
Janet Daniels
Jim Donaldson
(+1 tbd)

S/C Integration & Test

- Roy Zalameda -
(+1 tbd)

Significant increases necessary to implement new FM5 and FM6 work



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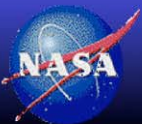


CERES Operational History

With the exception of the SW channel on the CERES/Aqua FM-4 Instrument, the CERES Terra/Aqua instruments are functioning nominally...

Spacecraft	Instruments	Launch	Science Initiation	Collected Data (Months)
TRMM	PFM	11/97	1/98	9
Terra	FM1, FM2	12/99	3/00	98 +
Aqua	FM3, FM4	5/02	6/02	71 +
NPP	FM5	June 2010	-	-
NPOESS C1	FM6A^{advanced} (Proposed)	January 2013	-	-
NPOESS C3	CERES II (Proposed)	January 2018	-	-

29 + Instrument Years of Data



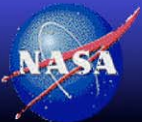
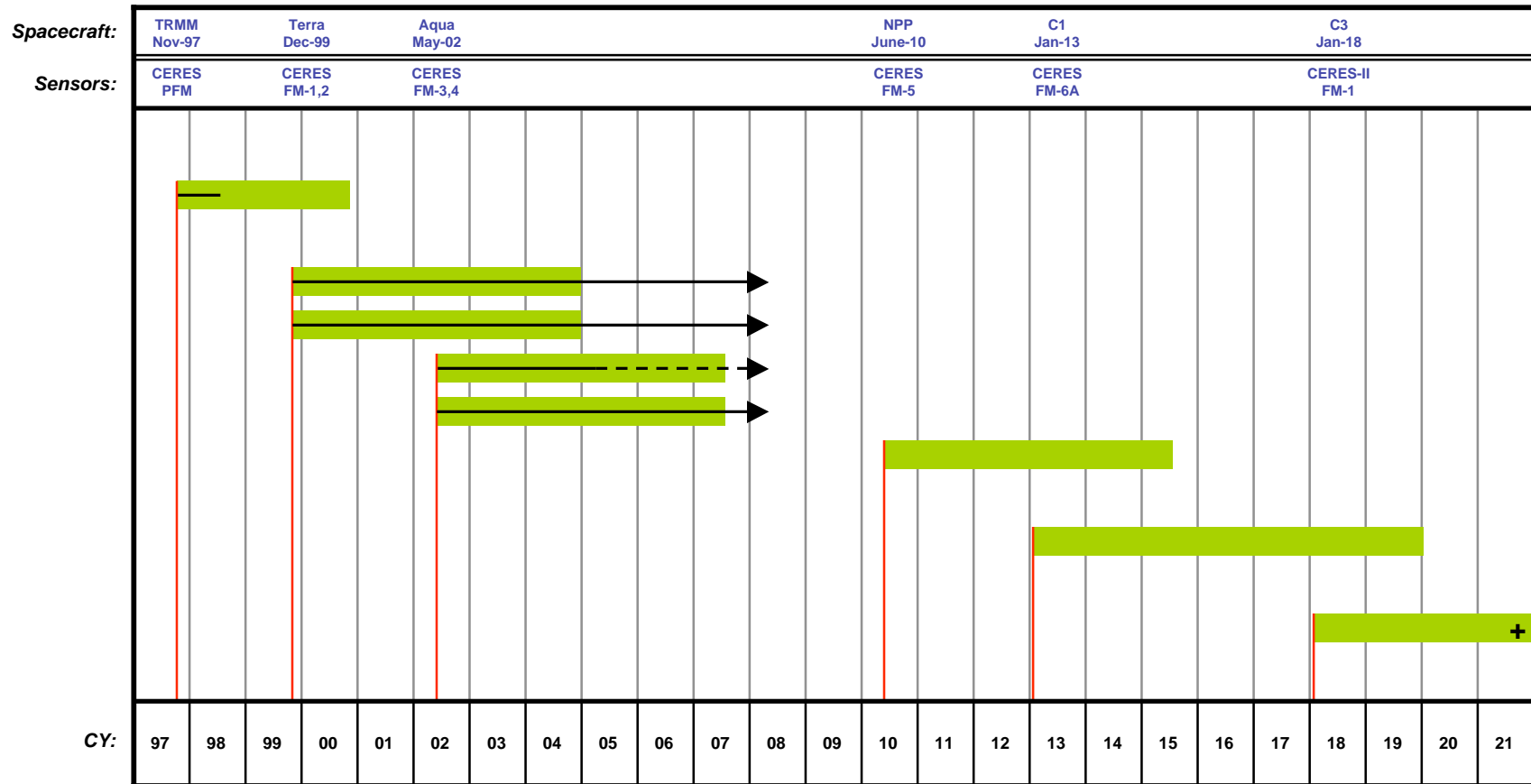
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Enabling Climate Data Record Continuity

CERES

Earth Radiation Budget Measurement Flight Schedule

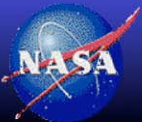
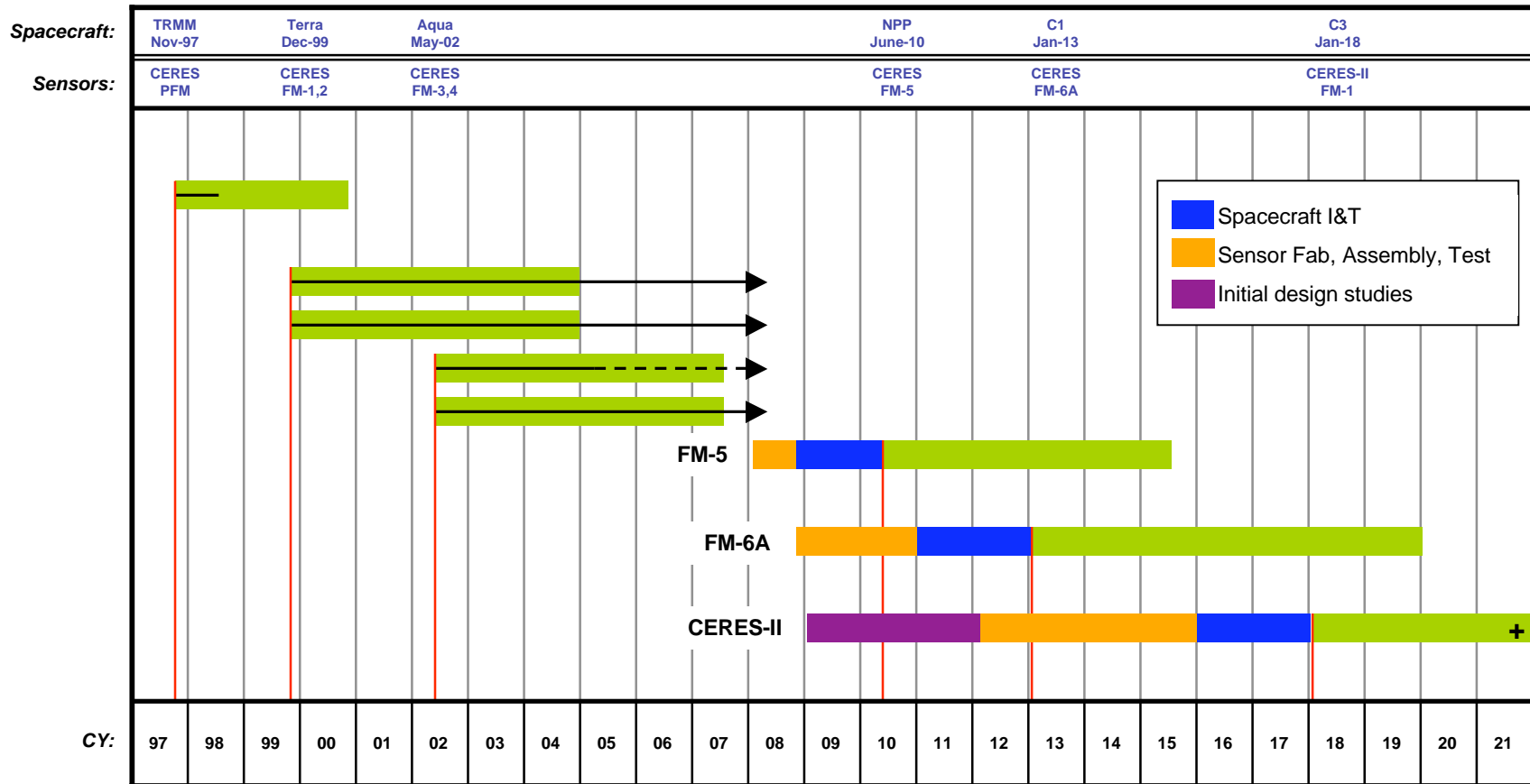


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Enabling Climate Data Record Continuity

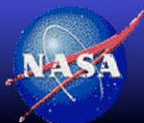
Earth Radiation Budget Measurement Flight Schedule



Key Capability Improvements

Capability	FM-5	FM-6A	CERES II
<i>Lineage</i>	As-Built	Build to Print, with modest upgrades, technology bridge	New Design
<i>Flight Software</i>	Bug fixes, minimal functionality improvements	Bug fixes, Full functionality improvements	Bug fixes, Full functionality improvements
<i>New Solar Calibration MAM</i>		Yes + enhanced screening	Yes + enhanced screening
<i>Shortwave Internal Cal Source Upgrade</i>		Minimal Spectral Capability	Multi-spectral Capability
<i>Replace 8-12 micron Channel</i>		5 - 100 Micron	5 - 100 Micron
<i>New Detectors</i>			Yes
<i>"10 km" FOV*</i>			Yes
<i>Ground Calibration</i>	Re-verify sources, revisit procedure	Re-verify sources, update procedures, upgrade data acquisition equipment, enhanced emphasis in SOW	Re-verify sources, update procedures, upgrade data acquisition equipment, enhanced emphasis in SOW

** Nominal improved FOV, final requirement set as part of CERES II instrument study

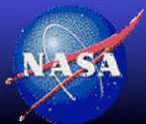
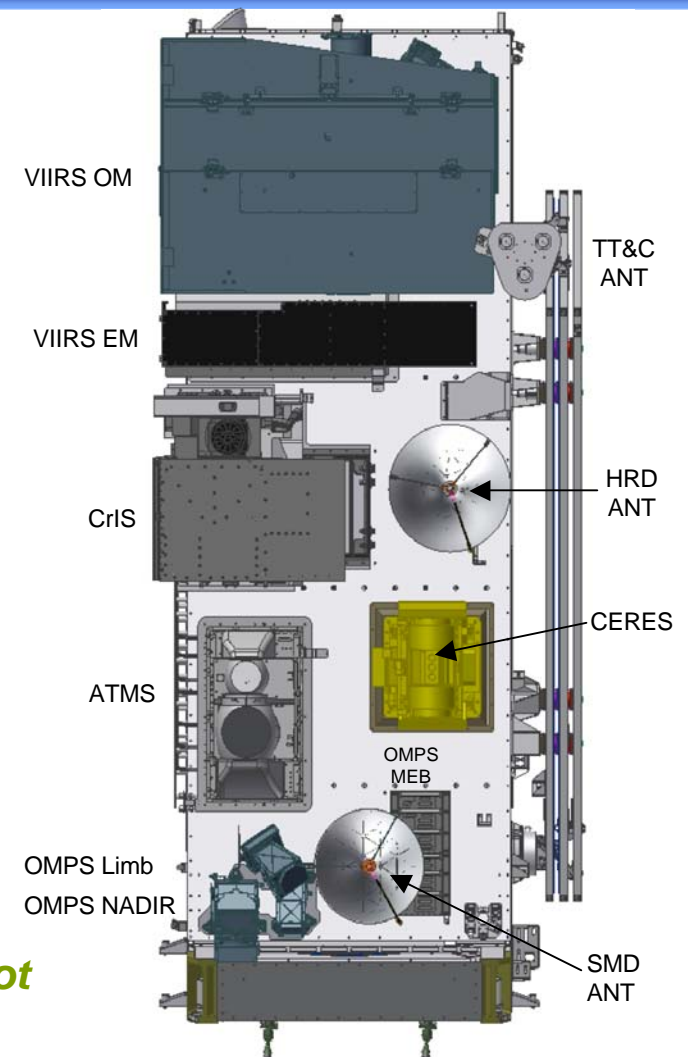


CERES Authorized for Flight on NPP

NASA HQ authorized multi-phase study in 2007 to assess feasibility of adding CERES back on NPP

- **Phase 1: Initial Feasibility Study (February – May 2007)**
 - Passed the sanity test
 - Recommended progression to Phase 2
- **Phase 2: Detailed Analysis and Engineering design (June 1, 2007 – September 14, 2007)**
 - Identified instrument, spacecraft & ground system modifications
 - No technical or schedule barriers identified
 - Results indicated CERES could be accommodated without impacting Sept. 2009 (now 6/10) Launch Readiness Date
- **Phase 3: Implement CERES Accommodation on NPP (October 15, 2007 – July 2008)**
 - Sensor ATP granted 1/23/08

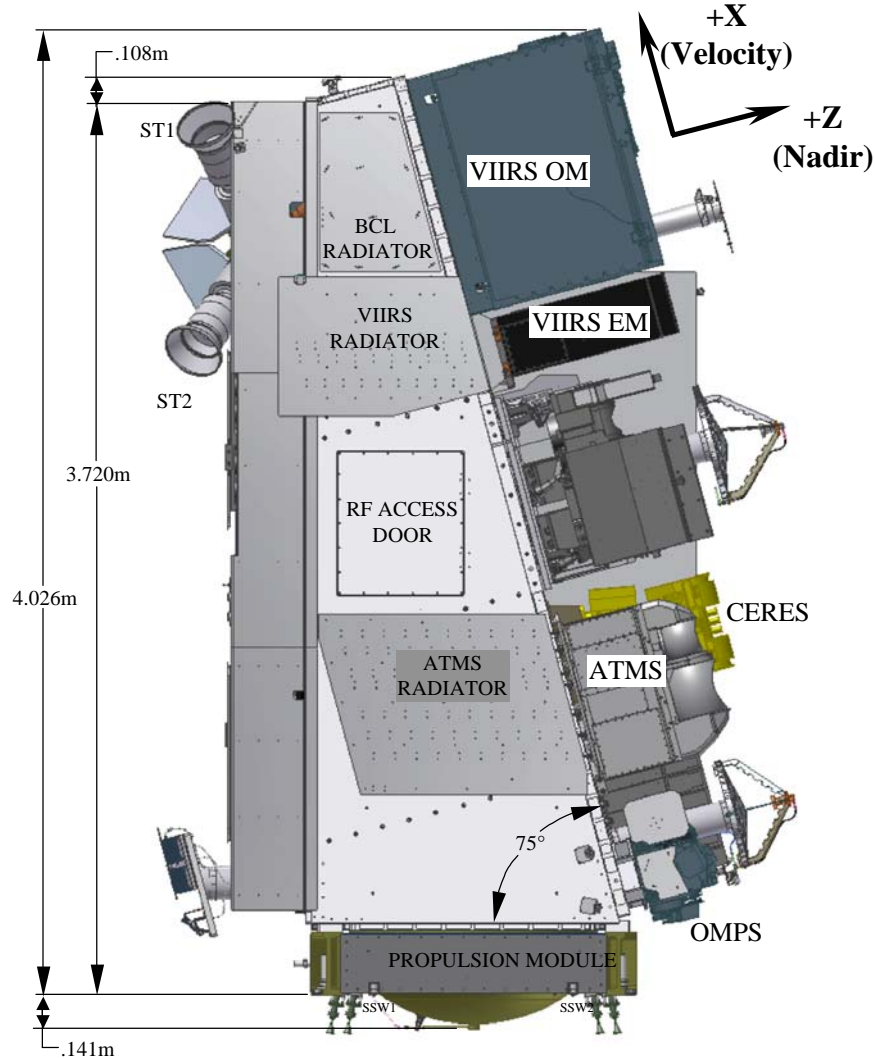
CERES originally carried as part of NPP mission but not approved at Mission Confirmation Review in Nov 03.



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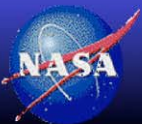


CERES Compatibility with NPP Spacecraft



Observatory Information

- Launch Readiness - June, 2010
- Location - Vandenberg AFB
- Launch Vehicle - Delta II
- Altitude - 824 Km
 - CERES FOV increases to ~ 24Km
- Inclination - Sun-Synch, 98.7-deg
- Crossing Time - 1:30pm, Ascending
- Payload -
 - CERES
 - VIIRS
 - OMPS
 - CRIS
 - ATMS

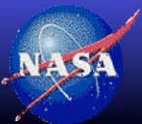


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CERES FM5 Project Scope

- **Instrument**
 - Modify, test, calibrate, and deliver CERES FM5 to NPP spacecraft vendor
 - Update electrical GSE to support instrument development
 - Support spacecraft I&T
- **Mission Operations**
 - Support MO development (NPOESS)
 - Conduct early instrument MO and calibration/validation
 - Conduct instrument MO throughout NPP mission
- **Science Algorithms and Data Processing Software**
 - Develop and maintain FM5/NPP specific algorithms
 - Develop and maintain FM5/NPP specific production data processing software
- **Data Processing, Archival, and Distribution**
 - Integrate FM5 data into the production of EOS climate data records
- **Science**
 - Conduct science studies and review all data products.

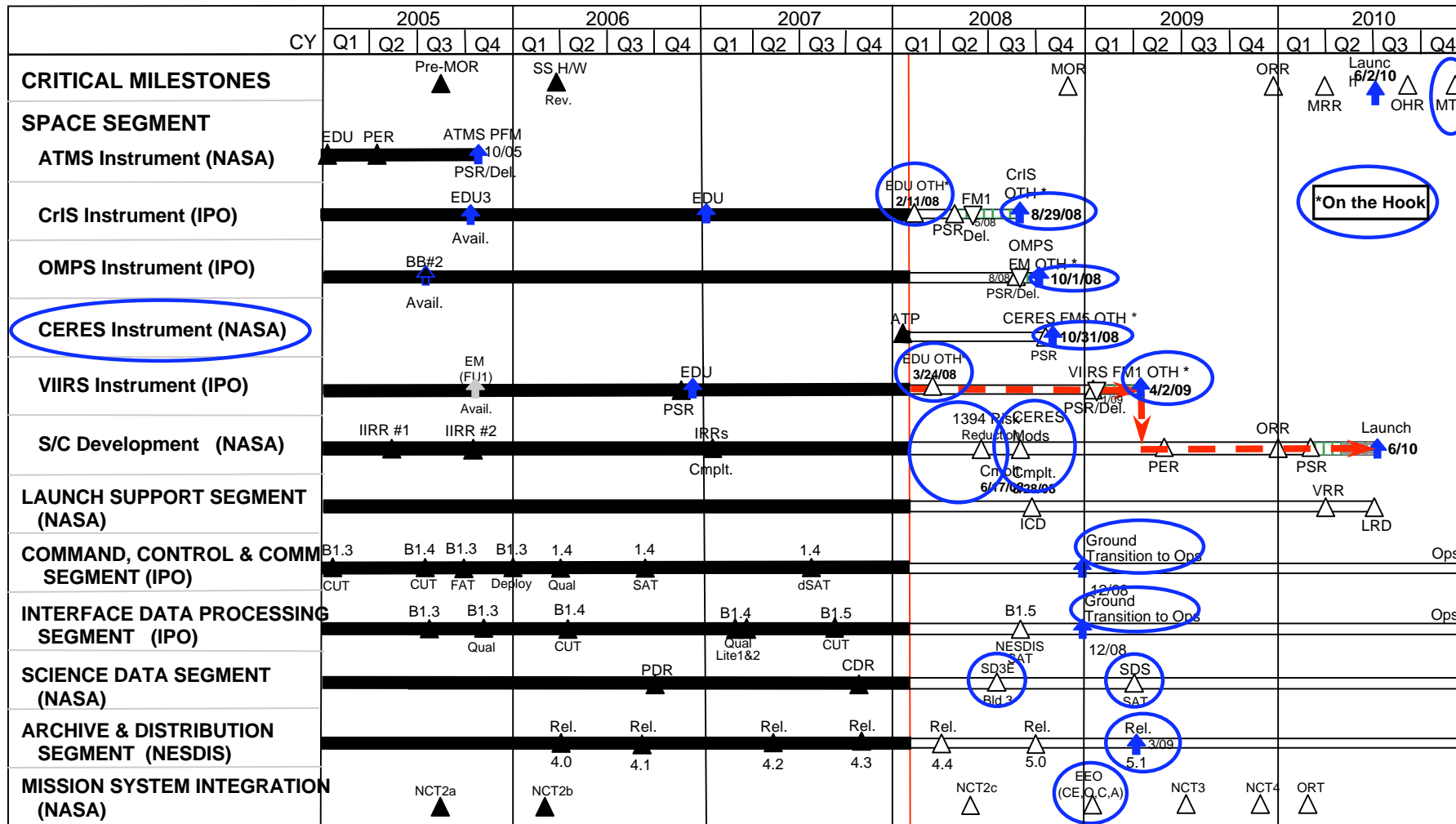


Source Data:
 NPP Schedule to Launch 2/5/08
 IPO Input as of 2/6/08

NPOESS Preparatory Project (NPP) Level 1 Joint Master Schedule

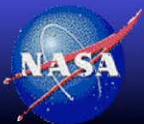
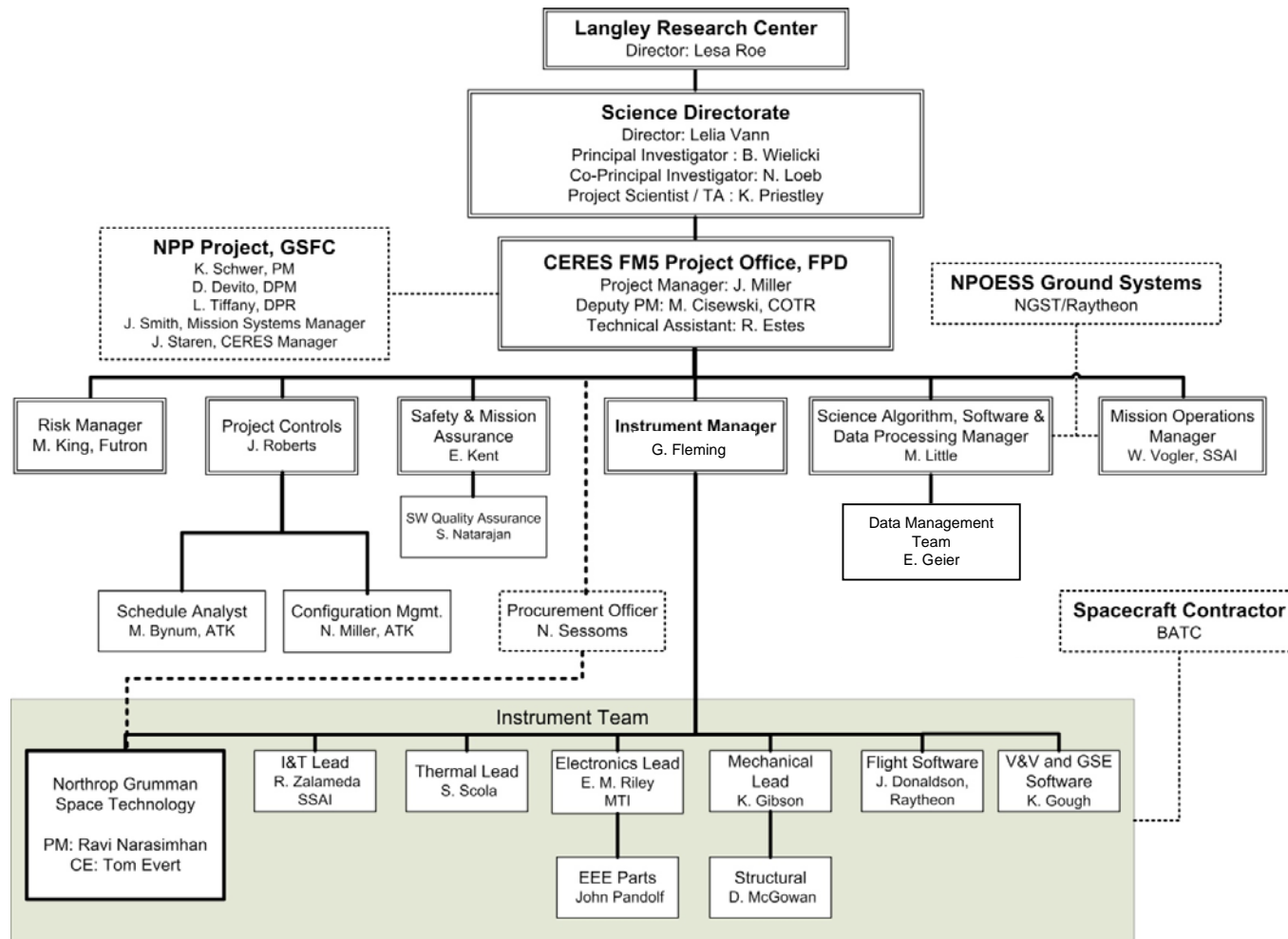
DRAFT

STATUS AS OF: 2/6/08



~ Signed 2/12/08 ~

CERES Project Organization



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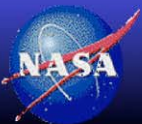
Baseline Status Review: CERES PM



Technical Milestones/Schedule

- Summary of Technical Milestones and status
 - Instrument Comprehensive Performance Test (CPT) - 3/18
 - Baseline Status Review - 3/26
 - Complete Electronics Design Update - 3/27
 - Delta Critical Design Review (CDR) - 5/14
 - Calibration Chamber Validation - 6/18
 - Complete Hardware/Software Modifications - 7/2
 - Engineering Evaluation of the Instrument - 7/15
 - Instrument Comprehensive Performance Test (CPT) - 7/28
 - Ground Systems Delta Design Review - 8/1 tbd
 - Pre-Environmental Readiness Review (PERR) - 8/2
 - Test Program Complete - 10/3
 - Pre-Ship Readiness Review (PSRR) - 10/20
 - Deliver sensor to Ball - 10/31

Note - Green Indicates completed tasks
All Dates are completion dates

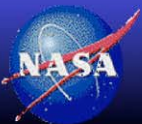


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CERES FM5 Schedule

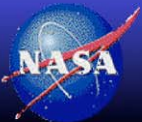
- **Delivery/on-the-hook date to NPP Spacecraft is October 31, 2008**
- **NPP Launch Readiness Date is currently June 2, 2010**
 - Initial NPP launch date was mid-2006
- **CERES FM5 schedule is tough however,**
 - We've had a "jump start" contract in place that's allowed work on critical path areas bridging delay in ATP
 - Initiated a unilateral modification of the CERES contract (bilateral agreement with NTE), signed by LaRC Center Director on 2/5/08, allowing NGST to move forward while final contract negotiations take place.



What is the impact of 8-years of storage?

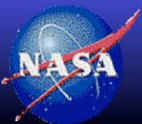
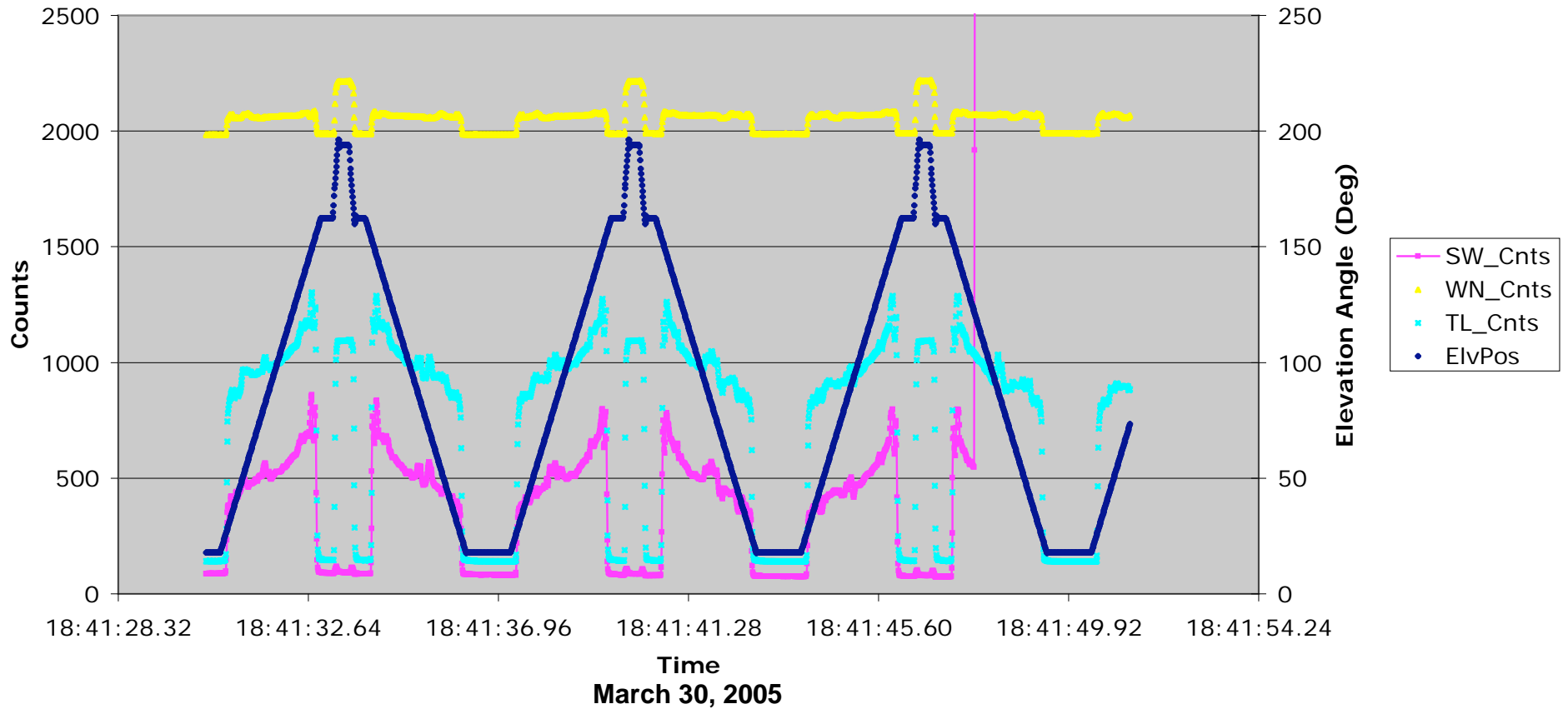
Key Concerns are being addressed :

- **Review of Electronic parts for age and radiation environment**
 - NPP Orbit provides different radiation environment
 - Parts Review underway
 - No significant concerns identified
- **Limited Life articles**
 - Bearing lubrication
 - N₂ purged storage environment was optimal
 - No concern for limiting lifetime
 - Onboard Calibration lamps
 - No known mechanisms to reduce life expectancy
- **Address on-orbit anomalies from Terra/Aqua**
 - FM4 SW channel Sensor Electronics Assembly failure
 - Tiger Team reconstituted
 - 90 years of operational lifetime on circuit with one failure
 - Awaiting Recommendation



CERES/Aqua FM-4 SW Anomaly Onset

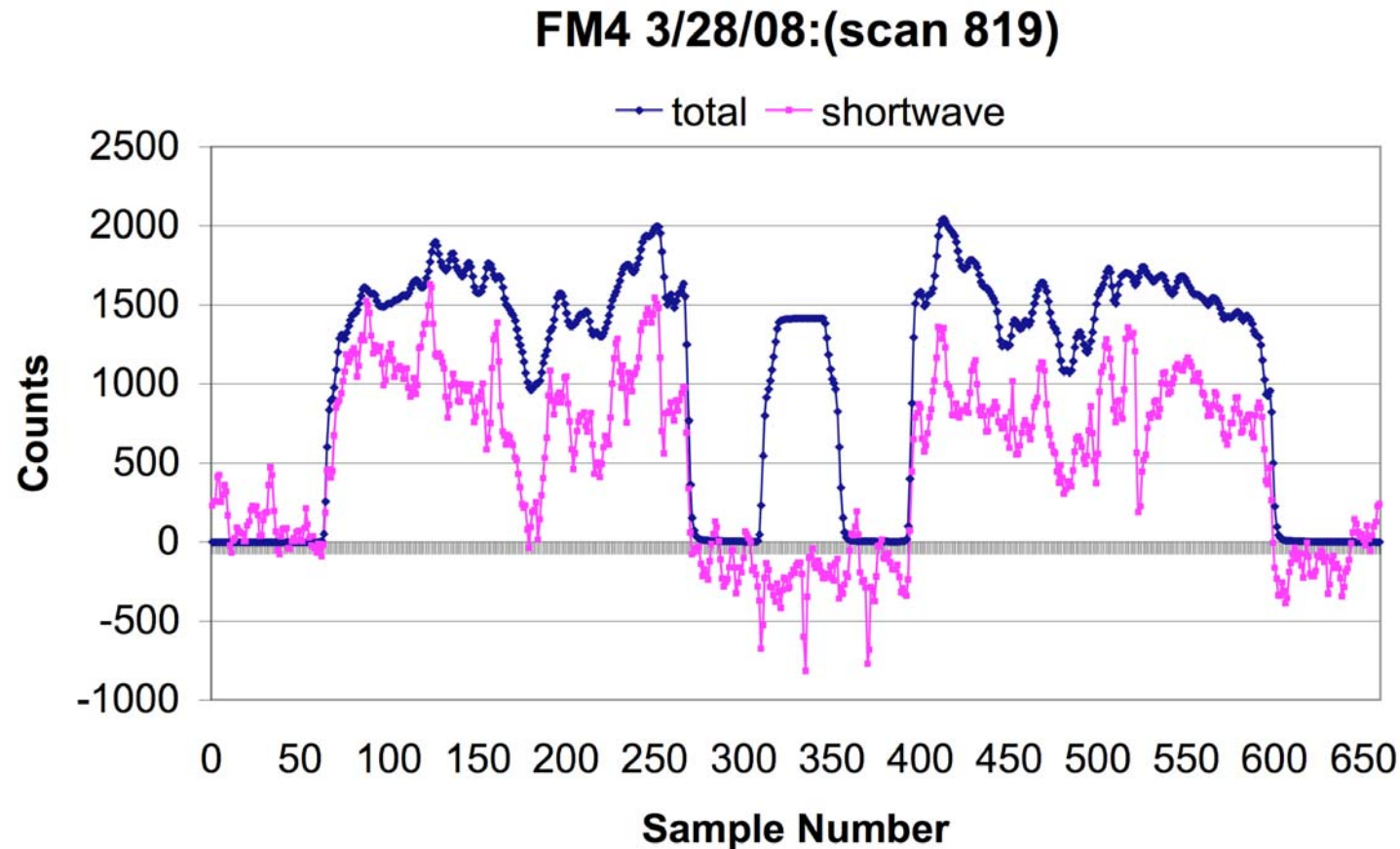
FM4 Raw Detector Counts



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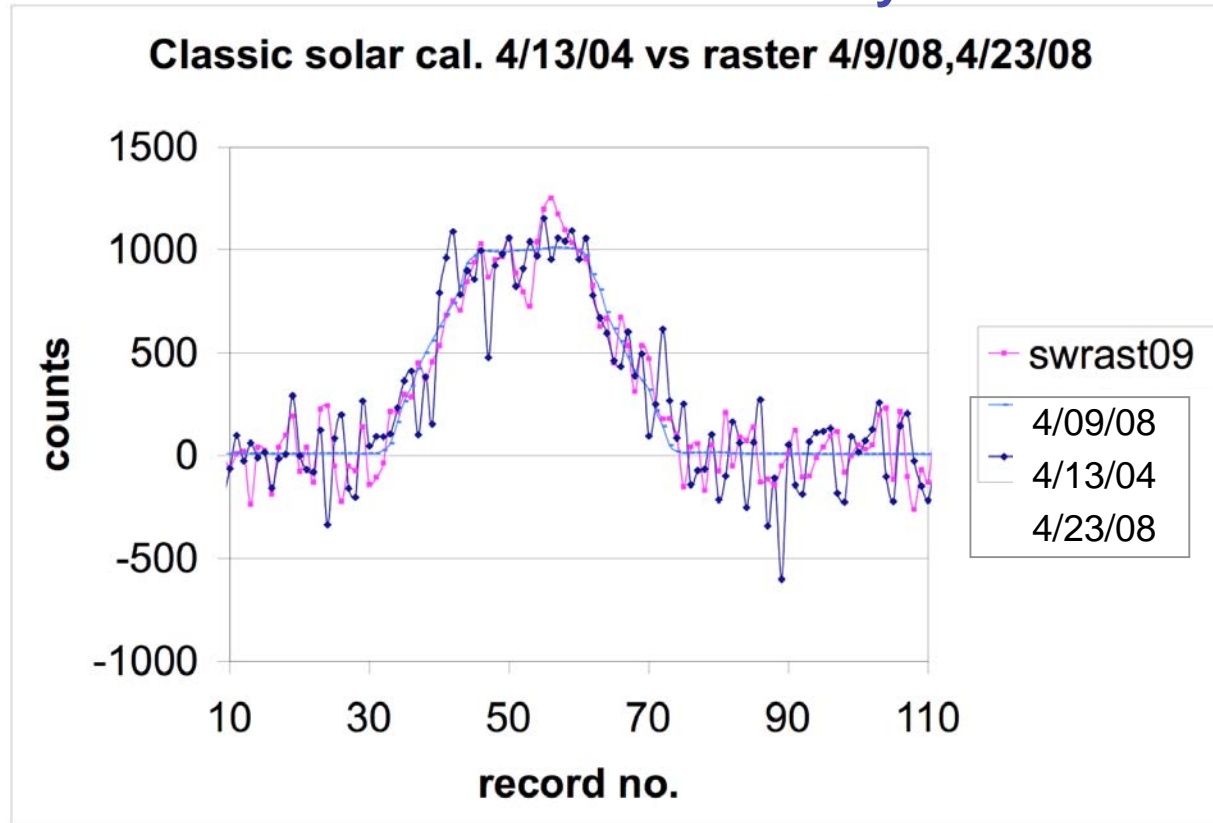
FM4 SW Channel Anomaly - April 2008 Status



No measurable change in radiometric gain
Sensor noise increased from 1-count to 100 counts one sigma

FM4 SW Channel Anomaly - April 2008 Status

Comparison of Solar Calibration Sequences Pre and Post Anomaly

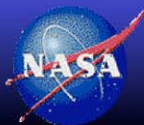


***No measurable change in radiometric gain
Sensor noise increased from 1-count to 200 counts one sigma***

Terra/Aqua Edition2 Status

Spacecraft	Product	Version	Available	Months Processed
TRMM	BDS	Edition1	Yes	1/98 - 8/98 , 3/00
	ERBE-Like	Edition1	Yes	1/98 - 8/98 , 3/00
		Edition2	Yes	1/98 - 8/98 , 3/00
Terra	BDS	Edition1	Yes	2/00 - present
		Edition2	Yes	2/00 - 12/07
	ERBE-like	Edition1	Yes	2/00 - present
		Edition2	Yes	2/00 - 12/07
Aqua	BDS	Edition1	Yes	6/02 - present
		Edition2	Yes	6/02 - 12/07
	ERBE-like	Edition1	Yes	6/02 - present
		Edition2	Yes	6/02 - 12/07

Note: Red text indicates months are in final validation prior to public release.



Terra/Aqua Edition3 Studies

Goal : characterize sensor radiometric stability by operational mode

- Characterize trends by Xtrack and RAPS mode, not by sensor

Methodology

Sort Clear Ocean (ClrOcn) and Deep Convective Cloud (DCC)unfiltered SW radiance measurements into Angular bins (I.e. VZA and RAZ)

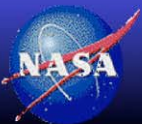
Determine monthly mean SW measurements for each bin

Calculate deseasonalized anomalies for each time series

Trends in ClrOCn and DCC deseasonalized anomalies define drops in spectral throughput at 0.4 and 0.65 microns respectively

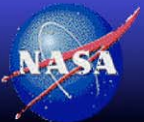
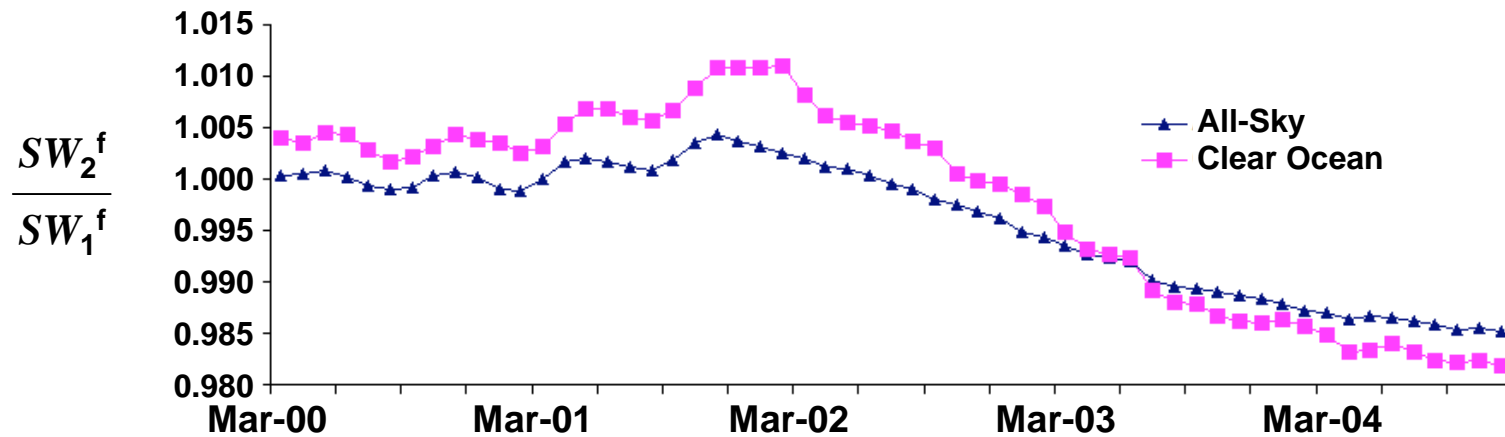
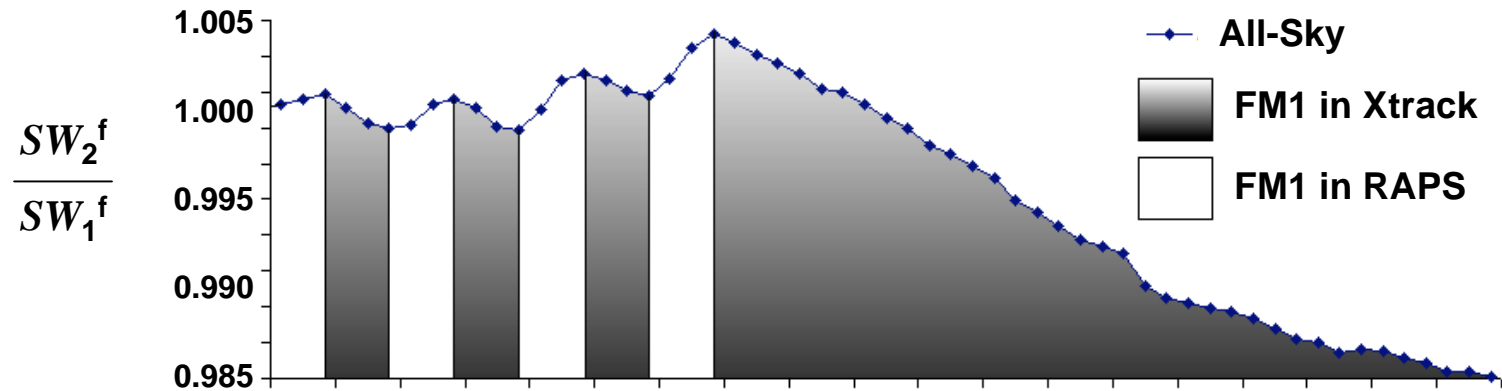
DCC directly

ClrOCn, relative trend of RAPS to Xtrack measurements



Terra Edition2 Nadir Direct Comparison

SW Nadir Radiances

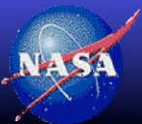


Terra/Aqua Edition3 Studies

New Approach based upon operational mode

Assumptions:

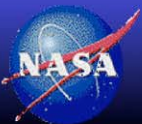
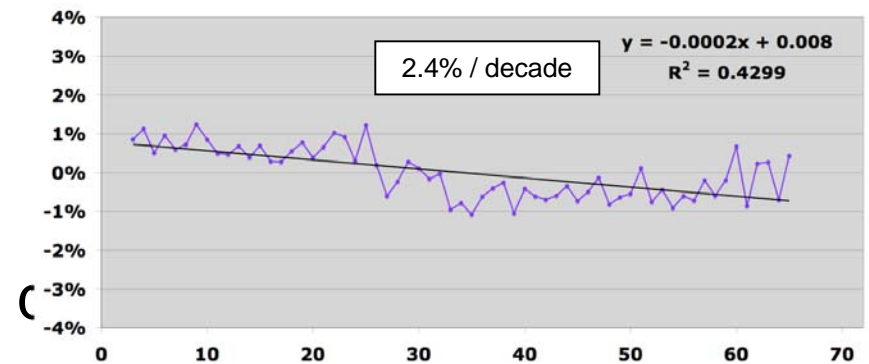
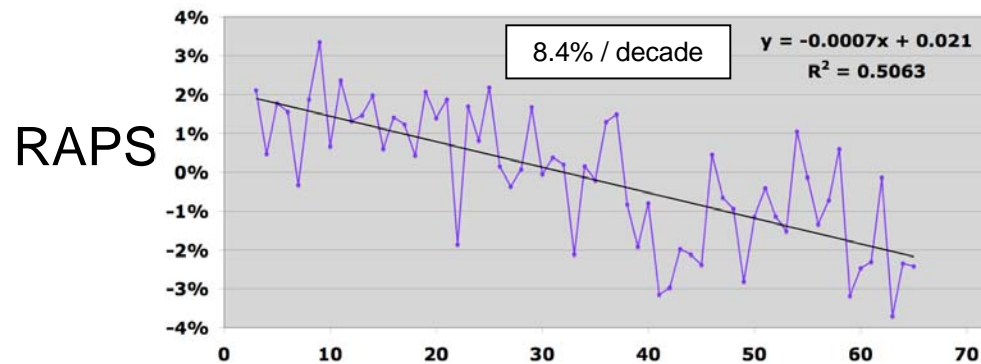
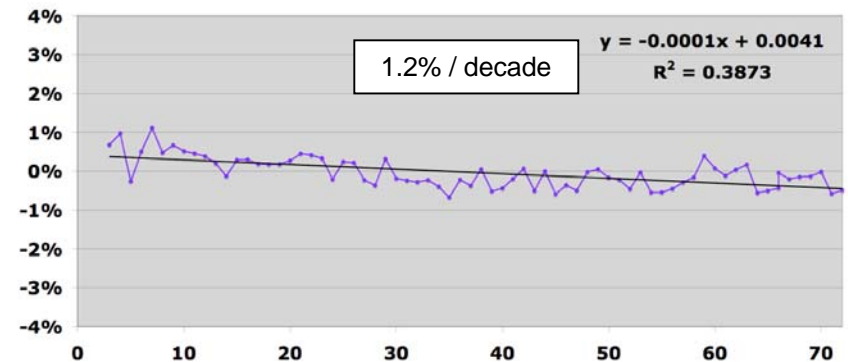
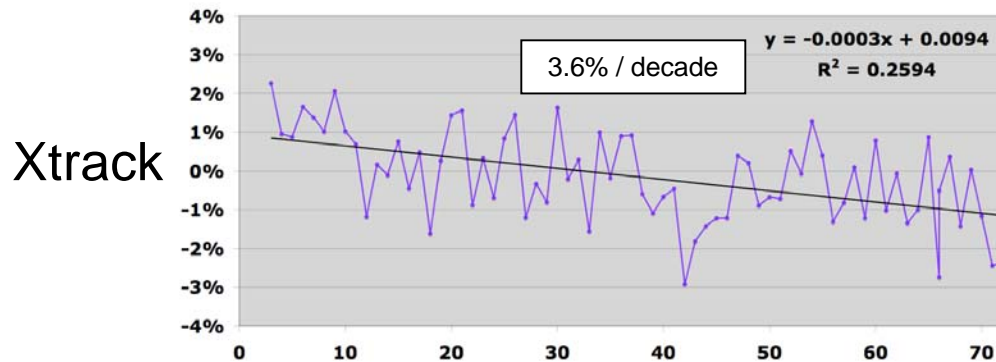
- Degradation is separable by operational mode
- SWICS Level 1 sensor response Indicates gain change exclusively
- SWICS Lamps are stable
- Temporal trends are linear in time - sufficient to remove gross trends
- Spectral change is isolated to be below 1-micron
- DCC provides an absolute stability metric
- ClrOcn provides a relative stability metric (RAPS relative to Xtrack)
- Trends are independent of VZA, RAZ bin used
- 0.4 micron is the weighted mean wavelength for Clear Ocean spectra
- 0.65 micron is the weighted mean wavelength for Deep Convective Clouds



Deseasonalized SW Anomalies

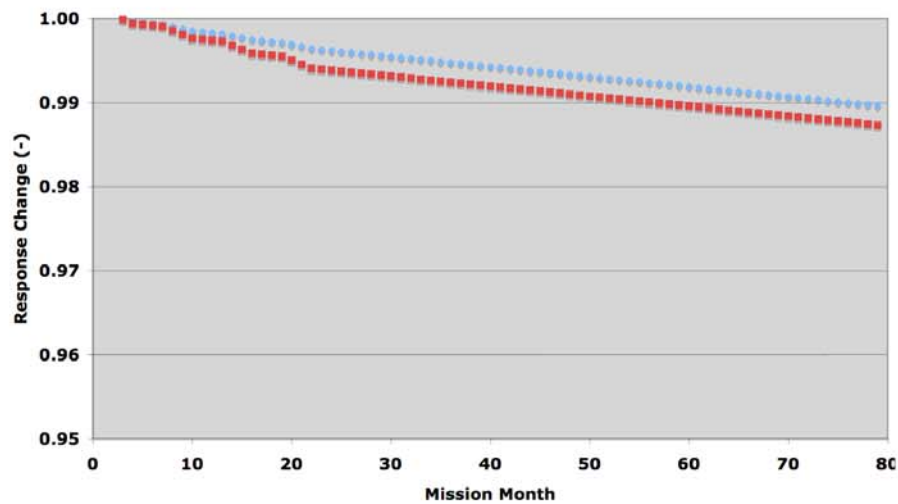
ClrOcn

DCC

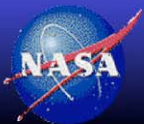
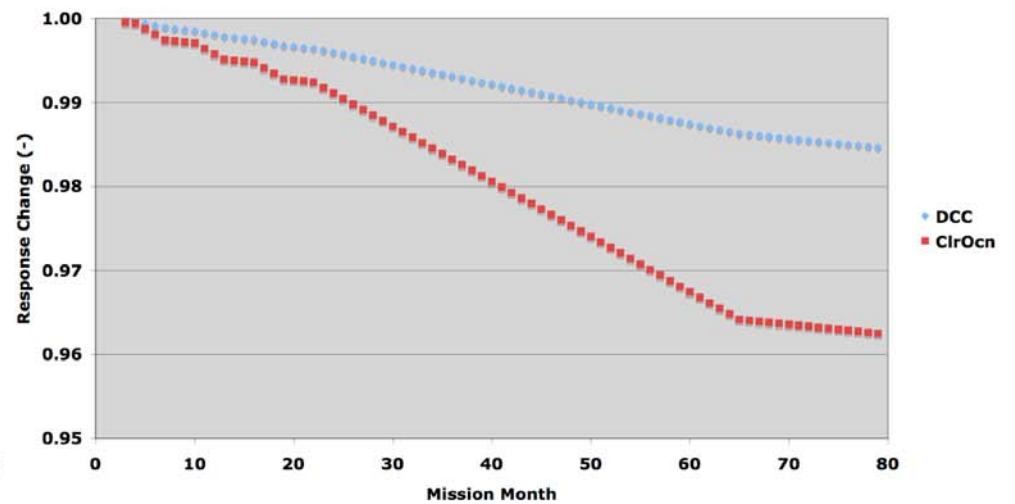


Spectral Drop for ClrOCn and DCC

FM1



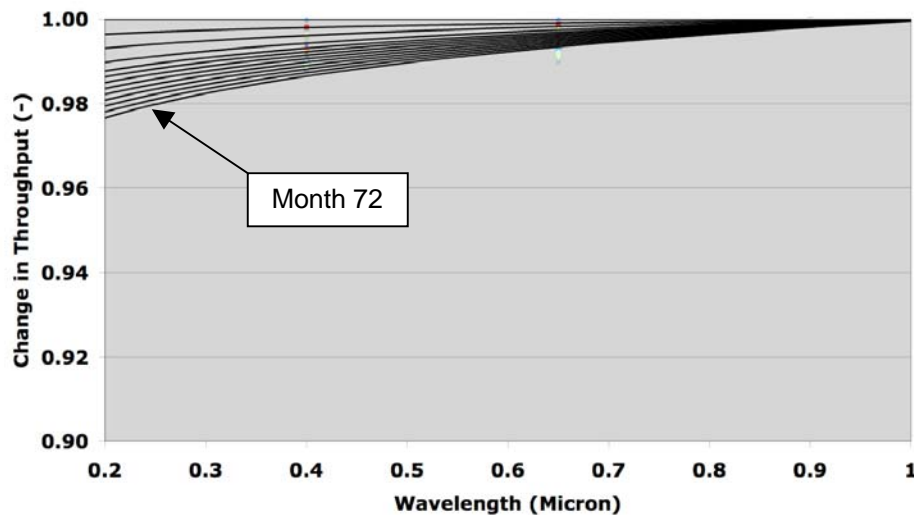
FM2



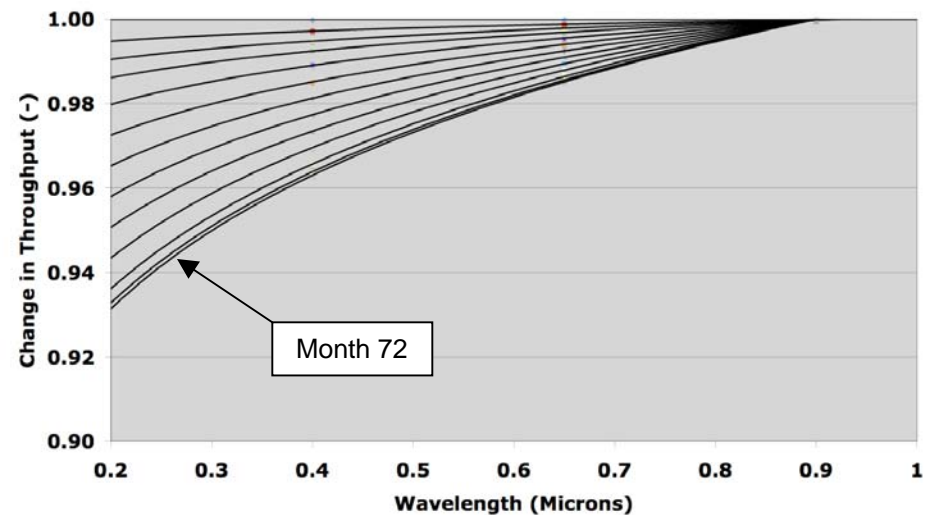
Spectral Response Degradation

Fit an exponential curve through the ClrOcn and DCC effective wavelengths of 0.4 and 0.65 microns on a monthly basis.

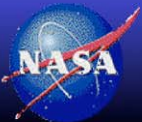
FM1



FM2



Note: Results shown for 6 month centers

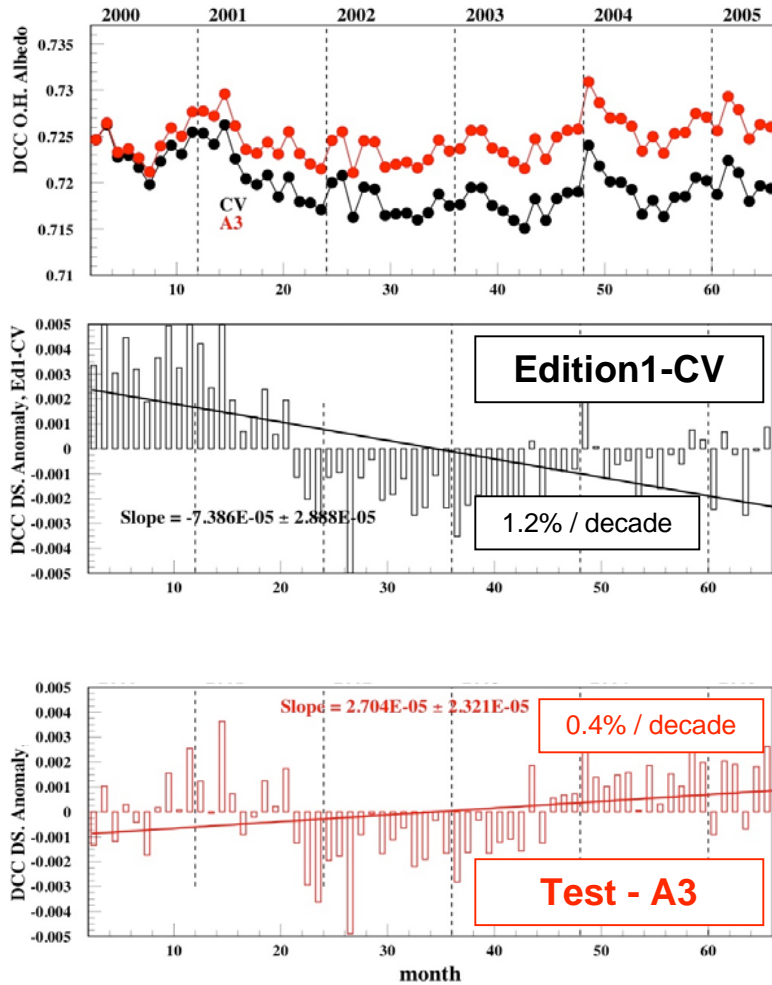


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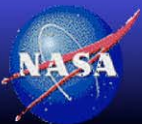
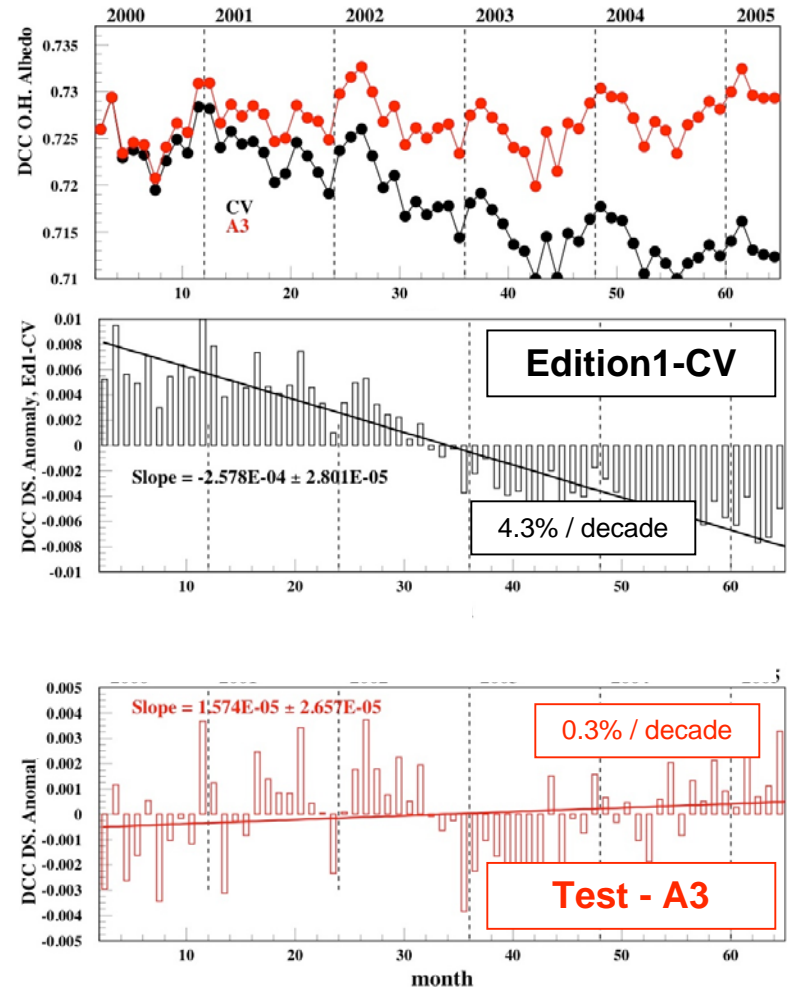


Terra - Deep Convective Cloud Albedo

FM-1

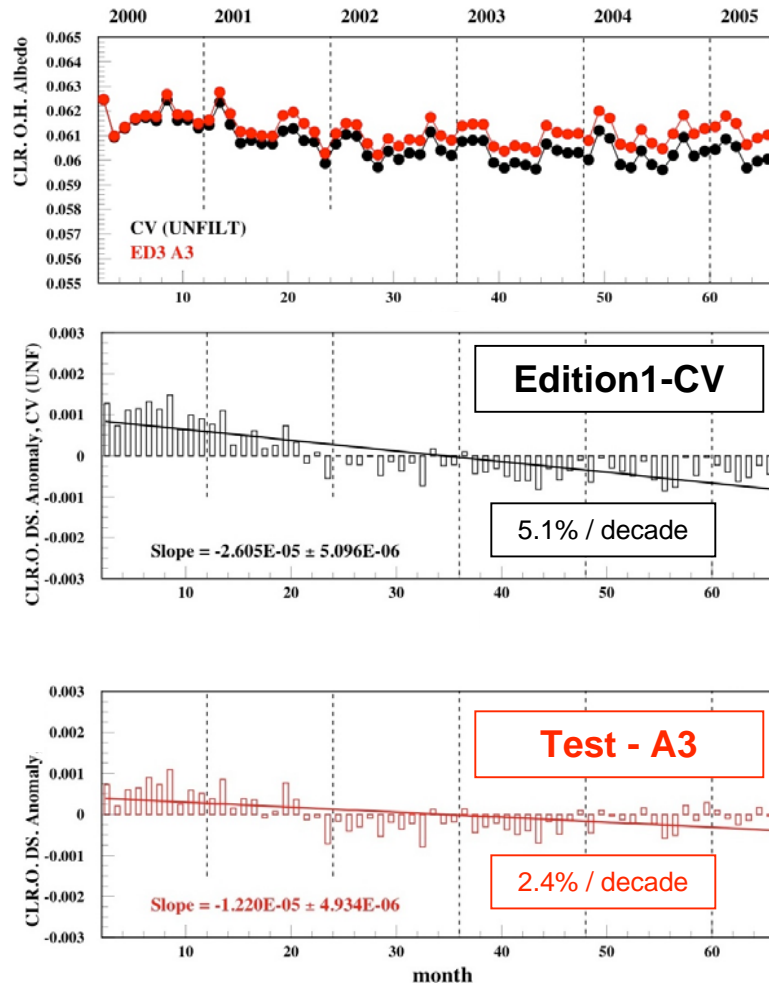


FM-2

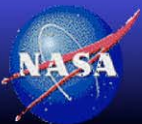
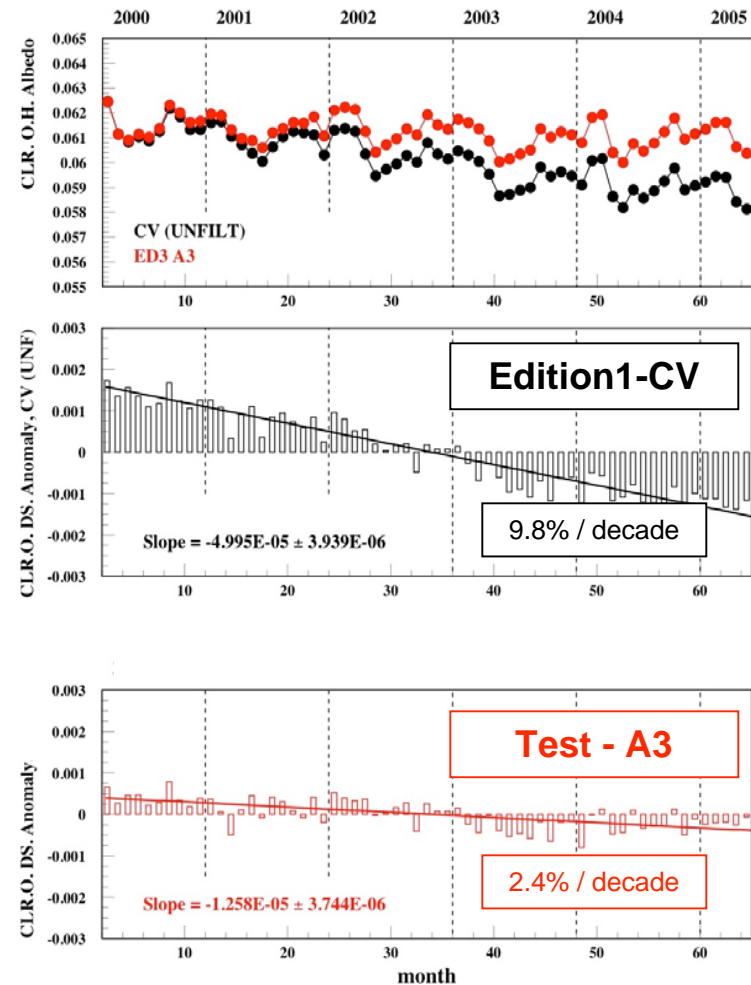


Terra - Clear Ocean Albedo

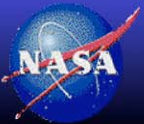
FM-1



FM-2



Back-up Slides

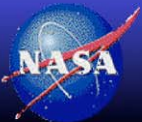
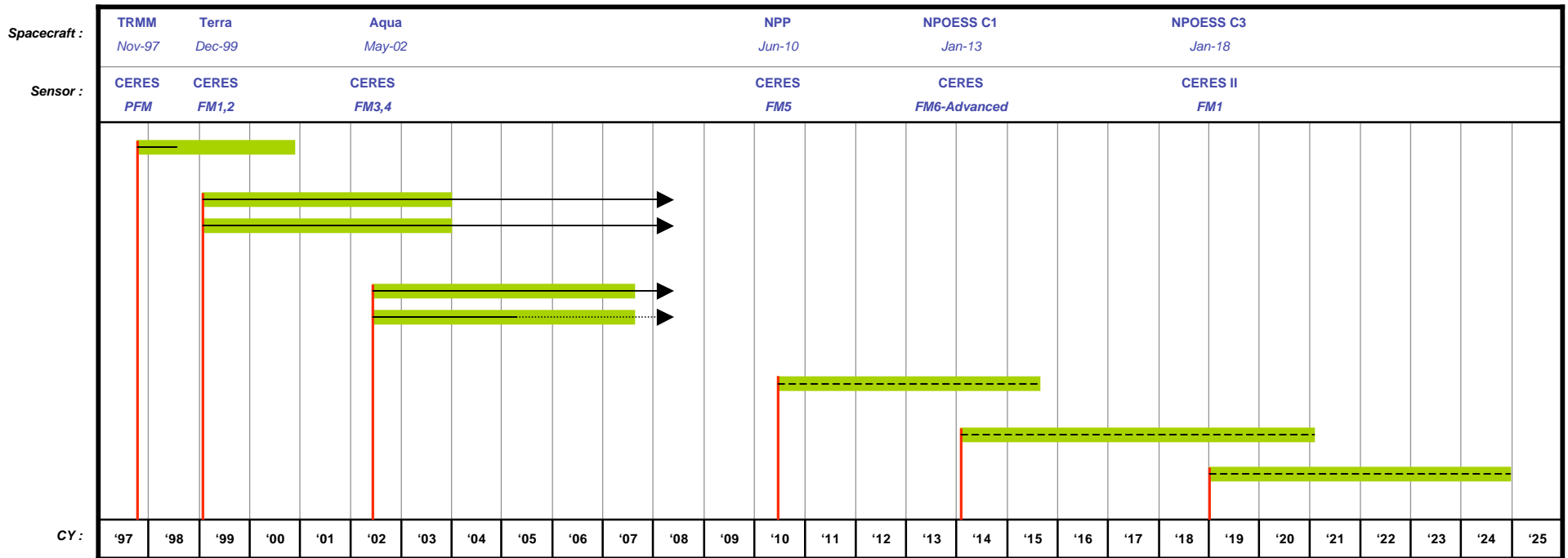


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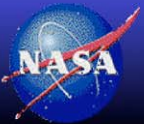
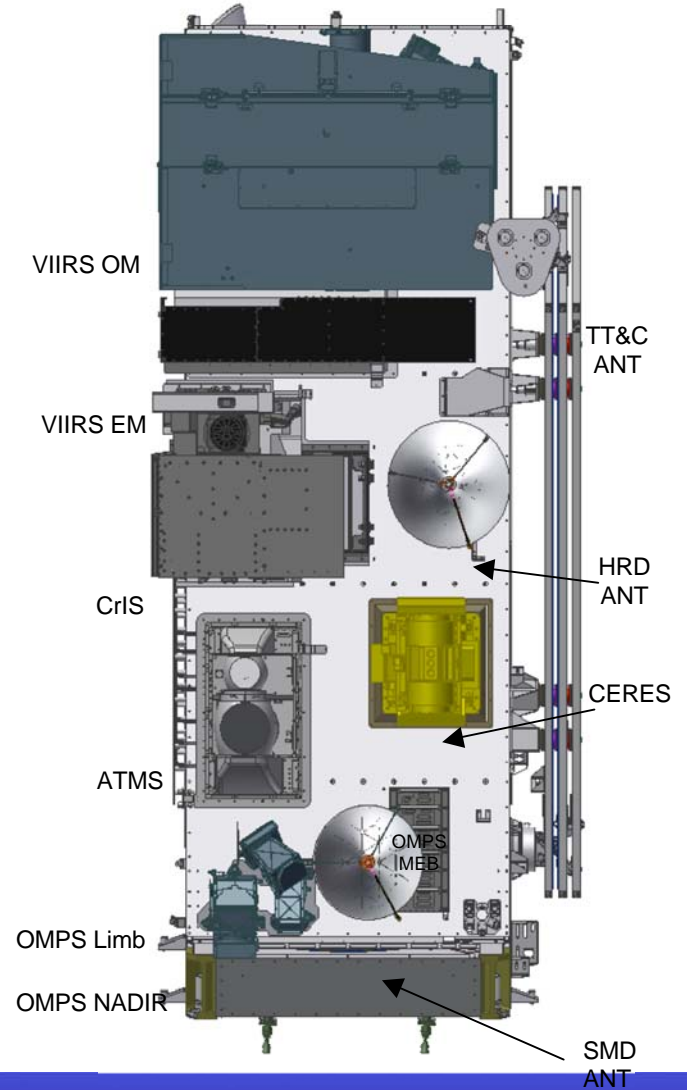
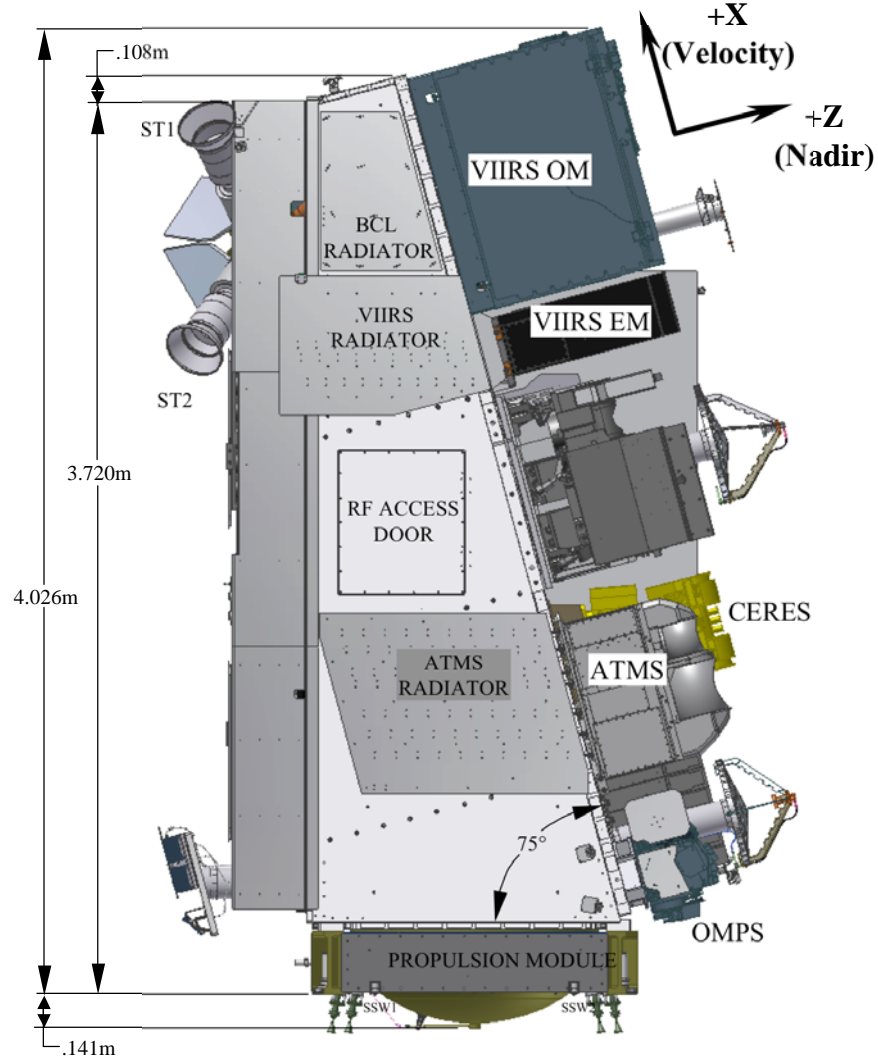


Climate Data Record Continuity

Earth Radiation Budget Measurement Flight Schedule



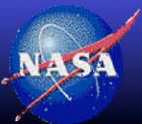
NPP S/C Layout - 1



CERES FM5 Tasks

CERES FM-5 is a Complete and Fully Functional Instrument

- **Instrument**
 - Modify flight software to incorporate fixes for all known bugs and patches demonstrated on the 5 operational units
 - Modify scan tables to accommodate higher orbital altitude
 - Minor data format changes (Header, APID, LEO&A packet)
 - Add “IMOK” functionality for missing time messages (12)
 - Waiver for programmable number of missing time messages
 - Review of electronic parts for age and radiation environment
 - Spot shield as necessary
 - Modify heritage Terra/Aqua Time Mark & Frequency interface for compatibility with NPP/NPOESS Time of Day pulse
 - Bypass discriminator circuit on spacecraft interface board
 - Add additional radiator surface
 - Update thermal and structural analysis to support NPP interface
 - Test and calibrate instrument



CERES Top Level Data Flow Diagram

