"The NPOESS Preparatory Project - NPP

Combining Operational and Climate Satellite Measurements

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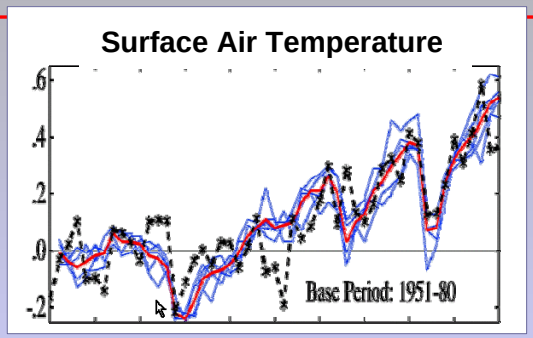
Time Series Data to Reveal Global Change

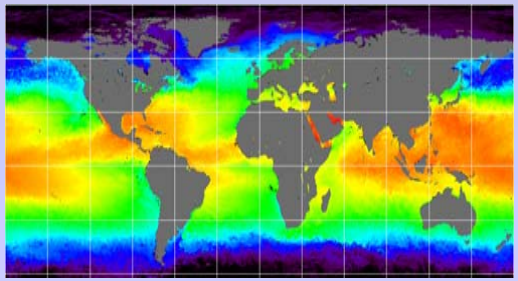
Satellites: POES → EOS → NPP → NPOESS

How is the global Earth system changing?

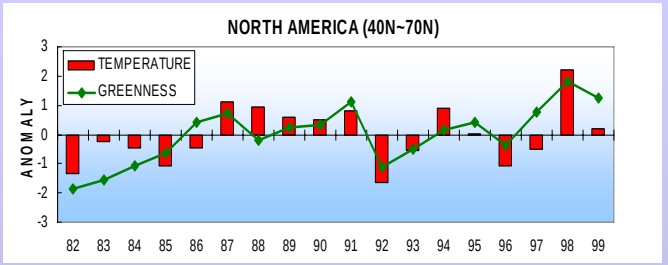
- atmospheric temperature and moisture profiles
- variability in ocean color and temperature
- vegetation productivity patterns



Atmospheric Sounding

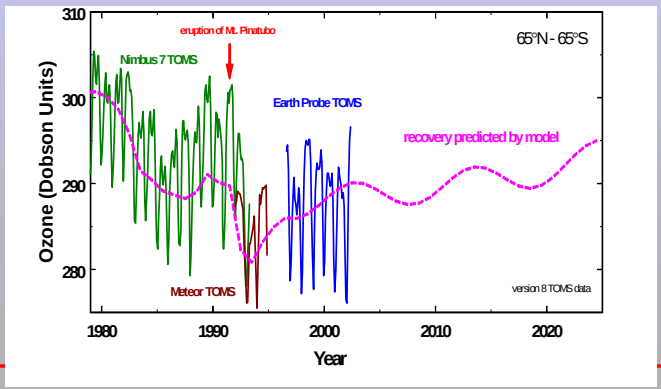


Multispectral Imaging / Surface Biophysical Properties



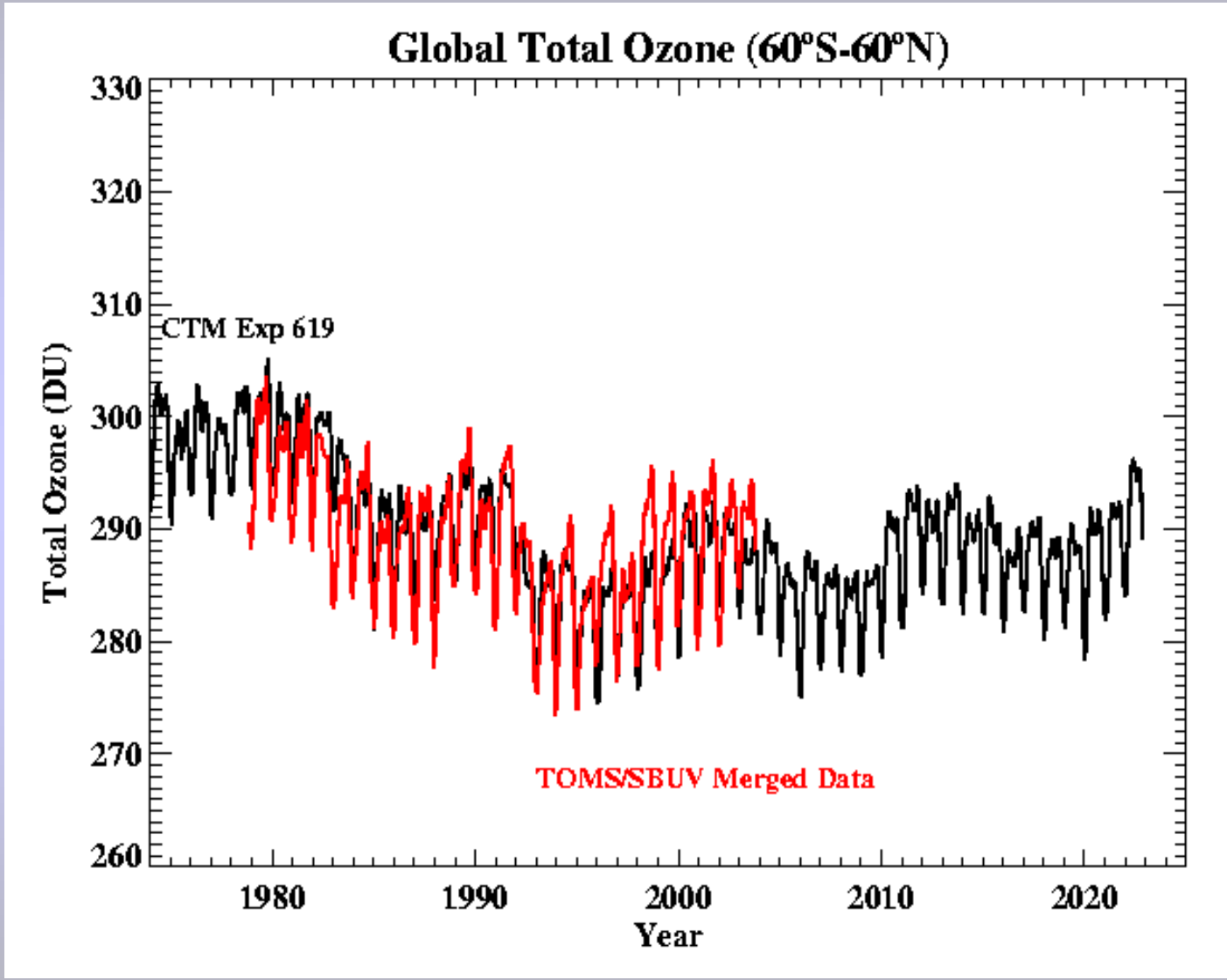
How does the Earth System respond to natural and human-induced changes?

- vegetation responses to climate
- ozone layer recovery
- clouds and aerosols



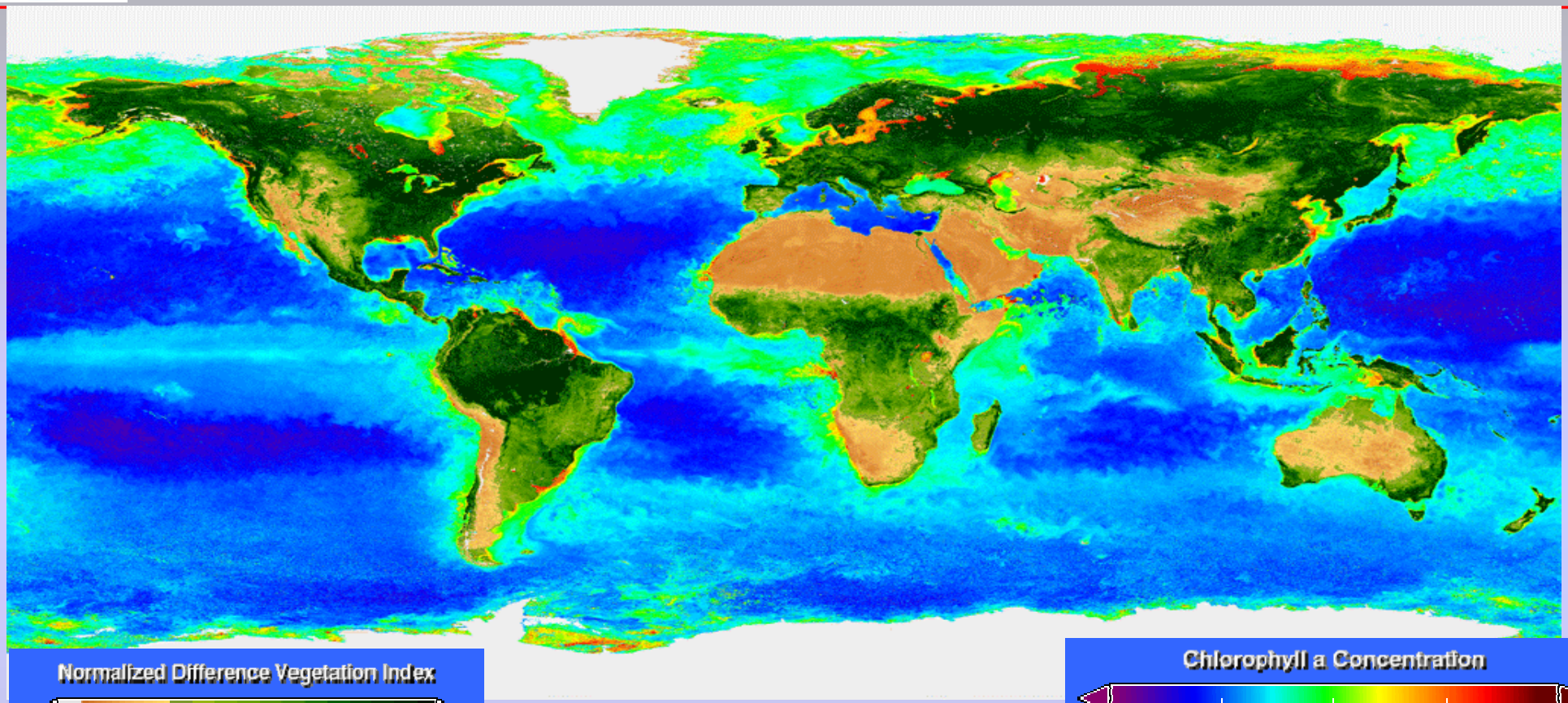
Total Ozone Monitoring

Satellite and 3D CTM Model Results



50 yr model run with the global ozone data

Carbon Cycle Questions

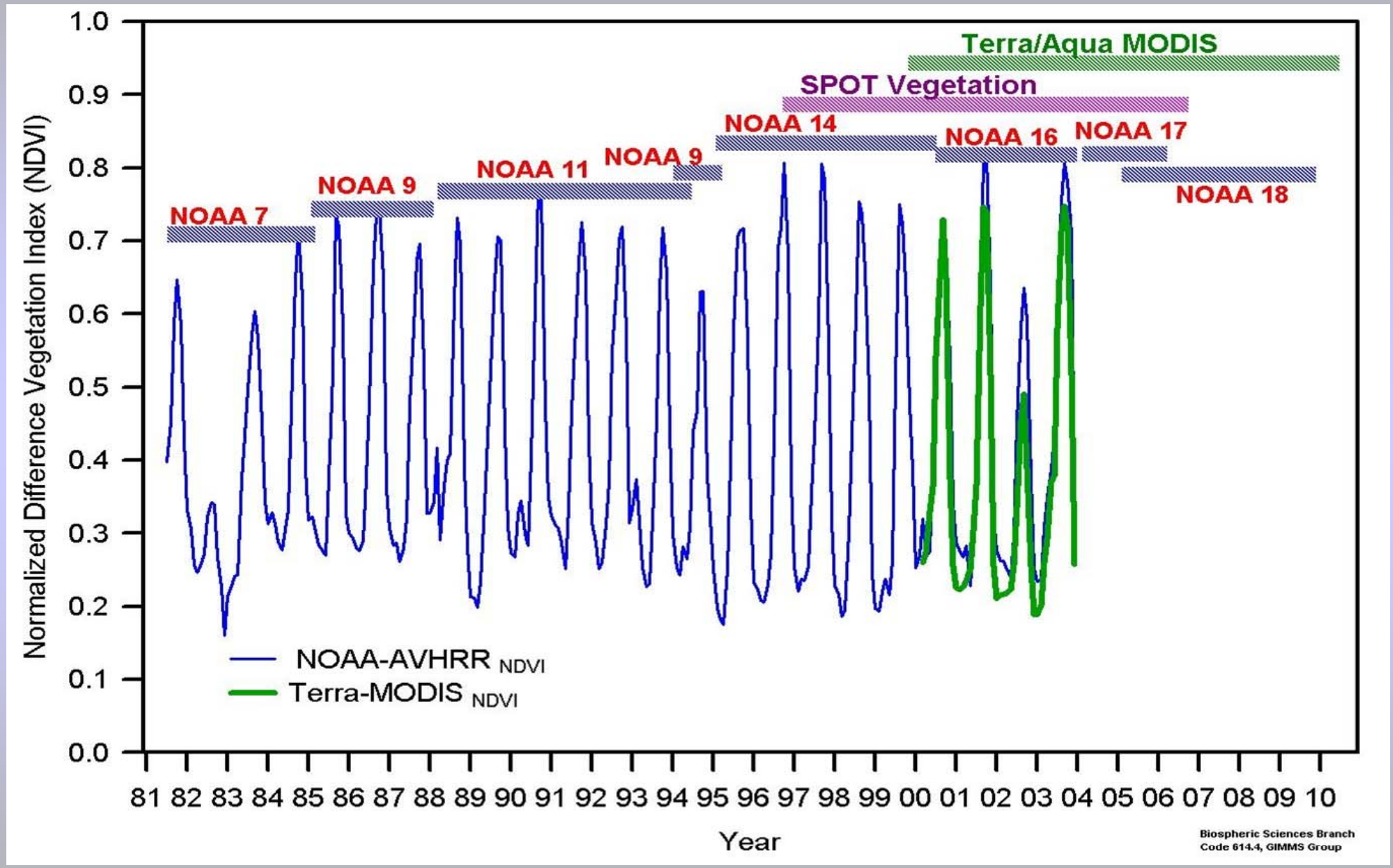


SeaWiFS July 2003

Where are the carbon sources and sinks?
Are source/sinks changing?
Is the biosphere changing?

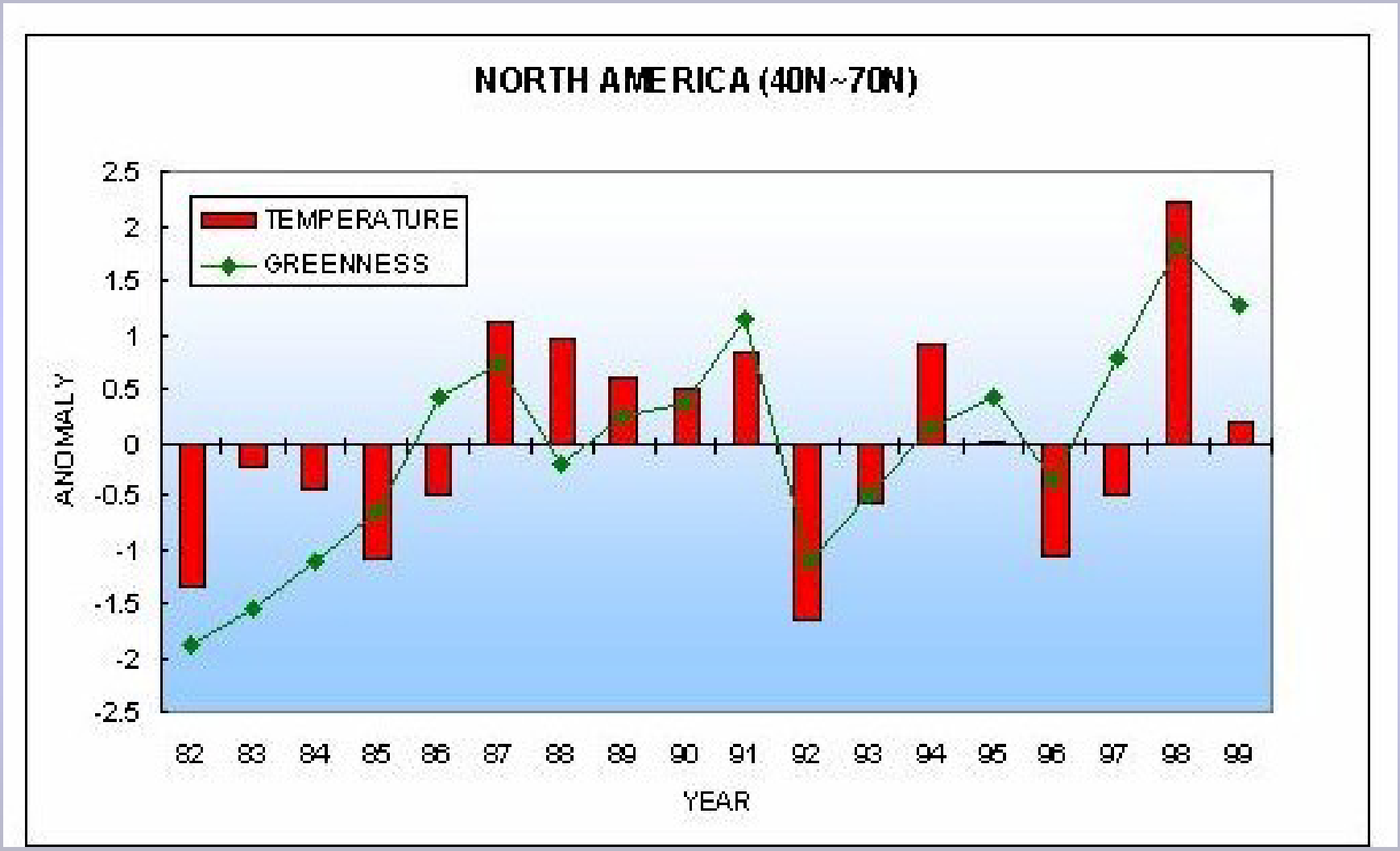
Data Sources: AVHRR, MODIS, LandSat

Multi satellite NDVI time series



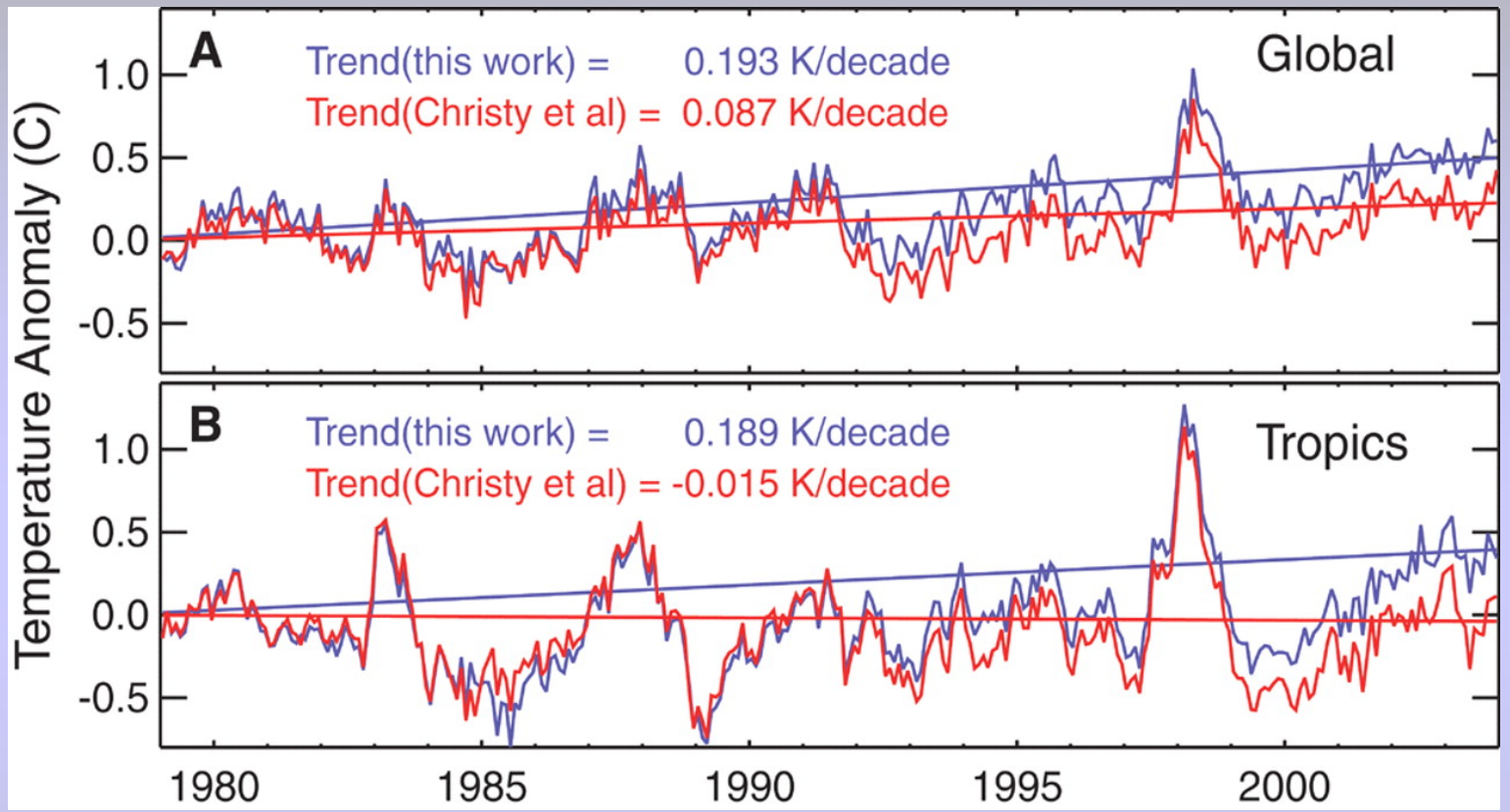
NDVI data set and the satellites that are used.

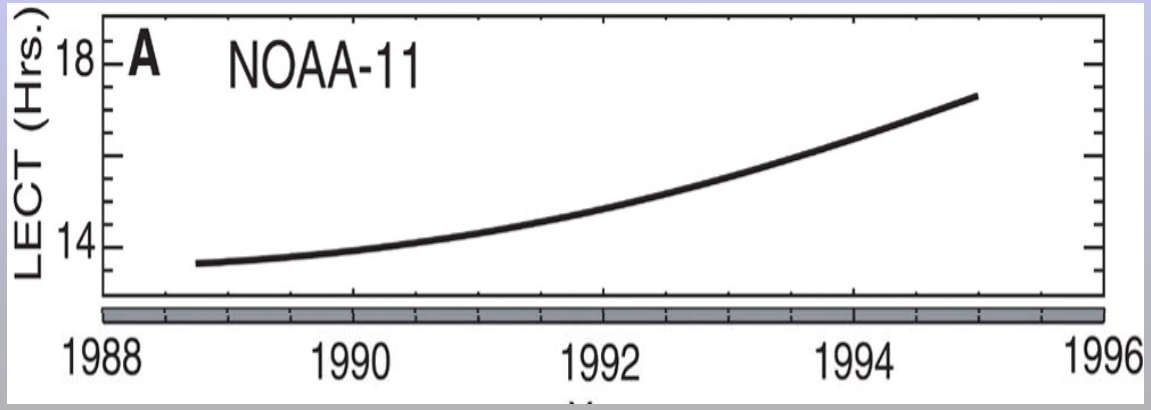
Growing and Temperature



MSU Tropospheric Temperature Trends

C. A. Mears et al., Science 309, 1548 -1551 (2005)

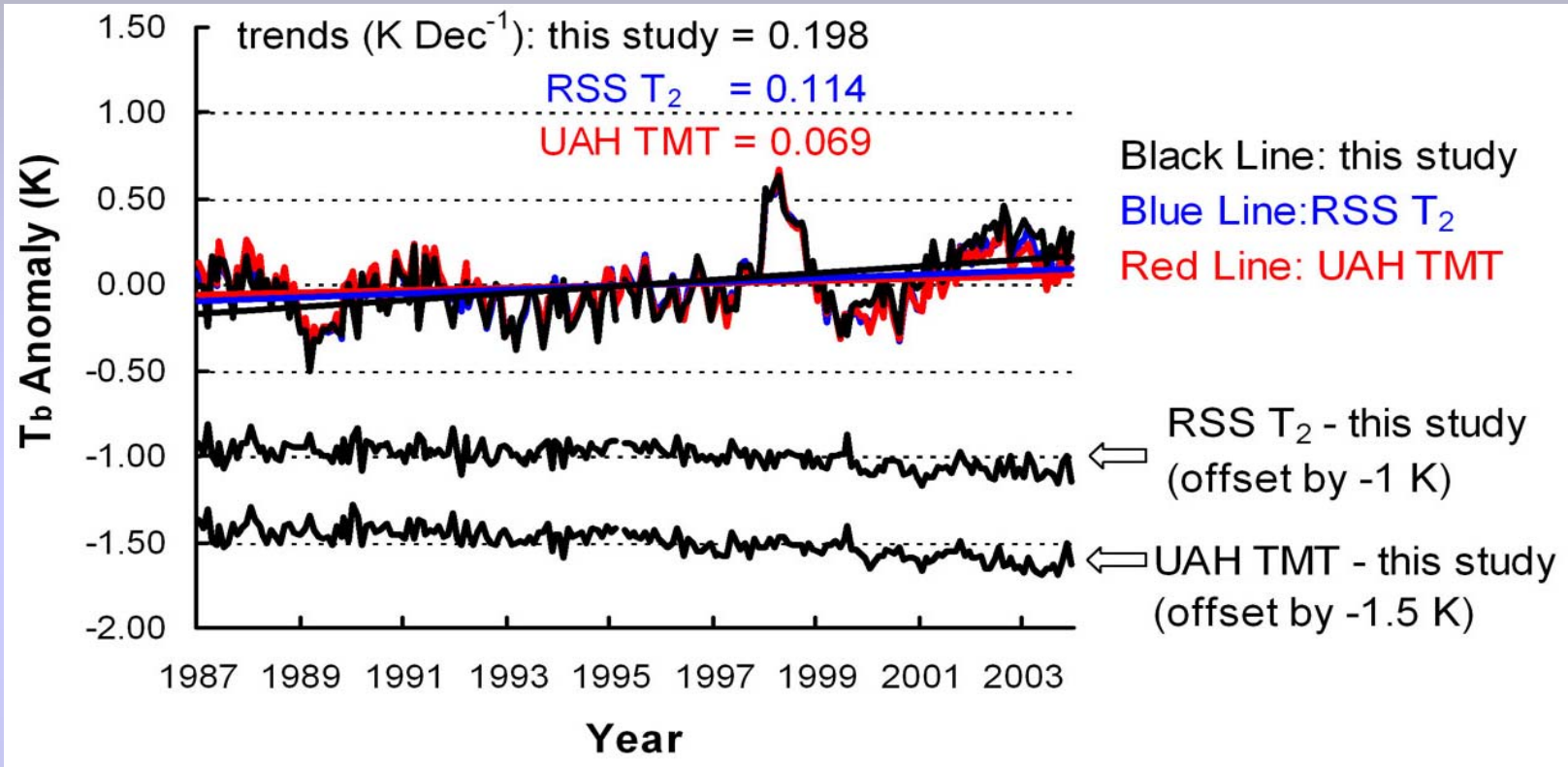


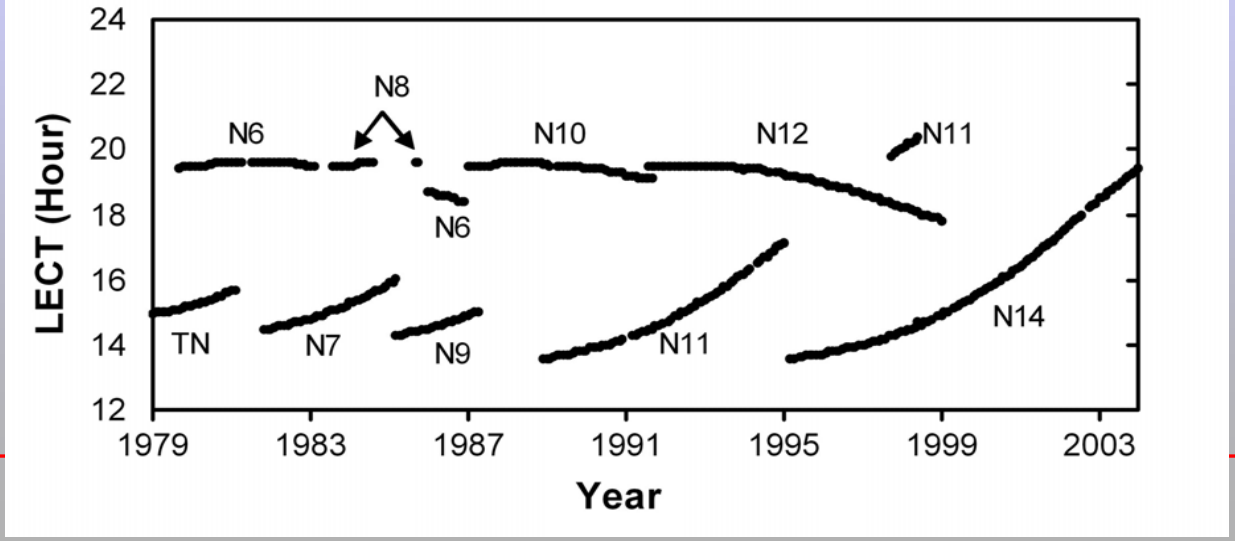


Science
AAAS

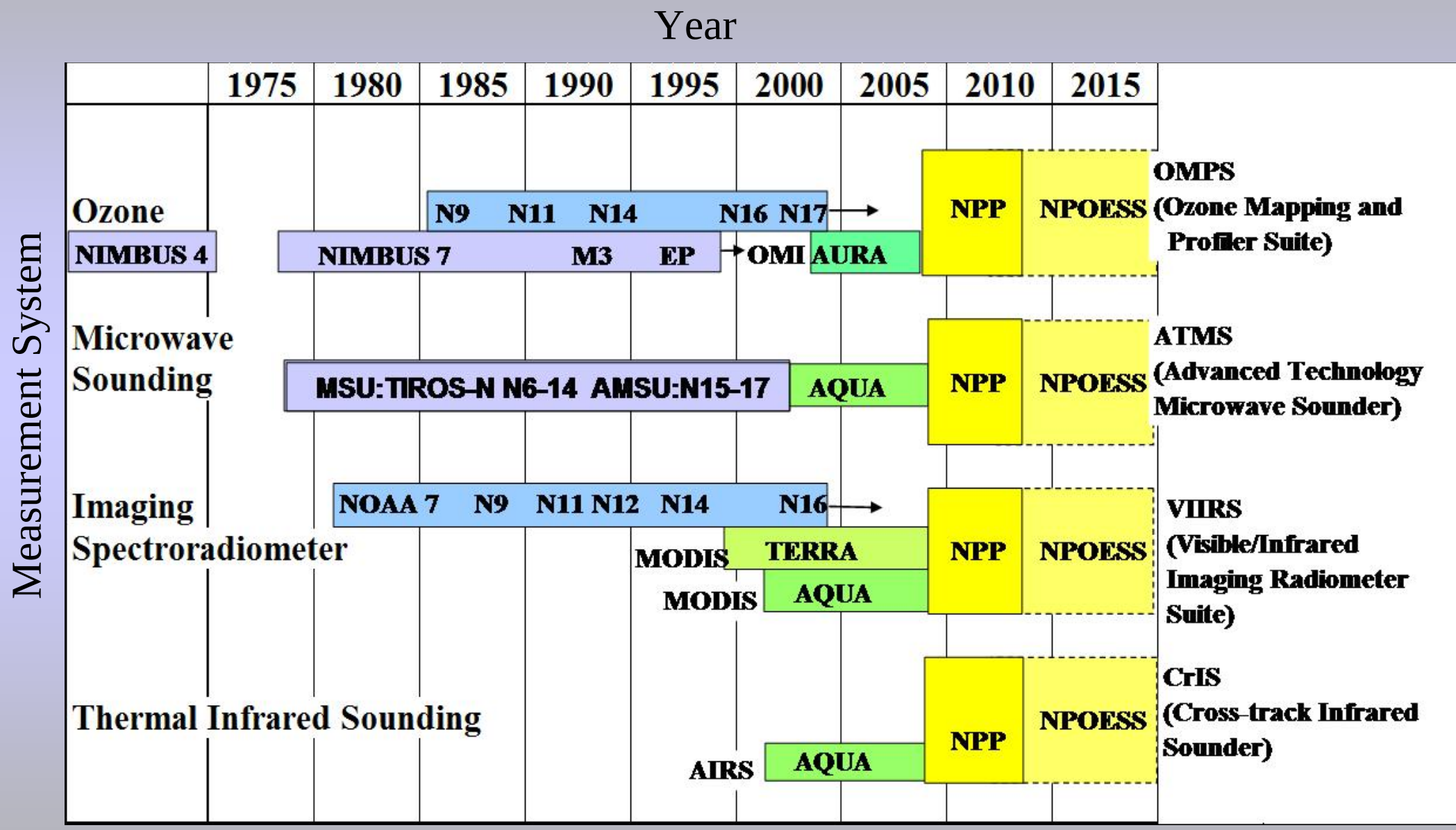
MSU Tropospheric Temperature Trends

Zou et al., JGR-Atm, 111 (D19): D19114 OCT 14 2006



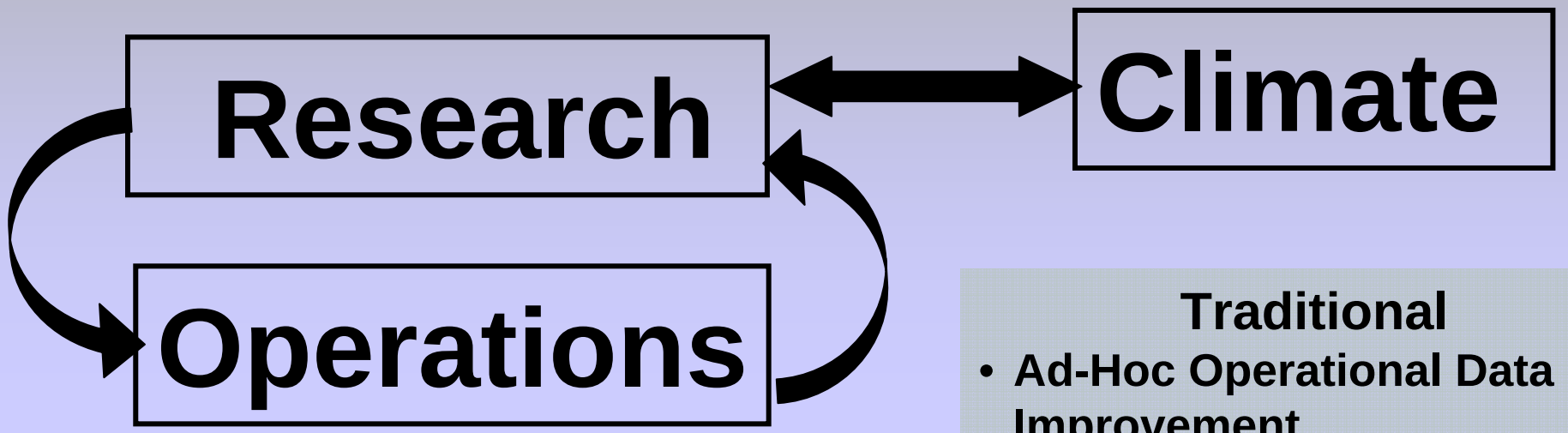


NPP/NPOESS Continues Data Record



Conventional Operations EOS Technology Jump Research Quality Operations

Research Instruments to Operational
Instruments Operational Data to Climate Data



Traditional

- Demonstrate New Measurements
- Show Improvements to Forecast
- Implement new measurements on "operational" platforms
- Send new data to NWP centers

Traditional

- Ad-Hoc Operational Data Set Improvement
- Limited by operational algorithms and instrument calibration

Future

- NPOESS Paradigm
- Build "research" features into operational instruments
- Strong IORD Requirements

Research to Operations to Climate

Pre Nunn-McCurdy:

NPOESS Convergence of 3 systems

- DoD Operational
- DOC Operational
- NASA/NOAA Climate

Post Nunn-McCurdy:

NPOESS Convergence of 2.5 systems

DoD Operational

DOC Operational

Partial NASA/NOAA Climate

- "Climate-only" sensors de-manifested

IORD Requirements still valid

The challenge of converting operational data to climate data remains

Nunn-McCurdy Certification of NPOESS

NPOESS Program was certified by DoD

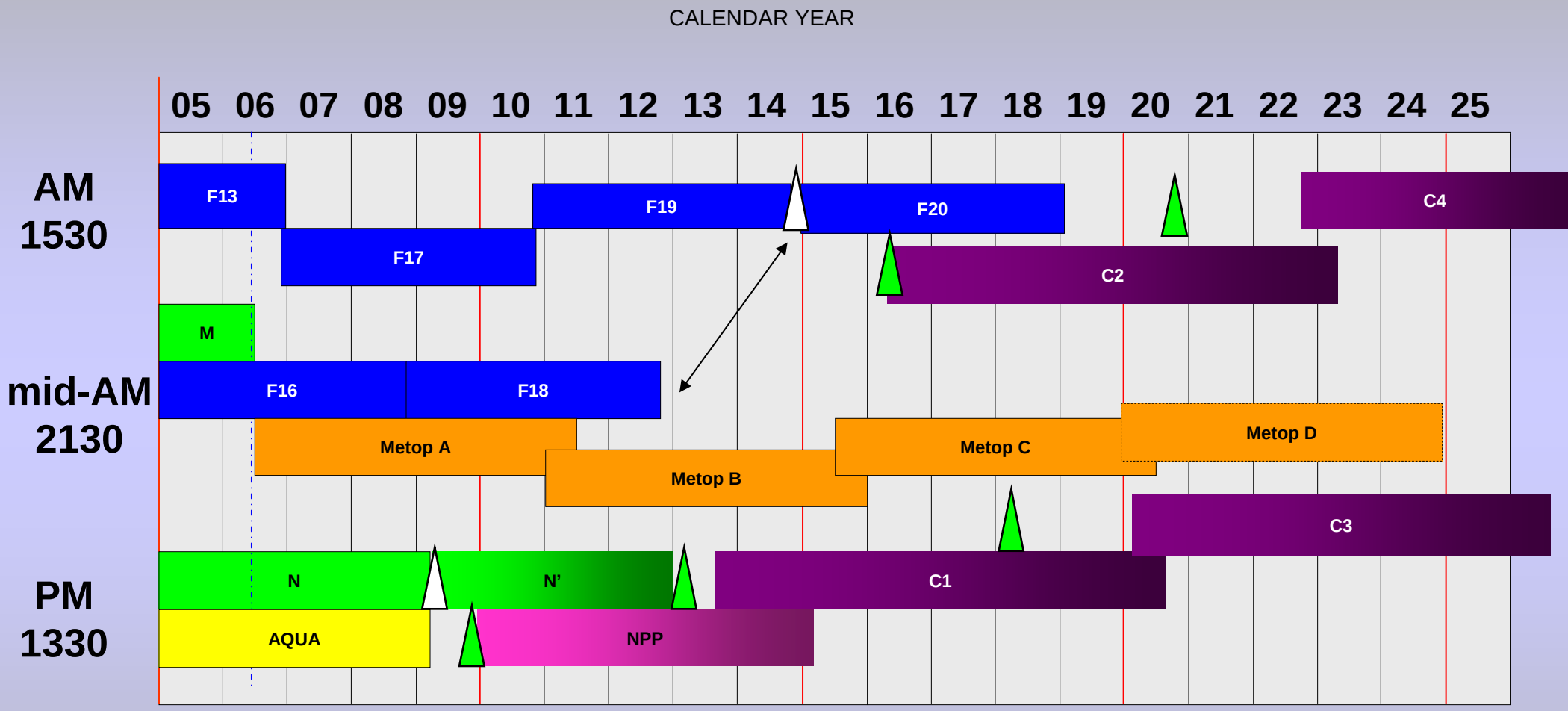
- Number of spacecraft reduced from 6 to 2+2
- EUMETSAT will provide mid-morning coverage

- Operational Data Continuity was Primary Requirement
- Instruments cancelled and de-scoped
- Instruments removed from program “De-manifested”
  - Spacecraft resources maintained should instruments be provided
- Launch schedules shifted
  - NPP September 30, 2009
  - C1 January 2013
  - C2 January 2016

Orbit Configuration Changes

	Crossing Time	
Old NPOESS	0530	2 satellites
	2130	2 satellites
	1330	2 satellites
New NPOESS	0530	1 satellite + 1 option
	2130	EUMETSAT METOP
	1330	1 satellite + 1 option

NPOESS Schedule



Instruments Changes

Instrument Descopes

- CMIS — Conical-scanning Microwave Imaging/Sounding
  - Imaging: SST, Soil Moisture, Ice/Snow Cover
  - Polarimetric Ocean Wind speed
  - Atmospheric Temperature/Moisture Sounding
- SESS — Space Environment: Electron/Particle energy spectrometers, UV imagery, Fly SEM

De-Manifested Instruments, could be provided GFE

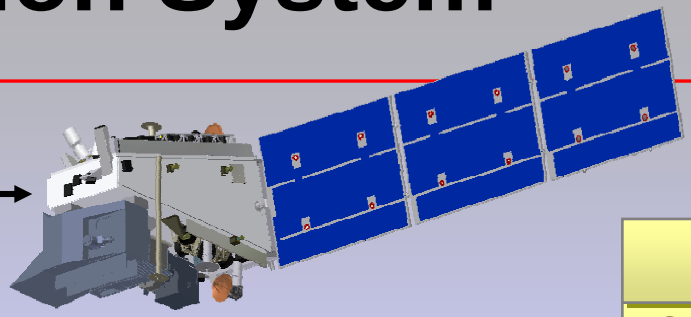
- TSIS - Total and Spectral Solar Irradiance
- ERBS - Earth Radiation Budget (looking at putting CERES on NPP)
- Alt - Sea Surface Altimetry
- APS - Aerosol Polarimetry Sensor
- Full SESS - Descoped SESS
- OMPS Limb - Ozone Profile (Restored)

Sensors and Platforms

	NPP	C1	C2	C3	C4
Launch	Oct 2009	2013	2016	2020	2022
Nodal Time	1330	1330	530	1330	530
VIIRS**	X	X	X	X	X
CrIS**	X	X		X	
ATMS**	X	X		X	
OMPS Nadir	X	X		X	
New Microwave Imager			X	X	X
SEM		X		X	
CERES	?	?		?	
SARSAT		X	X	X	X
ADCS		X		X	
OMPS Limb	Yes	?		?	
ERBS					
ALT					
TSIS					
APS					

NPP Mission System

-NASA
-IPO
-NOAA



Space Segment

Launch Support Segment (LSS)

- Launch vehicle
- Launch Support
- Payload Processing support

Space Segment

- Spacecraft
- ATMS

- VIIRS
- CrIS
- OMPS

Command, Control & Communication Segment (C3S)

- Manage Mission
- Manage Satellite Operations
- Space/Ground Communication
- Data Routing & Retrieval

Interface Data Processing Segment (IDPS)

- Ingest and validate raw SMD
- Process RDRs, SDRs, EDRs
- Perform operations cal proc
- Distribute data records

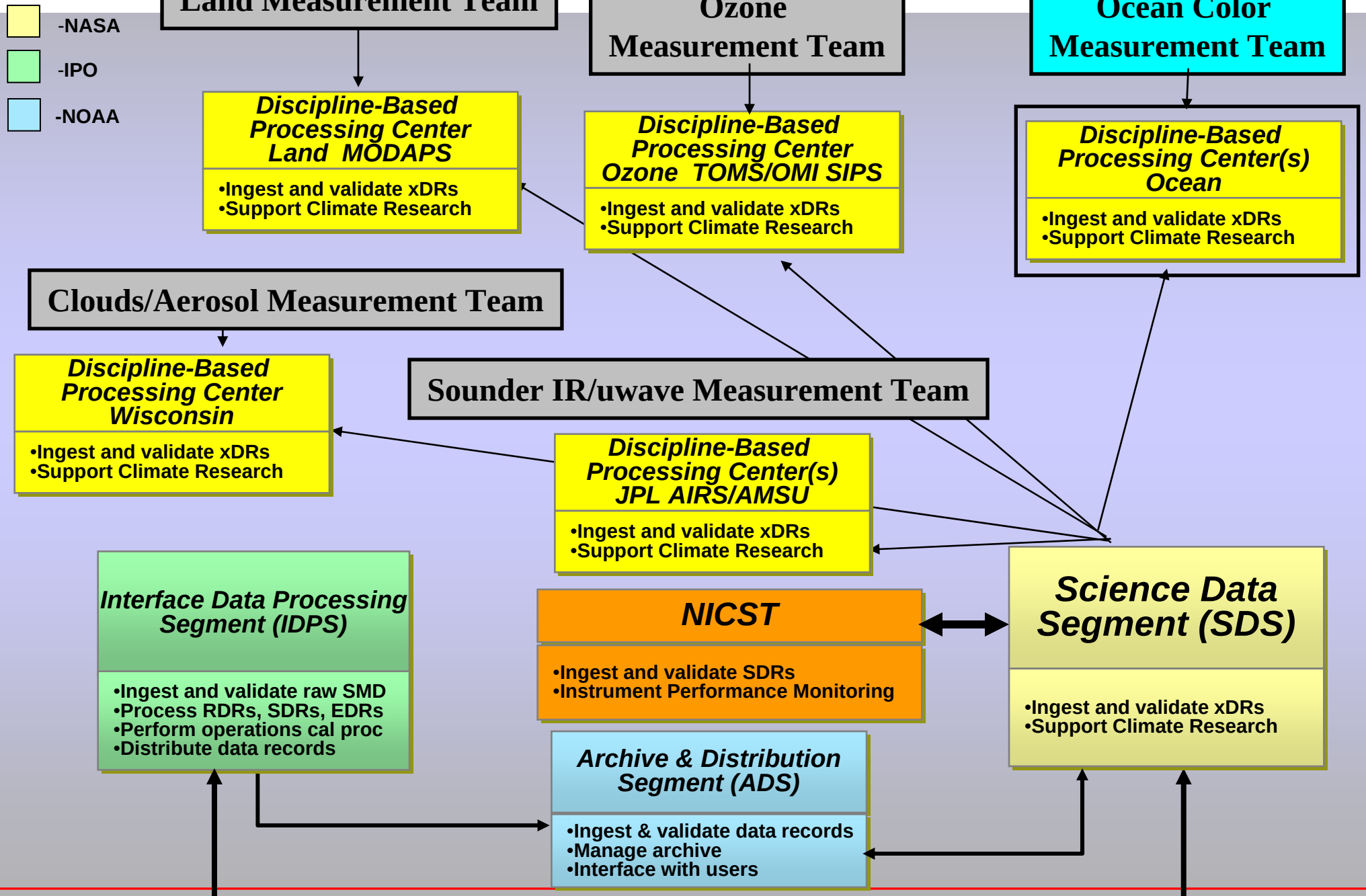
Archive & Distribution Segment (ADS)

- Ingest & validate data records
- Manage archive
- Interface with users

Science Data Segment (SDS)

- Ingest and validate RDRs
- Support Climate Research

NASA Science Data Processing



NPP Instruments

- **NPP provides a bridge between today's EOS instruments and NPOESS**

NPP Instrument	EOS Predecessor
Advanced Technology Microwave Sounder (ATMS)	Advanced Microwave Sounder Unit (AMSU)
Cross-track Infrared Sounder (CrIS)	Atmospheric Infrared Sounder (AIRS)
Ozone Mapping and Profiler Suite (OMPS)	Ozone Monitoring Instrument (OMI)
Visible/Infrared Imager Radiometer Suite (VIIRS)	Moderate Resolution Imaging Spectroradiometer (MODIS)

CrIMSS characteristics

- **CrIMSS instrument characteristics:**
  - **CrIS is a Michelson (FT) Interferometer w/ 1317 IR Channels**
  - **ATMS is a Microwave Radiometer w/ 22 Channels**
- **CrIS and ATMS are similar to AIRS and AMSU-A/B:**
  - **Spectral range, resolution**
  - **FOV, scan geometries**
  - **Data rates**
- **CrIMSS Processing Algorithms produce 3 EDRs:**
  - **Atmospheric Vertical Moisture Profile**
  - **Atmospheric Vertical Temperature Profile – including Surface Temperature**
  - **Atmospheric Vertical Pressure Profile**

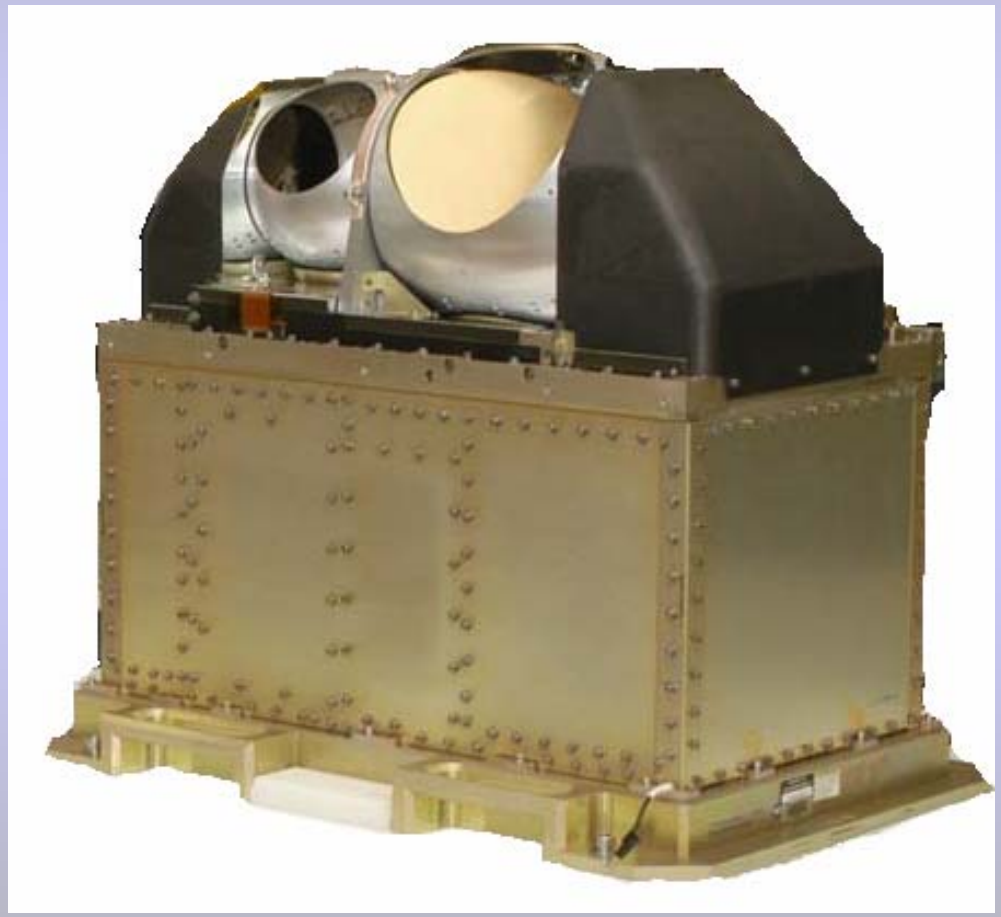
Advanced Technology Microwave Sounder (NASA / Northrop Grumman Electronic Systems)

Description

- **Purpose:** In conjunction with CrIS, global observations of temperature and moisture profiles at high temporal resolution (~ daily).
- **Predecessor Instruments:** AMSU A1 / A2, MHS
- **Approach:** Scanning passive microwave radiometer
- 22 channels
- 23GHz - 183GHz
- **Swath width:** 2300 km
- **Co-registration:** with CrIS

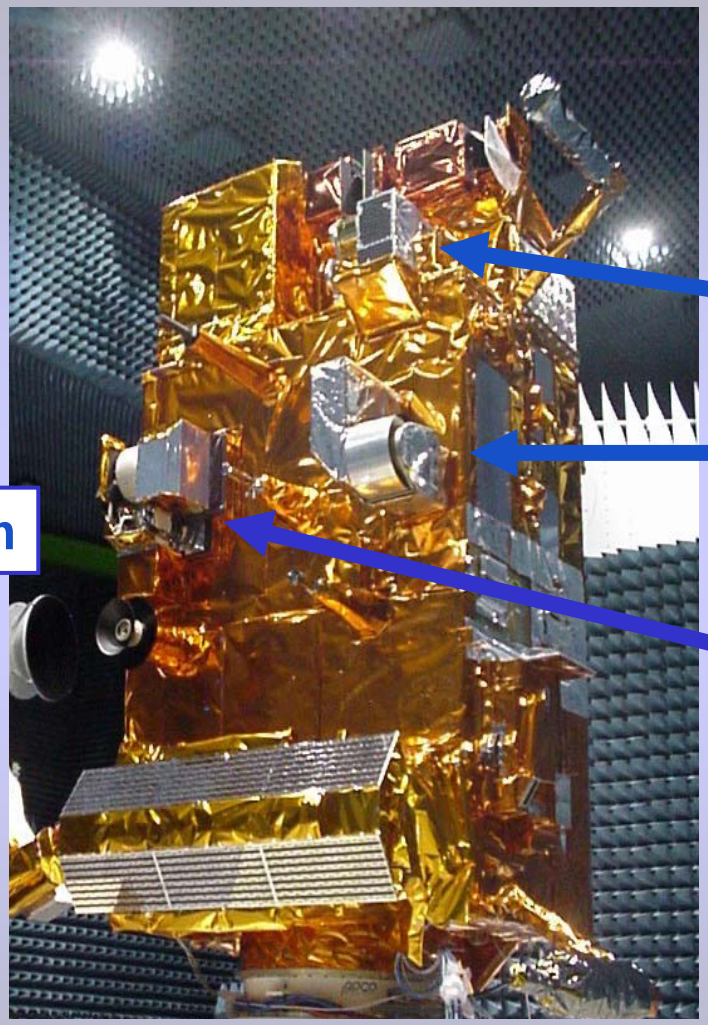
Status

- **Flight Unit on Spacecraft**



AMSU-A + AMSU-B + MHS = ATMS

First METOP in Test



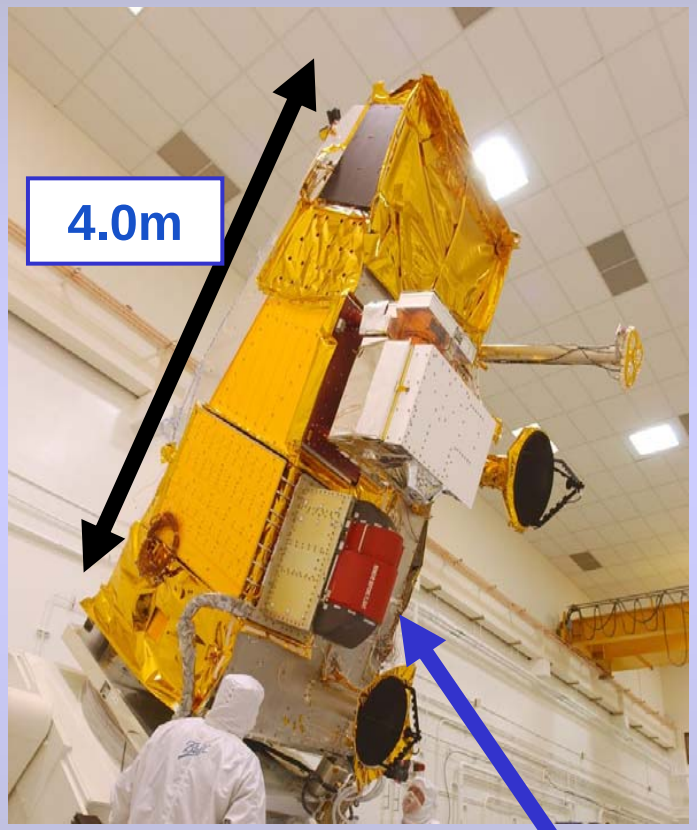
6.3m

AMSU-A1
55kg

AMSU-A2
50 kg

MHS
66 kg

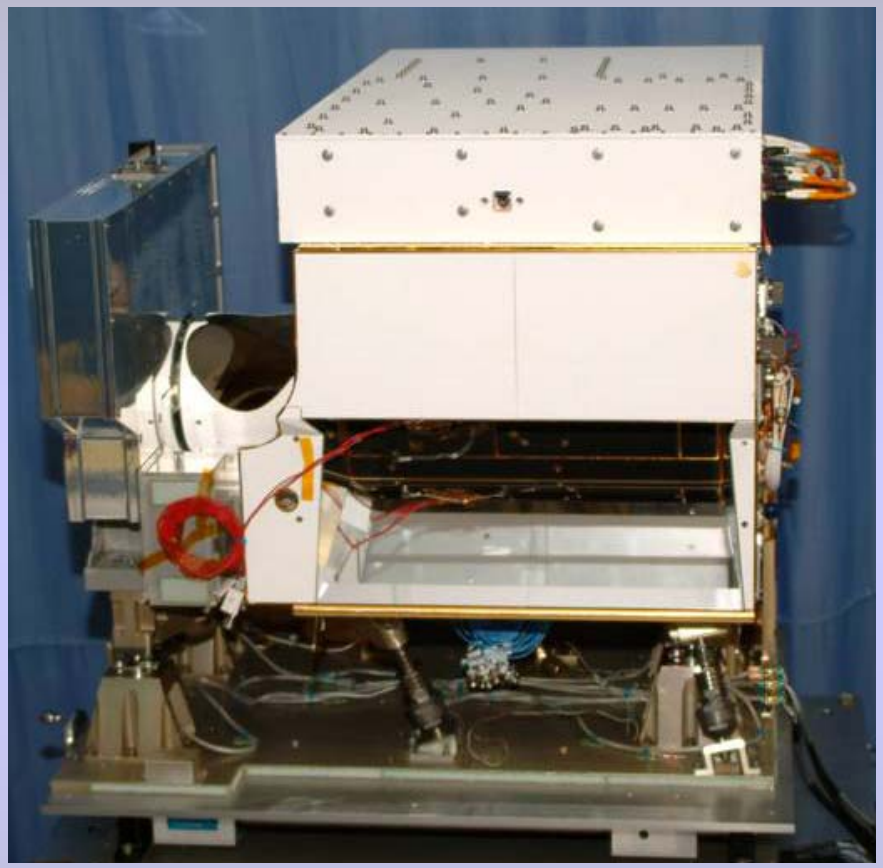
NPP



4.0m

ATMS
75 kg

CrIS Overview



	Spec
Mass, kg	165
Average Power, W	135
Average Data Rate, Mbps	1.5

- The Cross-track Infrared Sounder (CrIS) is a key sensor
  - Fourier Transform Spectrometer providing high resolution IR spectra:

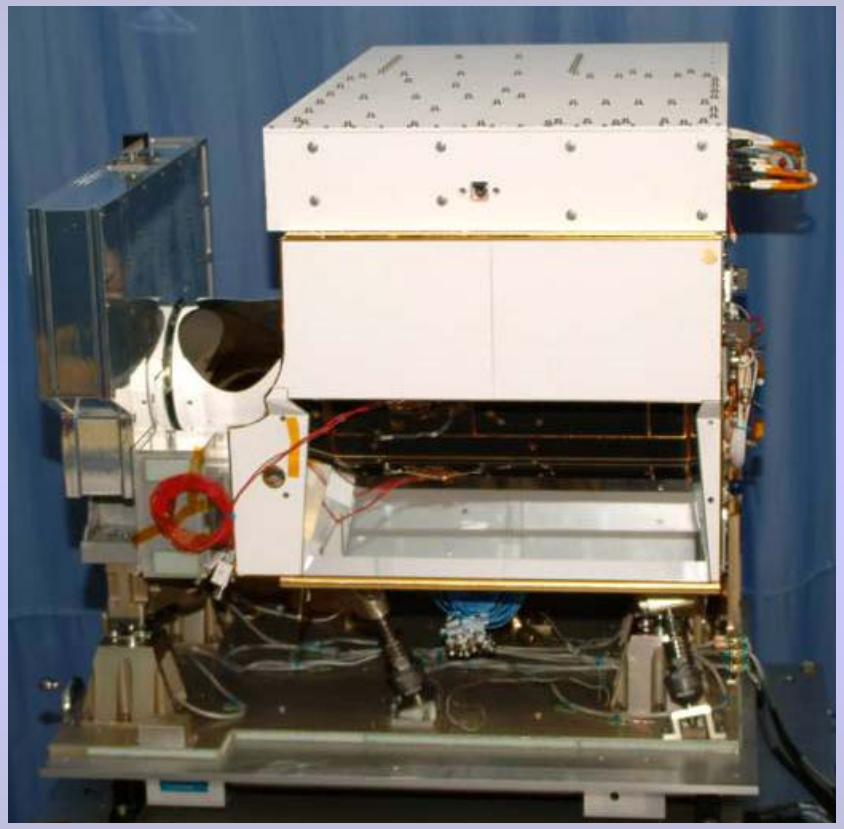
Band	Wavelength Range (cm-1)	(mm)	Sampling (cm-1)	No. Chan.
SWIR	2155-2550	4.64-3.92	2.5	159
MWIR	1210-1750	8.26-5.71	1.25	433
LWIR	650-1095	15.38-9.14	0.625	713

  - Fields of Regard each 3 x 3 FOVs
  - Photovoltaic Detectors in all 3 bands
  - 4-Stage Passive Detector Cooler
  - 14 km nadir spatial resolution
  - 2200 km swath width
  - On-board internal calibration target
- Science pioneer: AIRS on EOS Aqua, IASI on METOP-A
- Supplier: ITT Industries
- Key subcontractors:
  - ABB Bomem, Interferometer, ICT
  - DRS, detectors
  - AER, EDR algorithm

Cross-Track Infrared Sounder
IPO / NGST / ITT Industries

Description

- **Purpose:** In conjunction with ATMS, global observations of temperature and moisture profiles at high temporal resolution (~ daily)
- **Predecessor Instruments:** HIRS, AIRS, IASI
- **Approach:** Michelson Interferometer (1142 channels in 3 bands (3.5 µm - 16 µm)
- **Swath width:** 2300 km
- **Co-registration:** with ATMS

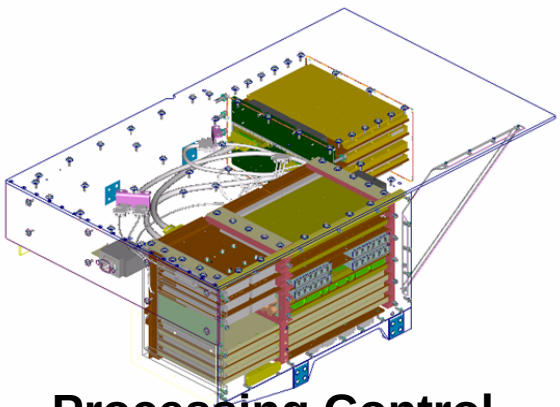


Status

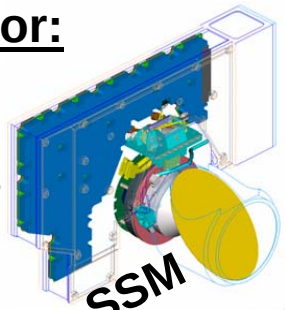
- **EDU qualification complete and has been delivered to Ball**
- **Flight Unit #1 Assembly underway**
- **Flight Unit #1 failed during vibe test**
- **Braze joints in instrument frame cracked**
- **Assessment is on-going**
- **Approximately 1 year delay**

Most of CrIS Survived Vib Failure Incident

PCE & Scene Scan Mirror:

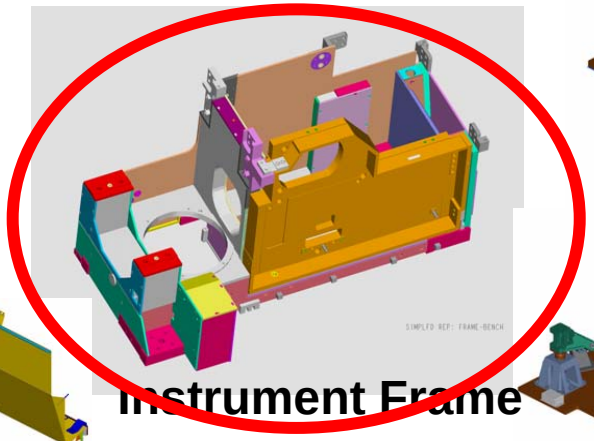


Processing Control Electronics (PCE)



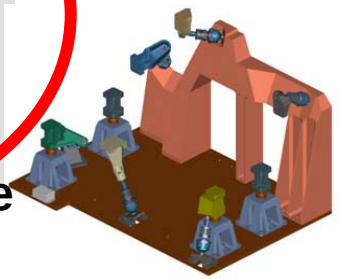
SSM

Mechanical Subsystems:



Instrument Frame

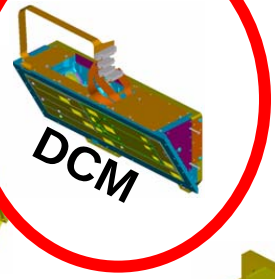
Shield



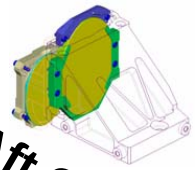
Isolation System

CrIS Super-Module:

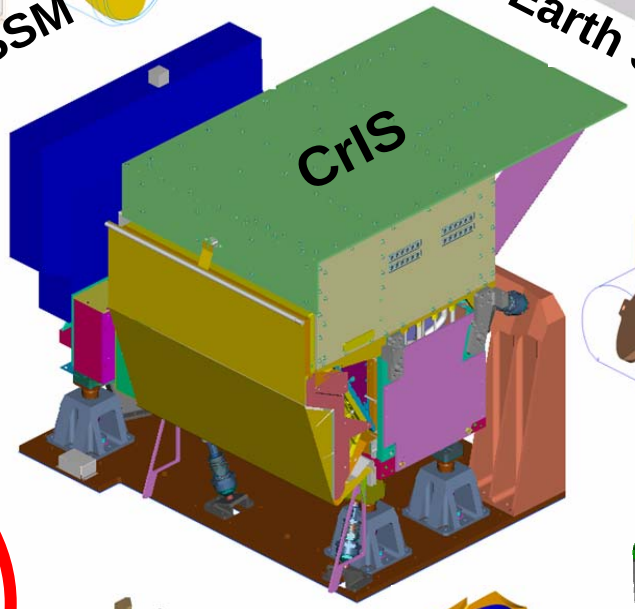
Earth Shield



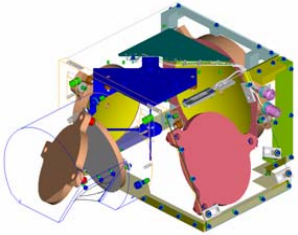
DCM



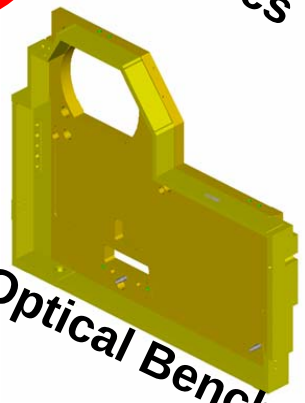
Aft Optics



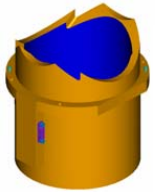
CrIS



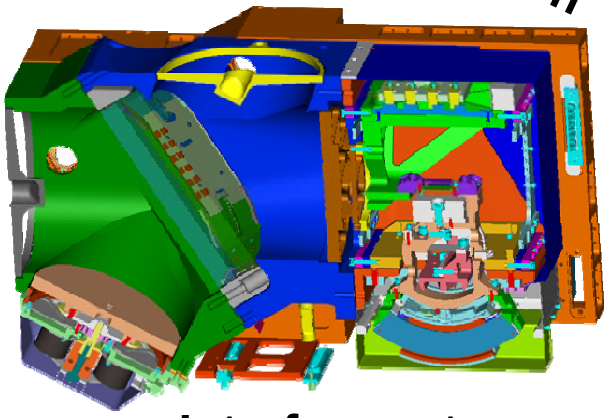
Telescope



Optical Bench



Internal Calibration Target (ICT)

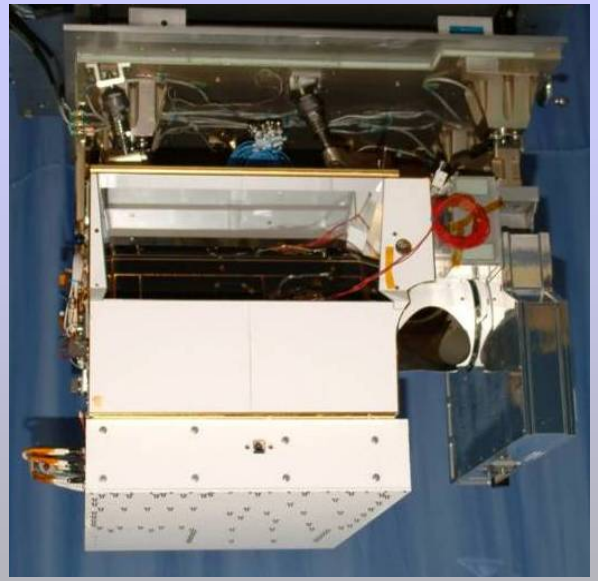


Interferometer

SSM – Scene Selection Mirror
DCM – Detector Cooler Module

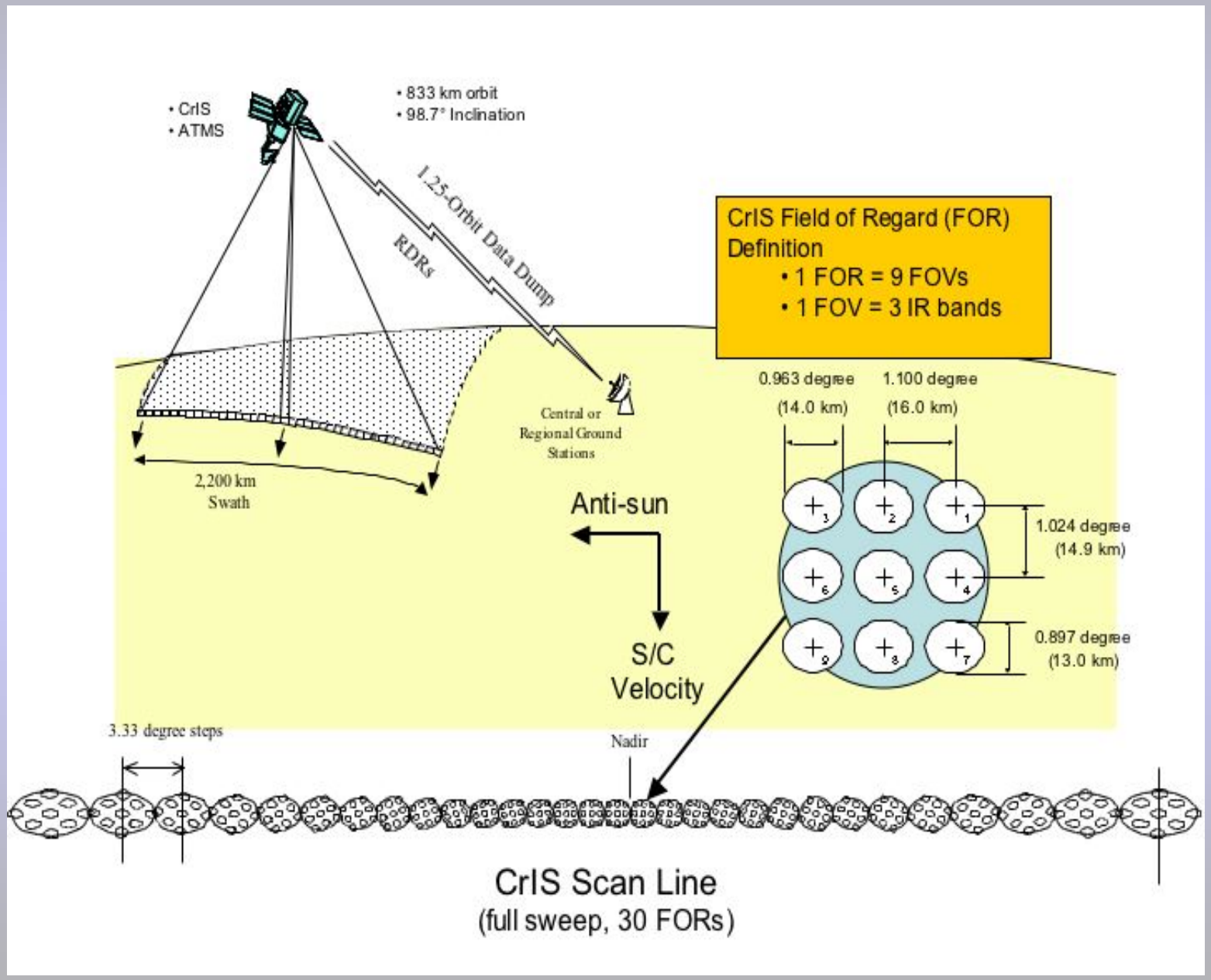
AIRS and CrIS Have Comparable Overall Performance

- **AIRS**
  - **Spatial: Range ±49.5°, IFOV = 1.1°**
  - **Spectral: 2378 Channels**
    - **650-1136 cm^{-1}, 0.41-1.05 cm^{-1}**
    - **1216-1613 cm^{-1}, 0.95-1.41 cm^{-1}**
    - **2181-2665 cm^{-1}, 1.75-2.13 cm^{-1}**
    - **Stability < 5 ppm**
  - **Radiometric: 0.1-0.2K, <10 mK/year**
  - **177 kg, 236 W, 0.9 m^3, 1.3 Mbps**

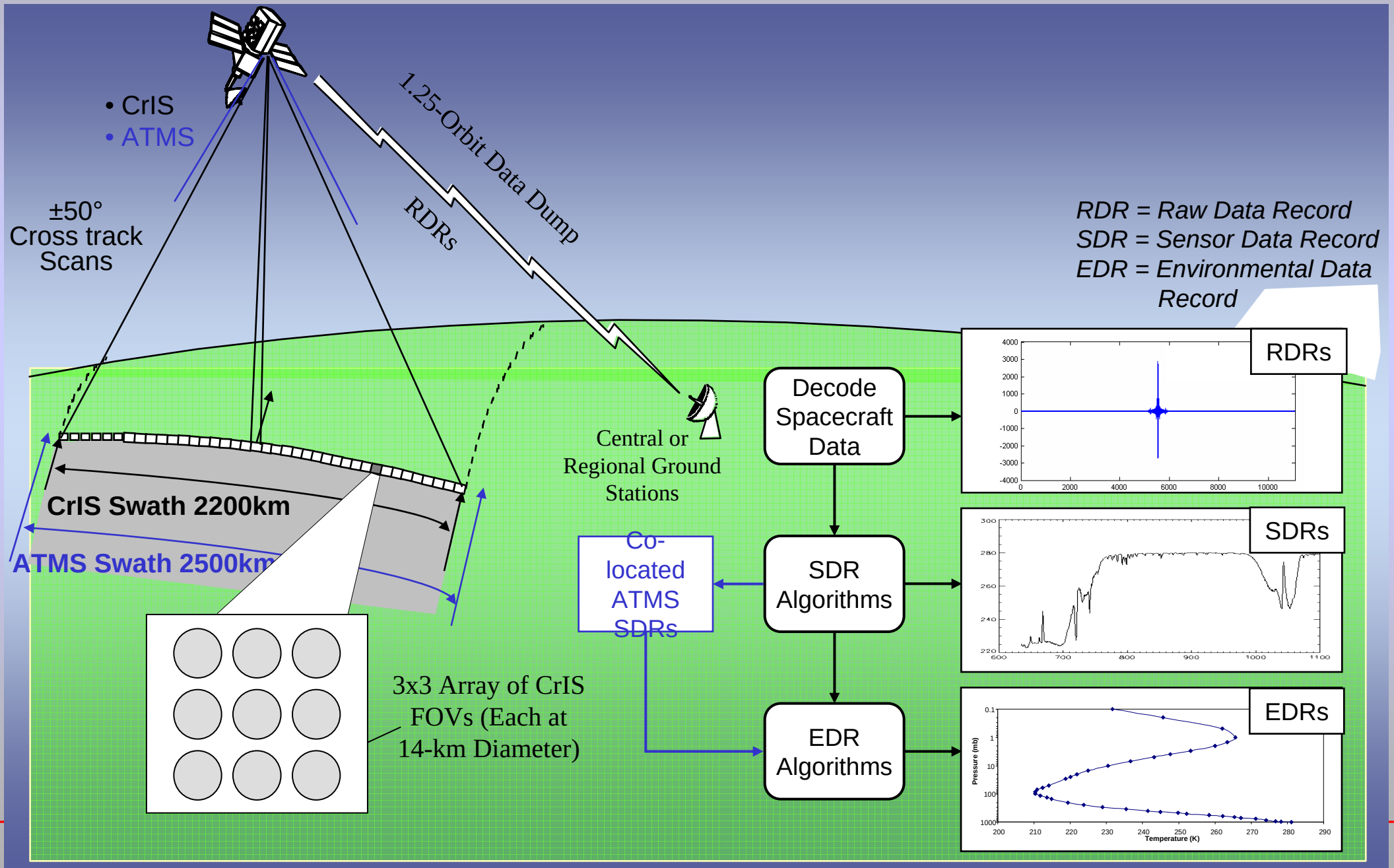


- **CrIS**
  - **Spatial: Range ±48.3°, IFOV = 1.1°**
  - **Spectral: 1302 Channels**
    - **650-1090 cm^{-1}, 0.625 cm^{-1}**
    - **1210-1750 cm^{-1}, 1.25 cm^{-1}**
    - **2155-2550 cm^{-1}, 2.5 cm^{-1}**
    - **Stability < 5 ppm**
  - **Radiometric: 0.2-0.8K, TBD mK/year**
  - **165 kg, 135 W, 0.5 m^3, 1.5 Mbps**

CrIS and ATMS Scan Geometry



ATMS/CrIS Sensors Produce Atmospheric Temp/Humidity Profiles



CrIMSS EDRs meet Spec

Moisture Profiles

Subject	Specified Value	IORD	Current Perf
1. *Clear, Surface to 600 mb	14.10%	20% (or 0.2g/kg)	8.00%
2. Clear, 600 mb to 300 mb	13.80%	35% (or 0.1g/kg)	7.40%
3. Clear, 300 mb to 100 mb	11.7% (or 0.05g/kg)	35% (or 0.1g/kg)	0.008k/kg
4. *Cloudy, Surface to 600 mb	15.80%	20% (or 0.2g/kg)	12.50%
5. Cloudy, 600 mb to 300 mb	17.10%	40% (or 0.1g/kg)	10.50%
6. Cloudy, 300 mb to 100 mb	16.4% (or 0.05g/kg)	40% (or 0.1g/kg)	0.015g/kg

Temperature Profiles

Subject	Specified Value	IORD	Current Estimate
1. *Clear, Surface to 300 mb	**0.9 K / 1 km Layer**	**1.6K**	0.77K
4. Clear, 300 mb to 30 mb	0.98 K / 3 km Layer	1.5K	0.7K
5. Clear, 30 mb to 1 mb	1.45 K / 5 km Layer	1.5K	1.25K
8. Clear, 1 mb to 0.5 mb	3.5 K / 5 km Layer	3.5K	1.73K
10. *Cloudy, Surface to 700 mb	**2.0 K / 1 km Layer**	**2.5K**	1.30K
11. Cloudy, 700 mb to 300 mb	1.4 K / 1 km Layer	1.5K	0.98K
12. Cloudy, 300 mb to 30 mb	1.3 K / 3 km Layer	1.5K	0.90K
13. Cloudy, 30 mb to 1 mb	1.45 K / 5 km Layer	1.5K	1.22K*
16. Cloudy, 1 mb to 0.5 mb	3.5 K / 5 km Layer	3.5K	1.78K

Joint Center Question?

IPO/NPOESS thinking is EDR-centric.

What does the JCSDA need for radiance assimilation?

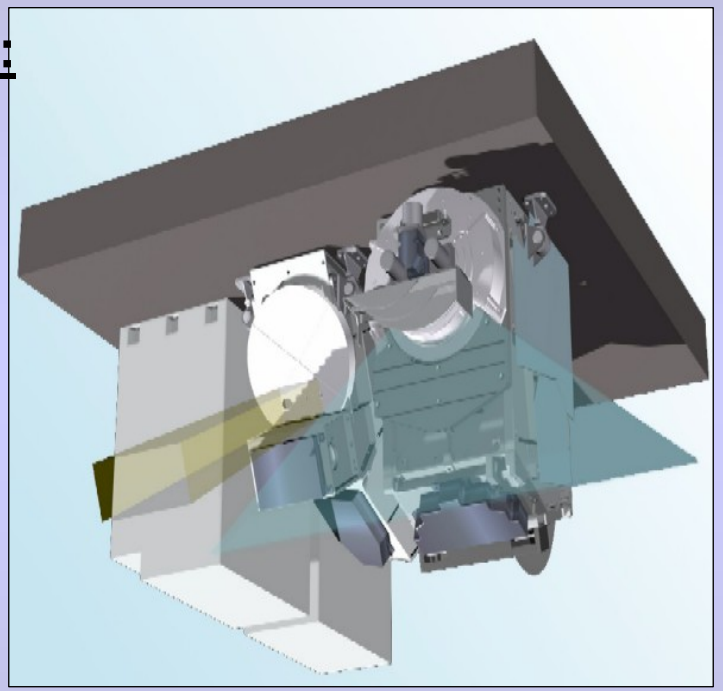
Have you communicated those requirements to your sponsors and the IPO?

Ozone Mapping Profiler Suite

Description

- **Purpose:** Monitors the total column and vertical profile of ozone

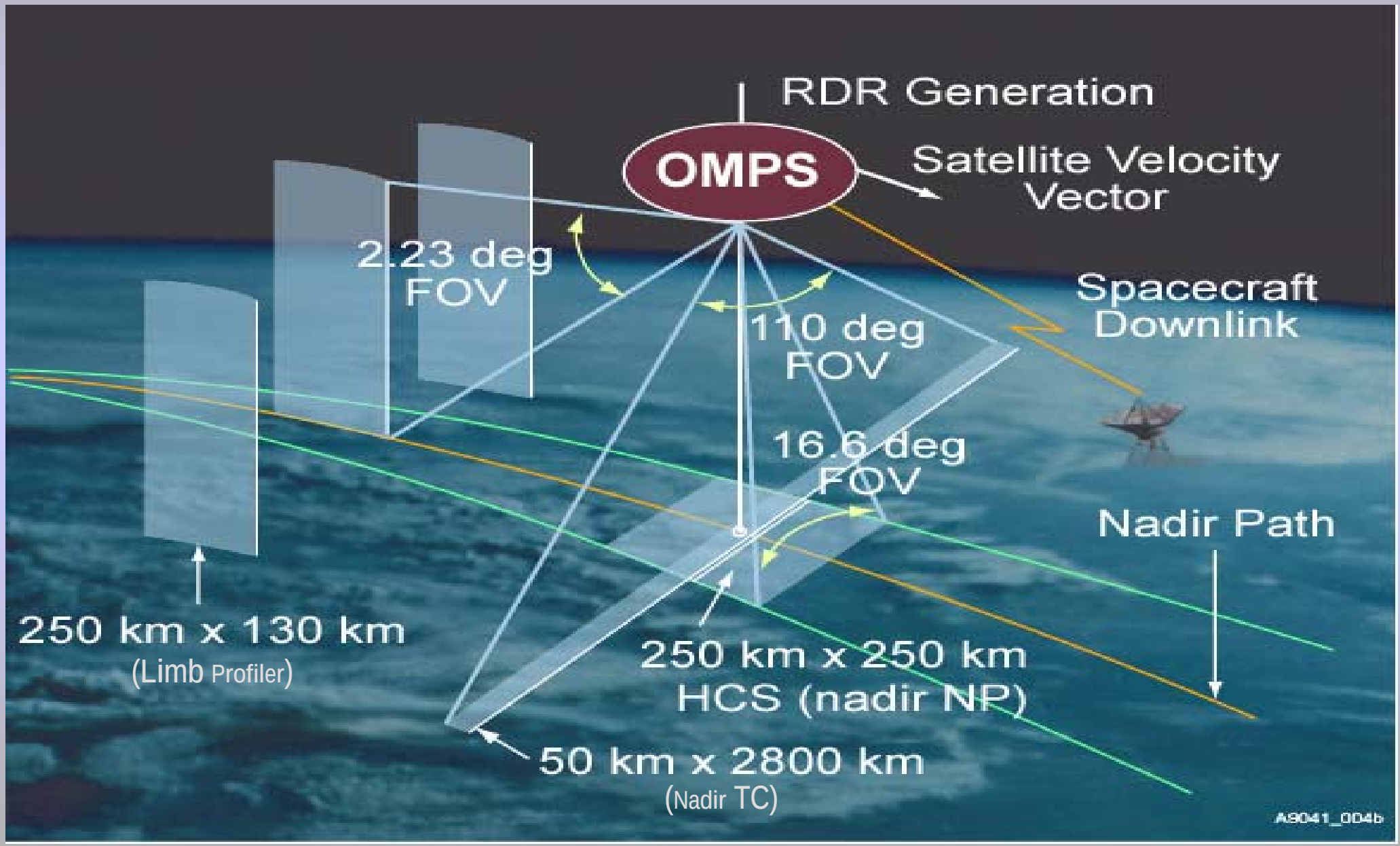
- **Predecessor Instruments:** TOMS, SBUV, GOME, OSIRIS, SCIAMACHY
- **Approach:**
  Nadir push broom
  CCD spectrometers
- **Swath width:** 2600 km
- **Algorithm Status:** Use TOMS/SBUV heritage approaches for Nadir Instruments



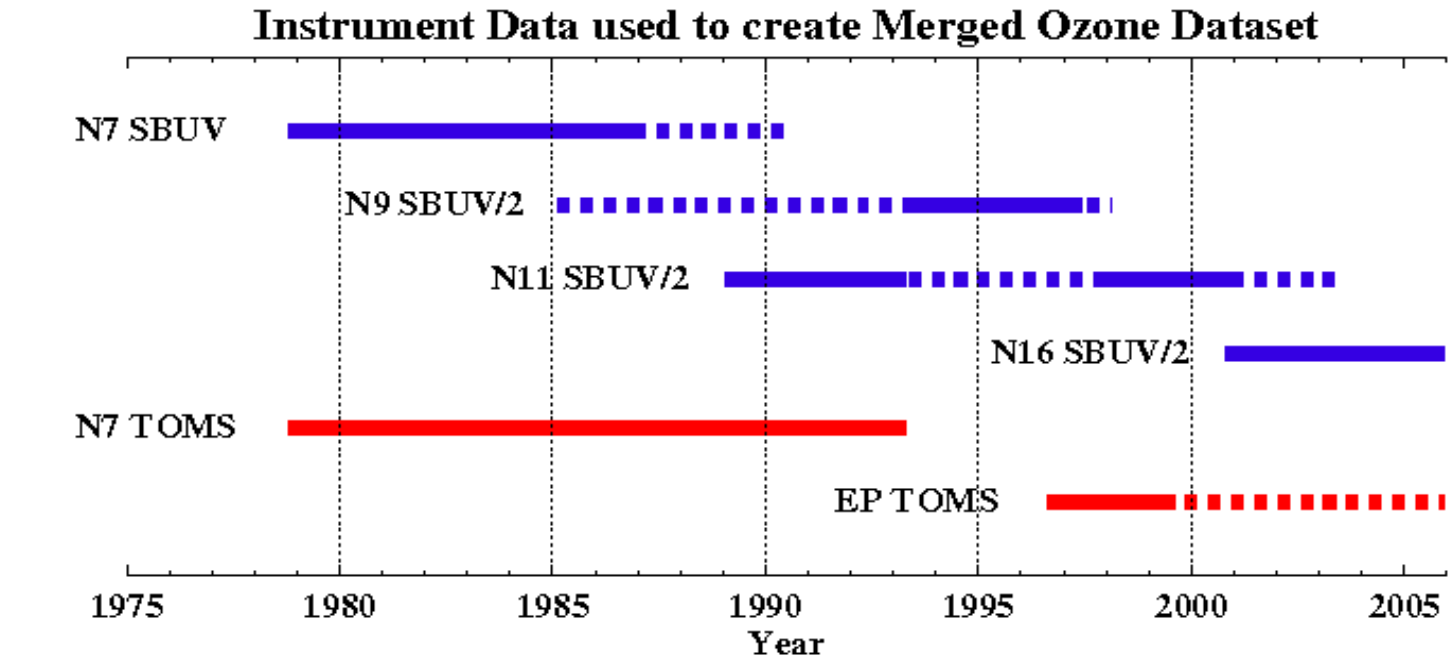
Status

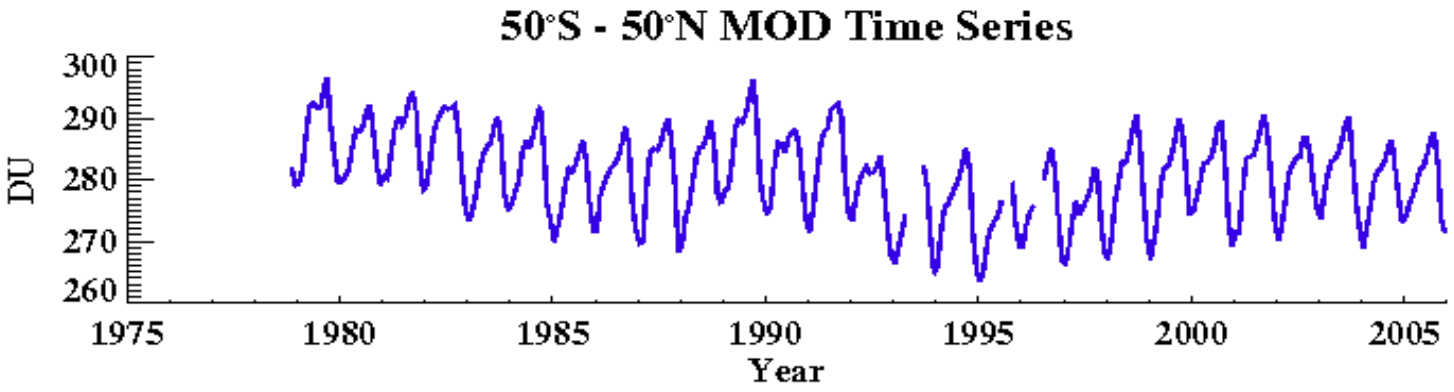
- Flight Unit #1 Calibration underway
- Limb Sub-System Re-manifested
- Instrument 50/50 cost share NOAA and NASA
  NASA to develop algorithm
  NOAA to support operational users

OMPS Scanning Track



NASA/NOAA Satellite Total Ozone





Ozone Trend Analysis

Total Ozone

Integrated Profile Ozone

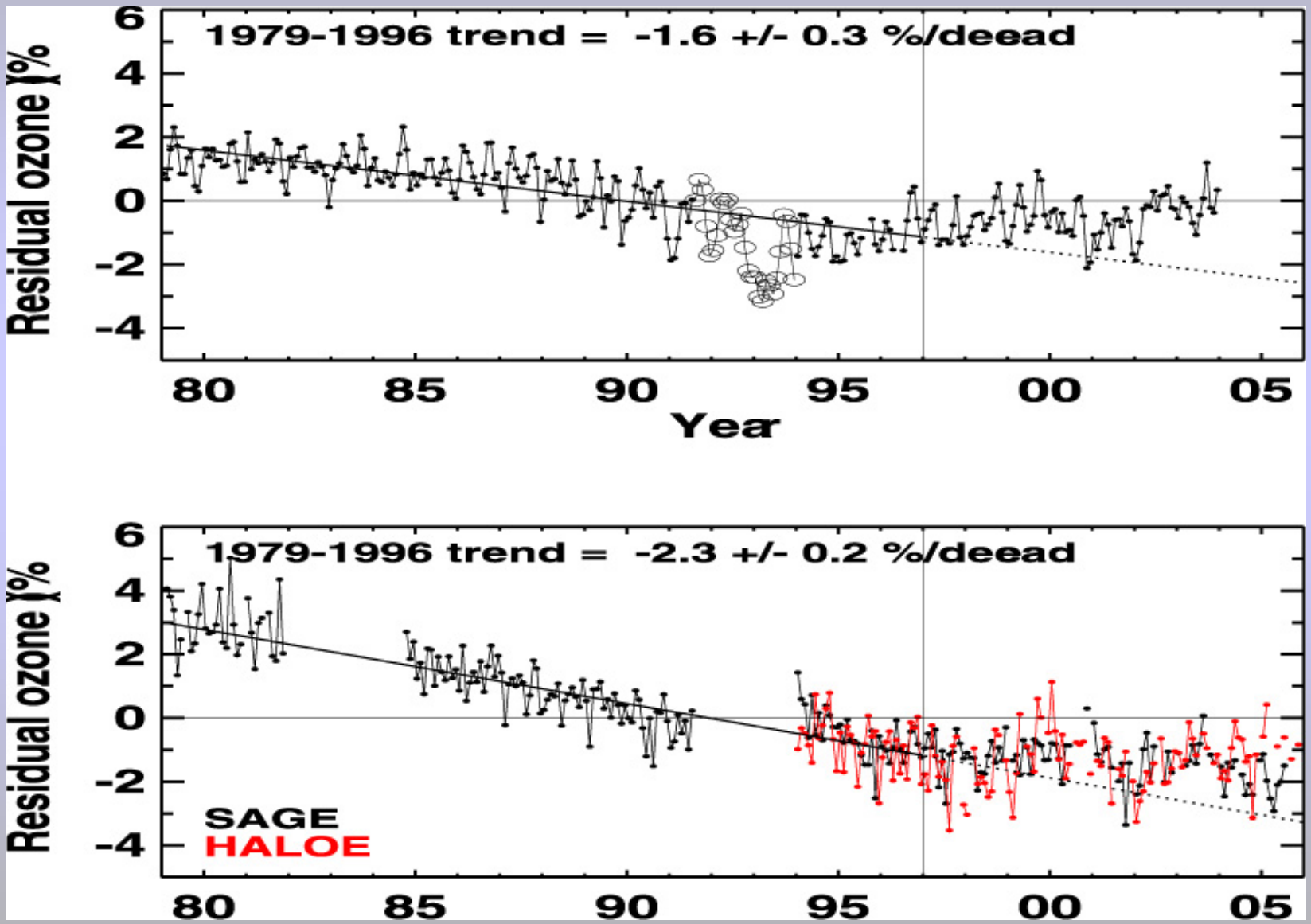
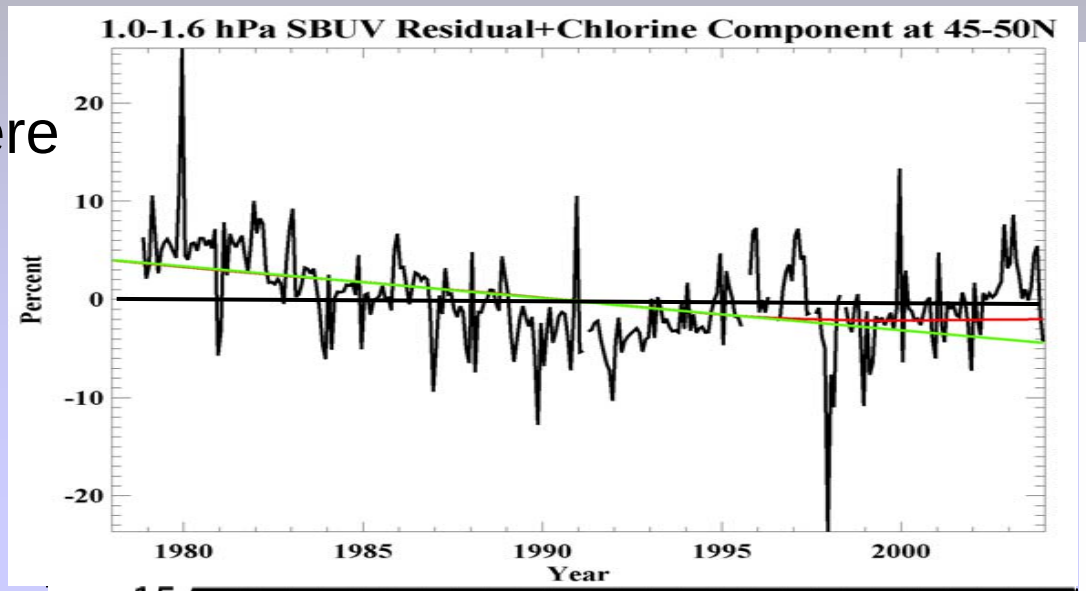


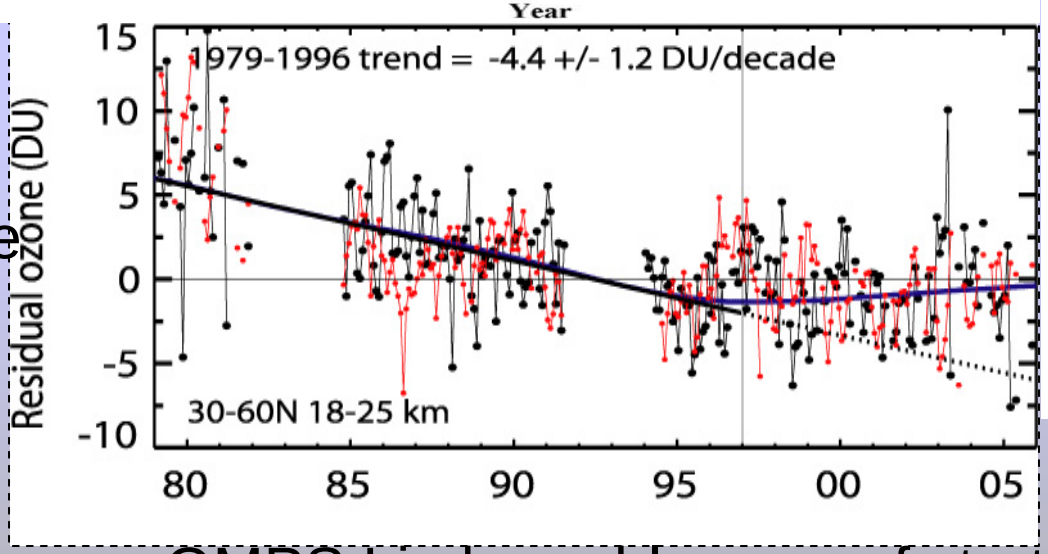
Figure from Yang et al, JGR-Atm 111, D17309, 2006

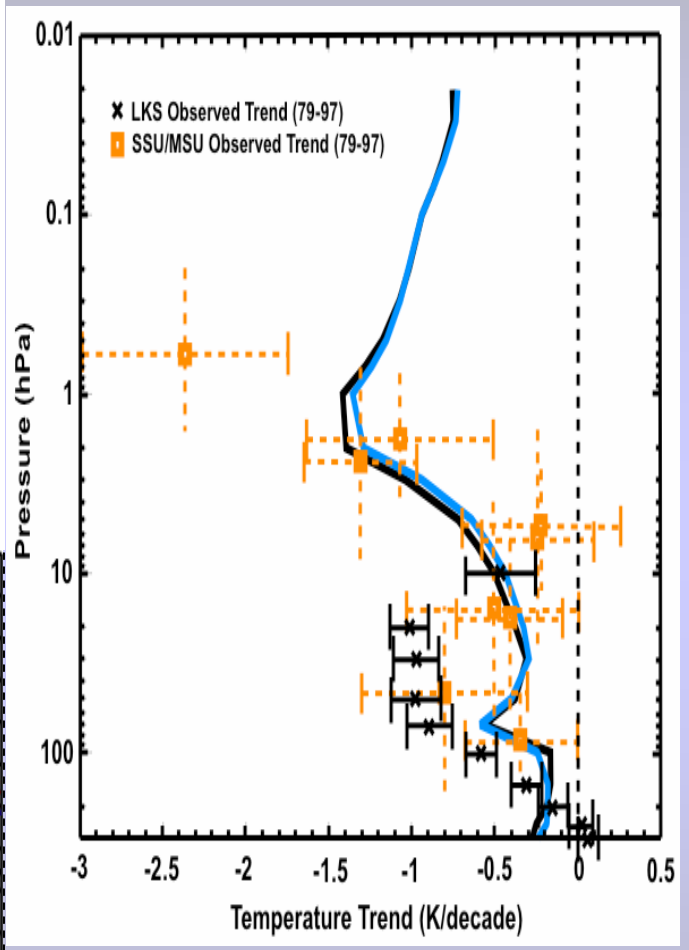
Ozone Profile Trend Analysis

Upper Stratosphere N Mid Lat



Lower Stratosphere N Mid Lat



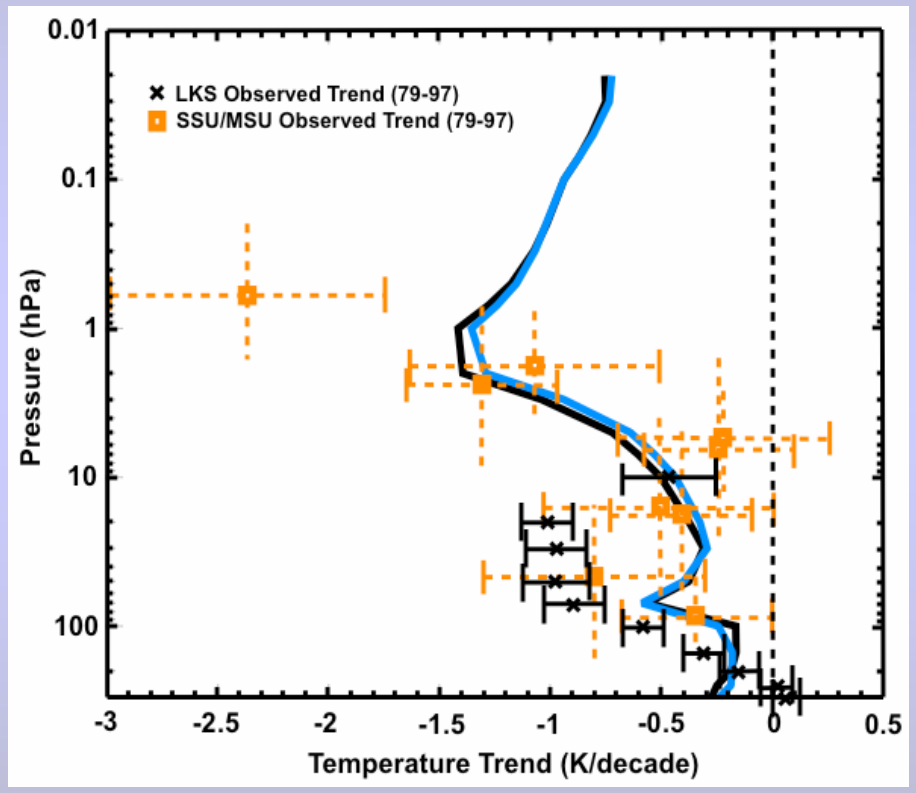


OMPS Limb enables use of stratospheric ozone as a diagnostic for global change understanding

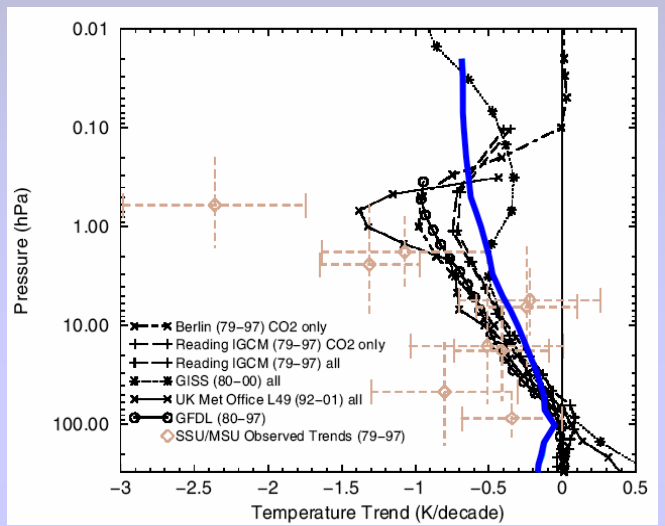
O_3 figure from Yang et al, JGR-Atm 111, D17309, 2006

Global Trend Compared to Data from SSU/MSU and Radio Sondes

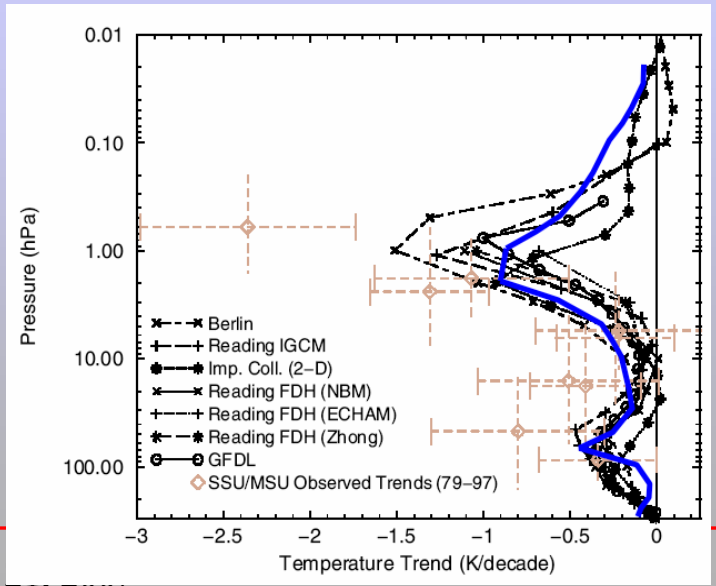
Trend vs Data



GHG Contribution



Ozone Contribution



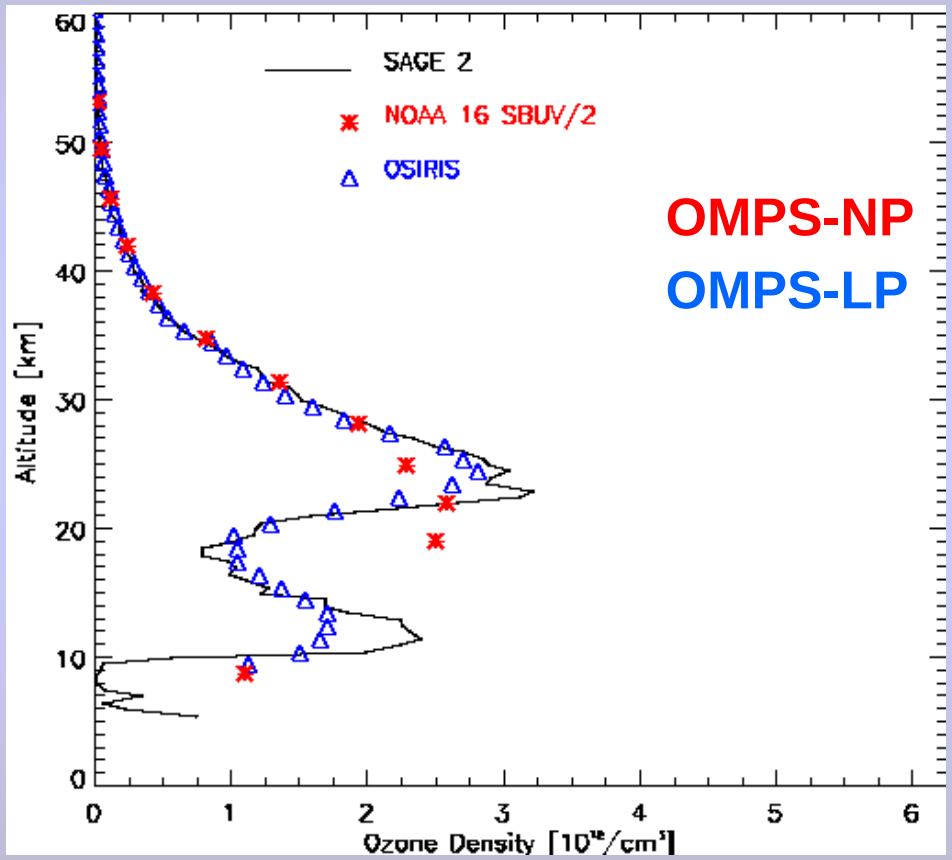
Figures from Shine et al,
Q. J. R. Meteorol. Soc., **129**, 1565 , 2003

OMPS Limb Algorithm Status

- **Limb Profile Algorithm Technical Content**
  - **Ozone Limb Profiles (LP) are successfully retrieved from four systems today (GOMOS, SCIAMACHY,OSIRIS & SAGE III)**
  - **NASA has developed an Ozone LP algorithm, and data from these systems are processed for ozone research**

- **Operational Production**
  - **POES SBUV/2 provides a model for NASA/NOAA cooperation to process OMPS LP data.**
    - > **Instrument calibration, data cal/val, performance monitoring, algorithm adjustments, and operational processing**

Ozone Profile Comparison
October 10, 2002



OMPS Limb Algorithm Plan

Continue SBUV/2 model of NASA/NOAA cooperation to process OMPS LP data.

- NASA led team with NOAA members
- Algorithm development and improvement
- Instrument calibration, Instrument performance monitoring, & data cal/val
- Adjusting algorithms for specific instrument performance issues
- Develop long-term ozone profile data set: SAGE II to Aura MLS to OMPS
- Develop algorithm and calibration for operational data production
-

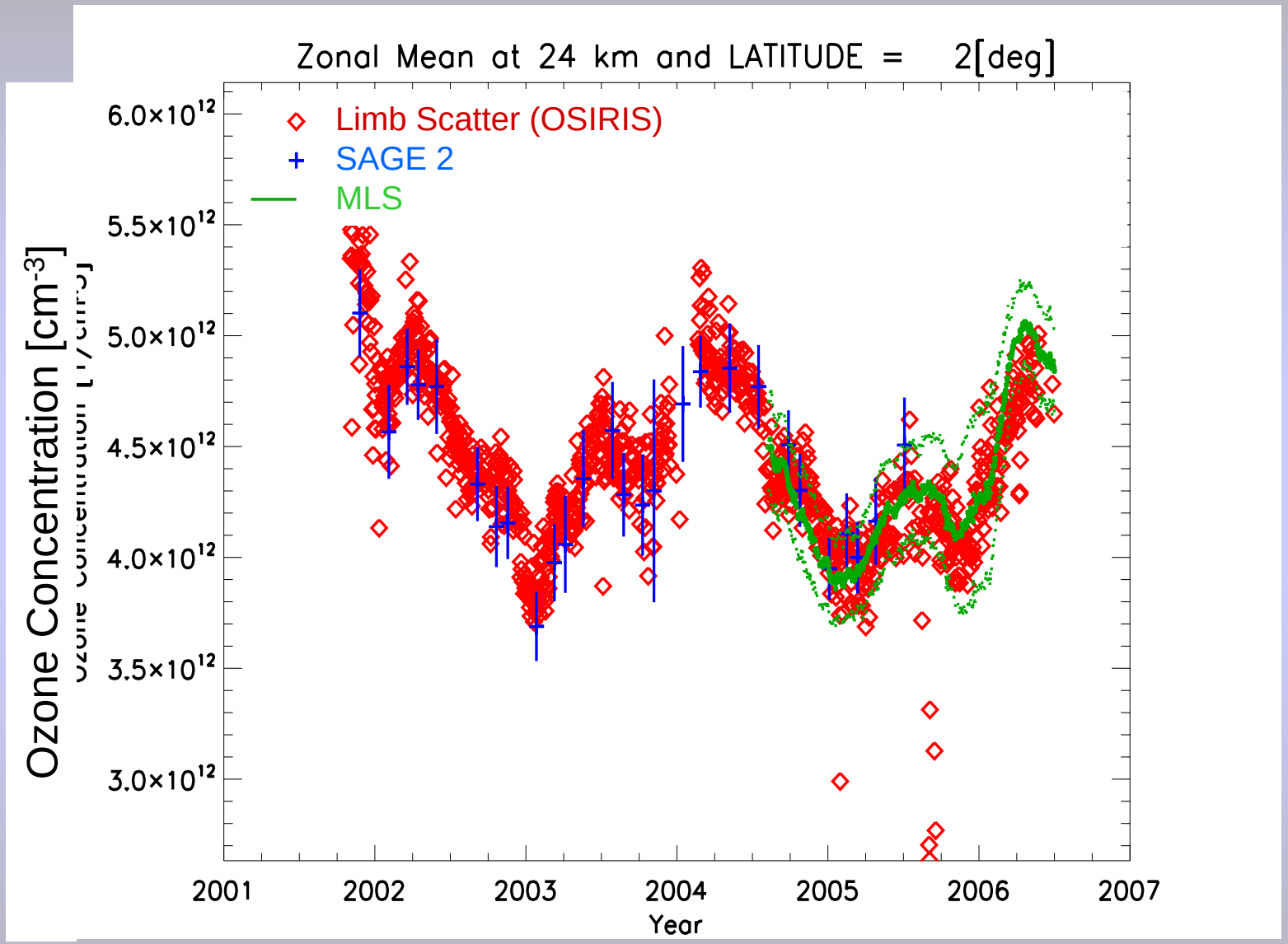
Research Data Production

- NASA Ozone PEATE provides facility for algorithm development, research data processing and long-term data set production.

Operational Data Production

- Use SBUV/2 Model: NASA/NOAA team produces algorithm, instrument calibration, performance monitoring, algorithm adjustments, and operational algorithm
- Current operational SBUV2 data processed by NESDIS
- Future operational OMPS LP data could be produced by NPOESS Data Exploitation (NDE).
  - NDE adapts operational algorithm for NDE system

Multi-Instrument Ozone Profile Data



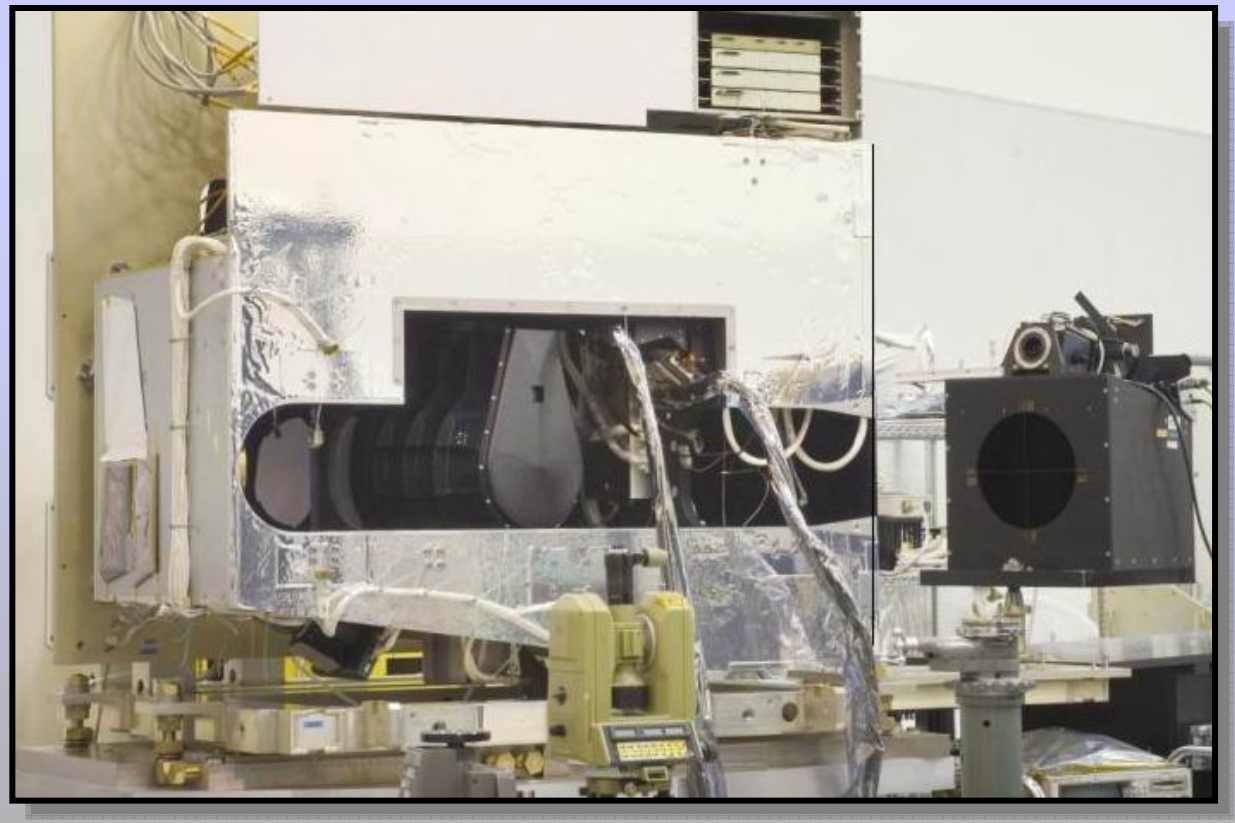
Limb Scatter data shows good agreement with past and current ozone profile data.

OSIRIS data courtesy of University of Saskatchewan

Visible Infrared Imaging Radiometer Suite
IPO /NGST/ Raytheon Santa Barbara Remote Sensing

Description

- **Purpose:** Global observations of land, ocean, & atmosphere parameters at high temporal resolution (~ daily)
- **Predecessor Instruments:** AVHRR, OLS, MODIS, SeaWiFS
- **Approach:** Multi-spectral scanning radiometer (22 bands between 0.4 μm and 12 μm) 12-bit quantization
- **Swath width:** 3000 km



Status

- EDU Finished T/Vac testing
- Flight Unit #1 Development continues
- Ambient Phase 1 test start this
- Week!

Visible Infrared Imaging Radiometer Suite

VIIRS Status

- Optical cross talk
  - Filter assembly identified as major cause of cross talk
    - Filter was reworked to seal light leaks
    - Filter was lowered to reduce scatter
    - Questions remain on M4 555nm band.
  - Sub-system test results show some improved performance.

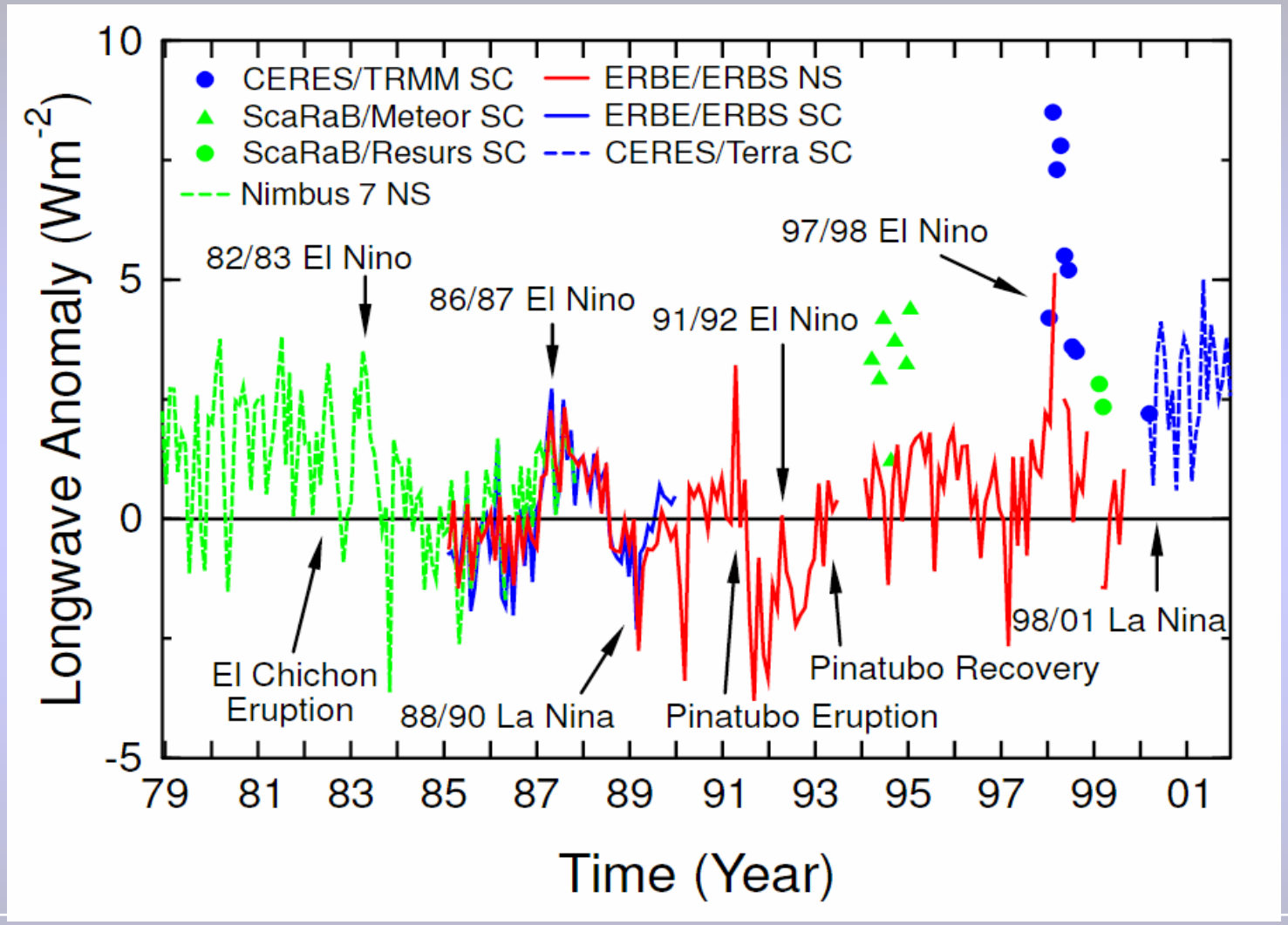
Cyro-radiator re-design and testing is moving forward.

Electronics module reassembly and cable rework is progressing.

Science Areas affected by cross talk effects;

- Ocean Color
- Aerosols
- Vegetation Index

Tropical (20S - 20N) TOA Radiation Anomalies: ERBE/ScaRaB/CERES Comparisons



Best absolute accuracy of 0.5 to 2% insufficient for climate anomalie

Overlap is Critical: stability capability exceeds absolute accuracy

Wong et al., J. Climate, in press

Study Objective, Background and Approach

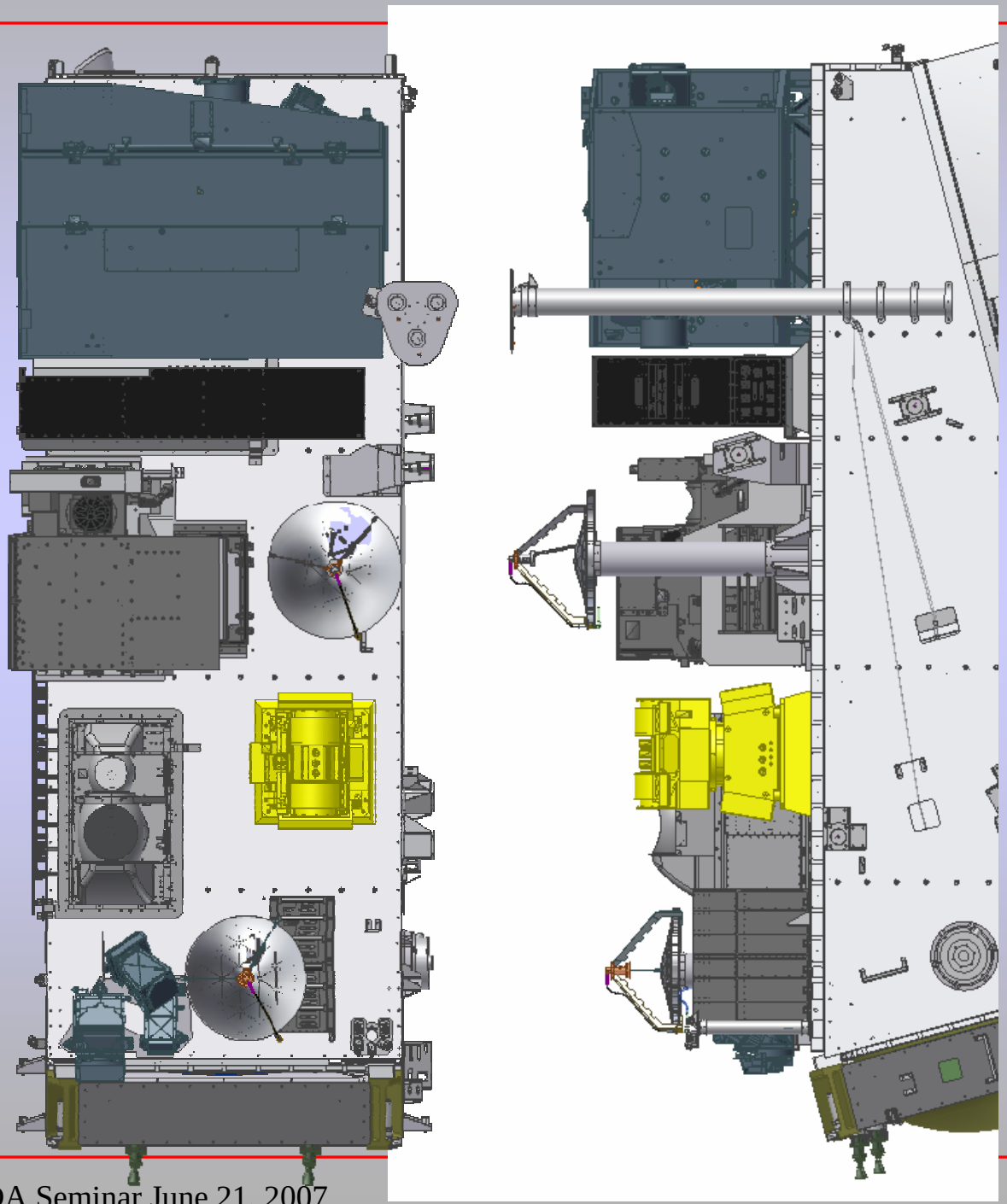
- **Study Objective**
  - **Assess accommodating CERES on the NPP mission; assess the impacts to the mission system (flight, ground and operations)**
- **Background**
  - **Decadal report emphasizes the need for continuous Earth radiation climate measurement**
  - **Need to cover the gap in CERES measurement between Aqua end of life and the launch of NPOESS C1 launch**
  - **Head of NPOESS PEO also requested agencies study the accommodation**
- **Approach**
  - **NPP Project coordinating a mission system impact; areas of assignment consistent with current roles and responsibilities**
    - **NASA**
      - **GSFC - spacecraft and instrument integration, Science Data Segment (SDS), pre-launch mission testing and operations readiness, launch vehicle, low fidelity instrument simulator**
      - **LaRC – CERES instrument, data processing and calibration / validation, instrument operations, instrument sustainment for mission life (anomaly & FSW support)**
    - **IPO / NPOESS contractor – Ground Systems, operations and sustainment**
    - **NOAA NESDIS – CLASS (long term archive and distribution)**

Three Phase Strategy

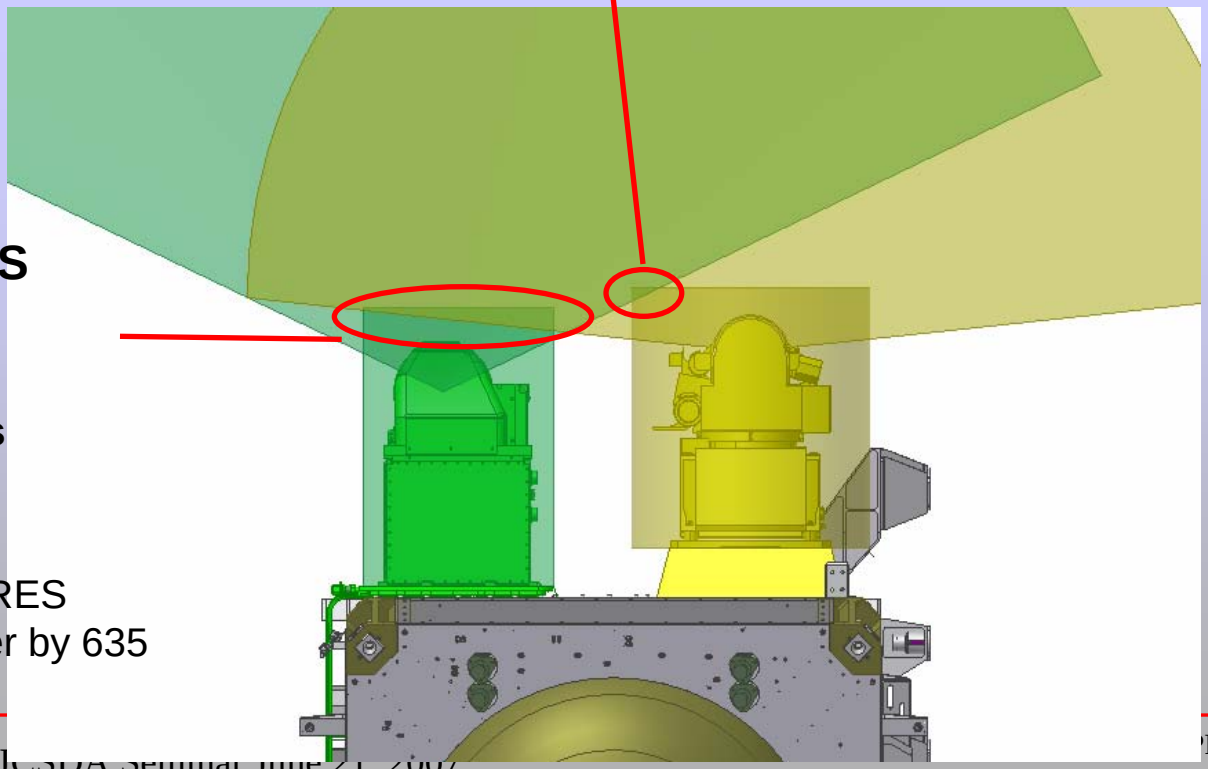
- **Phased approach to study and commitment**
- **Phase 1: Initial Study underway**
  - **Perform an initial assessment of system impacts and risks**
  - **Identify areas needing further analysis**
  - **Develop cost estimate for Phase 2 and cost ROM for Phase 3**
  - **Report findings April 27**
- **Phase 2: Detailed analysis and design (June 1, 2007 – September 14, 2007)**
  - **CERES**
    - **LaRC to issue task modification on the Northrop Grumman CERES contract to prepare CERES for NPP**
    - **Northrop Grumman to prepare proposal**
    - **LaRC CERES to evaluate proposal and be ready for an ATP**
  - **Spacecraft**
    - **NPP Project to issue a task to Ball to perform detailed analysis and design for S/C modifications**
    - **Ball to perform analysis / design and provide firm, fixed price for implementation**
    - **Update assessment of power margins given latest status of VIIRS, CrIS, and OMPS**
    - **Prepare contract modification to implement CERES on NPP and be ready for an ATP**
  - **Ground Systems**
    - **All ground system stake holders (GSFC, LaRC, NPOESS IPO, NOAA) to perform detailed analysis and design and operations assessment**
  - **Reassess launch schedule based on delivery dates for VIIRS, CrIS, OMPS and CERES**
  - **Phase 2 funding for GSFC and LaRC provided out of NPP Project contingency**
- **Phase 3: Implement CERES Accommodation on NPP (October 1, 2007 –)**

CERES Accommodation – Fields of View (1)

- **Re-locate RSE box**
- **Add ~5” pedestal under CERES**
  - **Required for CERES FOV to clear ATMS and Nadir sunsensor mast assy**
- **Limited CERES FOV accommodations**
  - **Only “cross track” FOV can be accommodated for science**
  - **Only “Back” solar cal FOV can be accommodated for solar cal**



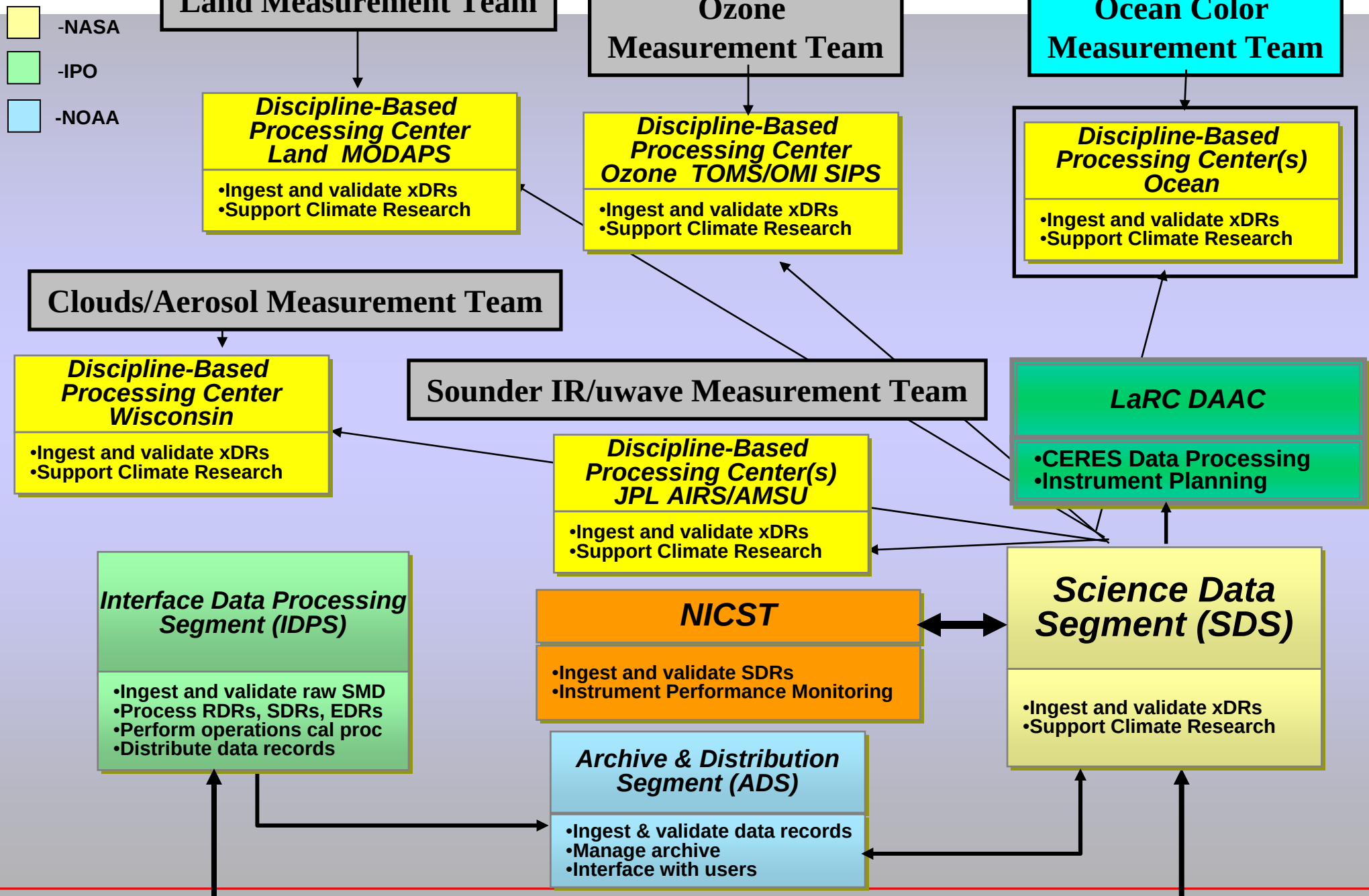
- **Requires agreement from CERES on**
  - Envelope **change to eliminate interference with SMD antenna FOV**
  - Envelope **change to eliminate interference with ATMS science FOV**



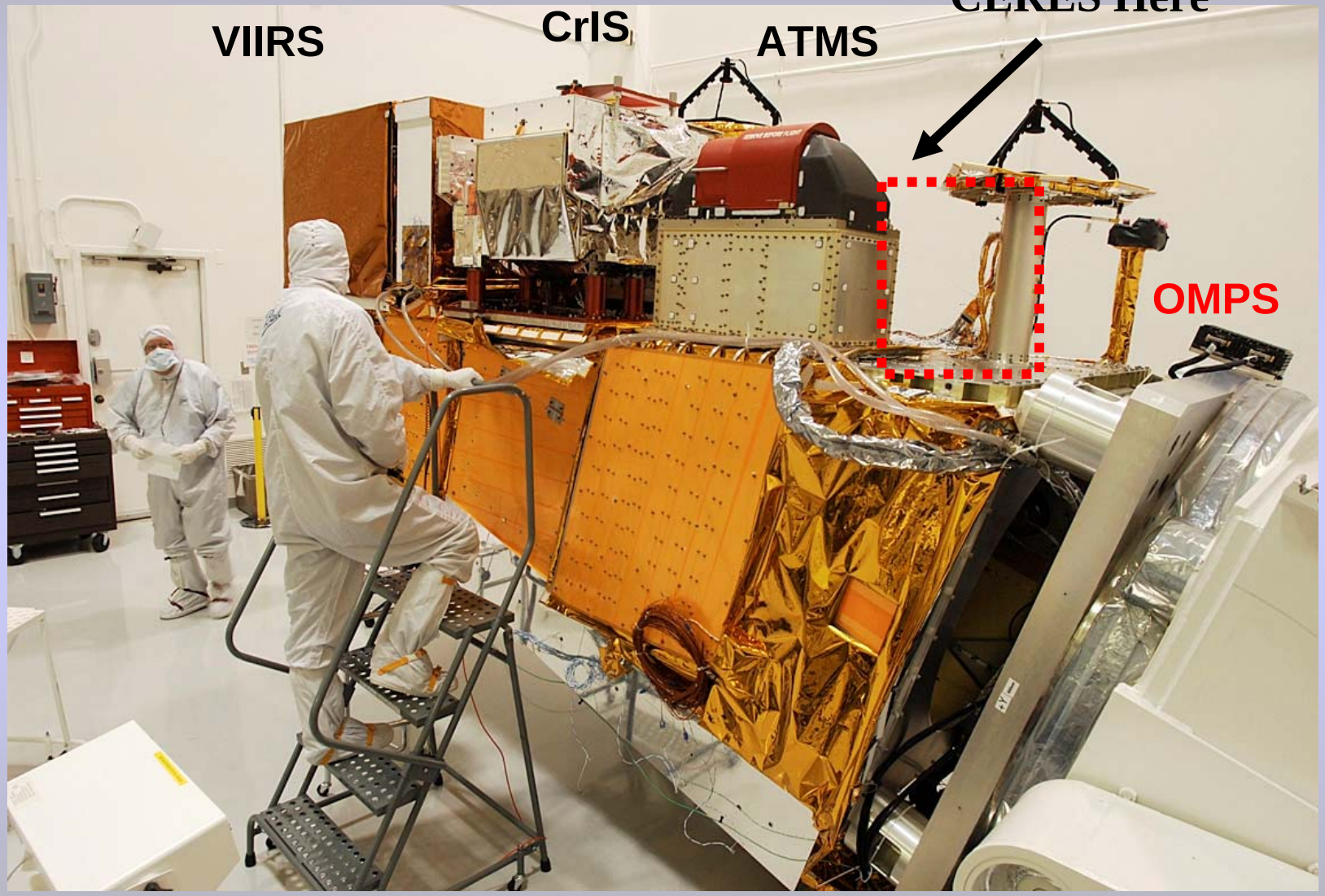
- **Requires agreement from ATMS on**
  - "Envelope" **change to eliminate interference with CERES cross track FOV**

The nominal physical envelope for the CERES instrument is a cylinder 602 mm in diameter by 635 mm tall and includes all swept areas.

NASA Science Data Processing



NPP in Ball Clean Room



Backup

CrIMSS Algorithm EDRs: AVMP, AVTP, AVPP

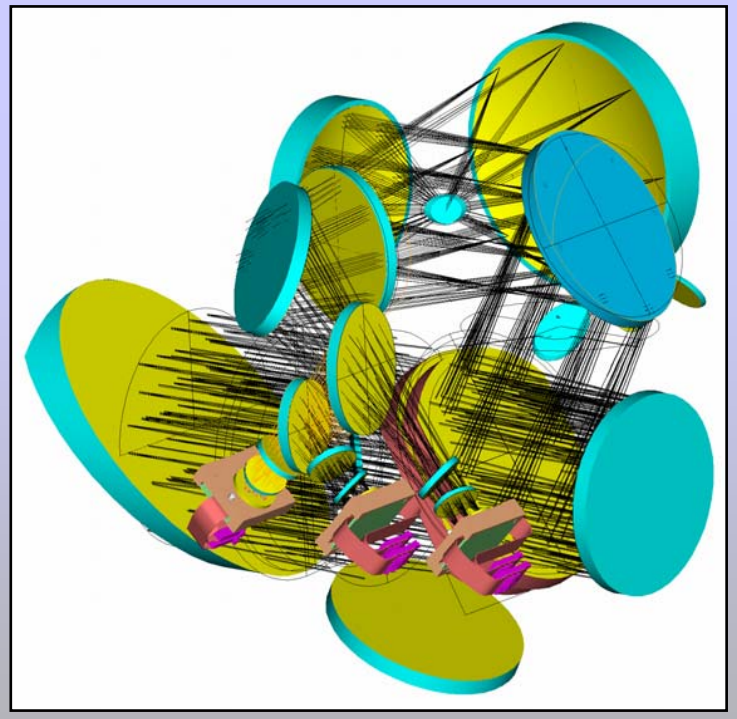
- **AVMP: Atmospheric Vertical Moisture Profile**
  - defined as a set of estimates of average mixing ratio in three-dimensional cells centered on specified points along a local vertical. The mixing ratio of a sample of air is the ratio of the mass of water vapor in the sample to the mass of dry air in the sample.
- **AVTP : Atmospheric Vertical Temperature Profile**
  - defined as a set of estimates of the average atmospheric temperature in three-dimensional cells centered on specified points along a local vertical.
- **AVPP: Atmospheric Vertical pressure Profile**
  - defined as a set of estimates of the atmospheric pressure at specified altitudes above the earth's surface. There is no NPP requirement on performance.

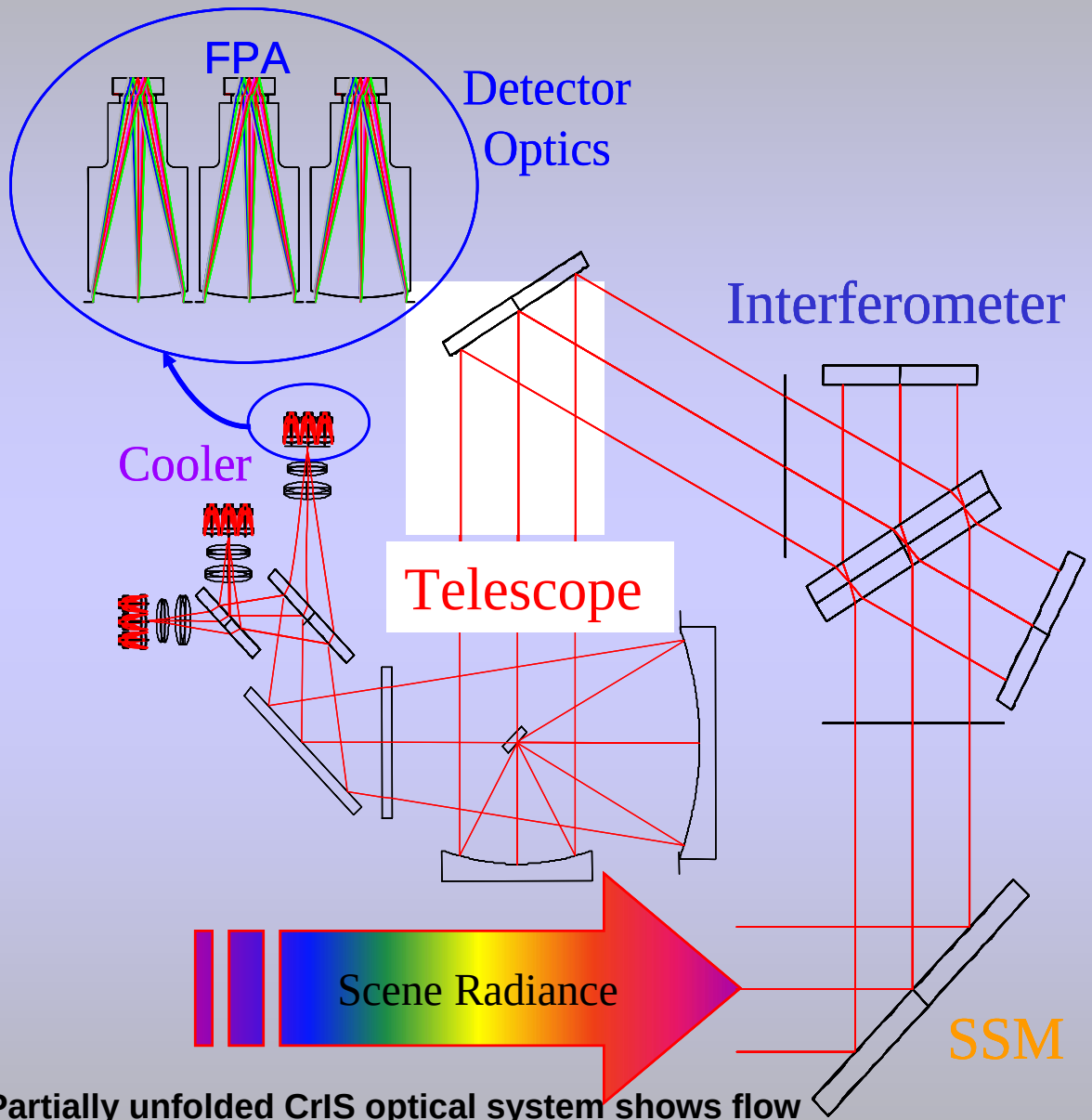
CrIMSS EDR Algorithm Description

- The CrIMSS EDR algorithm is a physical iterative algorithm to simultaneously retrieve atmospheric profiles and surface states from ATMS/CrIS SDRs
- It consists of two stages: first stage MW-only retrieval and the second stage IR&MW combined retrieval.
- The IR&MW combined retrieval is performed on MW radiances and cloud-cleared IR radiances. Cloud contamination is estimated and removed by the cloud-clearing module. This is done by using the MW-only retrieval as the first guess, and using the IR radiance contrast between neighboring FOVs which are assumed to have identical backgrounds but different amount of clouds.
- The retrieved parameters include:
  - **Temperature profile (reconstructed from 20 temperature EOFs)**
  - **Moisture profile (reconstructed from 10 moisture EOFs)**
  - **Surface temperature**
  - **Surface MW emissivity (reconstructed from 5 MW emissivity EOFs)**
  - **Surface IR emissivity (at 12 frequency hingepoints)**
  - **Surface IR reflectance (at 12 frequency hingepoints)**
  - **MW cloud top pressure and cloud liquid water path**
  - **Ozone column or profiles (reconstructed from 7 ozone EOFs)**
  - The post-processing module produces AVMP, AVTP and AVPP according to system requirements specifications

CrIS Sensor Design Packs High Performance into a Small Volume

- **Extremely Compact**
- **Large Aperture**
- **Excellent Image Quality**
- **Fully Wedged / Tilted**
- **Athermalized Design**
- **Pupil Imaging System**

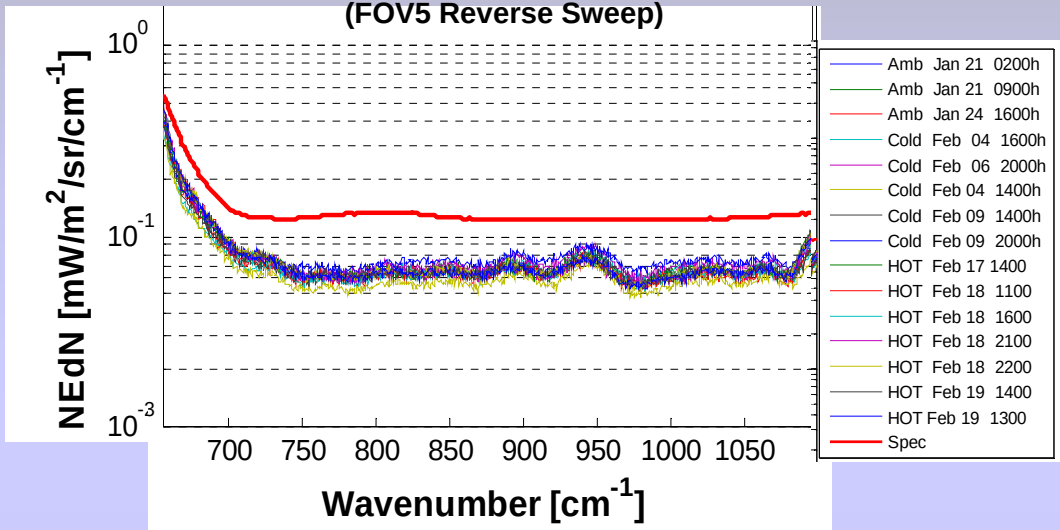




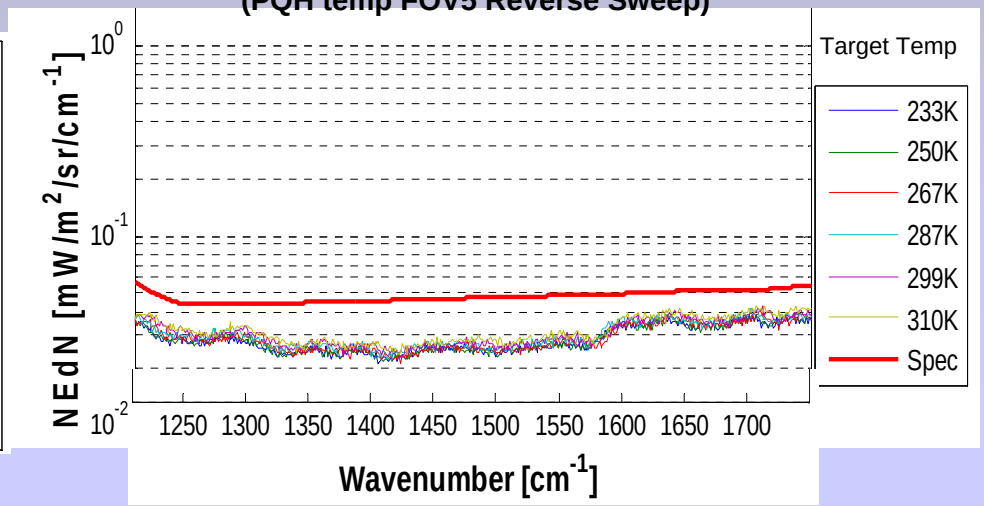
> **Partially unfolded CrIS optical system shows flow of signal radiance to detectors.**

CrIS EDU3 TVAC Testing Demonstrates NEdN Performance Margin

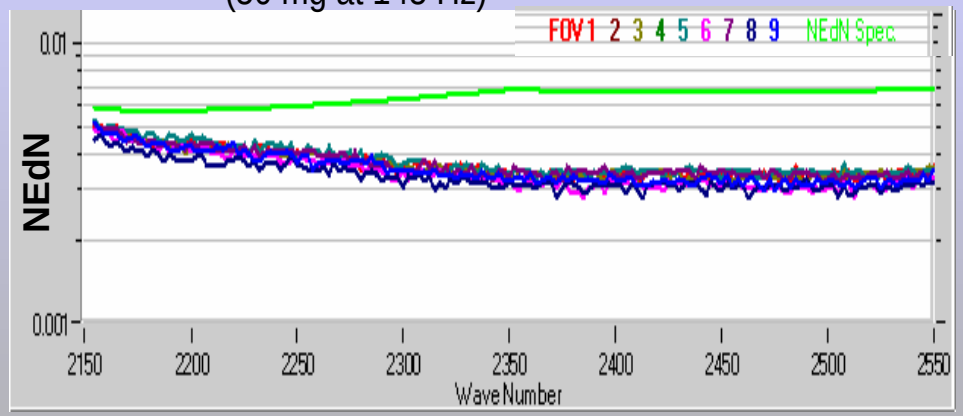
LW NEdN over Temperature
(FOV5 Reverse Sweep)



MW Radiometric Characterization
(PQH temp FOV5 Reverse Sweep)



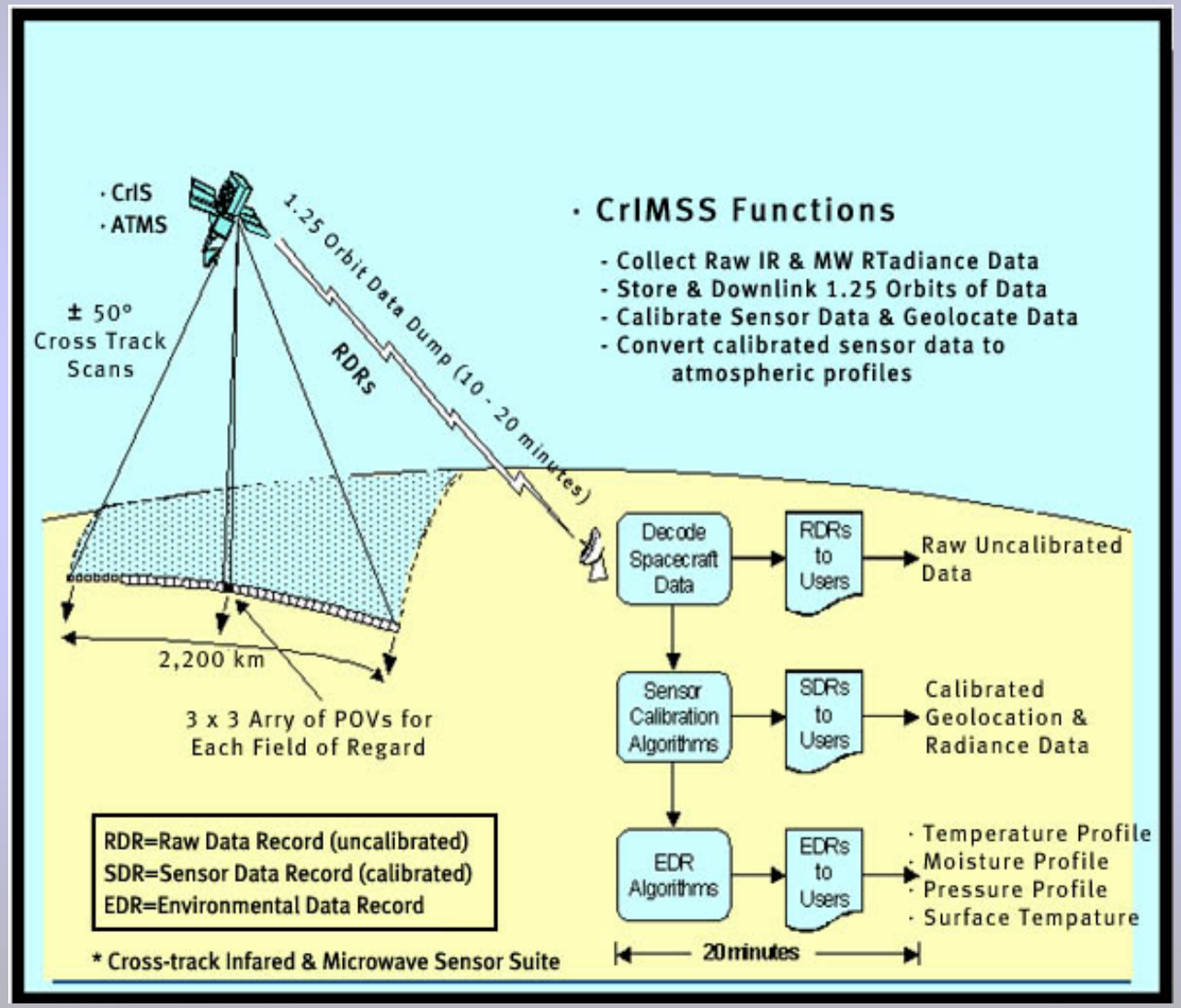
SW NEdN With Jitter Applied
(50 mg at 145 Hz)



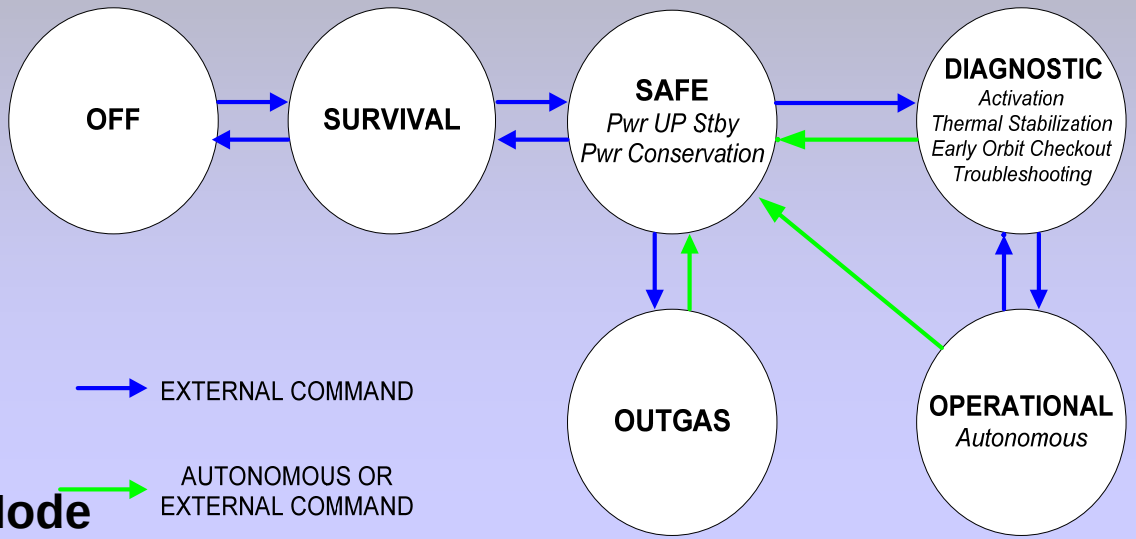
- NEdN performance stable over Temperature
  - **Tested long-wave performance at protoqual high, mid and low temperatures and mid-wave with varying target temperatures**
- NEdN also shown to be robust over the operational jitter environment

CrIMSS Products

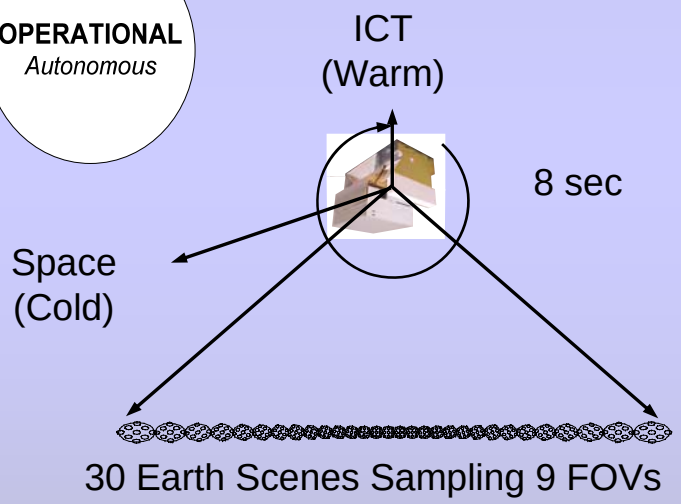
- **Raw Data Record (RDR) – uncalibrated**
- **Sensor Data Record (SDR) – calibrated and geolocated radiances**
- **Environmental Data Record (EDR)**
  - **Temperature Profile**
  - **Water Vapor Profile**
  - **Pressure Profile**
- **Intermediate Data Products (additionally)**



CrIS Sensor Modes and OpsCon Are Mature and Well Understood



- **Operational Mode**
  - **Sensor Continuously Collects Data**
    - > **8 Second scans: Synched to CrIMSS pulse**
    - > **30 Earth Locations: 9 FOVs per location, 3 spectral bands per FOV**
    - > **Two calibration looks per scan: Internal Calibration Target (ICT) — Warm and Deep Space— Cold. Separate calibrations for two interferometer scan directions**
  - **Autonomous Operation**
    - > **No additional ground commands required**
    - > **Meets all performance requirements over a >60 day period**
  - **Operates Through Station Keeping Maneuvers**

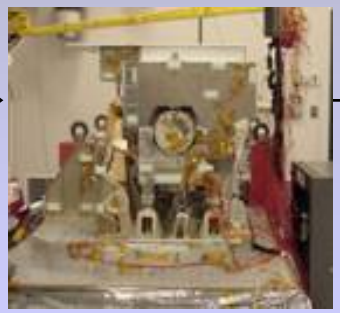


- **Tasking requirements – mode transitions**
- **Orbit operations – autonomous**
- **Uplink/Downlink requirements –**
- **Neon calibration time line**

Factory Calibration and Characterization Is a Key Part of the NPOESS Cal/Val Plan for CrIS

Bench Test

Vibration Testing



- Short Form Electrical
- X, Y, Z Axis Random sine and SRS, with Short Form Electrical between axes
- Vibration Isolation System Characterization
- Dynamic Interaction at Operational levels
- Cooler Door Deploy-ment Test

EMI Testing

- Short Form Electrical
- Radiated Emissions Testing
- Conducted Emissions Testing
- Conducted Susceptibility Testing with evaluation of the performance margins
- Radiated Susceptibility Testing with evaluation of the performance margins

Post-EMI/Vib Bench

- Short Form Electrical
- Full Electrical Performance (EP) Testing
- Bench FOV and Radiometric Testing

Thermal Vacuum Testing

- Short Form Electrical
- Thermal Cycles (3) with Gain Set
- Initial FOV, Spectral, and Radiometric Measurements at Mission Nominal
- FOV, Spectral, and Radiometric Tests at Protoflight Acceptance Low, with Additional Characterization
- Chamber Dynamic Interaction
- Full EP Testing
- Thermal Balance at Protoflight Low
- Cold Start / Survival / Warm-up Heater Test
- Performance Testing at Intermediate Cold Temperature
- FOV, Spectral, and Radiometric Testing at Protoflight Acceptance High, with Additional Characterization
- Full EP Testing
- Thermal Balance at Protoflight High
- Performance Testing at Intermediate Warm Temperature
- Follow-up FOV, Spectral, and Radiometric Measurements at Mission Nominal
- Scan Scenario Testing
- Short Form Electrical

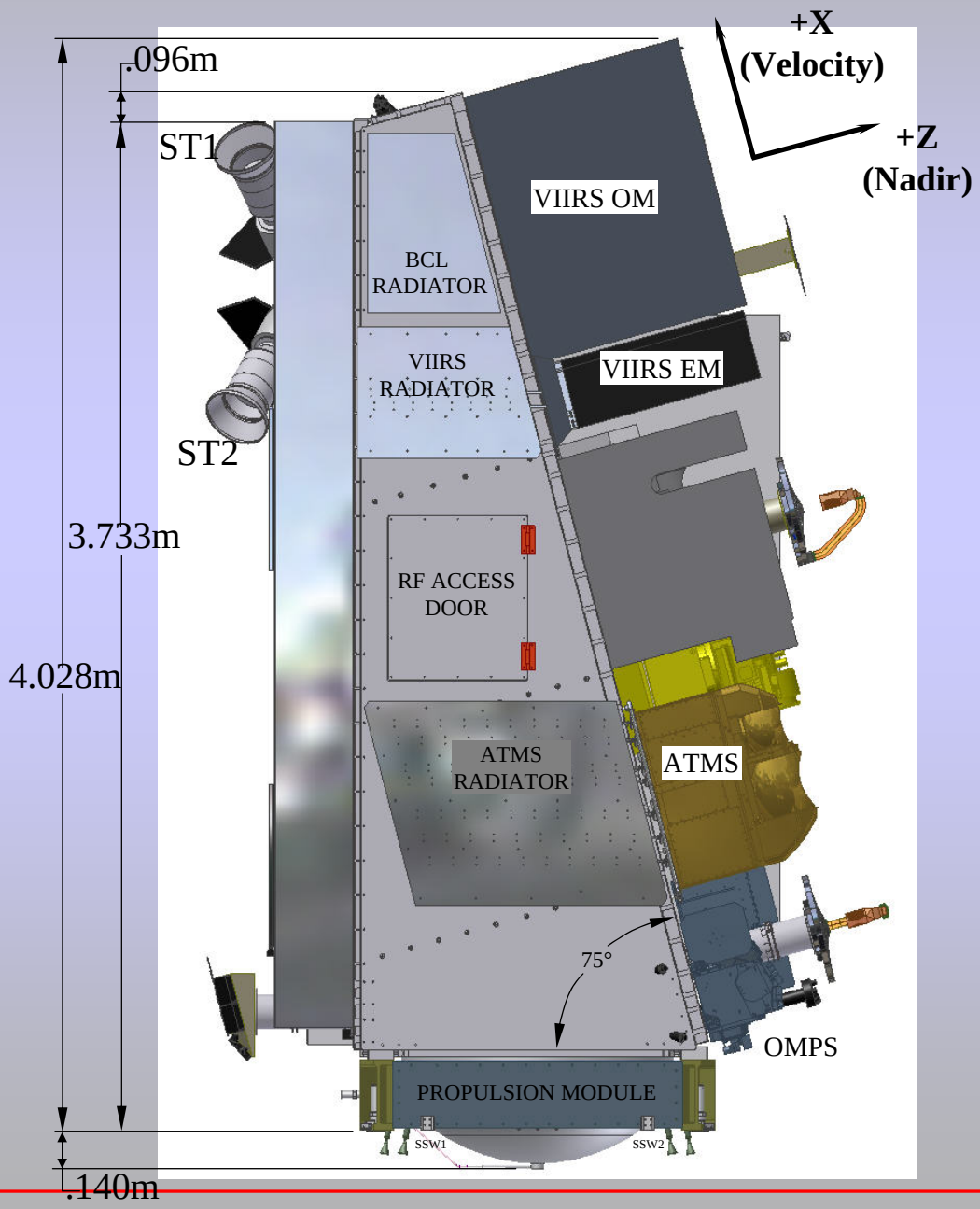
Pre p for Ship

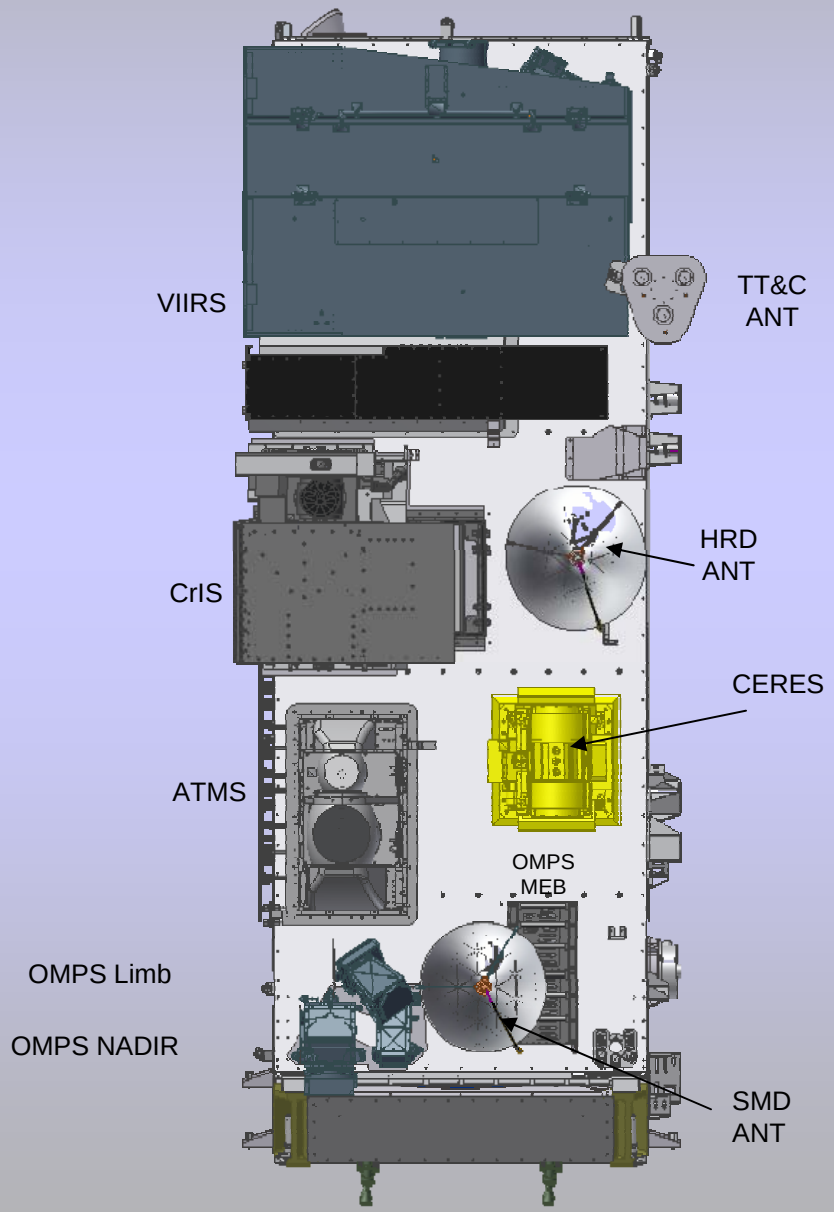
CrIS is Compliant with All TPMs

Sensor-Level TPMs (FM1)	Requirements	November 2004 Value	February 2005 Value	June 2005 Value
Band-Averaged LWIR NEdN Margin (Corner FOV)	Meet Spec	50% Margin	50% Margin	50% Margin
Worst Case LWIR Bin NEdN Margin	Meet Spec	35% Margin	35% Margin	35% Margin
Band-Averaged MWIR NEdN Margin (Corner FOV)	Meet Spec	44% Margin	44% Margin	44% Margin
Worst Case MWIR Bin NEdN Margin	Meet Spec	18% Margin	18% Margin	18% Margin
Band-Averaged SWIR NEdN Margin (Corner FOV)	Meet Spec	44% Margin	44% Margin	44% Margin
Worst Case SWIR Bin NEdN Margin	Meet Spec	10% Margin	10% Margin	10% Margin
LWIR Absolute Radiometric Uncertainty	≤0.45%	0.13%	0.13%	0.13%
LWIR Radiometric Long-Term Stability	≤0.4%	0.14%	0.14%	0.14%
ILS Shape Uncertainty (LWIR)	≤1.5% FWHM	0.56%	0.56%	0.56%
ILS Shape Stability (LWIR)	≤1.0% FWHM	0.02%	0.02%	0.02%
Spectral Uncertainty (LWIR)	≤10 ppm / 5 ppm	4.6	4.6	4.6
LOS Jitter (radial, 1-sigma)	≤71 urad Radial	68.0	68.0	68.0
Mapping Uncertainty	≤1.5 km	1.00	1.00	1.00
Band-to-Band Coregistration	≤1.4%	1.31%	1.31%	1.31%
Encircled Energy LWIR	≥ 93%			93.5%
Encircled Energy MWIR	≥ 94%			94.7%
Encircled Energy SWIR	≥ 95%			96.2%
Mass	≤165 kg	151.00	151.00	151.00
Average Operational Power (28 VDC)	≤117 W	125.4	123.3	109.6
Average 1394 Firewire Power	≤24 W			23.1
Peak Operational Power (28 VDC)	≤221 W	193.4	191.4	203
Peak 1394 Firewire Power	≤24 W			23.1
Volume (cm)	<878x938x731 mm	Complies	Complies	Complies
Average Data Rate	≤ 1.5 Mbps	1.442	1.444	1.444
Reliability	>0.86	0.8805	0.8805	0.8805
Availability (Total Down Time)	<122.2 hours	18.0 hours	18.0 hours	18.0 hours
Soft SEU Rate	<1 per 8 sec	1 per 8.9 days	1 per 8.9 days	1 per 8.9 days
Detector Cooler Thermal Margin (LWIR) Worst Case	>6 K	7.9K	7.9K	7.9K
Main CPU Resource Utilization	<50%	18%	18%	18%
Main CPU Program Memory Utilization	<50%	61%	61%	61%
Main CPU Data Memory Utilization	<50%	21%	21%	21%
Main CPU Software LOC	N/A	6,655	6,655	6,655
Sensor Fundamental Frequency (Stowed)	>50 Hz	61 Hz	61 Hz	61 Hz

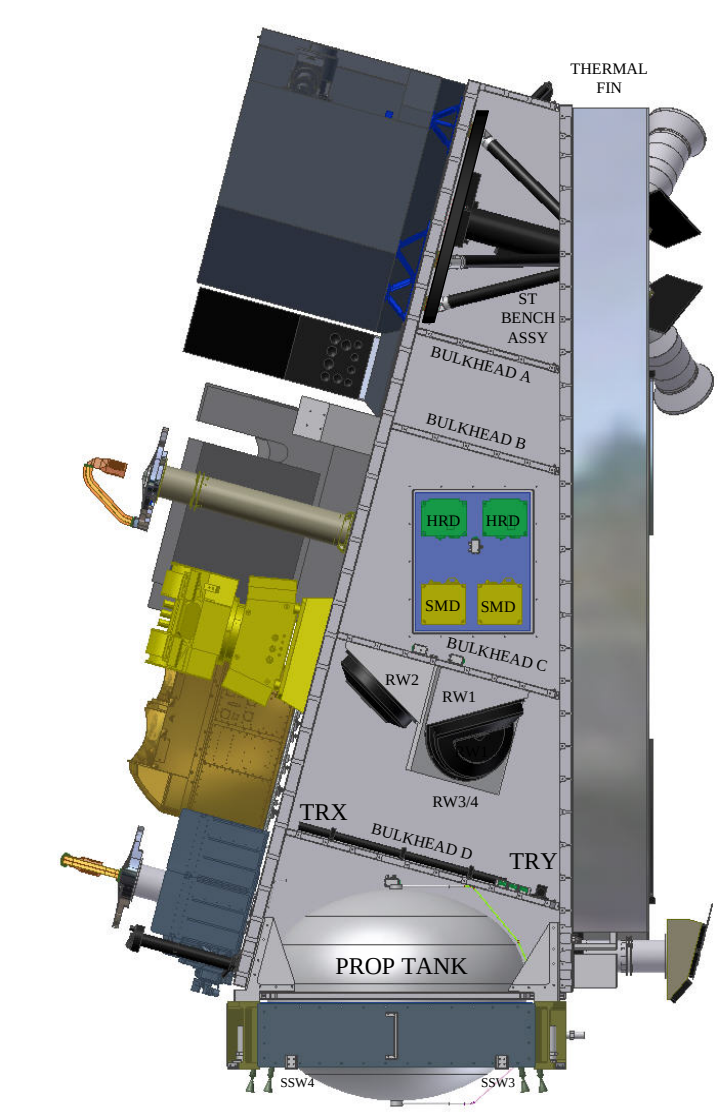
- Ave power spec changed from 117 W to 110 W to offset OMPS power growth on NPP.
- Margin substantially reduced with measurements of flight hw, especially new Aeroflex power supply

NPP S/C Layout - 1

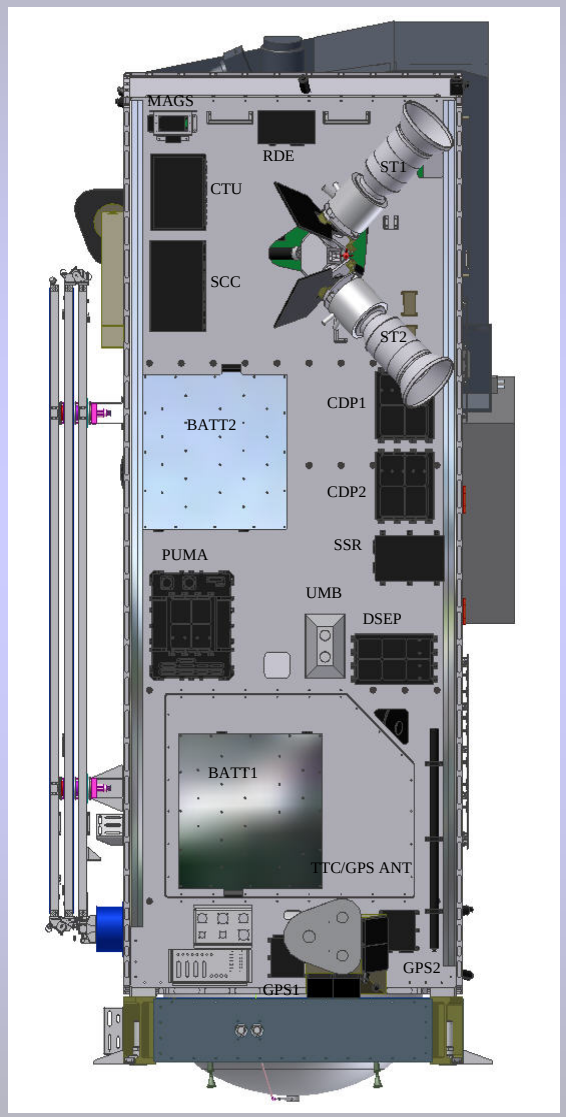




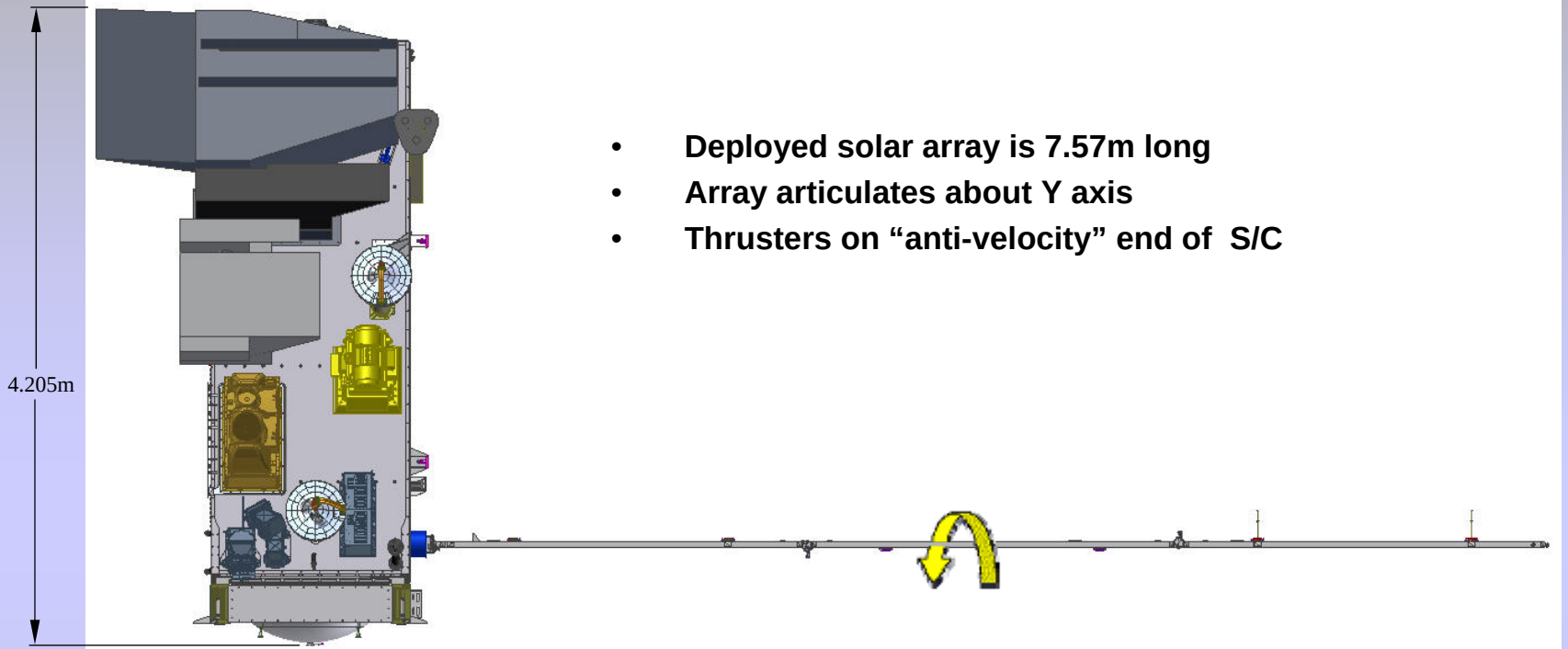
NPP S/C Layout - 2



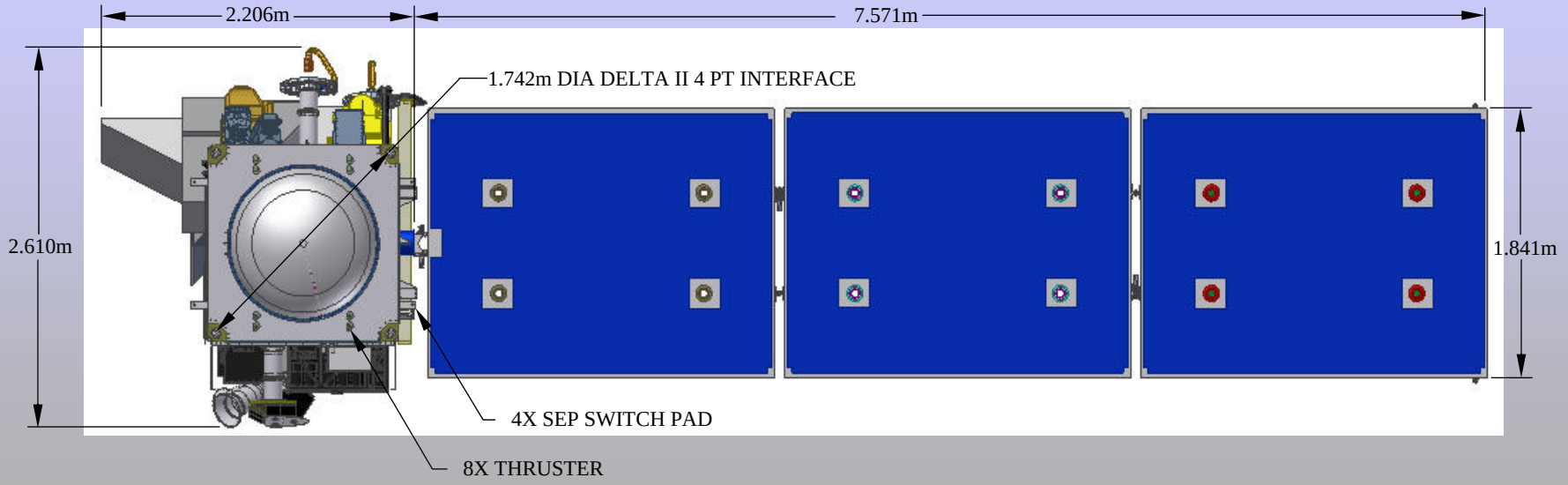
-Y SIDE VIEW
SOLAR ARRAY AND SPACECRAFT PANEL
REMOVED FOR CLARITY



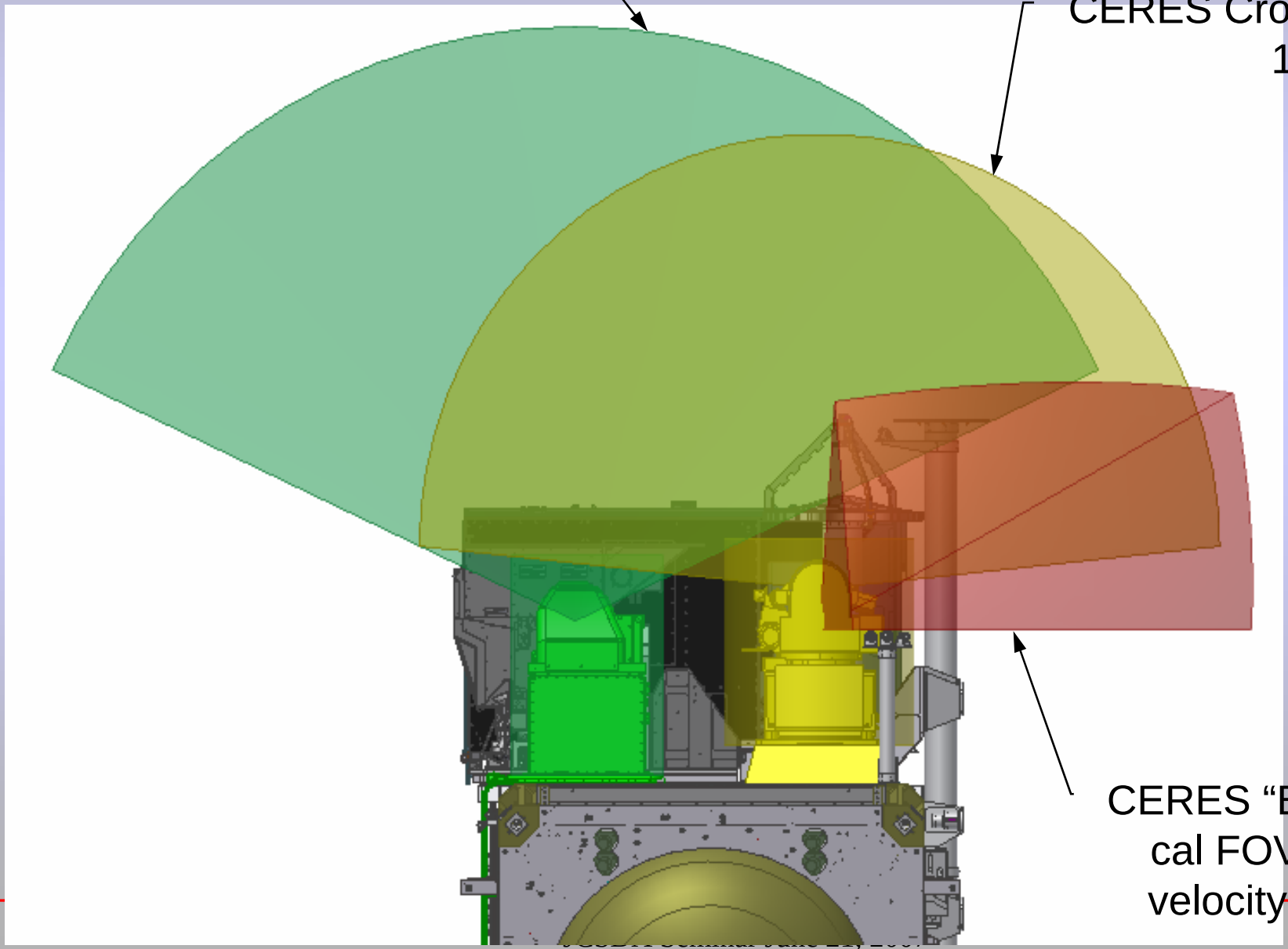
NPP S/C Layout - 3



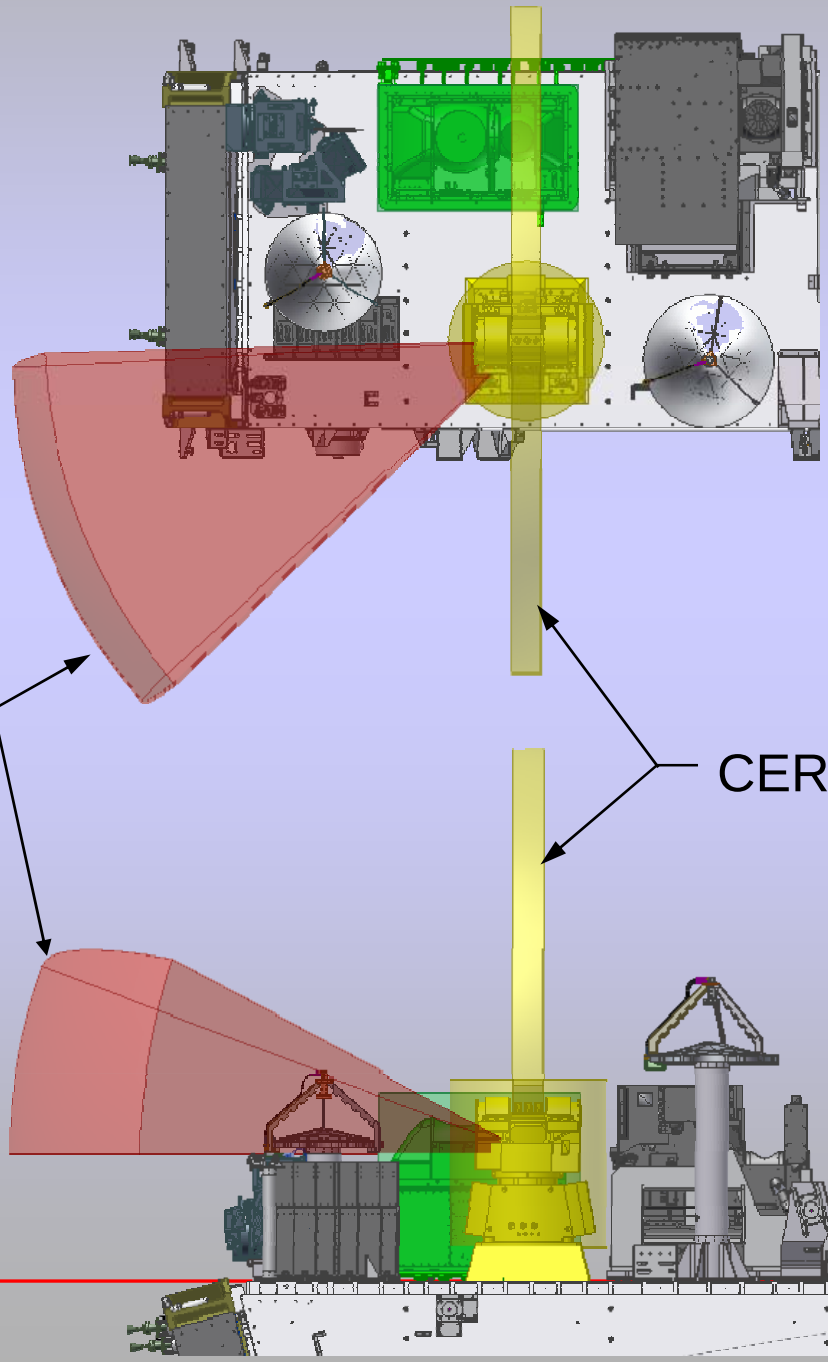
- **Deployed solar array is 7.57m long**
- **Array articulates about Y axis**
- **Thrusters on “anti-velocity” end of S/C**



CERES Accommodation – Fields of View (2)



CERES Accommodation – Fields of View (3)

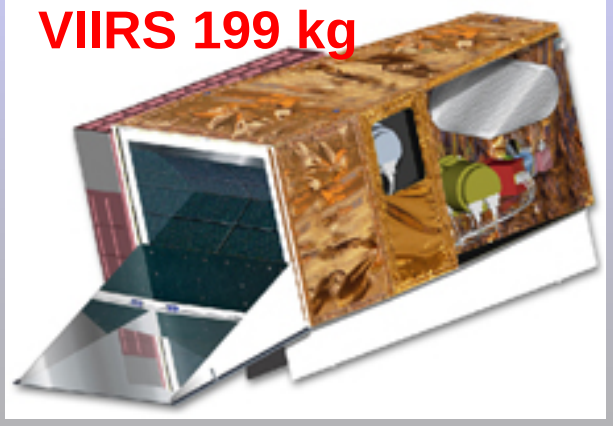


CERES "BACK" solar cal FOV

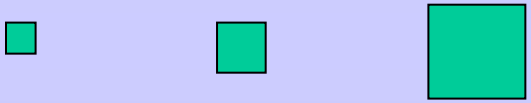
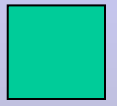
CERES Cross Track FOV

VIIRS Relative to AVHRR and MODIS

- VIIRS has 22 bands, 16 radiometric bands, 5 imaging band and 1 DNB. MODIS has 36 and AVHRR has 5.
- VIIRS replaces the paddle wheel mirror on MODIS with a rotating telescope (SEAWIFS) and a half-angle mirror design. (Less scattered light than MODIS)
- VIIRS has the solar diffuser and solar diffuser monitor as on MODIS but not the spectroradiometric calibration assembly.
- VIIRS does not have the 0.94 mm water bands, the 6.7 mm water vapor bands and the longwave CO2 bands. All of which have been used for cloud products.



Multi-Spectral Imaging Instrument Comparison

Instrument	Mass	Aspects	Mission	Resolution (# of bands)
VIIRS	265 kg	Rotating Telescope, 3 FPAs, (2 cooled), and DNB CCD	Operational	375 m (6), 750 m (15) 
MODIS	220 kg	Scanner, 2 FPAs (1 cooled)	Research	250 m (2), 500 m (5), 1 km (29) 
SeaWiFS		Rotating Telescope	Research	1.1 km (8) 
AVHRR	33 kg	Rotating Mirror	Operational	1.1 km (6) 
OLS	74 kg	Scanner, Low Light Imagery	Operational	500m (1), 1.9 km (1), 2.5km(1)