NPP Atmosphere Product Evaluation and Test Element (PEATE) at SSEC
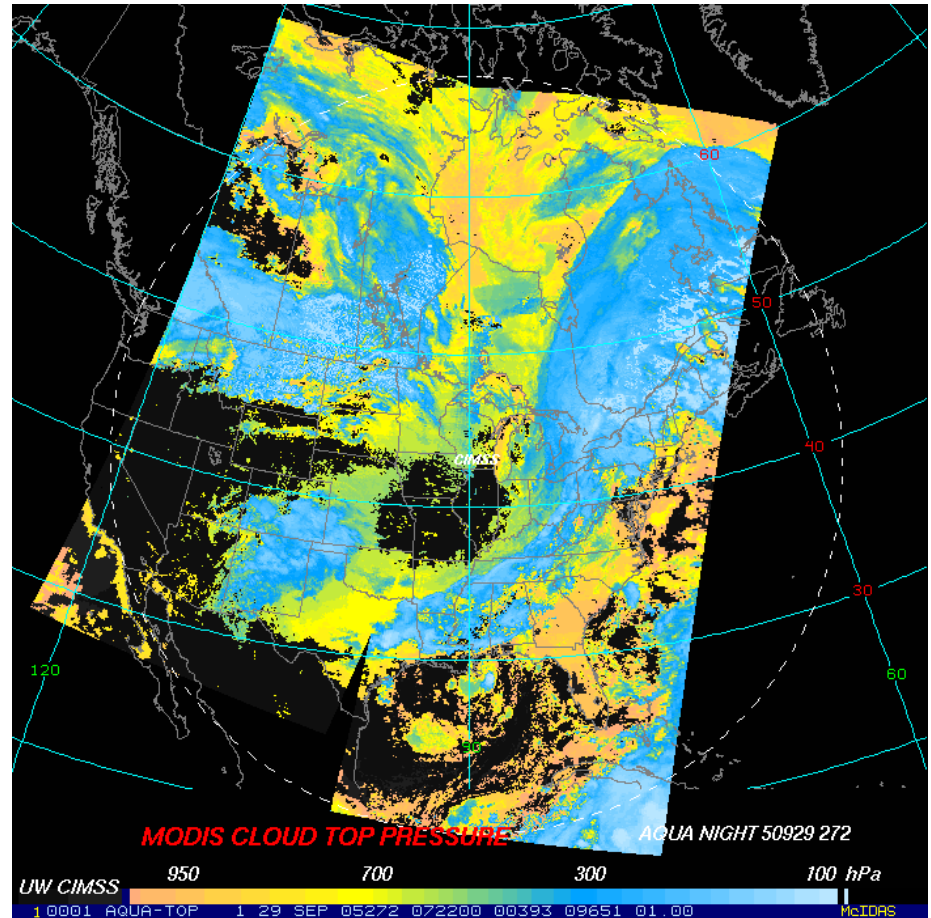
Liam Gumley

Space Science and Engineering Center

University of Wisconsin-Madison

October 28, 2005

McIDAS Users Group Meeting

Briefing Overview

1. NPP Mission and Science Goals
2. Role of the Science Data Segment
3. Role of the Atmosphere PEATE
4. SSEC activities in support of the PEATE

NPOESS Preparatory Project

- **NPP is a joint partnership between NASA's Science Mission Directorate and the NPOESS Integrated Program Office (IPO).**
- **Key program objectives:**
  - **To provide NASA with continuation of global change observations initiated by the Earth Observing System (EOS) Terra, Aqua, and Aura missions.**
  - **To provide the NPOESS operational community with risk reduction demonstration and validation for selected NPOESS instruments and algorithms, as well as the ground system.**

NPP Science Goals and Strategy

- **The NPP Science Charter:**
  "Continue the Scientific Data Record started by EOS".

- **"Measurement-based" instead of "Mission-based" data processing system.**

- **NPP is the first post-EOS mission to have this new science data processing strategy.**

  - **NPP data products will be produced by NPOESS data processing system (IDPS)**
  - **NPP data products will be archived by NOAA (CLASS/LTA).**
  - **NPP data products will be assessed for science quality at the NASA Science Data Segment (SDS) by the NPP Science Team.**

NPP System Architecture
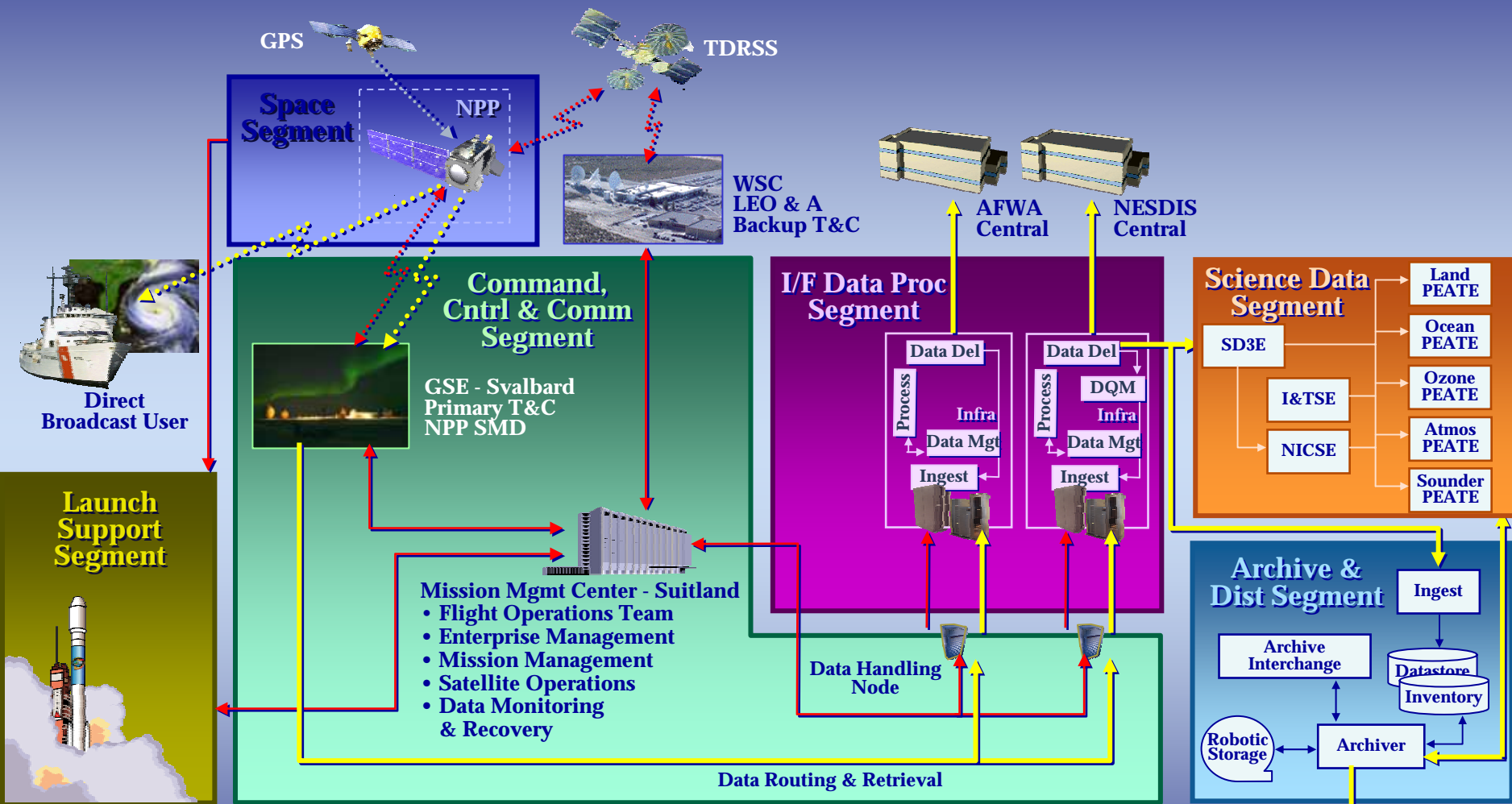
NPP Mission Summary

- **NPOESS Preparatory Project (NPP)**
  - April 2008 launch (subject to change)
  - 824 Km Sun Synchronous Orbit with 10:30 descending orbit
    - 16 day ground-track repeat similar to Landsat, Terra, Aqua, Aura
  - Science Instruments:
    - **Visible Infrared Imager Radiometer Suite (VIIRS)**
    - **Cross-Track Infrared Sounder (CrIS)**
    - **Advanced Technology Microwave Sounder (ATMS)**
    - **Ozone Mapping & Profiling Sensor (OMPS)**
  - Direct Broadcast of all data (X-Band)
- **NPOESS**
  - 1st Launch ~ 2011 into 833 Km orbit with 17:30 crossing time
  - Subsequent launches into 13:30 and 21:30 ascending orbits
  - Replacement satellites will be launched on failure of VIIRS
  - Continues into the indefinite future
  - Continuous Direct Broadcast of all data (X-Band)
  - Low Rate Data (LRD) broadcast on L-Band; lossy compression

NPP Developers (Industry)

Segments/ Elements	Contractor	Agency	Status
ATMS	NGES	NASA-GSFC	EDU Complete PFM Environmental Testing
CrIS	NGST/ ITT	IPO	EDU Complete Flight Development
OMPS	NGST/ Ball Aerospace	IPO	Flight Development
VIIRS	NGST/ Raytheon	IPO	EDU Development
Spacecraft	Ball Aerospace	NASA-GSFC	Qualification Complete
Launch Vehicle	Boeing	NASA-KSC	ATP Issued
C3	NGST/ Raytheon	IPO	Development
IDPS	NGST/ Raytheon	IPO	Development
ADS	CSC	NOAA	Development
SDS	GSFC	NASA-GSFC	Detailed Design

NPP Deliverables are Products

Raw Data Records (RDRs)

- **Similar to Level 1A for CEOS/NASA**
- **~ 150 giga bytes per day (similar to Terra or Aqua)**

Sensor Data Records (SDRs)

- **Similar to CEOS/NASA Level 1B**

Environmental Data Records (EDRs)

- **Similar to CEOS/NASA Level 2**
- *NPP Provides 25 of 55 NPOESS EDRs*

VIIRS (Imager)
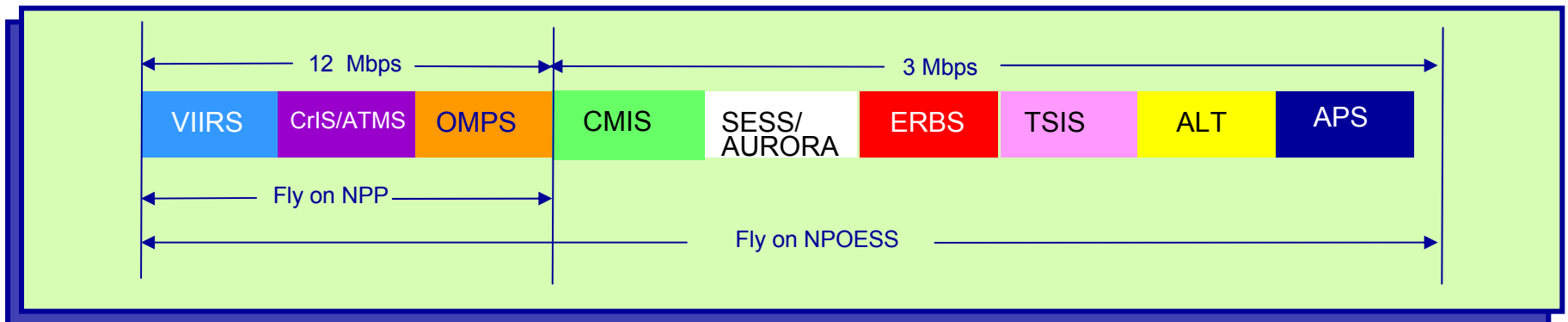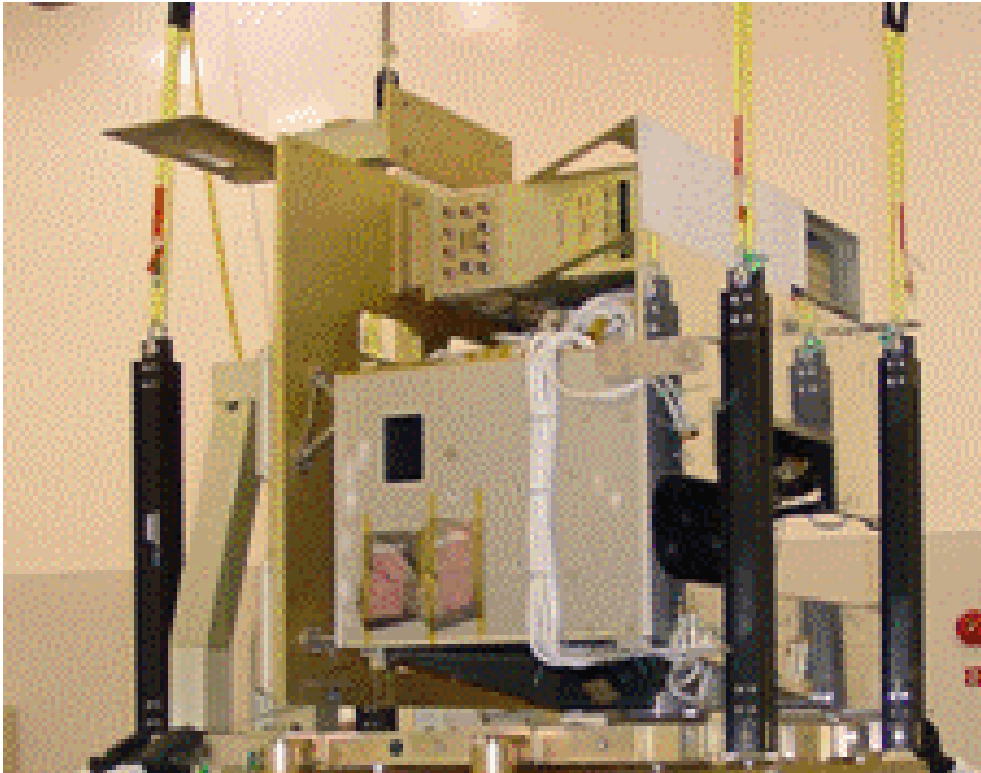
- **VIIRS:**
  - **Continuous Cross-track scanner**
  - **22 spectral bands**
  - **VisNIR, DNB, SWMIR, LWIR**

- **Heritage from MODIS on EOS Terra/Aqua**

- **Supplier: Santa Barbara Remote Sensing (Raytheon)**

- **Key Subcontractors (NPOESS):**
  - **Rotating Telescope - AXSYS**
  - **FPA's, Raytheon Vision Systems**
  - **Scan motor/encoder -BEI**

- **VIIRS Engineering Development Unit (EDU) is now in test**

- **VIIRS FU1 is being developed for NPP**

VIIRS Products

- **VIIRS measures Earth surface and atmospheric/cloud radiance**
- **21 of 22 VIIRS Bands are located in Atmospheric Windows**
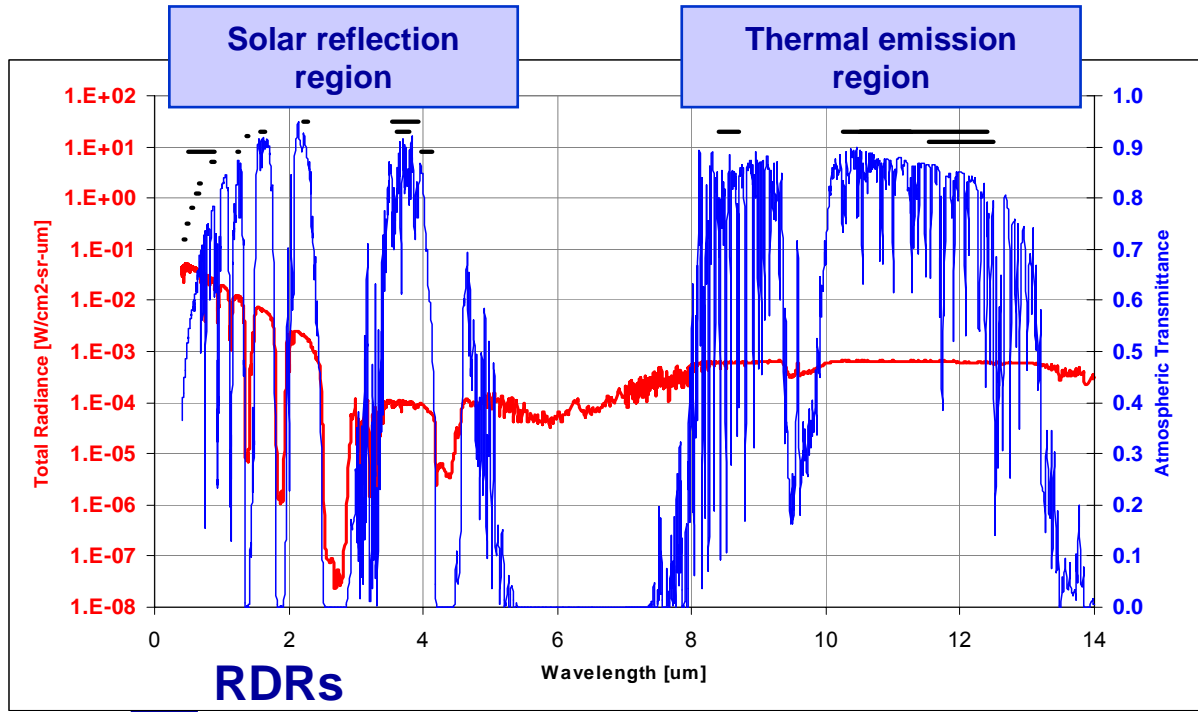
EDRs

- Imagery
- Sea Surface Temperature
- Soil Moisture
- Aerosols (3)
- Cloud Properties (7)
- Surface Albedo
- Land Surface Temperature
- Vegetation Index
- Snow Cover
- Land Surface Type
- Active Fires
- Ice Surface Temperature
- Net Heat Flux
- Ocean Color/Chlorophyll
- Sea Ice Characterization

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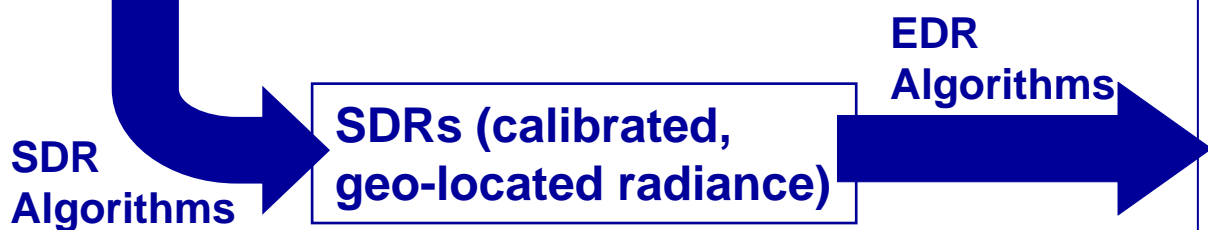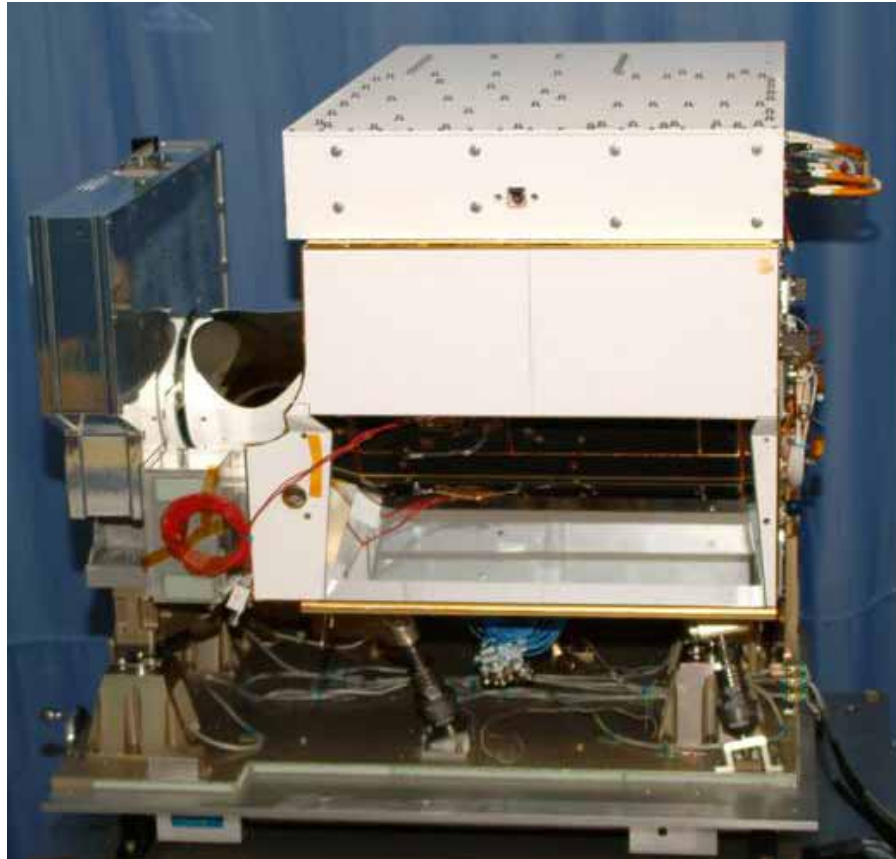
- The Cross-track Infrared Sounder (CrIS) is a key sensor
  - Fourier Transform Spectrometer providing high resolution IR spectra:

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
- Supplier: ITT Industries
- Key subcontractors:
  - ABB Bomem, Interferometer, ICT & SDR algorithm
  - DRS, detectors
  - AER, EDR algorithm

ATMS (Microwave Sounder)

- 22-channels (23.8 GHz – 183.3 GHz), functional-equivalent follow-on to AMSU-A and MHS, with improved sampling and coverage
- Total-power, two-point external calibration, self calibrated
- Continuous cross-track scanning, with torque & momentum compensation
- Four modes: Off/Survival, Safe Hold, Diagnostic, Operational
- Software upload capability; none required
- Built-in diagnostics capability
- In Operational Mode, operate continuously without additional commands
- Thermal control by spacecraft cold plate

OMPS (Ozone Profiler)

- Provides Ozone Total-Column and Profile measurements
  - Enables calculations of corresponding EDR
- Comprises 3 subsystems
  - Nadir Sensor, Limb Sensor, Main Electronic Boxes (MEB)
  - Sensors use identical FPAs
- Nadir Sensor comprises 2 co-boresighted spectrometers:
  - Nadir Total-Column (300 to 380 nm)
    - Based on TOMS heritage
    - 2800 km cross-track swath (110° FOV)
      - Divided in 35 bins (50 km at nadir)
  - Nadir Profile (250 to 310 nm)
    - Based on SBUV2 heritage
    - 250 km x 250 km cell
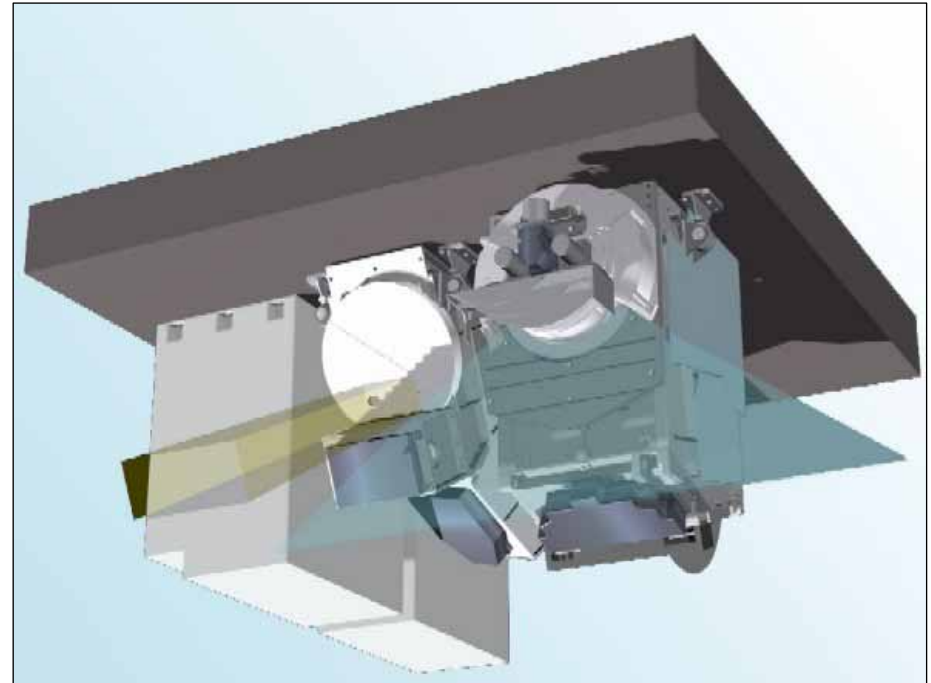
- **Limb Sensor measurements are made through 3 aft-viewing slits**
  - **1.95* degrees FOV**
  - **290 to 1000 nm spectral range**
  - **1 km sampling interval**
  - **Boresight at ~ 27.3° from velocity vector to look at Earth limb**

NPOESS EDR-to-Sensor Mapping

MISSION AREAS

- ▣ Atmosphere
- ▣ Climate
- ▣ Space
- ▣ Land
- ▣ Ocean

CMIS (19)

- ○ ▣ SOIL MOISTURE
- ▣ CLOUD LIQUID WATER
- ▣ PRECIPITABLE TYPE/RATE
- ▣ PRECIPITABLE WATER
- ○ ▣ SEA SURFACE WINDS
- ▣ CLOUD ICE WATER PATH
- ▣ Surface Wind Stress
- ▣ Total Water Content

SESS (13)

- ▣ Auroral Boundary
- ▣ Auroral Energy Deposition
- ▣ Electric Fields
- ▣ Electron Density Profile
- ▣ Auroral Imagery
- ▣ Energetic Ions
- ▣ Geomagnetic Field
- ▣ In-situ Plasma Fluctuation
- ▣ In-situ Plasma Temp
- ▣ Ionospheric Scintillation
- ▣ Med Energy Chgd Parts
- ▣ Neutral Density Profile
- ▣ Supra-Therm-Aurora Prop

VIIRS (22)

- ▣ **ALBEDO (SURFACE)**
- ▣ **CLOUD COVER/LAYERS**
- ▣ **CLOUD EFFECTIVE PART SIZE**
- ▣ **CLOUD OPTICAL THICKNESS**
- ▣ **CLOUD TOP HEIGHT**
- ▣ **CLOUD TOP PRESSURE**
- ▣ **CLOUD TOP TEMPERATURE**
- ▣ Net Heat Flux
- ▣ Ocean Color/Chlorophyll
- ▣ Suspended Matter
- ▣ Vegetative Index
- ▣ ACTIVE FIRES

- ▣ **CLOUD BASE HEIGHT**
- ▣ Ice Surface Temperature
- ○ ▣ **VISIBLE / IR IMAGERY**
- ▣ **LAND SURFACE TEMP**
- ▣ Sea Ice Characterization
- ▣ Snow Cover/Depth
- ▣ Surface Type
- ○ ▣ **SEA SURFACE TEMPERATURE**

- ○ ▣ **ATM VERT MOIST PROFILE**
- ○ ▣ **ATM VERT TEMP PROFILE**
- ▣ **PRESSURE (SURFACE/PROFILE)**

CrIS/ATMS (3)

ERBS (4)

- ▣ Down LW Radiance (Sfc)
- ▣ Down SW Radiance (Sfc)
- ▣ Net Solar Radiation (TOA)
- ▣ Outgoing LW Rad (TOA)

TSIS (1)

- ▣ Solar Irradiance

APS * (4)

- ▣ **AEROSOL OPTICAL THICKNESS**
- ▣ **AEROSOL PARTICLE SIZE**

- ▣ Aerosol Refractive Index
- ▣ Cloud Particle Size/Distrib

ALT (2)

- ▣ **OCEAN WAVE CHARACTERISTICS**
- ▣ Sea Surface Height

OMPS (1)

- ▣ O³-Total Column & Profile

16 Nov 2004
DOC, NOAA, NESDIS,
Integrated Program Office
D. Pierce, J. Whitcomb, J. Schaeffer

KEY

Underlined = NPP EDRs (25)
○ = NPOESS Key Performance Parameters
BOLD CAPS = LDR Environmental Data Records
* = not yet on contract

NASA Science Data Segment

SSEC

NPP Science Team

SDS Components

Network Infrastructure

SD3

I/T System

NOAA / CLASS

RDRs
SDRs
EDRs

IPO / IDPS

RDRs
SDRs
EDRs

CARS: Oceans
NASA GSFC
NPP PEATE

CARS: Land
NASA GSFC
NPP PEATE

CARS: Atmosphere
Univ. Wisconsin
NPP PEATE

CARS: Ozone
NASA GSFC
NPP PEATE

CARS: Sounder
NASA JPL
NPP PEATE

Project Science Office
NICST

McClain, Charles
Wang, Menghua
Minnett, Peter

Justice, Christopher
Loveland, Thomas
Lyapustin, Alexei
Maslanik, James
Privette, Jeffrey
Ranson, Jon
Schaaf, Crystal
Vermote, Eric
Wolfe, Robert

Baum, Bryan
Han, Qingyuan
Menzel, Paul
Stamnes, Knut
Torres, Omar

McPeters, Richard

Pagano, Thomas
Fishbein, Evan
Revercomb, Henry
Lambrigtsen, Bjorn
Staelin, David
Strow, Larrabee

CARS:
Climate Analysis Research System
PEATE:
Product Evaluation &Test Element

PEATE Role in SDS

- Pre Launch
- **Acquire, adapt and integrate operational SDR and EDR processing software**
- **Perform functional testing of operational code.**
- **Acquire and manage various preflight instrument characterization data sets provide to ST.**
- **Support Interface Confidence Tests, Functional Thread Tests and NPP Compatibility Tests**
- **Support (as needed) generation of test data sets for software and algorithm testing.**

- Post Launch
- **Acquire all RDRS, selected SDRs, EDRs and ancillary data**
- **Process RDRs to SDRs and EDRs**
  - **using operational code**
  - **using alternative calibration LUTS**
- **Process SDRs to EDRs using revised or alternative algorithms, as directed by ST**
- **Support browse and distribution of locally generated xDRs to ST**
- **Perform matchups and evaluation of EDRs with other Mission Data, e.g., MODIS, SeaBASS**
- **SDR Evaluation for Long-term stability**

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NPP Atmosphere PEATE at SSEC

- **Supports NPP Science Team evaluation of standard VIIRS RDR, SDR, and atmosphere EDRs**

- **Provides a testbed for improved EDR algorithms (VIIRS, CrIS, ATMS)**

- **Provides processing and visualization resources for NPP Science Team**

- **Serves as a building block for constructing in-house, long term, multi satellite climatology of cloud retrievals (funded by multiple agencies)**

- **Facilitates the development of product centric multi-mission satellite retrieval algorithms and software**

Areas of Expertise and Partners

- **Key Areas of Expertise at SSEC**
  - **RDR, SDR, EDR software testing and product evaluation**
  - **Improved algorithm development**
  - **Data ingest, storage, catalogue, retrieval, visualization**
  - **Processing system architecture (clusters)**
  - **Real-time operations**
- **Critical Partners in Atmosphere PEATE**
  - **NPP Science Team**
  - **Scientific programmers**
  - **Cal/Val partners**
  - **Direct Broadcast Community**
  - **Processing Systems Group**
  - **Data Center + IT support**

Atmosphere PEATE Organization

Project Management
Hank Revercomb (PI)
Liam Gumley (Co-I, PM)

Products & Algorithms
Bryan Baum (Lead)
Andy Heidinger
Chris Moeller
Dave Tobin
Rich Frey
Kathy Strabala
Suzanne Wetzel
Eva Borbas

Computing Systems
Paolo Antonelli (Lead)
Ray Garcia
Steve Dutcher
Erik Olson
Dave Santek
Tom Rink
Maciek Smuga-Otto

Operations
Dee Wade (Lead)
Jerry Robaidek
Dave Parker
Rosie Spangler
Janean Hill

Near Term Goals

- **Obtain and evaluate candidate SDR and EDR codes and sample data (CasaNosa)**

- **Port candidate codes to Linux batch processing environment***

- **Identify and ingest initial proxy data (e.g. MODIS, AIRS, IASI)**

- **Identify and acquire initial hardware (compute nodes, storage)**

*in cooperation with other PEATES

Products and Algorithms

- **Familiarization with Atmosphere ATBDs**
- **Review of SDR and EDR contents and metadata**
- **Obtain and evaluate (walkthrough) candidate SDR and EDR codes for VIIRS (e.g., calibration, cloud mask, cloud product)**
- **Identify proxy datasets for product comparison (e.g., POES AVHRR/HIRS, Aqua MODIS/AIRS, MetOp AVHRR/IASI)**
- **Identify pre-launch characterization and cal/val support activities**
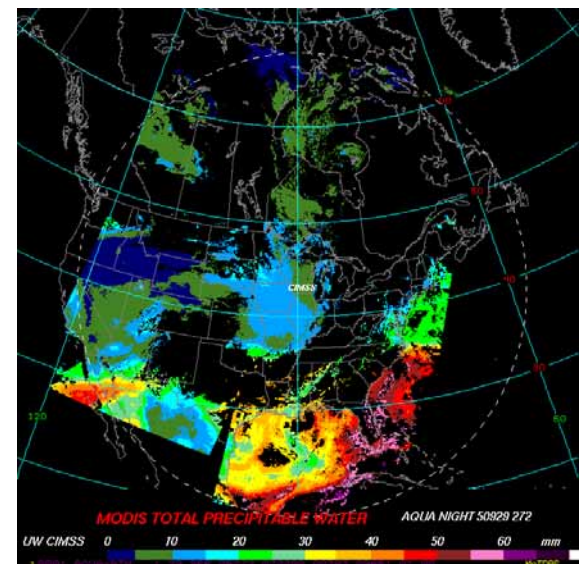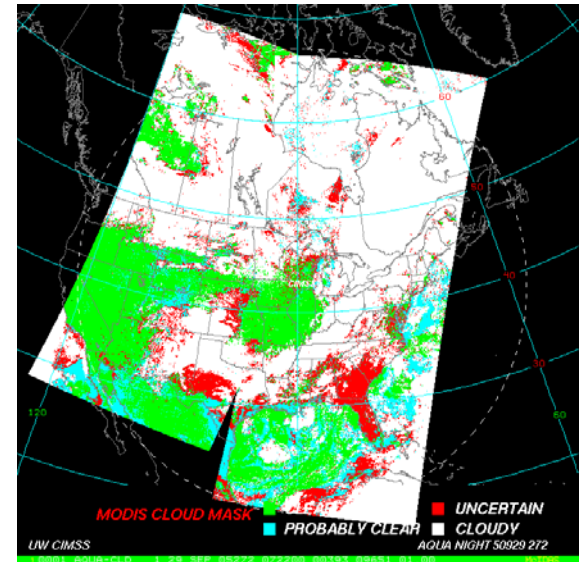
- **Identify near term hardware needs (computing, storage, networking)**

- **Procure and install new hardware**

- **Investigate strategies for running IDPS Sci and Ops code on Linux (with GSFC/DRL)**

- **Extend current parallel processing framework to work with OPS code**

Computing System Baseline

Existing Opteron Cluster (Rocks 3.3 64-bit)

Head node: Sun V40z
[4 x Opteron 2.2 GHz CPUs, 8 GB RAM, 6 x 73 GB disk]

8 compute nodes: Sun V20z
[2 x Opteron 2.2 GHz CPUs, 2 GB RAM, 2 x 73 GB disk]

Storage: 5.6 TB RAID
[16 x 400 GB SATA disks, 2 Gbps Fibrechannel interface]

Network: Gigabit Ethernet
[Dell Powerconnect 24-port switch]

Atmosphere PEATE EDRs

- **NPOESS VIIRS EDRs, including**

Cloud Mask	Cloud Top Pressure
Cloud Base Height	Cloud Top Temperature
Cloud Cover/Layers	Precipitable Water
Cloud Effective Particle Size	Suspended Matter
Cloud Optical Thickness	Aerosol Optical Thickness
Cloud Top Height	Aerosol Particle Size

[All currently generated at UW from Direct Broadcast]

- **Atmospheric CDRs from the NPP Science Team that can be generated from NPP VIIRS or VIIRS/CrIS combined data sets**

[Activities will be closely coordinated with NOAA & Sounder PEATE activities to maximize efficiency]

Atmosphere PEATE Work Plan

- **FY05**
  - **Establish links with NPP Science Team**
  - **Familiarization with Science & Operational EDR Algorithms**
  - **Begin to Define System Architecture**
- **FY06**
  - **Support Science Team evaluation of NGST EDR algorithms & development of improved algorithms**
  - **Define System Architecture & implement Phase I PEATE System**
  - **Define Cal/Val support tasks & develop Cal/Val plan**
  - **Conduct initial proxy data processing experiments**
- **FY07**
  - **Continue to support Science Team algorithm evaluation & devel.**
  - **Complete System Hardware Acquisition and Testing**
  - **Demonstrate 30x processing on proxy data**
  - **Demonstrate System Readiness, including Science Team Interface**
- **FY08 (Oct 2007 to Launch)**
  - **Continue to support Science Team algorithm evaluation & devel.**
  - **Complete third reprocessing of proxy dataset**

- **Run NGST science algorithms on proxy data:**
  - **FY06: 1 month each spring/summer/fall/winter from Terra/Aqua**
  - **FY07: complete mission record from Terra/Aqua**

- **Run improved algorithms developed by NPP Science Team on these datasets**

- **Provide the means to compare (at EDR and CDR level) the results of different algorithms**

- **Provide online archive of proxy data and NPP data for Science Team search, order, and delivery**