National Polar-orbiting Operational Environmental Satellite System
(NPOESS)

A Look into the New Millennium

Presentation at the

AIAA Space Technology Conference and Exposition

"Partnering in the 21st Century

September 28, 1999

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Assistant Administrator for Satellite and Information Services

National Oceanic and Atmospheric Administration

A Presidentially Directed, Tri-agency Effort to Leverage and Combine Environmental Satellite Activities

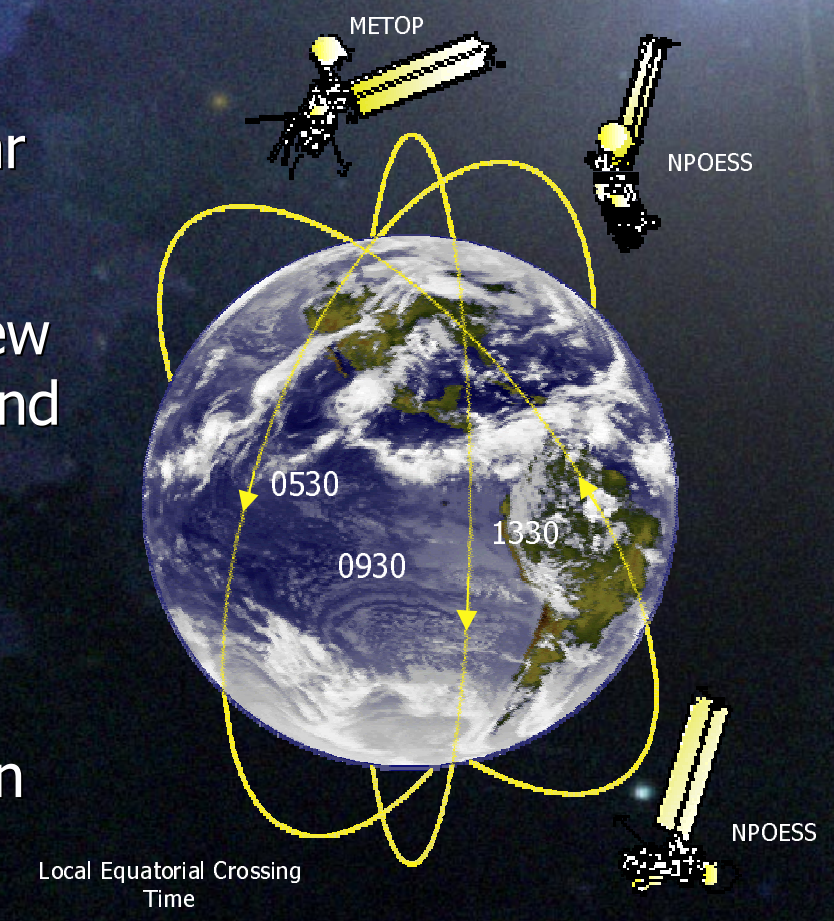
Mission

Provide a national, operational, polar remote-sensing capability

Achieve National Performance Review (NPR) savings by converging DoD and NOAA satellite programs

Incorporate new technologies from NASA

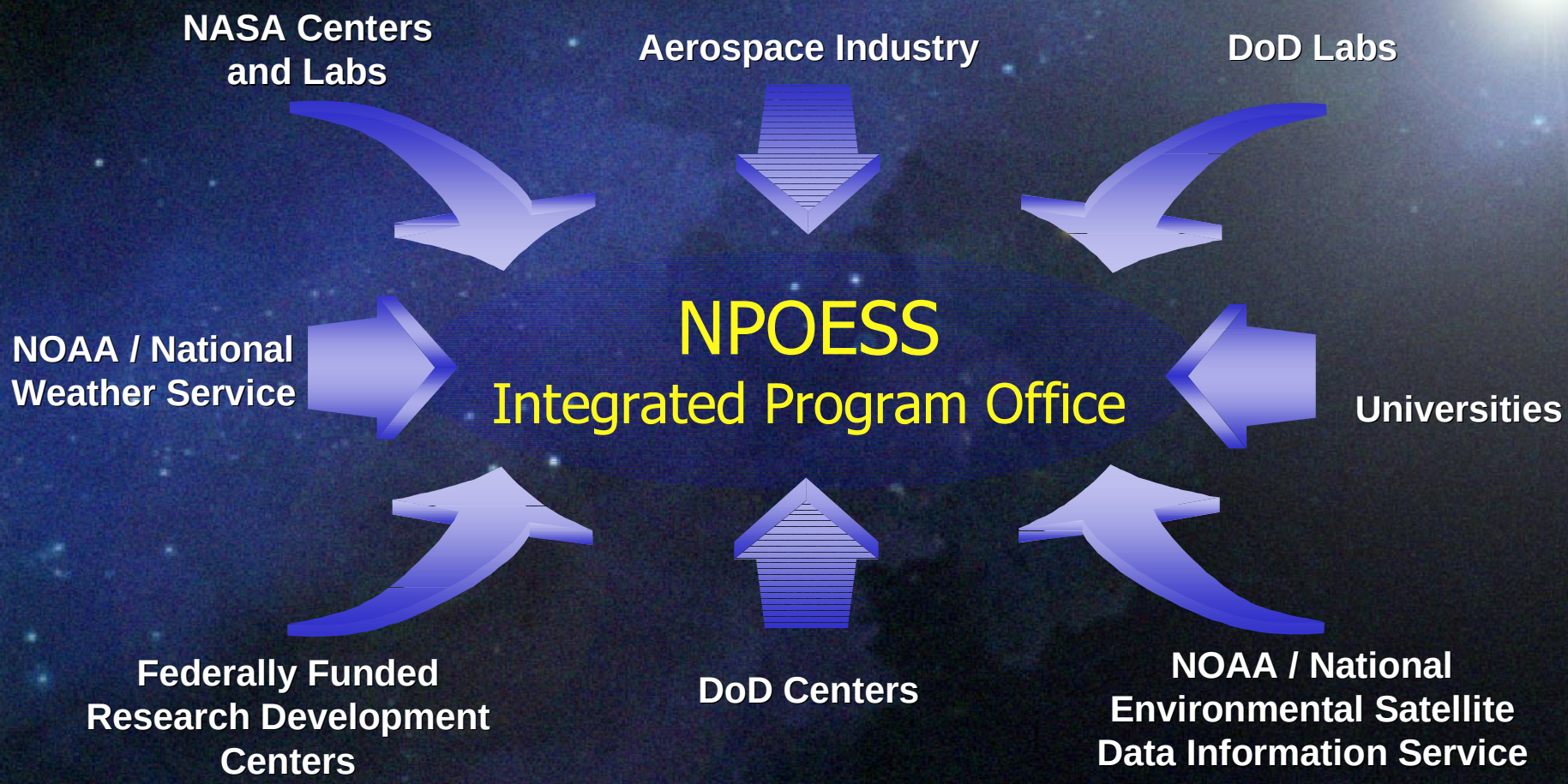
Encourage International Cooperation



Establishing NPOESS

- National Performance Review (NPR) -- September 1993
- OSTP Convergence Implementation Plan submitted to Congress -- May 1994
- Presidential Decision Directive/NSTC-2 -- May 1994
- Tri-agency Memorandum of Agreement (MOA) --May 1995
- EUMETSAT/NOAA Initial Joint Polar Agreement -- November 1998

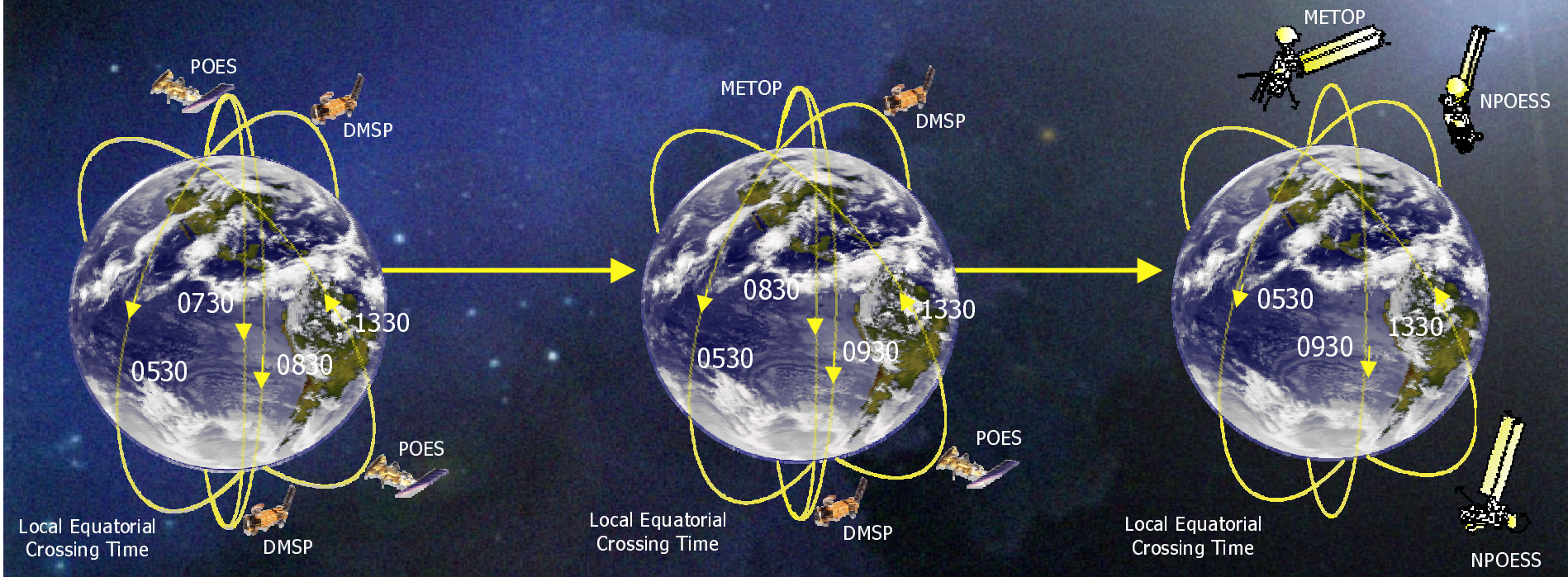
Contributions from Other Organizations



NPOESS development strategy employs the best talents of the Government, Academia, Industry, and the International space community to meet future space challenges

Evolution

U.S. civil and defense programs, working in partnership with EUMETSAT, will ensure improved global coverage and long-term continuity of observations at less cost!



Today

- 4-Orbit System
  - 2 US Military
  - 2 US Civilian

Tomorrow (2003)

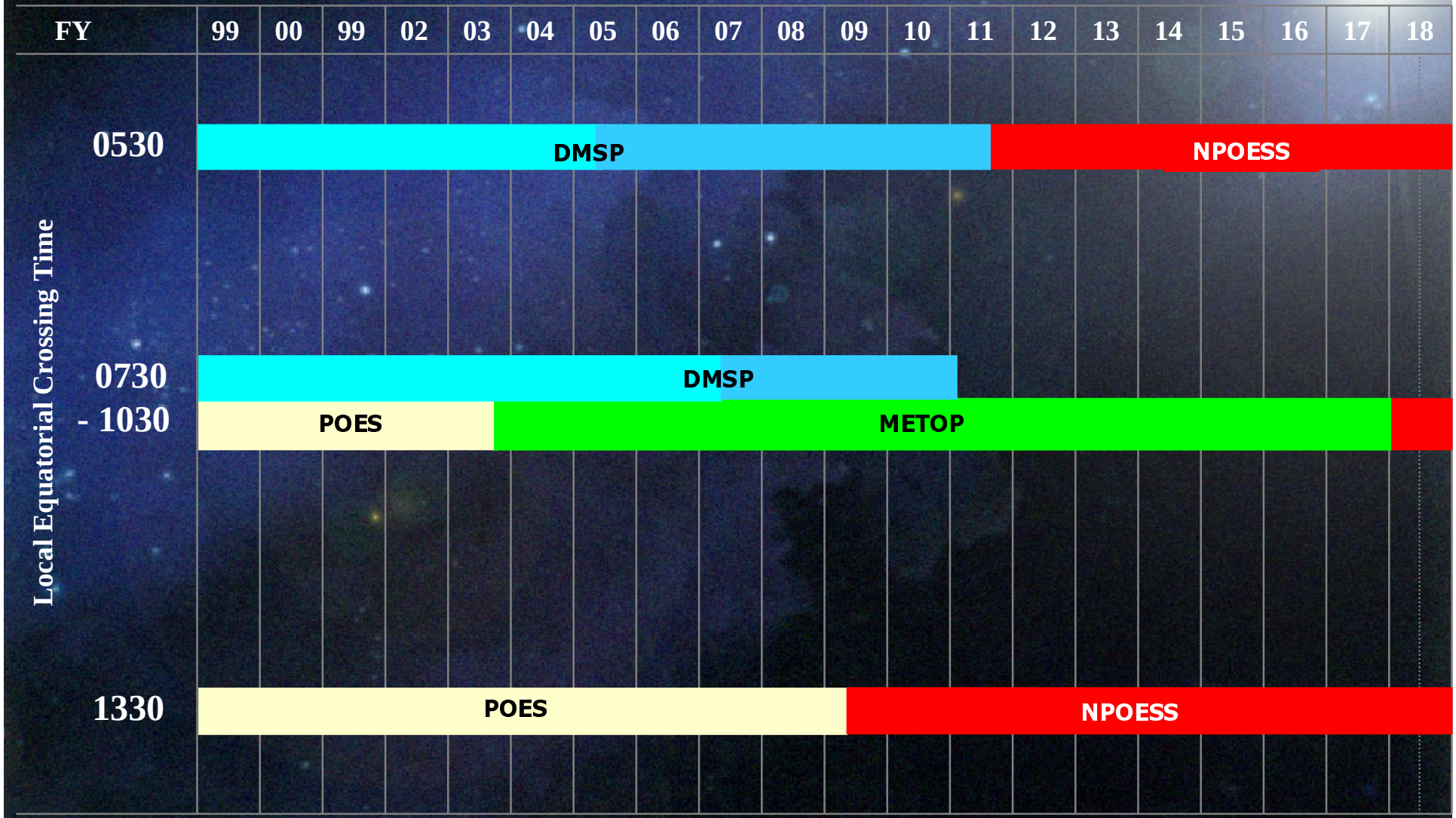
- 4-Orbit System
  - 2 US Military
  - 1 US Civilian
  - 1 EUMETSAT/METOP

Future (2008)

- 3-Orbit System
  - 2 US Converged
  - 1 EUMETSAT/METOP

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

Satellite Transition



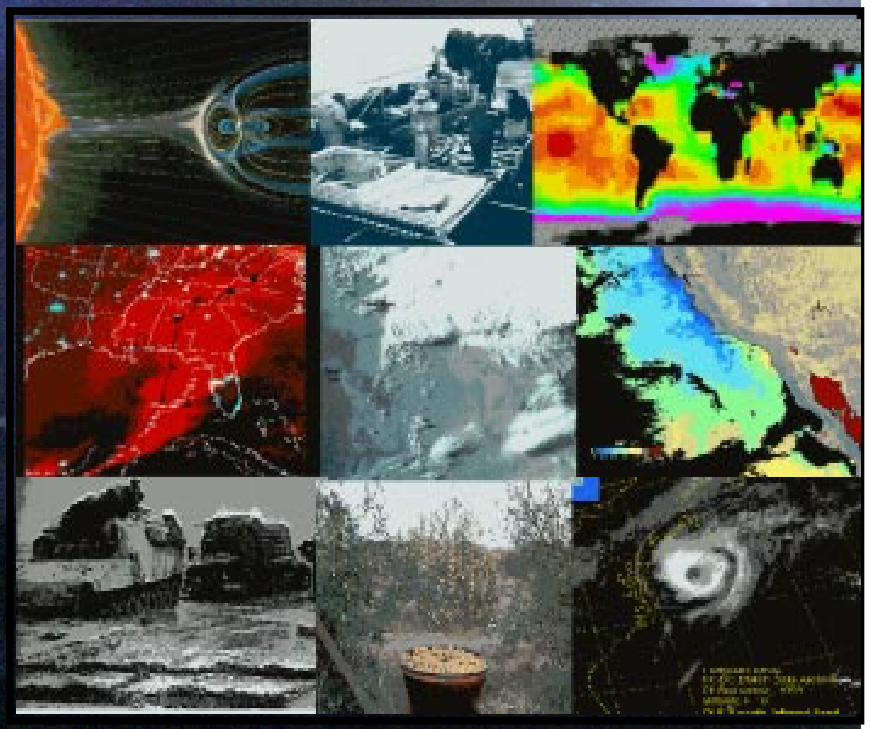
An End-to-End Responsibility

Requirements

Convergence of alternatives

- Integrated Operational Requirements Document (IORD-I)
  - 61 Data Products
  - 9 Enhancement Data Products
- Validated by
  - Deputy Under Secretary of Commerce for Oceans and Atmosphere
  - Vice Chairman of Joint Chiefs of Staff
  - NASA Associate Administrator for Earth Science Enterprise

Convergence of requirements



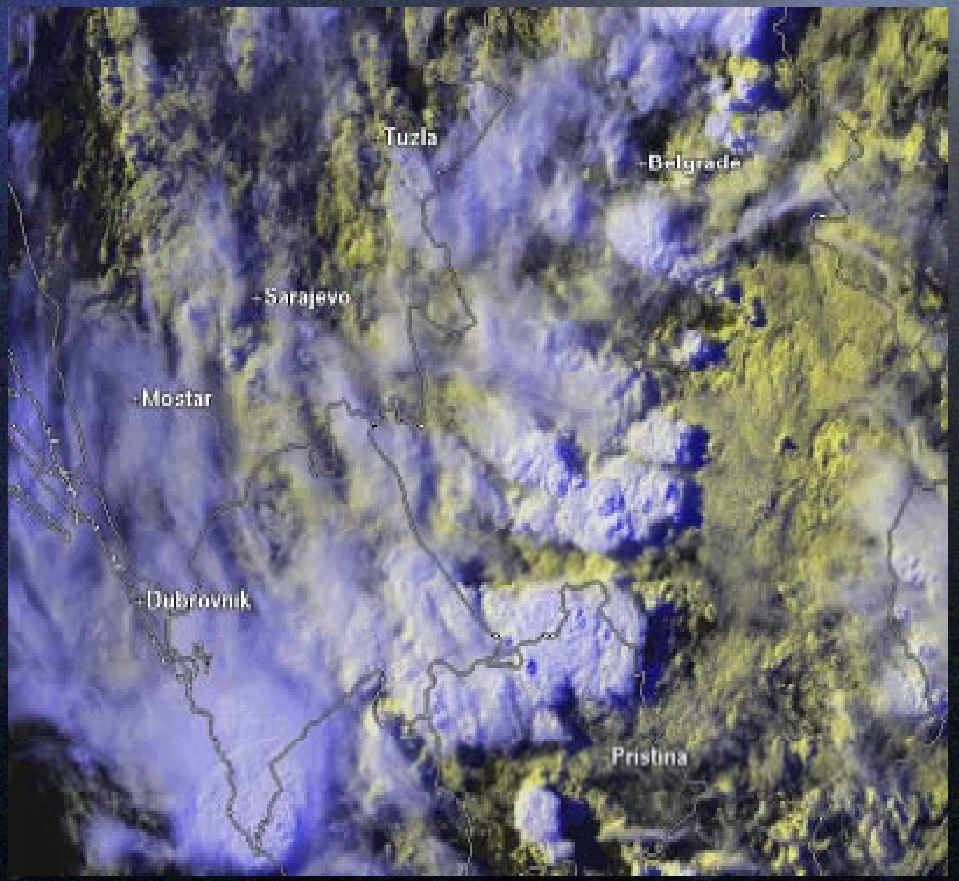
Converged requirements provide foundation for combined program

First success after eight previous attempts

A More Capable System

First Image from TIROS-1

High Resolution Multi-spectral Image from DMSP



Notional Payloads to Satisfy NPOESS Requirements

NPOESS Payloads	0530	1330	METOP 0930	NPP 1030
IPO Developed				
Visible/IR Imager Radiometer Suite (VIIRS)*	X	X	X (AVHRR)	X
Cross-track IR Sounder (CrIS)*		X	X (IASI/HIRS)	X
Conical MW Imager/Sounder (CMIS)*	X	X		
Ozone Mapper/Profiler Suite (OMPS)		X	X (GOME)	
GPS Occultation Sensor (GPSOS)	X	X	X (GRAS)	
Space Environmental Sensor Suite (SESS)	X	X	X (SEM)	
Leveraged				
Advanced Technology MW Sounder (ATMS)*		X	X (AMSU/MHS)	X
Data Collection System (DCS)	X	X	X	
Search and Rescue (SARSAT)	X		X	
Earth Radiation Budget Sensor		X		
Solar Irradiance Sensor (TSIS)	X			
Radar altimeter (ALT)	X			
Advanced Scatterometer (ASCAT)			X	

*** Critical payload - Failure constitutes need to replace satellite**

Contributions to EDRs by Sensor

Environmental Data Records (EDR)	Primary	Secondary
* Atmospheric Vertical Moisture Profile	CrIS/ATMS	CMIS
* Atmospheric Vertical Temperature Profile	CrIS/ATMS	CMIS
* Imagery	VIIRS	CMIS
* Sea Surface Temperature	VIIRS	CMIS
* Soil Moisture	CMIS	VIIRS
Aerosol Optical Thickness	VIIRS	
Aerosol Particle Size	VIIRS	
Albedo (surface)	VIIRS	
Auroral Boundary	SESS	
Auroral Imagery	SESS	
Cloud Cover/Layers	VIIRS	
Cloud Effective Particle Size	VIIRS	
Cloud Ice Water Path	CMIS	
Cloud Liquid Water	CMIS	
Cloud Optical Depth/Transmittance	VIIRS	
Cloud Top Height	VIIRS	
Cloud Top Pressure	VIIRS	
Cloud Top Temperature	VIIRS	
Currents (ocean)	VIIRS	Altimeter
Downward Longwave Radiance	ERBS	

* designates key EDR

Contributions to EDRs by Sensor

Environmental Data Records (EDR)	Primary	Secondary
Downward Longwave Radiance	ERBS	
Electric Fields	SESS	
Electron Density Profile/Ionospheric Spec	SESS	TSIS
Fresh Water Ice	VIIRS	CMIS
Geomagnetic Field	SESS	
Ice Surface Temperature	VIIRS	CMIS
In-Situ Ion Drift Velocity	SESS	
In-Situ Plasma Density	SESS	
In-Situ Plasma Fluctuations	SESS	
In-Situ Plasma Temperature	SESS	
Insolation	ERBS	
Ionspheric Scintillation	SESS	GPSOS
Land Surface Temperature	VIIRS	CMIS
Littoral Sediment Transport	VIIRS	
Net Heat Flux	ERBS	VIIRS
Net Short Wave Radiance (TOA)	ERBS	
NDPs/Neutral Atm Specification	SESS	
Normalized Difference Vegetation Index	VIIRS	
Ocean Color/Chlorophyll	VIIRS	
Ocean Wave Characteristics	OMPS	

Contributions to EDRs by Sensor

Environmental Data Records (EDR)	Primary	Secondary
Precipitable Water	CMIS	
Precipitable Type/Rate	CMIS	
Pressure (Surface/Profile)	CrIS/ATMS	
Radiation Belt/Low Energy Particles	SESS	
Sea Ice Age and Edge Motion	VIIRS	CMIS
Sea Surface Height/Topography	Altimeter	
Snow Cover/Depth	CMIS	VIIRS
Solar EUV Flux	SESS	
Solar Irradiance	TSIS	
Solar/Galactic Cosmic Ray Particles	SESS	
Supra-Thermal - Auroral Particles	SESS	
Surface Wind Stress	Altimeter	CMIS
Suspended Matter	VIIRS	
Total Auroral Energy Deposition	SESS	
Total Longwave Radiance (TOA)	ERBS	
Total Water Content	CMIS	
Turbidity	VIIRS	
Upper Atmospheric Airglow	SESS	
Vegetation Index/Surface Type	VIIRS	CMIS

Visible/Infrared Imager Radiometer Suite VIIRS

Description

Collects visible/infrared imagery and radiometric data. Data types include atmospheric, clouds, earth radiation budget, clear-air land/water surfaces, sea surface temperature, ocean color, and low light visible imagery. Primary instrument for satisfying 26 EDRs.

Specifications

Multiple VIS and IR channels between 0.3 and 14 microns

Imagery Spatial Resolution: 400m @ NADIR / 800m @ EOS

Heritage and Risk Reduction

POES - Advanced Very High Resolution Radiometer (AVHRR/3)

DMSP - Operational Linescan System (OLS) - MOLS on F18-F20

EOS - Moderate Resolution Imaging Spectroradiometer (MODIS)

NPP - Early validation of operational instrument and algorithms

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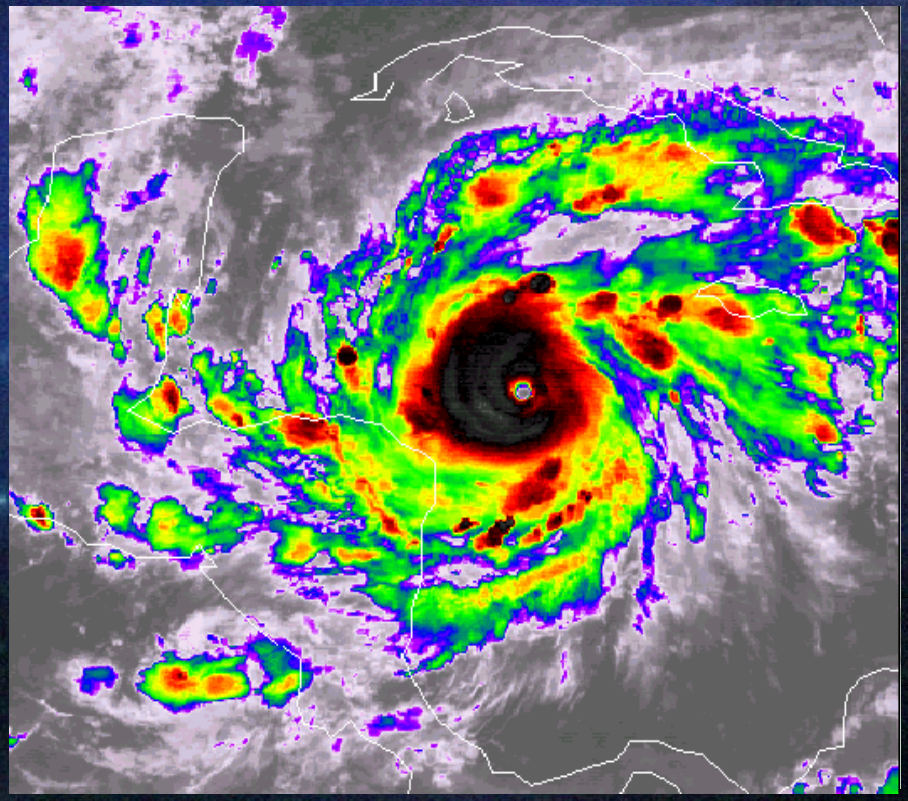

Visible Imagery of Hurricane

3-channel composite image of hurricane

Infrared Imagery of Hurricane

Fire detection

Smoke & Aerosols in Imagery

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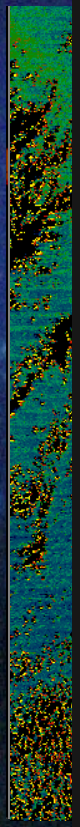
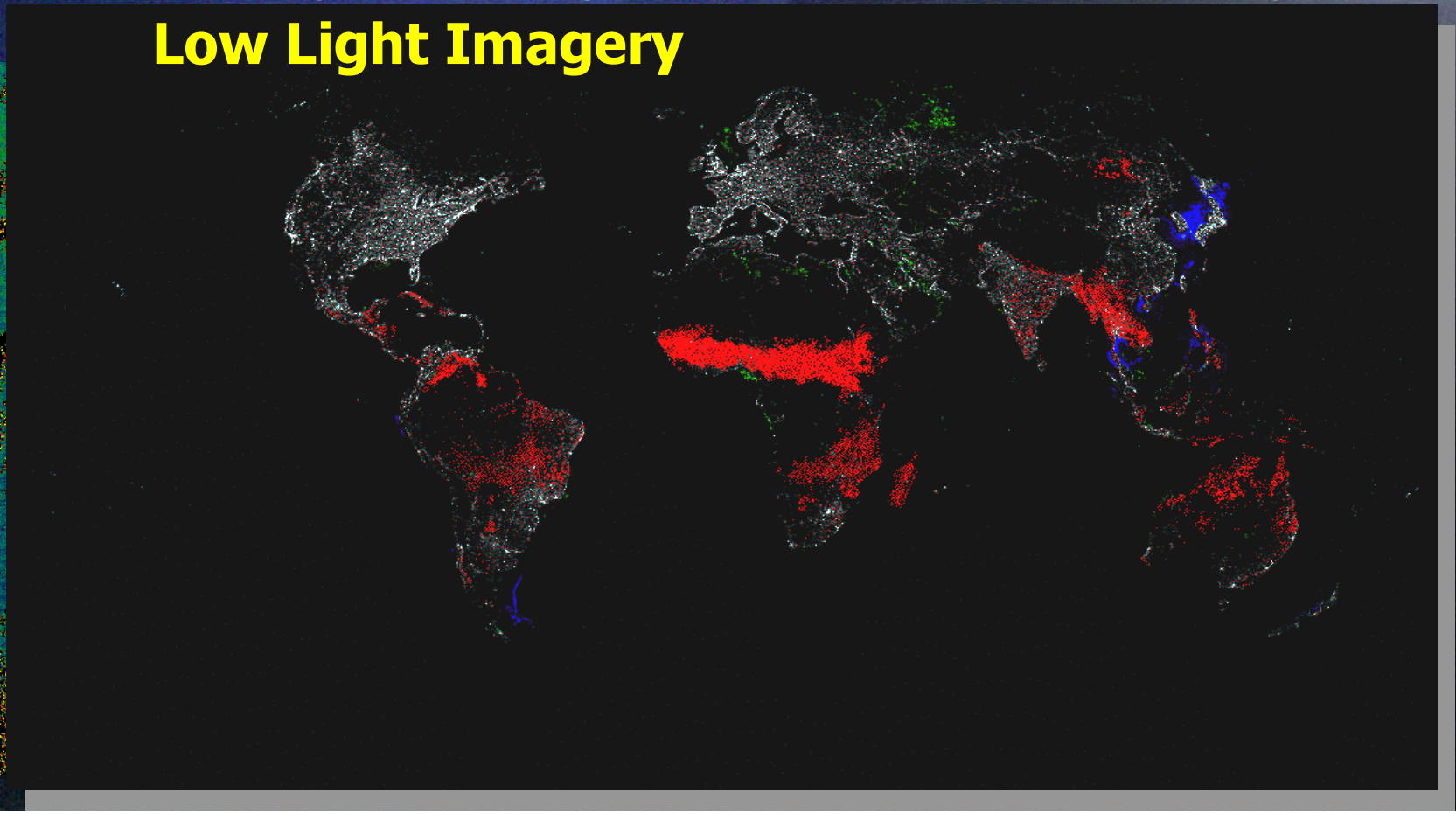
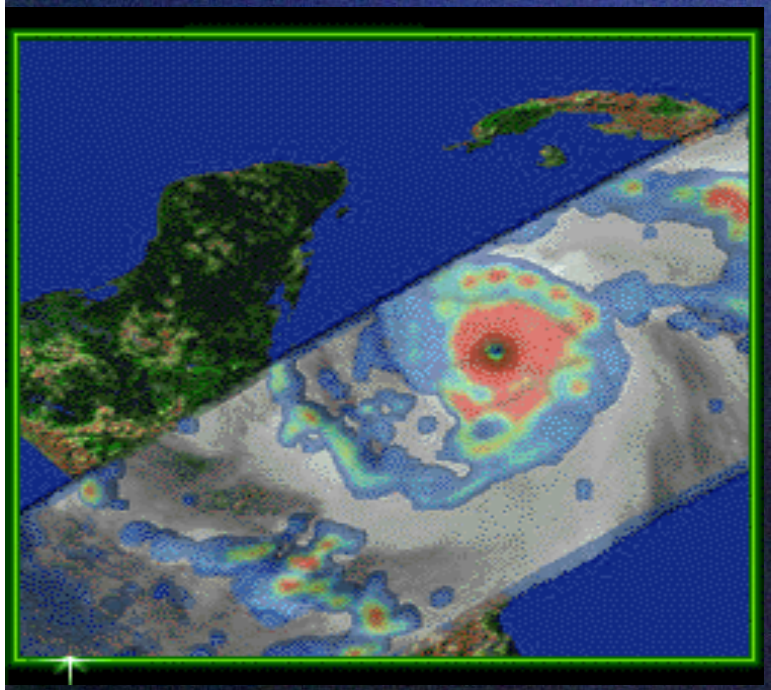




Conical Microwave Imager Sounder
CMIS

Description

Collects microwave radiometry and sounding data. Data types include atmospheric temperature and moisture profiles, clouds, sea surface winds, and all-weather land/water surfaces. Primary instrument for satisfying 20 EDRs.



Specifications

Resolution from 15km to 50km @ nadir
(depending on environmental parameter)
~2 meter aperture rotating reflector

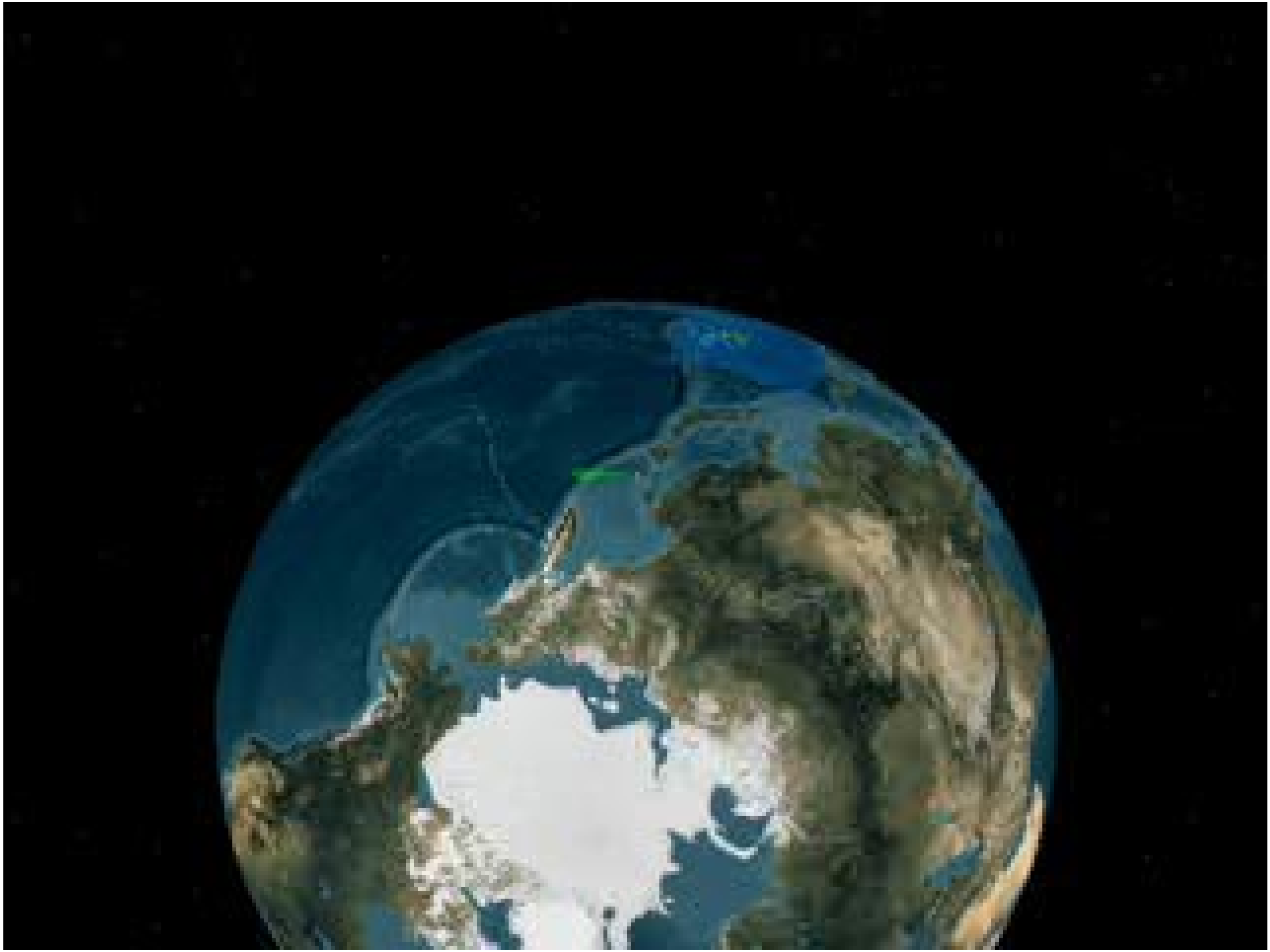
Heritage and Risk Reduction

DMSP - Special Sensor Microwave Imager (SSMI) and Special Sensor Microwave Imager/ Sounder (SSMIS)

TRMM - TRMM Microwave Imager (TMI)

EOS - Advanced Microwave Scanning Radiometer (AMSR)

WINDSAT - Operational validation of sea surface wind vector field



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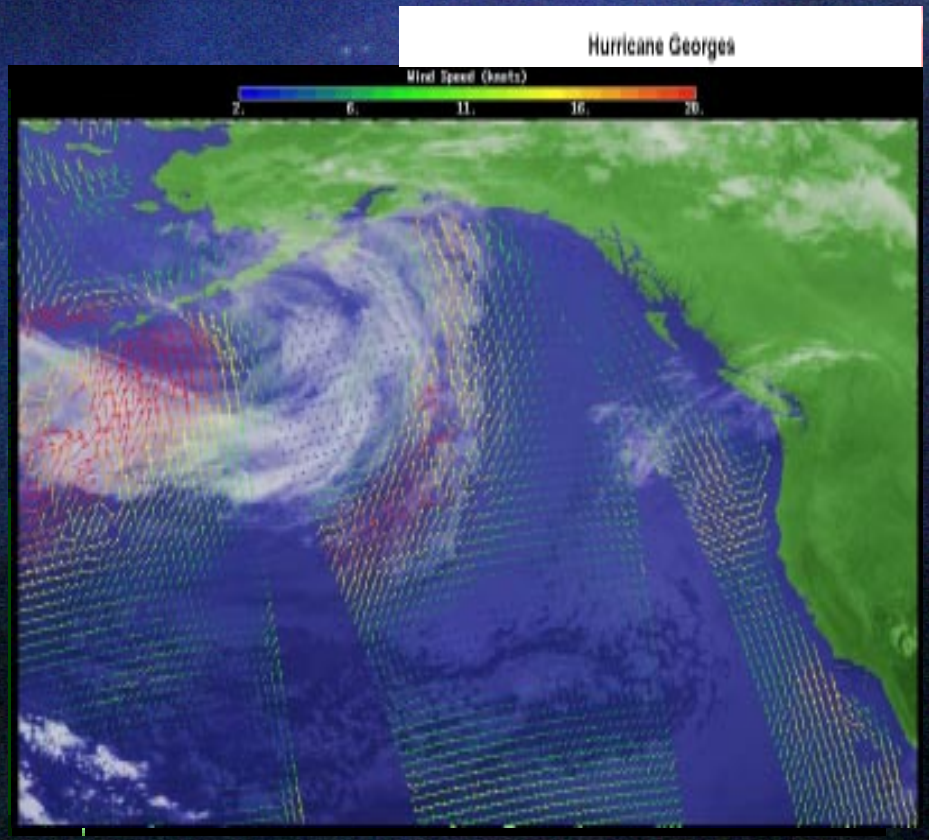
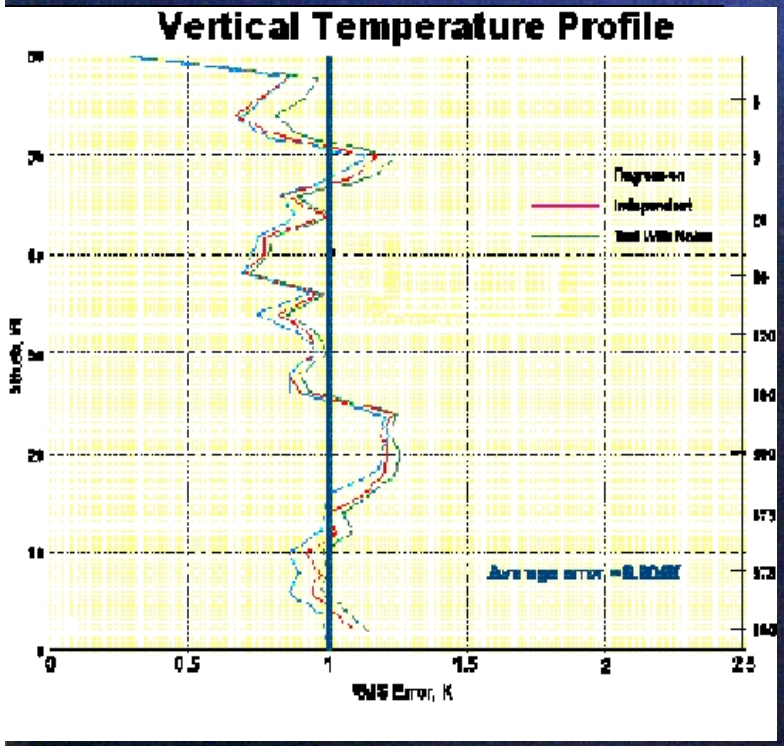


- **Hurricane's warm core revealed in temperature anomaly cross section derived using Advanced Microwave Sounding Unit temperature retrievals**
- **Forerunner to ATMS**
- **Temperature anomaly versus central pressure (a measure of intensity) for hurricane**
- **Ocean surface wind field superimposed on cloud imagery**

Cross Track Infrared Sounder
CrIS

Description

High spectral resolution measurements of Earth's radiation to determine the vertical distribution of temperature, moisture, and pressure in the atmosphere. Primary instrument for satisfying 3 EDRs.



Specifications

- Temperature Profile: 18.5 km @ Nadir
- Moisture Profile: 15 km @ Nadir
- Pressure Profile: 55 km @ Nadir
- 1 Kelvin / 1 km Layers

Vertical Temperature Profile Data Product

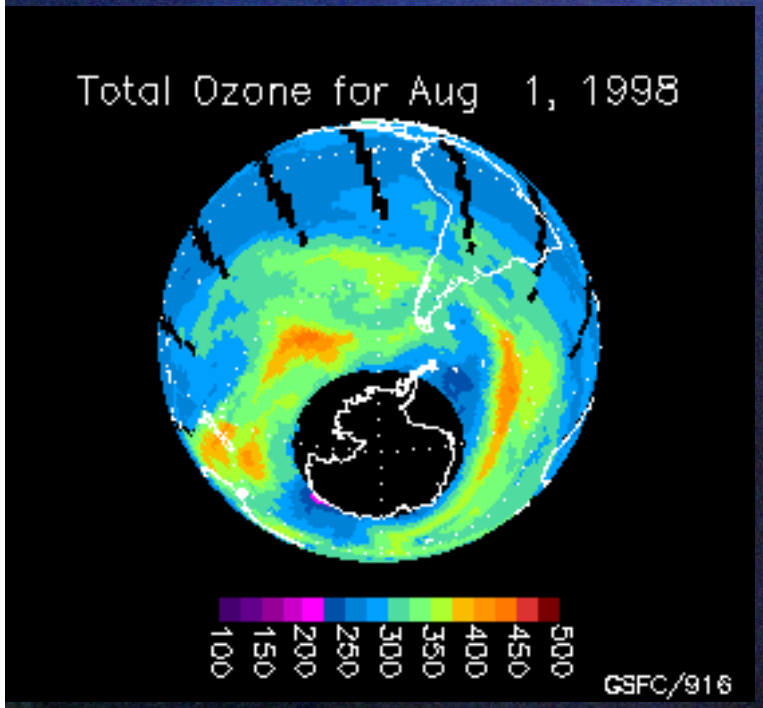
Heritage and Risk Reduction

POES -	High-resolution infrared sensor (HIRS)
NAST -	NPOESS Airborne Sounder Testbed
MIT/LL -	Prototype of flight Michelson Interferometer
NASA -	Atmospheric Infrared Sounder (AIRS)
EUMETSAT -	Infrared Atmospheric Sounding Interferometer Radiometer (IASI) on METOP
NPP -	Early validation of sensor and algorithms

Ozone Mapping and Profiler Suite
OMPS

Description

Collects data to permit the calculation of the vertical and horizontal distribution of Ozone in the earth's atmosphere. Primary instrument for satisfying 1 EDR.

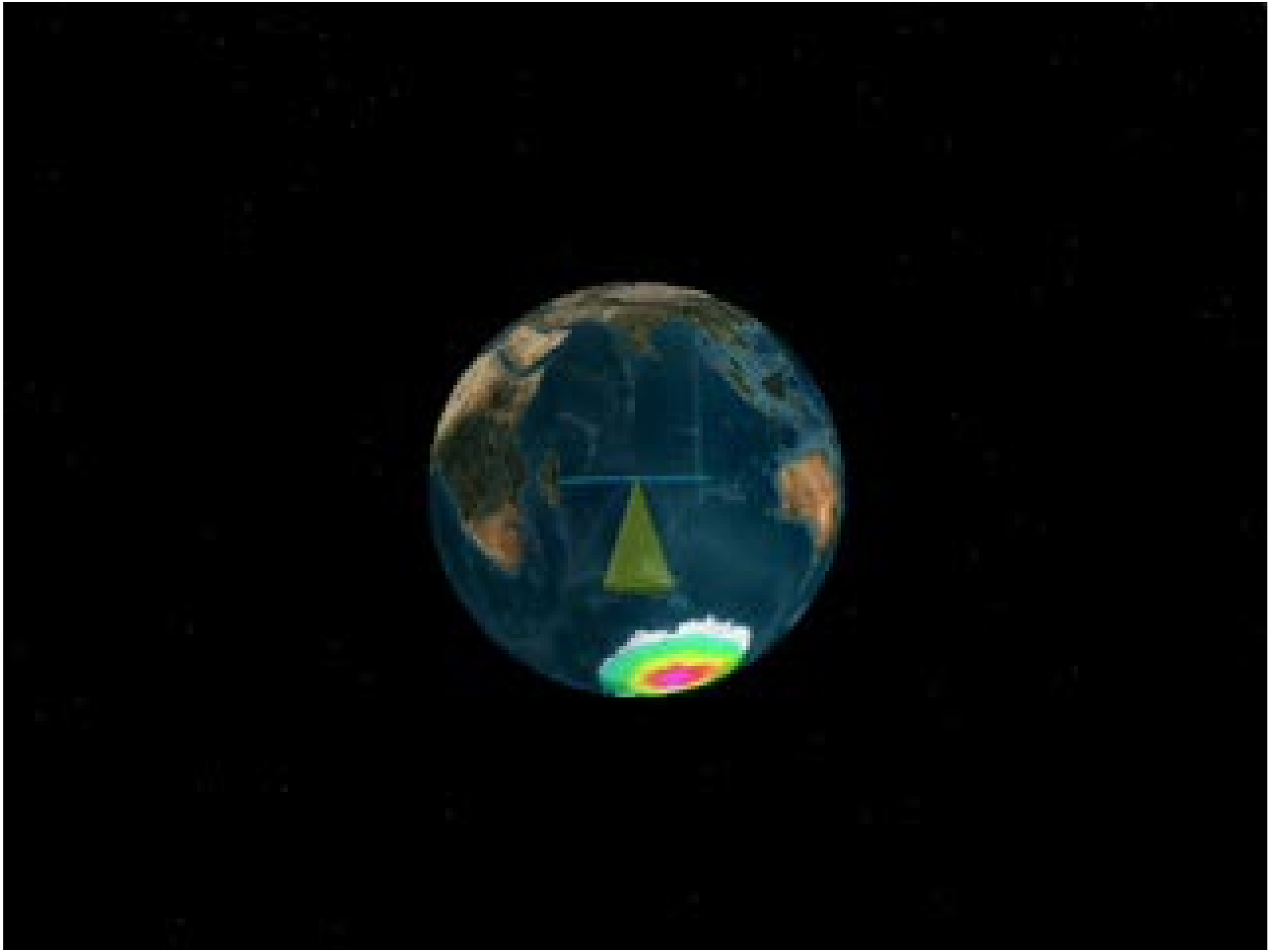


Specifications

Horizontal Res:	50km @ Nadir (column) 250km @ Nadir (profile)
Vertical Res:	5km (tropopause thru 60km)

Heritage and Risk Reduction

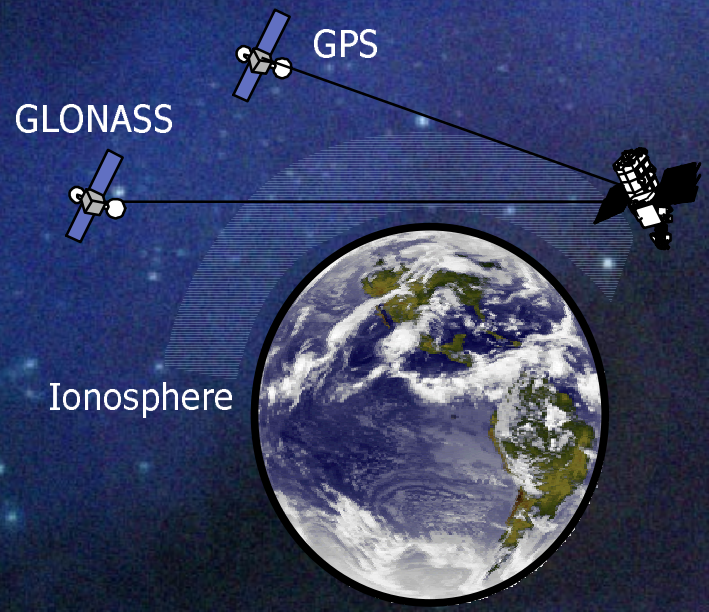
TOMS -	Total Ozone Mapping Spectrometer
SBUV -	Solar Backscatter UltraViolet
EUMETSAT -	Global Ozone Monitoring Experiment (GOME) on EUMETSAT/METOP
ISIR -	IR Technology demo on STS-85
SOLSE/LORE -	UV Limb demo on STS-87



GPS Occultation Sensor
GPSOS

Description

Measures the refraction of radiowave signals from the GPS and Russia's Global Navigation Satellite System (GLONASS) to characterize the Ionosphere. Primary instrument for electron density and ionospheric profiles. Secondary measurements for tropospheric temperature and humidity profiles.



Specifications

Multiple GPS receivers to measure electron density profile with vertical coverage 10km within 100km of E/F peaks and 20km elsewhere

Heritage and Risk Reduction

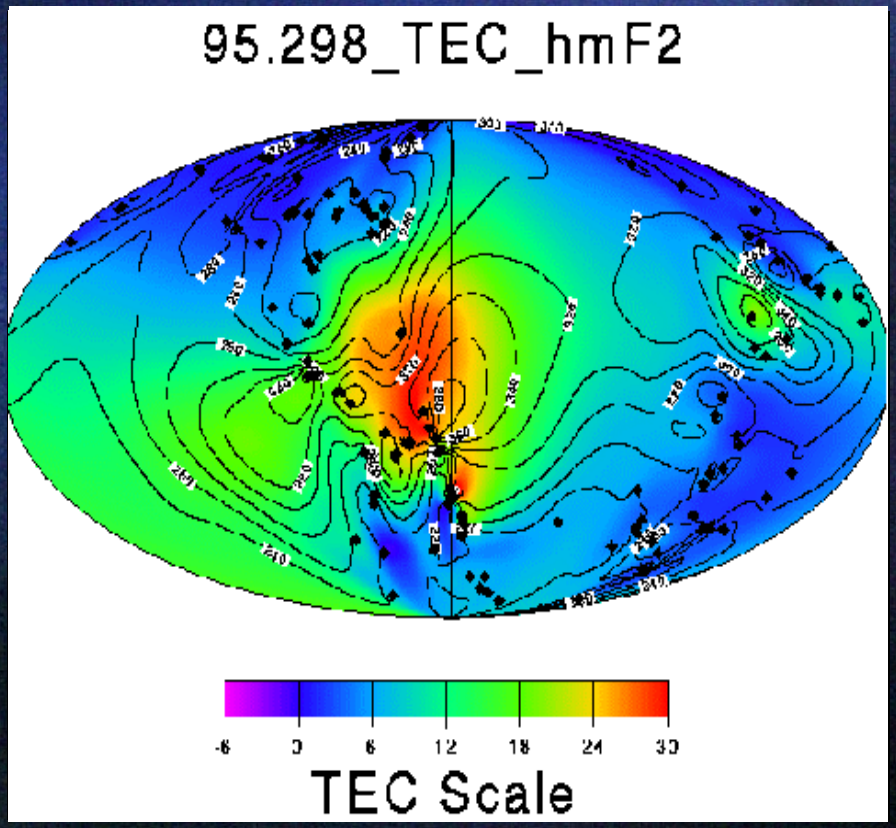
EUMETSAT - GNSS (Global Navigation Satellite System) Receiver for Atmospheric Sounder (GRAS) on METOP

GPS/MET - (Global Positioning System/ Meteorology)

Space Environmental Sensor Suite
SESS

Description

Measures the near-Earth space environment in terms of neutral and charged particles, electron and magnetic fields, and optical signatures of aurora. Primary sensor suite for satisfying 17 EDRs.



Specifications

Multiple sensors to measure auroral characteristics, geomagnetic field, electron density profile, and total electron content with 10 km vertical resolution from 60 km to 3000 km

Total Electron Content

Heritage and Risk Reduction

DMSP - Space Sensor

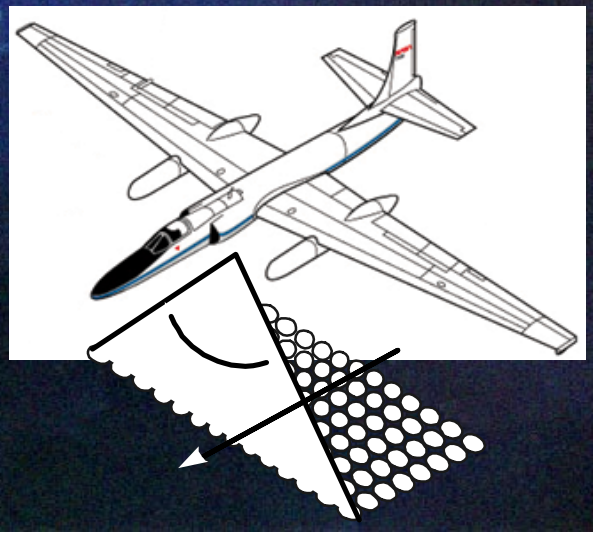
POES - Space Environment Monitor

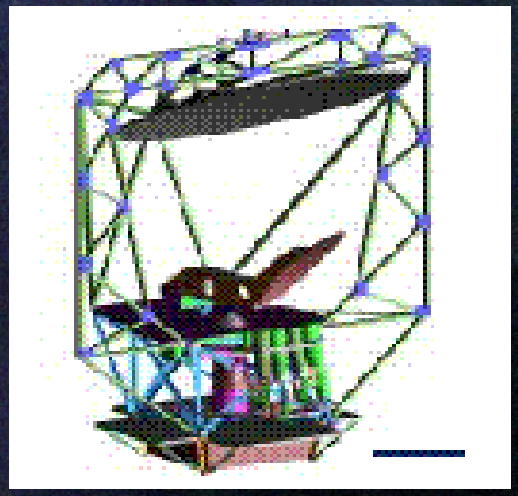
Ionospheric Profiling

Risk Reduction Activities

- Demonstration flights are not tied to operational satellites
  - Lower risk to operational users
  - Lower risk of launch delays due to operational schedule
- Share cost and risk among agencies
- Early delivery of NPOESS data to users

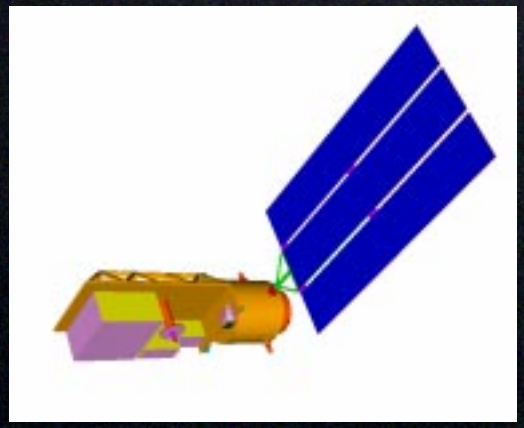
NAST





WindSat/Coriolis

NPP



NPOESS Aircraft Sounder Testbed (NAST)

OBJECTIVES

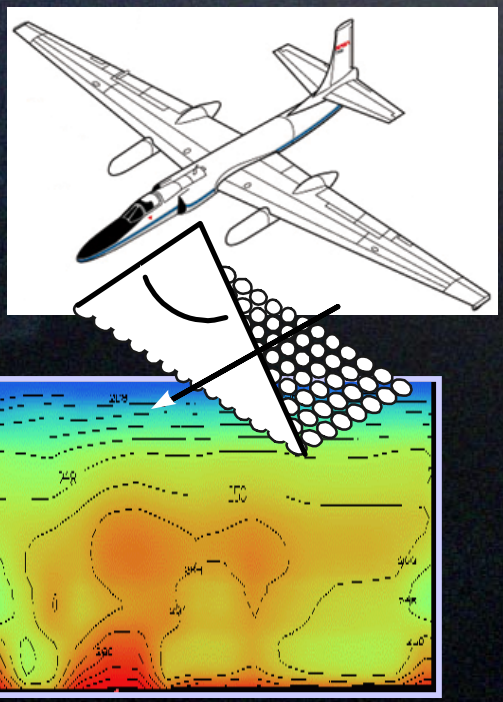
- SIMULATE CANDIDATE INSTRUMENTS
  - (CrIS, ATMS, IASI)
- EVALUATE KEY EDR ALGORITHMS
- PREVIEW HIGH RESOLUTION PRODUCTS
  - SPECTRAL AND SPATIAL
- UNDER FLIGHT VALIDATION

INSTRUMENTS

- NAST-I, NAST-M
- NAST-I: IR INTERFEROMETER SOUNDER
- NAST-M: MICROWAVE SOUNDER*

NASA ER-2

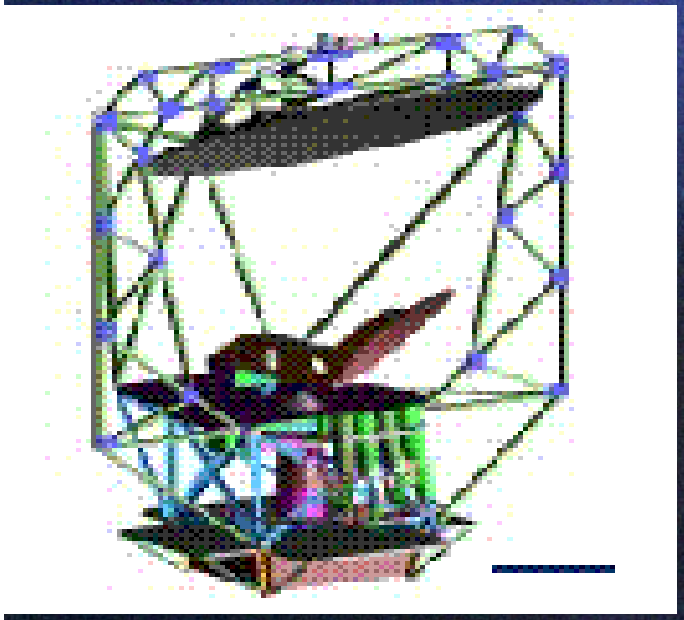
20 km ALTITUDE
NADIR 2.6 km IFOV
± 23 km GROUND COVERAGE



*Hurricane Bonnie Cross-Section

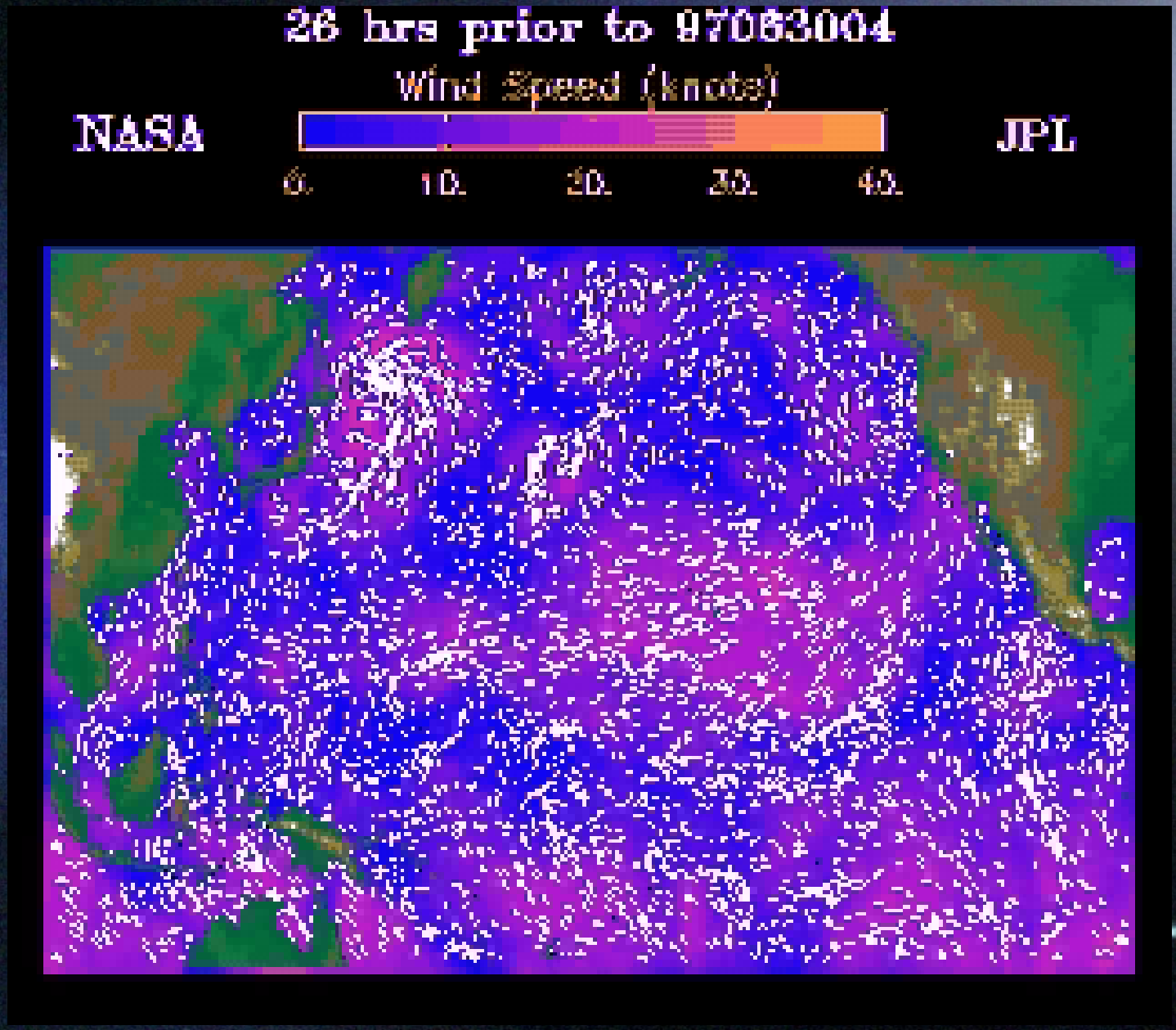
Joint IPO/DoD/NASA Risk Reduction Demo WindSat/Coriolis

Description: Measures Ocean Surface Wind Speed, Wind Direction, Using Polarimetric Radiometer on a Modified Satellite Bus, Launched Into a 830 km 98.7° Orbit by the Titan II Launch Vehicle. 3 Year Design Lifetime.



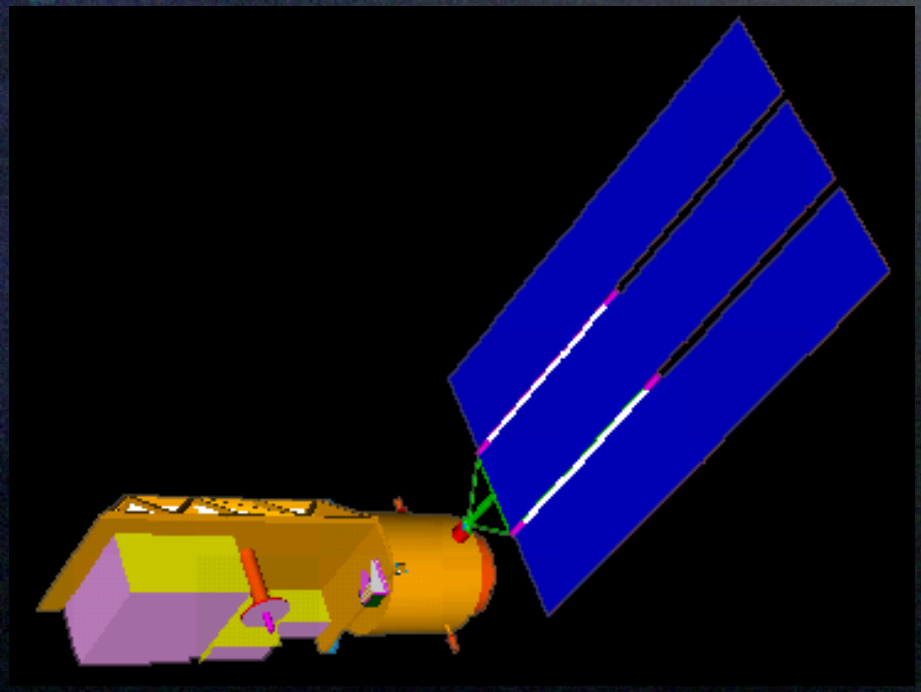
Capability/Improvements

- Measure Ocean Surface Wind Direction (Non- Precipitating Conditions)
- 25km spatial resolution
- Secondary Measurements
  - Sea Surface Temperature, Soil Moisture, Rain Rate, Ice, and Snow Characteristics, Water Vapor


26 hrs prior to 97063004
Wind Speed (knots)
NASA
JPL
6.
10.
20.
30.
40.

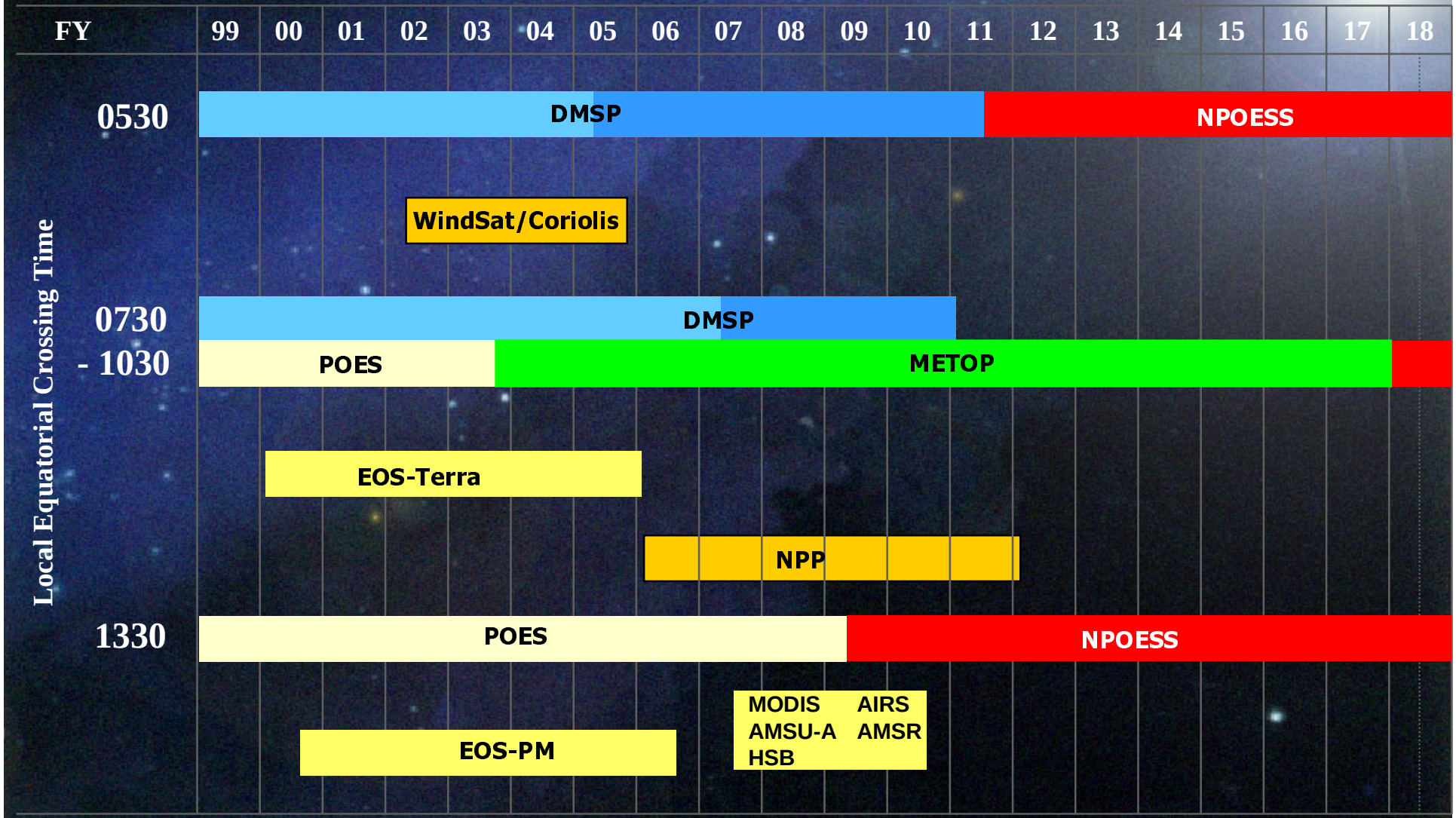
Proposed Joint IPO/NASA Risk Reduction Demo
Proposed NPOESS Preparatory Project (NPP)

- **Joint IPO/NASA flight of selected imager and sounding systems**
  - VIIRS - Vis/IR Imager Radiometer Suite (IPO Developed)
  - CrIS - Cross-track IR Sounder (IPO)
  - ATMS - Advanced Technology Microwave Sounder (NASA)
  - TBD - Instrument of Opportunity
- **Provides NPOESS with risk reduction demonstration**
- **Provides NASA with selected EOS AM and EOS PM continuity data**
- **Joint NASA/IPO study underway (GSFC has lead) to determine feasibility and costs**



NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

Satellite Transition

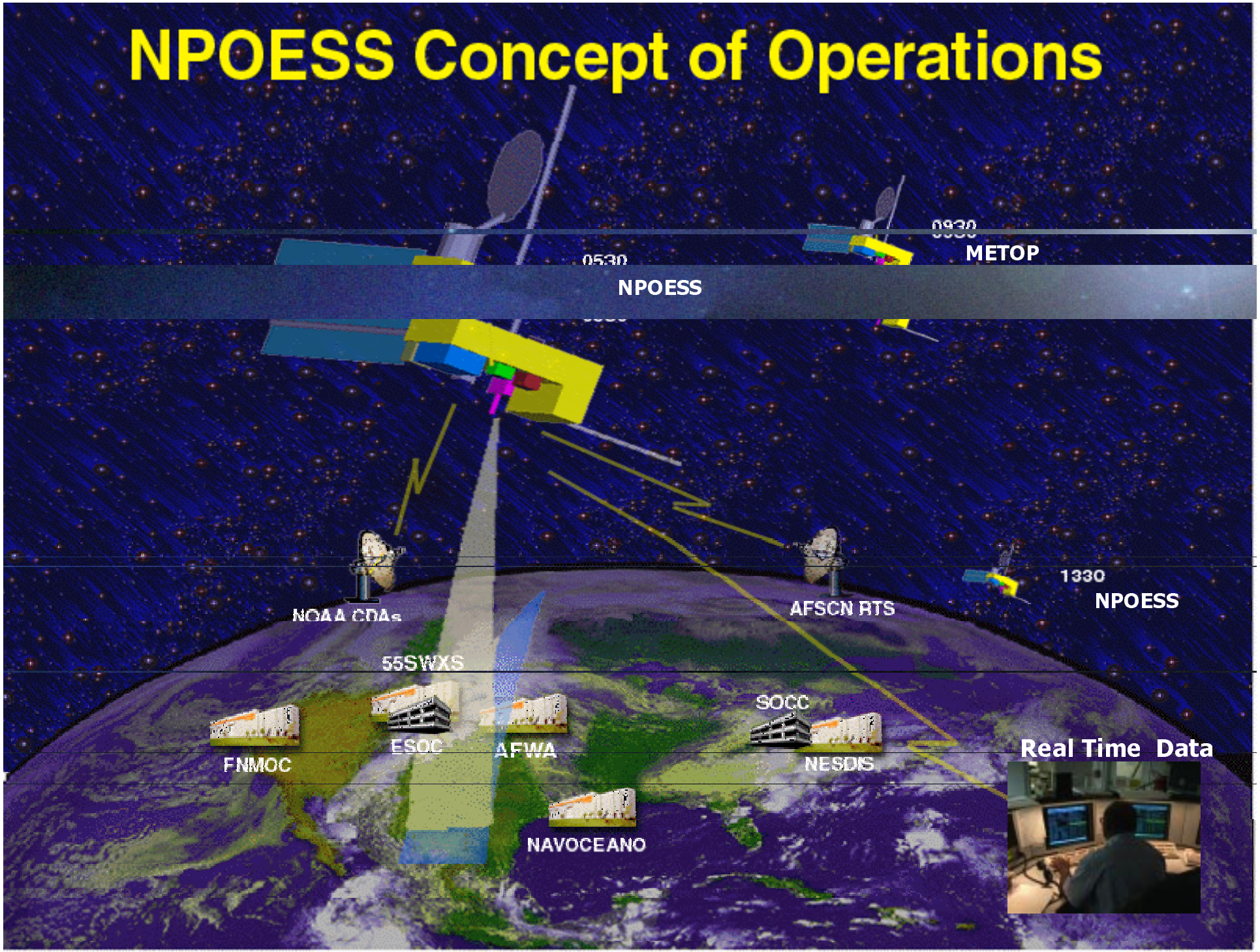


Operations Convergence

Fairbanks Multi-Mission Antennas

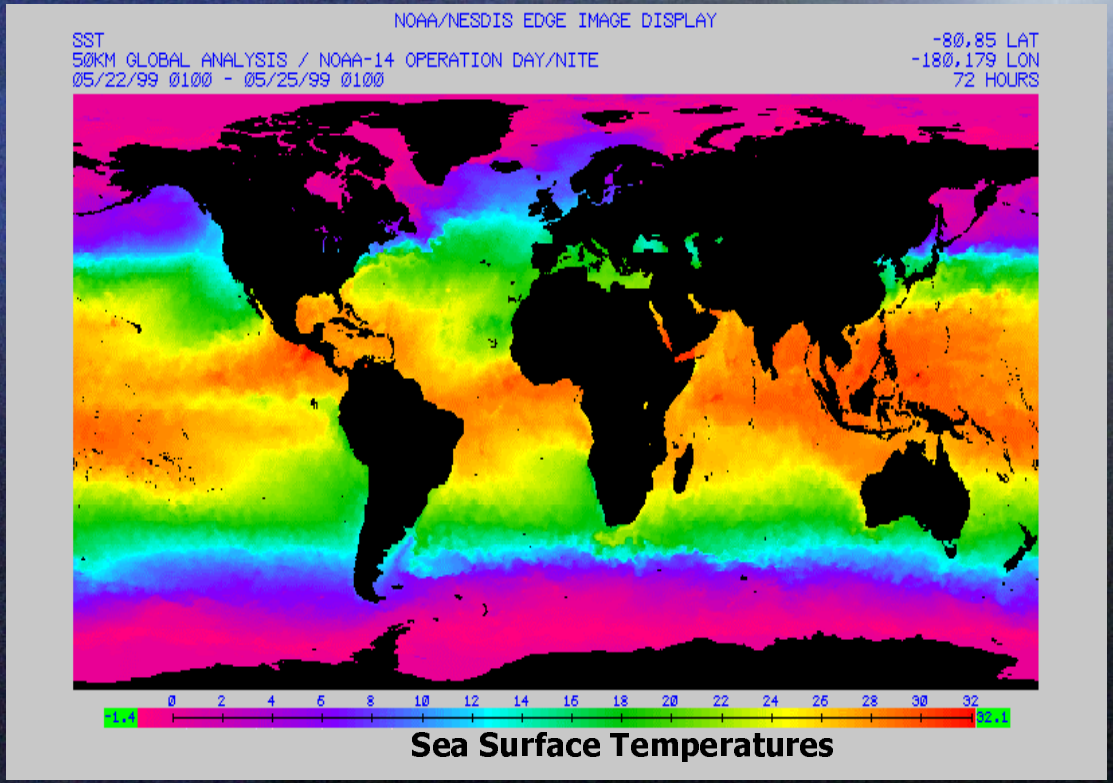
- Installation of 3, 13-meter antennas completed 1998
- Full Operational Capability 1999
- Construction and infrastructure improvements completed 2 years early and under budget
- X-band capable for future missions
  - METOP
  - NPOESS Preparatory Project
  - NPOESS

NPOESS Concept of Operations



Results of a Converged System

- Increased savings
- Better use of existing assets
- Maximize leveraged payloads from NASA, Navy, and Europeans
- Competitive development contracts for high risk/high payoff payloads
- Early risk reduction flight opportunities
- Early delivery of data to users for testing and evaluation

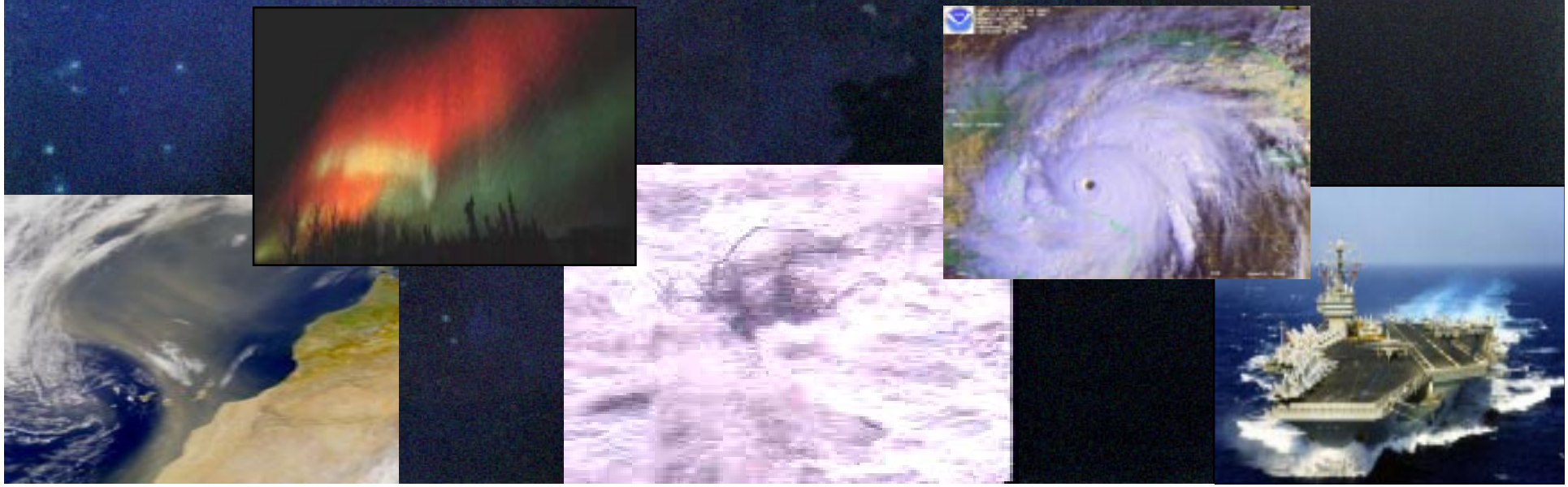


Sea Surface Temperatures

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

NPOESS

NPOESS is required to provide an operational remote sensing capability to acquire and receive in real-time at field terminals, and to acquire, store and disseminate to processing centers, global and regional environmental imagery and specialized meteorological, climatic, terrestrial, oceanographic and solar-geophysical and other data in support of mission requirements



Nighttime Lights of the World

This presentation can be downloaded from http://npoesslib.ipo.noaa.gov/