National Polar-orbiting Operational Environmental Satellite System
(NPOESS)

Satellite Meteorology: Past, Present, and Future

A Symposium in Celebration of CIMSS Silver Anniversary

" NPOESS/NPP/NAST Status and a Little on The NPOESS Atmospheric Sounders and Their Role in Approaching a Global Atmospheric Sounding System for NWP and Climate"

University of Wisconsin-Madison
Educational Sciences Center
July 12, 2005

Stephen A. Mango
Chief Scientist, NPOESS Integrated Program Office

Outline

- *The NPOESS & METOP sounders & imagers will represent a significant contribution to a polar-orbiting, atmospheric sounding & imager component of an emerging Global Earth Observation System of Systems [GEOSS] for NWP and Climate.*
  GOES-R & MSG sounders & imagers will represent an important geostationary component of such a GEOSS.

- **Overview of NPOESS/NPP & Status**

- **The roles of the CrIS/ATMS/OMPS/CMIS (& VIIRS) on NPOESS and the IASI/AMSU/MHS/GOME/ASCAT on METOP in coordinated polar, LEO orbits will be discussed in the plan for a constellation of sounding & imaging instruments to approach a meaningful, global Numerical Weather Prediction system with short_revisit times and low latency of processed information and an emergent global Climate Monitoring system.**

- **A description of the capabilities of the CrIS FTS :**
  its operational performance and its role in generating several, operational products of meteorological, environmental and climatological importance.
  Basic comparisons of the CrIS /IASI, and the OMPS/GOME-2 will be presented.

  An IPO developed, high spectral and spatial resolution, NPOESS Airborne Sounder Testbed [NAST], with its IR FTS, NAST-I, and its microwave sounder, NAST-M, and a Scanning S-HIS will be included as a critical component of an airborne, validation and calibration platform for CrIS/ATMS and IASI/AMSU/MHS.

The Global Framework
Global Earth Observation System of Systems (GEOSS)

- A historic series of events have taken place for establishing a global, integrated Earth observing system

- Nations and international agencies of the world have met and agreed to cooperate on developing a cooperative strategy for understanding the Earth's environment and its interaction with the peoples of the planet
  [Earth Summits]

- Frameworks, plans, and ideas were drafted in preparation for the last round of meetings in February, 2005

The Global Framework

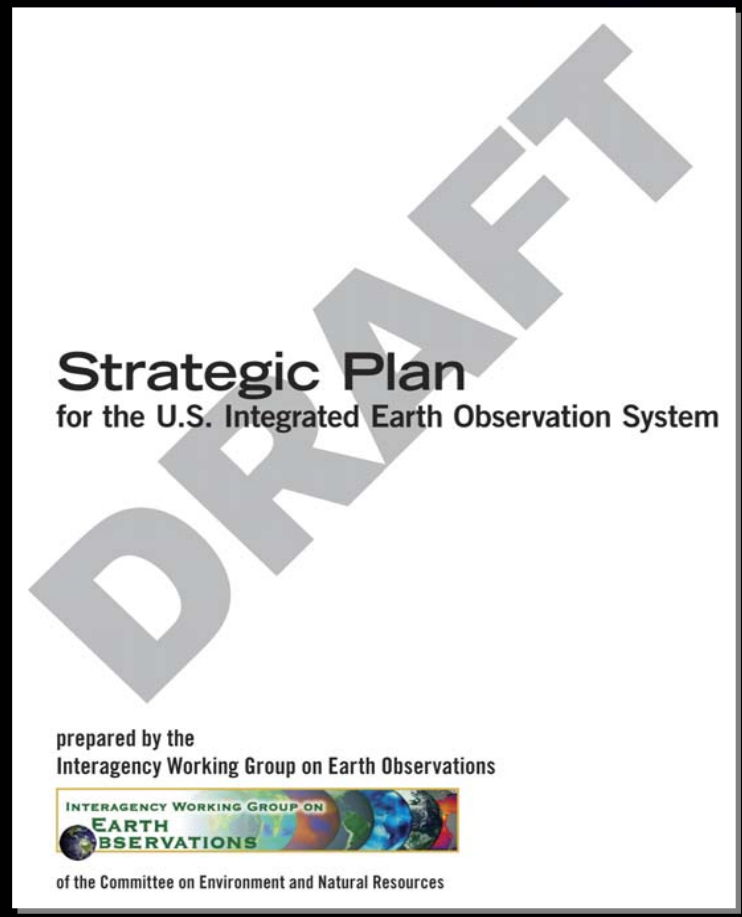
Global Earth Observation System of Systems (GEOSS)

- A distributed "system of systems"
  - Improves coordination of strategies and observation systems
  - Links all platforms: in situ, aircraft, and satellite networks
  - Identifies gaps in our global capacity
  - Facilitates exchange of data and information
  - Improves decision-makers' abilities to address pressing policy issues

"Potential U.S. Contributions to the GEOSS"

Strategic Plan for US Integrated Earth Observation System

- **VISION:** ***Enable*** ***a healthy public, economy, and planet*** ***through an integrated, comprehensive, and sustained Earth observation system***
- **US input to GEOSS – Final version to be available soon**
  - **Spring Workshop**
- **Establish Formal USG Mechanism**
  - **Capable of committing necessary resources and implementing functions**
- **Available at http://iwgeo.ssc.nasa.gov**



"Potential U.S. Contributions to the GEOSS"

What is in the US Plan? - Focus on 9 Societal Benefits Areas

Natural & Human Induced Disasters

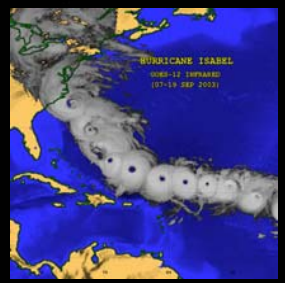
Water Resources

Ecosystems

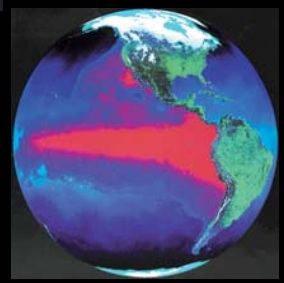
Human Health & Well-Being

Energy Resources

Sustainable Agriculture & Desertification



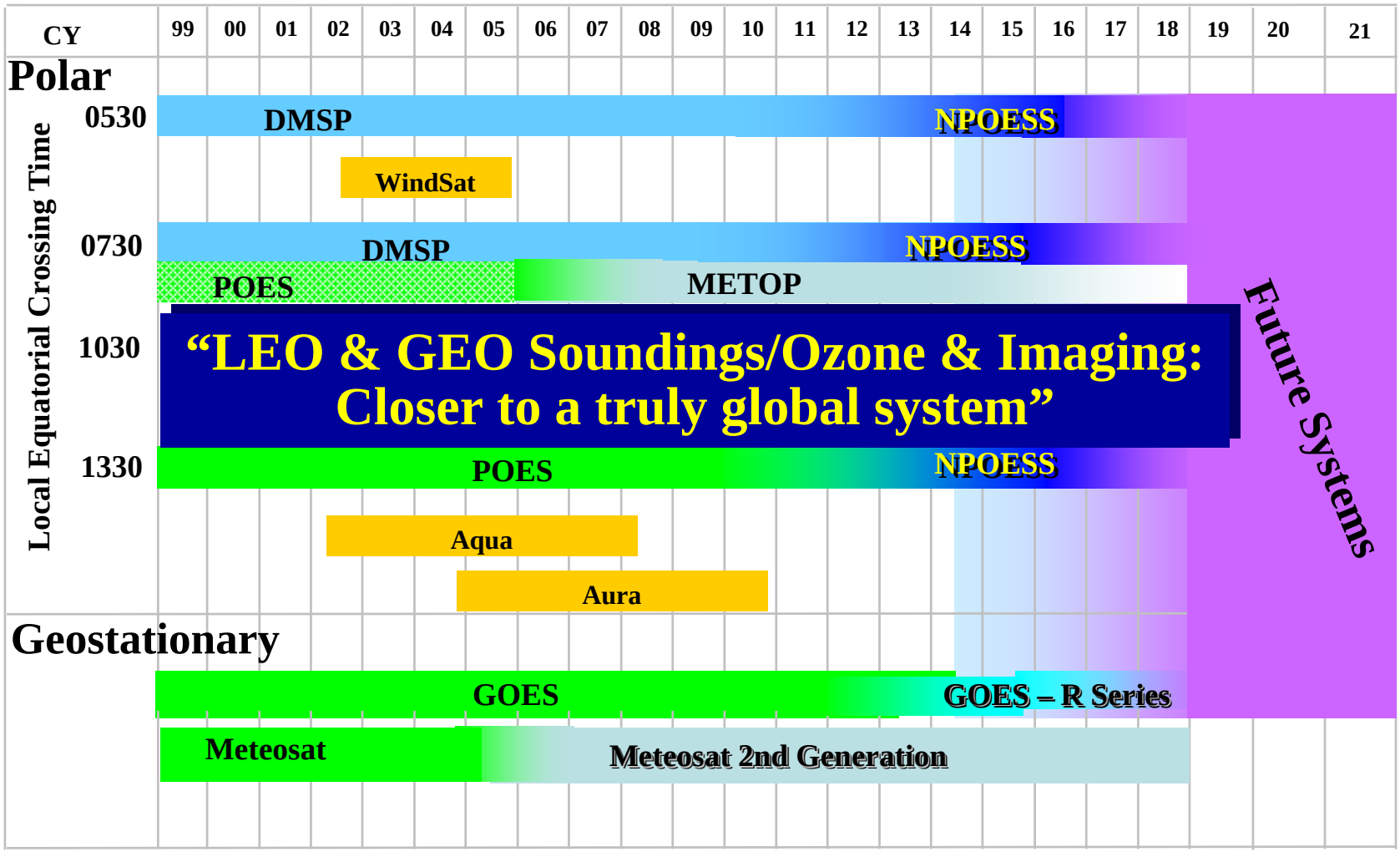
Weather Information, Forecasting & Warning



Climate Variability & Change

Oceans

Long-Range Integrated USA/European Satellite Transition



NOAA/EUMETSAT Cooperation since 1970's

European Instruments on NOAA polar orbiters since 1978

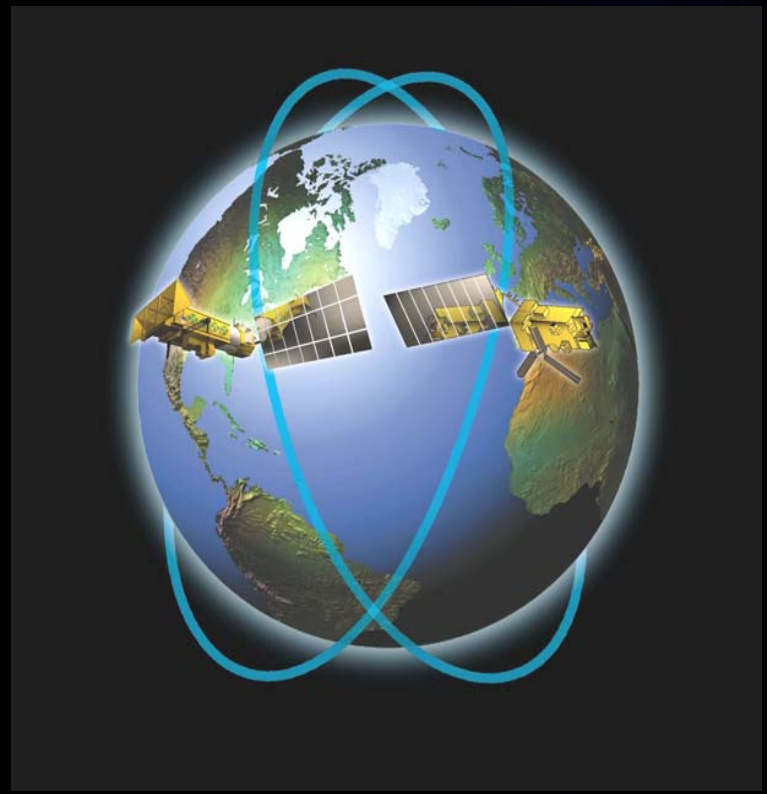
Economic Summit in 1980's identified key partnership

Geo backup in 1980's and 1990's; Meteosat-4 loan to US 1992-94

Initial Joint Polar System [IJPS]
Signed Nov 19, 1998 NOAA & EUMETSAT

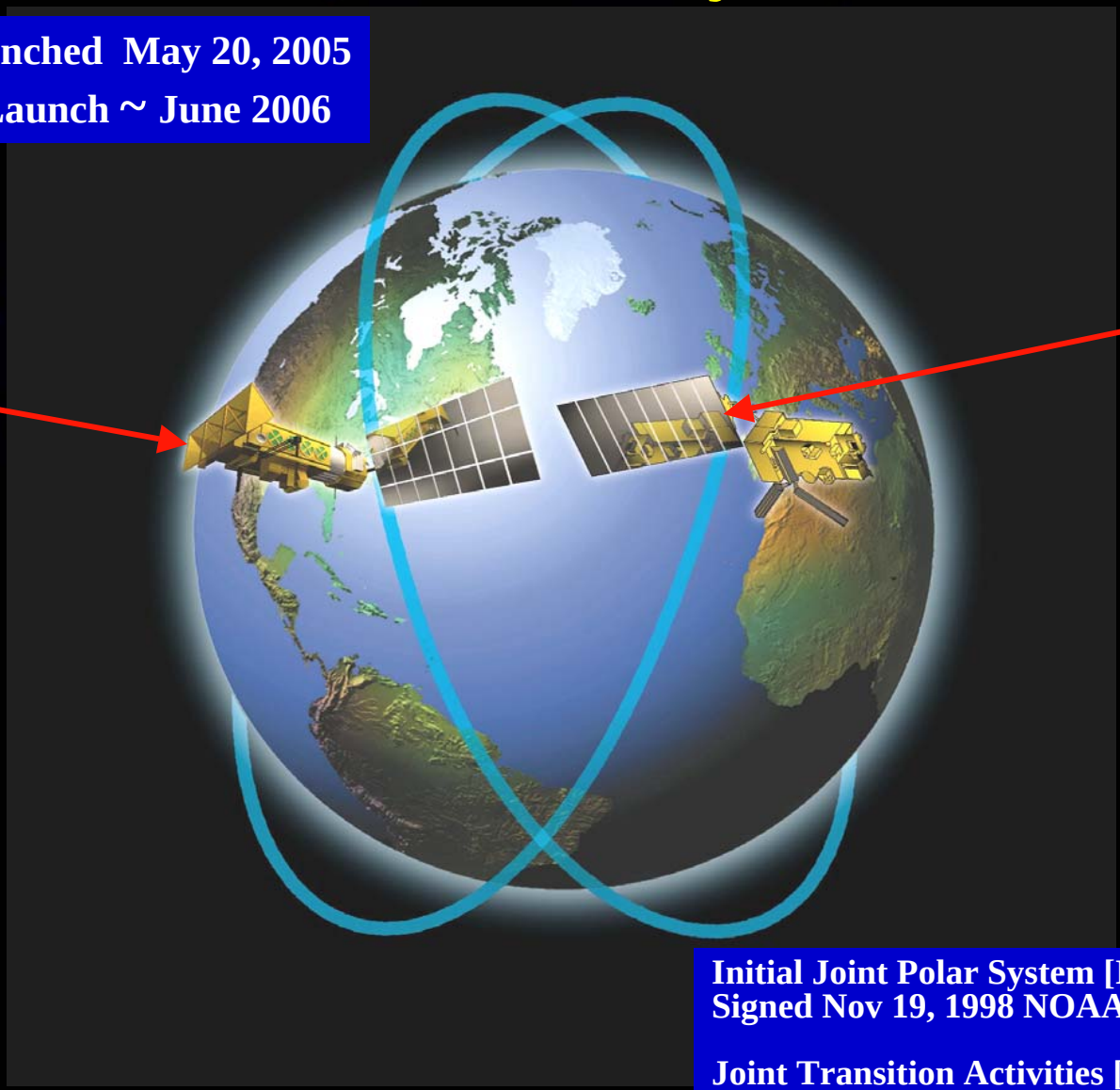
METOP-3, Svalbard Ground Station, NPP and JASON-II

Joint Transition Activities [JTA] Agreement
Signed Jun 24, 2003 NOAA & EUTMETSAT



The Initial Joint Polar System [IJPS] Is Underway

POES N – Launched May 20, 2005
METOP 1 - Launch ~ June 2006



POES N/N'
[NOAA]
HIRS/AMSU/MHS

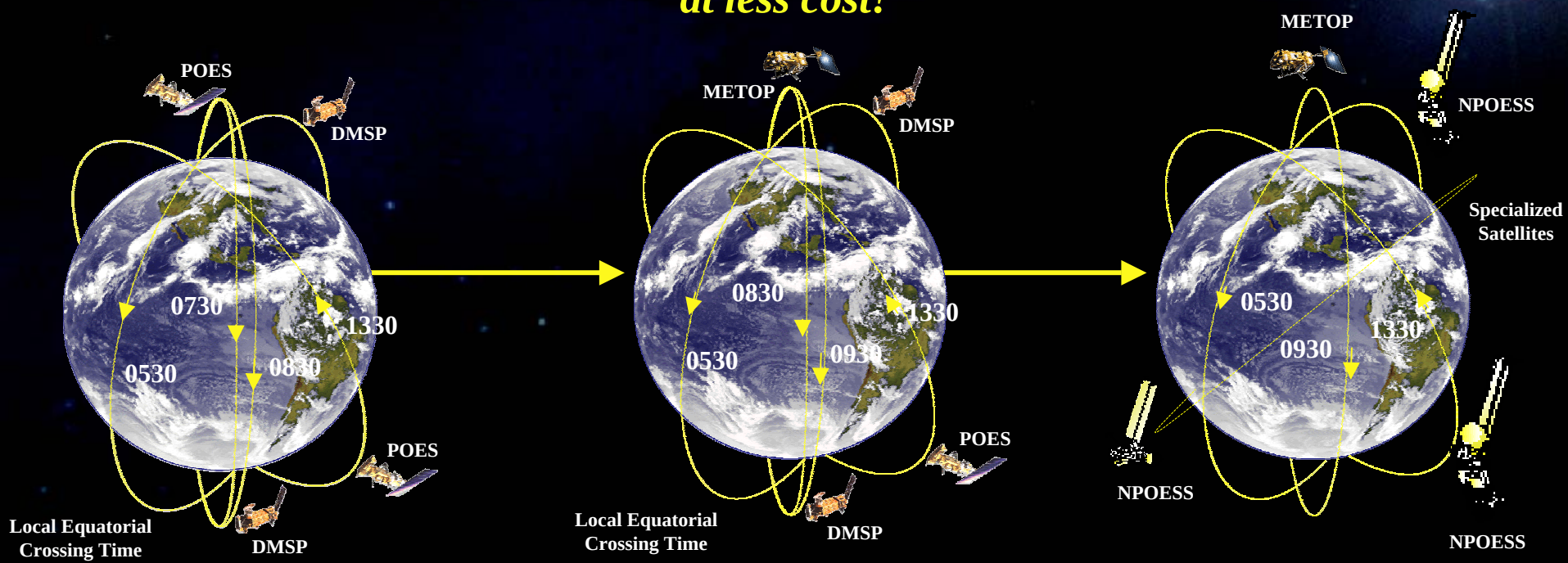
Metop 1/2
[EUMETSAT]
IASI/AMSU/MHS

Initial Joint Polar System [IJPS]
Signed Nov 19, 1998 NOAA & EUMETSAT

Joint Transition Activities [JTA] Agreement
Signed Jun 24, 2003 NOAA & EUTMETSAT

We Continue the Evolution

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



Today

- 2 US Military
- 2 US Civilian

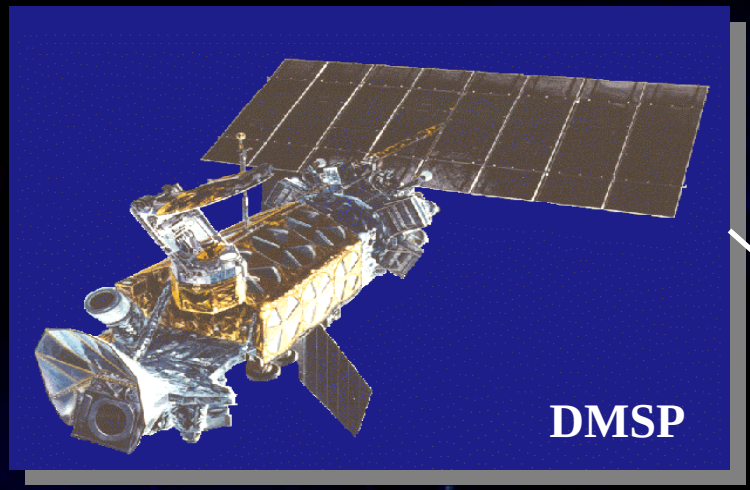
Tomorrow (~2006)

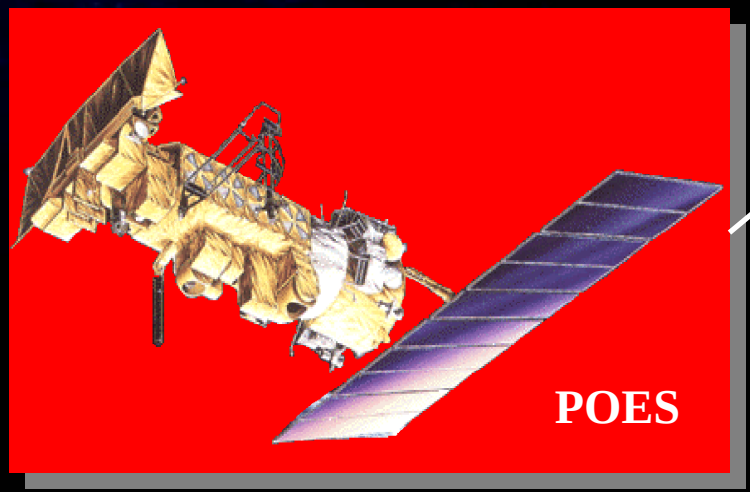
- 2 US Military
- 1 US Civilian and
- 1 European METOP

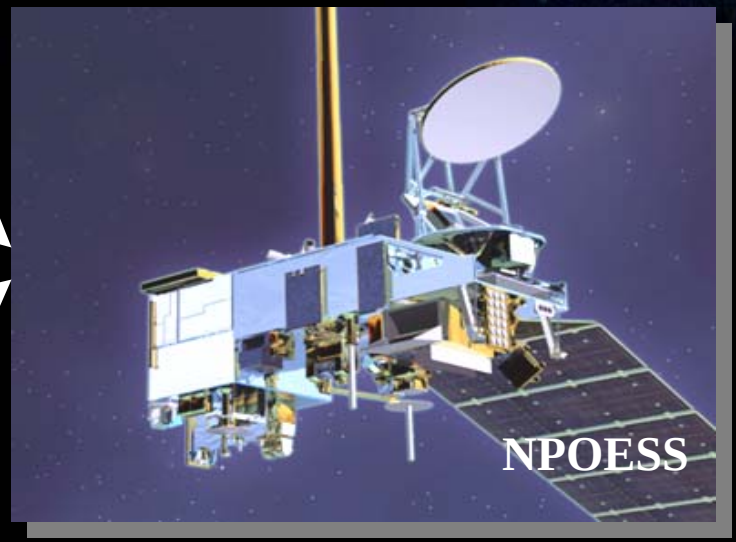
Future (~2014)

- 3 US Converged
- 1 (or 2)European METOP
- Specialized satellites?

DMSP/POES to NPOESS
Convergence / Evolution of Satellite Systems







DMSP/POES to NPOESS
Convergence / Evolution of Missions/Sensors

DMSP

OLS
SSM/I, SSM/T-1, SSM/T-2 or SSMIS
SES

-Imaging
-Sounding
-Space Environment

POES

AVHRR
HIRS
AMSU-A, AMSU-B, MHS
SBUV
SEM
DCS
SARSAT

-Imaging
-Sounding
-Climate
-Ozone
-Space Environment

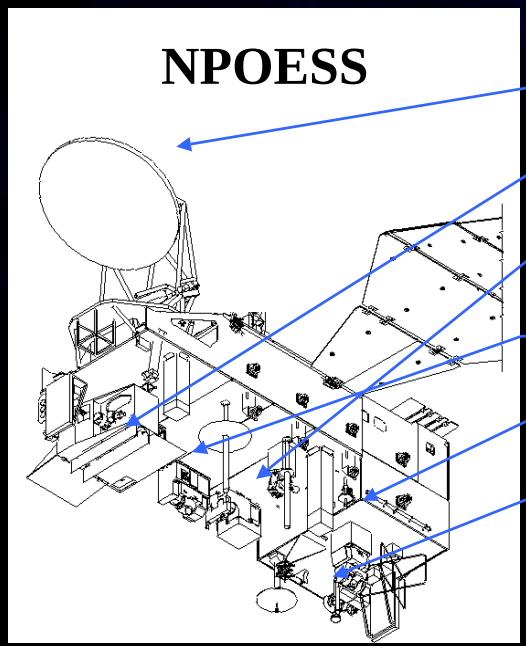
NPOESS

VIIRS
CMIS
CrIS, ATMS
OMPS
SESS
CERES
TSIS
ALT
DCS
SARSAT

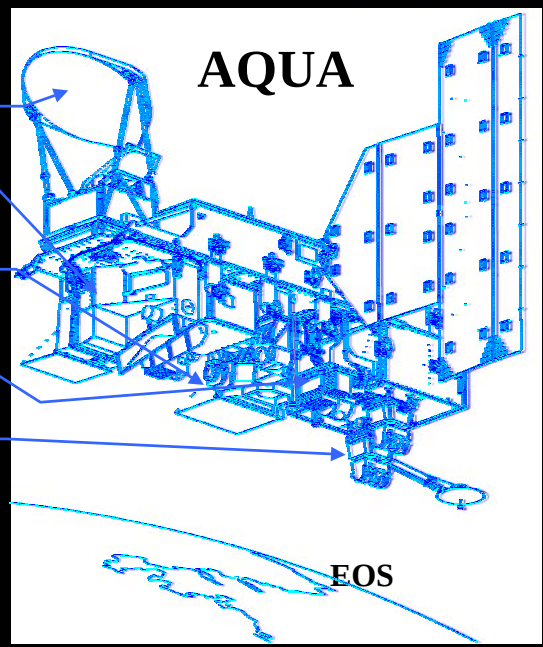
-Imaging
-Sounding
-Climate
-Ozone
-Space Environment

NASA EOS Payload Sensor Experience Directly Benefits NPOESS

- Similarity between EOS and NPOESS provides knowledge and experience in integrating the sensors to a heritage spacecraft.



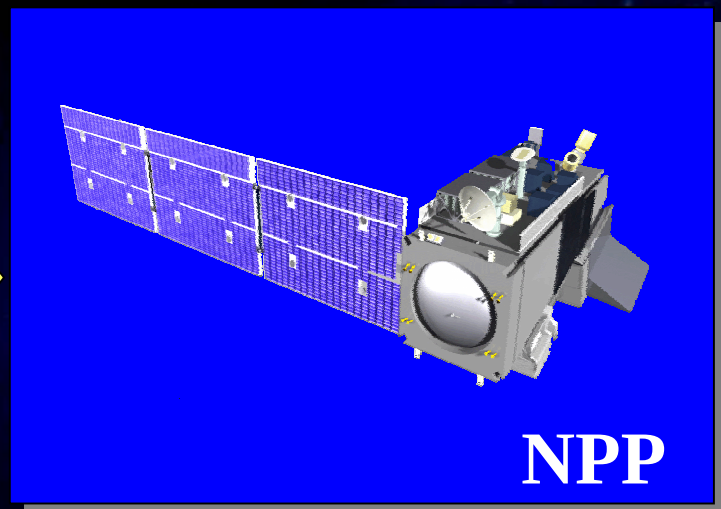
NPOESS	Sensors	AQUA
CMIS	Conical Scan Microwave	AMSR-E
VIIRS	EO Imager	MODIS
CrIS	I-R Sounder	AIRS
ATMS	Microwave Sounder(s)	AMSU/HSB
ERBS	Earth Radiation	CERES
OMPS	Ozone (UV-Vis)	OMI (Aura)



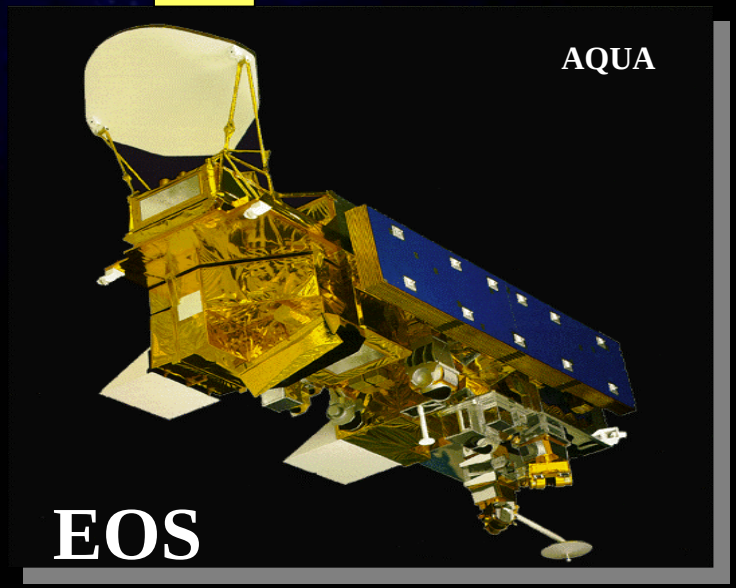
Satellite

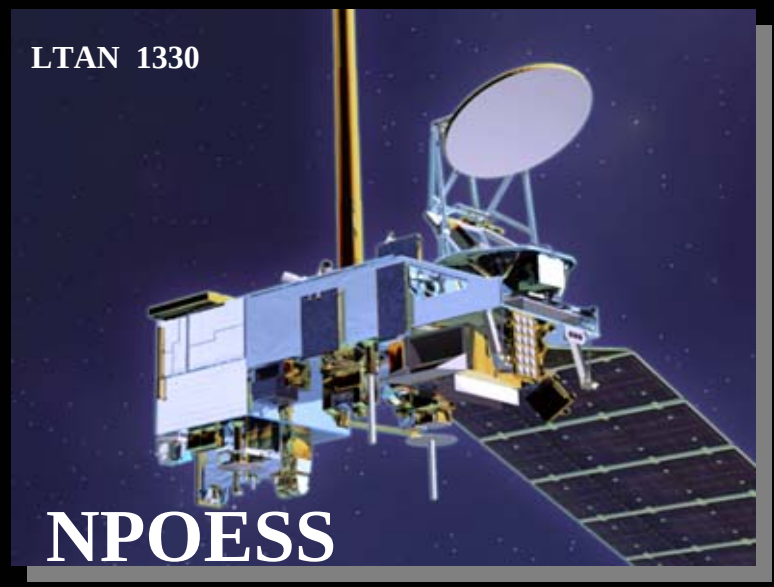
T330 Heritage Structure	LEO Sun-Sync Mission

NPOESS Preparatory Project [NPP]
"Bridge from EOS to NPOESS"



"Bridges EOS & NPOESS Climate Measurement Missions"





NPOESS Mission Statement

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 CIVILIAN and NATIONAL SECURITY missions

NPOESS

[National Polar-orbiting Operational Environmental Satellite System]

- **NPOESS – Represents for the U.S.**
  - The **next generation**, polar-orbiting, Low-Earth-Orbit [LEO] operational, satellite constellation
  - An **end-to-end system** for environmental remote sensing
  - A major portion of the **LEO component** of a **"Future National Operational Environmental Satellite System"** which could be envisioned as a significant contributing component moving towards a Global Earth Observation System of Systems [GEOSS].

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

NPOESS/NPP Data Products

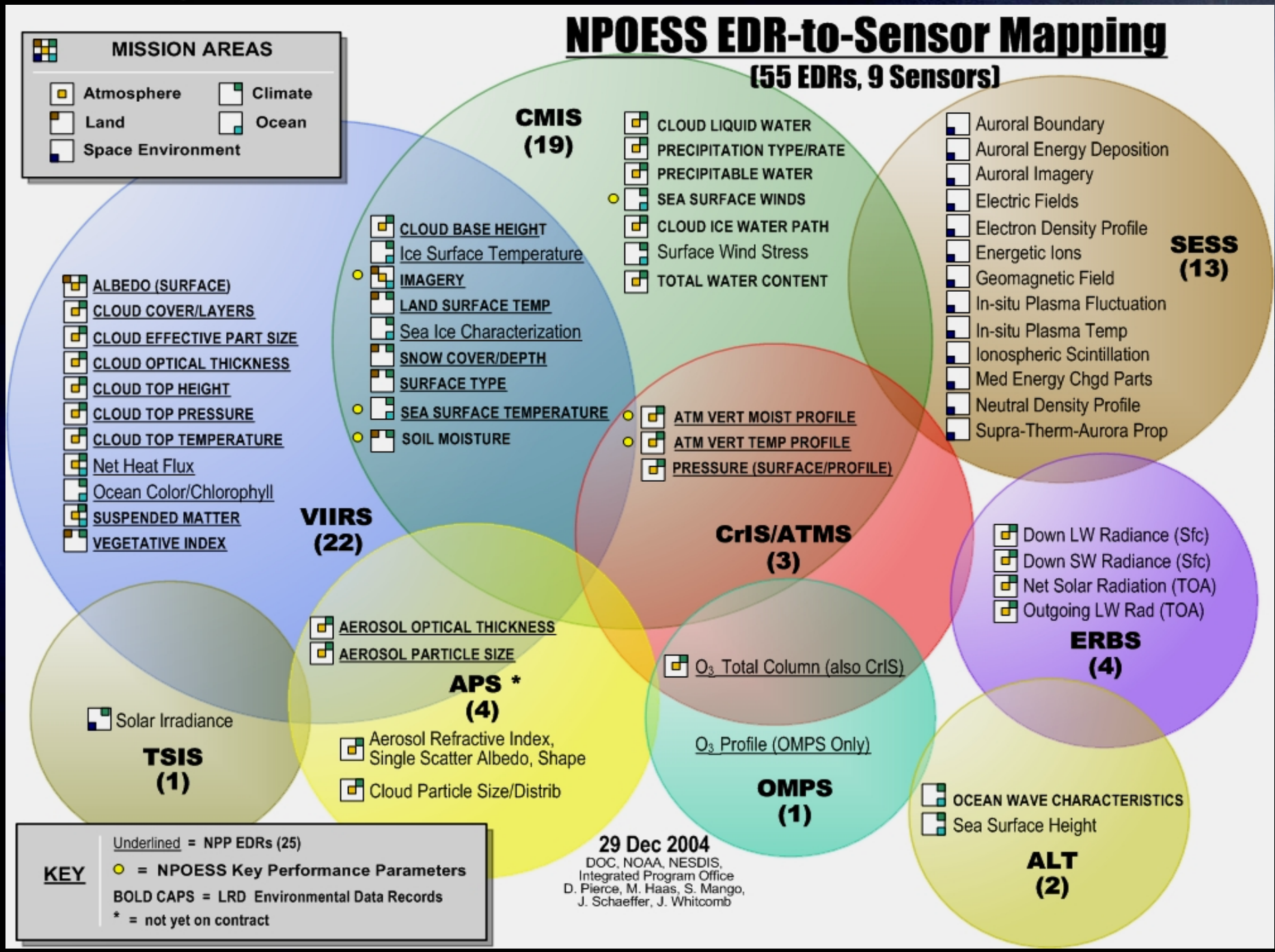
Raw Data Records (RDRs - Similar to Level 1A for CEOS/NASA.
~ 150 giga bytes per day (similar to Terra or Aqua).
Sensor Data Records (SDRs) - Similar to CEOS/NASA Level 1B

Environmental Data Records (EDRs)
Similar to CEOS/NASA Level 2.
NPP Provides 25 of 55 NPOESS EDRs.

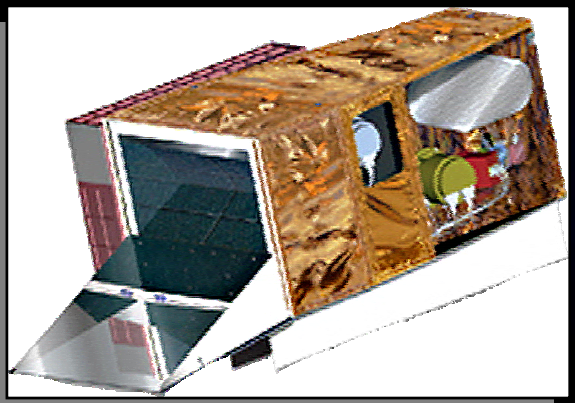
★ Atmospheric Vertical Moisture Profile	Cloud Top Pressure	Precipitable Water
★ Atmospheric Vertical Temp Profile	Cloud Top Temperature	Precipitation Type/Rate
★ Imagery	Downward Longwave Radiance (Sfc)	Pressure (Surface/Profile)
★ Sea Surface Temperature	Downward Shortwave Radiance(Sfc)	Sea Ice Characterization
★ Sea Surface Winds	Electric Field	Sea Surface Height/Topography
★ Soil Moisture	Electron Density Profile	Snow Cover/Depth
Aerosol Optical Thickness	Energetic Ions	Solar Irradiance
Aerosol Particle Size	Geomagnetic Field	Supra-Thermal-Auroral Particles
Aerosol Refractive Index	Ice Surface Temperature	Surface Type
Albedo (Surface)	In-*situ* Plasma Fluctuations	Wind Stress
Auroral Boundary	In-*situ* Plasma Temperature	Suspended Matter
Auroral Energy Deposition	Ionospheric Scintillation	Total Water Content
Auroral Imagery	Medium Energy Charged Particles	Vegetation Index
Cloud Base Height	Land Surface Temperature	
Cloud Cover/Layers	Net Heat Flux	
Cloud Effective Particle Size	Net Solar Radiation (TOA)	
Cloud Ice Water Path	Neutral Density Profile	
Cloud Liquid Water	Color/Chlorophyll	
Cloud Optical Thickness	Ocean Wave Characteristics	
Cloud Particle Size/Distribution	Outgoing Longwave Radiation (TOA)	
Cloud Top Height	Ozone - Total Column/Profile	

VIIRS (23)
CMIS (19)
CrIS/ATMS (3)
OMPS (1)
SES (13)
GPSOS (2)
ERBS (5)
TSIS (1)
ALTIMETER (3)
APS (4)

★ Environmental Data Records (EDRs) with Key Performance Parameters


NPOESS EDR-to-Sensor Mapping
(55 EDRs, 9 Sensors)
MISSION AREAS
Atmosphere
Climate
Land
Ocean
Space Environment
CMIS
(19)
CLOUD LIQUID WATER
PRECIPITATION TYPE/RATE
PRECIPITABLE WATER
SEA SURFACE WINDS
CLOUD ICE WATER PATH
Surface Wind Stress
TOTAL WATER CONTENT
CLOUD BASE HEIGHT
Ice Surface Temperature
IMAGERY
LAND SURFACE TEMP
Sea Ice Characterization
SNOW COVER/DEPTH
SURFACE TYPE
SEA SURFACE TEMPERATURE
SOIL MOISTURE
SESS
(13)
Auroral Boundary
Auroral Energy Deposition
Auroral Imagery
Electric Fields
Electron Density Profile
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
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
VIIRS
(22)
ATM VERT MOIST PROFILE
ATM VERT TEMP PROFILE
PRESSURE (SURFACE/PROFILE)
CrIS/ATMS
(3)
Down LW Radiance (Sfc)
Down SW Radiance (Sfc)
Net Solar Radiation (TOA)
Outgoing LW Rad (TOA)
ERBS
(4)
AEROSOL OPTICAL THICKNESS
AEROSOL PARTICLE SIZE
APS *
(4)
Aerosol Refractive Index,
Single Scatter Albedo, Shape
Cloud Particle Size/Distrib
O3 Total Column (also CrIS)
O3 Profile (OMPS Only)
OMPS
(1)
Solar Irradiance
TSIS
(1)
OCEAN WAVE CHARACTERISTICS
Sea Surface Height
ALT
(2)
KEY
Underlined = NPP EDRs (25)
= NPOESS Key Performance Parameters
BOLD CAPS = LRD Environmental Data Records
* = not yet on contract
29 Dec 2004
DOC, NOAA, NESDIS,
Integrated Program Office
D. Pierce, M. Haas, S. Mango,
J. Schaeffer, J. Whitcomb

NPOESS/NPP Risk Reduction Instruments

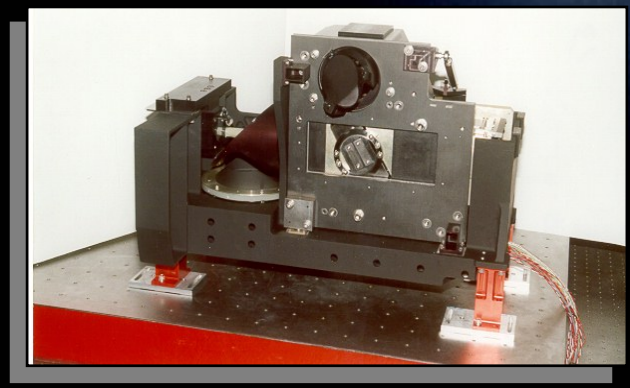


Visible/IR Imaging Radiometer Suite (VIIRS)
Raytheon SBRS

Ozone Mapping & Profiler Suite (OMPS)
Ball Aerospace

Conical-scanning Microwave Imager/Sounder (CMIS)
Boeing

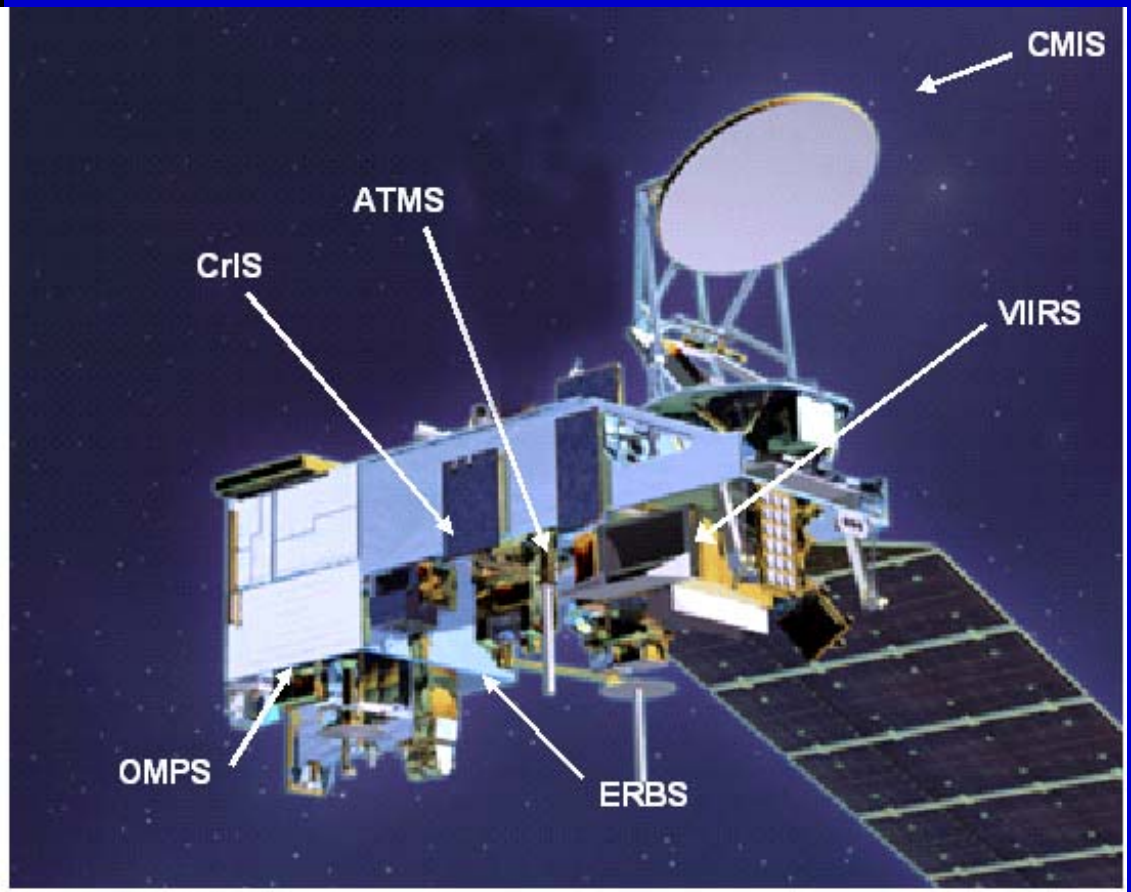
[NPOESS only]



Cross-track IR Sounder (CrIS)
ITT Industries

Advanced Technology Microwave Sounder (ATMS)
Northrop Grumman

NPOESS Satellite and Sensors



NPOESS 1330 Configuration

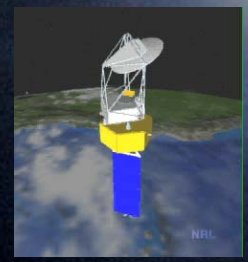
	1330	1730	2130	NPP
VIIRS	X	X	X	X
CMIS	X	X	X	
CrIS	X	X		X
ATMS	X	X		X
SESS	X	X	X	
OMPS	X			X
ADCS	X	X		
SARSAT	X	X	X	
TSIS		X		
ERBS	X			
ALT		X		
APS			X	
SS	X	X	X	
OLI			X	

X = changed since contract award

Single Satellite Design with Common Sensor Locations and "ring" Data Bus Allows Rapid Reconfiguration and Easy Integration

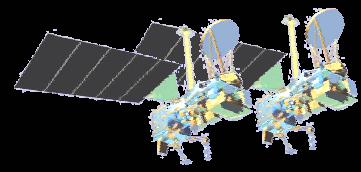
U.S. NPOESS Mission Capability Timeline

- **PROOF OF CONCEPT: 1998 - 2007**
  - NPOESS Airborne Sounder Testbed (NAST)
  - Operational Utilization of EOS data (Terra, Aqua, Quikscat, Jason-1….)
  - Windsat Coriolis Experiment
  - Shuttle Ozone Limb Sounding Experiment (SOLSE)
  - Solar Research and Climate Experiment (SORCE)

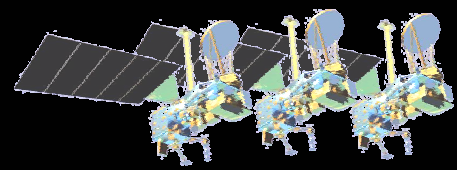


- **ON-ORBIT DEMONSTRATION: 2008 - 2013**
  - NPOESS Preparatory Project [NPP]
    - *Combined Test & Evaluation-VIIRS,CrIS,ATMS,OMPS*
    - *Users develop data exploitation applications & systems*
    - *Incorporate improvements into Operational System*

- **INITIAL OPERATIONAL CAPABILITY: 2012**
  - Two US Operational Orbits - Most KPPs met



- **FULL OPERATIONAL CAPABILITY: 2014**
  - Three US Operational Orbits - All KPPs met



NAST WINDSAT NPP NPOESS-C1 NPOESS-C2 NPOESS-C3

IOC FOC

NPOESS Preparatory Project (NPP)

NPP Contributions to NPOESS

- **Instrument Risk Reduction** - Early delivery/ instrument level test/system-level integration and test Provides lessons learned and allows for any required modifications in time to Support NPOESS first launch readiness
- **Ground System Risk Reduction**
  - Early delivery and test of a subset of NPOESS-like ground system elements
- **Early User Evaluation of NPOESS Data Products**
  - Provides algorithms/instrument verification and opportunities for instrument calibration/validation
  - Allows for algorithm modification prior to NPOESS first launch

Mission Characteristics

Instruments:
- Visible Infrared Imaging Radiometer Suite (VIIRS)
- Cross-track Infrared Sounder (CrIS)
- Advanced Technology Microwave Sounder (ATMS)
- Ozone Mapper and Profiler Suite (OMPS)

Launch:	October 2006 [FY07]
Orbit:	824 km polar sun-synch, 10:30 am descending node
Launch Site:	Western Test Range
Mission Duration:	5 year / 7.5 year consumables

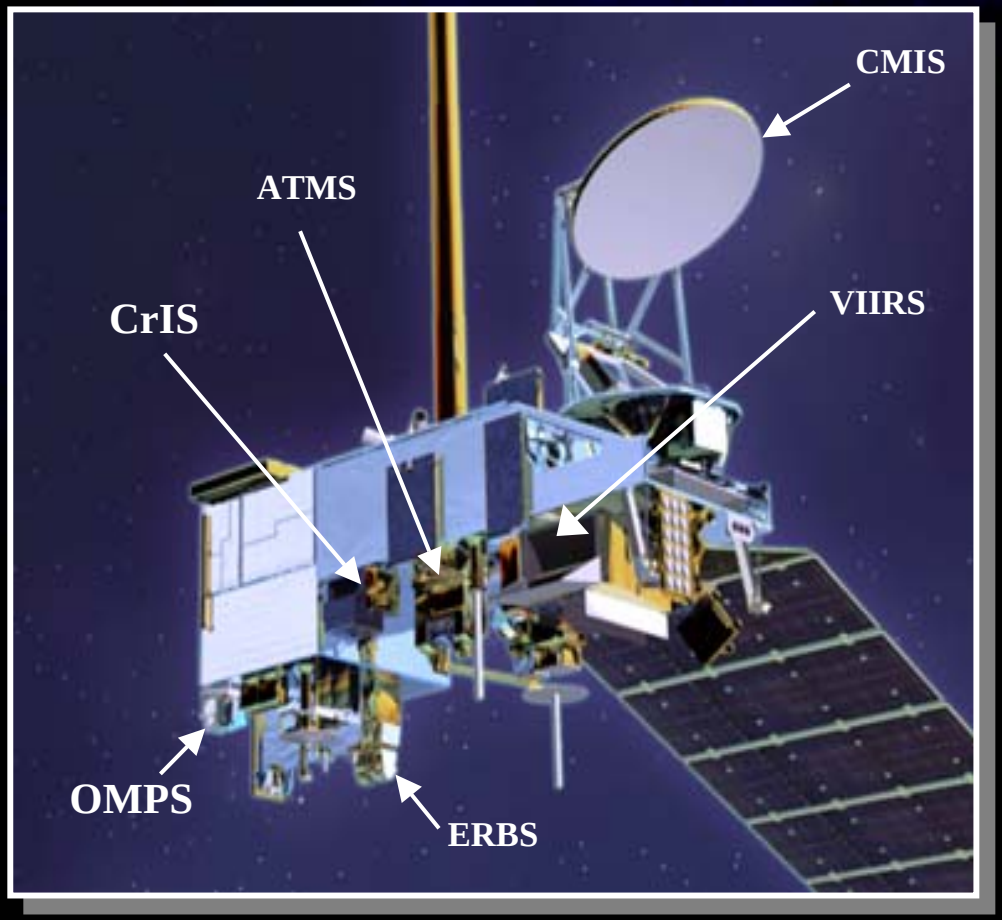
Responsibility Sharing*

IPO	NASA
Joint Program Management	Joint Program Management
VIIRS Instrument/Algorithms	Mission Systems Engineering, Integration, & Test
CrIS Instrument/Algorithms	ATMS Instrument/Algorithms
OMPS Instrument/Algorithms	Spacecraft and Subsystem Integration to the S/C
Command, Communications, Control Segment (C3S)	Launch Vehicle and Associated Activities
Interface Data Processing Segment (IDPS)	Science Data Segment (SDS)
Mission Management and Satellite Operations	Manage NPP Cal/Val for Level 1B and CDRs
Manage NPP Cal/Val [EDRs, SDRs, and EDRs]	Science Support (NRA)
Science Support (IGS,NIP)	

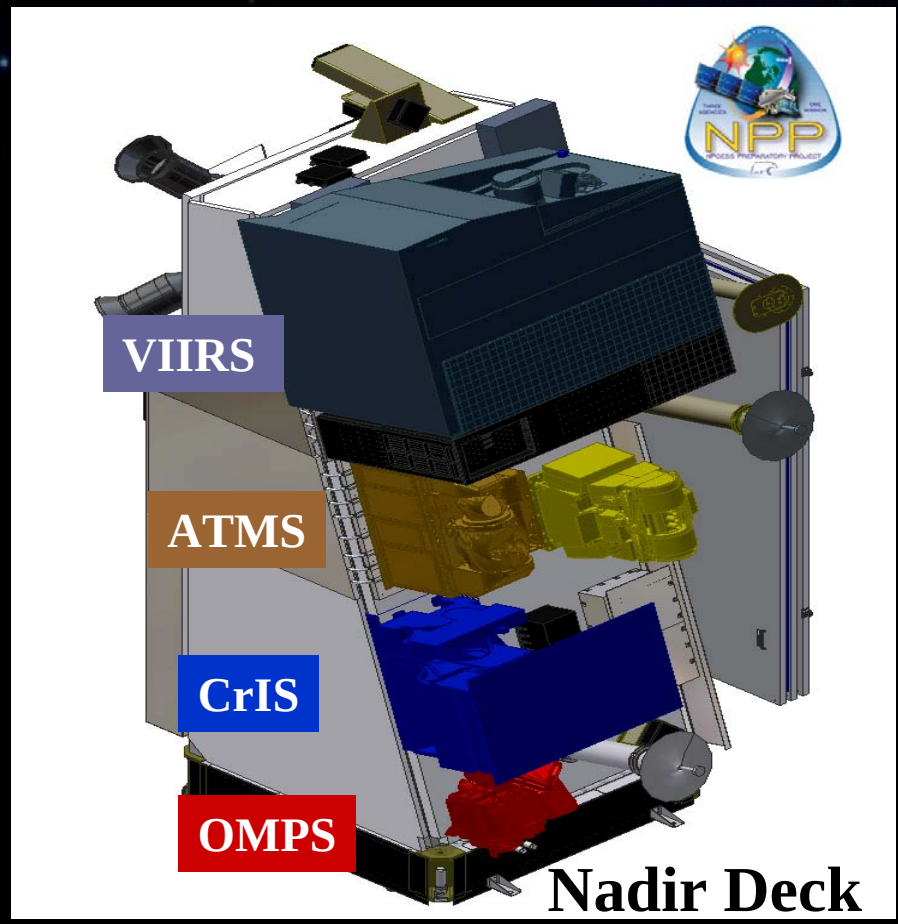
Note: NOAA/NCDC is supporting formulation of Archive and Distribution Segment (ADS).
* As documented in NASA/NOAA/DoD Initial Implementation Agreement, November 27, 1999

NPOESS/NPP CrIS/ATMS/OMPS/VIIRS Sensors

NPOESS 1330 Satellite



NPP 1030 (2230) Satellite

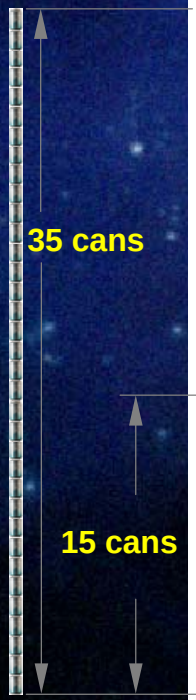


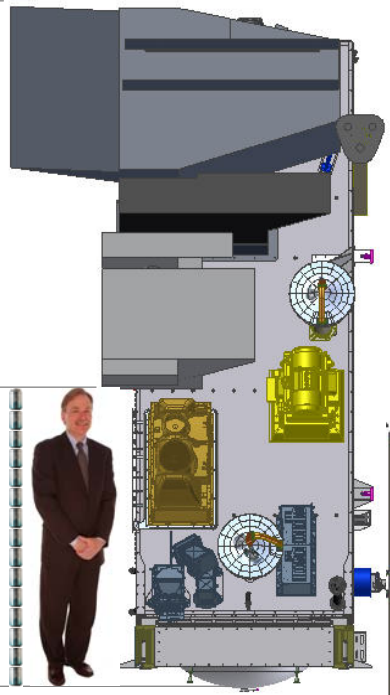
NPP Satellite – By Ball Aerospace "Bridge from EOS to NPOESS"

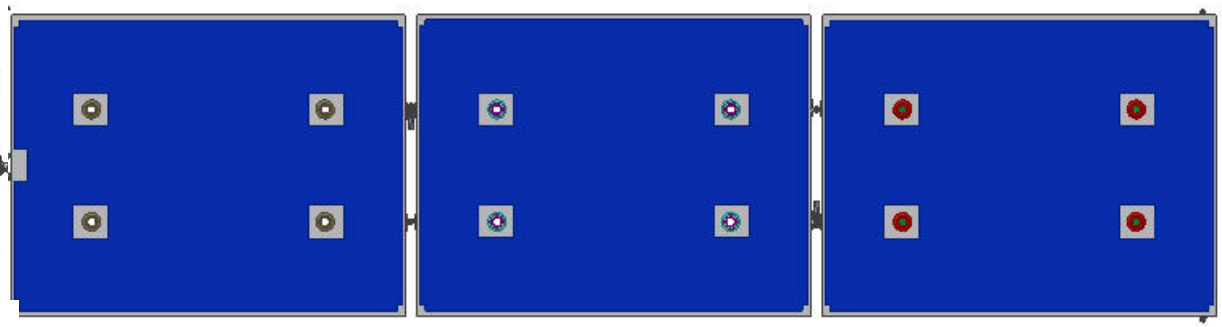
Weight: 137,100 cans (dry)
247 cases of your favorite beverage (wet)

Note: Units in 202/211 X 413 aluminum cans (can, end & tab)

- Mass: 2150 kg (nearly 5000 lbs)
- Power: 2200 watts
- Volume: 14 ft x 6 ft x 5 ft
- 40" diameter oblate tank holds 400 kg of propellant
- 1553 and 1394 data buses for the Instrument C&DH interface
- Solar Array - Single wing deployed length ~ 25 feet
- Orbit: 824 km, sun-synchronous, 98° inclination, descending 10:30AM ± 10 minute local mean time
- Dimensions: ~1.35 m x 1.35 m x 4.03 m



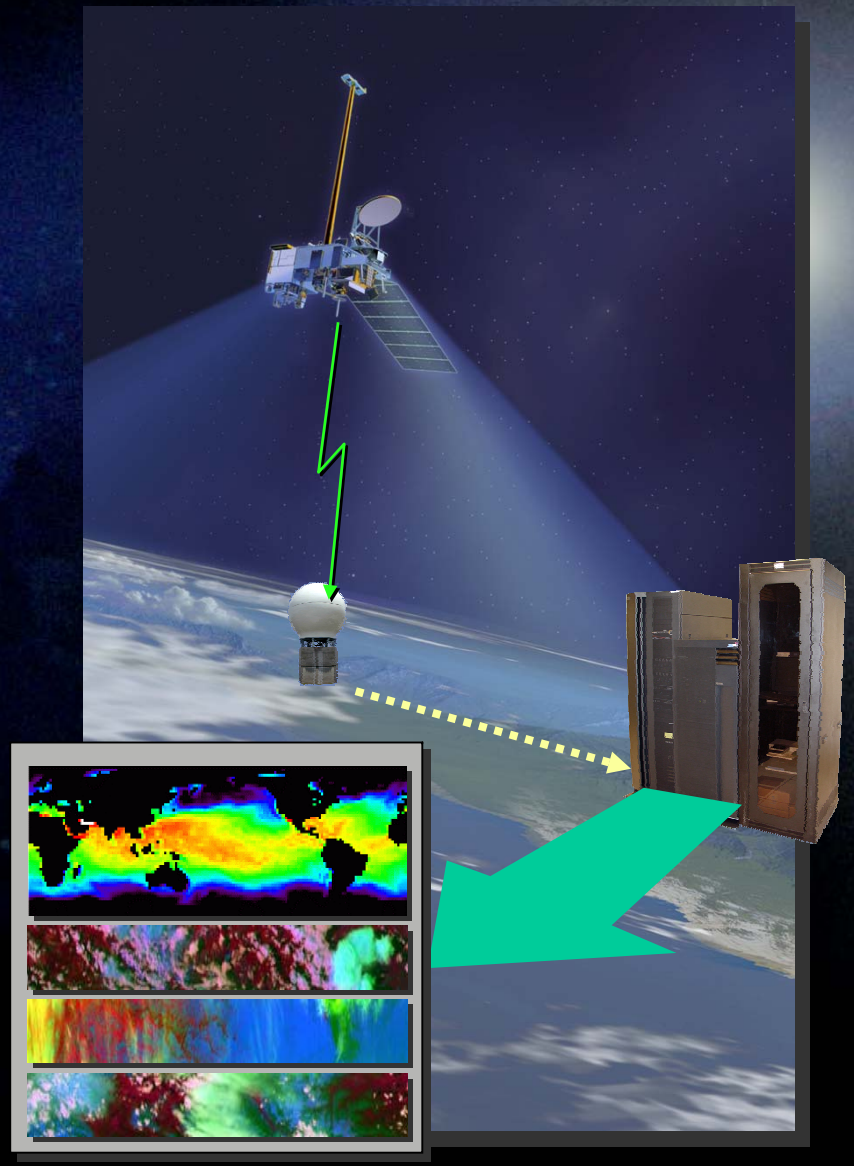




NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

NPOESS Program Schedule

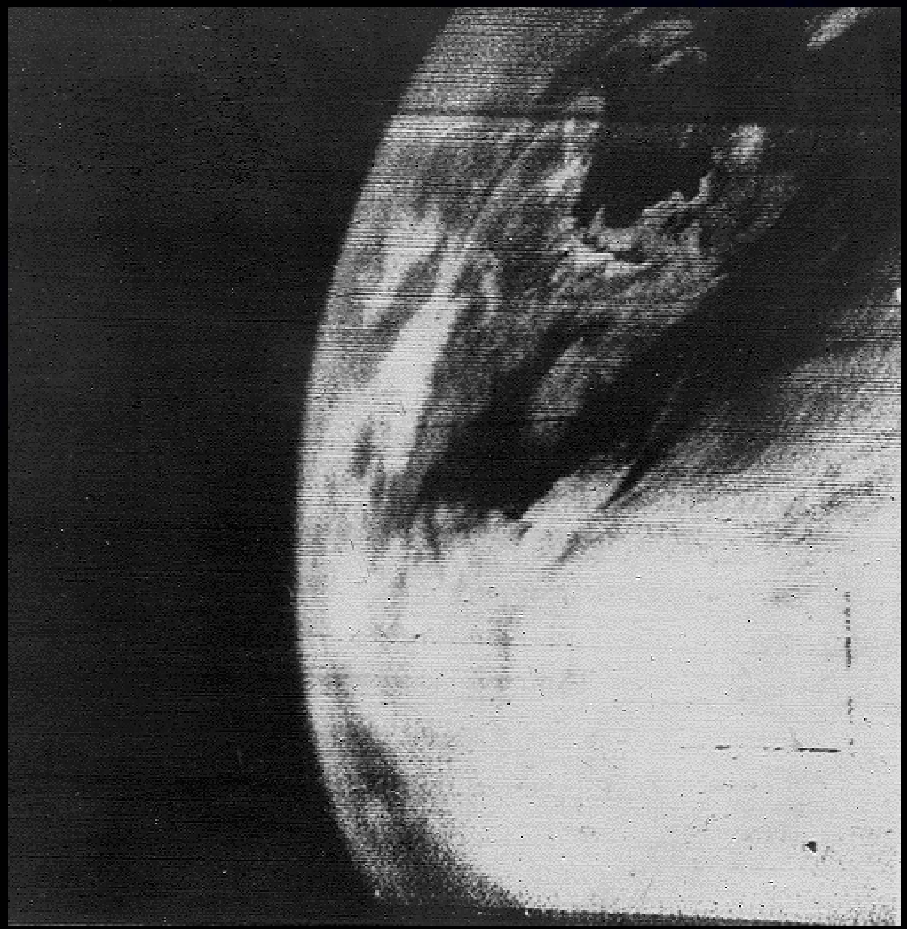
- 2002 A&O Contract Award
- 2003 NPP Delta Critical Design Review
- 2005 NPOESS Δ Preliminary Design Review
- 2007 NPOESS Critical Design Review
  NPP Ground Readiness
- 2008 NPP Launch
- 2009 NPOESS Ground Readiness
- 2010 NPOESS C1 Launch
- 2012 NPOESS C2 Launch
  Field Terminal Segment Readiness
  Initial Operational Capability
- 2014 NPOESS C3 Launch
- 2016 NPOESS C4 Launch
- 2018 NPOESS C5 Launch
- 2019 End of Phased Program Launches
- ~2026 OPS of Flying Systems



Reliable and timely collection, delivery, and processing of quality environmental data

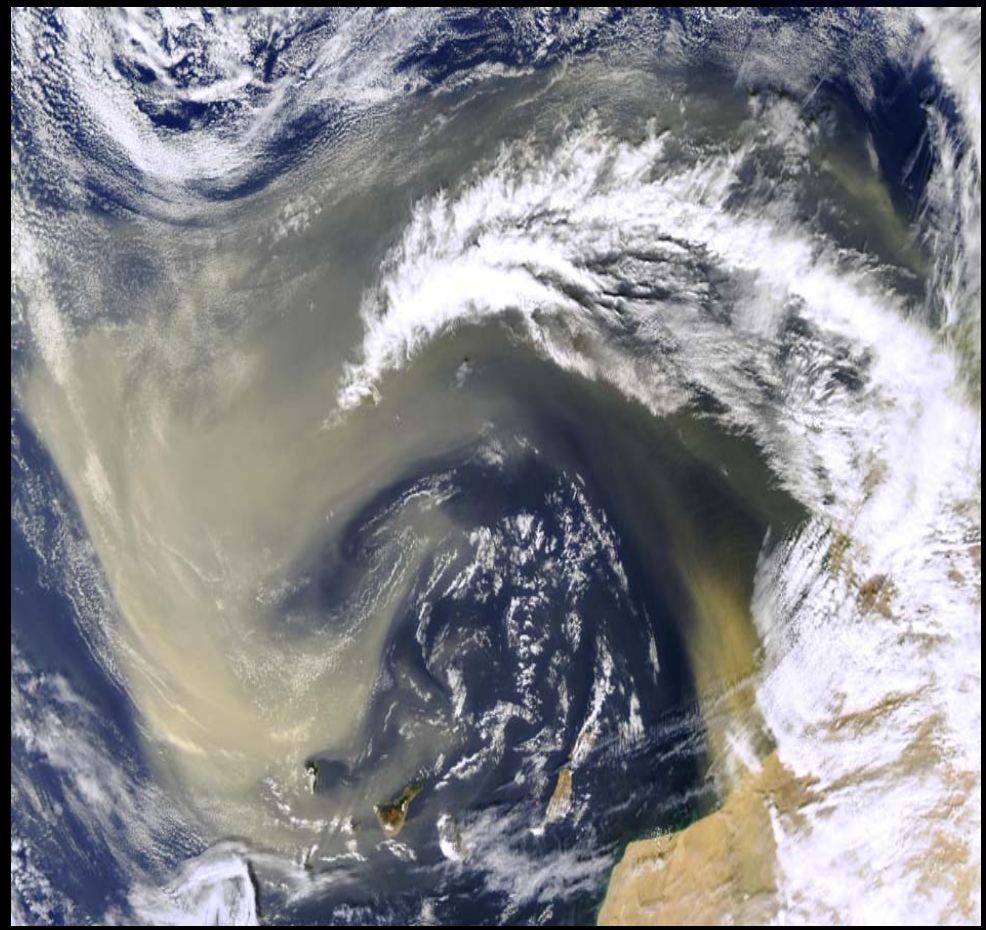
We're going a long way …
The Historical Context

First Image from TIROS-1



TIROS-1 Image - Saharan Area
1964

EOS-Aqua MODIS Image-250 m



Saharan Dust off the Canary Islands
18 February 2004

VIIRS EDRs

- Surface Albedo
- Cloud Base Height
- Cloud Cover/layers
- Cloud Effective Particle Size
- Cloud Top Heights
- Cloud Top Pressure
- Cloud Top Temperature
- Land Surface Temp
- Surface Type
- Net Heat Flux
- Ocean Color/Chlorophyll
- Suspended Matter
- Vegetative Index

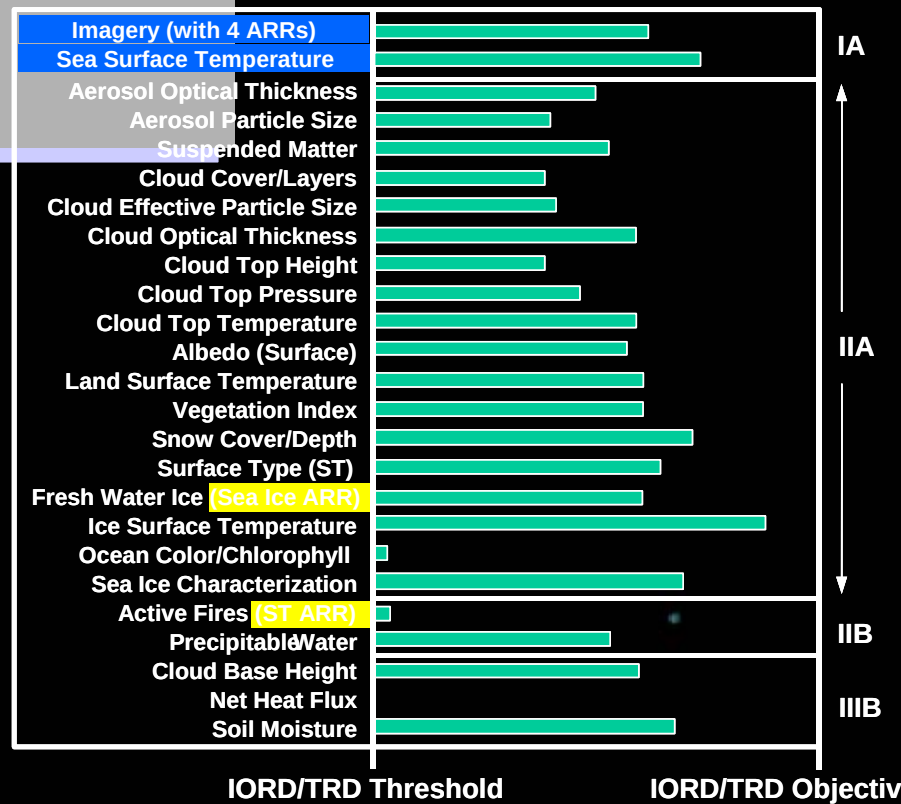
In conjunction with CMIS

- Ice Surface Temperature
- Imagery
- Sea Ice Characteristics
- Snow Cover/Depth
- Sea Surface Temperature
- Soil Moisture

In conjunction with APS

- Aerosol Optical Thickness
- Aerosol Particle Size

Key Performance Parameter



VIIRS Overview

Mass, kg	275
Average power, W	200
Average data rate, Mbps	8

- Visible Infrared Imaging Radiometer Suite (VIIRS) is a key sensor (22 EDRs total, 3 KPPs)
  - Continuous Cross-track scanner
  - 22 spectral bands
  - VisNIR, DNB, SWMIR, LWIR
- VIIRS heritage sensor (MODIS) on EOS Terra/Aqua
- Supplier: Raytheon Santa Barbara Remote Sensing
- VIIRS EDU now in test
- VIIRS FU1 being assembled for NPP

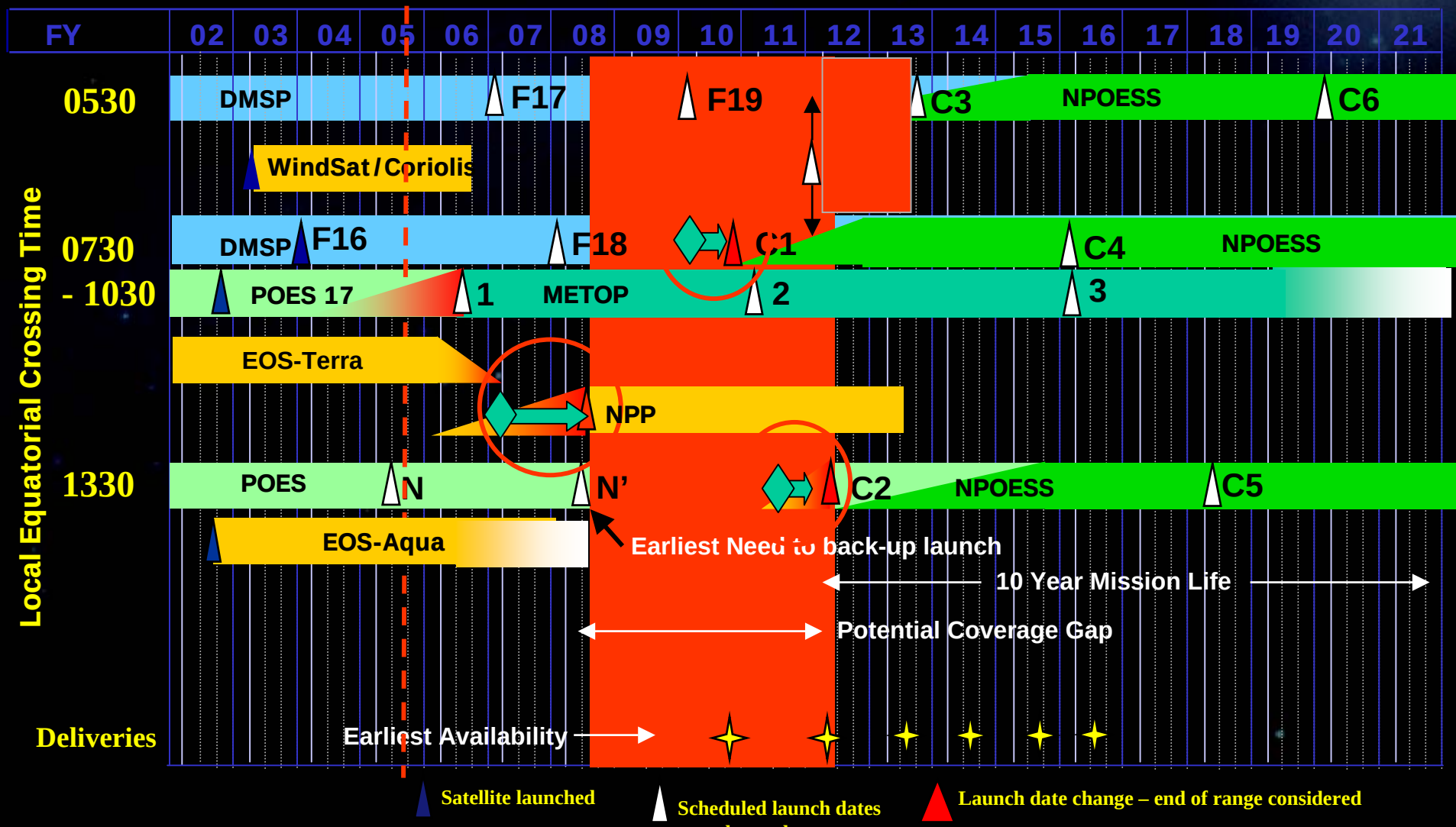
Some Principal Launch Delay Causes: VIIRS - Some Issues and Resolution Plans, but we are working our way forward

Issue	Resolution Plan
EDU Cryoradiator Thermo-Vac Anomaly 88 deg K achieved vs. 72 deg K expected	- Test results show basic design is sound. Performing according to the top level model. - 2 rigid mount designs in process, one using ULTEM and one using gamma alumina (GA - Technical recommendation is to continue both designs until CDR. Baseline GA pins. - All retrac. launch lock designs dropped. Active and alternative passive designs on hold. - ~40mw heat loss by dewar still not explained by thermal model. New T-Vac test underway. Performance uncertainty keeps this as high risk item.
Earthshine Contamination Calibration Measurements Distorted	- Prevents achievement of 2% uncertainty and 0.3% stability calibration requirements - Preferred fix is modified Solar Diffuser screen design. Eliminates all degradation. - FY 05 funding identified. Work progressing. - Stray light analysis for proposed fix in process. -100% fix solution is now a manufacturability issue. Vendor survey in progress.

Meteorological Satellite Transition – Some Possible Delays

Re-Plan Underway:

Shown are NPP, NPOESS C1 & C2 Ranges of *Potential* Change Only !

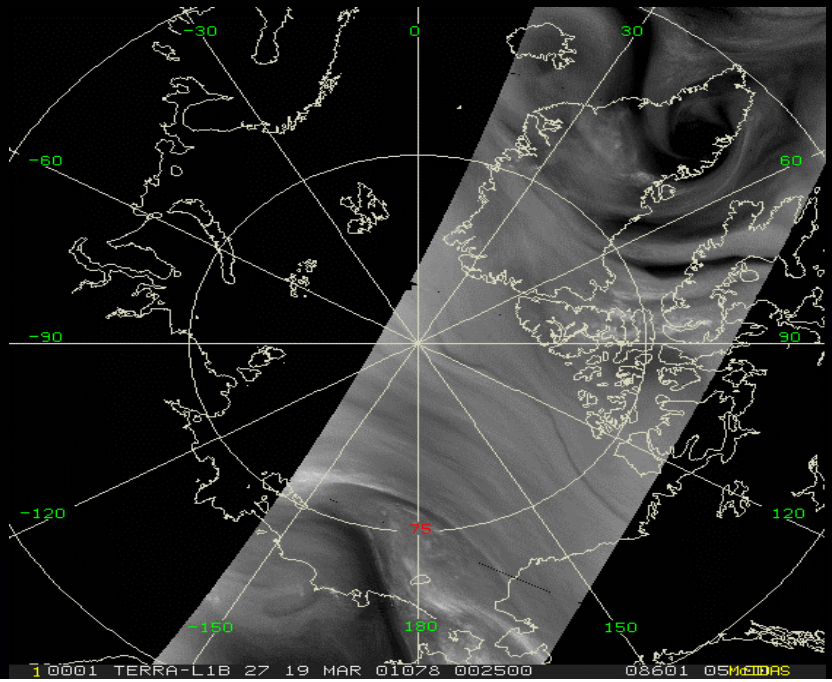


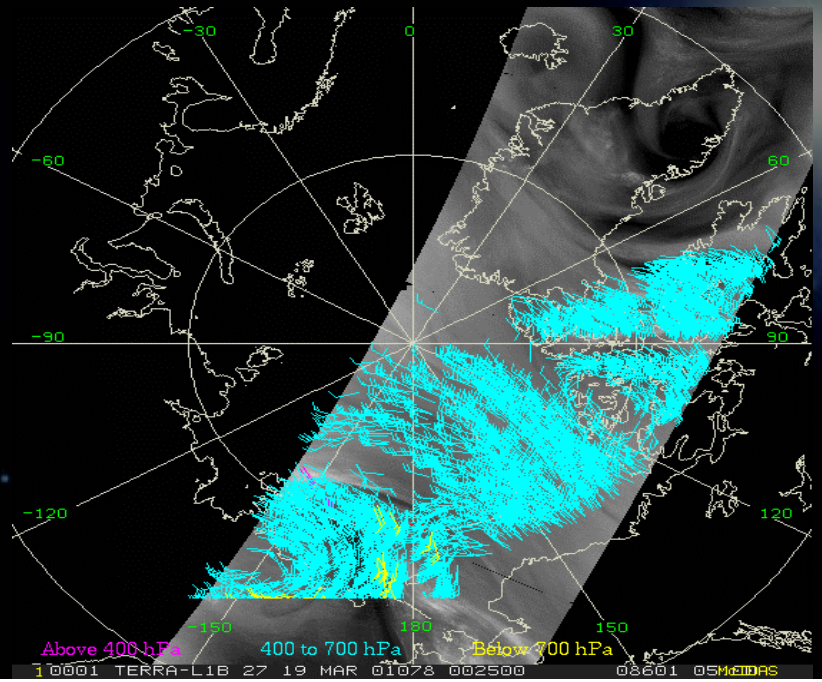
Baseline as of: 2 May 2005

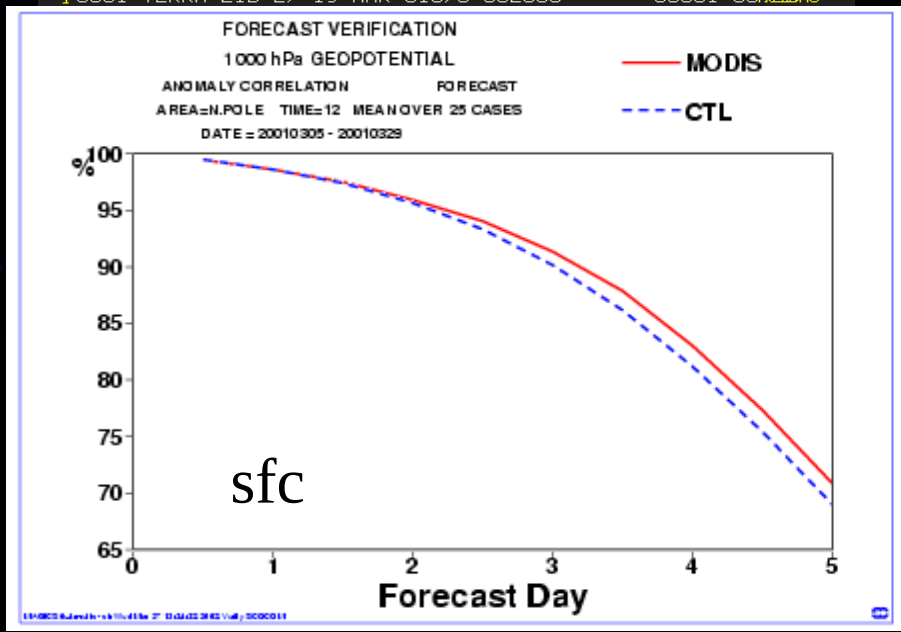
NPOESS P3I

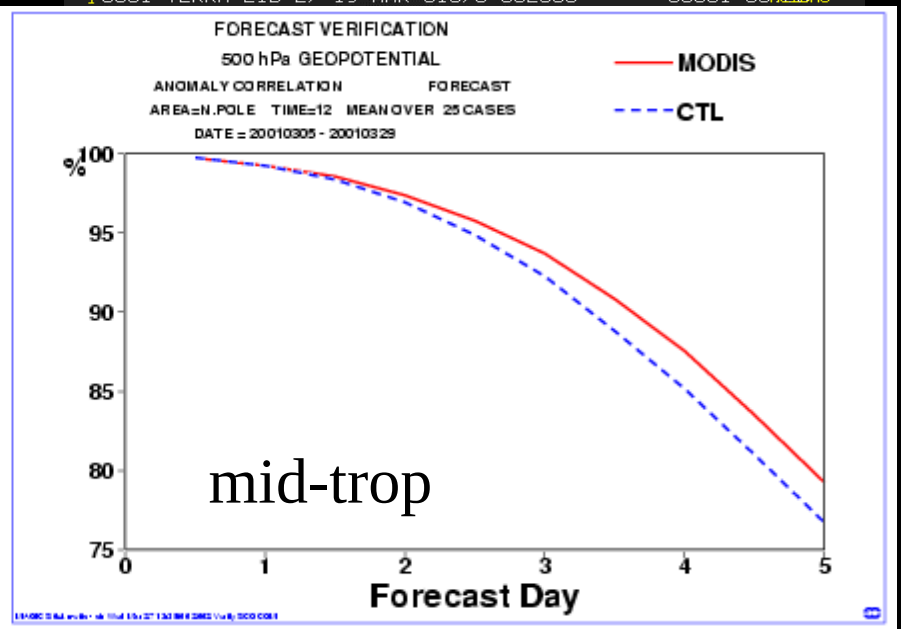
- **Need for continued evolution recognized from very beginning of program**
  - **P3I requirements in paras 1.6 and 4.1.6.8 of IORD II**
  - **NASA's role in NPOESS is technology development (per PDD 2 – Presidential Decision Directive # 2 – May 5, 1994)**
- **P3I is built into the NPOESS program to :**
  - **Respond to changing/modified user needs**
  - **To track, monitor, and respond to identified user products that the current NPOESS system can not implement due to technological constraints.**
- **Two forms of NPOESS P3I are envisioned**
  - **Modification of existing sensor to accomplish need**
  - **New sensor development required to implement need**

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM









Polar Water Vapor Winds Improve Weather Fcx - Courtesy of Dr. W. Paul Menzel – NOAA/NESDIS

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

Evolution of High Resolution IR Tropospheric Soundings

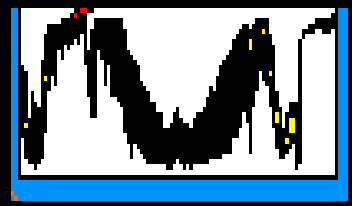
Nimbus 3 & 4
IRIS/SIRS
(1969-1972)

First Satellite Sounders

Nimbus 5/*ITPR*
ITOS/VTPR
Nimbus 6/NOAA *HIRS*
GOES/VAS & HIRS
(1972-2009)

High Horizontal Resolution

High Resolution Interferometer Sounder (*HIS*)
(1985-)



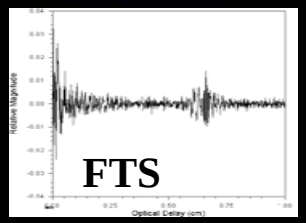
High Vertical Resolution

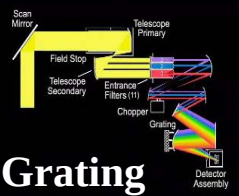
Aircraft
NAST-I / SHIS
(1995 -)

High Vertical Resolution Imagery

ADEOS
IMG
(1996-1997)

Aqua
AIRS
(2002-)

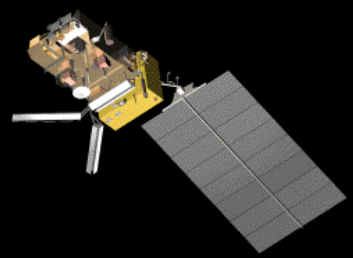




Grating

First Satellite High Vertical Resolution Sounding Spectrometers

METOP-*IASI*
(2006 -)

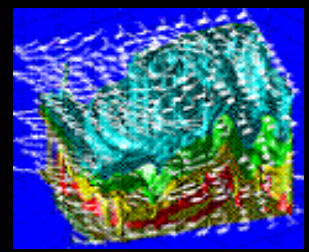


European High Vertical Resolution Sounder

NPP/NPOESS/*CrIS*
(2008 -)

US High Vertical Resolution Sounder

EO-3 *GIFTS*
GOES-*HES*
((2008,2012)-)

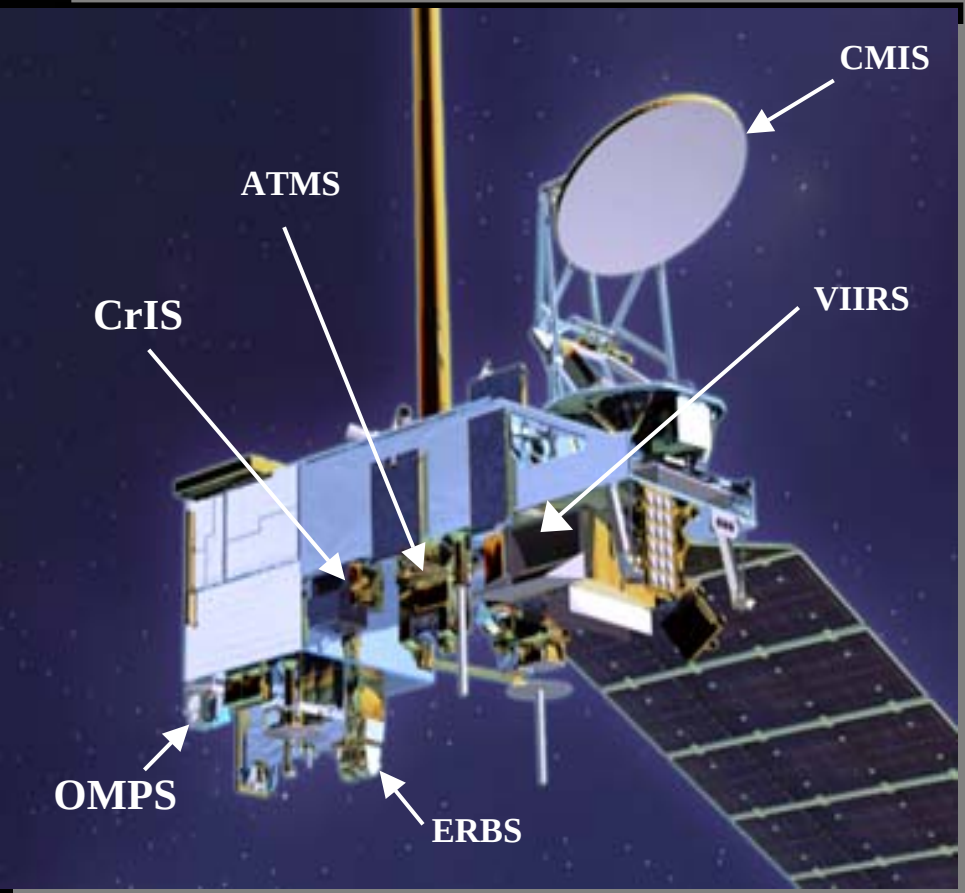


Geostationary Imaging 4-d T,q,"V" Sounder

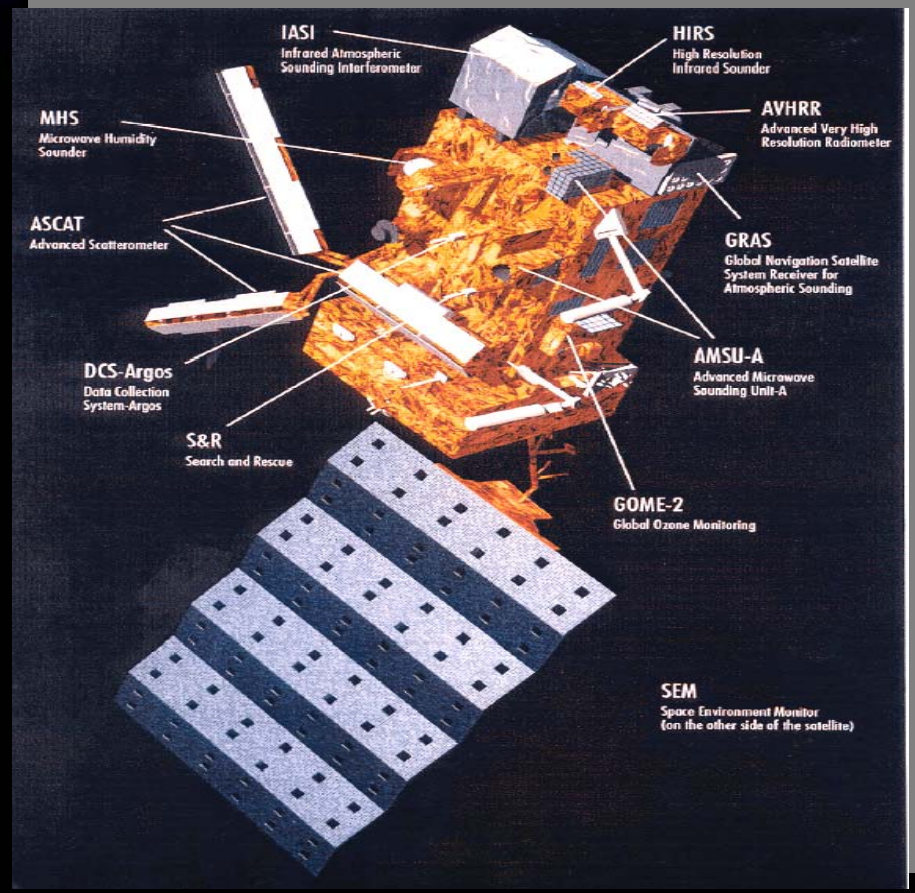
Courtesy of W.L. Smith

NPOESS/METOP Sensors

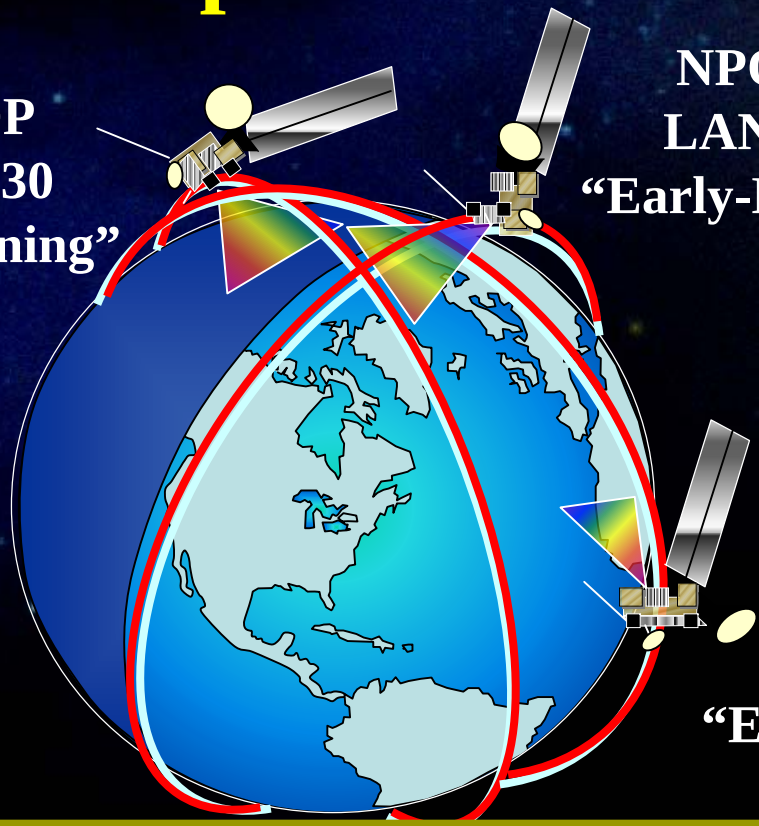
NPOESS 1330 Satellite



METOP 0930 (2130) Satellite



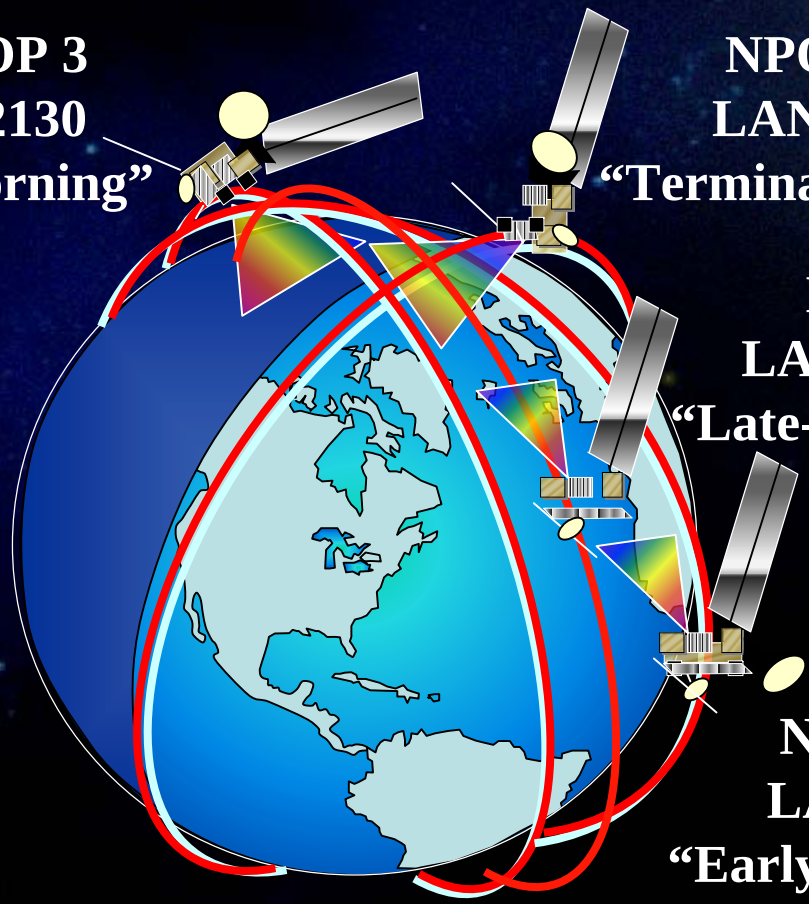
Joint Transition Activities [JTA] Agreement Notional Concept – "Towards a JPS"



	Launches	Lifetime	Ozone Sensors	Atmos Sounders
METOP [2130]	~2006, 2011, 2016	5 yr	GOME-2/IASI	IASI/AMSU/MHS
NPOESS [1330]	~ 2011, 2017	7 yr	OMPS/CrIS	CrIS/ATMS/CMIS
NPOESS [1730]	~2013, 2019	7 yr	CrIS	CrIS/ATMS/CMIS

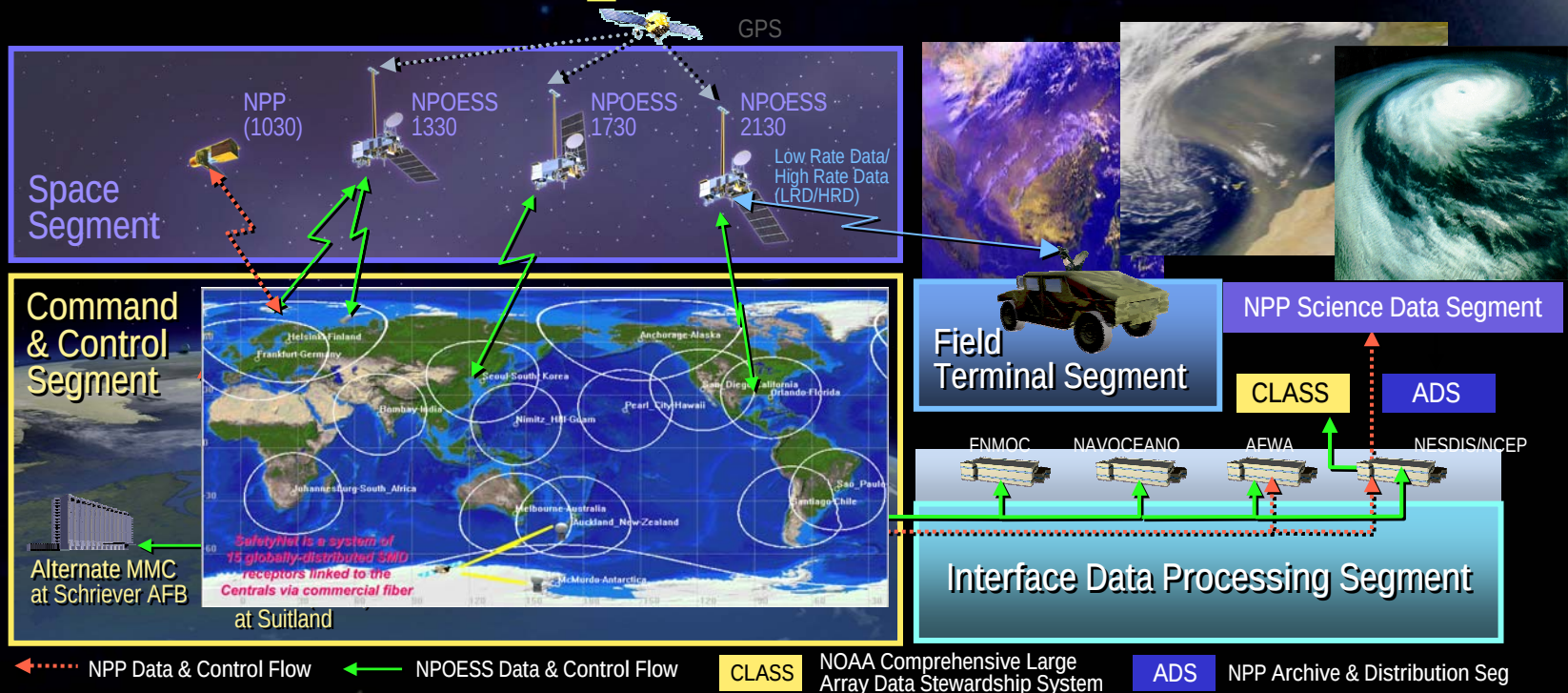
"Continuity of GLOBAL SOUNDINGS/OZONE Products from 2006 – 2026"

JTA Agreement with NPP - Notional Concept



	Launches	Lifetime	Ozone Sensors	Atmos Sounders
METOP [2130]	~2006, 2011, 2016	5 yr	GOME-2/IASI	IASI/AMSU/MHS
NPP [2230]	~2008	5 yr	OMPS/CrIS	CrIS/ATMS
NPOESS [1330]	~ 2010, 2016	7 yr	OMPS/CrIS	CrIS/ATMS/CMIS
NPOESS [1730]	~2013, 2019	7 yr	CrIS	CrIS/ATMS/CMIS

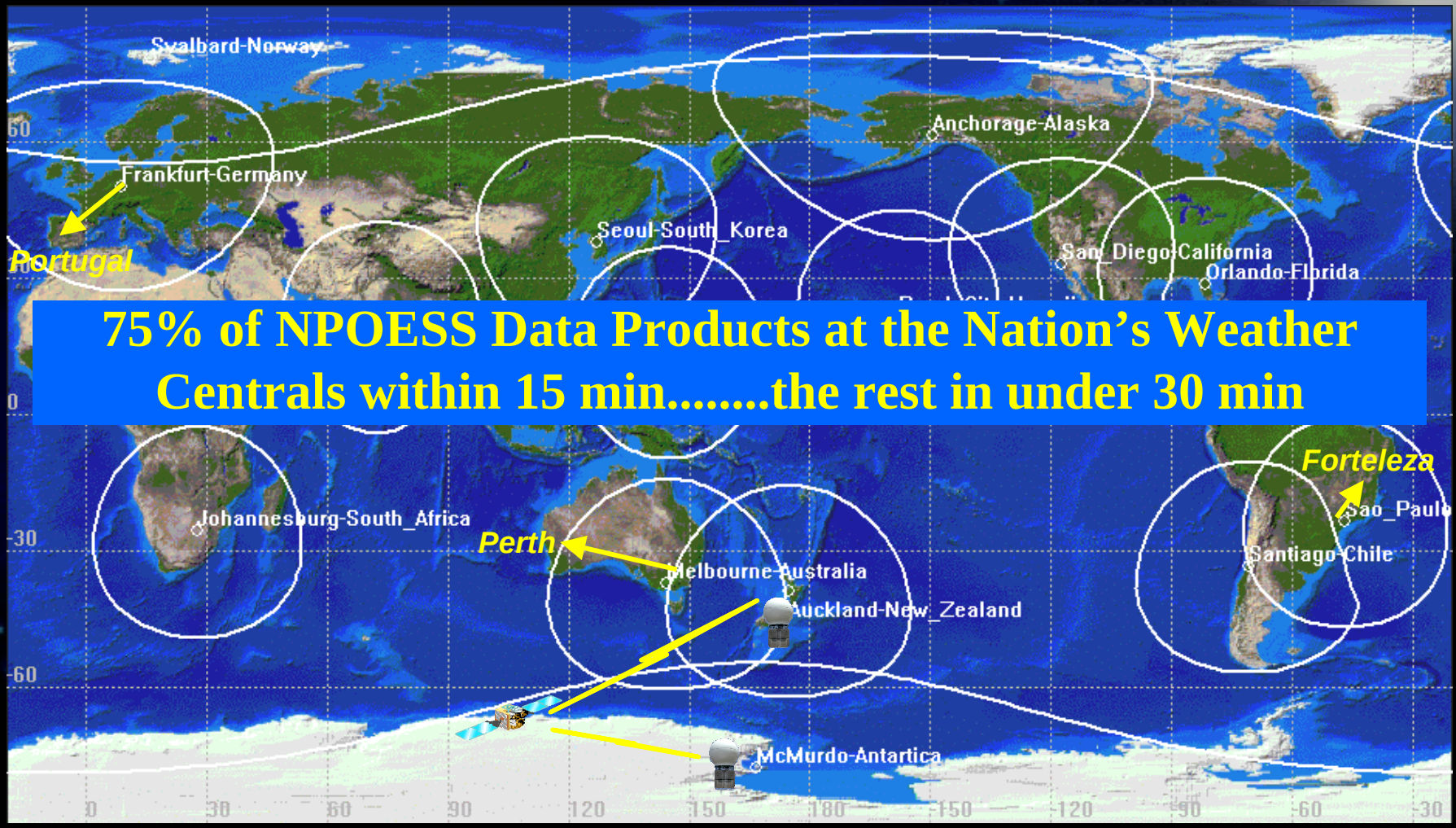
NPOESS Top Level Architecture



Data Quality		
SMD/HRD	128 attributes above, 724 at, 9 below threshold	
LRD	305 attributes above, 180 at, 0 below threshold	
Data Latency	Threshold	Objective
SMD	→	
HRD/LRD	→	
Data Availability	→	
Operational Availability	→	

NORTHROP GRUMMAN
Space Technology
Raytheon

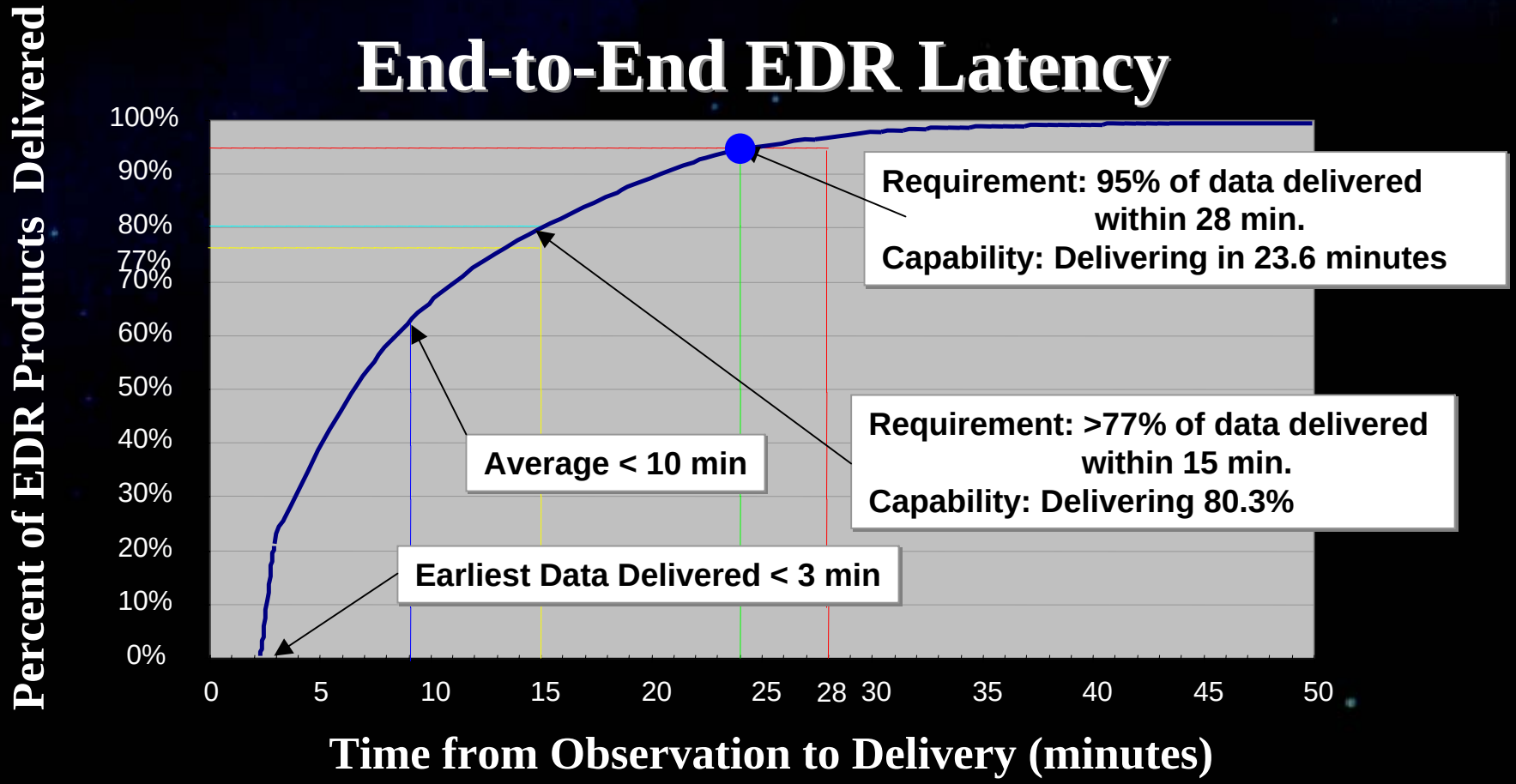
SafetyNet™ – The Key to NPOESS Low Data Latency and High Data Availability



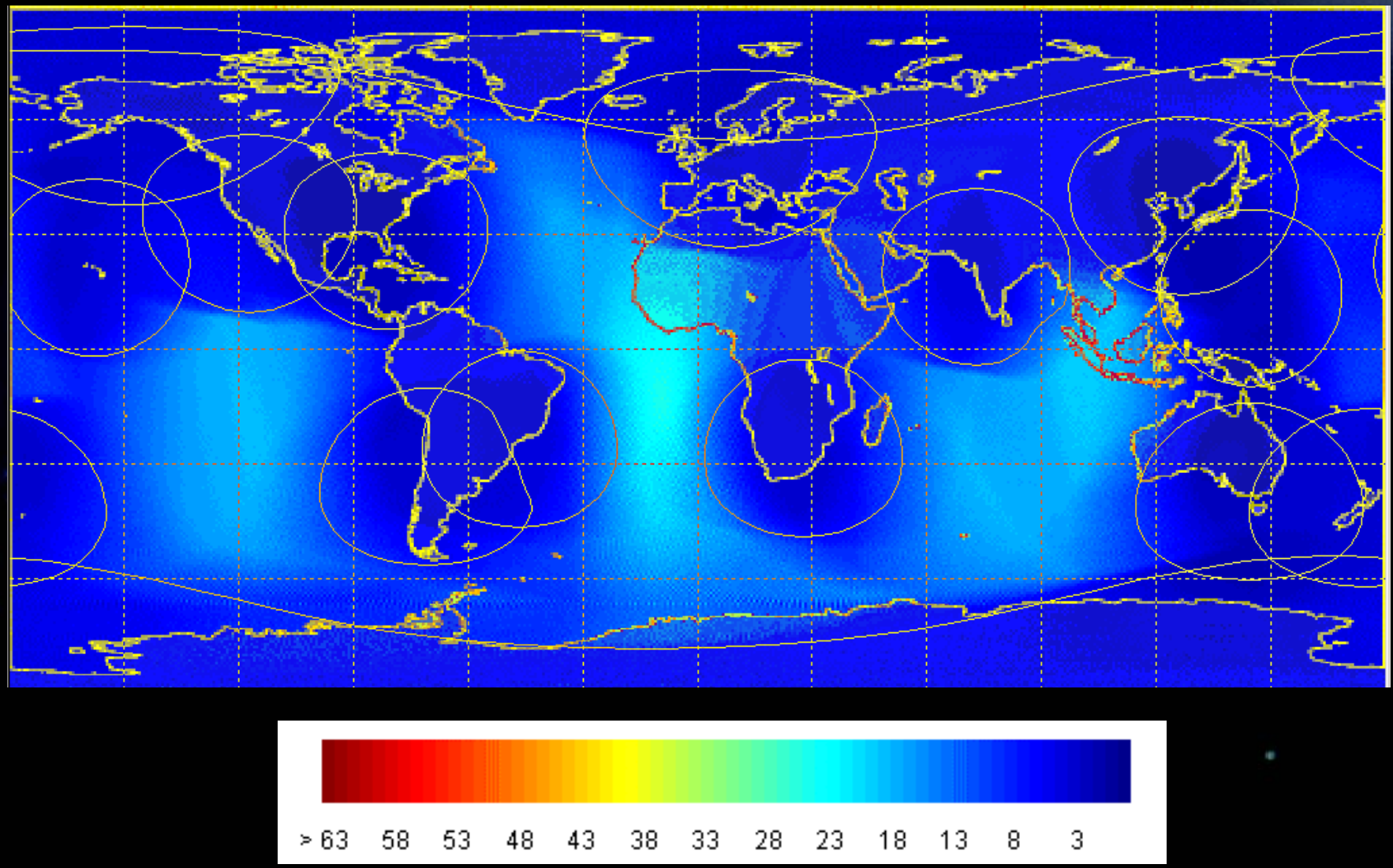
75% of NPOESS Data Products at the Nation's Weather Centrals within 15 min.....the rest in under 30 min

SafetyNet is a system of 15 globally distributed SMD receptors linked to the centrals via commercial fiber, it enables low data latency and high data availability

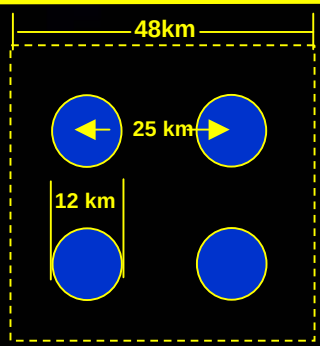
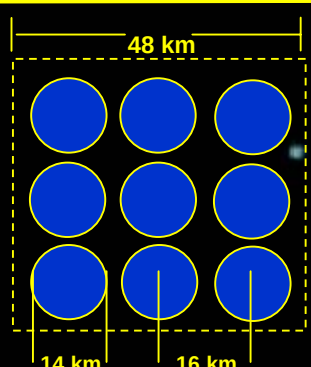
NPOESS EDR Processing Timeline



NPOESS EDR Average Data Latency



"IASI/CrIS Features - Enabling a Meaningful Global Atmospheric Sounding System"

		IASI	CrIS
# of Channels		8461	1305
Sprectral Range (cm^{-1})		650 to 770 770 to 980 1000 to 1070 1080 to 1150 1210 to 1650 2100 to 2150 2150 to 2250 2350 to 2420 2420 to 2700	650 - 1095 1210 - 1750 2155 - 2550
Sprectral Resolution (cm^{-1})		645 0.35 1210 0.35 2000 0.39 2450 0.45 2760 0.5	650-1095 <0.625 1210-1750 <1.25 2155-2550 <2.50
Sensor Parameters	Scan type	Step and dwell	Step and dwell
	Scan rate	8 sec. (30 steps earth & 3 calibration)	8 sec. (30 earth & 2 calibration)
	IFOV	3°.33 x 3°.33	3°.3 x 3°.3
	IFOV size at Nadir	12 km	14 km
	Sampling at Nadir	25 km	16 km
	Swath	± 48.3°	± 48 1/3° each side of Nadir
	Swath	± 1026 km	± 1100 km each side of Nadir
	Field of Regard (FOR)	48 km	48 km
	# IFOV's Per FOR	4 (2-by-2)	9 (3-by-3)
	Pixel/scan (FOVs x steps)	120 (4 X 30)	270 (9 X 30)
Field of Regard / Field of View			

"Enabling a Meaningful Global Atmospheric & Ozone Sounding System"

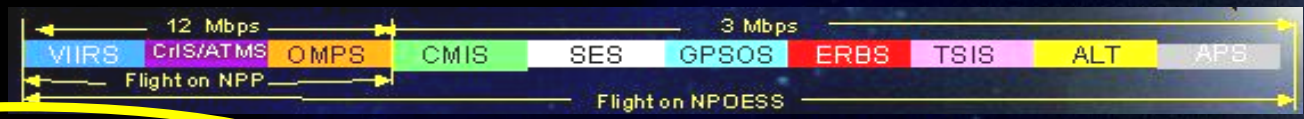
[CrIS/IASI & ATMS/AMSU-MHS & OMPS/GOME-2 & CMIS & GRAS]

Timeliness	METOP IASI/AMSU/MHS & GOME-2 & GRAS	NPOESS CrIS/ATMS & OMPS & CMIS
Latency Requirement (Minutes)	180	156 Threshold 15 Objective
Latency Performance (Minutes)	104 – 135	28
Revisit Time (Hours)	12 (Any One Satellite) 4 (METOP with 2 NPOESS)	6 (Two OZONE Satellites)[1] 4 (Three* Sounder Satellites)[2] *Incl. 2 NPOESS & 1 METOP

[1] 6 hour revisit for two phased satellites (OMPS on 1330 NPOESS & GOME-2 on METOP 2130)

[2] 4 hour revisit for three phased satellites (CrIS/ATMS/CMIS on NPOESS 1330 & 1730 & IASI/AMSU/MHS/GOME-2/GRAS on 2130 MTOP; also CMIS on NPOESS 2130)

CrIS Contributes to Sixteen (16) NPP/NPOESS Data Products



★ Atmospheric Vertical Moisture Profile	Cloud Top Pressure	Precipitable Water
★ Atmospheric Vertical Temp Profile	Cloud Top Temperature	Precipitation Type/Rate
★ Imagery	Downward Longwave Radiance (Sfc)	Pressure (Surface/Profile)
★ Sea Surface Temperature	Downward Shortwave Radiance(Sfc)	Sea Ice Characterization
★ Sea Surface Winds	Electric Field	Sea Surface Height/Topography
★ Soil Moisture	Electron Density Profile	Snow Cover/Depth
Aerosol Optical Thickness	Energetic Ions	Solar Irradiance
Aerosol Particle Size	Geomagnetic Field	Supra-Thermal-Auroral Particles
Aerosol Refractive Index	Ice Surface Temperature	Surface Type
Albedo (Surface)	In-situ Plasma Fluctuations	Wind Stress
Auroral Boundary	In-situ Plasma Temperature	Suspended Matter
Auroral Energy Deposition	Ionospheric Scintillation	Total Water Content
Auroral Imagery	Medium Energy Charged Particles	Vegetation Index
Cloud Base Height	Land Surface Temperature	
Cloud Cover/Layers	Net Heat Flux	
Cloud Effective Particle Size	Net Solar Radiation (TOA)	
Cloud Ice Water Path	Neutral Density Profile	
Cloud Liquid Water	Color/Chlorophyll	
Cloud Optical Thickness	Ocean Wave Characteristics	
Cloud Particle Size/Distribution	Outgoing Longwave Radiation (TOA)	
Cloud Top Height	Ozone - Total Column/Profile	

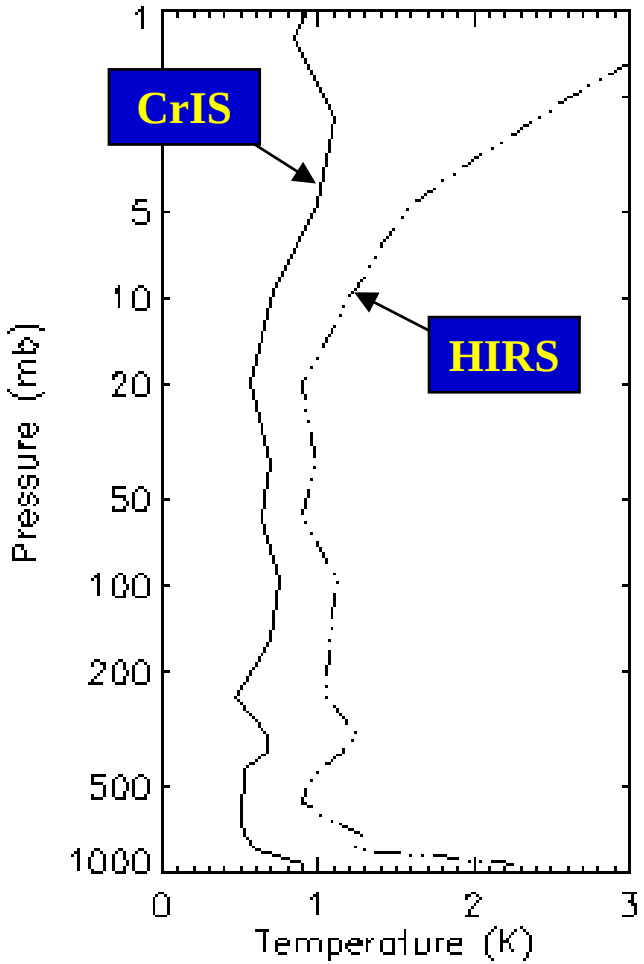
VIIRS (23)
CMIS (19)
CrIS/ATMS (3)
OMPS (1)
SES (13)
GPSOS (2)
ERBS (5)
TSIS (1)
ALTIMETER (3)
APS (4)

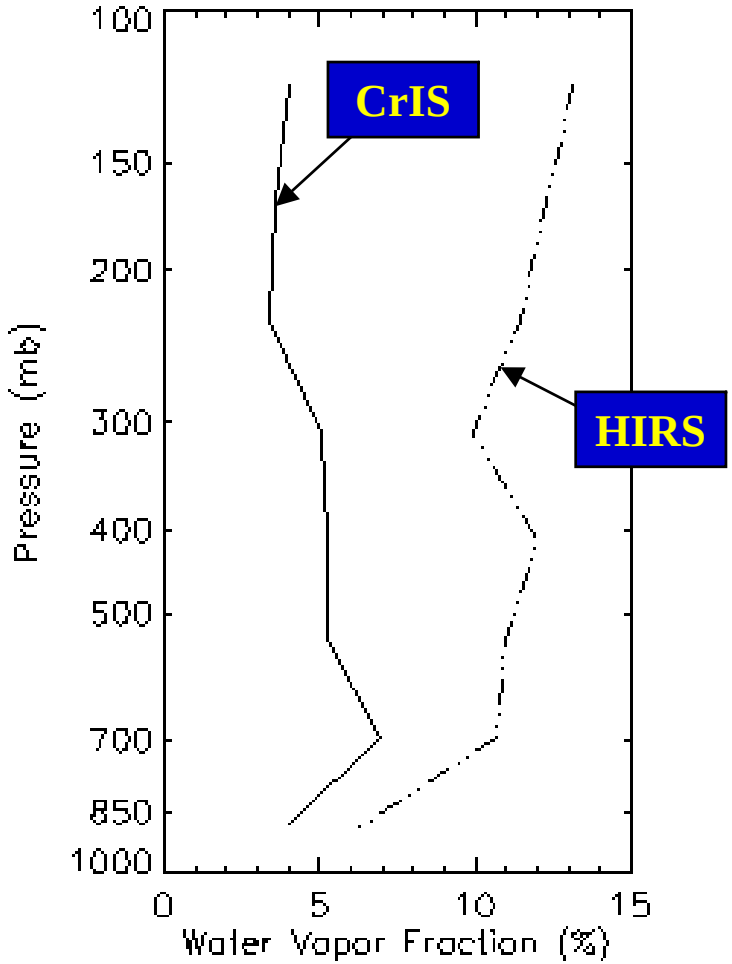
CrIS (16)

★ Environmental Data Records (EDRs) with Key Performance Parameters

Projected Performance

CrIS/HIRS "Clear" Performance Comparison



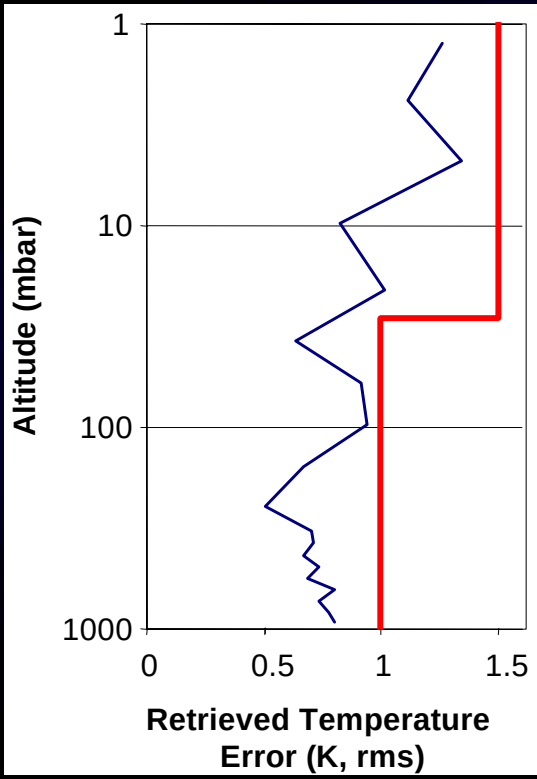


RMS Measurement Uncertainty, Global-Average Basis

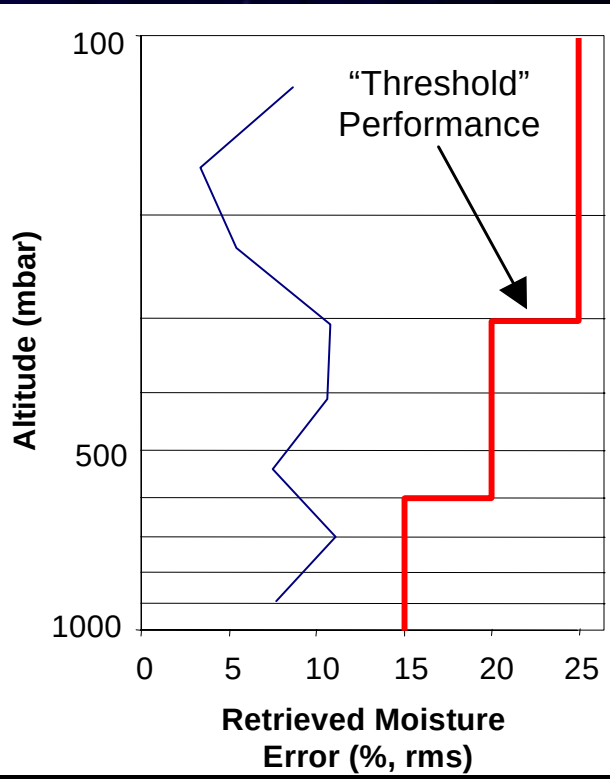
Projected Performance

Projected CrIS "Clear"EDR Performance

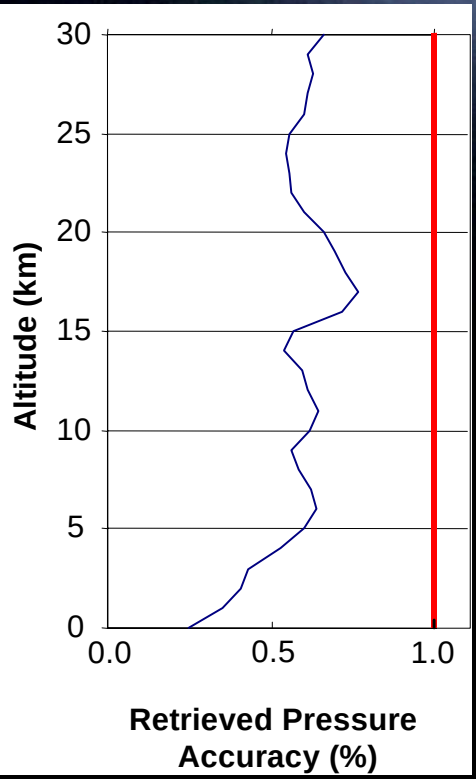
Temperature EDR



Moisture EDR



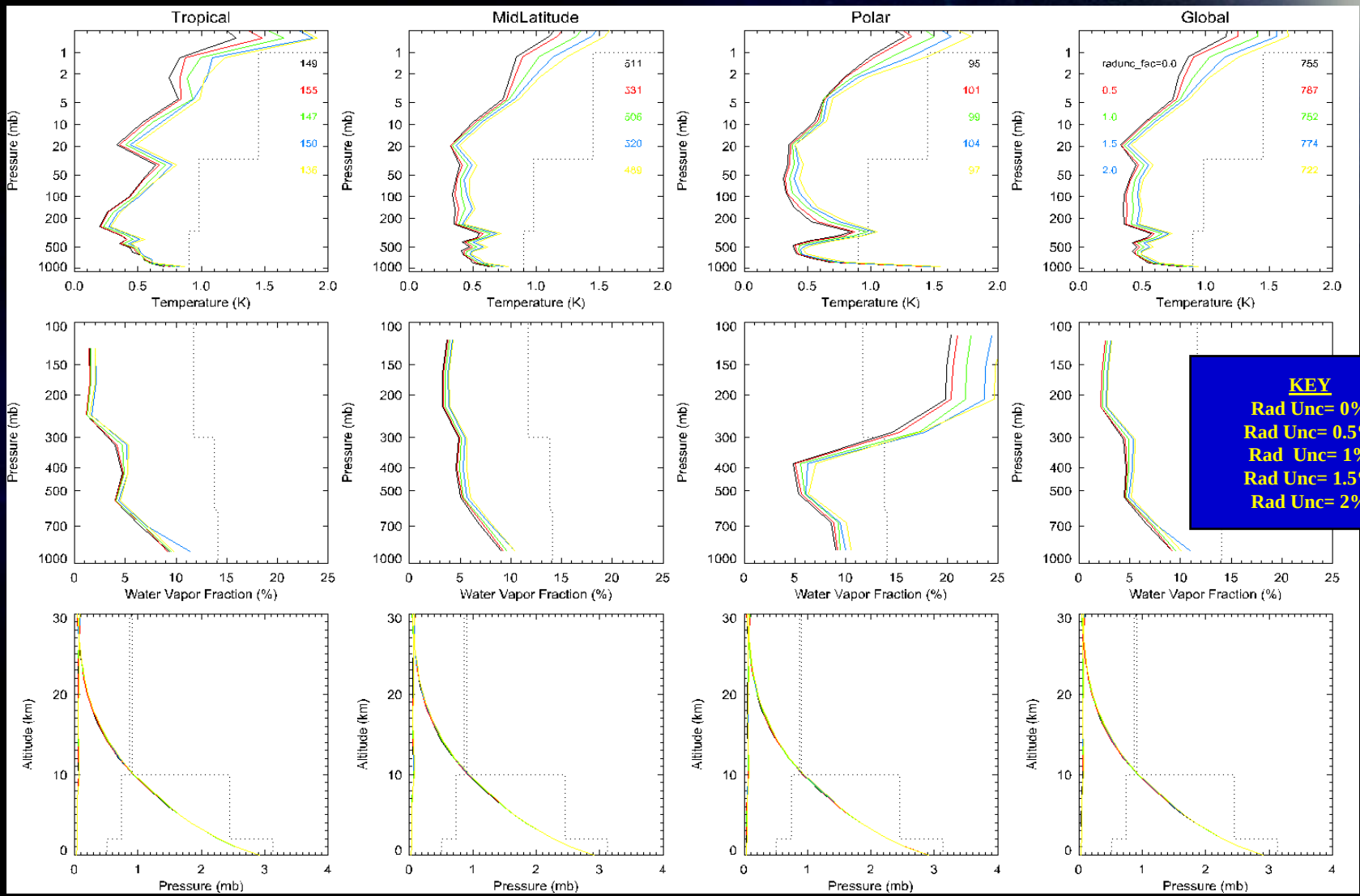
Pressure EDR



CrIS Projected to Exceed Minimum Threshold "Clear" Requirements

EDR Algorithms

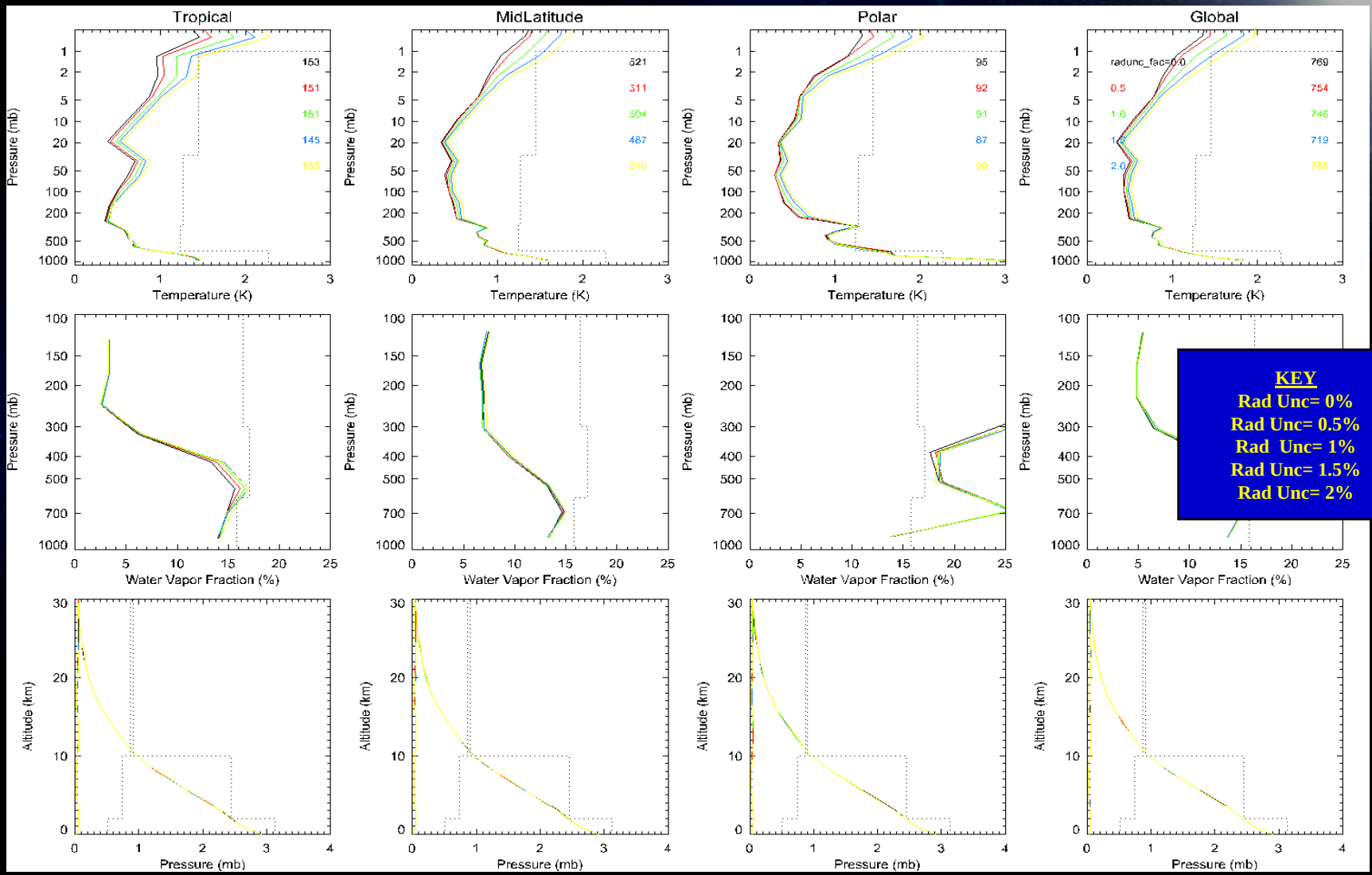
CrIS Performance NOAA88, Radiometric Uncertainty Sensitivity - Clear



KEY
Rad Unc= 0%
Rad Unc= 0.5%
Rad Unc= 1%
Rad Unc= 1.5%
Rad Unc= 2%

EDR Algorithms

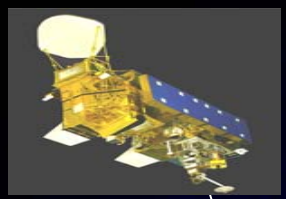
CrIS Performance NOAA88, Radiometric Uncertainty Sensitivity - Cloudy



NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

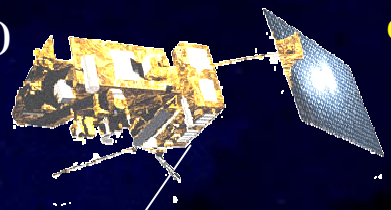
Near Real-Time Operational Demonstrations of Utilization of Advanced Sounder & Ozone Data for Improved NWP, Ozone Forecasting & Climate

"Aqua" [EOS-PM] (2002)
AIRS/AMSU/HSB & MODIS

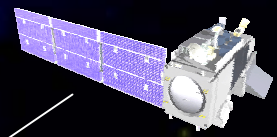


WindSat (2003)

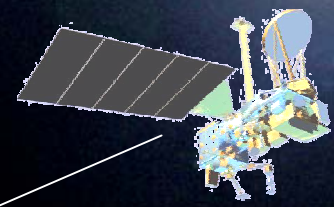
METOP (2006)
IASI/AMSU/MHS, GOME-2 & AVHRR



NPP (2008)
CrIS/ATMS, OMPS & VIIRS



NPOESS (2010,2012,2014)
CrIS/ATMS, VIIRS, CMIS, OMPS, ERBS



NOAA Near Real-Time Data Delivery Ground Station Scenario

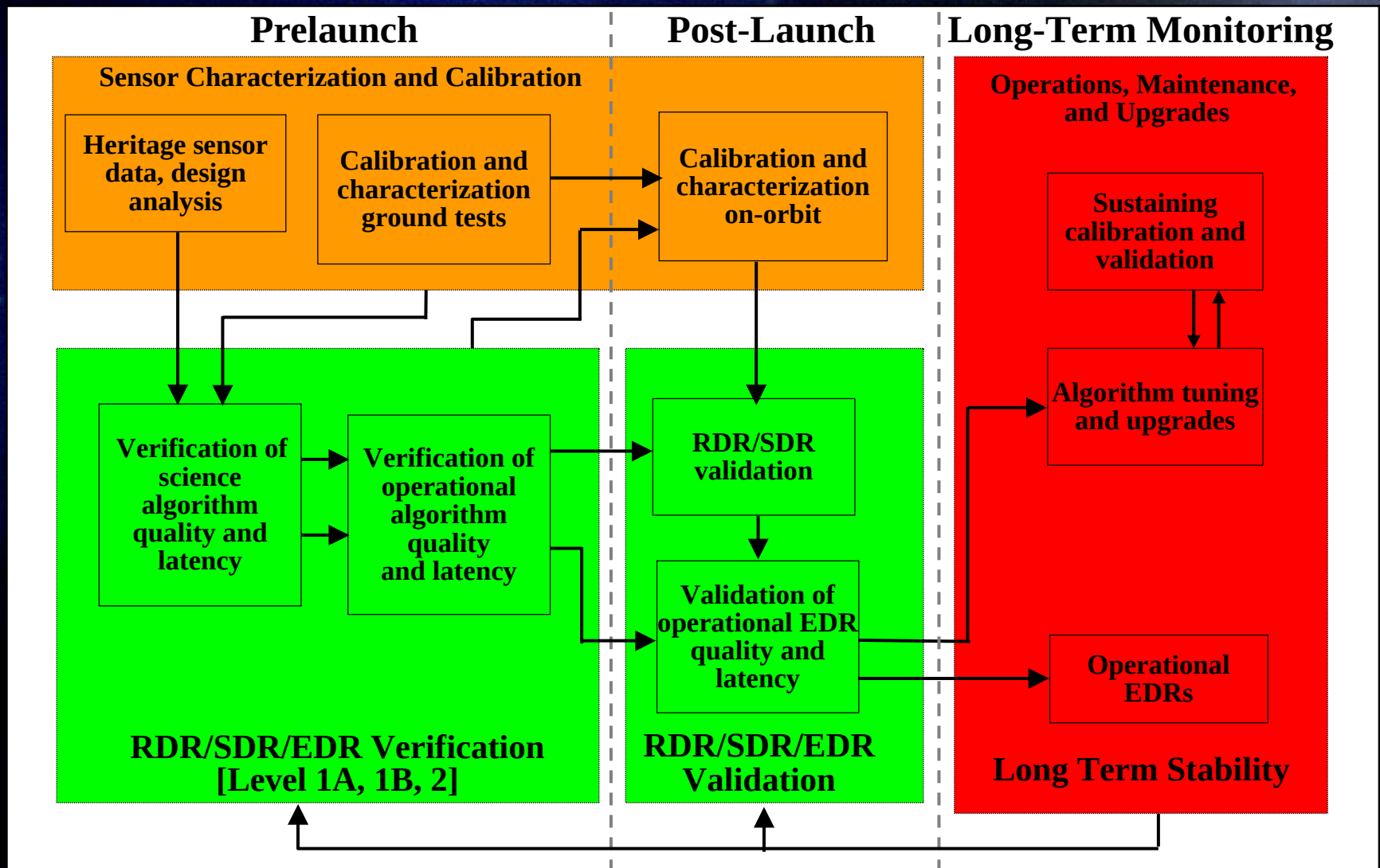
C3S → IDPS → NOAA Realtime User

Joint Center for Satellite Data Assimilation

NWS/NCEP
GSFC/DAO
ECMWF
UKMO
FNMOC
Meteo-France
BMRC-Australia
Met Serv Canada

→ NWP Forecasts

NPOESS/NPP Calibration/Verification/Validation Program System Perspective



The IPO NAST
[NPOESS Airborne Sounder Testbed]

The NAST Team

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

NPOESS Airborne Sounder Testbed - [NAST]

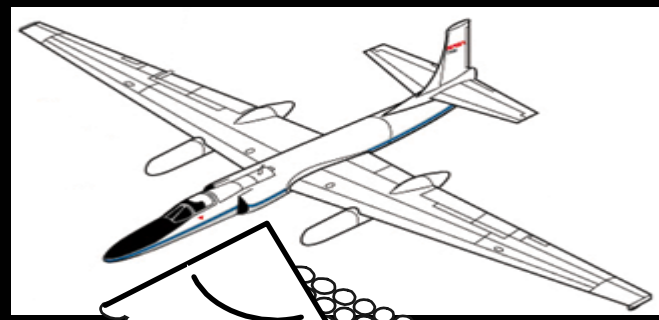
[NASA/LaRC, U. Wisconsin, MIT Lincoln Laboratory, MIT]

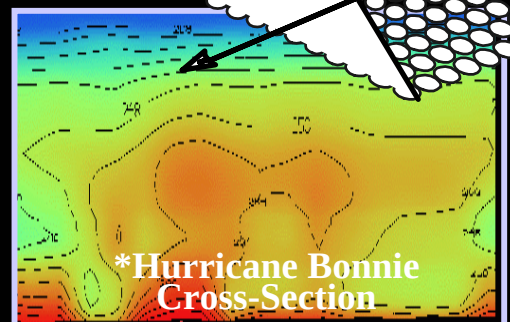
OBJECTIVES

- Developed by IPO to Simulate Candidate Spaceborne Instruments - CrIS, ATMS, IASI, AIRS, AMSU, HSB
- Science Issue & Risk ReductionTestbed
- Evaluate Key EDR Algorithms
- Preview High Resolution Products (Spectral & Spatial)
- Under Flight Calibration/Validation [AIRS,IASI,CrIS, AMSU, HSB, ATMS]

INSTRUMENTS [NAST-I & NAST-M]

- NAST-I: IR Michelson Interferometer [FTS] Sounder
- NAST-M: Microwave Sounder
- Co-Boresighted IR and Microwave
- IR Interferometer [FTS] Sounder 3.5 – 16 µm, 9000 Chan.
  - High Spectral Resolution 0.25 cm^{-1}
  - Calibrated Radiances-0.5K Abs. Accuracy, 0.1K Prec.
  - High Sensitivity in a cold scene
    - 0.10 K NEDT @ 14.9 µm (250K)
    - 0.15 K NEDT @ 8.2 µm (250K)
    - 0.20 K NEDT @ 4.7 µm (250K)
- Microwave Sounder
  [4 Bands, 29 Chan.] 50-56, 118.7±4, 183±11, 425±4 GHz





A Fundamental Purpose of NAST

- **The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Airborne Sounder Testbed (NAST) program was established to provide *real, experimental data needed to calibrate and validate:***
  - **(1) the design of the satellite sensors**
  - **(2) the data processing algorithms, and**
  - **(3) the actual scientific observations (i.e., SDRs and EDRs) obtained from the space deployment of the sounders**
  - **(4) Investigate the observation of other important surface and atmospheric composition variables (e.g., surface temperature and emissivity, precipitation cell height, atmospheric aerosol and dust plumes, cloud microphysical and geometric properties, and trace gases such as CO_2, CO, CH_4, N_2O, SO_2, $O_{3)}$, which might be extracted from CrIS and ATMS data**

NAST Objectives for NPOESS and NPP

Objective	Comments
Testbed for Risk Reduction for hardware, algorithms, radiative transfer & science/ operational products for Sounders	The NAST-I, NAST-M and S-HIS instruments provide a means to evaluate measurement performance characteristics to be expected with the NPOESS CrIS and ATMS instruments. Certain CrIS and ATMS spectral channel radiance measurement properties (e.g., noise, stability, etc.) have been evaluated with airborne NAST and S-HIS instruments resulting in improvements in sensor design and the data processing approach.
Calibration/Validation of NPP/NPOESS/METOP, and Heritage Sounders and Imagers (e.g. AIRS/AMSU/HSB/MODIS, HIRS/AMSU/MHS/AVHRR)	Measurements obtained by the NAST and S-HIS instruments are used to validate, and to correct the spectral and radiometric calibration, as necessary, the infrared and microwave measurements obtained from space with NPP/NPOESS heritage instruments, prior to the launch of the NPP/NPOESS system. Cal/Val for the Aqua AIRS/AMSU/HSB instrument suite, the POES HIRS/AMSU, and the GOES Sounder/Imager instruments has been performed with NAST/S-HIS data. The METOP IASI cal/val will be performed using NAST and SHIS once in orbit. It has been found that the only means to perform cal/val of SDRs/EDRs with the accuracy demands of the NPP/NPOESS system is through the use of high altitude aircraft FTS measurements.
Forward Radiative Transfer Model, Cloud Clearing, & Profile Retrieval Algorithm Validation & Development	Radiance measurements from the NAST and the S-HIS are used to validate the molecular and cloud radiative transfer models to be used for the processing of the METOP IASI/AMSU/AVHRR and the NPP/NPOESS CrIS/ATMS/VIIRS sounding system data. Retrieval methods developed by the NPOESS and METOP contractors are also validated using the aircraft radiance data and improvements in the retrieval algorithms are developed on the basis of the aircraft measurements.
NPOESS Product Definition and Accuracy Validation	The airborne NAST and S-HIS data are used to specify useful environmental products and validate the accuracy to which they should be able to be produced from the CrIS/ATMS/VIIRS data. EDR algorithm and product validations for the Aqua satellite AIRS/AMSU/MODIS measurements have already been performed using NAST measurements, resulting in many improvements in the EDR algorithms being used to process these data.

NAST Objectives for NPOESS and NPP (cont)

NPP/NPOESS/METOP Instrument On-Orbit Performance Validation	**The NAST/S-HIS high altitude aircraft system is important to be used throughout the lifetime of the operational NPOESS/METOP program to insure stable instrument operation, long term stability of the sounding products and accurate measurement performance, as judged from the results of airborne satellite under-flight Cal/Val campaigns, especially important for the climate assessment use of these data.**
Product Integrity Assurance	**EDR products retrieved from high altitude NAST/S-HIS data provide a high quality standard of the product accuracy, which should be achieved from the space system. No other validation approach can account for the spectral and radiometric measurement properties of the satellite instruments, or the time and space variability of the surface and atmospheric products being validated. The NAST/SHIS airborne system is crucial for the insuring the NPOESS/METOP operational products throughout the lifetime of this satellite system.**
Validation over Range of Environmental Conditions Required for NPOESS missions	**Validate retrieval algorithms and accuracies for different climatic zones, meteorological and surface conditions, and cloud situations; Demonstrate the utility of the NPOESS/NPP specified sounding system for observing significant atmospheric processes (e.g., storm genesis and evolution, jet stream position and intensity, sea breeze phenomena, fog formation and dissipation, clear air turbulence, precipitation and cloudiness, etc.).**
Other Surface & Atmospheric Parameters	**Investigate the observation of other important surface and atmospheric composition variables (e.g., surface temperature and emissivity, precipitation cell height, atmospheric aerosol and dust plumes, cloud microphysical and geometric properties, and trace gases such as CO_2, CO, CH_4, N_2O, SO_2, O_3) which might be extracted from CrIS and ATMS data**

IPO NAST Science Team*

- Prof. William L. Smith [Hampton U; NASA/LaRC;U Wisc]
- Prof. David H. Staelin [MIT & MIT/LL]
- Dr. Henry E. Revercomb [U. Wisc/SSEC]
- Dr. Daniel Mooney {MIT/LL]
- Dr. Allen M. Larar [NASA/LaRC]
- Dr. Stephen A. Mango [NPOESS IPO]
- Dr. W. Paul Menzel [NOAA/NESDIS]
- Dr. Daniel K. Zhou [NASA/LaRC]
- Dr. Michael Gazarik [NASA/LaRC]
- Dr. Xu Liu [NASA/LaRC; AER]
- Dr. Robert O. Knuteson [U Wisc/SSEC]
- Dr. David C. Tobin [U. Wisc/CIMSS]
- Prof. Allen H. Huang [U. Wisc]
- Dr. H.L. Huang [U. Wisc]
- Prof. Steven A. Ackerman [U. Wisc]
- Dr. Paolo Antonelli [U. Wisc/SSEC]
- Mr. Fred A. Best [U. Wisc/SSEC]
- Dr. Daniel D. LaPorte [U Wisc]
- Dr. Chris C. Moeller [U. Wisc]
- Prof. Philip W. Rosenkranz [MIT]
- Dr. Michael Kelly [MIT/LL]
- Dr. Michael Griffin [MIT/LL]
- Dr. Daniel Cousins [MIT/LL]
- Dr. J.L. Loparo [MIT/LL]
- Dr. William J. Blackwell [MIT, MIT/LL]
- Dr. J.W. Barrett [MIT/LL]
- Dr. F.W. Chen [MIT]
- Dr. R. Vincent Leslie [MIT/LL]
- Dr. M.J. Schwartz [MIT]
- Mr. Andrew Sanchez [MIT]
- Dr. Nicholas R. Nali [MIT]
- Dr. Henry Buijs [ABB Bomem]
- Dr. Jacque Giroux [ABB Bomem]
- Prof. Larrabee L. Strow [U Maryland BC]
- Dr. Harold Motteler [U Maryland BC]
- Dr. Gail E. Bingham [Utah State U/SDL]
- Dr. Greg W. Cantwell [Utah State U/SDL]
- Dr. Christopher Barnett [NOAA/NESDIS]

•Partial Listing of NAST Team and Collaborators;
see also Related IGS Sounding ScienceTeam

Related IPO IGS Sounding Science Team*

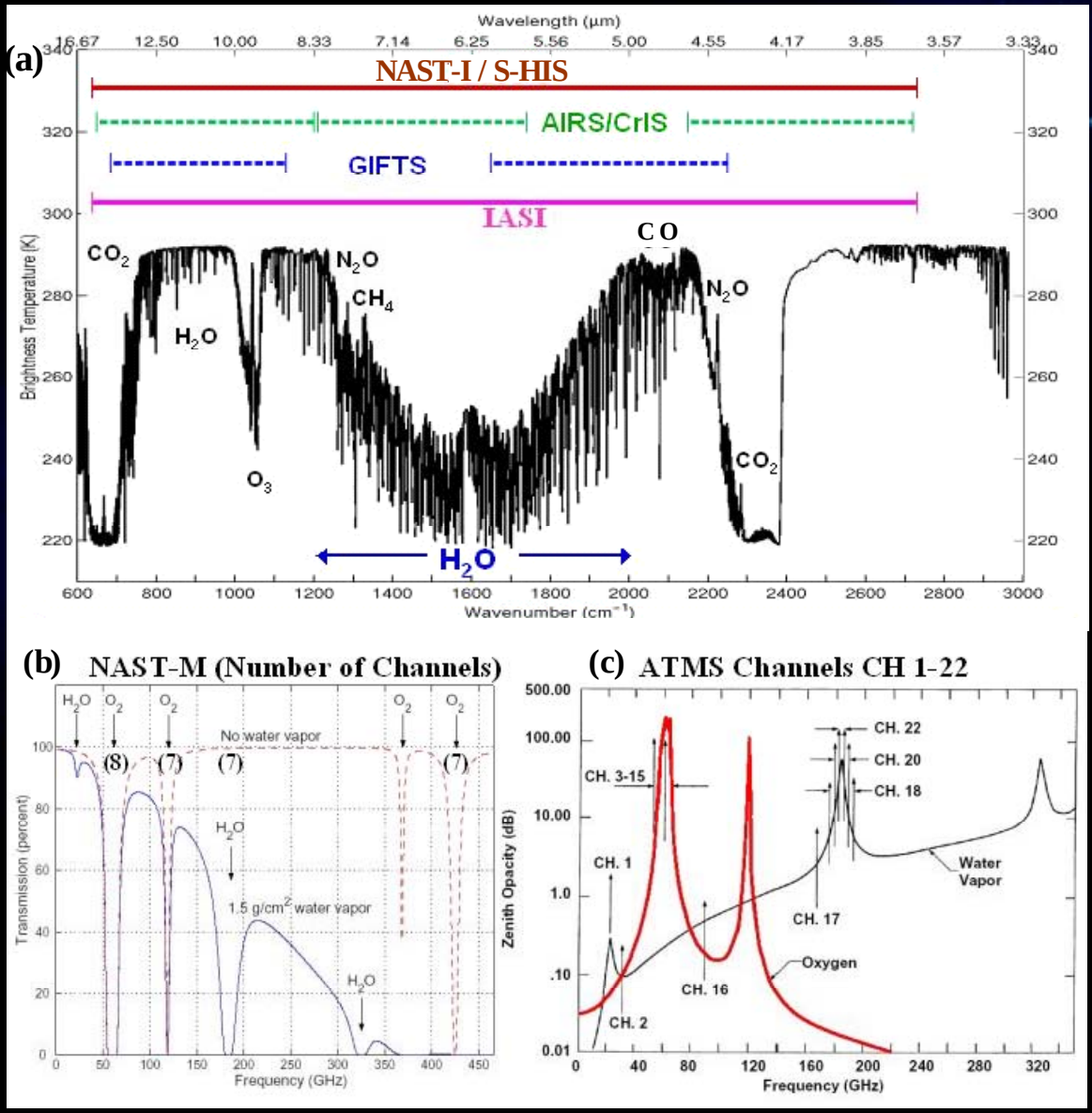
- Prof. James Anderson [Harvard U]
- Dr. Joel Susskind [NASA/GSFC]
- Prof. Roy Spencer [NASA/MSFC;UAH]
- Dr. Elena Loebl [NASA/MSFC]
- Mr. Mitch Goldberg [NOAA/NESDIS]
- Prof. Larrabee L. Strow [U MD BC]
- Dr. Harold Motteler [U MD BC]
- Dr. S.E. Hannon [U MD BC]
- Dr. Chris Barnett [NOAA/NESDIS]
- Dr. Jean-Luc Moncet [AER]
- Dr. Gail E. Bingham [Utah State /SDL]
- Dr. Greg W. Cantwell [Utah State /SDL]
- Dr. Joseph Rice [NIST]
- Dr. James Randa [NIST]
- Dr. James Yoe [NOAA/NESDIS]
- Dr. Al Gasiewski [NOAA/ETL;GA Tech]
- Dr. Thomas Kleespies [NOAA/NESDIS]
- Dr. Norman Grody [NOAA/NESDIS]
- Dr. Don Boucher [Aerospace]
- Dr. Thomas Kopp [Aerospace]
- Mr. Bruce Thomas [Aerospace]

* Partial Listing – Co-Investigators not listed

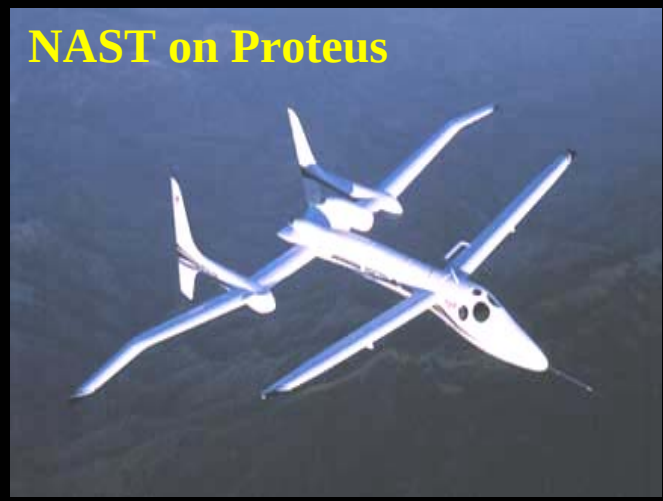
NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

NPOESS Airborne Sounder Testbed - [NAST]

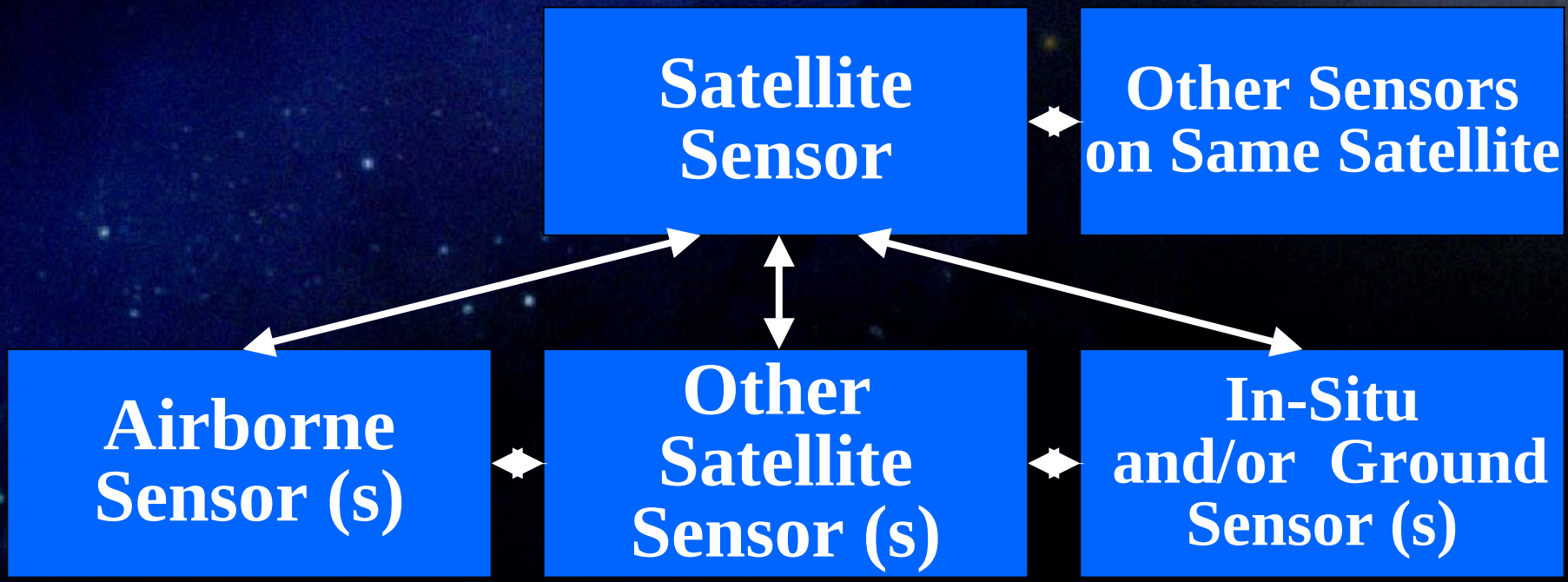
[NASA/LaRC, U. Wisconsin, MIT Lincoln Laboratory, MIT]



At 20 km ALTITUDE
NADIR 2.6 km IFOV
± 23 km GROUND COVERAGE
± 48 º Scan



Satellite Sensor Cross-Calibration/Validation



" Both Cross-Calibration of Sensors & Cross-Validation of Products Should be planned & executed ! "

On-Orbit Cross-Calibration & Validation Example Advanced Sounders

TOST (February 18 - March 13, 2003, HAFB, Hawaii). The 2003 Pacific *THORPEX Observing System Test (TOST)* was the first in a series of Pacific and Atlantic observation campaigns in support of the WWRP/USRP THORPEX Program. THORPEX - a Global Atmospheric Research Program aimed at improving short range (up to 3 days), medium range (3-7 days) and extended range (two week) weather predictions. Flights targeted frontal boundaries and storm systems, as well as satellite sensor validation underflights (TERRA, AQUA, and ICESat)

Aircraft Sensors Included:

ER-2 (NAST-I, NAST-M, S-HIS, MAS, CPL); G-IV (Dropsondes, in-situ O_3)

Satellite Platforms Included: Aqua & Terra; GOES-10

ER-2

G-IV

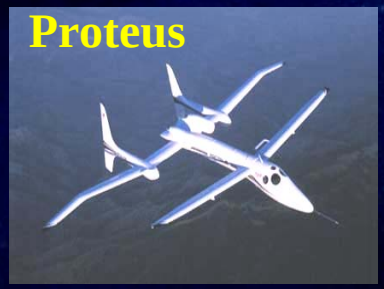
Ground

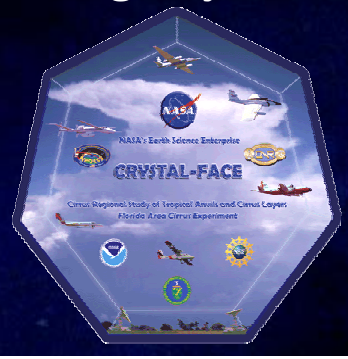
Sondes

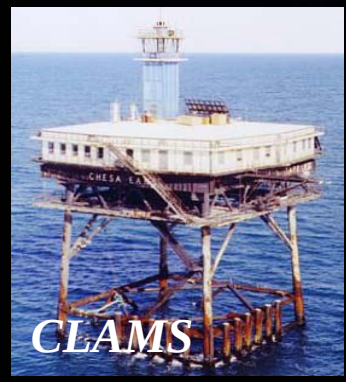
NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

NPOESS/NPP Airborne Calibration and Science Validation Program

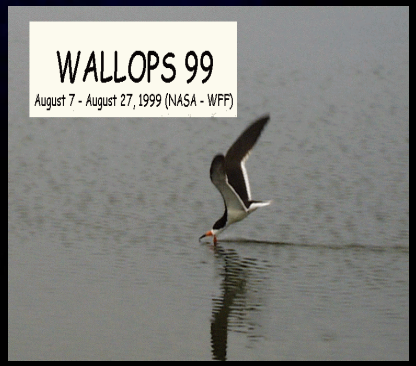
NPOESS/NPP Cal/Val Agency Participants [IPO,NASA, NOAA, DOE, DoD, NSF]





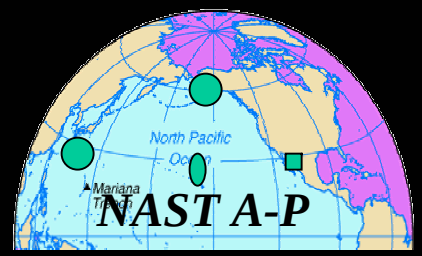


WALLOPS-98 & 99

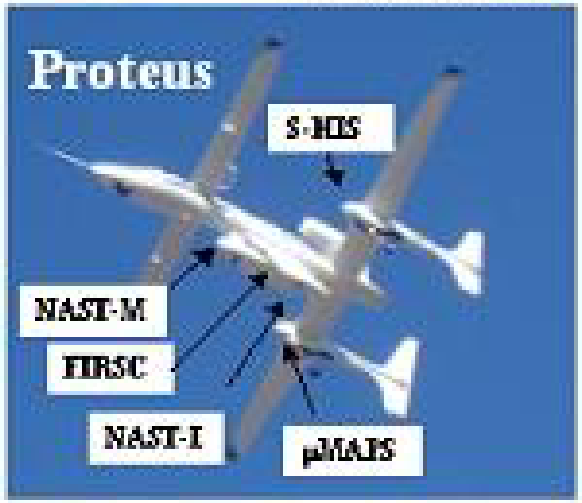


NAST has flown ~ 152 mission sorties accumulating over 850 hours of flight data in 17 field experiments:

Wallops98 (June-July, 1998); CAMEX-3 (Aug-Sep, 1998); WINTEX (Mar, 1999); Wallops99 (Aug, 1999); C-IOP (Mar, 2000), WV-IOP (Sep-Oct, 2000); AFWEX (Nov-Dec, 2000); Asian-Pacific (Feb-Mar, 2001); CLAMS (Jul-Aug, 2001); IHOP (May-Jun, 2002), CRYSTAL-FACE (Jul, 2002),TX2002 (2002), TOST (Feb-Mar, 2003), THORPEX 2003, INTEX (2004), EAQUATE-1 (2004), EAQUATE-2 (2004)



NAST Flight History



1998-2004

17 Missions; 152 Sorties; 850 Flight hours

Mission	Location	Platform	Year
Wallops 98	Virginia	ER-2	1998
Camex-3	Florida	ER-2	1998
WINTEX	Wisconsin	ER-2	1999
Wallops 99	Virginia	ER-2	1999
C-IOP	Oklahoma	Proteus	2000
WV-IOP	Oklahoma	Proteus	2000
AFWEX	Oklahoma	Proteus	2000
A-P	CA/HI/Japan/AK	Proteus	2001
CLAMS	Virginia	Proteus	2001
IHOP	Oklahoma	Proteus	2002
CRYSTAL-FACE	Florida	Proteus	2002
TX2002	Texas	ER-2	2002
THORPEX	Hawaii	ER-2	2003
ATOST	Maine	ER-2	2003
INTEX	Virginia	Proteus	2004
EAQUATE-1	Italy	Proteus	2004
EAQUATE-2	United Kingdom	Proteus	2004

SSEC/CIMSS Involvement

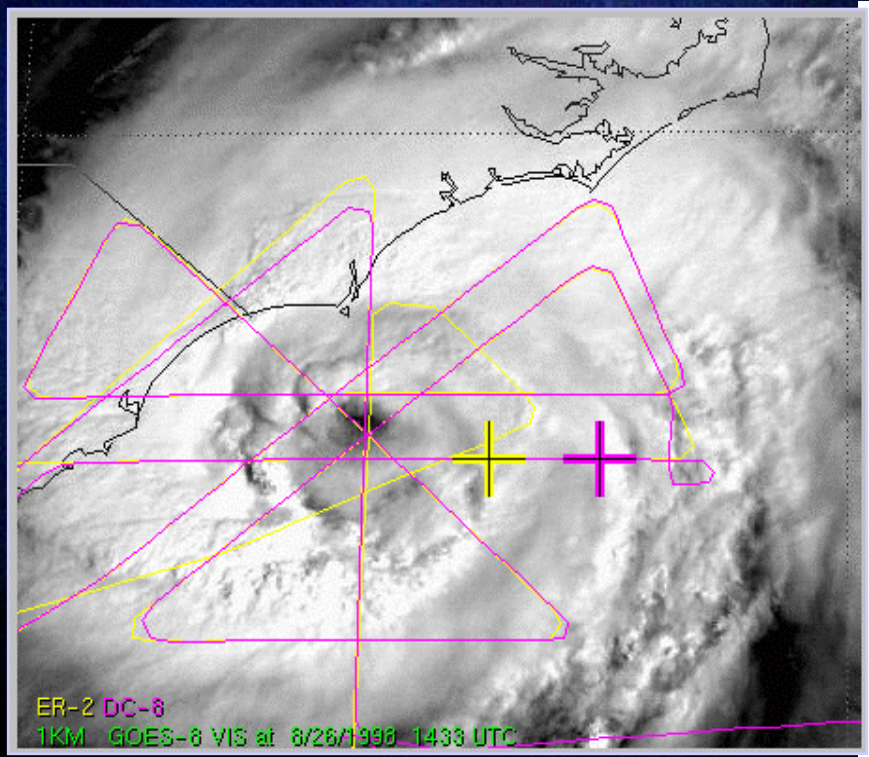
Satellite

Airborne

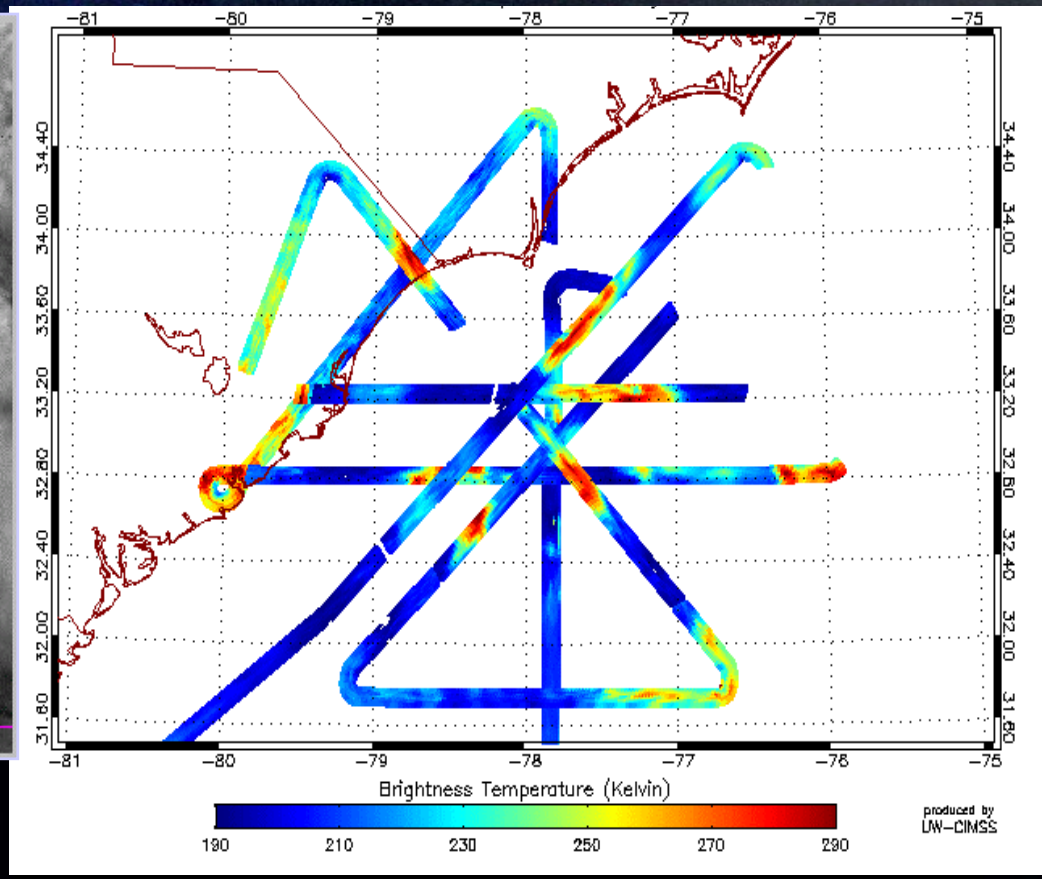
Ground-based

GOES Visible Image and NAST-I IR Window
Hurricane Bonnie (August 26, 1998)

GOES Visible Image with ER-2 and DC-8 Flight Tracks



NAST-I IR Window (900-905cm^{-1})

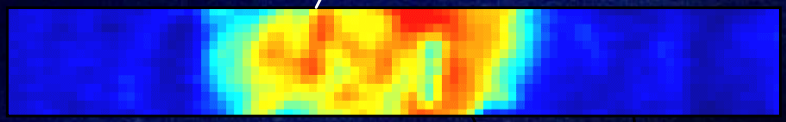


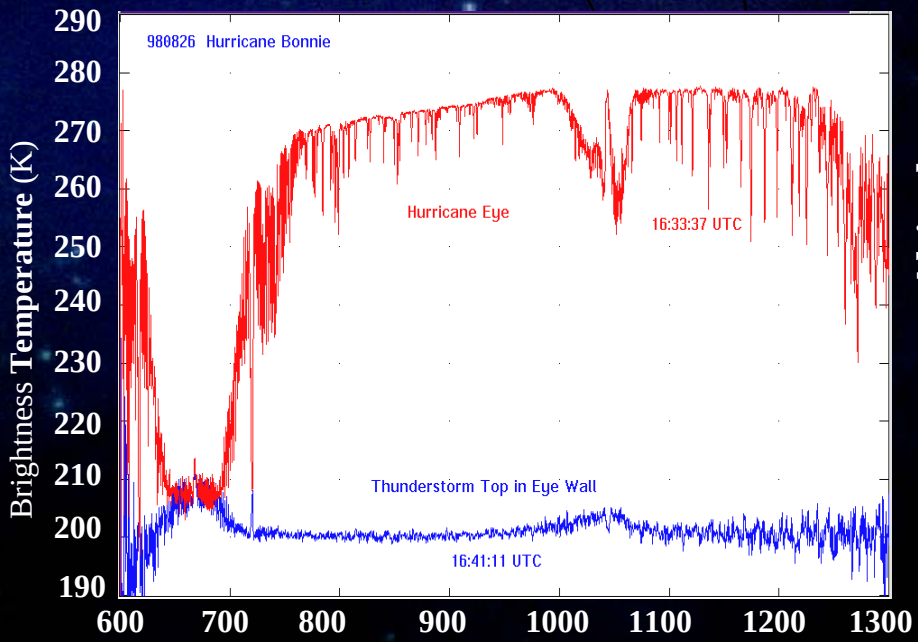
HURRICANE BONNIE - AUGUST 26, 1998
Landfall on North Carolina Coast

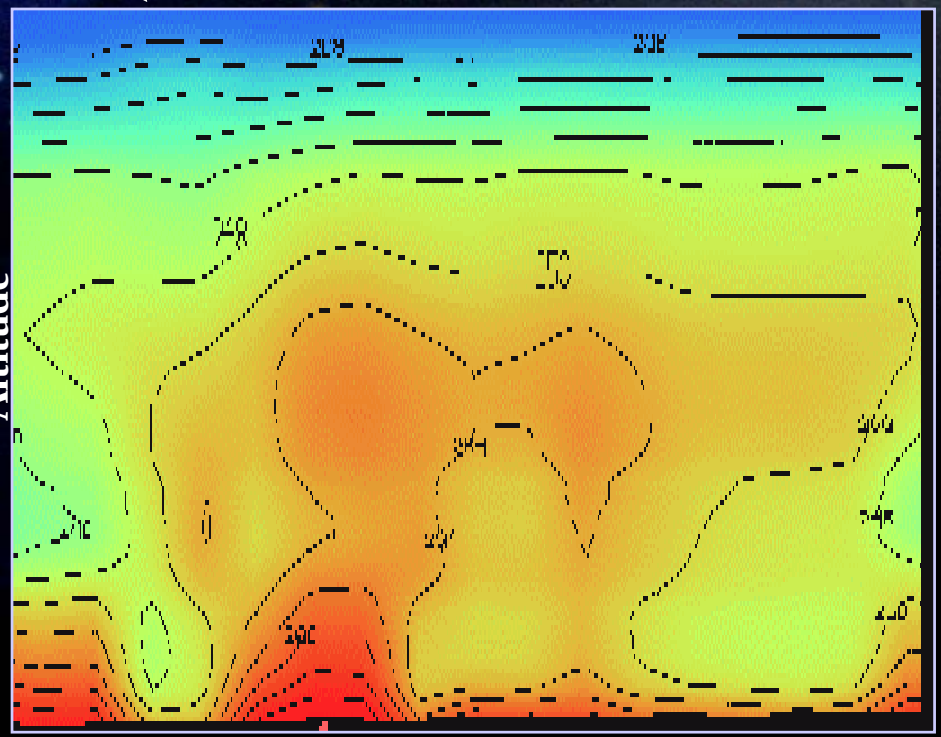
[NAST-I Observes 3-Dimensional Structure With High Spatial & Spectral Resolution and Radiometric Accuracy]

NAST-I 10 km Cross Track Image

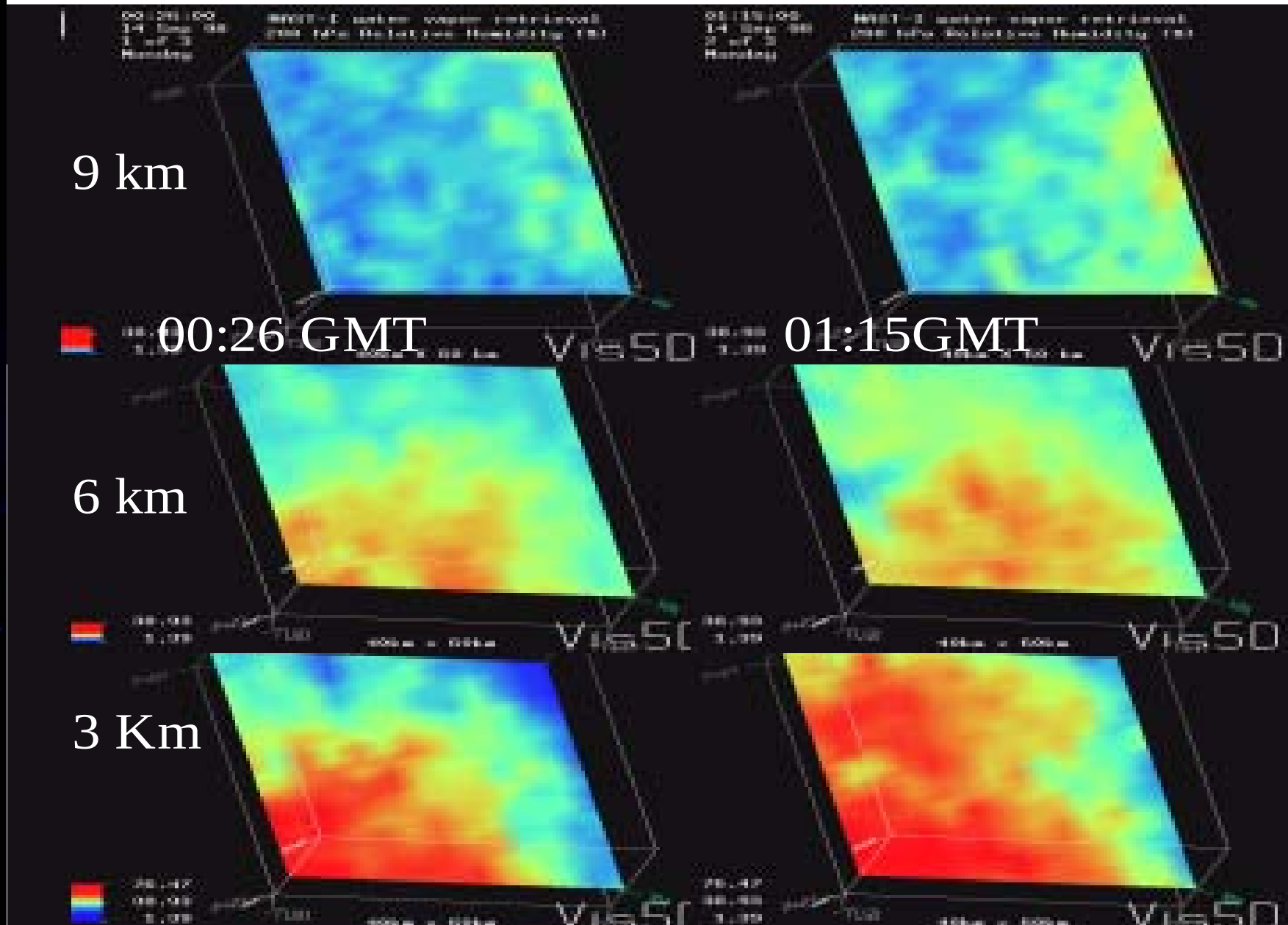
NAST-I Temperature Vertical Cross-section of Eye Region



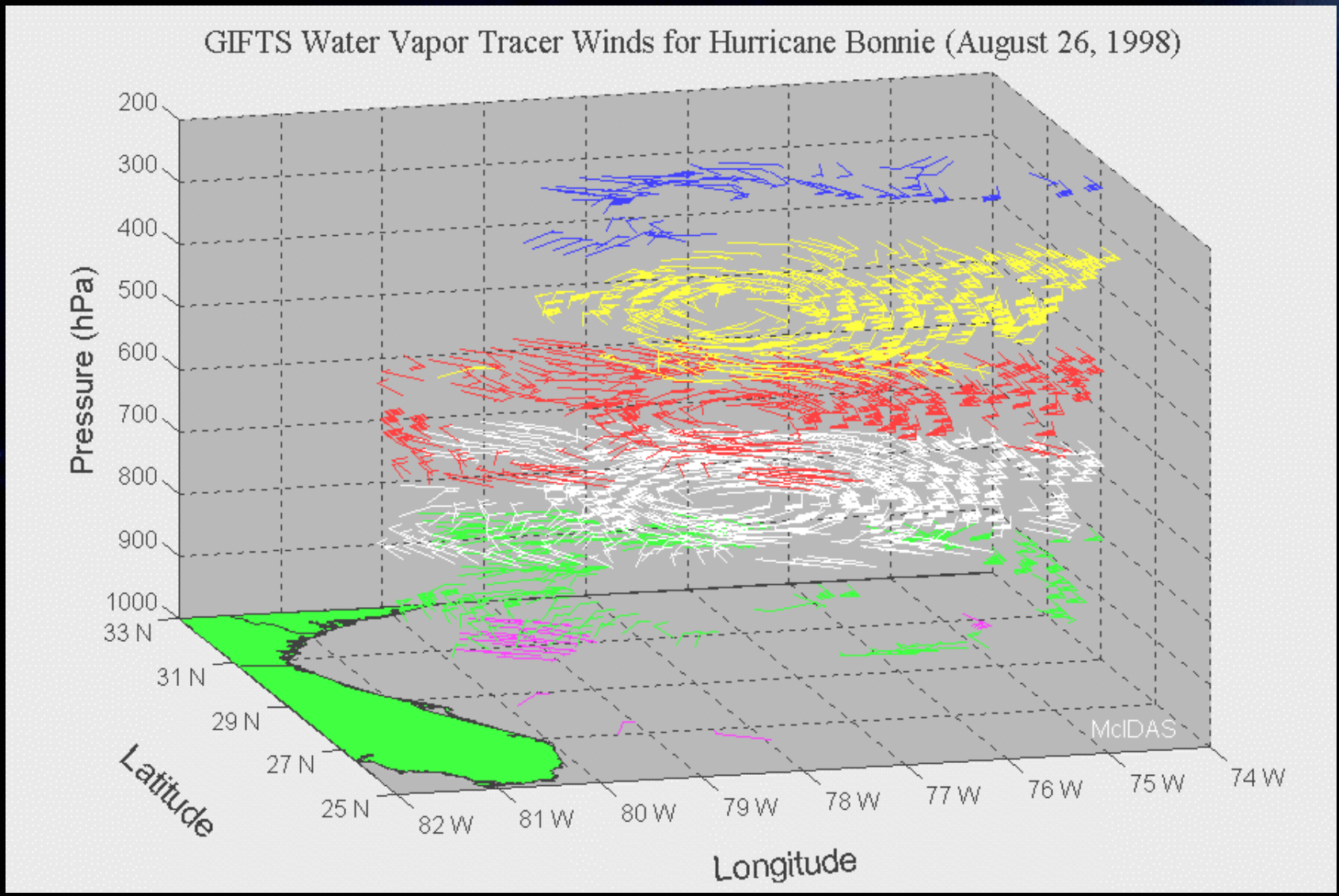




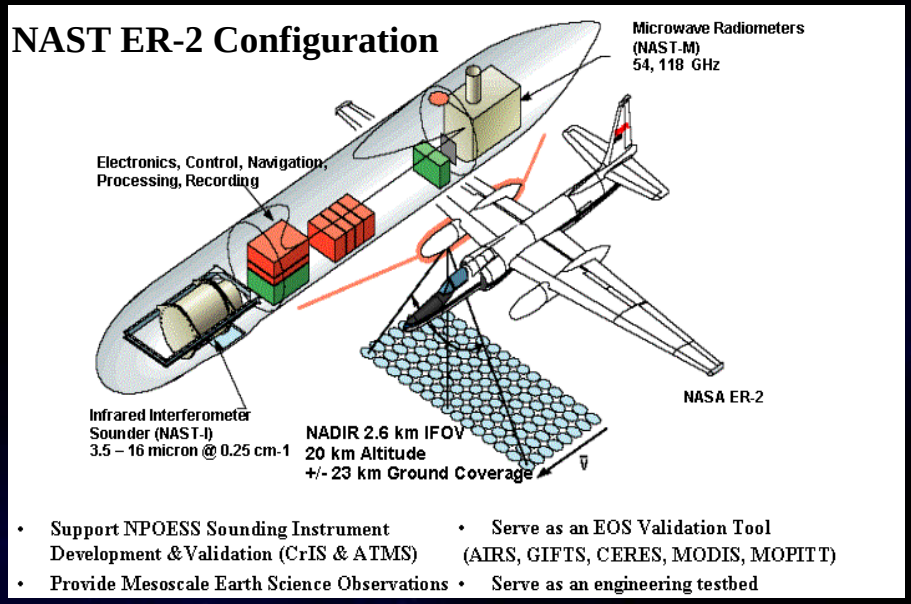
NAST-I Demonstration of GIFTS Wind Profiling Capability

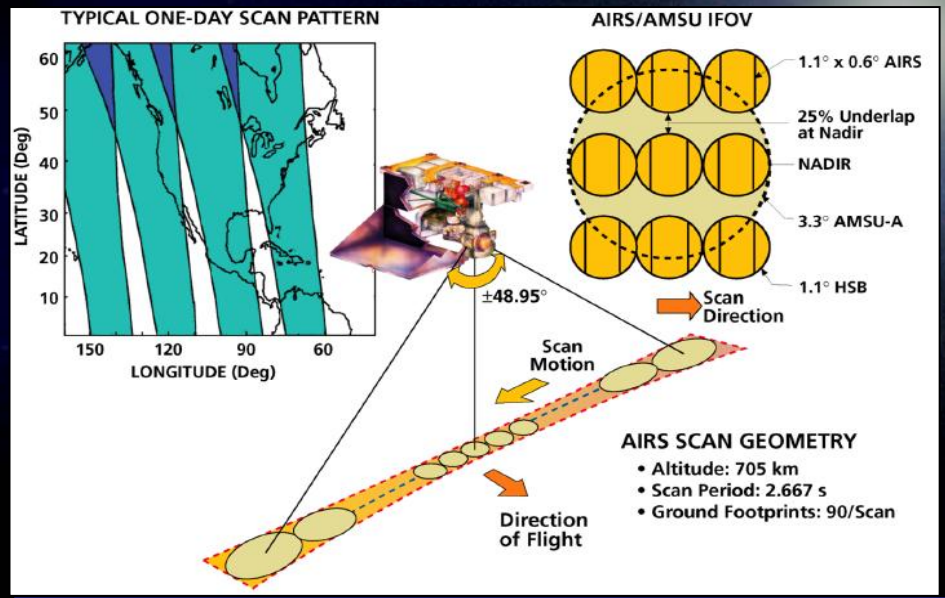


GIFTS Simulation of Hurricane Bonnie: Winds from Water Vapor Retrieval Tracking



Validation of CrIS Performance & Science Measurement Capability

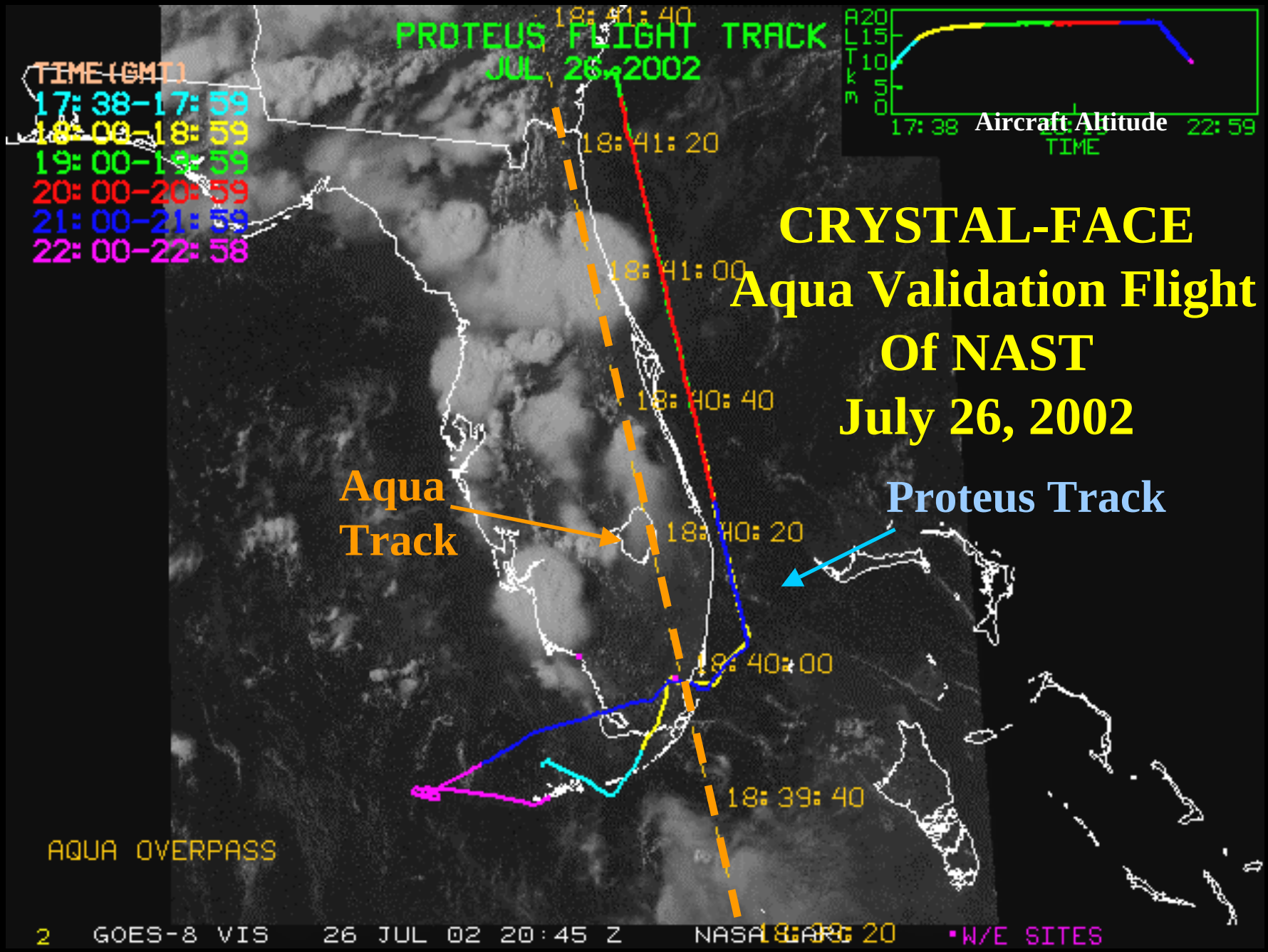




- The *NPOESS Airborne Sounder Testbed* (NAST) consists of a 9000 spectral channel infrared interferometer (NAST-I) with a spectral resolution of 0.25 cm^{-1} combined with a 29 channel microwave radiometer (NAST-M). Both instruments spatially scan and provide a ground resolution of about 2.6 km from an aircraft altitude of 20 km.

- The *Aqua AIRS* instrument is a ~2500 spectral channel cooled grating spectrometer with a spectral resolving power of ~ 1200 (0.5 – 2 cm^{-1} spectral resolution) operating within the spectral range 650 – 2700 cm^{-1}. The spatial resolution of the AIRS is about 15 km, at nadir, and its cross track scan providing a swath width of approximately 1400 km.

Adapted from William L. Smith et al.

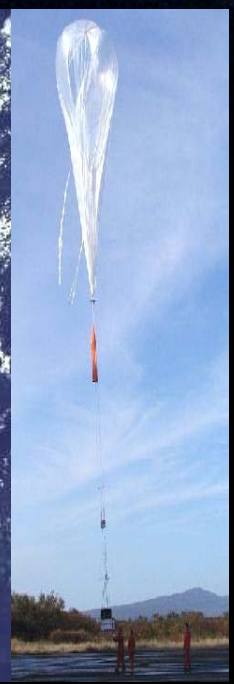

PROTEUS FLIGHT TRACK
JUL 26, 2002
TIME (GMT)
17:38-17:59
18:00-18:59
19:00-19:59
20:00-20:59
21:00-21:59
22:00-22:58
18:41:40
18:41:20
18:41:00
18:40:40
18:40:20
18:40:00
18:39:40
18:39:20
A20
L15
T10
k5
m0
17:38
22:59
TIME
Aircraft Altitude
CRYSTAL-FACE
Aqua Validation Flight
Of NASST
July 26, 2002
Aqua
Track
Proteus Track
AQUA OVERPASS
2 GOES-8 VIS 26 JUL 02 20:45 Z
W/E SITES

TOST

TOST (February 18 - March 13, 2003, HAFB, Hawaii). The 2003 Pacific ***THORPEX Observing System Test (TOST)*** was the first in a series of Pacific and Atlantic observation campaigns in support of the WWRP/USRP THORPEX Program. THORPEX - a Global Atmospheric Research Program aimed at improving short range (up to 3 days), medium range (3-7 days) and extended range (two week) weather predictions. Flights targeted frontal boundaries and storm systems, as well as satellite sensor validation underflights (TERRA, AQUA, and ICESat)

Aircraft Sensors Included:

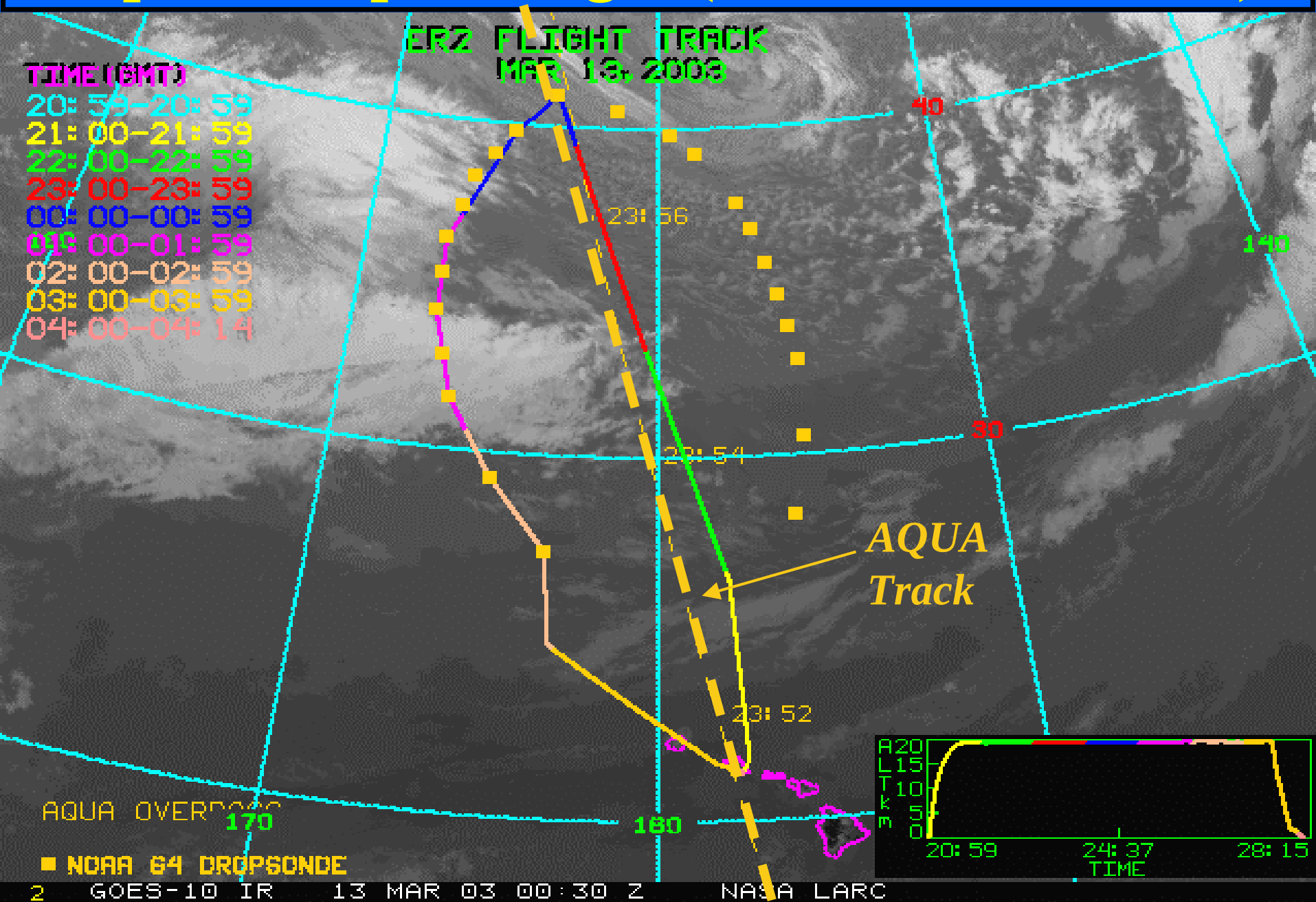
ER-2 (NAST-I, NAST-M, S-HIS, MAS, CPL); **G-IV** (Dropsondes, in-situ O_3)



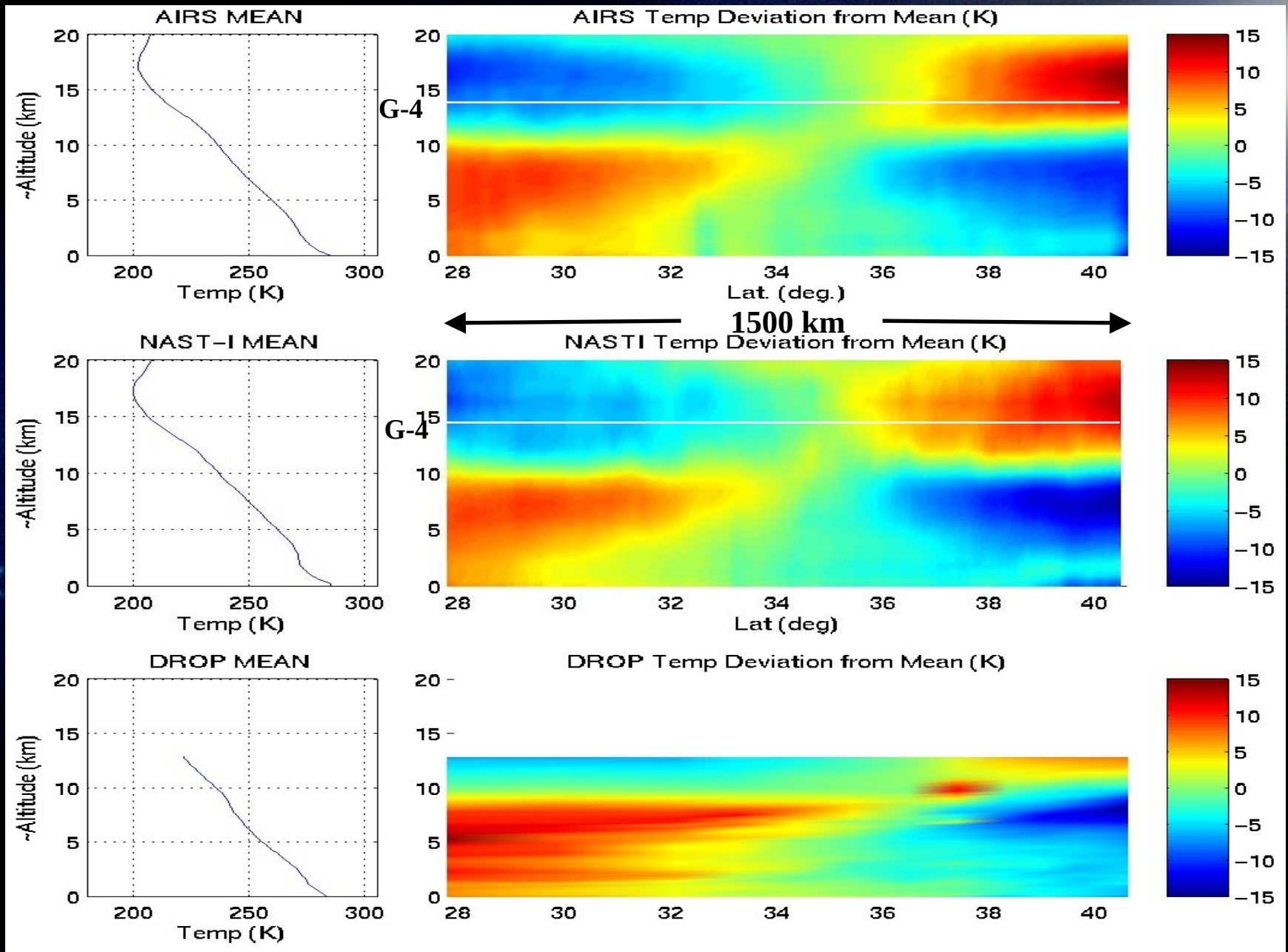
Satellite Platforms Included:

Terra & Aqua

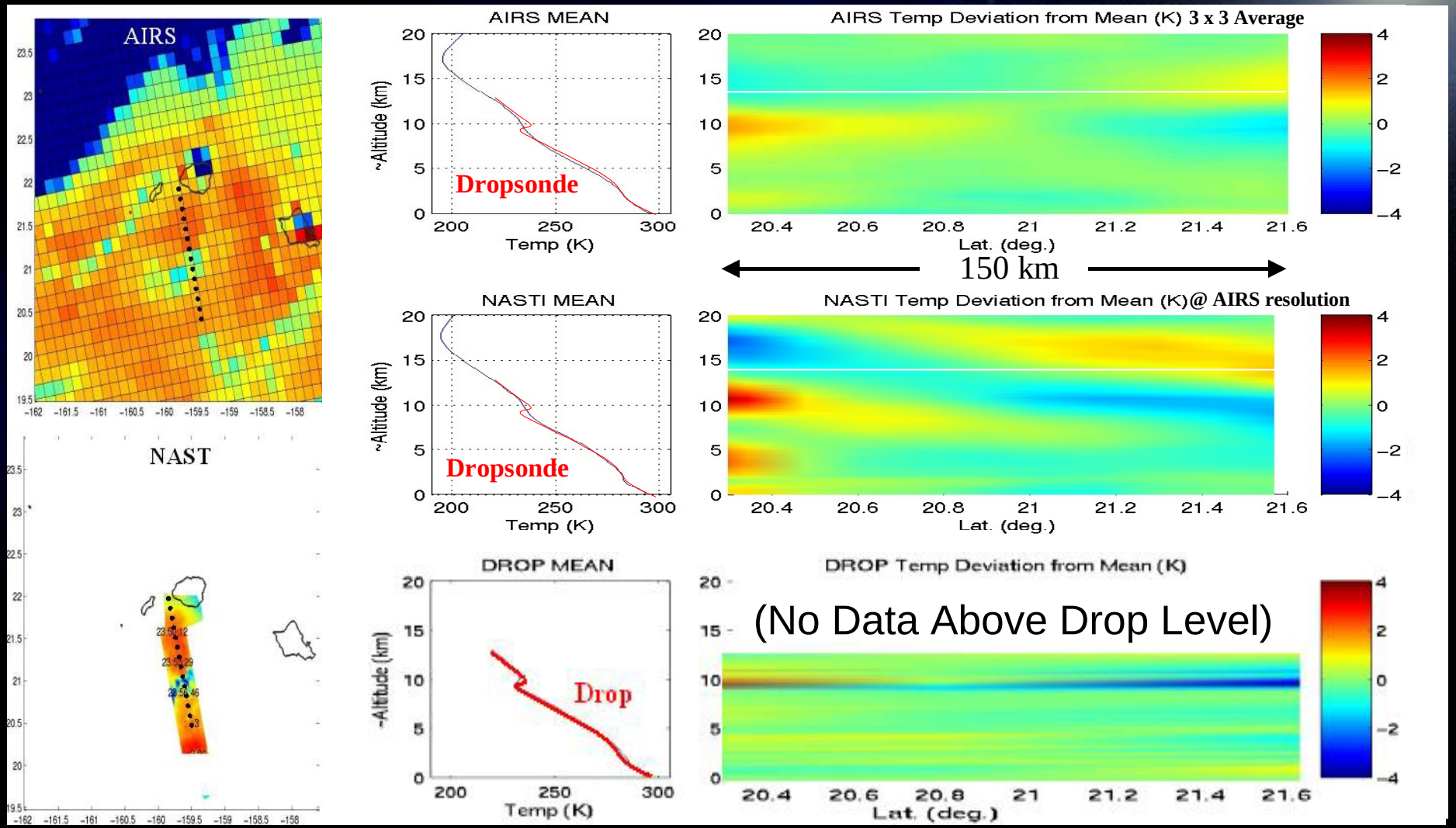
Aqua Overpass Flight (March 12/13, 2003)



Retrieval Comparisons (Deviation from the Mean)

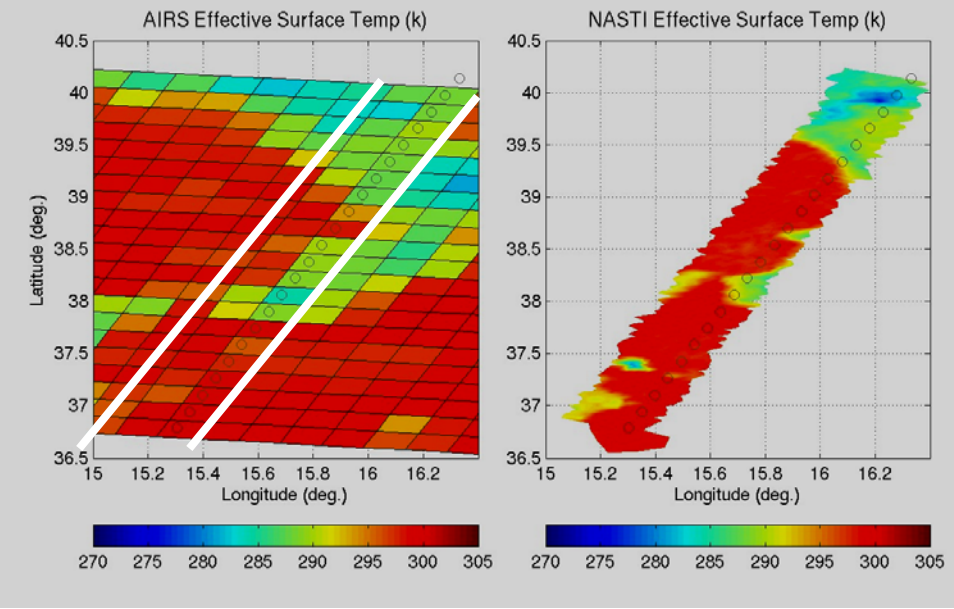


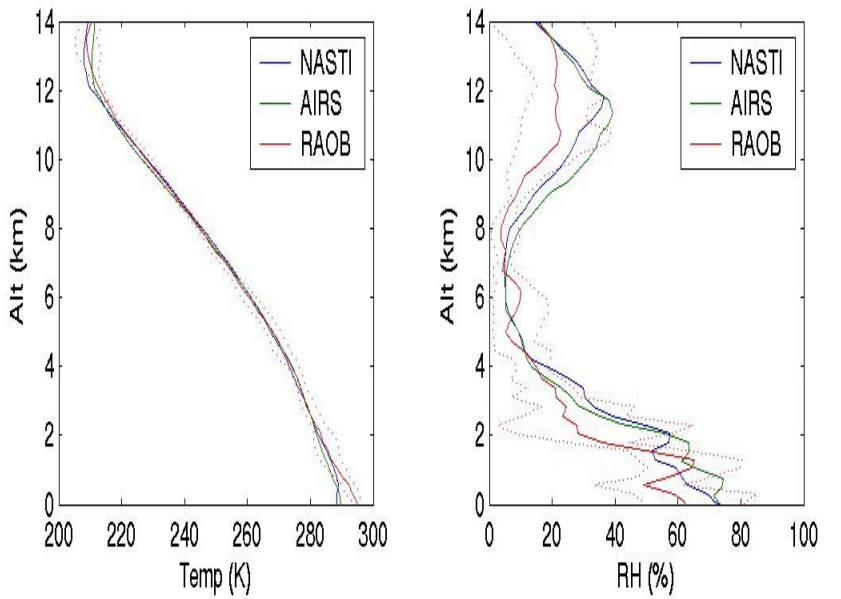
AIRS Noise Reduced (3 x 3 Avg.) Captures Vertical Structure

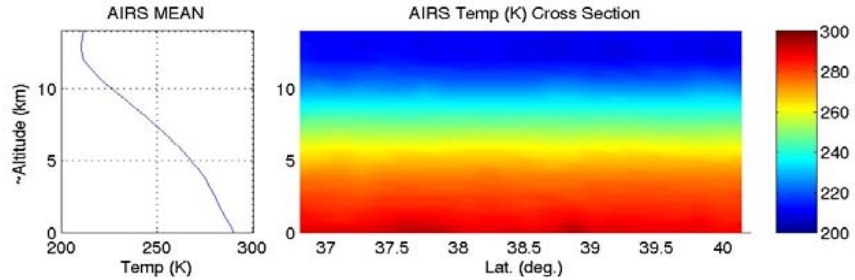


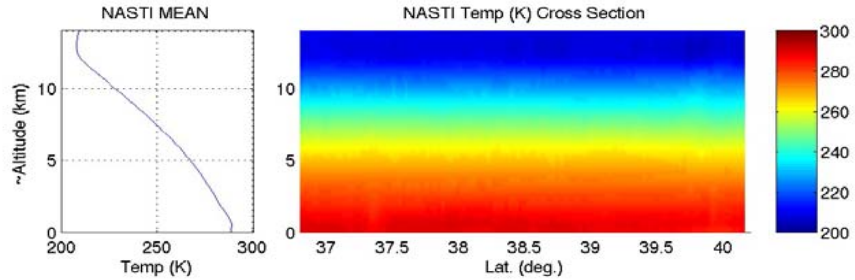
Adapted from William L. Smith et al.

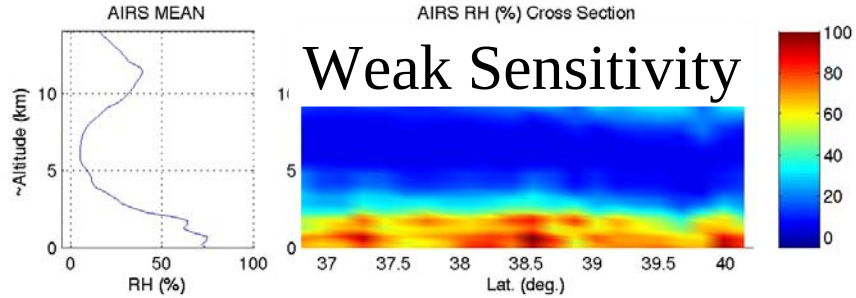
Comparison of AIRS vs NAST vs Radiosonde (September 10, 2004)



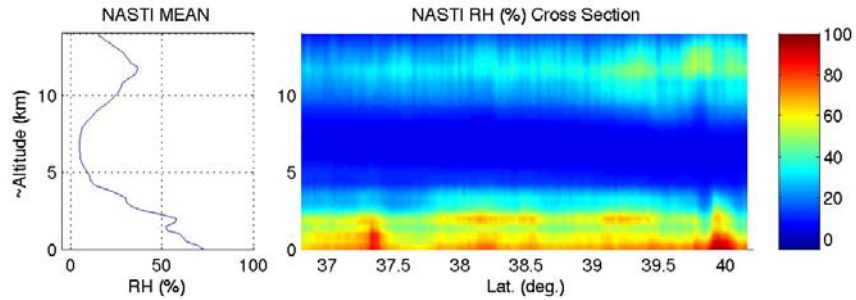




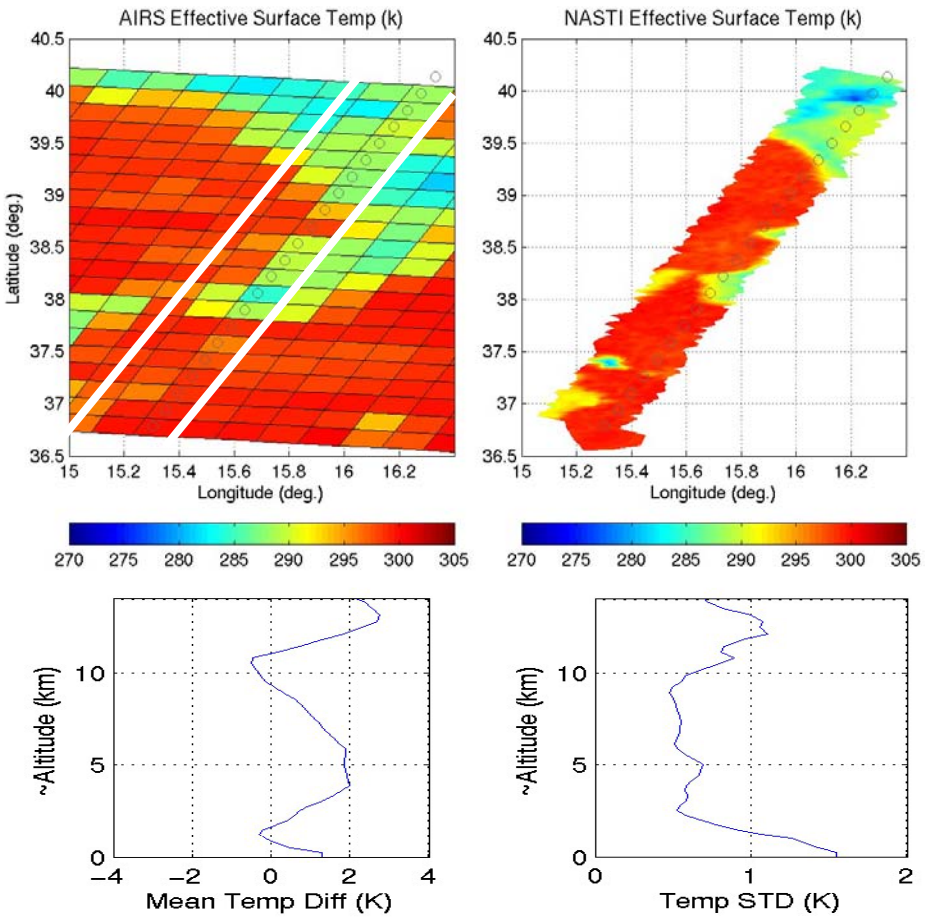




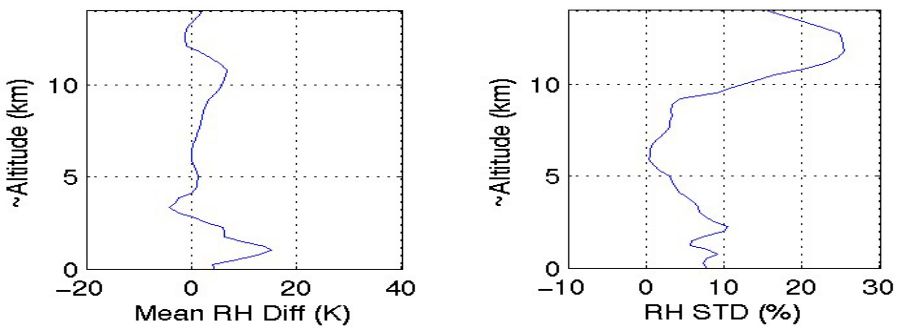
Weak Sensitivity

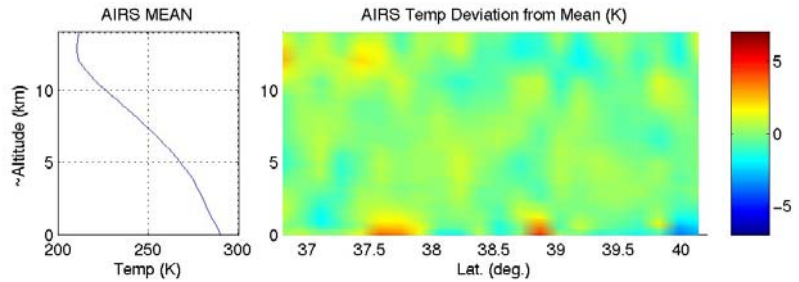


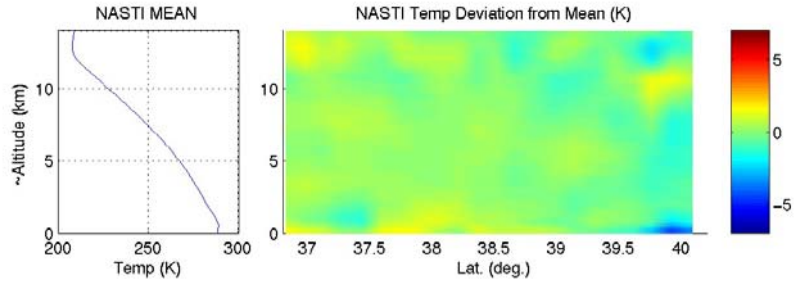
Comparison of AIRS and NAST (September 10, 2004)

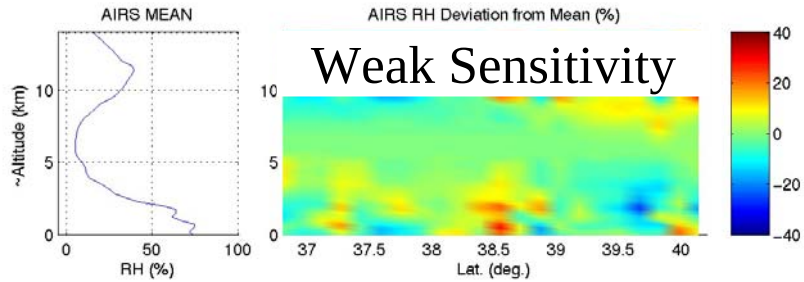


AIRS – NAST-I

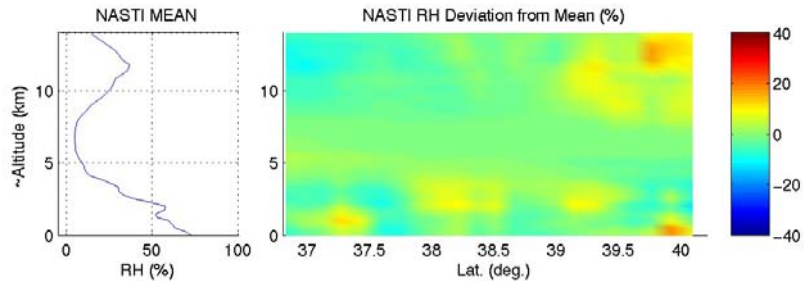






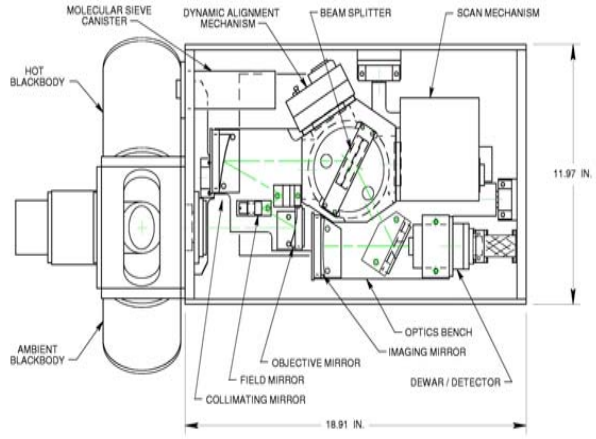


Weak Sensitivity



NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

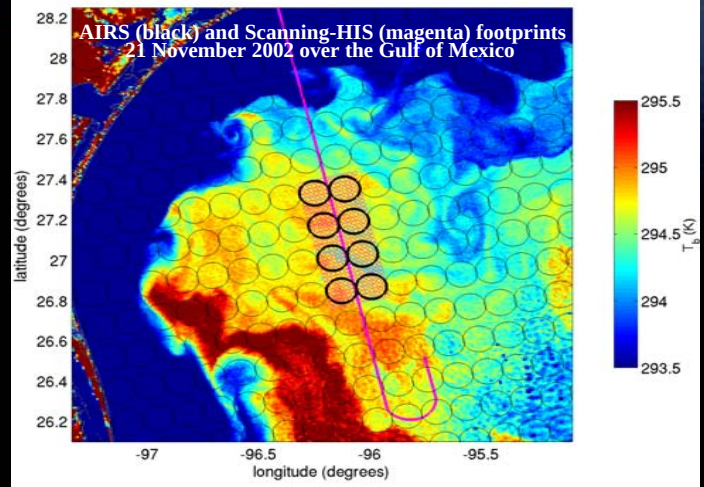
AIRS Radiance Validation with Scanning-HIS
S-HIS (Airborne) /AIRS (Spaceborne)



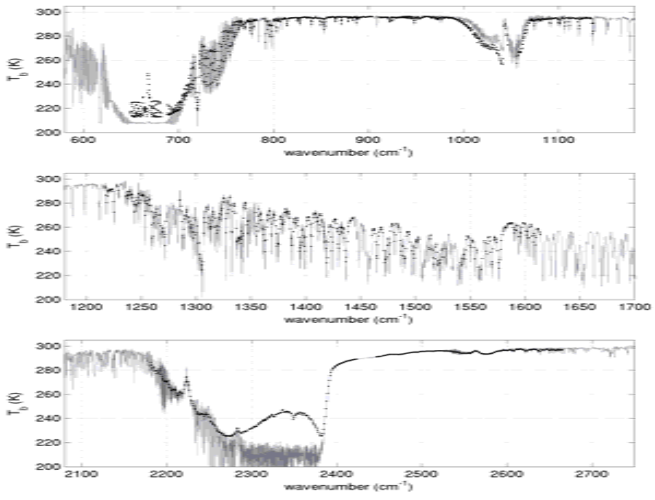
The Instrument – S-HIS

At 20 km ALTITUDE
NADIR 2.6 km IFOV
± 23 km GROUND COVERAGE
± 48 º Scan

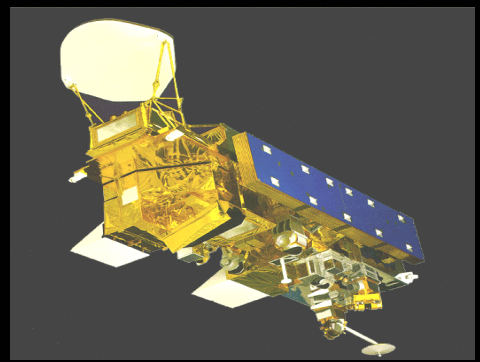
The Platform – ER-2



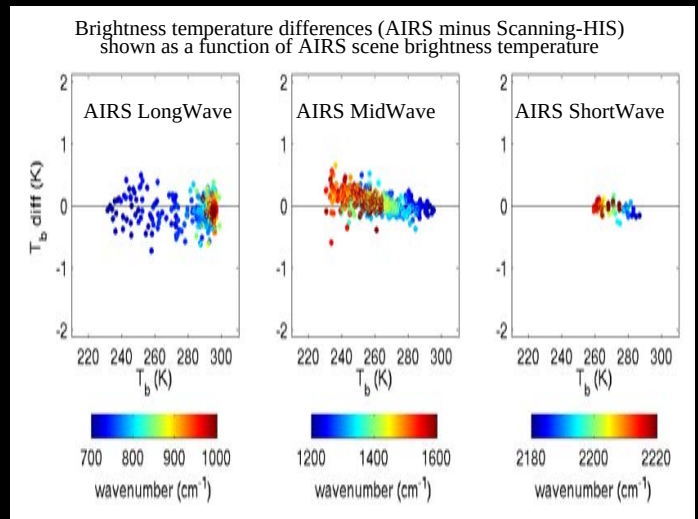
The Experiment – S-HIS/AIRS



The Basic Data – S-HIS/AIRS

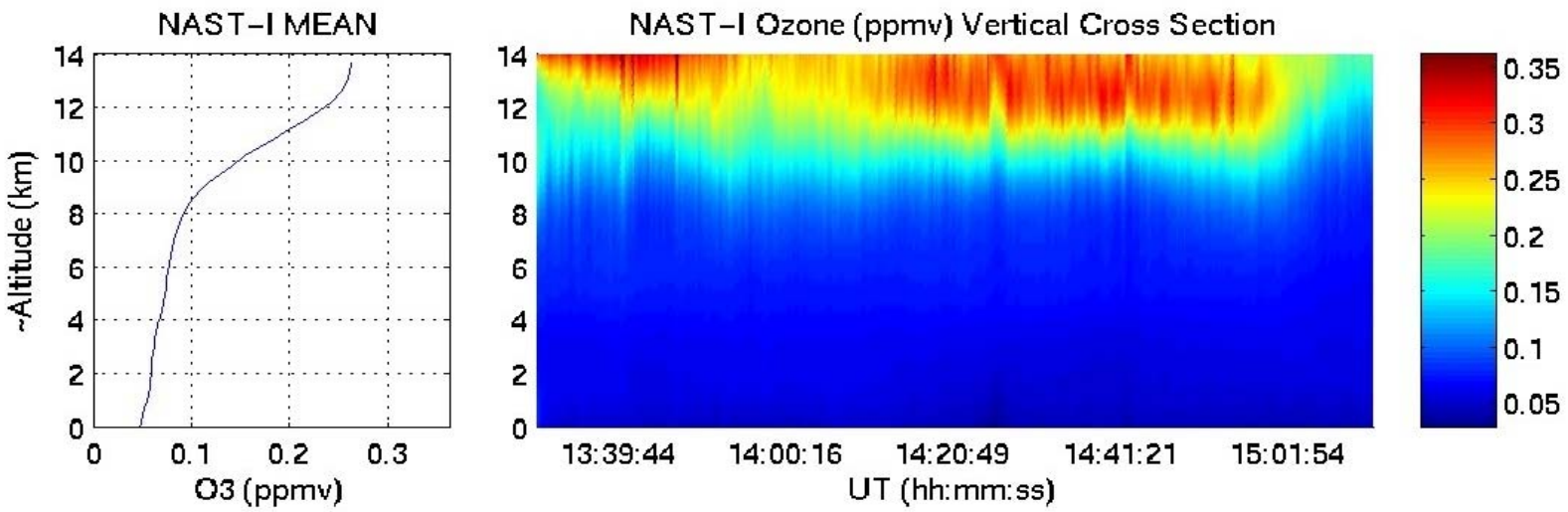


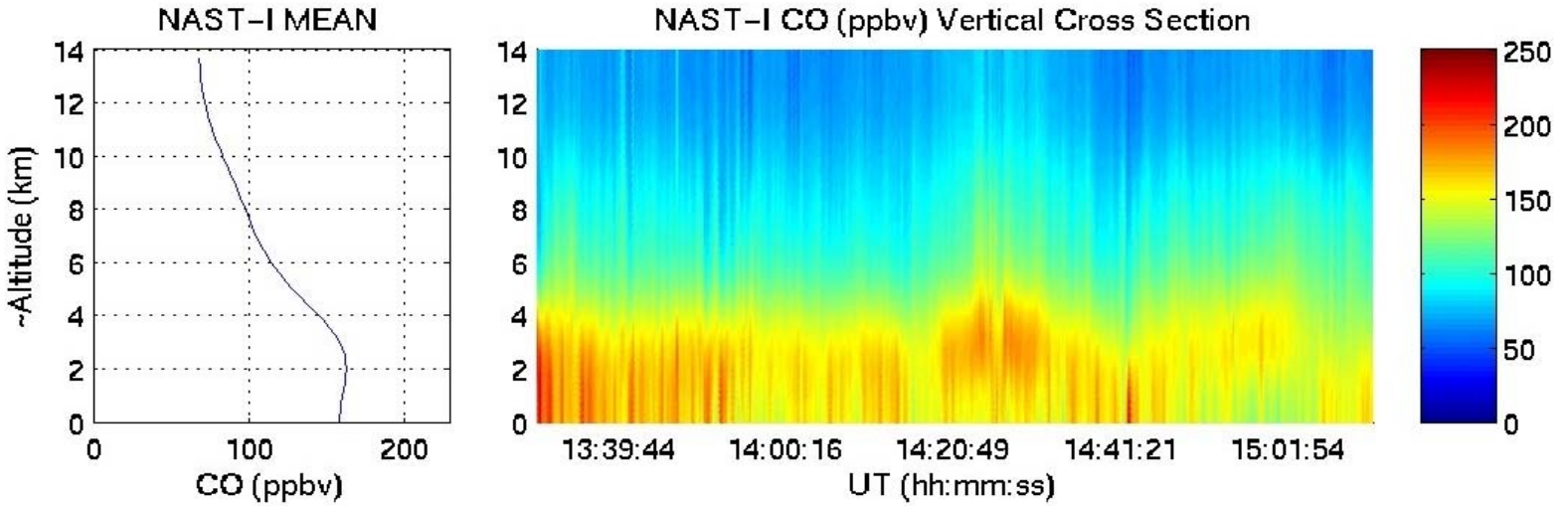
The S/C – EOS AQUA



The Analysis – S-HIS/AIRS

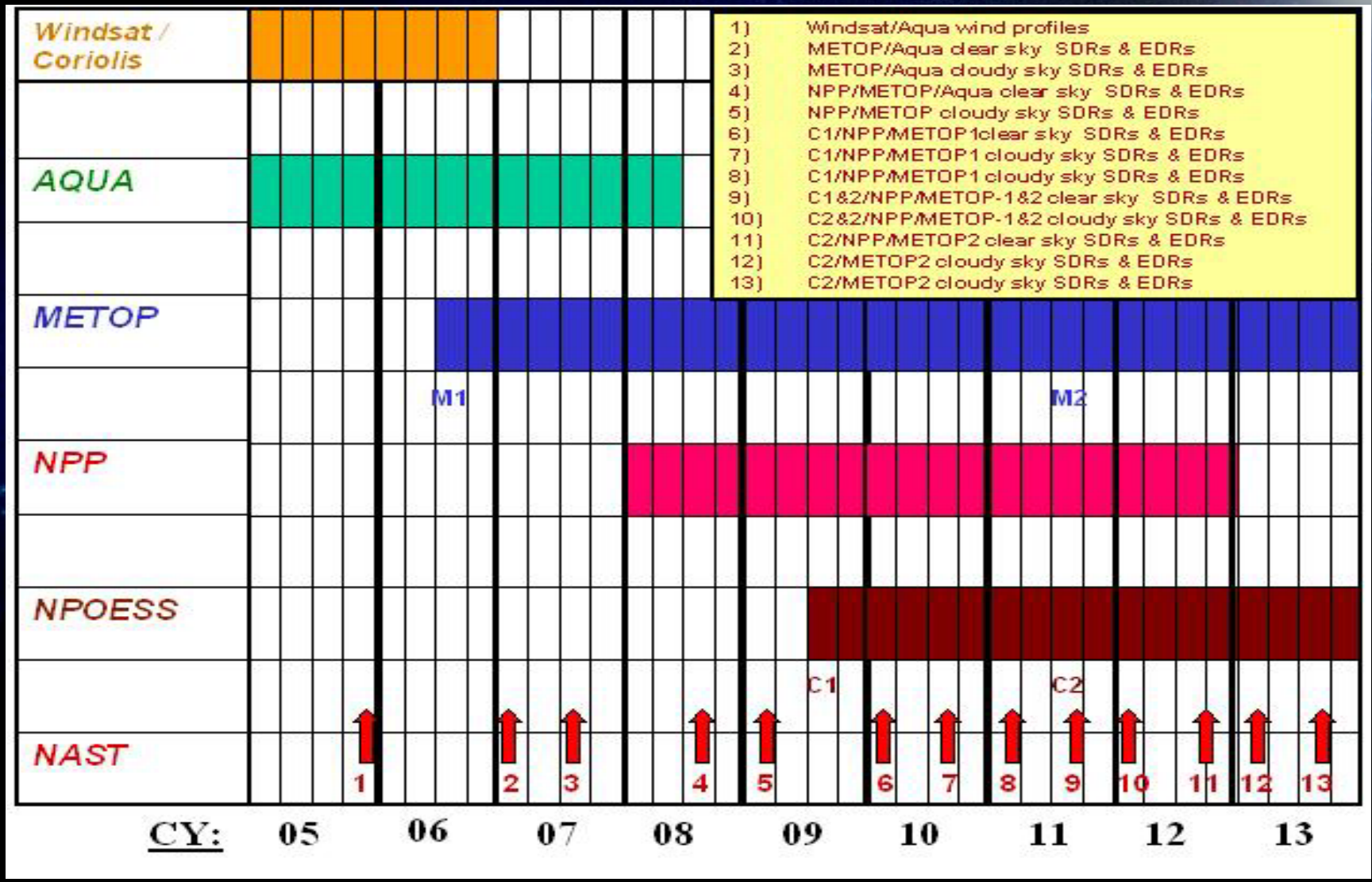
NAST-I Cross sections of Ozone [O_3] & Carbon Monoxide [CO] Retrieved along the Proteus INTEX flight track for July 22, 2004





NPOESS/NPP Airborne Calibration and Science Validation Future Program

NPOESS/NPP Cal/Val Agency Participants [IPO,NASA, NOAA, DOE, DoD, NSF]



NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

On the Occasion of CIMSS Day
July 12, 2005

Happy Birthday CIMSS !

From the NPOESS Integrated Program Office

Back to the Future !