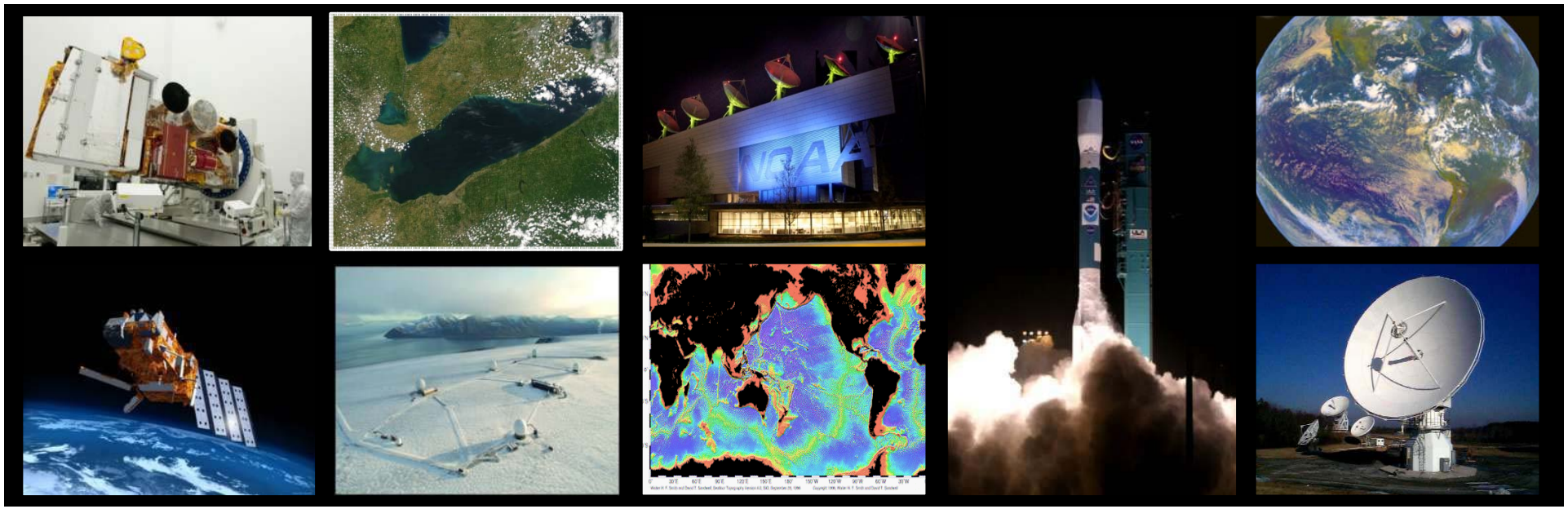
Status of the SUOMI National Polar-orbiting Partnership (NPP) Satellite Instruments



Mitchell D. Goldberg, NOAA JPSS Program Scientist

and the NPP SDR and EDR Team

The Team

NOAA, NASA, NRL, FNMOC, NAVO, AFWA

Cooperative Institutes (CIMSS, CIRA, CICS)

UMBC, HU, UTAH SDL, MIT-LL, AEROSPACE, NGAS, Miami, ...

Raytheon

External users: UKMO, ECMWF

TOPICS

Overview of NPP/JPSS Program

Initial Results from VIIRS, ATMS, CrIS, OMPS and CERES

SUCCESSFUL LAUNCH October 28, 2011!!!!

Courtesy of Ben Cooper

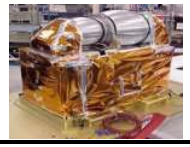
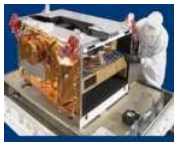
NPP to JPSS Program

Drivers and Benefits

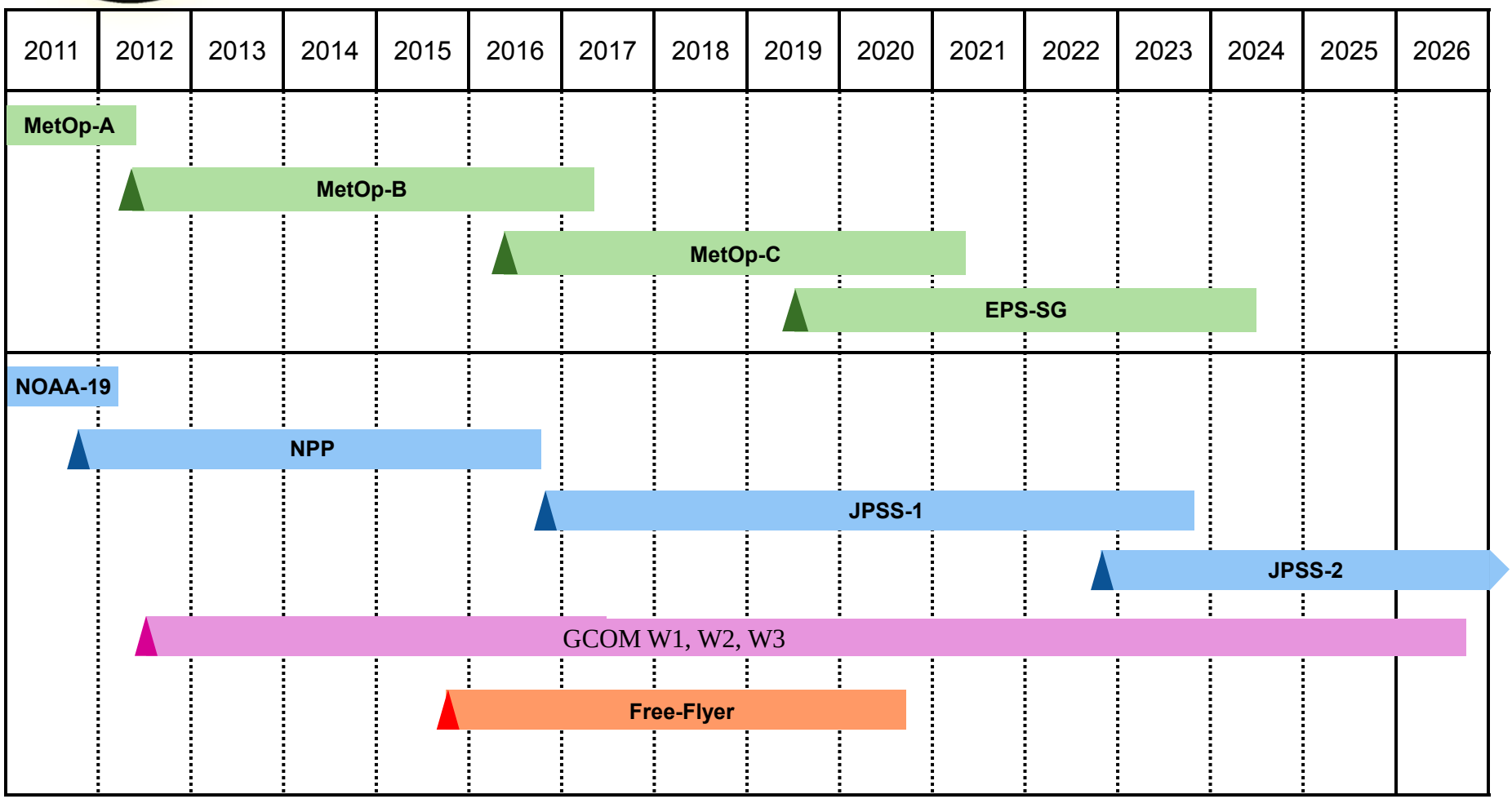
- Maintains continuity of weather/climate observations and critical environmental data from the polar orbit
- NOAA – JPSS provides improved continuity for POES
  - HIRS > CrIS
  - AMSU > ATMS
  - AVHRR > VIIRS
  - SBUV2 > OMPS
- NASA – JPSS provides continuity for EOS
  - AIRS > CrIS
  - AMSU > ATMS
  - MODIS > VIIRS
  - OMI > OMPS
  - CERES > CERES
  - AMSR-E > AMSR2 (JAXA-GCOM-W)

JPSS-1 Satellite
(NPP-clone)

NPP/JPSS Instruments

NPP/JPSS Instrument		Benefits to the NOAA Mission
	ATMS (NGES)	ATMS and CrIS together provide high vertical resolution temperature and water vapor information needed to maintain and improve forecast skill out to 5 to 7 days in advance for extreme weather events, including hurricanes and severe weather outbreaks.
	CrIS (ITT)	
	VIIRS (Raytheon SAS)	VIIRS provide a large set of parameters including snow/ice cover, clouds, fog, aerosols, fire, smoke plumes, vegetation health, phytoplankton abundance/chlorophyll needed for environmental assessments which impacts human health and key economic sectors (transportation, fishing, energy, agriculture)
	OMPS (Ball Aerospace and Technology Corp)	Total ozone for monitoring ozone hole and recovery of stratospheric ozone and for UV index forecasts
	CERES	Provide climate quality measurements of the Earth's outgoing radiation budget.

NOAA Operational Polar Program



Overall Structure

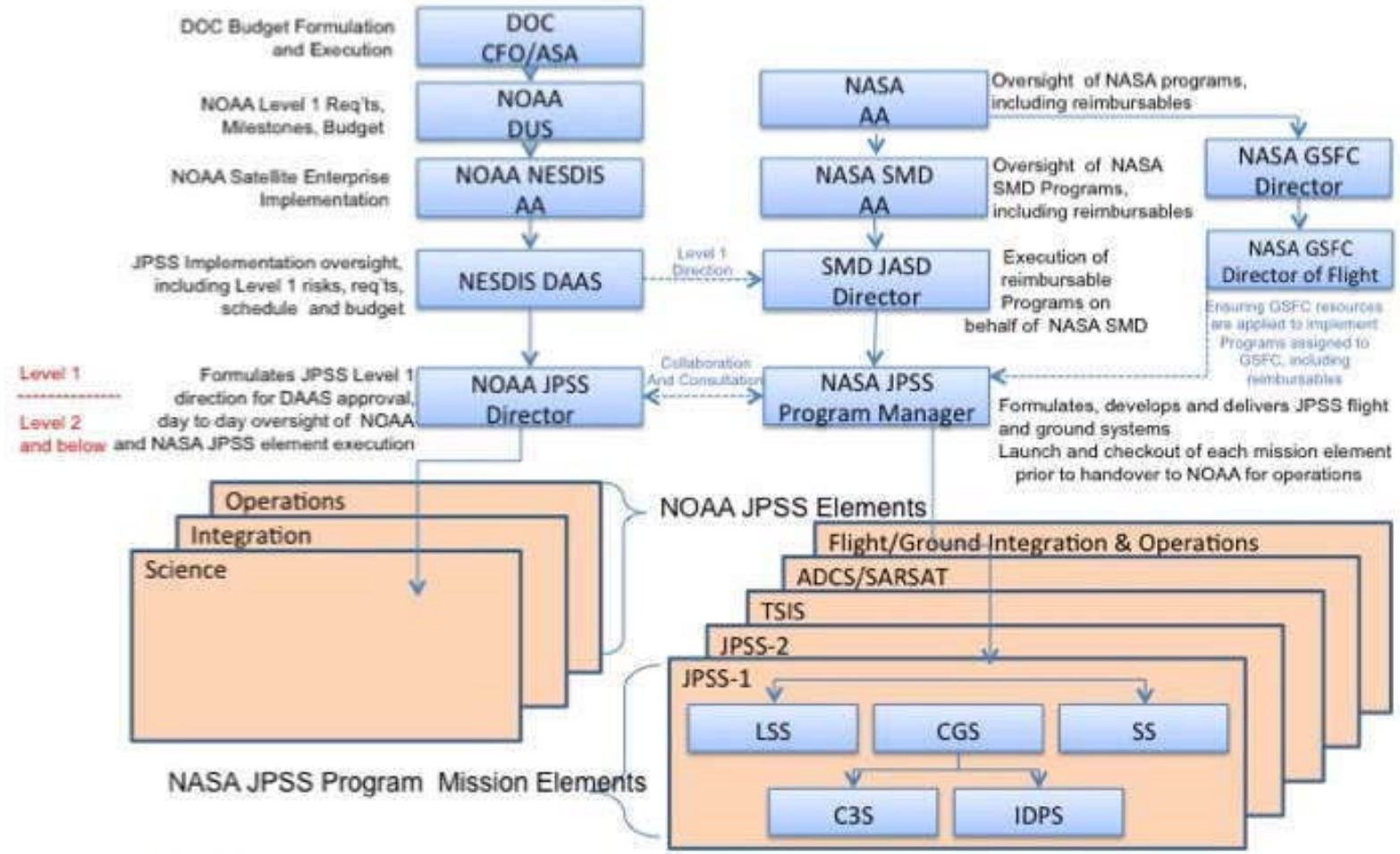
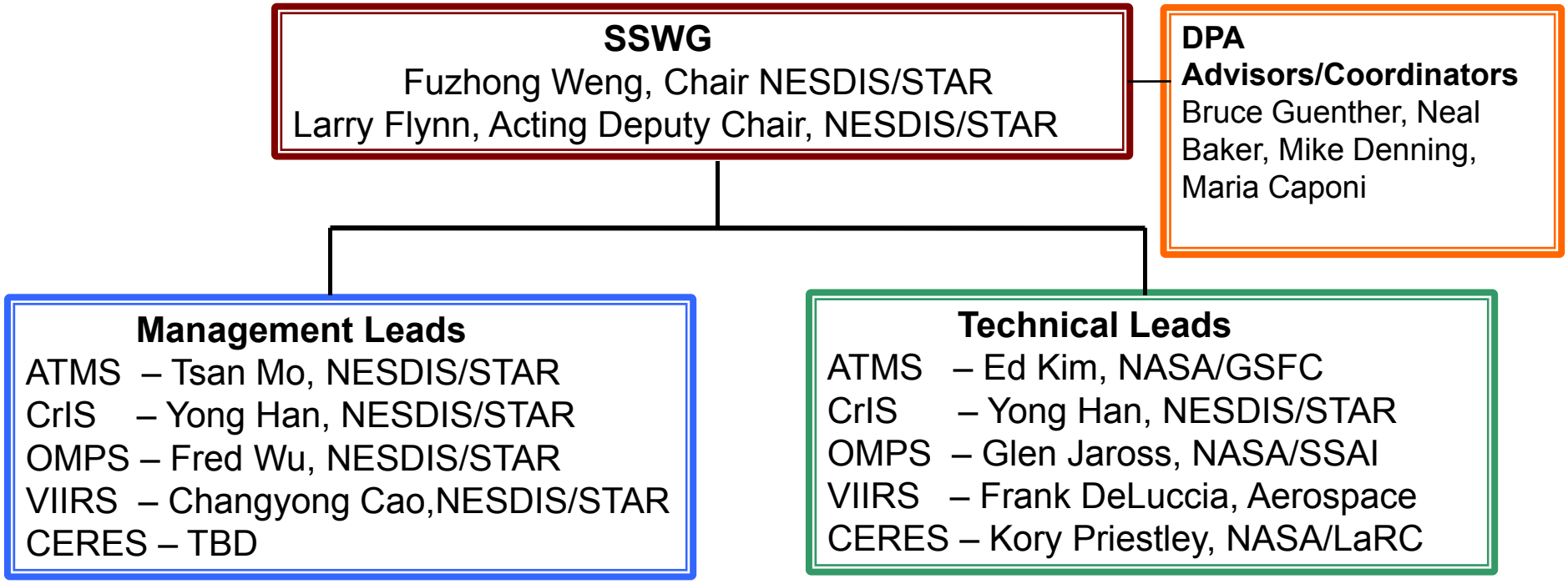
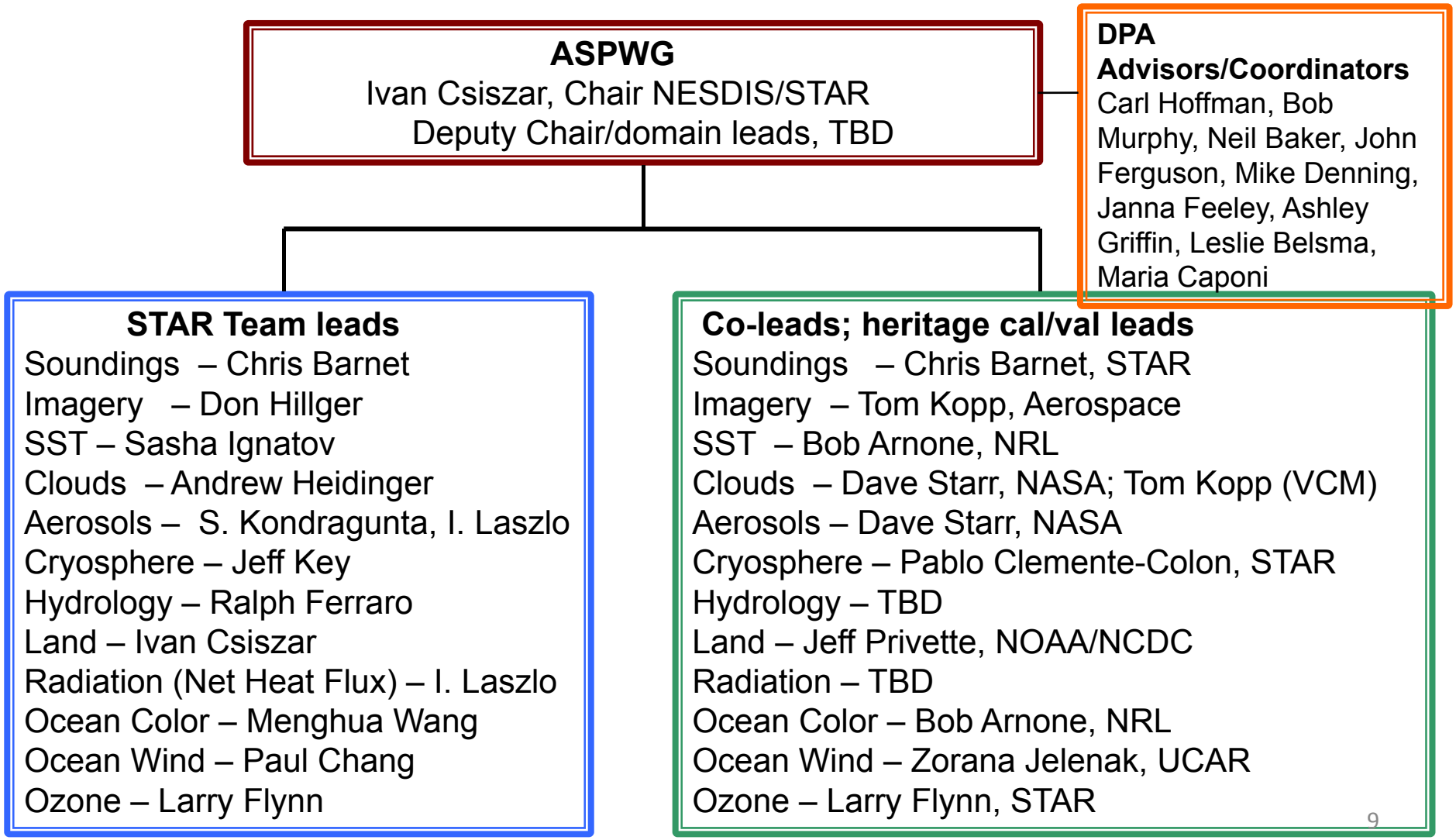


Figure 1: JPSS Hierarchical Structure and Responsibilities

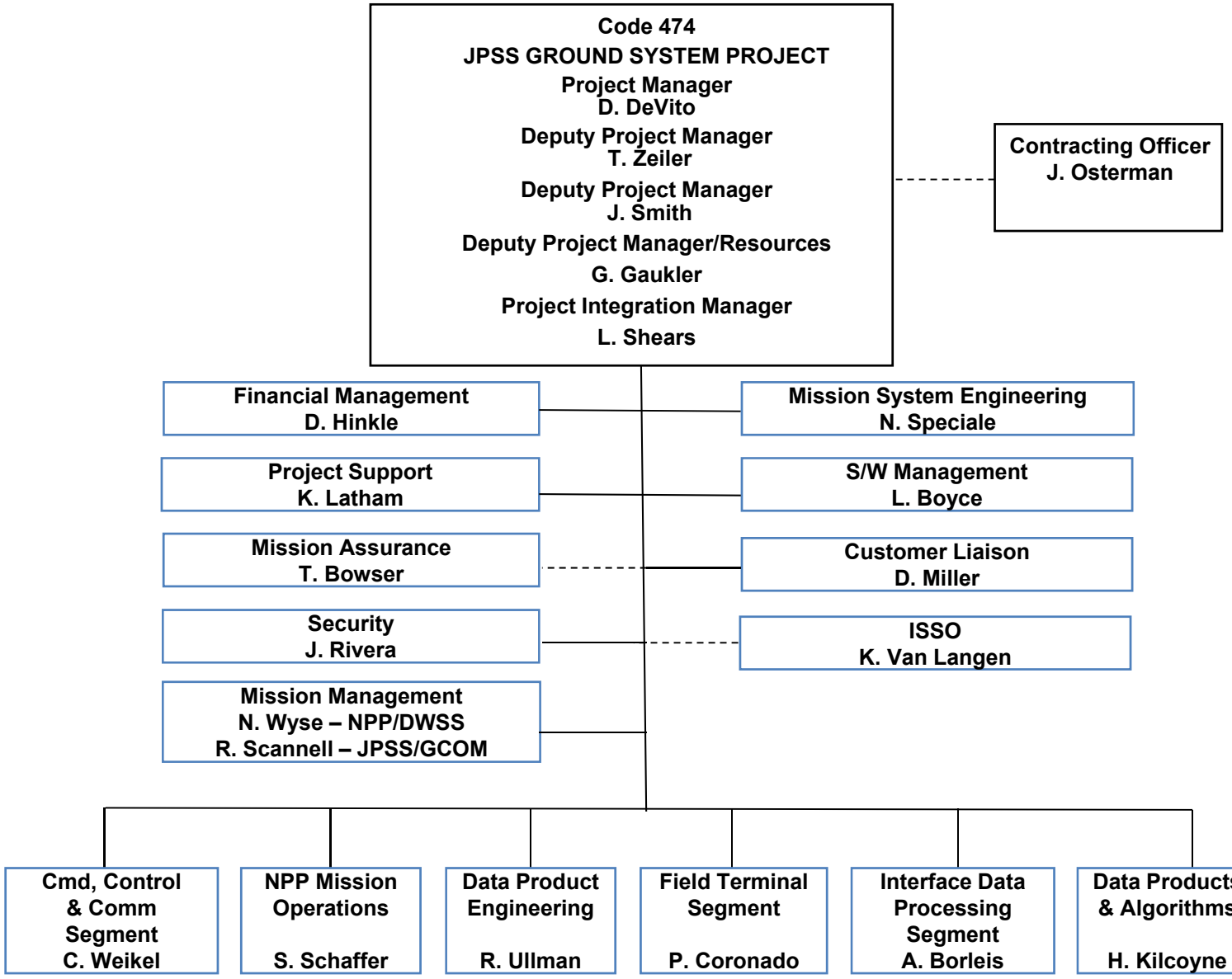
NPP/JPSS/ Sensor Science Working Group



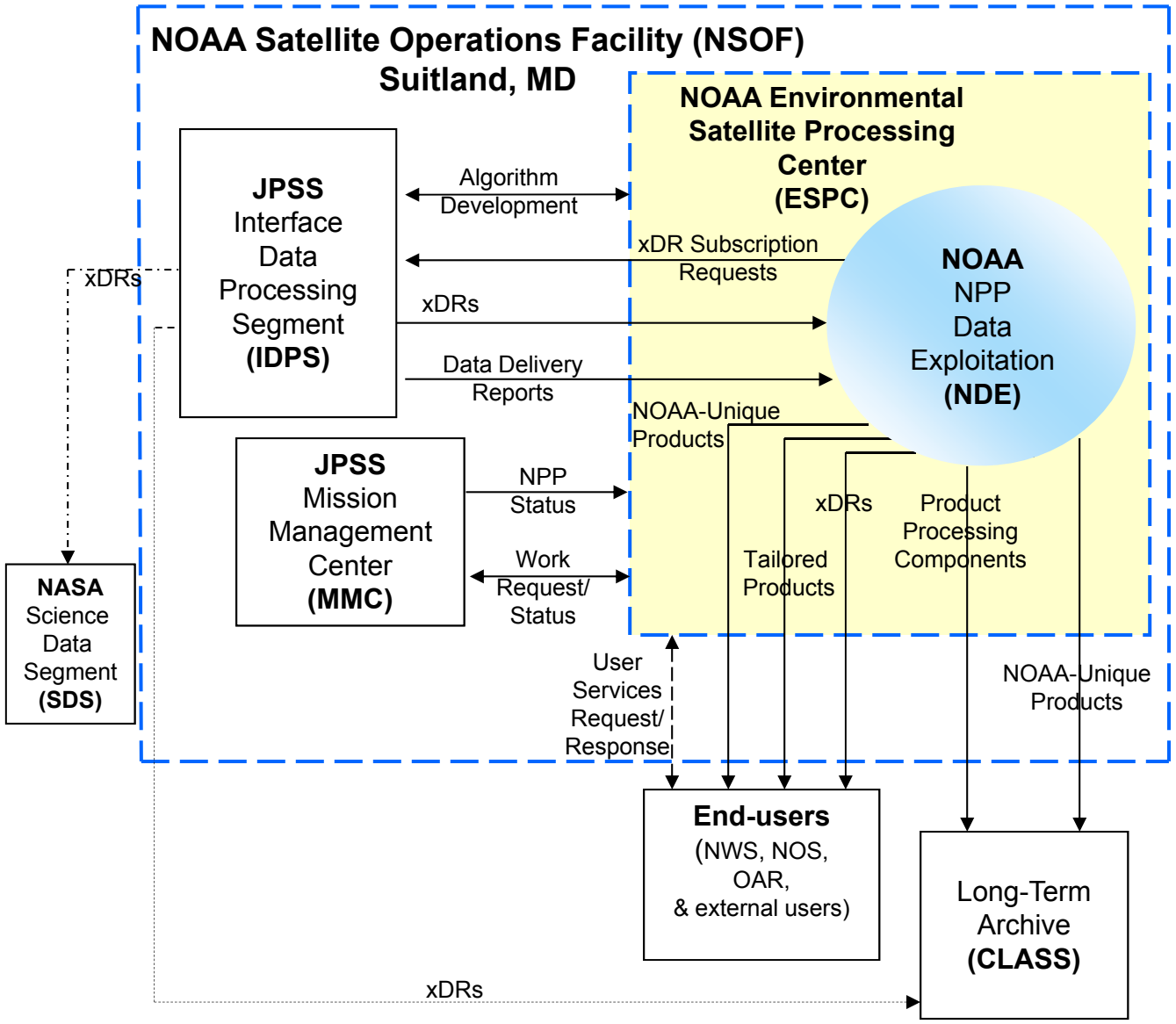
NPP/JPSS Algorithm Science and Product Working Group



JPSS Ground Project Organization



Functional Scope: The NESDIS Central



Office of Satellite & Product Operations (OSPO) will provide common services:

- Data Center Operations
- Telecommunications
- User Services (Help Desk)
- Config. Management
- Security Controls
- Distribution
- Ingest

Center for Satellite Applications and Research (STAR) and partners provides:

- Validation of sensor and environmental data records
- Algorithm development and improvements
- Supports both JPSS IDPS and NDE

Derived Products

VIIRS (22)

- ALBEDO (SURFACE)
- CLOUD BASE HEIGHT
- CLOUD COVER/LAYERS
- CLOUD EFFECTIVE PART SIZE
- CLOUD OPTICAL THICKNESS
- CLOUD TOP HEIGHT
- CLOUD TOP PRESSURE
- CLOUD TOP TEMPERATURE
- ICE SURFACE TEMPERATURE
- NET HEAT FLUX
- OCEAN COLOR/CHLOROPHYLL
- SUSPENDED MATTER
- VEGETATION INDEX
- AEROSOL OPTICAL THICKNESS
- AEROSOL PARTICLE SIZE
- ACTIVE FIRES
- IMAGERY
- SEA ICE CHARACTERIZATION
- SNOW COVER
- SEA SURFACE TEMPERATURE
- LAND SURFACE TEMP
- SURFACE TYPE

ESPC GCOM AMSR-2 (11)

- CLOUD LIQUID WATER
- PRECIPITATION TYPE/RATE
- PRECIPITABLE WATER
- SEA SURFACE WINDS SPEED
- SOIL MOISTURE
- SNOW WATER EQUIVALENT
- IMAGERY
- SEA ICE CHARACTERIZATION
- SNOW COVER/DEPTH
- SEA SURFACE TEMPERATURE
- SURFACE TYPE

OMPS (2)

- O_3 TOTAL COLUMN
- O_3 NADIR PROFILE

CERES (4)

- DOWN LW RADIATION (SFC)
- DOWN SW RADIATION (SFC)
- NET SOLAR RADIATION (TOA)
- OUTGOING LW RADIATION (TOA)

CrIS/ATMS (3)

- ATM VERT MOIST PROFILE
- ATM VERT TEMP PROFILE
- PRESSURE (SURFACE/PROFILE)

A-DCS

TSIS (1)

SOLAR IRRADIANCE

SARR & SARP

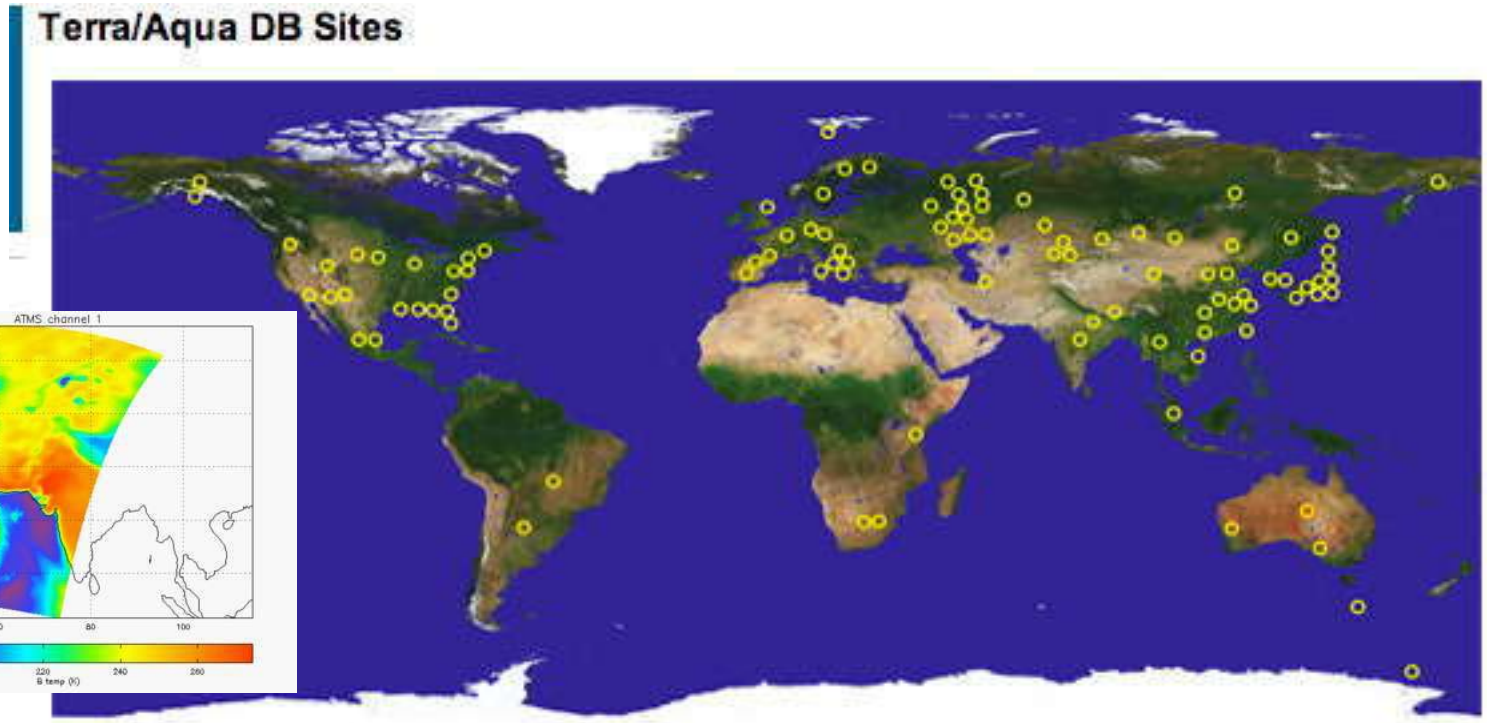
CrIS Thinned Radiances	Land Surface Temperature (ATMS)	Trace Gases (Carbon)
CrIS Cloud Cleared Radiances	Temperature Profiles (ATMS)	SST (AVHRR-like)
Total Precipitable Water (ATMS)	Moisture Profiles (ATMS)	Aerosol (AVHRR-like)
Snow Cover (ATMS)	Rain Water Path (ATMS)	Cloud Top Fraction (CrIS)
Precipitation Rate (ATMS)	Blended SST	Cloud Top Pressure (CrIS)
Land Surface Emissivity (ATMS)	SST Anomalies	Stability Products (CrIS)
Cloud Liquid Water (ATMS)	SST Degree Heating Weeks	Polar Winds (VIIRS)
Sea Ice Concentration (ATMS)	SST Hot Spots	Green Vegetation Fraction
Snow Water Equivalent (ATMS)	Coral Reef Bleaching Indices/Alerts	Blended Total Precipitable Water
Ice Water Path (ATMS)	Total Ozone (CrIS)	

NOAA Unique Products (NUPs)

KEY

- EDRs with Key Performance Parameters
- JPSS-1
- GCOM
- JPSS Program (Host TBD)

Direct Readout Stations using Xband



Output from CSPP test case

EOS Direct Broadcast Sites Worldwide – Updated January 25, 2010

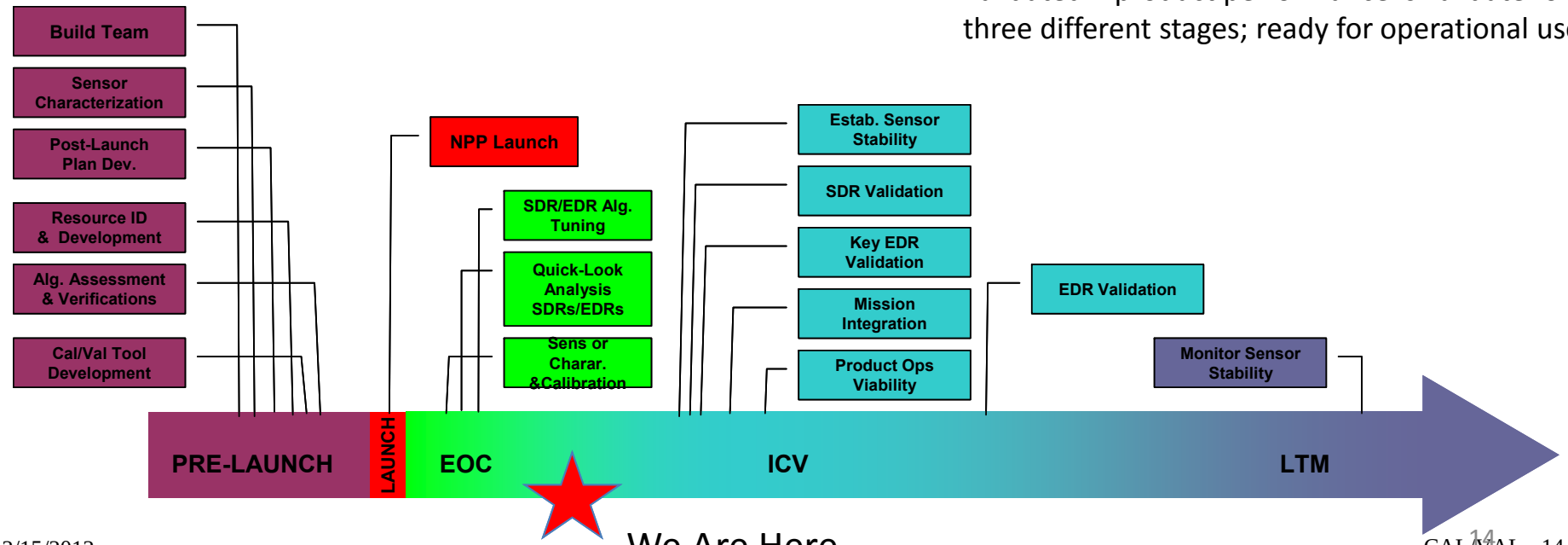
ANTARCTICA ARGENTINA AUSTRALIA BELARUS BRAZIL CHINA FINLAND FRANCE
GERMANY INDIA IRAN ITALY JAPAN KAZAKHSTAN KENYA MEXICO NORWAY
RUSSIA SCOTLAND SINGAPORE SOUTH AFRICA SOUTH KOREA SPAIN SWEDEN
TAIWAN THAILAND UNITED ARAB EMIRATES USA VIETNAM

UW CIMSS providing the Community Satellite Processing Package

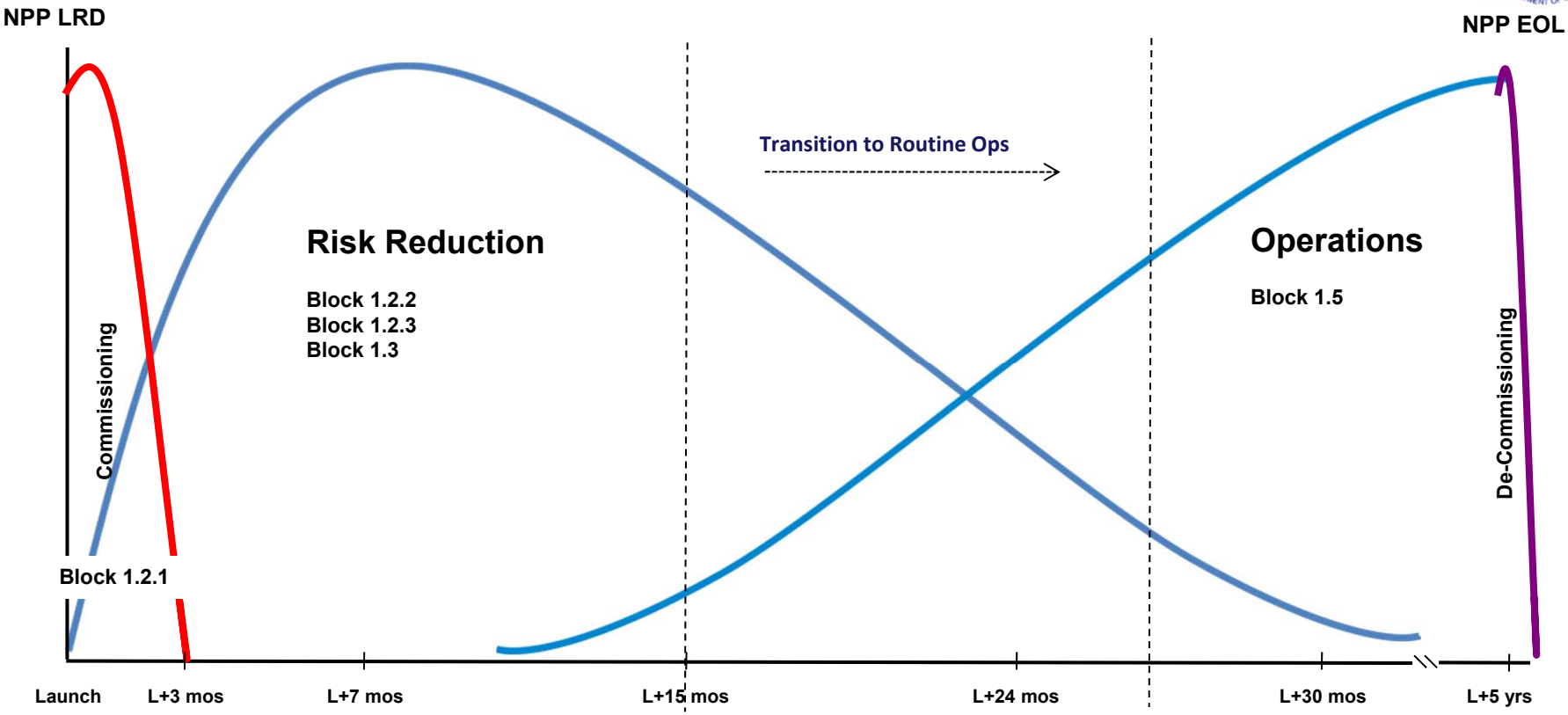
Cal/Val Phase Activities Defined for Each Product

- Four Phases of Cal/Val:
  1. Pre-Launch; all time prior to launch – Algorithm verification, sensor testing, and validation preparation
  2. Early Orbit Check-out (first 30-90 days) – System Calibration & Characterization
  3. Intensive Cal/Val (ICV); extending to approximately 24 months post-launch – xDR Validation
  4. Long-Term Monitoring (LTM); through life of sensors
- For each phase:
  - Exit Criteria established
  - Activities summarized
  - Products mature through phases independently

- Beta – products are minimally validated; available to users to verify formats and parameters
- Provisional – product quality may not be optimal, ready for operational evaluation
- Validated – product performance is validate for three different stages; ready for operational use



JPSS Ground System Evolution and NPP – On Orbit Mission Phases



Commissioning
- LEO
- S/C Activation
- Instrument Activation
- Sat Maneuver Verification
- Sat On-orbit Perf Evaluation

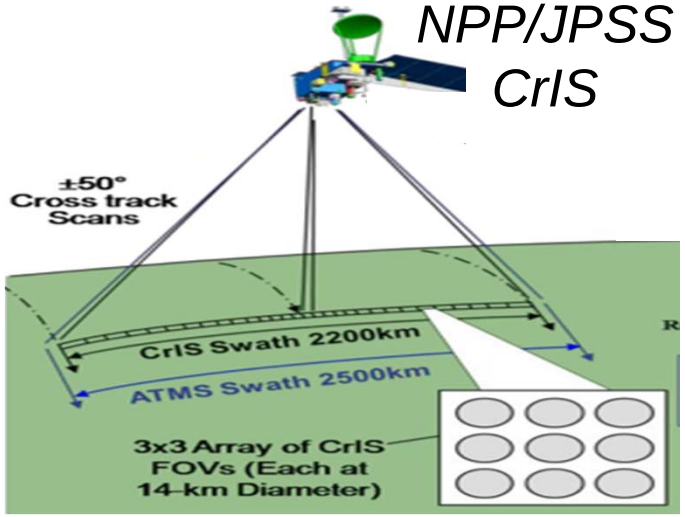
Risk Reduction
- Fixes / Enhancements
- Intensive Cal/Val
- Algorithm Fixes
- Cal / Characterization Maneuvers
- Operations Team Integration
- CGS Performance Tuning
- CGS Performance Eval
- Tech Refresh
- Security Updates
- Separate Operating Environs

Operations
- Nominal Operations
- Security Monitoring / Maintenance
- Ops Sustainment
- Long Term Monitoring & Trending
- Routine Cal Updates
- Periodic Cal Maneuvers

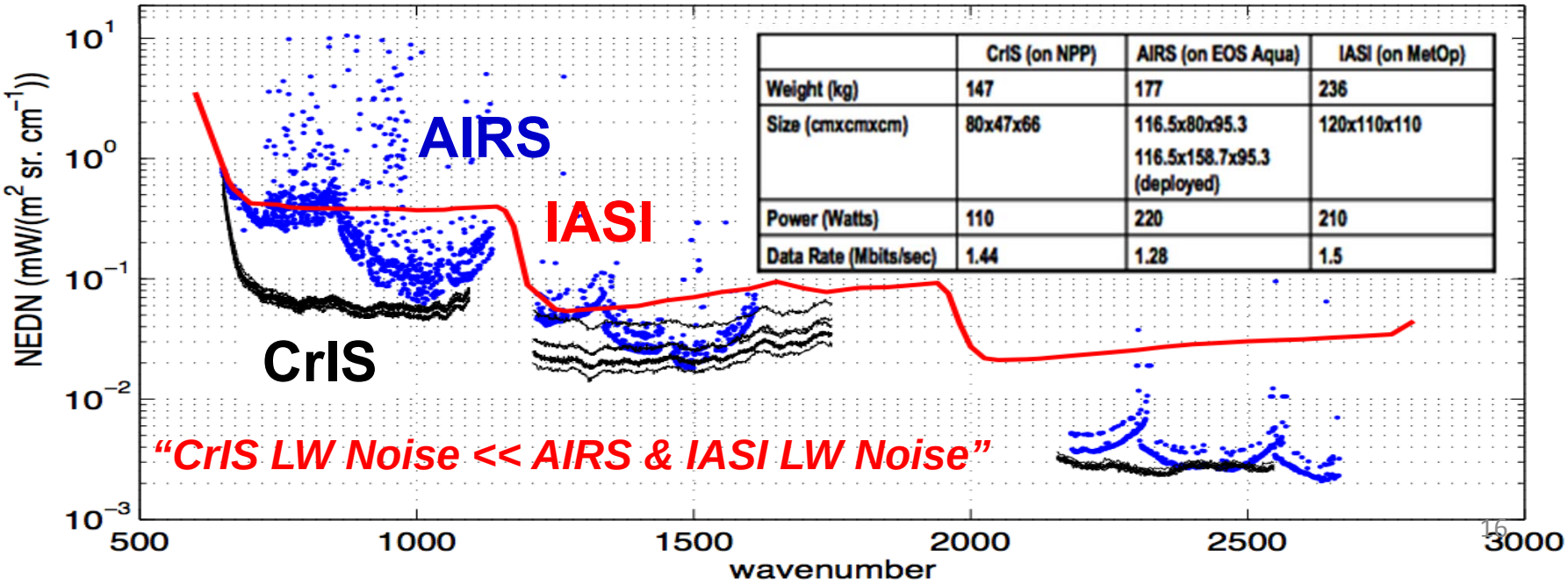
De-commissioning
- Sat Health & Propellant Monitoring
- De-orbit Planning / Script
- Controlled De-orbit

Cross-Track Infrared Sounder (CrIS)

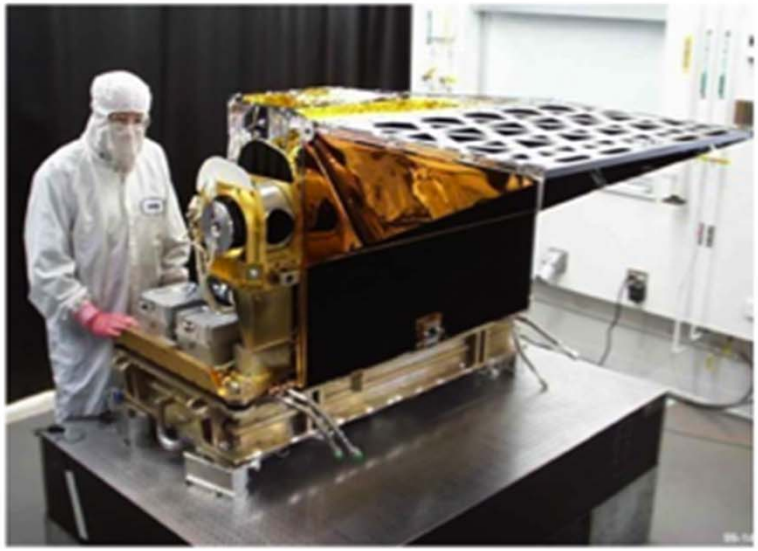
NPOESS Preparatory Satellite – Launch: October 2011



- Michelson Interferometer: 0.625,1.25, 2.5cm^{-1} (resolving power of 1000)
- Spectral range: 660-2600 cm^{-1}
- 3 x 3 HdCdTe focal plane passively cooled (4-stages) to 85K
- Focal plane 27 detectors, 1305 spectral channels
- 310 K Blackbody and space view provides radiometric calibration
- NEDT ranges from 0.05 K to 0. 5 K

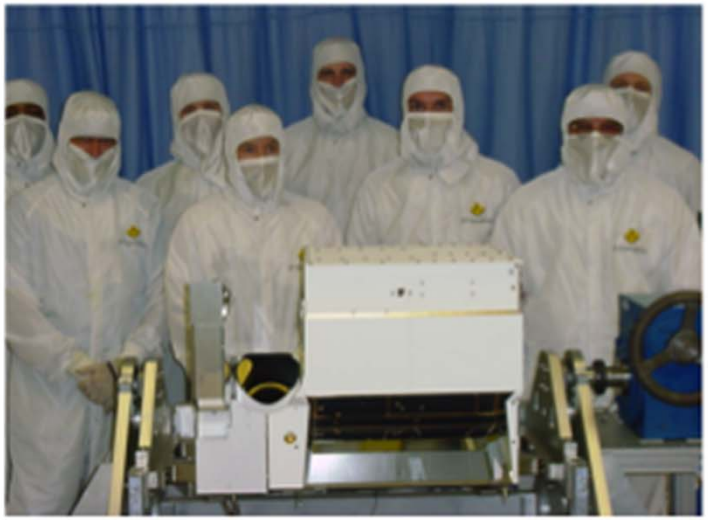


	CrIS (on NPP)	AIRS (on EOS Aqua)	IASI (on MetOp)
Weight (kg)	147	177	236
Size (cmxcmxcm)	80x47x66	116.5x80x95.3 116.5x158.7x95.3 (deployed)	120x110x110
Power (Watts)	110	220	210
Data Rate (Mbits/sec)	1.44	1.28	1.5



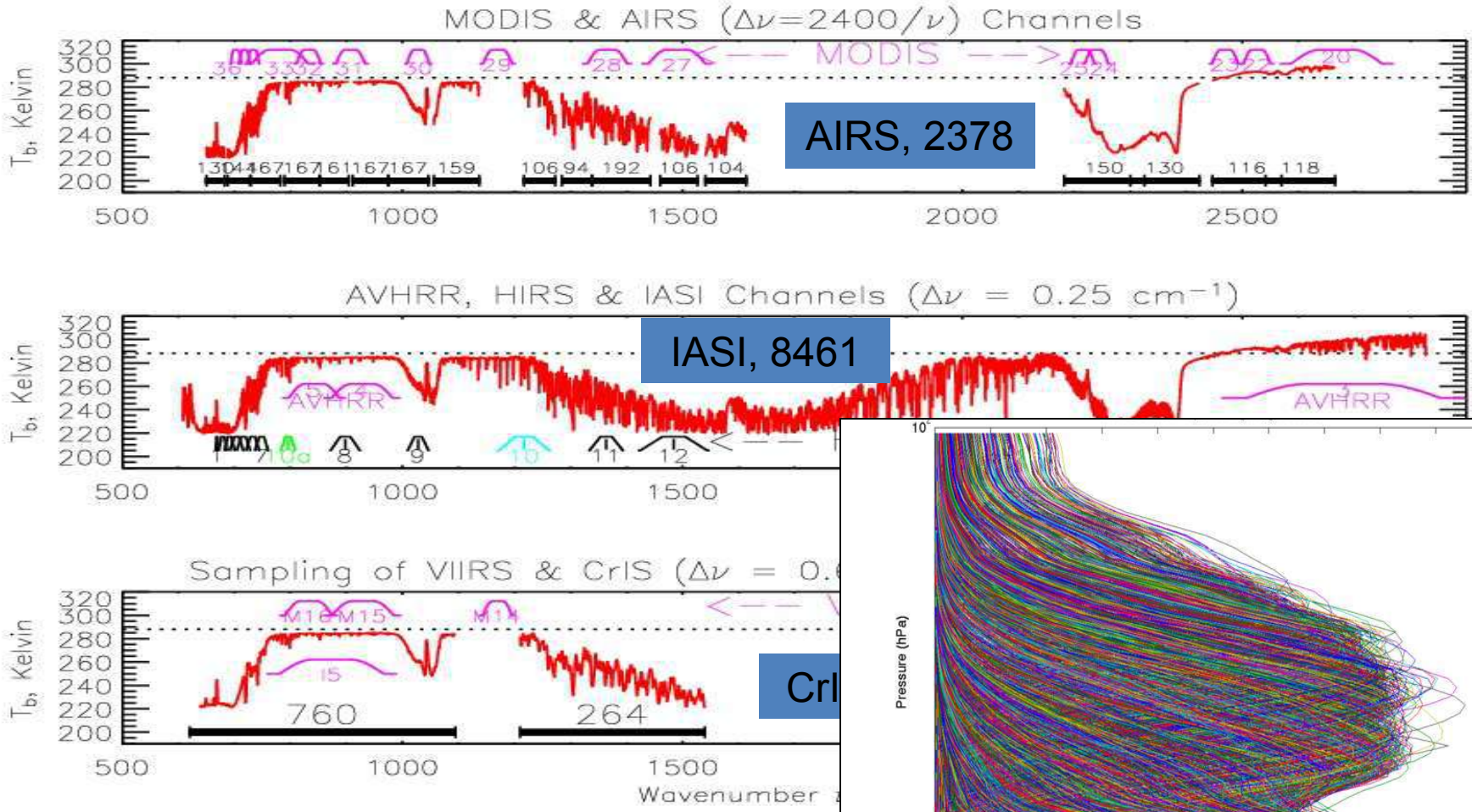
AIRS
Atmospheric InfraRed Sounder
Grating spectrometer
166 kg, 256 W
13.5 km FOV at nadir, contiguous
Launched on Aqua in 2002

IASI
Infrared Atmospheric Sounding Interferometer
Michelson interferometer
236 kg, 210 W
2x2 12 km FOVs at nadir, non-contiguous
Launched on Metop-A in 2006



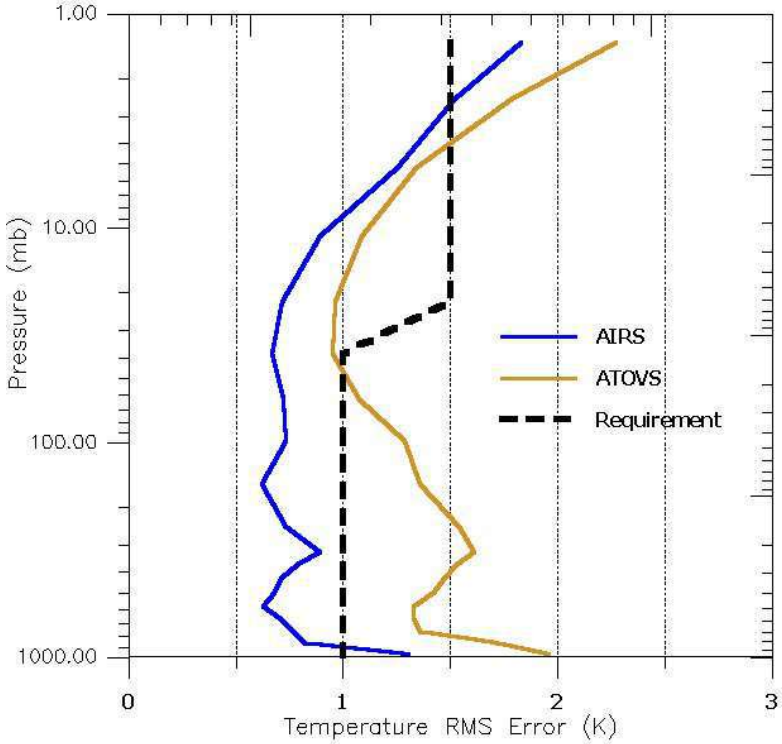
CrIS
Cross-track Infrared Sounder
Michelson interferometer
146 kg, 110 W
3x3 14 km FOVs at nadir, contiguous
To be launched on NPP

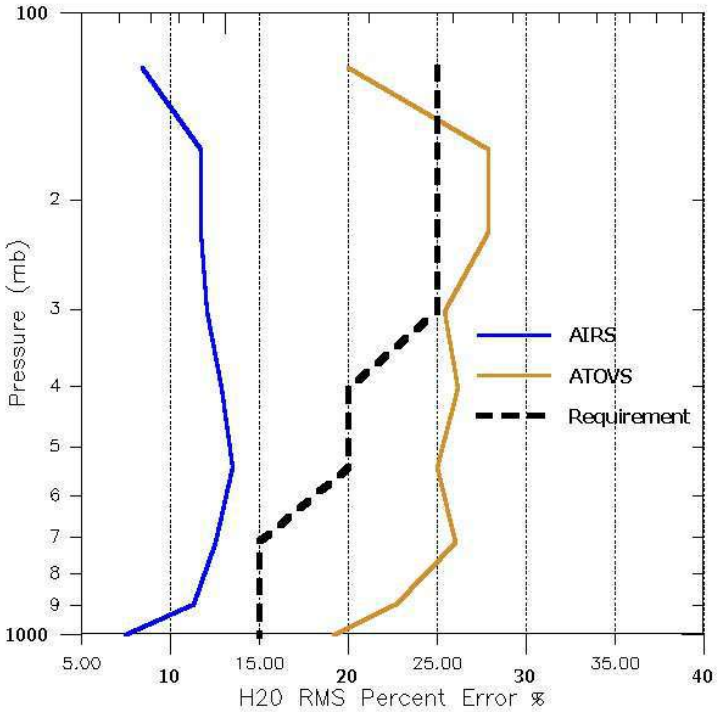
Spectral Coverage and Example Observations of AIRS, IASI, and CrIS



CIMSS

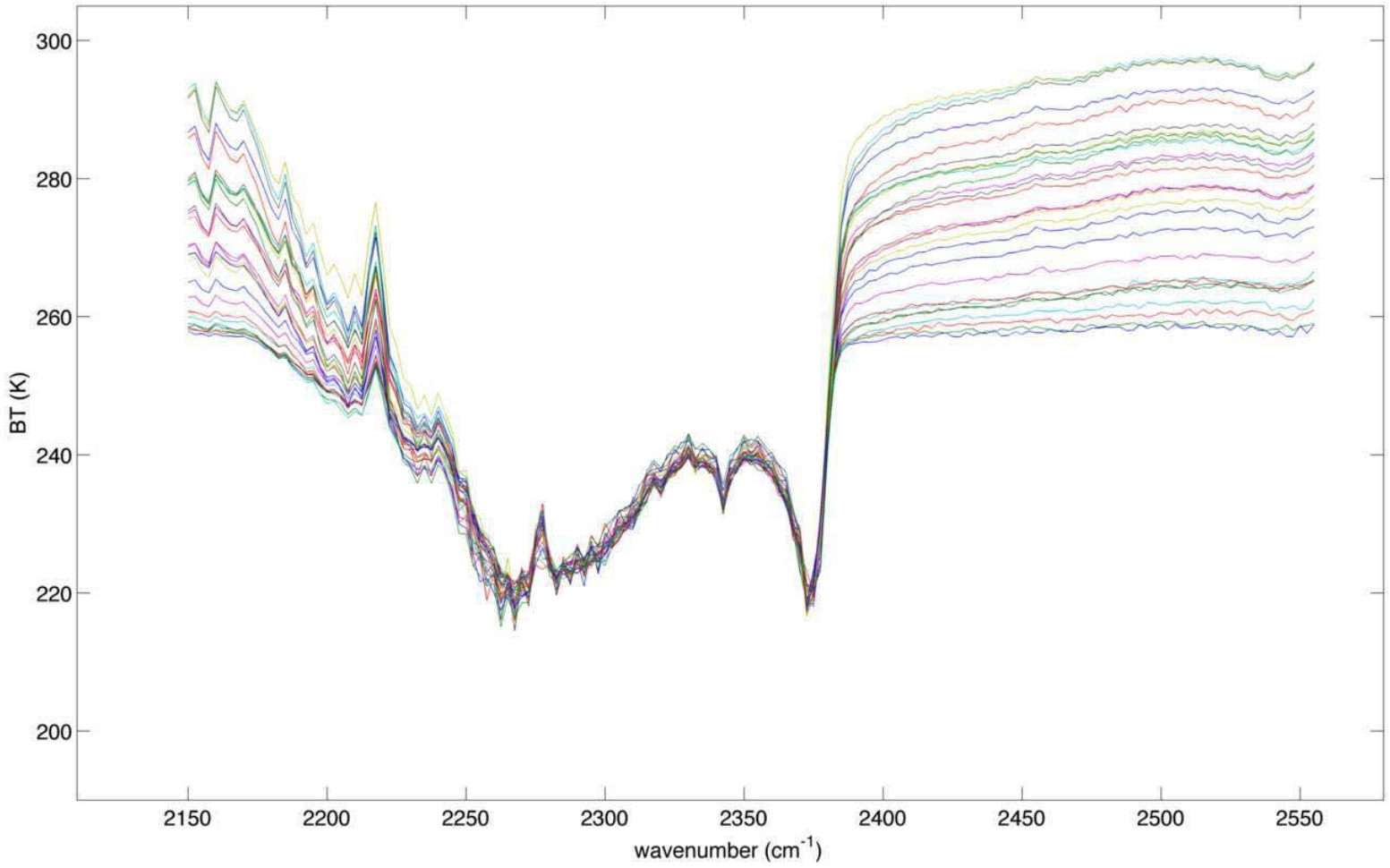
Benefits
(Improvements)

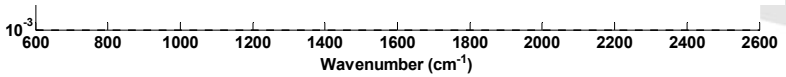




- CrIS (AIRS as proxy) provides significant improvements in temperature and moisture soundings over POES
  - Vertical resolution has improved from 3-5 km to 1-2 km
  - Improves accuracy of forecasts

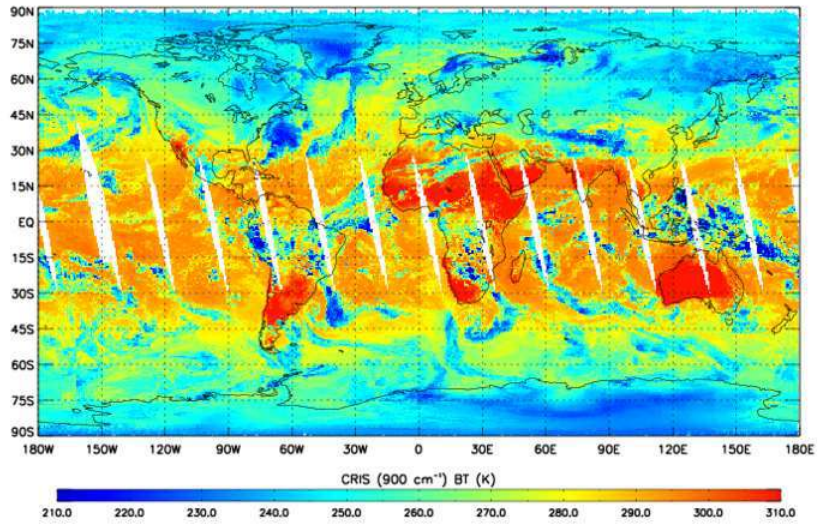
Example spectra (UW) and Noise Estimates (SDL)



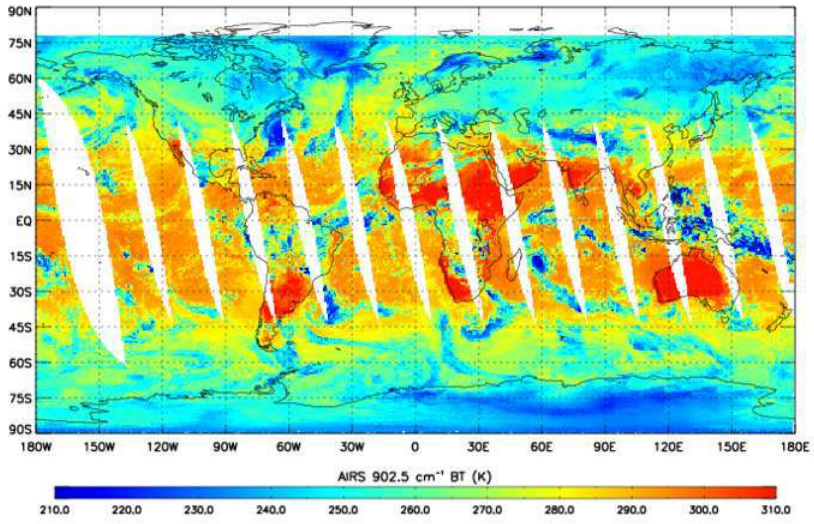


Comparison of CriS and AIRS for LW Window

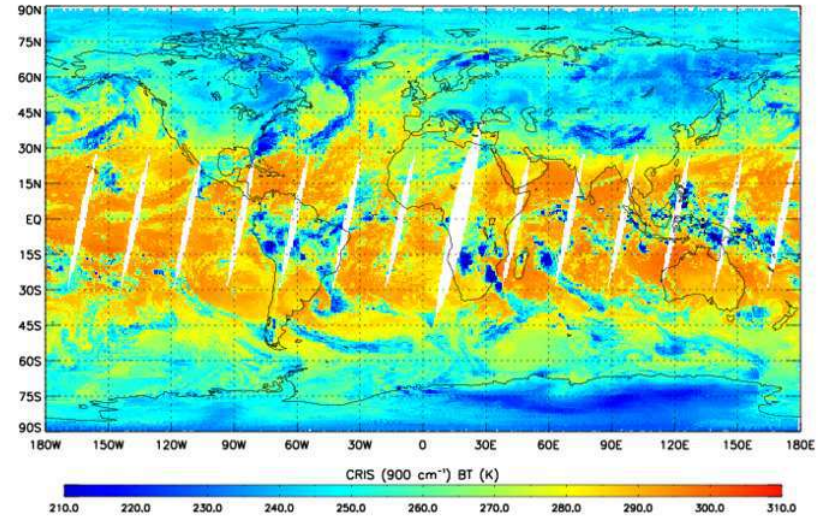
Ascending_orbits: CRIS (900 cm^{-1}) BT (K) Date: 2012-02-11



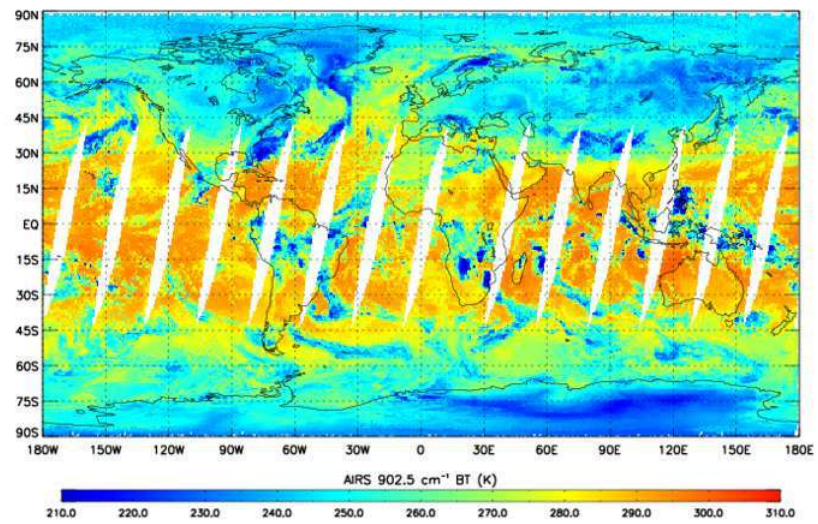
Ascending_orbits: AIRS 902.5 cm^{-1} BT (K) Date: 2012-02-11



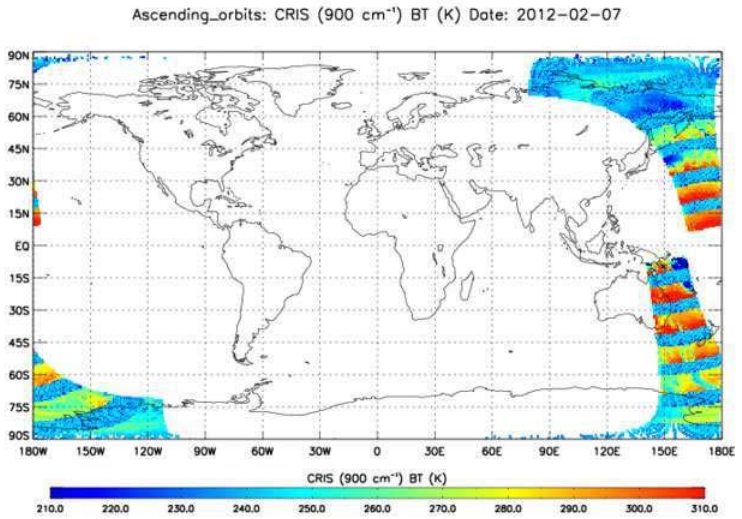
Descending_orbits: CRIS (900 cm^{-1}) BT (K) Date: 2012-02-11

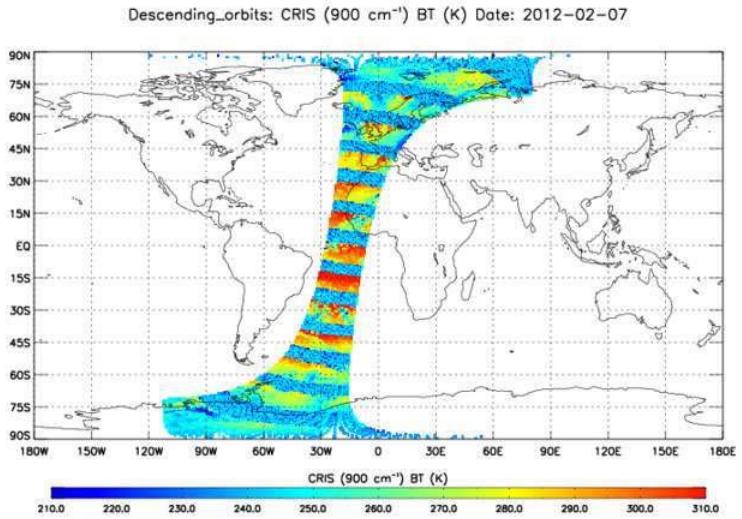


Descending_orbits: AIRS 902.5 cm^{-1} BT (K) Date: 2012-02-11

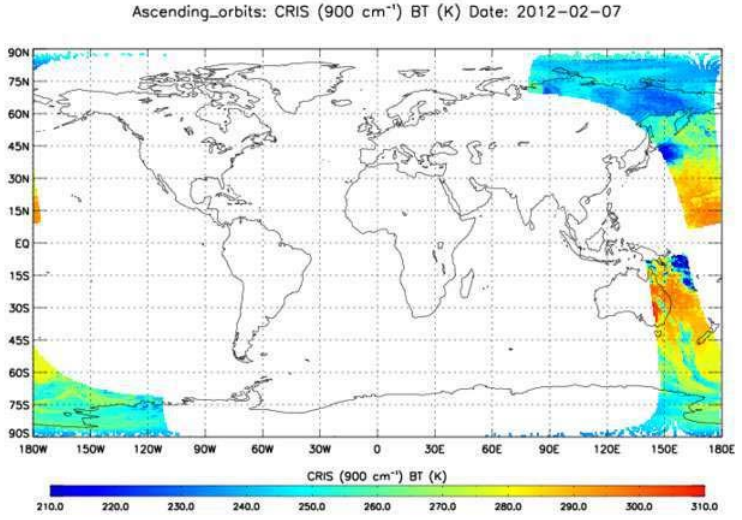


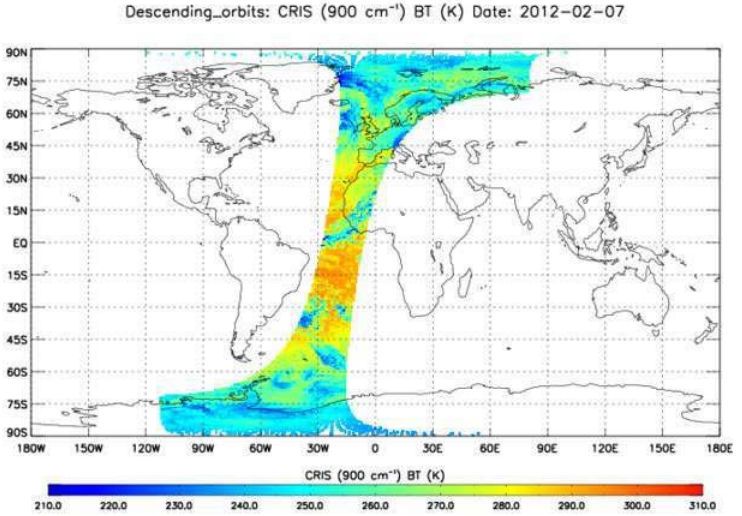
Radiance before & after the trim table problem fix





before

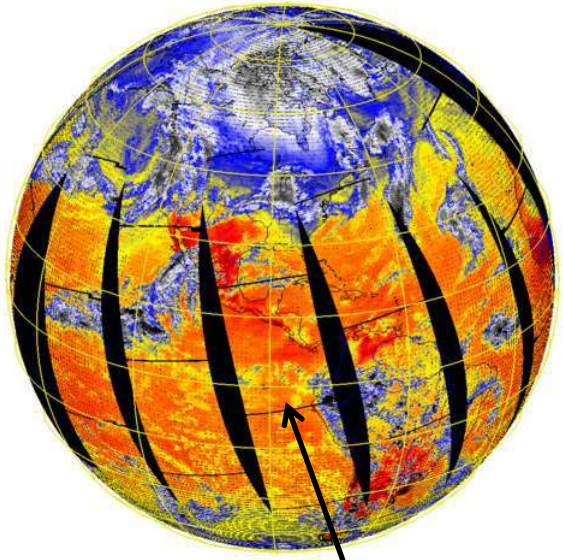


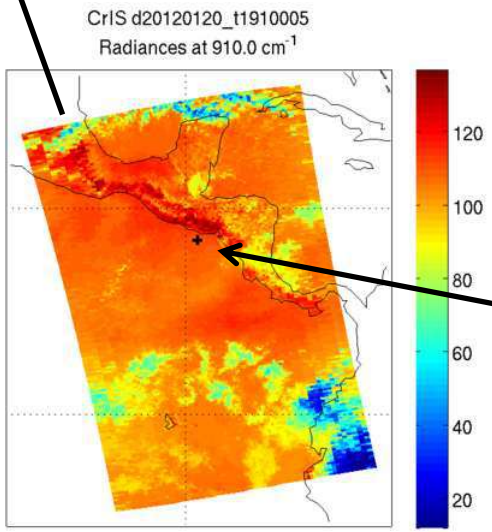


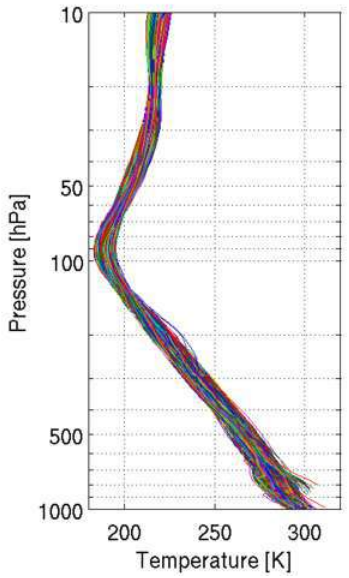
after

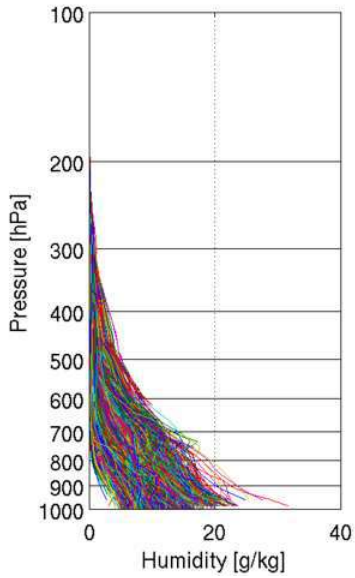
CrIS RTV for 20 Jan 2012, t1910005

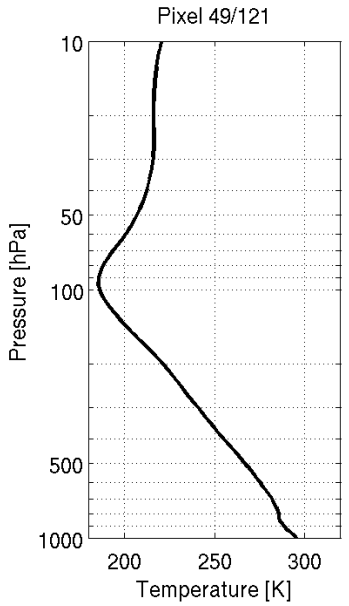
Single profiles

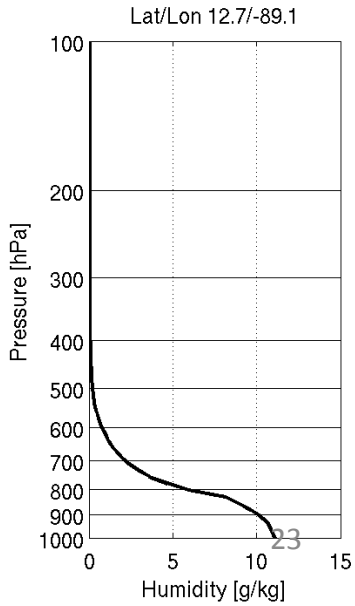








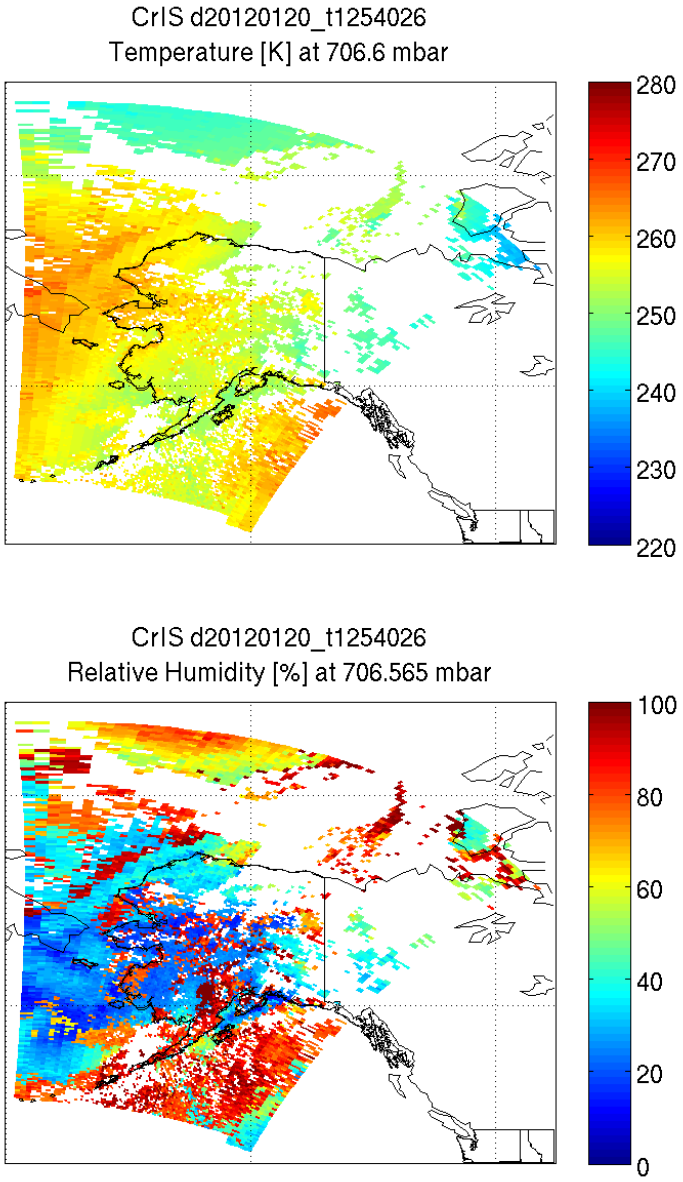


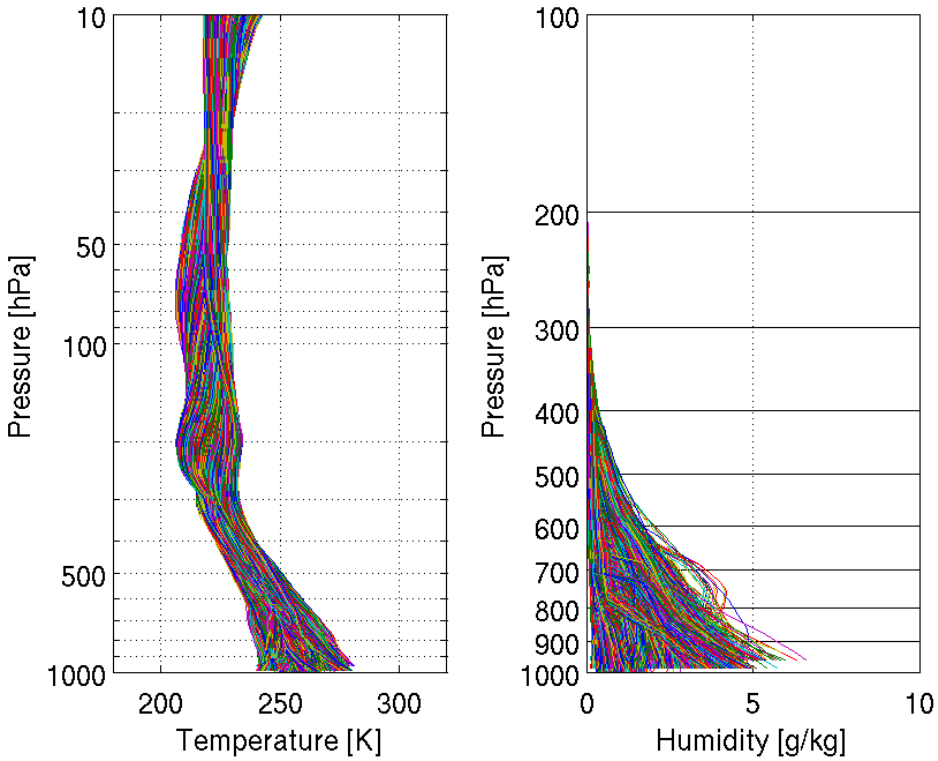


Courtesy: Dave Tobin, Bill Smith
Elisabeth Weisz

CrIS RTV for 20 Jan 2012, t1254026

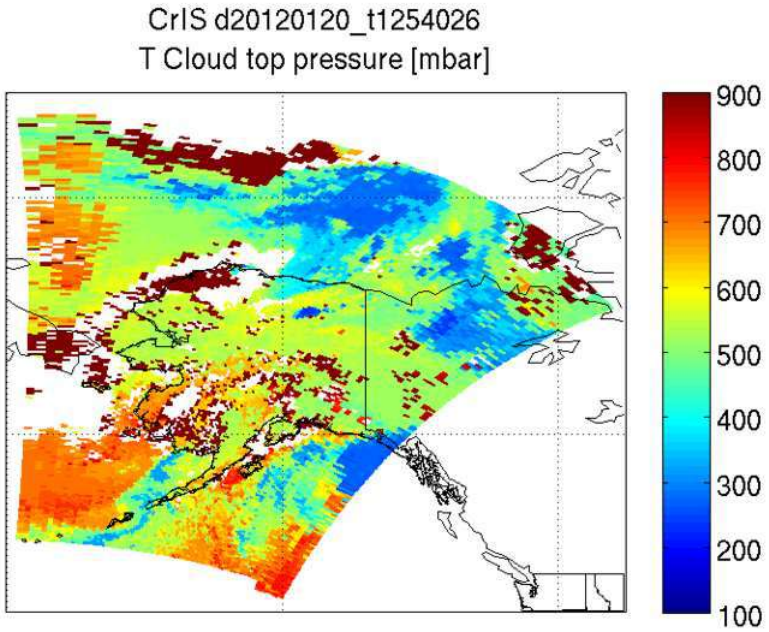
Temperature and Humidity

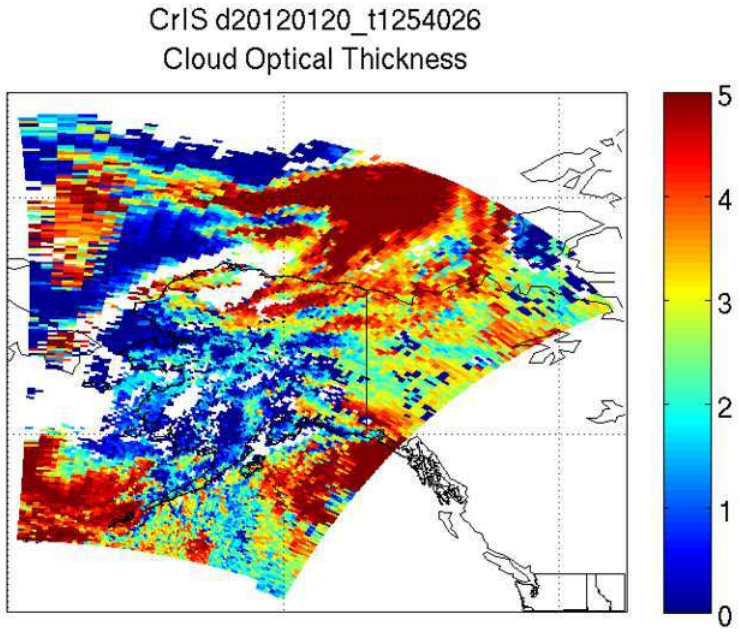




CrIS 20 Jan 2012, t1254026

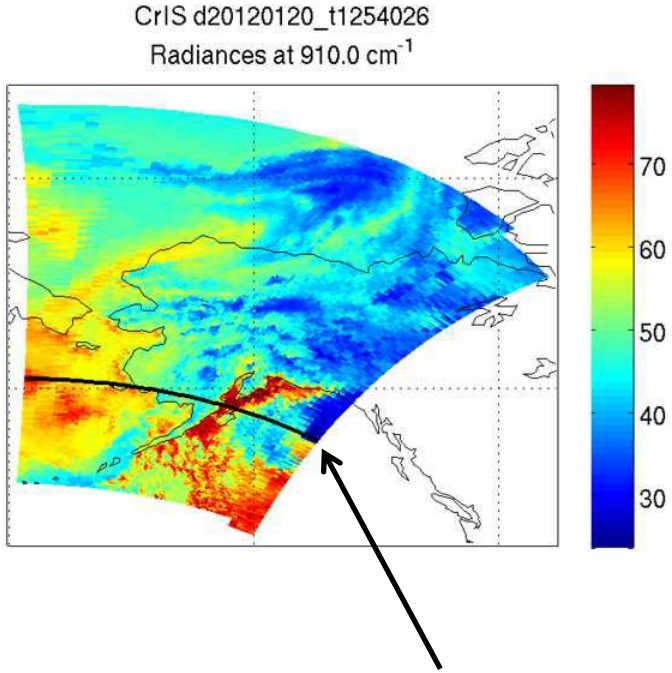
Cloud Top pressure and Cloud Optical Thickness



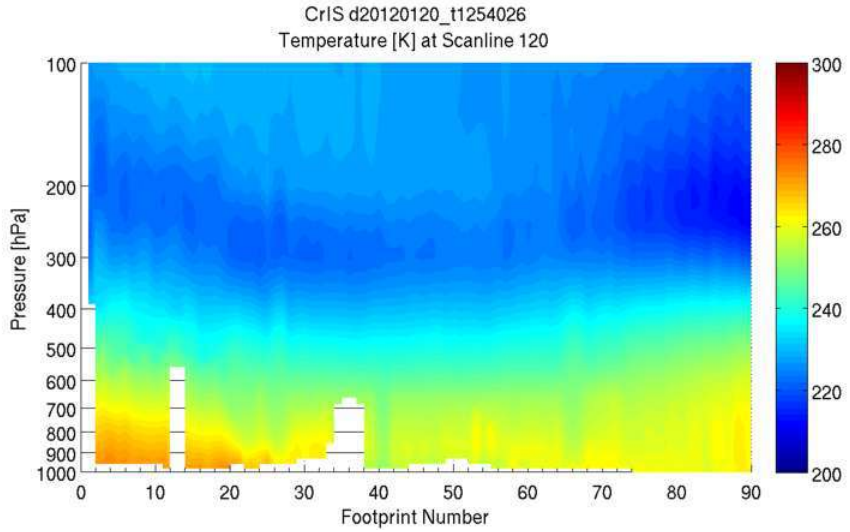


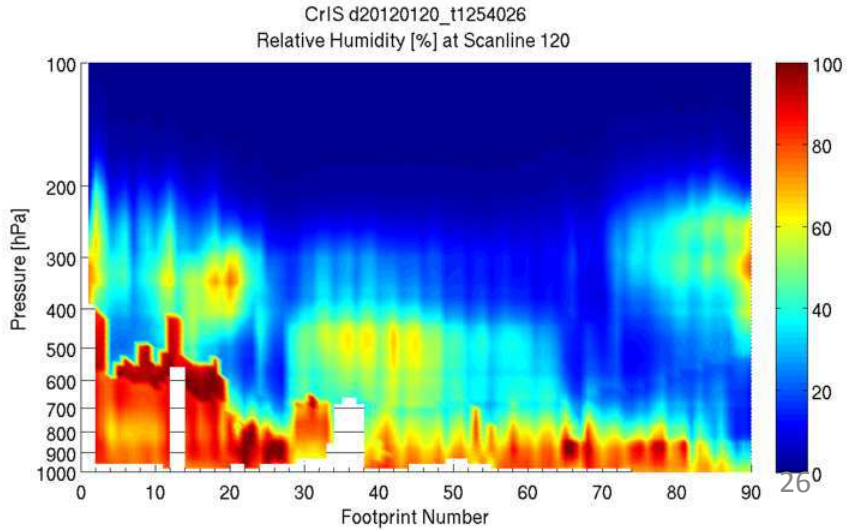
CrIS RTV for 20 Jan 2012, t1254026

Temperature and Relative Humidity Cross-sections



Scanline 120





Advanced Technology Microwave Sounder
Northrop Grumman Electronic Systems

Description

- **Purpose:** In conjunction with CrIS, global observations of temperature and moisture profiles at high temporal resolution (~ daily).
- **Predecessor Instruments:** AMSU A1 / A2, MHS
- **Approach:** Scanning passive microwave radiometer
- 22 channels (23GHz - 183GHz)
- **Swath width:** 2600 km
- **Co-registration:** with CrIS

ATMS Design Challenge

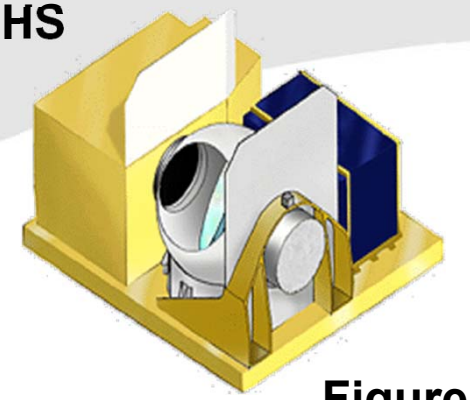
AMSU-A1

- 73x30x61 cm
- 67 W
- 54 kg
- 3-yr life

AMSU-A2

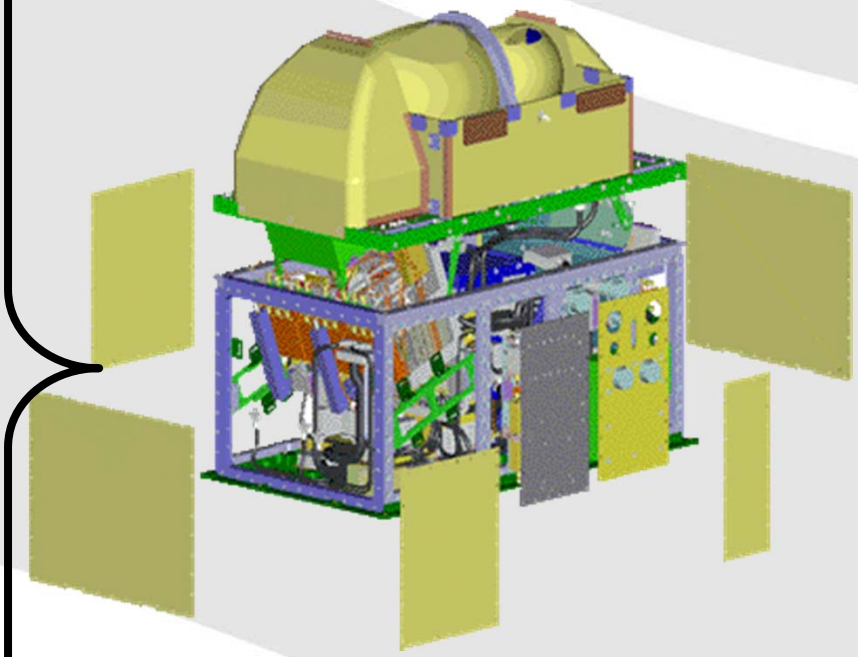
- 75x70x64 cm
- 24 W
- 50 kg
- 3-yr life

MHS



- 75x56x69 cm
- 61 W
- 50 kg
- 4-yr life

Reduce the volume by 3x



- 70x40x60 cm
- 110 W
- 85 kg
- 8 year life

Figure courtesy NGES, Azusa, CA

Spectral Differences: ATMS vs. AMSU/MHS

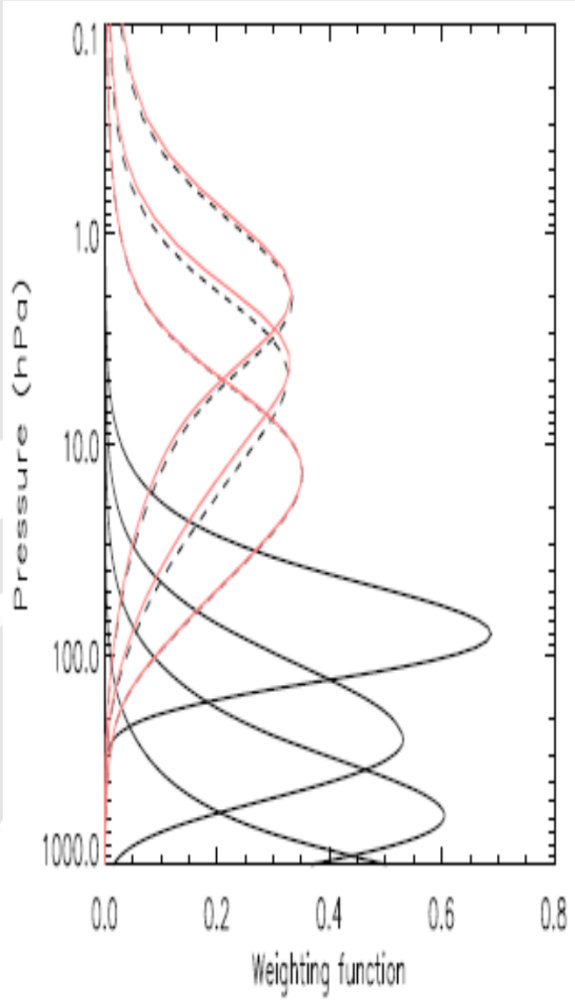
	AMSU/MHS			ATMS		
	Ch	GHz	Pol	Ch	GHz	Pol
AMSU-A	1	23.8	QV	1	23.8	QV
	2	31.399	QV	2	31.4	QV
	3	50.299	QV	3	50.3	QH
				4	51.76	QH
	4	52.8	QV	5	52.8	QH
	5	53.595 ± 0.115	QH	6	53.596 ± 0.115	QH
	6	54.4	QH	7	54.4	QH
	7	54.94	QV	8	54.94	QH
	8	55.5	QH	9	55.5	QH
	9	fo = 57.29	QH	10	fo = 57.29	QH
	10	fo ± 0.217	QH	11	fo±0.3222±0.217	QH
	11	fo±0.3222±0.048	QH	12	fo± 0.3222±0.048	QH
	12	fo ±0.3222±0.022	QH	13	fo±0.3222±0.022	QH
	13	fo± 0.3222±0.010	QH	14	fo±0.3222 ±0.010	QH
	14	fo±0.3222±0.0045	QH	15	fo± 0.3222±0.0045	QH
MHS	15	89.0	QV			
	16	89.0	QV	16	88.2	QV
	17	157.0	QV	17	165.5	QH
	18	183.31 ± 1	QH	18	183.31 ± 7	QH
	19	183.31 ± 3	QH	19	183.31 ± 4.5	QH
	20	191.31	QV	20	183.31 ± 3	QH
				21	183.31 ± 1.8	QH
				22	183.31 ± 1	QH

- **ATMS has 22 channels and AMSU/MHS have 20, with polarization differences between some channels**
  - **QV = Quasi-vertical; polarization vector is parallel to the scan plane at nadir**
  - **QH = Quasi-horizontal; polarization vector is perpendicular to the scan plane at nadir**

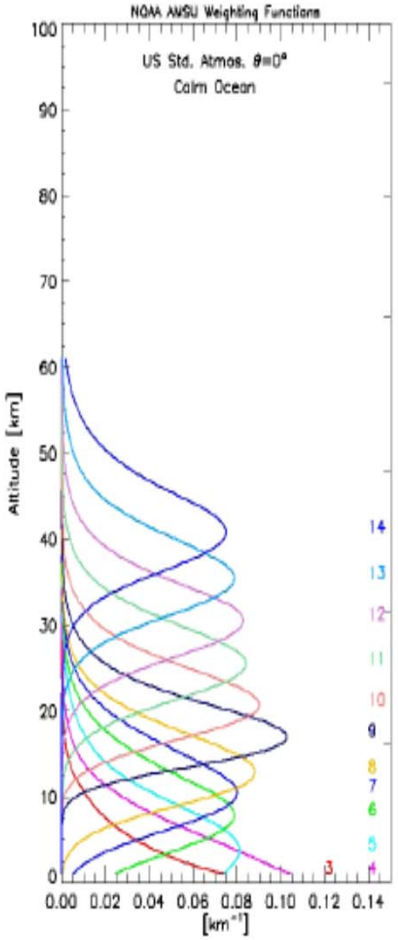
Exact match to AMSU/MHS
Only Polarization different
Unique Passband
Unique Passband, and Pol. different from closest AMSU/MHS channels

Microwave Temperature Sounding Vertical Resolution

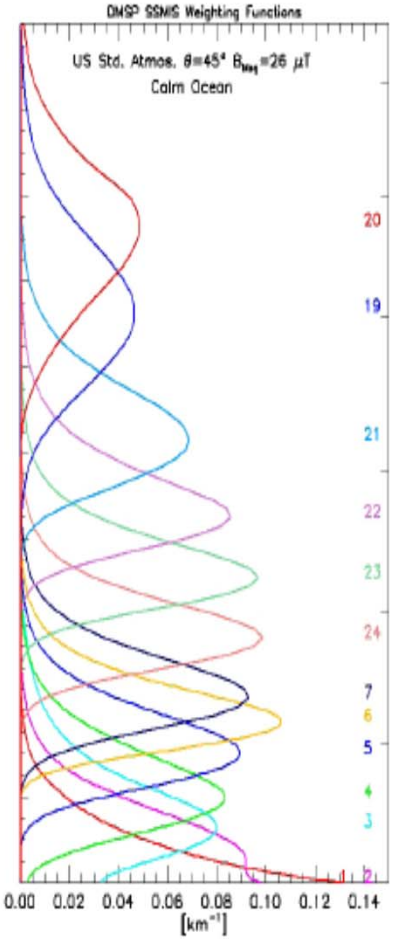
MSU+SSU (1978-2007)



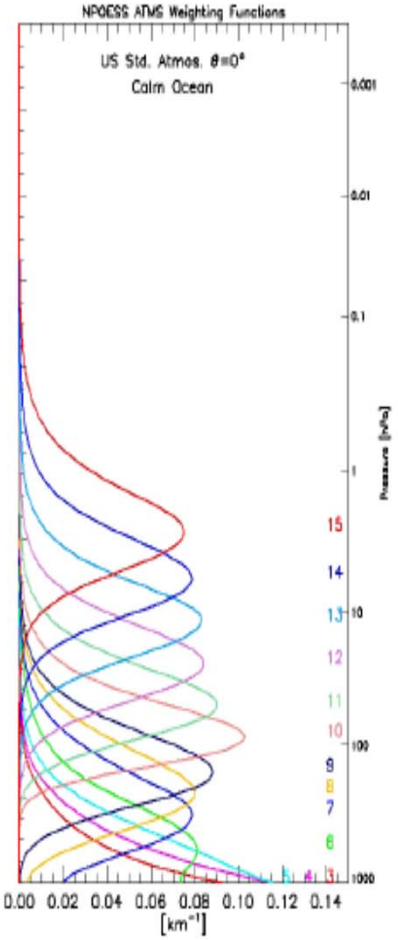
AMSU-A



SSMIS



ATMS



Spatial Differences: ATMS vs. AMSU/MHS

Beamwidth (degrees)

	ATMS	AMSU/MHS
23/31 GHz	5.2	3.3
50-60 GHz	2.2	3.3
89-GHz	2.2	1.1
160-183 GHz	1.1	1.1

Spatial sampling

	ATMS	AMSU/MHS
23/31 GHz	1.11	3.33
50-60 GHz	1.11	3.33
89-GHz	1.11	1.11
160-183 GHz	1.11	1.11
Swath (km)	~2600	~2200

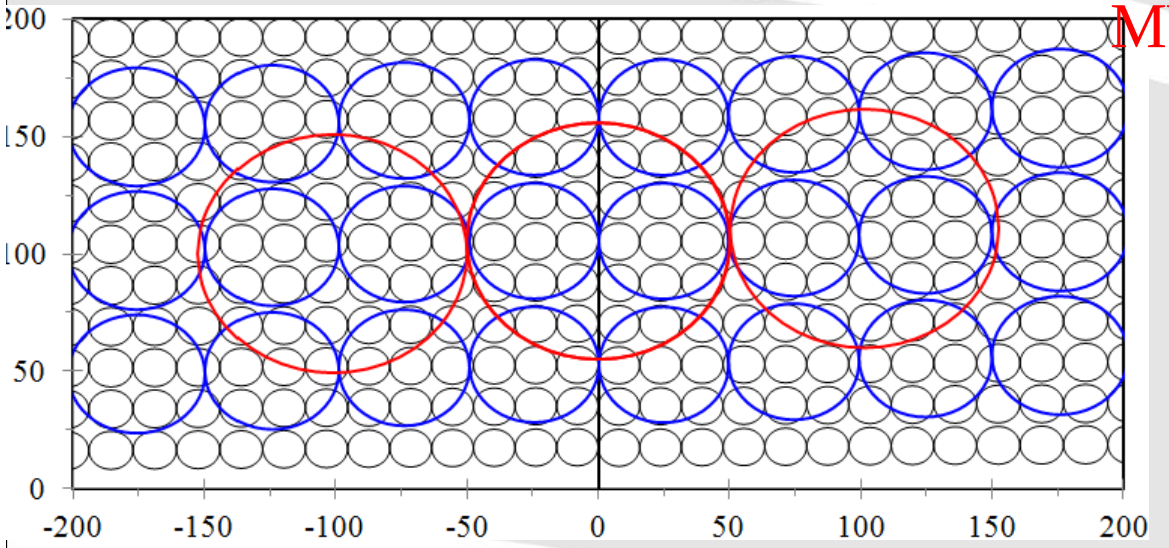
ATMS scan period: 8/3 sec; AMSU-A scan period: 8 sec
ATMS measures 96 footprints per scan (30/90 for AMSU-A/B)

NOAA, NPP and FY-3 MW Sounder FOV

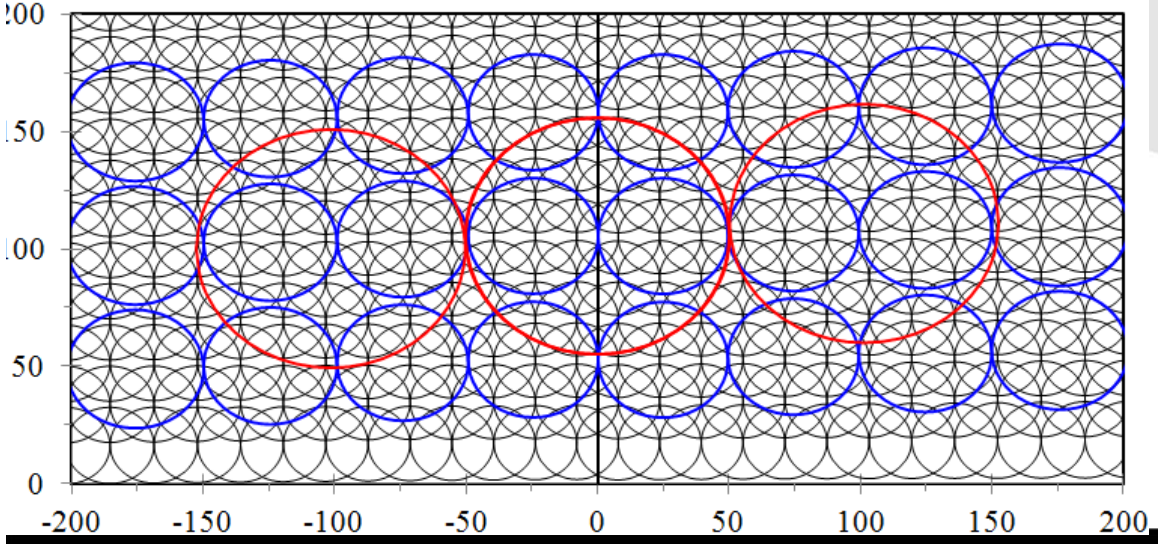
ATMS AMSU-A

MWTS

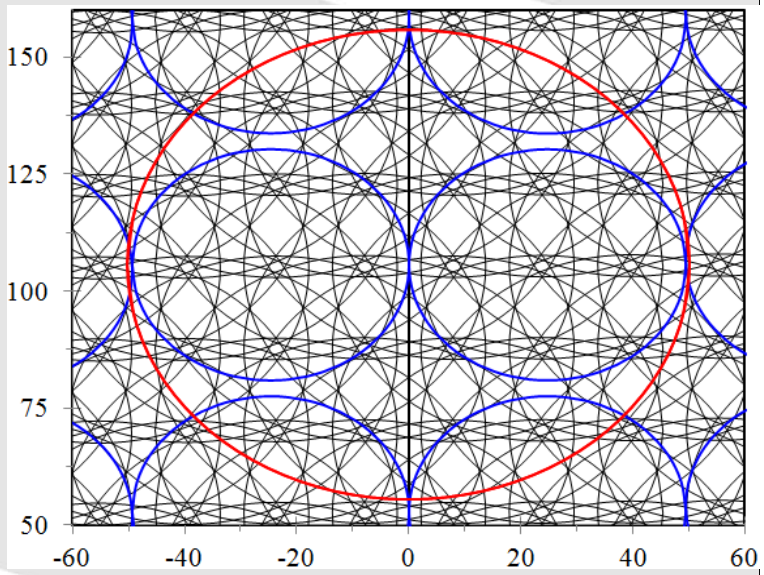
ATMS beam width 1.1º



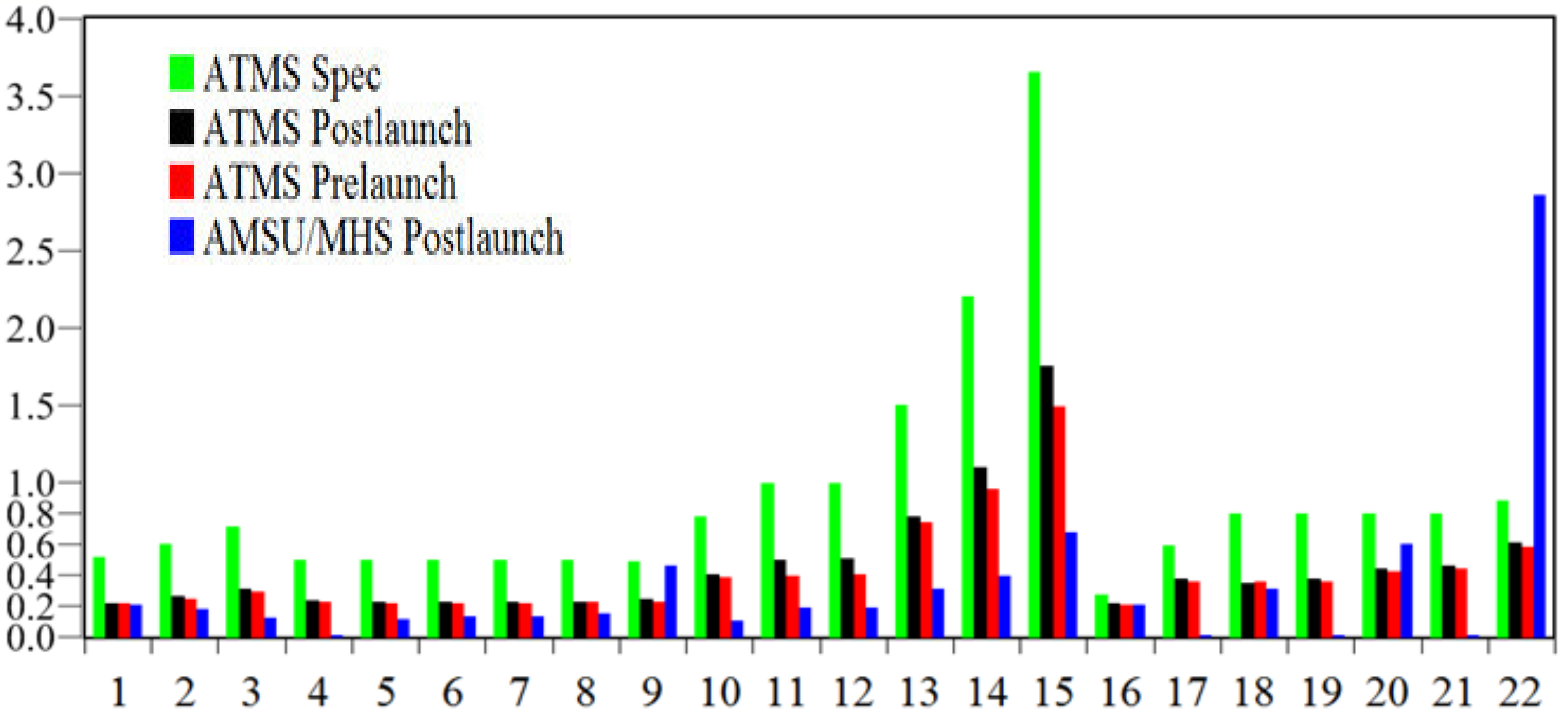
ATMS beam width 2.2º



ATMS beam width 5.2º

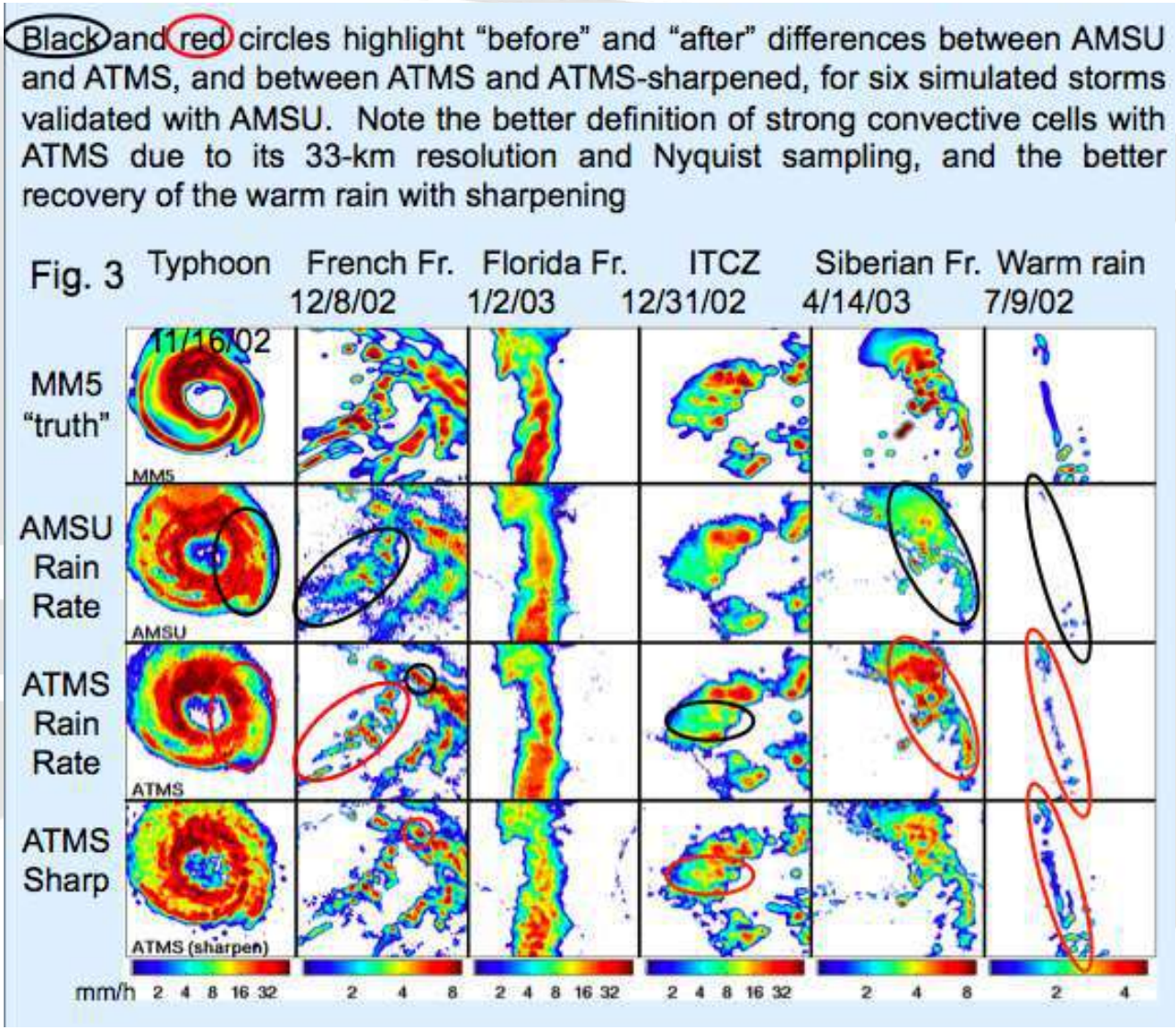


ATMS Inst. Performance



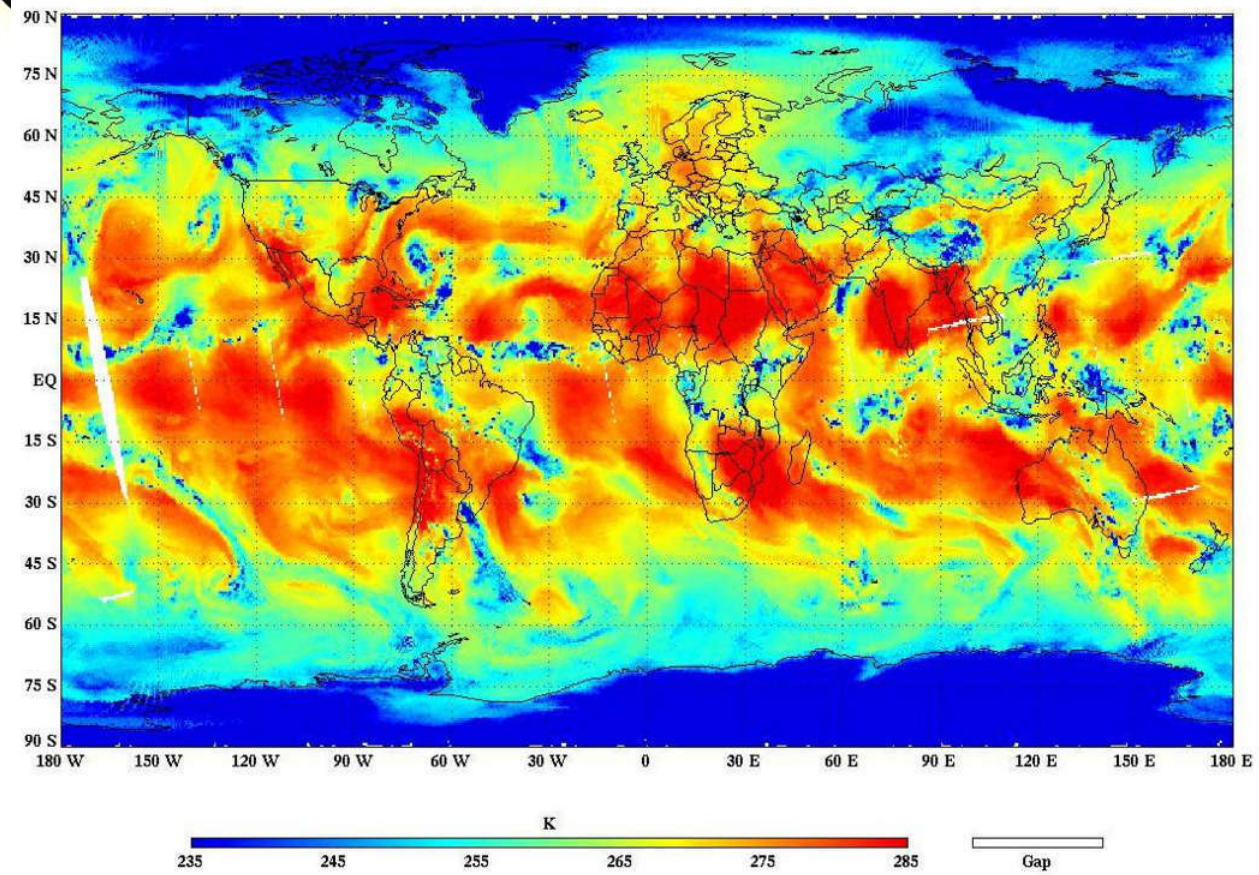
ATMS Noise Equivalent
Differential Temperature (NEDT)
in comparison with AMSU-A/MHS

ATMS Storm Mapping: Improvements Relative to AMSU



Source: Surussavadee and Staelin, NASA PMM Presentation, 7/08

First global ATMS image showing the channel 18-microwave antenna temperature at 183.3 GHz on November 8, 2011

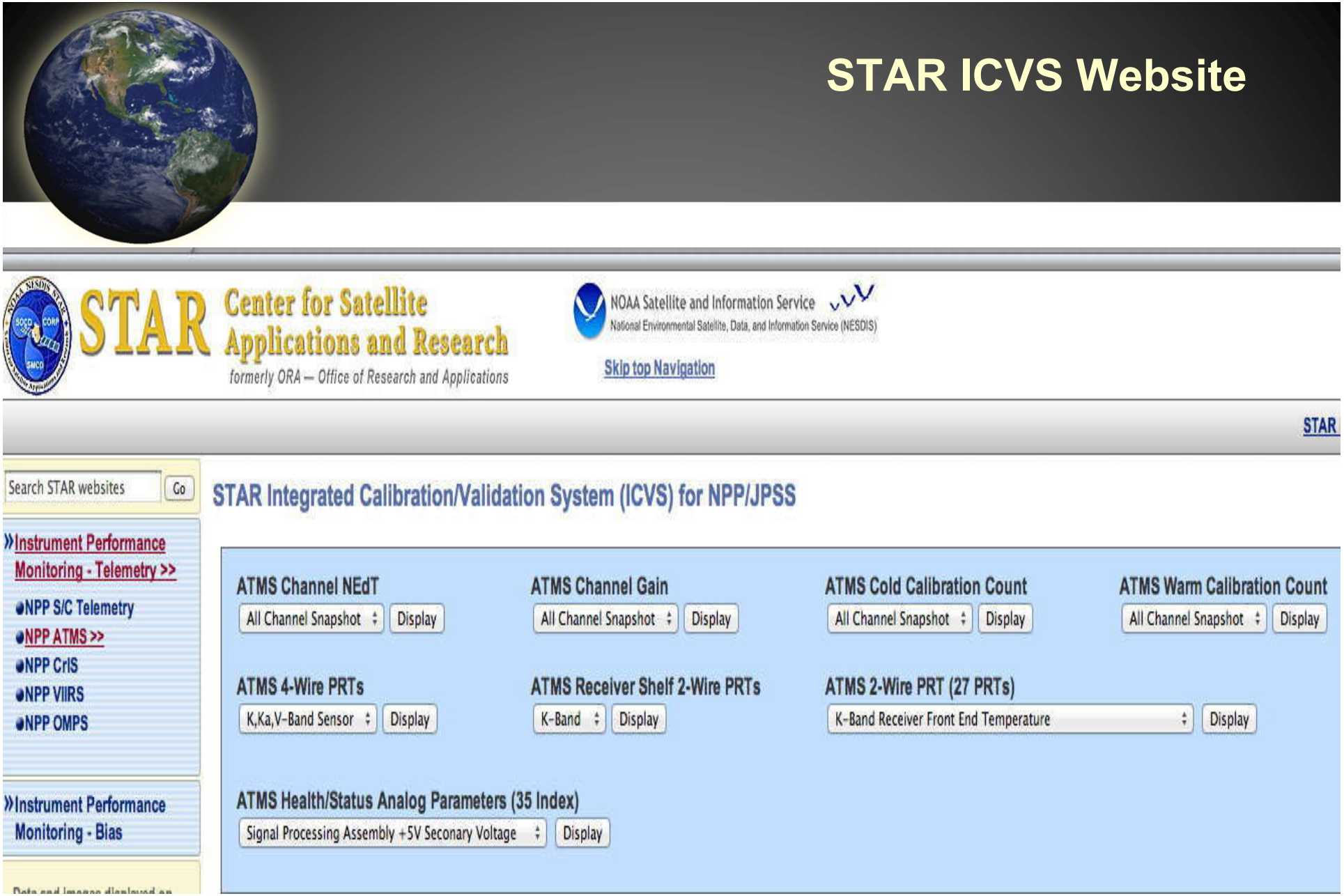


The ATMS data were processed at the NOAA Satellite Operations Facility (NSOF) in Suitland, MD and the image was generated by STAR

Quality of the image is superb, no indication of instrument artifacts, and by design no orbital gaps

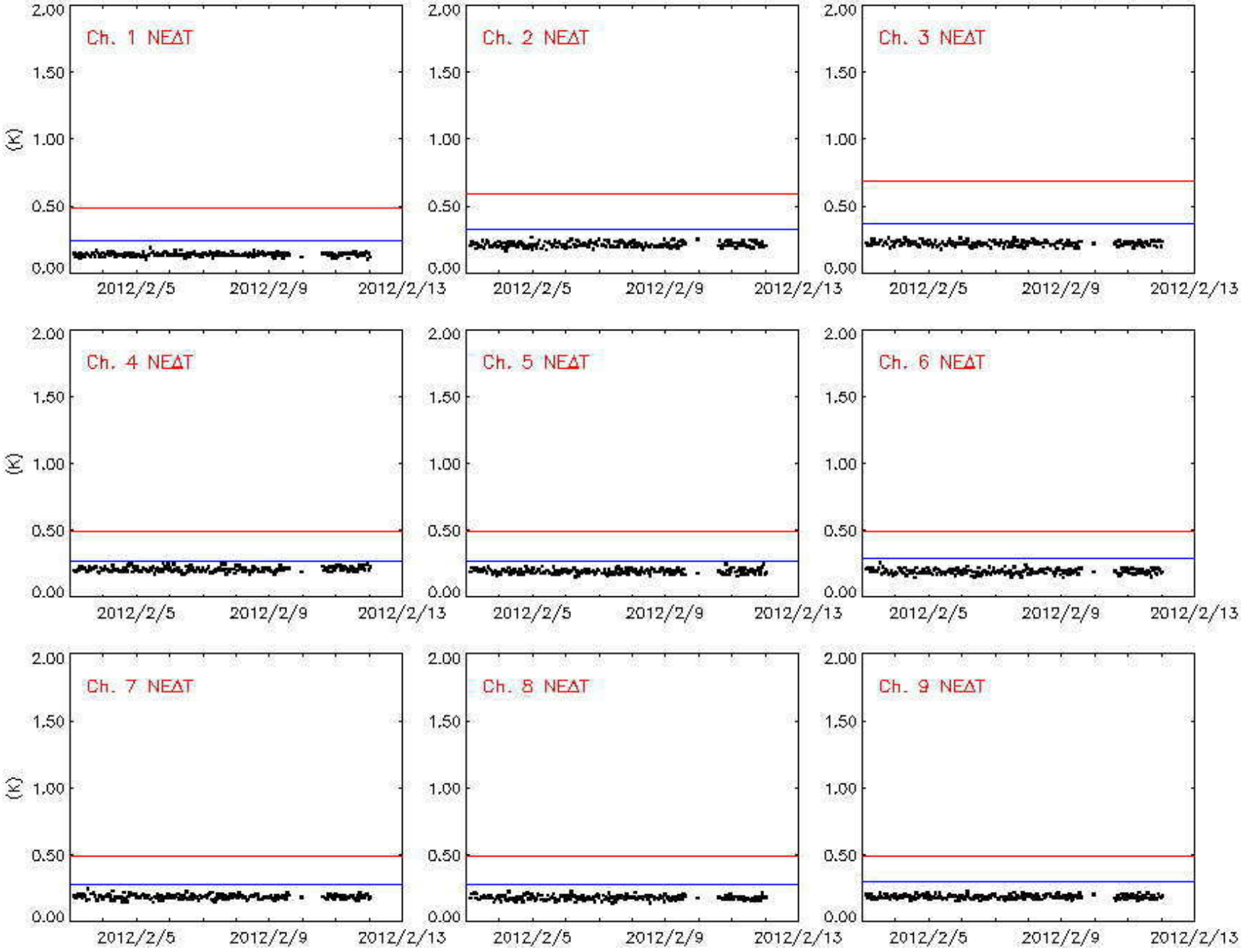
This channel measures atmospheric water vapor; note that Tropical Storm Sean is visible in the data, as the blue patch due to heavy precipitation, in the Atlantic off the coast of the Southeastern United States. ATMS provides critical water vapor information for weather forecasting and storm intensity assessments

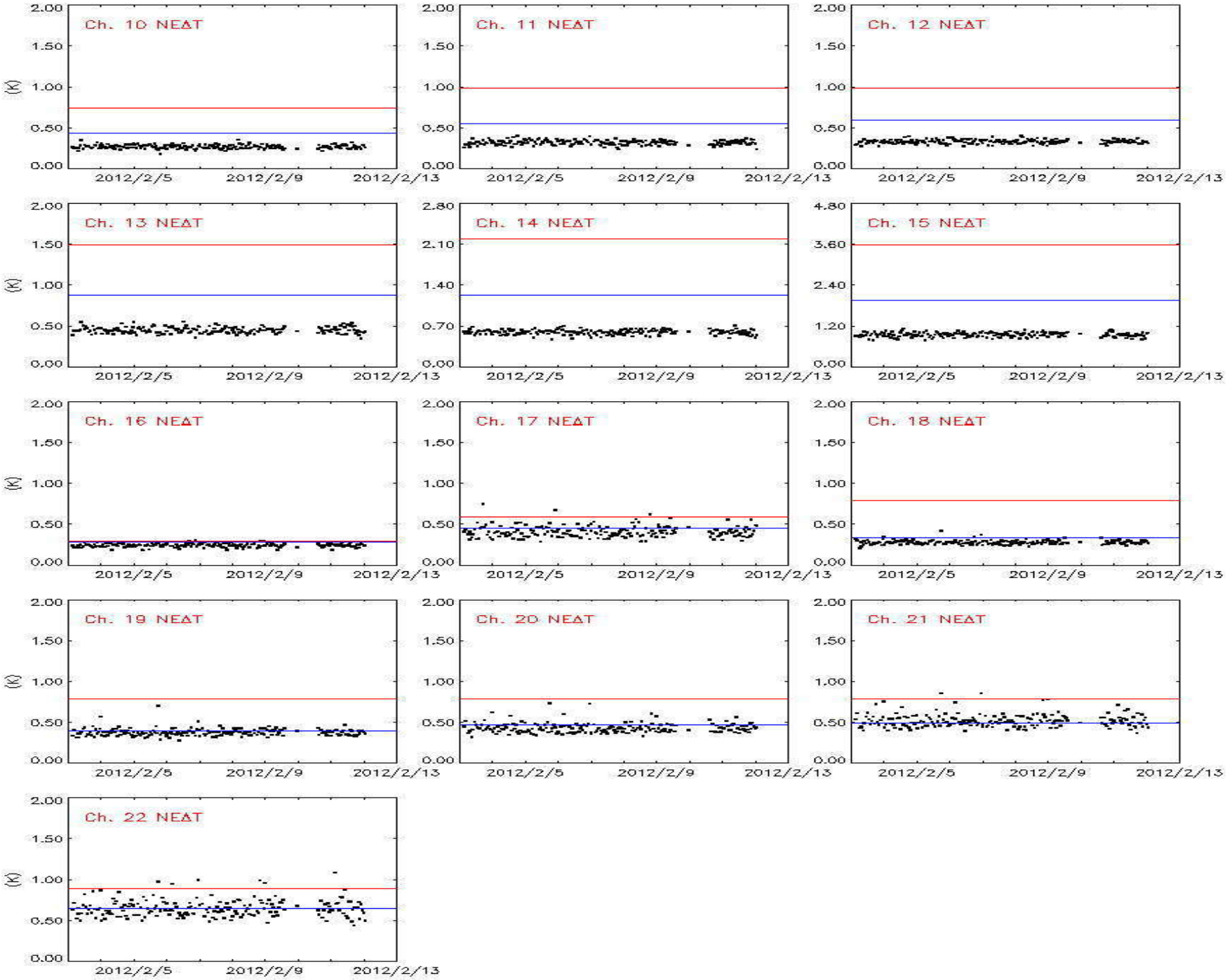
STAR ICVS Website



NPP ATMS Channel NEΔT
Science RDR

*** = Spec. (Updated at Sun Feb 12 04:30:51 2012 UTC) XXX = Pre-Launch



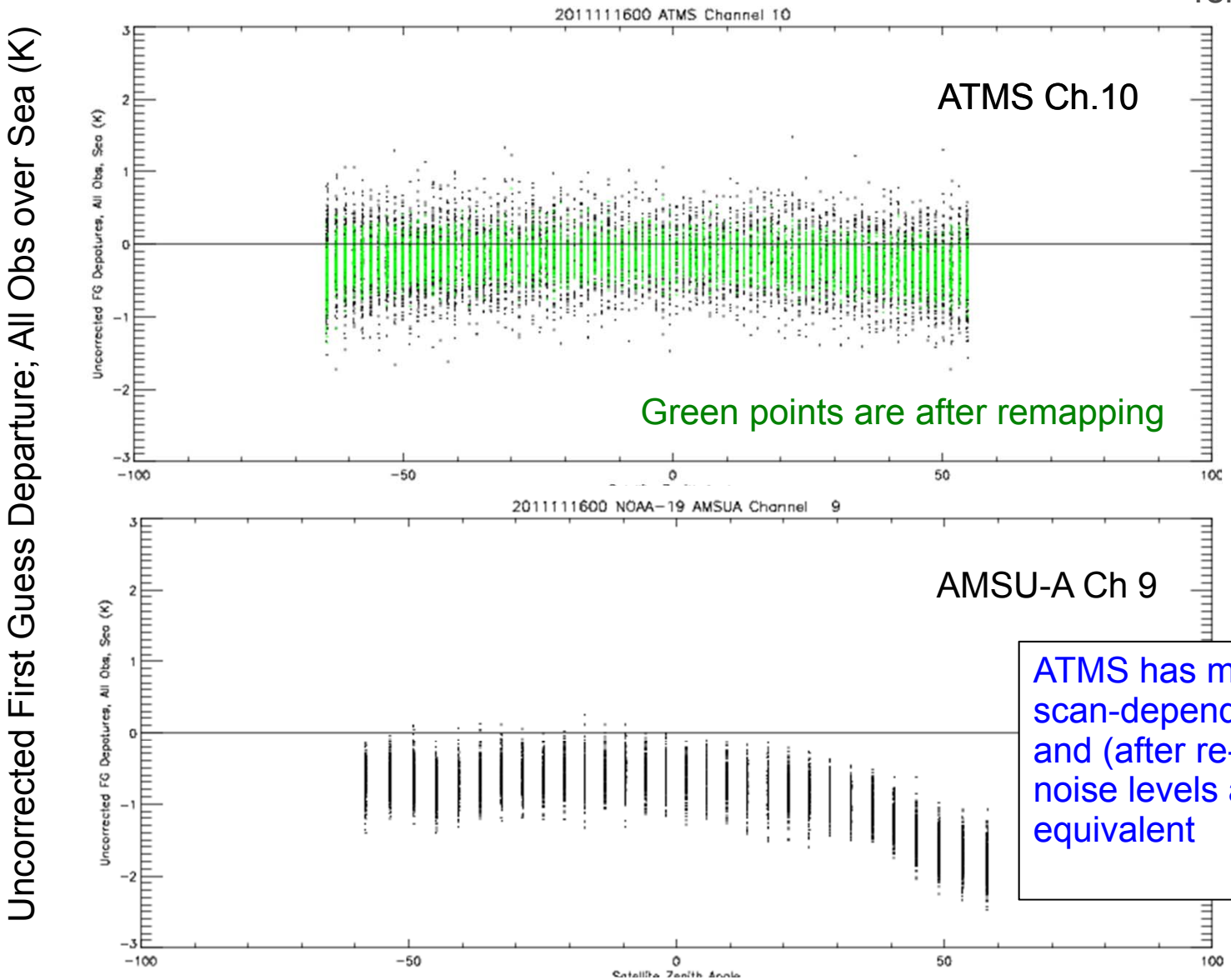

Ch. 10 NEΔT
Ch. 11 NEΔT
Ch. 12 NEΔT
Ch. 13 NEΔT
Ch. 14 NEΔT
Ch. 15 NEΔT
Ch. 16 NEΔT
Ch. 17 NEΔT
Ch. 18 NEΔT
Ch. 19 NEΔT
Ch. 20 NEΔT
Ch. 21 NEΔT
Ch. 22 NEΔT
(K)
2012/2/5
2012/2/9
2012/2/13

NCEP Initial Assessment

- ATMS observations appear to be of good quality.
- In particular the bias characteristics seem much better than for AMSU-A
- Using the AAPP re-mapping tool, AMSU-A like noise performance can be obtained.

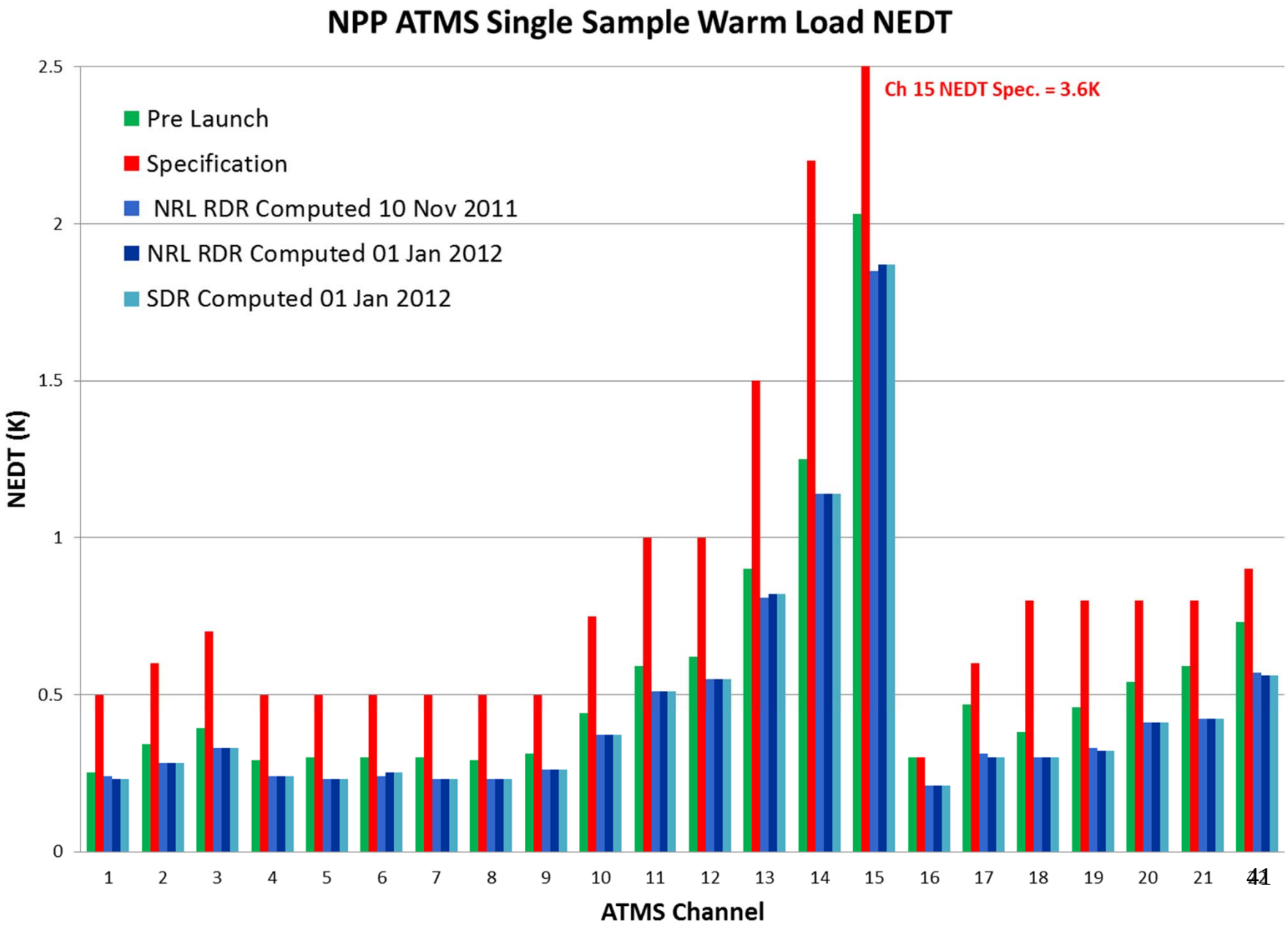
AMSU-A vs ATMS Stats

Antenna Temperatures



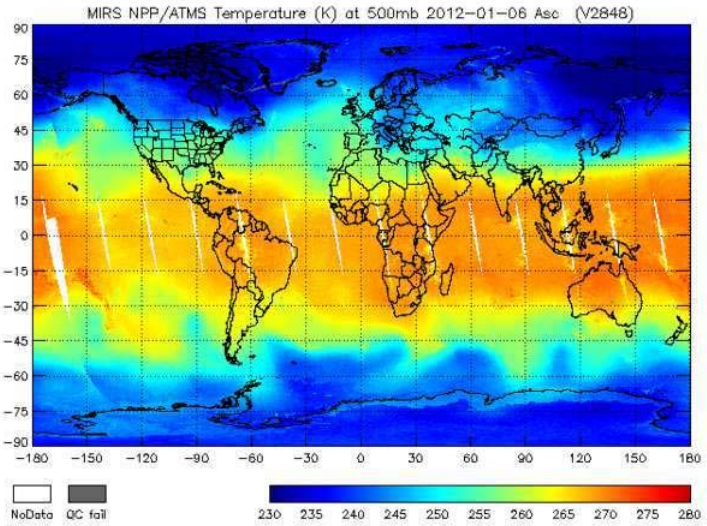
Uncorrected First Guess Departure; All Obs over Sea (K)

ATMS has much better scan-dependent bias and (after re-mapping) noise levels are equivalent

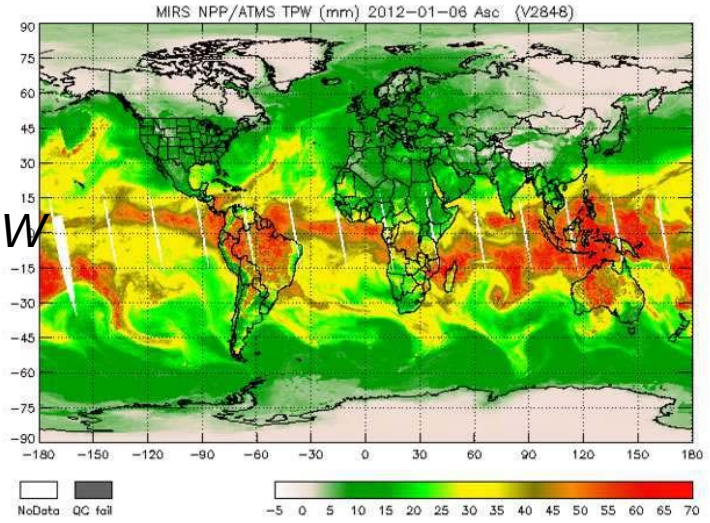

NPP ATMS Single Sample Warm Load NEDT
Ch 15 NEDT Spec. = 3.6K
Pre Launch
Specification
NRL RDR Computed 10 Nov 2011
NRL RDR Computed 01 Jan 2012
SDR Computed 01 Jan 2012
NEDT (K)
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
ATMS Channel

NOAA ATMS MIRS Products

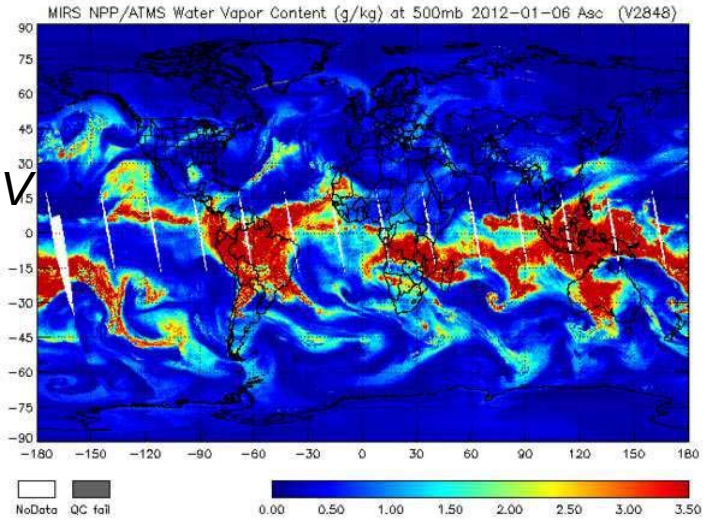
T



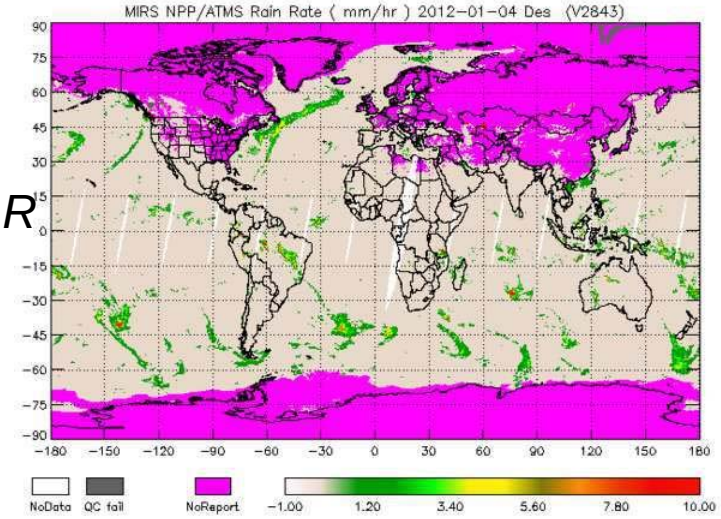
TPW



WV



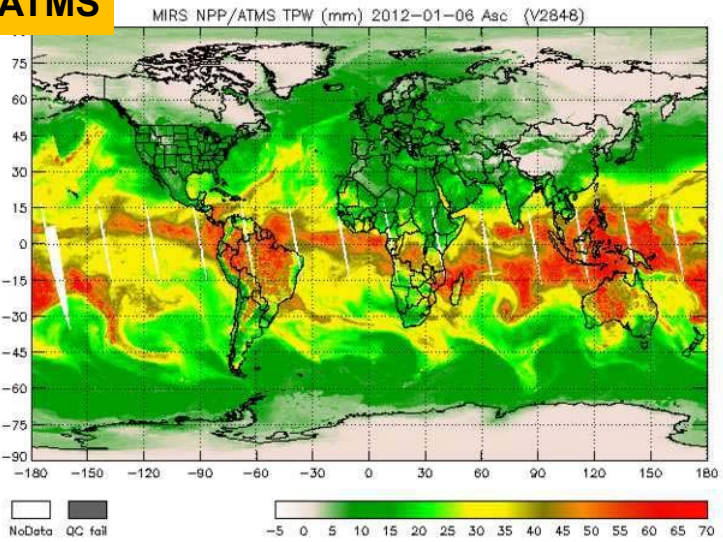
RR



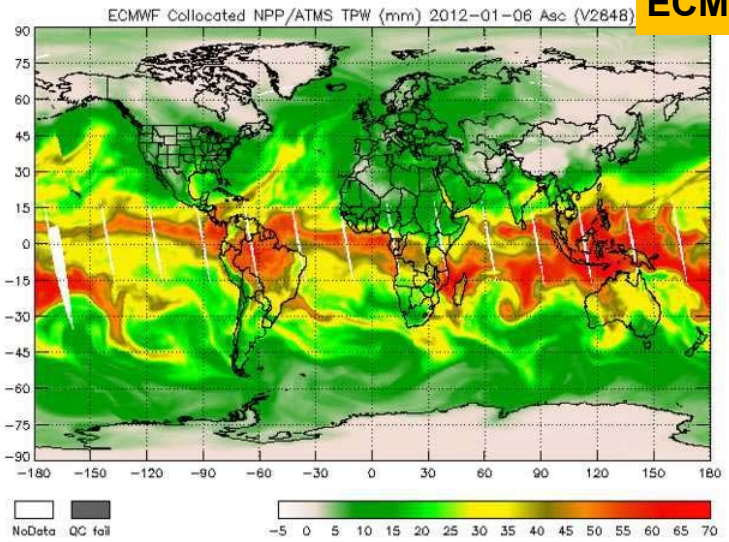
NPP/ATMS Real Data

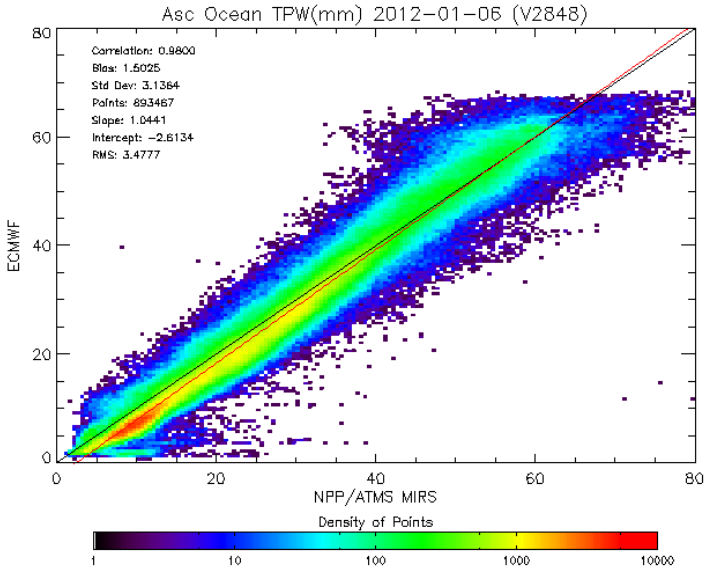
TPW

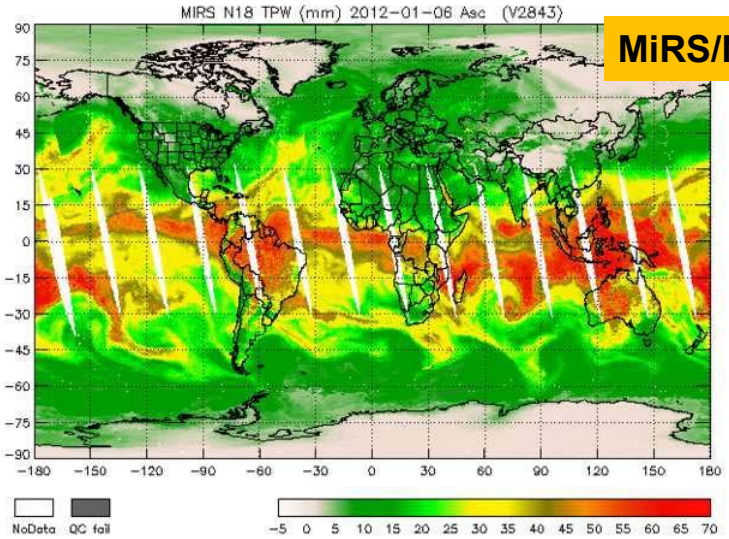
MiRS/ATMS



ECMWF

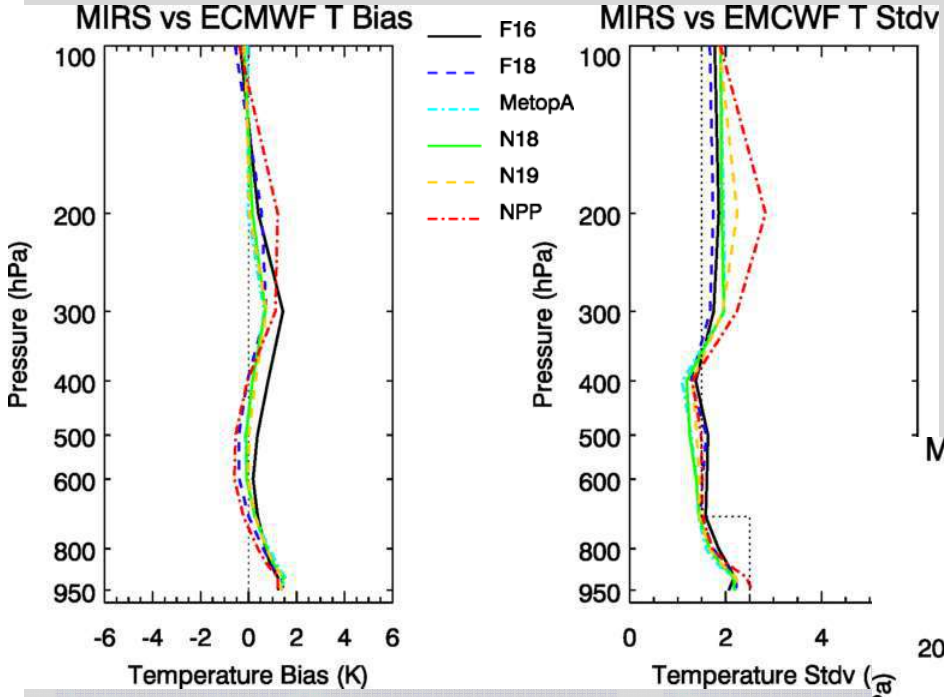




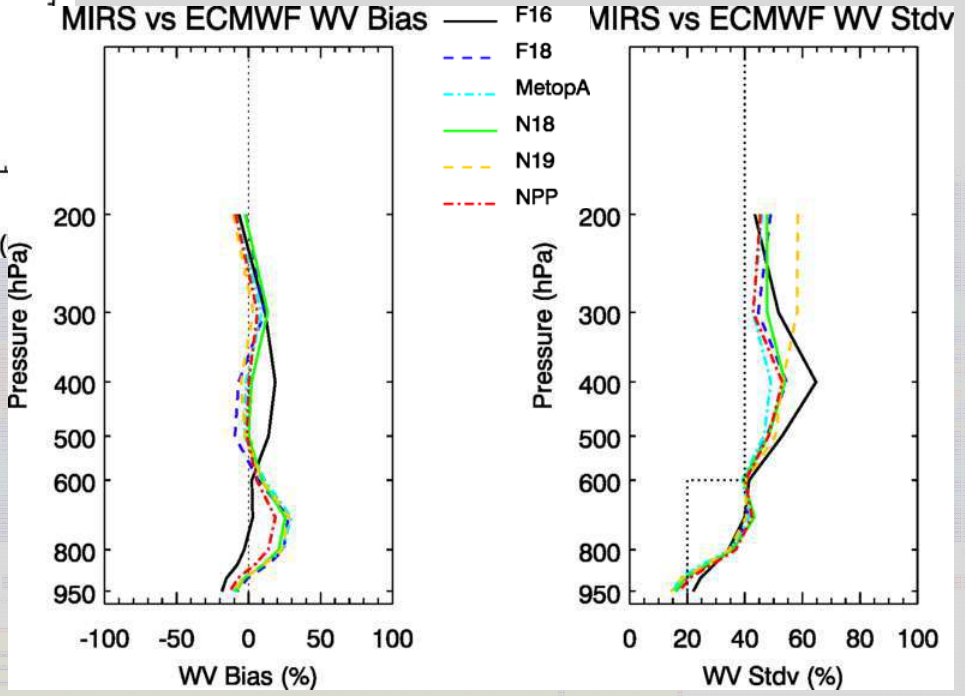


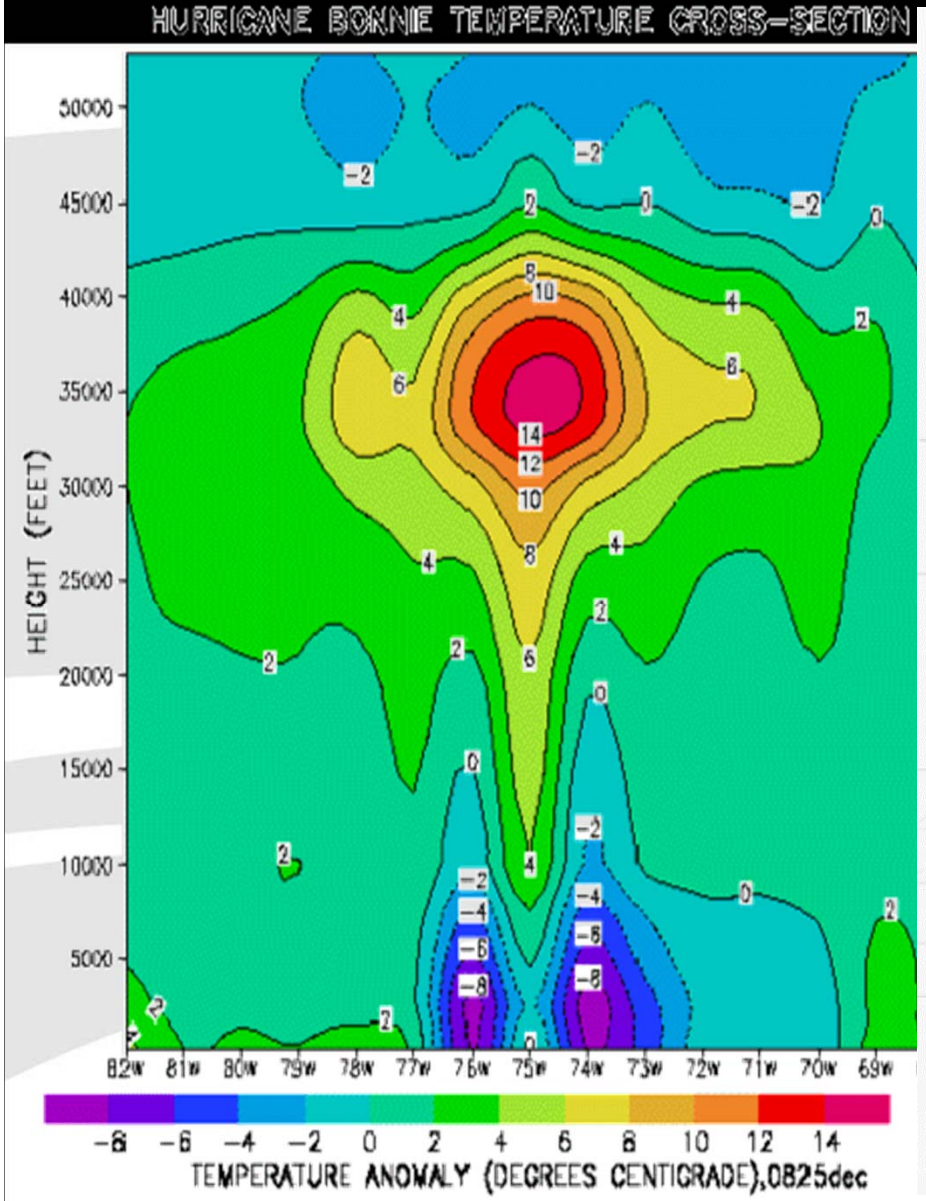
MiRS/N18

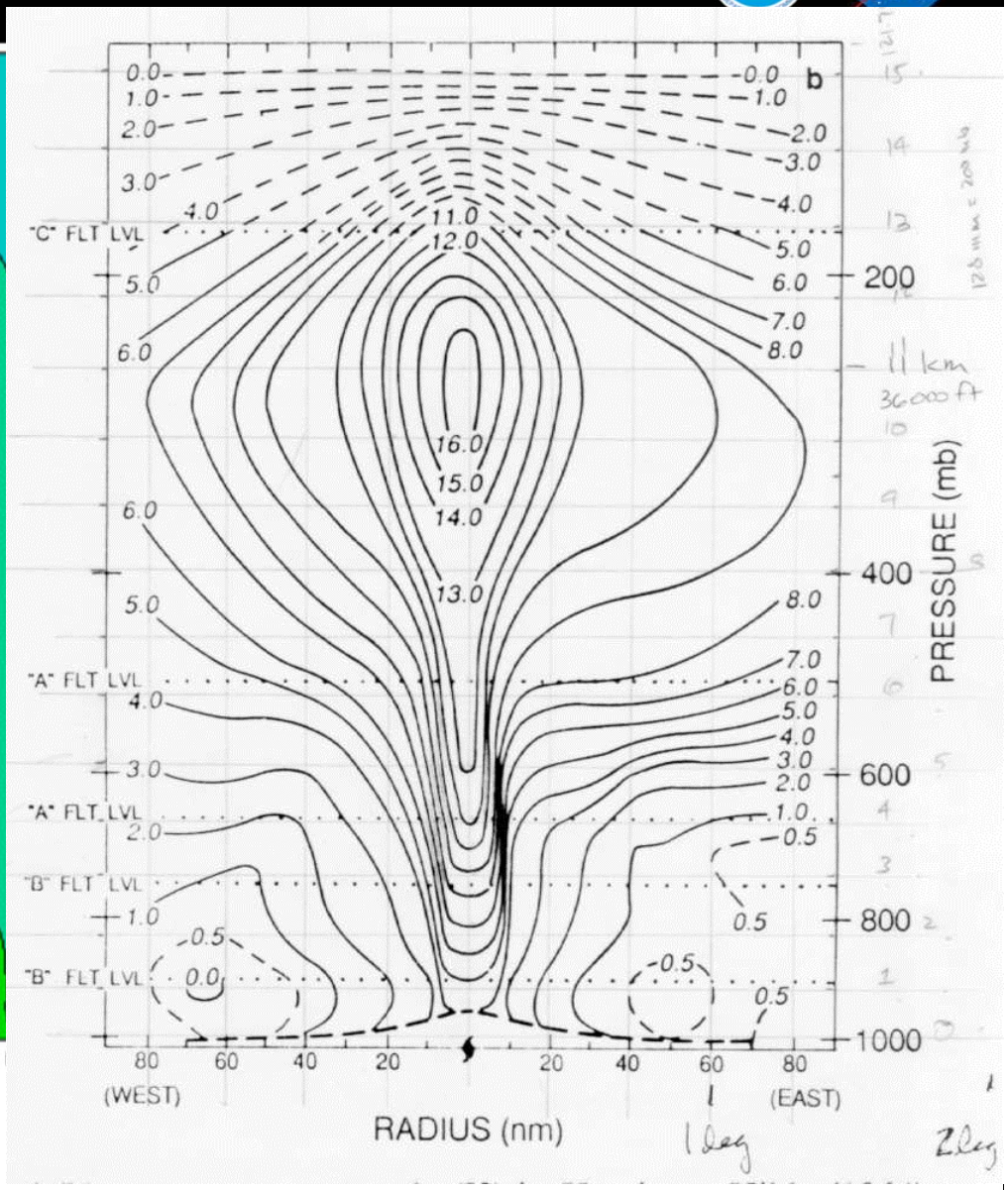
NPP/ATMS Real Data
Sounding



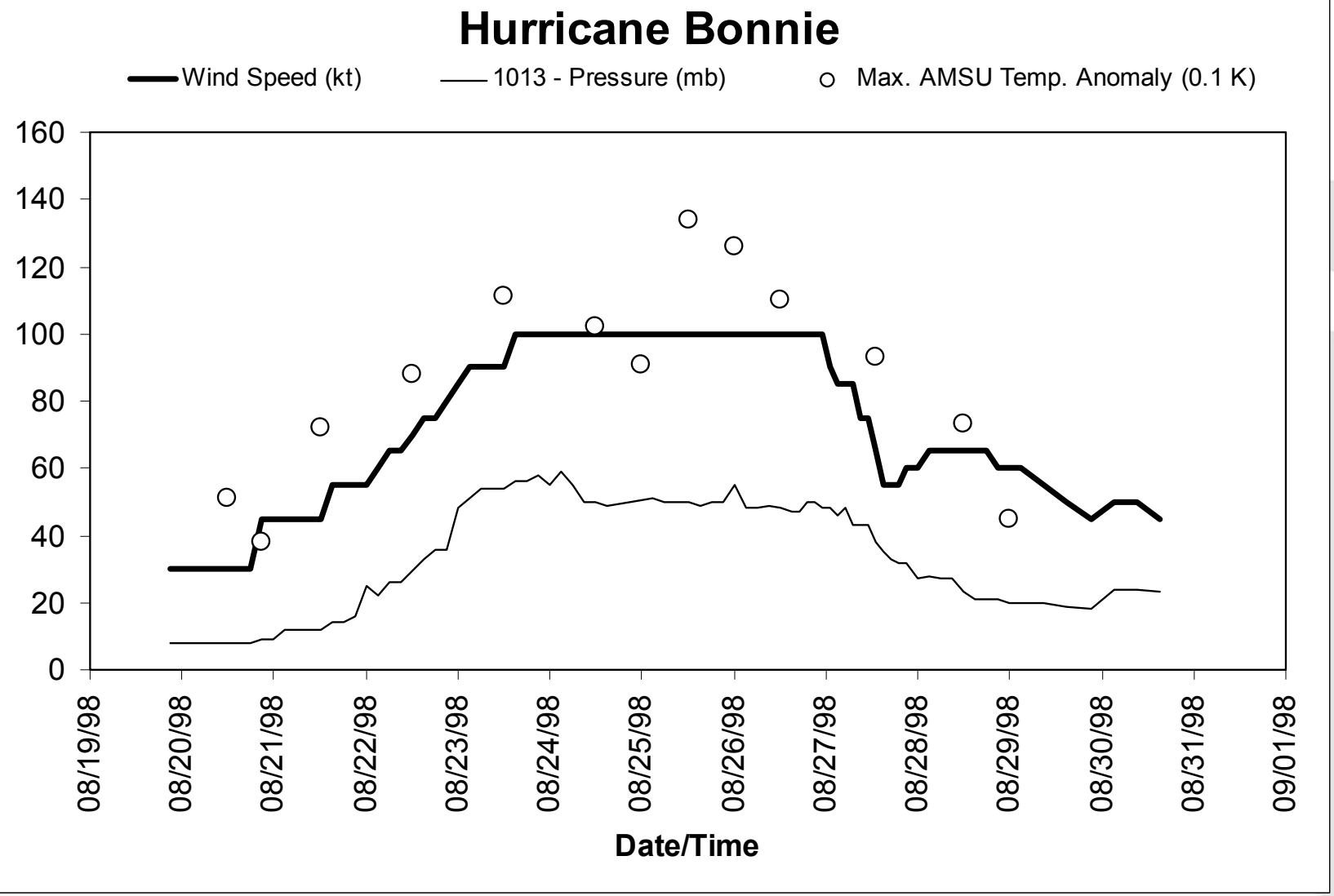
Temperature and water vapor performance intercomparison across MiRS N18, N19, MetopA, NPP, F16 and F18 soundings against ECMWF analysis for 2012-01-17





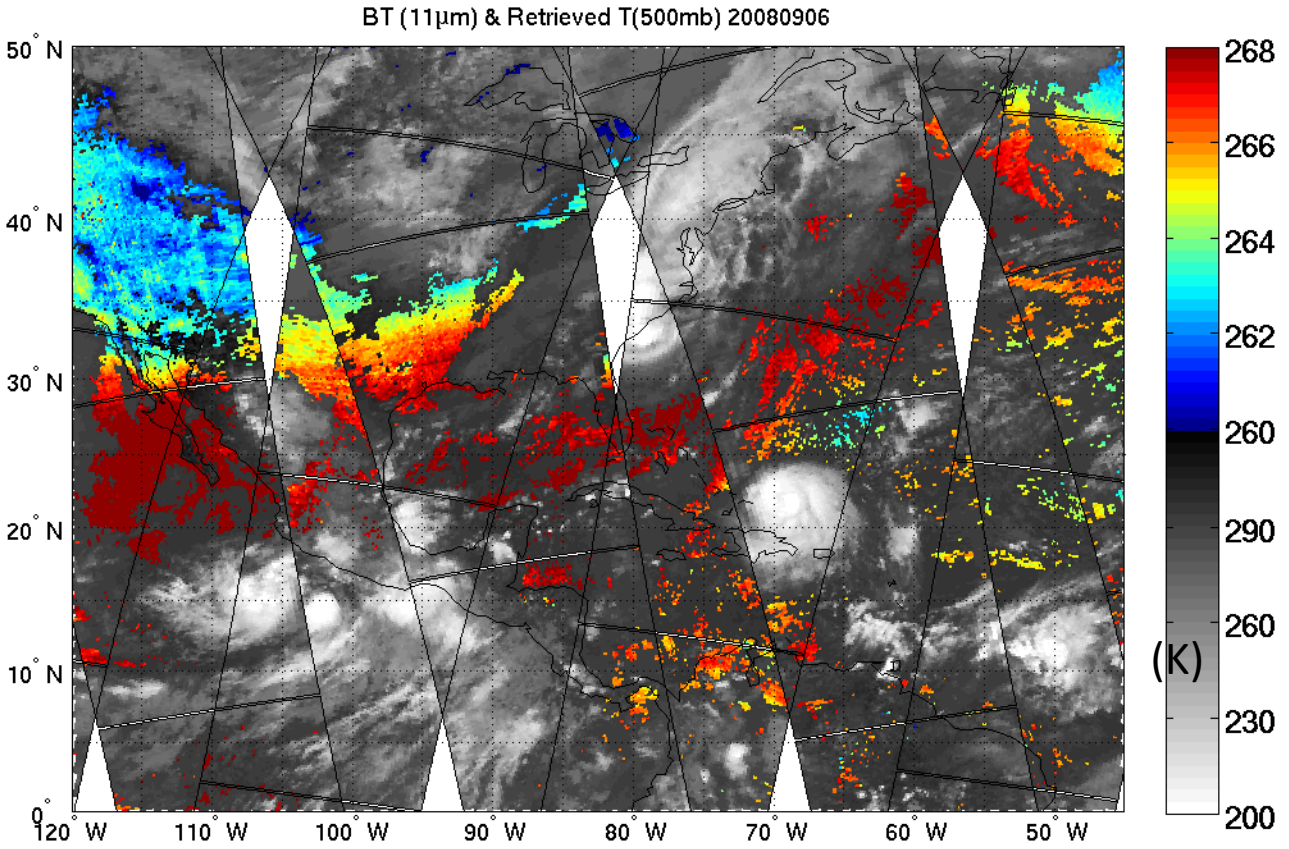


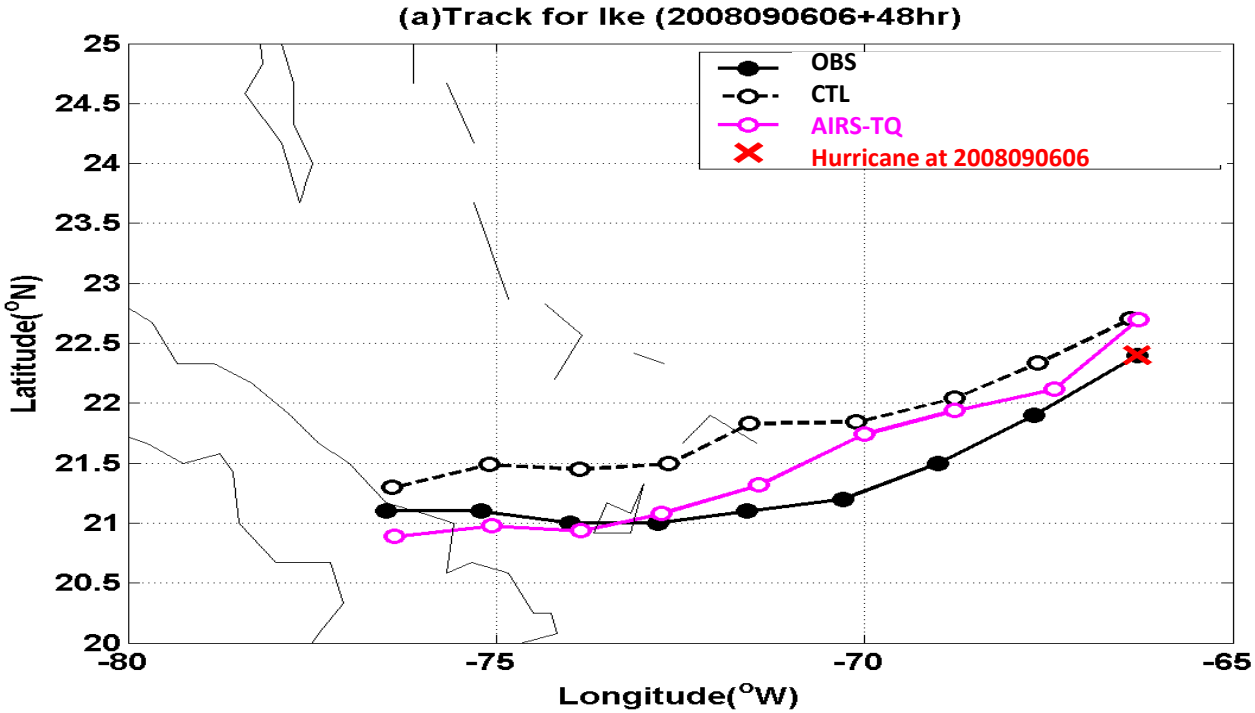
Hawkins, H. F., and D. T. Rubsam, 1968: Hurricane Hilda, 1964. II. Structure and budgets of the hurricane on October 1, 1964. *Mon. Wea. Rev.*, **96**, 617-636

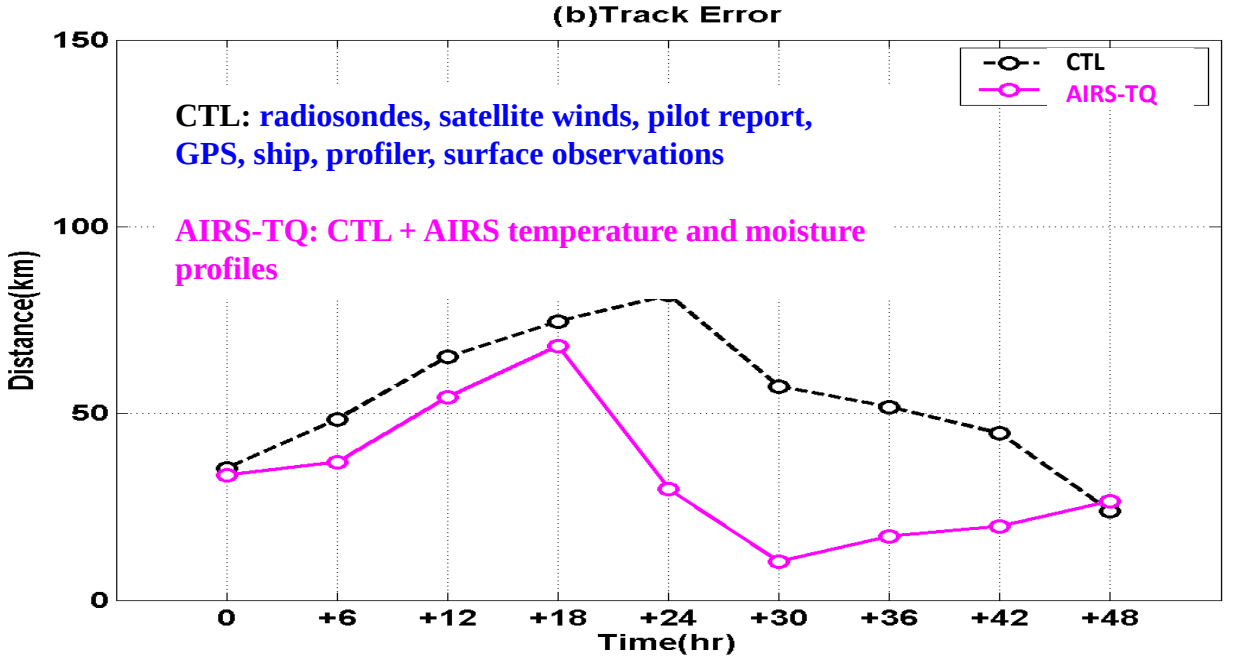

Hurricane Bonnie
Wind Speed (kt)
1013 - Pressure (mb)
Max. AMSU Temp. Anomaly (0.1 K)
160
140
120
100
80
60
40
20
0
08/19/98
08/20/98
08/21/98
08/22/98
08/23/98
08/24/98
08/25/98
08/26/98
08/27/98
08/28/98
08/29/98
08/30/98
08/31/98
09/01/98
Date/Time

New Applications: Use of Soundings for mesoscale models

AIRS 500 hPa temperature (color) retrievals superimposed on the 11 µm brightness temperature image on 06 September 2008.



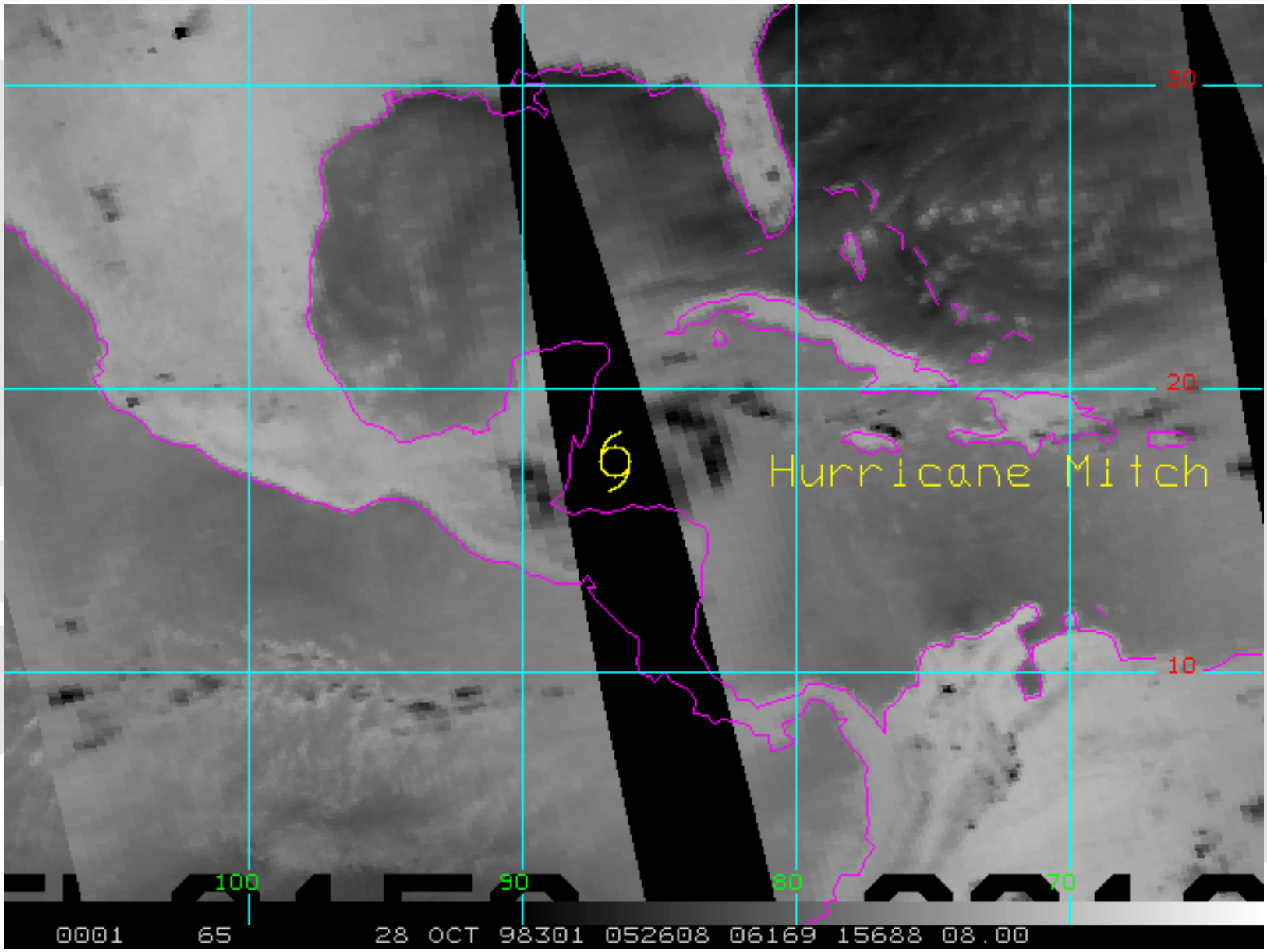




Courtesy:

Jun Li, CIMSS

ATMS has better spatial resolution and no gaps



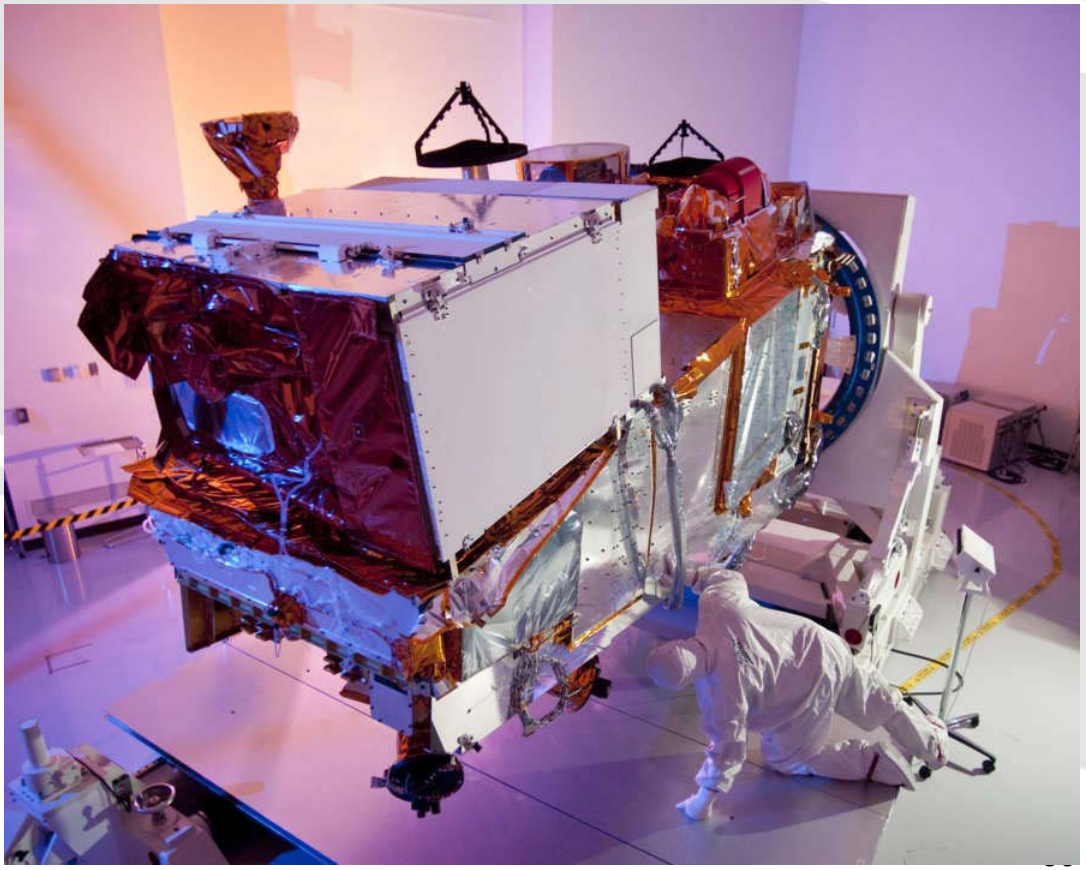
Visible Infrared Imaging Radiometer Suite
Raytheon SAS El Segundo, Ca

Description

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

Spatial Resolution

- 16 bands at 750m
- 5 bands at 325m
- DNB



VIIRS on NPP

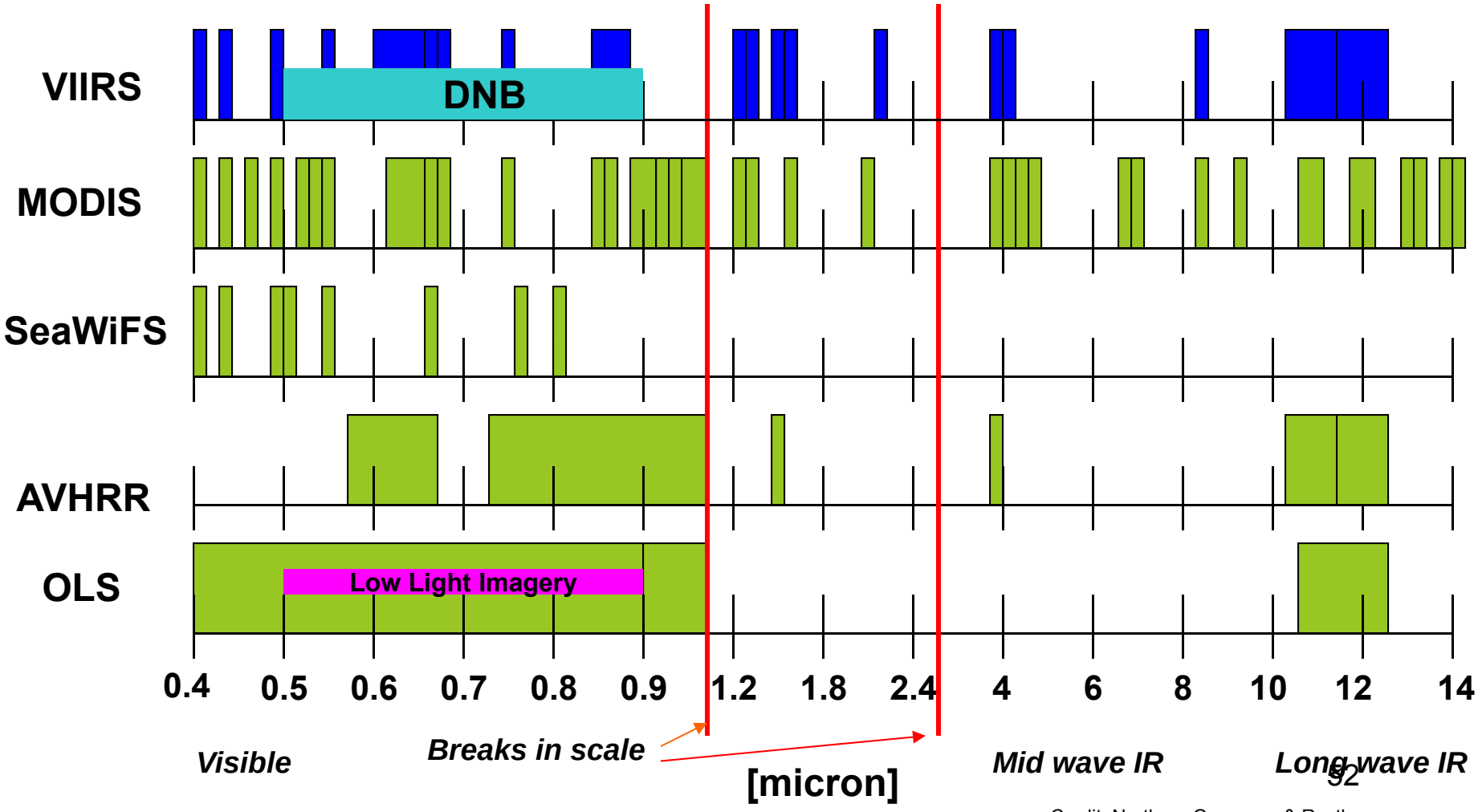
VIIRS Prelaunch Performance
(NPP F1 Bands and SNR/NEDT)

		Specification									
		Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan) Nadir	End of Scan	Band Gain	Ltyp or Ttyp (Spec)	Lmax or Tmax	SNR or NEdT (K)	Measured SNR or NEdT (K)	SNR Margin (%)
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58	High Low	44.9 155	135 615	352 316	723 1327	105% 320%
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58	High Low	40 146	127 687	380 409	576 1076	51.5% 163%
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58	High Low	32 123	107 702	416 414	658 1055	58.2% 155%
		M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58	High Low	21 90	78 667	362 315	558 882	54.1% 180%
		I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789	Single	22	718	119	265	122.7%
		M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58	High Low	10 68	59 651	242 360	360 847	49% 135%
		M6	Atmosph. Correct.	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58	Single	9.6	41	199	394	98.0%
		I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789	Single	25	349	150	299	99.3%
		M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58	High Low	6.4 33.4	29 349	215 340	545 899	154% 164%
	S/WMIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58	Single	5.4	165	74	349	371.6%
		M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58	Single	6	77.1	83	247	197.6%
		I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789	Single	7.3	72.5	6	165	2650.0%
		M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58	Single	7.3	71.2	342	695	103.2%
		M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58	Single	0.12	31.8	10	18	80.0%
Emissive Bands		I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789	Single	270	353	2.5	0.4	84.0%
		M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58	Single	270	353	0.396	0.12	69.7%
		M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58	High Low	300 380	343 634	0.107 0.423	0.044 --	59% --
	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58	Single	270	336	0.091	0.054	40.7%
		M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58	Single	300	343	0.07	0.028	60.0%
		I5	Cloud Imagery	10.500 - 12.400	0.371 x 0.387	0.80 x 0.789	Single	210	340	1.5	0.41	72.7%
		M16	SST	11.538 - 12.488	0.742 x 0.776	1.60 x 1.58	Single	300	340	0.072	0.036	50.0%

HSI uses 3 in-scan pixels aggregation at Nadir

Courtesy of H. Oudrari

Heritage Capabilities



Credit: Northrup Grumman & Raytheon

Comparison of "Imagery" Bands at Nadir

Wavelength	AVHRR	MODIS	VIIRS
.63 µm			
.86 µm			
1.6 µm			
3.7 µm			
11.4 µm			
	1.1 km	0.25 – 1 km	0.37 km

VIIRS has a very large cross track and near constant spatial resolution

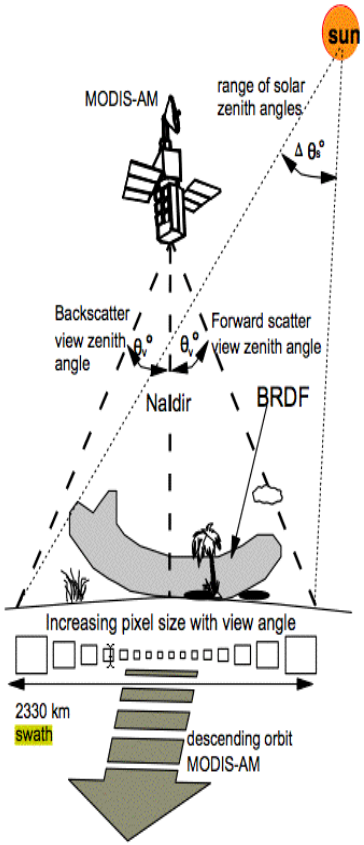
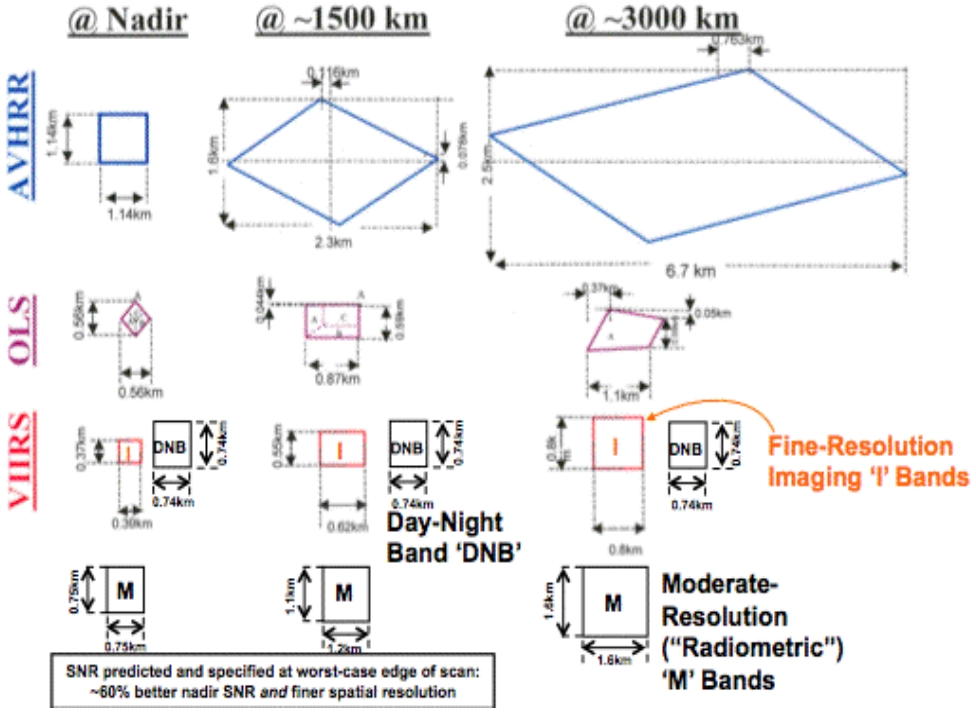
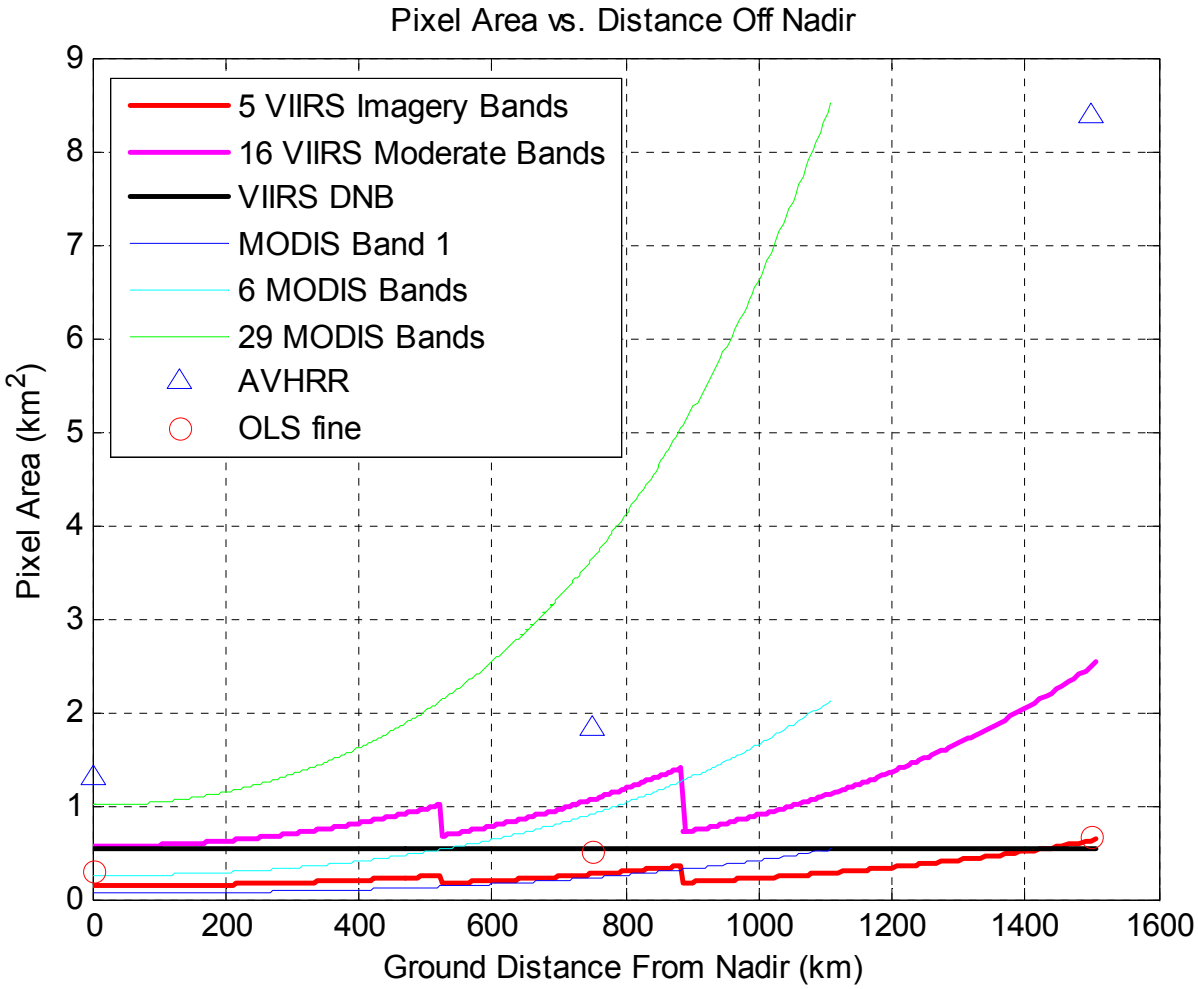


Figure 3.2.3: Illustration of MODIS data acquisition on the EOS-AM platform (not to scale). The bidirectional reflectance distribution function (BRDF) changes with view and sun geometry. Notice the shadow caused by clouds and canopy. MODIS pixel dimensions, cross-track and along-track, change with scan angles: 0° - 250 x 250 m; 15° - 270 x 260 m; 30° - 350 x 285 m; 45° - 610 x 380 m



Spatial Resolution Comparisons for VIIRS, AVHRR, MODIS and OLS at Nadir and Across Swath



Because of aggregation VIIRS has much better resolution away from nadir, pixel area 8 times smaller than AVHRR or MODIS

Products (EDRs) vs VIIRS channel

		DNB	M1	M2	M3	M4	I1	M5	M6	M7	I2	M8	M9	M10	I3	M11	M12	I4	M13	M14	M15	I5	M16
	Wavelength (um)	**0.7**	**0.412**	**0.445**	**0.488**	**0.555**	**0.64**	**0.672**	**0.746**	**0.865**	**0.865**	**1.24**	**1.378**	**1.61**	**1.61**	**2.25**	**3.7**	**3.74**	**4.05**	**8.55**	**10.76**	**11.45**	**12.01**
1	Imagery	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2	Sea Surface Temp																x				x		x
3	Cloud Base Height							x				x		x			x		x	x	x		x
4	Cloud cover/Layers							x				x		x			x		x	x	x		x
5	Cloud Optical Part Size							x				x		x			x			x	x		x
6	Cloud Thickness							x				x		x			x			x	x		x
7	Cloud Top Height							x				x		x			x		x	x	x		x
8	Cloud Top Pressure							x				x		x			x		x	x	x		x
9	Cloud Top Temp							x				x		x			x		x	x	x		x
10	Land Surface Temp.																x		x		x		x
11	Active Fires							x		x						x			x		x		x
12	Vegetation Index				x		x				x												
13	Snow Cover (Binary)						x				x				x						x	x	x
14	Snow Cover (Fraction)		x		x	x				x		x		x		x							
15	Surface Type		x	x	x	x	x	x		x	x	x		x		x	x		x	x	x		x
16	Surface Albedo		x	x	x	x		x		x		x		x		x							
17	Ice Surface Temp.																				x		x
18	Surface Temperature (IP)																				x	x	x
19	Ocean Color / Chloro		x	x	x	x		x	x	x													
20	Sea Ice Age						x				x										x	x	x
21	Aer Opt Thick (Ocean)					x		x	x	x		x	x	x		x	x				x		
22	Aer Opt Thick (Land)		x	x	x	x		x					x			x	x				x		
23	Aer Part Size (Ocean)		Uses AOT, but no SDRs																				
24	Aer Part Size (Land)		Uses AOT, but no SDRs																				
25	Suspended Matter																			x	x		x
26	Total Prec Water																x		x	x	x		x
27	Cloud Mask (IP)		x				x	x		x	x		x	x		x	x	x	x	x	x	x	x
28	Ice Location/Conc. (IP)		Imagery Application is not requ				x				x										x	x	x
29	Sfc Reflectance (IP)		x	x	x	x	x	x		x	x	x		x	x	x							

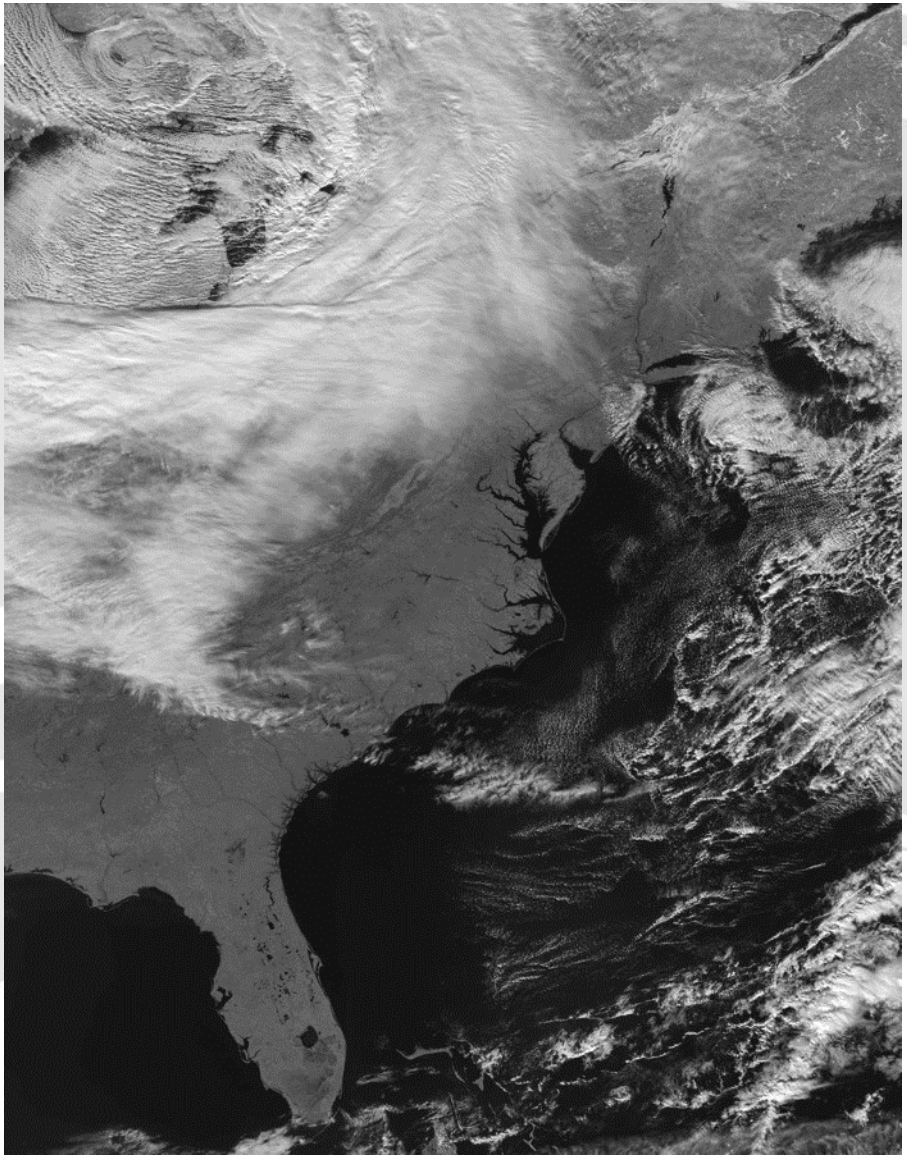
Ocean
Land
Aerosol
Clouds
Ice and Snow

Dual Gain Bands: M1-M5, M7, M13

VIS	NIR	SWIR	MWIR	LWIR

x Denotes bands that are **Not** primary inputs into algorithm. Used as internal check for algorithm.

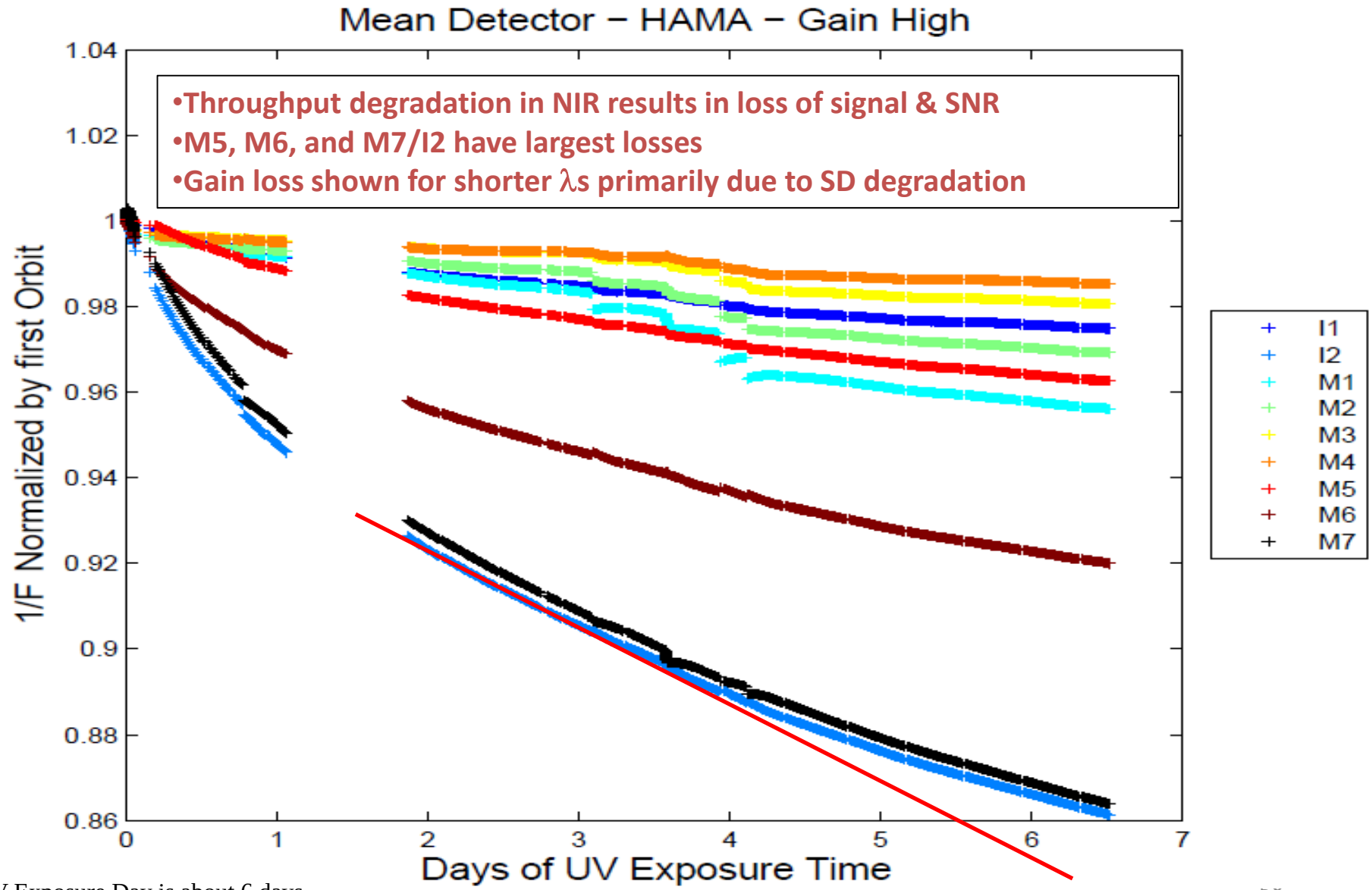
M07 (0.865 microns) grey scaled 19 January 2012



VIIRS Data Anomaly

- Degradation in M7/I2 observed after launch
- Smaller effect in M6 & M5
- Commissioning paused while anomaly was studied
- Degradation believed to be caused by an error in mirror coating process. An inadvertent layer of tungsten film was put on telescope mirrors
- Commissioning resumed Jan 18th
- Degradation is slowing, should level off
- No effect on VIIRS data products; VIIRS SNR in M7 expected to be above spec

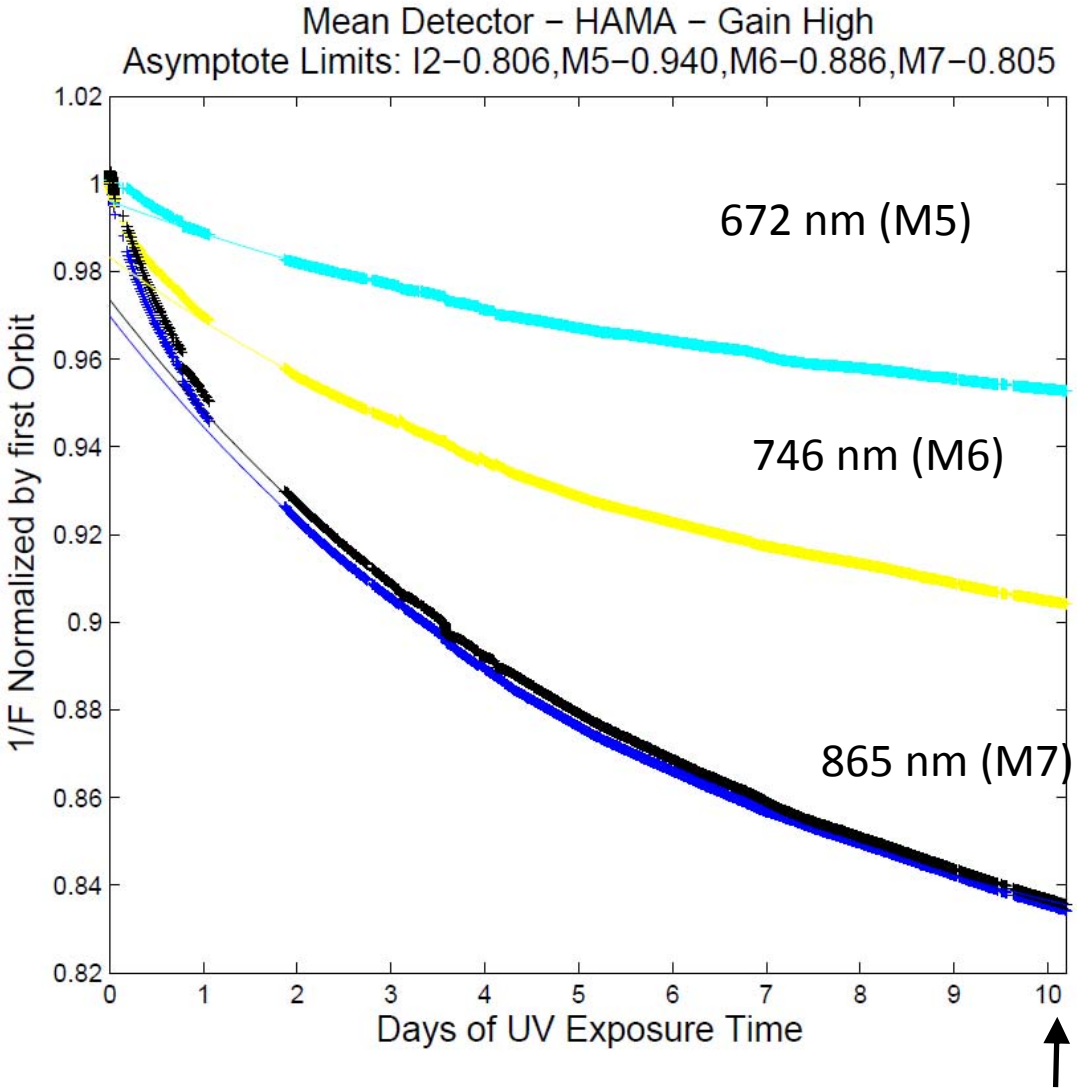
Gain vs. Exposure Time
(Aerospace Data Plot)



1 UV Exposure Day is about 6 days

F-factor is normalized to the first observation (Orbit 154)

VIIRS Anomaly
Change in VIIRS Solar Data as a function of UV exposure



Feb 5, 2012

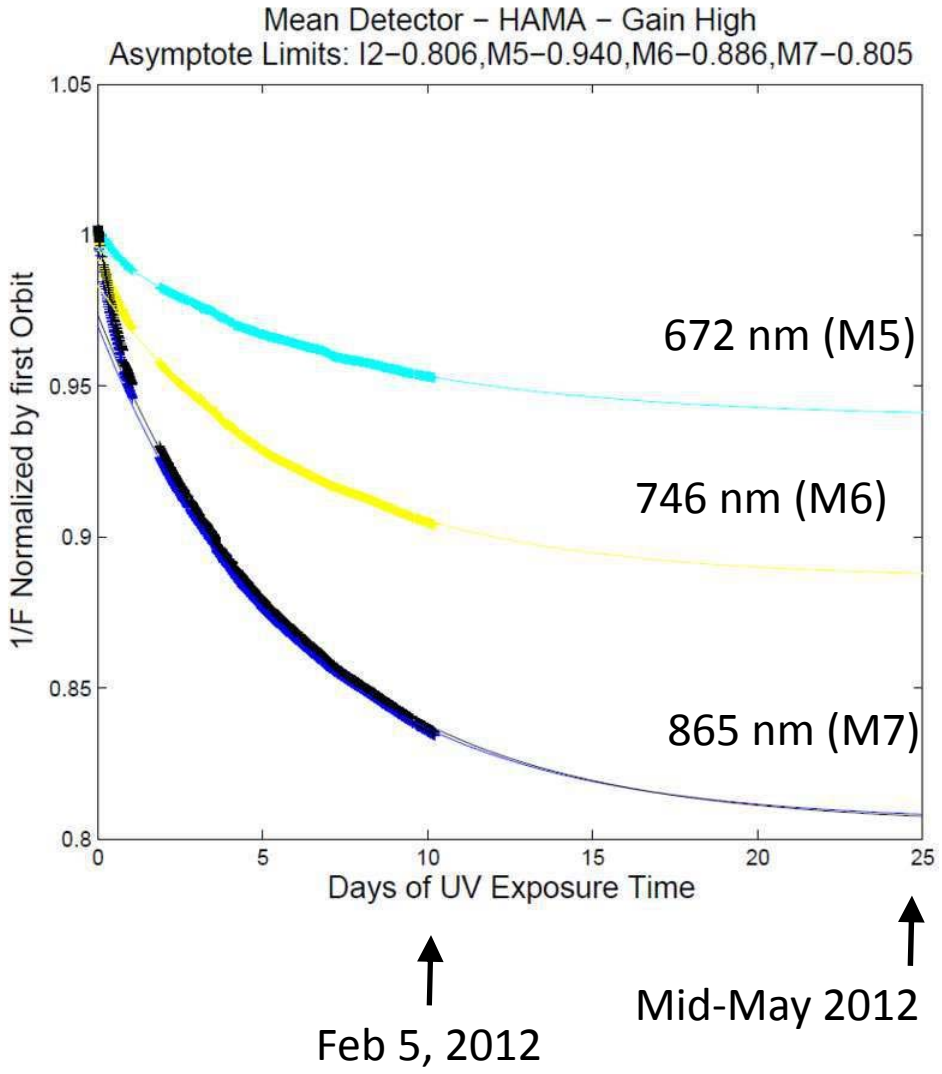
Anomaly depends on exposure to light, probably in the UltraViolet (UV) region.

Calculate amount of UV exposure in each orbit. Replot data, converting x-axis from orbit number to UV exposure time.

1 day UV exposure = 6.5 calendar days.

Data shows smooth dependence on UV exposure.

VIIRS Anomaly
Predict Amount of Change in VIIRS using Solar Data



1 day UV exposure = 6.5 calendar days.

For M7/I2 865 nm High Gain Signal-to-Noise (SNR)

	SNR	Margin
Specification	215	
Raytheon	419	95%

Analyze with a simple predictive optical model of multiple mirrors with an absorbing coating.

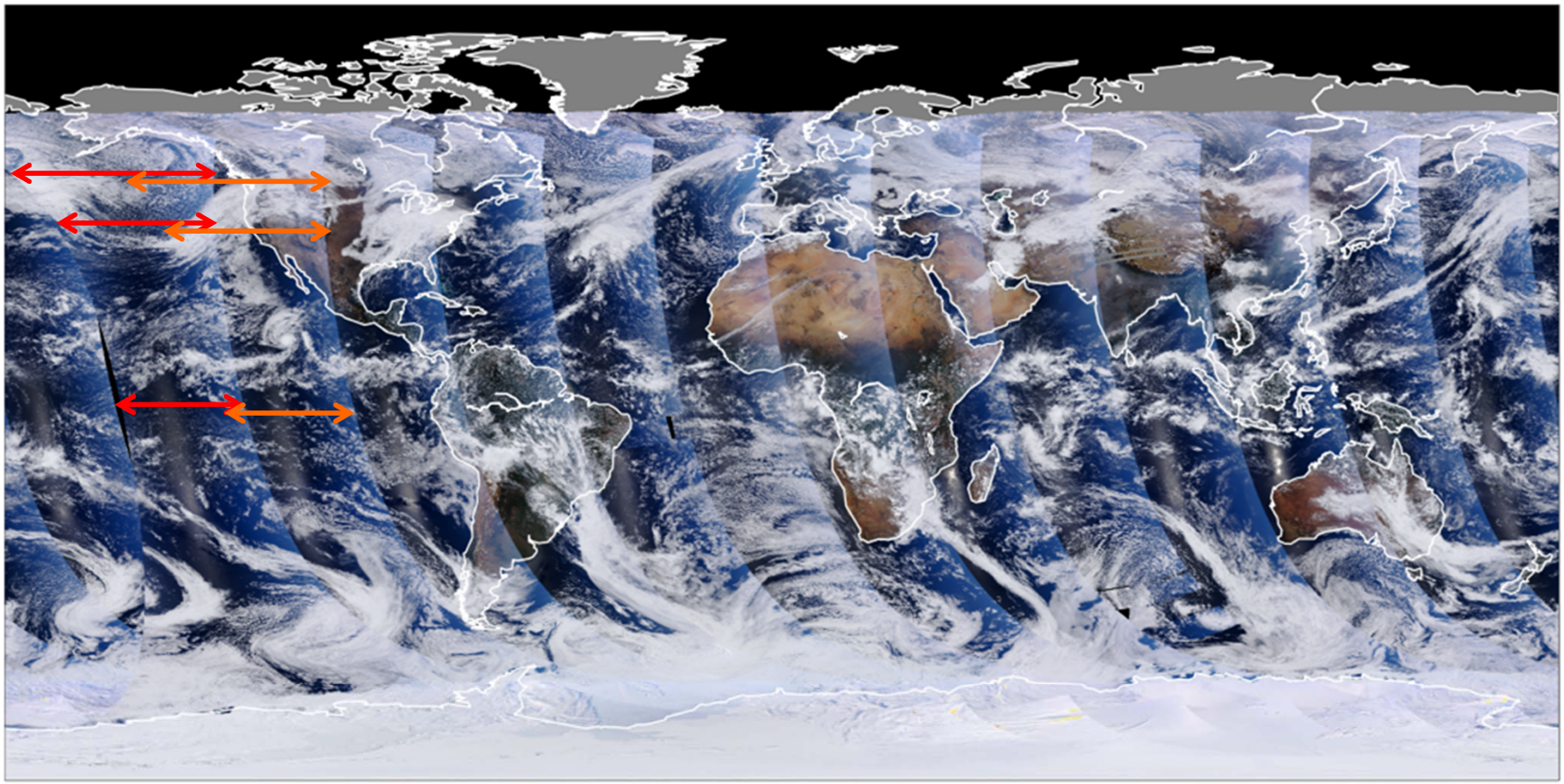
Model predicts throughput reduced to 81%

	SNR	Margin
Adjusted Raytheon	339	58%

Gov't estimates of VIIRS SNR are higher than Raytheon's.

Raytheon producing more sophisticated predictive optical model of VIIRS degradation.

First Global VIIRS Image



VIIRS RGB (True Color), 20111122

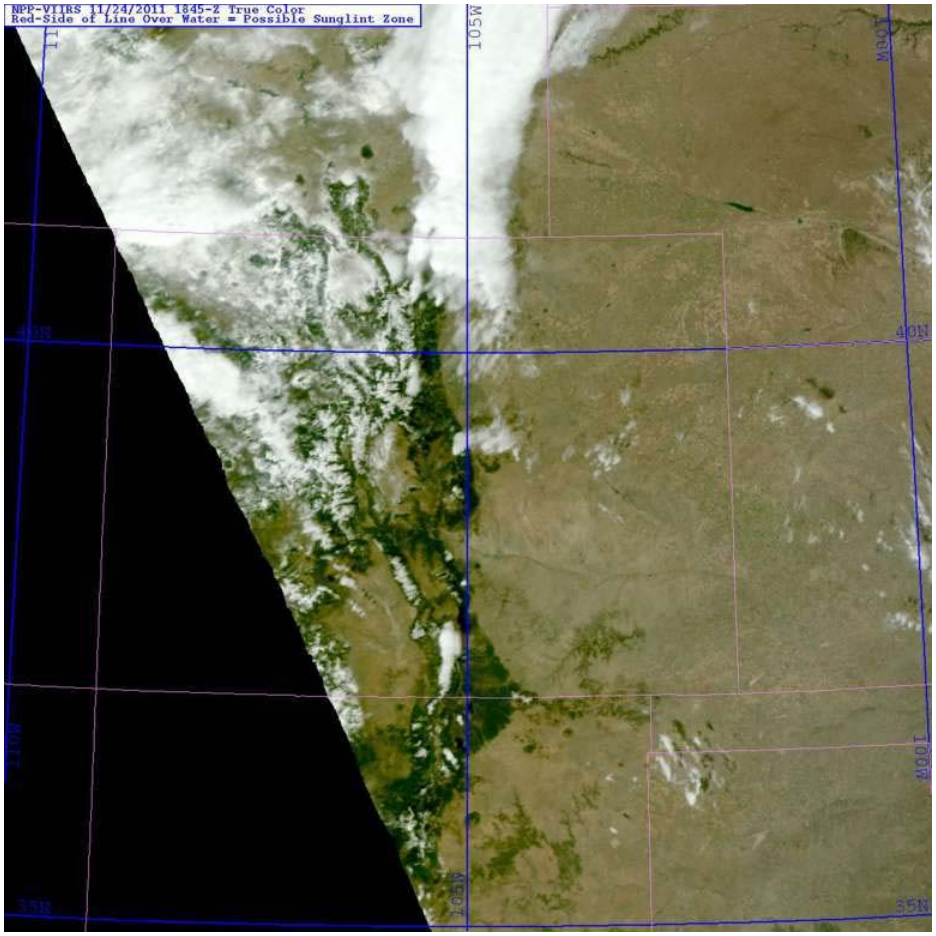
R : M05 (0.672 μm); G : M04 (0.555 μm); B : M02 (0.445 μm)

Creation date: 2011-11-26 07:19:26 Z

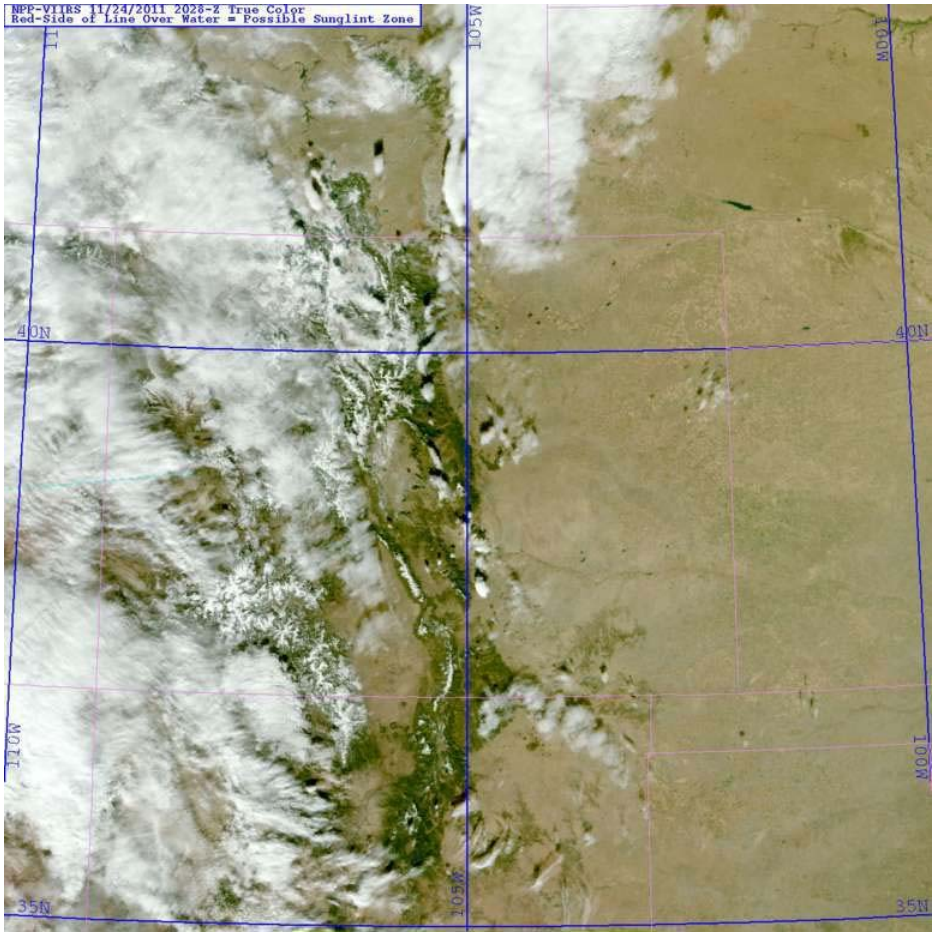
NPP VIIRS True Color Examples

Colorado

11.24.2011 1845 Z, Near Edge of Scan



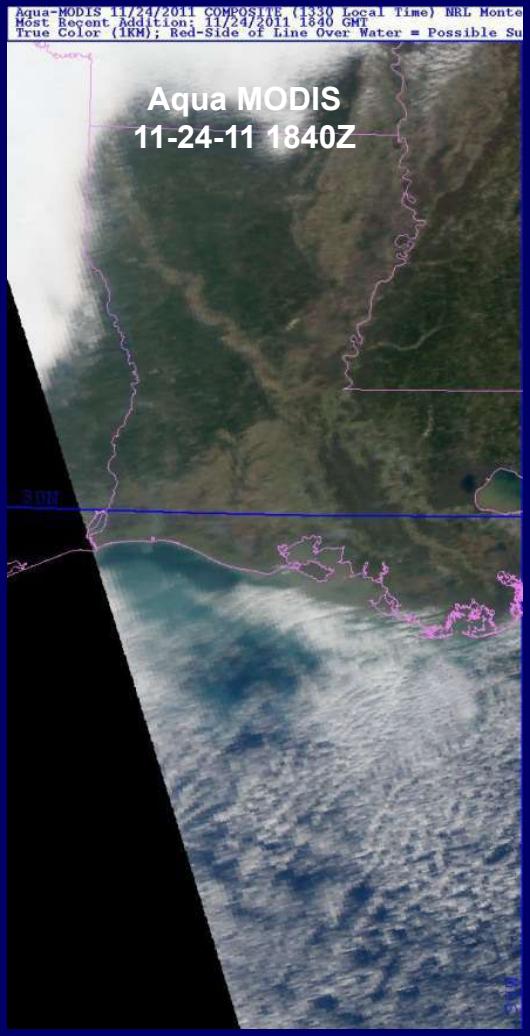
11.24.2011 2028 UTC, Near Nadir

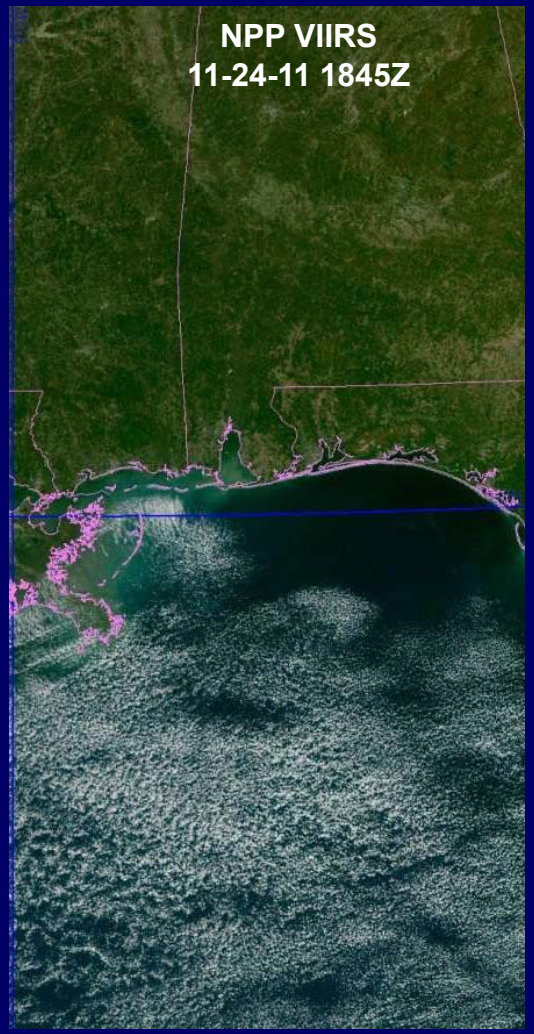


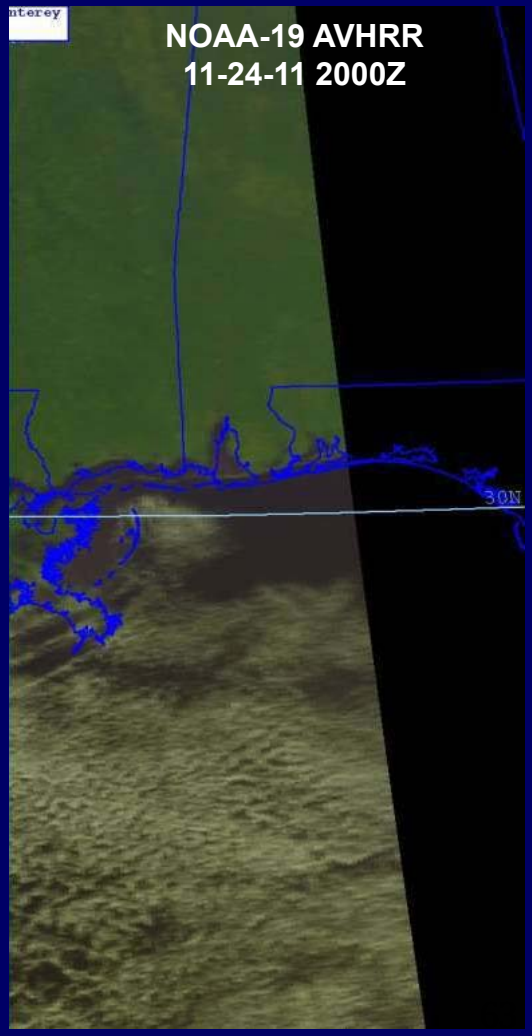
→ VIIRS maintains similar spatial resolution quality at edge of 3000 km swath

NPP VIIRS True Color Examples

Edge of Scan Intercomparisons

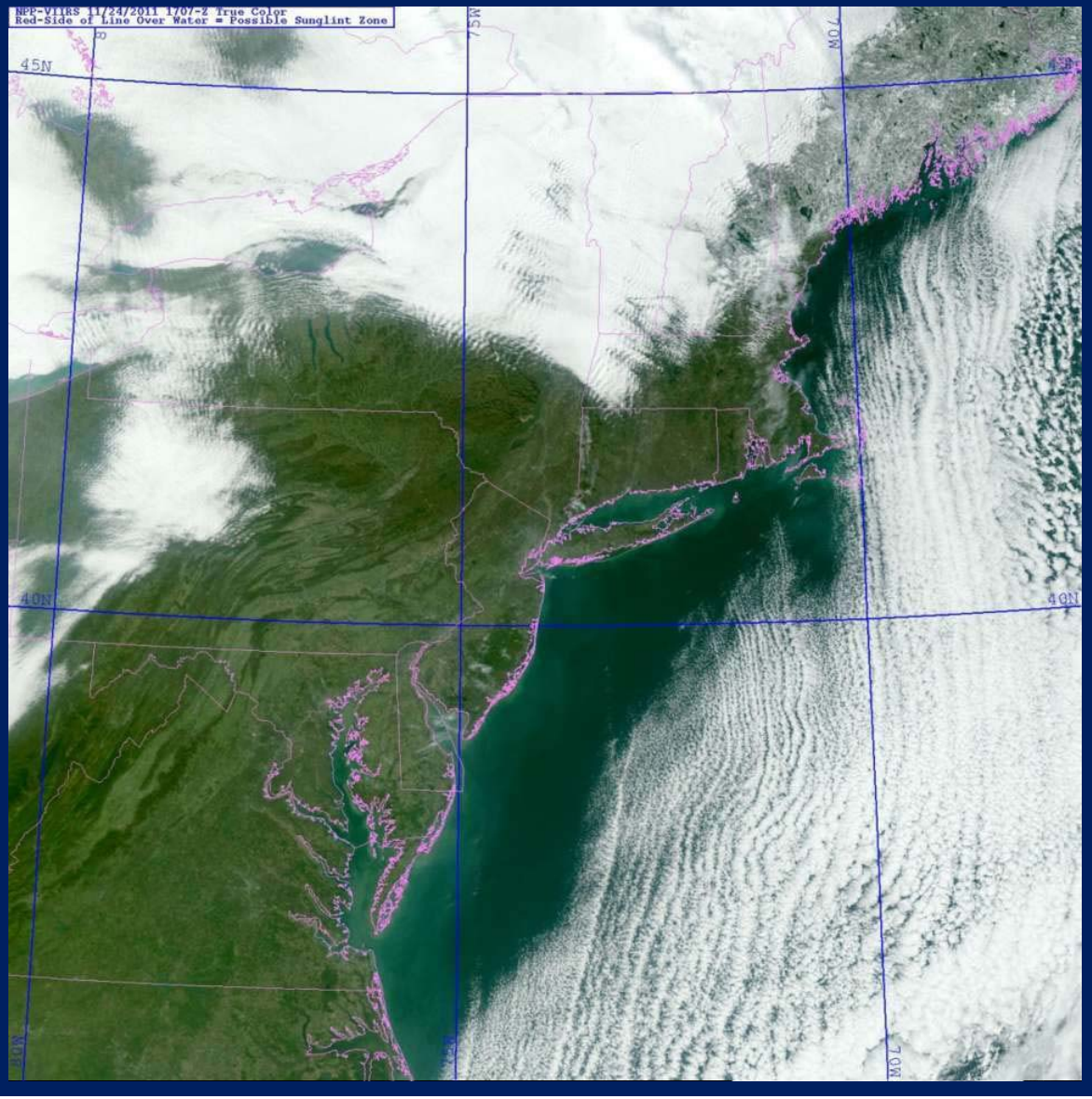






Multi-spectral Comparisons

True color - Northeast US

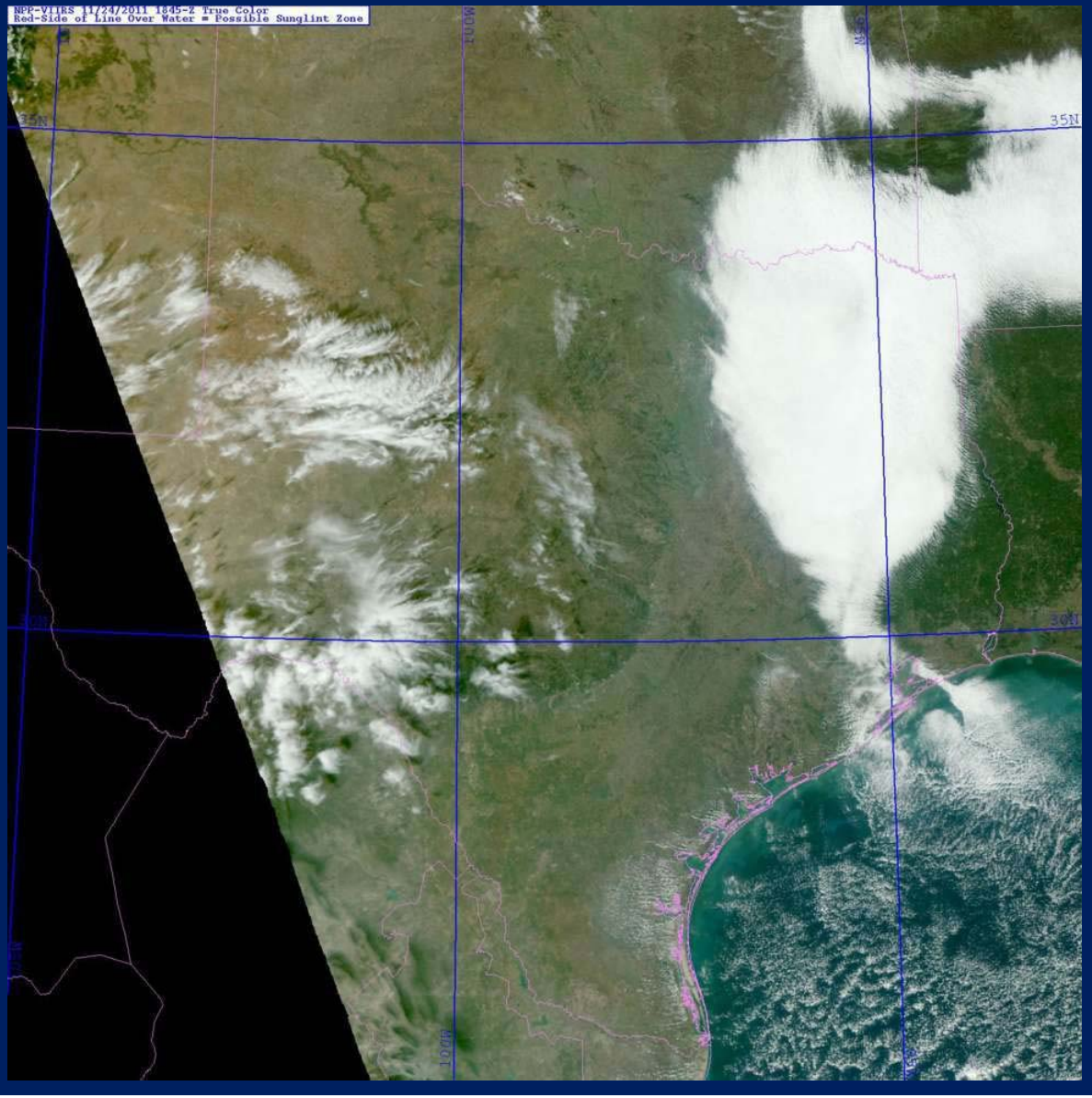


Multi-spectral Comparisons

True color – Texas

MODIS
1840z

VIIRS
1845Z

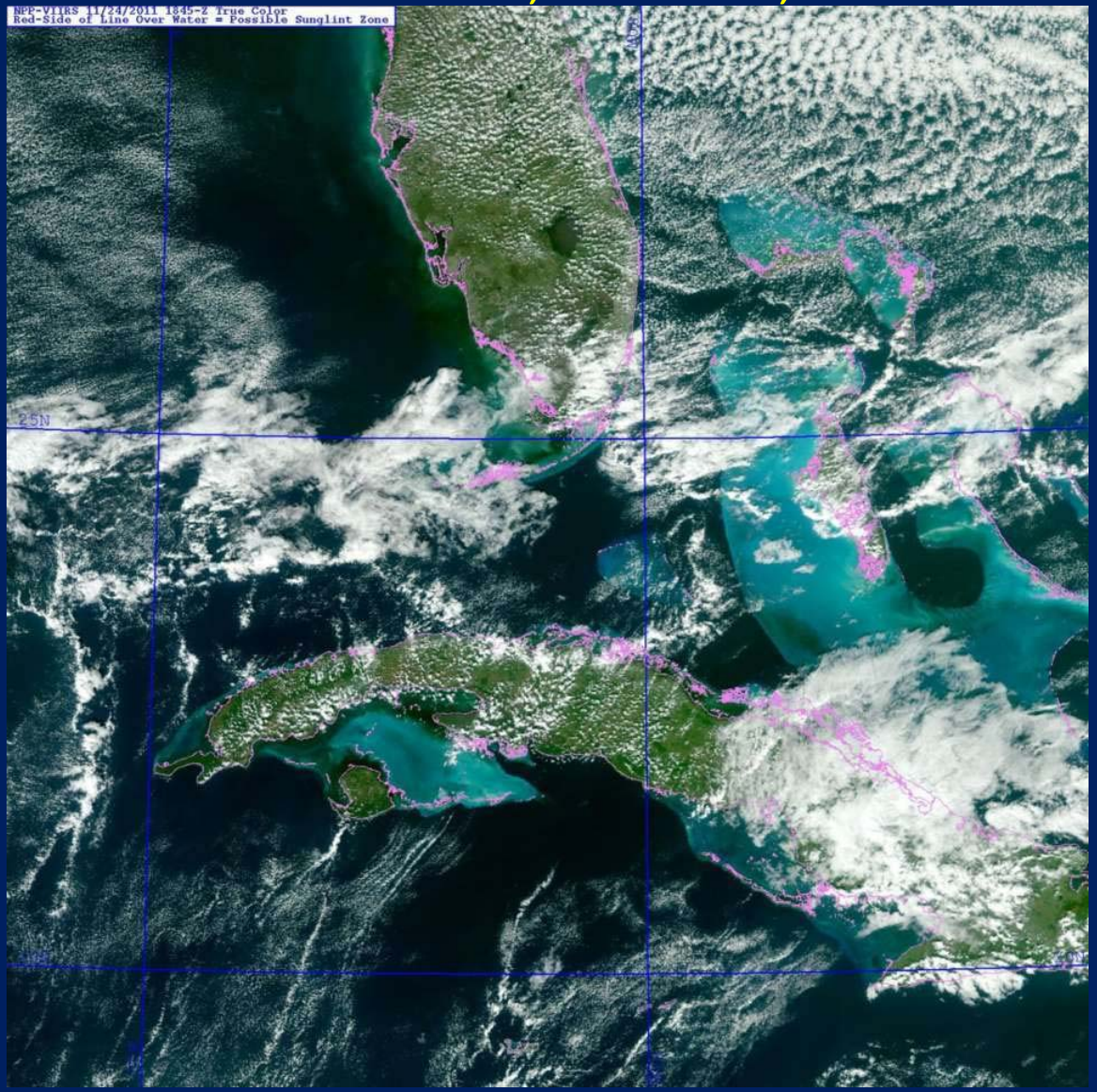


Multi-spectral Comparisons

True color – Florida, Bahamas, and Cuba

MODIS
1840z

VIIRS
1845Z

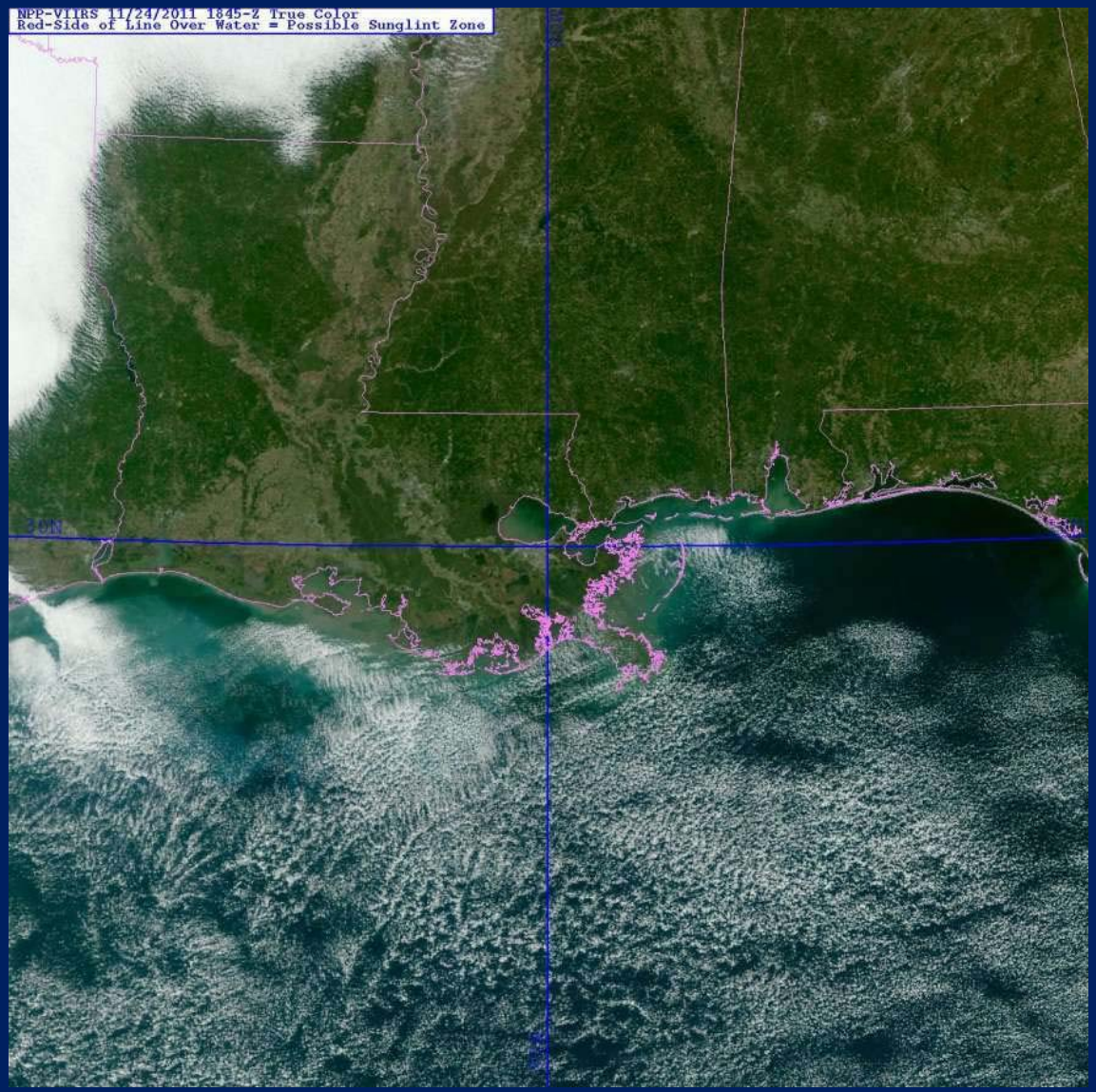


Multi-spectral Comparisons

True color – New Orleans

MODIS
1840z

VIIRS
1845Z



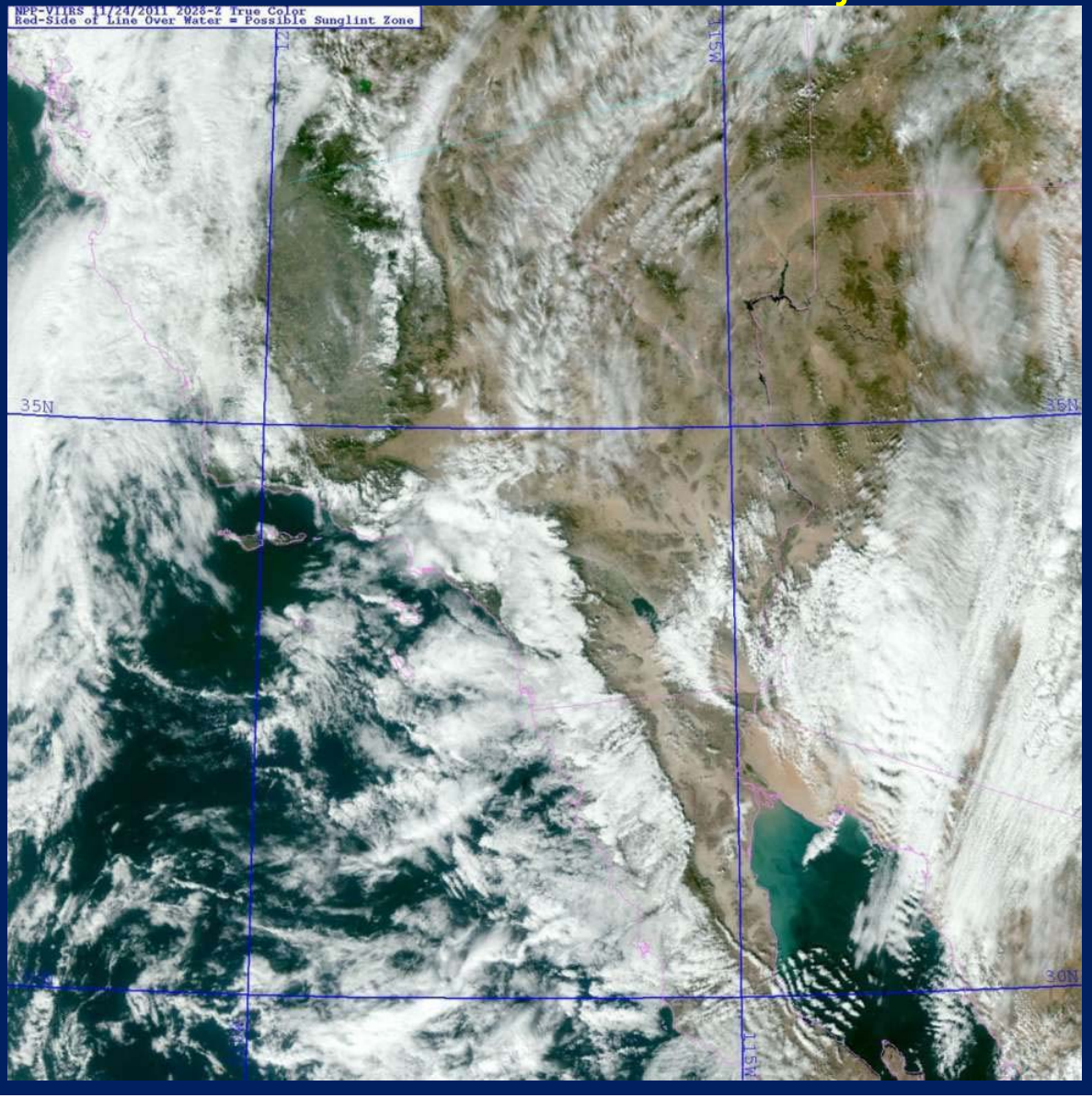
Resolution consistency across swath bodes well for AMV fidelity

Multi-spectral Comparisons

True color – SW USA & Baja

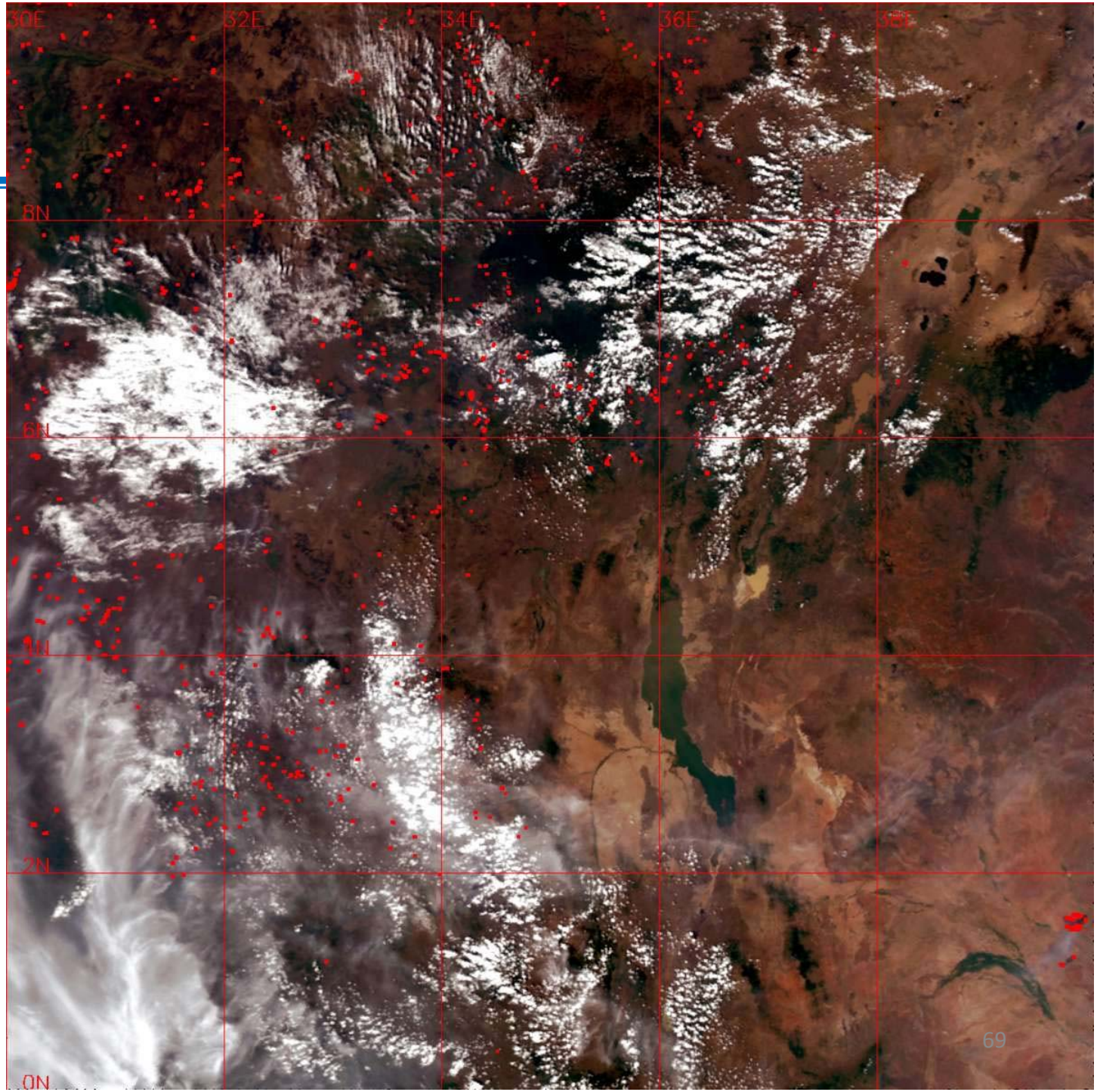
MODIS
2020Z

VIIRS
2028Z



…followed by Aqua MODIS five minutes later

Band 1-4-3 RGB
+
MYD14

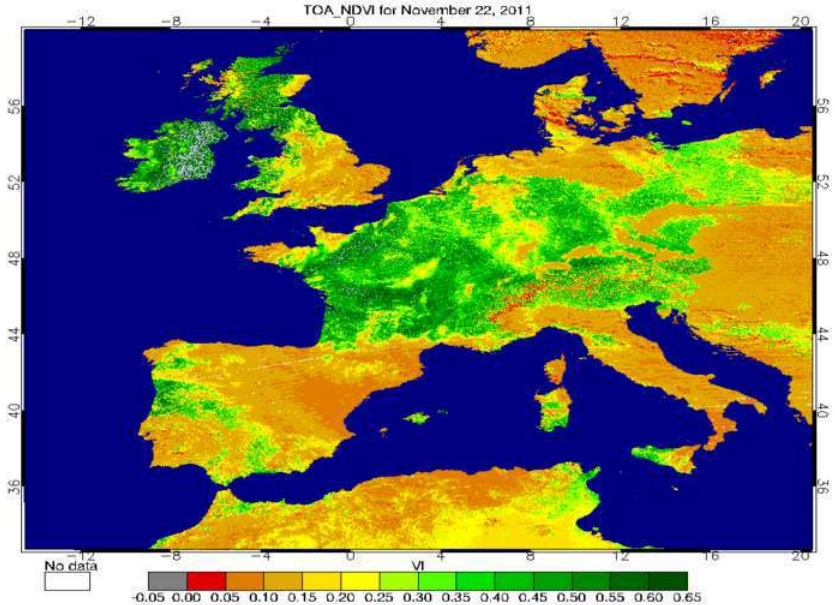


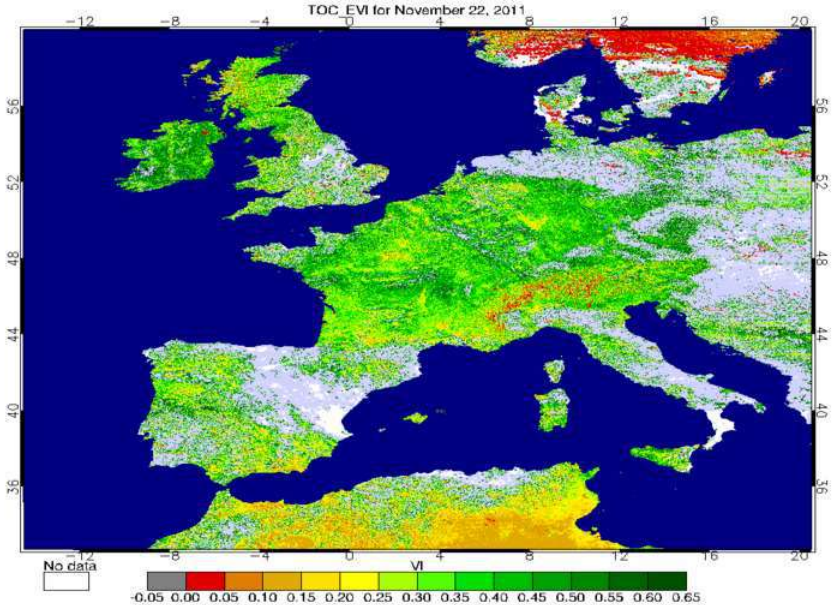
January 19, 2012
~11:05 UTC

Images froom VIIRS Land Team; Ivan Csiszar, NOAA/NESDIS/STAR

VIIRS Vegetation Index

- ***EDR description:*** The VIIRS Vegetation Index EDR produces a top-of-atmosphere (TOA) NDVI and a top-of-canopy (TOC) Enhanced Vegetation Index (EVI).
- ***Retrieval Strategy:***
  - The TOA NDVI calculation uses the traditional **NDVI** formulation with **TOA reflectance** inputs.
  - To produce the NDVI product, the algorithm uses reflectance acquired by the VIIRS 375 m resolution bands in the red part of the visible range (band I1; 640 nm) and in the near infrared (band I2; 865 nm).
  - The **TOC Enhanced Vegetation Index (EVI)** is computed utilizing a combination of 375 m resolution bands 640 nm (band I1) and 865 nm (band I2) and one 750 m resolution band, M3 (488 nm).
- ***Product Status and Expected Updates:*** The algorithm is based on AVHRR and MODIS heritage. No known issues in generating the Vegetation Index products. **TOC NDVI** will be included in the future.

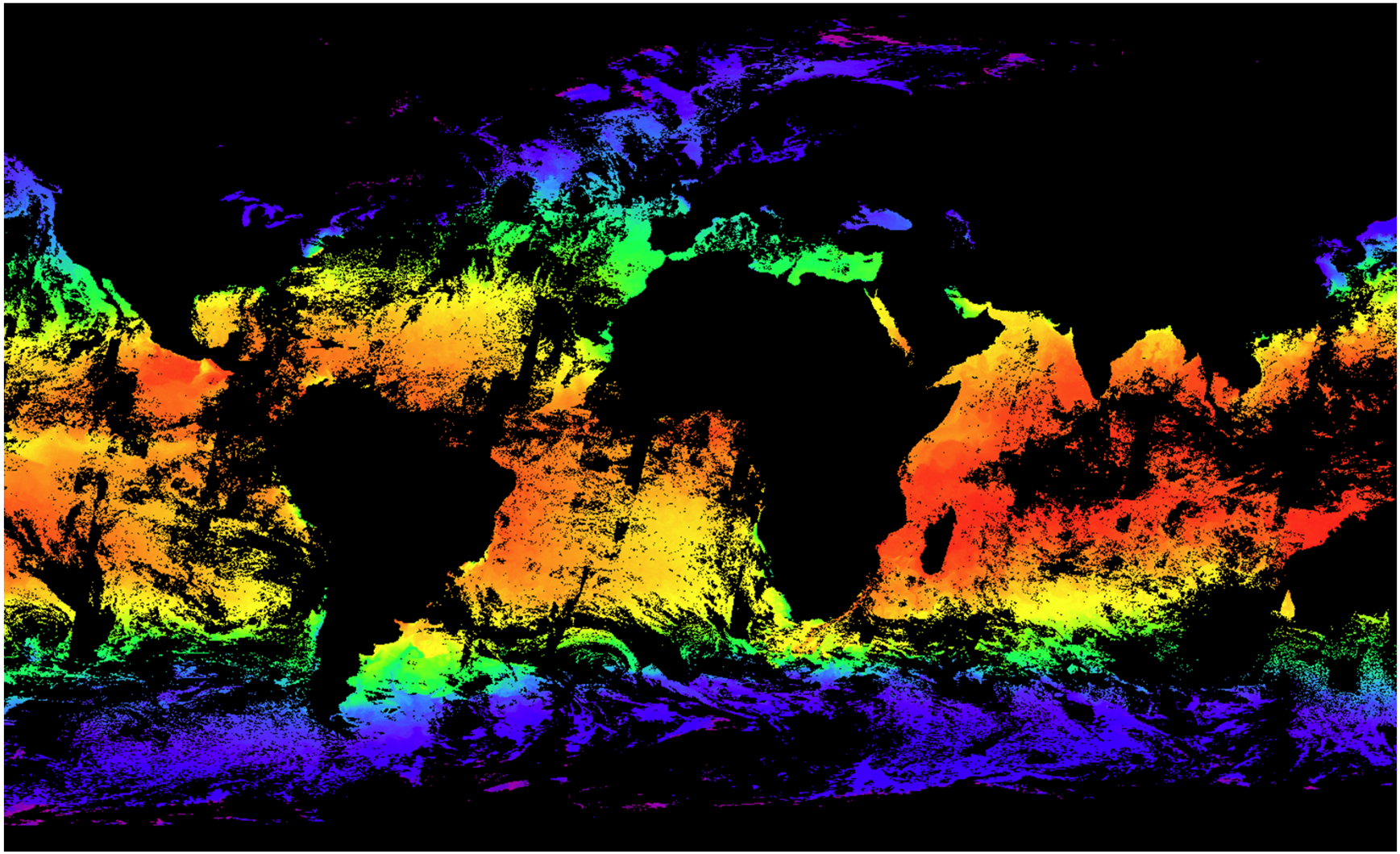




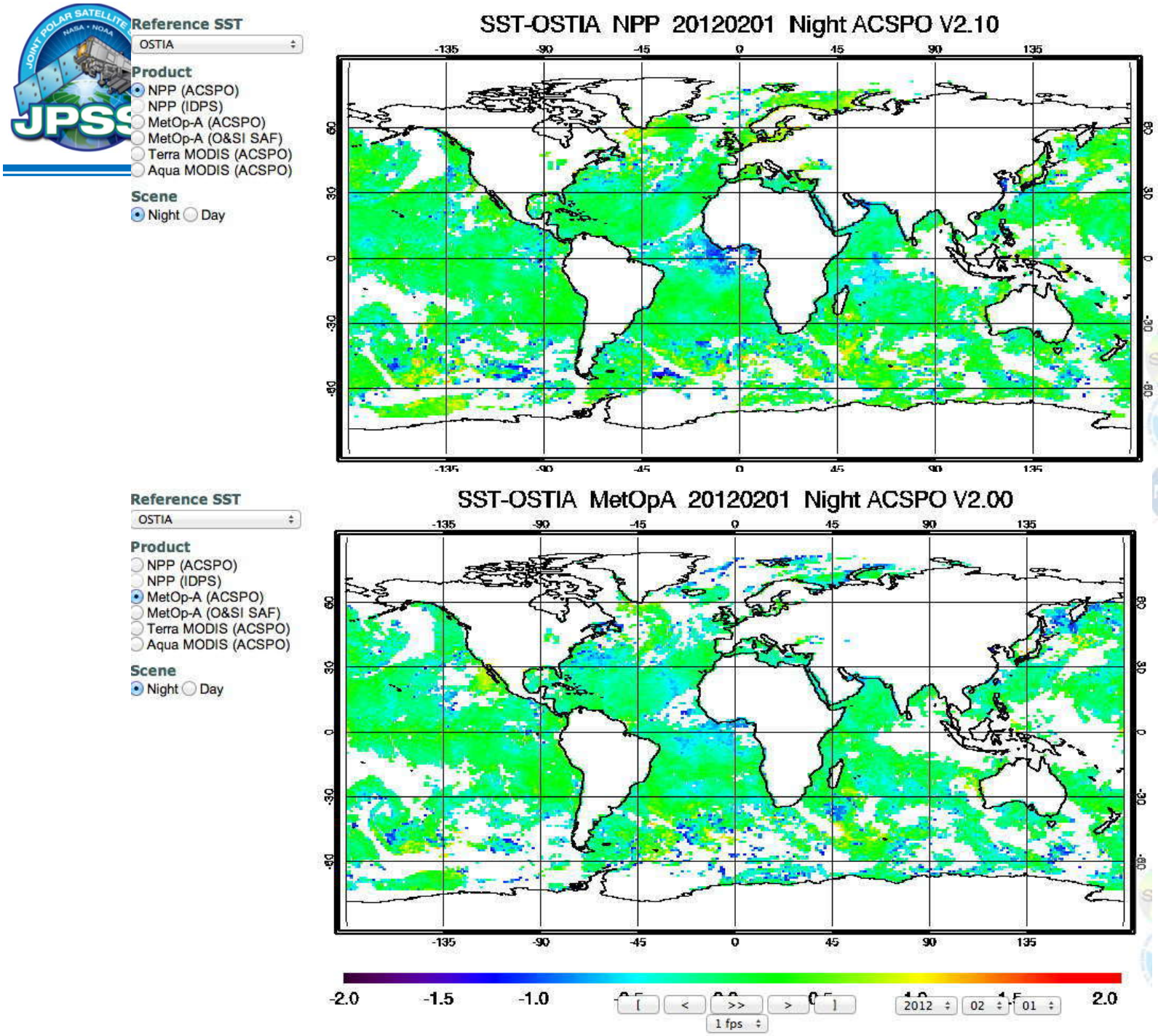
NDVI and EVI calculated from on-orbit VIIRS

M.Vargas, N. Shabanov NOAA/NESDIS/STAR

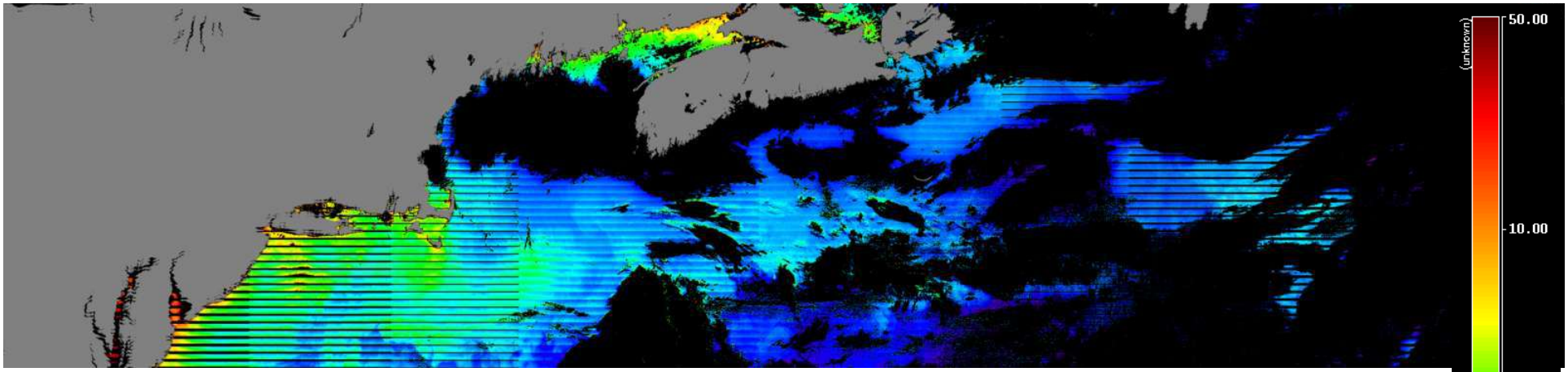
Feb 4 – 6, 2012



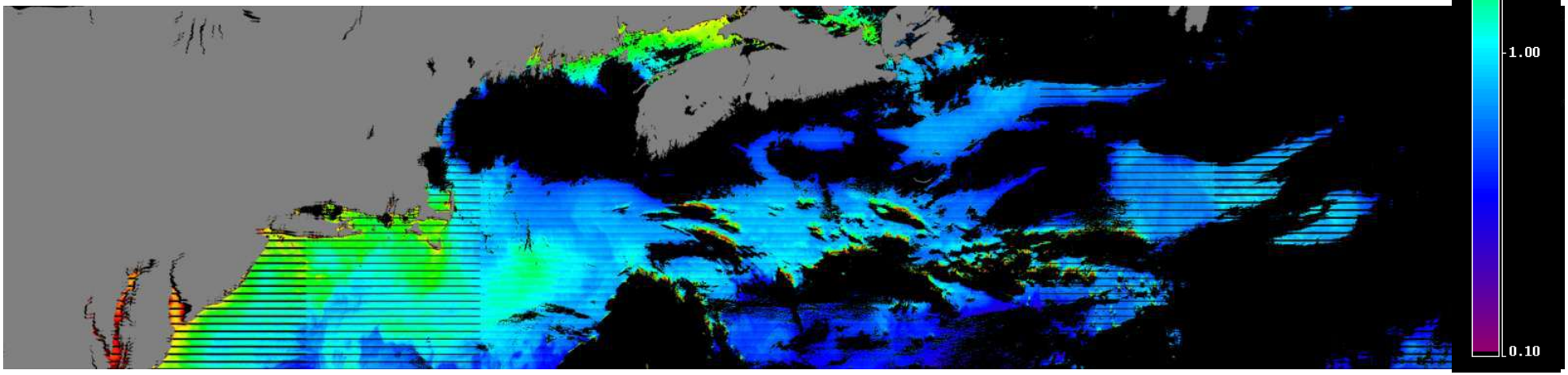
Courtesy: Bob Evans, Miami


Reference SST
OSTIA
Product
NPP (ACSPO)
NPP (IDPS)
MetOp-A (ACSPO)
MetOp-A (O&SI SAF)
Terra MODIS (ACSPO)
Aqua MODIS (ACSPO)
Scene
Night
Day
SST-OSTIA NPP 20120201 Night ACSPO V2.10
SST-OSTIA MetOpA 20120201 Night ACSPO V2.00
-135
-90
-45
0
45
90
135
60
30
0
-30
-60
-2.0
-1.5
-1.0
2.0
1 fps
2012
02
01

VIIRS Chl-a @ 2012/02/07 17:03 GMT

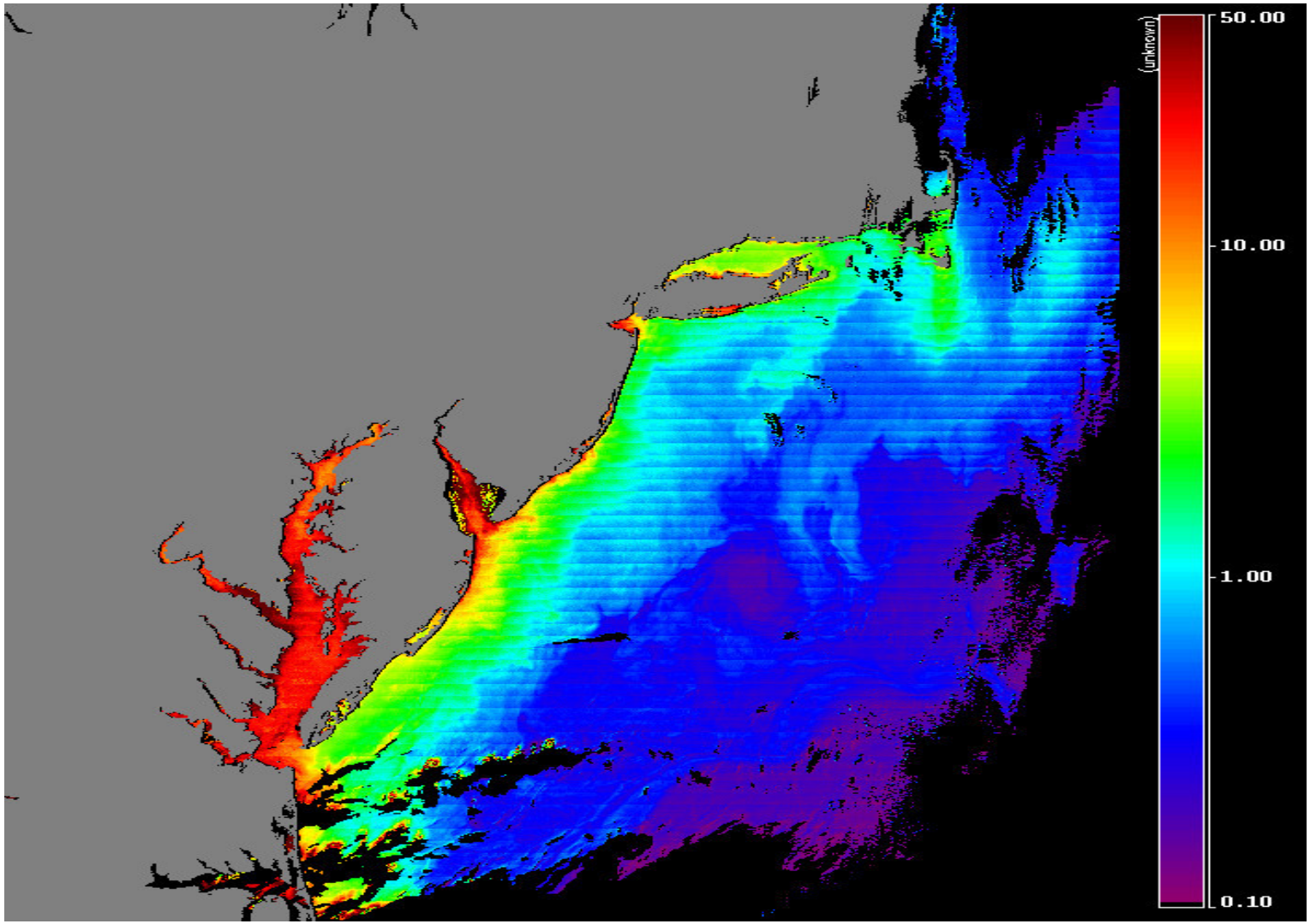


Official IDPS Chl-a Product



NOAA-MSL12 Produced Chl-a Product

MODIS-Aqua Chl-a @ 2012/02/07 18:25 GMT

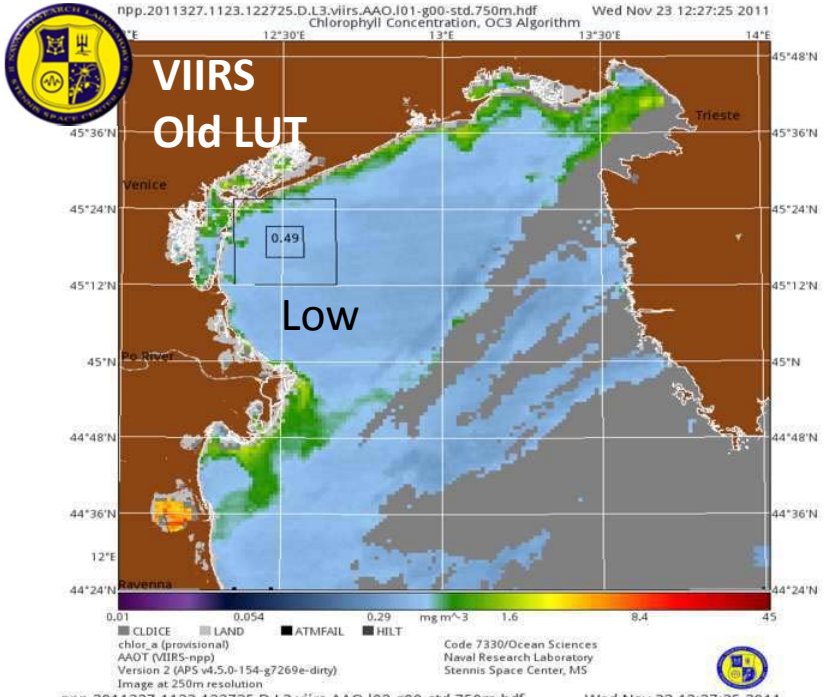


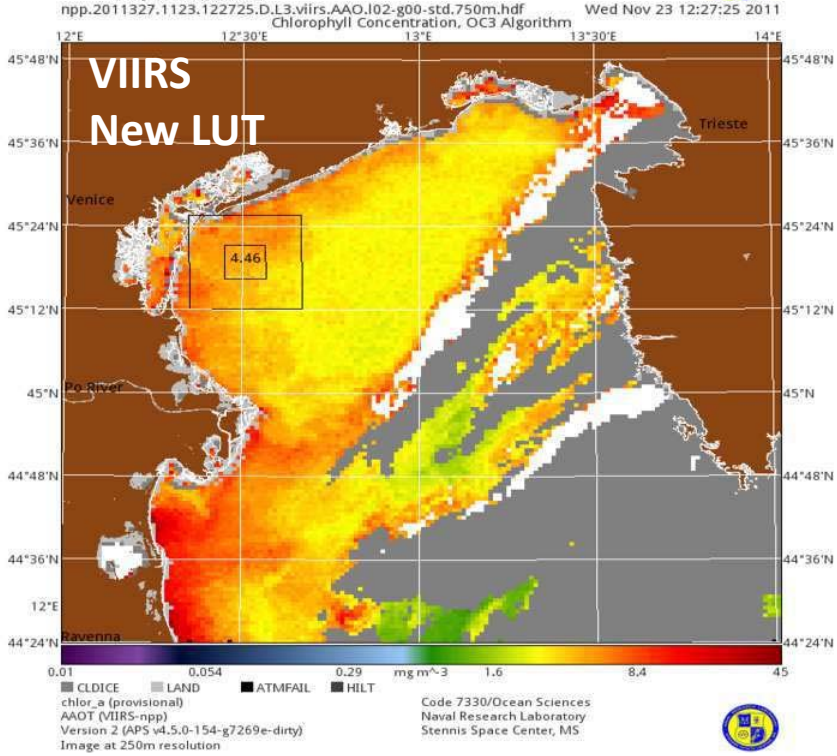
NOAA-MSL12 Processed Chl-a

Impact of new LUT on Chlorophyll

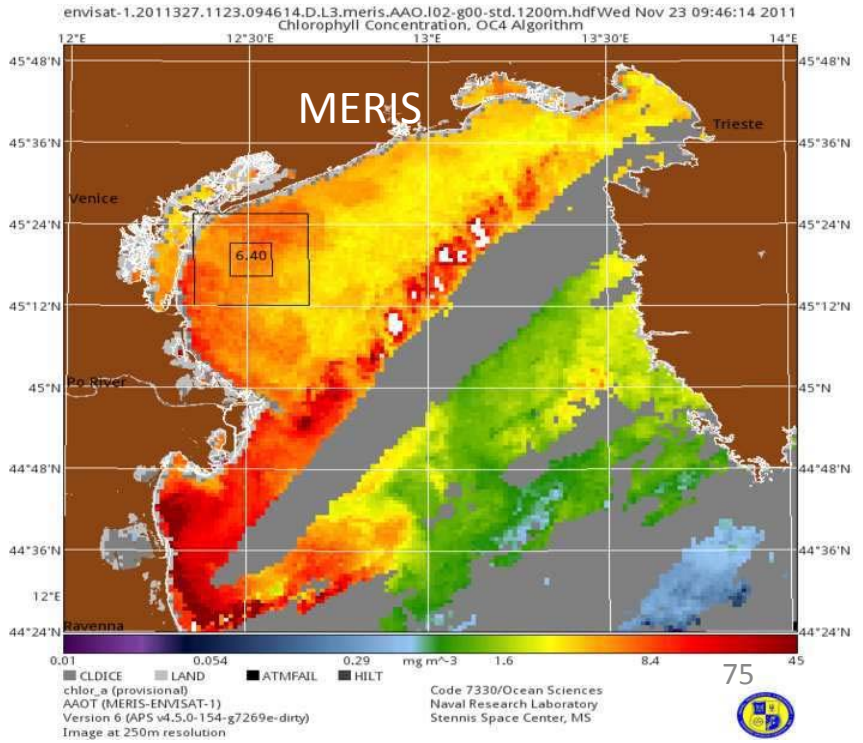
Comparison with MERIS products

Nov 23, 2012

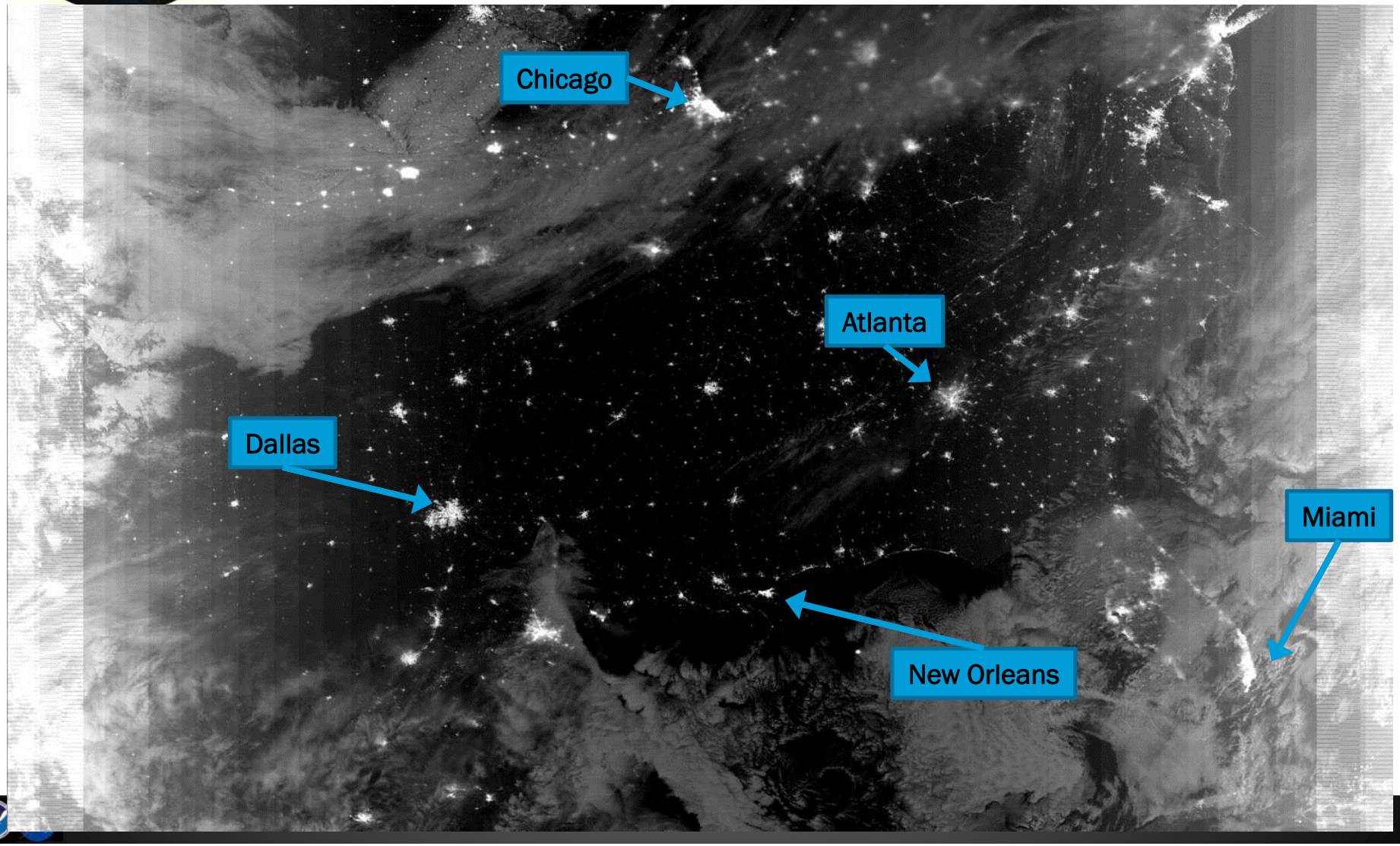




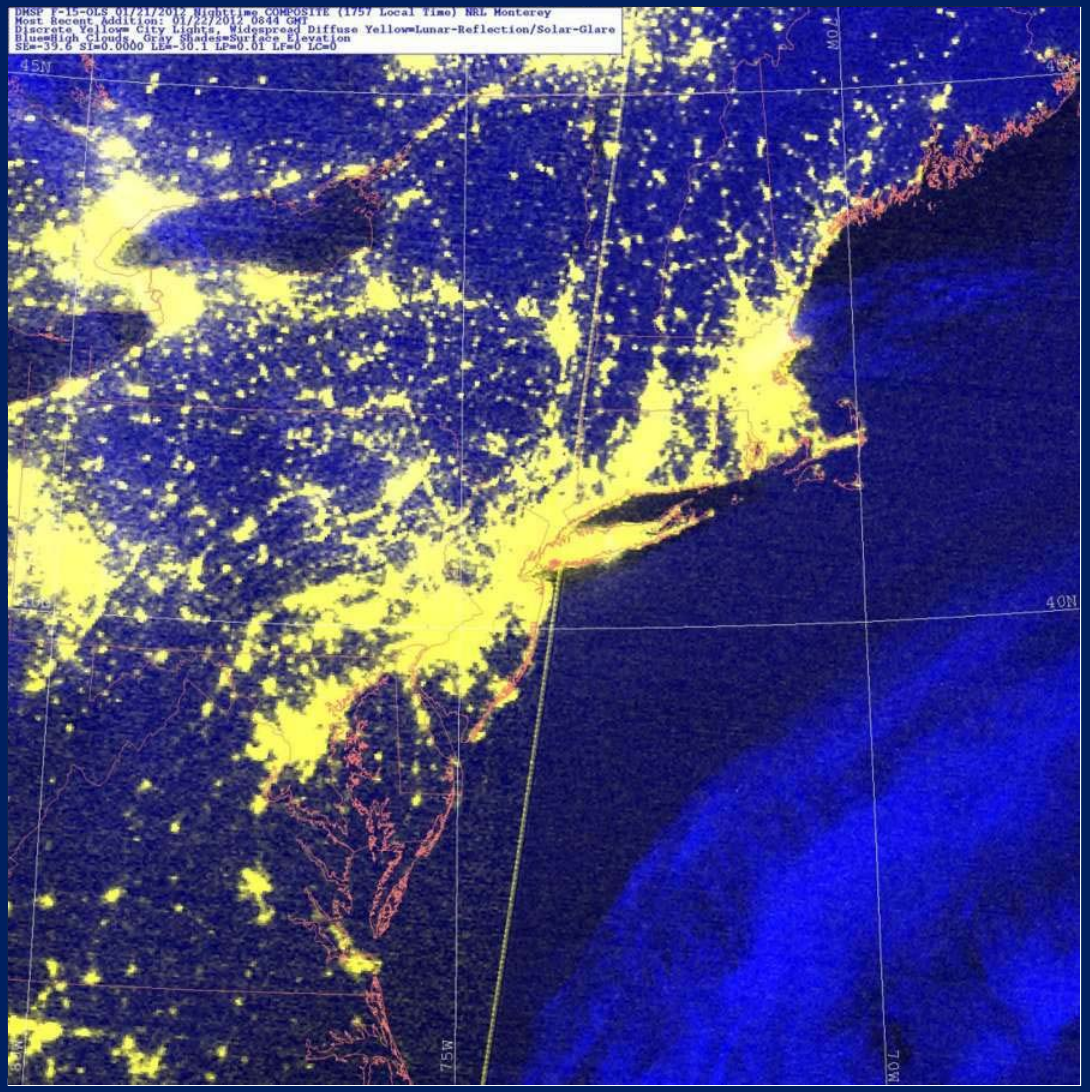
Similar Values



VIIRS Day Night Band



VIIRS Nighttime Visible - DNB



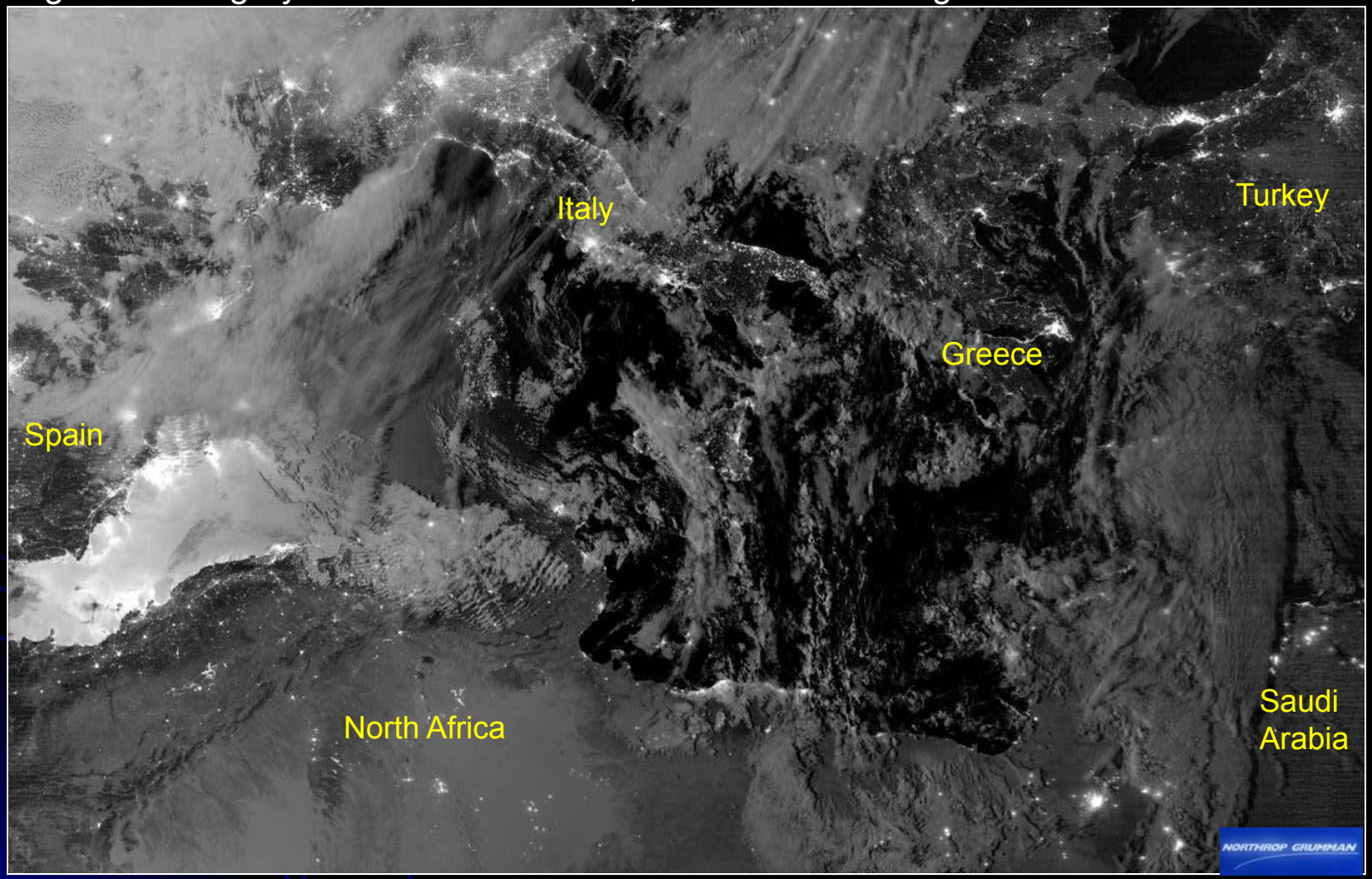
OLS 08:44Z
DNB 0718Z

Geolocation not corrected

Enhanced city light definition due to spatial resolution and quantization

Moonlight Imagery

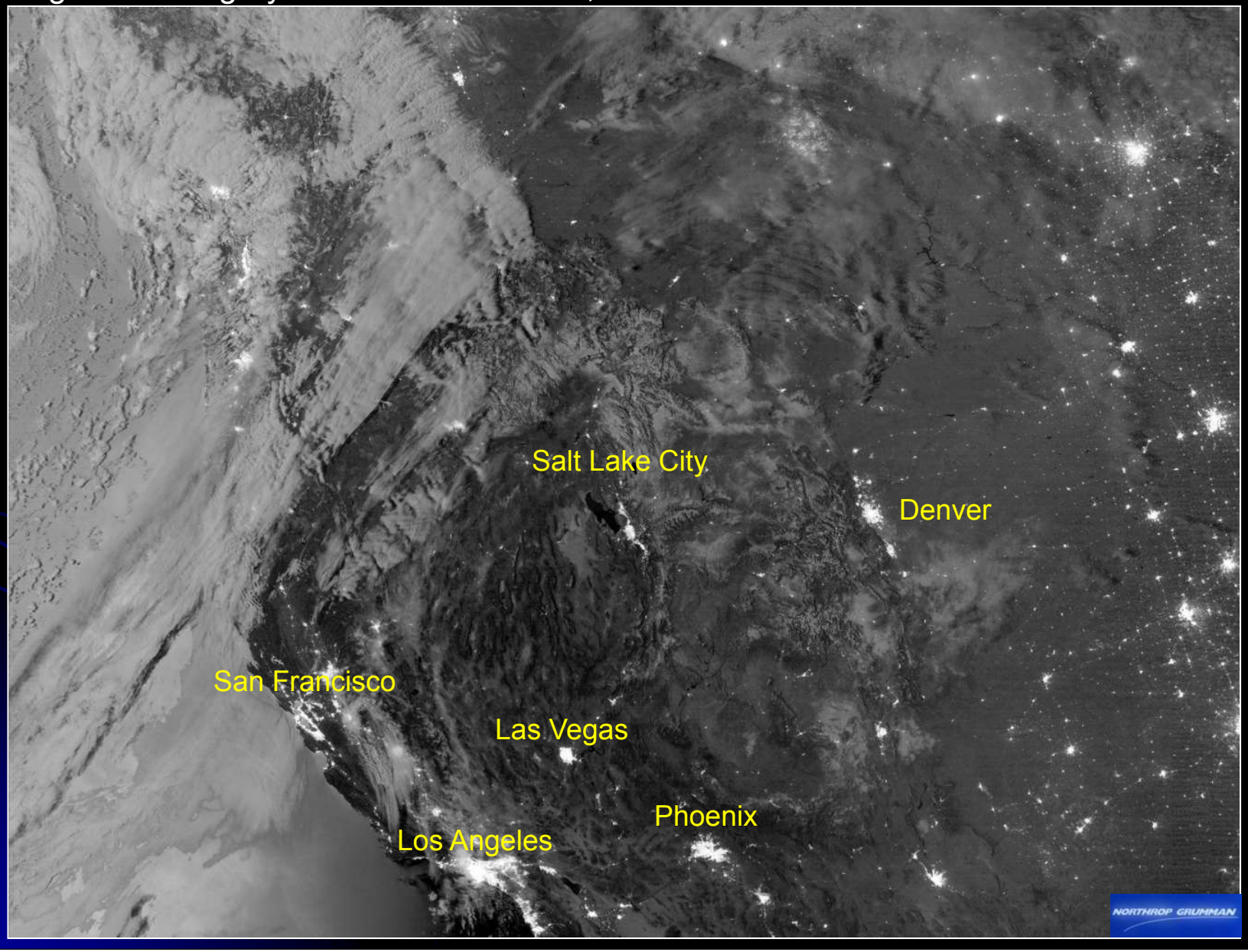
Nighttime Imagery: 1/5/2012 0053 UTC, Mediterranean Region



→ Moonglint scenes showcase the tremendous dynamic range and radiometric resolution of the new DNB sensor.

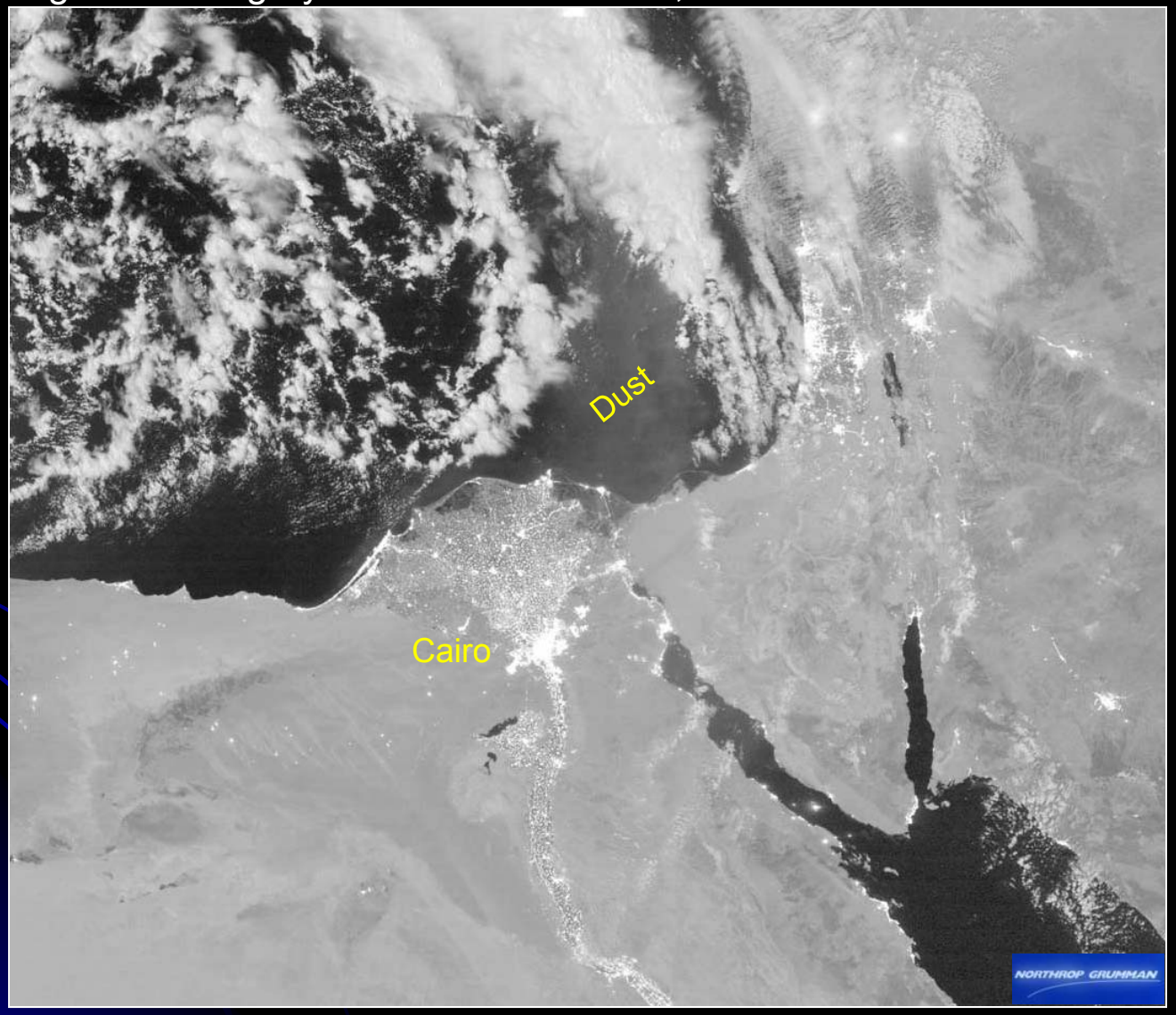
Moonlight Imagery

Nighttime Imagery: 1/5/2012 0920 UTC, Western U.S.



Dust Storm

Nighttime Imagery: 1/7/2012 2359 UTC, Eastern Mediterranean



Volcanic Ash

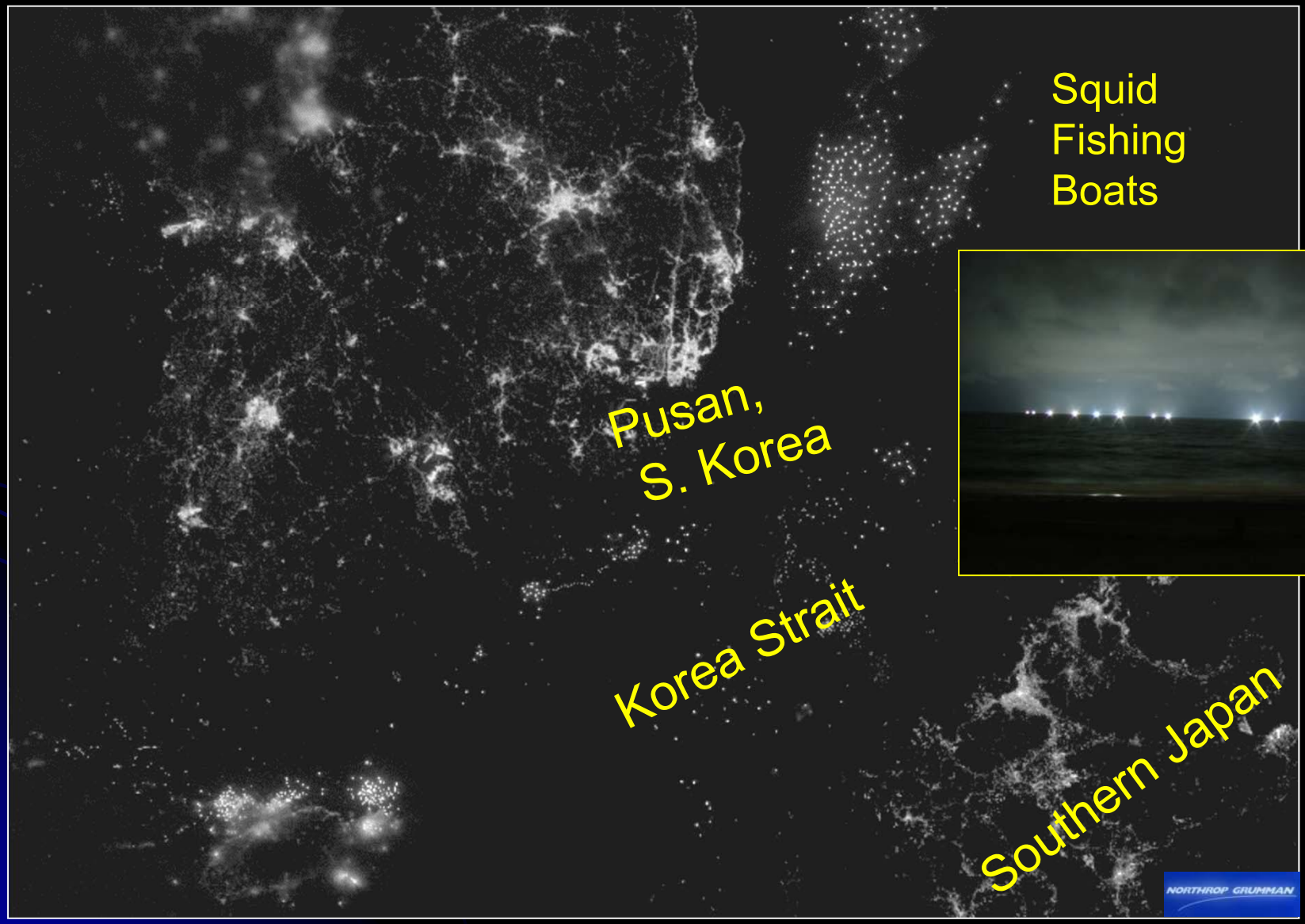
Puyehue-Cordon Caulle Volcanic Chain

12-13 Dec 2011

Afternoon | Night | Morning

→ Nighttime pass fills in the temporal gap between last PM and first available AM visible-light observations.

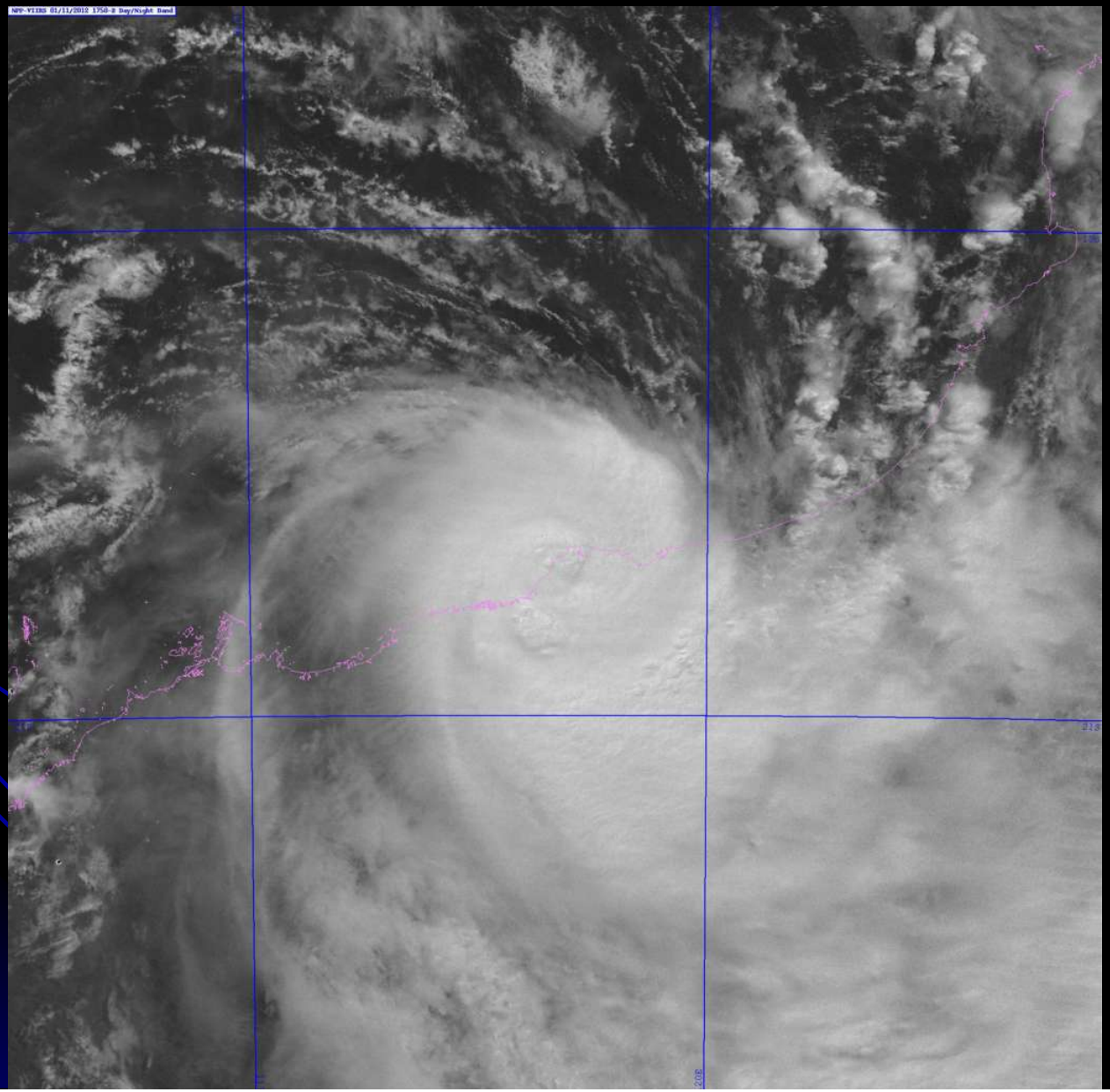
The Korean Strait



VIIRS Nighttime Visible - DNB

Tropical Cyclone 06S Heidi

VIIRS 1750 OLS 2005 OLS 2129



OMPS Instrument Design

Nadir Mapper

UV Backscatter, grating spectrometer, 2-D CCD

TOMS, SBUV(/2), GOME(-2), OMI

110 deg. cross track, 300 to 380 nm spectral, 1.1nm FWHM bandpass

Total Column Ozone, UV Effective Reflectivity, and Aerosol Index Daily Maps

Nadir Profiler

UV Backscatter, grating spectrometer, 2-D CCD

SBUV(/2), GOME(-2), OMI

Nadir view, 250 km cross track, 270 to 310 nm spectral, 1.1 nm FWHM bandpass

Ozone Vertical Profile, 7 to 10 KM resolution

Limb Profiler

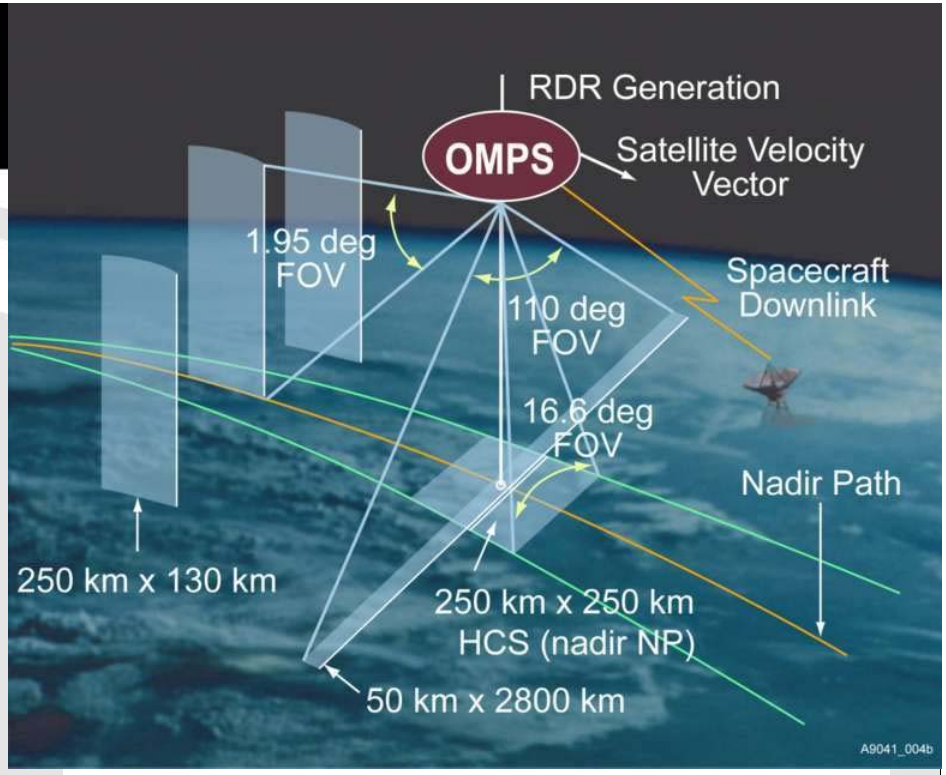
UV/Visible Limb Scatter, prism, 2-D CCD array

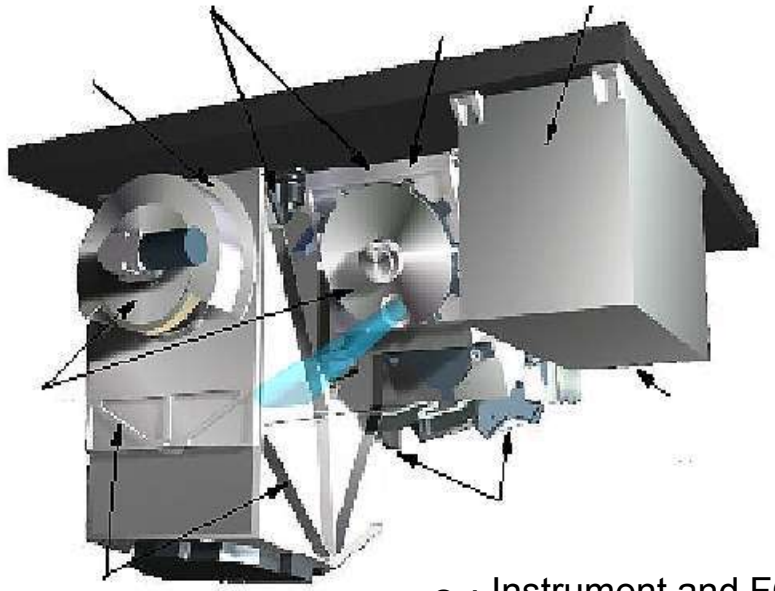
SOLSE/LORE, OSIRIS, SAGE III, SCIAMACHY

Three 100-KM vertical slits, 290 to 1000 nm spectral

Ozone Vertical Profile, 3 KM vertical resolution

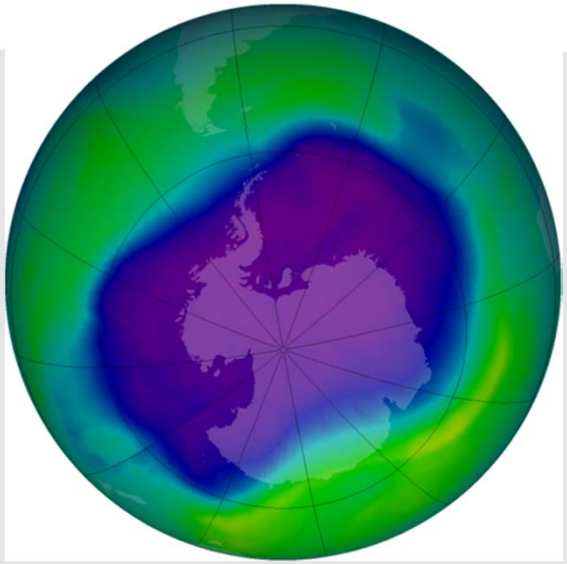
The calibration concepts use working and reference solar diffusers.

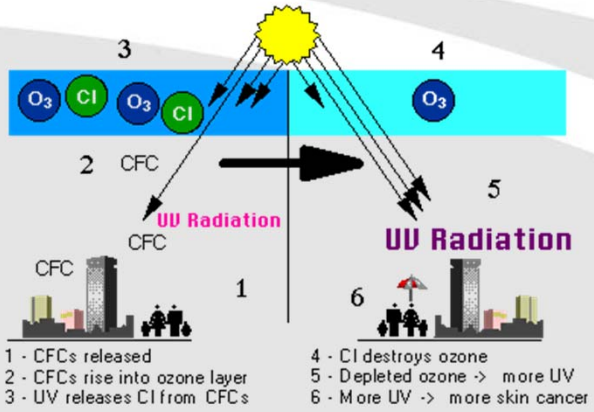




84 Instrument and FOV Graphics from BATC

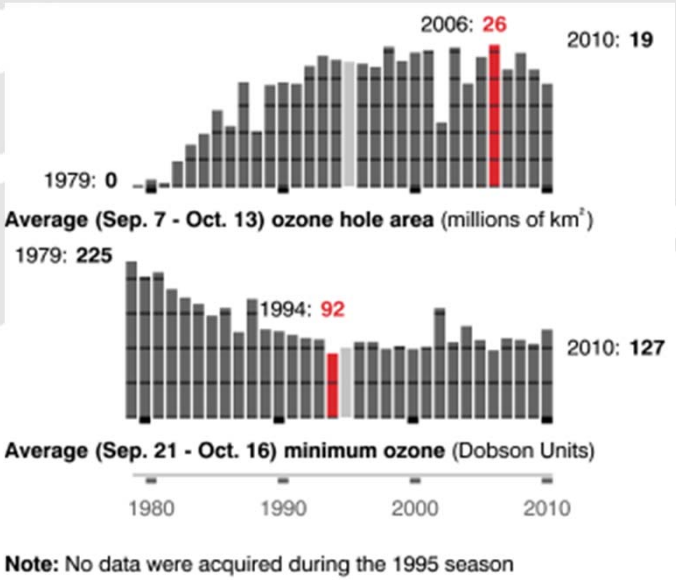
OMPS provides continuity of essential ozone products and applications

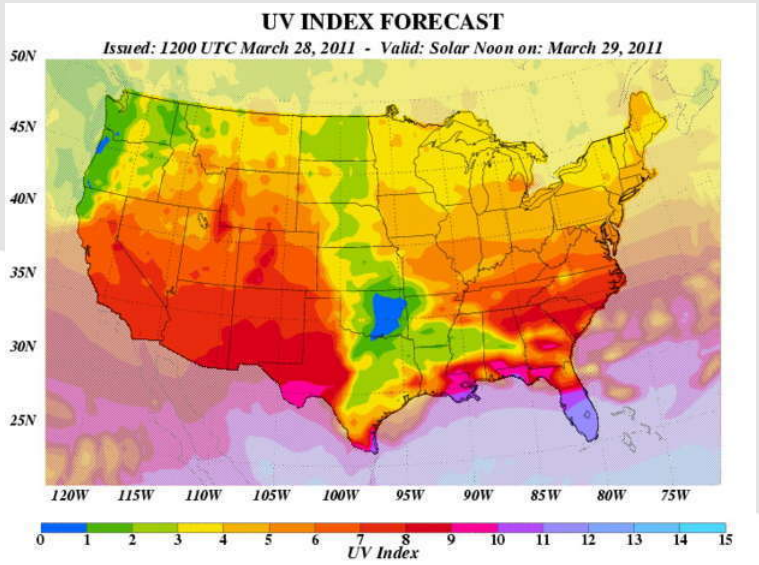




Monitoring ozone hole and recovering of ozone due to the Montreal Protocol for eliminating Chlorofluorocarbons (CFCs)

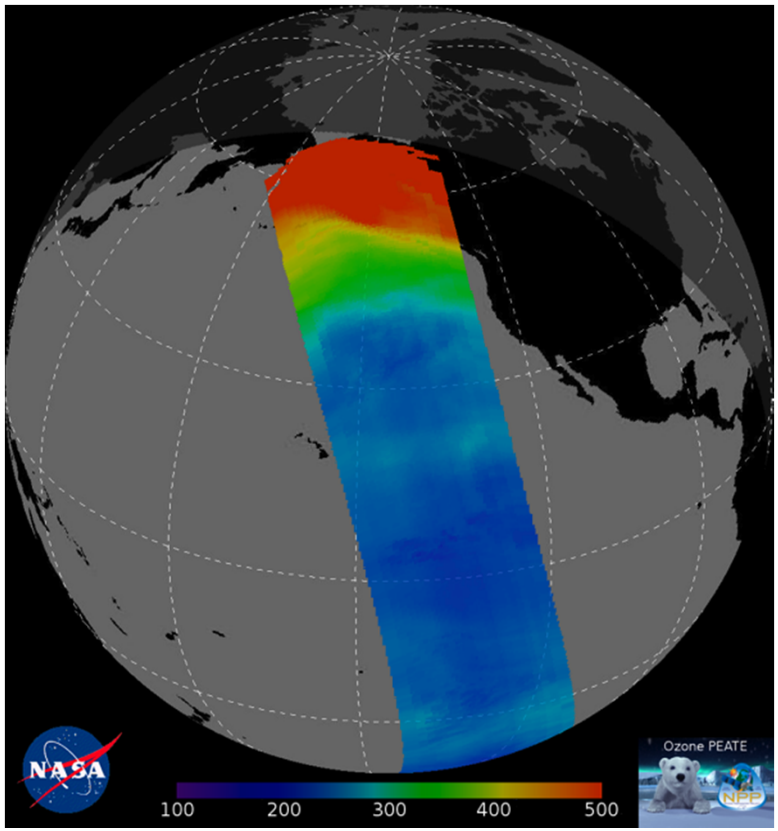
Used in NWS UV Index forecast to allow public to avoid overexposure to UV radiation



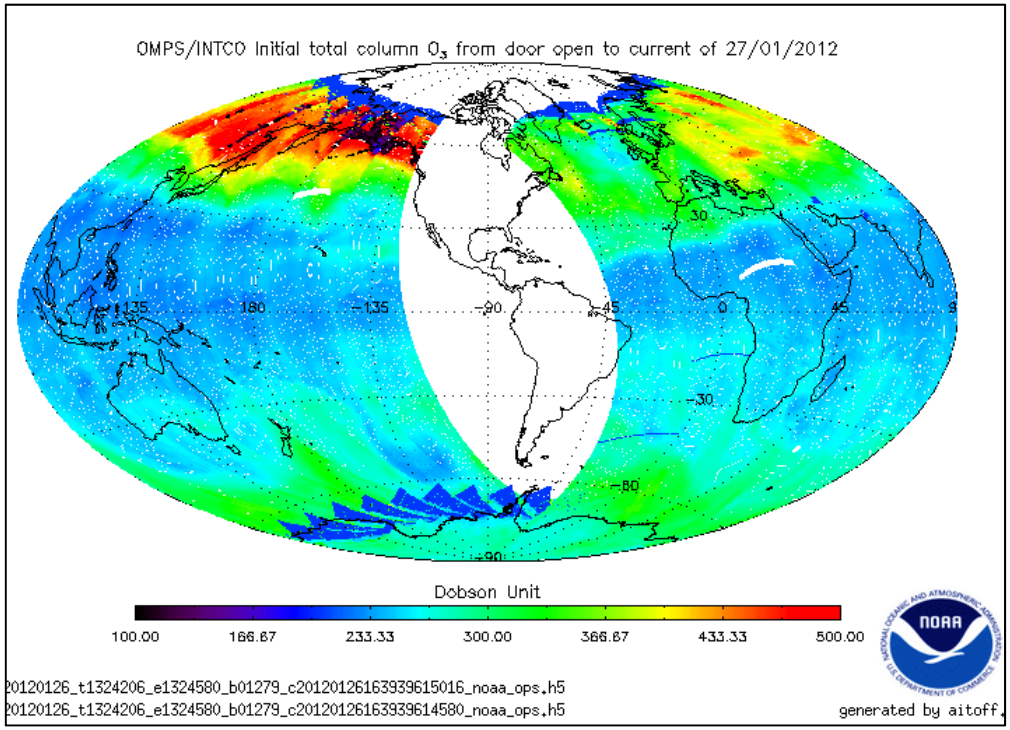


Ozone Monitoring and Profiling Suite
Regular Operations: January 27, 2012

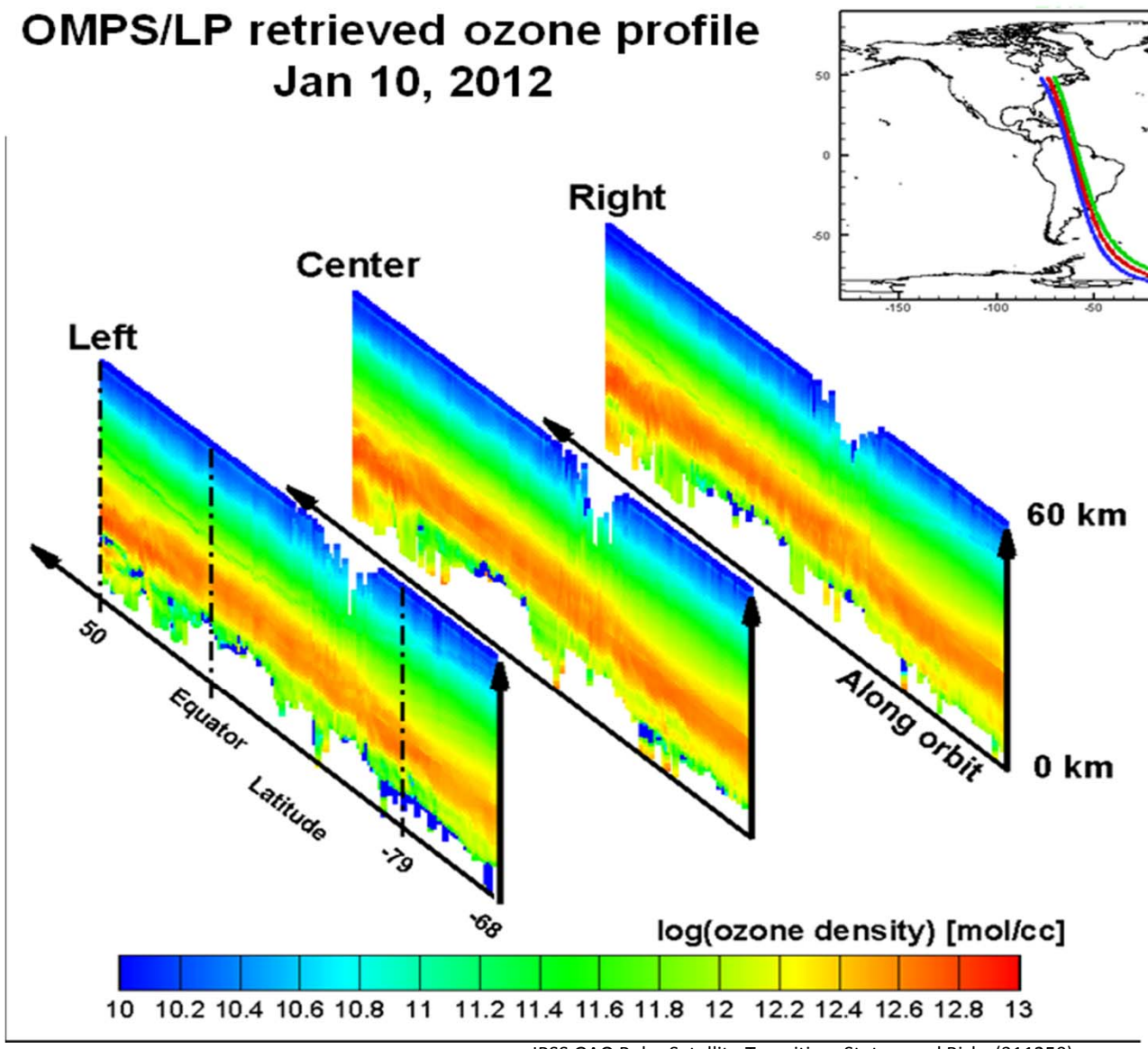
OMPS First Light Research Algorithms

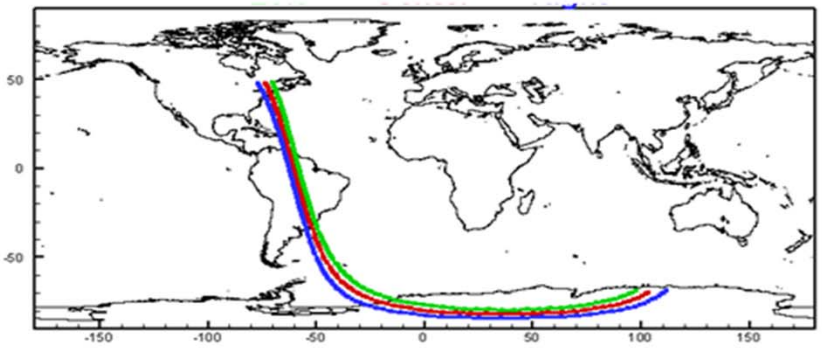


OMPS First Operational Data

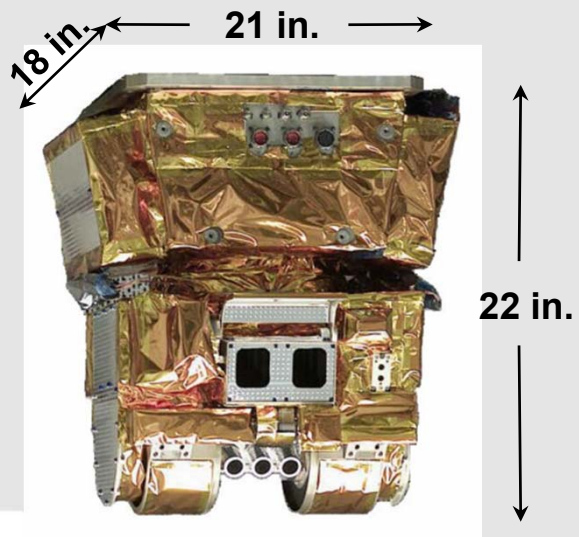


Ozone Profile and OMPS Limb





CERES Instrument Overview



CERES scanning radiometer measuring three spectral bands at TOA

- Total (0.3 to >50 μm)
- Shortwave (0.3 to 5.0 μm)
- Longwave (5 to 50 μm)

Operations, Data Processing, Products, and Science are a continuation of experience developed on

- TRMM (1), EOS Terra (2), EOS Aqua (2), in I&T on NPP

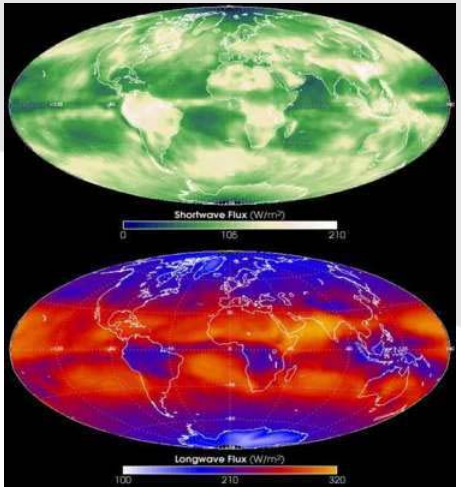
Critical Resource Margins

	CERES Value	Allocation	Margin
Mass, kg	46.8	54	13.3%
Power: Operational, Watts	45.85	50	8.3%
Power: Peak, Watts	60	75	20.0%
Power: Survival, Watts	39.5	40	1.3%
Heat Transfer - Hot Case, Watts	4.1	±5 W	18.0%
Heat Transfer - Cold Case, Watts	-1.7	±5 W	66.0%
Data Rate, Kb / sec	10	10	0
Pointing Control, arcsec	< 114	194	41.2%
Pointing Knowledge, arcsec	< 107	180	40.6%

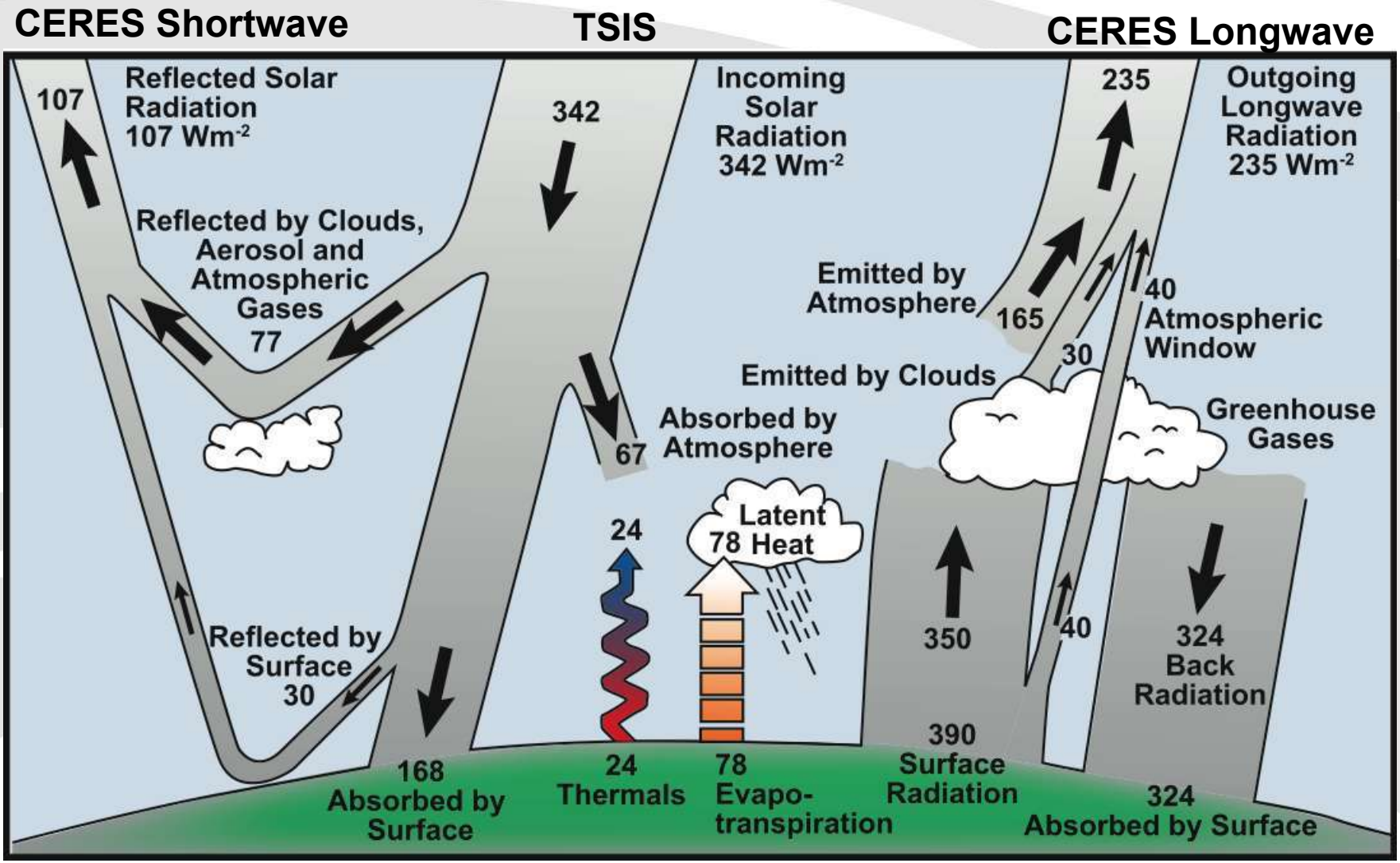
Primary CERES Climate Data Records

Reflected Solar Energy

Emitted Thermal Energy



Earth Radiation Budget



From IPCC AR4 FAQ

CERES Flight Model 5

First Light Data: January 26, 2012

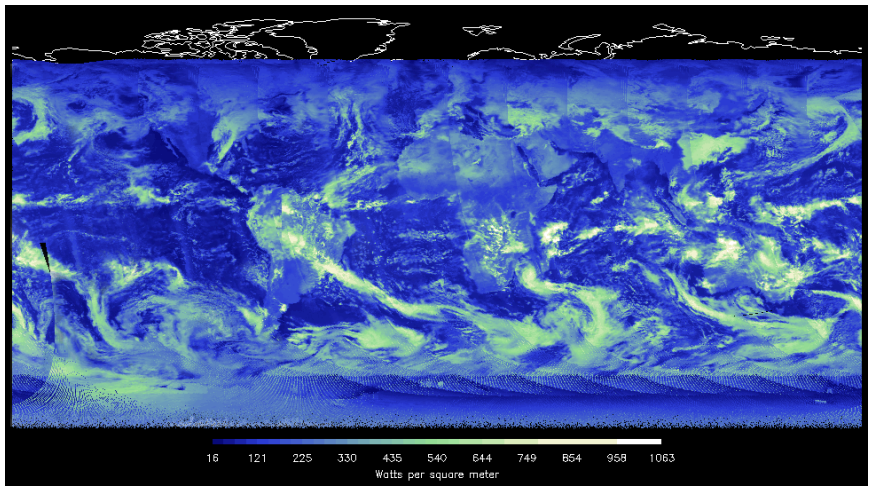
CERES scanning radiometer measuring three spectral bands at TOA

- Total (0.3 to >50 μm)
- Shortwave (0.3 to 5.0 μm)
- Longwave Bandpass (8 to 12 μm)

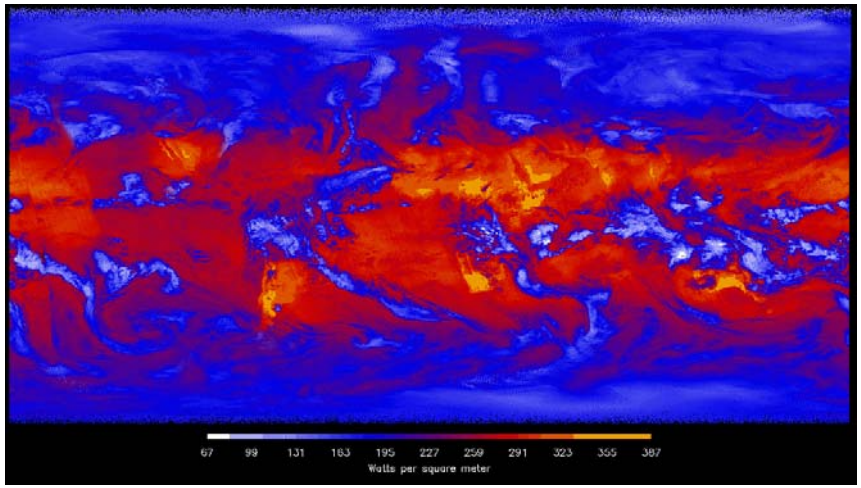
Operations, Data Processing, Products, and Science are a continuation of experience developed on

- TRMM (1), EOS Terra (2), EOS Aqua (2)

Reflected Solar Energy

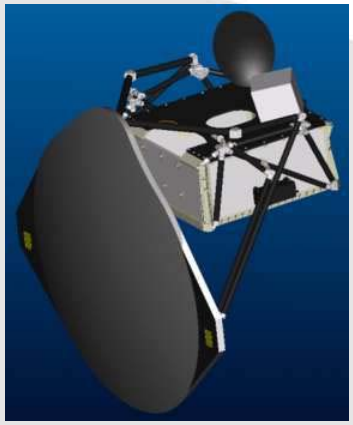


Emitted Thermal Energy



Overview of AMSR2 instrument on GCOM

Deployed



Stowed

- Deployable main reflector system with 2.0m diameter.
- Frequency channel set is identical to that of AMSR-E except 7.3GHz channel for RFI mitigation.
- 2-point external calibration with the improved HTS (hot-load).

AMSR2 characteristics	
Scan	**Conical scan**
Swath width	**1450km**
Antenna	**2.0m offset parabola**
Digitalization	**12bit**
Incidence angle	**nominal 55 degree**
Polarization	**Vertical and Horizontal**
Dynamic range	**2.7-340K**

AMSR2 Channel Set				
Center Freq. [GHz]	**Band width [MHz]**	**Polarization**	**Beam width [deg] (Ground res. [km])**	**Sampling interval [km]**
6.925/ 7.3	**350**	**V and H**	**1.8 (35 x 62)**	**10**
			1.7 (34 x 58)	
10.65	**100**		**1.2 (24 x 42)**	
18.7	**200**		**0.65 (14 x 22)**	
23.8	**400**		**0.75 (15 x 26)**	
36.5	**1000**		**0.35 (7 x 12)**	
89.0	**3000**		**0.15 (3 x 5)**	**5**

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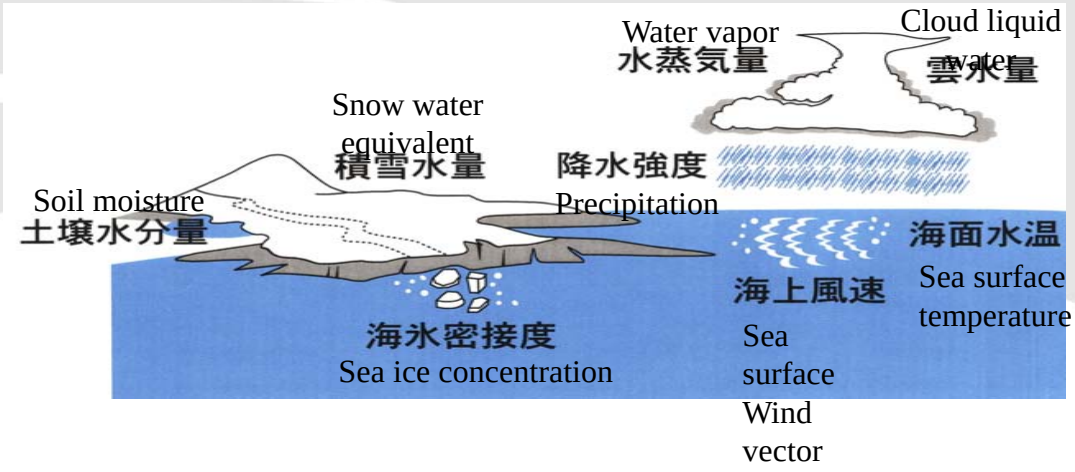
Overview of AMSR2 Products

Geophysical products	Comments
Integrated water vapor	Over global ocean*, columnar integrated value
Integrated cloud liquid water	Over global ocean*, columnar integrated value
Precipitation	Global (except over ice and snow), surface rain rate
Sea surface temperature	Global ocean*
Sea surface wind speed	Global ocean*
Sea ice concentration	High latitude ocean areas
Snow depth	Land surface (except dense forest regions)
Soil moisture	Land surface (except ice sheet and dense forest regions)



User Engagement & Feedback

Sustaining User Engagement is part of the JPSS Program

Demonstrate importance of NPP data to the Nation and to critical operational product and services and for improved research

Established a JPSS Proving Ground to focus on improved utilization of NPP/JPSS data for key application areas

Application Areas

- Tropical Cyclone Applications
- Cryosphere Applications
- Severe Weather/Aviation Applications
- Ocean/Coastal Applications (Coral Bleaching, Harmful Algae Bloom alerts)
- Land Applications (Agriculture, Droughts)
- Hazards Applications (Smoke, Fire, Aerosols, Air Quality, Flash Floods)
- Data Assimilation Applications
- Imagery/Visualization Applications
- Climate Applications

Conclusions

JPSS Mission will provide:

Input Observations for Weather Forecast Models
CrIS, ATMS, VIIRS, OMPS & GCOM

Short term Environmental Observations
(Events)
VIIRS, OMPS, CrIS, ATMS & GCOM

Long term Environmental Observations
(Climate Change Detection)
CERES, TSIS, VIIRS, OMPS, CrIS, ATMS & GCOM

User Engagement is critical for ultimate mission success

Backup Slides

AVHRR		MODIS		VIIRS		ABI	
1	580 - 680	8	405 - 420	M1	402 – 422 (750m)	1	450 – 490 (1km)
2	840 - 940	9	438 - 448	M2	436 - 464	2	590 – 690 (.5)
3	3.55 - 3.93	10	483 - 493	M3	478 - 498	3	846 – 885 (1)
4	10.3 - 11.3	12	546 - 556	M4	545 - 565	4	1.37-1.39 (2)
5	11.5 - 12.5	1	620 - 670	I1	580 – 680 (375m)	5	1.58 - 1.64 (1)
		13	662 - 672	M5	662 - 682	6	2.23 – 2.28 (2)
		15	743 - 753	M6	744 - 758	7	3.8 – 4.0
		16	862 - 877	M7	845 - 885	8	5.77 – 6.6
		2	841 - 877	I2	845 - 885	9	6.75 – 7.15
		5	1.23 - 1.25	M8	1.23 - 1.25	10	7.24 – 7.44
		26	1.36 - 1.39	M9	1.371 - 1.385	11	8.3 – 8.7
		6	1.63 - 1.65	M10	1.58 - 1.64	12	9.42 – 9.8
		7	2.11 - 2.16	I3	1.58 - 1.64	13	10.1 – 10.6
		20	3.66 - 3.84	M11	2.235 - 2.285	14	10.8 – 11.6
		23	4.02 - 4.08	M12	3.61 - 3.79	15	11.8 – 12.8
		29	8.40 - 8.70	I4	3.55 - 3.93	16	13.0 – 13.6
		31	10.78 - 11.28	M13	3.97 - 4.13		
		32	11.77 - 12.27	M14	8.40 - 8.7		
		33	13.2 – 13.5	M15	10.3 - 11.3		
		34	13.5 – 13.8	M16	11.5 - 12.5		
		35	13.8 – 14.1	I5	10.6 - 12.5		
		36	14.1 – 14.4				

VIIRS Improvements From AVHRR:
Radiometric properties

Greater spectral coverage with increased radiometric quality

VIIRS			MODIS Equivalent			AVHRR-3 Equivalent			OLS Equivalent		
Band	Range (um)	HSR (m)	Band	Range	HSR	Band	Range	HSR	Band	Range	HSR
DNB	0.500 - 0.900	750				Low light capabilities			HRD PMT	0.580 - 0.910 0.510 - 0.860	550 2700
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000						
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000						
M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000	Ocean Color, Aerosol					
M4	0.545 - 0.565	750	4 12	0.545 - 0.565 0.546 - 0.556	500 1000						
I1	0.600 - 0.680	375	1	0.620 - 0.670	250	1	0.572 - 0.703	1100			
M5	0.662 - 0.682	750	13 14	0.662 - 0.672 0.673 - 0.683	1000 1000	1	0.572 - 0.703	1100			
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000	Atm Correction					
I2	0.846 - 0.885	375	2	0.841 - 0.876	250	2	0.720 - 1.000	1100			
M7	0.846 - 0.885	750	16	0.862 - 0.877	1000	2	0.720 - 1.000	1100			
M8	1.230 - 1.250	750	5	SAME	500	Cloud Particle Size					
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000	Thin Cirrus					
I3	1.580 - 1.640	375	6	1.628 - 1.652	500	Snow Map					
M10	1.580 - 1.640	750	6	1.628 - 1.652	500	3a	SAME	1100			
M11	2.225 - 2.275	750	7	2.105 - 2.155	500	Cloud					
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000	3b	SAME	1100			
M12	3.660 - 3.840	750	20	SAME	1000	3b	3.550 - 3.930	1100			
M13	3.973 - 4.128	750	21 22 23	3.929 - 3.989 3.929 - 3.989 4.020 - 4.080	1000 1000 1000	SST, Fire					
M14	8.400 - 8.700	750	29	SAME	1000	Cloud Top Propoerties					
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000	4	10.300 - 11.300	1100			
I5	10.500 - 12.400	375	31 32	10.780 - 11.280 11.770 - 12.270	1000 1000	4 5	10.300 - 11.300 11.500 - 12.500	1100 1100	HRD	10.300 - 12.900	550
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000	5	11.500 - 12.500	1100			