National Environmental Satellite, Data, and Information Service

NPP Sensor Data Overview

Dr. Fuzhong Weng
JPSS Sensor Science Chair
Center for Satellite Applications and Research (STAR)
NOAA/NESDIS

IGARSS 2011, NPP User's Workshop
July 24, 2011

PRESIDENTIAL DECISION

NPOESS program was terminated on 30 September 2010.

- **NOAA assigned 1330 orbit**
  - – Joint Polar Satellite System (JPSS)
- **DoD assigned 0530 orbit**
  - – Defense Weather Satellite System (DWSS)
- **EUMETSAT provides 0930 orbit**
  - –Meteorological Operational Satellite System
- **Common Ground System (CGS)**
  - – Systems developed for JPSS/DWSS/GCOM etc
- **Advanced Sensors on JPSS**
  - VIIRS (MODIS heritage)
  - CrIS (AIRS/IASI heritage)
  - OMPS (OMI/TOMS heritage)
  - ATMS (AMSU/MHS heritage)

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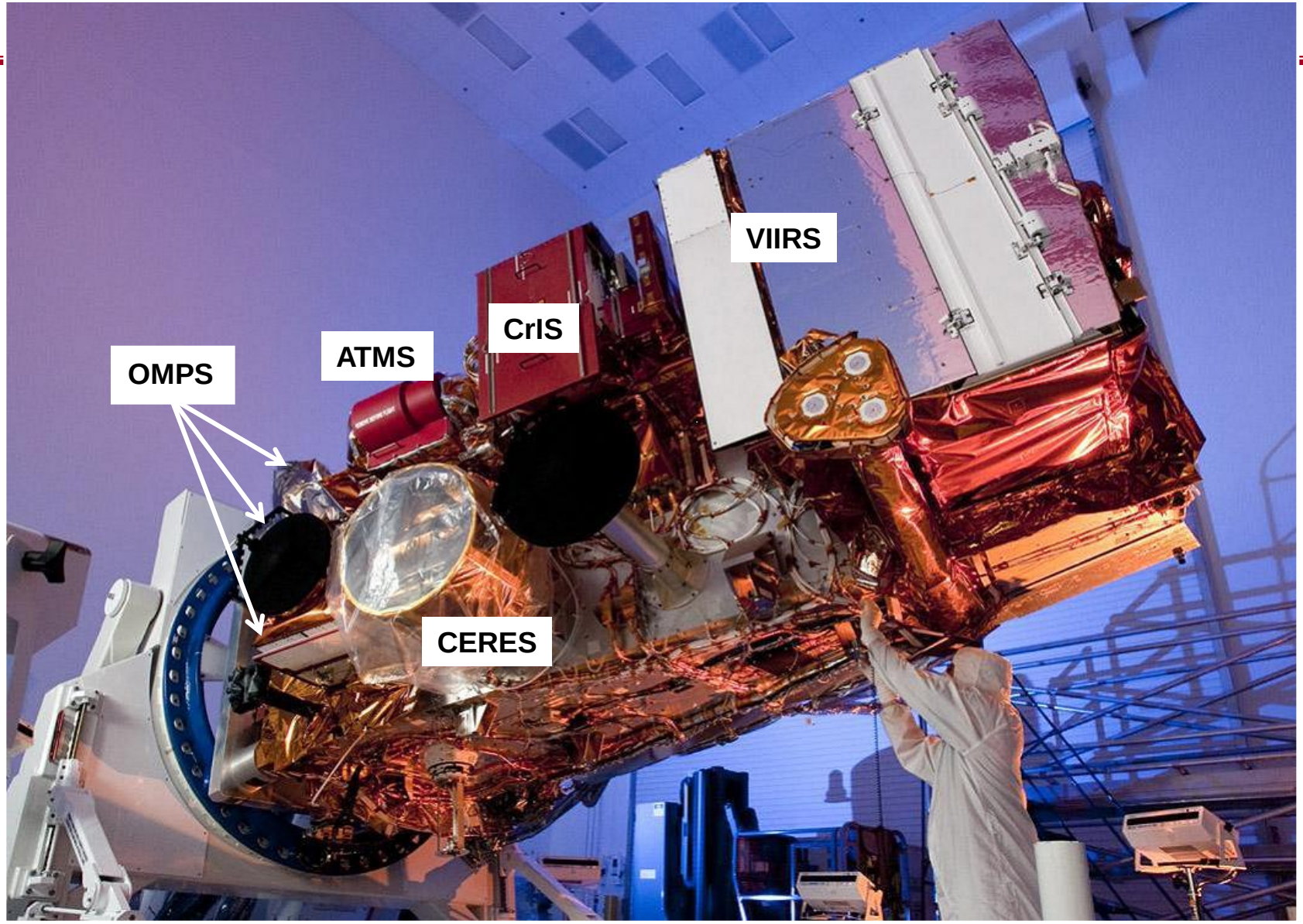
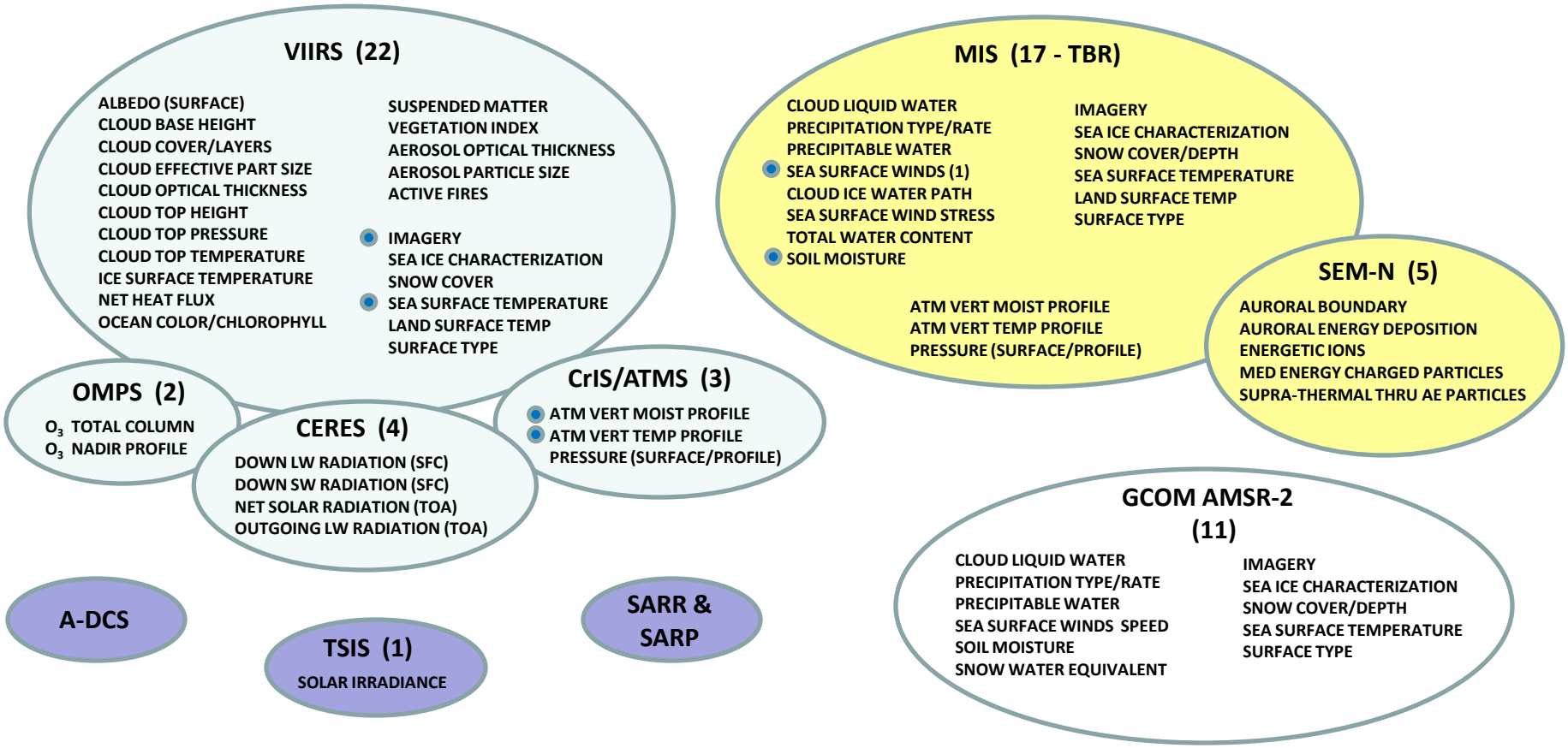
NPP Spacecraft and Payloads



JPSS L1RD Defined Environmental Data Records (EDRs)



Notes:

(1) Delivered as two MIS products – Speed (Key EDR) and Direction

PSE v1 2/28/11

Sensor Science Working Group

SSWG Chair
Fuzhong Weng, NESDIS/STAR

Advising/Coordination
Bruce Guenther
Neal Baker
Mike Denning

Management Leads
ATMS – Tsan Mo, STAR
CrIS – Yong Han, STAR
OMPS – Fred Wu, STAR
VIIRS – Changyong Cao,STAR
CERES – Mark Liu, STAR (acting)
SEM-N – Changyong Cao, STAR (acting)

Technical Leads
ATMS – Ed Kim, NASA/GSFC
CrIS – Yong Han, NESDIS/STAR
OMPS – Glen Jaross, NASA/SSAI
VIIRS – Frank DeLuccia, Aerospace
CERES – Kory Priestley, NASA/LaRC
SEM-N – Bill Denig, NESDIS/NGDC

Recent JPSS SSWG Activities

- SDR teams were inaugurated in December, 2010 after the approval of JPSS program and JPSS ground project senior management with recommended team leads
- Conduct Weekly Telecons with JPSS program stakeholders (mainly SDR):
  - ✓ NOAA
  - ✓ NASA
  - ✓ Raytheon
  - ✓ ITT
  - ✓ BALL
  - ✓ NGAS, NGES etc,
- Major Activities
  - ✓ Participate NPP launch readiness rehearsal
  - ✓ Review IDPS SDR code readiness for NPP launch
  - ✓ Provide independent assessments of NGAS deliverables (e.g. LUTs/coeff.)
  - ✓ Analyze NPP S/C TVAC data
  - ✓ Perform post-launch instrument cal/val
  - ✓ Established STAR ICVS for NPP LTM with initial trending of TVAC data

NPP IDPS SDR Processing Readiness (Mx5 Version)

- **SDRs**
  - VIIRS – Yes
  - CrIS – Yes
  - ATMS – Yes
  - ATMS Remap - Yes
  - OMPS TC – No (Mx6 – Science DRs opened by Cal/Val Team)
  - OMPS NP – Yes
- **KPPs**
  - Imagery - Yes
  - SST – Yes
  - CrIMSS – Yes
- **Canary**
  - Cloud Mask - Yes
  - Aerosols – Yes
  - OCC – No (PCRs in work for Mx6)
  - CTT IP – Yes
  - Veg Index – Yes

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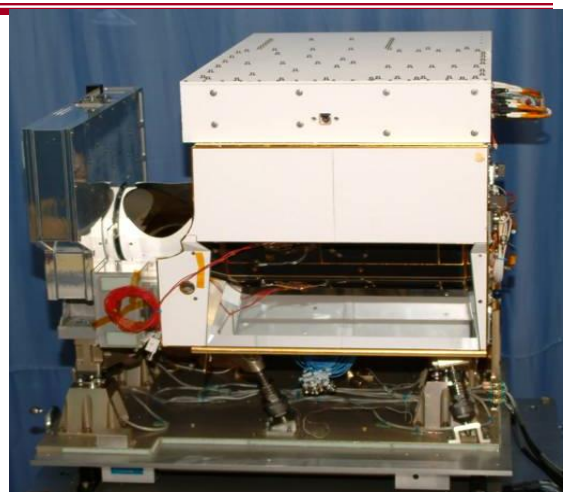
Cross-track Infrared Sounder (CrIS)

The Cross-track Infrared Sounder (CrIS) is a key sensor

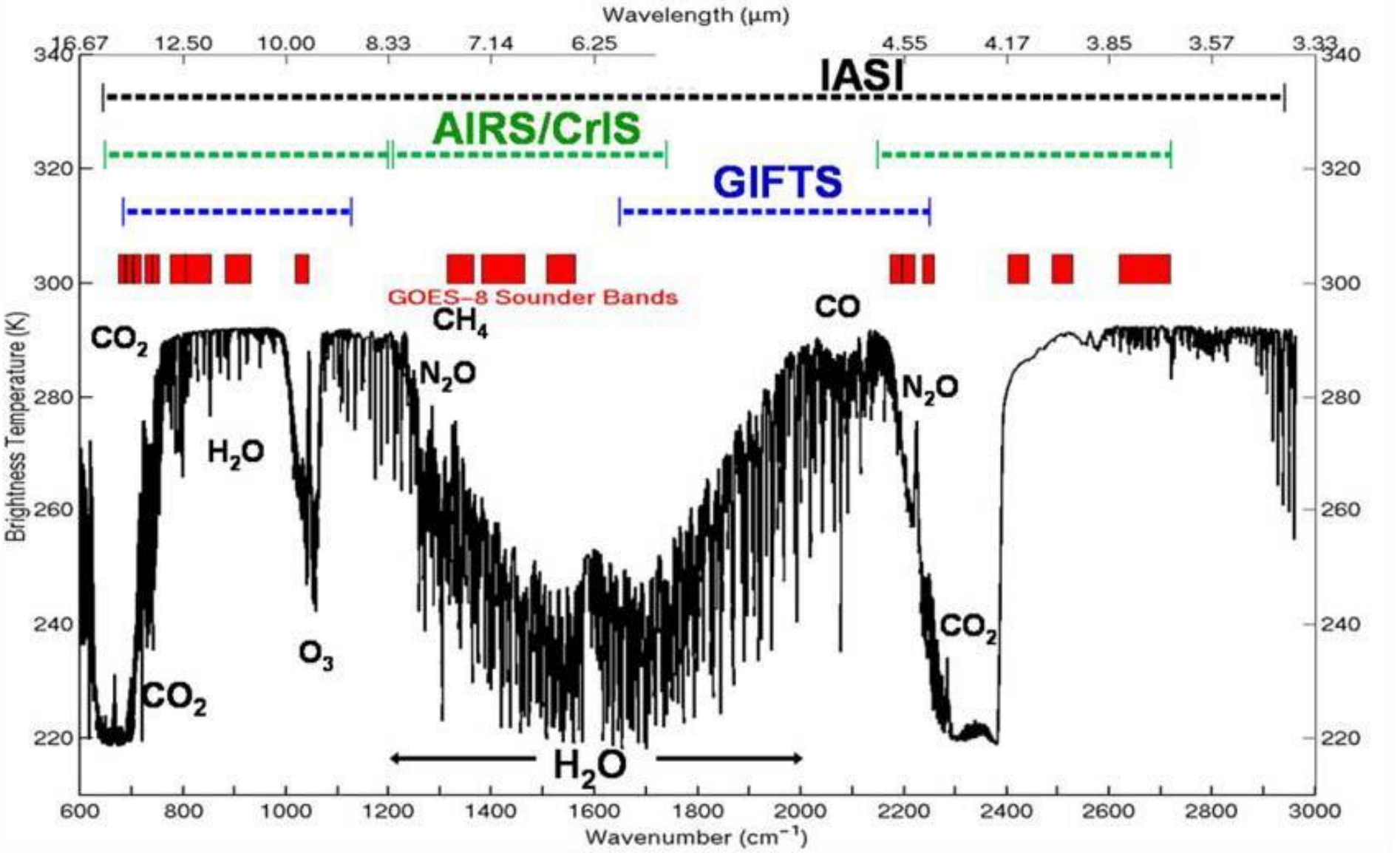
- ✓ Fourier Transform Spectrometer providing high resolution IR spectra
- ✓ Fields of Regard each 3x3 FOVs
- ✓ Photovoltaic Detectors in all 3 bands
- ✓ 4-Stage Passive Detector Cooler
- ✓ 14 km nadir spatial resolution
- ✓ 2200 km swath width
- ✓ On-board internal calibration target



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

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

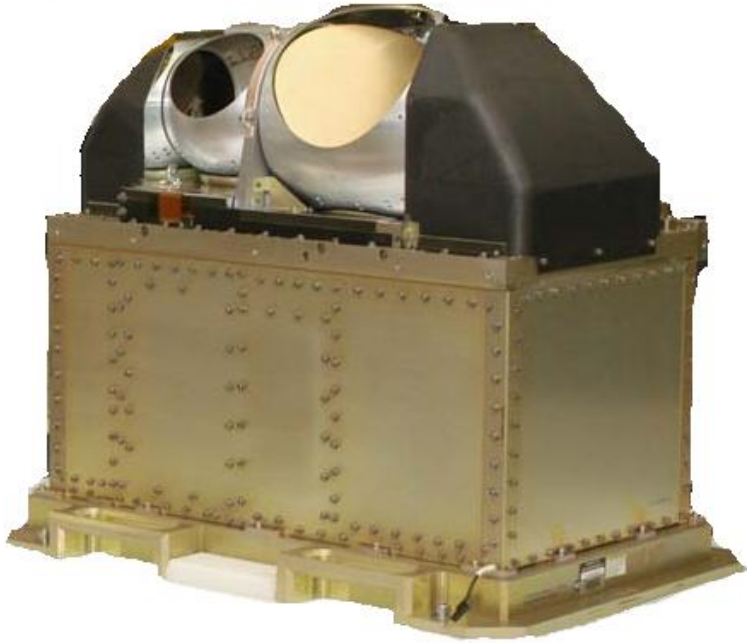
Infrared Earth Spectra



Advanced Technology Microwave Sounder (ATMS)

- Purpose:

  Profiling atmosphere under All-weather conditions. In conjunction with CrIS, global observations of temperature and moisture profiles at high temporal resolution (~ daily)



- Predecessor Instruments:

  AMSU A1/A2, MHS

- Approach:

  Scanning passive microwave radiometer
  22 channels (23GHz - 183GHz)

- Swath width: 2300 km

- Co-registration: with CrIS

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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

ATMS has 22 channels.

AMSU/MHS have 20, with polarization differences between some channels

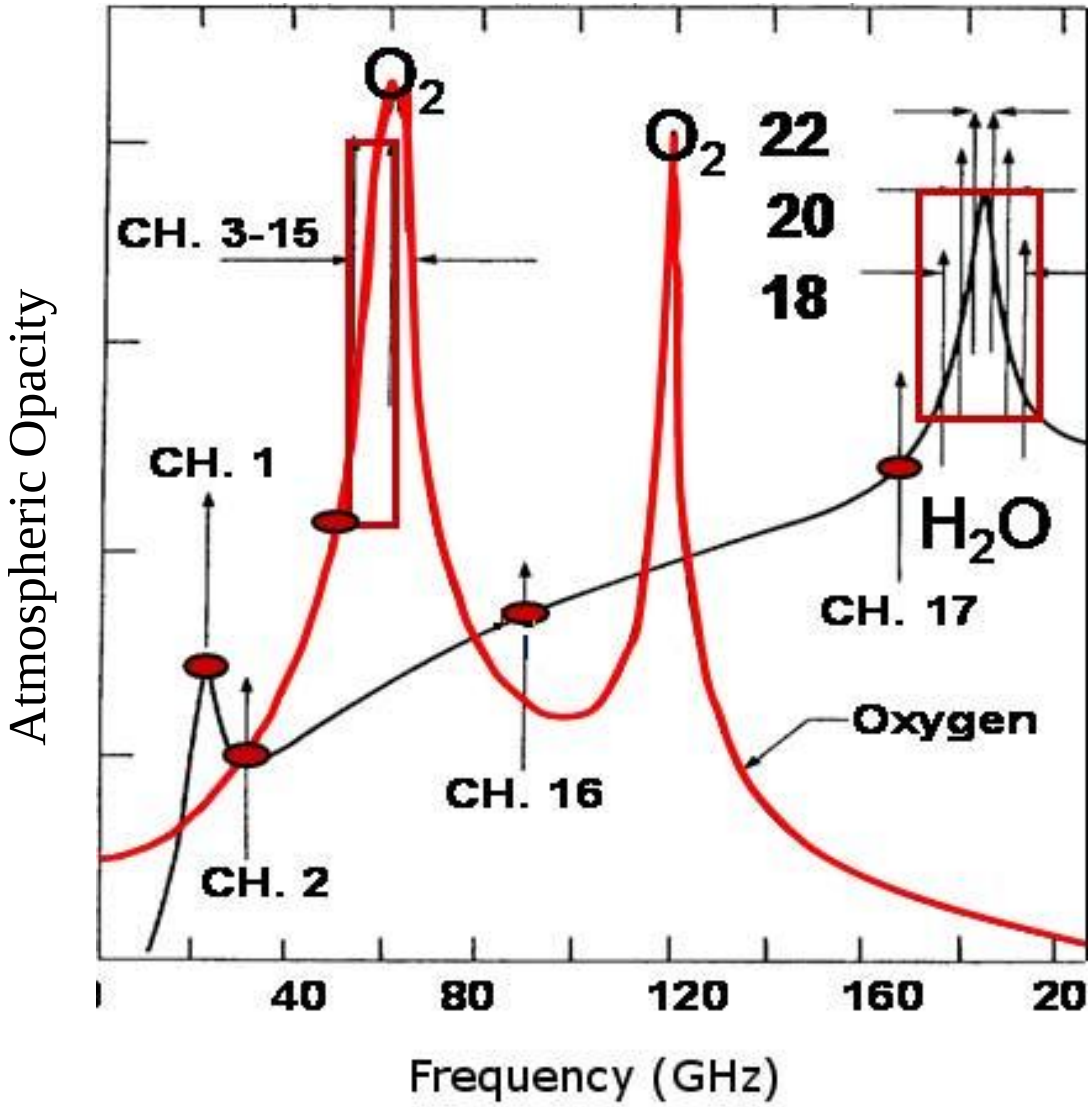
- Quasi-Vertical: polarization vector is parallel to the scan plane at nadir
- Quasi-Horizontal: polarization vector is perpendicular to the scan plane at nadir

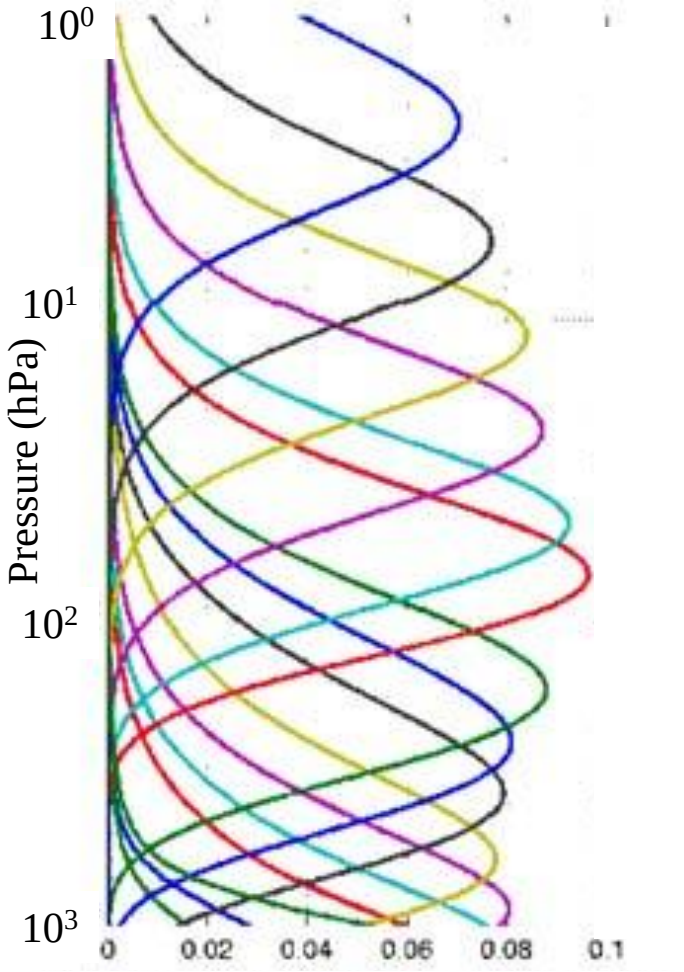
Only Polarization different

Unique Passband

Unique Passband, and Pol. different from closest AMSU/MHS channels

Microwave Earth Spectra





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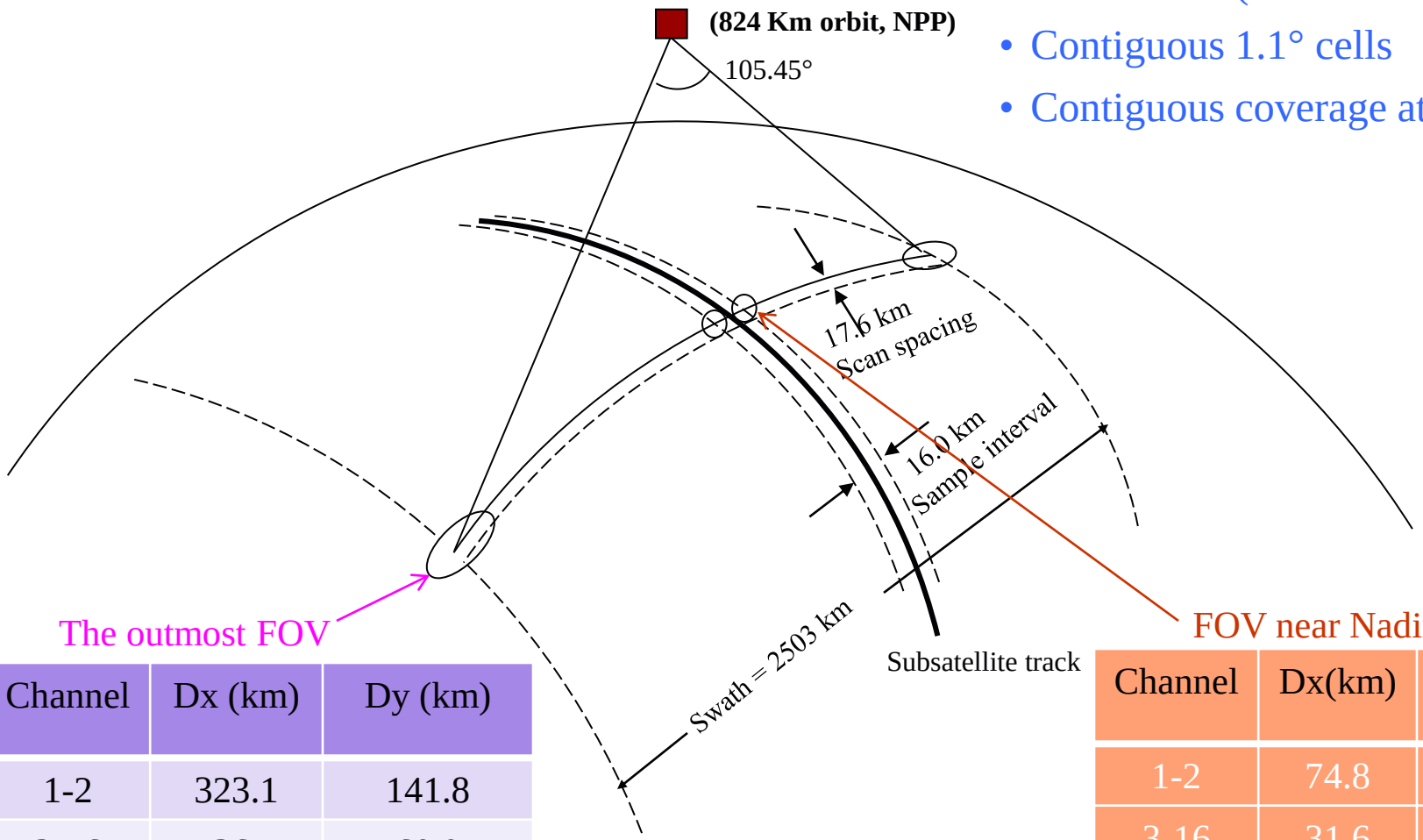
ATMS Scanning Characteristics

- Cross-track (for CrIS coincidence)
- Contiguous 1.1° cells
- Contiguous coverage at equator



Channel	Dx (km)	Dy (km)
1-2	323.1	141.8
3-16	136.7	60.0
17-22	68.4	30.0

Channel	Dx(km)	Beam Width
1-2	74.8	5.2°
3-16	31.6	2.2°
17-22	15.8	1.1°

Spatial Differences: ATMS vs. AMSU/MHS

Beamwidth (degrees)

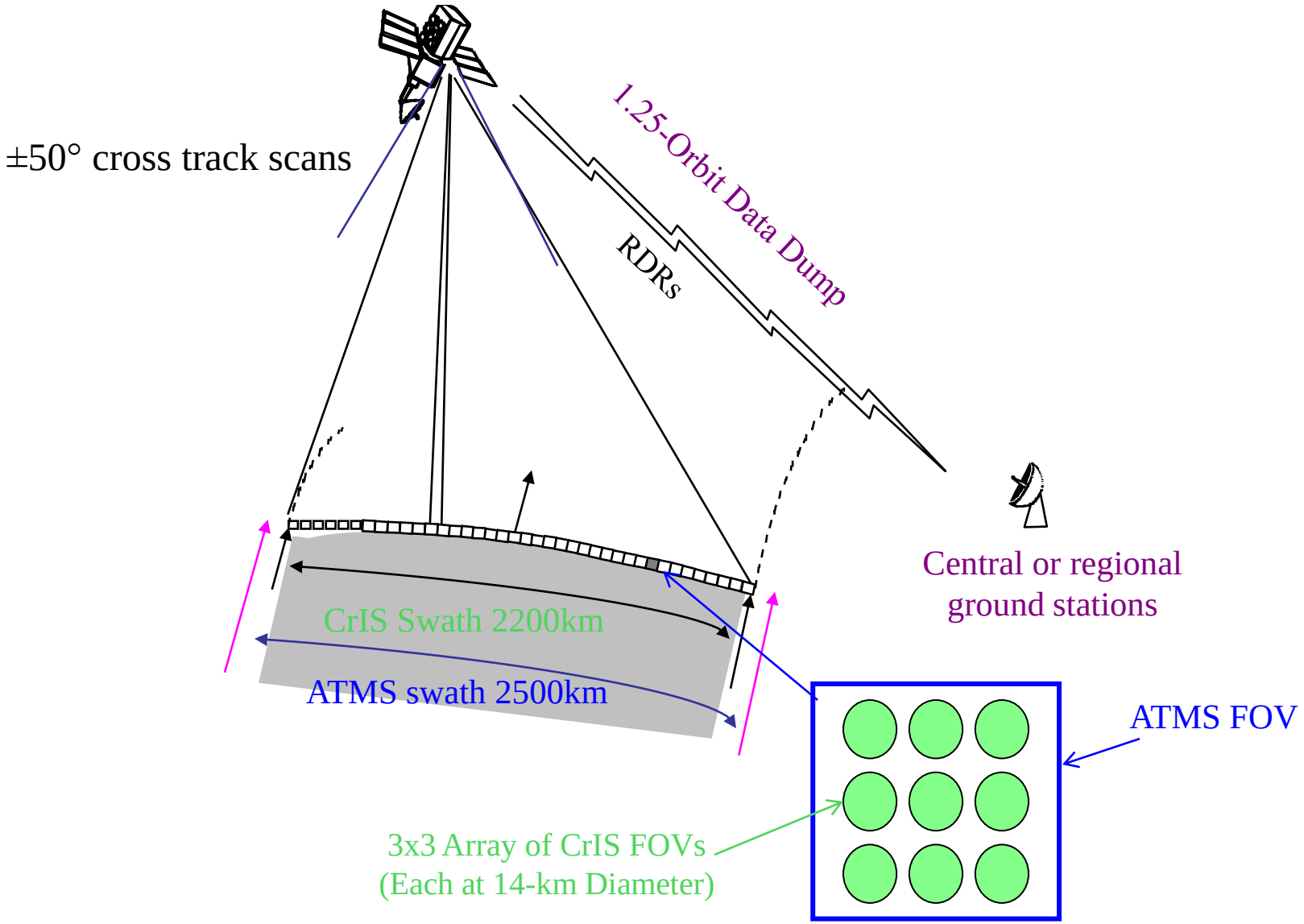
	ATMS	AMSU/MHS
23/31 GHz	5.2	3.3
50-60 GHz	2.2	3.3
89-GHz	2.2	1.1
160-183 GHz	1.1	1.1

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

Co-Registration of ATMS/CrIS Sensors



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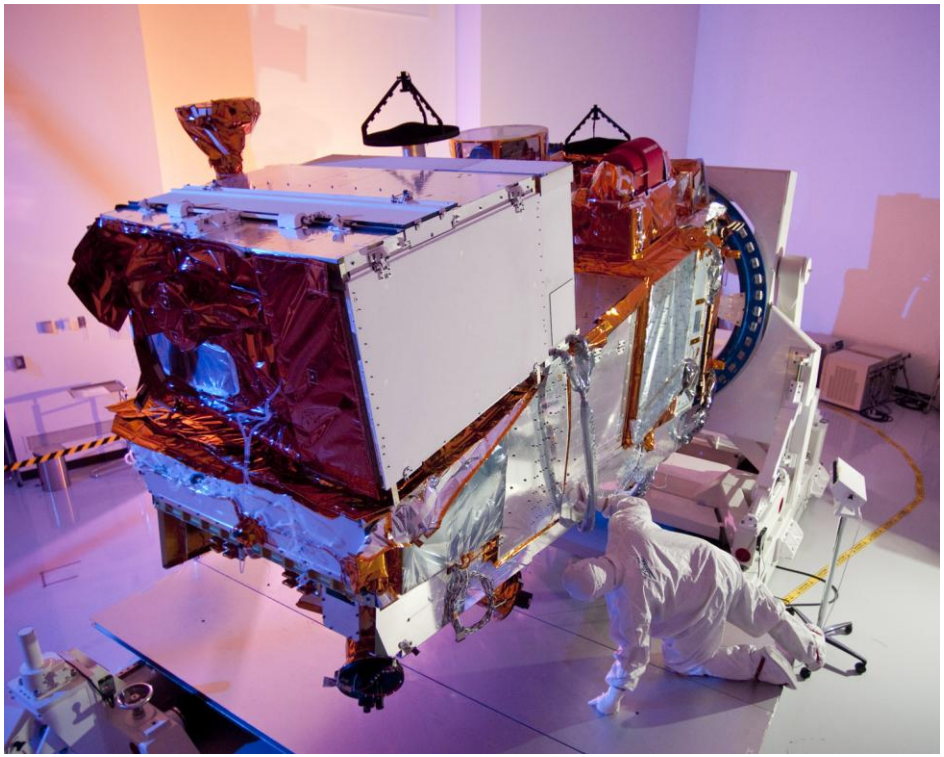
Visible Infrared Imaging Radiometer Suite
Raytheon SAS El Segundo, California

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



Spatial Resolution

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

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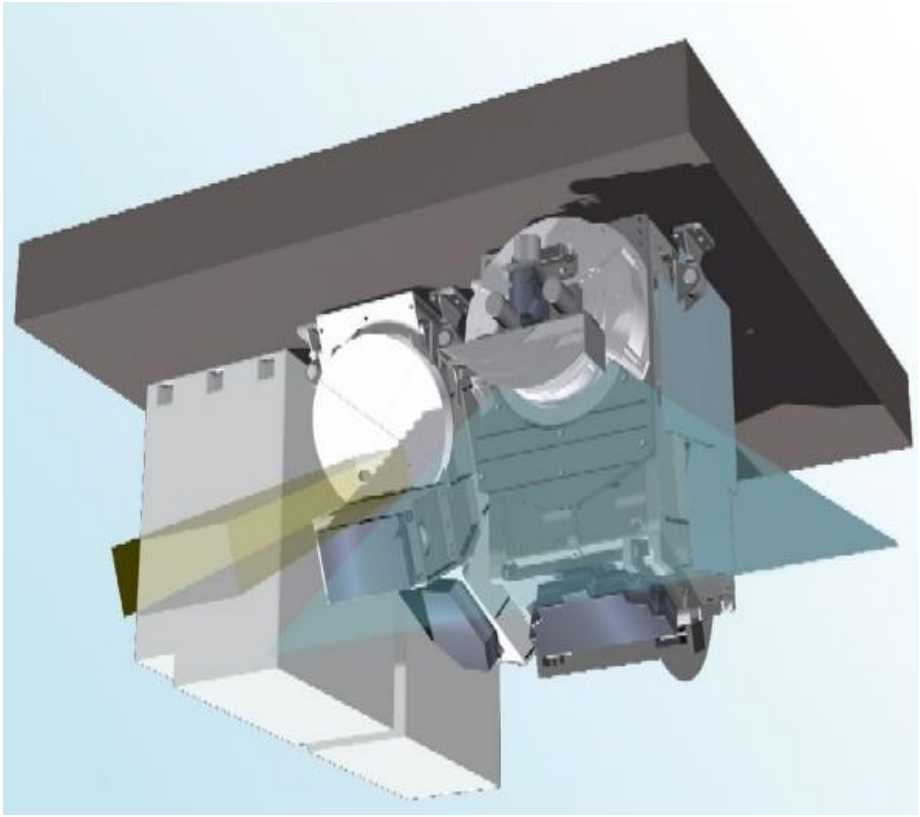
VIIRS Spectral, Spatial, & Radiometric Attributes

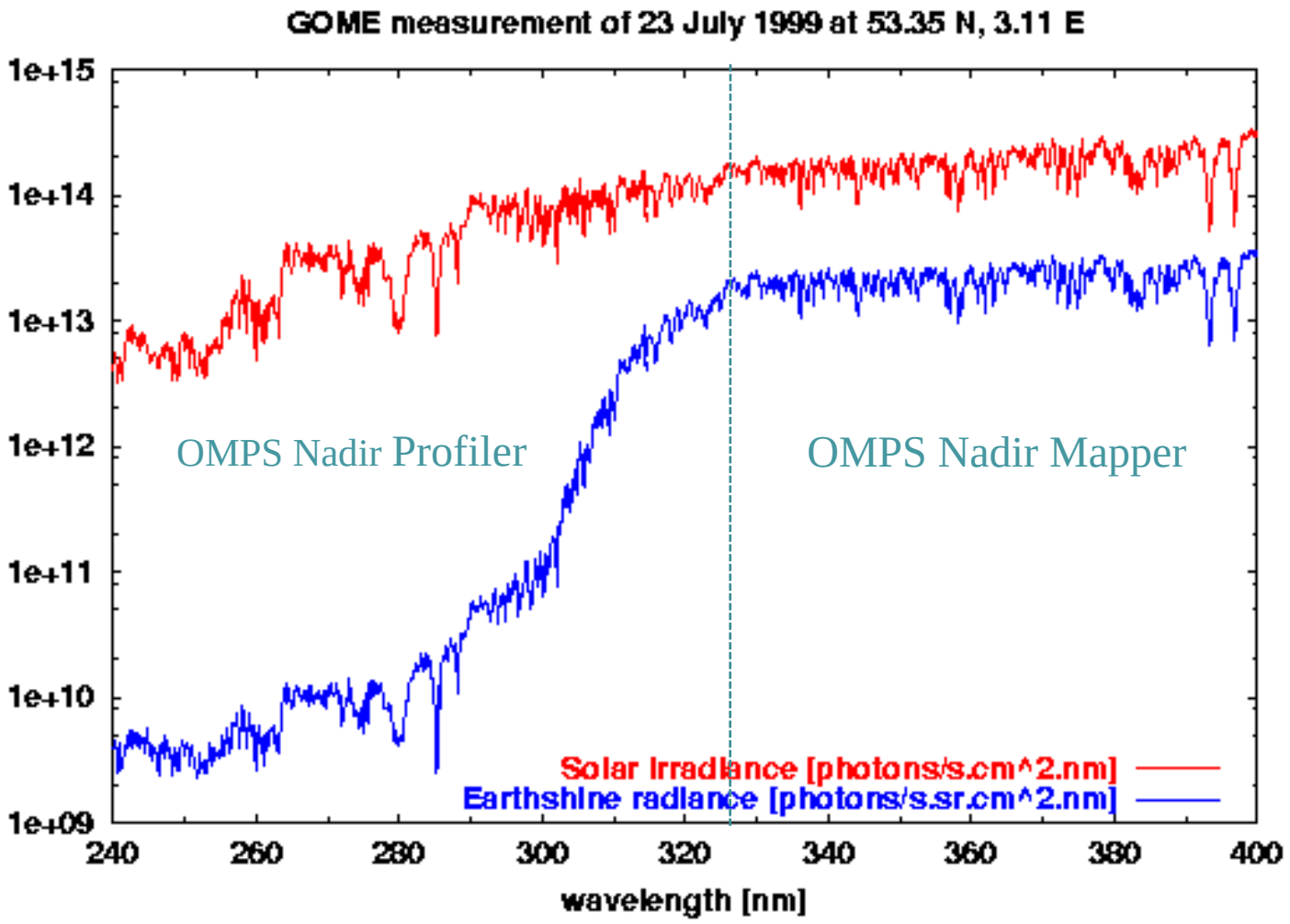
		Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radi-ance Range	Ltyp or Ttyp	Signal to Noise Ratio (dimensionless) or NEΔT (Kelvins)		
				Nadir	End of Scan				Required	Predicted	Margin
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	44.9	352	441	25%
						Aerosols	High	155	316	807	155%
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	40	380	524	38%
						Aerosols	High	146	409	926	126%
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	32	416	542	30%
						Aerosols	High	123	414	730	76%
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	21	362	455	26%
						Aerosols	High	90	315	638	102%
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22	119	146	23%
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	10	242	298	23%
						Aerosols	High	68	360	522	45%
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6	199	239	20%
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25	150	225	50%
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	6.4	215	388	81%
						Aerosols	High	33.4	340	494	45%
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05	6	5.7	-5%
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4	74	98	32%
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6	83	155	88%
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3	6.0	97	1523%
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3	342	439	28%
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12	10	17	66%
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K	2.500	0.486	415%
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K	0.396	0.218	82%
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST	Low	300 K	0.107	0.063	69%
						Fires	High	380 K	0.423	0.334	27%
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K	0.091	0.075	22%
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.070	0.038	85%
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K	1.500	0.789	90%
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.072	0.051	42%

Ozone Mapping Profiler Suite
Ball Aerospace and Technologies Corp.

- Purpose:
  Monitors the total column and vertical profile of ozone
- Predecessor Instruments:
  TOMS, SBUV, GOME, OSIRIS, SCIAMACHY
- Approach:
  Nadir and limb push broom CCD spectrometers
- Swath width:
  2600 km



Ultraviolet Solar and Earth Spectrum



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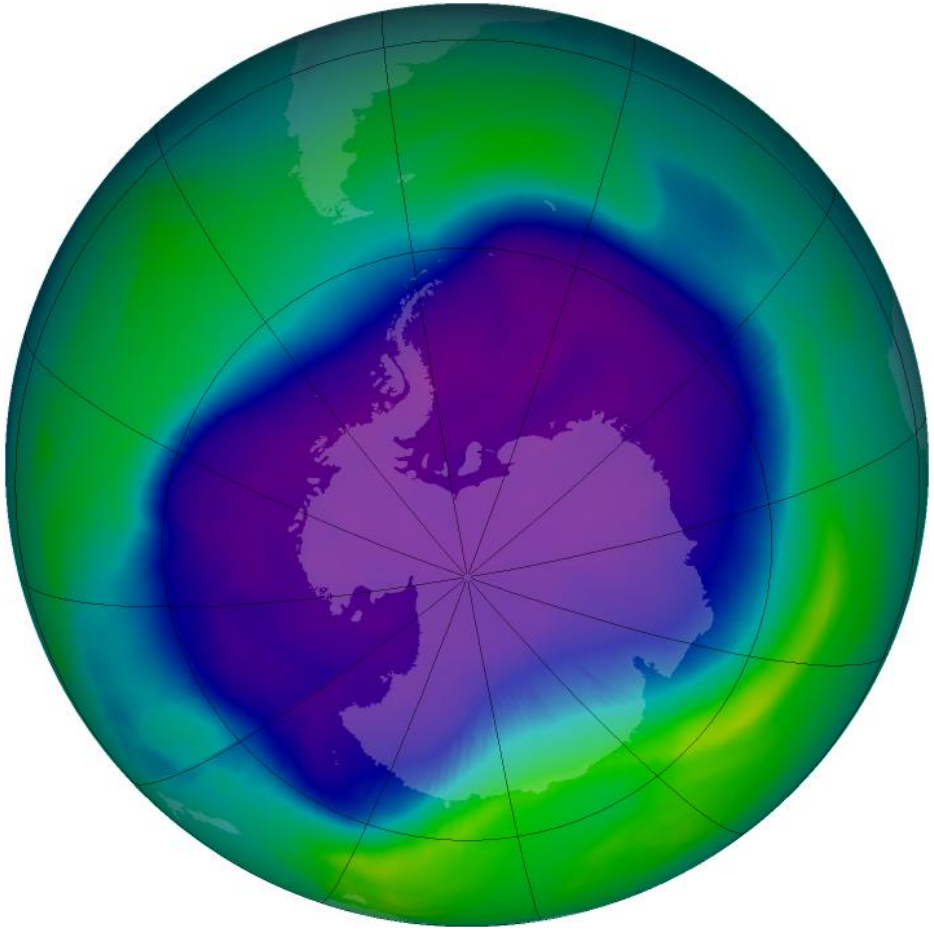
Ozone Hole on September 24, 2006



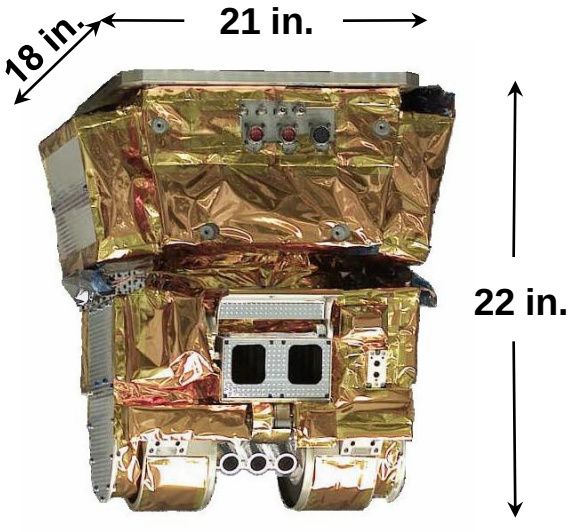
Largest Ozone Hole
30 million km^2

Area of North America
25 million km^2

CERES Instrument Overview

CERES scanning radiometer measuring three spectral bands at TOA

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



Operations, data processing, products, and science are a continuation of experience is developed on

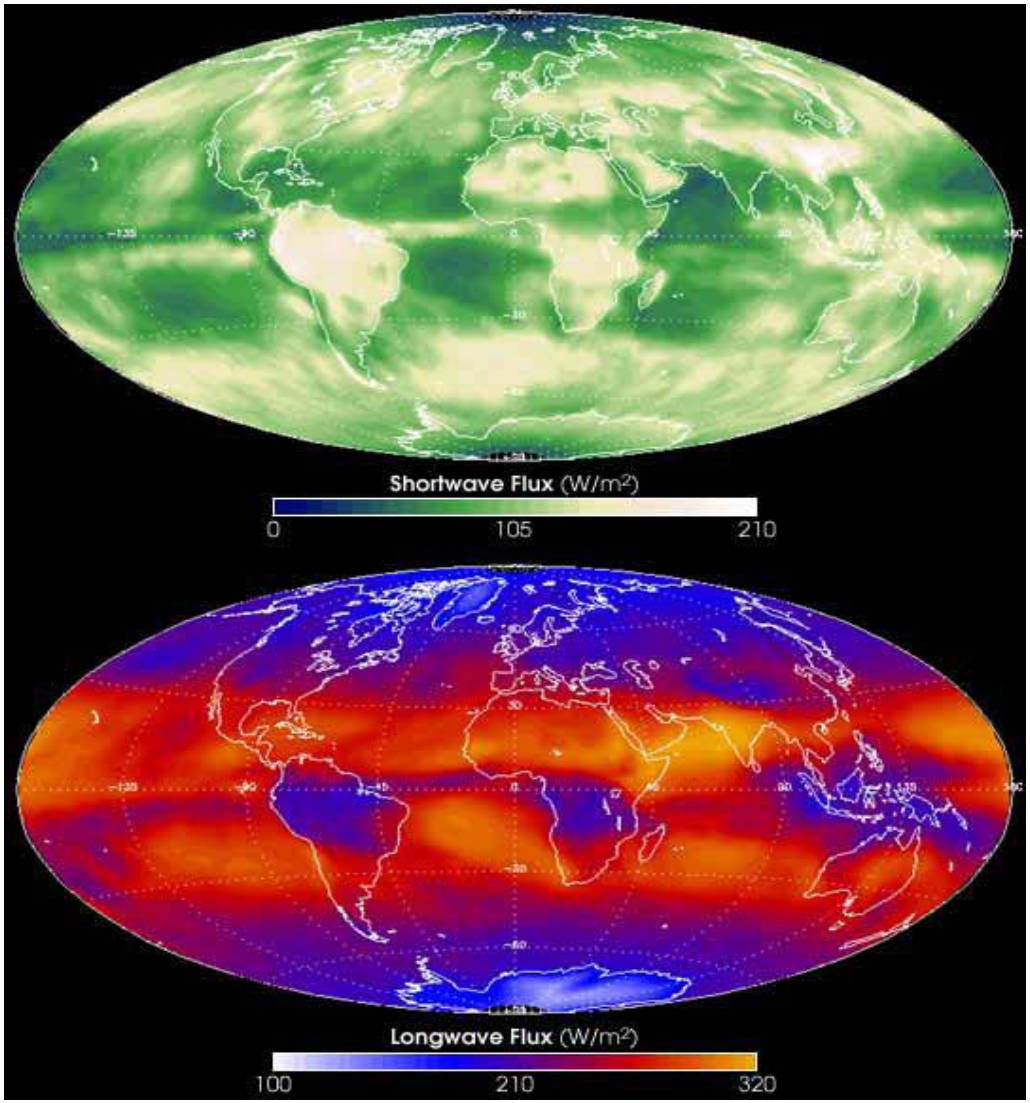
- TRMM
- EOS Terra
- EOS Aqua

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



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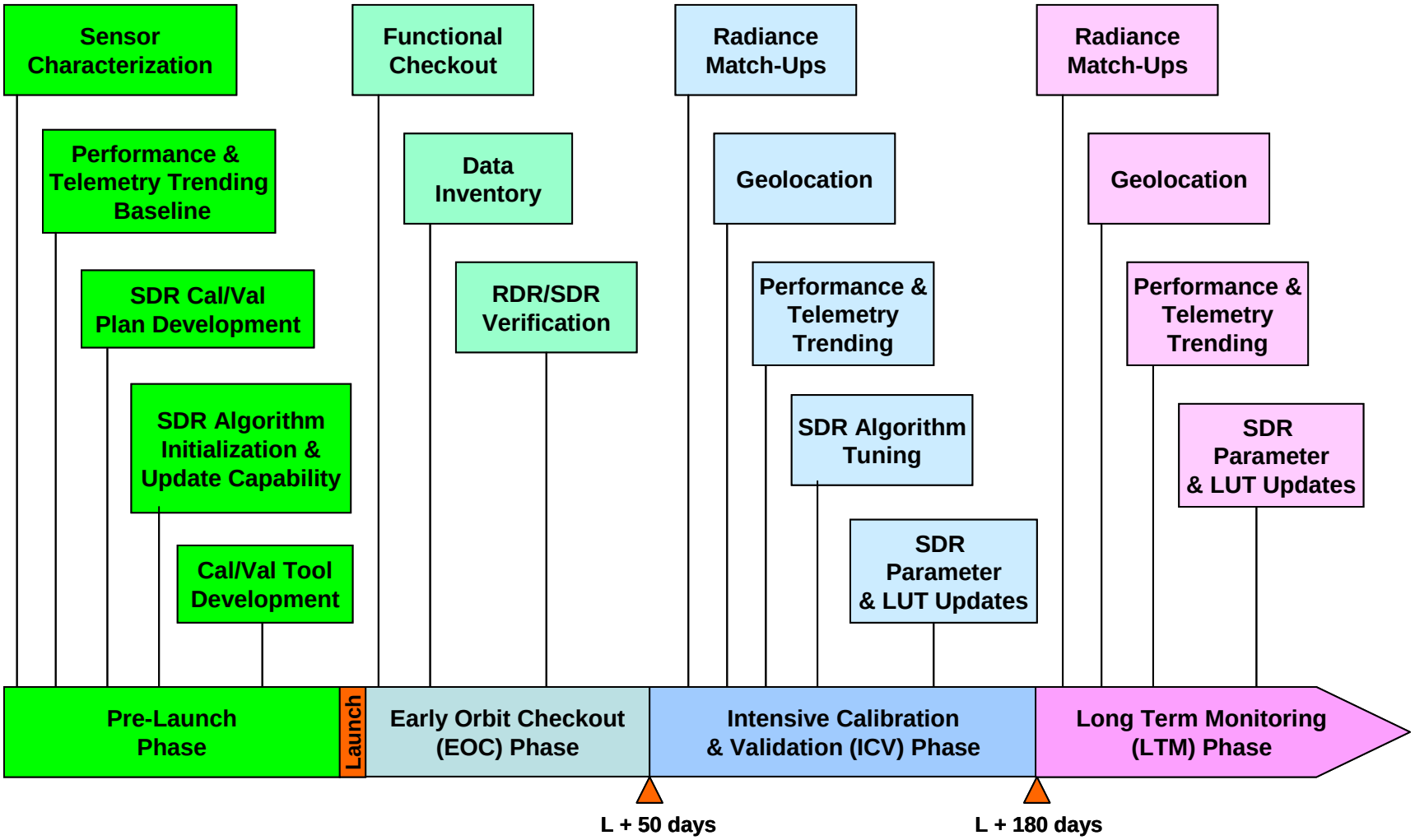
NPP Phases of Cal/Val: Activities Through the Life of the Program

Time

Pre-Launch	RDR Development and Verification	SDR Development and Verification	EDR Development and Verification
Early Orbit Check-out	RDR On-Orbit Verification	SDR Verification, Tuning, and Initial Validation	EDR Verification and Initial Validation
Intensive CalVal	Establish Sensor Stability	SDR Validation	EDR Validation
Long-term Monitoring	Sensor Long-Term Monitoring	SDR Detailed Validation and Maintenance	EDR Detailed Validation and Correction & Improvement

Product Chain

Example: VIIRS Cal/Val Activities by Phase



New Paradigm in NPP/JPSS Program

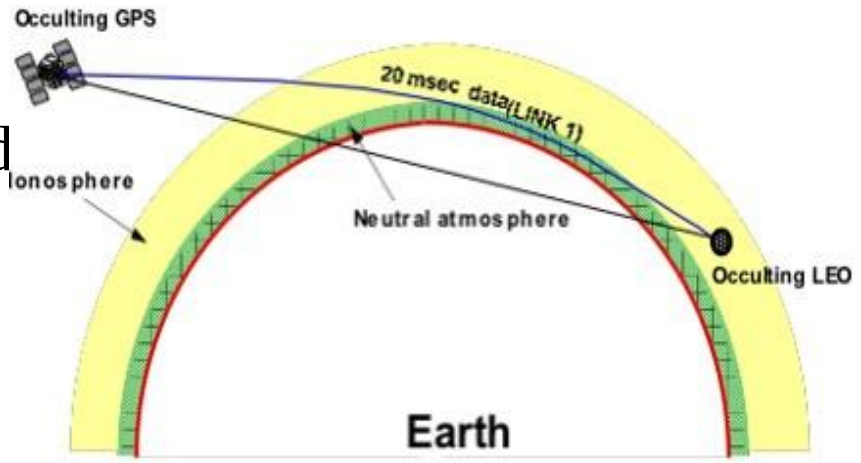
- **Advanced Calibration Methodology**
  - SI Traceable
  - Cross calibration
  - Global bias monitoring and instrument trending
- **New Information from ATMS**
  - More channels @ O2 (51 GHz) and H2O (183+-1.8, 4.5 Ghz)
  - ATMS Oversampling Data (30 km FOV) for severe weather
- **Linkage of ATMS to AMSU-A and MSU**
  - MSU (4 channels)
  - AMSU-A/MHS (15 channels)
  - ATMS (22 channels)
- **Expected Impacts from NPP Radiance Assimilation in NWP**
  - Three orbits Experiments
  - Hyperspectral sounding Experiments

Unique Characteristics GPS RO Data

（1） SI-traceable

（2） Data error not affected by cloud and precipitation

（3） High vertical resolution



（4） High consistency, data quality

not affected by GPS receiver types

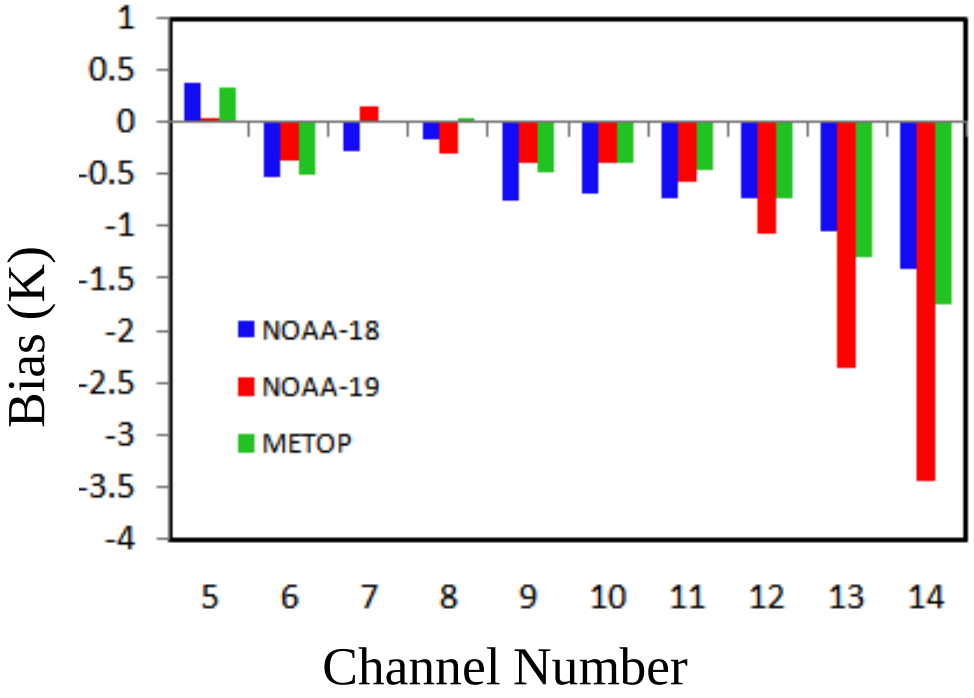
does not decay with time

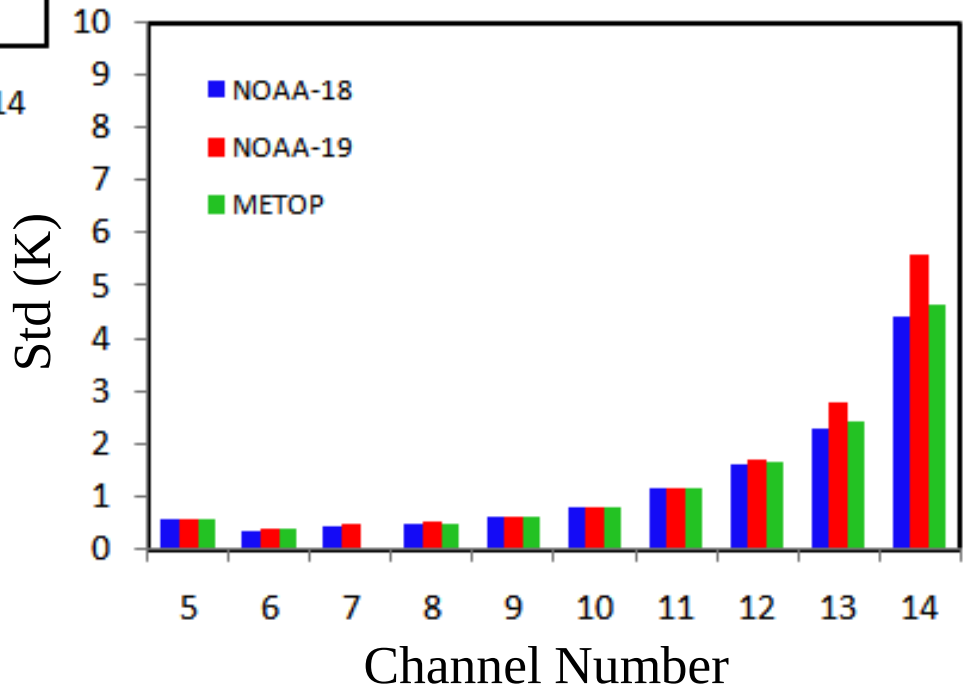
no mission-dependent systematic bias

（Hajj et al., 2004; Ho et al., 2009）

（5) Accurate temperature and pressure profiling within upper troposphere and stratosphere（Hajj et al. , 2004） - 0.1K

Global and Monthly Mean Biases & Standard Deviations





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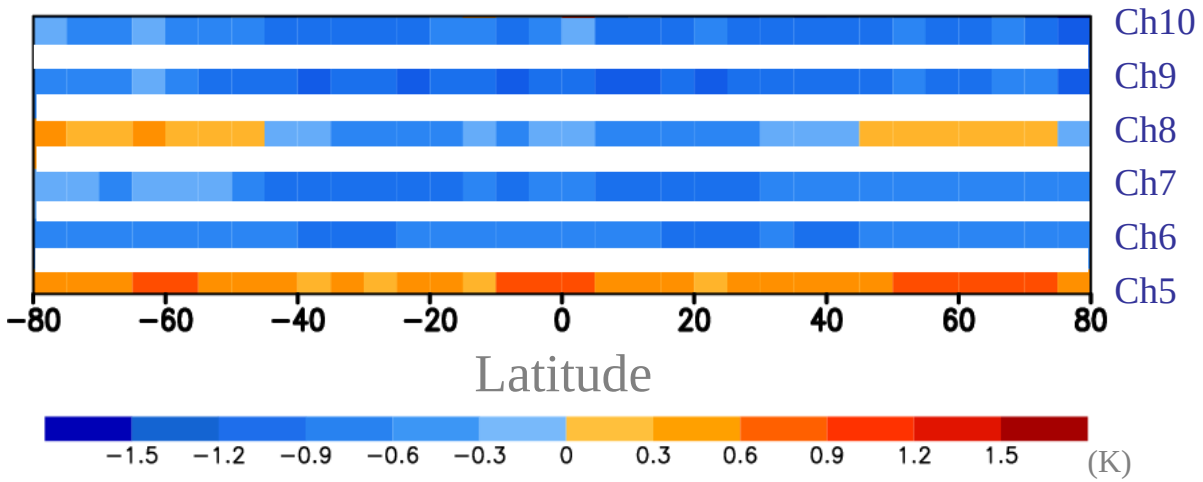
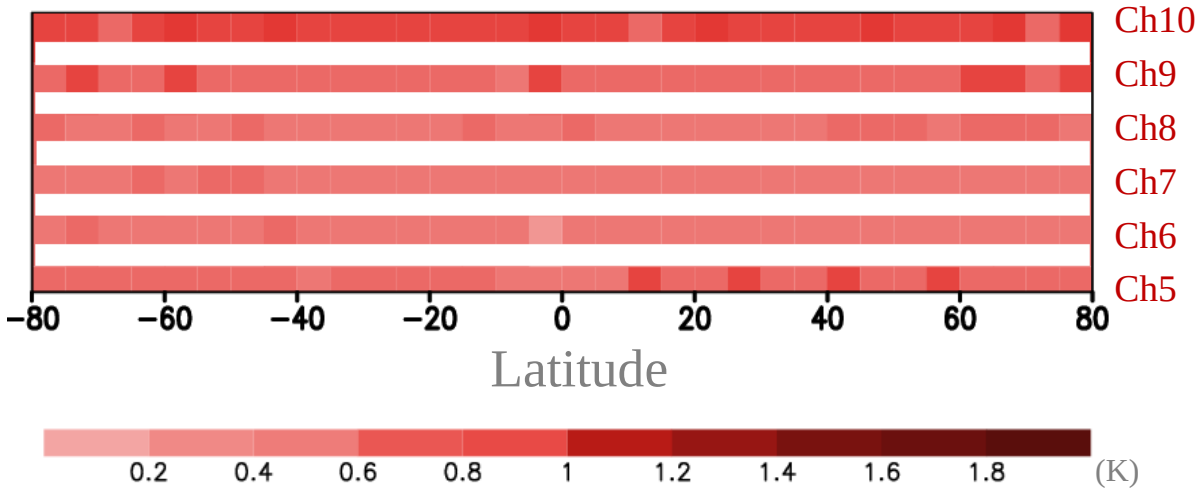
Latitudinal-Dependence of Biases & Std.

Bias



Std.



Search
Enter search term(s)
Go

»Integrated Cal/Val System

»Instrument Performance Monitoring
- NOAA-19 AMSU-A
- NOAA-19 MHS
- NOAA-19 AVHRR
- NOAA-19 HIRS
- MetOP-A AMSU-A
- MetOP-A MHS
- MetOP-A AVHRR
- MetOP-A HIRS
- NOAA-18 AMSU-A
- NOAA-18 MHS >>
- NOAA-18 HIRS
- DMSP F16 SSMIS
- DMSP F17 SSMIS
- DMSP F18 SSMIS
- GOES-11 Sounder
- GOES-12 Sounder
- GOES-13 Sounder
- GOES-14 Sounder
- GOES-15 Sounder

»Products Demonstration

»Meetings

»Publications

Satellite Integrated Calibration / Validation System (ICVS)

NOAA-18 MHS Instrument Performance Monitoring

Please select the instrument performance index & press 'Display' Button

MHS NEΔT: H-3 Display

MHS Gain: 10-Day Snapshot Display

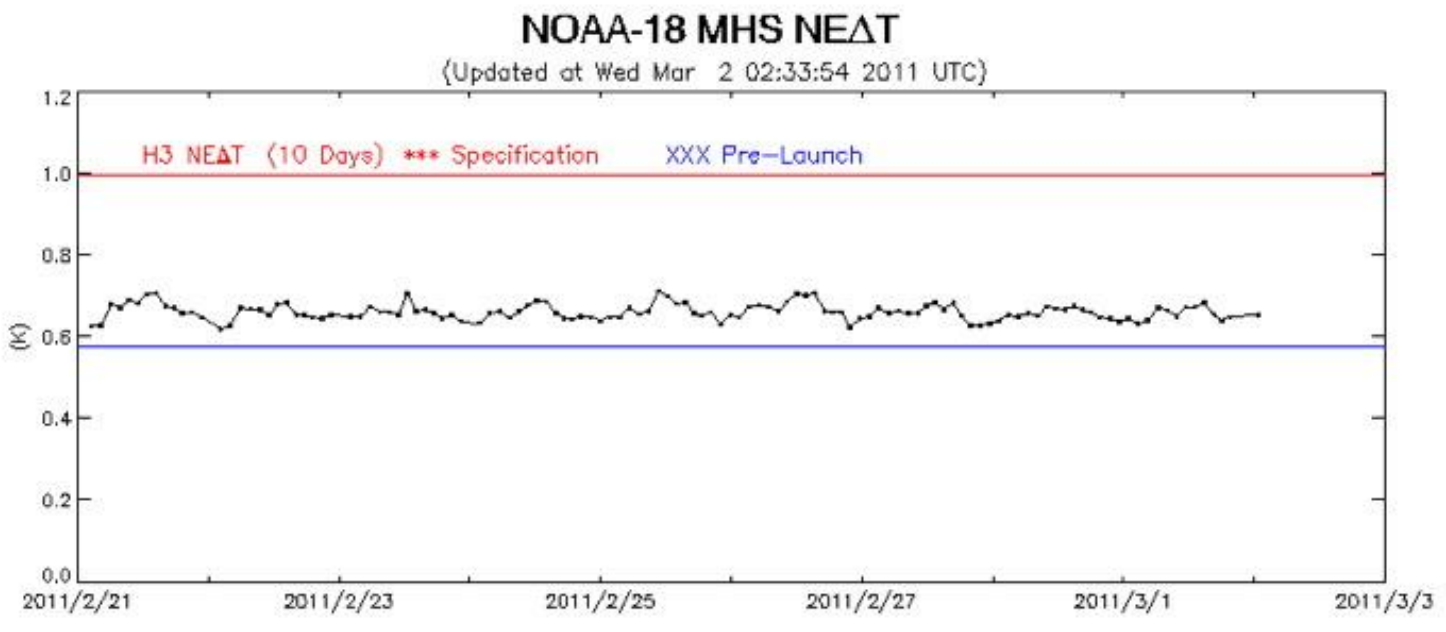
MHS Space View Count: 10-Day Snapshot Display

MHS PRT Temperature: OBCT PRT Temperature Display

MHS Local Oscillator Temperature: H-1 Display

MHS Mixer/LNA Temperature: H-1 Display

MHS Status: Weekly Orbit Status Display



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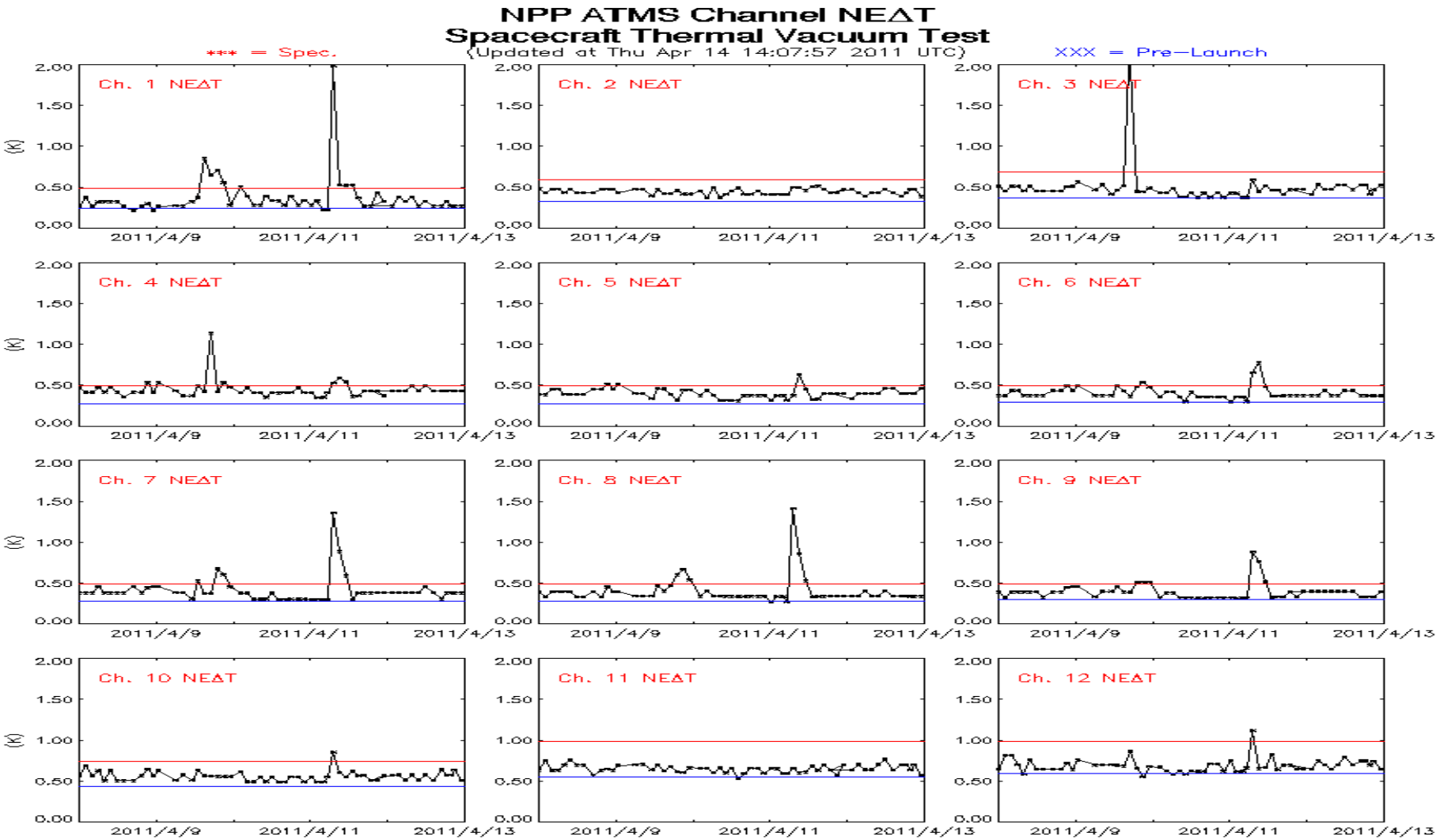
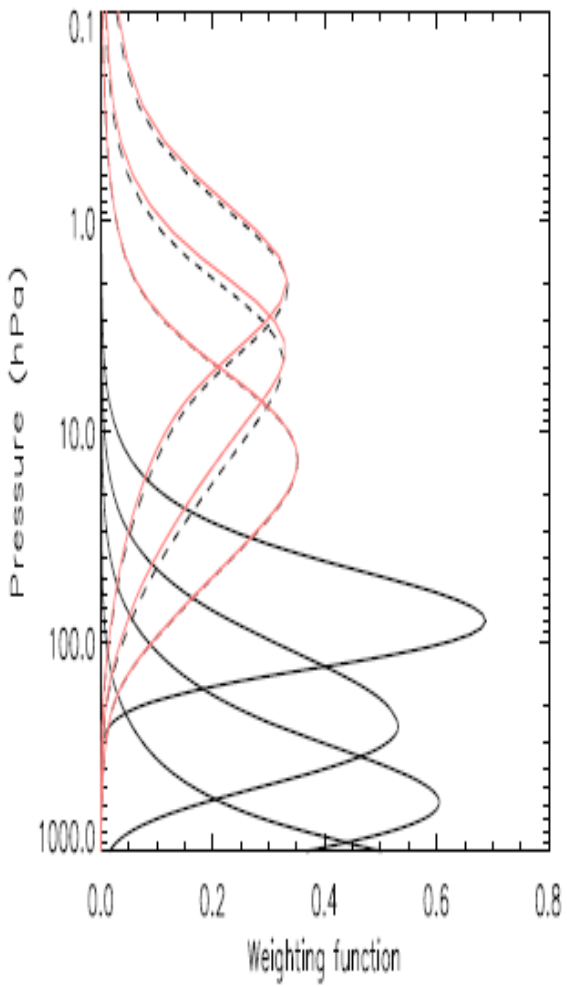
ATMS NEDT Analysis

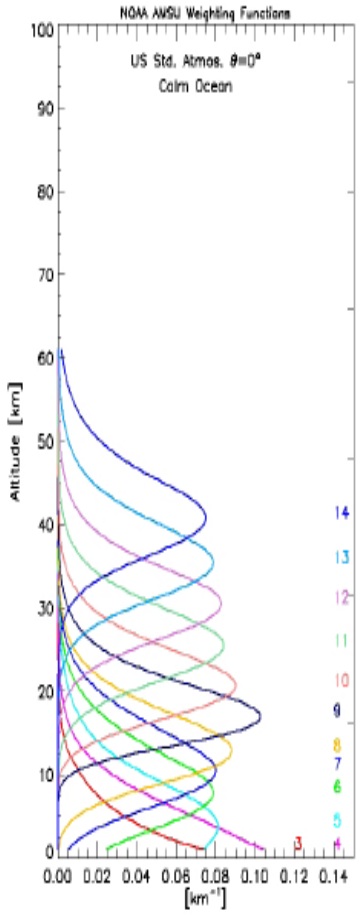


Microwave Temperature Sounding Vertical Resolution

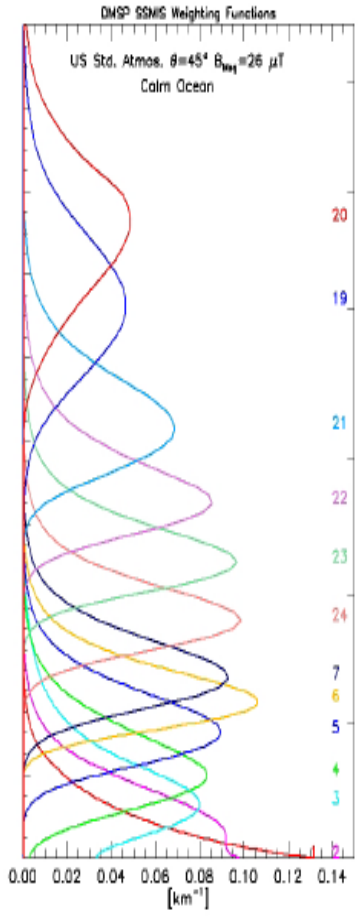
MSU+SSU (1978-2007)



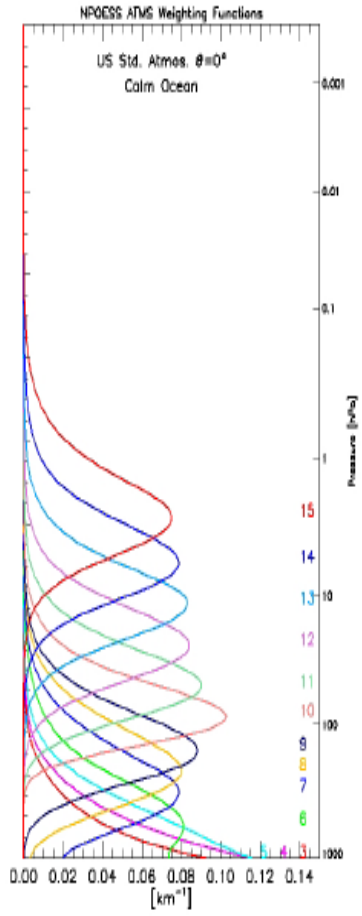
AMSU-A



SSMIS

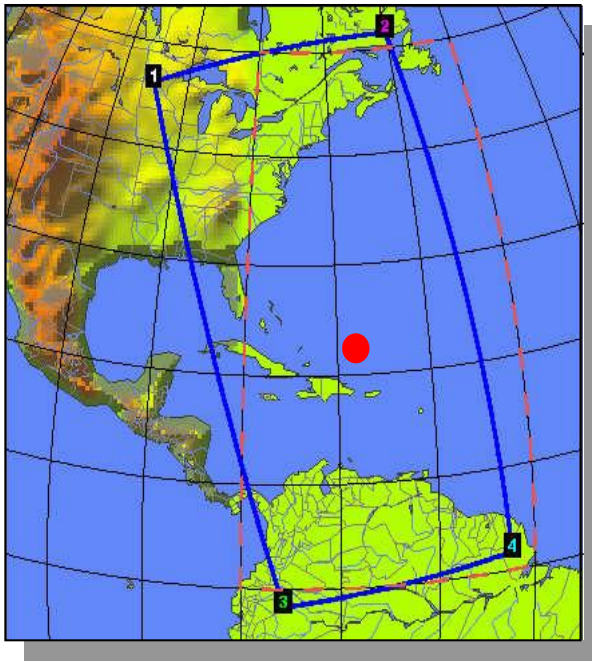


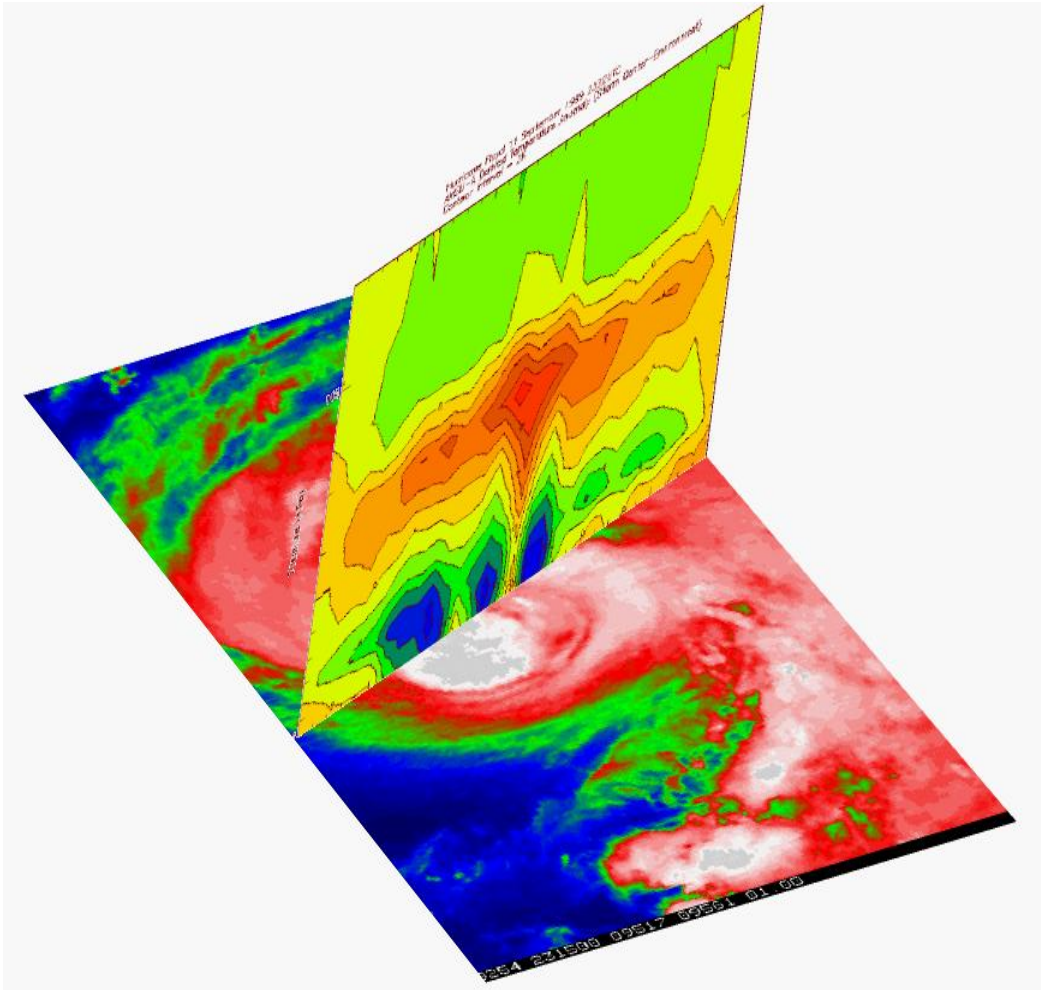
ATMS



AMSU Hurricane Intensity Estimation

NOAA-15 AMSU-A ΔT(C) 2332 UTC 11 Sep 99
GOES-8 IR 2315 UTC 11 Sep 99
Hurricane Floyd

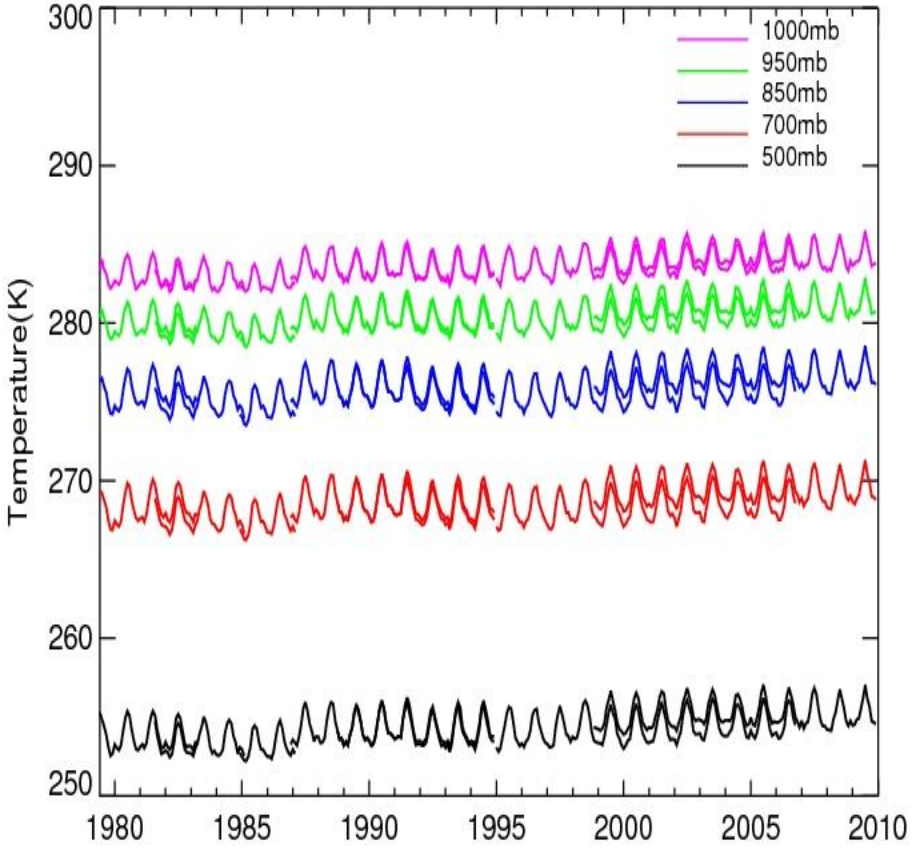


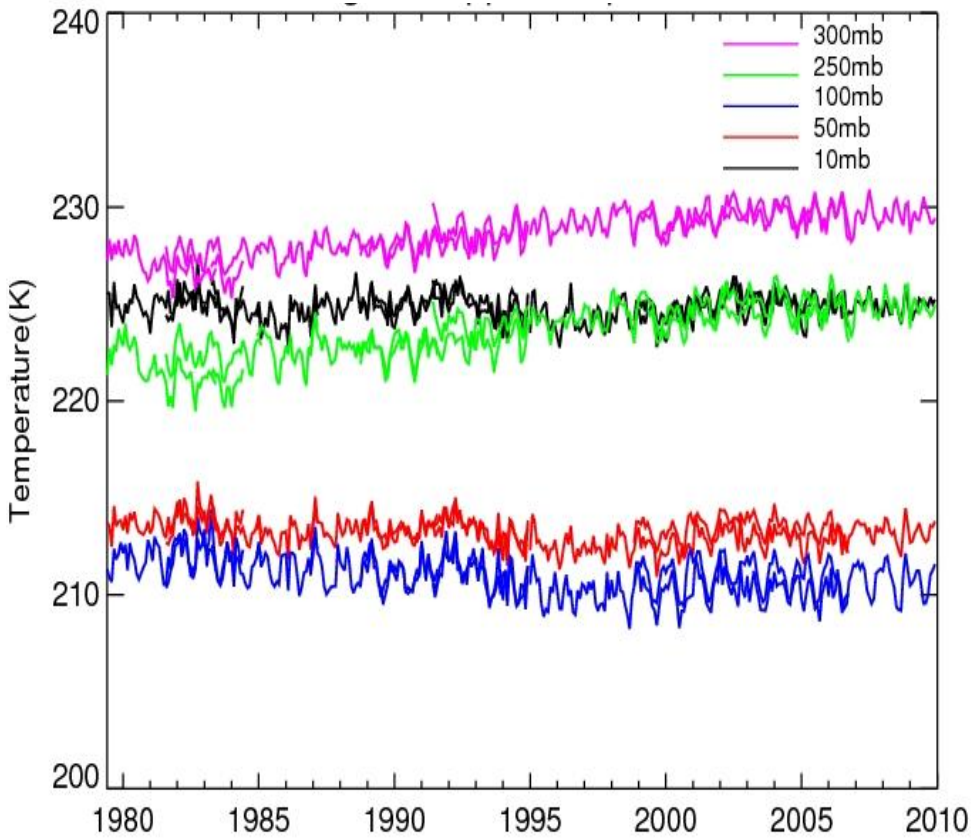


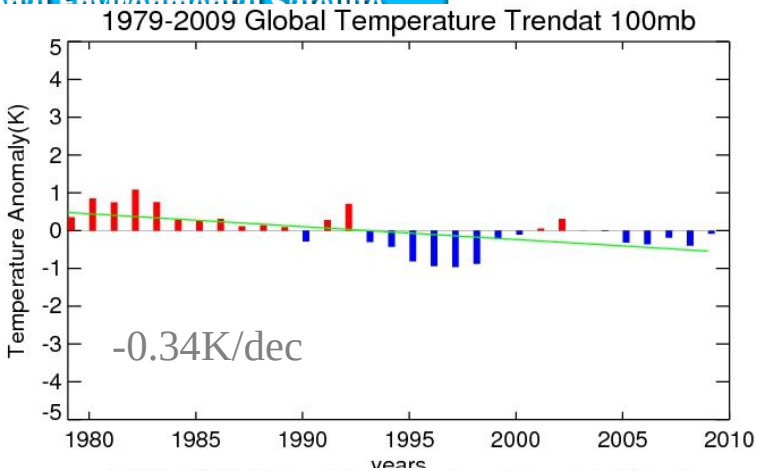
- **AMSU (blue) / GOES (dashed red) relative viewing geometry**

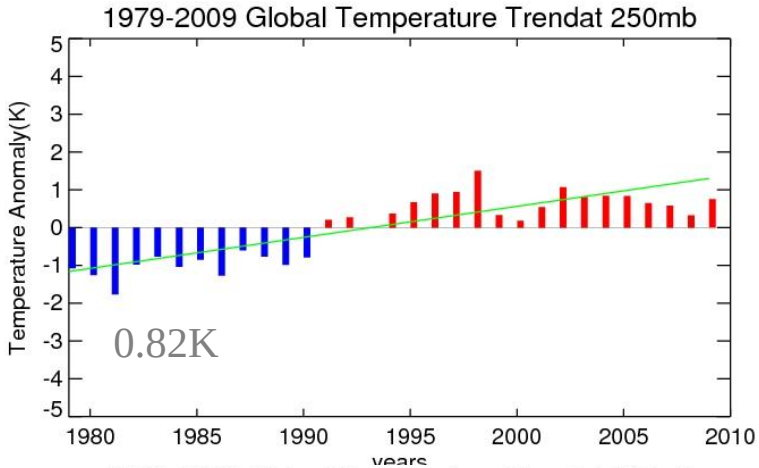
National Environmental Satellite, Data, and Information Service

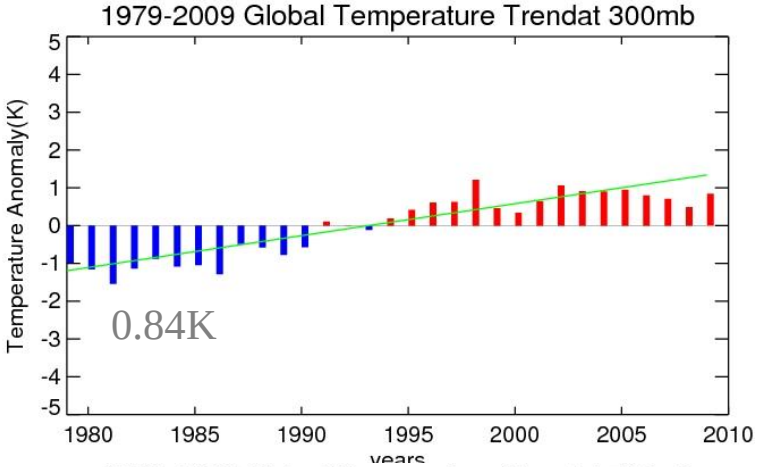
MSU/AMSU Derived Level 2 Atmospheric Temperature Trend in Past 30 years

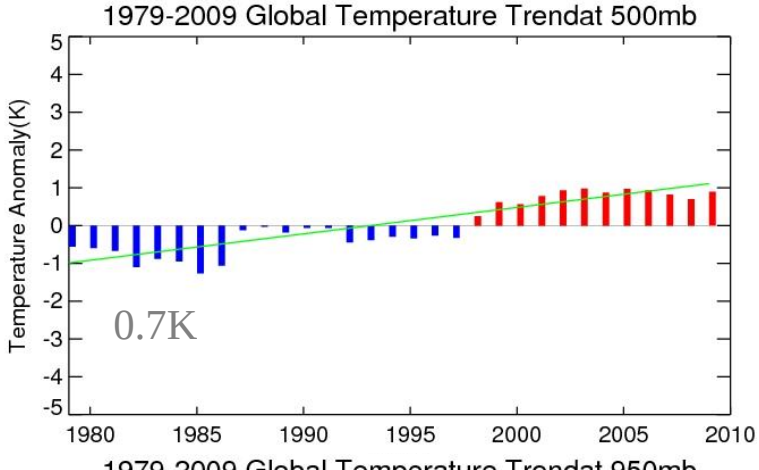


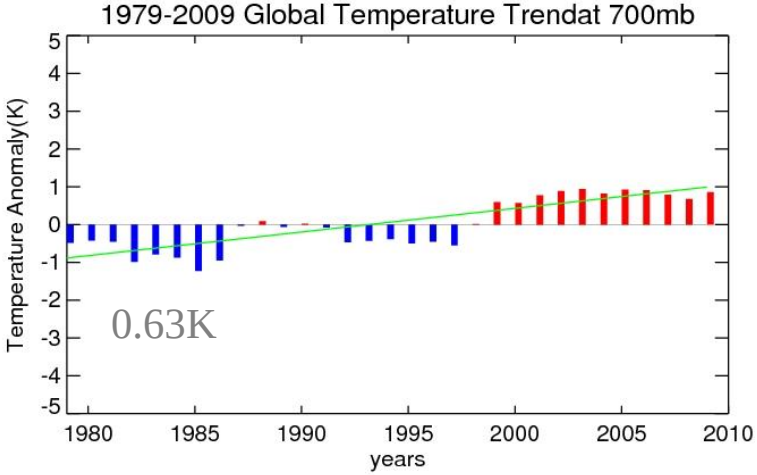


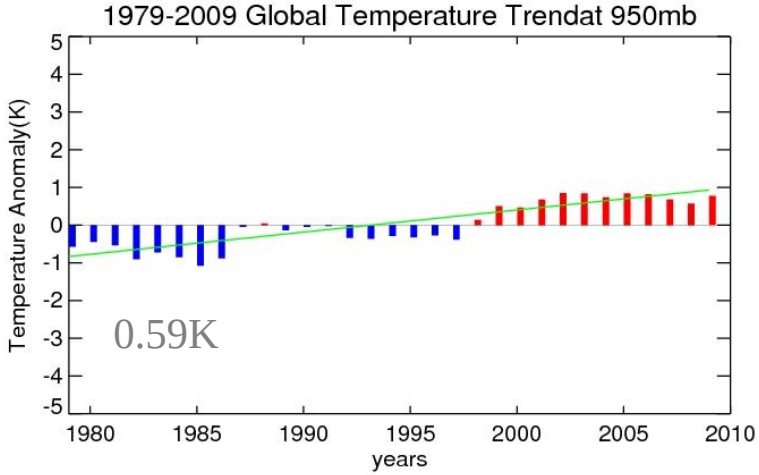

1979-2009 Global Temperature Trendat 100mb
Temperature Anomaly(K)
-0.34K/dec
1980 1985 1990 1995 2000 2005 2010
years

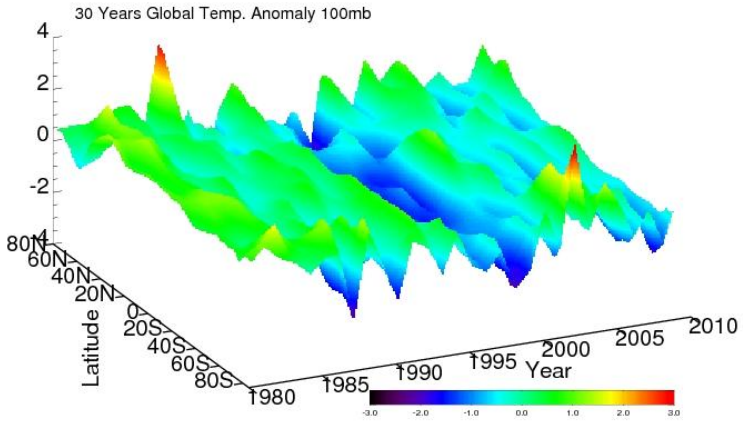

1979-2009 Global Temperature Trendat 250mb
Temperature Anomaly(K)
0.82K
1980 1985 1990 1995 2000 2005 2010
years

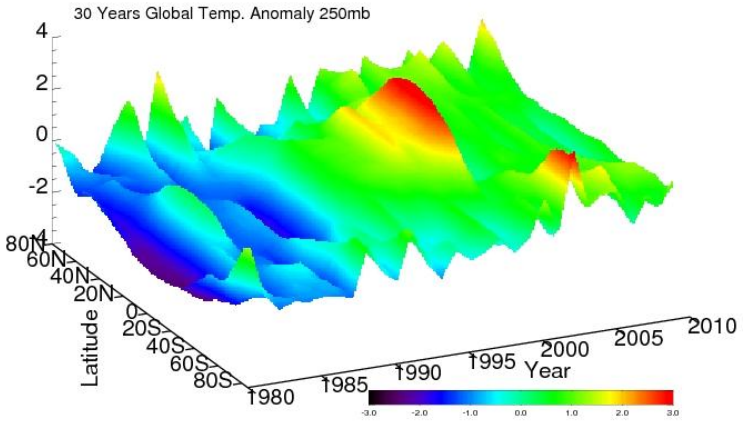

1979-2009 Global Temperature Trendat 300mb
Temperature Anomaly(K)
0.84K
1980 1985 1990 1995 2000 2005 2010
years

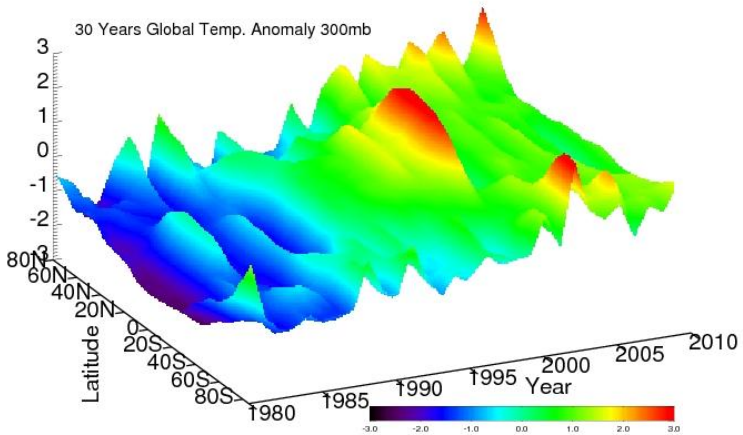

1979-2009 Global Temperature Trendat 500mb
Temperature Anomaly(K)
0.7K
1980 1985 1990 1995 2000 2005 2010
years

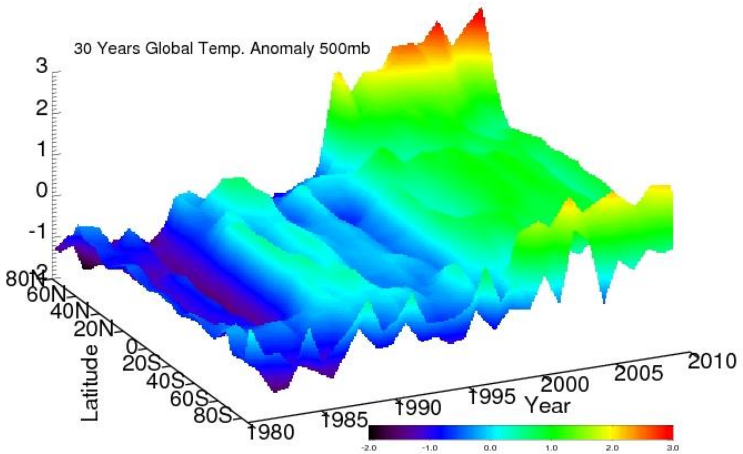

1979-2009 Global Temperature Trendat 700mb
Temperature Anomaly(K)
0.63K
1980 1985 1990 1995 2000 2005 2010
years

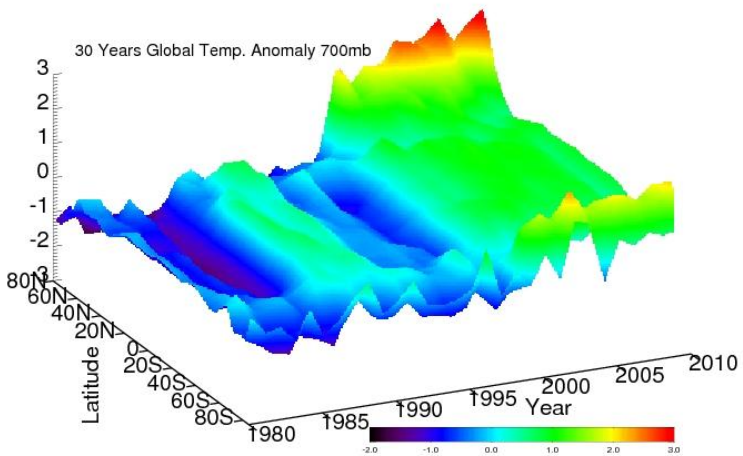

1979-2009 Global Temperature Trendat 950mb
Temperature Anomaly(K)
0.59K
1980 1985 1990 1995 2000 2005 2010
years

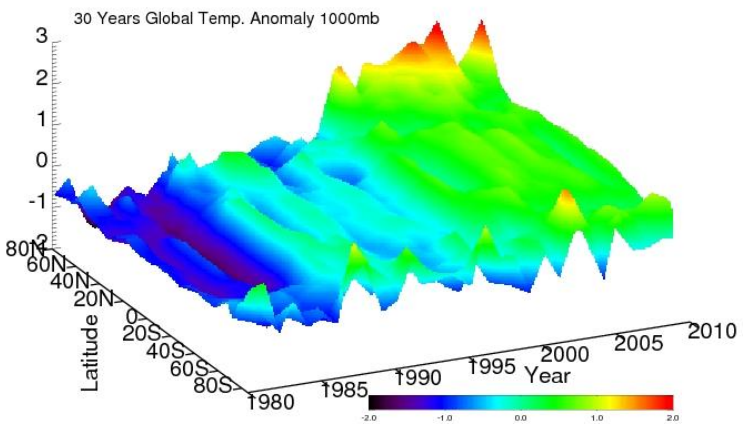

30 Years Global Temp. Anomaly 100mb
Latitude
Year


30 Years Global Temp. Anomaly 250mb
Latitude
Year


30 Years Global Temp. Anomaly 300mb
Latitude
Year

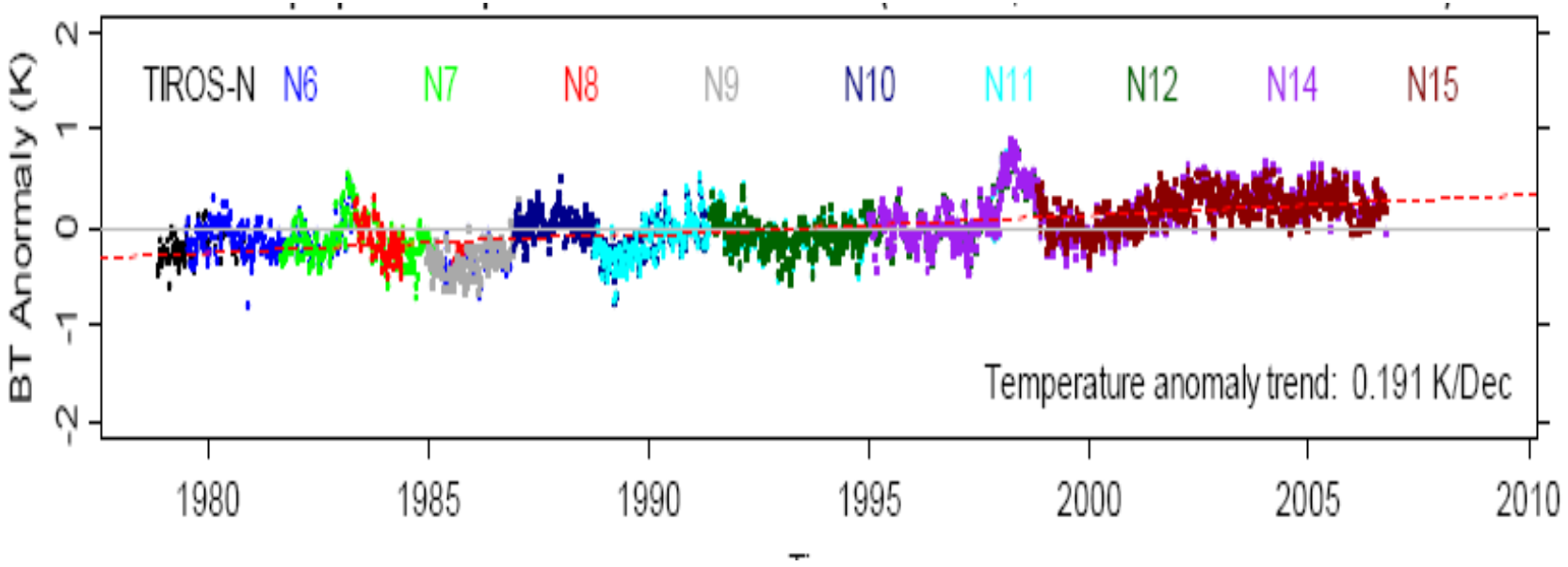

30 Years Global Temp. Anomaly 500mb
Latitude
Year


30 Years Global Temp. Anomaly 700mb
Latitude
Year


30 Years Global Temp. Anomaly 1000mb
Latitude
Year

Consistent Mid-Tropospheric Trend by Combining MSU and AMSU-A

MSU2/AMSU5—mid-tropospheric temperature

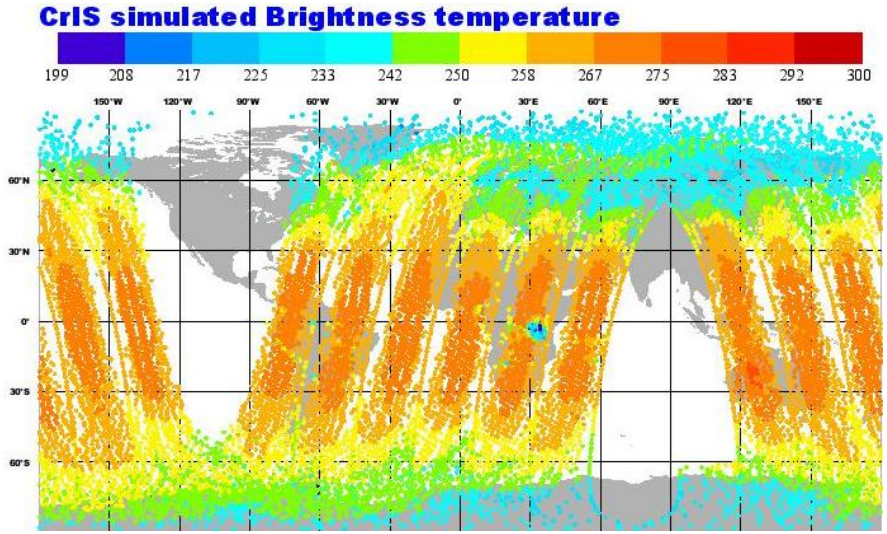


Multiple MSUs and AMSUs are cross-calibrated using Simultaneous Overpassing

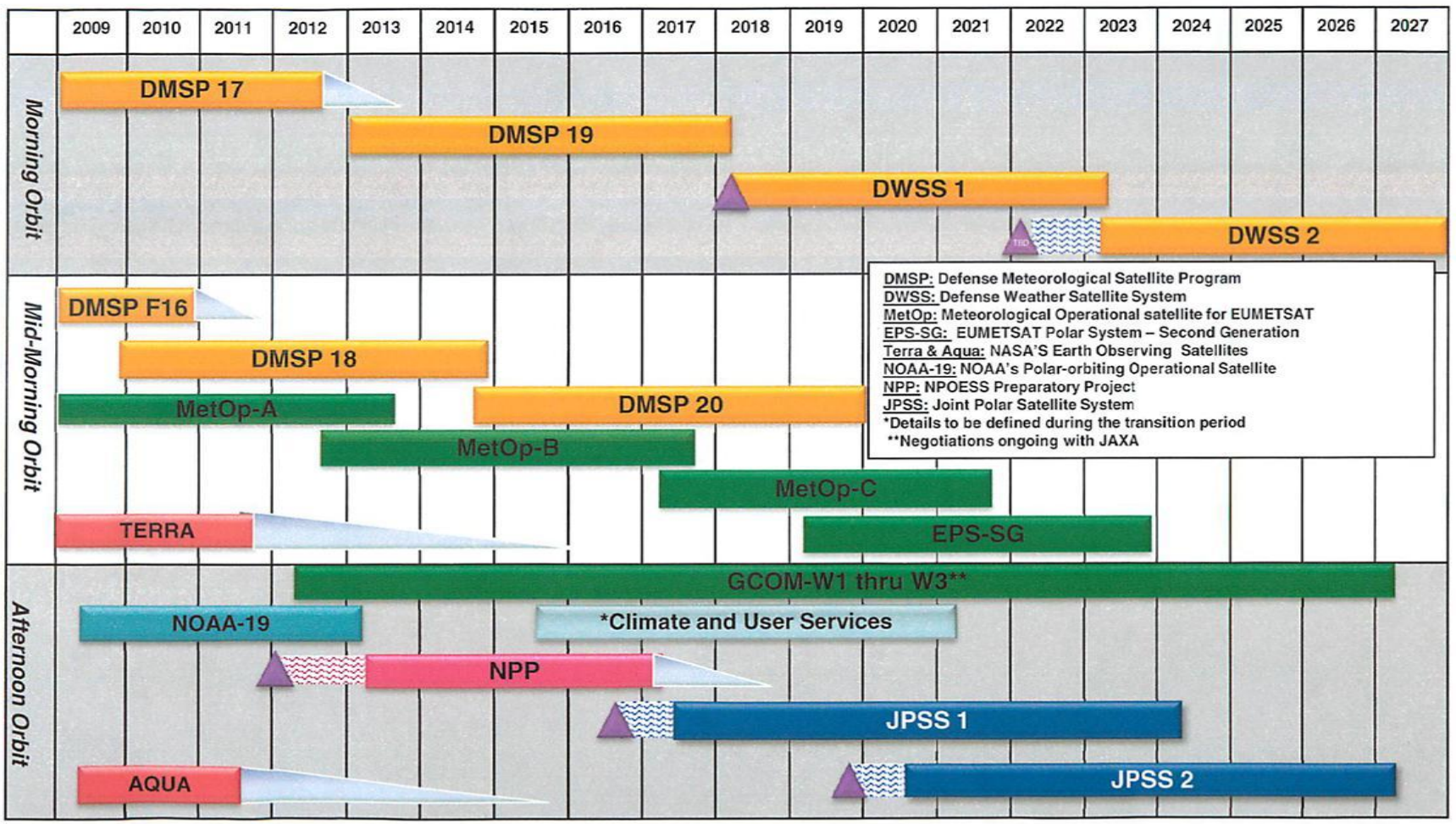
From Cheng-Zhi Zou, 2010 NOAA CDR Workshop

Preparations for CrIS/ATMS

- BUFR proxy data, from NESDIS, archived at ECMWF since Feb 2011
- CRTM Fast RT model coefficients available based on rectangular band shapes
- Code to handle CrIS / ATMS lodged in JCSDA vapor
- Preliminary results generated from simulated data, as technical check-out of code
- Aim to provide feedback on data quality within days during :
  - early orbit check-out
  - subsequent commissioning phase IF data is available in BUFR format & data streams in place



Continuity of Polar Operational Satellite Programs



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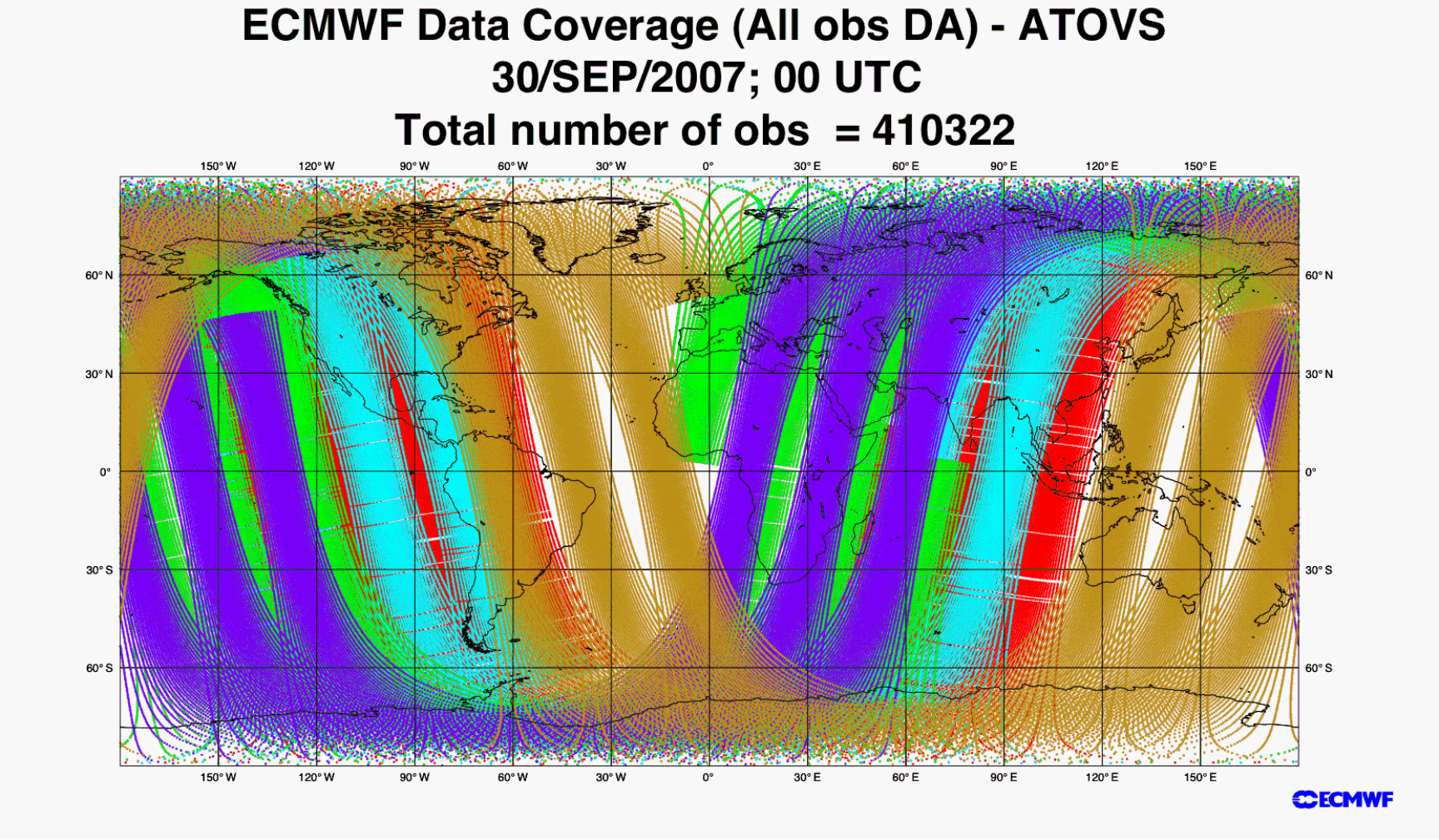
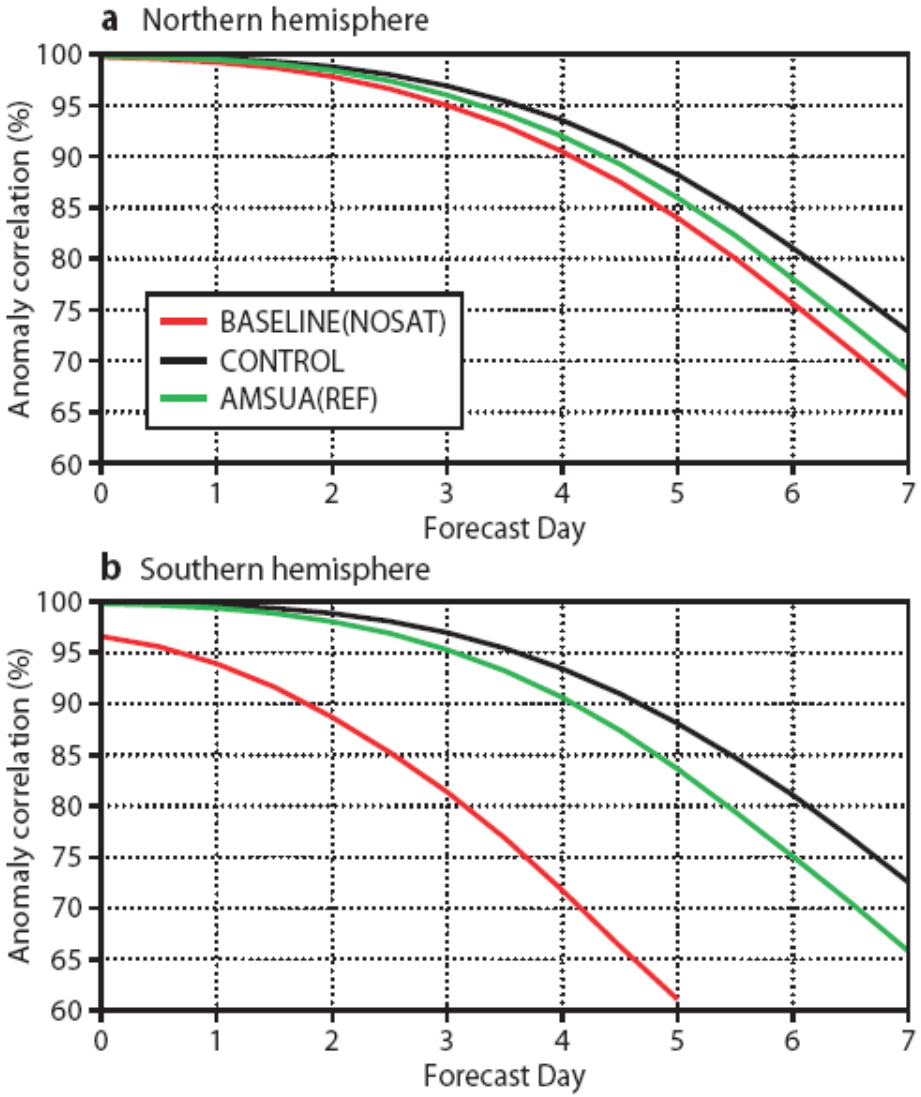
Three Orbital Planes are Needed to Cover the Globe Within NWP Analysis Cycle



Impact of Satellite Data in Forecast Skill

- 2007 ECMWF forecasting system,
- winter & summer seasons,
- Three experiments:
  1) no satellite data (NoSAT),
  2) NoSAT + 1 AMSU-A
  3) Control using all data

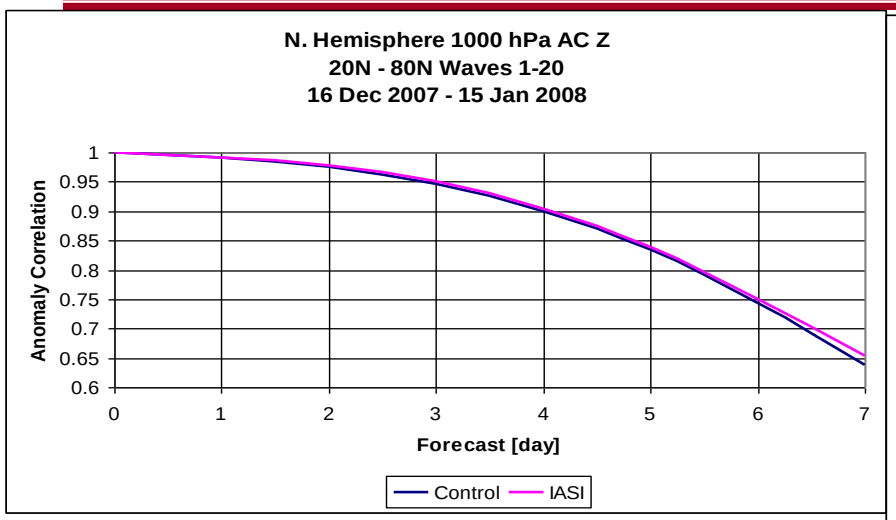
← 500 hPa *geopotential height* anomaly correlation

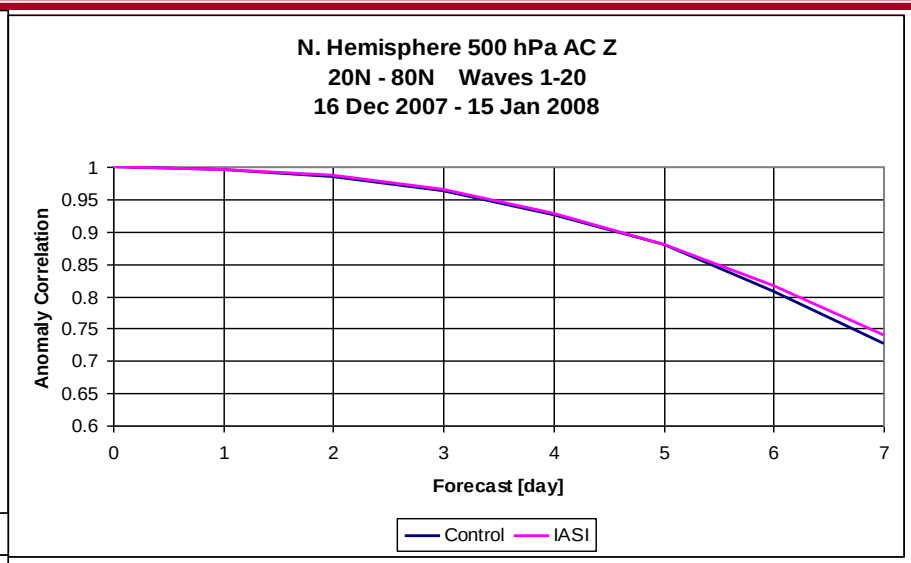


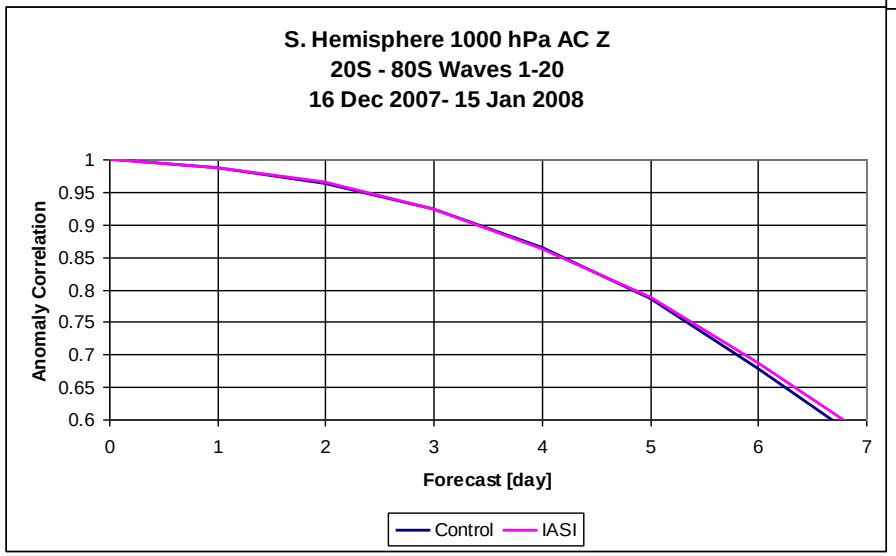
Slide courtesy of Erik Andersson, ECMWF

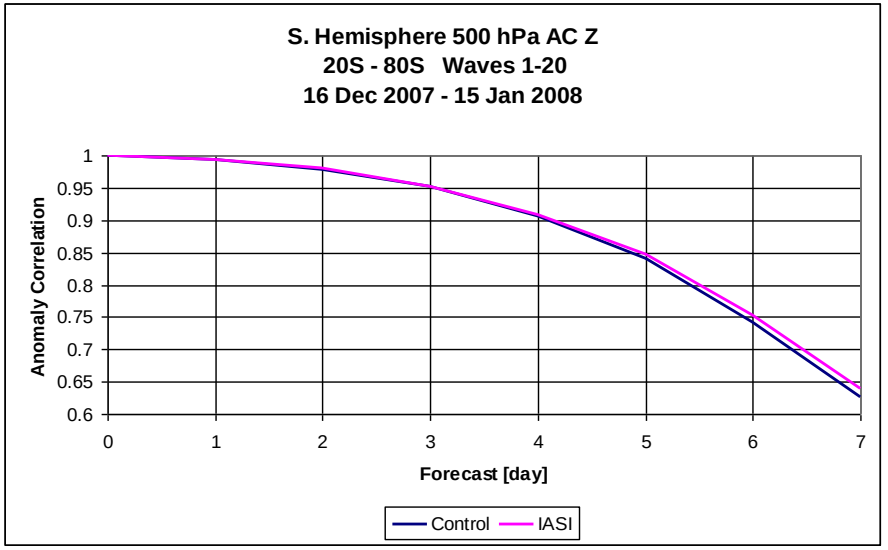
National Environmental Satellite, Data, and Information Service

IASI Impacts on Global Medium-Range Forecasts









Conclusions

- **NOAA is taking the lead for NPP/JPSS instrument CalVal**

- **JPSS program will provide well-calibrated radiances and well validated products**

1) Weather Forecast Models through
CrIS, ATMS, VIIRS, OMPS
2) Short term Environmental Observations (Events)
VIIRS, OMPS, CrIS
3) Long term Environmental Observations (Climate Change Detection)
CERES, TSIS, VIIRS, OMPS, CrIS, ATMS

- **NPP sensor proxy data (e.g. golden days, NWP BUFR) are made available for user preparation**