GSICS Coordination Plan

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National Environmental, Satellites, Data and Information Service
National Oceanic and Atmospheric Administration

Presented at the First GSICS Research Working Group Meeting
January 22-23, 2007

Agenda

- GSICS Coordination Plan
- NOAA Integrated Cal/Val System (ICVS)
- Impacts of NOAA Cal/Val on Weather and Climate Studies

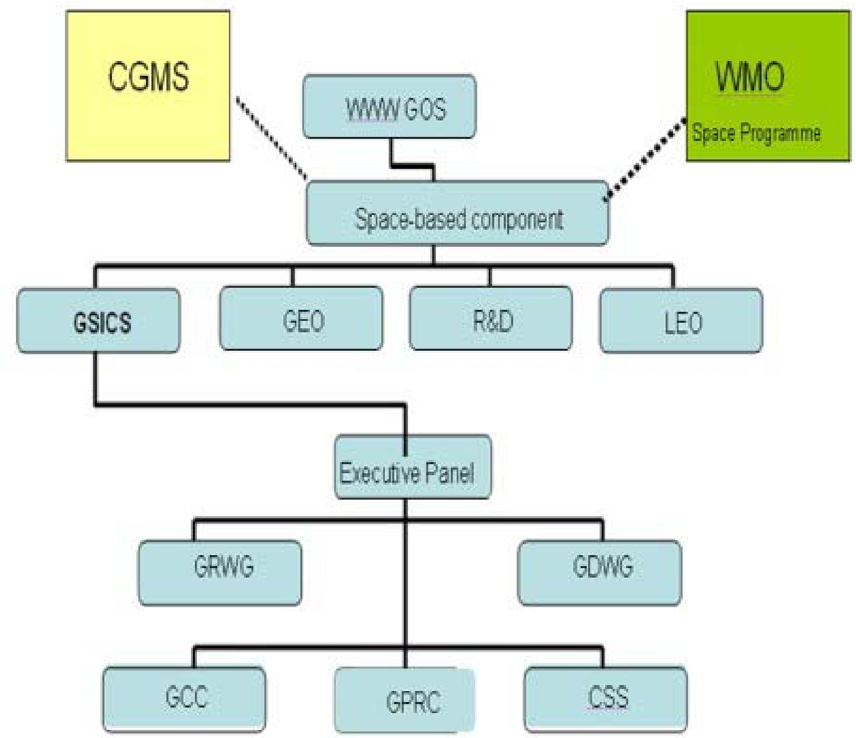
Global Space Based Inter-calibration System GSICS

Vision

GSICS will result in more accurate satellite observations for assimilation in numerical weather prediction models, the construction of more reliable climate data records, and achieving the societal goals of the Global Earth Observation System of Systems

Objectives

- To improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of satellite sensors.
- To provide for the ability to re-calibrate archived satellite data using the GSICS intercalibration system to enable the creation of stable long-term climate data sets
- To ensure that instruments meet specification, pre-launch tests are traceable to SI standards, and the on-orbit satellite instrument observations are well calibrated by means of careful analysis of instrument performance, satellite intercalibration, and validation with reference sites



GSICS Coordination Center (GCC) Structure

GCC Office

- **News Group**
  - Website
  - Quarterly
  - Report to WMO
  - Seminar
  - Orbit Prediction
- **LEO2LEO Group**
- **GEO2LEO Group**

  LEO2LEO and GEO2LEO Groups:
  - IR/VIS subtask
  - MW subtask
  - DMSP subtask
  - UV subtask

  GEO2LEO Group:
  - IR subtask
  - VIS subtask
- **Data Group**
  - Data archival
  - Dissemination

GCC Staff (on site at NESDIS)

- **News Group**
  - Task Lead: Bob Iacovazi
  - Advisor: Jerry Sullivan
- **LEO2LEO VIS/IR Group**
  - Task Lead: Alex Wang
  - Advisor: Changyong Cao
- **LEO2LEO MW Group**
  - Task Leads: Banghua Yan and BoB Iacovazi
  - Advisor: Fuzhong Weng
- **LEO2LEO UV Group**
  - Task Lead: Trevor Beck
  - Advisor: Larry Flynn
- **GEO2LEO Group**
  - Task Co-Leads: Fangfang Yu & Yaping Li
  - Advisor: Fred Wu and Alex Ignotov
- **Data Group**
  - Task Lead: Yaping Li
  - Advisor: Changyong Cao
- **Website**
  - Task Lead: Yaping Li
  - Advisors: Changyong Cao and Fuzhong Weng

GCC Major Facilities

- **Community Radiative Transfer Model (CRTM)**
- **Cal/Val Data Sets**
- **SNO/SCO Prediction Software**
- **Hyperspectral Convolution Software**
- **Satellite Instrument Trending System**

Linkage to Major NOAA Programs

- **GOES-R Algorithm Working Group (AWG) Cal/Val**
- **Joint Center for Satellite Data Assimilation (JCSDA)**
- **NOAA Satellite Cal/Val (in STAR 2008 budget)**
- **NOAA Scientific Data Stewardship (in STAR 2007 budget)**

GSICS Website

Science Page on GSICS Website

GSICS Homepage - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.orbit.nesdis.noaa.gov/smcd/spb/calibration/icvs/GSICS/index.html

Customize Links Free Hotmail Windows Media Windows

Global Space-Based Inter-Calibration System

- HOME
- PARTNERS
- ORGANIZATION
- PERSONNEL
- NEWSLETTERS
- SCIENCE PAGES
- SEMINARS
- MEETINGS
- PUBLICATIONS
- LINKS
- OPPORTUNITIES

LEO - LEO (NOAA 9)

NOAA 10	NOAA 11	NOAA 12

LEO - GEO (NOAA 14)

GOES 8	GOES 10	MET 5	MET 7	GMS 5

LEO -GEO (NOAA 15)

GOES 11	GOES 12	MET 8	MET 5

LEO - GEO (NOAA 16)

GOES 11	GOES 12	MET 8	MET 5

Done

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http://www.orbit.nesdis.noaa.gov/smcd/spb/calibration/icvs/GSICS/index.html

Agenda

- GSICS Coordination Plan
- NOAA Integrated Cal/Val System (ICVS)
- Impacts of NOAA Cal/Val on Weather and Climate Studies

Current STAR Support for NOAA Satellite Cal/Val Programs

Cal/Val Activities	POES	GOES	NPOESS	GOES-R	GEOSS
Prelaunch calibration	Yellow	Yellow	Yellow	Green	Yellow
On-orbit calibration	Green	Green	Red	Green	Red
Reference Sites	Yellow	Yellow	Red	Yellow	Red
Product validation	Yellow	Yellow	Red	Green	Red

Red: Little involvement

Yellow: Moderate involvements and contribution

Green: Strong leadership and major contribution

Solution requires an Integrated Cal/Val System with benefits to all satellite programs

- Establish the consistency
- Interoperability
- Data sharing
- Improved data quality
- Cost-saving
- Meet all user requirements

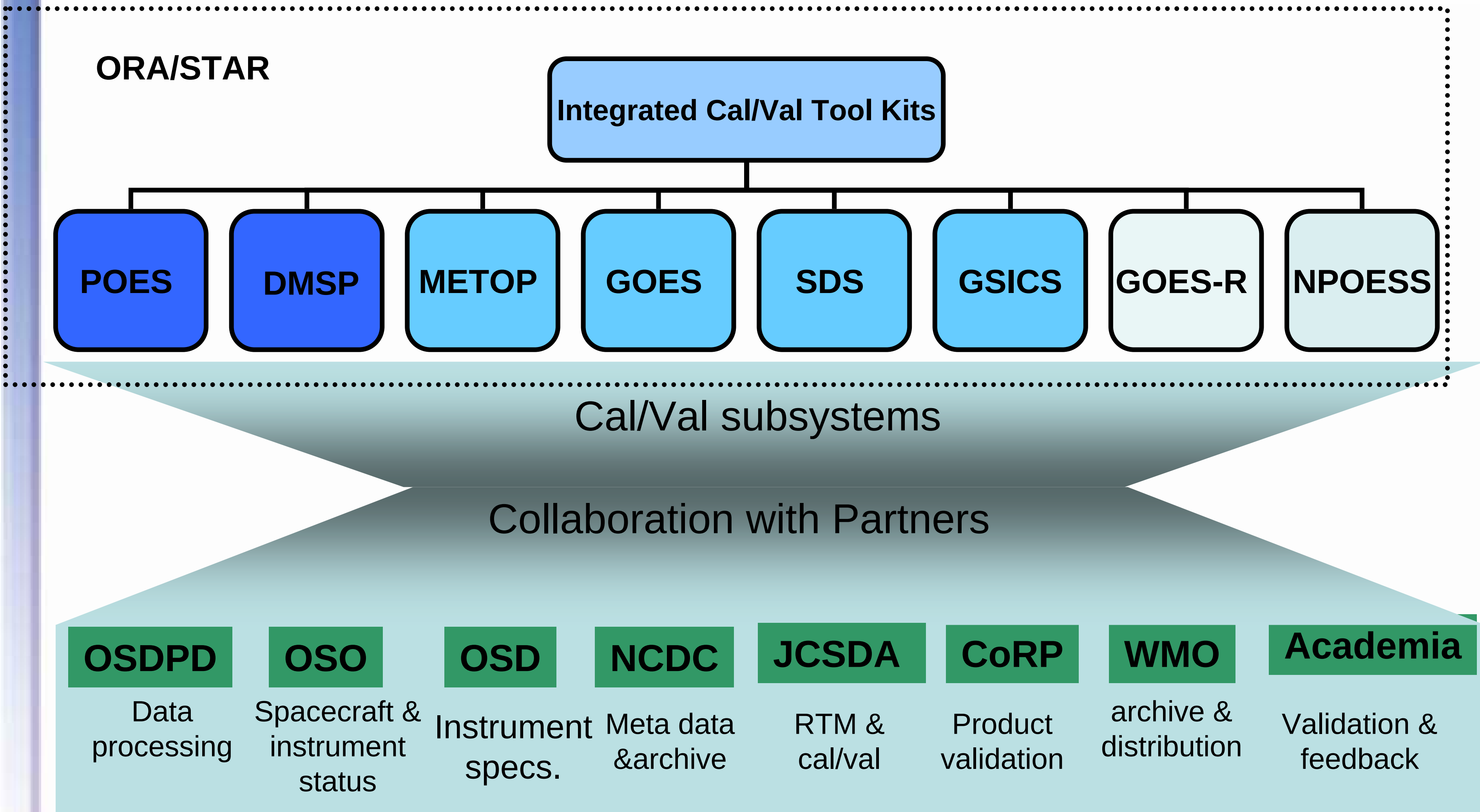
An End-to-End Cal/Val Process

- **Pre-launch**
  - **Pre-launch characterization**
  - **Common standards for vendor calibration**
  - **Traceability to system international units**
  - **New calibration models and algorithms**
- **Post-launch**
  - **Maintenance of operational satellite calibration**
  - **Inter-and Intra-calibration of satellite sensors**
  - **Online monitoring system for satellite instrument trending**
  - **Inter-comparison of satellite observations with simulations**
- **Product validation system**
  - **Existing products from newly launched**
  - **New products from research satellites**
  - **Define validation sites**
  - **Consensus algorithm and error budget models**
- **Impact assessment of new cal/val procedures**
  - **Climate trend analysis**
  - **Land cover analysis**
  - **Severe weather forecast**

An Integrated Cal/Val System for Operational Sensor Calibration

- **The cal/val program will be optimized through its developments of NOAA integrated satellite instrument cal/val enterprise system**
- **The integrated cal/val system is a framework on which scientists from universities, government labs and private sectors can communicate efficiently and work together. It has passed Preliminary Design Review on Sept 20, 2006.**
- **The system concept was first tested during NOAA-18 and MetOp satellite cal/val processes. NOAA delivered to users NOAA-18 data, 45 days after satellite launch.**
- **The integrated cal/val system will critically support the GEOSS by calibrating the operational instruments from METOP, FY-3, and JAXA, and NOAA to the same reference level for weather and climate applications**

Concept of Operation for Integrated Cal/Val System (ICVS) Framework



Tasks of Post-launch Calibration

- **Satellite in-orbit Verification (SIOV)**
  - Post launch noise
  - Update calibration coefficients
  - Optimized calibration targets
  - Corrections of contamination
    Geolocation and coregistration
- **SNO/SCO Real-time Prediction**
  - Data acquisition software
  - Data creation software
  - Analysis software
- **Instrument Trending System**
  - Telemetry
  - Noise
  - Calibration coefficients
- **Global Bias Analysis System**
  - Community radiative transfer model
  - Innovation vector (O-B)
  - Analysis residuals (O-A)

Satellite in-Orbit Verification

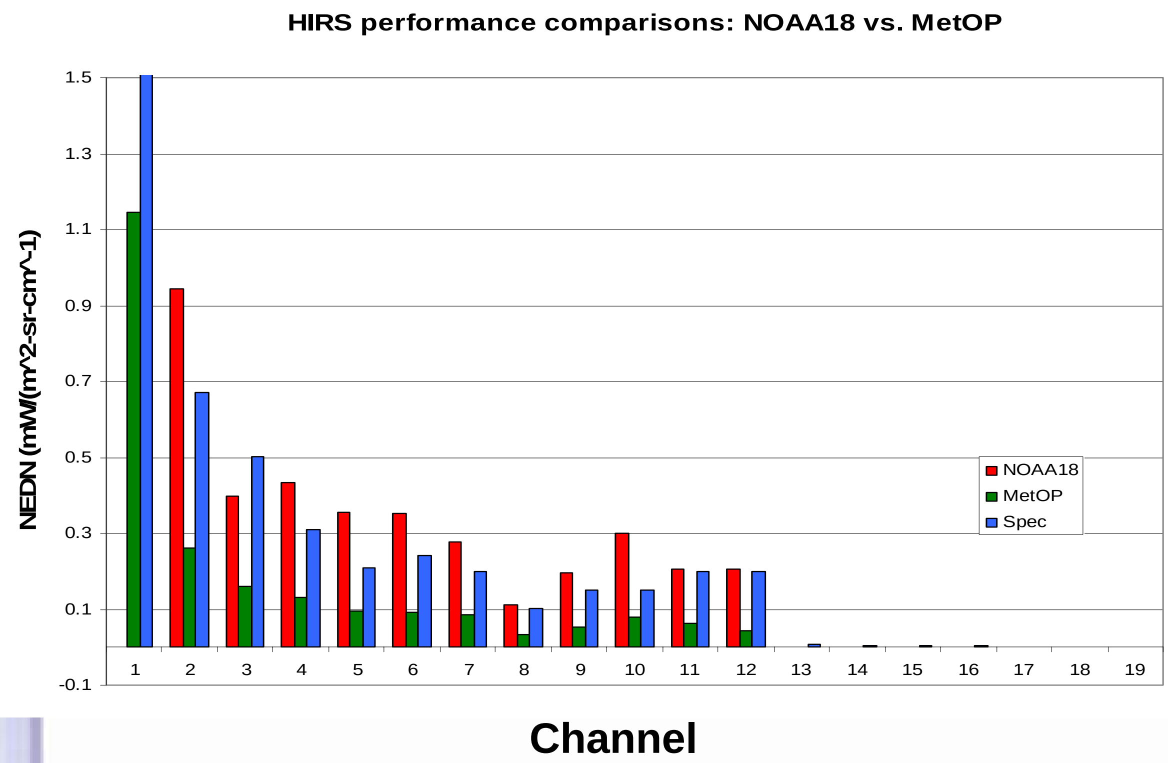
Summary of MetOp IOV Tasks

MetOp-A on-Orbit Verification Conducted by NOAA Scientists

Task #	Task Name	Status	Key Results	Principal Investigators
AM1005	Instrument trending	Completed	stable	Mo
AM1007	Determination of optimal space view	Completed	SV1 are ideal	Mo
AM1008	noise measurements-all channels	Completed	Meet the spec	Mo
AM1009	*satellite to satellite comparison*	*Completed*	*difference is within noise level*	*Yan&Iacavaci*
AM1010	BB PRT temperature accuracy	Completed	meet specification	Mo
AM1011	*Earth-scence bias characterization*	*Completed*	*A1 cross-track asymmetry*	*Kleespies, Huan*
AM1012	Channel co-registration	Completed	small ascending &desending difference	Kleespies
AVH005	space clamp noise and stability	Completed	stable	Sullivan
AVH006	*Imagery Evaluation Channels 1, 2 and 3A*	*Completed*	*NDVI and image products are fine*	*Sullivan*
AVH007	*Signal-to-Noise (S/N) Channels 1, 2 and 3A*	*On-going*	*Ch1,2,3A noise meet spec*	*Wu*
AVH010	NEDT/Dynamic range - channel 3B,4,5	Completed	meet the spec	Sullivan
AVH011	*instrument stablity - channels 3B,4,5*	*Completed*	*stable*	*Sullivan*
AVH012	*Imagery Evaluation Channels 3B, 4 and 5*	*Completed*	Ch4,5 some jumps 0.1-0.2K	*Sullivan*
AVH014	Operational calibration	Completed	Updated calibration coeff.	Wu/Sullivan
AVH018	*Detection of land-sea boundary*	*Completed*	*nearly 1-2 pixel offset near nadir,upto 3-5 pixels at edge*	*Sullivan*
AVH019	*NOAA-18,17, and 16 comparison*	*Completed*	*ch1 0.2% compared to MODIS*	*Cao*
AVH021	*Channel Registration*	*Completed*	*AVHRR is slightly misaligned with HIRS*	*Kleespies*
AVH022	*striping evaluation*	*Completed*	*Striping index in good range (4-8)*	*Wu/Sullivan*
HIR011	*NEDN - IR channels*	*Completed*	*Meet spec*	*Cao*
HIR012	*Instrument stability*	*Completed*	*noise stable*	*Cao*
HIR013	instrument trending	Completed	stable noise trend	Cao
HIR014	*Detection of land-sea boundary*	*Completed*	*no geolocation error*	*Cao*
HIR015	*Satellite-to-satellite comparsion*	*Completed*	*0.5 warmer than AIRS convolved*	*Wang/Cao*
HIR018	*Channel Registration*	*Completed*	*AVHRR is slightly misaligned with HIRS*	*Cao/Wang*

Tasks # with italics are requested in NASA reports

MetOP HIRS Noise

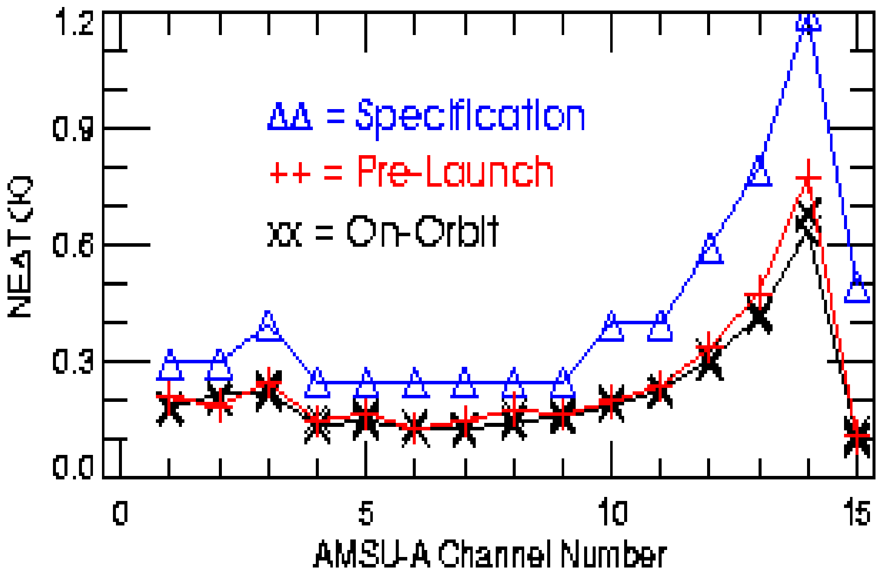


CH	NEDN	NEDN Spec	X spec.
1	1.145716	3.000000	0.38
2	0.261769	0.670000	0.39
3	0.158844	0.500000	0.32
4	0.131501	0.310000	0.42
5	0.094717	0.210000	0.45
6	0.091298	0.240000	0.38
7	0.084706	0.200000	0.42
8	0.032110	0.100000	0.32
9	0.054172	0.150000	0.36
10	0.078733	0.150000	0.52
11	0.061591	0.200000	0.31
12	0.044548	0.200000	0.22
13	0.001743	0.006000	0.29
14	0.001346	0.003000	0.45
15	0.001204	0.004000	0.30
16	0.001086	0.004000	0.27
17	0.000913	0.002000	0.46
18	0.000850	0.002000	0.42
19	0.000351	0.001000	0.35

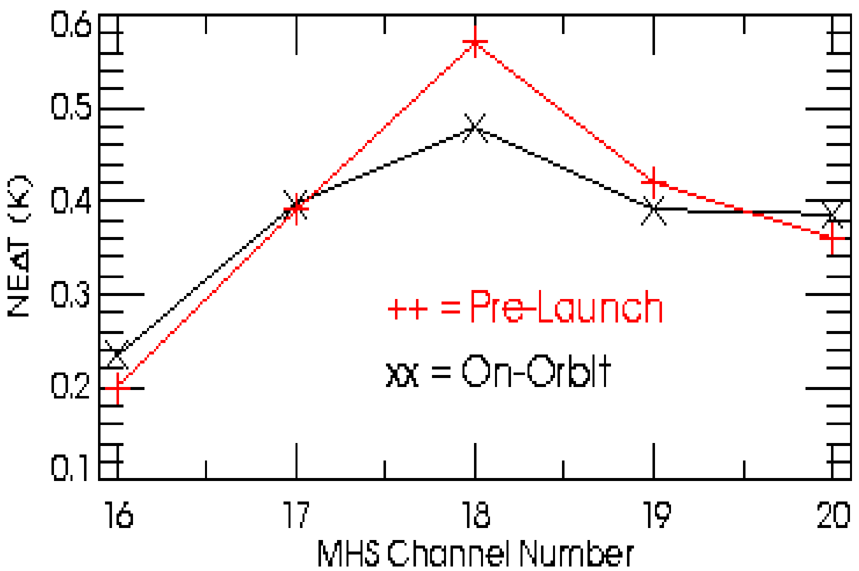
MetOp-A HIRS Noise is significantly smaller than NOAA-18 HIRS which has LW anomaly since its operation.
MetOp-A HIRS noise is also lower than the spec.

AMSU/MHS Noise Quantification

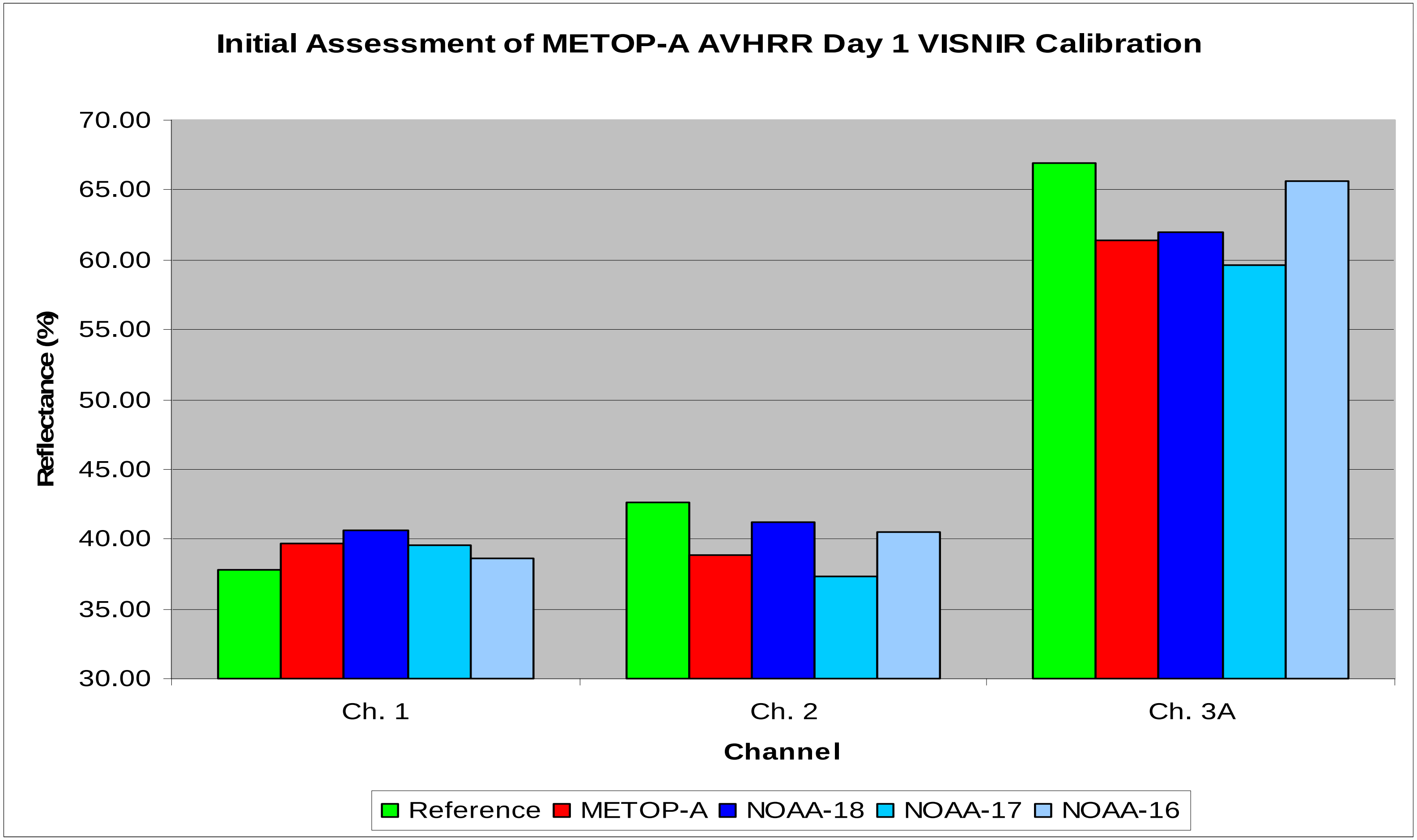
AMSU



MHS

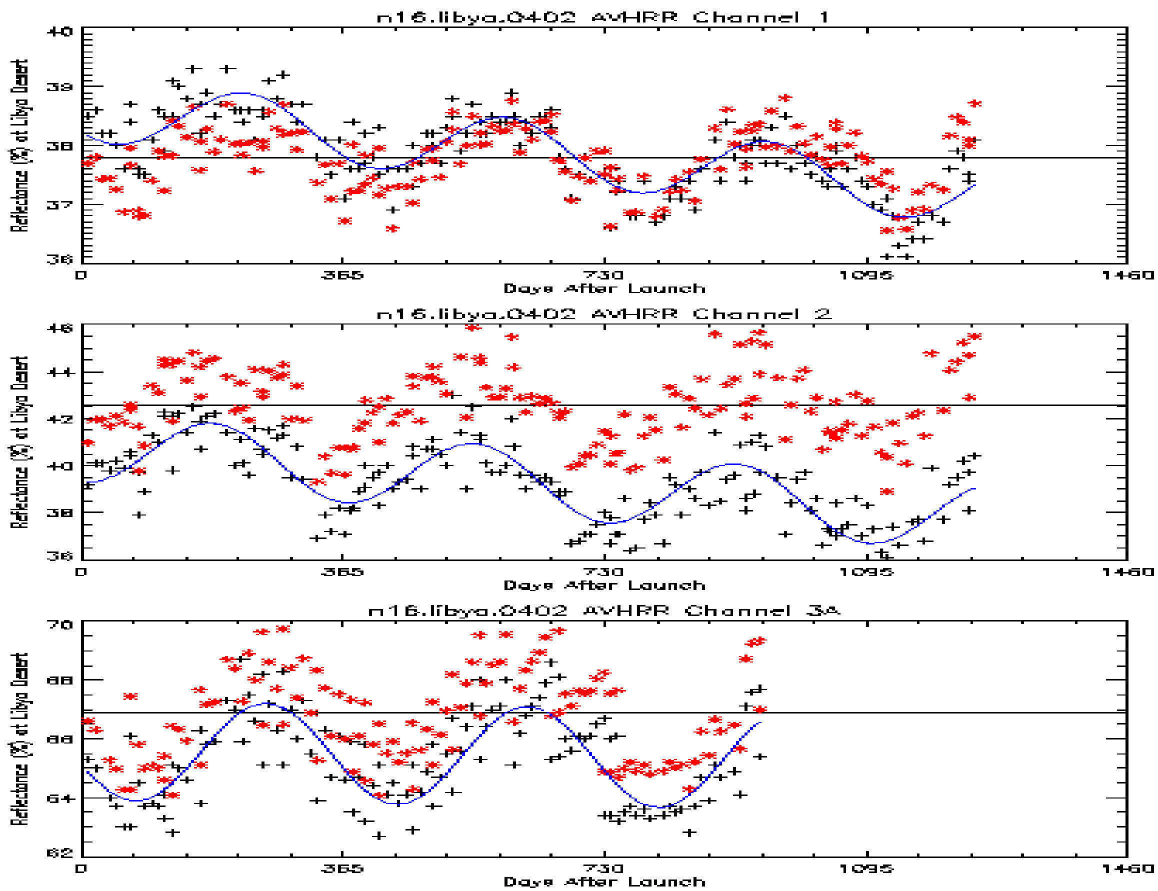


Post-Launch Solar Channel Calibration

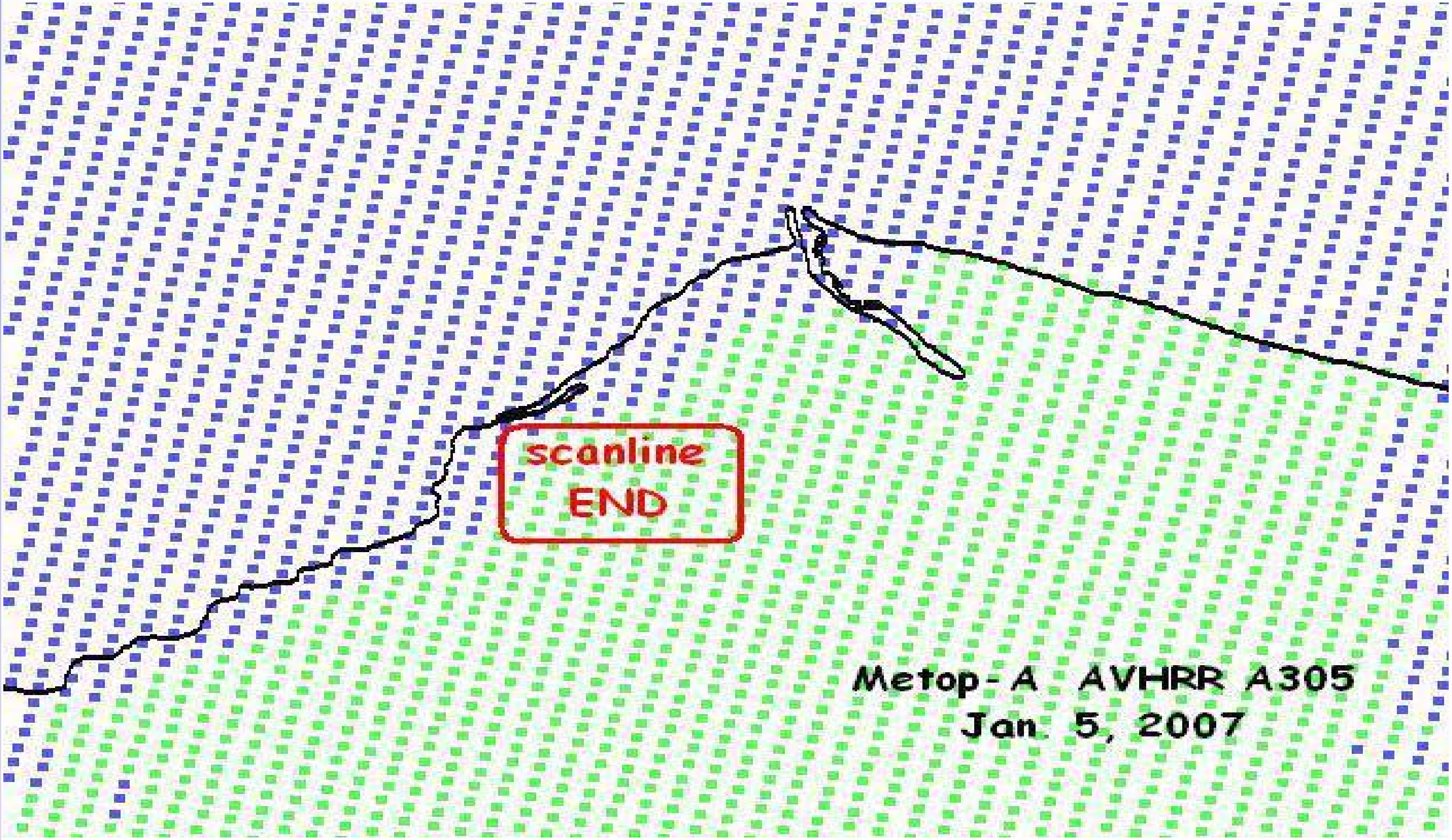


Multiply 0.9663, 1.1140, and 1.1058 to the pre-launch calibration results for METOP-A AVHRR Channel 1, 2, and 3A, respectively

Vicarious Calibration for AVHRR



AVHRR Navigation Errors

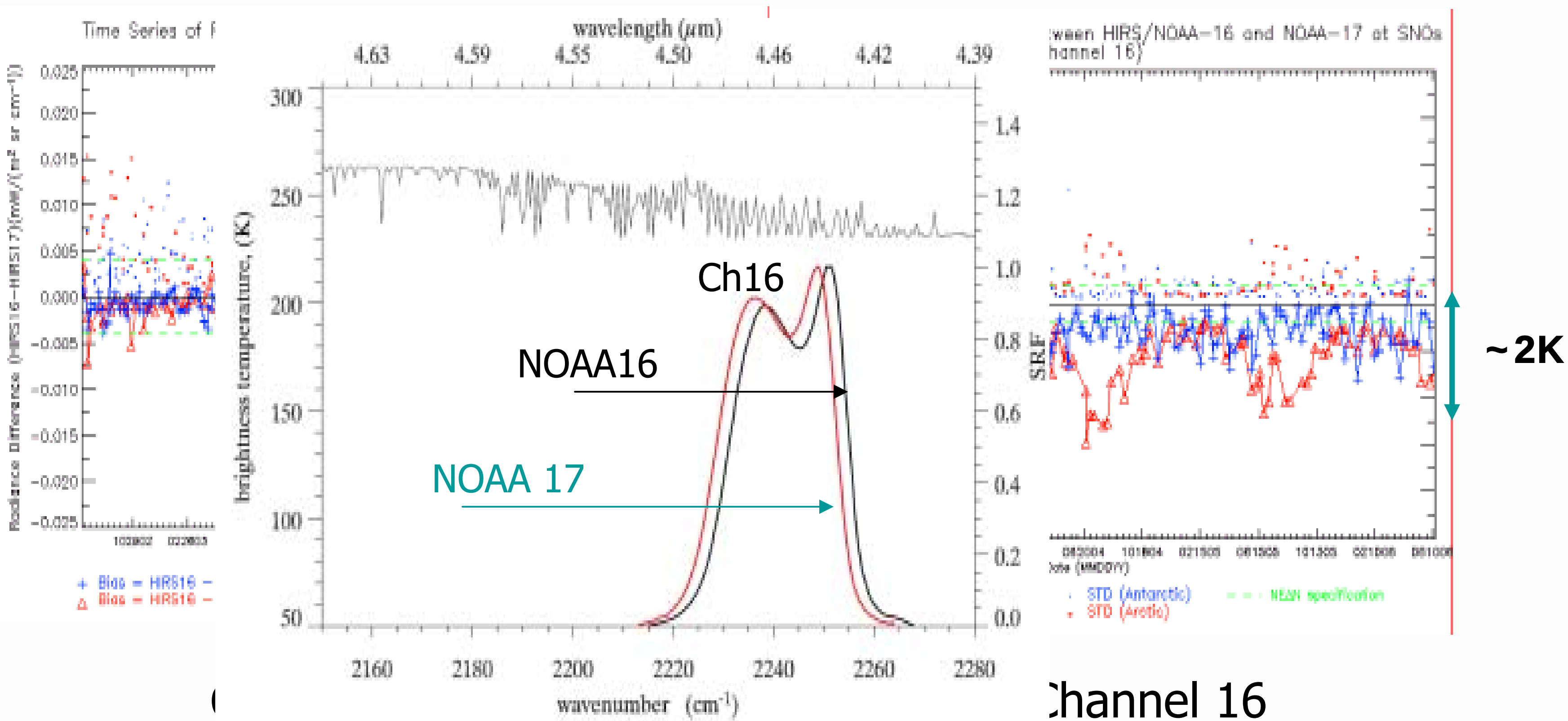


Error: 3-5 pixels near the end of scanline

SNO Derived Biases

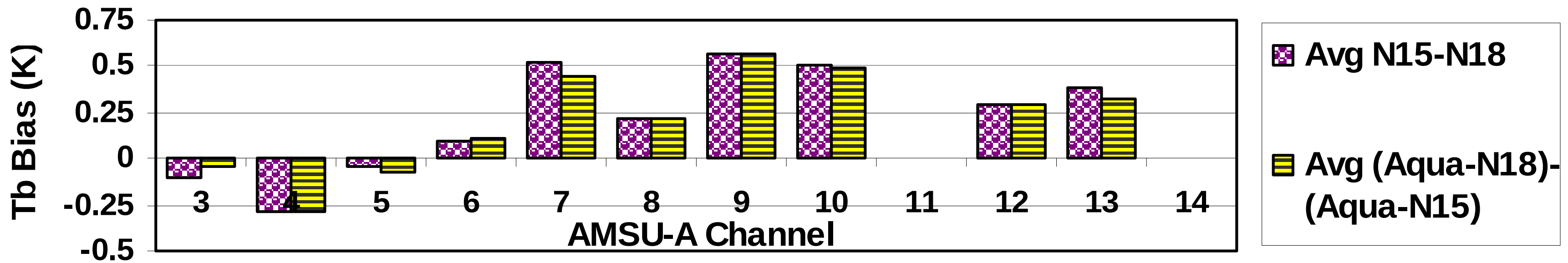
HIRS/NOAA16 minus HIRS/NOAA17

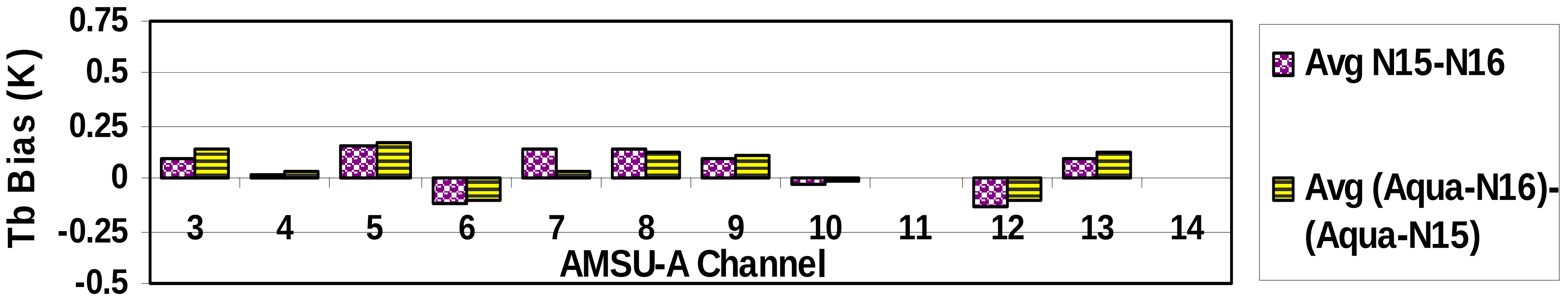
Inter-satellite comparison time series: 2002 – current

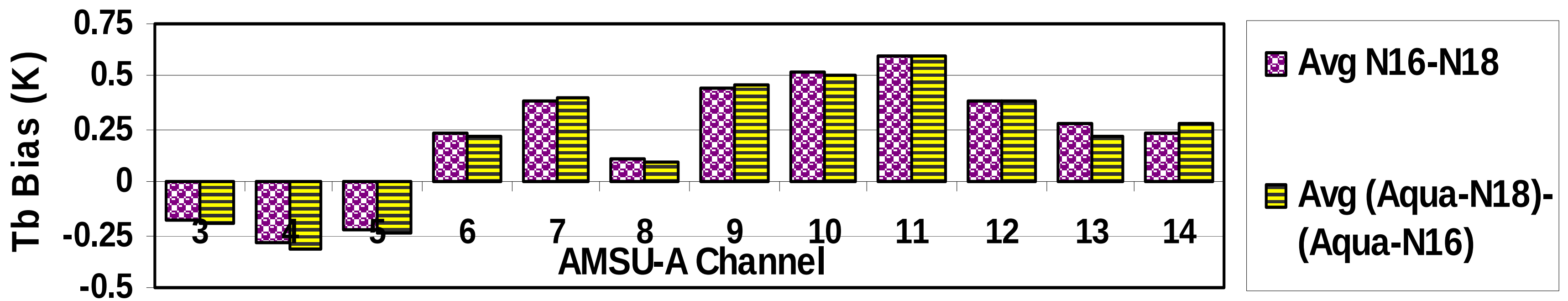


Measurements are consistent for some channels, while bias is revealed for other channels. The seasonal variation of biases is likely caused by the difference in spectral response functions, similar to the previous findings (Cao et al., 2005)

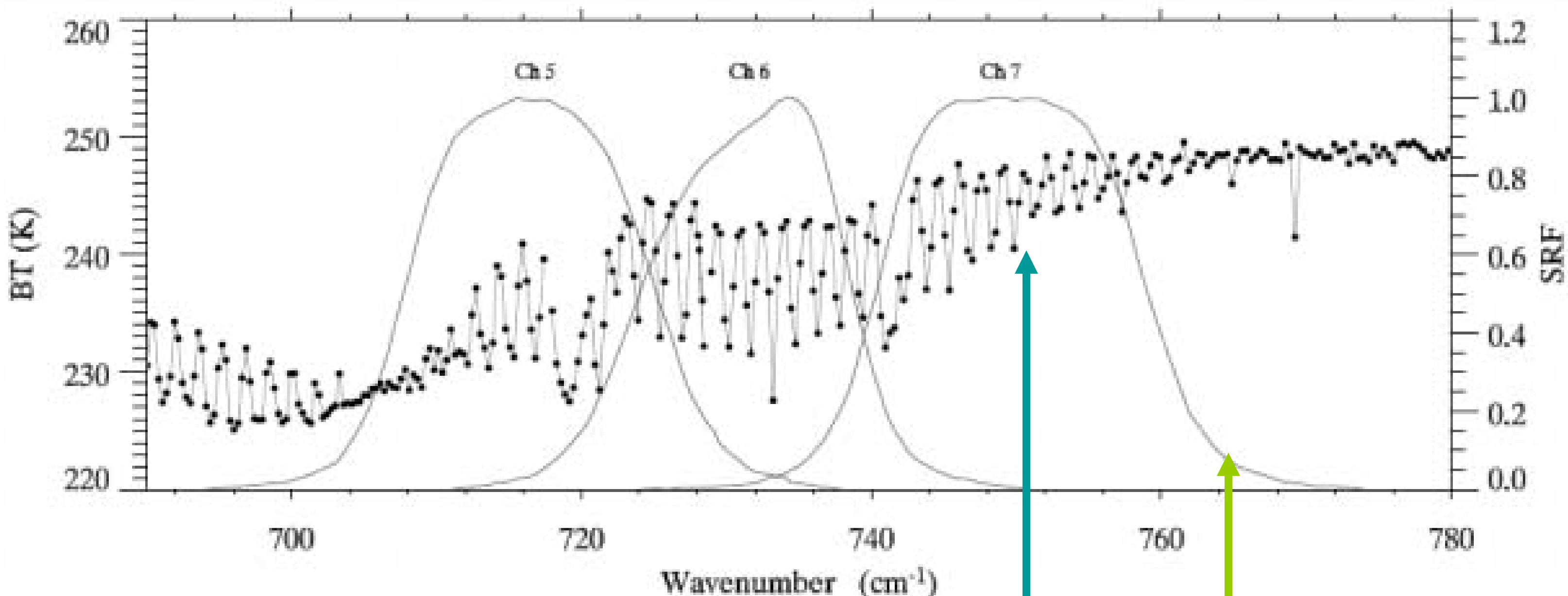
Observed and Predicted AMSU-A SNO Biases







Simulated HIRS (convolved from AIRS)

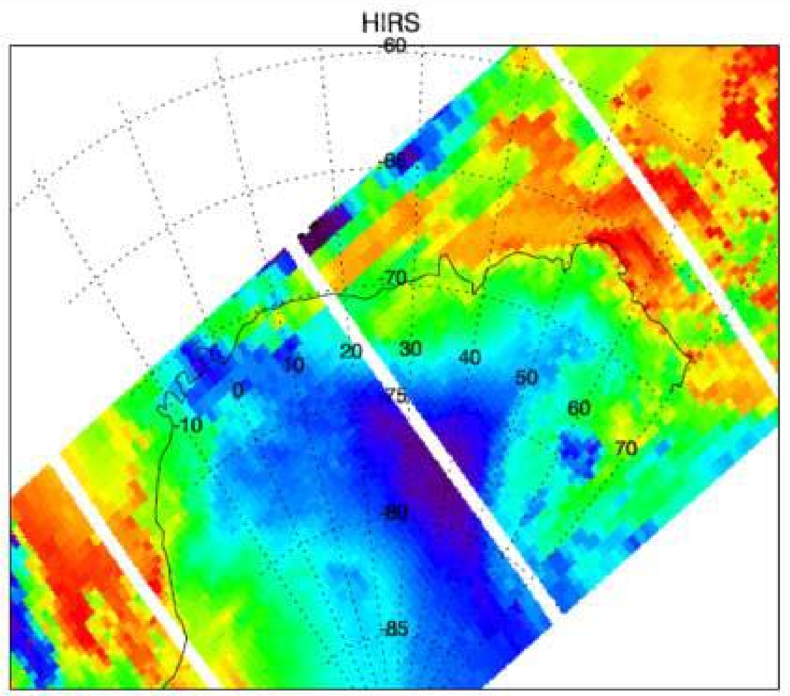


$$L_i = \frac{\int_{\nu_1}^{\nu_2} R(\nu)S_i(\nu)d\nu}{\int_{\nu_1}^{\nu_2} S_i(\nu)d\nu} + CC$$

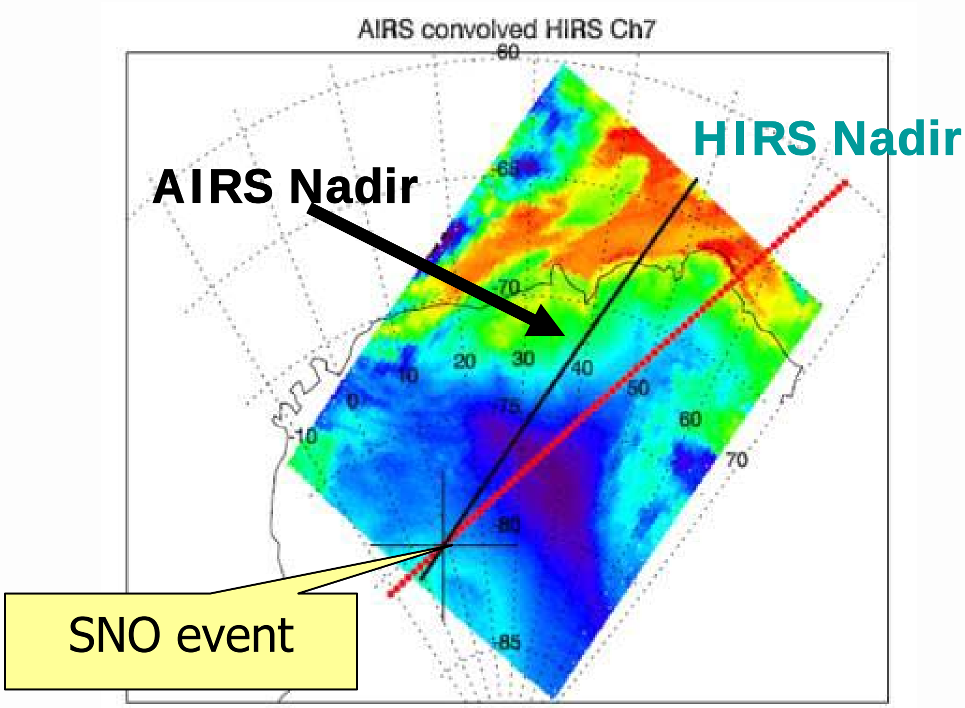
R is the AIRS radiance
S is the HIRS spectral response function
L is the AIRS convolved HIRS
i is the channel number
v is the wavenumber
CC is convolution error due to AIRS bad channels and spectral resolution, calculated from RTMs

Example

At Intersection: Time difference: <30 Sec
Distance: < 20 km

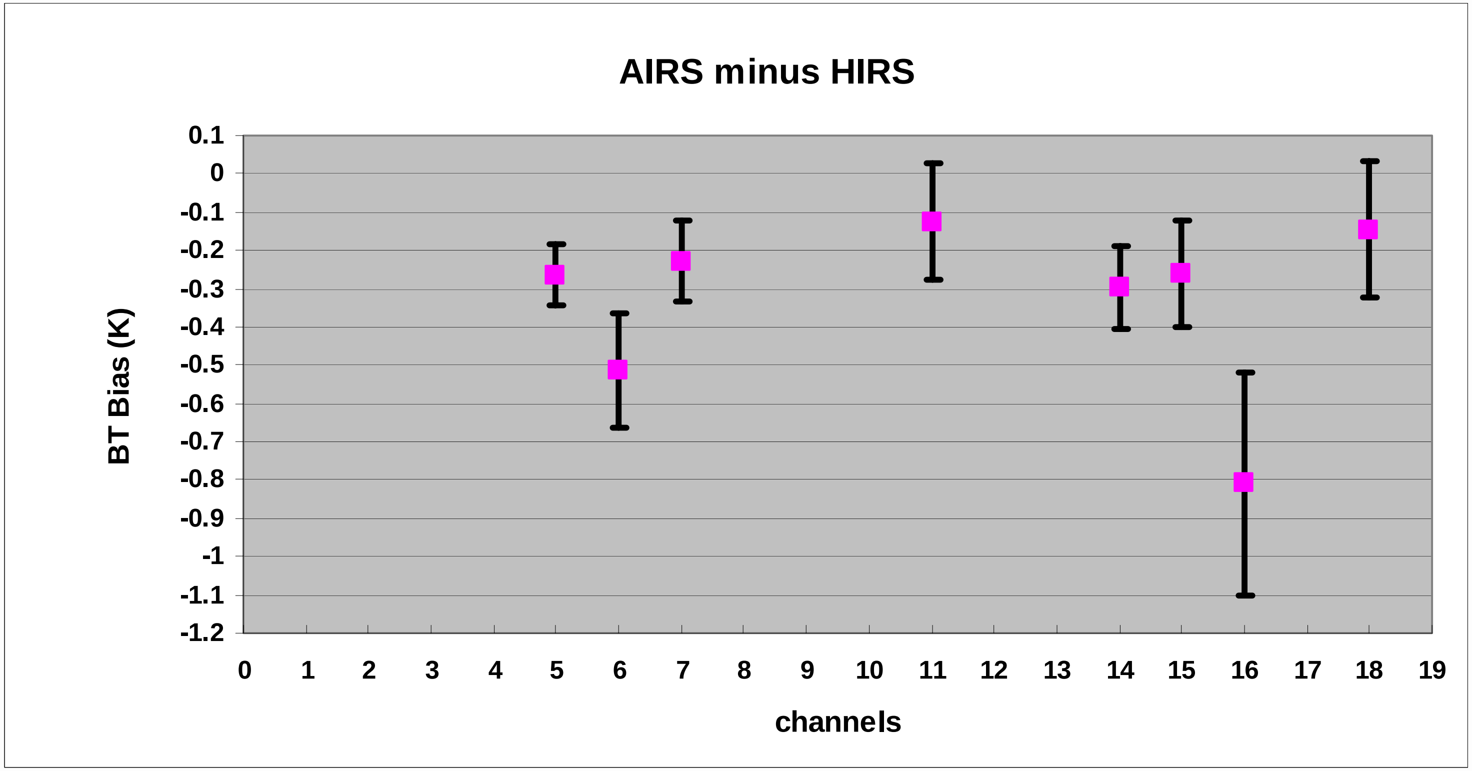


HIRS Image Channel 7



AIRS-convolved HIRS Image Channel 7

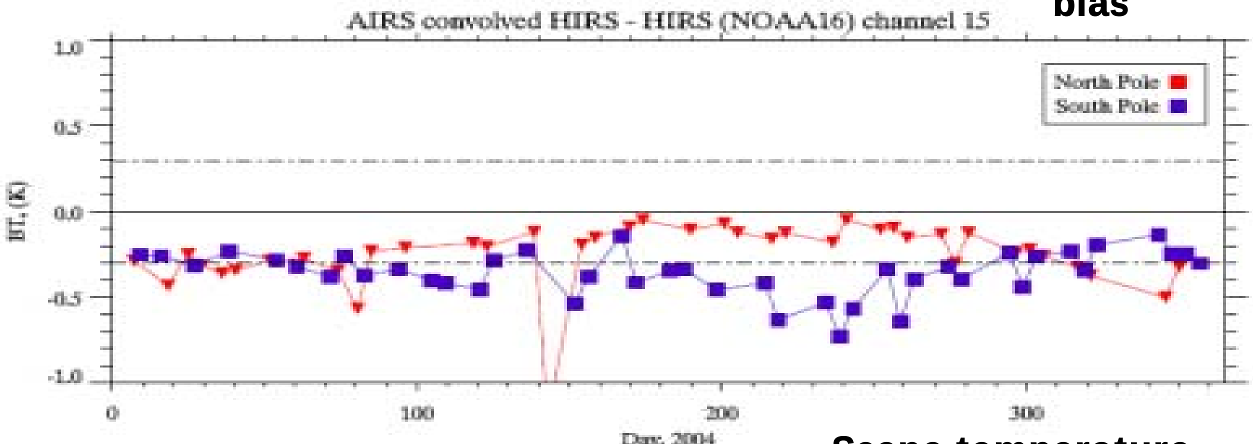
Mean bias between AIRS and HIRS



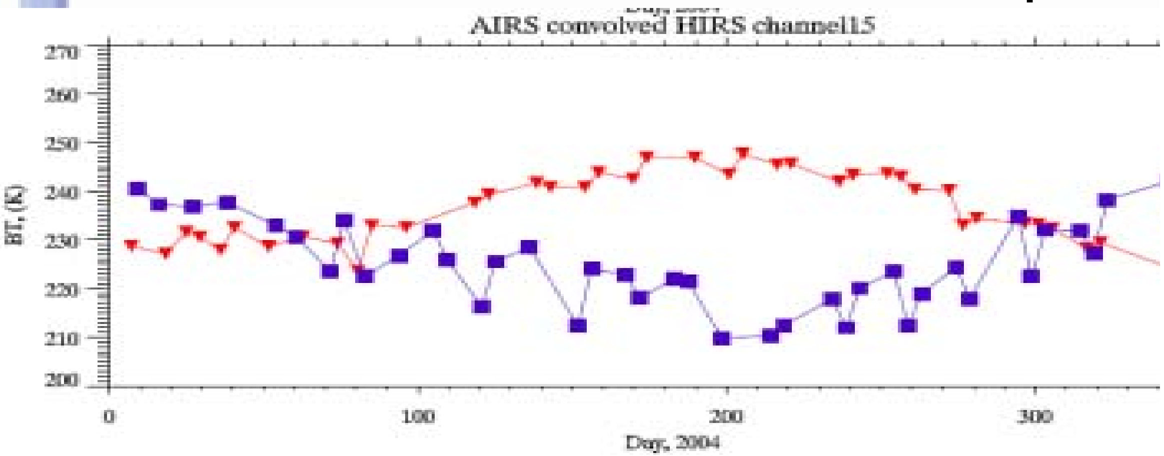
- HIRS bias relative to AIRS is on the order of ~0.5 K except channel 16 (0.8 K).
- HIRS is warmer than AIRS.

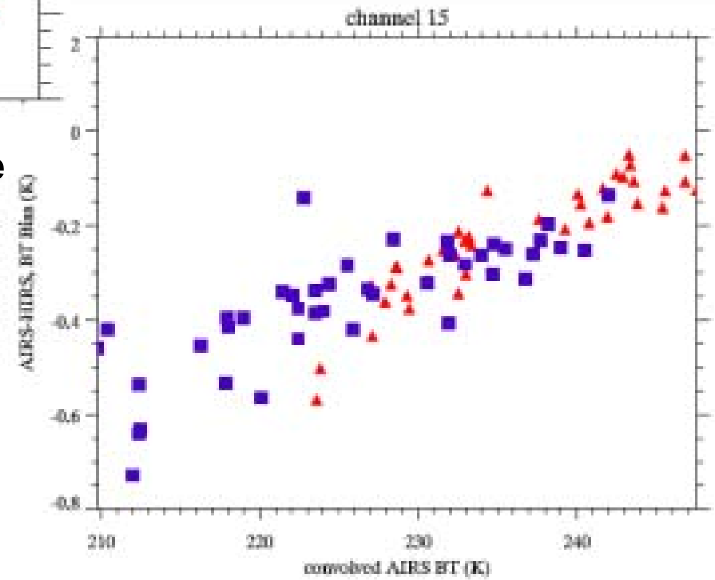
AIRS and HIRS SNO Biases

bias



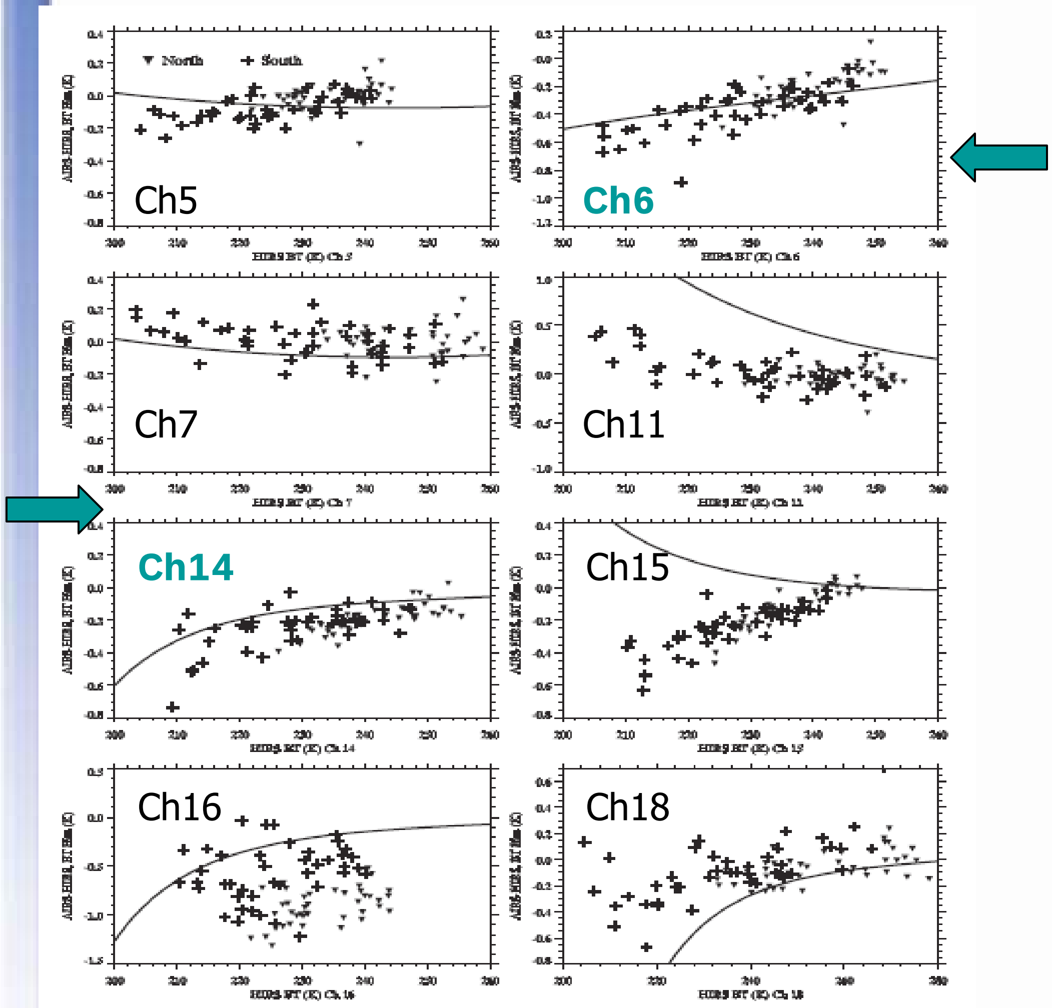
Scene temperature





Cause: SRF shift or nonlinearity?

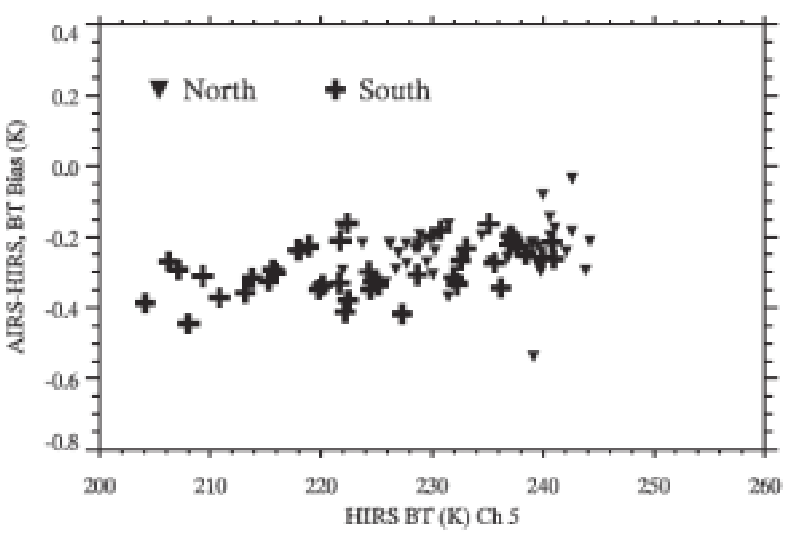
Nonlinearity effects



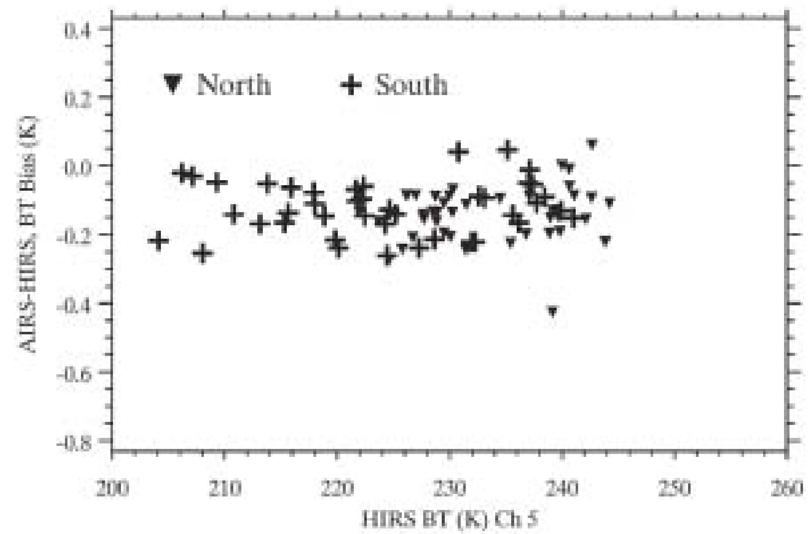
- **Nonlinearity curves work well for channels 6 and 14.**
- **However, for the other five channels, the nonlinear correction does not help too much or even introduces more problems.**
- **Therefore, prelaunch nonlinearity alone can not explain the temperature dependent bias for all channels.**

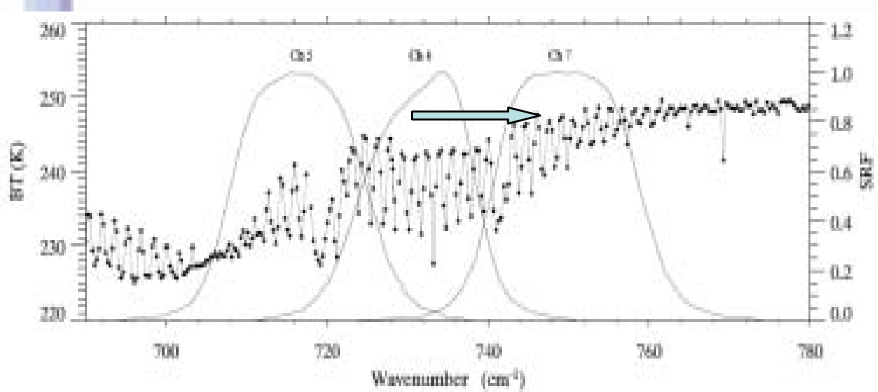
Spectral shift can remove temperature dependent bias

Without SRF shift



With SRF shift 0.2 cm-1



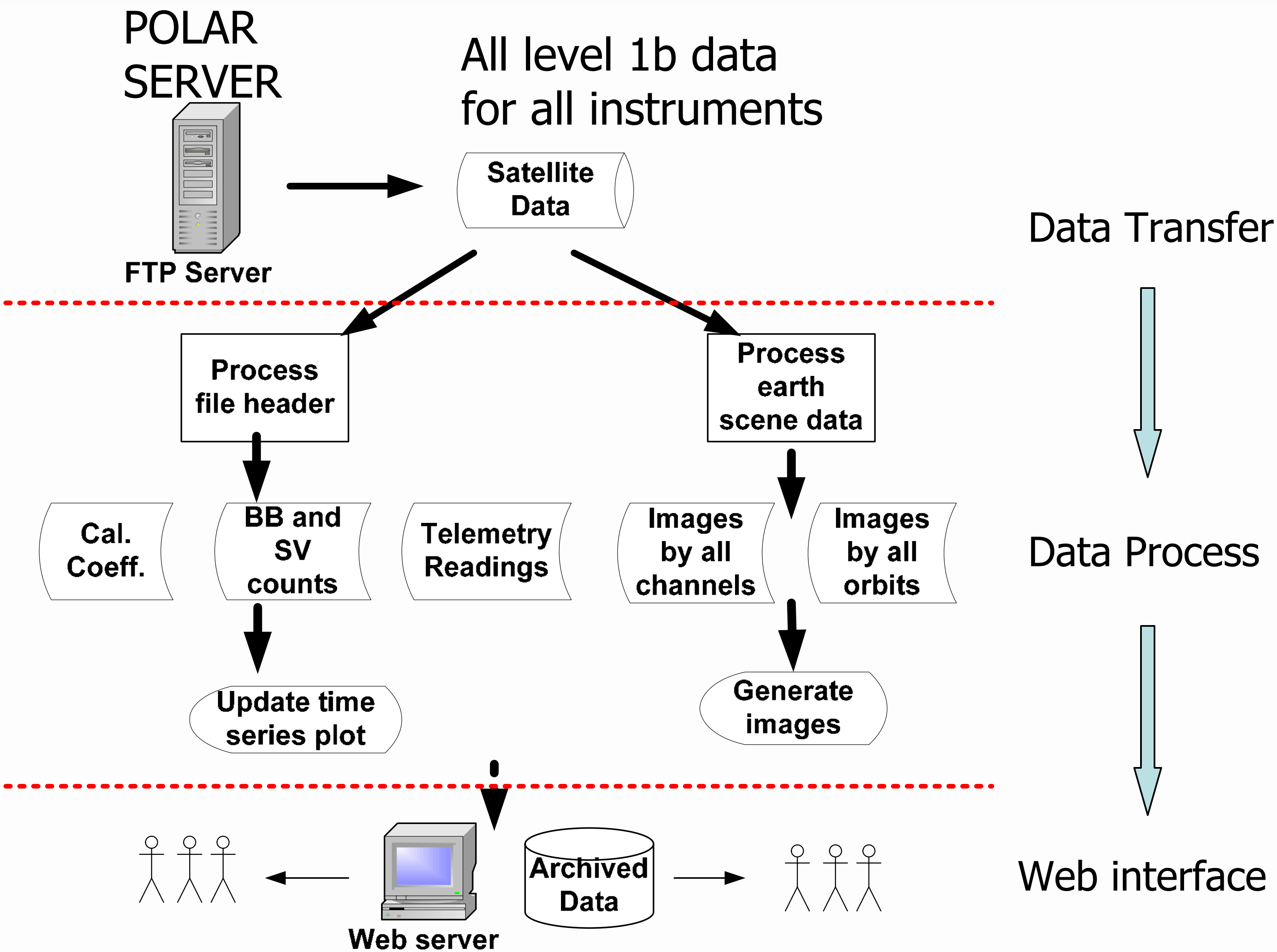


Since the HIRS sounding channels are located at the slope region of the atmospheric spectra, a small shift of the SRF can cause biases in observed radiances.

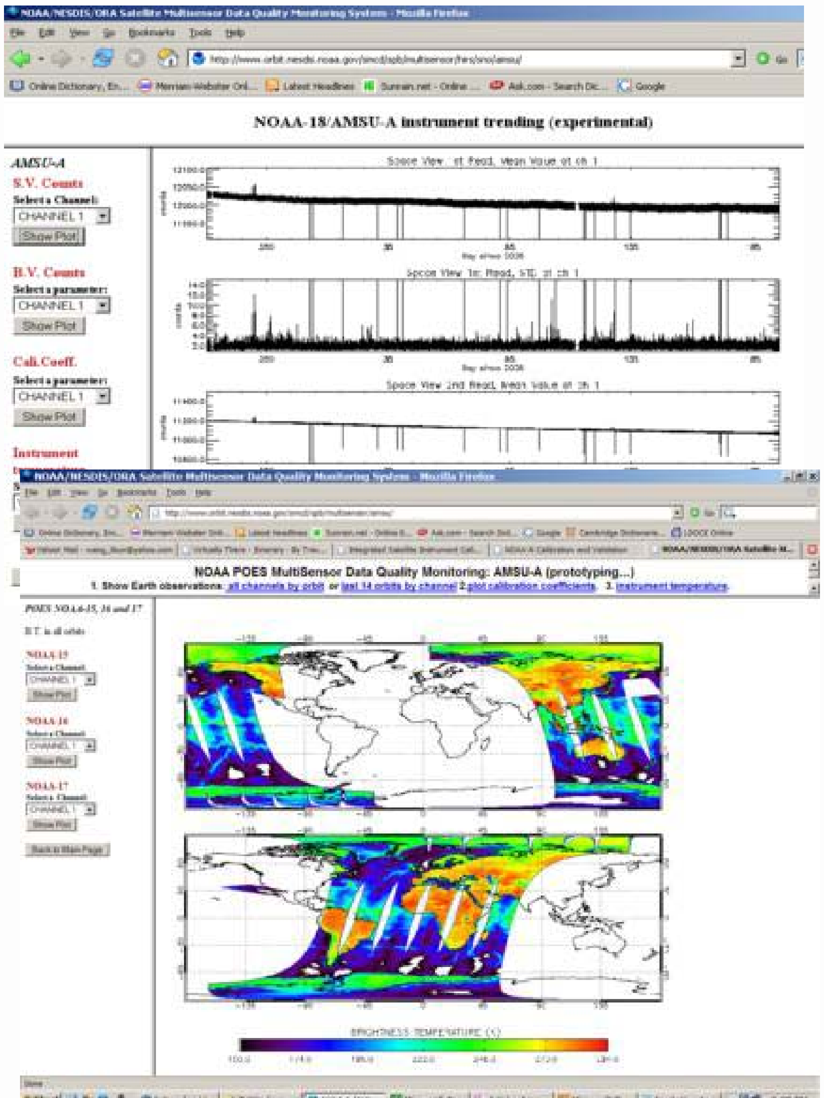
Details can be referred to Wang et al. (manuscript for JTECH, 2006)

Noise and Telemetry Trending

Instrument Trending System Design

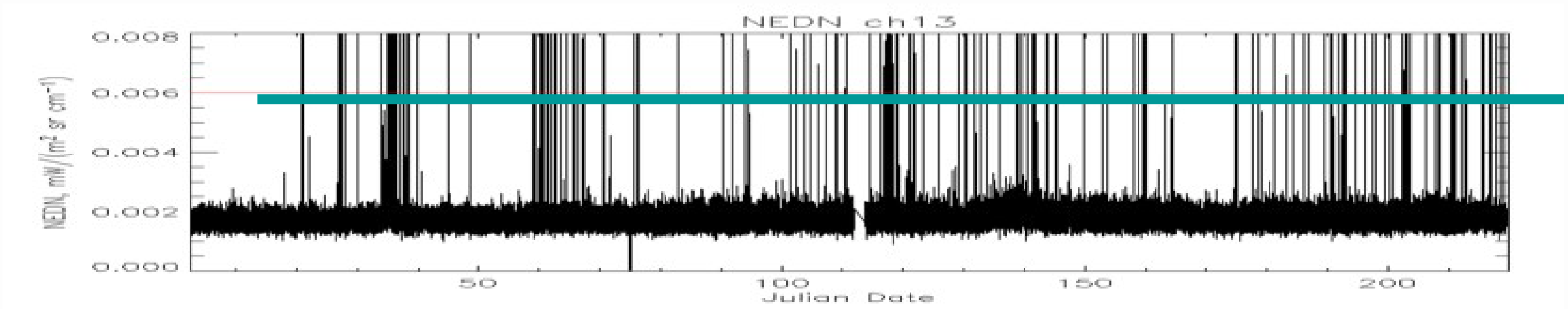


Web interface

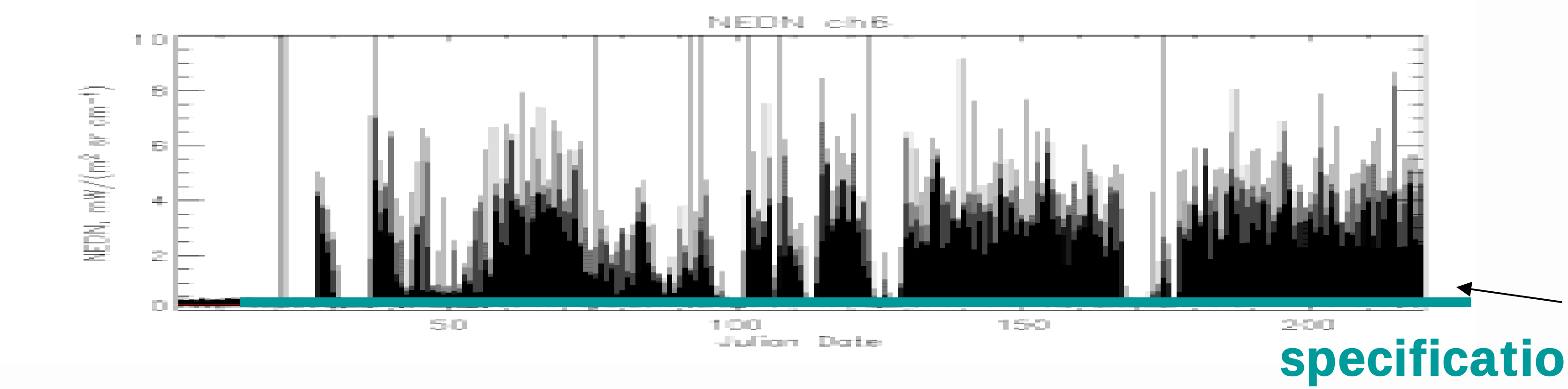


- Currently implemented for:
  - NOAA18 HIRS
  - NOAA18 AMSU
  - Ready for instruments on MetopA.
- Instrument parameters include:
  - Blackbody and space view count
  - Calibration Coefficients
  - NEDN
  - Component temperatures
- Data quality check
  - by all channels
  - By all orbits
- Updated daily

HIRS nedn trend in 2006
- monitor instrument noise

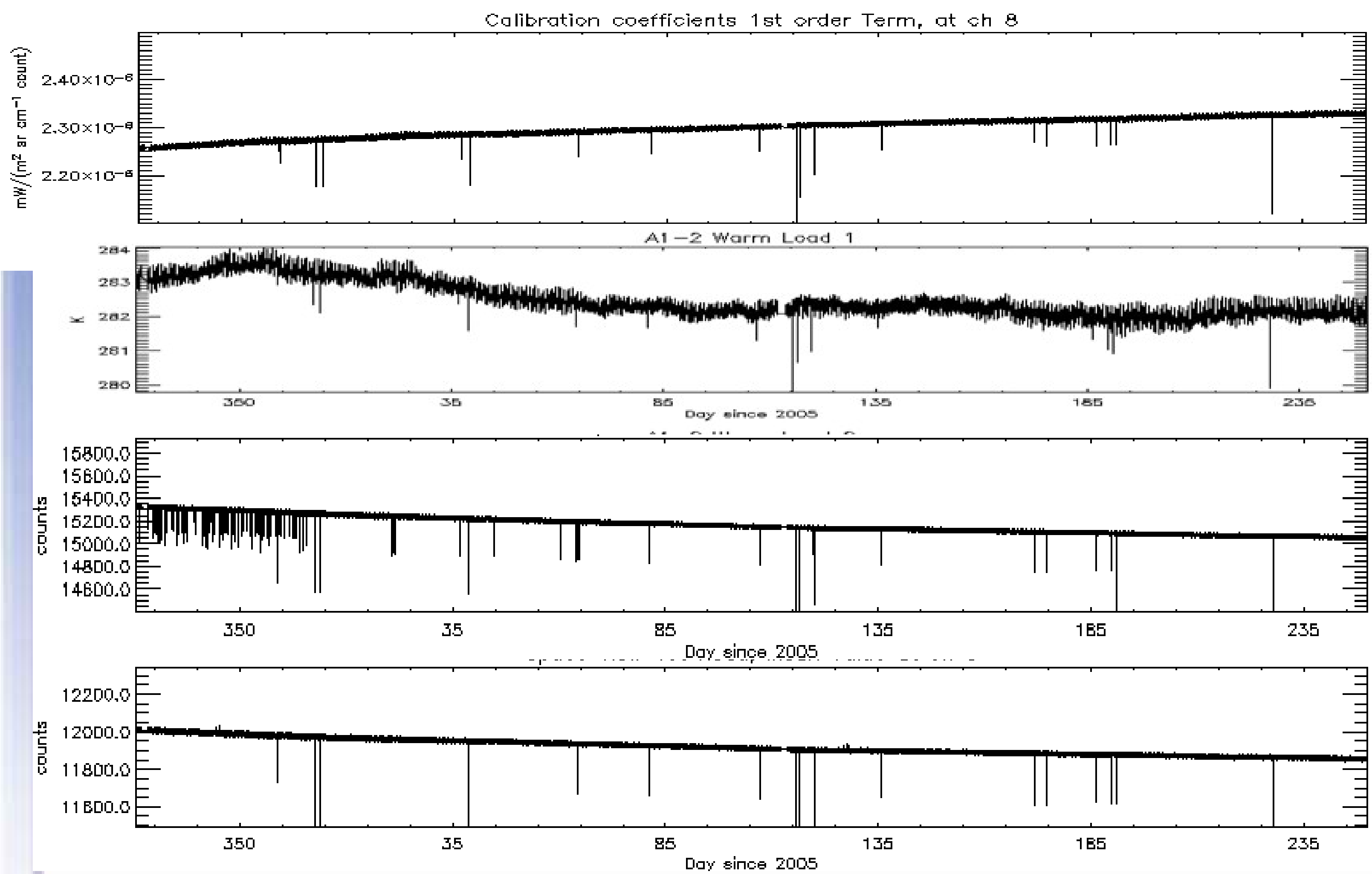


Shortwave channels: meet specification, with occasional noise spikes



Longwave channels: high noise with short periods of low noise

NOAA18 AMSU ch8



Cal. Coeff. 1st order

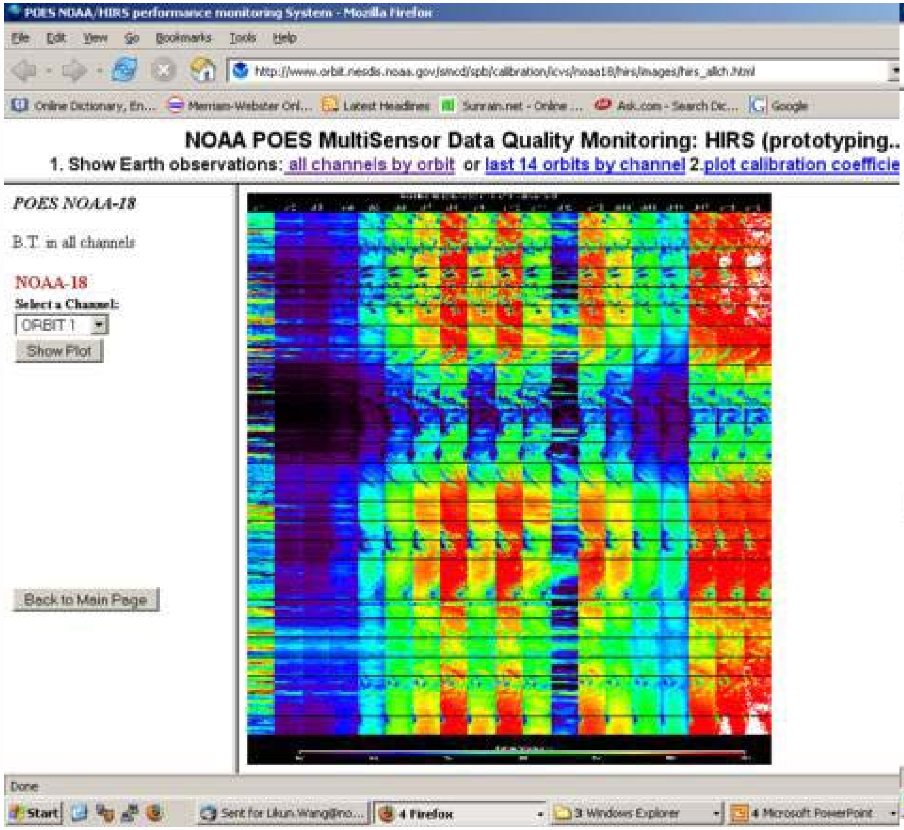
Warm load A1-2 temperature

Blackbody view count

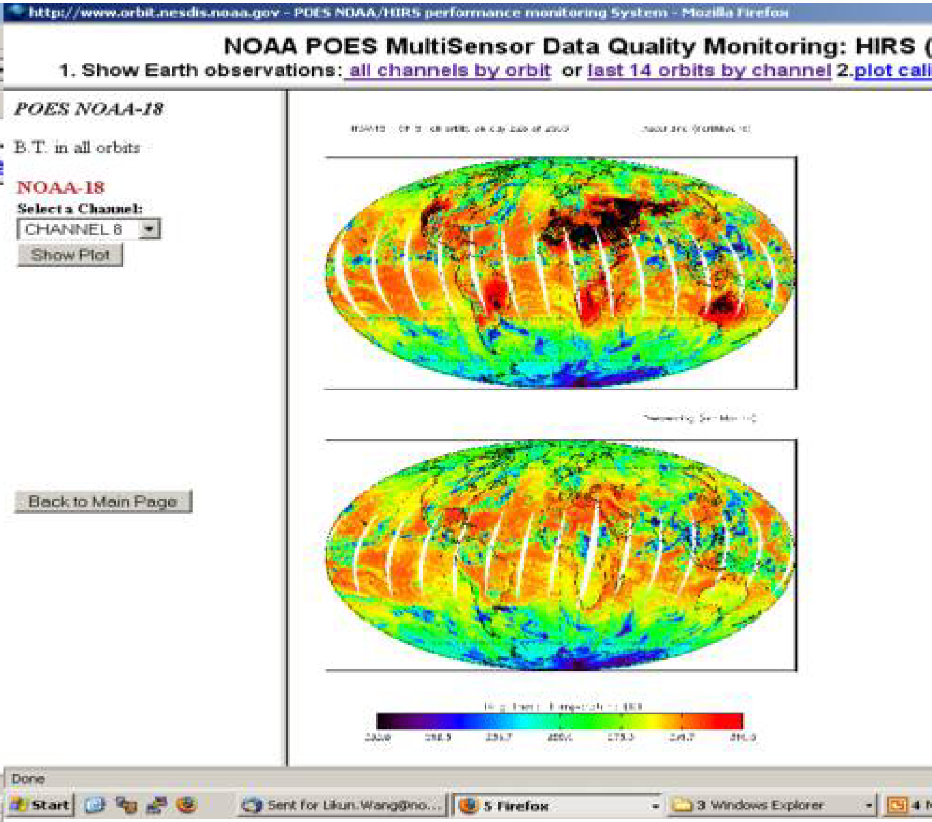
Space view count

Monitoring data quality near real time

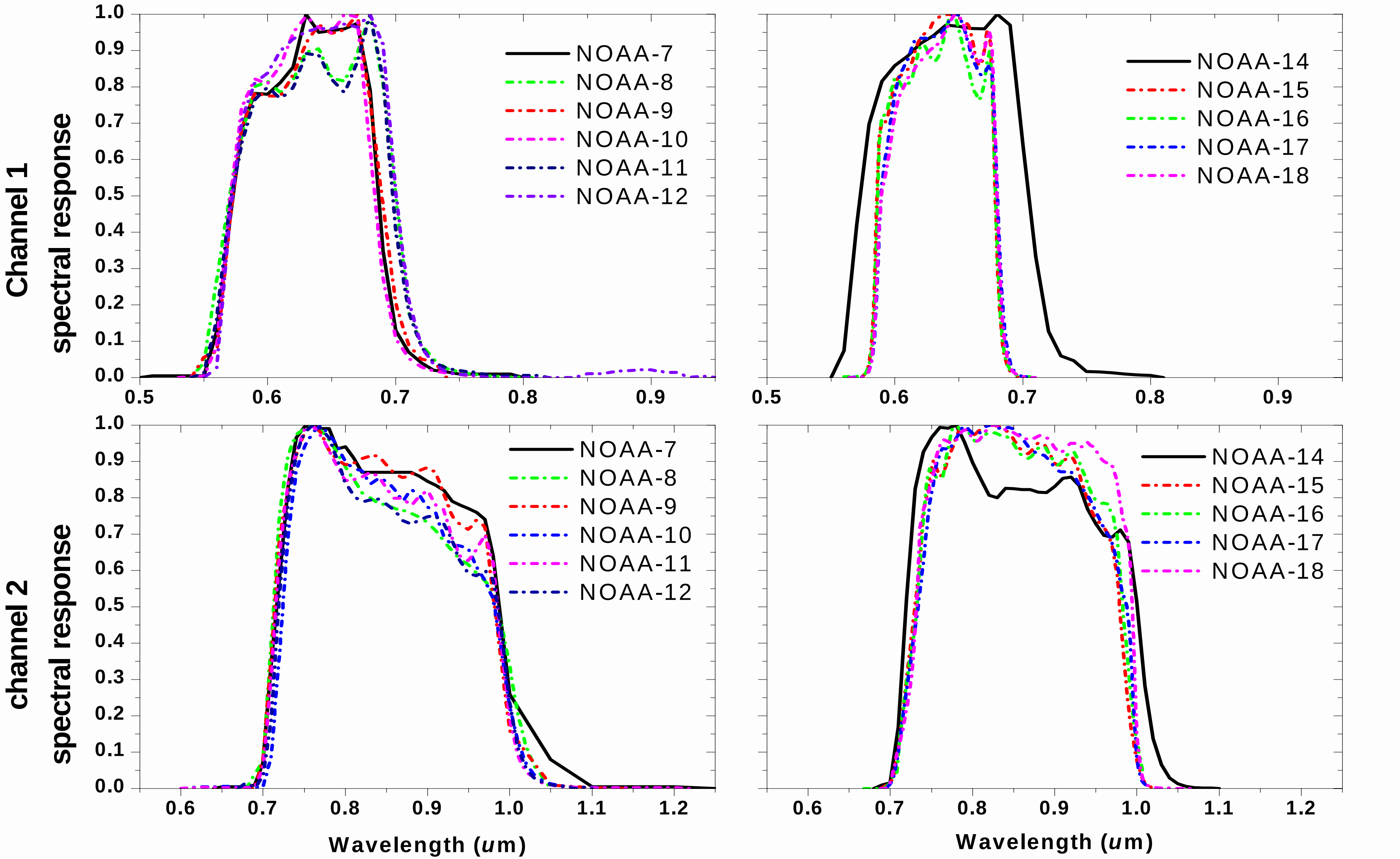
By all channels



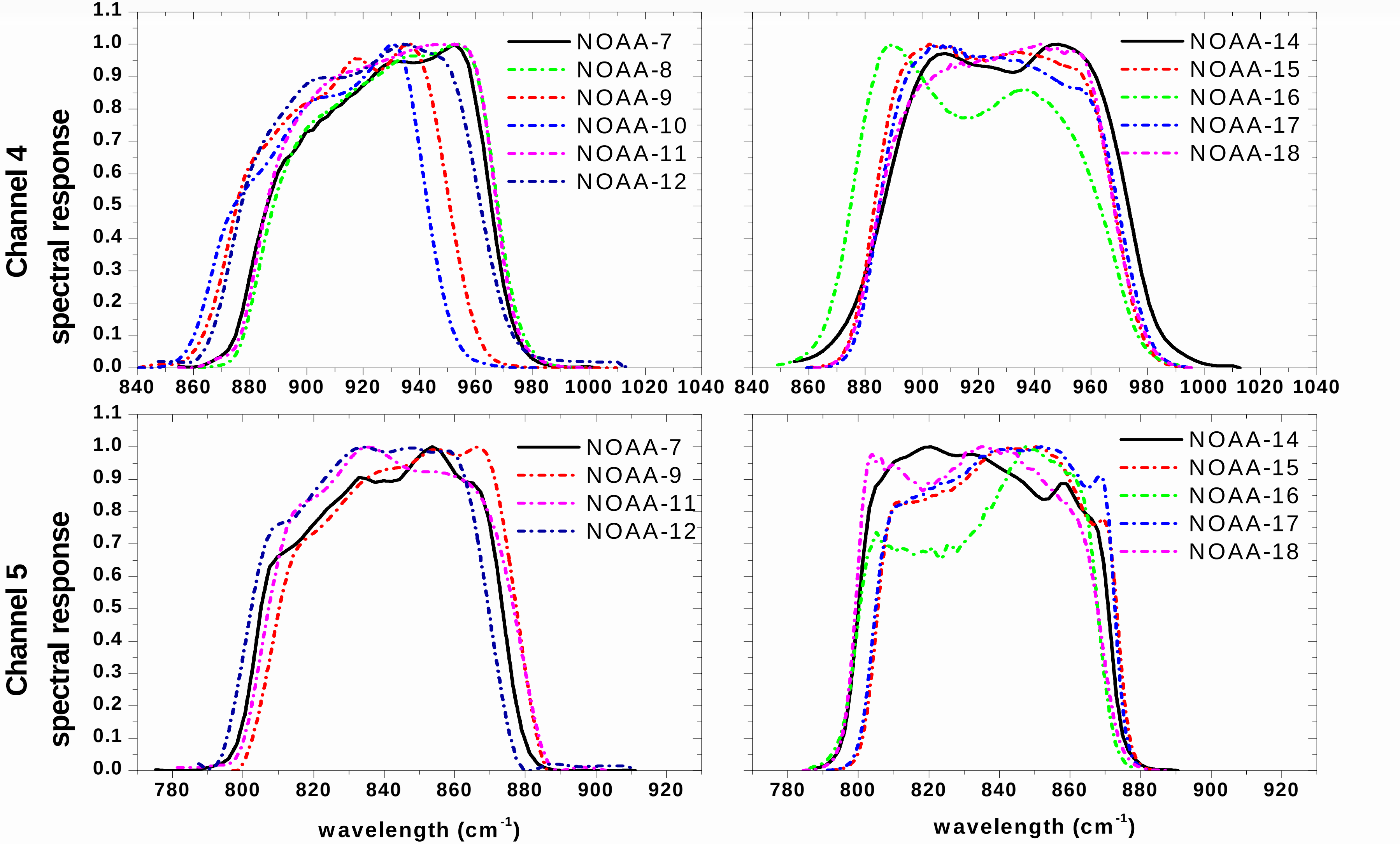
By all orbits



Spectral Response Function of Visible Channels

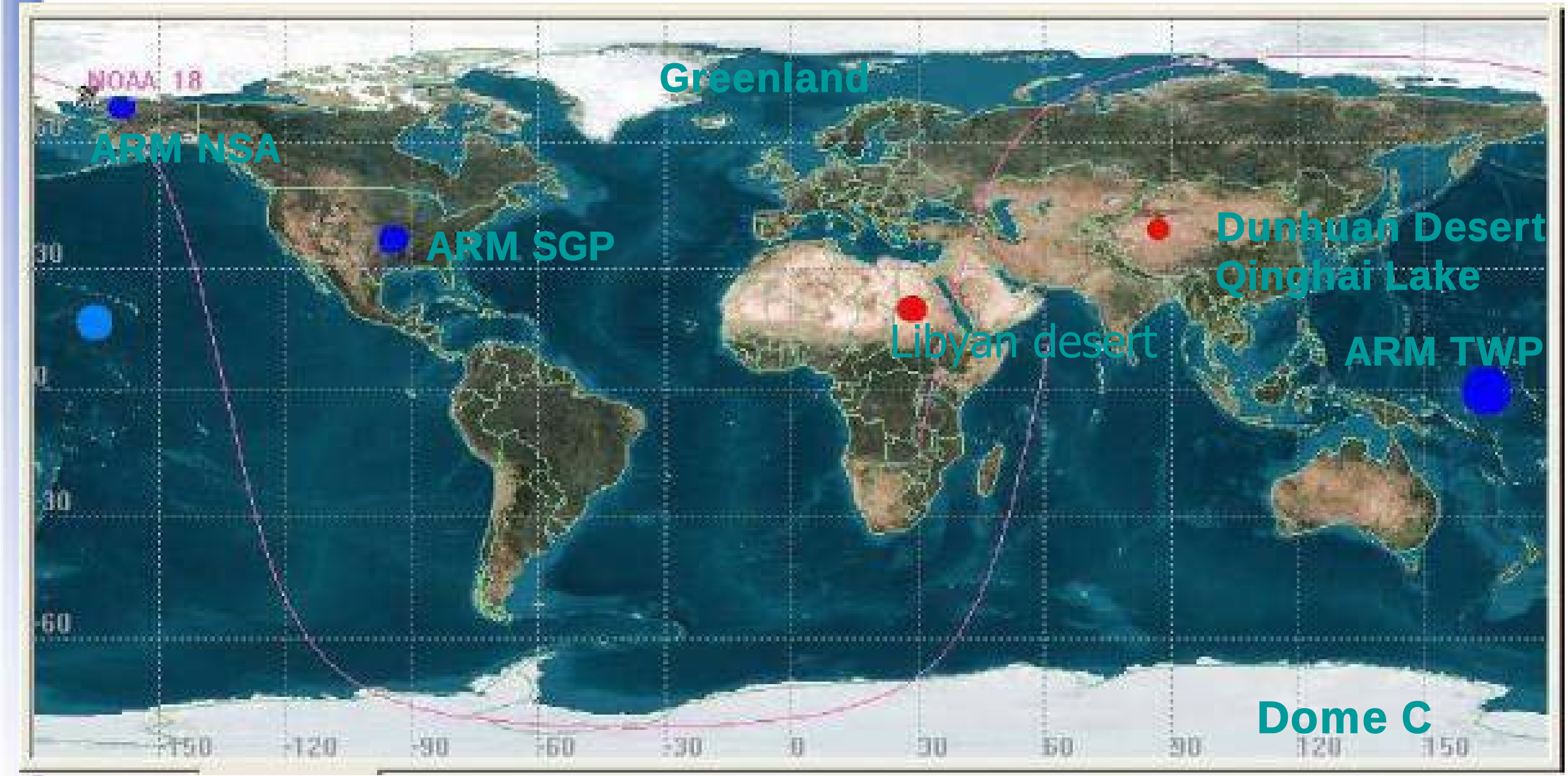


Spectral Response Function of IR Channels

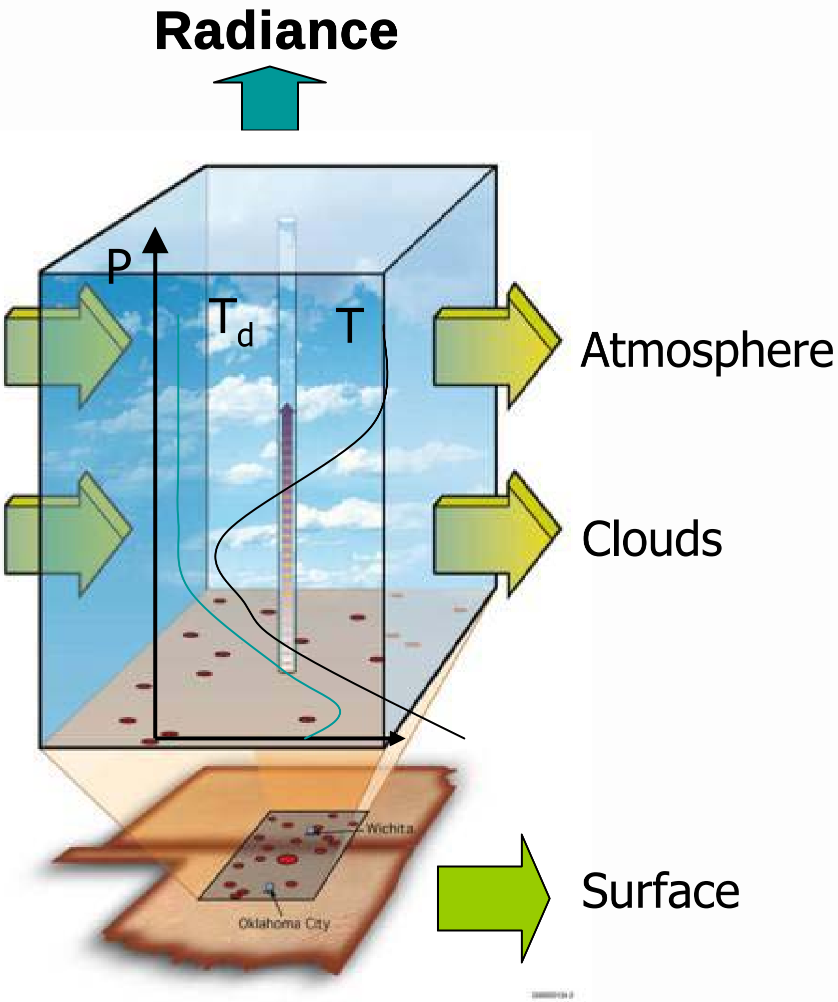


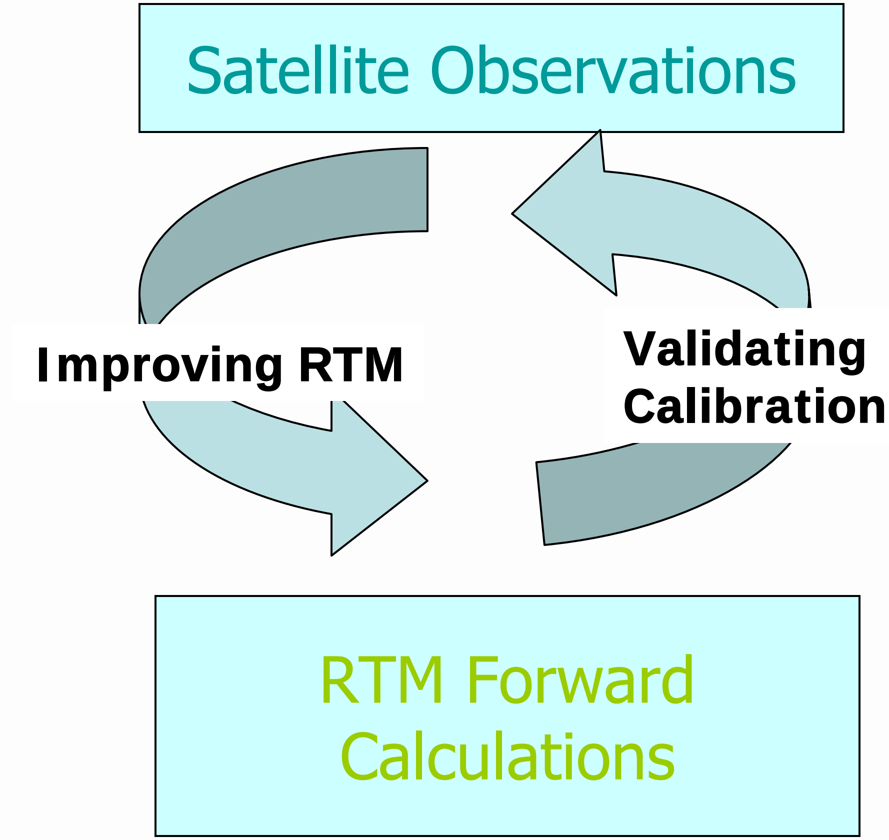
Radiance Validation at Reference Sites

Potential Ground Sites

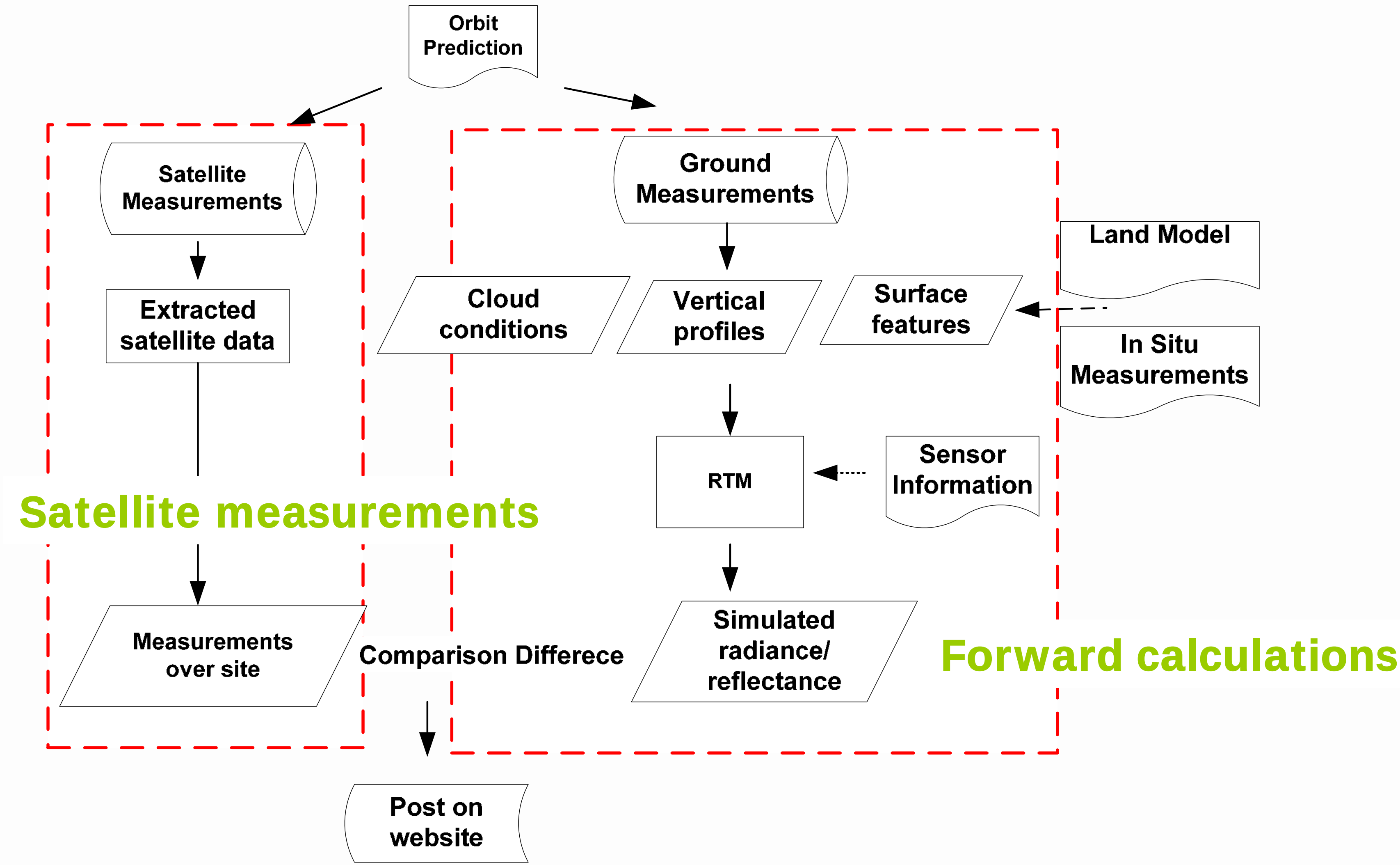


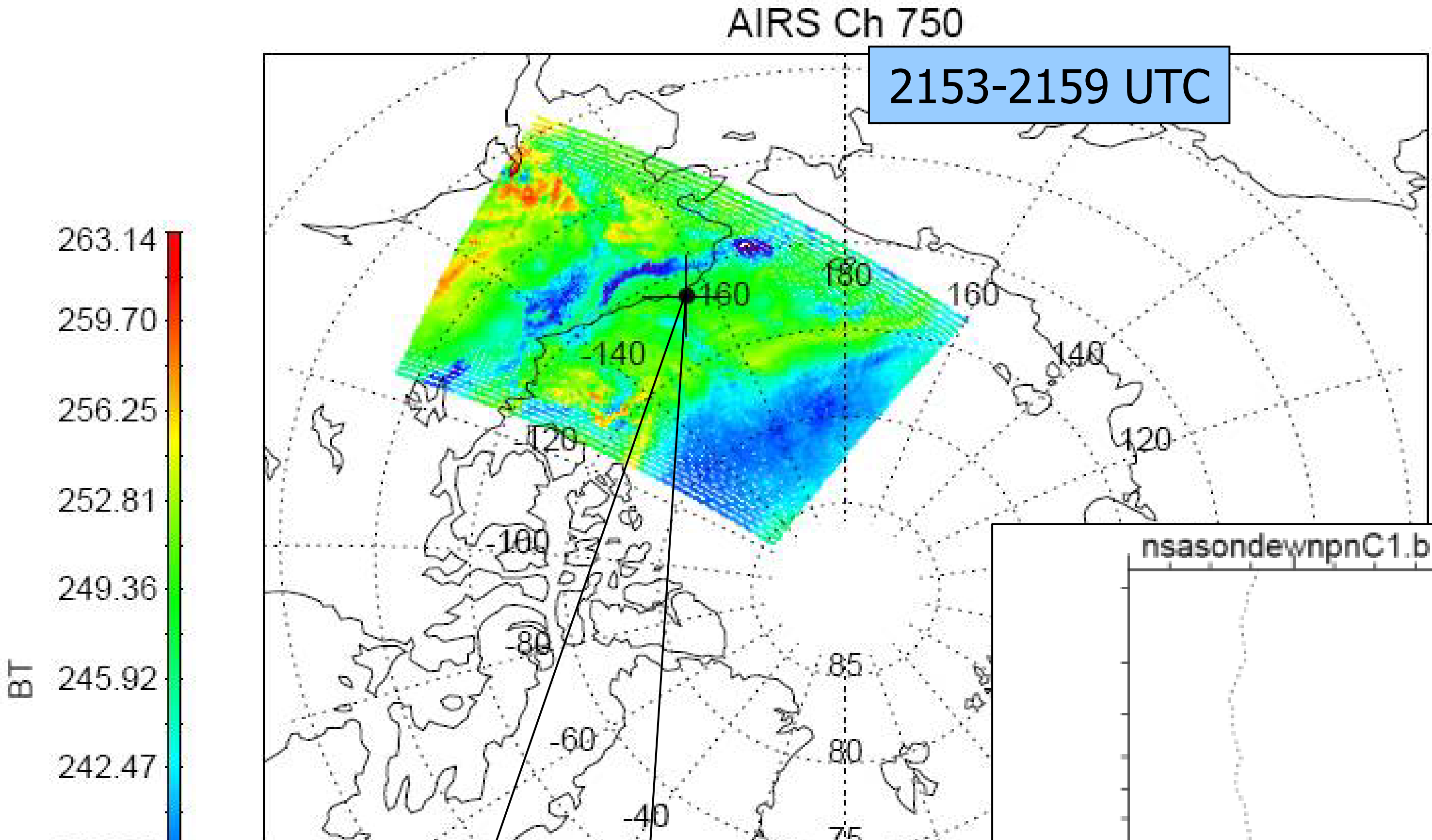
Validation at Reference Sites (3D Cubicle)



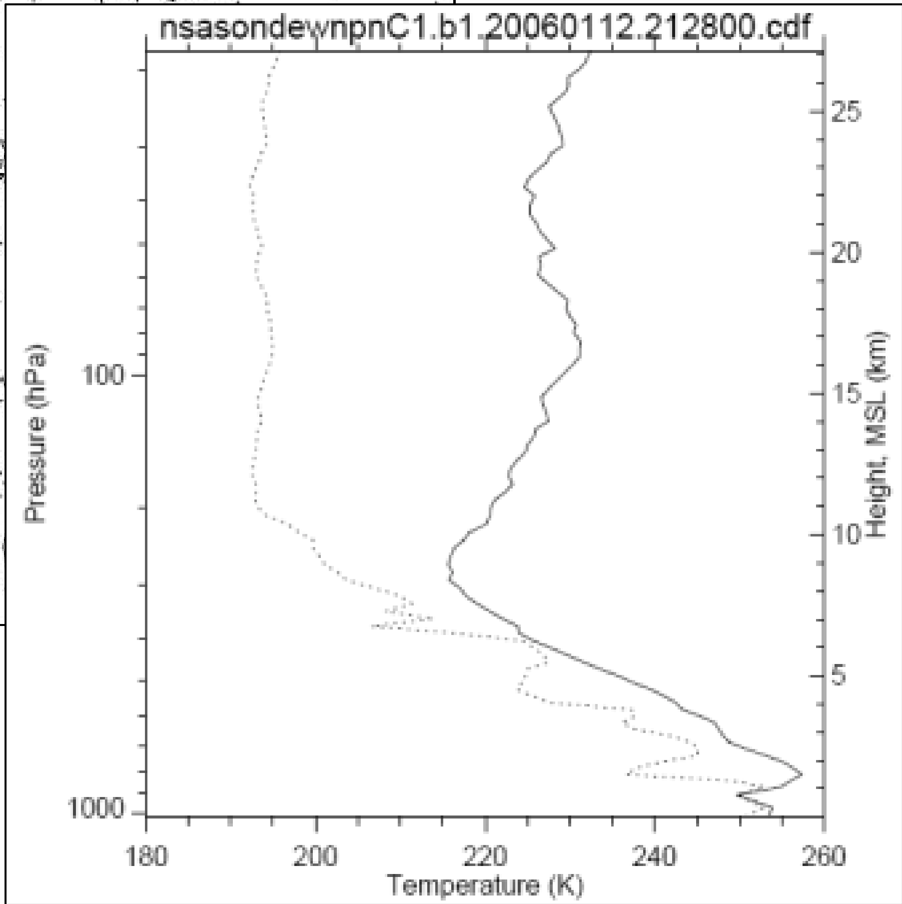


Validation Process Flow chart

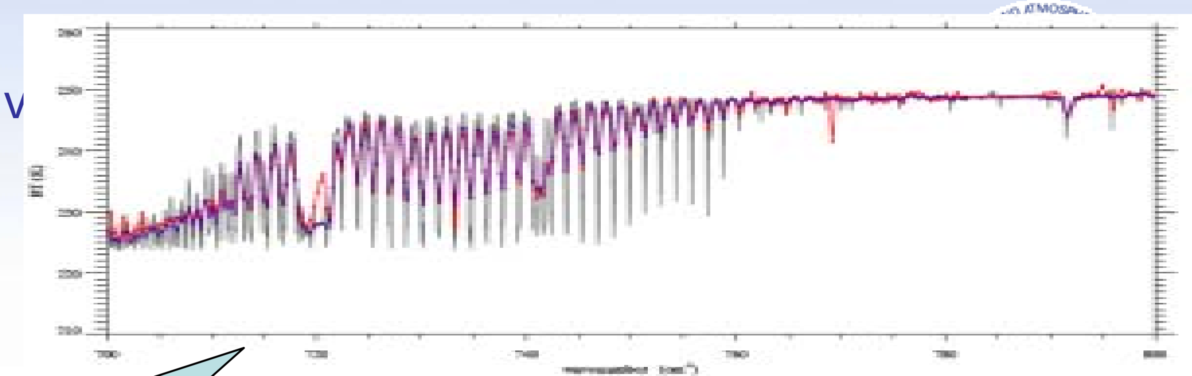



AIRS Ch 750
2153-2159 UTC
BT
263.14
259.70
256.25
252.81
249.36
245.92
242.47
180
160
160
-140
140
-120
120
-100
-80
-60
-40
20
85
80
75

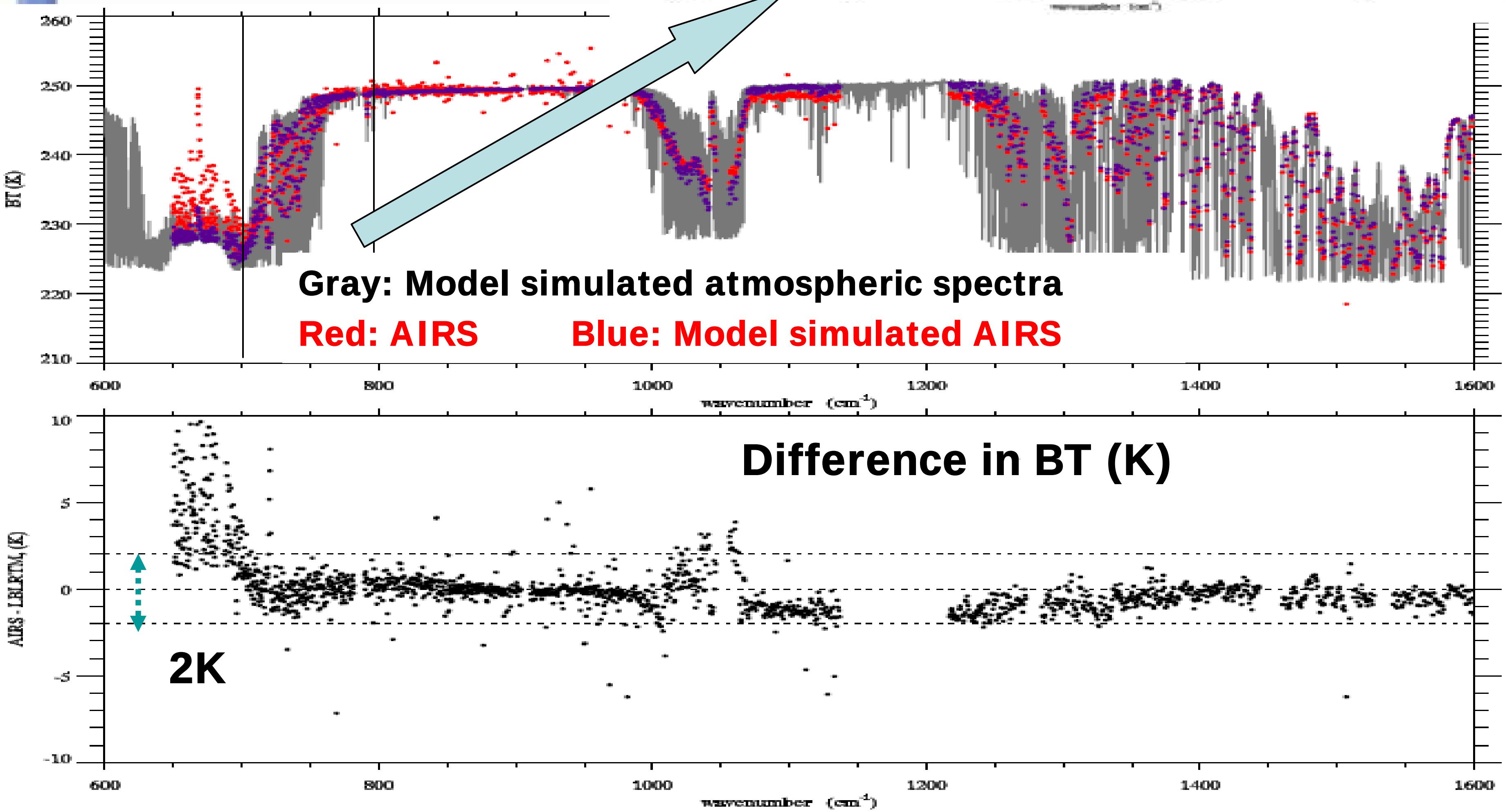

ARM North Slope of Alaska


2128 UTC
nsasondewnpnC1.b1.20060112.212800.cdf
Pressure (hPa)
100
1000
Height, MSL (km)
25
20
15
10
5
180
200
220
240
260
Temperature (K)

Longwav

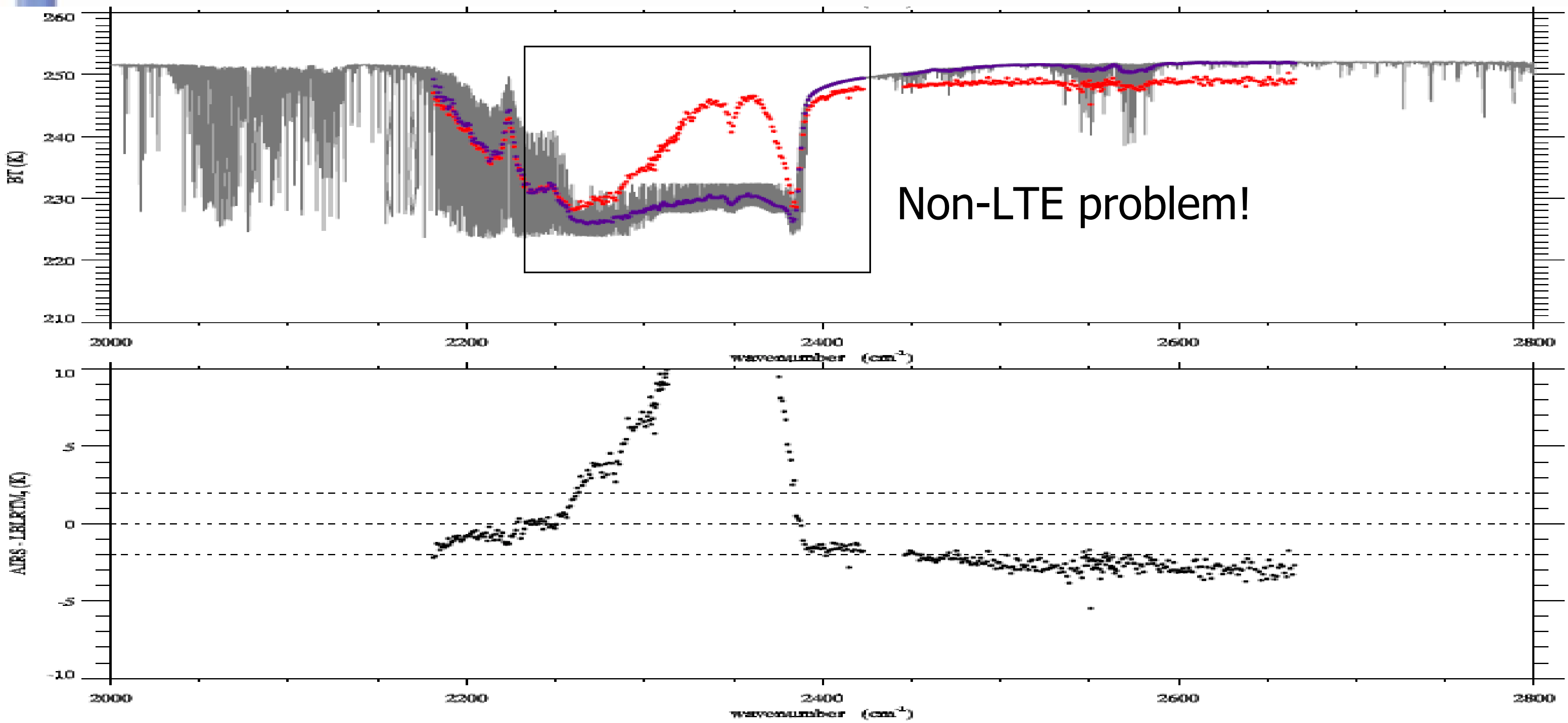


BT (K)
wavenumber (cm-1)



Gray: Model simulated atmospheric spectra
Red: AIRS
Blue: Model simulated AIRS
BT (K)
260
250
240
230
220
210
600
800
1000
1200
1400
1600
wavenumber (cm-1)
Difference in BT (K)
2K
AIRS - LBLRTM (K)
10
5
0
-5
-10

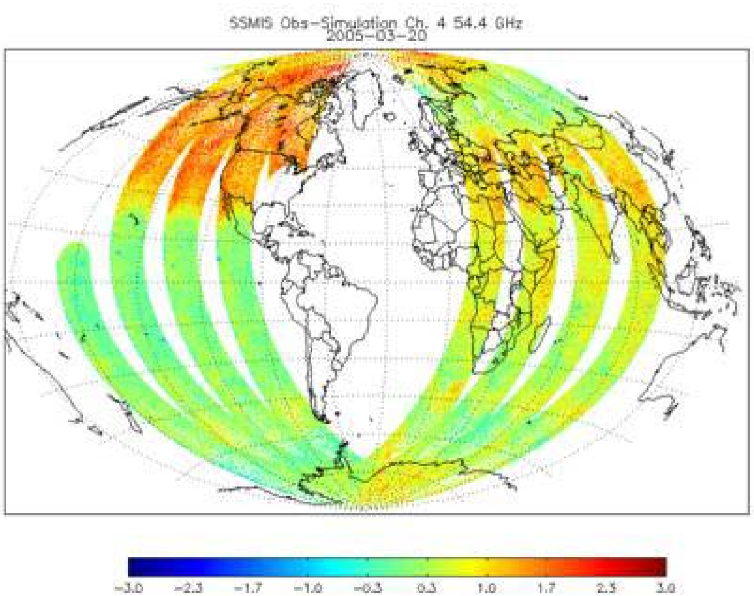
Shortwave region (2000-2800 cm^{-1})



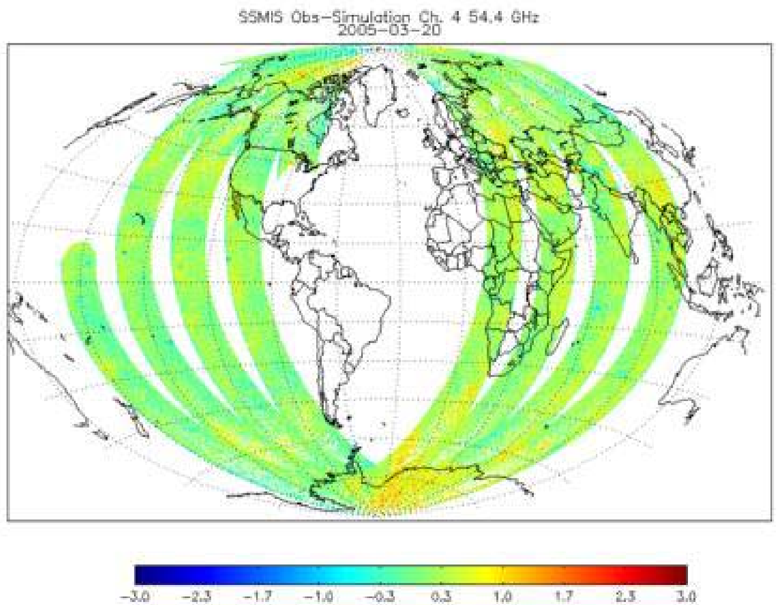
Global Bias Analysis System

DMSP Special Sensor Microwave Imager and Sounder (SSMIS) Calibration

Before NOAA Calibration

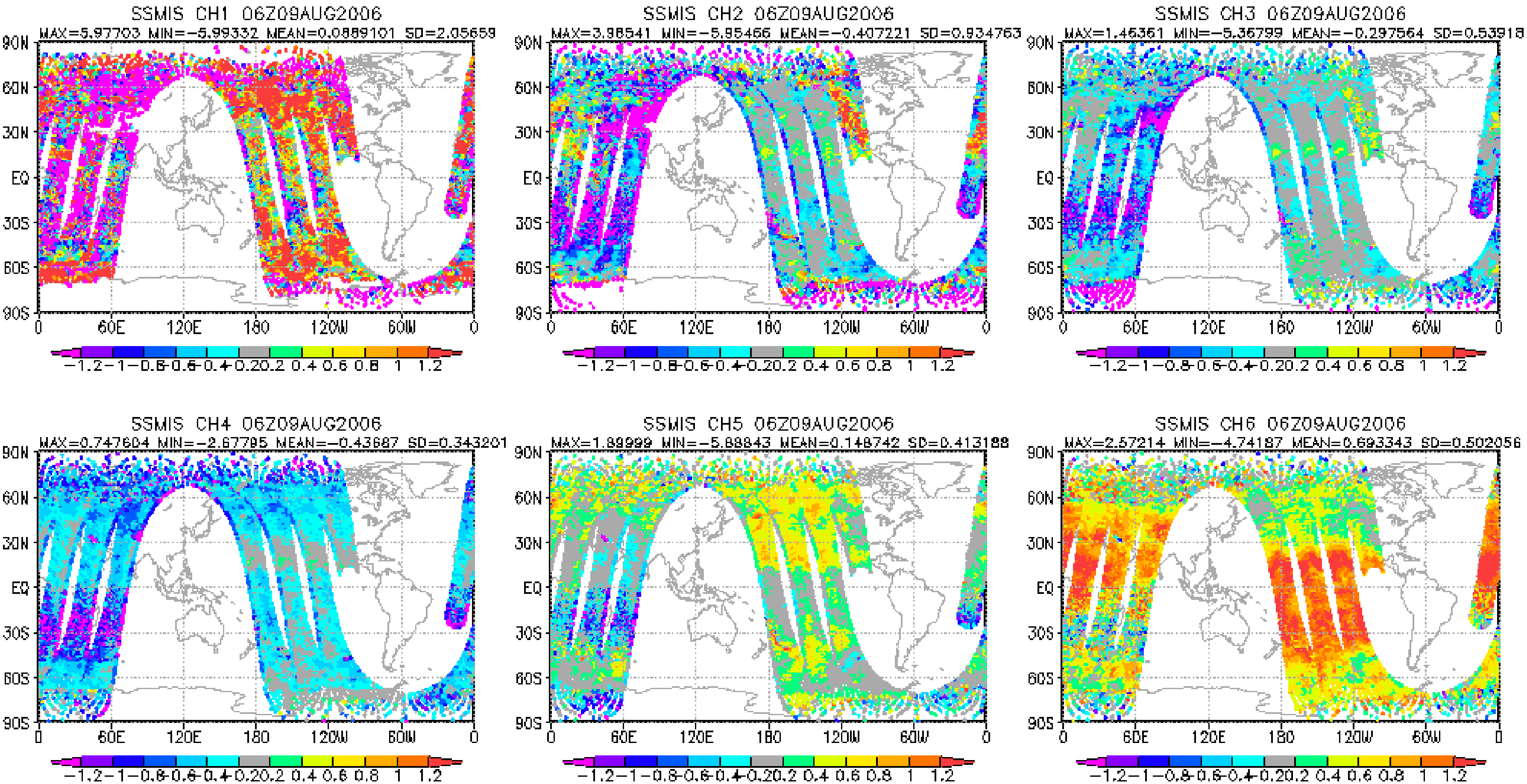


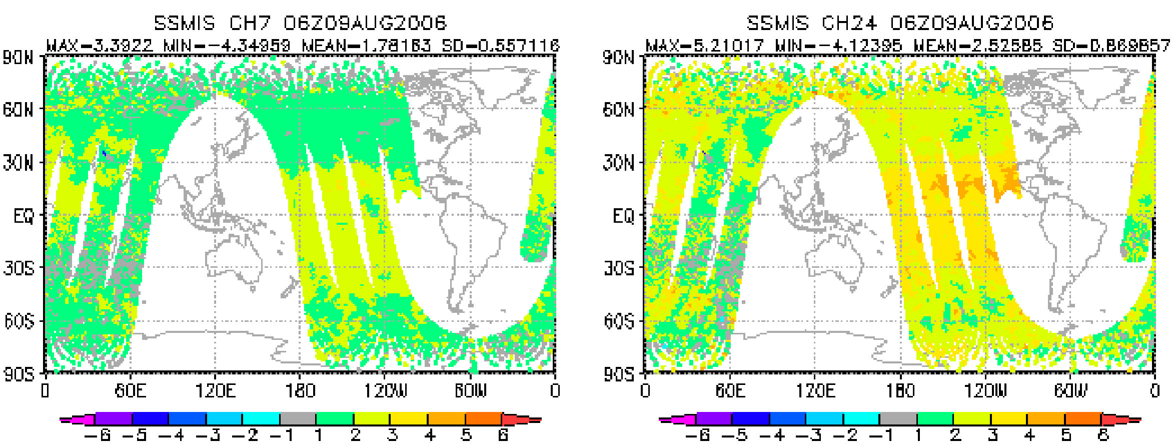
After NOAA Calibration



Shown is the difference between simulated and observed SSMIS 54.4 GHz. The SSMIS is the first conical microwave sounding instrument, precursor of NPOESS CMIS. The calibration of this instrument remains unresolved after 2 years of the lunch of DMSP F16. The outstanding anomalies have been identified from three processes: 1) antenna emission after satellite out of the earth eclipse which contaminates the measurements in ascending node and small part in descending node, 2) solar heating to the warm calibration target and 3) solar reflection from canister tip, both of which affect most of parts of descending node.

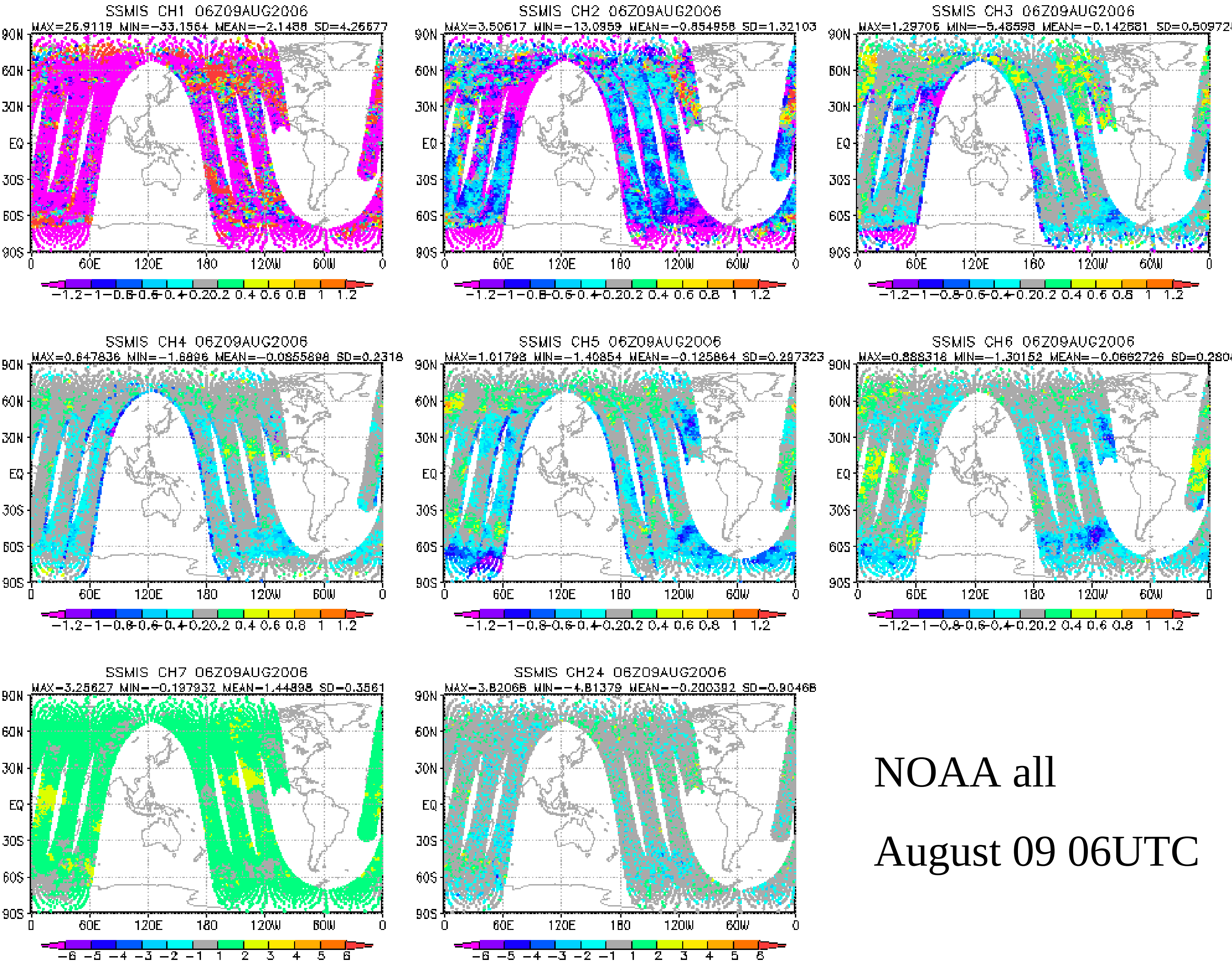
Correcting unintended instrument contamination is part of the cal/val process to provide accurate data for use in computerized weather forecast models





UK all

August 09 06UTC



NOAA all

August 09 06UTC

Agenda

- **GSICS Coordination Plan**
- **NOAA Integrated Cal/Val System (ICVS)**
- **Impacts of NOAA Cal/Val on Weather and Climate Studies**

Recent NOAA Cal/Val Accomplishments

- **Improved cal/val techniques as backbone supporting GEOSS**
  - Simultaneous nadir over-passing (SNO) for inter-sensor calibration
  - Uses of hyperspectral instrument as reference for intra-sensor calibration
  - Satellite instrument bias correction algorithms
  - Postlaunch nonlinearity correction from SNO analysis
  - Vicarious calibration for POES/GOES visible and near IR channels

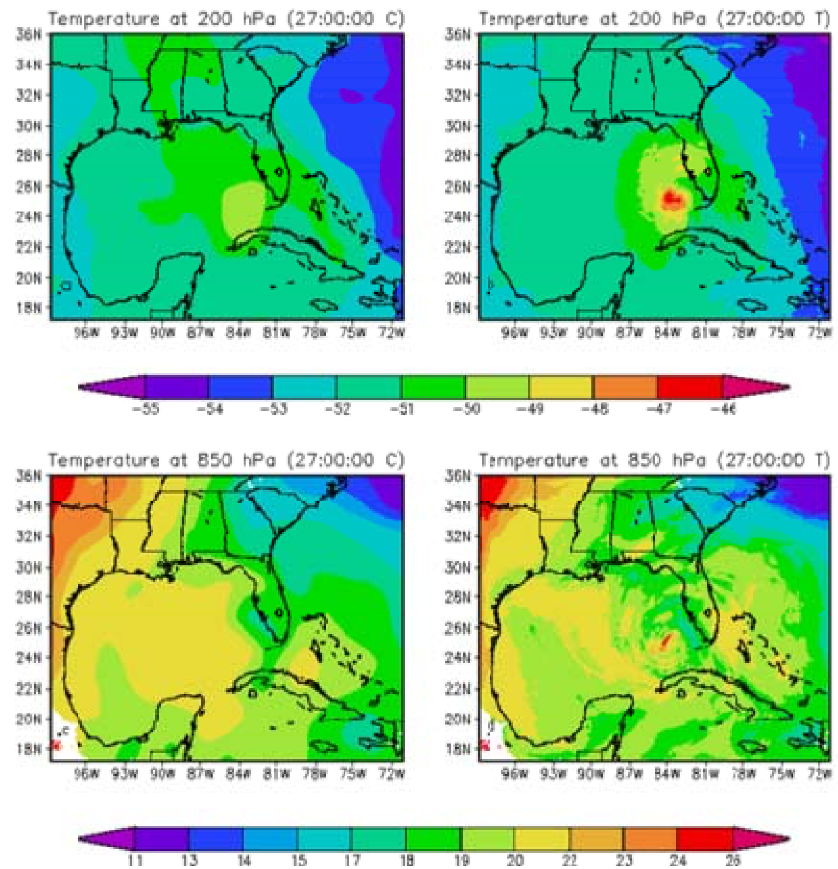
- **Improved satellite imagery and products for severe weather nowcasting**
  - GOES-E/W imagery animation for hurricane track and intensity
  - Flash flood from AMSU and GOES
  - Hurricane potential rainfall from AMSU TPW

- **Improved uses of current satellite data in NWP models**
  - More AIRS data used in NWP models
  - Increased use of AIRS, HIRS, SSMIS, AMSU-A data in stratosphere
  - Uses of MODIS wind products
  - AVHRR NDVI in NCEP NOAH

- **Improved uses of satellite data in climate trend analysis**
  - Reconciled MSU tropospheric temperature trends
  - Better ozone trend

STAR SSMIS Calibration Improved Hurricane Intensity Analysis and Forecasts

DMSP F-16 SSMIS radiances had major antenna and calibration target anomalies. After anomalies were corrected by STAR scientists, the impacted data were assimilated for the first time using NCEP 3Dvar data analysis. The data utilization rate increased from 40% to 80%. The SSMIS data alone improves the analysis of surface minimum pressure and temperature fields for Hurricane Katrina. 48-hour forecast of hurricane minimum pressure and maximum wind speed were significantly improved in the WRF model

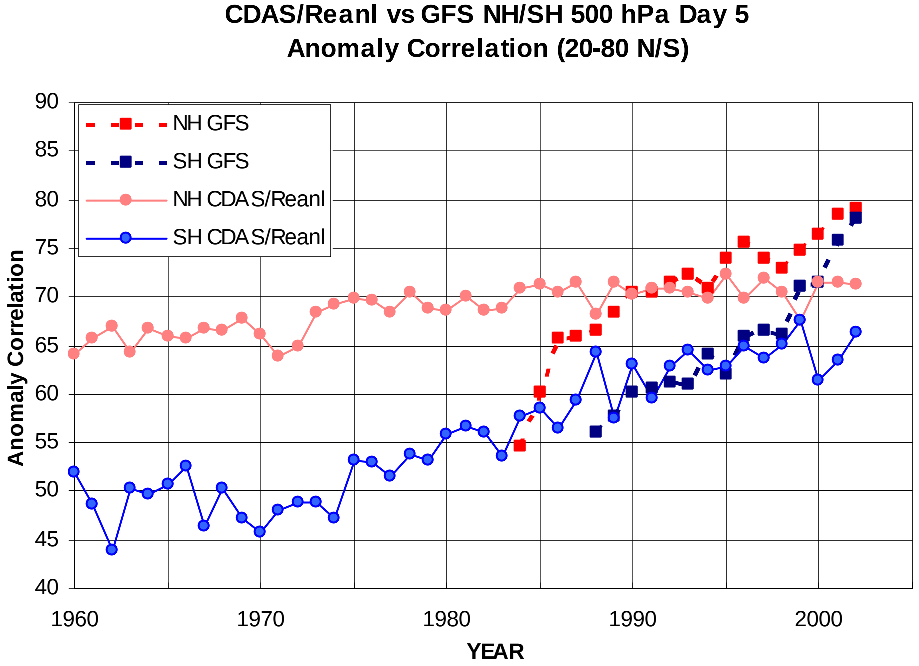


Current NCEP data forecast system underestimates hurricane intensity with much weaker warm core structures. Assimilation of the vital information provided by microwave sounding channel measurements can improve the severe storm forecasts.

The initial temperature field from control run (left panels) w/o use of SSMIS rain-affected radiances and test run (right panels) using SSMIS rain-affected radiances

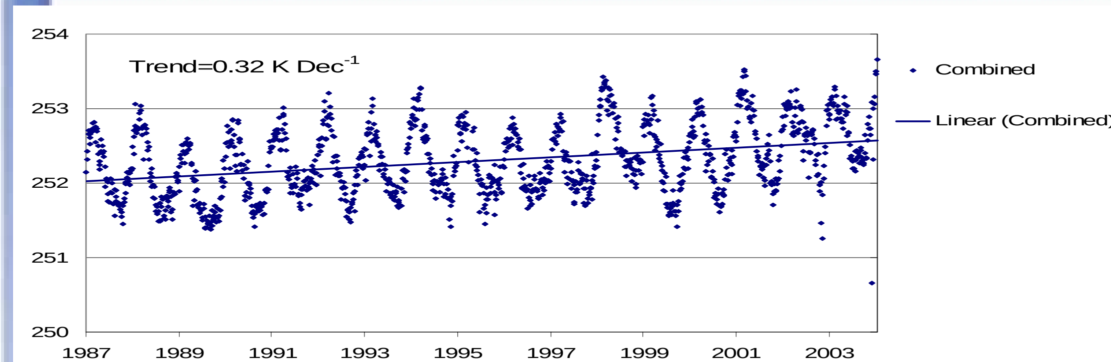
Impact: STAR Operational Sensor Cal/Val Improves NOAA Medium Range Weather Forecasts

- **Southern Hemisphere forecasts now as accurate as NH forecasts**
- **Today's 5-day forecasts as accurate as 3 day forecasts 25 years ago**
- BUT **.....forecast centers remove satellite biases approximately and empirically, assuming model analysis and radiative transfer model are correct**



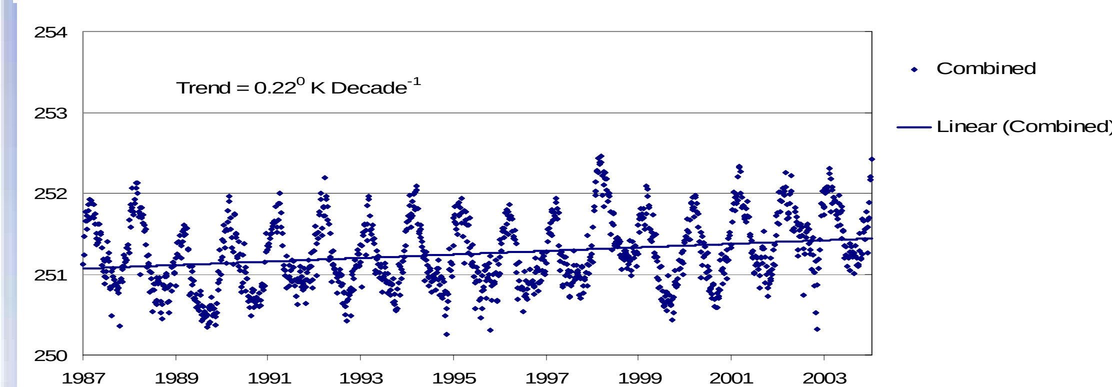
Satellite observations and assimilation systems have contributed to increased accuracy of forecasts – further gains expected from better calibration and intercalibration of observations

MSU Derived Climate Trend Is dependent on Calibration



Trends for linear calibration algorithm

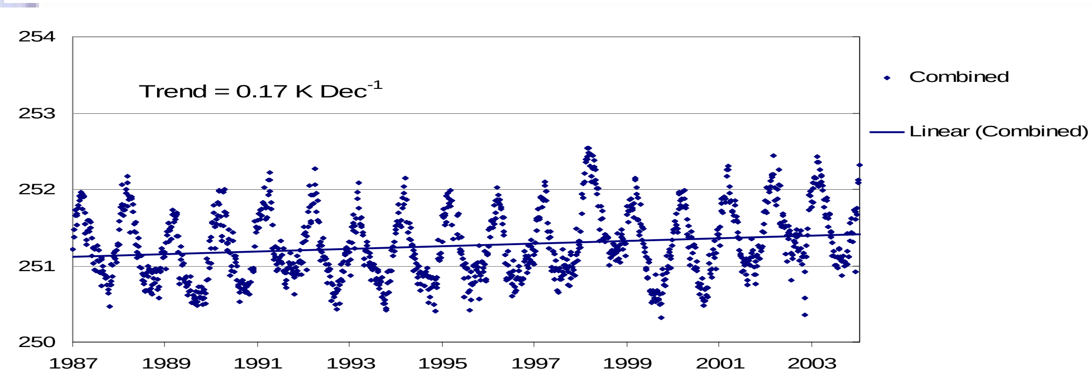
0.32 K Decade^{-1}



Trends for NESDIS operational calibration algorithm

0.22 K Decade^{-1}

(Vinnikov and Grody, 2003)



Trends for nonlinear calibration algorithm using SNO cross calibration

0.17 K Decade^{-1}

Improved calibration will eliminate uncertainty in trend

Summary

- NOAA has provided a centralized place for coordinating major activities for GSICS program
- NOAA will contribute to GSICS with key LEO2LEO calibration capability
- NOAA is closely working with all GSICS partners in achieving optimal GEO2LEO calibration