Global Space-based Inter-Calibration System (GSICS)

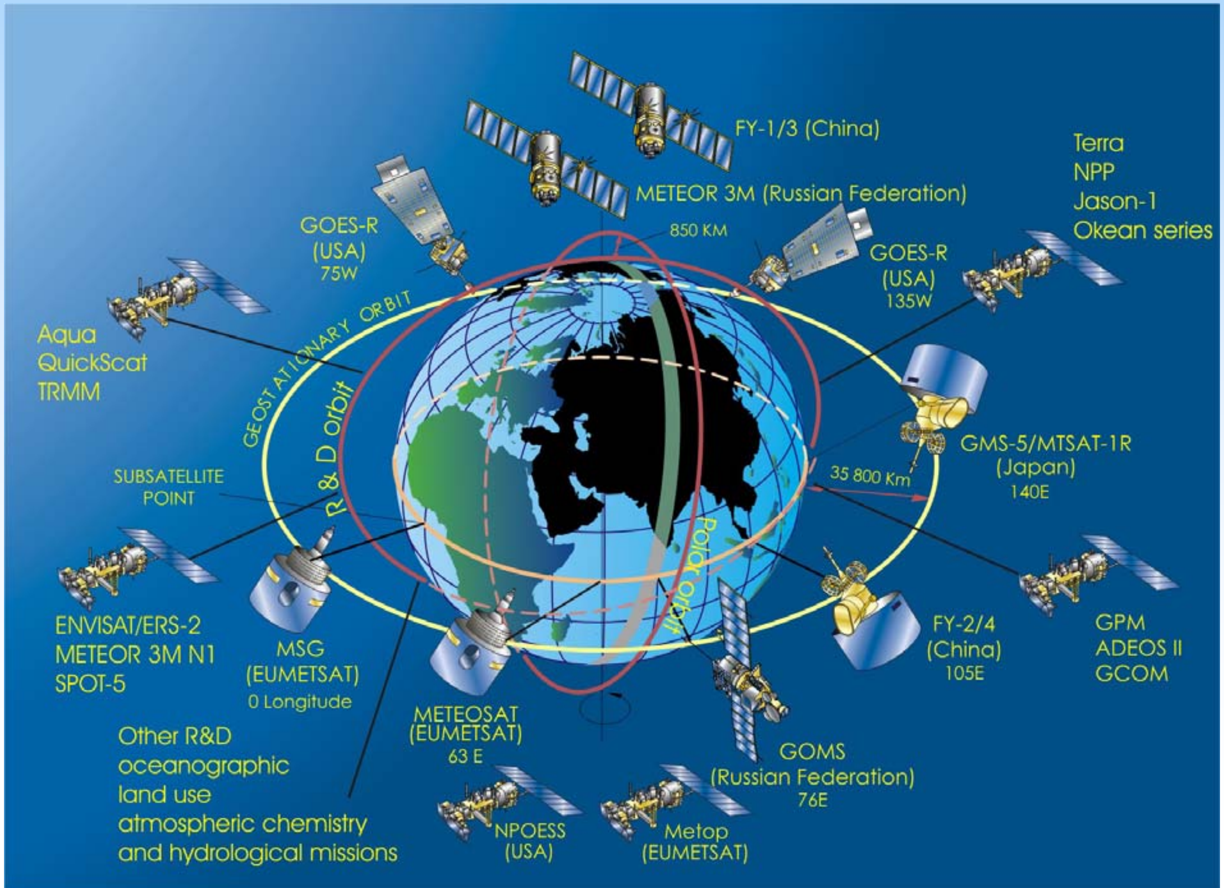
Mitchell D. Goldberg
NOAA/NESDIS
Center for SaTellite Applications and Research (STAR)
Satellite Meteorology and Climate Division

Motivation

- Applications are becoming more demanding
- Demanding applications require accurate, well calibrated & characterized measurements
- Reduce measurement uncertainty
- Growing global observing system

GEOSS

- GEOSS – international coordinated effort to share Earth observations to provide a level of information about the Earth not previously achieved.



Nine Societal Benefits

- Improve Weather Forecasting
- Reduce Loss of Life and Property from Disasters
- Protect and Monitor Our Ocean Resource
- Understand, Assess, Predict, Mitigate and Adapt to Climate Variability and Change
- Support Sustainable Agriculture and Forestry and Combat Land Degradation
- Understand the Effect of Environmental Factors on Human Health and Well-Being
- Develop the Capacity to Make Ecological Forecasts
- Protect and Monitor Water Resources
- Monitor and Manage Energy Resources

Science Requirements for GEOSS to meet the 9 societal benefits:

- Satellite Intercalibration & Sensor characterization
- Data Fusion & Integrated Products, including CDRs
- Data Assimilation & Modeling

What is GSICS?

- Global Space-based Inter-Calibration System (GSICS)
- WMO sponsored
- Goal - Enhance calibration and validation of satellite observations and to intercalibrate critical components global observing system

GSICS formulation

- The GCOS Climate Monitoring Principles (GCMPs) were extended to address the problems associated with developing long-term climate data records from satellite observations
  - Stable orbits
  - Continuity and adequate overlap of satellite observations
  - **Improved calibration and validation**

- CGMS tasked the WMO Space Programme to build an international consensus and consortium for a global space-based inter-calibration system for the World Weather Watch (WWW)/Global Observing System (GOS).

Formulation Team

- Mitch Goldberg – NOAA/NESDIS (Chair)
- Gerald Frazer – NIST
- Donald Hinsman – WMO (Space Program Director)
- Xu Jianmin (CMA)
- Toshiyuki Kurino (JMA)
- John LeMarshall - JC Sat. Data Assimilation
- Paul Menzel –NOAA/NESDIS
- Tillmann Mohr – WMO
- Hank Revercomb – Univ. of Wisconsin
- Johannes Schmetz – Eumetsat
- Jörg Schulz – DWD, CM SAF
- William Smith – Hampton University
- Steve Ungar – CEOS, Chairman WG Cal/Val

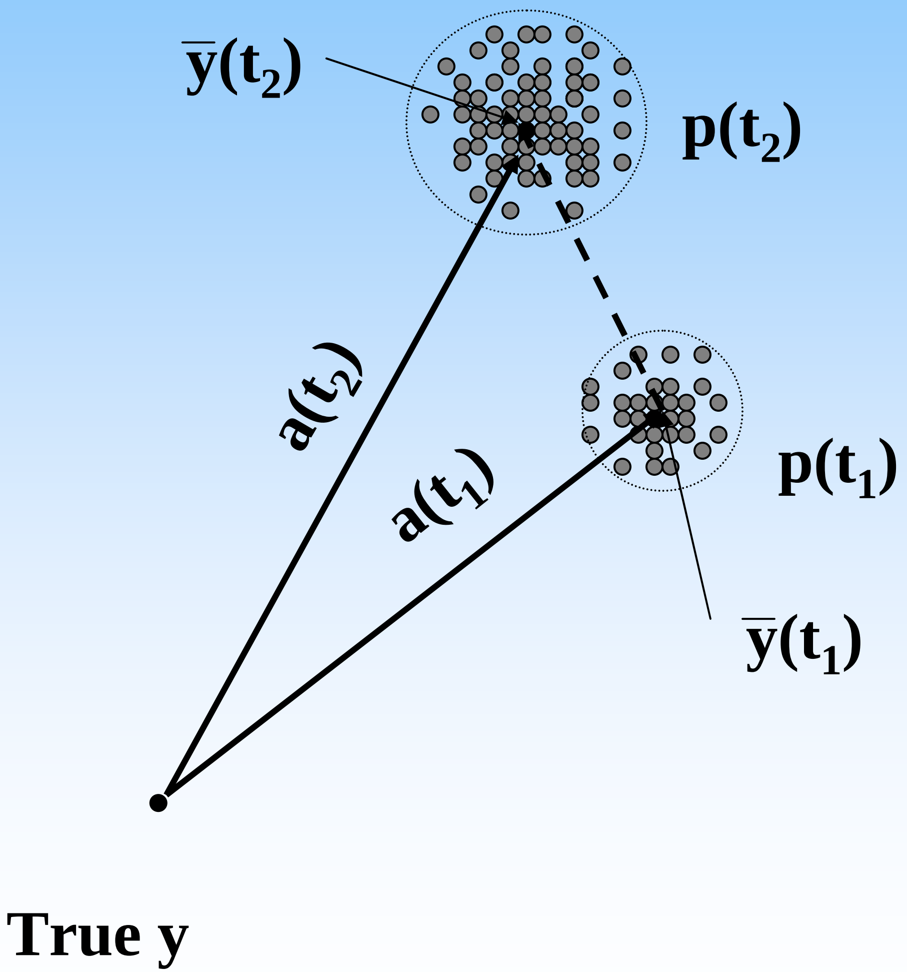
National Environmental Satellite, Data, and Information Service

Climate & Weather Requirements

- Need excellent accuracy and long-term stability
- Instruments must be inter-calibrated
- Need high precision (low noise)
- Measurements must be well characterized

Error Characteristics

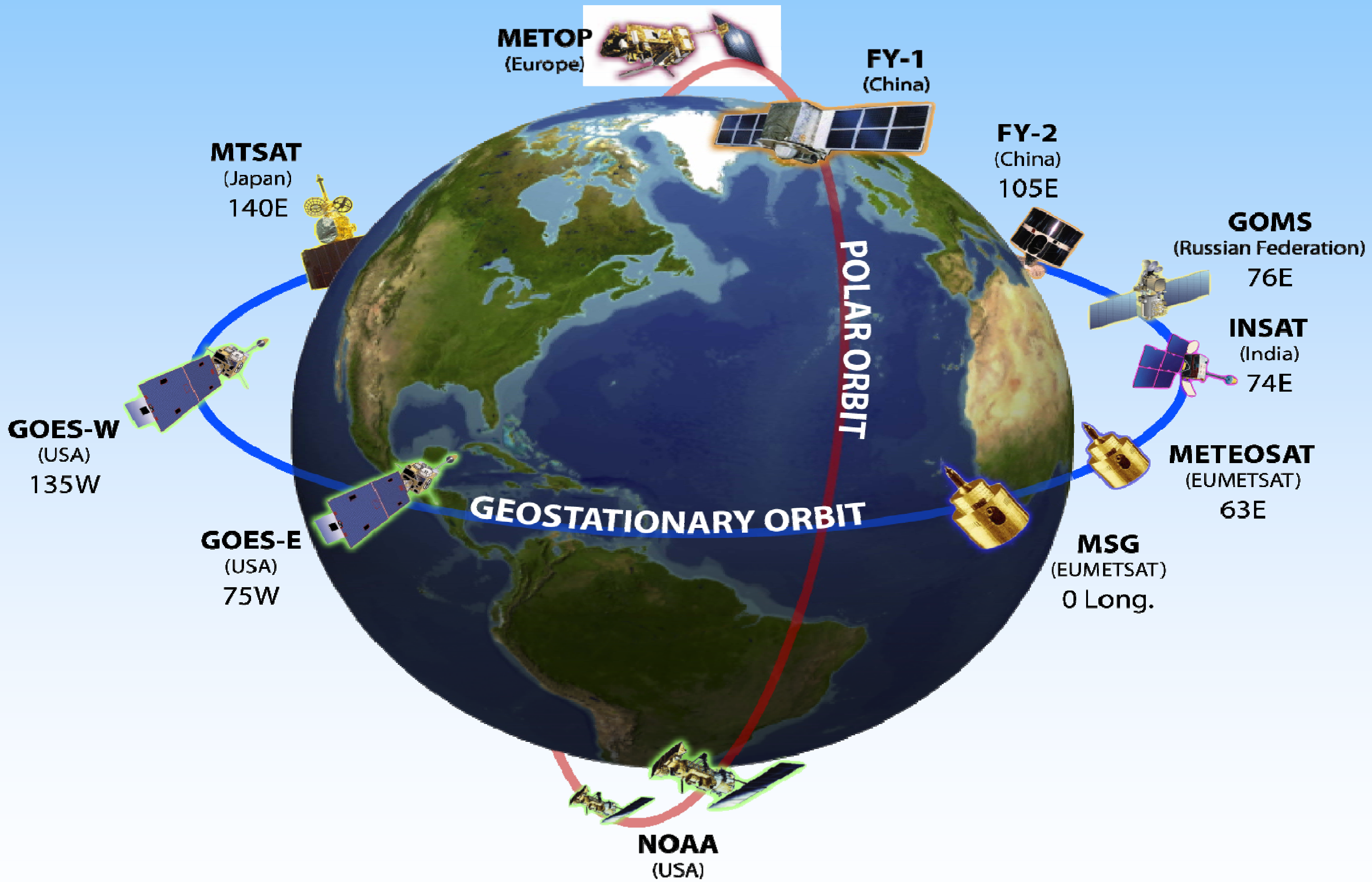
- Accuracy (bias)
- Precision (standard deviation)
- Stability



GSICS 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

Space-based Observing Systems Operational Environmental Satellites



Outcome

- Coordinated international cal/val program
- Exchange of critical datasets for cal/val
- Best practices/requirements for monitoring observing system performance
- Best practices/requirements for prelaunch characterisation
- Establish requirements for cal/val
- Advocate for benchmark systems
- Quarterly reports of observing system performance and recommended solutions
- Improved sensor characterisation
- High quality radiances for NWP & CDRs

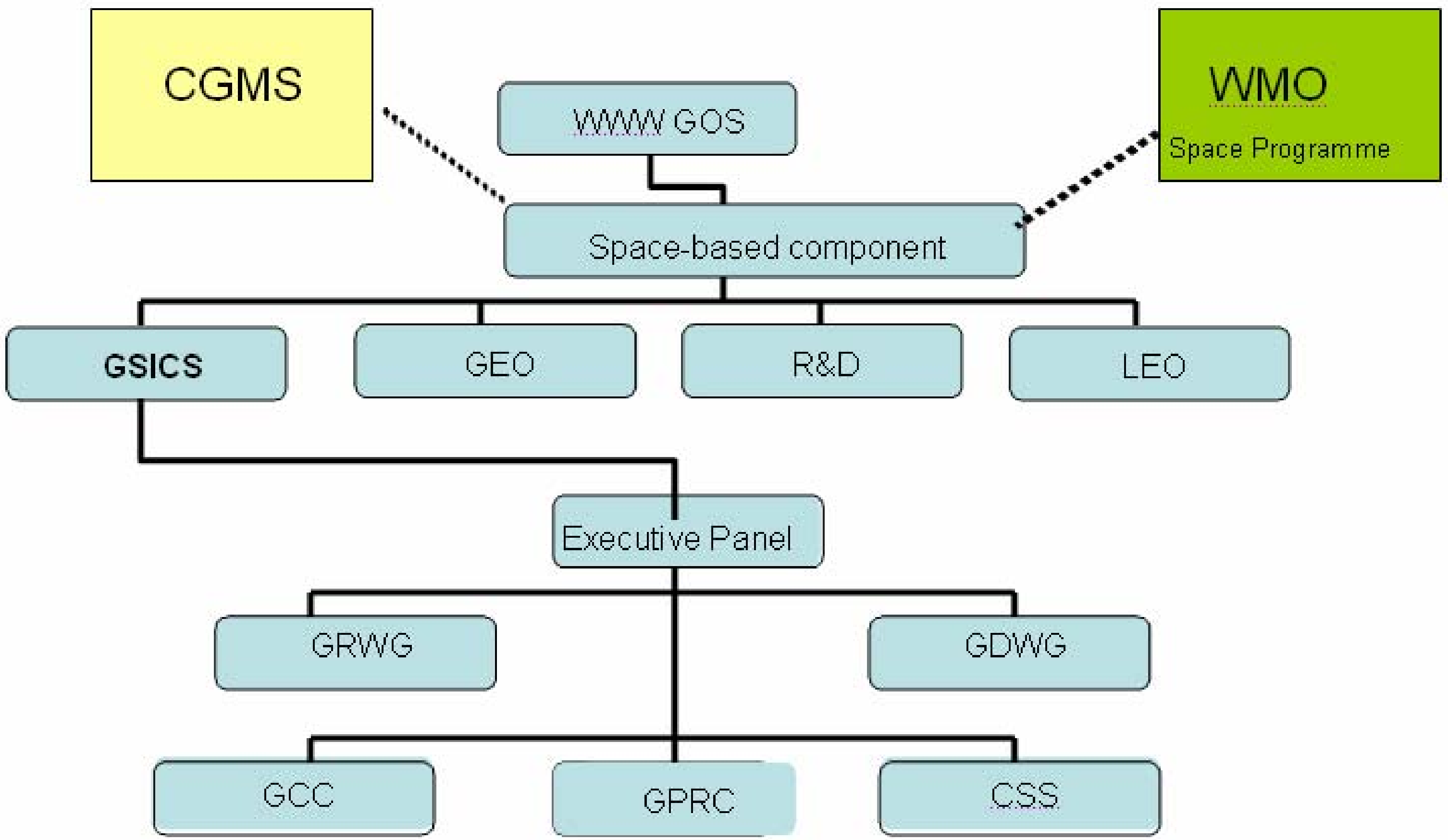
Prerequisites

- Extensive pre-launch characterization of all instruments traceable to SI standards
- Benchmark instruments in space with appropriate accuracy, spectral coverage and resolution to act as a standard for inter-calibration
- Independent observations (calibration/validation sites – ground based, aircraft)

Building Blocks for Satellite Intercalibration

- Collocation
  - Determination and distribution of locations for simultaneous observations by different sensors (space-based and in-situ)
  - Collocation with benchmark measurements
- Data collection
  - Archive, metadata - easily accessible
- Coordinated operational data analyses
  - Processing centers for assembling collocated data
  - Expert teams
- Assessments
  - communication including recommendations
  - Vicarious coefficient updates for “drifting” sensors

GSICS Organizational Chart

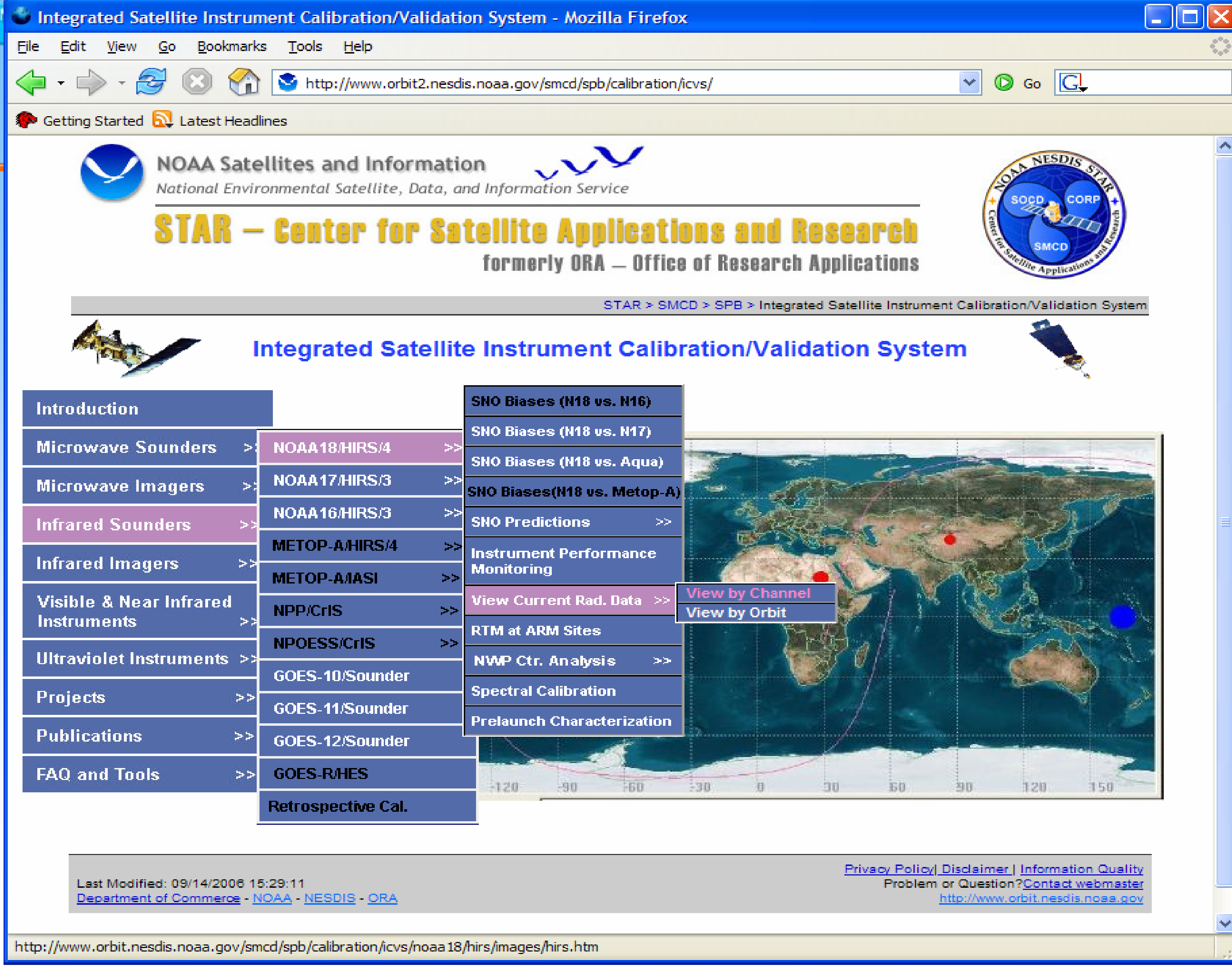


GSICS Components

- GSICS Executive Panel – reps from each operational satellite agency
  - Priorities, objectives and agreements
- GSICS Coordination Center (GCC) - NESDIS
  - Transmit intercalibration opportunities to GPRCs
  - Collect data from the GPRCs and provide access
  - Quarterly reports on performance
- GSICS Processing and Research Centers (GPRCs)
  - Operational satellite agencies
  - Activities:
    - Pre-launch calibration
    - Intersatellite calibration
    - Supporting research

Calibration Support Segments (CSS)

- Pre-launch Instrument Characterization
- Earth-based Reference Sites and Natural Calibration Sources
- Extraterrestrial Calibration Sources
- Model Simulations
- Benchmark Measurements (space-based, aircraft, groundbased)

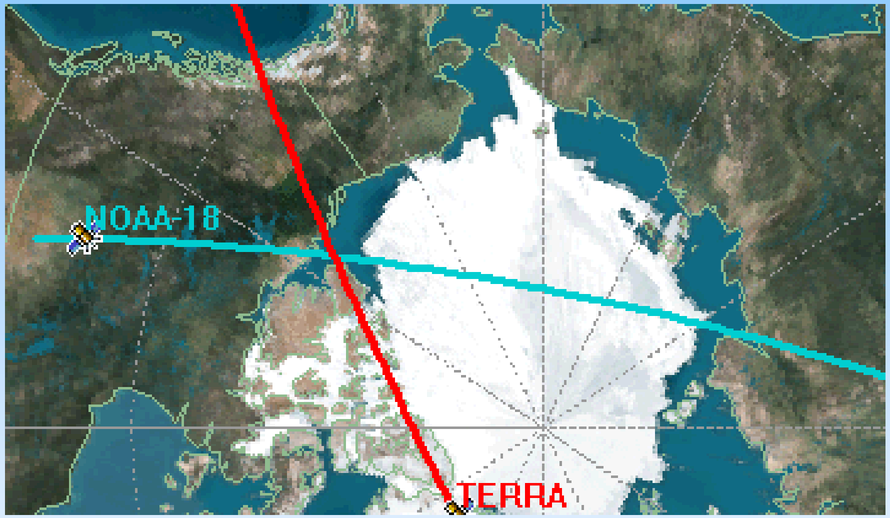

Integrated Satellite Instrument Calibration/Validation System - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://www.orbit2.nesdis.noaa.gov/smcd/spb/calibration/icvs/
Go
Getting Started
Latest Headlines
NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service
STAR – Center for Satellite Applications and Research
formerly ORA – Office of Research Applications
NOAA NESDIS STAR
SOCD
CORP
SMCD
Center for Satellite Applications and Research
STAR > SMCD > SPB > Integrated Satellite Instrument Calibration/Validation System
Integrated Satellite Instrument Calibration/Validation System
Introduction
Microwave Sounders >>
Microwave Imagers >>
Infrared Sounders >>
Infrared Imagers >>
Visible & Near Infrared Instruments >>
Ultraviolet Instruments >>
Projects >>
Publications >>
FAQ and Tools >>
NOAA18/HIRS/4 >>
NOAA17/HIRS/3 >>
NOAA16/HIRS/3 >>
METOP-A/HIRS/4 >>
METOP-A/IASI >>
NPP/CrIS >>
NPOESS/CrIS >>
GOES-10/Sounder
GOES-11/Sounder
GOES-12/Sounder
GOES-R/HES
Retrospective Cal.
SNO Biases (N18 vs. N16)
SNO Biases (N18 vs. N17)
SNO Biases (N18 vs. Aqua)
SNO Biases(N18 vs. Metop-A)
SNO Predictions >>
Instrument Performance Monitoring
View Current Rad. Data >>
RTM at ARM Sites
NWP Ctr. Analysis >>
Spectral Calibration
Prelaunch Characterization
View by Channel
View by Orbit
-120 -90 -60 -30 0 30 60 90 120 150
Last Modified: 09/14/2006 15:29:11
Department of Commerce - NOAA - NESDIS - ORA
Privacy Policy| Disclaimer | Information Quality
Problem or Question?Contact webmaster
http://www.orbit.nesdis.noaa.gov
http://www.orbit.nesdis.noaa.gov/smcd/spb/calibration/icvs/noaa18/hirs/images/hirs.htm

National Environmental Satellite, Data, and Information Service

Simultaneous Nadir Overpass (SNO) Method

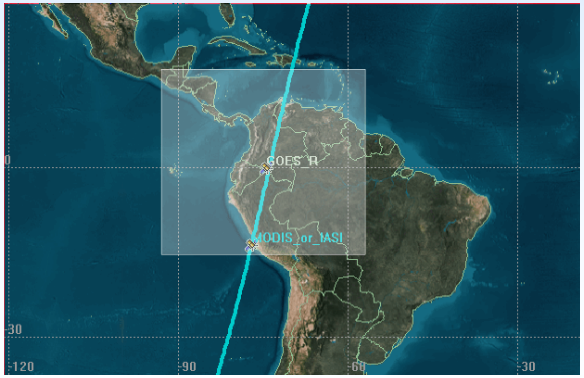
-a core component in the Integrated Cal/Val System

POES intercalibration



- Useful for remote sensing scientists, climatologists, as well as calibration and instrument scientists
- Support new initiatives (GEOSS and GSICS)
- Significant progress are expected in GOES/POES intercal in the near future

- Unique capabilities developed at NESDIS
- Has been applied to microwave, vis/nir, and infrared radiometers for on-orbit performance trending and climate calibration support
- Capabilities of 0.1 K for sounders and 1% for vis/nir have been demonstrated in pilot studies
- Method has been adopted by other agencies



GOES vs. POES

Integrated Cal/Val System Architecture

Calibration Opportunity Prediction

Data Acquisition Scheduler

Calibration Opportunity Register (CORE)

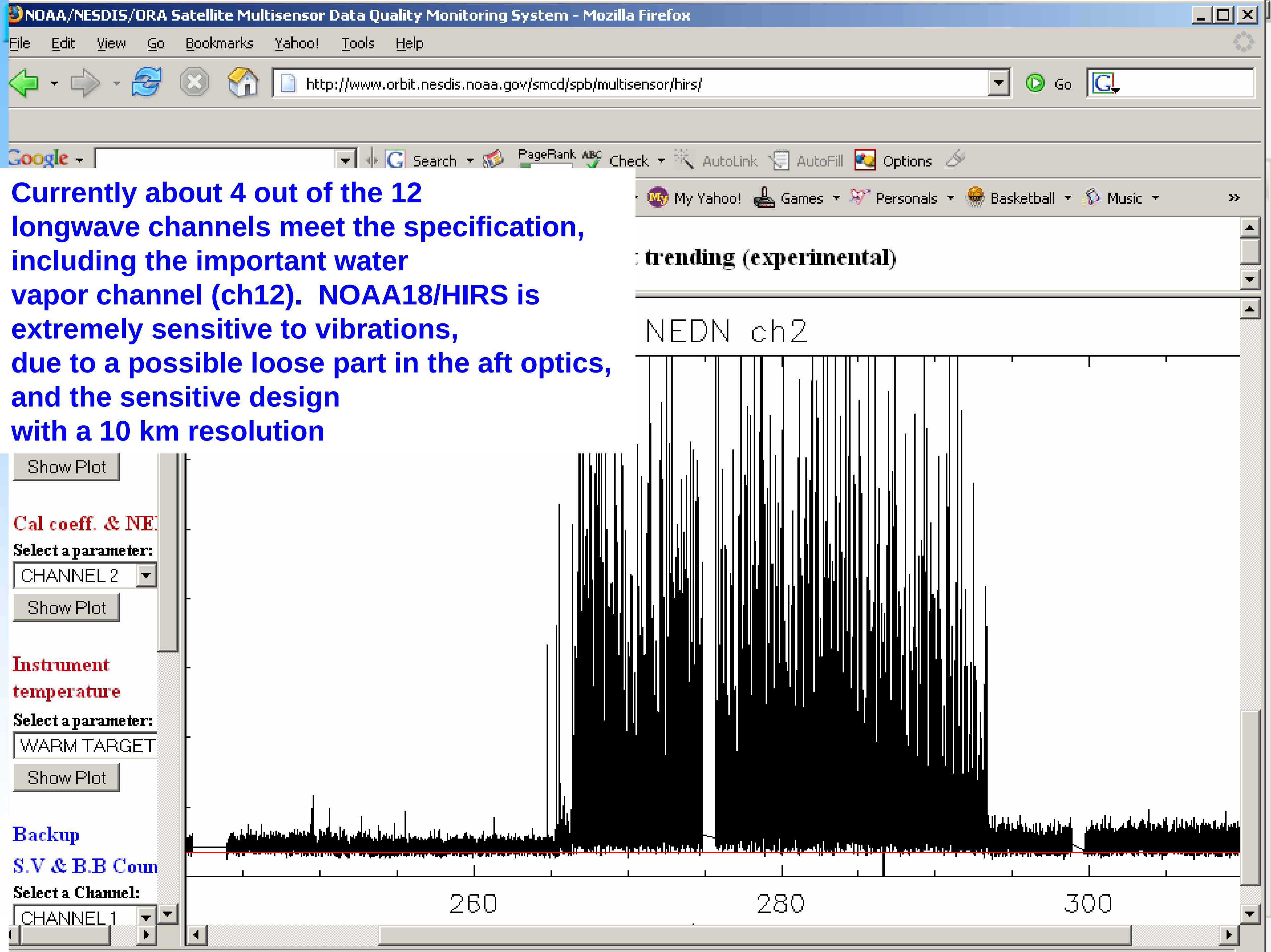
Raw Data Acquisition for Calibration Analyses

Stored Raw Data for Calibration Analyses

- SNO/ SCO Rad. Bias and Spectral Analysis
- Calibration Parameter Noise/ Stability Monitoring
- RTM Model Rad. at Calibration Reference Sites
- Inter-sensor Bias and Spectral Analysis
- Earth & Lunar Calibration
- Geolocation Assessment (Coastlines, etc.)

Assessment Reports and Calibration Updates

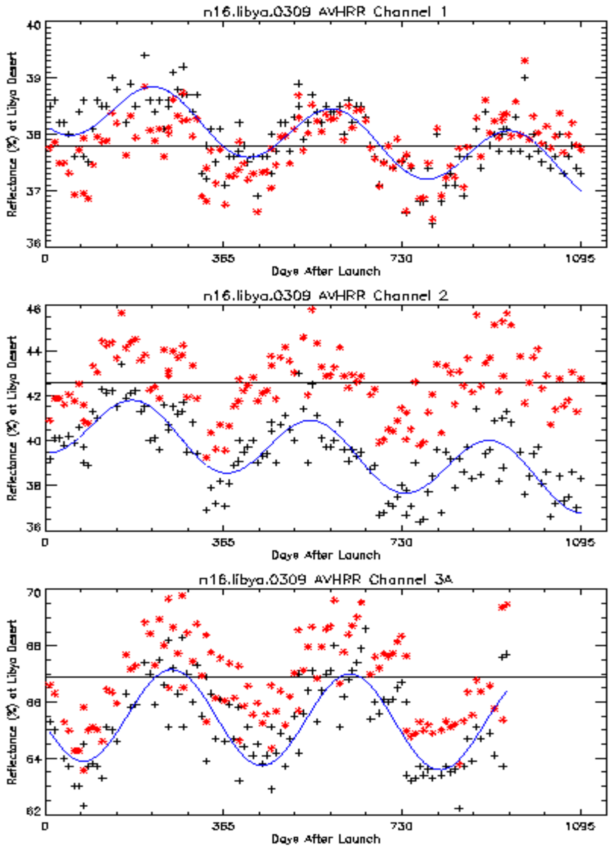
Currently about 4 out of the 12 longwave channels meet the specification, including the important water vapor channel (ch12). NOAA18/HIRS is extremely sensitive to vibrations, due to a possible loose part in the aft optics, and the sensitive design with a 10 km resolution



National Environmental Satellite, Data, and Information Service

AVHRR VIS/NIR Vicarious Calibration using the Libyan Desert Target

–NOAA 16 AVHRR Albedo

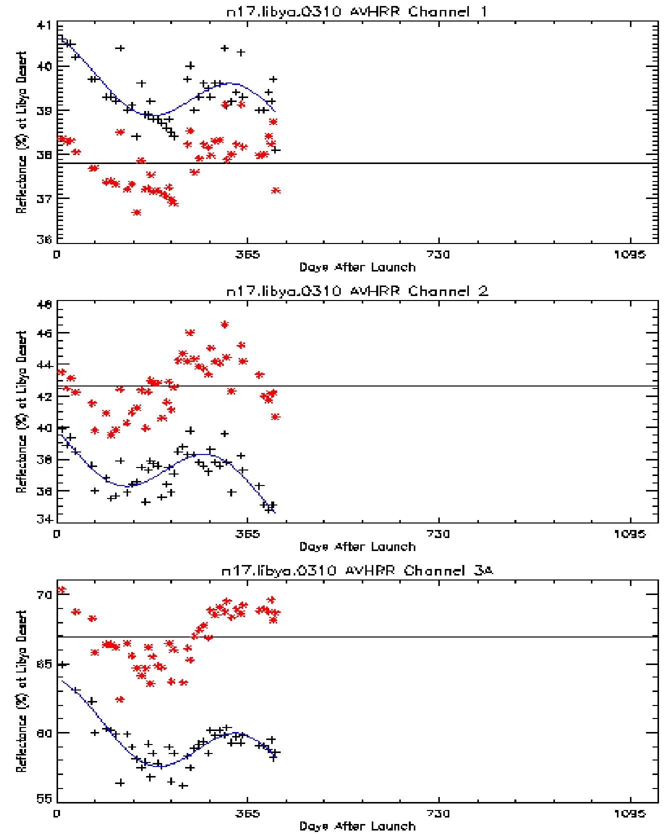


CH1

CH2

CH3

–NOAA 17 AVHRR Albedo



Courtesy of X. Wu

Simultaneous Nadir Overpass(SNO) Observation System - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop http://www.orbit.nesdis.noaa.gov/smcd/spb/calibration/sno/sno.html Search Print

Home Bookmarks Instant Message WebMail Calendar Radio People Yellow Pages Download Customize...

Intersatellite Biases from Simultaneous Nadir Overpass (SNO) Observations (updated monthly)

POES NOAA-16 vs. NOAA-17

HIRS

Select a HIRS Channel:

CHANNEL 1

Show Plot

AMSU-A

Select an AMSU Channel:

CHANNEL 1

Show Plot

AVHRR GAC

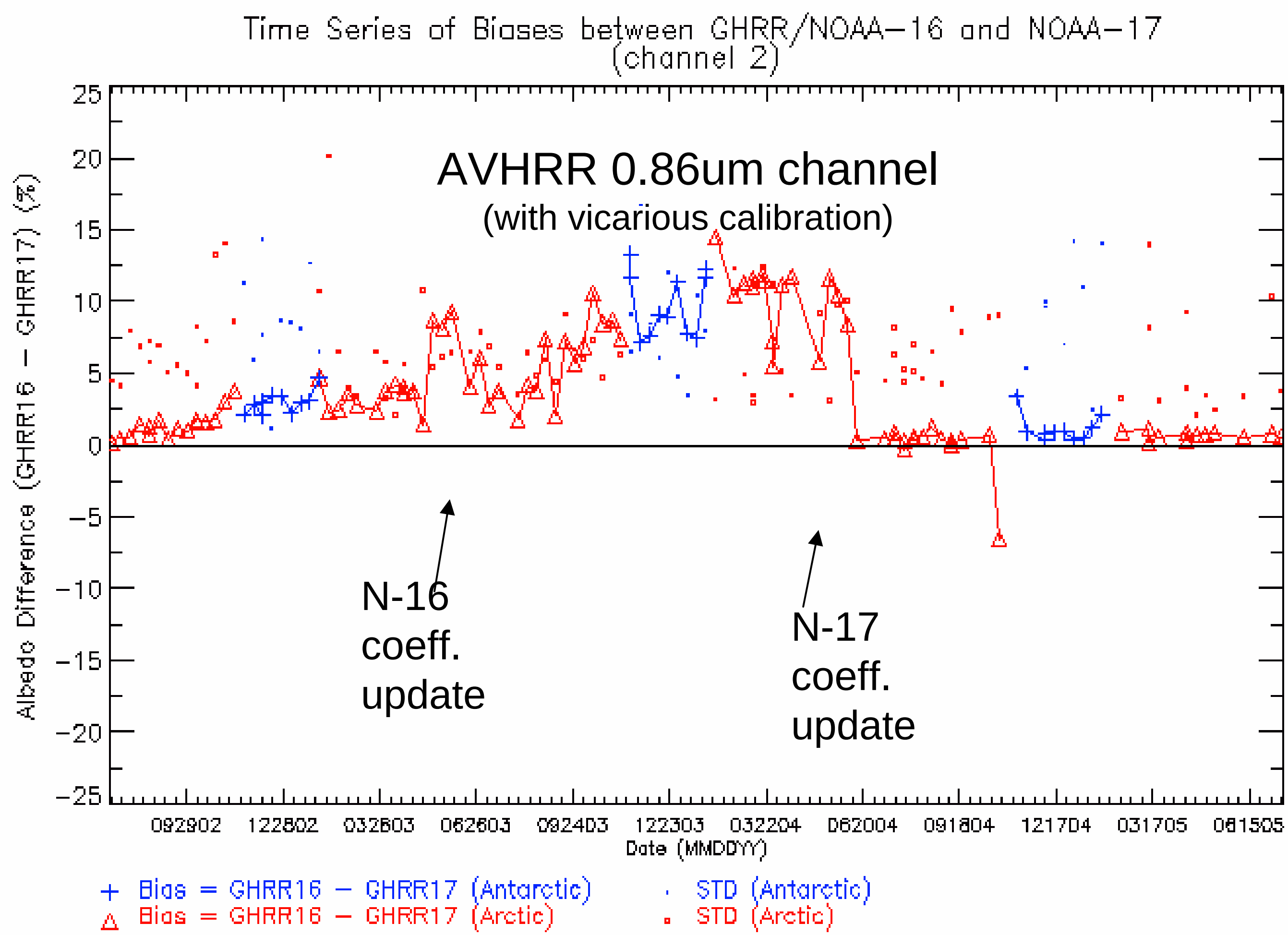
Select an AVHRR Channel:

(CH3 data not reliable due to CH3A/3B switching)

CHANNEL 2

Show Plot

Back to Main Page



SNO Events Between Concurrently Operating AMSU-A Instruments

Time Period: *May 21, 2005* to *July 31, 2006*

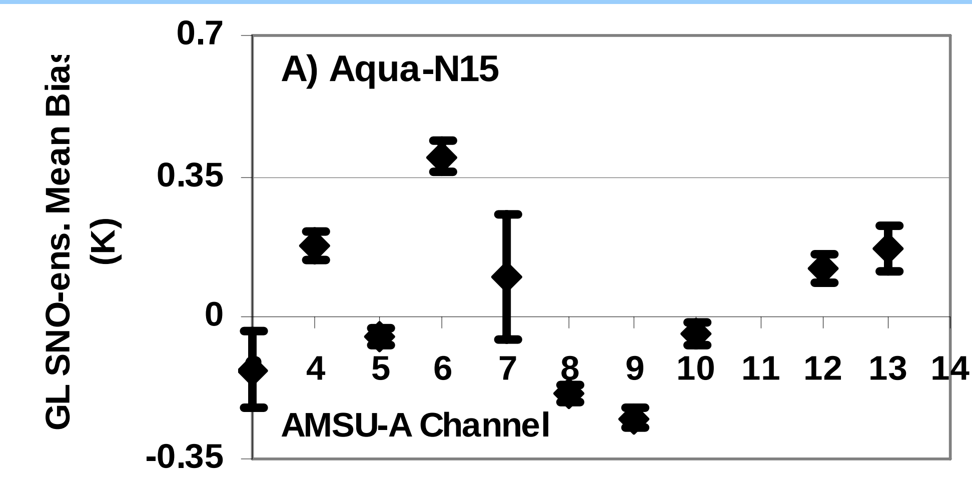
Locations: *Mainly Around 80^0 North and South*

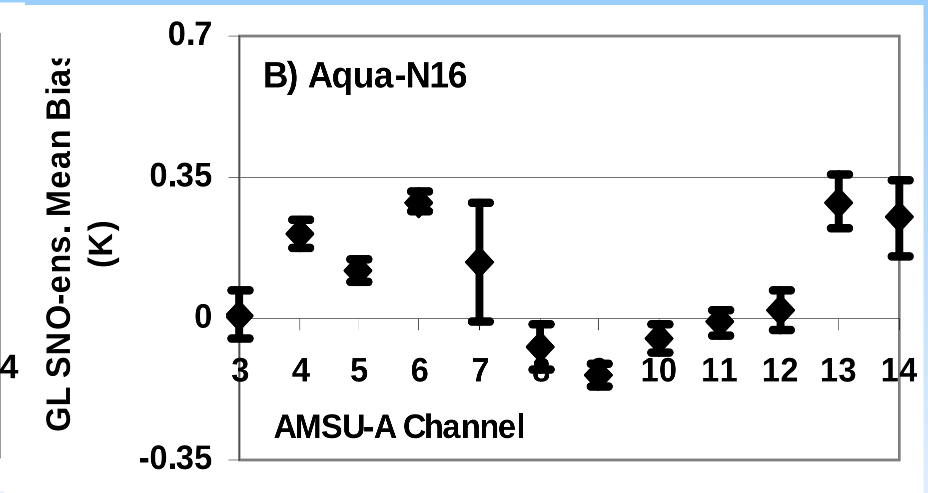
SNO Time Threshold: *30 Seconds*

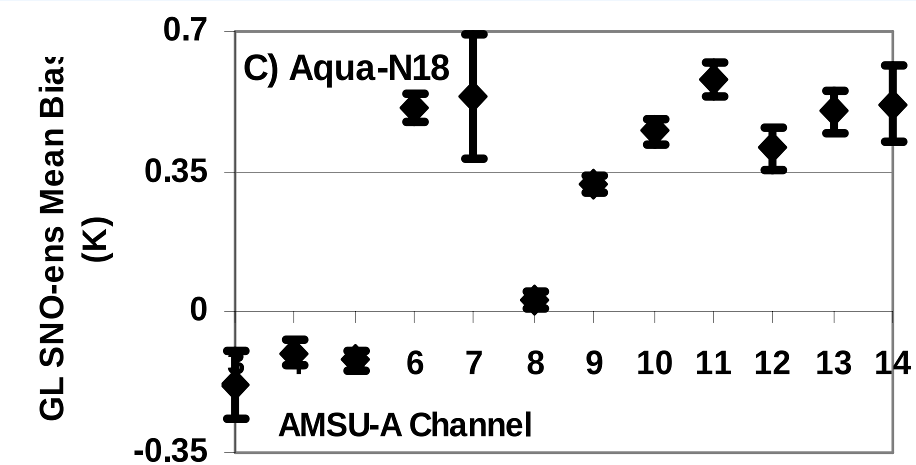
Number of SNOs:

	Aqua/ N15	Aqua/ N16	Aqua/ N18	N15/ N16	N15/ N18	N16/ N18
NH	63	57	58	57	60	54
SH	65	53	55	55	57	54
Globe	128	110	113	112	117	108

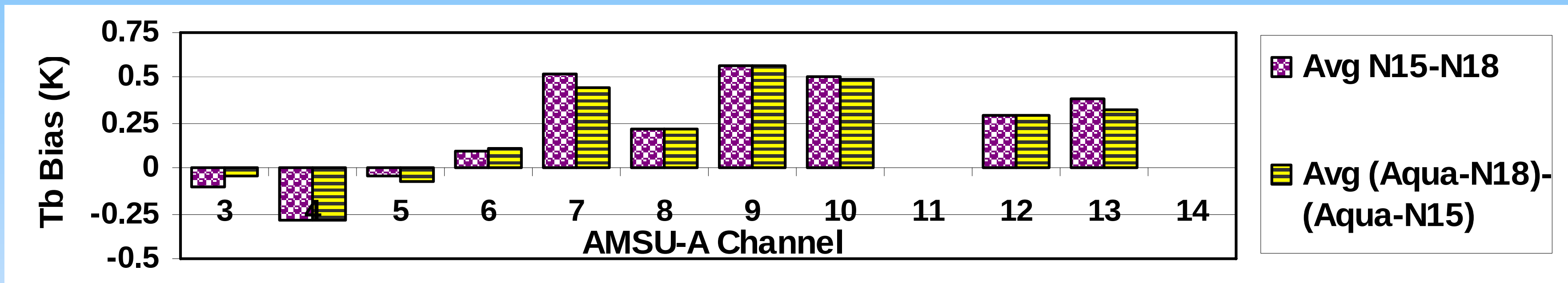
POES and Aqua AMSU-A SNO-ensemble Mean Biases and 99% Confidence Intervals

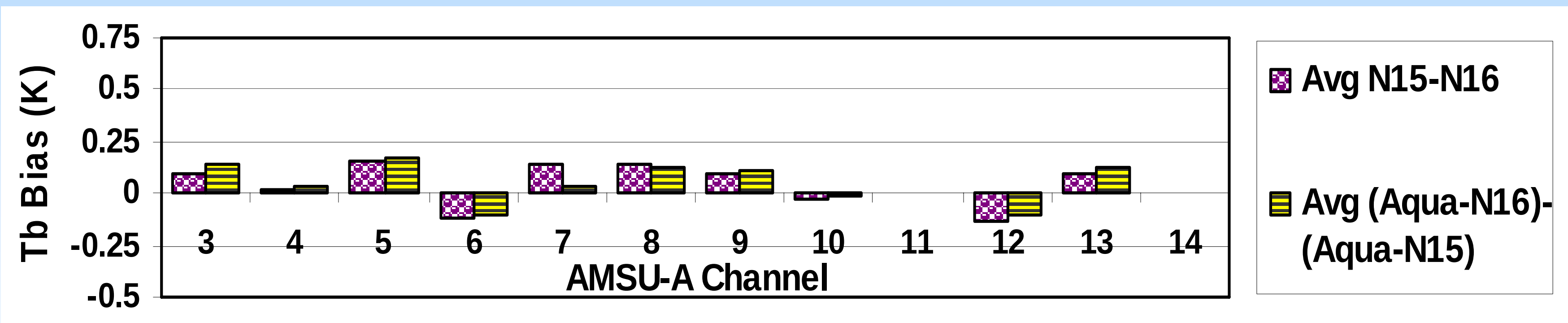


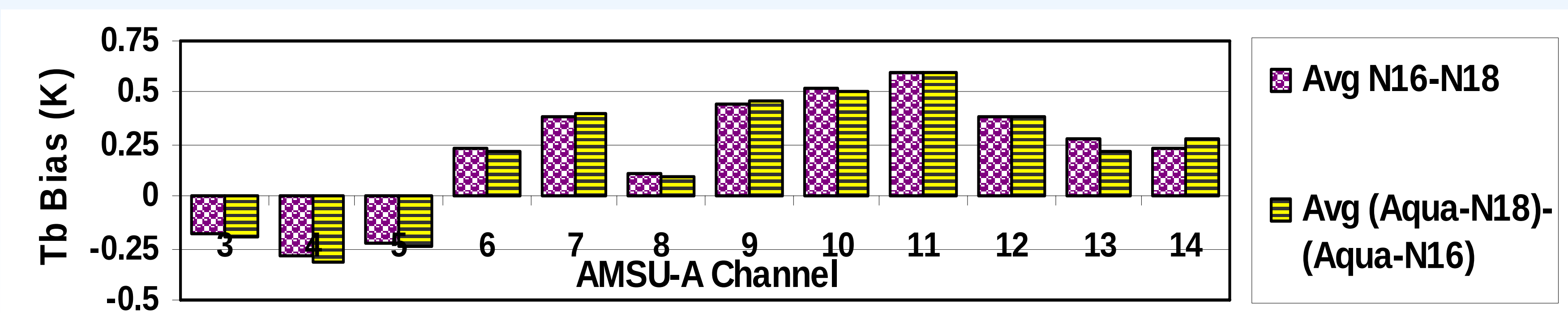




Observed and Predicted AMSU-A SNO biases using Aqua/AMSU-A as a Calibration Transfer Radiometer

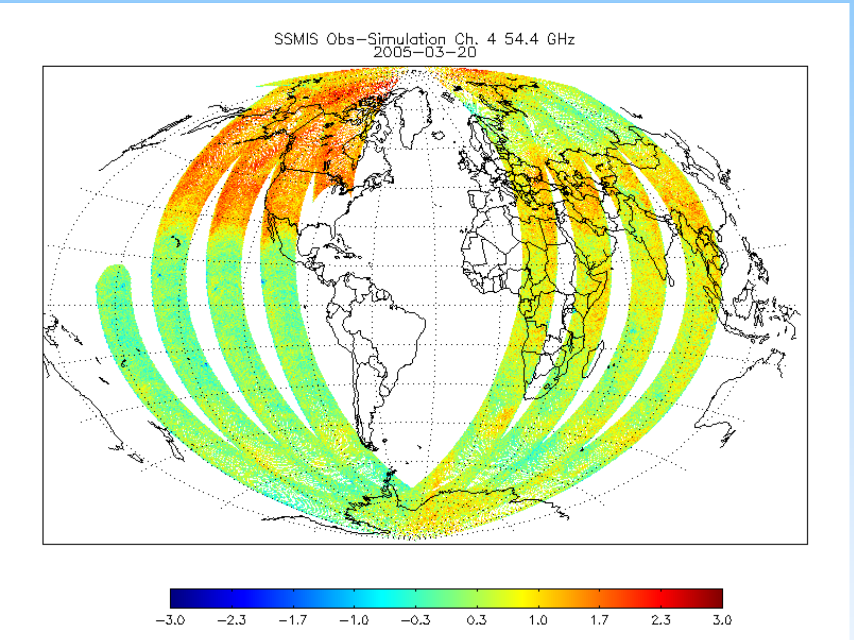


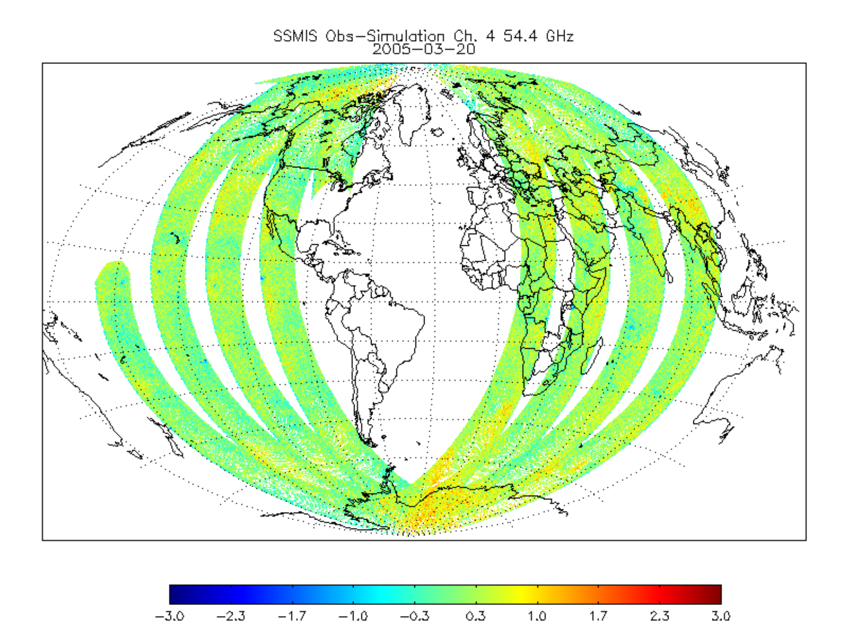




Understanding Global Biases and Developing Calibration Algorithms for Bias Correction

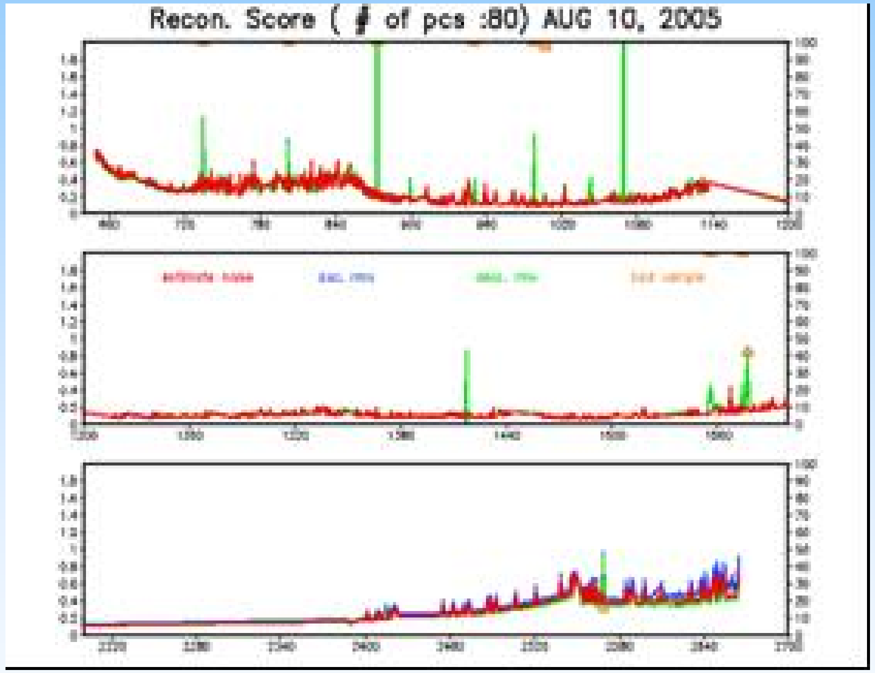
SSMIS (54.4 GHz)

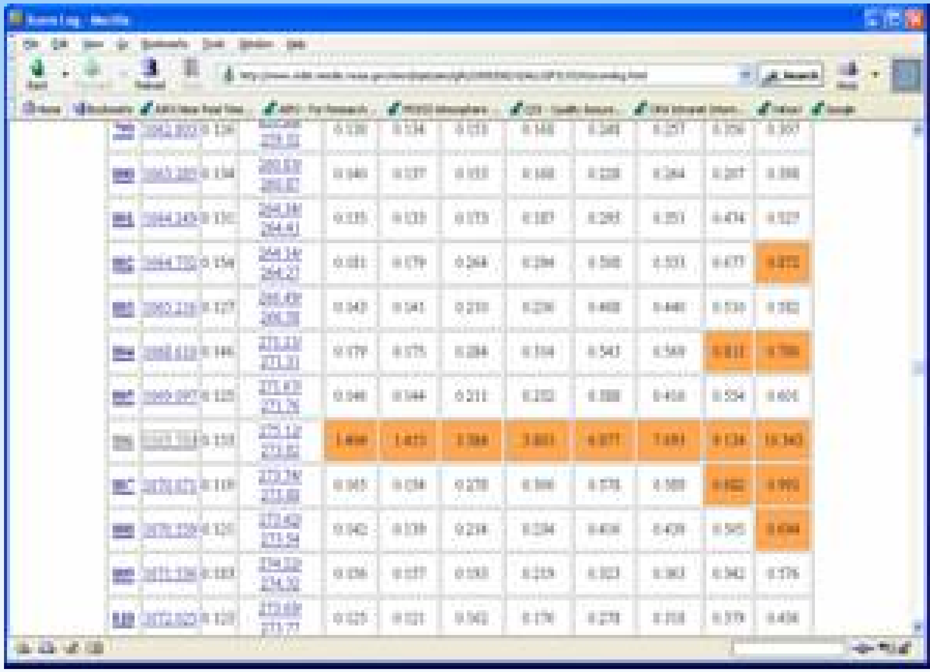




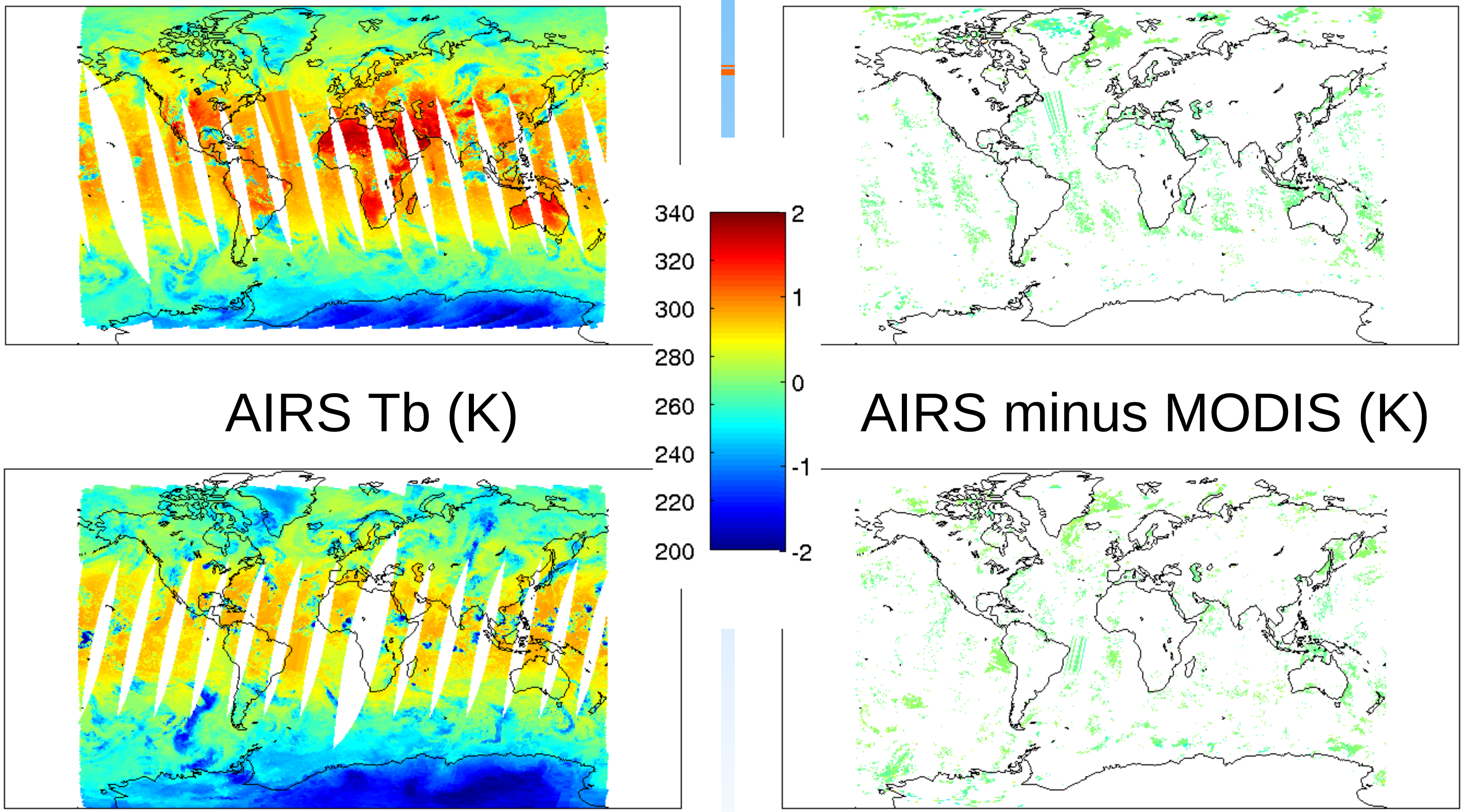
- SSMIS is the first conical microwave sounding instrument, precursor of NPOESS CMIS.
- Shown are the differences between observed and simulated measurements. Biases are caused by 1) antenna emission, 2) direct solar heating to warm load and 3) stray light contamination to its calibration targets.

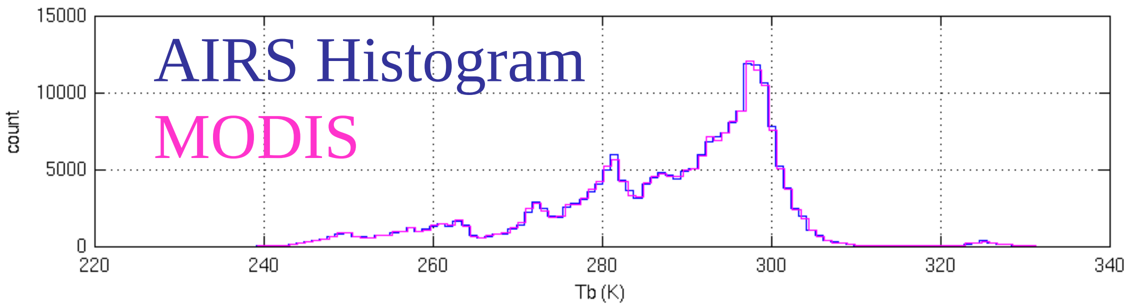
AIRS Noise Monitoring





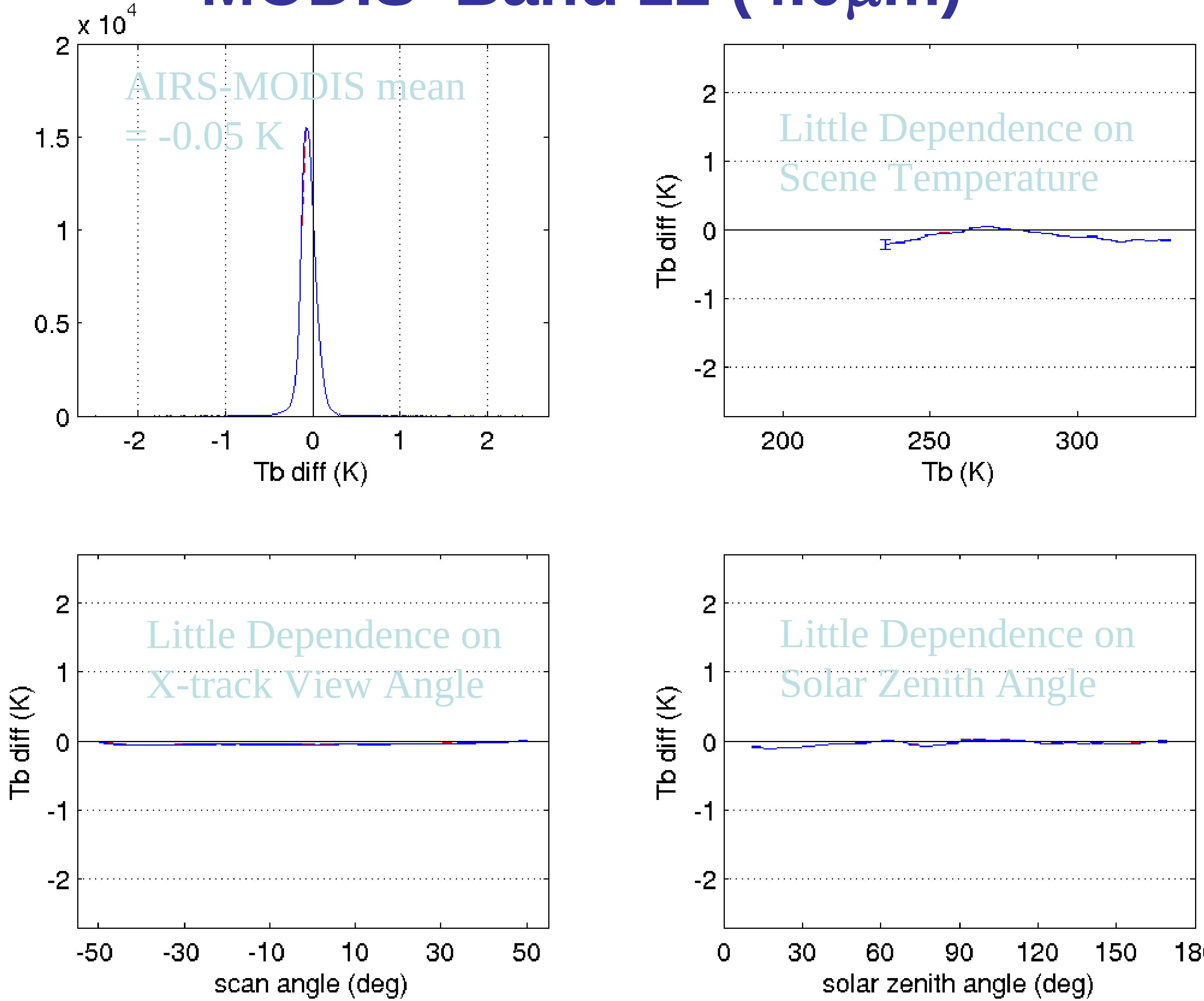
Fantastic AIRS - MODIS Agreement for Band 22 (4.0μm)!





Uniform Scenes Selected

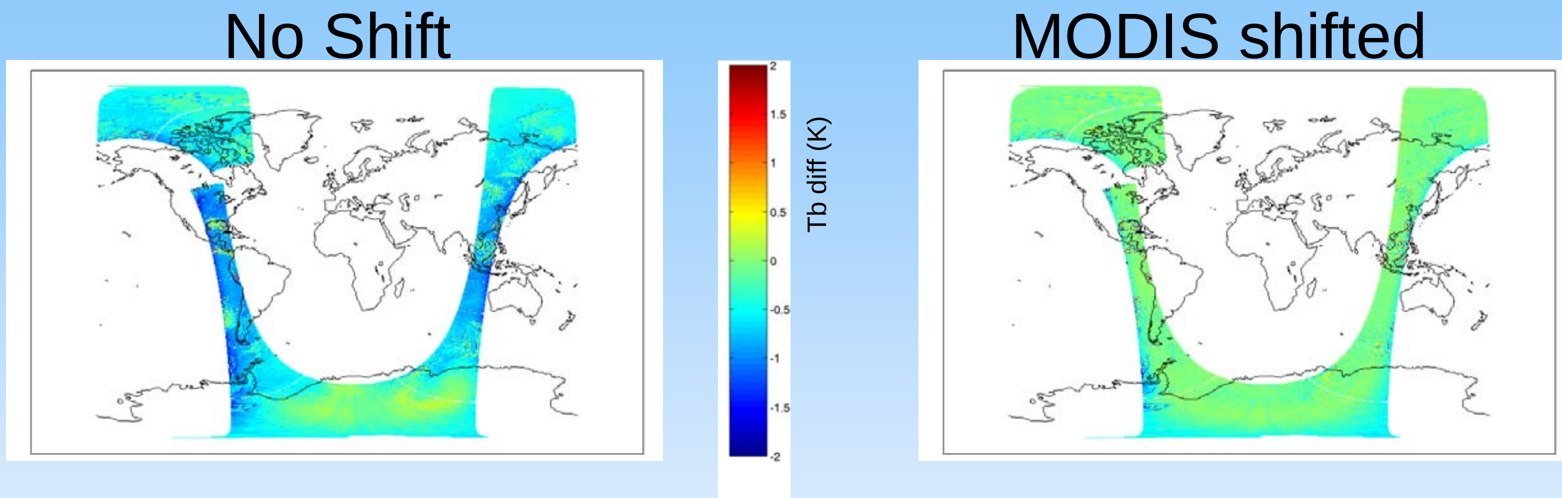
MODIS Band 22 (4.0μm)



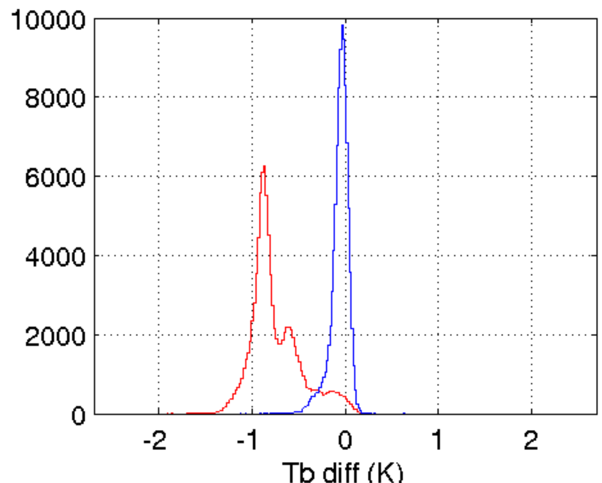
National Environmental Satellite, Data, and Information Service

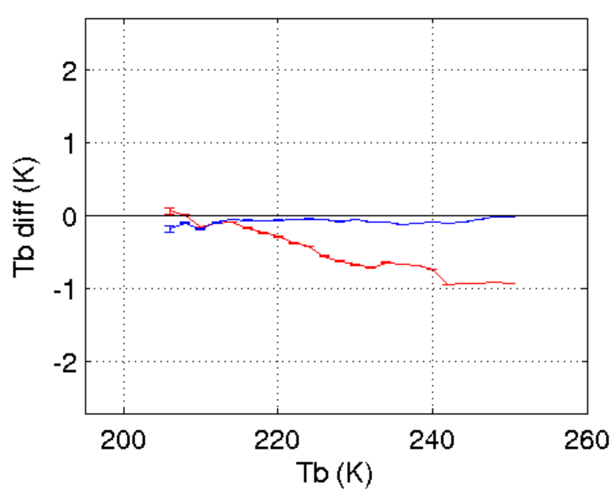
Shifting MODIS Band 35 (13.9 μm) by 0.8 cm^{-1} Works

to Remove Mean bias and Scene Tb Dependence

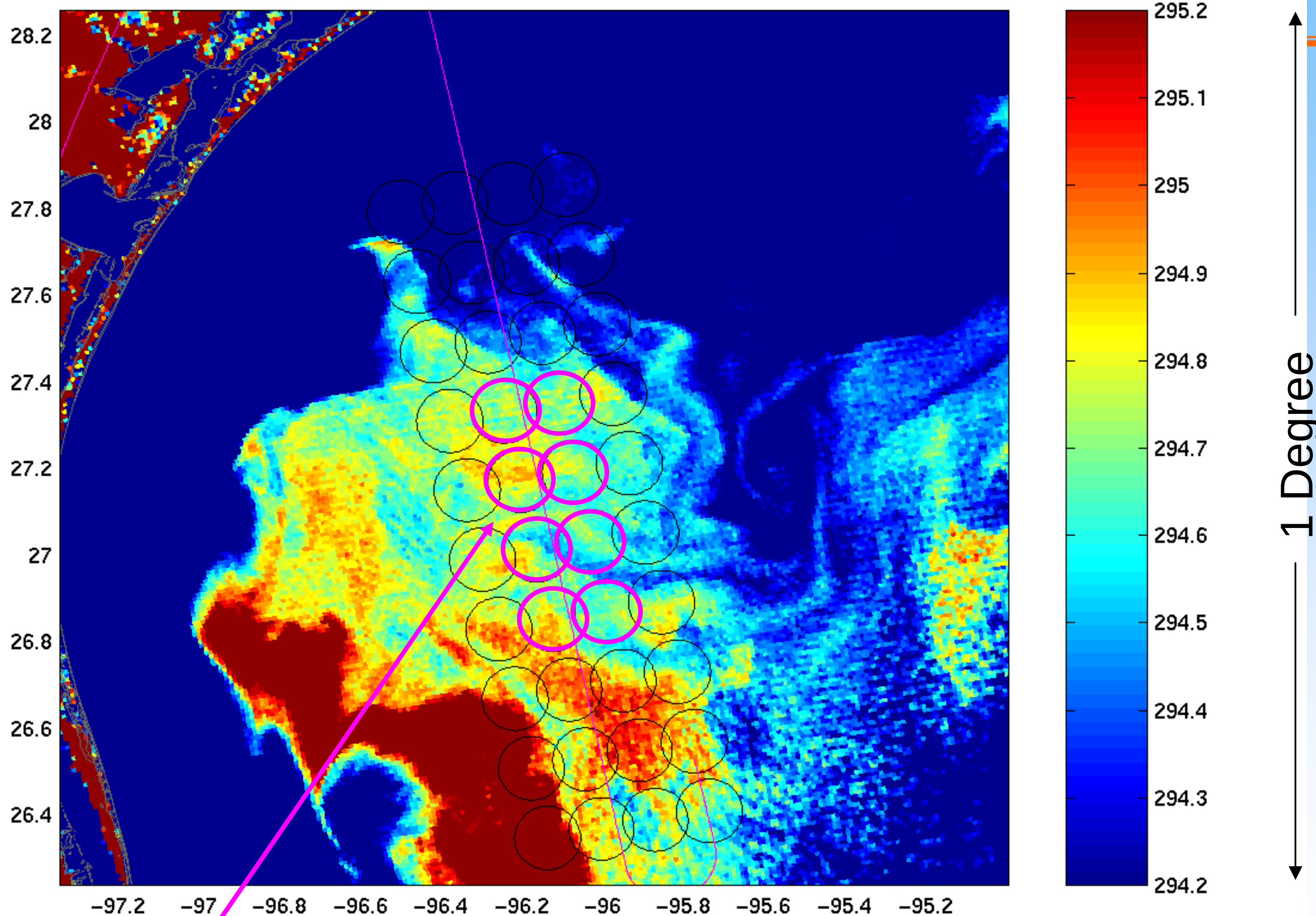


AIRS-MODIS: un-shifted, shifted





(ce (0.21K) not included here)



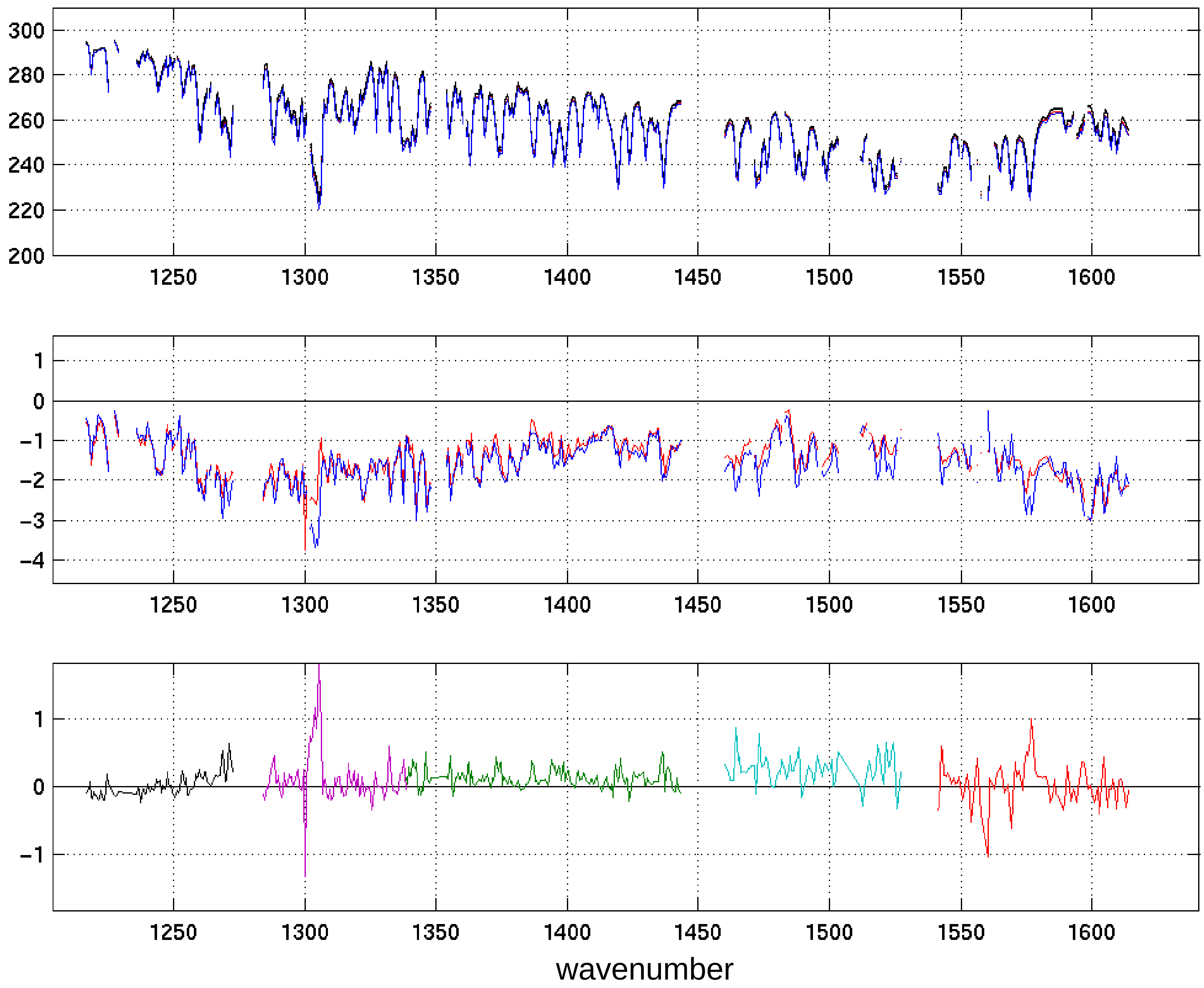
8 AIRS FOVs and SHIS Data w/in them (448 fovs) used in the following comparisons

"comparison 3"

AIRSobs
SHISobs

(AIRSobs-AIRScalc)
(SHISobs-SHIScalc)

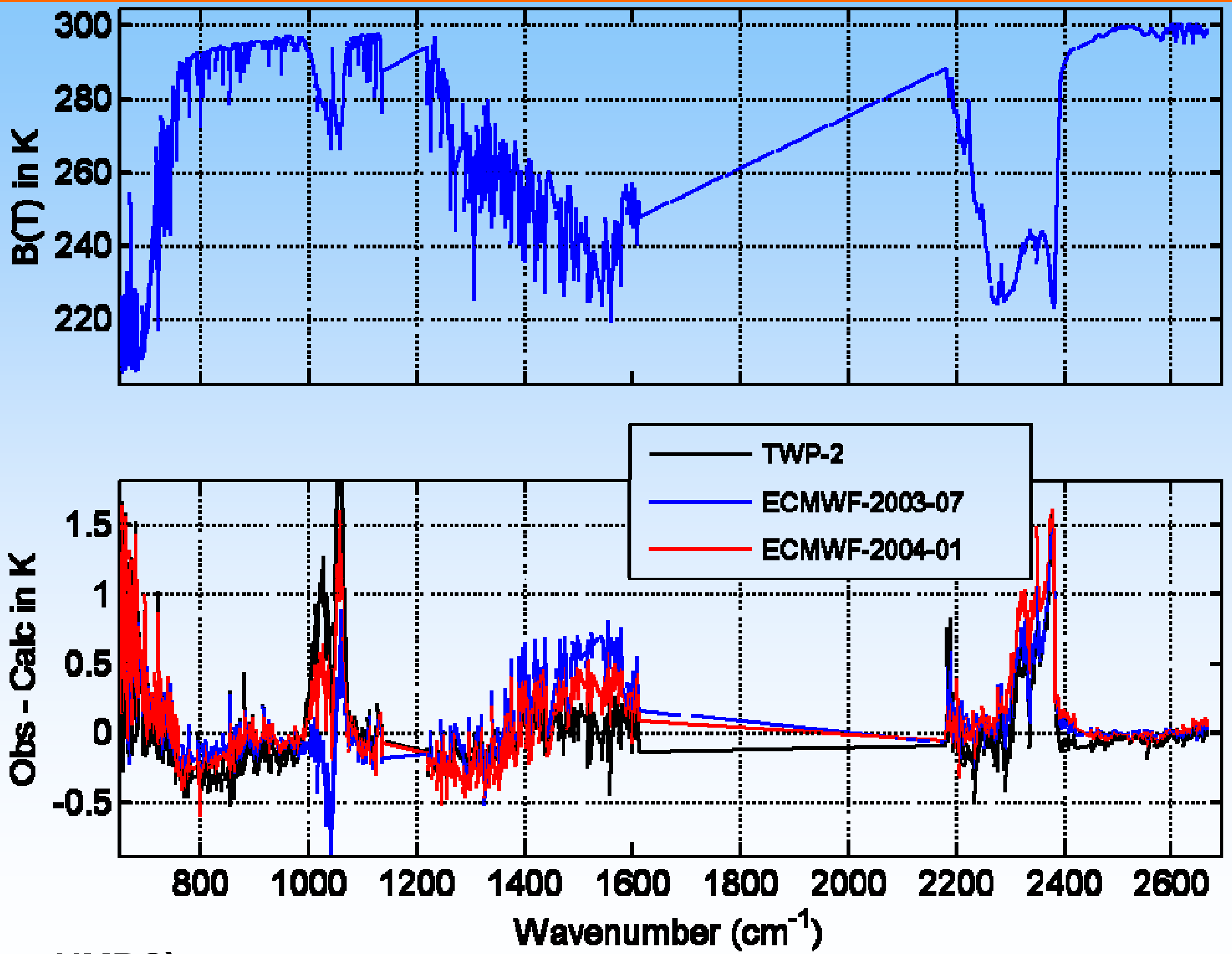
(AIRSobs-AIRScalc)-
(SHISobs-SHIScalc)



National Environmental Satellite, Data, and Information Service

TWP versus ECMWF

(ECMWF averaged over ~10-40 deg. Latitude)

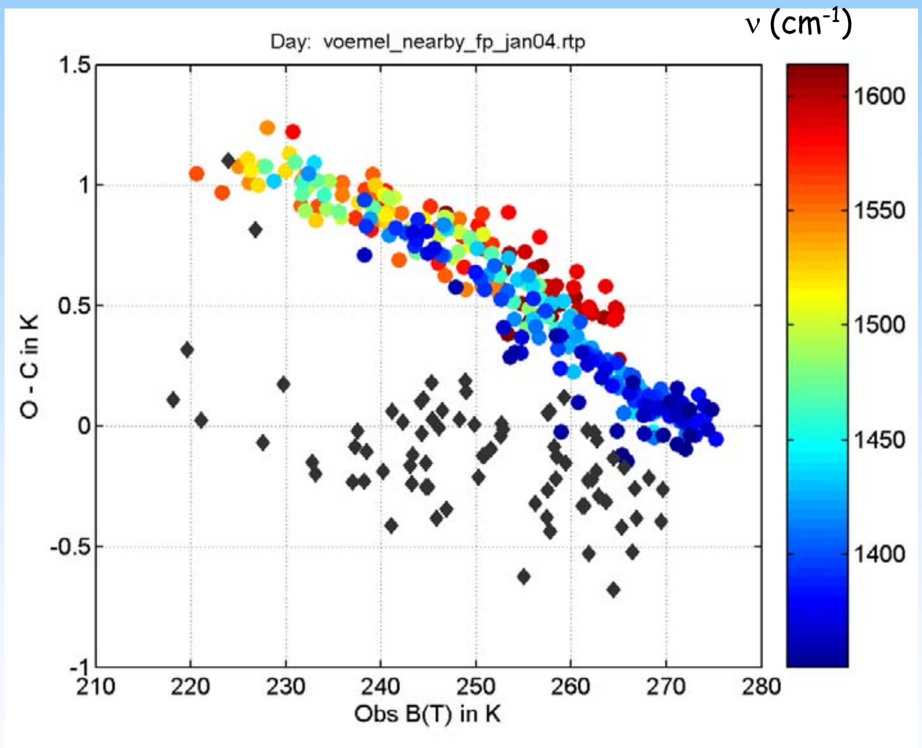


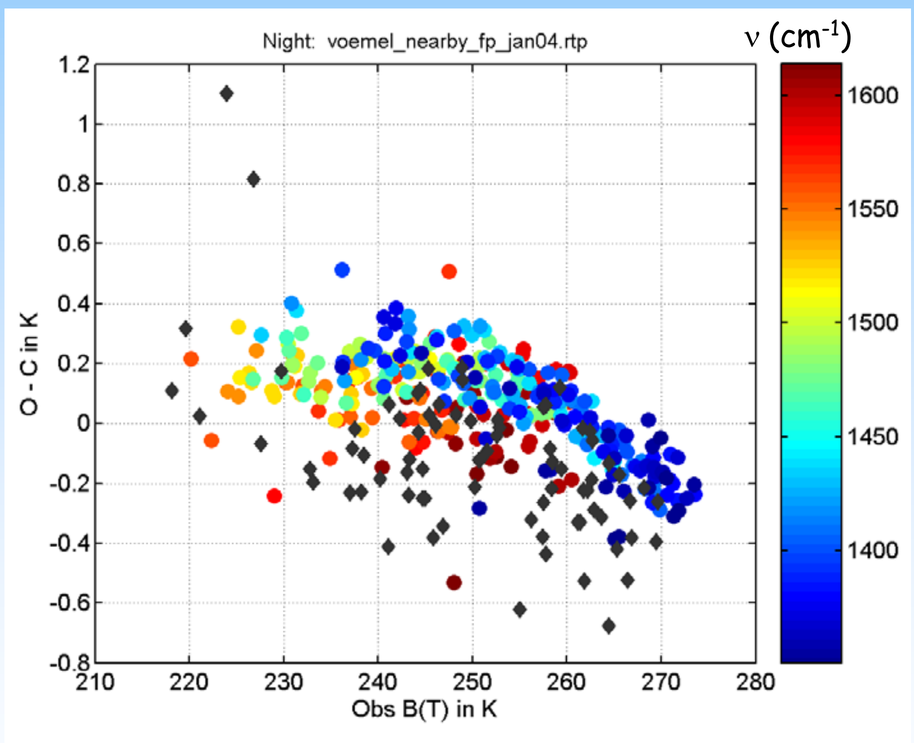
(Strow, UMBC)

Frost-Point Observations Show Significant Deviations

Frost-Point Observations by H. Voelmer: NOAA Boulder

Represents far fewer observations than RS-90's and inconsistencies day vs night.





Diamonds are CO_2 Biases for channels with similar peaking weighting functions.

Summary

- GSICS - coordinated effort to better characterise and improve the fundamental measurements of the Global Observing System
- Improve radiance quality >>>reduce uncertainties in forecasts and climate data records

WMO has approved the development of an Implementation Plan

- Co-ordination Group of Meteorological Satellites (CGMS) XXXIII WMO- WP-21 presented a draft concept and strategy for a Global Space-based Inter-calibration System (GSICS)

- *Action 33.15**:** CGMS Members to establish a Task Force lead by NESDIS (Mitch Goldberg) with participation by EUMETSAT (Johannes Schmetz), JMA (Toshiyuki Kurino), CMA (Xu Jianmin) and assisted by the WMO Space Programme to prepare a draft Implementation Plan for GSICS by 1 July 2006 for review by CGMS Members by 1 August 2006 and approval at CGMS XXXIV.*

National Environmental Satellite, Data, and Information Service

ORA Satellite Cal/Val Program Road Map (2005 - 2012)

Science Advance

By 2012, Global Environmental Observation System of Systems (GEOSS) data will be calibrated with a high quality for uses in the environmental data stewardship

Resources:

- OK
- Deficiency

Develop NPP, NPOESS and GOES-R calibration algorithms which are part of Cal/Val

Integrated cal/val enterprise system that delivers to WMO and other users SNO data.

Develop FY-3 series, METOP-A IASI and GOME2 calibration algorithms which are part of cal/val system

New cal/val sites deployed for GEOSS and GHG products

Integrate validation efforts to form prototype cal/val system

More product validation using existing validation sites will lead to robust products in NOAA operational products such as temp/water profiles in storm conditions

Integrate DMSP, GOES and EOS into sensor performance monitoring

DMSP microwave sounding instrument bias and anomaly correction algorithms are incorporated. GOES and EOS

An inter-sensor calibration system for monitoring sensor performance

NOAA POES instrument on-board performance can be monitored with inter-sensor and intra-sensor calibration, radiative transfer simulations. The anomaly can be captured in near-real time and the instrument biases can be corrected

Individual POES/GOES sensor calibration

Establish a basic infrastructure for operational POES instrument calibrations through on-board calibrators and vicarious technique for quantifying instrument noise and linear and non-linear calibration.

2005 2006 2007 2008 2009 2010 2011 2012

Global Ocean, Day and Night, BIAS