GSICS

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2010 Workshop on Climate Data Records from Satellite Microwave Radiometry
March 22-24, 2010 at the NOAA Science Center in Silver Spring, MD

Topics

- Overview of GSICS
- Examples of some current activities and techniques to establish high confidence
- Feedback from first GSICS User Workshop - (Microwave intercalibration request)

What is GSICS?

- **Global Space-based Inter-Calibration System (GSICS)**

- **Goal - Enhance calibration and validation of satellite observations and to intercalibrate critical components global observing system**

- **Part of WMO Space Programme**
  - GSICS Implementation Plan and Program formally endorsed at CGMS 34 (11/06)

Organizations contributing to GSICS

- **NOAA**
- **NIST**
- **NASA**
- **EUMETSAT**
- **CNES**
- **CMA**
- **JMA**
- **KMA**
- **WMO**

- **Official observers:**
  - JAXA
  - ESA

GSICS current focus is on the intercalibration of operational satellites, and makes use of key research instruments such as AIRS and MODIS to intercalibration the operational instruments

GSICS Mission

- To provide sustained calibration and validation of satellite observations

- To intercalibrate critical components of the global observing system to climate quality benchmark observations and/or reference sites

- To provide corrected observations and/or correction algorithms to the user community for current and historical data

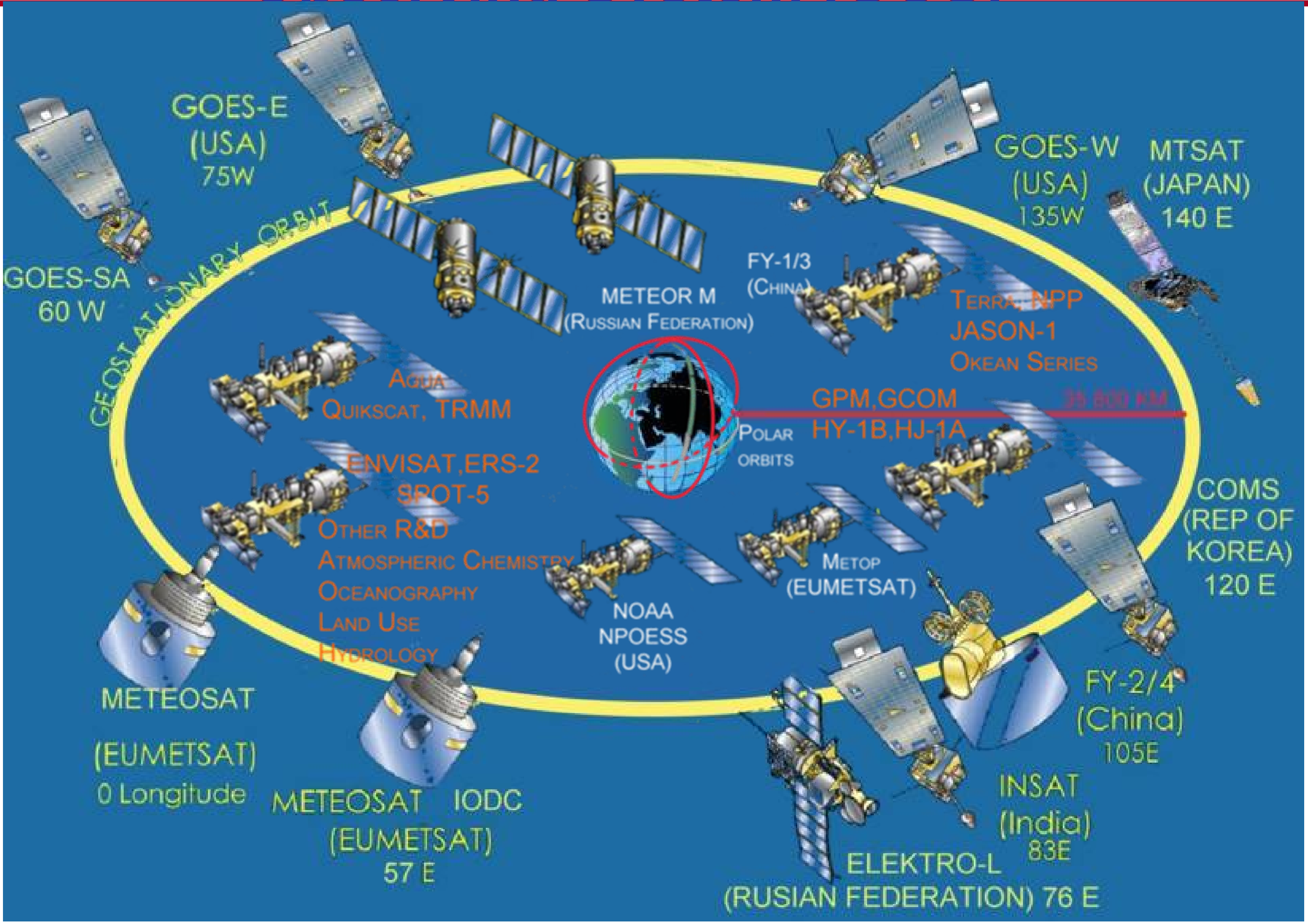
Or in technical terms:

- **Quantify the differences – magnitude and uncertainty**
- **Correct the differences – physical basis and empirical removal**
- **Diagnose the differences – root cause analysis**

Motivation

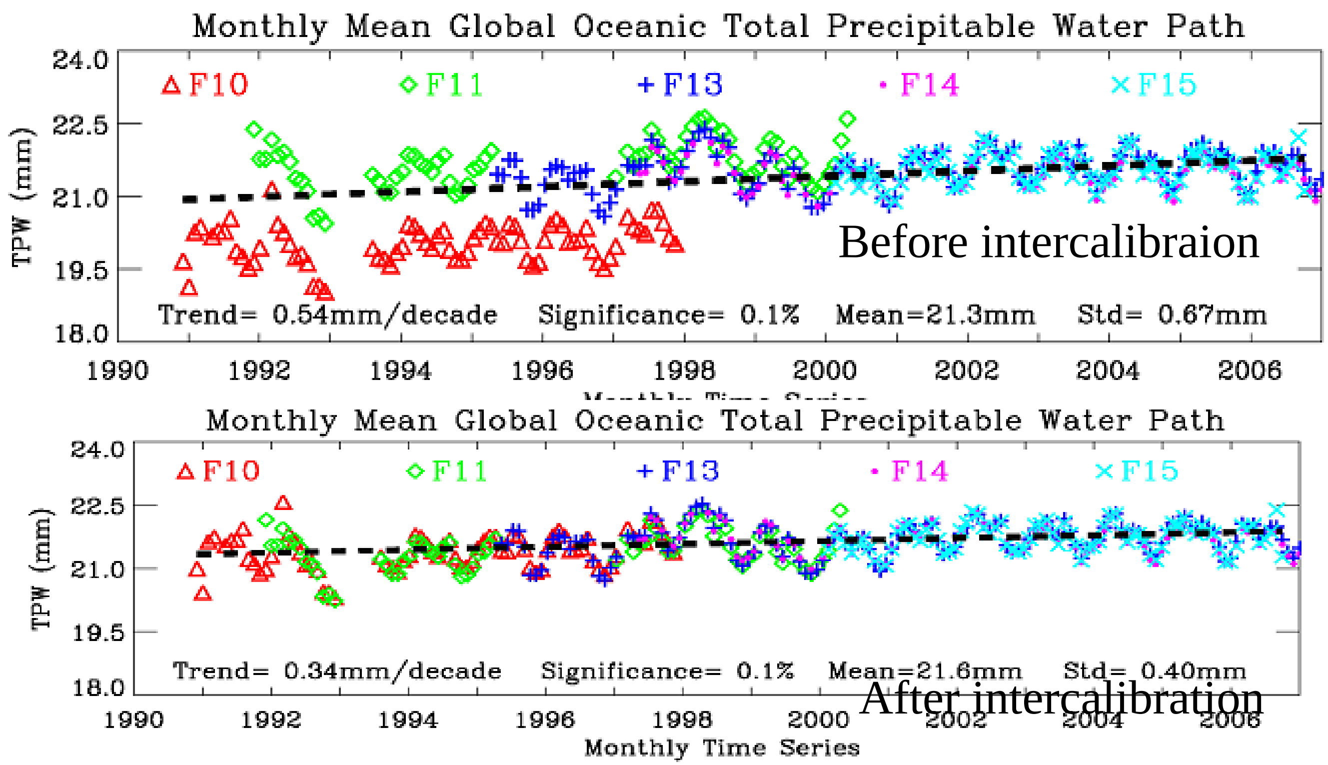
- **Demanding applications require well calibrated and intercalibrated measurements**
  - Climate Data Records
  - Radiance Assimilation in Numerical Weather Prediction
  - Data Fusion
- **Growing Global Observing System (GOS)**
- **Intercalibration of instruments achieves comparability of measurements from different instruments**

Space-Based component of the Global Observing System (GOS)



Intercalibration of instruments achieves comparability of measurements from different instruments

Calibration is Critical for Climate Change Detection



Trend of global oceanic total precipitable water decreases from 0.54 mm/decade to 0.34 mm/decade after intercalibrations! Calibration uncertainties translate to uncertainties in climate change detection

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Do we Care about Satellite Biases in NWP?

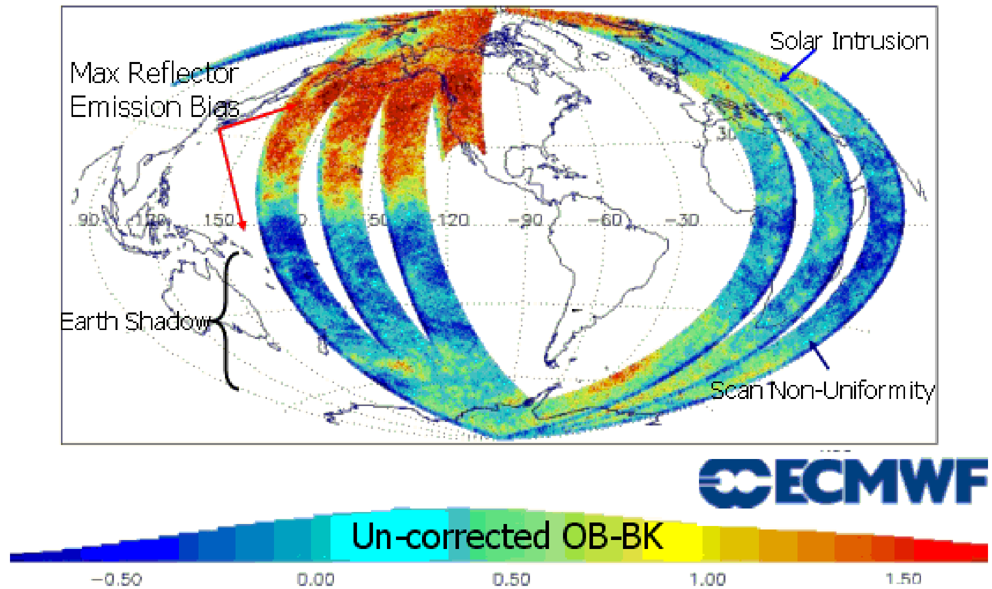
After McNally, Bell, et al. ECMWF, 2005 & 2009

Yes! Because:

1) We wish to understand the origin of the bias and ideally correct instrument / RT / NWP model at source

2) I*n principle* we do not wish to apply a correction to unbiased satellite data if it is the NWP model which is biased. Doing so is likely to:

- **Re-enforce the model bias** and degrade the analysis fit to other observations
- Produce a **biased analysis** (bad for re-analysis / climate applications)



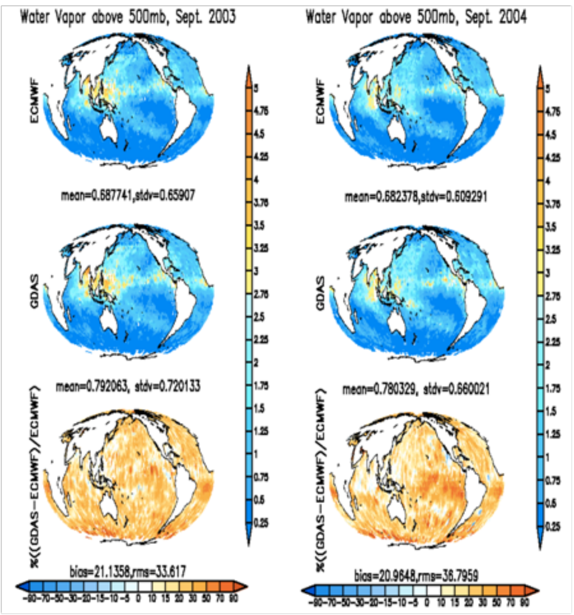
SSMIS calibration biases cause regional weather patterns

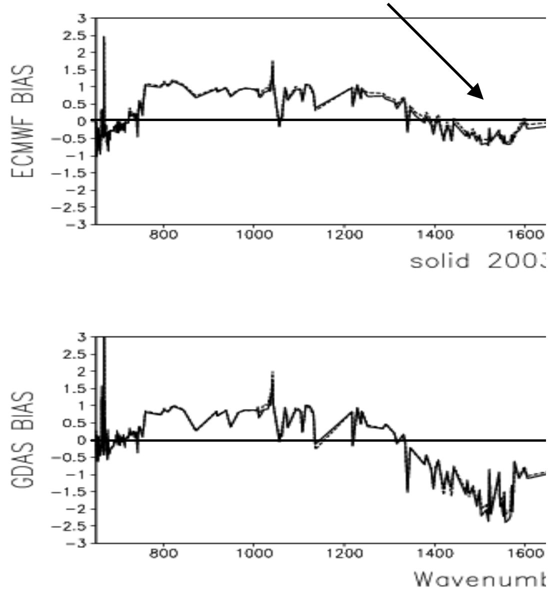
More accurate satellite observations will facilitate discovery of model errors and their correction. Additional gains in forecast accuracy can be expected.

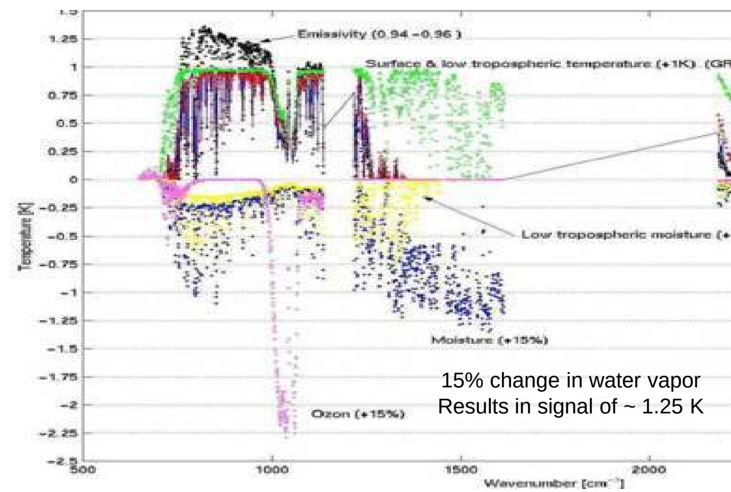
Bias free radiances important for NWP analyses

NCEP upper tropospheric water 20% higher than ECMWF, Which is right?

ECMWF computed radiances in water vapor band is 1.5 K closer agreement with AIRS than NCEP

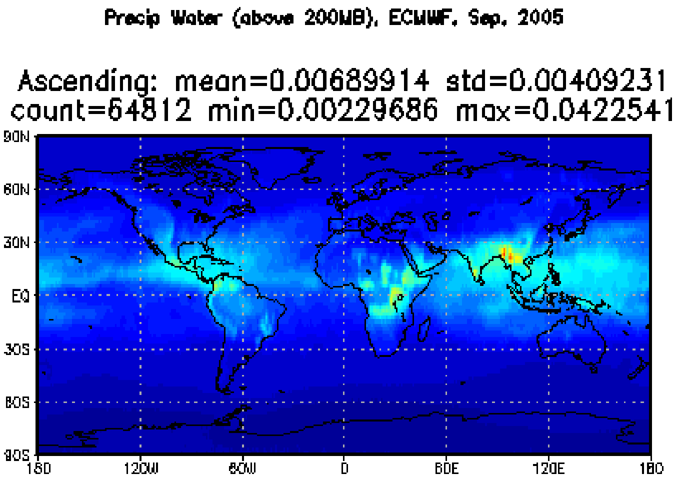


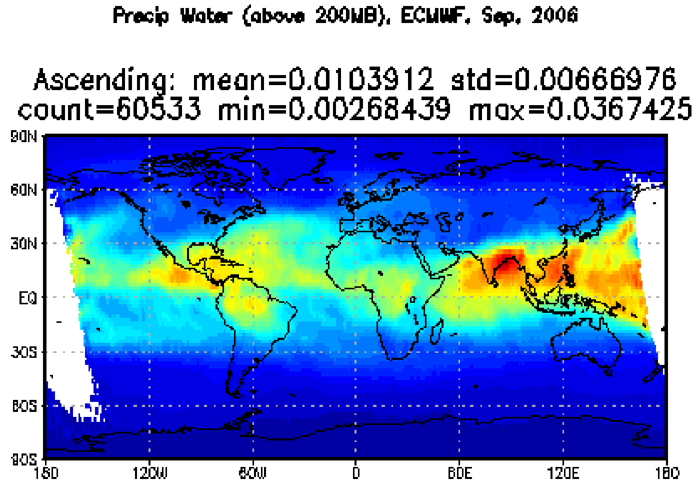


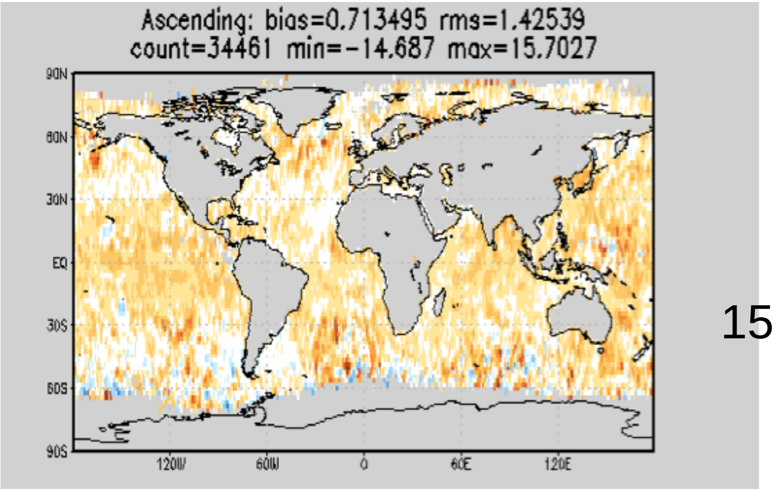


AIRS sensitivity to changes in geophysical parameters

ECMWF implemented adaptive bias correction of AIRS in 2006 which resulted in doubling water vapor in upper troposphere







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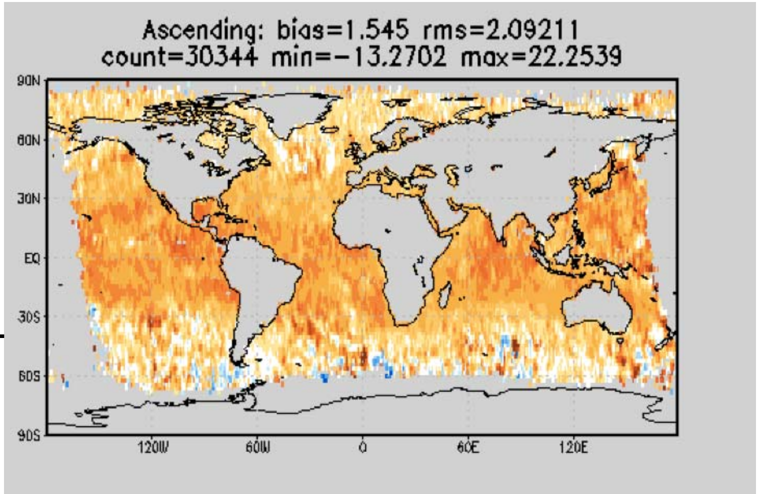
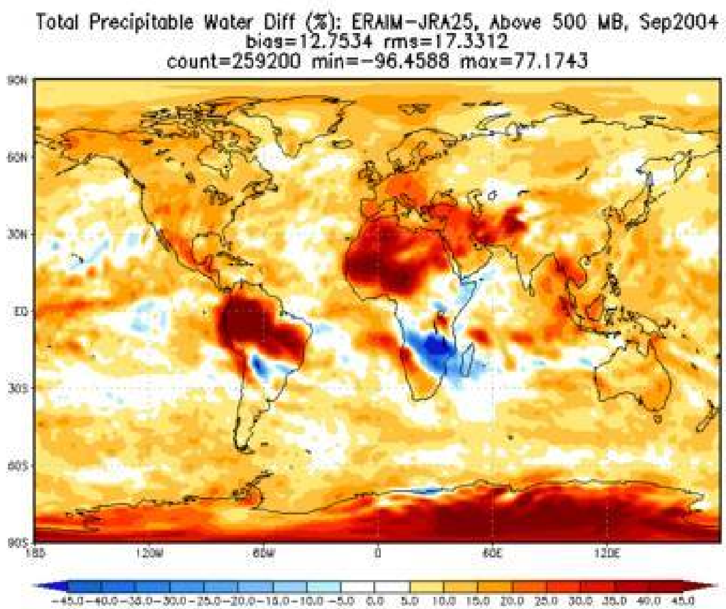
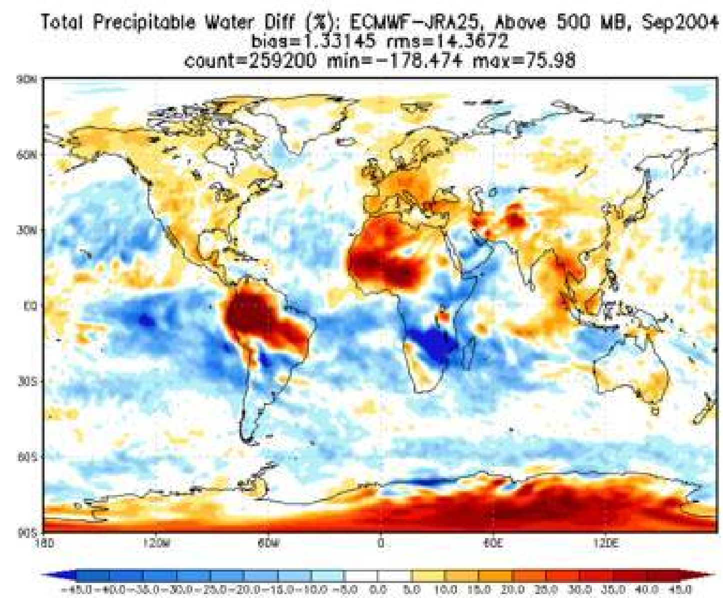


JRA25 vs ECMWF and ERA Interim (above 500 mb)

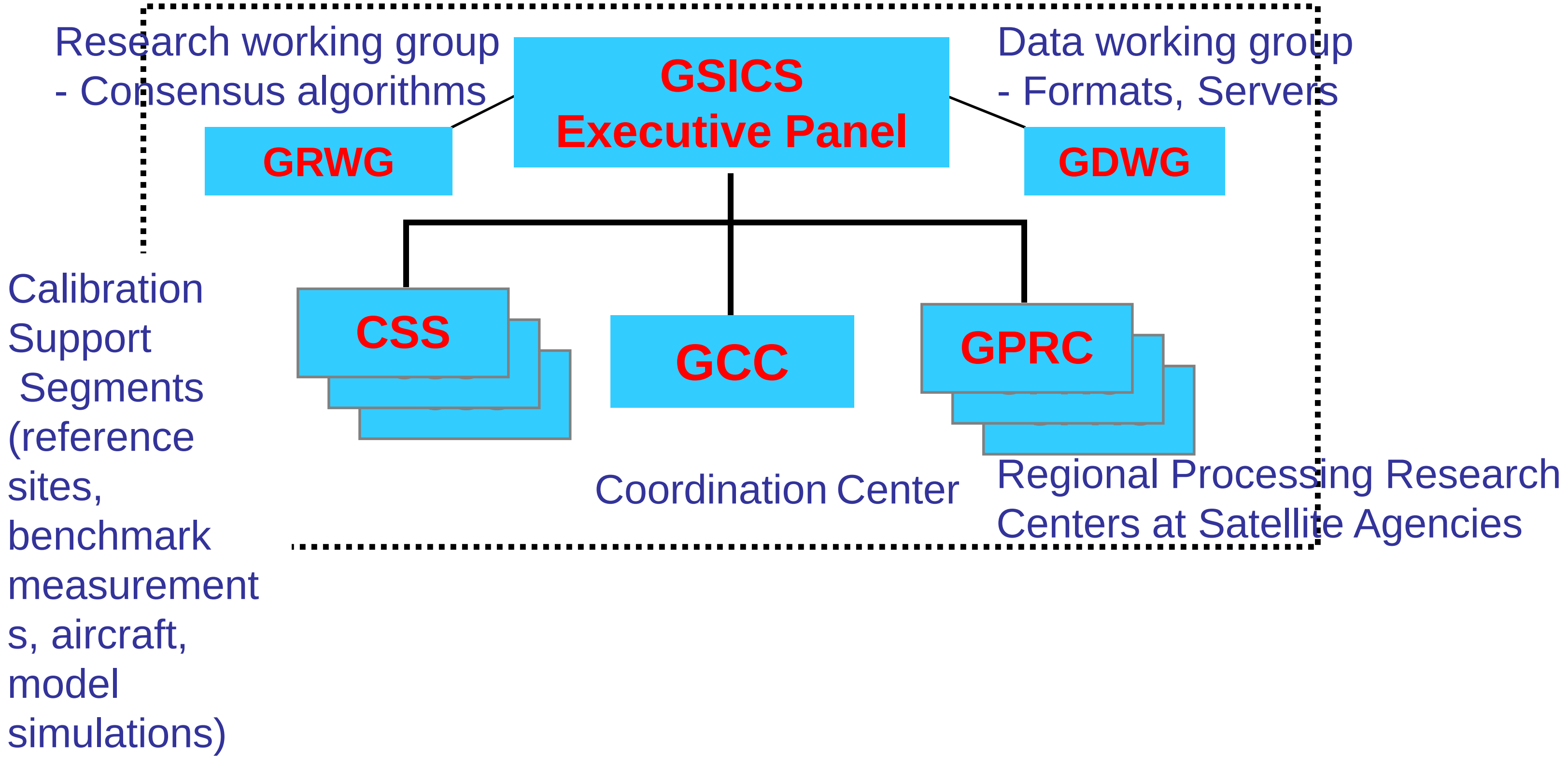


ERAIM - JRA25



ECMWF - JRA25

GSICS Organization



Current focus of GSICS

- **Interagency collaboration on algorithms (GRWG) and data (GDWG)**

- **Product acceptance and documentation requirements, metadata standards, data formats, website standards**

- **Routine intercalibration (monitor and correct) of all operational GEO Infrared imagers using IASI and AIRS**
  - MODIS and Deep Convective Clouds for visible channels

- **Intercalibration of LEO instruments**
  - HIRS, SSMI, AMSU, MHS, AVHRR, AIRS, IASI, FY3,
  - GOME-2, OMI, SBUV

- **Traceability**
  - Campaigns
  - Key collocation datasets
  - Requirements for pre-launch calibration

- **Root causes and corrections**

Best Practice Guidelines for Pre-Launch Characterization and Calibration of Instruments for Optical Remote Sensing

GSICS first guideline document

NISTIR XXXX

Best Practice Guidelines for Pre-Launch Characterization and Calibration of Instruments for Optical Remote Sensing

(Report to Global Space-based Inter-Calibration System (GSICS) Executive Panel, NOAA/NESDIS, World Weather Building, Camp Springs, Maryland 20746)

R. U. Datla, J. P. Rice, K. Lykke and B. C. Johnson
NIST Optical technology Division

J.J. Butler and X. Xiong
NASA Goddard Space Flight Center

January 2009

Integrated Cal/Val System Architecture

Calibration Opportunity Prediction

Data Acquisition Scheduler

Calibration Opportunity Register (COR)

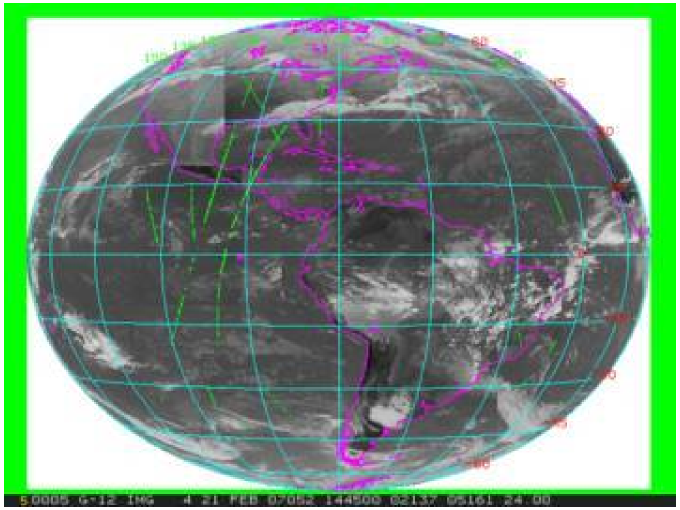
Raw Data Acquisition for Calibration Analyses

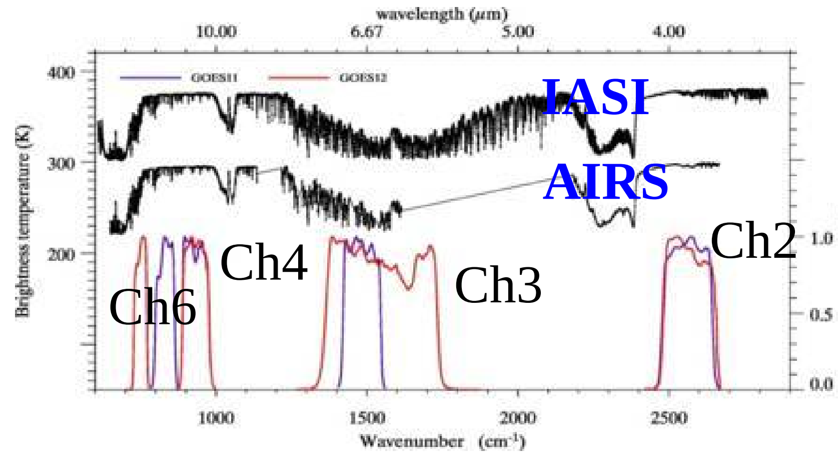
Store Raw Data for Calibration Analysis

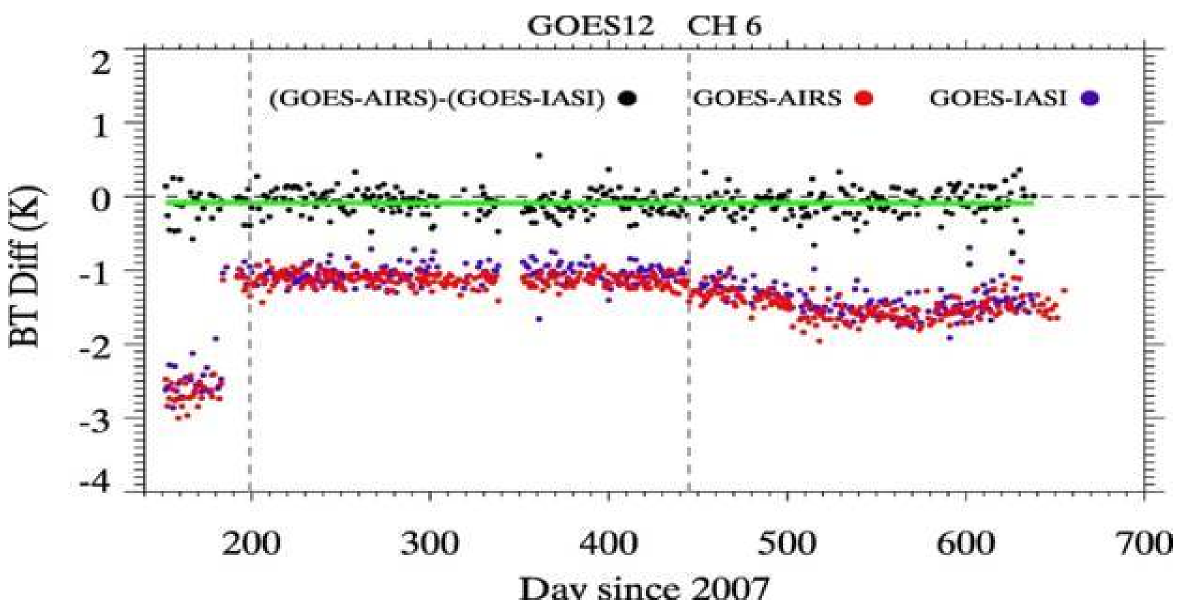
- SNO/ SCO Rad. Bias and Spectral Analysis
- Calibration Parameter Noise/ Stability Monitoring
- RTM Model Rad. at Calibration Reference Sites
- Inter-sensor Bias and Spectral Analysis
- Earth & Lunar Calibration
- Geolocation Assessment (Coastlines, etc.)

Assessment Reports and GSICS Corrections

First international coordinated GSICS project is the intercalibration of geostationary infrared channels with IASI and AIRS







Web Accessible

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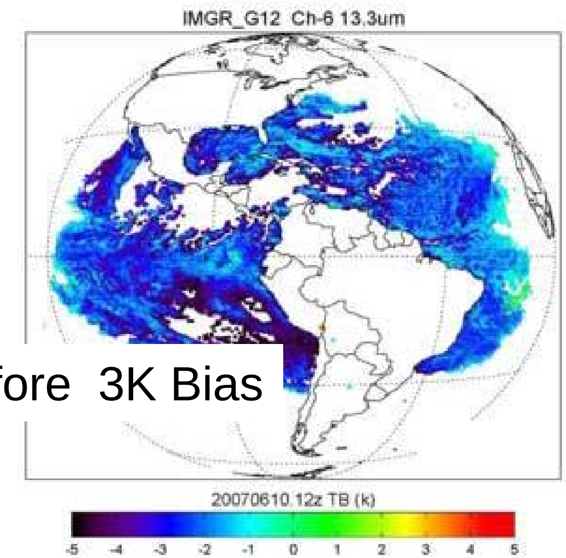
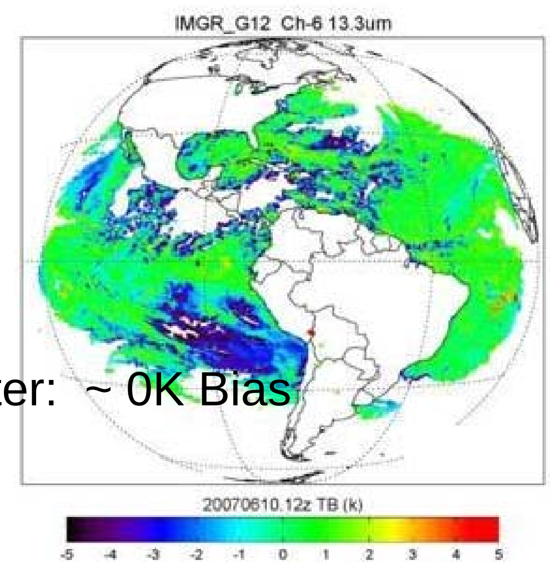
GSICS Correction Algorithm for Geostationary Infrared Imagers



Before 3K Bias



After: ~ 0K Bias

The first major deliverable to the user community is the GSICS correction algorithm for geostationary satellites.

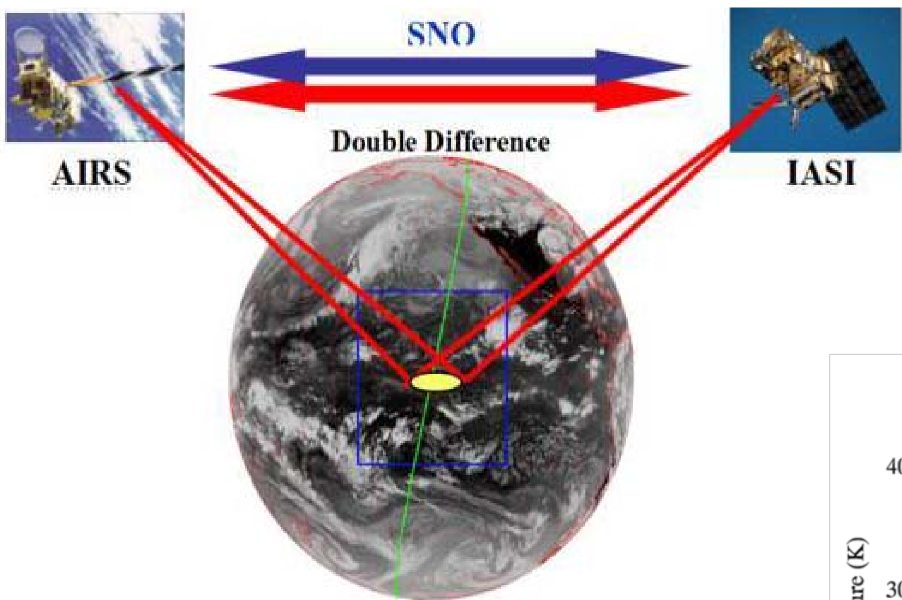
The user applies the correction to the original data using GSICS provided software and coefficients.

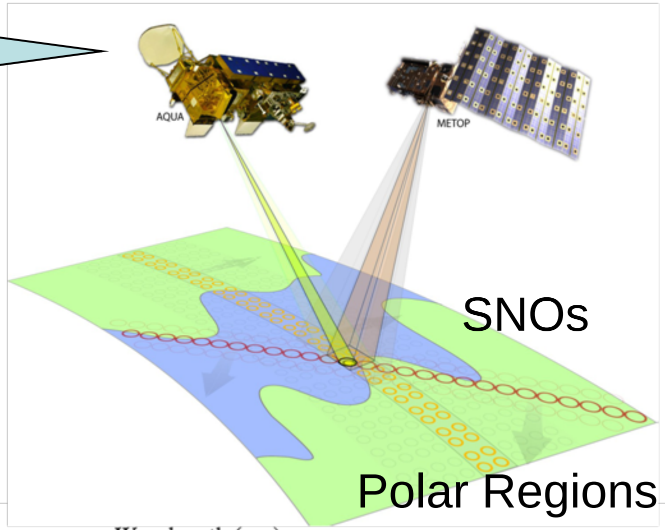
The correction adjusts the GOES data to be consistent with IASI and AIRS.

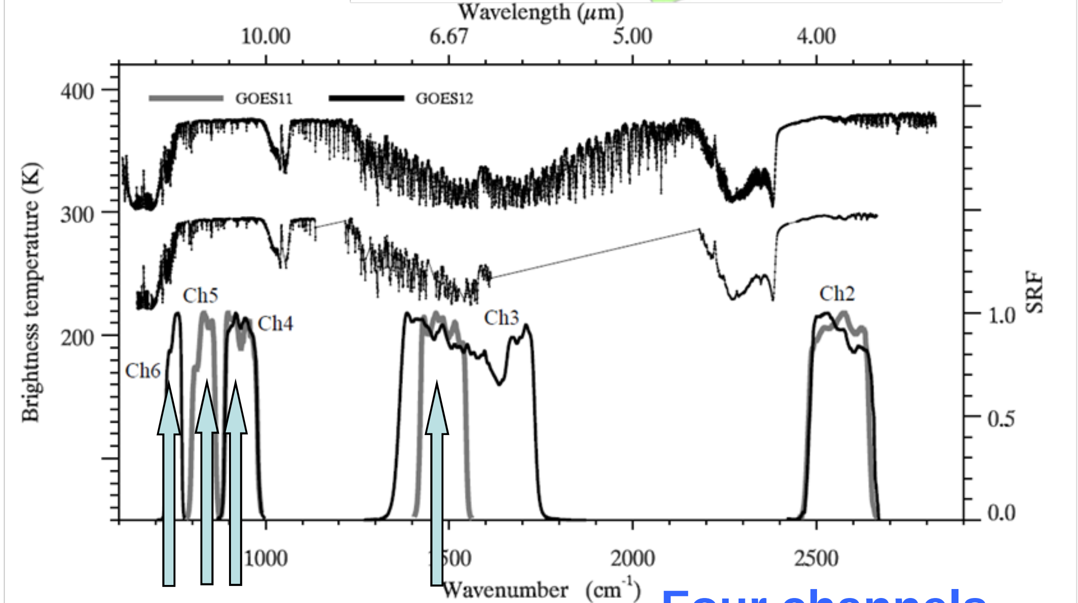
The figures to the left show the difference between observed and calculated brightness temperatures (from NCEP analysis) correction, respectively.

The bias is reduced from 3 K to nearly zero.

Double Difference versus SNOs



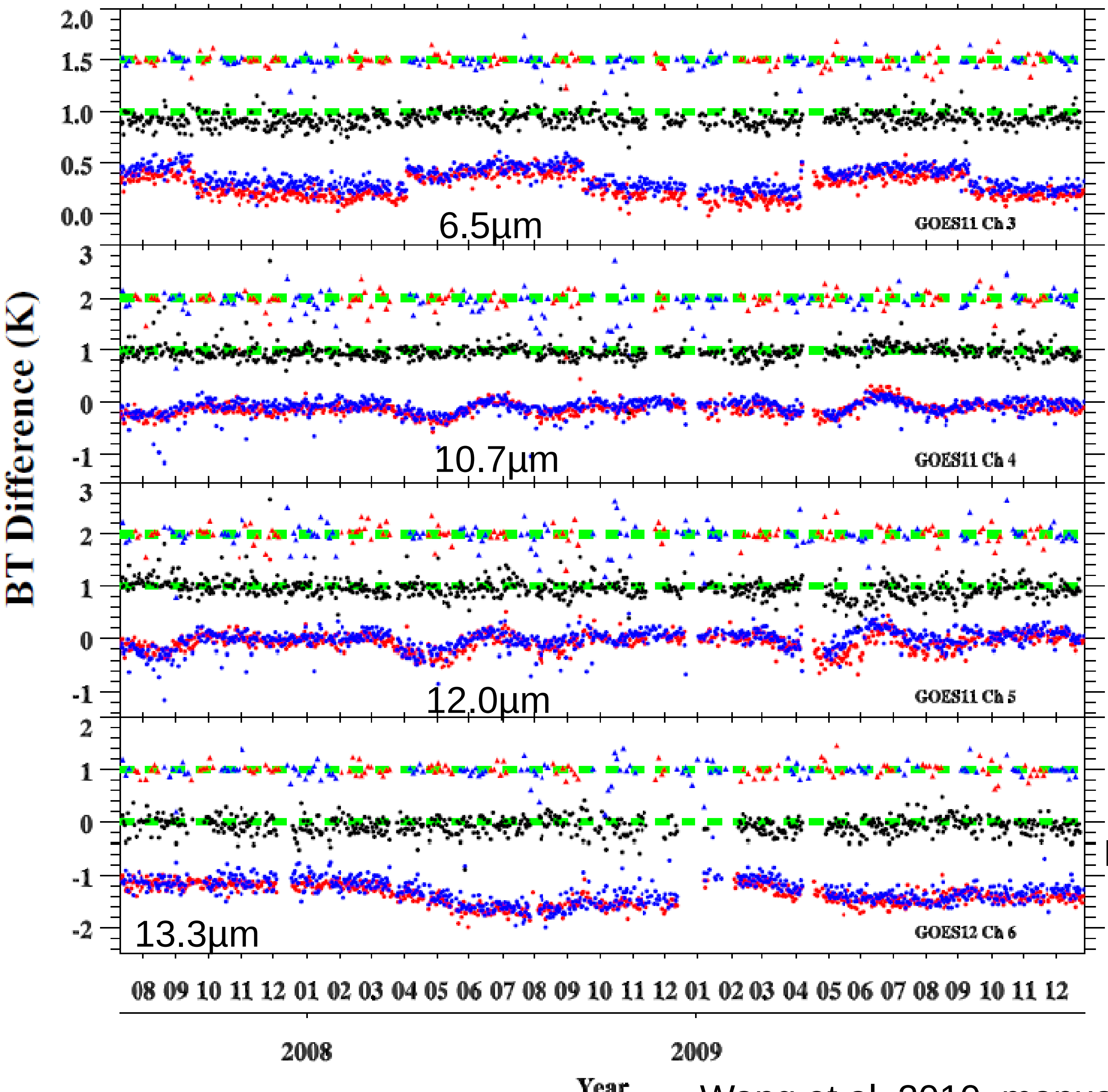




Four channels

1) Indirect vs. Direct comparison

2) Warm scenes vs. cold scenes



IASI-AIRS

Zero line

SNO North
SNO South

Double Difference

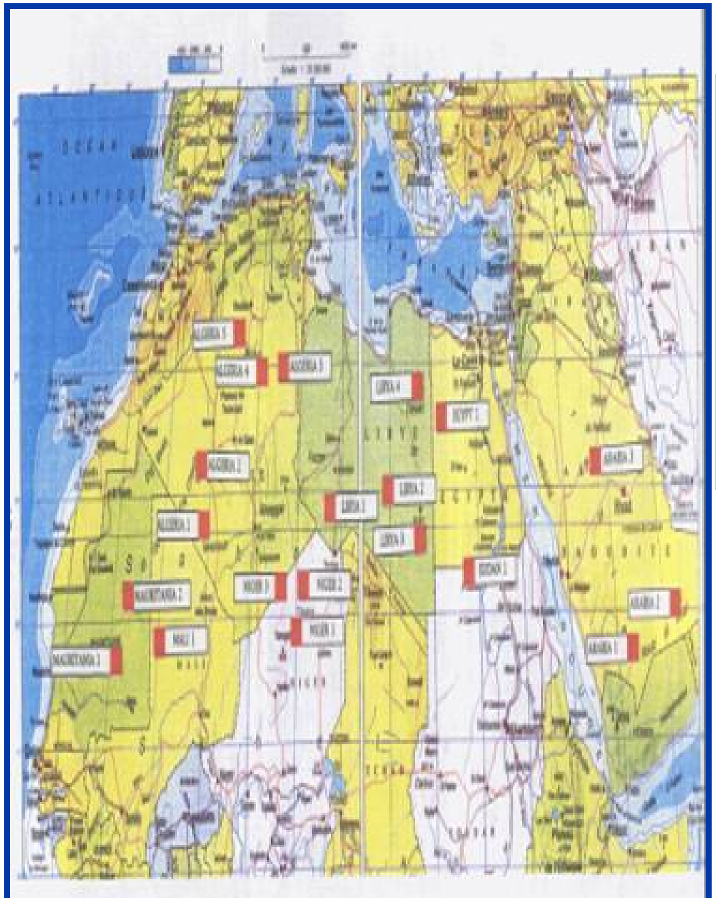
GOES-AIRS
GOES-IASI

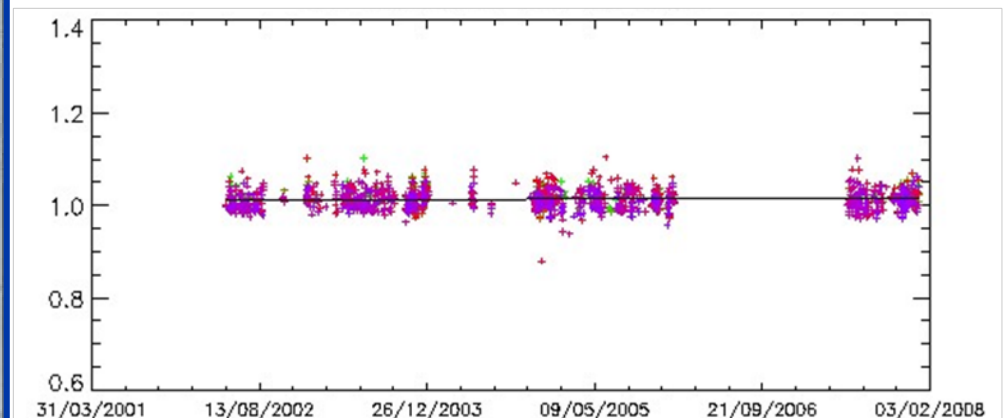
Wang et al. 2010, manuscript for GRL

Statistical results

		GOES-11 Ch3	GOES-11 Ch4	GOES-11 Ch5	GOES-12 Ch6
Central Wavelength (μm)		6.7	10.7	12.0	13.3
Double Differences	Sample number	694	688	691	626
	Mean (K)	-0.0707	-0.0262	-0.041	-0.0751
	95% confidence level (K)	0.0052	0.0116	0.0135	0.0124
SNOs	Sample number	228 *	228	228	228
	Mean (K)	-0.011	-0.0624	-0.010	-0.0124
	95% confidence level (K)	0.0091	0.0300	0.0295	0.0211

CNES SADE Data Base is critical for assessing stability of visible/near infrared reference instruments for intercalibration





Time series of the ratio of the ESA MERIS to NASA MODIS 0.665 micron visible channel reflectance from observations at 19 desert sites in North Africa and Saudi Arabia.

- **19 sites selected over North Africa and Arabia**

The results show very good agreement and stability between the two sensors

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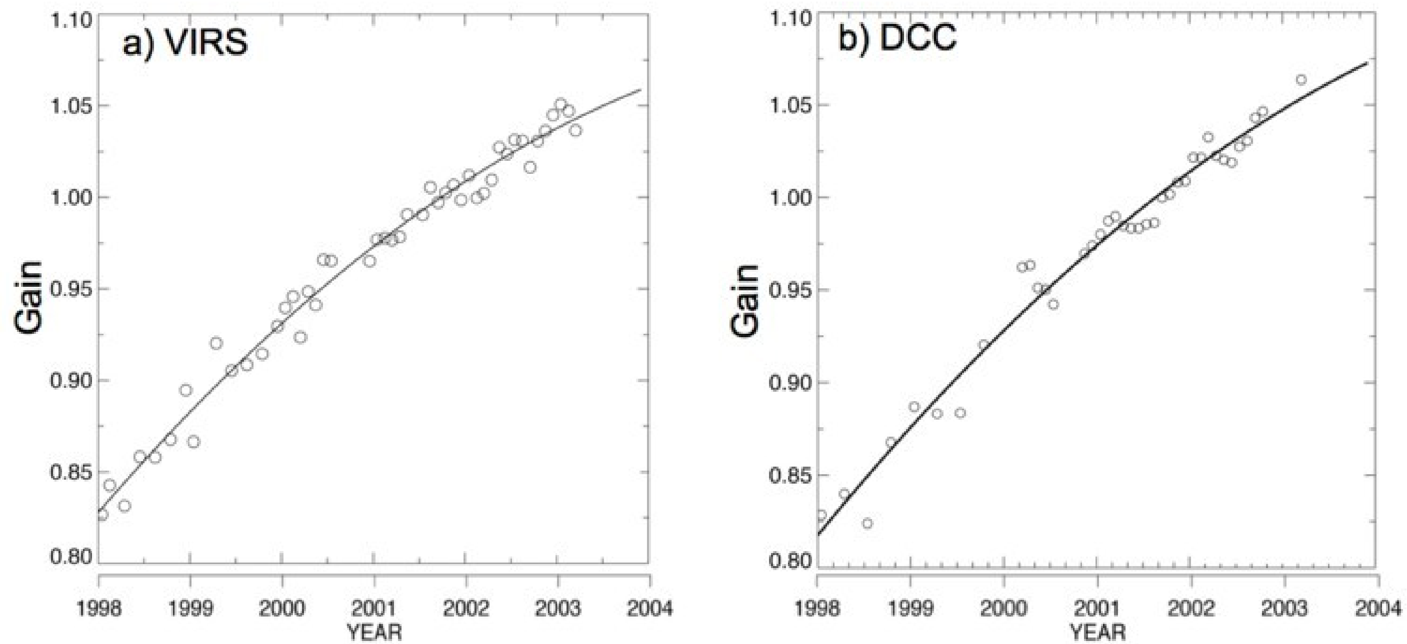
Use of Deep Convective Clouds to calibrated Visible and NIR channels



Monitoring of the GOES-8 visible (0.63µm) channel using the DCC and LEO/GEO inter-calibration methods.

The left panel (a) shows the GOES-8 visible gain during 1998 through 2003, based on the inter-calibration VIRS and GOES-8. The right panel (b) shows the relative DCC calibration, normalized to the VIRS/GOES-8 gain on January 2001, based on the degradation of the DCC visible digital counts over time.
A 2nd order regression is also plotted for each method. Note the excellent agreement between the two calibration methods.

Engage the User Community (first user meeting 9/09)

- Satellite Community – generation of CDRs
  - New WMO Space Programme SCOPE-CM
  - ISCCP
  - National programs - SDS, SAFs,
- Satellite Community - NWP direct radiance assimilation
- Reanalysis Community
  - Next reanalysis – 2012 - 2015
  - GSICS major deliverable - intercalibrated geostationary data using IASI/AIRS from 2003 – 2010+
- Satellite Acquisition Programs
  - Prelaunch instrument characterization guidelines
  - Cal/Val Plans

User feedback: Geostationary intercalibration, Microwave Intercalibration

User request for new GSICS Products

- **Microwave**
  Many of the attendees expressed a strong desire for GSICS to include products for the inter-calibration of microwave images and sounders. There is a great heritage of work in this area, so it was suggested that we invite researchers who have conducted independent reviews of the existing algorithms to a meeting, aiming to recommend a consensus method for each class of microwave radiometer. One outstanding issue is the definition of an inter-calibration reference for microwave instruments, given the absence of any traceable or hyperspectral observations on-orbit. [Suggested Action: GRWG to identify microwave experts and invite them to next GRWG meeting.]
- **Solar**
  Throughout the conference we heard a lot of interest (e.g. CLM SAF) in the calibration of the solar channels of GEO satellites – particularly MSG. Numerous different methods have been developed to inter-calibrate solar channels, many of which show evidence of biases in Meteosat and other GEO imagers. Within GSICS we need to define a consensus algorithm and inter-calibration reference for these channels. Potential references include MODIS, MERIS and GOME-2. [Suggested Actions: Invite experts on MERIS to next GRWG and focus the meeting on forming a consensus on solar inter-calibration method for GEO imagers.]

User request for new GSICS Products

- AVHRR Similarly, there was interest in including AVHRR. Although there are known deficiencies in its calibration, linearity and SRF definition, it is also widely used in the climate community because of its remarkably long data record. [Action: GRWG to review.]

- GEO-GEO The inter-calibration between different GEO imagers was also discussed. For IR channels this can be tackled by double-differencing using hyperspectral LEO sounders (or NWP models) as transfer radiometers, or by direct comparison of similar channels in overlapping areas. [Recommended Action: all GPRCs to pursue within GRWG.]

- GPS Radio-occultation It was suggested to investigate the use of GPS radio-occultation measurements in the future as an additional benchmark

- HEO missions Should the current plans for Highly Elliptical Orbit missions be confirmed, it would be useful to develop intercalibration methods for these missions.

Food for thought

- **Burden of proof**
- **Reference instruments and traceability are important for high confidence**
- **To reconcile differences start with simple cases**
  - – MSU -   Compare N10 to N14, ocean only

GSICS Outcome

- **Coordinated international intersatellite calibration program**
- **Exchange of critical datasets for cal/val**
- **Best practices/requirements for monitoring observing system performance (with CEOS WGCV)**
- **Best practices/requirements for prelaunch characterisation (with CEOS WGCV)**
- **Establish requirements for cal/val (with CEOS WGCV)**
- **Advocate for benchmark systems**
- **<u>Quarterly reports of observing system performance and recommended solutions</u>**
- **<u>Improved sensor characterisation</u>**
- **<u>High quality radiances for weather, climate & enviromental applications</u>**