Global Space-based Inter-Calibration System (GSICS)

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What is GSICS?

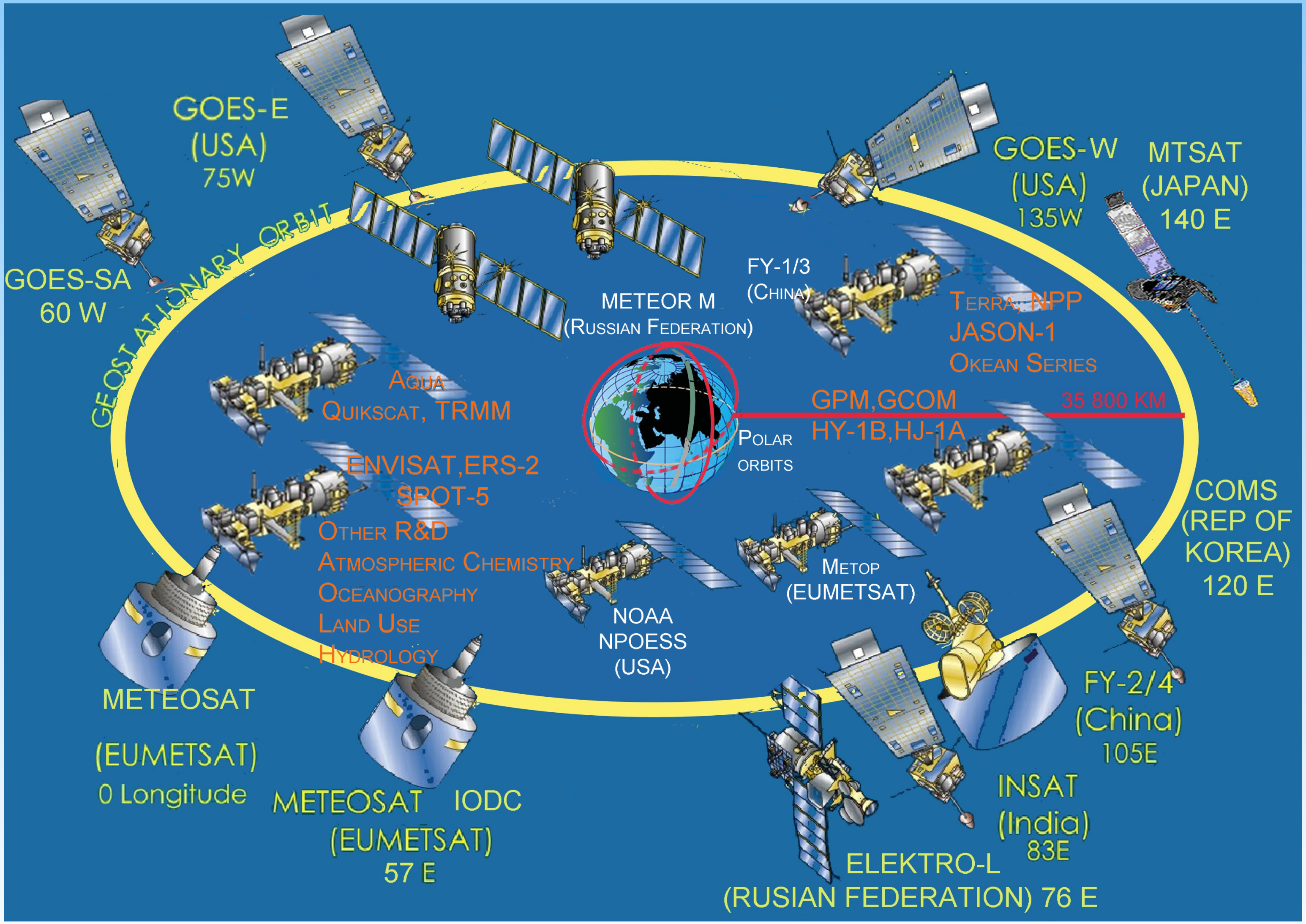
- Global Space-based Inter-Calibration System (GSICS)
- Goal - Enhance calibration and validation of satellite observations and to intercalibrate critical components global observing system
- Part of WMO Space Programme
  - GSICS Implementation Plan and Program formally endorsed at CGMS 34 (11/06)
- NOAA is the coordination center and chairs the GSICS Executive Panel

Organizations contributing to GSICS

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

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

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



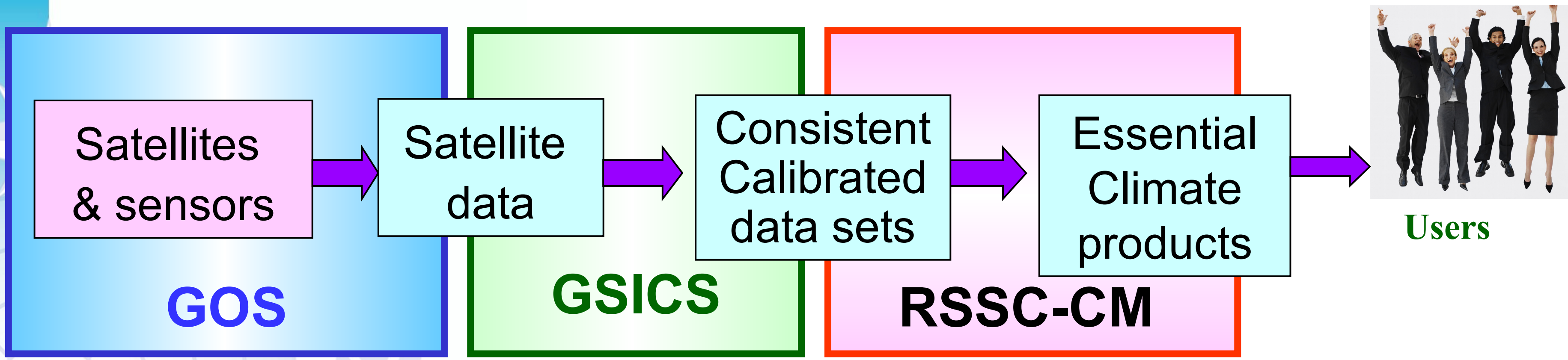
Motivation

- Demanding applications require well calibrated and intercalibrated measurements
  - Climate Data Records
  - Radiance Assimilation in Numerical Weather Prediction
  - Data Fusion
- Growing Global Observing System (GOS)
  - GEOSS

GSICS Objectives

- To improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of satellite sensors.
  - Observations are well calibrated through operational analysis of instrument performance, satellite intercalibration, and validation over reference sites
  - Pre-launch testing is traceable to SI standards
- Provide ability to re-calibrate archived satellite data with consensus GSICS approach, leading to stable fundamental climate data records (FCDR)

RSSC to maximize data usage



- Regional/Specialized Satellite Centres
  - Mobilize effort and expertise in some centres (or distributed virtual centres) to provide quality-controlled products following agreed specifications
  - Initial scope is Climate Monitoring (RSSC-CM) responding to GCOS requirements

GSICS 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

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

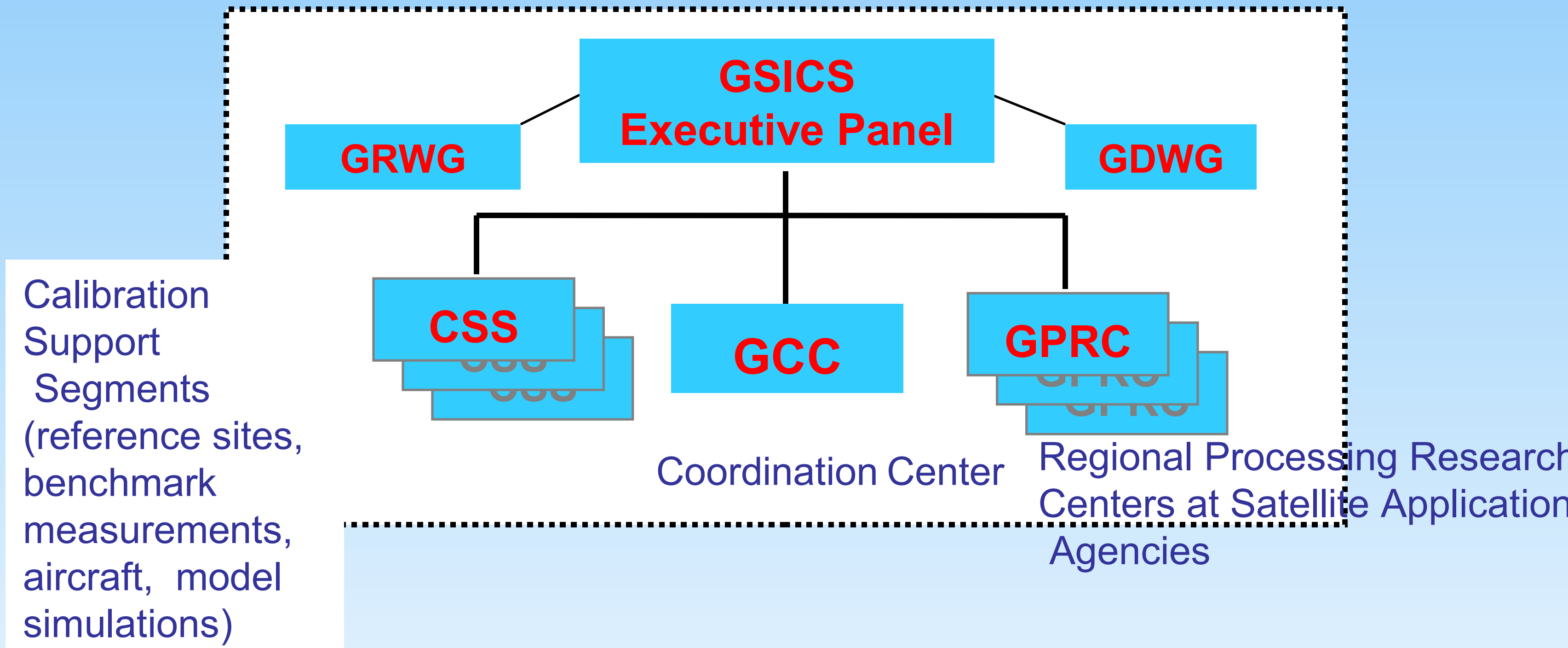
Other key building blocks for accurate measurements and intercalibration

- 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)

GSICS Organization



GSICS Executive Panel

Affiliation	Last Name	First Name
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CNES	Renaut	Didier
EUMETSAT	Schmetz	Johannes
JMA	Kurino	Toshiyuki
KMA	Ou	Mi-Lim
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WMO	Lafeuille	Jérôme
NASA	Butler	James
NIST	Datla	Raju

Affiliation	Last Name	First Name
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NOAA	Li	Yaping
NOAA	Sullivan	Jerry T. (GQ Co-Editor)
NOAA	Weng	Fuzhong (Director)

GSICS Data Working Group

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NOAA	Barkstrom	Bruce
NOAA	Jelenak	Aleksandar
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GSICS Research Working Group

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JMA	**Tahara**	**Yoshihiko**
KMA	Ahn	Myoung-Hwan
KMA	Chung	Sung-Rae
KMA	**Sohn**	**Byung-Ju**
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NASA	Minnis	Patrick
NASA	Nguyen	Louis
NASA	Xiong	Jack
NIST	Datla	Raju
NIST	Johnson	Carol
NOAA	Beck	Trevor
NOAA	Cao	Changyong
NOAA	Flynn	Larry
NOAA	Knapp	Ken
NOAA	Privette	Jeff
NOAA	Wang	Likun
NOAA	**Wu**	**Fred (Chair)**
NOAA	Yan	Banghua
NOAA	Yu	Fangfang
NOAA	Zou	Cheng-Zhi
SSEC	Tobin	David
WMO	Lafeuille	Jerome

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	Intra-sensor Bias and Spectral Analysis	Earth & Lunar Calibration	Geolocation Assessment (Coastlines, etc.)

Assessment Reports and Calibration Updates via website

2007 Activities

- Two Executive Panel meetings
- Annual Operating Plan
- Two GRWG meetings (chair, Fred Wu,NOAA)
  - Consensus algorithms for LEO to GEO intercalibration
- GDWG (chair, Volker Gaertner, EUMETSAT)
  - Data management issues, metadata
- Commissioned GSICS Website and routine LEO to LEO intersatellite calibration, with performance reports at NESDIS
- Routine Intercomparisons of AIRS and IASI
- Quarterly Newsletter

GSICS Quarterly

Global Space-based Inter-Calibration System

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

Vol. 1, No. 3, 2007

Robert A. Iacovazzi, Jr. and Jerry T. Sullivan, Co-Editors

GSICS LEO-LEO Inter-Calibration

In the past few years, estimation of post-launch inter-satellite calibration-related radiance biases between similar low-earth orbiting (LEO) satellite instruments has been improved substantially with the development of the Simultaneous Nadir Overpass/Simultaneous Conical Overpass (SNO/SCO) method (e.g., Cao and Heidinger 2002; Cao et al. 2004 and 2005). The essence of the SNO/SCO method is that similar space-borne radiometers flown on different LEO satellites periodically observe the same earth scene at the same time, which eliminates bias uncertainties related to meteorological evolution within the scene. The SNO/SCO method has been applied operationally to visible/near-infrared, infrared, and microwave radiometers on NOAA POES, EUMETSAT MetOp-A and NASA EOS Aqua satellites with excellent results, and is identified as an essential component of GSICS. In Figure 1, the SNO/SCO analysis is shown to be comprised of the following processes: SNO/SCO prediction; data access, subsetting, and collocation; and data analysis and plotting.

Since it is cumbersome to examine all data granules for SNO/SCO events, the Simplified General Perturbation Model Four (SGP4) and available satellite orbit ephemeris data are used to predict these events. From these predictions, it is found that the frequency of SNO/SCO events depends on the criteria of simultaneity and the nature of the orbital geometries and altitudes of a given pair of LEO satellites. Currently, a SNO/SCO is considered to occur if observations of a given scene by two satellite instruments on different polar-orbiting satellites are taken less than 30/60 seconds apart.

At the GSICS Coordination Center (GCC), access to operational satellite data is accomplished through a NOAA collaborative data environment, while research data sets are obtained through the host organization and stored locally on GCC computers for later use. Once the raw datasets are in place, data subsetting and collocation is an important next step in the process of SNO/SCO methodology.

For each SNO/SCO event, the data is subsetted near the point where the nadir tracks of the two spacecraft intersect. For the cross-track scanning instruments, data at SNO events are then collocated using either nearest-neighbor or bilinear interpolation collocation methods. The SCO observations are collocated using a new technique developed by Iacovazzi and Cao (2007) to reduce the effect of inhomogeneous surface properties on SCO observations at window channels.

After subsetting and collocation, individual SNO/SCO data analyses proceeds very quickly by finding the reflectance or brightness temperature bias between each pair of collocated data at an SNO/SCO, and then averaging these biases over the SNO/SCO region. Over time, as the population of SNO events from the two satellites increases, it becomes possible to compute SNO-ensemble average measurement biases and uncertainties, as well as other bias statistics. Currently, these statistics can be found in the "Science Pages" of the GSICS web site.

Predict SNO/SCO Events

SNO/SCO Event Register

Raw SNO/SCO Data Access/Subsetting/Collocation

Stored Raw Data for SNO/SCO Analysis

SNO/SCO Rad. Bias Analysis

SNO/SCO Estimated Bias Plots and Tables

Figure 1: Process of estimating inter-satellite calibration biases using the SNO/SCO method.

Acknowledgements: GSICS LEO-LEO SNO/SCO satellite data inter-comparisons have been made possible with the help of Drs. Changyong Cao, Pubu Ciren, Sunwook Hong, Robert Iacovazzi, Jr., Yaping Li, Haibing Sun, Ninghai Sun, Likun Wang, Fuzhong Weng, and Banghua Yan.

Simultaneous Nadir Overpass (SNO) Method
-a core component in the Integrated Cal/Val System

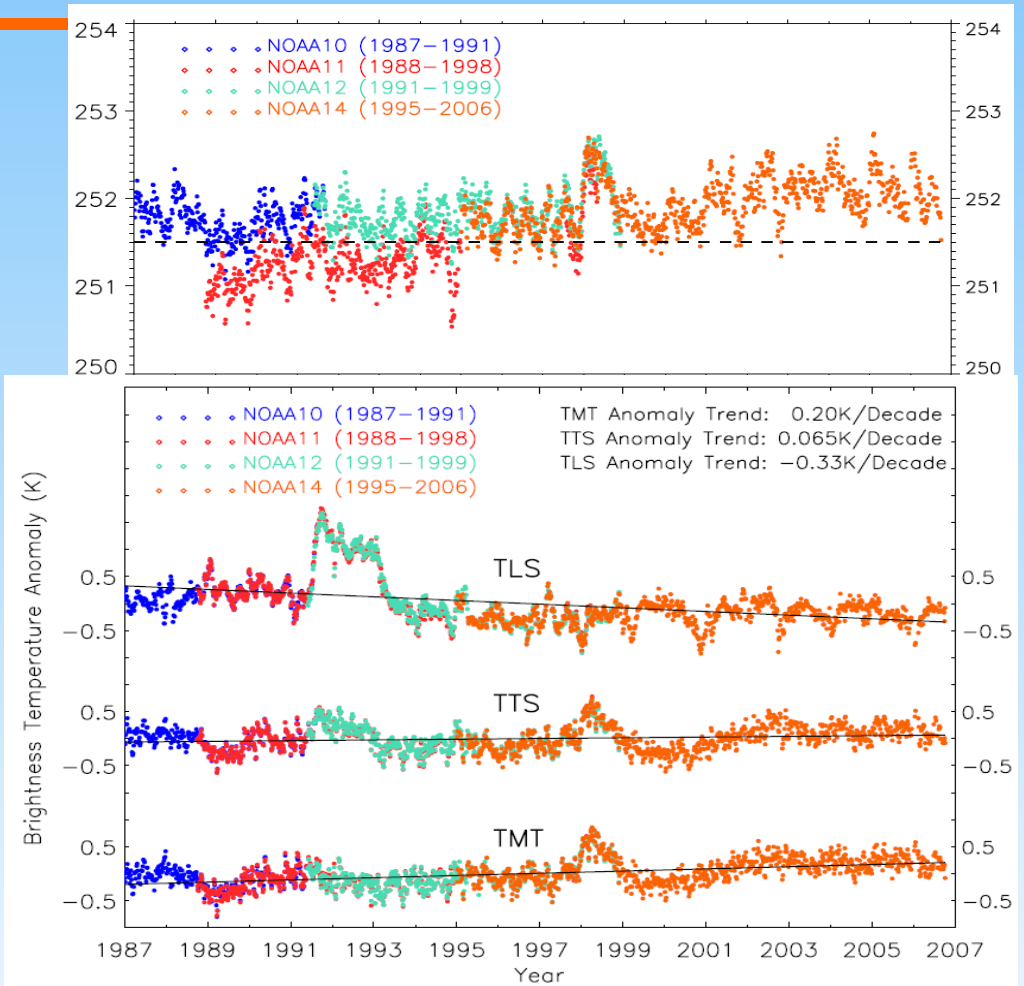
POES intercalibration

- 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

- 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

Satellite Intercalibration improves MSU time series

- NESDIS/STAR completed a recalibration on the MSU atmospheric channels for NOAA 10 to 14
- The current MSU data are well merged and provide accurate climate trend values.
- The radiance data are well merged for assimilation in reanalysis systems.



Top: Ocean-averaged MSU channel 2 time series for NOAA 10, 11, 12, and 14 for 1987-2007 before the SNO calibration; Bottom: Anomaly time series for MSU channels 2, 3, and 4 after the SNO recalibration. The abbreviations Middle Troposphere, Temperature Tropopause and Stratosphere TMT, TTS, and TLS refer respectively to Temperature, and Temperature Lower Stratosphere.

Intersatellite bias removal among the NOAA MSU instruments are crucial for climate trend detection.

Courtesy of C. Zou

Global Space-Based Inter-Calibration System

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000149

Number of Visitors since Aug. 27, 2007

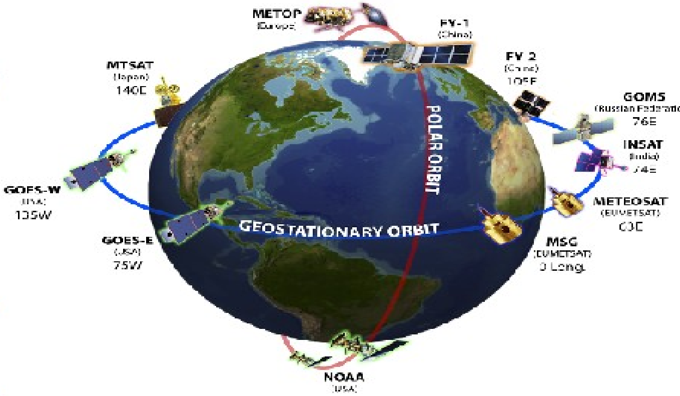
Mission:

Assure high-quality, inter-calibrated measurements from the international constellation of operational satellites to support the GEOSS goal of increasing the accuracy and interoperability of environmental products and applications for societal benefit.

Goals:

The primary goal of GSICS is to improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of the space component of the WMO World Weather Watch (WWW) Global Observing System (GOS) and Global Earth Observing System of Systems (GEOSS). The basic GSICS strategies to achieve this goal are:

- To establish a GSICS Virtual Library to efficiently share information, software and data relevant to calibration;
- To build collaborations ensuring that each satellite instrument meets specifications by making pre-launch tests traceable to SI standards;
- To improve on-orbit calibration of satellite instrument observations by means of an integrated cal/val system, including instrument performance monitoring, inter-satellite/inter-sensor calibration, lunar and stellar calibration, vicarious calibration and validation with reference sites;
- To establish a distributed research component and a plan for research to operations transition;
- To build collaborations to retrospectively re-calibrate archive satellite data using the operational inter-calibration system in order to make satellite data archives worthy for NWP forecasts and climate studies.



Satellite Inter-Calibration

LEO - LEO

- Microwave Sounder
- Microwave Imager
- Infrared Sounder
- VIS/IR Imager
- Method and Result Documentation

GEO -LEO

- Infrared Sounder
- VIS/IR Imager
- Method and Result Documentation

Microwave Sounder 🟢 :Active ⚫ : Inactive

	NOAA 9	NOAA 10	NOAA 11	NOAA 12	NOAA 14	NOAA 15	NOAA 16	NOAA 17	NOAA 18	Metop-A	Aqua
NOAA 9		⚫	⚫	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NOAA 10			⚫	⚫	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NOAA 11				⚫	⚫	N/A	N/A	N/A	N/A	N/A	N/A
NOAA 12					⚫	⚫	⚫	N/A	N/A	N/A	N/A
NOAA 14						⚫	⚫	⚫	⚫	⚫	⚫
NOAA 15							🟢	🟢	🟢	🟢	⚫
NOAA 16								🟢	🟢	🟢	⚫
NOAA 17									⚫	⚫	⚫
NOAA 18										🟢	🟢
Metop-A											🟢
Aqua											

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National Environmental Satellite, Data, and Information Service

Intersatellite Instrument Characteristics

POES NOAA18 AMSU-A and Metop-A AMSU-A

AMSUA

Tb Bias vs. Date

AMSU (57.252 GHz)

Show Plot

Tb Bias vs. Tb

AMSU (57.252 GHz)

Show Plot

Individual Inter-cal Event Distribution Statistics Table

AMSU (57.252 GHz)

Show Table

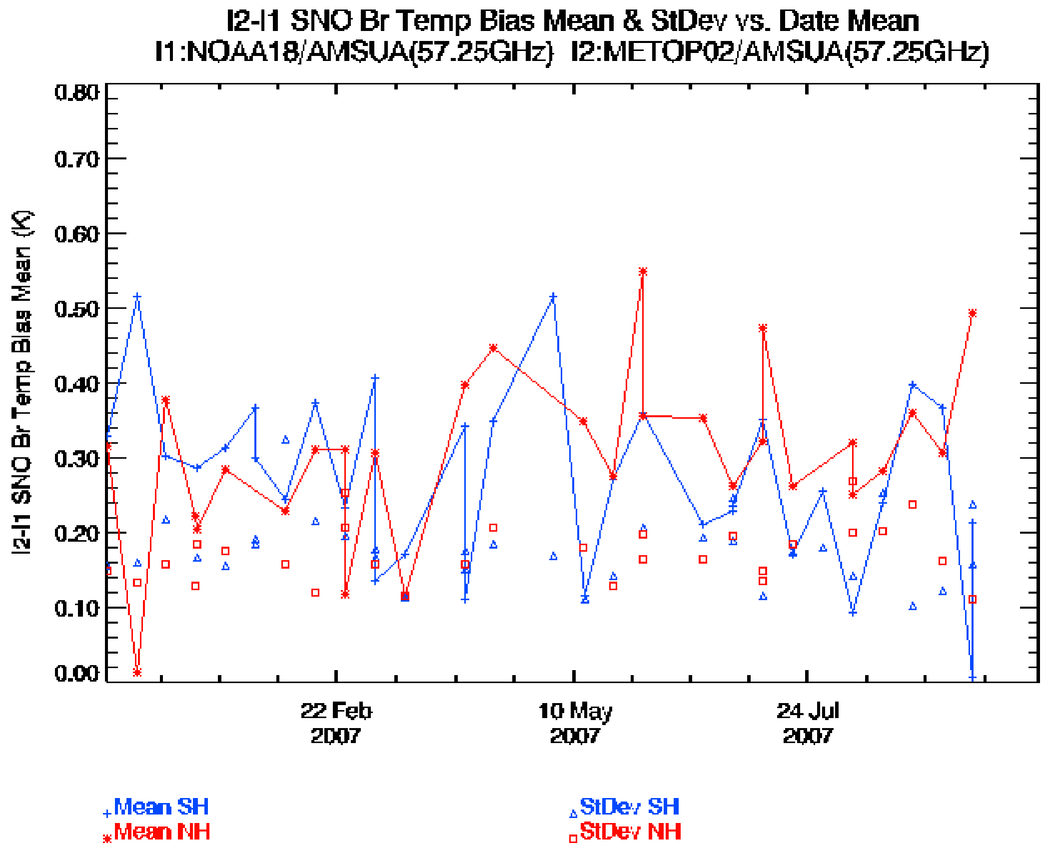
Individual Inter-cal Event Covariance Statistics Table

AMSU (57.252 GHz)

Show Table

Ensemble Statistics Table

Show Table



LEO-LEO SNO Ensemble Statistics

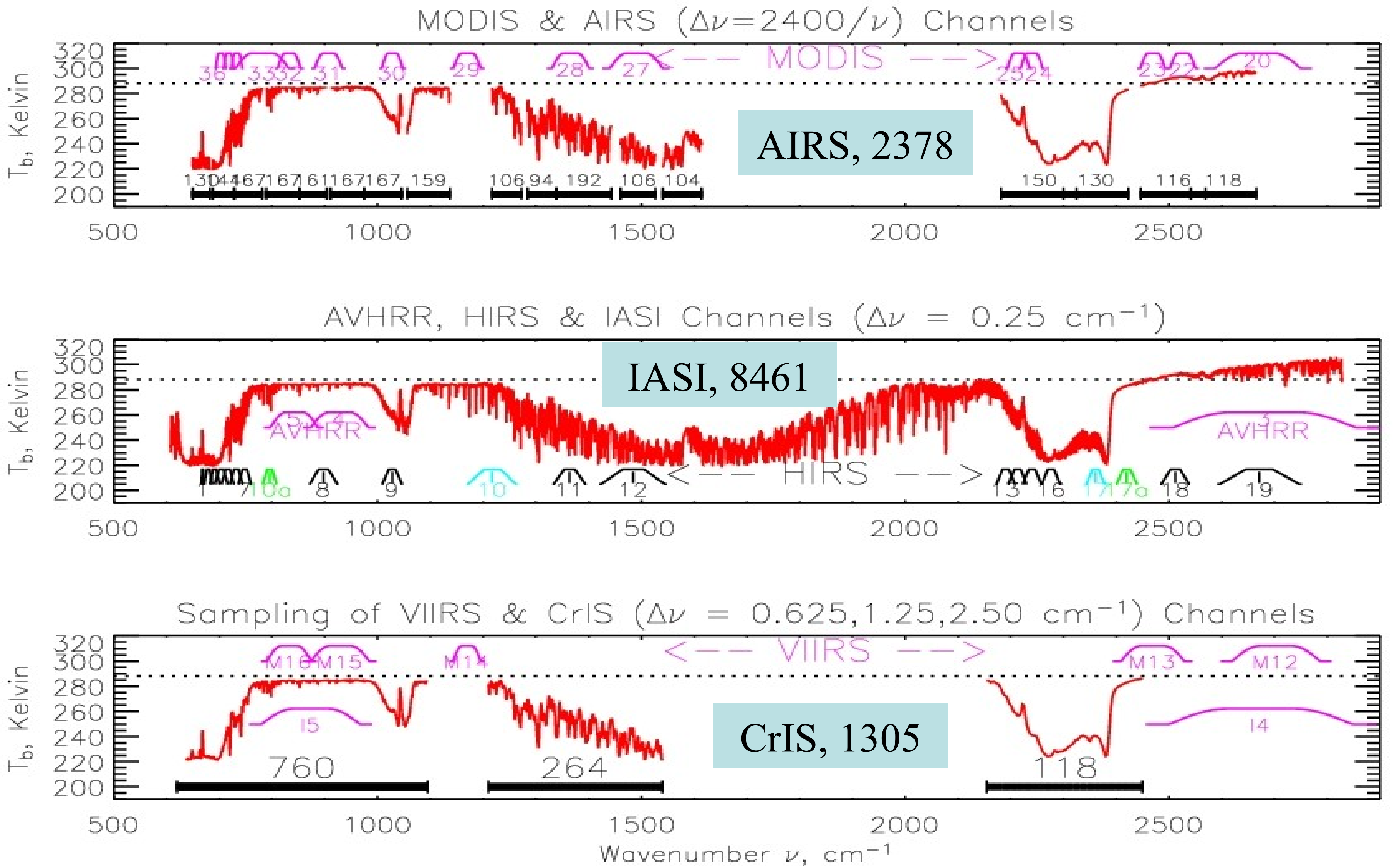
Satellite 1: NOAA18 Satellite 2: METOP02

Instrument 1: AMSUA Instrument 2: AMSUA

Ch_I1	Ch_I2	Parameter	Hemis	#SNOs	Average	StandDev	GaussDist	Sig_Avg	Trend_Param(t)	Sig_Trend	Slope_Param(BrT/Refl)	Sig_Slope	Avg_I1(BrT/Refl)	Avg_I2(BrT/Refl)	Avg_delTime	Avg_delLoc
00001	00001	BrTempBias	South	31	0.504	0.941	Yes	no@99%	-2.930	no@99%	-1.6185E-02	no@99%	202.244	202.748	15.3	19.69
00002	00002	BrTempBias	South	31	0.473	0.966	No	no@99%	-2.190	no@99%	-1.8961E-02	yes@99%	201.121	201.595	15.3	19.69
00003	00003	BrTempBias	South	32	-0.200	0.536	Yes	no@99%	-5.857	yes@99%	5.1997E-03	no@99%	218.958	218.759	15.3	19.69
00004	00004	BrTempBias	South	32	-0.226	0.201	Yes	yes@99%	-2.822	yes@99%	6.3014E-03	yes@99%	230.785	230.559	15.3	19.69
00005	00005	BrTempBias	South	32	-0.230	0.165	No	yes@99%	-1.698	yes@99%	9.3951E-03	yes@99%	230.518	230.288	15.3	19.69
00006	00006	BrTempBias	South	32	0.078	0.094	No	yes@99%	-1.668	yes@99%	7.4439E-03	yes@99%	223.174	223.251	15.3	19.69
00007	00007	BrTempBias	South	32	0.291	0.084	No	yes@99%	-0.649	no@99%	1.8069E-03	no@99%	216.976	217.267	15.3	19.69
00008	00008	BrTempBias	South	32	0.187	0.094	Yes	yes@99%	0.907	yes@99%	-2.0781E-03	no@99%	213.513	213.700	15.3	19.69
00009	00009	BrTempBias	South	32	0.273	0.116	No	yes@99%	-1.634	yes@99%	1.6123E-03	no@99%	210.095	210.369	15.3	19.69
00010	00010	BrTempBias	South	32	0.369	0.138	No	yes@99%	-0.530	no@99%	4.9849E-04	no@99%	210.686	211.054	15.3	19.69
00011	00011	BrTempBias	South	32	0.366	0.147	Yes	yes@99%	-1.314	yes@99%	5.1872E-04	no@99%	213.685	214.051	15.3	19.69
00012	00012	BrTempBias	South	32	0.230	0.145	No	yes@99%	-1.222	no@99%	4.8267E-04	no@99%	221.238	221.469	15.3	19.69
00013	00013	BrTempBias	South	32	0.130	0.222	Yes	no@99%	-2.263	yes@99%	-8.9412E-04	no@99%	233.044	233.174	15.3	19.69
00014	00014	BrTempBias	South	32	0.023	0.380	No	no@99%	1.305	no@99%	-3.1174E-03	no@99%	246.620	246.643	15.3	19.69
00015	00015	BrTempBias	South	32	0.089	1.104	Yes	no@99%	-9.018	no@99%	-2.0378E-03	no@99%	203.449	203.537	15.3	19.69
00001	00001	BrTempBias	North	29	0.278	1.493	No	no@99%	12.175	no@99%	-6.1263E-03	no@99%	214.128	214.406	16.0	19.67
00002	00002	BrTempBias	North	29	0.244	1.593	No	no@99%	13.848	no@99%	-8.5765E-03	no@99%	213.032	213.276	16.0	19.67
00003	00003	BrTempBias	North	29	-0.350	0.503	No	yes@99%	-6.933	no@99%	-1.4771E-02	yes@99%	234.872	234.521	16.0	19.67
00004	00004	BrTempBias	North	29	-0.099	0.136	Yes	yes@99%	-2.446	no@99%	-3.2917E-03	no@99%	245.023	244.924	16.0	19.67
00005	00005	BrTempBias	North	29	-0.124	0.108	Yes	yes@99%	-1.005	no@99%	-3.1786E-03	no@99%	241.009	240.886	16.0	19.67
00006	00006	BrTempBias	North	29	0.103	0.077	No	yes@99%	-0.262	no@99%	8.5038E-04	no@99%	230.615	230.719	16.0	19.67
00007	00007	BrTempBias	North	29	0.336	0.072	No	yes@99%	0.565	no@99%	1.1509E-03	no@99%	224.128	224.464	16.0	19.67
00008	00008	BrTempBias	North	29	0.207	0.086	Yes	yes@99%	0.205	no@99%	3.3178E-04	no@99%	221.386	221.593	16.0	19.67
00009	00009	BrTempBias	North	29	0.304	0.113	No	yes@99%	1.940	no@99%	6.5323E-04	no@99%	219.825	220.129	16.0	19.67
00010	00010	BrTempBias	North	29	0.346	0.114	Yes	yes@99%	1.512	no@99%	1.3000E-03	no@99%	221.043	221.389	16.0	19.67
00011	00011	BrTempBias	North	29	0.403	0.148	Yes	yes@99%	1.642	no@99%	-1.7633E-04	no@99%	224.738	225.141	16.0	19.67
00012	00012	BrTempBias	North	29	0.247	0.239	Yes	yes@99%	0.201	no@99%	-2.4013E-03	no@99%	232.296	232.543	16.0	19.67
00013	00013	BrTempBias	North	29	0.195	0.284	No	yes@99%	-3.925	no@99%	-1.2264E-02	yes@99%	243.009	243.204	16.0	19.67
00014	00014	BrTempBias	North	29	0.102	0.541	No	no@99%	-5.361	no@99%	-2.5504E-02	yes@99%	253.781	253.884	16.0	19.67
00015	00015	BrTempBias	North	29	0.123	1.217	No	no@99%	-22.803	no@99%	-2.2769E-02	no@99%	222.534	222.657	16.0	19.67

32 SNOs, BIAS 0.27 K, STDV 0.116 …….. Avg Time Dif 15.3 secs, Avg Dist 19.7 km

Routine Intercalibration of AIRS and IASI

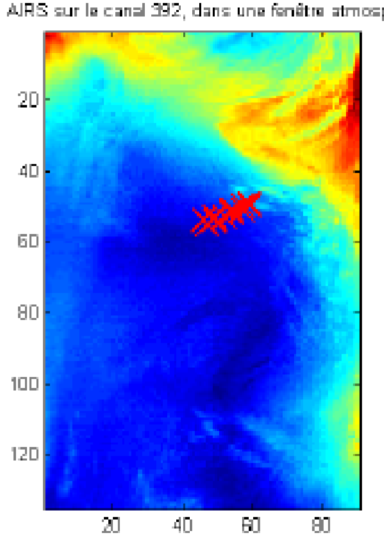


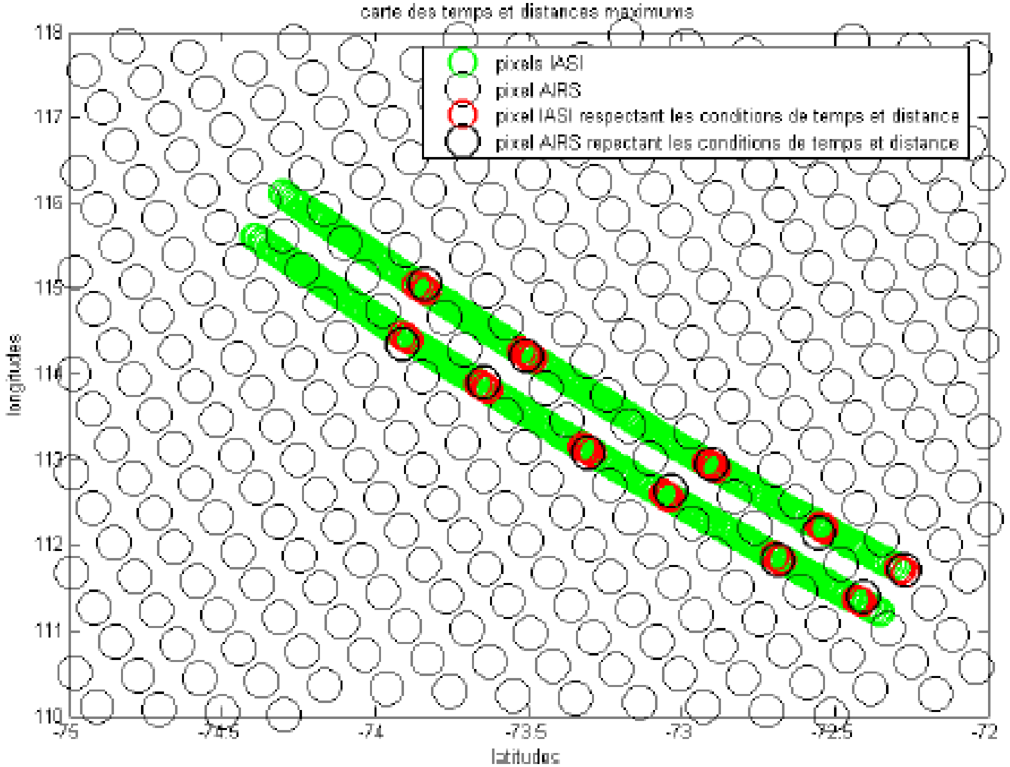
Radiometric calibration — IASI versus AIRS

Situation 16th of April

- IASI in External Cal.
  - Close to nadir
- Many comparison opportunities
  - 49 used
- Good uniformity
  - Cold scene

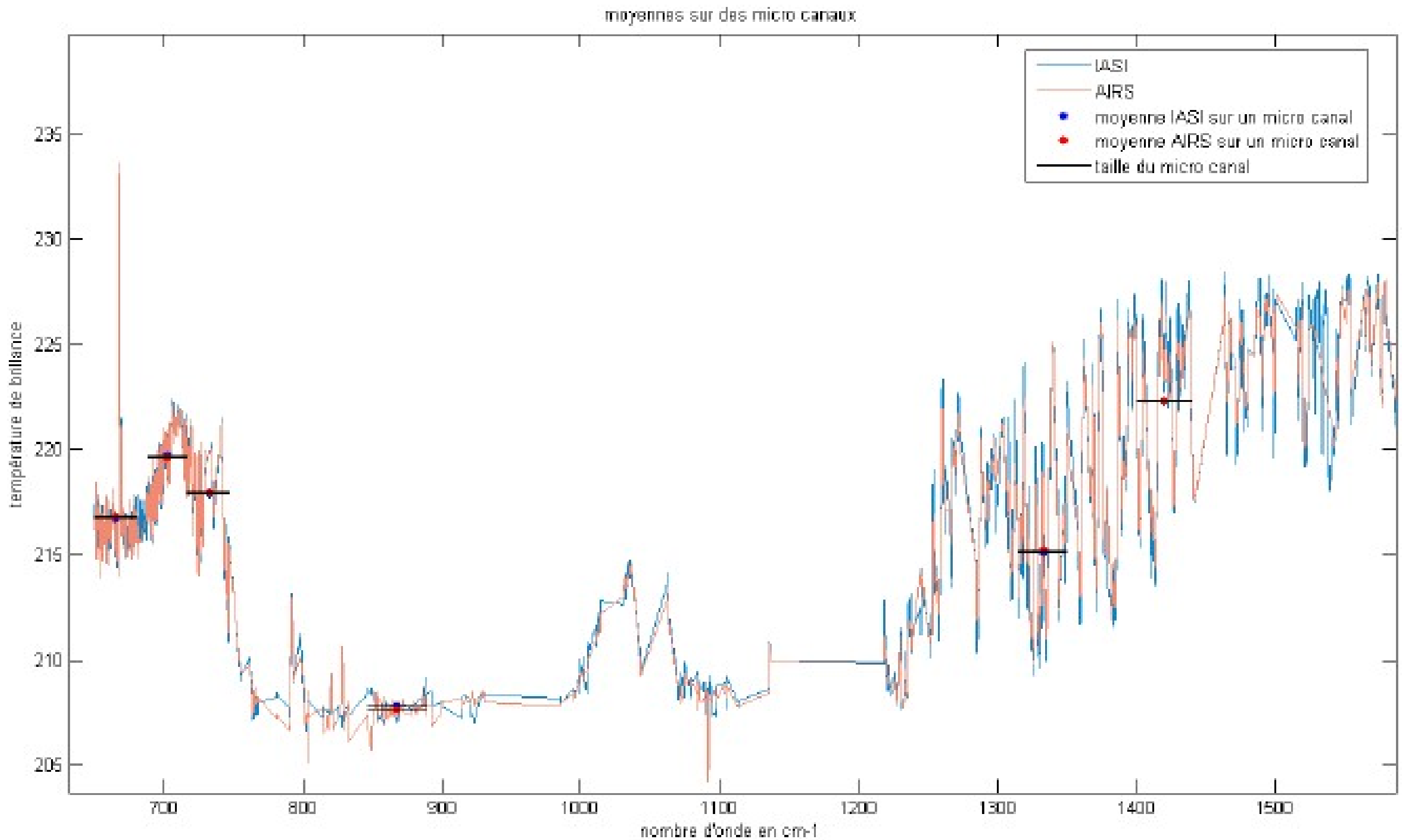
(Blumstein)





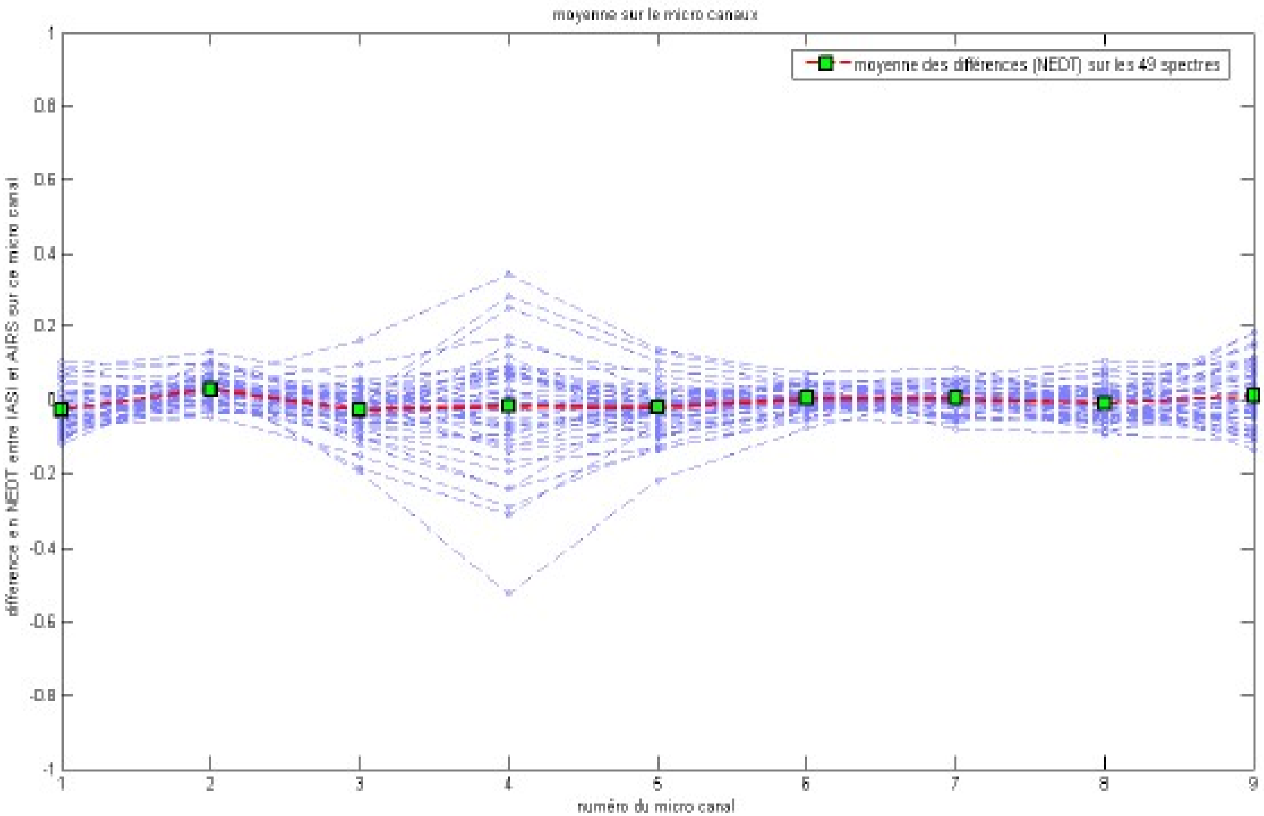
Radiometric calibration — IASI versus AIRS

Pseudo-channels

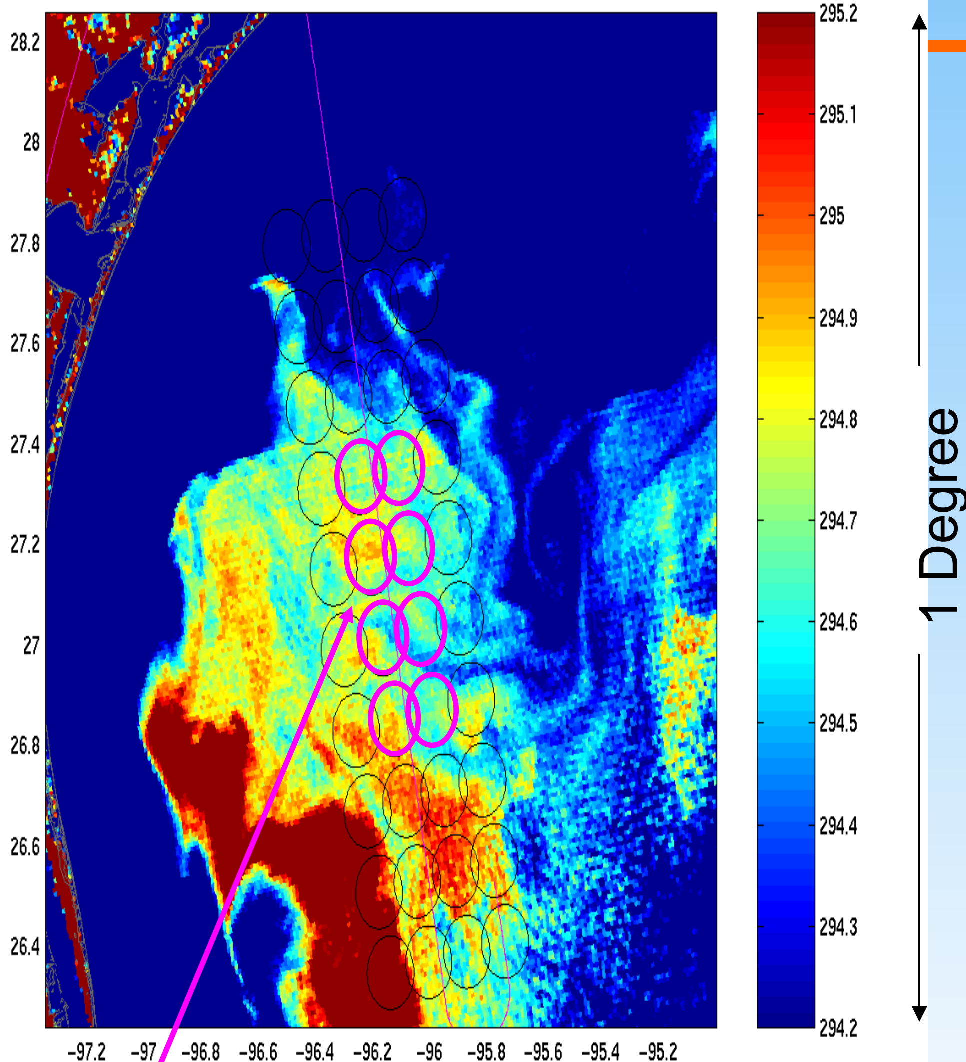


Summary results (case 16th of April 2007)

- IASI External Calibration Mode. Very uniform situation
- 9 pseudo-channels / 49 soundings / 210 K in atmospheric window
- Differences scaled to 280 K reference temperature

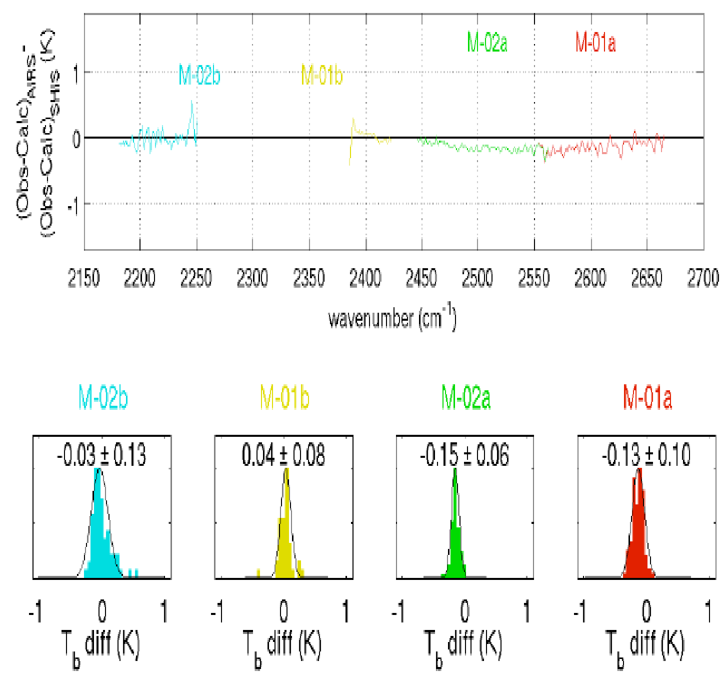


Use of aircraft interferometers to validate AIRS



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

Night-time case summary: Shortwave

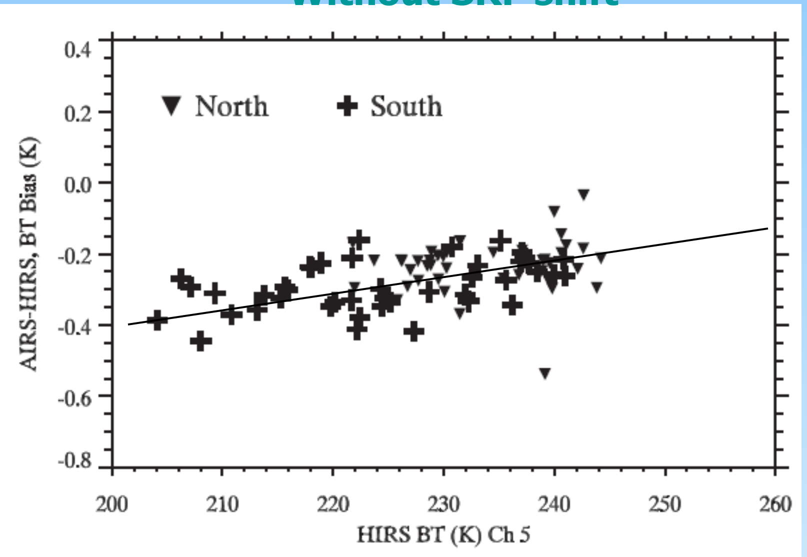


1st Direct SW Radiance Validation

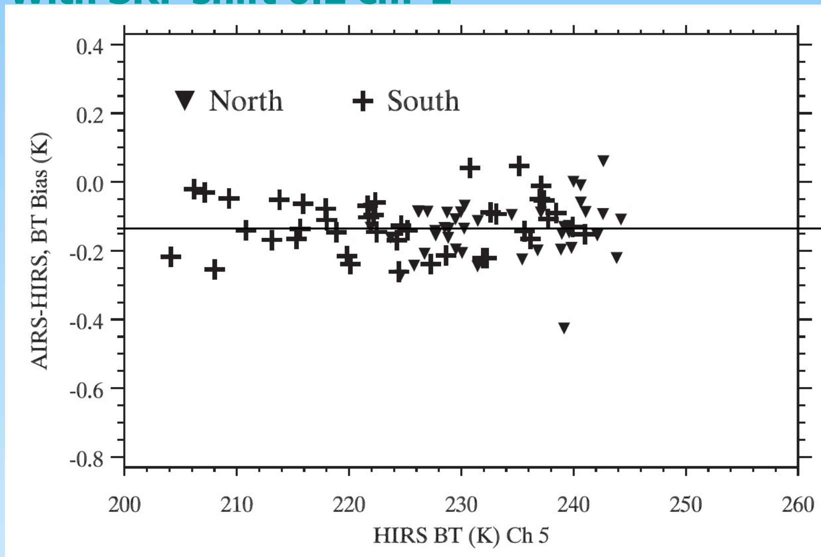
Excellent agreement for night-time comparison from Adriex/Italy campaign

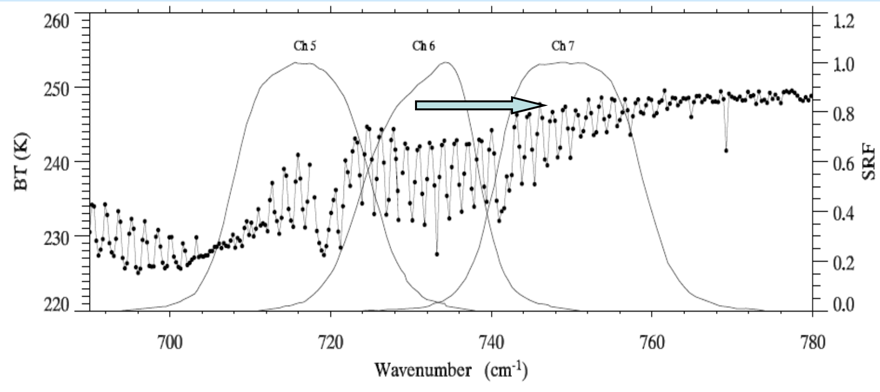
SRF Shift for HIRS Channel 6

Without SRF shift



With SRF shift 0.2 cm-1



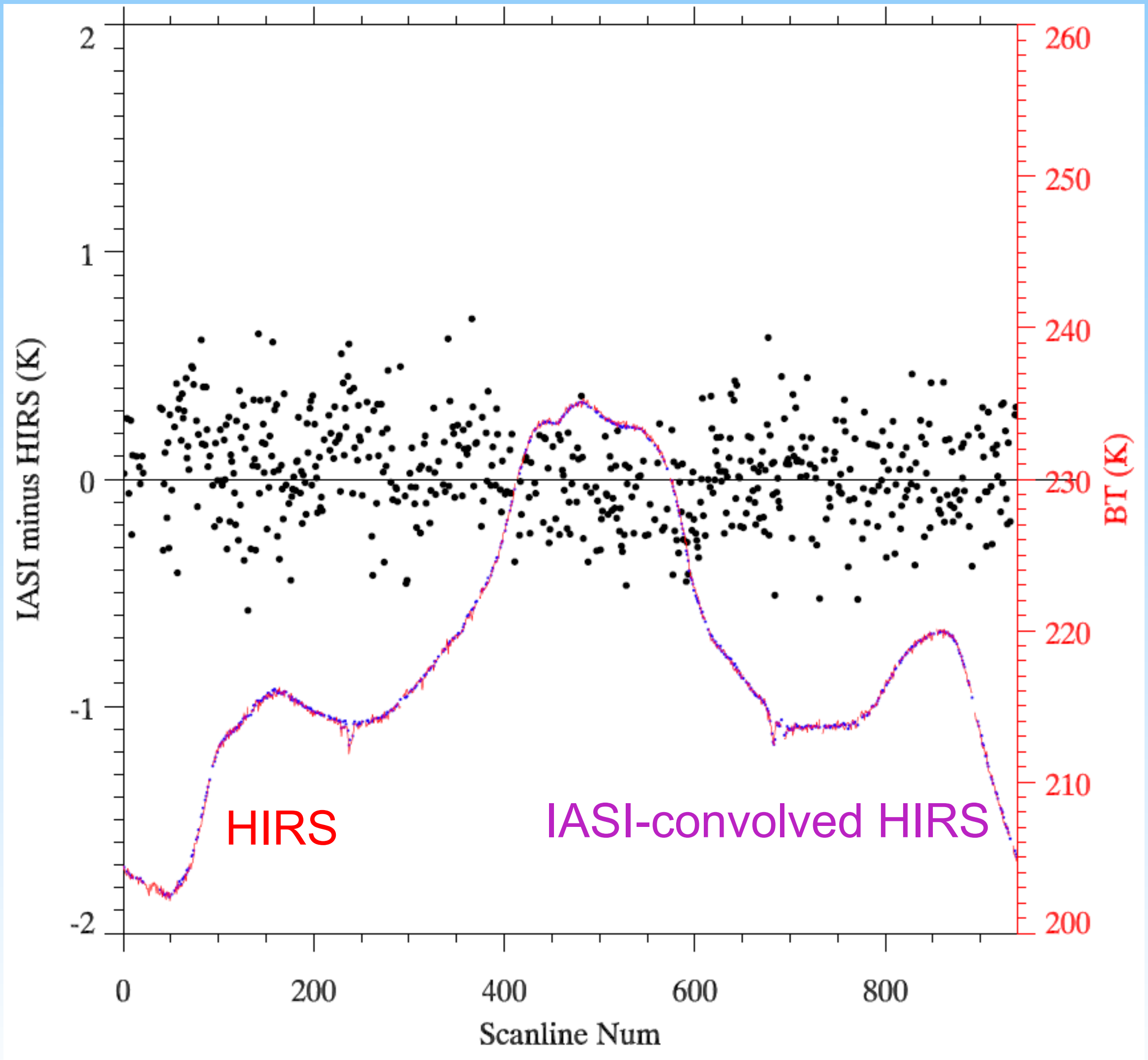


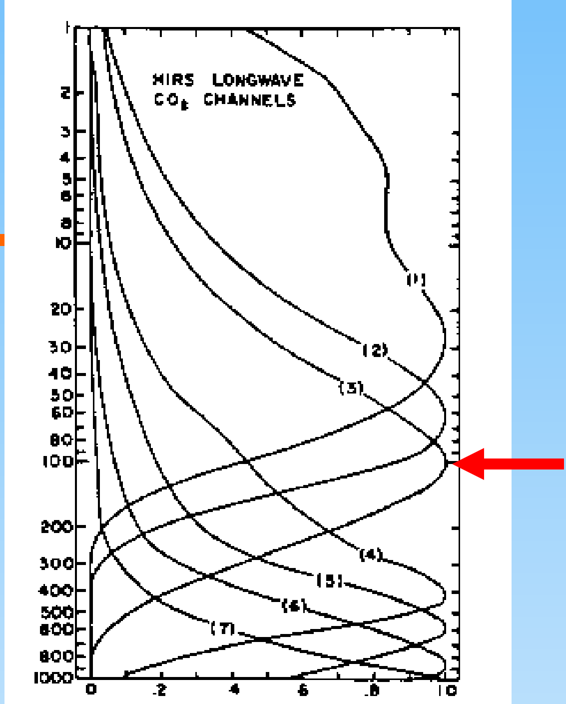
Since the HIRS sounding channels are located at the slope region of the atmospheric spectra, a small shift of the SRF can cause biases in observed radiances.

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

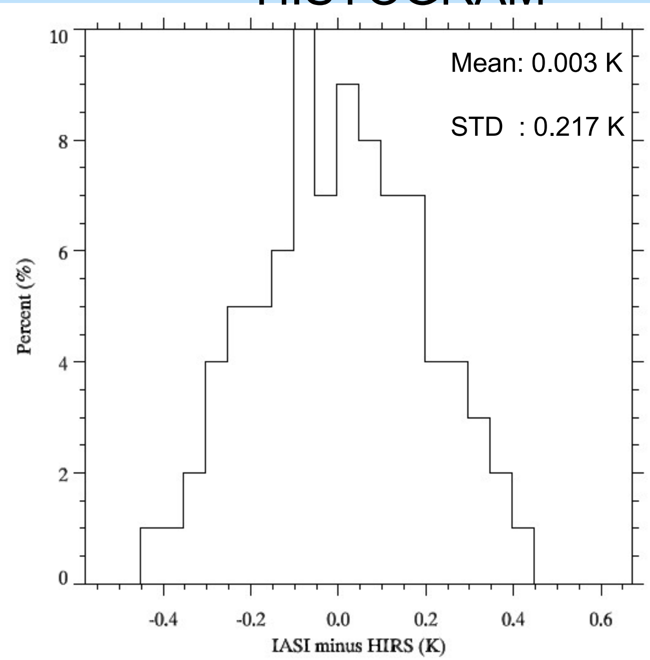
Channel 3 at nadir view

(Wang and Cao, NESDIS)





HISTOGRAM

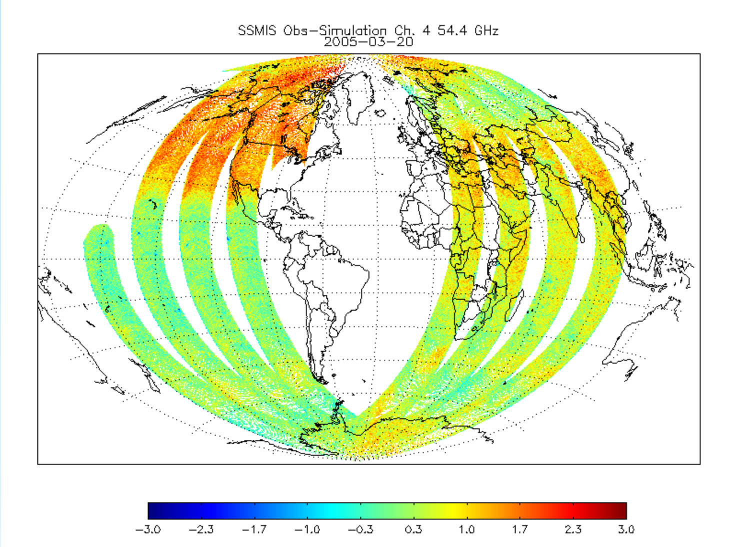


Correcting SSMIS Instrument Errors

DMSP Special Sensor Microwave Imager and Sounder (SSMIS) Calibration

SSMIS: First conical microwave sounder. Precursor to NPOESS CMIS.

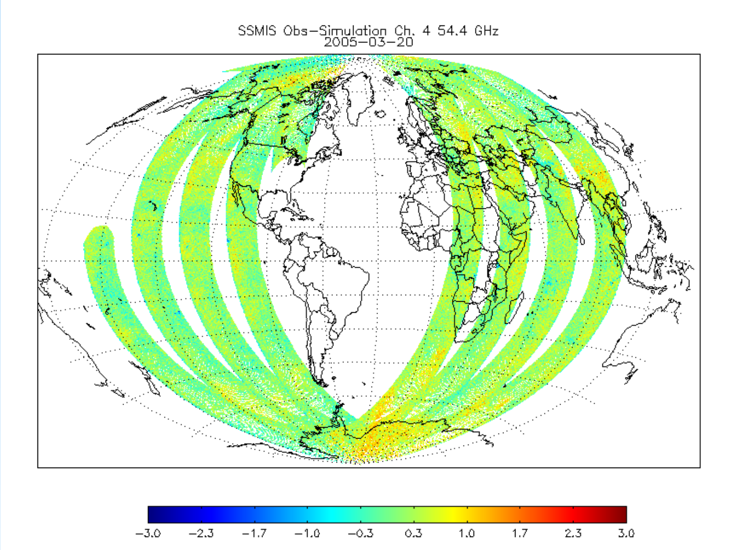
Before NOAA Calibration



Plots of difference between simulated and observed SSMIS 54.4 GHz.

(*Weng, 2007*)

After NOAA Calibration



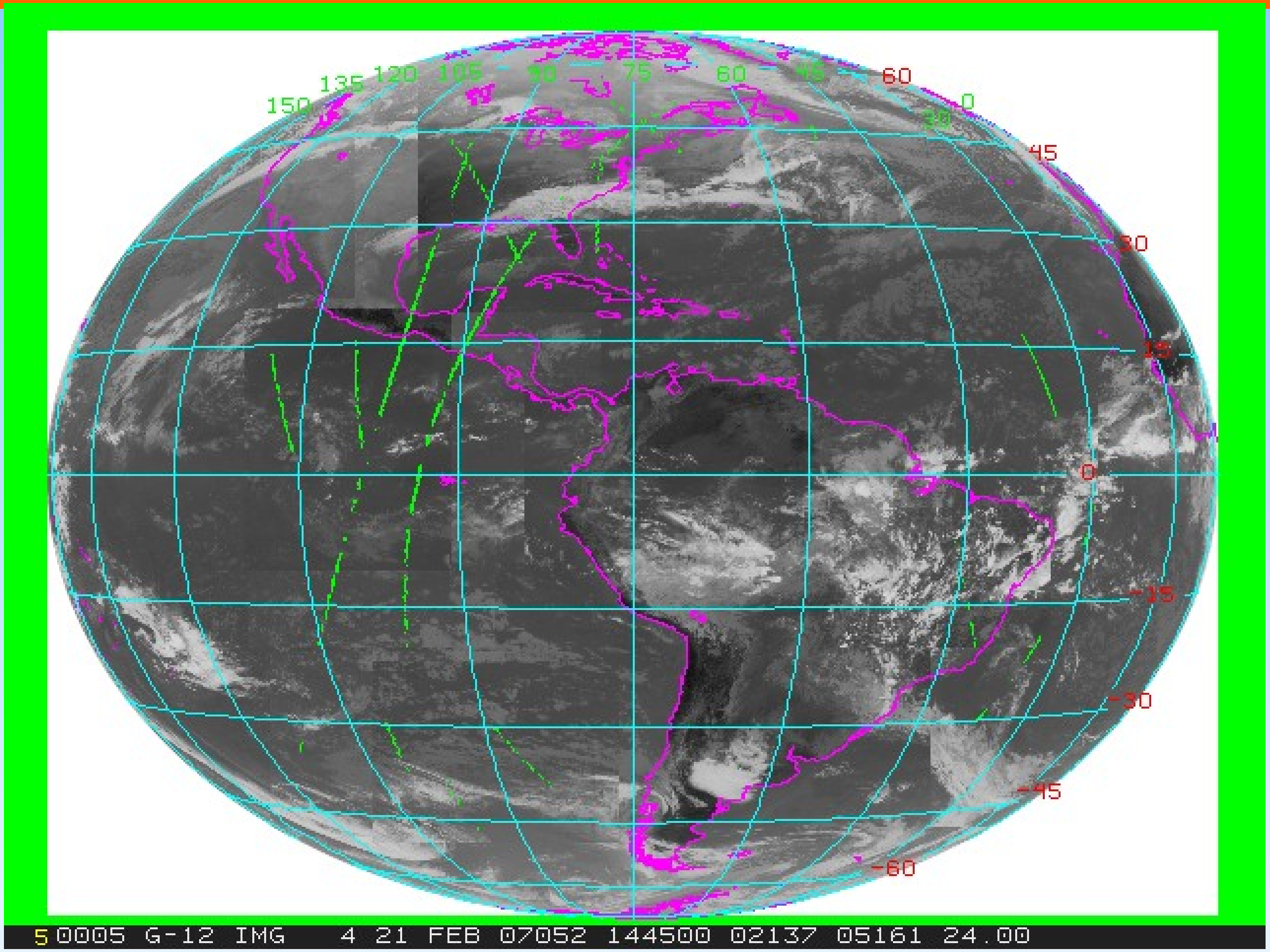
Anomalies have been identified from three processes: 1) antenna emission after satellite out of the earth eclipse which contaminates the measurements in ascending node and small part in descending node, 2) solar heating to the warm calibration target and 3) solar reflection from canister tip, both of 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

2008 Activities

- Commission intercalibration of MTSAT, MSG, GOES and FY2 Infrared Imagers with IASI and AIRS.
  - Routine intercomparisons between MSG (SEVIRI) and AIRS/IASI at EUMETSAT
  - Routine intercomparisons between GOES and AIRS/IASI at NESDIS
  - Routine intercomparisons between MTSAT and AIRS/IASI at JMA
  - Routine intercomparisons between FY2 and AIRS/IASI at CMA

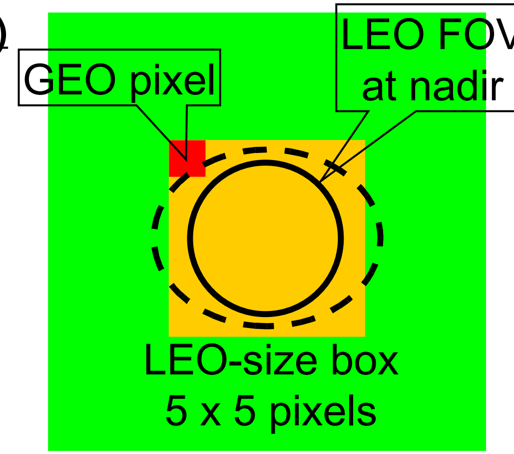
GOES 10.7 μm Co-locations with AIRS, 21feb02

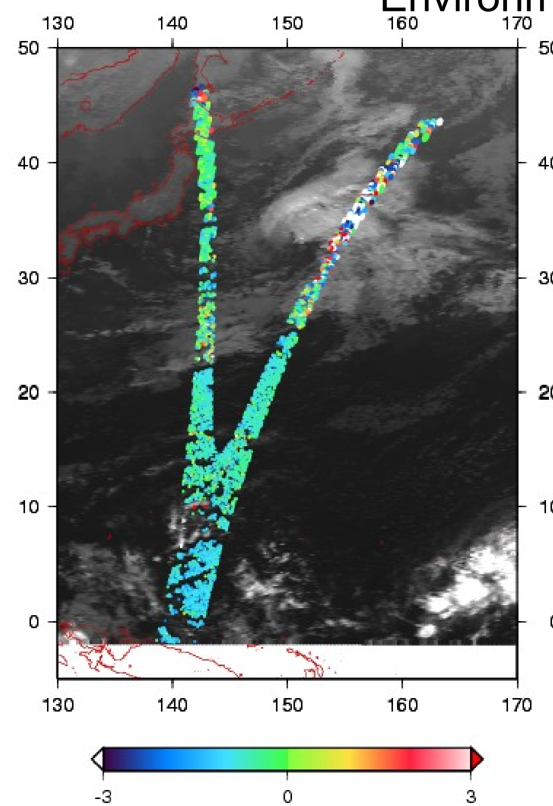


Intercalibration Algorithm Ver 0.0

(Delivered on May 5 by GCC, evaluation by JMA Tahara, Kato)

- Key match-up conditions between GEO and LEO
  - Difference of observing times < 1800 (sec)
  - Difference of 1/cos(sat. zenith angles) < 0.05
  - Environment uniformity check
    - To choose only spatially uniform area to alleviate navigation error, MTF, observing time difference, optical path difference, etc.
    - Environment domain = 11x11 IR pixel box (MTSAT-1R vs. AIRS)
    - env_stdv_tb < (TBD)
  - Representation check of LEO-size GEO pixels in the environment
    - z-test
    - LEO FOV = 5x5 IR pixel box (MTSAT-1R vs. AIRS)
    - abs(fov_mean_tb – env_mean_tb) < Gaussian x env_stdv_tb / 5

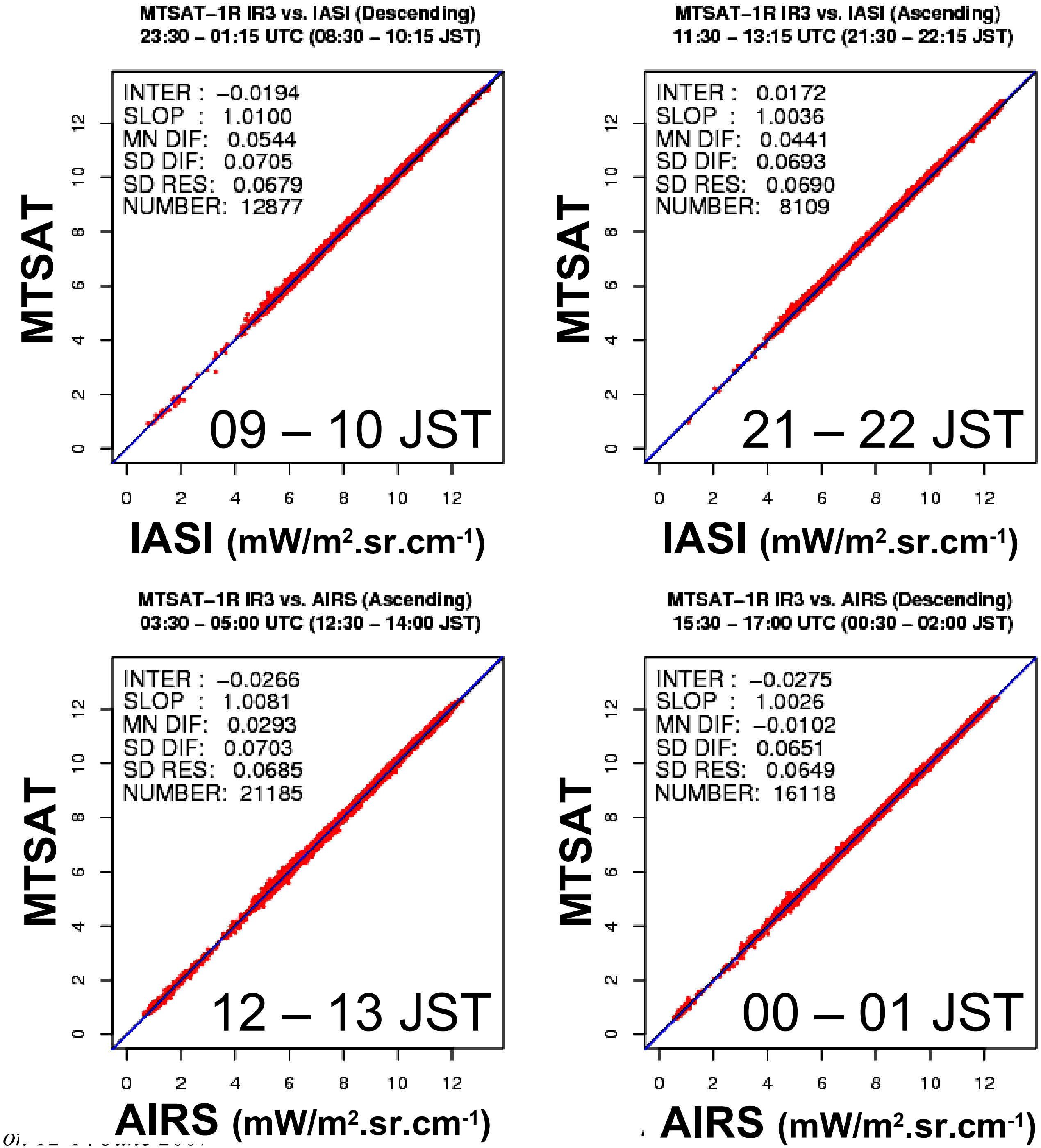




MTSAT-1R 6.8-um vs. AIRS/IASI

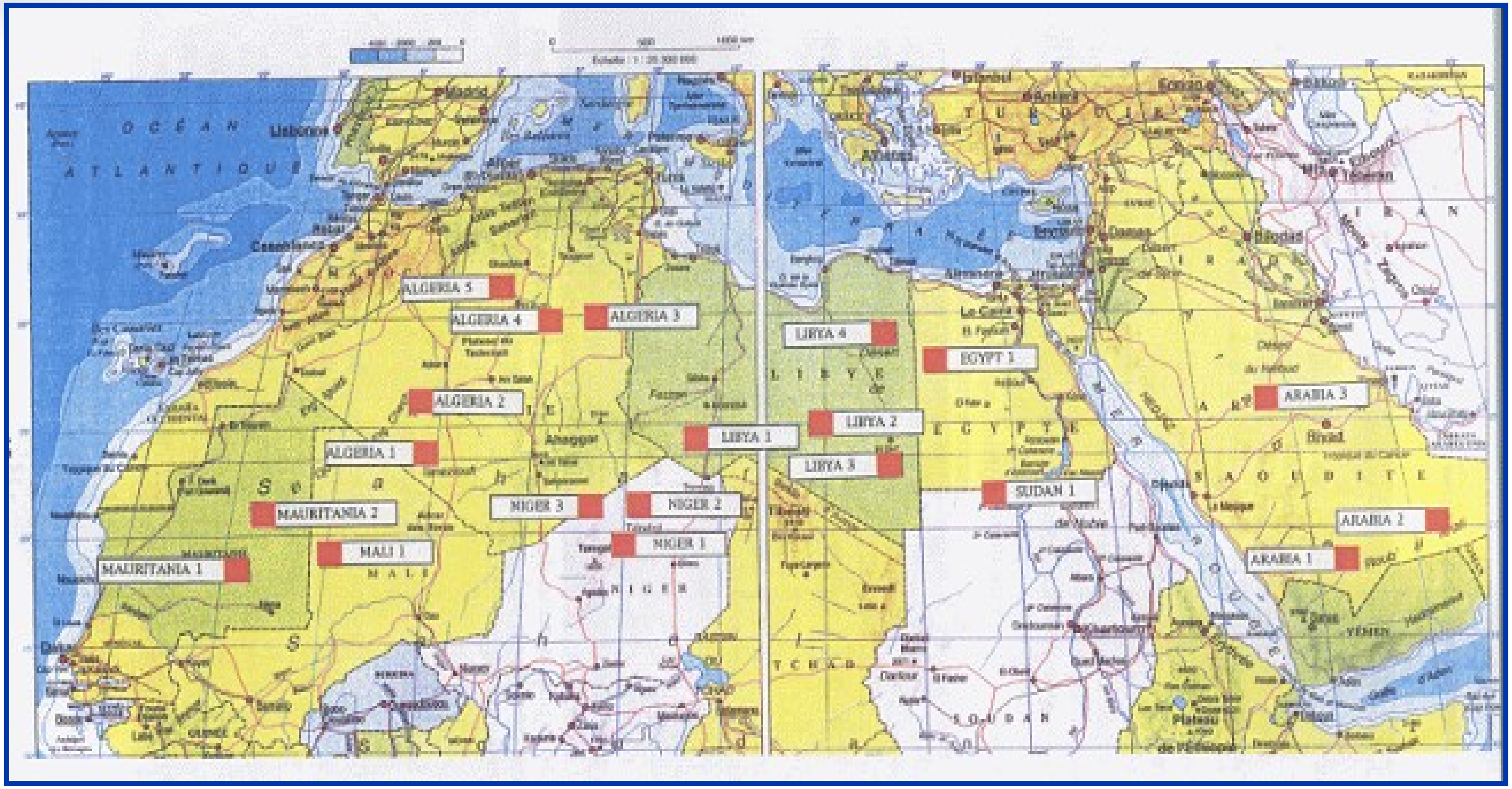
August 2008

* Compensation applied to AIRS super channel computation



SADE Data Base

Visible NIR

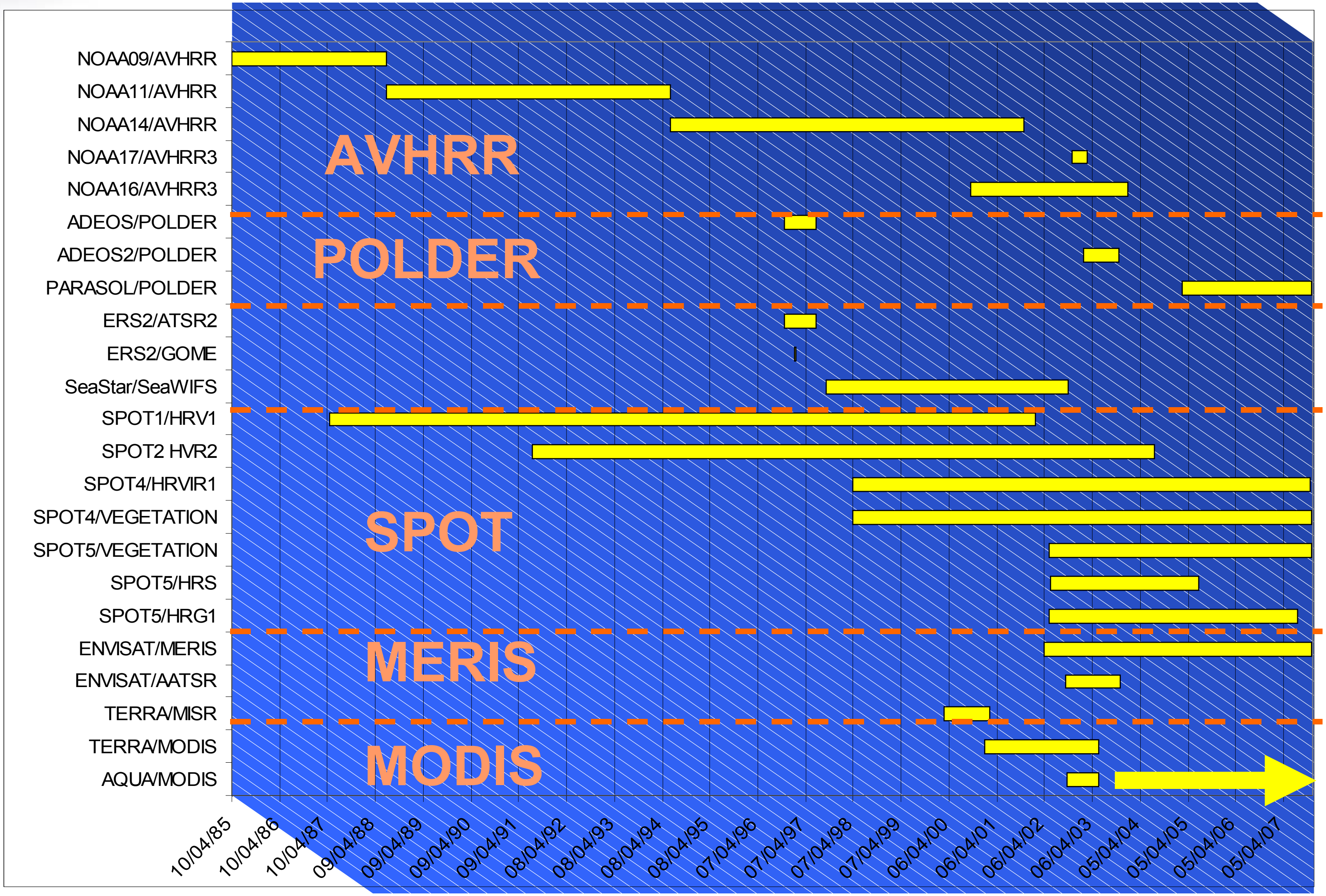


- **19 sites selected over North Africa and Arabia**

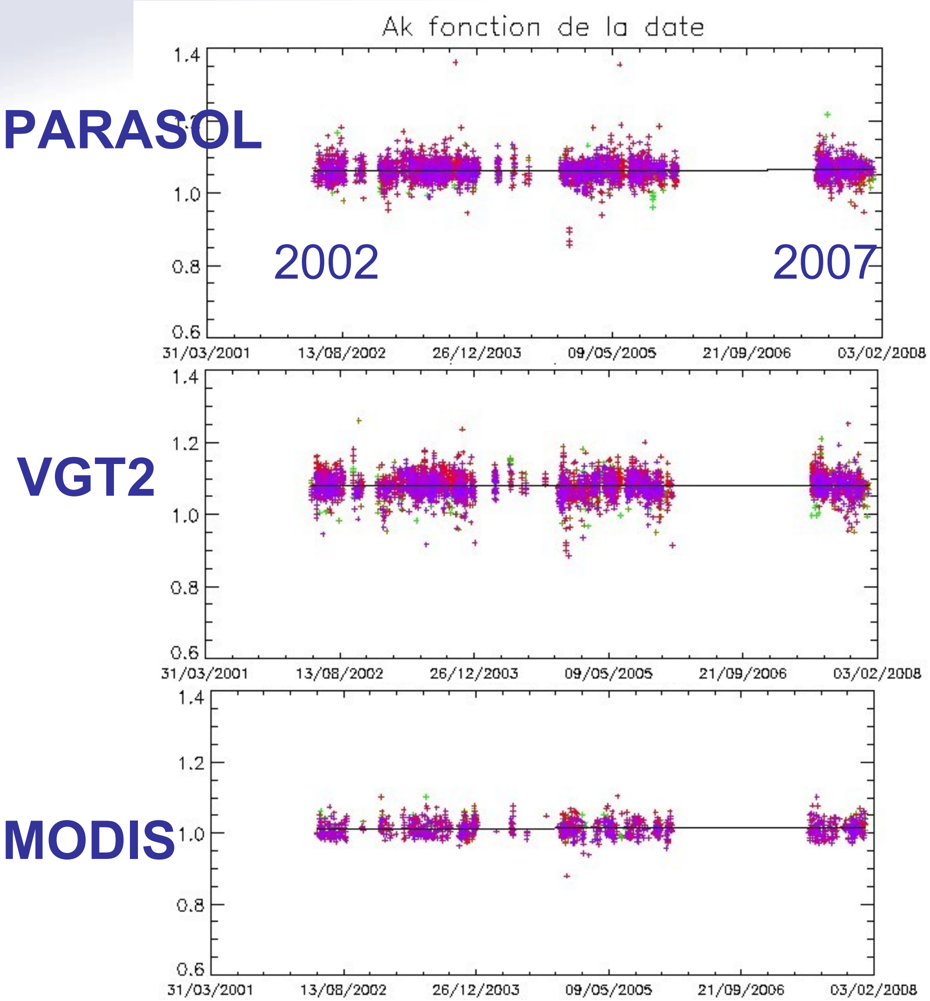
SADE Data Base

Visible NIR

- Desert Sites Database (from 1985 until 2008)



MERIS On-board Calibration Validation (Band 665)



Cross-calibration with PARASOL, VGT2 and MODIS as a function of time (19 sites)

Matching measurements =
same viewing and solar geometries

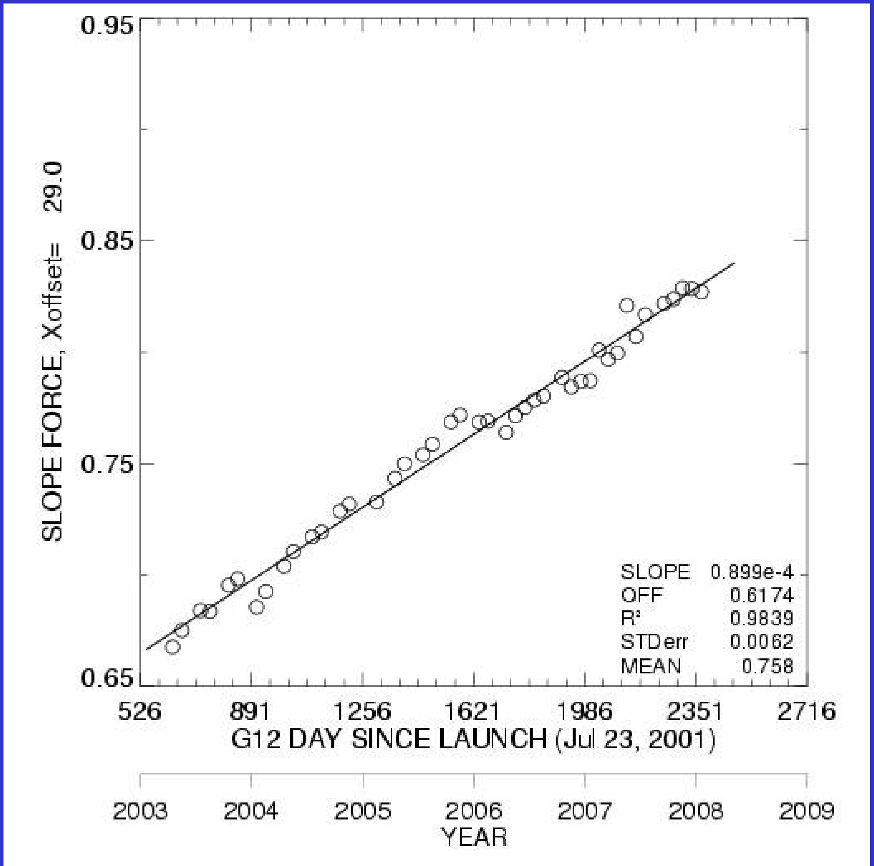
(no collocation with time)

PARASOL : 4000 match. meas.
VGT2 : 4600 match. meas.
MODIS : 1400 match. meas.

No signifiant variation with time

Agreement between all ref. sensors

GOES-12 visible gain degradation adjustment using MODIS

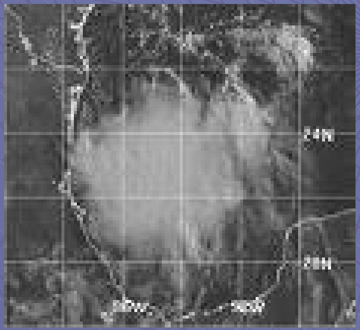


Testing Assumptions

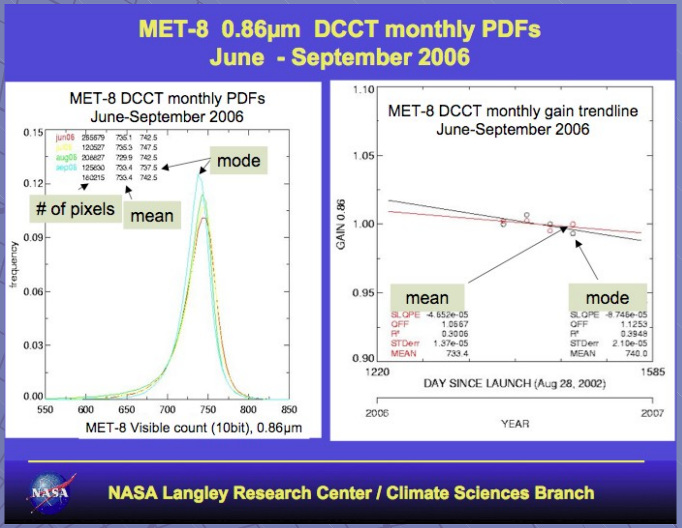
Deep Convective Cloud (DCC) Calibration

Features:

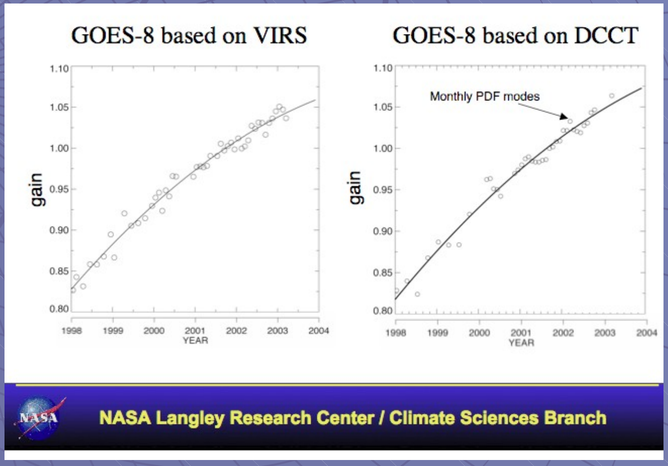
- DCCs are cold and bright tropopause targets in the tropics.
- DCCs provide maximum earth-view radiances in the solar reflective bands
- DCCs have with a nearly constant albedo at the top of the atmosphere.
- No apriori atmospheric profile or surface information is required to calibrate with DCCs.



DCC Image from the tropics.



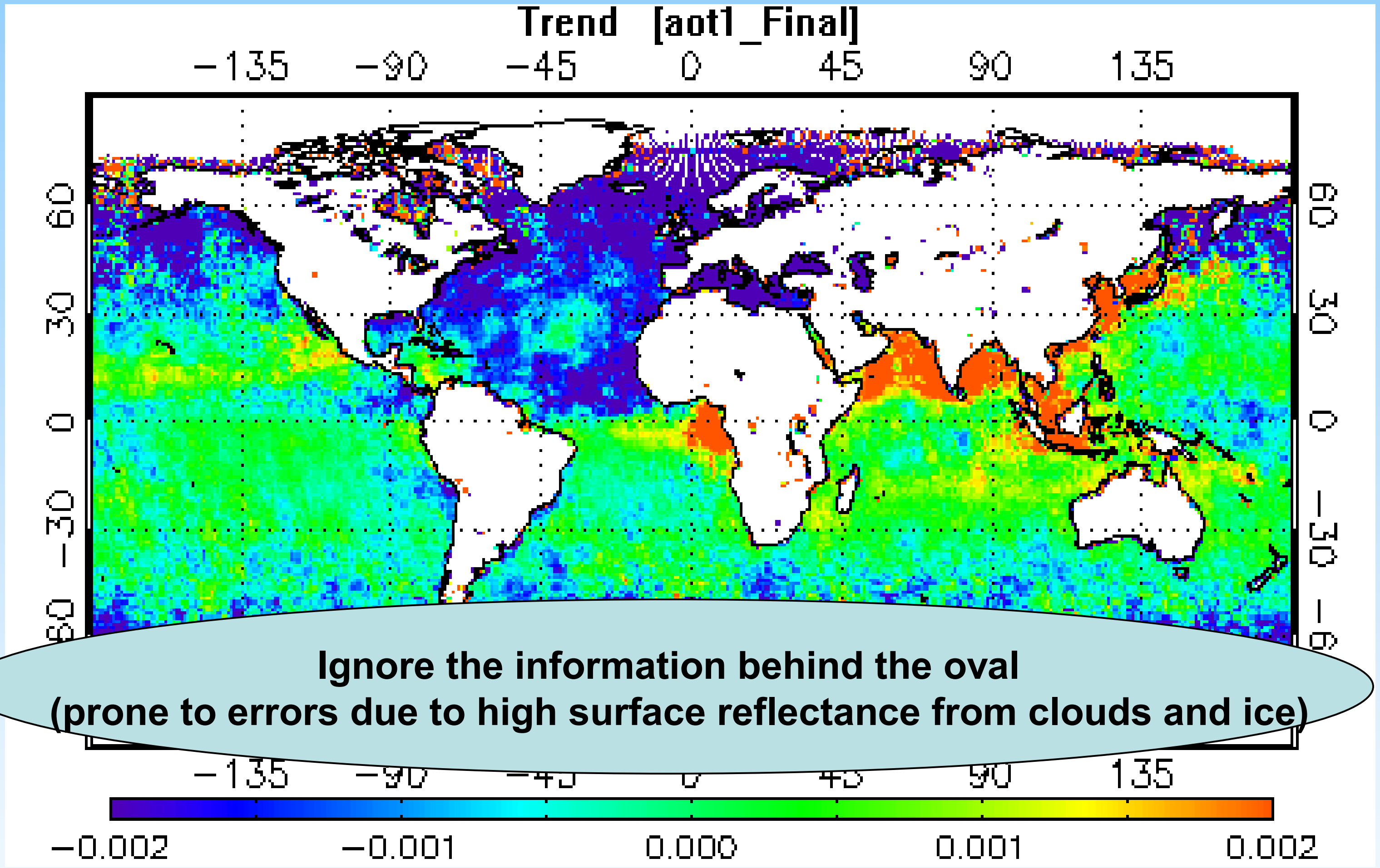
Top: (left) Monthly PDF of pixel counts converted to overhead sun; and **(right)** normalized mode and mean of PDF over time. Note each month uses more than 100,000 DCC pixels. Also, the middle month in the time series is used to normalize the mean or mode radiances.



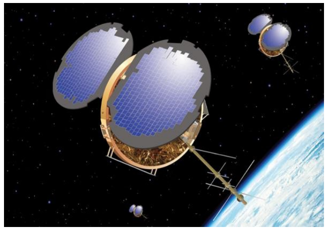
Bottom: GOES-8 five-year calibration trend based on **(left)** VIRS and **(right)** DCC matched gridded radiances.

(Doelling, 2007)

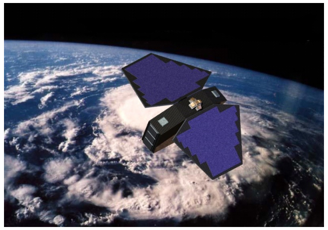
AVHRR Aerosol Climatology



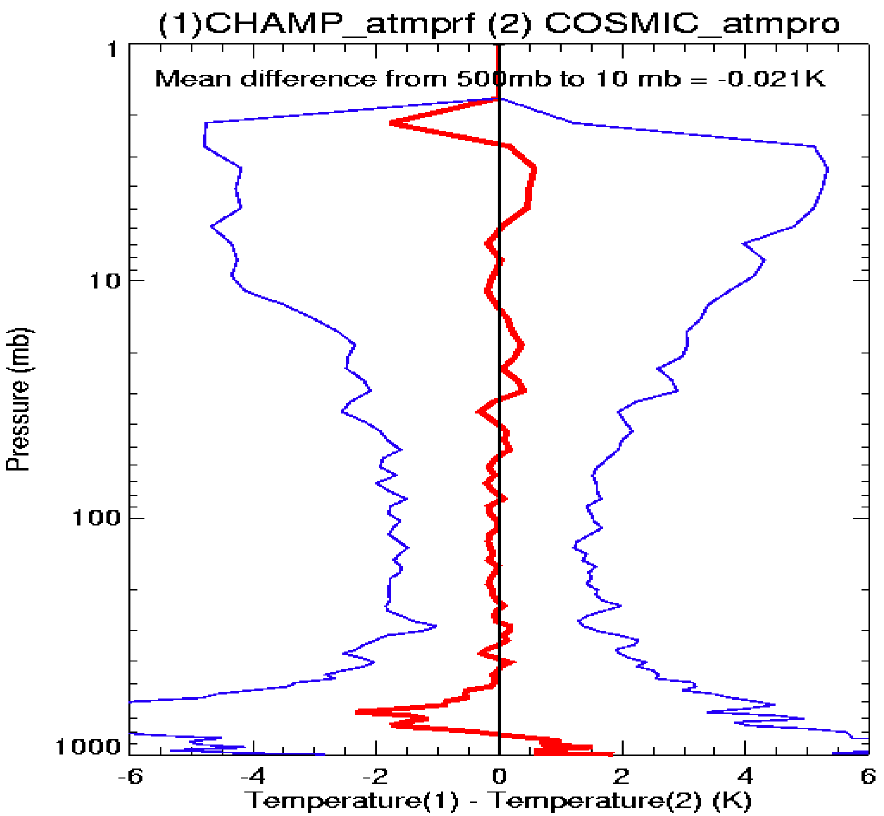
Ignore the information behind the oval
(prone to errors due to high surface reflectance from clouds and ice)

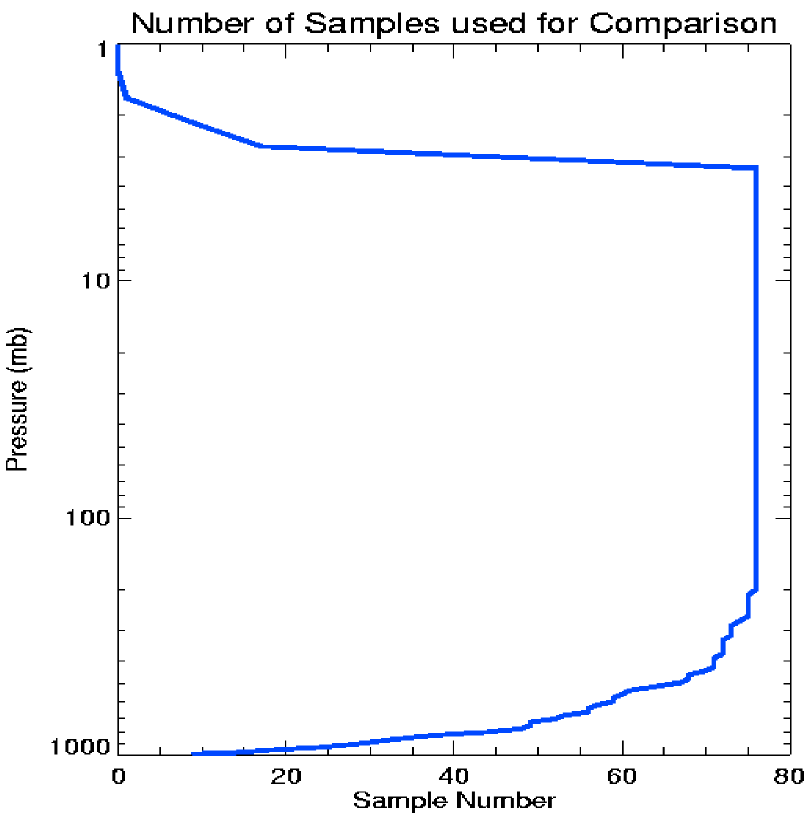


Difficulty II: to find measurements with long term stability



Mean bias CHAMP-COSMIC temp from 500mb to 5 mb =-0.021K

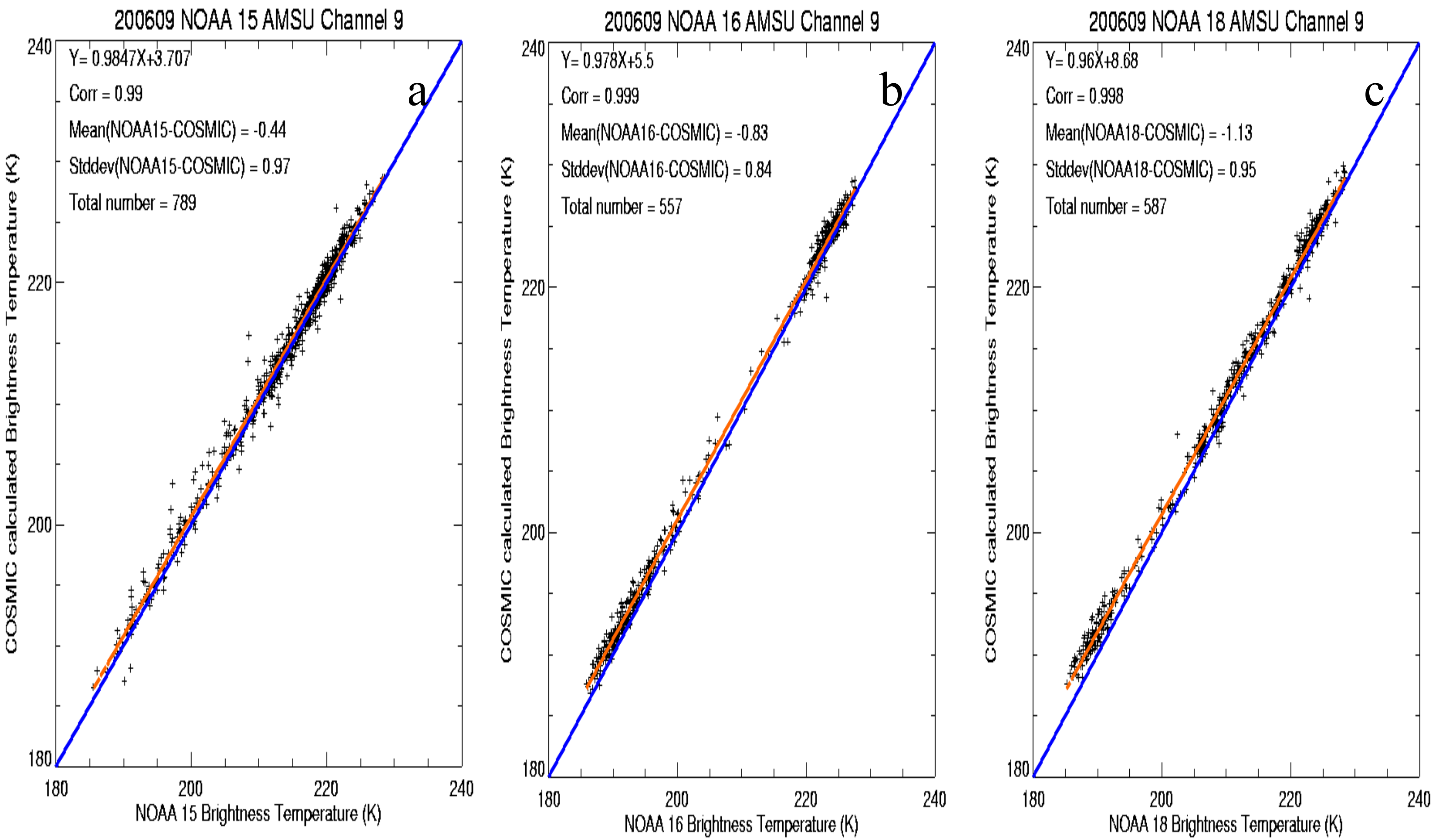




COSMIC (launched in 2006) vs. CHAMP (launched in 2000) atm tmp

Shu-peng Ben Ho, UCAR/COSMIC

Can we use GPS RO data to calibrate other instruments ?

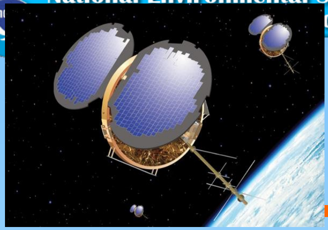


N15, N16 and N18 AMSU calibration against COSMIC

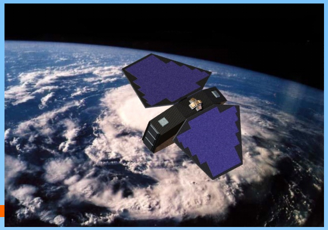
(Ho et al., TAO, 2007)

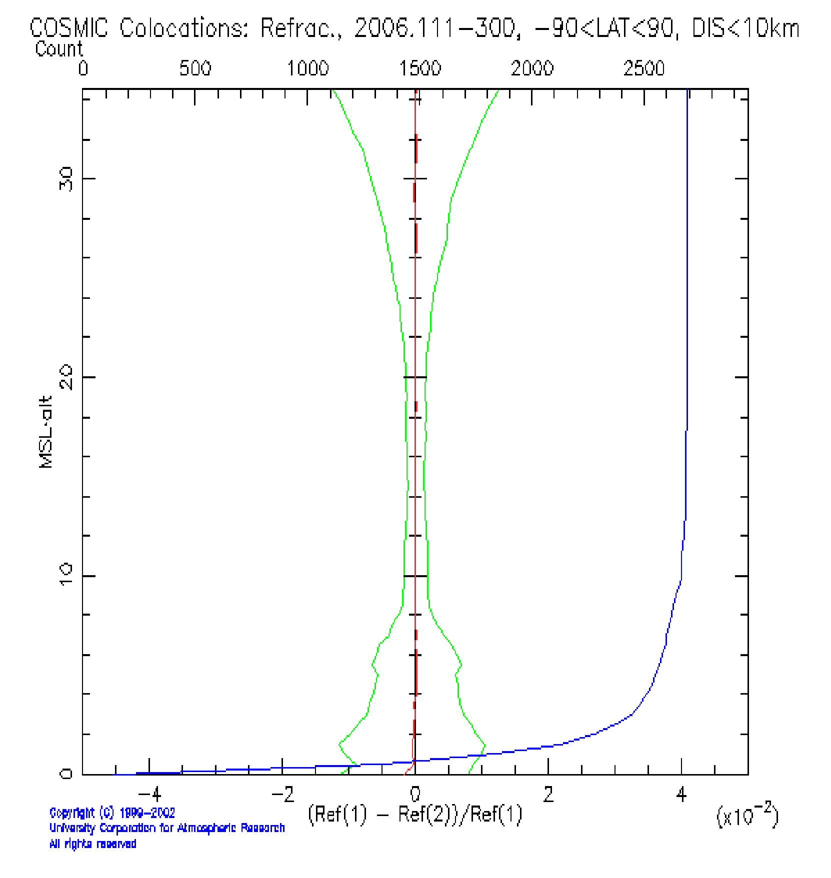
Shu-peng Ben Ho, UCAR/COSMIC

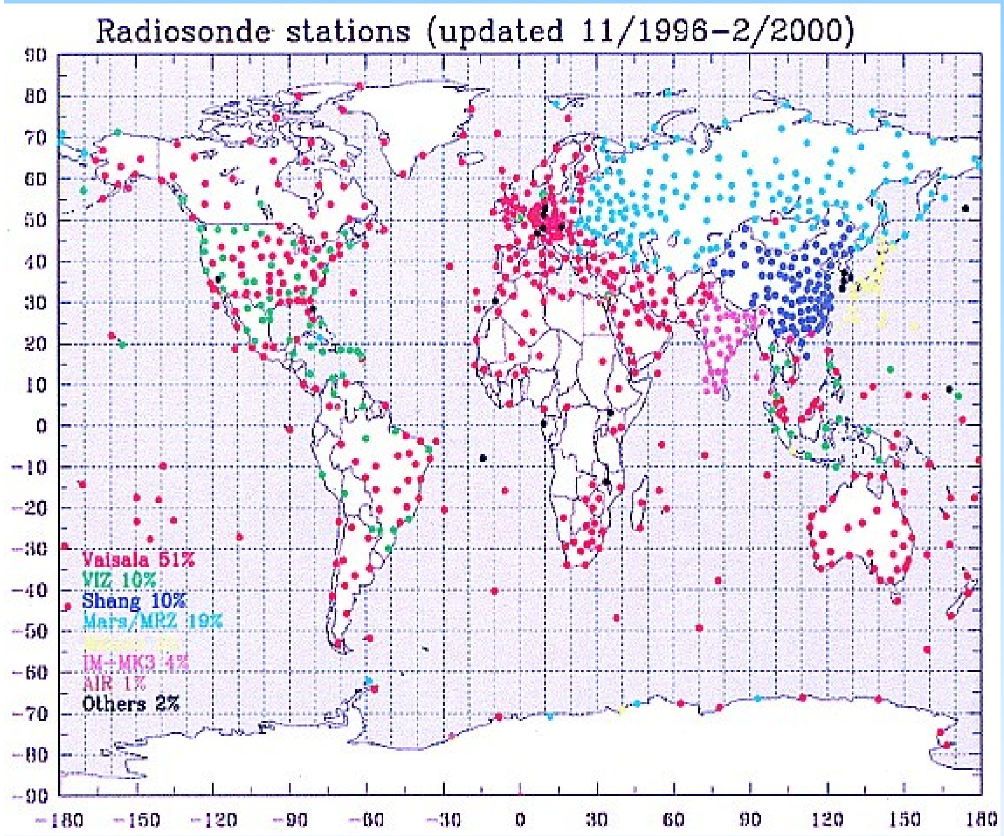
National Environmental Satellite,
on Service



Global Radiosondes







$$N = 77.6 \frac{P}{T} + 3.73 \times 10^5 \frac{P_W}{T^2}$$

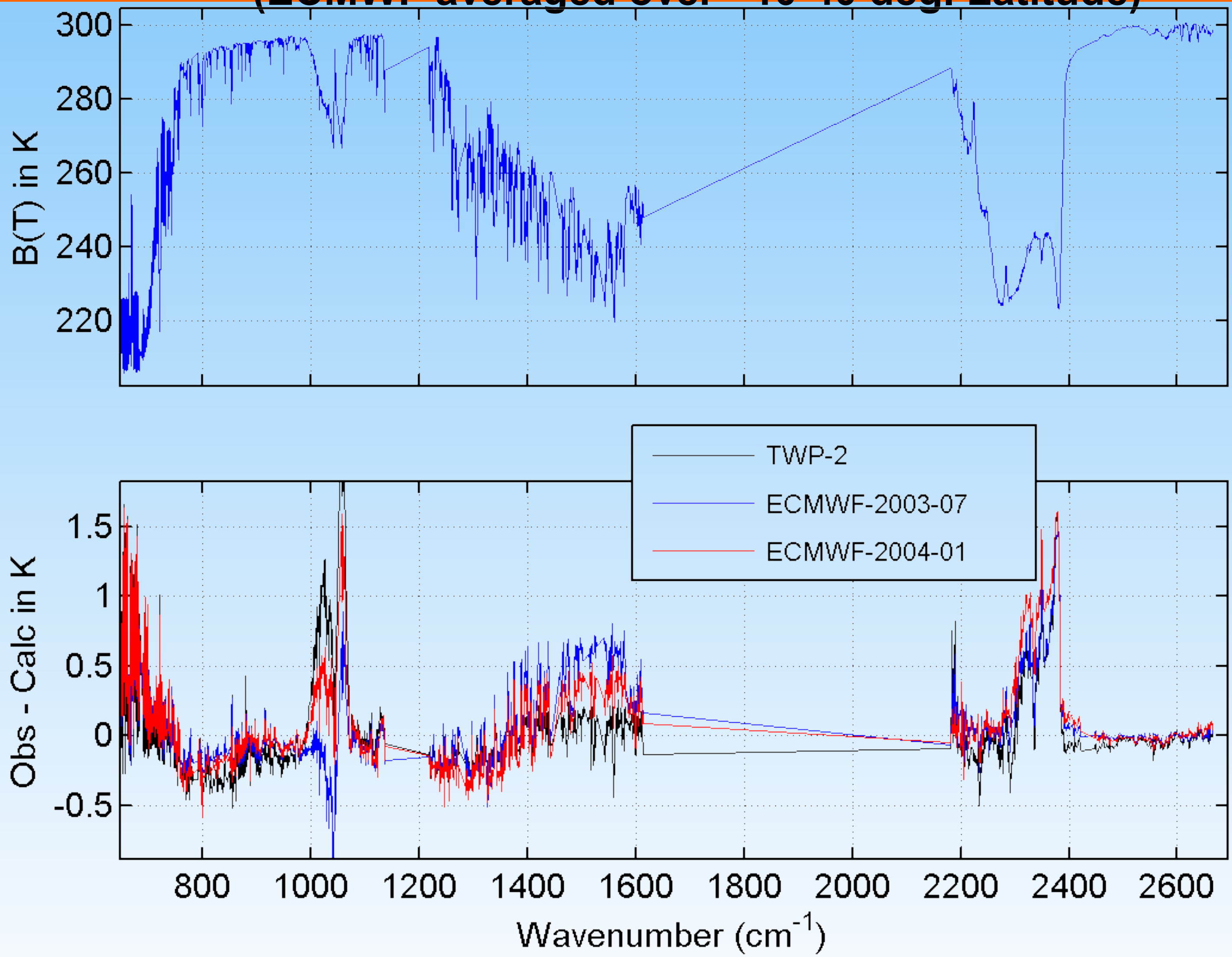
(Kuo et al., GRL, 2005)

Mean Absolute Fractional Differences and Standard Deviation (S.D.) of Refractivity Between CHAMP RO Soundings and the Soundings From Five Different Types of Radiosonde System

Regions	Sonde Type	#of Matches	Del Nradio/S.D.	Del Necmwf/S.D.
India	IM-MK3	87	0.82/3.2	0.15/1.
Russia	Mars	1003	0.3/1.3	0.09/0.9
Japan	MEISEI	107	0.26/1.7	0.14/1.1
China	Shanghai	402	0.19/1.4	0.15/1.0
Australia	Vaisala	366	0.18/1.3	0.13/0.9

Use of DOE ARM TWP reference sites to improve radiative transer

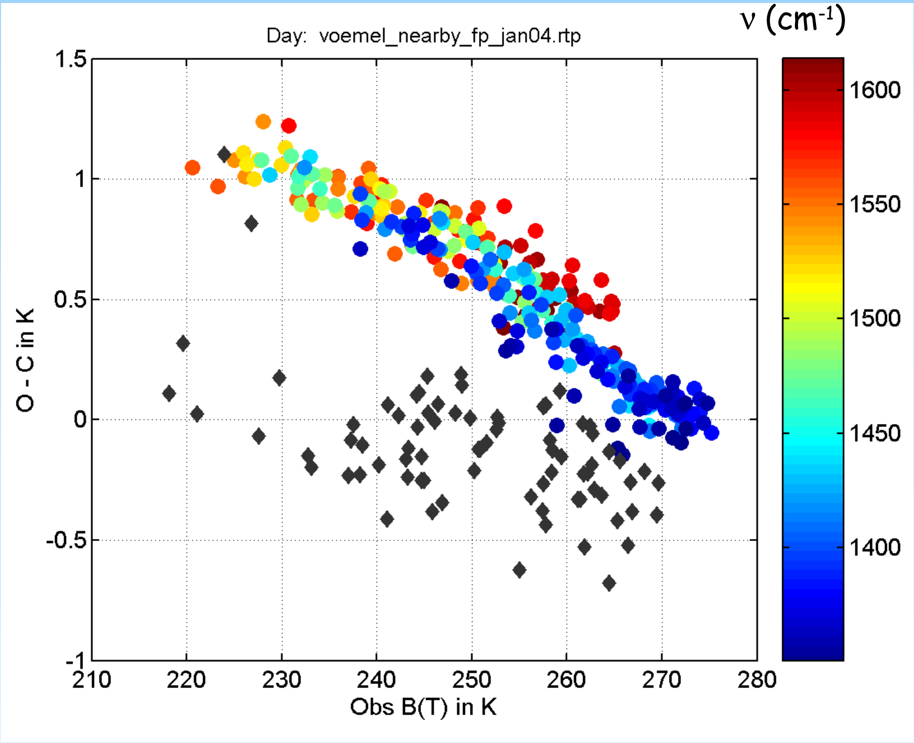
(ECMWF averaged over ~10-40 deg. Latitude)

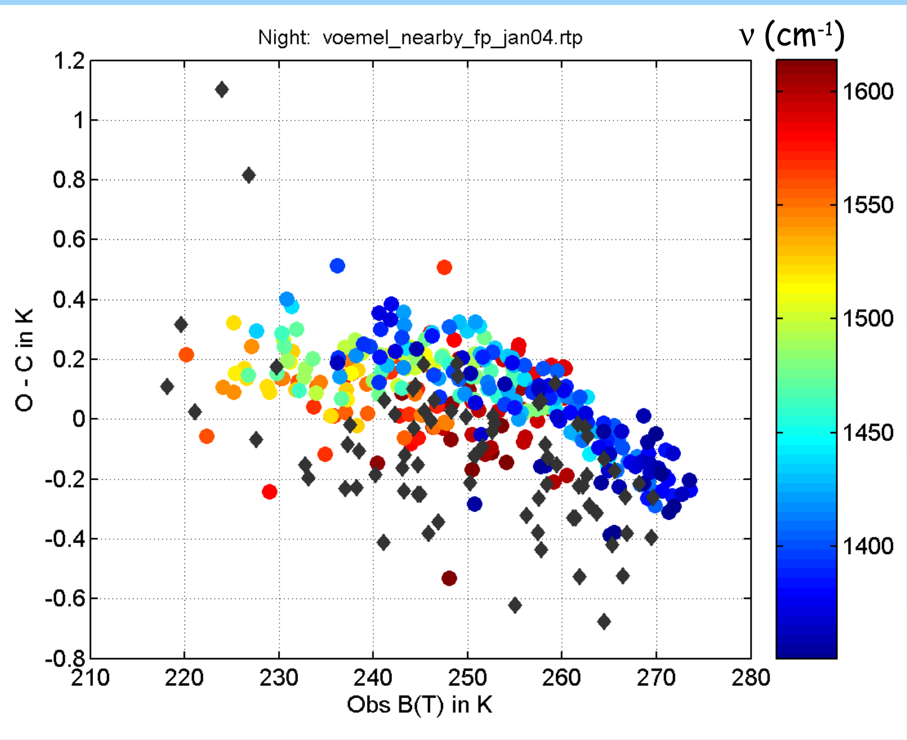


Frost-Point Observations Show Significant Day and Night Differences based on comparisons with AIRS

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.

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
- Quarterly reports of observing system performance and recommended solutions
- <u>Improved sensor characterisation</u>
- <u>High quality radiances for NWP & Climate</u>