GSICS Geostationary Infrared Correction

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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)

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**

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**

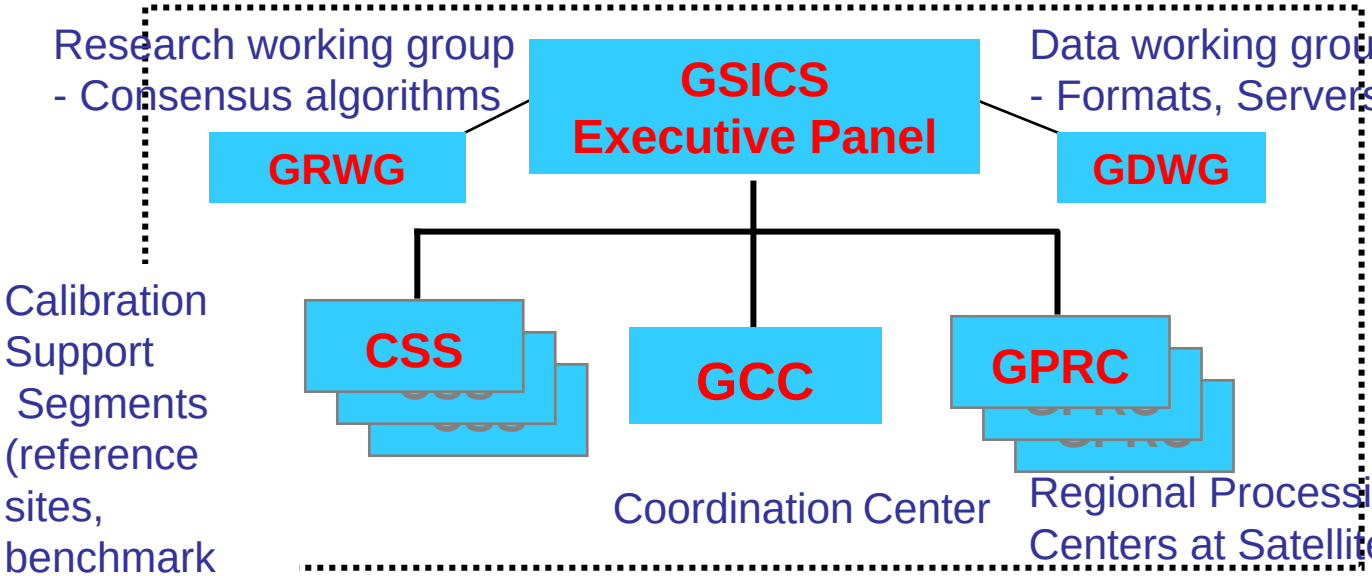
Organizations contributing to GSICS

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

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

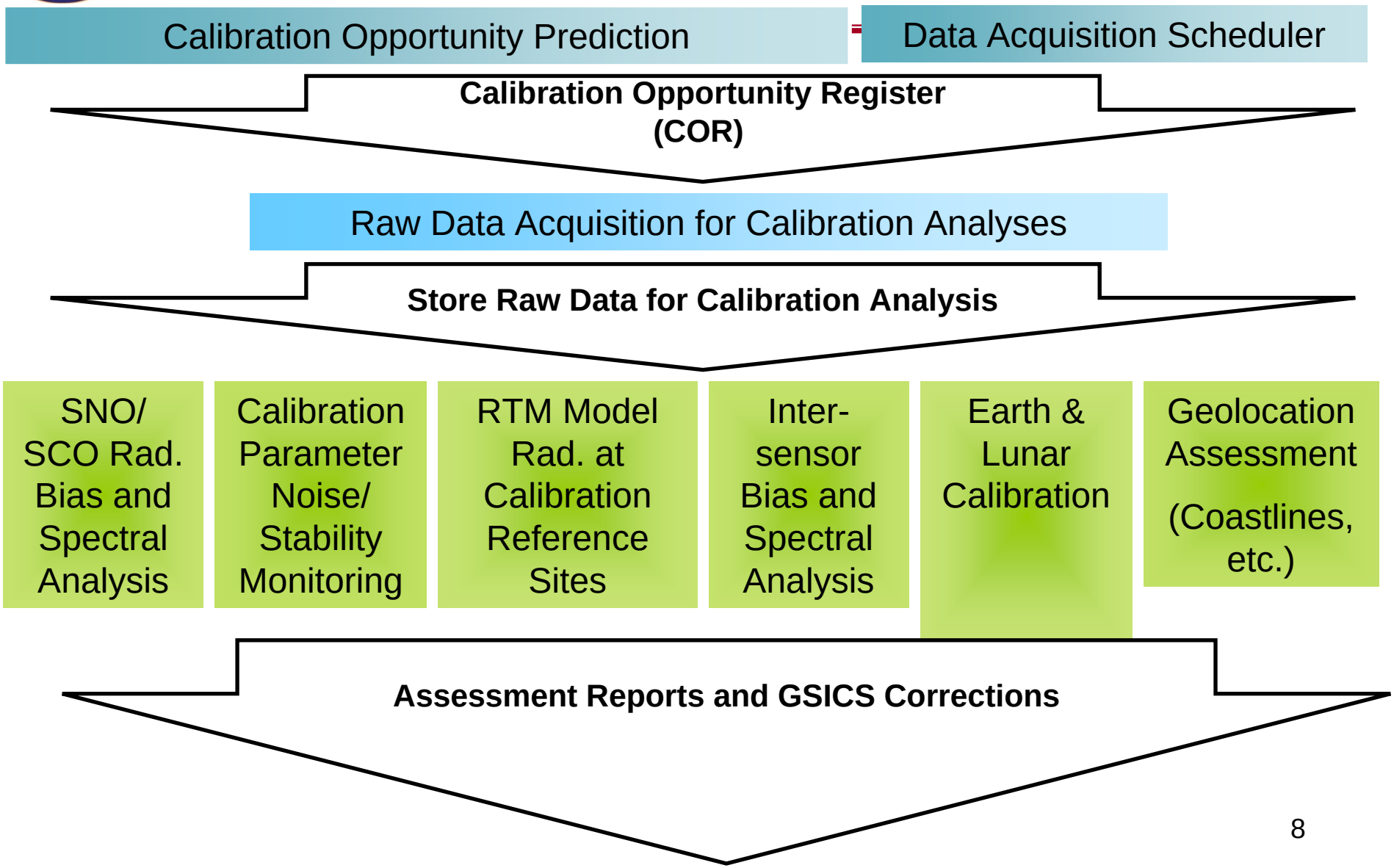
GSICS current focus is on the intercalibration of operational satellites, and makes use of key research instruments such as AIRS and MODIS to intercalibration the operational instruments

GSICS Organization

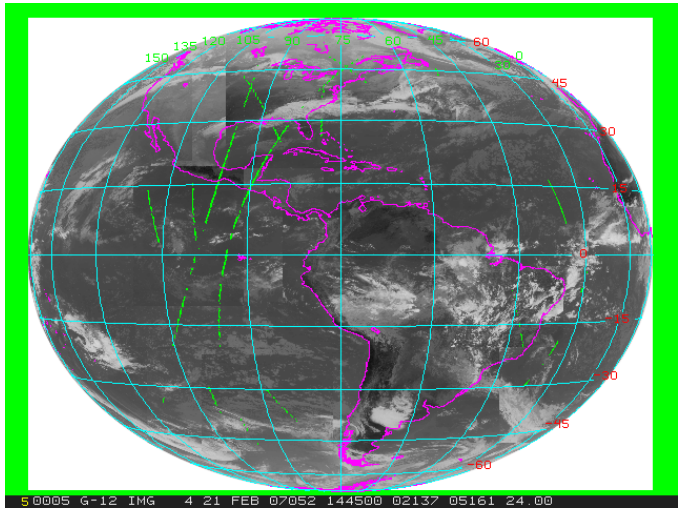


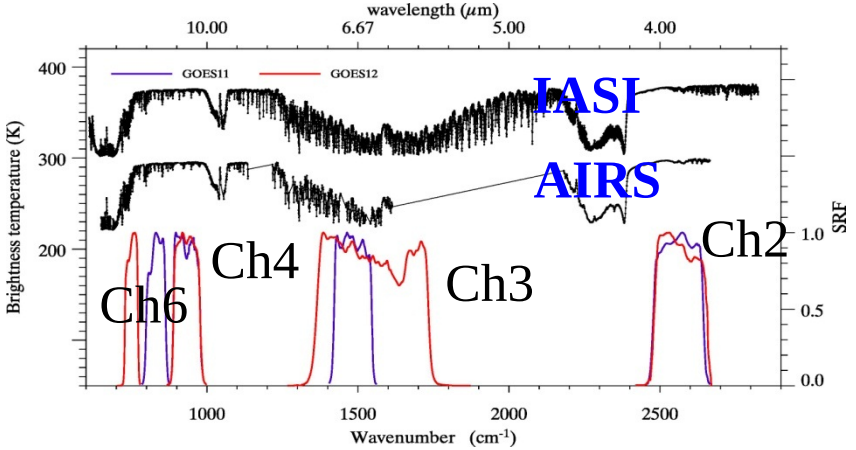
Calibration Support Segments (reference sites, benchmark measurements, aircraft, model simulations)

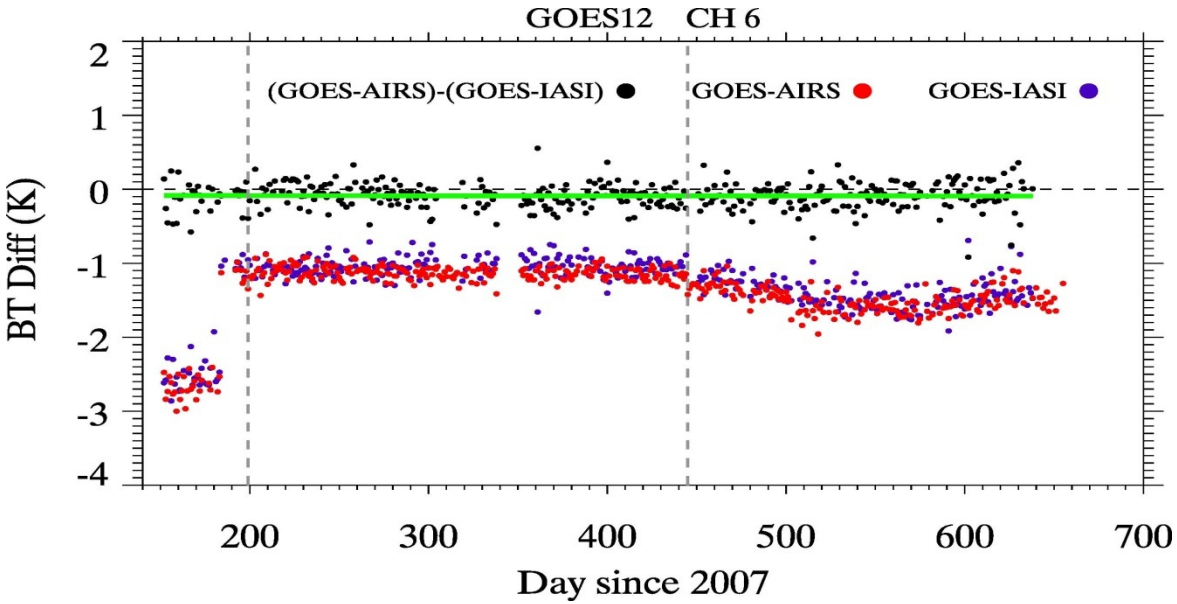
Integrated Cal/Val System Architecture



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

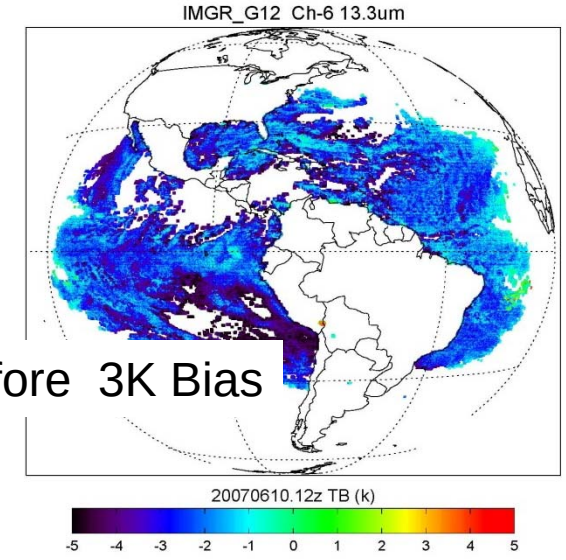




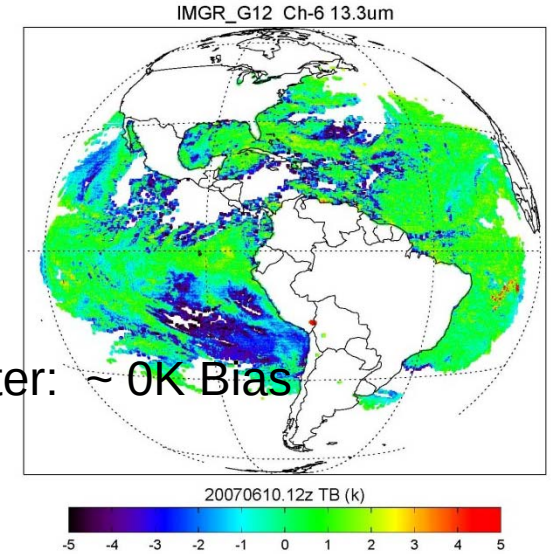


Web Accessible

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.

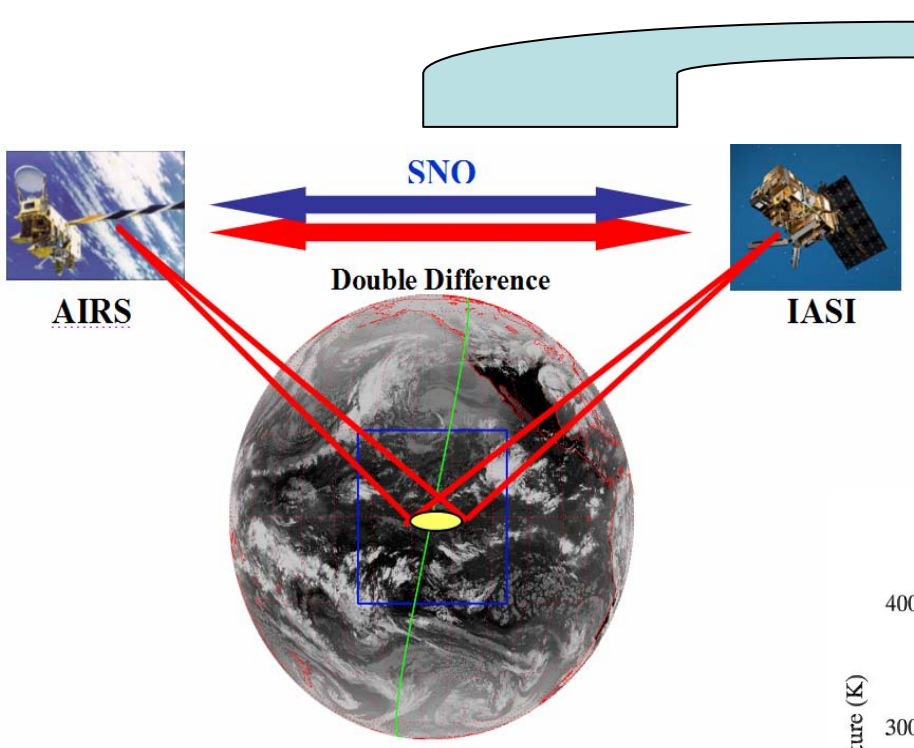
The user applies the correction to the original data using GSICS provided software and coefficients.

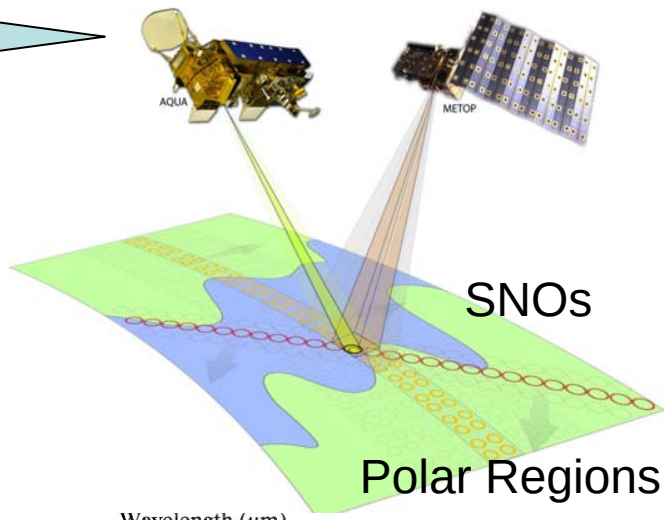
The correction adjusts the GOES data to be consistent with IASI and AIRS.

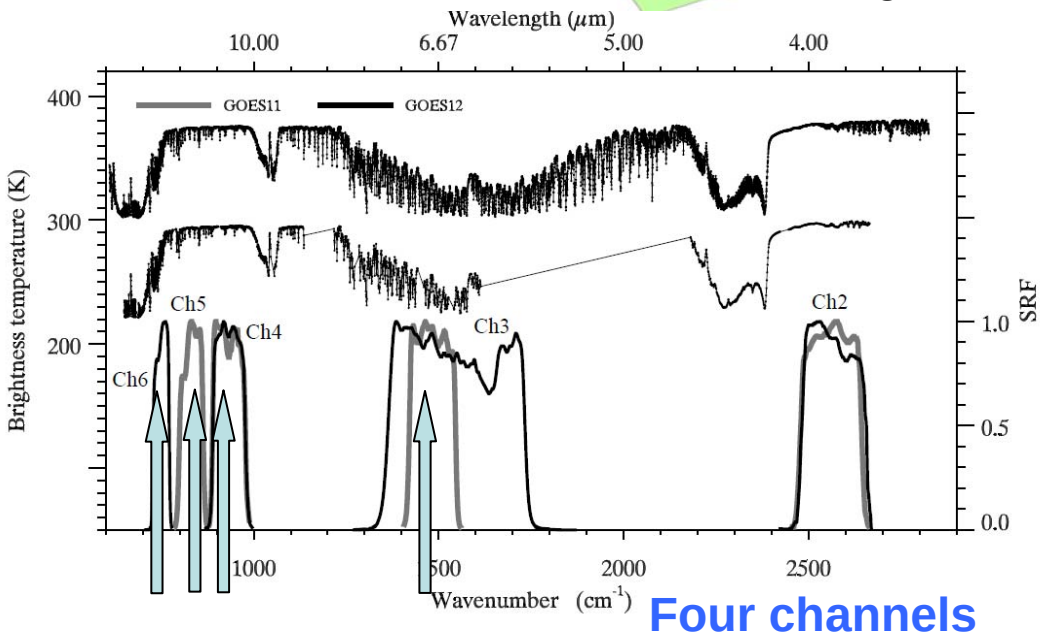
The figures to the left show the difference between observed and calculated brightness temperatures (from NCEP analysis) correction, respectively.

The bias is reduced from 3 K to nearly zero.

Double Difference versus SNOs



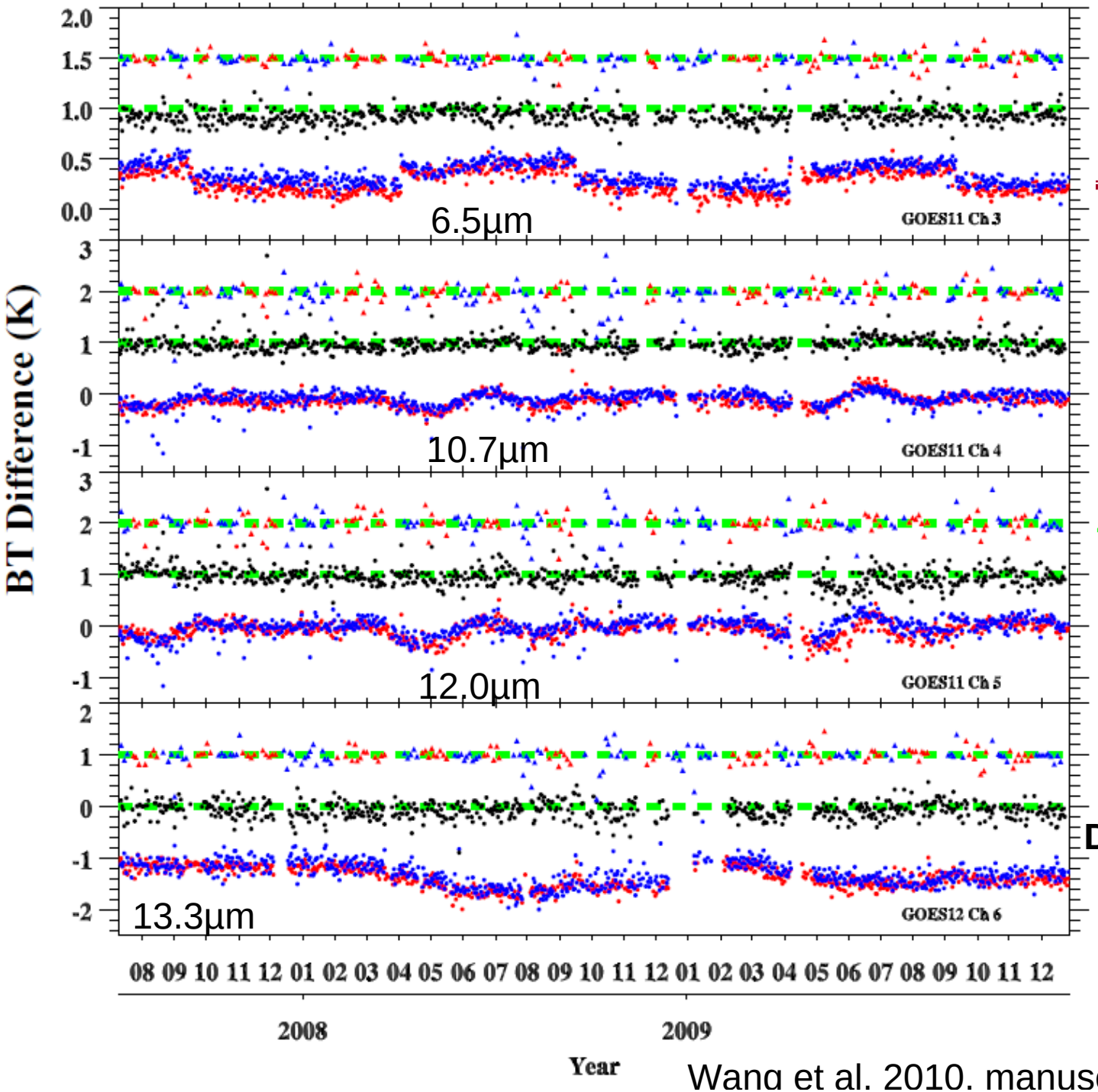




1) Indirect vs. Direct comparison

2) Warm scenes vs. cold scenes

Four channels



IASI-AIRS

Zero line

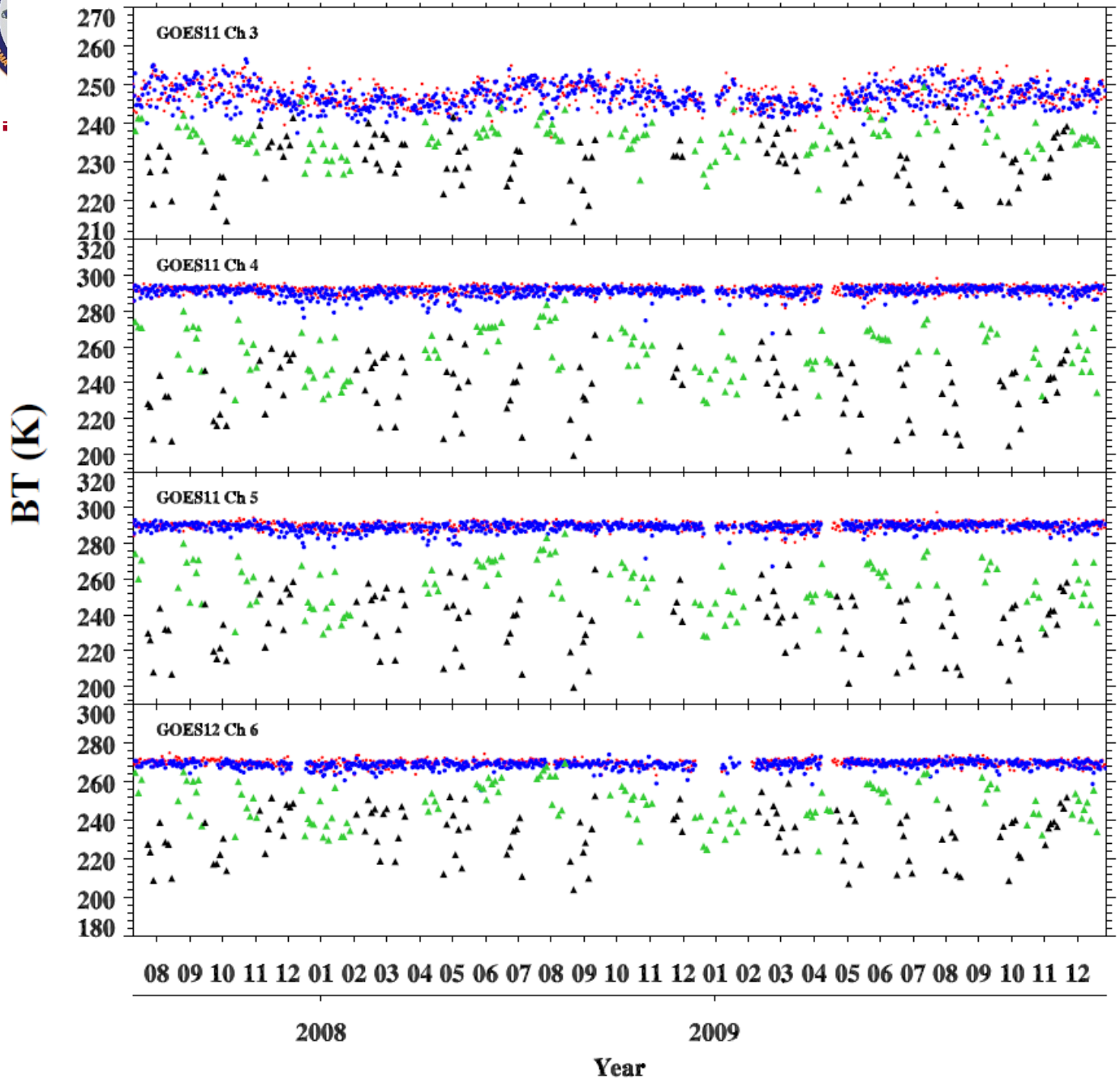
SNO North
SNO South

Double Difference

GOES-AIRS
GOES-IASI

Wang et al. 2010, manuscript for GRL

GOES-AIRS (blue dots) GOES-IASI (red dots)



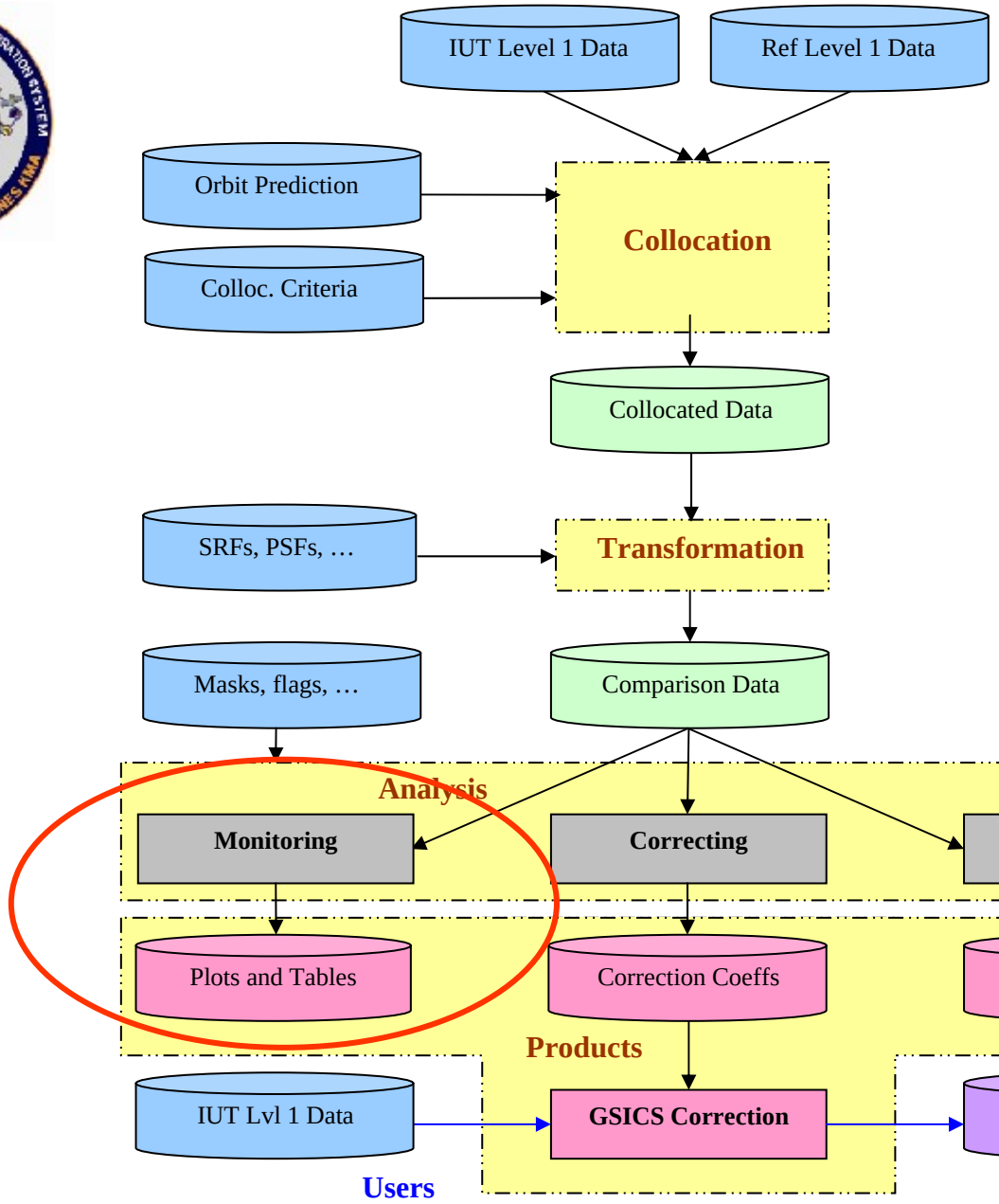
Scene Temp.

SNO North (green triangles)

SNO South (black triangles)

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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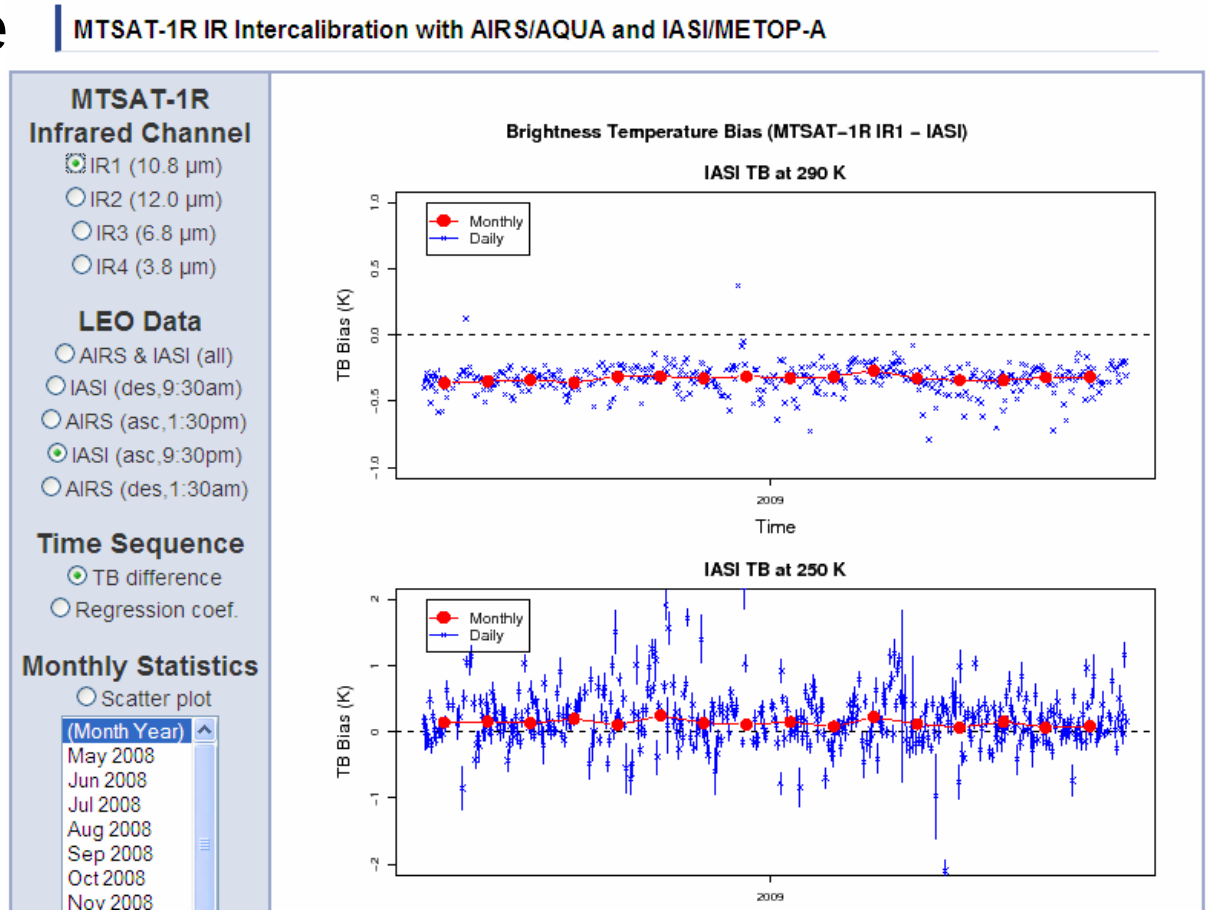
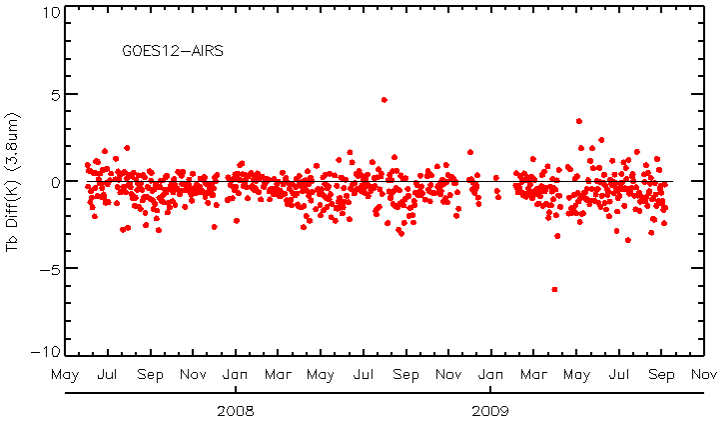
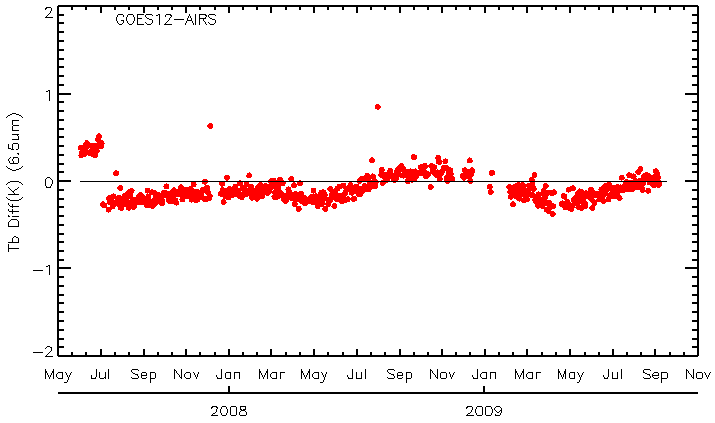
Monitoring MTSAT-AIRS/IASI

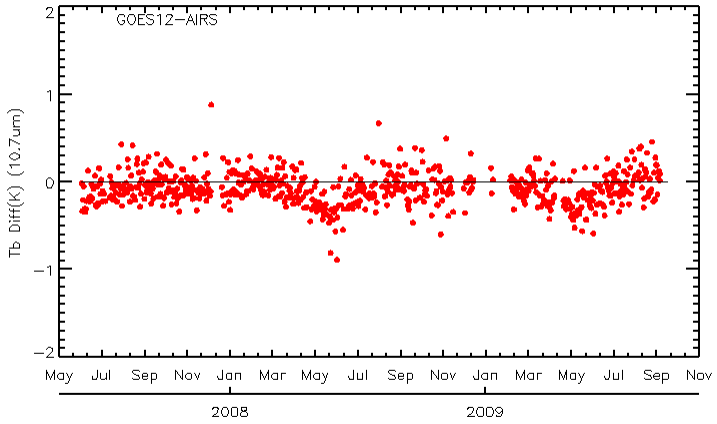
- Monitoring Example
- from JMA website
- MTSAT-1R – AIRS/IASI
- Time Series of Bias
  - at 220, 250, 290K
- and lots more…

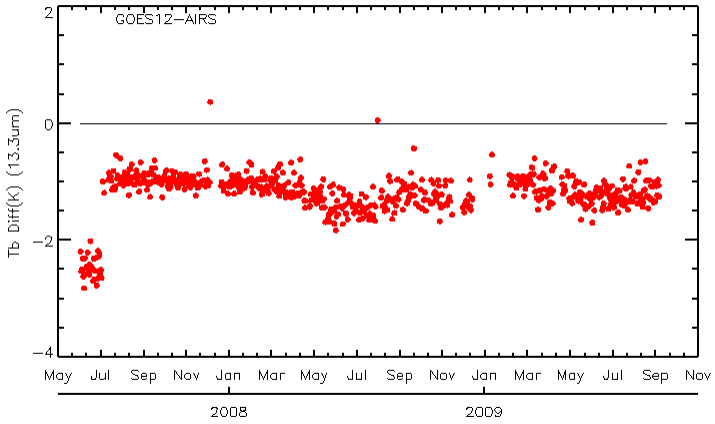


Monitoring GOES12-AIRS

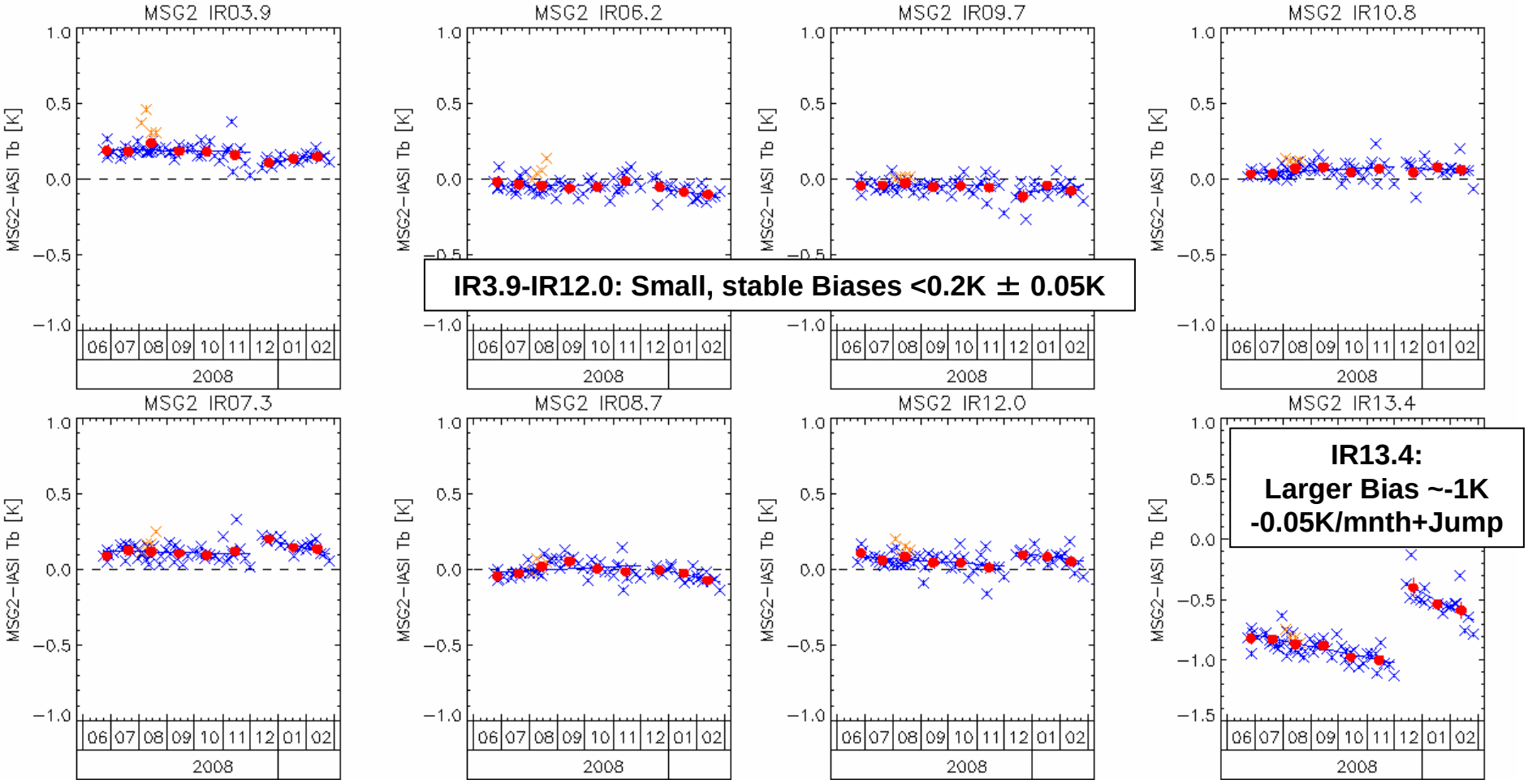




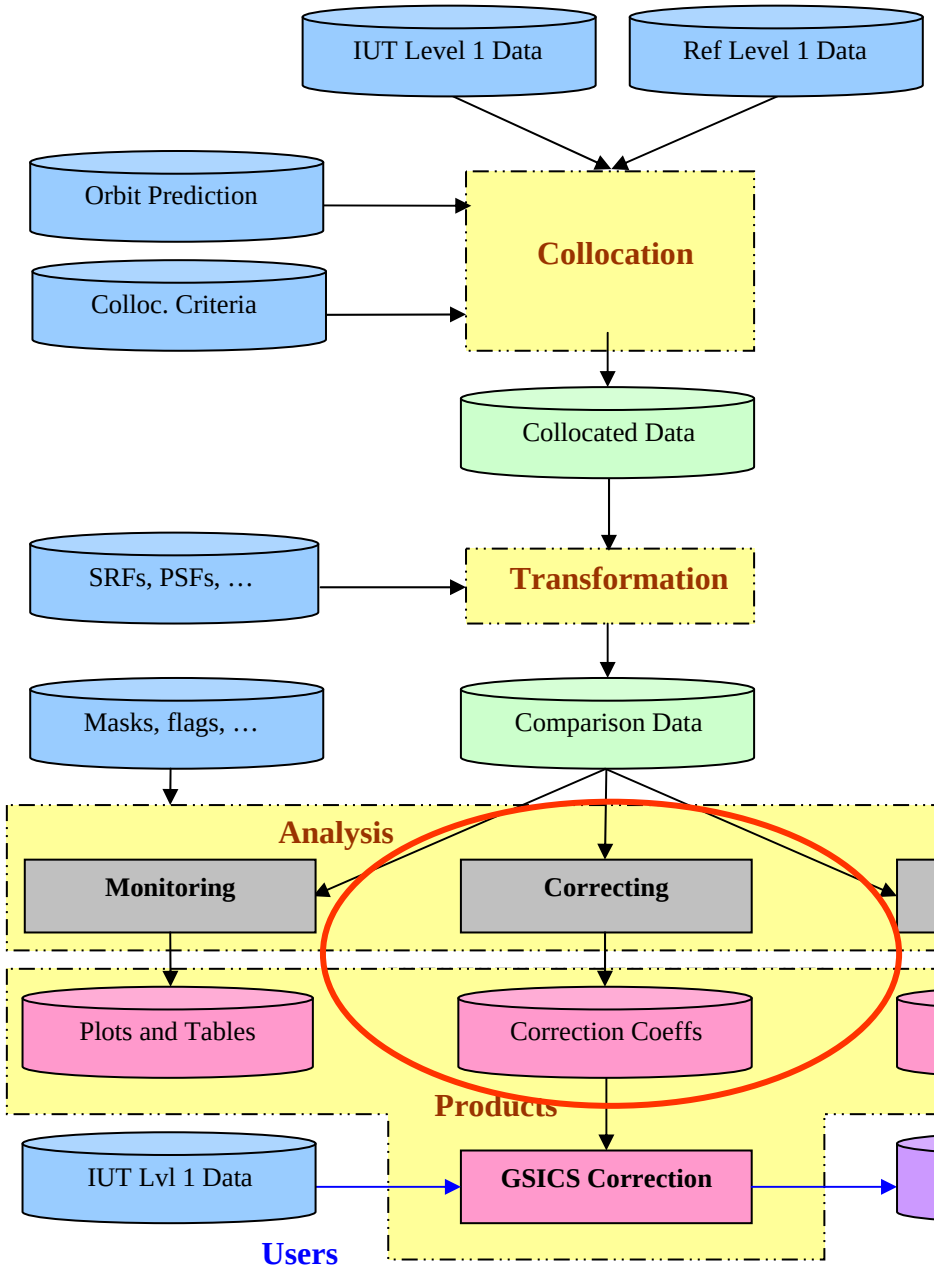




Monitoring Meteosat9-IASI



Time series of brightness temperature differences between MSG2-IASI for typical clear-sky radiances. Error bars represent statistical uncertainty on each mean bias (may be very small).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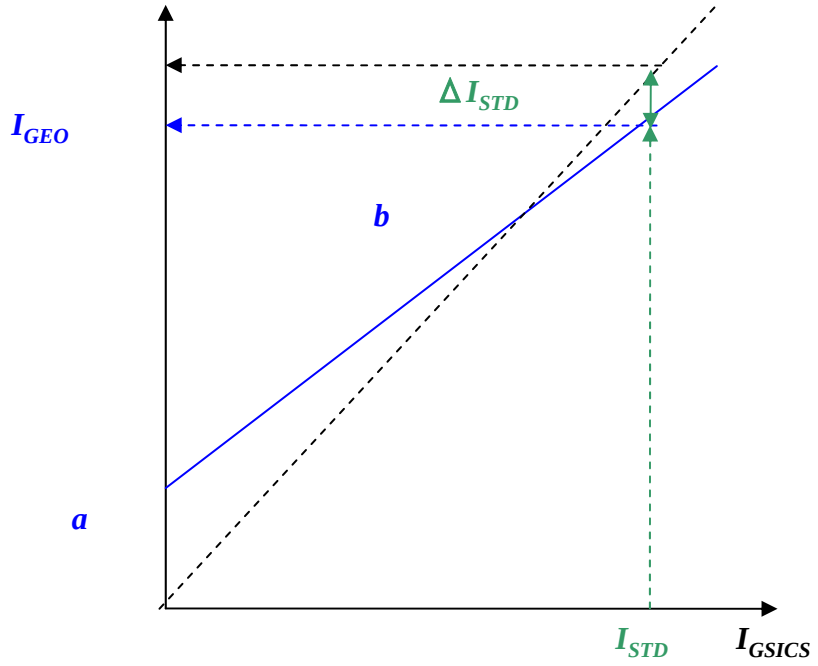
Analysis – Defining GSICS Correction

- GSICS Corrected radiance from GEO operational product
  - *a, b* from weighted regression
- Coalesce collocations over Period ~ 1 month

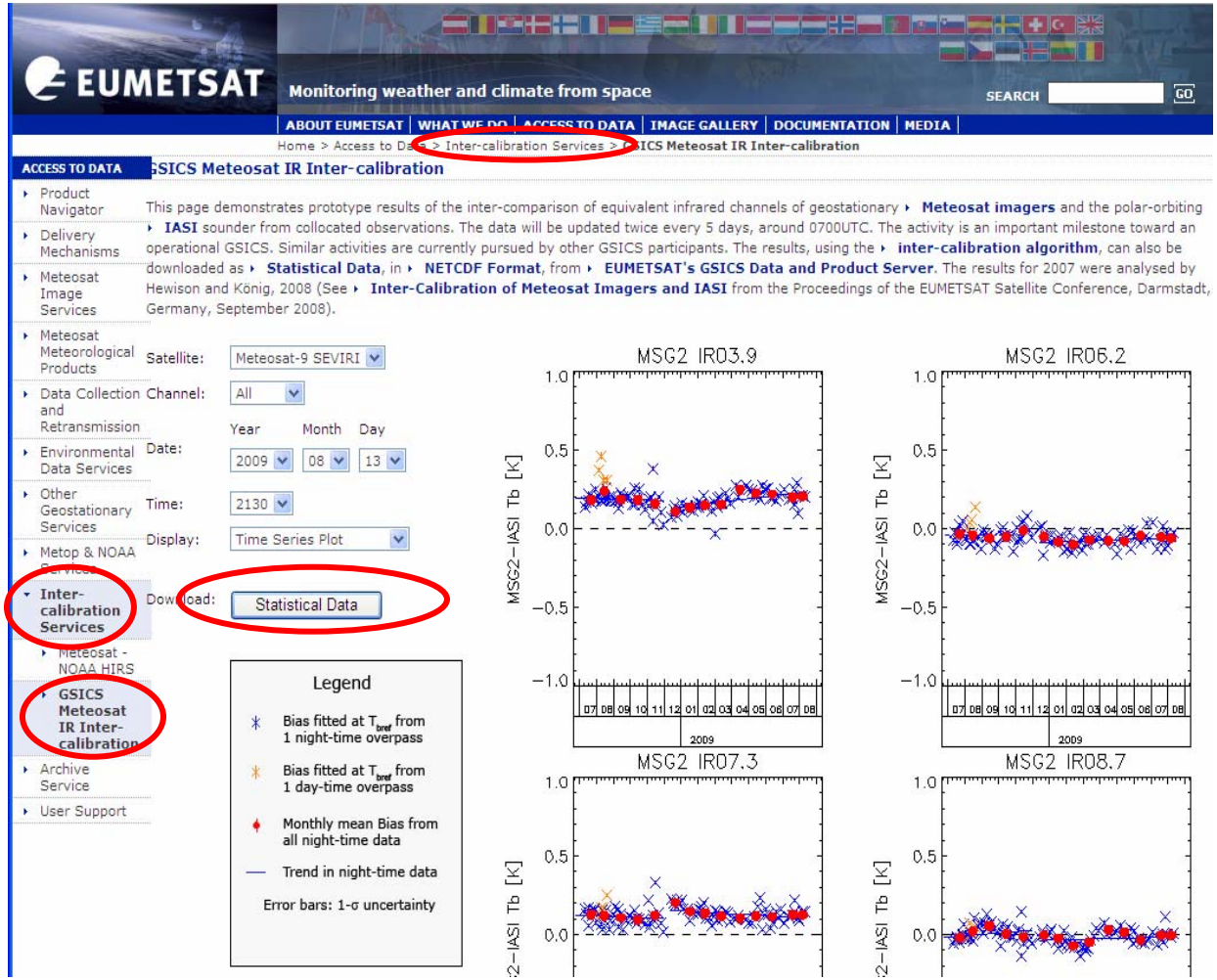


$$I_{GSICS} = -\frac{a}{b} + \frac{1}{b} I_{GEO}$$

$$\sigma_{I_{GSICS}} = \left(-\frac{\sigma_a}{b} \right)^2 + \left[(I_{GEO} - a)\sigma_b \right]^2 - 2\frac{I_{GEO} - a}{b}\sigma_{ab}$$

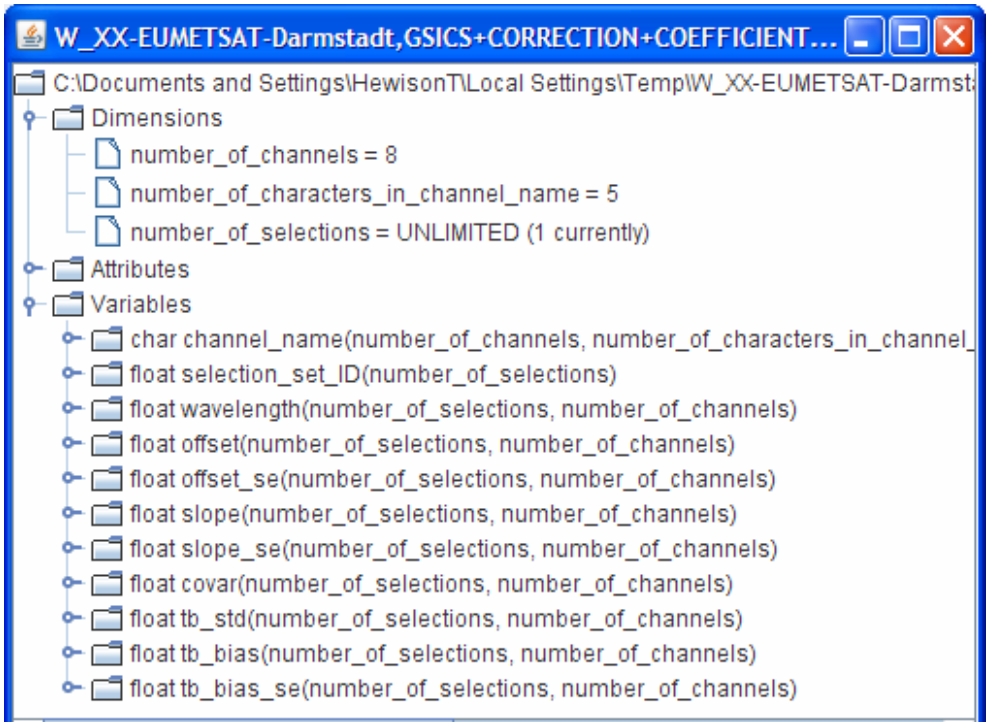
Analysis – Correcting

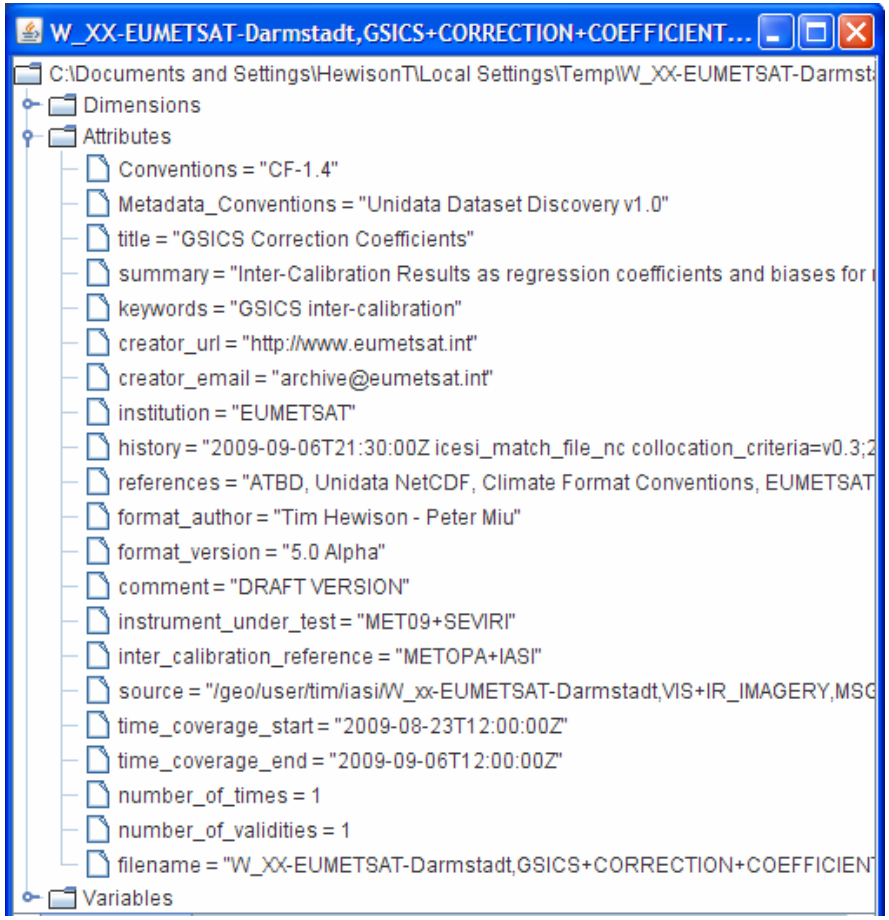
- EUMETSAT routinely run prototype inter-calibration of MSG-IASI
- Results published on webpage for *Inter-calibration Services* :
  - http://www.eumetsat.int/Home/Main/Access_to_Data/IntercalibrationServices
- This webpage also allows access to coefficients required to apply GSICS Correction
- Users can implement this as change in calibration coefficients



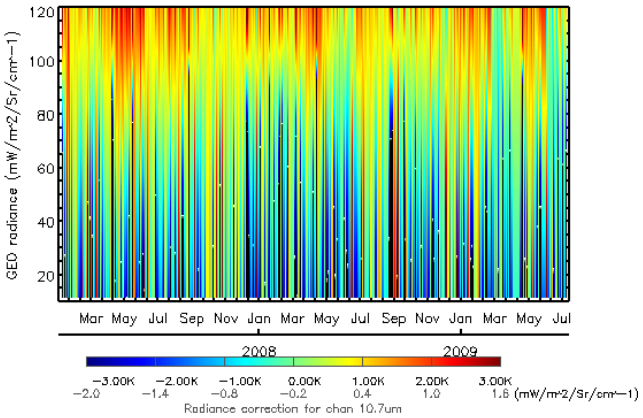
Analysis – Correcting

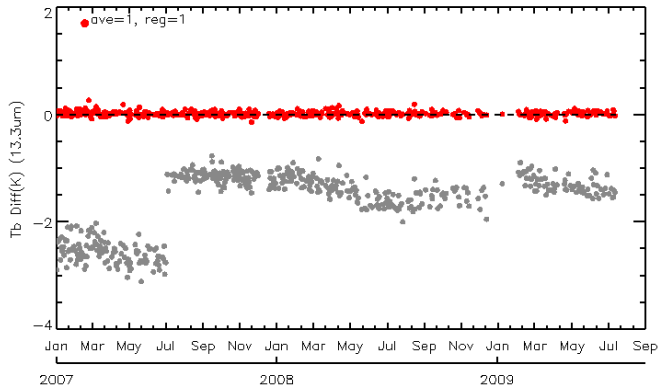
- GSICS *Correction Coefficients*
  - Contain best estimate of relationship between Instruments' radiance and Reference
  - Includes regression coefficients needed to apply GSICS Correction
  - Draft NetCDF Format defined

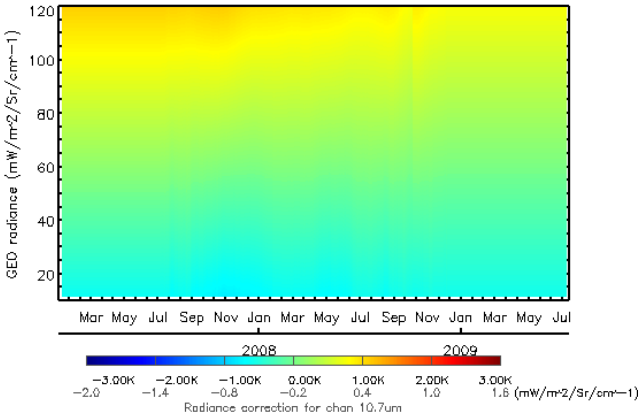


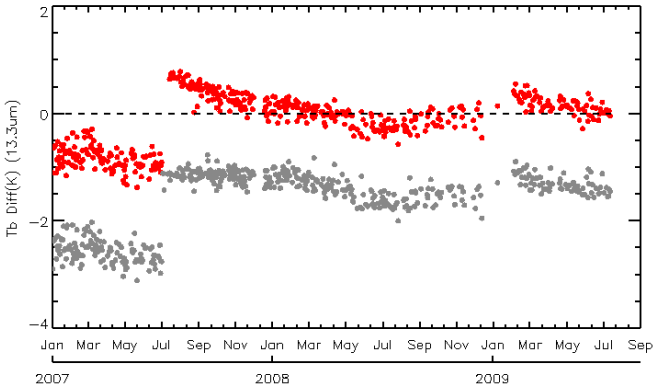


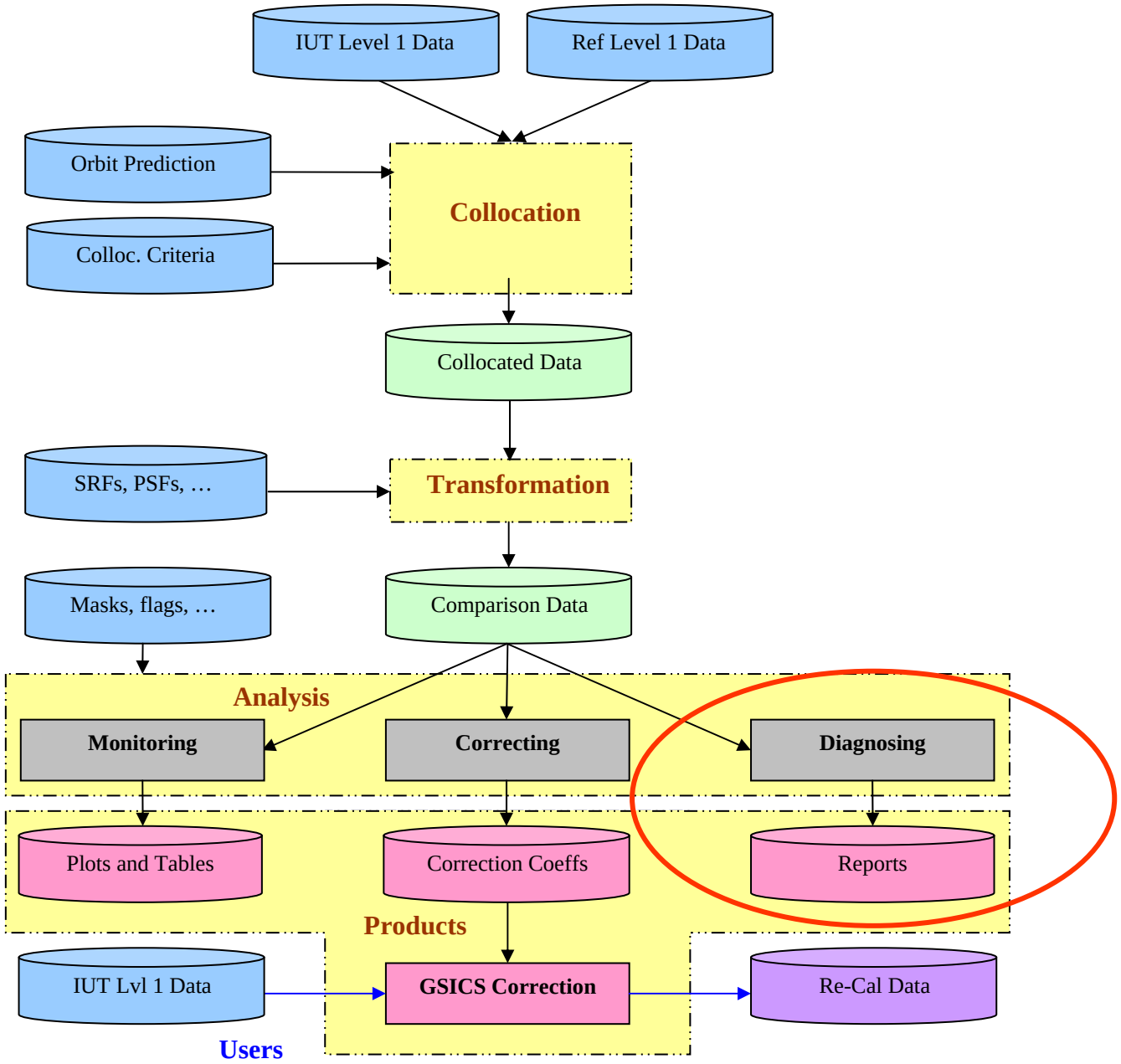
Analysis – Defining Coalescence Period







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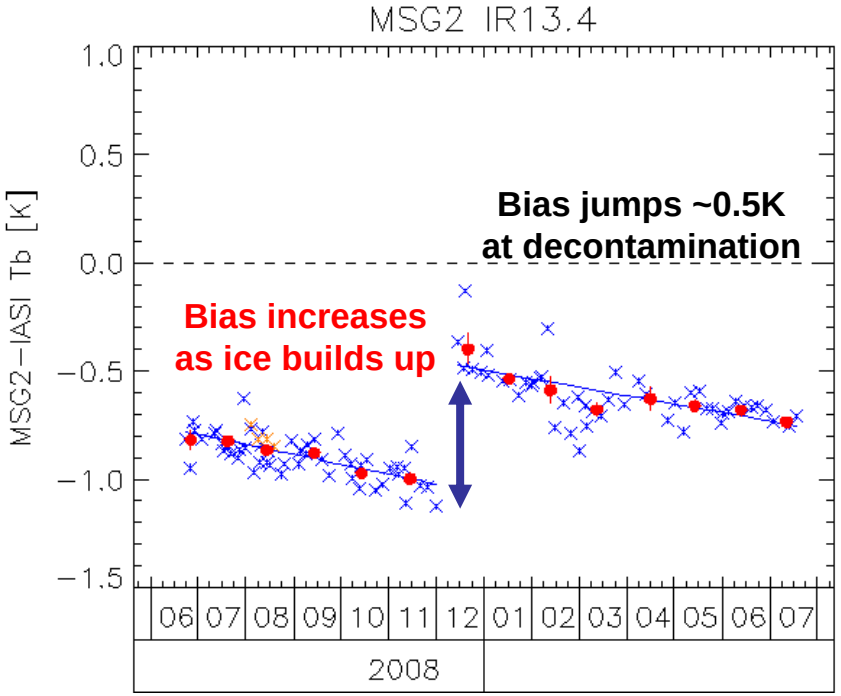
Analysis – Diagnosing

- Diagnosis is performed by offline
  - Investigating anomalous results
  - Generating reports and recommendations

- Examples
  - Meteosat-9 Ice Contamination of IR13.4 channel
  - GOES-13 Imager 13.3 μm channel cold bias
  - GOES-11/12 Sounder Channel 15 bias
  - GOES Midnight calibration anomaly
  - MODIS SRF errors

Diagnosing Ice Contamination of Meteosat-9 IR13.4

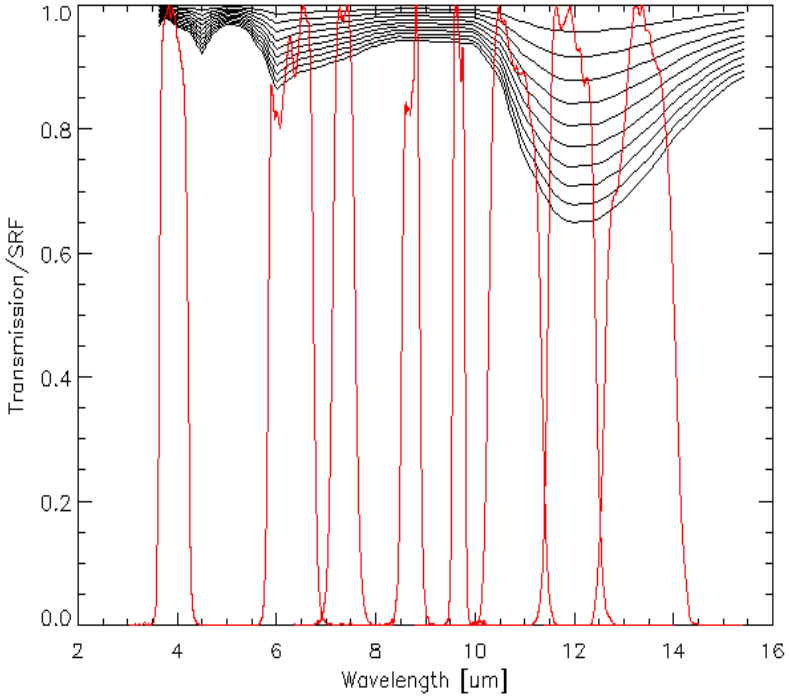
- Meteosat-9-IASI Bias
  - In 13.4µm channel
  - increasing by ~0.5K/yr
- Recovers after decontamination
- Theory: Ice on optics



Time series of radiances relative biases between IR13.4 channel of Meteosat-9(MSG2)-IASI for Standard Radiance scenes. Blue crosses indicate results from individual satellite orbits. Red circles show monthly means. Error bars represent statistical uncertainty on each mean bias. Solid blue lines show trends before and after the decontamination procedure of December 2008.

Diagnosing Ice Contamination of Meteosat-9 IR13.4

- Meteosat-9-IASI Bias
  - In 13.4µm channel
  - increasing by ~0.5K/yr
- Recovers after decontamination
- Theory: Ice on optics
- Ice absorption model
- Changes SRFs



Transmission spectra of ice layers of different thicknesses (black): 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 µm layers. Spectral Response Functions of Meteosat-8 infrared channels (red).

Diagnosing Ice Contamination of Meteosat-9 IR13.4

- Meteosat-9-IASI Bias
  - In 13.4µm channel
  - increasing by ~0.5K/yr
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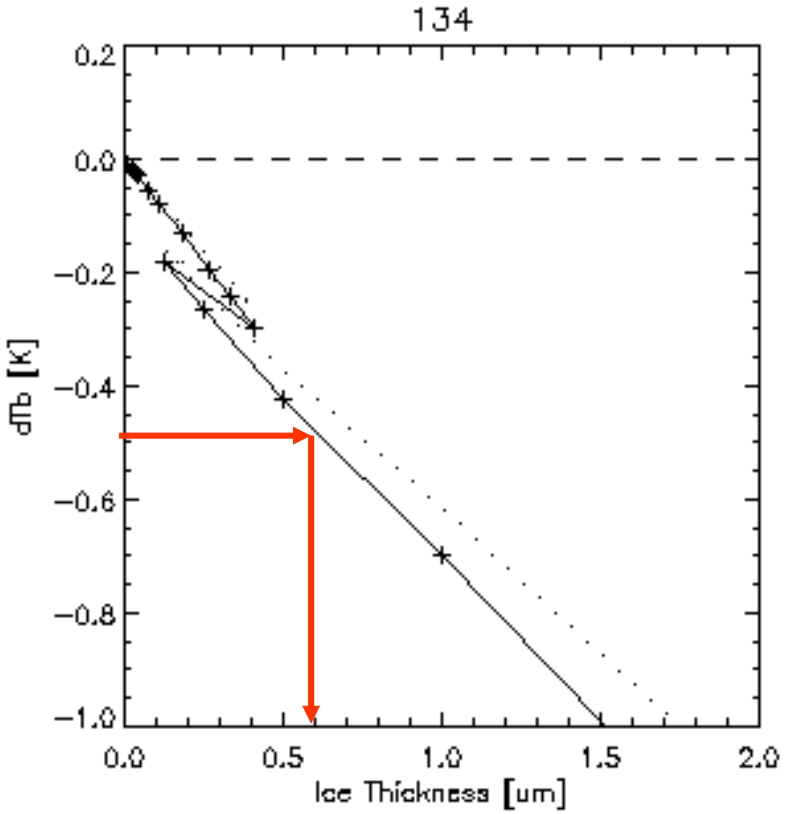
- Theory: Ice on optics
- Ice absorption model
- Changes SRFs
- Biases non-window channels
- Modelled by ~0.6µm ice



Brightness temperature bias modelled by modifying Meteosat-9's SRF by the absorption of different thicknesses of ice.

Diagnosing Ice Contamination of Meteosat-9 IR13.4

- Meteosat-9-IASI Bias
  - In 13.4µm channel
  - increasing by ~0.5K/yr
- Recovers after decontamination
- Theory: Ice on optics
- Ice absorption model
- Changes SRFs
- Biases non-window channels
- Modelled by ~0.6µm ice
- Consistent with gain changes

Channel	Feb-2006	d /µm	Jun-2006	d /µm	Dec-2006	d /µm	Dec-2007	d /µm	Dec-2008	d /µm
IR3.9	6%	0.5	6%	0.5	6%	0.5	6%	0.5	6%	0.5
IR6.2	21%	1.3	8%	0.5	6%	0.4	10%	0.6	7%	0.5
IR7.3	13%	1.0	4%	0.3	3%	0.3	6%	0.5	4%	0.4
IR8.7	8%	1.0	6%	0.8	4%	0.5	6%	0.7	3%	0.4
IR9.7	6%	0.7	1%	0.2	1%	0.1	2%	0.3	0%	0.0
IR10.8	44%	1.7	22%	0.9	14%	0.6	23%	1.0	16%	0.7
IR12.0	115%	1.6	49%	0.8	34%	0.6	50%	0.8	35%	0.6
IR13.4	66%	1.2	27%	0.5	23%	0.4	30%	0.6	23%	0.4

Gain Changes (%) in Meteosat-9 IR channels during decontaminations and estimated ice thickness (µm) from transmission model.

Engage the User Community

- 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

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
- Improved sensor characterisation
- High quality radiances for NWP & CDRs