GSICS Progress Update and Coordination

Fuzhong Weng and Mitch Goldberg

CEOS WGCV 28th Meeting

Sanya, China

February 24-28th, 2008

Agenda

- GSICS Progress
  - Data/News
  - LEO2LEO
  - GEO2LEO
  - Community Support
- Coordination Goals
- Summary

GSICS Coordination Center Staff (at NESDIS)

- News Group
  - Task Lead: Bob Iacovazzi
- LEO2LEO VIS/IR Group
  - Task Lead: Alex Wang
  - Advisor: Changyong Cao
- LEO2LEO MW Group
  - Task Leads: Banghua Yan and Bob Iacovazzi
  - 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
- Web Site
  - Task Lead: ??
  - Advisors: Bob Iacovazzi, Changyong Cao and Fuzhong Weng

News/Data

GSICS Quarterly

Global Space-based Inter-Calibration System

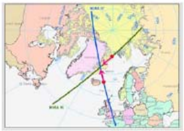
• CMA • CNES • EUMETSAT • JMA • KMA • NOAA • WMO •

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.

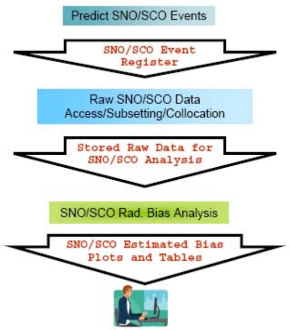


Figure 1: Process of estimating inter-satellite calibration biases using the SNO/SCO method.

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.

- Three informative issues since June
- Articles include GSICS organization and project overviews, science, meeting summaries, personnel, etc.
- Contributions from Germany, Japan, and US
- We need your GSICS–related articles …
  - Organization and Project Overviews
  - New Science
  - Meetings and Awards
  - Personnel
  - Classifieds

News/Data

Web Site Updates

- LEO-LEO results linked to "SCIENCE PAGES"
- GSICS Quarterly newsletters available
- Expanded list of publications
- Have any personnel changes, seminars, meetings, publications, links, data, opportunities … let us know.

News/Data

GSICS Meetings

- GSICS Executive Panel III, November 2007, Cocoa Beach, FL, USA

GSICS at Meetings

- IGARSS – July 2007, Barcelona, Spain
- SPIE Optics and Photonics – August 2007, San Diego, CA, USA
- AMS Sat. Met. & Ocn. Conf – September 2007, Amsterdam, Netherlands
- Calcon - October 2007, Logan, UT, USA
- 1st International IASI Conference, November 2007, Anglet, France.

LEO2LEO

- LEO-LEO results linked to web site.
- Automated AIRS/IASI simultaneous nadir overpass (SNO) inter-comparisons {*Software now implemented at EUMETSAT*}
- Other IASI inter-comparisons
- N16 AMSU-A Ch 4 anomaly detection
- SSM/I and SSM/IS simultaneous conical overpass (SCO) inter-comparisons

LEO2LEO

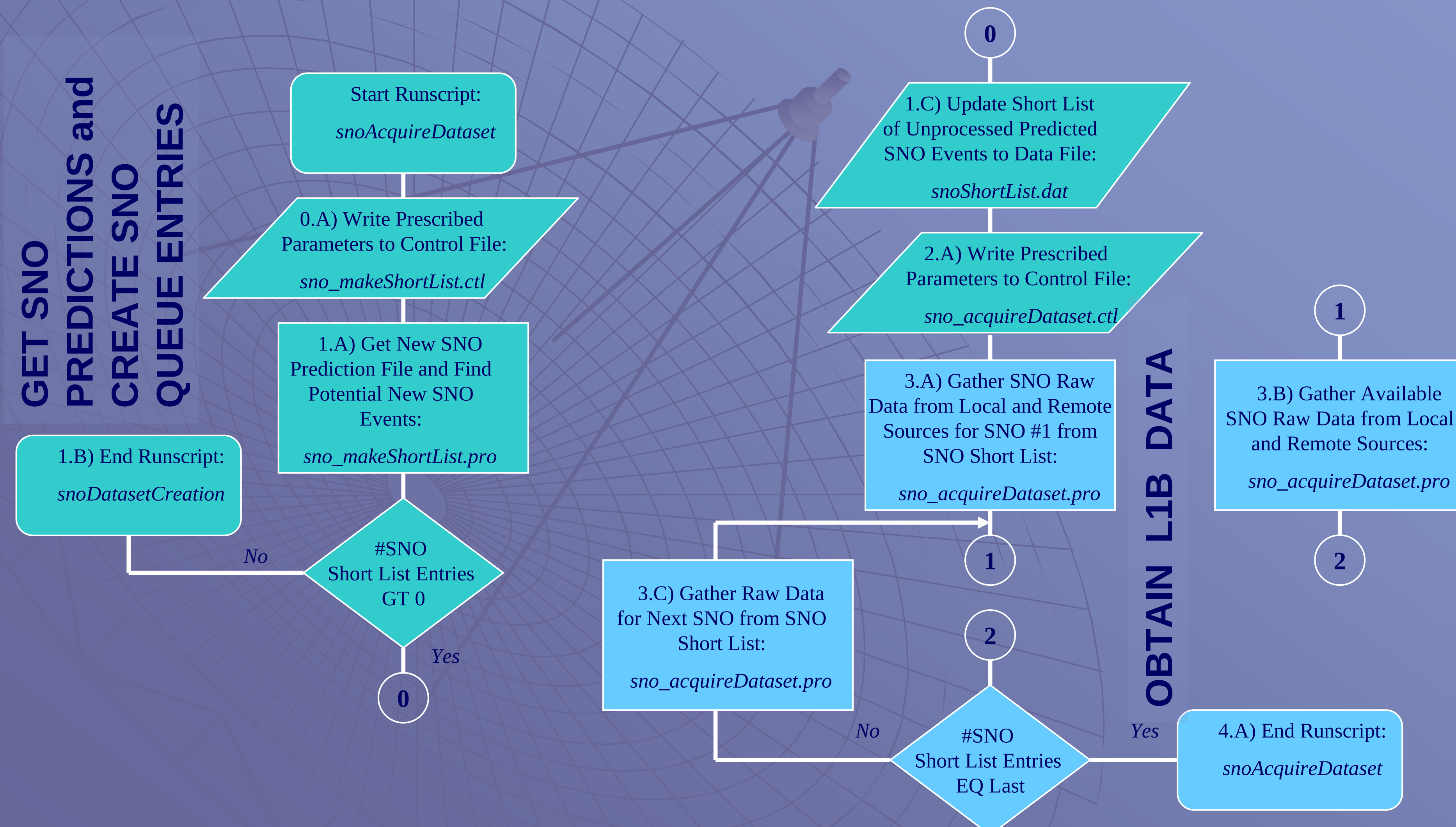
LEO-LEO results linked to web site

- Consists of graphs, tables, and documentation regarding SNO/SCO analysis.
- AIRS, AMSU-A, AVHRR, HIRS, IASI, MODIS, SSM/IS
- Most current & some historical instruments
- Working toward a uniform analysis product and more thorough documentation

LEO2LEO

POES and MetOP-A Instrument SNO/SCO Analysis

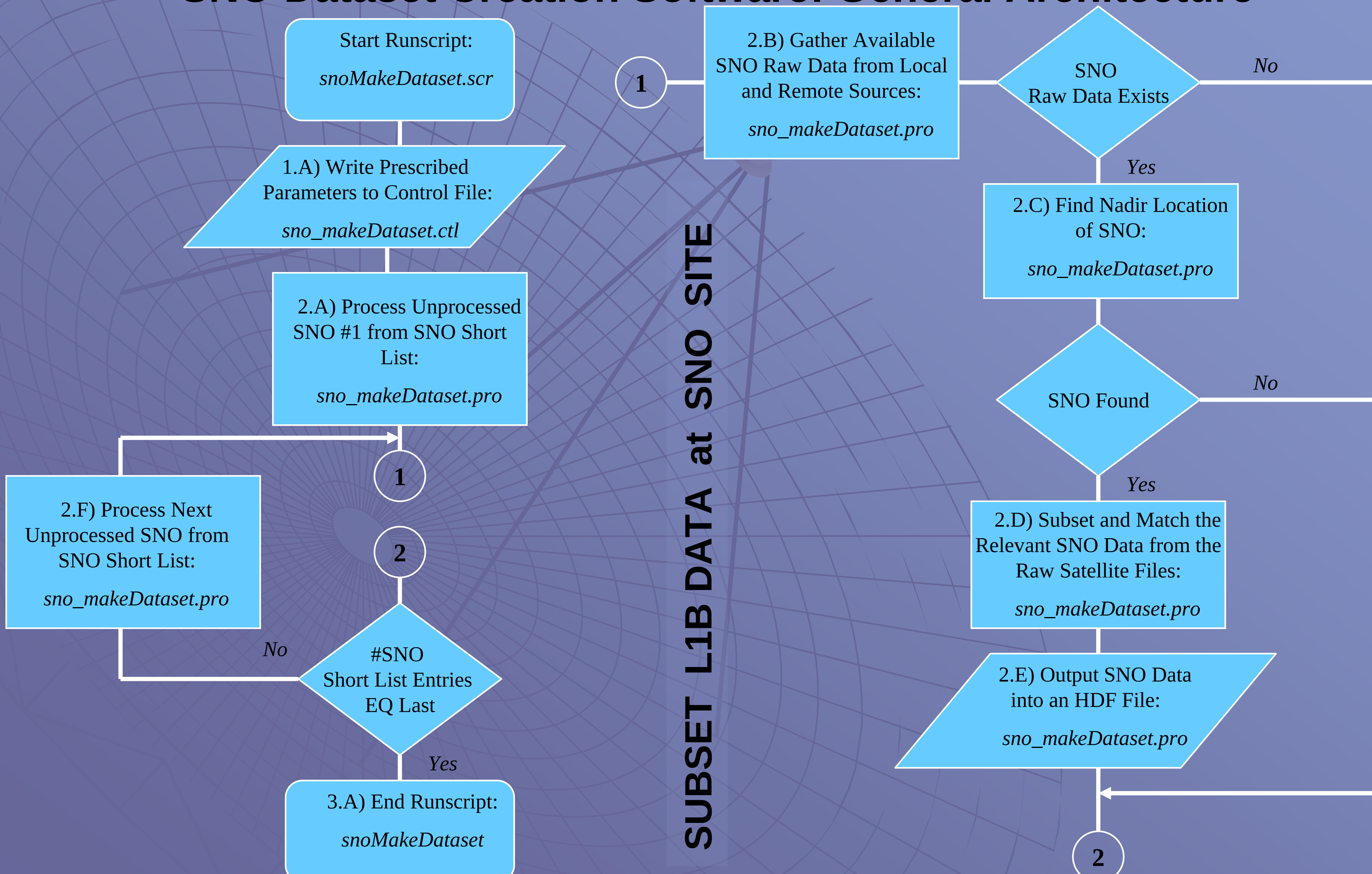
SNO Raw Data Acquisition Software: General Architecture



LEO2LEO

POES and MetOP-A Instrument SNO/SCO Analysis

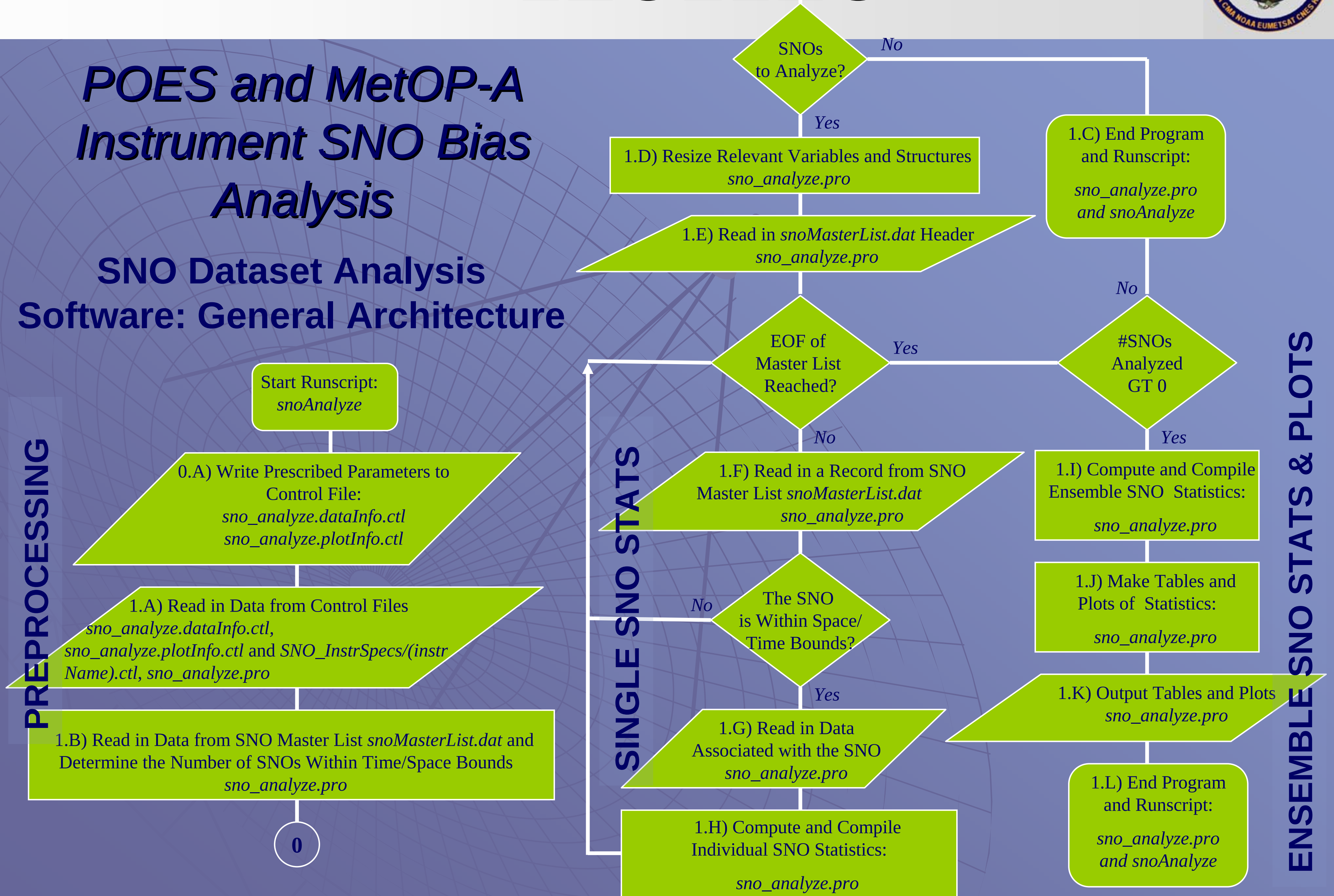
SNO Dataset Creation Software: General Architecture



LEO2LEO

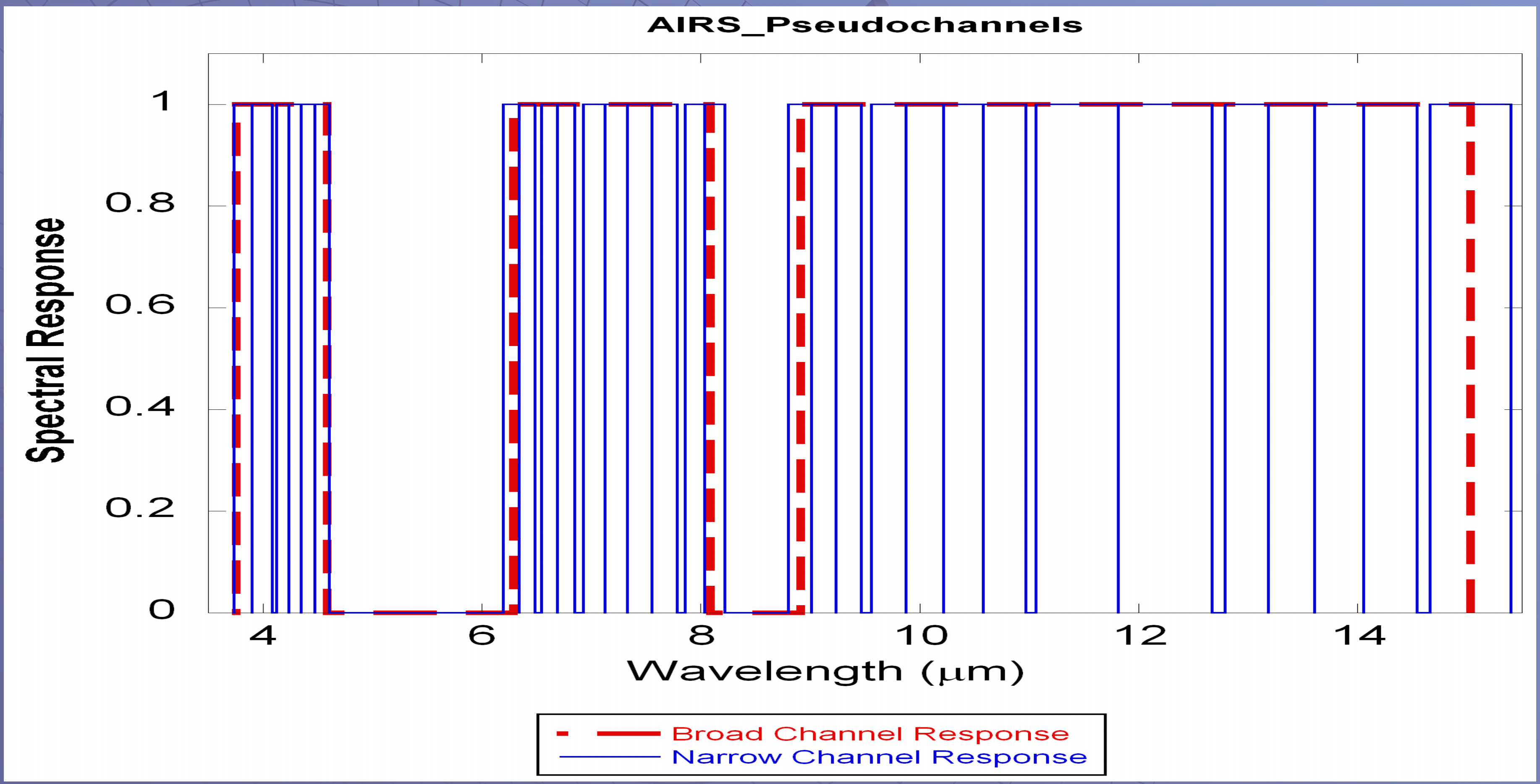
POES and MetOP-A Instrument SNO Bias Analysis

SNO Dataset Analysis Software: General Architecture



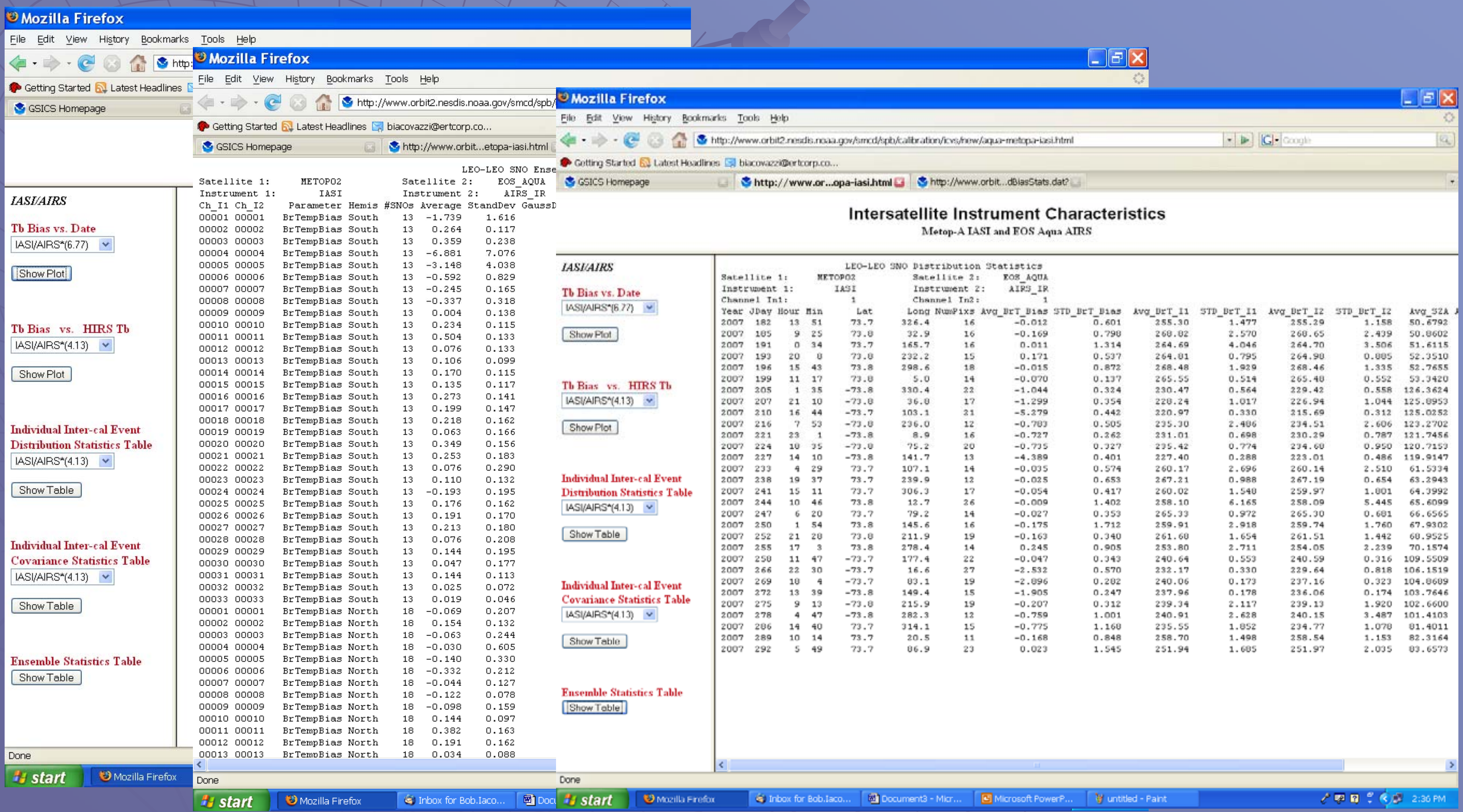
LEO2LEO

AIRS/IASI SNO Inter-comparison for 33 Boxcar Pseudochannels



LEO2LEO

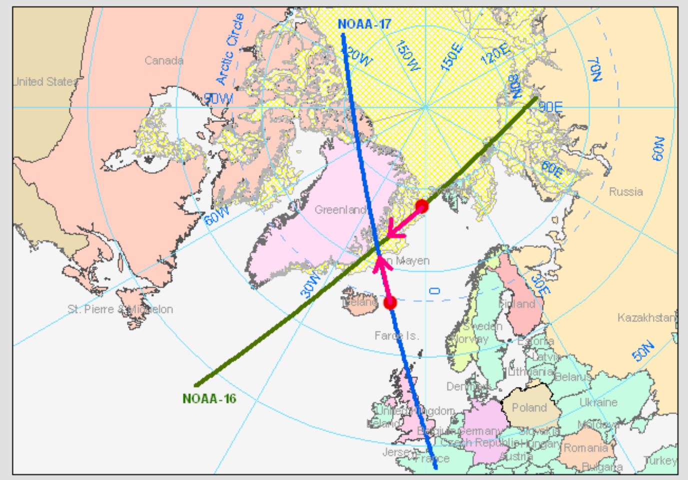
AIRS/IASI SNO Inter-comparison for 33 Boxcar Pseudochannels

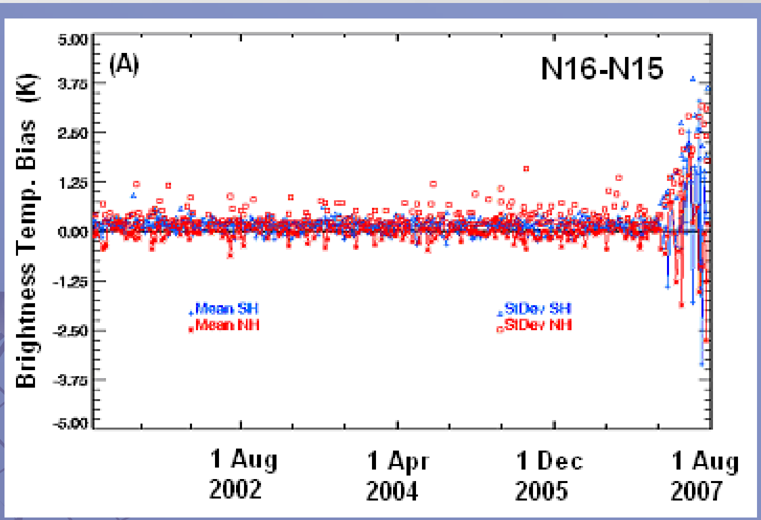


LEO2LEO

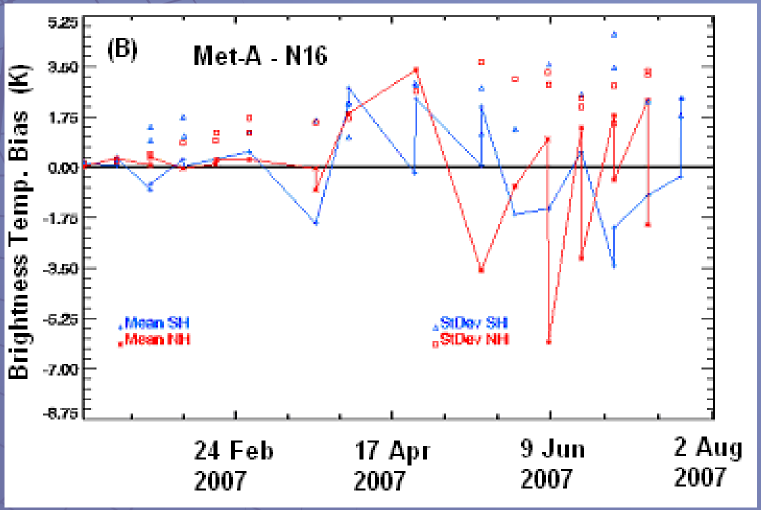
N16 AMSU-A Ch 4 Anomaly Detection

Automate Analysis of Simultaneous Nadir Overpasses between N16 and N15 AMSU-A and N16 and METOP-A AMSU-A





Time series of NOAA16 – NOAA15 AMSU-A Channel 4 T_b bias.

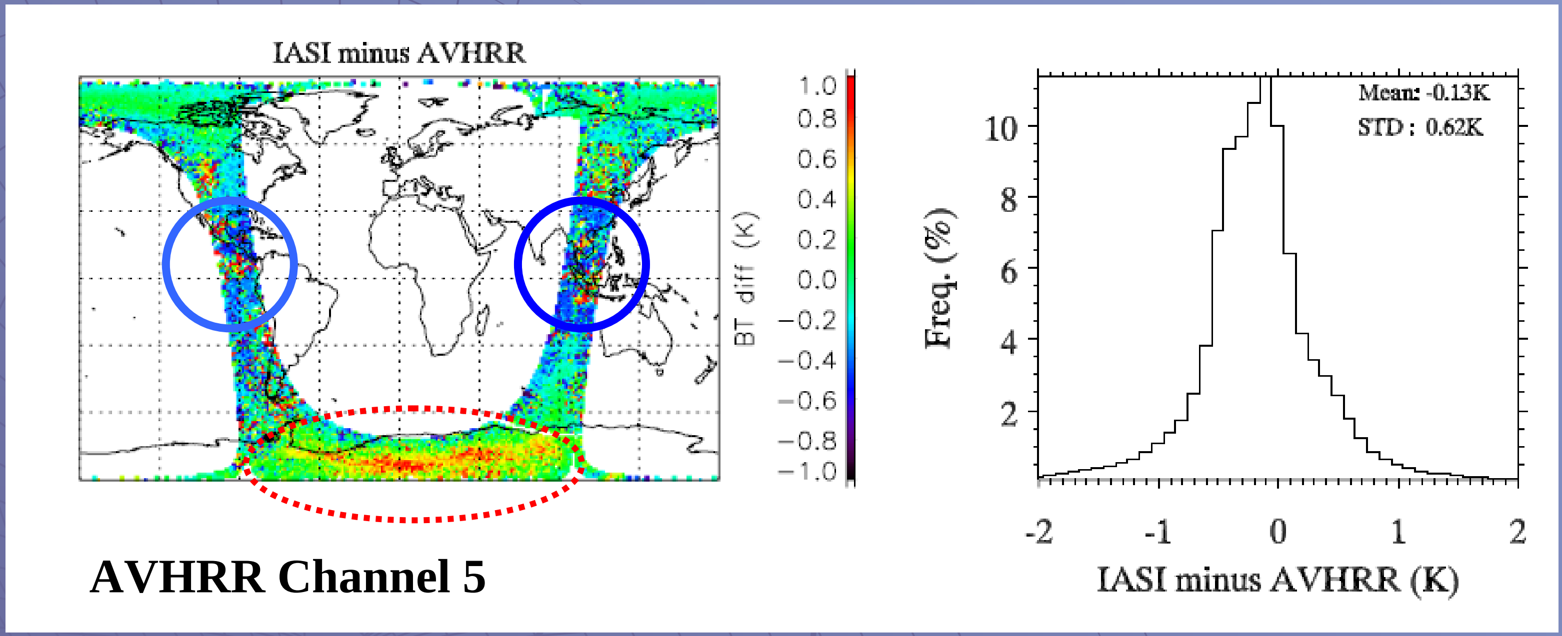


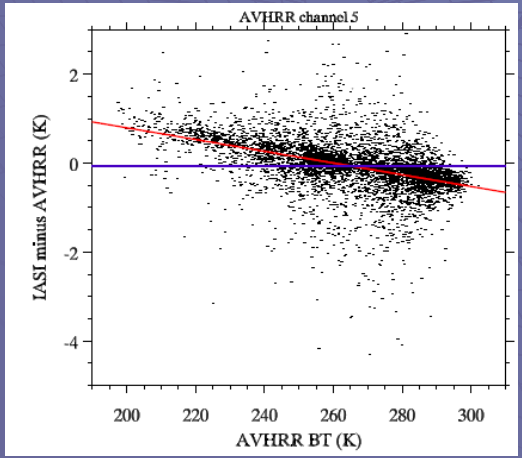
Time series of MetOp-A – NOAA16 AMSU-A Channel 4 T_b bias.

Please report significant anomalies of your instruments to GCC. They can be posted in GSICS Quarterly and/or our web site.

LEO2LEO

Difference between IASI and AVHRR



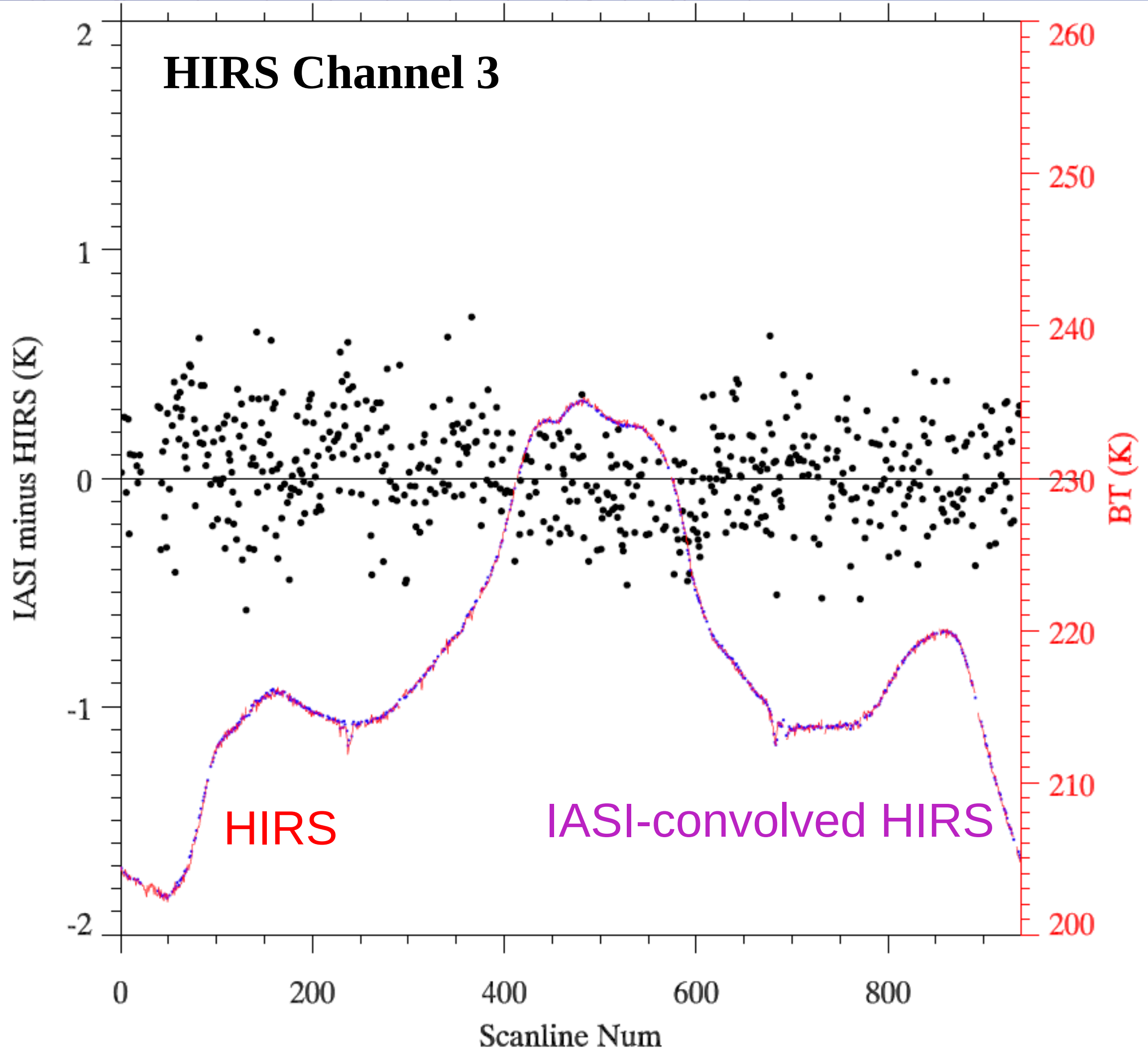


- Temperature observed from AVHRR channels 4 and 5 is slightly warmer than IASI.
- The bias distribution has spatial patterns, which is related to scene temperature.

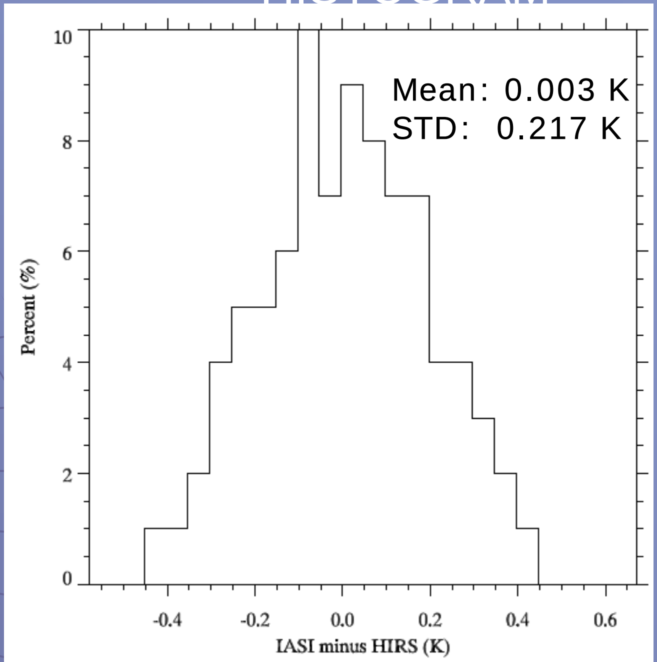
(*Wang and Cao, 2007*)

LEO2LEO Group Progress

Difference between IASI and HIRS



HISTOGRAM

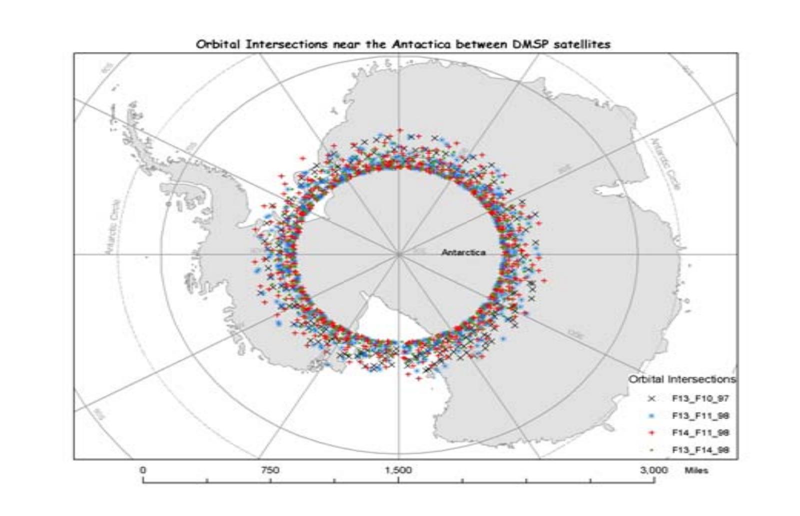


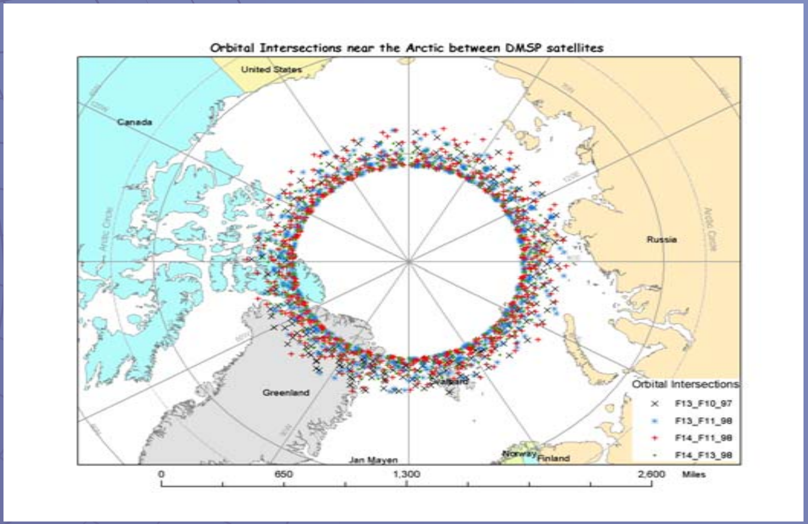
(*Wang and Cao, 2007*)

LEO2LEO

Specific Considerations in SSM/I SCO Processing

- SCO – every pair of polar-orbiting satellites with different altitudes pass their orbital intersections within a few seconds regularly in the polar regions
- Conical instruments produce more chances in matching than scanners due to their constant viewing angle
- Strong emissivity variation at high latitudes requires stringent check in surface homogeneity - sigma tests
- Time constraints are significant for microwave sensors





LEO2LEO

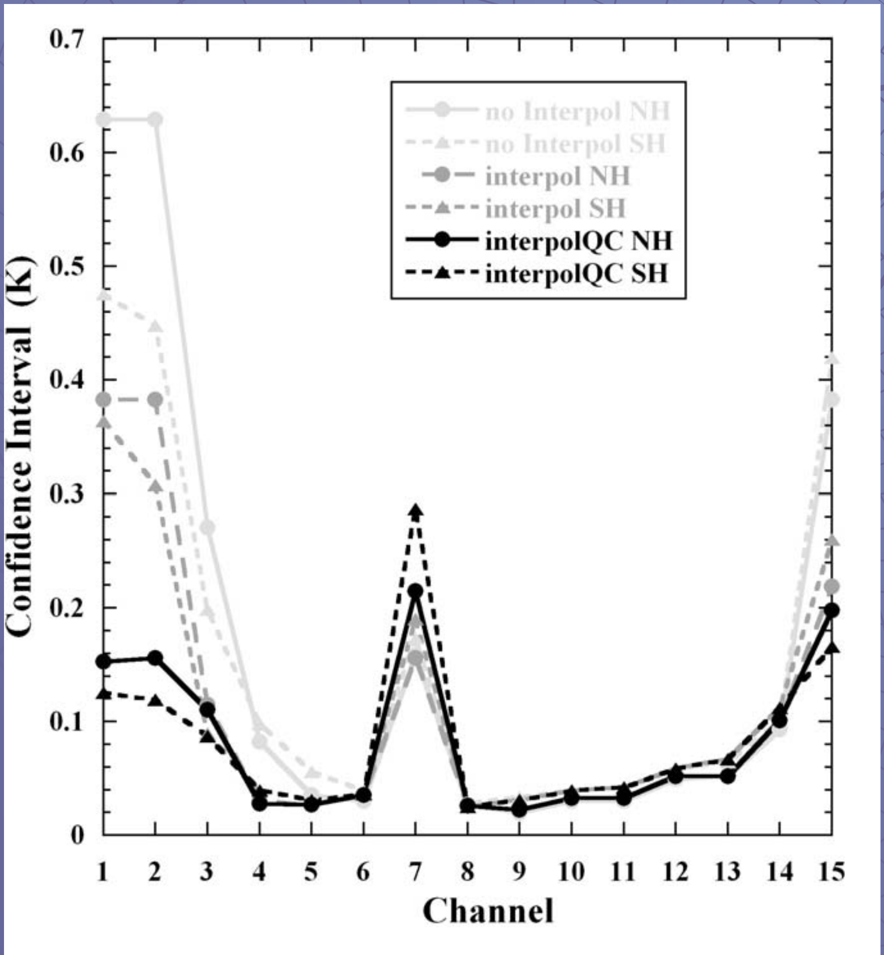
F13 and F14 SCO Bias vs. Quality Control

Channel & Polarization			19V	19H	22V	37V	37H	89V	89H
Bias	Land	QC1	2.55	3.56	2.42	1.41	2.28	1.07	1.62
		QC2	1.74	2.23	1.74	0.95	1.32	1.00	1.29
	Ice	QC1	0.29	0.78	0.39	-0.09	0.40	0.40	0.70
		QC2	0.05	0.84	0.10	-0.25	0.48	0.29	0.65
	Water	QC1	-0.02	0.21	0.14	-0.26	0.17	0.51	0.72
		QC2	-0.17	-0.03	-0.04	-0.38	0.06	0.44	0.62
Standard Deviation	Land	QC1	9.61	16.75	8.29	7.32	13.09	6.82	9.54
		QC2	7.55	12.88	6.76	6.08	10.18	5.88	7.82
	Ice	QC1	2.04	3.74	1.87	1.49	2.54	2.98	2.98
		QC2	1.49	1.97	1.57	1.58	1.89	2.87	2.96
	Water	QC1	3.96	6.88	3.31	2.90	5.48	2.71	3.66
		QC2	4.29	7.16	3.50	2.83	5.33	2.54	3.42
Quality Control Criteria			QC1: $\Delta d \leq 12.5$ km, $\Delta t \leq$ 60 seconds QC2: $\Delta d \leq 12.5$ km, $\Delta t \leq$ 10 seconds						

Channel & Polarization			19V	19H	22V	37V	37H	89V	89H
Bias	Land	QC1	1.74	2.23	1.74	0.95	1.32	1.00	1.29
		QC2	0.28	0.59	0.31	-0.32	0.26	0.12	0.20
	Ice	QC1	0.05	0.84	0.10	-0.25	0.48	0.29	0.65
		QC2	0.16	0.46	0.32	-0.28	0.13	0.64	0.67
	Water	QC1	-0.17	-0.03	-0.04	-0.38	0.06	0.44	0.62
		QC2	-0.16	0.28	0.22	-0.43	0.22	0.15	0.65
Standard Deviation	Land	QC1	7.55	12.88	6.76	6.08	10.18	5.88	7.82
		QC2	1.66	1.45	1.80	1.54	1.45	1.17	1.09
	Ice	QC1	1.49	1.97	1.57	1.58	1.89	2.87	2.96
		QC2	0.58	0.88	0.99	0.46	0.58	0.86	0.79
	Water	QC1	4.29	7.16	3.50	2.83	5.33	2.54	3.42
		QC2	0.63	0.57	0.88	0.69	0.86	0.94	1.15
Quality Control Criteria			QC1: $\Delta d \leq 12.5$ km, $\Delta t \leq$ 60 seconds QC2: $\Delta d \leq 12.5$ km, $\Delta t \leq$ 10 seconds Plus $\sigma \leq 2$K						

LEO2LEO

Reducing SNO Bias Estimation Uncertainties for AMSU-A Surface Channels



SNO-ensemble mean Tb bias 99 % confidence interval versus AMSU-A channel for the Northern (solid line/circles) and Southern (dashed line/triangles) Hemispheres. The SNO method was performed between N18 and Aqua AMSU-A satellite instruments using the

- **pixel-matching (light-gray),**
- **bilinear interpolation (gray), and**
- **bilinear interpolation with quality control (black)**

data collocation techniques.

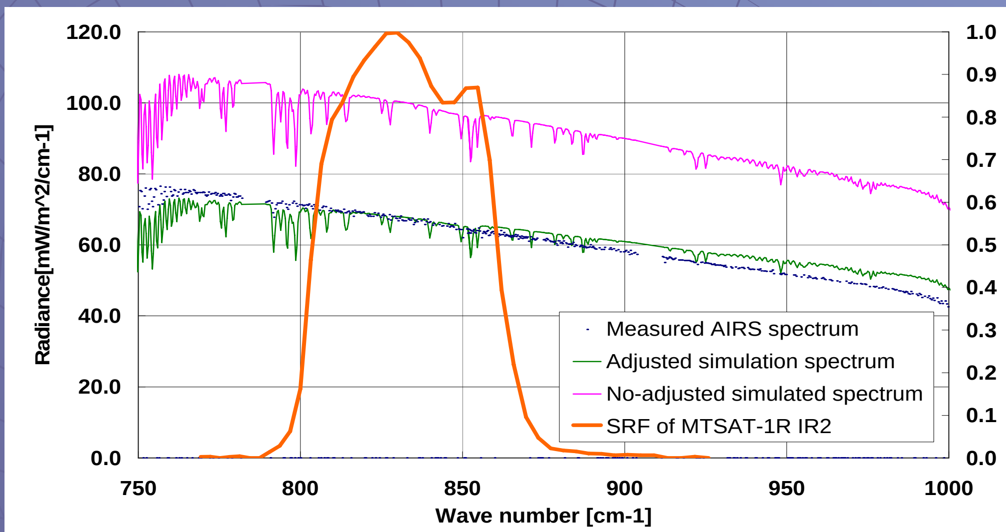
(Iacovazzi, Jr. and Cao, 2007)

GEO2LEO

- Dissemination of GEO-LEO analysis software
- AIRS/MTSAT, AIRS/GOES, IASI/SEVIRI and IASI/GOES Inter-comparisons
- Updates to GEO-LEO analysis software.

GEO2LEO

AIRS Gap Filling Technique

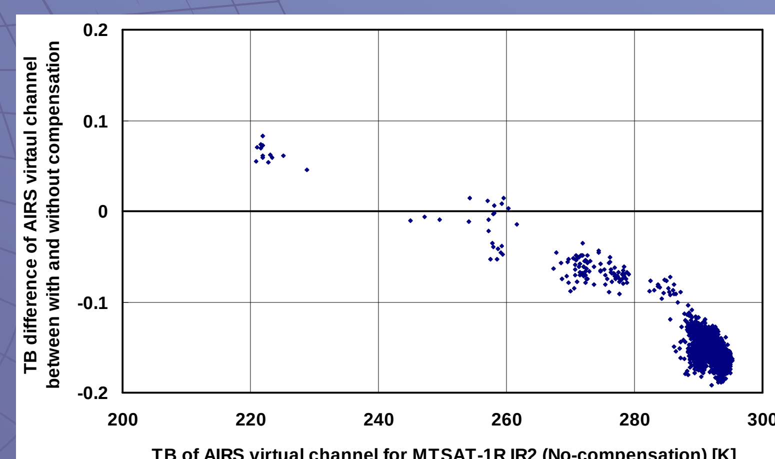


Method:

- Prepare line-by-line RTM simulated radiances with respect to a particular atmospheric model profile.
- Adjust the radiances to observed hyperspectral radiances.
- Adjustment is averaged ratio between observed hyperspectral radiances and corresponding simulated radiances computed from the line-by-line simulation.

Brightness temperature differences of the AIRS virtual channel computed with and without applying the proposed spectral gap filling method.

(Kato, 2007)

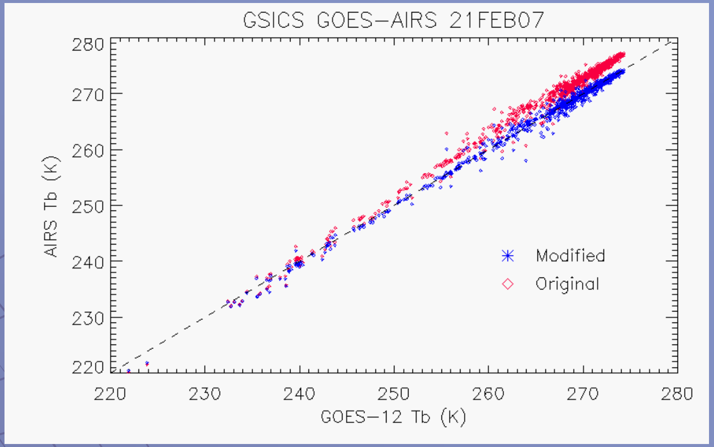


GEO2LEO

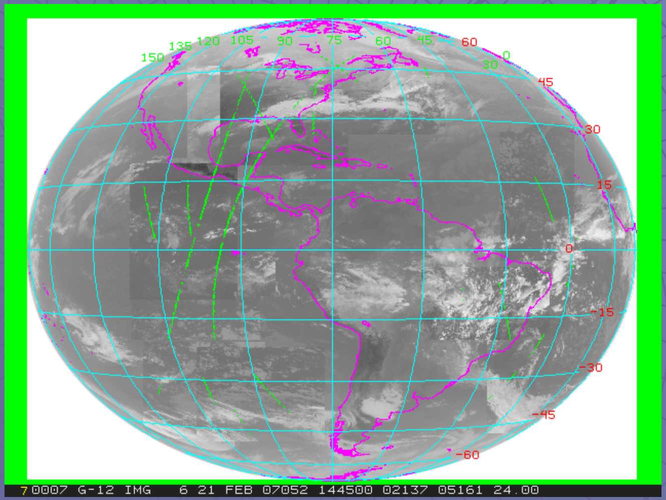
AIRS/GOES-12 Inter-Comparisons

Features:

- **Off-nadir GEO-LEO inter-comparisons that allow expanded coverage of diurnal cycle.**
- **FOV resolution allows instrument bias estimates to be made as functions of scene radiance or *Tb*.**
- **GSICS partners have come together to establish algorithm specifications and to develop code.**



Plot of AIRS-convolved *Tb* as a function of GOES-12 Imager *Tb* for the 13.3 μm band. Red circles indicate AIRS data convolved with measured SRF. Blue asterisks represent AIRS data convolved with shifted SRF.
(Wu, 2007)

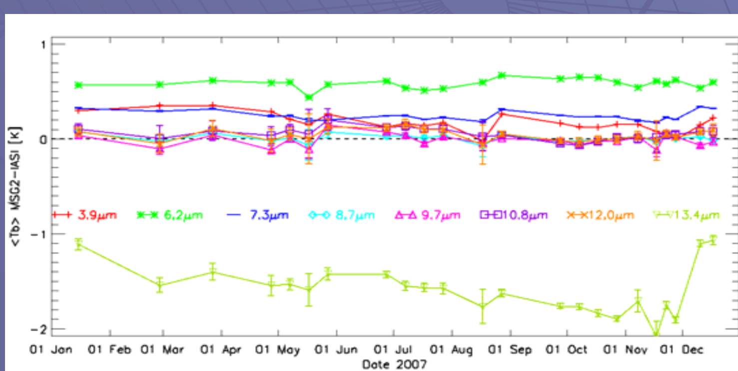


Green dots depict locations of AIRS-convolved and GOES-12 Imager 13.3 μm band inter-comparison data on 21 February 2002. *(Wu, 2007)*

GEO2LEO

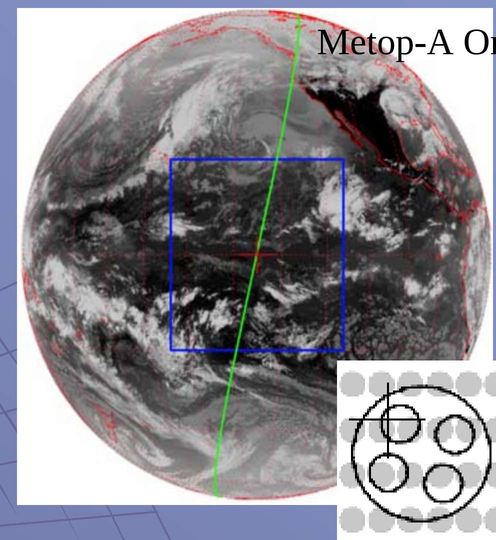
IASI/METEOSAT-SEVIRI Inter-Comparisons

Ch (µm)	Clear-sky Ref Scene T_{bref} (K)	Mean Bias MSG2-IASI at T_{bref} (K)	Standard Deviation (K)
3.9¶	290	0.17¶	0.10
6.2	240	0.61	0.05
7.3	260	0.25	0.04
8.7	290	0.02	0.04
9.7	270	0.00	0.07
10.8	290	0.03	0.06
12.0	290	0.05	0.06
13.4	270	-1.63	0.26



(Hewison, 2007)

IASI/GOES-Imager Inter-Comparisons

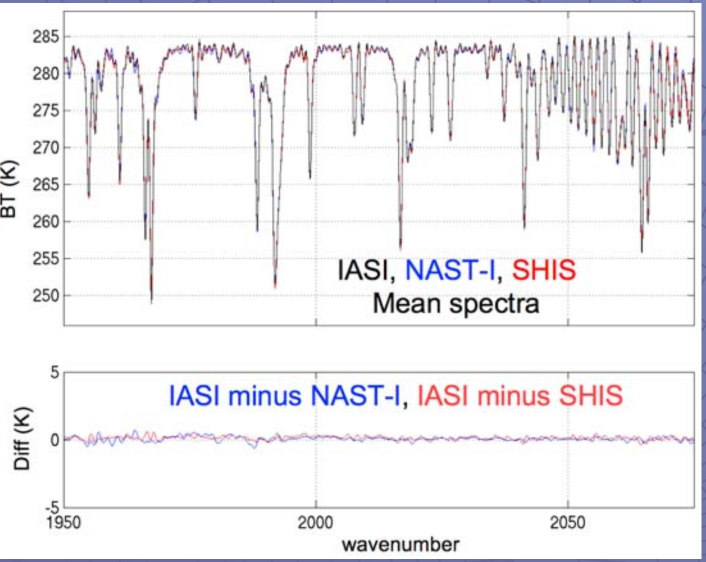


	Samples	Max(BT) -Min(BT) (K)	Mean BT (K)
IASI	4	0.509	294.006
GOES	17	0.719	294.061

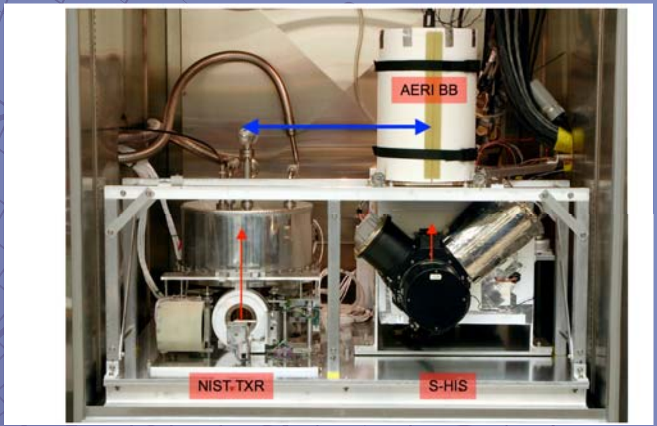
(Wang and Cao, 2007)

Calibration Support

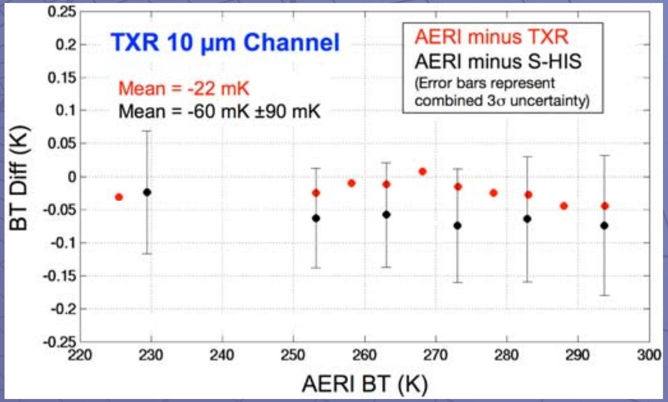
High-Altitude Aircraft Observations Providing SI-Traceable Benchmark Infrared Observations for GSICS



Validation of IASI spectral radiance observations using S-HIS and NAST-I data collected on 19 April 2007 over the Oklahoma ARM site.



Top: A photograph of the S-HIS / NIST TXR test setup.



Bottom: The difference between predicted AERI blackbody radiance and the measured S-HIS radiance and the predicted AERI blackbody radiance minus the measured TXR radiance for the 10 µm TXR channel.

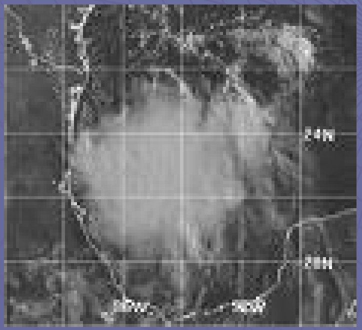
(Tobin, 2007)

Calibration Support

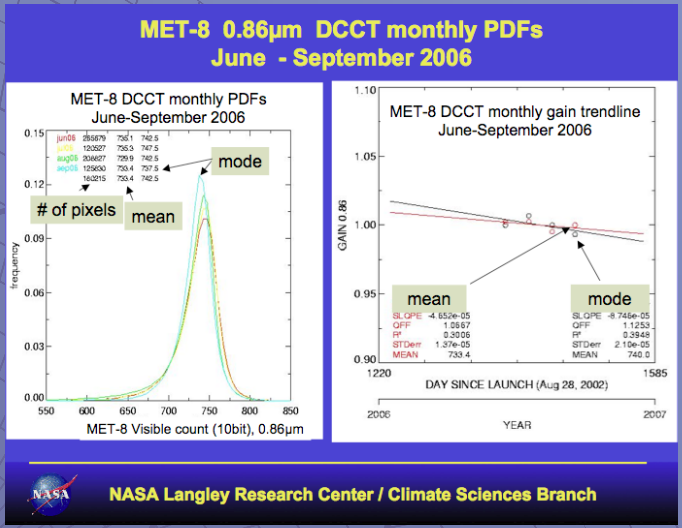
Deep Convective Cloud (DCC) Calibration

Features:

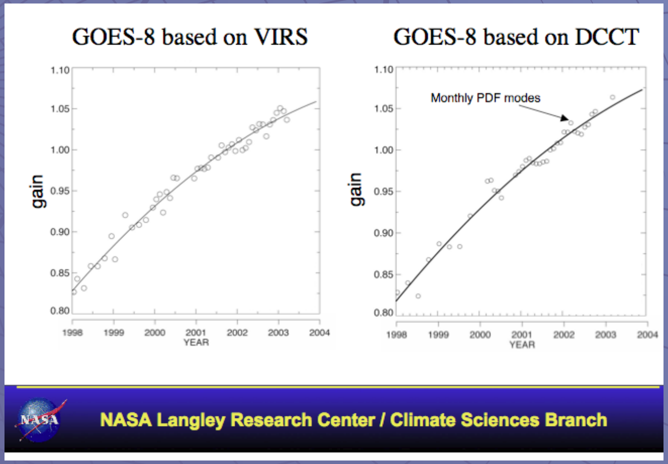
- DCCs are cold and bright tropopause targets in the tropics.
- DCCs provide maximum earth-view radiances in the solar reflective bands
- DCCs have with a nearly constant albedo at the top of the atmosphere.
- No apriori atmospheric profile or surface information is required to calibrate with DCCs.



DCC Image from the tropics.



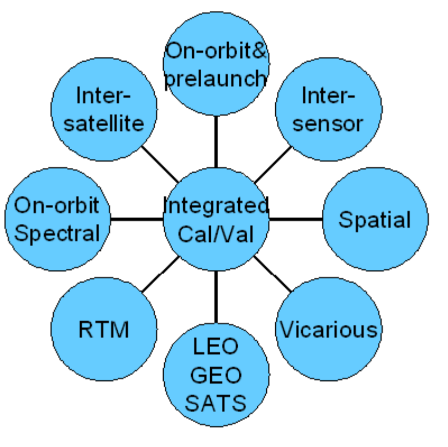
Top: (left) Monthly PDF of pixel counts converted to overhead sun; and **(right)** normalized mode and mean of PDF over time. Note each month uses more than 100,000 DCC pixels. Also, the middle month in the time series is used to normalize the mean or mode radiances.



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

(Doelling, 2007)

GCC Goals



Integrated Satellite Instrument Calibration/Validation System

- Independent assessment of pre-launch calibration data.
- On-line performance monitoring using an instrument parameter trending system.
- Independent radiance verification using SNO/SCO and GEO-LEO inter-satellite calibration bias estimation methods.
- Inter-sensor calibration - including inter-comparison between imager and sounder channels, and inter-channel calibration - to monitor the radiometric and spectral calibration stability in the long-term.
- Vicarious calibration using the Moon, stars, and desert sites for visible/near-infrared channels, and using the mid and upper atmosphere to check for scan asymmetry of sounding channels.
- SI-traceable satellite underflights by aircraft radiometers such as S-HIS, NAST-I, and NAST-M
- State-of-the-science radiative transfer models to resolve spectral induced biases, and perform regular validations at selected sites, such as the ARM sites.
- Geographic feature analysis of geolocation accuracy
- Cal/Val web interface accessible by data users.

Five-year Calibration/Validation Priority Plan

- Documents product specifications and quality assessment methods from design phase to end of life.
- Improvement of institutional memory.

GCC Goals

GSICS Virtual Library

Expand the storage and dissemination of GSICS data and information.

Components include

- Membership-limited Access;
- Fully-interactive group seminar, private discussion, and bulletin board facilities;
- Collaborative work area to create and edit documents, software, and project plans;
- Data archive portal;
- Program archive of official documents, presentations, meeting minutes, and newsletters;
- List of program-relevant journal articles and web links; and
- E-mail addresses and paging facilities to contact other members.

See http://www.decvar.org/ and http://scilands.wordpress.com/

Summary

Significant GCC progress attributed to all groups.

- NOAA contributing key LEO2LEO calibration capability
- GSICS partners collaborating to achieve optimal GEO2LEO calibration
- GSICS partners expanding competencies in regard to SI –traceability and long-term instrument monitoring
- GCC publishing informative GSICS Quarterly
- GCC expanding inter-calibration results and information on the GSICS web site