doi:10.7289/V54F1NNK

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.

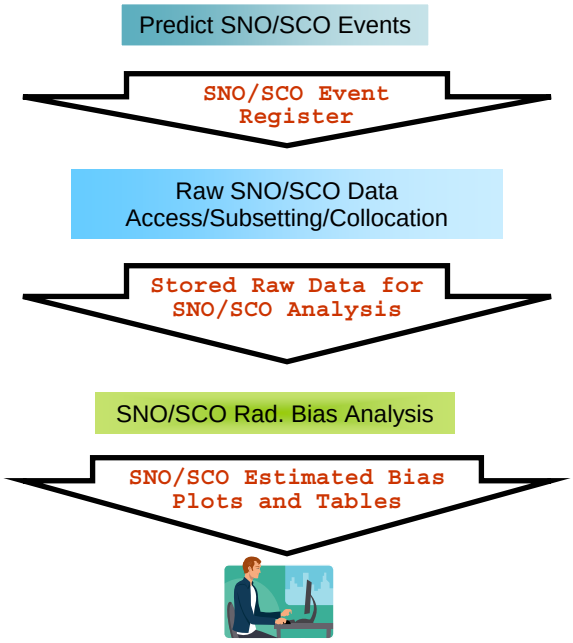

Figure 1: Process of estimating inter-satellite calibration biases using the SNO/SCO method.

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.

doi:10.7289/V54F1NNK

REFERENCES

Cao, C. and A. K. Heidinger. 2002: Intercomparison of the longwave infrared channels of MODIS and AVHRR/NOAA-16 using simultaneous nadir observations at orbit intersections. Proceedings, *Earth Observing Systems VII, SPIE Annual Meeting 2002*, Seattle, WA, The International Society for Optical Engineering, 306-316.

——, M. Weinreb, and H. Xu, 2004: Predicting Simultaneous Nadir Overpasses among Polar-orbiting Meteorological Satellites for the Intersatellite Calibration of Radiometers. *J. Atmos. and Ocn. Tech.*, **21**, 537-542.

——, H. Xu, J. Sullivan, L. McMillin, P. Ciren, and Y. Hou, 2005: Intersatellite radiance biases for the High Resolution Infrared Radiation Sounders (HIRS) onboard NOAA-15, -16, and -17 from simultaneous nadir observations. *J. Atmos. and Ocn. Tech.*, **22**, 381-395.

——, F. Weng, M. Goldberg, X. Wu, H. Xu, and P. Ciren, 2005: Intersatellite calibration of polar-orbiting radiometers using the SNO/SCO method. Geoscience and Remote Sensing Symposium, IGARSS Proceedings. 2005 IEEE International Volume 1, doi:10.1109/IGARSS.2005.1526116.

Iacovazzi, Jr., R. A. and C. Cao, 2007: Reducing uncertainties of SNO-estimated AMSU-A brightness temperature biases for surface-sensitive channels. *J. Atmos. And Ocn. Tech.*, **in press**.

(by Dr. R. Iacovazzi, Jr. [NOAA])

A Glimpse from GSICS Labs

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

The Scanning High-resolution Interferometer Sounder (S-HIS) and the NPOESS Airborne Sounder Testbed – Interferometer (NAST-I) are aircraft-based high spectral resolution infrared spectro-radiometers that have participated in numerous satellite validation campaigns in the past decade. Applications of the data have included cost-to-benefit and other sensor trade studies, radiative transfer model and atmospheric sounding algorithm development and validation, atmospheric sounding of temperature and water vapor and other trace gases, and surface and cloud remote sensing. The observations also benefit GSICS. Flying at high altitude and collecting observations which are coincident with the satellite overpasses, the S-HIS and NAST-I observations provide NIST-traceable validation of the on-orbit satellite observations. Underflights to date have focused on validating the calibration accuracy of the AIRS and IASI high spectral resolution sounders on Aqua and MetOp-A, respectively. The AIRS and IASI data are then used to inter-calibrate other polar-orbiting and geosynchronous infrared sensors during periods when they view the same earth scene at nearly the same time. The periodic aircraft campaigns and NIST-traceable characterization tests thus provide a firm and quantitative basis to not only inter-calibrate other sensors, but also to provide an absolute benchmark for the GSICS analyses.

As part of the Joint Airborne IASI Validation Experiment (JAIVEx) conducted earlier this year, the first underflights of IASI were obtained. A sample result obtained for clear sky conditions over the Atmospheric Radiation Measurement (ARM) site in north central Oklahoma is shown in Figure 1 for a portion of the IASI shortwave band. The analysis shows that the IASI absolute calibration is accurate to 0.1 to 0.2 K, which is not statistically significant compared to the calibration and inter-comparison accuracy of the aircraft data. Similar results have been obtained for AIRS for past and recent flights. Details of the analyses techniques and more results are available in the literature (e.g. Larar et al. 2003, Tobin et al. 2006).

To verify the calibration accuracy and provide direct NIST traceability of the aircraft radiance observations, laboratory tests of the S-HIS and the NIST Transfer Radiometer (TXR) were conducted earlier this year. The TXR was used to accomplish a more direct connection to the blackbody reference sources maintained by NIST than the normal traceability of blackbody temperature scales and paint emissivity measurements. The test involved the S-HIS and the TXR each observing a highly stable and accurate Atmospheric Emitted Radiance Interferometer (AERI) blackbody for a wide range of scene temperatures (227 to 290 K) while operating the S-HIS under typical flight conditions, with the optical

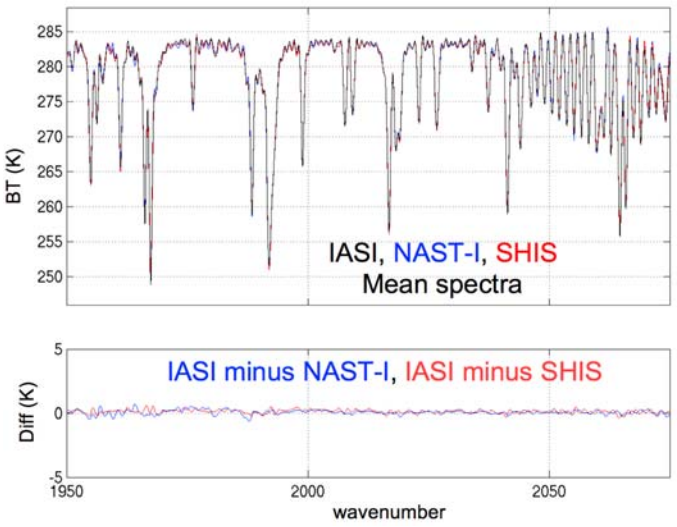

Figure 1: Validation of IASI spectral radiance observations using S-HIS and NAST-I data collected on 19 April 2007 over the Oklahoma ARM site.

doi:10.7289/V54F1NNK

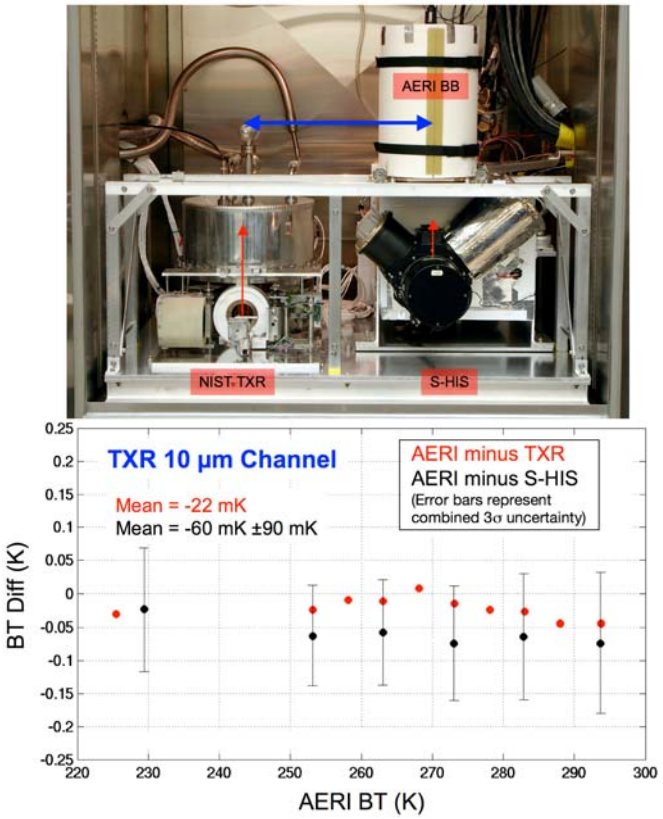

Figure 2: Top: A photograph of the S-HIS / NIST TXR test setup. Bottom: The difference between predicted AERI blackbody radiance and the measured S-HIS radiance and the predicted AERI blackbody radiance minus the measured TXR radiance for the 10 µm TXR channel.

bench at about 260 K. The test results, summarized in Figure 2 for the TXR longwave channel, show brightness temperature differences between the TXR and the S-HIS to be, on average, less than 40 mK. This verifies the S-HIS calibration accuracy and provides NIST traceability of the S-HIS radiance observations and the satellite validation results.

It is anticipated that periodic satellite underflights and laboratory characterization tests will be continued into the future as a prelude to the on-orbit benchmark measurements, such as those recommended in the recent National Academy of Sciences Decadal Survey for the CLARREO mission.

REFERENCES

Larar, A. M. et al. (2003), Validation studies using NAST-I measurements from recent field campaigns, Proc. SPIE Int. Soc. Opt. Eng. 5157, 23.

Tobin, D. C. et al. (2006), Radiometric and spectral validation of Atmospheric Infrared Sounder observations with the aircraft-based Scanning High-Resolution Interferometer Sounder, *J. Geophys. Res.*, **111**, D09S02, doi:10.1029/2005JD006094

(by Dr. D. Tobin [University of Wisconsin-Madison])

News in this Quarter

GSICS Acknowledged as GEO Early Achievement

GSICS has been recognized as an "Early Achievement" for the Global Earth Observing System of Systems (GEOSS) by the Group on Earth Observations (GEO). This is to be reported by GEO at the upcoming GEO Ministerial Summit in Cape Town, South Africa. GEO was established to organize international efforts towards a GEOSS, and includes 71 member countries, the European Commission, and 46 participating organizations. The GEO vision for GEOSS is to realize a future wherein decisions and actions for the benefit of humankind are informed via coordinated, comprehensive and sustained earth observations and information. GSICS is a GEO Early Achievement because of the progress that GSICS partners have made towards enabling inter-calibration of operational space-based radiance measurements.

(by Dr. R. Iacovazzi, Jr. [NOAA])

NIST/NOAA Meeting on Climate Data Records from MSU Observations

At the invitation of Dr. Raju Datla of the National Institute of Standards and Technology (NIST), NOAA scientists Drs. Cheng-Zhi Zou, Changyong Cao and Bob Iacovazzi, Jr. attended a one-day NIST/NOAA calibration meeting at the NIST main campus located in Gaithersburg, Maryland, USA. The primary meeting purpose was to share information about outstanding calibration issues related to developing long-term climate data records from NOAA Microwave Sounding Unit (MSU) observations, and to exchange ideas that focus on improving the quality of such data records. Meeting attendees on the NIST side included Drs. Antonio Possolo, Ron Boisvert, Jerry Fraser, Eric Shirley and Raju Datla, who are experts in statistics, mathematics, optical technology, physics, and/or computational science. The meeting was also attended by several NIST research staff members and contractors, as well as by Dr. David Walker. Dr. Walker is the microwave hardware specialist at the Electrical and Electronic Engineering Laboratory (EEEL) in Boulder, Colorado, USA.

The meeting started with Dr. Datla's briefing on the NOAA GSICS goals and activities. After the briefing, the inter-calibration technique, based on simultaneous nadir overpasses, that was applied to MSU observations to generate high-quality climate data records was presented by Dr. Zou, who will be awarded a U.S. Department of Commerce Silver Medal for Scientific/Engineering Achievement as a result of his work with the MSU data. Lively and fruitful discussion surrounded the presentation and stimulated thinking about the next steps of the data analysis. This two-hour seminar was followed by a

doi:10.7289/V54F1NNK

tour by Dr. Sergey Mekhontsev of NIST of some of the NIST facilities that provide optical calibration standards for radiometers and their calibration targets. In the afternoon, an inspiring discussion with Dr. Walker focused on identifying hardware issues in the MSU that affect calibration. In conclusion, the meeting initiated a potentially long-term collaborative effort between NOAA and NIST to resolve the existing MSU calibration issues and possibly those of other instruments, as well as to analyze climate data record uncertainties. Also, a follow-up meeting to be held at NOAA/STAR was highly encouraged.

(Drs. C. Zou [NOAA] and R. Datla [NIST])

GSICS Representation at SPIE Optics and Photonics Meeting

Several GSICS-related presentations were given at the recent SPIE Optics and Photonics Meeting held from 26 to 30 August 2007 in San Diego, California, USA. Mitch Goldberg, GSICS Executive Panel Chair, was Co-Chair of the conference session on *Atmospheric and Environmental Remote Sensing Data Processing and Utilization III: Readiness for GEOSS.* The GSICS-related talks included:

- **The global space-based inter-calibration system (GSICS) program *(Invited Paper)*,**
  M. D. Goldberg, NOAA [6684-01]
- **Intercalibration and reprocessing of MSU/AMSU measurements in support of GEOSS,**
  C. Zou, NOAA [6684-02]
- **Developing a solar channel calibration algorithm for the Korean geostationary satellite *(Invited Paper)*,**
  B. Sohn, H. Chun, J. Kim, Seoul Nat. Univ. of Tech. (South Korea) [6684-04]
- **Improving the SNO accuracy for the inter-calibration of the reflective solar bands of MetOP/AVHRR and Aqua/MODIS,**
  C. Cao, and X. F. Wu, NOAA; A. Wu, SSAI, Inc.; X. Xiong, NASA [6684-07]
- **The calibration of AVHRR visible dual gain using Meteosat- 8 for NOAA-16 to 18,**
  D. R. Doelling, V. Chakrapani, and D. Spangenberg ASM, Inc.; P. Minnis and L. Nguyen, NASA [6684-08]
- **Report on the first meeting of global space-based intercalibration system (GSICS) research working group *(Invited Paper)*,**
  X. F. Wu, NOAA [6684-09]
- **Radiance comparison of Metop-A AVHRR with AIRS and IASI,**
  L. Wang and C. Cao, NOAA [6684-43]
- **Intercalibrating geostationary imagers via polar orbiting high spectral resolution data,**
  M. M. Gunshor and D. C. Tobin Univ. of Wisconsin/Madison; T. J. Schmit and W. P. Menzel, NOAA [6684-56]

This impressive array of programmatic and technical talks covering a wide variety of topics related to satellite radiometer comparison and inter-calibration is evidence of measurable progress towards the GSICS goal of supporting the Global Earth Observing System of Systems (GEOSS).

(by Dr. R. Iacovazzi, Jr. [NOAA])

Seung-Hee Sohn, Visiting Scientist from KMA

Korea plans to launch its Communication, Ocean, and Meteorological Satellite (COMS) in 2009. Onboard the COMS will be an imaging instrument similar to the GOES-I/M Imager. In preparation for its operation and calibration, Ms. Seung-Hee Sohn, a scientist from Korea Meteorological Administration (KMA), has been visiting the Center for Satellite Applications and Research (STAR) of NOAA/NESDIS since the beginning of 2007. Part of her work at STAR is to help design and implement the GSICS geostationary (GEO) and low-earth orbit (LEO) satellite instrument inter-calibration system for the GSICS Coordination Center. Currently she is implementing the GSICS GEO-LEO algorithm for MTSAT-1R HRIT and EOS Aqua AIRS data. Later she plans to evaluate, and diagnose possible causes for, any biases between these two instruments. It is hoped that with the efforts of Ms. Sohn, and other calibration scientists around the world, that the GSICS GEO-LEO inter-calibration algorithm will be mature before the COMS launch, and transferred quickly for operational application to its meteorological instrument.

(by Dr. X. Wu [NOAA])

Just Around the Bend …

GSICS-Related Meetings

- **1st International IASI Conference, 13-16 November 2007, Anglet, France. (http://smsc.cnes.fr/IASI/A_conference.htm).**
- **AGU Fall Meeting, Special Session - *SI-Traceable Climate Measurements from Space: Realization and Applications*. 10-14 December 2007, San Francisco, CA, USA.**
- **GSICS GRWG-III and GDWG-II, February 2008, Washington, DC, USA.**

doi:10.7289/V54F1NNK

GSICS Classifieds

Are you looking to establish a GSICS-related collaboration, or do you have GSICS-related internships, exchange programs, and/or available data and services to offer? *GSICS Quarterly* includes a classified advertisements section on an as-needed basis to enhance communication amongst GSICS members and partners. If you wish to place a classified advertisement in the newsletter, please send a two to four sentence advertisement that includes your contact information to Bob.Iacovazzi@noaa.gov.

The GSICS Quarterly press crew is looking for short articles (<1 page), especially related to cal/val capabilities and how they have been used to positively impact weather and climate products. **Please submit contributions at least two weeks prior to the end of each quarter to Bob.Iacovazzi@noaa.gov, GSICS Quarterly Co-Editor.**

With Help From Our Friends:

The GSICS Quarterly Co-Editors would like to thank Ms. Regina Bellina for her help in proofreading this publication.