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Dr. Robert A. Iacovazzi, Jr., Editor

The CLARREO Mission

The 2007 National Research Council (NRC) report, *Earth Science and Applications From Space: National Imperatives for the Next Decade and Beyond* (commonly referred to as the Decadal Survey) provides the basis for the future direction of NASA's space-based Earth observation system. In the Decadal Survey, the NRC recommends the initiation of long-term climate records of high accuracy that are tested for systematic errors on-orbit, and are tied to irrefutable standards such as those maintained in the U.S. by the National Institute of Standards and Technology (NIST). This is the impetus behind the Climate Absolute Radiance and Refractivity Observatory (CLARREO) Mission. The combination of high spectral resolution and verifiable calibration also enables the potential use of CLARREO as a means for intercalibrating the satellite-borne components of Earth observing system, which makes this mission of particular interest to the GSICS community.

The foundation for CLARREO is the ability to produce irrefutable climate records through the use of exacting on-board traceability of the instrument accuracy and systematic sampling of the Earth. Spectral reflected solar and infrared radiances and Global Positioning System Radio Occultation (GPSRO) refractivity measured by CLARREO will be used to initiate an unprecedented, high accuracy record of climate change that is tested, trusted and necessary to provide sound policy decisions. This record of direct observables will have the high accuracy and information content necessary to detect decadal-scale climate change, to test and systematically improve climate predictions, and to assess and progress prediction of the impact of changes in climate forcing variables on climate change.

The accuracy goals are based on the objectives of detecting and unscrambling decadal scale change, making CLARREO quite different from missions designed to study atmospheric processes or to provide operational soundings. All aspects of CLARREO will be optimized for the creation of climate records. Compared with current instruments such as the Atmospheric InfraRed Sounder (AIRS) or the Infrared Atmospheric Sounding Interferometer (IASI), CLARREO will have greatly reduced spatial resolution and coverage. The goal is for smaller, simpler instruments with an emphasis on on-orbit calibration. To achieve the goals of decadal-scale change detection, calibration accuracy improvements of a factor of 2 to 3 in the infrared spectrum and a factor of 10 in the solar reflected spectrum are required. The orbits and field of view will be selected to provide unbiased direct spectral radiance benchmarks for decadal climate change, while ensuring pointing, spectral resolution, spectral coverage to assure that CLARREO can calibrate other solar and infrared sensors in LEO and GEO orbits.

These goals are ambitious, but attainable due to recent advances in scientific, metrology, and technological research, such as:

- a clearer understanding of the value of decadal change observations at high accuracy in providing the critical testing ground for the accuracy of climate model predictions;
- a clearer understanding of the level of uncertainty in climate forcings and feedbacks;
- improved accuracy of infrared blackbody sources using phase-change temperature measurements as part of highly accurate deep-well blackbodies;
- improved accuracy of spaceborne spectral and total solar irradiance using active cavity absolute detectors;
- major improvements in the sensitivity of active cavity detectors;
- new methods developed at national metrology laboratories to increase the accuracy of solar wavelength standards;
- greatly improved methods and understanding of how to accurately intercalibrate instruments in orbit including interferometers, imagers, and broadband radiation budget instruments;
- the first long-term, accurate measurements of far-infrared wavelengths longer than 15 μm.

As one of the four highest priority (Tier 1) missions recommended by the Decadal Survey, CLARREO is led by the NASA Langley Research Center and currently in Pre-Phase A formulation. The team is working on defining rigorous science objectives and instrument and mission requirements in anticipation of a Mission Concept Review in Fall 2009. Key studies are focused on high-level science questions concerning the use of the benchmark radiances for testing and improving climate models. A major element of the studies is the use of climate Observing System Simulation Experiments (OSSE). Simulated CLARREO infrared and solar reflected radiances will be generated from three leading climate models to test the utility of CLARREO data for

evaluating climate models. Sampling studies have been designed to determine optimal orbits for unbiased long-term trends. Finally, the team is performing studies using simulated CLARREO data from existing IR and visible hyperspectral sensors to establish the limitations of intercalibration accuracy. Results of these studies have been presented at a series of public workshops, the first of which were held in July 2008 and October 2008.

GSICS has been at the forefront in establishing rigorous calibration standards as the basis for the Earth observing system. The CLARREO mission is an opportunity to take the SI standards traceable tests currently used to characterize satellite instruments and their on-board calibration references before launch and apply them continually on orbit. By providing SI-traceable, spectrally-resolved, radiometric measurements that can be used for intercalibration, CLARREO has the potential to be the cornerstone of our Climate Observing System and to help GSICS achieve its goals. The CLARREO team looks forward to working with you in developing and implementing this critically important mission.

For more information, please see the CLARREO website (http://clarreo.larc.nasa.gov/) or contact the Mission Study Lead, David Young, at David.F.Young@nasa.gov

(Dr. D. Young, [NASA Langley Research Center])

SSM/I Intersensor Calibration Produces Improved Climate Trends

The Special Sensor Microwave Imager (SSM/I) on board Defense Meteorological Satellite Program (DMSP) F8 to F15 satellites provide one of the longest time series of satellite microwave measurements, spanning from July 1987 to present. The SSM/I is being followed with the Special Sensor Microwave Imager Sounder (SSMIS), which will continue to operate for at least the next decade. The measurements from multiple SSM/I and SSMIS instruments must be intercalibrated so that the systematic biases due to instrument degradation, interference and contamination are corrected.

The SSM/I measures the earth radiance at microwave frequencies in dual-polarization at 19.35, 37 and 85.5 GHz, and in vertical polarization at 22.235 GHz. In the top panel of Figure 1, a time series is displayed of rain-free monthly mean brightness temperature (T_b) at 37V GHz from SSM/I measurements over the 60°S-60°N oceanic areas. It is obvious that SSM/I instruments provide nearly continuous measurements since June 1987. However, T_b biases between measurements from different sensors are prominent. The biases of all pairs of overlapped SSM/I sensors shown in the bottom panel of Figure 1 indicate significant bias that varies with time and sensor pair. Since the T_b bias can change by as much as ±1K over the overlap period of a given pair of satellites, the SSM/I temperature data records (TDRs) and

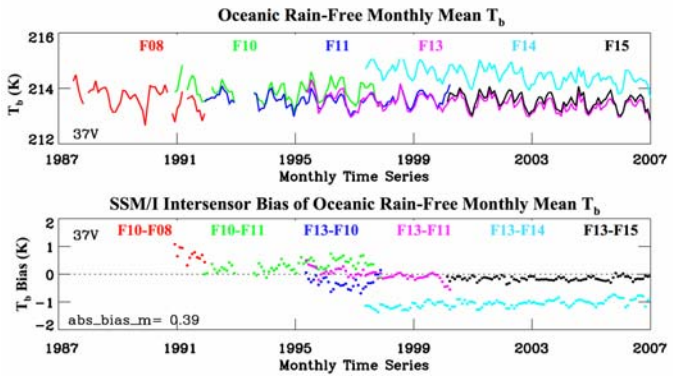

Figure 1. Time series of oceanic rain-free monthly mean T_b at SSM/I 37V GHz from 1987-2006 (top panel) and the associated intersensor bias for sensor pairs with operational overlap (bottom panel). The mean absolute bias against F13 is shown at the low-left corner.

sensor data records (SDRs), and their derived environmental data records (EDRs), may not be suitable for climate studies using the present calibration.

In this study, collocated SSM/I measurements from a pair of satellites are obtained when they simultaneously pass over the same local area. Since both SSM/I instruments are conically-scanning, the matched observations are referred as simultaneous conical overpass (SCO) data sets. Ideally, if both instruments are well calibrated, the SCO difference should be within the instrument noise level. However, a bias between two different SSM/I sensors normally exists as shown above. The actual bias between sensor observations at SCO events is characterized over various surface conditions. All SCO pairs include the F13 SSM/I, which has had the longest operational lifetime. The criteria of the SCO pixel pairs using F13 as the reference satellite are set as: spatial distance, $\Delta d \leq 3$ km; temporal difference, $\Delta t \leq 2$ min; mean standard deviation of nine SCO samples surrounding the selected SCO pixel, $\sigma \leq 2$ K; and brightness temperature difference, $|\Delta T_b| \leq 10$ K. In addition, the same satellite orbital ascending or descending mode and similar pixel positions are required. These criteria are separately applied for all SSM/I channels over water, land, and ice surface, except over the coast area where a $\sigma \leq 5$ K criteria is used due to the coastal surface inhomogeneity. The SSM/I scan angle dependent bias, and the RADCAL beacon interference error on F15 22V GHz channel since 15 August 2006, have to be corrected before any other intersensor calibrations.

Preliminary results show that removing intersatellite instrument measurement differences from the SDR calibrations lead to more consistent SSM/I T_b time series with dramatically reduced intersensor biases, indicating that the bias-adjusted SSM/I measurements are more suitable for climate related studies. The calibration scheme has a significant impact on climate reanalysis and trend studies, although the impact amplitude on EDRs is small. Results demonstrate that the EDRs from the calibrated SDRs are in better agreement with observations and previous publications.

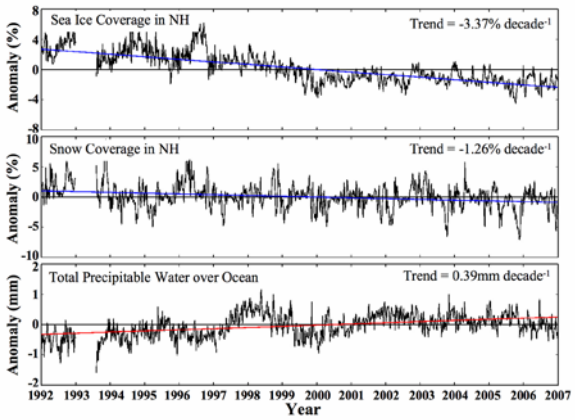

Figure 2. The pentad time series of sea ice cover, snow cover, and total precipitable water anomalies in NH (1992-2006) from EDRs based on the DMSP SSM/I intersensor calibrated SDRs.

As an example, Figure 2 presents the pentad time series of sea ice and snow coverage in the Northern Hemisphere (NH) and total precipitable water (TPW) over ocean based on the newly calibrated SDRs. Obvious decreasing trends of NH sea ice and snow cover are -3.37% decade^{-1} and -1.26% decade^{-1}, respectively, Meanwhile the increasing trend of oceanic TPW is about 0.39mm decade^{-1}. Detailed results and discussion by Yang et al. (2008) and Sun et al. (2008) are given in proceedings of the 4th International Precipitation Working Group meeting.

Reference

Yang, S., F. Weng, N. Sun, and B. Yan, 2008: Special Sensor Microwave Imager (SSM/I) intersensor calibration and impact on environmental data records. *Proceedings of the 4th International Precipitation Working Group (IPWG) Meeting*, Beijing, China.

Sun, N., F. Weng, R. Ferraro, and S. Yang, 2008: Prototype demonstration of special sensor microwave imager (SSM/I) based climate data records (CDRs) during 1992-2007 after intersensor calibration. *Proceedings of the 4th IPWG Meeting*, Beijing, China.

(Drs. F. Weng, S. Yang, N. Sun, and B. Yan, [NOAA/NESDIS])

News in this Quarter

NOAA's GSICS Data Server is Operational

GSICS data distribution came one step closer to reality when the NOAA GSICS data server became operational in early December 2008. The server is only the first in hopefully what will be a global network of GSICS data servers.

The NOAA server is capable of distributing future GSICS data using THREDDS and anonymous FTP services. The THREDDS service allows data access of entire files using the HTTP protocol, or over user-defined subfile data blocks using the OPeNDAP protocol. The THREDDS service also provides a human-friendly interface to the data collection through a series of catalog web pages that hierarchically follow file and directory structure on the server. More data distribution protocols using THREDDS will become available as the GSICS data metadata format evolves.

Besides data distribution, the NOAA server also hosts the GSICS wiki, a collaborative tool that will hopefully enable the GSICS community to document past work, plan future developments, and capture new ideas in an easier manner than now. The wiki's capability can be extended using a number of plug-ins. For example, a plug-in has been recently added which allows mathematical symbols and equations to be entered using LaTeX mark-up. The wiki requires registration for creating or editing its content, and is open to anyone in the GSICS community.

More information and the links to the above services are available from https://cs.star.nesdis.noaa.gov/.

(Dr. A. Jelenak, [NOAA/NESDIS])

New GSICS Web Meeting Capability

On 28 October 2008, the first GSICS Data Working Group (GDWG) web meeting was attended by nine participants. Two months later, on 16 December 2008, the first GSICS Research Working Group (GRWG) web meeting took place and included 19 attendees from six agencies located on three continents. EUMETSAT hosted both online meetings using Centra for eMeetings - a web conferencing tool provided by Saba.

Centra enables users to attend live meetings, seminars and conferences either from the office or at home. Furthermore, it allows attendees to interact, exchange knowledge and share information online in real time. Its features and interfaces include integrated audio conferencing, application sharing, PowerPoint presentation upload, file transfer, text chat, etc. Documents can even be edited collaboratively by participants during online sessions by using Centra's *Appshare* function. Centra supports software that can run on Windows, as well as Mac, operating systems.

Attending a Centra web meeting from anywhere in the world (even through corporate firewalls) requires users only to perform a system check, and to have a working headset or a microphone. Since attendees are invited via e-mail to a meeting, limiting a web meeting or event only to authorised persons is ensured.

There have been some limitations in using Centra for eMeeting that we are currently working to resolve. At this point, web meetings are constrained to about 20 participants – i.e., 20 internet lines – to guarantee smooth and efficient operation. In some organisations, there have been specific issues regarding software downloads, depending on their infrastructure and security procedures. One limitation noticed at some points during the online sessions was deteriorated audio, which was mainly related to participant's network

bandwidth. Also, there were a couple cases when participants could not upload their PowerPoint presentation.

However, the overall experience with Centra can be summarised as generally positive. Most participants who have already attended a web meeting held via Centra are convinced of its advantages. It is recommendable to use this tool for shorter meetings (< 3 hours) between GSICS members and partners in order to enhance communication and collaboration without incurring travel expenses.

(Ms. M. Uz, [EUMETSAT])

GSICS Executive Panel Meeting Five

The fifth meeting of the GSICS Executive Panel (EXP-5) was held immediately after closure of the 36th meeting of the Coordination Group for Meteorological Satellites (CGMS-36) in Maspalomas, Gran Canaria, Spain. The Chairman, Dr Mitch Goldberg, welcomed the Panel Members and the observers from the European Space Agency, Japan Aerospace Exploration Agency, and the Russian Federation Space Agency. He recalled that several reports on GSICS achievements had been presented at CGMS-36, and indicated that the main scope of EXP-5 was to finalize the discussion on items presented at the fourth meeting, and to define the 2009 GSICS Operations Plan.

After adoption of EXP-4 meeting minutes, and a review of the outstanding actions from EXP-3 and EXP-4, the Executive Panel was briefed that the NASA-NOAA CLARREO (Climate Absolute Radiance and Refractivity Observatory) mission concept had been recommended by the US National Research Council Decadal Survey, and should provide essential benchmark measurements that would be of direct relevance for GSICS. It was agreed that a presentation on CLARREO would be made by NOAA at the upcoming joint meeting of the GSICS Research and Data Working Groups (GRWG/GDWG) in Tokyo. Regarding the CNES SADE database, a web-based data request mechanism for GSICS members was proposed. This mechanism will allow requested data from SADE to be extracted by CNES from the database, and resulting data, graphs, and tables will be made available to the GSICS partners with accurate format descriptions on the web interface. EXP-5 welcomed these proposals and invited CNES to present the proposed mechanism to the upcoming joint GRWG/GDWG meeting in order to review the precise modalities.

The Executive Panel also made minor changes to the GSICS Information, Services, and Products Roster, which is a document intended to specify the information, services, and products available from GSICS, or those under consideration for future development and implementation. The Panel also made minor changes to the GSICS Procedure for Product Acceptance, which gives a pathway for mature products to be given a "stamp of approval" by GSICS. With these minor changes, the Panel adopted the procedure, and agreed to put it in operation as a first version, with the understanding that this procedure could be reviewed at a later stage in the light of experience.

The Executive Panel also discussed several documents, including a manual on operating practices for the GCOS Reference Upper Air Network (GRUAN), the *GSICS Implementation Plan*, a draft GSICS Bulletin of the American Meteorological Society article, and the draft *Quality Assurance Framework for Earth Observation (QA4EO)* developed by the CEOS Working Group on Cal/Val. The QA4EO addresses a matter of high relevance for GSICS, and GSICS should collaborate with CEOS WGCV to ensure that the final version of this documentation is applicable to the GSICS area of activity.

The draft 2009 Operations Plan provided by Dr. Goldberg was discussed in relation with plans indicated at EXP-4, outcomes of CGMS-36, and written contribution received from CNES. The following sectional structure was adopted:

I. Project meeting milestones
II. Outreach and user interaction
III. Data management and other cross-cutting tasks
IV. LEO-LEO UV, VIS, IR and MW intercomparison
V. GEO-LEO algorithm development and comparison

The Panel also agreed that GSICS had important contributions to bring to meetings of the Global Energy and Water Cycle Experiment (GEWEX) Radiation Panel (GRP), the Society of Photo-optical Instrument Engineers (SPIE), the Global Climate Observing System (GCOS) Steering Committee, and the World Climate Research Program (WCRP) Science Steering Committee. An action was given to all Panel members to identify by end of 2008 the major relevant meetings in order to organize GSICS participation in these meetings. The Panel also discussed GSICS as an important contribution to, and a possible useful model for, integration at the "Instrument level" of the WMO Integrated Global Observing Systems (WIGOS) initiative. A task to formulate a WIGOS Pilot Project based on GSICS was thus identified in the 2009 Operations Plan. The GSICS 2009 Operations Plan resulting from this discussion is included in Annex 4 of the EXP-5 meeting minutes, which can be found at URL http://www.wmo.int/pages/prog/sat/Reports.html#GSICS.

(J. Lafeuille, [WMO])

Just Around the Bend …

GSICS-Related Meetings

- **IGARSS,** 13-17 July 2009, Capetown, South Africa, Session on Radiometer Instruments and Calibration, http://www.igarss09.org/
- **SPIE Optics and Photonics,** 2-6 August 2009, San Diego, CA, USA, http://spie.org/optics-photonics.xml.
- **CALCON Technical Conference,** 24-27 August 2009, Logan, UT, USA, http://www.sdl.usu.edu/conferences/calcon/.

GSICS Publications

Hewison, T. J. and M. König, 2008: Intercalibration of Meteosat Imagers and IASI, Proceedings of EUMETSAT Satellite Conference, Darmstadt, Germany, September 2008.

Minnis, P., D. R. Doelling, L. Nguyen, W. F. Miller, and V. Chakrapani, 2008: Assessment of the visible channel calibrations of the VIRS on TRMM and MODIS on Aqua and Terra. *J. Atmos. Oceanic Technol.*, **25**, 385-400. www-pm.larc.nasa.gov/calibration/pub/journal/Minnis.etal.JTECH.08.pdf

Minnis, P., Q. Z. Trepte, S. Sun-Mack, Y. Chen, D. R. Doelling, D. F. Young, D. A. Spangenberg, W. F. Miller, B. A. Wielicki, R. R. Brown, S. C. Gibson, and E. B. Geier, 2008: Cloud detection in non-polar regions for CERES using TRMM VIRS and Terra and Aqua MODIS data. *IEEE Trans. Geosci. Remote Sens.*, 46, 3857-3884. www-pm.larc.nasa.gov/ceres/pub/journals/Minnis.etal.TGRS.08.pdf

Minnis, P., L. Nguyen, R. Palikonda, P. W. Heck, D. A. Spangenberg, D. R. Doelling, J. K. Ayers, W. L. Smith, Jr., M. M. Khaiyer, Q. Z. Trepte, L. A. Avey, F.-L. Chang, C. R. Yost, T. L. Chee, and S. Sun-Mack, 2008: Near-real time cloud retrievals from operational and research meteorological satellites. *Proc. SPIE Europe Remote Sens.* 2008, Cardiff, Wales, IK, 15-18 September, **7107**, No. 2, 8 pp. www-pm.larc.nasa.gov/assimilation/pub/conference/Minnis.etal.SPIE.abs.08.pdf

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.

With a Little Help from our Friends:

The *GSICS Quarterly* Editor would like to thank those individuals who contributed articles and information to this newsletter. The Editor would also like to thank *GSICS Quarterly* European Correspondent, Dr. Tim Hewison of EUMETSAT, in helping to secure articles for publication.

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. Unsolicited articles are accepted anytime, and will be published in the next available newsletter issue after approval/editing. **Please send articles to Bob.Iacovazzi@noaa.gov, *GSICS Quarterly* Editor.**