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ACHIEVING SATELLITE INSTRUMENT CALIBRATION FOR CLIMATE CHANGE (ASIC3): REPORT OF A WORKSHOP

NOAA-WP-18 provided a report from the Achieving Satellite Instrument Calibration for Climate Change (ASIC^3) workshop for CGMS consideration. ASIC^3 brought together some 100 participants, including experts in satellite instrument calibration, metrology scientists from the U.S. and U.K. national standards institutes, and remote sensing specialists. The workshop developed two overarching recommendations as well as a large number of technical recommendations on advancing the state of climate monitoring from satellite instruments.

Overarching recommendation 1: Conduct a set of satellite benchmark missions to create irrefutable records and calibrate other satellite sensors. Benchmark measurements in the context of long-term climate monitoring.

Overarching recommendation 2: Establish a U.S. Joint Center for Satellite Instrument Calibration (JCSIC).

The Center would be organized by NOAA, NASA, and NIST (and possibly other national agencies) and would be a distributed center, i.e., the Center's program would be conducted at the partner agencies.

The benefits of implementing the recommendations of the ASIC^3 Workshop would be:

- Early, irrefutable detection of climate change
- Verification of climate model predictions
- Achieving the societal benefit goals of the Global Earth Observation System of Systems (GEOSS), in particular, understanding, assessing, predicting, mitigating, and adapting to climate variability and change

ACHIEVING SATELLITE INSTRUMENT CALIBRATION FOR CLIMATE CHANGE (ASIC3): REPORT OF A WORKSHOP

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1 INTRODUCTION

The Workshop on Achieving Satellite Instrument Calibration for Climate Change (ASIC^3) was held at the National Conference Center, Lansdowne, VA, May 16-18, 2006. The major objective of the Workshop was to formulate a national roadmap for developing calibration systems that will enable us to monitor long-term global climate change. The Workshop was sponsored by the National Oceanic and Atmospheric Administration (NOAA), NASA, the National Institute of Standards and Technology (NIST), the Integrated Program Office for the National Polar-orbiting Operational Environmental Satellite System (NPOESS), and the Space Dynamics Laboratory of Utah State University

The Workshop established the following goal for satellite-based climate monitoring systems:

- Design of climate observing and monitoring systems must ensure global, long-term climate records that are of *high accuracy, tested for systematic errors on-orbit, and tied to irrefutable international standards* such as those maintained in the U.S. by the National Institute of Standards and Technology

Two overarching recommendations emerged from the Workshop:

- Conduct satellite benchmark missions to create irrefutable records and calibrate other satellite sensors

- Establish a U.S. Joint Center for Satellite Instrument Calibration (JCSIC)

Motivation

Climate change is probably the most compelling issue facing humanity today since it is the single issue that will impact all of humanity. But the magnitude and impact of climate change are not, at present, clearly understood. For the most part, satellite observations of climate are not presently of sufficient accuracy to establish a climate record that is tested and trusted. And satellite climate observations are not in place that can adequately constrain climate model predictions.

Measuring long-term global climate change from space is a daunting task. The climate signals we are trying to detect are extremely small: e.g., temperature trends of only a few tenths of a degree C per decade, ozone changes as little as 1%/decade and variations in the sun's output as tiny as 0.1%/decade or less. Current satellite systems are not up to the task. Sensors and onboard calibration sources degrade in orbit, long term data sets must be stitched together from a series of overlapping satellite observations, orbital drift introduces artifacts into long term time series, and insufficient attention is paid to meeting the high accuracy, high stability instrument requirements for monitoring global climate change.

While greenhouse climate models predict gradual climate change over the next century, the possibility of more abrupt climate change – large changes on decadal time scales – cannot be ruled out [*National Research Council*, 2002]. Early warning of such changes is also dependent on highly accurate observations.

2 Background

ASIC^3 was a follow-up to a 2002 Workshop [*Ohring et al.*, 2004; *Ohring et al*., 2005] that had developed the measurement requirements for a number of global climate variables. The 2002 Workshop defined the absolute accuracies and long-term stabilities of global climate data sets that are needed to detect expected trends, assessed needed satellite instrument accuracies and stabilities, and evaluated the ability of then current observing systems to meet these requirements.

3 Organization

ASIC^3 brought together some 100 participants, including experts in satellite instrument calibration, metrology scientists from the U.S. and U.K. national standards institutes, and remote sensing specialists. The Workshop format consisted of plenary sessions with invited papers, and breakout groups that reported to plenary sessions. Invited papers covered the following topics: Agency Roles, Review of Requirements for Measuring Global Climate Change, Calibration Status for Current Instruments and Plans for Future Instruments, and Concepts and Methodologies for Achieving Calibration of Global Climate Change Measurements.

Breakout groups were organized primarily according to the spectral regions used in space-based measurements, and they discussed current satellite instrument calibration capabilities, impediments to progress, and recommendations to accelerate progress: Breakout groups were formed on Infrared Instruments; Ultraviolet, Visible and Near-infrared Instruments; Microwave Instruments; Active Instruments (such as radars and lidars); and Broadband Instruments (such as Earth radiation budget and total solar irradiance). Two additional breakout groups were created: the group on Inter-calibration of Instruments focused on techniques for intercalibrating sensors on different satellites; the National Roadmap group prepared an outline of a Roadmap to implement the recommendations of the Workshop.

4 Recommendations

The workshop developed two overarching recommendations as well as a large number of technical recommendations on advancing the state of climate monitoring from satellite instruments.

Overarching recommendation 1: Conduct a set of satellite benchmark missions to create irrefutable records and calibrate other satellite sensors

Benchmark measurements in the context of long-term climate monitoring have the following characteristics [*Goody*, 2001]:

- Accuracy that extends over decades, or indefinitely
- Global observations of a variable that is critical to defining long-term climatic change
- Measurements that are tied to irrefutable standards, usually with a broad laboratory base
- Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation;
- Limited number of carefully selected observables, with highly confined objectives defining (a) climate forcings, (b) climate response.

The Workshop recommended the following with respect to benchmark measurements:

- Initiate absolute spectrally resolved measurements of Earth's emission spectrum
- Initiate spectrally resolved measurements of Earth's solar reflectance spectrum simultaneously calibrated/validated against multiple/redundant calibration targets (multiple diffusers, lamps, Moon, selected Earth targets)
- Ensure continuity of global sea level measurements with overlap of altimeter missions
- Ensure continuity of overlapped Broadband Earth Radiation Budget measurements
- Ensure continuity of overlapped Total Solar Irradiance observations

The last three recommendations are especially critical in view of the possible elimination of climate instruments from the NPOESS satellites.

Overarching recommendation 2: Establish a U.S. Joint Center for Satellite Instrument Calibration (JCSIC)

The Center would be organized by NOAA, NASA, and NIST (and possibly other national agencies) and would be a distributed center, i.e., the Center's program would be conducted at the partner agencies. Administrative headquarters would be established at one of the participating agencies, possibly NOAA. As demonstrated by the NASA-NOAA-DOD Joint Center for Satellite Data Assimilation, this kind of distributed joint center has been a very successful model for integrating federal activities that cross several agencies. A NOAA-NIST program to improve satellite instrument, scheduled to begin in FY 2009, will be an initial step toward formation of a national center and an important contribution toward reducing measurement uncertainties.

The mission of the Center would be to advance the state of the art of satellite instrument calibration. Its activities would include carrying out the technical recommendations the $ASIC^3$ Workshop, implementing the U.S. Component of the WMO's Global Satellite Inter-Calibration System (GSICS) – an evolving international program to inter-calibrate instruments on different Earth-observing satellites – and championing satellite benchmark measurements for climate monitoring.

5 Benefits

The benefits of implementing the recommendations of the $ASIC^3$ Workshop would be:

- Early, irrefutable detection of climate change
- Verification of climate model predictions
- Achieving the societal benefit goals of the Global Earth Observation System of Systems (GEOSS), in particular, understanding, assessing, predicting, mitigating, and adapting to climate variability and change

A complete Workshop Report is being prepared and will be published by NOAA.

6 References

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