NASA Calibration and Validation Update

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Recent NASA satellite and airborne instrument calibration and validation activities and assets of interest to the meteorological remote sensing community include the following: (1) improvement in the production of calibrated, geo-located (i.e. Level 1B) radiances from the Advanced InfraRed Sounder (AIRS) instrument on the Earth Observing System (EOS) Aqua satellite, (2) improvements in the production of calibrated, geo-located (i.e. Level 1B) reflectances/radiances

from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the EOS Terra and Aqua satellites, (3) the Committee on Earth Observation Satellites (CEOS) Visualization Environment (COVE) tool for satellite data acquisition planning and visualization, (4) the development of the Enhanced MODIS Airborne Simulator (eMAS), and (5) the development of the Airborne Visible/Imaging Infrared Spectrometer-Next Generation (AVIRIS-NG).

1. Improvement in the processing of AIRS level 1B radiances

AIRS radiance data are assimilated routinely at several national operational National Weather Prediction (NWP) centers around the world providing the highest impact of any single sensor to forecast improvement. Recently, researchers at ECMWF have found the impacts of the AIRS data and data from the Infrared Atmospheric Sounding Interferometer (IASI) on operational 24-hour forecasts to be roughly comparable and second only to the collective impact of four AMSU units (Cardinali 2009). While the NWP centers assimilate radiances, considerable impact has also been found to tropical cyclone position and intensity forecast assimilating AIRS retrieved temperature and water vapor profiles (Reale, 2009). Additionally assimilation of AIRS profiles have been shown to improve precipitation estimates in the short term forecast (McCarty, 2009) and in tropical cyclone prediction in the GEOS-5 model (Zhou 2010). Recent studies using AIRS data show that the Saharan Air Layer can intensify tropical cyclones when it is first formed and then weakening tropical cyclones when its dry air intrudes within 360 km of the tropical cyclone center (Shu 2009, Pan, 2011).

AIRS radiances, in addition to those obtained from the Infrared Atmospheric Sounding Interferometer (IASI) on the MetOp-A satellite, are used as an infrared reference in the on-orbit intercomparison of geostationary and low-earth orbit operational satellite instruments by the Global Space-based Intercalibration System (GSICS) and its many participating organizations.

While AIRS radiances (Level 1B) have not changed since launch, improvements to the characterization of the instrument accuracy has demonstrated radiometric stability to better than 10 mK/year and spectral frequency knowledge to better than 0.2 ppm. An improvement to the processing of AIRS radiances will include the implementation of a new gain table that will select redundant detectors and will recover over 50 of the 2378 channels that were lost over the last 9 years due to radiation exposure.

2. Improvements in the processing of MODIS Terra and Aqua level 1B reflectances/radiances:

The MODIS instruments on EOS Terra and Aqua continue to exhibit their normal radiometric, spectral, and spatial performance after 11+ and 9+ years of on-orbit operations, respectively. Similar to the AIRS instrument, MODIS radiances are used as a visible/near infrared, shortwave infrared reference in the on-orbit intercomparison of geostationary and low-earth orbit operational satellite instruments by the Global Space-based Intercalibration System (GSICS) and its many participating organizations.

MODIS Collection 6 (C6) Level 1B reprocessing is scheduled to begin in the Fall of 2011 and will implement code and/or look up table improvements in the following four areas: (1) an improved algorithm correcting for MODIS long-term response versus scan mirror angle changes in earth view measurements, (2) an improved algorithm based on sensor pre-launch and on-orbit calibration to derive a pixel-level, Level 1B uncertainty index, (3) addition of a noisy/inoperable sub-frame quality flag for 250m and 500m detectors, (4) and elimination of the interpolation of values for inoperable detectors using signals from adjacent, healthy detectors.

3. The Committee on Earth Observation Satellites (CEOS) Visualization Environment (COVE) tool for satellite data acquisition planning and visualization

The Committee on Earth Observation Satellites (CEOS) Visualization Environment (COVE) tool is a public browser-based system that utilizes Google-Earth to forecast potential satellite sensor coverage areas for data acquisition planning and visualization. The tool (www.ceos-cove.org) is developed by NASA's CEOS Systems Engineering Office (SEO) and supports numerous international calibration and validation campaigns as well as several Group on Earth Observation (GEO) initiatives.

COVE's support of calibration and validation projects is focused on identifying coincident events where multiple satellites pass over the same region within a specific time period. In addition, COVE can identify single-satellite potential data acquisitions over specific sites to optimize and prioritize mission data requests and thereby reduce the burden on mission managers.

COVE includes more than 50 current missions and several notional future missions. Forecasted satellite position is based on automated daily position updates from CelesTrak to ensure accurate sensor coverage forecasts several months into the future. Output results include position, UTC time, and solar information (inclination, azimuth, zenith). Other features include EXCEL output, collaborative sessions, KML and Shapefile compatibility, and saved viewing states. The COVE team plans to add many new enhancements in 2011 including a new dedicated website, more mission and instrument combinations, a "Rapid Acquisition Planning Tool", and an IPad / IPhone application.

4. Development of the Enhanced MODIS Airborne Simulator (eMAS)

The new NASA Enhanced MODIS Aircraft Simulator (eMAS) is based on the legacy MODIS Aircraft Simulator (MAS) system, which has been used extensively in support of the NASA EOS program since 1995 (Ellis 2011) eMAS consists of two separate instruments designed to fly together on the NASA ER-2 and Global Hawk high altitude aircraft.

The e-MAS-InfraRed (IR) instrument is an upgraded version of the legacy MAS line scanning spectrometer with 38 spectral bands in the wavelength range from 0.47 to 14.1 μm. The original LN2-cooled MAS MidWave InfraRed (MWIR) and LongWave InfraRed (LWIR) spectrometers are replaced with a single vacuum-sealed, Stirling cycle cooled assembly having a single MWIR and 12 LWIR bands. This module employs a temperature controlled cold optical bench to suppress infrared background noise and to ensure spectral stability during flight.

The e-MAS HyperSpectral (HS) instrument is a stand-alone, push-broom imaging spectrometer with 202 contiguous spectral bands in 0.38 to 2.40 μm wavelength range. The e-MAS HS instrument employs two Offner spectrometers mated to a 4-mirror anastigmatic telescope. Light from the telescope enters a single slit, is split into Visible Near InfraRed (VNIR) and ShortWave InfraRed (SWIR) wavelengths by a dichroic beamsplitter, and is sent to VNIR and SWIR focal plane arrays. The e-MAS HS instrument will be synchronized and bore-sighted with the IR instrument. The e-MAS HS instrument also includes an active source for monitoring in-flight calibration stability.

eMAS is intended to support future satellite missions including the Hyperspectral InfraRed Imager (HyspIRI), the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP), and the follow-on Joint Polar Satellite System (JPSS). Engineering test flights of e-MAS on the ER-2 are projected for July 2012.

5. Development of the Airborne Visible/Imaging Infrared Spectrometer-Next Generation (AVIRIS-NG)

The AVIRIS-NG is an upgraded version of the AVIRIS-Classic instrument operating over the full reflected solar wavelength range from 380 to 2510nm at 5 nm resolution. The instrument employs an advanced two mirror telescope and a uniform Offner spectrometer to illuminate a full range detector. The AVIRIS-NG incorporates a number of performance improvements over its predecessor instrument including higher spectral resolution (i.e. 5 nm vs.10 nm), higher signal to noise in the visible and shortwave infrared, an extended spatial sampling distance (i.e. 0.3 to 20m vs. 4 to 20m), and an improved measurement uncertainty (i.e. <5% vs. <10%). AVIRIS-NG is temperature controlled and incorporates an on-board calibration system. AVIRIS-NG is designed to be compatible with a broad array of aircraft platforms including the ER-2, the Twin-Otter turboprop, the Scaled Composites Proteus, and NASA's WB-57.

AVIRIS-NG is intended to support imaging spectroscopy based NASA Earth science and science applications, to test imaging spectrometer systems and subsystems that may be used in satellite instruments, and to provide a calibration and validation under flight resource for the HysplRI and instruments. AVIRIS-NG development is nearly complete, and all performance requirements are on schedule to be met. Initial test flights of AVIRIS-NG are projected for the Fall 2011 with data available for initial science validation activities in 2012.

6. References

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