Technical Session
Inter-Calibration and Validation of Operational Sensors

Performance comparison between sensors of differing scientific objectives, capabilities, and mission parameters to assess measurement bias and uncertainty

- Post-launch calibration using onboard and/or vicarious techniques
- Retrievals through data assimilation with various data used for validation
- Results of particular approaches, validation campaigns, and experiments
- Techniques, platforms, and instruments for validation
- Application of calibration results to scientific measurements
- Requirements and potential approaches for the calibration of global satellite observing sensors

2:50
VENµS: Mission Specificities, Products Features and In-orbit Absolute Calibration
Arthur Dick, Phillipe Gamet, Sebastien Marcq – Centre National d’Etudes Spatiales (CNES); Olivier Hagolle, Gerard Dedieu – Center for the Study of the Biosphere from Space (CESBIO)

ABSTRACT: Earth observation satellites like Sentinel-2 or Landsat 8 have already demonstrated the importance of a global coverage associated with high resolution (about 10 m) for regional and country scales applications. These applications, such as detailed land-cover mapping, agri-environment policies, water management, vegetation primary productivity and yield estimates, are crucial for defining global change mitigation or adaptation policies. To prepare the future earth observations systems, users raised one question about the increasing of the revisit period in order to limit the impact of cloud-coverage on the applications and to capture rapid phenomena. In this context, VENµS products offer an undeniable added value to explore the benefit of expanding the time rate of high resolution acquisition in visible and near infrared spectral bands.

VENµS is a joint space system venture of Israeli and French governments for Earth observation (EO). The scientific mission focuses on vegetation and land surface monitoring. VENµS was launched on August 1st, 2017. It provides 5 and 10 m resolution images in 12 shortwave spectral bands every two days over a set of 110 scientific sites, with constant viewing angle and overpass time. This article presents the objectives of the mission, its main characteristics and available products. A special focus is made on the in-orbit absolute calibration, based on vicarious techniques, including specific capabilities such as calibration using Moon images. The process of inter-calibration with Sentinel-2 through simultaneous nadir observation will be explained, and the results detailed.

VENµS data are freely available to everybody for peaceful and non-commercial uses on the French Theia land data center: http://www.theia-land.fr. Continuous observations will be performed all along the scientific mission duration, until mid-2020.

3:15
CLARREO Pathfinder: On-orbit Sensor Inter-calibration
Constantine Lukashin, Yolanda Shea, Bruce Wielicki, Kurt Thome – NASA Langley Research Center

ABSTRACT: The Climate Absolute Radiance and Refractivity Observatory (CLARREO) is a Tier 1 mission recommended by the NRC Decadal Survey 2007. In 2016, NASA allocated funding for a CLARREO Pathfinder mission to demonstrate essential measurement technologies required for the full mission. The allocated funds support the flight of a Reflected Solar spectrometer, hosted on the International Space Station (ISS) in the 2023 time-frame. One of the major objectives of CLARREO Pathfinder mission is to demonstrate on-orbit sensor inter-calibration. The CLARREO Pathfinder approach for reference inter-calibration is based on measuring spectral reflectance with high accuracy and establishing an on-orbit reference for operating Earth viewing sensors: CERES and VIIRS. The mission goal is to be able to
provide CLARREO reference observations that are matched in temporal, spectral, and angular domains with measurements from the aforementioned instruments, with sampling sufficient to overcome the random error sources from imperfect data matching. The inter-calibration method is to monitor changes in targeted sensor response function parameters: effective offset, gain, non-linearity, spectral response function, and sensitivity to polarization. We will present the CLARREO Pathfinder project status, development of its inter-calibration approach and algorithms, and expected sampling estimates.

3:40

**Radiometric Comparison of 0.76, 1.6 and 2.0-micron Bands of OCO-2 with Aqua MODIS over Sahara/Arabian Desert Sites**


ABSTRACT: With a three-channel hyperspectral imaging grating spectrometer, the Orbiting Carbon Observatory-2 (OCO-2) measures high resolution spectra (resolving power of ~17 000) of reflected solar radiation within the O2 A-band at 0.76 micron and two CO2 bands at 1.61 and 2.06 micron. OCO-2 was inserted at the front of the 705 km Afternoon Constellation (A-Train) on August 3, 2014, and flies about 6 minutes ahead of the Aqua spacecraft. The OCO-2 spectrometer collected its first-light spectra on August 6, 2014, and has been returning science data since September 6, 2014. OCO-2 uses onboard lamps with a reflective diffuser, solar observations through a transmissive diffuser, and lunar measurements as well as surface targets for radiometric calibration. Separating the lamp output or lamp or solar diffuser aging from the instrument degradation poses a challenge to OCO-2. Here, we present our methodology for trending the OCO-2 Build 8 radiometric calibration through comparisons with MODIS half-km radiances collocated to the OCO-2 footprints. The data over nine Sahara/Arabian desert sites have been used to quantify the drift of the OCO-2 instrument throughput. For the 0.76 micron band, a drift of -0.67±0.04 % per year was determined by combining data from all nine desert sites; data from a single desert site gave precisions on the order of ±0.2% per year. For the other two bands, no measurable changes were seen, indicating a drift of less than 0.2% per year. This same methodology is expected to play an important role in the radiometric calibration of the Orbiting Carbon Observatory-3 (OCO-3), currently scheduled to be installed on the International Space Station (ISS) in the spring of 2019. OCO-3 is equipped with onboard lamps, but will take very limited lunar measurements (~three times per year), and no solar measurements due to its configuration aboard the ISS.

4:05

**An Automated Algorithm to Detect MODIS, VIIRS and GEO Sensor Calibration Discontinuities**

David Doelling – NASA Langley Research Center; Conor Haney, Rajendra Bhatt, Benjamin Scarino, Arun Gopalan – Science Systems and Applications, Inc. (SSAI)

ABSTRACT: The CERES project relies on MODIS, VIIRS and geostationary (GEO) imager retrieved cloud properties to compute surface fluxes and convert CERES and GEO radiances into TOA fluxes. The CERES TOA and surface fluxes need to be of climate quality and any anomaly or discontinuity in the calibration of the MODIS, VIIRS, GEO radiances need to be mitigated or avoided. Otherwise the variations in the cloud properties will be improperly interpreted as climate signals. Due to the nature of the CERES instrument calibration, there is a lag time of 3 months before the processing of the CERES product. This allows the CERES team to investigate any unforeseen problems in the input datasets before processing.

The CERES geostationary imager calibration team has set up a daily monitoring system of GEO, MODIS and VIIRS radiances in order to detect any day to day discontinuities as part of the CERES/GEO coincident ray-matching calibration efforts. A MODIS calibration discontinuity can be detected using five GEO sensors simultaneously, whereas a GEO discontinuity can be detected using 2 MODIS and 2 VIIRS sensors simultaneously, thus increasing the sampling greatly over a single GEO/LEO radiance pairs. This method is being automated and has already detected a GOES-16 erroneous radiometric calibration for VNIR bands that was experienced between Jan 18 to 22, 2019. It has also detected the usage of an incorrect LUT for NOAA-20 VIIRS processing for the CERES project prompting a reprocessing effort. This monitoring system is more reliable than those based on invariant Earth targets and can nearly pinpoint the GMT time of the discontinuity.
4:30
An Image Striping Mitigation Strategy Using Advanced Baseline Imager Special Scans
Monica Cook, Francis Padula – GeoThinkTank LLC; David Pogorzala – Integrity Applications Incorporated; Joel McCorkel, Alexander Krimchansky – NASA Goddard Space Flight Center; Daniel Lindsey – NOAA/ National Environmental Satellite, Data, and Information Service (NESDIS)

ABSTRACT: The Advanced Baseline Imager (ABI) on the new generation of NOAA’s Geostationary Operational Environmental Satellites (GOES) utilizes large focal plane arrays to capture increased spatial and spectral resolution compared to the heritage GOES imagers. Large focal plane arrays have a larger risk of image striping due to the increased number of detectors, and this has prompted the need for new calibration and validation strategies. New strategies include active tasking of special collections such as North South Scans (NSS); NSS are an adaptation of the side-slither maneuver first developed to mitigate image striping in pushbroom sensors in low Earth orbit. The collection of a NSS is designed such that all detectors in a single channel image the same location on the Earth. NSS are tasked to capture uniform vicarious calibration/validation Earth targets including cloud top, open ocean or desert, depending on the ABI channel. NSS data can be used to characterize detector level performance and detector-to-detector non-uniformity, which corresponds with image striping in the L1b and L2+ ABI products. This work introduces an image striping mitigation strategy using NSS derived relative gains. NSS data of multiple targets were collected and analyzed to derive an optimal set of relative gains, per detector per channel. These gains were applied to multiple nominal ABI full disk scenes to investigate the relative calibration performance under various scene types and over time. The resulting images were evaluated qualitatively and quantitatively and showed improved image quality in all cases. This methodology offers new capabilities to improve the image quality of large focal plane array geostationary operational environmental satellites.