Monday, September 12, 2022 | 2:45 p.m.

Operational Sensor Inter-Calibration and Validation

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

In-Orbit Radiometric Performance of Sentinel-2/MSI: Inter-comparison with LANDSAT8/OLI-1 and LANDSAT9/OLI-2 Over Desert PICS using DIMITRI-toolbox

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ABSTRACT: The Sentinel-2 constellation consists of two units MSI-A & MSI-B, which are Earth Observation (EO) optical missions developed and operated by the European Space Agency (ESA) in the framework of the Copernicus programme of the European Commission.
The Copernicus Sentinel Optical Mission Performance Cluster (OPT-MPC) is responsible of the calibration, validation, and image quality of the user product. The inter-unit consistency of the radiometry measurements is critical for the mission as more Sentinel-2 platforms are planned in the future.

In order to assess the validity and temporal stability of the radiometry measurements we use independent vicarious calibration methods for EO optical sensors, that are implemented in DIMITRI (Database for Imaging Multispectral Instruments and Tools for Radiometric Intercomparison) toolbox. The results of the validation show an excellent image quality and stable radiometric performance, which meets the mission requirements target.

However, a small bias of 1.1% between the two sensors was observed in the VIS/NIR domain (see e.g. Alhammoud et al. 2021). Consequently, MSI-B measurements have been aligned with MSI-A by introducing a radiometric harmonisation factor on January 25th 2022 (PB04.00). Moreover, the OPT-MPC proposed to harmonize the sensors using MSI-A as reference for the new Collection 1 reprocessing campaign which is currently under preparation.

This presentation provides a status of the Sentinel-2/MSI radiometric validation activities performed by the OPT-MPC. The results illustrate the expected improvement of the radiometric harmonisation between both units MSI-A & B.
Furthermore, we present the results of cross-mission intercomparisons over desert PICS for MSI-A, MSI-B, OLI-1 and OLI-2. The preliminary results show a good agreement between MSI/OLI to better than 2% while the OLI-1/OLI-2 agreement to better than 1% over VNIR bands.

B. Alhammoud, C. Quang, V. Boccia and R. Q. Iannone, "Assessment of Copernicus Sentinel-2 Constellation After Five Years In-Orbit: Level-1C User-Products," 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021, pp. 7759-7762, doi: 10.1109/IGARSS47720.2021.9554851

TRISHNA In-orbit Radiometric Calibration

Sebastien Marcq, Emilie Delogu, Robin Marron – Centre National D'Etudes Spatiales (CNES)

ABSTRACT: TRISHNA is an Indian-French cooperative mission to be launched in 2025. Its principal focus will be on evapo-transpiration, ecosystem stress, and coastal oceans sea surface temperature.
The satellite will host two payloads: one instrument in the VSWIR range – 7 bands from 485 to 1600 nm under ISRO's responsibility, and one instrument in the TIR range – 4 bands from 8.5 to 11.5 μm. The resolution of both instruments is 57m at nadir and their swath is about 1000 km.

TRISHNA's TIR and VSWIR instruments will be extensively calibrated and characterized in on-ground facilities to ensure that their performance will meet the specifications throughout TRISHNA's lifetime. Yet, the operation in space after the launch and during several years

can lead to different behaviors as the ones expected from ground calibration, justifying a validation and if necessary a calibration of some parameters of the ground processing.

The TRISHNA TIR instrument radiometric performances rely on an on-board calibration device (blackbody) and cold space viewing. Some so-called vicarious calibration methods are being developed in the TIR using natural targets in order to validate and monitor the calibration performed using the blackbody, and to potentially be used as a backup in case of hardware failure. These natural targets include the oceans, the Moon, snow deserts in Antarctica or Greenland and instrumented sites.

The TRISHNA VSWIR instrument on the other hand will not benefit from an on-board calibration and will exclusively rely on vicarious calibration. CNES has experience in vicarious calibration in the VSWIR and will use some methods which have been already proven for other sensors (Rayleigh scattering, deserts, clouds, Moon and instrumented sites).

The presentation will focus on the description of the radiometric calibration strategy and the associated methods.

Radiometric Uncertainty Analysis of the GLAMR Calibration Facility

Brendan McAndrew, Joel McCorkel – NASA Goddard Space Flight Center; Julia Barsi – Science Systems and Applications, Inc.; Andrei Sushkov – Genesis Engineering, Inc.

ABSTRACT: The Goddard Laser for Absolute Measurement of Radiance (GLAMR) is a spectral and radiometric calibration facility developed for hyperspectral earth science instruments. A detailed study of the radiometric uncertainty has been conducted as part of our preparation for the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission Ocean Color Instrument testing. This instrument has particularly stringent calibration requirements, necessitating a comprehensive set of measurements to characterize sources of radiometric uncertainty. Included in these measurements are the spectrally dependent linearity, repeatability, uniformity, measurement noise, and fluorescence. Uncertainty of the absolute calibration provided by the National Institute of Standards and Technology is also included to establish an overall uncertainty of the radiance.

Improvements and additions to the hardware that have been implemented as part of this study are described, and corrections for linearity and fluorescence are presented. Total radiometric uncertainty at k=1 in the visible and near infrared is 0.2%, in the ultraviolet 0.3%, and in the short-wave infrared 0.4% outside of atmospheric absorption features. Primary contributors to uncertainty are the absolute calibration of the transfer radiometers and the uniformity of the integrating sphere.

GOES-18 Post-Launch Checkout: Side-by-side with GOES-17

Jon Fulbright – Arctic Slope Regional Corporation Federal (ASRC Federal); Katherine Pitts – Science and Technology Corporation; David Pogorzala – KBR; Xiangqian Wu – National Oceanic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data, and Information Service (NESDIS)/STAR; Elizabeth Kline – National Oceanic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data, and Information Service (NESDIS)/GOES-R

ABSTRACT: We report on the ongoing post-launch checkout of GOES-18 products. Due to the cooling performance issues with GOES-17 ABI, it was decided to drift GOES-18 to an orbit 0.4 degrees from the GOES-17 early to provide supplemental imagery as soon as reasonable. This alignment will last until GOES-18 takes over as the operational GOES West satellite in January 2023, or a period of about six months. This has created an opportunity for extended comparisons utilizing instruments of the same class observing both the Earth (with ABI and GLM) and the in-situ space environment (with MAG and SIESS). In this talk, we report on some of the early results from this alignment, the overall status of the GOES-18 products, and any potential calibration lessons learned from the execution.

Correction for Dependence of Instrument Elevation/Beta Angles on GOES-16 ABI Solar Calibration

Haifeng Qian, Fangfang Yu, Hyelim Yoo – Earth System Science Interdisciplinary Center (ESSIC)/Cooperative Institute for Satellite Earth System Studies (CISESS), University of Maryland; Xiangqian Wu – National Oceanic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data, and Information Service (NESDIS)/STAR; Aaron Pearlmanc – GeoThinkTank LLC.

ABSTRACT: GOES-16, the first in a series of new generation Geostationary Operational Environmental Satellite (GOES), carries an Advanced Baseline Imager (ABI) with six Visible and Near Infrared (VNIR) channels that are calibrated periodically with an onboard solar diffuser. After its launch in 2016, we found seasonal changes in the time series of some VNIR channel gains that cannot be explained by instrument degradation nor measurement errors. This was thought to be related to the implementation of the different solar calibration algorithm version and the impacts of satellite instrument angles condition. To characterize and quantify this seasonal variation and measurement bias, we firstly reprocessed all GOES-16 solar calibration events since January 15, 2017 with the same calibration algorithm and look-up-table (LUT), which excluded the impact of algorithm difference in implementation. Secondly, to correct for the impact of "imperfect" solar calibration timing (elevation angle not equal to zero) before Dec 12, 2017, we used the extra solar calibration events in 2018 with the same elevation angle as the ones in 2017 to estimate the degradation rate in the first year, and then corrected this for the previous events. After removal of the bias due to non-zero elevation angle, we then derived the relationship between seasonal variation of corrected gains with the instrument beta angle. Our result shows that there is an asymmetrical pattern between beta angle and the gains, especially band 1. This dependence of the gains on beta angle was likely related to Bidirectional Reflectance Distribution Function (BRDF) factor in solar calibration. We finally derive the bias correction coefficient and then applied to correct such a dependence. Our results show clearly that it improves the assessment the GOES-16 VNIR instrument degradation and calibration repeatability. We will present these and other details at the conference.

Sentinel-3 OLCI Level-1 Radiometric Uncertainties Validation

Alexis Deru, Ludovic Bourg, Nicolas Lamquin – ACRI-ST; Sam Hunt – National Physical Laboratory (NPL); Steffen Dransfeld – European Space Agency (ESA)/ESA Centre for Earth Observation (ESRIN)

ABSTRACT: The Sentinel-3 satellites, S3A and S3B, have been respectively launched in 2016 and 2018, by the European Space Agency (ESA) as part of the European Commission's (EC) Copernicus program, and have continuously acquired images of the Earth since then. Both satellites carry the Ocean and Land Colour Instrument (OLCI) dedicated to scanning the ocean and land surface to harvest information of Earth visible and NIR radiances returned from the Earth's surface to the sensor.

The quality of the OLCI data is ensured through rigorous calibration and validation activity, but also thanks to the provisioning of prognostic uncertainties on the measurements. Recently, a comprehensive model of the uncertainties associated with the level-1 radiometry of OLCI has been developed. This improvement will be transferred to operation later this year by the ESA. Following the GUM methodology, the OLCI level-1 per-pixel radiometric uncertainties have been estimated from the level-0 measurements by propagating all radiometric sources of uncertainty at each step of the global level-1 processing chain.

At this point a major difficulty is to provide a validation of these uncertainties. For this purpose, we took advantage of the 6 months tandem phase at the launch of S3B. The validation of the new OLCI uncertainties has been performed using the relative intercomparison of OLCI-A and B uncertainties-normalised difference, a metrological methodology already applied to the SLSTR instrument (Hunt et al. 2020) and adapted here to the OLCI specificities.

This paper presents an overview of the OLCI level-1 per-pixel radiometric uncertainties and then provides details of the validation results of the uncertainty product using the OLCI-A&B uncertainty-normalised difference.