Ocean Colour Satellite Sensor Calibration

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Introduction

This session was a meeting of the IOCCG Task Force on Ocean Colour Satellite Sensor Calibration. The Task Force is composed of Space Agency calibration and characterization experts and supports exchange of calibration methods and ideas. The Task Force presents recent advances and challenges in the pre-launch and on-orbit calibration of ocean colour satellite sensors. The Task Force focuses on the delivery of highly accurate top-of-atmosphere radiances (or reflectances) based on direct instrument calibrations.

Session Summary

The meeting allowed for virtual participation, which was extremely important due to travel restrictions for several speakers.

The overarching topic of the session was 'lessons learned'. For the first time, the workshop included presentations related to the calibration of **polarimeters**. Data from the polarimeters can be used directly for ocean color applications (e.g. to remove glint contamination), and they open the possibility for crosscalibration with regular ocean color sensors (e.g. for SPEXone and HARP2, being on the same platform as OCI provides simultaneity and identical geometry). Polarimeters such as SGLI and 3MI benefit immensely from improved radiometric characterization, because most radiometric artifacts lead to fake polarization results. In addition to the polarimeters mentioned above, the session discussed calibration issues related to on-orbit radiometers (OCI, OLCI, VIIRS, GOCI-II) and radiometers currently being built (GLIMR, SABIA-MAR, Advanced OLCI on Sentinel-3 Next Generation Optical).

An additional novelty was a presentation dedicated to **lunar irradiance models**. In addition to enabling lunar measurements to be used for temporal trending and straylight characterizations (several examples were provided in other talk in the session), a GSICS and CEOS/WGCV IVOS effort to improve the absolute accuracy of modelled lunar irradiances is ongoing, as are model inter-comparison exercises (LSICS). The ultimate goal is to allow sensors to either validate their absolute calibration or potentially use lunar observations as their primary method for absolute calibration. However, for most instruments, the moon is a challenging calibration source due to its small solid angle.

Solar diffusers provide a much more homogenous light source and have been the standard for most recent earth observing missions. Several lessons learned from solar diffuser calibration were discussed, such as:

- The need for an accurate prelaunch characterization. The BRDF needs to be measured for the illumination and viewing geometries that will be encountered during on-orbit solar calibrations, i.e. 'as-you-fly'. This includes the characterization of as many as possible detector elements (e.g. across the FOV). High accuracy should be particularly achieved on absolute BRDF values for a reference solar geometry at a high FOV sampling (0.5% (k=1) might be possible in the VIS range).
- An incorrect angular BRDF dependence may result in seasonal trends in sensor on-orbit radiometry. Therefore, early in the mission, dedicated spacecraft rotations (e.g. yaw maneuvers) should be used to characterize the angular BRDF dependence versus the absolute BRDF characterized prelaunch at the reference geometry.
- Solar diffuser reflectance temporal changes on-orbit need to be characterized. In most cases, several years of on-orbit data allow a more accurate characterization than the initial characterizations early in the mission.

The benefits of **redundancy** were also discussed. Independent methods for absolute calibration allow the use of one method to validate the other. Carrying two solar diffusers (instead of one) is an insurance policy e.g. in case of severe contamination of one of the diffusers. Multiple methods for on-orbit verification of spectral calibration increase the confidence in the data quality. An on-orbit measurement of linearity can be used to verify the prelaunch characterization.

It is important for every mission to establish **traceability** from the user/science requirements to the instrument requirements/specifications. During the design and build of the instrument, tradeoffs need to be made between various instrument performance aspects. Only a quantitative model that can predict the impact of an instrument performance change on the science products allows the instrument team to arrive at the optimal path forward when confronted with unexpected issues during design or build of the instrument. (Note that unexpected issues should be expected.)

An unexpected issue was found with the NOAA-21 (J2) VIIRS sensor: **vicarious calibration of the SWIR bands** over ocean suggests an instrument calibration issue on the order of 10% or more. There is at this moment no identified reason for this issue, but it could be a linearity issue (the SWIR bands are calibrated by solar diffuser radiances, which are much higher than ocean radiances).

The session focused mostly on radiometric calibration issues. During on-orbit commissioning, emphasis should be placed on obtaining accurate **geometric calibration** as soon as possible, because often data without a valid geometric calibration is radiometrically inferior. Also, the geometric performance should be reevaluated before every reprocessing with a change to the geometric calibration.

Review of Existing IOCS Recommendations

There are no updates to the existing recommendations.

New IOCS Recommendation(s)

We suggest the following new recommendations:

1) On-board solar diffusers should be characterized prelaunch as close to on-orbit conditions as possible ('as-you-fly'). High BRDF accuracy should be achieved at a reference solar geometry, which can then be used as a baseline for relative BRDF characterization via spacecraft rotations on-orbit. Characterization efforts must continue on-orbit with sensor temporal trending.
2) Increased focus should be dedicated to the prelaunch characterization of the SWIR bands at low level radiances. This is because the dynamic range between the top-of-atmosphere radiance over ocean and the calibration radiance (prelaunch or on-orbit) is typically even larger in the SWIR than in the visible spectrum.
3) GSICS and CEOS/WGCV IVOS are undertaking activities to reduce uncertainties and achieve absolute calibration of lunar irradiance models. The goal is to facilitate using the moon for on-orbit absolute calibration. Agencies are encouraged to support this effort.

All of these three recommendations are **to the space agencies**.