Publishable Executive summary

The project title is "Earth Observation Multi-mission Phase-E2 Operational Calibration: assessment of enhanced and new methodologies, technical procedures and systems scenarios". It corresponds to the Invitation to tender AO:1-7043/11/F/MOS.

This study aimed at developing methodologies for monitoring the sensor radiometry over three types of surface, ocean, sunglint and desert, and implementing them into the ESA DIMITRI software, which contained tools for the intercomparison of Top Of Atmosphere (TOA) radiance and reflectance values in the spectral range [0.400 -4] µm. The performance of the method has been assessed on temporal series of TOA reflectances acquired by ATSR-2, AATSR, PARASOL, MERIS, MODIS, and VEGETATION sensors over the different sites.

Before the development of the method, a **review of the current status of the vicarious calibration strategies** has been performed. It recaps the efforts and actions taken by the international institutions lead by CEOS/IVOS committee and its working group on Cal/Val (WGCV) to establish an internationally harmonised cal/val strategy, based on the principle of "traceability" as embodied in Quality Assurance for Earth Observation (QA4EO), including methods, reference standards and infrastructure, to meet the needs of space-based Earth observing systems for IVOS-relevant sensors.

To validate the methods, the first step was to improve the **cloud detection** in order to insure that the sensor radiometry monitoring is applied on clear acquisitions only. Some improvements have been made, in particular in a new branch dedicated to the cloud detection for data acquired over the sunglint in the ocean.

Then, the following methodologies were developed:

- Sensor radiometry monitoring using sunglint target;
- Sensor radiometry monitoring using ocean sites;
- Sensor radiometry monitoring using desert sites.

The three methods are based on the same principle that is to compare the measurements provided by the sensor above the selected sites to a simulation of the top-of-atmosphere reflectance. This ratio is computed for all acquisitions and monitored on a large period of time to detect possible change in sensor radiometry. 6SV Radiative transfer model has been used for the simulations. Meteorological Auxiliary data (wind, pressure, ozone content, and water vapor content) are from ECMWF ERA Interim dataset, available each 6 hours. Chlorophyll concentration needed for the method using ocean sites is from ESA Globcolour dataset.

Sensor radiometry monitoring using sunglint target: This method uses the specular reflection of the sun on the ocean surface because its signal is high, spectrally flat, covered large areas that can be observed from space. The sunglint reflectance can be modelled from geometrical conditions and the knowledge of the ocean surface roughness. Coupled to 6S which provides estimation of all atmospheric terms, the simulated TOA reflectances have been compared to the satellite measurements or the same geometrical conditions. The method has been applied for MERIS, MODIS/A, and PARASOL data for data acquired in the South Indian Ocean.

Sensor radiometry monitoring using ocean sites: This method uses the Rayleigh scattering over the ocean for spectral bands up to 670 nm. In this domain, the atmospheric signal can be predicted with accuracy using 6S RTM. 6SV accounts for a surface model (Morel et al. 1988) which is coupled to the atmosphere to simulate the TOA reflectances. Then, the simulated TOA reflectances have been compared to the satellite measurements or the same geometrical conditions. The method has been applied for MERIS, MODIS/A, AATSR, ATSR-2 and PARASOL data for data acquired in the South Indian Ocean.

Sensor radiometry monitoring using desert sites: The method uses the stability of the surface reflectance on selected desert sites to attribute the change on the TOA reflectances to the temporal change of the instrument's sensitivity. The surface properties of Libya4 site are described with a BRDF model developed by MODIS team allowing to compute the directional reflectance at any view or solar zenith angle desired. The MODIS BRDF/Albedo Model

Parameters products are from MCD43B1 products. They are spectrally resampled to the spectral bands of the sensor available into DIMITRI software. The BRDF is coupled to the SMAC method which allows to estimate fast the TOA reflectance. Then, the simulated TOA reflectances have been compared to the satellite measurements or the same geometrical conditions. The method has been applied for MERIS, MODIS/A, AATSR, ATSR-2, VEGETATION and PARASOL data for data acquired over the Pseudo-Invariant Calibration Sites Libya 4.

Software development: The three methods have been implemented in DIMITRI V3. Specific HMIs have been designed to allow the user to perform the sensor radiometry monitoring and exploit the results.

Recommendations: It is recommended to extend the validation of the cloud detection method based on the results obtained by the methods for sensor radiometry monitoring. Indeed, thresholds on scene cloud coverage used to select the data as input of the three methods could be not enough tight so that radiometry could be disturbed by clouds in the far-off vicinity. For the methodologies, the main recommendation to achieve the assessment of the algorithms is to perform sensitivity errors to confirm the level of errors due to each contributor of the method and compare it to the error analysis published in the literature.