Sentinel-3 yaw manoeuvres for solar diffuser characterization on orbit

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Sentinel-3 OLCI solar diffuser characterization

• Solar diffusers are OLCI primary radiometric standard
  – Knowledge of solar diffuser BRDF allows quantitative interpretation of absolute radiometric response and temporal degradation, via regular on-orbit radiometric calibrations [ESA/EUM Cal/Val plan, OLCI-L1B-CV-200]

• Importance of solar diffuser characterization for the quality of ocean colour products
  – Ocean colour products are particularly sensitive to instrument characterization [IOCCG Report 13]
    – Accuracy and stability of ocean colour products depend on solar diffuser BRDF uncertainties

• Pre-launch characterization
  – Pre-launch BRDF characterization is difficult and can only be made at a limited set of solar illumination and camera view angles, and at a few selected bands

• Potential of solar diffuser BRDF assessment on-orbit
  – Assessment of solar diffuser characterization is possible on-orbit with yaw maneuvers
  – Experience from Terra and Aqua MODIS and Suomi NPP VIIRS
OLCI solar diffuser pre-launch laboratory BRDF characterizations applied lessons learned from MERIS

- BRDF measurements relative and absolute for OLCI flight modules (FM) FM-A and FM-B were performed at Centre Spatial de Liège (CLS) for
  - all 5 cameras,
  - 7 wavelengths,
  - 7 incidence angles, and
  - 9 observation angles
- Traceability to the international standard was established by PTB, Germany
S3A OLCI solar diffuser BRDF modelling

• OLCI solar diffuser BRDF model
  – Lab BRDF measurements are fit with a model for the operational calibration processing
  – OLCI BRDF model is a variation of the MERIS BRDF Rahman model, the model was developed and tested to fit the absolute measurements with about 0.3% uncertainty
  – Experience with MERIS: radiometric gains displayed a seasonal pattern correlated with solar azimuth angles on the solar diffuser (BRDF model dependency)
  – Experience with OLCI: BRDF model reproduces the reference geometry within ± 0.9 %

• Only a single Lab BRDF incidence angle matches the on-orbit geometry of radiometric calibrations
S3A OLCI solar diffuser on-orbit activities

1 Sentinel-3 OLCI operational radiometric calibration cycles

2 OLCI in-flight solar diffuser assessment with yaw manoeuvres

1 Selection of a set of solar azimuth angles for OLCI operational radiometric calibration sequences, S01 and S04/05
   - The same set of predefined azimuths will be used year-after-year

2 Yaw manoeuvres to reproduce in a single day the annual range of variations in solar geometry on the diffuser
   - Assessment of solar diffuser BRDF on orbit with real on-orbit calibration geometries for
     - continues solar elevations,
     - more azimuth incidence angles,
     - all viewing angles and
     - all operational spectral bands
   - Yaw manoeuvres are a low risk routine, they replicate the geometries operationally encountered on orbit
   - Yaw manoeuvres only provide information on relative BRDF characterization, not absolute

Sentinel-3A yaw manoeuvres
- Sentinel-3A MAG endorsed “the scientifically robust approach to use one-off satellite yaw manoeuvres during the Phase-E2 PDGS Commissioning Ramp-up to perform an in-flight verification of the OLCI and SLSTR solar diffuser calibration measurements for all seasonal geometry changes” (S3MAG–M4–A10)
- OLCI Cal/Val task in the S3 Cal/Val Plan, 2014 (OLCI-L1B-CV-280)
- Sentinel-3A IOCR technical meeting recommendation (S3-MN-ESA-OL-752)
Evolution of solar azimuth angle on the OLCI solar diffuser over a full year on orbit
Added azimuth angles of operational radiometric calibrations S01
Added azimuth angles of pre-launch characterizations

- Sun azimuth angle with yaw steering
- Lab diffuser characterization azimuths
- Operational S01 calibrations about every 2 weeks

Sun azimuth at SZA=90deg - 41.25 sec on S/C XY plane [deg]

Elapsed time since 1st January 2017 [days]
Added angles of yaw manoeuvres

Sun azimuth angle with yaw steering
Lab diffuser characterization azimuths

Operational S01 calibrations about every 2 weeks
Yaw calibration Azimuths, corresponding annual times

Sun azimuth at SZA=90deg - 41.25 sec on S/C XY plane [deg]

Elapsed time since 1st January 2017 [days]
Defined the yaw manoeuvres with a tie to the pre-launch absolute BRDF reference value.

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Added azimuth angles of diffuser ageing calibrations S04/S05
### Yaw manoeuvres implementation

**Nominal option:**
- S01 calibration sequences were performed when the satellite was transitioned to predefined yaw steering for the event of the calibrations

![Diagram of yaw manoeuvres implementation]

- **OLCI and SLSTR solar diffuser yaw activity**
  - Yaw manoeuvres were extended to enable SLSTR SD acquisitions performed 3 min after OLCI calibrations
  - For SLSTR, the SD BRDF effects are secondary. The yaw data were used to characterize on-orbit the vignetting of the SLSTR SD at both sides of the SD baffle

![Diagram of yaw manoeuvres implementation with additional details]
Conclusions

• Yaw manoeuvres provided data for on-orbit solar diffuser BRDF model definition (presentations by Matthijs Krijger and Ludovic Bourg)

• Yaw manoeuvres provided accurate relative BRDF re-definition

• Absolute BRDF values need to tie to the prelaunch absolute BRDF measurements