Sentinel-3 OLCI In-Flight Diffuser Characterisation

E. Kwiatkowska  IOCS 2019
Solar diffusers are the radiometric standard of OLCI instrument

Lab characterization of solar diffusers is complex, performed at selected geometries/wavelengths

- S3A and S3B OLCI solar diffuser BRDF characterized in the lab at the same geometries and wavelengths
  - all 5 cameras
  - 7 incidence angles (and 2 additional angles at 681nm)
  - 7 wavelengths
  - 9 observation angles

OLCI-A – only a single Lab BRDF solar incidence angle matches the geometry of in-flight nominal calibrations ‘reference geometry’

OLCI –A and –B diffuser BRDF comparisons of lab measurements

- Differences in OLCI –A and –B Lab BRDF measurements
  - no spectral trend
  - differences +/- 1%

OLCI-A/B solar diffuser BRDF characterization

The same pre-flight characterization geometries between S3A and S3B OLCI

Single incidence angle corresponding to in-flight radiometric calibration geometry

OLCI-A/OLCI-B diffuser BRDF Ratio, Reference Geometry

Colours: observation angles
Symbols: OLCI cameras
S3 yaw manoeuvres for in-flight diffuser modelling

- **S3 OLCI pre-flight solar diffuser BRDF model**
  - Pre-flight diffuser BRDF model – Rahman
  - Pre-flight BRDF model reproduces the reference geometry within ±1%, the same in OLCI-A and OLCI-B
  - Experience with pre-flight model (Envisat MERIS, S3A and B OLCI): pre-flight BRDF model results in seasonal patterns in radiometric gains

- **Satellite yaw manoeuvres reproduce in a single day the annual range of variations in solar geometry on the solar diffuser**

- **Lessons learned from S3A yaw manoeuvres for an in-flight diffuser characterisation**
  - Yaw manoeuvres provide accurate relative BRDF model: RMS performance << 0.1%
  - For the SI-traceable lab absolute reflectance, need to tie to the pre-launch ‘reference geometry’

**Sentinel-3 yaw manoeuvres**
- S3 MAG recommendation to conduct satellite yaw manoeuvres during E2 PDGS Commissioning Ramp-up (S3MAG–M4–A10)
- OLCI Cal/Val task in ESA/EUM S3 Cal/Val Plan, 2014 (OLCI-L1B-CV-280)
- S3A IOCR technical meeting recommendation (S3-MN-ESA-OL-752)
- S3B IOCR technical meeting recommendation (S3-MN-ESA-SY-918)
OLCI-A - B differences in the diffuser normal vectors

- Normal vectors to the solar diffuser are different between OLCI-A and OLCI-B
  - Normal vector to the solar diffuser for S3A OLCI: 0.33373345, 0.18074450, -0.92517750
  - Normal vector to the solar diffuser for S3B OLCI: 0.32712910, 0.18138800, -0.92740760

- Difference in the diffuser normal causes differences in calibration geometries between OLCI-A/-B
  - OLCI-A and -B have 0.4° difference in diffuser normal vector
  - OLCI-B solar diffuser does not acquire the lab ‘reference geometry’ during nominal calibrations
  - The difference produces a shift in solar zenith angle for OLCI-B of about 6.6 sec compared to OLCI-A
Scheduling of the S3B yaw manoeuvres

• Requirements for the planning of S3B yaw maneuvers for OLCI solar diffuser in-flight modelling
  – Need to cover the geometry range of operational nominal calibrations
  – Need to reproduce the pre-launch ‘reference geometry’ to tie to the SI-traceable lab absolute reflectance
  – Need to replicate the geometries of OLCI-A yaw manoeuvres
  – Need to select geometries for the manoeuvres to provide a BRDF model within OLCI-A nominal calibration geometries and extendible to the past OLCI-B nominal geometries
  – Need to improve on the geometry prediction of the OLCI-A yaw manoeuvres

• Execution of S3B yaw manoeuvres on 11 Dec 2018 (yaw test on 6 Dec 2018)

<table>
<thead>
<tr>
<th>Cal#</th>
<th>Type</th>
<th>target SAA in SC frame [deg]</th>
<th>target SEA in SC frame [deg]</th>
<th>yaw bias [deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S01</td>
<td>28.919</td>
<td>-2.179</td>
<td>0.117</td>
</tr>
<tr>
<td>2</td>
<td>S01</td>
<td>35.0</td>
<td>-5.957</td>
<td>-3.249</td>
</tr>
<tr>
<td>3</td>
<td>S01</td>
<td>32.3</td>
<td>1.648</td>
<td>5.265</td>
</tr>
<tr>
<td>4</td>
<td>S01</td>
<td>27.41</td>
<td>7.771</td>
<td>0.158</td>
</tr>
<tr>
<td>5</td>
<td>S01</td>
<td>23.8</td>
<td>0.166</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>S01</td>
<td>21.3</td>
<td>-2.179</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>S01</td>
<td>28.919</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>S05</td>
<td>28.919</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cal#</th>
<th>Type</th>
<th>target SAA in SC frame [deg]</th>
<th>target SEA in SC frame [deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>S01</td>
<td>21.3846</td>
<td>-2.55304</td>
</tr>
<tr>
<td>1</td>
<td>S01</td>
<td>28.9956</td>
<td>-2.60774</td>
</tr>
<tr>
<td>2</td>
<td>S01</td>
<td>21.4035</td>
<td>-2.05690</td>
</tr>
<tr>
<td>3</td>
<td>S01</td>
<td>21.3846</td>
<td>-2.55304</td>
</tr>
<tr>
<td>4</td>
<td>S01</td>
<td>35.0921</td>
<td>-2.26595</td>
</tr>
<tr>
<td>5</td>
<td>S01</td>
<td>23.8826</td>
<td>-2.50057</td>
</tr>
<tr>
<td>6</td>
<td>S01</td>
<td>32.3914</td>
<td>-2.32562</td>
</tr>
<tr>
<td>7</td>
<td>S01</td>
<td>27.4926</td>
<td>-2.42725</td>
</tr>
<tr>
<td>8</td>
<td>S01</td>
<td>28.9962</td>
<td>-2.64484</td>
</tr>
<tr>
<td>9</td>
<td>S05</td>
<td>28.9962</td>
<td>-2.64484</td>
</tr>
</tbody>
</table>

2016 OLCI-A yaw measurements

reference geometry slightly missed

2018 OLCI-B yaw measurements

reference geometry well approximated
Results from S3B yaw manoeuvre diffuser BRDF model

- **New Model: Polynomial per pixel**
  - $P_0$ [absolute calibration] *
  - $(1+P_1*SZA+P_2*SAA$ [linear]
  - $+P_3*SAA*SZA$ [cross-term]
  - $+P_4*SZA^2+P_5*SAA^2$ [second order] )

- **New OLCI Diffuser BRDF Model**
  - Relative accuracy to $<0.05\%$ \(\Rightarrow\) derived from yaw maneuvers
  - Absolute model accuracy needs to tie to the pre-launch absolute reference reflectance which was characterized with 1% uncertainty; i.e. absolute accuracy $<1\%$ \(\Rightarrow\) dependent on on-ground calibration
Conclusions and lessons learned

- Yaw maneuvers provide accurate relative BRDF model
  - More Yaw angles allow a more accurate model and even characterization of diffuser speckles
  - The on-ground lab reference measurement dominates the absolute calibration accuracy
  - Repeat several times to achieve the lowest possible uncertainties of the lab reference
- For OLCI-B, compensate diffuser normal offset by scheduling the nominal calibrations 6.6 sec earlier to match OLCI-A nominal calibration geometries
- Recommendation implemented for OLCI-B: OLCI-B nominal calibrations now routinely acquire the lab reference geometry and match OLCI-A calibration geometries
- OLCI-A and -B radiometric temporal evolution is now modelled accurately!