## PREPARATION AND OPERATIONS OF THE MISSION PERFORMANCE CENTRE (MPC) FOR THE COPERNICUS SENTINEL-3 MISSION

## **S3 OLCI Cyclic Performance Report**

**S3-A** 

Cycle No. 047

Start date: 10/07/2019

End date: 06/08/2019

**S3-B** 

Cycle No. 028

Start date: 20/07/2019

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SENTINEL 3



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The work performed in the frame of this contract is carried out with funding by the European Union. The views expressed herein can in no way be taken to reflect the official opinion of either the European Union or the European Space Agency.









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## 1 Processing Baseline Version

## 1.1 Sentinel3-A

| IPF     | IPF / Processing Baseline version | Date of deployment                                     |
|---------|-----------------------------------|--|
| OL1     | 06.08 / 2.55                      | NRT: 30/07/2019 10:17 UTC<br>NTC 30/07/2019 10:17 UTC  |
| OL2     | 06.12 / 2.38                      | NRT: 29/08/2018 09:24 UTC<br>NTC: 29/08/2018 09:33 UTC |
| SY2     | 06.17 / 2.51                      | NTC: 30/05/2019 11:00 UTC                              |
| SY2_VGS | 06.07 / 2.44                      | NTC: 21/01/2019 10:06 UTC                              |

## 1.2 Sentinel3-B

| IPF     | IPF / Processing Baseline version | Date of deployment                                     |
|---------|-----------------------------------|--|
| OL1     | 06.08 / 1.27                      | NRT: 30/07/2019 09:37 UTC<br>NTC: 30/07/2019 09:37 UTC |
| OL2     | 06.12 / 1.09                      | NRT: 29/08/2018 09:24 UTC<br>NTC: 29/08/2018 09:33 UTC |
| SY2     | 06.17 / 1.23                      | NTC: 30/05/2019 11:00 UTC                              |
| SY2_VGS | 06.07 / 1.16                      | NTC: 21/01/2019 10:06 UTC                              |

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## 2 Instrument monitoring

#### 2.1 CCD temperatures

#### 2.1.1 OLCI-A

The monitoring of the CCD temperatures is based on MPMF data extractions not yet operational. In the meantime, we monitor the CCD temperatures on the long-term using Radiometric Calibration Annotations (see Figure 1). Variations are very small (0.09 C peak-to-peak) and no trend can be identified. Data from current cycle (rightmost data points) do not show any specificity.

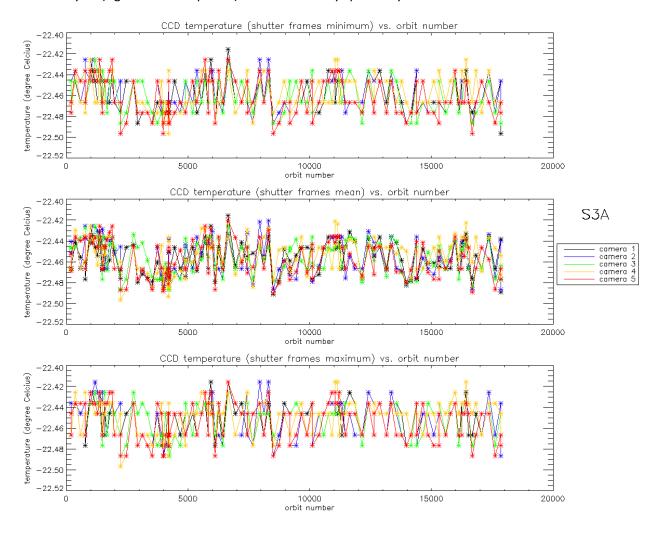


Figure 1: long term monitoring of OLCI-A CCD temperatures using minimum value (top), time averaged values (middle), and maximum value (bottom) provided in the annotations of the Radiometric Calibration Level 1 products, for the Shutter frames, all radiometric calibrations so far except the first one (absolute orbit 183) for which the instrument was not yet thermally stable.

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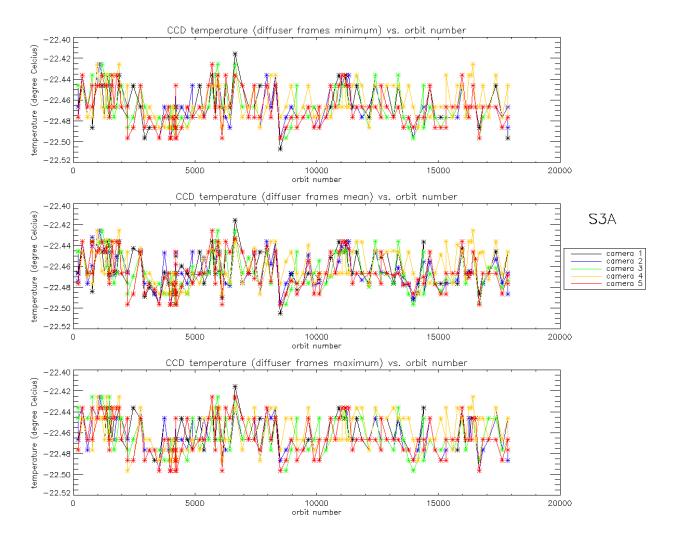


Figure 2: Same as Figure 1 for diffuser frames.

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#### 2.1.2 OLCI-B

As for OLCI-A, the variations of CCD temperature are very small (0.08 C peak-to-peak) and no trend can be identified. Data from current cycle (rightmost data points) do not show any specificity.

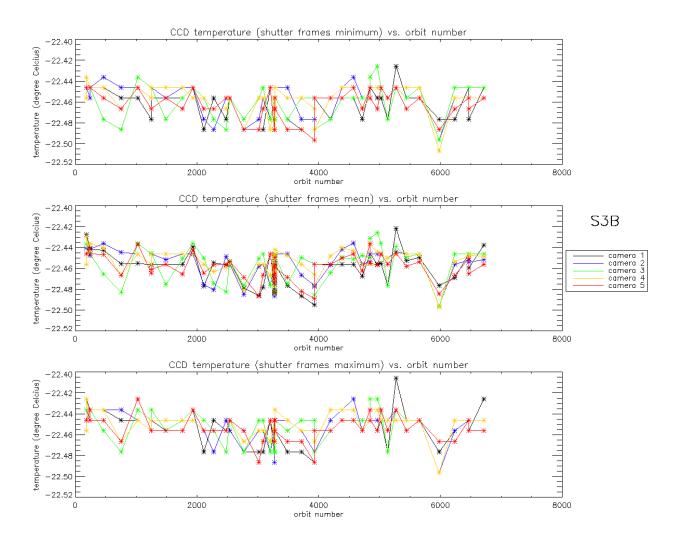


Figure 3: long term monitoring of OLCI-B CCD temperatures using minimum value (top), time averaged values (middle), and maximum value (bottom) provided in the annotations of the Radiometric Calibration Level 1 products, for the Shutter frames, all radiometric calibrations so far except the first one (absolute orbit 167) for which the instrument was not yet thermally stable.

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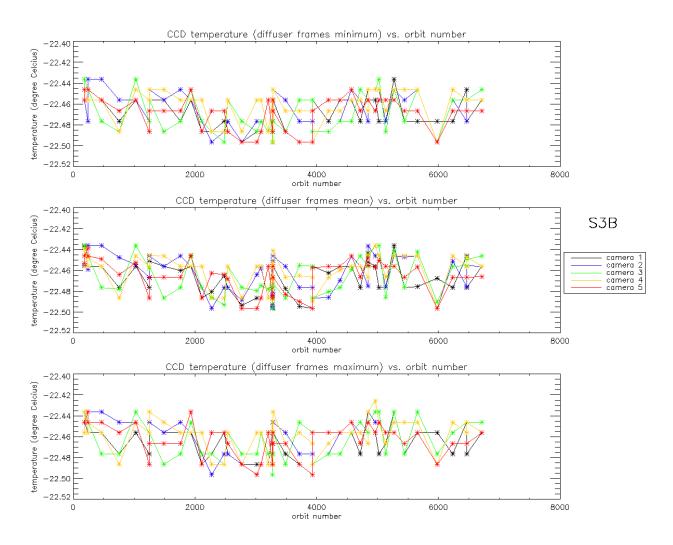


Figure 4: same as Figure 3 for diffuser frames.



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#### 2.2 Radiometric Calibration

For OLCI-A, two Radiometric Calibration Sequences have been acquired during Cycle 047:

- S01 sequence (diffuser 1) on 23/07/2019 00:33 to 00:34 (absolute orbit 17856)
- S05 sequence (diffuser 2) on 23/07/2019 02:14 to 02:15 (absolute orbit 17857)

For OLCI-B, three Radiometric Calibration Sequences have been acquired during Cycle 028:

- S01 sequence (diffuser 1) on 23/07/2019 11:40 to 11:42 (absolute orbit 6469)
- S05 sequence (diffuser 2) on 23/07/2019 13:21 to 13:23 (absolute orbit 6470)
- S01 sequence (diffuser 1) on 09/08/2019 12:41 to 12:43 (absolute orbit 6712)

The acquired Sun azimuth angles are presented on Figure 5 for OLCI-A and Figure 6 for OLCI-B, on top of the nominal values without Yaw Manoeuvre (i.e. with nominal Yaw Steering control of the satellite).

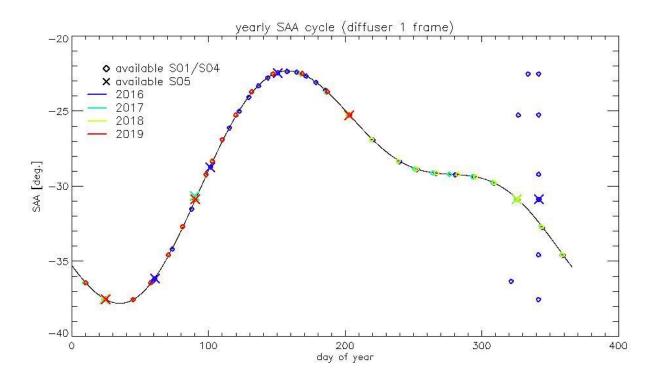


Figure 5: Sun azimuth angles during acquired OLCI-A Radiometric Calibrations (diffuser frame) on top of nominal yearly cycle (black curve). Diffuser 1 with diamonds, diffuser 2 with crosses, 2016 acquisitions in blue, 2017 in green, 2018 in yellow and 2019 in red.



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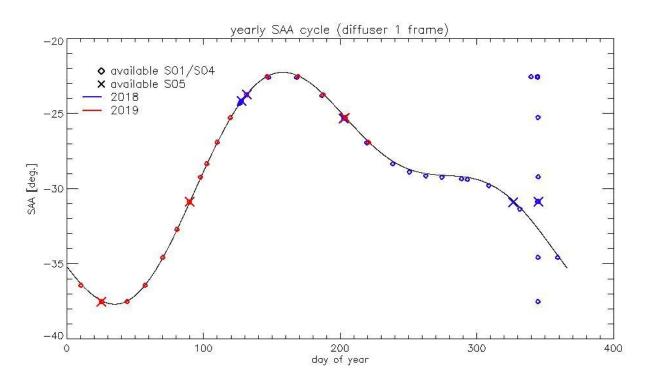


Figure 6: same as Figure 5 for OLCI-B (2018 in blue, 2019 in red).

Sun Azimuth Angles as a function of solar zenith Angles are presented in Figure 7 for OLCI-A and Figure 8 for OLCI-B.

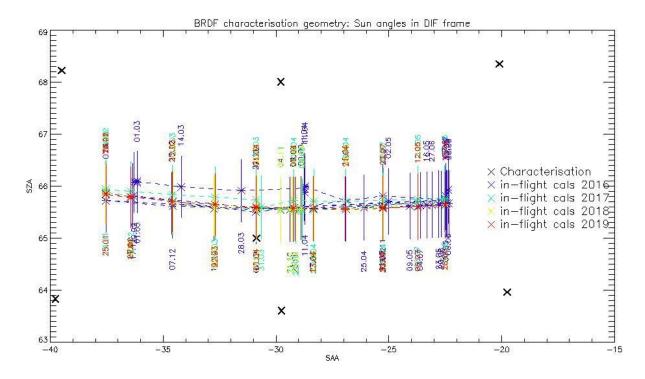


Figure 7: OLCI-A Sun geometry during radiometric Calibrations on top of characterization ones (diffuser frame)

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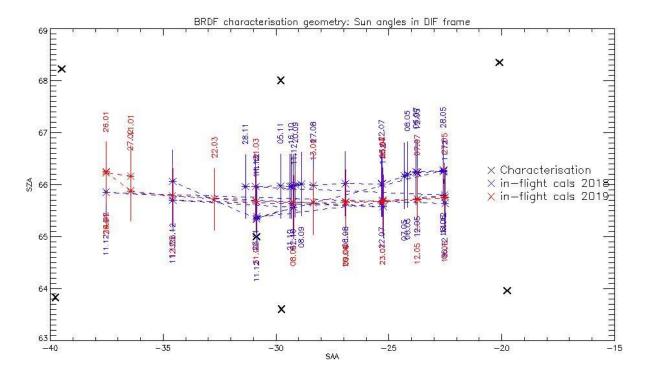


Figure 8: same as Figure 7 for OLCI-B

#### 2.2.1 Dark Offsets [OLCI-L1B-CV-230]

#### **Note about the High Energy Particles:**

The filtering of High Energy Particle (HEP) events from radiometric calibration data has been implemented (for shutter frames only) in a post processor, allowing generating Dark Offset and Dark Current tables computed on filtered data. The post-processor starts from IPF intermediate data (corrected counts), applies the HEP detection and filtering and finally computes the Dark Offset and Dark Current tables the same way as IPF. An example of the impact of HEP filtering is given in Figure 9.

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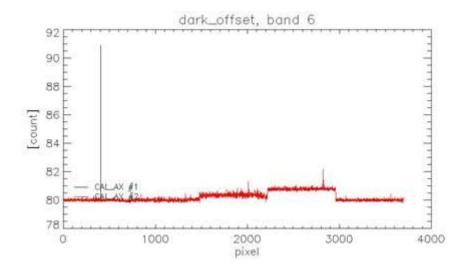


Figure 9: Dark Offset table for band Oa06 with (red) and without (black) HEP filtering (Radiometric Calibration of 22 July 2017). The strong HEP event near pixel 400 has been detected and removed by the HEP filtering.

All results presented below in this section have been obtained using the HEP filtered Dark Offset and Dark Current tables.

#### 2.2.1.1 OLCI-A

#### **Dark offsets**

Dark offsets are continuously affected by the global offset induced by the Periodic Noise on the OCL convergence. Current Cycle calibrations are affected the same way as others. The amplitude of the shift varies with band and camera from virtually nothing (e.g. camera 2, band 0a1) to up to 5 counts (Oa21, camera 3). The Periodic Noise itself comes on top of the global shift with its known signature: high frequency oscillations with a rapid damp. This effect remains more or less stable with time in terms of amplitude, frequency and decay length, but its phase varies with time, introducing the global offset mentioned above.

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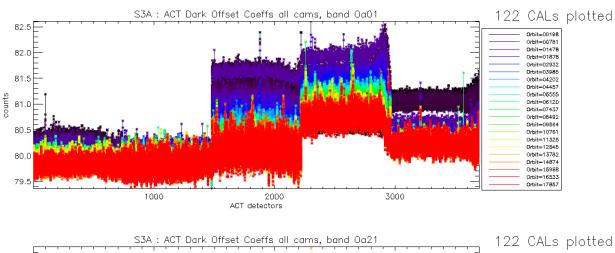
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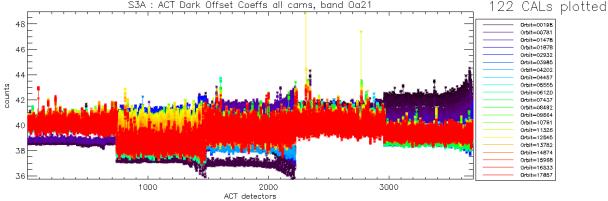


Figure 10: OLCI-A Dark Offset for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.

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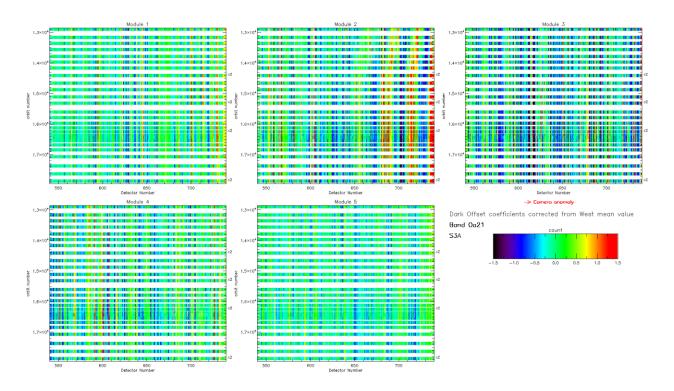


Figure 11: map of OLCI-A periodic noise for the 5 cameras, for band Oa21. X-axis is detector number (East part, from 540 to 740, where the periodic noise occurs), Y-axis is the orbit number. Y-axis range is focused on the most recent 5000 orbits. The counts have been corrected from the West detectors mean value (not affected by periodic noise) in order to remove mean level gaps and consequently to have a better visualisation of the long term evolution of the periodic noise structure. At the beginning of the mission the periodic noise for band Oa21 had strong amplitude in camera 2, 3 and 5 compared to camera 1 and 4. However PN evolved through the mission and these discrepancies between cameras have been reduced. At the time of this Cyclic Report Camera 2 still shows a slightly higher PN than other cameras.

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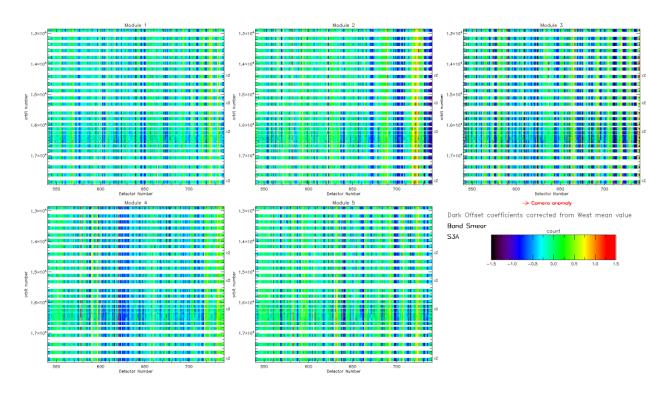


Figure 12: same as Figure 11 for smear band.

Figure 11 and Figure 12 show the so-called 'map of periodic noise' in the 5 cameras, for respectively band 21 and smear band. These maps have been computed from the dark offsets after removal of the mean level of the WEST detectors (not impacted by PN) in order to remove mean level gaps from one CAL to the other and consequently to highlight the shape of the PN. Maps are focused on the last 200 EAST detectors where PN occurs and on a time range covering only the last 5000 orbits in order to better visualize the current cycle's CALs.

As there was no camera anomaly during the current cycle, there is no sudden change of periodic noise to report during the current cycle. For camera 2 band Oa21 a slight PN phase drift occurred between orbit 13500 and 14500 but is now stabilized.

#### **Dark Currents**

Dark Currents (Figure 13) are not affected by the global offset of the Dark Offsets, thanks to the clamping to the average blind pixels value. However, the oscillations of Periodic Noise remain visible. There is no significant evolution of this parameter during the current cycle except the small regular increase (almost linear), for all detectors, since the beginning of the mission (see Figure 14).

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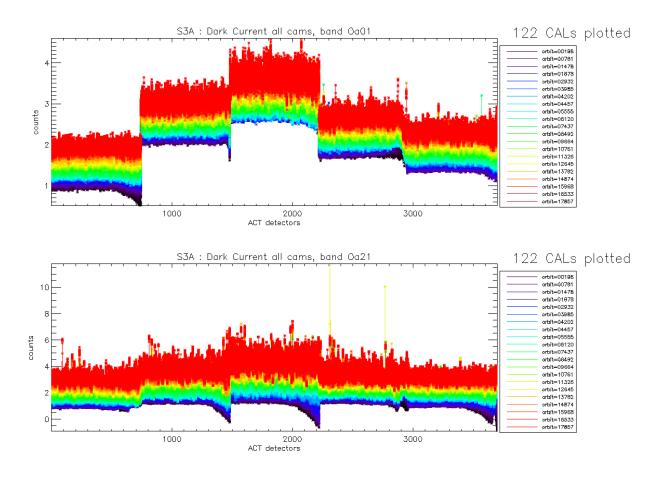


Figure 13: OLCI-A Dark Current for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.

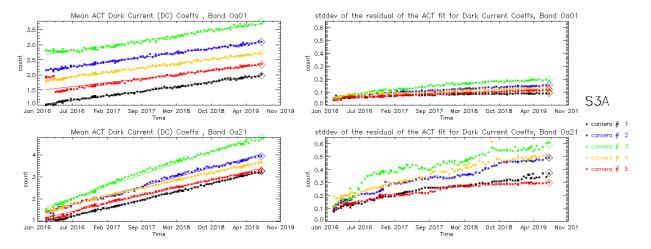


Figure 14: left column: ACT mean on 400 first detectors of OLCI-A Dark Current coefficients for spectral band Oa01 (top) and Oa21 (bottom). Right column: same as left column but for Standard deviation instead of mean.

We see an increase of the DC level as a function of time especially for band Oa21.



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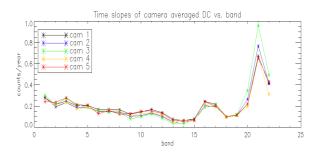
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A possible explanation of the regular increase of DC could be the increase of the number of hot pixels which is more important in Oa21 because this band is made of more CCD lines than band Oa01 and thus receives more cosmic rays impacts. It is known that cosmic rays degrade the structure of the CCD, generating more and more hot pixels at long term scales. Indeed, when computing the time slopes of the spatially averaged Dark Current as a function of band, i.e. the slopes of curves in left plots of Figure 14, one can see that Oa21 is by far the most affected, followed by the smear band (Figure 15, left); when plotting these slopes against total band width (in CCD rows, regardless of the number of micro-bands), the correlation between the slope values and the width becomes clear (Figure 15, right).



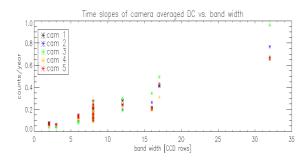


Figure 15: OLCI-A Dark current increase rates with time (in counts per year) vs. band (left) and vs. band width (right)

#### 2.2.1.2 OLCI-B

#### **Dark Offsets**

Dark offsets for OLCI-B show a similar behaviour than for OLCI-A: mean level gaps between different orbits, induced by the presence of a pseudo periodic noise on the east edge of the cameras with a drifting phase.

Evolution of OLCI-B Dark Offset coefficients for band Oa01 and Oa21 are represented in Figure 16.

The periodic noise maps are shown for band Oa21 and smear band respectively in Figure 17 and Figure 18. As it happened for OLCI-A after a few thousands of orbits, the strong periodic noise phase and amplitude drift, present at the very beginning of the mission is now showing a clear stabilization.

An instrument anomaly occurred on OLCI-B on 29 May 2019 (reported in document "S3MPC.ACR.MEM.061") followed by a reset of the instrument on 31 May 2019. This reset is probably responsible of the slight change of PN shape visible in camera 3 band Oa21 (see Figure 17) and of the slight change of PN phase in camera 3 smear band (see Figure 18).

There is no specific behaviour of the PN to report in the current cycle.

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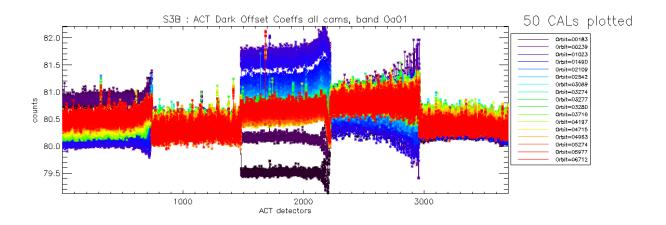
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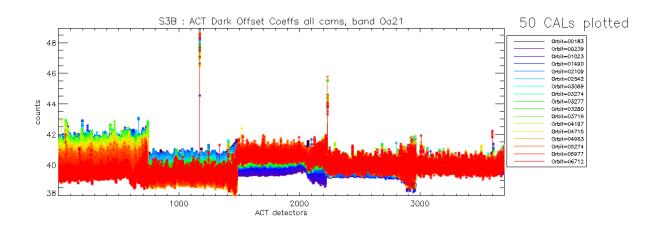


Figure 16: OLCI-B Dark Offset for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 167) for which the instrument was not thermally stable yet.



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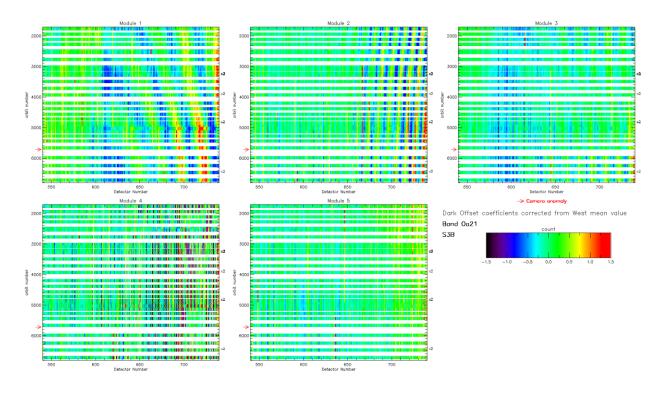


Figure 17: OLCI-B map of periodic noise for the 5 cameras, for band Oa21. X-axis is detector number (East part, from 540 to 740, where the periodic noise occurs), Y-axis is the orbit number. The counts have been corrected from the West detectors mean value (not affected by periodic noise) in order to remove mean level gaps and consequently to have a better visualisation of the long term evolution of the periodic noise structure.

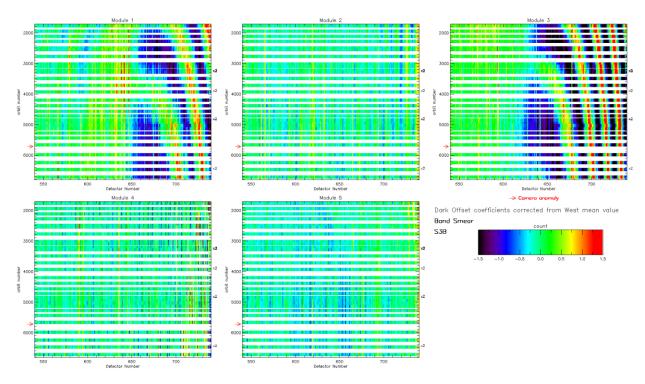


Figure 18: same as Figure 17 for smear band.

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#### **Dark Currents**

As for OLCI-A there is no significant evolution of the Dark Current coefficients (Figure 19) during the current cycle except the small regular increase (almost linear), for all detectors, since the beginning of the mission (see Figure 20) probably due to an increase of hot pixels (see Figure 21).

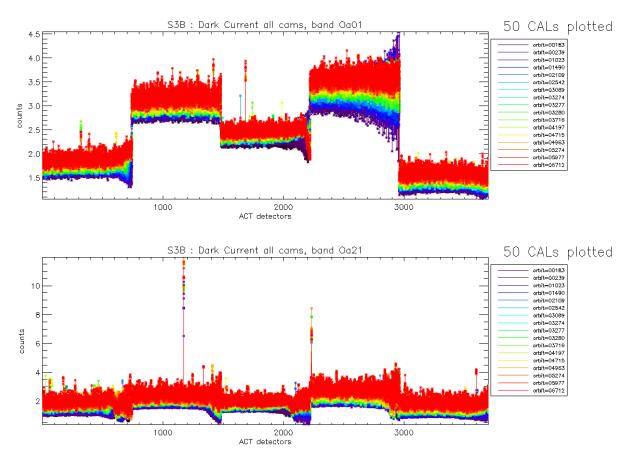


Figure 19: OLCI-B Dark Current for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 167) for which the instrument was not thermally stable yet.

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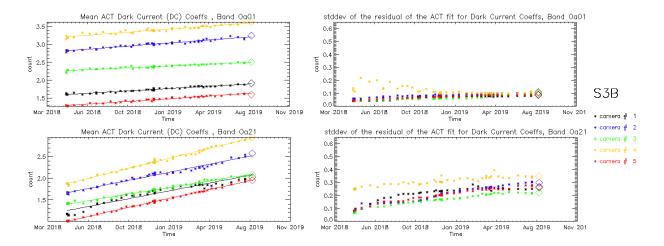


Figure 20: left column: ACT mean on 400 first detectors of OLCI-B Dark Current coefficients for spectral band Oa01 (top) and Oa21 (bottom). Right column: same as left column but for Standard deviation instead of mean.

We see an increase of the DC level as a function of time especially for band Oa21.

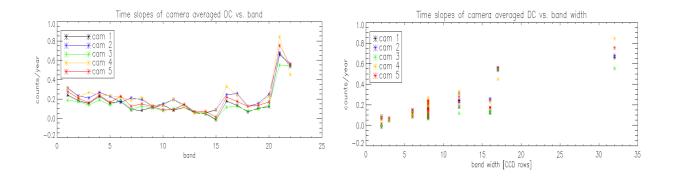


Figure 21: OLCI-B Dark Current increase rates with time (in counts per year) vs. band (left) and vs. band width (right)



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#### 2.2.2 Instrument response and degradation modelling [OLCI-L1B-CV-250]

#### 2.2.2.1 Instrument response monitoring

#### 2.2.2.1.1 OLCI-A

Figure 22 shows the gain coefficients of every pixel for two OLCI-A channels, Oa1 (400 nm) and Oa21 (1020 nm), highlighting the significant evolution of the instrument response since early mission.

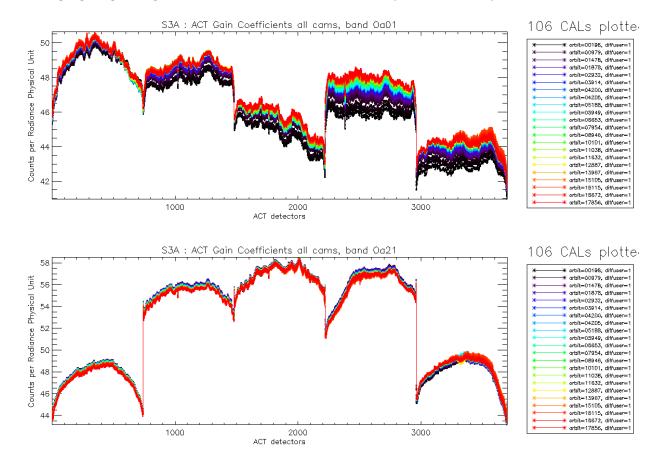


Figure 22: OLCI-A Gain Coefficients for band Oa1 (top) and Oa21 (bottom), all diffuser 1 radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.

The gains plotted in Figure 22, however are derived using the ground BRDF model — as the only one available in the operational processing software so far — which is known to suffer from illumination geometry dependent residual errors (see previous Cyclic Reports for more details). Consequently they are post-processed to replace the ground BRDF model by the in-flight version, based on Yaw Manoeuvres data, prior to determine the radiometric evolution.

Figure 23 displays a summary of the time evolution derived from post-processed gains: the cross-track average of the BRDF corrected gains (taking into account the diffuser ageing) is plotted as a function of time, for each module, relative to a given reference calibration (the 07/12/2016). It shows that, if a



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significant evolution occurred during the early mission, the trends tend to stabilize, with the exception of band 1 of camera 1 and 4.

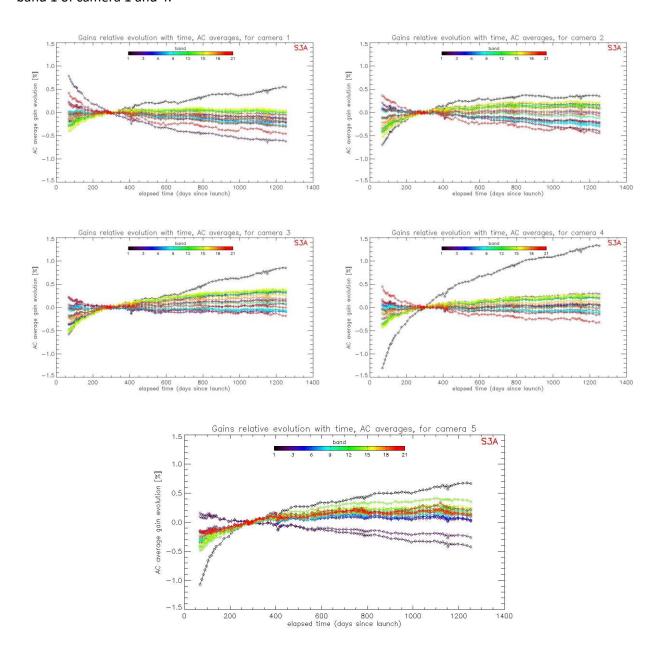


Figure 23: camera averaged gain relative evolution with respect to "best geometry" calibration (07/12/2016), as a function of elapsed time since the change in OLCI channels settings (25/04/16); one curve for each band (see colour code on plots), one plot for each module. The diffuser ageing has been taken into account.

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#### 2.2.2.1.2 OLCI-B

Figure 24 shows the gain coefficients of every pixel for two OLCI-B channels, Oa1 (400 nm) and Oa21 (1020 nm), highlighting the significant evolution of the instrument response since early mission.

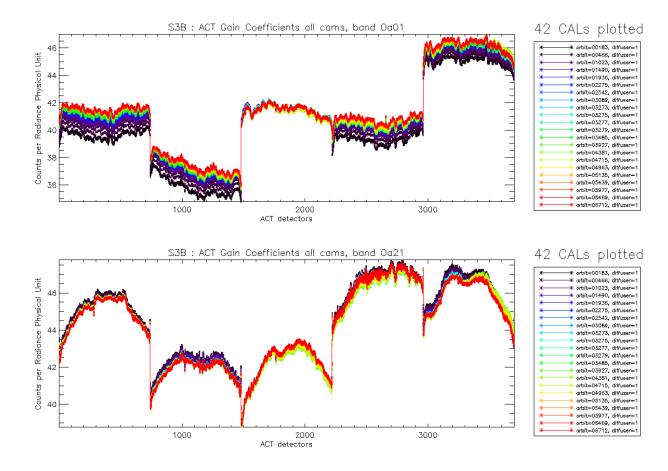


Figure 24: OLCI-B Gain Coefficients for band Oa1 (top) and Oa21 (bottom), all diffuser 1 radiometric calibrations so far except the first one (orbit 167) for which the instrument was not thermally stable yet.

Figure 25 displays a summary of the time evolution derived from post-processed gains: the cross-track average of the BRDF corrected gains is plotted as a function of time, for each module, relative to a given reference calibration (first calibration after channel programming change: 18/06/2018). It shows that, if a significant evolution occurred during the early mission, the trends tend to stabilize. The large amount of points near elapsed time = 220 days is due to the yaw manoeuvre campaign.

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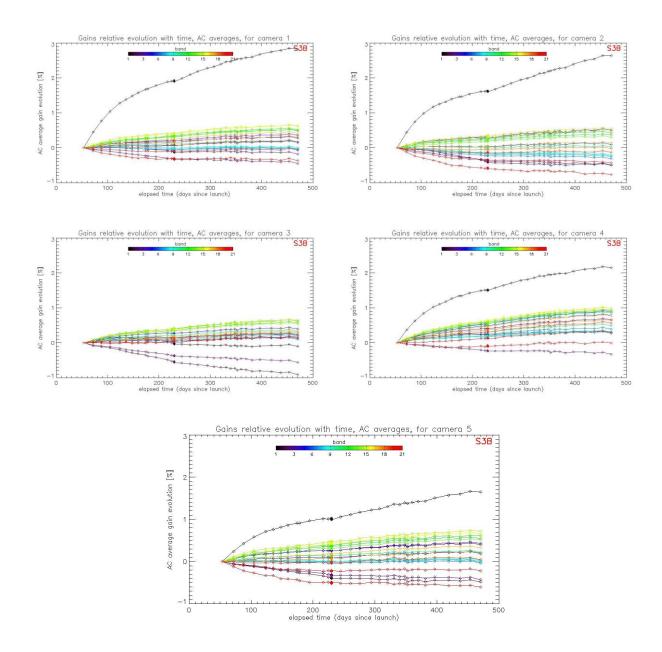


Figure 25: OLCI-B camera averaged gain relative evolution with respect to first calibration after channel programming change (18/06/2018), as a function of elapsed time since the beginning of the mission; one curve for each band (see colour code on plots), one plot for each module. The diffuser ageing is not taken into account (too early to model it yet).



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#### 2.2.2.2 Instrument evolution modelling

#### 2.2.2.2.1 OLCI-A

The OLCI-A Radiometric Model has been refreshed and put in operations the 11/04/2019 (Processing Baseline 2.48). The model has been derived on the basis of an extended Radiometric Calibration dataset (from 25/04/2016 to 25/01/2019). It includes the correction of the diffuser ageing for the five bluest bands (Oa1 to Oa5) for which it is clearly measurable. The model performance over the complete dataset (including the 14 calibrations in extrapolation over about 7 months) remains better than 0.1% (at the exception of band Oa01) when averaged over the whole field of view (Figure 26) while the previous model, trained on a Radiometric Dataset limited to 27/08/2017, shows a strong drift of the model with respect to most recent data (Figure 27). Comparison of the two figures shows the improvement brought by the updated Model over almost all the mission: only Oa01 show a lower performance for the very first calibration with the new model.

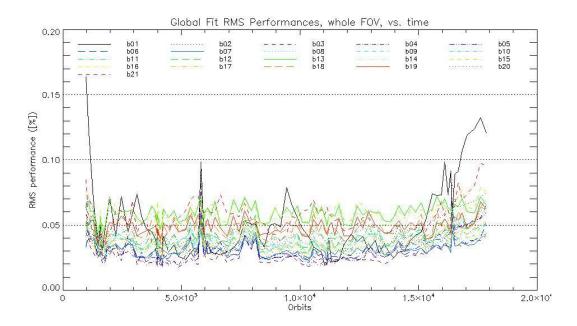


Figure 26: RMS performance of the OLCI-A Gain Model of the current processing baseline as a function of orbit.

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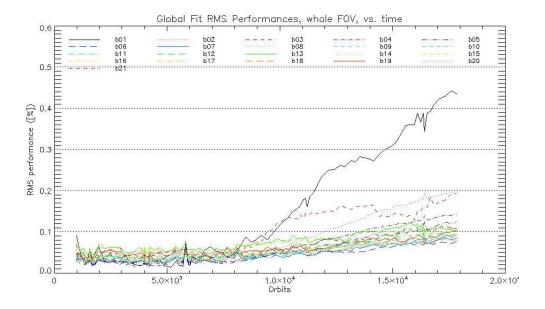


Figure 27: RMS performance of the OLCI-A Gain Model of the previous Processing Baseline as a function of orbit.

The overall instrument evolution since channel programming change (25/04/2016) is shown on Figure 28.

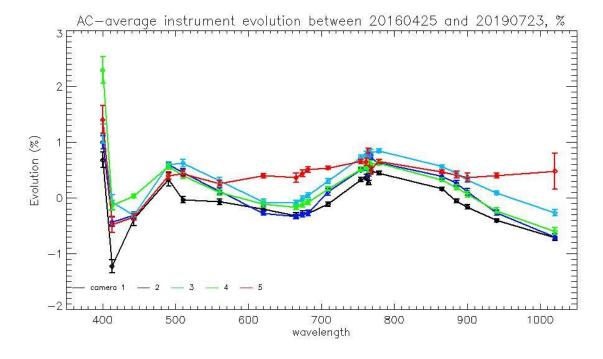


Figure 28: OLCI-A Camera-averaged instrument evolution since channel programming change (25/04/2016) and up to most recent calibration (23/07/2019) versus wavelength.



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The overall per camera performance, as a function of wavelength, and at each orbit is shown on Figure 29 as the average and standard deviation of the model over data ratio.

Finally, Figure 30 to Figure 32 show the detail of the model performance, with across-track plots of the model over data ratios at each orbit, one plot for each channel.

Comparisons of Figure 30 to Figure 32 with their counterparts in Report of Cycle 42 clearly demonstrate the improvement brought by the new model whatever the level of detail.

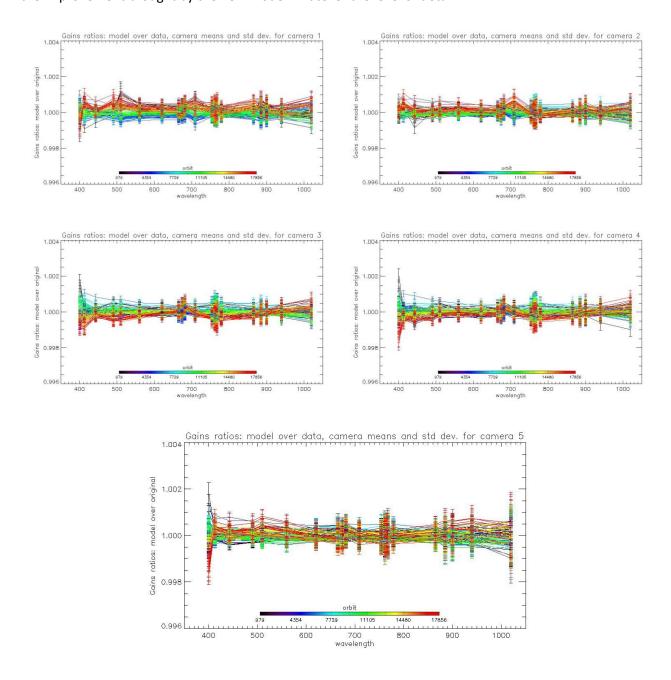


Figure 29: For the 5 cameras: OLCI-A Evolution model performance, as camera-average and standard deviation of ratio of Model over Data vs. wavelength, for each orbit of the test dataset, including 14 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent).

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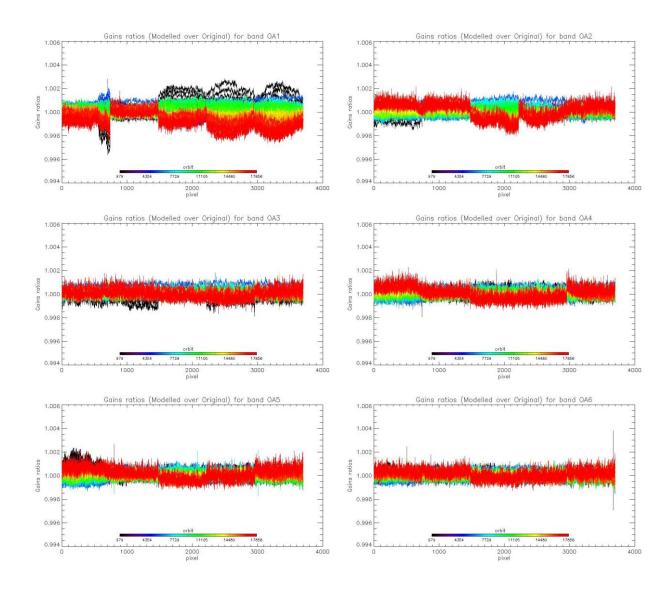


Figure 30: Evolution model performance, as ratio of Model over Data vs. pixels, all cameras side by side, over the whole current calibration dataset (since instrument programing update), including 14 calibrations in extrapolation, channels Oa1 to Oa6.

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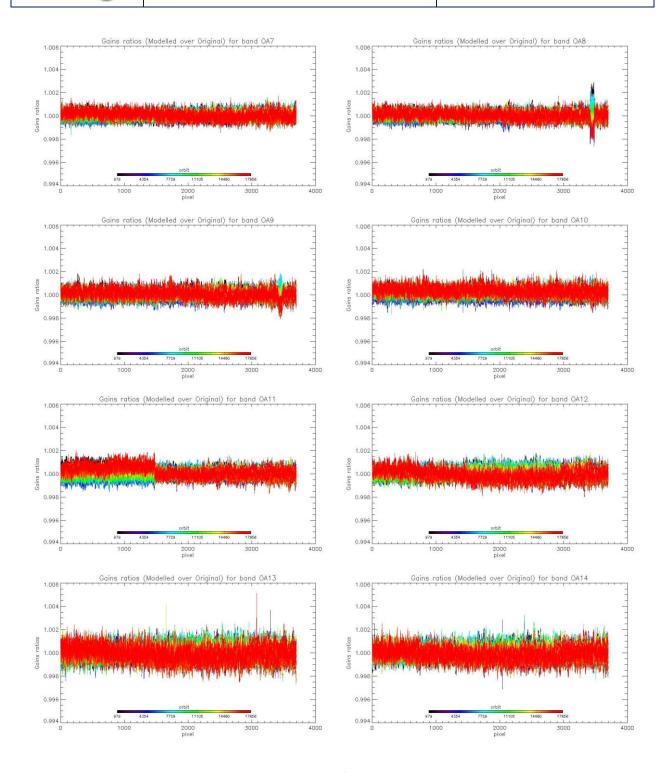


Figure 31: same as Figure 14 for channels Oa7 to Oa14.

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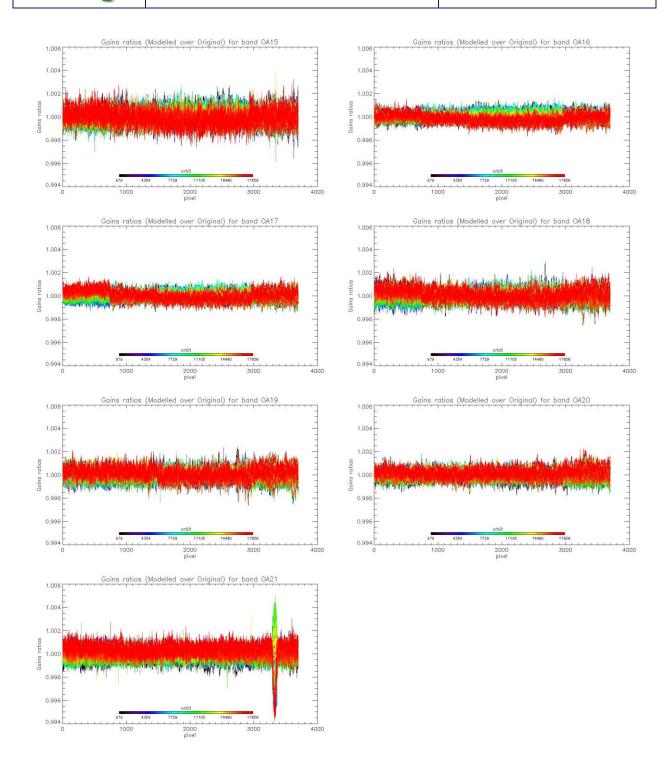


Figure 32: same as Figure 30 for channels Oa15 to Oa21.

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#### 2.2.2.2. OLCI-B

Instrument response and degradation modelling for OLCI-B, including the use of the in-flight BRDF model (based on 11<sup>th</sup> December 2018 Yaw Manoeuvres), has been deployed at PDGS on 11<sup>th</sup> April 2019 (Processing Baseline 1.20). The model performance over the complete dataset (including the 13 calibrations in extrapolation over about 6 months) is illustrated in Figure 33. It remains better than 0.15% when averaged over the whole field of view except for Oa01 which already shows a strong drift (0.47%).

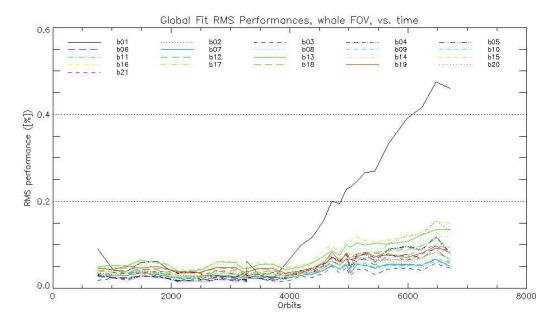


Figure 33: RMS performance of the OLCI-B Gain Model of the current processing baseline as a function of orbit

The overall instrument evolution since channel programming change (18/06/2018) is shown on Figure 28.

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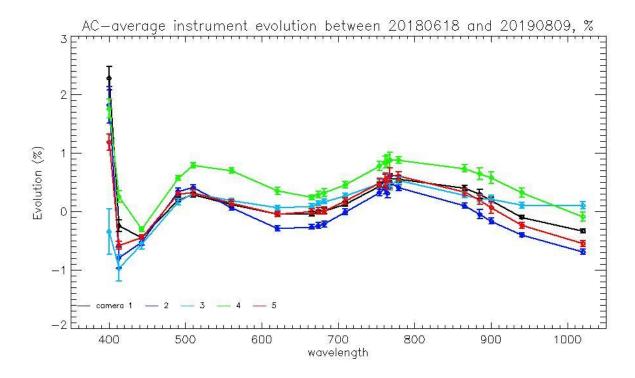


Figure 34: OLCI-B Camera-averaged instrument evolution since channel programming change (18/06/2018) and up to most recent calibration (09/08/2019) versus wavelength.

The overall per camera performance, as a function of wavelength, and at each orbit is shown on Figure 35 as the average and standard deviation of the model over data ratio.

Finally, Figure 36 to Figure 38 show the detail of the model performance, with across-track plots of the model over data ratios at each orbit, one plot for each channel.

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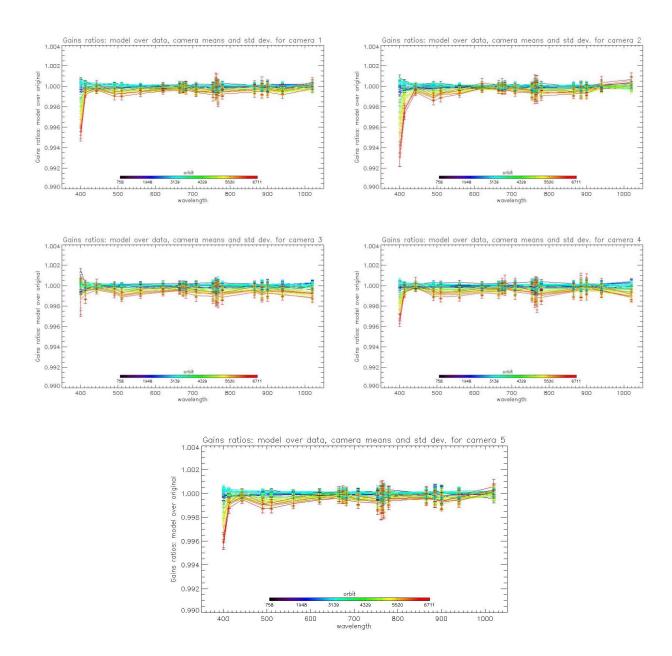


Figure 35: For the 5 cameras: OLCI-B Evolution model performance, as camera-average and standard deviation of ratio of Model over Data vs. wavelength, for each orbit of the test dataset, including 13 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent).

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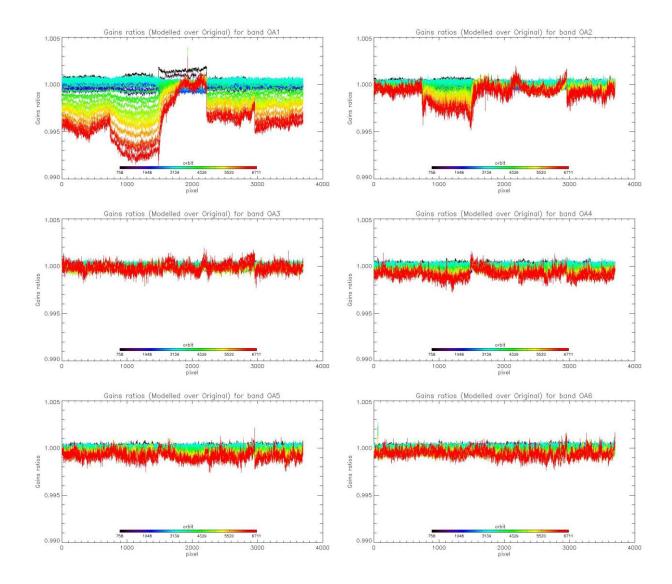


Figure 36: Evolution model performance, as ratio of Model over Data vs. pixels, all cameras side by side, over the whole current calibration dataset (since instrument programming update), including 13 calibrations in extrapolation, channels Oa1 to Oa6.

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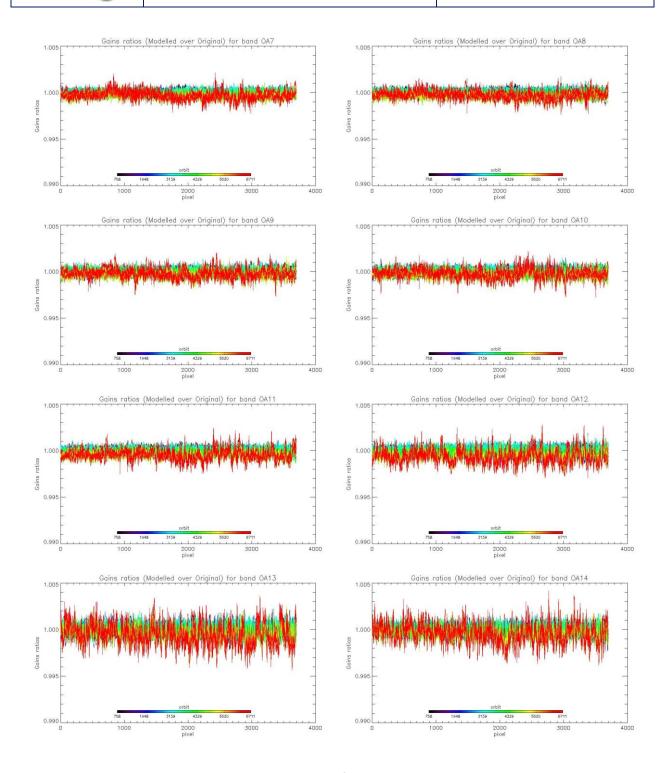


Figure 37: same as Figure 14 for channels Oa7 to Oa14.

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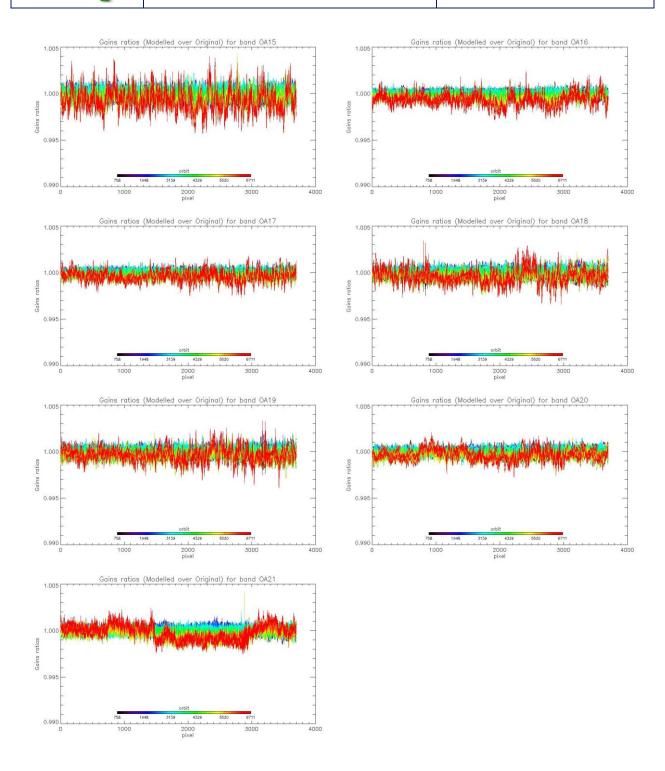


Figure 38: same as Figure 30 for channels Oa15 to Oa21.

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### 2.2.3 Ageing of nominal diffuser [OLCI-L1B-CV-240]

#### 2.2.3.1 OLCI-A

There has been one calibration sequence S05 (reference diffuser) for OLCI-A during acquisition cycle **047**:

\$05 sequence (diffuser 2) on 23/07/2019 02:14 to 02:15 (absolute orbit 17857)

With the associated S01 sequence in order to compute ageing:

S01 sequence (diffuser 1) on 23/07/2019 00:33 to 00:34 (absolute orbit 17856)

The diffuser 1 Ageing is computed for each 3700 detector and each spectral band by formula:

Ageing(orb)=G1(orb)/G2(orb)-G1(orb\_ref)/G2(orb\_ref)

#### Where:

- G1 is the diffuser 1 (= nominal diffuser) Gain coefficients
- G2 is the diffuser 2 (= reference diffuser) Gain coefficients
- orb\_ref is a reference orbit chosen at the beginning of the mission

Ageing is represented in Figure 39 for band Oa01 and in Figure 40 for band Oa17. The negative shift of the sequence at orbit 5832 (for which a slight increase would be expected instead) is not explained so far and still under investigation. It should be noted that the corresponding orbit of diffuser 1 (nominal) has also been detected as an outlier in the modelling of the radiometric long-term trend with an unexpected excess of brightness.

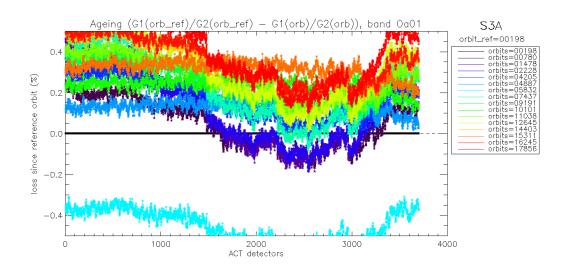


Figure 39: diffuser 1 ageing for spectral band Oa01. We see strong ACT low frequency structures that are due to residual of BRDF modelling.



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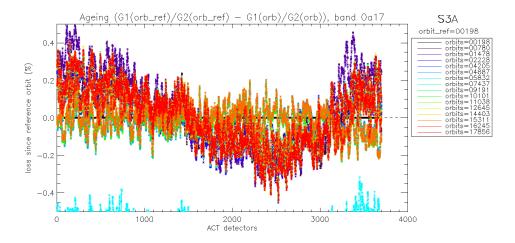


Figure 40: same as Figure 39 for spectral band Oa17. We use this band in order to normalize other bands and remove the ACT structures due to residual of BRDF modelling. Normalized curve for spectral band Oa01 is presented in Figure 41.

Figure 39 and Figure 40 show that the Ageing curves are impacted by a strong ACT pattern which is due to residuals of the bad modelling (on-ground) of the diffuser BRDF. This pattern is dependant of the azimuth angle. It is a 'white' pattern which means it is the same for all spectral bands. As such, we can remove this pattern by normalizing the ageing of all bands by the curve of band Oa17 which is expected not to be impacted by ageing because in the red part of the spectrum. We use an ACT smoothed version (window of 100 detectors) of band Oa17 in order to reduce the high frequency noise. Normalized ageing for spectral band Oa01 is represented in Figure 41 where we can see that this band is impacted by ageing of the diffuser.

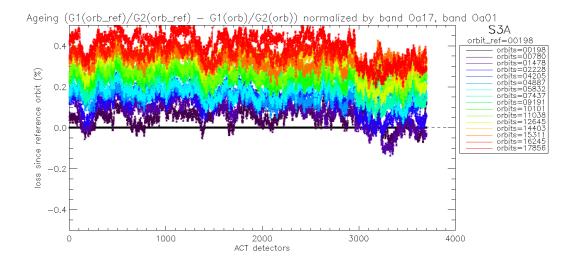


Figure 41: same as Figure 39 after normalization by band Oa17. Ageing of the diffuser 1 is now visible in the 5 cameras.



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Camera averaged ageing (normalized by band Oa17) as a function of wavelength is represented in Figure 42 where we can see that ageing is stronger in the 'bluest' spectral bands (short wavelengths). Ageing is clearly visible only for the 5 first spectral bands so far in the OLCI mission life.

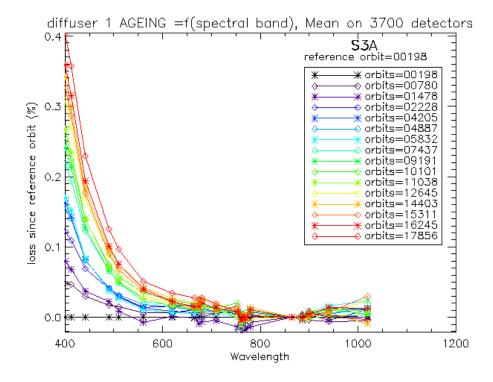


Figure 42: Diffuser 1 ageing as a function of wavelength (or spectral band). Ageing is clearly visible in spectral band #1 to #5.

Figure 43 shows the evolution, for spectral band Oa01, of the 5 cameras averaged ageing as a function of time.

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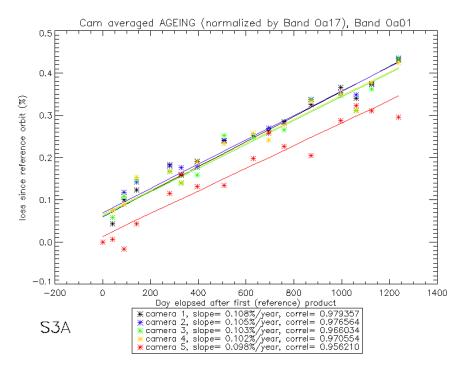


Figure 43: Camera averaged ageing for band Oa01 (normalized by band Oa17) as a function of elapsed time. Linear fit for each camera is plotted. The slope (% loss per year) and the correlation coefficient.

A model of diffuser ageing as a function of cumulated exposure time (i.e. number of acquisition sequence on nominal diffuser, regardless of the band setting) has been built and is described in Cyclic #23 Report. The results of this model confirm the need to model ageing against cumulated exposure rather than elapsed time, as it provides a more linear trend, even if not perfect (see Figure 21 of Cyclic #23 Report).

The slope of this ageing model (% of loss per exposure) as a function of wavelength is presented in Figure 44).

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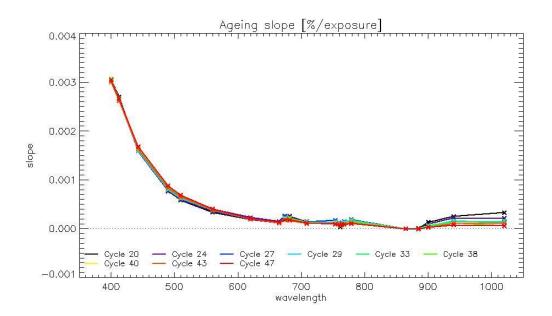


Figure 44: Slope of ageing fit (% of loss per exposure) vs wavelengths, using all the available ageing sequence at the time of the current cycle (red curve) and at the time of previous cycle for which an ageing sequence was measured (see legend within the figure).

In Figure 44, we see that the Ageing slopes have not significantly changed between the current Cycle and the last eight cycles with a S05 sequence (cycles #43, #40, #38, #33, #29, #27, #24 and #20). Cycle #27 has been used to derive the Ageing Correction model used for the currently operational Gain Model). The exposure time dependent ageing model is used to derive the Gain Model, the most recent version of which has been put in operations in PDGS on 11<sup>th</sup> April 2019.

#### 2.2.3.2 OLCI-B

There has been one calibration sequence S05 (reference diffuser) for OLCI-B during acquisition cycle 028:

S05 sequence (diffuser 2) on 23/07/2019 13:21 to 13:23 (absolute orbit 6470)

with the associated S01 sequence in order to compute ageing:

S01 sequence (diffuser 1) on 23/07/2019 11:40 to 11:42 (absolute orbit 6469)



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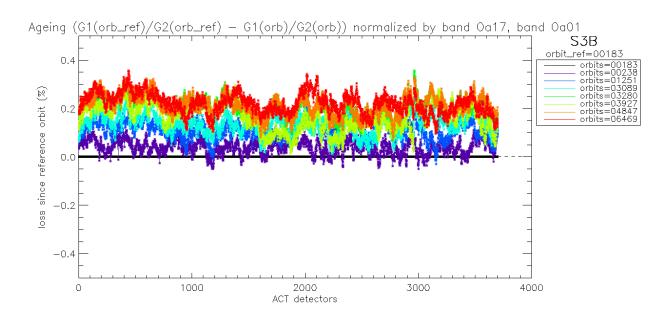


Figure 45: OLCI-B diffuser 1 ageing for spectral band Oa01 after normalisation by Oa17.

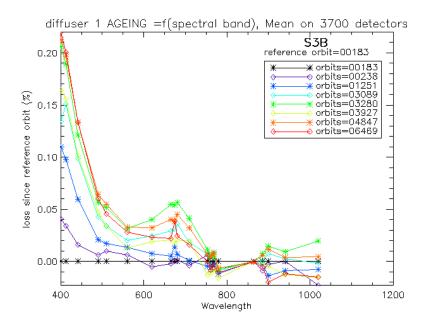


Figure 46: Diffuser 1 ageing as a function of wavelength (spectral bands).

As for OLCI-A, the ageing is clearly visible in spectral band Oa01 to Oa05. However, we see for OLCI-B a bump around 680 nm which is probably due to characterisation errors that are strongly geometry dependant and affect differently the various camera as shown in *Figure 47*. This behaviour is under investigation.

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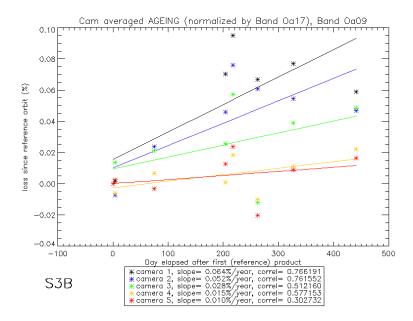


Figure 47: OLCI-B camera averaged ageing for band Oa09 (normalized by Oa17). Oa09 is 674 nm, that is in the bump of Error! Reference source not found. We see that only camera 1 and 2 contribute to this bump.

### 2.2.4 Updating of calibration ADF [OLCI-L1B-CV-260]

#### 2.2.4.1.1 OLCI-A

No CAL\_AX was delivered to PDGS during the reported period for OLCI-A.

#### 2.2.4.1.2 OLCI-B

No CAL\_AX was delivered to PDGS during the reported period for OLCI-B.

## 2.2.5 Radiometric Calibrations for sun azimuth angle dependency and Yaw Manoeuvres for Solar Diffuser on-orbit re-characterization [OLCI-L1B-CV-270 and OLCI-L1B-CV-280]

#### 2.2.5.1.1 OLCI-A

This activity has not evolved during cycle 047 and results presented in Cycle 15 report are still valid.

#### 2.2.5.1.2 OLCI-B

Activity has started for S3B-OLCI. The SAA domain explored is now increased by the acquisitions from the Yaw Manoeuvres and analysis becomes meaningful. Analysis is on-going.



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## 2.3 Spectral Calibration [OLCI-L1B-CV-400]

#### 2.3.1 OLCI-A

There has been no Spectral Calibration (S02 + S03) acquisition and no Spectral Calibration S09 for OLCI-A during the reporting period.

Consequently, the last results presented in Cyclic Report #46/#47 (S3A/S3B) remain valid.

#### 2.3.2 OLCI-B

There has been no Spectral Calibration (S02 + S03) acquisition and no Spectral Calibration S09 for OLCI-B during the reporting period.

Consequently, the last results presented in Cyclic Report #46/#47 (S3A/S3B) remain valid.

### 2.4 Signal to Noise assessment [OLCI-L1B-CV-620]

#### 2.4.1 SNR from Radiometric calibration data

#### 2.4.1.1 OLCI-A

SNR computed for all calibration data (S01, S04 and S05 sequences) as a function of band number is presented in Figure 48.

SNR computed for all calibration data as a function of orbit number for band Oa01 (the less stable band) is presented in Figure 49.

There is no significant evolution of this parameter during the current cycle and the ESA requirement is fulfilled for all bands.

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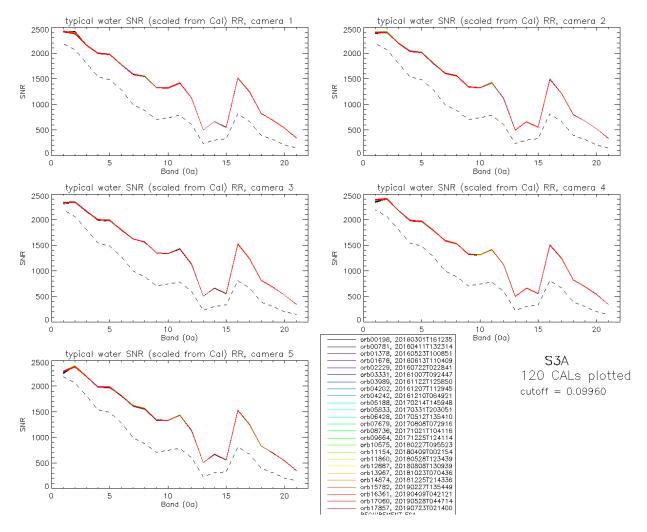


Figure 48: OLCI-A Signal to Noise ratio as a function of the spectral band for the 5 cameras. These results have been computed from radiometric calibration data. All calibrations except first one (orbit 183) are presents with the colours corresponding to the orbit number (see legend). The SNR is very stable with time: the curves for all orbits are almost superimposed. The dashed curve is the ESA requirement.

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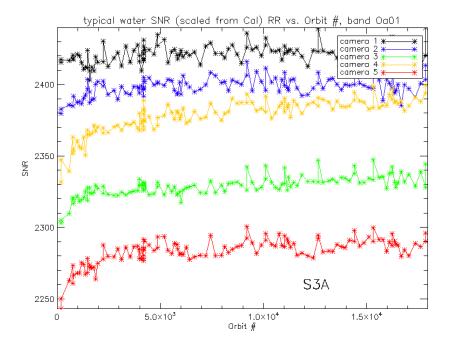


Figure 49: long-term stability of the SNR estimates from Calibration data, example of channel Oa1.

The mission averaged SNR figures are provided in Table 1 below, together with their radiance reference level. According to the OLCI SNR requirements, these figures are valid at these radiance levels and at Reduced Resolution (RR, 1.2 km). They can be scaled to other radiance levels assuming shot noise (CCD sensor noise) is the dominating term, i.e. radiometric noise can be considered Gaussian with its standard deviation varying as the square root of the signal; in other words:  $SNR(L) = SNR(L_{ref}) \cdot \sqrt{\frac{L}{L_{ref}}}$ . Following the same assumption, values at Full Resolution (300m) can be derived from RR ones as 4 times smaller.



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Table 1: OLCI-A SNR figures as derived from Radiometric Calibration data. Figures are given for each camera (time average and standard deviation), and for the whole instrument. The requirement and its reference radiance level are recalled (in mW.sr<sup>-1</sup>.m<sup>-2</sup>.nm<sup>-1</sup>).

|          | $L_{ref}$ | SNR  | C1   |     | C2   |     | C3   |     | C4   |      | C5   |     | А    | II  |
|----------|-----------|------|------|-----|------|-----|------|-----|------|------|------|-----|------|-----|
| nm       | LU        | RQT  | avg  | std | avg  | std | avg  | std | avg  | std  | avg  | std | avg  | std |
| 400.000  | 63.0      | 2188 | 2421 | 6.2 | 2398 | 6.7 | 2328 | 7.1 | 2378 | 11.8 | 2283 | 9.1 | 2362 | 7.0 |
| 412.000  | 74.1      | 2061 | 2391 | 8.6 | 2407 | 5.8 | 2340 | 4.8 | 2401 | 5.0  | 2383 | 8.1 | 2384 | 4.8 |
| 442.000  | 65.6      | 1811 | 2160 | 5.2 | 2198 | 5.7 | 2165 | 4.8 | 2185 | 4.1  | 2196 | 5.3 | 2181 | 3.6 |
| 490.000  | 51.2      | 1541 | 2001 | 4.7 | 2036 | 5.1 | 1997 | 4.1 | 1983 | 4.4  | 1988 | 4.8 | 2001 | 3.5 |
| 510.000  | 44.4      | 1488 | 1979 | 5.4 | 2014 | 4.8 | 1984 | 4.7 | 1966 | 4.5  | 1985 | 4.6 | 1986 | 3.7 |
| 560.000  | 31.5      | 1280 | 1776 | 4.6 | 1802 | 4.1 | 1802 | 4.9 | 1794 | 3.9  | 1818 | 3.4 | 1798 | 3.1 |
| 620.000  | 21.1      | 997  | 1591 | 4.1 | 1609 | 4.2 | 1624 | 3.3 | 1593 | 3.4  | 1615 | 3.6 | 1607 | 2.7 |
| 665.000  | 16.4      | 883  | 1546 | 4.2 | 1558 | 4.4 | 1566 | 3.9 | 1533 | 3.7  | 1561 | 4.0 | 1553 | 3.2 |
| 674.000  | 15.7      | 707  | 1329 | 3.5 | 1338 | 3.8 | 1350 | 2.8 | 1323 | 3.3  | 1342 | 3.6 | 1336 | 2.5 |
| 681.000  | 15.1      | 745  | 1319 | 3.7 | 1326 | 3.2 | 1338 | 2.7 | 1314 | 2.4  | 1333 | 3.6 | 1326 | 2.2 |
| 709.000  | 12.7      | 785  | 1420 | 4.5 | 1420 | 4.2 | 1435 | 3.4 | 1414 | 3.6  | 1430 | 3.1 | 1424 | 2.9 |
| 754.000  | 10.3      | 605  | 1127 | 3.2 | 1120 | 3.0 | 1135 | 3.5 | 1124 | 2.5  | 1139 | 3.0 | 1129 | 2.5 |
| 761.000  | 6.1       | 232  | 502  | 1.2 | 498  | 1.2 | 505  | 1.2 | 500  | 1.1  | 507  | 1.5 | 503  | 0.9 |
| 764.000  | 7.1       | 305  | 663  | 1.6 | 658  | 1.5 | 667  | 2.1 | 661  | 1.6  | 670  | 2.2 | 664  | 1.4 |
| 768.000  | 7.6       | 330  | 558  | 1.6 | 554  | 1.3 | 562  | 1.3 | 556  | 1.5  | 564  | 1.3 | 559  | 1.1 |
| 779.000  | 9.2       | 812  | 1515 | 5.0 | 1498 | 5.0 | 1525 | 5.3 | 1511 | 5.1  | 1526 | 5.1 | 1515 | 4.4 |
| 865.000  | 6.2       | 666  | 1244 | 3.6 | 1213 | 3.8 | 1238 | 4.0 | 1246 | 3.7  | 1250 | 2.9 | 1238 | 3.1 |
| 885.000  | 6.0       | 395  | 823  | 1.7 | 801  | 1.7 | 814  | 2.0 | 824  | 1.5  | 831  | 1.8 | 819  | 1.2 |
| 900.000  | 4.7       | 308  | 691  | 1.7 | 673  | 1.3 | 683  | 1.7 | 693  | 1.4  | 698  | 1.6 | 688  | 1.0 |
| 940.000  | 2.4       | 203  | 534  | 1.1 | 522  | 1.1 | 525  | 1.0 | 539  | 1.1  | 542  | 1.4 | 532  | 0.8 |
| 1020.000 | 3.9       | 152  | 345  | 0.9 | 337  | 0.9 | 348  | 0.7 | 345  | 0.9  | 351  | 0.8 | 345  | 0.5 |



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#### 2.4.1.2 OLCI-B

SNR computed for all OLCI-B calibration data (S01, S04 (but not the dark-only S04) and S05 sequences) as a function of band number is presented in Figure 50.

SNR computed for all OLCI-B calibration data as a function of orbit number for band Oa01 (the less stable band) is presented in Figure 51.

As for OLCI-A the SNR is very stable in time. There is no significant evolution of this parameter during the current cycle and the ESA requirement is fulfilled for all bands.

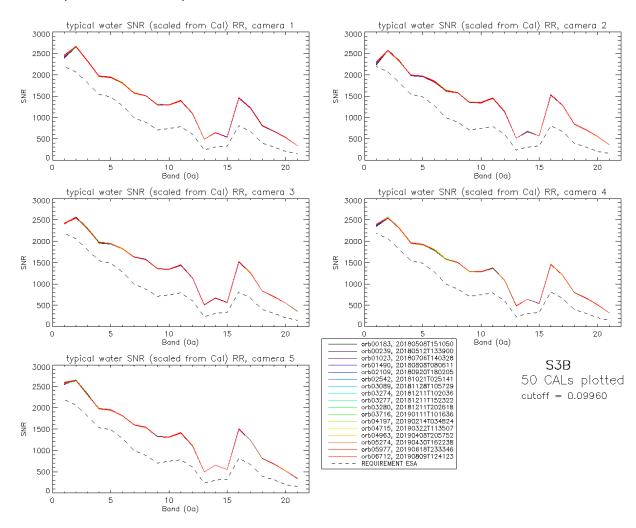


Figure 50: OLCI-B Signal to Noise ratio as a function of the spectral band for the 5 cameras. These results have been computed from radiometric calibration data. All calibrations except first one (orbit 167) are presents with the colours corresponding to the orbit number (see legend). The SNR is very stable with time: the curves for all orbits are almost superimposed. The dashed curve is the ESA requirement.

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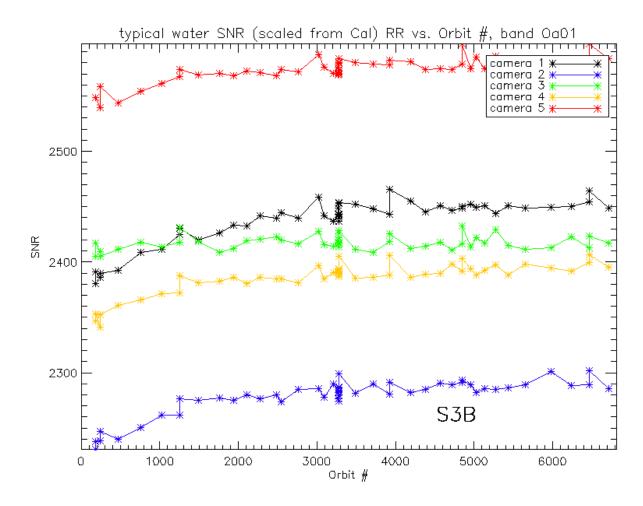


Figure 51: long-term stability of the OLCI-B SNR estimates from Calibration data, example of channel Oa1.



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Table 2: OLCI-B SNR figures as derived from Radiometric Calibration data. Figures are given for each camera (time average and standard deviation), and for the whole instrument. The requirement and its reference radiance level are recalled (in mW.sr<sup>-1</sup>.m<sup>-2</sup>.nm<sup>-1</sup>).

|          | $L_{ref}$ | SNR  | C1   |      | C2   |      | C3   |     | C4   |      | C5   |      | All  |      |
|----------|-----------|------|------|------|------|------|------|-----|------|------|------|------|------|------|
|          |           |      |      |      |      |      |      |     | 1    |      |      |      |      |      |
| nm       | LU        | RQT  | avg  | std  | avg  | std  | avg  | std | avg  | std  | avg  | std  | avg  | std  |
| 400.000  | 63.0      | 2188 | 2437 | 20.3 | 2278 | 16.3 | 2417 | 6.2 | 2385 | 14.4 | 2573 | 11.6 | 2418 | 12.8 |
| 412.000  | 74.1      | 2061 | 2655 | 6.5  | 2570 | 6.1  | 2550 | 8.2 | 2549 | 6.0  | 2641 | 7.0  | 2593 | 5.0  |
| 442.000  | 65.6      | 1811 | 2327 | 6.4  | 2318 | 6.3  | 2304 | 6.3 | 2307 | 6.2  | 2312 | 6.3  | 2314 | 5.3  |
| 490.000  | 51.2      | 1541 | 1965 | 4.9  | 1986 | 6.0  | 1971 | 5.4 | 1951 | 5.2  | 1978 | 5.0  | 1970 | 4.2  |
| 510.000  | 44.4      | 1488 | 1937 | 5.7  | 1964 | 5.3  | 1942 | 5.1 | 1921 | 4.6  | 1950 | 4.5  | 1943 | 4.0  |
| 560.000  | 31.5      | 1280 | 1812 | 5.1  | 1846 | 5.9  | 1828 | 4.7 | 1802 | 5.2  | 1816 | 4.8  | 1821 | 4.2  |
| 620.000  | 21.1      | 997  | 1572 | 4.6  | 1626 | 5.0  | 1625 | 3.8 | 1576 | 4.2  | 1601 | 3.4  | 1600 | 3.2  |
| 665.000  | 16.4      | 883  | 1512 | 4.2  | 1579 | 4.0  | 1573 | 4.2 | 1501 | 3.2  | 1546 | 4.1  | 1542 | 3.0  |
| 674.000  | 15.7      | 707  | 1301 | 4.0  | 1358 | 4.3  | 1353 | 3.6 | 1292 | 3.0  | 1328 | 3.2  | 1326 | 2.8  |
| 681.000  | 15.1      | 745  | 1292 | 3.5  | 1347 | 3.5  | 1343 | 3.1 | 1285 | 2.8  | 1316 | 3.0  | 1317 | 2.3  |
| 709.000  | 12.7      | 785  | 1389 | 4.4  | 1447 | 4.4  | 1442 | 4.8 | 1372 | 3.3  | 1412 | 4.2  | 1412 | 3.5  |
| 754.000  | 10.3      | 605  | 1094 | 4.3  | 1141 | 3.9  | 1141 | 4.1 | 1088 | 3.0  | 1114 | 4.0  | 1115 | 3.5  |
| 761.000  | 6.1       | 232  | 487  | 1.4  | 508  | 1.2  | 508  | 1.4 | 485  | 1.2  | 497  | 1.4  | 497  | 1.1  |
| 764.000  | 7.1       | 305  | 643  | 1.7  | 671  | 2.1  | 671  | 2.1 | 640  | 1.8  | 657  | 2.1  | 656  | 1.7  |
| 768.000  | 7.6       | 330  | 541  | 1.5  | 567  | 1.4  | 564  | 1.5 | 540  | 1.4  | 554  | 1.7  | 553  | 1.2  |
| 779.000  | 9.2       | 812  | 1465 | 4.6  | 1533 | 5.0  | 1524 | 6.3 | 1464 | 4.0  | 1504 | 5.0  | 1498 | 4.3  |
| 865.000  | 6.2       | 666  | 1220 | 4.0  | 1286 | 4.2  | 1257 | 4.3 | 1203 | 3.4  | 1237 | 3.3  | 1240 | 3.2  |
| 885.000  | 6.0       | 395  | 807  | 2.7  | 847  | 1.9  | 833  | 2.2 | 798  | 1.9  | 814  | 2.1  | 820  | 1.7  |
| 900.000  | 4.7       | 308  | 679  | 1.4  | 714  | 2.0  | 704  | 1.6 | 669  | 1.5  | 682  | 1.5  | 690  | 1.2  |
| 940.000  | 2.4       | 203  | 527  | 1.3  | 549  | 1.6  | 550  | 1.5 | 509  | 1.2  | 522  | 1.5  | 532  | 1.0  |
| 1020.000 | 3.9       | 152  | 336  | 0.8  | 359  | 1.2  | 358  | 0.9 | 318  | 0.8  | 339  | 1.2  | 342  | 8.0  |



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#### 2.4.2 SNR from EO data

#### 2.4.2.1 OLCI-A

There has been no update on SNR assessment from EO data during the cycle. Last figures (cycle 9) are considered valid.

#### 2.4.2.2 OLCI-B

The SNR assessment from EO data has not been applied to OLCI-B considering a) that SNR estimates from RC data have been proved more reliable for OLCI-A and b) that it requires a significant amount of human and machine resources that can be more efficiently used for other tasks.

### 2.5 Geometric Calibration/Validation

#### 2.5.1 OLCI-A

#### 2.5.1.1 Global performance

The good performance of OLCI-A georeferencing since the introduction of the upgraded Geometric Calibration on 14/03/2018 is confirmed. The following figures show time series of the overall RMS performance (requirement criterion) and of the across-track and along-track biases for each camera. The performance improvement on the 14/03/2018 is obvious on each figure, the most dramatic improvements affecting along-track bias of Camera 3 (Figure 55) and across-track biases of Cameras 4 and 5 (Figure 56 & Figure 57, respectively). Compliance is comfortably met since then (Figure 52): RMS values remain around 0.3 pixel and all biases below 0.2 pixel from 14/03 on, except for the along-track bias of camera 3 for which a small drift can be noticed, implying a performance slightly below -0.2 pixel since a few weeks (Figure 55, right).

It can be seen that the peak RMS value on 14/08/2018 is associated to a very low number of GCPs: only 345 (out of scale on Figure 52) and can be considered as an outlier. The same remark applies to the AC and AL biases displayed in Figure 53 to Figure 57.



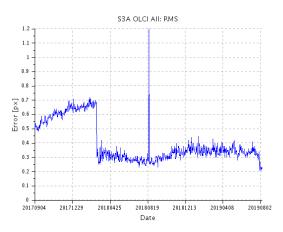
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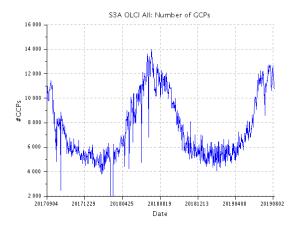
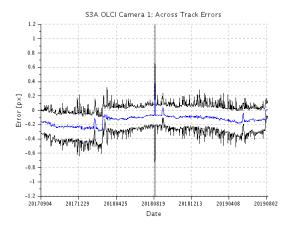


Figure 52: overall OLCI-A georeferencing RMS performance time series (left) and number of validated control points corresponding to the performance time series (right) over the whole monitoring period



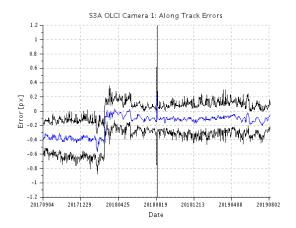
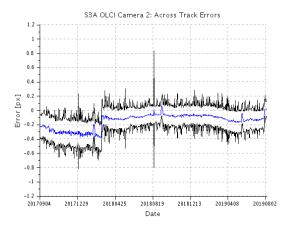


Figure 53: across-track (left) and along-track (right) georeferencing biases time series for Camera 1.



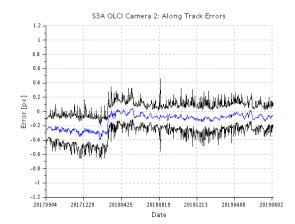


Figure 54: same as Figure 53 for Camera 2.



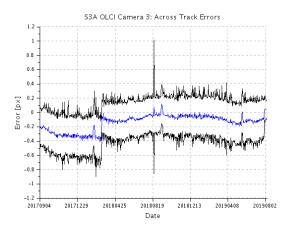
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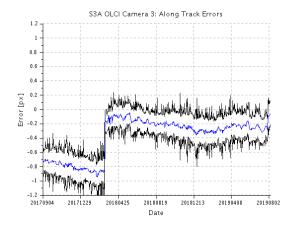
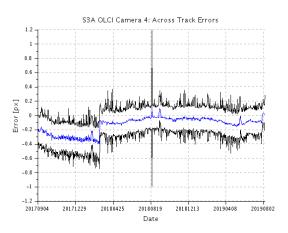


Figure 55: : same as Figure 53 for Camera 3.



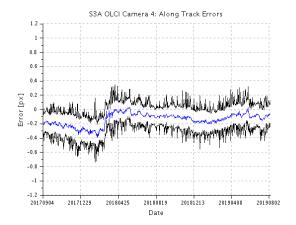
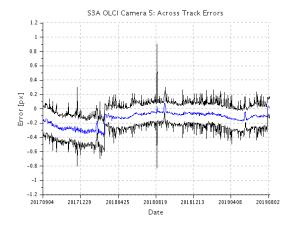


Figure 56: : same as Figure 53 for Camera 4.



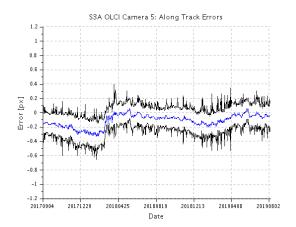


Figure 57: : same as Figure 53 for Camera 5.



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#### 2.5.1.2 Cross-FOV analysis

An update of the geometric monitoring tools and procedures now allows to analyse the performance at a more detailed level and in particular with respect to the across-track position (in instrument grid).

This allowed to identify optical distortion implying a variation of the georeferencing performance across the field-of view. An example is provided below for the 5<sup>th</sup> of May 2019 (Figure 58). It shows that the performance remains generally correct for all pixels, except at the edge of camera 2 where it exceeds 0.5 pixel in absolute value. It also shows that the variation of the biases are in the same direction for all cameras, implying a maximum misregistration at the cameras interface.

Re-calibration of the instrument pixels pointing vectors (IPPVM) to correct this issue has been done and put in production since 30/07/2019, improvement on the coregistration performance at camera interfaces can be seen at the very end of the time series of Figure 59.

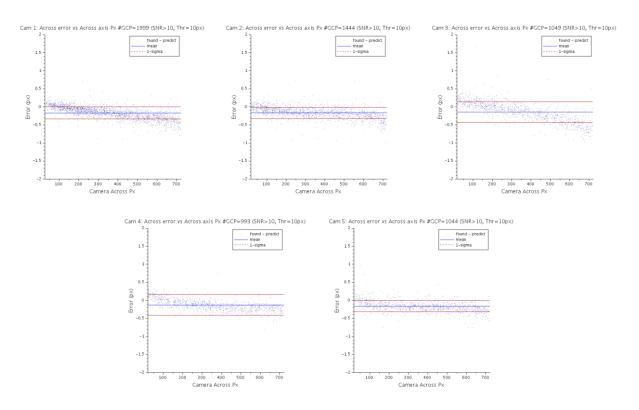


Figure 58: OLCI-A across-track georeferencing error (pixels) as a function of instrument spatial pixel for each camera (1 to 5 from left to right and top to bottom), example of 5/5/2019.

A long-term monitoring has been put in place and, considering the behaviour highlighted above, puts emphasis, on the one hand on the differences at the camera interfaces, and on the other hand on the maximum misregistration within each camera. Values are roughly stable with time.

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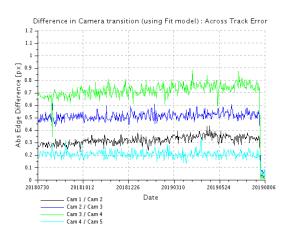
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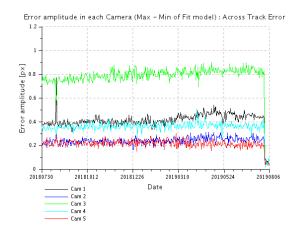


Figure 59: OLCI-A spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left).

#### 2.5.2 OLCI-B

#### 2.5.2.1 Global performance

The performance of OLCI-B georeferencing is within requirements since the introduction of the 3<sup>rd</sup> Geometric Calibration on 12/12/2018 (instrument to platform alignment correction terms). In addition, a new Geometric Calibration has been put in production on the 30/07/2019, this time addressing the pixels pointing vectors (IPPVMs, see section 2.5.2.2) further improving the pointing performance. The following figures show time series of the overall RMS performance (requirement criterion) and of the across-track and along-track biases for each camera. The performance of across-track pointing is excellent over the whole mission. The along-track performance, showing initially significant drifts for all cameras is well corrected with the latest instrument/platform Calibration (12/12/18). Since the recent upgrade of the IPPVMs the georeferencing performance is further improved for all indicators (global RMS or per camera across-track and along-track biases), together with a significant reduction of their variability, as the upgrade of the pixels pointing vectors provides a more homogeneous performance across the instrument field of view.



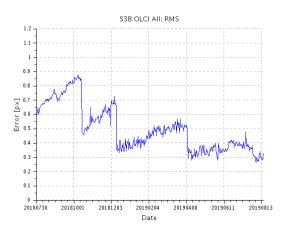
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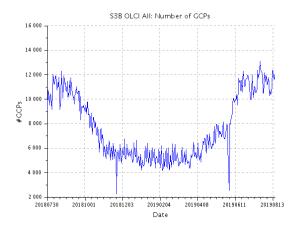
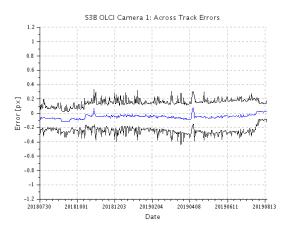


Figure 60: overall OLCI-B georeferencing RMS performance time series (left) and number of validated control points corresponding to the performance time series (right) over the whole monitoring period



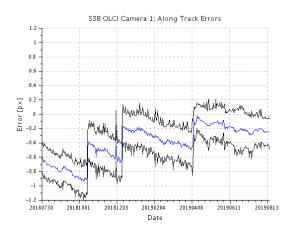
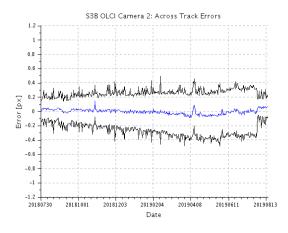


Figure 61: across-track (left) and along-track (right) georeferencing biases time series for Camera 1.



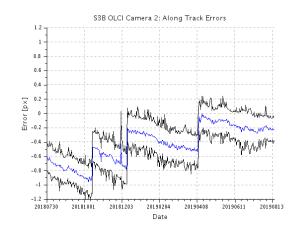


Figure 62: same as Figure 61 for Camera 2.



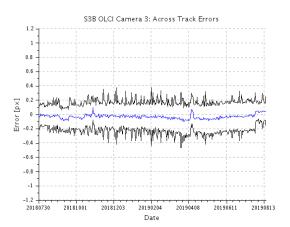
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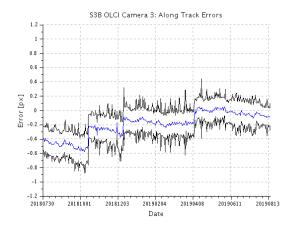
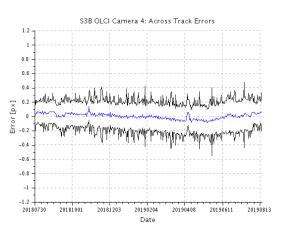


Figure 63: same as Figure 61 for Camera 3.



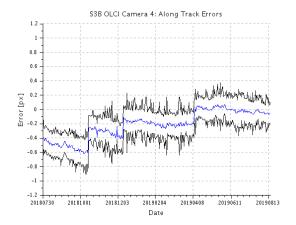
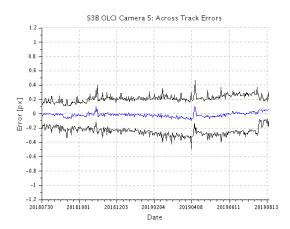


Figure 64: same as Figure 61 for Camera 4.



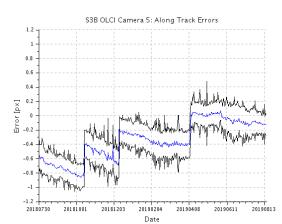


Figure 65: same as Figure 61 for Camera 5.

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#### 2.5.2.2 Cross-FOV analysis

The same cross-FOV performance analysis as described for OLCI-A has been applied to OLCI-B. It highlighted even larger optical distortion implying a variation of the georeferencing performance across the field-of view. The same example (5<sup>th</sup> of May 2019) is shown on Figure 66. It shows higher variations that for OLCI-A, with biases exceed 0.5 pixel at edges of cameras 1 2 and 3, and a significantly non-linear cross-FOV variation inside camera 1. As for OLCI-A the general trends of the biases variations are in the same direction for all cameras, implying a maximum misregistration at the cameras interface.

Re-calibration of the instrument pixels pointing vectors (IPPVM) to correct this issue has been done and put in production since 30/07/2019, improvement on the coregistration performance at camera interfaces can be seen at the very end of the time series of Figure 67.

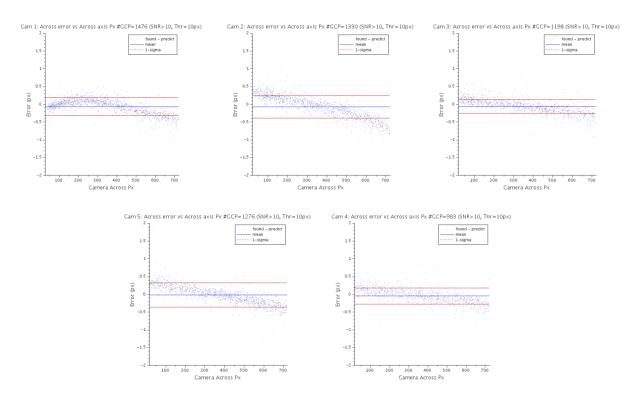


Figure 66: OLCI-B across-track georeferencing error (pixels) as a function of instrument spatial pixel for each camera (1 to 5 from left to right and top to bottom), example of 5/5/2019.



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The same long-term monitoring has been put in place and, considering the behaviour highlighted above, puts emphasis, on the one hand on the differences at the camera interfaces, and on the other hand on the maximum misregistration within each camera (Figure 67). Misregistration before the IPPVM correction reached up to 1 pixel, both at transitions and within a given camera while the performance wince the introduction of the upgraded Pointing Vectors is around 0.1 pixel (0.2 at transition between cameras 1 and 2). In the OLCI-B case, the values are not stable in time: the performance is not independent of the platform to instrument alignment correction recalibrated more frequently.

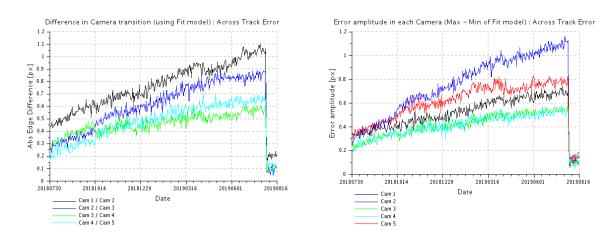


Figure 67: OLCI-B spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left).

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## 3 OLCI Level 1 Product validation

## 3.1 [OLCI-L1B-CV-300], [OLCI-L1B-CV-310] - Radiometric Validation

#### 3.1.1 S3ETRAC Service

#### **Activities done**

The S3ETRAC service extracts OLCI L1 RR and SLSTR L1 RBT data and computes associated statistics over 49 sites corresponding to different surface types (desert, snow, ocean maximizing Rayleigh signal, ocean maximizing sunglint scattering and deep convective clouds). The S3ETRAC products are used for the assessment and monitoring of the L1 radiometry (optical channels) by the ESLs.

All details about the S3ETRAC/OLCI and S3ETRAC/SLSTR statistics are provided on the S3ETRAC website <a href="http://s3etrac.acri.fr/index.php?action=generalstatistics">http://s3etrac.acri.fr/index.php?action=generalstatistics</a>

- Number of OLCI products processed by the S3ETRAC service
- Statistics per type of target (DESERT, SNOW, RAYLEIGH, SUNGLINT and DCC)
- Statistics per sites
- Statistics on the number of records

For illustration, we provide below statistics on the number of S3ETRAC/OLCI records generated per type of targets (DESERT, SNOW, RAYLEIGH, SUNGLINT and DCC) for both OLCI-A (Figure 68) and OLCI-B (Figure 69).

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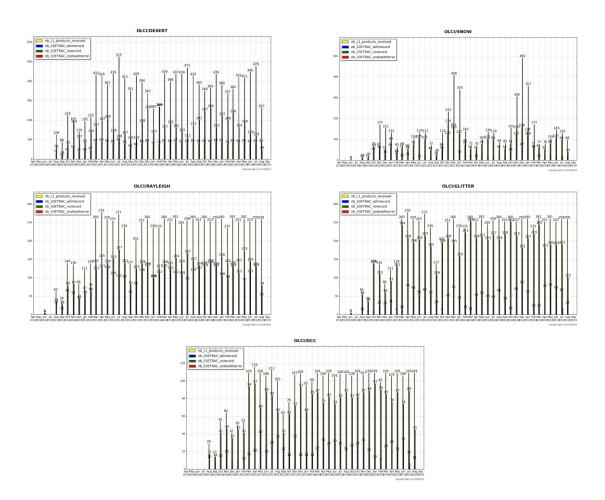


Figure 68: summary of S3ETRAC products generation for OLCI-A

(number of OLCI-A L1 products Ingested, yellow – number of S3ETRAC extracted products generated, blue –
number of S3ETRAC runs without generation of output product (data not meeting selection requirements), green
– number of runs ending in error, red, one plot per site type).

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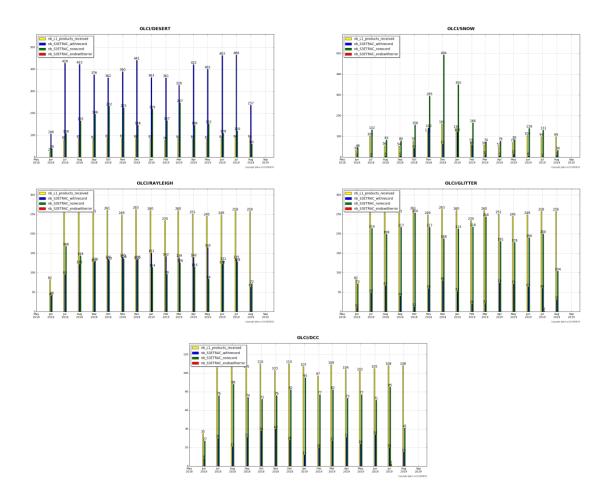


Figure 69: summary of S3ETRAC products generation for OLCI-B

(number of OLCI-B L1 products Ingested, yellow – number of S3ETRAC extracted products generated, blue – number of S3ETRAC runs without generation of output product (data not meeting selection requirements), green – number of runs ending in error, red, one plot per site type).

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### 3.1.2 Radiometric validation with DIMITRI

### Highlights

S3A/OLCI and S3B/OLCI L1B radiometry verification as follow:

- The verification is performed until the 15<sup>th</sup> of August 2019.
- All OLCI-A and OLCI-B results over Rayleigh, Glint and PICS are consistent with the previous cycle over the used CalVal sites.
- Good stability of both sensors could be observed; the time-series averages show slightly higher reflectance for OLCI-A.
- Bands with high gaseous absorption are excluded.

#### **I-Validation over PICS**

- 1. Ingestion of all the available L1B-LN1-NT products in the S3A-Opt database over the 6 desert calvalsites (Algeria3 & 5, Libya 1 & 4 and Mauritania 1 & 2) has been performed until the 15<sup>th</sup> of August 2019.
- 2. The results are consistent over all the six used PICS sites (Figure 70 & Figure 71). Both sensors show a good stability over the analysed period.
- 3. The temporal average over the period January 2019 present of the elementary ratios (observed reflectance to the simulated one) for OLCI-A shows gain values within 2-4% over all the VNIR bands (Figure 72). Unlikely, the temporal average over the same period of the elementary ratios (observed reflectance to the simulated one) for OLCI-B shows values within 2% (mission requirement) over the whole spectral range (Figure 72).
- 4. The spectral bands with significant absorption from water vapour and O<sub>2</sub> (Oa11, Oa13, Oa14 and Oa15) are excluded.

# Sentine 3 Mission Performance Centre

# **Sentinel-3 MPC**

# **S3 OLCI Cyclic Performance Report**

**S3A Cycle No. 047 – S3B Cycle No. 028** 

Ref.: S3MPC.ACR.PR.01-047-028

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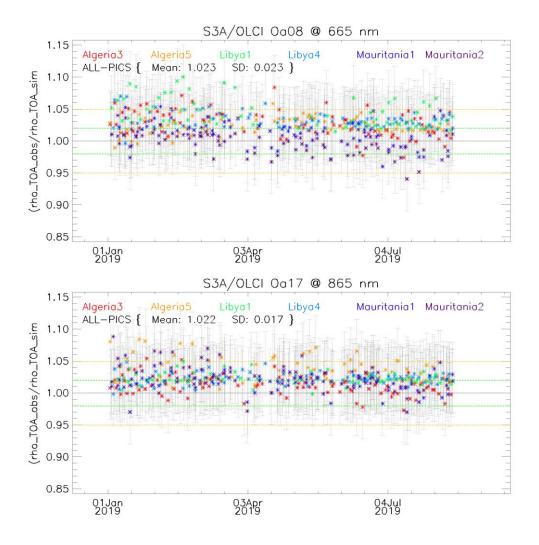


Figure 70: Time-series of the elementary ratios (observed/simulated) signal from S3A/OLCI for (top to bottom) bands Oa08 and Oa17 respectively over January 2019 - Present from the six PICS Cal/Val sites. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the desert methodology uncertainty.

# **Sentinel-3 MPC**

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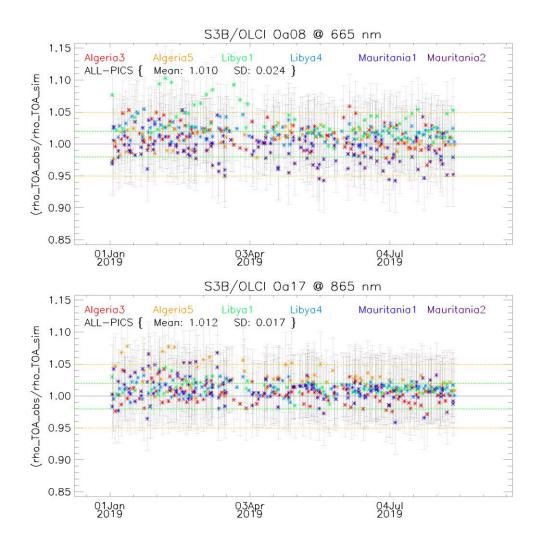


Figure 71: Same as Figure 70 for OLCI-B.

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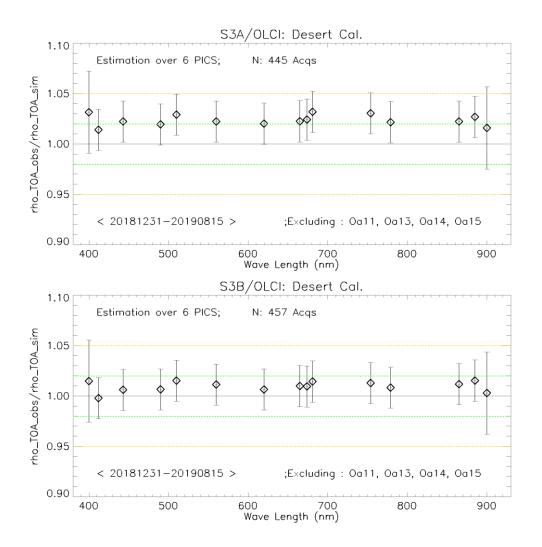


Figure 72: The estimated gain values for OLCI-A (top) and OLCI-B (bottom) from the 6 PICS sites identified by CEOS over the period January 2019 – present as a function of wavelength. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the desert methodology uncertainty.

#### **II- Cross-mission Intercomparison over PICS**

X-mission Intercomparison with MODIS-A and MSI-A has been performed until February and April 2019 respectively.

Figure 73 shows time-series of the elementary ratios from S2A/MSI, Aqua/MODIS and S3A/OLCI and S3B/OLCI over the LYBIA4 site over the period April-2016 until February and April 2019 respectively. We observe a clear stability over the three sensors, associated with higher reflectance from OLCI-A wrt to MSI-A and MODISA. MODISA shows higher fluctuation wrt to MSI-A and OLCI-A/B ones.

Figure 74 shows the estimated gain over different time-series for different sensors MSI-A, MSI-B, OLCI-A, OLCI-B and MODIS-A) over PICS. The spectral bands with significant absorption from water vapour and O2 are excluded. OLCI-A seems to have higher gain wrt the other sensors, which means that OLCI-A has brighter reflectance than its simulated one by PICS method.

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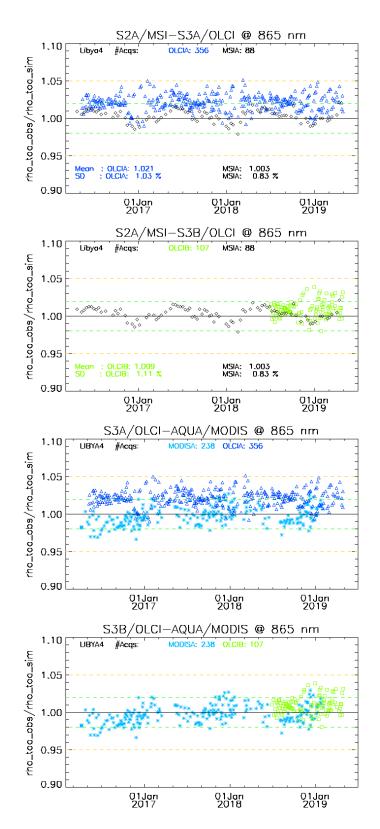


Figure 73: Time-series of the elementary ratios (observed/simulated) signal from (black) S2A/MSI, (blue) S3A/OLCI, (green) S3B/OLCI and (Cyan) Aqua/MODIS for band Oa17 (865nm) over the LIBYA4 site. Dashed-green and orange lines indicate the 2% and 5% respectively. The systematic and total uncertainties of the desert methodology are 1% and 5% respectively.

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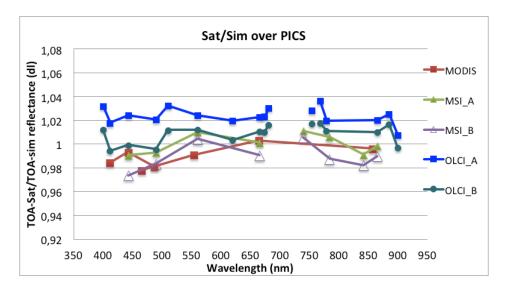


Figure 74: Ratio of observed TOA reflectance to simulated one for (green) S2A/MSI, (purple) S2B/MSI, (red)
Aqua/MODIS, (blue) S3A/OLCI and (dark-green) S3B/OLCI averaged over the six PICS test sites as a function of wavelength.

# **III-Validation over Rayleigh**

Rayleigh method has been performed over the available mini-files on the Opt-server from November 2018 to present for OLCI-A and OLCI-B. The results are produced with the configuration (ROI-AVERAGE). The gain coefficients of OLCI-A are consistent with the previous results. Bands Oa01-Oa05 display biases values between 5%-7% while bands Oa6-Oa9 exhibit biases between 2%-3%, higher than the 2% mission requirements (Figure 75). The gain coefficients of OLCI-B are lower than OLCI-A ones, where bands Oa01-Oa05 display biases values about 3-5%, when bands Oa6-Oa9 exhibit biases better than 2%, the mission requirement (Figure 75).

### **IV-Validation over Glint and synthesis**

Glint calibration method with the configuration (ROI-PIXEL) has been performed over the period November 2018-present for OLCI-A and OLCI-B. The outcome of this analysis shows a good consistency with the desert outputs over the NIR spectral range Oa06-Oa09 for both sensors. Glint results show that the VNIR bands are within 2% (mission requirement), except Oa21 which show biases of ~5% (see Figure 75). Again, the glint gains from OLCI-B look slightly lower than OLCI-A one.

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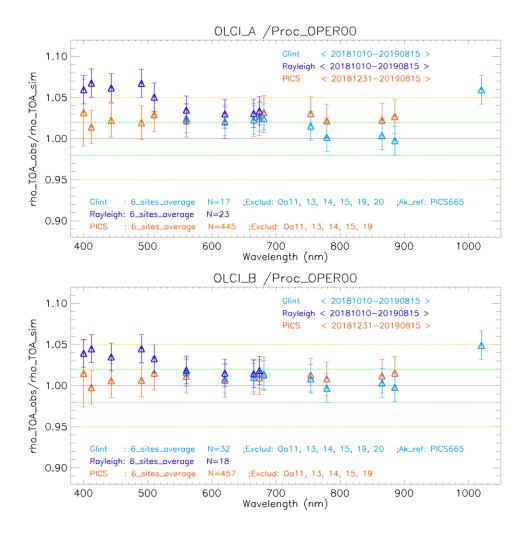


Figure 75: The estimated gain values for OLCI-A and OLCI-B from Glint, Rayleigh and PICS methods over the period November 2018-Present as a function of wavelength. We use the gain value of Oa8 from PICS-Desert method as reference gain for Glint method. Dashed-green and orange lines indicate the 2% and 5% respectively.

Error bars indicate the method uncertainties.

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# 3.1.3 Radiometric validation with OSCAR

The OSCAR Rayleigh have been applied to the S3A and S3B S3ETRAC data from the 6 oceanic calibration sites listed in Table 3.

Table 3. S3ETRAC Rayleigh Calibration sites

| Site Name | Ocean                 | North<br>Latitude | South<br>Latitude | East<br>Longitude | West<br>Longitude |
|-----------|-----------------------|-------------------|-------------------|-------------------|-------------------|
| PacSE     | South-East of Pacific | -20.7             | -44.9             | -89               | -130.2            |
| PacNW     | North-West of Pacific | 22.7              | 10                | 165.6             | 139.5             |
| PacN      | North of Pacific      | 23.5              | 15                | 200.6             | 179.4             |
| AtIN      | North of Atlantic     | 27                | 17                | -44.2             | -62.5             |
| AtIS      | South of Atlantic     | -9.9              | -19.9             | -11               | -32.3             |
| IndS      | South of Indian       | -21.2             | -29.9             | 100.1             | 89.5              |

The weighted average OSCAR S3A and S3B Rayleigh results for July 2019 and the standard deviation calibration are shown below (Figure 76 and Table 4). In the spectral bands for which the Rayleigh calibration method is applicable (i.e. from Oa1 till Oa12). S3A seems to be significantly brighter than S3B, by about 0.3% to 2.2%, with largest differences observed in Blue bands. It should be noted however than S3-A results for July 2019 show unusually high dispersion (Table 4).

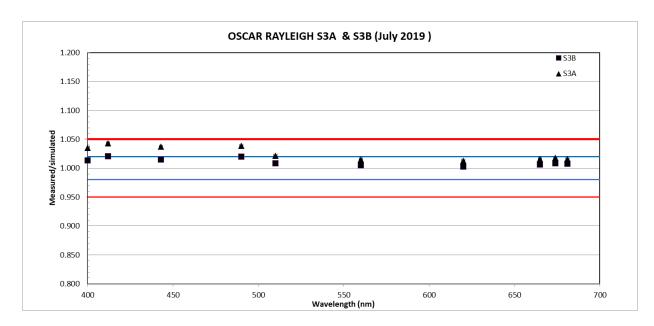


Figure 76: OSCAR Rayleigh S3A and S3B Calibration results: weighted average from July 2019.

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Table 4. OSCAR Rayleigh S3A and S3B results for July 2019.

| OLCI | Wavelength | Oscar Rayleigh S3A | July 2019 | Oscar Rayleigh S3B July 2019 |       |  |
|------|------------|--------------------|-----------|------------------------------|-------|--|
| band | (nm)       | Weight. Average    | stdev     | Weight. Average              | stdev |  |
| Oa01 | 400        | 1.035              | 0.033     | 1.013                        | 0.021 |  |
| Oa02 | 412        | 1.043              | 0.032     | 1.021                        | 0.020 |  |
| Oa03 | 443        | 1.037              | 0.036     | 1.015                        | 0.018 |  |
| Oa04 | 490        | 1.038              | 0.044     | 1.020                        | 0.013 |  |
| Oa05 | 510        | 1.021              | 0.043     | 1.008                        | 0.010 |  |
| Oa06 | 560        | 1.015              | 0.052     | 1.005                        | 0.011 |  |
| Oa07 | 620        | 1.013              | 0.066     | 1.003                        | 0.012 |  |
| Oa08 | 665        | 1.016              | 0.076     | 1.006                        | 0.013 |  |
| Oa09 | 674        | 1.018              | 0.078     | 1.009                        | 0.013 |  |
| Oa10 | 681        | 1.015              | 0.079     | 1.007                        | 0.013 |  |
| Oa11 | 709        | 1.001              | 0.080     | 0.996                        | 0.014 |  |
| Oa12 | 754        | 1.010              | 0.088     | 1.007                        | 0.013 |  |
| Oa13 | 761.25     | NA                 | NA        | NA                           | NA    |  |
| Oa14 | 764.375    | NA                 | NA        | NA                           | NA    |  |
| Oa15 | 767.5      | NA                 | NA        | NA                           | NA    |  |
| Oa16 | 778.75     | NA                 | NA        | NA                           | NA    |  |
| Oa17 | 865        | NA                 | NA        | NA                           | NA    |  |
| Oa18 | 885        | NA                 | NA        | NA                           | NA    |  |
| Oa19 | 900        | NA                 | NA        | NA                           | NA    |  |
| Oa20 | 940        | NA                 | NA        | NA                           | NA    |  |
| Oa21 | 1020       | NA                 | NA        | NA                           | NA    |  |

<sup>\*</sup>OSCAR Rayleigh results for band Oa01 have to be considered with care due to larger uncertainty in the radiative transfer calculation

# 3.2 [OLCI-L1B-CV-320] - Radiometric Validation with Level 3 products

# 3.2.1 OLCI-A

There has been no new result during the cycle. Last figures (cycle 20) are considered valid.

# 3.2.2 OLCI-B

This activity has not started for OLCI-B.

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# 4 Level 2 Land products validation

# 4.1 [OLCI-L2LRF-CV-300]

#### 4.1.1 Routine extractions

#### 4.1.1.1 OLCI-A

- The focus for this time period has been on the rolling archive Non Time Critical (NT) data until the 25<sup>th</sup> of July 2019. More data available for statistical analysis as a concatenation procedure for all available data in the MERMAID processing has been implemented.
- Concatenated time series of OLCI Global Vegetation Index and OLCI Terrestrial Chlorophyll Index have been regenerated on the current rolling archive availability including previous extractions since April 2016. The time series therefore represent spring, summer and fall season.

Figure 77 to Figure 86 below present the CoreLand Sites OLCI time series over the current OLCI-A mission.

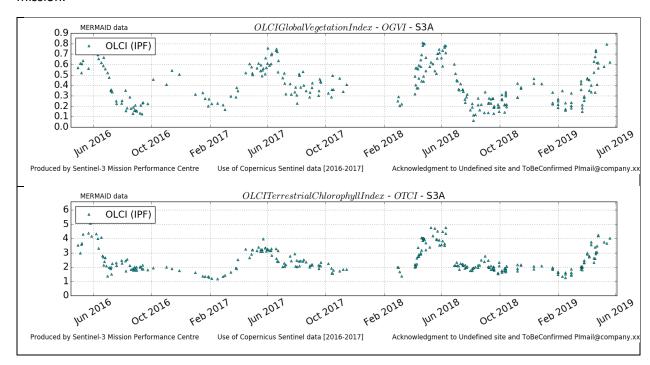


Figure 77: DeGeb time series over current report period

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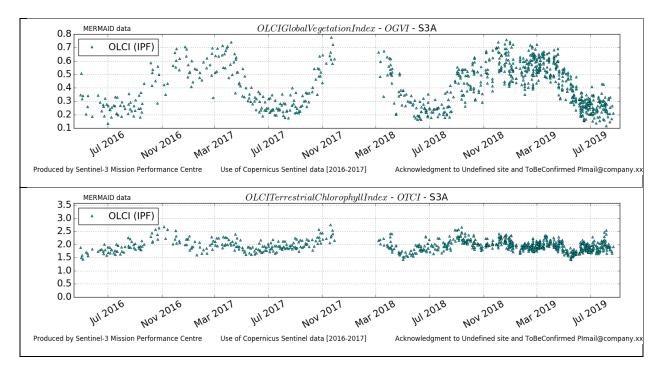


Figure 78: ITCat time series over current report period

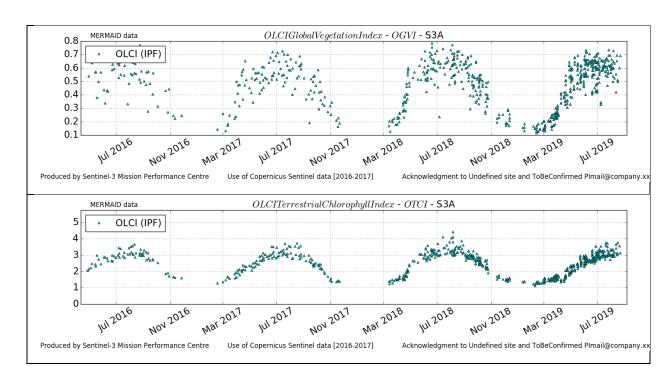


Figure 79: ITsp time series over current report period

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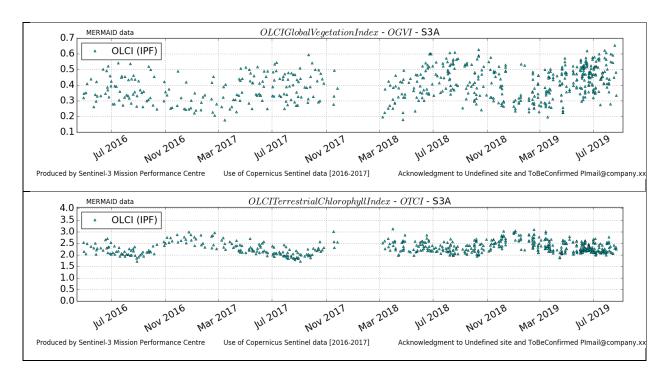


Figure 80: ITSro time series over current report period

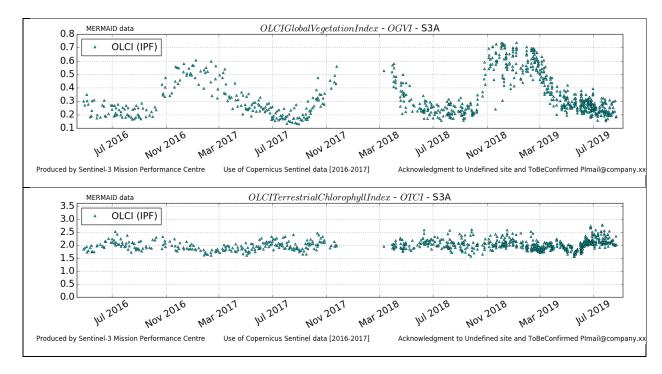


Figure 81: ITTra time series over current report period

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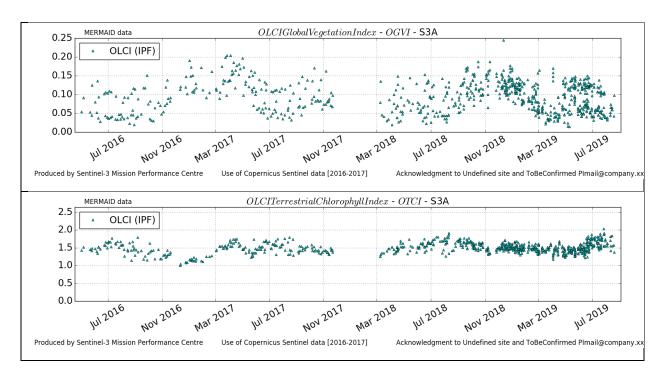


Figure 82: SPAli time series over current report period

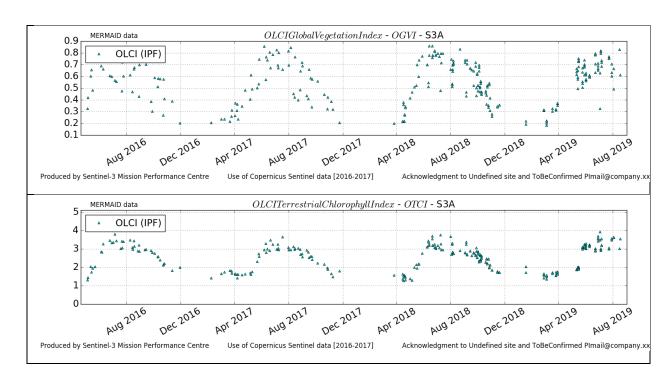


Figure 83: UKNFo time series over current report period

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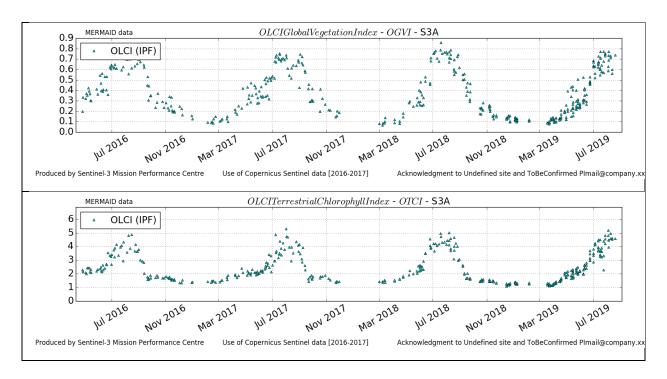


Figure 84: USNe1 time series over current report period

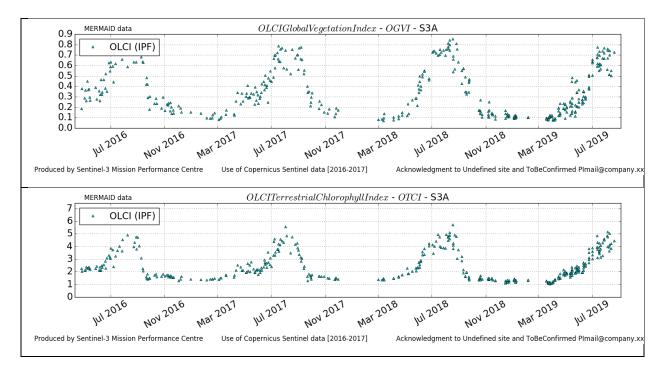


Figure 85: USNe2 time series over current report period

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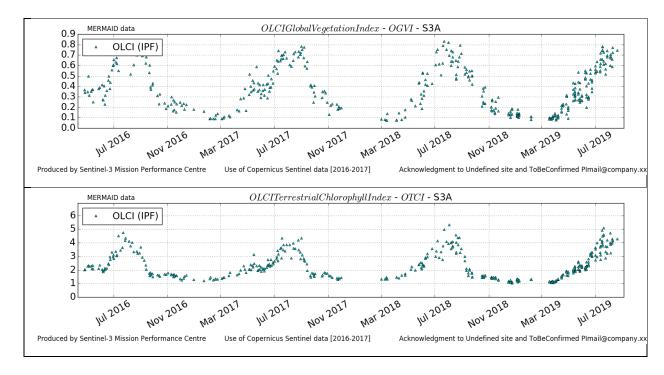


Figure 86: USNe3 time series over current report period

### 4.1.1.2 OLCI-B

Figure 87 to Figure 96 below present the CoreLand Sites OLCI S3-B time series over the current reprocessing period.

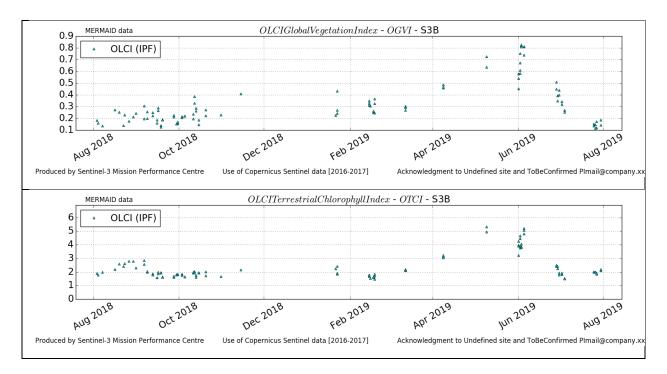


Figure 87: DeGeb time series over current report period

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#### Sentinel-3 MPC

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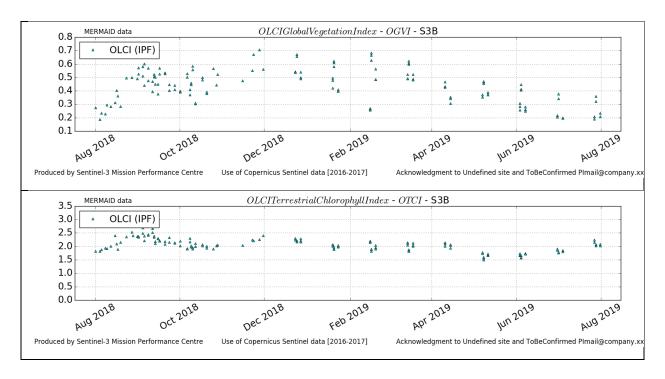


Figure 88: ITCat time series over current report period

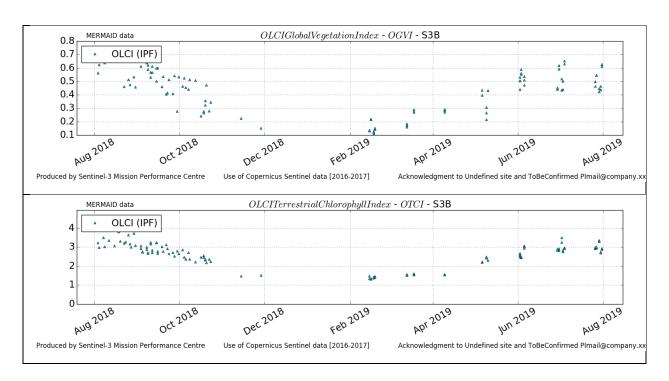


Figure 89: ITsp time series over current report period

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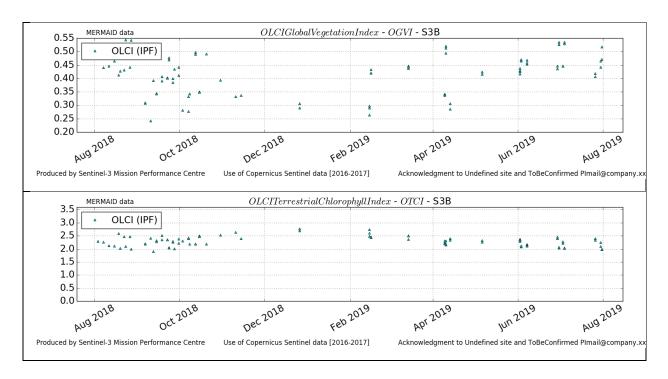


Figure 90: ITSro time series over current report period

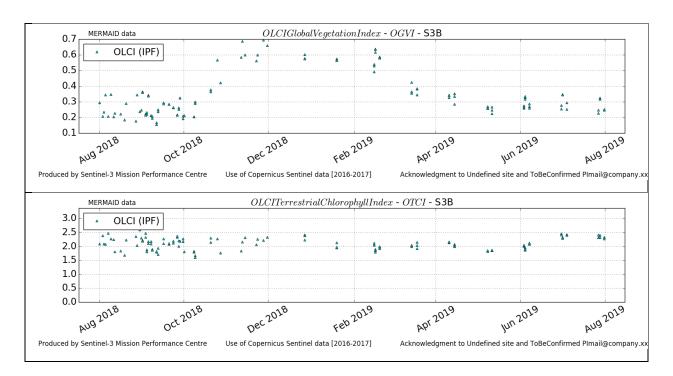


Figure 91: ITTra time series over current report period

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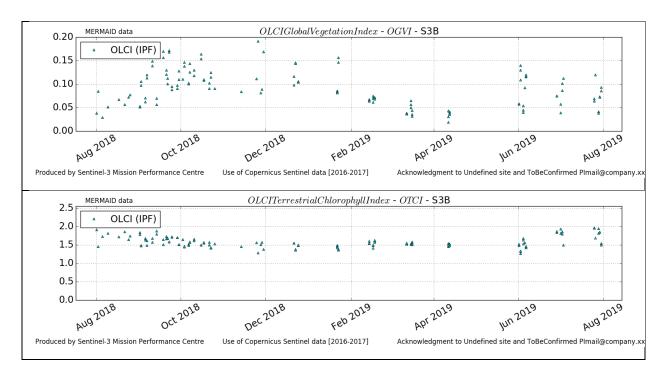


Figure 92: SPAli time series over current report period

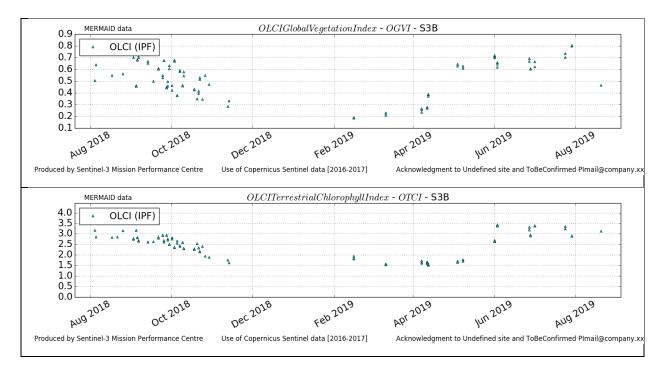


Figure 93: UKNFo time series over current report period

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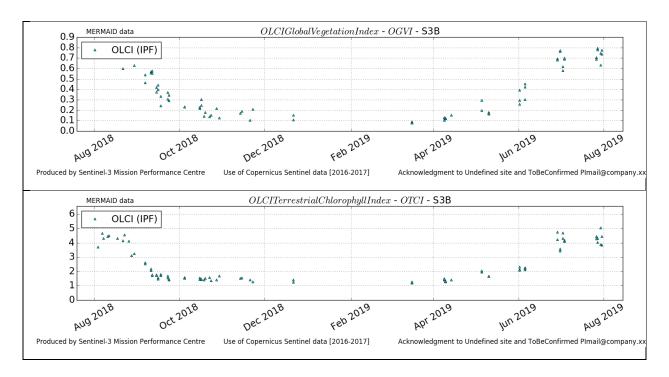


Figure 94: USNe1 time series over current report period

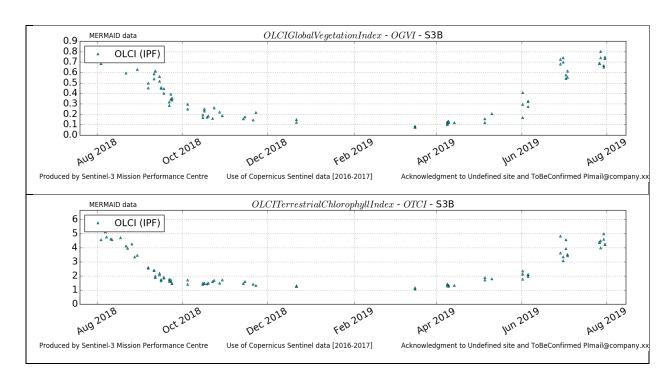


Figure 95: USNe2 time series over current report period



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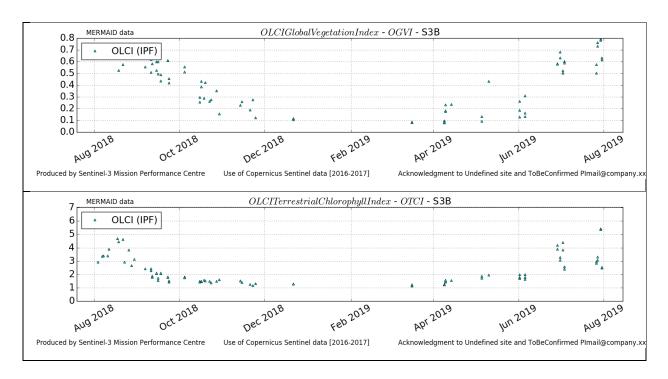


Figure 96: USNe3 time series over current report period

### 4.1.2 Comparisons with MERIS MGVI and MTCI climatology

#### **Assessment**

This section presents the comparison between land products of S3A/B and MERIS archive data (also referred to as MERIS climatology) for the period between 13 June 2019 and 16 August 2019. Notice this report includes data from S3A cycles 46 and 47 and S3B cycles 27 and 28. The evaluation of the S3 products' performance was conducted on 32 validation sites scattered across the globe that include a variety of land cover types (Table 5). Pixel profiles of MERIS and S3 products are obtained over the validation sites on a 3x3 pixel window to account for sensors' geometric imprecisions. These temporal pixel profiles are then aggregated to a monthly time step. Overall, S3 products follow the climatology trend. Figure 97 shows that over the last cycles the products reached climax of greenness and now start to decline; consistent with the seasonal trend at BE-Brasschaat, Belgium, land cover Needle-leaved, evergreen. Table 6 summarises the agreement statistics for the rest of the validation sites. In general, there is consistency between S3A/B products and climatology. The bias is consistent with that observed in previous cycles i.e. slightly negative bias for OTCI and slightly positive bias for OGVI. Greater coefficient of determination (R<sup>2</sup>) and lower normalised squared difference (NRMSD) is observed for S3A data as compared to S3B. Figure 98 shows the monthly mean of all S3A available data against the MERIS climatology for 53 sites. Note that depending on latitude and climate, some sites may have missing data in winter. When all data are pooled together the bias is in accordance with what is observed at individual site level (i.e. negative bias for OTCI and negative bias for OGVI). Bias is more evident at higher values of deciduous and evergreen forests (Figure 98).

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# Table 5: Validation sites included in report S3A 46-47/S3B 27-28. Land cover data from GLC2000.

| Acronym             | Contry         | Network                          | Lat     | Lon Landcover GLC2000                  |
|---------------------|----------------|----------------------------------|---------|--|
| BE-Brasschaat       | Belgium        | ICOS                             | 51.308  | 4.520 Needle-leaved, evergreen         |
| DE-Hones-Holz       | Deutschland    | ICOS                             | 52.085  | 11.222 Broadleaved, deciduous, closed  |
| FR-Montiers         | France         | ICOS                             | 48.538  | 5.312 Broadleaved, deciduous, closed   |
| US-Mountain-Lake    | United States  | NEON, AERONET                    | 37.378  | -80.525 Broadleaved, deciduous, closed |
| US-Smithsonian      | United States  | NEON, AERONET                    | 38.893  | -78.140 Broadleaved, deciduous, closed |
| IT-Collelongo       | Italy          | EFDC                             | 41.849  | 13.588 Broadleaved, deciduous, closed  |
| US-Harvard          | United States  | NEON, AERONET                    | 42.537  | -72.173 Broadleaved, deciduous, closed |
| FR-Hesse            | France         | ICOS                             | 48.674  | 7.065 Broadleaved, deciduous, closed   |
| US-Oak-Rige         | United States  | NEON, AERONET                    | 35.964  | -84.283 Broadleaved, deciduous, closed |
| AU-Great-Western    | Australia      | TERN-SuperSites, AusCover/OzFlux | -30.192 | 120.654 Broadleaved, deciduous, open   |
| DE-Haininch         | Deutschland    | ICOS Associated                  | 51.079  | 10.453 Broadleaved, deciduous, closed  |
| AU-Litchfield       | Australia      | TERN-SuperSites, AusCover/OzFlux | -13.180 | 130.790 Broadleaved, evergreen         |
| BE-Vielsalm         | Belgium        | ICOS                             | 50.305  | 5.998 Needle-leaved, evergreen         |
| AU-Tumbarumba       | Australia      | TERN-SuperSites, AusCover/OzFlux | -35.657 | 148.152 Broadleaved, evergreen         |
| IT-Lison            | Italy          | ICOS                             | 45.740  | 12.750 Cropland                        |
| US-Steigerwarldt    | United States  | NEON                             | 45.509  | -89.586 Broadleaved, deciduous, closed |
| DE-Tharandt         | Deutschland    | ICOS                             | 50.964  | 13.567 Needle-leaved, evergreen        |
| US-Bartlett         | United States  | NEON, AERONET                    | 44.064  | -71.287 Broadleaved, deciduous, closed |
| CR-Santa-Rosa       | Costa Rica     | ENVIRONET                        | 10.842  | -85.616 Broadleaved, evergreen         |
| US-Talladega        | United States  | NEON, AERONET                    | 32.950  | -87.393 Needle-leaved, evergreen       |
| NE-Loobos           | Netherlands    | ICOS Associated                  | 52.166  | 5.744 Needle-leaved, evergreen         |
| AU-Robson-Creek     | Australia      | TERN-SuperSites, AusCover/OzFlux | -17.117 | 145.630 Broadleaved, evergreen         |
| FR-Estrees-Mons     | France         | ICOS Associated                  | 49.872  | 3.021 Cultivated and managed areas     |
| UK-Wytham-Woods     | United Kingdom | ForestGeo - NPL                  | 51.774  | -1.338 Broadleaved, deciduous, closed  |
| FR-Aurade           | France         | ICOS                             | 43.550  | 1.106 Cropland                         |
| CZ-Bili-Kriz        | Czechia        | ICOS                             | 49.502  | 18.537 Needle-leaved, evergreen        |
| BR-Mata-Seca        | Brazil         | ENVIRONET                        | -14.880 | -43.973 Herbaceous, closed-open        |
| AU-Cape-Tribulation | Australia      | TERN-SuperSites, OzFlux          | -16.106 | 145.378 Broadleaved, evergreen         |
| US-Jornada          | United States  | LTER                             | 32.591  | -106.843 Shrub, closed-open, deciduous |
| US-Central-Plains   | United States  | NEON, AERONET                    | 40.816  | -104.746 Shrub, closed-open, deciduous |
| FR-Puechabon        | France         | ICOS                             | 43.741  | 3.596 Needle-leaved, evergreen         |
| CA-Mer-Bleue        | Canada         | National Capitol Comission       | 45.400  | -75.493 Peatland                       |

# **Sentinel-3 MPC**

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Table 6: Comparison statistics between monthly S3A/B OLCI land products and MERIS archive data.

| Site                |      |            |       | 3A   |            |      |      | S3B        |       |                |       |       |  |
|---------------------|------|------------|-------|------|------------|------|------|------------|-------|----------------|-------|-------|--|
| Acronym             |      | OTCI vs MT | a     |      | OGVI vs MG | SVI  |      | OTCI vs MT | a     | OGVI vs MGVI   |       |       |  |
| Acronym             | R²   | NRMSD      | Bias  | R²   | NRMSD      | Bias | R²   | NRMSD      | Bias  | R <sup>2</sup> | NRMSD | Bias  |  |
| BE-Brasschaat       | 0.99 | 0.03       | -0.10 | 0.95 | 0.08       | 0.05 | 0.91 | 0.08       | -0.18 | 0.76           | 0.16  | 0.01  |  |
| DE-Hones-Holz       | 0.99 | 0.05       | 0.01  | 0.99 | 0.05       | 0.04 | 0.86 | 0.16       | -0.22 | 0.92           | 0.12  | -0.01 |  |
| FR-Montiers         | 0.99 | 0.05       | -0.05 | 0.97 | 0.08       | 0.07 | 0.97 | 0.07       | -0.06 | 0.93           | 0.15  | 0.05  |  |
| US-Mountain-Lake    | 0.99 | 0.03       | -0.38 | 0.98 | 0.08       | 0.00 | 0.96 | 0.07       | -0.57 | 0.97           | 0.08  | -0.01 |  |
| US-Smithsonian      | 0.99 | 0.04       | -0.27 | 0.98 | 0.07       | 0.03 | 0.98 | 0.06       | -0.16 | 0.97           | 0.12  | -0.01 |  |
| IT-Collelongo       | 0.98 | 0.06       | -0.01 | 0.95 | 0.14       | 0.01 | 0.72 | 0.25       | -0.09 | 0.84           | 0.27  | 0.00  |  |
| US-Harvard          | 0.98 | 0.04       | -0.11 | 0.97 | 0.09       | 0.05 | 0.94 | 0.07       | -0.14 | 0.91           | 0.16  | 0.00  |  |
| FR-Hesse            | 0.98 | 0.05       | 0.01  | 0.98 | 0.06       | 0.05 | 0.91 | 0.11       | -0.03 | 0.97           | 0.08  | 0.02  |  |
| US-Oak-Rige         | 0.98 | 0.06       | -0.04 | 0.98 | 0.07       | 0.04 | 0.98 | 0.05       | -0.16 | 0.92           | 0.14  | 0.02  |  |
| AU-Great-Western    | 0.97 | 0.02       | 0.11  | 0.89 | 0.10       | 0.05 | 0.92 | 0.02       | 0.11  | 0.69           | 0.10  | 0.03  |  |
| DE-Haininch         | 0.97 | 0.09       | -0.05 | 0.97 | 0.13       | 0.08 | 0.89 | 0.18       | -0.17 | 0.94           | 0.15  | 0.07  |  |
| AU-Litchfield       | 0.97 | 0.02       | -0.01 | 0.83 | 0.12       | 0.04 | 0.89 | 0.04       | 0.05  | 0.65           | 0.12  | 0.02  |  |
| BE-Vielsalm         | 0.97 | 0.03       | -0.03 | 0.87 | 0.11       | 0.11 | 0.99 | 0.02       | -0.16 | 0.98           | 0.06  | 0.10  |  |
| AU-Tumbarumba       | 0.96 | 0.03       | 0.31  | 0.55 | 0.06       | 0.12 | 0.90 | 0.04       | 0.24  | 0.04           | 0.16  | 0.07  |  |
| IT-Lison            | 0.95 | 0.05       | -0.06 | 0.94 | 0.10       | 0.07 | 0.89 | 0.05       | -0.12 | 0.86           | 0.16  | 0.06  |  |
| US-Steigerwarldt    | 0.95 | 0.06       | 0.16  | 0.99 | 0.05       | 0.01 | 0.78 | 0.12       | -0.02 | 0.99           | 0.05  | 0.00  |  |
| DE-Tharandt         | 0.95 | 0.05       | -0.01 | 0.94 | 0.12       | 0.07 | 0.92 | 0.07       | -0.25 | 0.98           | 0.06  | 0.08  |  |
| US-Bartlett         | 0.94 | 0.05       | 0.03  | 0.97 | 0.10       | 0.05 | 0.87 | 0.09       | 0.03  | 0.86           | 0.22  | 0.01  |  |
| CR-Santa-Rosa       | 0.93 | 0.07       | 0.01  | 0.68 | 0.20       | 0.10 | 0.85 | 0.12       | -0.12 | 0.78           | 0.16  | 0.03  |  |
| US-Talladega        | 0.93 | 0.03       | -0.08 | 0.97 | 0.05       | 0.07 | 0.87 | 0.05       | -0.22 | 0.92           | 0.13  | 0.08  |  |
| NE-Loobos           | 0.92 | 0.04       | -0.04 | 0.90 | 0.10       | 0.05 | 0.67 | 0.05       | -0.01 | 0.83           | 0.13  | 0.04  |  |
| AU-Robson-Creek     | 0.92 | 0.03       | -0.09 | 0.64 | 0.11       | 0.10 | 0.70 | 0.06       | -0.15 | 0.28           | 0.13  | 0.10  |  |
| FR-Estrees-Mons     | 0.91 | 0.09       | 0.00  | 0.83 | 0.14       | 0.06 | 0.89 | 0.11       | 0.05  | 0.91           | 0.11  | 0.05  |  |
| UK-Wytham-Woods     | 0.91 | 0.09       | 0.17  | 0.88 | 0.12       | 0.09 | 0.83 | 0.09       | 0.01  | 0.84           | 0.19  | 0.07  |  |
| FR-Aurade           | 0.90 | 0.08       | 0.14  | 0.87 | 0.16       | 0.14 | 0.79 | 0.10       | 0.12  | 0.83           | 0.19  | 0.09  |  |
| CZ-Bili-Kriz        | 0.88 | 0.03       | 0.13  | 0.92 | 0.10       | 0.07 | 0.82 | 0.06       | -0.01 | 0.95           | 0.10  | 0.05  |  |
| BR-Mata-Seca        | 0.88 | 0.10       | -0.04 | 0.94 | 0.12       | 0.01 | 0.84 | 0.12       | -0.06 | 0.91           | 0.20  | 0.04  |  |
| AU-Cape-Tribulation | 0.87 | 0.04       | -0.07 | 0.29 | 0.06       | 0.14 | 0.83 | 0.03       | -0.19 | 0.15           | 0.19  | 0.08  |  |
| US-Jornada          | 0.85 | 0.04       | 0.02  | 0.77 | 0.20       | 0.01 | 0.19 | 0.05       | 0.11  | 0.07           | 0.20  | -0.01 |  |
| US-Central-Plains   | 0.84 | 0.03       | -0.08 | 0.87 | 0.21       | 0.02 | 0.62 | 0.04       | -0.10 | 0.69           | 0.42  | 0.01  |  |
| FR-Puechabon        | 0.83 | 0.05       | 0.03  | 0.75 | 0.09       | 0.08 | 0.81 | 0.06       | 0.09  | 0.88           | 0.09  | 0.04  |  |
| CA-Mer-Bleue        | 0.79 | 0.11       | 0.03  | 0.99 | 0.03       | 0.06 | 0.83 | 0.08       | -0.02 | 0.91           | 0.11  | 0.02  |  |

### **Sentinel-3 MPC**

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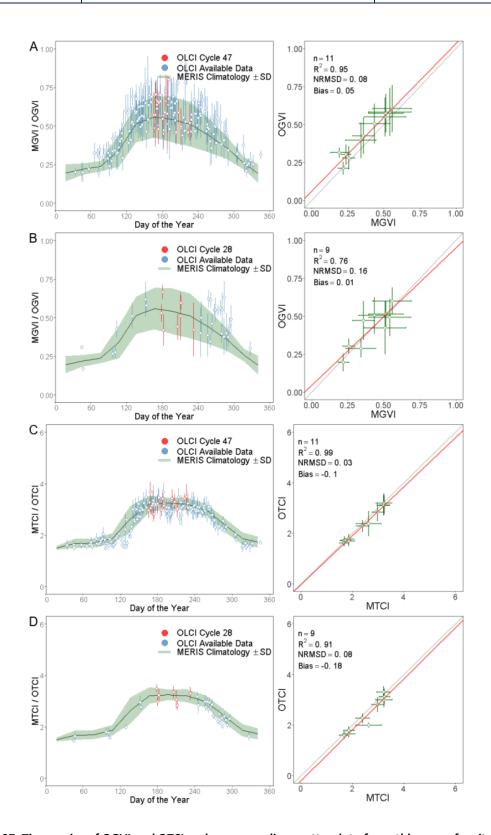


Figure 97: Time-series of OGVI and OTCI and corresponding scatterplot of monthly mean for site BE-Brasschaat, Belgium, land cover Needle-leaved, evergreen. A and C represent S3A; B and D represent S3B. Dotted rectangle encapsulates S3A/S3B cycles 46/27; dashed rectangle encapsulates S3A/S3B cycles 47/28.

# Senne. 3 Mission Performance Centre

### **Sentinel-3 MPC**

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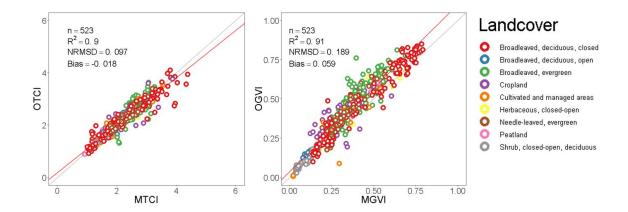


Figure 98: Comparison of OTCI-MTCI (a) and OGVI-MGVI (b). Points in the scatterplot represent the monthly mean of all available S3A and MERIS data over 53 validation sites. Red and grey lines represent the modelled and 1:1 lines respectively. Scatterplots are updated to include extractions from cycles S3A 46-47 and S3B 27-28.

# 4.2 [OLCI-L2LRF-CV-410 & OLCI-L2LRF-CV-420] — Cloud Masking & Surface Classification for Land Products

There has been no new result during the cycle. Last figures (cycle 27) are considered valid.

# Sentinel-3 MPC



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# 5 Level 2 Water products validation

# 5.1 [OLCI-L2-CV-210, OLCI-L2-CV-220] — Vicarious calibration of the NIR and VIS bands

# 5.1.1 OLCI-A

There has been no update of the SVC (System Vicarious Calibration) during Cycle 047. Last figures (cycle 17) are considered valid.

#### 5.1.2 OLCI-B

There has been no update of the SVC (System Vicarious Calibration) during Cycle 028. Last figures (cycle 023) are considered state of the art.

5.2 [OLCI-L2WLR-CV-300, OLCI-L2WLR-CV-310, OLCI-L2WLR-CV-32, OLCI-L2WLR-CV-330, OLCI-L2WLR-CV-340, OLCI-L2WLR-CV-350, OLCI-L2WLR-CV-360 and OLCI-L2WLR-CV-370] — Level 2 Water-leaving Reflectance product validation.

### 5.2.1 Acknowledgements

S3-MPC acknowledges all PIs mentioned below and their respective institutions for their valuable contribution to the validation of OLCI L2 water products with a special emphasis on AERONET-OC PIs for their unique contribution to NRT data validation and a special mention to Giuseppe Zibordi maintaining and providing data over 5 ground stations. AERONET-OC is indeed from far the largest contributor of Fiducial Reference Measurements for routine quantitative data validation.

## AERONET-OC

- AAOT, Galata, Gloria, GDT, HLH: Giuseppe Zibordi, Joint Research Centre of the European Commission
- leodo: Young-Je Park & Hak-Yeol You, Korean Institute of Ocean Science and Technology & Korea Hydrographic and Oceanographic Administration
- LISCO: Sam Ahmed, Alex Gilerson, City College of New York
- MVCO: Hui Feng and Heidi Sosik, Ocean Process Analysis Laboratory (OPAL), Woods Hole Oceanographic Institution
- Thornton: Dimitry Van der Zande, RBINS/OD Nature
- Lucinda: Thomas Schroeder, Integrated Marine Observing System, IMOS
- WaveCIS: Alan Weidemann, Bill Gibson, Robert Arnone, University of Southern MS, Coastal Studies Inst – LSU, Naval Research Laboratory

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### BOUSSOLE

- David Antoine, Enzo Vellucci (Curtin University, Perth & Laboratoire d'Oceanographie de Villefranche, CNRS)
- MOBY
  - Kenneth Voss & Carol Johnson (University of Miami & NIST)
- SLGO
  - Simon Belanger, Thomas Jaegler & Peter Galbraith (Arctus, Inc & Department of fisheries and Ocean Canada)
- AWI
  - Astrid Bracher (Alfred-Wegener-Institut)
- IMOS
  - Thomas Schroeder (Integrated Marine Observing System, IMOS)
- BSH
  - Holger Klein (Bundesamt für Seeschifffahrt und Hydrographie, BSH)
- Proval
  - Edouard Leymarie (Laboratoire d'Oceanographie de Villefranche, CNRS)

#### 5.2.2 OLCI-A

# **Activities done**

- The focus for this time period has been on the rolling archive Non Time Critical (NT) data until August the 15<sup>th</sup>.
- Current reporting period is hereafter compared to the reprocessed archive covering the April 2016 to November 2017 period. No issues are reported neither in the extraction process nor in OLCI data.
- All extractions and statistics have been regenerated on the current rolling archive availability including all the extraction since July 2017. The available matchups therefore represent over almost three years of operation.
- At best 297 and 302 matchups at 490 and 560nm respectively are useful for this time period. OLCI's performances remain nominal.

# **Overall Water-leaving Reflectance performance**

# **Scatter plots and Performance Statistics**

Figure 99 and Figure 100 below present the scatterplots and statistics of OLCI FR versus in situ reflectance. Two time periods are considered:

The reprocessed archive covering the April 2016 to November 2017 time period

### **Sentinel-3 MPC**

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The current reporting period computed on the NT dataset.

The current reporting period statistics are in line with the reprocessed dataset.

Table 7 below summarises the statistics over the reprocessing period while Table 8 provides the same figures for the NT rolling Archive over July 2017 – present. The latter statistics are almost within the requirements (5% accuracy in the blue/green bands) – as demonstrated by the RPD values between 1.5 and 7% – performances over the current period appear a bit lower than for the calibration period (except at 412 nm), but of the same order of magnitude.

# Mission Performance Control

### **Sentinel-3 MPC**

# **S3 OLCI Cyclic Performance Report**

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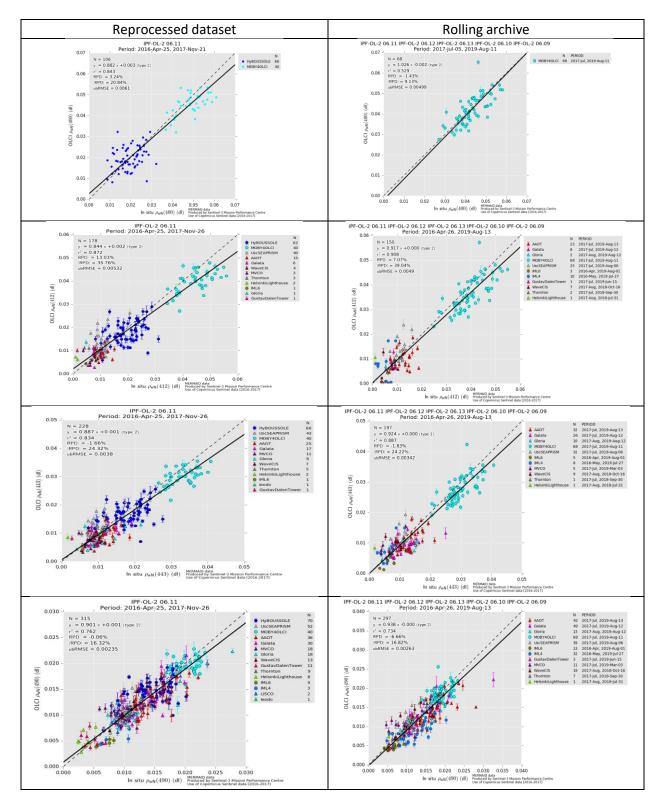


Figure 99: Scatter plots of OLCI-A versus in situ radiometry (FR data). Reprocessed dataset (left), all available data for the current time period (right), Oa1 to Oa4 (400 to 490 nm)

# Mission Performance Centre

### **Sentinel-3 MPC**

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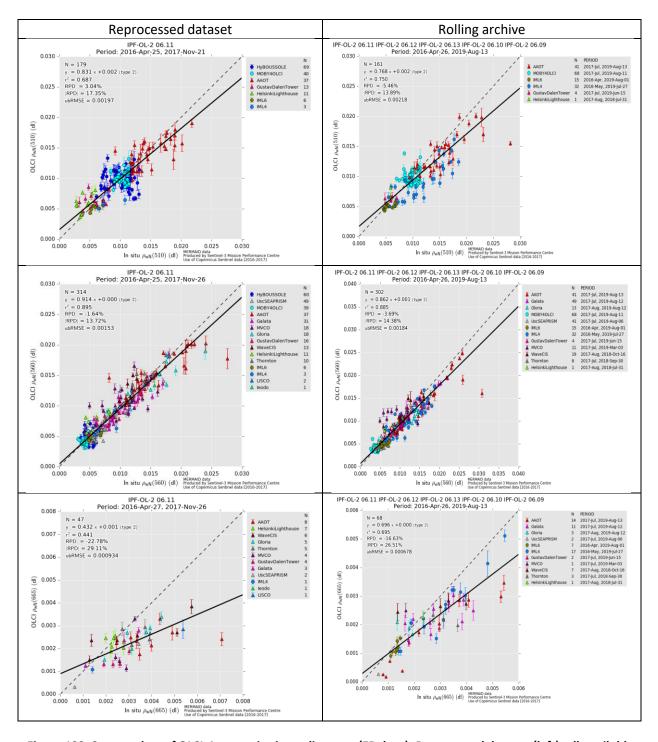


Figure 100: Scatter plots of OLCI-A versus in situ radiometry (FR data). Reprocessed dataset (left), all available data for the current time period (right), Oa5 Oa6 and Oa8 (510, 560 and 665 nm).

### **Sentinel-3 MPC**

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Table 7: OLCI-A FR statistics over REP\_006 period; FR data.

| lambda | N   | RPD     | RPD    | MAD     | RMSE   | slope  | intercept | r2     |
|--------|-----|---------|--------|---------|--------|--------|-----------|--------|
| 400    | 105 | 3.52%   | 20.74% | -0.0009 | 0.0062 | 0.8774 | 0.0029    | 0.8435 |
| 412    | 178 | 13.03%  | 35.76% | -0.0011 | 0.0054 | 0.8444 | 0.0021    | 0.8721 |
| 443    | 228 | -1.66%  | 24.32% | -0.0013 | 0.0040 | 0.8874 | 0.0006    | 0.8336 |
| 490    | 315 | -0.06%  | 16.32% | -0.0004 | 0.0024 | 0.9009 | 0.0009    | 0.7618 |
| 510    | 179 | 3.04%   | 17.35% | -0.0002 | 0.0020 | 0.8314 | 0.0015    | 0.6869 |
| 560    | 314 | -1.64%  | 13.72% | -0.0003 | 0.0016 | 0.9139 | 0.0004    | 0.8946 |
| 665    | 47  | -22.78% | 29.11% | -0.0009 | 0.0013 | 0.4325 | 0.0009    | 0.4406 |

Table 8: OLCI-A FR statistics over July 2017-May 2019 reporting period.

| lambda | N   | RPD     | RPD    | MAD     | RMSE   | slope  | intercept | r2     |
|--------|-----|---------|--------|---------|--------|--------|-----------|--------|
| 400    | 68  | -1.43%  | 9.13%  | -0.0009 | 0.0051 | 1.0261 | -0.0020   | 0.5286 |
| 412    | 141 | 7.07%   | 39.04% | -0.0016 | 0.0051 | 0.9174 | 0.0004    | 0.9077 |
| 443    | 176 | -1.83%  | 24.22% | -0.0013 | 0.0037 | 0.9244 | 0.0000    | 0.8869 |
| 490    | 266 | -6.66%  | 16.82% | -0.0012 | 0.0029 | 0.9378 | -0.0003   | 0.7344 |
| 510    | 154 | -5.46%  | 13.89% | -0.0009 | 0.0024 | 0.7684 | 0.0017    | 0.7497 |
| 560    | 270 | -3.69%  | 14.38% | -0.0007 | 0.0020 | 0.8615 | 0.0007    | 0.8849 |
| 665    | 62  | -16.63% | 26.51% | -0.0005 | 0.0009 | 0.6960 | 0.0003    | 0.6946 |

# **Time series**

Figure 101 and Figure 102 below present AAOT and MOBY in situ and OLCI time series over the June 2017-May 2019 period, for the same IPF configuration (from a scientific point of view).

# Mission Performance Centre

### **Sentinel-3 MPC**

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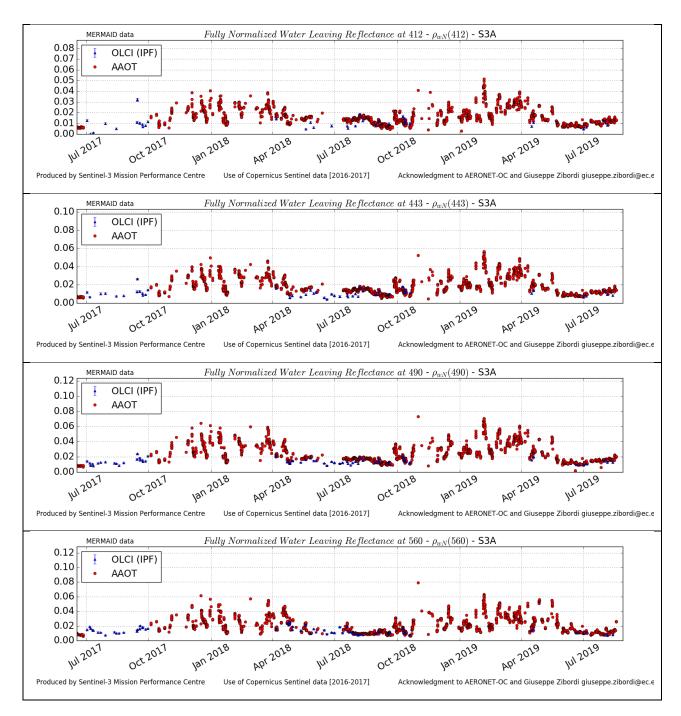


Figure 101: AAOT time series over current report period

# Mission Performance Centre

#### Sentinel-3 MPC

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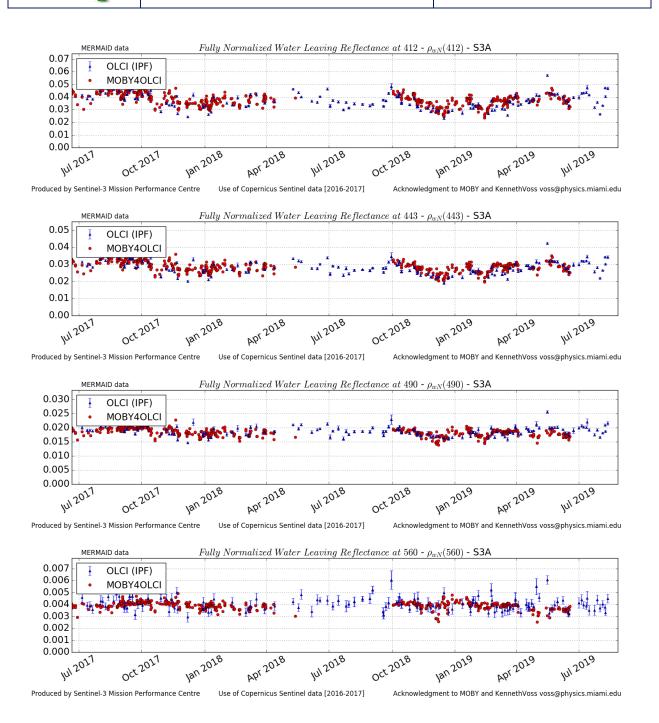


Figure 102: MOBY time series over current report period

### **Sentinel-3 MPC**

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### 5.2.3 OLCI-B

# **Activities done**

- The focus for this time period has been on the rolling archive Non Time Critical (NT) data until August the 15<sup>th</sup>.
- All extractions and statistics have been regenerated on the current rolling archive availability including all the extraction since February 2019.
- At best 88 and 94 matchups at 490 and 560nm respectively are useful for this time period.

It must be noted that OLCI-B has no SVC adjustment and as such cannot be expected to provide performances of the same level of quality than OLCI-A.

# **Overall Water-leaving Reflectance performance**

# **Scatter plots and Performance Statistics**

- Figure 103 below presents the scatterplots and statistics of OLCI-B FR versus in situ reflectance.
- ❖ Table 9 below summarises the statistics over the current reporting period.

### **Sentinel-3 MPC**

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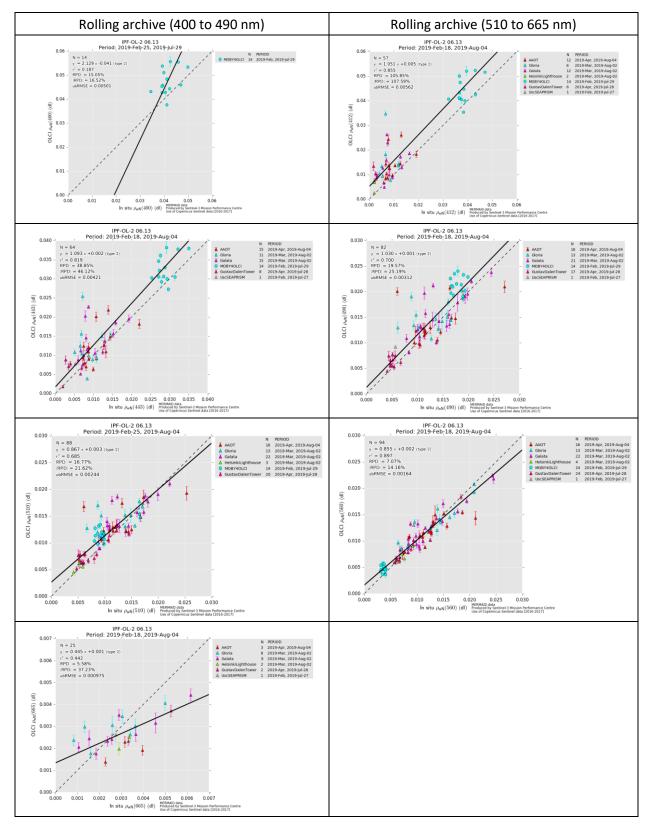


Figure 103: Scatter plots of OLCI-B versus in situ radiometry (FR data). All available data for the current time period.

# **Sentinel-3 MPC**

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# Table 9: OLCI-B FR statistics over February to May 2019 reporting period.

| lambda | N  | RPD     | RPD     | MAD     | RMSE   | slope  | intercept | r2     |
|--------|----|---------|---------|---------|--------|--------|-----------|--------|
| 400    | 14 | 15.05%  | 16.52%  | 0.0061  | 0.0079 | 2.1292 | -0.0408   | 0.1874 |
| 412    | 30 | 105.85% | 107.59% | 0.0059  | 0.0082 | 1.0509 | 0.0051    | 0.8554 |
| 443    | 33 | 38.85%  | 46.12%  | 0.0029  | 0.0051 | 1.0935 | 0.0017    | 0.8190 |
| 490    | 37 | 19.57%  | 25.19%  | 0.0016  | 0.0035 | 1.0301 | 0.0013    | 0.6996 |
| 510    | 39 | 16.77%  | 21.62%  | 0.0012  | 0.0027 | 0.8668 | 0.0026    | 0.6846 |
| 560    | 39 | 7.07%   | 14.16%  | 0.0002  | 0.0016 | 0.8550 | 0.0016    | 0.8968 |
| 665    | 12 | 5.58%   | 37.23%  | -0.0003 | 0.0010 | 0.4451 | 0.0013    | 0.4415 |

# **Time series**

Figure 104 and Figure 105 below present AAOT and MOBY in situ and OLCI-B time series over the current reprocessing period.

# Mission Performance Centre

# **Sentinel-3 MPC**

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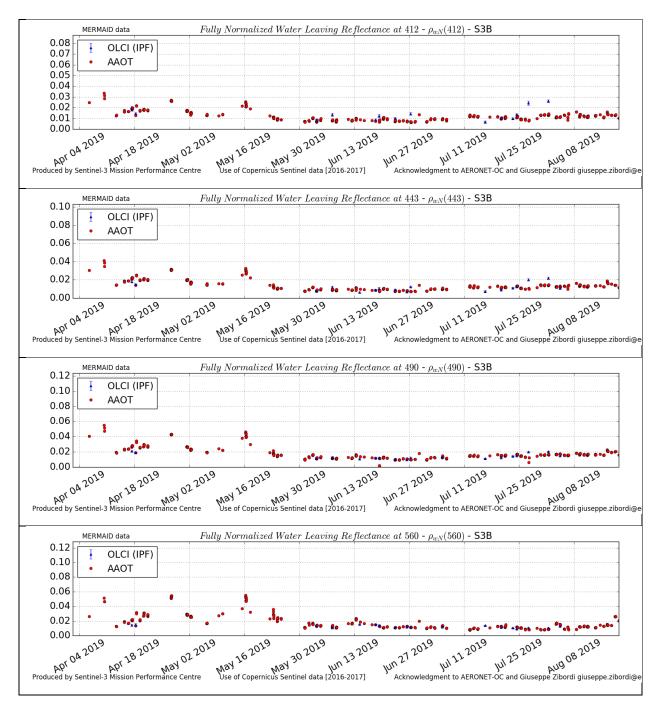


Figure 104: AAOT time series over current report period

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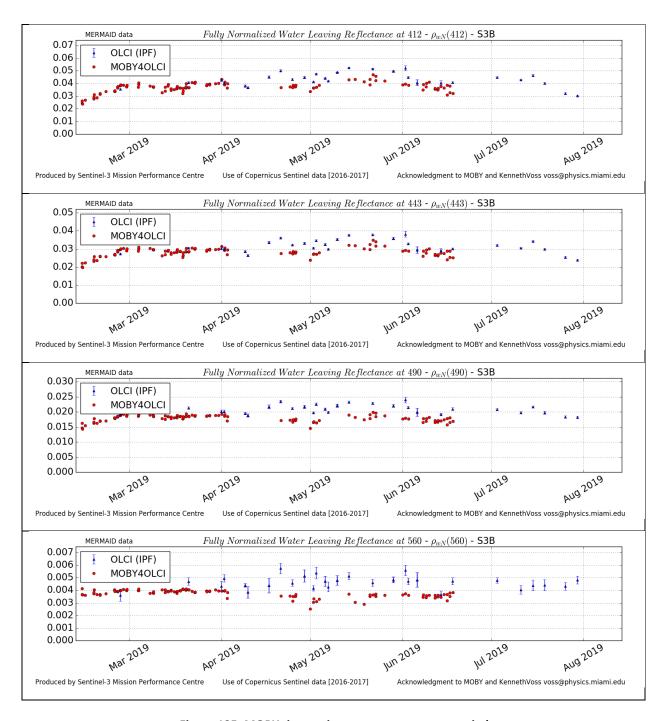


Figure 105: MOBY time series over current report period



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## 5.3 [OLCI-L2WLR-CV-430] – Algorithm performance over spatial and temporal domains

There has been no new result during the cycle. Last figures (cycle 27) are considered valid.

## 5.4 [OLCI-L2WLR-CV-510 & 520] – Cloud Masking & Surface Classification for Water Products

There has been no new result during the cycle. Last figures (cycle 27) are considered valid.

### 5.5 [OLCI-L2WLR-CV530] Validation of Aerosol Product

### 5.6 Validation of Aerosol Product

To validate OLCI's Aerosol product (aerosol optical thickness and Angstroem coefficient at 865nm), we continuously compare it with data from AERONET (Holben et al 1998), AERONET-OC (Zibordi et al 2009) and MARITIME AERONET (Smirnow et al 2009). This is an ongoing process, where co-located data are collected and analysed. Only quality assured L2 AERONET has been used, which comes with a delay of up to one year. However, we found that the difference between L2 and the L1.5 AERONET data (which comes much faster) is insignificant with respect to direct solar transmission measurements (aerosol optical thickness, Angstroem coefficient and total amount of water vapour). Due to that change, we could increase the amount of co-locations to 117.000 (OLCI A) for the period between June 2016 and August 2019, 800 of them usable for aerosol validation. For OLCI B AERONET level 2 would not provide any co-location yet, but level 1.5 provides already 18000 for the period between March 2019 and August 2019, 42 of them are valid matchups.

Only OLCI measurements which are cloud-free (according to the L2 standard cloud flags: *cloud, cloud margin and cloud ambiguous*) in an area of about 10x10 km² around the AERONET acquisition have been used. Further, all recommended flags from *Sentinel-3 OLCI Marine User Handbook* (EUM/OPS-SEN3/MAN/17/907205) have been applied. Eventually, to reduce the influence of undetected (sub pixel or sub visual) clouds, only matchups have been used, where the standard deviation of the aerosol optical thickness within the 10x10 km² area was less than 0.3. The results of the comparison are summarized in Figure 106. A clear systematic overestimation of 30% or more becomes apparent. The Angstroem coefficient does agree to some extend: OLCI A and AERONET have their centre around 1.5, however, the linear co-relation is quite low. A first glance on OLCI B shows no significant difference to OLCI A.

The temporal evolution shows no significant trend, however the systematic overestimation of OLCI A appears to decrease. It remains to be investigated, whether and how stable this decrease is.

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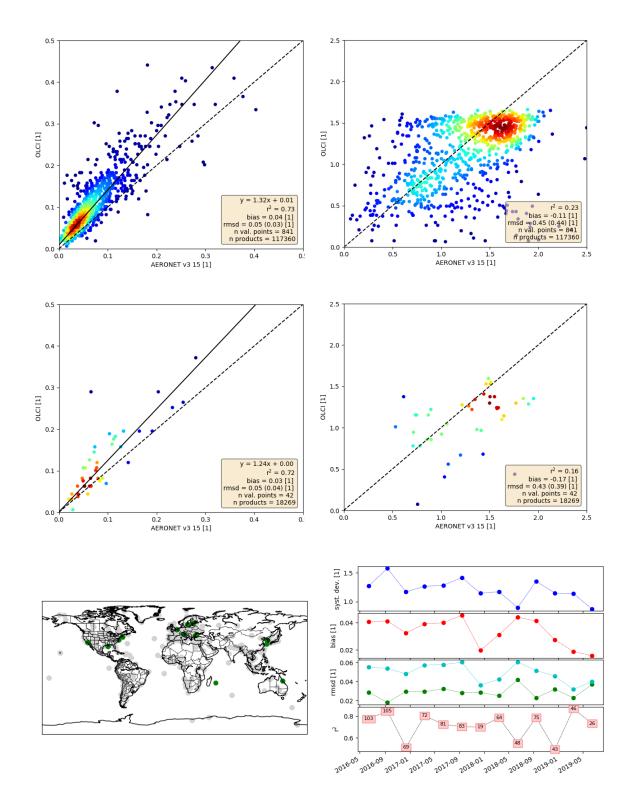


Figure 106: Upper and middle left: Scatter plot of the AOT at 870 nm product (OLCI A upper, OLCI B lower) vs.

AERONET Upper right: As Left, but for the Angstrom coefficient. Lower left: Positions of the used AERONET stations (grey: no valid matchup). The green dots are mostly AERONET-OC stations. Lower right: temporal evolution of the statistical measures describing the AOT quality: systematic deviation, bias, root mean squared difference (dark green is bias corrected) and Pearson's correlation coefficient.



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Zibordi G., B.Holben, I.Slutsker, D.Giles, D.D'Alimonte, F.Mélin, J.-F. Berthon, D. Vandemark, H.Feng,G.Schuster, B.Fabbri, S.Kaitala, J.Seppälä. AERONET-OC: a network for the validation of Ocean Color primary radiometric products. Journal of Atmospheric and Oceanic Technology, 26, 1634-1651, 2009.

# 5.7 [OLCI-L2WLR-CV-380] Development of calibration, product and science algorithms

There has been no new development on calibration, product and science algorithms during the cycle.



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### 6 Validation of Integrated Water Vapour over Land & Water

The OLCI IWV above land surface product is continuously validated using various sources of ground truth data. In contrast to the previous results, the data base has been extended to OLCI B.

OLCI's IWV above land surface is validated using the following ground truth data:

- 1. Global GNSS data, with a focus to north America (SUOMI NET, Ware et al. 2000)
- 2. Microwave radiometer measurements at the *Atmospheric Radiation Measurement* (ARM) *Climate Research Facility* of the US Department of Energy (Turner et al. 2003, Turner et al. 2007).
- 3. GRUAN radiosonde observations IWV (Immler et al 2010, Bodeker 2015)
- 4. AERONET (Holben et al 1998), using atmospheric transmission measurements at  $0.9\mu m$

### 6.1 IWV validation using SUOMI NET

340,000 potential matchups within the period of June 2016 to August 2019 for OLCI A and 33.000 matchups for OLCI B within the period of March 2019 to August 2019 have been analysed yet. The scenes cover high and low elevations, however, the majority of the used SUOMI-NET ground stations are in North and Central America. Only OLCI measurements are taken for the validation which are above land and are cloud-free in an area of about 10x10 km² around the GNSS stations. For the cloud detection, the standard L2 cloud-mask has been applied (including the cloud ambiguous and cloud margin flags). The comparison of OLCI and GNSS shows a very high agreement and no significant difference between OLCI A and B (Figure 107). The correlation between both quantities is better than 0.97. The root-mean-squared-difference is 2.2 kg/m². The systematic overestimation by OLCI is 12%-13%. The bias corrected *rmsd* is 1.3-1.4 kg/m². The slight differences between both OLCIs are smaller than the variation in the temporal evolution of the quality measures for OLCI A. The temporal evolution shows no trend but clear seasonality, in particular due to the seasonal variation of the integrated water vapour itself.

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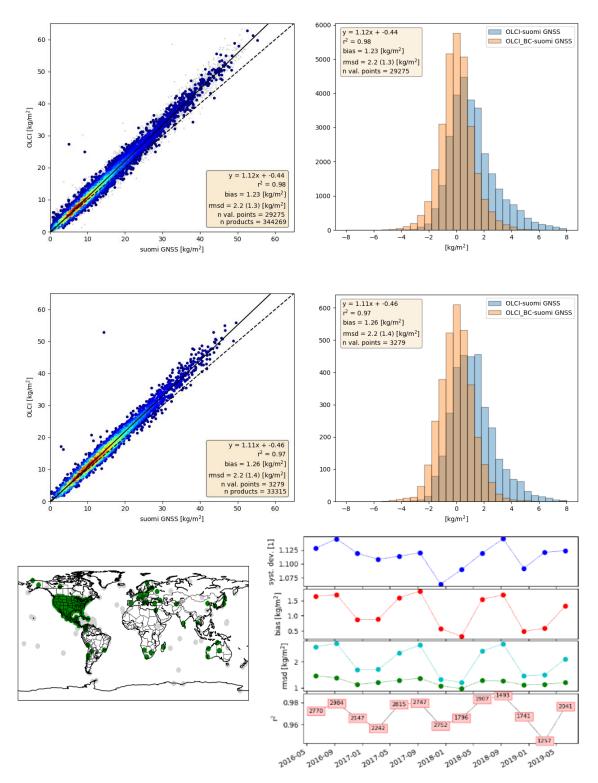


Figure 107: Upper and middle left: Scatter plot of the IWV products, derived from OLCI A (upper) and OLCI B (middle) above land and from SUOMI NET GNSS measurements. Upper and middle right: Histogram of the difference between OLCI A (upper), OLCI B (middle) and GNSS (blue: original OLCI, orange: bias corrected OLCI). Lower left: Positions of the GNSS stations (grey: no valid matchup). Lower right: temporal evolution of the performance measures of OLCI A: systematic deviation, bias, root mean squared difference (dark green is bias corrected) and Pearson's correlation coefficient.

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### 6.2 IWV validation using passive microwave radiometer at ARM

Microwave radiometer measurements at the *Atmospheric Radiation Measurement* (ARM) *Climate Research Facility* of the US Department of Energy provides the ground truth with the highest accuracy (0.6 kg/m²). Currently 3 ARM sites are operated continuously, only the SGP (southern great planes) site provided cloud free measurements. 2400 potential matchups for OLCI A within the period of June 2016 to August 2019 and 340 potential matchups for OLCI B within the period of March 2019 to August 2019, have been analysed yet. Only OLCI measurements are taken for the validation, which are cloud-free in an area of about 10x10 km² around SGP. For the cloud detection, the standard L2 cloud-mask has been applied (including the cloud ambiguous and cloud margin flags), resulting in 190 valid matchups for OLCI A and 18 matchups for OLCI B. The comparison shows a very high agreement (Figure 108). The correlation between both quantities is 0.99. The root-mean-squared-difference is 1.5 kg/m². The systematic overestimation by OLCI is 9%. The bias corrected *rmsd* is 0.9 kg/m², close to the uncertainty of ARM. As for the comparisons with GNSS, the slight differences between both OLCIs are smaller than the variation in the temporal evolution of the quality measures for OLCI A. The temporal evolution shows clear seasonal variations, in particular due to the seasonal variation of the integrated water vapour at SGP. As for GNSS, it shows no trend.

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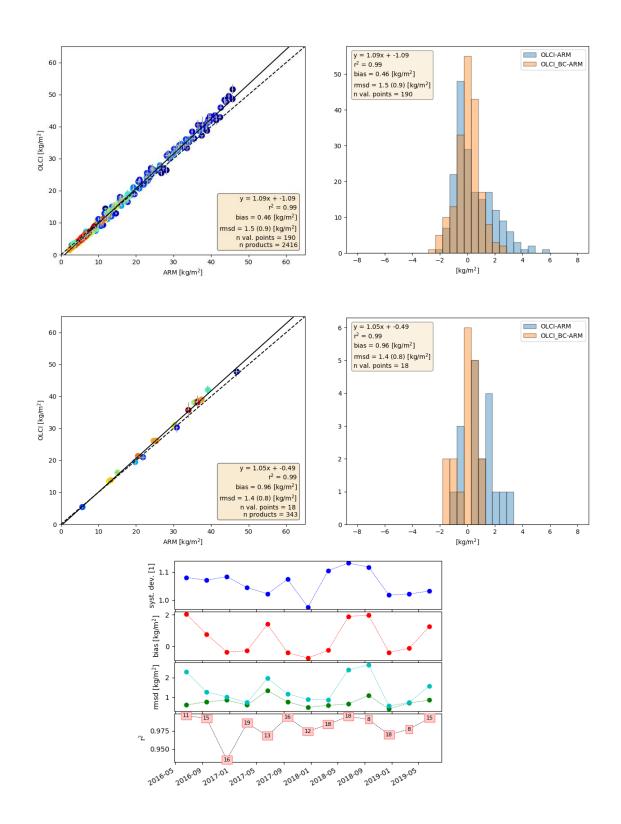


Figure 108: Upper and middle left: Scatter plot of the IWV products, derived from OLCI A (upper) and OLCI B (middle) above land and from ARM microwave radiometer measurements. Upper and middle right: Histogram of the difference between OLCI A (upper), OLCI B (middle) and GNSS (blue: original OLCI, orange: bias corrected OLCI). Lower temporal evolution of the performance measures of OLCI A.



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### 7 Level 2 SYN products validation

There has been no new result during the cycle. Last figures (cycle 43/24) are considered valid.

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### **8** Events

For OLCI-A, two Radiometric Calibration Sequences have been acquired during Cycle 047:

- \$ S01 sequence (diffuser 1) on 23/07/2019 00:33 to 00:34 (absolute orbit 17856)
- \$05 sequence (diffuser 2) on 23/07/2019 02:14 to 02:15 (absolute orbit 17857)

For OLCI-B, three Radiometric Calibration Sequences have been acquired during Cycle 028:

- Sol sequence (diffuser 1) on 23/07/2019 11:40 to 11:42 (absolute orbit 6469)
- S05 sequence (diffuser 2) on 23/07/2019 13:21 to 13:23 (absolute orbit 6470)
- S01 sequence (diffuser 1) on 09/08/2019 12:41 to 12:43 (absolute orbit 6712)



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### 9 Appendix A

Other reports related to the Optical mission are:

\$3 SLSTR Cyclic Performance Report, S3A Cycle No. 047, S3B Cycle No. 028 (ref. S3MPC.RAL.PR.02-047-028)

All Cyclic Performance Reports are available on MPC pages in Sentinel Online website, at: <a href="https://sentinel.esa.int">https://sentinel.esa.int</a>

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