COPERNICUS SPACE COMPONENT SENTINEL OPTICAL IMAGING MISSION PERFORMANCE CLUSTER SERVICE

Data Quality Report

Sentinel-3 OLCI

July 2022



Optical Mission Performance Cluster

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Data Quality Report –Sentinel-3 OLCI

July 2022

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1.1 Sentinel3-A

IPF	IPF / Processing Baseline version	Date of deployment
OL1	06.13 / OLL1002.23.00	19/07/2022 00:00 UTC
OL2 LAND	06.16 / OL_L2L.002.10.00	26/01/2021 10:15 UTC
SY2	06.22 / SYN_L2002.15.00	27/01/2022 10:15 UTC
SY2_VGS	06.10 / SYN_L2V.002.07.00	27/01/2022 10:15 UTC
SY2_AOD	01.06 / AOD_NTC.002.06.00	27/01/2022 10:15 UTC

1.2 Sentinel3-B

IPF	IPF / Processing Baseline version	Date of deployment
OL1	06.13 / OLL1002.23.00	19/07/2022 00:00 UTC
OL2 Land	06.16 / OLL2L.002.10.00	26/01/2021 10:15 UTC
SY2	06.22 / SYN_L2002.15.00	27/01/2022 10:15 UTC
SY2_VGS	06.10 / SYN_L2V.002.07.00	27/01/2022 10:15 UTC
SY2_AOD	01.06 / AOD_NTC.002.06.00	27/01/2022 10:15 UTC



2 Instrument monitoring

2.1 CCD temperatures

2.1.1 OLCI-A

The long-term monitoring of the CCD temperatures is based on 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 reporting period (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.





Figure 2: Same as Figure 1 for diffuser frames.



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 reporting period (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.





Figure 4: same as Figure 3 for diffuser frames.

2.2 Radiometric Calibration

For OLCI-A, three Radiometric Calibration sequences have been acquired during the reported period:

- S01 sequence (diffuser 1) on 06/07/2022 22:51 to 22:53 (absolute orbit 33255)
- So1 sequence (diffuser 1) on 22/07/2022 22:37 to 22:39 (absolute orbit 33483)
- S05 sequence (diffuser 2) on 23/07/2022 00:18 to 00:20 (absolute orbit 33484)

For OLCI-B, three Radiometric Calibration sequences have been acquired during the reported period:

- S01 sequence (diffuser 1) on 08/07/2022 09:32 to 09:34 (absolute orbit 21882)
- S01 sequence (diffuser 1) on 24/07/2022 09:18 to 09:20 (absolute orbit 22110)
- S05 sequence (diffuser 2) on 24/07/2022 10:59 to 11:01 (absolute orbit 22111)



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. Different colours correspond to different years of acquisition (see the legend inside the figure).



Figure 6: same as Figure 5 for OLCI-B.



Sun Zenith Angles as a function of Sun Azimuth 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)



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.



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.



2.2.1.2 OLCI-A

Dark offsets

Dark offsets are continuously affected by the global offset induced by the Periodic Noise on the OCL (Offset Control Loop) convergence. Current reporting period 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.



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.



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.



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 CALs of the current reporting period.

Figure 11 and Figure 12 show that at this stage of the mission the PN is very stable in all cameras. There is no special behaviour noticed during the reporting period.

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 reporting period except the small regular increase (almost linear), for all detectors, since the beginning of the mission (see Figure 14).



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.



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)

2.2.1.3 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.

Despite this overall stabilization, small evolutions are still noticeable in some bands/camera, like for example camera 1 in band Oa21 (upper left map in Figure 17) or in camera 1 band smear (upper left map in Figure 18).

Globally, OLCI-B PN is slightly less stabilized than OLCI-A PN.



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.



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.



Dark Currents

As for OLCI-A there is no significant evolution of the Dark Current coefficients (Figure 19) during the current reporting period 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.



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.

Sep 2017

Jan 2019

May 2020 Time Oct 2021

Feb 202

Feb 2023

Sep 2017

Jan 2019

May 2020 Time Oct 2021



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



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), derived using the in-flight BRDF model. The dataset is made of all diffuser 1 radiometric calibrations since orbit 979.

Figure 23 displays a summary of the time evolution of the cross-track average of the gains (in-flight BRDF, taking into account the diffuser ageing), for each module, relative to a given reference calibration (the 25/04/2016, change of OLCI channel settings). It shows that, if a significant evolution occurred during the



early mission, the trends tend in general to stabilize, with some exceptions (e.g. band 1 of camera 1 and 4, bands 2 & 3 of camera 5).



Figure 23: camera averaged gain relative evolution with respect to calibration of 25/04/2016 (change of OLCI channel settings), 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 taken into account.



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), derived using the in-flight BRDF model. The dataset is made of all diffuser 1 radiometric calibrations since orbit 758.

Figure 25 displays a summary of the time evolution of the cross-track average of the gains (in-flight BRDF, taking into account diffuser ageing), 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. The slight discontinuity near "day 920 since launch" is due to the upgrade of the Ageing model.



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 taken into account.



2.2.2.2 Instrument evolution modelling

2.2.2.2.1 OLCI-A

The current OLCI-A Radiometric Model has been put in operations at PDGS the 18/11/2021 (Processing Baseline 3.01). This model has been derived on the basis of a more recent (compared to the previous model) Radiometric Calibration dataset, going from 25/01/2018 to 03/10/2021. It includes the correction of the diffuser ageing for the six bluest bands (Oa1 to Oa6) for which it is clearly measurable. The model performance over the complete dataset (including the 22 calibrations in extrapolation over about 9 months) remains better than about 0.10% for all bands at the exception of Oa01 (0.14%) and of the presence of two isolated peaks, near orbit 30500 and 33000, where performance degrades for several bands, up to about 0.14% for band Oa01. These peaks are present in Gain measurements, thus reflect in model performance. The same behaviour is seen on OLCI-B (see Figure 33) even if the second peak is less marked, suggesting that it is not linked to the instrument sensitivity. A small drift of the model with respect to the most recent data is now visible for all bands. The previous model, trained on a Radiometric Dataset limited to 08/08/2020, shows clearly a more pronounced 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. Performance shown on Figure 26 adopts, as for OLCI-B, the multiple model approach, i.e. different models (three for OLCI-A since PB, three for OLCI-B since PB 1.57) are used to cover the whole mission (red dashed line on Figure 26), each model being fitted on a partial dataset (green dashed line on Figure 26) whose coverage is optimised to provide best performance.



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





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 the most recent calibration (22/07/2022) versus wavelength.


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 62 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 22 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent).



Figure 30: OLCI-A 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 22 calibrations in extrapolation, channels Oa1 to Oa6.





ratios

Soins

Figure 31: same as Figure 30 for channels Oa7 to Oa14.



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



2.2.2.2.2 OLCI-B

The current instrument response and degradation modelling for OLCI-B, including the use of the in-flight BRDF model (based on 11th December 2018 Yaw Manoeuvres), has been deployed at PDGS on 18/11/2021 (Processing Baseline 3.01). This model has been derived on the basis of an extended Radiometric Calibration dataset (from 18/06/2019 to 16/09/2021), and most of all a revised Ageing model. 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 23 calibrations in extrapolation over about 10.5 months) is illustrated in Figure 33. It remains better than 0.11% when averaged over the whole field of view for all bands, at the exception of an isolated peak which is present near orbit 19000 where performance degrades for all bands, up to about 0.15 % for band Oa01. This peak is present in Gain measurements, thus reflects in model performance. The same behaviour is seen on OLCI-A (see Figure 26), suggesting that it is not linked to the instrument sensitivity. A small drift of the model with respect to the most recent data is now visible for all bands. The previous model, trained on a Radiometric Dataset limited to 09/08/2020, shows clearly a more pronounced drift of the model with respect to most recent data, especially for band Oa01 (Figure 34). Comparison of the two figures shows the improvement brought by the updated Model over all the mission.



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





Figure 34: RMS performance of the OLCI-B Gain Model of the previous processing baseline as a function of orbit (please note the different vertical scale with respect to Figure 33).



The overall instrument evolution since channel programming change (18/06/2018) is shown on Figure 35.



Figure 35: OLCI-B Camera-averaged instrument evolution since channel programming change (18/06/2018) and up to most recent calibration (24/07/2022) versus wavelength.

The overall per camera performance, as a function of wavelength, and at each orbit is shown on Figure 36 as the average and standard deviation of the model over data ratio.

Finally, Figure 37 to Figure 39 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.



Figure 36: 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 23 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent).



Figure 37: OLCI-B 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 23 calibrations in extrapolation, channels Oa1 to Oa6.



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Figure 38: same as Figure 37 for channels Oa7 to Oa14.



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Figure 39: same as for channels Oa15 to Oa21.



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 the current reported period :

S05 sequence (diffuser 2) on 23/07/2022 00:18 to 00:20 (absolute orbit 33484)

With the associated S01 sequence (nominal diffuser) in order to compute ageing:

So1 sequence (diffuser 1) on 22/07/2022 22:37 to 22:39 (absolute orbit 33483)

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 40 for band Oa01 and in Figure 41 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 40: diffuser 1 ageing for spectral band Oa01. We see strong ACT low frequency structures that are due to residual of BRDF modelling.



Figure 41: same as Figure 40 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 42.

Figure 40 and Figure 41 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 42 where we can see that this band is impacted by ageing of the diffuser.





Figure 42: same as Figure 40 after normalization by band Oa17. Ageing of the diffuser 1 is now visible in the 5 cameras.

Camera averaged ageing (normalized by band Oa17) as a function of wavelength is represented in Figure 43 where we can see that ageing is stronger in the 'bluest' spectral bands (short wavelengths). Ageing is clearly visible only for the 6 first spectral bands so far in the OLCI mission life.



Figure 43: Diffuser 1 ageing as a function of wavelength (or spectral band). Ageing is clearly visible in spectral band #1 to #6. Note that all ageing sequences are plotted but in order to fit in the figure the box legend only displays 1 ageing sequence over 2 (including the most recent one).



Figure 44 shows the evolution, for spectral band Oa01, of the 5 cameras averaged ageing as a function of time.



Figure 44: 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 45).



Figure 45: Slope of ageing fit (% of loss per exposure) vs wavelengths, using all the available ageing sequence at the time of the current reporting period (red curve) and at the time of previous reporting periods for which an ageing sequence was measured (see legend within the figure).

In Figure 45, we see that the Ageing slopes have not significantly changed between the current reporting period and the last 21 reporting periods containing a S05 sequence (month #202201, #202203, cycles #80, #74, #70, #67, #65, #60, #56, #58, #54, #52, #47, #43, #40, #38, #33, #29, #27, #24 and #20). Cycle #47 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 18th November 2021 (Processing Baseline 3.01).

2.2.3.2 OLCI-B

There has been one calibration sequence S05 (reference diffuser) for OLCI-B during acquisition Cycle 63:

S05 sequence (diffuser 2) on 24/07/2022 10:59 to 11:01 (absolute orbit 22111)

with the associated S01 sequence in order to compute ageing:

S01 sequence (diffuser 1) on 24/07/2022 09:18 to 09:20 (absolute orbit 22110)

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 46 for band Oa01 and in Figure 47 for band Oa17.





Figure 46: OLCI-B diffuser 1 ageing for spectral band Oa01. We see strong ACT low frequency structures that are due to residual of BRDF modelling.



Figure 47: same as Figure 46 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 48.

Figure 46 and Figure 47 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 48 where we can see that this band is impacted by ageing of the diffuser.





Figure 48: same as Figure 46 after normalization by band Oa17. Ageing of the diffuser 1 is now visible in the 5 cameras.

Camera averaged ageing (normalized by band Oa17) as a function of wavelength is represented in Figure 49 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-B mission life. We see a bump around 680 nm which is probably due to characterisation errors that are strongly geometry dependant and affect differently the various camera. This behaviour is under investigation.



Figure 49: OLCI-B Diffuser 1 ageing as a function of wavelength (or spectral band). Ageing is clearly visible in spectral band #1 to #5.

As for OLCI-A, the OLCI-B Diffuser Ageing has been modelled as a function of cumulated exposure time (i.e. number of acquisition sequence on nominal diffuser, regardless of the band setting). The OLCI-A modelling methodology has been applied to OLCI-B. The results of this modelling, iterated at each new Ageing Sequence acquisition, expressed as the rate of ageing (% of loss per exposure) as a function of wavelength is presented in Figure 50.





Figure 50: Slope of ageing fit (% of loss per exposure) vs wavelengths, using all the available ageing sequence at the time of the current reporting period (red curve) and at the time of previous reporting periods for which an ageing sequence was measured (see legend within the figure).

The general behaviour of the ageing assessment strongly differs to that of OLCI-A (Figure 45) in two ways: variability with time is much higher and the spectral shape is not as expected. This is interpreted as an unexpected dependency of the *ratio* of diffusers BRDF with illumination conditions. This justified the used of an alternative method using direct comparisons of two nominal diffuser observations, acquired under the same geometry (i.e. directly comparable) and the same day (i.e. with no significant instrument sensitivity evolution) but separated by 7 more exposures to light (during the Yaw Manoeuvres dedicated to the in-flight BRDF modelling). This is in theory the best ageing measurement but as composed of only one measure, it is subject to a large uncertainty. At the time it was derived, it showed a reliable spectral shape up to 850 nm and a good agreement with the nominal assessment in the blue (Figure 51), so that it was used until recently to derive the Radiometric Gain Models. It is referred to as the "YM model".



Figure 51: OLCI-B diffuser ageing (after 100 exposures, i.e. about two years) according to direct assessment from Yaw Manoeuvres (blue) and nominal method at Cycle 28 (orange).

The regular decrease of the ageing slopes according to the nominal method makes YM ageing model more and more overestimated, and a new method has been defined and presented in previous DQM. This method has been applied, including the latest ageing assessment mentioned above.



As the anomalous ageing estimated in the red have shown to be correlated with Sun illumination geometry, a reanalysis of the Ageing sequences has been done on sub-sets of sequences with equal or close illumination conditions. Once sorted by Sun azimuth angles, a set of 3 clusters (Figure 52) provide independent ageing estimates. The estimates quality can be inferred from in-FOV consistency, both inside each camera and between cameras, as the diffuser ageing is independent of the viewing direction. The final estimate is a weighted average of the clusters assessments.



Figure 52: clustered Ageing sequences illumination geometries.

The results are quite satisfactory with good in-FOV consistency, well improved with respect to other methods, and a rather good inter-cluster consistency. The final results, together with those of the two other methods, are shown on Figure 53: the variation between the two Ageing slopes estimates of 20220331 and 20220724 are extremely small.





Figure 53: various estimates of the ageing rate, according to nominal method for cycles 28, 46 and 62, according to direct assessment during Yaw manoeuvres, and according to the Equal SAA clustering for data up to 03/2022 and 07/2022.

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

2.2.4.1 OLCI-A

No CAL_AX ADF has been delivered during the report period for OLCI-A.

2.2.4.2 OLCI-B

No CAL_AX ADF has been delivered during the report period for OLCI-B.

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

2.3.1 OLCI-A

There has been no S02+S03 nor S09 Spectral Calibration for OLCI-A in the reporting period.



Consequently, the last spectral calibration results, presented in the June 2022 DQR, remain valid.

2.3.2 OLCI-B

There has been no S02+S03 nor S09 Spectral Calibration for OLCI-B in the reporting period.

Consequently, the last spectral calibration results, presented in the June 2022 DQR, 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 54.

SNR computed for all calibration data as a function of orbit number for band Oa01 (the less stable band) is presented in Figure 55.

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



Figure 54: 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.





Figure 55: 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⁻¹.m⁻².nm⁻¹).

	L _{ref}	SNR	C1		C2		С3		C4		C5		All	
nm	LU	RQT	avg	std	avg	std	avg	std	avg	std	avg	std	avg	std
400.000	63.0	2188	2421	6.1	2398	6.3	2332	7.9	2384	12.0	2287	9.2	2364	6.9
412.000	74.1	2061	2387	9.4	2403	7.1	2339	5.0	2401	5.0	2380	9.0	2382	5.6
442.000	65.6	1811	2158	6.0	2196	6.1	2163	4.9	2185	4.1	2193	5.8	2179	4.2
490.000	51.2	1541	1999	4.7	2036	4.8	1998	4.2	1984	4.4	1988	4.4	2001	3.2
510.000	44.4	1488	1979	5.4	2014	4.9	1986	4.5	1967	4.4	1985	4.2	1986	3.4
560.000	31.5	1280	1775	4.7	1802	4.1	1803	4.7	1794	3.8	1818	3.3	1799	3.0
620.000	21.1	997	1591	4.1	1608	4.4	1624	3.1	1593	3.3	1615	3.4	1606	2.6
665.000	16.4	883	1546	4.2	1557	4.6	1566	4.0	1533	3.6	1561	3.6	1552	3.0
674.000	15.7	707	1328	3.4	1337	3.8	1350	2.8	1323	3.3	1343	3.4	1336	2.5
681.000	15.1	745	1319	3.6	1325	3.3	1338	2.6	1314	2.5	1334	3.4	1326	2.2
709.000	12.7	785	1420	4.2	1420	4.1	1435	3.2	1414	3.5	1431	3.1	1424	2.7
754.000	10.3	605	1127	3.1	1121	2.8	1136	3.1	1125	2.5	1139	2.7	1130	2.2
761.000	6.1	232	502	1.1	498	1.1	505	1.1	501	1.0	508	1.3	503	0.8
764.000	7.1	305	663	1.5	658	1.6	668	2.0	662	1.5	670	2.0	664	1.3
768.000	7.6	330	558	1.4	554	1.3	563	1.3	557	1.3	564	1.3	559	1.0
779.000	9.2	812	1516	4.7	1498	4.5	1526	5.1	1512	4.9	1527	4.8	1516	4.0
865.000	6.2	666	1243	3.6	1213	3.4	1239	3.8	1246	3.5	1250	2.8	1238	2.8
885.000	6.0	395	823	1.7	801	1.6	814	1.9	824	1.5	831	1.6	819	1.1
900.000	4.7	308	691	1.6	673	1.3	683	1.6	693	1.5	698	1.5	688	1.0
940.000	2.4	203	534	1.2	522	1.2	525	1.0	539	1.1	542	1.3	532	0.7
1020.000	3.9	152	345	0.9	337	0.8	348	0.7	345	0.8	351	0.8	345	0.5

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 56.



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 57.

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



Figure 56: 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.





Figure 57: long-term stability of the OLCI-B SNR estimates from Calibration data, example of channel Oa1.



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 ⁻¹ .m ⁻² .nm ⁻¹).

	L _{ref}	SNR	C1		C2		С3		C4		C5		All	
nm	LU	RQT	avg	std	avg	std	avg	std	avg	std	avg	std	avg	std
400.000	63.0	2188	2455	18.9	2295	16.7	2419	6.5	2398	13.9	2586	14.1	2431	13.0
412.000	74.1	2061	2654	6.9	2569	6.2	2544	8.3	2550	6.2	2638	7.4	2591	5.4
442.000	65.6	1811	2324	6.6	2316	6.2	2299	6.6	2302	6.8	2308	6.7	2310	5.6
490.000	51.2	1541	1966	4.9	1990	5.7	1971	5.1	1952	4.7	1979	4.6	1972	3.9
510.000	44.4	1488	1939	4.8	1968	5.9	1943	5.0	1924	4.9	1951	4.8	1945	4.0
560.000	31.5	1280	1813	4.7	1848	5.0	1829	4.6	1804	4.8	1817	4.0	1822	3.6
620.000	21.1	997	1572	4.3	1626	4.6	1624	3.9	1576	3.7	1601	3.4	1600	3.0
665.000	16.4	883	1513	4.2	1579	3.8	1573	3.8	1501	3.0	1546	3.8	1542	2.8
674.000	15.7	707	1301	3.8	1358	3.6	1353	3.2	1292	2.7	1328	2.9	1326	2.3
681.000	15.1	745	1293	3.6	1347	3.2	1343	2.9	1285	2.7	1316	2.9	1317	2.1
709.000	12.7	785	1390	4.1	1447	4.1	1443	4.1	1373	2.9	1412	3.7	1413	3.0
754.000	10.3	605	1096	3.7	1143	3.7	1142	3.4	1089	2.8	1116	3.2	1117	2.9
761.000	6.1	232	488	1.2	509	1.2	509	1.4	485	1.2	498	1.4	498	1.0
764.000	7.1	305	643	1.6	672	2.0	672	1.8	641	1.8	658	1.8	657	1.5
768.000	7.6	330	541	1.5	568	1.5	564	1.3	541	1.4	555	1.6	554	1.1
779.000	9.2	812	1467	4.2	1535	4.7	1527	5.4	1467	4.0	1507	4.4	1501	3.9
865.000	6.2	666	1221	3.6	1287	3.8	1258	3.7	1205	3.7	1238	2.9	1242	2.8
885.000	6.0	395	808	2.3	848	1.9	834	2.0	799	1.7	815	2.1	821	1.5
900.000	4.7	308	679	1.4	714	2.0	704	1.7	670	1.5	683	1.5	690	1.2
940.000	2.4	203	527	1.3	549	1.5	551	1.3	510	1.1	522	1.3	532	0.9
1020.000	3.9	152	336	0.8	358	1.2	358	0.8	318	0.7	338	0.9	342	0.6



2.5 Geometric Calibration/Validation

2.5.1 OLCI-A

OLCI-A georeferencing performance is compliant since the introduction of MPC Geometric Calibration, put in production on the 14th of March 2018. It has however significantly improved after its last full revision of GCMs (Geometric Calibration Models, or platform to instrument alignment quaternions) and IPPVMs (Instrument Pixels Pointing Vectors) both derived using the GeoCal Tool and put in production on 30/07/2019.

The following figures (Figure 58 to Figure 63) show time series of the overall RMS performance (requirement criterion) and of the across-track and along-track biases for each camera. New plots (Figure 64 and Figure 65) introduce monitoring of the performance homogeneity within the field of view: georeferencing errors in each direction at camera transitions (difference between last pixel of camera N and first pixel of camera N+1) and within a given camera (maximum bias minus minimum inside each camera). The performance improvement since the 30/07/2019 is significant on most figures: the global RMS value decreases form around 0.35 to about 0.2 (Figure 58), the across-track biases decrease significantly for all cameras (Figure 59 to Figure 63), the along-track bias reduces for at least camera 3 (Figure 61) and the field of view homogeneity improves drastically (Figure 64 and Figure 65, but also reduction of the dispersion – distance between the ± 1 sigma lines – in Figure 59 to Figure 63).



Figure 58: 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 59: across-track (left) and along-track (right) OLCI-A georeferencing biases time series for Camera 1. Blue line is the average, black lines are average plus and minus 1 sigma.



Figure 60: same as Figure 59 for Camera 2.



Figure 62: same as Figure 59 for Camera 4.



Figure 63: same as Figure 59 for Camera 5.



Figure 64: OLCI-A spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left).



Figure 65: OLCI-A spatial along-track misregistration at each camera transition (left) and maximum amplitude of the along-track error within each camera (left).

2.5.2 OLCI-B

Georeferencing performance of OLCI-B improved significantly with the fourth geometric calibration introduced the 30/07/2019. However, the instrument pointing is still evolving, in particular for camera 2 (Figure 72) and a new geometric calibration has been done and introduced in the processing chain on the 16th of April 2020. Its impact is significant on the along-track biases of all cameras (Figure 67 to Figure 71), but also on the continuity at camera interfaces (Figure 72, left) and on intra-camera homogeneity (Figure 72, right). Since then, further adjustments to the geometric calibration have been introduced, mainly to correct the along-track drifts. The most recent was put in production on 29/07/2021and its effect can be seen e.g. on left graphs of Figure 68, Figure 69 and Figure 71 (across-track biases of cameras 2, 3 & 5).



Figure 66: overall OLCI-B georeferencing RMS performance time series over the whole monitoring period (left) and corresponding number of validated control points (right)



Figure 67: across-track (left) and along-track (right) OLCI-B georeferencing biases time series for Camera 1.



Figure 68: same as Figure 67 for Camera 2.



Figure 71: same as Figure 67 for Camera 5.



Figure 72: OLCI-B spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left).



Figure 73: OLCI-B spatial along-track misregistration at each camera transition (left) and maximum amplitude of the along-track error within each camera (left).



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 http://s3etrac.acri.fr/index.php?action=generalstatistics.

- 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 74) and OLCI-B (Figure 75).


Figure 74: summary of S3ETRAC products generation for OLCI-A (number of OLCI-A L1 products Ingested, blue – number of S3ETRAC extracted products generated, green – number of S3ETRAC runs without generation of output product (data not meeting selection requirements), yellow – number of runs ending in error, red, one plot per site type).



Figure 75: 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).

3.1.2 Radiometric validation with DIMITRI

There has been no new result during the reporting period. Last figures (reported in the May issue of the OLCI Data Quality Report) are considered valid.

3.1.3 Radiometric validation with OSCAR

OSCAR Rayleigh results

The OSCAR Rayleigh have been applied to the S3A and S3B S3ETRAC data from the 6 oceanic calibration sites (Table 3) using a new chlorophyll climatology which has been derived from the CMEMS OLCI monthly CHL products from considering the years 2017, 2018 and 2019.



Site Name	Ocean	North Latitude	South Latitude	East Longitude	West 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
AtlN	North of Atlantic	27	17	-44.2	-62.5
AtlS	South of Atlantic	-9.9	-19.9	-11	-32.3
IndS	South of Indian	-21.2	-29.9	100.1	89.5

Table 3: S3ETRAC Rayleigh Calibration sites

In Figure 76 the average OSCAR OLCI-A and OLCI-B Rayleigh results are given for July 2022. In Figure 77 and Table 4 the average of all 2022 scenes currently processed with this new climatology is given.

The plot for this month's results indicates a much lower value for band Oa2 and slightly lower for Oa3. This is due to the limited number of data selected for the post processing of these results, as indicated by the increased error bar.



OSCAR Rayleigh OLCI-3A&B July 2022

Figure 76: OSCAR Rayleigh S3A and S3B Calibration results as a function of wavelength for July 2022. The results are obtained with a new climatology derived from CMEMS OLCI monthly CHL products.





Figure 77. OSCAR Rayleigh S3A and S3B Calibration results as a function of wavelength for Jan – July 2022. Average and standard deviation over all scenes currently (re)processed with the new climatology.



July 2022

Table 4. OSCAR Rayleigh calibration results for S3A and S3B (average and standard deviation over all 2022acquisitions) over all scenes currently (re)processed with the new climatology and observed difference (in %)between OLCIA and OLCIB

OLCI	Wavelength	Oscar Rayleigh OLCIA		Oscar Rayl	eigh OLCIB	% difference
band	(nm)	avg	stdev	avg	stdev	OLCIA and
Oa01	400	1.048	0.030	0.989	0.015	5.59%
Oa02	412	1.058	0.031	1.012	0.016	4.38%
Oa03	443	1.050	0.028	1.029	0.029	2.01%
Oa04	490	1.046	0.017	1.027	0.020	1.86%
Oa05	510	1.025	0.011	1.010	0.020	1.48%
Oa06	560	1.016	0.009	1.004	0.012	1.16%
Oa07	620	1.011	0.007	1.001	0.007	1.00%
Oa08	665	1.016	0.005	1.008	0.005	0.81%
Oa09	674	1.018	0.005	1.013	0.017	0.50%
Oa10	681	1.015	0.005	1.007	0.006	0.81%
Oa11	709	1.000	0.006	0.993	0.008	0.63%
Oa12	754	1.009	0.002	1.008	0.002	0.14%

3.1.4 Radiometric validation with Moon observations

There has been no new result during the reporting period. Last figures (reported in Data Quality Report for February 2022) are considered valid.



4 Level 2 Land products validation

4.1 [OLCI-L2LRF-CV-300]

4.1.1 Routine extractions

- The focus for this time period has been on the rolling archive Non Time Critical (NT) data until the 31st of July 2022. 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 June 2016 and April 2018 for S3A and S3B respectively.

4.1.1.1 OLCI-A

Figure 78 to Figure 87 below present the Core Land Sites OLCI-A time series over the current period.



Figure 78: DeGeb time series over current report period



Figure 79: ITCat time series over current report period



Figure 80: ITIsp time series over current report period



Figure 81: ITSro time series over current report period



Figure 82: ITTra time series over current report period



Figure 83: SPAli time series over current report period



Figure 84: UKNFo time series over current report period



Figure 85: USNe1 time series over current report period



Figure 86: USNe2 time series over current report period



Figure 87: USNe3 time series over current report period

4.1.1.2 OLCI-B

Figure 88 to Figure 97 below present the Core Land Sites OLCI-B time series over the current period.



Figure 88: DeGeb time series over current report period



Figure 89: ITCat time series over current report period





Figure 91: ITSro time series over current report period





Figure 93: SPAli time series over current report period





Figure 95: USNe1 time series over current report period





Figure 97: USNe3 time series over current report period

4.1.2 Comparisons with MERIS MGVI and MTCI climatology

There has been no new result during the reporting period. Last figures (reported in OLCI Data Quality Report covering May 2022) are considered valid.

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

For the OPT-MPC a more systematic QC of the cloud masking was proposed, to better fulfil the needs of the DQR and in general for a good data quality monitoring. A TN defining the validation and monitoring methodologies is currently generated. This activity includes the generation of a data collection plan for the following planned QC activities:

- Routine (PixBox) pixel collection/validation
- Critical scene collection/analysis
- Aeronet cloud products (Study)
- L3 generation
- Quality Control (QC) using ground-based sky cameras.

In this DQR we want to briefly explain the method listed last, the QC using ground-based sky cameras. And show results from an initial test validation and also for July 2022.



4.2.1 Sky Camera based validation approach

In the aftermath of the Cloud Mask Intercomparison exercise (CMIX), the idea of a network of low-cost ground-based sky cameras (stereo) was born, to provide an objective and sensor independent source for cloud mask validation. The sky camera design was developed by NASA GSFC and University of Maryland¹. Within the framework of ESA's Quality assurance framework for earth observation (QA4EO), a pair of sky cameras (SC) was installed at La Sapienza University in Rome. The objective of the project was to analyse the usage of ground-based sky cameras, as an independent validation source for satellite cloud masking algorithms. The scope of this work was to prototype algorithms and methods to process sky camera data and compare them with satellite-based cloud masks.

4.2.1.1 Instrumentation setup:

- A set of two cameras (stereo pair) was setup at La Sapienza University in Rome (see Figure 98).
- The cameras use a Raspberry Pi 4 and the Omnivision OV5647 sensor. The field of view is 194 (horizontal) and 142 (vertical). Distance between cameras is around 260 meters. Currently, the cameras are collecting data every minute between 08:00 and 14:00 UTC.







Sky Camera 1: Marconi

Sky Camera 2: Fermi

Figure 98: Sky camera setup

4.2.1.2 Pre-processing of the SC data:

Pre-processing of sky camera data is needed to better match the satellite observations

¹ Skakun, S., Vermote, E. F., Santamaria-Artigas, A., Rountree, W. H., & Roger, J. C. (2021). An experimental sky-image-derived cloud validation dataset for Sentinel-2 and Landsat 8 satellites over NASA GSFC. International Journal of Applied Earth Observation and Geoinformation, 95, 102253.



- Crop: Reduce geometric distortion (increasing outside of the centre).
- Rotate: The SCs are installed looking a bit northwest.
- Flip: The SC is looking from the ground up and the satellite does the opposite.

4.2.1.3 Automated classification of the SC data:

Since the SC data cannot be classified manually in an operational setup, a classification method for the SC data was needed. Two Random Forest classifiers (one for each SC) have been trained and validated against manual classifications.

Validation of the RF classifier shows high accuracy between 93% and 96% Overall Accuracy (OA), as shown in Figure 99 and Figure 100.

_		Sky Cu	incra 1 man	dui clubbilico		
ımera 1 automatic classificatio	Class	Clear	Cloud	Sum	U A	Е
	CLEAR	30	2	32	93.8	6.2
	CLOUD	2	27	29	93.1	6.9
	Sum	32	29	61		
	ΡA	93.8	93.1		OA:	93.44
Sky Ca	E	6.2	6.9		BOA:	93.45

SkyCam 1 manual classification vs. SkyCam 1 auto classification Sky Camera 1 manual classification

> Scotts Pi: 0.868 Krippendorfs alpha: 0.869 Cohens kappa: 0.868

Figure 99: Validation results of RF classifier for SC1



SkyCam 2 manual classification vs. SkyCam 2 auto classification

c		Sky Ca	mera 2 man	ual classifica	ition	
imera 2 automatic classificatio	Class	Clear	Cloud	Sum	U A	Е
	CLEAR	38	1	39	97.4	2.6
	CLOUD	1	26	27	96.3	3.7
	Sum	39	27	66		
	ΡA	97.4	96.3		OA:	96.97
iky Ca	E	2.6	3.7		BOA:	96.85

Scotts Pi: 0.937 Krippendorfs alpha: 0.937 Cohens kappa: 0.937

Figure 100: Validation results of RF classifier for SC2

4.2.1.4 Test validation for OLCI – automatic SC classification

Sky Camera validation over Rome Using 2021 LFR data

SC 1 automatic classification vs. OLCI L2 LFR Cloud & Ambiguous & Margin

Sky Camera 1

	Class	Clear	Cloud	Sum	UA	E
	CLEAR	136	7	143	95.1	4.9
-2 LFR	CLOUD	53	86	139	61.9	38.1
OLCI I	Sum	189	93	282		
	ΡA	72.0	92.5		OA:	78.72
	E	28.0	7.5		BOA:	82.25

Scotts Pi: 0.56 Krippendorfs alpha: 0.561 Cohens kappa: 0.572

Figure 101: 2021 test validation results for OLCI FR using reference data from SC1

A test was made with all Sentinel-3 OLCI L2 data between 01.01.2021 and 31.12.2021. 282 matchups have been identified between the SC sites and S3 OLCI overpasses. One OLCI pixel over SC site is validated against cloud fraction in a defined window of SC. The SC cloud is defined as 50% cloud cover in 500x500 pixel window. This definition was chosen as a starting point and needs to be adapted. The results (Figure



101) show comparably low OA of 78%. This is due to the skewed reference data (189 clear vs. 93 cloud). Calculation of balanced overall accuracy (BOA) can correct for this and leads to a BOA of 82%.

These numbers are quite comparable with the validation results of OLCI PixBox validation (2021) over land surfaces, as shown in Figure 102.

Sky Camera validation over Rome Using 2021 LFR data

PixBox validation 2021 using 2018 data over land surfaces

SC 1 automatic classification vs. OLCI L2 LFR Cloud & Ambiguous & Margin Sky Camera 1

	Class	Clear	Cloud	Sum	U A	E	
	CLEAR	136	7	143	95.1	4.9	
-2 LFR	CLOUD	53	86	139	61.9	38.1	
OLCI I	Sum	189	93	282			
	ΡA	72.0	92.5		OA:	78.72	
	E	28.0	7.5		BOA:	82.25	
Scotts Di: 0.56							

Krippendorfs alpha: 0.561 Cohens kappa: 0.572 OLCI A+B FR IdePix cloud val. - land surfaces

			III-Situ Da	labase		
	Class	Clear	Cloud	Sum	U A	E
OLCI FR IdePix	CLEAR	3442	443	3885	88.6 75.4	11.4
	CLOUD	1039	3183	4222		24.6
	Sum	4481	3626	8107		
	ΡA	76.8	87.8		OA:	81.72
	E	23.2	12.2		BOA:	82.3

Scotts Pi: 0.634 Krippendorfs alpha: 0.634 Cohens kappa: 0.635

Figure 102: Comparison between PixBox and Sky Camera validation

Again, the skewed distribution of SC classification hinders the comparison a bit. Nevertheless, the BOA is quite comparable.

4.2.2 Sky Camera based validation – prototype results July 2022

Figure 103 shows the prototype validation results for July 2022. The weather in July around Rome is always quite arid. Therefore, all SC observation show no clouds. This lack of cloud observations unfortunately makes the interpretation of the results a bit complicated since the calculation of a BOA makes no sense if not at least a few cloud observations are present. Nevertheless, the detection of the clear cases is very good.



SC 1 automatic classification vs. OLCI L2 LFR Cloud & Ambiguous & Margin

	Sky Camera 1								
	Class	Clear	Cloud	Sum	U A	Е			
OLCI L2 LFR	CLEAR	36	0	36	100.0	0.0			
	CLOUD	2	0	2	0.0	100.0			
	Sum	38	0	38					
	ΡA	94.7	0		OA:	94.74			
	E	5.3	100		BOA:	47.35			

Scotts Pi: -0.027 Krippendorfs alpha: -0.013 Cohens kappa: 0.0

Figure 103: Confusion matrix showing validation results for OLCI L2 cloud screening against SC1 automated classification



5 Validation of Integrated Water Vapour over Land & Water

The OLCI L2 IWV processor distinguishes between ocean and land surfaces and works very differently above the respective surfaces. The algorithm above water shows some serious flaws, nevertheless we use comparison to ground truth as a stability measure, since the ocean retrievals belong to low light conditions in contrast to land retrievals.

OLCI's IWV 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 version 3 level 1.5 (Holben et al 1998, Gilles et al 2019), using atmospheric transmission measurements at 0.9μm

The focus for the routine observation is on L2 *wrr NT* (Ocean Colour Product, reduced resolution, non time critical). SUOMI NET and AERONET level 1.5 are used as ground truth.

OLCI A data partly belong to reprocessed data if processed before Nov. 2017. The ocean colour products from OLCI A have been taken from EUMETSAT's rolling archive CODA (Copernicus Online Data Access) CODA (<u>https://coda.eumetsat.int/#/home</u>) or reprocessed OLCI A CODAREP (<u>https://codarep.eumetsat.int/#/home</u>) websites. All OLCI B data is from EUMETSAT's CODA.

SUOMI NET provides by far the most data with an almost near real time availability and a low uncertainty. On this account, we choose it as the principal for system monitoring. 640000 (OLCI-A) and 326000 (OLCI-B) potential matchups within the period of June 2016 (OLCI-A) January 2019 (OLCI-B) to August 2022 have been analysed yet. The global service of SUOMI-NET has been reduced at the end of 2018; thus OLCI-B colocations are rare outside North America.

Figure 104 is summarizing the results of the comparisons. Nothing has changed with respect to the previous comparisons. But we found that the number of valid matchups did hardly increase compared to the last investigations (OLCI-A: $35454 \rightarrow 35456$, OLCI-B: $19812 \rightarrow 19816$), although the number of potential colocations increase by approximately 20000 for each instrument. This is unphysical and we started an error diagnostic. Eventually it turned out that the orbit location procedure of CODA returns wrong results for all reduced resolution orbits since April 2022. Thus, we have no new SUOMI NET comparisons since April. The comparisons with AERONET are based on full resolution data (WFR), which is not affected by the CODA bug, further the spatial distribution of AERONET data covers the globe better than SUOMI NET, thus we take it as the principal stability indicator, ignoring of the fact that AERONET water vapour retrievals show a dry bias (Perez-Ramirez et al 2014). The temporal evolution of several quality measures (Figure 105 compared to SUOMI NET, Figure 106 compared to AERONET), indicates small seasonal variations, which are certainly related to retrieval assumptions. Apart from these features, neither systematic temporal changes nor differences between OLCI A and B have been observed



Similar investigations have been performed for water surfaces using AERONET –OC data as reference. As mentioned before, the quality over ocean is much worse, but neither a temporal evolution nor an instrumental difference is perceivable (Figure 107).

The CODA service will be discontinued in Sep 2022. As a replacement SENTINEL-3 data has been integrated in the EUMETSAT datastore (<u>https://data.eumetsat.int/</u>). The future IWV quality monitoring will be based on this.



Figure 104: Upper: Scatter plot of the IWV products, derived from OLCI (A left, B right) above land and from SUOMI NET GNSS measurements. Middle: Histogram of the difference between OLCI (A: left, B: right) and GNSS (blue: original OLCI, orange: bias corrected OLCI). Lower: Positions of the GNSS (A: left, B: right).



Figure 105: Temporal evolution of different quality measures for OLCI A (left) and OLCI B (right) with respect to SUOMI Net. From top to bottom: systematic deviation factor, bias, root mean squared difference (with and without bias correction), explained variance (number in boxes are the numbers of matchups)



Figure 106: As Figure 105 but with respect to Aeronet version 3 level 1.5



Figure 107: Upper: Scatter plot of the IWV products, derived from OLCI (A left, B right) above sea against AERONET-OC measurements. Lower: Temporal evolution of different quality measures for OLCI A (left) and OLCI B (right) with respect to AERONET-OC. From top to bottom: systematic deviation factor, bias, root mean squared difference (with and without bias correction), explained variance (number in boxes are the numbers of matchups).

2019

2017

2015

2019

2020

2021

2022



6 Level 2 SYN products validation

6.1 SYN L2 SDR products

There has been no new result during the reporting period. Most recent performance figures can be found in the S3MPC OPT Annual Performance Report - Year 2021 (S3MPC.ACR.APR.009, issue 1.0, 08/12/2021), available on-line at:

https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-olci/document-library.

6.2 SY_2_VGP, SY_2_VG1 and SY_2_V10 products

6.2.1 Data quality improvement following the last processing baseline

The last processing baseline – SYN_L2_.002.16.00, delivered on 14/07/2022 – has been deployed on S3A production service on the 23rd of August and will be soon deployed on S3B production service.

This processing baseline provides important improvement regarding VGT-like product quality.

First, some data gaps, distributed like draughtboard, were observed in VG1 product on high latitude and only on the western side of the OLCI orbits. These patterns were also visible in VGP products (see left panel on Figure 108) and were affecting all radiometric datasets but also the contextual parameters such as surface flag.

This issue is now corrected, unfilled plate-carrée pixels are now cosmetically filled using the first filled pixel found amongst the direct neighbours (see right panel on Figure 108). The land/sea surface classification is well provided for all pixels.



Figure 108; B2 VGP channel with blue background - Left: PB SYN_L2_.002.15.00 , Right: PB SYN_L2_.002.16.00

Another issue was the possibility, on VGP and VG1 products, to have pixels with radiometry set to NaN and the status map set to "GOOD" regrading radiometric data. This issue was valid for all VGT bands and appears mostly on inland waters pixels.

A full review of the status map and of the internal handling of inland water surface classification has been performed. The latest processing baseline is then improving the handling of Fillvalue pixels or erroneous pixels to avoid any contamination in the band mapping and/or in the projection process.

The resulting VGT-like product is no longer including unfilled pixel with a status map set to "GOOD" radiometry and including better representation of the surface.

Finally, we modify the treatment of some saturated parameters to consolidate the consistency between all datasets and avoid having pixels with GOOD B2 and B3 radiometry but no NDVI value.

Previously, any saturated NDVI value – i.e., lying outside the expected range of [-0.08; 0.92] – was replaced by a _FillValue. Thanks to the last processing baseline, any saturated NDVI value is replaced by the valid_max/min value, i.e., -0.008 or 0.92 when appropriate.

Same treatment is applied on the Aerosol Optical Depth on all VGT-like products.

Note however that no specific flag has been defined to identify saturated value. This evolution is planned for the next processing baseline delivery.



6.2.2 Validation against PROBA-V archive

The similarity of SYN VGT like products with the PROBA-V archive is evaluated through intercomparison of 10-daily composites extractions over LANDVAL [1] sites. Since there is no overlap with the PROBA-V nominal operational phase and no PROBA-V Collection 2 climatology is available yet, direct comparison is done by comparing the SY_2_V10 NTC products starting January/2021 with those of PROBA-V S10-TOC since January/2018.

The temporal evolution of statistics results below is based on intercomparison over the entire periods up to June/2022. The scatterplots are based on intercomparison between SY_2_V10 products of July/2022 with PROBA-V Collection 2 S10-TOC products of July/2019.

Products availability

Availability of SY_2_VG1 and SY_2_V10 products is checked through an automated query and download via the Copernicus Collaborative Node and the Copernicus Open Access Hub feeding the products database Belgian Collaborative Ground Segment (Terrascope, <u>www.terrascope.be</u>).

For the month July/2022, there were no problems with products availability.

Statistical consistency

The scatter density plots with geometric mean regression equation, coefficient of determination (R^2) and APU statistics based on intercomparison between SY_2_V10 products of July/2022 with PROBA-V Collection 2 products of July/2019 are shown in Figure 109. The APU statistics are defined as: Accuracy (A) or average bias, Precision (P) or the standard deviation of the bias, and Uncertainty (U) or the Root Mean Squared Distance. Accuracy is best for BLUE (< 1%), less good for RED and NIR (~2%) and worse for SWIR (~-8%). The relatively large values for Precision (large scatter, low R²) are related to the fact that products of two different years are compared. The disagreement for the SWIR band is related to the SLSTR calibration offset (in bands S5 and S6).



Figure 109: Scatter density plots between SY_V10 S3A (top) or S3B (bottom) and PROBA-V C2 S10-TOC for BLUE, RED, NIR and SWIR bands (left to right), July/2022 vs. July /2019

Temporal consistency

The temporal evolution of APU statistics derived from intercomparison of SY_2_V10 NTC products January/2021 – July/2022 with those of PROBA-V S10-TOC January/2018 – July/2019 (Figure 110). The



APU statistics show stable evolution over time, although some seasonal pattern is observed for the mainly the SWIR channel, and to a lesser extent the RED and NIR channel. The temporal behaviour is stable.



Figure 110: Temporal evolution of APU statistics between SY_2_V10 S3A (left) or S3B (right) and PROBA-V S10-TOC for BLUE, RED, NIR and SWIR bands (top to bottom), January/2021- July /2022 vs. January /2018- July/2019

References

 B. Fuster *et al.*, "Quality Assessment of PROBA-V LAI, fAPAR and fCOVER Collection 300 m Products of Copernicus Global Land Service," *Remote Sens.*, vol. 12, no. 6, p. 1017, Mar. 2020, doi: 10.3390/rs12061017.

6.3 SYN L2 AOD NTC products

There has been no new result during the reporting period. Last figures (reported in OLCI Data Quality Report covering May 2022) are considered valid.



7 Events

For OLCI-A, three Radiometric Calibration sequences have been acquired during the reported period:

- So1 sequence (diffuser 1) on 06/07/2022 22:51 to 22:53 (absolute orbit 33255)
- So1 sequence (diffuser 1) on 22/07/2022 22:37 to 22:39 (absolute orbit 33483)
- S05 sequence (diffuser 2) on 23/07/2022 00:18 to 00:20 (absolute orbit 33484)

For OLCI-B, three Radiometric Calibration sequences have been acquired during the reported period:

- So1 sequence (diffuser 1) on 08/07/2022 09:32 to 09:34 (absolute orbit 21882)
- So1 sequence (diffuser 1) on 24/07/2022 09:18 to 09:20 (absolute orbit 22110)
- S05 sequence (diffuser 2) on 24/07/2022 10:59 to 11:01 (absolute orbit 22111)



8 Appendix A

Other reports related to the Optical mission are:

- S2 L1C MSI Data Quality Report, July 2022 (ref. OMPC.CS.DQR.001.02-2022 i77r0)
- S2 L2A MSI Data Quality Report, July 2022 (ref. OMPC.CS.DQR.002.02-2022 i51r0)
- Data Quality Report Sentinel-3 SLSTR, July 2022, (ref. OMPC.RAL.DQR.04.07-2022)

All Data Quality Reports, as well as past years Data Quality Reports and Annual Performance Reports, are available on dedicated pages in Sentinel Online website, at:

- https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-olci/data-guality-reports
- https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-3-slstr/data-qualityreports
- OPT Annual Performance Report Year 2021 (PDF document)

End of document