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

S3-A OLCI Cyclic Performance Report

Cycle No. 035

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List of Changes

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1 Processing Baseline Version

IPF	IPF / Processing Baseline version	Date of deployment
OL1	06.08 / 2.38	CGS: 29/08/2018 09:24 UTC PAC: 29/08/2018 09:33 UTC
OL2	06.12 / 2.38	CGS: 29/08/2018 09:24 UTC PAC: 29/08/2018 09:33 UTC
SY2	06.14 / 2.39	PAC: 24/07/2018 07:12 UTC
SY2_VGS	06.06 / 2.26	PAC: 11/01/2018 10:52 UTC



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2 Instrument monitoring

2.1 CCD temperatures

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.

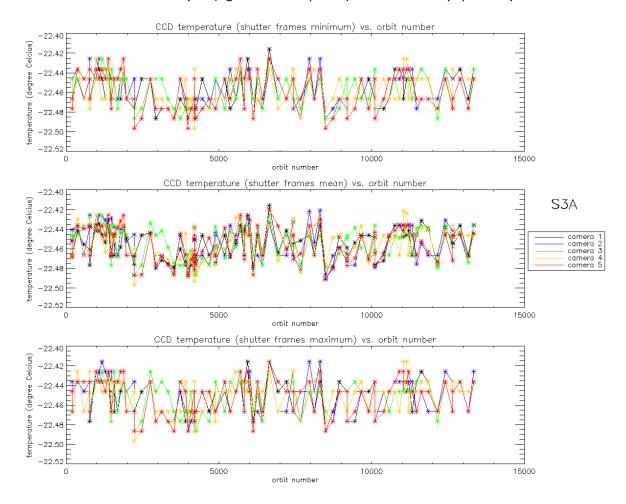


Figure 1: long term monitoring of CCD temperatures using minimum value (top), time averaged values (middle), and maximum value (bottom) provided in the annotations of the Radiometric Calibration Level 1 products, for the Shutter frames, all radiometric calibrations so far.

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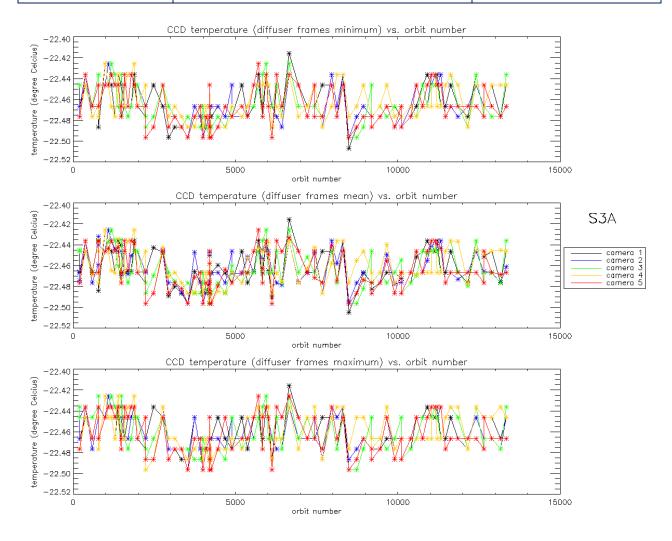


Figure 2: Same as Figure 1 for diffuser frames.

2.2 Radiometric Calibration

Two OLCI Radiometric Calibration Sequence has been acquired during Cycle 035:

- S01 sequence (diffuser 1) on 27/08/2018 23:25 to 23:26 (absolute orbit 13164)
- So1 sequence (diffuser 1) on 09/09/2018 21:08 to 21:10 (absolute orbit 13348)

The acquired Sun azimuth angles are presented on Figure 3, on top of the nominal values without Yaw Manoeuvre (i.e. with nominal Yaw Steering control of the satellite).



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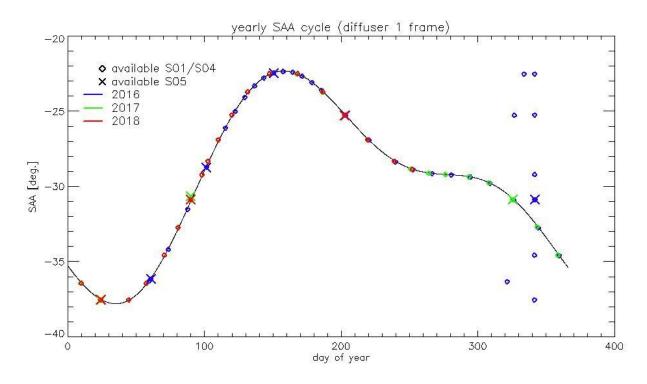


Figure 3: Sun azimuth angles during acquired Radiometric Calibrations (diffuser frame) on top of nominal yearly cycle (black curve). Diffuser 1 with diamonds, diffuser 2 with crosses, 2016 acquisitions in blue, 2017 in green, 2018 in red.

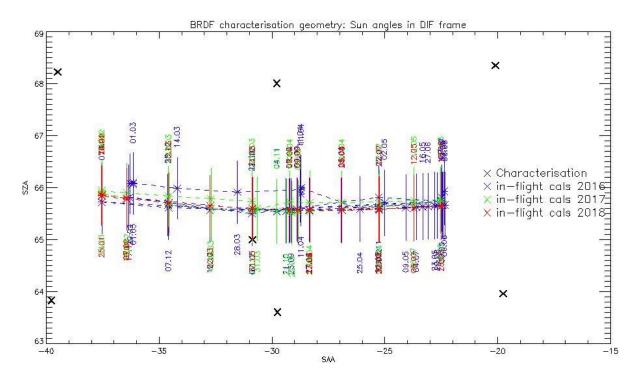


Figure 4: Sun geometry during radiometric Calibrations on top of characterization ones (diffuser frame)

This section presents the overall monitoring of the parameters derived from radiometric calibration data and highlights, if present, specificity of current cycle data.



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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 5.

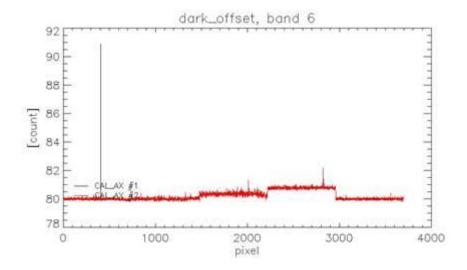


Figure 5: Dark Offset table for band Oa06 with (red) and without (black) HEP filtering (Radiometric Calibration of 22 July 2017). The strong HEP event near pixel 400 has been detected and removed by the HEP filtering.

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

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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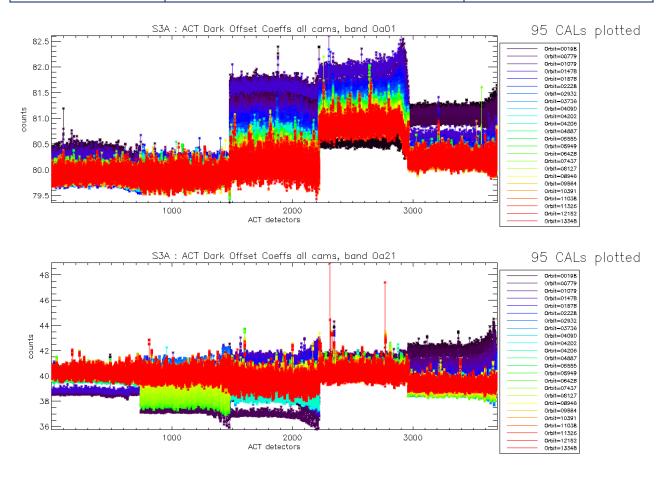


Figure 6: Dark Offset for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.



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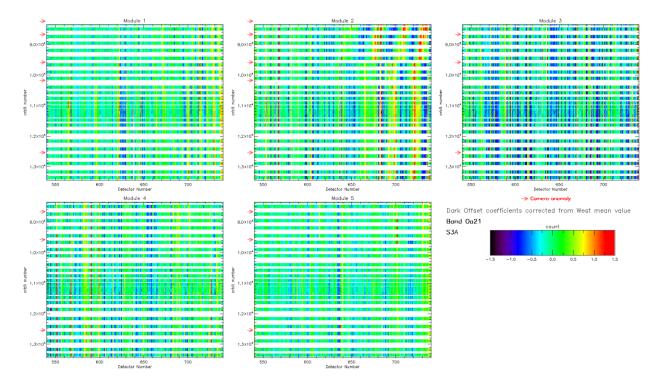


Figure 7: map of periodic noise for the 5 cameras, for band Oa21. X-axis is detector number (East part, from 540 to 740, where the periodic noise occurs), Y-axis is the orbit number. Y-axis range is focused on the most recent 5000 orbits. The counts have been corrected from the West detectors mean value (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. Periodic noise amplitude is high in camera 2, 3 and 4. It is lower in camera 4 and small in camera 1.

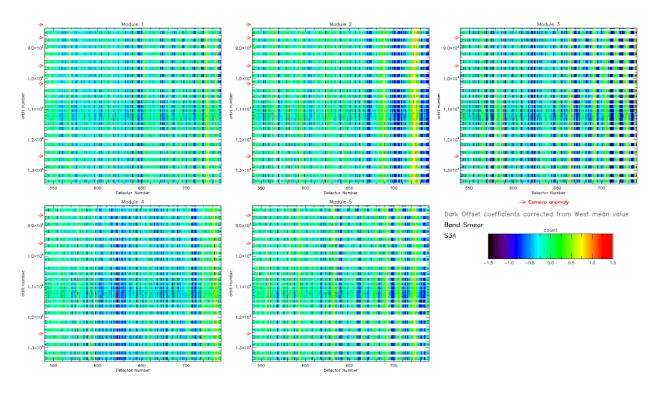


Figure 8: same as Figure 7 for smear band.



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Figure 7 and Figure 8 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 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 the last 5000 orbits.

As there was no camera anomaly during the current cycle, there is no sudden change of periodic noise to report during the current cycle. The hot pixel impacting one of the "East blind pixels" for camera 4 smear band, presented in cycle #26 report, is still present.

In PDGS, the dark levels are corrected using a CAL_AX containing reference Dark LUTs derived from the 25/01/2017 calibration. This CAL_AX was delivered to MPC-CC on 08/02/2018 and deployed in PDGS on 16/03/2018.

Dark Currents

Dark Currents (Figure 9) 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 10).

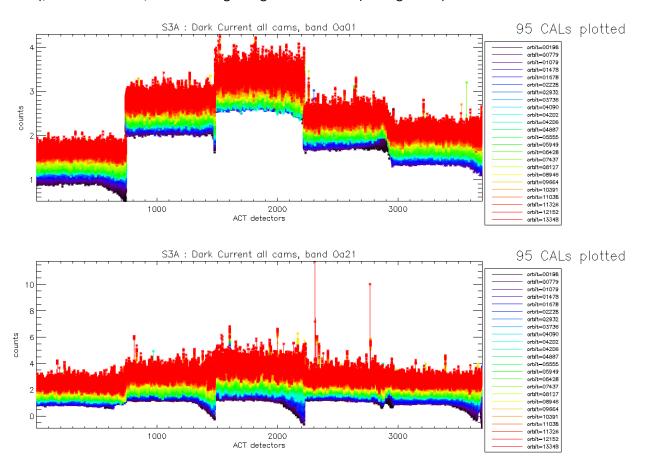


Figure 9: Dark Current for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.

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Sentinel-3 MPC

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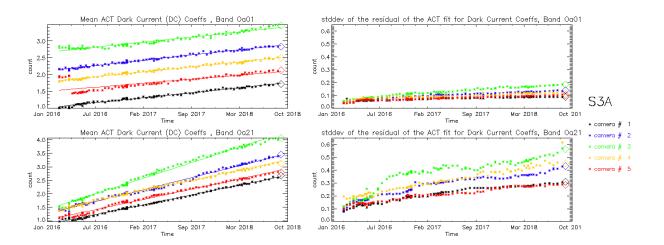


Figure 10: left column: ACT mean on 400 first detectors of Dark Current coefficients for spectral band Oa01 (top) and Oa21 (bottom). Right column: same as left column but for Standard deviation instead of mean. We see an increase of the DC level as a function of time especially for band Oa21. A possible explanation 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.

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

2.2.2.1 Instrument response monitoring

Figure 11 shows the gain coefficients of every pixel for two OLCI channels, Oa1 (400 nm) and Oa21 (1020 nm), highlighting the significant evolution of the instrument response since early mission.



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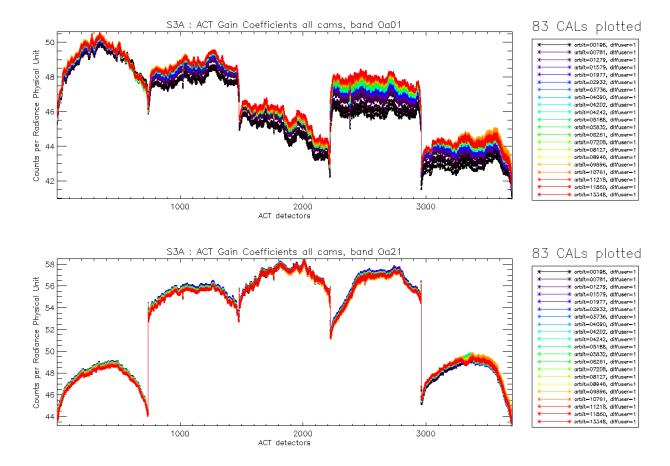


Figure 11: Gain Coefficients for band Oa1 (top) and Oa21 (bottom), all diffuser 1 radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.

The gains plotted in Figure 11, 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 12 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 significant evolution occurred during the early mission, the trends tend to stabilize, with the exception of band 1 of camera 1 and 4.



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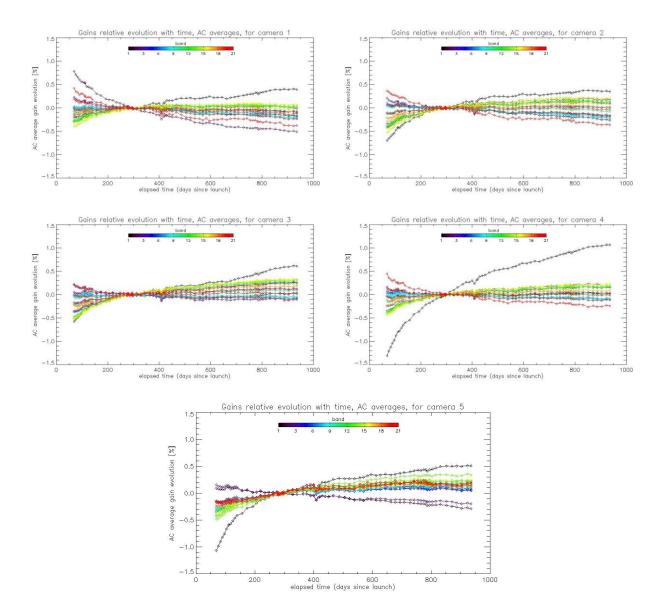


Figure 12: camera averaged gain relative evolution with respect to "best geometry" calibration (07/12/2016), as a function of elapsed time since the change in OLCI channels settings (25/04/16); one curve for each band (see colour code on plots), one plot for each module. The diffuser ageing has been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

2.2.2.2 Instrument evolution modelling

As mentioned in cycle #22 report, the OLCI Radiometric Model has been refreshed, and put in operations the 11/10/2017. The model has been derived on the basis of an extended Radiometric Calibration dataset (from 25/04/2016 to 27/08/2017), and 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 27 calibrations in extrapolation over about 13 months) remains better than 0.10% – except for channels Oa1 (400 nm), Oa2 (412.5 nm) and Oa21 (1020 nm) which are respectively < 0.28%, < 0.13% and < 0.17% – when averaged over the whole field of view (Figure 13) even if a small drift of the model with respect to most recent data is now visible. The previous model,



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trained on a Radiometric Dataset limited to 12/03/2017, shows a stronger drift of the model with respect to most recent data (Figure 14). Comparison of the two figures shows the improvement brought by the updated Model.

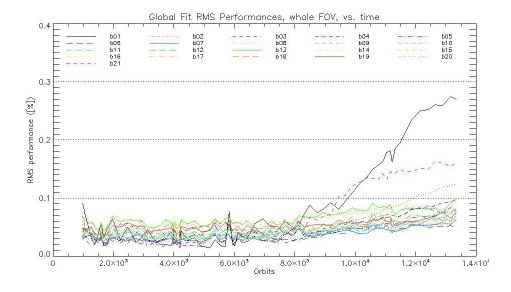


Figure 13: RMS performance of the Gain Model of current Processing Baseline as a function of orbit.

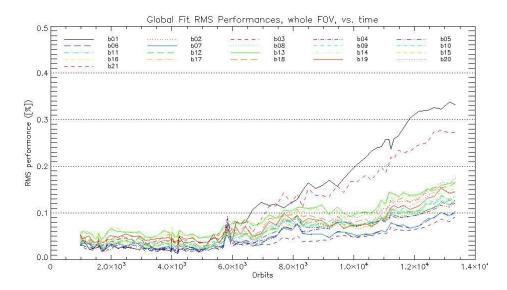


Figure 14: RMS performance of the Gain Model of previous Processing Baseline as a function of orbit.



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The overall instrument evolution since channel programming change (25/04/2016) is shown on Figure 15.

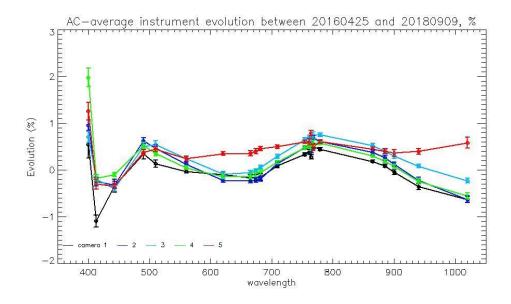


Figure 15: Camera-averaged instrument evolution since channel programming change (25/04/2016) and up to most recent calibration (09/09/2018) versus wavelength.

The overall per camera performance, as a function of wavelength, and at each orbit is shown on Figure 16 as the average and standard deviation of the model over data ratio.

Finally, Figure 17 to Figure 19 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 17 to Figure 19 with their counterparts in Report of Cycle 22 clearly demonstrate the improvement brought by the new model whatever the level of detail.

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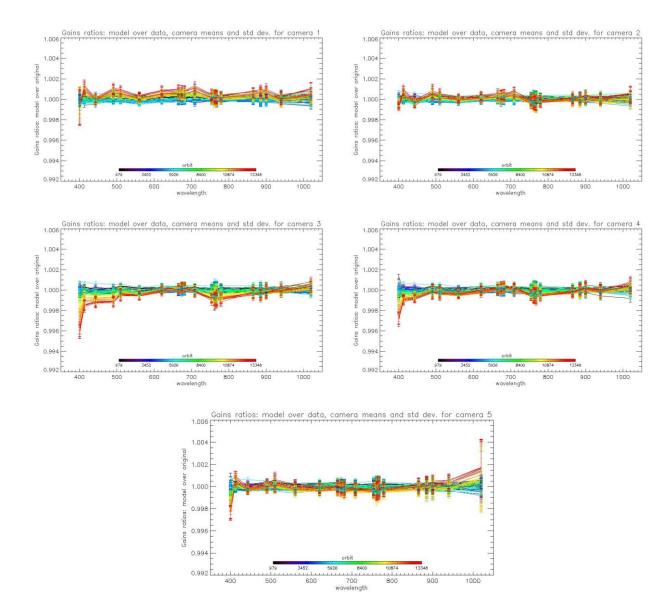


Figure 16: For the 5 cameras: Evolution model performance, as camera-average and standard deviation of ratio of Model over Data vs. wavelength, for each orbit of the test dataset, including 27 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent).

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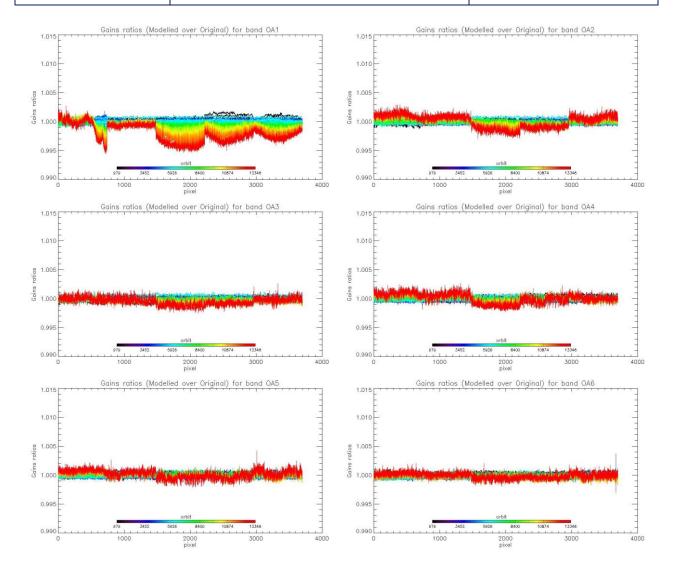


Figure 17: Evolution model performance, as ratio of Model over Data vs. pixels, all cameras side by side, over the whole current calibration dataset (since instrument programing update), including 27 calibrations in extrapolation, channels Oa1 to Oa6.

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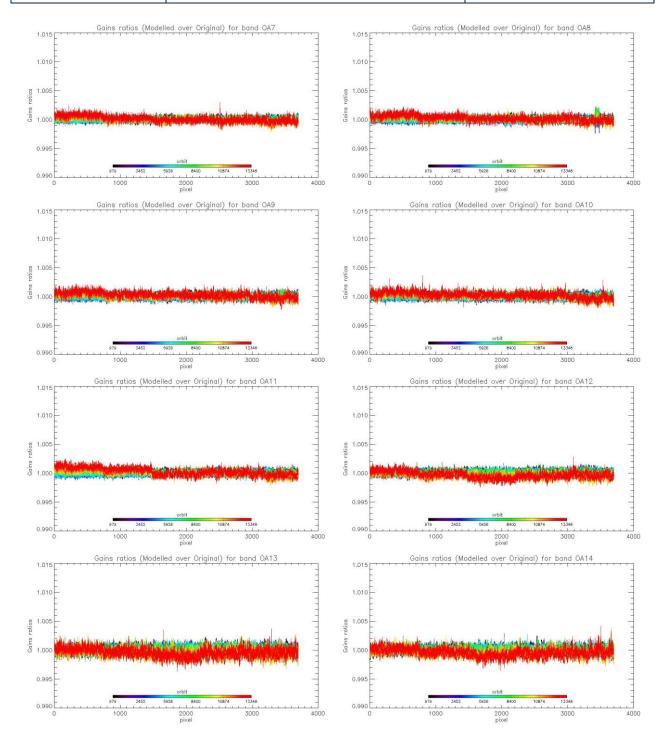


Figure 18: same as Figure 14 for channels Oa7 to Oa14.

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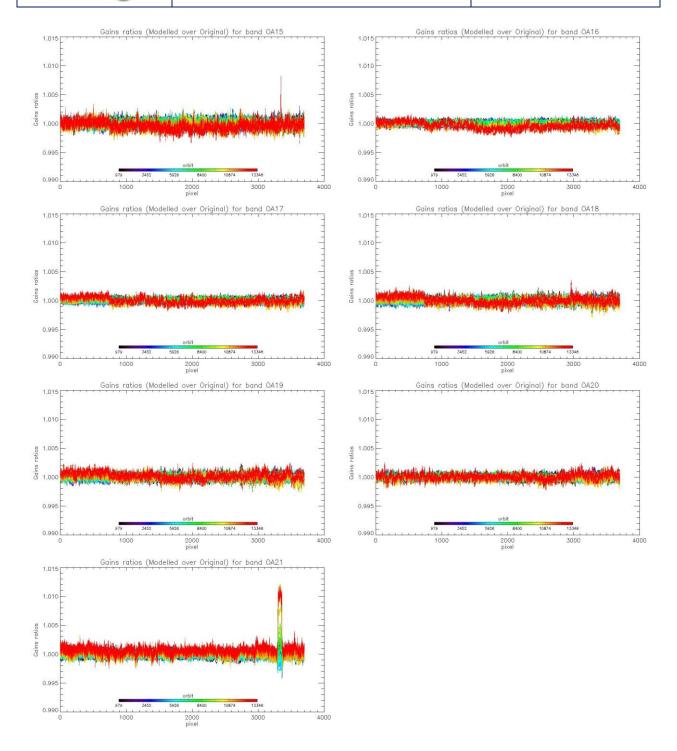


Figure 19: same as Figure 17 for channels Oa15 to Oa21.



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

There has been no calibration sequence S05 (reference diffuser) acquisition during cycle 035.

Consequently, the last updated results (cycle 033) are still valid.

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

There has been no Calibration ADF generation during the current cycle.

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]

This activity has not evolved during cycle 035 and results presented in Cycle 15 report are still valid.

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

There has been no Spectral Calibration (S02 + S03) acquisition during the reporting period.

Consequently, last results, presented in cycle 032 report are still valid.

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

2.4.1 SNR from Radiometric calibration data

SNR computed for all calibration data (S01, S04 and S05 sequences) as a function of band number is presented in Figure 20.

SNR computed for all calibration data as a function of orbit number for band Oa01 (the less stable band) is presented in Figure 21.

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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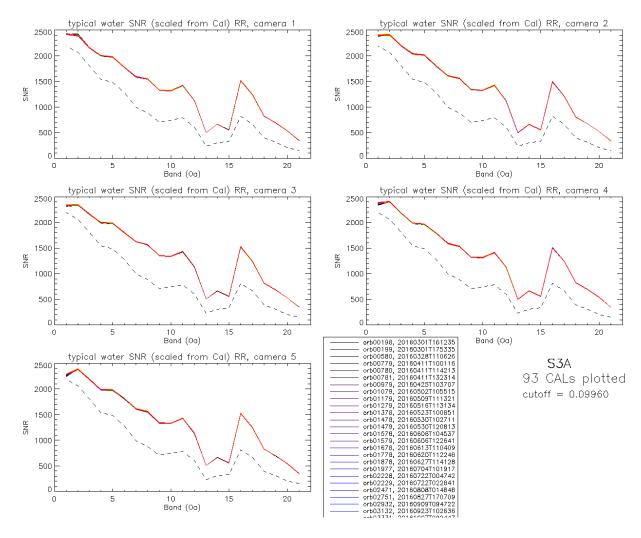


Figure 20: Signal to Noise ratio as a function of the spectral band for the 5 cameras. These results have been computed from radiometric calibration data. All calibrations except first one (orbit 183) are presents with the colours corresponding to the orbit number (see legend). The SNR is very stable with time: the curves for all orbits are almost superimposed. The dashed curve is the ESA requirement.

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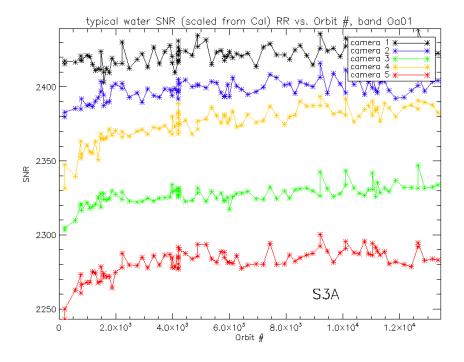


Figure 21: long-term stability of the SNR estimates from Calibration data, example of channel Oa1.

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: 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	C	1	C	2	C	3	C4	4	С	5	Α	II
nm	LU	RQT	avg	std	avg	std	avg	std	avg	std	avg	std	avg	std
400.000	63.0	2188	2421	6.1	2397	6.5	2327	6.6	2375	11.6	2281	9.4	2360	6.9
412.000	74.1	2061	2393	8.1	2408	5.5	2340	4.7	2402	4.6	2385	7.4	2385	4.3
442.000	65.6	1811	2160	5.2	2199	5.7	2165	4.8	2185	4.1	2197	5.0	2181	3.4
490.000	51.2	1541	2000	4.8	2036	5.2	1996	3.8	1982	3.9	1988	4.8	2000	3.4
510.000	44.4	1488	1979	5.2	2014	4.9	1984	4.8	1966	4.7	1985	4.6	1985	3.8
560.000	31.5	1280	1776	4.6	1802	4.3	1802	4.9	1794	3.9	1818	3.6	1798	3.1
620.000	21.1	997	1591	4.3	1610	4.1	1624	3.2	1593	3.4	1615	3.6	1607	2.7
665.000	16.4	883	1546	4.4	1558	4.5	1566	3.8	1533	3.9	1560	3.9	1553	3.3
674.000	15.7	707	1329	3.5	1338	3.6	1350	2.8	1323	3.1	1342	3.8	1336	2.5
681.000	15.1	745	1319	3.8	1327	3.1	1337	2.8	1314	2.6	1333	3.7	1326	2.3
709.000	12.7	785	1420	4.6	1420	4.3	1435	3.5	1413	3.6	1430	3.1	1424	3.0
754.000	10.3	605	1127	3.3	1120	3.0	1134	3.6	1124	2.6	1139	3.1	1129	2.6
761.000	6.1	232	502	1.2	498	1.2	505	1.3	500	1.0	507	1.5	502	1.0
764.000	7.1	305	663	1.6	658	1.5	667	2.1	661	1.6	669	2.1	663	1.4
768.000	7.6	330	558	1.7	554	1.3	562	1.4	556	1.5	564	1.3	559	1.2
779.000	9.2	812	1515	5.0	1497	4.9	1524	5.3	1510	5.2	1525	5.0	1514	4.4
865.000	6.2	666	1244	3.7	1213	4.0	1238	4.1	1246	3.8	1250	3.0	1238	3.2
885.000	6.0	395	823	1.8	801	1.7	814	2.0	824	1.5	831	1.9	818	1.3
900.000	4.7	308	691	1.6	673	1.3	683	1.7	693	1.5	698	1.5	687	1.1
940.000	2.4	203	534	1.1	522	1.1	525	1.0	539	1.1	542	1.3	532	0.8
1020.000	3.9	152	345	0.8	337	0.9	348	0.7	345	8.0	351	0.7	345	0.5

2.4.2 SNR from EO data

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



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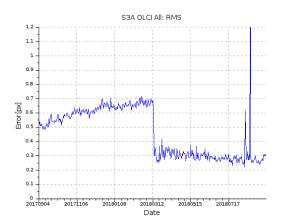
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2.5 Geometric Calibration/Validation

OLCI georeferencing performance was slowly degrading among the last months, down to the point at which compliance to the requirement (0.5 pixel RMS) was not met anymore. A new geometric calibration has been done by ESTEC, provided to S3-MPC for formatting into the appropriate ADF and validation (successful and reported in S3MPC.ACR.VR.030); it was put in production on the 14th of March 2018.

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 and compliance is comfortably met again (Figure 22): RMS values remain around 0.3 pixel from 14/03 on. The most dramatic improvements affect along-track bias of Camera 3 (Figure 26) and across-track biases of Cameras 4 and 5 (Figure 27 & Figure 28, respectively).

It can be seen that the peak RMS value on 14/08/2018 is also associated to a very low number of GCPs: only 345 (out of scale on Figure 23). The same remark applies to the AC and AL biases displayed in Figure 24 to Figure 28. On the other hand, the anomalous value of 22/08 does not correspond to a low number of GCPs, but is rather due to few GCPs with very large biases affecting the global performance while the biases histograms remain centered on the average values, indicating that no major issue is to be expected. This case and is under investigation.



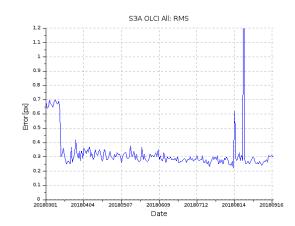


Figure 22: overall OLCI georeferencing RMS performance time series over the whole monitoring period (left) and restricted to March 2018 on (right)



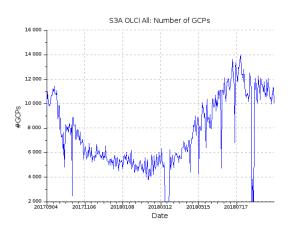
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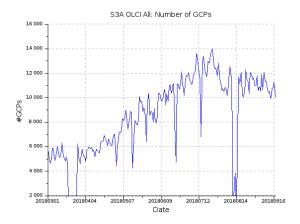
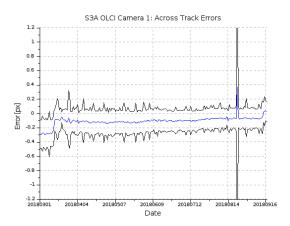


Figure 23: number of validated control points corresponding to the performance time series of Figure 22 for the same periods (complete, left, and restricted to March 2018, right).



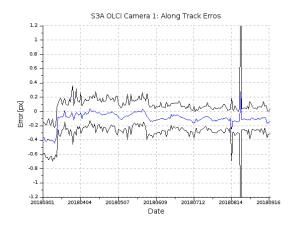
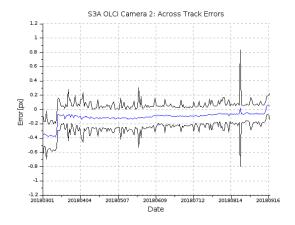


Figure 24: across-track (left) and along-track (right) georeferencing biases time series for Camera 1 (starting 01/03/2018).



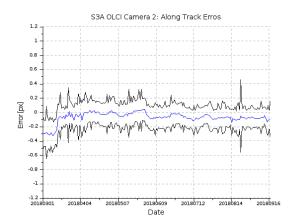


Figure 25: same as Figure 24 for Camera 2.



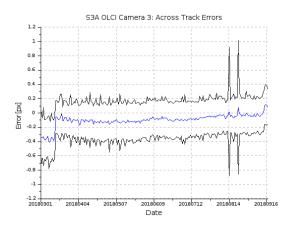
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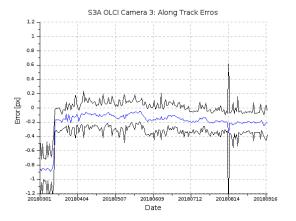
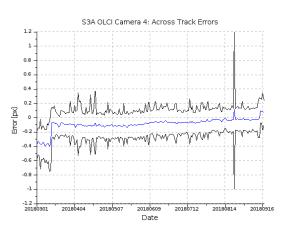


Figure 26: same as Figure 24 for Camera 3.



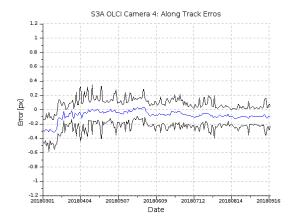
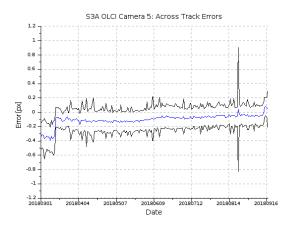


Figure 27: same as Figure 24 for Camera 4.



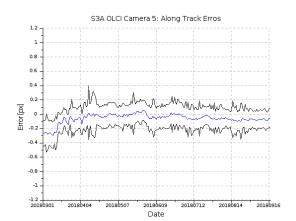


Figure 28: same as Figure 24 for Camera 5.



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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 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).



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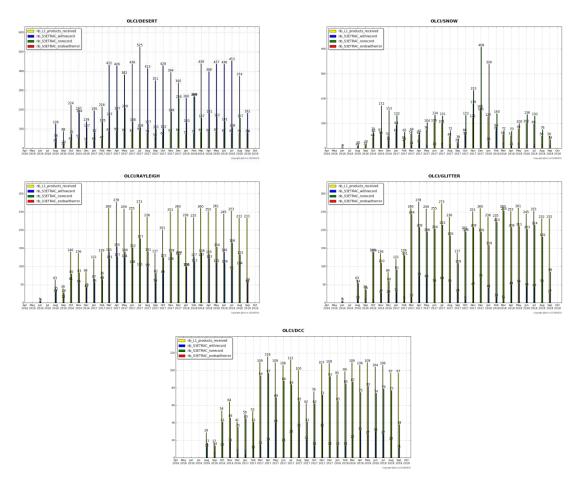


Figure 29: summary of S3ETRAC products generation for OLCI
(number of OLCI L1 products Ingested, yellow – number of S3ETRAC extracted products generated, blue –
number of S3ETRAC runs without generation of output product (data not meeting selection requirements), green
– number of runs ending in error, red, one plot per site type).

3.1.2 Radiometric validation with DIMITRI

Highlights

S3A/OLCI L1B radiometry verification as follow:

- The gaps in Rayleigh and Glint time series are completed from the reprocessed data REP006 over the period April-2016 until September 2017 and Desert methods have been performed over the available products from the reprocessed data REP006 over the period April-2016 until October 2017. The verification is performed until 17th September 2018.
- All results over Rayleigh, Glint and PICS are consistent with the previous cycle over the used CalVal sites.
- Good stability of the sensor could be observed, nevertheless the time-series average shows slightly higher reflectance over the VNIR spectral range with bias of 2%-4% except bands Oa06-Oa09



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Sands 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 calval-sites (Algeria3 & 5, Libya 1 & 4 and Mauritania 1 & 2) has been performed until 23rd August 2018.
- 2. The results are consistent overall the six used PICS sites (Figure 30). OLCI reflectance shows a good stability over the analysed period.
- 3. The temporal average over the period **April 2016 September 2018** of the elementary ratios (observed reflectance to the simulated one) shows values higher than/around 2-3% (the mission requirements) over all the VNIR bands (Figure 31). The spectral bands with significant absorption from water vapor and O_2 (Oa11, Oa13, Oa14 and Oa15) are excluded.

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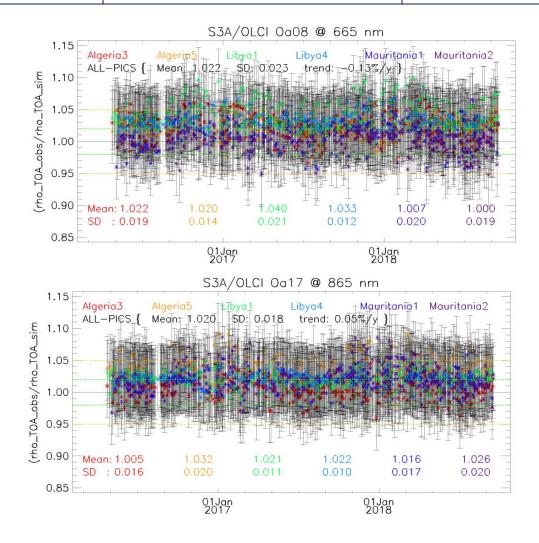


Figure 30: Time-series of the elementary ratios (observed/simulated) signal from S3A/OLCI for (top to bottom) bands Oa08 and Oa17 respectively over Six PICS Cal/Val sites. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the desert methodology uncertainty.



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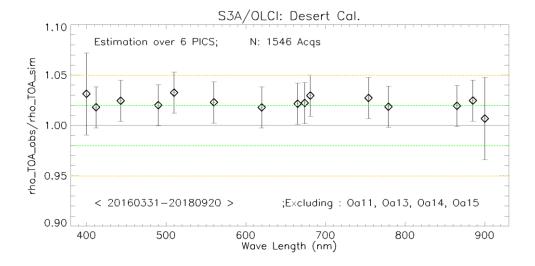


Figure 31: The estimated gain values for S3A/OLCI over the 6 PICS sites identified by CEOS over the period April 2016 – September 2018 as a function of wavelength. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the desert methodology uncertainty.

II- Cross-mission Intercomparison over PICS

X-mission Intercomparison with MODIS-A and MSI-A has been performed until May and June 2018 respectively. Figure 32 shows time-series of the elementary ratios from S2A/MSI, Aqua/MODIS and S3A/OLCI over the LYBIA4 site over the period April-2016 until August 2018 (for OLCI).

We observe a clear stability over the three sensors, associated with higher reflectance from OLCI wrt to MSI and MODISA. MODISA shows higher fluctuation with respect to MSI and OLCI ones.

Figure 33 shows the estimated gain over the different time-series from different sensors (MERIS (3REP archive), MSI-A, MODIS-A and OLCI) over PICS for the common bands. The spectral bands with significant absorption from water vapour and O_2 are excluded. OLCI-A seems to have higher gain (Figure 33) than the other sensors, which means that OLCI-A has higher reflectance that the ones simulated by the PICS method.

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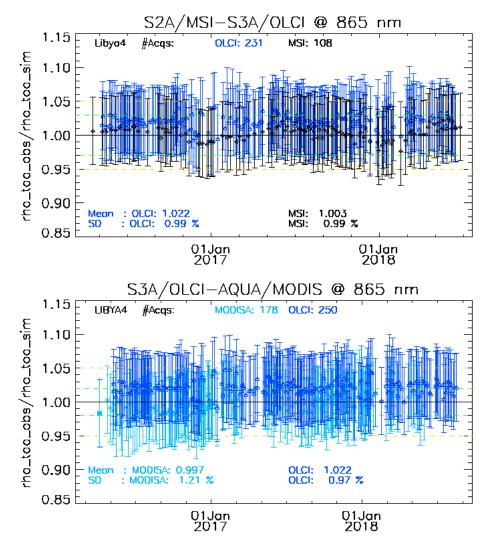


Figure 32: Time-series of the elementary ratios (observed/simulated) signal from (black) S2A/MSI, (blue) S3A/OLCI, and (Cyan) MODIS-A for band Oa17 (865nm) over the LIBYA4 site. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the desert methodology uncertainty.

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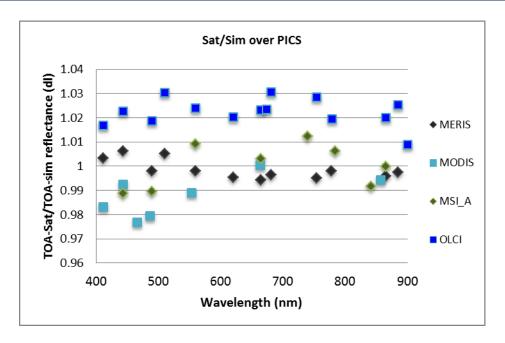


Figure 33: Ratio of observed TOA reflectance to simulated one for (black) MERIS/3REP, (green) S2A/MSI, (cyan) Aqua/MODIS and (blue) S3A/OLCI averaged over the six PICS test sites as a function of wavelength.

III-Validation over Rayleigh

Rayleigh method has been performed over the available mini-files on the Opt-server from October 2017 until September 2018, completed by the reprocessed data REP006 over the period April 2016-September 2017. The results are produced with the configuration (ROI-AVERAGE). The gain coefficients are consistent with the previous results (Cycle-34). Bands Oa01-Oa05 display biases values between 4%-5% while bands Oa6-Oa9 exhibit biases between 2%-3%, slightly higher than the 2% mission requirement (Figure 34 and Figure 35).



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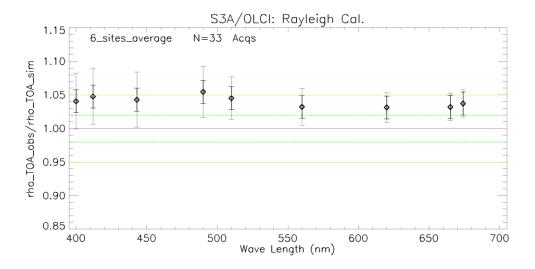


Figure 34: The estimated gain values for S3A/OLCI over the 6 Ocean CalVal sites (Atl-NW_Optimum, Atl-SW_Optimum, Pac-NE_Optimum, Pac-NW_Optimum, SPG_Optimum and SIO_Optimum) over the period April 2016 – September 2018 as a function of wavelength. Dashed-green, and orange lines indicate the 2%, 5% respectively. Error bars indicate (black) the methodology uncertainty and (grey) the standard deviation over the 6 CalVal sites.

IV-Validation over Glint

Glint calibration method with the configuration (ROI-PIXEL) has been extended over the period April 2016 – September 2018, as for the Rayleigh method (above). The outcome of this analysis shows a good consistency with Rayleigh and the desert outputs over the NIR spectral range Oa06-Oa09, while bands Oa12, Oa16, Oa17 and Oa18 are within the 2% mission requirements, band Oa21 show a bias of ~7% (see Figure 35).

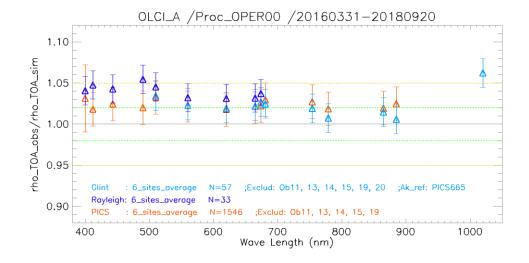


Figure 35: The estimated gain values for S3A/OLCI from Glint, Rayleigh and PICS over the period April 2016 – September 2018 for Desert, Glint and Rayleigh methods as a function of wavelength. We use the gain value of Oa8 from Desert method as reference gain for Glint. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the methods uncertainties.



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3.1.3 Radiometric validation with OSCAR

The OSCAR Rayleigh have been applied to all S3ETRAC data acquired during August 2018.

Table 2: S3ETRAC Rayleigh Calibration sites

Site Name	Ocean	North	South	East	West
	Ocean	Latitute	Latitude	Longitude	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 average OSCAR Rayleigh results and their standard deviation are shown below (Figure 36) and in Table 2. Results are in line with previously reported results.

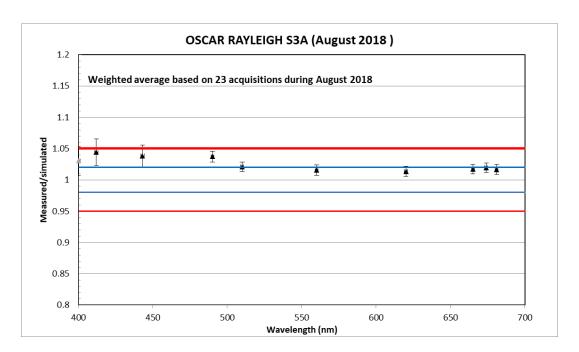


Figure 36: OSCAR Rayleigh Calibration results: weighted average over all sites and standard deviation for August 2018

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

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



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4 Level 2 Land products validation

4.1 [OLCI-L2LRF-CV-300]

4.1.1 Routine extractions

Activities done

- The focus for this time period has been on the rolling archive Near Real Time Critical (NT) data from June 2 nd to August 29 th. More data available for statistical analysis as a concatenation procedure for all available data in the MERMAID processing has been implemented.
- Time series on OLCI vegetation index and OLCI terrestrial Chlorophyll Index have been regenerated on the current rolling archive availability including all the extraction since April 2018. The timeseries therefore represent spring and summer season.

Figure 37 to Figure 46 below present the CoreLand Sites OLCI time series over the current reprocessing period.

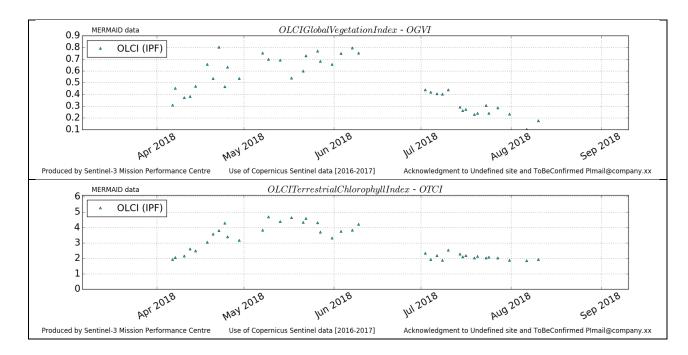


Figure 37: DeGeb time series over current report period

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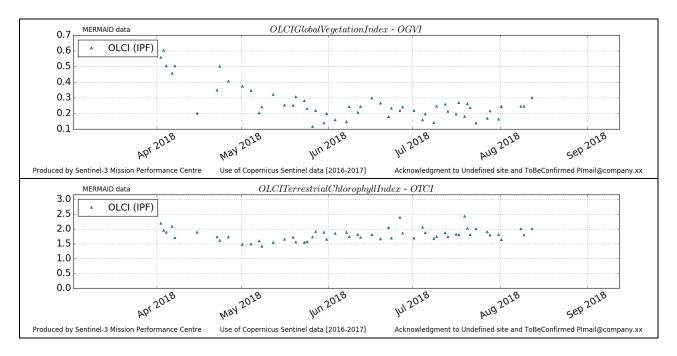


Figure 38: ITCat time series over current report period

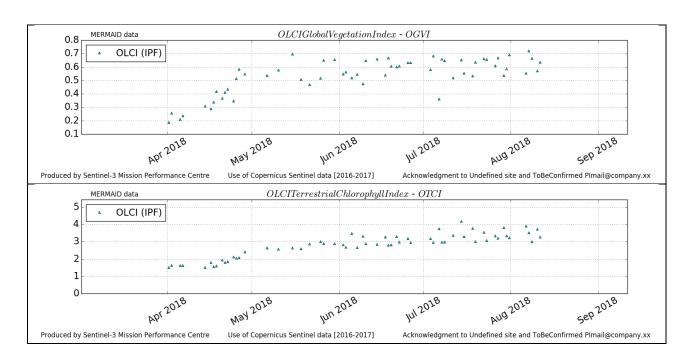


Figure 39: ITsp time series over current report period

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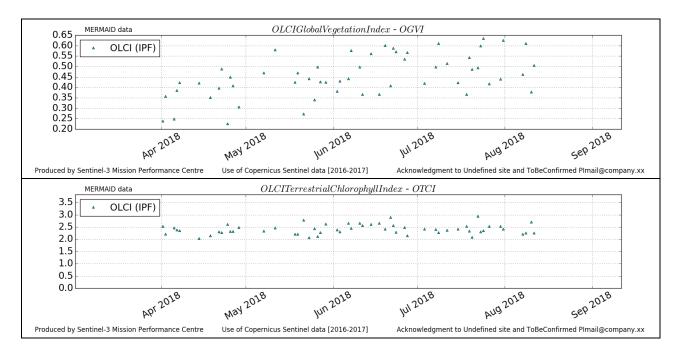


Figure 40: ITSro time series over current report period

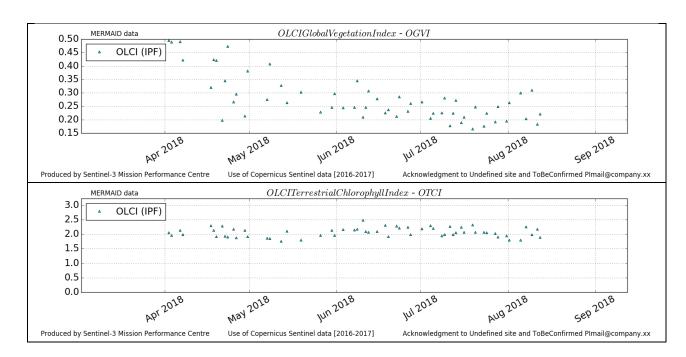


Figure 41: ITTra time series over current report period

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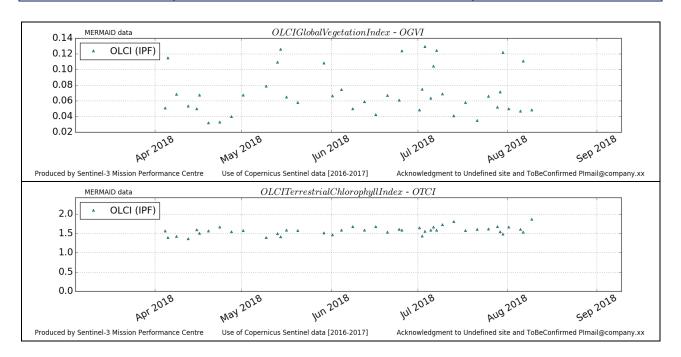


Figure 42: SPAli time series over current report period

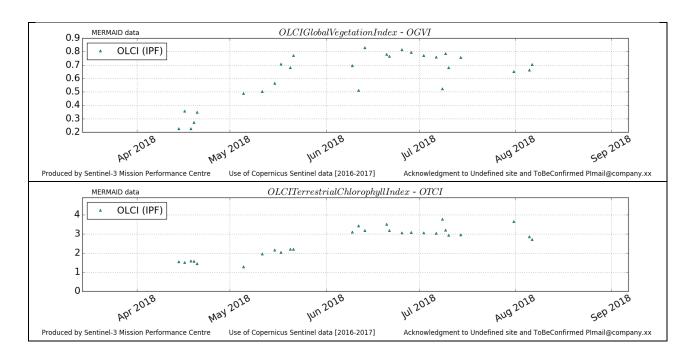


Figure 43: UKNFo time series over current report period

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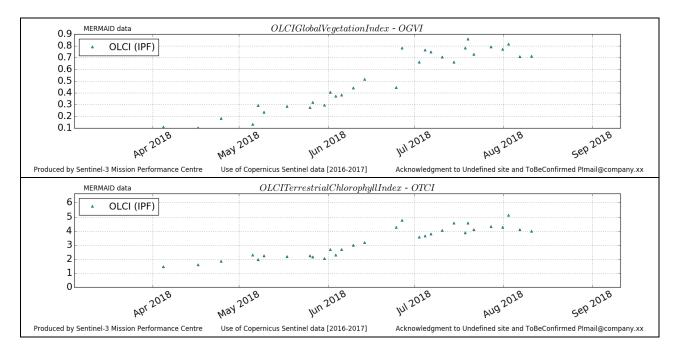


Figure 44: USNe1 time series over current report period

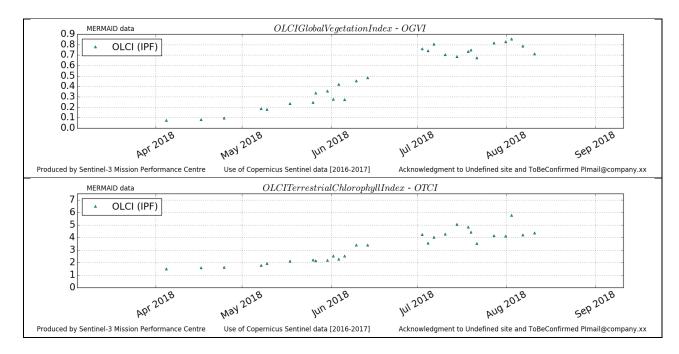


Figure 45: USNe2 time series over current report period



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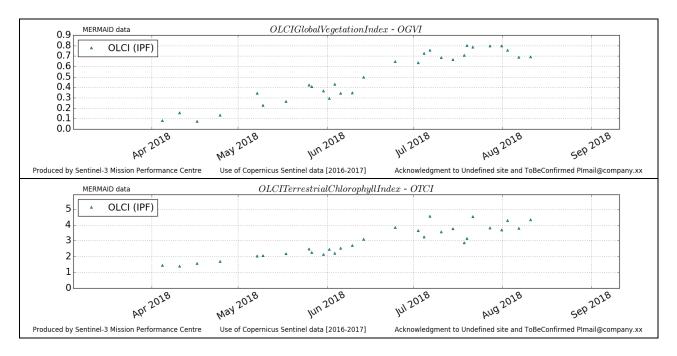


Figure 46: USNe3 time series over current report period

4.1.2 Comparisons with MERIS MGVI and MTCI climatology

4.1.2.1 Introduction

This report presents an assessment of the OGVI and OTCI performance over the validation sites for the up to the current cycle. Unlike previous reports, this includes the supersites in addition to the core validation sites. The justification for sites selection and a description of the sites is presented. Timeseries of representative land cover types are shown to visually assess the consistency of OGVI and OTCI with respect to the monthly climatology from the Medium Resolution Imaging Spectrometer (MERIS) MTCI.

4.1.2.2 Criteria for site selection and sites description

The additional sites presented in this report correspond to the Committee on Earth Observation Satellites (CEOS) Land Validation Products Subgroup (LPV). The sites include locations in Europe and other parts of the world. The LPV sites satisfy criteria of land cover representativeness, homogeneity, topography, accessibility, scientific legacy among others. The criteria is summarised below:

- Vegetation type: The sites were selected to cover a range of representative land cover types.
- Representativeness: The sites should be representative of their respective biomes
- Homogeneity: The sites must be spatially extensive and homogeneous to allow the validation activities for satellites up to 300-500 m spatial resolution.
- Topography: The desired topography of sites is preferably flat.
- Scientific legacy: Sites with a history of scientific activity, characterised and preferably with facilities nearby.



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Table 1 presents a description of CEOS LPV sites. The sites are spread across more than 15 countries and represent eight land cover types.

Table 3: Committee on Earth Observation Satellites Land Products Validation sites.

Country	Acronym	Network	Lat	Lon	Landcover (GLC2000)
Namibia	NA-Gobabeb	BSRN	-23.561	15.042	Bare Area
Italy	IT-Collelongo	EFDC	41.849	13.588	Tree Cover, broadleaved, deciduous, closed
Russia	RS-Fyodorovsky	EFDC	56.462	32.922	ENF/Tree Cover, mixed leaf type
Brasil	BR-Mata Seca	ENVIRONET	-14.880	-43.973	Herbaceous Cover, closed-open
Canada	CN-Peace River	ENVIRONET	56.234	- 117.553	Cropland / Shrub or Grass Cover
Costa Rica	CR-Santa Rosa	ENVIRONET	10.842	-85.616	Tree Cover, broadleaved, evergreen
UK		ForestGeo - NPL	51.774	-05.010	Tree Cover, broadleaved, deciduous, closed
France	UK-Wytham Woods FR-Aurade	ICOS	43.550	1.106	
	CZ-Bili Kriz				Cropland
Czechia	BE-Brasschaat	ICOS	49.502 51.308	18.537	Tree Cover, needle-leaved, evergreen Tree Cover, needle-leaved, evergreen
Belgium		ICOS		4.520	Tree Cover, mixed leaf type
Italy France	IT-Casterporziano2	ICOS ICOS	41.704 48.476	12.357 2.780	Tree Cover, broadleaved, deciduous, closed
	FR-Fontainebleau				
France	FR-Hesse	ICOS	48.674	7.065	Tree Cover, broadleaved, deciduous, closed
Deutschland	DE-Hones Holz	ICOS	52.085	11.222	Tree Cover, broadleaved, deciduous, closed
Finland	FN- Hyytiala	ICOS	61.847	24.295	Tree Cover, needle-leaved, evergreen
Czechia	CZ-Lanzhot	ICOS	48.682	16.946	Tree Cover, broadleaved, deciduous, closed
Italy	IT-Lison	ICOS	45.741	12.750	Cropland
France	FR-Montiers	ICOS	48.538	5.312	Tree Cover, broadleaved, deciduous, closed
France	FR-Puechabon	ICOS	43.741	3.596	Tree Cover, needle-leaved, evergreen
Deutschland	DE-Selhausen	ICOS	50.866	6.447	Cropland
Sweden	SW-Svartberget	ICOS	64.256	19.775	Tree Cover, needle-leaved, evergreen
Deutschland	DE-Tharandt	ICOS	50.964	13.567	Tree Cover, needle-leaved, evergreen
Belgium	BE-Vielsalm	ICOS	50.305	5.998	Tree Cover, needle-leaved, evergreen
France	FR-Estrees-Mons	ICOS Associated	49.872	3.021	Cultivated and managed areas
Fr Guayana	FR-Guayaflux	ICOS Associated	5.279	-52.925	Tree Cover, broadleaved, evergreen
Deutschland	DE-Haininch	ICOS Associated	51.079	10.453	Tree Cover, broadleaved, deciduous, closed
Finland	FN- Kenttarova	ICOS Associated	67.987	24.243	Tree Cover, needle-leaved, evergreen
Netherlands	NE-Loobos	ICOS Associated	52.166	5.744	Tree Cover, needle-leaved, evergreen
Senegal	SE-Dahra	KIT / UC	15.400	-15.430	Cultivated and managed areas
USA	US-Jornada	LTER	32.591	106.843	Shrub Cover, closed-open, deciduous
Canada	CA-Mer Bleue	National Capitol Commission	45.400	-75.493	Peatland
Puerto Rico	PR-Guanica	NEON	17.970	-66.869	Tree Cover, broadleaved, evergreen
USA	US-Steigerwarldt	NEON	45.509	-89.586	Tree Cover, broadleaved, deciduous, closed
USA	US-Bartlett	NEON, AERONET	44.064	-71.287	Tree Cover, broadleaved, deciduous, closed
USA	US- Central Plains	NEON, AERONET	40.816	104.746	Shrub Cover, closed-open, deciduous
USA	US-Harvard	NEON, AERONET	42.537	-72.173	Tree Cover, broadleaved, deciduous, closed
		,		-	, , , , ,
USA	US-Moab Site	NEON, AERONET	38.248	109.388	Shrub Cover, closed-open, deciduous
USA	US-Mountain Lake	NEON, AERONET	37.378	-80.525	Tree Cover, broadleaved, deciduous, closed
USA	US- Oak Rige	NEON, AERONET	35.964	-84.283	Tree Cover, broadleaved, deciduous, closed
USA	US-Ordway-Swisher	NEON, AERONET	29.689	-81.993	Tree Cover, needle-leaved, evergreen
USA	US-Smithsonian	NEON, AERONET	38.893	-78.140	Tree Cover, broadleaved, deciduous, closed
USA	US-Talladega	NEON, AERONET	32.950	-87.393	Tree Cover, needle-leaved, evergreen
Australia	AU-Rushworth	TERN-AusCover	-36.753	144.966	Tree Cover, broadleaved, deciduous, open
Australia	AU-Watts Creek	TERN-AusCover	-37.689	145.685	Tree Cover, broadleaved, evergreen
Australia	AU-Zigzag Creek	TERN-AusCover	-37.474	148.339	Tree Cover, broadleaved, evergreen
Australia	AU-Cape Tribulation	TERN-SuperSites, OzFlux	-16.106	145.378	Tree Cover, broadleaved, evergreen
Australia	AU-Alice Mulga	TERN-SuperSites, AusCover/OzFlux	-22.283	133.251	Tree Cover, closed (76% cover), evergreen
Australia	AU-Calperum	TERN-SuperSites, AusCover/OzFlux	-34.003	140.588	Shrub Cover, closed-open, deciduous
Australia	AU-Cumberland	TERN-SuperSites, AusCover/OzFlux	-33.615	150.723	Tree Cover, broadleaved, evergreen
Australia	AU-Great Western	TERN-SuperSites, AusCover/OzFlux	-30.192	120.654	Tree Cover, broadleaved, deciduous, open
Australia	AU-Litchfield	TERN-SuperSites, AusCover/OzFlux	-13.180	130.790	Tree Cover, broadleaved, evergreen
Australia	AU-Robson Creek	TERN-SuperSites, AusCover/OzFlux	-17.117	145.630	Tree Cover, broadleaved, evergreen
Australia	AU-Tumbarumba	TERN-SuperSites, AusCover/OzFlux	-35.657	148.152	Tree Cover, broadleaved, evergreen
Australia	AU-Warra Tall	TERN-SuperSites, AusCover/OzFlux	-43.095	146.654	Tree Cover, broadleaved, evergreen
Australia	AU- Wombat	TERN-SuperSites, AusCover/OzFlux	-37.422	144.094	Tree Cover, broadleaved, evergreen



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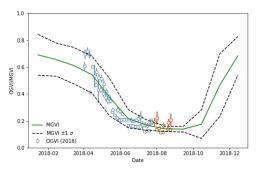
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4.1.2.3 Assessment

A slight overestimation is evident in OGVI for herbaceous cover, closed-open, whereas OTCI is within ±1 standard deviation (SD) (Figure 47), Mata-Seca, Brazil. Similarly, slight overestimation is observable for peatland in Mer-Bleue, Canada (Figure 48) but overall, values for both indices are within ±1 SD. Shrub Cover, closed-open, deciduous on the other hand seems to follow the general trend in Moab-Site, USA (Figure 49).

In general OGVI and OTCI perform within ±1 SD for tree cover, broadleaved, deciduous, closed (Figure 50 to Figure 54). However, in Steigerwarldt, USA, OTCI is above 1 SD. On the contrary, Mountain-Lake Smithsonian, USA OTCI presents lower values. In the case of tree cover, broadleaved, deciduous, open (Figure 55) OGVI is above 1 SD with a low value outlier.

Except for Vielsalm, Belgium (Figure 57) OGVI is overestimating for tree cover, needle-leaved, evergreen (Figure 56 to Figure 58). Conversely, OTCI seems to be within ±1 SD except for Vielsalm, Belgium, which seems overestimated for this cycle (Figure 59). Overall, for the current cycle OGVI and OTCI are overestimating in tree cover, broadleaved, evergreen sites located in Australia and Costa Rica. Values are above the average trend and in some cases above 1 SD (Figure 60 to Figure 64). For cropland, OGVI and OTCI are underestimating. Values are below 1 SD (Figure 65).



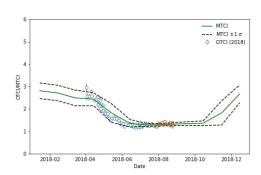
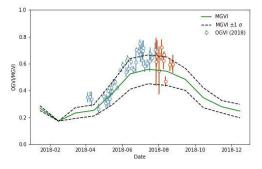


Figure 47 : Time-series of OGVI compared to MGVI and MTCI compared to MTCI for Herbaceous Cover, closedopen, Mata-Seca, Brazil.



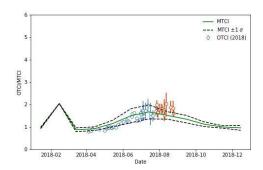


Figure 48 : Same as Figure 47 for Peatland, Mer-Bleue, Canada.



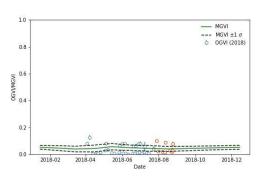
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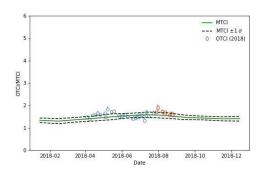
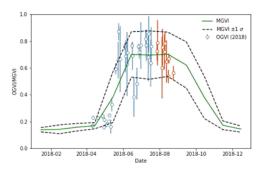


Figure 49: Same as Figure 47 for Shrub Cover, closed-open, deciduous, Moab-Site, USA.



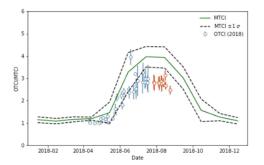
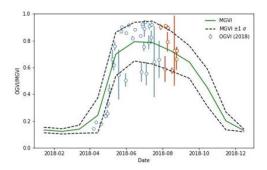


Figure 50 : Same as Figure 47 for Tree Cover, broadleaved, deciduous, closed, Mountain-Lake, USA.



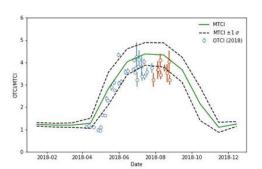
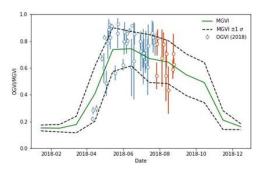


Figure 51: Same as Figure 47 for for Tree Cover, broadleaved, deciduous, closed, Smithsonian, USA.



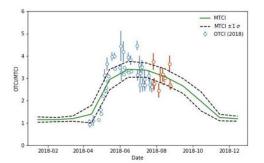


Figure 52 : Same as Figure 47 for for Tree Cover, broadleaved, deciduous, closed, Oak-Rige, USA.



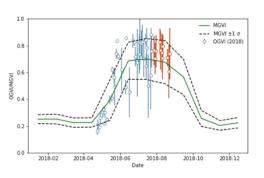
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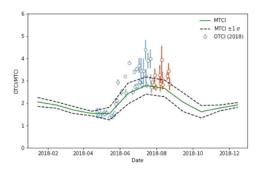
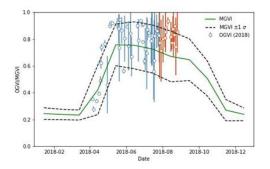


Figure 53: Same as Figure 47 for for Tree Cover, broadleaved, deciduous, closed, Steigerwarldt, USA.



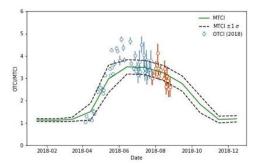
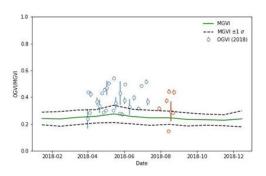


Figure 54 : Same as Figure 47 for for Tree Cover, broadleaved, deciduous, closed, Montiers, France.



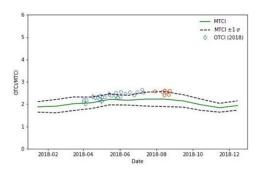
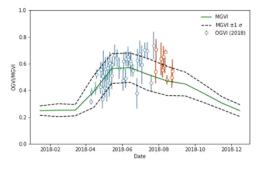


Figure 55 : Same as Figure 47 for for Tree Cover, broadleaved, deciduous, open, Rushworth, Australia.



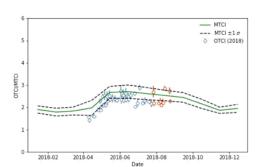


Figure 56 : Same as Figure 47 for for Tree Cover, needle-leaved, evergreen, Talladega, USA.



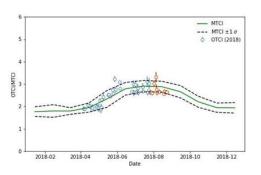
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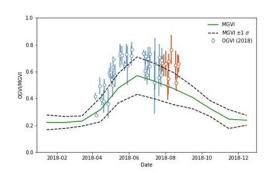
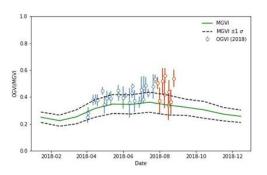


Figure 57 : Same as Figure 47 for for Tree Cover, needle-leaved, evergreen, Vielsalm, Belgium.



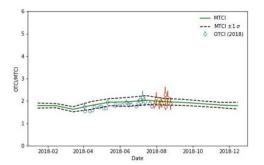
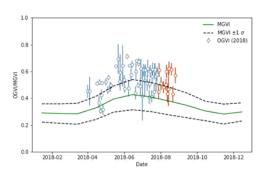


Figure 58 : Same as Figure 47 for for Tree Cover, needle-leaved, evergreen, Ordway-Swisher, USA.



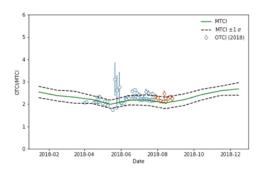
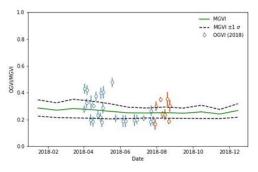


Figure 59 : Same as Figure 47 for for Tree Cover, needle-leaved, evergreen, Puechabon, France.



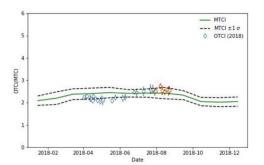


Figure 60 : Same as Figure 47 for for Tree Cover, broadleaved, evergreen, Zigzag-Creek, Australia.



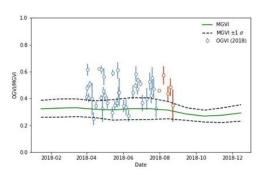
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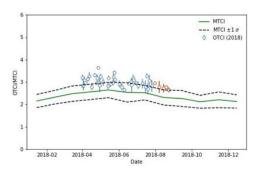
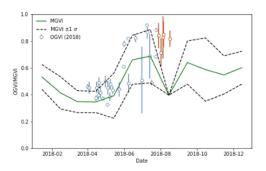


Figure 61 : Same as Figure 47 for for Tree Cover, broadleaved, evergreen, Tumbarumba, Australia.



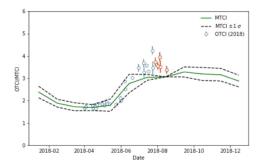
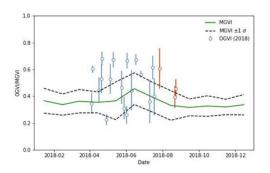


Figure 62 : Same as Figure 47 for for Tree Cover, broadleaved, evergreen, Santa-Rosa, Costa Rica.



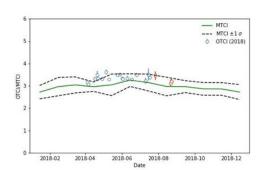
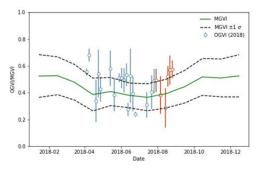


Figure 63 : Same as Figure 47 for for Tree Cover, broadleaved, evergreen, Watts-Creek, Australia.



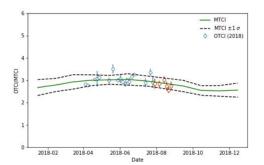


Figure 64: Same as Figure 47 for for Tree Cover, broadleaved, evergreen, Robson-Creek, Australia.

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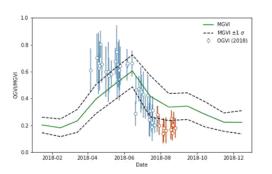
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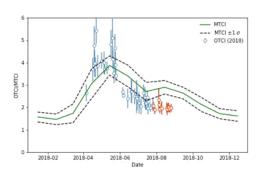


Figure 65 : Same as Figure 47 for for Cropland, Selhausen, Deutschland.

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.



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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

There has been no update of the SVC (System Vicarious Calibration) during Cycle 035. Last figures (cycle 17) are considered valid.

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.

Activities done

- The focus for this time period has been on the rolling archive None Time Critical (NT) data from June 2 nd to August 29 th. More data available for statistical analysis as a concatenation procedure for all available data in the MERMAID processing has been implemented. Current reporting period is her after compared to the reprocessed archive covering the April 2016 to November 2017 period. None 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 one year of operation.
- At best 53 matchups at 490 and 560nm are useful for this time period. OLCI's performances remain nominal.

Overall Water-leaving Reflectance performance

Figure 66 and Figure 67 below presents 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
- The current reporting period computed on the NT dataset.

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

Table 2 and Table 4 below summarise the statistics over reprocessed time period and the current reporting period, respectively. Some statistical variables can differ very much as a consequence of the little number of points (ex: slope and intercept). Nonetheless RMSE are in the same order of magnitude for both dataset.



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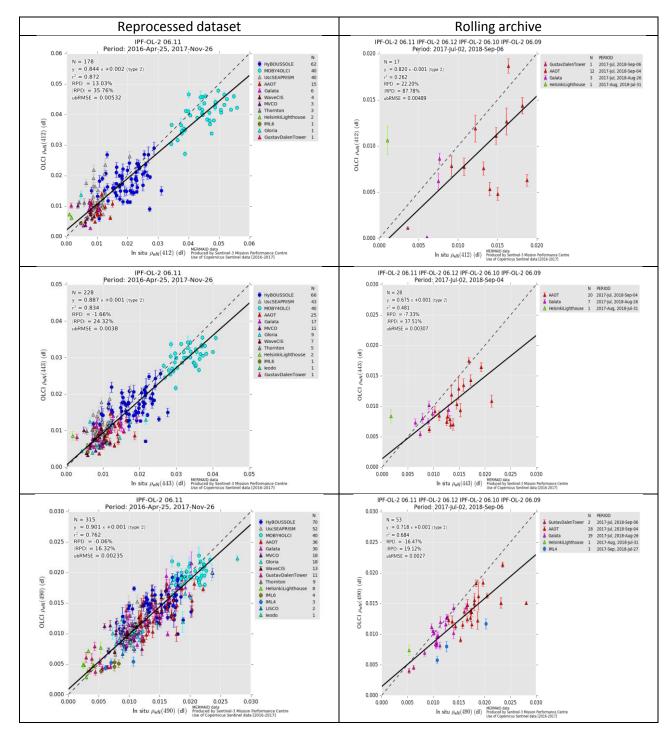


Figure 66: Scatter plots of OLCI versus in situ radiometry (FR data). Reprocessed dataset (left), all available data for the current time period (right)

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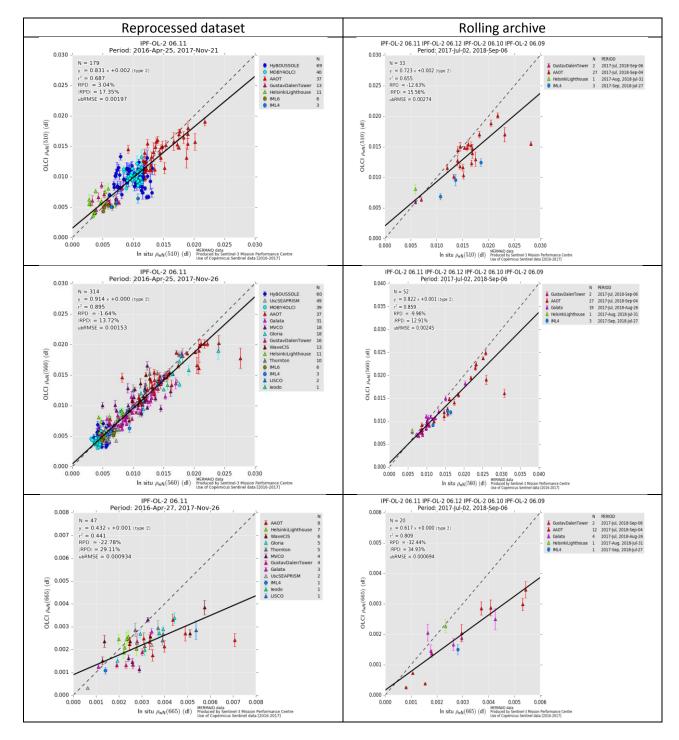


Figure 67: Scatter plots of OLCI versus in situ radiometry (FR data). Reprocessed dataset (left), all available data for the current time period (right)



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Table 4: 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 5: FR statistics over March 2018-June 2018 reporting period, cyclic report#033-035; FR data.

lambda	N	RPD	RPD	MAD	RMSE	slope	intercept	r2
412	17	22.20%	87.78%	-0.0031	0.0058	0.8201	-0.0010	0.2616
443	28	-7.33%	37.51%	-0.0027	0.0041	0.6752	0.0014	0.4812
490	53	-16.47%	19.12%	-0.0027	0.0038	0.7179	0.0015	0.6842
510	33	-12.63%	15.56%	-0.0024	0.0036	0.7231	0.0021	0.6547
560	52	-9.96%	12.91%	-0.0018	0.0030	0.8221	0.0008	0.8593
665	20	-32.44%	34.93%	-0.0010	0.0012	0.6167	0.0002	0.8087

Figure 68 and Figure 69 below present AAOT and GALATA in situ and OLCI time series over the current reprocessing period.

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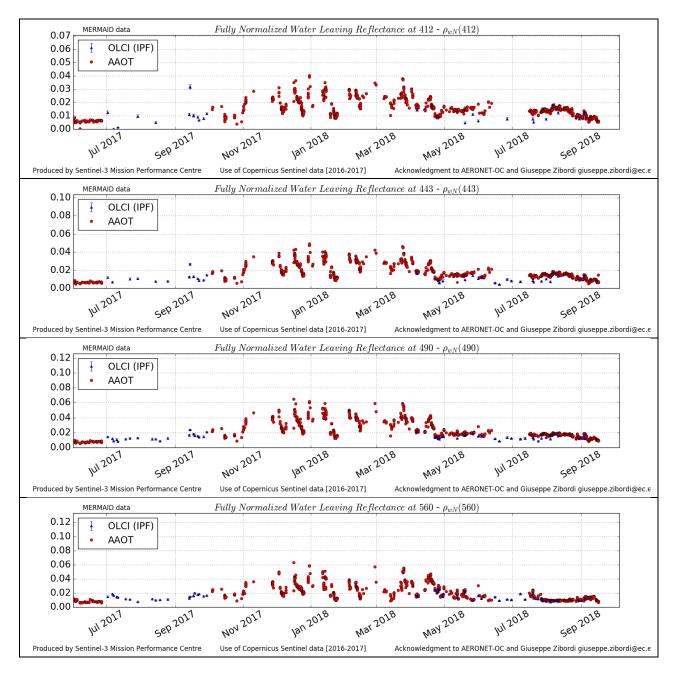


Figure 68: AAOT time series over current report period

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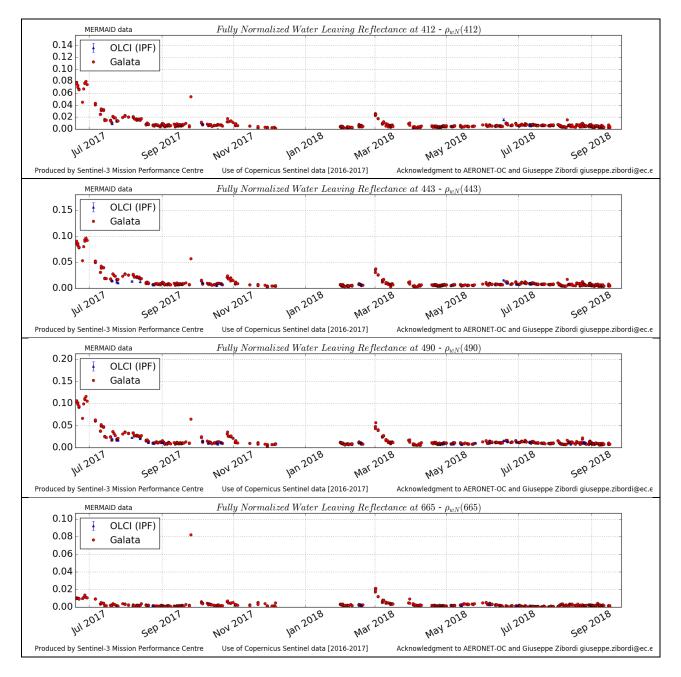


Figure 69: Galata time series over current report period



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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

There has been no new result during the cycle. Last figures (cycle 31) are considered valid.

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

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



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6 Validation of Integrated Water Vapour over Land & Water

There has been no new result during the cycle. Last figures (cycle 31) are considered valid.



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7 Level 2 SYN products validation

7.1 [SYN-L2-CV-100]

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

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8 Events

Two OLCI Radiometric Calibration Sequence has been acquired during Cycle 035:

- S01 sequence (diffuser 1) on 27/08/2018 23:25 to 23:26 (absolute orbit 13164)
- S01 sequence (diffuser 1) on 09/09/2018 21:08 to 21:10 (absolute orbit 13348)



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9 Appendix A

Other reports related to the Optical mission are:

S3-A SLSTR Cyclic Performance Report, Cycle No. 035 (ref. S3MPC.RAL.PR.02-035)

All Cyclic Performance Reports are available on MPC pages in Sentinel Online website, at: https://sentinel.esa.int

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