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## Sentinel-3A Product Notice – OLCI Level-2 Ocean Colour

<b>Mission</b>		Sentinel-3A
<b>Sensor</b>		OLCI
<b>Product</b>		<ul style="list-style-type: none"> <li>Level 2 Ocean Colour</li> </ul> OL_2_WFR and OLC_2_WRR at Near Real Time (NRT) and Non-Time Critical (NTC) timeliness
<b>Product Notice ID</b>		EUM/OPS-SEN3/DOC/17/928907 S3A.PN.OLCI-L2M.01
<b>Issue Date</b>		05/07/2017
<b>Version</b>		1.0
<b>Preparation</b>		This Product Notice was prepared by EUMETSAT with assistance from the S3 Mission Performance Centre.
<b>Approval</b>		EUMETSAT Mission Management

### Summary

This is a Product Notice for the public release of Sentinel-3 Ocean and Land Colour Instrument (OLCI) Level-2 Ocean Colour products. The products are distributed at Full (FR) and Reduced Resolution (RR) at Near Real Time (NRT) and Non-Time Critical (NTC) timeliness.

The Notice describes the OLCI current Processing Baseline and Ocean Colour products, their quality, limitations, and product availability.

The Notice provides guidance on the use of the products, including the use of flags to mask cloudy or unreliable pixels.



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### Processing Baseline

<b>Processing Baseline</b>	<ul style="list-style-type: none"> <li>IPF Processing Baseline: 2.16</li> </ul>
<b>IPFs versions</b>	<ul style="list-style-type: none"> <li>OL1 IPF version: 06.07</li> <li>OL2 IPF version: 06.10</li> <li>PUG version: 03.29</li> </ul>

### Current Operational Processing Baseline

IPF	IPF Version	In operations since
OL1	06.07	NRT mode: 05/07/2017 13:10 UTC NTC mode: 05/07/2017 13:10 UTC
OL2	06.10	NRT mode: 05/07/2017 13:10 UTC NTC mode: 05/07/2017 13:10 UTC
PUG	03.29	NRT mode: 05/07/2017 13:10 UTC NTC mode: 05/07/2017 13:10 UTC

### Status of the Processing Baseline

The current Processing Baseline for Sentinel-3A OLCI Level-2 Ocean Colour products is v2.16 as deployed in the Marine Centre on 5<sup>th</sup> July 2017. The summary of Level 1 product quality is first discussed with impact on Level 2 products (for more details, please refer to OLCI Level-1 Product Notice for the Processing Baseline v2.16). Level 2 product quality status next follows.

Information on the Sentinel-3 OLCI Level 2 Ocean Colour products can be found on [EUMETSAT website](#), including links to the OLCI Level 2 Algorithm Theoretical Basis Documents and the Sentinel-3 OLCI Marine Handbook.

#### Level 1 Product Summary:

- Radiometric Calibration**
  - OLCI radiometric model uses data from OLCI in-flight radiometric calibrations with the nominal solar diffuser since April 2016. The model is based on radiometric gain coefficients at a reference date and a long-term evolution model.
  - OLCI absolute radiometry has a positive bias of up to 2 to 3 percent, varying with spectral bands and higher in band Oa21 (1020nm). Actions are in place to achieve OLCI radiometric compliancy (2% absolute accuracy < 900 nm, [S3 MRTD, 2011](#)).
  - OLCI radiometric temporal behaviour is stable. The accurate evolution model has been developed using new OLCI solar diffuser relative Bidirectional Reflectance Distribution Function developed in flight using Sentinel-3A yaw manoeuvres.
- Spectral Calibration**
  - OLCI spectral model accuracy meets the mission requirements ([S3 MRTD, 2011](#)).
  - OLCI spectral response information is provided in a separate note ([S3A OLCI SRF, 2016](#)). OLCI SRF



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datasets are given in section 7 of this document.

- **Geometric Calibration**

- OLCI geolocation accuracy meets the mission requirements in terms of global RMS value ( $< 0.5$  pixel RMS according to [S3 MRTD, 2011](#)). Monitoring using Landsat ground control points shows that the geolocation accuracy varies per camera. Along track accuracy of camera 3 is slightly above 0.5 pixel RMS.

## Level 2 Products:

- **OLCI product contents**

- All OLCI standard products are available.
- Per-pixel error estimates in the products should not be used, they have not been validated (some products do not contain per-pixel error estimates, like T865, A865 and PAR).
- All OLCI standard products are available in Full Resolution (300 m) and Reduced Resolution (1.2 km).
- All OLCI standard products are available in NRT and NTC timeliness.

- **Pixel classification and flagging**

- OLCI pixel classification, and particularly cloud flagging, has been significantly improved for this Processing Baseline. The cloud flagging applies a neural network trained with manually classified pixels and an optimised pixel classification logic. In general, the cloud flagging is clear sky conservative.
- It is recommended that the users apply the flag combinations listed in Table 1 to mask cloudy or unreliable pixels for the individual products. This pixel masking is advised for any automated analyses aside from manual scene and pixel inspections. All flags are available in the Level 2 products.
- All product status information provided in this Note is based on validations using the recommended flag combinations.

- **Open Water products – Water Leaving Reflectances (Oa\*\*\_reflectance)**

- OLCI Water Leaving Reflectances in the VIS bands mostly meet S3 Mission Requirements (S3 MRTD excerpt, 2011) at averaged global and temporal scales. Reflectances have been validated with in situ measurements and through inter-comparisons with other missions. The results however also show significant spatial and time variability of the quality.
- OLCI VIS Water Leaving Reflectances in comparison with in situ measurements show average Relative Percent Differences (RPD) of the order up to 3% for bands 412-665nm and 6% at 400nm, absolute RPD ( $|RPD|$ ) of up to 30%, and Root Mean Squared Error (RMSE) of up to 0.006 in reflectance [dimensionless].
- OLCI VIS Water Leaving Reflectances match other missions' data on average within 5% in the range between 412 and 560nm in open ocean and turbid waters, in corresponding bands. There are however potential seasonal trends in comparisons.
- Water Leaving Reflectances have been validated using
  - in situ measurements from the AERONET – Ocean Colour sites,
  - in situ MOBY and BOUSSOLE measurements (verification),
  - contemporaneous ocean colour products from MODIS-Aqua and VIIRS-SNPP,
  - MERIS-Envisat climatology, courtesy of NASA's Ocean Biology Processing Group,
  - GlobColour multi-sensor 10 year climatology, courtesy of ESA's GlobColour project.



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Product names	Products	Common flags	Processing chain flags	Product flags
Water leaving reflectances	Oa**_reflectance → Oa**_reflectance	<b>Ocean Colour Products</b>  (WATER or INLAND_WATER) and not (CLOUD CLOUD_AMBIGUOUS CLOUD_MARGIN INVALID COSMETIC SATURATED SUSPECT HISOLZEN HIGHGLINT SNOW_ICE)	<b>Open Water products</b>	<i>none</i>
Algal pigment concentration in open waters	chl_oc4me → CHL_OC4ME		<i>not</i> (AC_FAIL WHITECAPS ANNOT_ABSO_D ANNOT_MIXR1 ANNOT_DROUT ANNOT_TAU06 RWNEG_O2 RWNEG_O3 RWNEG_O4 RWNEG_O5 RWNEG_O6 RWNEG_O7 RWNEG_O8)	<i>not</i> OC4ME_FAIL
Diffuse attenuation coefficient	trsp → KD490_M07		<i>not</i> KDM_FAIL	
Photosynthetically Active Radiation	par → PAR		<i>not</i> PAR_FAIL	
Aerosol Optical Thickness and Ångström exponent	w_aer → T865, A865		<i>none</i>	
Algal pigment concentration in complex waters	chl_nn → CHL_NN		<b>Complex Water Products</b>	<i>not</i> OCNN_FAIL
Total suspended matter concentration	tsm_nn → TSM_NN		<i>no specific flags to be applied</i>	<i>not</i> OCNN_FAIL
Coloured Detrital and Dissolved Material absorption	iop_nn → ADG443_NN		<i>not</i> OCNN_FAIL	
Integrated Water Vapour Column	iwv → IWV	<b>Atmospheric Products</b>	<b>Water Vapour over WATER</b> <i>not</i> MEGLINT	<i>not</i> WV_FAIL

Table 1. Recommended OLCI Level 2 flag combinations for masking of cloudy or unreliable pixels for individual products.

- **Open Water products – Algal Pigment Concentration in open water (CHL\_OC4ME)**

- Because of scarcity of contemporaneous in situ chlorophyll measurements available, validation of this product is still preliminary.
- OLCI Algal Pigment Concentrations have been inter-compared against other mission chlorophyll products. In oligotrophic waters, OLCI is on average, globally and across time, lower than other missions by about 45%, but in mesotrophic and eutrophic waters OLCI on average matches other missions within 10%. These comparison results show quite significant temporal and spatial variability.
- Algal Pigment Concentrations have been inter-compared using
  - contemporaneous chlorophyll concentration products from MODIS-Aqua and VIIRS-SNPP,
  - MERIS-Envisat climatology, courtesy of NASA's Ocean Biology Processing Group,
  - GlobColour multi-sensor 10 year climatology, courtesy of ESA's GlobColour project.



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- **Open Water products – KD490\_M07, PAR, T865, A865**

- Validation of diffuse attenuation coefficient at 490nm is still preliminary. The product has been inter-compared with other missions, similarly to chlorophyll. Across spatial and temporal average, diffuse attenuation compares within 5% in oligotrophic waters to the same product from MODIS-Aqua. The differences gradually increase in mesotrophic and eutrophic waters and have increasing variabilities.
- OLCI Photosynthetically Active Radiation has not yet been validated due to unavailability of concurrent instantaneous in situ or satellite measurements.
- Aerosol Optical Thickness and Aerosol Ångström exponent are by-products of the atmospheric correction. These products have not yet been validated.

- **Complex Water products – CHL\_NN, TSM\_NN, ADG443\_NN**

- OLCI Complex Water atmospheric correction and water processing have been developed to be applicable in complex waters. It is recommended that these products are used in mesotrophic and eutrophic waters exceeding 0.1 mg/m<sup>3</sup> in chlorophyll concentration.
- Because of scarcity of contemporaneous in situ chlorophyll, TSM and CDM measurements during the OLCI mission lifetime, validation of these products is still preliminary.
- OLCI Algal Pigment Concentrations in turbid waters have been inter-compared against other mission chlorophyll products. In mesotrophic waters, at global and time average, OLCI is about 20% higher than MODIS-Aqua and VIIRS-NPP. In eutrophic waters, OLCI may show lower values than these missions and a significant variability.
- OLCI Total suspended matter concentration has not yet been validated.
- OLCI Coloured Detrital and Dissolved Material absorption has shown at global and time average to be within about 10% of the MODIS-Aqua and VIIRS-NPP products with a possible high inter-comparison variability.

- **System Vicarious Calibration**

- System Vicarious Calibration (SVC) is an integral part of Ocean Colour missions and it has been implemented for OLCI Level-2 products. SVC is a single adjustment to the Top-of-the-Atmosphere absolute radiance level for both NIR and VIS band ranges. For OLCI NIR bands, two methods gave equivalent results: a free log-log fit of aerosol reflectances in 5 NIR bands, and the assumption on a maritime aerosol and a unity gain at 865nm following the method of Franz, *et al.*, 2007. The methods were applied over the South Pacific Gyre and Southern Indian Ocean oligotrophic sites. VIS bands are vicariously calibrated using highest accuracy radiometric in situ Fiducial Reference Measurements (FRM) from dedicated SVC infrastructure (Zibordi *et al.*, 2015). Due to the short OLCI time series, a small number of FRM matchups was complemented by additional SVC sources. MOBY, BOUSSOLE and GlobColour marine gyre climatology were used. For NIR and VIS bands, SVC gains have been derived using the Open Water processing chain.
- The SVC gains applied in Processing Baseline 2.16 are shown in Table 2. Without SVC, OLCI absolute radiometric bias produces significant biases in Level 2 products which many times exceed the mission requirements (S3 MRTD excerpt, 2011). For this release, the SVC gains are applied not only to the Open Water products but also to the Complex Water products because the SVC methodology has not yet been implemented for the Complex Waters processing chain but the SVC gain benefits are evident.

$\lambda$	400	412.5	442.5	490	510	560	620	665	673.8	681.3
SVC gains	0.9798	0.9718	0.9747	0.9781	0.9827	0.9892	0.9922	0.9920	0.9943	0.9962



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<b><math>\lambda</math></b>	708.8	753.8	<i>761.3</i>	<i>764.4</i>	<i>767.5</i>	778.8	865	885	<i>900</i>	<i>940</i>	1020
<b>SVC gains</b>	0.996	1.003	<i>1</i>	<i>1</i>	<i>1</i>	1.005	1	0.996	<i>1</i>	<i>1</i>	0.914

Table 2. OLCI SVC gains applied in Processing Baseline 2.16. Bands in *Italic* are not relevant to SVC.

- **Atmospheric products – Integrated Water Vapour (IWV)**

- Over Land
  - General features and structures are well represented. The qualitative agreement is good. IWV fields follow the surface elevation as expected, and the weather conditions (as provided in ECMWF data), e.g. inflow of wet and dry air. The high spatial resolution allows observation of effects, which are not observable with analysis data (e.g. Lee-waves at mountains).
  - Validation of OLCI IWV using the GPS SUOMI network shows a correlation of 0.9 and a root-mean-squared-difference of 2.3 kg/m<sup>2</sup>. There is a systematic overestimation by OLCI of 10%, which leads to a bias of 1.1 kg/m<sup>2</sup>. The bias corrected RMSE is 1.9 kg/m<sup>2</sup>.
- Over Water
  - General features and structures are well represented. The quantitative agreement between OLCI and ECMWF analysis and is good.
  - Quantitative validation with ground truth is pending.
  - There is strong overestimation of IWV in the transition from glint to off-glint.

### Known product quality limitations

Sentinel-3A OLCI Level 2 product limitations are described below.

- **Remaining biases and variability in Level 2 Ocean Colour products**
  - As summarized in the previous section, OLCI Level 2 Water Leaving Reflectances in the standard ocean colour VIS bands are within the mission requirements, if regionally and time averaged. However, other products may contain meaningful biases.
  - All Level 2 product quality may show seasonal and regional variability.
- **Residual Level 2 flag limitations**
  - OLCI Level 2 flags may still show limitations despite significant improvements and validations, including the cloud flag set: CLOUD, CLOUD\_AMBIGUOUS, CLOUD\_MARGIN. Some examples:
    - clouds may be falsely detected as SNOW\_ICE
    - cloud flag may be TRUE over bright surfaces e.g. sands/coastlines/deserts/salt lakes
    - camera boundaries may be noticeable
    - some flags may be incorrectly raised in specific situations, such as ANNOT\_ABSO\_D, WHITE\_CAPS
  - It is highly advisable to apply the recommended list of product specific flags to mask cloudy or unreliable pixels.
- **Noise in Level 2 Open Water products**
  - 'Salt and pepper' noise is observable in OLCI Open Water products. The noise affects the quality of products when analysed at high spatial resolutions.



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- **Use of OLCI Level 2 error products is not recommended**
  - Level 2 per-pixel error products do not include the uncertainty estimate from Level 1 products because it is not yet available.
  - Level 2 error products have not been validated.
- **Reduced quality in coastal / turbid areas in Open Water products**
  - Level 2 Open Water processing applies an adjustment for non-negligible water contribution to NIR reflectances which is called the Bright Pixel Atmospheric Correction (BPAC). This correction experiences frequent failures and may produce unreliable Water Leaving Reflectances values.
- **Complex Water products in intertidal areas**
  - The classification of intertidal areas into dry-fallen, or slightly water covered areas is not working optimally. The quality flag of the Complex Water products is not always identifying these areas as they look similar to very turbid waters.

### Product Availability

- Copernicus Online Data Access (<https://coda.eumetsat.int/>)
- EUMETCast (<https://eoportal.eumetsat.int/>)
- EUMETSAT Data Centre (<https://eoportal.eumetsat.int/>)
- FTP server address login: login password: password
- Other

Product	EUMETCast	ODA*	CODA**	EUMETSAT Data Centre
L2 RR Ocean Colour	NRT	NRT, NTC	NRT, NTC	NRT, NTC
L2 FR Ocean Colour		NRT, NTC	NRT, NTC	NRT, NTC

\* ODA is available only for Copernicus Services and S3VT users

\*\* CODA is the pilot service Copernicus Online Data Access and is available to all users

### User Support

Please direct questions about OLCI products to the Sentinel-3 User Support desk at:

- [ops@eumetsat.int](mailto:ops@eumetsat.int)





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## References

Sentinel-3 Mission Requirements Traceability Document (MRTD), C. Donlon, EOP-SM/2184/CD-cd, 2011  
<https://sentinel.esa.int/documents/247904/1848151/Sentinel-3-Mission-Requirements-Traceability>

Sentinel-3 OLCI-A spectral response functions (SRF), Sentinel 3 CalVal Team, S3-TN-ESA-OL-660, 2016,  
<http://www.eumetsat.int/website/home/Data/CopernicusServices/Sentinel3Services/OceanColour/index.html>

EUMETSAT Ocean Colour website, 2017,

<http://www.eumetsat.int/website/home/Data/CopernicusServices/Sentinel3Services/OceanColour/index.html>

Bryan A. Franz, Sean W. Bailey, P. Jeremy Werdell, and Charles R. McClain, Sensor-independent approach to the vicarious calibration of satellite ocean color radiometry, App. Optics, vol. 46, no. 22, 5068-5082, 2007.

Giuseppe Zibordi, Frédéric Mélin, Kenneth J. Voss, B. Carol Johnson, Bryan A. Franz, Ewa Kwiatkowska, Jean-Paul Huot, Menghua Wang, David Antoine, System vicarious calibration for ocean color climate change applications: Requirements for in situ data, Rem. Sens. Env., 159, 361-369, 2015.

Sentinel-3 MRTD Ocean Colour Requirements excerpt taken from S3 MRTD, 2011.

Name	Description	Units	Resolution	Range	Goal Accuracy		Prod. Level	Delivery
					Case-1:	Case-2		
Marine Reflectance (R)	Surface directional reflectance, corrected for atmosphere and Sun specular reflection, at all channels except those dedicated to atmosphere absorption measurements, and associated error estimates. (atmospherically corrected)	-	0.3 - 1.2 km	0.001 - 0.04	5 x 10 <sup>-4</sup>	5 x 10 <sup>-4</sup>	L2	NRT
Photosynthetically available radiation (PAR)	Quantum energy flux from the Sun in the spectral range 400-700 nm and associated error estimates.	μmol quanta/m <sup>2</sup> /s	0.3 - 1.2 km	0 - 1400	5%	5%	L2	NRT and NTC
Diffuse attenuation coefficient (Kd)	Diffuse attenuation coefficient for downwelling irradiance, and associated error estimates	m <sup>-1</sup>	0.3 - 1.2 km	0.001 - 0.1	5%	5%	L2	NRT and NTC
Chlorophyll (Chl)	Chlorophyll-a concentration, and associated error estimates in coastal and open ocean waters.	mg/m <sup>3</sup>	0.3 - 1.2 km	0.001 - 150	Thresh. 30 % goal 10 %	Thresh. 70 % goal 10 %	L2	NRT and NTC
Total Suspended Matter (TSM)	Total suspended matter concentration, and associated error estimates	g/m <sup>3</sup>	0.3 - 1.2 km	0 - 100	Thresh. 30 % goal 10 %	Thresh. 70 % goal 10 %	L2	NRT and NTC
Coloured Dissolved Organic Material (CDOM)	Absorption of Coloured Detrital and Dissolved Material, and associated error estimates, at 443 nm.	m <sup>-1</sup>	0.3 - 1.2 km	0.01 - 2	Thresh. 50 % goal 10 %	Thresh. 70 % goal 10 %	L2	NRT and NTC
Integrated Water vapour column (IWV)	Global coverage of total amount of water vapour integrated over an atmosphere column, and associated error estimates over land and ocean (global).	kg.m <sup>-2</sup> .	0.3 - 1.2 km	0 - 50			L2	NRT and NTC
Aerosol Optical Depth (AOD (τ)) over water at 865 nm	Global coverage over water of aerosol load, expressed in optical depth at 865 nm, and associated error estimates.	-	0.3 - 1.2 km	0-3	50% [RD-118]	10%	L2	NRT and NTC
Aerosol Angstrom exponent (Å) over water at 865 nm	Global coverage over water of spectral dependency of the Aerosol Optical Depth with associated error estimates.	-	0.3 - 1.2 km	0 - 3			L2	NRT and NTC

## Operational Configuration Ancillary Data Files

### OLCI Level 2 Marine ADFs, IPF-OL-2

- S3A\_OL\_2\_ACP\_AX\_20160216T000000\_20991231T235959\_20170609T120000\_\_\_\_\_MPC\_O\_AL\_004.SEN3
- S3A\_OL\_2\_CLP\_AX\_20160216T000000\_20991231T235959\_20170210T120000\_\_\_\_\_MPC\_O\_AL\_003.SEN3
- S3A\_OL\_2\_OCP\_AX\_20160216T000000\_20991231T235959\_20170609T120000\_\_\_\_\_MPC\_O\_AL\_003.SEN3





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#### Operational Configuration Ancillary Data Files

- S3A\_OL\_2\_PCP\_AX\_20160216T000000\_20991231T235959\_20170609T120000 MPC\_O\_AL\_002.SEN3
- S3A\_OL\_2\_PPP\_AX\_20160216T000000\_20991231T235959\_20170609T120000 MPC\_O\_AL\_005.SEN3
- S3A\_OL\_2\_VGP\_AX\_20160216T000000\_20991231T235959\_20170113T120000 MPC\_O\_AL\_004.SEN3
- S3A\_OL\_2\_WVP\_AX\_20160216T000000\_20991231T235959\_20170113T120000 MPC\_O\_AL\_003.SEN3

***End of the Product Notice***