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

Operational Products and Full-Mission Reprocessed Time Series

Mission	Sentinel-3A
Sensor	OLCI

Product	Level 2 Ocean Colour
	• Operations:
	  • OL_2_WFR and OL_2_WRR at Near Real Time (NRT) and Non-Time Critical (NTC) timeliness
	• Reprocessed full-mission time series:
	  • OL_2_WFR and OL_2_WRR at Non-Time Critical (NTC) timeliness
	  • Granules of 2 minutes
	  • Reprocessing time period 26 April 2016 – 29 November 2017

Product Notice ID	EUM/OPS-SEN3/DOC/17/964713 S3A.PN.OLCI-L2M.02
Issue Date	11/01/2018
Version	1.0
Preparation	This Product Notice was prepared by EUMETSAT with assistance from the S3 Mission Performance Centre.
Approval	EUMETSAT Mission Management

Summary

This is a Product Notice for the new Processing Baseline for Sentinel-3 Ocean and Land Colour Instrument (OLCI) Level-2 Ocean Colour products. This Baseline has been deployed in the Marine Centre and used for OLCI full-mission reprocessing.

The Notice describes the OLCI 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.

Processing Baseline	
Processing Baseline	• IPF Processing Baseline: 2.23
IPFs versions	• OL1 IPF version: 06.07 • OL2 IPF version: 06.11 • PUG version: 03.30

Current Operational Processing Baseline		
IPF	**IPF Version**	**In operations since**
OL1	06.07	NRT mode: 11/10/2017 07:32 UTC NTC mode: 11/10/2017 07:32 UTC
OL2	06.11	NRT mode: 29/11/2017 11:00 UTC NTC mode: 29/11/2017 11:00 UTC
PUG	03.30	NRT mode: 23/10/2017 09:00 UTC NTC mode: 23/10/2017 09:00 UTC

Status of the Processing Baseline

The current Processing Baseline for Sentinel-3A OLCI Level-2 Ocean Colour products is v2.23. The Baseline was operationally deployed in the Marine Centre on 29th November 2017 and was used in OLCI full-mission reprocessing from 26 April 2016 to 29 November 2017.

The major changes from the last processing baseline 2.16 are the following:

1. Upgrade of the OLCI Radiometric Evolution Model which ensures long-term stability of Level-2 Ocean Colour products.
2. Reduction in occurrence of horizontal and vertical striping in products due to updated configuration of Dark Correction to limit dark-offset periodic noise and due to filtering of High Energy Particles from radiometric calibration data.
3. Improvements in processing over inland waters: updated flagging of Complex Water Neural Network (NN) products to eliminate masking of inland waters, and updated gaseous correction in Open Water products.

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 User Handbook.

For status of OLCI Level-1 products in the Processing Baseline v2.23, please refer to the Sentinel-3 OLCI Level-1 v2.23 Product Notice.

Level 2 Ocean Colour Products

- **OLCI product contents**
  - All OLCI standard products are available.

- Per-pixel error estimates in the products are not verified or not available, like in T865, A865 and PAR products. They can only be used for qualitative evaluations.
- 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, including cloud flagging, has not been changed since the last Processing Baseline.
  - Erroneous flagging of Complex Water NN products in inland waters has been eliminated.
  - It is recommended that the users apply the flag combinations listed in Table 1 to mask cloudy or unreliable pixels. 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 show spatial and time variability in the product quality.
  - OLCI VIS Water Leaving Reflectances in comparison with in situ measurements show average Relative Percent Differences (RPD) in bands 443, 490, 510, and 560 nm within the 5% mission requirement. Bands 400 and 412nm are within about 10% and 665nm within 3-7%. Absolute RPD (|RPD|) is from 13 to 40%, and Root Mean Squared Error (RMSE) is 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.

- **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 20%. 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.

Product names	Products	Common flags	Processing chain flags	Product flags
Water leaving reflectances	Oa**_reflectance → Oa**_reflectance	**Ocean Colour Products** (WATER *or* INLAND_WATER) *and not* (CLOUD CLOUD_AMBIGUOUS CLOUD_MARGIN INVALID COSMETIC SATURATED SUSPECT HISOLZEN HIGHGLINT SNOW_ICE)	**Open Water products** *not* (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)	*none*
Algal pigment concentration in open waters	chl_oc4me → CHL_OC4ME			*not* OC4ME_ FAIL
Diffuse attenuation coefficient	trsp → KD490_M07			*not* KDM_FAIL
Photosynthetically Active Radiation	par → PAR			*not* PAR_ FAIL
Aerosol Optical Thickness and Ångström exponent	w_aer → T865, A865			*none*
Algal pigment concentration in complex waters	chl_nn → CHL_NN		**Complex Water Products** *no specific flags to be applied*	*not* OCNN_FAIL
Total suspended matter concentration	tsm_nn → TSM_NN			*not* OCNN_FAIL
Coloured Detrital and Dissolved Material absorption	iop_nn → ADG443_NN			*not* OCNN_FAIL
Integrated Water Vapour Column	iwv → IWV	**Atmospheric Products**	**Water Vapour** over WATER *not* MEGLINT	*not* WV_FAIL

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

- **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^3 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 and eutrophic waters, at global and time average, OLCI is about 20% higher than VIIRS-NPP.
- 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.

- **System Vicarious Calibration**
  - System Vicarious Calibration (SVC) gains remain unchanged from the Processing Baseline v2.16.
  - OC-SVC is an integral part of Ocean Colour missions and 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 few FRM matchups, FRMs were 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 2.23 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. The SVC methodology has not yet been implemented in the Complex Waters processing chain but the SVC gain benefits are evident.

λ	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

λ	708.8	753.8	*761.3*	*764.4*	*767.5*	778.8	865	885	*900*	*940*	1020
SVC gains	0.996	1.003	*1*	*1*	*1*	1.005	1	0.996	*1*	*1*	0.914

Table 2. OLCI SVC gains applied in Processing Baseline 2.23. Bands in *Italic* are not relevant to SVC.

- **Atmospheric products – Integrated Water Vapour (IWV)**
  - Over Land
    - General features and structures of water vapour 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 ECMWF 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^2. There is a systematic overestimation by OLCI of 10-15%, which leads to a bias of 1-2 kg/m^2.
- 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 no-glint (medium glint).

Known product quality limitations

- **Remaining biases and variability in Level 2 Ocean Colour products**
  - OLCI Level 2 Water Leaving Reflectances are mostly 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.
  - There may be potential airmass dependence.

- **Reduced quality in coastal / turbid areas in Open Water products**
  - Recurring negative water-leaving reflectances in coastal / turbid areas may occur in Level 2 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 Correction (BPAC). This correction experiences high rates of non-convergence and may produce unreliable Water Leaving Reflectance values.

- **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 resolution.

- **Residual Level 2 flag limitations**
  - OLCI Level 2 flags may still show limitations despite significant improvements and validations, including in the cloud flag set: CLOUD, CLOUD_AMBIGUOUS, CLOUD_MARGIN. Some examples:
    - clouds may be falsely detected as SNOW_ICE or not detected over glint
    - cloud flag may be TRUE over bright surfaces e.g. sands/coastlines/desserts/salt lakes
    - camera boundaries may be noticeable
    - some flags may be incorrectly raised in specific situations, such as ANNOT_ABSO_D, WHITE_CAPS
    - intertidal or water covered area classification into dry-fallen is not working optimally in Complex Water products
  - It is highly advisable to apply the recommended list of product specific flags to mask cloudy or unreliable pixels.

- **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 verified.

Product Availability

Operations:

☒ 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 Copernicus Online Data Access and is available to all users

Reprocessed full-mission time series (26 April 2016 – 29 November 2017):

☒ Copernicus Online Data Access for Reprocessing (https://codarep.eumetsat.int/)

Product	CODArep**
L2 RR Ocean Colour	NTC
L2 FR Ocean Colour	NTC

**** CODArep** is the Copernicus Online Data Access reprocessing service 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

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, 2018, 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 10-4	5 x 10-4	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/ m2/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^{-1}	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^3	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^3	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^{-1}	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).	$kg.m^{-2}$.	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_20170915T120000_____MPC_O_AL_004.SEN3

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