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

Mission	Sentinel-3A & Sentinel-3B	
Sensor	OLCI-A & OLCI-B	
Product	Level 2 Ocean Colour • OL_2_WFR in NRT and NTC • OL_2_WRR in NRT and NTC	
Product Notice ID	EUM/OPS-SEN3/TEN/19/1068317	S3.PN-OLCI-L2M.001
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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 Sentinel-3A and -3B Ocean and Land Colour Instrument (OLCI) Level-2 Ocean Colour operational products. It describes the status of the Processing Baselines (PB) v.2.43 (OLCI-A) and 1.15 (OLCI-B) available from the Marine Centre. The main update is related to the public release of OLCI-B Level-2 Ocean Colour products on 20 March 2019.

OLCI-A and OLCI-B L2 Ocean Colour processing is identical, except for the difference in application of System Vicarious Calibration (SVC):

- For OLCI-A, SVC gains are applied;
- For OLCI-B, SVC gains are set to 1.0, i.e. no vicarious gains are applied.

This Notice describes the Level-2 product current status, the processing baseline, product quality and known limitations for both OLCI-A and OLCI-B.

General information on the Sentinel-3 OLCI Level 2 Ocean Colour products can be found on EUMETSAT website, including OLCI Level 2 Algorithm Theoretical Basis Documents, Sentinel-3 OLCI Marine User Handbook, and this and past Product Notices.

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Processing Baseline

	S3A	S3B
Processing Baseline	• Processing Baseline: 2.43	• Processing Baseline: 1.15
IPFs version	• OL_2 IPF version: 06.13 • PUG version: 3.35	

Current Operational Processing Baselines

IPF	IPF Version	Into operations since
S3A OL2	06.13	NRT mode: 12/12/2018 10:15 UTC NTC mode: 12/12/2018 10:15 UTC
S3B OL2	06.13	NRT mode: 12/12/2018 10:15 UTC NTC mode: 12/12/2018 10:15 UTC
PUG	3.35	NRT mode: 12/06/2018 10:15 UTC NTC mode: 12/06/2018 10:15 UTC

Status of the Processing Baseline

This PN covers operational OLCI-A and OLCI-B Level-2 Ocean Colour products generated using PB 2.43 and PB 1.15, respectively. The baselines have been available in the Marine Centre since 12/12/2018.

OLCI-A and OLCI-B L2 Ocean Colour processing is identical, performed by L2 IPF v06.13, except for the following change in the Auxiliary Data File OL_2_ACP_AX:

- For OLCI-A, System Vicarious Calibration gains are applied;
- For OLCI-B, System Vicarious Calibration gains are set to 1.0, i.e. no vicarious gains are applied.

The current OLCI-A and -B Level-2 Ocean Colour PBs are based on OLCI-A and -B Level-1 products defined by the PBs v2.42 (OLCI-A) and v1.14 (OLCI-B) from 12 December 2018. The S3 OLCI Level-1 Product Notice is available from the EUMETSAT website, it accompanied the OLCI-B Level-1 public release.

Level 2 Ocean Colour product overall status (WFR and WRR)

- 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 (FR, 300 m) and Reduced Resolution (RR 1.2 km) and at near real time (NRT) and non-time critical (NTC) timeliness.
- OLCI-A and OLCI-B products are different for two main reasons:
  - differences in the instrument radiometric response and the modelling of the temporal evolution at Level-1 products (see OLCI Level-1 Product Notice),
  - differences in the System Vicarious Calibration, vicarious gains have been applied to OLCI-A but not to OLCI-B where they are set to 1.0 (see below about System Vicarious Calibration).

  Other minor discrepancies come from slight differences in OLCI-A and -B Spectral Response Functions and further radiometric and geometric behaviour of both instruments.

Pixel classification and flagging

- OLCI pixel classification and flagging strategy is the same between OLCI-A and -B. Flag activation may however be different based on the differences in radiometry.
- To mask cloudy or unreliable pixels in large scale global analyses, the same flag combinations are recommended for OLCI-A and -B, which are listed in Table 1.
- To mask cloudy or unreliable pixels at regional scales, e.g. matchups with in situ measurements, it is recommended to use the flag combinations from Table 1, yet investigate whether the flags ANNOT_DROUT and ANNOT_MIXR1 are not masking useful pixels.
- All product status information provided in this Product Notice is based on validations using the recommended flag combinations from Table 1.

Product names	Products	Common flags	Processing chain flags	Product flags
Water leaving reflectances – Open Waters	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 – Open Waters	chl_oc4me → CHL_OC4ME			*not* OC4ME_ FAIL
Diffuse attenuation coefficient – Open Waters	trsp → KD490_M07			*not* KDM_FAIL
Photosynthetically Active Radiation – Open Waters	par → PAR			*not* PAR_ FAIL
Aerosol Optical Thickness and Ångström exponent – Open Waters	w_aer → T865, A865			*none*
Algal pigment concentration – Complex Waters	chl_nn → CHL_NN		**Complex Water Products** *no specific flags to be applied*	*not* OCNN_FAIL
Total suspended matter concentration – Complex Waters	tsm_nn → TSM_NN			*not* OCNN_FAIL
Coloured Detrital and Dissolved Material absorption – Complex Waters	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 in large scale global analyses. *At regional scales for Open Water products, the flags ANNOT_DROUT and ANNOT_MIXR1 should be additionally investigated as they may mask useful pixels.

Open Water products – Water-leaving Reflectance, directional (Oa** reflectance)

- **OLCI-A** Water-leaving Reflectances in the VIS bands partly meet S3 Mission Requirements at averaged global and temporal scales (MRD, 2007)
  - Bands 490, 510, 560nm within the 5% mission requirement uncertainty for all water types
  - Bands 400, 412, 442nm within 5 – 10% uncertainty depending on water types (average underestimation)
  - Other bands have uncertainties higher and/or dependent on a water type

- **OLCI-B** Water-leaving Reflectances do not yet meet S3 Mission Requirements (MRD, 2007) due to unavailability of System Vicarious Calibration (see section below on System Vicarious Calibration)
    - Blue and green bands have positive bias within 7 – 20% depending on water types (average overestimation)
- Larger variability in OLCI-A and -B may exist at regional and temporal scales (see section on 'Known Product Quality Limitations').
- Product quality has been established through validations with
    - in situ measurements: AERONET-OC, MOBY (courtesy of AERONET-OC PIs, EC JRC, NASA, and NOAA)
    - global contemporaneous missions: MODIS-A, VIIRS L3 daily binned files (courtesy NASA)
    - climatology: MERIS L3 binned files (courtesy ESA and NASA)

Open Water products – Algal Pigment Concentration (CHL_OC4ME)

- **OLCI-A** Algal Pigment Concentrations partly meet S3 Mission Requirements at averaged global and temporal scales (MRD, 2007)
    - Mesotrophic and eutrophic waters within 30% mission requirement uncertainty
    - Oligotrophic waters underestimated by about 40%
- **OLCI-B** Algal Pigment Concentrations may partly meet S3 Mission Requirements at averaged global and temporal scales (MRD, 2007)
    - All water types may be within 30% uncertainty mission requirement
    - However, no in situ measurements are available to confirm this result and the conclusion comes from inter-comparisons with contemporaneous missions and climatologies
- Larger variability in OLCI-A and -B may exist at regional and temporal scales (see section on 'Known Product Quality Limitations').
- Product quality has been established through validations with
    - in situ measurements for OLCI-A only: SeaBASS (courtesy of NASA and SeaBASS PIs)
    - global contemporaneous missions: MODIS-A, VIIRS L3 daily binned files (courtesy NASA)
    - climatology: MERIS L3 binned files (courtesy ESA and NASA)

Open Water products – Diffuse Attenuation coefficient at 490nm (KD490_M07)

- **OLCI-A** Diffuse Attenuation coefficient may partly meet the 5%-uncertainty S3 Mission Requirement in oligotrophic waters at averaged global and temporal scales (MRD, 2007), based on inter-comparisons with contemporaneous missions.
- **OLCI-B** Diffuse Attenuation coefficient matches closely OLCI-A and may similarly partly meet S3 Mission Requirements.

Open Water products – Aerosol Optical properties (T865, A865), PAR

- **OLCI-A** Aerosol Optical Thickness over water shows overestimation at coastal AERONET-OC sites.
- **OLCI-A** Aerosol Angstrom exponent over water shows reduced correlation at coastal AERONET-OC sites.

- **OLCI-B** preliminary validations show similar to OLCI-A overestimation of Aerosol Optical Thickness at coastal AERONET-OC sites. Aerosol Angstrom results are pending.
- There are no validations of the instantaneous Photosynthetically Available Radiation product.

Complex Water products – Algal Pigment Concentration (CHL_NN)

- Product quality of **OLCI-A** and **OLCI-B** Complex Water Algal Pigment Concentrations is variable and dependent on water type.
- Complex Water atmospheric correction and water processing have been developed to be applicable in complex waters. CHL_NN is recommended to be used in mesotrophic and eutrophic waters exceeding 0.1 mg/m^3 in chlorophyll concentration.

Complex Water products – Total Suspended Matter concentration (TSM_NN), Coloured Detrital and Dissolved Material absorption (ADG443_NN)

- **OLCI-A** TSM and ADG results from the Sentinel-3 Validation Team are variable. Potential maximum limits on product values have been reported.
- **OLCI-B** validations are pending.

Atmospheric products – Integrated Water Vapour (IWV)

- **OLCI-A** Integrated Water Vapour over land
  - General features and structures of water vapour are well represented. 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.
  - Validation using the GPS SUOMI network, ARM Climate Research Facility and GRUAN shows a correlation of ~0.98 and a root-mean-squared-difference of 1.5 – 2.4 kg/m^2. There is a systematic overestimation by OLCI of 9 – 13%, which leads to a bias of 0.9 – 2.0 kg/m^2 (validation data courtesy of UCAR, US Department of Energy, DWD, and all PIs)
- **OLCI-A** Integrated Water Vapour over water
  - General features and structures of water vapour are well represented. The quantitative agreement between OLCI and ECMWF analysis and is good but validation with ground truth is pending.
  - There is a strong overestimation of IWV in the transition from glint to no-glint.
- **OLCI-B** validations are pending.

Ocean Colour System Vicarious Calibration (OC-SVC)

- OC-SVC is an integral part of Ocean Colour missions (Franz, *et al.*, 2007, Zibordi *et al.*, 2017). OC-SVC gains are the requirement to mitigate radiometric biases at Level-1B products and achieve mission requirements for L2 Ocean Colour products (MRD, 2007).
- **OLCI-A** OC-SVC gains implemented in Level-2 processing are shown in Table 2 (Sentinel-3 OLCI Marine User Handbook, 2018). The gains have not changed since PB 2.16.
  - For NIR bands, two methods with equivalent results were applied over the South Pacific Gyre and Southern Indian Ocean oligotrophic sites (a free log-log fit of aerosol

reflectance 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).

- For VIS bands, the standard methodology of Franz, *et al.*, 2007 was extended to MOBY, BOUSSOLE and GlobColour marine gyre climatology due to the few matchups from the dedicated OC-SVC infrastructure (MOBY, BOUSSOLE and GlobColour datasets courtesy of NOAA, LOV, ESA/Copernicus, S3 MPC, and associated teams and funders).
- For NIR and VIS bands, OC-SVC gains were derived using the Open Water processing chain. Although OC-SVC gains are specific to the Level-2 processing algorithm, the same gains are currently applied to the Open and Complex Water products. This is because the OC-SVC methodology has not yet been implemented in the Complex Waters processing chain but the OC-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 OC-SVC gains applied starting from PB 2.16. Bands in *Italic* are not relevant to SVC.

- **OLCI-B** OC-SVC gains are not implemented in the Level-2 processing, i.e. the gains are set to unity in this OLCI-B PB 1.15. Reliable OC-SVC gains have not been possible in the short time-frame of the OLCI-B mission. The reasons:
  - OC-SVC field infrastructure was largely unavailable during 2018 and the few available matchups show large variability between the infrastructure field deployments.
  - The back-up method of using the climatology did not achieve reliable gains due to seasonal variabilities, which require the complete annual cycle to resolve.

Known Product Quality Limitations

OLCI-A and -B remaining biases and variability in Ocean Colour products

- OLCI-A Water-leaving Reflectances partly meet S3 Mission Requirements at averaged global and temporal scales and OLCI-B Reflectances do not meet the Mission Requirements (MRD, 2007).
- OLCI-A CHL_OC4ME significantly underestimates oligotrophic chlorophyll. In both missions, CHL_NN is variable and dependent on water type.
- Other products may contain meaningful biases.
- All Level 2 Ocean Colour product quality may show seasonal and regional variability and a potential airmass dependence.

Reduced quality in coastal and complex-water areas (e.g. CDOM dominated)

- Products may display recurring negative Water-leaving Reflectances.

- All products may have reduced quality in coastal and complex-water areas, including absorbing waters like Baltic Sea or in lakes.
- An adjustment for non-negligible water contribution to NIR reflectances, i.e. Bright Pixel Correction (BPAC), experiences high rates of non-convergence and may produce unreliable Water-leaving Reflectance values.

Noise in Open Water products

- 'Salt and pepper' noise may be present in Open Water products. The noise affects the quality of products when analysed at high spatial resolution.

Residual Level 2 flag limitations

- Residual cloud flag limitations over bright surfaces e.g. snow/sands/coastlines/desserts/glint and at camera interfaces
- Underperforming flags, e.g. ANNOT_DROUT, ANNOT_MIXR1
- Occurrences of some flags 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

- **Use of OLCI Level 2 error products is not recommended**
  - Level 2 per-pixel error products do not include the uncertainty estimate from Level -1B products because it is not yet available.
  - Level 2 error products have not been verified

Products Availability

☒ Copernicus Online Data Access (https://coda.eumetsat.int/), NRT and NTC

☒ EUMETCast (https://eoportal.eumetsat.int/), NRT

☒ EUMETSAT Data Centre (https://eoportal.eumetsat.int/), NRT and NTC

☐ 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 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

References

- Sentinel-3 Mission Requirements Document (MRD), Mark Drinkwater and Helge Rebhan, EOP-SMO/1151/MD-md, v.2, 2007.
  https://earth.esa.int/c/document_library/get_file?folderId=13019&name=DLFE-799.pdf

- Product Data Format Specification – OLCI Level 1 & 2 Instrument Products, Ref: S3IPF.PDS.005.1, Issue: 2.7, Date: 06/02/2018
  https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-slstr/document-library
  https://www.eumetsat.int/website/home/Data/TechnicalDocuments/index.html

- EUMETSAT Ocean Colour website, 2019, https://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Sentinel3/OceanColourServices/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, Marco Talone, System Vicarioous Calibration for Copernicus Ocean Colour Missions, JRC Technical Report, 2017, http://publications.jrc.ec.europa.eu/repository/bitstream/JRC108912/kjna28851enn.pdf.

Operational Configuration Ancillary Data Files

S3A 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
- 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

S3B OLCI Level 2 Marine ADFs, IPF-OL-2:

- S3B_OL_2_ACP_AX_20180425T000000_20991231T235959_20180628T120000_____MPC_O_AL_002.SEN3
- S3B_OL_2_CLP_AX_20180425T000000_20991231T235959_20180409T120000_____MPC_O_AL_001.SEN3
- S3B_OL_2_OCP_AX_20180425T000000_20991231T235959_20180409T120000_____MPC_O_AL_001.SEN3
- S3B_OL_2_PCP_AX_20180425T000000_20991231T235959_20180409T120000_____MPC_O_AL_001.SEN3
- S3B_OL_2_PPP_AX_20180425T000000_20991231T235959_20180409T120000_____MPC_O_AL_001.SEN3
- S3B_OL_2_VGP_AX_20180425T000000_20991231T235959_20180409T120000_____MPC_O_AL_001.SEN3
- S3B_OL_2_WVP_AX_20180425T000000_20991231T235959_20180409T120000_____MPC_O_AL_001.SEN3

End of Product Notice