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

Mission	Sentinel-3A and Sentinel-3B	
Sensor	OLCI-A and OLCI-B	
Product	Level 2 Ocean Colour <ul style="list-style-type: none"> • OL_2_WFR in NRT and NTC • OL_2_WRR in NRT and NTC 	
Product Notice ID	EUM/OPS-SEN3/DOC/21/1214497	S3.PN-OLCI-L2M.003.00
Issue/Rev Date	16/02/2021	
Version	1.0	
Preparation	This Product Notice was prepared by EUMETSAT	
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 released as Collection 3 version OL_L2M.003.00. OLCI Ocean Colour Collection 3 is available for OLCI-A and OLCI-B from the Marine Centre from 16 Feb 2021.

Collection 3 constitutes a major update in OLCI Ocean Colour algorithms. The goal is to achieve accuracy and consistency across OLCI-A and -B products and to introduce several algorithm improvements. Among the main updates

- System Vicarious Calibration gains are updated in OLCI-A and OLCI-B,
- revised Bright Pixel Correction new Chlorophyll Index algorithm for oligotrophic waters, and improved whitecap correction are introduced in the Open Water processing chain,
- new Neural Network v.2 is introduced in the Complex Water processing chain,
- new and updated flags are available, together with a new flag recommendation for users.

Refer to ‘Sentinel-3 OLCI L2 report for baseline collection OL_L2M_003’ on EUMETSAT’s [Ocean Colour Services website](#) for details of algorithm changes, validation results and product status. This Notice summarizes the Level-2 product status, the processing baseline, product quality and known limitations for both OLCI-A and OLCI-B.



Processing Baseline

Sentinel-3A and Sentinel-3B OLCI	
Baseline Collection	<ul style="list-style-type: none"> Collection 3: OL_L2M.003.00
Processing Baseline	<ul style="list-style-type: none"> 2.72-MARINE
IPF version	<ul style="list-style-type: none"> IPF-OL-2 version: 07.00 PUG version: 3.38

Current Operational Processing Baselines

IPF	IPF Version	Processing start with OLCI Sensing Time
S3A OL-2	07.00	NRT mode: 16/02/2021 08:35 UTC NTC mode: 15/02/2021 05:46 UTC
S3B OL-2	07.00	NRT mode: 16/02/2021 07:56 UTC NTC mode: 15/02/2021 06:47 UTC



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Status of the Processing Baseline

This Product Notice covers operational OLCI-A and OLCI-B Level-2 Ocean Colour products generated as Collection 3 (OL_L2M.003.00) in the Marine Centre since 16/02/2021.

With Collection 3, major updates have been introduced to Sentinel-3 OLCI Level-2 Ocean Colour processing, justifying the increment from Collection 002 to 003. Collection 3 is produced using OLCI Level-2 processor IPF-OL-2 version 07.00 applied on existing operational Level-1B products from Collection 002.

'Sentinel-3 OLCI L2 report for baseline collection OL_L2M_003' on EUMETSAT's [Ocean Colour Services website](#) describes details of algorithm changes, validation results and product status (Collection 3 Report, 2021).

The goal of Collection-3 is to achieve accuracy and consistency across OLCI-A and -B Ocean Colour products and to introduce several algorithm improvements. Among the main updates

- Ocean Colour System Vicarious Calibration (OC-SVC) gains are updated for OLCI-A and OLCI-B,
- revised Bright Pixel Correction (BPC), new Chlorophyll Index algorithm for oligotrophic waters, and improved whitecap correction are introduced in the Open Water processing chain,
- new Neural Network v.2 is introduced in the Complex Water processing chain,
- new and updated flags are available, together with a new flag recommendation for users.

The processing is identical for OLCI-A and OLCI-B except for OC-SVC gains, which are different between the two missions.

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

- OLCI-A and OLCI-B L2 products are highly consistent. OLCI-A and OLCI-B blue/green Water Reflectance and Algal Pigment Concentration products match within 2% or better. This is achieved thanks to application of traceable and harmonised OC-SVC to both sensors.
- OLCI-A and OLCI-B L2 products bring
 - improvement at low chlorophyll (oligotrophic waters now meet Mission Requirements),
 - improvement in coastal retrievals,
 - reduced «salt and pepper» noise,
 - improvement in cloud flagging.
- All OLCI L2 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.
- Per-pixel error estimates in the products are not verified or not available, like in T865, A865 and PAR products. Users are advised to apply them with care, only for qualitative evaluations.

Pixel classification and flagging

- Users are strongly cautioned to apply flag definitions from the products and not from hard-coded flag bits, the flag coding has changed with Collection 3.
- There are two new flags implemented in OLCI Collection 3 (Collection 3 Report, 2021):
 - COASTLINE
 - TURBID_ATMOSPHERE



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- A new additional test for CLOUD_AMBIGUOUS is implemented (Collection 3 Report, 2021). Cloud flagging improvements eliminate many cloud omissions and the need to apply other flags to compensate for cloud flagging failure.
- The definition of the ADJAC and ANNOT_DROUT flags is updated (Collection 3 Report, 2021).
- OC4ME_FAIL is updated to flag Open Water OC4ME chlorophyll algorithm failure for chlorophyll values 100 mg/m³ and higher, and not from 30 mg/m³ as in the previous processor version.
- User recommendation for the list of flags to mask cloudy or unreliable pixels is updated and available in Table 1.
 - the list does not include the ANNOT flags any more, following user recommendations, which is possible due to application of improved cloud flagging, but it includes a new updated ADJAC flag,
 - users are advised to apply the flag recommendations to ensure traceability across applications and validation processes.
- All product status information documented 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 reflectance – BAC 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)	Baseline Atmospheric Correction (BAC) Open Water Products <i>not</i> (AC_FAIL WHITECAPS ADJAC RWNEG_O2 RWNEG_O3 RWNEG_O4 RWNEG_O5 RWNEG_O6 RWNEG_O7 RWNEG_O8)	<i>none</i>	
Algal pigment concentration – BAC Open Waters	chl_oc4me → CHL_OC4ME			<i>not</i> OC4ME_FAIL	
Diffuse attenuation coefficient – BAC Open Waters	trsp → KD490_M07			<i>not</i> KDM_FAIL	
Photosynthetically Active Radiation – BAC Open Waters	par → PAR			<i>not</i> PAR_FAIL	
Aerosol Optical Thickness and Ångström exponent – BAC Open Waters	w_aer → T865, A865		<i>none</i>		
Algal pigment concentration – AAC Complex Waters	chl_nn → CHL_NN		Alternative Atmospheric Correction (AAC) Complex Water Products <i>no specific flags to be applied</i>	<i>not</i> OCNN_FAIL	
Total suspended matter concentration – AAC Complex Waters	tsm_nn → TSM_NN			<i>not</i> OCNN_FAIL	
Coloured Detrital and Dissolved Material absorption – AAC Complex Waters	iop_nn → ADG443_NN			<i>not</i> OCNN_FAIL	
Integrated Water Vapour Column	iwv → IWV		Atmospheric Products	Water Vapour <i>not</i> MEGLINT	<i>not</i> WV_FAIL

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



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

- **OLCI-A** Water Reflectance products in the VIS bands partly meet S3 Mission Requirements in comparison with coastal AERONET-OC measurements (MRD, 2007; Zibordi *et al.*, 2020; Collection 3 Report, 2021)
 - bands 412.5, 442.5 nm are within the 5% Mission Requirement,
 - bands 490 – 560 nm are within 8% uncertainty (average underestimation),
 - other bands have uncertainties higher and/or dependent on a water type.
- **OLCI-B** Water Reflectance products in the VIS bands partly meet S3 Mission Requirements in comparison with coastal AERONET-OC measurements (MRD, 2007; Zibordi *et al.*, 2020; Collection 3 Report, 2021)
 - bands 490, 510 nm are within the 5% Mission Requirement,
 - bands 412.5, 442.5, 560 nm are within 8% uncertainty,
 - other bands have uncertainties higher and/or dependent on a water type.
- **OLCI-A and OLCI-B** Water Reflectance verifications in Open Ocean show that OLCI may be within S3 Mission Requirements in these waters for bands 400 – 620 nm (Collection 3 Report, 2021).

Open Water products – Algal Pigment Concentration (CHL_OC4ME)

- **OLCI-A** Algal Pigment Concentrations meet S3 Mission Requirements in comparison with in situ measurements in oligotrophic and mesotrophic waters (MRD, 2007; Collection 3 Report, 2021)
 - within 30% Mission Requirement.
- **OLCI-B** Algal Pigment Concentrations meet S3 Mission Requirements in comparison with in situ measurements in oligotrophic and mesotrophic waters (MRD, 2007; Collection 3 Report, 2021)
 - within 30% Mission Requirement.
- **OLCI-A and OLCI-B** Algal Pigment Concentrations have no reliable in situ validation results in eutrophic waters but large-scale mission inter-comparisons indicate that OLCI may overestimate in these waters (Collection 3 Report, 2021). S3 Mission Requirements however quote 70% uncertainties in case-2 waters, thus the preliminary results would put OLCI within the requirements (MRD, 2007).

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

- No in situ validations are available for **OLCI-A and OLCI-B** Diffuse Attenuation coefficient. S3 Mission Requirements quote 5% uncertainty (MRD, 2007).

Open Water products – Photosynthetically Active Radiation (PAR)

- No in situ validations are available for **OLCI-A and OLCI-B** Photosynthetically Active Radiation. S3 Mission Requirements quote 5% uncertainty (MRD, 2007).

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

- No S3 Mission Requirements are available for Aerosol products. These products are considered as diagnostic of the performance of the Open Water Baseline Atmospheric Correction (BAC).



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- **OLCI-A and OLCI-B** Aerosol Optical Thickness over water shows large overestimation at coastal in situ AERONET-OC sites (Zibordi *et al.*, 2020). The biases are lower in the open ocean in comparison with ship-borne in situ measurements.
- **OLCI-A and OLCI-B** Aerosol Angstrom exponent over water shows poor correlation with measurements at coastal in situ AERONET-OC sites (Zibordi *et al.*, 2020). OLCI Angstrom is limited to 1.6 in value.

Complex Water products – Algal Pigment Concentration (CHL NN)

- **OLCI-A and OLCI-B** Algal Pigment Concentration product performance is variable and dependent on water type. Product validation with in situ measurements is preliminary; S3VT-OC confirms improved quality with NNv2. S3 Mission Requirements quote 30% uncertainty in case-1 and 70% uncertainty in case-2 waters (MRD, 2007).
- **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)

- **OLCI-A and OLCI-B** Total Suspended Matter product performance is variable. Product validation with in situ measurements is preliminary; S3VT-OC confirms improved quality with NNv2. S3 Mission Requirements quote 30% uncertainty in case-1 and 70% uncertainty in case-2 waters (MRD, 2007).

Complex Water products – Coloured Detrital and Dissolved Material absorption (ADG443 NN)

- **OLCI-A and OLCI-B** Coloured Detrital and Dissolved Material absorption product performance is variable and validation with in situ measurements is preliminary. S3 Mission Requirements quote 50% uncertainty in case-1 and 70% uncertainty in case-2 waters (MRD, 2007).

Atmospheric products – Integrated Water Vapour (IWV)

- Collection 3 introduces no changes to the processing of the Integrated Water Vapour product. Therefore, the IWV product has the same status as in the previous processing baseline.
- **OLCI-A and OLCI-B** 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 $1.5 - 2.4 \text{ kg/m}^2$. There is a systematic overestimation by OLCI of 9 – 13%, which leads to a bias of $0.9 - 2.0 \text{ kg/m}^2$ (validation data courtesy of UCAR, US Department of Energy, DWD, and all PIs)
- **OLCI-A and OLCI-B** Integrated Water Vapour over water
 - General features and structures of water vapour are well represented. The quantitative agreement between OLCI and ECMWF analysis is good but validation is pending.
 - There is a strong overestimation of IWV in the transition from glint to no-glint.



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Ocean Colour System Vicarious Calibration (OC-SVC)

- OC-SVC is an integral part of Ocean Colour missions (IOCCG, 2012). 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).
- New OLCI OC-SVC implements traceable and harmonised SVC gains for OLCI-A and OLCI-B to ensure quality and consistency of Ocean Colour retrievals from both missions.
- The standard community OC-SVC methodology is applied to derive the gains in the Open Water processing chain. Nevertheless, the same OC-SVC gains are applied in the Complex Water processing chain because the Neural Network SVC strategy requires more development, yet SVC gains improve the Complex Water products.
- Details are available in Collection 3 Report, 2021, and on a dedicated OC-SVC [website](#).
- **OLCI-A and OLCI-B** OC-SVC gains implemented in L2 processing are shown in Tables 2 and 3.

<i>VIS bands</i>	400	412.5	442.5	490	510	560	620	665	673.75	681.25
S3A	0.97546	0.97406	0.97492	0.9689	0.97184	0.97571	0.98001	0.97834	0.9786	0.97908

<i>NIR bands</i>	708.75	753.75	778.75	865	885	1020
S3A	0.98013	0.98552	0.98772	0.986	0.98657	0.91316

Table 2: OLCI-A OC-SVC gains for Collection 3 (OL_L2M.003.00).

<i>VIS bands</i>	400	412.5	442.5	490	510	560	620	665	673.75	681.25
S3B	0.99458	0.9901	0.99221	0.9862	0.98898	0.99114	0.99769	0.99684	0.99716	0.99802

<i>NIR bands</i>	708.75	753.75	778.75	865	885	1020
S3B	0.99782	1.00163	1.00259	1	1.00089	0.94064

Table 3: OLCI-B OC-SVC gains for Collection 3 (OL_L2M.003.00).

Known Product Quality Limitations

Anomalies identified for immediate update in the next release

- Scaling of the TSM_NN product now limits TSM values to 100 g/m³ and will be extended to 400 g/m³.
- Excessive flagging as CLOUD_AMBIGUOUS of pixels along the coastline will be reduced in FR products.

Remaining biases and variability in Ocean Colour products

- OLCI Water Reflectance products only partially meet Sentinel-3 Mission Requirements.



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- Open-Water Algal Pigment Concentration product has an updated range 0.01 to 100 mg/m³, as OC4ME_FAIL flag now stopped masking chlorophyll above 30 mg/m³. Nevertheless, the OC4ME algorithm is not designed for higher chlorophyll values and there is evidence that it may produce overestimate. Users are cautioned about higher OC4ME values, validation feedback is welcome.
- OLCI product quality and Mission Requirement status are evaluated at averaged spatial and temporal scales and they may vary for individual scenes depending on water type and atmospheric conditions.
- Open Water products may show potential air mass dependence exhibited as cross-track or seasonal variability.

Reduced quality in coastal and complex-water areas

- OLCI products still exhibit large uncertainties in more complex waters, particularly in absorbing waters with coloured dissolved matter contribution like Baltic Sea and in lakes.
- Products may display recurring negative Water Reflectances.

Noise in Open Water products

- Residual noise may be present in Open Water products.

Residual Level 2 flag limitations

- Residual cloud flag limitations may be present over bright surfaces e.g. snow/sands/coastlines/desserts/glint and at camera interfaces.
- CLOUD_AMBIGUOUS may flag some coastline pixels and then CLOUD_MARGIN would expand the flagged area.
- Intertidal or water covered area classification into dry-fallen is not working optimally in Complex Water products.

Positive bias in the Integrated Water Vapour product

- Systematic overestimation IWV of 9 – 13% over land and larger uncertainties over water.

Caution with OLCI Level 2 error products

- 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 validated.

Limited availability of in situ measurements

- OLCI product quality status is defined through inter-comparisons with ground truth in situ measurements but these measurements are severely limited or lacking for certain products. Consequently, none or preliminary quality status is provided at this time.



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Product 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 (EUMETCast Terrestrial)	NRT, NTC	NRT, NTC	NRT, NTC

* ODA is available only for Copernicus Services and S3VT users

User Support

Please direct questions about OLCI products to the User Support Helpdesk at:
ops@eumetsat.int

References

- Sentinel-3 OLCI L2 report for baseline collection OL_L2M_003, EUMETSAT, Collection 3, 2021, <https://www.eumetsat.int/ocean-colour-resources>.
- EUMETSAT Ocean Colour Services website, 2021, <https://www.eumetsat.int/ocean-colour-services>.
- 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
- G. Zibordi, B.N. Holben, M. Talone, D. D'Alimonte, I. Slutsker, D.M. Giles and M.G. Sorokin, Advances in the Ocean Color component of the Aerosol Robotic Network (AERONET-OC). Journal of Atmospheric and Oceanic Technology, <https://doi.org/10.1175/JTECH-D-20-0085.1>, 2020.
- C. R. McClain and G. Meister (eds.), Mission Requirements for Future Ocean-Colour Sensors. Reports of the International Ocean-Colour Coordinating Group, No. 13, IOCCG, Dartmouth, Canada, <https://ioccg.org/wp-content/uploads/2015/10/ioccg-report-13.pdf>, 2012.



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- Ocean Colour System Vicarious Calibration (OC-SVC) tool, <https://www.eumetsat.int/ocean-colour-system-vicarious-calibration-tool>.

Acknowledgements

Algorithm evolutions implemented in Collection OL_L2M.003 follow EUMETSAT's Marine Roadmap and recommendations from the Sentinel-3 OLCI/SYN Quality Working Group (QWG) and Sentinel-3 Validation Team, Ocean Colour (S3VT-OC).

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Operational Configuration Ancillary Data Files

S3A OLCI Level 2 Marine ADFs, IPF-OL-2:

- S3A_OL_2_ACP_AX_20160216T000000_20991231T235959_20200929T072910_____EUM_O_AL_006.SEN3
- S3A_OL_2_CLP_AX_20160216T000000_20991231T235959_20170210T120000_____MPC_O_AL_003.SEN3
- S3A_OL_2_OCP_AX_20160216T000000_20991231T235959_20201008T115034_____MPC_O_AL_006.SEN3
- S3A_OL_2_PCP_AX_20160216T000000_20991231T235959_20191023T120000_____MPC_O_AL_003.SEN3
- S3A_OL_2_PPP_AX_20160216T000000_20991231T235959_20201008T121527_____MPC_O_AL_006.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_20200921T062520_____EUM_O_AL_004.SEN3
- S3B_OL_2_CLP_AX_20180425T000000_20991231T235959_20180409T120000_____MPC_O_AL_001.SEN3
- S3B_OL_2_OCP_AX_20180425T000000_20991231T235959_20201008T115618_____MPC_O_AL_003.SEN3
- S3B_OL_2_PCP_AX_20180425T000000_20991231T235959_20191023T120000_____MPC_O_AL_002.SEN3
- S3B_OL_2_PPP_AX_20180425T000000_20991231T235959_20201008T140748_____MPC_O_AL_002.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