

# OPT-MPC

Copernicus Sentinel



Optical Mission Performance Cluster

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## Disclaimer

The work performed in the frame of this contract is carried out with funding by the European Union. The views expressed herein can in no way be taken to reflect the official opinion of either the European Union or the European Space Agency.





## Changes Log

Version	Date	Changes
1.0	15/02/2021	First version
1.1	16/12/2021	Updated version related to the OGIVI files renamed in GIFAPAR
1.2	14/04/2023	Updated version related to the inclusion of OLCI L1 uncertainties

## List of Changes

Version	Section	Changes
1.1	5.2.2	Updated section
	7.4	Updated section
1.2	/	References updated to new OPT-MPC contract
	8.2	Updates regarding Processing baseline version
	7	Updated validation results

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## 1 Introduction

This Copernicus Sentinel-3 OLCI Land User Handbook aims to provide a summary of key information needed for users interested in OLCI land products and their applications.

After providing a general introduction to the Copernicus programme, the role of the European Space Agency and the scope of the Sentinel-3 mission, it gives detailed information about OLCI products: the algorithms, processing levels, and product contents and format. A brief review of the data quality is also given.

Lastly, a Helpdesk section provides useful practical information, such as how to access and visualize the products. This section includes a list of frequently asked questions (FAQ) and useful links and references for more details about the OLCI products.

## 2 OLCI Land Quick Start

OLCI is an imaging spectrometer, with 21 spectral bands (see Section 4.2), flying on the Sentinel-3A and Sentinel-3B satellites.

OLCI land products provide four types of measurement described in this document:

- ❖ Level-2 **OTCI**: OLCI Terrestrial Chlorophyll Index maps (Section 5.2.1)
- ❖ Level-2 **GIFAPAR**: OLCI Green Instantaneous Fraction of Absorbed Photosynthetically Available Radiation (Section 5.2.2)
- ❖ Level 2 **IWV**: OLCI Integrated Water Vapour ( $\text{kg/m}^2$ )
- ❖ Level-1 **TOAR**: Top of atmosphere radiance ( $\text{mW/m}^2/\text{sr}/\text{nm}$ ) maps (Section 5.1)

Products are supplied in NetCDF-4 format in 3 minutes ‘product data units’ (PDUs, see Section 6.4).

These products can be downloaded from the **ESA Copernicus Open Access Hub** (<https://scihub.copernicus.eu>), either searching by observation time, or by area of the globe (see Section 8.1.1). The global revisit time at the equator is slightly above one day when combining both satellites (see Section 4.1).



Figure 1: ESA Copernicus Open Access Hub user interface

Once products are downloaded, they can be read, displayed and analysed using:

- ❖ The ESA SNAP toolbox (see Section 8.4.5)
- ❖ Other generic NetCDF tools, e.g. the **NASA Panoply tool**
- ❖ Standard Unix command, **ncdump** (ncdump -h to view the header only)
- ❖ Scripting languages, e.g. using the **Python netCDF4 library**

## Land Level 2 products

- ❖ The **OL\_2\_LFR/OL\_2\_LRR** products contain two vegetation and one atmosphere monitoring parameters derived from the OLCI instrument measurements at a spatial resolution of 0.3 and 1.2 km, respectively.
- ❖ Vegetation monitoring parameters: These parameters are the OLCI Terrestrial Chlorophyll Index (OTCI, section 5.2.1) and the Green Instantaneous Fraction of Absorbed Photosynthetically Available Radiation (GIFAPAR, section 5.2.2).
- ❖ Atmosphere monitoring parameter: This parameter is the Integrated Water Vapour content (IWV, section 5.2.3)
- ❖ OTCI and GIFAPAR data are only provided for clear sky land observations: no data is available over water or cloudy pixels; IWV is provided for all clear sky observations: no data is available over cloudy pixels. As part of the Level-2 processing chain and before entering the retrieval algorithms, data are quality checked with regards to input Level-1 data and cloudiness. All pixels not suitable for further processing are identified with exception flags and discarded.
- ❖ Validation (sections 7.3, 7.4 and 7.5) provides evidence of the products meeting their mission requirements.
- ❖ With respect to utilisation of best quality data, it is recommended to apply the cloud margin mask as well as the dedicated quality indicators accompanying the products (sections 5.2.1.1 and 5.2.2.1 respectively).

## Level-1 radiance products

The **OL\_1\_EFR/OL\_1\_ERR** products contain top of atmosphere radiances (visible and near infrared):

- ❖ Radiances are mapped to a 0.3 and 1 km regular grid (respectively) using a nearest neighbour algorithm (section 5.1 and 6.6).
- ❖ Radiances are accurate to within 3% for OLCI-A and 1% for OLCI-B except for channel Oa21 (1020 nm) that shows a bright bias of about 5% for OLCI-A and 4% for OLCI-B. For both instruments, still excluding Oa21, the interband calibration is excellent with an agreement better than 0.6% (section 7.1).
- ❖ The geometric accuracy is within 100 m (section 7.2).
- ❖ Since September 2022, the radiometric uncertainty for each spatial pixel and spectral channel are now provided in the ESA's OLCI L1 products in specific per channel netCDF files.

Important note: since the 16<sup>th</sup> of December 2021, in the OLCI level 2 products, the OGVI files have been renamed in GIFAPAR (see section 5.2.2). The user shall bear in mind that products processed before that date still contain the 'OGVI' name.

## 3 General information

### 3.1 The Copernicus Programme

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Copernicus has been specifically designed in response to user requirements for environmental monitoring. Based on satellite and in-situ observations, the Copernicus services deliver near-real-time data on a global level which can also be used for local and regional needs, to help us better understand our planet and sustainably manage the environment we live in.

Copernicus is served by a set of dedicated satellites (the Sentinels) and contributing missions (existing commercial and public satellites). The Sentinel satellites are specifically designed to meet the needs of the Copernicus services and their users. Since the launch of Sentinel-1A in 2014, the European Union set in motion a process to place a constellation of almost 20 more satellites in orbit before 2030.

Copernicus also collects information from in-situ systems such as ground stations, which deliver data acquired by a multitude of sensors on the ground, at sea or in the air.

There are six Copernicus services whose aim is to transform the satellite and in-situ data into value-added information by processing and analysing the data. These services are: atmosphere, marine, land, climate change, security, emergency. The information provided by the Copernicus services can be used by end users for a wide range of applications in a variety of areas. The main users of Copernicus services are policymakers and public authorities who need the information to develop environmental legislation and policies or to take critical decisions in the event of an emergency, such as a natural disaster or a humanitarian crisis.

The Copernicus programme is coordinated and managed by the [European Commission](#). The development of the observation infrastructure is performed under the aegis of the European Space Agency for the space component and of the European Environment Agency and the Member States for the in-situ component.

### 3.2 The European Space Agency

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The European Space Agency ([ESA](#)) is dedicated to the peaceful exploration and use of space for the benefit of everyone. Established in 1975, ESA is an international organisation with 22 Member States and, for more than 40 years, has promoted European scientific and industrial interests in space. By coordinating the financial and intellectual resources of its members, it can undertake programmes and activities far beyond the scope of any single European country.

ESA's programmes are designed to find out more about Earth, its immediate space environment, our Solar System and the Universe, as well as to develop satellite-based technologies and services, and to promote European industries. ESA also works closely with space organisations outside Europe.

ESA's purpose shall be to provide for, and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems:

- ❖ by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;
- ❖ by elaborating and implementing activities and programmes in the space field;
- ❖ by coordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;
- ❖ by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

The ESA Member States are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. Slovenia and Latvia are Associate Members. Canada takes part in some projects under a cooperation agreement. Bulgaria, Croatia, Cyprus, Malta, Lithuania and Slovakia have cooperation agreements with ESA.

The budget of ESA for 2019 is €5.72 billion. ESA operates on the basis of geographical return, i.e. it invests in each Member State, through industrial contracts for space programmes, an amount more or less equivalent to each country's contribution.

ESA is developing a new family of missions called Sentinels specifically for the operational needs of the Copernicus programme. Each Sentinel mission is based on a constellation of (at least) two satellites to fulfil revisit and coverage requirements, providing robust datasets for Copernicus Services. These missions carry a range of technologies, such as radar and multi-spectral imaging instruments for land, ocean and atmospheric monitoring.

Looking to the future, six high-priority candidate missions are being studied to address EU policy and gaps in Copernicus user needs, and to expand the current capabilities of the Copernicus space component: CHIME – Copernicus Hyperspectral Imaging Mission, CIMR – Copernicus Imaging Microwave Radiometer, CO2M – Copernicus Anthropogenic Carbon Dioxide Monitoring, CRISTAL – Copernicus Polar Ice and Snow Topography Altimeter, LSTM – Copernicus Land Surface Temperature Monitoring, ROSE-L – L-band Synthetic Aperture Radar.

### 3.3 The Sentinel-3 mission

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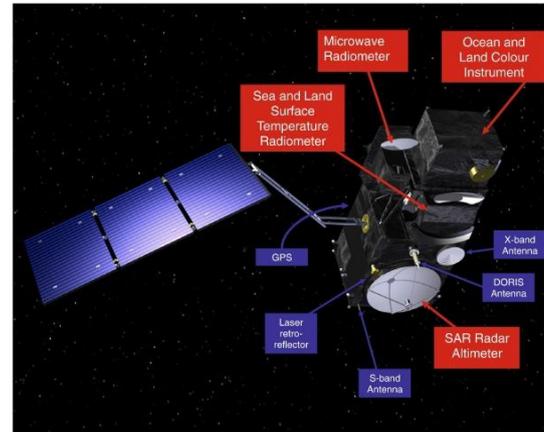
The Sentinel-3 mission is jointly operated by ESA and EUMETSAT to deliver operational ocean and land observation services. The main objective of the Sentinel-3 mission is to measure sea surface topography, sea and land surface temperature, and ocean and land surface colour with high accuracy and reliability to support ocean forecasting systems, environmental monitoring and climate monitoring. The mission definition was driven by the need for continuity in provision of ERS, ENVISAT and SPOT vegetation data, with improvements in instrument performance and coverage.

Sentinel-3A was launched on 16 February 2016 and Sentinel-3B was launched on 25 April 2018.

The spacecraft carries four main instruments:

- ❖ OLCI: Ocean and Land Colour Instrument
- ❖ SLSTR: Sea and Land Surface Temperature Instrument
- ❖ SRAL: SAR Radar Altimeter
- ❖ MWR: Microwave Radiometer
- ❖ These are complemented by three instruments for Precise Orbit Determination (POD):

- DORIS: a Doppler Orbit Radio positioning system
- GNSS: a GPS receiver, providing precise orbit determination and tracking multiple satellites simultaneously
- LRR: to accurately locate the satellite in orbit using a Laser Retro-Reflector system.



The Sentinel-3 orbit is similar to the orbit of Envisat allowing continuation of the ERS/Envisat time series. It uses a high inclination orbit (98.65°) for optimal coverage of ice and snow parameters in high latitudes.

The Sentinel-3 orbit is a near-polar, sun-synchronous orbit with a descending node equatorial crossing at 10:00 h Mean Local Solar time. In a sun-synchronous orbit, the surface is always illuminated at the same sun angle. The orbit reference altitude is 814.5 km.

The orbital cycle is 27 days (14+7/27 orbits per day, 385 orbits per cycle). The orbit cycle is the time taken for the satellite to pass over the same geographical point on the ground.

The two in-orbit Sentinel-3 satellites enable a short revisit time of less than two days for OLCI and less than one day for SLSTR at the equator based on the instruments' respective swath widths.

Sentinel-3B's orbit is identical to Sentinel-3A's orbit but flies +/-140° out of phase with Sentinel-3A.

## 4 OLCI acquisitions

### 4.1 Coverage

The Sentinel-3 satellites operate in a sun-synchronous orbit with a mean altitude of 814.5 km, completing 385 orbits (i.e., 770 pole-to-pole tracks) in exactly 27 days, with a descending nodal crossing time of 10:00 am. Sentinel-3B, launched in April 2018 retains the orbital characteristics of Sentinel-3A, but offset by 140° phase. This offset allows a denser pattern of coverage to be obtained.

OLCI observes over a 44-minute time window on the descending path of each orbit, over the period during which the Sun Zenith Angle (SZA) at the sub-satellite point is below 80 degrees (Figure 2). The OLCI instrument having a field of view of 68.5 degrees that covers a swath width of 1270 km, the mean global coverage revisit time for OLCI land colour observations is 2.2 days at the equator (one operational satellite) or 1.1 days (in constellation) with the values decreasing at higher latitudes, due to orbital convergence.

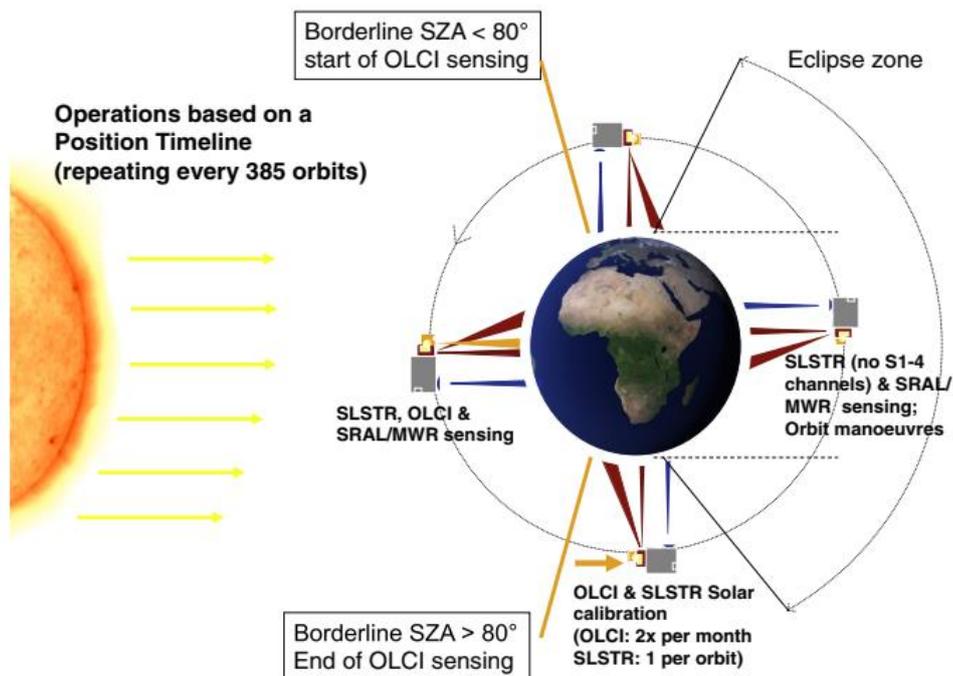
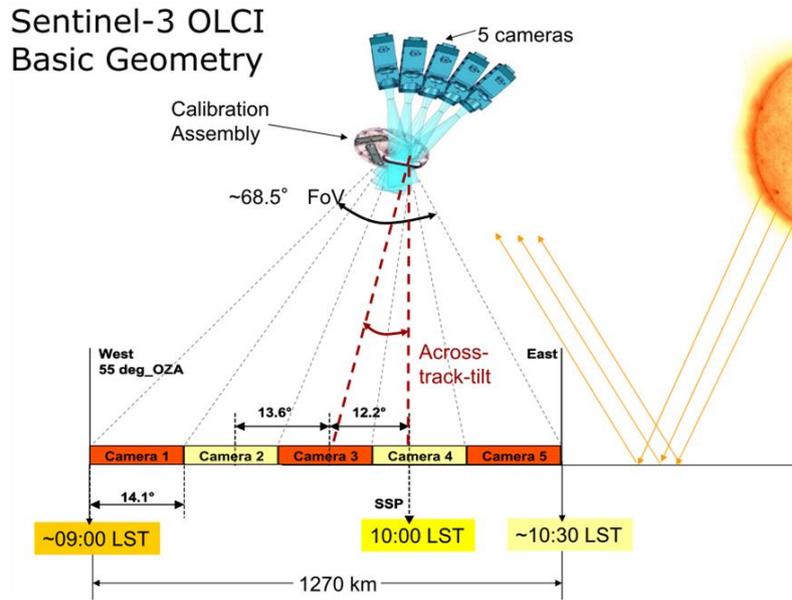


Figure 2: An overview of Sentinel-3 operations and instrument payload acquisitions for each orbit. Blue indicates SRAL, red SLSTR and orange OLCI.

### 4.2 OLCI instrument specifics

OLCI (Ocean and Land Colour Instrument) is a programmable, medium-spatial resolution, imaging spectrometer operating in the reflective solar spectral range (390 nm to 1040 nm) (Donlon et al., 2012).

Its twenty-one spectral bands are programmable by ground command both in width and in position by steps of 1.25nm (Donlon et al., 2012). The 1270 km field of view is shared between five identical cameras arranged in a fan shape configuration, each camera covering a 14 degrees field of view (see Figure 3).



**Figure 3: OLCI basic viewing geometry.**

The image is constructed using the push-broom principle, where a narrow strip of the earth is imaged into the entrance slit of the spectrometer, defining the across track dimension, while the motion of the satellite provides the along track dimension.

The spectral dimension is achieved by imaging the entrance slit of the spectrometer via a dispersing grating onto a 2-D CCD array. The CCD covers the spectral range with a nominal 1.25 nm spectral sampling interval. The OLCI spectral bands are constructed by first binning one or more CCD spectral samples, in the shift register of the CCD detector, into micro-bands; and further grouping them into bands digitally (spectral relaxation) before transmission to ground. Main spectral and radiometric characteristics of the OLCI bands are listed in Table 1.

**Table 1: OLCI bands characteristics, adapted from (Donlon et al., 2012).**

Band	$\lambda$ centre	Width	Lmin	Lref	Lsat	SNR	Function
	nm	nm	W/(m <sup>2</sup> sr $\mu$ m)	W/(m <sup>2</sup> sr $\mu$ m)	W/(m <sup>2</sup> sr $\mu$ m)	@Lref & 1.2km	
Oa1	400	15	21.6	62.95	413.5	2188	Aerosol correction, improved water constituent retrieval.
Oa2	412.5	10	25.93	74.14	501.3	2061	Yellow substance and detrital pigments (Turbidity).
Oa3	442.5	10	23.96	65.61	466.1	1811	Chl absorption max., Biogeochemistry, vegetation.
Oa4	442	10	19.78	51.21	483.3	1541	High Chl, other pigments.
Oa5	510	10	17.45	44.39	449.6	1488	Chl, sediment, turbidity, red tide.
Oa6	560	10	12.73	31.49	524.5	1280	Chlorophyll reference (Chl minimum)
Oa7	620	10	8.86	21.14	397.9	997	Sediment loading
Oa8	665	10	7.12	16.38	364.9	883	Chl (2 <sup>nd</sup> Chl abs. max.), sediment, yellow substance/vegetation
Oa9	673.75	7.5	6.87	15.7	443.1	707	For improved fluorescence retrieval
Oa10	681.25	7.5	6.65	15.11	350.3	745	Chl fluorescence peak, red edge.
Oa11	708.75	10	5.66	12.73	332.4	785	Chl fluorescence baseline, red edge transition.
Oa12	753.75	7.5	4.7	10.33	377.7	605	O <sub>2</sub> absorption reference, clouds, vegetation.
Oa13	761.25	2.5	2.53	6.09	369.5	232	O <sub>2</sub> absorption band, fluorescence over land.
Oa14	764.375	3.75	3	7.13	373.4	305	O <sub>2</sub> absorption band, fluorescence over land.
Oa15	767.5	2.5	3.27	7.58	250	330	O <sub>2</sub> absorption band, fluorescence over land.
Oa16	778.75	15	4.22	9.18	277.5	812	Atmos. Corr./aerosol corr.
Oa17	865	20	2.88	6.17	229.5	666	Atmos. Corr./aerosol corr., clouds, pixel co-registration. Common reference band with SLSTR instrument.
Oa18	885	10	2.8	6	281	395	Water vapour absorption reference band.
Oa19	900	10	2.05	4.73	237.6	308	Water vapour absorption/vegetation monitoring (max. reflectance).
Oa20	940	20	0.94	2.39	171.7	203	Water vapour absorption, atmos./aerosol corr.
Oa21	1020	40	1.81	3.86	163.7	152	Atmos./aerosol corr.

### 4.3 Land measurement principles

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Vegetation canopy spectral response is characterised by two distinctive elements. First, low reflectance in the visible range of the spectrum (400-675 nm) as a result of chlorophyll absorption. Second, a relative high reflectance of NIR radiation (750-1350 nm) because of incident light scattering by leaf cell walls and intracellular air spaces (Pastor-Guzman, 2020).

Deriving products monitoring vegetation status from TOA radiance measurements thus requires first to account for atmosphere contribution and second to account for directional effects, implicitly or explicitly. The last stage consists in deriving geophysical products representative of the vegetation status from the spectral shape of the Top of Canopy reflectance. See section 5.2 for more details.

### 4.4 Calibration and Validation

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The radiometric calibration of OLCI is performed with the use of two identical on-board sun-lit radiometric calibration diffuser plates. Calibration of OLCI is performed at the orbital South Pole where diffuser plates are deployed, exposed to Sun light while inserted in the instrument field-of-view. OLCI radiometric calibration thus relies on the diffuser's on-ground characterisation, which acts as an on-board secondary reflectance standard. The dark offset is measured just before thanks to a shutter and provides the second point of the calibration line.

OLCI Radiometric Calibration sequences are acquired about every two to three weeks. The stability of the nominal diffuser plate is monitored using a reference plate deployed only about every 3 months.

## 5 OLCI Algorithms and Processing levels

### 5.1 Level 1

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Level 1 Earth Observation (EO) processing output is [Level-1B](#) data, i.e. radiometrically calibrated, geo-referenced and annotated TOA radiances.

EO processing involves the calibration of the numerical counts transmitted by the instrument into radiances, geo-locating the acquired pixels on the Earth's surface and re-sampling the image onto an orthogonal product grid, representing the instrument's ideal swath. The final steps involve quality flags, meteorological annotations and pixel classification flags, appended with computed variables to the generated Level-1B products.

EO processing is divided into six steps:

1. Data extraction and quality checks from input Level 0 data.
2. Radiometric scaling: derivation of calibrated TOA radiance values from the numerical counts previously extracted.
3. Stray light correction: a two-step process that estimates and corrects stray light contamination.
4. Geo-referencing: Computation, for every pixel, of the first intersection between the pixel line-of-sight and the Earth's surface (assumed to be perfectly represented by the WGS84 Reference Ellipsoid completed by a Digital Elevation Model).
5. Pixel classification: to classify the pixels according to underlying surface, whatever the atmospheric conditions, to provide preliminary detection of cloudy pixels and to detect pixels showing a risk of contamination by sun glint.
6. Spatial re-sampling: definition and filling of the output products grid, according to the product's resolution, full or reduced. The product grid is defined as the instrument's ideal swath: with a constant spatial resolution on ground, perfectly aligned cameras without any overlap at their interface. Calibrated pointing vectors of individual instrument pixels are used to determine the correspondence between the instrument and the product grid.

Since September 2022, the per-pixel radiometric uncertainties are also propagated all along the OLCI L1b processing and provided in separate files.

## 5.2 Level 2

### 5.2.1 OTCI

Chlorophyll content is a key controlling factor in determining the physiological status of a plant and has temporal and spatial variability. As chlorophyll content is related to the amount of photosynthetic activity that is occurring, by measuring it over space and time it will act as a key input for models simulating vegetation health, terrestrial primary productivity and gas exchanges. The OTCI is based upon the legacy of the MERIS Terrestrial Chlorophyll Index (MTCI) a product produced by the MERIS sensor on board the ESA Envisat mission (Dash et al., 2004).

Vegetation canopy spectral response is characterised by two distinctive elements. First, low reflectance in the visible range of the spectrum (400-675 nm) as a result of chlorophyll absorption. Second, a relative high reflectance of NIR radiation (750-1350 nm) because of incident light scattering by leaf cell walls and intracellular air spaces (Pastor-Guzman, 2020). The narrow transitional region formed between these two features is known as the Red-Edge (RE). The RE position (REP) responds to increasing levels of chlorophyll by shifting towards longer wavelengths. Therefore, the REP can be successfully exploited for the remote sensing of canopy chlorophyll content (CCC). Through the exploitation of the “red-shift” the OTCI product remains sensitive at high chlorophyll content levels, whereas traditional vegetation indices such as Normalized Difference Vegetation Index (NDVI) saturate (Richter et al., 2008).

The MTCI was the first operational product to measure CCC from space, operating from 2004 to 2012. It has been used in a wide range of scientific applications such as characterising land surface phenology, land cover mapping, crop yield predictions and terrestrial productivity modelling. As OLCI has the same band configuration to MERIS, there is an opportunity to continue the global CCC data set at 300 m resolution. OTCI is a dimensionless quantity between 0 – 6.5.

As shown in Figure 4, pre-processing which includes atmospheric correction is performed before OTCI is calculated. Initially, top of atmosphere (TOA) reflectance is generated from L1B TOA radiance using the solar spectral irradiance and the sun zenith angle. Interference from gaseous components in the atmosphere such as O<sub>3</sub>, O<sub>2</sub> and H<sub>2</sub>O is then removed. Then Rayleigh correction is applied to the TOA reflectance to account for the effect of molecular scattering. The final pre-processing step is used to correct an across track field of view gradient caused by the variation in the central wavelength.

The different input parameters required to calculate the OTCI are OLCI band 5, OLCI band 10, OLCI band 11, OLCI band 12 and a series of auxiliary data including sun and view zenith angles, and the cloud, invalid and land pixel flags. Before the calculation of the OTCI the input data is initially screened to remove cloud and water pixels to avoid calculation of meaningless values. An additional spectral test is applied to land pixels using band 5, 510 nm, to identify the non-vegetated land surface pixels.

OTCI is then calculated using OLCI red, red-edge and NIR bands (band 10, 11 and 12) using the following equation:

$$OTCI = \frac{Band\ 12 - Band\ 11}{Band\ 11 - Band\ 10}$$

If the output for the OTCI calculation exceeds either the minimum or maximum threshold, 0 and 6.5 respectively, then an out-of-range flag value is applied to the pixel. A key improvement of the OTCI over the Envisat MTCI is the provision of a per-pixel uncertainty estimate which is generated through the propagation the TOA radiance uncertainties.

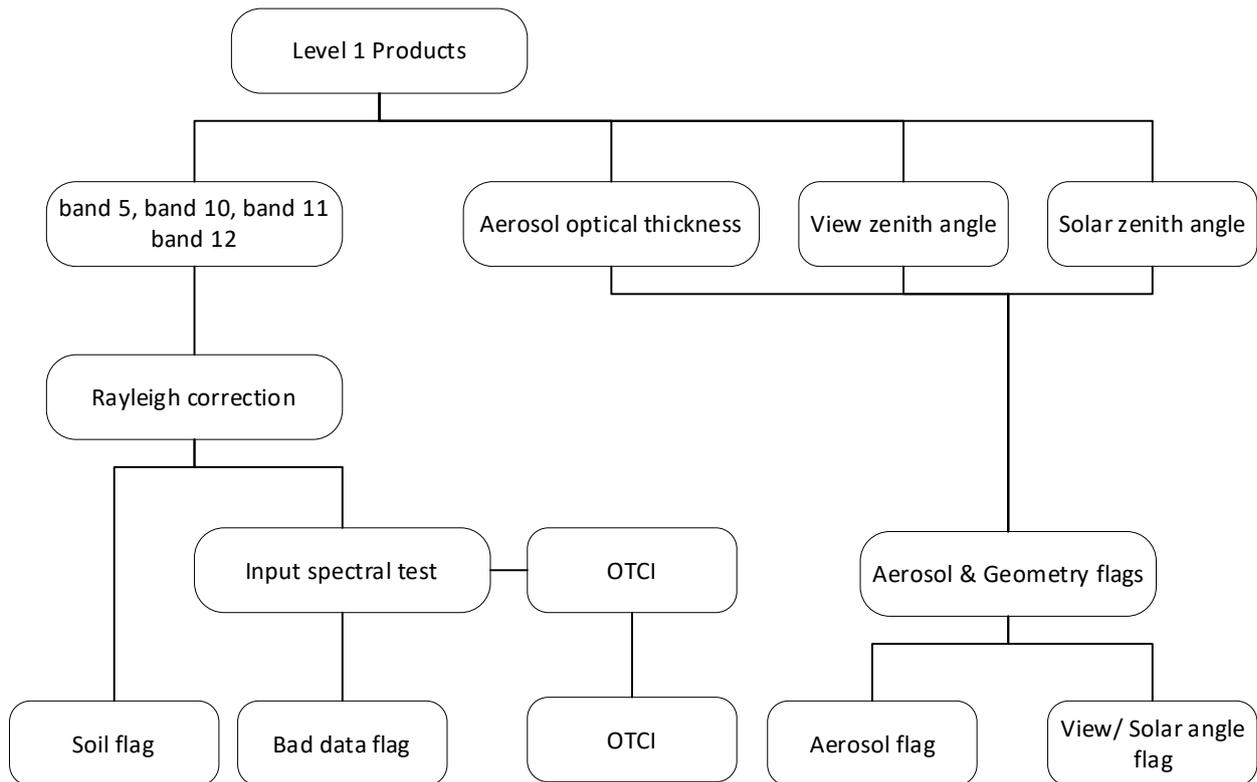


Figure 4: Flow chart of the Sentinel-3 OLCI Terrestrial Chlorophyll Index (OTCI)

### 5.2.1.1 Quality Flags

The Sentinel-3 OTCI is accompanied by a data layer with 8-bit encoded information related to individual aspects of data quality: (i) bad data, (ii) view angle, (iii) aerosols, and (iv) soil (Table 2).

The bad data flag is designed to identify highly reflective pixels, possibly signifying cloud and snow, which has remained undetected in the LQSF flags. Firstly, the input spectrum is passed through a series of spectral tests then the generated OTCI value is checked against the valid range (0 – 6.5) If any of the tests fail then the pixel is classified as bad data.

The view angle flag was developed by assessing the impact of different combinations of solar zenith angle and solar azimuth angles on increasing values of OTCI. Currently the view angle flag is not implemented in the processor itself.

As the impact of the aerosol optical thickness (AOT) varies across different wavelengths even band ratio vegetation indices can be affected by AOT. In cases of low AOT ( $AOT_{440} < 0.3$ ) this could contribute a 2.9% error in the OTCI calculation, rising up to a 21.6% error at high AOT levels ( $AOT_{440} > 1.4$ ). Currently, there are no operationally produced AOT estimates produced by OLCI, however, there is an AOT product generated by the OLCI and Sea and Land Surface Temperature Radiometer (SLSTR) synergy. In the absence of an OLCI-only AOT product the aerosol flags are set to very good condition.

Bare soil pixels with no CCC can generate erroneous OTCI values between 1.5 – 1.9. Therefore a test for identifying pixels with a high background soil contribution to the signal is needed. OLCI bands 12 (NIR), 10 (red) and 5 (green) are used to calculate a soil flag according to the following formula:

$$\text{Soil Discrimination Index} = \frac{\rho_{NIR}/\rho_{red}}{\rho_{red}/\rho_{green}}$$

A threshold value of 0.9 for the index was selected to classify bare soil pixels not suitable for OTCI calculation.

**Table 2: Sentinel-3 OTCI quality flags descriptions**

Bits	Indicator	Value		Quality	Description
8 – 7	Bad data	1	1	Very good	$\text{pred} < 0.2; \rho_{NIR} > 0.1; (\rho_{NIR} - \text{pred}) > 0.1$
		0	0	Poor	$\text{pred} > 0.2; \rho_{NIR} < 0.1; (\rho_{NIR} - \text{pred}) < 0.1$
6 – 5	View angle	1	1	Very good	$VZA < 30^\circ; SZA > 40^\circ$
		1	0	Good	$VZA 30^\circ < 40^\circ; SZA > 30^\circ \leq 40^\circ$
		0	1	Fair	$VZA \geq 40^\circ < 50^\circ; SZA > 20^\circ \leq 30^\circ$
		0	0	Poor	$VZA \geq 50^\circ; SZA \leq 20^\circ$
4 – 3	Aerosol	1	1	Very good	$AOT_{440} < 0.3$
		1	0	Good	$AOT_{440} 0.3 - 0.7$
		0	1	Fair	$AOT_{440} 0.7 - 1.4$
		0	0	Poor	$AOT_{440} > 1.4$
2 – 1	Soil	1	1	Very good	$\geq 0.9$ Land cover non-soil
		1	0	Good	$\geq 0.9$ Land cover non-soil
		0	1	Fair	$< 0.9$ Land cover soil
		0	0	Poor	$< 0.9$ Land cover soil

## 5.2.2 GIFAPAR

Important note: since the ddth of September 2021, in the OLCI level 2 products, the OGVI files have been renamed in GIFAPAR (see section 5.2.2). The user shall bear in mind that products processed before that date still contain the 'OGVI' name.

Incoming solar radiation is absorbed on or near the oceanic and terrestrial surface. This energy is ultimately released back into the atmosphere through the fluxes of infrared radiation. A key controller in the exchanges of the fluxes is the leaf surface in the photosphere. Solar radiation in the spectral range 400 – 700 nm, known as the photosynthetically active radiation (PAR), provides the energy required to produce organic materials from mineral components. The amount of PAR absorbed by plants is known as the FAPAR. It is recognised as one of the fundamental Essential Climate Variables (ECV) by Global Terrestrial Observing System (GTOS) and Global Climate Observing System (GCOS) (GCOS ECV documentation). It is a dimensionless quantity that ranges from 0 to 1.

There have been a number of FAPAR algorithms developed for different optical instruments such as the MERIS Global Vegetation Index (MGVI) (MERIS ATBD). The algorithm described in this section is called the JRC-OLCI FAPAR and is suitable for any surface applications requiring the monitoring of the state of the land surface. There are several different definitions for FAPAR depending on if the calculation is based upon an instantaneous measurement or a daily averaged value to account for different illumination geometries. Additionally, green FAPAR refers to the fraction of PAR radiation absorbed by live leaves only, whilst total FAPAR refers to the fraction of PAR radiation absorbed by all elements of the canopy i.e., woody material (in forests) or dead leaves (in crops).

**OGVI refers to the instantaneous and green value definition. As such it has recently been renamed to Green Instantaneous FAPAR (GIFAPAR) (Q3 2020).**

As shown in Figure 5, pre-processing which includes atmospheric correction is carried out before OGVI is calculated. Initially, the top of atmosphere (TOA) reflectance is computed using L1B TOA radiance using the solar spectral irradiance and the sun zenith angle. Interference from gaseous components in the atmosphere such as O<sub>3</sub>, O<sub>2</sub> and H<sub>2</sub>O is then removed. Then Rayleigh correction is applied to the TOA reflectance to account for the effect of molecular scattering. The final pre-processing step is used to correct an across track field of view gradient caused by the variation in the central wavelength.

The different input parameters required to calculate the GIFAPAR are OLCI band 3, OLCI band 10 and OLCI band 17. Before the calculation of the GIFAPAR a number of screening tests are performed to remove pixels affected by water, cloud or with bad input values, i.e. non vegetated pixels. The blue band is then combined with the information in the red and NIR bands to generate "rectified channels" at the wavelengths 681 and 685 nm. The rectification aims to minimise the difference between the values in the rectified channels and the spectral reflectance that would be measured at the top of the canopy under a standard geometry of illumination and observation. The proposed algorithm assumes that ratios of polynomials are appropriate to generate both the "rectified channels" and the final spectral index (GIFAPAR).

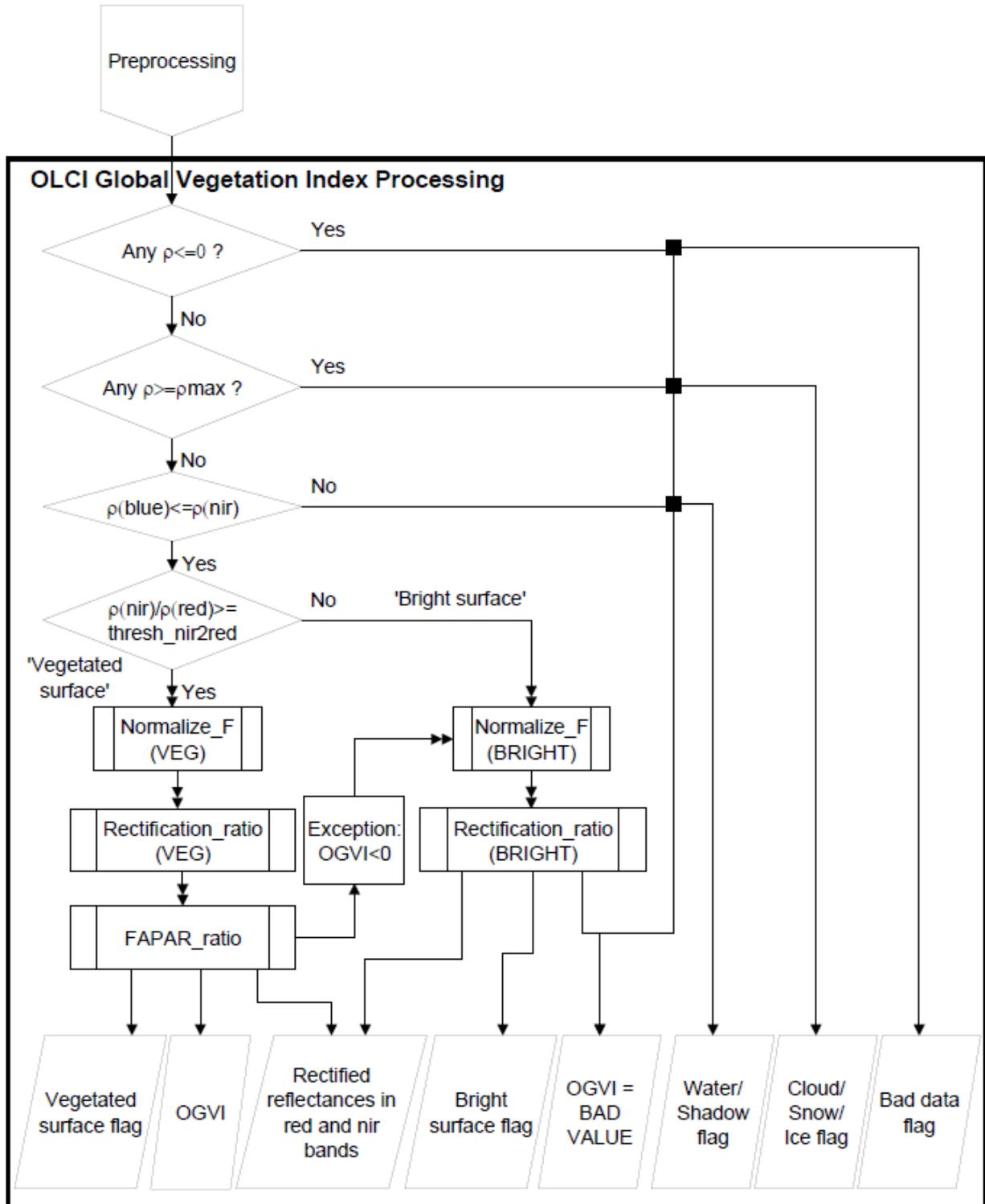


Figure 5 Flow chart of the Sentinel-3 OLCI Global Vegetation Index (GIFAPAR).

### 5.2.2.1 Quality Flags

The Sentinel-3 GIFAPAR is accompanied by a data layer with 8-bit encoded information related to individual aspects of data quality: (i) bad data, (ii) cloud, snow and ice, (iii) waterbodies and deep shadow, and (iv) bright surfaces. The pixel labelling criteria is shown in Table 3.

The pixel labelling is performed via a series of threshold tests using the values in the spectral bands already utilised by the algorithm. For each geophysical category, the tests were developed using pre-existing knowledge about the multi-spectral response of the geophysical system. This labelling criteria is computationally efficient as no extra information is needed. However, users can utilise other masks supplied in the OLCI product to further filter erroneous values.

**Table 3: Sentinel-3 GIFAPAR quality flag descriptions**

Bits	Indicator	Spectral Test
0	Land surface	$0 < p_{blue} < 0.3$ <i>and</i> $0 < p_{red} < 0.5$ <i>and</i> $0 < p_{nir} < 0.7$  <i>and</i> $0 < p_{blue} \leq p_{nir}$ <i>and</i> $p_{nir} \geq p_{red}$
1	Bad data	$p_{blue} \leq 0$ <i>or</i> $p_{red} \leq 0$ <i>or</i> $p_{nir} \leq 0$
2	Cloud, snow and ice	$p_{blue} \geq 0.3$ <i>or</i> $p_{red} \geq 0.5$ <i>or</i> $p_{nir} \geq 0.7$
3	Water body and deep shadow	$0 < p_{blue} < 0.3$ <i>and</i> $0 < p_{red} < 0.5$ <i>and</i> $0 < p_{nir} < 0.7$  <i>and</i> $p_{blue} > p_{nir}$
4	Bright surface	$0 < p_{blue} < 0.3$ <i>and</i> $0 < p_{red} < 0.5$ <i>and</i> $0 < p_{nir} < 0.7$  <i>and</i> $0 < p_{blue} \leq p_{nir}$ <i>and</i> $1.3p_{red} \geq p_{nir}$
5	Undefined	$pr_{red} < 0$ <i>or</i> $pr_{nir} < 0$

Bits	Indicator	Spectral Test
6	No vegetation	$FAPAR < 0$
7	Vegetation (out of bounds)	$FAPAR > 1$

### 5.2.3 IWV

The algorithm for the retrieval of TCWV from measurements of OLCI is based on the exploitation of the pronounced water vapour absorption band beyond 900 nm, using the differential absorption of water vapour. Three spectral channels are used for the retrieval of water vapour: Channels Oa17 and Oa18, located at 865 nm and 885 nm, respectively, provide measurements in the atmospheric window region whereas channel Oa19, located at 900 nm, at the shortwave edge of the  $\rho\tau$ -absorption band, is strongly influenced by atmospheric water vapour while not saturating even at large airmass factors and high humidity. Here the ratio of OLCI bands 19 and 18 is used for the approximation of the atmospheric transmittance in the water vapour absorption band, in turn closely related to the total column amount. In order to avoid errors due to the spectral variation of the surface reflectivity between 885nm and 900nm, OLCI channel 17 is additionally used for the linear extrapolation of the surface reflectivity from MERIS 865 and 885 nm to 900nm.

The “maximum likelihood” water vapour column over a pixel is estimated by comparing Radiative Transfer (RT) based simulations of the ratio  $\rho_{900}/\rho_{885}$  with the corresponding OLCI measurement. The RT-simulations are approximated by a product of the precise atmospheric transmission (using exponential sums of uncorrelated k-distribution terms) and an estimation of the scattering – absorption - interaction – factor, stored in pre-calculated LUTs. The optimization is done by the gradient descent (“newton-secant”) method. It usually requires 1 to 5 iterations.

A priori Land/Ocean classification is used to select among different LUTs for the computation of correction factor for the scattering – absorption interaction.

## 6 OLCI products

### 6.1 Product types

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The OLCI product types distributed to the users are divided into two main products.

- ❖ Level-1B product
  - The Level-1 product provides measured Top Of Atmosphere Radiances for each pixel in the image grid and each OLCI channel, with per-pixel uncertainties and annotation data associated to OLCI pixels.
  - OLCI Level-2 Products are:
    - OL\_1\_EFR: Full Resolution
    - OL\_1\_ERR: Reduced Resolution
- ❖ Level-2 Land products
  - The level-2 land product provides land and atmospheric geophysical parameters computed for full and Reduced Resolution.
  - OLCI Level-2 Products are:
    - OL\_2\_LFR: Land Full Resolution
    - OL\_2\_LRR: Land Reduced Resolution

In addition to the Level 2 OLCI product, the SENTINEL-3 SYN product is produced by combining products of OLCI and SLSTR products. More information on the SYN product can be found on the SENTINEL-3 SYNERGY handbook.

### 6.2 Timeliness

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SENTINEL 3 OLCI products are associated to different timeliness:

- ❖ The **Near Real Time** (NRT) timeliness implies a delivery in less than 3 hours after data acquisition. This timeliness is mainly used for marine meteorology and ocean-atmosphere gas transfer studies.
- ❖ The **Non-Time Critical** (NTC) timeliness is typically defined for deliveries within 1 month after data acquisition. This additional delay allows consolidation of some auxiliary or ancillary data (e.g. precise orbit data) and the data are mainly used for geophysical studies and operational oceanography.

As consequences, OLCI L1/L2 scenes can be found twice, processed in NRT and NTC conditions and including the following suffix "NR" or "NT" in their filename.

The differences between NRT and NTC products are due to auxiliary data:

	<b>Copernicus Sentinel-3 OLCI Land User Handbook</b>	Ref.: OMPC.ACR.HBK.001 Issue: 1.2 Date: 14/04/2023 Page: 20
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- ❖ Consolidated orbit files used in NTC processing
- ❖ Forecast ECMWF Meteorological dataset used in NRT processing instead of analysis ECMWF data in NTC processing.

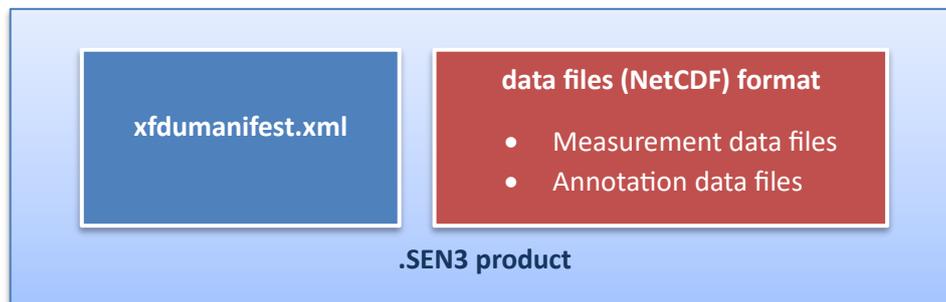
Only NTC products are archived in the long-term.

### 6.3 Data format

The OLCI data format follows the format defined for each SENTINEL-3 product in the PDGS product specification, based on a tailoring of the SAFE (Standard Archive Format for Europe) norm dedicated to Sentinel Earth Observation data products.

Each product package – a directory named according to the convention described in section 6.5 – includes:

- ❖ a manifest file, in XML format, containing a metadata section and a data object section,
- ❖ measurement data files, in NetCDF format,
- ❖ annotation data files, in NetCDF format (if defined).



**Figure 6: SEN3 product structure**

SENTINEL-3 user products are disseminated in Product Dissemination Units (PDU), in order to ease the online dissemination and data handling for the users. The PDU is a portion of data and is defined per product type.

### 6.4 PDUs

All SENTINEL-3 products released to the users are called PDU (Product Dissemination Unit) and are generated by the Product Unit Generator (PUG).

The direct output of the IPF is a so-called granule, which has a constant duration but not a constant positioning along the track. This non-constant positioning prevents from an easy comparison over time.

PDUs have a constant duration and they have a constant positioning along the track over time, as displayed in the next figures.

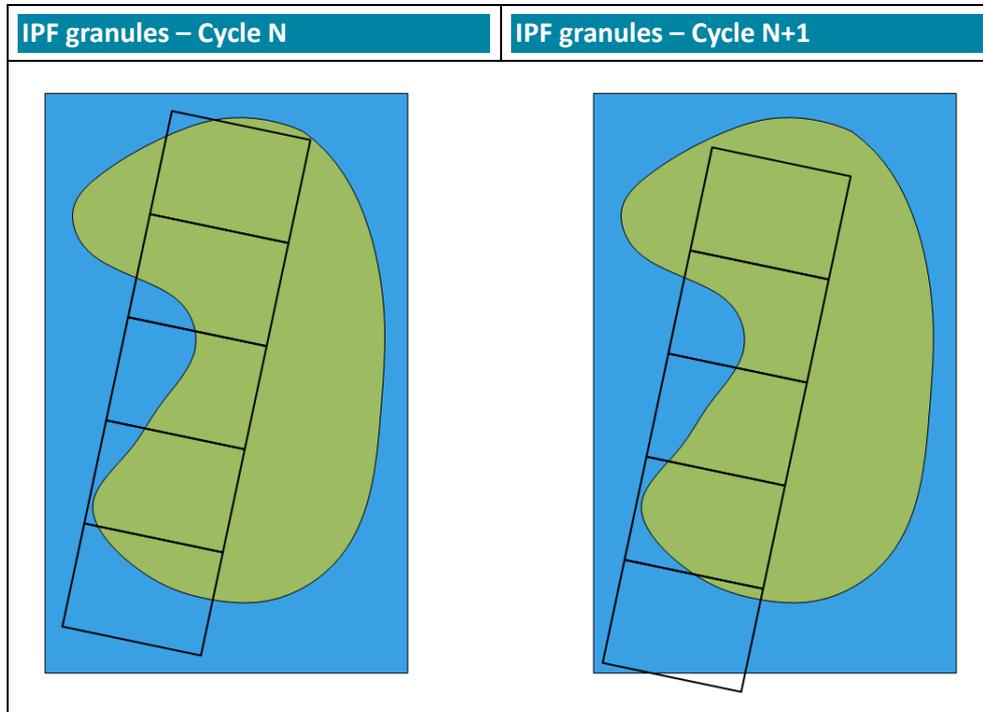


Figure 7: IPF granules over two different cycles

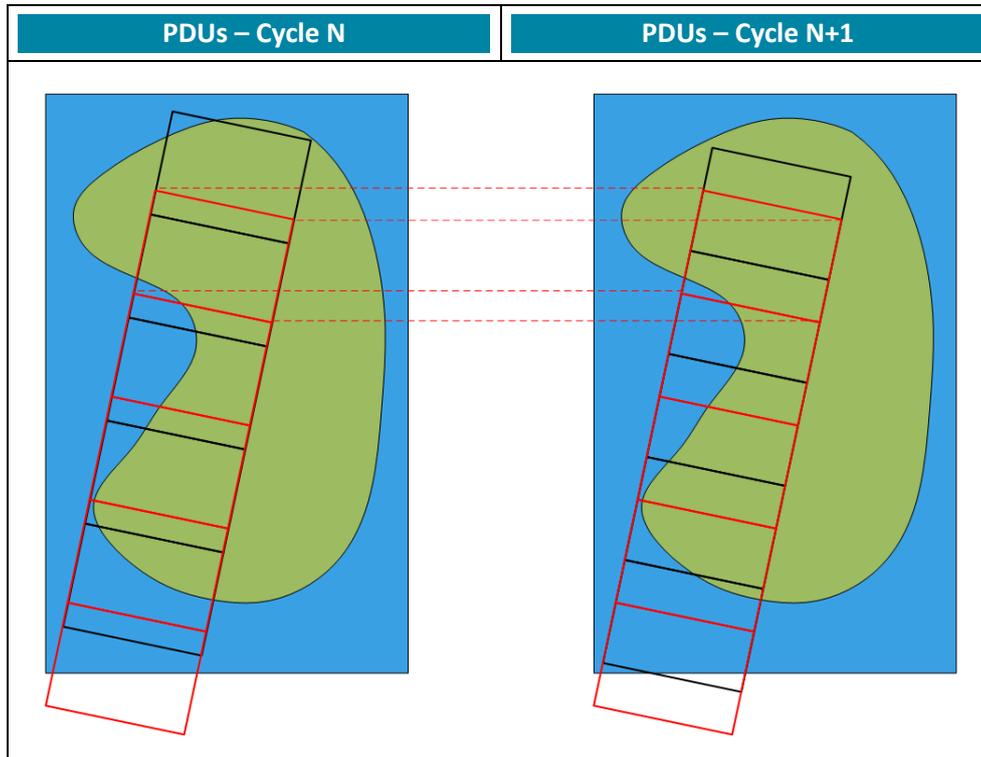


Figure 8: PDUs over two different cycles

It is important to note that the PUG does not modify the content of the products: there is no processing done on the physical content of data, the PUG being just a cutter/formatter of data, able to take M granules to make N PDUs.

## 6.5 Naming Convention

The file naming convention for OLCI products is identified by the sequence of fields described here:

**MMM\_OL\_L\_TTTTTT\_yyyymmddThhmmss\_YYYYMMDDTHHMMSS\_YYYYMMDDTHHMMSS\_[instance ID]\_GGG\_[class ID].SEN3**

- ❖ **MMM** is the mission ID:
  - S3A = SENTINEL-3A
  - S3B = SENTINEL-3B
  - S3\_ = for both SENTINEL-3A and 3B
- ❖ **OL** is the data source/consumer (OL = OLCI)
- ❖ **L** is the processing level
  - “0” for Level-0
  - “1” for Level-1
  - “2” for Level-2

- underscore “\_” if processing level is not applicable.
- ❖ **TTTTTT** is the Data Type ID
  - Level-1 OLCI data:
    - “EFR\_\_\_” = TOA radiances at full resolution
    - “ERR\_\_\_” = TOA radiances at reduced resolution
  - Level-2 OLCI data:
    - “LFR\_\_\_” = full resolution land colour and atmosphere parameters
    - “LRR\_\_\_” = reduced resolution land colour and atmosphere parameters
- ❖ **yyyymmddThhmmss** is the sensing start time
- ❖ **YYYYMMDDTHHMMSS** is the sensing stop time
- ❖ **YYYYMMDDTHHMMSS** is the product creation date
- ❖ **[instance ID]** The field consists of 17 characters, either uppercase letters or digits or underscores “\_”:
  - The instance id fields include, for instrument data products:
    - Duration, “\_”, cycle number, “\_”, relative orbit number, “\_”, FFFF “\_”  
DDDD\_CCC\_LLL\_FFFF\_
    - Frame along track coordinate “FFFF”= four digits; elapsed time in seconds from the ascending node indicating the frame start time.
- ❖ **GGG** identifies the centre which generated the file
- ❖ **[class ID]** identifies the class ID for instrument data products with conventional sequence “P\_XX\_NNN” where:
  - P indicates the platform (O for operational, F for reference, D for development, R for reprocessing)
  - XX indicates the timeliness of the processing workflow (NR for Near Real Time, ST for Short Time Critical, NT for Non Time Critical)
  - NNN indicates the baseline collection or data usage.
- ❖ **.SEN3** is the directory extension.

**Example of filename:**

- ❖ S3A\_OL\_2\_LFR\_\_\_20201101T185950\_20201101T190250\_20201102T231050\_0179\_064\_298\_4140\_LN1\_O\_NT\_002.SEN3
  - Acquired on the 1<sup>st</sup> of November 2020 between 18:59:50 and 19:02:50 UTC
  - Generated on the 2<sup>nd</sup> of November 2020 at 23:10:50 UTC
  - Whose duration is 179 seconds

- Acquired during cycle 064 and relative orbit 298
- 4140 seconds from the ascending node
- Generated at LN1 centre, in NTC timeliness
- Whose baseline collection is 002.

More details are given in document “Sentinel-3 PDGS File Naming Convention” (ref. GMES-S3GS-EOPG-TN-09-0009).

## 6.6 Level 1 product content

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The OLCI Level 1 products are generated and provided to users in two spatial resolution: the Full Resolution product *OL\_1\_EFR* and the Reduced Resolution *OL\_1\_ERR*. The former has a spatial resolution of about 300 m, corresponding to the instrument resolution at the sub-satellite point, the latter has a resolution of about 1.2 km, artificially built during the Level 1 product generation.

- ❖ *OL\_1\_EFR*, the OLCI Level-1 Full Resolution product, includes twenty-two measurement data files and seven annotation data files.
- ❖ *OL\_1\_ERR*, the OLCI Level-1 Reduced Resolution product, includes twenty-one measurement data files and seven annotation data files.

Measurement and annotation data files are provided in NetCDF format.

The Measurement data files include:

- ❖ the Top Of Atmosphere (TOA) radiance at every pixel of the Product Grid: *Oann\_radiance.nc*, where *nn* stands for the OLCI channel index, in 01 to 21.
- ❖ The Radiometric Uncertainty Estimate at every pixel of the Product Grid: *Oann\_radiance\_unc.nc*, where *nn* stands for the OLCI channel index, in 01 to 21. Note that these are provided log10-scaled to preserve radiometric resolution while optimizing data storage.
- ❖ The “removed pixels” data file, provided only in the Full Resolution Product, *removed\_pixels.nc*, containing the pixels that were discarded during the spatial regridding, necessary to restore the spatial continuity as the OLCI cameras show a slight overlap at their interface. This file contains all the information related to removed pixels, TOA radiances of course but also their uncertainties and all kinds of annotations.

The annotation data files, also written in NetCDF 4 format, are described in Table 4 below. Annotations are provided either at the image grid sampling, i.e. for each product pixel, or at the Tie Points sampling, i.e. a sub-sampling of the image grid, in which case the file name is prefixed by “tie\_”.

**Table 4: Description of annotation data files included in OLCI User products**

File Name	Dimensions	Contents
time_coordinates.nc	Number of lines in the product image	Time stamp
geo_coordinates.nc	Number of lines and columns in the product image	Longitude, Latitude, Altitude
qualityFlags.nc	Number of lines and columns in the product image	Quality flags
Instrument_data.nc	Number of lines and columns in the product image, number of instrument detectors per frame and number of OLCI bands	<i>lambda0,</i> <i>FWHM,</i> <i>solar_flux,</i> <i>detector_index,</i> <i>frame_offset,</i> <i>relative_spectral_covariance</i>
tie_geo_coordinates.nc	Number of lines and columns in the tie-point grid	Longitude, latitude
tie_geometries.nc	Number of lines and columns in the tie-point grid	Sun and observation angles: <i>Sun Zenith Angle (SZA)</i> <i>Sun Azimuth Angle (SAA),</i> <i>Observation Zenith Angle (OZA),</i> <i>Observation Azimuth Angle (OAA)</i>
tie_meteo.nc	Number of lines and columns in the tie-point grid	ECMWF data: <i>horizontal_wind,</i> <i>sea_level_pressure,</i> <i>total_ozone, humidity,</i> <i>reference_pressure_level,</i> <i>atmospheric_temperature_profile,</i> <i>total_columnar_water_vapour</i>

## 6.7 Level 2 product content

The OLCI Land Level 2 products are generated from the Level 1 products, separately for each resolution. They are thus provided to users in the same two spatial resolution: the Full Resolution product OL\_2\_LFR and the Reduced Resolution OL\_2\_LRR. As for Level 1 products, the former has a spatial resolution of about 300 m, corresponding to the instrument resolution at the sub-satellite point, the latter has a resolution of about 1.2 km.

- ❖ OL\_2\_LFR, the OLCI Level-2 Land Full Resolution product, includes four measurement data files and seven annotation data files.
- ❖ OL\_1\_ERR, the OLCI Level-1 Reduced Resolution product, includes four measurement data files and seven annotation data files.

Measurement and annotation data files are provided in NetCDF format.

The Measurement data files include:

- ❖ the OLCI Terrestrial Chlorophyll Index (OTCI) data file, [otci.nc](#), containing the OTCI values at every image pixel, their uncertainty and specific quality flags.
- ❖ the OLCI Green Instantaneous Fraction of Absorbed Photosynthetically Available Radiation (GIFAPAR) data file, [ogvi.nc](#), containing the GIFAPAR values at every image pixel and their uncertainty.
- ❖ the Rectified Reflectance data file, [rc\\_ogvi.nc](#), containing the rectified reflectances at 665 and 865 nm, used to compute the GIFAPAR values, at every image pixel and their uncertainty.
- ❖ the OLCI Integrated Water Vapour data file, [iww.nc](#), containing the total column water vapour values at every image pixel and their uncertainty.

The annotation data files are identical to those of the Level 1 products to the exception of the Quality Flags file here names [lqsf.nc](#), standing for Land Quality and Science Flags. They are described in Table 4 above. Annotations are provided either at the image grid sampling, i.e., for each product pixel, or at the Tie Points sampling, i.e., a sub-sampling of the image grid, in which case the file name is prefixed by “tie\_”.

## 7 Data Quality Information

### 7.1 Radiometric quality

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**Absolute and inter-band calibration performance** is monitored by indirect methods over natural targets. Three methods are used within OPT-MPC: the “Rayleigh” method (molecular atmospheric backscattering over clear sky off-glint open ocean) provides absolute calibration in the blue-to-red spectral domain; the “Glint” method (spectral dependency of the Sun specular reflection over ocean) provides inter-band calibration; and the PICS method (Pseudo-Invariant Calibration Sites, temporally stable desert areas) provides absolute calibration over the whole spectral domain as well as cross-mission comparisons for sensors with comparable channels.

Two of these methods, Rayleigh and Glint, are undertaken by two different implementations (DIMITRI and OSCAR) providing very consistent results. The third method is only implemented in DIMITRI. Recent results are displayed on Figure 9 below, for both S3A and S3B.

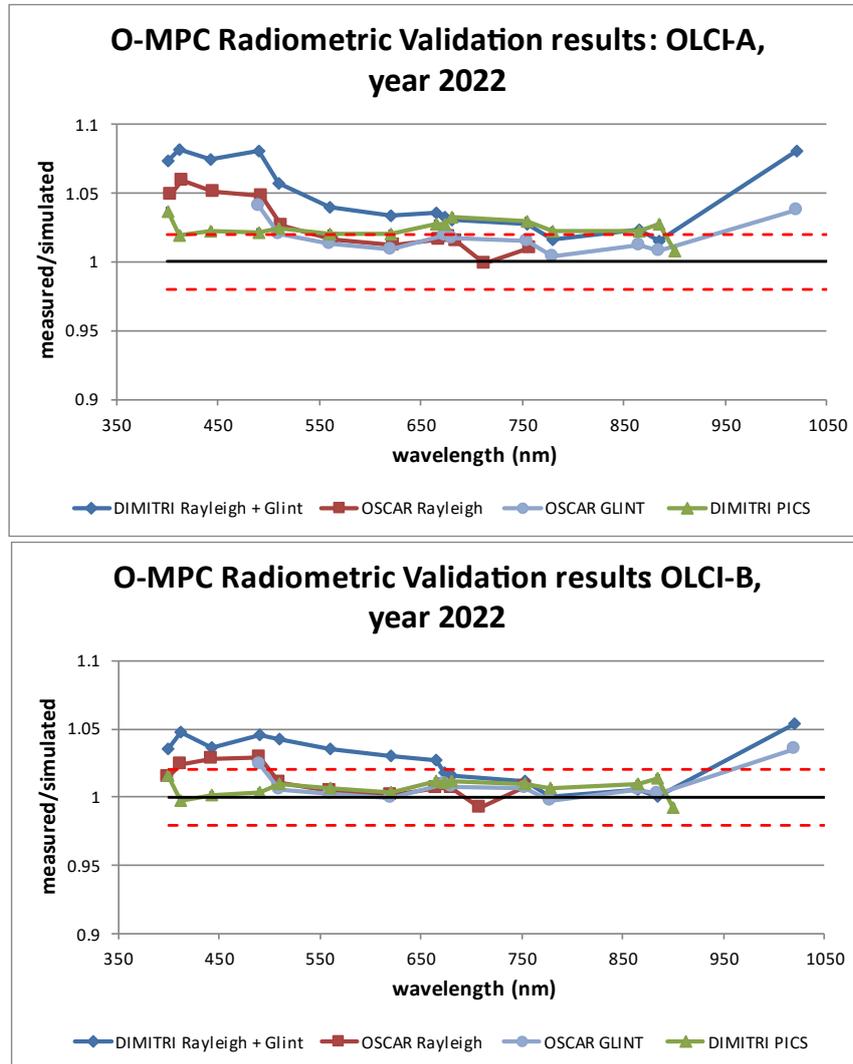


Figure 9: Comparative results about OLCI-A and OLCI-B radiometric validation from the various methods.

All methods point out an excess of brightness for OLCI-A radiances. Results are in pretty close agreement around 2-3% (except DIMITRI Rayleigh, a bit higher) between 510 and 900 nm. Biases are a bit worse in the blue, but the different methods do not agree in that spectral range: Rayleigh DIMITRI gives about 7-8%, Rayleigh OSCAR 5-6% while PICS remains around 2%. The Rayleigh method is however suspected to underestimate the simulated signal at those wavelengths so PICS are considered more reliable. Channel Oa21 (1020 nm) is only addressed by the Glint interband method and the results are much worse: 6 to 8%, depending on the reference band.

Radiometric validation for OLCI-B indicates performance within the 2% requirement for all bands from 510 nm (Oa04) to 940 nm (Oa20) with remarkable agreement for all methods but DIMITRI Rayleigh. As for OLCI-A, the two Rayleigh methods indicate excess of brightness for the 4 bluest channels, between 2 and 5%, while the PICS results provide very good performance estimates. Here again, results for 1020 nm are much worse (4 to 6%, depending on the reference band).

Interband calibration is excellent for both instruments for all bands with a spectral consistency below 1%, except at 1020 nm (3% inter-band bias).

No significant temporal trending can be evidenced by vicarious methods from reprocessed data.

The excess of brightness of OLCI-A has however not been identified as a significant issue by the Level 2 Land validation (see sections 7.3 and 7.4), in particular considering that OLCI-A and OLCI-B show similar performance for Level 2 Land products.

## 7.2 Geolocation accuracy

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The georeferencing accuracy of OLCI-A and OLCI-B is validated using visible data from channel Oa17 correlated with ground control points. Current georeferencing shows a global accuracy below about 0.3 pixel (90 m) RMS, well within the 0.5 pixel requirement. The same process also allows to evaluate per camera along- and across-track performance: biases are below 0.1 pixel in both directions for both instruments since the implementation of revised instrument geometric calibration data (14/03/2018 for OLCI-A and 29/10/2019 for OLCI-B), further improved since then. Details can be found in the [OLCI Data Products Quality Reports](#).

## 7.3 OTCI quality and validation

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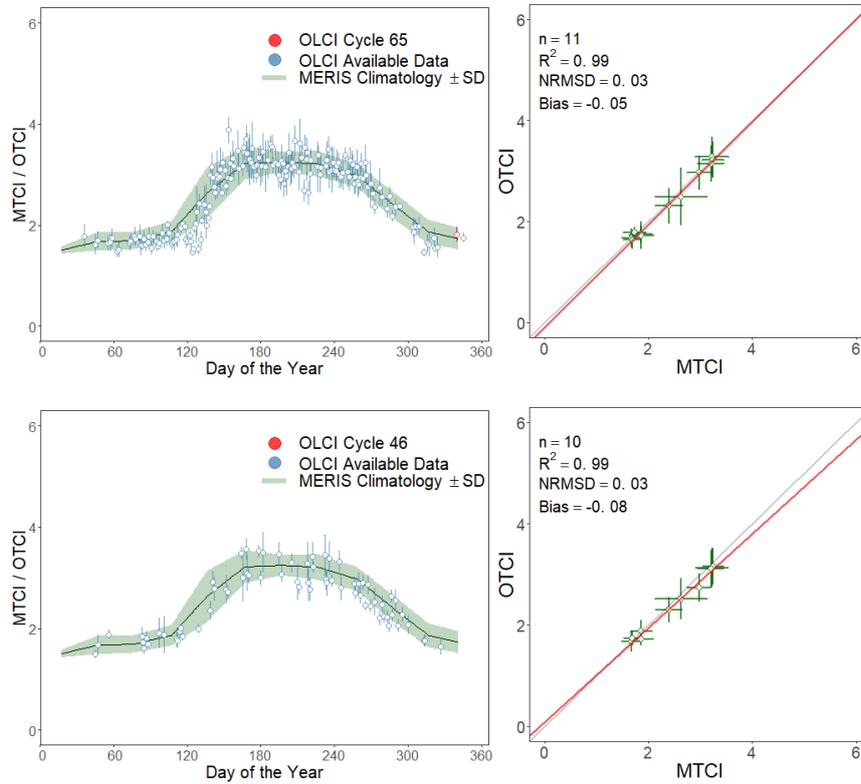
### 7.3.1 Indirect validation

Validation of OTCI products has been performed using two main approaches, inter-comparison with the MTCI archive and direct validation against data collected in field campaigns.

The inter-comparison are routinely performed every 27 days and the results published in Data Product Quality Reports available at the following link: <https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-3-olci/data-quality-reports>.

The inter-comparison is performed over 37 validation sites, which represent a range of land cover types, regions, and species. These sites include the CEOS WGCV LPV supersites, which are recommended for the validation of land products as well as several 'core' sites chosen by the Sentinel-3 Validation Team. Each of the sites, is well characterized and established with a history of validation activities. Extractions covering a 3 x 3 full resolution (300 m) footprint are taken from all available Level-2 Sentinel-3 OTCI and third reprocessing Envisat MTCI data. The footprint size accounts for any geometric inaccuracies and the point spread function of the sensors.

The inter-comparison performance for three sites with different vegetation types: BE-Brasschaat (evergreen needle leaf forest), DE-Haininch (deciduous broadleaf forest) and FR-EstreesMons (cultivated) for Sentinel-3A cycle 65 and Sentinel-3B cycle 46, are shown in **Figure 10 to Figure 12**. Across all sites, similar seasonal trajectories and vegetation dynamics are displayed. When comparing the monthly mean extractions across all sites (Figure 13), the OTCI shows a very strong agreement with the MERIS archive with an  $R^2 = 0.93$ ,  $NRMSD < 0.08$  with very low bias,  $-0.02$ .



**Figure 10: Time-series and corresponding scatterplot of monthly mean of OTCI for site BE-Brasschaat, Belgium, land cover Needle-leaved, evergreen. The top row represents S3A; the bottom row represents S3B.**

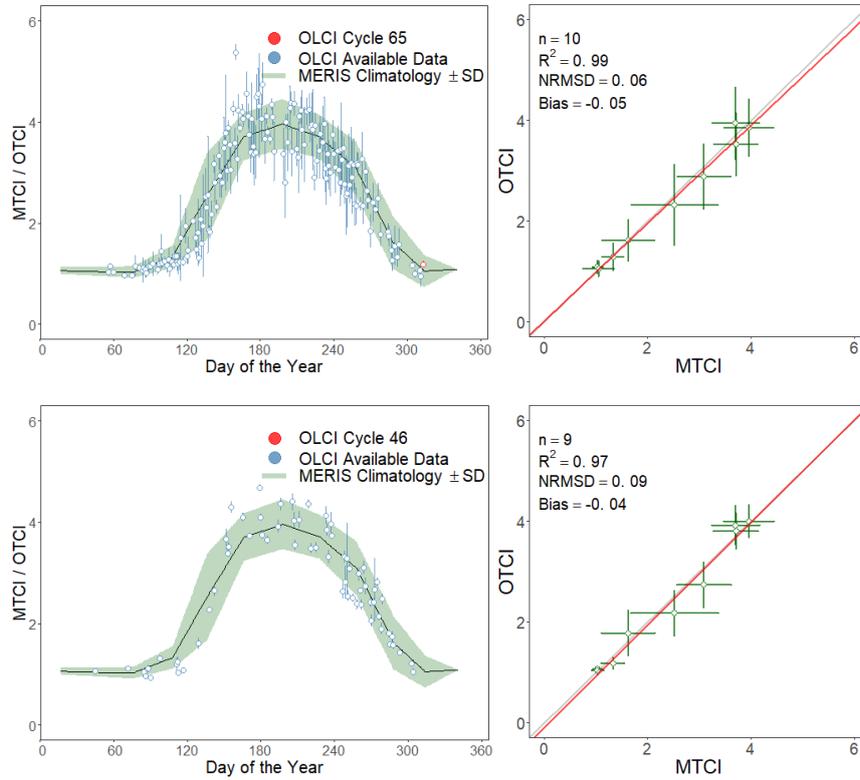
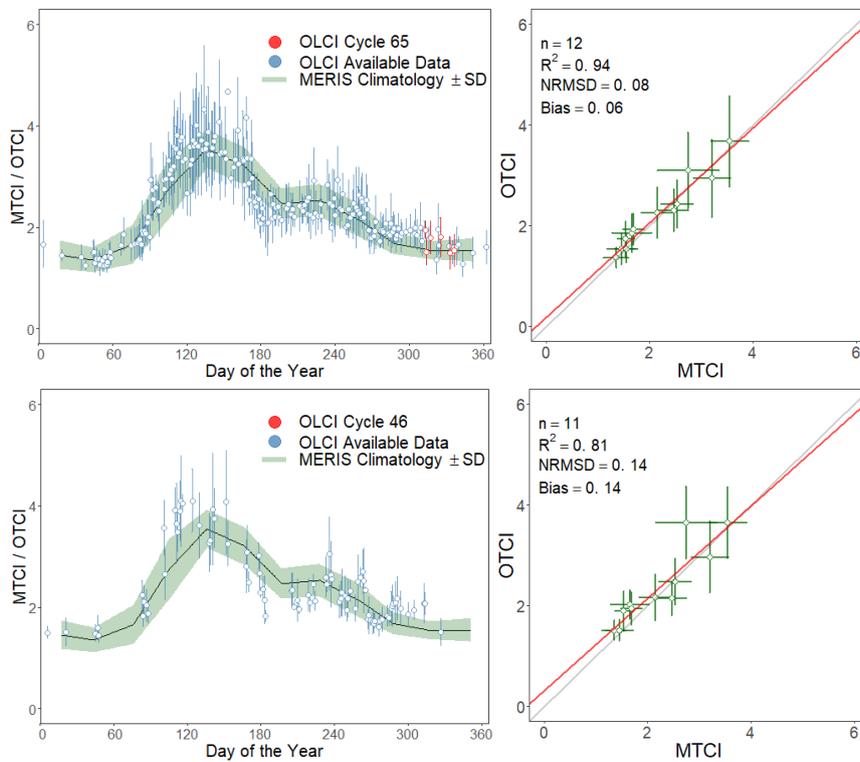
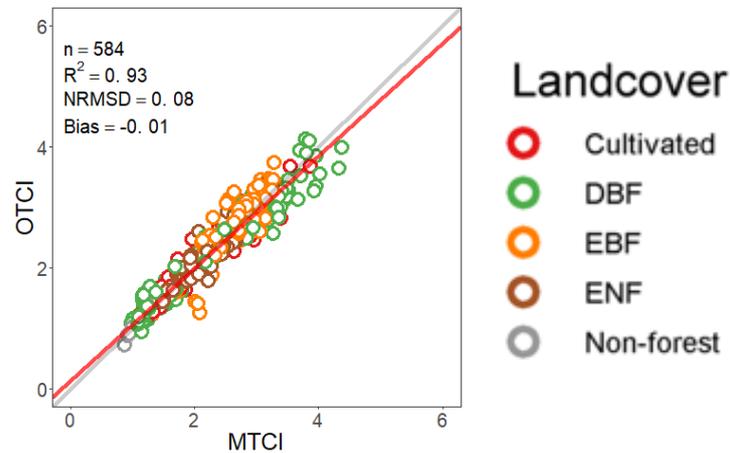


Figure 11: Time-series and corresponding scatterplot of monthly mean of OTCI for site DE-Haininch, Deutschland, land cover Broadleaved, deciduous, closed. The top row represents S3A; the bottom row represents S3B.



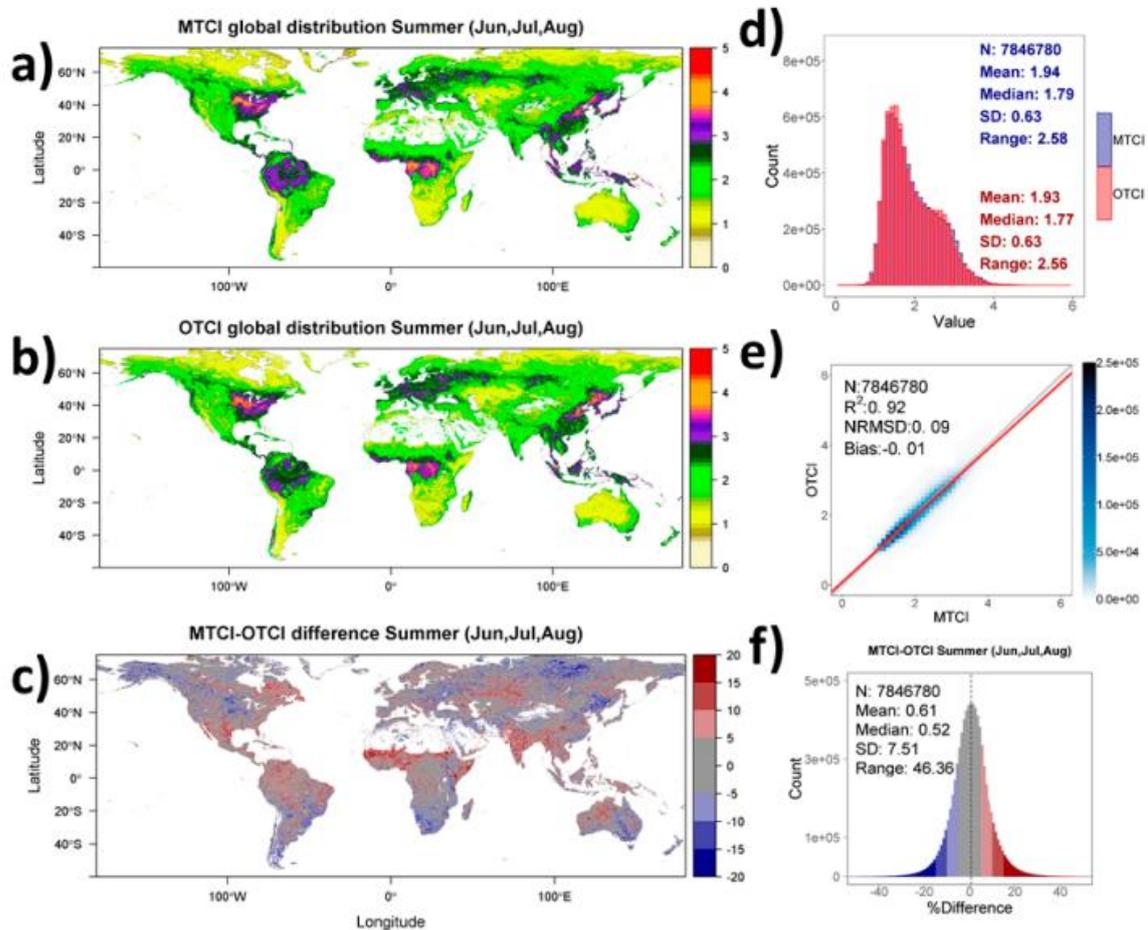
**Figure 12: Time-series and corresponding scatterplot of monthly mean of OTCI for site FR-Estrees-Mons, France, land cover Cultivated and managed areas. The top row represents S3A; the bottom row represents S3B.**



**Figure 13: Comparison of OTCI-MTCI. Points in the scatterplot represent the monthly mean of all available S3A and MERIS archive over 37 validation sites. Red and grey lines represent the modelled and 1:1 lines respectively.**

A global analysis of the spatial consistency of the OTCI products has been published in the following paper “The Sentinel-3 OLCI Terrestrial Chlorophyll Index (OTCI): Algorithm Improvements, spatiotemporal Consistency and Continuity with the MERIS Archive” by Pastor-Guzman et al. (2020). Global composites of the different seasons were generated at 9.2 km resolution (Figure 14). Analysis on the overall distribution alongside the impact of latitudinal gradient on consistency was performed.

Overall, the study found a strong correlation between the products ( $R^2 > 0.88$ ), low global mean percentage difference (-1.86 to 0.61), low absolute bias (<0.1), and minimal error (NRMSD ~0.1).



**Figure 14: Global composites of Sentinel-3 OTCI (mean of 2016 to 2019) and Envisat MTCI (mean of 2002 to 2012) values for summer—i.e. Jun, Jul, Aug (a,b)—and spatial distribution of differences (c). Index value frequency distribution (d), density scatterplot of agreement between the two products (e), and frequency distribution of differences (f). For (c) and (f), difference is expressed in percentage computed as the ratio of per pixel absolute difference to the mean. Blue indicates areas where the Sentinel-3 OTCI is greater than the Envisat MTCI, conversely, red indicates areas where the Envisat MTCI is greater than the Sentinel-3 OTCI. Grey pixels are areas where the difference between the Envisat MTCI and Sentinel-3 OTCI is within  $\pm 5\%$ .**

Note that **Global Composites of OTCI and GIFAPAR** are now routinely generated and publicly available for Validation as Monthly and 8-days synthesis products. Information on how to access to these Composites products is available [here](#), at the bottom of the page under the MPC Run Tools header.

### 7.3.2 Direct validation

So far, four ESA funded ground validation campaigns have been carried out. The campaigns have been performed across different vegetation types and land cover uses (Table 5). For all campaigns, in-situ measurements using digital hemispherical photography and the Konica-Minolta SPAD-502 chlorophyll meter are used to obtain quantities of leaf area index and leaf chlorophyll concentration. These values are combined and used to derive high resolution maps of Canopy Chlorophyll Concentration (CCC) through linear regression of vegetation indices from Sentinel-2 data (Brown et al, 2019). Direct validation of the OTCI product is performed after a spatial aggregation of the CCC maps to 300 m (Figure 15). As shown in

Table 5, strong relationships have been found between the in-situ measurements and the OTCI products. The weaker relationship found at Wytham Woods has been attributed to the relatively low range of OTCI values at the site, due to the campaign being held at the peak of the growing season when the vegetation canopy was fully developed.

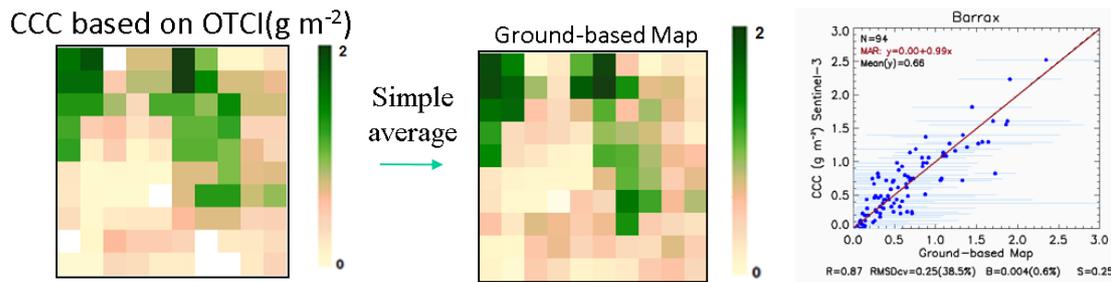


Figure 15: Aggregated CCC map based on OTCI and ground based map of CCC derived from Sentinel-2 data for the Barrax field site. Graphs produced from FRM4VEG data. The relationship between the two products pixels is displayed on the right hand plot.

Table 5: Site information for the direct validation field campaigns for OTCI and OGVI.

Site	Location	Year	Land Cover	R <sup>2</sup> OTCI	R <sup>2</sup> OGVI
New Forest, UK	50.86° N, 1.57° W	2016	Deciduous broadleaf forest	0.88	-
Valencia Anchor Station, Spain	39.57° N, 1.28° W	2017	Vine / fruit trees	0.60	-
Barrax, Spain	39.04° N, 2.09° W	2018	Cropland	0.76	0.67
Wytham, UK	51.77° N, 1.34° W	2018	Deciduous broadleaf forest	0.64	0.74

## 7.4 GIFAPAR quality and validation

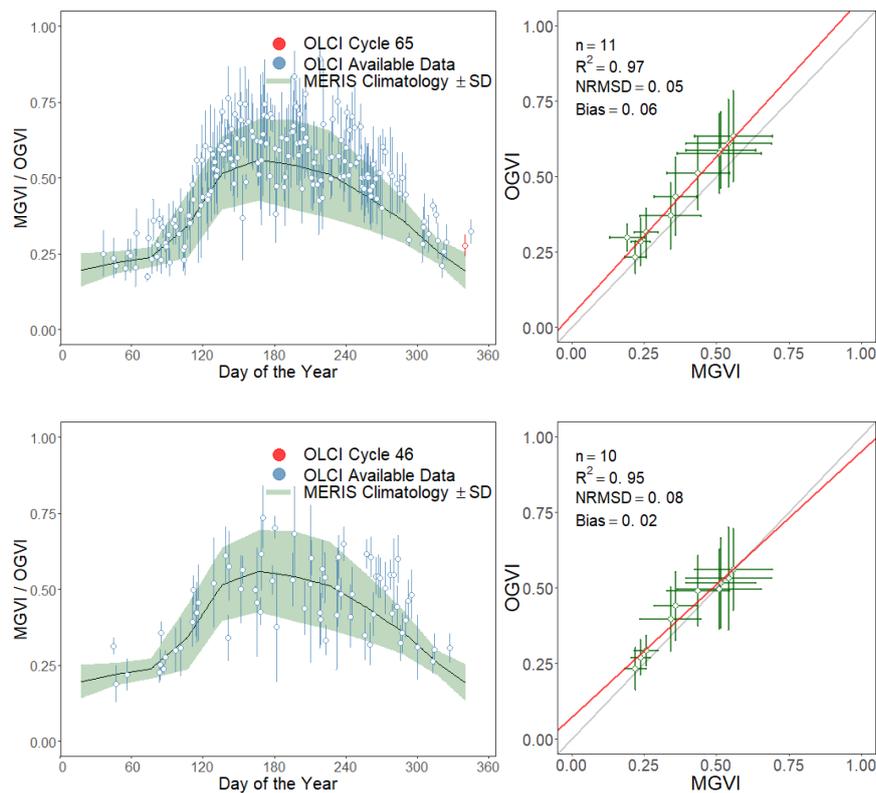
### 7.4.1 Indirect validation

Validation of GIFAPAR products has been performed using two main approaches, inter-comparison with the MGVI archive and direct validation against data collected in field campaigns.

The inter-comparison is routinely performed every 27 days and the results published in Data Product Quality Reports available at the following link: <https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-3-olci/data-quality-reports>. The inter-comparison is performed over 37 validation sites,

which represent a range of land cover types, regions, and species. These sites include the CEOS WGCV LPV supersites, which are recommended for the validation of land products as well as several ‘core’ sites chosen by the Sentinel-3 Validation Team. Each of the sites, is well characterized and established with a history of validation activities. Extractions covering a 3 x 3 full resolution (300 m) footprint are taken from all available Level-2 Sentinel-3 OGVI and third reprocessing Envisat MGVI data. The footprint size accounts for any geometric inaccuracies and the point spread function of the sensors.

The inter-comparison performance for three sites with different vegetation types: BE-Brasschaat (evergreen needle leaf forest), DE-Haininch (deciduous broadleaf forest) and FR-EstreesMons (cultivated) for Sentinel-3A cycle 65 and Sentinel-3B cycle 46, are shown in Figure 16 to Figure 18. Across all sites similar seasonal trajectories and timings are displayed. When comparing the monthly mean extractions across all sites (Figure 19), the OGVI shows a very strong agreement with the MERIS archive with an  $R^2 = 0.93$ ,  $NRMSD < 0.15$  with very low bias,  $-0.06$ .



**Figure 16: Time-series and corresponding scatterplot of monthly mean of OGVI for site BE-Brasschaat, Belgium, land cover Needle-leaved, evergreen. The top row represents S3A; the bottom row represents S3B.**

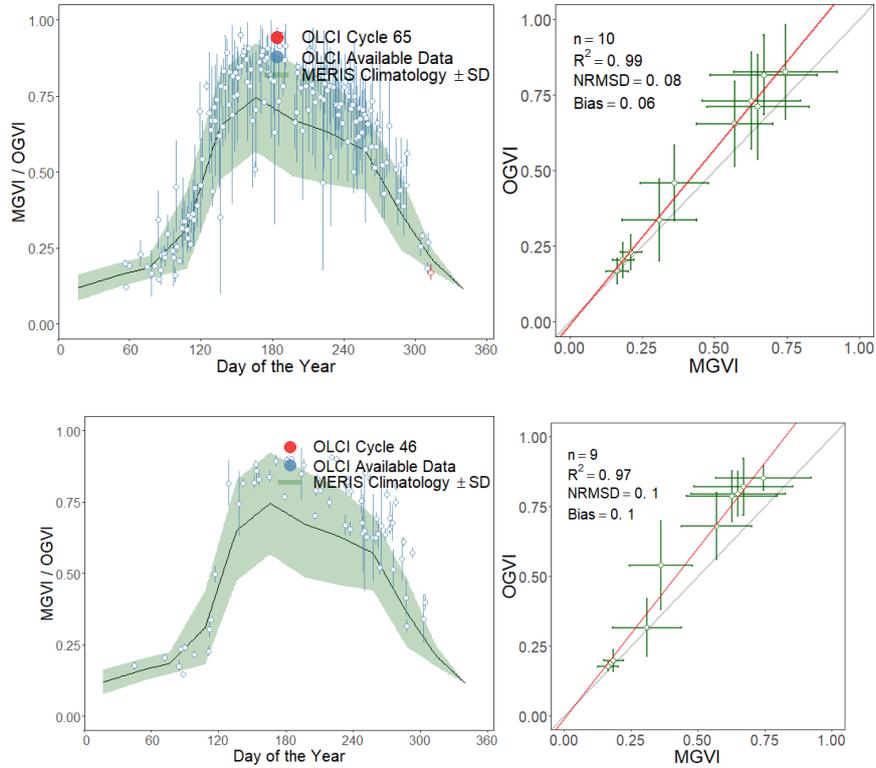
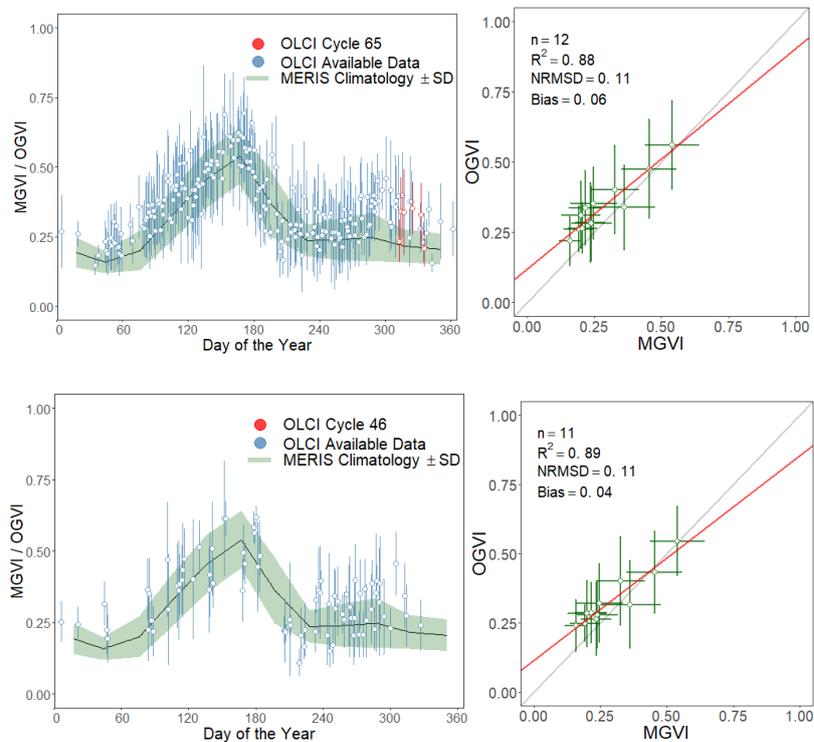
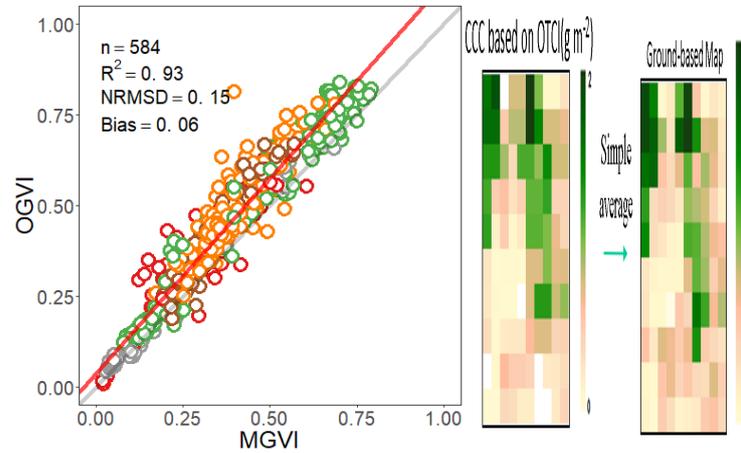


Figure 17: Time-series and corresponding scatterplot of monthly mean of OGVI for site DE-Haininch, Deutschland, land cover Broadleaved, deciduous, closed. The top row represents S3A; the bottom row represents S3B.



**Figure 18: Time-series and corresponding scatterplot of monthly mean of OGVI for site FR-Estrees-Mons, France, land cover Cultivated and managed areas. The top row represents S3A; the bottom row represents S3B.**



**Figure 19: Comparison OGVI-MGVI. Points in the scatterplot represent the monthly mean of all available S3A and MERIS archive over 37 validation sites. Red and grey lines represent the modelled and 1:1 lines respectively.**

#### 7.4.2 Direct validation - Comparison with GBOV (Ground-Based Observations for Validation)

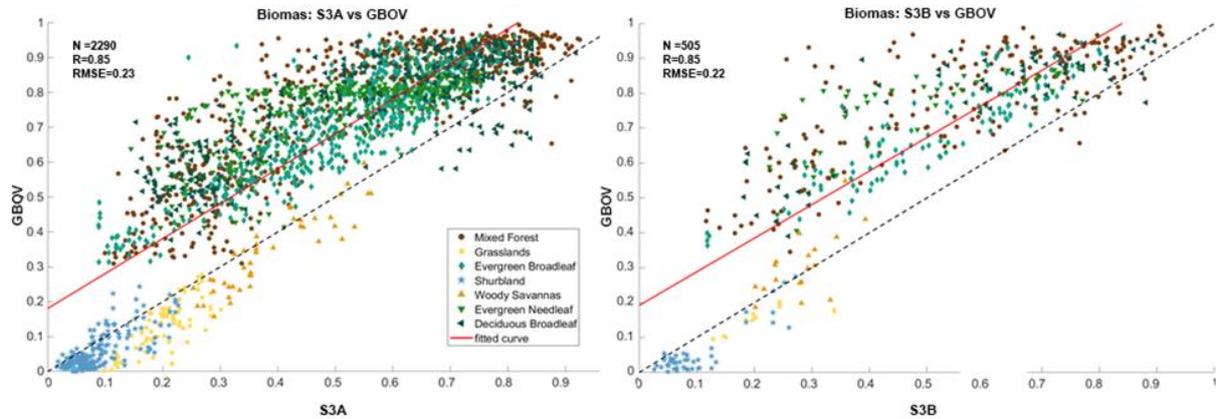
OLCI GIFAPAR have been validated against Ground-based measurements from the Copernicus GBOV service from the GLCS (Global Land Cover Service). The validation is conducted using the MERMAID extractions of Sentinel-3 over thirteen established validation sites and GBOV FAPAR land product (LP4) at 300 m (WGS-84). The in-situ data are measured with DHP methodology providing FIPAR that is up-scaled at 300 m. The selected sites are distributed across various geographical locations representing different land cover types.

The methodology involves: 1°) extracting the GBOV values of the Land Product (LP) at 300 m (WGS-84) overlapping the S3 pixels; 2°) filtering OLCI-A/OLCI-B and GBOV data regarding several flags as cloud or bad quality, and 3°) plotting the temporal profiles.

Sentinel data are filtered following the quality flags (i.e., GIFAPAR\_FAIL, CLOUD, GIFAPAR\_CLASS\_BAD, GIFAPAR\_CLASS\_WS, GIFAPAR\_CLASS\_CSI, GIFAPAR\_CLASS\_BRIGHT, COSMETIC, SUSPECT, no valid values - 255). GBOV data are filtered according to the recommendations (<https://gbov.acri.fr/userSupport/>). Hence the following values have been removed: 1) values with input or output out of range, 2) values outside the season used to establish the calibration function (Min DOY and Max DOY Table) and 3) threshold <50% on the percentage of valid native spatial resolution pixels. Two protocols have been evaluated. The first one considers all the pixels extracted by MERMAID, and the second one performs the validation centred in the MERMAID extraction's central point and the surrounding 3×3 window. The second method improves the validation because it reduces the heterogeneity of the validation site.

**Table 6: GBOV validation sites analysed.**

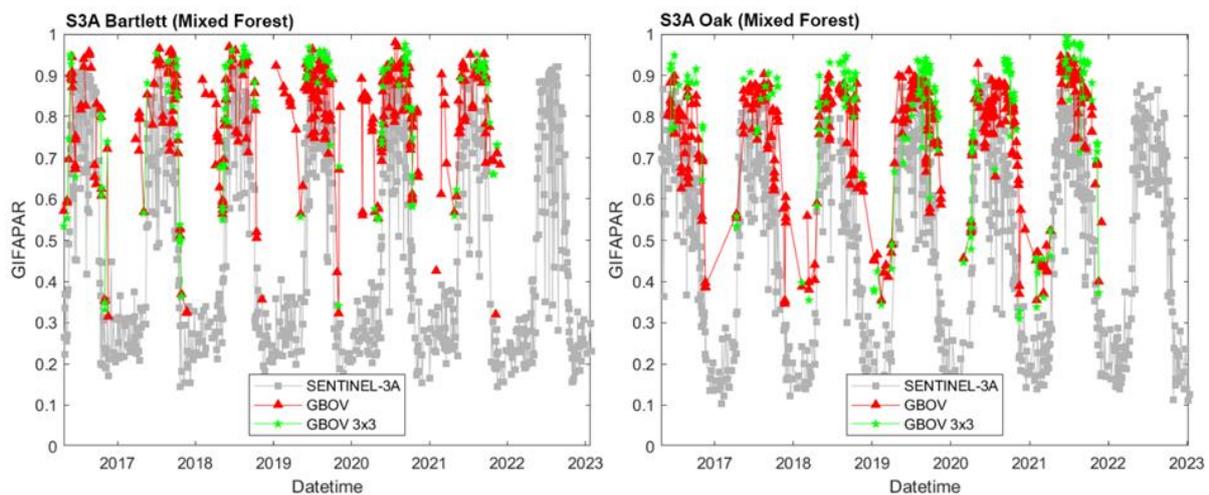
ID	Name	Country	LAT	LON	IGBP	GBOV Dates	Min DOY MaxDOY
USA_BART	Bartlett Experimental Forest	USA	44.0639	-71.2873	Mixed Forest	20140104 - 20211217	8 - 349
USA_CPER	Central Plains Experimental Range	USA	40.81555	-104.7460	Grasslands	20140116 - 20211229	3 - 362
PRI_GUAN	Guanica Forest	Puerto Rico	17.9695	-66.8687	Evergreen Broadleaf	20150131- 20211228	8 - 349
GER-HAIN	Hainich	Germany	51.0792	10.4522	Mixed Forest	20200102 - 20211221	8-349
USA_HARV	Harvard	USA	42.5378	-72.1715	Mixed Forest	20140104 - 20211228	8 - 349
USA_JORN	Jornada	USA	32.5907	-106.842	Open Shrubland	20160106 - 20211229	3 - 362
AUS_Litchfield	Litchfield	AUS	-13.18	130.79	Woody Savannas	20210308 – 20211215	3 - 362
USA_Moab	Moab	USA	38.2483	-109.388	Open Shrubland	20150108 – 20201220	3 - 362
USA_ORNL	Oak Ridge	USA	35.9641	-84.2826	Mixed Forest	20150117 – 20211230	8 - 349
USA_SCBI	Smithsonian Conservation Biology	USA	38.8902	-78.1395	Mixed Forest	20150105 – 20211224	8 – 349
USA_STEI	Steigerwaldt Land Services	USA	45.5089	-89.5864	Deciduous Broadleaf	20160123 – 20211229	8 - 349
USA_TALL	Talladega National Forest	USA	32.9504	-87.3933	Evergreen Needleleaf	20150131 - 202112283	8 - 349
AUS_TUMB	Tumbarumba	AUS	-35.6565	148.1516	Evergreen Broadleaf	20200103- 20201230	8 - 349



**Figure 20: Comparison of GBOV vs OLCI-A (left) and GBOV vs OLCI-B (right). Points in the scatterplot represent the monthly mean of all available S3A and GBOV data (3×3) over 13 validation sites. Red and black lines represent the modelled and 1:1 line, respectively.**

OLCI-A reproduces the temporal variations of GBOV values for almost all sites satisfactorily. However, GBOV products provide systematically higher values than satellite products in forest classes. On the contrary, for shrubland and grasslands, satellite products tend to present higher values than GBOV. When applying the 3×3 windows (red colours), results remove outliers and suspicious values compared with the validation considering all the S3A values (i.e., 81).

Overall, there are similar seasonal trajectories between OLCI-B and GBOV. The pattern is similar to OLCI-A, with higher values of GBOV than in OLCI-B for forest classes. Similarly, grassland and shrubland classes show lower values than OLCI-B. Furthermore, the number of GBOV values after filtering must be increased to perform the validation, mainly in grasslands and shrublands sites (i.e., Moab, Central Plains).



**Figure 21 : Time series of GBOV FIPAR LP4 (red/green) and OLCI-A GIFAPAR (grey for sites Bartlett (Left) and Oak (right))**

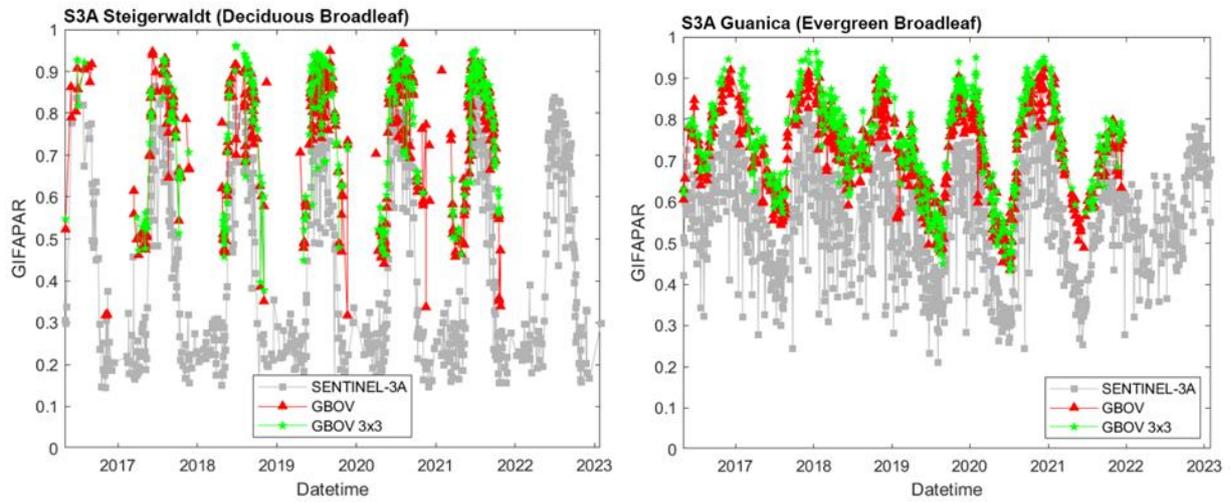


Figure 22: Time series of GBOV FIPAR LP4 (red/green) and OLCI-A GIFAPAR (grey) for sites Steigerwaldt (left) and Guanica (right)

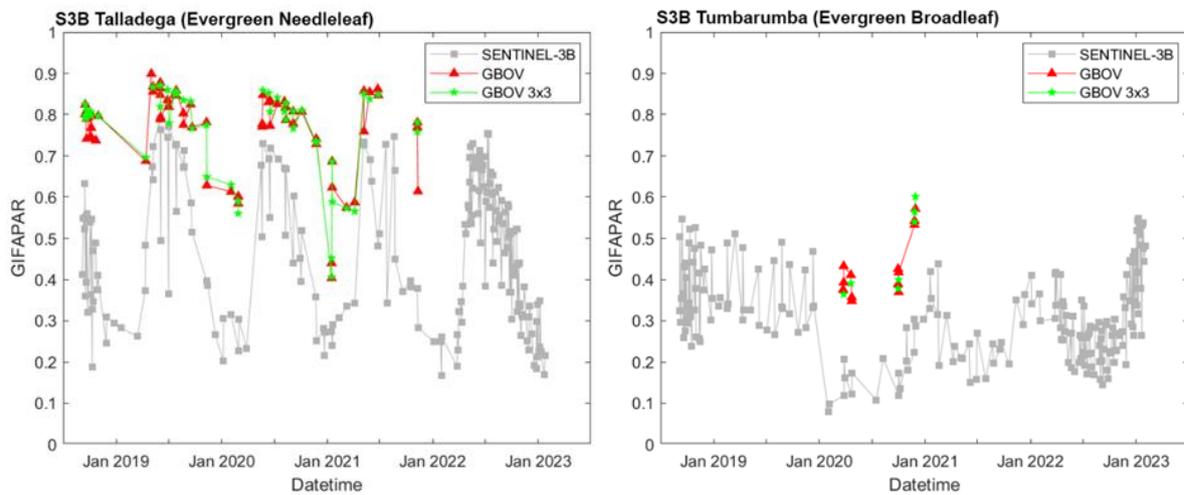


Figure 23: Time series of GBOV FIPAR LP4 (red/green) and OLCI-B GIFAPAR (grey) for sites Talladega (Left) and Tumarumba (right)

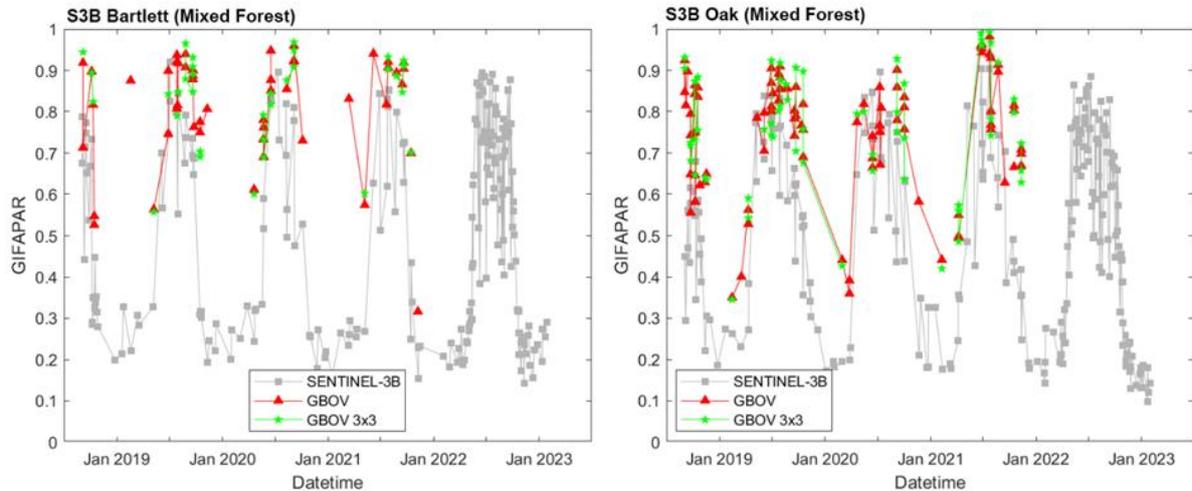


Figure 24: Time series of GBOV FIPAR LP4 (red/green) and OLCI-B GIFAPAR (grey) for sites Bartlett (Left) and Oak (right)

## 7.5 IWV quality and validation

The OLCI L2 IWV retrieval distinguishes between ocean and land surfaces and works very differently above the respective surfaces. Hence, the validation of the IWV product is performed for both surface types independently.

The validation above land is performed via comparisons with ground based GNSS (Ware et al.,2000) measurements, water vapor from AERONET (Pérez-Ramírez et al.,2014, Holben et al.,1998) and water vapour from ground-based microwave radiometer at the Atmospheric Radiation Measurement (ARM) Climate Research Facility of the US Department of Energy ARM. (Turner et al. 2003, Turner et al. 2007).

Above ocean a quantitative verification has been undertaken using GNSS (Ware et al.,2000) and AERONET-OC (Zibordi et al.,2009).

- ❖ Validation over Land demonstrates that the product is stable and **provides high quality retrievals above land surfaces**. There is however a systematic overestimation of around 9%-13% depending on the used ground base reference (Figure 25). The AMR microwave radiometer is regarded as the most accurate method, thus we assume that the bias is in the order of 9%. Further, we know, that SUOMI-GNSS has a dry-bias of 3% with respect to ARM measurements (Figure 26), which is fully consistent with our observations.
- ❖ Retrievals above ocean show an overestimation in transition zones between glint and off glint. This is a clear deficit of the description of the scattering-absorption interaction. Further the IWV over ocean has a large wet bias, about  $9 \text{ kg.m}^{-2}$ , and a systematic overestimation of 20% (Figure 27).
- ❖ Details and recent results can be found in <https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-olci/data-quality-reports>

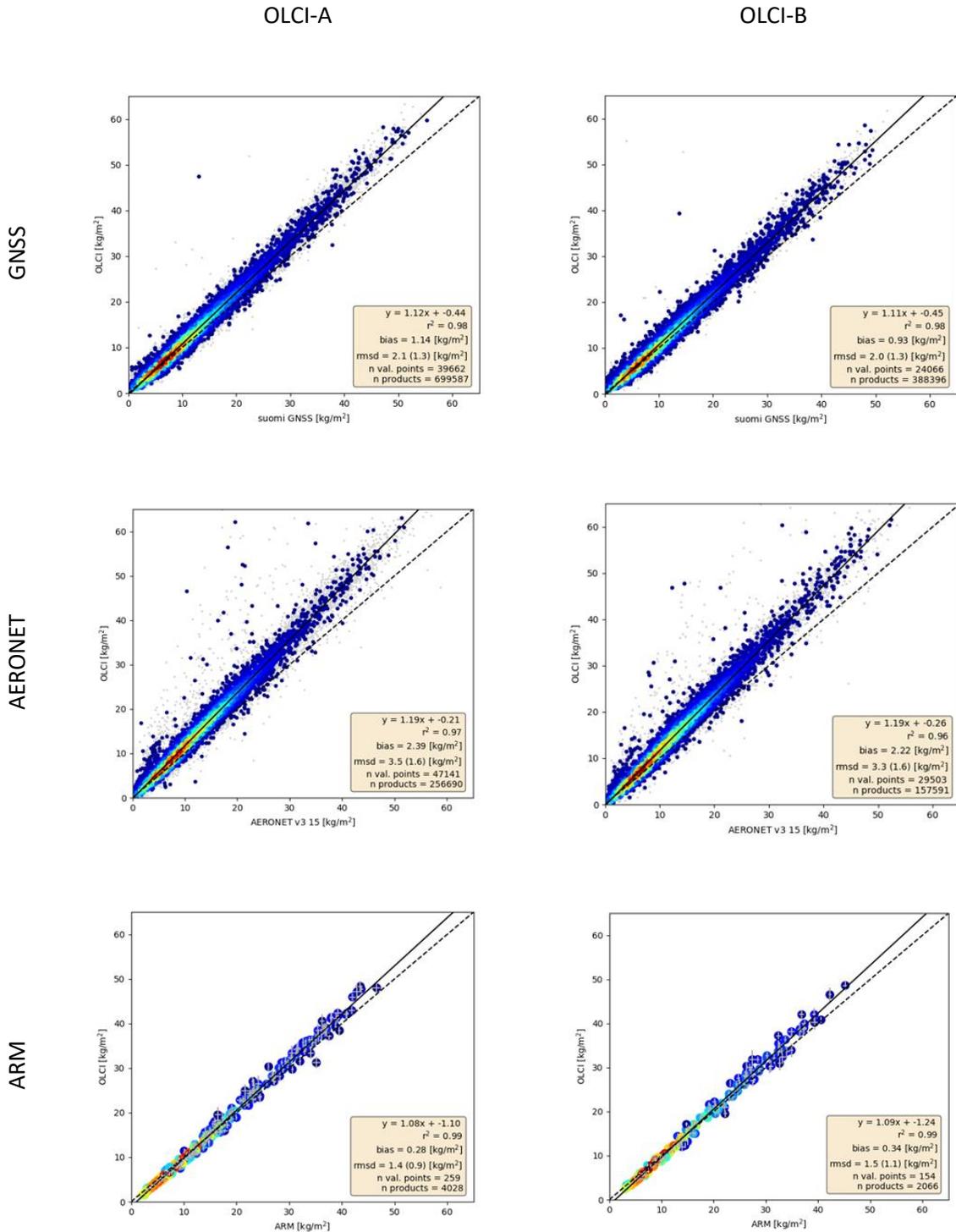


Figure 25: IWV validation over Land, density scatter plots for OLCI-A (left) and OLCI-B (right) against GNSS data (top), AERONET data (centre) and ARM data (bottom).

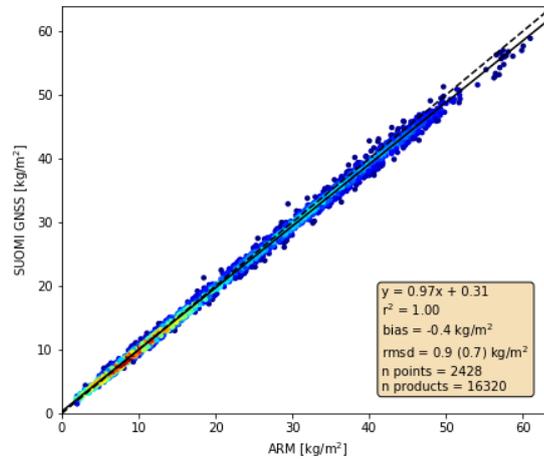


Figure 26: ARM vs. GNSS IWV retrievals for the SGP site for the one-year period between Nov 2017 and Oct 2018. Only cloud free data has been used, according to the liquid/ice water path from the microwave radiometer

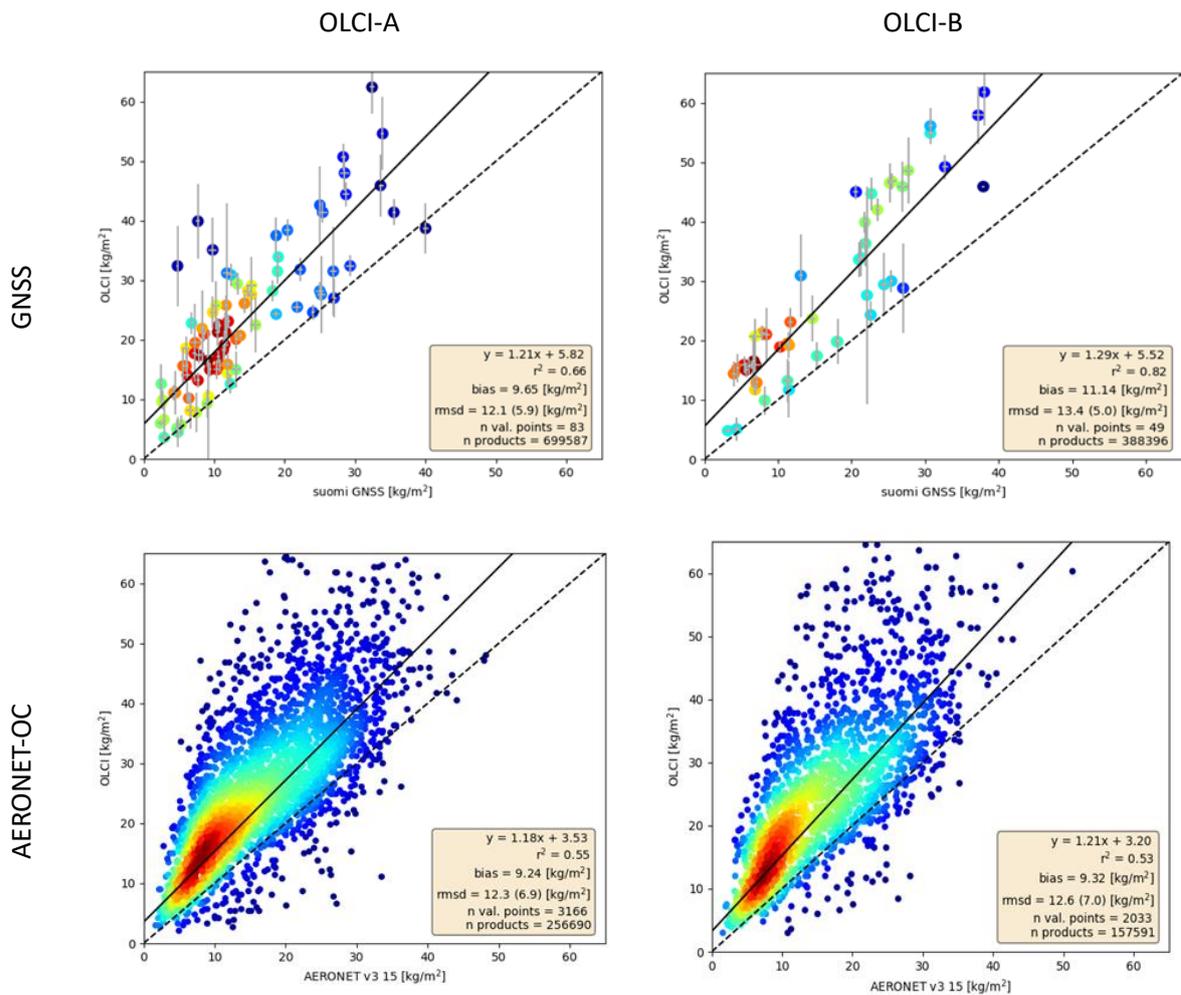


Figure 27: IWV validation over Water, density scatter plots for OLCI-A (left) and OLCI-B (right) against GNSS data (top) and AERONET-OC data (bottom).

## 8 Helpdesk

### 8.1 Access and use of OLCI products

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#### 8.1.1 How to get access to OLCI products?

The Copernicus programme has adopted a free, full and an open data policy for all users.

The main source of access to OLCI products is the **Copernicus Data Hub**, accessible at this address: <https://scihub.copernicus.eu>. A simple self-registration is necessary to access the service. The hub gives also news and further information about the service.

Access can be done via a graphical user interface or via the API Hub which allows to run scripts without going through the graphical interface.

In addition to the download services, the SENTINEL Data Products are also available in the Copernicus Data and Information Access Service (DIAS) cloud environments. Each DIAS provides processing resources, tools and complimentary data sources at commercial conditions to further facilitate the access to SENTINEL data.

#### 8.1.2 How to read and display the OLCI products?

The OLCI product being composed of a set of NetCDF files and a manifest file in xml format, there exist many software allowing to open these files.

In addition to these individual tools (not inventoried here), the SENTINEL-3 Toolbox (SNAP) is particularly well adapted to OLCI products (and SLSTR and SYN products). It is composed of a set of visualisation, analysis and processing tools for the exploitation. It is worth noting that it also supports the ESA missions Envisat (MERIS & AATSR), ERS (ATSR), SMOS as well as third party data from MODIS (Aqua and Terra), Landsat (TM), ALOS (AVNIR & PRISM) and others.

Once SNAP has been downloaded (see §8.4.5) and installed, it is very easy to open L1 and L2 OLCI products, by just opening the *xfdumanifest.xml* file, from which all other NetCDF files can be read and displayed.

	<b>Copernicus Sentinel-3 OLCI Land User Handbook</b>	Ref.: OMPC.ACR.HBK.001 Issue: 1.2 Date: 14/04/2023 Page: 45
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## 8.2 FAQ

### 8.2.1 Where can I find information about the latest version of processing?

- ❖ Every time a new major version of the processing chain is deployed, a Product Notice (PN) is released in which the main changes are summarised; the notice gives a status of the performances as well as all known anomalies not yet fixed.
- ❖ All PNs are available on the SENTINEL Online web site.

### 8.2.2 What is a Processing Baseline?

- ❖ A processing baseline (PB) is composed of one IPF version and a set of ADFs. Any change affecting the version of the IPF or of at least one ADF changes the version of the PB.
- ❖ Since November 2021, Processing baseline version is still indicated in the Product Notice but also in the product manifest.

```

<sentinel3:generalProductInformation>
  <sentinel3:productName>S3B_OL_1_EFR____20220831T110906_20220831T111206_20220831T234022_0180_0
  <sentinel3:productType>OL_1_EFR____</sentinel3:productType>
  <sentinel3:timeliness>NT</sentinel3:timeliness>
  <sentinel3:baselineCollection>002</sentinel3:baselineCollection>
  <sentinel3:processingBaseline>OL_L1_002.23.00</sentinel3:processingBaseline>
  <sentinel3:creationTime>20220831T234022</sentinel3:creationTime>
  <sentinel3:productSize>940160792</sentinel3:productSize>
  <sentinel3:dumpInformation>
    <sentinel3:granuleNumber>1</sentinel3:granuleNumber>
    <sentinel3:granulePosition>FIRST</sentinel3:granulePosition>
    <sentinel3:dumpStart>2022-08-31T10:33:19.073253Z</sentinel3:dumpStart>
    <sentinel3:receivingGroundStation>CGS</sentinel3:receivingGroundStation>
    <sentinel3:receivingStartTime>2022-08-31T10:39:52.156969Z</sentinel3:receivingStartTime>
    <sentinel3:receivingStopTime>2022-08-31T10:39:54.216033Z</sentinel3:receivingStopTime>
  </sentinel3:dumpInformation>
  <sentinel3:dispositionMode>Operational</sentinel3:dispositionMode>
  <sentinel3:productUnit>
    <sentinel3:type>FRAME</sentinel3:type>
    <sentinel3:duration>180</sentinel3:duration>
    <sentinel3:alongtrackCoordinate>3600</sentinel3:alongtrackCoordinate>
  </sentinel3:productUnit>
</sentinel3:generalProductInformation>
</manifest>

```

Figure 28 : Processing Baseline version in xfdumanifest.xml

### 8.2.3 How can I find the IPF or the ADF version used for the processing?

- ❖ This information is included in the manifest of all products.
- ❖ In Figure 29 and Figure 30, examples are given showing the version of the IPFs used (all levels are available) and the version of the ADF used.

```

<sentinel-safe:resource name="S3A_OL_2_LFR___20201101T182232_20201101T190649_20201102T210707_265
  <sentinel-safe:processing name="DataProcessing" outputLevel="2" start="2020-11-02T21:06:47.367
    <sentinel-safe:facility name="Land OLCI Processing and Archiving Centre [LN1]" organisation
      <sentinel-safe:hardware name="OPE"/>
      <sentinel-safe:software name="IPF-OL-2" version="06.14"/>
    </sentinel-safe:facility>
    <sentinel-safe:resource name="S3A_OL_1_EFR___20201101T182232_20201101T190649_20201102T1917
      <sentinel-safe:processing name="DataProcessing" outputLevel="1" start="2020-11-02T19:17:
        <sentinel-safe:facility name="Land OLCI Processing and Archiving Centre [LN1]" organi
          <sentinel-safe:hardware name="OPE"/>
          <sentinel-safe:software name="IPF-OL-1-EO" version="06.08"/>
        </sentinel-safe:facility>
        <sentinel-safe:resource name="S3A_TM_0_NAT___20201101T181016_20201101T195025_2020110
          <sentinel-safe:processing name="DataProcessing" outputLevel="0" start="2020-11-01T
            <sentinel-safe:facility name="Land OLCI Processing and Archiving Centre [LN1]"
              <sentinel-safe:hardware name="OPE"/>
              <sentinel-safe:software name="IPF-0" version="06.12"/>
            </sentinel-safe:facility>
          </sentinel-safe:resource>
        </sentinel-safe:processing>
      </sentinel-safe:resource>
    </sentinel-safe:processing>
  </sentinel-safe:resource>

```

Figure 29: IPF version in xfdumanifest.xml

```

:re>
: name="S3A_OL_2_ACP_AX_20160216T000000_20991231T235959_20170609T120000_____MPC_O_AL_004.SEN3" 1
: ssing name="AdfProcessing">
: facility name="ESA Mission Performance Coordinating Centre (MPC)" organisation="ESA Mission Performance Coordin
: :hardware name="OPE"/>
: :software name="ADC" version="1.0"/>
: facility>
: source name="S3IPF.PDS.007 - i2r5 - Auxiliary Data Format Specification" role="Product Data Specification Doc
: resource>
: essing>
: re>
: name="S3A_OL_2_OCP_AX_20160216T000000_20991231T235959_20170609T120000_____MPC_O_AL_003.SEN3" 1
: ssing name="AdfProcessing">

```

Figure 30: ADF version xfdumanifest.xml

- ❖ Information about the successive processing baselines is also available in SENTINEL Online, in the form of timelines as shown in Figure 31.

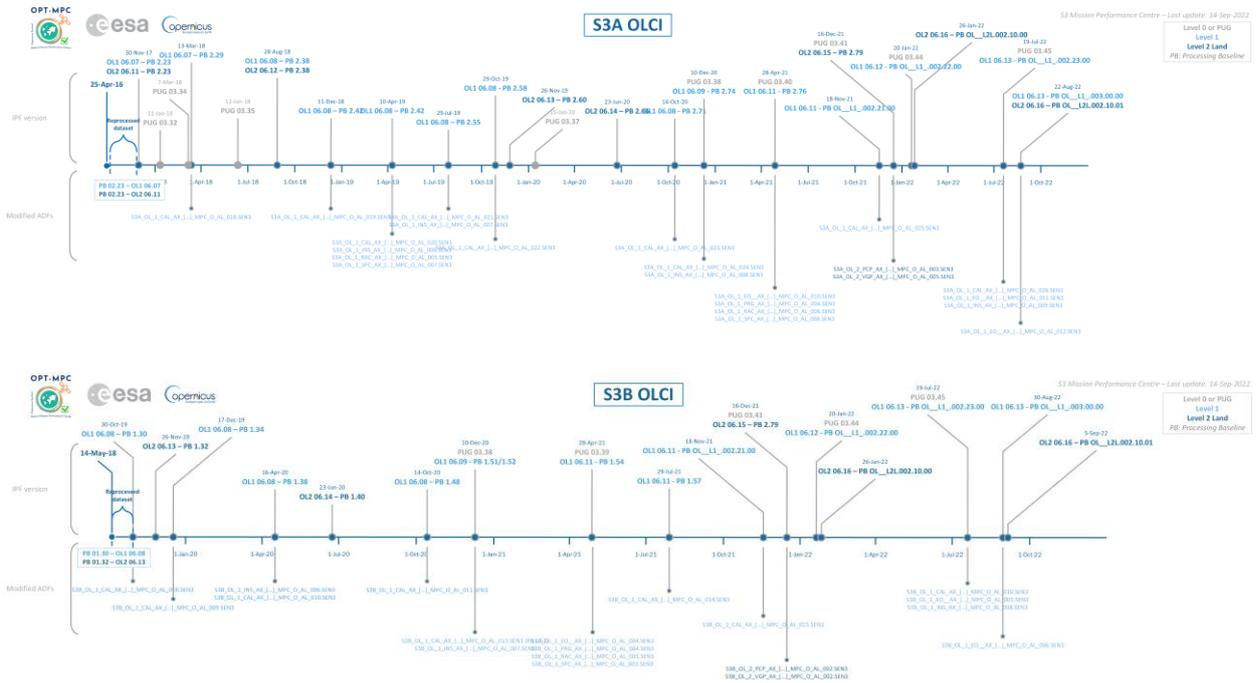


Figure 31: S3A and S3B processing baseline timelines (dated on 14-Sep-2022)

### 8.2.4 If I want to know about past anomalies or events, how can I get the information?

- ❖ A specific page is available in SENTINEL Online providing all information about anomalies or events affecting the NTC products :

<https://sentinel.esa.int/zh/web/sentinel/technical-guides/sentinel-3-olci/anomalies-and-events>

- ❖ In addition, monthly Reports are published which detail the instrument performance and anomalies:

<https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-olci/data-quality-reports>

### 8.2.5 How to use the spectral information provided in the instrument\_data.nc file?

The instrument\_data.nc file provides three types of spectral information: channel central wavelengths ( $\lambda_0$ ), channels bandwidths ( $FWHM$ ) and in-band equivalent solar irradiance ( $solar\_flux$ ). All these quantities are provided for each instrument detector, i.e. across-track spatial position inside the instrument.

It is important to stress here that there is a significant variation of these parameters across the instrument field-of-view (Figure 32), due to its imaging spectrometer nature and the fact that the field of view is shared by five “cameras”, i.e. five independent sensors mounted on the same optical bench.

Since the instrument detector affected to a given image column varies along the orbit (in particular with satellite altitude), its index is provided for each image pixel in the *detector\_index* variable of the *instrument\_data.nc* file. It can be used in turn to address the spectral parameter arrays. Instrument detector ranges from 0 to 3699, it corresponds to columns 0 to 739 of the CCD of each camera, on top of an offset  $m \cdot 740$  for camera  $m$ ,  $m$  in  $[0,4]$ ; both CCD column and camera indices increasing from West to East (at low latitudes; an additional *detector\_index* value of -1 identifies those image pixels to which no measurement is affected).

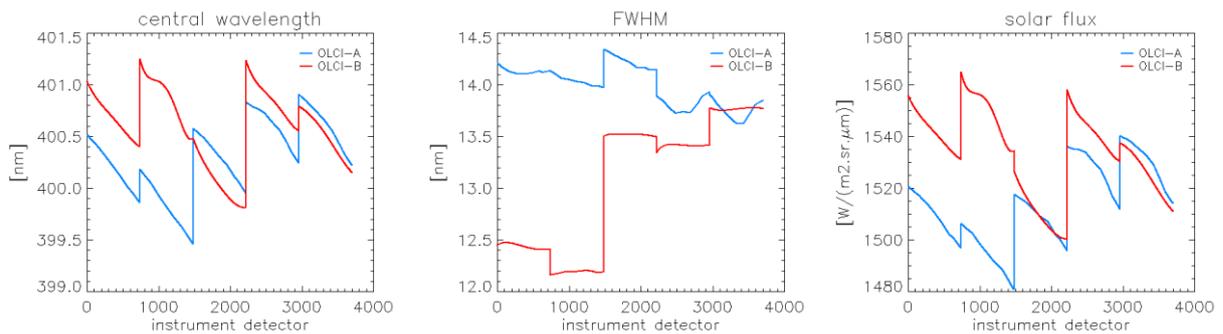


Figure 32: OLCI-A and OLCI-B spectral parameters for channel Oa01 (400 nm) against instrument detector.

### 8.2.6 How to interpolate from tie point to image grid?

The tie point grid is a more coarsely sampled grid used to store the acquisition geometry and meteorological parameters (Level-1 and 2). The grid spacing is 64 pixels for Full Resolution products and 16 pixels for Reduced Resolution ones in across-track direction and 1 pixel in along-track direction for both resolutions. Values can be easily interpolated at pixels from Tie Points by linear interpolation using the image column coordinate.

### 8.2.7 How to calculate the acquisition time of any pixel in a L1/L2 image?

The 'time\_stamp' dataset (*time\_coordinates.nc* file) provides a time stamp for each image line, corresponding to the satellite Nadir viewing plane overpass. It means that it assumes a perfect instrument pointing and can be wrong by a few acquisition time steps due to actual pointing for a given pixel line of sight.

In the case of Full Resolution products, a very accurate acquisition time can be computed for a given pixel using dedicated annotation data. The 'frame\_offset' dataset (*instrument\_data.nc* file) is now providing for each pixel and can be used directly to compute the pixel ( $i,j$ ) accurate time as follows:

$$t_{i,j} = time\_stamp_i - frame\_offset_{i,j} \cdot \Delta t^{FR}$$

where  $\Delta t^{FR}$  is the OLCI time sampling step in full resolution that can be approximated to 0.044 s, even if a more accurate value is provided in the product's manifest file under tag 'alTimeSampling', in  $\mu s$ .

### 8.2.8 How to calculate the relative angle between the satellite and Sun?

The solar and satellite zenith and azimuth angles are provided in the Level-1 product on the tie point grid in the *tie\_geometry.nc* file.

### 8.2.9 How to convert from radiance to reflectance in the Level-1 product?

The Level 1 product provides measurements of top of atmosphere (ToA) radiances ( $\text{mW}/\text{m}^2/\text{sr}/\text{nm}$ ). These values can be converted to normalised reflectance for better comparison or merging of data with different sun angles as follows:

$$\text{reflectance} = \pi * (\text{ToA radiance} / \text{solar irradiance} / \cos(\text{solar zenith angle}))$$

where the solar irradiance at ToA is given in the 'solar\_flux' dataset (*instrument\_data.nc* file) for each detector and each channel, and the solar zenith angle is given at Tie Points in the 'SZA' dataset (*tie\_geometry.nc* file). The appropriate instrument detector is given at each pixel by the 'detector\_index' dataset (*instrument\_data.nc* file).

### 8.2.10 How to find the OLCI spectral response functions?

The OLCI spectral response functions are provided on the [dedicated Sentinel Online webpage](#).

### 8.2.11 How to find the centre of the swath in the image?

The OLCI swath is not symmetrical about the Sentinel-3 satellite track. The satellite Nadir is supposed to match the Tie Point index 56.5, i.e. fall exactly in between Tie Points 56 and 57 (indices counted from 0) that corresponds to image column 3616. However, it can vary by a few pixels due to the spacecraft attitude.

## 8.3 If you have a question

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The Services Coordinated Interface (SCI) is the user service dedicated to Copernicus users. The SCI handles the Copernicus users' enquiries, orders and complaints, and coordinates the data provision according to user requirements and data offer.

While SENTINEL dedicated information is available in the present pages, the Copernicus Space Component Data Access system (CSCDA) web site is the entry point for obtaining information regarding the global data offer, available tools and data provisions status.

The SCI is available for user support; they can be contacted via email at [EOSupport@copernicus.esa.int](mailto:EOSupport@copernicus.esa.int) for support, in particular for:

- ❖ Clarifications regarding the registration process
- ❖ SENTINEL enquiries
- ❖ Reporting issues related to products/service quality

## 8.4 Useful links

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### 8.4.1 About Copernicus

- ❖ CSCDA: <https://spacedata.copernicus.eu>
- ❖ EU Copernicus: <https://www.copernicus.eu/en>
- ❖ ESA Copernicus: [http://www.esa.int/Applications/Observing\\_the\\_Earth/Copernicus](http://www.esa.int/Applications/Observing_the_Earth/Copernicus)

### 8.4.2 About ESA and the SENTINELs missions

- ❖ ESA website: <http://www.esa.int>
- ❖ SENTINEL Online: <https://sentinel.esa.int/web/sentinel/home>

### 8.4.3 About Sentinel-3 Validation Team

- ❖ [S3VT website](#)
- ❖ [S3VT Tools page](#), this page provide links to a number of useful tools, and in particular holds the information allowing to access Land Validation Global Level 3 Composite products described in section 7.3.1.

### 8.4.4 About OLCI

- ❖ User guides: <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci>
- ❖ Technical guide: <https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-olci>
- ❖ Processing Baselines information: <https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-olci/processing-baseline>
- ❖ Anomalies and Events related to OLCI: <https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-olci/anomalies-and-events>
- ❖ OLCI Data Quality Reports: <https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-3-olci/data-quality-reports>

### 8.4.5 About S3 toolbox

- ❖ STEP: <http://step.esa.int/main/download/>
- ❖ Forum: <https://forum.step.esa.int>

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- ❖ Envisat's Medium Resolution Resolution Imaging Spectrometer (MERIS) ATBD: FAPAR and Rectified Channels over Terrestrial Surfaces. DOI: [10.2788/27108](https://doi.org/10.2788/27108)
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## 8.6 Acronyms and abbreviations

AC	Across-track
ADF	Auxiliary Data File
AL	Along-track
ANX	Ascending Node Crossing
API	Application Programming Interface
ATBD	Algorithm Theoretical Basis Document
CCC	Canopy Chlorophyll Content
CCD	Charge-Coupled Device
CCSDS	Consultative Committee for Space Data Systems
CNES	Centre National d'Etudes Spatiales
CSCDA	Copernicus Space Component Data Access
DIAS	Copernicus Data and Information Access Service
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
EO	Earth Observation
ESA	European Space Agency
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FR	Full Resolution
GIFAPAR	Green Instantaneous FAPAR
GCOS	Global Climate Observing System
GTOS	Global Terrestrial Observing System

IPF	Instrument Processing Facility
JRC	Joint Research Centre (of the European Union)
MERIS	MEdium Resolution Imaging Spectrometer
MGVI	MERIS Global Vegetation Index
MODIS	Moderate Resolution Imaging Spectroradiometer
MTCI	MERIS Terrestrial Chlorophyll Index
NaN	Not a Number
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NEDL	Noise Equivalent Delta Radiance
NetCDF	Network Common Data Format
NIR	Near Infrared
NTC	Non Time Critical
OGVI	OLCI Global Vegetation Index
OLCI	Ocean and Land Colour Instrument
OTCI	OLCI Terrestrial Chlorophyll Index
OZA	Observation Zenith Angle
PAR	Photosynthetically Active Radiation
PDFS	Product Data Format Specification
PDGS	Payload Data Ground Segment
PDU	Product Dissemination Unit
PDF	probability density function
POD	Precise Orbit Determination
PUG	Product Unit Generator
RE	Red Edge
REP	Red Edge Position
RR	Reduced Resolution
RT	Radiative Transfer
SAFE	Standard Archive Format for Europe
SNAP	Sentinel Applications Platform
SNR	Signal to Noise Ratio
STEP	Science Toolbox Exploitation Platform
SZA	Sun Zenith Angle
TCWV	Total Column Water Vapour
TOA	Top of Atmosphere



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TOC	Top of Canopy
UTC	Coordinated Universal Time
XML	Extensible Markup Language
XFDU	XML Formatted Data Units
WGS84	World Geodetic System 1984

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