CP CCI ICDR: Product User Guide and Specification

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History of modifications

Version	Date	Description of modification	Chapters / Sections
V1.0	28/11 /2022	Brought forward from previous phase of C3S. Updated to include description of merged Sentinel-3A and -3B level 3 products	All
V1.1	06/03 /2023	Updated to address reviewer's comments	All
v1.2	26/05 /2023	Addition of chapter 2.3.2 to list gaps and anomalies	Ch. 2.3.2

List of datasets covered by this document

Deliverable ID	Product title	Product type (CDR, ICDR)	Version number	Delivery date
D3.3.17-v3.0	ECV Cloud properties brokered from ESA's Cloud_cci ATSR-AATSRv3 dataset	CDR	V3.0	30/04/2020
D3.3.18-v3.x	ECV Cloud properties derived from SLSTR	ICDR	V3.1	30/11/2020 - 30/09 /2021
D2.1.1-P1/2 D2.1.3-P1	ECV Cloud Properties derived from SLSTR	ICDR	V3.1.1 V4.0	31/05/2022 - onward

Related documents

Reference ID	Document
D1	Thomas, G. (2023) C3S Cloud Properties Service: Algorithm Theoretical Basis Document. Copernicus Climate Change Service, Document ref. C3S2_D312a_Lot1.2.1.3-v4.0_202301_ATBD_CCICloudProperties_v1.2 CP CCI ICDR: Algorithm Theoretical Basis Document Last accessed on 16/05/2023
D2	Algorithm Theoretical Basis Document, v.6.2. ESA Cloud_cci. https://climate.esa.int/media/documents/Cloud_Algorithm-Theoretical-Baseline-Document-ATBD_v6.2.pdf Last accessed on 16/05/2023
D3	Product User Guide, v5.1. ESA Cloud_cci, https://climate.esa.int/media/documents/Cloud_Product-User-Guide-PUG_v5.1.pdf Last accessed on 16/05/2023
D4	Comprehensive Error Characterisation Report, v4.1. ESA Cloud_cci. https://climate.esa.int/media/documents/Cloud_Comprehensive-Error-Characterisation-Report-CECR_v4.1.pdf Last accessed on 16/05/2023
D5	Karlsson, K.-G., et al., (2023) C3S Cloud Properties CDRs releases until 2021: Target Requirements and Gap Analysis Document. Copernicus Climate Change Service. Document ref. C3S2_D312a_Lot1.3.1.1-2021_TRGAD-CLD_v1.1 CP: Target Requirements and Gap Analysis Document Last accessed on 16/05/2023

Acronyms

Acronym	Definition
AATSR	Advanced Along-Track Scanning Radiometer
(A)ATSR	Shorthand for the Along-Track Scanning Radiometer series of instruments. In the current context, refers to ATSR-2 and AATSR.
ATBD	Algorithm Theoretical Basis Document
ATSR-1, -2	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
C3S	Copernicus Climate Change Service
CC4CL	Community Cloud for CLimate
CCI	(ESA) Climate Change Initiative
CDR	Climate Data Record
CDS	Climate Data Store
CER	Cloud Particle Effective Radius
CFC	Cloud Fractional Cover
COT	Clout Optical Thickness
CPH	Cloud Phase
CTH	Cloud Top Height
CTP	Cloud Top Pressure

CTT	Clout Top Temperature
DARD	Data Access Requirements Document
ECV	Essential Climate Variable
ENVISAT	(the) Environmental Satellite
ERS-2	Environmental Research Satellite
ESA	European Space Agency
FCDR	Fundamental Climate Data Record
GCOS	Global Climate Observing System
ICDR	Interim Climate Data Record
IWP	Cloud Ice Water Path
LWP	Cloud Liquid Water Path
MODIS	Moderate Resolution Imaging Spectroradiometer
NIR	Near-Infrared
ORAC	Optimal Retrieval of Aerosol and Cloud
PUG	Product User Guide
RAL	Rutherford Appleton Laboratory
SLSTR	Sea and Land Surface Temperature Radiometer
STFC	Science and Technology Facilities Council
UKRI	UK Research and Innovation
WMO	World Meteorological Organisation

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General definitions

Table 1: Summary of variables and definitions

Variables	**Abbreviation**	**Definition**
Cloud mask / Cloud fraction	CMA/ CFC	A binary cloud mask per pixel (L2) and from there derived monthly total cloud fractional coverage (L3C)
Cloud optical thickness	COT	The line integral of the absorption extinction coefficient (at 0.55m wavelength) along the vertical in cloudy pixels.
Cloud effective radius	CER	The area-weighted radius of the cloud droplet and crystal particles, respectively.

Cloud top pressure/ height/ temperature	CTP/ CTH/ CTT	The air pressure [hPa] /height [m] /temperature [K] of the uppermost cloud layer that could be identified by the retrieval system.
Cloud liquid water path/ Ice water path	LWP/ IWP	The vertical integrated liquid/ice water content of existing cloud layers; derived from CER and COT. LWP and IWP together represent the cloud water path (CWP)

Table 2: Definition of processing levels

Processing level	**Definition**
Level-1b	The full-resolution geolocated radiometric measurements (for each view and each channel), rebinned onto a regular spatial grid.
Level-2 (L2)	Retrieved cloud variables at full input data resolution, thus with the same resolution and location as the sensor measurements (Level-1b).
Level-3C (L3C)	Cloud properties of Level-2 orbits of one single sensor combined (averaged) on a global spatial grid. Both daily and monthly products provided through C3S are Level-3C.

Table 3: Definition of various technical terms used in the document

Jargon	**Definition**
Brokered product	The C3S Climate Data Store (CDS) provides both data produced specifically for C3S and so-called brokered products. The latter are existing products produced under an independent programme or project which are made available through the CDS.
Climate Data Store (CDS)	The front-end and delivery mechanism for data made available through C3S.
Retrieval	A numerical data analysis scheme which uses some form of mathematical inversion to derive physical properties from some form of measurement. In this case, the derivation of cloud properties from satellite measured radiances.
Forward model	A deterministic model which predicts the measurements made of a system, given its physical properties. The forward model is the function which is mathematically inverted by a retrieval scheme. In this case, the forward model predicts the radiances measured by a satellite instrument as a function of atmospheric and surface state, and cloud properties.
TCDR	It is a consistently-processed time series of a geophysical variable of sufficient length and quality.
ICDR	An Interim Climate Data Record (ICDR) denotes an extension of TCDR, processed with a processing system as consistent as possible to the generation of TCDR.
CDR	A Climate Data Record (CDR) is defined as a time series of measurements with sufficient length, consistency, and continuity to determine climate variability and change.

Scope of the document

This Product User Guide and Specification (PUGS) document is associated with the Climate Data Store (CDS) catalogue entry: Cloud properties global gridded monthly and daily data from 1982 to present derived from satellite observations. This Climate Data Record (CDR) comprises inputs from two sources: (i) brokered products from the Cloud Climate Change Initiative (ESA's Cloud_cci), namely those coming from processing of the Advanced Along-Track Scanning Radiometer (A)ATSR) data and (ii) those produced under this contract for the CDS, specifically those coming from processing of the Sea and Land Surface Temperature Radiometers (SLSTR). Both CDRs are produced by Rutherford Appleton Laboratory (RAL) Space using the Optimal Retrieval of Aerosol and Cloud (ORAC) algorithm, using the Community Cloud for Climate (CC4CL) processor under the ESA Cloud_cci project.

This document provides information on how to use these products and it is not part of the official CCI documentation, but produced only in the scope of the brokering to the CDS.

Executive summary

The ESA Climate Change Initiative (CCI) Cloud Properties Climate Data Record (CDR) is a brokered product from the ESA Cloud_cci project, while the extension Interim CDR (ICDR) produced from the Sea and Land Surface Temperature Radiometers (SLSTR) is produced specifically for C3S. The product is generated by RAL Space, using the Community Cloud for Climate (CC4CL) processor, based on the Optimal Retrieval of Aerosol and Cloud (ORAC) algorithm.

The Cloud_cci dataset comprises 17 years (1995-2012) of satellite-based measurements derived from the Along Track Scanning Radiometers (ATSR-2 and AATSR) onboard the ESA second European Research Satellite (ERS-2) and ENVISAT. This CDR is partnered with the ICDR produced from the Sentinel-3 Sea and Land Surface Temperature Radiometers (SLSTR), beginning in 2017 (Sentinel-3A) and 2018 (Sentinel-3B), when data from each platform became available.

The CDR provides level-3 data (monthly means) on a regular global latitude-longitude grid (with a resolution of 0.5°× 0.5°) as well as level-2 data (daily means) on a regular global latitude-longitude grid (with a resolution of 0.1°× 0.1°) and includes these products: cloud fractional cover (CFC), cloud phase (water/ice), cloud optical thickness (COT), cloud particle effective radius (CER), cloud liquid/ice water path (LWP/IWP), and cloud-top pressure (CTP), height (CTH) and temperature (CTT).

These products are brokered to (in the case of (A)ATSR) or produced for the Climate Data Store (in the case of SLSTR) by the Copernicus Climate Change Services (C3S). The respective data products (daily and monthly means) are first described in terms of their input data and a brief overview of the algorithms; their target requirements in the scope of C3S and achieved performances are given; relevant information for usage is provided. The latter comprises geographical grid specifications, the data format, naming conventions, and the acknowledgement policy.

1. Cloud_cci global monthly cloud products

The Cloud_cci global monthly cloud properties product, version 3.0, is brokered to the CDS by the C3S from STFC RAL Space. The SLSTR ICDR, versions 3.1.1 and 4.0, is supplied to the CDS via the same route and uses the same processing software and infrastructure as the CDR. Although the format of the brokered data products differs from the official CCI products, the intellectual property rights remain with the Cloud_cci team. In detail, the official daily and monthly files from Cloud_cci contain more than 180 variables, but the specified C3S format splits them into separate parts per ECV. That way, each file has a reduced data amount as well as an increased usability. The landing page for the official CCI products is https://climate.esa.int/en/projects/cloud/.

The product provides estimates of monthly mean global cloud properties over land and ocean from the Along Track Scanning Radiometer ((A)ATSR) series of satellite sensors, on a 0.5°×0.5° latitude-longitude grid from mid-1995 until early 2012. The SLSTR based ICDR extends the coverage, with a five-year gap, from 2017 onwards and is only available through the CDS. Version 3.x of the ICDR provides data from a single SLSTR (flying on board either Sentinel-3a or -3b), while version 4.0 combines data from both SLSTR instruments into a single combined product (starting with the launch of the Sentinel-3b in late 2018). The processing of version 3.1.1 and 4.0 are identical – the sole difference is whether the two instruments are separately or treated as a single data-stream.

1.1 Product description

The Cloud_cci product brokered to the CDS consists of cloud properties derived from the (A)ATSR instruments; specifically:

- ATSR-2, which flew on the second European Research Satellite (ERS-2) from June 1995 until January 2008. ERS-2 lost global coverage in June 2003, due to failure of the onboard data storage; Cloud_cci data do not extent beyond this date (thus providing approximately one-year of overlap with the succeeding AATSR product).
- Advanced-ATSR (AATSR), which flew on ENVISAT from May 2002 until the satellite's failure in April 2012.

When referred to in terms of a continuous data record, these two instruments are commonly described as (A)ATSR. The preceding ATSR-1 instrument lacked the visible-NIR channels provided by (A)ATSR and thus isn't included in the Cloud_cci product.

The Cloud_cci also produced cloud products from the Advanced Very High Resolution Radiometer (AVHRR) series of instruments and the Moderate Resolution Imaging Spectroradiometer (MODIS), using a common retrieval technique, but only the (A)ATSR products are brokered to the CDS.

The analysis algorithm applied in producing the Cloud_cci products is the Optimal Retrieval of Aerosol and Clouds (ORAC), while the overall data processing system used in the project is referred to as Community Cloud for Climate (CC4CL). The algorithm, processing chain and all input and auxiliary data are detailed in the C3S ATBD [D1], Cloud_cci ATBD [D2], Sus et al. (2018) and McGarragh et al. (2018).

The brokered CDR is extended, with a five-year gap, from 2017 with an ICDR derived from the SLSTR instruments, which fly onboard the Copernicus operational Sentinel-3 satellites. From late 2018, a second Sentinel-3 platform is available, which doubles the spatial coverage of SLSTR and allows for nearly complete global coverage twice a day. The SLSTR product is produced using the same processing chain as the (A)ATSR CDR.

1.2 Target requirements

The target requirements for cloud observations are laid-out in the Target Requirements and Gap Analysis Document (TRGAD) [D5], but are summarised here. These requirements originate from the WMO Global Climate Observing System (GCOS) initiative, which defines and lays down targets for the observation of essential climate variables (ECVs). It should be noted that GCOS defines ideal targets for Earth observation systems, which are often not attainable using existing or historical observing systems. Table 1-1 provides an overview of the GCOS requirements for cloud properties.

Table 1-1: GCOS targets for cloud properties ECVs. Note that the Cloud_cci doesn't meet the temporal requirements due to the nature of the satellite observations, but exceeds the spatial resolution and aims to achieve the uncertainty and stability requirements.

Quantity	Cloud_cci variable	Targets
Cloud amount	CFC	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 0.01-0.05 • Stability: 0.01/decade

Cloud top pressure	CTP	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 15-50 hPa • Stability: 3-15 hPa/decade
Cloud top temperature	CTT	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 1-5 K • Stability: 0.25 K/decade
Cloud Optical Depth	COT	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 10% • Stability: 5% /decade
Cloud Water Path	LWP, IWP	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 25% • Stability: 5% /decade
Effective particle radius	CER	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 1m • Stability: 1m/decade

1.3 Data usage information

Cloud_cci and SLSTR ICDR products are provided in NetCDF (version 4), which are compliant with the conventions CF 1.8 and the NASA Global Change Master Directory (GCMD) Science Keywords vocabulary. Filenames follow the structure:

C3S-312bL1-L3C-MONTHLY-CLOUD-*INSTORACPLATFORM{}*YYYYMM{_}_fvVVV.nc,

where *INST* and *PLATFORM* refer to the instrument and platform from which data originates (either ATSR2 and ERS2, or AATSR and ENVISAT for the CDR, or SLSTR and Sentinel-3a or -3b for the ICDR), *YYYYMM* provides the year and month covered by the monthly mean product, and *VVV* denotes the product version (3.0 for the TCDR, 3.1 for the ICDR).

Data are provided as monthly means of cloud properties, as described in Table 1-2, on a regular latitude-longitude grid, with a spacing of 0.5° in both dimensions (thus grid centres lie at -89.75°, -89.25°, -88.75°, …, 89.75° in latitude and -179.75°, -179.25°, -178.75°, …, 179.75° in longitude).

The list of cloud properties, the variable names used within the NetCDF data files and their units are given in Table 1-2.

Table 1-2: Cloud properties included in Cloud_cci TCDR and SLSTR ICDR monthly products.

Property	Unit	Variable name	Comment
Cloud fractional cover	-	cfc	
Cloud-top pressure	hPa	ctp	
Cloud-top height	km	cth	
Cloud-top temperature	K	ctt	
Cloud optical thickness	-	cot	Only retrieved on day-light side of orbit
Cloud effective radius	µm	cer	Only retrieved on day-light side of orbit
Cloud liquid water path	gm^{-2}	lwp	Only retrieved on day-light side of orbit
Cloud ice water path	gm^{-2}	iwp	Only retrieved on day-light side of orbit

For lists and details of known issues and limitations of the data, the user is referred to the referenced ATBDs and papers in Section 1.1, as well as the TRGAD [D5]. In particular, it should be noted that the monthly mean is computed using data from sun-synchronous polar-orbiting satellites, with a relatively narrow swath. Thus, it cannot be considered a representation of the mean properties of clouds across the whole month for two reasons:

- The narrow swath of the (A)ATSR instruments means that it requires approximately three days of measurements to provide full global coverage.
- The sun-synchronous orbit used by ERS-2, ENVISAT and Sentinel-3, means that observations are made near two fixed local solar times[1]; 10:00 and 22:00 for the descending and ascending halves of the ENVISAT and Sentinel-3 orbit, and 10:30 and 22:30 for ERS-2. Thus, the diurnal cycle is poorly sampled.

[1] At high latitudes temporal sampling becomes somewhat better, as adjacent orbits overlap.

1.3.1 Uncertainties

The ORAC retrieval algorithm is an implementation of Optimal Estimation (Rodgers, 2000) and as such provides uncertainty estimates on all retrieved parameters, propagated from the uncertainty in the input satellite measurements (as well as any forward modelling error included in the uncertainty calculations). The propagation of the L2 uncertainty into L3 products, such as those brokered to the CDS, is not straight forward. Users should refer to the Cloud_cci Comprehensive Error Characterisation Report [D4].

Uncertainty and variability in the monthly mean cloud properties is expressed using three separate values, as described by Bennartz (2017):

1. Standard deviation about the mean. This value is the unweighted standard deviation of the L2 retrieval values about the mean value reported for each L3 pixel.

2. Propagated uncertainty in value. The value represents the L2 uncertainty propagated to the L3 pixel under the assumption that the L2 values used in the L3 average are independent and uncorrelated. It is calculated by summing the L2 uncertainties in quadrature and normalizing by the number of observations:

$$ \sigma_{prop} = \sqrt{\frac{1}{N} } \ \ (Eq. 1)$$

where $_i$ are the uncertainties of the *N* L2 pixels included in the average, and the <> indicates the mean value.

3. Correlated uncertainty in value. If a L2 pixels are assumed to be correlated with each other, the uncertainty in the resulting average can be calculated using:

$$\sigma_{corr} = \sqrt{\sigma_{std}^2 - (1-c) \sqrt{ \langle \sigma_{i}^2 \rangle - \langle \sigma_{i} \rangle ^2 }} \ \ (Eq. 2)$$

where $^2_{std}$ is the unweighted standard deviation about the mean and *c* is the correlation between the L2 pixels.

2. Cloud_cci global daily cloud products

The Cloud_cci global daily cloud properties product, version 3.0, is brokered to the CDS by the C3S from STFC RAL Space. The SLSTR ICDR, versions 3.1.1 and 4.0 are supplied to the CDS via the same route and uses the same processing software and infrastructure as the CDR. Although the format of the brokered data products differs from the official Cloud_cci products, the intellectual property rights remain with the Cloud_cci team. In detail, the official daily and monthly files from Cloud_cci contain more than 180 variables, but the specified C3S format splits them into separated parts per ECV. That way, each file has a reduced data amount as well as an increased usability. The landing page for the official CCI products is https://climate.esa.int/en/projects/cloud/.

The product provides estimates of daily mean global cloud properties over land and ocean from the Along Track Scanning Radiometer ((A)ATSR) series of satellite sensors, on a 0.1°×0.1° latitude-longitude grid from mid-1995 until early 2012. The SLSTR based ICDR extends the coverage, with a five-year gap, from 2017 onwards and is only available through the CDS. Version 3.x of the ICDR provides data from a single SLSTR (flying on board either Sentinel-3a or -3b), while version 4.0 combines data from both SLSTR instruments into a single combined product (starting with the launch of the Sentinel-3b in late 2018). The processing of version 3.x and 4.0 are identical – the sole difference is whether the two instruments are separately or treated as a single data-stream.

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The analysis algorithm applied in producing the Cloud_cci products is the Optimal Retrieval of Aerosol and Clouds (ORAC), while the overall data processing system used in the project is referred to as Community Cloud for Climate (CC4CL), and these are detailed in the C3S ATBD [D1], Cloud_cci ATBD [D2], Sus et al. (2018) and McGarragh et al. (2018).

The brokered CDR is extended, with a five-year gap, from 2017 with an ICDR derived from the SLSTR instruments, which fly onboard the Copernicus operational Sentinel-3 satellites. From late 2018, a second Sentinel-3 platform is available, which doubles the spatial coverage of SLSTR and allows for nearly complete global coverage twice a day. The SLSTR product is produced using the same processing chain as the (A)ATSR CDR.

2.2 Target requirements

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Table 2-1: GCOS targets for cloud ECVs. Note that the Cloud_cci doesn't meet the temporal requirements due to the nature of the satellite observations, but exceeds the spatial resolution and aims to achieve the uncertainty and stability requirements.

Quantity	Cloud_cci variable	Targets
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Cloud Water Path	LWP, IWP	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 25% • Stability: 5% /decade
Effective particle radius	CER	• Frequency: 3hr • Resolution: 50 km • Measurement uncertainty: 1µm • Stability: 1µm/decade

2.3 Data usage information

Cloud_cci products are provided in NetCDF (version 4), which are compliant with the conventions CF 1.8 and the NASA Global Change Master Directory (GCMD) Science Keywords vocabulary. Filenames follow the structure:

C3S-312bL1-L3C-DAILY-CLOUD-*INSTORACPLATFORM*{}YYYYMMDD{_}*fv*VVV{_}.nc,

where *INST* and *PLATFORM* refer to the instrument and platform from which data originates (either ATSR2 and ERS2, or AATSR and ENVISAT for the CDR, or SLSTR and Sentinel-3a or -3b for the ICDR), *YYYYMMDD* provides the year, month and day covered by the daily mean product, and *VVV* denotes the product version (3.0 for the TCDR, 3.1 for the ICDR).

Data are provided as daily means of cloud properties, as described in Table 2-2, on a regular latitude-longitude grid, with a spacing of 0.1° in both dimensions (thus grid centres lie at -89.95°, -89.85°, -89.75°, …, 89.95° in latitude and -179.95°, -179.85°, -179.75°, …, 179.95° in longitude).

Unlike the monthly product, the daily product separates the variables into day and night observations, stored in different variables within the product. In this context "day" measurements are defined as those where the solar zenith angle is low enough that the solar reflectance can be used in the retrieval scheme. In the case of ORAC this means a solar zenith angle of 0<80°. There are two main reasons for this approach:

1. In a given location and day, observations made by a sun-synchronous satellite during day and night will be separated by approximately 12 hours. By separating the averages into day and night values, we are essentially representing an instantaneous spatial average, rather than combining two instantaneous measurements separated by many hours.

2. Furthermore, if an average of all available data for a given day was taken, some grid-cells would contain data from both day and night observations, some would contain only day and some only night observations. Thus, the resulting product would contain discontinuities which would be solely an artefact of the averaging.

These two factors combine to mean that separate day and night averages are both more geophysically relevant and easier to interpret than a simple average over the whole day.

The list of cloud properties, the variable names used within the NetCDF data files and their units are given in Table 2-2.

Table 2-2: Cloud properties included in Cloud_cci TCDR and SLSTR ICDR daily products.

Property	Unit	Variable name	Comment
Cloud fractional cover-day	-	cfc_day	
Cloud fractional cover-night	-	cfc_night	
Cloud-top pressure-day	hPa	ctp_day	
Cloud-top pressure-night	hPa	ctp_night	
Cloud-top height-day	km	cth_day	
Cloud-top height-night	km	cth_night	
Cloud-top temperature-day	K	ctt_day	
Cloud-top temperature-night	K	ctt_night	
Cloud optical thickness-day	-	cot_day	
Cloud effective radius-day	µm	cer_day	
Cloud liquid water path-day	gm^{-2}	lwp_day	
Cloud liquid water path-night	gm^{-2}	lwp_night	
Cloud ice water path-day	gm^{-2}	iwp_day	
Cloud ice water path-night	gm^{-2}	iwp_night	

For lists and details of known issues and limitations of the data, the user is referred to the referenced ATBDs and papers in Section 1.1.

2.3.1 Uncertainties

The ORAC retrieval algorithm is an implementation of Optimal Estimation (Rodgers, 2000) and as such provides uncertainty estimates on all retrieved parameters, propagated from the uncertainty in the input satellite measurements (as well as any forward modelling error included in the uncertainty calculations). The propagation of the L2 uncertainty into L3 products, such as those brokered to the CDS, is not straight forward. Users should refer to the Cloud_cci Comprehensive Error Characterisation Report [D4].

Uncertainty and variability in the monthly mean cloud properties is expressed using three separate values, as described by Bennartz (2017):

1. Standard deviation about the mean. This value is the unweighted standard deviation of the L2 retrieval values about the mean value reported for each L3 pixel.

2. Propagated uncertainty in value. The value represents the L2 uncertainty propagated to the L3 pixel under the assumption that the L2 values used in the L3 average are independent and uncorrelated. It is calculated by summing the L2 uncertainties in quadrature and normalizing by the number of observations:

$$ \sigma_{prop} = \sqrt{\frac{1}{N} \langle \sigma_{i}^2 \rangle} \ \ (Eq. 3)$$

where $_i$ are the uncertainties of the L2 pixels included in the average, and the <> indicates the mean value.

3. Correlated uncertainty in value. If a L2 pixels are assumed to be correlated with each other, the uncertainty in the resulting average can be calculated using:

$$\sigma_{corr} = \sqrt{\sigma_{std}^2 - (1-c) \sqrt{ \langle \sigma_{i}^2 \rangle - \langle \sigma_{i} \rangle ^2 }} \ \ (Eq. 4)$$

where $^2_{std}$ is the unweighted standard deviation about the mean and *c* is the correlation between the L2 pixels.

2.3.2 Gaps and anomalies

A small number of gaps occurs in the daily means of the dataset. These are due to maintenance reasons or outages of instruments. In addition, anomalies appear and lead to a number of days which should be treated with caution. Table 2-3 provides a list of days which are either not available or anomalous.

Table 2-3: Summary of gaps and anomalies for each satellite

Satellite	Gaps	Anomalies
	15/02/2017 - 16/02/2017	17/02/2017 - 19/02/2017

Sentinel-3A		16/03/2017 - 17/03/2017
		13/06/2017 - 14/06/2017
	31/07/2017 - 05/08/2017	30/07/2017 - 31/08/2017 (cfc only)
	16/02/2018 - 20/02/2018	
		06/06/2018 - 07/06/2018
	14/09/2018 - 16/09/2018	17/09/2018 - 19/09/2018
	21/05/2019 - 25/05/2019	
		05/09/2019 - 06/09/2019
	04/02/2020 - 11/02/2020	
	14/05/2020 - 21/05/2020	
		01/10/2020 - 02/10/2020 (cfc only)
	20/04/2021	
		27/09/2021 - 28/09/2021
Sentinel-3B	27/10/2018 - 28/10/2018	
	31/10/2018 - 01/11/2018	
	12/04/2019 - 16/04/2019	
		01/06/2019 - 14/06/2019 (cer only)
		03/09/2019 - 04/09/2019
	20/09/2019 - 24/09/2019	
		28/09/2020 - 29/09/2020 (cfc only)
	12/11/2020	
		30/09/2021 - 01/10/2021
		26/12/2021 - 31/12/2021 (iwp only)
	20/06/2022 - 21/06/2022	

3. Data access information

The original repository for the CCI formatted L3 data can be accessed through the Cloud_cci homepage https://climate.esa.int/en/projects/cloud/data/, as can all relevant documentation from the project. It should be noted that Cloud_cci L3 data is not in the same format as data brokered to the CDS, however the same L2 retrieval output was used to produce both products. In detail, the official daily and monthly files from Cloud_cci contain more than 180 variables, but the specified C3S format split them into separate parts per ECV. That way, each file has a reduced data amount as well as an increased usability.

Cloud_cci data should also be available through the ESA_cci data portal http://cci.esa.int/data, which provides online data mining, analysis and visualization tools for CCI data through the CCI Toolbox.

Only the brokered (A)ATSR based CDR is available through CCI, with SLSTR data being supplied only to the CDS.

3.1 Data access through CCI

Within C3S, the distribution will be through the CDS (https://cds.climate.copernicus.eu/) where documentation created for the inclusion of the data in the CDS, such as this PUGS, will be also provided.

3.2 Data access through the CDS

Within C3S, the distribution will be through the CDS (https://cds.climate.copernicus.eu/) where documentation created for the inclusion of the data in the CDS, such as this PUGS, will be also provided.

3.3 Product ordering process

You need to be registered and logged in to order products in the CDS. A login is provided upon registration, all products in the CDS are delivered free of charge.

References

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Related articles

- SEC Version 5.0: System Quality Assurance Document (SQAD)
- SEC Version 5.0: Product Quality Assessment Report (PQAR)
- SEC Version 5.0: Product User Guide and Specification (PUGS)
- IV data version 1.5: Product Quality Assurance Document (PQAD)
- IV data version 1.5: System Quality Assurance Document (SQAD)