S5P Mission Performance Centre CLOUD [L2__CLOUD_] Readme

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[1] The S5PVT AO project summaries can be found at https://earth.esa.int/web/guest/pi-community/search-results-and-projects/mission

CHANGE LOG

Reason for change	Issue	Revision	Date
Table 2: addition of version 01.01.08	1	5	18/03/2020
Updates for processor version 02.01.03	2	0	16/07/2020
• Table 2: updates for processor version 02.01.04 • Added first paragraph of section 4.1	2	1	30/11/2020
• Table 2: adapting to version 02.02.01 of the processor • Section 4.1 & Section 4.2: some text moved from Section 4.1 (Known Data Quality Issues) to Section 4.2 (Solved Data Quality Issues) • Section 6.1: added format changes related to version 02.02.01	2	2	05/07/2021

1 Summary

This is the Product Readme File (PRF) of the Copernicus Sentinel 5 Precursor Tropospheric Monitoring Instrument (S5P/TROPOMI) Cloud Level 2 data product and is applicable for both the Near Real Time (NRTI) and Offline (OFFL) timeliness data products.

Product Identifier: **L2__CLOUD_**

Example filename:

S5P_OFFL_L2__CLOUD__20190729T012853_20190729T031221_09274_01_020103_20200511T161148.nc
S5P_NRTI_L2__CLOUD__20180704T085914_20180704T090414_03746_01_020103_20180704T094813.nc

The OFFL product has the following DOI: http://doi.org/10.5270/S5P-w1qgt16

The Readme file describes the current processing baseline, product and quality limitations, and product availability status. More information on this data product is available from the Sentinel product webpage:

https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/products-algorithms,

and from the TROPOMI product webpage http://www.tropomi.eu/data-products.

Note that the cloud parameters are given for two different cloud models:

(a) CAL (Clouds-As-Layers) [`cloud_fraction, cloud_top_height, cloud_optical_thickness`]

(b) CRB Clouds-as-Reflecting-Boundaries) [`cloud_fraction_crb, cloud_height_crb, cloud_albedo_crb`]

Note that the cloud fraction in the CLOUD Level 2 product is the Radiometric Cloud Fraction (RCF).

As a user guideline for the data quality a `qa_value` is given with the data. In order to avoid misinterpretation of the data quality, it is recommended at the current stage to only use those pixels with a `qa_value` above 0.5.

Note: starting from this processor version 2.2.1, new improved Level 1b version 2.0 data products are used as input [RD09].

Validation by Mission Performance Centre (MPC) Cal/Val experts and the Sentinel-5 Precursor Validation Team (S5PVT) conclude that the Cloud data is compliant with the requirements as defined in the **S5P Calibration and Validation Plan** [RD01], see Table 1.

Up to date validation results are available in the Routine Operations Consolidated Validation Reports (ROCVR) that are accessible through the MPC Validation Data Analysis Facility (VDAF) website at http://mpc-vdaf.tropomi.eu. The ROCVR reports are issued quarterly.

Parameter	Data product	Bias	Random
Radiometric Cloud Fraction	NRTI and OFFL	20%	0.05
Optical Thickness (Albedo)	NRTI and OFFL	20%	10 (0.05)
Cloud Height (Pressure)	NRTI and OFFL	20%	0.5 km (30 hPa)

Table 1: Cloud product requirements

2 Processing baseline description

Table 2 contains the history of the CLOUD processor versions. Note that the processor version for CLOUD is changing when there is a change to any of the products belonging to the UPAS processor suite (SO2, HCHO, O3 NRTI, O3 OFFL, Tropospheric O3, CLOUD) even if the change is not affecting the CLOUD product.

Please note that the processor version annotation in the filenames of **OFFL** orbits **4147** to **4158** are not correct. Those products are actually processed with the UPAS version 01.01.02, but in the filename it is written 01.01.01. For **NRTI** orbits **4243** to **4244** the processor version annotations are not correct. From orbit 4245 onwards all products have the correct (01.01.02) annotation in the filenames.

Processor Version	In operation from	In operation until	Relevant improvements
02.02.01	NRTI: orbit 19308, 2021-07-05 OFFL: orbit 19258, 2021-07-01	Current version	- New cloud-free maps based on 3 years of TROPOMI data - Improved handling of snow / ice conditions in the cloud fraction a priori retrieval - Improved scan angle correction based on 3 years of TROPOMI data - Optimized for the new L1b V2.0 input by calculating an offset between the reflectance degradation (calculated based on three years of L1b V1.0 data) and the irradiance degradation (contained in L1b V2.0) - New fallback surface albedo climatology based on 3 years of TROPOMI data - Improved clear-sky filtering in background correction - The variable `surface_altitude_precision` is now correctly written (previous versions reported fill-value) - Added the variable `surface_temperature` (see section 6.1) **Note**: starting from this processor version 2.2.1, new improved Level 1b version 2.0 data products are used as input [RD09].
02.01.04	NRTI: orbit 16259, 2020-12-02 OFFL: orbit 16213, 2020-11-29	Orbit 19306, 2021-07-05 Orbit 19257, 2021-07-01	No changes with respect to previous version
02.01.03	NRTI: orbit 14285, 2020-07-16 OFFL: orbit14239, 2020-07-13	Orbit 16256, 2020-12-02 Orbit 16212, 2020-11-29	- New surface albedo retrieval algorithm (GE_LER) from TROPOMI replaced the MERIS climatology - New OCRA cloud-free maps based on TROPOMI instead of OMI - Since this version, SNPP data for UVIS and NIR are ingested and written into the **OFFL** CLOUD product - New cloud flags have been introduced (e.g. ice-clouds) - The required interpolation of cloud properties between band 3-4 and band 6 due to the instrument co-registration issues has been improved

			- Updated metadata generation to reflect the improved spatial resolution after 6th Aug 2019 - Improved handling of the ECMWF information, reading and deriving snow-ice information, extracting Geopotential at Ground/Water Surface level, and propagating wind-information in the level 2 products (see section 6.1) - Improved the parameter `qa_value` determination - Invalid values of `geolocation_flags` set to correct values - New variables added (see section 6.1)
01.01.08	NRTI: orbit 12482, 2020-03-11 OFFL: orbit 12432, 2020-03-07	orbit 14285, 2020-07-16 orbit14238, 2020-07-12	No changes with respect to previous version
01.01.07	NRTI: orbit 7999, 2019-04-30 RPRO: orbit 2818, 2018-04-30 OFFL: orbit 7907, 2019-04-23	Orbit 12482, 2020-03-11 Orbit 7906, 2019-04-23 Orbit 12431, 2020-03-07	No changes with respect to previous version
01.01.06	NRTI: orbit 7631, 2019-04-04 OFFL: orbit 7542, 2019-03-28	Orbit 7999, 2019-04-30 Orbit 7906, 2019-04-23	- Cloud height values were too close to "*a priori*" values in previous versions (see section 4.2) - Surface classification climatology updated - Fixed a bug in the interpolation of the surface albedo climatology - Variable `cloud_top_pressure` was erroneously not set to invalid when `cloud_top_height` was set to invalid - Variables related to precision (`cloud_fraction_precision`, `cloud_fraction_crb_precision`, etc) were erroneously very high on row indices 81 and 333 in previous versions (see section 4.2)
01.01.05	NRTI: orbit 5932, 2018-12-05 OFFL: orbit 5833, 2018-11-28	Orbit 7631, 2019-04-04 Orbit 7541, 2019-03-28	No changes with respect to previous version
01.01.02	NRTI: orbit 4243, 2018-08-08 OFFL: orbit 4147, 2018-08-01	Orbit 5929, 2018-12-05 Orbit 5832, 2018-11-28	Variable `delta_time` was not correctly calculated in previous version (see section 4.2)
01.01.01	NRTI: orbit 3947, 2018-07-18 OFFL: orbit 3848, 2018-07-11	Orbit 4242, 2018-08-08 Orbit 4146, 2018-08-01	- Solved a problem while computing `time_coverage_start` and `time_coverage_end` of a granule overpassing midnight (see section 4.2) - Variable `processing_quality_flags` was not correctly calculated in previous version - The scan angle correction was not properly activated; fixed the calculation of the error of the variable `cloud_optical_thickness`
01.00.00	NRTI: orbit 3745, 2018-07-04 OFFL: orbit 3661, 2018-06-28	Orbit 3946, 2018-07-18 Orbit 3847, 2018-07-11	Initial operational version

Table 2: History of CLOUD processor versions. In orange, the data versions that are no longer available to the users on the Pre-operations hub.

3 Product Quality

3.1 Recommendations for data usage

In order to avoid misinterpretation of the data quality, it is recommended at the current stage to only use those TROPOMI pixels associated with a **`qa_value` >= 0.5**. The `qa_value` summarizes the quality of the product by taking into consideration several aspects like the spectral channel quality flags from L1B data, geometry limitations (e.g. not reliable retrievals for SZA>75º), inhomogeneous scene warnings, high residual of the fitting process etc. The `qa_value` is only a rough guideline for the data user to estimate the cloud retrieval quality for a given scene.

If cloud retrievals over snow and ice should be included, only data with **qa_value >= 0.25** should be used. This allows to include some snow/ice scenes while still filtering out retrievals with very low Root-Mean-Square (RMS).

For application in trace gas retrievals, the lower value of **qa_value >= 0.25** could be used in order to increase the data yield. **It should be noted that this recommendation is only preliminary, may be subject to change and is not based on any extensive analysis.**

The most appropriate usage of the CLOUD product depends on the use-case and should be based on the `qa_value` in conjunction with the retrieval diagnostics and warning and error flags provided in the CLOUD product and summarized in Table 5-1 of the CLOUD ATBD [RD02]. These inputs together represent a much more detailed and more appropriate information than the `qa_value` alone.

For further details, data users are encouraged to read the Product User Manual (PUM) and Algorithm Theoretical Basis Document (ATBD) associated with this data product, available on https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/products-algorithms.

3.2 Validation results

3.2.1 Status of product validation

Validation by MPC Cal/Val experts conclude that the Cloud data is in good overall agreement with (i) reference measurements collected from global ground-based networks, and (ii) the corresponding satellite data products from VIIRS & MODIS, and (iii) is compliant with the requirements as defined in the **S5P Calibration and Validation Plan** [RD01], see Table 1.

Up to date validation results are available in ROCVR reports that are accessible through the MPC VDAF website at http://mpc-vdaf.tropomi.eu. The reports are issued quarterly.

A manuscript detailing the comprehensive validation of the S5P CLOUD CAL and S5P CLOUD CRB data products using satellite and ground-based data is published (Compernolle et al., 2021) [RD08].

4 Data Quality Remarks

4.1 Known Data Quality Issues

Note that since version 02.01.03, S5P L2_CLOUD OFFL and NRTI are slightly different because the OFFL also incorporates VIIRS cloud mask information in its Background correction.

Currently, the following data quality issues are known, not covered by the quality flags, and should be kept in mind when looking at the CLOUD product itself.

An instrument feature: spatial mis-registration between TROPOMI bands 3-4 (OCRA, UV trace gas fitting window) and band 6 (ROCINN fitting window)

The band 3-4 (450 pixels per scanline) footprints are not fully aligned with the band 6 (448 pixels per scanline) ones. In the worst case, the mis-alignment can be in the order of half a ground pixel. The OCRA algorithm retrieves the a priori cloud fraction at bands 3 and 4 and interpolates it linearly, according to the covered area as described by the TROPOMI interband coregistration mapping tables, to band 6. This is an *a priori* to the ROCINN algorithm, which works in band 6. Over heterogeneous scenes the mis-registration might have a large impact on the data quality. The cloud height and optical thickness retrieved in band 6 are interpolated back to the band 3 footprints. Due to missing overlap with the band 6 footprints, the first pixel in band 3 (no overlap) and the second pixel in band 3 (only partial overlap), do not contain cloud products with full quality. This is also reflected in the cloud data `qa_value`.

Insensitivity to very thin clouds

The retrieval takes place in the UV-VIS-NIR bands only up to 770 nm. In this part of the spectrum, the optically thin clouds (i.e., COT < 5) are retrieved less accurately compared to, for example, MODIS or VIIRS that use also channels in the μm range.

Treatment of multi-layer clouds

The cloud retrieval algorithm assumes that there is a single-cloud layer in the atmosphere. For cases with more than one cloud layer present, the retrieved parameters might be under- or over-estimated. For more details about the quantification of multi-layer clouds, refer to Loyola et al. (2018) [RD04].

Treatment of ice clouds

Regarding the CAL model, the current parameterization of clouds is based on liquid water clouds. Therefore, ice or mixed-phase clouds might not be accurately retrieved. From the initial preliminary validation, it seems that the ice clouds are retrieved with an overestimated optical thickness. Since version 02.xx.xx, a new variable called `cloud_phase` is introduced to the product and discriminates between liquid water and ice clouds.

Snow/Ice conditions

Over bright surfaces (especially when there is no permanent snow/ice coverage), the performance of the algorithm is decreased. This might result in overestimation of the cloud fraction; cloud (top) height is very close to the surface height and the cloud optical thickness overestimated. As outlined in Table 2, an improved a priori cloud fraction retrieval over snow/ice has been introduced in 02.02.01. This also has a positive impact on the cloud (top) height, cloud albedo and optical thickness retrievals under these challenging surface conditions.

Unknown straylight impact in the NIR

The TROPOMI out-off-band straylight effect is not yet well assessed. The L1B radiance data in bands 5 and 6 (near infrared wavelength range) are corrected for the out-of-band straylight, but the correction scheme has not been fully validated. The pixels at the poles seem to be more sensitive to non-optimal straylight correction.

4.2 Solved Data Quality Issues

Wrong Sensing dates in metadata (solved in version 01.01.01)

Note that there is a non-systematic problem in the sensing dates around mid-night: the reported dates in the global attributes can be wrong by one day ahead. This issue is solved with the activation of version 01.01.01 (see Table 2).

NRTI data gaps northern hemisphere (solved in version 01.01.01)

The NRTI data stream shows data gaps over Kazakhstan, southern part of Russia and Canada due to a miss-configuration of the processing facility. This issue is solved with the activation of processor version 01.01.01 mid-July 2018 (see Table 2).

Bug in `delta_time` variable (solved in version 01.01.02)

In version 01.01.01 (see Table 2) the `delta_time` variable might be wrong. The error is usually in the range of less than a minute but in the worst case it might be up to 45 min. It is therefore recommended not to use the time variable for data with this processor version.

Orbit numbering in NRTI and OFFL (solved in version 01.01.05)

Note that NRTI orbit numbers are set with respect to the downlink orbit while OFFL orbit numbers are set with respect to the equator crossing time. This creates an inconsistency between the NRTI and OFFL orbit numbers, which is removed with the activation of processor version 01.01.05 (see Table 2).

Bug with cloud height (solved in version 01.01.06)

In versions prior to 01.01.06, for some pixels the cloud height was not correctly retrieved. The `cloud_height_crb` and `cloud_top_height` variables were converging to the a-priori value of 3.8 km. From version 01.01.06, this issue is resolved (see Table 2).

Variables related to precision extremely high for rows 81 and 333 (solved in version 01.01.06)

Variables related to the precision: `cloud_fraction_precision` (CAL), `cloud_fraction_crb_precision` (CRB), `cloud_base_height_precision` (CAL), `cloud_top_height_precision` (CAL), `cloud_height_crb_precision` (CRB) are erroneously very high on row indices 81 and 333. Note that for neighbouring rows, the problem with the "`_precision`" variables disappears. `qa_value` is often 100, thus these erroneous values are not filtered. From version 01.01.06, this issue is resolved (see Table 2).

Bug with missing fillvalues in the cloud pressure (solved in version 01.01.06)

In versions prior to 01.01.05, the `cloud_top_pressure` and `cloud_pressure_crb` did not contain fillvalues for clear-sky scenes (i.e., when cloud fraction is 0). Instead, the cloud pressure contained a valid value equal to the surface pressure. For versions 01.01.06 and higher, this bug is fixed.

Metadata/Attributes (solved with version 02.01.03)

The spatial resolution of the TROPOMI measurements is improved by bringing the along track ground pixel size from 7.0 to 5.5 Km starting on 6th August 2019. Note that, after this operations change, the metadata/Attributes fields related to the spatial resolution, remained **unchanged** (hence not aligned to the improved resolution) - but with version 02.01.03 this is corrected.

Metadata values exchanged (solved)

The global attributes `geospatial_lon_min` and `geospatial_lon_max` values are exchanged; therefore, the user is advised to switch the values for these fields, making note that the `geospatial_lat_min` and `geospatial_lat_max` values are correct. This is an issue traceable to L1b data (version 01.00.00) and is corrected since the switch to version 02.00.00 of the Level 1B processor on July 2021.

Flagging of saturation (solved)

Some TROPOMI pixels might be affected by saturation. Those pixels are flagged and their quality is reflected in the `qa_value`. Nevertheless, in the vicinity of saturated pixels there might be pixels also affected by saturation due to the so-called blooming effect. For those pixels, the ROCINN cloud parameters tend to be overestimated. In general, saturation is present over bright scenes (e.g. fully cloudy scenes with large optical depths). The pixels affected by blooming effect have been flagged since version 02.00.00 of the Level 1b processor, operational since July 2021.

4.3 Data features

This section describes some characteristics of the data that might seem anomalous, however they are physically correct and not related to any problem.

Pixel geolocation around North Pole (feature)

The solar irradiance is measured on a daily basis over the North Pole at a reference azimuth angle to remove seasonal effects on the measurements. To this end, a yaw manoeuvre is executed when the instrument is still in radiance mode, causing possible distortion on the scanlines observed during this manoeuvre (i.e. crossing scanlines, "bow-tie" ground pixel shape instead of rectangular). This occurs at most during the last 26 seconds of radiance measurements in few orbits (7-9 per week). Though this may seem anomalous, it is physically correct, and not related to any problem on the data geolocation.

4.4 Mission Operations Changes

A change in the Copernicus Sentinel-5P operations scenario, increasing the spatial resolution from 7.0 km to 5.5 km along track for all measurements, became operational starting from 6 August 2019, orbit 9388.

5 Algorithm Change Record

For a detailed description of the L2__CLOUD_ algorithms, please refer to the ATBD [RD02] or to Loyola et al. (2018) [RD04] and Loyola et al. (2020) [RD07].

6 Data Format

The product is stored as NetCDF4 file. The NetCDF4 file contains both the data and the metadata for the product.

For OFFL data the product is stored as a single file per satellite orbit, for NRTI data the product is stored as multiple files per orbit.

Please note that consecutive data granules of the NRTI product show an overlap of about 12 scan lines.

Details of the data format are provided in the Product User Manual (PUM) [RD03].

6.1 Data format changes

6.1.1 Version 02.02.01

New fields added

```
/PRODUCT/SUPPORT_DATA/INPUT_DATA/surface_temperature
/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS/ attribute cloud_phase:flag_meanings
/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS/ attribute cloud_phase:flag_values
```

6.1.2 Version 02.01.04

There are no format changes with respect to the previous version.

6.1.3 Version 02.01.03

New fields added

```
/PRODUCT/latitude_nir
/PRODUCT/longitude_nir
/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/latitude_bounds_nir
/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/longitude_bounds_nir
/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/geolocation_flags_nir
/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/solar_zenith_angle_nir
/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/solar_azimuth_angle_nir
/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/viewing_zenith_angle_nir
/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/viewing_azimuth_angle_nir
/PRODUCT/SUPPORT_DATA/INPUT_DATA/sea_ice_cover
/PRODUCT/SUPPORT_DATA/INPUT_DATA/snow_cover
/PRODUCT/SUPPORT_DATA/INPUT_DATA/northward_wind
/PRODUCT/SUPPORT_DATA/INPUT_DATA/eastward_wind
/PRODUCT/SUPPORT_DATA/INPUT_DATA/viirs_cloud_fraction_nir
/PRODUCT/SUPPORT_DATA/INPUT_DATA/viirs_cloud_fraction
/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS/cloud_top_temperature
/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS/cloud_phase
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_height
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_height_precision
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_pressure
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_pressure_precision
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_height_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_albedo_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_height_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/effective_scene_albedo_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/condition_number_ge_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/degrees_of_freedom_ge_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/shannon_information_content_ge_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/fitted_root_mean_square_ge_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/number_of_iterations_ge_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/coregistration_weight_sums_ge
/PRODUCT/SUPPORT_DATA/INPUT_DATA/surface_altitude_nir
/PRODUCT/SUPPORT_DATA/INPUT_DATA/surface_pressure_nir
```

/PRODUCT/SUPPORT_DATA/INPUT_DATA/surface_classification_nir
/PRODUCT/SUPPORT_DATA/INPUT_DATA/surface_albedo_nir
/PRODUCT/SUPPORT_DATA/INPUT_DATA/snow_ice_flag_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_fraction_apriori_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/coregistration_weight_sums_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_height_crb_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_albedo_crb_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_fraction_crb_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/surface_albedo_fitted_crb_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_height_crb_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_albedo_crb_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_fraction_crb_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/surface_albedo_fitted_crb_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/degrees_of_freedom_crb_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/number_of_iterations_crb_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/fitted_root_mean_square_crb_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/coregistration_weight_sums_crb
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_top_height_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_optical_thickness_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_fraction_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/surface_albedo_fitted_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_top_height_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_optical_thickness_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/cloud_fraction_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/surface_albedo_fitted_precision_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/degrees_of_freedom_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/number_of_iterations_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/fitted_root_mean_square_nir
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/coregistration_weight_sums_cal

Renamed variables

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/regularization_parameter_crb
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/regularization_parameter_crb_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/condition_number_crb
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/condition_number_crb_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/shannon_information_content_crb
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/shannon_information_content_crb_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/convergence_flag_crb
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/convergence_flag_crb_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/fitted_state_vector_crb
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/fitted_state_vector_crb_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/covariance_matrix_diagonal_crb
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/covariance_matrix_diagonal_crb_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/regularization_parameter
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/regularization_parameter_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/condition_number
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/condition_number_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/shannon_information_content
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/shannon_information_content_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/convergence_flag
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/convergence_flag_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/fitted_state_vector
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/fitted_state_vector_nir

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/covariance_matrix_diagonal
→ /PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/covariance_matrix_diagonal_nir

Datatype changes - from NC_USSHORT to NC_FLOAT

/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/number_of_iterations
/PRODUCT_SUPPORT_DATA/DETAILED_RESULTS/number_of_iterations_crb

New Metadata

Added "Status_BG" as global attribute.

7 Product Availability

All S5P/TROPOMI data are available on the Copernicus Open Data Hub https://scihub.copernicus.eu.

Information on data handling tools is available from the web page http://www.tropomi.eu/tools.

For further questions regarding S5P/TROPOMI data products please contact EOSupport@Copernicus.esa.int.

The access and use of any Copernicus Sentinel data available through the Copernicus Sentinel Data Hub is governed by the Legal Notice on the use of Copernicus Sentinel Data and Service Information and is given here:

https://sentinels.copernicus.eu/documents/247904/690755/Sentinel_Data_Legal_Notice.

8 References

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url: https://sentinels.copernicus.eu/documents/247904/2476257/Sentinel-5P-TROPOMI-Level-1B-ATBD

More information on this data product is available from the Sentinel product webpage:

https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/products-algorithms,

and from the corresponding TROPOMI product webpage http://www.tropomi.eu/data-products.

Abbreviations and acronyms

ATBD	Algorithm Theoretical Basis Document
BIRA-IASB	Royal Belgian Institute for Space Aeronomy
CAL	Clouds As Layers
CF	Cloud Fraction (fractional cloud cover)
CLOUDNET	Cloud properties monitoring Network
COT	Cloud Optical thickness
CRB	Clouds as Reflecting Boundaries
CTH	Cloud Top Height
DLR	German Aerospace Center / Deutsches Zentrum für Luft- und Raumfahrt
DOI	Digital Object Identifier
EARLINET	European Aerosol Research Lidar Network
ESA	European Space Agency
ESL	Expert Support Laboratory
GOME(-2)	Global Ozone Monitoring Experiment(-2)
KNMI	Royal Netherlands Meteorological Institute
lidar	LIght Detection And Ranging
MPC	Mission Performance Centre
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NRTI	Near Real Time (timeliness of products)
OCRA	Optical Cloud Recognition Algorithm
OFFL	Offline (timeliness of products)
OMI	Ozone Monitoring Instrument
PRF	Product Readme File
PUM	Product User Manual
QWG	Quality Working Group
RCF	Radiometric Cloud Fraction
RMS	Root-Mean-Square
ROCINN	Retrieval Of Cloud Information using Neural Networks
ROCVR	Routine Operations Consolidated Validation Report
S5P	Sentinel-5 Precursor
S5PVT	Sentinel-5 Precursor Validation Team
Suomi NPP	Suomi National Polar-orbiting Partnership
TROPOMI	Tropospheric Monitoring Instrument
VDAF	Validation Data Analysis Facility
VIIRS	Visible Infrared Imaging Radiometer Suite