S5P Total Column Water Vapour [L2__TCWV_] Readme

document number	S5P-DLR-PRF-TCWV	
issue	1.6.1	
date	2025-08-01	
product version	V01.06.01	
status	Review	
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Document approval record

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Document Change Record

issue	date	item	comments
1.0	2020-12-15	All	Initial version
1.1	2022-06-24		Updated version with multiple corrections
1.5	2023-10-27		QDOAS polynomials integration
1.6.1	2025-08-01		Updated header for version and date. Updated processor description in Section 4

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1 References

[RD01]   Sentinel-5 precursor/TROPOMI Level 2 Algorithm Theoretical Basis Document TCWV
source: DLR; **ref**: S5P-L2-DLR-ATBD-TCWV;

[RD02]   Sentinel-5 precursor/TROPOMI Level 2 Product User Manual TCWV **source**: DLR;
ref: S5P-L2-DLR-PUM-TCWV;

[RD03]   Chan, K. L., Valks, P., Slijkhuis, S., Köhler, C., and Loyola, D., "**Total column water
vapor retrieval for Global Ozone Monitoring Experience-2 (GOME-2) visible blue
observations"**, *Atmos. Meas. Tech.*, 13, 4169–4193, 2020.
https://doi.org/10.5194/amt-13-4169-2020

[RD04]   Chan, K-L, Xu, J., Slijkhuis S., Valks P., Loyola, D.G., "**TROPOspheric Monitoring
Instrument observations of total column water vapour: algorithm and
validation**", *Science of The Total Environment*, 821, 153232, 2022.
https://doi.org/10.1016/j.scitotenv.2022.153232

[RD05]   Garane, K., Chan, K. L., Koukouli, M.-E., Loyola, D., and Balis, D., "**TROPOMI/S5P
Total Column Water Vapor Validation against AERONET ground-based
measurements**", Atmos. Meas. Tech. Discuss., in review, 2022.
https://doi.org/10.5194/amt-2022-94

More information on this data product is available from the S5P ATMOS webpage
https://atmos.eoc.dlr.de/tropomi

2   Abbreviations and acronyms

ATBD   Algorithm Theoretical Basis Document

DLR   German Aerospace Center / Deutsches Zentrum für Luft- und Raumfahrt

DOI   Digital Object Identifier

ESA   European Space Agency

GOME(-2)   Global Ozone Monitoring Experiment(-2)

NRTI   Near Real Time (timeliness of products)

OFFL   Offline (timeliness of products)

PRF   Product Readme File

PUM   Product User Manual

S5P   Sentinel-5 Precursor

TROPOMI   Tropospheric Monitoring Instrument

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3   Summary

This is the Product Readme File (PRF) of the Tropospheric Monitoring Instrument on board the Copernicus Sentinel 5 Precursor satellite (TROPOMI/S5P) total column water vapor Level 2 data product and is applicable for Offline (OFFL) timeliness data products.

Product Identifier: **L2__TCWV__**

Example file name:

S5P_OFFL_L2__TCWV___20191201T005539_20191201T015402_11047_01_000100_202 00714T195701.nc

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 S5P ATMOS webpage https://atmos.eoc.dlr.de/tropomi.

The data file contains the water_vapor_column_density which gives the total atmospheric column between the surface and the tropopause. The random error uncertainty originating from the spectral fit is given in the water_vapor_column_density_precision.

Note that the TCWV data product may be used in different ways, and different fields in the file are relevant depending on the application. For this, we refer to the product user manual [RD02]. The averaging kernels and the *a priori* profiles are provided and should be used for e.g., comparisons with models or profile measurements.

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4   Processing baseline description

Table 1 contains the history of the TCWV processor versions.

Processor Version	In operation from	In operation until	Relevant improvements
00.01.00	na	na	- Initial operational version
01.01.00	2022-06-24		- Changes to output content variables and bug fixes
01.05.00	2023-10-27		- Integrated QDOAS polynomials in the output product
01.06.00	2025-06-12		- Upgrade QDOAS to 3.7.3 - Fix Index out of bounds error - Handle QDOAS key error by catching exception - Scanline mismatch L2 > L1B errors
01.06.01	2025-08-01		- Fix scanline mismatch error L1B > L2 - QA values set to incorrect values based on SCD and VCD

Table 1: History of TCWV processor versions.

5 Product Quality

5.1 Recommendations for data usage

The current version of TCWV product does not contain any qa value. In order to avoid misinterpretation of the data, it is recommended at the current stage to only use those TROPOMI pixels associated with cloud radiance fraction (cloud_radiance_fraction) smaller, 0.5 and solar zenith angle (solar_zenith_angle) smaller than 85° and root mean square of spectral fit residual (fitted_root_mean_square) smaller than 0.002.

For further details, data users are encouraged to read the Product User Manual (PUM) [RD02] and Algorithm Theoretical Basis Document (ATBD) [RD01] associated with this data product.

5.2 Validation results

5.2.1 Status of product validation

TCWV derived from TROPOMI/S5P observations agree well with the other data sets with Pearson correlation coefficient (R) ranging from 0.96 to 0.99. The mean bias between TROPOMI and ERA5 data is -1.24 kg m^{-2} for measurements over land and 0.73 kg m^{-2} for measurements over water. The comparison to MODIS observations show similar results with small dry bias of 1.51 kg m^{-2} for measurements over land and a small wet bias of 1.25 kg m^{-2} for measurements over water. Slightly larger dry bias of 1.98 kg m^{-2} for measurements over land and 1.74 kg m^{-2} for measurements over water are found when compared to GOME-2 observations [RD03]. Compared to SSMIS data over water, TROPOMI observations are bias low by 3.25 kg m^{-2}, see [RD04] for more details.

Furthermore, TROPOMI/S5P TCWV was validated using ground-based data from AERONET. The correlation coefficient of the two products is found to be 0.9 and the mean bias of the relative percentage differences is of the order of only -3 % for the mid-latitudes and the tropics (±60°), see [RD05] for more details.

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6   Data Quality Remarks

6.1   Known Data Quality Issues

- Currently none

6.2   Solved Data Quality Issues

- Dynamic processing parameter **num_proc** has been removed. A new dynamic processing parameter **File_Class** has been added

- Addressed data format discrepancies mentioned in section 5 of [PFS] and [PUM] [RD02]

6.3   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.

6.4   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.

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7 Algorithm Change Record

For a detailed description of the L2__TCWV__ algorithms, please refer to the ATBD [RD01].

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8   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.

Details of the data format are provided in the Product User Manual (PUM) [RD02].

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9   Product Availability

The pre-operational TROPOMI/S5P TCWV products are available on the S5P-PAL Data Portal https://data-portal.s5p-pal.com/products/tcwv.html.

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.