S5P/TROPOMI Level 2 Product User Manual
Total Column Water Vapour TCWV

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Contents

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1 Introduction

1.1 Identification

This document describes the technical characteristics of TROPOMI/S5P Level 2 product that are needed for efficient and correct use of the data contained. This product user manual is specific for total column water vapour (TCWV).

1.2 Purpose and objective

The Sentinel-5 Precursor (S5p) mission is a low Earth orbit polar satellite system that provides information on air quality, climate and the ozone layer. The mission is part of the Global Monitoring of the ESA/European Commission COPERNICUS programme and consists of a satellite platform, the TROPOspheric Monitoring Instrument (TROPOMI) payload, and a ground system. The mission is extensively detailed in [RD2]; a peer-reviewed publication on the mission can be found in [RD1].
The algorithms for the TROPOMI raw data treatment (L0 – L1b) and the actual L2 data processing are each described in an algorithm theoretical basis document (ATBD). This Product User Manual (PUM) describes the technical characteristics of the TROPOMI/S5P Level 2 geophysical data products that are needed for efficient and correct use of the data contained.
In the PUM, the specific section related to the total column water vapour product TCWV is described.

1.3 Document overview

Chapter 2 lists the applicable and reference documentation relevant for this document. Chapter 3 gives an overview of terms, definitions and abbreviations. Chapter 4 describes the TCWV L2 product in general. Chapter 5 indicates the general structure of S5P/TROPOMI L2 files. Metadata and attributes are described in chapter 6. All elements common to all S5P/TROPOMI L2 products are mentioned in chapter 7. The content of the TCWV L2 files is given in chapter 8.

2 Applicable and reference documents

2.1 Applicable documents

[AD01] GMES Sentinel-5 Precursor – S5P System Requirement Document (SRD);source: ESA/ESTEC; ref: S5P-RS-ESA-SY-0002; issue: 4.1; date: 2011-04-29

[AD02] Sentinel-5P Level 2 Processor Development – Statement of Work -;source: ESA; ref: S5P-SW-ESA-GS-053; issue: 1.1; date: 2012-05-21

[AD03] S5P Level 2 Processor Development – Level 2 Processor Requirements Specifications
source: ESA; ref: S5P-SW-ESA-GS-054; issue 1.2 draft; date: 2014-09-15

[AD04] S5P/TROPOMI Level 2 Product Development Plan, source: KNMI, ref: S5P-KNMI-L2CO-0010-PL issue: 1.1.0 date: 2014-06-02

[AD05] S5P – Tailoring of ECSS Standards for the Level 2 Processor Development; source: ESA; ref: SP-RS-ESA-GS-055; issue 1.1dr; date: 2012-10-31

[AD06] Sentinel-5P Level 2 Processor Development: Coordination Tasks; source: ESA; ref: S5P-SW-ESA-GS-081; issue: 1; date: 2012-06-27

2.2 Standard documents

There are no standard documents

2.3 Reference documents

[RD01] Terms, definitions and abbreviations for TROPOMI L01b data processor; source: KNMI; ref: S5P-KNMI-L01B-0004-LI; issue: 3.0.0; date: 2013-11-08

[RD02] Terms, and symbols in the TROPOMI Algorithm Team; source: KNMI; ref: SN-TROPOMI-KNMI-L2-049-MA; issue: 1.0.0; date: 2015-07-16

[RD03] Science Requirements Document for TROPOMI. Volume 1; source: KNMI & SRON; ref: RS-TROPOMI-KNMI-017; issue: 2.0; date: 2008-10-30.

[RD04] GMES Sentinels-4 and-5 Mission Requirements Document (MRD);source: ESA; ref: EO-SMA-/1507/JL; issue: 3; date: 2011-09-21

[RD05] Report Of The Review Of User Requirements For Sentinels-4/-5; source: ESA; ref: EO-SMA-/1507/JL; issue: 2.1; date: 2011-12-21

[RD06] CAPACITY: Operational Atmospheric Chemistry Monitoring Missions – Final report; source: KNMI; ref: CAPACITY; date: Oct. 2005.

[RD07] CAMELOT: Observation Techniques and Mission Concepts for Atmospheric Chemistry; source: KNMI; ref: RP-CAM-KNMI-050; date: Nov. 2009.

[RD08] TRAQ: Performance Analysis and Requirements Consolidation - Final Report; source: KNMI; ref: RP-ONTRAQ-KNMI-051; date: Jan. 2010.

[RD09] S5P/TROPOMI ATBD of the Aerosol data products; source: KNMI; ref: S5P-KNMI-L2-0008-RP-TROPOMI_ATBD_UVAI; issue: 1.1.0; date: 2018-06-15.

[RD10] S5P/TROPOMI ATBD of the Cloud data products; source: DLR; ref: S5P-L2-DLR-ATBD-400I_Clouds; issue: 2.2.0; date: 2020-06-15.

[RD11] S5P/TROPOMI ATBD of the total and tropospheric NO2 data products; source: KNMI; ref: S5P-KNMI-L2-0005-RP-ATBD_NO2_data_products; issue: 1.4.0; date: 2019-02-06.

[RD12] S5P/TROPOMI ATBD of the SO_2 data products; source: BIRA-IASB; ref: S5P-L2-BIRA-ATBD-SO2-400E; issue: 2.2.0; date: 2020-06-15.

[RD13] S5P/TROPOMI Static input for Level 2 processors; source: KNMI; ref: S5P-KNMI-L2CO-0004-SD; issue: 3.0.0; date: 2015-02-27

[RD14] TROPOMI Instrument and Performance Overview; source: KNMI; ref: S5P-KNMI-L2-0010-RP; issue:0.10.0; date: 2014-03-15.

[RD15] Sentinel-5 Precursor Level 2UPAS Processor Input / Output Definition Document; source: DLR; ref: S5P-L2-DLR-IODD-3002; issue:3.5.0; date:2019-08-09.

[RD16] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Formaldehyde HCHO; source: DLR; ref: S5P-L2-DLR-PUM-400F; issue: 2.2.0; date: 2020-06-15.

[RD17] Quarterly Validation Report of the Copernicus Sentinel-5 Precursor Operational Data Products; ref: S5P-MPC-IASB-ROCVR; issue: 6.0.1; date: 2020-03-30.

[RD18] S5P/TROPOMI ATBD of the Total Column Water Vapour data products; soure: DLR; ref: S5P-L2-DLR-ATBD-TCWV; issue: 1.2; date: 2021-12-15.

[RD19] S5P-PAL: Sentinel 5P Product Algorithm Laboratory – L2 Processor File Format Guidelines; source: S&T; ref: ST-ESA-S5P_PAL-L2FFG-001; issue: 1.2; date: 2021-02-24.

2.4 Electronic references

[URL01] http://uv-vis.aeronomie.be/software/QDOAS/

[URL02] http://uv-vis.aeronomie.be/software/QDOAS/QDOAS_manual.pdf

[URL03] https://atmospherictoolbox.org/

3 Terms, definitions and abbreviated terms

Terms, definitions and abbreviated terms that are used in the development program for the TROPOMI L0-1b data processor are described in [RD01]. Terms, definitions and abbreviated terms that are used in the development program for the TROPOMI L2 data processors are described in [RD02]. Terms, definitions and abbreviated terms that are specific for this document can be found below.

3.1 Terms and definitions

The most important symbols related to the data product described in this document – some of which are not in [RD02]– are the following:

AK	averaging kernel
ΔAMF	altitude-resolved box air mass factor
AMF	air-mass factor
SCD	slant column density
VCD	vertical column density

3.2 Acronyms and abbreviations

AAI	Absorbing Aerosol Index
AMF	Air Mass Factor
BRDF	Bidirectional reflectance distribution function
CRB	Clouds as Reflecting Boundaries
CTM	Chemistry Transport Model
DOAS	Differential Optical Absorption Spectroscopy
ECMWF	European Centre for Medium-Range Weather Forecasts
ENVISAT	Environmental Satellite
ERS	European Remote Sensing satellite
GOME-2	Global Ozone Monitoring Experiment–2
LOS	Line Of Sight
MAG	Mission Advisory Group
MetOp	Meteorological Operational Satellite
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NRT	near-real time (i.e. processing within 3 hours of measurement)
OCRA	Optical Cloud Recognition Algorithm

OE	Optimal Estimation
OMI	Ozone Monitoring Instrument
PDGS	Sentinel-5Precursor Payload Data Ground Segment (at DLR)
RAA	Relative Azimuth Angle
ROCINN	Retrieval of Cloud Information using Neural Networks
SCIAMACHY	Scanning Imaging Absorption spectroMeter for Atmospheric Cartography
SZA	Solar Zenith Angle
TM 4/5	Data assimilation / chemistry transport model (version 4 or 5)
TROPOMI	Tropospheric Monitoring Instrument
VOC	Volatile Organic Compound
VZA	Viewing Zenith Angle

4 S5P/TROPOMI L2 TCWV Product description.

4.1 Data Product Examples

This section will refer to possible online data example as soon as they become available.

4.2 Product Geophysical Validation

Future validation activities and their results are to be described here.

4.3 History of Product Changes

Here a brief summary of data product changes is given. Details can be found in the ATBD [RD18].

Table 1: History of product changes of TCWV.

Processor Version	Description
01.00.00	First demonstration version
01.01.00	Version with data format specification changes and bug fixes
01.05.00	QDOAS polynomial integration

5 General structure of S5P/TROPOMI Level 2 files

The current TCWV L2 files are stored as netCDF-4 files and structured according to the guidelines provided in S5P-PAL L2 Processor File Format Guidelines [RD19]. This document outlines a somewhat simpler internal file organization than used for the current operationally produced S5P L2 products, but provides an equivalent structure.

Table 2 shows the group structure of the S5P L2 TCWV product.

Table 2: Group structure

Group name	Depth	Description
PRODUCT	0	Contains the main output variables and dimensions.
SUPPORT_DATA	1	Contains only sub groups.
DETAILED_RESULTS	2	Sub group of SUPPORT_DATA. Contains additional outputs, such as slant columns of all fitted species.
GEOLOCATIONS	2	Sub group of SUPPORT_DATA. Lists all parameters related to observation geometry and geo-location.
INPUT_DATA	2	Sub group of SUPPORT_DATA. Contains all parameters that the TCWV algorithm needs as input.

6 Generic Metadata and Attributes

As for the general L2 file structure, a general description of adopted metadata and attribute conventions is shared between de different products.

Table 3 lists the global attributes within the S5P L2 TCWV product.

Table 3: Global attributes

Name	Value	Description
Conventions	“CF-1.7”	CF (Climate and Forecast) conventions used for this product.
Institution	“DLR”	Institution responsible for the processing.
source	“Sentinel 5 precursor, TROPOMI, space-borne remote sensing, L2”	Fixed value.
history	“{YYYY-MM-DDThh:mm:ssZ} {executable} {arguments}”	Time of file creation in format “YYYY-MM-DDThh:mm:ssZ” and processor execution.
summary	“TROPOMI/S5P Total Column Water Vapor L2 data Swath 5.5x3.5km”	Fixed for this product.
id	S5P_OFFL_L2__TCWV__{YYYYMMDDThhmmss}_{YYYYMMDDThhmmss}_{ooooo}_{cc}_{pppppp}_{YYYYMMDDThhmmss}	File id containing measurement start, stop, and file creation date/time. See also [RD19].
time_reference	“{YYYY-MM-DDThh:mm:ssZ}”	Start of the day of sensing time.
collection_identifier	“{xx}”	Two character collection number. Same as is included in the filename. Example: “01”
time_coverage_start	“{YYYY-MM-DDThh:mm:ss.fffZ}”	Start time of first measurement, to millisecond precision.
time_coverage_end	“{YYYY-MM-DDThh:mm:ss.fffZ}”	Start time of last measurement, to millisecond precision.
Time_coverage_resolution	“PT{duration}S”	Duration of scanline in seconds
orbit	nnnnn	Orbit number
processor name	“TCWV”	Name of the processor
processor_version	“{xx.yy.zz}”	Processor version

processing_center	“{Processing_Station}”	Name of institution where the processing has taken place.
file_class	“OFFL”	Indicates offline product
footprint	“{GeoJson string}”	Footprint of orbit as GeoJson string
input_files	[“aa.ea”, ”bb.eb”, …]	String containing a list of all input files to the processor

7 Common elements in all S5P products

This section describes the elements that are common to all S5P/TROPOMI products.

Table 4 contains all variables in the group GEOLOCATIONS.

Table 4: Variables in the group GEOLOCATIONS

Variable Type Attribute name	Dimensions Attribute type	Units Attribute value	Description
geolocation_flags			
NC_UBYTE	(time, scanline, ground_pixel)	1	Ground pixel quality flag
coordinates flag_masks flag_meanings flag_values long_name max_val min_val units	NC_CHAR NC_UBYTE NC_CHAR NC_UBYTE NC_CHAR NC_UBYTE NC_UBYTE NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude” 0, 1, 2, 4, 8, 16, 128 no_error solar_eclipse sun_glint_possible descending night geo_boundary_crossing geolocation_error 0, 1, 2, 4, 8, 16, 128 “ground pixel quality flag” 128 0 “1”	
latitude_bounds			
NC_FLOAT	(time, scanline, ground_pixel, 4)	degree	Ground pixel corner coordinate latitudes
units	NC_CHAR	“degree_north”	
longitude_bounds			
NC_DOUBLE	(time, scanline, ground_pixel, 4)	degree	Ground pixel corner coordinate longitudes
units	NC_CHAR	“degree_east”	
satellite_altitude			
NC_FLOAT	(time, scanline)	degree	Satellite altitude
comment long_name units	NC_CHAR NC_CHAR NC_CHAR	“The altitude of the satellite with respect to the geodetic sub satellite point on the WGS84 reference ellipsoid” “satellite altitude”	

val_max	NC_FLOAT	“m”	
val_min	NC_FLOAT	90000.	
		70000.	
satellite_latitude			
NC_FLOAT	(time, scanline)	degree	Satellite latitude
comment	NC_CHAR	“Latitude of the geodetic sub satellite point on the WGS84 reference ellipsoid”	
long_name	NC_CHAR	“Sub satellite latitude”	
units	NC_CHAR	“degree north”	
val_max	NC_FLOAT	90.	
val_min	NC_FLOAT	-90.	
satellite_longitude			
NC_FLOAT	(time, scanline)	degree	Satellite longitude
comment	NC_CHAR	“Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid”	
long_name	NC_CHAR	“Sub satellite longitude”	
units	NC_CHAR	“degree east”	
val_max	NC_FLOAT	90.	
val_min	NC_FLOAT	-90.	
satellite_orbit_phase			
NC_FLOAT	(time, scanline)	1	Satellite fractional orbit phase
comment	NC_CHAR	“Relative offset [0.0, ..., 1.0] of the measurement in the orbit”	
long_name	NC_CHAR	“fractional satellite orbit phase”	
units	NC_CHAR	“1”	
val_max	NC_FLOAT	1.02	
val_min	NC_FLOAT	-1.02	
solar_azimuth_angle			
NC_DOUBLE	(time, scanline, ground_pixel)	degree	Solar azimuth angle
comments	NC_CHAR	“Solar azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = -180) “	
coordinates	NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude”	
long_name	NC_CHAR	“solar azimuth angle”	
standard_name	NC_CHAR	“solar_azimuth_angle”	
units	NC_CHAR	“degree”	

val_max val_min	NC_FLOAT NC_FLOAT	180. -180.	
solar_zenith_angle			
NC_DOUBLE	(time, scanline, ground_pixel)	degree	Solar zenith angle
comments coordinates long_name standard_name units val_max val_min	NC_CHAR NC_CHAR NC_CHAR NC_CHAR NC_CHAR NC_FLOAT NC_FLOAT	“Solar zenith angle at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical“ “/PRODUCT/longitude /PRODUCT/latitude” “solar zenith angle” “solar_zenith_angle” “degree” 180. 0.	
viewing_azimuth_angle			
NC_DOUBLE	(Time, scanline, ground_pixel)	degree	Viewing azimuth angle
comments coordinates long_name standard_name units val_max val_min	NC_CHAR NC_CHAR NC_CHAR NC_CHAR NC_CHAR NC_FLOAT NC_FLOAT	“Satellite azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = -180)” “/PRODUCT/longitude /PRODUCT/latitude” “viewing azimuth angle” “viewing_azimuth_angle” “degree” 180. -180.	
viewing_zenith_angle			
NC_DOUBLE	(Time, scanline, ground_pixel)	degree	Viewing zenith angle
comments coordinates long_name standard_name units val_max val_min	NC_CHAR NC_CHAR NC_CHAR NC_CHAR NC_CHAR NC_FLOAT NC_FLOAT	“Zenith angle of the satellite at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical” “/PRODUCT/longitude /PRODUCT/latitude” “viewing zenith angle” “viewing_zenith_angle” “degree” 180. 0.	

8 Description of the Total Column Water Vapour product

In this first version, this chapter lists the variables generated in the TCWV L2 files that are currently in the netCDF4 format. Name of variables follow the HARP 1.1 name convention.

In Table 5 and Table 6, respectively, the variables of the PRODUCT group in the S5P TCWV product are listed.

Table 7 covers the variables in the DETAILED_RESULTS group whereas Table 8 contains the variables in the group INPUT_DATA that are obtained directly from the input products.

Table 5: Variables in group/PRODUCT

Variable **Type** **Attribute name**	**Dimensions** **Attribute type**	**Units** **Attribute value**	**Description**
total_column_water_vapor			
NC_FLOAT	(time, scanline, ground_pixel)	kg m-2	Total vertical column of water vapor
coordinates long_name standard_name units	NC_CHAR NC_CHAR NC_CHAR NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude" "Total vertical column of water vapor" "total_mass_content_of_water_vapor" "kg m-2"	
total_column_water_vapor_precision			
NC_FLOAT	(time, scanline, ground_pixel)	kg m-2	Total vertical column of water vapor uncertainty
coordinates long_name standard_name units	NC_CHAR NC_CHAR NC_CHAR NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude" "Precision of the total vertical column of water vapor" "total_mass_content_of_water_vapor_standard_error" "kg m-2"	
delta_time			
NC_INT	(time, scanline)	milliseconds	Offset from reference start time of measurement
long_name units	NC_CHAR NC_CHAR	"offset of start time of measurement relative to time reference" "milliseconds since {YYYY-MM-DD 00:00:00}"	

latitude			
NC_FLOAT	(time, scanline, ground_pixel)	degree	Center latitude of ground pixel
bounds long_name standard_name units valid_min valid_max	NC_FLOAT NC_CHAR NC_CHAR NC_CHAR NC_FLOAT NC_FLOAT	"/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/ latitude_bounds" "pixel center latitude" "latitude" "degrees_north" -90. 90.	
longitude			
NC_FLOAT	(time, scanline, ground_pixel)	degree	Center longitude of ground pixel
Bounds long_name standard_name units valid_min valid_max	NC_FLOAT NC_CHAR NC_CHAR NC_CHAR NC_FLOAT NC_FLOAT	"/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/ longitude_bounds" "pixel center longitude" "longitude" "degrees_east" -180. 180.	
qa_value			
NC_UBYTE	(time, scanline, ground_pixel)		Quality
add_offset comment coordinates long_name scale_factor valid_max valid_min	NC_float NC_CHAR NC_CHAR NC_CHAR NC_FLOAT NC_UBYTE NC_UBYTE	0. "A continuous quality descriptor, varying between 0 (no data) and 1 (full quality data). Recommend to ignore data with qa_value < 0.75" "/PRODUCT/longitude /PRODUCT/latitude" "data quality value" 0.01 100 0	

Table 6: Dimension variables in group/PRODUCT

Name Type Attribute name	Size Attribute type	Units Attribute value	Description
corner			

NC_FLOAT	(4)	1	Pixel corner dimension
comment	NC_CHAR	“This coordinate variable defines the indices for the pixel corners; index starts a 0 (counter-clockwise, starting from south-western corner of the pixel in ascending part of the orbit).”	
long_name	NC_CHAR	“pixel corner index”	
units	NC_CHAR	”1”	
ground_pixel			
NC_INT	(450)		Across-track pixel index dimension
axis	NC_CHAR	“X”	
comment	NC_CHAR	“This coordinate variable defines the indices across track, from west to east; index starts at 0”	
long_name	NC_CHAR	“across-track dimension index”	
units	NC_CHAR	“1”	
layer			
NC_INT	(60)		Vertical layer index dimension
axis	NC_CHAR	“Z”	
long_name	NC_CHAR	“across-track dimension index”	
units	NC_CHAR	“1”	
scanline			
NC_INT	({# scan lines})	seconds since 2010-01-01 00:00:00	Along-track pixel index dimension
axis	NC_CHAR	“Y”	
comment	NC_CHAR	“This coordinate variable defines the indices along track; index starts at 0”	
long_name	NC_CHAR	“along-track dimension index”	
units	NC_CHAR	“1”	
time			
NC_INT	(1)		Reference time dimension
axis	NC_CHAR	“T”	
comment	NC_CHAR	“The time in this variable corresponds to the time in the time_reference global attribute”	
long_name	NC_CHAR	“reference time for the measurements”	
standard_name	NC_CHAR	“time”	

units	NC_CHAR	“1”	
polynomial_coefficients			
NC_INT	(5)	(1)	Qdoas polynomial coefficients
comment long_name units	NC_CHAR NC_CHAR NC_CHAR	“QDOAS polynomials coefficients from x0 to x4” “1”	

Table 7: Variables in the group DETAILED_RESULTS

Name **Type** **Attribute name**	**Size** **Attribute type**	**Units** **Attribute value**	**Description**
air_mass_factor_total			
NC_FLOAT	(time, scanline, ground_pixel)		
coordinates long_name units	NC_CHAR NC_CHAR NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude” “Total air mass factor” “1”	
air_mass_factor_clear			
NC_FLOAT	(time, scanline, ground_pixel)		
coordinates long_name units	NC_CHAR NC_CHAR NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude” “Air mass factor for the cloud-free part of the scene” “1”	
air_mass_factor_cloudy			
NC_FLOAT	(time, scanline, ground_pixel)		
coordinates long_name units	NC_CHAR NC_CHAR NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude” “Air mass factor for the cloud-covered part of the scene” “1”	
water_vapor_slant_column			

NC_FLOAT	(time, scanline, ground_pixel)	kg m-2	The slant column of water vapor
coordinates	NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude"	
long_name	NC_CHAR	"total_mass_content_of_water_vapor_slant_column"	
units	NC_CHAR	"kg m-2"	
water_vapor_slant_column_precision			
NC_FLOAT	(time, scanline, ground_pixel)	kg m-2	The slant column of water vapor uncertainty
coordinates	NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude"	
long_name	NC_CHAR	"Precision of the slant column of water vapor"	
units	NC_CHAR	"kg m-2"	
cloud_radiance_fraction			
NC_FLOAT	(time, scanline, ground_pixel)		Effective cloud fraction at the retrieval wavelength band
coordinates	NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude"	
long_name	NC_CHAR	"Cloud radiance fraction"	
units	NC_CHAR	"1"	
qdoas_polynomial_coefficients			
NC_FLOAT	(time, scanline, ground_pixel, polynomial_coefficients)		DOAS polynomial coefficients from x0 to x4
coordinates	NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude"	
long_name	NC_CHAR	"DOAS polynomial coefficients"	
units	NC_CHAR	"1"	
water_vapor_profile_apriori			
NC_FLOAT	(time, scanline, ground_pixel, layer)	kg kg-1	A priori vertical profile of water vapor
coordinates	NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude"	
long_name	NC_CHAR	"a-priori mass mixing ratio profile of water vapor"	
units	NC_CHAR	"kg kg-1"	
averaging_kernel			
NC_FLOAT	(time, scanline, ground_pixel, layer)	1	Averaging kernel
coordinates	NC_CHAR	"/PRODUCT/longitude /PRODUCT/latitude"	
long_name	NC_CHAR	"total column averaging kernel"	

units	NC_CHAR	“1”	
ground_pixel			
NC_FLOAT	(ground_pixel)	1	Across track pixel index
comment long_name units	NC_CHAR NC_CHAR NC_CHAR	“This coordinate variable defines the indices across track, from west to east; index starts at 0” “across-track dimension index”” “1”	
root_mean_square_error_of_fit			
NC_FLOAT	(time, scanline, ground_pixel)	1	
coordinates long_name units	NC_CHAR NC_CHAR NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude” “Root mean square residual of the fit” “1”	

Table 8: Variables in the group INPUT_DATA

Variable **Type** **Attribute name**	**Dimensions** **Attribute type**	**Units** **Attribute value**	**Description**
cloud_albedo			
NC_FLOAT	(time, scanline, ground_pixel)		Cloud albedo from TROPOMI operational cloud product
comments coordinates long_name units	NC_CHAR NC_CHAR NC_CHAR NC_CHAR	“Albedo of cloud using the OCRA/ROCINN CRB model” “/PRODUCT/longitude /PRODUCT/latitude” “cloud albedo from the CRB model” “1”	
cloud_fraction			
NC_FLOAT	(time, scanline, ground_pixel)		Radiometric cloud fraction from from TROPOMI operational cloud product
Comments coordinates long_name	NC_CHAR NC_CHAR NC_CHAR	“Retrieved effective radiometric cloud fraction using the OCRA/ROCINN CRB model” “/PRODUCT/longitude /PRODUCT/latitude” “effective radiometric cloud fraction from the CRB model”	

units	NC_CHAR	“1”	
cloud_pressure"			
NC_FLOAT	(time, scanline, ground_pixel)		Cloud top pressure from from TROPOMI operational cloud product
Comments coordinates long_name units	NC_CHAR NC_CHAR NC_CHAR NC_CHAR	“Retrieved atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model” “/PRODUCT/longitude /PRODUCT/latitude” “cloud radiometric optical centroid pressure from the CRB model” “Pa”	
pressure_constant_a_bottom			
NC_FLOAT	(layer)		pressure constant parameter for the calculation of the lower edge of each layer
long_name units	NC_CHAR NC_CHAR	“pressure constant parameter A for lower bound of the layer” “Pa”	
pressure_constant_a_top			
NC_FLOAT	(layer)		pressure constant parameter for the calculation of the upper edge of each layer
long_name units	NC_CHAR NC_CHAR	“pressure constant parameter A for upper bound of the layer” “Pa”	
pressure_constant_b_bottom			
NC_FLOAT	(layer)		pressure constant parameter for the calculation of the lower edge of each layer
long_name units	NC_CHAR NC_CHAR	“pressure constant parameter B for lower bound of the layer” “1”	
pressure_constant_b_top			
NC_FLOAT	(layer)		pressure constant parameter for the calculation of the upper edge of each layer
long_name	NC_CHAR	“pressure constant parameter B for upper bound of	

units	NC_CHAR	the layer” “1”	
snow_ice_flag			
NC_FLOAT	(time, scanline, ground_pixel)		Flag indicating surface covered with snow or ice
Comments	NC_CHAR	“flag indicating snow/ice at center of ground pixel”	
coordinates	NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude”	
long_name	NC_CHAR	“snow-ice mask”	
units	NC_CHAR	“1”	
surface_pressure			
NC_FLOAT	(layer)		Air pressure at surface level
coordinates	NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude”	
long_name	NC_CHAR	“surface pressure”	
standard_name	NC_CHAR	“surface_air_pressure”	
units	NC_CHAR	“Pa”	
surface_albedo			
NC_FLOAT	(layer)		Surface albedo
coordinates	NC_CHAR	“/PRODUCT/longitude /PRODUCT/latitude”	
long_name	NC_CHAR	“surface albedo”	
standard_name	NC_CHAR	“surface albedo”	
units	NC_CHAR	“1”	