Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Cloud Properties

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1 Introduction

1.1 Identification

This document, identified as S5P-L2-DLR-PUM-400I, describes the technical characteristics of the S5p/TROPOMI Level 2 products that are needed for efficient and correct use of the data contained. This product user manual is specific for Cloud.

1.2 Purpose and objective

The Sentinel-5 Precursor (S5p) mission is a low Earth orbit polar satellite system to provide information and services on air quality, climate and the ozone layer. The S5p mission is part of the Global Monitoring of the Environment and Security (GMES/COPERNICUS) space component programme. The S5p mission consists of a satellite bus, the payload consisting of the TROPOspheric Monitoring Instrument (TROPOMI), and a ground system. A journal paper describing the mission and its objectives can be found in [RD1], while a comprehensive description of the mission can be found in [RD2]. Furthermore, various websites are maintained with S5p/TROPOMI information, e.g. [ER1, ER2].

From the data collected by the TROPOMI instrument, a number of geophysical (L2) products are derived. The algorithms for the 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 S5p/TROPOMI Level 2 geophysical data products that are needed for efficient and correct use of the data contained.

In the PUM, the common structure of the datafiles and metadata used in all the delivered L2 products as well as a specific section related to the Cloud product are described.

1.3 Document overview

We start with a summary of the S5p L2 products and information needed to obtain and inspect data, as well as how to obtain product support. The Cloud data product is described next, with examples, and information about the use of the data. Format, L2 structure and metadata are addressed in the next chapter, followed by the detailed description of the Cloud data. We then continue with a discussion of units and quality assurance parameters. The final chapter contains information about generic metadata and the Appendix lists measurement flags, processing quality flags, and surface classifications.

2 Applicable and reference documents

2.1 Applicable documents

[AD1] Tailoring of the Earth Observation File Format Standard for the Sentinel 5 precursor Ground Segment. **source:** ESA/ESTEC; **ref:** S5P-TN-ESA-GS-106; **issue:** 2.2; **date:** 2015-02-20.

2.2 Standard documents

There are no standard documents

2.3 Reference documents

[RD1] J. P. Veefkind, I. Aben, K. McMullan *et al.*; TROPOMI on the ESA Sentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications. *Remote Sens. Environ.*; **120** (2012), 70; 10.1016/j.rse.2011.09.027.

[RD2] Input/output data specification for the TROPOMI L01b data processor. **source:** KNMI; **ref:** S5P-KNMI-L01B-0012-SD; **issue:** 5.0.0; **date:** 2015-09-22.

[RD3] S5P/TROPOMI ATBD Cloud Products. **source:** DLR; **ref:** S5P-DLR-L2-ATBD-400I; **issue:** 2.1.0; **date:** 2020-02-28.

[RD4] S5P-NPP Cloud Processor ATBD. **source:** RAL Space; **ref:** S5P-NPPC-RAL-ATBD-0001; **issue:** 0.11.0; **date:** 2014-05-15.

[RD5] S5P/TROPOMI HCHO ATBD. **source:** BIRA; **ref:** S5P-BIRA-L2-400F-ATBD; **issue:** 2.1.0; **date:** 2020-02-28.

[RD6] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual HCHO. **source:** DLR; **ref:** S5P-L2-DLR-PUM-400F; **issue:** 2.1.0; **date:** 2020-02-28.

[RD7] S5P/TROPOMI SO_2 ATBD. **source:** BIRA; **ref:** S5P-BIRA-L2-400E-ATBD; **issue:** 2.1.0; **date:** 2020-02-28.

[RD8] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual SO_2. **source:** DLR; **ref:** S5P-L2-DLR-PUM-400E; **issue:** 2.1.0; **date:** 2020-02-28.

[RD9] S5P/TROPOMI Total ozone ATBD. **source:** DLR/BIRA; **ref:** S5P-L2-DLR-ATBD-400A; **issue:** 2.1.0; **date:** 2020-02-28.

[RD10] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Total Ozone Column. **source:** DLR; **ref:** S5P-L2-DLR-PUM-400A; **issue:** 2.1.0; **date:** 2020-02-28.

[RD11] TROPOMI ATBD of tropospheric ozone data products. **source:** DLR/IUP; **ref:** S5P-DLR-IUP-L2-400C; **issue:** 2.1.0; **date:** 2020-02-28.

[RD12] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Ozone Tropospheric Column. **source:** DLR; **ref:** S5P-L2-DLR-PUM-400C; **issue:** 2.1.0; **date:** 2020-02-28.

[RD13] TROPOMI ATBD of the Aerosol Layer Height product. **source:** KNMI; **ref:** S5P-KNMI-L2-0006-RP; **issue:** 1.0.1; **date:** 2019-06-24.

[RD14] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Aerosol Layer Height. **source:** KNMI; **ref:** S5P-KNMI-L2-0022-MA; **issue:** 0.0.2dr; **date:** 2014-10-16.

[RD15] TROPOMI ATBD of the UV aerosol index. **source:** KNMI; **ref:** S5P-KNMI-L2-0008-RP; **issue:** 1.0.0; **date:** 2016-02-03.

[RD16] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Aerosol Index. **source:** KNMI; **ref:** S5P-KNMI-L2-0026-MA; **issue:** 0.0.2dr; **date:** 2014-10-16.

[RD17] TROPOMI ATBD Ozone profile and tropospheric profile.
source: KNMI; **ref:** S5P-KNMI-L2-0004-RP; **issue:** 0.13.0; **date:** 2015-09-15.

[RD18] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Ozone Profile and Tropospheric Ozone Profile.
source: KNMI; **ref:** S5P-KNMI-L2-0020-MA; **issue:** 0.0.2dr; **date:** 2014-10-16.

[RD19] TROPOMI ATBD of the total and tropospheric NO_2 data products.
source: KNMI; **ref:** S5P-KNMI-L2-0005-RP; **issue:** 1.0.0; **date:** 2016-02-05.

[RD20] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Nitrogen Dioxide.
source: KNMI; **ref:** S5P-KNMI-L2-0021-MA; **issue:** 0.0.2dr; **date:** 2014-10-16.

[RD21] Algorithm Theoretical Baseline Document for Sentinel-5 Precursor: Carbon Monoxide Total Column Retrieval.
source: SRON; **ref:** SRON-S5P-LEV2-RP-002; **issue:** 1.0.0; **date:** 2016-02-05.

[RD22] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Carbon Monoxide Column.
source: SRON/KNMI; **ref:** SRON-S5P-LEV2-MA-002; **issue:** 0.0.2dr; **date:** 2014-10-16.

[RD23] Algorithm Theoretical Baseline Document for Sentinel-5 Precursor methane retrieval.
source: SRON; **ref:** SRON-S5P-LEV2-RP-001; **issue:** 1.0.0; **date:** 2016-02-05.

[RD24] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Methane.
source: SRON/KNMI; **ref:** SRON-S5P-LEV2-MA-001; **issue:** 0.0.2dr; **date:** 2014-10-16.

[RD25] Tailoring of the Earth Observation File Format Standard for the Sentinel 5 precursor Ground Segment.
source: ESA/ESTEC; **ref:** S5P-TN-ESA-GS-106; **issue:** 2.2; **date:** 2015-02-20.

[RD26] Earth Observation – Ground segment file format standard.
source: ESA/ESTEC; **ref:** PE-TN-ESA-GS-0001; **issue:** 2.0; **date:** 2012-05-03.

[RD27] Geographic information – Metadata.
source: ISO; **ref:** ISO 19115:2003(E); **issue:** 1; **date:** 2003-05-01.

[RD28] Geographic information – Metadata – Part 2: Extensions for imagery and gridded data.
source: ISO; **ref:** ISO 19115-2:2009(E); **issue:** 1; **date:** 2009-02-12.

[RD29] Geographic information – Data quality.
source: ISO; **ref:** ISO 19157; **issue:** 1; **date:** 2013-10-10.

[RD30] Earth Observation Metadata profile of Observations & Measurements.
source: Open Geospatial Consortium; **ref:** OGC 10-157r3; **issue:** 1.0; **date:** 2012-06-12.

[RD31] Data Standards Requirements for CCI Data Producers.
source: ESA; **ref:** CCI-PRGM-EOPS-TN-13-0009; **issue:** 1.1; **date:** 2013-05-24.

[RD32] Metadata specification for the TROPOMI L1b products.
source: KNMI; **ref:** S5P-KNMI-L01B-0014-SD; **issue:** 2.0.0; **date:** 2014-12-09.

[RD33] Sentinel-4 UVN Phase B2, C/D and support to phase E1 – Level 0 to Level 1b data processing software Input/Output Data Specification (IODS): Level 1b output products and metadata contents and format.
source: ESA/ESTEC; **ref:** S4.ESA.UVN.TN.1206; **issue:** 1.0; **date:** 2011-06-23.

[RD34] Algorithm theoretical basis document for the TROPOMI L01b data processor.
source: KNMI; **ref:** S5P-KNMI-L01B-0009-SD; **issue:** 6.0.0; **date:** 2015-09-22.

[RD35] Data elements and interchange formats – Information interchange – Representation of dates and times.
source: ISO; **ref:** ISO 8601:2004(E); **issue:** 3; **date:** 2004-12-01.

[RD36] John Caron; Annotated Schema for NcML (2011). URL `http://www.unidata.ucar.edu/software/netcdf/ncml/v2.2/AnnotatedSchema4.html`.

[RD37] INSPIRE Metadata Regulation, Commission Regulation (EC), No1205/2008.
source: EC; **ref:** Commission Regulation (EC) No 1205/2008; **date:** 2008-12-03.

[RD38] INSPIRE Metadata Implementing Rules: Technical Guidelines based on EN ISO 19115 and EN ISO 19119.
source: EC JRC; **ref:** MD_IR_and_ISO_v1_2_20100616; **issue:** 1.2; **date:** 2010-06-16.

[RD39] Geographic Information – Observations and Measurements.
source: ISO; **ref:** ISO 19156:2011(E); **date:** 2011-12-20.

[RD40] Geographic information – Metadata – XML schema implementation.
source: ISO; **ref:** ISO 19139:2007(E); **issue:** 1; **date:** 2010-12-13.

[RD41] Observations and Measurements - XML Implementation.
source: OGC; **ref:** OGC 10-025r1; **issue:** 2.0; **date:** 2011-03-22.

[RD42] Observations and Measurements – XML Implementation..
source: Open Geospatial Consortium; **ref:** OGC 10-025r1; **issue:** 2.0; **date:** 2011-03-22.

[RD43] Sentinel-5 Precursor Level 2 UPAS Processor Input/Output Definition Document.
source: DLR-IMF; **ref:** S5P-L2-DLR-IODD-3002; **issue:** 3.6.0; **date:** 2020-02-28.

[RD44] S5P-NPP Cloud Processor IODD.
source: RAL; **ref:** S5P-NPPC-RAL-IODD-0001; **issue:** 0.10.0; **date:** 2014-05-28.

[RD45] M.L. Carroll, J.R. Townshend, C.M. DiMiceli *et al.*; A new global raster water mask at 250 m resolution. *International Journal of Digital Earth*; **2** (2009) (4), 291; 10.1080/17538940902951401.

2.4 Electronic references

[ER1] Tropomi official website. URL `http://www.tropomi.eu`.

[ER2] S5P official website. URL `https://sentinel.esa.int/web/sentinel/missions/sentinel-5p`.

[ER3] Robert B. Schmunk; Panoply netCDF, HDF and GRIB Data Viewer. URL `http://www.giss.nasa.gov/tools/panoply/`.

[ER4] Infrastructure for Spatial Information in the European Community (INSPIRE) Directive 2007/2/EC. URL `http://inspire.jrc.ec.europa.eu/`.

[ER5] Brian Eaton, Jonathan Gregory, Bob Drach *et al.*; *NetCDF Climate and Forecast (CF) Metadata Conventions*. Lawrence Livermore National Laboratory (2014). Version 1.7 draft; URL `http://cfconventions.org`.

[ER6] ESIP; *Attribute Conventions for Dataset Discovery (ACDD)*. 1st edition (2013). URL `http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery_(ACDD)`.

[ER7] NetCDF Users Guide (2011). URL `http://www.unidata.ucar.edu/software/netcdf/docs/netcdf.html`.

[ER8] Unidata; *NetCDF library and documentation*. URL `http://www.unidata.ucar.edu/software/netcdf/`.

[ER9] UDUNITS 2 Manual (2011). URL `http://www.unidata.ucar.edu/software/udunits/`.

[ER10] Cooperative Ocean/Atmosphere Research Data Service; Conventions for the standardization of NetCDF files (1995). URL `http://ferret.wrc.noaa.gov/noaa_coop/coop_cdf_profile.html`.

[ER11] USGS; Global Land Cover Characteristics Data Base Version 2.0 (2012). Website last visited on March 6, 2017; URL `https://lta.cr.usgs.gov/glcc/globdoc2_0`.

[ER12] The ECS SDP Toolkit (2012). DEM and land-sea mask data itself is available from `ftp://edhs1.gsfc.nasa.gov/edhs/sdptk/DEMdata`; URL `http://newsroom.gsfc.nasa.gov/sdptoolkit/TKDownload.html`.

3 Terms, definitions and abbreviated terms

Terms, definitions, and abbreviated terms that are specific for this document can be found below.

3.1 Terms and definitions

ATBD	Algorithm Theoretical Basis Document
TBA	To be Added
TBC	To be Confirmed
TBD	To be Defined

3.2 Acronyms and Abbreviations

ATBD	Algorithm Theoretical Basis Document
DLR	Deutsches Zentrum für Luft- und Raumfahrt
ESA	European Space Agency
KNMI	Koninklijk Nederlands Meteorologisch Instituut
IODD	Input Output Data Definition
OCRA	Optical Cloud Recognition Algorithm
PUM	Product User Manual
ROCINN	Retrieval of Cloud Information using Neural Networks
QA	Quality Assurance
UPAS	Universal Processor for UV/VIS Atmospheric Spectrometers

4 Overview of the Sentinel 5 precursor/TROPOMI Level 2 Products

The Sentinel 5 Precursor mission aims at providing information and services on air quality and climate in the timeframe 2017–2023. The S5p mission is part of the Global Monitoring of the European Programme for the establishment of a European capacity for Earth Observation (COPERNICUS). TROPOMI will make daily global observations of key atmospheric constituents, including ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, methane, formaldehyde as well as cloud and aerosol properties. The list of standard S5p/TROPOMI L2 products is given in table 1. Other products, such as UV index, are under development and will made available at a later date.

Table 1: Standard S5P L2 products with name, identifier, and responsible institutes.

Product	**ATBD**	**PUM**	**Identifier**	**Institution**
Cloud	[RD3]	This document	`L2__CLOUD_`	DLR
NPP-VIIRS Clouds	[RD4]	[RD4]	`L2__NP_BDx`	RAL
HCHO	[RD5]	[RD6]	`L2__HCHO__`	BIRA/DLR
SO_2	[RD7]	[RD8]	`L2__SO2___`	BIRA/DLR
O_3 Total Column	[RD9]	[RD10]	`L2__O3____`	BIRA/DLR
O_3 Tropospheric Column	[RD11]	[RD12]	`L2__O3_TCL`	IUP/DLR
Aerosol layer height	[RD13]	[RD14]	`L2__AER_LH`	KNMI
Ultra violet aerosol index	[RD15]	[RD16]	`L2__AER_AI`	KNMI
O_3 Full Profile	[RD17]	[RD18]	`L2__O3__PR`	KNMI
O_3 Troposheric Profile	[RD17]	[RD18]	`L2__O3_TPR`	KNMI
NO_2	[RD19]	[RD20]	`L2__NO2___`	KNMI
CO	[RD21]	[RD22]	`L2__CO____`	SRON/KNMI
CH_4	[RD23]	[RD24]	`L2__CH4___`	SRON/KNMI

4.1 File name convention

The table specifies an identifier that is a substring of real name. The complete filename conventions for all the S5p products can be found in [RD25, chapter 4]. Note that intermediate L2 products beside those listed in table 1 may exist within the PDGS framework. For each of the products listed in the table, a PUM is available. Note that product documentation, e.g. ATBDs and PUMs, will be updated with new releases of processors. User documentation is distributed through the tropomi website [ER1]. Information about S5p mission can be found at the official ESA website for the Sentinel 5 precursor mission [ER2].

In the current PUM the Cloud product is described and an example of the full real name is as following:
`S5P_NRTI_L2__CLOUD__20140101T000000_20140102T000000_00099_01_000200_20141010T173511.nc`
The components of this file name are given in table 2

Table 2: Components of an S5P product file name. Components are separated by underscores, except for the file extension at the end, which is separated by a period. Character indices start counting at 0, the end-index is a Python style index, it lists the first character not in the block.

Start	End	Length	Meaning
0	3	3	Mission name, always "`S5P`"
4	8	4	Processing stream, one of "`NRTI`" (near real-time), "`OFFL`" (offline) or "`RPRO`" (reprocessing)
9	19	10	Product identifier, as listed in table 1
20	35	15	Start of granule in UTC as "`YYYYMMDD`**`T`**`HHMMSS`". The "`T`" is a fixed character.
36	51	15	End of the granulein UTC as "`YYYYMMDD`**`T`**`HHMMSS`". The "`T`" is a fixed character.
52	57	5	Orbit number
58	60	2	Collection number
61	67	6	Processor version number as "`MMmmpp`", with "`MM`" the major version number, "`mm`" the minor version number, and "`pp`" the patch level.
68	83	15	The time of processing for this granule in UTC as "`YYYYMMDD`**`T`**`HHMMSS`". The "`T`" is a fixed character.
84	86	2	The file name extension. All Sentinel 5 precursor files are netCDF-4 files and use the extension "`nc`"

5 Data Distribution and Product Support

The S5P/TROPOMI data is available via the ESA Copernicus Open Access Hub (`https://scihub.copernicus.eu/`) in the 'Sentinel-5P Pre-Operations Hub' (`https://s5phub.copernicus.eu/dhus/home`)

6 General Reader and Visualisation Tools

For reading and visualising you may find Panoply [ER3] a useful tool. Panoply is a cross-platform application that plots geo-gridded and other arrays from netCDF, HDF, GRIB, and other datasets, including the Sentinel 5 precursor Level 2 datafiles. With Panoply 4 you can:

- Slice and plot geo-gridded latitude-longitude, latitude-vertical, longitude-vertical, or time-latitude arrays from larger multidimensional variables.
- Slice and plot "generic" 2D arrays from larger multidimensional variables.
- Slice 1D arrays from larger multidimensional variables and create line plots.
- Combine two geo-gridded arrays in one plot by differencing, summing or averaging.
- Plot lon-lat data on a global or regional map using any of over 100 map projections or make a zonal average line plot.
- Overlay continent outlines or masks on lon-lat map plots.
- Use any of numerous color tables for the scale colorbar, or apply your own custom ACT, CPT, or RGB color table.
- Save plots to disk GIF, JPEG, PNG or TIFF bitmap images or as PDF or PostScript graphics files.

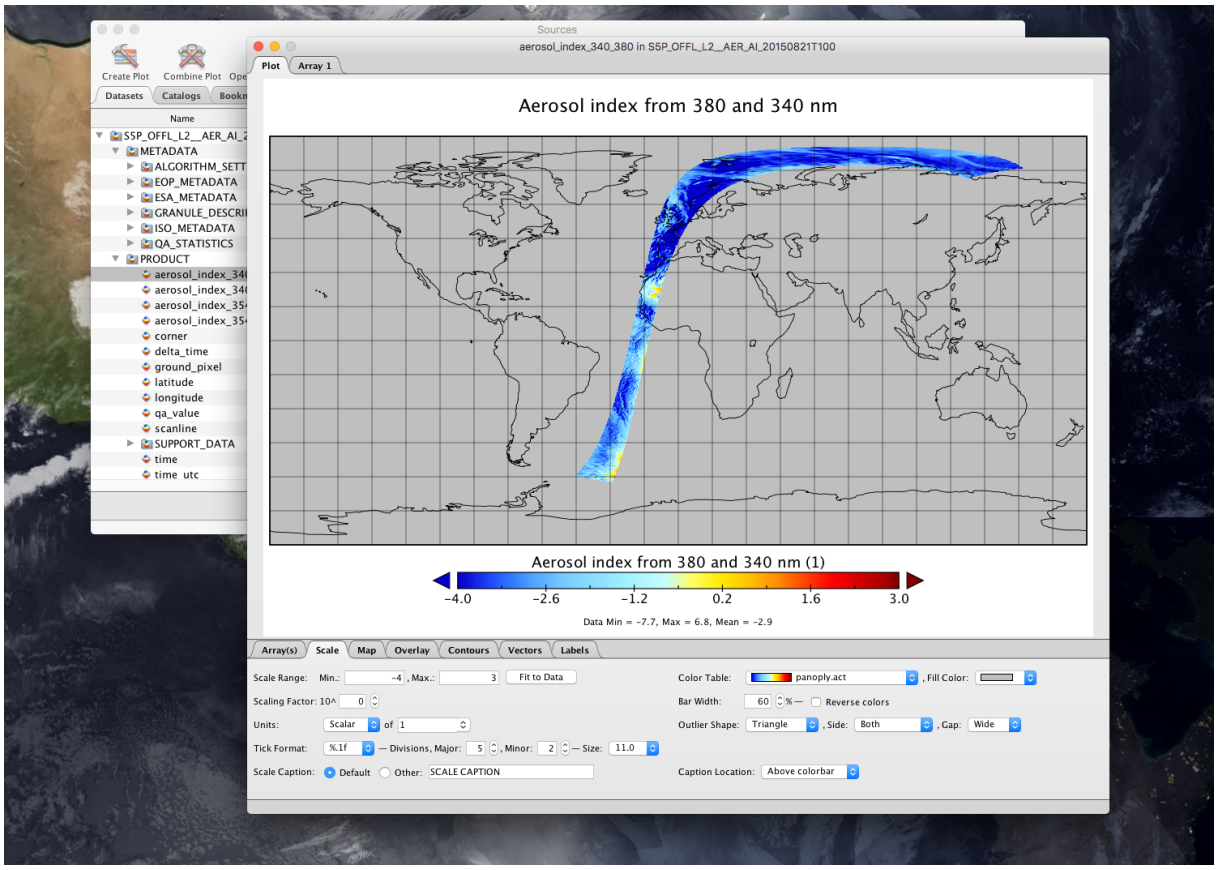

Figure 1: Panoply

- Export lon-lat map plots in KMZ format.
- Export animations as AVI or MOV video or as a collection of invididual frame images.

7 S5p/TROPOMI L2 Cloud Product Description

ROCINN algorithms have been employed as cloud retrieval algorithms based on measurements in and around the O_2 A-band at 760 nm for the GOME-family of sensors. These are all based on the Independent Pixel Approximation (IPA), which is the assumption that the "radiative properties of a single satellite “Pixel” are considered in isolation from neighbouring pixels" (definition of the American Meteorological Society). The IPA allows for the application of pseudo-spherical radiative transfer (RT) model in the forward simulation of cloud-contaminated atmospheric scenarios. The ROCINN algorithm is also based on O_2 A-band measurements, and is currently being used in the operational GOME and GOME-2 products. ROCINN 2.0 retrieves as primary quantities the cloud height and cloud albedo. The broad-band polarization measurements from GOME, SCIAMACHY and GOME-2 are used for computing cloud fraction, see for example OCRA which is also based on the IPA. In OCRA, optical sensor measurements are divided into two components: a cloud-free background and a contribution attributed to clouds. OCRA was first developed for GOME in the late 1990s, when enough data from the three sub-pixel broad-band PMDs (Polarization Measurement Devices) had accumulated to allow for the construction of the global cloud-free composite which is the key element in the algorithm. Over the course of the 16-year GOME record, the algorithm was refined and the cloud-free composite adjusted as more data became available. OCRA has also been applied to SCIAMACHY and GOME-2. Initial cloud-free composites for these sensors were based on GOME data before dedicated measurements became available from SCIAMACHY and GOME-2. For S5p, the initial cloud-free composite is based on GOME-2 and OMI (see [RD3], chapter 5.2).
ROCINN is based on the comparison of measured and simulated satellite sun-normalized radiances in and near the O_2 A-band, and it uses a neural network algorithm to retrieve cloud height and cloud albedo. ROCINN accepts the cloud fraction from OCRA as an input and retrieves the rest of the cloud parameters. Early versions of ROCINN used a transmittance model to compute simulated radiances, but the latest versions are based on the use of the VLIDORT radiative transfer scattering model. For GOME and GOME-2, ROCINN Version 2.0 is the current operational algorithm in the GDP [GOME Data Processor]. This version is based on the assumption that clouds are simple Lambertian reflecting surfaces, so that the two main retrieval products are the cloud height and the cloud albedo. This is the “Clouds-as-Reflecting-Boundaries” (CRB) model. Later, ROCINN has been updated to Version 3.0, in which the Tikhonov regularization technique was introduced for the solution of the inverse RT equation. For TROPOMI/S5p, we use ROCINN Version 4.0, which is based on a more realistic treatment of clouds as optically uniform layers of light-scattering particles (water droplets). This is the “Clouds-As-Layers" (CAL) model – here, the two main retrieval products are the cloud-top height and the cloud optical thickness. Although the CAL model will be the default for S5p, it has been requested that the CRB method should also be retained as an option. CAL is the preferred method for the relatively small TROPOMI/S5p ground pixels ($7.0 \times 3.5\,\mathrm{km}^2$, respectively $5.5 \times 3.5\,\mathrm{km}^2$ since 6th of August 2019). On the contrary, the CRB model might be considered more accurate for sensors with coarse spatial resolution footprints such as those from GOME (footprint size 320 x 40 km^2). Studies have shown that for the smaller GOME-2 pixels, CAL retrieval produces more reliable cloud information than CRB, not only with regard to the accuracy of the cloud parameters themselves, but also with regard to the effect of cloud parameter uncertainties on total O_3 accuracy [RD3]. In the current S5p/TROPOMI L2 Cloud both CAL and CRB models are included.

The latest OCRA 3.1 / ROCINN 4.1 includes changes in OCRA by the replacement of the OMI-based scan angle dependency correction and clear-sky reflectance composite maps with the TROPOMI data themselves (April 2018 - March 2019) and changes in ROCINN with an effective scene retrieval mode. This allows the replacement of a static surface albedo climatology with an dynamic on-line surface albedo retrieval. In addition, a more accurate treatment of the co-registration issue between bands 3/4 (UVVIS) and band 6 (NIR) has been implemented.
Refer to the specific ATBD [RD3] documentation for further information about the L2 Cloud.

7.1 Data Product Examples

Quicklooks are reported in this section as data product examples of the Cloud. Cloud fraction, cloud pressure and cloud optical thickness parameters are reported in Figures 2, 3 and 4, respectively. Further quicklooks may be found here: `https://atmos.eoc.dlr.de/tropomi`

7.2 Product Geophysical Validation

For a detailed description of early validation results, please refer to section 3.2 of the S5P MPC Product Readme Cloud v2.0.0 (S5P-MPC-DLR-PRF-CLOUD).

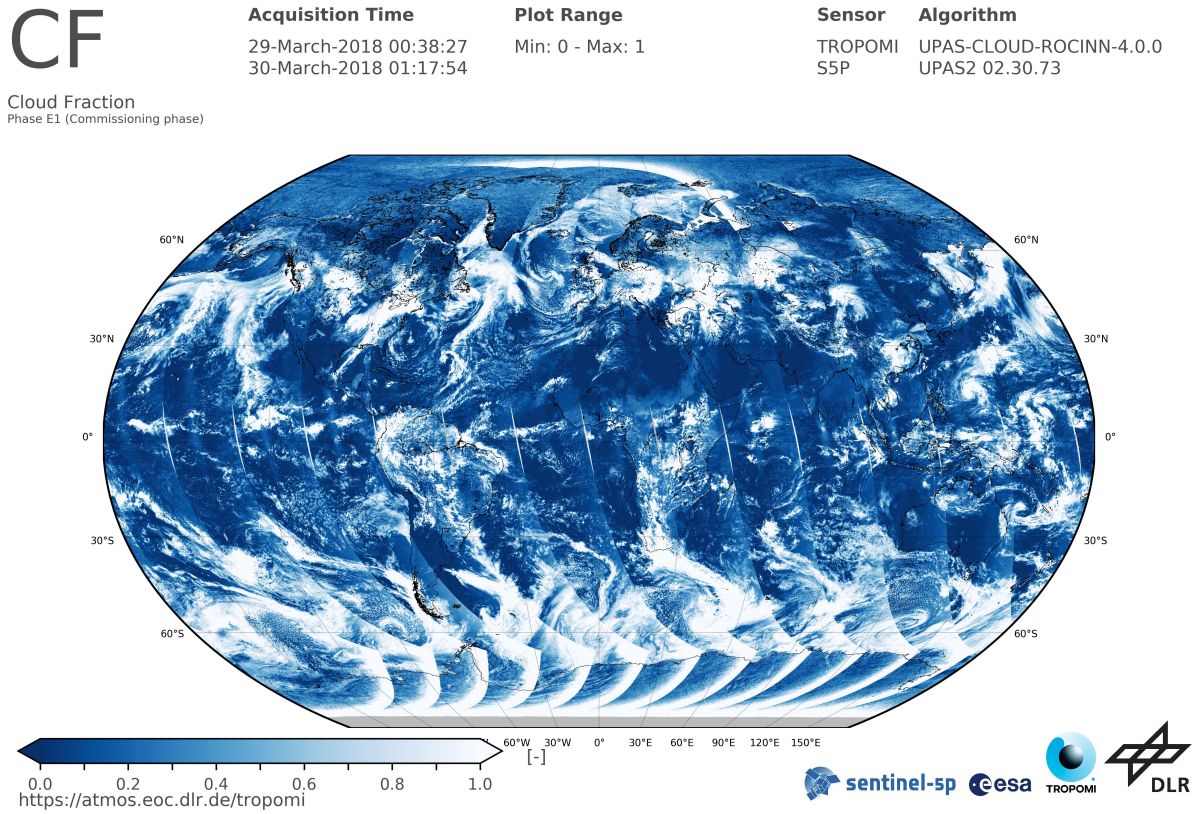

Figure 2: A full day plot of the cloud fraction parameter acquired on 29th March 2018. Further quicklooks may be found here: `https://atmos.eoc.dlr.de/tropomi`

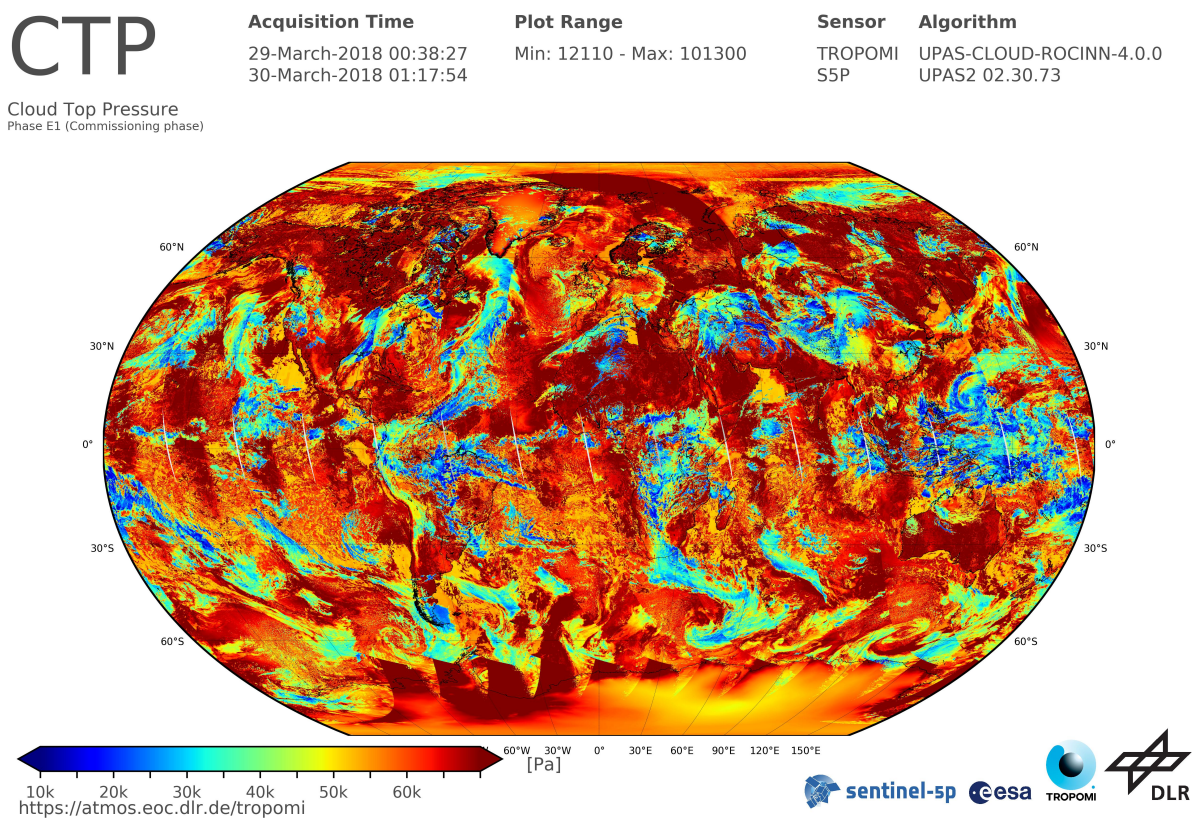

Figure 3: A full day plot of the cloud pressure parameter acquired on 29th March 2018. Further quicklooks may be found here: `https://atmos.eoc.dlr.de/tropomi`

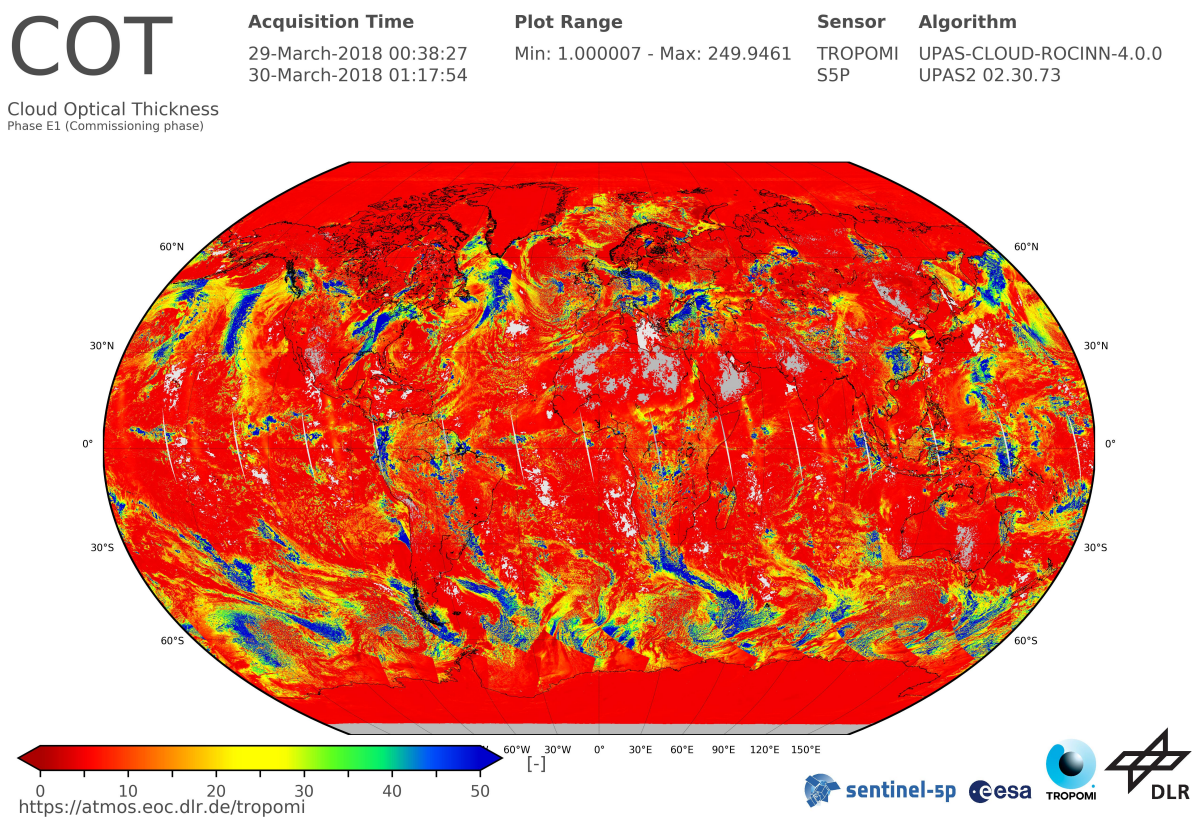

Figure 4: A full day plot of the cloud optical thickness parameter acquired on 29th March 2018. Further quicklooks may be found here: `https://atmos.eoc.dlr.de/tropomi`

7.3 History of product changes

This manual describes the current version of the L2 Cloud product. A brief description of data product changes is given here. Detailed description of the changes can be found in appropriate versions of the ATBD.

Table 3: History of product changes of Cloud

Version	Description
2.1	Mainly changes to the background correction product (e.g. added qa-value, geolocations)
2.0	Added near infrared (nir) geolocations
2.0	Added effective scene variables
2.0	Retrieval parameters are now provided for nir geolocations as well as for the uvis geolocations (where they are coregistered)
2.0	Added diagnostic variables for the coregistration between uvis and nir
2.0	Added new ECMWF variables (wind-speed, snow-ice variables)
2.0	Added cloud-temperature and cloud-phase variables
1.1	Minor changes in long name attributes
0.12	Official version for E2 delivery

7.4 Using the S5p/TROPOMI L2 Cloud

For a detailed description of known data quality issues and suggestions on the usage of the data (e.g. incorporating the *qa_value*), please refer to section 4 of the S5P MPC Product Readme Cloud v2.0.0 (S5P-MPC-DLR-PRF-CLOUD).

8 General structure of S5P/TROPOMI Level 2 files

This section gives an overview of the basic structure of all Sentinel 5 precursor level 2 files. In subsections 8.2 – 8.3 and sections 9 – 11 some details are provided on the background of the structure of the level 2 files of Sentinel 5 precursor. A complete description of the variables in the Cloud files is given in section 13. Figure 5 gives a graphical representation of the generic structure of a TROPOMI Level 2 file. The outermost layer is the file itself. Within the file different groups are used to organise the data and make it easier to find what you are looking for. Within the file there are two groups: "PRODUCT" and "METADATA". Both of these groups contain sub-groups. The purpose of each group are discussed below.

PRODUCT The variables in this group will answer the questions *what*, *when*, *where* and *how well*. This group stores the main data fields of the product, including the precision of the main parameters, latitude, longitude and variable to determine the observation time and the dimensions needed for the data (a time reference dimension (time), the number of measurements in the granule (scanline), the number of spectra in a measurement (ground_pixel) and depending on the product also a pressure-level dimension, or state-vector dimensions). The "qa_value" parameter summarizes the processing flags into a continuous value, giving a quality percentage: 100 % is the most optimal value, 0 % is a processing failure, in between lies a continuum of values[1].

In the 'PRODUCT' group a sub-group 'SUPPORT_DATA' can be found:

SUPPORT_DATA Additional data that is not directly needed for using and understanding the main data product is stored in sub-groups of this group.

The data in this group is further split up into the following sub groups:

GEOLOCATIONS Additional geolocation and geometry related fields, including the pixel boundaries (pixel corners), viewing- and solar zenith angles, azimuth angles, and spacecraft location.

DETAILED_RESULTS Additional output, including state-vector elements that are not the main parameter(s), output describing the quality of the retrieval result, such as a χ^2 value, and detailed processing flags.

INPUT_DATA Additional input data, such as meteorological input data, surface albedo values, surface altitude and other data that was used to derive the output. Note that input profile information is not stored here, but is available for download from elsewhere.

METADATA This is a group to collect metadata items, such as the items that appear in the header file [RD26, section 7] and items required by INSPIRE [ER4], ISO 19115 [RD27], ISO 19115-2 [RD28], ISO 19157 [RD29] and OGC 10-157r3 [RD30]. These metadata standards are all meant to facilitate dataset discovery.

The metadata will be stored as attributes, while grouping attributes that belong to a specific standard will be done by using sub-groups in the Metadata group. Some attributes are required to be attached to the global level by convention, such as the CF metadata conventions [ER5], the Attribute Convention for Dataset Discovery [ER6], the NetCDF-4 user guide [ER7] and the ESA CCI project [RD31]. For interoperability reasons the conventions are followed, and the specified global attributes are added to the output files at the root-level.

ALGORITHM_SETTINGS An attribute is added to this group for each key in the configuration file. The exact contents differ for each processor.

GRANULE_DESCRIPTION Parameters describing the granule, such as an outline of the geolocations covered in the granule, the time coverage, and processing facility.

QA_STATISTICS Quality assurance statistics. This group contains two types of data:

1. The total number of pixel matching a certain criterion: number of input pixels, number of pixels successfully processed and the number of pixels that failed for specific reasons. Also part of the pixel counting are the number of warnings that were raised, including those for the south Atlantic anomaly, sun glint and solar eclipse. This is collectively known as 'event counting'.
2. Histogram(s) of the main parameter(s) in the file. Histograms are additive and allow for easy monitoring of changes over time. This can be a valuable addition for quality monitoring of the science data.

ESA_METADATA The metadata items that are required in the ESA header.

ISO_METADATA The ISO metadata items, organized in subgroups.

[1] More detailed processing flags indicating precisely why the 100 % value isn't reached, are available elsewhere in the product.

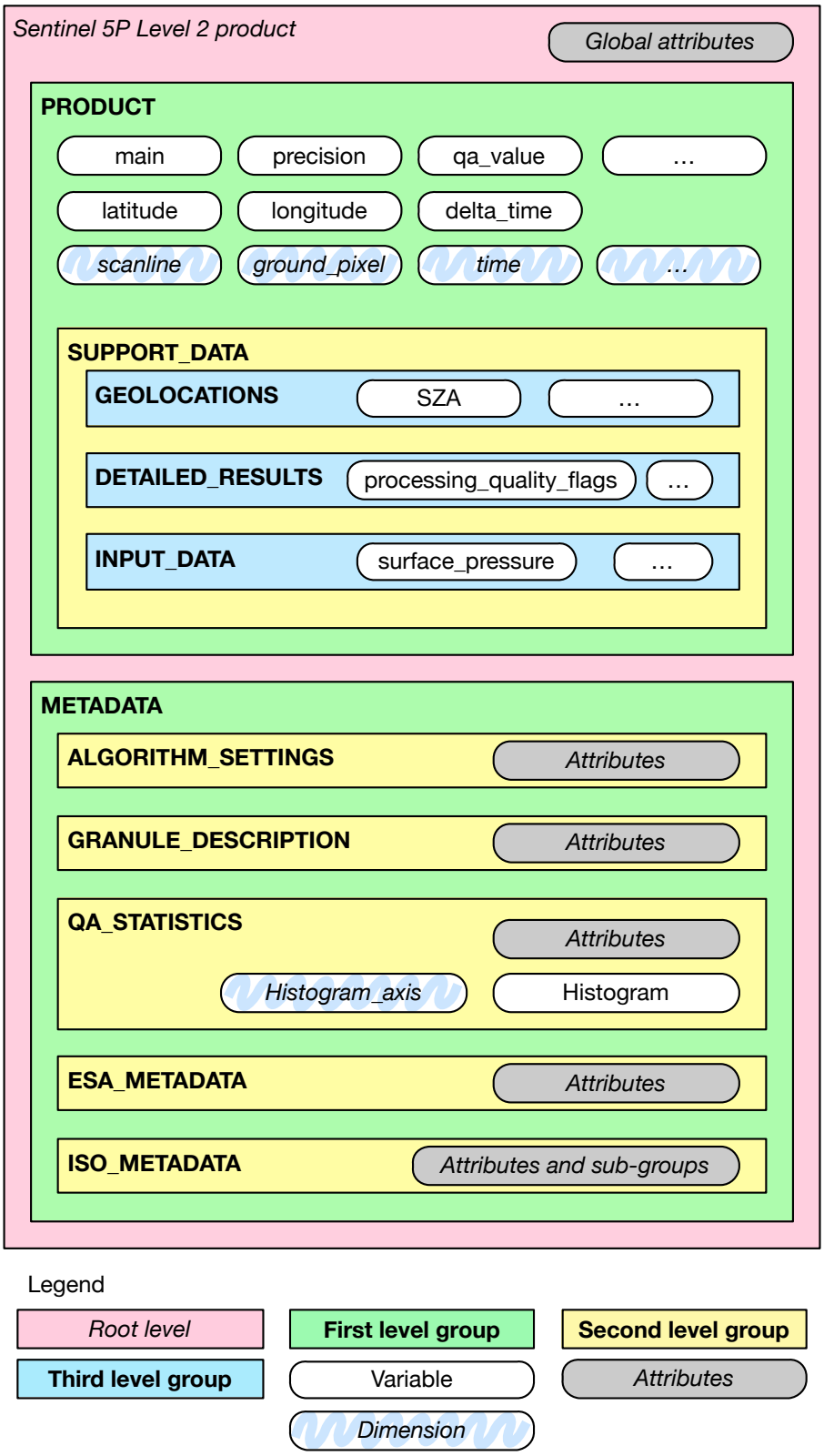

Figure 5: Graphical description of the generic structure of a Level 2 file. The elements labelled as a dimension are coordinate variables. See section 8 for a full description.

EOP_METADATA The EOP metadata items, organized in subgroups.

The work of Level 1B on metadata as described in the metadata specification for TROPOMI L01b data processor [RD32] is used as the basis for the level 2 metadata, in particular for the items in the 'ISO_METADATA' and 'EOP_METADATA' subgroups. The listed metadata standards give a data model and an implementation guideline for producing an XML file with the metadata – as a side-file to the data-file itself. The Level 1B IODS [RD2] describes a method to store the metadata in the NetCDF-4 file, and produce XML side-files as needed. A detailed discussion on metadata as it applies to Level 2 can be found in section 11.

Details of the specific format of the level 2 product file for the Cloud product is given in section 13. Here all variables are described in detail. A dump output of the final structure proposed in Figure 5 shall have a hierarchy as follows:

```
/root/PRODUCT
/root/PRODUCT/SUPPORT_DATA
/root/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS
/root/PRODUCT/SUPPORT_DATA/GEOLOCATION
/root/PRODUCT/SUPPORT_DATA/INPUT_DATA
/root/METADATA
/root/METADATA/ALGORITHM_SETTINGS
/root/METADATA/ESA_METADATA
/root/METADATA/GRANULE_DESCRIPTION
/root/METADATA/ISO_METADATA
/root/METADATA/QA_STATISTICS
```

Where `root` is the file itself or the outer level.
The geo-coordinates of the pixel corners are shown in Figure 6. Note that this choice follows the CF metadata standard [ER5, section 7.1].

8.1 S5p/TROPOMI L2 File Format

The file format used for all the L2 product is **netCDF-4** [ER8]. This file format is very versatile and flexible and will be used for other Sentinel missions, e.g. S4 mission [RD33] , as well as other ESA and NASA missions. The netCDF-4 library is built on top of NetCDF-3 and HDF-5 libraries and it allows a grouping mechanism as well as a wide collection of datatypes and other features tailored from the HDF-5 library. This permits the user to use either the netCDF-4 or HDF-5 APIs in order to read the data. Those APIs are written in many data-analysis packages such as IDL, NCO, Matlab, R, and Mathematica or in general programming languages including Python, Ruby, C, C++, Java and Fortran 90.

8.2 Dimensions and dimension ordering

All variables in a NetCDF-4 file use named and shared dimensions. This explicitly connects variables to dimensions, and to each other. A few of the dimension names were already shown in figure 5.

time A time dimension. The length of this dimension is 1, at least for S5P. The reason this dimension is used are compatibility with Level 1B, and forward compatibility with Sentinel 4 and Level 3 output. Details are provided in sections 8.4.

scanline The dimension that indicates the flight direction.

ground_pixel The dimension perpendicular to the flight direction.

Other dimensions can be added as needed, but these names shall be the default for these roles.

The climate and forecast metadata conventions recommend a specific order for dimensions in a variable [ER5, section 2.4]. Spatiotemporal dimensions should appear in the relative order: "date or time" (T), "height or depth" (Z), "latitude" (Y), and "longitude" (X). Note that the ordering of the dimensions in CDL, our documentation and C/C++ is row-major: the last dimension is stored contiguously in memory[2].

[2] Fortran uses column-major order, effectively reversing the dimensions in the code compared to the documentation.

Using straight latitude and longitude is fine with model parameters, but the S5P/TROPOMI Level 1B/Level 2 observation grid is not a regular grid. Because of the polar orbit, the across track dimension ('ground_pixel') corresponds most closely with the longitude, and therefore is associated with the X-dimension, while the along track dimensions ('scanline') corresponds most directly with latitude, and is therefore labelled as the Y-dimension.

However, in the CF conventions goes on to recommend that additional dimensions are added before the (T,Z,Y,X) axes, that is to have contiguous (T,Z,Y,X) hyperslabs, and spread out the data in other dimensions. We do not follow this recommendation. Instead we recommend to keep units that are likely to be accessed as a unit together in memory, but following the recommended order for (T,Y,X). Note that we do not follow the CF conventions for profiles as they are more likely accessed as complete profiles rather than horizontal slices. A few examples will help:

Tropospheric NO_2 column This variable contains a single value per ground pixel, and the dimensions are (time, scanline, ground_pixel).

The state_vector_length variable that accompanies the state_vector_length dimension is a string array, giving the names of the state vector elements.

8.3 Geolocation, pixel corners and angles

The latitude, longitude, pixel corner coordinates and related angles and satellite position in the level 2 files are copied from the level 1B input data [RD34, chapters 26 and 27]. Details about the definitions can be found there. Note that the latitude and longitude have not been corrected for the local surface altitude, but are instead given at the intersection of the line of sight with the WGS84 ellipsoid.

The geo-coordinates of the pixel corners are shown in Figure 6. Note that this choice follows the CF metadata standard [ER5, section 7.1].

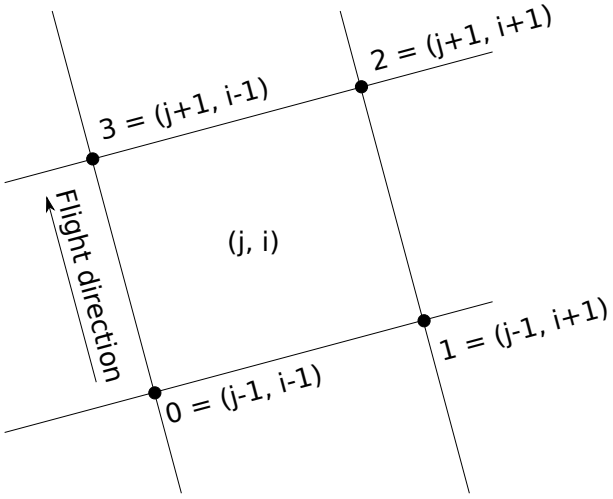

Figure 6: Pixel corner coordinates. The sequence $\{0,1,2,3\}$ refers to the elements in the `corner` dimension.

The azimuth angles, i.e. the solar azimuth angle φ_0 and the viewing azimuth angle φ give the angle of the sun and the instrument respectively at the intersection of the line of sight with the WGS84 ellipsoid. Both angles are given as degrees east relative to the local north. This definition is identical to the definition of the azimuth angles in both the OMI and GOME-2 instruments, but requires some care when comparing to a radiative transfer model. A radiative transfer model will typically use $\varphi - \varphi_0$ which differs by 180° as it follows the path of the light.

8.4 Time information

Time information is stored in two steps. We have the time dimension, which indicates the reference time. This reference time is defined to be UTC midnight before the start of the orbit, which itself is defined by spacecraft midnight. The `time` variable contains the reference time in seconds since 2010-01-01, UTC midnight.

Alternative representations of the reference time are listed in table 4. The offset of individual measurements within the granule is given in milliseconds with respect to this reference time in the variable `delta_time`.

The reason for this double reference is to more closely follow the CF conventions. Because the flight direction relates the latitude and the time within the orbit, we have Y and T dimensions that are closely related. By separating these into a `time` dimension of length 1 and a `scanline` dimension, we obtain independent Y and T dimensions. The actual observation time of an individual observation must be reconstructed from an offset and a time-delta.

As a service to the users, the time is also stored in the '`time_utc`' variable. This variable is a string array, with each observation time stored as an ISO date string [RD35].

Table 4: Reference times available in a S5P L2 file. Types: (A) global attribute, (D) dimensional variable, (V) variable. All reference times ignore leap seconds.

Name	Type	Description
time_reference	(A)	ISO date/time string [RD35]
time_reference_days_since_1950	(A)	The number of days since January first, 1950, UTC midnight, as used in several weather and climate models (ECMWF, TM5).
time_reference_julian_day	(A)	The Julian date of the reference time as used in astronomy. This is the reference time system as used in IDL.
time_reference_seconds_since_1970	(A)	The number of seconds since January first, 1970, UTC midnight. This is also known as the unix epoch. Time functions on many systems will accept this number.
time	(D)	This variable contains the number of seconds since 2010-01-01, UTC midnight.
time_utc	(V)	Array of ISO date/time strings [RD35], one for each observation, i.e. one for each element in the scanline dimension

8.5 Vertical coordinates

Different ATBD authors have specified different vertical grids for the retrieval, which means that the various Level 2 products are not consistent in this respect. There are several options, depending on the choice made by the authors of the retrieval algorithm. Some authors choose to use a vertical grid on a fixed height scale[3], others use a grid that is defined in pressure relative to the surface pressure, similar to the ECMWF vertical grid.

The ECMWF vertical grid is a "atmosphere hybrid sigma pressure coordinate" in CF conventions terminology [ER5, appendix D].

$$p(n,k,j,i) = a_{\mathrm{p}}(k) + b(k)p_{\mathrm{s}}(n,j,i) \tag{1}$$

where $p(n,k,j,i)$ is the pressure at gridpoint (n,k,j,i) on the (T,Z,Y,X) axes; $a_{\mathrm{p}}(k)$ and $b(k)$ the components of the hybrid coordinate at level k and $p_{\mathrm{s}}(n,j,i)$ the surface pressure at coordinate (n,j,i). As a consequence the surface pressure must be added to the output file, otherwise the pressure levels on which the profiles are reported cannot be reconstructed. In addition the $a_{\mathrm{p}}(k)$ and $b(k)$ coefficients must be added to the output as separate variables.

For the fixed height grid there is no reduced pressure grid available, and similarly calculating a height from the pressure profile requires some assumptions. In some cases the full four-dimensional pressure grid will be given.

9 Units

The `units` attribute originates from the NetCDF-4 users guide [ER7]. This means that the use of this attribute is integral to the use of NetCDF-4 itself, and that the use of the `units` attribute in the NetCDF-4 users guide is a hard requirement. The NetCDF-4 users guide [ER7] strongly suggests to use the UDUnits [ER9] package to handle units. The CF metadata conventions reinforce this requirement [ER5, sections 1.3 and 3.1].

[3] This is 'height' as defined by the CF conventions: distance above the surface; 'altitude' is the distance above the geoid or approximate sea level.

Making the UDUnits package [ER9] a requirement, and thereby forcing all units to be compliant with formal SI units[4] is a good thing for consistency and will help avoid confusion in the long run. In the short term it will require adjustments within the earth observation community, as many of the units that the user community is accustomed to are not SI, and are therefore not available within the UDUnits package. The MAG has decided that Sentinel 5 precursor will represent all level 2 output in SI units. In particular, all column amounts will be given in $\mathrm{mol\,m^{-2}}$.

To make it easier for end-users to adjust to these 'new' units, conversion factors are attached to the appropriate variables.

multiplication_factor_to_convert_to_molecules_percm2 Multiply the contents of the variable with this scale factor ($6.02214 \times 10^{+19}$) to obtain columns in $\mathrm{molecules\,cm^{-2}}$

multiplication_factor_to_convert_to_DU Multiply the contents of the variable with this scale factor (2241.15) to obtain columns in DU.

multiplication_factor_to_convert_to_photons_persecond_pernm_percm2_persr Multiply the contents of the variable with this scale factor ($6.02214 \times 10^{+19}$) to obtain a radiance in photons $\mathrm{s^{-1}\,nm^{-1}\,cm^{-2}\,sr^{-1}}$.

10 Quality Assurance parameters

The Level 2 output will include automated quality assurance parameters. These include 'event counters' for each of the flags defined in the processing quality flags, see tables 12 and 13. These processing quality flags are made uniform across all products, and include flags that may not be applicable to a particular algorithm. We still count all flags, so this list is the same for all products, a list is provided in table 5.

In addition to these 'event counters', we also store a histogram of the main parameters. Storing a histogram of retrieved values is easy during processing, and allows for continuous statistical quality monitoring of the retrieval. It also makes it easy to collect histograms of S5P/TROPOMI data for longer periods. The bins for the histogram depend on the parameter in the Level 2 product, and are defined in the configuration file.

In addition to the histogram an approximation of a probability density function can be created:

$$f_{\mathrm{pdf}}(x_j) = \frac{1}{N} \sum_{i=0}^{N} \frac{\cos\left(\delta_{\mathrm{geo},i}\right)}{\sigma_i \sqrt{2\pi}} \exp\left[\frac{(x_j - x_i)^2}{2\sigma_i^2}\right] \tag{2}$$

This is a discrete approximation of a continuous probability density function, for discrete values x_j for all successful retrievals $i = 1, \ldots, N$. The value of $\cos\left(\delta_{\mathrm{geo},i}\right)$ is used to make the result less sensitive to the relative oversampling of S5P at high latitude.

The mission performance center for Sentinel 5 precursor maintains a record of quality control/quality assurance parameters for monitoring purposes.

[4] And some deeply entrenched non-SI units such as DU.

Table 5: Common quality assurance parameters. The actual integer values of incident occurrences are stored. Using percentages stored as integers will hide potential issues, especially given the total number of pixels in a S5P/TROPOMI granule.

Name	Description
number_of_groundpixels	Number of ground pixels in the file.
number_of_processed_pixels	Number of ground pixels where a retrieval was attempted. This is the number_of_groundpixels minus the pixels that were rejected on trivial grounds, such as the solar zenith angle.
number_of_successfully_processed_pixels	Number of ground pixels where a retrieval was successful.
number_of_rejected_pixels_not_enough_spectrum	Number of ground pixels where a retrieval was not attempted because too many spectral pixels were flagged as bad.
number_of_failed_retrievals	Number of pixels that were attempted but failed.
number_of_ground_pixels_with_warnings	Number of pixels with one or more warnings.
number_of_missing_scanlines	Number of scanlines that are missing from the input, presumably transmission errors.
number_of_radiance_missing_occurrences	Number of ground pixels where “the number of spectral pixels in the radiance due to flagging is too small to perform the fitting” occurred.
number_of_irradiance_missing_occurrences	Number of ground pixels where “the number of spectral pixels in the irradiance due to flagging is too small to perform the fitting” occurred.
number_of_input_spectrum_missing_occurrences	Number of ground pixels where “the reflectance spectrum does not contain enough points to perform the retrieval. This is different from (ir)radiance_-missing in that the missing points may not be aligned” occurred.
number_of_reflectance_range_error_occurrences	Number of ground pixels where “any of the reflectances is out of bounds ($R < 0$ or $R > R_{\text{max}}$)” occurred.
number_of_ler_range_error_occurrences	Number of ground pixels where “lambert-equivalent reflectivity out of range error” occurred.
number_of_snr_range_error_occurrences	Number of ground pixels where “too low signal to noise to perform retrieval” occurred.
number_of_sza_range_error_occurrences	Number of ground pixels where “solar zenith angle out of range, maximum value from configuration” occurred.
number_of_vza_range_error_occurrences	Number of ground pixels where “viewing zenith angle out of range, maximum value from configuration” occurred.
number_of_lut_range_error_occurrences	Number of ground pixels where “extrapolation in lookup table (airmass factor, cloud radiances)” occurred.

Table 5: Common quality assurance parameters. (continued).

Name	Description
number_of_ozone_range_error_occurrences	Number of ground pixels where “ozone column significantly out of range of profile climatology” occurred.
number_of_wavelength_offset_error_occurrences	Number of ground pixels where “wavelength offset exceeds maximum from configuration” occurred.
number_of_initialization_error_occurrences	Number of ground pixels where “an error occurred during the processing of the pixel, no output was generated. The following errors raise this flag: Mismatch between irradiance and radiance wavelengths; The on-ground distance between band 1 and band 2 ground pixels exceeds a threshold set in the configuration. Derived a-priori information does not validate, no processing is possible” occurred.
number_of_memory_error_occurrences	Number of ground pixels where “memory allocation or deallocation error” occurred.
number_of_assertion_error_occurrences	Number of ground pixels where “error in algorithm detected during assertion” occurred.
number_of_io_error_occurrences	Number of ground pixels where “error detected during transfer of data between algorithm and framework” occurred.
number_of_numerical_error_occurrences	Number of ground pixels where “general fatal numerical error occurred during inversion” occurred.
number_of_lut_error_occurrences	Number of ground pixels where “error in accessing the lookup table” occurred.
number_of_ISRF_error_occurrences	Number of ground pixels where “error detected in the input instrument spectral response function input data” occurred.
number_of_convergence_error_occurrences	Number of ground pixels where “the main algorithm did not converge” occurred.
number_of_cloud_filter_convergence_error_occurrences	Number of ground pixels where “the cloud filter did not converge” occurred.
number_of_max_iteration_convergence_error_occurrences	Number of ground pixels where “no convergence because retrieval exceeds maximum number of iterations. Maximum value from configuration” occurred.
number_of_aot_lower_boundary_convergence_error_occurrences	Number of ground pixels where “no convergence because the aerosol optical thickness crosses lower boundary twice in succession” occurred.
number_of_other_boundary_convergence_error_occurrences	Number of ground pixels where “no convergence because a state vector element crosses boundary twice in succession. Note that a separate failure flag is defined for non-convergence due to crossing of lower AOT boundary” occurred.

Table 5: Common quality assurance parameters. (continued).

Name	Description
number_of_geolocation_error_occurrences	Number of ground pixels where “geolocation out of range” occurred.
number_of_ch4_noscat_zero_error_occurrences	Number of ground pixels where “the CH_4 column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0” occurred.
number_of_h2o_noscat_zero_error_occurrences	Number of ground pixels where “the H_2O column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0” occurred.
number_of_max_optical_thickness_error_occurrences	Number of ground pixels where “maximum optical thickness exceeded during iterations” occurred.
number_of_aerosol_boundary_error_occurrences	Number of ground pixels where “boundary hit of aerosol parameters at last iteration” occurred.
number_of_boundary_hit_error_occurrences	Number of ground pixels where “fatal boundary hit during iterations” occurred.
number_of_chi2_error_occurrences	Number of ground pixels where “χ^2 is not-a-number or larger than 10^{10}” occurred.
number_of_svd_error_occurrences	Number of ground pixels where “singular value decomposition failure” occurred.
number_of_dfs_error_occurrences	Number of ground pixels where “degree of freedom is not-a-number” occurred.
number_of_radiative_transfer_error_occurrences	Number of ground pixels where “errors occurred during the radiative transfer computations, no processing possible” occurred.
number_of_optimal_estimation_error_occurrences	Number of ground pixels where “errors occurred during the optimal estimation, processing has been terminated” occurred.
number_of_profile_error_occurrences	Number of ground pixels where “flag that indicates if there were any errors during the computation of the ozone profile” occurred.
number_of_cloud_error_occurrences	Number of ground pixels where “no cloud data” occurred.
number_of_model_error_occurrences	Number of ground pixels where “forward model failure” occurred.
number_of_number_of_input_data_points_too_low_error_occurrences	Number of ground pixels where “not enough input ozone columns to calculate a tropospheric column” occurred.
number_of_cloud_pressure_spread_too_low_error_occurrences	Number of ground pixels where “cloud pressure variability to low to estimate a tropospheric column” occurred.
number_of_cloud_too_low_level_error_occurrences	Number of ground pixels where “clouds are too low in the atmosphere to assume sufficient shielding” occurred.
number_of_generic_range_error_occurrences	Number of ground pixels where “generic range error” occurred.
number_of_generic_exception_occurrences	Number of ground pixels where “catch all generic error” occurred.

Table 5: Common quality assurance parameters. (continued).

Name	Description
number_of_input_spectrum_alignment_error_occurrences	Number of ground pixels where “input radiance and irradiance spectra are not aligned correctly” occurred.
number_of_abort_error_occurrences	Number of ground pixels where “not processed because processor aborted prematurely (time out or user abort)” occurred.
number_of_wrong_input_type_error_occurrences	Number of ground pixels where “wrong input type error, mismatch between expectation and received data” occurred.
number_of_wavelength_calibration_error_occurrences	Number of ground pixels where “an error occurred in the wavelength calibration of this pixel” occurred.
number_of_coregistration_error_occurrences	Number of ground pixels where “no colocated pixels found in a supporting band” occurred.
number_of_slant_column_density_error_occurrences	Number of ground pixels where “slant column fit returned error, no values can be computed” occurred.
number_of_airmass_factor_error_occurrences	Number of ground pixels where “airmass factor could not be computed” occurred.
number_of_vertical_column_density_error_occurrences	Number of ground pixels where “vertical column density could not be computed” occurred.
number_of_signal_to_noise_ratio_error_occurrences	Number of ground pixels where “the signal to noise ratio for this spectrum is too low for processing” occurred.
number_of_configuration_error_occurrences	Number of ground pixels where “error while parsing the configuration” occurred.
number_of_key_error_occurrences	Number of ground pixels where “key does not exist” occurred.
number_of_saturation_error_occurrences	Number of ground pixels where “saturation in input spectrum” occurred.
number_of_max_num_outlier_exceeded_error_occurrences	Number of ground pixels where “the number of outliers detected in the DOAS fit exceeds a maximum set for healthy spectra. ” occurred.
number_of_solar_eclipse_filter_occurrences	Number of ground pixels where “solar eclipse” occurred.
number_of_cloud_filter_occurrences	Number of ground pixels where “the cloud filter triggered causing the pixel to be skipped” occurred.
number_of_altitude_consistency_filter_occurrences	Number of ground pixels where “too large difference between ECMWF altitude and DEM altitude value” occurred.
number_of_altitude_roughness_filter_occurrences	Number of ground pixels where “too large standard deviation of altitude in DEM” occurred.

Table 5: Common quality assurance parameters. (continued).

Name	Description
number_of_sun_glint_filter_occurrences	Number of ground pixels where “for pixels over water, viewing direction inside sun glint region. Definition of sun glint angle and threshold value from ATBD” occurred.
number_of_mixed_surface_type_filter_occurrences	Number of ground pixels where “pixel contains land and water areas (e.g. coastal pixel)” occurred.
number_of_snow_ice_filter_occurrences	Number of ground pixels where “pixel contains snow/ice: Snow/ice flag according to dynamic input OR climatological surface albedo at VIS wavelength is larger than 0.5” occurred.
number_of_aai_filter_occurrences	Number of ground pixels where “AAI smaller than 2.0” occurred.
number_of_cloud_fraction_fresco_filter_occurrences	Number of ground pixels where “pixel contains clouds: The FRESCO effective cloud fraction is larger than threshold. Threshold value from ATBD” occurred.
number_of_aai_scene_albedo_filter_occurrences	Number of ground pixels where “pixel contains clouds: The difference between scene albedo at 380 nm from AAI calculation and the climatologcal surface albedo exceeds threshold. Threshold value from ATBD. This test filters out clouds” occurred.
number_of_small_pixel_radiance_std_filter_occurrences	Number of ground pixels where “pixel contains clouds: Standard deviation of radiances in small-pixel column exceeds threshold. Threshold value from ATBD” occurred.
number_of_cloud_fraction_viirs_filter_occurrences	Number of ground pixels where “pixel contains clouds: The cloud fraction from VIIRS / NPP exceeds theshold. Threshold value from ATBD” occurred.
number_of_cirrus_reflectance_viirs_filter_occurrences	Number of ground pixels where “pixel contains clouds: Cirrus reflectance from VIIRS / NPP exceeds threshold. Threshold value from ATBD” occurred.
number_of_cf_viirs_swir_ifov_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P SWIR ground pixel exceeds a priori threshold from configuration” occurred.
number_of_cf_viirs_swir_ofova_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVa exceeds a priori threshold from configuration” occurred.
number_of_cf_viirs_swir_ofovb_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVb exceeds a priori threshold from configuration” occurred.
number_of_cf_viirs_swir_ofovc_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVc exceeds a priori threshold from configuration” occurred.
number_of_cf_viirs_nir_ifov_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P NIR ground pixel exceeds a priori threshold from configuration” occurred.

Table 5: Common quality assurance parameters. (continued).

Name	Description
number_of_cf_viirs_nir_ofova_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVa exceeds a priori threshold from configuration” occurred.
number_of_cf_viirs_nir_ofovb_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVb exceeds a priori threshold from configuration” occurred.
number_of_cf_viirs_nir_ofovc_filter_occurrences	Number of ground pixels where “fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVc exceeds a priori threshold from configuration” occurred.
number_of_refl_cirrus_viirs_swir_filter_occurrences	Number of ground pixels where “average VIIRS cirrus reflectance within SWIR ground pixel exceeds a priori threshold from configuration” occurred.
number_of_refl_cirrus_viirs_nir_filter_occurrences	Number of ground pixels where “average VIIRS cirrus reflectance within NIR ground pixel exceeds a priori threshold from configuration” occurred.
number_of_diff_refl_cirrus_viirs_filter_occurrences	Number of ground pixels where “difference in VIIRS average cirrus reflectance between SWIR and NIR ground pixel exceeds a priori threshold from configuration” occurred.
number_of_ch4_noscat_ratio_filter_occurrences	Number of ground pixels where “the ratio between $[CH_4]_{weak}$ and $[CH_4]_{strong}$ is below or exceeds a priori thresholds from configuration” occurred.
number_of_ch4_noscat_ratio_std_filter_occurrences	Number of ground pixels where “the standard deviation of $[CH_4]_{weak}/[CH_4]_{strong}$ within the SWIR pixel and the 8 neighbouring pixels exceeds a priori threshold from configuration” occurred.
number_of_h2o_noscat_ratio_filter_occurrences	Number of ground pixels where “the ratio between $[H_2O]_{weak}$ and $[H_2O]_{strong}$ is below or exceeds a priori thresholds from configuration” occurred.
number_of_h2o_noscat_ratio_std_filter_occurrences	Number of ground pixels where “the standard deviation of $[H_2O]_{weak}/[H_2O]_{strong}$ within the SWIR pixel and the 8 neigbouring pixels exceeds a priori threshold from configuration” occurred.
number_of_diff_psurf_fresco_ecmwf_filter_occurrences	Number of ground pixels where “difference between the FRESCO apparent surface pressure and the ECMWF surface pressure exceeds a priori threshold from configuration” occurred.
number_of_psurf_fresco_stdv_filter_occurrences	Number of ground pixels where “the standard deviation of the FRESCO apparent surface pressure in the NIR pixel and the 8 surrounding pixels exceeds a priori threshold from configuration” occurred.
number_of_ocean_filter_occurrences	Number of ground pixels where “the ground pixel is over ocean (and ocean glint retrievals are not switched on)” occurred.

Table 5: Common quality assurance parameters. (continued).

Name	Description
number_of_time_range_filter_occurrences	Number of ground pixels where “time is out of the range that is to be processed” occurred.
number_of_pixel_or_scanline_index_filter_occurrences	Number of ground pixels where “not processed because pixel index does not match general selection criteria” occurred.
number_of_geographic_region_filter_occurrences	Number of ground pixels where “pixel falls outside the specified regions of interest” occurred.
number_of_input_spectrum_warning_occurrences	Number of ground pixels where “number of good pixels in radiance, irradiance or calculated reflectance below threshold from configuration” occurred.
number_of_wavelength_calibration_warning_occurrences	Number of ground pixels where “offset from wavelength fit is larger than limit set in configuration” occurred.
number_of_extrapolation_warning_occurrences	Number of ground pixels where “pressure or temperature outside cross section LUT range, other lookup table extrapolation” occurred.
number_of_sun_glint_warning_occurrences	Number of ground pixels where “sun glint posibility warning” occurred.
number_of_south_atlantic_anomaly_warning_occurrences	Number of ground pixels where “TROPOMI is inside the south Atlantic anomaly while taking these measurements” occurred.
number_of_sun_glint_correction_occurrences	Number of ground pixels where “A sun glint correction has been applied” occurred.
number_of_snow_ice_warning_occurrences	Number of ground pixels where “snow/ice flag is set, i.e. using scene data from the cloud support product” occurred.
number_of_cloud_warning_occurrences	Number of ground pixels where “cloud filter based on FRESCO apparent surface pressure (VIIRS not available), cloud fraction above threshold or cloud pressure adjusted to force cloud above surface. In case of Cloud product this flag indicates the possiblity of ice-clouds” occurred.
number_of_AAI_warning_occurrences	Number of ground pixels where “possible aerosol contamination as either indicated by the AAI (O_3 profile) or other criteria (Cloud)” occurred.
number_of_pixel_level_input_data_missing_occurrences	Number of ground pixels where “dynamic auxiliary input data (e.g.. cloud) is missing for this ground pixel. A fallback option is used” occurred.

Table 5: Common quality assurance parameters. (continued).

Name	Description
number_of_data_range_warning_occurrences	Number of ground pixels where "carbon monoxide column tends to negative values; Water column tends to negative values; Heavy water (HDO) column tends to negative values; others. In case of the O_3 product this flag indicates VCD or effective albedo values outside a valid range. In case of the SO_2 or the HCHO product this flag indicates AMF values outside a valid range" occurred.
number_of_low_cloud_fraction_warning_occurrences	Number of ground pixels where "low cloud fraction, therefore no cloud pressure retrieved" occurred.
number_of_altitude_consistency_warning_occurrences	Number of ground pixels where "difference between ECMWF surface elevation and high-resolution surface elevation exceeds threshold from configuration" occurred.
number_of_signal_to_noise_ratio_warning_occurrences	Number of ground pixels where "signal to noise ratio in SWIR and/or NIR band below threshold from configuration. For the O_3 and HCHO products this flag indicates an RMS above a certain threshold" occurred.
number_of_deconvolution_warning_occurrences	Number of ground pixels where "failed deconvolution irradiance spectrum (not pixel-specific, but row-specific)" occurred.
number_of_so2_volcanic_origin_likely_warning_occurrences	Number of ground pixels where "warning for SO_2 BL product, UTLS products: volcanic origin except for heavily polluted sites" occurred.
number_of_so2_volcanic_origin_certain_warning_occurrences	Number of ground pixels where "warning for SO_2 BL product, UTLS products: volcanic origin certain" occurred.
number_of_interpolation_warning_occurrences	Number of ground pixels where "warning for interpolation on partially missing data. In this case the valid available data is used, potentially leading to a bias" occurred.
number_of_saturation_warning_occurrences	Number of ground pixels where "saturation occurred spectrum, possibly causing biases in the retrieval" occurred.
number_of_high_sza_warning_occurrences	Number of ground pixels where "warning for high solar zenith angle. In this case, the processing can be performed with less final quality" occurred.
number_of_cloud_retrieval_warning_occurrences	Number of ground pixels where "warning occurring when the retrieval diagnostic indicates a degraded quality of the cloud retrieval" occurred.
number_of_cloud_inhomogeneity_warning_occurrences	Number of ground pixels where "the cloud coregistration inhomogeneity parameter is above a given threshold" occurred.

11 Generic metadata and attributes

Metadata gives information about the satellite, algorithms, configuration as well as other parameters useful for the interpretation of the processed data and tracing the production process of the level 2 files. The Sentinel 5 precursor product files, both for level 1B and level 2 contain a rich amount of metadata, both at the variable level and at the granule level. The full description of the metadata in the files for the Cloud product is given in the file format description, in section 13.2. Here we provide some background on what can be found in which location. The abbreviations listed in table 6 are used in the following part of this document to better identify the nature of the attributes.

Table 6: The abbreviations used in metadata descriptions to indicate the origin of a specific attribute, and the abbreviations used to indicate the type of an attribute.

Abbreviation	Description
NUG	netCDF-4 Users Guide [ER7]
CF	Climate and Forecast metadata conventions [ER5], which includes the COARDS [ER10] conventions
ISO	ISO standards 19115, 19115-2 and 19157 [RD27, RD28, RD29]
Inspire	Inspire directive [ER4]
ACDD	ESIP-ACDD Attribute convention for dataset discovery [ER6]
CCI	Attributes requested by the ESA climate change initiative project. These largely overlap with the ACDD attributes.
ESA	Fixed ESA Header [RD26]
S5P	Internal use – mostly for retrieval settings, possibly as an extension to ISO 19115 [RD27]
S	Attribute is a string attribute
P	Attribute has the data-type of the variable with which it is associated (‘parent’ data type).
I	Attribute is an integer value
F	Attribute is a floating point value (either 32-bit or 64-bit).
T	Attribute is a CCSDS-ASCII time representation (“`UTC=`” + ISO 8601 [RD35])

We follow several metadata conventions in the S5P level 2 files, as can be seen in table 6. These include ISO 19115-2 [RD28], OGC 10.157r3 [RD30], the ESA earth observation header [RD26] and the Climate and Forecast metadata conventions [ER5]. Following ISO 19115-2 also ensures compliance with the Inspire directive, with the provision that a few items that are optional in the ISO standard are required by Inspire. These metadata standards prescribe the generation of XML files as side-files to the main product file. These metadata standards are mostly intended for data discovery and data dissemination. This means that the metadata must be ingested by a server so that it can be stored in a database. This database will end users help to find the data they need. Ingestion of this metadata is facilitated by storing the metadata in a predefined XML format. While it is possible to store the required XML directly in a NetCDF variable or attribute, it is hard to use these directly to extract metadata. Using attributes for the individual metadata fields makes it far easier for users to read the metadata from their programs, as the interface becomes uniform: just netCDF-4.

Then the question becomes how to store the metadata for the ISO 19115-2, OGC 10.157r3 and the ESA earth observation header in the NetCDF datafile, in a way that facilitates automated creation of the XML side files for ingestion into the database for dissemination en discovery. Fortunately this problem has already been solved by the S5P L1B team, and a description can be found in the L1B input/output data specification and the metadata specification [RD2, RD32]. The short version is that the attributes in the data file can be exported as NcML [RD36], which can be translated into the desired output using an XSLT transformation. Support attributes are added to the data file to facilitate this. Creating such a transformation script has been declared out of scope for the level 1B and level 2 processor CFI providers.

11.1 The Climate and Forecast conventions

The CF metadata conventions [ER5] provide guidelines for attributes for variables so that the link between data and its geolocation and time of observation can be made automatically. Applying the CF-metadata conventions to the output products already limits the number of choices we will have to make. Units and other attributes are

already defined and some structure is provided by the CF-conventions, for instance in linking data fields with geolocation.

11.2 NetCDF User Guide Conventions

A full description of the conventions might be found in the NetCDF user manual [ER7]]. In general, names starting with underscore character are always reserved for use by the NetCDF library. NUG conventions are a subset of the CF-conventions.

11.3 Global attributes

Global attributes that are present at the `root` level of a S5p L2 product as described in section 13. These are mostly `string` attributes.

11.4 ESA earth observation header

The ESA earth observations file format guidelines and tailoring for S5P [RD26, RD25] specify the creation of a header file with a basic description of the contents of an output file. This header file consists of a fixed part and a customizable variable part. The variable part contains the lineage of the product is repeated, see section 12.28.1.43 for a description the the attributes contained in this part of the header. The fixed header is described in tables 7 – 9.

Table 7: Metadata in the fixed header required by the ESA earth observation file format standard. The data types refer to the short list in table 6.

Name	Data type	Definition
File_Name	S	File name of the product without extension.
File_Description	S	Description of the file type.
Notes	S	Any type of notes/comments (multi-lines).
Mission	S	Description of the mission (Fixed to “S5P”)
File_Class	S	Description of the file class. It is redundant with the File Class element embedded in the File Name.(e.g., “NRTI”)
File_Type	S	Description of the file type, for the current product it is set to “L2_-_Cloud”. It is redundant with the File Type element embedded in the File Name.
Validity_Period	Group, see table 8	Time coverage of the data.
File_Version	I	It is redundant with the File Version element embedded in the File Name.
Source	Group, see table 9	Information about the ground segment facility where the product was generated.

Table 8: Fields in the Validity_Period group. The data types refer to the short list in table 6.

Name	Data type	Definition
Validity_Start	T	This is the UTC Validity Start Time, the same as the Validity Start Time in the File Name and the time_coverage_start global attribute.
Validity_Stop	T	This is the UTC Validity Stop Time, the same as the Validity Stop Time in the File Name and the time_coverage_end global attribute.

Table 9: Fields in the source group. The data types refer to the short list in table 6.

Name	Data type	Definition
System	S	Name of the Ground Segment element creating the file.

Table 9: Fields in the source group (continued).

Name	Data type	Definition
Creator	S	Name of the facility or tool, within the Ground Segment element, creating the file.
Creator_Version	S	Version of the tool.
Creation_Date	T	This is the UTC Creation Date. This field also appears in the file name and in the date_created global attribute.

11.5 Inspire directive

INSPIRE is based on the infrastructures for spatial information established and operated by the 27 Member States of the European Union. The INSPIRE directive came into force on 15 May 2007 and will be developed in several stages until a complete release with due date set in 2019. The INSPIRE directive aims to create a European Union (EU) spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organizations and better facilitate public access to spatial information across Europe. The European Commission issued a Metadata Regulation [RD37] which aims at setting the requirements for the creation and maintenance of metadata for spatial data sets, spatial data set series and spatial data services corresponding to the themes listed in the annexes of the regulation.

Since many different standard are involved, collisions may occur. The INSPIRE Metadata Implementing Rules [RD38] define how the Regulation can be implemented using ISO 19115. As also reported in [RD32], the conclusion of the study pointed out the following:

1. The conformance of an ISO 19115 metadata set to the ISO 19115 Core does not guarantee the conformance to INSPIRE.
2. The use of these guidelines to create INSPIRE metadata ensures that the metadata is not in conflict with ISO 19115. However, full conformance to ISO 19115 implies the provision of additional metadata elements which are not required by INSPIRE.

11.6 ISO and OGC standards

Two ISOs standards useful for the description of collection of Earth Observation products and to the description of individual EO products are ISO 19115-2 [RD28] and ISO 19156 [RD39], respectively. However, these two ISOs do not provide any encoding syntax but they are merely conceptual models. On the other hand, standards that provide encoding and XML schema for describing, validating and exchanging metadata about geographic datasets and for observations and measurements are:

1. ISO 19139 [RD40]
2. OGC 10-025C [RD41]
3. OGC 10-157 [RD30]

Full description of all above mentioned standard is not part of this document. The S5p L01B evelopment team have addressed and analyzed the complex structure of the application of all those ISOs and OGC standard in the S5P L01B metadata specification [RD32].

11.7 Attributes

In Table 11 a list of attributes that can be appended to variables in S5p products. Not all of these attributes will be used on all variables, but for each variables an appropriate selection is made. The different types with their respective abbreviations are shown in Table 6. The NetCDF attribute `_FillValue` which represents missing or undefined data can assume the default values listed in Table 10.

Table 10: netCDF-4 type definitions and fill values. In order to avoid rounding errors, it is recommended to use the hexadecimal notation when specifying fill values for float and double types. Note that these are the netCDF-4 default fill values, there should be no need to specify these values explicitly. In some cases the fill value for float or double variables may fall within the valid range of a variable. For those cases an explicit fill value must be set, the value $-9.9692099683868690 \times 10^{36}$ (hex: `-0x1.ep+122`) is recommended for these cases.

Type	Description	Fill value
byte	8-bit signed integer	-127
ubyte	8-bit unsigned integer	255
short	16-bit signed integer	-32767
ushort	16-bit unsigned integer	65535
int	32-bit signed integer	-2147483647
uint	32-bit unsigned integer	4294967295
float	32-bit floating point	$9.9692099683868690 \times 10^{36}$ (hex: `0x1.ep+122`)
double	64-bit floating point	$9.9692099683868690 \times 10^{36}$ (hex: `0x1.ep+122`)

Table 11: Attributes for variables used in S5p netCDF-4 files. The data types refer to the short list in table 6.

Name	Type	Std.	Description
ancillary_variables	S	CF	Identifies a variable that contains closely associated data, e.g. the measurement uncertainties of instrument data.
bounds	S	CF	Connects a boundary variable to a coordinate variable.
cell_measures	S	CF	Identifies variables that contain cell areas or volumes. This can be used to connect approximate ground pixel coverage in km^2 to data-fields.
comment	S	CF	Miscellaneous information about the data or methods used to produce it.
coordinates	S	CF	Identifies auxiliary coordinate variables, providing a connection between data and geolocation, time.
_FillValue	P	NUG	Value to represent missing or undefined data. Recommended (default) values are given in table 10.
flag_masks	P	CF	Provides a list of bit fields expressing Boolean or enumerated flags.
flag_meanings	S	CF	Use in conjunction with flag_values to provide descriptive words or phrases for each flag value.
flag_values	P	CF	Provides a list of the flag values. Use in conjunction with flag_meanings.
formula	S	CF	Formula to calculate the values for an adaptive grid, for instance for a dimensionless vertical coordinate. Example: "`hyam hybm (mlev=hyam+hybm*aps)`".
formula_terms	S	CF	Identifies variables that correspond to the terms in a formula, for instance for a dimensionless vertical coordinate. Example: "`ap: hyam b: hybm ps: aps`"
institution	S	CF	Specifies where the original data was produced.
long_name	S	CF	A descriptive name that indicates a variable's content. This name is not standardized.
positive	S	CF	Direction of increasing vertical coordinate value ('up' for z in m or 'down' for p in hPa).
references	S	CF	References that describe the data or methods used to produce it.
source	S	CF	Method of production of the original data.

Table 11: Attributes for variables used in S5p netCDF-4 files (continued).

Name	Type	Std.	Description
standard_error_multiplier	F	CF	If a data variable with a standard_name modifier of standard_-error has this attribute, it indicates that the values are the stated multiple of one standard error. The only allowed value for S5p files is 1, used only to disambiguate.
standard_name	S	CF	A standard name that references a description of a variable's content in the standard name table.
units	S	CF	Units of a variable's content. See section 9 for a detailed discussion.
valid_max	P	NUG	Largest valid value of a variable.
valid_min	P	NUG	Smallest valid value of a variable.
valid_range	P[2]	NUG	Smallest and largest valid values of a variable. This attribute should not be combined with either valid_min or valid_max

12 Common elements in all S5P products

This section describes the elements that are common to all S5P/TROPOMI products. The product specific descriptions include references to this section. References to standards follow the abbreviations given in table 6.

12.1 Common file-level attributes

These are the file-level attributes.

Attributes in global

Group attributes attached to global		
Name	*Value*	*Type*
Conventions	'CF-1.7' (static)	NC_STRING
Name of the conventions followed by the dataset. Note that while we try to follow the climate and forecast metadata conventions, there are some features – notably the use of groups to hierarchicaly organize the data – that are not part of version 1.6 of the CF metadata conventions. In those cases we try to follow the spirit of the conventions. This attribute originates from the NUG standard.		
institution	'%(institute)s' (dynamic)	NC_STRING
The institute where the original data was produced. The actual processing center is given in the `ProcessingCenter` attribute, here we would like to indicate the responsible parties. The value is a combination from BIRA, DLR, ESA, FMI, IUP, KNMI, MPIC, SRON, ... The actual value is a combination of the ATBD institute and the institute that developed the processor. This attribute originates from the NUG standard.		
source	'Sentinel 5 precursor, TROPOMI, space-borne remote sensing, L2' (dynamic)	NC_STRING
Method of production of the original data. Value includes instrument, generic description of retrieval, product level, and adds a short product name and processor version. This attribute originates from the CF standard.		
history		NC_STRING
Provides an audit trail for modifications to the original data. Well-behaved generic netCDF filters will automatically append their name and the parameters with which they were invoked to the global history attribute of an input netCDF file. Each line shall begin with a timestamp indicating the date and time of day that the program was executed. This attribute originates from the NUG, CF standards.		
summary		NC_STRING
Miscellaneous information about the data or methods used to produce it. If processing in a degraded mode occured, then a note should be placed in this attribute. A degraded processing mode can occur for several reasons, for instance the use of static backup data for nominally dynamic input or an irradiance product that is older than a few days. A machine-parseable description is available in the "`processing_status`" attribute. This attribute originates from the CF standard.		
tracking_id		NC_STRING
This unique tracking ID is proposed by the Climate Change Initiative – European Space Agency project. This ID is a UUID and allows files to be referenced, and linked up to processing description, input data, documentation, etc. The CCI-ESA project uses version 4 UUIDs (random number based) for consistency with CMIP5. This attribute originates from the CCI standard.		
id	'%(logical_filename)s' (dynamic)	NC_STRING
The "id" and "naming_authority" attributes are intended to provide a globally unique identification for each dataset. The "id" value should attempt to uniquely identify the dataset. The naming authority allows a further refinement of the "id". The combination of the two should be globally unique for all time. We use the logical file name for the "id" attribute. This attribute originates from the CCI standard.		
time_reference	'YYYY-MM-DDT00:00:00Z' (dynamic)	NC_STRING
UTC time reference as an ISO 8601 [RD35] string. This corresponds to the UTC value in the `time` dimensional variable. By definition it indicates UTC midnight before the start of the granule.		

time_reference_days_since_1950	0 (dynamic)	NC_INT
The reference time expressed as the number of days since 1950-01-01. This is the reference time unit used by both TM5 and ECMWF.		
time_reference_julian_day	0.0 (dynamic)	NC_DOUBLE
The reference time expressed as a Julian day number.		
time_reference_seconds_since_1970	0 (dynamic)	NC_INT64
The reference time expressed as the number of seconds since 1970-01-01 00:00:00 UTC. This is the reference time unit used by Unix systems.		
time_coverage_start	'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)	NC_STRING
Start of the data granule in UTC as an ISO 8601 [RD35] string. See the discussion of the `delta_time` variable on page 39 for details.		
time_coverage_end	'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)	NC_STRING
End of the data granule in UTC as an ISO 8601 [RD35] string. See the discussion of the `delta_time` variable on page 39 for details.		
time_coverage_duration		NC_STRING
Duration of the data granule as an ISO 8601 [RD35] duration string ("PT%(duration_seconds)sS"). This attribute originates from the CCI standard.		
time_coverage_resolution		NC_STRING
Interval between measurements in the data granule as an ISO 8601 [RD35] duration string ("PT%(interval_seconds)fS"). For most products this is 840 or 1080 ms in nominal operation, except for "`L2__O3__PR`", which uses 3240 ms due to coaddition. This attribute originates from the CCI standard.		
orbit	0 (dynamic)	NC_INT
The absolute orbit number, starting at 1 – first ascending node crossing after spacecraft separation. For pre-launch testing this value should be set to "-1".		
references	'%(references)s' (static)	NC_STRING
References that describe the data or methods used to produce it. This attribute originates from the CF standard.		
processor_version	'%(version)s' (dynamic)	NC_STRING
The version of the data processor, as string of the form "major.minor.patch".		
keywords_vocabulary	'AGU index terms, http://publications.agu.org/author-resource-center/index-terms/' (static)	NC_STRING
The guidelines followed for the keywords attribute. We use the index terms published by the AGU.		
keywords	'%(keywords_agu)s' (dynamic)	NC_STRING
Keywords from the "`keywords_vocabulary`" describing the contents of the file. To be provided by the ATBD authors.		
standard_name_vocabulary	'NetCDF Climate and Forecast Metadata Conventions Standard Name Table (v29, 08 July 2015), http://cfconventions.org/standard-names.html' (static)	NC_STRING
The table followed for the standard_name attributes.		
naming_authority	'%(naming_authority)s' (dynamic)	NC_STRING
Specify who is giving out the `id` attribute. This attribute originates from the CCI standard.		
cdm_data_type	'Swath' (static)	NC_STRING
The THREDDS data type appropriate for this dataset, fixed to "Swath" for S5P level 2 products. This attribute originates from the CCI standard.		
date_created	'YYYY-mm-ddTHH:MM:SS.ffffffZ' (dynamic)	NC_STRING
The date on which this file was created. This attribute originates from the CCI standard.		
creator_name	'%(credit)s' (dynamic)	NC_STRING

The name of the creator, equal to the value of the “gmd:credit” attribute. For S5P this attribute is set to “The Sentinel 5 Precursor TROPOMI Level 2 products are developed with funding from the European Space Agency (ESA), the Netherlands Space Office (NSO), the Belgian Science Policy Office, the German Aerospace Center (DLR) and the Bayerisches Staatsministerium für Wirtschaft und Medien, Energie und Technologie (StMWi).” This attribute originates from the CCI standard.

creator_url ‘%(creator_url)s’ (dynamic) NC_STRING

Hyperlink to a location where more information on the product can be found. Set to `http://www.tropomi.eu/`. This attribute originates from the CCI standard.

creator_email ‘EOSupport@Copernicus.esa.int’ (dynamic) NC_STRING

Point of contact for more information and support for this product. Set to “mailto:EOSupport@Copernicus.esa.int”. This attribute originates from the CCI standard.

project ‘Sentinel 5 precursor/TROPOMI’ (dynamic) NC_STRING

The name of the scientific project that created the data. This attribute originates from the CCI standard.

geospatial_lat_min NC_FLOAT

Lowest latitude present in the file in decimal degrees. This attribute originates from the CCI standard.

geospatial_lat_max NC_FLOAT

Highest latitude present in the file in decimal degrees. This attribute originates from the CCI standard.

geospatial_lon_min NC_FLOAT

Lowest longitude present in the file in decimal degrees. This attribute originates from the CCI standard.

geospatial_lon_max NC_FLOAT

Highest longitude present in the file in decimal degrees. This attribute originates from the CCI standard.

license ‘No conditions apply’ (static) NC_STRING

describe the restrictions to data access and distribution. For S5P “No conditions apply”. This attribute originates from the CCI standard.

platform ‘S5P’ (static) NC_STRING

Name of the satellite, set to “S5P”. This attribute originates from the CCI standard.

sensor ‘TROPOMI’ (static) NC_STRING

Name of the sensor, set to “TROPOMI”. This attribute originates from the CCI standard.

spatial_resolution NC_STRING

Spatial resolution at nadir. For most products this is either “$7.0 \times 3.5\,\mathrm{km}^2$” or “$5.5 \times 3.5\,\mathrm{km}^2$” (for the new pixel size since 6th of August 2019), except for “`L2__O3__PR`”, which uses “$28 \times 21\,\mathrm{km}^2$” and “`L2__CO____`” and “`L2__CH4___`”, which both use“$7 \times 7\,\mathrm{km}^2$”. This attribute originates from the CCI standard.

cpp_compiler_version NC_STRING

The version of the compiler used for the C++ code. The value of this attribute is set via the Makefile.

cpp_compiler_flags NC_STRING

The compiler flags passed to the C++ compiler. The value of this attribute is set via the Makefile.

f90_compiler_version NC_STRING

The version of the compiler version used for the Fortran code. The value of this attribute is set via the Makefile. Note that not all processors make use of Fortran code.

f90_compiler_flags NC_STRING

The compiler flags passed to the Fortran compiler. The value of this attribute is set via the Makefile. Note that not all processors make use of Fortran code.

exe_linker_flags NC_STRING

The flags will be used by the linker when creating an executable. The value of this attribute is set via the Makefile.

build_date NC_STRING

The date on which the processor was built.

revision_control_identifier ‘%(revision_control_source_identifier)s’ (dynamic) NC_STRING

Revision control system identifier for the source used to build this processor.

geolocation_grid_from_band NC_INT

The band from which the geolocation was taken, useful for colocating the level 2 output with other products.		
identifier_product_doi	'%(product_doi)s' (dynamic)	NC_STRING
This is the DOI ("Digital Object Identifier") of the current product. It allows to easily find download and background information, even if that location is moved after the file has been created.		
identifier_product_doi_authority	'http://dx.doi.org/' (static)	NC_STRING
This attribute defines the authoritative service for use with DOI values in resolving to the URL location.		
algorithm_version	'%(algorithm_version)s' (dynamic)	NC_STRING
The algorithm version, separate from the processor (framework) version, to accomodate different release schedules for different products.		
product_version	'0.0.0' (dynamic)	NC_STRING
The product version, separate from the processor (framework) and algorithm version.		
processing_status	'Nominal' (dynamic)	NC_STRING
Description the processing status of the granule on a global level, mainly based on the availability of auxiliary input data.		
Possible values: Nominal, Degraded		

12.2 Common file-level attributes for DLR

These are the file-level attributes, DLR-L2 specific.

Name	*Value*	*Type*
cloud_mode		NC_STRING
The attribute aims at identifying the source of the cloud parameter, either "cal" or "crb".		
Possible values: crb, cal		

12.3 Status dynamic ECMWF auxiliary data

If the ECMWF dynamic auxiliary data is not available a fallback solution will be used. In this case the Level 2 output file will be flagged using the "`Status_MET_2D`" global attribute.

Name	*Value*	*Type*
Status_MET_2D		NC_STRING
The status of ECMWF input, either "Nominal" or "Fallback". Note that the "MET_2D" auxiliary input is used as an achor point for *all* meteorological data (where applicable).		
Possible values: Nominal, Fallback		

12.4 Status dynamic NISE auxiliary data

If the NISE dynamic auxiliary data is not available a fallback solution will be used. In this case the Level 2 output file will be flagged using the "`Status_NISE__`" global attribute.

Name	*Value*	*Type*
Status_NISE__		NC_STRING
The status of NISE input, either "Nominal" or "Fallback".		
Possible values: Nominal, Fallback		

12.5 Status background correction auxiliary data

In case of unavailability of background correction auxiliary data, the correction will be not applied and the L2 output file will be flag accordingly.

Name	*Value*	*Type*
Status_BG		NC_STRING
The status of background correction input, either “Nominal” or “Fallback”.		
Possible values: Nominal, Fallback		

12.6 Status dynamic NPP-VIIRS auxiliary data

The NPP-VIIRS dynamic auxiliary data is written into the level-2 product and then later used by the background processors to generate the AUX_BGCLD_ and AUX_BGO3__ products. The availability does not affect the processing status of the current product.

Name	*Value*	*Type*
Status_NP_BD3		NC_STRING
The status of the NPP-VIIRS band 3 input, either “Nominal” or “Unavailable”.		
Possible values: Nominal, Unavailable		

12.7 Common dimensions

The dimensions that are common to all products. These are all located in the “PRODUCT” group, and can be accessed from that group and all sub-groups of the “PRODUCT” group, that is everywhere except the “METADATA” group.

scanline The number of measurements along the swath, in the flight-direction.

size Unlimited.
mode Present in all modes.

ground_pixel The number of ground pixels across track. This depends on the product and will follow the dimension found in the main input Level 1B product.

size -1 (dynamic)
source L1B.
mode Present in all modes.

time The time dimension. See the discussion of the associated dimensional variable on page 37 for details.

size 1 (fixed)
mode Present in all modes.

12.8 Coordinate variables

All dimensions have an associated variable. These variables give a meaning to the dimension, spanning the axis of other variables.

scanline

Description: The coordinate variable `scanline` refers to the along-track dimension of the measurement. The scanlines are time-ordered, meaning that “earlier” measurements have a lower index than “later” measurements. This variable merely contains an index to ensure that when indicating a pixel in a file the same index is used. This avoids the off-by-one confusion that frequently occurred in OMI discussions.

Dimensions: scanline (coordinate variable).

Type: NC_INT.

Source: Processor.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
units	‘1’ (static)	NC_STRING
Dimensionless, no physical quantity. This attribute originates from the CF standard.		

	axis	'Y' (static)	NC_STRING
	long_name	'along-track dimension index' (static)	NC_STRING
	comment	'This coordinate variable defines the indices along track; index starts at 0' (static)	NC_STRING

ground_pixel

Description: The coordinate variable `ground_pixel` refers to the across-track dimension of the measurement. The `ground_pixel` ordering is from left to right with respect to the flight direction. For the Sentinel 5 precursor orbit this corresponds to west to east during the ascending part of the orbit, i.e. a higher index corresponds to a higher longitude. This variable merely contains an index to ensure that when indicating a pixel in a file the same index is used. This avoids the off-by-one confusion that frequently occurred in OMI discussions.

Dimensions: ground_pixel (coordinate variable).

Type: NC_INT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless, no physical quantity. This attribute originates from the CF standard.		
	axis	'X' (static)	NC_STRING
	long_name	'across-track dimension index' (static)	NC_STRING
	comment	'This coordinate variable defines the indices across track, from west to east; index starts at 0' (static)	NC_STRING

time

Description: The variable `time(time)` is the reference time of the measurements. The reference time is set to YYYY-MM-DDT00:00:00 UTC, midnight UTC before spacecraft midnight, the formal start of the current orbit. The `delta_time(scanline)` variable indicates the time difference of the observations with the reference time. Thus combining the information of `time(time)` and `delta_time(scanline)` yields the measurement time for each scanline as UTC time. The reference `time(time)` corresponds to the global attribute `time_reference` which is specified as a UTC time specified as an ISO 8601 [RD35] date.

Dimensions: time (coordinate variable).

Type: NC_INT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'seconds since 2010-01-01 00:00:00' (dynamic)	NC_STRING
	standard_name	'time' (static)	NC_STRING
	axis	'T' (static)	NC_STRING
	long_name	'reference time for the measurements' (static)	NC_STRING
	comment	'The time in this variable corresponds to the time in the time_reference global attribute' (static)	NC_STRING

12.9 Corner Dimension

All dimensions have an associated variable. Corner dimension is included in a separated file.

corner

Description:	An index for the pixel corners. We follow the CF-Metadata conventions [ER5, section 7.1]. The full coordinate system is right-handed, and the order of the pixel corners is counter-clockwise, starting in the "lower-left" corner (i.e. the smallest value in both latitude and longitude on the ascending part of the orbit, or equivalently for TROPOMI the lowest value for both the `ground_pixel` and `scanline` indices). See figure 6 on page 16 for a graphical depiction of the corners.		
Dimensions:	corner (coordinate variable).		
Type:	NC_INT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless, no physical quanity. This attribute originates from the CF standard.		
	long_name	'pixel corner index' (static)	NC_STRING
	comment	'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).' (static)	NC_STRING

12.10 The geolocation fields

The latitude and longitude. Used in all products, placed in the "PRODUCT" group.

latitude			
Description:	The latitude of the pixel centers of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'pixel center latitude' (static)	NC_STRING
	units	'degrees_north' (static)	NC_STRING
	standard_name	'latitude' (static)	NC_STRING
	valid_min	-90.0 (static)	NC_FLOAT
	valid_max	90.0 (static)	NC_FLOAT
	bounds	'/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/latitude_bounds' (static)	NC_STRING
	A link to the boundary coordinates, i.e. the pixel corners. Note that the use of group-names in this attribute is an extension of the climate and forecasting metadata conventions.		
longitude			
Description:	The longitude of the pixel centers of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*

	long_name	'pixel center longitude' (static)	NC_STRING
	units	'degrees_east' (static)	NC_STRING
	standard_name	'longitude' (static)	NC_STRING
	valid_min	-180.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT
	bounds	'/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/ longitude_bounds' (static)	NC_STRING
	A link to the boundary coordinates, i.e. the pixel corners. Note that the use of group-names in this attribute is an extension of the climate and forecasting metadata conventions.		

12.11 Common product fields

delta_time

Description: The `delta_time(scanline)` variable indicates the time difference with the reference time `time(time)` (see page 37). Thus combining the information of `time(time)` and `delta_time(scanline)` yields the start of the measurement time for each scanline as TAI2010 time. Combining the information in the global attribute `time_reference` with `delta_time(scanline)` yields the start of the measurement time in UTC time. The UTC time derived for the first scanline corresponds to the global attribute `time_coverage_start`. However, the UTC time derived for the last scanline does not correspond to global attribute `time_coverage_end`. One scanline measurement is the result of adding independent measurements during one coaddition period. The scanline measurement is given the measurement time of the first sample in this co-addition. It is the measurement time of the last sample in the coaddition period of the last scanline that corresponds to `time_coverage_end`.

This variable gives the time offset in ms accuracy.

Dimensions: time, scanline, ground_pixel.

Type: NC_INT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'offset from reference start time of measurement' (static)	NC_STRING
	units	'milliseconds since %(ref_time)s' (static)	NC_STRING

time_utc

Description: The time of observation expressed as ISO 8601 [RD35] date-time string.

Dimensions: time, scanline.

Type: NC_STRING.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'Time of observation as ISO 8601 date-time string' (static)	NC_STRING

qa_value

Description: A continuous quality descriptor, varying between 0 (no data) and 1 (full quality data). The value will change based on observation conditions and retrieval flags. Detailed quality flags are provided in the `processing_quality_flags` elsewhere in the product.

Dimensions: time, scanline, ground_pixel.

Type: NC_UBYTE.

Source: Processor.

Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	scale_factor	0.01 (static)	NC_FLOAT
	add_offset	0 (static)	NC_FLOAT
	valid_min	0 (static)	NC_UBYTE
	valid_max	100 (static)	NC_UBYTE
	long_name	'data quality value' (static)	NC_STRING
	comment	'A continuous quality descriptor, varying between 0 (no data) and 1 (full quality data). Recommend to ignore data with qa_value < 0.5' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

12.12 Main CAL Cloud Product

Variables in main_cloud_product_cal

cloud_fraction			
Description:	Retrieved effective radiometric cloud fraction using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	long_name	'effective radiometric cloud fraction' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Coregistered effective radiometric cloud fraction using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
cloud_fraction_precision			
Description:	Error of the retrieved effective radiometric cloud fraction using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	long_name	'effective radiometric cloud fraction precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING

	comment	'Error of the coregistered effective radiometric cloud fraction using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_top_pressure

Description: Retrieved atmospheric pressure at the level of cloud top using the OCRA/ROCINN CAL model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'air_pressure_at_cloud_top' (static)	NC_STRING
	long_name	'cloud optical centroid top pressure' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Coregistered and converted atmospheric pressure at the level of cloud top using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_top_pressure_precision

Description: Error of the retrieved atmospheric pressure at the level of cloud top using the OCRA/ROCINN CAL model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'air_pressure_at_cloud_top standard_error' (static)	NC_STRING
	long_name	'cloud optical centroid top pressure precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the coregistered and converted atmospheric pressure at the level of cloud top using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_base_pressure

Description: Cloud base pressure calculated using the OCRA/ROCINN CAL model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'air_pressure_at_cloud_base' (static)	NC_STRING
	long_name	'cloud base pressure assumed in ROCINN retrieval' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Coregistered and converted cloud base pressure retrieved using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_base_pressure_precision

Description: Error of the cloud base pressure calculated using the OCRA/ROCINN CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'air_pressure_at_cloud_base standard_error' (static)	NC_STRING
	long_name	'cloud base pressure precision assumed in ROCINN retrieval' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the coregistered and converted cloud base pressure retrieved using the OCRA/ROCINN CAL model' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_top_height

Description: Retrieved vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	long_name	'cloud top height' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Coregistered vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_top_height_precision

Description:	Error of the retrieved vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	long_name	'cloud top height precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the coregistered vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_base_height

Description:	Cloud base height calculated w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	long_name	'cloud base height assumed in ROCINN retrieval' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Coregistered cloud base height w.r.t. the geoid/ MSL using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_base_height_precision

Description:	Error of the cloud base height calculated w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	long_name	'cloud base height precision assumed in ROCINN retrieval' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the coregistered cloud base height w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
cloud_optical_thickness			
Description:	Cloud Optical Thickness using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	standard_name	'atmosphere_optical_thickness_due_to_cloud' (static)	NC_STRING
	long_name	'cloud optical thickness' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Coregistered cloud optical thickness based on the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
cloud_optical_thickness_precision			
Description:	Error of the cloud Optical Thickness using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	standard_name	'atmosphere_optical_thickness_due_to_cloud standard_error' (static)	NC_STRING
	long_name	'cloud optical thickness precision coregistered using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the coregistered cloud optical thickness based on the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

12.13 Additional geolocation support fields

satellite_latitude			
Description:	Latitude of the geodetic sub satellite point on the WGS84 reference ellipsoid.		
Dimensions:	time, scanline.		
Type:	NC_FLOAT.		
Source:	L1B.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'sub satellite latitude' (static)	NC_STRING

	units	'degrees_north' (static)	NC_STRING
	comment	'Latitude of the geodetic sub satellite point on the WGS84 reference ellipsoid' (static)	NC_STRING
	valid_min	-90.0 (static)	NC_FLOAT
	valid_max	90.0 (static)	NC_FLOAT

satellite_longitude

Description: Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid.
Dimensions: time, scanline.
Type: NC_FLOAT.
Source: L1B.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'satellite_longitude' (static)	NC_STRING
	units	'degrees_east' (static)	NC_STRING
	comment	'Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid' (static)	NC_STRING
	valid_min	-180.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT

satellite_altitude

Description: The altitude of the satellite with respect to the geodetic sub satellite point on the WGS84 reference ellipsoid.
Dimensions: time, scanline.
Type: NC_FLOAT.
Source: L1B.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'satellite altitude' (static)	NC_STRING
	units	'm' (static)	NC_STRING
	comment	'The altitude of the satellite with respect to the geodetic sub satellite point on the WGS84 reference ellipsoid' (static)	NC_STRING
	valid_min	700000.0 (static)	NC_FLOAT
	valid_max	900000.0 (static)	NC_FLOAT

satellite_orbit_phase

Description: Relative offset $[0.0, \ldots, 1.0]$ of the measurement in the orbit.
Dimensions: time, scanline.
Type: NC_FLOAT.
Source: L1B.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'fractional satellite orbit phase' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	comment	'Relative offset [0.0, ..., 1.0] of the measurement in the orbit' (static)	NC_STRING
	valid_min	-0.02 (static)	NC_FLOAT
	valid_max	1.02 (static)	NC_FLOAT

solar_zenith_angle

Description: Solar zenith angle ϑ_0 at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical. ESA definition of day side: $\vartheta_0 < 92^\circ$. Pixels are processed when $\vartheta_0 \leq \vartheta_0^{\text{max}}$ with $80^\circ \leq \vartheta_0^{\text{max}} \leq 88^\circ$, depending on the algorithm. The actual value for ϑ_0^{max} can be found in the algorithm metadata settings.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: L1B.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'solar zenith angle' (static)	NC_STRING
standard_name	'solar_zenith_angle' (static)	NC_STRING
units	'degree' (static)	NC_STRING
valid_min	0.0 (static)	NC_FLOAT
valid_max	180.0 (static)	NC_FLOAT
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
comment	'Solar zenith angle at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical' (static)	NC_STRING

solar_azimuth_angle

Description: The solar azimuth angle at the ground pixel location on the reference ellipsoid. The angle is measured clockwise from the North (North = 0°, East = 90°, South = 180°, West = 270°). This is the same definition that is use in both OMI and GOME-2 level 1B files.

See the note on the `viewing_azimuth_angle` on the calculation of the relative azimuht angle as used in radiative transfer calculations.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: L1B.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'solar azimuth angle' (static)	NC_STRING
standard_name	'solar_azimuth_angle' (static)	NC_STRING
units	'degree' (static)	NC_STRING
valid_min	-180.0 (static)	NC_FLOAT
valid_max	180.0 (static)	NC_FLOAT
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
comment	'Solar azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = 270)' (static)	NC_STRING

viewing_zenith_angle

Description: Zenith angle of the satellite ϑ at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source:	L1B.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'viewing zenith angle' (static)	NC_STRING
	standard_name	'viewing_zenith_angle' (static)	NC_STRING
	units	'degree' (static)	NC_STRING
	valid_min	0.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
	comment	'Zenith angle of the satellite at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical' (static)	NC_STRING

viewing_azimuth_angle

Description:	The satellite azimuth angle at the ground pixel location on the reference ellipsoid. The angle is measured clockwise from the North (North = $0°$, East = $90°$, South = $180°$, West = $270°$). This is the same definition that is use in both OMI and GOME-2 level 1B files. To calculate the azimuth difference $\varphi - \varphi_0$ it is not sufficient to just subtract `solar_azimuth_angle` from `viewing_azimuth_angle`. The angle needed for radiative transfer calculations is $(180° - (\varphi - \varphi_0)) \bmod 360°$.
Dimensions:	time, scanline, ground_pixel.
Type:	NC_FLOAT.
Source:	L1B.
Mode:	Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'viewing azimuth angle' (static)	NC_STRING
	standard_name	'viewing_azimuth_angle' (static)	NC_STRING
	units	'degree' (static)	NC_STRING
	valid_min	-180.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
	comment	'Satellite azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = 270)' (static)	NC_STRING

latitude_bounds

Description:	The latitude of the pixel corners of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid. The order of the pixel corners follows the CF-metadata conventions [ER5, section 7.1], i.e. the ordering is counter-clockwise when viewed from above. A graphical representation is given in figure 6.
Dimensions:	time, scanline, ground_pixel, corner.
Type:	NC_FLOAT.
Source:	Processor.

Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'degrees_north' (static)	NC_STRING

longitude_bounds

Description:	The longitude of the pixel corners of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid. The order of the pixel corners follows the CF-metadata conventions [ER5, section 7.1], i.e. the ordering is counter-clockwise when viewed from above. A graphical representation is given in figure 6.		
Dimensions:	time, scanline, ground_pixel, corner.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'degrees_east' (static)	NC_STRING

geolocation_flags

Description:	Additional flags describing the ground pixel, including the influence of a solar eclipse, the possibility of sun glint, whether we are in the descending part of the orbit, whether we are on the night side of the orbit, whether the pixel crosses the dateline (useful for plotting), or if there was some geolocation error.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_UBYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	_FillValue	255 (static)	NC_UBYTE
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	flag_masks	0, 1, 2, 4, 8, 16, 128 (static)	NC_UBYTE
	flag_meanings	'no_error solar_eclipse sun_glint_possible descending night geo_boundary_crossing geolocation_error' (static)	NC_STRING
	flag_values	0, 1, 2, 4, 8, 16, 128 (static)	NC_UBYTE
	long_name	'ground pixel quality flag' (static)	NC_STRING
	max_val	254 (static)	NC_UBYTE
	min_val	0 (static)	NC_UBYTE
	units	'1' (static)	NC_STRING

12.14 Main fields for Cloud Product based on CRB model

Variables in main_cloud_product_crb

cloud_fraction_crb

Description:	Retrieved effective radiometric cloud fraction using the OCRA/ROCINN CRB model.
Dimensions:	time, scanline, ground_pixel.
Type:	NC_FLOAT.
Source:	Processor.
Mode:	Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'TBD' (static)	NC_STRING
	long_name	'effective radiometric cloud fraction from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Coregistered effective radiometric cloud fraction using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_fraction_crb_precision

Description: Error of the retrieved effective radiometric cloud fraction using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'TBD' (static)	NC_STRING
	long_name	'effective radiometric cloud fraction precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered effective radiometric cloud fraction using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_pressure_crb

Description: Retrieved atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid pressure from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Coregistered and converted atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
cloud_pressure_crb_precision			
Description:	Error of the retrieved atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid pressure precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered and converted atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
cloud_height_crb			
Description:	Retrieved height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid height from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Coregistered height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
cloud_height_crb_precision			
Description:	Error of the retrieved height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING

	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid height precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_albedo_crb

Description: Albedo of cloud using the OCRA/ROCINN CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'cloud_albedo' (static)	NC_STRING
	long_name	'cloud albedo from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_albedo_crb_precision

Description: Error of the albedo of cloud using the OCRA/ROCINN CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'cloud_albedo_standard_error' (static)	NC_STRING
	long_name	'cloud albedo precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

12.15 Detailed Results related to OCRA/ROCINN CAL Cloud Product

Variables in detailed_results_cloud_product_cal

surface_albedo_fitted			
Description:	Surface albedo fitted using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'surface_albedo' (static)	NC_STRING
	long_name	'surface albedo fitted' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Coregistered surface albedo fitted using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
surface_albedo_fitted_precision			
Description:	Error of the fitted surface albedo calculated using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	standard_name	'surface_albedo_standard_error' (static)	NC_STRING
	long_name	'surface albedo fitted precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	comment	'Error of the coregistered surface albedo fitted using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

12.16 Detailed Results related to the NIR variables of the Cloud Product

Variables in detailed_results_cloud_product_nir

cloud_fraction_apriori_nir			
Description:	A Priori Cloud Fraction coregistered by the OCRA/ROCINN model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*

	units	'1' (static)	NC_STRING
	long_name	'effective radiometric cloud fraction a priori' (static)	NC_STRING
	comment	'Coregistered radiometric cloud fraction based on the OCRA model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_top_height_nir

Description: Retrieved vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	long_name	'cloud top height' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Retrieved vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_optical_thickness_nir

Description: Cloud Optical Thickness using the OCRA/ROCINN CAL model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	standard_name	'atmosphere_optical_thickness_due_to_cloud' (static)	NC_STRING
	long_name	'cloud optical thickness' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Retrieved cloud optical thickness based on the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_fraction_nir

Description: Retrieved effective radiometric cloud fraction using the OCRA/ROCINN CAL model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	long_name	'effective radiometric cloud fraction' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Retrieved effective radiometric cloud fraction using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

surface_albedo_fitted_nir

Description:	Surface albedo fitted using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'surface_albedo' (static)	NC_STRING
	long_name	'surface albedo fitted' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Surface albedo fitted using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_top_height_precision_nir

Description:	Error of the retrieved vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	long_name	'cloud top height precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the retrieved vertical distance of the cloud top above the surface w.r.t. the geoid/MSL using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_optical_thickness_precision_nir

Description:	Error of the cloud Optical Thickness using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	standard_name	'atmosphere_optical_thickness_due_to_cloud standard_error' (static)	NC_STRING
	long_name	'cloud optical thickness precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the retrieved cloud optical thickness based on the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_fraction_precision_nir

Description:	Error of the retrieved effective radiometric cloud fraction using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	long_name	'effective radiometric cloud fraction precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Error of the retrieved effective radiometric cloud fraction using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

surface_albedo_fitted_precision_nir

Description:	Error of the fitted surface albedo calculated using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	standard_name	'surface_albedo_standard_error' (static)	NC_STRING
	long_name	'surface albedo fitted precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		

	comment	'Error of the fitted surface albedo calculated using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

regularization_parameter_nir

Description: Regularization parameter of the rocinn inversion using the CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'regularization parameter of the rocinn inversion using the CAL model' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

condition_number_nir

Description: Final condition number of the rocinn inversion using the CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final condition number of the rocinn inversion using the CAL model' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

degrees_of_freedom_nir

Description: Final Degrees of freedom of the rocinn inversion using the CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final degrees of freedom of the rocinn inversion using the CAL model' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.

shannon_information_content_nir

Description: Final Shannon information content of the rocinn inversion using the CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final shannon information content of the rocinn inversion using the CAL model' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.

number_of_iterations_nir

Description: Number of rocinn iterations for the CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_USHORT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'number of rocinn iterations reached per pixel for the CAL model' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.

fitted_root_mean_square_nir

Description: Final root mean square residual of the rocinn inversion using the CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'root mean square residual' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.

convergence_flag_nir

Description: Flag signaling the convergence of the rocinn inversion using the CAL model.
Dimensions: time, scanline, ground_pixel.

Type: NC_UBYTE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'flag signaling the convergence of the cal algorithm' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

fitted_state_vector_nir

Description: Fitting vector results from the CAL ROCINN retrieval.
Dimensions: time, scanline, ground_pixel, number_fitting_parameter.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'various' (static)	NC_STRING
	long_name	'fitted parameters in CAL ROCINN retrieval' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
	index_meaning	'1' (dynamic)	NC_STRING
	This attribute provides the meaning of the indexes for the current variable. Indexes are supposed to be divided by a blank space.		

covariance_matrix_diagonal_nir

Description: Diagonal of the covariance matrix from the CAL ROCINN retrieval.
Dimensions: time, scanline, ground_pixel, number_fitting_parameter.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'The diagonal entries of the covariance matrix of the CAL ROCINN retrieval' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
	index_meaning	'1' (dynamic)	NC_STRING
	This attribute provides the meaning of the indexes for the current variable. Indexes are supposed to be divided by a blank space.		

cloud_height_crb_nir

Description:	Retrieved height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid height from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Retrieved height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_albedo_crb_nir

Description:	Albedo of cloud using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'cloud_albedo' (static)	NC_STRING
	long_name	'cloud albedo from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Retrieved cloud albedo based on the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_fraction_crb_nir

Description:	Retrieved effective radiometric cloud fraction using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'TBD' (static)	NC_STRING
	long_name	'effective radiometric cloud fraction from the CRB model' (static)	NC_STRING

	source	'crb' (static)	NC_STRING
	comment	'Retrieved effective radiometric cloud fraction using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

surface_albedo_fitted_crb_nir

Description: Surface albedo fitted using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'surface_albedo' (static)	NC_STRING
	long_name	'surface albedo fitted from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Surface albedo fitted using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_height_crb_precision_nir

Description: Error of the retrieved height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid height precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the retrieved height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_albedo_crb_precision_nir

Description: Error of the albedo of cloud using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'cloud_albedo_standard_error' (static)	NC_STRING
	long_name	'cloud albedo precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the retrieved cloud albedo based on the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_fraction_crb_precision_nir

Description:	Error of the retrieved effective radiometric cloud fraction using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'TBD' (static)	NC_STRING
	long_name	'effective radiometric cloud fraction precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the retrieved effective radiometric cloud fraction using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

surface_albedo_fitted_crb_precision_nir

Description:	Error of the fitted surface albedo calculated using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'surface_albedo_standard_error' (static)	NC_STRING
	long_name	'surface albedo fitted precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING

	comment	'Error of the fitted surface albedo calculated using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

regularization_parameter_crb_nir

Description: Regularization parameter of the rocinn inversion using the CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'regularization parameter of the rocinn inversion using the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

condition_number_crb_nir

Description: Final condition number of the rocinn inversion using the CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final condition number of the rocinn inversion using the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

degrees_of_freedom_crb_nir

Description: Final Degrees of freedom of the rocinn inversion using the CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final degrees of freedom of the rocinn inversion using the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING

	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

shannon_information_content_crb_nir

Description: Final Shannon information content of the rocinn inversion using the CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final shannon information content of the rocinn inversion using the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

number_of_iterations_crb_nir

Description: Number of rocinn iterations for the CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_USHORT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'number of rocinn iterations reached per pixel for the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

fitted_root_mean_square_crb_nir

Description: Final root mean square residual of the rocinn inversion using the CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'root mean square residual from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

convergence_flag_crb_nir

Description: Flag signaling the convergence of the rocinn inversion using the CRB model.

Dimensions:	time, scanline, ground_pixel.		
Type:	NC_UBYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'flag signaling the convergence of the crb algorithm' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

fitted_state_vector_crb_nir

Description:	Fitting vector results from the CRB ROCINN retrieval.		
Dimensions:	time, scanline, ground_pixel, number_fitting_parameter_crb.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'various' (static)	NC_STRING
	long_name	'fitted parameters in CRB ROCINN retrieval' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
	index_meaning	'1' (dynamic)	NC_STRING
	This attribute provides the meaning of the indexes for the current variable. Indexes are supposed to be divided by a blank space.		

covariance_matrix_diagonal_crb_nir

Description:	Diagonal of the covariance matrix from the CRB ROCINN retrieval.		
Dimensions:	time, scanline, ground_pixel, number_fitting_parameter_crb.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'The diagonal entries of the covariance matrix of the CRB ROCINN retrieval' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
	index_meaning	'1' (dynamic)	NC_STRING
	This attribute provides the meaning of the indexes for the current variable. Indexes are supposed to be divided by a blank space.		

effective_scene_height_nir

Description:	Retrieved effective scene height w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'effective scene height from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Retrieved effective scene height w.r.t. the geoid/ MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
effective_scene_albedo_nir			
Description:	Albedo of effective scene using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'effective_scene_albedo' (static)	NC_STRING
	long_name	'effective scene albedo from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Retrieved albedo of effective scene based on the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		
effective_scene_height_precision_nir			
Description:	Error of the retrieved scene height w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'effective scene height precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING

	comment	'Error of the retrieved effective scene height w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

effective_scene_albedo_precision_nir

Description: Error of the albedo of effective scene using the OCRA/ROCINN CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'effective_scene_albedo_standard_error' (static)	NC_STRING
	long_name	'effective scene albedo precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the retrieved albedo of effective scene based on the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

condition_number_ge_nir

Description: Final condition number of the rocinn inversion using the CRB model for the effective scene.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final condition number of the rocinn inversion using the CRB model for the effective scene' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

degrees_of_freedom_ge_nir

Description: Final Degrees of freedom of the rocinn inversion using the CRB model for the effective scene.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*

	units	'1' (static)	NC_STRING
	long_name	'final degrees of freedom of the rocinn inversion using the CRB model for the effective scene' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

shannon_information_content_ge_nir

Description: Final Shannon information content of the rocinn inversion using the CRB model for the effective scene.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final shannon information content of the rocinn inversion using the CRB model for the effective scene' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

number_of_iterations_ge_nir

Description: Number of rocinn iterations for the CRB model for the effective scene.

Dimensions: time, scanline, ground_pixel.

Type: NC_USHORT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'number of rocinn iterations reached per pixel for the CRB model for the effective scene' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

fitted_root_mean_square_ge_nir

Description: Final root mean square residual of the rocinn inversion using the CRB model for the effective scene.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING

	long_name	'root mean square residual from the CRB model for the effective scene' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

12.17 Additional detailed results fields

processing_quality_flags			
Description:	Processing quality flag. This flag indicates processing errors or reasons for not processing a particular pixel (collectively 'errors', leading to a fill value in the output) and warnings that occured while processing this pixel (warnings which may affect the quality of the retrieval result). A detailed description is provided in appendix A.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_UINT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'Processing quality flags' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	comment	'Flags indicating conditions that affect quality of the retrieval.' (static)	NC_STRING

flag_meanings	‘success radiance_missing irradiance_missing input_spectrum_missing reflectance_range_error ler_range_error snr_range_error sza_range_error vza_range_error lut_range_error ozone_range_error wavelength_offset_error initialization_error memory_error assertion_error io_error numerical_error lut_error ISRF_error convergence_error cloud_filter_convergence_error max_iteration_convergence_error aot_lower_boundary_convergence_error other_boundary_convergence_error geolocation_error ch4_noscat_zero_error h2o_noscat_zero_error max_optical_thickness_error aerosol_boundary_error boundary_hit_error chi2_error svd_error dfs_error radiative_transfer_error optimal_estimation_error profile_error cloud_error model_error number_of_input_data_points_too_low_error cloud_pressure_spread_too_low_error cloud_too_low_level_error generic_range_error generic_exception input_spectrum_alignment_error abort_error wrong_input_type_error wavelength_calibration_error coregistration_error slant_column_density_error airmass_factor_error vertical_column_density_error signal_to_noise_ratio_error configuration_error key_error saturation_error solar_eclipse_filter cloud_filter altitude_consistency_filter altitude_roughness_filter sun_glint_filter mixed_surface_type_filter snow_ice_filter aai_filter cloud_fraction_fresco_filter aai_scene_albedo_filter small_pixel_radiance_std_filter cloud_fraction_viirs_filter cirrus_reflectance_viirs_filter cf_viirs_swir_ifov_filter cf_viirs_swir_ofova_filter cf_viirs_swir_ofovb_filter cf_viirs_swir_ofovc_filter cf_viirs_nir_ifov_filter cf_viirs_nir_ofova_filter cf_viirs_nir_ofovb_filter cf_viirs_nir_ofovc_filter refl_cirrus_viirs_swir_filter refl_cirrus_viirs_nir_filter diff_refl_cirrus_viirs_filter ch4_noscat_ratio_filter ch4_noscat_ratio_std_filter h2o_noscat_ratio_filter h2o_noscat_ratio_std_filter diff_psurf_fresco_ecmwf_filter psurf_fresco_stdv_filter ocean_filter time_range_filter pixel_or_scanline_index_filter geographic_region_filter input_spectrum_warning wavelength_calibration_warning extrapolation_warning sun_glint_warning south_atlantic_anomaly_warning sun_glint_correction snow_ice_warning cloud_warning AAI_warning pixel_level_input_data_missing data_range_warning low_cloud_fraction_warning altitude_consistency_warning signal_to_noise_ratio_warning deconvolution_warning so2_volcanic_origin_likely_warning so2_volcanic_origin_certain_warning interpolation_warning saturation_warning high_sza_warning cloud_retrieval_warning cloud_inhomogeneity_warning’ (static)	NC_STRING

	flag_masks	255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 256, 512, 1024, 2048, 4096, 8192, 16384, 32768, 65536, 131072, 262144, 524288, 1048576, 2097152, 4194304, 8388608, 16777216, 33554432, 67108864, 134217728, 268435456, 536870912 (static)	NC_UINT
	flag_values	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 256, 512, 1024, 2048, 4096, 8192, 16384, 32768, 65536, 131072, 262144, 524288, 1048576, 2097152, 4194304, 8388608, 16777216, 33554432, 67108864, 134217728, 268435456, 536870912 (static)	NC_UINT
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

12.18 Debug fields for UPAS

debug_upas2_levels_1 Level Dim for debugging porpuse.

size -1 (fixed)
mode Present in all modes.

debug_upas2_float1D			
Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_double1D	
Description:	Debug field, not available in operational environment.
Dimensions:	time, scanline.
Type:	NC_DOUBLE.
Source:	Processor.
Mode:	Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_int1D

Description: Debug field, not available in operational environment.
Dimensions: time, scanline.
Type: NC_INT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ubyte1D

Description: Debug field, not available in operational environment.
Dimensions: time, scanline.
Type: NC_UBYTE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_byte1D

Description: Debug field, not available in operational environment.
Dimensions: time, scanline.
Type: NC_BYTE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ushort1D

Description: Debug field, not available in operational environment.
Dimensions: time, scanline.
Type: NC_USHORT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float2D_1

Description: Debug field, not available in operational environment.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING

	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float2D_2

Description: Debug field, not available in operational environment.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float2D_3

Description: Debug field, not available in operational environment.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_double2D_1

Description: Debug field, not available in operational environment.
Dimensions: time, scanline, ground_pixel.
Type: NC_DOUBLE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_double2D_2

Description: Debug field, not available in operational environment.
Dimensions: time, scanline, ground_pixel.
Type: NC_DOUBLE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_double2D_3

Description: Debug field, not available in operational environment.
Dimensions: time, scanline, ground_pixel.
Type: NC_DOUBLE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_int2D_1

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_INT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_int2D_2

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_INT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_int2D_3

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_INT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ubyte2D_1

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_UBYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ubyte2D_2

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_UBYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ubyte2D_3

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		

Type:	NC_UBYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_byte2D_1

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_BYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_byte2D_2

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_BYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_byte2D_3

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_BYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ushort2D_1

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_USHORT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ushort2D_2

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_USHORT.		
Source:	Processor.		

Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_ushort2D_3

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_USHORT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float3D_1

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel, debug_upas2_levels_1.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float3D_2

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel, debug_upas2_levels_1.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float3D_3

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel, debug_upas2_levels_1.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float3D_4

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel, debug_upas2_levels_1.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*

	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float3D_5

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel, debug_upas2_levels_1.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

debug_upas2_float3D_6

Description:	Debug field, not available in operational environment.		
Dimensions:	time, scanline, ground_pixel, debug_upas2_levels_1.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

12.19 Computed polynomials and shift/squeeze values

Wavelength calibrations are written in the product.

12.19.1 Group "WAVELENGTH_CALIBRATIONS"

Dimensions in WAVELENGTH_CALIBRATIONS

number_of_calibrations The number of the calibrations depending on the solar spectrum.

size 1 (dynamic)
source Processor.
mode Present in all modes.

degrees_of_polynomial_shift Dimension relative to the degrees of the polynomial shift. It may have multiple windows.

size 1 (dynamic)
source Processor.
mode Present in all modes.

number_of_subwindows The number of subwindows used in order to calculate the shift. It may have multiple windows.

size 1 (dynamic)
source Processor.
mode Present in all modes.

Variables in WAVELENGTH_CALIBRATIONS

calibration_polynomial_coefficients in WAVELENGTH_CALIBRATIONS

Description: Computed coefficients of the polynomial function. It may have multiple windows.
Dimensions: number_of_calibrations, degrees_of_polynomial_shift.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'computed coefficients of the polynomial function' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING

calibration_subwindows_shift in WAVELENGTH_CALIBRATIONS

Description: Computed wavelengths shift values per subwindow. It may have multiple windows.
Dimensions: number_of_calibrations, number_of_subwindows.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'nm' (static)	NC_STRING
	long_name	'irradiance wavelengths shift fitted values per subwindow' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING

calibration_subwindows_squeeze in WAVELENGTH_CALIBRATIONS

Description: Computed wavelengths squeeze values per subwindow. It may have multiple windows.
Dimensions: number_of_calibrations, number_of_subwindows.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'irradiance wavelengths squeeze fitted values per subwindow' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING

calibration_subwindows_root_mean_square in WAVELENGTH_CALIBRATIONS

Description: Computed RMS values per subwindow. It may have multiple windows.
Dimensions: number_of_calibrations, number_of_subwindows.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'calibration rms per subwindow' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING

calibration_subwindows_wavelength in WAVELENGTH_CALIBRATIONS

Description: Calibration wavelength center in each subwindow. It may have multiple windows.
Dimensions: number_of_subwindows.
Type: NC_FLOAT.
Source: Processor.

Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'nm' (static)	NC_STRING
	long_name	'calibration wavelength center in each subwindow' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING

12.20 Additional data support fields

surface_altitude

Description:	The mean of the sub-pixels of the surface altitude above the reference geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	surface elevation database.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'surface altitude' (static)	NC_STRING
	standard_name	'surface_altitude' (static)	NC_STRING
	units	'm' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
	source	'http://topotools.cr.usgs.gov/gmted_viewer/' (static)	NC_STRING
	comment	'The mean of the sub-pixels of the surface altitude above the reference geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database' (static)	NC_STRING

surface_altitude_precision

Description:	The standard deviation of sub-pixels used in calculating the mean surface altitude above the reference geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	surface elevation database.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'surface altitude precision' (static)	NC_STRING
	standard_name	'surface_altitude standard_error' (static)	NC_STRING
	units	'm' (static)	NC_STRING
	standard_error_multiplier	1.0 (static)	NC_FLOAT
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
	source	'http://topotools.cr.usgs.gov/gmted_viewer/' (static)	NC_STRING

	comment	'The standard deviation of sub-pixels used in calculating the mean surface altitude above the reference geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database' (static)	NC_STRING

surface_classification

Description: This is a combined land/water mask and surface classification data field.

Dimensions: time, scanline, ground_pixel.

Type: NC_UBYTE.

Source: surface elevation database (including flag attributes).

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
units	'1' (static)	NC_STRING
long_name	'land-water mask' (static)	NC_STRING
comment	'flag indicating land/water and further surface classifications for the ground pixel' (static)	NC_STRING
source	'USGS (http://edc2.usgs.gov/glcc/globdoc2_0.php) and NASA SDP toolkit (http://newsroom.gsfc.nasa.gov/sdptoolkit/toolkit.html)' (static)	NC_STRING
flag_meanings	'land, water, some_water, coast, value_covers_majority_of_pixel, water+shallow_ocean, water+shallow_inland_water, water+ocean_coastline-lake_shoreline, water+intermittent_water, water+deep_inland_water, water+continental_shelf_ocean, water+deep_ocean, land+urban_and_built-up_land, land+dryland_cropland_and_pasture, land+irrigated_cropland_and_pasture, land+mixed_dryland-irrigated_cropland_and_pasture, land+cropland-grassland_mosaic, land+cropland-woodland_mosaic, land+grassland, land+shrubland, land+mixed_shrubland-grassland, land+savanna, land+deciduous_broadleaf_forest, land+deciduous_needleleaf_forest, land+evergreen_broadleaf_forest, land+evergreen_needleleaf_forest, land+mixed_forest, land+herbaceous_wetland, land+wooded_wetland, land+barren_or_sparsely_vegetated, land+herbaceous_tundra, land+wooded_tundra, land+mixed_tundra, land+bare_ground_tundra, land+snow_or_ice' (static)	NC_STRING
flag_values	0, 1, 2, 3, 4, 9, 17, 25, 33, 41, 49, 57, 8, 16, 24, 32, 40, 48, 56, 64, 72, 80, 88, 96, 104, 112, 120, 128, 136, 144, 152, 160, 168, 176, 184 (static)	NC_UBYTE
flag_masks	3, 3, 3, 3, 4, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249 (static)	NC_UBYTE
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].

instrument_configuration_identifier

Description: The IcID from the instrument configuration in the Level 1B data product. The TROPOMI instrument has many configurable parameters. For example, the exposure time, co-addition period, gains and (for UVN-DEMs) the binning factors can be varied. As a result, the instrument can be operated in many different modes or configurations. Each combination of instrument settings is referred to as an instrument configuration and is identified by an instrument configuration ID, a number in the range $[1, 65535]$. This instrument configuration ID, or IcID, is primarily used by the instrument, where it identifies an entry in the instrument configuration tables. On ground, the IcID is used to determine the intended purpose of a measurement and is used in the L0 to 1b data processing to determine the processing path.

Dimensions: time, scanline.

Type: NC_INT.

Source: L1B.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'IcID' (static)	NC_STRING
comment	'The Instrument Configuration ID defines the type of measurement and its purpose. The number of instrument configuration IDs will increase over the mission as new types of measurements are created and used' (static)	NC_STRING

instrument_configuration_version

Description: For an IcID (see the `instrument_configuration_identifier` above), it is possible to have multiple versions, identified by the instrument configuration version or IcVersion. The combination of IcID and IcVersion uniquely identifies the set of configuration settings of the instrument. At a given time, only one IcVersion of an IcID can be active within the instrument. The IcVersion allows to have multiple versions of a measurement with the same purpose, but with different settings. As a result of, for example, instrument degradation, it may be required to change the settings for a measurement. In that case, it is not necessary to create a new IcID, instead the same IcID can be using with a new IcVersion.

Dimensions: time, scanline.

Type: NC_SHORT.

Source: L1B.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'IcVersion' (static)	NC_STRING
comment	'Version of the instrument_configuration_identifier' (static)	NC_STRING

scaled_small_pixel_variance

Description: The scaled variance of the small pixel values for each ground pixel.

$$\langle R(t,r,c)\rangle = \frac{1}{N_{\text{small pixels}}} \sum_{i=0}^{N_{\text{small pixels}}-1} R(t,r,c,i) \tag{3}$$

$$V(t,r,c) = \frac{1}{N_{\text{small pixels}}} \sum_{i=0}^{N_{\text{small pixels}}-1} \left(R(t,r,c,i) - \langle R(t,r,c)\rangle\right)^2 \tag{4}$$

$$V_{\text{scaled}}(t,r,c) = \frac{V(t,r,c)}{\langle R(t,r,c)\rangle^2} \tag{5}$$

with $\langle R(t,r,c)\rangle$ the mean reflectance for small pixels of ground pixel (t,r,c), $V(t,r,c)$ the variance of the small pixels, $V_{\text{scaled}}(t,r,c)$ the scaled small pixel variance, and $R(t,r,c,i)$ with $i = [0,\ldots,N_{\text{small pixels}}-1]$ the small pixel reflectance of ground pixel (t,r,c). The reflectance R is calculated as $R = (\pi I)/(\mu_0 E_0)$, with I the radiance, E_0 the irradiance and $\mu_0 = \cos(\vartheta_0)$, where ϑ_0 is the solar zenith angle.

Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'scaled small pixel variance' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
	comment	'The scaled variance of the reflectances of the small pixels' (static)	NC_STRING
	radiation_wavelength		NC_FLOAT
	The approximate wavelength of the small pixel column in nm. Note that due to the spectral smile this wavelength will depend on the ground_pixel index.		

12.21 Input data common to all the L2 DLR products

Variables in input_data
The variables described in section 12.20 "Additional data support fields" on page 78 are included in the output at this location.

surface_pressure			
Description:	Surface pressure from ECMWF model data.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'surface_air_pressure' (static)	NC_STRING
	long_name	'surface_air_pressure' (static)	NC_STRING
	source		NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
northward_wind			
Description:	10 meter V wind component		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm s-1' (static)	NC_STRING
	Velocity in meters per second This attribute originates from the NUG, CF standards.		
	standard_name	'northward_wind' (static)	NC_STRING

	long_name	'Northward wind from ECMWF at 10 meter height level' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
eastward_wind			
Description:	10 meter U wind component		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'm s-1' (static)	NC_STRING
	Velocity in meters per second This attribute originates from the NUG, CF standards.		
	standard_name	'eastward_wind' (static)	NC_STRING
	long_name	'Eastward wind from ECMWF at 10 meter height level' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

12.21.1 Group "PROCESSOR"

The `processing_configuration` attribute of the PROCESSOR group aims at tracking the original configuration used for processing the current L2 product. It is also used in the latest version of the S5P L1b product.

Attributes in PROCESSOR

Group attributes attached to PROCESSOR		
Name	*Value*	*Type*
processing_configuration	'Processing configuration used to generate the current product' (static)	NC_STRING

12.22 Original and computed snow-ice flag

Variables in snow_ice_flag_var

snow_ice_flag_nise			
Description:	This is the original snow/ice classification data field from NSIDC/NISE. In case this auxiliary data was not available while processing, only FillValue are present in the data.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_UBYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'snow-ice mask' (static)	NC_STRING

_FillValue	'254UB' (static)	NC_STRING
comment	'flag indicating snow/ice at center of ground pixel' (static)	NC_STRING
source	'NSIDC/NISE' (static)	NC_STRING
flag_meanings	'snow-free_land sea_ice_1_percent sea_ice_2_percent sea_ice_3_percent sea_ice_4_percent sea_ice_5_percent sea_ice_6_percent sea_ice_7_percent sea_ice_8_percent sea_ice_9_percent sea_ice_10_percent sea_ice_11_percent sea_ice_12_percent sea_ice_13_percent sea_ice_14_percent sea_ice_15_percent sea_ice_16_percent sea_ice_17_percent sea_ice_18_percent sea_ice_19_percent sea_ice_20_percent sea_ice_21_percent sea_ice_22_percent sea_ice_23_percent sea_ice_24_percent sea_ice_25_percent sea_ice_26_percent sea_ice_27_percent sea_ice_28_percent sea_ice_29_percent sea_ice_30_percent sea_ice_31_percent sea_ice_32_percent sea_ice_33_percent sea_ice_34_percent sea_ice_35_percent sea_ice_36_percent sea_ice_37_percent sea_ice_38_percent sea_ice_39_percent sea_ice_40_percent sea_ice_41_percent sea_ice_42_percent sea_ice_43_percent sea_ice_44_percent sea_ice_45_percent sea_ice_46_percent sea_ice_47_percent sea_ice_48_percent sea_ice_49_percent sea_ice_50_percent sea_ice_51_percent sea_ice_52_percent sea_ice_53_percent sea_ice_54_percent sea_ice_55_percent sea_ice_56_percent sea_ice_57_percent sea_ice_58_percent sea_ice_59_percent sea_ice_60_percent sea_ice_61_percent sea_ice_62_percent sea_ice_63_percent sea_ice_64_percent sea_ice_65_percent sea_ice_66_percent sea_ice_67_percent sea_ice_68_percent sea_ice_69_percent sea_ice_70_percent sea_ice_71_percent sea_ice_72_percent sea_ice_73_percent sea_ice_74_percent sea_ice_75_percent sea_ice_76_percent sea_ice_77_percent sea_ice_78_percent sea_ice_79_percent sea_ice_80_percent sea_ice_81_percent sea_ice_82_percent sea_ice_83_percent sea_ice_84_percent sea_ice_85_percent sea_ice_86_percent sea_ice_87_percent sea_ice_88_percent sea_ice_89_percent sea_ice_90_percent sea_ice_91_percent sea_ice_92_percent sea_ice_93_percent sea_ice_94_percent sea_ice_95_percent sea_ice_96_percent sea_ice_97_percent sea_ice_98_percent sea_ice_99_percent sea_ice_100_percent permanent_ice snow mixed_pixels_at_coastlines suspect_ice_value corners ocean' (static)	NC_STRING

	flag_values	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 103, 252, 253, 254, 255 (static)	NC_UBYTE
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

snow_ice_flag

Description: This is binary snow/ice classification flag. It is computed internally in the processor based on external dynamic data (e.g. NSIDC/NISE or climatology). In case the original value of the pixel is greater than 30 percent, the flag is set to 1 (snow/ice presence), otherwise 0 (snow/ice free).

Dimensions: time, scanline, ground_pixel.

Type: NC_UBYTE.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	threshold	'0.3' (static)	NC_STRING
	The threshold in percentage to identify the pixel as snow/ice or snow free.		
	long_name	'snow-ice mask' (static)	NC_STRING
	_FillValue	'254UB' (static)	NC_STRING
	comment	'flag indicating snow/ice at center of ground pixel' (static)	NC_STRING
	source		NC_STRING
	Possible values: NSIDC/NISE, Fallback_climatology		
	flag_meanings	'snow_free snow_ice' (static)	NC_STRING
	flag_values	0, 1 (static)	NC_UBYTE
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

snow_cover

Description: The snow cover in the region of the pixel

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'snow-cover' (static)	NC_STRING
	source	'ECMWF' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].

sea_ice_cover

Description:	The sea-ice cover in the region of the pixel
Dimensions:	time, scanline, ground_pixel.
Type:	NC_FLOAT.
Source:	Processor.
Mode:	Present in all modes.

Attributes:

Name	*Value*	*Type*
units	'1' (static)	NC_STRING
long_name	'sea-ice-cover' (static)	NC_STRING
source	'ECMWF' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

12.23 Quality assurance statistics

Quality assurance statistics are gathered in variables located in this group. These can include histograms of the main parameters and event occurrence statistics. The contents of this group is under discussion. Note that the QA statistics may be stored as scalar variables rather than attributes. The former allow attributes to be attached to them, providing a more meaningful description than just the name.

Name	*Value*	*Type*
number_of_groundpixels	0 (static)	NC_INT
Number of ground pixels in the file.		
number_of_processed_-pixels	0 (static)	NC_INT
Number of ground pixels where a retrieval was attempted. This is the `number_of_groundpixels` minus the pixels that were rejected based on time or configuration (range and step-size in scanline or ground_pixel index).		
number_of_successfully_-processed_pixels	0 (static)	NC_INT
Number of ground pixels where a retrieval was successful.		
number_of_rejected_pixels_-not_enough_spectrum	0 (static)	NC_INT
Number of pixels where processing was not attempted because after filtering for bad and missing pixels there were not enough spectral pixels left in either the radiance, irradiance or after calculating the reflectance.		
number_of_failed_retrievals	0 (static)	NC_INT
Number of pixels where processing failed for whatever reason.		
number_of_ground_pixels_-with_warnings	0 (static)	NC_INT
Number of pixels with one or more warnings.		
number_of_radiance_miss-ing_occurrences	0 (static)	NC_INT
Number of ground pixels where processing error "the number of spectral pixels in the radiance due to flagging is too small to perform the fitting" occurred, i.e. where the lower 8 bits of the `processing_-quality_flags` have the value "1".		

number_of_irradiance_missing_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “the number of spectral pixels in the irradiance due to flagging is too small to perform the fitting” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “2”.

number_of_input_spectrum_missing_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “the reflectance spectrum does not contain enough points to perform the retrieval. This is different from (ir)radiance_missing in that the missing points may not be aligned” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “3”.

number_of_reflectance_range_error_occurrences	0 (static)	NC_INT
number_of_ler_range_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “lambert-equivalent reflectivity out of range error” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “5”.

number_of_snr_range_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “too low signal to noise to perform retrieval” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “6”.

number_of_sza_range_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “solar zenith angle out of range, maximum value from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “7”.

number_of_vza_range_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “viewing zenith angle out of range, maximum value from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “8”.

number_of_lut_range_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “extrapolation in lookup table (airmass factor, cloud radiances)” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “9”.

number_of_ozone_range_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “ozone column significantly out of range of profile climatology” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “10”.

number_of_wavelength_offset_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “wavelength offset exceeds maximum from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “11”.

number_of_initialization_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “an error occurred during the processing of the pixel, no output was generated. The following errors raise this flag: Mismatch between irradiance and radiance wavelengths; The on-ground distance between band 1 and band 2 ground pixels exceeds a threshold set in the configuration. Derived a-priori information does not validate, no processing is possible” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “12”.

number_of_memory_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “memory allocation or deallocation error” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “13”.

number_of_assertion_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “error in algorithm detected during assertion” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “14”.

number_of_io_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “error detected during transfer of data between algorithm and framework” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “15”.

number_of_numerical_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “general fatal numerical error occurred during inversion” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “16”.

number_of_lut_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “error in accessing the lookup table” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “17”.

number_of_ISRF_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “error detected in the input instrument spectral response function input data” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “18”.

number_of_convergence_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “the main algorithm did not converge” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “19”.

number_of_cloud_filter_convergence_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “the cloud filter did not converge” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “20”.

number_of_max_iteration_convergence_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “no convergence because retrieval exceeds maximum number of iterations. Maximum value from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “21”.

number_of_aot_lower_boundary_convergence_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “no convergence because the aerosol optical thickness crosses lower boundary twice in succession” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “22”.

number_of_other_boundary_convergence_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “no convergence because a state vector element crosses boundary twice in succession. Note that a separate failure flag is defined for non-convergence due to crossing of lower AOT boundary” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “23”.

number_of_geolocation_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “geolocation out of range” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “24”.

number_of_ch4_noscat_zero_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “the CH_4 column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “25”.

number_of_h2o_noscat_zero_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “the H_2O column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “26”.

number_of_max_optical_thickness_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “maximum optical thickness exceeded during iterations” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “27”.

number_of_aerosol_boundary_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “boundary hit of aerosol parameters at last iteration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “28”.

number_of_boundary_hit_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “fatal boundary hit during iterations” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “29”.

number_of_chi2_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “χ^2 is not-a-number or larger than 10^{10}” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “30”.

number_of_svd_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “singular value decomposition failure” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “31”.

number_of_dfs_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “degree of freedom is not-a-number” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “32”.

number_of_radiative_transfer_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “errors occurred during the radiative transfer computations, no processing possible” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “33”.

number_of_optimal_estimation_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “errors occurred during the optimal estimation, processing has been terminated” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “34”.

number_of_profile_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “flag that indicates if there were any errors during the computation of the ozone profile” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “35”.

number_of_cloud_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “no cloud data” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “36”.

number_of_model_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “forward model failure” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “37”.

number_of_number_of_input_data_points_too_low_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “not enough input ozone columns to calculate a tropospheric column” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “38”.

number_of_cloud_pressure_spread_too_low_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “cloud pressure variability to low to estimate a tropospheric column” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “39”.

number_of_cloud_too_low_level_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “clouds are too low in the atmosphere to assume sufficient shielding” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “40”.

number_of_generic_range_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “generic range error” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “41”.

number_of_generic_exception_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “catch all generic error” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “42”.

number_of_input_spectrum_alignment_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “input radiance and irradiance spectra are not aligned correctly” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “43”.

number_of_abort_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “not processed because processor aborted prematurely (time out or user abort” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “44”.

number_of_wrong_input_type_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “wrong input type error, mismatch between expectation and received data” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “45”.

number_of_wavelength_calibration_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “an error occurred in the wavelength calibration of this pixe” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “46”.

number_of_coregistration_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “no colocated pixels found in a supporting ban” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “47”.

number_of_slant_column_density_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “slant column fit returned error, no values can be compute” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “48”.

number_of_airmass_factor_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “airmass factor could not be compute” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “49”.

number_of_vertical_column_density_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “vertical column density could not be compute” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “50”.

number_of_signal_to_noise_ratio_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “the signal to noise ratio for this spectrum is too low for processin” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “51”.

number_of_configuration_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “error while parsing the configuratio” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “52”.

number_of_key_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “key does not exis” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “53”.

number_of_saturation_error_occurrences	0 (static)	NC_INT

Number of ground pixels where processing error “saturation in input spectru” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “54”.

number_of_solar_eclipse_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “solar eclipse” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “64”.

number_of_cloud_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “the cloud filter triggered causing the pixel to be skipped” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “65”.

number_of_altitude_consistency_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “too large difference between ECMWF altitude and DEM altitude value” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “66”.

number_of_altitude_roughness_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “too large standard deviation of altitude in DEM” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “67”.

number_of_sun_glint_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “for pixels over water, viewing direction inside sun glint region. Definition of sun glint angle and threshold value from ATBD” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “68”.

number_of_mixed_surface_type_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “pixel contains land and water areas (e.g. coastal pixel)” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “69”.

number_of_snow_ice_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “pixel contains snow/ice: Snow/ice flag according to dynamic input OR climatological surface albedo at VIS wavelength is larger than 0.5” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “70”.

number_of_aai_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “aAI smaller than 2.0” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “71”.

number_of_cloud_fraction_fresco_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “pixel contains clouds: The FRESCO effective cloud fraction is larger than threshold. Threshold value from ATBD” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “72”.

number_of_aai_scene_albedo_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “pixel contains clouds: The difference between scene albedo at 380 nm from AAI calculation and the climatologcal surface albedo exceeds threshold. Threshold value from ATBD. This test filters out clouds” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “73”.

number_of_small_pixel_radiance_std_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “pixel contains clouds: Standard deviation of radiances in small-pixel column exceeds threshold. Threshold value from ATBD” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “74”.

number_of_cloud_fraction_viirs_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “pixel contains clouds: The cloud fraction from VIIRS / NPP exceeds theshold. Threshold value from ATBD” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “75”.

number_of_cirrus_reflectance_viirs_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “pixel contains clouds: Cirrus reflectance from VIIRS / NPP exceeds threshold. Threshold value from ATBD” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “76”.

number_of_cf_viirs_swir_ifov_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P SWIR ground pixel exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “77”.

number_of_cf_viirs_swir_ofova_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVa exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “78”.

number_of_cf_viirs_swir_ofovb_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVb exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “79”.

number_of_cf_viirs_swir_ofovc_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVc exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “80”.

number_of_cf_viirs_nir_ifov_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P NIR ground pixel exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “81”.

number_of_cf_viirs_nir_ofova_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVa exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “82”.

number_of_cf_viirs_nir_ofovb_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVb exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “83”.

number_of_cf_viirs_nir_ofovc_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVc exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “84”.

number_of_refl_cirrus_viirs_swir_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “average VIIRS cirrus reflectance within SWIR ground pixel exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “85”.

number_of_refl_cirrus_viirs_nir_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “average VIIRS cirrus reflectance within NIR ground pixel exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “86”.

number_of_diff_refl_cirrus_viirs_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “difference in VIIRS average cirrus reflectance between SWIR and NIR ground pixel exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “87”.

number_of_ch4_noscat_ratio_filter_occurrences	0 (static)	NC_INT

Number of ground pixels where input filter “the ratio between $[CH_4]_{weak}$ and $[CH_4]_{strong}$ is below or exceeds a priori thresholds from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “88”.

number_of_ch4_noscat_ratio_std_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “the standard deviation of $[CH_4]_{weak}/[CH_4]_{strong}$ within the SWIR pixel and the 8 neighbouring pixels exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “89”.

number_of_h2o_noscat_ratio_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “the ratio between $[H_2O]_{weak}$ and $[H_2O]_{strong}$ is below or exceeds a priori thresholds from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “90”.

number_of_h2o_noscat_ratio_std_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “the standard deviation of $[H_2O]_{weak}/[H_2O]_{strong}$ within the SWIR pixel and the 8 neigbouring pixels exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “91”.

number_of_diff_psurf_fresco_ecmwf_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “difference between the FRESCO apparent surface pressure and the ECMWF surface pressure exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “92”.

number_of_psurf_fresco_stdv_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “the standard deviation of the FRESCO apparent surface pressure in the NIR pixel and the 8 surrounding pixels exceeds a priori threshold from configuration” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “93”.

number_of_ocean_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “the ground pixel is over ocean (and ocean glint retrievals are not switched on)” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “94”.

number_of_time_range_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “time is out of the range that is to be processed” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “95”.

number_of_pixel_or_scanline_index_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “not processed because pixel index does not match general selection criteria” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “96”.

number_of_geographic_region_filter_occurrences 0 (static) NC_INT

Number of ground pixels where input filter “pixel falls outside the specified regions of interest” occurred, i.e. where the lower 8 bits of the `processing_quality_flags` have the value “97”.

number_of_input_spectrum_warning_occurrences 0 (static) NC_INT

Number of ground pixels where processing warning “number of good pixels in radiance, irradiance or calculated reflectance below threshold from configuration” occurred, i.e. where bit 8 in the `processing_quality_flags` is set to “1”.

number_of_wavelength_calibration_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “offset from wavelength fit is larger than limit set in configuration” occurred, i.e. where bit 9 in the `processing_quality_flags` is set to “1”.

number_of_extrapolation_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “pressure or temperature outside cross section LUT range, other lookup table extrapolation” occurred, i.e. where bit 10 in the `processing_quality_flags` is set to “1”.

number_of_sun_glint_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “sun glint posibility warning” occurred, i.e. where bit 11 in the `processing_quality_flags` is set to “1”.

number_of_south_atlantic_anomaly_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “tROPOMI is inside the south Atlantic anomaly while taking these measurements” occurred, i.e. where bit 12 in the `processing_quality_flags` is set to “1”.

number_of_sun_glint_correction_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “a sun glint correction has been applied” occurred, i.e. where bit 13 in the `processing_quality_flags` is set to “1”.

number_of_snow_ice_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “snow/ice flag is set, i.e. using scene data from the cloud support product” occurred, i.e. where bit 14 in the `processing_quality_flags` is set to “1”.

number_of_cloud_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “cloud filter based on FRESCO apparent surface pressure (VIIRS not available), cloud fraction above threshold or cloud pressure adjusted to force cloud above surface” occurred, i.e. where bit 15 in the `processing_quality_flags` is set to “1”.

number_of_AAI_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “possible aerosol contamination as indicated by the AAI” occurred, i.e. where bit 16 in the `processing_quality_flags` is set to “1”.

number_of_pixel_level_input_data_missing_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “dynamic auxiliary input data (e.g.. cloud) is missing for this ground pixel. A fallback option is used” occurred, i.e. where bit 17 in the `processing_quality_flags` is set to “1”.

number_of_data_range_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “carbon monoxide column tends to negative values; Water column tends to negative values; Heavy water (HDO) column tends to negative values; others” occurred, i.e. where bit 18 in the `processing_quality_flags` is set to “1”.

number_of_low_cloud_fraction_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “low cloud fraction, therefore no cloud pressure retrieved” occurred, i.e. where bit 19 in the `processing_quality_flags` is set to “1”.

number_of_altitude_consistency_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “difference between ECMWF surface elevation and high-resolution surface elevation exceeds threshold from configuration” occurred, i.e. where bit 20 in the `processing_quality_flags` is set to “1”.

number_of_signal_to_noise_ratio_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “signal to noise ratio in SWIR and/or NIR band below threshold from configuration” occurred, i.e. where bit 21 in the `processing_quality_flags` is set to “1”.

number_of_deconvolution_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “failed deconvolution irradiance spectrum (not pixel-specific, but row-specific)” occurred, i.e. where bit 22 in the `processing_quality_flags` is set to “1”.

number_of_so2_volcanic_origin_likely_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “warning for SO_2 BL product, UTLS products: volcanic origin except for heavily polluted sites” occurred, i.e. where bit 23 in the `processing_quality_flags` is set to “1”.

number_of_so2_volcanic_origin_certain_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “warning for SO_2 BL product, UTLS products: volcanic origin certain” occurred, i.e. where bit 24 in the `processing_quality_flags` is set to “1”.

number_of_interpolation_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “warning for interpolation on partially missing data. In this case the valid available data is used, potentially leading to a bias” occurred, i.e. where bit 25 in the `processing_quality_flags` is set to “1”.

number_of_saturation_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “saturation occurred spectrum, possibly causing biases in the retrieva” occurred, i.e. where bit 26 in the `processing_quality_flags` is set to “1”.

number_of_high_sza_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “warning for high solar zenith angle. In this case, the processing can be performed with less final quality” occurred, i.e. where bit 27 in the `processing_quality_flags` is set to “1”.

number_of_cloud_retrieval_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “warning occurring when the retrieval diagnostic indicates a degraded quality of the cloud retrieval” occurred, i.e. where bit 28 in the `processing_quality_flags` is set to “1”.

number_of_cloud_inhomogeneity_warning_occurrences	0 (static)	NC_INT

Number of ground pixels where processing warning “the cloud coregistration inhomogeneity parameter is above a given threshol” occurred, i.e. where bit 29 in the `processing_quality_flags` is set to “1”.

global_processing_warnings	'None' (static)	NC_STRING
All warning messages, separated by newlines, with duplicates removed.		
time_for_algorithm_initialization	-1.0 (static)	NC_DOUBLE
Time in seconds needed for initialization.		
time_for_processing	-1.0 (static)	NC_DOUBLE
Time in seconds needed for processing.		
time_per_pixel	-1.0 (static)	NC_DOUBLE
Time per pixel in seconds needed for processing.		
time_standard_deviation_per_pixel	-1.0 (static)	NC_DOUBLE
Standard deviation of the time per pixel in seconds needed for processing.		

vertices For the histogram boundaries.

size 2 (fixed)
mode Present in all modes.

histogram_axis Histogram axis.

size 100 (fixed)
mode Present in all modes.

pdf_axis Probability density function axis.

size 400 (fixed)
mode Present in all modes.

histogram_axis			
Description:	Horizontal axis for the histograms of the main parameter.		
Dimensions:	histogram_axis (coordinate variable).		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (dynamic)	NC_STRING
	Same unit as the main parameter. Other attributes – `standard_name`, `long_name` – are to be copied from the main parameter as well. This attribute originates from the CF standard.		
	bounds	'histogram_bounds' (static)	NC_STRING

pdf_axis			
Description:	Horizontal axis for the probability distribution functions of the main parameter.		
Dimensions:	pdf_axis (coordinate variable).		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (dynamic)	NC_STRING
	Same unit as the main parameter. Other attributes – `standard_name`, `long_name` – are to be copied from the main parameter as well. This attribute originates from the CF standard.		
	bounds	'pdf_bounds' (static)	NC_STRING

12.24 Algorithm settings

The algorithm settings are attached as attributes to this group. The current settings are listed here, each item in the list is a string attribute.

12.25 Granule metadata

Common granule level metadata.

Attributes in GRANULE_METADATA

Group attributes attached to GRANULE_METADATA		
Name	*Value*	*Type*
GranuleStart		NC_STRING
Start of the granule as ISO date/time string in UTC: *YYYY*-*MM*-*DD*T*HH*:*MM*:*SS*.*mmmmmm*Z. The formal definition of ISO date/time strings is given in [RD35].		
GranuleEnd		NC_STRING
End of the granule as ISO date/time string in UTC: *YYYY*-*MM*-*DD*T*HH*:*MM*:*SS*.*mmmmmm*Z. The formal definition of ISO date/time strings is given in [RD35].		
InstrumentName	'TROPOMI' (static)	NC_STRING
The name of the instrument, fixed to "TROPOMI".		
MissionName	'Sentinel-5 precursor' (static)	NC_STRING
The name of the mission, fixed to "Sentinel-5 precursor".		
MissionShortName	'S5P' (static)	NC_STRING
The short name of the mission, fixed to "S5P".		
ProcessLevel	'2' (static)	NC_STRING
This is a level 2 product.		
ProcessingCenter	'%(processingcenter)s' (dynamic)	NC_STRING
Where was the processor run? The source is the probably the joborder, the most likely value for operational use is "DLR/Oberpfaffenhofen".		
ProcessingNode		NC_STRING
The name of the machine that processed the data. This may aid in diagnosing failures in the processing.		
ProcessorVersion	'%(version)s' (dynamic)	NC_STRING
The version number of the processor used to produce the file. This is a string formatted as "major.minor.bugfix".		
ProductFormatVersion	1 (static)	NC_INT
The version of the format of the product file. This should be incremented whenever a datafield is added to the files.		
ProcessingMode		NC_STRING
This attribute indicates the mode of the processor.		
Possible values: Near-realtime, Offline, Reprocessing, Test, SyntheticTest		

12.26 ESA metadata

12.26.1 Group "ESA_METADATA"

Metadata defined in the ESA file format standard [RD26].

12.26.1.1 Group "earth_explorer_header" in "ESA_METADATA"

Attributes in ESA_METADATA/earth_explorer_header

Group attributes attached to earth_explorer_header		
Name	*Value*	*Type*
objectType	'Earth_Explorer_Header' (static)	NC_STRING

12.26.1.2 Group "fixed_header" in "earth_explorer_header"

The fixed header. We do not use a variable header, so only the fixed header is present.

Attributes in ESA_METADATA/earth_explorer_header/fixed_header

Group attributes attached to fixed_header		
Name	*Value*	*Type*
objectType	'Fixed_Header' (static)	NC_STRING
File_Name	'%(logical_filename)s' (dynamic)	NC_STRING
The *logical* file name, i.e. the file name without extension.		
File_Description		NC_STRING
This is a copy of the global "title" attribute.		
Notes		NC_STRING
This is a copy of the global "comment" attribute.		
Mission	'S5P' (static)	NC_STRING
The mission identifier for the Sentinel 5-precursor mission is "S5P".		
File_Class	'%(mode)s' (dynamic)	NC_STRING
The file class of the output. Values are taken from the tailoring of the EO file format tailoring for S5P [RD25, section 4.1.2].		
File_Type	'%(shortname)s' (dynamic)	NC_STRING
Following the EO file format tailoring for S5P [RD25, sections 4.1.3.1 and 4.1.3.2].		
File_Version	0 (dynamic)	NC_INT
The file version information is not part of the file name conventions for S5P. If a file version number is to be recorded in this attribute, then it has to be provided by the PDGS via the job order. If provided, then the value is ≥ 1. If not provided the fill value is 0.		

12.26.1.3 Group "validity_period" in "fixed_header"

Attributes in ESA_METADATA/earth_explorer_header/fixed_header/validity_period

Group attributes attached to validity_period		
Name	*Value*	*Type*
objectType	'Validity_Period' (static)	NC_STRING
Validity_Start		NC_STRING
The value is the string "`UTC=`" concatenated with the `time_coverage_start` global attribute. This attribute corresponds to the "Validity_Start" element in the "Validity_Period" XML structure in the header file.		
Validity_Stop		NC_STRING
The value is the string "`UTC=`" concatenated with the `time_coverage_end` global attribute. This attribute corresponds to the "Validity_Stop" element in the "Validity_Period" XML structure in the header file.		

12.26.1.4 Group "source" in "fixed_header"

Attributes in ESA_METADATA/earth_explorer_header/fixed_header/source

Group attributes attached to source		
Name	*Value*	*Type*
objectType	'Source' (static)	NC_STRING
System	'%(processingcenter)s' (dynamic)	NC_STRING
Name of the Ground Segment element creating the file. For Level 2 files, this is the PDGS, but for testing a different value may be used. This attribute corresponds to the "System" element in the "Source" XML structure in the header file.		
Creator	'%(processor_name)s' (dynamic)	NC_STRING
Name of the facility or tool, within the Ground Segment element, creating the file. This attribute corresponds to the "Creator" element in the "Source" XML structure in the header file.		
Creator_Version	'%(version)s' (dynamic)	NC_STRING
Version number of the tool that created the file. This attribute corresponds to the "Creator_Version" element in the "Source" XML structure in the header file.		
Creation_Date		NC_STRING
The start date and time of processing, as a string: "`UTC=YYYY-MM-DDThh:mm:ss`". This attribute corresponds to the "Creator_Date" element in the "Source" XML structure in the header file.		

12.26.1.5 Group "variable_header" in "earth_explorer_header"

Attributes in ESA_METADATA/earth_explorer_header/variable_header

Group attributes attached to variable_header		
Name	*Value*	*Type*
objectType	'Variable_Header' (static)	NC_STRING

12.26.1.6 Group "gmd:lineage" in "variable_header"

Non-quantitative quality information about the lineage of the data specified by the scope.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage

Group attributes attached to gmd:lineage		
Name	*Value*	*Type*
objectType	'gmd:LI_Lineage' (static)	NC_STRING
gmd:statement	'L2 %(product)s dataset produced by %(processingcenter)s from the S5P/TROPOMI L1B product' (dynamic)	NC_STRING
General explanation of the data producer's knowledge about the lineage of a dataset. Insert short description of the actual Level 2 product in this string (at the %(...)s).		

12.26.1.7 Group "gmd:processStep" in "gmd:lineage"

Information about an event or transformation in the life of the dataset including details of the algorithm and software used for processing.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep

Group attributes attached to gmd:processStep		
Name	*Value*	*Type*
objectType	'gmi:LE_ProcessStep' (static)	NC_STRING
gmd:description	'Processing of L1b to L2 %(product)s data for orbit %(orbit)d using the %(institute)s processor version %(version)s' (dynamic)	NC_STRING

Description of the event, including related parameters or tolerances. Insert short description of the actual Level 2 product, the orbit number, the name of the institude responsible for the CFI and the software version in this string (at the respective %(...)s and %(...)d).

12.26.1.8 Group "gmi:output" in "gmd:processStep"

Description of the output.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:output

Group attributes attached to gmi:output		
Name	*Value*	*Type*
gmd:description		NC_STRING
Short description of the output, a copy of the global 'title' attribute.		
objectType	'gmi:LE_Source' (static)	NC_STRING

12.26.1.9 Group "gmd:sourceCitation" in "gmi:output"

Reference to the actual filename of the output data and production date and time.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation

Group attributes attached to gmd:sourceCitation		
Name	*Value*	*Type*
gmd:title	'%(logical_filename)s' (dynamic)	NC_STRING
Output file name without extension.		
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.26.1.10 Group "gmd:date" in "gmd:sourceCitation"

Production date and time of the output file.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date		NC_STRING
Production date and time of the output file. Note that the definition in the XML schema appears to allow the use of a "CI_DateTime" instead of a "CI_Date".		
objectType	'gmd:CI_DateTime' (static)	NC_STRING

12.26.1.11 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'creation' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.26.1.12 Group “gmd:identifier” in “gmd:sourceCitation”

Identification of the output product.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:identifier

Group attributes attached to gmd:identifier		
Name	*Value*	*Type*
gmd:code	‘%(shortname)s’ (dynamic)	NC_STRING
The product short name, a copy of the ‘ProductShortName’ attribute in ‘/METADATA/GRANULE_DESCRIPTION’.		
objectType	‘gmd:MD_Identifier’ (static)	NC_STRING

12.26.1.13 Group “gmi:processedLevel” in “gmi:output”

Process level of the output file.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:output/gmi:processedLevel

Group attributes attached to gmi:processedLevel		
Name	*Value*	*Type*
gmd:code	‘L2’ (static)	NC_STRING
objectType	‘gmd:MD_Identifier’ (static)	NC_STRING

12.26.1.14 Group “gmi:processingInformation” in “gmd:processStep”

Description of the processor in more detail.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation

Group attributes attached to gmi:processingInformation		
Name	*Value*	*Type*
objectType	‘gmi:LE_Processing’ (static)	NC_STRING

12.26.1.15 Group “gmi:identifier” in “gmi:processingInformation”

Identification of the processor.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:identifier

Group attributes attached to gmi:identifier		
Name	*Value*	*Type*
gmd:code	‘%(institute)s L2 %(product)s processor, version %(version)s’ (dynamic)	NC_STRING
Descriptive name of the processor, with the %(. . .)s placeholders replaced with the responsible institute’s name, product name and software release version.		
objectType	‘gmd:MD_Identifier’ (static)	NC_STRING

12.26.1.16 Group “gmi:softwareReference” in “gmi:processingInformation”

Reference to document describing processing software.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference

Group attributes attached to gmi:softwareReference		
Name	*Value*	*Type*
gmd:title	'L2 %(product)s processor description' (dynamic)	NC_STRING
Title of processor description.		
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.26.1.17 Group "gmd:date" in "gmi:softwareReference"

Release date (compile date) of the processor.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date		NC_STRING
Release date of the processor expressed as an ISO 8601 date string [RD35].		
objectType	'gmd:CI_DateTime' (static)	NC_STRING

12.26.1.18 Group "gmd:dateType" in "gmd:date"

Confirm that this is the release date of the processor.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'creation' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.26.1.19 Group "gmi:documentation#1" in "gmi:processingInformation"

Reference to the ATBD of the product.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1

Group attributes attached to gmi:documentation#1		
Name	*Value*	*Type*
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_atbd)s' (dynamic)	NC_STRING
The filename of the current release of the ATBD of the current product.		

12.26.1.20 Group "gmd:date" in "gmi:documentation#1"

Release date of the ATBD.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'%(date_atbd)s' (dynamic)	NC_STRING
Release date of the ATBD expressed as an ISO 8601 date string [RD35].		

objectType	'gmd:CI_Date' (static)	NC_STRING

12.26.1.21 Group "gmd:dateType" in "gmd:date"

Confirm that this is the date of publication.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.26.1.22 Group "gmi:documentation#2" in "gmi:processingInformation"

Reference to the PUM of the product.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2

Group attributes attached to gmi:documentation#2		
Name	*Value*	*Type*
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_pum)s' (dynamic)	NC_STRING
The filename of the current release of the PUM of the current product.		

12.26.1.23 Group "gmd:date" in "gmi:documentation#2"

Release date of the PUM.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'%(date_pum)s' (dynamic)	NC_STRING
Release date of the PUM expressed as an ISO 8601 date string [RD35].		
objectType	'gmd:CI_Date' (static)	NC_STRING

12.26.1.24 Group "gmd:dateType" in "gmd:date"

Confirm that this is the date of publication.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.26.1.25 Group "gmi:report" in "gmd:processStep"

Short report of what occurred during the process step.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmi:report

Group attributes attached to gmi:report		
Name	*Value*	*Type*
gmi:description	'Sentinel 5-precursor TROPOMI L1b processed to L2 data using the %(institute)s L2 %(product)s processor' (dynamic)	NC_STRING
Textual description of what occurred during the process step. Replace %(. . .)s as indicated.		
gmi:fileType	'netCDF-4' (static)	NC_STRING
Type of file that contains the processing report, in our case the processing report is contained in the main output file.		
gmi:name	'%(logical_filename)s.nc' (dynamic)	NC_STRING
objectType	'gmi:LE_ProcessStepReport' (dynamic)	NC_STRING

12.26.1.26 Group "gmd:source#1" in "gmd:processStep"

Information about the source data used in creating the data specified by the scope. Repeat group as needed, incrementing the number of the source (after the # mark).

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmd:source#1

Group attributes attached to gmd:source#1		
Name	*Value*	*Type*
objectType	'gmi:LE_Source' (static)	NC_STRING
gmd:description		NC_STRING
Description of the input data, including L1B, L2, dynamic auxiliary input data and semi-static auxiliary input data. Base strings are "TROPOMI L1B %s radiance product", "TROPOMI L1B %s irradiance product", "TROPOMI L2 %s product", "Auxiliary ECMWF %s Meteorological forecast data", "Processor %s configuration file", "Auxiliary %s reference data", "Auxiliary %s algorithm lookup table", "Auxiliary CTM %s model input data", "Auxiliary snow and ice input data" and "Auxiliary NPP/VIIRS cloud screening input data". The %s to be replaced with specific descriptors.		

12.26.1.27 Group "gmi:processedLevel" in "gmd:source#1"

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmd:source#1/gmi:processedLevel

Group attributes attached to gmi:processedLevel		
Name	*Value*	*Type*
gmd:code	*Empty!*	NC_STRING
objectType	'gmd:MD_Identifier' (static)	NC_STRING

12.26.1.28 Group "gmd:sourceCitation" in "gmd:source#1"

Reference to the actual filename of the input data.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation

Group attributes attached to gmd:sourceCitation		
Name	*Value*	*Type*
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.26.1.29 Group "gmd:date" in "gmd:sourceCitation"

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date		NC_STRING
Production date and time of the input file(s) in this group expressed as an ISO 8601 date-time string [RD35]. Note that the definition in the XML schema appears to allow the use of a "CI_DateTime" instead of a "CI_Date".		
objectType	'gmd:CI_Date' (static)	NC_STRING

12.26.1.30 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'creation' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.26.1.31 Group "gmd:title" in "gmd:sourceCitation"

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:title

Group attributes attached to gmd:title		
Name	*Value*	*Type*
gco:characterString		NC_STRING
Textual description of the input file group (same as the "`gmd:description`" attribute in the "`gmi:LE_Source`" object).		

12.26.1.32 Group "gmd:alternateTitle#1" in "gmd:sourceCitation"

All filenames in this group, in case more files of a particular file type are delivered, for instance for meteorological or model input. Repeat group as needed, incrementing the number of the input file (after the # mark).

Attributes in ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:alternateTitle#1

Group attributes attached to gmd:alternateTitle#1		
Name	*Value*	*Type*
gmx:FileName	*Empty!*	NC_STRING
The basename of the input file.		

12.27 EOP metadata

12.27.1 Group "EOP_METADATA"

Based on the OGC 10-025 standard for Observations & Measurements [RD42], an Earth Observation Product (EOP) schema was developed which refines an observation into the feature type earth observation. This schema was then extended with sensor-specific thematic schemas.

Attributes in EOP_METADATA

Group attributes attached to EOP_METADATA		
Name	*Value*	*Type*
gml:id	'%(logical_filename)s.ID' (dynamic)	NC_STRING
Unique ID for this "atm:EarthObservation" object. Constructed from the logical output filename and the extension "ID" separated by a dot.		
objectType	'atm:EarthObservation' (static)	NC_STRING

12.27.1.1 Group "om:phenomenonTime" in "EOP_METADATA"

Time coverage of the granule.

Attributes in EOP_METADATA/om:phenomenonTime

Group attributes attached to om:phenomenonTime		
Name	*Value*	*Type*
gml:beginPosition		NC_STRING
Start of time coverage of the data in the granule expressed as an ISO 8601 date-time string [RD35].		
gml:endPosition		NC_STRING
End of time coverage of the data in the granule expressed as an ISO 8601 date-time string [RD35].		
objectType	'gml:TimePeriod' (static)	NC_STRING

12.27.1.2 Group "om:procedure" in "EOP_METADATA"

Platform, instrument and sensor used for the acquisition and the acquisition parameters.

Attributes in EOP_METADATA/om:procedure

Group attributes attached to om:procedure		
Name	*Value*	*Type*
gml:id	'%(logical_filename)s.EOE' (dynamic)	NC_STRING
Unique ID for this "eop:EarthObservationEquipment" object. Constructed from the logical output filename and the extension "EOE" separated by a dot.		
objectType	'eop:EarthObservationEquipment' (static)	NC_STRING

12.27.1.3 Group "eop:platform" in "om:procedure"

Platform name and orbit type.

Attributes in EOP_METADATA/om:procedure/eop:platform

Group attributes attached to eop:platform		
Name	*Value*	*Type*
eop:shortName	'Sentinel-5p' (static)	NC_STRING
objectType	'eop:Platform' (static)	NC_STRING

12.27.1.4 Group “eop:instrument” in “om:procedure”

Instrument descriptor.

Attributes in EOP_METADATA/om:procedure/eop:instrument

Group attributes attached to eop:instrument		
Name	*Value*	*Type*
eop:shortName	‘TROPOMI’ (static)	NC_STRING
objectType	‘eop:Instrument’ (static)	NC_STRING

12.27.1.5 Group “eop:sensor” in “om:procedure”

Sensor description.

Attributes in EOP_METADATA/om:procedure/eop:sensor

Group attributes attached to eop:sensor		
Name	*Value*	*Type*
eop:sensorType	‘ATMOSPHERIC’ (static)	NC_STRING
objectType	‘eop:Sensor’ (static)	NC_STRING

12.27.1.6 Group “eop:acquisitionParameters” in “om:procedure”

Additional parameters describing the data acquisition. Only an orbit number is used here.

Attributes in EOP_METADATA/om:procedure/eop:acquisitionParameters

Group attributes attached to eop:acquisitionParameters		
Name	*Value*	*Type*
eop:orbitNumber	%(orbit)d (dynamic)	NC_INT
objectType	‘eop:Acquisition’ (static)	NC_STRING

12.27.1.7 Group “om:observedProperty” in “EOP_METADATA”

An xlink to the observed property definition.

Attributes in EOP_METADATA/om:observedProperty

Group attributes attached to om:observedProperty		
Name	*Value*	*Type*
nilReason	‘inapplicable’ (dynamic)	NC_STRING
This element should use the attribute ‘nilReason=”inapplicable”’.		

12.27.1.8 Group “om:featureOfInterest” in “EOP_METADATA”

Attributes in EOP_METADATA/om:featureOfInterest

Group attributes attached to om:featureOfInterest		
Name	*Value*	*Type*
objectType	‘eop:FootPrint’ (static)	NC_STRING
gml:id	‘%(logical_filename)s.FP’ (dynamic)	NC_STRING
Unique ID for this “eop:FootPrint” object. Constructed from the logical output filename and the extension “FP” separated by a dot.		

12.27.1.9 Group “eop:multiExtentOf” in “om:featureOfInterest”

Acquisition footprint coordinates, described by a closed polygon – the last point is equal to the first point, using latitude, longitude pairs. The expected structure is “gml:Polygon/gml:exterior/gml:LinearRing/gml:posList”.

Attributes in EOP_METADATA/om:featureOfInterest/eop:multiExtentOf

Group attributes attached to eop:multiExtentOf		
Name	*Value*	*Type*
objectType	‘gml:MultiSurface’ (static)	NC_STRING

12.27.1.10 Group “gml:surfaceMembers” in “eop:multiExtentOf”

Attributes in EOP_METADATA/om:featureOfInterest/eop:multiExtentOf/gml:surfaceMembers

Group attributes attached to gml:surfaceMembers		
Name	*Value*	*Type*
objectType	‘gml:Polygon’ (static)	NC_STRING

12.27.1.11 Group “gml:exterior” in “gml:surfaceMembers”

Attributes in EOP_METADATA/om:featureOfInterest/eop:multiExtentOf/gml:surfaceMembers/gml:exterior

Group attributes attached to gml:exterior		
Name	*Value*	*Type*
gml:posList		NC_STRING
The Polygon geometry shall be encoded in the EPSG:4326 geographic coordinate reference system (WGS-84) and the coordinate pairs shall be ordered as latitude/longitude. Polygons enclose areas with points listed in counter-clockwise direction.		
objectType	‘gml:LinearRing’ (static)	NC_STRING

12.27.1.12 Group “eop:metaDataProperty” in “EOP_METADATA”

This group contains all the metadata relative to the Eath observation product that do not fit inside one of the other groups, i.e. metadata that do not describe the time, the mechanism, the location or the result of the observation.

These metadata are mainly the EarthObservation identifier, the acquisition type and information relative to the downlink and archiving centers.

Attributes in EOP_METADATA/eop:metaDataProperty

Group attributes attached to eop:metaDataProperty		
Name	*Value*	*Type*
objectType	‘eop:EarthObservationMetaData’ (static)	NC_STRING
eop:acquisitionType	‘NOMINAL’ (dynamic)	NC_STRING
Used to distinguish at a high level the appropriateness of the acquisition for “general” use, whether the product is a nominal acquisition, special calibration product or other. Copy from L1b. For Level 2 this should *always* be ‘NOMINAL’.		
eop:identifier	‘%(logical_filename)s’ (dynamic)	NC_STRING
Logical file name.		
eop:doi	‘%(product_doi)s’ (dynamic)	NC_STRING
Digital Object Identifier identifying the product (see `http://www.datacite.org` for DOIs for datasets).		

eop:parentIdentifier	'urn:ogc:def:EOP:ESA:SENTINEL.S5P_TROP_-%(shortname)s' (dynamic)	NC_STRING
Unique collection identifier for metadata file, see the Level 1B metadata specification [RD32, table 5] for a discussion of the value. This is a copy of the "gmd:fileIdentifier" attribute in the "/METADATA/ISO_METADATA" group.		
eop:productType	'S5P_%(mode)s_%(product)s' (dynamic)	NC_STRING
Product type identifier. Replace %(mode)s with the operational mode the processor is running in ('NRTI', 'OFFL' or 'RPRO', as per [RD25]) and %(product)s with the 10 character output file name semantic descriptors as given in section **??**, the DLR IODD [RD43, section 3.2.2] and the RAL IODD [RD44, section 4.7] .		
eop:status	'ACQUIRED' (dynamic)	NC_STRING
Refers to product status. Values listed in the standard: 'ARCHIVED', 'ACQUIRED', 'CANCELLED', 'FAILED', 'PLANNED', 'POTENTIAL', 'REJECTED', 'QUALITY-DEGRADED'. Copied from L1B.		
eop:productQualityStatus	'NOMINAL' (dynamic)	NC_STRING
Indicator that specifies whether the product quality is degraded or not. Allowed values: 'DEGRADED', 'NOMINAL'.		
eop:productQualityDegradationTag	'NOT APPLICABLE' (dynamic)	NC_STRING
Contains further textual information concerning the quality degradation. According to the metadata standards it shall be provided *only* if "eop:productQualityStatus" value is set to 'DEGRADED'. Because the way we generate out output files, this attribute will always be present, even when "eop:productQualityStatus" value is 'NOMINAL'. In those cases the value shall be set to "NOT APPLICABLE". Possible values are "MISSING AUXILIARY INPUT" and "NOT APPLICABLE". Note that Level 1B does not set this value, so only problems detectable in the processor are covered.		

12.27.1.13 Group "eop:processing" in "eop:metaDataProperty"

Processing information.

Attributes in EOP_METADATA/eop:metaDataProperty/eop:processing

Group attributes attached to eop:processing		
Name	*Value*	*Type*
objectType	'eop:ProcessingInformation' (static)	NC_STRING
eop:processingCenter	'%(processingcenter)s' (dynamic)	NC_STRING
The processing center, taken from the "`Processing_Station`" key in the joborder.		
eop:processingDate	'YYYY-mm-ddTHH:MM:SSZ' (dynamic)	NC_STRING
The processing date, as an ISO 8601 date-time string [RD35].		
eop:processingLevel	'L2' (static)	NC_STRING
These are all Level 2 products.		
eop:processorName	'%(processor_name)s' (static)	NC_STRING
The name of the processor, "`tropnll2dp.exe`" for KNMI and "`upas-l2`" for DLR.		
eop:processorVersion	'%(version)s' (dynamic)	NC_STRING
Version of the processor, as "major.minor.bugfix".		
eop:nativeProductFormat	'netCDF-4' (static)	NC_STRING
Native product format.		
eop:processingMode	'%(mode)s' (dynamic)	NC_STRING
Processing mode taken from mission specific code list. For S5P we use the *File Class* identifiers [RD25, section 4.1.2]: 'TEST', 'OGCA', 'GSOV', 'OPER', 'NRTI', 'OFFL', 'RPRO'.		

12.28 ISO metadata

12.28.1 Group "ISO_METADATA"

Metadata that is structured following the ISO metadata standards [RD27, RD40], especially part 2. The metadata in this group is structured using the methods from Level 1B, which is described in the Level 1B metadata specification [RD32].

All "`objectType`" attributes indicate the XML object when generating an ISO 19139 [RD40] compliant XML metadata file.

Note that this group is meant to be treated as a 'black box'. The information is collected here so that it can be extracted into XML side-files for ingestion into data search tools and metadata collections.

Attributes in ISO_METADATA

Group attributes attached to ISO_METADATA		
Name	*Value*	*Type*
gmd:dateStamp	'2015-10-16' (static)	NC_STRING
Date of creation of the metadata, as ISO 8601 [RD35] string specifying year, month and day.		
gmd:fileIdentifier	'urn:ogc:def:EOP:ESA:SENTINEL.S5P_TROP_-%(shortname)s' (dynamic)	NC_STRING
Unique identifier for metadata file, see the Level 1B metadata specification [RD32, table 5] for a discussion of the value. Replace %(...)s with the "`ProductShortName`" value from the Level 2 "`/METADATA/GRANULE_-DESCRIPTION`" metadata group.		
gmd:hierarchyLevelName	'EO Product Collection' (static)	NC_STRING
Name of the hierarchy levels for which the metadata is provided.		
gmd:metadataStandardName	'ISO 19115-2 Geographic Information - Metadata Part 2 Extensions for imagery and gridded data' (static)	NC_STRING
Name of the metadata standard.		
gmd:metadataStandardVersion	'ISO 19115-2:2009(E), S5P profile' (static)	NC_STRING
Version (profile) of the metadata standard used.		
objectType	'gmi:MI_Metadata' (static)	NC_STRING
Name of the metadata class [RD32, table 5].		

12.28.1.1 Group "gmd:language" in "ISO_METADATA"

Language used for the metadata, fixed to English.

Attributes in ISO_METADATA/gmd:language

Group attributes attached to gmd:language		
Name	*Value*	*Type*
codeList	'http://www.loc.gov/standards/iso639-2/' (static)	NC_STRING
codeListValue	'eng' (static)	NC_STRING
objectType	'gmd:LanguageCode' (static)	NC_STRING

12.28.1.2 Group "gmd:characterSet" in "ISO_METADATA"

The character encoding used for the metadata. This is fixed to UTF-8, but the climate and forecasting conventions, version 1.6 limits this further to 7-bit ASCII (which is a subset of UTF-8).

Attributes in ISO_METADATA/gmd:characterSet

Group attributes attached to gmd:characterSet		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_CharacterSetCode' (static)	NC_STRING

codeListValue	'utf8' (static)	NC_STRING
objectType	'gmd:MD_CharacterSetCode' (static)	NC_STRING

12.28.1.3 Group "gmd:hierarchyLevel" in "ISO_METADATA"

Scope to wich metadata applies.

Attributes in ISO_METADATA/gmd:hierarchyLevel

Group attributes attached to gmd:hierarchyLevel		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_ScopeCode' (static)	NC_STRING
codeListValue	'series' (static)	NC_STRING
objectType	'gmd:MD_ScopeCode' (static)	NC_STRING

12.28.1.4 Group "gmd:contact" in "ISO_METADATA"

Contact information for the product.

Attributes in ISO_METADATA/gmd:contact

Group attributes attached to gmd:contact		
Name	*Value*	*Type*
gmd:organisationName	'Copernicus Space Component Data Access System, ESA, Services Coordinated Interface' (static)	NC_STRING
objectType	'gmd:CI_ResponsibleParty' (static)	NC_STRING

12.28.1.5 Group "gmd:contactInfo" in "gmd:contact"

The detailed contact information.

Attributes in ISO_METADATA/gmd:contact/gmd:contactInfo

Group attributes attached to gmd:contactInfo		
Name	*Value*	*Type*
objectType	'gmd:CI_Contact' (static)	NC_STRING

12.28.1.6 Group "gmd:address" in "gmd:contactInfo"

The actual email address.

Attributes in ISO_METADATA/gmd:contact/gmd:contactInfo/gmd:address

Group attributes attached to gmd:address		
Name	*Value*	*Type*
gmd:electronicMailAddress	'EOSupport@copernicus.esa.int' (static)	NC_STRING
objectType	'gmd:CI_Address' (static)	NC_STRING

12.28.1.7 Group "gmd:role" in "gmd:contact"

The role of the adress provided in this group.

Attributes in ISO_METADATA/gmd:contact/gmd:role

Group attributes attached to gmd:role		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_RoleCode' (static)	NC_STRING
codeListValue	'pointOfContact' (static)	NC_STRING
objectType	'gmd:CI_RoleCode' (static)	NC_STRING

12.28.1.8 Group "gmd:identificationInfo" in "ISO_METADATA"

Identification information contains information to uniquely identify the data. Identification information includes information about the citation for the resource, an abstract, the purpose, credit, the status and points of contact. The MD_Identification entity is mandatory. The MD_Identification entity is specified (subclassed) as MD_DataIdentification because in this case it is used to identify data.

Attributes in ISO_METADATA/gmd:identificationInfo

Group attributes attached to gmd:identificationInfo		
Name	*Value*	*Type*
gmd:abstract		NC_STRING

Brief narrative summary of the content of the resource. This is product specific.

L2__AER_AI (KNMI) Aerosol index with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__AER_LH (KNMI) Altitude of elevated aerosol layer for cloud-free observations with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__NO2___ (KNMI) Nitrogen dioxide tropospheric column with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__O3__PR (KNMI) Ozone profile with a vertical resolution of 6 km and a horizontal resolution of $28 \times 21\,km^2$ observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__O3_TPR (KNMI) Tropospheric ozone profile with a vertical resolution of 6 km and a horizontal resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__CH4___ (SRON) Dry-air mixing ratio of methane for cloud-free observations over land with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__CO____ (SRON) Carbon monoxide column over land with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__FRESCO (KNMI) Cloud fraction and cloud pressure with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI (KNMI cloud support product)

L2__CLOUD_ (DLR) Cloud fraction, cloud pressure and cloud albedo with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__HCHO__ (BIRA) Formaldehyde tropospheric column with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__O3____ (DLR/BIRA) Ozone total column with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__O3_TCL (DLR/IUP) Tropospheric ozone with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__SO2___ (BIRA) Sulfur dioxide column with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI

L2__NP_BD(3,6,7) Regridded NPP-VIIRS data with a spatial resolution of either $7.0 \times 3.5\,km^2$ or $5.5 \times 3.5\,km^2$ (for the small pixels since 6th of august 2019)

gmd:credit	'%(credit)s' (static)	NC_STRING
Recognition of those who contributed to the resource(s).		
gmd:language	'eng' (static)	NC_STRING
gmd:topicCategory	'climatologyMeteorologyAtmosphere' (static)	NC_STRING
Main theme(s) of the dataset.		

objectType	'gmd:MD_DataIdentification' (static)	NC_STRING
Name of the metadata class [RD32, table 10].		

12.28.1.9 Group "gmd:citation" in "gmd:identificationInfo"

Citation data for the resource.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:citation

Group attributes attached to gmd:citation		
Name	*Value*	*Type*
gmd:title		NC_STRING
Name by which the cited resource is known. This is the same as the global "`title`" attribute.		
objectType	'gmd:CI_Citation' (static)	NC_STRING
Name of the metadata class [RD32, table 11].		

12.28.1.10 Group "gmd:date" in "gmd:citation"

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:citation/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'%(processor_release_date)s' (static)	NC_STRING
objectType	'gmd:CI_Date' (static)	NC_STRING

12.28.1.11 Group "gmd:dateType" in "gmd:date"

Event used for reference date.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:citation/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'creation' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.12 Group "gmd:identifier" in "gmd:citation"

Unique identifier for metadata file, see the Level 1B metadata specification [RD32, table 5] for a discussion of the value.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:citation/gmd:identifier

Group attributes attached to gmd:identifier		
Name	*Value*	*Type*
gmd:code	'urn:ogc:def:EOP:ESA:SENTINEL.S5P_TROP_-%(shortname)s' (dynamic)	NC_STRING
Replace "%(shortname)s" with the "`ProductShortName`" value from the Level 2 "`/METADATA/GRANULE_-DESCRIPTION`" metadata group.		
objectType	'gmd:MD_Identifier' (static)	NC_STRING

12.28.1.13 Group "gmd:pointOfContact" in "gmd:identificationInfo"

See description of the "`gmd:contact`" attribute above.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:pointOfContact

Group attributes attached to gmd:pointOfContact		
Name	*Value*	*Type*
gmd:organisationName	'Copernicus Space Component Data Access System, ESA, Services Coordinated Interface' (static)	NC_STRING
objectType	'gmd:CI_ResponsibleParty' (static)	NC_STRING

12.28.1.14 Group "gmd:contactInfo" in "gmd:pointOfContact"

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:pointOfContact/gmd:contactInfo

Group attributes attached to gmd:contactInfo		
Name	*Value*	*Type*
objectType	'gmd:CI_Contact' (static)	NC_STRING

12.28.1.15 Group "gmd:address" in "gmd:contactInfo"

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:pointOfContact/gmd:contactInfo/gmd:address

Group attributes attached to gmd:address		
Name	*Value*	*Type*
gmd:electronicMailAddress	'EOSupport@copernicus.esa.int' (static)	NC_STRING
objectType	'gmd:CI_Address' (static)	NC_STRING

12.28.1.16 Group "gmd:role" in "gmd:pointOfContact"

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:pointOfContact/gmd:role

Group attributes attached to gmd:role		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_RoleCode' (static)	NC_STRING
codeListValue	'distributor' (static)	NC_STRING
objectType	'gmd:CI_RoleCode' (static)	NC_STRING

12.28.1.17 Group "gmd:descriptiveKeywords#1" in "gmd:identificationInfo"

Provides category keywords, their type, and reference source. Within the framework of GEMET the choise of keywords is very limited. More meaningful keywords can be derived from the Climate and Forecast metadada conventions' standard name list, see "`gmd:descriptiveKeywords#2`" below.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1

Group attributes attached to gmd:descriptiveKeywords#1		
Name	*Value*	*Type*
gmd:keyword#1	'Atmospheric conditions' (static)	NC_STRING
objectType	'gmd:MD_Keywords' (static)	NC_STRING

12.28.1.18 Group "gmd:type" in "gmd:descriptiveKeywords#1"

Subject matter used to group similar keywords.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:type

Group attributes attached to gmd:type		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_KeywordTypeCode' (static)	NC_STRING
codeListValue	'theme' (static)	NC_STRING
objectType	'gmd:MD_KeywordTypeCode' (static)	NC_STRING

12.28.1.19 Group "gmd:thesaurusName" in "gmd:descriptiveKeywords#1"

Name by which the cited resource is known.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:thesaurusName

Group attributes attached to gmd:thesaurusName		
Name	*Value*	*Type*
gmd:title	'GEMET - INSPIRE themes, version 1.0' (static)	NC_STRING
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.28.1.20 Group "gmd:date" in "gmd:thesaurusName"

Reference date for the cited resource.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:thesaurusName/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'2008-06-01' (static)	NC_STRING
objectType	'gmd:CI_Date' (static)	NC_STRING

12.28.1.21 Group "gmd:dateType" in "gmd:date"

What date is used for the reference date.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:thesaurusName/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.22 Group "gmd:descriptiveKeywords#2" in "gmd:identificationInfo"

Provides category keywords, their type, and reference source. These keywords are taken from the Climate and Forecast metadada conventions' standard name list [ER5]. The keywords listed below identify the most important parameters in the product.

L2__AER_AI (KNMI) ultraviolet_aerosol_index

L2__AER_LH (KNMI) height_of_elevated_aerosol_layer

L2__NO2___ (KNMI) troposphere_mole_content_of_nitrogen_dioxide, stratosphere_mole_content_of_nitrogen_dioxide, atmosphere_mole_content_of_nitrogen_dioxide

L2__O3__PR (KNMI) mole_fraction_of_ozone_in_air

L2__O3_TPR (KNMI) mole_fraction_of_ozone_in_air

L2__CH4___ (SRON) atmosphere_mole_fraction_of_methane_in_dry_air

L2__CO____ (SRON) atmosphere_mole_content_of_carbon_monoxide

L2__FRESCO (KNMI)

L2__CLOUD_ (DLR)

L2__HCHO__ (BIRA) troposphere_mole_content_of_formaldehyde

L2__O3____ (DLR/BIRA) atmosphere_mole_content_of_ozone

L2__O3_TCL (DLR/IUP) troposphere_mole_content_of_ozone

L2__SO2___ (BIRA) atmosphere_mole_content_of_sulfur_dioxide

L2__NP_BDx (RAL)

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2

Group attributes attached to gmd:descriptiveKeywords#2		
Name	*Value*	*Type*
gmd:keyword#1		NC_STRING
objectType	'gmd:MD_Keywords' (static)	NC_STRING

12.28.1.23 Group "gmd:thesaurusName" in "gmd:descriptiveKeywords#2"

Name by which the cited resource is known.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2/gmd:thesaurusName

Group attributes attached to gmd:thesaurusName		
Name	*Value*	*Type*
gmd:title	'CF Standard Name Table v29' (static)	NC_STRING
xlink:href	'http://cfconventions.org/standard-names.html' (dynamic)	NC_STRING
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.28.1.24 Group "gmd:date" in "gmd:thesaurusName"

Reference date for the cited resource.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2/gmd:thesaurusName/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'2015-07-08' (static)	NC_STRING
objectType	'gmd:CI_Date' (static)	NC_STRING

12.28.1.25 Group "gmd:dateType" in "gmd:date"

What date is used for the reference date.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2/gmd:thesaurusName/

gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.26 Group "gmd:resourceConstraints" in "gmd:identificationInfo"

Provides information about constraints which apply to the resource.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:resourceConstraints

Group attributes attached to gmd:resourceConstraints		
Name	*Value*	*Type*
gmd:useLimitation	'no conditions apply' (static)	NC_STRING
Limitation affecting the fitness for use of the resource or metadata.		
objectType	'gmd:MD_LegalConstraints' (static)	NC_STRING

12.28.1.27 Group "gmd:accessConstraints" in "gmd:resourceConstraints"

Access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the resource or metadata.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:resourceConstraints/gmd:accessConstraints

Group attributes attached to gmd:accessConstraints		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_RestrictionCode' (static)	NC_STRING
codeListValue	'copyright' (static)	NC_STRING
objectType	'gmd:MD_RestrictionCode' (static)	NC_STRING

12.28.1.28 Group "gmd:spatialRepresentationType" in "gmd:identificationInfo"

Method used to spatially represent geographic information.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:spatialRepresentationType

Group attributes attached to gmd:spatialRepresentationType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_SpatialRepresentation-TypeCode' (static)	NC_STRING
codeListValue	'grid' (static)	NC_STRING
objectType	'gmd:MD_SpatialRepresentationTypeCode' (static)	NC_STRING

12.28.1.29 Group "gmd:spatialResolution" in "gmd:identificationInfo"

Ground sample distance.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:spatialResolution

Group attributes attached to gmd:spatialResolution		
Name	*Value*	*Type*

gmd:distance	7.0 (dynamic)	NC_FLOAT
uom	'km' (static)	NC_STRING
objectType	'gmd:MD_Resolution' (static)	NC_STRING

12.28.1.30 Group "gmd:characterSet" in "gmd:identificationInfo"

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:characterSet

Group attributes attached to gmd:characterSet		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_CharacterSetCode' (static)	NC_STRING
codeListValue	'utf8' (static)	NC_STRING
objectType	'gmd:MD_CharacterSetCode' (static)	NC_STRING

12.28.1.31 Group "gmd:extent" in "gmd:identificationInfo"

Extent information including the bounding box, bounding polygon, vertical, and temporal extent of the dataset.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:extent

Group attributes attached to gmd:extent		
Name	*Value*	*Type*
objectType	'gmd:EX_Extent' (static)	NC_STRING

12.28.1.32 Group "gmd:geographicElement" in "gmd:extent"

Geographic position of the granule. This is only an approximate reference so specifying the coordinate reference system is unnecessary. The usual limitations apply: $-180^\circ \leq \vartheta \leq 180^\circ$ and $-90^\circ \leq \delta \leq 90^\circ$. Note that for full orbits these values provide little information as at lease one pole will be present in the data, ensuring full longitudinal coverage.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:extent/gmd:geographicElement

Group attributes attached to gmd:geographicElement		
Name	*Value*	*Type*
gmd:eastBoundLongitude	180.0 (dynamic)	NC_FLOAT
gmd:northBoundLatitude	90.0 (dynamic)	NC_FLOAT
gmd:southBoundLatitude	-90.0 (dynamic)	NC_FLOAT
gmd:westBoundLongitude	-180.0 (dynamic)	NC_FLOAT
gmd:extentTypeCode	'true' (static)	NC_STRING
Indication of whether the bounding polygon encompasses an area covered by the data or an area where data is not present. The value "true" indicates *inclusion*.		
objectType	'gmd:EX_GeographicBoundingBox' (static)	NC_STRING

12.28.1.33 Group "gmd:temporalElement" in "gmd:extent"

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:extent/gmd:temporalElement

Group attributes attached to gmd:temporalElement		
Name	*Value*	*Type*
objectType	'gmd:EX_TemporalExtent' (static)	NC_STRING

12.28.1.34 Group "gmd:extent" in "gmd:temporalElement"

Time period covered by the content of the dataset.

Attributes in ISO_METADATA/gmd:identificationInfo/gmd:extent/gmd:temporalElement/gmd:extent

Group attributes attached to gmd:extent		
Name	*Value*	*Type*
gml:beginPosition	'2014-11-14T19:58:00' (dynamic)	NC_STRING
Time of the start of the granule, expressed as ISO 8601 [RD35] date-time string.		
gml:endPosition	'2014-11-14T20:08:00' (dynamic)	NC_STRING
Time of the end of the granule, expressed as ISO 8601 [RD35] date-time string.		
objectType	'gml:TimePeriod' (static)	NC_STRING

12.28.1.35 Group "gmd:dataQualityInfo" in "ISO_METADATA"

This group contains a general assessment of the quality of the dataset. In addition, the package contains information about the sources and production processes used in producing a dataset, which is of particular importance for imagery and gridded data.

For the TROPOMI 2 products the use of the contained class LI_Lineage (group "gmd:lineage", section 12.28.1.43 on page 122) is important for describing the sources which are either used or produced (output) in a series of process steps. The sources refer to the various L1b data products used as inputs (and the L0 products used in producing *those* products) and the auxiliary data (static and especially dynamic) when producing the L2 products.

Attributes in ISO_METADATA/gmd:dataQualityInfo

Group attributes attached to gmd:dataQualityInfo		
Name	*Value*	*Type*
objectType	'gmd:DQ_DataQuality' (static)	NC_STRING

12.28.1.36 Group "gmd:scope" in "gmd:dataQualityInfo"

The specific data to which the data quality information applies.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:scope

Group attributes attached to gmd:scope		
Name	*Value*	*Type*
objectType	'gmd:DQ_Scope' (static)	NC_STRING

12.28.1.37 Group "gmd:level" in "gmd:scope"

Hierarchical level of the data specified by the scope.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:scope/gmd:level

Group attributes attached to gmd:level		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_ScopeCode' (static)	NC_STRING
codeListValue	'dataset' (static)	NC_STRING
objectType	'gmd:MD_ScopeCode' (static)	NC_STRING

12.28.1.38 Group "gmd:report" in "gmd:dataQualityInfo"

Value (or set of values) obtained from applying a data quality measure or the outcome of evaluating the obtained value (or set of values) against a specified acceptable conformance quality level.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:report

Group attributes attached to gmd:report		
Name	*Value*	*Type*
objectType	'gmd:DQ_DomainConsistency' (static)	NC_STRING

12.28.1.39 Group "gmd:result" in "gmd:report"

Value (or set of values) obtained from applying a data quality measure or the outcome of evaluating the obtained value (or set of values) against a specified acceptable conformance quality level.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result

Group attributes attached to gmd:result		
Name	*Value*	*Type*
objectType	'gmd:DQ_ConformanceResult' (static)	NC_STRING
gmd:pass	'true' (static)	NC_STRING
Indication of confomance result. The value "*true*" indicates "*pass*".		
gmd:explanation	'INSPIRE Data specification for orthoimagery is not yet officially published so conformity has not yet been evaluated' (static)	NC_STRING
Explanation of the meaning of conformance for this result. Within the context of INSPIRE conformance can currently not be determined.		

12.28.1.40 Group "gmd:specification" in "gmd:result"

Citation of product specification or user requirement against which data is being evaluated.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result/gmd:specification

Group attributes attached to gmd:specification		
Name	*Value*	*Type*
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'INSPIRE Data Specification on Orthoimagery - Guidelines, version 3.0rc3' (static)	NC_STRING

12.28.1.41 Group "gmd:date" in "gmd:specification"

Reference date for the cited resource.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result/gmd:specification/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'2013-02-04' (static)	NC_STRING
objectType	'gmd:CI_Date' (static)	NC_STRING

12.28.1.42 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result/gmd:specification/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING

codeListValue	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.43 Group "gmd:lineage" in "gmd:dataQualityInfo"

Non-quantitative quality information about the lineage of the data specified by the scope.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage

Group attributes attached to gmd:lineage		
Name	*Value*	*Type*
objectType	'gmd:LI_Lineage' (static)	NC_STRING
gmd:statement	'L2 %(product)s dataset produced by %(processingcenter)s from the S5P/TROPOMI L1B product' (dynamic)	NC_STRING
General explanation of the data producer's knowledge about the lineage of a dataset. Insert short description of the actual Level 2 product in this string (at the %(. . .)s).		

12.28.1.44 Group "gmd:processStep" in "gmd:lineage"

Information about an event or transformation in the life of the dataset including details of the algorithm and software used for processing.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep

Group attributes attached to gmd:processStep		
Name	*Value*	*Type*
objectType	'gmi:LE_ProcessStep' (static)	NC_STRING
gmd:description	'Processing of L1b to L2 %(product)s data for orbit %(orbit)d using the %(institute)s processor version %(version)s' (dynamic)	NC_STRING
Description of the event, including related parameters or tolerances. Insert short description of the actual Level 2 product, the orbit number, the name of the institude responsible for the CFI and the software version in this string (at the respective %(. . .)s and %(. . .)d).		

12.28.1.45 Group "gmi:output" in "gmd:processStep"

Description of the output.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output

Group attributes attached to gmi:output		
Name	*Value*	*Type*
gmd:description		NC_STRING
Short description of the output, a copy of the global 'title' attribute.		
objectType	'gmi:LE_Source' (static)	NC_STRING

12.28.1.46 Group "gmd:sourceCitation" in "gmi:output"

Reference to the actual filename of the output data and production date and time.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation

Group attributes attached to gmd:sourceCitation		
Name	*Value*	*Type*
gmd:title	'%(logical_filename)s' (dynamic)	NC_STRING
Output file name without extension.		
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.28.1.47 Group “gmd:date” in “gmd:sourceCitation”

Production date and time of the output file.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date		NC_STRING
Production date and time of the output file. Note that the definition in the XML schema appears to allow the use of a “CI_DateTime” instead of a “CI_Date”.		
objectType	‘gmd:CI_DateTime’ (static)	NC_STRING

12.28.1.48 Group “gmd:dateType” in “gmd:date”

Meaning of the reference date for the cited resource.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	‘http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode’ (static)	NC_STRING
codeListValue	‘creation’ (static)	NC_STRING
objectType	‘gmd:CI_DateTypeCode’ (static)	NC_STRING

12.28.1.49 Group “gmd:identifier” in “gmd:sourceCitation”

Identification of the output product.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:identifier

Group attributes attached to gmd:identifier		
Name	*Value*	*Type*
gmd:code	‘%(shortname)s’ (dynamic)	NC_STRING
The product short name, a copy of the ‘ProductShortName’ attribute in ‘/METADATA/GRANULE_DESCRIPTION’.		
objectType	‘gmd:MD_Identifier’ (static)	NC_STRING

12.28.1.50 Group “gmi:processedLevel” in “gmi:output”

Process level of the output file.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmi:processedLevel

Group attributes attached to gmi:processedLevel		
Name	*Value*	*Type*
gmd:code	‘L2’ (static)	NC_STRING
objectType	‘gmd:MD_Identifier’ (static)	NC_STRING

12.28.1.51 Group “gmi:processingInformation” in “gmd:processStep”

Description of the processor in more detail.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation

Group attributes attached to gmi:processingInformation		
Name	*Value*	*Type*
objectType	'gmi:LE_Processing' (static)	NC_STRING

12.28.1.52 Group "gmi:identifier" in "gmi:processingInformation"

Identification of the processor.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:identifier

Group attributes attached to gmi:identifier		
Name	*Value*	*Type*
gmd:code	'%(institute)s L2 %(product)s processor, version %(version)s' (dynamic)	NC_STRING
Descriptive name of the processor, with the %(. . .)s placeholders replaced with the responsible institute's name, product name and software release version.		
objectType	'gmd:MD_Identifier' (static)	NC_STRING

12.28.1.53 Group "gmi:softwareReference" in "gmi:processingInformation"

Reference to document describing processing software.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference

Group attributes attached to gmi:softwareReference		
Name	*Value*	*Type*
gmd:title	'L2 %(product)s processor description' (dynamic)	NC_STRING
Title of processor description.		
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.28.1.54 Group "gmd:date" in "gmi:softwareReference"

Release date (compile date) of the processor.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date		NC_STRING
Release date of the processor expressed as an ISO 8601 date string [RD35].		
objectType	'gmd:CI_DateTime' (static)	NC_STRING

12.28.1.55 Group "gmd:dateType" in "gmd:date"

Confirm that this is the release date of the processor.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'creation' (static)	NC_STRING

objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.56 Group "gmi:documentation#1" in "gmi:processingInformation"

Reference to the ATBD of the product.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1

Group attributes attached to gmi:documentation#1		
Name	*Value*	*Type*
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_atbd)s' (dynamic)	NC_STRING
The filename of the current release of the ATBD of the current product.		
doi	'%(atbd_doi)s' (dynamic)	NC_STRING
DOI for the algorithm theoretical basis document.		

12.28.1.57 Group "gmd:date" in "gmi:documentation#1"

Release date of the ATBD.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'%(date_atbd)s' (dynamic)	NC_STRING
Release date of the ATBD expressed as an ISO 8601 date string [RD35].		
objectType	'gmd:CI_Date' (static)	NC_STRING

12.28.1.58 Group "gmd:dateType" in "gmd:date"

Confirm that this is the date of publication.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.59 Group "gmi:documentation#2" in "gmi:processingInformation"

Reference to the PUM of the product.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2

Group attributes attached to gmi:documentation#2		
Name	*Value*	*Type*
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_pum)s' (dynamic)	NC_STRING
The filename of the current release of the PUM of the current product.		

doi	'%(pum_doi)s' (dynamic)	NC_STRING
DOI for the product user manual.		

12.28.1.60 Group "gmd:date" in "gmi:documentation#2"

Release date of the PUM.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date	'%(date_pum)s' (dynamic)	NC_STRING
Release date of the PUM expressed as an ISO 8601 date string [RD35].		
objectType	'gmd:CI_Date' (static)	NC_STRING

12.28.1.61 Group "gmd:dateType" in "gmd:date"

Confirm that this is the date of publication.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.62 Group "gmi:report" in "gmd:processStep"

Short report of what occurred during the process step.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:report

Group attributes attached to gmi:report		
Name	*Value*	*Type*
gmi:description	'Sentinel 5-precursor TROPOMI L1b processed to L2 data using the %(institute)s L2 %(product)s processor' (dynamic)	NC_STRING
Textual description of what occurred during the process step. Replace %(...)s as indicated.		
gmi:fileType	'netCDF-4' (static)	NC_STRING
Type of file that contains the processing report, in our case the processing report is contained in the main output file.		
gmi:name	'%(logical_filename)s.nc' (dynamic)	NC_STRING
objectType	'gmi:LE_ProcessStepReport' (dynamic)	NC_STRING

12.28.1.63 Group "gmd:source#1" in "gmd:processStep"

Information about the source data used in creating the data specified by the scope. Repeat group as needed, incrementing the number of the source (after the # mark).

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1

Group attributes attached to gmd:source#1		
Name	*Value*	*Type*
objectType	'gmi:LE_Source' (static)	NC_STRING
gmd:description		NC_STRING
Description of the input data, including L1B, L2, dynamic auxiliary input data and semi-static auxiliary input data. Base strings are "TROPOMI L1B %s radiance product", "TROPOMI L1B %s irradiance product", "TROPOMI L2 %s product", "Auxiliary ECMWF %s Meteorological forecast data", "Processor %s configuration file", "Auxiliary %s reference data", "Auxiliary %s algorithm lookup table", "Auxiliary CTM %s model input data", "Auxiliary snow and ice input data" and "Auxiliary NPP/VIIRS cloud screening input data". The %s to be replaced with specific descriptors.		

12.28.1.64 Group "gmi:processedLevel" in "gmd:source#1"

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmi:processedLevel

Group attributes attached to gmi:processedLevel		
Name	*Value*	*Type*
gmd:code	*Empty!*	NC_STRING
objectType	'gmd:MD_Identifier' (static)	NC_STRING

12.28.1.65 Group "gmd:sourceCitation" in "gmd:source#1"

Reference to the actual filename of the input data.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation

Group attributes attached to gmd:sourceCitation		
Name	*Value*	*Type*
objectType	'gmd:CI_Citation' (static)	NC_STRING

12.28.1.66 Group "gmd:date" in "gmd:sourceCitation"

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:date

Group attributes attached to gmd:date		
Name	*Value*	*Type*
gmd:date		NC_STRING
Production date and time of the input file(s) in this group expressed as an ISO 8601 date-time string [RD35]. Note that the definition in the XML schema appears to allow the use of a "CI_DateTime" instead of a "CI_Date".		
objectType	'gmd:CI_Date' (static)	NC_STRING

12.28.1.67 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	*Value*	*Type*
codeList	'http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING

codeListValue	'creation' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

12.28.1.68 Group "gmd:title" in "gmd:sourceCitation"

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:title

Group attributes attached to gmd:title		
Name	*Value*	*Type*
gco:characterString		NC_STRING
Textual description of the input file group (same as the "`gmd:description`" attribute in the "`gmi:LE_Source`" object).		

12.28.1.69 Group "gmd:alternateTitle#1" in "gmd:sourceCitation"

All filenames in this group, in case more files of a particular file type are delivered, for instance for meteorological or model input. Repeat group as needed, incrementing the number of the input file (after the # mark).

Attributes in ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:alternateTitle#1

Group attributes attached to gmd:alternateTitle#1		
Name	*Value*	*Type*
gmx:FileName	*Empty!*	NC_STRING
The basename of the input file.		

12.28.1.70 Group "gmi:acquisitionInformation" in "ISO_METADATA"

Metadata regarding the acquisition of the original data.

Attributes in ISO_METADATA/gmi:acquisitionInformation

Group attributes attached to gmi:acquisitionInformation		
Name	*Value*	*Type*
objectType	'gmi:MI_AcquisitionInformation' (static)	NC_STRING

12.28.1.71 Group "gmi:platform" in "gmi:acquisitionInformation"

The platform we are on.

Attributes in ISO_METADATA/gmi:acquisitionInformation/gmi:platform

Group attributes attached to gmi:platform		
Name	*Value*	*Type*
gmi:description	'Sentinel 5 Precursor' (static)	NC_STRING
objectType	'gmi:MI_Platform' (static)	NC_STRING

12.28.1.72 Group "gmi:identifier" in "gmi:platform"

Short identifier of the platform.

Attributes in ISO_METADATA/gmi:acquisitionInformation/gmi:platform/gmi:identifier

Group attributes attached to gmi:identifier		
Name	*Value*	*Type*
gmd:code	'S5P' (static)	NC_STRING
gmd:codeSpace	'http://www.esa.int/' (static)	NC_STRING
objectType	'gmd:RS_Identifier' (static)	NC_STRING

12.28.1.73 Group "gmi:instrument" in "gmi:platform"

The instrument used for the observations.

Attributes in ISO_METADATA/gmi:acquisitionInformation/gmi:platform/gmi:instrument

Group attributes attached to gmi:instrument		
Name	*Value*	*Type*
objectType	'gmi:MI_Instrument' (static)	NC_STRING
gmi:type	'UV-VIS-NIR-SWIR imaging spectrometer' (static)	NC_STRING
Type of the instrument.		

12.28.1.74 Group "gmi:identifier" in "gmi:instrument"

Unique identifier for the instrument.

Attributes in ISO_METADATA/gmi:acquisitionInformation/gmi:platform/gmi:instrument/gmi:identifier

Group attributes attached to gmi:identifier		
Name	*Value*	*Type*
gmd:code	'TROPOMI' (static)	NC_STRING
The actual identifier.		
gmd:codeSpace	'http://www.esa.int/' (static)	NC_STRING
Name or identifier of the organization responsible for the namespace.		
objectType	'gmd:RS_Identifier' (static)	NC_STRING

13 Description of Cloud product

Global attributes in CLOUD_

The attributes described in section 13 "Common file-level attributes" on page 129 are included in the output at this location.

The attributes described in section 12.2 "Common file-level attributes for DLR" on page 35 are included in the output at this location.

The attributes described in section 12.3 "Status dynamic ECMWF auxiliary data" on page 35 are included in the output at this location.

The attributes described in section 12.4 "Status dynamic NISE auxiliary data" on page 35 are included in the output at this location.

The attributes described in section 12.5 "Status background correction auxiliary data" on page 35 are included in the output at this location.

The attributes described in section 12.6 "Status dynamic NPP-VIIRS auxiliary data" on page 36 are included in the output at this location.

The attributes described in section 12.6 "Status dynamic NPP-VIIRS auxiliary data" on page 36 are included in the output at this location.

Group attributes attached to CLOUD_		
Name	*Value*	*Type*

title	'TROPOMI/S5P Cloud' (dynamic)	NC_STRING
This is a short description of the product. In near-realtime processing the granule may be shorter than 1 orbit. In that case the title will become dynamic. This attribute originates from the NUG standard.		
references	'https://atmos.eoc.dlr.de/tropomi' (static)	NC_STRING
References that describe the data or methods used to produce it. A URI to the ATBD seems to be an appropriate starting point. This attribute originates from the CF standard.		

13.1 Group "PRODUCT" in "CLOUD_"

This is the main group containing the Cloud product. At this level the dimensions are defined, the actual data can be found one level deeper.

Dimensions in CLOUD_/PRODUCT
The dimensions described in section 12.7 "Common dimensions" on page 36 are included in the output at this location.

The dimensions described in section 12.7 "Common dimensions" on page 36 are included in the output at this location.

Variables in CLOUD_/PRODUCT
The variables described in section 12.8 "Coordinate variables" on page 36 are included in the output at this location.

The variables described in section 12.9 "Corner Dimension" on page 37 are included in the output at this location.

The variables described in section 12.10 "The geolocation fields" on page 38 are included in the output at this location.

The variables described in section 12.11 "Common product fields" on page 39 are included in the output at this location.

The variables described in section 12.12 "Main CAL Cloud Product" on page 40 are included in the output at this location.

latitude_nir in CLOUD_/PRODUCT

Description:	The latitude of the pixel centers of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid.
Dimensions:	time, scanline, ground_pixel.
Type:	NC_FLOAT.
Source:	Processor.
Mode:	Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'pixel center latitude' (static)	NC_STRING
units	'degrees_north' (static)	NC_STRING
standard_name	'latitude' (static)	NC_STRING
valid_min	-90.0 (static)	NC_FLOAT
valid_max	90.0 (static)	NC_FLOAT
bounds	'/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/ latitude_bounds_nir' (static)	NC_STRING

A link to the boundary coordinates, i.e. the pixel corners. Note that the use of group-names in this attribute is an extension of the climate and forecasting metadata conventions.

longitude_nir in CLOUD_/PRODUCT

Description:	The longitude of the pixel centers of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid.
Dimensions:	time, scanline, ground_pixel.
Type:	NC_FLOAT.

Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'pixel center longitude' (static)	NC_STRING
	units	'degrees_east' (static)	NC_STRING
	standard_name	'longitude' (static)	NC_STRING
	valid_min	-180.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT
	bounds	'/PRODUCT/SUPPORT_DATA/GEOLOCATIONS/ longitude_bounds_nir' (static)	NC_STRING
	A link to the boundary coordinates, i.e. the pixel corners. Note that the use of group-names in this attribute is an extension of the climate and forecasting metadata conventions.		

13.1.1 Group "SUPPORT_DATA" in "PRODUCT"

13.1.1.1 Group "GEOLOCATIONS" in "SUPPORT_DATA"

Variables in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS
The variables described in section 12.13 "Additional geolocation support fields" on page 44 are included in the output at this location.

solar_zenith_angle_nir in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS			
Description:	Solar zenith angle ϑ_0 at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical. ESA definition of day side: $\vartheta_0 < 92^\circ$. Pixels are processed when $\vartheta_0 \leq \vartheta_0^{\max}$ with $80^\circ \leq \vartheta_0^{\max} \leq 88^\circ$, depending on the algorithm. The actual value for $\vartheta_0^{\max}$ can be found in the algorithm metadata settings.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	L1B.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'solar zenith angle' (static)	NC_STRING
	standard_name	'solar_zenith_angle' (static)	NC_STRING
	units	'degree' (static)	NC_STRING
	valid_min	0.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
	comment	'Solar zenith angle at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical' (static)	NC_STRING
solar_azimuth_angle_nir in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS			
Description:	The solar azimuth angle at the ground pixel location on the reference ellipsoid. The angle is measured clockwise from the North (North = 0°, East = 90°, South = 180°, West = 270°). This is the same definition that is use in both OMI and GOME-2 level 1B files.		

See the note on the `viewing_azimuth_angle` on the calculation of the relative azimuht angle as used in radiative transfer calculations.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: L1B.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'solar azimuth angle' (static)	NC_STRING
standard_name	'solar_azimuth_angle' (static)	NC_STRING
units	'degree' (static)	NC_STRING
valid_min	-180.0 (static)	NC_FLOAT
valid_max	180.0 (static)	NC_FLOAT
coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].	
comment	'Solar azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = 270)' (static)	NC_STRING

viewing_zenith_angle_nir in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

Description: Zenith angle of the satellite ϑ at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: L1B.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'viewing zenith angle' (static)	NC_STRING
standard_name	'viewing_zenith_angle' (static)	NC_STRING
units	'degree' (static)	NC_STRING
valid_min	0.0 (static)	NC_FLOAT
valid_max	180.0 (static)	NC_FLOAT
coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].	
comment	'Zenith angle of the satellite at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical' (static)	NC_STRING

viewing_azimuth_angle_nir in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

Description: The satellite azimuth angle at the ground pixel location on the reference ellipsoid. The angle is measured clockwise from the North (North = $0°$, East = $90°$, South = $180°$, West = $270°$). This is the same definition that is use in both OMI and GOME-2 level 1B files.

To calculate the azimuth difference $\varphi - \varphi_0$ it is not sufficient to just subtract `solar_azimuth_angle` from `viewing_azimuth_angle`. The angle needed for radiative transfer calculations is $(180° - (\varphi - \varphi_0)) \bmod 360°$.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.
Source: L1B.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'viewing azimuth angle' (static)	NC_STRING
	standard_name	'viewing_azimuth_angle' (static)	NC_STRING
	units	'degree' (static)	NC_STRING
	valid_min	-180.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		
	comment	'Satellite azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = 270)' (static)	NC_STRING

latitude_bounds_nir in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

Description: The latitude of the pixel corners of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid.

The order of the pixel corners follows the CF-metadata conventions [ER5, section 7.1], i.e. the ordering is counter-clockwise when viewed from above. A graphical representation is given in figure 6.

Dimensions: time, scanline, ground_pixel, corner.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'degrees_north' (static)	NC_STRING

longitude_bounds_nir in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

Description: The longitude of the pixel corners of the ground pixels in the data. Latitude, longitude coordinates for the ground pixel center and the ground pixel corners are calculated at the WGS84 ellipsoid.

The order of the pixel corners follows the CF-metadata conventions [ER5, section 7.1], i.e. the ordering is counter-clockwise when viewed from above. A graphical representation is given in figure 6.

Dimensions: time, scanline, ground_pixel, corner.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'degrees_east' (static)	NC_STRING

geolocation_flags_nir in CLOUD_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

Description: Additional flags describing the ground pixel, including the influence of a solar eclipse, the possibility of sun glint, whether we are in the descending part of the orbit, whether we are on the night side of the orbit, whether the pixel crosses the dateline (useful for plotting), or if there was some geolocation error.

Dimensions: time, scanline, ground_pixel.

Type:	NC_UBYTE.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	_FillValue	255 (static)	NC_UBYTE
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	flag_masks	0, 1, 2, 4, 8, 16, 128 (static)	NC_UBYTE
	flag_meanings	'no_error solar_eclipse sun_glint_possible descending night geo_boundary_crossing geolocation_error' (static)	NC_STRING
	flag_values	0, 1, 2, 4, 8, 16, 128 (static)	NC_UBYTE
	long_name	'ground pixel quality flag' (static)	NC_STRING
	max_val	254 (static)	NC_UBYTE
	min_val	0 (static)	NC_UBYTE
	units	'1' (static)	NC_STRING

13.1.1.2 Group "DETAILED_RESULTS" in "SUPPORT_DATA"

The groups described in section 12.18 "Debug fields for UPAS" on page 70 are included in the output at this location.

The groups described in section 12.19 "Computed polynomials and shift/squeeze values" on page 76 are included in the output at this location.

Dimensions in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

number_fitting_parameter_ge The number of fitting parameters used in the ROCINN effective scene retrieval.

size 1 (dynamic)
source Processor.
mode Present in all modes.

number_fitting_parameter_crb The number of fitting parameters used in the ROCINN CRB cloud retrieval.

size 1 (dynamic)
source Processor.
mode Present in all modes.

number_fitting_parameter The number of fitting parameters used in the ROCINN CAL cloud retrieval.

size 1 (dynamic)
source Processor.
mode Present in all modes.

Variables in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

The variables described in section 12.14 "Main fields for Cloud Product based on CRB model" on page 48 are included in the output at this location.

The variables described in section 12.15 "Detailed Results related to OCRA/ROCINN CAL Cloud Product" on page 51 are included in the output at this location.

The variables described in section 12.16 "Detailed Results related to the NIR variables of the Cloud Product" on page 52 are included in the output at this location.

The variables described in section 12.17 "Additional detailed results fields" on page 68 are included in the output at this location.

The variables described in section 12.17 "Additional detailed results fields" on page 68 are included in the output at this location.

surface_albedo_fitted_crb in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Surface albedo fitted using the OCRA/ROCINN CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'surface_albedo' (static)	NC_STRING
	long_name	'surface albedo fitted from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Coregistered surface albedo fitted using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

surface_albedo_fitted_crb_precision in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Error of the fitted surface albedo calculated using the OCRA/ROCINN CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'surface_albedo_standard_error' (static)	NC_STRING
	long_name	'surface albedo fitted precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered surface albedo fitted using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

sun_glint_flag in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Flag describing the possibility of occurence of sunglint.
Dimensions: time, scanline, ground_pixel.
Type: NC_UBYTE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	long_name	'sun glint binary mask' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_top_temperature in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Atmospheric temperature at cloud top level using the OCRA/ROCINN CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'K' (static)	NC_STRING
	standard_name	'air_temperature_at_cloud_top' (static)	NC_STRING
	long_name	'cloud top temperature' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	comment	'Atmospheric temperature at the level of cloud top using the OCRA/ROCINN CAL model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_phase in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Phase of the retrieved cloud
Dimensions: time, scanline, ground_pixel.
Type: NC_UBYTE.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	long_name	'cloud phase' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_fraction_apriori in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: A Priori Cloud Fraction computed by the OCRA/ROCINN model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'effective radiometric cloud fraction a priori' (static)	NC_STRING
	comment	'Retrieved radiometric cloud fraction based on the OCRA model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

wavelength_shift in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Wavelength shift fitted using the OCRA/ROCINN CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.

Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'nm' (static)	NC_STRING
	long_name	'wavelength shift' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

wavelength_shift_precision in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description:	Error of the fitted wavelength shift using the OCRA/ROCINN CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'nm' (static)	NC_STRING
	long_name	'wavelength shift precision' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

wavelength_shift_crb in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description:	Wavelength shift fitted using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'nm' (static)	NC_STRING
	long_name	'wavelength shift' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

wavelength_shift_crb_precision in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description:	Error of the fitted wavelength shift using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'nm' (static)	NC_STRING
	long_name	'wavelength shift precision' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

number_of_iterations in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description:	Number of rocinn iterations for the CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'number of rocinn iterations reached per pixel for the CAL model' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

number_of_iterations_crb in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description:	Number of rocinn iterations for the CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'number of rocinn iterations reached per pixel for the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

fitted_root_mean_square in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description:	Final root mean square residual of the rocinn inversion using the CAL model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'root mean square residual' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

fitted_root_mean_square_crb in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description:	Final root mean square residual of the rocinn inversion using the CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING

	long_name	'root mean square residual from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

degrees_of_freedom in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Final Degrees of freedom of the rocinn inversion using the CAL model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final degrees of freedom of the rocinn inversion using the CAL model' (static)	NC_STRING
	source	'cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

degrees_of_freedom_crb in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Final Degrees of freedom of the rocinn inversion using the CRB model.
Dimensions: time, scanline, ground_pixel.
Type: NC_FLOAT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'final degrees of freedom of the rocinn inversion using the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

number_of_spectral_points_in_retrieval in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: The number of points in the spectrum that were used in the CAL retrieval.
Dimensions: time, scanline, ground_pixel.
Type: NC_USHORT.
Source: Processor.
Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	long_name	'Number of spectral points used in the CAL retrieval' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING

The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].

effective_scene_height in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Retrieved effective scene height w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
units	'm' (static)	NC_STRING
standard_name	'TBD' (static)	NC_STRING
long_name	'effective scene height from the CRB model' (static)	NC_STRING
source	'crb' (static)	NC_STRING
comment	'Coregistered effective scene height w.r.t. the retrieved geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.

effective_scene_height_precision in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Error of the retrieved scene height w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
units	'm' (static)	NC_STRING
standard_name	'TBD' (static)	NC_STRING
long_name	'effective scene height precision from the CRB model' (static)	NC_STRING
source	'crb' (static)	NC_STRING
comment	'Error of the coregistered effective scene height w.r.t. the retrieved geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.

effective_scene_pressure in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Retrieved effective scene atmospheric pressure using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
units	'Pa' (static)	NC_STRING
standard_name	'TBD' (static)	NC_STRING

	long_name	'effective scene optical centroid pressure from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Coregistered and converted effective scene atmospheric pressure retrieved using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

effective_scene_pressure_precision in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Error of the retrieved effective scene atmospheric pressure using the OCRA/ROCINN CRB model.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'Pa' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'effective scene pressure precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered and converted effective scene atmospheric pressure retrieved using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

coregistration_weight_sums_nir in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Value describing the sum of the weights of the linear coregistration from band 3/4 to band 6 for each pixel .

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'coregistration weight sums nir' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

coregistration_weight_sums_crb in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Value describing the sum of the weights of the linear coregistration from band 6 to band 3/4 for values from the CRB retrieval for each pixel.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'coregistration weight sums crb' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

coregistration_weight_sums_cal in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Value describing the sum of the weights of the linear coregistration from band 6 to band 3/4 for values from the CAL retrieval for each pixel.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'coregistration weight sums cal' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

coregistration_weight_sums_ge in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Value describing the sum of the weights of the linear coregistration from band 6 to band 3/4 for values from the effective scene retrieval for each pixel.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'coregistration weight sums ge' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

cloud_coregistration_inhomogeneity_parameter in CLOUD_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Value describing the cloud inhomogeneity based on the coregistration table provided by KNMI. The value range is [0,1] where high values indicate inhomogenous scenes.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	long_name	'cloud coregistration inhomogeneity parameter' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.		

13.1.1.3 Group "INPUT_DATA" in "SUPPORT_DATA"

The groups described in section 12.21 "Input data common to all the L2 DLR products" on page 81 are included in the output at this location.

Dimensions in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

reflectances The number of ocra reflectances.

size 3 (fixed)
source Processor.
mode Present in all modes.

Variables in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA
The variables described in section 12.22 "Original and computed snow-ice flag" on page 82 are included in the output at this location.

reflectances_ocra in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description:	OCRA reflectance at wavelength ranges R, G, B.		
Dimensions:	time, scanline, ground_pixel, reflectances.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	comment	'Colors used in the OCRA model. Index 0 is color B, index 1 is color G and index 2 is fill_value (color R is not used for TROPOMI).' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
	long_name	'toa bidiretional ocra rgb reflectances' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

continuum_reflectance_oxygen_Aband in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description:	Reflectance at first pixel of O2 A-band fitting window.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
	long_name	'toa bidirectional o2a continuum reflectance' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

viirs_cloud_fraction in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description:	Ratio of VIIRS pixels classified as CONFIDENTLY$_CLOUDY in the UV/VIS$

Dimensions:	time, scanline, ground_pixel.		
Type:	NC_SHORT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	scale_factor	0.0001 (static)	NC_FLOAT
	standard_name	'viirs_cloud_fraction_uvis' (static)	NC_STRING
	long_name	'Ratio of VIIRS pixels classified as CONFIDENTLY_CLOUDY in the UV/VIS' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

viirs_cloud_fraction_nir in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description:	Ratio of VIIRS pixels classified as CONFIDENTLY$_{C}LOUDYinthenearinfrared$		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_SHORT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	scale_factor	0.0001 (static)	NC_FLOAT
	standard_name	'viirs_cloud_fraction_nir' (static)	NC_STRING
	long_name	'Ratio of VIIRS pixels classified as CONFIDENTLY_CLOUDY in the near infrared' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

surface_albedo_nir in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description:	The used surface albedo (either from a climatology or retrieved) for the retrieval of the cloud parameters of the pixel		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	long_name	'surface albedo nir' (static)	NC_STRING
	standard_name	'surface_albedo_nir' (static)	NC_STRING
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

	comment	'The used surface albedo for the retrieval' (static)	NC_STRING

surface_altitude_nir in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description: The mean of the sub-pixels of the surface altitude above the reference geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: surface elevation database.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
long_name	'surface altitude' (static)	NC_STRING
standard_name	'surface_altitude' (static)	NC_STRING
units	'm' (static)	NC_STRING
coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].	
source	'http://topotools.cr.usgs.gov/gmted_viewer/' (static)	NC_STRING
comment	'The mean of the sub-pixels of the surface altitude above the reference geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database' (static)	NC_STRING

surface_pressure_nir in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description: Surface pressure from ECMWF model data.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

Source: Processor.

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
units	'Pa' (static)	NC_STRING
standard_name	'surface_air_pressure' (static)	NC_STRING
long_name	'surface_air_pressure' (static)	NC_STRING
source		NC_STRING
coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].	

surface_classification_nir in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description: This is a combined land/water mask and surface classification data field.

Dimensions: time, scanline, ground_pixel.

Type: NC_UBYTE.

Source: surface elevation database (including flag attributes).

Mode: Present in all modes.

Attributes:

Name	*Value*	*Type*
units	'1' (static)	NC_STRING
long_name	'land-water mask' (static)	NC_STRING
comment	'flag indicating land/water and further surface classifications for the ground pixel' (static)	NC_STRING

	source	'USGS (http://edc2.usgs.gov/glcc/globdoc2_0.php) and NASA SDP toolkit (http://newsroom.gsfc.nasa.gov/sdptoolkit/toolkit.html)' (static)	NC_STRING
	flag_meanings	'land, water, some_water, coast, value_covers_majority_of_pixel, water+shallow_ocean, water+shallow_inland_water, water+ocean_coastline-lake_shoreline, water+intermittent_water, water+deep_inland_water, water+continental_shelf_ocean, water+deep_ocean, land+urban_and_built-up_land, land+dryland_cropland_and_pasture, land+irrigated_cropland_and_pasture, land+mixed_dryland-irrigated_cropland_and_pasture, land+cropland-grassland_mosaic, land+cropland-woodland_mosaic, land+grassland, land+shrubland, land+mixed_shrubland-grassland, land+savanna, land+deciduous_broadleaf_forest, land+deciduous_needleleaf_forest, land+evergreen_broadleaf_forest, land+evergreen_needleleaf_forest, land+mixed_forest, land+herbaceous_wetland, land+wooded_wetland, land+barren_or_sparsely_vegetated, land+herbaceous_tundra, land+wooded_tundra, land+mixed_tundra, land+bare_ground_tundra, land+snow_or_ice' (static)	NC_STRING
	flag_values	0, 1, 2, 3, 4, 9, 17, 25, 33, 41, 49, 57, 8, 16, 24, 32, 40, 48, 56, 64, 72, 80, 88, 96, 104, 112, 120, 128, 136, 144, 152, 160, 168, 176, 184 (static)	NC_UBYTE
	flag_masks	3, 3, 3, 3, 4, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249, 249 (static)	NC_UBYTE
	coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
	The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

snow_ice_flag_nir in CLOUD_/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description:	This is binary snow/ice classification flag. It is computed internally in the processor based on external dynamic data (e.g. NSIDC/NISE or climatology). In case the original value of the pixel is greater than 30 percent, the flag is set to 1 (snow/ice presence), otherwise 0 (snow/ice free).
Dimensions:	time, scanline, ground_pixel.
Type:	NC_UBYTE.
Source:	Processor.
Mode:	Present in all modes.

Attributes:	*Name*	*Value*	*Type*
	units	'1' (static)	NC_STRING
	threshold	'0.3' (static)	NC_STRING
	The threshold in percentage to identify the pixel as snow/ice or snow free.		
	long_name	'snow-ice mask' (static)	NC_STRING
	_FillValue	'254UB' (static)	NC_STRING

comment	'flag indicating snow/ice at center of ground pixel' (static)	NC_STRING
source		NC_STRING
Possible values: NSIDC/NISE, Fallback_climatology		
flag_meanings	'snow_free snow_ice' (static)	NC_STRING
flag_values	0, 1 (static)	NC_UBYTE
coordinates	'/PRODUCT/longitude_nir /PRODUCT/latitude_nir' (static)	NC_STRING
The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].		

13.2 Group "METADATA" in "CLOUD_"

This is a group to collect metadata items, such as the items that also appear in the header file and items required by Inspire [ER4]. Most metadata will be stored as attributes. Grouping attributes that belong to a specific standard is done by using sub-groups in the Metadata group.

Included in this group are the granule description and quality assurance parameters.

Note that some metadata attributes are required to be attached to the global level by convention, such as the CF-Metadata convention [ER5] and the NetCDF user guide [ER7]. The groups described in section 12.26 "ESA metadata" on page 97 are included in the output at this location.

The groups described in section 12.27 "EOP metadata" on page 105 are included in the output at this location.

The groups described in section 12.28 "ISO metadata" on page 109 are included in the output at this location.

13.2.1 Group "QA_STATISTICS" in "METADATA"

The groups described in section 12.23 "Quality assurance statistics" on page 85 are included in the output at this location.

Variables in CLOUD_/METADATA/QA_STATISTICS

cloud_histogram in CLOUD_/METADATA/QA_STATISTICS			
Description:	Histogram of the cloud values in the current granule.		
Dimensions:	histogram_axis.		
Type:	NC_INT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	comment	'Histogram of cloud data in the current granule' (static)	NC_STRING
cloud_pdf in CLOUD_/METADATA/QA_STATISTICS			
Description:	Probability density function of cloud values in the current granule. The values are weighted with $\cos(\delta_{\text{geo}})$ and spread out using the error estimate.		
Dimensions:	pdf_axis.		
Type:	NC_FLOAT.		
Source:	Processor.		
Mode:	Present in all modes.		
Attributes:	*Name*	*Value*	*Type*
	comment	'Probability density function of cloud data in the current granule' (static)	NC_STRING

13.2.2 Group “ALGORITHM_SETTINGS” in “METADATA”

13.2.3 Group “GRANULE_DESCRIPTION” in “METADATA”

Attributes in CLOUD_/METADATA/GRANULE_DESCRIPTION
The attributes described in section 12.25 “Granule metadata” on page 96 are included in the output at this location.

Group attributes attached to GRANULE_DESCRIPTION		
Name	*Value*	*Type*
ProductShortName	‘L2__CLOUD_’ (static)	NC_STRING
The short product name. For the Cloud product this is fixed to “L2 _ _ CLOUD _”.		

A Flag descriptions

The following tables describe the Measurement flags, Processing quality flags (processing failures and filter conditions, errors and warnings) and Surface classifications.
Please be aware that this section is work in progress and the flags are not included in the product yet. The aim of this section is for review only.

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2. Warnings are listed in table 13. The value in the first column is the result of a bitwise 'and' of 255 (0xFF) and the value in the "processing_quality_flags" variable.

#	Short name	Description	Algorithm
0	success	No failures, output contains value. Warnings still possible.	All
1	radiance_missing	The number of spectral pixels in the radiance due to flagging is too small to perform the fitting.	All
2	irradiance_missing	The number of spectral pixels in the irradiance due to flagging is too small to perform the fitting.	All
3	input_spectrum_missing	The reflectance spectrum does not contain enough points to perform the retrieval. This is different from (ir)radiance_missing in that the missing points may not be aligned.	All
4	reflectance_range_error	Any of the reflectances is out of bounds ($R < 0$ or $R > R_{\text{max}}$).	FRESCO
5	ler_range_error	Lambert-equivalent reflectivity out of range error.	CO, CH_4
6	snr_range_error	Too low signal to noise to perform retrieval.	CO
7	sza_range_error	Solar zenith angle out of range, maximum value from configuration.	All
8	vza_range_error	Viewing zenith angle out of range, maximum value from configuration.	Development phase only
9	lut_range_error	Extrapolation in lookup table (airmass factor, cloud radiances).	NO_2
10	ozone_range_error	Ozone column significantly out of range of profile climatology.	Total O_3 column
11	wavelength_offset_error	Wavelength offset exceeds maximum from configuration.	FRESCO, NO_2
12	initialization_error	An error occurred during the processing of the pixel, no output was generated. The following errors raise this flag: Mismatch between irradiance and radiance wavelengths; The on-ground distance between band 1 and band 2 ground pixels exceeds a threshold set in the configuration. Derived a-priori information does not validate, no processing is possible.	All
13	memory_error	Memory allocation or deallocation error.	CO, CH_4
14	assertion_error	Error in algorithm detected during assertion.	CO
15	io_error	Error detected during transfer of data between algorithm and framework.	CO, ALH, CH_4, O_3 profile
16	numerical_error	General fatal numerical error occurred during inversion.	CO, FRESCO
17	lut_error	Error in accessing the lookup table.	CH_4
18	ISRF_error	Error detected in the input instrument spectral response function input data.	CH_4
19	convergence_error	The main algorithm did not converge.	All
20	cloud_filter_convergence_error	The cloud filter did not converge.	CO

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
21	max_iteration_convergence_error	No convergence because retrieval exceeds maximum number of iterations. Maximum value from configuration.	ALH
22	aot_lower_boundary_convergence_error	No convergence because the aerosol optical thickness crosses lower boundary twice in succession.	ALH
23	other_boundary_convergence_error	No convergence because a state vector element crosses boundary twice in succession. Note that a separate failure flag is defined for non-convergence due to crossing of lower AOT boundary.	ALH
25	ch4_noscat_zero_error	The CH_4 column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0.	CH_4
26	h2o_noscat_zero_error	The H_2O column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0.	CH_4
27	max_optical_thickness_error	Maximum optical thickness exceeded during iterations.	CH_4
28	aerosol_boundary_error	Boundary hit of aerosol parameters at last iteration.	CH_4
29	boundary_hit_error	Fatal boundary hit during iterations.	CH_4
30	chi2_error	χ^2 is not-a-number or larger than 10^{10}.	CH_4
31	svd_error	Singular value decomposition failure.	CH_4
32	dfs_error	Degree of freedom is not-a-number.	CH_4
33	radiative_transfer_error	Errors occurred during the radiative transfer computations, no processing possible.	O_3 profile
34	optimal_estimation_error	Errors occurred during the optimal estimation, processing has been terminated.	O_3 profile
35	profile_error	Flag that indicates if there were any errors during the computation of the ozone profile.	O_3 profile
36	cloud_error	No cloud data.	Cloud
37	model_error	Forward model failure.	Cloud, Total O_3 column
38	number_of_input_data_points_too_low_error	Not enough input ozone columns to calculate a tropospheric column.	Tropospheric O_3 column
39	cloud_pressure_spread_too_low_error	Cloud pressure variability to low to estimate a tropospheric column.	Tropospheric O_3 column
40	cloud_too_low_level_error	Clouds are too low in the atmosphere to assume sufficient shielding.	Tropospheric O_3 column
41	generic_range_error	Generic range error.	All
42	generic_exception	Catch all generic error.	All
43	input_spectrum_alignment_error	Input radiance and irradiance spectra are not aligned correctly.	All
44	abort_error	Not processed because processor aborted prematurely (time out or user abort)	All

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
45	wrong_input_type_error	Wrong input type error, mismatch between expectation and received data.	All
46	wavelength_calibration_error	An error occurred in the wavelength calibration of this pixel	All
47	coregistration_error	No colocated pixels found in a supporting band	All
51	signal_to_noise_ratio_error	The signal to noise ratio for this spectrum is too low for processing	All
52	configuration_error	Error while parsing the configuration	All
53	key_error	Key does not exist	All
54	saturation_error	Saturation in input spectrum	All
55	max_num_outlier_exceeded_error	The number of outliers detected in the DOAS fit exceeds a maximum set for healthy spectra.	NO_2
64	solar_eclipse_filter	Solar eclipse.	All
65	cloud_filter	The cloud filter triggered causing the pixel to be skipped.	CO, ALH, CH_4
66	altitude_consistency_filter	Too large difference between ECMWF altitude and DEM altitude value.	CO, CH_4
67	altitude_roughness_filter	Too large standard deviation of altitude in DEM.	CO, ALH, CH_4
68	sun_glint_filter	For pixels over water, viewing direction inside sun glint region. Definition of sun glint angle and threshold value from ATBD.	ALH
69	mixed_surface_type_filter	Pixel contains land and water areas (e.g. coastal pixel).	ALH
70	snow_ice_filter	Pixel contains snow/ice: Snow/ice flag according to dynamic input OR climatological surface albedo at VIS wavelength is larger than 0.5.	ALH
71	aai_filter	AAI smaller than 2.0.	ALH
72	cloud_fraction_fresco_filter	Pixel contains clouds: The FRESCO effective cloud fraction is larger than threshold. Threshold value from ATBD.	ALH
73	aai_scene_albedo_filter	Pixel contains clouds: The difference between scene albedo at 380 nm from AAI calculation and the climatologcal surface albedo exceeds threshold. Threshold value from ATBD. This test filters out clouds.	ALH
74	small_pixel_radiance_std_filter	Pixel contains clouds: Standard deviation of radiances in small-pixel column exceeds threshold. Threshold value from ATBD.	ALH, CH_4
75	cloud_fraction_viirs_filter	Pixel contains clouds: The cloud fraction from VIIRS / NPP exceeds theshold. Threshold value from ATBD.	ALH
76	cirrus_reflectance_viirs_filter	Pixel contains clouds: Cirrus reflectance from VIIRS / NPP exceeds threshold. Threshold value from ATBD.	ALH

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
77	cf_viirs_swir_ifov_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR ground pixel exceeds a priori threshold from configuration.	CH_4
78	cf_viirs_swir_ofova_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVa exceeds a priori threshold from configuration.	CH_4
79	cf_viirs_swir_ofovb_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVb exceeds a priori threshold from configuration.	CH_4
80	cf_viirs_swir_ofovc_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVc exceeds a priori threshold from configuration.	CH_4
81	cf_viirs_nir_ifov_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR ground pixel exceeds a priori threshold from configuration.	CH_4
82	cf_viirs_nir_ofova_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVa exceeds a priori threshold from configuration.	CH_4
83	cf_viirs_nir_ofovb_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVb exceeds a priori threshold from configuration.	CH_4
84	cf_viirs_nir_ofovc_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVc exceeds a priori threshold from configuration.	CH_4
85	refl_cirrus_viirs_swir_filter	Average VIIRS cirrus reflectance within SWIR ground pixel exceeds a priori threshold from configuration.	CH_4
86	refl_cirrus_viirs_nir_filter	Average VIIRS cirrus reflectance within NIR ground pixel exceeds a priori threshold from configuration.	CH_4
87	diff_refl_cirrus_viirs_filter	Difference in VIIRS average cirrus reflectance between SWIR and NIR ground pixel exceeds a priori threshold from configuration.	CH_4
88	ch4_noscat_ratio_filter	The ratio between $[CH_4]_{weak}$ and $[CH_4]_{strong}$ is below or exceeds a priori thresholds from configuration.	CH_4
89	ch4_noscat_ratio_std_filter	The standard deviation of $[CH_4]_{weak}/[CH_4]_{strong}$ within the SWIR pixel and the 8 neighbouring pixels exceeds a priori threshold from configuration.	CH_4
90	h2o_noscat_ratio_filter	The ratio between $[H_2O]_{weak}$ and $[H_2O]_{strong}$ is below or exceeds a priori thresholds from configuration.	CH_4
91	h2o_noscat_ratio_std_filter	The standard deviation of $[H_2O]_{weak}/[H_2O]_{strong}$ within the SWIR pixel and the 8 neigbouring pixels exceeds a priori threshold from configuration.	CH_4

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
92	diff_psurf_fresco_ecmwf_filter	Difference between the FRESCO apparent surface pressure and the ECMWF surface pressure exceeds a priori threshold from configuration.	CH_4
93	psurf_fresco_stdv_filter	The standard deviation of the FRESCO apparent surface pressure in the NIR pixel and the 8 surrounding pixels exceeds a priori threshold from configuration.	CH_4
94	ocean_filter	The ground pixel is over ocean (and ocean glint retrievals are not switched on).	CH_4
95	time_range_filter	Time is out of the range that is to be processed.	All
96	pixel_or_scanline_index_filter	Not processed because pixel index does not match general selection criteria.	All
97	geographic_region_filter	Pixel falls outside the specified regions of interest.	All

Table 13: Processing quality flags, warnings for S5P Level 2. Errors, processing failures and filter conditions are listed in table 12. If a bitwise 'and' of the mask value and the value in the "processing_quality_flags" variable is not zero, then the warning applies to the specific retrieval.

Bit #	Mask (hex)	Short name	Description	Algorithm
0–7	0x000000FF	error	If non-zero an error has occurred when processing the pixel, see table 12 for details.	All
8	0x00000100	input_spectrum_warning	Number of good pixels in radiance, irradiance or calculated reflectance below threshold from configuration.	All
9	0x00000200	wavelength_calibration_warning	Offset from wavelength fit is larger than limit set in configuration.	Most
10	0x00000400	extrapolation_warning	Pressure or temperature outside cross section LUT range, other lookup table extrapolation.	CO, CH_4
11	0x00000800	sun_glint_warning	Sun glint posibility warning.	All
12	0x00001000	south_atlantic_anomaly_warning	TROPOMI is inside the south Atlantic anomaly while taking these measurements.	All
13	0x00002000	sun_glint_correction	A sun glint correction has been applied.	Cloud
14	0x00004000	snow_ice_warning	Snow/ice flag is set, i.e. using scene data from the cloud support product.	NO_2, Cloud
15	0x00008000	cloud_warning	Cloud filter based on FRESCO apparent surface pressure (VIIRS not available), cloud fraction above threshold or cloud pressure adjusted to force cloud above surface. In case of Cloud product this flag indicates the possiblity of ice-clouds.	CH_4, O_3 profile, Cloud
16	0x00010000	AAI_warning	Possible aerosol contamination as indicated by the AAI (O_3 profile).	O_3 profile

Table 13: Processing quality flags, warnings for S5P Level 2 (continued).

Bit #	Mask (hex)	Short name	Description	Algorithm
17	0x00020000	pixel_level_input_data_missing	Dynamic auxiliary input data (e.g.. cloud) is missing for this ground pixel. A fallback option is used.	All
18	0x00040000	data_range_warning	Carbon monoxide column tends to negative values; Water column tends to negative values; Heavy water (HDO) column tends to negative values; others. In case of the O_3 product this flag indicates VCD or effective albedo values outside a valid range. In case of the SO_2 or the HCHO product this flag indicates AMF values outside a valid range.	CO, CH_4, O_3, SO_2, HCHO
19	0x00080000	low_cloud_fraction_warning	Low cloud fraction, therefore no cloud pressure retrieved.	Cloud
20	0x00100000	altitude_consistency_warning	Difference between ECMWF surface elevation and high-resolution surface elevation exceeds threshold from configuration.	CH_4
21	0x00200000	signal_to_noise_ratio_warning	Signal to noise ratio in SWIR and/or NIR band below threshold from configuration. For the O_3 and HCHO products this flag indicates an RMS above a certain threshold.	CH_4, O_3, HCHO
22	0x00400000	deconvolution_warning	Failed deconvolution irradiance spectrum (not pixel-specific, but row-specific).	CO, CH_4
23	0x00800000	so2_volcanic_origin_likely_warning	Warning for SO_2 BL product, UTLS products: volcanic origin except for heavily polluted sites.	SO_2
24	0x01000000	so2_volcanic_origin_certain_warning	Warning for SO_2 BL product, UTLS products: volcanic origin certain.	SO_2
25	0x02000000	interpolation_warning	Warning for interpolation on partially missing data. In this case the valid available data is used, potentially leading to a bias.	All
26	0x04000000	saturation_warning	Saturation occurred spectrum, possibly causing biases in the retrieval	All
27	0x08000000	high_sza_warning	Warning for high solar zenith angle. In this case, the processing can be performed with less final quality.	All
28	0x10000000	cloud_retrieval_warning	Warning occurring when the retrieval diagnostic indicates a degraded quality of the cloud retrieval.	Cloud
29	0x20000000	cloud_inhomogeneity_warning	The cloud coregistration inhomogeneity parameter is above a given threshold. Also when the coregistration_weight_sums are less than 1.	Cloud

Table 14: Surface classification for S5P Level 2. This is a combined land/water mask and surface classification data field. For land the "Global Land Cover Characteristics Data Base Version 2.0" is used [ER11], specifically the "USGS Land Use/Land Cover System (Modified Level 2)" classification. Over water the classification from the NASA SDP toolkit [ER12], which is based on [RD45].

Bit #	Mask (hex)	Short name	Description
0	0x03	Land	The pixel is over land, for more than 50 %
1	0x03	Water	The pixel is over water, for more than 50 %
2	0x03	some_water	Pixel contains water (however small the fraction), i.e. at least one of the 15×15 arcsecond subpixels in the SDP dataset is classified as water
3	0x03	coastline	Pixel is water, but contains land (coastline)
0	0x04	mixed_surface	Pixel has a mixed surface type. Classification is result of highest bin, not overwhelming majority, i.e. type covers less than 50 % of pixel surface
4	0x04	value_covers_majority_of_pixel	Pixel is dominated by surface type, i.e. type covers more than 50 % of pixel surface
9	0xF9	Water+Shallow_Ocean	Water, shallow ocean
17	0xF9	Water+Shallow_Inland_Water	Water, shallow inland water (lake)
25	0xF9	Water+Ocean_Coastline-Lake_Shoreline	Water, mixed with land; coastline
33	0xF9	Water+Intermittent_Water	Intermittent water, for instance the Wadden Sea
41	0xF9	Water+Deep_Inland_Water	Deep inland water
49	0xF9	Water+Continental_Shelf_Ocean	Water, continental shelf ocean
57	0xF9	Water+Deep_Ocean	Water, deep ocean
8	0xF9	Land+Urban_And_Built-up_Land	Land, urban areas
16	0xF9	Land+Dryland_Cropland_And_Pasture	Land, Dryland Cropland and Pasture
24	0xF9	Land+Irrigated_Cropland_And_Pasture	Land, Irrigated Cropland and Pasture
32	0xF9	Land+Mixed_Dryland-irrigated_Cropland_And_Pasture	Land, Mixed Dryland/Irrigated Cropland and Pasture
40	0xF9	Land+Cropland-grassland_Mosaic	Land, Cropland/Grassland Mosaic
48	0xF9	Land+Cropland-woodland_Mosaic	Land, Cropland/Woodland Mosaic
56	0xF9	Land+Grassland	Land, Grassland
64	0xF9	Land+Shrubland	Land, Shrubland
72	0xF9	Land+Mixed_Shrubland-grassland	Land, Mixed Shrubland/Grassland
80	0xF9	Land+Savanna	Land, Savanna
88	0xF9	Land+Deciduous_Broadleaf_Forest	Land, Deciduous Broadleaf Forest

Table 14: Surface classification for S5P Level 2 (continued).

Bit #	Mask (hex)	Short name	Description
96	0xF9	Land+Deciduous_Needleleaf_Forest	Land, Deciduous Needleleaf Forest
104	0xF9	Land+Evergreen_Broadleaf_Forest	Land, Evergreen Broadleaf Forest
112	0xF9	Land+Evergreen_Needleleaf_Forest	Land, Evergreen Needleleaf Forest
120	0xF9	Land+Mixed_Forest	Land, Mixed Forest
128	0xF9	Land+Herbaceous_Wetland	Land, Herbaceous Wetland
136	0xF9	Land+Wooded_Wetland	Land, Wooded Wetland
144	0xF9	Land+Barren_Or_Sparsely_Vegetated	Land, Barren or Sparsely Vegetated
152	0xF9	Land+Herbaceous_Tundra	Land, Herbaceous Tundra
160	0xF9	Land+Wooded_Tundra	Land, Wooded Tundra
168	0xF9	Land+Mixed_Tundra	Land, Mixed Tundra
176	0xF9	Land+Bare_Ground_Tundra	Land, Bare Ground Tundra
184	0xF9	Land+Snow_Or_Ice	Land, Snow or Ice