

# Sentinel-5 precursor/TROPOMI Level 2 Product User Manual UV Aerosol Index





document number : S5P-KNMI-L2-0026-MA

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CI identification : CI-7570-PUM

issue : 2.4.0
applicable to processor release : 2.4.0
date : 2022-07-11
status : released

# **Document approval record**

This document was prepared by Arnoud Apituley, Mattia Pedergnana, Maarten Sneep, J. Pepijn Veefkind, Diego Loyola, Deborah Stein Zweers.

# **Document change record**

issue	date	item	comments
1.0.0	2018-06-13		Prepared and updated for public release of the UV aerosol index dataproduct.
2.0.0	2021-06-24		Released with L2 processor update July 2021
2.0.1	2021-11-15		Updated for release 2.3.1 of the processor.
3.0.0	2022-07-11		Updated for release 2.4.0 of the processor.

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### 1 Introduction

#### 1.1 Identification

This document, identified as S5P-KNMI-L2-0026-MA, 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 UV Aerosol Index.

### 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 UV Aerosol Index 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 UV Aerosol Index 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 UV Aerosol Index 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: 10.0.0; date: 2019-07-19.
- [RD3] S5P/TROPOMI ATBD Cloud Products. source: DLR; ref: S5P-DLR-L2-ATBD-400I; issue: 2.3.0; date: 2021-06-25.
- [RD4] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Cloud. source: DLR; ref: S5P-L2-DLR-PUM-400I; issue: 2.4.0; date: 2022-07-11.
- [RD5] S5P-NPP Cloud Processor ATBD.
  source: RAL Space; ref: S5P-NPPC-RAL-ATBD-0001; issue: 1.0.0; date: 2016-02-12.
- [RD6] S5P/TROPOMI HCHO ATBD. source: BIRA; ref: S5P-BIRA-L2-400F-ATBD; issue: 2.4.1; date: 2022-06-22.
- [RD7] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual HCHO. source: DLR; ref: S5P-L2-DLR-PUM-400F; issue: 2.4.0; date: 2022-07-11.
- [RD8] S5P/TROPOMI SO<sub>2</sub> ATBD. source: BIRA; ref: S5P-BIRA-L2-400E-ATBD; issue: 2.4.0; date: 2022-06-22.
- [RD9] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual SO<sub>2</sub>. **source:** DLR; **ref:** S5P-L2-DLR-PUM-400E; **issue:** 2.4.0; **date:** 2022-07-11.
- [RD10] S5P/TROPOMI Total ozone ATBD. source: DLR; ref: S5P-L2-DLR-ATBD-400A; issue: 2.3.0; date: 2021-06-04.
- [RD11] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Total Ozone Column. source: DLR; ref: S5P-L2-DLR-PUM-400A; issue: 2.4.0; date: 2022-07-11.
- [RD12] TROPOMI/S5P ATBD of tropospheric ozone data products. source: DLR/IUP; ref: S5P-DLR-IUP-L2-400C; issue: 2.3.0; date: 2021-06-04.
- [RD13] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Ozone Tropospheric Column. source: DLR; ref: S5P-L2-DLR-PUM-400C; issue: 2.3.0; date: 2021-06-04.
- [RD14] TROPOMI ATBD of the Aerosol Layer Height product. source: KNMI; ref: S5P-KNMI-L2-0006-RP; issue: 2.4.0; date: 2022-04-08.
- [RD15] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Aerosol Layer Height. source: KNMI; ref: S5P-KNMI-L2-0022-MA; issue: 2.4.0; date: 2022-07-11.
- [RD16] TROPOMI ATBD of the UV aerosol index. source: KNMI; ref: S5P-KNMI-L2-0008-RP; issue: 2.0.0; date: 2021-07-05.

- [RD17] TROPOMI ATBD Ozone profile and tropospheric profile. source: KNMI; ref: S5P-KNMI-L2-0004-RP; issue: 1.0.0; date: 2021-10-22.
- [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: 2.4.0; date: 2022-07-11.
- [RD19] TROPOMI ATBD of the total and tropospheric NO<sub>2</sub> data products. **source:** KNMI; **ref:** S5P-KNMI-L2-0005-RP; **issue:** 2.4.0; **date:** 2022-07-11.
- [RD20] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Nitrogen Dioxide. source: KNMI; ref: S5P-KNMI-L2-0021-MA; issue: 2.4.0; date: 2022-07-11.
- [RD21] Algorithm Theoretical Baseline Document for Sentinel-5 Precursor: Carbon Monoxide Total Column Retrieval.
  source: SRON; ref: SRON-S5P-LEV2-RP-002; issue: 2.4.0; date: 2022-07-12.
- [RD22] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Carbon Monoxide Column. source: SRON/KNMI; ref: SRON-S5P-LEV2-MA-002; issue: 2.4.0; date: 2022-07.11.
- [RD23] Algorithm Theoretical Baseline Document for Sentinel-5 Precursor methane retrieval. source: SRON; ref: SRON-S5P-LEV2-RP-001; issue: 2.4.0; date: 2022-05-30.
- [RD24] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Methane.
  source: SRON/KNMI; ref: SRON-S5P-LEV2-MA-001; issue: 2.4.0; date: 2022-07-11.
- [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] Algorithm theoretical basis document for the TROPOMI L01b data processor. source: KNMI; ref: S5P-KNMI-L01B-0009-SD; issue: 9.0.0; date: 2019-07-19.
- [RD27] Earth Observation Ground segment file format standard. source: ESA/ESTEC; ref: PE-TN-ESA-GS-0001; issue: 2.0; date: 2012-05-03.
- [RD28] Geographic information Metadata. source: ISO; ref: ISO 19115:2003(E); issue: 1; date: 2003-05-01.
- [RD29] 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.
- [RD30] Geographic information Data quality. source: ISO; ref: ISO 19157; issue: 1; date: 2013-10-10.
- [RD31] Earth Observation Metadata profile of Observations & Measurements. source: Open Geospatial Consortium; ref: OGC 10-157r3; issue: 1.0; date: 2012-06-12.
- [RD32] Data Standards Requirements for CCI Data Producers. source: ESA; ref: CCI-PRGM-EOPS-TN-13-0009; issue: 1.1; date: 2013-05-24.
- [RD33] Metadata specification for the TROPOMI L1b products. source: KNMI; ref: S5P-KNMI-L01B-0014-SD; issue: 6.0.0; date: 2019-07-19.
- [RD34] 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.
- [RD35] Wavelength calibration in the Sentinel 5-precursor Level 2 data processors. **source:** KNMI; **ref:** S5P-KNMI-L2-0126-TN; **issue:** 1.0.0; **date:** 2015-09-11.
- [RD36] 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.
- [RD37] Geographic information Metadata XML schema implementation. **source:** ISO; **ref:** ISO 19139:2007(E); **issue:** 1; **date:** 2010-12-13.

- [RD38] Observations and Measurements XML Implementation.. source: Open Geospatial Consortium; ref: OGC 10-025r1; issue: 2.0; date: 2011-03-22.
- [RD39] Sentinel 5 precursor/TROPOMI KNMI and SRON level 2 Input Output Data Definition. source: KNMI; ref: S5P-KNMI-L2-0009-SD; issue: 15.0; date: 2021-08-05.
- [RD40] Sentinel-5 Precursor Level 2 UPAS Processor Input/Output Definition Document. source: DLR-IMF; ref: S5P-L2-DLR-IODD-3002; issue: 3.3.0; date: 2017-06-01.
- [RD41] S5P-NPP Cloud Processor IODD. source: RAL; ref: S5P-NPPC-RAL-IODD-0001; issue: 0.10.0; date: 2014-05-28.
- [RD42] John Caron; Annotated Schema for NcML (2011). URL http://www.unidata.ucar.edu/software/netcdf/ncml/v2.2/AnnotatedSchema4.html.
- [RD43] INSPIRE Metadata Regulation, Commission Regulation (EC), No1205/2008. source: EC; ref: Commission Regulation (EC) No 1205/2008; date: 2008-12-03.
- [RD44] 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.
- [RD45] Geographic Information Observations and Measurements. **source**: ISO; **ref**: ISO 19156:2011(E); **date**: 2011-12-20.
- [RD46] Observations and Measurements XML Implementation. source: OGC; ref: OGC 10-025r1; issue: 2.0; date: 2011-03-22.

### 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] 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.
- [ER9] 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.
- [ER10] UDUNITS 2 Manual (2011). URL http://www.unidata.ucar.edu/software/udunits/.
- [ER11] 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.

### 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 AddedTBC To be ConfirmedTBD 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 makes 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]	[RD4]	L2CLOUD_	DLR
NPP-VIIRS Clouds	[RD5]	[RD5]	L2NP_BDx	RAL
НСНО	[RD6]	[RD7]	L2HCHO	BIRA/DLR
SO <sub>2</sub>	[RD8]	[RD9]	L2S02	BIRA/DLR
O <sub>3</sub> Total Column	[RD10]	[RD11]	L203	BIRA/DLR
O <sub>3</sub> Tropospheric Column	[RD12]	[RD13]	L203_TCL	IUP/DLR
Aerosol layer height	[RD14]	[RD15]	L2AER_LH	KNMI
Ultra violet aerosol index	[RD16]	This document	L2AER_AI	KNMI
O <sub>3</sub> Full Profile	[RD17]	[RD18]	L203PR	KNMI
NO <sub>2</sub>	[RD19]	[RD20]	L2NO2	KNMI
CO	[RD21]	[RD22]	L2CO	SRON/KNMI
CH <sub>4</sub>	[RD23]	[RD24]	L2CH4	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 UV Aerosol Index product is described and an example of the full real name is as following:

 ${\tt S5P\_NRTI\_L2\_AER\_AI\_20190920T054303\_20190920T054803\_10028\_01\_010302\_20190920T062930.nc}$  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 "YYYYMMDDTHHMMSS". The "T" is a fixed character.
36	51	15	End of the granule in UTC as "YYYYMMDDTHHMMSS". 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 ${f T}$ 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 TROPOMI UV Aerosol Index product data are available from the Copernicus Open Data Hub https://scihub.copernicus.eu.

The access and use of any Copernicus Sentinel data available through the Sentinel Data Hub is governed by the Legal Notice on the use of Copernicus Sentinel Data and Service Information and is given here: https://sentinels.copernicus.eu/documents/247904/690755/Sentinel\_Data\_Legal\_Notice.

### 5.1 Information to supply with a support request

We have been very careful in the preparation of the processors, the processing system, the data distribution system and all other components that generate the level 2 products for the Sentinel 5 precursor mission. You may encounter problems when reading the level 2 files despite our care, or you may not understand what we have written in the product user manual or the ATBD. You can contact us through the earth observation help desk operated by ESA at EOSupport@copernicus.esa.int. Please clearly indicate that you are requesting support for Sentinel 5 precursor (S5p) / TROPOMI mission.

If you are requesting technical support it is helpful to provide us with details of the file you are trying to read. The easiest way to do this is to provide a "dump" of the header of the file. This can be generated using the "ncdump" tool provided with the netCDF-4 library. Only the header is required, so "ncdump -h FILE.nc > FILE.cdl" will provide us with all metadata in the file and help us pinpoint how the file was produced. Here you replace FILE.nc with the actual file name on the command line.

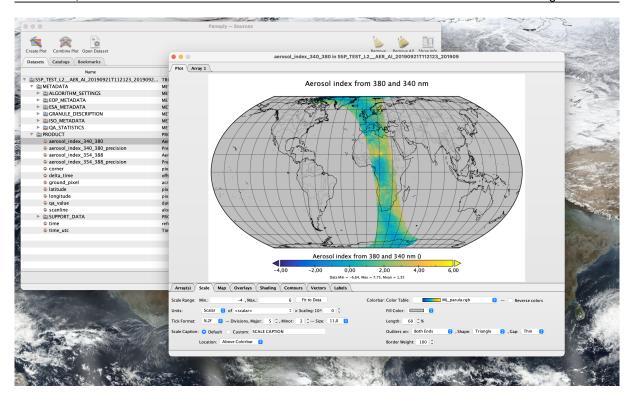


Figure 1: Panoply

If generating the header fails, please provide us with the exact original file name of the granule you are trying to read, the exact error message you get and the exact version of the software you are using, including the versions of netCDF-4 and HDF-5. Providing us with a checksum to verify file integrity can also speed up our response.

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

## 7 Instrument description

On 13 October 2017 the Copernicus Sentinel 5 Precursor (S5P), the first of the European Sentinel satellites dedicated to monitoring of atmospheric composition, was launched. The mission objectives of S5P are to

globally monitor air quality, climate and the ozone layer in the time period between 2017 and 2023. The first 6 months of the mission were used for special observations to commission the satellite and the ground processing systems; the operational phase started in April of 2018.

The single payload of the S5P mission is TROPOspheric Monitoring Instrument (TROPOMI), which has been developed by The Netherlands in cooperation with the European Space Agency (ESA). TROPOMI is a nadir viewing shortwave spectrometer that measures in the UV-visible wavelength range (270–500 nm), the near infrared (710–770 nm) and the shortwave infrared (2314–2382 nm).

The instrument uses passive remote sensing techniques to attain its objective by measuring at the top of the atmosphere the solar radiation reflected by and radiated from the Earth. The instrument operates in a push-broom configuration with a wide swath. Light from the entire swath is recorded simultaneously and dispersed onto two-dimensional imaging detectors: the position along the swath is projected onto one direction of the detectors, and the spectral information for each position is projected on the other direction.

The instrument images a strip of the Earth on a two dimensional detector for a period of approximately 1 second during which the satellite moves by about 7 km. This strip has dimensions of approximately 2600 km in the direction across the track of the satellite and 7 km in the along-track direction. After the 1 second measurement a new measurement is started thus the instrument scans the Earth as the satellite moves. The two dimensions of the detector are used to detect the different ground pixels in the across track direction and for the different wavelengths. The measurement principle of TROPOMI is shown in figure 2.

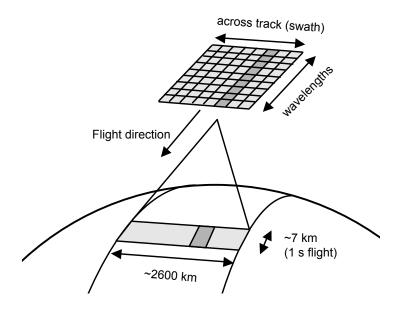


Figure 2: TROPOMI measurement principle.

On August 6th, 2019, the instrument settings of TROPOMI were changed. The nominal integration time was reduced from 1080 ms to 840 ms. Before the change the pixel size is  $7.2 \times 3.6 \, \text{km}^2$  for bands 2–6, (UVN)  $7.2 \times 7.2 \, \text{km}^2$  for bands 7 and 8 (SWIR), and  $21.6 \times 28.8 \, \text{km}^2$  for band 1 (deep UV), after co-addition in the flight direction. After the change in the settings, the pixel dimension in the flight direction is reduced. The new sizes become  $5.6 \times 3.6 \, \text{km}^2$  for bands 2–6,  $5.6 \times 7.2 \, \text{km}^2$  for bands 7 and 8, and  $28 \times 28.8 \, \text{km}^2$  for band 1, after co-addition in the flight direction.

For the UVN spectrometers about 20 million spectra are observed per day. With that resolution TROPOMI is a major step forward compared to its predecessors OMI (Ozone Monitoring Instrument), SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric Chartography) and GOME-2 (Global Ozone Monitoring Experiment-2). The spatial resolution is combined with a wide swath to allow for daily global coverage. The TROPOMI/S5P geophysical (Level 2) operational data products are listed in section 4.

The S5P will fly in a so-called loose formation with the U.S. Suomi NPP (National Polar-orbiting Partnership) satellite. The primary objective for this formation flying is to use the high spatial resolution cloud observation capabilities of the VIIRS instrument (Visible Infrared Imager Radiometer Suite). The temporal separation between TROPOMI and VIIRS is less than 5 minutes, both having an equator crossing time near 13:30 local solar time. This formation enables synergistic data products and scientific research potentials.

The spectral range is split over 4 different detectors. By design these detectors do not observe on the

same geographic grid. Combining products that were derived from different detectors will require some careful re-mapping to take care of this spatial mismatch.

More details on the TROPOMI instrument and the operational concepts can be found in the Level 0 to 1B ATBD [RD26, parts I – III].

### 8 S5p/TROPOMI L2 UV Aerosol Index Product Description

The Aerosol Index (AI) is a well-established data product that has been calculated for several different satellite instruments spanning a period of nearly 40 years. The Aerosol Index described here is called the UVAI since it is based on spectral contrast in the ultraviolet (UV) spectral range for a given wavelength pair, where the difference between observed and modelled reflectance results in a residual value. When this residual is positive it indicates the presence of UV-absorbing aerosols. like dust and smoke (from both biomass burning and volcanic sources), and is often referred to as the Absorbing Aerosol Index (AAI). Unlike satellite-based aerosol optical thickness measurements, AAI can also be calculated in the presence of clouds so that daily, global coverage is possible. This is ideal for tracking the evolution of episodic aerosol plumes from dust outbreaks, volcanic ash, and biomass burning. The relatively simple calculation of the Aerosol Index is based on wavelength dependent changes in Rayleigh scattering in the UV spectral range where ozone absorption is very small, i.e. wavelengths longer than about 340 nm. For a given wavelength pair a ratio is calculated from measured top of the atmosphere (TOA) reflectance and pre-calculated theoretical reflectance for a Rayleigh scattering-only atmosphere and results in a residual value. Positive values of this residual indicate the presence of UV-absorbing aerosol. The UVAI is dependent upon aerosol layer characteristics including aerosol optical thickness, aerosol single scattering albedo, aerosol layer height (ALH), and the underlying surface albedo. The UVAI is a robust calculation that is well proven based on years of data, where the major strengths include speed of calculation, global coverage, ease of use, and the potential for creation of long-term climate data records. To maintain heritage with the OMI mission and with other aerosol index data records, both the 354/388 nm and the 340/380 nm pairs are calculated and included in the S5P UVAI data product.

### 8.1 Data Product Examples

In figures 3 and 4 TROPOMI UV Aerosol Index global product examples are shown for both wavelength pairs (340/380 nm and 354/388 nm) on 2018-03-31. In figure 5 a zoom in is shown over northern Africa of a large dust event the same day. In figure 6 a zoom in is shown over central Africa on 2017-11-10, showing the smoke plumes of individual fires.

### 8.2 Product Geophysical Validation

In general, TROPOMI captures aerosol plumes originating from desert dust, biomass burning and volcanic eruptions in great detail owing to its high spatial resolution and high signal-to-noise ratio. Comparison of TROPOMI UVAI with other satellite-derived aerosol index data has been carried out with using data from OMI and OMPS. Based on these initial comparisons, The values of TROPOMI are observed to be lower than OMI and OMPS. It is known that the aerosol index is sensitive to small variations in the calibrated radiance which can lead to offsets, also as compared to the aerosol index from other satellite datasets. These relative offsets as compared to OMI and to OMPS are within the reported UVAI error of  $\pm\,1.0$  index point as provided in the TROPOMI data product.

### 8.3 Using the S5p/TROPOMI L2 UV Aerosol Index

The most important feature that data user should be aware of is sun glint. Glint yields high values of UVAI and its effects can be removed by using UVAI data with ga-values greater than 0.8.

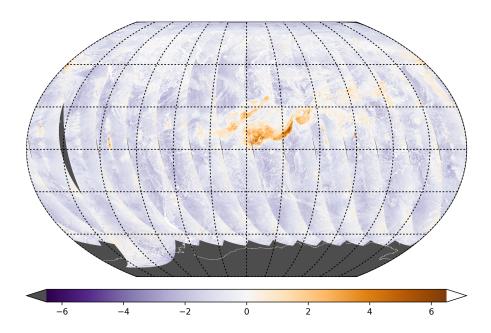


Figure 3: Aerosol Index Example using the 340/380 wavelength pair from spectra observed on 2018-03-31.

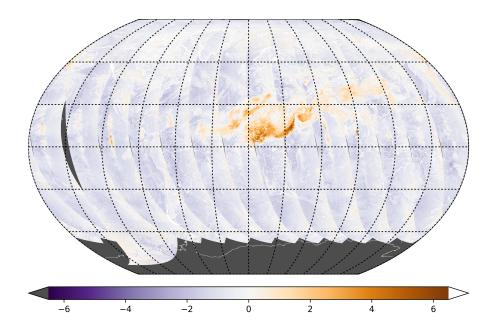
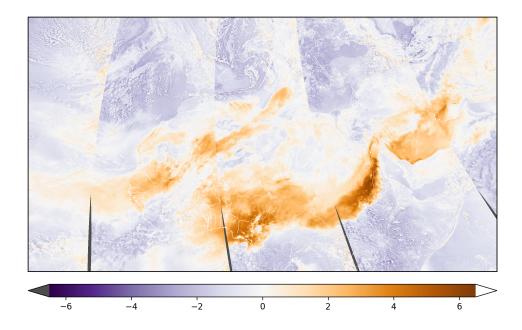
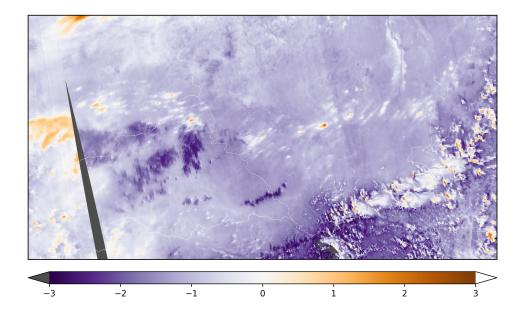


Figure 4: Aerosol Index Example using the 354/388 wavelength pair from spectra observed on 2018-03-31.



**Figure 5**: Aerosol Index Example using the 354/388 wavelength pair from spectra observed on 2018-03-31, zoomed in over northern Africa and the Middle-East. The height of the figure is 6500 km, the width is 12 000 km.



**Figure 6**: A zoom in over central Africa on 2017-11-10, showing the smoke plumes of individual fires in the UV aerosol index using the 340/380 nm wavelength pair. The height of the figure is 1300 km, the width is 2500 km. Note the different colour scale.

### 9 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 9.1 – 9.3 and sections 11 – 13 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 UV Aerosol Index files is given in section 10. Figure 7 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<sup>1</sup>.

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  $\chi^2$  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 [RD27, section 7] and items required by INSPIRE [ER4], ISO 19115 [RD28], ISO 19115-2 [RD29], ISO 19157 [RD30] and OGC 10-157r3 [RD31]. 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 [RD32]. 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.

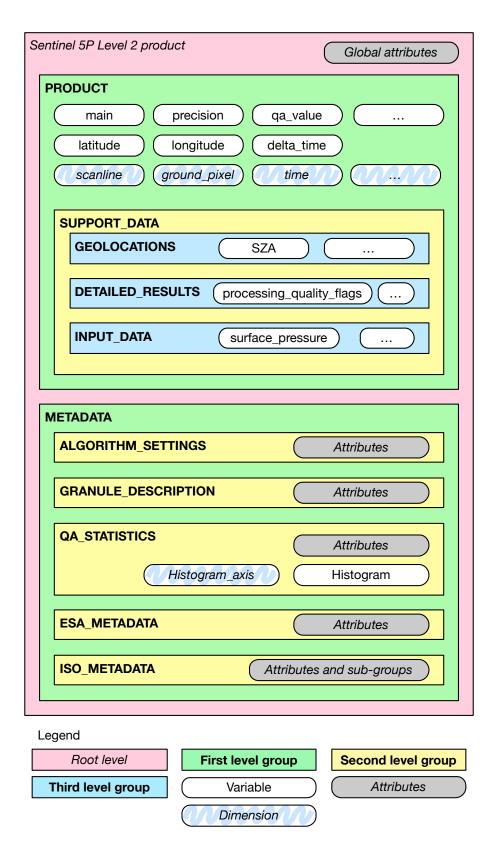
QA\_STATISTICS Quality assurance statistics. This group contains two types of data:

- 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.

<sup>&</sup>lt;sup>1</sup> More detailed processing flags indicating precisely why the 100% value isn't reached, are available elsewhere in the product.



**Figure 7**: Graphical description of the generic structure of a Level 2 file. The elements labelled as a dimension are coordinate variables. See section 9 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 [RD33] 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 13.

Details of the specific format of the level 2 product file for the UV Aerosol Index product is given in section 10. Here all variables are described in detail.

### 9.1 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 7.

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 9.2.

**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<sup>2</sup>.

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<sub>2</sub> 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.

### 9.2 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 3. 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.

<sup>&</sup>lt;sup>2</sup> Fortran uses column-major order, effectively reversing the dimensions in the code compared to the documentation.

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 [RD34].

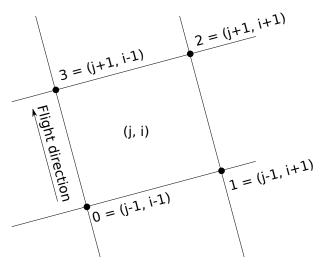
**Table 3**: Reference times available in a S5P L2 file. Types: (A) global attribute, (D) dimensional variable, (V) variable. All reference times ignore leap seconds.

Name	Type	Description
time_reference	(A)	ISO date/time string [RD34]
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 [RD34], one for each observation, i.e. one for each element in the scanline dimension

### 9.3 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 [RD26, 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 8. Note that this choice follows the CF metadata standard [ER5, section 7.1].



**Figure 8**: 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  $\varphi_0$  and the viewing azimuth angle  $\varphi$  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  $\phi-\phi_0$  which differs by 180° as it follows the path of the light.

### 10 Description of the aerosol index product

Description of the main output file for the aerosol index product from the TROPOMI instrument on the Sentinel 5-precursor mission.

These are the file-level attributes.

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.

### Global attributes in AER AI

Group attributes attach	ed to AER_AI	
Name	Value	Туре
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 NC\_STRING sensing, L2' (dynamic)

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 [RD34] 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\_- 0 (dynamic) NC\_INT since\_1950

The reference time expressed as by both TM5 and ECMWF.	·	
time_reference_julian_day	0.0 (dynamic)	NC_DOUBLE
The reference time expressed a	s a Julian day number.	
time_reference_seconds since_1970	0 (dynamic)	NC_INT64
The reference time expressed reference time unit used by Unix	as the number of seconds since 1970-01-01 00:00:00 $\ensuremath{\text{L}}_{\kappa}$ systems.	JTC. This is the
time_coverage_start	'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)	NC_STRING
Start of the data granule in UTO variable on page 27 for details.	C as an ISO 8601 [RD34] string. See the discussion of the	<b>ne</b> time_delta
time_coverage_end	'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)	NC_STRING
End of the data granule in UTC variable on page 27 for details.	as an ISO 8601 [RD34] string. See the discussion of the	ne time_delta
time_coverage_duration		NC_STRING
Duration of the data granule as attribute originates from the CC	an ISO 8601 [RD34] duration string ("PT%(duration_secondstand).	conds)sS"). This
time_coverage_resolution		NC_STRING
seconds)fS"). For most product	in the data granule as an ISO 8601 [RD34] duration string ts this is 1080 ms in nominal operation, except for " ${\tt L2}$ This attribute originates from the CCI standard.	
orbit	0 (dynamic)	NC_INT
The absolute orbit number, star pre-launch testing this value sho	rting at 1 – first ascending node crossing after spacecraft buld be set to " $-1$ ".	separation. For
references	'%(references)s' (static)	NC_STRING
References that describe the d standard.	ata or methods used to produce it. This attribute origina	tes from the CF
processor_version	'%(version)s' (dynamic)	NC_STRING
The version of the data process	or, as string of the form "major.minor.patch".	
keywords_vocabulary	'AGU index terms, http://publications.agu.org/author-	NC_STRING
	resource-center/index-terms/' (static)	_
The guidelines followed for the	resource-center/index-terms/ (static) keywords attribute. We use the index terms published by t	he AGU.
The guidelines followed for the keywords	` ,	ne AGU.
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keywords Keywords from the "keywords ATBD authors. standard_name_vocabulary  The table followed for the standard_naming_authority Specify who is giving out the idcom_data_type The THREDDS data type approximately.	'%(keywords_agu)s' (dynamic) _vocabulary" describing the contents of the file. To be  'NetCDF Climate and Forecast Metadata Conventions Standard Name Table (v29, 08 July 2015), http:// cfconventions.org/standard-names.html' (static) ard_name attributes.  '%(naming_authority)s' (dynamic) attribute. This attribute originates from the CCI standard. 'Swath' (static) ropriate for this dataset, fixed to "Swath" for S5P level 2	NC_STRING provided by the  NC_STRING  NC_STRING  NC_STRING
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keywords Keywords from the "keywords ATBD authors. standard_name_vocabulary  The table followed for the standard_naming_authority Specify who is giving out the idcom_data_type The THREDDS data type approaution approached to the composition of the composition o	'%(keywords_agu)s' (dynamic) _vocabulary" describing the contents of the file. To be  'NetCDF Climate and Forecast Metadata Conventions Standard Name Table (v29, 08 July 2015), http:// cfconventions.org/standard-names.html' (static) ard_name attributes.  '%(naming_authority)s' (dynamic) attribute. This attribute originates from the CCI standard. 'Swath' (static) ropriate for this dataset, fixed to "Swath" for S5P level 2 I standard.  'YYYY-mm-ddTHH:MM:SS.ffffffZ' (dynamic)	NC_STRING provided by the  NC_STRING  NC_STRING  NC_STRING  products. This

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.

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. NC\_STRING creator email 'EOSupport@Copernicus.esa.int' (dynamic) information Point of contact for more and support for this Set to "mailto:EOSupport@Copernicus.esa.int". This attribute originates from the CCI standard. 'Sentinel 5 precursor/TROPOMI' (dynamic) NC STRING project 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. NC FLOAT geospatial lon min 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. '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 " $3.5 \times 7 \,\mathrm{km}^2$ ", except for " $\mathrm{L}2\_03$ 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. NC STRING cpp compiler version 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. NC STRING build date 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\_au-

'http://dx.doi.org/' (static)

NC STRING

thority

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 accommodate different release schedules for different products.

title

'TROPOMI/S5P Aerosol Index %s L2 Swath %sx%skm' NC\_STRING (dynamic)

This is a short description of the product. In near-realtime processing the granule is shorter than 1 orbit, and this attribute must be adapted accordingly. The nominal title is "TROPOMI/S5P Aerosol Index 1-Orbit L2 Swath yx3.5km", with the y dimension adjusted according to the spatial sampling of the input (7.0 or 5.5). This attribute originates from the NUG standard.

product version

'1.3.0' (dynamic)

NC STRING

Included for compatibility with the CCI project, where this item is defined as "the product version of this data file." We will use the file format version for this attribute following several CCI sub-projects. This attribute originates from the CCI standard.

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

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

### 10.1 Group "PRODUCT" in "AER AI"

This is the main group containing the aerosol index product. At this level the dimensions and the main data fields are defined. Support data can be found in the "SUPPORT" DATA" group.

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.

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

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

### **Dimensions in AER AI/PRODUCT**

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

size Unlimited.

**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.

corner The number of corners for a pixel.

size 4 (fixed)

time The time dimension. See the discussion of the associated dimensional variable on page 25 for details.

size 1 (fixed)

### Variables in AER AI/PRODUCT

### scanline in AER AI/PRODUCT

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.

Attributes:

Name	Value	Туре
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	NC_STRING
	track; index starts at 0' (static)	

#### ground pixel in AER AI/PRODUCT

Description:

The coordinate variable <code>ground\_pixel</code> refers to the across-track dimension of the measurement. The <code>ground\_pixel</code> 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.

Attributes:

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

### time in AER\_AI/PRODUCT

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 [RD34] date.

Dimensions: time (coordinate variable).

Type: NC\_INT. Source: Processor.

Attributes:

Name	Value	Туре
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

	commont	'The time in this variable corresponds to the time in	NC_STRING
	comment	the time_reference global attribute' (static)	NO_STAING
	R_AI/PRODUCT		
Description:	The full coordinate clockwise, starting longitude on the asc both the ground_p depiction of the cor		orners is counter- both latitude and ne lowest value for
Dimensions:	corner (coordinate	variable).	
Type:	NC_INT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
		physical quantity. This attribute originates from the CF	
	long_name	'pixel corner index' (static)	NC_STRING
	comment	'This coordinate variable defines the indices for the pixel corners; index starts at 0 (counter-clockwise, starting from south-western corner of the pixel in ascending part of the orbit)' (static)	NC_STRING
latitude in AE	R_AI/PRODUCT		
Description:	coordinates for the WGS84 ellipsoid.	e pixel centers of the ground pixels in the data. La ground pixel center and the ground pixel corners are	
Dimensions:	time, scanline, grou	ınd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	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
		ary coordinates, i.e. the pixel corners. Note that the us n extension of the climate and forecasting metadata c	
longitude in /	AER_AI/PRODUCT		
Description:	_	ne pixel centers of the ground pixels in the data. La ground pixel center and the ground pixel corners are	-
Dimensions:	time, scanline, grou	ınd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	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/ NC\_STRING longitude bounds' (static)

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.

### delta time in AER AI/PRODUCT

Description:

The delta\_time (scanline) variable indicates the time difference with the reference time time (time) (see page 25). Thus combining the information of time (time) and delta\_time (scanline) yields the start of the measurement time for each scanline as TAl2010 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.

Type: NC\_INT.
Source: Processor.

Attributes: Name Value Type

long\_name 'offset of start time of measurement relative to NC\_STRING time\_reference' (static)

units 'milliseconds' (static) NC\_STRING

time utc in AER AI/PRODUCT

Description: The time of observation expressed as ISO 8601 [RD34] date-time string.

Dimensions: time, scanline.

Type: NC\_STRING.

Source: Processor.

Attributes: Name Value Type

long\_name 'Time of observation as ISO 8601 date-time string' NC\_STRING

(static)

### qa value in AER AI/PRODUCT

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.

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	'longitude latitude' (static)	NC_STRING		
aerosol_inde	x_354_388 in AER_A	AI/PRODUCT			
Description:	The main output of the Aerosol Index retrieval algorithm (at wavelengths 354/388, i.e. the OMI pair).				
Dimensions:	time, scanline, ground_pixel.				
Type:	NC_FLOAT.				
Source:	Processor.				
Attributes:	Name	Value	Туре		
	units	'1' (static)	NC_STRING		
	proposed_stand- ard_name	'ultraviolet_aerosol_index' (static)	NC_STRING		
	comment	'Aerosol index from 388 and 354 nm' (static)	NC_STRING		
	long_name	'Aerosol index from 388 and 354 nm' (static)	NC_STRING		
	radiation wavelength	354.0, 388.0 (static)	NC_FLOAT		
	The wavelengths us	sed for the determination of the aerosol index.			
	coordinates	'longitude latitude' (static)	NC_STRING		
	ancillary_vari- ables	'aerosol_index_354_388_precision' (static)	NC_STRING		
aerosol_inde	x_340_380 in AER_A	AI/PRODUCT			
Docorintion:	The main output of the Aerosol Index retrieval algorithm (at wavelengths 340/380, i.e. the				
Description:	The main output of TOMS pair).	the Aerosor index retrieval algorithm (at waveleng	113 340/300, i.e. 111		
•	-	-	ins 040/000, i.e. in		
Dimensions:	TOMS pair).	-	ins 540/500, i.e. in		
Dimensions: Type:	TOMS pair). time, scanline, grou	-	ins 540/500, i.e. in		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT.	-	Type		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor.	nd_pixel.	<i>Type</i> NC_STRING		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor. Name	nd_pixel.  Value	Туре		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor. Name units proposed_stand-	nd_pixel.  Value  '1' (static)	<i>Type</i> NC_STRING		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor. Name units proposed_stand- ard_name	value '1' (static) 'ultraviolet_aerosol_index' (static)	Type NC_STRING NC_STRING		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor. Name units proposed_stand- ard_name comment	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static)	Type  NC_STRING  NC_STRING  NC_STRING		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index.	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor. Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static) sed for the determination of the aerosol index. 'longitude latitude' (static)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING		
Dimensions: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index.	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING		
Dimensions: Type: Source: Attributes:	TOMS pair). time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates ancillary_vari- ables x_335_367 in AER_A	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) '340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING		
Dimensions: Type: Source: Attributes:	TOMS pair). time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates ancillary_vari- ables x_335_367 in AER_A	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING		
Dimensions: Type: Source: Attributes:  aerosol_inde Description:	TOMS pair). time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates ancillary_vari- ables x_335_367 in AER_A The main output of	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)  Al/PRODUCT the Aerosol Index retrieval algorithm (at waveleng	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING		
Dimensions: Type: Source: Attributes:  aerosol_inde Description: Dimensions:	TOMS pair).  time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates ancillary_vari- ables  x_335_367 in AER_A The main output of OMI pair).	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)  Al/PRODUCT the Aerosol Index retrieval algorithm (at waveleng	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING		
Dimensions: Type: Source: Attributes:  aerosol_inde Description: Dimensions: Type:	TOMS pair).  time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates ancillary_vari- ables  x_335_367 in AER_A The main output of OMI pair). time, scanline, grou	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)  Al/PRODUCT the Aerosol Index retrieval algorithm (at waveleng	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING		
Dimensions: Type: Source: Attributes:  aerosol_inde Description: Type: Source:	TOMS pair).  time, scanline, grou  NC_FLOAT.  Processor.  Name  units  proposed_stand- ard_name  comment  long_name  radiation wavelength  The wavelengths us coordinates ancillary_vari- ables  x_335_367 in AER_A  The main output of OMI pair). time, scanline, grou  NC_FLOAT.	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)  Al/PRODUCT the Aerosol Index retrieval algorithm (at waveleng	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING		
Dimensions: Type: Source: Attributes:  aerosol_inde Description: Type: Source:	TOMS pair).  time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates ancillary_vari- ables x_335_367 in AER_A The main output of OMI pair). time, scanline, grou NC_FLOAT. Processor.	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) 340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)  AI/PRODUCT the Aerosol Index retrieval algorithm (at waveleng nd_pixel.	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING  NC_STRING  ths 354/388, i.e. th		
Description: Dimensions: Type: Source: Attributes:  aerosol_inde Description: Dimensions: Type: Source: Attributes:	TOMS pair).  time, scanline, grou  NC_FLOAT.  Processor.  Name  units  proposed_stand- ard_name  comment  long_name  radiation wavelength  The wavelengths us  coordinates  ancillary_vari- ables  x_335_367 in AER_A  The main output of  OMI pair).  time, scanline, grou  NC_FLOAT.  Processor.  Name	Value '1' (static) 'ultraviolet_aerosol_index' (static)  'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) '340.0, 380.0 (static)  sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)  Al/PRODUCT the Aerosol Index retrieval algorithm (at waveleng nd_pixel.  Value	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING  Type		
Dimensions: Type: Source: Attributes:  aerosol_inde Description: Type: Source:	TOMS pair). time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand- ard_name comment long_name radiation wavelength The wavelengths us coordinates ancillary_vari- ables x_335_367 in AER_A The main output of OMI pair). time, scanline, grou NC_FLOAT. Processor.  Name units proposed_stand-	Value '1' (static) 'ultraviolet_aerosol_index' (static) 'Aerosol index from 380 and 340 nm' (static) 'Aerosol index from 380 and 340 nm' (static) '340.0, 380.0 (static) sed for the determination of the aerosol index. 'longitude latitude' (static) 'aerosol_index_340_380_precision' (static)  Al/PRODUCT the Aerosol Index retrieval algorithm (at waveleng nd_pixel.  Value '1' (static)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_STRING  NC_STRING  Type  NC_STRING		

	radiation wavelength	335.0, 367.0 (static)	NC_FLOAT
	The wavelengths us	ed for the determination of the aerosol index.	
	coordinates	'longitude latitude' (static)	NC_STRING
	ancillary_vari- ables	'aerosol_index_335_367_precision' (static)	NC_STRING
aerosol_inde	x_354_388_precisio	n in AER_AI/PRODUCT	
Description:	The precision of the pair).	Aerosol Index retrieval algorithm (at wavelengths 354	/388, i.e. the O
Dimensions:	time, scanline, groun	nd_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	proposed_stand- ard_name	'ultraviolet_aerosol_index standard_error' (static)	NC_STRING
	comment	'Precision of aerosol index from 388 and 354 nm' (static)	NC_STRING
	long_name	'Precision of aerosol index from 388 and 354 nm' (static)	NC_STRING
	radiation wavelength	354.0, 388.0 (static)	NC_FLOAT
	The wavelengths us	ed for the determination of the aerosol index.	
aerosol_inde	The precision of the	'longitude latitude' (static)  n in AER_AI/PRODUCT  e Aerosol Index retrieval algorithm (at wavelengths	NC_STRING 340/380, i.e. tl
Description:  Dimensions:	x_340_380_precisio	n in AER_AI/PRODUCT e Aerosol Index retrieval algorithm (at wavelengths	<del>_</del>
Description: Dimensions: Type:	ex_340_380_precision  The precision of the TOMS pair).  time, scanline, ground	n in AER_AI/PRODUCT e Aerosol Index retrieval algorithm (at wavelengths	
Description: Dimensions: Type: Source:	ex_340_380_precision  The precision of the TOMS pair).  time, scanline, ground NC_FLOAT.	n in AER_AI/PRODUCT e Aerosol Index retrieval algorithm (at wavelengths	
Description: Dimensions: Type: Source:	ex_340_380_precision The precision of the TOMS pair). time, scanline, ground NC_FLOAT. Processor.	n in AER_AI/PRODUCT e Aerosol Index retrieval algorithm (at wavelengths nd_pixel.	340/380, i.e. tl
Description: Dimensions: Type:	ex_340_380_precision The precision of the TOMS pair). time, scanline, ground NC_FLOAT. Processor. Name	n in AER_AI/PRODUCT e Aerosol Index retrieval algorithm (at wavelengths nd_pixel.  Value	340/380, i.e. tl
Description: Dimensions: Type: Source:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_stand-	n in AER_AI/PRODUCT e Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value  '1' (static)	340/380, i.e. tl  Type  NC_STRING
Description: Dimensions: Type: Source:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor. Name units proposed_standard_name	n in AER_AI/PRODUCT e Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value  '1' (static)  'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm'	340/380, i.e. ti  Type  NC_STRING  NC_STRING
Description: Dimensions: Type: Source:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor. Name units proposed_standard_name comment	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value  '1' (static)  'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm'	Type NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_standard_name comment long_name  radiation wavelength The wavelengths us	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value '1' (static) 'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  340.0, 380.0 (static)  ed for the determination of the aerosol index.	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING
Description: Dimensions: Type: Source:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_standard_name comment  long_name  radiation wavelength	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value '1' (static) 'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  '340.0, 380.0 (static)	Type NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_stand-ard_name comment long_name  radiation wavelength The wavelengths us coordinates ex_335_367_precisio The precision of the	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value '1' (static) 'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  340.0, 380.0 (static)  ed for the determination of the aerosol index.	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING
Description:  Dimensions: Type: Source: Attributes:  aerosol_inde Description:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_stand-ard_name comment  long_name  radiation wavelength The wavelengths us coordinates ex_335_367_precisio The precision of the pair).	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value  '1' (static) 'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  340.0, 380.0 (static)  ed for the determination of the aerosol index. 'longitude latitude' (static)  n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths 354)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING
Description:  Dimensions: Type: Source: Attributes:  aerosol_inde Description: Dimensions:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_stand-ard_name comment  long_name  radiation wavelength The wavelengths us coordinates ex_335_367_precisio The precision of the pair). time, scanline, groun	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value  '1' (static) 'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  340.0, 380.0 (static)  ed for the determination of the aerosol index. 'longitude latitude' (static)  n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths 354)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING
Description:  Dimensions: Type: Source: Attributes:  aerosol_inde Description: Dimensions: Type:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_stand-ard_name comment  long_name  radiation wavelength The wavelengths us coordinates ex_335_367_precisio The precision of the pair). time, scanline, groun NC_FLOAT.	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value  '1' (static) 'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  340.0, 380.0 (static)  ed for the determination of the aerosol index. 'longitude latitude' (static)  n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths 354)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING
Description: Dimensions: Type: Source: Attributes:	ex_340_380_precisio The precision of the TOMS pair). time, scanline, groun NC_FLOAT. Processor.  Name units proposed_stand-ard_name comment  long_name  radiation wavelength The wavelengths us coordinates ex_335_367_precisio The precision of the pair). time, scanline, groun	n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths and_pixel.  Value  '1' (static) 'ultraviolet_aerosol_index standard_error' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  'Precision of aerosol index from 380 and 340 nm' (static)  340.0, 380.0 (static)  ed for the determination of the aerosol index. 'longitude latitude' (static)  n in AER_AI/PRODUCT Aerosol Index retrieval algorithm (at wavelengths 354)	Type  NC_STRING  NC_STRING  NC_STRING  NC_STRING  NC_STRING

units	'1' (static)	NC_STRING
proposed_stand- ard_name	'ultraviolet_aerosol_index standard_error' (static)	NC_STRING
comment	'Precision of aerosol index from 367 and 335 nm' (static)	NC_STRING
long_name	'Precision of aerosol index from 367 and 335 nm' (static)	NC_STRING
radiation wavelength	335.0, 367.0 (static)	NC_FLOAT
The wavelengths us	ed for the determination of the aerosol index.	
coordinates	'longitude latitude' (static)	NC_STRING

### 10.1.1 Group "SUPPORT\_DATA" in "PRODUCT"

# 10.1.1.1 Group "GEOLOCATIONS" in "SUPPORT\_DATA"

# Variables in AER\_AI/PRODUCT/SUPPORT\_DATA/GEOLOCATIONS

satellite_latit Description:	_	- Natic sub satellite point on the WGS84 reference alling	oid	
Dimensions:	Latitude of the geodetic sub satellite point on the WGS84 reference ellipsoid.			
	time, scanline. NC FLOAT.			
Type:	L1B.			
Source:	Name	Value	Time	
Attributes:			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 long				
agrenite_ioné	<b>gitude</b> in AER_AI/PR	ODUCT/SUPPORT_DATA/GEOLOCATIONS		
Description:	-	ODUCT/SUPPORT_DATA/GEOLOCATIONS odetic sub satellite point on the WGS84 reference elli	psoid.	
	-	<del>-</del>	psoid.	
Description:	Longitude of the ge	<del>-</del>	psoid.	
Description: Dimensions:	Longitude of the ge time, scanline.	<del>-</del>	psoid.	
Description: Dimensions: Type:	Longitude of the ge time, scanline. NC_FLOAT.	<del>-</del>	psoid.	
Description: Dimensions: Type: Source:	Longitude of the ge time, scanline. NC_FLOAT. L1B.	odetic sub satellite point on the WGS84 reference elli		
Description: Dimensions: Type: Source:	Longitude of the ge time, scanline. NC_FLOAT. L1B. Name	odetic sub satellite point on the WGS84 reference elli  Value	Туре	
Description: Dimensions: Type: Source:	Longitude of the ge time, scanline. NC_FLOAT. L1B. Name long_name	odetic sub satellite point on the WGS84 reference elli  Value  'satellite_longitude' (static)	Type NC_STRING	
Description: Dimensions: Type: Source:	Longitude of the ge time, scanline. NC_FLOAT. L1B. Name long_name units	Value  'satellite_longitude' (static)  'degrees_east' (static)  'Longitude of the geodetic sub satellite point on the	Type  NC_STRING  NC_STRING	
Description: Dimensions: Type: Source:	Longitude of the ge time, scanline.  NC_FLOAT.  L1B.  Name  long_name  units  comment	Value  'satellite_longitude' (static)  'degrees_east' (static)  'Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid' (static)	Type NC_STRING NC_STRING NC_STRING	
Description: Dimensions: Type: Source: Attributes:	Longitude of the ge time, scanline.  NC_FLOAT.  L1B.  Name long_name units comment  valid_min valid_max	Value  'satellite_longitude' (static)  'degrees_east' (static)  'Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid' (static)  -180.0 (static)	Type  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT	
Description: Dimensions: Type: Source: Attributes:	Longitude of the ge time, scanline.  NC_FLOAT.  L1B.  Name long_name units comment  valid_min valid_max ude in AER_AI/PROI	Value  'satellite_longitude' (static)  'degrees_east' (static)  'Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid' (static)  -180.0 (static)  180.0 (static)	Type  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_FLOAT	
Description: Dimensions: Type: Source: Attributes:	Longitude of the getime, scanline.  NC_FLOAT.  L1B.  Name long_name units comment  valid_min valid_max ude in AER_AI/PROI The altitude of the se	Value  'satellite_longitude' (static)  'degrees_east' (static)  'Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid' (static)  -180.0 (static)  180.0 (static)  DUCT/SUPPORT_DATA/GEOLOCATIONS	Type  NC_STRING  NC_STRING  NC_STRING  NC_FLOAT  NC_FLOAT	

Source:	L1B.		
Attributes:	Name	Value	Туре
	long_name	'satellite altitude' (static)	NC_STRING
	units	'm' (static)	NC_STRING
	comment	'The altitude of the satellite with respect to the geo- detic 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_orb	t_phase in AER_AI	/PRODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:	Relative offset [0.0	$[0,\ldots,1.0]$ of the measurement in the orbit.	
Dimensions:	time, scanline.		
Type:	NC_FLOAT.		
Source:	L1B.		
Attributes:	Name	Value	Туре
	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 in AER_AI/P	RODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:	measured away from when $\vartheta_0 \leq \vartheta_0^{\max}$ when	e $\vartheta_0$ at the ground pixel location on the reference elementh the vertical. ESA definition of day side: $\vartheta_0 < 92^\circ$ . Pix with $80^\circ \leq \vartheta_0^{\sf max} \leq 88^\circ$ , depending on the algorithm. The d in the algorithm metadata settings.	els are processed
Dimensions:	time, scanline, gro		
Type:	NC_FLOAT.		

Source: L1B.

Name	Value	Туре
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
T 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	the state of the s	

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].

'Solar zenith angle at the ground pixel location on NC\_STRING the reference ellipsoid. Angle is measured away from the vertical' (static)

### solar\_azimuth\_angle in AER\_AI/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 =  $0^{\circ}$ , East =  $90^{\circ}$ , South =  $\pm 180^{\circ}$ , West =  $-90^{\circ}$ ).

This is the same definition that is use in both OMI and GOME-2 level 1B files.

See the note on the <code>viewing\_azimuth\_angle</code> on the calculation of the relative azimuth angle as used in radiative transfer calculations.

Dimensions: time, scanline, ground\_pixel.

Type:	NC_FLOAT.		
Source:	L1B.		
Attributes:	Name	Value	Туре
	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
		ngitude are in a different group. How to specify the case is not specified in the climate and forecast	• .
	comment	'Solar azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clock- wise from the North (East = 90, South = +/-180, West = -90)' (static)	NC_STRING
viewing_zen	ith_angle in AER_AI	/PRODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:	Zenith angle of the is measured away to	satellite $\vartheta$ at the ground pixel location on the referen from the vertical.	ce ellipsoid. Angle
Dimensions:	time, scanline, grou	und_pixel.	
Type:	NC_FLOAT.		
Source:	L1B.		
Attributes:	Name	Value	Туре
	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
		ngitude are in a different group. How to specify the case is not specified in the climate and forecast	• ,
	comment	'Zenith angle of the satellite at the ground pixel loc- ation on the reference ellipsoid. Angle is measured away from the vertical' (static)	NC_STRING
viewing_azin	nuth_angle in AER_	AI/PRODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:	is measured clock $-90^{\circ}$ ). This is the s	th angle at the ground pixel location on the reference exwise from the North (North = $0^{\circ}$ , East = $90^{\circ}$ , South same definition that is use in both OMI and GOME-2	= $\pm 180^{\circ}$ , West = level 1B files.
	azimuth_angle f fer calculations is (	zimuth difference $\varphi-\varphi_0$ it is not sufficient to just rom <code>viewing_azimuth_angle</code> . The angle needed $180^\circ-(\varphi-\varphi_0)) \mod 360^\circ$ .	
Dimensions:	time, scanline, grou	und_pixel.	
Type:	NC_FLOAT.		
Source:	L1B.		
Attributes:	Name	Value	Туре
	long_name	'viewing azimuth angle' (static)	NC_STRING
	standard_name	'viewing_azimuth_angle' (static)	NC_STRING
	units	'degree' (static)	NC_STRING

valid_n	nax	180.0 (static)	NC_FLOAT
coordin	nates	/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	ates in this c	itude are in a different group. How to specify the rase is not specified in the climate and forecast r	• ,
comme	1	Satellite azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = +/.180, West = -90)' (static)	NC_STRING

### latitude\_bounds in AER\_AI/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 8.

Dimensions: time, scanline, ground\_pixel, corner.

Type: NC\_FLOAT. Source: Processor.

### Iongitude bounds in AER AI/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 8.

Dimensions: time, scanline, ground pixel, corner.

Type: NC\_FLOAT. Source: Processor.

### geolocation flags in AER AI/PRODUCT/SUPPORT DATA/GEOLOCATIONS

Description:

Attributes:

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.

1 100000011		
Name	Value	Туре
_FillValue	255 (static)	NC_UBYTE
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
flag_masks	0, 1, 2, 4, 8, 16, 32, 128 (static)	NC_UBYTE
flag_meanings	'no_error solar_eclipse sun_glint_possible des- cending night geo_boundary_crossing spacecraft manoeuvre geolocation_error' (static)	NC_STRING
flag_values	0, 1, 2, 4, 8, 16, 32, 128 (static)	NC_UBYTE
long_name	'geolocation flags' (static)	NC_STRING
max_val	254 (static)	NC_UBYTE
min_val	0 (static)	NC_UBYTE
units	'1' (static)	NC_STRING

### 10.1.1.2 Group "DETAILED\_RESULTS" in "SUPPORT\_DATA"

### Variables in AER\_AI/PRODUCT/SUPPORT\_DATA/DETAILED\_RESULTS

processing_quality_flags in AER_AI/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS			
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.		
Attributes:	Name	Value	Туре
	long_name	'Processing quality flags' (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 max num outlier exceeded 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 pixel level input data missing AAI warning 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\_recloud inhomogeneity warning trieval warning thermal instability warning' (static)

NC STRING

	flag_masks	255, 255, 255, 255, 255, 255, 255, 255,	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, 55, 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, 1073741824 (static)	NC_UINT
		'/PRODUCT/longitude /PRODUCT/latitude' (static) ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	
number_of_s	pectral_points_in_re	etrieval in AER_AI/PRODUCT/SUPPORT_DATA/DET	AILED_RESULTS
Description:	The number of point	ts in the spectrum that were used in the retrieval.	
Dimensions:	time, scanline, groun	nd_pixel.	
Type:	NC_USHORT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	long_name	'Number of spectral points used in the retrieval' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	• .
scene_albedo	<b>o_388</b> in AER_AI/PR	ODUCT/SUPPORT_DATA/DETAILED_RESULTS	
Description:	Scene albedo at 388	3 nm (calculated from top of atmosphere reflectance)	
Dimensions:	time, scanline, groun	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	long_name	'Scene albedo at 388 nm calculated from the top of atmosphere reflectance. For a cloud- and aerosol- free scene this is equivalent to the surface albedo' (static)	NC_STRING

	radiation wavelength	388.0 (static)	NC_FLOAT	
	The wavelengthat which the surface albedo was determined. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.			
•	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING	
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast n		
	ancillary_vari- ables	'scene_albedo_388_precision' (static)	NC_STRING	
scene_albedo	o_388_precision in A	AER_AI/PRODUCT/SUPPORT_DATA/DETAILED_RE	SULTS	
Description:	Precision of the sca	ene albedo at 388 nm (calculated from top of atmostifithe reflectance).	ohere reflectance	
Dimensions:	time, scanline, ground_pixel.			
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
•	units	'1' (static)	NC_STRING	
	long_name	'Precision of the scene albedo at 388 nm calculated from the top of atmosphere reflectance and its precision. For a cloud- and aerosol-free scene this is equivalent to the surface albedo' (static)	NC_STRING	
	radiation wavelength	388.0 (static)	NC_FLOAT	
	The wavelengthat which the surface albedo was determined. The CF-conventions propose			
	to use a coordinate variable for this, but this seems more appropriate.			
	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].			
reflectance r		R_AI/PRODUCT/SUPPORT_DATA/DETAILED_RESU	JLTS	
renectance_i	neasured_354 in AE			
Description:	<del>-</del>	ere reflectance at 354 nm.		
_	The top of atmosph			
Description:	The top of atmosph			
Description: Dimensions:	The top of atmosphetime, scanline, grou			
Description: Dimensions: Type:	The top of atmosphotime, scanline, ground NC_FLOAT.		Туре	
Description: Dimensions: Type: Source:	The top of atmosphotime, scanline, ground NC_FLOAT.  Processor.	nd_pixel.	Type NC_STRING	
Description: Dimensions: Type: Source:	The top of atmosphotime, scanline, ground NC_FLOAT. Processor.  Name	nd_pixel.  Value		
Description: Dimensions: Type: Source:	The top of atmosphotime, scanline, ground NC_FLOAT. Processor.  Name units	nd_pixel.  Value  '1' (static)	NC_STRING	
Description: Dimensions: Type: Source:	The top of atmosphotime, scanline, ground NC_FLOAT. Processor. Name units standard_name	Value  '1' (static)  'toa_bidirectional_reflectance' (static)	NC_STRING NC_STRING	
Description: Dimensions: Type: Source:	The top of atmosphotime, scanline, ground NC_FLOAT. Processor.  Name units standard_name long_name radiation wavelength The wavelengths u	Value  '1' (static)  'toa_bidirectional_reflectance' (static)  'Top of atmosphere reflectance at 354 nm' (static)	NC_STRING NC_STRING NC_STRING NC_FLOAT CF-conventions	
Description: Dimensions: Type: Source:	The top of atmosphotime, scanline, ground NC_FLOAT. Processor.  Name units standard_name long_name radiation wavelength The wavelengths u	Value  '1' (static)  'toa_bidirectional_reflectance' (static)  'Top of atmosphere reflectance at 354 nm' (static)  354.0 (static)  sed for the determination of the aerosol index. The	NC_STRING NC_STRING NC_STRING NC_FLOAT CF-conventions	
Description: Dimensions: Type: Source:	The top of atmosphotime, scanline, ground NC_FLOAT. Processor.  Name units standard_name long_name radiation wavelength The wavelengths upropose to use a cocordinates The latitude and lore	Value  '1' (static)  'toa_bidirectional_reflectance' (static)  'Top of atmosphere reflectance at 354 nm' (static)  354.0 (static)  sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropri	NC_STRING NC_STRING NC_STRING NC_FLOAT CF-conventions oriate. NC_STRING elated geospatial	

Description:	The precision of the	e top of atmosphere reflectance at 354 nm.	
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance standard_error' (static)	NC_STRING
	long_name	'Precision of the top of atmosphere reflectance at 354 nm' (static)	NC_STRING
	radiation wavelength	354.0 (static)	NC_FLOAT
	-	sed for the determination of the aerosol index. The pordinate variable for this, but this seems more approp	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	
reflectance_r	neasured_388 in AE	R_AI/PRODUCT/SUPPORT_DATA/DETAILED_RESU	JLTS
Description:	The top of atmosph	ere reflectance at 388 nm.	
Dimensions:	time, scanline, grou	nd_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
•	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
	long_name	'Top of atmosphere reflectance at 388 nm' (static)	NC_STRING
	radiation wavelength	388.0 (static)	NC_FLOAT
	•	sed for the determination of the aerosol index. The pordinate variable for this, but this seems more approp	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	• .
•	ancillary_vari- ables	'reflectance_measured_388_precision' (static)	NC_STRING
reflectance_r	measured_388_pred	ision in AER_AI/PRODUCT/SUPPORT_DATA/DETA	ILED_RESULTS
Description:	The precision of the	e top of atmosphere reflectance at 388 nm.	
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance standard_error' (static)	NC_STRING
	long_name	'Precision of the top of atmosphere reflectance at 388 nm' (static)	NC_STRING
-	radiation wavelength	388.0 (static)	NC_FLOAT

The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.

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].

#### reflectance calculated 354 in AER AI/PRODUCT/SUPPORT DATA/DETAILED RESULTS

Description: The calculated top of atmosphere reflectance at 354 nm.

Dimensions: time, scanline, ground pixel.

Type: NC\_FLOAT. Source: Processor.

Attributes:

Name	Value	Type
units	'1' (static)	NC_STRING
standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
long_name	'Calculated top of atmosphere reflectance at 354 nm' (static)	NC_STRING
radiation wavelength	354.0 (static)	NC_FLOAT

The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.

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].

 ancillary\_vari 'reflectance\_calculated\_354\_precision' (static)
 NC\_STRING

 ables

#### reflectance calculated 354 precision in AER AI/PRODUCT/SUPPORT DATA/DETAILED RESULTS

Description: The precision of the calculated top of atmosphere reflectance at 354 nm.

Dimensions: time, scanline, ground\_pixel.

Type: NC\_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
standard_name	'toa_bidirectional_reflectance standard_error' (static)	NC_STRING
long_name	'Precision of the calculated top of atmosphere re- flectance at 354 nm' (static)	NC_STRING
radiation wavelength	354.0 (static)	NC_FLOAT

The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.

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].

### scene\_albedo\_380 in AER\_AI/PRODUCT/SUPPORT\_DATA/DETAILED\_RESULTS

Description: Scene albedo at 380 nm (calculated from top of atmosphere refelctance).

Dimensions: time, scanline, ground\_pixel.

Type: NC FLOAT.

Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (static)	NC_STRING	
	long_name	'Scene albedo at 380 nm calculated from the top of	NC_STRING	
-		atmosphere reflectance. For a cloud- and aerosol-		
		free scene this is equivalent to the surface albedo' (static)		
	radiation	380.0 (static)	NC FLOAT	
	wavelength	ooo.o (statio)	140_1 20/11	
	The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.			
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING	
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r		
	ancillary_vari- ables	'scene_albedo_380_precision' (static)	NC_STRING	
scene_albed	o_380_precision in /	AER_AI/PRODUCT/SUPPORT_DATA/DETAILED_RE	SULTS	
Description:	Precision of the sca and the precision of	ene albedo at 380 nm (calculated from top of atmospeter the reflectance).	ohere reflectance	
Dimensions:	time, scanline, grou	nd_pixel.		
Туре:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (static)	NC_STRING	
	long_name	'Precision of the scene albedo at 380 nm calculated from the top of atmosphere reflectance and its precision. For a cloud- and aerosol-free scene this is equivalent to the surface albedo' (static)	NC_STRING	
	radiation wavelength	380.0 (static)	NC_FLOAT	
	The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.			
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING	
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r		
reflectance_r	measured_340 in AE	R_AI/PRODUCT/SUPPORT_DATA/DETAILED_RESU	JLTS	
Description:	The top of atmosph	ere reflectance at 340 nm.		
Dimensions:	time, scanline, grou	nd_pixel.		
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (static)	NC_STRING	
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING	
	long_name	'Top of atmosphere reflectance at 340 nm' (static)	NC_STRING	
	radiation wavelength	340.0 (static)	NC_FLOAT	
		sed for the determination of the aerosol index. The ordinate variable for this, but this seems more appropriate the control of		

'/PRODUCT/longitude /PRODUCT/latitude' (static) coordinates 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]. ancillary\_vari-'reflectance\_measured\_340\_precision' (static) NC\_STRING ables reflectance measured 340 precision in AER AI/PRODUCT/SUPPORT DATA/DETAILED RESULTS The precision of the top of atmosphere reflectance at 340 nm. Description: Dimensions: time, scanline, ground\_pixel. Type: NC FLOAT. Source: Processor. Attributes: Name Value Туре '1' (static) NC STRING units standard name 'toa bidirectional reflectance standard error' NC STRING (static) 'Precision of the top of atmosphere reflectance at NC\_STRING long\_name 340 nm' (static) radiation -340.0 (static) NC FLOAT wavelength The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate. '/PRODUCT/longitude /PRODUCT/latitude' (static) coordinates 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]. reflectance measured 380 in AER AI/PRODUCT/SUPPORT DATA/DETAILED RESULTS Description: The top of atmosphere reflectance at 380 nm. Dimensions: time, scanline, ground pixel. NC FLOAT. Type: Source: Processor. Attributes: Name Value Type NC STRING units '1' (static) NC STRING standard name 'toa bidirectional reflectance' (static) 'Top of atmosphere reflectance at 380 nm' (static) NC\_STRING long\_name radiation\_-NC\_FLOAT 380.0 (static) wavelength The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate. '/PRODUCT/longitude /PRODUCT/latitude' (static) coordinates 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]. ancillary vari-'reflectance measured 380 precision' (static) NC STRING ables reflectance measured 380 precision in AER AI/PRODUCT/SUPPORT DATA/DETAILED RESULTS Description: The precision of the top of atmosphere reflectance at 380 nm. Dimensions: time, scanline, ground\_pixel. NC\_FLOAT. Type: Source: Processor. Attributes: Name Value Туре

	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance standard_error' (static)	NC_STRING
	long_name	'Precision of the top of atmosphere reflectance at 380 nm' (static)	NC_STRING
	radiation wavelength	380.0 (static)	NC_FLOAT
	•	sed for the determination of the aerosol index. The ordinate variable for this, but this seems more approp	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude are in a different group. How to specify the recase is not specified in the climate and forecast n	
reflectance_c	calculated_340 in AE	R_AI/PRODUCT/SUPPORT_DATA/DETAILED_RES	ULTS
Description:	The calculated top	of atmosphere reflectance at 340 nm.	
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
	long_name	'Calculated top of atmosphere reflectance at 340 nm' (static)	NC_STRING
	radiation wavelength	340.0 (static)	NC_FLOAT
	•	sed for the determination of the aerosol index. The ordinate variable for this, but this seems more approp	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	coordinates in this	ngitude are in a different group. How to specify the recase is not specified in the climate and forecast n	• .
	tions [ER5].		
	ancillary_variables	'reflectance_calculated_340_precision' (static)	NC_STRING
reflectance_c	ancillary_vari- ables	'reflectance_calculated_340_precision' (static)  cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA	<del>-</del>
reflectance_c Description:	ancillary_vari- ables calculated_340_pred		<del>-</del>
_	ancillary_vari- ables calculated_340_pred	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm.	<del>-</del>
Description:	ancillary_vari- ables calculated_340_pred Precision of the calc	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm.	<del>-</del>
Description: Dimensions:	ancillary_vari- ables calculated_340_pred Precision of the calculated time, scanline, grou	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm.	
Description: Dimensions: Type:	ancillary_variables calculated_340_precipion of the calculated, scanline, ground NC_FLOAT.	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm.	<del>-</del>
Description: Dimensions: Type: Source:	ancillary_variables calculated_340_prediction of the calculated time, scanline, ground NC_FLOAT.  Processor.	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm. nd_pixel.	ILED_RESULTS
Description: Dimensions: Type: Source:	ancillary_variables calculated_340_pred Precision of the calculated, scanline, grount NC_FLOAT. Processor. Name	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm. nd_pixel.  Value	ILED_RESULTS  Type
Description: Dimensions: Type: Source:	ancillary_variables calculated_340_precent Precision of the calculated, scanline, grount NC_FLOAT. Processor. Name units	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm. nd_pixel.  Value  '1' (static)  'toa_bidirectional_reflectance standard_error'	ILED_RESULTS  Type  NC_STRING
Description: Dimensions: Type: Source:	ancillary_variables calculated_340_precipitation of the calculated second in the calculation of the calculation of the calculation, scanline, group NC_FLOAT.  Processor.  Name units standard_name	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm. nd_pixel.  Value  '1' (static)  'toa_bidirectional_reflectance standard_error' (static)  'Precision of the calculated top of atmosphere re-	Type NC_STRING NC_STRING
Description: Dimensions: Type: Source:	ancillary_variables calculated_340_precedure Precision of the calculated, scanline, ground NC_FLOAT. Processor.  Name units standard_name  long_name  radiation wavelength The wavelengths units and	cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA culated top of atmosphere reflectance at 340 nm. nd_pixel.  Value  '1' (static)  'toa_bidirectional_reflectance standard_error' (static)  'Precision of the calculated top of atmosphere reflectance at 340 nm' (static)	Type NC_STRING NC_STRING NC_STRING NC_STRING CFLOAT CF-conventions

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].

scene\_albedo\_367 in AER\_AI/PRODUCT/SUPPORT\_DATA/DETAILED\_RESULTS

Description: Scene albedo at 367 nm (calculated from top of atmosphere reflectance).

Dimensions: time, scanline, ground\_pixel.

Type: NC\_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'Scene albedo at 367 nm calculated from the top of atmosphere reflectance. For a cloud- and aerosol- free scene this is equivalent to the surface albedo' (static)	NC_STRING
radiation wavelength	367.0 (static)	NC_FLOAT

The wavelengthat which the surface albedo was determined. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.

**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].

### scene\_albedo\_367\_precision in AER\_AI/PRODUCT/SUPPORT\_DATA/DETAILED\_RESULTS

Description: Precision of the scene albedo at 367 nm (calculated from top of atmosphere reflectance

and the precision of the reflectance).

Dimensions: time, scanline, ground pixel.

Type: NC\_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'Precision of the scene albedo at 367 nm calculated from the top of atmosphere reflectance and its precision. For a cloud- and aerosol-free scene this is equivalent to the surface albedo' (static)	NC_STRING
radiation wavelength	367.0 (static)	NC_FLOAT

The wavelengthat which the surface albedo was determined. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.

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].

#### reflectance measured 335 in AER AI/PRODUCT/SUPPORT DATA/DETAILED RESULTS

Description: The top of atmosphere reflectance at 335 nm.

Dimensions: time, scanline, ground\_pixel.

Type: NC\_FLOAT. Source: Processor.

Attributes: Name Value Type

tions [ER5].

	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
	long_name	'Top of atmosphere reflectance at 335 nm' (static)	NC_STRING
	radiation wavelength	335.0 (static)	NC_FLOAT
	The wavelengths u	used for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriate the control of the control	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	
	ancillary_vari- ables	'reflectance_measured_335_precision' (static)	NC_STRING
reflectance_r	measured_335_pred	ision in AER_AI/PRODUCT/SUPPORT_DATA/DETA	ILED_RESULTS
Description:	The precision of the	e top of atmosphere reflectance at 335 nm.	
Dimensions: Type:	time, scanline, grou	nd_pixel.	
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance standard_error' (static)	NC_STRING
	long_name	'Precision of the top of atmosphere reflectance at 335 nm' (static)	NC_STRING
	radiation wavelength	335.0 (static)	NC_FLOAT
	The wavelengths used for the determination of the aerosol index. The CF-conventions propose to use a coordinate variable for this, but this seems more appropriate.		
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	
reflectance_r	measured_367 in AE	R_AI/PRODUCT/SUPPORT_DATA/DETAILED_RES	ULTS
Description:	The top of atmosph	ere reflectance at 367 nm.	
Dimensions:	time, scanline, grou	nd_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
	long_name	'Top of atmosphere reflectance at 367 nm' (static)	NC_STRING
	radiation wavelength	367.0 (static)	NC_FLOAT
	The wavelengths u	ised for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriate the control of the control	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and lo	ngitude are in a different group. How to specify the r	elated geospatia

coordinates in this case is not specified in the climate and forecast metadata conven-

	ancillary_vari- ables	'reflectance_measured_367_precision' (static)	NC_STRING
reflectance_ı	measured_367_prec	ision in AER_AI/PRODUCT/SUPPORT_DATA/DETA	ILED_RESULTS
Description:	The precision of the	e top of atmosphere reflectance at 367 nm.	
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance standard_error' (static)	NC_STRING
	long_name	'Precision of the top of atmosphere reflectance at 367 nm' (static)	NC_STRING
	radiation wavelength	367.0 (static)	NC_FLOAT
	•	sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriate the control of the control o	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast n	
reflectance_c	calculated_335 in AE	ER_AI/PRODUCT/SUPPORT_DATA/DETAILED_RES	ULTS
Description:	The calculated top	of atmosphere reflectance at 335 nm.	
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'toa_bidirectional_reflectance' (static)	NC_STRING
	long_name	'Calculated top of atmosphere reflectance at 335 nm' (static)	NC_STRING
		(5.5)	
	radiation wavelength	335.0 (static)	NC_FLOAT
	wavelength The wavelengths u		CF-conventions
	wavelength The wavelengths u	335.0 (static) sed for the determination of the aerosol index. The	e CF-conventions
	wavelength The wavelengths u propose to use a cocordinates The latitude and los	335.0 (static) sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriate the content of the content o	e CF-conventions oriate.  NC_STRING elated geospatial
	wavelength The wavelengths upropose to use a cocoordinates The latitude and locoordinates in this	335.0 (static) sed for the determination of the aerosol index. The pordinate variable for this, but this seems more apprope '/PRODUCT/longitude /PRODUCT/latitude' (static) ingitude are in a different group. How to specify the results of the second	e CF-conventions oriate.  NC_STRING elated geospatial
reflectance_c	wavelength The wavelengths upropose to use a cocoordinates The latitude and locoordinates in this tions [ER5].  ancillary_variables	335.0 (static)  sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropt '/PRODUCT/longitude /PRODUCT/latitude' (static) ingitude are in a different group. How to specify the recase is not specified in the climate and forecast in	e CF-conventions oriate.  NC_STRING elated geospatial netadata conven-
reflectance_o	wavelength The wavelengths upropose to use a cocoordinates The latitude and locoordinates in this tions [ER5]. ancillary_variables calculated_335_precessors	335.0 (static) sed for the determination of the aerosol index. The pordinate variable for this, but this seems more apprope '/PRODUCT/longitude /PRODUCT/latitude' (static) ingitude are in a different group. How to specify the recase is not specified in the climate and forecast in 'reflectance_calculated_335_precision' (static)	e CF-conventions oriate.  NC_STRING elated geospatial netadata conven-  NC_STRING
_	wavelength The wavelengths upropose to use a cocoordinates The latitude and locoordinates in this tions [ER5]. ancillary_variables calculated_335_precessors	335.0 (static)  sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriately of the product of the pro	e CF-conventions oriate.  NC_STRING elated geospatial netadata conven-  NC_STRING  ILED_RESULTS
Description:	wavelength The wavelengths upropose to use a cocordinates The latitude and locoordinates in this tions [ER5].  ancillary_variables calculated_335_precent	335.0 (static)  sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriately of the product of the pro	e CF-conventions oriate.  NC_STRING elated geospatial netadata conven-  NC_STRING  ILED_RESULTS
Description: Dimensions:	wavelength The wavelengths upropose to use a cocordinates The latitude and locoordinates in this tions [ER5].  ancillary_variables Calculated_335_precent the precision of the time, scanline, grounds	335.0 (static)  sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriately of the product of the pro	e CF-conventions oriate.  NC_STRING elated geospatial netadata conven-  NC_STRING
Description: Dimensions: Type:	wavelength The wavelengths upropose to use a cocordinates The latitude and locoordinates in this tions [ER5].  ancillary_variables Calculated_335_pred The precision of the time, scanline, ground NC_FLOAT.	335.0 (static)  sed for the determination of the aerosol index. The pordinate variable for this, but this seems more appropriately of the product of the pro	e CF-conventions oriate.  NC_STRING elated geospatial netadata conven-  NC_STRING
Description: Dimensions: Type: Source:	wavelength The wavelengths upropose to use a cocordinates The latitude and locoordinates in this tions [ER5].  ancillary_variables Calculated_335_precent The precision of the time, scanline, ground NC_FLOAT. Processor.	335.0 (static)  sed for the determination of the aerosol index. The pordinate variable for this, but this seems more approper '/PRODUCT/longitude /PRODUCT/latitude' (static) ingitude are in a different group. How to specify their case is not specified in the climate and forecast in 'reflectance_calculated_335_precision' (static)  cision in AER_AI/PRODUCT/SUPPORT_DATA/DETA is calculated top of atmosphere reflectance at 335 nm. and_pixel.	e CF-conventions oriate.  NC_STRING elated geospatial netadata conven-  NC_STRING  ILED_RESULTS

	long_name	'Precision of the calculated top of atmosphere re- flectance at 335 nm' (static)	NC_STRING	
	radiation wavelength	335.0 (static)	NC_FLOAT	
		sed for the determination of the aerosol index. The ordinate variable for this, but this seems more appropriate the control of		
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING	
	coordinates in this tions [ER5].	ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	netadata conver	
	<del>-</del>	AER_AI/PRODUCT/SUPPORT_DATA/DETAILED_R		
Description:	Fitted wavelength of	fset from the wavelength calibration pre-fit in the Leve	el 2 processor.	
		$\lambda_{true} = \lambda_{nominal} + \delta \lambda$	(1	
	See [RD35] for deta	ils about the wavelength fit.		
Dimensions:	time, scanline, grou	nd_pixel.		
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	long_name	'wavelength offset' (static)	NC_STRING	
	units	'nm' (static)	NC_STRING	
	wavelength_fit window_start	0.0 (static)	NC_FLOAT	
	The start wavelength of the wavelength fit window.			
	wavelength_fit window_end	0.0 (static)	NC_FLOAT	
	The end wavelength	of the wavelength fit window.		
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING	
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r		
	ancillary_vari- ables	'wavelength_calibration_offset_precision' (static)	NC_STRING	
	comment	'True wavelength = nominal wavelength + wavelength offset + wavelength stretch * scaled wavelength' (static)	NC_STRING	
wavelength_c	calibration_offset_pr	ecision in AER_AI/PRODUCT/SUPPORT_DATA/DET	AILED_RESULT	
Description:	A posteriori precisio	n of the fitted wavelength offset.		
Dimensions:	time, scanline, grou	nd_pixel.		
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	long_name	'wavelength offset precision' (static)	NC_STRING	
	units	'nm' (static)	NC_STRING	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING	
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r		
wovolongth		n AER_AI/PRODUCT/SUPPORT_DATA/DETAILED_I	RESILITS	

NC STRING

Description: Fitted wavelength stretch *q* from the wavelength calibration pre-fit in the Level 2 processor.

$$\lambda_{\text{true}} = \lambda_{\text{nominal}} + \delta\lambda + q\lambda^* \tag{2}$$

with  $\lambda^*$  a scaled wavelength to the range [-1,1] over the full fit window. This is an optional

fit parameter.

Dimensions: time, scanline, ground pixel.

coordinates

Type: NC\_FLOAT. Source: Processor.

Attributes:	Name	Value	Туре
	long_name	'wavelength stretch' (static)	NC_STRING
	units	'1' (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].

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

ancillary\_variables

'wavelength\_calibration\_stretch\_precision' (static) NC\_STRING

Comment

'True wavelength = nominal wavelength + NC\_STRING
wavelength offset + wavelength stretch \* scaled
wavelength' (static)

wavelength\_calibration\_stretch\_precision in AER\_AI/PRODUCT/SUPPORT\_DATA/DETAILED\_RESULTS

Description: A posteriori precision of the fitted wavelength stretch.

Dimensions: time, scanline, ground\_pixel.

Type: NC\_FLOAT. Source: Processor.

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].

wavelength\_calibration\_chi\_square in AER\_AI/PRODUCT/SUPPORT\_DATA/DETAILED\_RESULTS

Description: The  $\chi^2$  from the wavelength calibration pre-fit in the Level 2 processor.

Dimensions: time, scanline, ground\_pixel.

Type: NC\_FLOAT. Source: Processor.

Attributes: Name Value Type

long\_name 'wavelength calibration chi square' (static) NC\_STI

 long\_name
 'wavelength calibration chi square' (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].

 ${\bf wavelength\_calibration\_irradiance\_offset} \ {\bf in} \ {\bf AER\_AI/PRODUCT/SUPPORT\_DATA/DETAILED\_RESULTS}$ 

Description:	Fitted wavelength or processor.	offset from the irradiance wavelength calibration pre	-fit in hte Level 2
	processor.	$\lambda_{true} = \lambda_{nominal} + \delta \lambda$	(3
	See [RD35] for deta	ils about the wavelength fit.	
Dimensions:	time, ground_pixel.	· ·	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	long_name	'irradiance wavelength offset' (static)	NC_STRING
	units	'nm' (static)	NC_STRING
	wavelength_fit window_start	0.0 (static)	NC_FLOAT
	The start wavelengt	h of the irradiance wavelength fit window.	
	wavelength_fit window_end	0.0 (static)	NC_FLOAT
	The end wavelength of the irradiance wavelength fit window.		
	ancillary_vari-	'wavelength_calibration_irradiance_offset_preci-	NC_STRING
	ables	sion' (static)	
	comment	'True wavelength = nominal wavelength + wavelength offset + wavelength stretch * scaled wavelength' (static)	NC_STRING
wavelength_ DETAILED_R	_	ce_offset_precision in AER_AI/PRODUCT/S	SUPPORT_DATA
Description:	A posteriori precisio	n of the fitted wavelength offset for the irradiance spe	ectrum.
Dimensions:	time, ground_pixel.		
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	long_name	'irradiance wavelength offset precision' (static)	NC_STRING
	units	'nm' (static)	NC_STRING
wavelength_ RESULTS	calibration_irradian	ce_chi_square in AER_AI/PRODUCT/SUPPORT_D	ATA/DETAILED_
Description:	The $\chi^2$ from the irra	diance wavelength calibration pre-fit in the Level 2 pr	ocessor.
Dimensions:	time, ground_pixel.		
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	long_name	'wavelength calibration irradiance chi squared' (static)	NC_STRING
	units	'1' (static)	NC_STRING

### 10.1.1.3 Group "INPUT\_DATA" in "SUPPORT\_DATA"

## Variables in AER\_AI/PRODUCT/SUPPORT\_DATA/INPUT\_DATA

### surface\_altitude in AER\_AI/PRODUCT/SUPPORT\_DATA/INPUT\_DATA

Description: The mean of the sub-pixels of the surface altitude within the approximate field of view, based

on the GMTED2010 surface elevation database. The surface altitude is referenced to the

Earth Gravitational Model 1996 (EGM96) geoid.

Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	surface elevation da	atabase.	
Attributes:	Name	Value	Туре
	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
	source	'http://topotools.cr.usgs.gov/gmted_viewer/' (static)	NC_STRING
	comment	'The mean of the sub-pixels of the surface altitude- within the approximate field of view, based on the GMTED2010 surface elevation database' (static)	NC_STRING
surface altitu	ude precision in AE	R_AI/PRODUCT/SUPPORT_DATA/INPUT_DATA	
Description:	_ <del>-</del>	tion of sub-pixels used in calculating the mean surfac	ce altitude, based

on the GMTED2010 surface elevation database. See the description of the surface\_-

altitude variable for details.

Dimensions: time, scanline, ground pixel.

NC FLOAT. Type:

Source: surface elevation database.

Attributes:

Name	Value	Туре
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
source	'http://topotools.cr.usgs.gov/gmted_viewer/' (static)	NC_STRING
comment	'The standard deviation of sub-pixels used in cal- culating the mean surface altitude, based on the GMTED2010 surface elevation database' (static)	NC_STRING

#### surface classification in AER AI/PRODUCT/SUPPORT DATA/INPUT DATA

Description:

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 [ER8], specifically the "USGS Land Use/Land Cover System (Modified Level 2)" classification. Over water the classification from the NASA SDP toolkit [ER9], which is based on [RD36].

The structure of this variable is indicated with the flag meanings, flag values and flag masks, following the CF-metadata convensions. Bits 0 and 1 indicate the land-water mask at two levels, bit 2 gives a rough statistic on the coverage of the pixel, and the remainder of the byte indicates the surface classification in more detail. Note that these values are static and based on the databases indicated above.

Dimensions: time, scanline, ground\_pixel.

NC UBYTE. Type:

Source: surface elevation database (including flag attributes).

Attributes: Name Value Туре 'Land-water mask and surface classification based NC STRING long name on a static database' (static) 'Flag indicating land/water and further surface clas-NC STRING comment sifications for the ground pixel' (static)

source	'USGS (https://lta.cr.usgs.gov/GLCC) 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+cropland-grassland_mosaic land+cropland-woodland_mosaic land+grassland land+shrubland land+mixed_shrubland-grassland land+savanna land+deciduous_broadleaf_forest land+evergreen_broadleaf_forest land+evergreen_needleleaf_forest land+mixed_forest land+herbaceous_wetland land+wooded_wetland land+barren_or_sparsely_vegetated 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,	NC_UBYTE
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING

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.

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 in AER\_AI/PRODUCT/SUPPORT\_DATA/INPUT\_DATA

For an IcID (see the instrument configuration identifier above), it is possible Description:

> to have multiple versions, identified by the instrument configuration version or lcVersion. 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. NC SHORT. Type:

Source: L1B.

Attributes: Name Value Type long\_name 'IcVersion' (static) NC STRING

'Version of the instrument\_configuration\_identifier' NC STRING comment

(static)

## scaled\_small\_pixel\_variance in AER\_AI/PRODUCT/SUPPORT\_DATA/INPUT\_DATA

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

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

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

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

$$(5)$$

$$V(t,r,c) = \frac{1}{N_{\text{small pixels}}} \sum_{i=0}^{N_{\text{small pixels}}-1} (R(t,r,c,i) - \langle R(t,r,c) \rangle)^2$$
 (5)

$$V_{\text{scaled}}(t,r,c) = \frac{V(t,r,c)}{\langle R(t,r,c) \rangle^2}$$
 (6)

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  $i = [0, \dots, N_{\mathsf{small \; pixels}} - 1]$  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  $\vartheta_0$  is the solar zenith angle.

Dimensions: time, scanline, ground pixel.

NC FLOAT. Type: Source: Processor.

Attributes:

Name	Value	lype
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	NC_STRING
	small pixels' (static)	

#### NC FLOAT radiation wavelength

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.

#### eastward wind in AER AI/PRODUCT/SUPPORT DATA/INPUT DATA

Description: The horizontal component of the wind at 10 meter height in the eastward direction. This is

the 10U parameter from ECMWF (grib variable 165).

Dimensions: time, scanline, ground pixel.

NC FLOAT. Type:

Source:	Processor.		
Attributes:	Name	Value	Туре
	standard_name	'eastward_wind' (static)	NC_STRING
	long_name	'Eastward wind from ECMWF at 10 meter height level' (static)	NC_STRING
	units	'm s-1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	ancillary_vari- ables	'northward_wind' (static)	NC_STRING
northward_w	ind in AER_AI/PRO	DUCT/SUPPORT_DATA/INPUT_DATA	
Description:		ponent of the wind at 10 meter height in the northward from ECMWF (grib variable 166).	d direction. This i
Dimensions:	time, scanline, grou	und_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	standard_name	'northward_wind' (static)	NC_STRING
	long_name	'Northward wind from ECMWF at 10 meter height level' (static)	NC_STRING
	units	'm s-1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	ancillary_vari- ables	'eastward_wind' (static)	NC_STRING
ozone_total_	column in AER_AI/F	PRODUCT/SUPPORT_DATA/INPUT_DATA	
Description:	Total O <sub>3</sub> column fro	om ECMWF model data.	
Dimensions:	time, scanline, grou	und_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'mol m-2' (static)	NC_STRING
	standard_name	'atmosphere_mole_content_of_ozone' (static)	NC_STRING
	long_name	'total column amount of ozone from ECMWF model data' (static)	NC_STRING
	source		NC_STRING
	Possible values: E0	CMWF, Multi-sensor reanalysis (climatology)	_
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ingitude are in a different group. How to specify the race is not specified in the climate and forecast races.	
	multiplication factor_to_con- vert_to_DU	2241.15 (static)	NC_FLOAT
	The quantities in S value this means the	entinel 5 precursor files are given in SI units. For an integration of the unit is $mol  m^{-2}$ . Traditionally the unit for an integration of the unit for an integration of the unit is attributed provided the multiplication factor to	egrated column

The quantities in Sentinel 5 precursor files are given in SI units. For an integrated column value this means that the unit is  $mol\,m^{-2}$ . Traditionally the unit for an integrated column is "DU" or Dobson Units. This attribute provides the multiplication factor to calculate the total column in DU from the value in  $mol\,m^{-2}$ . This is provided as a convenience to users who have tools that work in DU.

multiplication\_- 6.022140857e+19 (static) NC\_FLOAT factor\_to\_convert\_to\_mo-lecules\_percm2

The quantities in Sentinel 5 precursor files are given in SI units. For an integrated column value this means that the unit is  $\mathrm{mol}\,\mathrm{m}^{-2}$ . Traditionally the unit for an integrated column is "molecules cm<sup>-2</sup>". This attribute provides the multiplication factor to calculate the total column in  $\mathrm{molecules}\,\mathrm{cm}^{-2}$  from the value in  $\mathrm{mol}\,\mathrm{m}^{-2}$ . This is provided as a convenience to users who have tools that work in  $\mathrm{molecules}\,\mathrm{cm}^{-2}$ .

#### surface pressure in AER AI/PRODUCT/SUPPORT DATA/INPUT DATA

Description: Surface pressure, corrected for the difference between the surface altitude in the DEM and

the surface altitude assumed by ECMWF.

Dimensions: time, scanline, ground pixel.

Type: NC\_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'Pa' (static)	NC_STRING
standard_name	'surface_air_pressure' (static)	NC_STRING
long_name	'surface_air_pressure' (static)	NC_STRING
source		NC STRING

Possible values: ECMWF, Using DEM and assuming fixed sea-level pressure of 1013 hPa and scale height of 8.3 km

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].

#### 10.2 Group "METADATA" in "AER AI"

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, algorithm settings 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].

#### 10.2.1 Group "QA STATISTICS" in "METADATA"

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.

### Attributes in AER\_AI/METADATA/QA\_STATISTICS

Group attributes attached to Q	A_STATISTICS	
Name	Value	Туре
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 <code>number\_of\_groundpixels</code> minus the pixels that were rejected based on time or configuration (range and step-size in scanline or ground\_pixel index).

 number\_of\_successfully\_ 0 (static)

 processed\_pixels

NC\_INT

Number of ground pixels where a retrieval was successful.

number\_of\_rejected\_pixels\_- 0 (static)
not enough spectrum

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\_- 0 (static) NC\_INT with\_warnings

Number of pixels with one or more warnings.

number\_of\_missing\_scan- 0 (static) NC\_INT lines

Number of scanlines that are missing from the input.

number\_of\_radiance\_miss- 0 (static) NC\_INT ing\_occurrences

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\_miss- 0 (static)

NC\_INT

NC INT

ing\_occurrences

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\_spec- 0 (static)
trum missing occurrences

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\_- 0 (static) NC\_INT range error occurrences

Number of ground pixels where processing error "any of the reflectances is out of bounds (R < 0 or  $R > R_{\text{max}}$ )" occurred, i.e. where the lower 8 bits of the processing\_quality\_flags have the value "4".

number\_of\_ler\_range\_er- 0 (static) NC\_INT ror occurrences

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\_er- 0 (static) NC\_INT ror occurrences

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\_er- 0 (static) NC\_INT ror occurrences

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 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".

#### 

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\_er- 0 (static) ror occurrences

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\_off- 0 (static) set\_error\_occurrences

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\_er- 0 (static)

NC INT

ror\_occurrences

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\_- 0 (static)

NC\_INT

occurrences

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

NC INT

— Niverala au af ausavuad mivela v

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\_occur- 0 (static) rences

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)

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\_occur- 0 (static)

NC\_INT

rences

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\_oc- 0 (static) currences

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\_er- 0 (static)
ror\_occurrences

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\_-

0 (static)

NC INT

convergence\_error\_occur-

rences

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\_- 0 (static)

NC INT

convergence\_error\_occur-

rences

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\_-

0 (static)

NC\_INT

boundary\_convergence\_er-

ror occurrences

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 bound-

0 (static)

NC INT

ary\_convergence\_error\_oc-

currences

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\_er-** 0 (static)

NC\_INT

ror\_occurrences

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<sub>4</sub> 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\_-

0 (static)

NC\_INT

thickness\_error\_occur-

rences

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\_- 0 (static)
error occurrences

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".

NC INT

Number of ground pixels where processing error " $\chi^2$  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 O (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\_occur- 0 (static)
rences

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\_trans- 0 (static)

NC INT

fer\_error\_occurrences

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\_estima- 0 (static)

NC INT

tion error occurrences

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\_oc- 0 (static)

NC INT

currences

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".

 ${\color{red}\textbf{number\_of\_cloud\_error\_oc-}} \quad \textbf{0 (static)}$ 

NC\_INT

currences

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\_oc- 0 (static)
currences

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\_in- 0 (static)

NC INT

put data points too low -

error occurrences

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\_pres-

0 (static)

NC\_INT

sure\_spread\_too\_low\_er-

ror\_occurrences

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\_- 0 (static)

NC INT

level error occurrences

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\_- 0 (static)
error occurrences

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\_excep- 0 (static)

NC INT

tion\_occurrences

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\_spec-

0 (static)

NC INT

trum\_alignment\_error\_oc-

currences

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\_oc-

0 (static)

0 (static)

NC INT

currences

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\_-

NC INT

type\_error\_occurrences

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\_cal- 0 (static)

NC INT

ibration\_error\_occurrences

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 ground pixels where processing error "no colocated pixels found in a supporting ban" occurred,

number\_of\_coregistration\_- 0 (static)

NC INT

error\_occurrences

i.e. where the lower 8 bits of the processing\_quality\_flags have the value "47".

number of slant column - 0 (static)

NC INT

density error occurrences

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\_- 0 (static)
error occurrences

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\_-

0 (static)

NC INT

column\_density\_error\_-

occurrences

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 -

0 (static)

NC INT

noise\_ratio\_error\_occur-

rences

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)

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 max num out-

0 (static)

NC INT

lier\_exceeded\_error\_occur-

rences

Number of ground pixels where processing error "the number of outliers detected in the DOAS fit exceeds a maximum set for healthy spectra." occurred, i.e. where the lower 8 bits of the processing\_quality\_-flags have the value "55".

number\_of\_solar\_eclipse\_fil- 0 (static)

NC\_INT

ter\_occurrences

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\_oc- 0 (static)

NC INT

currences

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\_consist- 0 (static)

NC INT

ency\_filter\_occurrences

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\_rough-

0 (static)

NC INT

ness\_filter\_occurrences

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\_- 0 (static)
occurrences

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\_- 0 (static)

NC INT

type\_filter\_occurrences

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\_- 0 (static) occurrences

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\_occur- 0 (static)
rences

NC INT

Number of ground pixels where input filter "aAl 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\_- 0 (static)

NC INT

fresco filter occurrences

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)

Number of ground pixels where input filter "pixel contains clouds: The difference between scene albedo at 380 nm from AAI calculation and the climatological 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\_radi- 0 (static) ance\_std\_filter\_occurrences

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\_- 0 (static)

NC\_INT

viirs\_filter\_occurrences

Number of ground pixels where input filter "pixel contains clouds: The cloud fraction from VIIRS / NPP exceeds the shold. Threshold value from ATBD" occurred, i.e. where the lower 8 bits of the processing\_quality\_flags have the value "75".

number\_of\_cirrus\_reflect-

0 (static)

NC INT

ance\_viirs\_filter\_occur-

rences

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\_-** 0 (static)

NC INT

ifov\_filter\_occurrences

Number of ground pixels where input filter "fraction of cloudy VIIRS pixels within 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\_- 0 (static)

NC\_INT

ofova\_filter\_occurrences

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\_- 0 (static) ofovb filter occurrences

NC\_INT

Number of ground pixels where input filter "fraction of cloudy VIIRS pixels within 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\_- 0 (static) ofovc\_filter\_occurrences

NC INT

Number of ground pixels where input filter "fraction of cloudy VIIRS pixels within 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\_-

0 (static)

NC\_INT

ifov\_filter\_occurrences

Number of ground pixels where input

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\_-

0 (static)

NC\_INT

ofova\_filter\_occurrences

Number of ground pixels where

Number of ground pixels where input filter "fraction of cloudy VIIRS pixels within 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\_-0 (static) NC INT

ofovc\_filter\_occurrences

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 - 0 (static)

NC INT

viirs filter occurrences

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 ra-

NC INT

tio\_filter\_occurrences

Number of ground pixels where input filter "the ratio between [CH<sub>4</sub>]<sub>weak</sub> and [CH<sub>4</sub>]<sub>strong</sub> 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".

0 (static) number of ch4 noscat ratio\_std\_filter\_occurrences

NC INT

Number of ground pixels where input filter "the standard deviation of [CH<sub>4</sub>]<sub>weak</sub>/[CH<sub>4</sub>]<sub>strong</sub> 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 ra-0 (static) NC INT

tio filter occurrences

Number of ground pixels where input filter "the ratio between [H<sub>2</sub>O]<sub>weak</sub> and [H<sub>2</sub>O]<sub>strong</sub> 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\_ra-0 (static) tio\_std\_filter\_occurrences

NC\_INT

Number of ground pixels where input filter "the standard deviation of [H2O]weak/[H2O]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 -

0 (static)

NC INT

fresco ecmwf filter occur-

rences

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 -0 (static) stdv filter occurrences

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\_oc- 0 (static) currences

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\_fil-

0 (static)

NC INT

ter\_occurrences

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\_scan-

0 (static)

NC\_INT

line\_index\_filter\_occur-

rences

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\_re-

NC\_INT

gion\_filter\_occurrences

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\_spec-

0 (static)

0 (static)

NC INT

trum\_warning\_occurrences

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\_-

0 (static)

NC\_INT

calibration warning occur-

rences

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\_- 0 (static)

NC INT

warning occurrences

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\_warn- 0 (static

NC INT

ing\_occurrences

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 - 0 (static)

NC INT

anomaly warning occur-

rences

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\_cor-

0 (static)

NC INT

rection\_occurrences

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\_warn- 0 (station

NC\_INT

ing\_occurrences

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\_- 0 (static)

NC INT

occurrences

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. In case of Cloud product this flag indicates the possiblity of ice-clouds" occurred, i.e. where bit 15 in the processing\_quality\_flags is set to "1".

# number\_of\_AAI\_warning\_occurrences

(static)

NC\_INT

Number of ground pixels where processing warning "possible aerosol contamination as either indicated by the AAI (O<sub>3</sub> profile)" occurred, i.e. where bit 16 in the processing quality flags is set to "1".

number\_of\_pixel\_level\_in-

0 (static)

NC INT

put\_data\_missing\_occur-

rences

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\_-

0 (static)

NC INT

warning\_occurrences

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. 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. For  $O_3$  profile this warning indicates an out of range cost function, or an out of range RMS difference between retrieval and a priori" occurred, i.e. where bit 18 in the processing\_quality\_flags is set to "1".

# number\_of\_low\_cloud\_frac- 0 (static)

NC\_INT

tion\_warning\_occurrences

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".

# ${\color{red}\textbf{number\_of\_altitude\_consist-}} \quad \textbf{0 (static)}$

NC\_INT

ency\_warning\_occurrences

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\_-

0 (static)

NC\_INT

noise\_ratio\_warning\_occur-

rences

Number of ground pixels where processing 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" occurred, i.e. where bit 21 in the processing\_quality\_flags is set to "1".

# number\_of\_deconvolution\_- 0 (static)

NC INT

warning\_occurrences

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\_- 0 (static)

NC INT

origin\_likely\_warning\_occur-

rences

Number of ground pixels where processing warning "warning for  $SO_2$  BL product, UTLS products: volcanic origin except for heavily polluted sites. For  $O_3$  profile this warning is issued in case of a large  $SO_2$  column which has an impact on the  $O_3$  profile retrieval" occurred, i.e. where bit 23 in the processing\_quality\_-flags is set to "1".

number of so2 volcanic -0 (static) NC INT

origin certain warning oc-

currences

Number of ground pixels where processing warning "warning for SO<sub>2</sub> 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 -0 (static) warning\_occurrences

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 warn- 0 (static)

NC INT

ing occurrences

Number of ground pixels where processing warning "saturation occurred spectrum, possibly causing biases in the retrieval" occurred, i.e. where bit 26 in the processing\_quality\_flags is set to "1".

number of high sza warn-0 (static) ing\_occurrences

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\_- 0 (static)

NC\_INT

warning\_occurrences

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\_inhomo-

0 (static)

NC\_INT

geneity\_warning\_occur-

rences

Number of ground pixels where processing warning "the cloud coregistration inhomogeneity parameter is above a given threshold. This warning is also set when the coregistration weight sums are less than 1" occurred, i.e. where bit 29 in the processing\_quality\_flags is set to "1".

number\_of\_thermal\_instabil- 0 (static)

NC INT

ity\_warning\_occurrences

Number of ground pixels where processing warning "input spectra have been labeled with a thermal instability warning flag" occurred, i.e. where bit 30 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 initializ--1.0 (static) ation

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.

#### Dimensions in AER AI/METADATA/QA STATISTICS

vertices For the histogram boundaries.

size 2 (fixed)

aerosol\_index\_354\_388\_histogram\_axis Histogram axis.

size 100 (fixed)

aerosol\_index\_354\_388\_pdf\_axis Probability density function axis.

size 400 (fixed)

aerosol\_index\_340\_380\_histogram\_axis Histogram axis.

size 100 (fixed)

aerosol\_index\_340\_380\_pdf\_axis Probability density function axis.

size 400 (fixed)

aerosol\_index\_335\_367\_histogram\_axis Histogram axis.

size 100 (fixed)

aerosol\_index\_335\_367\_pdf\_axis Probability density function axis.

size 400 (fixed)

#### Variables in AER AI/METADATA/QA STATISTICS

aerosoi_inde	x_354_388_histog	ram_axis in AER_AI/METADATA/QA_STATISTICS		
Description:	Horizontal axis for the histograms of the aerosol indices.			
Dimensions:	aerosol_index_35	4_388_histogram_axis (coordinate variable).		
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
-	units	'1' (dynamic)	NC_STRING	
	Same unit as the	main parameter. This attribute originates from the CF s	tandard.	
	comment	'Histogram axis of the aerosol index' (static)	NC_STRING	
•	long_name	'Histogram axis of the aerosol index' (static)	NC_STRING	
	bounds	'aerosol_index_354_388_histogram_bounds' (static)	NC_STRING	
aerosol_inde	x_354_388_pdf_a	kis in AER_AI/METADATA/QA_STATISTICS		
Description:	Horizontal axis for	the probability distribution functions of aerosol index.		
Dimensions:	aerosol_index_35	4_388_pdf_axis (coordinate variable).		
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
·	units	'1' (dynamic)	NC_STRING	
	Same unit as the main parameter. This attribute originates from the CF standard.			
	comment	'Probability density function of the aerosol index' (static)	NC_STRING	
	long_name	'Probability density function of the aerosol index'	NC_STRING	
		(static)		

Type: NC\_FLOAT. Source: Processor.

#### aerosol index 354 388 pdf bounds in AER AI/METADATA/QA STATISTICS

Dimensions: aerosol\_index\_354\_388\_pdf\_axis, vertices.

Type: NC\_FLOAT. Source: Processor.

Description:	`	gram_axis in AER_AI/METADATA/QA_STATISTICS  r the histograms of the aerosol indices				
Description: Dimensions:	Horizontal axis for the histograms of the aerosol indices.  aerosol_index_340_380_histogram_axis (coordinate variable).					
туре:	NC FLOAT.					
Source:	Processor.					
Attributes:	Name	Value	Туре			
Attributes.	units	'1' (dynamic)	NC STRING			
		, ,	_			
	Same unit as the main parameter. This attribute originates from the CF standard.  comment 'Histogram axis of the aerosol index' (static) NC_STRING					
	long_name	'Histogram axis of the aerosol index' (static)	NC_STRING			
	bounds	'aerosol_index_340_380_histogram_bounds'	NC_STRING			
	bounds	(static)	NO_STRING			
aerosol_inde	x_340_380_pdf_a	xis in AER_AI/METADATA/QA_STATISTICS				
Description:	Horizontal axis for the probability distribution functions of aerosol index.					
Dimensions:	aerosol_index_340_380_pdf_axis (coordinate variable).					
Туре:	NC_FLOAT.					
Source:	Processor.					
Attributes:	Name	Value	Туре			
	units	'1' (dynamic)	NC_STRING			
	Same unit as the main parameter. This attribute originates from the CF standard.					
	comment	'Probability density function of the aerosol index' (static)	NC_STRING			
	long_name	'Probability density function of the aerosol index' (static)	NC_STRING			
	bounds	'aerosol_index_pdf_bounds' (static)	NC_STRING			
aerosol_inde	x_340_380_histo	gram_bounds in AER_AI/METADATA/QA_STATISTICS	3			
Dimensions:	aerosol_index_340_380_histogram_axis, vertices.					
Type:	NC_FLOAT.					
Source:	Processor.					
aerosol_inde	x_340_380_pdf_b	ounds in AER_AI/METADATA/QA_STATISTICS				
Dimensions:	aerosol_index_340_380_pdf_axis, vertices.					
Туре:	NC_FLOAT.					
Source:	Processor.					
aerosol_inde	x_335_367_histo	gram_axis in AER_AI/METADATA/QA_STATISTICS				
Description:	Horizontal axis fo	r the histograms of the aerosol indices.				
Dimensions:	aerosol_index_33	35_367_histogram_axis (coordinate variable).				
Туре:	NC_FLOAT.					
Source:	Processor.					
Attributes:	Name	Value	Туре			
	units	'1' (dynamic)	NC_STRING			
	Same unit as the main parameter. This attribute originates from the CF standard.					
	comment	'Histogram axis of the aerosol index' (static)	NC_STRING			
	long_name	'Histogram axis of the aerosol index' (static)	NC_STRING			
	bounds	'aerosol_index_335_367_histogram_bounds' (static)	NC_STRING			
aerosol_inde	x_335_367_pdf_a	xis in AER_AI/METADATA/QA_STATISTICS				
Description:	Horizontal axis for the probability distribution functions of aerosol index.					
Dimensions:	aerosol_index_335_367_pdf_axis (coordinate variable).					

T	NO FLOAT					
Type:	NC_FLOAT.					
Source:	Processor.	Value	T			
Attributes:	Name	Value	Type			
	units	'1' (dynamic)	NC_STRING			
	Same unit as the main parameter. This attribute originates from the CF standard.					
	comment	'Probability density function of the aerosol index' (static)	NC_STRING			
	long_name	'Probability density function of the aerosol index' (static)	NC_STRING			
	bounds	'aerosol_index_pdf_bounds' (static)	NC_STRING			
aerosol_inde	x_335_367_histogra	m_bounds in AER_AI/METADATA/QA_STATISTICS				
Dimensions:	aerosol_index_335_	_367_histogram_axis, vertices.				
Type:	NC_FLOAT.					
Source:	Processor.					
aerosol_inde	x_335_367_pdf_bou	Inds in AER_AI/METADATA/QA_STATISTICS				
Dimensions:	aerosol_index_335_	_367_pdf_axis, vertices.				
Type:	NC_FLOAT.					
Source:	Processor.					
aerosol_inde	x_354_388_histogra	nm in AER_AI/METADATA/QA_STATISTICS				
Description:	Histogram of the aerosol index from the 354/388 nm wavelength pair in the current granule.					
Dimensions:	aerosol_index_340_380_histogram_axis.					
Type:	NC_INT.					
Source:	Processor.					
Attributes:	Name	Value	Туре			
	comment	'Histogram of the aerosol index of the 354/388 nm pair in the current granule' (static)	NC_STRING			
	number_of_over- flow_values	0 (dynamic)	NC_INT			
	The number of enco	ountered values that are larger than the top of the hist	togram.			
	number_of_un-	0 (dynamic)	NC_INT			
	derflow_values	,	_			
	The number of encountered values that are smaller than the base of the histogram.					
aerosol_inde	x_340_380_histogra	nm in AER_AI/METADATA/QA_STATISTICS				
Description:	Histogram of the ae	Histogram of the aerosol index from the 340/380 nm wavelength pair in the current granule.				
Dimensions:	aerosol_index_340_	_380_histogram_axis.				
Type:	NC_INT.					
Source:	Processor.					
Attributes:	Name	Value	Туре			
	comment	'Histogram of the aerosol index of the 340/380 nm pair in the current granule' (static)	NC_STRING			
	number_of_over- flow_values	0 (dynamic)	NC_INT			
	The number of encountered values that are larger than the top of the histogram.					
	number of un-	0 (dynamic)	NC INT			
	derflow_values	• • • • • • • • • • • • • • • • • • • •				
	The number of enco	ountered values that are smaller than the base of the	histogram.			
aerosol inde		nm in AER_AI/METADATA/QA_STATISTICS				
Description:	Histogram of the aerosol index from the 335/367 nm wavelength pair in the current granule.					
			<u> </u>			

Dimensions:	aerosol index 340				
Type:	NC INT.	_ooo_motogram_axto.			
Source:	Processor.				
Attributes:	Name	Value	Туре		
	comment	'Histogram of the aerosol index of the 354/388 nm pair in the current granule' (static)	NC_STRING		
	number_of_over- flow_values	0 (dynamic)	NC_INT		
	The number of encountered values that are larger than the top of the histogram.				
	number_of_un- derflow_values	0 (dynamic)	NC_INT		
	The number of encountered values that are smaller than the base of the histogram.				
aerosol_inde	<b>x_354_388_pdf</b> in Al	ER_AI/METADATA/QA_STATISTICS			
Dimensions:	the current granule. estimate. aerosol_index_354_	function of the aerosol index from the 354/388 nm where The values are weighted with $\cos(\delta_{\rm geo})$ and spread comparison388_pdf_axis.			
Type:	NC_FLOAT.				
Source:	Processor.				
Attributes:	Name	Value	Туре		
	comment	'Probability density function of the aerosol index of the 354/388 nm pair in the current granule' (static)	NC_STRING		
	geolocation sampling_total	0 (static)	NC_FLOAT		
	The sum of cosine values of latitudes from the pixels that were used in the pdf.				
<del>-</del>		ER_AI/METADATA/QA_STATISTICS			
Description:	•	function of the aerosol index from the 340/380 nm which The values are weighted with $\cos(\delta_{ m geo})$ and spread continuous continuous continuous from the second continuous con			
Dimensions:	aerosol_index_340_	_380_pdf_axis.			
Type:	NC_FLOAT.				
Source:	Processor.				
Attributes:	Name	Value	Туре		
-	comment	'Probability density function of the aerosol index of the 340/380 nm pair in the current granule' (static)	NC_STRING		
	geolocation sampling_total	0 (static)	NC_FLOAT		
	The sum of cosine values of latitudes from the pixels that were used in the pdf.				
aerosol_inde	x_ <b>335_367_pdf</b> in Al	ER_AI/METADATA/QA_STATISTICS			
Description:	Probability density function of the aerosol index from the 335/367 nm wavelength pair in the current granule. The values are weighted with $\cos(\delta_{\rm geo})$ and spread out using the erro estimate.				
Dimensions:	aerosol_index_335_	_367_pdf_axis.			
Type:	NC_FLOAT.				
Source:	Processor.				
Attributes:	Name	Value	Туре		
· .	comment	'Probability density function of the aerosol index of the 335/367 nm pair in the current granule' (static)	NC_STRING		
	geolocation sampling_total	0 (static)	NC_FLOAT		

The sum of cosine values of latitudes from the pixels that were used in the pdf.

#### 10.2.2 Group "ALGORITHM\_SETTINGS" in "METADATA"

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.

#### Configurations in AER\_AI/METADATA/ALGORITHM\_SETTINGS

#### configuration.version.framework 1.2.0

Allow the framework to verify that the configuration file is up to date.

#### configuration.version.algorithm 1.4.0

Allow the processor to verify that the configuration file is up to date.

#### processing.algorithm AER\_AI

Define the algorithm that is to be loaded.

#### input.count 1

Define the number of input files.

#### input.1.type L1B RA BD3

Define the input type (band) for the first input.

#### input.1.irrType L1B\_IR\_UVN

Define which irradiance accompanies the first input.

#### input.1.band 3

Which band is this (for selecting the irradiance and coregistration to output).

#### output.count 1

Define the number of output products

#### output.useFletcher32 true

Boolean to indicate status of Fletcher32 filter (default is on).

#### output.useCompression true

Boolean to set status of comression (default is on).

#### output.useShuffleFilter true

Boolean to set status of shuffle filter (default is on).

#### output.compressionLevel 3

Integer value to set compression level, default is 3.

#### output.1.type L2\_\_AER\_AI

Output product short name.

#### output.1.config product.AER Al.xml

Output product specification.

#### output.1.band 3

Geolocation in output follows this band.

#### algo.n pair 3

The number of aerosol index pairs.

#### algo.algorithm variant 1

Several algorithm variants are included in the code, this keys selects the variant that is used. Number 1 is nominal (and recommended). Here a wavelength band is used and a triangular weighting is used.

#### algo.pair\_1.id TOMS\_pair

Identifier for the first aerosol index pair.

#### algo.pair 1.wavelength 1 340

Shortest wavelength of the first aerosol index pair, in nm.

#### algo.pair 1.wavelength 2 380

Longest wavelength of the first aerosol index pair, in nm.

#### algo.pair 1.delta wavelength 2.0

The width of the wavelength band for selecting pixels for index pair number 1. Not used in algorithm variant 1

#### algo.pair\_1.number\_spectral\_pixels 7

The number of spectral pixels used for calculating the reflectance for index pair number 1.

#### algo.pair 1.min wavelength 1

The minimum number of spectral pixels before we declare a complete failure for index pair number 1.

#### algo.pair\_1.radiance\_correction\_factor\_1 1.0

Multiplication factor for the radiance at wavelength 1 of pair 1 (340 nm).

#### algo.pair\_1.radiance\_correction\_factor\_2 1.0

Multiplication factor for the radiance at wavelength 2 of pair 1 (380 nm).

#### algo.pair\_1.aai\_add\_offset -1.05

Additive offset for the AAI value of pair 1 (340/380 nm).

#### algo.pair 2.id OMI pair

Identifier for the second aerosol index pair.

#### algo.pair 2.wavelength 1 354

Shortest wavelength of the second aerosol index pair, in nm.

#### algo.pair 2.wavelength 2 388

Longest wavelength of the second aerosol index pair, in nm.

#### algo.pair\_2.delta\_wavelength 2.0

The width of the wavelength band for selecting pixels for index pair number 2, not used in algorithm variant 1.

#### algo.pair\_2.number\_spectral\_pixels 7

The number of spectral pixels used for calculating the reflectance for index pair number 2.

#### algo.pair\_2.min\_wavelength 1

The minimum number of spectral pixels before we declare a complete failure for index pair number 2.

#### algo.pair 2.radiance correction factor 1 1.0

Multiplication factor for the radiance at wavelength 1 of pair 2 (354 nm).

#### algo.pair\_2.radiance\_correction\_factor\_2 1.0

Multiplication factor for the radiance at wavelength 2 of pair 2 (388 nm).

#### algo.pair 2.aai add offset -0.85

Additive offset for the AAI value of pair 2 (354/388 nm).

#### algo.pair 3.id TOMS-EP pair

algo.pair 3.wavelength 1 335

algo.pair\_3.wavelength\_2 367

algo.pair 3.delta wavelength 4.0

algo.pair 3.number spectral pixels 13

algo.pair 3.min wavelength 1

algo.pair\_3.radiance\_correction\_factor\_1 1.0

algo.pair\_3.radiance\_correction\_factor\_2 1.0

algo.pair\_3.aai\_add\_offset -1.1

processing.vzaMin 0.0

The minimum viewing zenith angle.

#### processing.vzaMax 78.0

The maximum viewing zenith angle.

#### processing.szaMin 0.0

The minimum solar zenith angle.

#### processing.szaMax 88.0

The maximum solar zenith angle.

### processing.groupDem DEM\_RADIUS\_05000

Which DEM to use.

#### processing.correct\_surface\_pressure\_for\_altitude true

Flag to control the correction of the surface pressure for local orography. Default is true.

#### processing.ignore pixel flags False

When set to 'True', the pixel quality flags are ignored. When set to 'False', only pixels where none of the flags are set will be used in processing.

#### processing.exclude flags 4294967295

#### output.histogram.aerosol\_index\_340\_380.start -6

Start value for the histogram of the aerosol index from the TOMS pair.

#### output.histogram.aerosol\_index\_340\_380.end 14

End value for the histogram of the aerosol index from the TOMS pair.

#### output.histogram.aerosol\_index\_354\_388.start -6

Start value for the histogram of the aerosol index from the OMI pair.

#### output.histogram.aerosol index 354 388.end 14

End value for the histogram of the aerosol index from the OMI pair.

#### output.histogram.aerosol index 335 367.start -6

output.histogram.aerosol index 335 367.end 14

#### processing.signal\_to\_noise.test yes

lag pixels when signal to noise ratio is below threshold. Default no testing, unless processing.signal\_to\_noise.window.range is set.

#### processing.signal to noise.window.range 350.0, 355.0

avelength pixel range for testing signal to noise ratio. Default range is all wavelengts, but only if processing.signal to noise.test is set

#### processing.signal to noise.threshold 12

Threshold value for signal to noise ratio, in decibel. Ground-pixel is flagged when majority wavelength pixels has signal to noise below threshold. Default is 12.

#### processing.radiancePixelsMinError 2

inumum number of valid spectral pixels required for processing ground-pixel. With less pixels a PQF\_E\_-INPUT\_SPECTRUM\_MISSING is generated.

#### processing.radiancePixelsMinWarning 7

ith less valid spectral pixels a PQF\_W\_INPUT\_SPECTRUM\_WARNING is generated. The ground-pixel can still be processed.

#### wavelength\_calibration.perform\_wavelength\_fit yes

Master switch for the wavelength calibration.

#### wavelength calibration.window 330.0, 390.0

The wavelength calibration window. This must contain all wavelengths in the algorithm, i.e. 340 - 388, with a margin.

#### wavelength calibration.rad.polynomial order 3

wavelength calibration.irr.polynomial order 2

#### wavelength\_calibration.include\_stretch no

For aerosol index we do not include a stretch/squeeze parameter.

#### wavelength\_calibration.rad.include\_ring yes

wavelength\_calibration.irr.include\_ring no

#### wavelength\_calibration.initial\_guess.a0 1.0

Initial guess for the parameters of the polynomial in the wavelength fit. 1, 0.1, 0.01, 0.01, ... for a0, a1, a2, a3, ... as appropriate.

### wavelength\_calibration.initial\_guess.a1 0.1

wavelength calibration.initial guess.a2 0.01

#### wavelength\_calibration.initial\_guess.shift 0.0

Initial guess for the wavelength shift.

#### wavelength\_calibration.initial\_guess.ring 0.06

Initial guess for the Ring coefficient.

#### wavelength calibration.initial guess.stretch 0.0

Initial guess for the strech parameter.

#### wavelength\_calibration.sigma.a0 1.0

a priori precision of the polynomial coefficients. 1, 0.1, 0.1, 0.1, 0.1, ... for a0, a1, a2, a3, ... as appropriate.

#### wavelength\_calibration.sigma.a1 0.1

#### wavelength calibration.sigma.shift 3.0

a priori precision of the wavelength shift. Set to the spectral sampling for band 3 divided by 3.

#### wavelength\_calibration.sigma.ring 0.06

a priori precision of the Ring coefficient.

#### wavelength calibration.sigma.stretch 0.07

a priori precision of the strech parameter. Due to scaling equal to pixel size scaling at end of window.

#### wavelength calibration.max iterations 12

The maximum number of iterations for the wavelength fit.

#### wavelength\_calibration.irr.max\_iterations 20

#### wavelength\_calibration.convergence\_threshold 1.0

Convergence criterium (auto scaled).

### qa\_value.input\_spectrum\_warning 70.0

he qa\_value multiplication factor (in percent) for when the number of pixels in the input spectrum is below nominal.

#### ga value.wavelength calibration warning 90.0

he ga value multiplication factor (in percent) for when the wavelength calibration offset is larger than a

configured threshold.

#### ga value.extrapolation warning 100.0

he qa\_value multiplication factor (in percent) for when extrapolation was used in the retrieval.

#### qa value.sun glint warning 70.0

he qa\_value multiplication factor (in percent) for when the pixel is potentially affected by sun glint.

#### qa value.south atlantic anomaly warning 100.0

he qa\_value multiplication factor (in percent) for when the instrument was flying through the South Atlantic Anomaly while taking this measurement.

### qa value.sun glint correction 100.0

he ga value multiplication factor (in percent) for when the cloud fraction was corrected for sun glint.

#### qa value.snow ice warning 100.0

he qa\_value multiplication factor (in percent) for when the snow\_ice\_warning flag is raised.

#### qa\_value.cloud\_warning 100.0

he qa\_value multiplication factor (in percent) for when the cloud\_warning flag is raised.

#### qa\_value.AAI\_warning 100.0

he qa\_value multiplication factor (in percent) for when the AAI\_warning flag is raised.

## qa\_value.pixel\_level\_input\_data\_missing 80.0

he qa\_value multiplication factor (in percent) for when the pixel\_level\_input\_data\_missing flag is raised.

### qa\_value.data\_range\_warning 100.0

he ga value multiplication factor (in percent) for when the data range warning flag is raised.

#### ga value.low cloud fraction warning 100.0

he qa\_value multiplication factor (in percent) for when the low\_cloud\_fraction\_warning flag is raised.

### qa\_value.altitude\_consistency\_warning 100.0

he ga value multiplication factor (in percent) for when the altitude consistency warning flag is raised.

#### qa value.signal to noise ratio warning 100.0

he qa\_value multiplication factor (in percent) for when the signal\_to\_noise\_ratio\_warning flag is raised.

#### qa\_value.deconvolution\_warning 100.0

he ga value multiplication factor (in percent) for when the deconvolution warning flag is raised.

### qa\_value.so2\_volcanic\_origin\_likely\_warning 100.0

he qa\_value multiplication factor (in percent) for when the so2\_volcanic\_origin\_likely\_warning flag is raised.

#### qa value.so2 volcanic origin certain warning 100.0

he qa\_value multiplication factor (in percent) for when the so2\_volcanic\_origin\_certain\_warning flag is raised.

#### ga value.interpolation warning 100.0

he qa\_value multiplication factor (in percent) for when the interpolation\_warning flag is raised.

#### qa\_value.thermal\_instability\_warning 100.0

he qa\_value multiplication factor (in percent) for when the thermal\_instability\_warning flag is raised.

#### quality control.qa value.limit 0.5

f the maximum qa\_value in the granule is smaller than this limit, then a warning shall be issued. Default = 0.5

#### quality\_control.missing\_input.max\_fraction 0.25

If the fraction of successfully processed pixels that has a pixel level input data missing warning attached it exceeds this fraction, then a warning will be issued. Default = 0.5

### quality\_control.success.min\_fraction 0.001

If the fraction of successfully processed pixels is smaller than this limit, then a warning will be issued. Default = 0.001

## 10.2.3 Group "GRANULE\_DESCRIPTION" in "METADATA"

Common granule level metadata.

#### Attributes in AER AI/METADATA/GRANULE DESCRIPTION

Group attributes attached to GRANULE_DESCRIPTION			
Name	Value	Туре	
GranuleStart		NC_STRING	

Start of the granule as ISO date/time string in UTC: YYYY-MM-DDTHH:MM:SS.mmmmmmZ. The formal definition of ISO date/time strings is given in [RD34].

GranuleEnd NC STRING

End of the granule as ISO date/time string in UTC: YYYY-MM-DDTHH:MM:SS.mmmmmmZ. The formal definition of ISO date/time strings is given in [RD34].

definition of 100 date/time st	definition of 100 date/time strings is given in [rtb0+].				
InstrumentName	'TROPOMI' (static)	NC_STRING			
The name of the instrument,	The name of the instrument, fixed to "TROPOMI".				
MissionName	'Sentinel-5 precursor' (static)	NC_STRING			
The name of the mission, fix	ed 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			
When we also we are a compact the compact also we have the compact the compact the compact and					

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

### LongitudeOfDaysideNadirEquatorCrossing

NC FLOAT

The longitude of the nadir-point at the day-side equator crossing. This gives a rough indication where the orbit is located. The value is calculated using an orbit propagator before the observation, so that a consisten value is used for all processing stages.

CollectionIdentifier '%(collection\_identifier)s' (dynamic) NC\_STRING
Identification of the processing collection, i.e. the group of products that can be used together as a

consistent data set.

ProductShortName 'L2 AER Al' (static) NC STRING

The short product name. For the aerosol index product this is fixed to "L2\_\_AER\_AI".

### 10.2.3.1 Group "ISO\_METADATA" in "iso\_metadata"

Metadata that is structured following the ISO metadata standards [RD28, RD37], 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 [RD33].

All "objectType" attributes indicate the XML object when generating an ISO 19139 [RD37] 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 AER\_AI/METADATA/ISO\_METADATA

Group attributes attached to ISO_METADATA			
Name	Value	Туре	
gmd:dateStamp	'2015-10-16' (static)	NC_STRING	

Date of creation of the metadata, as ISO 8601 [RD34] string specifying year, month and da	Date of creation of the metadata	. as ISO 8601 [RD	341 string specifying year.	month and day.
---	----------------------------------	-------------------	-----------------------------	----------------

gmd:fileldentifier	'urn:ogc:def:EOP:ESA:SENTINEL.S5P_TROP	NC_STRING
	%(shortname)s' (dynamic)	

Unique identifier for metadata file, see the Level 1B metadata specification [RD33, 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 [RD	33, table 5].		

#### 10.2.3.2 Group "gmd:language" in "ISO METADATA"

Language used for the metadata, fixed to English.

### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:language

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

### 10.2.3.3 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 AER\_AI/METADATA/ISO\_METADATA/gmd:characterSet

Group attributes attached to gmd:characterSet			
Name	Value	Туре	
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	

## 10.2.3.4 Group "gmd:hierarchyLevel" in "ISO\_METADATA"

Scope to wich metadata applies.

### Attributes in AER AI/METADATA/ISO METADATA/gmd:hierarchyLevel

Group attributes attached to gmd:hierarchyLevel			
Name	Value	Туре	
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	

### 10.2.3.5 Group "gmd:contact" in "ISO\_METADATA"

Contact information for the product.

#### Attributes in AER AI/METADATA/ISO METADATA/gmd:contact

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

### 10.2.3.6 Group "gmd:contactInfo" in "gmd:contact"

The detailed contact information.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:contact/gmd:contactInfo

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

### 10.2.3.7 Group "gmd:address" in "gmd:contactInfo"

The actual email address.

### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:contact/gmd:contactInfo/gmd:address

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

## 10.2.3.8 Group "gmd:role" in "gmd:contact"

The role of the adress provided in this group.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:contact/gmd:role

Group attributes attached to gmd:role		
Name	Value	Туре
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

## 10.2.3.9 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 AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo

Group attributes att	ached to gmd:identificationInfo	
Name	Value	Туре
gmd:abstract		NC_STRING

Brief narrative summary of the content of the resource. This is product specific, with modifications for timeliness and and pixel size. The pixel size listed below are the "small" pixels, with a length of 5.5 km in the flight direction for the main bands. For observations before August 6, 2019, the length in the flight direction is 7 km. Ozone profile adds several pixels in the flight direction, and has an approximate pixel size of  $30 \times 30 \, \text{km}^2$  for the "small" pixels, and  $35 \times 30 \, \text{km}^2$  for the "large" pixels.

- **L2\_AER\_AI (KNMI)** Aerosol index with a spatial resolution of  $5.5 \times 3.5 \, \text{km}^2$  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  $5.5 \times 3.5 \, \text{km}^2$  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  $5.5 \times 3.5 \, \text{km}^2$  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  $30 \times 30 \, \text{km}^2$  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 with a spatial resolution of  $5.5 \times 7 \, \text{km}^2$  observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2\_CO\_\_\_ (SRON)** Carbon monoxide column with a spatial resolution of  $5.5 \times 7 \, \text{km}^2$  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  $5.5 \times 3.5 \, \text{km}^2$  observed at about 13:30 local solar time from spectra measured by TROPOMI (KNMI FRESCO cloud support product)
- **L2\_O22CLD (KNMI)**  $O_2-O_2$  cloud retrieval with a spatial resolution of  $5.5 \times 3.5 \, \text{km}^2$  observed at about 13:30 local solar time from spectra measured by TROPOMI (KNMI  $O_2-O_2$  cloud support product)

gmd:credit	'%(credit)s' (static)	NC_STRING
Recognition of those who cor	ntributed 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 [RD33, table 10].		

### 10.2.3.10 Group "gmd:citation" in "gmd:identificationInfo"

Citation data for the resource.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:citation

Group attributes att	ached to gmd:citation	
Name	Value	Туре
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 metad	ata class [RD33, table 11].	

## 10.2.3.11 Group "gmd:date" in "gmd:citation"

Attributes in AER AI/METADATA/ISO METADATA/gmd:identificationInfo/gmd:citation/gmd:date

Group attributes attach	ned to gmd:date	
Name	Value	Туре
gmd:date	'%(processor_release_date)s' (static)	NC_STRING
objectType	'gmd:CI_Date' (static)	NC_STRING

### 10.2.3.12 Group "gmd:dateType" in "gmd:date"

Event used for reference date.

### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:citation/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType		
Name	Value	Туре
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

### 10.2.3.13 Group "gmd:identifier" in "gmd:citation"

Unique identifier for metadata file, see the Level 1B metadata specification [RD33, table 5] for a discussion of the value.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:citation/gmd:identifier

Group attributes attached to	o gmd:identifier	
Name	Value	Туре
gmd:code	'urn:ogc:def:EOP:ESA:SENTINEL.S5P_TROP %(shortname)s' (dynamic)	NC_STRING
Replace "%(shortname)s" w	with the "ProductShortName" value from the Level 2 "/META group.	ADATA/GRANULE
objectType	'gmd:MD_Identifier' (static)	NC_STRING

## 10.2.3.14 Group "gmd:pointOfContact" in "gmd:identificationInfo"

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

## $Attributes\ in\ AER\_AI/METADATA/ISO\_METADATA/gmd: identification Info/gmd: point Of Contact$

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

## 10.2.3.15 Group "gmd:contactInfo" in "gmd:pointOfContact"

### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:pointOfContact/gmd:contactInfo

Group attributes attacl	hed to gmd:contactInfo	
Name	Value	Туре
objectType	'gmd:CI_Contact' (static)	NC_STRING

#### 10.2.3.16 Group "gmd:address" in "gmd:contactInfo"

# $Attributes \ in \ AER\_AI/METADATA/ISO\_METADATA/gmd: identification Info/gmd: point Of Contact/gmd: contact Info/gmd: address$

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

### 10.2.3.17 Group "gmd:role" in "gmd:pointOfContact"

### Attributes in AER AI/METADATA/ISO METADATA/gmd:identificationInfo/gmd:pointOfContact/gmd:role

Group attributes attached to gmd:role		
Name	Value	Туре
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

### 10.2.3.18 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 AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1

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

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

Subject matter used to group similar keywords.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:type

Group attributes attached to gmd:type			
Name	Value	Туре	
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	

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

Name by which the cited resource is known.

Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:thesaurusName

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

#### 10.2.3.21 Group "gmd:date" in "gmd:thesaurusName"

Reference date for the cited resource.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:thesaurusName/gmd:date

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

#### 10.2.3.22 Group "gmd:dateType" in "gmd:date"

What date is used for the reference date.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/gmd:thesaurusName/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType			
Name	Value	Туре	
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	

### 10.2.3.23 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\_CH4\_ (SRON) atmosphere\_mole\_fraction\_of\_methane\_in\_dry\_air
- L2\_CO\_\_\_(SRON) atmosphere\_mole\_content\_of\_carbon\_monoxide
- **L2\_\_FRESCO (KNMI)** air\_pressure\_at\_cloud\_optical\_centroid, effective\_cloud\_area\_fraction\_assuming\_-fixed\_cloud\_albedo, cloud\_albedo\_assuming\_completely\_cloudy\_sky, air\_pressure\_at\_cloud\_optical\_centroid\_assuming\_completely\_cloudy\_sky
- **L2\_O22CLD (KNMI)** air\_pressure\_at\_cloud\_optical\_centroid, effective\_cloud\_area\_fraction\_assuming\_fixed\_-cloud\_albedo, cloud\_albedo\_assuming\_completely\_cloudy\_sky, air\_pressure\_at\_cloud\_optical\_centroid\_-assuming\_completely\_cloudy\_sky

Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2

Group attributes attached to gmd:descriptiveKeywords#2			
Name	Value	Туре	
gmd:keyword#1		NC_STRING	
objectType	'gmd:MD_Keywords' (static)	NC_STRING	

### 10.2.3.24 Group "gmd:thesaurusName" in "gmd:descriptiveKeywords#2"

Name by which the cited resource is known.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2/gmd:thesaurusName

Group attributes attached to gmd:thesaurusName			
Name	Value		Туре
gmd:title	'CF Standard Name Table v65' (static)		NC_STRING
xlink:href	'http://cfconventions.org/standard-names.html' namic)	(dy-	NC_STRING
objectType	'gmd:CI_Citation' (static)		NC_STRING

## 10.2.3.25 Group "gmd:date" in "gmd:thesaurusName"

Reference date for the cited resource.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2/gmd:thesaurusName/gmd:date

Group attributes attached to gmd:date			
Name	Value	Туре	
gmd:date	'2019-04-09' (static)	NC_STRING	
objectType	'gmd:CI_Date' (static)	NC_STRING	

### 10.2.3.26 Group "gmd:dateType" in "gmd:date"

What date is used for the reference date.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2/gmd:thesaurusName/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType			
Name	Value	Туре	
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	

## 10.2.3.27 Group "gmd:resourceConstraints" in "gmd:identificationInfo"

Provides information about constraints which apply to the resource.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:resourceConstraints

Group attributes attached to gmd:resourceConstraints			
Name	Value	Туре	
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	

### 10.2.3.28 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 AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:resourceConstraints/gmd:accessConstraints

Group attributes attached to gmd:accessConstraints			
Name	Value	Туре	
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	

### 10.2.3.29 Group "gmd:spatialRepresentationType" in "gmd:identificationInfo"

Method used to spatially represent geographic information.

### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:spatialRepresentationType

Group attributes attached to gmd:spatialRepresentationType			
Name	Value	Туре	
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	

### 10.2.3.30 Group "gmd:characterSet" in "gmd:identificationInfo"

#### Attributes in AER AI/METADATA/ISO METADATA/gmd:identificationInfo/gmd:characterSet

Group attributes attached to gmd:characterSet			
Name	Value	Туре	
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	

## 10.2.3.31 Group "gmd:extent" in "gmd:identificationInfo"

Extent information including the bounding box, bounding polygon, vertical, and temporal extent of the dataset.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:extent

Group attributes attac	ched to gmd:extent	
Name	Value	Туре
objectType	'gmd:EX_Extent' (static)	NC_STRING

#### 10.2.3.32 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 AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:extent/gmd:geographicElement

Group attributes attached to gmd:geographicElement			
Name	Value	Туре	
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 <i>inclusion</i> .			
objectType	'gmd:EX_GeographicBoundingBox' (static)	NC_STRING	

#### 10.2.3.33 Group "gmd:temporalElement" in "gmd:extent"

### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:extent/gmd:temporalElement

Group attributes attached to gmd:temporalElement		
Name	Value	Туре
objectType	'gmd:EX_TemporalExtent' (static)	NC_STRING

### 10.2.3.34 Group "gmd:extent" in "gmd:temporalElement"

Time period covered by the content of the dataset.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:identificationInfo/gmd:extent/gmd:temporalElement/gmd:extent

Group attributes attached t	to gmd:extent	
Name	Value	Туре
gml:beginPosition	'2014-11-14T19:58:00' (dynamic)	NC_STRING
Time of the start of the granule, expressed as ISO 8601 [RD34] date-time string.		
gml:endPosition	'2014-11-14T20:08:00' (dynamic)	NC_STRING
Time of the end of the granule, expressed as ISO 8601 [RD34] date-time string.		
objectType	'gml:TimePeriod' (static)	NC_STRING

## 10.2.3.35 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 level 2 products the use of the contained class LI\_Lineage (group "gmd:lineage", section 10.2.3.43 on page 84) 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 AER AI/METADATA/ISO METADATA/gmd:dataQualityInfo

Group attributes attack	ned to gmd:dataQualityInfo	
Name	Value	Туре
objectType	'gmd:DQ_DataQuality' (static)	NC_STRING

### 10.2.3.36 Group "gmd:scope" in "gmd:dataQualityInfo"

The specific data to which the data quality information applies.

#### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:scope

Group attributes attached to gmd:scope			
Name	Value	Туре	
objectType	'gmd:DQ_Scope' (static)	NC_STRING	

#### 10.2.3.37 Group "gmd:level" in "gmd:scope"

Hierarchical level of the data specified by the scope.

### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:scope/gmd:level

Group attributes attached to gmd:level			
Name	Value	Туре	
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	

## 10.2.3.38 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 AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:report

Group attributes attached to gmd:report			
Name	Value	Туре	
objectType	'gmd:DQ_DomainConsistency' (static)	NC_STRING	

### 10.2.3.39 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 AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result

Name	Value	Туре
objectType	'gmd:DQ_ConformanceResult' (static)	NC_STRING
gmd:pass	'true' (static)	NC_STRING
Indication of confoman	ce 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

#### 10.2.3.40 Group "gmd:specification" in "gmd:result"

Citation of product specification or user requirement against which data is being evaluated.

Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result/gmd:specification

Group attributes attached to gmd:specification			
Name	Value	Туре	
objectType	'gmd:CI_Citation' (static)	NC_STRING	
gmd:title	'INSPIRE Data Specification on Orthoimagery Guidelines, version 3.0rc3' (static)	- NC_STRING	

### 10.2.3.41 Group "gmd:date" in "gmd:specification"

Reference date for the cited resource.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result/gmd:specification/gmd:date

Group attributes attached to gmd:date			
Name	Value	Туре	
gmd:date	'2013-02-04' (static)	NC_STRING	
objectType	'gmd:CI_Date' (static)	NC_STRING	

### 10.2.3.42 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:report/gmd:result/gmd:specification/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType			
Name	Value	Туре	
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	

### 10.2.3.43 Group "gmd:lineage" in "gmd:dataQualityInfo"

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

#### Attributes in AER AI/METADATA/ISO METADATA/gmd:dataQualityInfo/gmd:lineage

Group attributes attached Name	Value	Туре
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
·	e data producer's knowledge about the lineage of a dataset. Insert duct in this string (at the $\%()$ s).	short description

#### 10.2.3.44 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 AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep

Group attributes attached to gmd:processStep		
Name	Value	Туре
objectType	'gmi:LE_ProcessStep' (static)	NC_STRING

gmd:description	'Processing of L1b to L2 %(product)s data for orbit	NC_STRING
	%(orbit)d using the %(institute)s processor version	
	%(version)s' (dynamic)	

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).

### 10.2.3.45 Group "gmi:output" in "gmd:processStep"

Description of the output.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output

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

## 10.2.3.46 Group "gmd:sourceCitation" in "gmi:output"

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

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation

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

### 10.2.3.47 Group "gmd:date" in "gmd:sourceCitation"

Production date and time of the output file.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:date

Group attributes at	tached to gmd:date		
Name	Value	Туре	
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	

#### 10.2.3.48 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:date/gmd:dateType

Group attributes at	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

## 10.2.3.49 Group "gmd:identifier" in "gmd:sourceCitation"

Identification of the output product.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:identifier

Group attributes attached to gmd:identifier			
Name	Value	Туре	
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	

### 10.2.3.50 Group "gmi:processedLevel" in "gmi:output"

Process level of the output file.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmi:processedLevel

Group attributes attached to gmi:processedLevel		
Name	Value	Туре
gmd:code	'L2' (static)	NC_STRING
objectType	'gmd:MD_Identifier' (static)	NC_STRING

## 10.2.3.51 Group "gmi:processingInformation" in "gmd:processStep"

Description of the processor in more detail.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation

Group attributes attached to gmi:processingInformation		
Name	Value	Туре
objectType	'gmi:LE_Processing' (static)	NC_STRING

## 10.2.3.52 Group "gmi:identifier" in "gmi:processingInformation"

Identification of the processor.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:identifier

Group attributes attac	hed to gmi:identifier	
Name	Value	Туре
gmd:code	'%(institute)s L2 %(product)s processor, version %(version)s' (dynamic)	NC_STRING
-	he processor, with the $\%(\dots)$ s placeholders replaced with the respondent software release version.	onsible institute's
objectType	'gmd:MD_Identifier' (static)	NC_STRING

### 10.2.3.53 Group "gmi:softwareReference" in "gmi:processingInformation"

Reference to document describing processing software.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference

Group attributes attached to gmi:softwareReference			
Name	Value	Туре	
gmd:title	'%(processor_name)s processor' (dynamic)	NC_STRING	
Name of the processor.			
objectType	'gmd:CI_Citation' (static)	NC_STRING	

### 10.2.3.54 Group "gmd:date" in "gmi:softwareReference"

Release date (compile date) of the processor.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference/gmd:date

Group attributes attached to gmd:date			
Name	Value	Туре	
gmd:date	'%(processor_release_date)s' (dynamic)	NC_STRING	
Release date of the p	rocessor expressed as an ISO 8601 date string [RD34].		
objectType	'gmd:CI_DateTime' (static)	NC_STRING	

## 10.2.3.55 Group "gmd:dateType" in "gmd:date"

The release date of the processor.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference/gmd:date/gmd:dateType

Group attributes attached to gmd:dateType			
Name	Value	Туре	
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	

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

Reference to the ATBD of the product.

# Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1

Group attributes attach	ed to gmi:documentation#1	
Name	Value	Туре
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_atbd)s' (dynamic)	NC_STRING
Specification of the cur	rent release of the ATBD of the product.	
doi	'%(atbd_doi)s' (dynamic)	NC_STRING
DOI for the algorithm th	neoretical basis document.	

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

Release date of the ATBD.

# Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1/gmd:date

Group attributes attached to gmd:date			
Name	Value	Туре	
gmd:date	'%(date_atbd)s' (dynamic)	NC_STRING	
Release date of the A	TBD expressed as an ISO 8601 date string [RD34].		
objectType	'gmd:CI_Date' (static)	NC_STRING	

### 10.2.3.58 Group "gmd:dateType" in "gmd:date"

Specify the type of the date of the ATBD (revision of publication).

## Attributes in AER\_AI/METADATA/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	Туре
codeList	'http://www.isotc211.org/2005/resources/Codelist/ gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'revision' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

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

Reference to the PUM of the product.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2

Group attributes attached to gmi:documentation#2			
Name	Value	Туре	
objectType	'gmd:CI_Citation' (static)	NC_STRING	
gmd:title	'%(title_pum)s' (dynamic)	NC_STRING	
Specification of the current release of the PUM of the product.			
doi	'%(pum_doi)s' (dynamic)	NC_STRING	
DOI for the product user manual.			

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

Release date of the PUM.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2/gmd:date

Group attributes attached to gmd:date			
Name	Value	Туре	
gmd:date	'%(date_pum)s' (dynamic)	NC_STRING	
Release date of the PUM expressed as an ISO 8601 date string [RD34].			
objectType	'gmd:CI_Date' (static)	NC_STRING	

## 10.2.3.61 Group "gmd:dateType" in "gmd:date"

Specify the type of the date of the PUM (revision of publication).

Attributes in AER\_AI/METADATA/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	Туре	
codeList	'http://www.isotc211.org/2005/resources/Codelist/ gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING	
codeListValue	'revision' (static)	NC_STRING	
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING	

### 10.2.3.62 Group "gmi:report" in "gmd:processStep"

Short report of what occurred during the process step.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:report

Group attributes attached to gmi:report		
Name	Value	Туре
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 $\%(\dots)s$ as indicat	ed.
gmi:fileType	'netCDF-4' (static)	NC_STRING
Type of file that contains th output file.	e processing report, in our case the processing report is contained.	ained in the main
gmi:name	'%(logical_filename)s.nc' (dynamic)	NC_STRING
objectType	'gmi:LE_ProcessStepReport' (dynamic)	NC_STRING

### 10.2.3.63 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 AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1

Group attributes attach	ned to gmd:source#1	
Name	Value	Туре
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.

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

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmi:processedLevel

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

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

Reference to the actual filename of the input data.

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation

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

### 10.2.3.66 Group "gmd:date" in "gmd:sourceCitation"

## Attributes in AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:date

Group attributes atta	ached to gmd:date	
Name	Value	Туре
gmd:date		NC_STRING
Production date and time of the input file(s) in this group expressed as an ISO 8601 date-time string [RD34]. 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

## 10.2.3.67 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

## Attributes in AER\_AI/METADATA/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	Туре	
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	

### 10.2.3.68 Group "gmd:title" in "gmd:sourceCitation"

# $Attributes \ in \ AER\_AI/METADATA/ISO\_METADATA/gmd: dataQualityInfo/gmd: lineage/gmd: processStep/gmd: source \#1/gmd: source Citation/gmd: title$

Group attributes a	ttached to gmd:title	
Name	Value	Туре
gco:characterStr	ing	NC_STRING
Textual description of the input file group (same as the "gmd:description" attribute in the "gmi:LESource" object).		

### 10.2.3.69 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 AER\_AI/METADATA/ISO\_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/

### gmd:source#1/gmd:sourceCitation/gmd:alternateTitle#1

Group attributes attached	d to gmd:alternateTitle#1	
Name	Value	Туре
gmx:FileName	Empty!	NC_STRING
The basename of the inp	out file.	

### 10.2.3.70 Group "gmi:acquisitionInformation" in "ISO\_METADATA"

Metadata regarding the acquisition of the original data.

### Attributes in AER Al/METADATA/ISO METADATA/gmi:acquisitionInformation

Group attributes attac	hed to gmi:acquisitionInformation	
Name	Value	Туре
objectType	'gmi:MI_AcquisitionInformation' (static)	NC_STRING

### 10.2.3.71 Group "gmi:platform" in "gmi:acquisitionInformation"

The platform we are on.

#### Attributes in AER Al/METADATA/ISO METADATA/gmi:acquisitionInformation/gmi:platform

Group attributes attached	l to gmi:platform	
Name	Value	Туре
gmi:description	'Sentinel 5 Precursor' (static)	NC_STRING
objectType	'gmi:MI_Platform' (static)	NC_STRING

## 10.2.3.72 Group "gmi:identifier" in "gmi:platform"

Short identifier of the platform.

#### Attributes in AER\_AI/METADATA/ISO\_METADATA/gmi:acquisitionInformation/gmi:platform/gmi:identifier

Group attributes attached	to gmi:identifier	
Name	Value	Туре
gmd:code	'S5P' (static)	NC_STRING
gmd:codeSpace	'http://www.esa.int/' (static)	NC_STRING
objectType	'gmd:RS_Identifier' (static)	NC_STRING

## 10.2.3.73 Group "gmi:instrument" in "gmi:platform"

The instrument used for the observations.

## $Attributes\ in\ AER\_AI/METADATA/ISO\_METADATA/gmi: acquisition Information/gmi: platform/gmi: instrument$

Group attributes attached to	gmi:instrument	
Name	Value	Туре
objectType	'gmi:MI_Instrument' (static)	NC_STRING
gmi:type	'UV-VIS-NIR-SWIR imaging spectrometer' (static)	NC_STRING
Type of the instrument.		

### 10.2.3.74 Group "gmi:identifier" in "gmi:instrument"

Unique identifier for the instrument.

Attributes in AER\_AI/METADATA/ISO\_METADATA/gmi:acquisitionInformation/gmi:platform/gmi:instrument/gmi:identifier

Group attributes attached	to gmi:identifier	
Name	Value	Туре
gmd:code	'TROPOMI' (static)	NC_STRING
The actual identifier.		
gmd:codeSpace	'http://www.esa.int/' (static)	NC_STRING
Name or identifier of the o	rganization responsible for the namespace.	
objectType	'gmd:RS_Identifier' (static)	NC_STRING

### 10.2.3.75 Group "EOP\_METADATA" in "EOP\_metadata"

Based on the OGC 10-025 standard for Observations & Measurements [RD38], 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 AER\_AI/METADATA/EOP\_METADATA

Group attributes attach	ned to EOP_METADATA	
Name	Value	Туре
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

### 10.2.3.76 Group "om:phenomenonTime" in "EOP\_METADATA"

Time coverage of the granule.

### Attributes in AER AI/METADATA/EOP METADATA/om:phenomenonTime

Group attributes atta	ached to om:phenomenonTime	
Name	Value	Туре
gml:beginPosition NC_		NC_STRING
Start of time coverage of the data in the granule expressed as an ISO 8601 date-time string [RD34].		
gml:endPosition NC_STRIN		NC_STRING
End of time coverage of the data in the granule expressed as an ISO 8601 date-time string [RD34].		
objectType	'gml:TimePeriod' (static)	NC_STRING

## 10.2.3.77 Group "om:procedure" in "EOP\_METADATA"

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

### Attributes in AER\_AI/METADATA/EOP\_METADATA/om:procedure

Group attributes attac	hed to om:procedure	
Name	Value	Туре
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

## 10.2.3.78 Group "eop:platform" in "om:procedure"

Platform name and orbit type.

## Attributes in AER\_AI/METADATA/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

### 10.2.3.79 Group "eop:instrument" in "om:procedure"

Instrument descriptor.

## Attributes in AER\_AI/METADATA/EOP\_METADATA/om:procedure/eop:instrument

Group attributes attached to eop:instrument		
Name	Value	Туре
eop:shortName	'TROPOMI' (static)	NC_STRING
objectType	'eop:Instrument' (static)	NC_STRING

### 10.2.3.80 Group "eop:sensor" in "om:procedure"

Sensor description.

### Attributes in AER\_AI/METADATA/EOP\_METADATA/om:procedure/eop:sensor

Group attributes attached to eop:sensor		
Name	Value	Туре
eop:sensorType	'ATMOSPHERIC' (static)	NC_STRING
objectType	'eop:Sensor' (static)	NC_STRING

### 10.2.3.81 Group "eop:acquisitionParameters" in "om:procedure"

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

## Attributes in AER\_AI/METADATA/EOP\_METADATA/om:procedure/eop:acquisitionParameters

Group attributes attached to eop:acquisitionParameters		
Name	Value	Туре
eop:orbitNumber	0 (dynamic)	NC_INT
objectType	'eop:Acquisition' (static)	NC_STRING

## 10.2.3.82 Group "om:observedProperty" in "EOP\_METADATA"

An xlink to the observed property definition.

## Attributes in AER\_AI/METADATA/EOP\_METADATA/om:observedProperty

Group attributes attached to om:observedProperty		
Name	Value	Туре
nilReason	'inapplicable' (dynamic)	NC_STRING
This element should u	se the attribute 'nilReason="inapplicable".	

## 10.2.3.83 Group "om:featureOfInterest" in "EOP\_METADATA"

## Attributes in AER\_AI/METADATA/EOP\_METADATA/om:featureOfInterest

Group attributes attached to om:featureOfInterest		
Name	Value	Туре
objectType	'eop:FootPrint' (static)	NC_STRING

gml:id	'%(logical_filename)s.FP' (dynamic)	NC_STRING
Unique ID for this "eop:FootPrir" "FP" separated by a dot.	nt" object. Constructed from the logical output file	ename and the extension

#### 10.2.3.84 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 AER AI/METADATA/EOP METADATA/om:featureOfInterest/eop:multiExtentOf

Group attributes attached to eop:multiExtentOf		
Name	Value	Туре
objectType	'gml:MultiSurface' (static)	NC_STRING

#### 10.2.3.85 Group "gml:surfaceMembers" in "eop:multiExtentOf"

### Attributes in AER\_AI/METADATA/EOP\_METADATA/om:featureOfInterest/eop:multiExtentOf/gml:surfaceMembers

Group attributes attached to gml:surfaceMembers		
Name	Value	Туре
objectType	'gml:Polygon' (static)	NC_STRING

### 10.2.3.86 Group "gml:exterior" in "gml:surfaceMembers"

## Attributes in AER\_AI/METADATA/EOP\_METADATA/om:featureOfInterest/eop:multiExtentOf/gml:surfaceMembers/gml:exterior

Group attributes at	tached to gml:exterior	
Name	Value	Туре
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

### 10.2.3.87 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 AER\_AI/METADATA/EOP\_METADATA/eop:metaDataProperty

Group attributes attached to eop:metaDataProperty		
Name	Value	Туре
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 identifyir	g the product (see http://www.datacite.org for	DOIs for datasets).
eop:parentldentifier	'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 [RD33, table 5] for a discussion of the value.		
This is a copy of the "gmd:fileIde	entifier" 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 [RD39, RD40, RD41].		
eop:status	'ACQUIRED' (dynamic)	NC_STRING
Refers to product status. Values	isted in the standard: 'ARCHIVED', 'ACQUIRED', 'CAN	ICELLED', 'FAILED',

eop:productQualityStatus 'NOMINAL' (dynamic)

NC STRING

Indicator that specifies whether the product quality is degraded or not. Allowed values: 'DEGRADED', 'NOMINAL'.

'PLANNED', 'POTENTIAL', 'REJECTED', 'QUALITY-DEGRADED'. Copied from L1B.

## eop:productQualityDegradationTal@T 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.

### 10.2.3.88 Group "eop:processing" in "eop:metaDataProperty"

Processing information.

## Attributes in AER\_AI/METADATA/EOP\_METADATA/eop:metaDataProperty/eop:processing

Group attributes attached to eop:processing		
Name	Value	Туре
objectType	'eop:ProcessingInformation' (static)	NC_STRING
eop:processingCenter	'%(processingcenter)s' (dynamic)	NC_STRING
The processing center, taken fr	om the "Processing_Station" key in the joborder.	
eop:processingDate	'YYYY-mm-ddTHH:MM:SSZ' (dynamic)	NC_STRING
The processing date, as an ISC	8601 date-time string [RD34].	
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, "tropn112dp.exe" for KNMI and "upas-12" 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 <i>File Class</i> identifiers [RD25, section 4.1.2]: 'TEST', 'OGCA', 'GSOV', 'OPER', 'NRTI', 'OFFL', 'RPRO'.		

## 10.2.3.89 Group "ESA\_METADATA" in "ESA\_metadata"

Metadata defined in the ESA file format standard [RD27].

## 10.2.3.90 Group "earth\_explorer\_header" in "ESA\_METADATA"

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header

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

### 10.2.3.91 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 AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/fixed\_header

Group attributes attached to	o fixed_header	
Name	Value	Туре
objectType	'Fixed_Header' (static)	NC_STRING
File_Name	'%(logical_filename)s' (dynamic)	NC_STRING
The logical file name, i.e. the	ne 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 th	e Sentinel 5-precursor mission is "S5P".	
File_Class		NC_STRING
The file class of the output. section 4.1.2].	Values are taken from the tailoring of the EO file form	mat tailoring for S5P [RD25,
File_Type	'%(shortname)s' (dynamic)	NC_STRING
Following the EO file formation	t tailoring for S5P [RD25, sections 4.1.3.1 and 4.1.3	3.2].
File_Version	0 (dynamic)	NC_INT
	is not part of the file name conventions for S5P. If a nen it has to be provided by the PDGS via the job of I the fill value is 0.	

## 10.2.3.92 Group "validity\_period" in "fixed\_header"

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/fixed\_header/validity\_period

Group attributes att	ached to validity_period	
Name	Value	Туре
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		

### 10.2.3.93 Group "source" in "fixed\_header"

### Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/fixed\_header/source

Group attributes attache	d to source	
Name	Value	Туре
objectType	'Source' (static)	NC_STRING
System	'%(processingcenter)s' (dynamic)	NC_STRING
	gment element creating the file. For Level 2 files, the used. This attribute corresponds to the "System" ile.	
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 to- in the "Source" XML stru	ol that created the file. This attribute corresponds to acture in the header file.	the "Creator_Version" element
Creation_Date		NC_STRING
The start date and time	of processing, as a string: "UTC=YYYY-MM-DDThh:	mm:ss". This attribute corres-

#### 10.2.3.94 Group "variable\_header" in "earth\_explorer\_header"

### Attributes in AER Al/METADATA/ESA METADATA/earth explorer header/variable header

ponds to the "Creator\_Date" element in the "Source" XML structure in the header file.

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

### 10.2.3.95 Group "gmd:lineage" in "variable\_header"

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

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage

Group attributes attached Name	to gma:iineage  Value	Туре
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
•	e data producer's knowledge about the lineage of a dataset. Insert duct in this string (at the $%()$ s).	short description

## 10.2.3.96 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 AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep

Group attributes attached to gmd:processStep			
Name	Value	Туре	
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).

#### 10.2.3.97 Group "gmi:output" in "gmd:processStep"

Description of the output.

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:output

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

### 10.2.3.98 Group "gmd:sourceCitation" in "gmi:output"

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

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation

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

### 10.2.3.99 Group "gmd:date" in "gmd:sourceCitation"

Production date and time of the output file.

## Attributes in AER\_AI/METADATA/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	Туре	
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	

## 10.2.3.100 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

Attributes in AER\_AI/METADATA/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	Туре	
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	

## 10.2.3.101 Group "gmd:identifier" in "gmd:sourceCitation"

Identification of the output product.

## Attributes in AER\_AI/METADATA/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	Туре	
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	

## 10.2.3.102 Group "gmi:processedLevel" in "gmi:output"

Process level of the output file.

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:output/gmi:processedLevel

Group attributes attach	ed to gmi:processedLevel	
Name	Value	Туре
gmd:code	'L2' (static)	NC_STRING
objectType	'gmd:MD_Identifier' (static)	NC_STRING

## 10.2.3.103 Group "gmi:processingInformation" in "gmd:processStep"

Description of the processor in more detail.

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:processingInformation

Group attributes attac	hed to gmi:processingInformation	
Name	Value	Туре
objectType	'gmi:LE_Processing' (static)	NC_STRING

### 10.2.3.104 Group "gmi:identifier" in "gmi:processingInformation"

Identification of the processor.

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:identifier

Group attributes attached to gmi:identifier			
Name	Value	Туре	
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	

### 10.2.3.105 Group "gmi:softwareReference" in "gmi:processingInformation"

Reference to document describing processing software.

Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference

Group attributes attached to gmi:softwareReference			
Name	Value	Туре	
gmd:title	'%(processor_name)s processor' (dynamic)	NC_STRING	
Name of the processor.			
objectType	'gmd:CI_Citation' (static)	NC_STRING	

### 10.2.3.106 Group "gmd:date" in "gmi:softwareReference"

Release date (compile date) of the processor.

Attributes in AER\_AI/METADATA/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	Туре
gmd:date	'%(processor_release_date)s' (dynamic)	NC_STRING
Release date of the processor expressed as an ISO 8601 date string [RD34].		
objectType	'gmd:CI_DateTime' (static)	NC_STRING

#### 10.2.3.107 Group "gmd:dateType" in "gmd:date"

The release date of the processor.

Attributes in AER\_AI/METADATA/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	Туре	
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	

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

Reference to the ATBD of the product.

Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1

Group attributes attach	ed to gmi:documentation#1	
Name	Value	Туре
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_atbd)s' (dynamic)	NC_STRING
Specification of the cur	rent release of the ATBD of the product.	

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

Release date of the ATBD.

Attributes in AER\_AI/METADATA/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	Туре
gmd:date	'%(date_atbd)s' (dynamic)	NC_STRING
Release date of the A	ATBD expressed as an ISO 8601 date string [RD34].	
objectType	'gmd:CI_Date' (static)	NC_STRING

### 10.2.3.110 Group "gmd:dateType" in "gmd:date"

Specify the type of the date of the ATBD (revision of publication).

Attributes in AER\_AI/METADATA/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	Туре
codeList	'http://www.isotc211.org/2005/resources/Codelist/ gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING
codeListValue	'revision' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

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

Reference to the PUM of the product.

Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2

Group attributes attach	ned to gmi:documentation#2	
Name	Value	Туре
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_pum)s' (dynamic)	NC_STRING
Specification of the cur	rent release of the PUM of the product.	

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

Release date of the PUM.

Attributes in AER\_AI/METADATA/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	Туре
gmd:date	'%(date_pum)s' (dynamic)	NC_STRING
Release date of the PUM expressed as an ISO 8601 date string [RD34].		
objectType	'gmd:CI_Date' (static)	NC_STRING

## 10.2.3.113 Group "gmd:dateType" in "gmd:date"

Specify the type of the date of the PUM (revision of publication).

Attributes in AER\_AI/METADATA/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	Туре
codeList	'http://www.isotc211.org/2005/resources/Codelist/ gmxCodelists.xml#CI_DateTypeCode' (static)	NC_STRING

codeListValue	'revision' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

#### 10.2.3.114 Group "gmi:report" in "gmd:processStep"

Short report of what occurred during the process step.

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmi:report

Group attributes attached	Group attributes attached to gmi:report		
Name	Value	Туре	
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	t occurred during the process step. Replace $\%(\dots)$ s as indicate	ed.	
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	

### 10.2.3.115 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 AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmd:source#1

Group attributes attached to gmd:source#1		
Name	Value	Туре
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.

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

## Attributes in AER\_AI/METADATA/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		Туре
gmd:code	Empty!	NC_STRING
objectType	'gmd:MD_Identifier' (static)	NC_STRING

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

Reference to the actual filename of the input data.

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation

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

### 10.2.3.118 Group "gmd:date" in "gmd:sourceCitation"

## Attributes in AER\_AI/METADATA/ESA\_METADATA/earth\_explorer\_header/variable\_header/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:date

Group attributes at	Group attributes attached to gmd:date		
Name	Value	Туре	
gmd:date		NC_STRING	
Production date and time of the input file(s) in this group expressed as an ISO 8601 date-time string [RD34]. 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	

### 10.2.3.119 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

## Attributes in AER\_AI/METADATA/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	Туре
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

### 10.2.3.120 Group "gmd:title" in "gmd:sourceCitation"

## Attributes in AER\_AI/METADATA/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	Туре
gco:characterString		NC_STRING
Textual description of the input file group (same as the "gmd:description" attribute in the "gmi:LESource" object).		

## 10.2.3.121 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 AER\_AI/METADATA/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	Туре
gmx:FileName	Empty!	NC_STRING
The basename of the inp	out file.	

## 11 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 [ER10] package to handle units. The CF metadata conventions reinforce this requirement [ER5, sections 1.3 and 3.1].

Making the UDUnits package [ER10] a requirement, and thereby forcing all units to be compliant with formal SI units $^3$  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 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 molecules cm<sup>-2</sup>

**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 s<sup>-1</sup> nm<sup>-1</sup> cm<sup>-2</sup> sr<sup>-1</sup>.

## 12 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 11 and 12. 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 4.

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:

$$f_{\text{pdf}}(x_j) = \frac{1}{N} \sum_{i=0}^{N} \frac{\cos\left(\delta_{\text{geo},i}\right)}{\sigma_i \sqrt{2\pi}} \exp\left[\frac{(x_j - x_i)^2}{2\sigma_i^2}\right]$$
(7)

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  $\cos\left(\delta_{\text{geo},i}\right)$  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.

<sup>&</sup>lt;sup>3</sup> And some deeply entrenched non-SI units such as DU.

**Table 4**: 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 $(R < 0 \text{ or } R > R_{\text{max}})$ " 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 4**: Common quality assurance parameters. (continued).

Name		
number_of_ozone_range_error_occurrences		
number_of_wavelength_offset_error_occurrences		
number_of_initialization_error_occurrences		
number_of_memory_error_occurrences		
number_of_assertion_error_occurrences		
number_of_io_error_occurrences		
number_of_numerical_error_occurrences		
number_of_lut_error_occurrences		
number_of_ISRF_error_occurrences		
number_of_convergence_error_occurrences		
number_of_cloud_filter_convergence_error_occurrences		
number_of_max_iteration_convergence_error_occurrences		
number_of_aot_lower_boundary_convergence_error_occurrences		

number\_of\_other\_boundary\_convergence\_error\_occurrences

#### Description

Number of ground pixels where "ozone column significantly out of range of profile climatology" occurred.

Number of ground pixels where "wavelength offset exceeds maximum from configuration" occurred.

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 ground pixels where "memory allocation or deallocation error" occurred.

Number of ground pixels where "error in algorithm detected during assertion" occurred.

Number of ground pixels where "error detected during transfer of data between algorithm and framework" occurred.

Number of ground pixels where "general fatal numerical error occurred during inversion" occurred.

Number of ground pixels where "error in accessing the lookup table" occurred.

Number of ground pixels where "error detected in the input instrument spectral response function input data" occurred.

Number of ground pixels where "the main algorithm did not converge" occurred.

Number of ground pixels where "the cloud filter did not converge" occurred.

Number of ground pixels where "no convergence because retrieval exceeds maximum number of iterations. Maximum value from configuration" occurred.

Number of ground pixels where "no convergence because the aerosol optical thickness crosses lower boundary twice in succession" occurred.

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 4: 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 <sub>4</sub> 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 " $\chi^2$ 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.
<pre>number_of_number_of_input_data_points_too_low_error_occurrences</pre>	Number of ground pixels where "not enough input ozone columns to calculate a tropospheric column" occurred.
<pre>number_of_cloud_pressure_spread_too_low_error_occurrences</pre>	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 4: 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 4**: Common quality assurance parameters. (continued).

Name					
number	of	sun	glint	filter	occurrences

number\_of\_mixed\_surface\_type\_filter\_occurrences

number of snow ice filter occurrences

number\_of\_aai\_filter\_occurrences
number\_of\_cloud\_fraction\_fresco\_filter\_occurrences

 $\verb|number_of_aai_scene_albedo_filter_occurrences|\\$ 

 $\verb|number_of_small_pixel_radiance_std_filter_occurrences|\\$ 

number\_of\_cloud\_fraction\_viirs\_filter\_occurrences

number\_of\_cirrus\_reflectance\_viirs\_filter\_occurrences

 $\verb|number_of_cf_viirs_swir_ifov_filter_occurrences|\\$ 

 $\verb|number_of_cf_viirs_swir_ofova_filter_occurrences|\\$ 

number\_of\_cf\_viirs\_swir\_ofovb\_filter\_occurrences

 $\verb|number_of_cf_viirs_swir_ofovc_filter_occurrences|\\$ 

number\_of\_cf\_viirs\_nir\_ifov\_filter\_occurrences

#### Description

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 ground pixels where "pixel contains land and water areas (e.g. coastal pixel)" occurred.

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 ground pixels where "AAI smaller than 2.0" occurred.

Number of ground pixels where "pixel contains clouds: The FRESCO effective cloud fraction is larger than threshold. Threshold value from ATBD" occurred.

Number of ground pixels where "pixel contains clouds: The difference between scene albedo at 380 nm from AAI calculation and the climatological surface albedo exceeds threshold. Threshold value from ATBD. This test filters out clouds" occurred.

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 ground pixels where "pixel contains clouds: The cloud fraction from VIIRS / NPP exceeds the shold. Threshold value from ATBD" occurred.

Number of ground pixels where "pixel contains clouds: Cirrus reflectance from VIIRS / NPP exceeds threshold. Threshold value from ATBD" occurred.

Number of ground pixels where "fraction of cloudy VIIRS pixels wihtin S5P SWIR ground pixel exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "fraction of cloudy VIIRS pixels within S5P SWIR OFOVa exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVb exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVc exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "fraction of cloudy VIIRS pixels wihtin S5P NIR ground pixel exceeds a priori threshold from configuration" occurred.

**Table 4**: Common quality assurance parameters. (continued).

P	ı	_	n	_	^
•	v	и	n	п	e

number of cf viirs nir ofova filter occurrences number of cf viirs nir ofovb filter occurrences number of cf viirs nir ofovc filter occurrences number of refl cirrus viirs swir filter occurrences number of refl\_cirrus\_viirs\_nir\_filter\_occurrences number of diff refl cirrus viirs filter occurrences number of ch4 noscat ratio filter occurrences number of ch4 noscat ratio std filter occurrences number of h2o noscat ratio filter occurrences number of h2o noscat ratio std filter occurrences number of diff psurf fresco\_ecmwf filter occurrences number\_of\_psurf\_fresco\_stdv\_filter\_occurrences number\_of\_ocean\_filter\_occurrences

#### Description

Number of ground pixels where "fraction of cloudy VIIRS pixels within S5P NIR OFOVa exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "fraction of cloudy VIIRS pixels within S5P NIR OFOVb exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVc exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "average VIIRS cirrus reflectance within SWIR ground pixel exceeds a priori threshold from configuration" occurred.

Number of ground pixels where "average VIIRS cirrus reflectance within NIR ground pixel exceeds a priori threshold from configuration" occurred.

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 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 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 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 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 ground pixels where "difference between the FRESCO apparent surface pressure and the ECMWF surface pressure exceeds a priori threshold from configuration" occurred.

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 ground pixels where "the ground pixel is over ocean (and ocean glint retrievals are not switched on)" occurred.

Table 4: 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 <sub>3</sub> profile)" 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.

gnostic indicates a degraded quality of the cloud retrieval" occurred.

Table 4: 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. For $O_3$ profile this warning indicates an out of range cost function, or an out of range RMS difference between retrieval and a priori" occurred.
number_of_low_cloud_fraction_warning_occurrences	Number of ground pixels where "low cloud fraction, therefore no cloud pressure retrieved" occurred.
<pre>number_of_altitude_consistency_warning_occurrences</pre>	Number of ground pixels where "difference between ECMWF surface elevation and high-resolution surface elevation exceeds threshold from configuration" occurred.
<pre>number_of_signal_to_noise_ratio_warning_occurrences</pre>	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. For $O_3$ profile this warning is issued in case of a large $SO_2$ column which has an impact on the $O_3$ profile retrieval" occurred.
<pre>number_of_so2_volcanic_origin_certain_warning_occurrences</pre>	Number of ground pixels where "warning for SO <sub>2</sub> 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 dia-

Table 4: Common quality assurance parameters. (continued).

Name	Description
number_of_cloud_inhomogeneity_warning_occurrences	Number of ground pixels where "the cloud coregistration inhomogeneity parameter is above a given threshold. This warning is also set when the coregistration weight sums are less than 1" occurred.
<pre>number_of_thermal_instability_warning_occurrences</pre>	Number of ground pixels where "input spectra have been labeled with a thermal instability warning flag" occurred.

# 13 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 UV Aerosol Index product is given in the file format description, in section 10.2. Here we provide some background on what can be found in which location. The abbreviations listed in table 5 are used in the following part of this document to better identify the nature of the attributes.

**Table 5**: 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.

<b>Abbreviation</b>	Description
NUG	netCDF-4 Users Guide [ER7]
CF	Climate and Forecast metadata conventions [ER5], which includes the COARDS [ER11] conventions
ISO	ISO standards 19115, 19115-2 and 19157 [RD28, RD29, RD30]
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 [RD27]
S5P	Internal use – mostly for retrieval settings, possibly as an extension to ISO 19115 [RD28]
S	Attribute is a string attribute
Р	Attribute has the data-type of the variable with which it is associated ('parent' data type).
1	Attribute is an integer value
F	Attribute is a floating point value (either 32-bit or 64-bit).
Т	Attribute is a CCSDS-ASCII time representation ("UTC=" + ISO 8601 [RD34])

We follow several metadata conventions in the S5P level 2 files, as can be seen in table 5. These include ISO 19115-2 [RD29], OGC 10.157r3 [RD31], the ESA earth observation header [RD27] 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.

The then 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, RD33]. The short version is that the attributes in the data file can be exported as NcML [RD42], 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.

### 13.1 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.

## 13.2 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.

#### 13.3 Global attributes

Global attributes that are present at the root level of a S5p L2 product as described in section 10. These are mostly string attributes.

#### 13.4 ESA earth observation header

The ESA earth observations file format guidelines and tailoring for S5P [RD27, 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 10.2.3.43 for a description the the attributes contained in this part of the header. The fixed header is described in tables 6-8.

**Table 6**: Metadata in the fixed header required by the ESA earth observation file format standard. The data types refer to the short list in table 5.

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 "L2UV Aerosol Index". It is redundant with the File Type element embedded in the File Name.
Validity_Period	Group, see table 7	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 8	Information about the ground segment facility where the product was generated.

Table 7: Fields in the Validity\_Period group. The data types refer to the short list in table 5.

Name	Data type	Definition
Validity_Start	Т	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	Т	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 8**: Fields in the source group. The data types refer to the short list in table 5.

Name	Data type	Definition
System	S	Name of the Ground Segment element creating the file.
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	Т	This is the UTC Creation Date. This field also appears in the file name and in the date_created global attribute.

## 13.5 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 [RD43] 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 [RD44] define how the Regulation can be implemented using ISO 19115. As also reported in [RD33], 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.

#### 13.6 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 [RD29] and ISO 19156 [RD45], 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 [RD37]
- 2. OGC 10-025C [RD46]
- 3. OGC 10-157 [RD31]

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 [RD33].

## 13.7 Attributes

In Table 10 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 5. The NetCDF attribute \_FillValue which represents missing or undefined data can assume the default values listed in Table 9.

**Table 9**: 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:  $-0 \times 1.ep+122$ ) 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 10: Attributes for variables used in S5p netCDF-4 files. The data types refer to the short list in table 5.

Name	Туре	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 <sup>2</sup> 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	Р	NUG	Value to represent missing or undefined data. Recommended (default) values are given in table 9.
flag_masks	Р	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	Р	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 10**: 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 11 for a detailed discussion.
valid_max	Р	NUG	Largest valid value of a variable.
valid_min	Р	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

# A Flag descriptions

The following tables describe the Measurement flags, Processing quality flags (processing failures and filter conditions, errors and warnings) and surface classifications.

**Table 11**: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2. Warnings are listed in table 12. 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 to 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 $R > R_{max}$ ).	FRESCO	
5	ler_range_error	Lambert-equivalent reflectivity out of range error.	CO, CH <sub>4</sub>	
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 <sub>3</sub> column	
11	wavelength_offset_error	Wavelength offset exceeds maximum from configuration.	FRESCO, NO <sub>2</sub>	
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 <sub>4</sub>	
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 <sub>4</sub> , O <sub>3</sub> profile	
16	numerical_error	General fatal numerical error occurred during inversion.	CO, FRESCO	
17	lut_error	Error in accessing the lookup table.	CH <sub>4</sub>	
18	ISRF_error	Error detected in the input instrument spectral response function input data.	CH <sub>4</sub>	
19	convergence_error	The main algorithm did not converge.	All	
20	cloud_filter_convergence_error	The cloud filter did not converge.	CO	

 Table 11: 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 $\text{CH}_4$ column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0.	CH₄
26	h2o_noscat_zero_error	The $\rm H_2O$ column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0.	CH₄
27	max_optical_thickness_error	Maximum optical thickness exceeded during iterations.	CH <sub>4</sub>
28	aerosol_boundary_error	Boundary hit of aerosol parameters at last iteration.	CH <sub>4</sub>
29	boundary_hit_error	Fatal boundary hit during iterations.	CH₄
30	chi2_error	$\chi^2$ is not-a-number or larger than $10^{10}$ .	CH <sub>4</sub>
31	svd_error	Singular value decomposition failure.	CH <sub>4</sub>
32	dfs_error	Degree of freedom is not-a-number.	CH <sub>4</sub>
33	radiative_transfer_error	Errors occurred during the radiative transfer computations, no processing possible.	O <sub>3</sub> profile
34	optimal_estimation_error	Errors occurred during the optimal estimation, processing has been terminated.	O <sub>3</sub> profile
35	profile_error	Flag that indicates if there were any errors during the computation of the ozone profile.	O <sub>3</sub> profile
36	cloud_error	No cloud data.	Cloud
37	model_error	Forward model failure.	Cloud, Total O <sub>3</sub> column
38	number_of_input_data_points_too_low_error	Not enough input ozone columns to calculate a tropospheric column.	Tropospheric O <sub>3</sub> column
39	cloud_pressure_spread_too_low_error	Cloud pressure variability to low to estimate a tropospheric column.	Tropospheric O <sub>3</sub> column
40	cloud_too_low_level_error	Clouds are too low in the atmosphere to assume sufficient shielding.	Tropospheric O <sub>3</sub> 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 11: 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 <sub>2</sub>
64	solar_eclipse_filter	Solar eclipse.	All
65	cloud_filter	The cloud filter triggered causing the pixel to be skipped.	CO, ALH, CH <sub>4</sub>
66	altitude_consistency_filter	Too large difference between ECMWF altitude and DEM altitude value.	CO, CH <sub>4</sub>
67	altitude_roughness_filter	Too large standard deviation of altitude in DEM.	CO, ALH, CH <sub>4</sub>
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 climatological 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 <sub>4</sub>
75	cloud_fraction_viirs_filter	Pixel contains clouds: The cloud fraction from VIIRS / NPP exceeds the shold. 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 11: 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 within S5P SWIR ground pixel exceeds a priori threshold from configuration.	CH <sub>4</sub>
78	cf_viirs_swir_ofova_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVa exceeds a priori threshold from configuration.	CH₄
79	cf_viirs_swir_ofovb_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVb exceeds a priori threshold from configuration.	CH₄
80	cf_viirs_swir_ofovc_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVc exceeds a priori threshold from configuration.	CH₄
81	cf_viirs_nir_ifov_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR ground pixel exceeds a priori threshold from configuration.	CH₄
82	cf_viirs_nir_ofova_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVa exceeds a priori threshold from configuration.	CH₄
83	cf_viirs_nir_ofovb_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVb exceeds a priori threshold from configuration.	CH₄
84	cf_viirs_nir_ofovc_filter	Fraction of cloudy VIIRS pixels within S5P NIR OFOVc exceeds a priori threshold from configuration.	CH₄
85	refl_cirrus_viirs_swir_filter	Average VIIRS cirrus reflectance within SWIR ground pixel exceeds a priori threshold from configuration.	CH₄
86	refl_cirrus_viirs_nir_filter	Average VIIRS cirrus reflectance within NIR ground pixel exceeds a priori threshold from configuration.	CH₄
87	diff_refl_cirrus_viirs_filter	Difference in VIIRS average cirrus reflectance between SWIR and NIR ground pixel exceeds a priori threshold from configuration.	CH₄
88	ch4_noscat_ratio_filter	The ratio between $[CH_4]_{weak}$ and $[CH_4]_{strong}$ is below or exceeds a priori thresholds from configuration.	CH₄
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.	CH₄
90	h2o_noscat_ratio_filter	The ratio between $[H_2O]_{weak}$ and $[H_2O]_{strong}$ is below or exceeds a priori thresholds from configuration.	CH₄
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.	CH₄

**Table 11**: 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.	CH₄
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.	CH₄
94	ocean_filter	The ground pixel is over ocean (and ocean glint retrievals are not switched on).	CH <sub>4</sub>
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 12**: Processing quality flags, warnings for S5P Level 2. Errors, processing failures and filter conditions are listed in table 11. 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 11 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, CH₄
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 <sub>2</sub> , 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 <sub>4</sub> , O <sub>3</sub> profile, Cloud
16	0x00010000	AAI_warning	Possible aerosol contamination as either indicated by the AAI (O <sub>3</sub> profile).	O <sub>3</sub> profile

**Table 12**: Processing quality flags, warnings for S5P Level 2 (continued).

it#	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 CO, CH <sub>4</sub> , O <sub>3</sub> , SO <sub>2</sub> , HCHO
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. For $O_3$ profile this warning indicates an out of range cost function, or an out of range RMS difference between retrieval and a priori.	CO, CH <sub>4</sub> , O <sub>3</sub> , SO <sub>2</sub> , 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.	CH₄
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 <sub>4</sub> , O <sub>3</sub> , HCHO
22	0x00400000	deconvolution_warning	Failed deconvolution irradiance spectrum (not pixel-specific, but row-specific).	CO, CH <sub>4</sub>
23	0x00800000	so2_volcanic_origin_likely_warning	Warning for $SO_2$ BL product, UTLS products: volcanic origin except for heavily polluted sites. For $O_3$ profile this warning is issued in case of a large $SO_2$ column which has an impact on the $O_3$ profile retrieval.	SO <sub>2</sub> , O <sub>3</sub> profile
24	0x01000000	so2_volcanic_origin_certain_warning	Warning for SO <sub>2</sub> BL product, UTLS products: volcanic origin certain.	SO <sub>2</sub>
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. This warning is also set when the coregistration weight sums are less than 1.	Cloud Cloud All
30	0x40000000	thermal_instability_warning	Input spectra have been labeled with a thermal instability warning flag.	All

**Table 13**: 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 [ER8], specifically the "USGS Land Use/Land Cover System (Modified Level 2)" classification. Over water the classification from the NASA SDP toolkit [ER9], which is based on [RD36].

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 $15\times15\mathrm{arcsecond}$ 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 13: 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