

Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Formaldehyde HCHO





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1 Introduction

8 1.1 Identification

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- This document, identified as S5P-L2-DLR-PUM-400F, 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 Formaldehyde HCHO.

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 products as well as a specific section related to the Formaldehyde HCHO product are described.

27 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 Formaldehyde HCHO 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 Formaldehyde HCHO 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

40 2.3 Reference documents

- [RD1] J. P. Veefkind, I. Aben, K. McMullan *et al.*; TROPOMI on the ESA Sentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications. *Remote Sens. Environ.*; **120** (2012), 70; 10.1016/j.rse.2011.09.027.
- [RD2] Input/output data specification for the TROPOMI L01b data processor.
 source: KNMI; ref: S5P-KNMI-L01B-0012-SD; issue: 5.0.0; date: 2015-09-22.
- [RD3] S5P/TROPOMI ATBD Cloud Products.
 source: DLR; ref: S5P-DLR-L2-ATBD-400I; issue: 2.3.0; 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: 2021-07-11.
- [RD5] S5P-NPP Cloud Processor ATBD.
 source: RAL Space; ref: S5P-NPPC-RAL-ATBD-0001; issue: 0.11.0; date: 2014-05-15.
- [RD6] S5P/TROPOMI HCHO ATBD.
 source: BIRA; ref: S5P-BIRA-L2-400F-ATBD; issue: 2.4.1; date: 2022-06-22.
- [RD7] S5P/TROPOMI SO₂ ATBD.

 source: BIRA; ref: S5P-BIRA-L2-400E-ATBD; issue: 2.4.1; date: 2022-06-22.
- [RD8] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual SO₂.

 source: DLR; ref: S5P-L2-DLR-PUM-400E; issue: 2.4.0; date: 2022-07-11.
- [RD9] S5P/TROPOMI Total ozone ATBD.

 source: DLR/BIRA; ref: S5P-L2-DLR-ATBD-400A; issue: 2.3.0; date: 2021-06-04.
- [RD10] 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: 2021-07-11.
- [RD11] TROPOMI ATBD of tropospheric ozone data products.

 source: DLR/IUP; ref: S5P-DLR-IUP-L2-400C; issue: 2.3.0; date: 2021-06-04.
- [RD12] 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.
- [RD13] TROPOMI ATBD of the Aerosol Layer Height product.
 source: KNMI; ref: S5P-KNMI-L2-0006-RP; issue: 1.0.1; date: 2019-06-24.
- [RD14] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Aerosol Layer Height. source: KNMI; ref: S5P-KNMI-L2-0022-MA; issue: 0.0.2dr; date: 2014-10-16.
- [RD15] TROPOMI ATBD of the UV aerosol index.
 source: KNMI; ref: S5P-KNMI-L2-0008-RP; issue: 1.0.0; date: 2016-02-03.
- [RD16] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Aerosol Index. source: KNMI; ref: S5P-KNMI-L2-0026-MA; issue: 0.0.2dr; date: 2014-10-16.

- ⁷⁴ [RD17] TROPOMI ATBD Ozone profile and tropospheric profile.
 ⁷⁵ **source:** KNMI; **ref:** S5P-KNMI-L2-0004-RP; **issue:** 0.13.0; **date:** 2015-09-15.
- ⁷⁶ [RD18] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Ozone Profile and Tropospheric Ozone Profile.
- source: KNMI; ref: S5P-KNMI-L2-0020-MA; issue: 0.0.2dr; date: 2014-10-16.
- ⁷⁹ [RD19] TROPOMI ATBD of the total and tropospheric NO₂ data products.

 source: KNMI; ref: S5P-KNMI-L2-0005-RP; issue: 1.0.0; date: 2016-02-05.
- [RD20] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Nitrogen Dioxide. source: KNMI; ref: S5P-KNMI-L2-0021-MA; issue: 0.0.2dr; date: 2014-10-16.
- [RD21] Algorithm Theoretical Baseline Document for Sentinel-5 Precursor: Carbon Monoxide Total Column Retrieval.
- source: SRON; ref: SRON-S5P-LEV2-RP-002; issue: 1.0.0; date: 2016-02-05.
- [RD22] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Carbon Monoxide Column.
 source: SRON/KNMI; ref: SRON-S5P-LEV2-MA-002; issue: 0.0.2dr; date: 2014-10-16.
- [RD23] Algorithm Theoretical Baseline Document for Sentinel-5 Precursor methane retrieval.
 source: SRON; ref: SRON-S5P-LEV2-RP-001; issue: 1.0.0; date: 2016-02-05.
- [RD24] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Methane.
 source: SRON/KNMI; ref: SRON-S5P-LEV2-MA-001; issue: 0.0.2dr; date: 2014-10-16.
- [RD25] Tailoring of the Earth Observation File Format Standard for the Sentinel 5 precursor Ground Segment. source: ESA/ESTEC; ref: S5P-TN-ESA-GS-106; issue: 2.2; date: 2015-02-20.
- [RD26] Earth Observation Ground segment file format standard.

 source: ESA/ESTEC; ref: PE-TN-ESA-GS-0001; issue: 2.0; date: 2012-05-03.
- [RD27] Geographic information Metadata.
 source: ISO; ref: ISO 19115:2003(E); issue: 1; date: 2003-05-01.
- [RD28] Geographic information Metadata Part 2: Extensions for imagery and gridded data.
 source: ISO; ref: ISO 19115-2:2009(E); issue: 1; date: 2009-02-12.
- [RD29] Geographic information Data quality.

 source: ISO; ref: ISO 19157; issue: 1; date: 2013-10-10.
- [RD30] Earth Observation Metadata profile of Observations & Measurements.

 source: Open Geospatial Consortium; ref: OGC 10-157r3; issue: 1.0; date: 2012-06-12.
- [RD31] Data Standards Requirements for CCI Data Producers.
 source: ESA; ref: CCI-PRGM-EOPS-TN-13-0009; issue: 1.1; date: 2013-05-24.
- [RD32] Metadata specification for the TROPOMI L1b products.
 source: KNMI; ref: S5P-KNMI-L01B-0014-SD; issue: 2.0.0; date: 2014-12-09.
- [RD33] Sentinel-4 UVN Phase B2, C/D and support to phase E1 Level 0 to Level 1b data processing software Input/Output Data Specification (IODS): Level 1b output products and metadata contents and format. source: ESA/ESTEC; ref: S4.ESA.UVN.TN.1206; issue: 1.0; date: 2011-06-23.
- [RD34] Algorithm theoretical basis document for the TROPOMI L01b data processor. source: KNMI; ref: S5P-KNMI-L01B-0009-SD; issue: 6.0.0; date: 2015-09-22.
- [RD35] Data elements and interchange formats Information interchange Representation of dates and times.
- source: ISO; ref: ISO 8601:2004(E); issue: 3; date: 2004-12-01.
- [RD36] John Caron; Annotated Schema for NcML (2011). URL http://www.unidata.ucar.edu/software/netcdf/ncml/v2.2/AnnotatedSchema4.html.

- [RD37] INSPIRE Metadata Regulation, Commission Regulation (EC), No1205/2008.

 source: EC; ref: Commission Regulation (EC) No 1205/2008; date: 2008-12-03.
- [RD38] INSPIRE Metadata Implementing Rules: Technical Guidelines based on EN ISO 19115 and EN ISO 19119.
- source: EC JRC; ref: MD_IR_and_ISO_v1_2_20100616; issue: 1.2; date: 2010-06-16.
- [RD39] Geographic Information Observations and Measurements. source: ISO; ref: ISO 19156:2011(E); date: 2011-12-20.
- [RD40] Geographic information Metadata XML schema implementation. source: ISO; ref: ISO 19139:2007(E); issue: 1; date: 2010-12-13.
- [RD41] Observations and Measurements XML Implementation.
 source: OGC; ref: OGC 10-025r1; issue: 2.0; date: 2011-03-22.
- [RD42] Observations and Measurements XML Implementation.. source: Open Geospatial Consortium; ref: OGC 10-025r1; issue: 2.0; date: 2011-03-22.
- [RD43] Sentinel 5 precursor/TROPOMI KNMI and SRON level 2 Input Output Data Definition. source: KNMI; ref: S5P-KNMI-L2-0009-SD; issue: 5.0.0; date: 2016-04-19.
- [RD44] Sentinel-5 Precursor Level 2 UPAS Processor Input/Output Definition Document. source: DLR-IMF; ref: S5P-L2-DLR-IODD-3002; issue: 3.7.3; date: 2022-06-24.
- [RD45] S5P-NPP Cloud Processor IODD.
 source: RAL; ref: S5P-NPPC-RAL-IODD-0001; issue: 0.10.0; date: 2014-05-28.
- [RD46] M.L. Carroll, J.R. Townshend, C.M. DiMiceli *et al.*; A new global raster water mask at 250 m resolution. *International Journal of Digital Earth*; **2** (2009) (4), 291; 10.1080/17538940902951401.

2.4 Electronic references

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- [ER2] S5P official website. URL https://sentinel.esa.int/web/sentinel/missions/sentinel-5p.
- [ER3] Robert B. Schmunk; Panoply netCDF, HDF and GRIB Data Viewer. URL http://www.giss.nasa.
 gov/tools/panoply/.
- [ER4] Infrastructure for Spatial Information in the European Community (INSPIRE) Directive 2007/2/EC. URL http://inspire.jrc.ec.europa.eu/.
- [ER5] Brian Eaton, Jonathan Gregory, Bob Drach *et al.*; *NetCDF Climate and Forecast (CF) Metadata Conventions*. Lawrence Livermore National Laboratory (2014). Version 1.7 draft; URL http://cfconventions.org.
- [ER6] ESIP; Attribute Conventions for Dataset Discovery (ACDD). 1st edition (2013). URL http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery_(ACDD).
- [ER7] NetCDF Users Guide (2011). URL http://www.unidata.ucar.edu/software/netcdf/docs/netcdf.html.
- [ER8] Unidata; NetCDF library and documentation. URL http://www.unidata.ucar.edu/software/netcdf/.
- [ER9] UDUNITS 2 Manual (2011). URL http://www.unidata.ucar.edu/software/udunits/.
- [ER10] Cooperative Ocean/Atmosphere Research Data Service; Conventions for the standardization of NetCDF files (1995). URL http://ferret.wrc.noaa.gov/noaa_coop/coop_cdf_profile. html.
- [ER11] USGS; Global Land Cover Characteristics Data Base Version 2.0 (2012). Website last visited on March 6, 2017; URL https://lta.cr.usgs.gov/glcc/globdoc2_0.

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

3 Terms, definitions and abbreviated terms

⁵⁶⁶ Terms, definitions, and abbreviated terms that are specific for this document can be found below.

67 3.1 Terms and definitions

ATBD Algorithm Theoretical Basis Document

TBA To be Added

TBC To be Confirmed

TBD To be Defined

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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
170	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]	This document	L2HCHO	BIRA/DLR
SO ₂	[RD7]	[RD8]	L2SO2	BIRA/DLR
O ₃ Total Column	[RD9]	[RD10]	L203	BIRA/DLR
O ₃ Tropospheric Column	[RD11]	[RD12]	L203_TCL	IUP/DLR
Aerosol layer height	[RD13]	[RD14]	L2AER_LH	KNMI
Ultra violet aerosol index	[RD15]	[RD16]	L2AER_AI	KNMI
O ₃ Full Profile	[RD17]	[RD18]	L2 <u>03</u> PR	KNMI
O ₃ Troposheric Profile	[RD17]	[RD18]	L203_TPR	KNMI
NO ₂	[RD19]	[RD20]	L2NO2	KNMI
CO	[RD21]	[RD22]	L2CO	SRON/KNMI
CH ₄	[RD23]	[RD24]	L2CH4	SRON/KNMI

4.1 File name convention

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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 Formaldehyde HCHO product is described and an example of the full real name is as following:

```
S5P_NRTI_L2_HCHO___20140101T000000_20140102T000000_00099_01_000200_20141010T173511.nc
The components of this file name are given in table 2
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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 granulein 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 Formaldehyde HCHO 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.

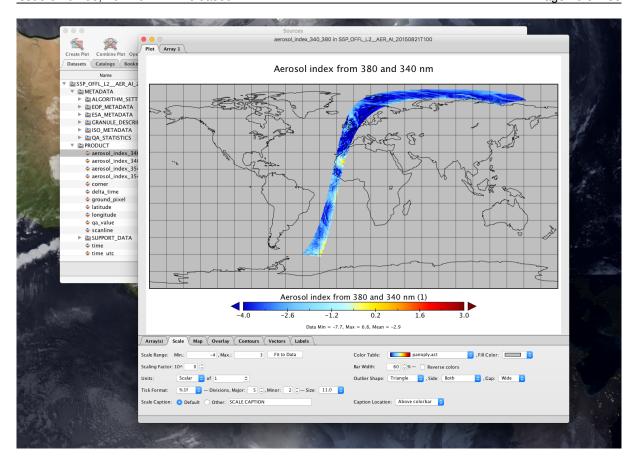


Figure 1: Panoply

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

HCHO Acquisition Time
29-March-2018 00:38:27
30-March-2018 01:17:54

Plot RangeMin: -1074.15 - Max: 1285.202

Sensor Algorithm

TROPOMI UPAS-HCHO-DOAS_LUT-5.0.0 S5P UPAS2 02.30.73

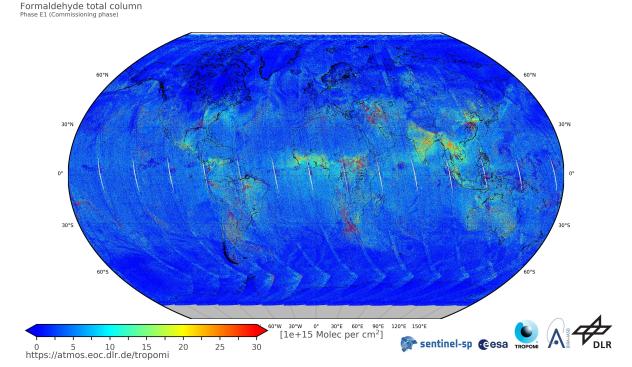


Figure 2: A full day plot of the Formaldehyde HCHO product acquired on 29th March 2018. Further quicklooks may be found here: https://atmos.eoc.dlr.de/tropomi

7 S5p/TROPOMI L2 Formaldehyde HCHO Product Description

Long term satellite observations of tropospheric formaldehyde HCHO are essential to support air quality and chemistry-climate related studies from the regional to the global scale. Formaldehyde is an intermediate gas in almost all oxidation chains of non-methane volatile organic compounds (NMVOC), leading eventually to CO₂. Non-Methane Volatile Organic Compounds (NMVOCs) are, together with NO_x, CO and CH₄, among the most important precursors of tropospheric O₃. NMVOCs also produce secondary organic aerosols and influence the concentrations of OH, the main tropospheric oxidant. The major HCHO source in the remote atmosphere is CH₄ oxidation. Over the continents, the oxidation of higher NMVOCs emitted from vegetation, fires, traffic and industrial sources results in important and localized enhancements of the HCHO levels. The seasonal and inter-annual variations of the formaldehyde distribution are principally related to temperature changes and fire events, but also to changes in anthropogenic activities. Its lifetime being of the order of a few hours, HCHO concentrations in the boundary layer can be directly related to the release of short-lived hydrocarbons, which mostly cannot be observed directly from space. Furthermore, HCHO observations provide information on the chemical oxidation processes in the atmosphere, including CO chemical production from CH₄ and NMVOCs. For these reasons, HCHO satellite observations are used in combination with tropospheric chemistry transport models to constrain NMVOC emission inventories in so-called top-down inversion approaches [RD6]. Refer to the specific ATBD [RD6] documentation for further information about the L2 Formaldehyde HCHO.

7.1 Data Product Examples

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Quicklooks are reported in this section as a data product examples of the Formaldehyde HCHO product (see Figure 2). Further quicklooks may be found here: https://atmos.eoc.dlr.de/tropomi

7.2 Product Geophysical Validation

The Mission Performance Centre (MPC) validation reports are regularly updated and can be found here:

http://mpc-vdaf.tropomi.eu.

7.3 History of product changes

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

Table 3: History of product changes of Formaldehyde HCHO

Version	Description
2.4	Added thermal instability warning to processing flags
2.3.1	Added metadata related to fallback background correction
2.1	Added surface temperature, DOAS polynomial coefficients
2.1	Added additional fields with background data information
2.0	Added tropopause layer index information from TM5 (tm5_tropopause_layer_index)
2.0	Added 10m Wind information from ECMWF (eastward_wind, northward_wind)
2.0	Updated QA value calculation
1.1	New kernels variables added due to updated prototype algorithms
1.1	Added BACKGROUND_CORRECTION group including the information of the AUX_BGHCHO file
0.12	Official version for E2 delivery

7.4 Using the S5p/TROPOMI L2 Formaldehyde HCHO

The Product Readme File (PRF, available here: http://www.tropomi.eu/sites/default/files/files/publicSentinel-5P-Formaldehyde-Readme.pdf) for HCHO describes the current processing baseline, product and quality limitations, and product availability status. More information on this data product is available from the Sentinel product webpage (https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/products-algorithms) and from the TROPOMI product webpage (http://www.tropomi.eu/data-products).

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8 General structure of S5P/TROPOMI Level 2 files

This section gives an overview of the basic structure of all Sentinel 5 precursor level 2 files. In subsections 8.2–8.3 and sections 9–11 some details are provided on the background of the structure of the level 2 files of Sentinel 5 precursor. A complete description of the variables in the Formaldehyde HCHO files is given in section 12. Figure 3 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 values¹.

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

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

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

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

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

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

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

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

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

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

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

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

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

ISO_METADATA The ISO metadata items, organized in subgroups.

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

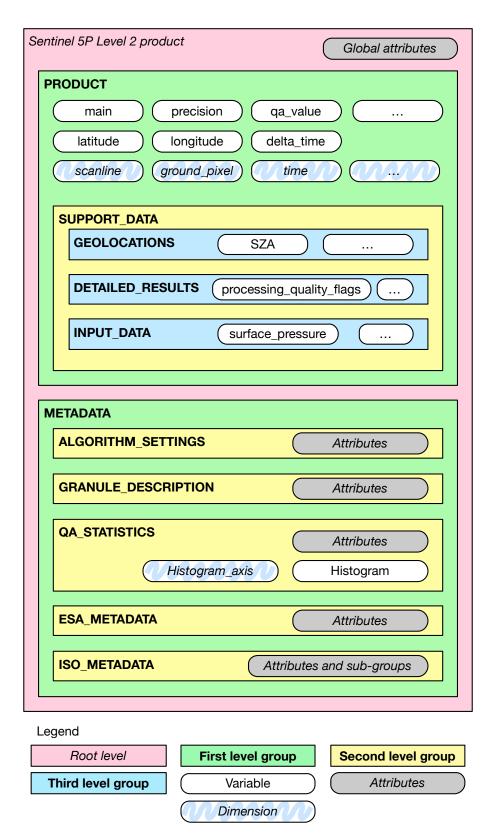


Figure 3: Graphical description of the generic structure of a Level 2 file. The elements labelled as a dimension are coordinate variables. See section 8 for a full description.

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EOP METADATA The EOP metadata items, organized in subgroups.

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

Details of the specific format of the level 2 product file for the Formaldehyde HCHO product is given in section 12.
Here all variables are described in detail. A dump output of the final structure proposed in Figure 3 shall have a hierarchy as follows:

```
/root/PRODUCT
   /root/PRODUCT/SUPPORT_DATA
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   /root/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS
325
   /root/PRODUCT/SUPPORT_DATA/GEOLOCATION
   /root/PRODUCT/SUPPORT_DATA/INPUT_DATA
327
   /root/METADATA
328
   /root/METADATA/ALGORITHM_SETTINGS
329
   /root/METADATA/ESA_METADATA
   /root/METADATA/GRANULE_DESCRIPTION
331
   /root/METADATA/ISO_METADATA
332
   /root/METADATA/QA_STATISTICS
333
```

Where root is the file itself or the outer level.

The geo-coordinates of the pixel corners are shown in Figure 5. Note that this choice follows the CF metadata standard [ER5, section 7.1].

8.1 S5p/TROPOMI L2 File Format

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

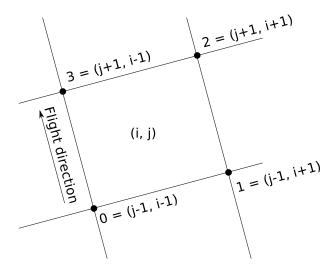


Figure 4: Pixel corner coordinates following [ER5, section 7.1].

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8.2 Dimensions and dimension ordering

All variables in a NetCDF-4 file use named and shared dimensions. This explicitly connects variables to dimensions, and to each other. A few of the dimension names were already shown in figure 3.

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

scanline The dimension that indicates the flight direction.

ground_pixel The dimension perpendicular to the flight direction.

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

The climate and forecast metadata conventions recommend a specific order for dimensions in a variable [ER5, section 2.4]. Spatiotemporal dimensions should appear in the relative order: "date or time" (T), "height or depth" (Z), "latitude" (Y), and "longitude" (X). Note that the ordering of the dimensions in CDL, our documentation and C/C++ is row-major: the last dimension is stored contiguously in memory².

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 NO₂ column This variable contains a single value per ground pixel, and the dimensions are (time, scanline, ground_pixel).

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

8.3 Geolocation, pixel corners and angles

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

The geo-coordinates of the pixel corners are shown in Figure 5. Note that this choice follows the CF metadata standard [ER5, section 7.1].

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

8.4 Time information

Time information is stored in two steps. We have the time dimension, which indicates the reference time. This reference time is defined to be UTC midnight before the start of the orbit, which itself is defined by spacecraft midnight. The time variable contains the reference time in seconds since 2010-01-01, UTC midnight. Alternative representations of the reference time are listed in table 4. The offset of individual measurements within the granule is given in milliseconds with respect to this reference time in the variable delta_time.

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

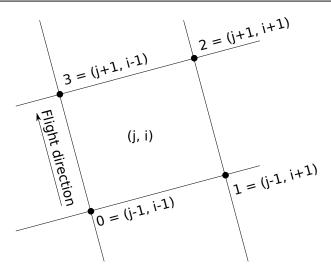


Figure 5: Pixel corner coordinates. The sequence $\{0,1,2,3\}$ refers to the elements in the corner dimension.

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

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

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

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

8.5 Vertical coordinates

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Different ATBD authors have specified different vertical grids for the retrieval, which means that the various Level 2 products are not consistent in this respect. There are several options, depending on the choice made by the authors of the retrieval algorithm. Some authors choose to use a vertical grid on a fixed height scale³, others use a grid that is defined in pressure relative to the surface pressure, similar to the ECMWF vertical grid. The ECMWF vertical grid is a "atmosphere hybrid sigma pressure coordinate" in CF conventions terminology [ER5, appendix D].

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

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

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

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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⁻²

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

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

10 Quality Assurance parameters

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

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

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

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

This is a discrete approximation of a continuous probability density function, for discrete values x_j for all successful retrievals $i=1,\ldots,N$. The value of $\cos\left(\delta_{\text{geo},i}\right)$ 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.

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

Name	Description
number_of_groundpixels	Number of ground pixels in the file.
number_of_processed_pixels	Number of ground pixels where a retrieval was attempted. This is the number_of_groundpixels minus the pixels that were rejected on trivial grounds, such as the solar zenith angle.
number_of_successfully_processed_pixels	Number of ground pixels where a retrieval was successful.
number_of_rejected_pixels_not_enough_spectrum	Number of ground pixels where a retrieval was not attempted because too many spectral pixels were flagged as bad.
number_of_failed_retrievals	Number of pixels that were attempted but failed.
number_of_ground_pixels_with_warnings	Number of pixels with one or more warnings.
number_of_missing_scanlines	Number of scanlines that are missing from the input, presumably transmission errors.
number_of_radiance_missing_occurrences	Number of ground pixels where "the number of spectral pixels in the radiance due to flagging is too small to perform the fitting" occurred.
number_of_irradiance_missing_occurrences	Number of ground pixels where "the number of spectral pixels in the irradiance due to flagging is too small to perform the fitting" occurred.
number_of_input_spectrum_missing_occurrences	Number of ground pixels where "the reflectance spectrum does not contain enough points to perform the retrieval. This is different from (ir)radiance_missing in that the missing points may not be aligned" occurred.
number_of_reflectance_range_error_occurrences	Number of ground pixels where "any of the reflectances is out of bounds $(R < 0 \text{ or } R > R_{\text{max}})$ " 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 5: 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 5: Common quality assurance parameters. (continued).

Name	Description		
number_of_geolocation_error_occurrences	Number of ground pixels where "geolocation out of range" occurred.		
number_of_ch4_noscat_zero_error_occurrences	Number of ground pixels where "the CH ₄ column retrieved by the non scattering CO algorithm from the weak band or strong band is 0" occurred.		
number_of_h2o_noscat_zero_error_occurrences	Number of ground pixels where "the H_2O column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0" occurred.		
number_of_max_optical_thickness_error_occurrences	Number of ground pixels where "maximum optical thickness exceeded during iterations" occurred.		
number_of_aerosol_boundary_error_occurrences	Number of ground pixels where "boundary hit of aerosol parameters at last iteration" occurred.		
number_of_boundary_hit_error_occurrences	Number of ground pixels where "fatal boundary hit during iterations" occurred.		
number_of_chi2_error_occurrences	Number of ground pixels where " χ^2 is not-a-number or larger than 10^{10} " occurred.		
number_of_svd_error_occurrences	Number of ground pixels where "singular value decomposition failure" occurred.		
number_of_dfs_error_occurrences	Number of ground pixels where "degree of freedom is not-a-number" occurred.		
number_of_radiative_transfer_error_occurrences	Number of ground pixels where "errors occurred during the radiative transfer computations, no processing possible" occurred.		
number_of_optimal_estimation_error_occurrences	Number of ground pixels where "errors occurred during the optimal estimation, processing has been terminated" occurred.		
number_of_profile_error_occurrences	Number of ground pixels where "flag that indicates if there were any errors during the computation of the ozone profile" occurred.		
number_of_cloud_error_occurrences	Number of ground pixels where "no cloud data" occurred.		
number_of_model_error_occurrences	Number of ground pixels where "forward model failure" occurred.		
<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.		
number_of_cloud_pressure_spread_too_low_error_occurrences	Number of ground pixels where "cloud pressure variability to low to estimate a tropospheric column" occurred.		
number_of_cloud_too_low_level_error_occurrences	Number of ground pixels where "clouds are too low in the atmosphere to assume sufficient shielding" occurred.		
number_of_generic_range_error_occurrences	Number of ground pixels where "generic range error" occurred.		
number_of_generic_exception_occurrences	Number of ground pixels where "catch all generic error" occurred.		

Number of ground pixels where "too large standard deviation of altitude in

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

number_of_altitude_roughness_filter_occurrences

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.

DEM" occurred.

Table 5: 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
number of aai_scene albedo filter_occurrences

number_of_small_pixel_radiance_std_filter_occurrences

number_of_cloud_fraction_viirs_filter_occurrences
number_of_cirrus_reflectance_viirs_filter_occurrences
number_of_cf_viirs_swir_ifov_filter_occurrences
number_of_cf_viirs_swir_ofova_filter_occurrences
number_of_cf_viirs_swir_ofovb_filter_occurrences
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 5: Common quality assurance parameters. (continued).

N	2	m	Δ
IV	-		-

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 [H₂O]_{weak} and [H₂O]_{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 5: Common quality assurance parameters. (continued).

Name	Description
number_of_time_range_filter_occurrences	Number of ground pixels where "time is out of the range that is to be processed" occurred.
number_of_pixel_or_scanline_index_filter_occurrences	Number of ground pixels where "not processed because pixel index does not match general selection criteria" occurred.
number_of_geographic_region_filter_occurrences	Number of ground pixels where "pixel falls outside the specified regions of interest" occurred.
number_of_input_spectrum_warning_occurrences	Number of ground pixels where "number of good pixels in radiance, irradiance or calculated reflectance below threshold from configuration" occurred.
number_of_wavelength_calibration_warning_occurrences	Number of ground pixels where "offset from wavelength fit is larger than limit set in configuration" occurred.
number_of_extrapolation_warning_occurrences	Number of ground pixels where "pressure or temperature outside cross section LUT range, other lookup table extrapolation" occurred.
number_of_sun_glint_warning_occurrences	Number of ground pixels where "sun glint posibility warning" occurred.
number_of_south_atlantic_anomaly_warning_occurrences	Number of ground pixels where "TROPOMI is inside the south Atlantic anomaly while taking these measurements" occurred.
number_of_sun_glint_correction_occurrences	Number of ground pixels where "A sun glint correction has been applied" occurred.
number_of_snow_ice_warning_occurrences	Number of ground pixels where "snow/ice flag is set, i.e. using scene data from the cloud support product" occurred.
number_of_cloud_warning_occurrences	Number of ground pixels where "cloud filter based on FRESCO apparent surface pressure (VIIRS not available), cloud fraction above threshold or cloud pressure adjusted to force cloud above surface. In case of Cloud product this flag indicates the possiblity of ice-clouds" occurred.
number_of_AAI_warning_occurrences	Number of ground pixels where "possible aerosol contamination as either indicated by the AAI (O ₃ profile) or other criteria (Cloud)" occurred.
number_of_pixel_level_input_data_missing_occurrences	Number of ground pixels where "dynamic auxiliary input data (e.g cloud) is missing for this ground pixel. A fallback option is used" occurred.

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

Name	Description
number_of_data_range_warning_occurrences	Number of ground pixels where "carbon monoxide column tends to negative values; Water column tends to negative values; Heavy water (HDO) column tends to negative values; others. In case of the O ₃ product this flag indicates VCD or effective albedo values outside a valid range. In case of the SO ₂ or the HCHO product this flag indicates AMF values outside a valid range" occurred.
number_of_low_cloud_fraction_warning_occurrences	Number of ground pixels where "low cloud fraction, therefore no cloud pressure retrieved" occurred.
<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" occurred.
<pre>number_of_so2_volcanic_origin_certain_warning_occurrences</pre>	Number of ground pixels where "warning for SO_2 BL product, UTLS products: volcanic origin certain" occurred.
number_of_interpolation_warning_occurrences	Number of ground pixels where "warning for interpolation on partially missing data. In this case the valid available data is used, potentially leading to a bias" occurred.
number_of_saturation_warning_occurrences	Number of ground pixels where "saturation occurred spectrum, possibly causing biases in the retrieval" occurred.
number_of_high_sza_warning_occurrences	Number of ground pixels where "warning for high solar zenith angle. In this case, the processing can be performed with less final quality" occurred.
number_of_cloud_retrieval_warning_occurrences	Number of ground pixels where "warning occurring when the retrieval diagnostic indicates a degraded quality of the cloud retrieval" occurred.
number_of_cloud_inhomogeneity_warning_occurrences	Number of ground pixels where "the cloud coregistration inhomogeneity parameter is above a given threshold" occurred.

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11 Generic metadata and attributes

Metadata gives information about the satellite, algorithms, configuration as well as other parameters useful for the interpretation of the processed data and tracing the production process of the level 2 files. The Sentinel 5 precursor product files, both for level 1B and level 2 contain a rich amount of metadata, both at the variable level and at the granule level. The full description of the metadata in the files for the Formaldehyde HCHO product is given in the file format description, in section 12.2. Here we provide some background on what can be found in which location. The abbreviations listed in table 6 are used in the following part of this document to better identify the nature of the attributes.

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

Abbreviation	Description
NUG	netCDF-4 Users Guide [ER7]
CF	Climate and Forecast metadata conventions [ER5], which includes the COARDS [ER10] conventions
ISO	ISO standards 19115, 19115-2 and 19157 [RD27, RD28, RD29]
Inspire	Inspire directive [ER4]
ACDD	ESIP-ACDD Attribute convention for dataset discovery [ER6]
CCI	Attributes requested by the ESA climate change initiative project. These largely overlap with the ACDD attributes.
ESA	Fixed ESA Header [RD26]
S5P	Internal use – mostly for retrieval settings, possibly as an extension to ISO 19115 [RD27]
S	Attribute is a string attribute
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).
T	Attribute is a CCSDS-ASCII time representation ("UTC=" + ISO 8601 [RD35])

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

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

11.1 The Climate and Forecast conventions

The CF metadata conventions [ER5] provide guidelines for attributes for variables so that the link between data and its geolocation and time of observation can be made automatically. Applying the CF-metadata conventions to the output products already limits the number of choices we will have to make. Units and other attributes are already defined and some structure is provided by the CF-conventions, for instance in linking data fields with geolocation.

11.2 NetCDF User Guide Conventions

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

486 11.3 Global attributes

Global attributes that are present at the root level of a S5p L2 product as described in section 12. These are mostly string attributes.

11.4 ESA earth observation header

The ESA earth observations file format guidelines and tailoring for S5P [RD26, RD25] specify the creation of a header file with a basic description of the contents of an output file. This header file consists of a fixed part and a customizable variable part. The variable part contains the lineage of the product is repeated, see section 12.2.3.91 for a description the the attributes contained in this part of the header. The fixed header is described in tables 7 – 9.

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

Name	Data type	Definition
File_Name	S	File name of the product without extension.
File_Description	S	Description of the file type.
Notes	S	Any type of notes/comments (multi-lines).
Mission	S	Description of the mission (Fixed to "S5P")
File_Class	S	Description of the file class. It is redundant with the File Class element embedded in the File Name.(e.g., "NRTI")
File_Type	S	Description of the file type, for the current product it is set to "L2Formaldehyde HCHO". It is redundant with the File Type element embedded in the File Name.
Validity_Period	Group, see table 8	Time coverage of the data.
File_Version	I	It is redundant with the File Version element embedded in the File Name.
Source	Group, see table 9	Information about the ground segment facility where the product was generated.

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

Name	Data type	Definition
Validity_Start	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 9: Fields in the source group. The data types refer to the short list in table 6.

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

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

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

11.5 Inspire directive

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

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

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

11.6 ISO and OGC standards

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

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

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

11.7 Attributes

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

Table 10: netCDF-4 type definitions and fill values. In order to avoid rounding errors, it is recommended to use the hexadecimal notation when specifying fill values for float and double types. Note that these are the netCDF-4 default fill values, there should be no need to specify these values explicitly. In some cases the fill value for float or double variables may fall within the valid range of a variable. For those cases an explicit fill value must be set, the value $-9.9692099683868690 \times 10^{36}$ (hex: $-0 \times 1.ep+122$) is recommended for these cases.

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

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

Name	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 ² to data-fields.
comment	S	CF	Miscellaneous information about the data or methods used to produce it.
coordinates	S	CF	Identifies auxiliary coordinate variables, providing a connection between data and geolocation, time.
_FillValue	Р	NUG	Value to represent missing or undefined data. Recommended (default) values are given in table 10.
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 11: Attributes for variables used in S5p netCDF-4 files (continued).

Name	Type	Std.	Description
standard_error_multiplier	F	CF	If a data variable with a standard_name modifier of standarderror has this attribute, it indicates that the values are the stated multiple of one standard error. The only allowed value for S5p files is 1, used only to disambiguate.
standard_name	S	CF	A standard name that references a description of a variable's content in the standard name table.
units	S	CF	Units of a variable's content. See section 9 for a detailed discussion.
valid_max	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

12 Description of the Tropospheric Formaldehyde product

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

These are the file-level attributes.

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

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.

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

If the TM5 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_CTMFCT_CTMANA" global attribute.

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

In case of unavailability of Aerosol Index auxiliary data, fallback solution will be used and the L2 output file will be flagged accordingly.

If the L2 Cloud auxiliary data is not available or not valid it will be automatically internally computed. In this case the Level 2 output file will be flagged using the "Status_L2__CLOUD_" global attribute as "Internal".

The information tracks if the earthshine spectrum was used instead of the solar spectrum. In this case the Level 2 output file will be flagged using the "Status_reference_spectrum" global attribute.

Global attributes in HCHO__

Group attributes attach	ned to HCHO	
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 [RD35] string. This corresponds to the UTC value in the time dimensional variable. By definition it indicates UTC midnight before the start of the granule.

time_reference_days_since_1950 0 (dynamic)

NC_INT

The reference time expressed as the number of days since 1950-01-01. This is the reference time unit used by both TM5 and ECMWF.

time reference julian day

0.0 (dynamic)

NC DOUBLE

The reference time expressed as a Julian day number.

time_reference_seconds_since 1970 0 (dynamic)

NC INT64

The reference time expressed as the number of seconds since 1970-01-01 00:00:00 UTC. This is the reference time unit used by Unix systems.

time_coverage_start

'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)

NC_STRING

Start of the data granule in UTC as an ISO 8601 [RD35] string. See the discussion of the $delta_time$ variable on page 39 for details.

time coverage end

'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)

NC STRING

End of the data granule in UTC as an ISO 8601 [RD35] string. See the discussion of the delta_time variable on page 39 for details.

time coverage duration

NC STRING

Duration of the data granule as an ISO 8601 [RD35] duration string ("PT%(duration_seconds)sS"). This attribute originates from the CCI standard.

time coverage resolution

NC STRING

Interval between measurements in the data granule as an ISO 8601 [RD35] duration string ("PT%(interval_seconds)fS"). For most products this is 840 or 1080 ms in nominal operation, except for "L2__O3__PR", which uses 3240 ms due to coaddition. This attribute originates from the CCI standard.

orbit

0 (dynamic)

NC INT

The absolute orbit number, starting at 1 – first ascending node crossing after spacecraft separation. For pre-launch testing this value should be set to "-1".

references

'%(references)s' (static)

NC STRING

References that describe the data or methods used to produce it. This attribute originates from the CF standard.

processor version

'%(version)s' (dynamic)

NC STRING

The version of the data processor, as string of the form "major.minor.patch".

keywords vocabulary

'AGU index terms, http://publications.agu.org/author-resource-center/index-terms/' (static)

NC STRING

The guidelines followed for the keywords attribute. We use the index terms published by the AGU.

keywords

'%(keywords_agu)s' (dynamic)

NC STRING

Keywords from the "keywords_vocabulary" describing the contents of the file. To be provided by the ATBD authors.

standard_name_vocabulary	'NetCDF Climate and Forecast Metadata Conventions	NC_STRING
	Standard Name Table (v29, 08 July 2015), http://cfconventions.org/standard-names.html' (static)	
The table followed for the standa	rd_name attributes.	
naming_authority	'%(naming_authority)s' (dynamic)	NC_STRING
Specify who is giving out the ${\tt id}$	attribute. This attribute originates from the CCI standard.	
cdm_data_type	'Swath' (static)	NC_STRING
The THREDDS data type approattribute originates from the CCI	opriate for this dataset, fixed to "Swath" for S5P level 2 standard.	products. This
date_created	'YYYY-mm-ddTHH:MM:SS.ffffffZ' (dynamic)	NC_STRING
The date on which this file was o	reated. This attribute originates from the CCI standard.	
creator_name	'%(credit)s' (dynamic)	NC_STRING
to "The Sentinel 5 Precursor TR Space Agency (ESA), the Nether Aerospace Center (DLR) and the	to the value of the "gmd:credit" attribute. For S5P this OPOMI Level 2 products are developed with funding from the Space Office (NSO), the Belgian Science Policy Office Bayerisches Staatsministerium für Wirtschaft und Medicute originates from the CCI standard.	m the European fice, the German
creator_url	'%(creator_url)s' (dynamic)	NC_STRING
Hyperlink to a location where more u/. This attribute originates fro	e information on the product can be found. Set to $\mathtt{http://m}$ m the CCI standard.	/www.tropomi.
creator_email	'EOSupport@Copernicus.esa.int' (dynamic)	NC_STRING
Point of contact for mo- "mailto:EOSupport@Copernicus	re information and support for this productesa.int". This attribute originates from the CCI standard.	Set to
project	'Sentinel 5 precursor/TROPOMI' (dynamic)	NC_STRING
The name of the scientific project	t that created the data. This attribute originates from the	CCI standard.
geospatial_lat_min		NC_FLOAT
Lowest latitude present in the file	e in decimal degrees. This attribute originates from the Co	CI standard.
geospatial_lat_max		NC_FLOAT
Highest latitude present in the fil	e in decimal degrees. This attribute originates from the C	CI standard.
geospatial_lon_min		NC_FLOAT
Lowest longitude present in the f	file in decimal degrees. This attribute originates from the	CCI standard.
geospatial_lon_max		NC_FLOAT
Highest longitude present in the	file in decimal degrees. This attribute originates from the	CCI standard.
license	'No conditions apply' (static)	NC_STRING
describe the restrictions to data originates from the CCI standard	access and distribution. For S5P "No conditions apply I.	". This attribute
platform	'S5P' (static)	NC_STRING
Name of the satellite, set to "S5F	P". This attribute originates from the CCI standard.	
sensor	'TROPOMI' (static)	NC_STRING
Name of the sensor, set to "TRO	POMI". This attribute originates from the CCI standard.	
spatial_resolution		NC_STRING
size since 6th of August 2019),	ost products this is either " $7.2 \times 3.6 \text{km}^2$ " or " $5.6 \times 3.6 \text{km}^2$ " except for " L2 03PR", which uses " $28 \times 21 \text{km}^2$ " and use" $7 \times 7 \text{km}^2$ ". This attribute originates from the CCI states	"L2CO"
cpp_compiler_version		NC STRING
	for the C++ code. The value of this attribute is set via the	_
cpp_compiler_flags		NC_STRING
	C++ compiler. The value of this attribute is set via the M	_
f90 compiler version	,	NC_STRING

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

f90 compiler flags

NC STRING

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

exe_linker_flags

NC STRING

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

build date

NC STRING

The date on which the processor was built.

revision_control_identifier

'%(revision_control_source_identifier)s' (dynamic)

NC_STRING

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

geolocation grid from band

NC_INT

The band from which the geolocation was taken, useful for colocating the level 2 output with other products.

identifier_product_doi

'%(product doi)s' (dynamic)

NC STRING

This is the DOI ("Digital Object Identifier") of the current product. It allows to easily find download and background information, even if that location is moved after the file has been created.

identifier_product_doi_au-

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

NC_STRING

This attribute defines the authoritative service for use with DOI values in resolving to the URL location.

algorithm_version

'%(algorithm_version)s' (dynamic)

NC STRING

The algorithm version, separate from the processor (framework) version, to accommodate different release schedules for different products.

product version

'0.0.0' (dynamic)

NC STRING

The product version, separate from the processor (framework) and algorithm version.

processing_status

'Nominal' (dynamic)

NC_STRING

Description the processing status of the granule on a global level, mainly based on the availability of auxiliary input data.

Possible values: Nominal, Degraded

cloud_mode

NC STRING

The attribute aims at identifying the source of the cloud parameter, either "cal" or "crb".

Possible values: crb, cal

title

'TROPOMI/S5P Tropospheric Formaldehyde HCHO' (dynamic)

NC_STRING

This is a short description of the product. In near-realtime processing the granule may be shorter than 1 orbit. In that case the title will become dynamic. This attribute originates from the NUG standard.

references

'https://atmos.eoc.dlr.de/tropomi' (static)

NC_STRING

References that describe the data or methods used to produce it. A URI to the ATBD seems to be an appropriate starting point. This attribute originates from the CF standard.

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

Status_NISE_

NC STRING

The status of NISE input, either "Nominal" or "Fallback".

Possible values: Nominal, Fallback

Status_CTMFCT_CTMANA

NC_STRING

The status of TM5 Temperature profiles, NO_2 , SO_2 and HCHO profiles, either "Nominal" or "Fallback". Possible types of TM5 data are "AUX_CTMFCT" for forecast or "AUX_CTMANA" for analysis.

B "1	
Possible values: Nominal, Fallback	
Status_BG	NC_STRING
The status of background correction input, either "Nominal" or "Fallback".	
Possible values: Nominal, Fallback	
Status_AER_AI	NC_STRING
The status of Aerosol Index input, either "Nominal", "Fallback" or "Unneeded".	
Possible values: Nominal, Fallback, Unneeded	
Status_L2CLOUD_	NC_STRING
The status of L2 cloud input, either "External" or "Internal".	
Possible values: External, Internal	
Status_reference_spectrum 'solar earth' (dynamic)	NC_STRING
The status of reference spectrum, either "earth" or "solar". Note that the earthshine s from the auxiliary BG processor and it is read in the L2 processor from this intermed	•
Possible values: earth, solar	·

12.1 Group "PRODUCT" in "HCHO__"

This is the main group containing the tropospheric formaldehyde HCHO product. At this level the dimensions are defined, the actual data can be found one level deeper.

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.

The corner dimension is common to certain 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.

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

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

Dimensions in HCHO /PRODUCT

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

size Unlimited.

550

554

555

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566

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574

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.
```

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

size 1 (fixed)

corner The number of corners for a pixel.

size 4 (fixed)

1573 layer The number of layers in the averaging kernels, a-priori profile and ECMWF constants.

```
size 1 (dynamic) source Processor.
```

Variables in HCHO /PRODUCT

NC STRING

scanline in HCHO /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.

scanline (coordinate variable). Dimensions:

Type: NC INT. Source: Processor.

Attributes: Name Value Type

'1' (static)

Dimensionless, no physical quantity. This attribute originates from the CF standard.

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

ground pixel in HCHO /PRODUCT

units

Description: The coordinate variable ground_pixel refers to the across-track dimension of the meas-

> urement. The ground_pixel ordering is from left to right with respect to the flight direction. For the Sentinel 5 precursor orbit this corresponds to west to east during the ascending part of the orbit, i.e. a higher index corresponds to a higher longitude. This variable merely contains an index to ensure that when indicating a pixel in a file the same index is used.

This avoids the off-by-one confusion that frequently occurred in OMI discussions.

Dimensions: ground pixel (coordinate variable).

Type: NC INT. Source: Processor.

Attributes: Name Value Type

> '1' (static) NC STRING units

Dimensionless, no physical quantity. This attribute originates from the CF standard.

axis	'X' (static)	NC_STRING
long_name	'across-track dimension index' (static)	NC_STRING
comment	'This coordinate variable defines the indices across track, from west to east; index starts at 0' (static)	NC_STRING

time in HCHO /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 [RD35] date.

Dimensions: time (coordinate variable).

Type: NC INT.

Source: Processor. **Attributes**

s:	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

	comment	'The time in this variable corresponds to the time in	NC_STRING	
		the time_reference global attribute' (static)	NO_OTHING	
corner in HCI	HO/PRODUCT			
Description:	An index for the pixel corners. We follow the CF-Metadata conventions [ER5, section 7.1]. The full coordinate system is right-handed, and the order of the pixel corners is counterclockwise, starting in the "lower-left" corner (i.e. the smallest value in both latitude and longitude on the ascending part of the orbit, or equivalently for TROPOMI the lowest value for both the <code>ground_pixel</code> and <code>scanline</code> indices). See figure 5 on page 17 for a graphical depiction of the corners.			
Dimensions:	corner (coordinate variable).			
Type:	NC_INT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (static)	NC_STRING	
	Dimensionless, no	physical quanity. 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 a 0 (counter-clockwise, starting from south-western corner of the pixel in ascending part of the orbit).' (static)	NC_STRING	
latitude in HC	CHO/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 l	HCHO/PRODUCT			
Description:	_	ne pixel centers of the ground pixels in the data. L 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 HCHO /PRODUCT

Description:

The delta_time (scanline) variable indicates the time difference with the reference time time (time) (see page 37). Thus combining the information of time (time) and delta_time (scanline) yields the start of the measurement time for each scanline as 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, ground_pixel.

Type: NC_INT.
Source: Processor.

Attributes: Name Value Type

 long_name
 'offset from reference start time of measurement' (static)
 NC_STRING

 units
 'milliseconds since %(ref_time)s' (static)
 NC_STRING

time utc in HCHO /PRODUCT

Description: The time of observation expressed as ISO 8601 [RD35] 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 HCHO /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	Туре
units	'1' (static)	NC_STRING
scale_factor	0.01 (static)	NC_FLOAT
add_offset	0 (static)	NC_FLOAT
valid_min	0 (static)	NC_UBYTE
valid_max	100 (static)	NC_UBYTE
long_name	'data quality value' (static)	NC_STRING
comment	'A continuous quality descriptor, varying between 0 (no data) and 1 (full quality data). Recommend to ignore data with qa_value < 0.5' (static)	NC_STRING

	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
formaldehyd	e_tropospheric_ver	tical_column in HCHO/PRODUCT	
Description:	Vertical column den	sity of tropospheric formaldehyde HCHO product.	
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Type
	units	'mol m-2' (static)	NC_STRING
	standard_name	'troposphere_mole_content_of_formaldehyde' (static)	NC_STRING
	long_name	'vertical column of formaldehyde' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the 0	
	multiplication factor_to_con- vert_to_DU	2241.15 (static)	NC_FLOAT
	value this means th "DU" or Dobson Uni	entinel 5 precursor files are given in SI units. For an integrate the unit is $molm^{-2}$. Traditionally the unit for an integrate. This attribute provides the multiplication factor to the value in $molm^{-2}$. This is provided as a convenient of $molm^{-2}$.	egrated column is calculate the total
	multiplication factor_to_con- vert_to_mo- lecules percm2	6.02214e+19 (static)	NC_FLOAT
		entinal 5 procureer files are given in Stupits. For an i	ntograted column
	The quantities in Se value this means the is "molecules cm ⁻² ". column in molecules	entinel 5 precursor files are given in SI units. For an intensity is $molm^{-2}$. Traditionally the unit for an intensity is $molm^{-2}$. This attribute provides the multiplication factor to $molm^{-2}$ from the value in $molm^{-2}$. This is provided as its that work in molecules $molm^{-2}$.	ntegrated column calculate the total
formaldehyd	The quantities in Se value this means the is "molecules cm ⁻² ". column in molecules users who have too	nat the unit is $\mathrm{mol}\mathrm{m}^{-2}$. Traditionally the unit for an in This attribute provides the multiplication factor to ccm^{-2} from the value in $\mathrm{mol}\mathrm{m}^{-2}$. This is provided as	ntegrated column calculate the total
formaldehyden Description:	The quantities in Se value this means the is "molecules cm ⁻² ". column in molecules users who have too e_tropospheric_vert	nat the unit is $\mathrm{mol}\mathrm{m}^{-2}$. Traditionally the unit for an in. This attribute provides the multiplication factor to cscm^{-2} from the value in $\mathrm{mol}\mathrm{m}^{-2}$. This is provided as ls that work in molecules cm^{-2} .	ntegrated column calculate the total a convenience to
-	The quantities in Se value this means the is "molecules cm ⁻² ". column in molecules users who have too e_tropospheric_vert	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as also that work in molecules cm ⁻² . tical_column_precision in HCHO/PRODUCT ertical column density of tropospheric formaldehyde H	ntegrated column calculate the total a convenience to
Description:	The quantities in Se value this means the is "molecules cm ⁻² ". column in molecules users who have too e_tropospheric_vertor Random error of Vertor the second sec	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as also that work in molecules cm ⁻² . tical_column_precision in HCHO/PRODUCT ertical column density of tropospheric formaldehyde H	ntegrated column calculate the total a convenience to
Description: Dimensions:	The quantities in Se value this means the is "molecules cm-2". column in molecules users who have too e_tropospheric_vertandom error of Vettime, scanline, group	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as also that work in molecules cm ⁻² . tical_column_precision in HCHO/PRODUCT ertical column density of tropospheric formaldehyde H	ntegrated column calculate the total a convenience to
Description: Dimensions: Type:	The quantities in Se value this means the second of the se	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as also that work in molecules cm ⁻² . tical_column_precision in HCHO/PRODUCT ertical column density of tropospheric formaldehyde H	ntegrated column calculate the total a convenience to
Description: Dimensions: Type: Source:	The quantities in Se value this means the second means the second means are column in molecules users who have too etropospheric_vertandom error of Vertime, scanline, group NC_FLOAT. Processor.	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as ls that work in molecules cm ⁻² . tical_column_precision in HCHO/PRODUCT ertical column density of tropospheric formaldehyde H md_pixel.	ntegrated column calculate the total a convenience to CHO product.
Description: Dimensions: Type: Source:	The quantities in Se value this means the second of the se	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as list hat work in molecules cm ⁻² . tical_column_precision in HCHO/PRODUCT ertical column density of tropospheric formaldehyde H and_pixel. Value	ntegrated column calculate the total a convenience to CHO product. Type
Description: Dimensions: Type: Source:	The quantities in Se value this means the substitution of the subs	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as ls that work in molecules cm ⁻² . tical_column_precision in HCHO/PRODUCT entical column density of tropospheric formaldehyde H nd_pixel. Value 'mol m-2' (static) 'troposphere_mole_content_of formaldehyde	ntegrated column calculate the total a convenience to CHO product. Type NC_STRING
Description: Dimensions: Type: Source:	The quantities in Se value this means the second of the se	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to conscm ⁻² from the value in mol m ⁻² . This is provided as list hat work in molecules cm ⁻² . **tical_column_precision* in HCHO/PRODUCT ertical column density of tropospheric formaldehyde H and_pixel. **Value* 'mol m-2' (static) 'troposphere_mole_content_of formaldehyde standard_error' (static)	ntegrated column calculate the total a convenience to CHO product. Type NC_STRING NC_STRING
Description: Dimensions: Type: Source:	The quantities in Se value this means the second means the second means the second means are second means and the second means are second means and the second means are second means.	nat the unit is mol m ⁻² . Traditionally the unit for an in. This attribute provides the multiplication factor to compare the value in mol m ⁻² . This is provided as ls that work in molecules cm ⁻² . **tical_column_precision* in HCHO/PRODUCT* ertical column density of tropospheric formaldehyde H and_pixel. **Value** 'mol m-2' (static)* 'troposphere_mole_content_of formaldehyde standard_error' (static)* 'random error of vertical column density' (static)*	Type NC_STRING NC_STRING NC_STRING NC_STRING AC_STRING

factor_to_con-vert_to_DU

NC FLOAT

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_- 6.02214e+19 (static) factor_to_con-

vert 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⁻²". 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 $\mathrm{molecules}\,\mathrm{cm}^{-2}$.

12.1.1 Group "SUPPORT_DATA" in "PRODUCT"

12.1.1.1 Group "GEOLOCATIONS" in "SUPPORT DATA"

Variables in HCHO__/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

satellite_latitude in HCHO_	_/PRODUCT/SUPPORT_	DATA/GEOLOCATIONS

Description: Latitude of the geodetic sub satellite point on the WGS84 reference ellipsoid.

Dimensions: time, scanline. Type: NC_FLOAT.

Source: L1B.

Attributes:	Name	Value	Type
	long_name	'sub satellite latitude' (static)	NC_STRING
	units	'degrees_north' (static)	NC_STRING
	comment	'Latitude of the geodetic sub satellite point on the	NC_STRING

	WGS84 reference ellipsoid' (static)	
valid_min	-90.0 (static)	NC_FLOAT
valid max	90.0 (static)	NC FLOAT

satellite longitude in HCHO /PRODUCT/SUPPORT DATA/GEOLOCATIONS

Description: Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid.

Dimensions: time, scanline.

Type: NC_FLOAT.

Source: L1B.

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

satellite_altitude in HCHO__/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

Description: The altitude of the satellite with respect to the geodetic sub satellite point on the WGS84

reference ellipsoid.

Dimensions: time, scanline.

Type:	NC_FLOAT.		
Source:	L1B.		
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_orbi	t_phase in HCHO	PRODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:	Relative offset [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 HCHO/P	PRODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:	measured away from when $artheta_0 \leq artheta_0^{\sf max}$ with	ϑ_0 at the ground pixel location on the reference el m the vertical. ESA definition of day side: $\vartheta_0 < 92^\circ$. Pix ith $80^\circ \le \vartheta_0^{\sf max} \le 88^\circ$, depending on the algorithm. The in the algorithm metadata settings.	els are processed
Dimensions:	time, scanline, grou	ınd_pixel.	
Type:	NC_FLOAT.		
Source:	L1B.		
Attributes:	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
		ngitude are in a different group. How to specify the r case is not specified in the climate and forecast r	
	comment	'Solar zenith angle at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical' (static)	NC_STRING

solar_azimuth_angle in HCHO__/PRODUCT/SUPPORT_DATA/GEOLOCATIONS

Description: The solar azimuth angle at the ground pixel location on the reference ellipsoid. The angle is measured clockwise from the North (North = 0° , East = 90° , South = $\pm 180^{\circ}$, West = -90°).

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, grou	und_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	_
	The latitude and lo	ngitude are in a different group. How to specify the	· —
		case is not specified in the climate and forecas	
	comment	'Solar azimuth angle at the ground pixel location o the reference ellipsoid. Angle is measured clock wise from the North (East = 90, South = +/-180 West = -90)' (static)	<-
viewing_zeni	i th_angle in HCHO_	_/PRODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:	Zenith angle of the is measured away	satellite ϑ at the ground pixel location on the refere from the vertical.	nce 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' (station) NC_STRING
		ngitude are in a different group. How to specify the case is not specified in the climate and forecas	.
	comment	'Zenith angle of the satellite at the ground pixel location on the reference ellipsoid. Angle is measure away from the vertical' (static)	
viewing_azin	nuth_angle in HCHC	D/PRODUCT/SUPPORT_DATA/GEOLOCATIONS	}
Description:	is measured clock	h angle at the ground pixel location on the reference wise from the North (North = 0° , East = 90° , Sour same definition that is use in both OMI and GOME-2	th = $\pm 180^{\circ}$, West =
	,	zimuth difference $arphi-arphi_0$ it is not sufficient to jus	
	azimuth_angle ${\sf f}$	rom viewing_azimuth_angle. The angle neede $180^{\circ}-(\varphi-\varphi_0)) \bmod 360^{\circ}.$	
Dimensions:	time, scanline, grou		
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

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	valid_min	-180.0 (static)	NC_FLOAT
	valid_max	180.0 (static)	NC_FLOAT
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		longitude are in a different group. How to specify the is case is not specified in the climate and forecast	• .
	comment	'Satellite azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = +/-180, West = -90)' (static)	
latitude_bou	nds in HCHO/Pl	RODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:		he pixel corners of the ground pixels in the data. In the ground pixel corners and the ground pixel corners are ground pixel corners.	
		pixel corners follows the CF-metadata conventions [EF punter-clockwise when viewed from above. A graphical	
Dimensions:	time, scanline, gr	ound_pixel, corner.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'degrees_north' (static)	NC_STRING
longitude_bo	ounds in HCHO/	PRODUCT/SUPPORT_DATA/GEOLOCATIONS	
Description:		the pixel corners of the ground pixels in the data.	

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 5.

Dimensions: time, scanline, ground_pixel, corner.

Type: NC_FLOAT. Source: Processor.

 Attributes:
 Name
 Value
 Type

 units
 'degrees_east' (static)
 NC_STRING

geolocation_flags in HCHO__/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.

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

12.1.1.2 Group "DETAILED_RESULTS" in "SUPPORT_DATA"

Wavelength calibrations are written in the product.

Dimensions in HCHO_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

number of slant columns The number of slant columns density.

size 1 (dynamic) source Processor.

number_of_slant_columns_first_win1 The number of slant columns density for the first interval.

size 1 (dynamic)
source Processor.

number_of_doas_polynomial_coefficients The number of the DOAS polynomial coefficients

size 1 (dynamic) source Processor.

debug_upas2_levels_1 Level Dim for debugging porpuse.

size -1 (fixed)

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Variables in HCHO /PRODUCT/SUPPORT DATA/DETAILED RESULTS

 $\begin{tabular}{ll} formal dehyde_tropospheric_vertical_column_trueness & in HCHO_/PRODUCT/SUPPORT_DATA/DETAILED RESULTS \\ \end{tabular}$

Description: Systematic error of Vertical column density of tropospheric formaldehyde HCHO product.

Dimensions: time, scanline, ground pixel.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'mol m-2' (static)	NC_STRING
long_name	'Systematic error of vertical column density' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

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

multiplication_- 2241.15 (static)

NC_FLOAT

factor_to_convert to DU

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 "DU" or Dobson Units. This attribute provides the multiplication factor to calculate the total column in DU from the value in $\mathrm{mol}\,\mathrm{m}^{-2}$. This is provided as a convenience to users who have tools that work in DU.

multiplication_- 6 factor_to_con-

6.02214e+19 (static)

NC FLOAT

vert_to_molecules_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⁻²". 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 $\mathrm{molecules}\,\mathrm{cm}^{-2}$.

fitted_slant_columns in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Slant Column Density N^s

Dimensions: time, scanline, ground_pixel, number_of_slant_columns.

Type: NC_DOUBLE. Source: Processor.

Attributes:

Name	Value	Туре
units	'mol m-2' (static)	NC_STRING
long_name	'slant columns of all absorbers' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

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

index_meaning '1' (dynamic)

NC_STRING

This attribute provides the meaning of the indexes for the current variable. Indexes are supposed to be divided by a blank space.

multiplication_- 2241.15 (static) factor_to_convert to DU

NC_FLOAT

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 - 6.02214e+19 (static)

NC FLOAT

factor_to_convert_to_molecules_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^{-2} ". 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 $\mathrm{molecules}\,\mathrm{cm}^{-2}$.

fitted_slant_columns_precision in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Slant Column Density N^s Random Error

Dimensions: time, scanline, ground_pixel, number_of_slant_columns.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'mol m-2' (static)	NC_STRING
long_name	'slant columns errors of all absorbers' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

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

index_meaning '1' (dynamic)

NC_STRING

This attribute provides the meaning of the indexes for the current variable. Indexes are supposed to be divided by a blank space.

multiplication_- 2241.15 (static) factor_to_convert to DU

NC_FLOAT

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 "DU" or Dobson Units. This attribute provides the multiplication factor to calculate the total column in DU from the value in $\mathrm{mol}\,\mathrm{m}^{-2}$. This is provided as a convenience to users who have tools that work in DU.

multiplication_-

6.02214e+19 (static)

NC FLOAT

factor_to_convert_to_molecules 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⁻²". 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 $\mathrm{molecules}\,\mathrm{cm}^{-2}$.

formaldehyde_slant_column_corrected_trueness

HCHO /PRODUCT/SUPPORT DATA/

DETAILED_RESULTS

Description: Systematic error of the slant column density.

Dimensions: time, scanline, ground pixel.

Type: NC_FLOAT.
Source: Processor.

Attributes:

Name	Value	Туре
units	'mol m-2' (static)	NC_STRING
standard_name	'TBA' (static)	NC_STRING
long_name	'systematic error of the slant column density' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

multiplication_- 2241.15 (static)

NC FLOAT

factor_to_convert_to_DU

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 "DU" or Dobson Units. This attribute provides the multiplication factor to calculate the total column in DU from the value in $\mathrm{mol}\,\mathrm{m}^{-2}$. This is provided as a convenience to users who have tools that work in DU.

multiplication_-

6.02214e+19 (static)

NC_FLOAT

factor_to_convert_to_molecules 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⁻²". 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 $\mathrm{molecules}\,\mathrm{cm}^{-2}$.

formaldehyde_slant_column_corrected in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RES-ULTS

Description: Slant column density N^s corrected by the background correction algorithm.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'mol m-2' (static)	NC_STRING
standard_name	'TBA' (static)	NC_STRING
long_name	'corrected slant column density' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

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

multiplication_- 2241.15 (static)

NC FLOAT

factor_to_convert to DU

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 "DU" or Dobson Units. This attribute provides the multiplication factor to calculate the total column in DU from the value in $\mathrm{mol}\,\mathrm{m}^{-2}$. This is provided as a convenience to users who have tools that work in DU.

multiplication_-

6.02214e+19 (static)

NC FLOAT

factor_to_convert_to_molecules_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^{-2} ". 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 $\mathrm{molecules}\,\mathrm{cm}^{-2}$.

 ${\bf formaldehyde_slant_column_correction_flag} \ \ {\bf in} \ \ {\bf HCHO_/PRODUCT/SUPPORT_DATA/DETAILED_-RESULTS}$

Description: Flag pixel-wise which indicates if the background correction could have been applied to the

slant column density.

Dimensions: time, scanline, ground_pixel.

Type: NC_UBYTE. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
standard_name	'TBA' (static)	NC_STRING
long_name	'slant column density background correction flag' (static)	NC_STRING
comment	Empty!	NC_STRING
flag_meanings	'not-corrected,corrected' (static)	NC_STRING
flag_values	0, 1 (static)	NC_UBYTE
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

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

formaldehyde_tropospheric_vertical_column_correction in HCHO_/PRODUCT/SUPPORT_DATA/ DETAILED_RESULTS

Description: Background correction value which is added to the vertical column density.

Dimensions: time, scanline, ground_pixel.

Type: NC FLOAT.

Source: Attributes:

Processo	r.		
Name		Value	Туре
units		'mol m-2' (static)	NC_STRING
standard	_name	'TBA' (static)	NC_STRING
long_nar	ne	'background correction value which is added to the vertical column density' (static)	NC_STRING
coordina	tes	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		igitude coordinates of the TROPOMI swath is not defin	ed as a Cartesian

product of latitude and longitude axes.

multiplication_-2241.15 (static) factor_to_convert to DU

NC FLOAT

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_-

6.02214e+19 (static)

NC FLOAT

factor_to_convert_to_molecules percm2

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 "molecules cm⁻²". This attribute provides the multiplication factor to calculate the total column in molecules cm⁻² from the value in mol m⁻². This is provided as a convenience to users who have tools that work in molecules cm⁻².

formaldehyde_tropospheric_air_mass_factor in HCHO_/PRODUCT/SUPPORT_DATA/DETAILED_-

RESULTS Description:

Dimensions:

Total air mass factor, M time, scanline, ground_pixel.

NC FLOAT. Type: Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'tropospheric air mass factor' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

formaldehyde clear air mass factor in HCHO /PRODUCT/SUPPORT DATA/DETAILED RESULTS

Description: Clear air mass factor

Dimensions: time, scanline, ground pixel.

NC FLOAT. Type: Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'clear air mass factor' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

formaldehyde_cloudy_air_mass_factor in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RES-

ULTS

Description: Cloudy air mass factor
Dimensions: time, scanline, ground pixel.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'cloudy air mass factor' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

formaldehyde_tropospheric_air_mass_factor_precision in HCHO__/PRODUCT/SUPPORT_DATA/ DETAILED RESULTS

Description: Random error of the total air mass factor M

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'random error of the tropospheric air mass factor' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

formaldehyde_tropospheric_air_mass_factor_trueness in HCHO_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Systematic error of the total air mass factor M

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'systematic error of the tropospheric air mass factor' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

fitted radiance shift in HCHO /PRODUCT/SUPPORT DATA/DETAILED RESULTS

Description: earth-measurements wavelength shift from the doas fit.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT. Source: Processor.

Attributes:	Name	Value	Type
	units	'nm' (static)	NC_STRING
	long_name	'radiance wavelength shift from the doas fit' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ngitude coordinates of the TROPOMI swath is not defin and longitude axes. Following [ER5, section 5.2] we us	

connect the data with the geolocation. This attribute originates from the CF standard.

fitted radiance squeeze in HCHO /PRODUCT/SUPPORT DATA/DETAILED RESULTS

Description: earth-measurements wavelength squeeze/stretch from the doas fit.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'radiance wavelength squeeze/stretch from the doas fit' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

averaging kernel in HCHO /PRODUCT/SUPPORT DATA/DETAILED RESULTS

Description: Total column averaging kernel.

Dimensions: time, scanline, ground pixel, layer.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'total column averaging kernel' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

formaldehyde_profile_apriori in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Volume mixing ratio.

Dimensions: time, scanline, ground_pixel, layer.

Type: NC_FLOAT. Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
long_name	'tm5_hcho a priori profile (vmr) interpolated in space and time on ground pixel' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.

fitted_root_mean_square in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Root mean square from the doas fit.

Dimensions: time, scanline, ground_pixel.

Type: NC_FLOAT.

	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	long_name	'root mean square from the doas fit' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard.		
fitted_root_m	nean_square_win1	in HCHO/PRODUCT/SUPPORT_DATA/DETAILED_	RESULTS
Description:	Root mean square	e from prefitted BrO doas fit.	
Dimensions:	time, scanline, gro	ound_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	long_name	'root mean square in the first interval of the doas fit' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		with the geolocation. This attribute originates from the (ICHO/PRODUCT/SUPPORT_DATA/DETAILED_RES	
-			BOLIS
Description:		sity from prefitted BrO doas fit.	JOLIS
Dimensions:	time, scanline, gro	sity from prefitted BrO doas fit. bund_pixel, number_of_slant_columns_first_win1.	OCLIG
Dimensions: Type:	time, scanline, gro NC_DOUBLE.	•	JOLIS
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor.	und_pixel, number_of_slant_columns_first_win1.	
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor. Name	ound_pixel, number_of_slant_columns_first_win1. Value	Туре
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor.	value 'mol m-2' (static)	Type NC_STRING
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor. Name	ound_pixel, number_of_slant_columns_first_win1. Value	Туре
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor. Name units	Value 'mol m-2' (static) 'slant columns of all absorbers in the first interval	Type NC_STRING
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor. Name units long_name index_meaning This attribute prov	Value 'mol m-2' (static) 'slant columns of all absorbers in the first interval of the doas fit' (static)	Type NC_STRING NC_STRING NC_STRING
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor. Name units long_name index_meaning This attribute prov	Value 'mol m-2' (static) 'slant columns of all absorbers in the first interval of the doas fit' (static) '1' (dynamic) vides the meaning of the indexes for the current variation.	Type NC_STRING NC_STRING NC_STRING
·	time, scanline, gro NC_DOUBLE. Processor. Name units long_name index_meaning This attribute prov supposed to be di coordinates The latitude and lo product of latitude	Value 'mol m-2' (static) 'slant columns of all absorbers in the first interval of the doas fit' (static) '1' (dynamic) vides the meaning of the indexes for the current variations of the space.	Type NC_STRING NC_STRING Able. Indexes a NC_STRING ed as a Cartesia se this attribute
Dimensions: Type: Source:	time, scanline, gro NC_DOUBLE. Processor. Name units long_name index_meaning This attribute prov supposed to be di coordinates The latitude and lo product of latitude	Value 'mol m-2' (static) 'slant columns of all absorbers in the first interval of the doas fit' (static) '1' (dynamic) vides the meaning of the indexes for the current variation vided by a blank space. '/PRODUCT/longitude /PRODUCT/latitude' (static) ongitude coordinates of the TROPOMI swath is not definand longitude axes. Following [ER5, section 5.2] we use	Type NC_STRING NC_STRING Able. Indexes a NC_STRING ed as a Cartesise this attribute

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_- 6.02214e+19 (static) NC_FLOAT factor_to_con-vert_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⁻²". 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 $\mathrm{molecules}\,\mathrm{cm}^{-2}$.

fitted_slant_columns_win1_precision in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Description: Random error of the column density from prefitted BrO doas fit.

Dimensions: time, scanline, ground_pixel, number_of_slant_columns_first_win1.

Type: NC_FLOAT. Source: Processor.

Attributes: Name

Name	value	Type
units	'mol m-2' (static)	NC_STRING
long_name	'slant columns errors of all absorbers in the first interval of the doas fit' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

number_of_iterations_in_retrieval in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

Dimensions: time, scanline, ground pixel.

Type: NC_USHORT. Source: Processor.

Attributes: Name Value Type

units '1' (static) NC_STRING

long_name 'number of iterations used in the retrieval' (static) NC_STRING

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

number_of_iterations_in_retrieval_win1 in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RES-ULTS

Dimensions: time, scanline, ground_pixel.

Type: NC_USHORT. Source: Processor.

Attributes: Name Value Type

		7 I ⁻ -
units	'1' (static)	NC_STRING
long_name	'number of iterations used in the retrieval in the first interval of the doas fit' (static)	NC_STRING
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING

number_of_spectral_points_in_retrieval in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RES-ULTS

Description: The number of points in the spectrum that were used in the DOAS retrieval.

Dimensions: time, scanline, ground_pixel.

Type: NC_USHORT. Source: Processor.

Attributes: Name Value Type

		,,
long_name	'Number of spectral points used in the DOAS retrieval' (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].

Number of spectral points used in the retrieval in the first interval of the DOAS fit. Description: Dimensions: time, scanline, ground pixel. NC USHORT. Type: Source: Processor. Attributes: Name Value Type '1' (static) NC STRING units 'Number of spectral points used in the retrieval in NC STRING long name the first interval of the DOAS fit' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) coordinates NC STRING formaldehyde tropospheric air mass factor kernel trueness in HCHO /PRODUCT/SUPPORT -DATA/DETAILED RESULTS Description: Systematic error of the tropospheric air mass factor M when kernels are used. time, scanline, ground pixel. Dimensions: Type: NC FLOAT. Source: Processor. Attributes: Name Value Type units '1' (static) NC STRING 'systematic error of the air mass factor for the kernel NC STRING long name tropospheric formaldehyde' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) coordinates NC STRING The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard. formaldehyde tropospheric vertical column kernel trueness in HCHO /PRODUCT/SUPPORT -DATA/DETAILED RESULTS Systematic error of the tropospheric vertical column when kernels are used. Description: Dimensions: time, scanline, ground pixel. NC FLOAT. Type: Source: Processor. Attributes: Name Value Type units 'mol m-2' (static) NC STRING 'systematic error of the air mass factor for the kernel long name NC STRING tropospheric formaldehyde' (static) coordinates '/PRODUCT/longitude /PRODUCT/latitude' (static) NC STRING The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. Following [ER5, section 5.2] we use this attribute to connect the data with the geolocation. This attribute originates from the CF standard. doas_polynomial_coefficients in HCHO__/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS time, scanline, ground_pixel, number_of_doas_polynomial_coefficients. Dimensions: NC FLOAT. Type: Source: Processor. Attributes: Name Value Tvpe '1' (static) units NC STRING long_name 'DOAS polynomial coefficients' (static) NC STRING '/PRODUCT/longitude /PRODUCT/latitude' (static) NC STRING coordinates 'Values of the DOAS polynomial coefficients' comment NC STRING (static) processing_quality_flags in HCHO_ _/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.

	long nome	'Dressesing quality flags' (statis)	NC CTDI
Attributes:	Name	Value	Туре

 long_name
 'Processing quality flags' (static)
 NC_STRING

 units
 '1' (static)
 NC_STRING

 comment
 'Flags indicating conditions that affect quality of the
 NC_STRING

retrieval.' (static)

flag_meanings

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

low cloud fraction warn-

deconvolution_warning

interpolation warning

cloud inhomogeneity warning

signal to -

data range warning

noise_ratio_warning

trieval warning

origin certain warning

ing altitude_consistency_warning

thermal instability warning' (static)

so2_volcanic_origin_likely_warning so2_volcanic_-

saturation_warning high_sza_warning cloud_re-

'success radiance missing irradiance missing

NC STRING

	flag maaka	255 255 255 255 255 255 255 255 255	NC LINT
	flag_masks	255, 255, 255, 255, 255, 255, 255, 255,	NC_UINT
		1048576, 2097152, 4194304, 8388608, 16777216, 33554432, 67108864, 134217728, 268435456, 536870912, 1073741824 (static)	
	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
-	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		ongitude are in a different group. How to specify the rs case is not specified in the climate and forecast r	
	tions [ER5].	o dase is not specified in the diffiate and foredast i	netadata conver
debug_upas2	tions [ER5].	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	
	tions [ER5]. 2_float1D in HCHO		
	tions [ER5]. 2_float1D in HCHO	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	
Description: Dimensions:	tions [ER5]. 2_float1D in HCHO Debug field, not av	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	
Description: Dimensions: Type:	tions [ER5]. 2_float1D in HCHO Debug field, not av time, scanline.	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	
Description: Dimensions:	tions [ER5]. 2_float1D in HCHO Debug field, not av time, scanline. NC_FLOAT.	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	6
Description: Dimensions: Type: Source:	tions [ER5]. 2_float1D in HCHO Debug field, not av time, scanline. NC_FLOAT. Processor.	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value	Туре
Description: Dimensions: Type: Source:	tions [ER5]. 2_float1D in HCHO Debug field, not av time, scanline. NC_FLOAT. Processor. Name	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static)	6
Description: Dimensions: Type: Source: Attributes:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value	Type NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)	Type NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) HO/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	Type NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not avenue avenue avenue.	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) HO/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	Type NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not avenue, scanline.	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) HO/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	Type NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not avenue, scanline. NC_DOUBLE.	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) HO/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment.	Type NC_STRING NC_STRING LTS
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type:	tions [ER5]. 2_float1D in HCHO Debug field, not aven time, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not aven time, scanline. NC_DOUBLE. Processor. Name	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) HO/PRODUCT/SUPPORT_DATA/DETAILED_RESULT vailable in operational environment. Value	Type NC_STRING NC_STRING LTS Type
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not avenue, scanline. NC_DOUBLE. Processor. Name units	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) HO/PRODUCT/SUPPORT_DATA/DETAILED_RESULT vailable in operational environment. Value '1' (static)	Type NC_STRING NC_STRING LTS Type NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not avenue, scanline. NC_DOUBLE. Processor. Name units coordinates		Type NC_STRING NC_STRING LTS Type
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes:	tions [ER5]. 2 float1D in HCHO Debug field, not aven time, scanline. NC_FLOAT. Processor. Name units coordinates 2 double1D in HCH Debug field, not aven time, scanline. NC_DOUBLE. Processor. Name units coordinates 2 int1D in HCHO		Type NC_STRING NC_STRING LTS Type NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes: debug_upas2 Description:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not avenue, scanline. NC_DOUBLE. Processor. Name units coordinates 2_int1D in HCHO Debug field, not avenue, scanline.		Type NC_STRING NC_STRING LTS Type NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions:	tions [ER5]. 2_float1D in HCHO Debug field, not aven time, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCHO Debug field, not aven time, scanline. NC_DOUBLE. Processor. Name units coordinates 2_int1D in HCHO Debug field, not aven time, scanline.		Type NC_STRING NC_STRING LTS Type NC_STRING
Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes: debug_upas2 Description:	tions [ER5]. 2_float1D in HCHO Debug field, not avenue, scanline. NC_FLOAT. Processor. Name units coordinates 2_double1D in HCH Debug field, not avenue, scanline. NC_DOUBLE. Processor. Name units coordinates 2_int1D in HCHO Debug field, not avenue, scanline.		Type NC_STRING NC_STRING LTS Type NC_STRING

	units	'1' (static)	NC STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug upas:		/PRODUCT/SUPPORT_DATA/DETAILED_RESULT	
Description:	_ •	ailable in operational environment.	
Dimensions:	time, scanline.		
Type:	NC UBYTE.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING
debug upas?	2 byte1D in HCHO	/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	-
Description:		ailable in operational environment.	
Dimensions:	time, scanline.		
Type:	NC BYTE.		
Source:	Processor.		
Attributes:	Name	Value	Туре
- -	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING
debug upas?	ushort1D in HCHC	D_/PRODUCT/SUPPORT_DATA/DETAILED_RESUL	
Description:	_	ailable in operational environment.	
Dimensions:	time, scanline.	·	
Type:	NC_USHORT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2	2_float2D_1 in HCH0	D/PRODUCT/SUPPORT_DATA/DETAILED_RESUL	_TS
Descriptions			
บธรบาทเเดน:	Debug field, not ava	ailable in operational environment.	
•	Debug field, not ava time, scanline, grou	·	
Dimensions:	-	·	
Dimensions:	time, scanline, grou	·	
Dimensions: Type:	time, scanline, grou	·	Туре
Dimensions: Type: Source:	time, scanline, grou NC_FLOAT. Processor.	ind_pixel.	Type NC_STRING
Dimensions: Type: Source:	time, scanline, grou NC_FLOAT. Processor. Name	value	NC_STRING
Dimensions: Type: Source: Attributes:	time, scanline, grou NC_FLOAT. Processor. Name units coordinates	Value '1' (static)	NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2	time, scanline, grou NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2	time, scanline, grou NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESUL	NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2 Description:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not available.	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESUL	NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC Tourner Standard NC Tourner Sta	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESUL	NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC_FLOAT.	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESUL	NC_STRING
Attributes: debug_upas2 Description: Dimensions:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC_FLOAT. Processor.	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESULATED in operational environment. Ind_pixel.	NC_STRING NC_STRING .TS
Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC_FLOAT. Processor. Name	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D_/PRODUCT/SUPPORT_DATA/DETAILED_RESULATION (static) (static) ailable in operational environment. und_pixel. Value	NC_STRING NC_STRING TS
Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC_FLOAT. Processor. Name units coordinates	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESULATION (static) pailable in operational environment. und_pixel. Value '1' (static)	NC_STRING NC_STRING TS Type NC_STRING NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_3 in HCHO	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D_/PRODUCT/SUPPORT_DATA/DETAILED_RESULATION (processed of the processed	NC_STRING NC_STRING TS Type NC_STRING NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes: debug_upas2 Description:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_3 in HCHO	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESULT ailable in operational environment. Ind_pixel. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESULT ailable in operational environment.	NC_STRING NC_STRING TS Type NC_STRING NC_STRING
Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type: Source: Attributes:	time, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_2 in HCHO Debug field, not avaitime, scanline, ground NC_FLOAT. Processor. Name units coordinates 2_float2D_3 in HCHO Debug field, not avaitine, scanline, scanline, ground NC_FLOAT.	Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESULT ailable in operational environment. Ind_pixel. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) D/PRODUCT/SUPPORT_DATA/DETAILED_RESULT ailable in operational environment.	NC_STRING NC_STRING TS Type NC_STRING NC_STRING

Attributes:	Name	Value	Туре
•	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2	2_double2D_1 in H	CHO/PRODUCT/SUPPORT_DATA/DETAILED_RES	SULTS
Description:	Debug field, not av	vailable in operational environment.	
Dimensions:	time, scanline, gro	und_pixel.	
Туре:	NC_DOUBLE.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2	2_double2D_2 in H	CHO/PRODUCT/SUPPORT_DATA/DETAILED_RES	SULTS
Description:	Debug field, not av	vailable in operational environment.	
Dimensions:	time, scanline, gro	und_pixel.	
Type:	NC_DOUBLE.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2	2_double2D_3 in H	CHO/PRODUCT/SUPPORT_DATA/DETAILED_RES	SULTS
Description:	Debug field, not av	vailable in operational environment.	
Dimensions:	time, scanline, gro	und pixel.	
Type:	NC DOUBLE.	_	
Source:	Processor.		
Attributes:	Name	Value	Туре
Attributes:	Name units	Value '1' (static)	Type NC_STRING
Attributes:			Type NC_STRING NC_STRING
	units coordinates	'1' (static)	NC_STRING
debug_upas2	units coordinates 2_int2D_1 in HCHO	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2 Description:	units coordinates 2_int2D_1 in HCHO	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)/PRODUCT/SUPPORT_DATA/DETAILED_RESULTs vailable in operational environment.	NC_STRING
debug_upas2	units coordinates 2_int2D_1 in HCHO Debug field, not av	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)/PRODUCT/SUPPORT_DATA/DETAILED_RESULTs vailable in operational environment.	NC_STRING
debug_upas2 Description: Dimensions:	units coordinates 2_int2D_1 in HCHO Debug field, not av time, scanline, gro	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)/PRODUCT/SUPPORT_DATA/DETAILED_RESULTs vailable in operational environment.	NC_STRING
debug_upas2 Description: Dimensions: Type:	units coordinates 2_int2D_1 in HCHO Debug field, not av time, scanline, gro NC_INT.	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)/PRODUCT/SUPPORT_DATA/DETAILED_RESULTs vailable in operational environment.	NC_STRING
debug_upas2 Description: Dimensions: Type: Source:	units coordinates 2_int2D_1 in HCHO Debug field, not av time, scanline, gro NC_INT. Processor.	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULT: /ailable in operational environment. und_pixel.	NC_STRING NC_STRING S
debug_upas2 Description: Dimensions: Type: Source:	units coordinates 2_int2D_1 in HCHO Debug field, not av time, scanline, gro NC_INT. Processor. Name	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment. und_pixel. Value	NC_STRING NC_STRING S
debug_upas2 Description: Dimensions: Type: Source: Attributes:	units coordinates 2_int2D_1 in HCHO Debug field, not av time, scanline, gro NC_INT. Processor. Name units coordinates	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) _/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS vailable in operational environment. und_pixel. Value '1' (static)	NC_STRING NC_STRING S Type NC_STRING
debug_upas2 Description: Dimensions: Type: Source: Attributes:	units coordinates 2_int2D_1 in HCHO Debug field, not avenue, scanline, gro NC_INT. Processor. Name units coordinates 2_int2D_2 in HCHO	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment. und_pixel. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING NC_STRING S Type NC_STRING
debug_upas2 Description: Dimensions: Type: Source: Attributes:	units coordinates 2_int2D_1 in HCHO Debug field, not avenue, scanline, gro NC_INT. Processor. Name units coordinates 2_int2D_2 in HCHO	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment. und_pixel. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment.	NC_STRING NC_STRING S Type NC_STRING
debug_upas2 Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions:	units coordinates 2_int2D_1 in HCHO Debug field, not avenue, scanline, gro NC_INT. Processor. Name units coordinates 2_int2D_2 in HCHO Debug field, not avenue	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment. und_pixel. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment.	NC_STRING NC_STRING S Type NC_STRING
debug_upas2 Description: Dimensions: Type: Source: Attributes: debug_upas2 Description: Dimensions: Type:	units coordinates 2_int2D_1 in HCHO Debug field, not avenue, scanline, gro NC_INT. Processor. Name units coordinates 2_int2D_2 in HCHO Debug field, not avenue, scanline, gro	'1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment. und_pixel. Value '1' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS //ailable in operational environment.	NC_STRING NC_STRING S Type NC_STRING
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Source:	Processor.		
Attributes:	Name	Value	Туре
•	units	'1' (static)	NC STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug upas2	2 ubyte2D 1 in HC	CHO /PRODUCT/SUPPORT DATA/DETAILED RES	
Description:		vailable in operational environment.	
Dimensions:	time, scanline, gro	·	
Type:	NC_UBYTE.	_	
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2	2_ ubyte2D_2 in HC	CHO_/PRODUCT/SUPPORT_DATA/DETAILED_RES	ULTS
Description:	Debug field, not a	vailable in operational environment.	
Dimensions:	time, scanline, gro	·	
Туре:	NC_UBYTE.		
Source:	Processor.		
Attributes:	Name	Value	Туре
•	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2	2_ubyte2D_3 in HC	CHO/PRODUCT/SUPPORT_DATA/DETAILED_RES	ULTS
Description:		vailable in operational environment.	
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_UBYTE.	_	
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas2	2_byte2D_1 in HCl	HO/PRODUCT/SUPPORT_DATA/DETAILED_RESU	LTS
Description:	Debug field, not a	vailable in operational environment.	
Dimensions:	time, scanline, gro	ound_pixel.	
Туре:	NC_BYTE.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug upas2	2 byte2D 2 in HCl	HO_/PRODUCT/SUPPORT_DATA/DETAILED_RESU	LTS
Description:	- · -	vailable in operational environment.	
Dimensions:	time, scanline, gro	·	
Type:	NC_BYTE.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug upas2		HO_/PRODUCT/SUPPORT_DATA/DETAILED_RESU	
Description:		vailable in operational environment.	
Dimensions:	time, scanline, gro	·	
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	Attributes:			* *
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Variety Value Va	•	-	·	
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pescription: Debug field, not available in operational environment.				LIO
	Description:	Debug field, not a	valiable in operational environment.	

Dimensions:		ınd_pixel, debug_upas2_levels_1.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug_upas	2_float3D_4 in HCH0	D/PRODUCT/SUPPORT_DATA/DETAILED_RESUL	_TS
Description:	Debug field, not ava	ailable in operational environment.	
Dimensions:	time, scanline, grou	ınd_pixel, debug_upas2_levels_1.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug upas	2 float3D 5 in HCH0	O /PRODUCT/SUPPORT DATA/DETAILED RESUL	
Description:		ailable in operational environment.	
Dimensions:	-		
Type:	NC FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
debug upas		O /PRODUCT/SUPPORT DATA/DETAILED RESUL	
Description:		ailable in operational environment.	0
Dimensions:	•	ind_pixel, debug_upas2_levels_1.	
Type:	NC FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
7 1111 115 115 115	units	'1' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING
cloud fractio		ed in HCHO/PRODUCT/SUPPORT_DATA/DETAIL	
Description:	-	cloudy weighting factor.	LD_11200210
Dimensions:	time, scanline, grou	, ,	
Type:	NC_FLOAT.	a_pixoi.	
Source:	Processor.		
Attributes:	Name	Value	Туре
Attributes.	units	'1' (static)	NC_STRING
		. This attribute originates from the NUG, CF standard	
	long_name	'cloud fraction intensity weighted' (static)	NC_STRING
	valid min	0.0 (static)	NC FLOAT
	valid max	1.0 (static)	NC FLOAT
	comment	'VCD clear sky vs. cloudy weighting factor.' (static)	NC_STRING
		'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING NC_STRING
	coordinates The latitude and lor	. ,	_
		igitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the	
cloud fractic		ed_precision in HCHO/PRODUCT/SUPPORT_D	
RESULTS	torioity_weight	<u> </u>	,, , , , , , , , , , , , , , , , , ,
·			

Description:	Error of the VCD clear sky vs. cloudy weighting factor.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	Dimensionless unit. This attribute originates from the NUG, CF standards.		
	long_name	'random error of the cloud fraction intensity weighted' (static)	NC_STRING
	valid_min	0.0 (static)	NC_FLOAT
	valid_max	1.0 (static)	NC_FLOAT
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the 0	

12.1.1.3 Group "WAVELENGTH_CALIBRATIONS" in "_wlcalibration"

Dimensions in HCHO_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS/WAVELENGTH_CALIBRATIONS

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

size 1 (dynamic)
source Processor.

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

size 1 (dynamic) source Processor.

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

size 1 (dynamic)
source Processor.

Variables in HCHO_/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS/WAVELENGTH_CALIBRATIONS

calibration_polynomial_coefficients in HCHO/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS/ WAVELENGTH_CALIBRATIONS			
Description:	Computed coefficients of the polynomial function. It may have multiple windows.		
Dimensions:	number_of_calibrations, degrees_of_polynomial_shift.		
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	long_name	'computed coefficients of the polynomial function' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING
calibration_subwindows_shift in HCHO/PRODUCT/SUPPORT_DATA/DETAILED_RESULTS WAVELENGTH_CALIBRATIONS			ILED_RESULTS/
Description:	Computed wavelen	gths shift values per subwindow. It may have multiple	windows.

Dimensions: number_of_calibrations, number_of_subwindows.

Type: NC_FLOAT.

Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'nm' (static)	NC_STRING
	long_name	'irradiance wavelengths shift fitted values per sub- window' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING
	subwindows_squee H_CALIBRATIONS	ze in HCHO/PRODUCT/SUPPORT_DATA/DETA	ILED_RESULTS/
Description:	Computed waveler	ngths squeeze values per subwindow. It may have mul	tiple windows.
Dimensions:	number_of_calibra	tions, number_of_subwindows.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	long_name	'irradiance wavelengths squeeze fitted values per subwindow' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING
Dimensions: Type: Source:	number_of_calibra NC_FLOAT. Processor.	tions, number_of_subwindows.	
Attributes:	Name	Value	Туре
Attributes.	units	'1' (static)	NC STRING
	long_name	'calibration rms per subwindow' (static)	NC STRING
	standard name	'TBA' (static)	NC STRING
WAVELENGT	subwindows_wavele H_CALIBRATIONS	ength in HCHO/PRODUCT/SUPPORT_DATA/DETA	AILED_RESULTS
Description:		ngth center in each subwindow. It may have multiple w	indows.
Dimensions:	number_of_subwin	luows.	
Type:	NC_FLOAT.		
Source:	Processor. Name	Value	Tupo
Attributes:	units		Type NC_STRING
		'nm' (static)	
	long_name	'calibration wavelength center in each subwindow' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING

12.1.1.4 Group "INPUT_DATA" in "SUPPORT_DATA"

Variables in HCHO_/PRODUCT/SUPPORT_DATA/INPUT_DATA

snow_ice_flag_nise in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description: This is the original snow/ice classification data field from NSIDC/NISE. In case this auxiliary

data was not available while processing, only FillValue are present in the data.

Dimensions: time, scanline, ground_pixel.

Type: NC_UBYTE.

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Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	long_name	'snow-ice mask' (static)	NC_STRING
	FillValue	'254UB' (static)	NC STRING
	comment	'flag indicating snow/ice at center of ground pixel'	NC STRING
	Comment	(static)	
	source	'NSIDC/NISE' (static)	NC_STRING
	flag_meanings	'snow-free_land sea_ice_1_percent sea_ice_2 percent sea_ice_3_percent sea_ice_4_percent sea_ice_5_percent sea_ice_6_percent sea_ice 7_percent sea_ice_8_percent sea_ice_9_percent	NC_STRING
		sea_ice_10_percent sea_ice_11_percent sea_ice_12_percent sea_ice_13_percent sea_ice_14_percent sea_ice_15_percent sea_ice_16_percent sea_ice_17_percent sea_ice_18_percent sea_ice_18_pe	
		ice_19_percent sea_ice_20_percent sea_ice_21 percent sea_ice_22_percent sea_ice_23_percent sea_ice_24_percent sea_ice_25_percent sea	
		ice_26_percent sea_ice_27_percent sea_ice_28 percent sea_ice_29_percent sea_ice_30_percent sea_ice_31_percent sea_ice_32_percent sea_ice_33_percent sea_ice_34_percent sea_ice_35	
		percent sea_ice_36_percent sea_ice_37_percent sea_ice_38_percent sea_ice_39_percent sea_ice_40_percent sea_ice_41_percent sea_ice_42	
		percent sea_ice_43_percent sea_ice_44_percent sea_ice_45_percent sea_ice_46_percent sea_ice_47_percent sea_ice_48_percent sea_ice_49	
		percent sea_ice_50_percent sea_ice_51_percent sea_ice_52_percent sea_ice_53_percent sea	
		ice_54_percent sea_ice_55_percent sea_ice_56 percent sea_ice_57_percent sea_ice_58_percent	
		sea_ice_59_percent sea_ice_60_percent sea_ice_61_percent sea_ice_62_percent sea_ice_63_percent sea_ice_64_percent sea_ice_65_percent	
		sea_ice_66_percent sea_ice_67_percent sea_ice_68_percent sea_ice_69_percent sea_ice_70	
		percent sea_ice_71_percent sea_ice_72_percent sea_ice_73_percent sea_ice_74_percent sea	
		ice_75_percent sea_ice_76_percent sea_ice_77 percent sea_ice_78_percent sea_ice_79_percent	
		sea_ice_80_percent sea_ice_81_percent sea_ice_84 ice_82_percent sea_ice_83_percent sea_ice_84	
		percent sea_ice_85_percent sea_ice_86_percent sea_ice_87_percent sea_ice_88_percent sea_ice_80_percent sea_ice_81_percent sea_i	
		ice_89_percent sea_ice_90_percent sea_ice_91 percent sea_ice_92_percent sea_ice_93_percent	
		sea_ice_94_percent sea_ice_95_percent sea_ice_96_percent sea_ice_97_percent sea_ice_98_percent sea_ice_99_percent sea_ice_100_percent	
		permanent_ice snow mixed_pixels_at_coastlines	

suspect_ice_value corners ocean' (static)

NC STRING

flag_values	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,	NC_UBYTE
	17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29,	
	30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42,	
	43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55,	
	56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68,	
	69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81,	
	82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94,	
	95, 96, 97, 98, 99, 100, 101, 103, 252, 253, 254,	
	255 (static)	
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING

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

snow_ice_flag in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA

Description:

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

Dimensions: time, scanline, ground_pixel.

NC UBYTE. Type: Source: Processor.

Attributes:

Name	Value	Туре
units	'1' (static)	NC_STRING
threshold	'0.3' (static)	NC_STRING

The threshold in percentage to identify the pixel as snow/ice or snow free.

long_name	'snow-ice mask' (static)	NC_STRING
_FillValue	'254UB' (static)	NC_STRING
comment	'flag indicating snow/ice at center of ground pixel' (static)	NC_STRING

Possible values: NSIDC/NISE, Fallback_climatology

flag_meanings	'snow_free snow_ice' (static)	NC_STRING	
flag_values	0, 1 (static)	NC_UBYTE	
coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC STRING	

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

snow cover in HCHO /PRODUCT/SUPPORT DATA/INPUT DATA

Description: The snow cover in the region of the pixel

Dimensions: time, scanline, ground_pixel.

source

Type: NC FLOAT. Processor. Source:

Attributes:

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

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

		UCT/SUPPORT_DATA/INPUT_DATA		
Description:	, , , , , , , , , , , , , , , , , , , ,			
Dimensions:				
Type:	NC_FLOAT.			
Source:	Processor.	Value	Time	
Attributes:	Name	Value	Type	
	units	'1' (static)	NC_STRING	
	long_name	'sea-ice-cover' (static)	NC_STRING	
	coordinates	'ECMWF' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING 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].			
cloud_fractio	on_crb in HCHO/P	RODUCT/SUPPORT_DATA/INPUT_DATA		
Description:	Retrieved effective	radiometric cloud fraction using the OCRA/ROCINN C	CRB model.	
Dimensions:	time, scanline, grou	nd_pixel.		
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (static)	NC_STRING	
	Dimensionless unit.	This attribute originates from the NUG, CF standard	S.	
	standard_name	'TBD' (static)	NC_STRING	
	long_name	'effective radiometric cloud fraction from the CRB model' (static)	NC_STRING	
	source	'crb' (static)	NC_STRING	
	comment	'Coregistered effective radiometric cloud fraction using the OCRA/ROCINN CRB model.' (static)	NC_STRING	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING	
		gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the 0		
cloud_fractio	on_crb_precision in	HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA		
Description:	model.	ed effective radiometric cloud fraction using the OCF	RA/ROCINN CR	
Dimensions:	time, scanline, grou	nd_pixel.		
Туре:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (static)	NC_STRING	
		This attribute originates from the NUG, CF standard		
	standard_name	'TBD' (static)	NC_STRING	
	long_name	'effective radiometric cloud fraction precision from the CRB model' (static)	NC_STRING	
	source	'crb' (static)	NC_STRING	
	comment	'Error of the coregistered effective radiometric cloud fraction using the OCRA/ROCINN CRB model.' (static)	NC_STRING	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING	
	The latitude and longitude coordinates of the TROPOMI swath is not defined as a Cartesian product of latitude and longitude axes. This attribute originates from the CF standard.			

source

'crb' (static)

NC_STRING

cloud_pressu	_		
Description:	Retrieved atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model.		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'Pa' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid pressure from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Coregistered and converted atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the 0	
cloud_pressu	ure_crb_precision in	HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA	4
Description:	Error of the retrieve CRB model.	d atmospheric pressure at the level of cloud using the	OCRA/ROCINN
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'Pa' (static)	NC_STRING
	standard_name	'TBD' (static)	NC_STRING
	long_name	'cloud radiometric optical centroid pressure precision from the CRB model' (static)	NC_STRING
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered and converted atmo-	NC_STRING
		spheric pressure at the level of cloud using the OCRA/ROCINN CRB model.' (static)	
	coordinates		NC_STRING
	The latitude and lon	OCRA/ROCINN CRB model.' (static)	ed as a Cartesian
cloud_height	The latitude and lon product of latitude a	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defin	ed as a Cartesian
cloud_height Description:	The latitude and lon product of latitude at _crb in HCHO/PR	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not definant longitude axes. This attribute originates from the 0	ed as a Cartesian CF standard.
	The latitude and lon product of latitude at crb in HCHO/PR Retrieved height at	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the ODUCT/SUPPORT_DATA/INPUT_DATA the level of cloud w.r.t. the geoid/MSL using the OCF	ed as a Cartesian CF standard.
Description:	The latitude and lon product of latitude at crb in HCHO/PR Retrieved height at model.	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the ODUCT/SUPPORT_DATA/INPUT_DATA the level of cloud w.r.t. the geoid/MSL using the OCF	ed as a Cartesian CF standard.
Description: Dimensions:	The latitude and lon product of latitude at crb in HCHO_/PR Retrieved height at model. time, scanline, grou	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the ODUCT/SUPPORT_DATA/INPUT_DATA the level of cloud w.r.t. the geoid/MSL using the OCF	ed as a Cartesian CF standard.
Description: Dimensions: Type:	The latitude and lon product of latitude at crb in HCHO/PR Retrieved height at model. time, scanline, ground NC_FLOAT.	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the ODUCT/SUPPORT_DATA/INPUT_DATA the level of cloud w.r.t. the geoid/MSL using the OCF	ed as a Cartesian CF standard.
Description: Dimensions: Type: Source:	The latitude and lon product of latitude at crb in HCHO/PR Retrieved height at model. time, scanline, grou NC_FLOAT. Processor.	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the (ODUCT/SUPPORT_DATA/INPUT_DATA the level of cloud w.r.t. the geoid/MSL using the OCF and_pixel.	ed as a Cartesian CF standard. RA/ROCINN CRB
Description: Dimensions: Type: Source:	The latitude and lon product of latitude at crb in HCHO/PR Retrieved height at model. time, scanline, grou NC_FLOAT. Processor. Name	OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the of ODUCT/SUPPORT_DATA/INPUT_DATA the level of cloud w.r.t. the geoid/MSL using the OCF nd_pixel. Value	ed as a Cartesian CF standard. RA/ROCINN CRB

	comment	'Coregistered height at the level of cloud w.r.t. the	NC_STRING
		geoid/MSL using the OCRA/ROCINN CRB model.' (static)	_
-	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	· · · · · · · · · · · · · · · · · · ·	gitude coordinates of the TROPOMI swath is not define nd longitude axes. This attribute originates from the O	
cloud height		CHO /PRODUCT/SUPPORT DATA/INPUT DATA	
Description:	Error of the retriev	ved height at the level of cloud w.r.t. the geoid B model.	d/MSL using the
Dimensions:	time, scanline, groui	nd_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
-	units	'm' (static)	NC_STRING
-	standard_name	'TBD' (static)	NC_STRING
-	long_name	'cloud radiometric optical centroid height precision from the CRB model' (static)	NC_STRING
-	source	'crb' (static)	NC_STRING
-	comment	'Error of the coregistered height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.' (static)	NC_STRING
-			
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	The latitude and long	'/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not define nd longitude axes. This attribute originates from the 0	ed as a Cartesiar
cloud_albedo	The latitude and long product of latitude a	gitude coordinates of the TROPOMI swath is not define	ed as a Cartesiar
_	The latitude and long product of latitude a _crb in HCHO/PR	gitude coordinates of the TROPOMI swath is not define nd longitude axes. This attribute originates from the O	ed as a Cartesiar
Description:	The latitude and long product of latitude a _crb in HCHO/PR	gitude coordinates of the TROPOMI swath is not define and longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model.	ed as a Cartesiar
Description: Dimensions:	The latitude and long product of latitude a crb in HCHO/PR Albedo of cloud usin	gitude coordinates of the TROPOMI swath is not define and longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model.	ed as a Cartesiar
Description: Dimensions: Type:	The latitude and long product of latitude a pcrb in HCHO_/PR Albedo of cloud using time, scanline, ground	gitude coordinates of the TROPOMI swath is not define and longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model.	ed as a Cartesiar
Description: Dimensions: Type: Source:	The latitude and long product of latitude a pcrb in HCHO_/PR Albedo of cloud usin time, scanline, groun NC_FLOAT.	gitude coordinates of the TROPOMI swath is not define and longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model.	ed as a Cartesiar
Description: Dimensions:	The latitude and long product of latitude a pcrb in HCHO/PR Albedo of cloud usin time, scanline, groun NC_FLOAT. Processor.	gitude coordinates of the TROPOMI swath is not definent longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Ind_pixel.	ed as a Cartesiar CF standard.
Description: Dimensions: Type: Source:	The latitude and long product of latitude a crb in HCHO/PR Albedo of cloud usin time, scanline, groun NC_FLOAT. Processor. Name units	gitude coordinates of the TROPOMI swath is not define and longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model. and pixel. Value	ed as a Cartesiar CF standard. Type NC_STRING
Description: Dimensions: Type: Source:	The latitude and long product of latitude a crb in HCHO/PR Albedo of cloud usin time, scanline, groun NC_FLOAT. Processor. Name units	gitude coordinates of the TROPOMI swath is not define and longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static)	ed as a Cartesiar CF standard. Type NC_STRING
Description: Dimensions: Type: Source:	The latitude and long product of latitude a pcrb in HCHO_/PR Albedo of cloud usin time, scanline, groun NC_FLOAT. Processor. Name units Dimensionless unit.	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static) This attribute originates from the NUG, CF standards	ed as a Cartesiar CF standard. Type NC_STRING s. NC_STRING NC_STRING
Description: Dimensions: Type: Source:	The latitude and long product of latitude a pcrb in HCHO_/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name	gitude coordinates of the TROPOMI swath is not define and longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static)	ed as a Cartesiar CF standard. Type NC_STRING s. NC_STRING
Description: Dimensions: Type: Source:	The latitude and long product of latitude a pcrb in HCHO_/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud albedo from the CRB model' (static)	ed as a Cartesiar CF standard. Type NC_STRING s. NC_STRING NC_STRING
Description: Dimensions: Type: Source:	The latitude and long product of latitude a p_crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/	Type NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source:	The latitude and long product of latitude a pcrb in HCHO_/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static)	Type Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes:	The latitude and long product of latitude at crb in HCHO_/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude a	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defined.	Type Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes:	The latitude and long product of latitude a crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude and long product of latitude a crb_precision in H	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Ind_pixel. Value '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo' (static) 'cloud albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the OCRA/ROCINN CRB model.'	Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes:	The latitude and long product of latitude a crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude and long product of latitude a crb_precision in H	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Malue '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo' (static) 'cloud albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CRA/ROCINN CRB model. CHO/PRODUCT/SUPPORT_DATA/INPUT_DATA of cloud using the OCRA/ROCINN CRB model.	Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: cloud_albedo Description: Dimensions:	The latitude and long product of latitude at crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude at crb_precision in Herror of the albedo of the content of the subset of latitude at crb_precision in Herror of the albedo of the latitude at crb_precision in Herror of the albedo of the latitude at crb_precision in Herror of the albedo of the latitude at	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Malue '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo' (static) 'cloud albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CRA/ROCINN CRB model. CHO/PRODUCT/SUPPORT_DATA/INPUT_DATA of cloud using the OCRA/ROCINN CRB model.	Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: cloud_albedo Description: Dimensions: Type:	The latitude and long product of latitude a crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude and long product of latitude and long product of the albedo of time, scanline, ground latitude, ground latitud	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Malue '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo' (static) 'cloud albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CRA/ROCINN CRB model. CHO/PRODUCT/SUPPORT_DATA/INPUT_DATA of cloud using the OCRA/ROCINN CRB model.	Type NC_STRING
Description: Dimensions: Type: Source: Attributes: cloud_albedo Description: Dimensions: Type: Source:	The latitude and long product of latitude at crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude at latitude and long product of latitude at	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Malue '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo' (static) 'cloud albedo from the CRB model' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CRA/ROCINN CRB model. CHO/PRODUCT/SUPPORT_DATA/INPUT_DATA of cloud using the OCRA/ROCINN CRB model.	Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: cloud_albedo Description: Dimensions: Type: Source:	The latitude and long product of latitude a crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude and long product	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA and the OCRA/ROCINN CRB model. **Model of the Number of the	Type Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING CSTRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source: Attributes: cloud_albedo Description:	The latitude and long product of latitude at crb in HCHO/PR Albedo of cloud using time, scanline, ground NC_FLOAT. Processor. Name units Dimensionless unit. standard_name long_name source comment coordinates The latitude and long product of latitude at l	gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CODUCT/SUPPORT_DATA/INPUT_DATA ag the OCRA/ROCINN CRB model. Malue '1' (static) This attribute originates from the NUG, CF standards 'cloud_albedo' (static) 'cloud_albedo' (static) 'crb' (static) 'Coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) gitude coordinates of the TROPOMI swath is not defined longitude axes. This attribute originates from the CCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA of cloud using the OCRA/ROCINN CRB model. md_pixel. Value	Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING CONC_STRING NC_STRING

	long_name	'cloud albedo precision from the CRB model'	NC STRING
		(static)	_
	source	'crb' (static)	NC_STRING
	comment	'Error of the coregistered cloud albedo based on the OCRA/ROCINN CRB model.' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
		gitude coordinates of the TROPOMI swath is not defin and longitude axes. This attribute originates from the 0	
surface_altit	ude in HCHO/PRO	DUCT/SUPPORT_DATA/INPUT_DATA	
Description:		o-pixels of the surface altitude above the reference geol Id of view, based on the GMTED2010 surface elevation	
Dimensions:	time, scanline, grou	nd_pixel.	
Туре:	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
		ngitude are in a different group. How to specify the r	_
		case is not specified in the climate and forecast r	• .
	source	'http://topotools.cr.usgs.gov/gmted_viewer/' (static)	NC_STRING
	comment	'The mean of the sub-pixels of the surface altitude above the reference geoid (WGS84) within the ap- proximate field of view, based on the GMTED2010 surface elevation database' (static)	NC_STRING
surface altitu	ude precision in HC	HO/PRODUCT/SUPPORT_DATA/INPUT_DATA	
Description:	The standard deviat	ion of sub-pixels used in calculating the mean surface GS84) within the approximate field of view, based on	
Dimensions:	time, scanline, grou	nd pixel.	
Туре:	NC_FLOAT.	-	
Source:	surface elevation da	atabase.	
Attributes:	Name	Value	Туре
ttiribatoo.	long_name	'surface altitude precision' (static)	NC STRING
	standard_name	'surface_altitude_standard_error' (static)	NC_STRING
	units	'm' (static)	NC STRING
	standard error -	1.0 (static)	NC FLOAT
	multiplier		
	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	
	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 above the refer- ence geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database' (static)	NC_STRING

surface classification in HCHO /PRODUCT/SUPPORT DATA/INPUT DATA This is a combined land/water mask and surface classification data field. Description: Dimensions: time, scanline, ground pixel. Type: NC UBYTE. surface elevation database (including flag attributes). Source: Attributes: Value Name Type '1' (static) NC STRING units NC STRING 'land-water mask' (static) long name comment 'flag indicating land/water and further surface clas-NC STRING sifications for the ground pixel' (static) **'USGS** (http://edc2.usgs.gov/glcc/globdoc2 -NC STRING source and NASA SDP (qdq.0 toolkit 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 land+irrigated cropland and pasture. land+mixed dryland-irrigated cropland and pasture, land+cropland-grassland mosaic, land+cropland-woodland mosaic, land+grassland, land+shrubland. land+mixed shrublandgrassland, land+savanna, land+deciduous broadleaf_forest, land+deciduous_needleleaf_forest, land+evergreen_broadleaf_forest, land+evergreen needleleaf forest, land+mixed forest, land+herbaceous wetland, land+wooded wetland. land+barren or sparsely vegetated, land+herbaceous tundra, land+wooded tundra, land+mixed_tundra, land+bare_ground_tundra, land+snow_or_ice' (static) flag_values 0, 1, 2, 3, 4, 9, 17, 25, 33, 41, 49, 57, 8, 16, 24, 32, NC_UBYTE 40, 48, 56, 64, 72, 80, 88, 96, 104, 112, 120, 128, 136, 144, 152, 160, 168, 176, 184 (static) flag masks 3, 3, 3, 3, 4, 249, 249, 249, 249, 249, 249, 249, NC UBYTE 249, 249, 249 (static) coordinates '/PRODUCT/longitude /PRODUCT/latitude' (static) NC STRING The latitude and longitude are in a different group. How to specify the related geospatial coordinates in this case is not specified in the climate and forecast metadata conventions [ER5].

instrument configuration identifier in HCHO /PRODUCT/SUPPORT DATA/INPUT DATA

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.

NC INT. Type: Source: L1B.

Name	Value	Туре
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 HCHO /PRODUCT/SUPPORT DATA/INPUT DATA

Description:

Attributes:

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

Dimensions: time, scanline. NC_SHORT. Type:

L1B. Source:

Attributes:

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

scaled_small_pixel_variance in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA

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

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

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

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

$$(3)$$

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

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

with $\langle R(t,r,c)\rangle$ the mean reflectance for small pixels of ground pixel (t,r,c), V(t,r,c) the variance of the small pixels, $V_{\text{scaled}}(t,r,c)$ the scaled small pixel variance, and R(t,r,c,i) with $i = [0, \dots, N_{\mathsf{small \; pixels}} - 1]$ 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 ϑ_0 is the solar zenith angle.

Dimensions: time, scanline, ground pixel.

NC FLOAT. Type:

Source:	Processor.		
Attributes:	Name	Value	Туре
	long_name	'scaled small pixel variance' (static)	NC_STRING
	units	'1' (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	metadata conver
	comment	'The scaled variance of the reflectances of the small pixels' (static)	NC_STRING
	radiation_waveler	igth	NC_FLOAT
		avelength of the small pixel column in nm. Note that c th will depend on the ground_pixel index.	due to the spectra
surface_pres	sure in HCHO/PF	ODUCT/SUPPORT_DATA/INPUT_DATA	
Description:	Surface pressure fr	om ECMWF model data.	
Dimensions:	time, scanline, grou	ınd_pixel.	
Туре:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'Pa' (static)	NC_STRING
	standard_name	'surface_air_pressure' (static)	NC_STRING
			NC CTDING
	long name	'surface air pressure' (static)	NC STRING
	long_name source	'surface_air_pressure' (static)	NC_STRING NC_STRING
	source coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING NC_STRING
surface tomi	source coordinates The latitude and lo coordinates in this tions [ER5].	'/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	NC_STRING NC_STRING related geospatia
	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA	NC_STRING NC_STRING related geospatia
Description:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data.	NC_STRING NC_STRING related geospatia
Description: Dimensions:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure from time, scanline, ground in the source in the scanline in the s	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data.	NC_STRING NC_STRING related geospatia
Description: Dimensions: Type:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, ground NC_FLOAT.	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data.	NC_STRING NC_STRING related geospatia
Description: Dimensions: Type: Source:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, ground NC_FLOAT. Processor.	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. und_pixel.	NC_STRING NC_STRING related geospatia metadata conver
Description: Dimensions: Type: Source:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, ground NC_FLOAT. Processor. Name	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. ind_pixel. Value	NC_STRING NC_STRING related geospatia metadata conver
Description: Dimensions: Type: Source:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO_ Surface pressure fretime, scanline, ground NC_FLOAT. Processor. Name units	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. und_pixel. Value 'K' (static)	NC_STRING NC_STRING related geospatia metadata conver
Description: Dimensions: Type: Source:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, ground NC_FLOAT. Processor. Name units standard_name	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. und_pixel. Value 'K' (static) 'surface_air_temperature' (static)	NC_STRING NC_STRING NC_STRING related geospatia metadata conver
Description: Dimensions: Type: Source:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO_ Surface pressure fr time, scanline, groun NC_FLOAT. Processor. Name units standard_name long_name	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. und_pixel. Value 'K' (static)	NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING
Description:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, groun NC_FLOAT. Processor. Name units standard_name long_name source	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. ind_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static)	NC_STRING NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING
Description: Dimensions: Type: Source:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO_ Surface pressure fr time, scanline, groun NC_FLOAT. Processor. Name units standard_name long_name source coordinates	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. und_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING NC_STRING NC_STRING related geospatia metadata convei
Description: Dimensions: Type: Source:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO_ Surface pressure fr time, scanline, groun NC_FLOAT. Processor. Name units standard_name long_name source coordinates The latitude and lo	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. ind_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static)	NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING related geospatia
Description: Dimensions: Type: Source: Attributes:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, ground NC_FLOAT. Processor. Name units standard_name long_name source coordinates The latitude and lo coordinates in this tions [ER5].	'/PRODUCT/longitude /PRODUCT/latitude' (static) ngitude are in a different group. How to specify the recase is not specified in the climate and forecast recommendate. /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. und_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static) '/PRODUCT/longitude /PRODUCT/latitude' (static) ngitude are in a different group. How to specify the recase is not specify the recase in a different group.	NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING related geospatia
Description: Dimensions: Type: Source: Attributes:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, ground NC_FLOAT. Processor. Name units standard_name long_name source coordinates The latitude and lo coordinates in this tions [ER5].	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. and_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static) '/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 DDUCT/SUPPORT_DATA/INPUT_DATA	NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING related geospatia
Description: Dimensions: Type: Source: Attributes: northward_w Description:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure free time, scanline, groun NC_FLOAT. Processor. Name units standard_name long_name source coordinates The latitude and lo coordinates in this tions [ER5]. rind in HCHO_/PRO	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. ind_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static) '/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 DDUCT/SUPPORT_DATA/INPUT_DATA Imponent	NC_STRING NC_STRING related geospatia metadata convert Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING related geospatia
Description: Dimensions: Type: Source: Attributes: northward_w Description: Dimensions:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, groun NC_FLOAT. Processor. Name units standard_name long_name source coordinates The latitude and lo coordinates in this tions [ER5]. Find in HCHO/PRO 10 metre V wind coordinates	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. ind_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static) '/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 DDUCT/SUPPORT_DATA/INPUT_DATA Imponent	NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING related geospatia
Description: Dimensions: Type: Source: Attributes: northward_w Description: Dimensions: Type:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure fr time, scanline, ground NC_FLOAT. Processor. Name units standard_name long_name source coordinates The latitude and lo coordinates in this tions [ER5]. rind in HCHO/PRO 10 metre V wind coutime, scanline, ground in the scanline,	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. ind_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static) '/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 DDUCT/SUPPORT_DATA/INPUT_DATA Imponent	NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING related geospatia
Description: Dimensions: Type: Source: Attributes:	source coordinates The latitude and lo coordinates in this tions [ER5]. perature in HCHO Surface pressure free time, scanline, groun NC_FLOAT. Processor. Name units standard_name long_name source coordinates The latitude and lo coordinates in this tions [ER5]. rind in HCHO/PRO 10 metre V wind countine, scanline, groun NC_FLOAT.	'/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 /PRODUCT/SUPPORT_DATA/INPUT_DATA om ECMWF model data. ind_pixel. Value 'K' (static) 'surface_air_temperature' (static) 'surface_air_temperature' (static) '/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 DDUCT/SUPPORT_DATA/INPUT_DATA Imponent	NC_STRING NC_STRING related geospatia metadata conver Type NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING NC_STRING related geospatia

		per second This attribute originates from the NUG, CF	NO CEDIMO
	standard_name	'northward_wind' (static)	NC_STRING
	long_name	'Northward wind from ECMWF at 10 meter height level' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	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 n	
_		DUCT/SUPPORT_DATA/INPUT_DATA	
Description:	10 metre U wind co	•	
Dimensions:	time, scanline, grou	nd_pixel.	
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Type
	units	'm s-1' (static)	NC_STRING
		er second This attribute originates from the NUG, CF	
	standard_name	'eastward_wind' (static)	NC_STRING
	long_name	'Eastward wind from ECMWF at 10 meter height level' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
	coordinates in this	case is not specified in the climate and lorecast in	nelauala convei
tm5_constan	tions [ER5]. t_a in HCHO/PRO	case is not specified in the climate and forecast no DUCT/SUPPORT_DATA/INPUT_DATA	netadata conver
Dimensions:	tions [ER5].		neladala conver
Dimensions: Type:	tions [ER5]. t_a in HCHO/PRO time, layer.		neladala convei
Dimensions: Type: Source:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT.		Type
Dimensions: Type: Source:	tions [ER5]. t_a in HCHO/PRC time, layer. NC_FLOAT. Processor.	DUCT/SUPPORT_DATA/INPUT_DATA	
Dimensions: Type: Source: Attributes:	tions [ER5]. t_a in HCHO/PRC time, layer. NC_FLOAT. Processor. Name units	DUCT/SUPPORT_DATA/INPUT_DATA Value	Туре
Dimensions: Type: Source: Attributes: tm5_constan	tions [ER5]. t_a in HCHO/PRC time, layer. NC_FLOAT. Processor. Name units	Value 'Pa' (static)	Туре
Dimensions: Type: Source: Attributes: tm5_constan Dimensions:	tions [ER5]. t_a in HCHO/PRC time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRC	Value 'Pa' (static)	Туре
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer.	Value 'Pa' (static)	Туре
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT.	Value 'Pa' (static)	Туре
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor.	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA	Type NC_STRING
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value Value	Type NC_STRING Type
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA	Type NC_STRING Type
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopa Dimensions:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units units use_layer_index in layer.	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA	Type NC_STRING Type
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopal Dimensions: Type: Type:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units units use_layer_index in latime, scanline, group	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA	Type NC_STRING Type
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopal Dimensions: Type: Source: Source: Source: Source:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units use_layer_index in I time, scanline, grou NC_INT.	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA	Type NC_STRING Type
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopal Dimensions: Type: Source: Source: Source: Source: Source:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units use_layer_index in I time, scanline, grou NC_INT. Processor.	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA Ind_pixel.	Type NC_STRING Type NC_STRING
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopa Dimensions: Type: Source: Attributes:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units use_layer_index in I time, scanline, grou NC_INT. Processor. Name units	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA Ind_pixel. Value	Type NC_STRING Type NC_STRING
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopal Dimensions: Type: Source: Attributes: Attributes:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units use_layer_index in I time, scanline, grou NC_INT. Processor. Name units x_340_380 in HCHO	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA Ind_pixel. Value '1' (static)	Type NC_STRING Type NC_STRING Type NC_STRING
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopa Dimensions: Type: Source: Attributes: aerosol_inde Description:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units use_layer_index in I time, scanline, grou NC_INT. Processor. Name units x_340_380 in HCHO Aerosol index from	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA Ind_pixel. Value '1' (static)/PRODUCT/SUPPORT_DATA/INPUT_DATA L2 AER _ AI (at wavelengths 340/380, i.e. the TC	Type NC_STRING Type NC_STRING Type NC_STRING
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopa Dimensions: Type: Source: Attributes:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units use_layer_index in I time, scanline, grou NC_INT. Processor. Name units x_340_380 in HCHO Aerosol index from OFFL mode.	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA Ind_pixel. Value '1' (static)/PRODUCT/SUPPORT_DATA/INPUT_DATA L2 AER _ AI (at wavelengths 340/380, i.e. the TC	Type NC_STRING Type NC_STRING Type NC_STRING
Dimensions: Type: Source: Attributes: tm5_constan Dimensions: Type: Source: Attributes: tm5_tropopal Dimensions: Type: Source: Attributes: defined a constan Dimensions: Type: Source: Dimensions: Dimensions:	tions [ER5]. t_a in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units t_b in HCHO/PRO time, layer. NC_FLOAT. Processor. Name units use_layer_index in I time, scanline, grou NC_INT. Processor. Name units x_340_380 in HCHO Aerosol index from OFFL mode. time, scanline, grou itime, scanline, grou	Value 'Pa' (static) DUCT/SUPPORT_DATA/INPUT_DATA Value '1' (static) HCHO/PRODUCT/SUPPORT_DATA/INPUT_DATA Ind_pixel. Value '1' (static)/PRODUCT/SUPPORT_DATA/INPUT_DATA L2 AER _ AI (at wavelengths 340/380, i.e. the TC	Type NC_STRING Type NC_STRING Type NC_STRING

	units	'1' (static)	NC_STRING
	standard_name	'ultraviolet_aerosol_index' (static)	NC_STRING
	long_name	'Aerosol index from 380 and 340 nm' (static)	NC_STRING
	radiation wavelength	340.0, 380.0 (static)	NC_FLOAT
	The wavelengths us	ed for the determination of the aerosol index.	
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING
surface_albe	do in HCHO/PRO[DUCT/SUPPORT_DATA/INPUT_DATA	
Description:	Surface Albedo from OMI database at 342nm for HCHO fitting window		
Dimensions:	time, scanline, ground_pixel.		
Type:	NC_FLOAT.		
Source:	Processor.		
Attributes:	Name	Value	Туре
	units	'1' (static)	NC_STRING
	standard_name	'TBA' (static)	NC_STRING
	long_name	'surface albdeo' (static)	NC_STRING
	coordinates	'/PRODUCT/longitude /PRODUCT/latitude' (static)	NC_STRING

12.1.1.5 Group "BACKGROUND_CORRECTION" in "INPUT_DATA"

This is the main group containing the background correction HCHO.

Attributes in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_CORRECTION

Group attributes attached to BA	CKGROUND_CORRECTION	
Name	Value	Туре
time_coverage_start	'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)	NC_STRING
Start of the data granule in UTO variable on page 39 for details.	C as an ISO 8601 [RD35] string. See the discussion of	the delta_time
time_coverage_end	'YYYY-MM-DDTHH:MM:SS.mmmmmmZ' (dynamic)	NC_STRING
End of the data granule in UTC variable on page 39 for details.	as an ISO 8601 [RD35] string. See the discussion of	the delta_time
orbit	0 (dynamic)	NC_INT
The absolute orbit number whi computing the background corre	ch indicates the first minor orbit of the given set of L2 pection.	oroducts used for
earthshine_reference_valid	'false' (dynamic)	NC_STRING
Flag indicating if the computation	n of the L1b earthshine was successful (true) or not (fals	se).
background_correction valid	'false' (dynamic)	NC_STRING
Flag indicating if the computation	n of the Background Correction was successful (true) or	not (false).
valid_latitude_start	0 (dynamic)	NC_DOUBLE
First valid latitude point of the pe	olynomial.	
valid_latitude_end	0 (dynamic)	NC_DOUBLE
Last valid latitude point of the po	olynomial.	
-		

Dimensions in HCHO_/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_CORRECTION

polynomial_coefficients Dimension which indicates the number of polynomial coefficients used for computing the background correction HCHO.

size 9 (fixed)

619

detector_rows Cross-pixel dimension.

size 450 (fixed) 622 source L1B.

wavelengths Wavelength dimension for the calculation of the earthshine spectra. 624

size 9000 (fixed)

latitude grids Number of latitude grids. 626

size 36 (fixed) 627

RECTION

Variables in HCHO_/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_CORRECTION

offsets in HCHO /PRODUCT/SUPPORT DATA/INPUT DATA/BACKGROUND CORRECTION Description: Calculated offsets for each detector row of the background calculation. Dimensions: detector rows. NC FLOAT. Type: Source: Processor. Attributes: Value Name Type units 'mol m-2' (static) NC STRING offsets scd0 in HCHO /PRODUCT/SUPPORT DATA/INPUT DATA/BACKGROUND CORRECTION Calculated offsets of scd0 for each detector row of the background calculation. Description: Dimensions: detector rows. Type: NC FLOAT. Source: Processor. Attributes: Value Name Type 'mol m-2' (static) NC STRING units polynomial_coefficients in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND COR-**RECTION** Calculated coefficients of the polynomial of the background calculation. Description: polynomial_coefficients (coordinate variable). Dimensions: Type: NC FLOAT. Source: Processor. Attributes: Name Value Type '1' (static) NC STRING units polynomial coefficients scd0 in HCHO /PRODUCT/SUPPORT DATA/INPUT DATA/BACKGROUND -CORRECTION Calculated coefficients of the polynomial of scd0 for the background calculation. Description: Dimensions: polynomial coefficients. Type: NC FLOAT. Source: Processor. Attributes: Name Value Type units '1' (static) NC STRING amf_scd0_median in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_CORREC-TION Description: **TBA** Dimensions: latitude_grids, detector_rows. NC FLOAT. Type: Source: Processor. Attributes: Value Name Type units '1' (static) NC STRING

amf scd0 error median in HCHO /PRODUCT/SUPPORT DATA/INPUT DATA/BACKGROUND COR-

Description: TBA

Dimensions: latitude grids, detector rows.

Type: NC_FLOAT. Source: Processor.

 Attributes:
 Name
 Value
 Type

 units
 '1' (static)
 NC STRING

vcd_scd0_median in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_CORREC-

TION

Description: TBA

Dimensions: latitude_grids, detector_rows.

Type: NC_FLOAT. Source: Processor.

Attributes: Name Value Type
units 'molec cm-2' (static) NC STRING

vcd_scd0_error_median in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_COR-

RECTION

Description: TBA

Dimensions: latitude_grids, detector_rows.

Type: NC_FLOAT. Source: Processor.

 Attributes:
 Name
 Value
 Type

 units
 'molec cm-2' (static)
 NC_STRING

clear_amf_scd0 in HCHO_/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_CORRECTION

Description: TBA

Dimensions: latitude grids, detector rows.

Type: NC_FLOAT. Source: Processor.

Attributes: Name Value Type

 units
 'molec cm-2' (static)
 NC_STRING

 ne reference wavelength
 in
 HCHO /PRODUCT/SUPPORT DATA/INPUT DATA/

earthshine_reference_wavelength
BACKGROUND CORRECTION

Description: Wavelength grid of the calculated earthshine spectra.

Dimensions: wavelengths.

Type: NC_FLOAT.

Source: Processor.

Attributes: Name Value Type

in

units 'nm' (static) NC_STRING

HCHO /PRODUCT/SUPPORT DATA/INPUT DATA/

earthshine_reference_radiance
BACKGROUND CORRECTION

Description: Calculated earthshine spectra. Dimensions: detector rows, wavelengths.

Type: NC_FLOAT. Source: Processor.

Attributes: Name Value Type
units 'mol.m-2.nm-1.sr-1.s-1' (static) NC STRING

12.1.1.6 Group "METADATA" in " bghcho"

Attributes in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA/BACKGROUND_CORRECTION/METADATA

Group attributes attached to METADATA	
Name Value	Туре
ProductShortName 'AUX_BGHCHO' (static)	NC_STRING
The short product name. For the auxiliary background correction HCF_BGHCHO".	HO. output this is fixed to "AUX
input_orbits_I2	NC_STRING
List of L2 orbits ID that were used to produce Background correction file.	
input_files_l2	NC_STRING
Absolute path of L2 products which were used to produce Background co	rrection file.
input_orbits_I1b	NC_STRING
List of L1b orbits ID that were used to calculate the L1b Earthshine spectr	a.
input_files_l1b	NC_STRING
Absolute path of band 3 L1B products that were used to calculate the L1b	Earthshine spectra.
processingMode	NC_STRING
Processor MODE (NRTI, OFFL, RPRO or TEST).	
fallback_reference_date	NC_STRING
Reference date that was selected in case the fallback background correct	ion data was used.
fallback_reference_date_difference	NC_STRING
Time difference to the reference date that was selected in case the fallback used.	background correction data was
fallback_aux_bg_source_filename	NC_STRING
Original filename of the fallback background generation file that has been	used.
fallback_aux_bg_source_processingMode	NC_STRING
Processing mode of the original background correction file that has been	used as fallback.
fallback_l2_source_filename	NC_STRING
Original filename of the level-2 file from which the fallback background co	rrection was retrieved.
fallback_l2_source_processingMode	NC_STRING
Processing mode of the level-2 file from which the fallback background co	rrection was retrieved.
fallback_l2_source_orbit	NC_STRING
	retrieved.
Orbit of the level-2 file from which the fallback background correction was	
Orbit of the level-2 file from which the fallback background correction was fallback_I2_source_sensing_time_start	NC_STRING
-	-
fallback_I2_source_sensing_time_start	-

12.1.1.7 Group "PROCESSOR" in "input_data"

635

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

Attributes in HCHO__/PRODUCT/SUPPORT_DATA/INPUT_DATA/PROCESSOR

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

641

642

NC INT

12.2 Group "METADATA" in "HCHO__"

This is a group to collect metadata items, such as the items that also appear in the header file and items required by Inspire [ER4]. Most metadata will be stored as attributes. Grouping attributes that belong to a specific standard is done by using sub-groups in the Metadata group.

Included in this group are the granule description and quality assurance parameters.

Note that some metadata attributes are required to be attached to the global level by convention, such as the CF-Metadata convention [ER5] and the NetCDF user guide [ER7].

12.2.1 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 HCHO /METADATA/QA STATISTICS

number of input spec-

trum missing occurrences

Group attributes attached to QA	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
· ·	a retrieval was attempted. This is the nused on time or configuration (range and s	
number_of_successfully processed_pixels	0 (static)	NC_INT
Number of ground pixels where	a retrieval was successful.	
number_of_rejected_pixels not_enough_spectrum	0 (static)	NC_INT
	ing was not attempted because after filter s left in either the radiance, irradiance or	
number_of_failed_retrievals	0 (static)	NC_INT
Number of pixels where proces	sing failed for whatever reason.	
number_of_ground_pixels with_warnings	0 (static)	NC_INT
Number of pixels with one or m	ore warnings.	
number_of_radiance_miss- ing_occurrences	0 (static)	NC_INT
•	re processing error "the number of spe in the fitting" occurred, i.e. where the large "1".	•
number_of_irradiance_miss-	0 (static)	NC_INT
ing_occurrences		
<u> </u>	e processing error "the number of spec n the fitting" occurred, i.e. where the le	•

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".

0 (static)

set error occurrences

number_of_reflectance range_error_occurrences	0 (static)	NC_INT
number_of_ler_range_er- ror_occurrences	0 (static)	NC_INT

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

number_of_snr_range_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)

 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_vza_range_er- 0 (static) NC_INT ror occurrences

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

number_of_lut_range_er- 0 (static) NC_INT ror occurrences

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 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) 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)

 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 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) NC_INT rences

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

number_of_numerical_error_occurrences

0 (static)

NC_INT

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

 $number_of_lut_error_occur-$

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)

NC_INT

currences

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)

NC INT

ror_occurrences

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)

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 -

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_-

0 (static)

NC INT

zero error occurrences

Number of ground pixels where processing error "the CH₄ 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".

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)

NC INT

error_occurrences

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

number_of_chi2_error_oc-

0 (static)

NC_INT

currences

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

number_of_svd_error_oc-

0 (static)

NC INT

currences

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)

NC INT

rences

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)
currences

NC_INT

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

number_of_cloud_error_oc- 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 (statio
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_pressure_spread_too_low_er0 (static)

NC INT

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 occurrences

0 (static)

NC INT

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

number of wrong input -

0 (static)

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_coregistration_-

0 (static)

0 (static)

NC INT

NC_INT

error_occurrences

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

number of slant column -

density_error_occurrences

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

number of airmass factor error occurrences

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 -

NC INT

error_occurrences

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 oc-

0 (static)

0 (static)

NC INT

currences

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 er-

0 (static)

NC INT

ror occurrences

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

number of solar eclipse 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 occurrences

0 (static)

NC INT

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

number of altitude consist-0 (static)

NC INT

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

number of altitude rough-

ency filter occurrences

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 "aAI smaller than 2.0" occurred, i.e. where the lower 8 bits of the processing_quality_flags have the value "71".

number of cloud fraction -

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 al-

NC INT

bedo_filter_occurrences

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 wihtin S5P SWIR ground pixel exceeds a priori threshold from configuration" occurred, i.e. where the lower 8 bits of the processing_quality_flags have the value "77".

number_of_cf_viirs_swir_-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)

NC_INT

ofovb_filter_occurrences

Number of ground pixels where input filter "fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVb exceeds a priori threshold from configuration" occurred, i.e. where the lower 8 bits of the processing quality __ flags have the value "79".

number_of_cf_viirs_swir_- 0 (static)
ofovc filter occurrences

NC INT

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

number_of_cf_viirs_nir_-ifov_filter_occurrences

0 (static) NC_INT

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

number_of_cf_viirs_nir_ofova filter occurrences

0 (static)

NC_INT

Number of ground pixels where input filter "fraction of cloudy VIIRS pixels within S5P NIR OFOVa exceeds a priori threshold from configuration" occurred, i.e. where the lower 8 bits of the processing_quality_-

number_of_cf_viirs_nir_-

0 (static)

NC_INT

ofovb_filter_occurrences

flags have the value "82".

Number of ground pixels where input filter "fraction of cloudy VIIRS pixels within S5P NIR OFOVb exceeds a priori threshold from configuration" occurred, i.e. where the lower 8 bits of the processing_quality_-flags have the value "83".

number_of_cf_viirs_nir_ofovc filter occurrences 0 (static)

NC_INT

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

0 (static)

NC INT

viirs swir filter occur-

rences

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_-

0 (static)

NC INT

viirs_nir_filter_occurrences

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- 0

0 (static)

NC INT

tio_filter_occurrences

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

number_of_ch4_noscat_ra- 0 (static)

NC_INT

tio_std_filter_occurrences

Number of ground pixels where input filter "the standard deviation of [CH₄]_{weak}/[CH₄]_{strong} within the SWIR pixel and the 8 neighbouring pixels exceeds a priori threshold from configuration" occurred, i.e. where the lower 8 bits of the processing_quality_flags have the value "89".

NC INT

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

number_of_h2o_noscat_ratio_std_filter_occurrences NC_INT

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

number_of_diff_psurf_-

0 (static)

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)

NC_INT

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)

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

number_of_time_range_filter occurrences 0 (static)

NC INT

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

number of pixel or 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-

0 (static)

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)

NC INT

trum_warning_occurrences

Number of ground pixels where proce

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_warning_occurrences 0 (static)

NC INT

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

number of sun glint warn-0 (static) ing_occurrences

NC INT

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

number of south atlantic -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-

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 (static) 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" occurred, i.e. where bit 15 in the processing_quality_flags is set to "1".

number of AAI warning -0 (static) NC INT

occurrences

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

number of pixel level in-

0 (static)

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 warning occurrences

0 (static)

NC_INT

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

number of low cloud 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".

number_of_altitude_consist-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" occurred, i.e. where bit 21 in the processing quality_flags is set to "1".

number of deconvolution -0 (static) warning_occurrences

NC INT

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

number of so2 volcanic -

NC INT

origin_likely_warning_occur-

rences

Number of ground pixels where processing warning "warning for SO₂ BL product, UTLS products: volcanic origin except for heavily polluted sites" occurred, i.e. where bit 23 in the processing quality flags is set to "1".

number_of_so2_volcanic_-

0 (static)

0 (static)

NC INT

origin certain warning oc-

currences

Number of ground pixels where processing warning "warning for SO₂ 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) NC INT

warning occurrences

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 retrieva" occurred, i.e. where bit 26 in the processing_quality_flags is set to "1".

number of high sza warn-0 (static) NC INT

ing occurrences

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 threshol" occurred, i.e. where bit 29 in the processing_quality_flags is set to "1".

global processing warn-

'None' (static)

NC STRING

ings

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)

-1.0 (static)

NC_DOUBLE

Time in seconds needed for processing.

time per pixel

NC DOUBLE

Time per pixel in seconds needed for processing.

time_standard_deviation_- -1.0 (static)

per_pixel

NC_DOUBLE

Standard deviation of the time per pixel in seconds needed for processing.

Dimensions in HCHO__/METADATA/QA_STATISTICS

vertices For the histogram boundaries.

size 2 (fixed)

654

656

653 histogram_axis Histogram axis.

size 100 (fixed)

pdf_axis Probability density function axis.

size 400 (fixed)

Variables in HCHO /METADATA/QA STATISTICS

Variables in H	CHO/METAD	DATA/QA_STATISTICS		
histogram_a	xis in HCHO	/METADATA/QA_STATISTICS		
Description:	Horizontal axi	s for the histograms of the main paramete	er.	
Dimensions:	histogram axis (coordinate variable).			
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (dynamic)	NC_STRING	
		the main parameter. Other attributes – s^4 rom the main parameter as well. This attrib		
	bounds	'histogram_bounds' (static)	NC_STRING	
pdf_axis in H	CHO/METAL	DATA/QA_STATISTICS		
Description:	Horizontal axi	s for the probability distribution functions	of the main parameter.	
Dimensions:	pdf_axis (coo	rdinate variable).		
Type:	NC_FLOAT.			
Source:	Processor.			
Attributes:	Name	Value	Туре	
	units	'1' (dynamic)	NC_STRING	
		the main parameter. Other attributes – si rom the main parameter as well. This attrib		
	bounds	'pdf_bounds' (static)	NC_STRING	
formaldehyd	e_total_colum	n_histogram in HCHO/METADATA/QA	_STATISTICS	
Description:	Histogram of	the total column ${\sf O}_3$ values in the current ${\sf Q}$	granule.	
Dimensions:	histogram ax	is.		

Dimensions: histogram_axis.

Type: NC_INT.
Source: Processor.

Attributes: Name Value Type

comment 'Histogram of HCHO in the current granule' (static) NC_STRING

formaldehyde total column pdf in HCHO /METADATA/QA STATISTICS

Description: Probability density function of HCHO values in the current granule. The values are weighted

with $\cos(\delta_{\text{geo}})$ and spread out using the error estimate.

Dimensions: pdf_axis.

Type: NC_FLOAT.

Source: Processor.

Attributes:	Name	Value	Туре
	comment	'Probability density function of hcho in the current granule' (static)	NC_STRING

12.2.2 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.

661 12.2.3 Group "GRANULE_DESCRIPTION" in "METADATA"

662 Common granule level metadata.

Attributes in HCHO__/METADATA/GRANULE_DESCRIPTION

· · · · · · · · · · · · · · · · · · ·	GRANULE_DESCRIPTION	
Name	Value	Туре
GranuleStart		NC_STRING
Start of the granule as ISO of definition of ISO date/time s	date/time string in UTC: YYYY-MM-DDTHH:MM:S3 trings is given in [RD35].	S.mmmmmm Z . The forma
GranuleEnd		NC_STRING
End of the granule as ISO d definition of ISO date/time s	ate/time string in UTC: YYYY-MM-DD T HH:MM:SS trings is given in [RD35].	S.mmmmmm Z . The formation
InstrumentName	'TROPOMI' (static)	NC_STRING
The name of the instrument	, fixed to "TROPOMI".	
MissionName	'Sentinel-5 precursor' (static)	NC_STRING
The name of the mission, fix	ed to "Sentinel-5 precursor".	
MissionShortName	'S5P' (static)	NC_STRING
The short name of the missi	on, fixed to "S5P".	
ProcessLevel	'2' (static)	NC_STRING
This is a level 2 product.		
ProcessingCenter	'%(processingcenter)s' (dynamic)	NC_STRING
Where was the processor ru use is "DLR/Oberpfaffenhofe	n? The source is the probably the joborder, the most en".	t likely value for operationa
ProcessingNode		NC_STRING
The name of the machine th	at processed the data. This may aid in diagnosing	failures in the processing.
ProcessorVersion	'%(version)s' (dynamic)	NC_STRING
The version number of the jor.minor.bugfix".	e processor used to produce the file. This is a	string formatted as "ma
ProductFormatVersion	1 (static)	NC_INT
The version of the format of the files.	the product file. This should be incremented whene	ever a datafield is added to
ProcessingMode		NC_STRING
This attribute indicates the r	node of the processor.	
Possible values: Near-realti	me, Offline, Reprocessing, Test, SyntheticTest	
CollectionIdentifier	'%(collection_identifier)s' (dynamic)	NC_STRING
Identification of the proces consistent data set.	sing collection, i.e. the group of products that ca	an be used together as a
ProductShortName	'L2_HCHO' (static)	NC_STRING
The short product name. Fo	or the full O ₃ Total Column product this is fixed to "La	2 HCHO "

4 12.2.3.1 Group "ESA_METADATA" in "ESA_metadata"

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

12.2.3.2 Group "earth explorer header" in "ESA METADATA"

Attributes in HCHO__/METADATA/ESA_METADATA/earth_explorer_header

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

12.2.3.3 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 HCHO__/METADATA/ESA_METADATA/earth_explorer_header/fixed_header

Group attributes attach	ed to fixed_header	
Name	Value	Туре
objectType	'Fixed_Header' (static)	NC_STRING
File_Name	'%(logical_filename)s' (dynamic)	NC_STRING
The <i>logical</i> file name, i.	e. the file name without extension.	
File_Description		NC_STRING
This is a copy of the glo	bbal "title" attribute.	
Notes		NC_STRING
This is a copy of the glo	obal "comment" attribute.	
Mission	'S5P' (static)	NC_STRING
The mission identifier for the Sentinel 5-precursor mission is "S5P".		
File_Class		NC_STRING
The file class of the output. Values are taken from the tailoring of the EO file format tailoring for S5P [RD25, section 4.1.2].		
File_Type	'%(shortname)s' (dynamic)	NC_STRING
Following the EO file format tailoring for S5P [RD25, sections 4.1.3.1 and 4.1.3.2].		
File_Version	0 (dynamic)	NC_INT
	tion is not part of the file name conventions for S5P. If a te, then it has to be provided by the PDGS via the job rided the fill value is 0.	

12.2.3.4 Group "validity_period" in "fixed_header"

672

Attributes in HCHO__/METADATA/ESA_METADATA/earth_explorer_header/fixed_header/validity_period

Group attributes atta	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.

12.2.3.5 Group "source" in "fixed_header"

Attributes in HCHO_/METADATA/ESA_METADATA/earth_explorer_header/fixed_header/source

Group attributes attached to source			
Name	Value	Туре	
objectType	'Source' (static)	NC_STRING	
System	'%(processingcenter)s' (dynamic)	NC_STRING	

Name of the Ground Segment element creating the file. For Level 2 files, this is the PDGS, but for testing a different value may be used. This attribute corresponds to the "System" element in the "Source" XML structure in the header file.

Creator '%(processor_name)s' (dynamic)

NC STRING

Name of the facility or tool, within the Ground Segment element, creating the file. This attribute corresponds to the "Creator" element in the "Source" XML structure in the header file.

Creator Version

679

'%(version)s' (dynamic)

NC STRING

Version number of the tool that created the file. This attribute corresponds to the "Creator_Version" element in the "Source" XML structure in the header file.

Creation_Date NC_STRING

The start date and time of processing, as a string: "UTC=YYYY-MM-DDThh:mm:ss". This attribute corresponds to the "Creator_Date" element in the "Source" XML structure in the header file.

12.2.3.6 Group "variable_header" in "earth_explorer_header"

Attributes in HCHO__/METADATA/ESA_METADATA/earth_explorer_header/variable_header

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

81 12.2.3.7 Group "gmd:lineage" in "variable_header"

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

Attributes in HCHO__/METADATA/ESA_METADATA/earth_explorer_header/variable_header/gmd:lineage

gmd:statement 'L2 %(product)s dataset produced by %(processingcen- NC_STRIN	Group attributes attached	to gmd:lineage	
gmd:statement 'L2 %(product)s dataset produced by %(processingcen- NC_STRIN	Name	Value	Туре
	objectType	'gmd:LI_Lineage' (static)	NC_STRING
ter)s from the S5P/TROPOMI L1B product' (dynamic)	gmd:statement	'L2 %(product)s dataset produced by %(processingcenter)s from the S5P/TROPOMI L1B product' (dynamic)	NC_STRING

General explanation of the data producer's knowledge about the lineage of a dataset. Insert short description of the actual Level 2 product in this string (at the %(...)s).

12.2.3.8 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 HCHO__/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).

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

Description of the output.

Attributes in HCHO__/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

993 12.2.3.10 Group "gmd:sourceCitation" in "gmi:output"

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

Attributes in HCHO__/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

12.2.3.11 Group "gmd:date" in "gmd:sourceCitation"

998 Production date and time of the output file.

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

Group attributes atta	ached 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

12.2.3.12 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

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

Group attributes at	tached 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

12.2.3.13 Group "gmd:identifier" in "gmd:sourceCitation"

706 Identification of the output product.

Attributes in HCHO__/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	

12.2.3.14 Group "gmi:processedLevel" in "gmi:output"

Process level of the output file.

Attributes in HCHO__/METADATA/ESA_METADATA/earth_explorer_header/variable_header/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

12.2.3.15 Group "gmi:processingInformation" in "gmd:processStep"

Description of the processor in more detail.

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

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

7 12.2.3.16 Group "gmi:identifier" in "gmi:processingInformation"

ldentification of the processor.

Attributes in HCHO__/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	
•	he processor, with the $\%(\dots)$ s placeholders replaced with the respondent software release version.	onsible institute's	
objectType	'gmd:MD_Identifier' (static)	NC_STRING	

12.2.3.17 Group "gmi:softwareReference" in "gmi:processingInformation"

Reference to document describing processing software.

Attributes in HCHO__/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	'UPAS L2 %(product)s processor' (dynamic)	NC_STRING
Title of processor descript	tion.	
objectType	'gmd:CI_Citation' (static)	NC_STRING

25 12.2.3.18 Group "gmd:date" in "gmi:softwareReference"

Release date (compile date) of the processor.

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

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

12.2.3.19 Group "gmd:dateType" in "gmd:date"

Confirm that this is the release date of the processor.

Attributes in HCHO__/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	

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

Reference to the ATBD of the product.

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

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

737 12.2.3.21 Group "gmd:date" in "gmi:documentation#1"

738 Release date of the ATBD.

Attributes in HCHO__/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 th	e ATBD expressed as an ISO 8601 date string [RD35].	
objectType	'gmd:CI_Date' (static)	NC_STRING

12.2.3.22 Group "gmd:dateType" in "gmd:date"

Confirm that this is the date of publication.

Attributes in HCHO__/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	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

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

Reference to the PUM of the product.

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

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

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

Release date of the PUM.

Attributes in HCHO__/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 [RD35].		
objectType	'gmd:CI_Date' (static)	NC_STRING

12.2.3.25 Group "gmd:dateType" in "gmd:date"

Confirm that this is the date of publication.

Attributes in HCHO__/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 gm	d: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

57 12.2.3.26 Group "gmi:report" in "gmd:processStep"

Short report of what occurred during the process step.

Attributes in HCHO__/METADATA/ESA_METADATA/earth_explorer_header/variable_header/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	Textual description of what occurred during the process step. Replace %()s as indicated.		
gmi:fileType	'netCDF-4' (static)	NC_STRING	
Type of file that contains the processing report, in our case the processing report is contained in the main output file.			
gmi:name	'%(logical_filename)s.nc' (dynamic)	NC_STRING	
objectType	'gmi:LE_ProcessStepReport' (dynamic)	NC_STRING	

12.2.3.27 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 HCHO__/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.

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

Attributes in HCHO__/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	Туре
gmd:code	Empty!	NC_STRING
objectType	'gmd:MD_Identifier' (static)	NC_STRING

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

Reference to the actual filename of the input data.

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Attributes in HCHO__/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

12.2.3.30 Group "gmd:date" in "gmd:sourceCitation"

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

Group attributes attached to gmd:date		
Name	Value	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 [RD35]. Note that the definition in the XML schema appears to allow the use of a "CI_DateTime" instead of a "CI_Date".		0
objectType	'gmd:CI_Date' (static)	NC_STRING

778 12.2.3.31 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

Attributes in HCHO__/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

12.2.3.32 Group "gmd:title" in "gmd:sourceCitation"

Attributes in HCHO__/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:characterSt	tring	NC_STRING
Textual description Source" object).	, , ,	:description" attribute in the "gmi:LE

12.2.3.33 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 HCHO__/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.	

791 12.2.3.34 Group "EOP_METADATA" in "EOP_metadata"

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

795 Attributes in HCHO__/METADATA/EOP_METADATA

Group attributes attached 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

12.2.3.35 Group "om:phenomenonTime" in "EOP_METADATA"

Time coverage of the granule.

798 Attributes in HCHO__/METADATA/EOP_METADATA/om:phenomenonTime

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

12.2.3.36 Group "om:procedure" in "EOP_METADATA"

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

Attributes in HCHO__/METADATA/EOP_METADATA/om:procedure

Group attributes attached 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	

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

803 Platform name and orbit type.

Attributes in HCHO /METADATA/EOP METADATA/om:procedure/eop:platform

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

12.2.3.38 Group "eop:instrument" in "om:procedure"

806 Instrument descriptor.

807 Attributes in HCHO__/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	

12.2.3.39 Group "eop:sensor" in "om:procedure"

809 Sensor description.

Attributes in HCHO_/METADATA/EOP_METADATA/om:procedure/eop:sensor

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

12.2.3.40 Group "eop:acquisitionParameters" in "om:procedure"

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

Attributes in HCHO_/METADATA/EOP_METADATA/om:procedure/eop:acquisitionParameters

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

12.2.3.41 Group "om:observedProperty" in "EOP_METADATA"

815 An xlink to the observed property definition.

816 Attributes in HCHO__/METADATA/EOP_METADATA/om:observedProperty

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

12.2.3.42 Group "om:featureOfInterest" in "EOP_METADATA"

Attributes in HCHO__/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:FootPrint" object. Constructed from the logical output filename and the extension "FP" separated by a dot.			

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12.2.3.43 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 HCHO__/METADATA/EOP_METADATA/om:featureOfInterest/eop:multiExtentOf

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

12.2.3.44 Group "gml:surfaceMembers" in "eop:multiExtentOf"

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

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

12.2.3.45 Group "gml:exterior" in "gml:surfaceMembers"

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

Group attributes attached 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	

12.2.3.46 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 HCHO__/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 identifying the product (see http://www.datacite.org for DOIs for datasets).			

eop:parentIdentifier 'urn:ogc:def:EOP:ESA:SENTINEL.S5P_TROP_- NC_STRING %(shortname)s' (dynamic)

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

This is a copy of the "gmd:fileIdentifier" attribute in the "/METADATA/ISO METADATA" group.

eop:productType 'S5P %(mode)s %(product)s' (dynamic) NC STRING

Product type identifier. Replace %(mode)s with the operational mode the processor is running in ('NRTI', 'OFFL' or 'RPRO', as per [RD25]) and %(product)s with the 10 character output file name semantic descriptors as given in [RD43, RD44, RD45].

eop:status 'ACQUIRED' (dynamic)

Refers to product status. Values listed in the standard: 'ARCHIVED', 'ACQUIRED', 'CANCELLED', 'FAILED', 'PLANNED', 'POTENTIAL', 'REJECTED', 'QUALITY-DEGRADED'. Copied from L1B.

eop:productQualityStatus 'NOMINAL' (dynamic)

NC_STRING

NC STRING

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

eop:productQualityDegradationTagT APPLICABLE' (dynamic)

NC STRING

Contains further textual information concerning the quality degradation. According to the metadata standards it shall be provided *only* if "eop:productQualityStatus" value is set to 'DEGRADED'. Because the way we generate out output files, this attribute will always be present, even when "eop:productQualityStatus" value is 'NOMINAL'. In those cases the value shall be set to "NOT APPLICABLE".

Possible values are "MISSING AUXILIARY INPUT" and "NOT APPLICABLE". Note that Level 1B does not set this value, so only problems detectable in the processor are covered.

12.2.3.47 Group "eop:processing" in "eop:metaDataProperty"

839 Processing information.

Attributes in HCHO /METADATA/EOP METADATA/eop:metaDataProperty/eop:processing

Group attributes attached to eo	p: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	0 8601 date-time string [RD35].	
eop:processingLevel	'L2' (static)	NC_STRING
These are all Level 2 products.		
eop:processorName	'%(processor_name)s' (static)	NC_STRING
The name of the processor, "ta	copnl12dp.exe" for KNMI and "upas-12" for DLR.	
eop:processorVersion	'%(version)s' (dynamic)	NC_STRING
Version of the processor, as "m	ajor.minor.bugfix".	
eop:nativeProductFormat	'netCDF-4' (static)	NC_STRING
Native product format.		
eop:processingMode	'%(mode)s' (dynamic)	NC_STRING
•	nission specific code list. For S5P we use the <i>File Class</i> 'GSOV', 'OPER', 'NRTI', 'OFFL', 'RPRO'.	identifiers [RD25,

12.2.3.48 Group "ISO_METADATA" in "iso_metadata"

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

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

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

Attributes in HCHO__/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 [RD35] string specifying year, month and o	day.	
gmd:fileldentifier	'urn:ogc:def:EOP:ESA:SENTINEL.S5P_TROP %(shortname)s' (dynamic)	NC_STRING	
Unique identifier for metadata file of the value.	, see the Level 1B metadata specification [RD32, table 5]	for a discussion	
Replace %()s with the "ProductShortName" value from the Level 2 "/METADATA/GRANULEDESCRIPTION" metadata group.			
gmd:hierarchyLevelName	'EO Product Collection' (static)	NC_STRING	
Name of the hierarchy levels for	Name of the hierarchy levels for which the metadata is provided.		
gmd:metadataStandardName	'ISO 19115-2 Geographic Information - Metadata Part 2 Extensions for imagery and gridded data' (static)	NC_STRING	
Name of the metadata standard.			
gmd:metadataStandardVersion 'ISO 19115-2:2009(E), S5P profile' (static) NC_STRING			
Version (profile) of the metadata standard used.			
objectType	'gmi:MI_Metadata' (static)	NC_STRING	
Name of the metadata class [RD32, table 5].			

12.2.3.49 Group "gmd:language" in "ISO_METADATA"

Language used for the metadata, fixed to English.

52 Attributes in HCHO /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

12.2.3.50 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 HCHO /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

57 12.2.3.51 Group "gmd:hierarchyLevel" in "ISO_METADATA"

Scope to wich metadata applies.

Attributes in HCHO__/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

860 12.2.3.52 Group "gmd:contact" in "ISO_METADATA"

861 Contact information for the product.

Attributes in HCHO__/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	

863 12.2.3.53 Group "gmd:contactInfo" in "gmd:contact"

864 The detailed contact information.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:contact/gmd:contactInfo

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

12.2.3.54 Group "gmd:address" in "gmd:contactInfo"

The actual email address.

*** Attributes in HCHO__/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

12.2.3.55 Group "gmd:role" in "gmd:contact"

The role of the adress provided in this group.

871 Attributes in HCHO__/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

2 12.2.3.56 Group "gmd:identificationInfo" in "ISO_METADATA"

ldentification 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.

77 Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo

Group attributes attached to gmd:identificationInfo		
Name	Value	Туре
gmd:abstract		NC_STRING

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

- **L2_AER_AI (KNMI)** Aerosol index with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_AER_LH (KNMI)** Altitude of elevated aerosol layer for cloud-free observations with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_NO2__ (KNMI)** Nitrogen dioxide tropospheric column with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_O3_PR (KNMI)** Ozone profile with a vertical resolution of 6 km and a horizontal resolution of $28 \times 21 \, \text{km}^2$ observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_O3_TPR (KNMI)** Tropospheric ozone profile with a vertical resolution of 6 km and a horizontal resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_CH4__ (SRON)** Dry-air mixing ratio of methane for cloud-free observations over land with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- L2_CO___(SRON) Carbon monoxide column over land with a spatial resolution of either 7.2 × 3.6 km² or 5.6 × 3.6 km² (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_FRESCO (KNMI)** Cloud fraction and cloud pressure with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI (KNMI cloud support product)
- $\begin{array}{l} \textbf{L2_CLOUD_(DLR)} \ \ \text{Cloud fraction, cloud pressure and cloud albedo with a spatial resolution of either} \\ 7.2\times3.6\,\text{km}^2 \ \text{or} \ 5.6\times3.6\,\text{km}^2 \ \text{(for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI \\ \end{array}$
- **L2_HCHO_ (BIRA)** Formaldehyde tropospheric column with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_O3__ (DLR/BIRA)** Ozone total column with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_O3_TCL (DLR/IUP)** Tropospheric ozone with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_SO2__ (BIRA)** Sulfur dioxide column with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019) observed at about 13:30 local solar time from spectra measured by TROPOMI
- **L2_NP_BD(3,6,7)** Regridded NPP-VIIRS data with a spatial resolution of either $7.2 \times 3.6 \, \text{km}^2$ or $5.6 \times 3.6 \, \text{km}^2$ (for the small pixels since 6th of august 2019)

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

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

12.2.3.57 Group "gmd:citation" in "gmd:identificationInfo"

879 Citation data for the resource.

880 Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:citation

Group attributes attached 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 metadata class [RD32, table 11].			

12.2.3.58 Group "gmd:date" in "gmd:citation"

88 Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:citation/gmd:date

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

84 12.2.3.59 Group "gmd:dateType" in "gmd:date"

885 Event used for reference date.

88 Attributes in HCHO__/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	

12.2.3.60 Group "gmd:identifier" in "gmd:citation"

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

•• Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:citation/gmd:identifier

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

12.2.3.61 Group "gmd:pointOfContact" in "gmd:identificationInfo"

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

893 Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:pointOfContact

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	

12.2.3.62 Group "gmd:contactInfo" in "gmd:pointOfContact"

48 Attributes in HCHO /METADATA/ISO METADATA/gmd:identificationInfo/gmd:pointOfContact/gmd:contactInfo

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

12.2.3.63 Group "gmd:address" in "gmd:contactInfo"

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Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:pointOfContact/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	

12.2.3.64 Group "gmd:role" in "gmd:pointOfContact"

Attributes in HCHO__/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	

12.2.3.65 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 HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1

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

9 12.2.3.66 Group "gmd:type" in "gmd:descriptiveKeywords#1"

910 Subject matter used to group similar keywords.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#1/912 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	

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

914 Name by which the cited resource is known.

Attributes in HCHO__/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	

12.2.3.68 Group "gmd:date" in "gmd:thesaurusName"

918 Reference date for the cited resource.

Attributes in HCHO__/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	

12.2.3.69 Group "gmd:dateType" in "gmd:date"

922 What date is used for the reference date.

Attributes in HCHO__/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	

12.2.3.70 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

 gen_dioxide, atmosphere_mole_content_of_nitrogen_dioxide
- 933 L2_O3_PR (KNMI) mole_fraction_of_ozone_in_air
- L2_O3_TPR (KNMI) mole_fraction_of_ozone_in_air
- L2_CH4_ (SRON) atmosphere_mole_fraction_of_methane_in_dry_air
- L2_CO___(SRON) atmosphere_mole_content_of_carbon_monoxide
- 937 L2 FRESCO (KNMI)
- 938 L2__CLOUD_ (DLR)
- L2_HCHO_ (BIRA) troposphere_mole_content_of_formaldehyde
- 940 L2_O3___ (DLR/BIRA) atmosphere_mole_content_of_ozone
- L2_O3_TCL (DLR/IUP) troposphere_mole_content_of_ozone
- 942 L2_SO2___(BIRA) atmosphere_mole_content_of_sulfur_dioxide
- 943 L2 NP BDx (RAL)

44 Attributes in HCHO /METADATA/ISO METADATA/gmd:identificationInfo/gmd:descriptiveKeywords

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

945 12.2.3.71 Group "gmd:thesaurusName" in "gmd:descriptiveKeywords#2"

Name by which the cited resource is known.

Attributes in HCHO__/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 v29' (static)		NC_STRING
xlink:href	'http://cfconventions.org/standard-names.html' namic)	(dy-	NC_STRING
objectType	'gmd:CI_Citation' (static)		NC_STRING

12.2.3.72 Group "gmd:date" in "gmd:thesaurusName"

950 Reference date for the cited resource.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:descriptiveKeywords#2/ gmd:thesaurusName/gmd:date

Group attributes attached to gmd:date			
Name	Value	Туре	
gmd:date	'2015-07-08' (static)	NC_STRING	
objectType	'gmd:CI_Date' (static)	NC_STRING	

12.2.3.73 Group "gmd:dateType" in "gmd:date"

954 What date is used for the reference date.

Attributes in HCHO__/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	

957 12.2.3.74 Group "gmd:resourceConstraints" in "gmd:identificationInfo"

Provides information about constraints which apply to the resource.

Attributes in HCHO_/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

12.2.3.75 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 HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:resourceConstraints/gmd:accessCons

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	

12.2.3.76 Group "gmd:spatialRepresentationType" in "gmd:identificationInfo"

Method used to spatially represent geographic information.

Attributes in HCHO__/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	

12.2.3.77 Group "gmd:spatialResolution" in "gmd:identificationInfo"

Ground sample distance.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:spatialResolution

Group attributes attache	d to gmd:spatialResolution	
Name	Value	Туре
gmd:distance	7.0 (dynamic)	NC_FLOAT
uom	'km' (static)	NC_STRING
objectType	'gmd:MD_Resolution' (static)	NC_STRING

12.2.3.78 Group "gmd:characterSet" in "gmd:identificationInfo"

Attributes in HCHO /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	

12.2.3.79 Group "gmd:extent" in "gmd:identificationInfo"

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

Attributes in HCHO_/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:extent

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

12.2.3.80 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: $-180^{\circ} \le \vartheta \le 180^{\circ}$ and $-90^{\circ} \le \delta \le 90^{\circ}$. 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.

4ttributes in HCHO /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	

12.2.3.81 Group "gmd:temporalElement" in "gmd:extent"

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4ttributes in HCHO__/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

12.2.3.82 Group "gmd:extent" in "gmd:temporalElement"

Time period covered by the content of the dataset.

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Attributes in HCHO__/METADATA/ISO_METADATA/gmd:identificationInfo/gmd:extent/gmd:temporalElement/ gmd:extent

Group attributes attached t	o gmd:extent		
Name	Value	Туре	
gml:beginPosition	'2014-11-14T19:58:00' (dynamic)	NC_STRING	
Time of the start of the grain	nule, expressed as ISO 8601 [RD35] date-time string.		
gml:endPosition	'2014-11-14T20:08:00' (dynamic)	NC_STRING	
Time of the end of the granule, expressed as ISO 8601 [RD35] date-time string.			
objectType	'gml:TimePeriod' (static)	NC_STRING	

12.2.3.83 Group "gmd:dataQualityInfo" in "ISO_METADATA"

This group contains a general assessment of the quality of the dataset. In addition, the package contains information about the sources and production processes used in producing a dataset, which is of particular importance for imagery and gridded data.

For the TROPOMI 2 products the use of the contained class LI_Lineage (group "gmd:lineage", section 12.2.3.91 on page 115) 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 HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo

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

12.2.3.84 Group "gmd:scope" in "gmd:dataQualityInfo"

The specific data to which the data quality information applies.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:scope

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

12.2.3.85 Group "gmd:level" in "gmd:scope"

Hierarchical level of the data specified by the scope.

Attributes in HCHO_/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	

12.2.3.86 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 HCHO_/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:report

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

12.2.3.87 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 HCHO /METADATA/ISO METADATA/qmd:dataQualityInfo/gmd:report/qmd:result

Group attributes attached t	o gmd:result	
Name	Value	Туре
objectType	'gmd:DQ_ConformanceResult' (static)	NC_STRING
gmd:pass	'true' (static)	NC_STRING
Indication of confomance r	esult. The value "true" indicates "pass".	
gmd:explanation	'INSPIRE Data specification for orthoimagery is not yet officially published so conformity has not yet been evaluated' (static)	NC_STRING
Explanation of the meaning currently not be determined	${\mathfrak g}$ of conformance for this result. Within the context of INSPIRE ${\mathfrak g}$	conformance can

12.2.3.88 Group "gmd:specification" in "gmd:result"

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

₁₅ Attributes in HCHO /METADATA/ISO METADATA/gmd:dataQualityInfo/gmd:report/gmd:result/gmd:specification

Group attributes attach	ned 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

12.2.3.89 Group "gmd:date" in "gmd:specification"

Reference date for the cited resource.

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Attributes in HCHO__/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	

12.2.3.90 Group "gmd:dateType" in "gmd:date"

Meaning of the reference date for the cited resource.

Attributes in HCHO__/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	

12.2.3.91 Group "gmd:lineage" in "gmd:dataQualityInfo"

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

Attributes in HCHO /METADATA/ISO METADATA/gmd:dataQualityInfo/gmd:lineage

Group attributes attached	d to gmd:lineage	
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
General explanation of the	e data producer's knowledge about the lineage of a dataset. Insert	short description

General explanation of the data producer's knowledge about the lineage of a dataset. Insert short description of the actual Level 2 product in this string (at the %(...)s).

12.2.3.92 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 HCHO__/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 %(orbit)d using the %(institute)s processor version %(version)s' (dynamic)	NC_STRING	

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

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

Description of the output.

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Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output

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

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

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

Attributes in HCHO__/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	

12.2.3.95 Group "gmd:date" in "gmd:sourceCitation"

Production date and time of the output file.

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Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/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	

12.2.3.96 Group "gmd:dateType" in "gmd:date"

1044 Meaning of the reference date for the cited resource.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/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	

12.2.3.97 Group "gmd:identifier" in "gmd:sourceCitation"

1048 Identification of the output product.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmd:sourceCitation/gmd:identifier

Oug. us attails uton atta		
Group attributes attac	ched to gmd:identifier	
Name	Value	Туре
gmd:code	'%(shortname)s' (dynamic)	NC_STRING
•	me, a copy of the 'ProductShortName' attribute in '/MET	ADATA/GRANULE_DESCRIP-
TION'.		
objectType	'gmd:MD_Identifier' (static)	NC_STRING

12.2.3.98 Group "gmi:processedLevel" in "gmi:output"

Process level of the output file.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:output/gmi:processedLevel

Group attributes at	tached to gmi:processedLevel	
Name	Value	Туре

gmd:code	'L2' (static)	NC_STRING
objectType	'gmd:MD_Identifier' (static)	NC_STRING

12.2.3.99 Group "gmi:processingInformation" in "gmd:processStep"

Description of the processor in more detail.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/ gmi:processingInformation

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

12.2.3.100 Group "gmi:identifier" in "gmi:processingInformation"

060 Identification of the processor.

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Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:identifier

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

12.2.3.101 Group "gmi:softwareReference" in "gmi:processingInformation"

¹⁰⁶⁴ Reference to document describing processing software.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference

Group attributes attached to g	mi:softwareReference	
Name	Value	Туре
gmd:title	'UPAS L2 %(product)s processor' (dynamic)	NC_STRING
Title of processor description.		
objectType	'gmd:CI_Citation' (static)	NC_STRING

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

Release date (compile date) of the processor.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:softwareReference/gmd:date

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

12.2.3.103 Group "gmd:dateType" in "gmd:date"

Confirm that this is the release date of the processor.

Attributes in HCHO__/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

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

1076 Reference to the ATBD of the product.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1

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

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

Release date of the ATBD.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#1/gmd:date

Group attributes attach	ned to gmd:date	
Name	Value	Туре
gmd:date	'%(date_atbd)s' (dynamic)	NC_STRING
Release date of the AT	BD expressed as an ISO 8601 date string [RD35].	
objectType	'gmd:CI_Date' (static)	NC_STRING

12.2.3.106 Group "gmd:dateType" in "gmd:date"

1084 Confirm that this is the date of publication.

Attributes in HCHO__/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	'publication' (static)	NC_STRING
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING

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

Reference to the PUM of the product.

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmi:processingInformation/gmi:documentation#2

Group attributes attach	ed to gmi:documentation#2	
Name	Value	Туре
objectType	'gmd:CI_Citation' (static)	NC_STRING
gmd:title	'%(title_pum)s' (dynamic)	NC_STRING
The filename of the cur	rent release of the PUM of the current product.	
doi	'%(pum_doi)s' (dynamic)	NC_STRING
DOI for the product use	r manual.	

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

1092 Release date of the PUM.

Attributes in HCHO__/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 P	UM expressed as an ISO 8601 date string [RD35].		
objectType	'gmd:CI_Date' (static)	NC_STRING	

12.2.3.109 Group "gmd:dateType" in "gmd:date"

1096 Confirm that this is the date of publication.

Attributes in HCHO__/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#Cl_DateTypeCode' (static)	NC_STRING	
codeListValue	'publication' (static)	NC_STRING	
objectType	'gmd:CI_DateTypeCode' (static)	NC_STRING	

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

Short report of what occurred during the process step.

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Attributes in HCHO__/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 %()s as indicated.			
gmi:fileType	'netCDF-4' (static)	NC_STRING	
Type of file that contains the processing report, in our case the processing report is contained in the main output file.			
gmi:name	'%(logical_filename)s.nc' (dynamic)	NC_STRING	
objectType	'gmi:LE_ProcessStepReport' (dynamic)	NC_STRING	

12.2.3.111 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 HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1

Group attributes attached	d 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.

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

Attributes in HCHO__/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	

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

Reference to the actual filename of the input data.

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Attributes in HCHO__/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	

12.2.3.114 Group "gmd:date" in "gmd:sourceCitation"

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:date

Group attributes a	ttached to gmd:date	
Name	Value	Туре
gmd:date		NC_STRING
	nd time of the input file(s) in this group expressed as a inition in the XML schema appears to allow the us	9
objectType	'gmd:Cl Date' (static)	NC STRING

12.2.3.115 Group "gmd:dateType" in "gmd:date"

1121 Meaning of the reference date for the cited resource.

Attributes in HCHO__/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	

12.2.3.116 Group "gmd:title" in "gmd:sourceCitation"

1124

1133

Attributes in HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:title

Group attributes att	ached to gmd:title	
Name	Value	Туре
gco:characterStrii	ng	NC_STRING
Textual description Source" object).	of the input file group (same as the "gm	d:description" attribute in the "gmi:LE

12.2.3.117 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 HCHO__/METADATA/ISO_METADATA/gmd:dataQualityInfo/gmd:lineage/gmd:processStep/gmd:source#1/gmd:sourceCitation/gmd:alternateTitle#1

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

12.2.3.118 Group "gmi:acquisitionInformation" in "ISO_METADATA"

1134 Metadata regarding the acquisition of the original data.

Attributes in HCHO__/METADATA/ISO_METADATA/gmi:acquisitionInformation

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

12.2.3.119 Group "gmi:platform" in "gmi:acquisitionInformation"

The platform we are on.

1138 Attributes in HCHO /METADATA/ISO METADATA/qmi:acquisitionInformation/qmi:platform

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

objectType	'gmi:MI_Platform' (static)	NC_STRING
• • •	• - ,	_

12.2.3.120 Group "gmi:identifier" in "gmi:platform"

1140 Short identifier of the platform.

Attributes in HCHO__/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	

12.2.3.121 Group "gmi:instrument" in "gmi:platform"

The instrument used for the observations.

Attributes in HCHO_/METADATA/ISO_METADATA/gmi:acquisitionInformation/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.				

1145 12.2.3.122 Group "gmi:identifier" in "gmi:instrument"

Unique identifier for the instrument.

Attributes in HCHO__/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.	The actual identifier.				
gmd:codeSpace	'http://www.esa.int/' (static)	NC_STRING			
Name or identifier of the organization responsible for the namespace.					
objectType	'gmd:RS_Identifier' (static)	NC_STRING			

A Flag descriptions

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

Please be aware that this section is work in progress and the flags are not included in the product yet. The aim of this section is for review only.

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2. Warnings are listed in table 13. The value in the first column is the result of a bitwise 'and' of 255 (0xFF) and the value in the "processing_quality_flags" variable.

#	Short name	Description	Algorithm
0	success	No failures, output contains value. Warnings still possible.	All
1	radiance_missing	The number of spectral pixels in the radiance due to flagging is too small to perform the fitting.	All
2	irradiance_missing	The number of spectral pixels in the irradiance due to flagging is too small to perform the fitting.	All
3	input_spectrum_missing	The reflectance spectrum does not contain enough points to perform the retrieval. This is different from (ir)radiance_missing in that the missing points may not be aligned.	All
4	reflectance_range_error	Any of the reflectances is out of bounds ($R < 0$ or $R > R_{max}$).	FRESCO
5	ler_range_error	Lambert-equivalent reflectivity out of range error.	CO, CH ₄
6	snr_range_error	Too low signal to noise to perform retrieval.	CO
7	sza_range_error	Solar zenith angle out of range, maximum value from configuration.	All
8	vza_range_error	Viewing zenith angle out of range, maximum value from configuration.	Development phase only
9	lut_range_error	Extrapolation in lookup table (airmass factor, cloud radiances).	NO ₂
10	ozone_range_error	Ozone column significantly out of range of profile climatology.	Total O ₃ column
11	wavelength_offset_error	Wavelength offset exceeds maximum from configuration.	FRESCO, NO ₂
12	initialization_error	An error occurred during the processing of the pixel, no output was generated. The following errors raise this flag: Mismatch between irradiance and radiance wavelengths; The on-ground distance between band 1 and band 2 ground pixels exceeds a threshold set in the configuration. Derived a-priori information does not validate, no processing is possible.	All
13	memory_error	Memory allocation or deallocation error.	CO, CH ₄
14	assertion_error	Error in algorithm detected during assertion.	CO
15	io_error	Error detected during transfer of data between algorithm and framework.	CO, ALH, CH ₄ , O ₃ profile
16	numerical_error	General fatal numerical error occurred during inversion.	CO, FRESCO
17	lut_error	Error in accessing the lookup table.	CH ₄
18	ISRF_error	Error detected in the input instrument spectral response function input data.	CH ₄
19	convergence_error	The main algorithm did not converge.	All
20	cloud_filter_convergence_error	The cloud filter did not converge.	CO

 Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
21	max_iteration_convergence_error	No convergence because retrieval exceeds maximum number of iterations. Maximum value from configuration.	ALH
22	aot_lower_boundary_convergence_error	No convergence because the aerosol optical thickness crosses lower boundary twice in succession.	ALH
23	other_boundary_convergence_error	No convergence because a state vector element crosses boundary twice in succession. Note that a separate failure flag is defined for non-convergence due to crossing of lower AOT boundary.	ALH
25	ch4_noscat_zero_error	The CH_4 column retrieved by the non-scattering CO algorithm from the weak band or strong band is 0.	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.	CH ₄
27	max_optical_thickness_error	Maximum optical thickness exceeded during iterations.	CH ₄
28	aerosol_boundary_error	Boundary hit of aerosol parameters at last iteration.	CH ₄
29	boundary_hit_error	Fatal boundary hit during iterations.	CH ₄
30	chi2_error	χ^2 is not-a-number or larger than 10^{10} .	CH₄
31	svd_error	Singular value decomposition failure.	CH ₄
32	dfs_error	Degree of freedom is not-a-number.	CH₄
33	radiative_transfer_error	Errors occurred during the radiative transfer computations, no processing possible.	O ₃ profile
34	optimal_estimation_error	Errors occurred during the optimal estimation, processing has been terminated.	O ₃ profile
35	profile_error	Flag that indicates if there were any errors during the computation of the ozone profile.	O ₃ profile
36	cloud_error	No cloud data.	Cloud
37	model_error	Forward model failure.	Cloud, Total O ₃ column
38	number_of_input_data_points_too_low_error	Not enough input ozone columns to calculate a tropospheric column.	Tropospheric O ₃ column
39	cloud_pressure_spread_too_low_error	Cloud pressure variability to low to estimate a tropospheric column.	Tropospheric O ₃ column
40	cloud_too_low_level_error	Clouds are too low in the atmosphere to assume sufficient shielding.	Tropospheric O ₃ column
41	generic_range_error	Generic range error.	All
42	generic_exception	Catch all generic error.	All
43	input_spectrum_alignment_error	Input radiance and irradiance spectra are not aligned correctly.	All
44	abort_error	Not processed because processor aborted prematurely (time out or user abort)	All

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
45	wrong_input_type_error	Wrong input type error, mismatch between expectation and received data.	All
46	wavelength_calibration_error	An error occurred in the wavelength calibration of this pixel	All
47	coregistration_error	No colocated pixels found in a supporting band	All
51	signal_to_noise_ratio_error	The signal to noise ratio for this spectrum is too low for processing	All
52	configuration_error	Error while parsing the configuration	All
53	key_error	Key does not exist	All
54	saturation_error	Saturation in input spectrum	All
55	max_num_outlier_exceeded_error	The number of outliers detected in the DOAS fit exceeds a maximum set for healthy spectra.	NO ₂
64	solar_eclipse_filter	Solar eclipse.	All
65	cloud_filter	The cloud filter triggered causing the pixel to be skipped.	CO, ALH, CH ₄
66	altitude_consistency_filter	Too large difference between ECMWF altitude and DEM altitude value.	CO, CH ₄
67	altitude_roughness_filter	Too large standard deviation of altitude in DEM.	CO, ALH, CH ₄
68	sun_glint_filter	For pixels over water, viewing direction inside sun glint region. Definition of sun glint angle and threshold value from ATBD.	ALH
69	mixed_surface_type_filter	Pixel contains land and water areas (e.g. coastal pixel).	ALH
70	snow_ice_filter	Pixel contains snow/ice: Snow/ice flag according to dynamic input OR climatological surface albedo at VIS wavelength is larger than 0.5.	ALH
71	aai_filter	AAI smaller than 2.0.	ALH
72	cloud_fraction_fresco_filter	Pixel contains clouds: The FRESCO effective cloud fraction is larger than threshold. Threshold value from ATBD.	ALH
73	aai_scene_albedo_filter	Pixel contains clouds: The difference between scene albedo at 380 nm from AAI calculation and the 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 ₄
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 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
77	cf_viirs_swir_ifov_filter	Fraction of cloudy VIIRS pixels within S5P SWIR ground pixel exceeds a priori threshold from configuration.	CH ₄
78	cf_viirs_swir_ofova_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVa exceeds a priori threshold from configuration.	CH ₄
79	cf_viirs_swir_ofovb_filter	Fraction of cloudy VIIRS pixels within S5P SWIR OFOVb exceeds a priori threshold from configuration.	CH ₄
80	cf_viirs_swir_ofovc_filter	Fraction of cloudy VIIRS pixels wihtin S5P SWIR OFOVc exceeds a priori threshold from configuration.	CH ₄
81	cf_viirs_nir_ifov_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR ground pixel exceeds a priori threshold from configuration.	CH ₄
82	cf_viirs_nir_ofova_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVa exceeds a priori threshold from configuration.	CH₄
83	cf_viirs_nir_ofovb_filter	Fraction of cloudy VIIRS pixels wihtin S5P NIR OFOVb exceeds a priori threshold from configuration.	CH ₄
84	cf_viirs_nir_ofovc_filter	Fraction of cloudy VIIRS pixels within S5P NIR OFOVc exceeds a priori threshold from configuration.	CH ₄
85	refl_cirrus_viirs_swir_filter	Average VIIRS cirrus reflectance within SWIR ground pixel exceeds a priori threshold from configuration.	CH ₄
86	refl_cirrus_viirs_nir_filter	Average VIIRS cirrus reflectance within NIR ground pixel exceeds a priori threshold from configuration.	CH ₄
87	diff_refl_cirrus_viirs_filter	Difference in VIIRS average cirrus reflectance between SWIR and NIR ground pixel exceeds a priori threshold from configuration.	CH ₄
88	ch4_noscat_ratio_filter	The ratio between $[CH_4]_{weak}$ and $[CH_4]_{strong}$ is below or exceeds a priori thresholds from configuration.	CH ₄
89	ch4_noscat_ratio_std_filter	The standard deviation of [CH ₄] _{weak} /[CH ₄] _{strong} within the SWIR pixel and the 8 neighbouring pixels exceeds a priori threshold from configuration.	CH ₄
90	h2o_noscat_ratio_filter	The ratio between $[H_2O]_{weak}$ and $[H_2O]_{strong}$ is below or exceeds a priori thresholds from configuration.	CH ₄
91	h2o_noscat_ratio_std_filter	The standard deviation of $[H_2O]_{weak}/[H_2O]_{strong}$ within the SWIR pixel and the 8 neigbouring pixels exceeds a priori threshold from configuration.	CH ₄

Table 12: Processing quality flags, errors, processing failures and filter conditions for S5P Level 2 (continued).

#	Short name	Description	Algorithm
92	diff_psurf_fresco_ecmwf_filter	Difference between the FRESCO apparent surface pressure and the ECMWF surface pressure exceeds a priori threshold from configuration.	CH ₄
93	psurf_fresco_stdv_filter	The standard deviation of the FRESCO apparent surface pressure in the NIR pixel and the 8 surrounding pixels exceeds a priori threshold from configuration.	CH₄
94	ocean_filter	The ground pixel is over ocean (and ocean glint retrievals are not switched on).	CH ₄
95	time_range_filter	Time is out of the range that is to be processed.	All
96	pixel_or_scanline_index_filter	Not processed because pixel index does not match general selection criteria.	All
97	geographic_region_filter	Pixel falls outside the specified regions of interest.	All

Table 13: Processing quality flags, warnings for S5P Level 2. Errors, processing failures and filter conditions are listed in table 12. If a bitwise 'and' of the mask value and the value in the "processing_quality_flags" variable is not zero, then the warning applies to the specific retrieval.

Bit#	Mask (hex)	Short name	Description	Algorithm	
0–7	0x000000FF	error	If non-zero an error has occurred when processing the pixel, see table 12 for details.	All	
8	0x00000100	input_spectrum_warning	Number of good pixels in radiance, irradiance or calculated reflectance below threshold from configuration.	All	
9	0x00000200	wavelength_calibration_warning	Offset from wavelength fit is larger than limit set in configuration.	Most	
10	0x00000400	extrapolation_warning	Pressure or temperature outside cross section LUT range, other lookup table extrapolation.	CO, CH ₄	
11	0x00000800	sun_glint_warning	Sun glint posibility warning.	All	
12	0x00001000	south_atlantic_anomaly_warning	TROPOMI is inside the south Atlantic anomaly while taking these measurements.	All	ω,
13	0x00002000	sun_glint_correction	A sun glint correction has been applied.	Cloud	S5P-
14	0x00004000	snow_ice_warning	Snow/ice flag is set, i.e. using scene data from the cloud support product.	NO ₂ , Cloud	_ <u> </u>
15	0x00008000	cloud_warning	Cloud filter based on FRESCO apparent surface pressure (VIIRS not available), cloud fraction above threshold or cloud pressure adjusted to force cloud above surface. In case of Cloud product this flag indicates the possiblity of ice-clouds.	CH ₄ , O ₃ profile, Cloud	Page 128 of 130
16	0x00010000	AAI_warning	Possible aerosol contamination as either indicated by the AAI (O ₃ profile).	O ₃ profile	130

Table 13: Processing quality flags, warnings for S5P Level 2 (continued).

it#	Mask (hex)	Short name	Description	Algorithm	35P L2 F ssue 02
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	S5P L2 PUM Fo
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.	Algorithm All CO, CH ₄ , O ₃ , SO ₂ , HCH	ognaldehyde HCHO 2022-07-11 – released
19	0x00080000	low_cloud_fraction_warning	Low cloud fraction, therefore no cloud pressure retrieved.	Cloud	ed.
20	0x00100000	altitude_consistency_warning	Difference between ECMWF surface elevation and high-resolution surface elevation exceeds threshold from configuration.	CH ₄	
21	0x00200000	signal_to_noise_ratio_warning	Signal to noise ratio in SWIR and/or NIR band below threshold from configuration. For the $\rm O_3$ and HCHO products this flag indicates an RMS above a certain threshold.	CH ₄ , O ₃ , HCHO	
22	0x00400000	deconvolution_warning	Failed deconvolution irradiance spectrum (not pixel-specific, but row-specific).	CO, CH ₄	
23	0x00800000	so2_volcanic_origin_likely_warning	Warning for SO_2 BL product, UTLS products: volcanic origin except for heavily polluted sites. 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 ₂ , O ₃ profile	
24	0x01000000	so2_volcanic_origin_certain_warning	Warning for SO ₂ BL product, UTLS products: volcanic origin certain.	SO ₂	
25	0x02000000	interpolation_warning	Warning for interpolation on partially missing data. In this case the valid available data is used, potentially leading to a bias.	All	
26	0x04000000	saturation_warning	Saturation occurred spectrum, possibly causing biases in the retrieval	All	
27	0x08000000	high_sza_warning	Warning for high solar zenith angle. In this case, the processing can be performed with less final quality.	All	S5
28	0x10000000	cloud_retrieval_warning	Warning occurring when the retrieval diagnostic indicates a degraded quality of the cloud retrieval.	Cloud	S5P-L2-DLR-PUM-4 Page 129 of
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	DLR-PUN Page 129
30	0x40000000	thermal_instability_warning	Input spectra have been labeled with a thermal instability warning flag.	All	29 ∨

Table 14: Surface classification for S5P Level 2. This is a combined land/water mask and surface classification data field. For land the "Global Land Cover Characteristics Data Base Version 2.0" is used [ER11], specifically the "USGS Land Use/Land Cover System (Modified Level 2)" classification. Over water the classification from the NASA SDP toolkit [ER12], which is based on [RD46].

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 14: Surface classification for S5P Level 2 (continued).

Bit#	Mask (hex)	Short name	Description
96	0xF9	Land+Deciduous_Needleleaf_Forest	Land, Deciduous Needleleaf Forest
104	0xF9	Land+Evergreen_Broadleaf_Forest	Land, Evergreen Broadleaf Forest
112	0xF9	Land+Evergreen_Needleleaf_Forest	Land, Evergreen Needleleaf Forest
120	0xF9	Land+Mixed_Forest	Land, Mixed Forest
128	0xF9	Land+Herbaceous_Wetland	Land, Herbaceous Wetland
136	0xF9	Land+Wooded_Wetland	Land, Wooded Wetland
144	0xF9	Land+Barren_Or_Sparsely_Vegetated	Land, Barren or Sparsely Vegetated
152	0xF9	Land+Herbaceous_Tundra	Land, Herbaceous Tundra
160	0xF9	Land+Wooded_Tundra	Land, Wooded Tundra
168	0xF9	Land+Mixed_Tundra	Land, Mixed Tundra
176	0xF9	Land+Bare_Ground_Tundra	Land, Bare Ground Tundra
184	0xF9	Land+Snow_Or_Ice	Land, Snow or Ice