HONO Product Format Specification

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Version History

Revision	Date	Author(s)	Description
1.0	14/02/2026	Jonas Vlietinck, Nicolas Theys	First release.
1.1	20/02/2026	Jonas Vlietinck, Nicolas Theys	small corrections.
1.2	3/03/2026	Jonas Vlietinck, Nicolas Theys	corrections of global attributes + removal of geolocation_flags variable
1.3	10/03/2026	Jonas Vlietinck, Nicolas Theys	correction of flags variable attribute + global attribute correction

Contents

1 Introduction.

This document serves as a guide to understand the layout and format specifications of the Level-2 (L2) HONO product. For an interpretation and explanation of the data in the HONO product, see [1]. An explanation of the filename structure of the product is given in section 2. Nitrous acid (HONO) is a precursor of the hydroxyl radical in the atmosphere, which controls the degradation of greenhouse gases, contributes to photochemical smog and ozone production, and influences air quality. Understanding the sources and sinks of HONO in the atmosphere is therefore important for advancing our knowledge in atmospheric chemistry. However, measurements of HONO are sparse and have been mostly limited to laboratory experiments, remote-sensing or in-situ measurements from ground-based or aircraft platforms. Recently, there has been a growing effort to detect HONO from satellite measurements. An overview of the variables that contain the main retrieval results is given in section 4.1. The product is stored in a NetCDF4 binary format, following the CF-convention. Furthermore, the file format should be compliant with the guidelines provided in [2]. A description of the global attributes is provided in section 3. A full list of all variables that can be found in the L2 HONO together with all the metadata is provided in section 4.

2 filename construction

S5P_<fileclass>_L2__HONO___<start>_<end>_<orbit>_<coll>_<proc>_<mod>.nc

- **fileclass [4 characters** :] File class of the product. (example: PAL_)
- **start [YYYYMMDDThhmmss** :] start time of the orbit
- **end [YYYYMMDDThhmmss** :] end time of the orbit
- **orbit [5 digits** :] orbit number
- **coll [2 digits** :] collection id
- **proc [6 digits** :] processor version
- **mod [YYYYMMDDThhmmss** :] modification or creation time

3 global attributes

In this section the global attributes in a product file are listed. The name of the attribute is provided together with the datatype. The static or dynamic nature of the attributes is also given. Static means that the attribute has the same values across all product files, dynamic means that the attributes values depends on the orbit of the product file.

Conventions [int32] (*static*)

CF-1.7 (Version of CF conventions that is followed.)

collection_identifier [int32] (*static*)

03

comment [string] (*dynamic*)

(Version of the python packages from which the processor is composed off).

- cobra-hono : 3.1.4
- lindoas : 1.1.0
- s5p-hono-amf : 1.1.4

file_class [string] (*dynamic*)

File class of the product.

footprint [string] (*dynamic*)

GeoJSON format. Footprint of the product as a single GeoJSON string value.

history [string] (*dynamic*)

YYY-MM-DDThh:mm:ssZ cobra_hono <name of the xml input file>, with the time string the time of creation of the file.

id [string] (*dynamic*)

Product name (filename without extension)

input_files [string] (*dynamic*)

List that contains the filenames of all inputs to the processor.

institution [string] (*static*)

BIRA-IASB

orbit [int32] (*dynamic*)

orbit number. (matches the orbit number in the filename)

processing_center [string] (*static*)

S5P-PAL

processor_name [string] (*static*)

S5P_L2_HONO

processor_version [string] (*dynamic*)

xx.yy.zz (version number of the processor)

source [string] (*static*)

Sentinel 5 precursor, TROPOMI, space-borne remote sensing, L2

summary [string] (*static*)

TROPOMI/S5P HONO L2 data Swath 5.5x3.5km2

time_coverage_end [string] (*dynamic*)

YYYY-MM-DDThh:mm:ss.fffZ (Start time of last measurement in the product)

time_coverage_resolution [string] (*dynamic*)

PT<duration>S (duration in seconds of the scanline)

time_coverage_start [string] (*dynamic*)

YYYY-MM-DDThh:mm:ss.fffZ (Start time of first measurement in the product)

time_reference [string] (*static*)

YYYY-MM-DDThh:mm:ss.fffZ (Start of the day of the sensing time)

tracking_id [string] (*dynamic*)

UUID

4 variables

4.1 HONO main retrieval results

The following variables contain useful information of the HONO content of sources:

- nitrousacid_vertical_column
- nitrousacid_slant_column_density
- qa_value

nitrousacid_vertical_column represents the VCD, nitrousacid_slant_column_density the SCD. Pixels contain a detectable HONO source if qa_value is equal to one. See [1] for more details about the retrieval variables that are contained in the product.

4.2 /PRODUCT

ah [float32] (*ah*)

- **units :** km
- **long_name :** aerosol height
- **comment :** coordinate variable for aerosol height

aod [float32] (*aod*)

- **units :** 1
- **long_name :** aerosol optical depth
- **comment :** coordinate variable for the aerosol optical depth

corner [int32] (*corner*)

- **units :** 1
- **long_name :** pixel corner index
- **comment :** Indices start at 0 (counter-clockwise, starting from south-western corner of the pixel in ascending part of the orbit).

delta_time [int32] (*time, scanline*)

- **long_name :** offset from reference start time of measurement
- **units :** milliseconds since 2025-10-19 00:00:00

ground_pixel [int32] (*ground_pixel*)

- **units :** 1
- **axis :** X
- **long_name :** across-track dimension index
- **comment :** This coordinate variable defines the indices across track, from west to east; index starts at 0

latitude [float32] (*time, scanline, ground_pixel*)

- **long_name :** pixel center latitude
- **units :** degrees_north
- **standard_name :** latitude
- **valid_min :** -90.0
- **valid_max :** 90.0
- **bounds :** /PRODUCT/SUPPORT_DATA/GEOLOCATIONS/latitude_bounds

longitude [float32] (*time, scanline, ground_pixel*)

- **long_name :** pixel center longitude
- **units :** degrees_east
- **standard_name :** longitude
- **valid_min :** -180.0
- **valid_max :** 180.0
- **bounds :** /PRODUCT/SUPPORT_DATA/GEOLOCATIONS/longitude_bounds

nitrousacid_vertical_column [float32] (*time, scanline, ground_pixel, ah, ssa, aod*)

- **units :** mol m-2
- **long_name :** vertical column of HONO for different plume heights, single scattering albedo's and optical thickness of aerosols.
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

qa_value [uint8] (*time, scanline, ground_pixel*)

- **units :** 1
- **valid_min :** 0
- **valid_max :** 1
- **long_name :** data quality value
- **comment :** A discrete quality descriptor, varying between 0 (no reliable HONO detection) and 1 (reliable HONO detection).
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

scanline [int32] (*scanline*)

- **units :** 1
- **axis :** Y
- **long_name :** along-track dimension index
- **comment :** This coordinate variable defines the indices along track; index starts at 0

ssa [float32] (*ssa*)

- **units :** 1
- **long_name :** single scattering albedo
- **comment :** coordinate variable for single scattering albedo

time [int32] (*time*)

- **units :** seconds since 2010-01-01 00:00:00
- **standard_name :** time
- **axis :** T
- **long_name :** reference time for the measurements
- **comment :** The time in this variable corresponds to the time in the time_reference global attribute

4.3 /PRODUCT/SUPPORT_DATA/GEOLOCATIONS

latitude_bounds [float32] (*time, scanline, ground_pixel, corner*)

- **units :** degrees_north

longitude_bounds [float32] (*time, scanline, ground_pixel, corner*)

- **units :** degrees_east

satellite_altitude [float32] (*time, scanline*)

- **long_name :** satellite altitude
- **units :** m
- **comment :** The altitude of the satellite with respect to the geodetic sub satellite point on the WGS84 reference ellipsoid
- **valid_min :** 700000.0
- **valid_max :** 900000.0

satellite_latitude [float32] (*time, scanline*)

- **long_name :** sub satellite latitude
- **units :** degrees_north
- **comment :** Latitude of the geodetic sub satellite point on the WGS84 reference ellipsoid
- **valid_min :** -90.0
- **valid_max :** 90.0

satellite_longitude [float32] (*time, scanline*)

- **long_name :** satellite_longitude
- **units :** degrees_east
- **comment :** Longitude of the geodetic sub satellite point on the WGS84 reference ellipsoid
- **valid_min :** -180.0
- **valid_max :** 180.0

satellite_orbit_phase [float32] (*time, scanline*)

- **long_name :** fractional satellite orbit phase
- **units :** 1
- **comment :** Relative offset [0.0, ..., 1.0] of the measurement in the orbit
- **valid_min :** -0.02
- **valid_max :** 1.02

solar_azimuth_angle [float32] (*time, scanline, ground_pixel*)

- **long_name :** solar azimuth angle
- **standard_name :** solar_azimuth_angle
- **units :** degree
- **valid_min :** -180.0
- **valid_max :** 180.0
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude
- **comment :** Solar azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = 270)

solar_zenith_angle [float32] (*time, scanline, ground_pixel*)

- **long_name :** solar zenith angle
- **standard_name :** solar_zenith_angle
- **units :** degree
- **valid_min :** 0.0
- **valid_max :** 180.0
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude
- **comment :** Solar zenith angle at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical

viewing_azimuth_angle [float32] (*time, scanline, ground_pixel*)

- **long_name :** viewing azimuth angle
- **standard_name :** viewing_azimuth_angle
- **units :** degree
- **valid_min :** -180.0
- **valid_max :** 180.0
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude
- **comment :** Satellite azimuth angle at the ground pixel location on the reference ellipsoid. Angle is measured clockwise from the North (East = 90, South = 180, West = 270)

viewing_zenith_angle [float32] (*time, scanline, ground_pixel*)

- **long_name :** viewing zenith angle
- **standard_name :** viewing_zenith_angle
- **units :** degree
- **valid_min :** 0.0
- **valid_max :** 180.0
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude
- **comment :** Zenith angle of the satellite at the ground pixel location on the reference ellipsoid. Angle is measured away from the vertical

4.4 /PRODUCT/SUPPORT_DATA/INPUT_DATA

aerosol_index_340_380 [float32] (*time, scanline, ground_pixel*)

- **units :** 1
- **standard_name :** ultraviolet_aerosol_index
- **comment :** Aerosol index from 380 and 340 nm
- **long_name :** aerosol index from 380 and 340 nm
- **radiation_wavelength :** [340. 380.]
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

cloud_albedo [float32] (*time, scanline, ground_pixel*)

- **units :** 1
- **standard_name :** cloud_albedo
- **long_name :** cloud albedo from the CRB model
- **source :** crb
- **comment :** Coregistered cloud albedo based on the OCRA/ROCINN CRB model.
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

cloud_fraction [float32] (*time, scanline, ground_pixel*)

- **units :** 1
- **standard_name :** cloud_fraction
- **long_name :** effective radiometric cloud fraction from the CRB model
- **source :** crb
- **comment :** Coregistered effective radiometric cloud fraction using the OCRA/ROCINN CRB model.
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

cloud_height [float32] (*time, scanline, ground_pixel*)

- **units :** m
- **standard_name :** cloud_height
- **long_name :** cloud radiometric optical centroid height from the CRB model
- **source :** crb
- **comment :** Coregistered height at the level of cloud w.r.t. the geoid/MSL using the OCRA/ROCINN CRB model.
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

cloud_pressure [float32] (*time, scanline, ground_pixel*)

- **units :** Pa
- **standard_name :** cloud_pressure
- **long_name :** cloud radiometric optical centroid pressure from the CRB model
- **source :** crb
- **comment :** Coregistered and converted atmospheric pressure at the level of cloud using the OCRA/ROCINN CRB model.
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

snow_ice_flag [uint8] (*time, scanline, ground_pixel*)

- **units :** 1
- **threshold :** 0.3
- **long_name :** snow-ice mask
- **comment :** flag indicating snow/ice at center of ground pixel
- **flag_meanings :** snow_free snow_ice
- **flag_values :** [0 1]
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

surface_altitude [float32] (*time, scanline, ground_pixel*)

- **long_name :** surface altitude
- **standard_name :** surface_altitude
- **units :** m
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude
- **source :** http://topotools.cr.usgs.gov/gmted_viewer/
- **comment :** The mean of the sub-pixels of the surface altitude above the reference geoid (WGS84) within the approximate field of view, based on the GMTED2010 surface elevation database

surface_pressure [float32] (*time, scanline, ground_pixel*)

- **units :** Pa
- **standard_name :** surface_air_pressure
- **long_name :** surface_air_pressure
- **source :**
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

4.5 /PRODUCT/SUPPORT_DATA/DETAILED_RESULTS

nitrogendioxide_slant_column_density [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column of NO2 from linear DOAS retrieval
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrogendioxide_slant_column_density_corrected [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column of NO2 destriped and background corrected
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrogendioxide_slant_column_density_precision [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column density random error of NO2 from the DOAS method
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_air_mass_factor [float32] (*time, scanline, ground_pixel, ah, ssa, aod*)

- **units :** 1
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude
- **long_name :** Air mass factor of HONO for different plume heights, single scattering albedo's and optical thickness of aerosols.

nitrousacid_detection_flag [int32] (*time, scanline, ground_pixel*)

- **units :** 1
- **long_name :** nitrous acid detection flag
- **flag_meanings :** no_detection detection_reasonable_confidence_snr_gt_4 detection_good_confidence_snr_gt_8 detection_high_confidence_snr_gt_16
- **flag_values :** [0 1 2 3]
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_slant_column_density [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column density of HONO
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_slant_column_density_cobra [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column density of HONO retrieved with the COBRA method
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_slant_column_density_cobra_precision [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column density random error of HONO from the COBRA method
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_slant_column_density_cobra_rms [float32] (*time, scanline, ground_pixel*)

- **units :** 1
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude
- **long_name :** root mean square residual from cobra method

nitrousacid_slant_column_density_doas [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column density of HONO retrieved with the DOAS method
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_slant_column_density_doas_corrected [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column of HONO destriped and background corrected
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_slant_column_density_doas_precision [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column density random error of HONO from the DOAS method
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

nitrousacid_slant_column_density_precision [float32] (*time, scanline, ground_pixel*)

- **units :** mol m-2
- **long_name :** slant column density random error of HONO
- **coordinates :** /PRODUCT/longitude /PRODUCT/latitude

References

[1] *S5P HONO [L2__HONO_] Readme.* **source**: BIRA; **ref**: S5P-BIRA-PRF-HONO; **issue**: 1.0.0; **date**: 16-02-2026.

[2] *S5P-PAL: Sentinel 5P Product Algorithm Laboratory L2 Processor File Format Guidelines.* **source**: S&T; **ref**: ST-ESA-S5P_PAL-L2FFG-001; **issue**: 1.4; **date**: 2023-03-27.