



S5P/TROPOMI Level 2 File Format and Units

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File Format



1. Select a file format that users are already familiar with
2. Use a base format that is already well supported in data-analysis packages
3. Use a self-describing file format
4. Build on experience with supporting previous missions

Basic choices

1. NetCDF-4 (build on top of HDF5)
2. Climate & Forecast Metadata Conventions
3. One product per file
4. Store metadata in separate group structure for Inspire/ISO, ESA, OGC, EOP metadata
5. Add our own wishes & constraints
 - Group structure, names of variables, ...

Formal requirements



- Metadata
 - ESA metadata from file format standard
 - ISO 19115 metadata (Inspire directive)
 - OGC metadata
- Climate & Forecast metadata conventions

CF-Conventions



- Used by climate modellers and weather forecasters, additional users are coming from earth observation and other climate researchers.
- Declared applicable to ESA's Climate Change Initiative/Essential Climate Variables projects.
- Maintained by volunteers, KNMI contributes to CF-2.0

Variable level metadata



- From CF Metadata Conventions
 - Standard name
 - Units
 - Comment
 - Long name

Advantages of CF



- Standard names describe exactly what quantity is contained in a variable
- Units define how the quantity is expressed
- Other attributes link to ancillary data (location, time, precision, flagging, averaging kernel, ...)
- The combination of all aspects means that correct use of the data is promoted

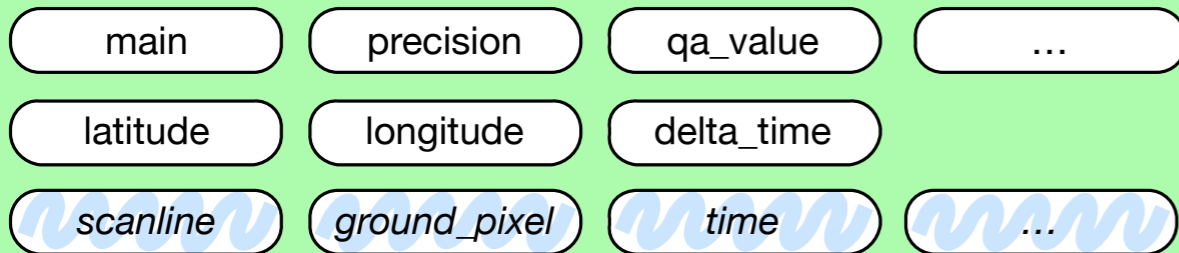
S5P Level 2 file structure



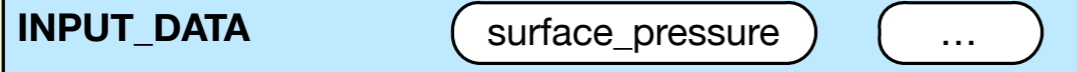
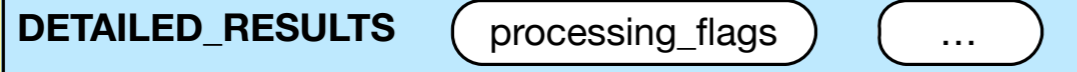
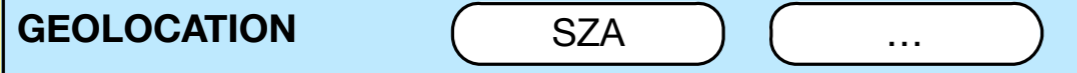
Sentinel 5P Level 2 product

Global attributes

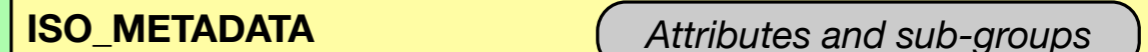
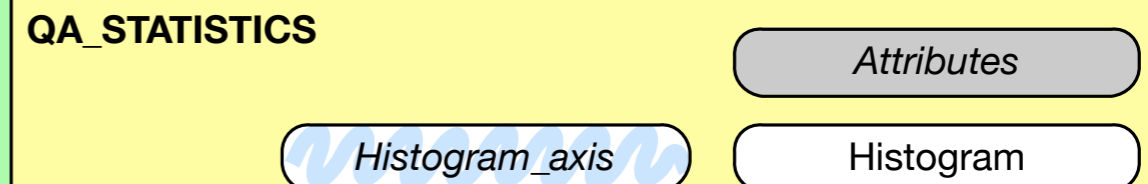
PRODUCT



SUPPORT_DATA



METADATA



Root level

First level group

Second level group

Third level group

Variable

Attributes

Dimension

Sources



Create Plot



Combine Plot



Open Dataset



Remove



Remove All



Hide Info

Datasets

Catalogs

Bookmarks

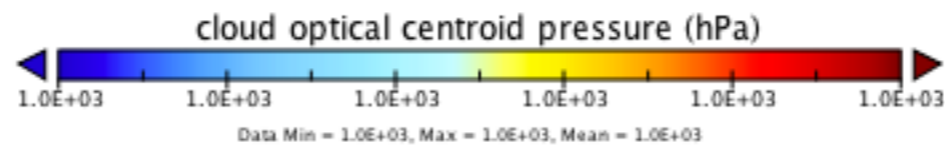
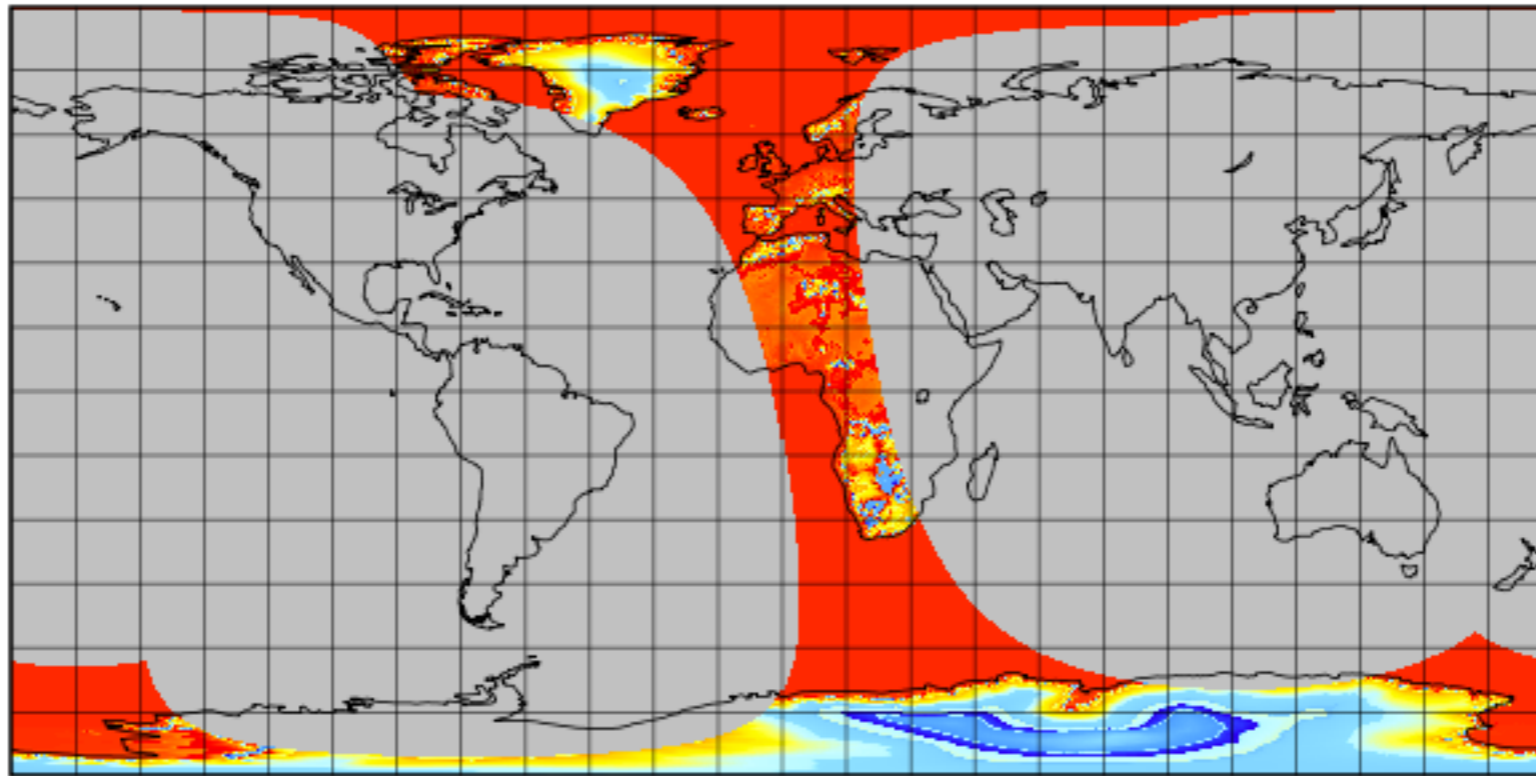
Name	Long Name	Type
▼ S5P_OFFL_L2__FRESCO_2014031...	S5P_OFFL_L2__FRESCO_20140319T173535_20140319T183246_0000...	Local File
▼ METADATA	METADATA	—
▶ ALGORITHM_SETTINGS	METADATA/ALGORITHM_SETTINGS	—
▶ ESA_METADATA	METADATA/ESA_METADATA	—
▶ GRANULE_DESCRIPTION	METADATA/GRANULE_DESCRIPTION	—
▶ ISO_METADATA	METADATA/ISO_METADATA	—
▶ QA_STATISTICS	METADATA/QA_STATISTICS	—
▼ PRODUCT	PRODUCT	—
▶ apparent_scene_pressure	apparent scene pressure	Geo2D
▶ apparent_scene_pressure_...	apparent scene pressure precision	Geo2D
▶ cloud_albedo	cloud albedo	Geo2D
▶ cloud_albedo_precision	cloud albedo precision	Geo2D
▶ cloud_fraction	effective cloud fraction	Geo2D
▶ cloud_fraction_precision	effective cloud fraction precision	Geo2D
▶ cloud_height	cloud optical centroid height	Geo2D
▶ cloud_height_precision	cloud optical centroid height precision	Geo2D
▶ cloud_pressure	cloud optical centroid pressure	Geo2D
▶ cloud_pressure_precision	cloud optical centroid pressure precision	Geo2D
▶ corner	pixel corner index.	1D
▶ delta_time	offset from reference start time of measurement	1D
▶ ground_pixel	along-track dimension index.	1D
▶ latitude	pixel center latitude	2D
▶ longitude	pixel center longitude	2D
▶ qa_value	qa_value	Geo2D
▶ scanline	along-track dimension index.	1D
▶ scene_albedo	scene albedo	Geo2D
▶ scene_albedo_precision	scene albedo precision	Geo2D
▶ SUPPORT_DATA	PRODUCT/SUPPORT_DATA	—
▶ time	reference time for the measurements	—

Show: All variables



Plot Array 1

cloud optical centroid pressure



Array(s) Scale Map Overlay Contours Vectors Labels

Plot Map of Array 1 Only interpolate

Array 1: cloud_pressure

Reference time for the measurements: 1 of 1 = 2010-01-01 00:00:00

Sources



Create Plot



Combine Plot



Open Dataset



Remove



Remove All



Show Info

Datasets

Catalogs

Bookmarks

Name	Long Name	Type
latitude	pixel center latitude	2D
longitude	pixel center longitude	2D
qa_value	qa_value	Geo2D
scanline	along-track dimension index.	1D
scene_albedo	scene albedo	Geo2D
scene_albedo_precision	scene albedo precision	Geo2D
▼ SUPPORT_DATA	PRODUCT/SUPPORT_DATA	—
▼ DETAILED_RESULTS	PRODUCT/SUPPORT_DATA/DETAILED_RESULTS	—
chi_square	chi squared parameter	2D
covariance_matrix_el...	covariance of cloud pressure and cloud fraction	2D
processing_quality_fl...	Processing quality flags	2D
▼ GEOLOCATION	PRODUCT/SUPPORT_DATA/GEOLOCATION	—
latitude_bounds	latitude_bounds	2D
longitude_bounds	longitude_bounds	2D
satellite_altitude	satellite altitude	1D
satellite_latitude	sub satellite latitude	1D
satellite_longitude	satellite longitude	1D
satellite_orbit_phase	fractional satellite orbit phase	1D
solar_azimuth_angle	solar azimuth angle	2D
solar_zenith_angle	solar zenith angle	2D
viewing_azimuth_angle	viewing azimuth angle	2D
viewing_zenith_angle	viewing zenith angle	2D
▼ INPUT_DATA	PRODUCT/SUPPORT_DATA/INPUT_DATA	—
measurement_flag	measurement flags	1D
snow_ice_flag	snow-ice mask	2D
surface_albedo_assu...	assumed surface albedo	2D
surface_altitude	surface altitude	2D
surface_altitude_prec...	surface altitude precision	2D
surface_classification	land-water mask	2D
time	reference time for the measurements	—

Show: All variables



TROPOMI

SI-Units



- Follow IUPAC recommendation we adapt SI units.
- The NetCDF Users' Guide specifies that variables should have a 'units' attribute
- CF-standard names list gives a “canonical unit”, for example: mol/m^2
- Use UDUnits for conversion

Units: Examples



- 300 DU \rightarrow 0.134 mol/m²
- 2.0e+15 molecules/cm² \rightarrow 33 μ mol/m²

Conclusions



- S5P/TROPOMI L1B and L2 formats are based on NetCDF 4 with CF metadata.
 - File format documents are available on request
- For the units the SI units are adapted.

IUPAC



- Units for use in atmospheric chemistry (IUPAC Recommendations 1995)
 - <http://www.iupac.org/publications/pac/67/8/1377/>
 - Pure Appl. Chem., 1995, Vol. 67, No. 8-9, pp. 1377-1406. DOI:10.1351/pac199567081377

Units



- L1B uses “ $\text{mol.s}^{-1}.\text{m}^{-2}.\text{nm}^{-1}.\text{sr}^{-1}$ ” for radiance, normalised to 1 A.U.