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Sentinel-5P Data

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Introduction to Sentinel-5P

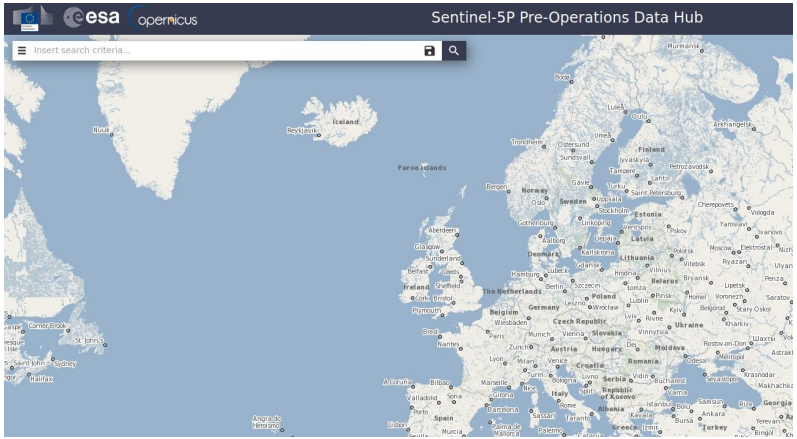
ESA Copernicus **Sentinel-5 Precursor** mission dedicated to **monitor the atmosphere** (**TROPOMI**):

1. Spatial resolution: 5.5 x 5.5 km (7 x 7 km before August 2019)
2. Temporal resolution: Global daily coverage

Where: Sentinel Copernicus Hub (https://s5phub.copernicus.eu/dhus/#/home)
Data output format: netCDF

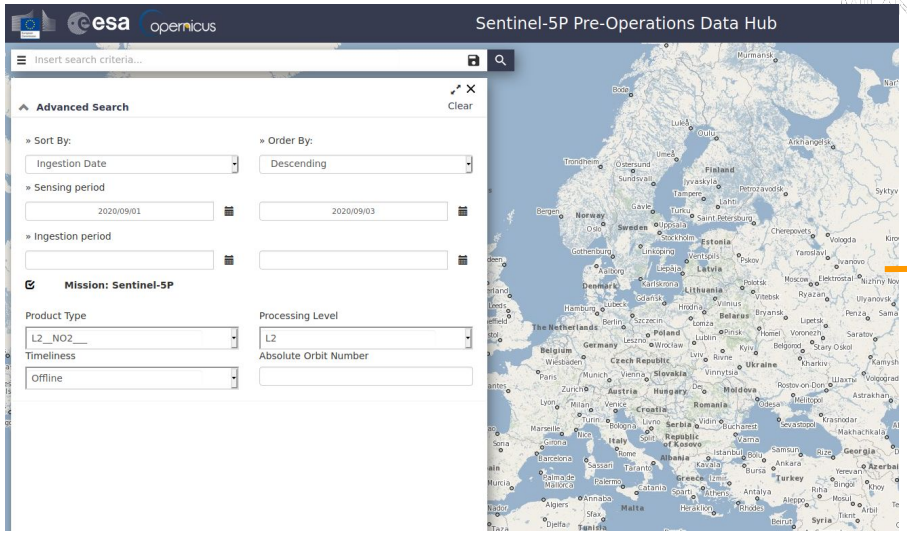
Measured parameters:

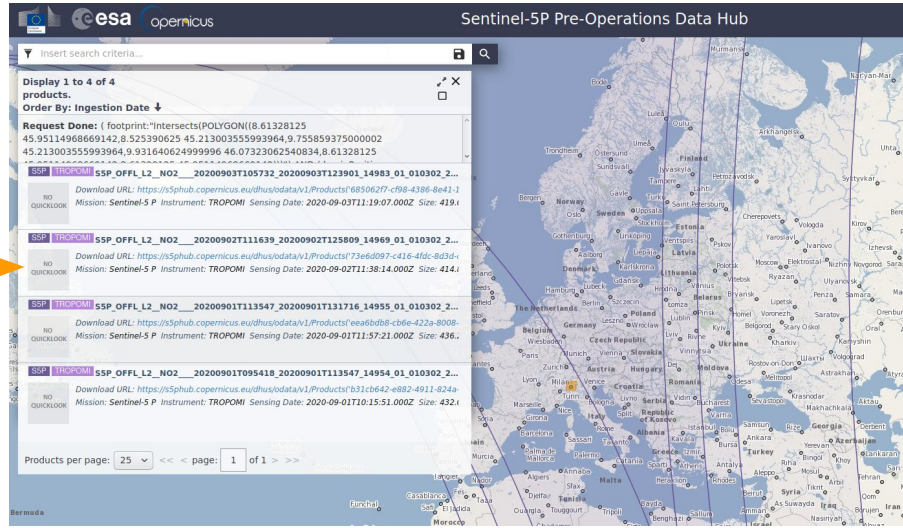
1. Ozone
2. NO_2
3. SO_2
4. Formaldehyde
5. Aerosol
6. Carbon-monoxide
7. Methane
8. Clouds



https://earth.esa.int/web/guest/missions/esa-eo-missions/sentinel-5p

Sentinel Hub Search example

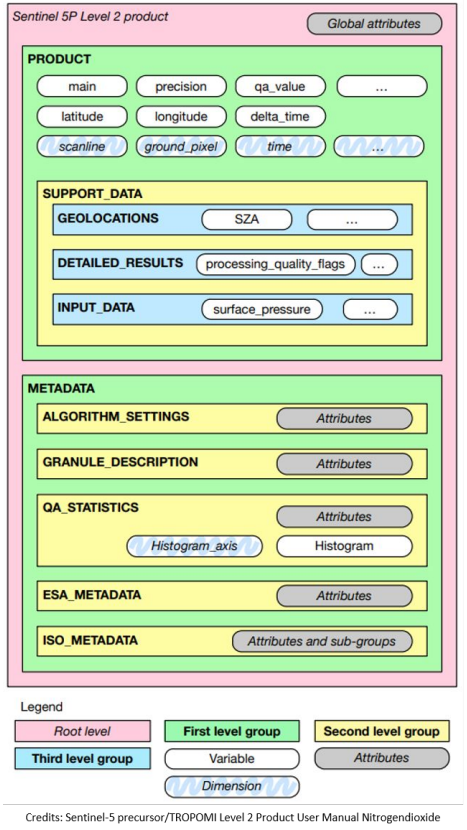




NetCDF Files

Data products from Sentinel Hub are downloaded in **Level 2 netCDF** files.

- Multilayer files
- Data organized by groups
- Product
  - What? When? Where? How well?
  - Main data fields
  - Precision, latitude, longitude, observation time, number of measurements.
  - Qa_value: quality percentage (objective: above 75%)
- Metadata
  - Items that appear in header file
  - Items required by standards (INSPIRE, ISO, OGC)
  - ESA Metadata



Credits: Sentinel-5 precursor/TROPOMI Level 2 Product User Manual Nitrogendioxide

HARP + XArray

HARP is a toolkit for **reading**, **processing** and inter-comparing **satellite** remote sensing data, model data, in-situ data, and ground based **remote sensing data**.

- By chaining the calls we can combine different products.

xarray is an open source Python package that makes working with labelled multi-dimensional arrays simple and efficient.

netCDF files processing

With this we can now access:

1. The product data
   a. Sensor reading (e.g. Nitrogendioxide_tropospheric_column)
   b. Time
   c. Latitude and longitude

NetCDF Files Example (xarray)

```
Global attrbutes of product:
 <xarray.Dataset>
Dimensions:  ()
Data variables:
    *empty*
Attributes:
    Conventions:                CF-1.7
    institution:                DLR-IMF
    source:                     Sentinel 5 precursor, TROPOMI, space-...
    history:                    2020-10-06 14:03:30.157230 f_s5pops u...
    summary:                    TROPOMI/S5P L2 data Swath 5.5x3.5km2 ...
    tracking_id:                2b43b9e2-3528-4f02-80f4-7c42cb0752f3
    id:                         S5P_OFFL_L2__SO2___20201004T111316_2...
```

1

Three main groups

```
METADATA/GRANULE_DESCRIPTION Group:
 <xarray.Dataset>
Dimensions:  ()
Data variables:
    *empty*
Attributes:
    GranuleStart:           2020-10-04T11:34:49
    GranuleEnd:             2020-10-04T12:33:14
    InstrumentName:         TROPOMI
    MissionName:            Sentinel-5 precursor
```

2

3

```
PRODUCT Group:
 <xarray.Dataset>
Dimensions:                                  (corner: 4, ground_pixel: 450, layer: 34, scanline: 4173, time:
1)
Coordinates:
  * scanline                                 (scanline) float64 0.0 ... 4.172e+03
  * ground_pixel                             (ground_pixel) float64 0.0 ... 449.0
  * time                                     (time) datetime64[ns] 2020-10-04
  * corner                                   (corner) float64 0.0 ... 3.0
  * layer                                    (layer) int32 0 1 2 ... 32 33
Data variables:
    latitude                                 (time, scanline, ground_pixel) float32 ...
    longitude                                (time, scanline, ground_pixel) float32 ...
    delta_time                               (time, scanline, ground_pixel) datetime64[ns] ...
    time_utc                                 (time, scanline) object ...
    qa_value                                 (time, scanline, ground_pixel) float32 ...
    sulfurdioxide_total_vertical_column      (time, scanline, ground_pixel) float32 ...
    sulfurdioxide_total_vertical_column_precision (time, scanline, ground_pixel) float32 ...
```

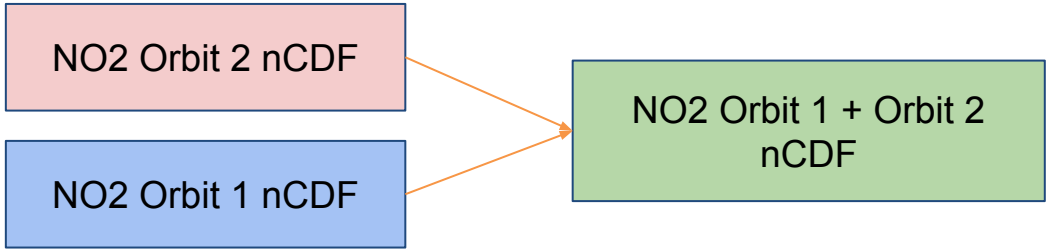
NetCDF Files Combination

Files can be combined into a single product. For this, the following steps are needed:

1. Process nCDF file into a harp.product
2. Filter unused variables
3. Apply harp.concatenate function

Result: New object that will contain both of the products in a single file

This operation can be done as long as it contains data of the same type.



(e.g. to integrate data of all Europe in one file)

Integration with ODC

It is important to note that according to **ODC** official website, the **software is not prepared** to browse the catalog of **Sentinel-5P**. There are a few options that can be tested to integrate nCDF data into the Data Cube:

1. Use Psychopg library to import netCDF files into PostgreSQL
2. Use Pandas or xarray to import data
3. Transform nCDF files into raster data to be integrated to the Data Cube

Thank you for your attention

Questions?

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