

Analyzing Air Pollution Using Sentinel-5P TROPOMI Data

This Project is Aimed at monitoring the air quality at a particular location using the data collected by Sentinel-5p TROPOMI satellite. This manual along with the accompanying code will help to do the same for any location.

This manual is made for a Linux system So for any other Operating systems there maybe dome discrepancies

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Requirements

- Anaconda 4.3.0
- Python 3.5

The below packages comes along with anaconda but can be installed using pip if needed

- netcdf4 >= 1.5
- numpy >= 1.19
- pandas >= 1.1
- matplotlib >= 3.3

Installation

We recommend using **conda** to create and manage a virtual environment when using this set of scripts.

Install Anaconda following this guide.

Create a conda environment using the code given below with all the dependencies already installed.

```
conda create --override-channels -c conda-forge -c stcorp --file requirements.txt --name <envname>
conda activate <envname>
```

Note: While running the scripts If any dependencies error occurs or packages are missing installed the given packages **pip** .

Downloading Data

Setup the Earth-data account and filtering data

The Data is downloaded for Earth-data Website using the GES-DISC Portal. You have to first create an earthdata account and link it to GES-DISC. Once you are registered you should be able to download the data using the following steps.

- Login to the GES-DISC Portal.

- Search for TROPOMI in the search box which will list out all the datasets of TROPOMI satellite.
- Go to the **Subset/Get Data** option of the gas whose data you want.

📁 Get Sentinel-5P TROPOMI Tropospheric NO2 1-Orbit L2 5.5km x 3.5km data ×

Estimated size of results
620 days, 8,804 links, 3.5 TB

Download Method ?

☐ Download Method ☒ Get Original Files Reset

Method Options ?

▸ Refine Date Range: 2019-08-06 to 2021-04-16 Reset

▸ Refine Region: -180, -90, 180, 90 Reset

Output format ?

File Format: netCDF

Reset All Get Data

- Refine the date and the region according to the region and the time-frame for which you want the data.
- We can change the download method to Get File subset to Refine the components of the total data which you need by selection the variables we want in the variables section.

- ☒ averaging_kernel (Averaging kernel)
- ☒ nitrogendioxide_tropospheric_column (Tropospheric vertical column of nitrogen dioxide)
- ☒ nitrogendioxide_tropospheric_column_precision (Precision of the tropospheric vertical column of nitrogen dioxide)
- ☒ nitrogendioxide_tropospheric_column_precision_kernel (Precision of the tropospheric vertical column of nitrogen dioxide when applying the averaging kernel)
- ☒ qa_value (data quality value)
- ☒ time_utc (Time of observation as ISO 8601 date-time string)

An example of variables we have chosen for the NO2 data.

- We are only choosing these values to generate the concentration of the concerned gas over the area selected.
- For generating the heat map of an area for a particular day you have to get the whole data set.
- Click on get data which will generate a list of links for all the dataset for the given time period.
- To Download all the dataset together download the list of links using the option provided.

📎 Data File Links for [Sentinel-5P TROPOMI Tropospheric NO2 1-Orbit L2 5.5km x 3.5km](#)

Results (found 8768 links in range from 2019-08-06 to 2021-04-16):

[Download links list](#) (This list is valid for 2 days) | [Instructions for downloading](#)

README Document

S5P_OFFL_L2_NO2_2019

S5P_OFFL_L2_NO2_2019

S5P_OFFL_L2_NO2_2019

S5P_OFFL_L2_NO2_2019

S5P_OFFL_L2_NO2_2019

S5P_OFFL_L2_NO2_2019

S5P_OFFL_L2_NO2_20190806T122904_20190806T141033_09394_01_010302_20190812T150057.SUB.nc4

S5P_OFFL_L2_NO2_20190806T141033_20190806T155203_09395_01_010302_20190812T162428.SUB.nc4

S5P_OFFL_L2_NO2_20190806T155203_20190806T173332_09396_01_010302_20190812T175526.SUB.nc4

1. If you have not already done so, please register!

- Create an Earthdata account
- Link GES DISC with your account
- Verify by downloading this example data file URL

2. Download the list of links

3. Follow the instructions for `wget`

040854.SUB.nc4

060847.SUB.nc4

075428.SUB.nc4

094118.SUB.nc4

111228.SUB.nc4

133052.SUB.nc4

▶ Selected Parameters

To download the files using wget

A version of wget 1.18 compiled with gnuTLS 3.3.3 or OpenSSL 1.0.2 or LibreSSL 2.0.2 or later is recommended

- Create a cookie file. This file will let you download GES DISC resources without having to re-login.
 1. Open a run-command window by pressing Win-Key + R
 2. Next, enter “cmd” in the text field and click “OK”
 3. Navigate to the directory you wish to create the cookies file in. In this guide, we place it under the C drive, but any directory will do. You can navigate to the C drive by entering `C:`
 4. Finally, enter `NUL > .urs_cookies`. Note: you may need to re-create `.urs_cookies` in case you have already executed `wget` without valid authentication.

Note: you can get ‘Access denied’ error. Enter ‘dir’ to verify that ‘.urs_cookies’ file is listed in your directory.

- To download the files run the following command

```
wget --load-cookies C:\.urs_cookies --save-cookies C:\.urs_cookies --auth-no-challenge=
```

the user name of the earth-data account.

= path to the files containing the list of links.

- The files will be downloaded to the current folder.

Processing Data

Put the names of the dataset files you want to analyze in the `fileList.txt` file.

Study The SDS (Variables) or Content of a particular file.

- This can be done using the script named `read_tropomi_and_list_sds.py`

- Just follow the instruction given in the scripts and it will list all the variables contained within the file.

Map the spacial pattern of the monitored gas over the area

- This can be done using the script named `map_tropomi.py`
- For different gases/particles we have to change the SDS variable in the script for the particular gas which is given below with the map label or units in bracket.

NO2 - nitrogendioxide_tropospheric_column (mol/ m²)

SO2 - sulfurdioxide_total_vertical_column (mol/ m²)

CO - carbonmonoxide_total_column (mol/ m²)

AEROSOL - aerosol_index_340_380 or aerosol_index_354_388
(aerosol index)

O3 - ozone_total_vertical_column (mol/ m²)

Export the Average Value of a day to csv file

- This can be Done using the script named `read_and_export_at_a_location.py`
- Change the SDS variable as mentioned above along with all the other variables which are needed in the scripts corresponding to the gas being monitored. The variable names can be confirmed with the SDS scripts and also can be seen in the downloading step when we are selecting the variables.
- By default the script will read all the files in the `fileList.txt` and take the average of the SDS value in all the location contained within the file and export the time series data onto a csv file called `data_val.csv`

Note : For different gas we have to do different calculations as mentioned in the papers given in the tropomi portal corresponding to different gases.

Plotting the time series graph

- This can be done using the script `plot_graph.py` .
- Change the labels, colors and pattern and any other properties according to our needs .