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Abstract Technical note describing TROPEX products

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CHANGE HISTORY

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1.0	25 Oct 2021	First version

INTRODUCTION

TropEx (Tropomi Extractor) software is designed to download Sentinel 5P TROPOMI data from ONDA and Copernicus portals and to extract the information referred to regions of interest (ROIs).

S5p products are distributed as relatively large-sized files (several hundred of Mb each) spatially related to the regions probed during its orbit on the entire globe. The TropEx selection of data on the ROIs produces smaller size files that can be easily analysed without needing significant computational power.

This document provides a brief guide to TropEx products.

ACRONYMS

Acronym	Definition
APL	Atmospheric Physics Laboratory (at Sapienza)
BAQUNIN	Boundary-layer Air Quality-analysis Using Network of INstruments
ROI	Region of Interest
S5P	Sentinel-5-Precursor satellite
TROPOMI	TROPOspheric Monitoring Instrument
TropEx	TROPOMI Extractor

OVERVIEW

TROPOMI is an atmospheric observation instrument on board the Copernicus Sentinel-5 Precursor satellite. The Sentinel-5 Precursor (S5P) was launched on 13 October 2017, planned for a mission of seven years. The TROPOMI instrument has the capability of observing several key atmospheric species, needed for air quality, climate, and ozone layer monitoring services.

TROPOMI Level2 product files contain all the information collected during a S5P single orbit; a single file size can generally be of several hundreds of Mb size. Although these files provide a global picture of the retrieved quantities, the monitoring of a specified region could prove computationally heavy, due to the large quantity of data involved.

TropEx (TROPOMI Extractor) is a Serco service providing the extraction of TROPOMI files content on specified Regions of Interest (ROIs), thus producing smaller files more suitable for regional analysis.

TROPOMI files are distributed through the Copernicus S5P Pre-Operations Hub (https://www.copernicus.eu/en) and the ONDA Hub (https://www.onda-dias.eu/cms/). TropEx checks every day the last TROPOMI files published, verifying for each ROI if an overpass is present; in this case, the file is downloaded, data referring to the ROI are extracted and an output file with the extraction results is produced and distributed through an FTP server.

Information for TropEx data access (server ip, username and password) can be requested to the TropEx team by mail, writing at gabriele.mevi@serco.com.

1. TROPOMI PRODUCT FILES

TropEx works on TROPOMI Level 2 product files, distributed by ONDA Dias S5P Hub or Copernicus S5P Pre-Operations Hub. Every day the system searches the new ingested products, checks if they were overpassing the selected ROIs, download them and extract data for each separate ROI.

All products downloaded are **offline** (not real time processing) and **Level 2** (analysis level) products. Complete information about TROPOMI products can be found on instrument's products documentation: https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-5p-tropomi/document-library. Products files are classified by their product type, related to the main atmospheric quantity reported in them. TropEx downloads the products referring to aerosol, CH4, CO, clouds, HCHO, NO2 and O3 (see Table 1).

Files are saved maintaining the original S5p name, which allows identifying the product type. A TROPOMI file name is composed by an identifier of the mission, processing stream and data quality (always "S5P_OFFL_L2" in TropEx files, in yellow in the example below), a file type identifier (red marker in the example below, see also Table 1), start and stop date and time of the measurement (green and blue markers respectively), orbit number, data collection and processor version number (in black) and ingestion time (orange marker); date and time are in format yyyymmddTHHMMSS.

S5P_OFFL_L2__AER_AI_20210917T104952_20210917T123122_20360_02_020200_20210919T003739

A single S5p Level 2 file size is generally several hundreds of Mb (up to 800 Mb); it contains all measurements collected during a S5P single orbit.

The original TROPOMI format (uncompressed) is netcdf (nc), a common file format used for scientific data reporting. The atmospheric parameters are saved as **variables,** 2D matrices of values. The netcdf file format allows the association to the entire file or to the single variable comments and other useful information, called **global** or **variable attributes** respectively. The variables in TROPOMI files are divided into groups and subgroups; this subdivision is used by TropEx to identify a target variable for the extraction.

Table 1: TROPOMI product types ingested by TropEx and their files type identifier

Product type	File name marker
UV Aerosol Index	AER_AI
Aerosol Layer Height	AER_LH
Nitrogen Dioxide	NO2
Carbon Monoxide	CO
Formaldehyde	HCHO
Ozone	O3
Methane	CH4
Cloud Products	CLOUD

2. TROPEX OUTPUT FILES

Each TROPOMI file successfully processed by TropEx has a correspondent output file. TropEx output files maintain the netcdf format and are composed by a selection of the main TROPOMI variables describing the atmospheric properties extracted on the ROIs and their variable attributes. Table 2 reports ROI names and areas which refer to, identified by maximum and minimum longitude and latitude and Figure 1 the map of the ROIs. Table 3 describes the TropEx files global attributes.

Output files content and the number and type of extracted variables depend on file type (Table 1); the TropEx output files do not maintain the variables subdivision by groups.

The Output files name is composed of the original TROPOMI name, with the addition of the marker **"_BAQ_[ROI name]"** at the end, allowing the user to identify the ROI. The S5P file used as example above, extracted above Lazio ROI will produce an output file name called:

S5P_OFFL_L2__AER_AI_20210917T104952_20210917T123122_20360_02_020200_20210919T003739_BAQ_Lazio.nc

Output file size is smaller with respect to the original TROPOMI file, just several hundreds of kB, and are saved divided in subfolders by ROI, year, and month of measurement.

Table 2: ROI name and coordinates

ROI name	ROI area (min longitude, min latitude, max longitude, max latitude) [deg]
Aosta	6.65617, 45.2503, 7.94383, 46.1497
Bologna	10.0391, 43.6007, 12.5609, 45.3993
Capogranitola	11.6, 36.6,13.6, 39.6
Lameziaterme	15.2, 37.8, 17.2, 39.8
Lampedusa	10.8430, 34.1510, 14.1570, 36.8490
Lazio	10.0835, 40.1014, 14.9165, 43.75
Milano	8.11692, 44.6007, 10.6831, 46.3993
Napoli	13.0120, 39.9007, 15.3880, 41.6993
Taranto	16.0173, 39.6007, 18.3827, 41.3993
Thule	-70, 76, -65, 77

Table 3: output files global attributes

Global attribute	Description
ROI_name	Name of the ROI
Coord	Coordinates identifying the ROI in format min longitude, min latitude, max longitude max latitude
Extraction_date	Date and time of file creation by TropEx
Extractor_name	Name of the system extracted data (TropEx by default)
Extractor_PI	Principal investigator and responsible of data extraction (Serco Italy by default)

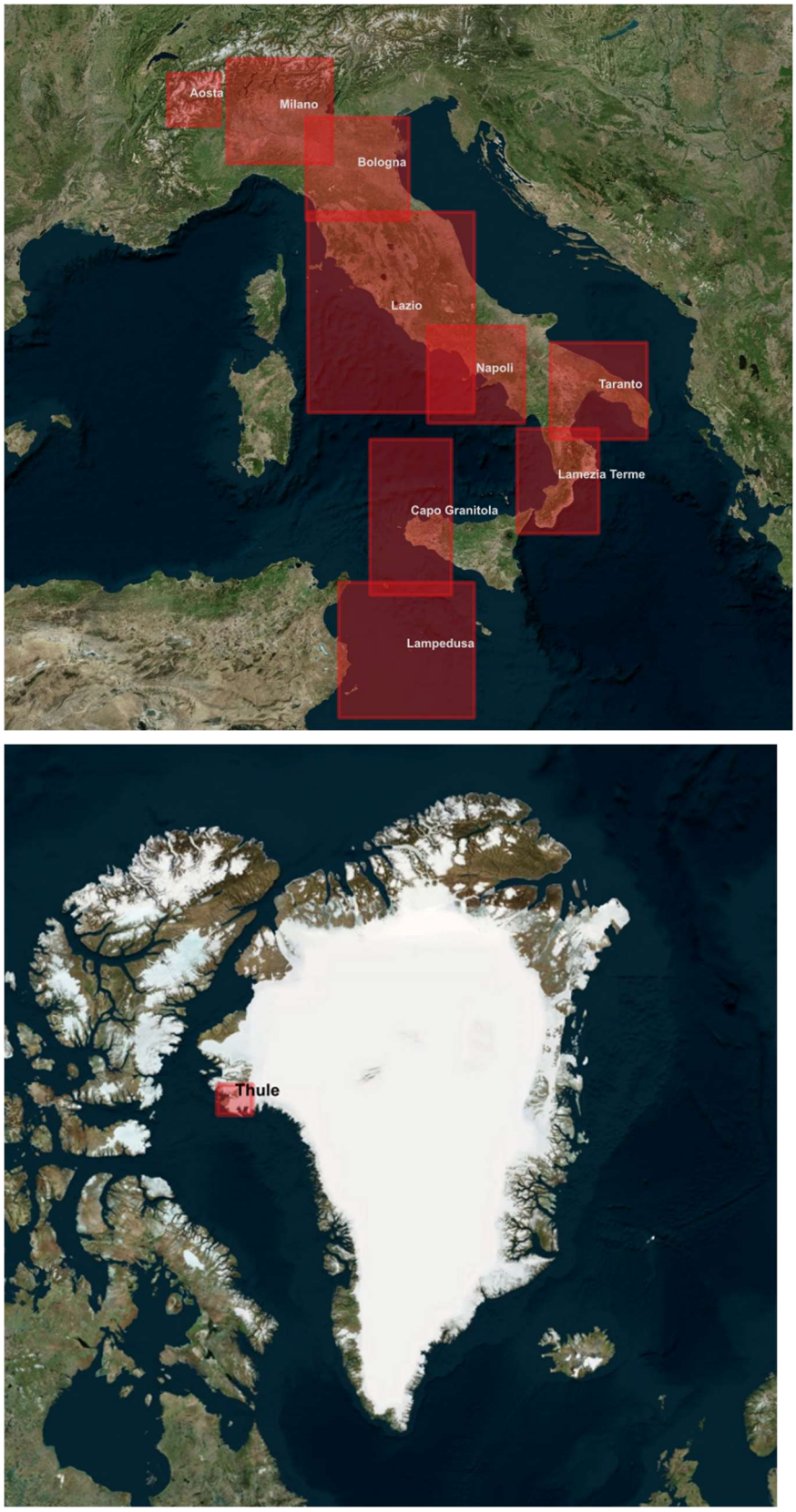

Figure 1: map of the ROIs

Variables in TropEx files are renamed according to Table 4, that reports TropEx variable names and their correspondent in TROPOMI product files. Table's bold subtitles refer to the group the variables belong in the original TROPOMI file; they can be used to identify where variables can be found. As example **TROPOMI.COMMON.PRODUCT** variables are present in all file types. An example of group name is showed below.

TROPOMI.S5P_OFFL_L2__NO2____.PRODUCT/SUPPORT_DATA/INPUT_DATA

The example identifies variables of nitrogen dioxide offline L2 products belonging to the group support data, subgroup input data. Variables belonging toa certain file type in TROPOMI products (aerosol or nitrogen dioxide, as example) can be found in the corresponding TropEx file type. Variable attributes report units, original name in the TROPOMI file, long name, and eventual comments.

Table 4: TropEx variables and their correspondent TROPOMI variables

TropEx variable name	TROPOMI original variable name
[TROPOMI.COMMON.PRODUCT]	
time	time
time_utc	time_utc
delt	delta_time
gr_px	ground_pixel
lat	latitude
lon	longit
qav	qa_value
[TROPOMI.COMMON.PRODUCT/SUPPORT_DATA/GEOLOCATIONS]	
lat_b	latitude_bounds
lon_b	longitude_bounds
sat_lat	satellite_latitude
sat_lon	satellite_longitude
saa	solar_azimuth_angle
sza	solar_zenith_angle
vaa	viewing_azimuth_angle
vza	viewing_zenith_angle
[TROPOMI.COMMON.PRODUCT/SUPPORT_DATA/INPUT_DATA]	
cf_crb	cloud_fraction_crb
cf_crb_p	cloud_fraction_crb_precision
cth_crb	cloud_height_crb
cth_crb_p	cloud_height_crb_precision

ptp_crb	cloud_pressure_crb
ctp_crb_p	cloud_pressure_crb_precision
[TROPOMI.S5P_OFFL_L2__NO2____.PRODUCT]	
amf_tot	air_mass_factor_total
amf_trop	air_mass_factor_troposphere
no2_tc	nitrogendioxide_tropospheric_column
no2_tc_p	nitrogendioxide_tropospheric_column_precision
no2_tc_p_ak	nitrogendioxide_tropospheric_column_precision_kernel
tm5_trop_ind	tm5_tropopause_layer_index
[TROPOMI.S5P_OFFL_L2__NO2____.PRODUCT/SUPPORT_DATA/DETAILED_RESULTS]	
amf_clear	air_mass_factor_clear
amf_cloud	air_mass_factor_cloudy
amf_strat	air_mass_factor_stratosphere
cf_crb_no2	cloud_fraction_crb_nitrogendioxide_window
no2_gc	nitrogendioxide_ghost_column
no2_scd	nitrogendioxide_slant_column_density
no2_scd_p	nitrogendioxide_slant_column_density_precision
no2_strat	nitrogendioxide_stratospheric_column
no2_strat_p	nitrogendioxide_stratospheric_column_precision
no2_vcd_sum	nitrogendioxide_summed_total_column
no2_vcd_sum_p	nitrogendioxide_summed_total_column_precision
no2_vcd_sum_p_ak	nitrogendioxide_summed_total_column_precision_kernel
no2_vcd	nitrogendioxide_total_column
no2_vcd_p	nitrogendioxide_total_column_precision
no2_vcd_p_ak	nitrogendioxide_total_column_precision_kernel
h2o_scd	water_slant_column_density
h2o_scd_p	water_slant_column_density_precision
[TROPOMI.S5P_OFFL_L2__NO2____.PRODUCT/SUPPORT_DATA/INPUT_DATA]	
pres_surf	surface_pressure
wind_u	eastward_wind
wind_v	northward_wind

ai_354_388	aerosol_index_354_388
surf_alb	surface_albedo
scene_alb	scene_albedo
[TROPOMI.S5P_OFFL_L2__O3_____.PRODUCT]	
o3_vcd	ozone_total_vertical_column
o3_vcd_p	ozone_total_vertical_column_precision
[TROPOMI.S5P_OFFL_L2__O3_____.PRODUCT/SUPPORT_DATA/DETAILED_RESULTS]	
o3_et	ozone_effective_temperature
o3_gc	ozone_ghost_column
pres_sc	scene_pressure
[TROPOMI.S5P_OFFL_L2__HCHO___.PRODUCT]	
hcho_tc	formaldehyde_tropospheric_vertical_column
hcho_tc_p	formaldehyde_tropospheric_vertical_column_precision
[TROPOMI.S5P_OFFL_L2__HCHO___.PRODUCT/SUPPORT_DATA/DETAILED_RESULTS]	
hcho_amf_clear	formaldehyde_clear_air_mass_factor
hcho_amf_cloud	formaldehyde_cloudy_air_mass_factor
hcho_amf	formaldehyde_tropospheric_air_mass_factor
hcho_amf_p	formaldehyde_tropospheric_air_mass_factor_precision
[TROPOMI.S5P_OFFL_L2__CLOUD__.PRODUCT]	
cbh	cloud_base_height
cnh_p	cloud_base_height_precision
cbp	cloud_base_pressure
cbp_p	cloud_base_pressure_precision
cf	cloud_fraction
cf_p	cloud_fraction_precision
cot	cloud_optical_thickness
cot_p	cloud_optical_thickness_precision
cth	cloud_top_height

cth_p	cloud_top_height_precision
ctp	cloud_top_pressure
ctp_p	cloud_top_pressure_precision
[TROPOMI.S5P_OFFL_L2__CLOUD__.PRODUCT/SUPPORT_DATA/DETAILED_RESULTS]	
ch_crb	cloud_height_crb
ch_crb_p	cloud_height_crb_precision
cp_crb	cloud_pressure_crb
cp_crb_p	cloud_pressure_crb_precision
qa_crb	qa_value_crb
[TROPOMI.S5P_OFFL_L2__CO_____.PRODUCT]	
co_vcd	carbonmonoxide_total_column
co_vcd_p	carbonmonoxide_total_column_precision
[TROPOMI.S5P_OFFL_L2__CO_____.PRODUCT/SUPPORT_DATA/DETAILED_RESULTS]	
h2o_vcd	water_total_column
h2o_vcd_p	water_total_column_precision
[TROPOMI.S5P_OFFL_L2__CO_____.PRODUCT/SUPPORT_DATA/INPUT_DATA]	
wind_u	eastward_wind
wind_v	northward_wind
cl_surf	surface_classification
pres_surf	surface_pressure
h_surf	surface_altitude
h_surf_p	surface_altitude_precision
[TROPOMI.S5P_OFFL_L2__CH4____.PRODUCT]	
ch4_mr	methane_mixing_ratio
ch4_mr_corr	methane_mixing_ratio_bias_corrected
ch4_mr_p	methane_mixing_ratio_precision
[TROPOMI.S5P_OFFL_L2__CH4____.PRODUCT/SUPPORT_DATA/DETAILED_RESULTS]	

aod_nir	aerosol_optical_thickness_NIR
aod_swir	aerosol_optical_thickness_SWIR
alh_avg	aerosol_mid_altitude
alh_avg_p	aerosol_mid_altitude_precision
anc	aerosol_number_column
anc_p	aerosol_number_column_precision
[TROPOMI.S5P_OFFL_L2__AER_LH_.PRODUCT]	
amh	aerosol_mid_height
amh_p	aerosol_mid_height_precision
amp	aerosol_mid_pressure
amp_p	aerosol_mid_pressure_precision
[TROPOMI.S5P_OFFL_L2__AER_LH_.PRODUCT/SUPPORT_DATA/DETAILED_RESULTS]	
aod	aerosol_optical_thickness
aod_p	aerosol_optical_thickness_precision
[TROPOMI.S5P_OFFL_L2__AER_LH_.PRODUCT/SUPPORT_DATA/INPUT_DATA]	
wind_u	eastward_wind
wind_v	northward_wind
pres_surf	surface_pressure
cm_viirs	viirs_cloud_mask
cf	cloud_fraction
[TROPOMI.S5P_OFFL_L2__AER_AI_.PRODUCT]	
ai_340_380	aerosol_index_340_380
ai_340_380_p	aerosol_index_340_380_precision
ai_354_388	aerosol_index_354_388
ai_354_388_p	aerosol_index_354_388_precision
[TROPOMI.S5P_OFFL_L2__AER_AI_.PRODUCT/SUPPORT_DATA/INPUT_DATA]	
wind_u	eastward_wind
wind_v	northward_wind

pres_surf	surface_pressure

REFERENCES

R1. BAQUNIN website: https://www.baqunin.eu

R2. Copernicus Hub website: https://www.copernicus.eu/en

R3. ONDA-Dias website: https://www.onda-dias.eu/cms/it/

R4. TROPOMI products manuals: https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-5p-tropomi/document-library

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