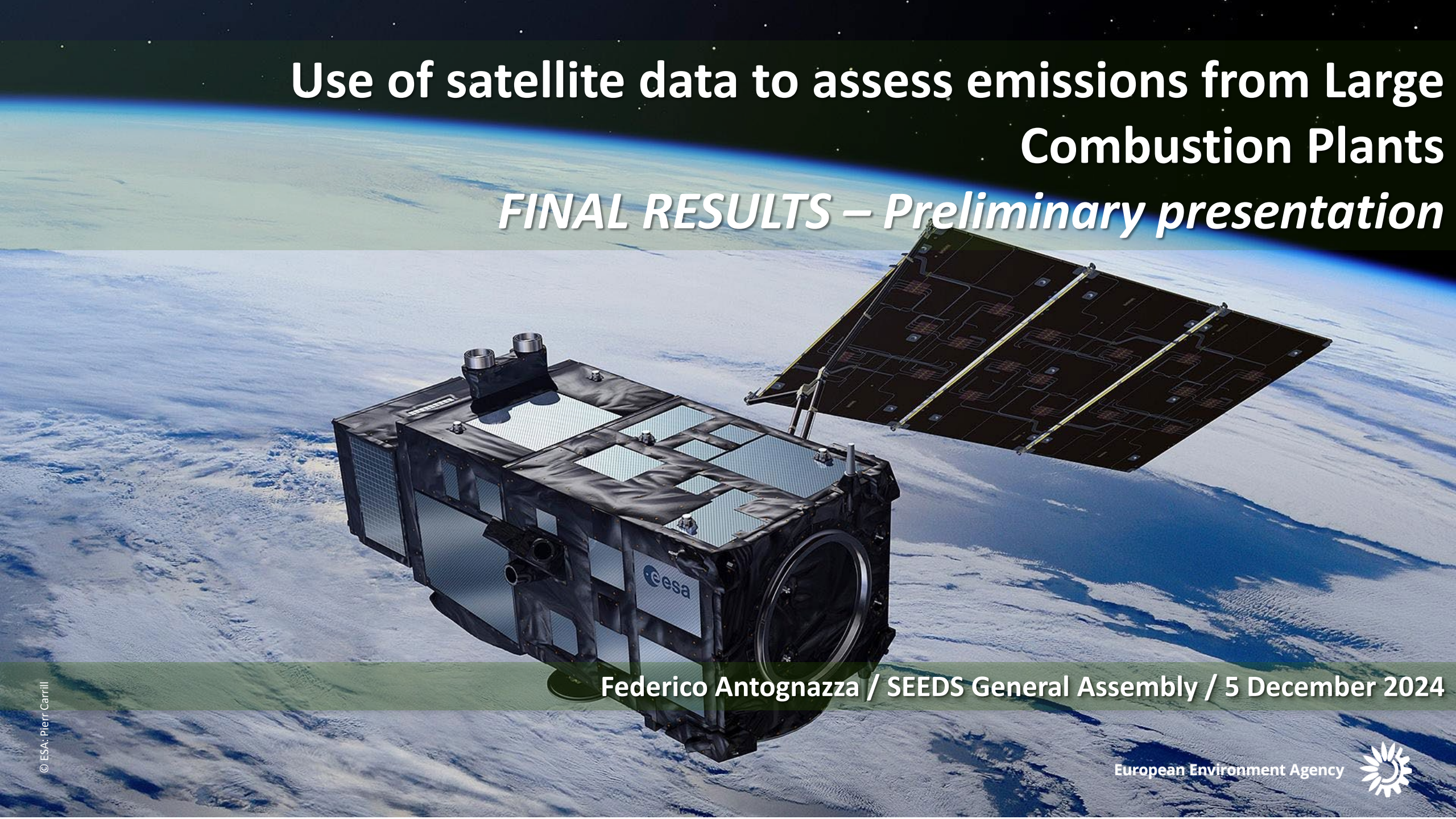
Use of satellite data to assess emissions from Large Combustion Plants

FINAL RESULTS – Preliminary presentation



Federico Antognazza / SEEDS General Assembly / 5 December 2024

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Use of satellite emissions data at EEA

ASSESSMENT OF RELEVANT SOURCES

- NATURAL SOURCES
- FOREST FIRES

SUPPORT ON DATA REPORTING

- QA
- GAP FILLING
- ASSESSMENT

POLICY

- NECD IMPLEMENTATION
- AQ PLANS

Use of Copernicus data for assessing emissions from Large Combustion Plants

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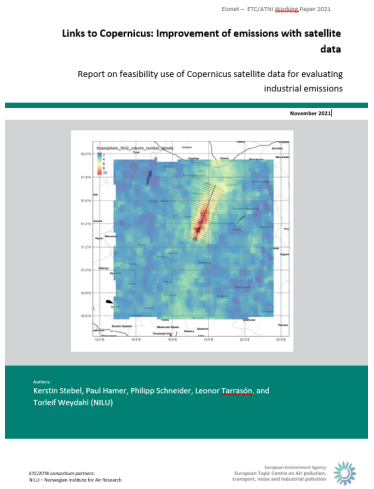
What we have done and what we are doing

2021

Case Study

12 LCPs

Model set-up



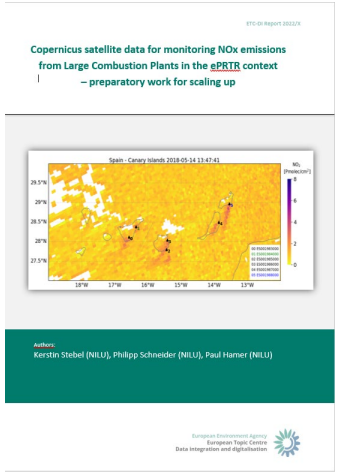
2022

Extensive analysis

Wider number of LCPs

Sensitivity

Evaluation of possible implementation



2023

Implementation?

QA input to reporting data validation

Gap-filling of late or not reported dataset

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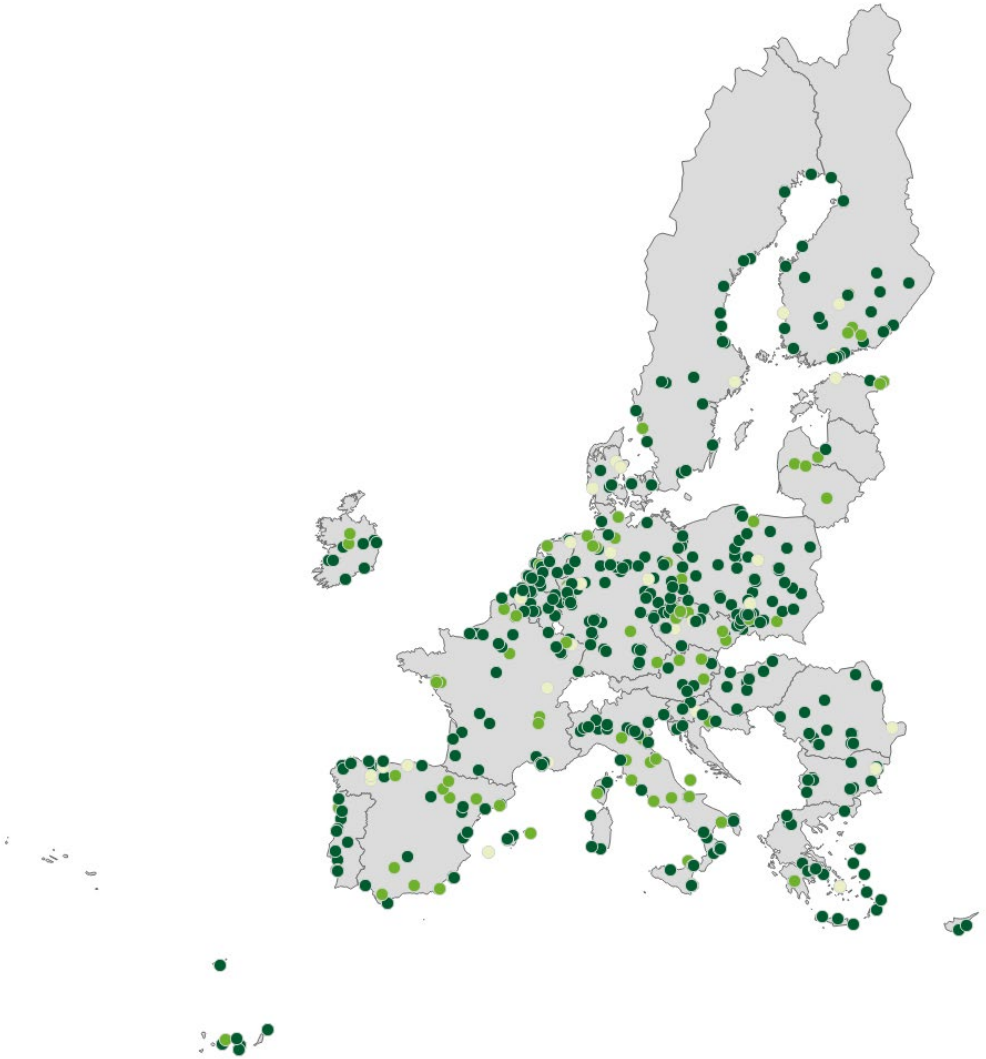
Scope of the study

Facilities with NOx > 250 tonnes



- Cover time period **May 2018 – December 2022**
- All facilities with LCPs with aggregated annual NOx emission > 250t
- Comprehensive **assessment report on usability of Sentinel-5P** to estimate status of emissions from LCPs in Europe

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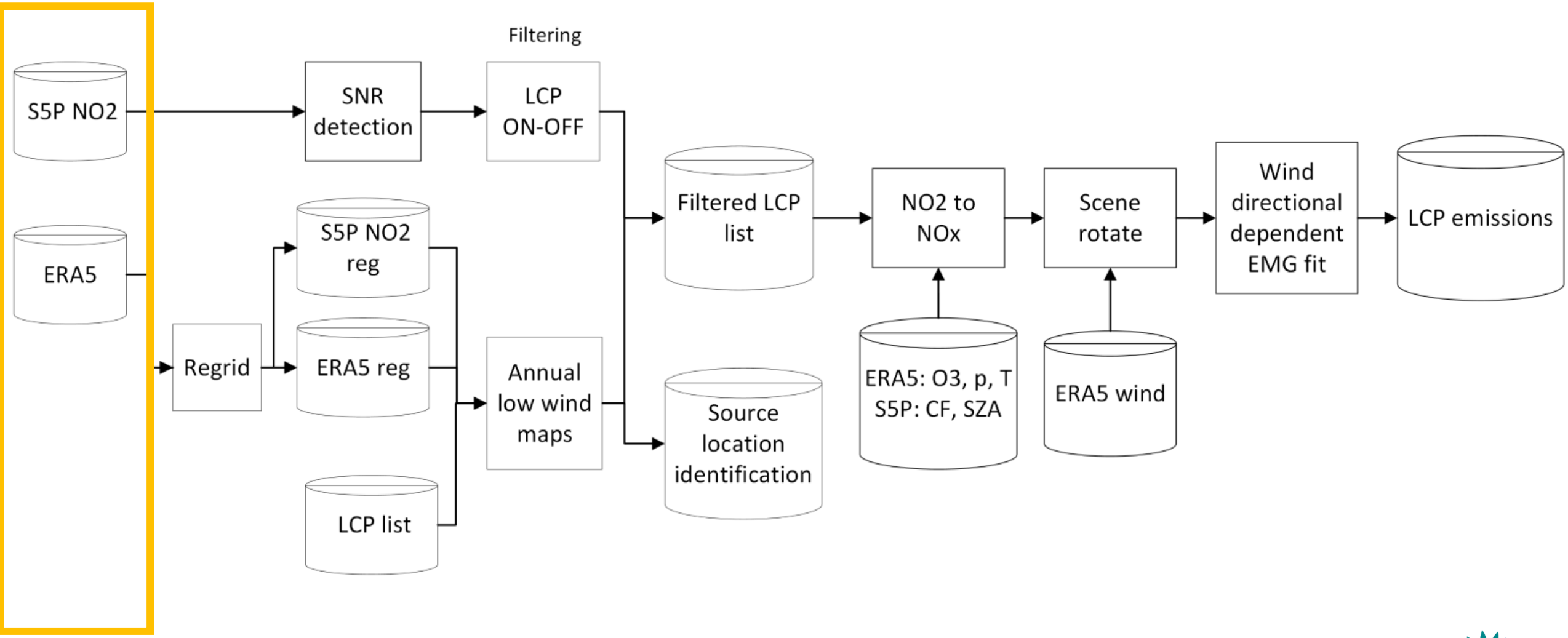
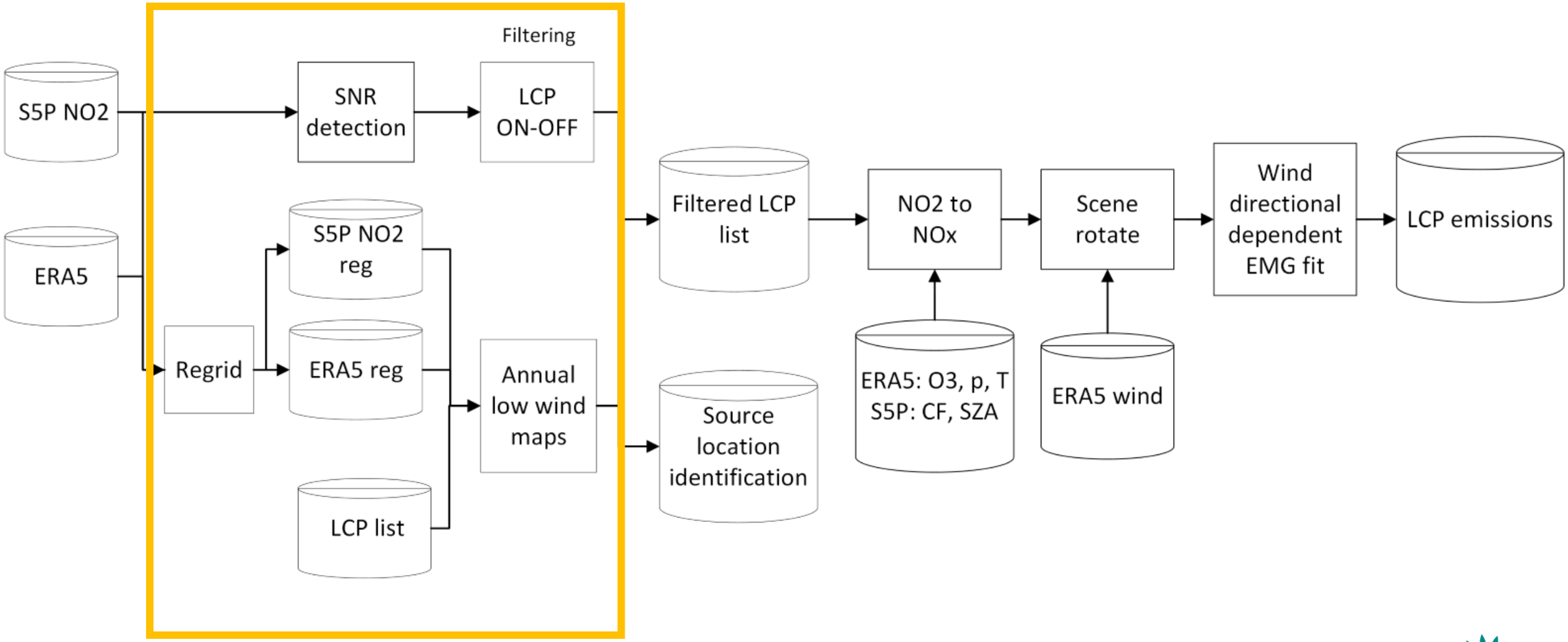
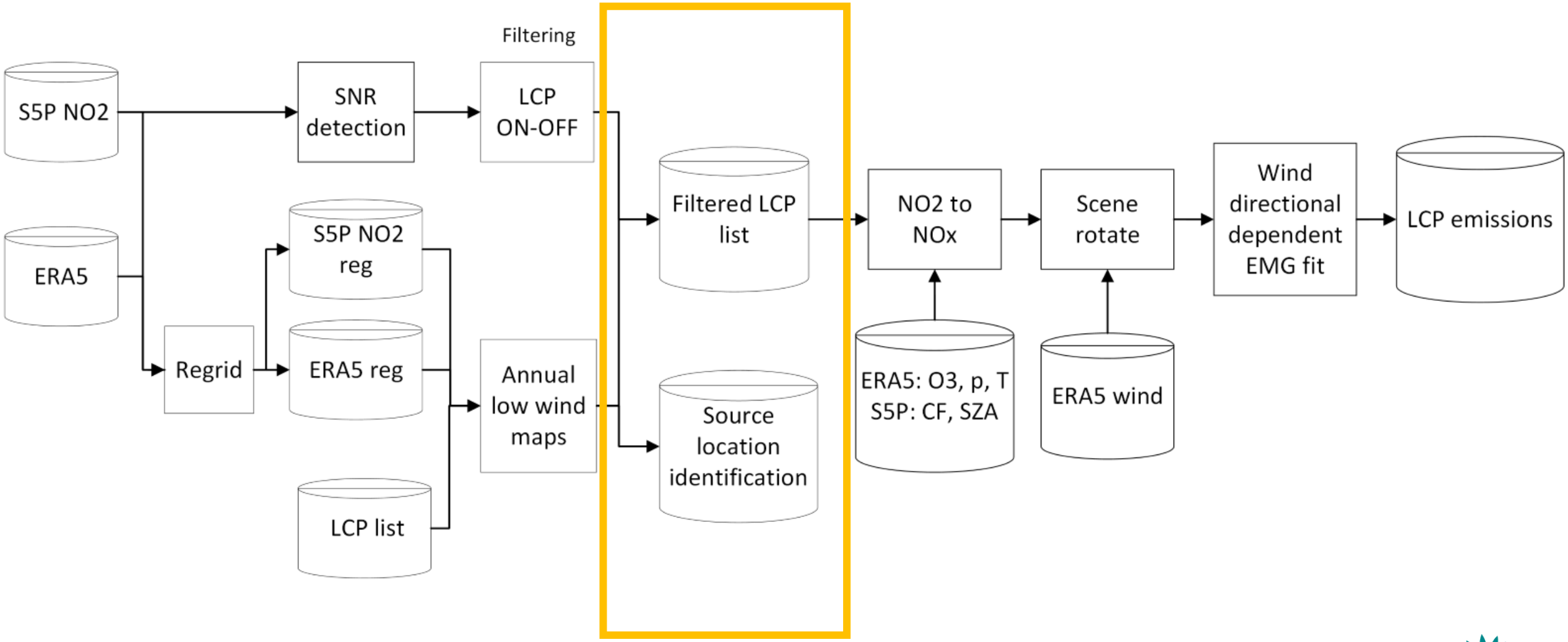
General concept of work



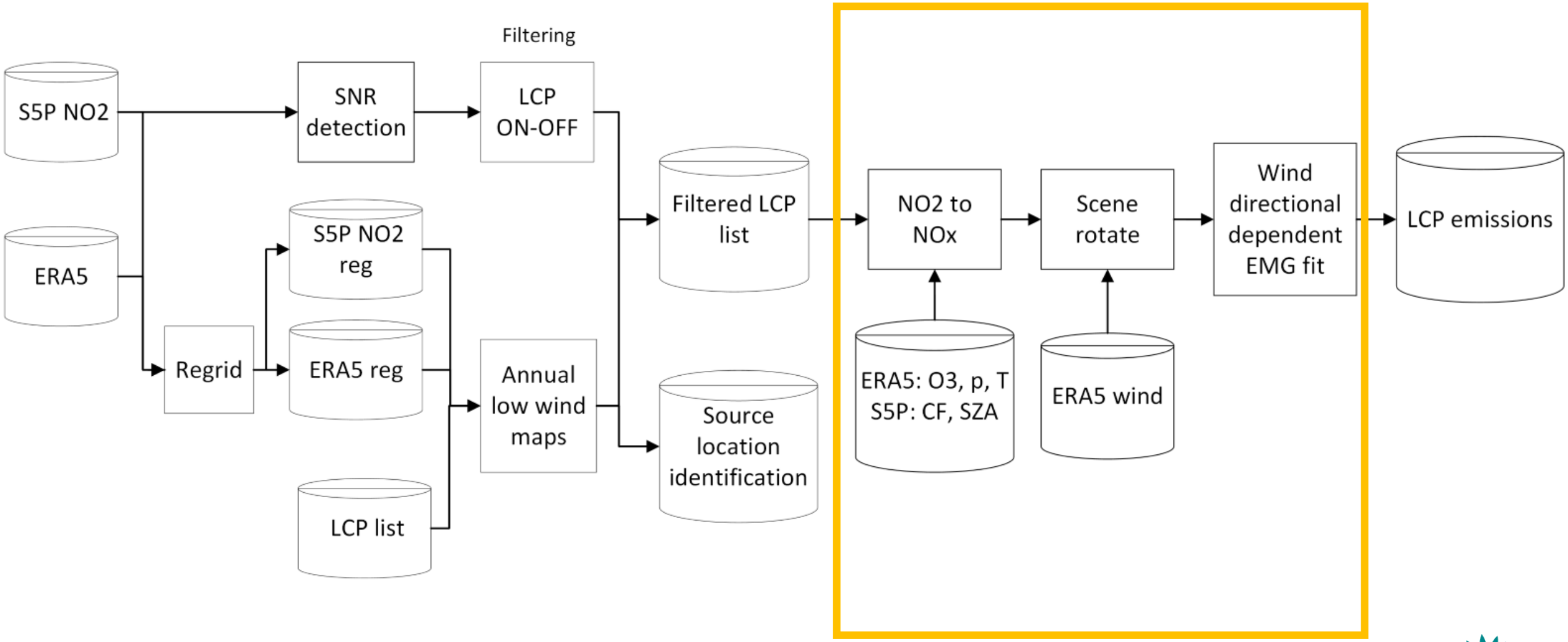
General concept of work



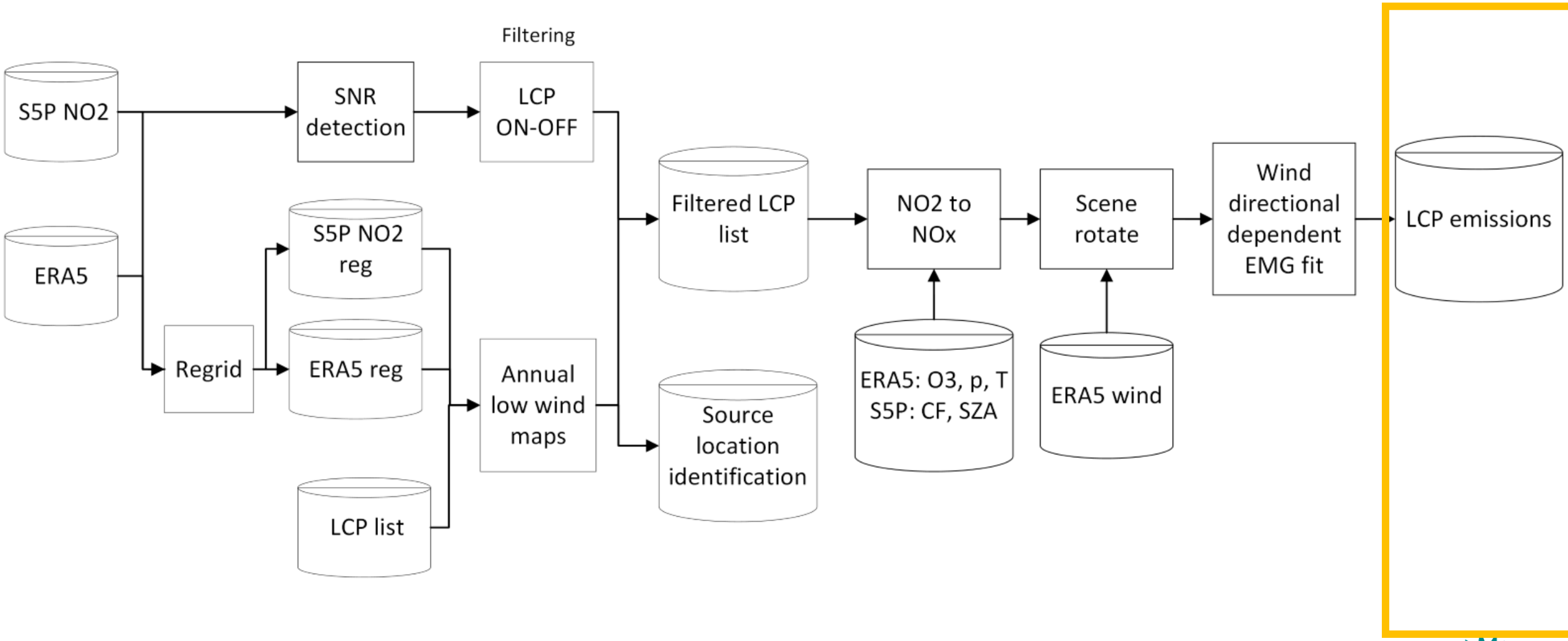
General concept of work



General concept of work

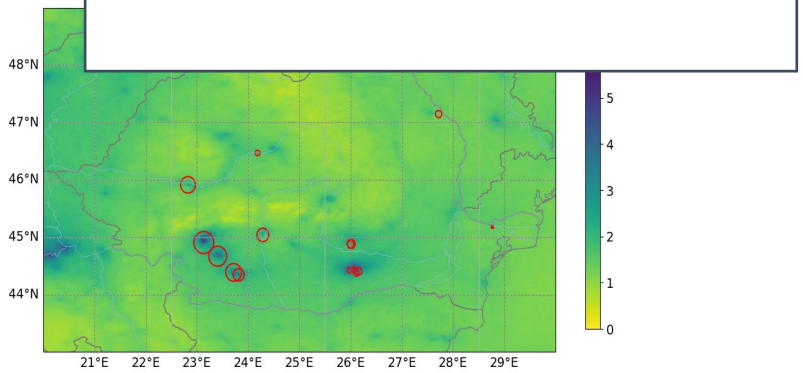


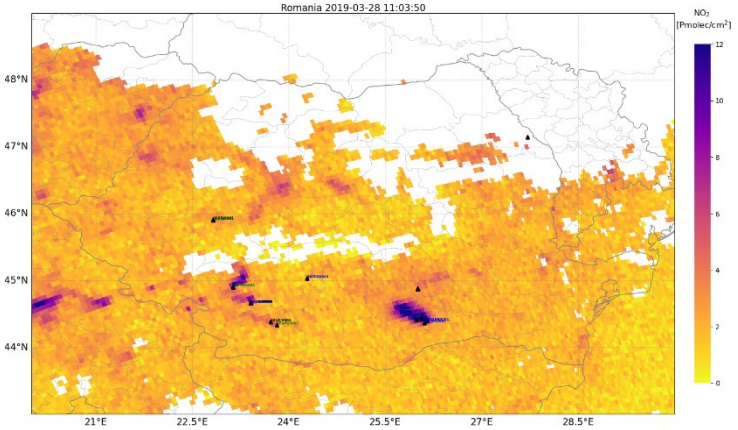
General concept of work



Input data

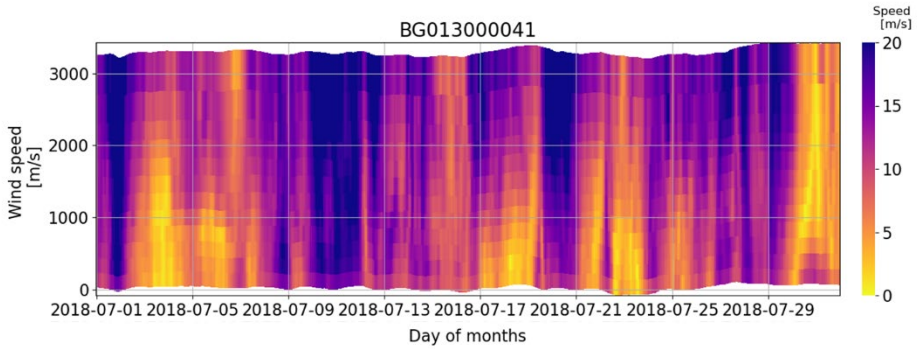
TROPOMI NO2





ERA5 meteorological data from ECMWF

- (hourly data have a spatial horizontal resolution of 0.25° x 0.25°)



Coordinates of LCP from E-PRTR/LCP Database

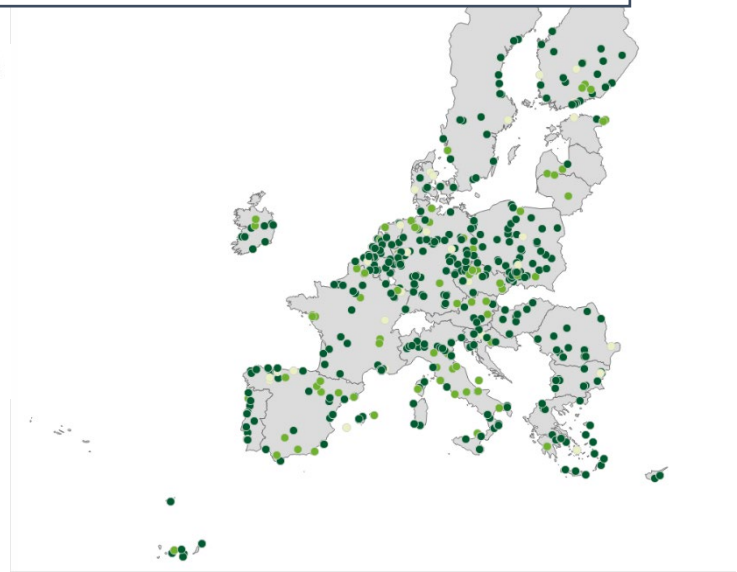


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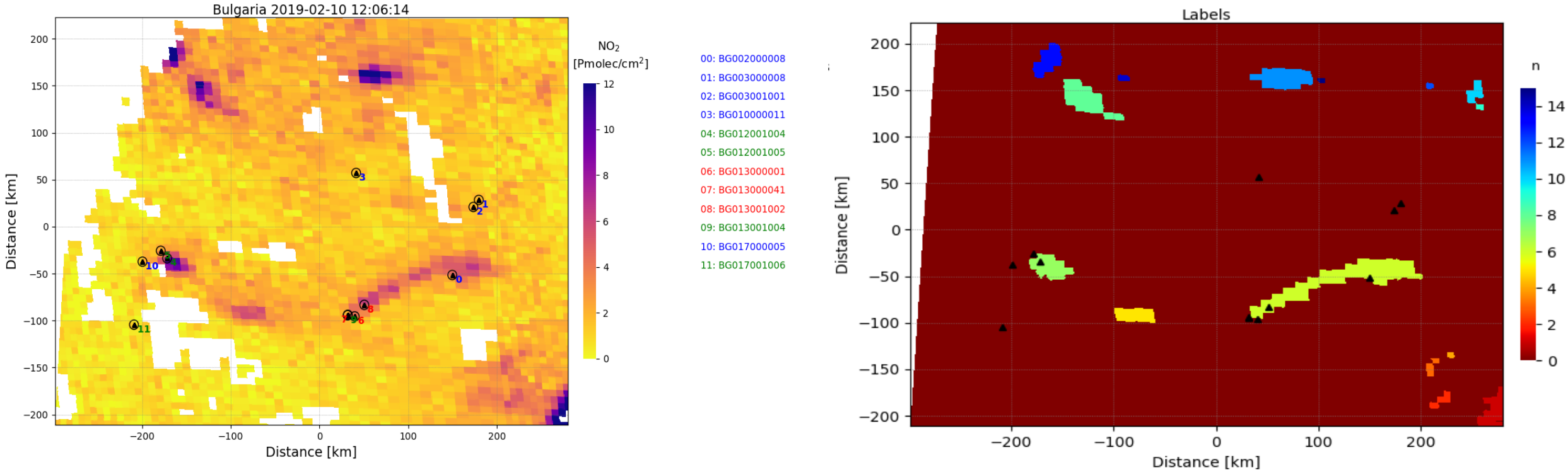
Image processing

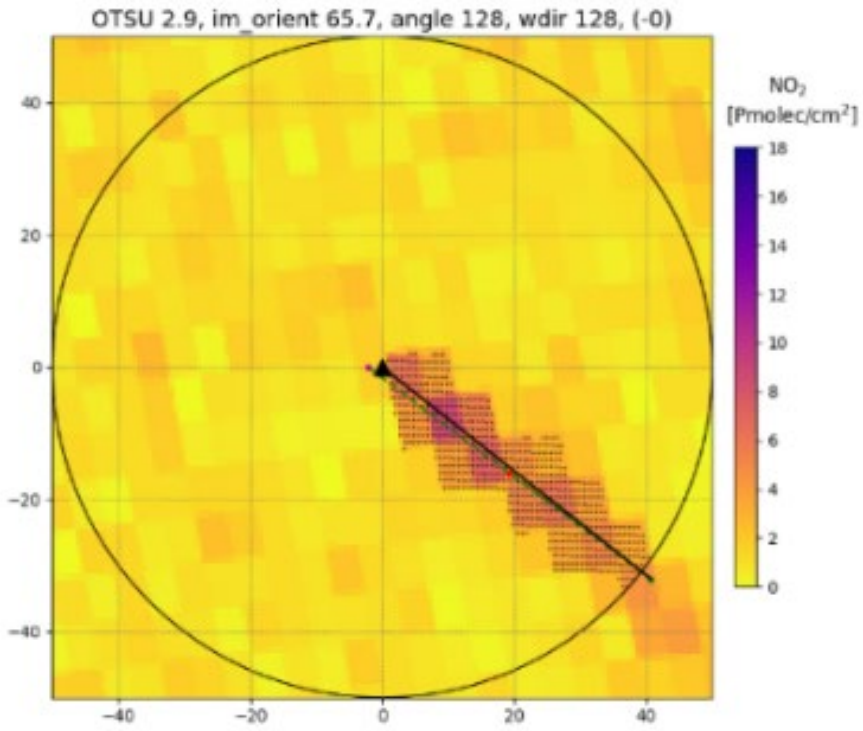


Example of plume detection and plume sequencing for a single overpass over Bulgaria. The left panel shows the NO_2 observations and the location of the different facilities (color code represents emissions below 0.5 kt (blue), between 0.5 – 1 kt (green) and above 1 kt (red)). The right panel shows the plume segmentation

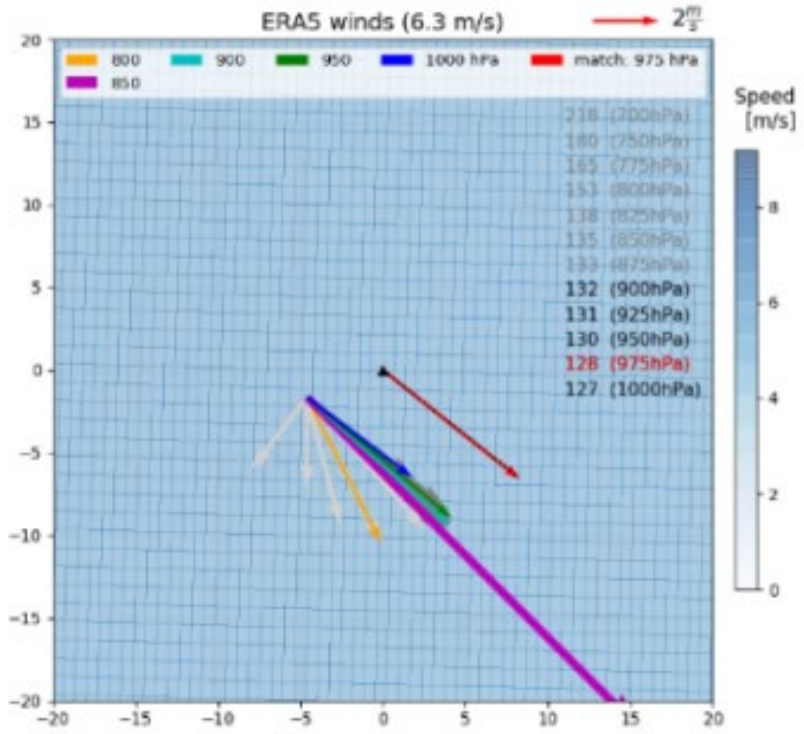
$$\frac{X_p - X_{\mathrm{bg}}}{\sqrt{\frac{s_{ssp}^2}{n_p} + s_{bg}^2}} > z(q),$$

Eurc

Matching plume direction with winds



TROPOMI NO_2 plume (20 km circle around LCP site)



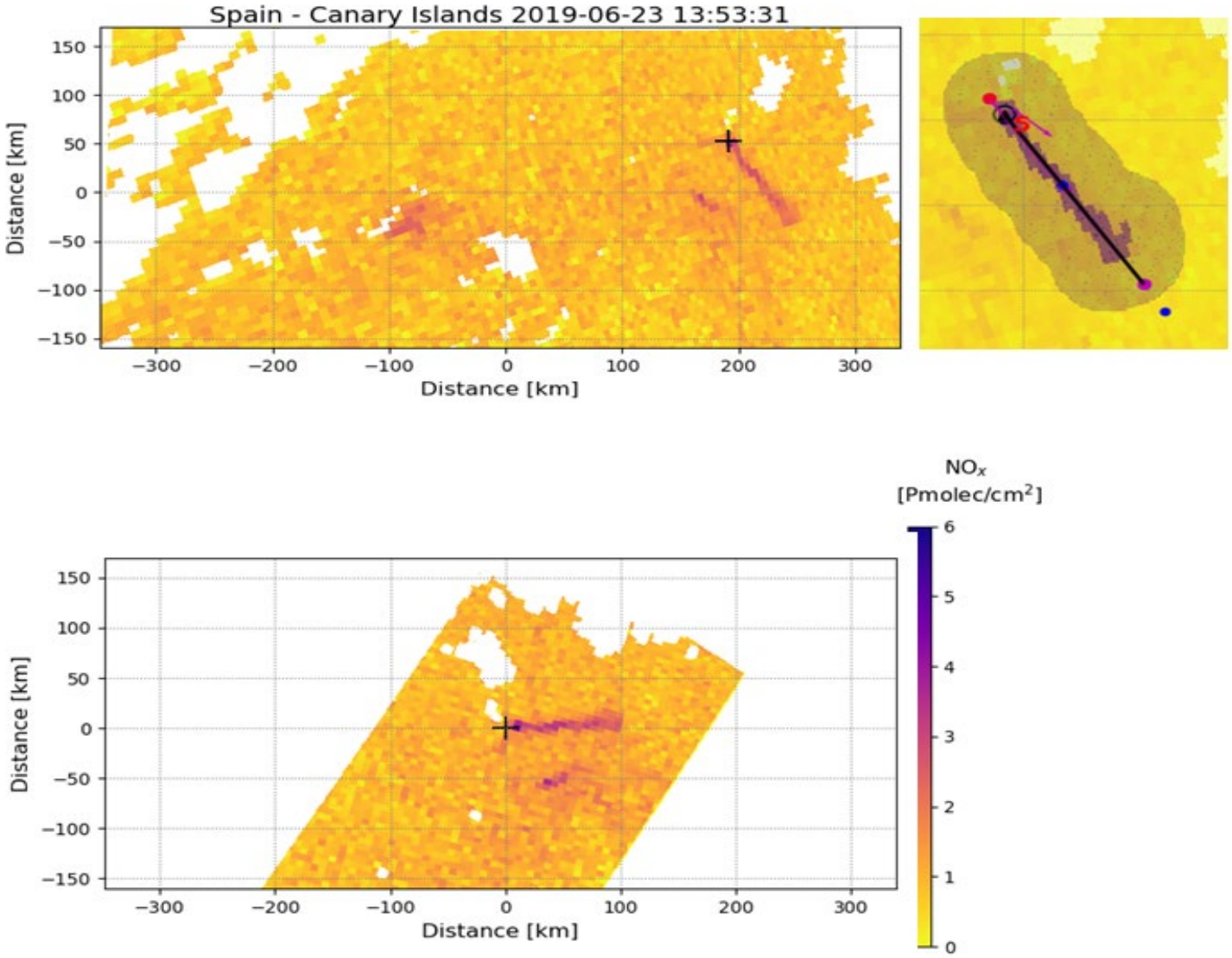
ECMWF winds at different pressure levels

Determination of pressure level (ERA5 winds and O_3) to be used for the NO_2 to NO_x conversion and wind-speed for the emission estimates.

Rotation of all plumes to increase SNR

Eur

Plume rotation



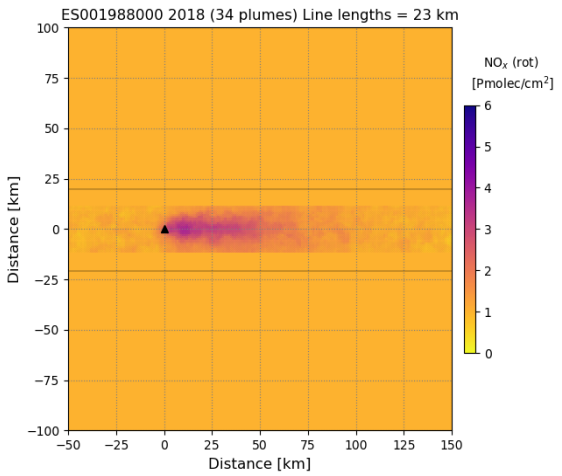
Example for plume rotation. The upper left panel shows the NOx column densities for an overpass on June 23rd, 2019. The upper right panel gives an example of the plume direction (black line) and wind direction for the Punta Grande *power station on Lanzarote. The triangle marks the location of the facility, with a five km circle around the site. Note the dots indicating centre and endpoints of the plume and an area around. The lower panel shows the rotated plume.*

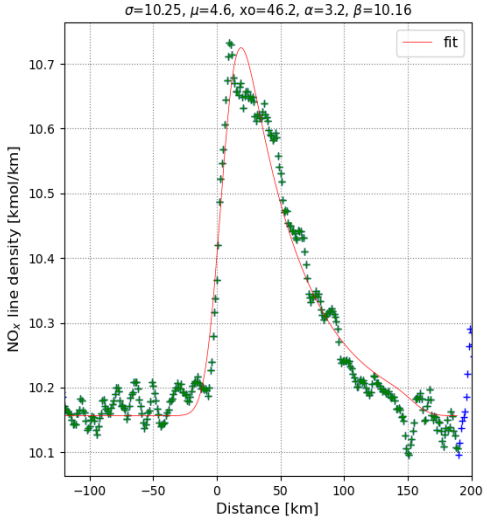
Conversion of NOx and TROPOMI line density

NO_x / NO_2 conversion factor for the photochemical steady state

$$\frac{[NO_x]}{[NO_2]} = 1 + \frac{[NO]}{[NO_2]} = 1 + \frac{J_{NO_2}}{k_{NO+O_3} * n_{O_3}}$$

TROPOMI NO_2 line density (S)





w = 6.4 m/s

τ = 2.0 h

E = 266.4 g/s (8402 t/year)

From Exponentially Modified Gaussian fit determine:

$\tau = x0\ w$ effective lifetime

$E = \alpha\ /\ \tau$ NOx emission rate

Illustration of EMG fit procedure. Left panel: Visualization of the averaged rotated plume and the determined width for the line-density calculation for the LCP facility ES00198000, which is located on the Canary Islands for the year 2018. Right panel: line density (green points) and EMG fit (red line). α, the total number of NOx observed near the power plant, $x0$ is the e-folding time, w is wind-speed

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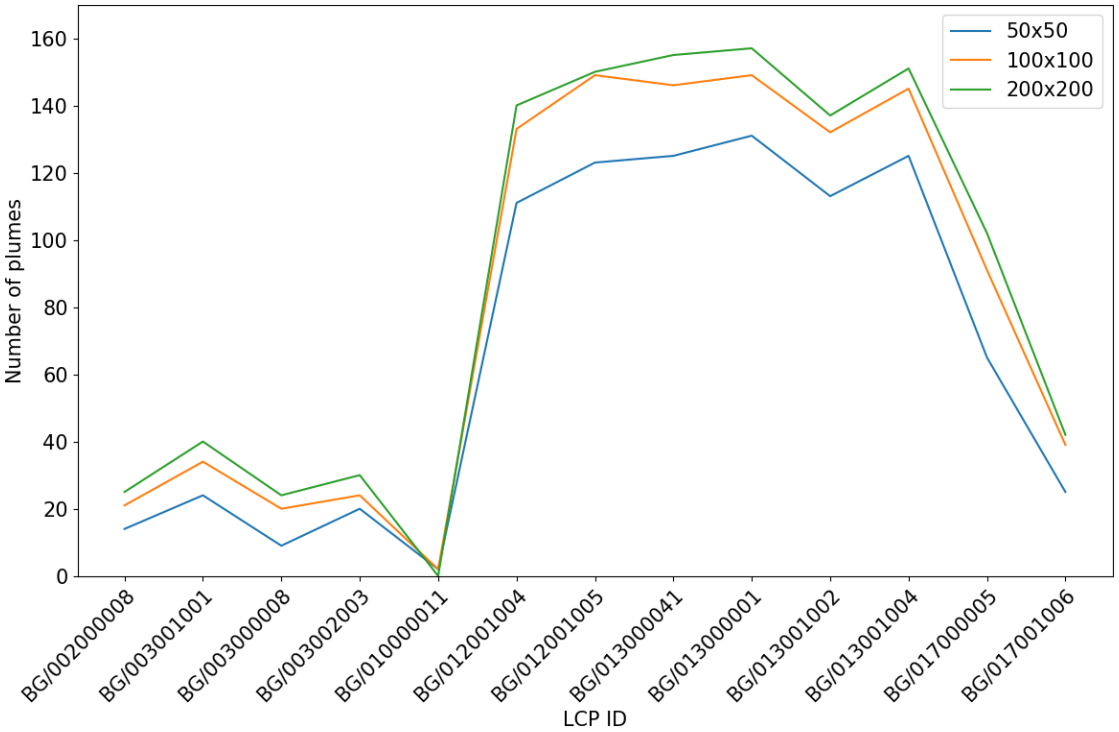
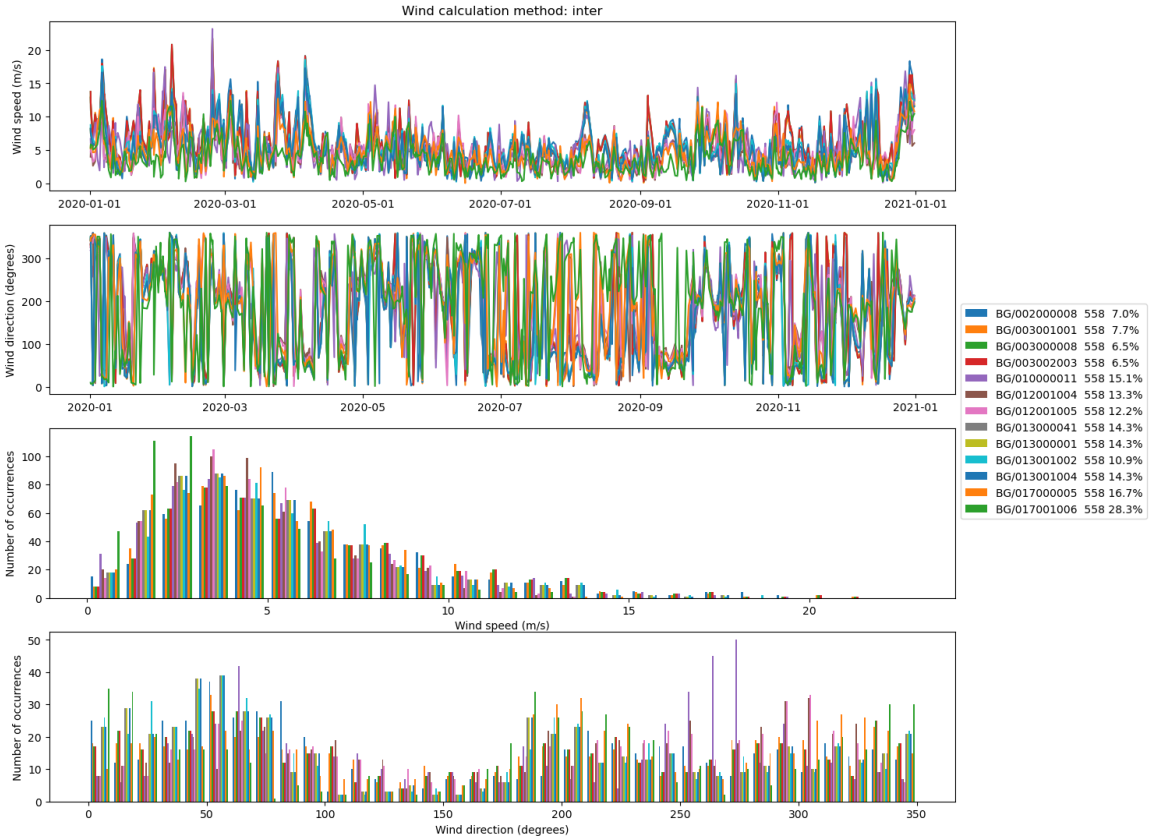
Sensitivity analysis

Number of visible plums according to pixel window size





Wind and speed direction and percentage of values in the quiet wind zone (< 2m/s)

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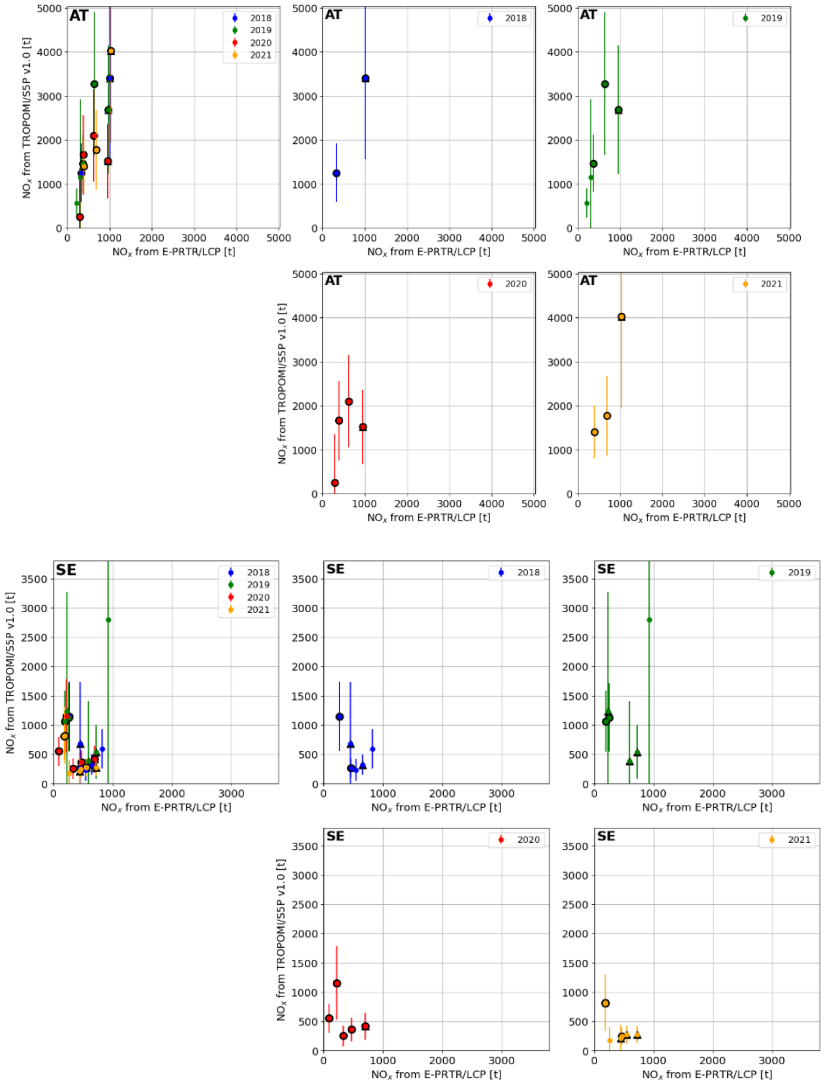
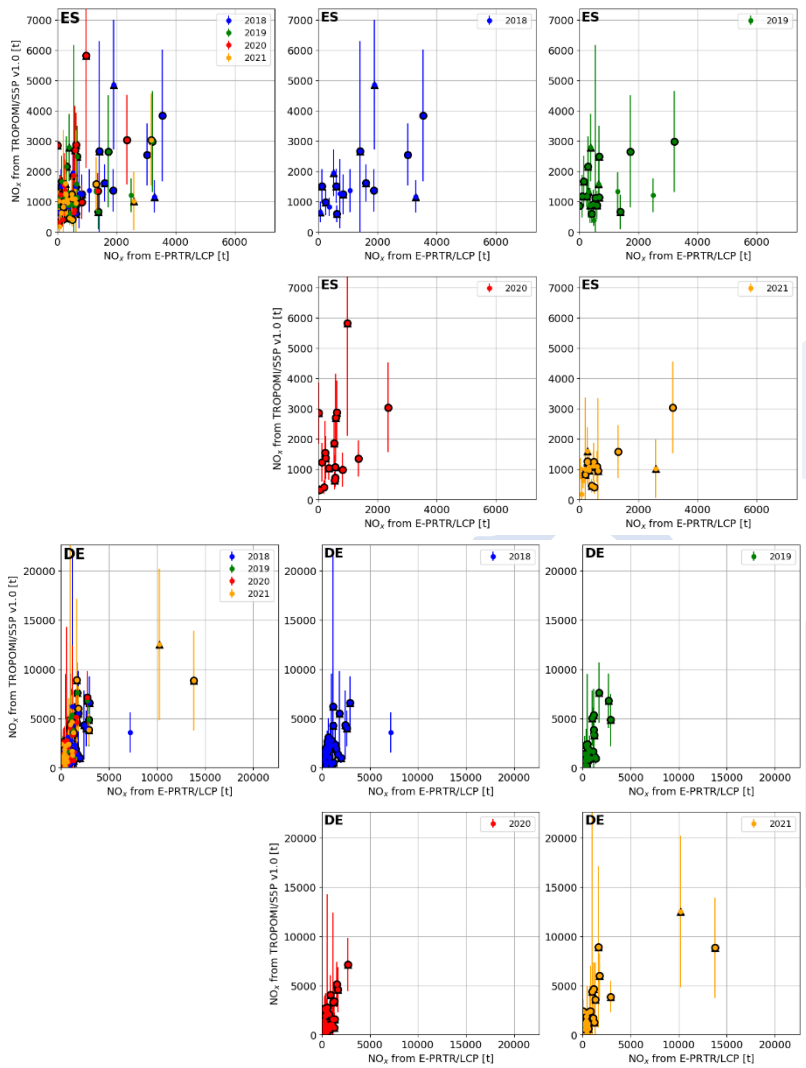
Final results





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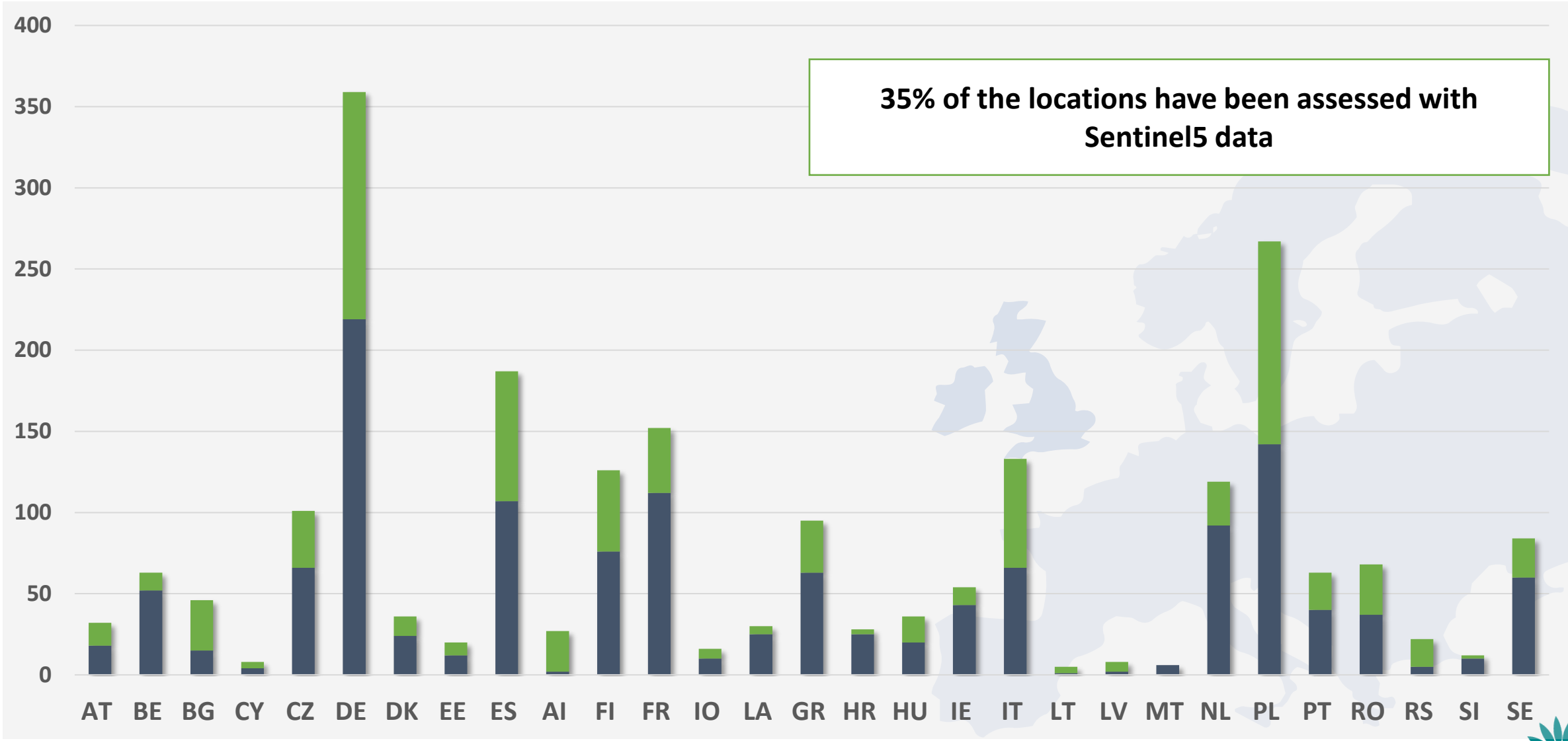
Final results



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Key findings

- Use of a **single instrument** key to have robust assessment
- About **35% of the reported points above the threshold have been assessed**
- **Detection threshold**: 1kt NOx per year
- **Background NOx pollution level** is a key limiting factor to identify clear point sources
- **Big cities proximity** prevent from assessing point sources
- Sensitivity analysis and improvement in methodology helps **in identifying country specific limits**

Thank you

Federico Antognazza / SEEDS Assembly / 5 December 2024

With the contribution of: Kerstin Stebel, Philipp Schneider, Arve Kylling, Paul Hamer (NILU)

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