SEEDS

Sentinel EO-based Emission and Deposition Service

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SEEDS NOx emissions from industrial plants

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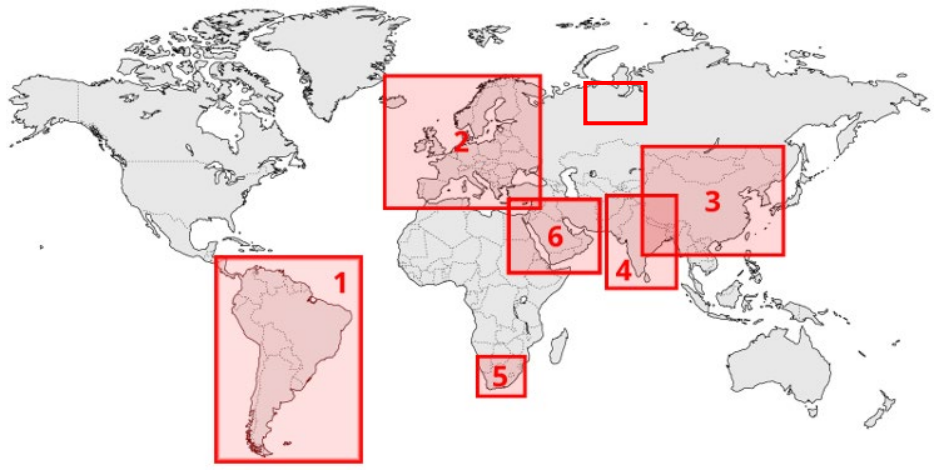
Contents

- Method: NOx emissions using DECSO applied to TROPOMI observations
- NOx emissions of point sources:
  - Possibilities and limitations

DECSO
Daily Estimates Constrained by Satellite Observations

State vector forecast	$\mathbf{x}^{f}(t_{i+1}) = M_i\,[\mathbf{x}^{a}(t_i)]$
Error covariance forecast	$\mathbf{P}^{f}(t_{i+1}) = \mathbf{M}_i\mathbf{P}^{a}(t_i)\mathbf{M}_i^{T} + \mathbf{Q}(t_i)$
Kalman gain matrix	$\mathbf{K}_i = \mathbf{P}^{f}(t_i)\mathbf{H}_i^{T}[\mathbf{H}_i\mathbf{P}^{f}(t_i)\mathbf{H}_i^{T} + \mathbf{R}_i]^{-1}$
State vector analysis	$\mathbf{x}^{a}(t_i) = \mathbf{x}^{f}(t_i) + \mathbf{K}_i(\mathbf{y}_i^{o} - H_i\,[\mathbf{x}^{f}(t_i)])$
Error covariance analysis	$\mathbf{P}^{a}(t_i) = (\mathbf{I} - \mathbf{K}_i\mathbf{H}_i)\,\mathbf{P}^{f}(t_i)$

- It is fast: one model run per assimilation step of 1 day
- No *a priori* information: unknown sources become visible.
- Latest version of CHIMERE: v2020r3
- Latest version of TROPOMI NO2: PAL data set
- Used for <u>daily</u> NO_x and NH_3 emissions



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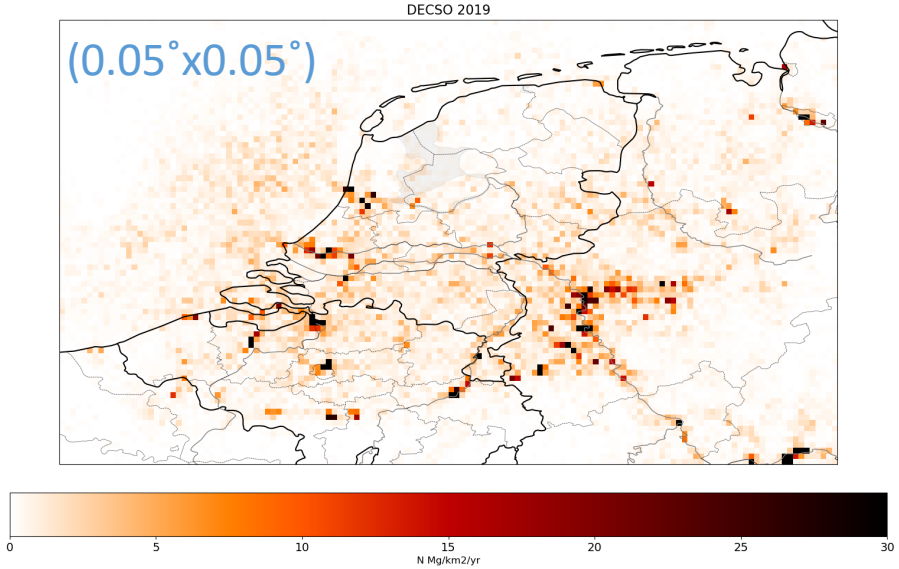
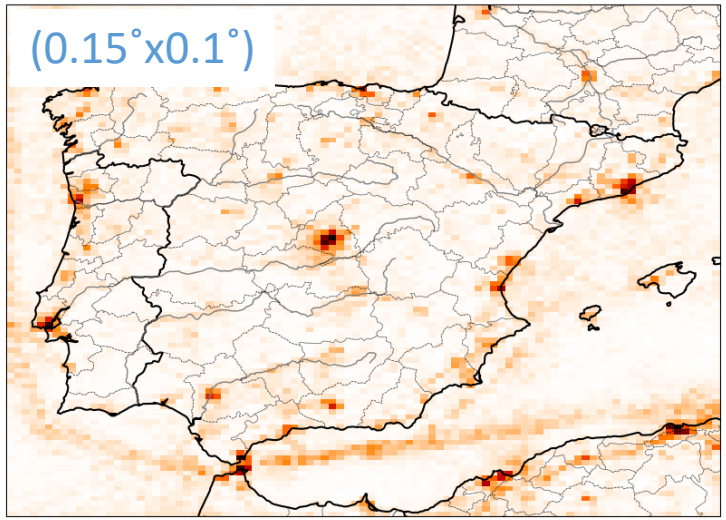
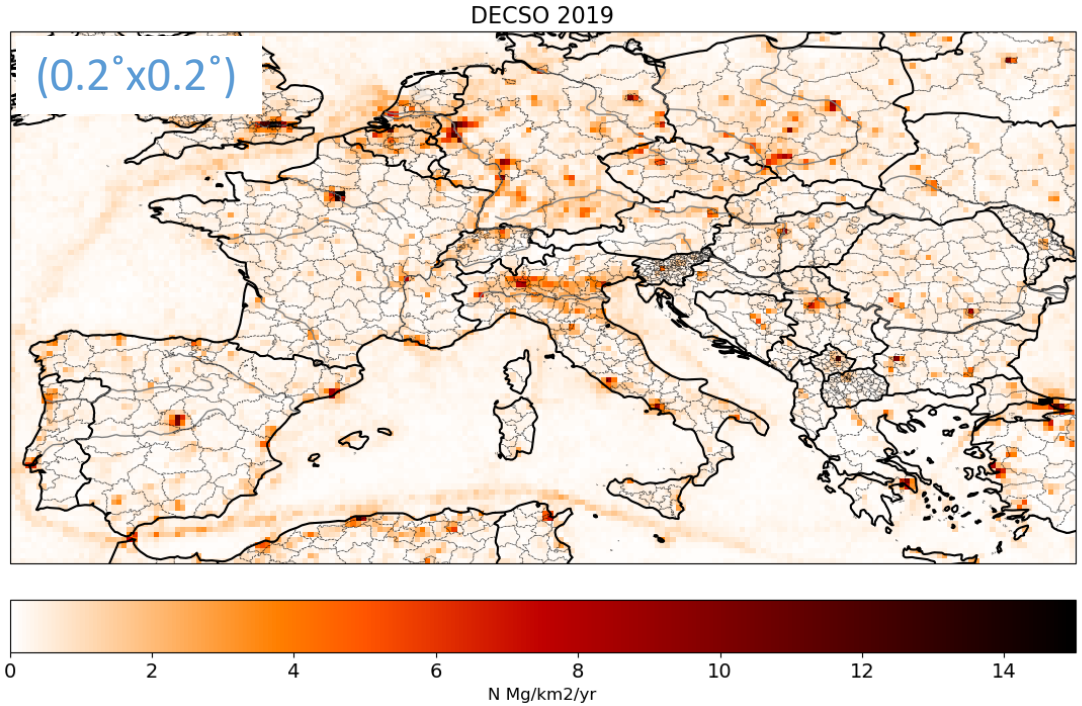
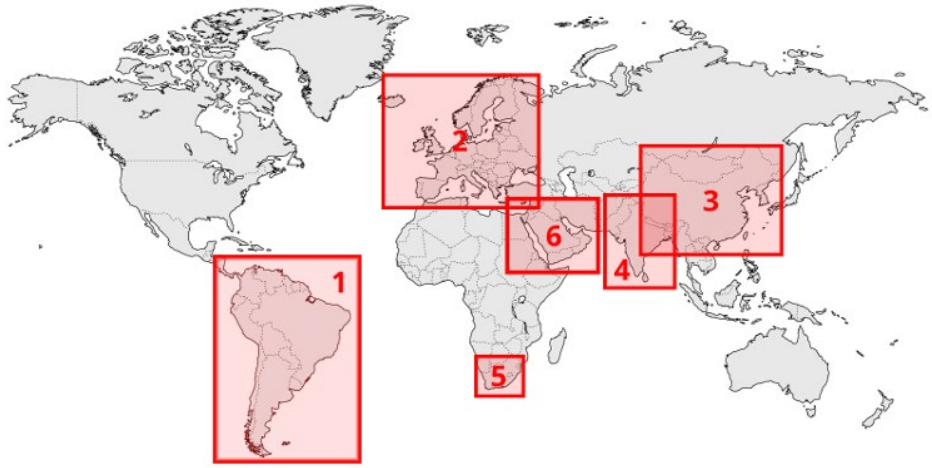
Regions at various resolutions



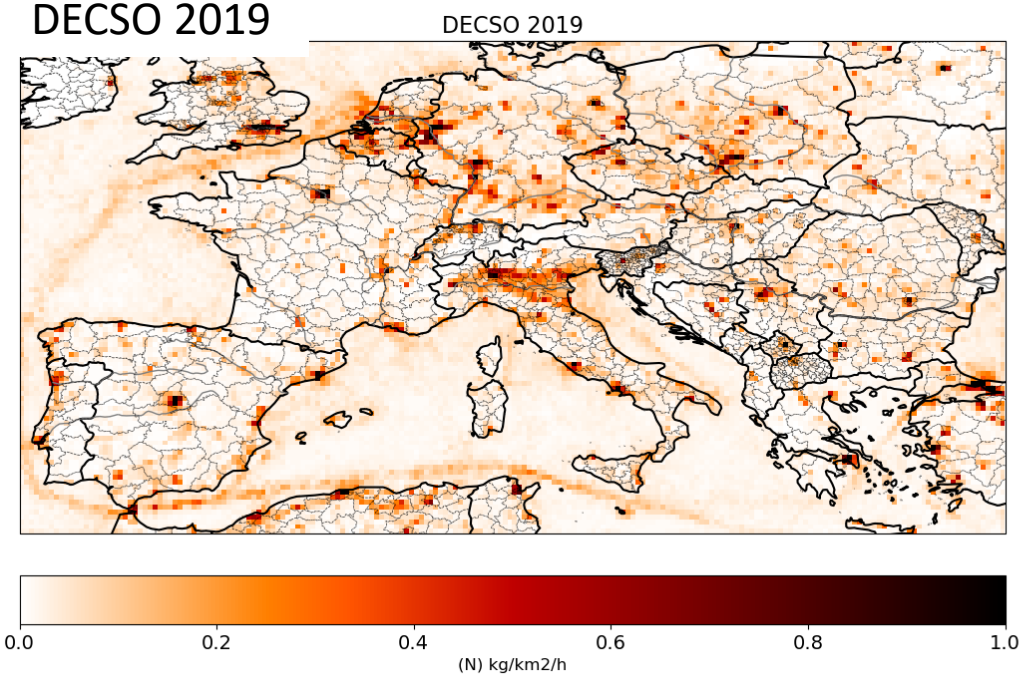




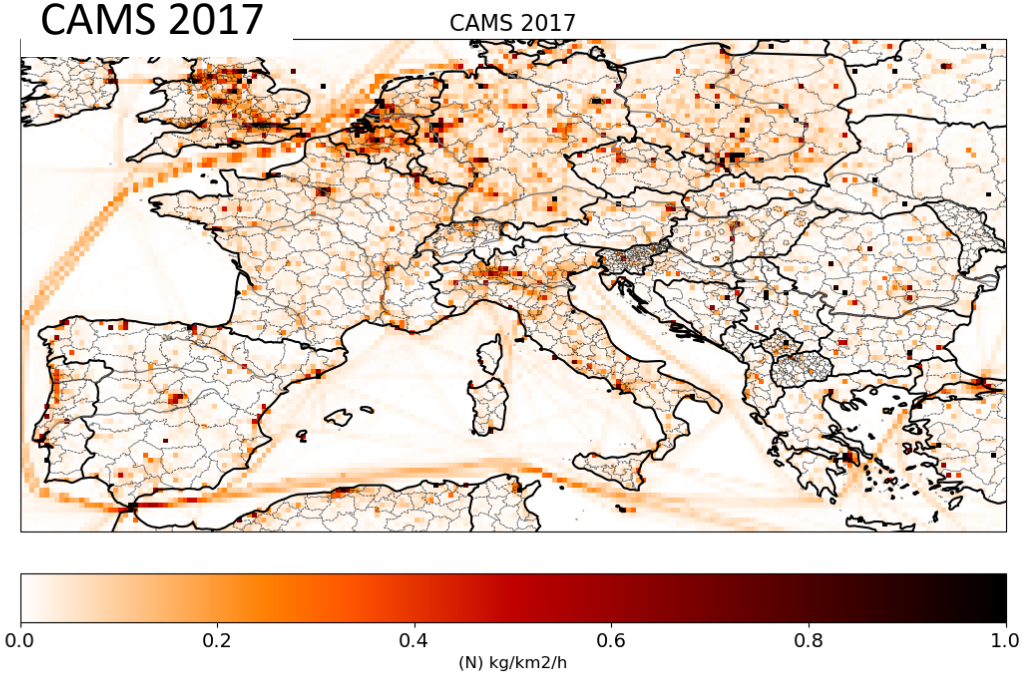


Comparison to CAMS emissions

DECSO 2019

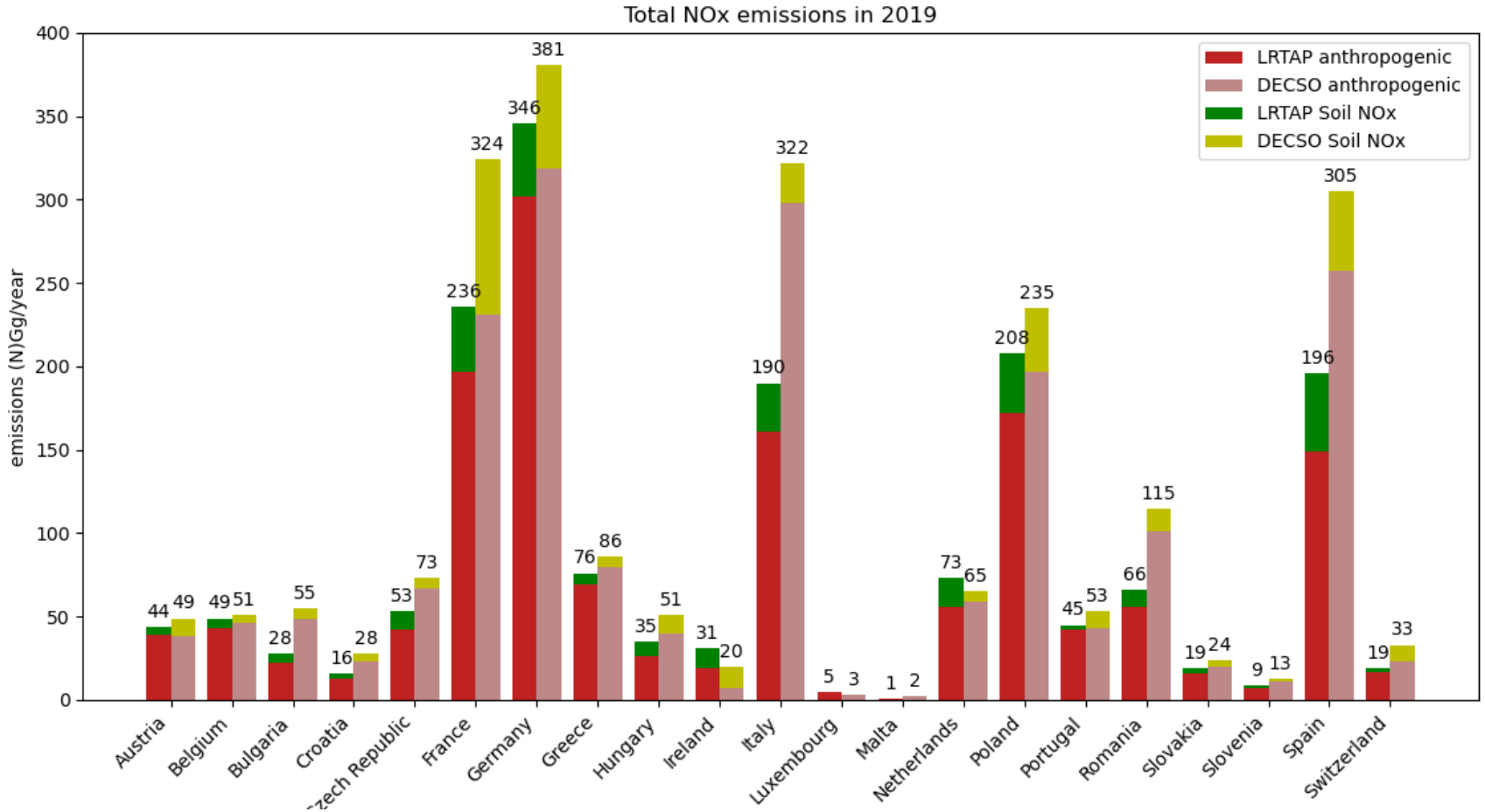


CAMS 2017



Country totals of NOx vs. LRTAP

- DECSO: light color bars
- LRTAP (EEA): dark color bars



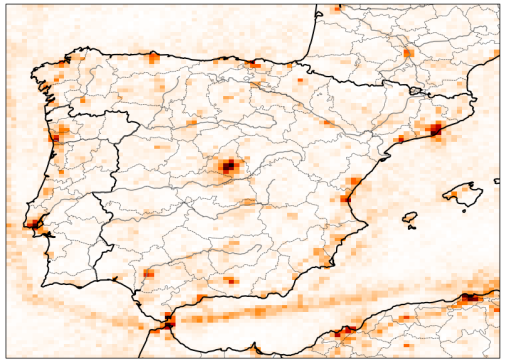
Anthropogenic NOx emissions of point sources

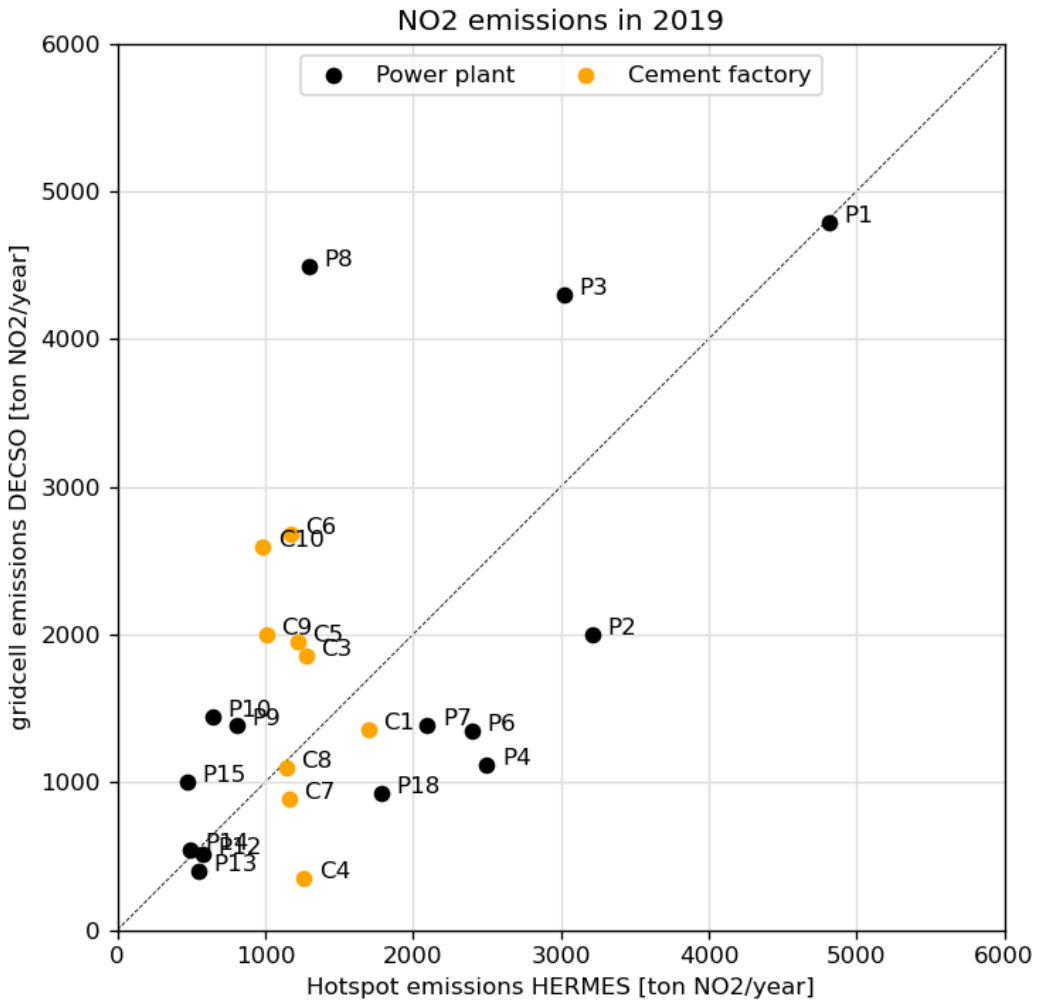
Comparison with power plants and cement factories

Comparison for Spain

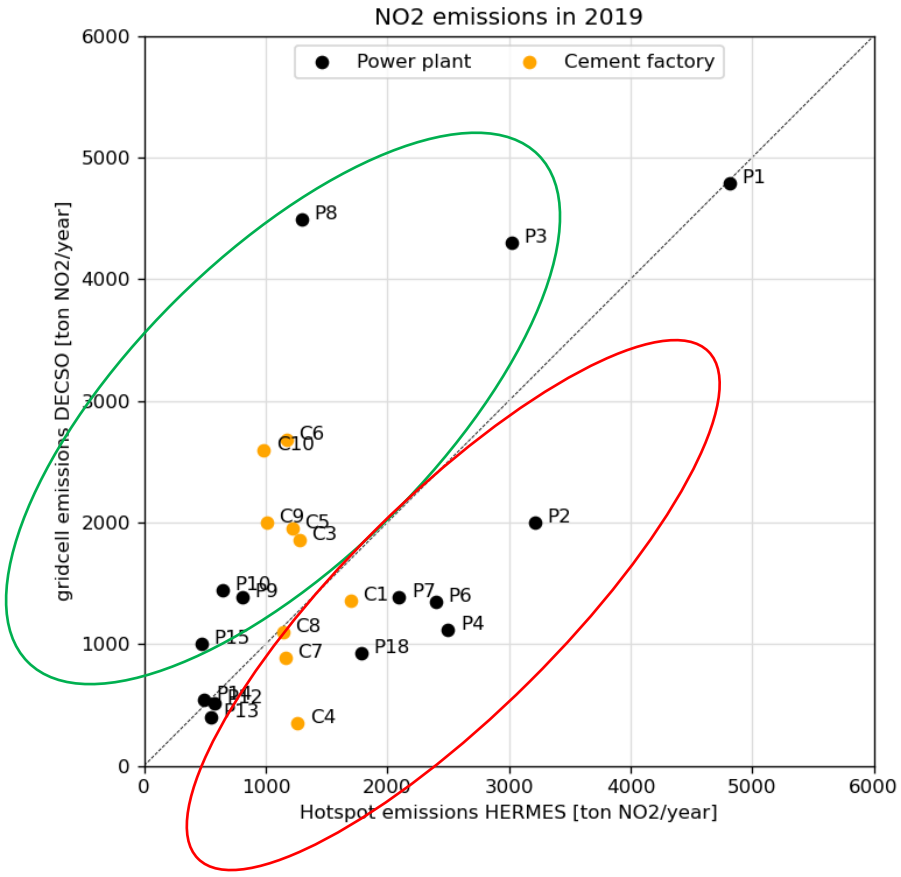
- DECSO derived at **0.1 x 0.15 degree**
- Point sources from HERMES/E-PRTR

(We started a similar study for the Netherlands)





Check of grid cells containing the point source using a visual check in Google-Earth

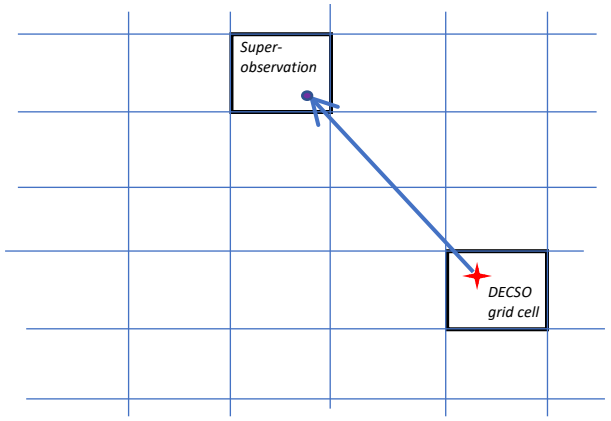


Point sources in green ellipse:
Other sources (cities, industry) in the same grid cell

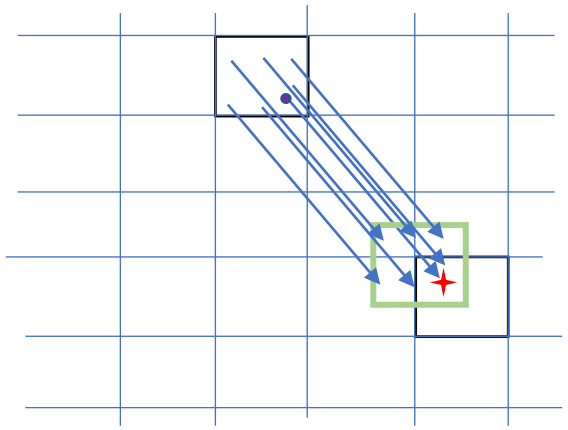
Point sources in red ellipse:
Isolated sources that seem to be underestimated by DECSO

Smoothing of isolated point sources

Trajectory along wind field



Multiple trajectories from observation to grid cell

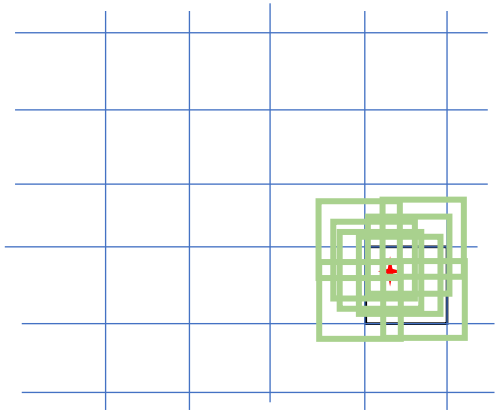


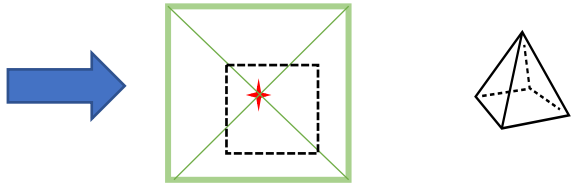
Point source

Because of the resolution of the satellite observations and the grid cells, the resulting emissions are smoothed.

For individual cases (known location of the plant) a deconvolution is possible to find the real emissions.

Many trajectories along the plume, many orbits:

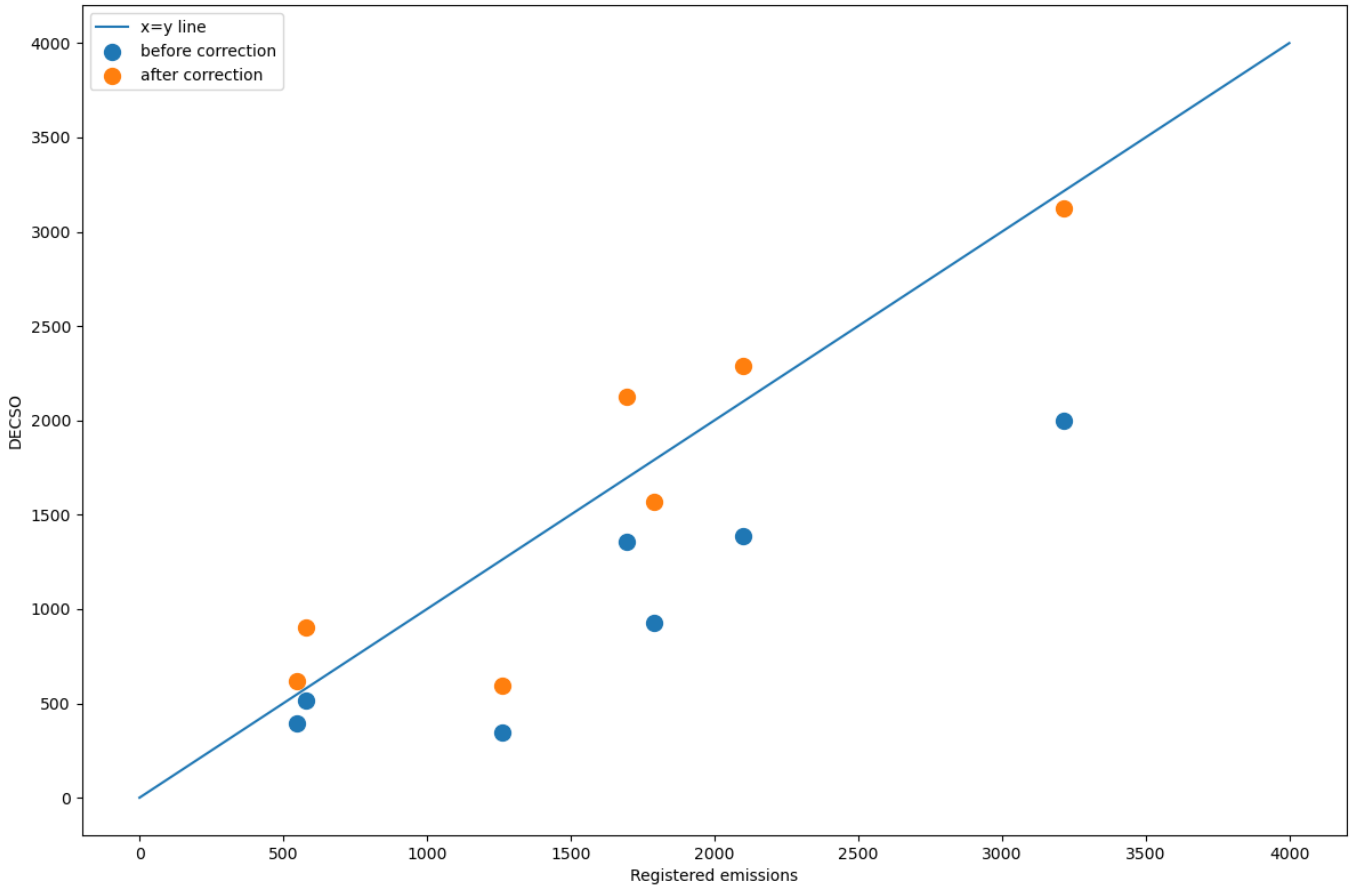




smoothing (weighted by a pyramid shape)

…..deconvolution is possible

Comparison accounting for the resolution

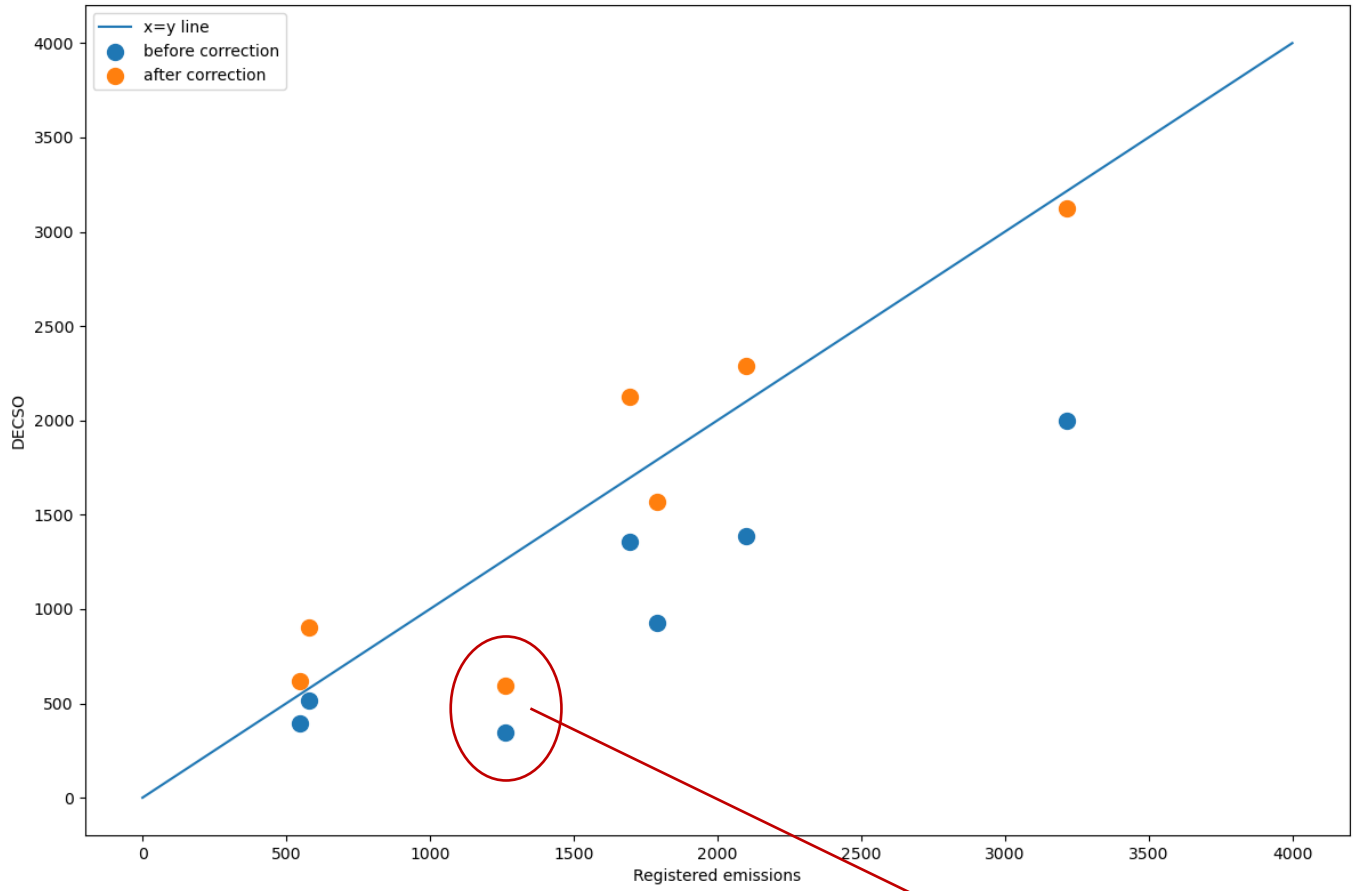


DECSO

Registered emissions

- Emissions directly taken from grid cell
- Emissions accounting for resolution effects

Comparison accounting for the resolution



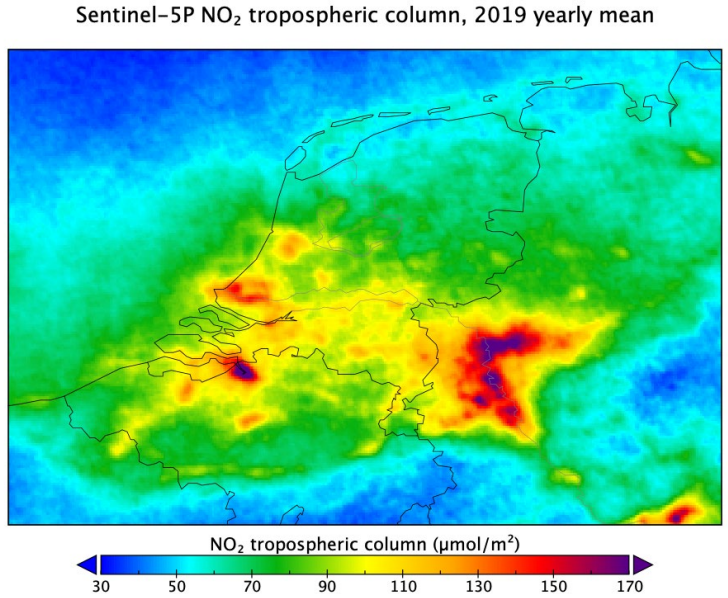
DECSO

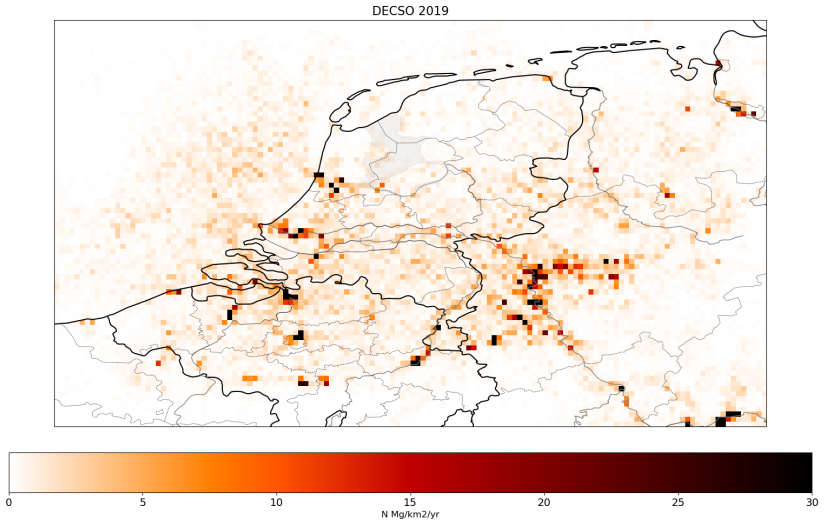
Registered emissions

- Emissions directly taken from grid cell
- Emissions accounting for resolution effects

Cement factory Alcanar

Going to a higher grid resolution: 5x3 km

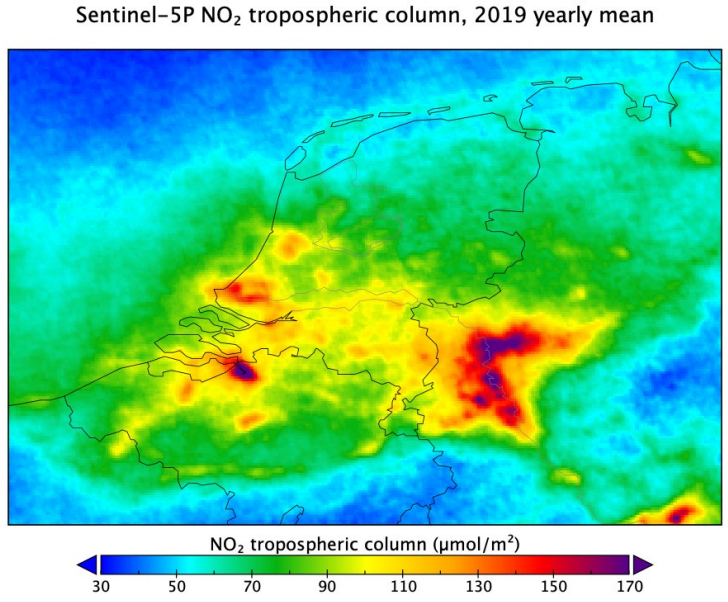


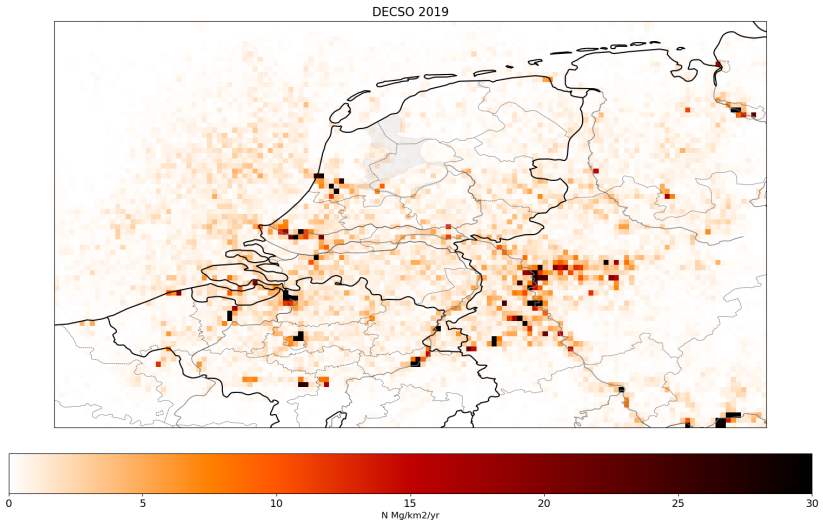


- Averaged TROPOMI NO2 observations (3.5x5 km)

- Calculated NOx emissions (daily)
- Resolution is 0.05˚ (5x3.5 km)
- New error parametrizations for DECSO are needed

Going to a higher grid resolution: 5x3 km





- Ave
  obse
- Calc
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- New
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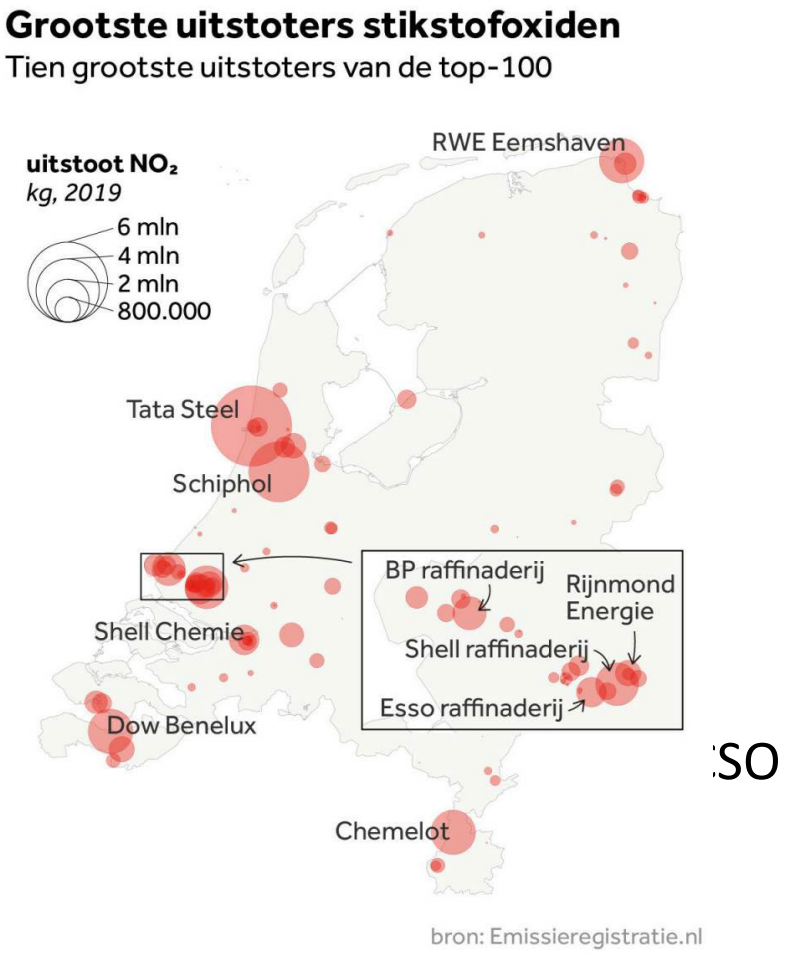
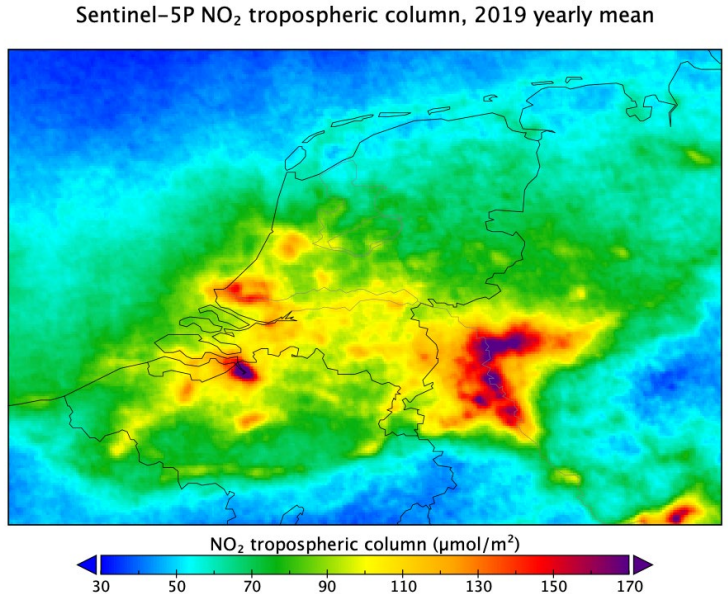
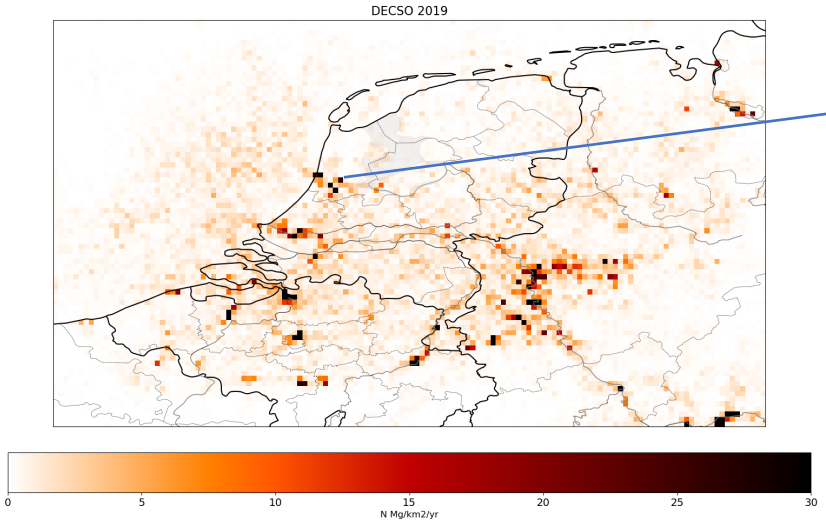


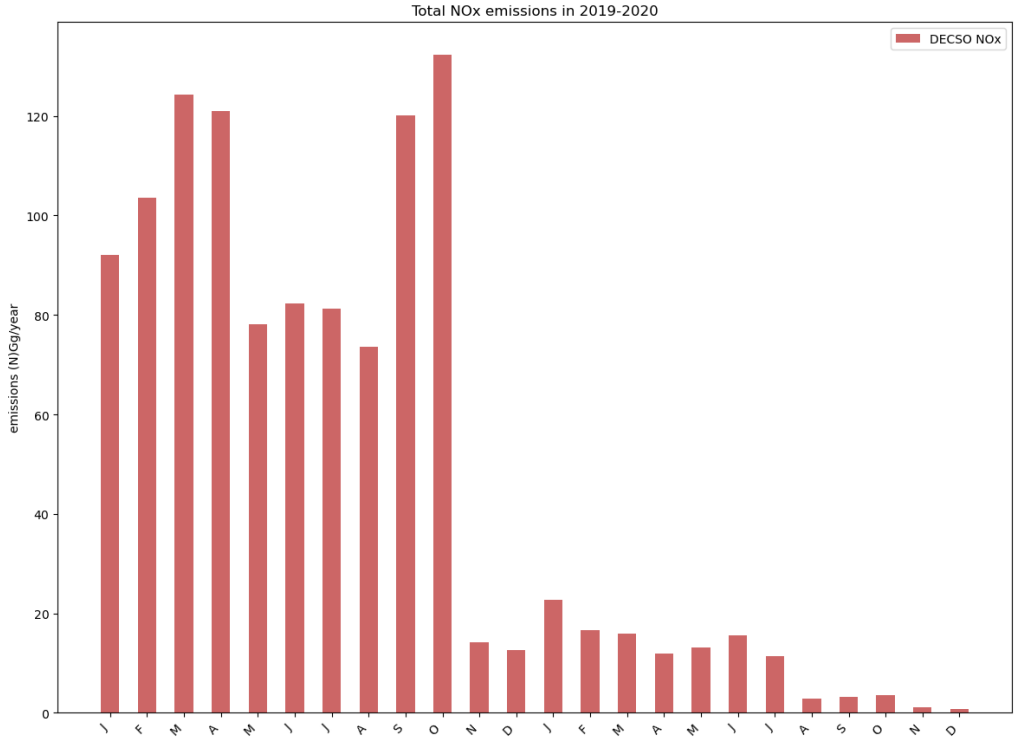
SO

Going to a higher grid resolution: 3x5 km



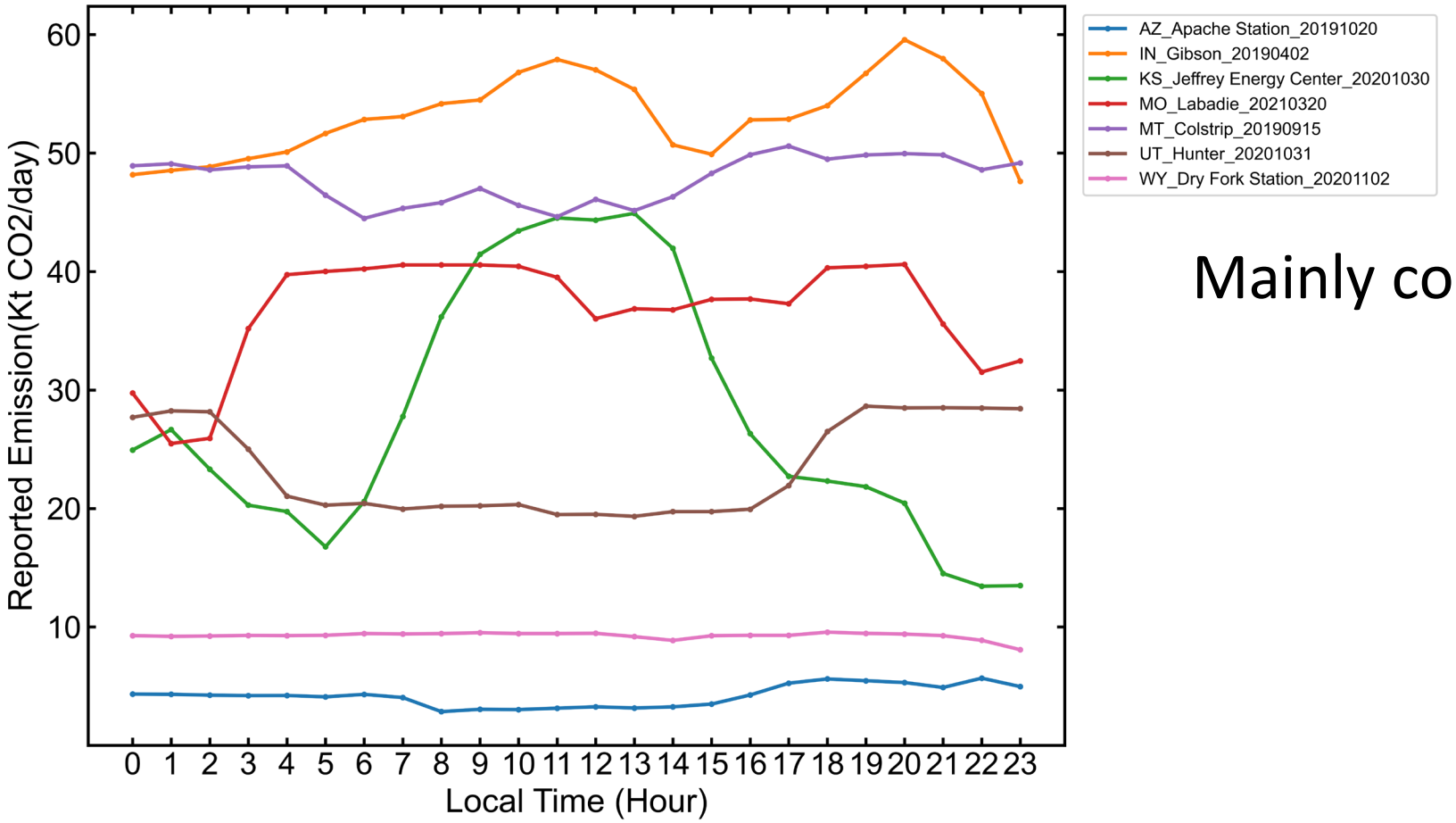


Powerplant “Hemweg centrale” decommissioned end of 2019



Diurnal variability

power plant data in the US (from EPA)



Mainly coal power plants

Can we monitor NOx emissions of point sources ?

- The emissions of power plants or industry are included in the emissions seen by satellite.
- Temporal evaluations of a power plant or industrial facility are feasible.
- On-going study to improve the high-resolution results

Current limitations:

- The current TROPOMI/DECSO combination smooths a point source over maximum 10 km distance. However, for individual cases of isolated plants a (deconvolution) calculation can be made to find the correct emissions.
- Because of the short lifetime of NO_2 (2-5 hours): TROPOMI sees only NO_2 emitted before 13:30 (overpass time of TROPOMI). Note that power plant emissions are highly variable (linked to energy demand and solar/wind energy production).