SEEDS

Sentinel EO-based Emission and Deposition Service

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SEEDS NOx emissions from industrial plants

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KNMI

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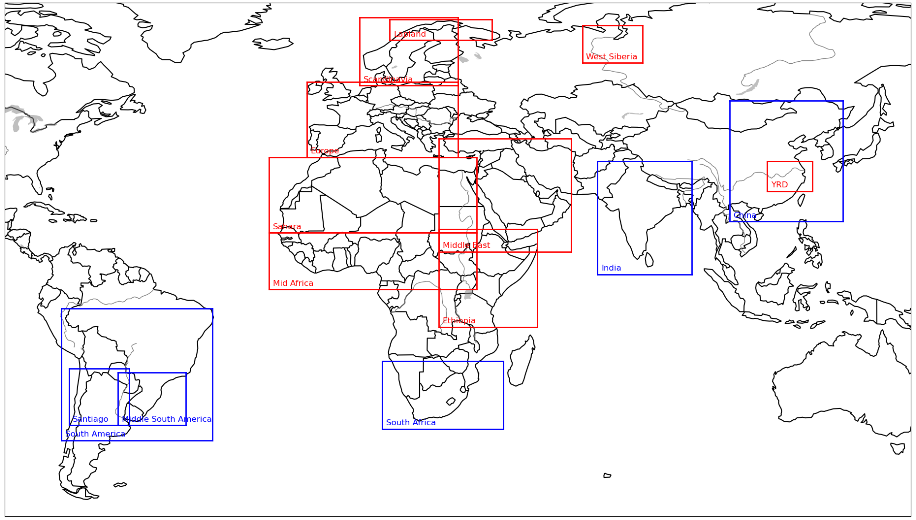
Contents

- Method: NOx emissions using DECSO applied to TROPOMI observations
- Comparison with power plants
- Examples of results for 2019-2022

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.
- Model: CHIMERE v2020r3
- Observations: TROPOMI NO2 v2.4
- Includes error estimate
- Used for <u>daily</u> NO_x and NH_3 emissions



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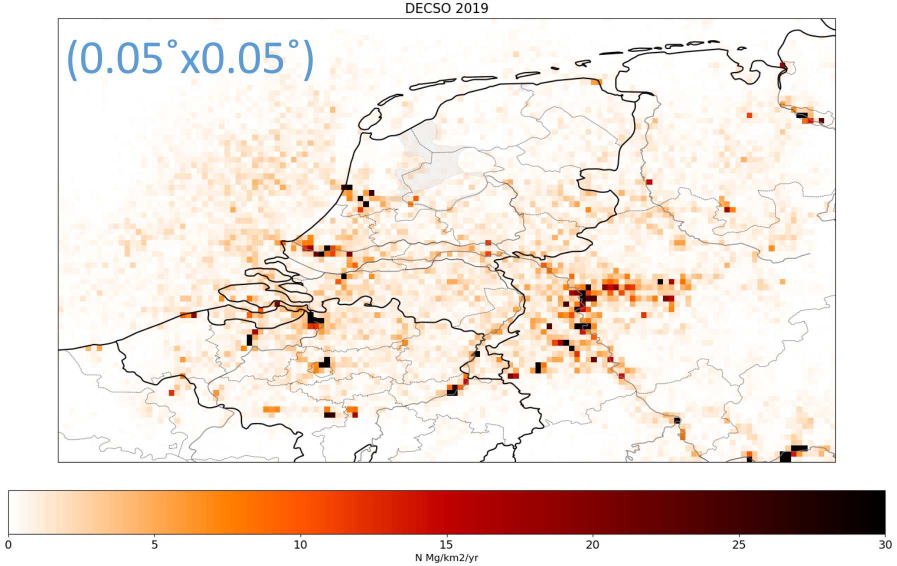
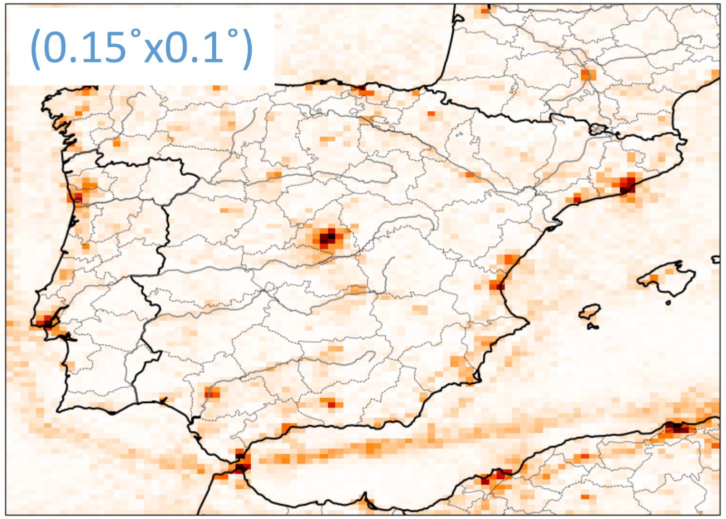
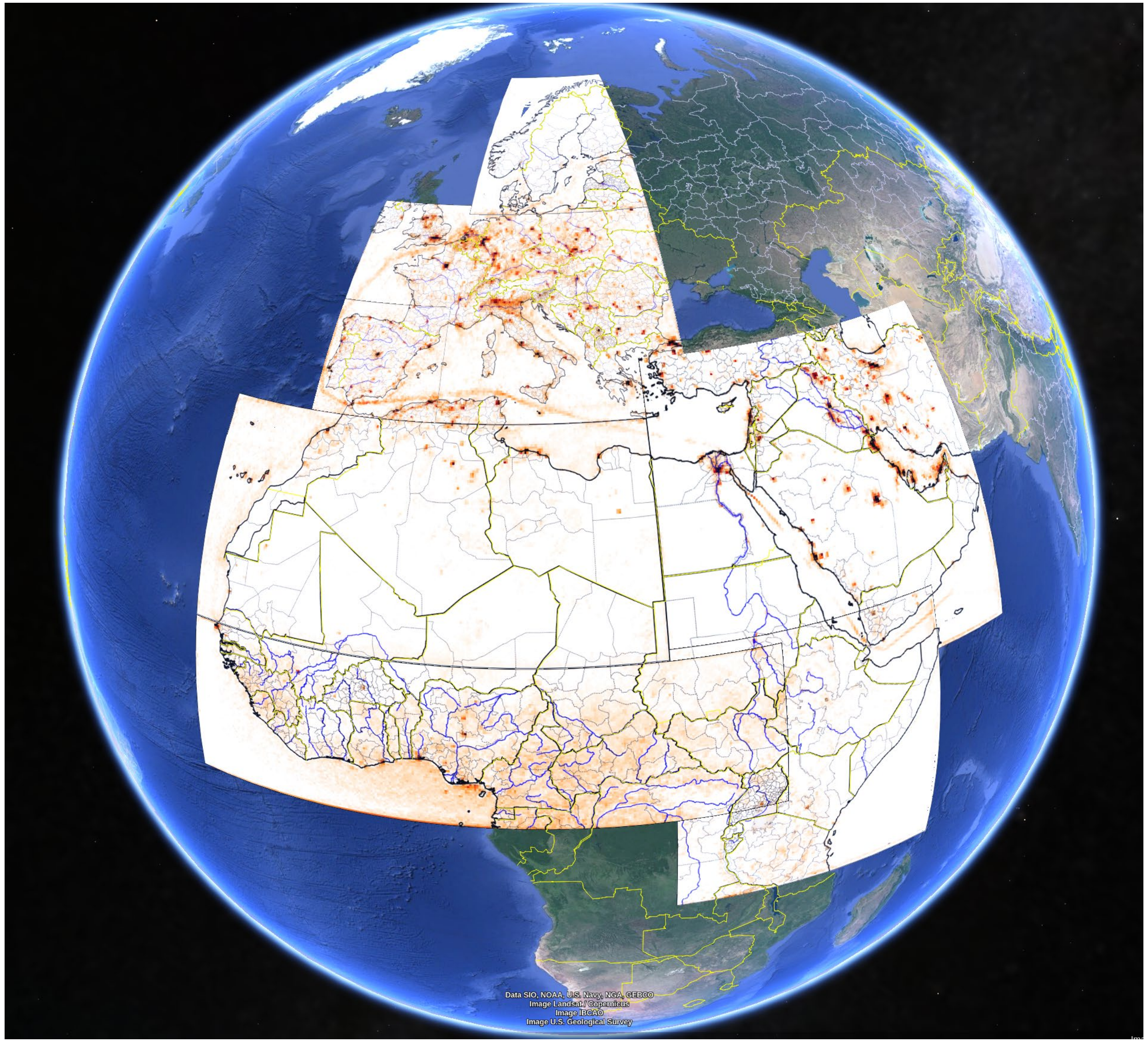
Regions at various resolutions

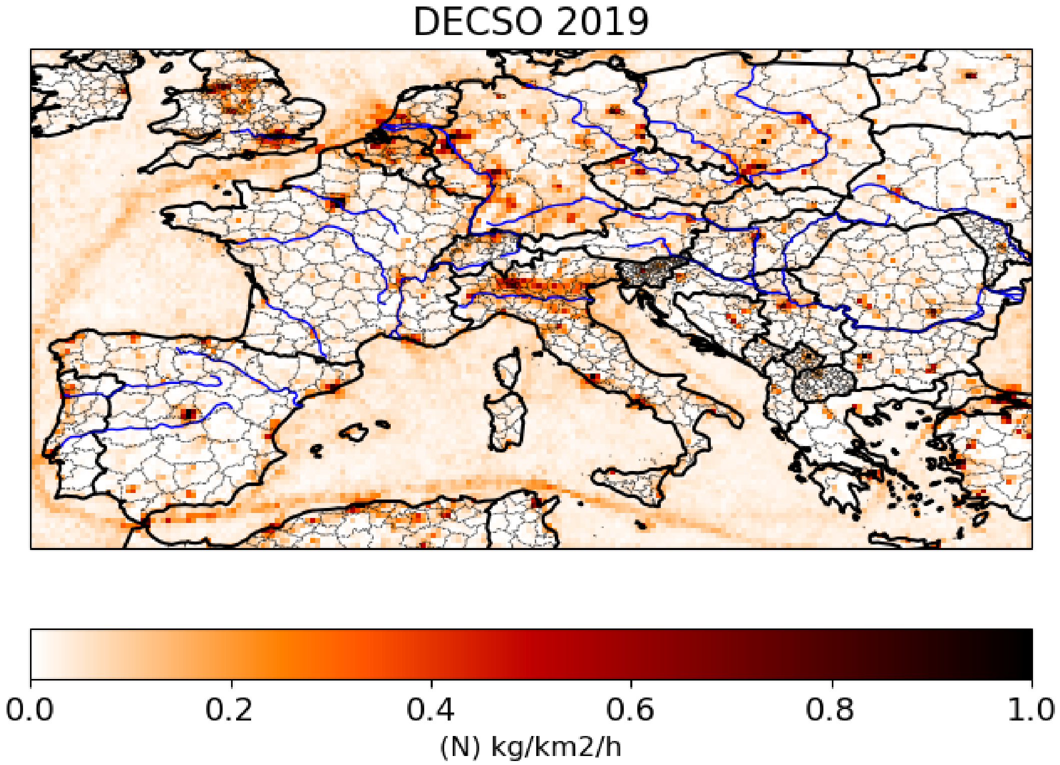


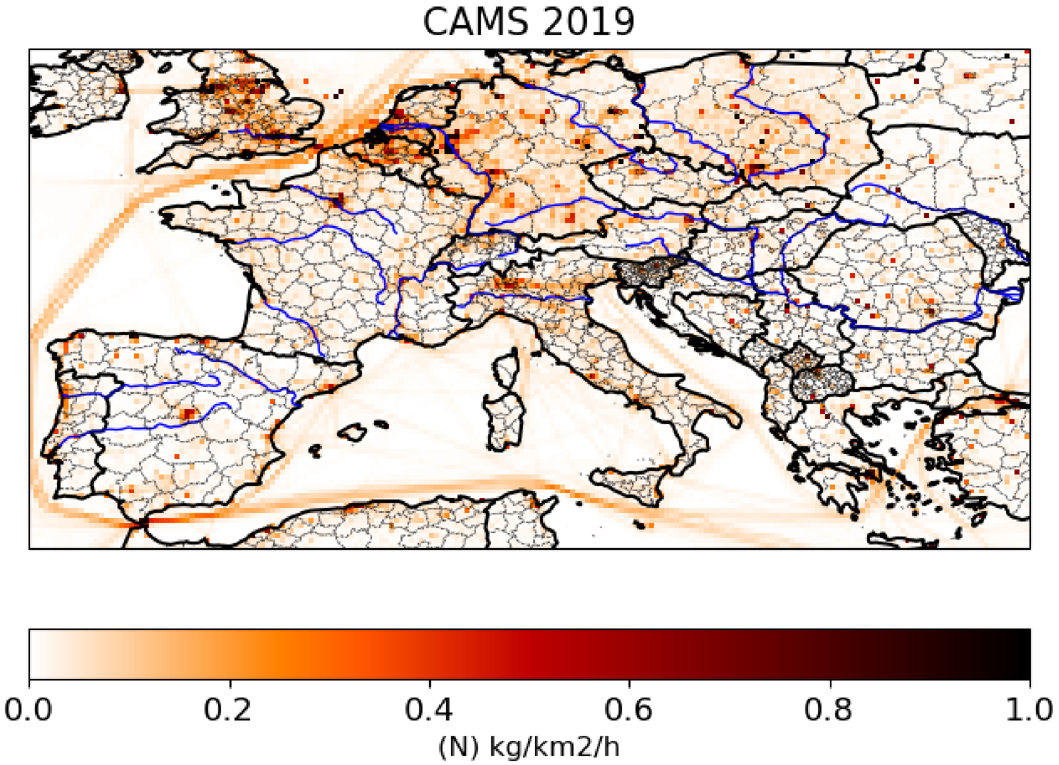


(0.2˚x0.2˚)

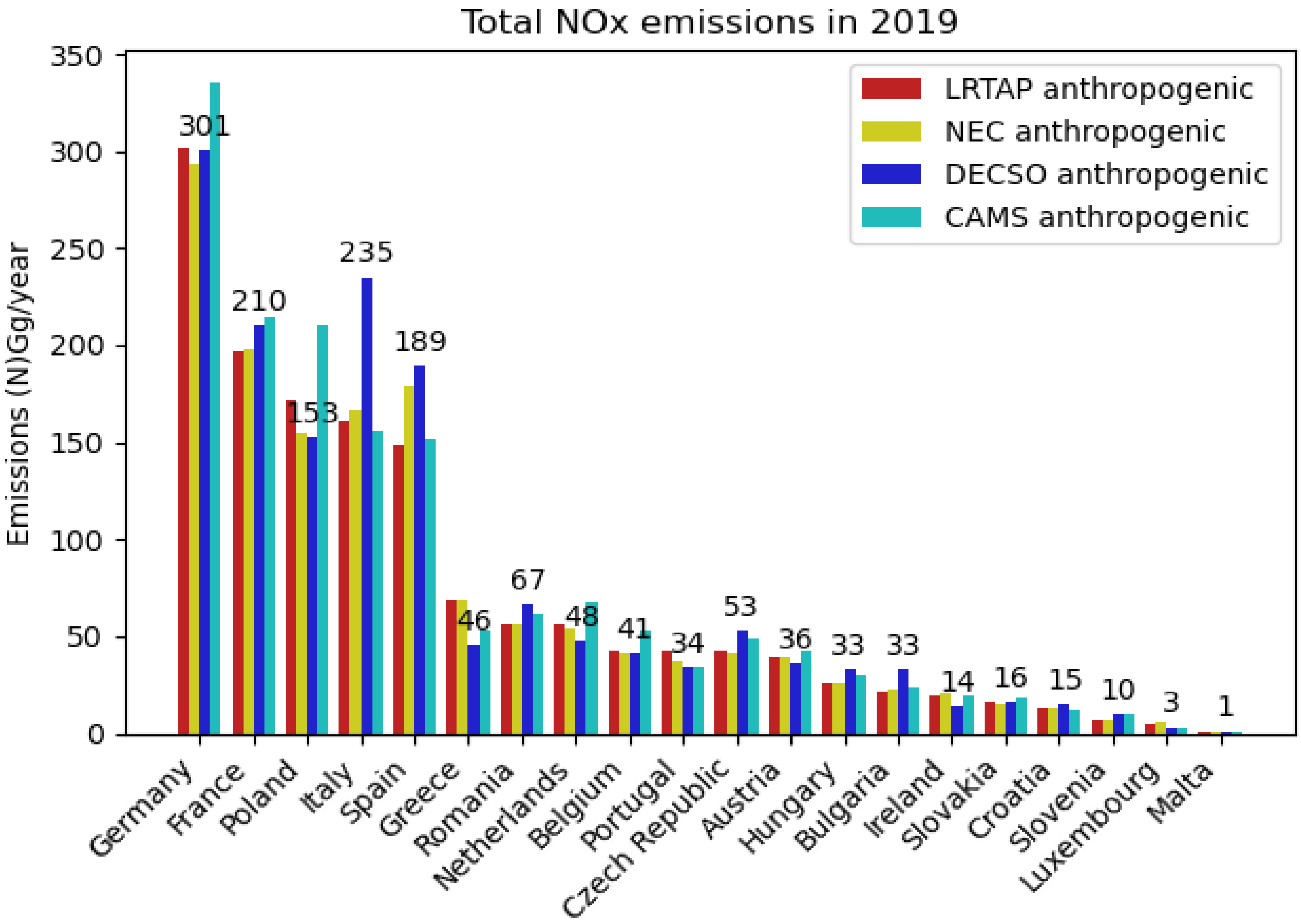


Comparison to CAMS emissions





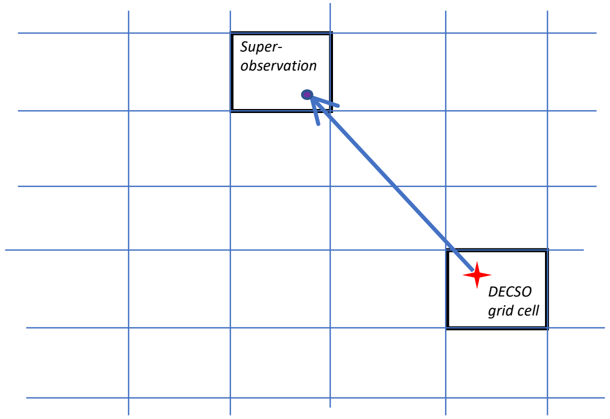
Country totals of NOx



Anthropogenic NOx emissions of point sources

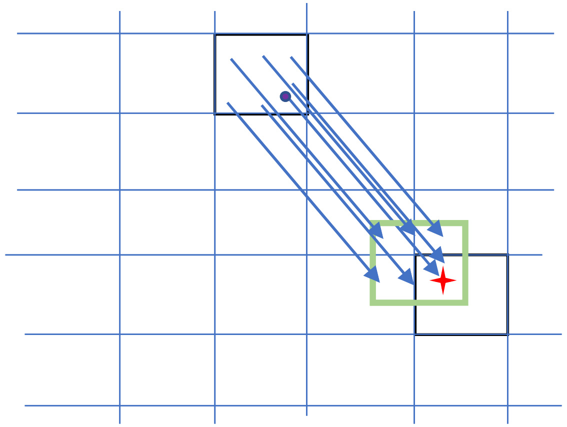
Comparing of isolated point sources

Trajectory along wind field

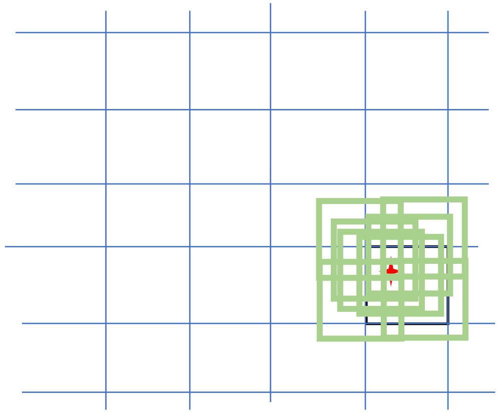


+ *Point source*

Multiple trajectories from one observation to grid cell

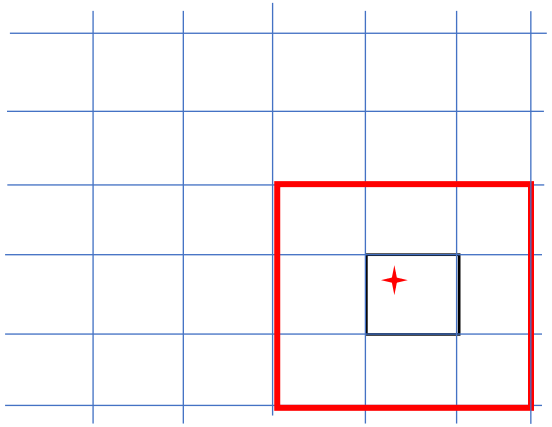


Many trajectories along the plume, many orbits leads to smoothing:



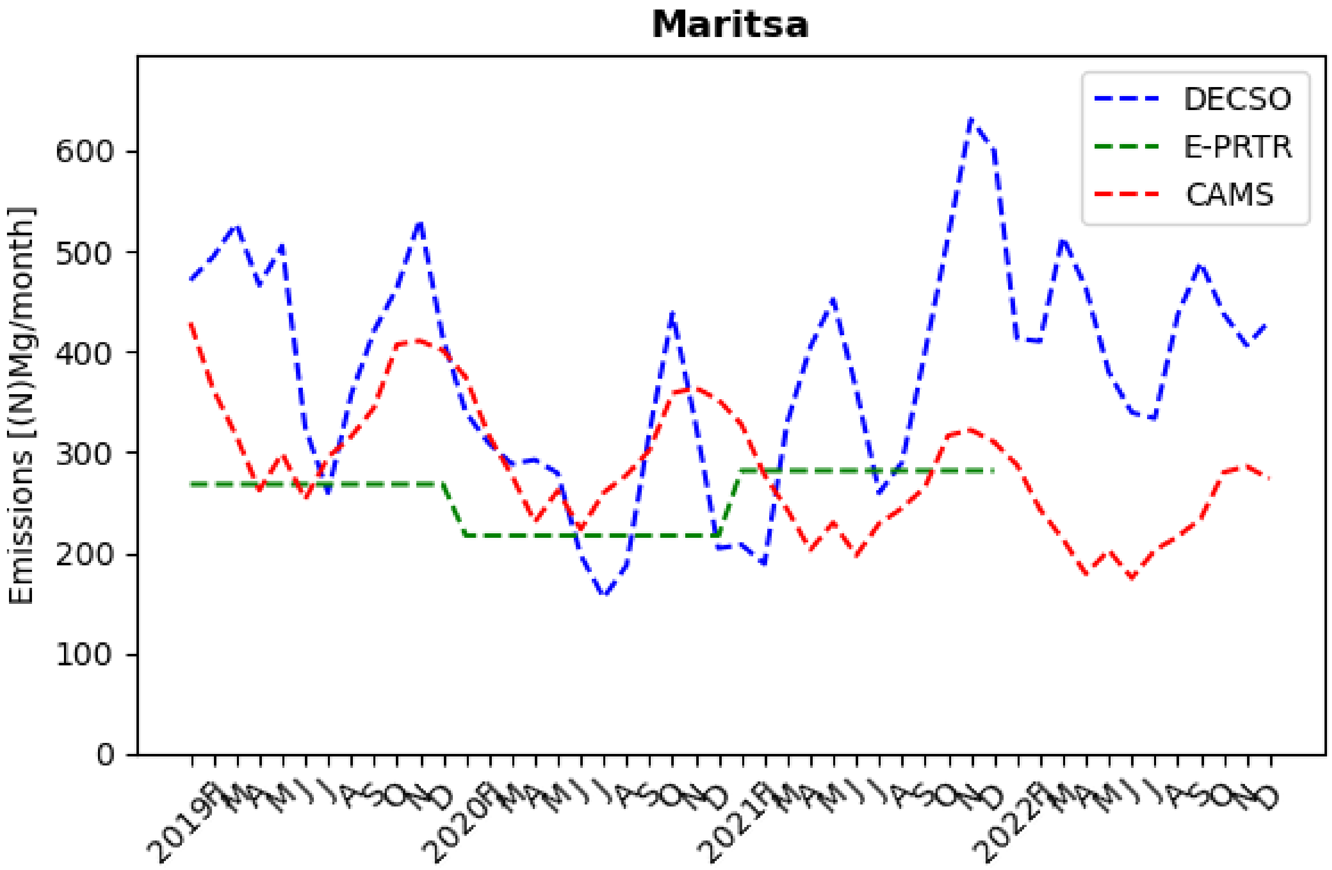
Because of the resolution of both observations and grid cells, the resulting emissions are spread to neighbouring grid cells.

Solution:
We compare 3x3 grid cells, and making sure that no other big emitters are nearby.



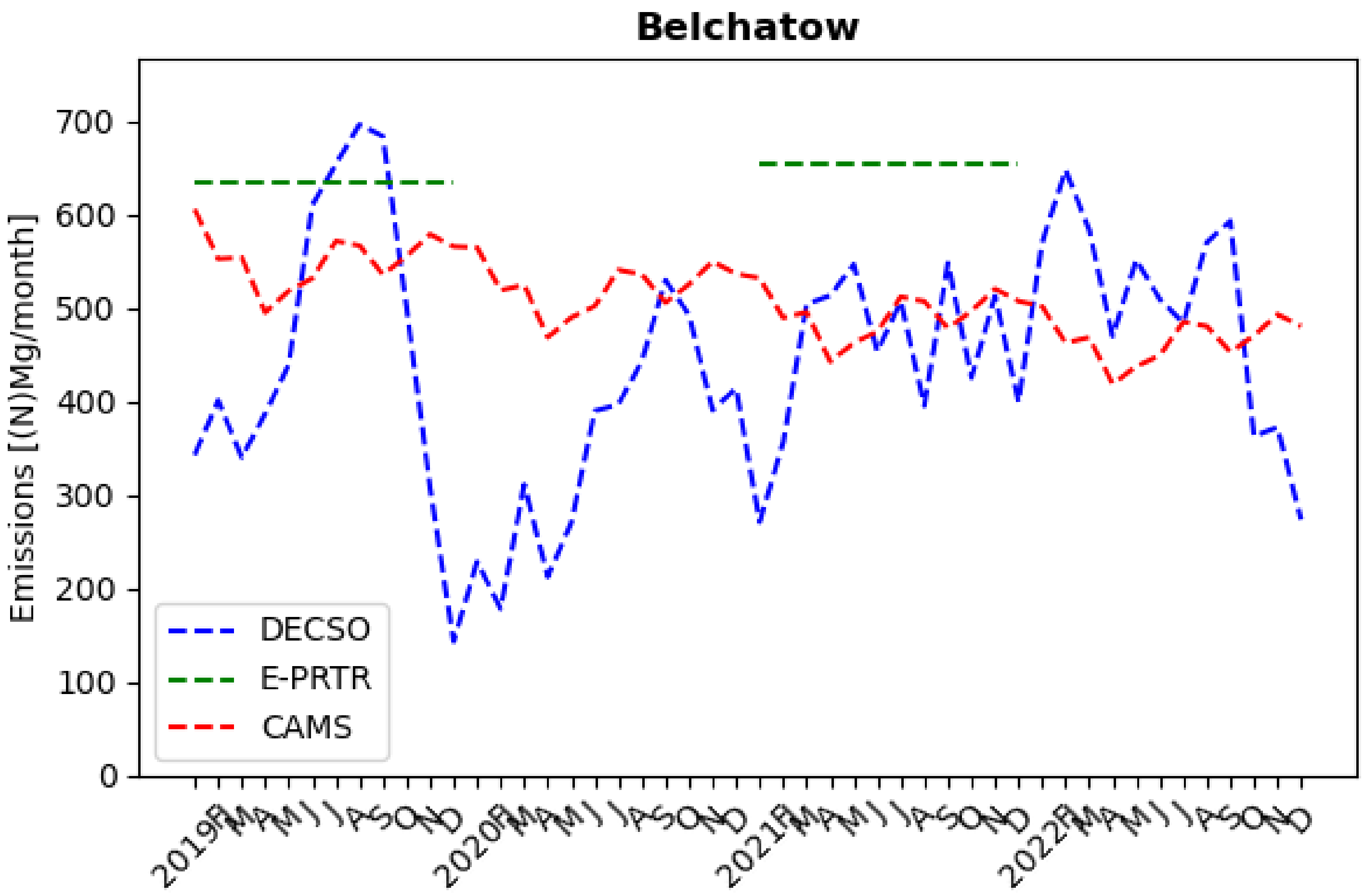
Anthropogenic NOx emissions of point sources

Maritsa-Iztok power plants, Bulgaria



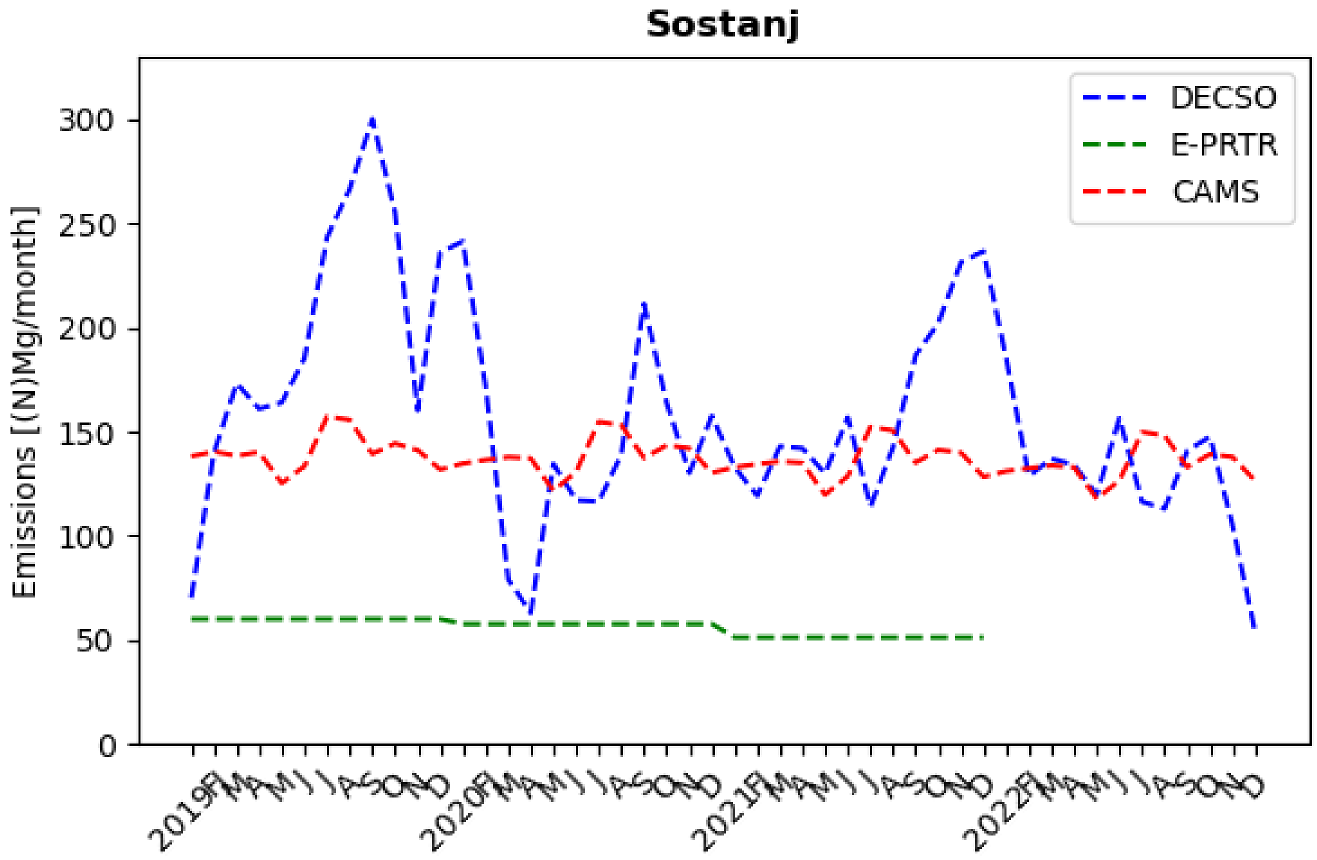
- Good agreement
- Lower emissions in Covid period

Belchatow lignite power plant, Poland



- Biggest emitter in Europe
- No E-PRTR in 2020
- DECSO at high latitudes in winter have less accuracy
- E-PRTR higher than CAMS and DECSO

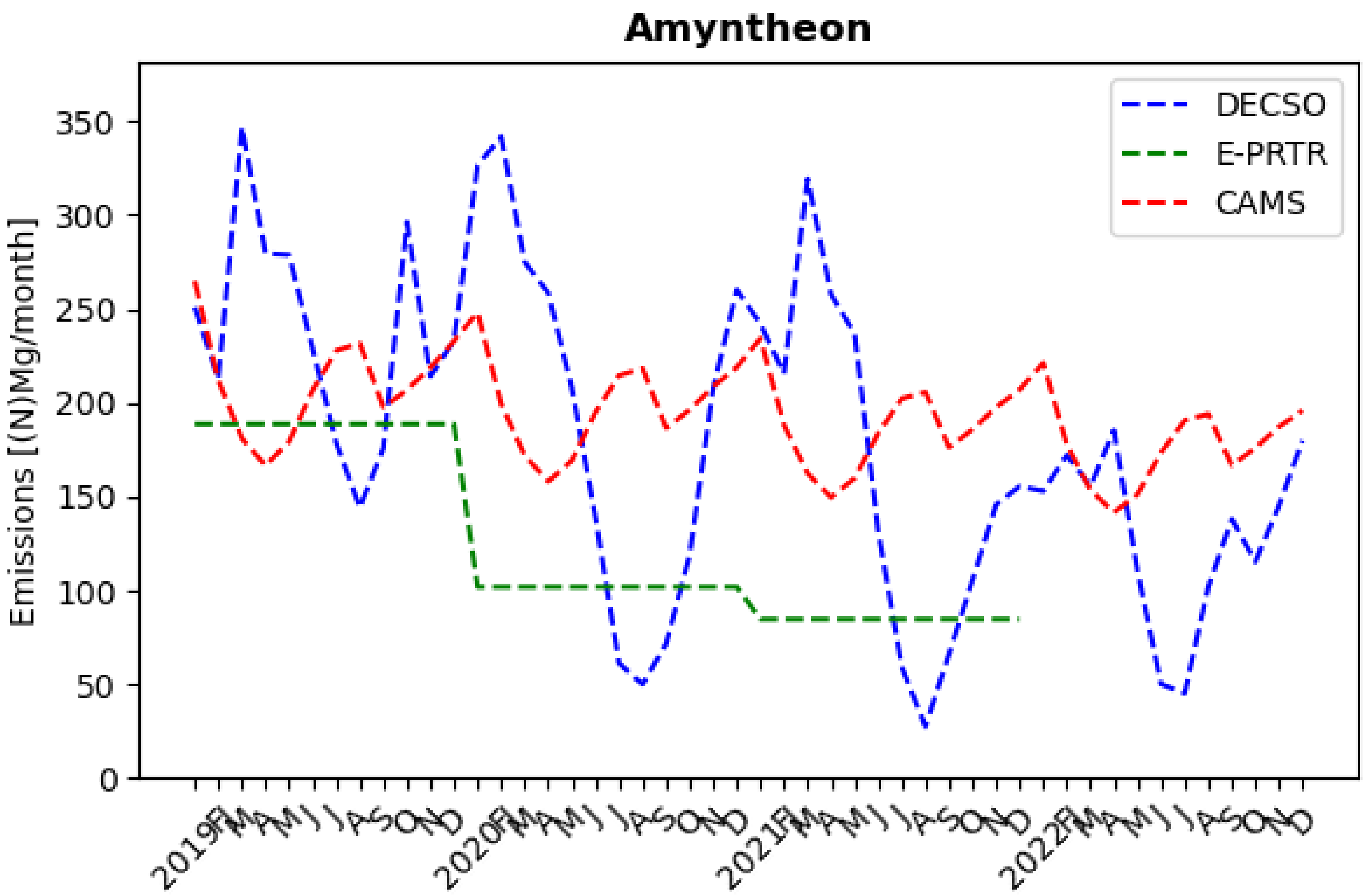
Sostanj power plant, Slovenia



- Despite the location of small cities in the neighbourhood, E-PRTR is much lower than CAMS/DECSO

- Good agreement DECSO and CAMS, but more variability in DECSO

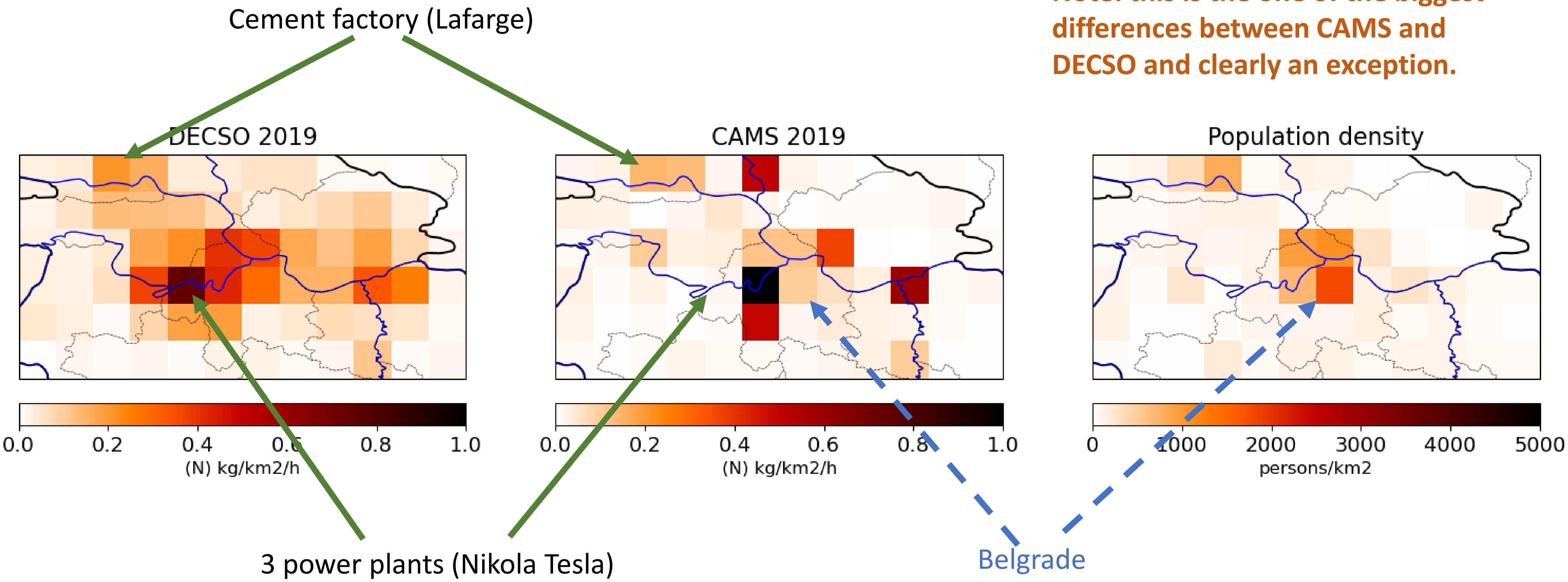
Group of power plants in North of Greece



- Summer dip: energy from lignite is more expensive than renewables
- Trend is similar, but trend in E-PRTR seems stronger than DECSO

Biggest industrial emitters in Serbia

Note: this is the one of the biggest differences between CAMS and DECSO and clearly an exception.



Conclusions NOx emissions of industrial facilities

- Independent check of emissions of industrial facilities using DECSO applied to TROPOMI observations
- Annual emissions of CAMS and DECSO often agree, but E-PRTR can deviate significantly (too high or too low)
- Temporal evaluations of a power plant or industrial facility are feasible.

Challenges:

1. The current TROPOMI/DECSO combination spreads a point source over 10 km distance.
2. TROPOMI sees only NO_2 that is emitted in the hours before 13:30 (overpass time of TROPOMI).

Future improvements:

1. Derive emissions on 10x10 km over Europe to lessen spatial smoothing.
2. DECSO has already been developed and tested for observations of geostationary satellites! (part of SEEDS tasks)