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NO_x and NH_3 emissions derived from satellite observations

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KNMI

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DECSO Daily Emissions Constrained by Satellite Observations

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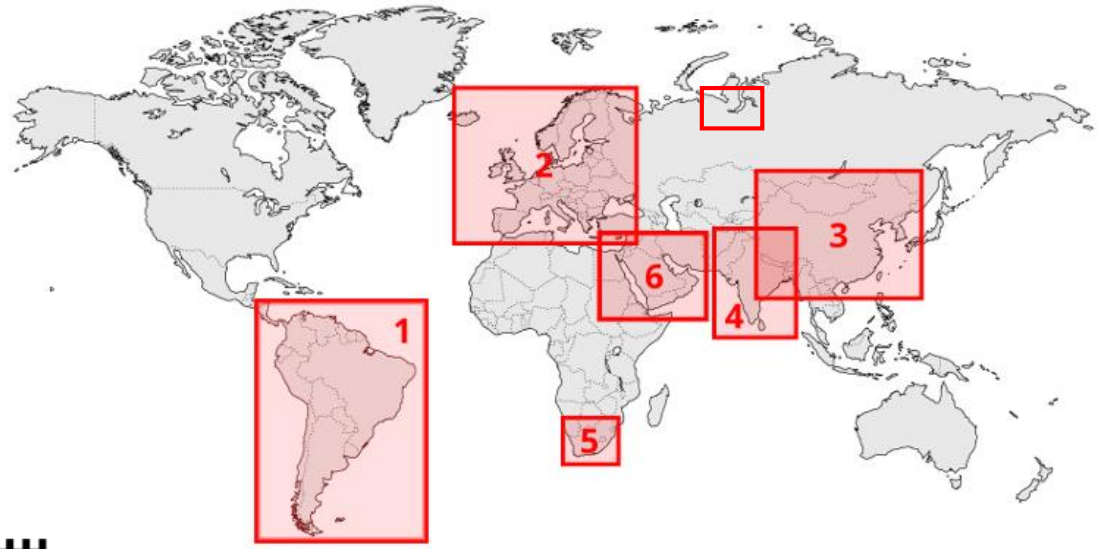
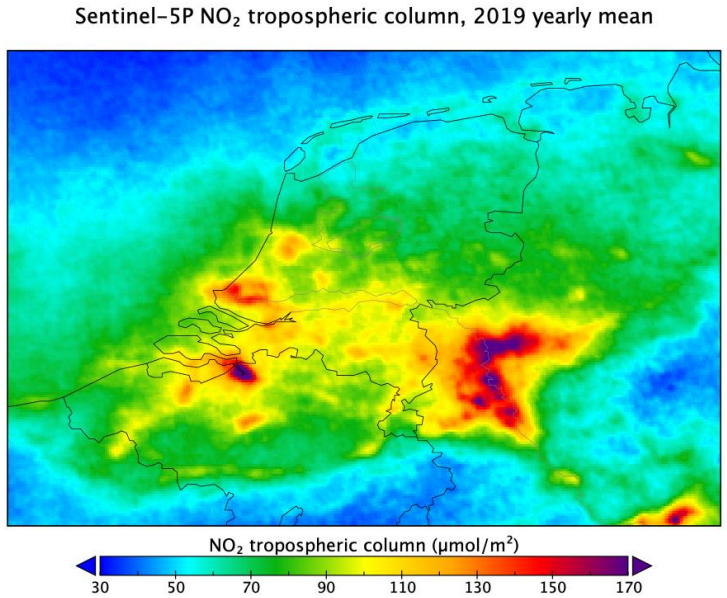
- It is fast: one model run per assimilation step of 1 day
- No *a priori* information needed: unknown sources will become visible.
- Full error estimation of new emission inventory
- Used for daily NO_x and NH_3 emissions

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

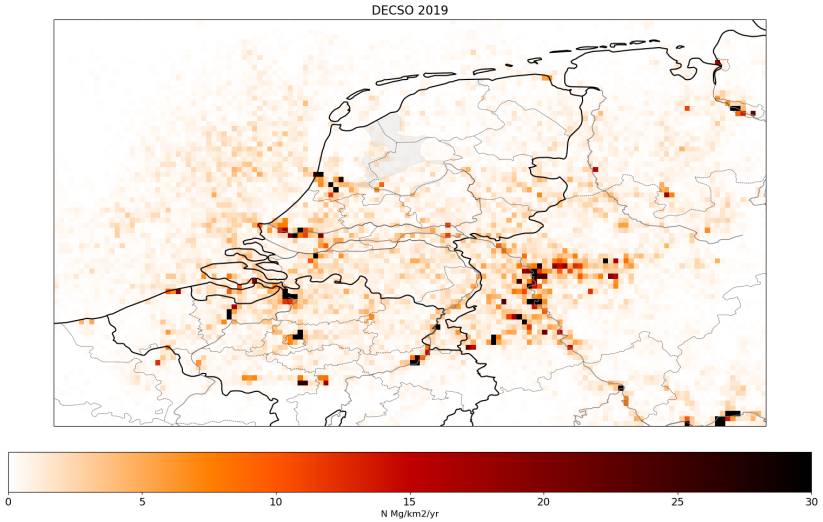
- DECSO v6.1
- Model: CHIMERE 2020 r3
- Observations:
  - TROPOMI NO2;
  - CrIS NH3 (provided by Mark Shephard*)

*Environment and Climate Change Canada



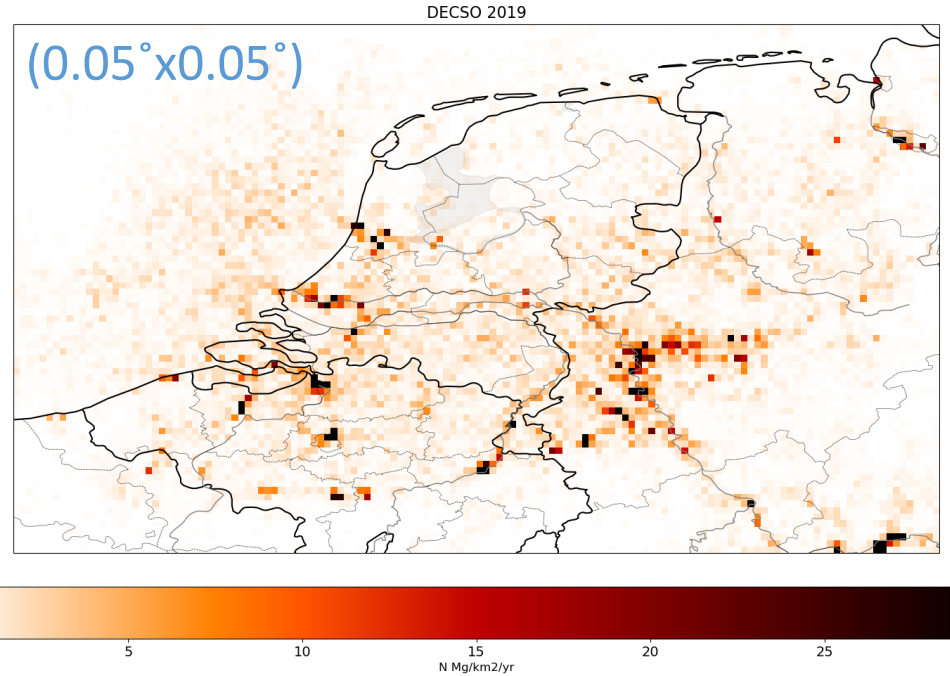


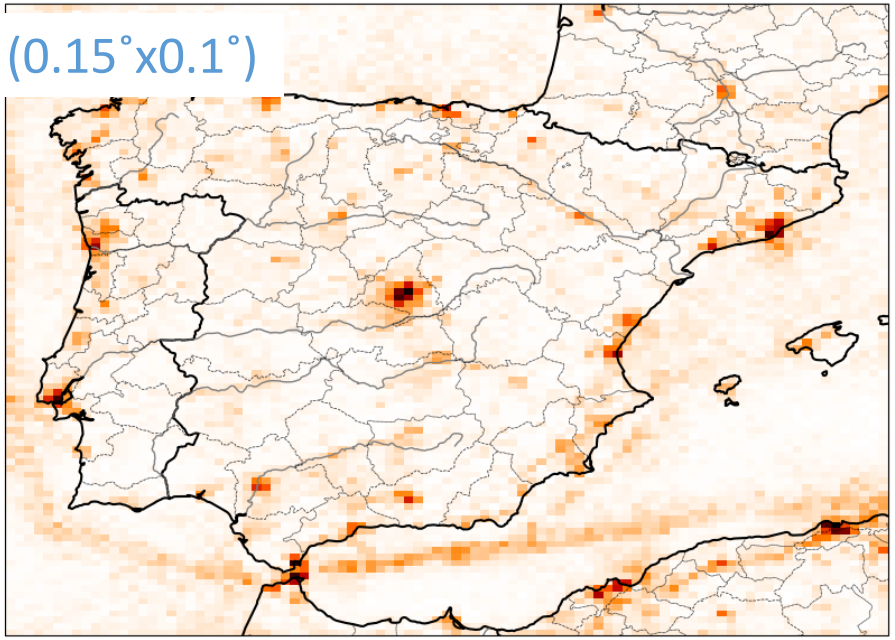
- Averaged TROPOMI NO2 observations (3.5x5 km)
- Meteorology plays a role

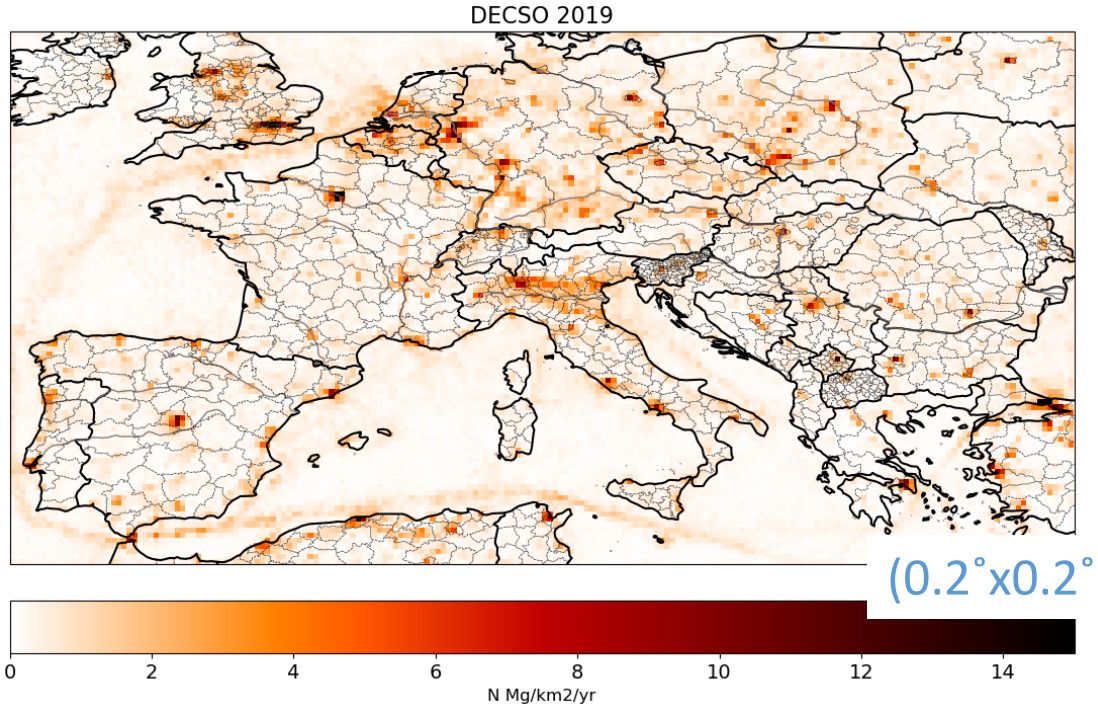


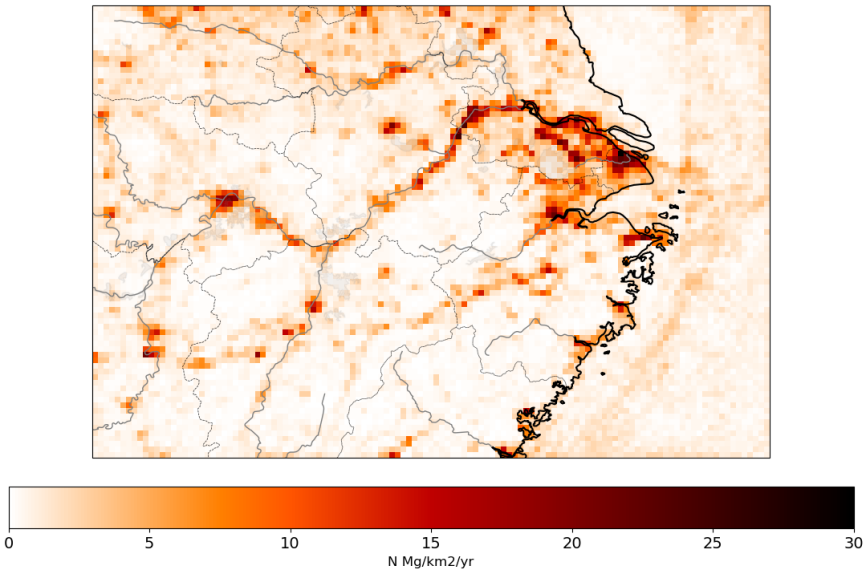
- Calculated NOx emissions (daily)
- Resolution is 0.05˚ (4-5 km)

Regions at various resolutions







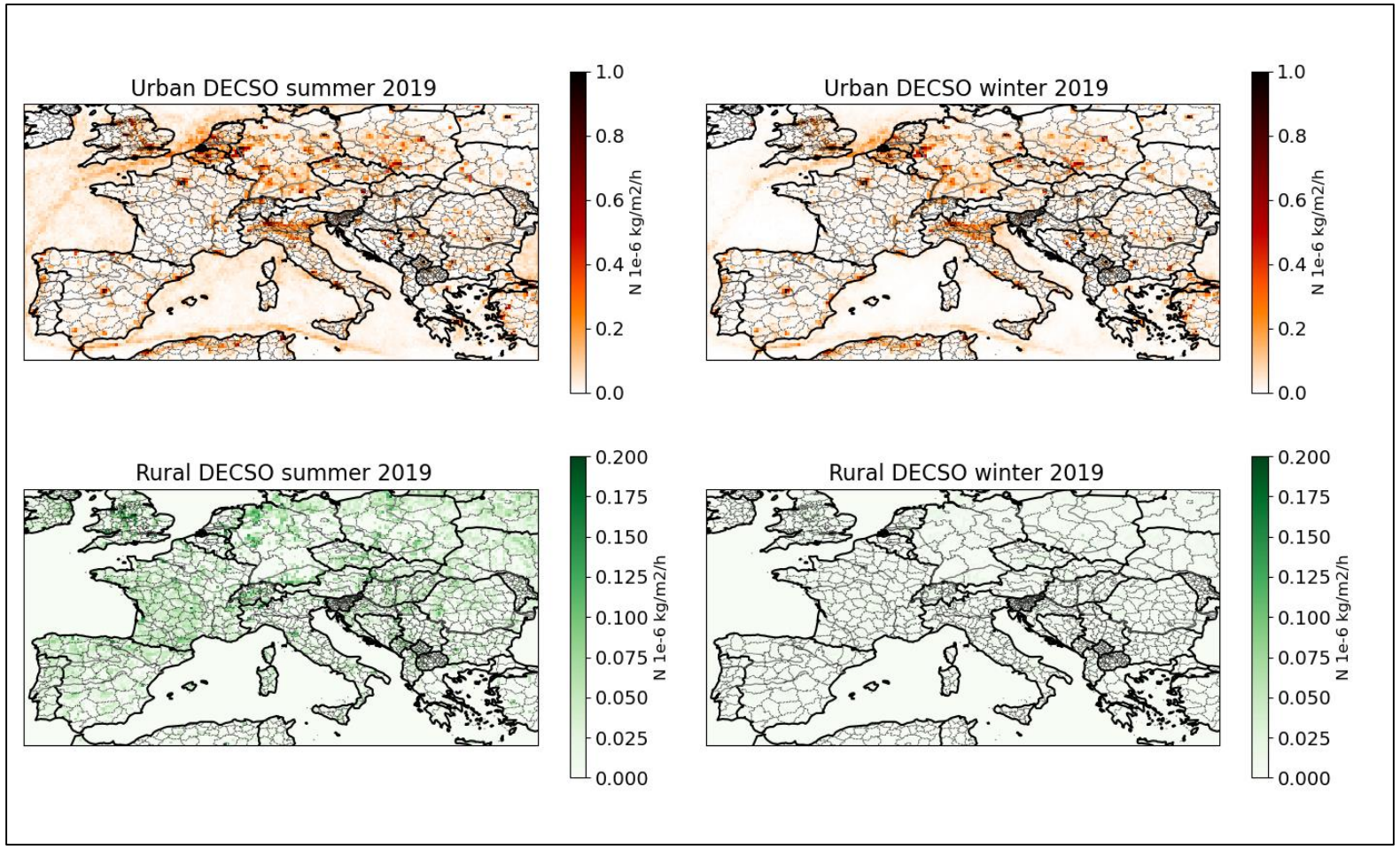


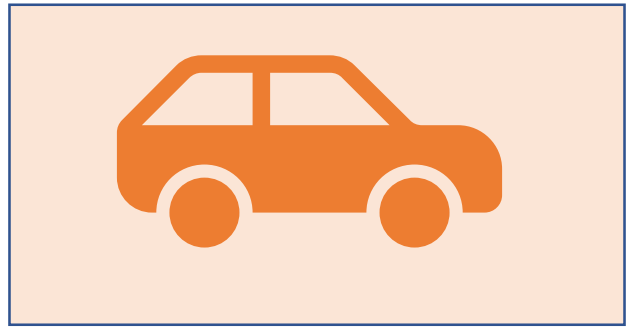
Split-up in anthropogenic and biogenic source sector

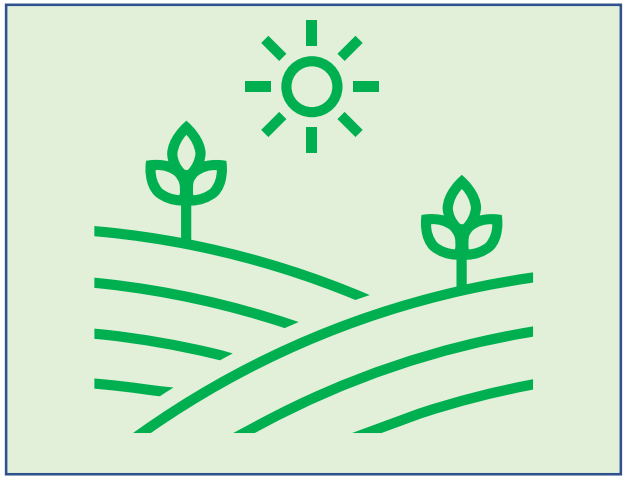
Distinguish sectors per grid cell based on the following assumptions:

1. Biogenic emissions in winter can be neglected, but have a strong signal in summer
2. Anthropogenic emissions do not show a seasonal cycle
3. All emissions over sea are of anthropogenic origin

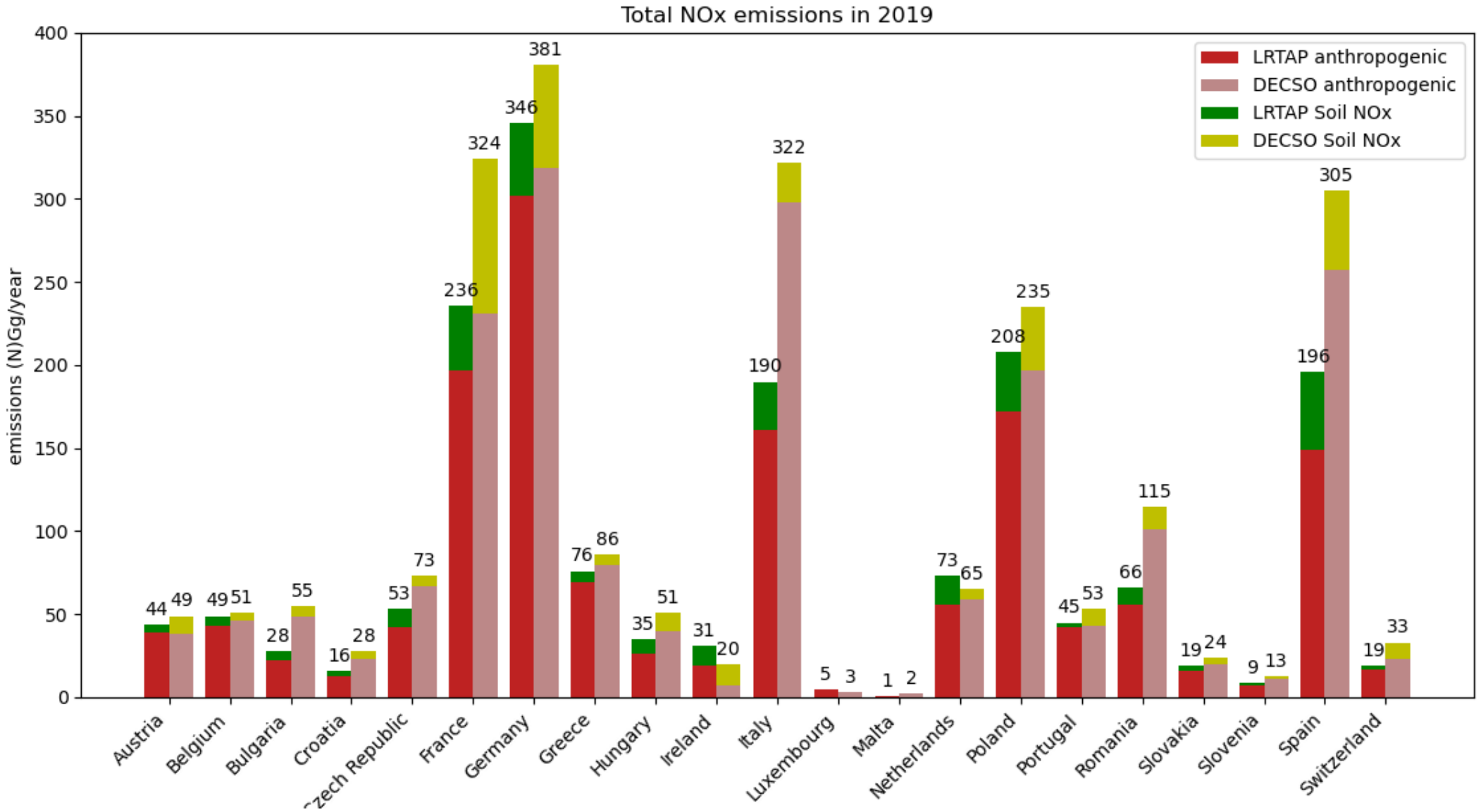
Anthropogenic and biogenic NOx emissions





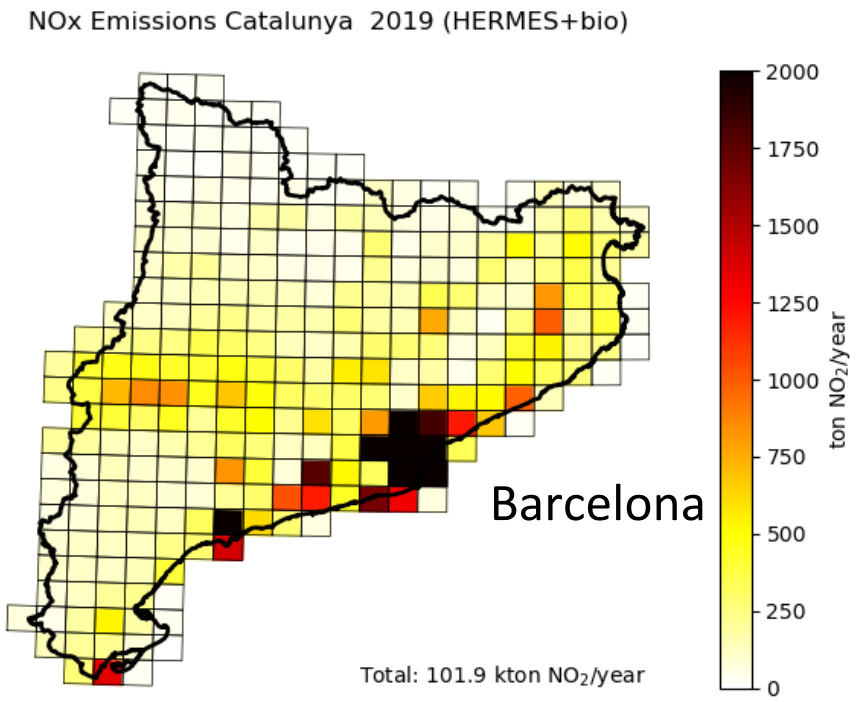


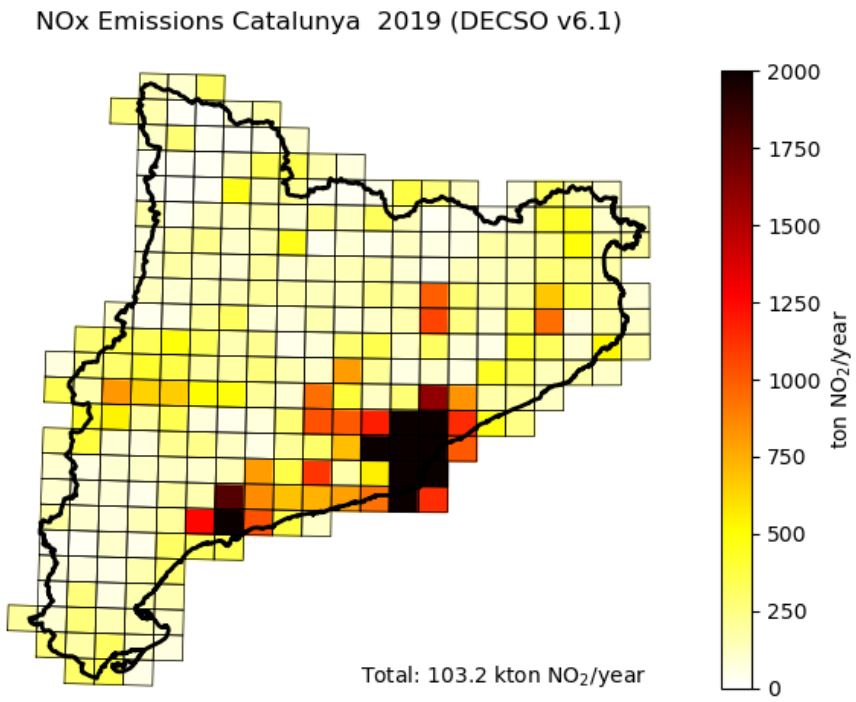
Country totals of NOx



LRTAP (National emissions reported to the convention on long-range transboundary air pollution) from EEA

Comparison with regional bottom-up inventory HERMES (Catalonia, Spain)





HERMES

Credits: Barcelona Supercomputing Centre

+ MEGAN (biogenic NOx)

DECSO

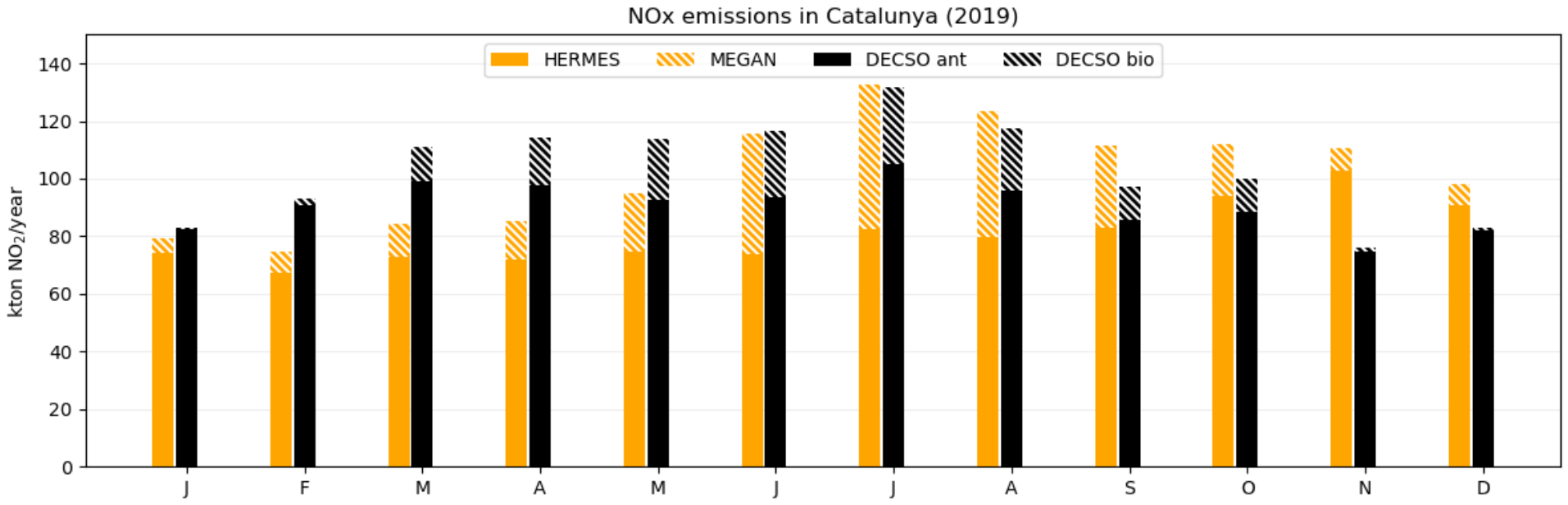
(anthropogenic plus biogenic NOx)

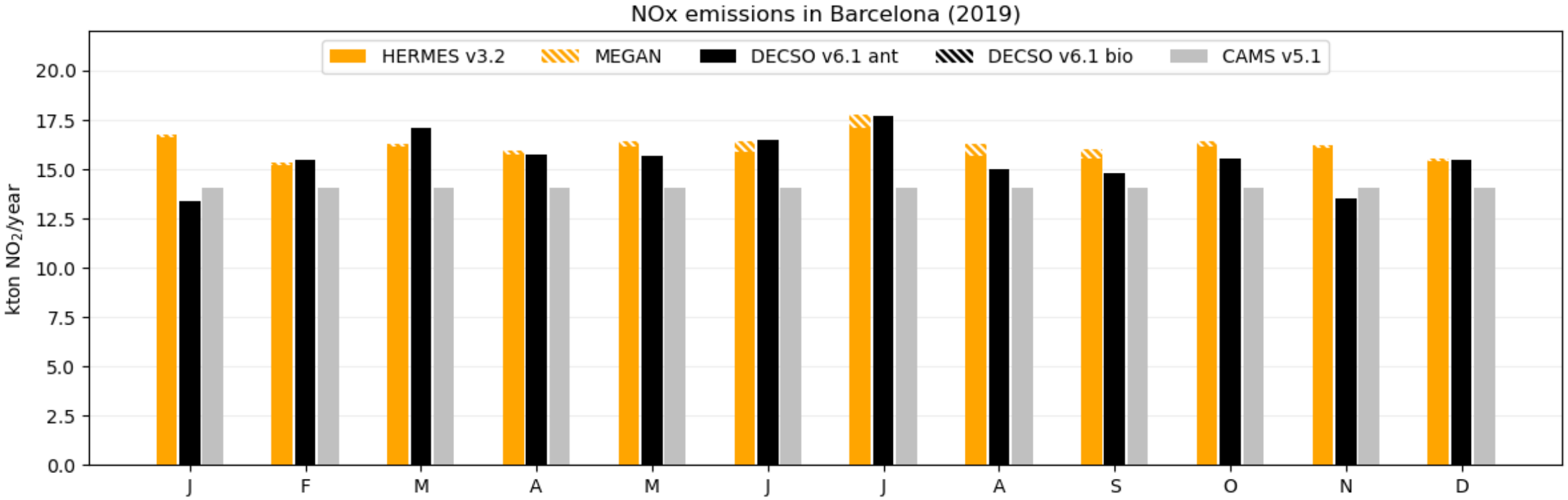
Comparison of NOx emissions over Catalonia

satellite-derived: DECSO anthropogenic and biogenic

vs.

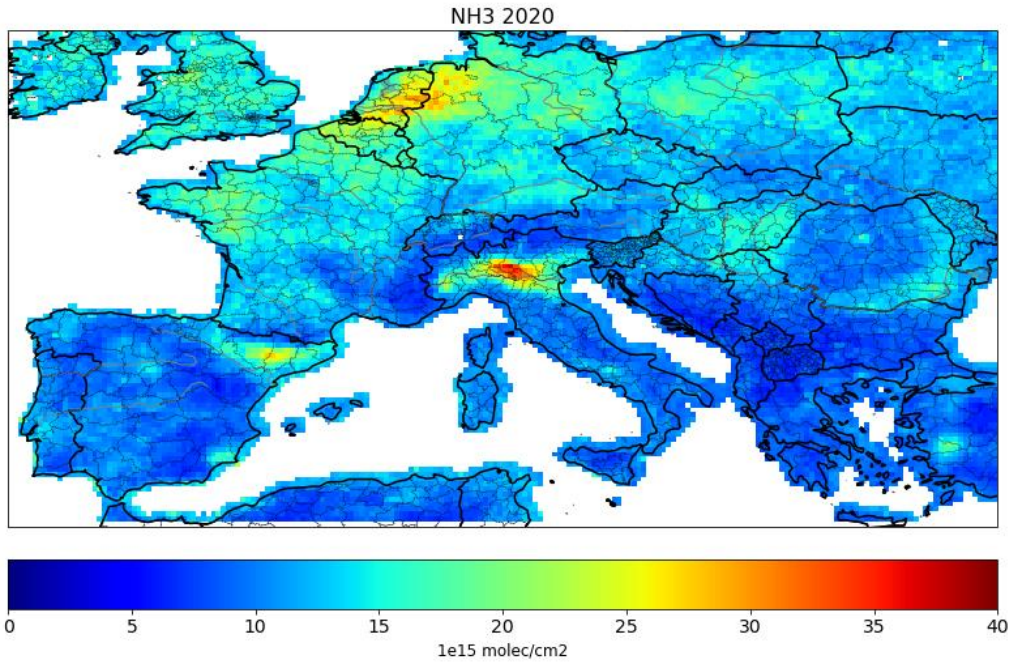
bottom-up: HERMES (anthropogenic) and MEGAN (biogenic)

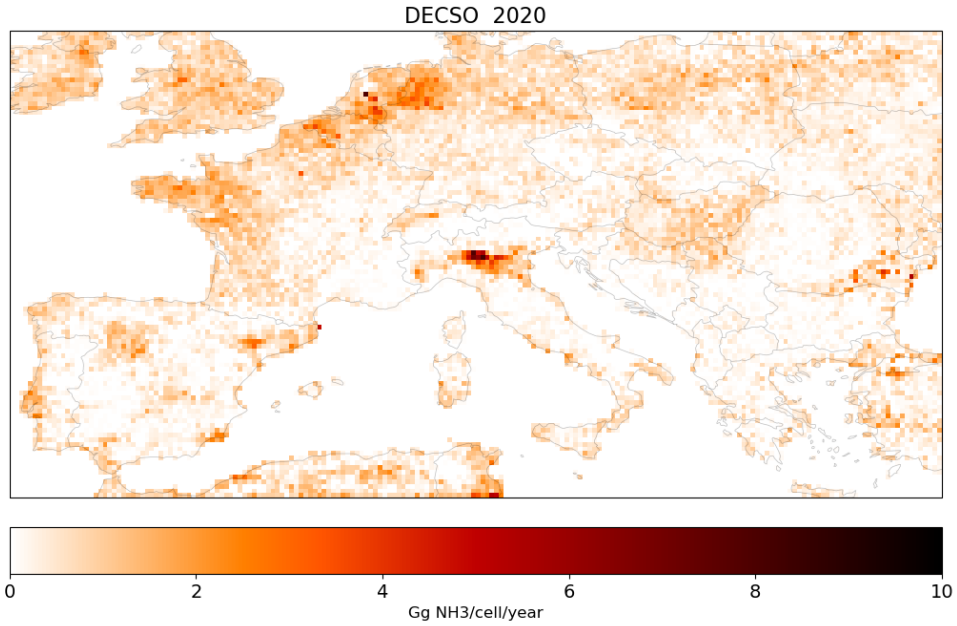



NOx emissions in Barcelona (2019)
HERMES v3.2
MEGAN
DECSO v6.1 ant
DECSO v6.1 bio
CAMS v5.1
kton NO2/year
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
J
F
M
A
M
J
J
A
S
O
N
D

Concentrations to Emissions

NH3

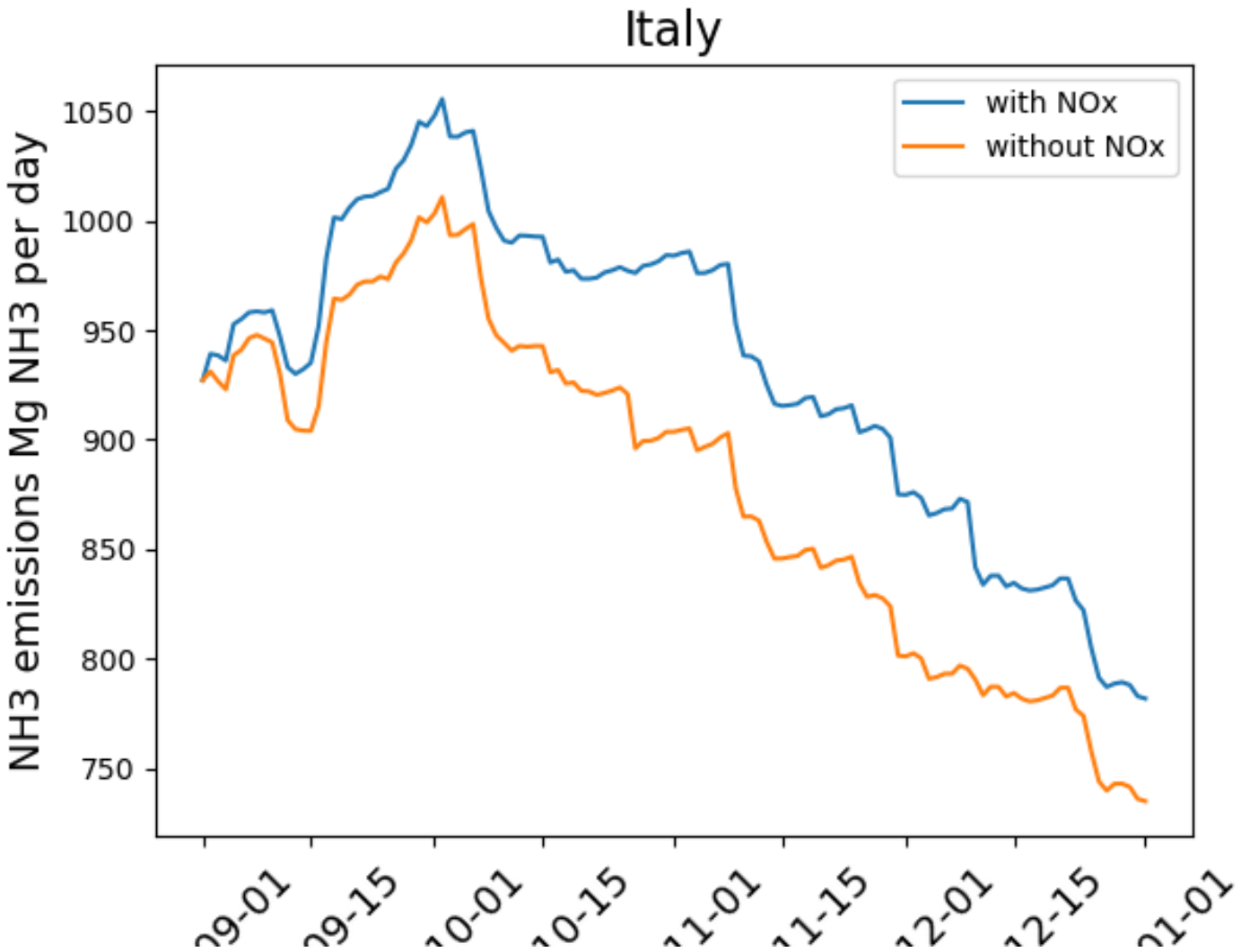




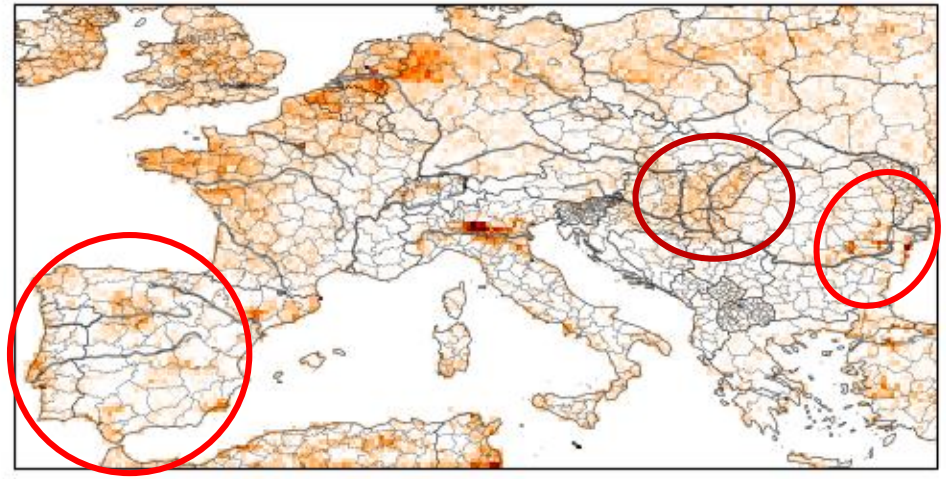
NH3 emission estimates

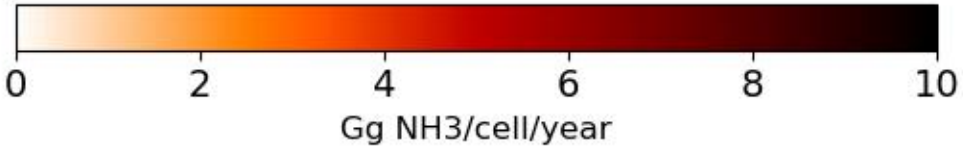
NOx emissions updated daily using TROPOMI

NOx emissions from bottom-up inventory (no daily updates)

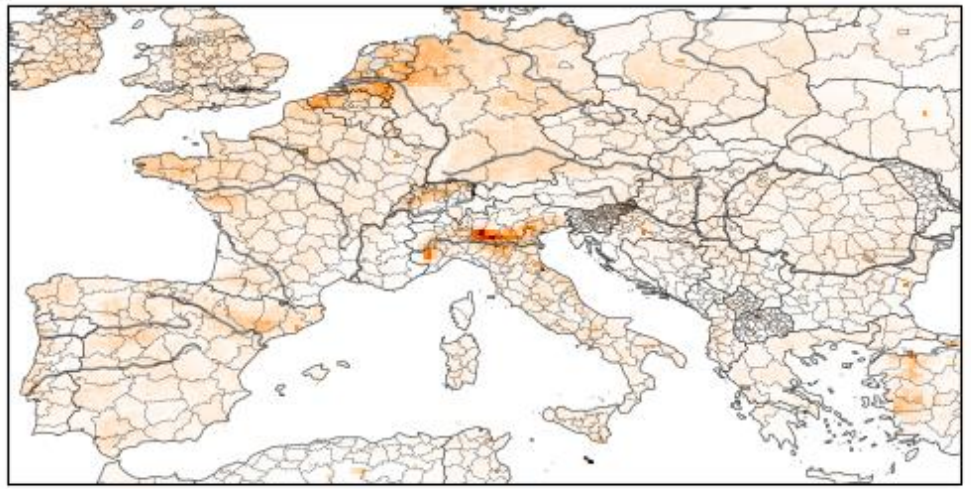


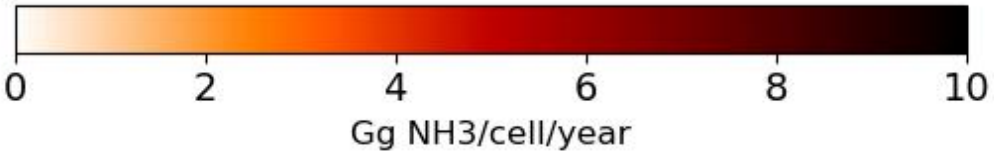
DECSO 2020

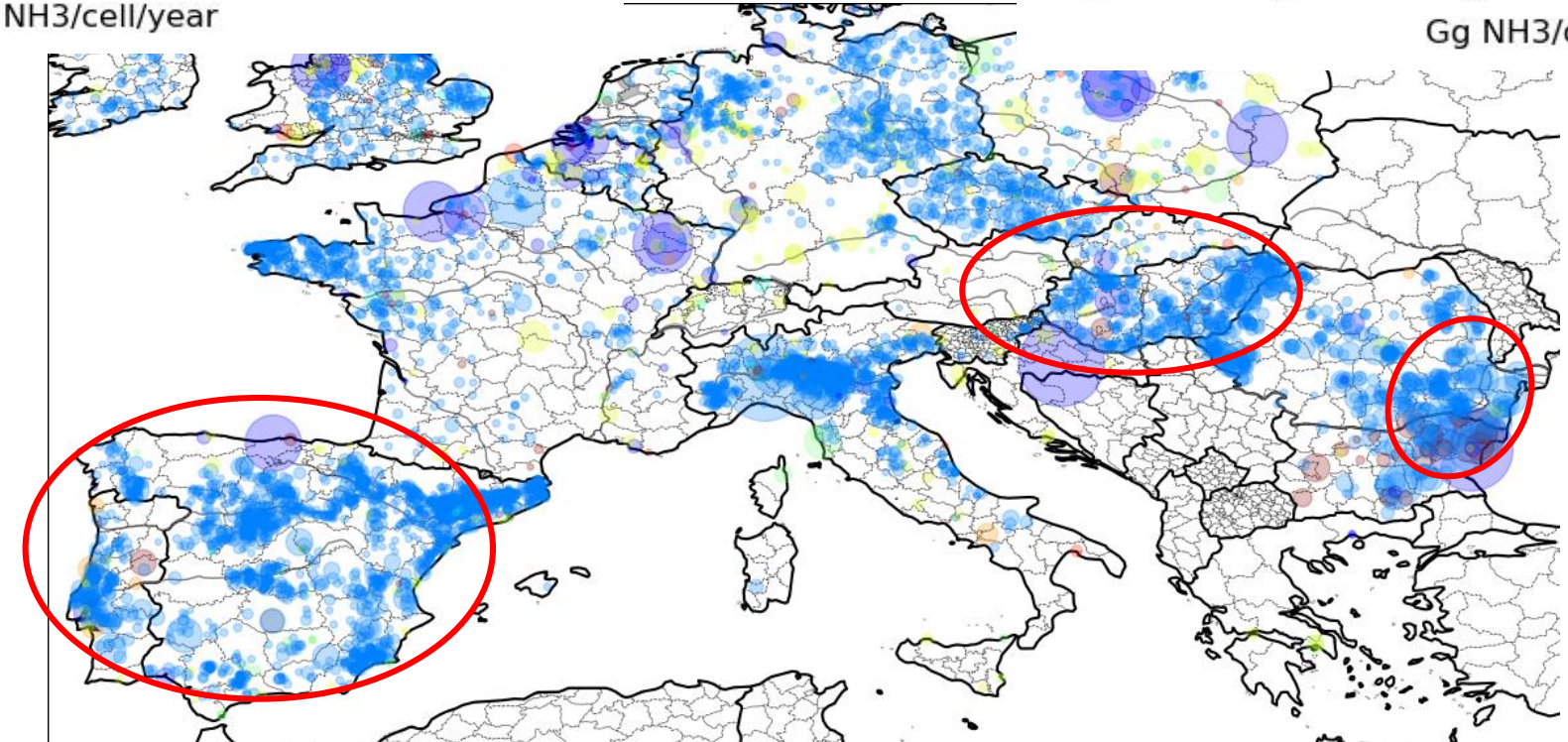




HTAP 2018







Country totals of NH3 (vs. LRTAP)

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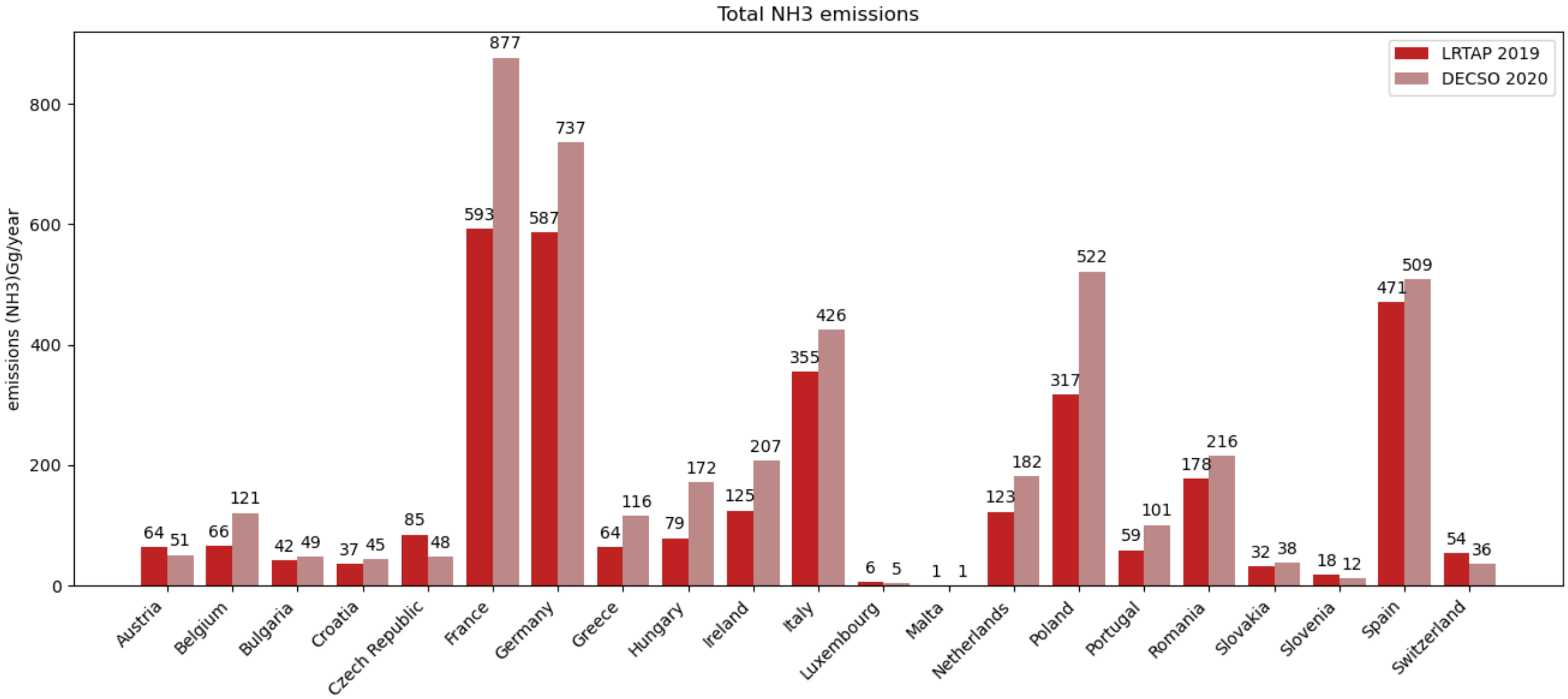
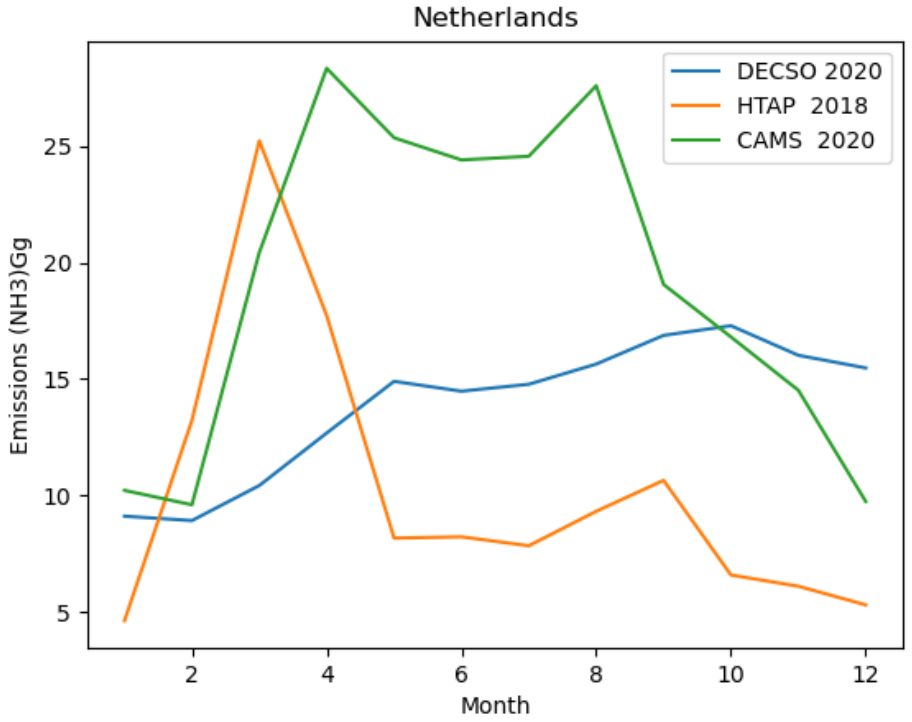
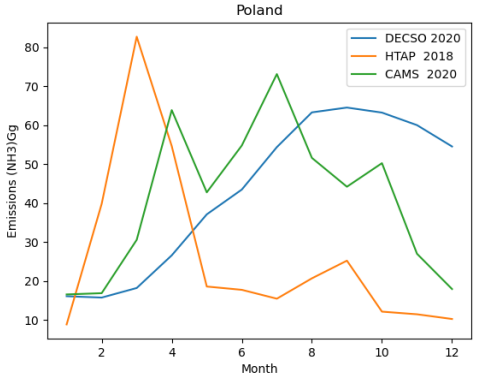
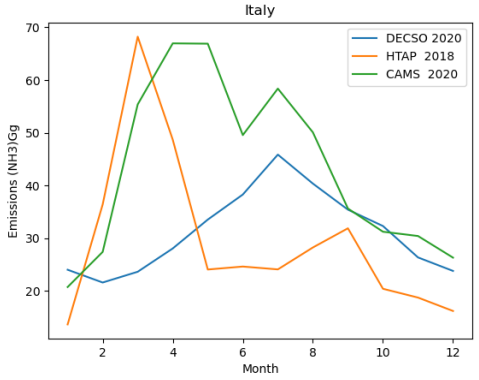


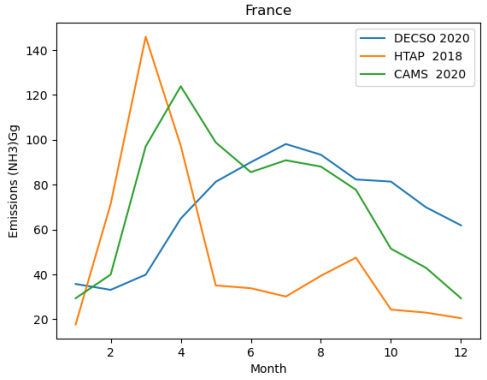
Seasonality

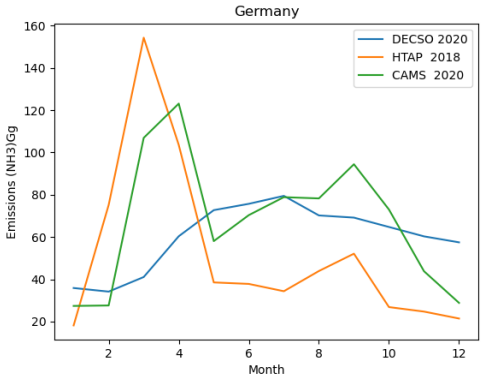




DECSO 2020
HTAP 2018
CAMS 2020







Highlights

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- With TROPOMI NO2 observations, NOx emissions are well estimated by the inversion technique.
- We derive up-to-date high resolution NOx emission inventories due to high resolution TROPOMI observations.
- For NH3 emission estimates, up-to-date NOx emissions are crucial for the inversion method using CTM.