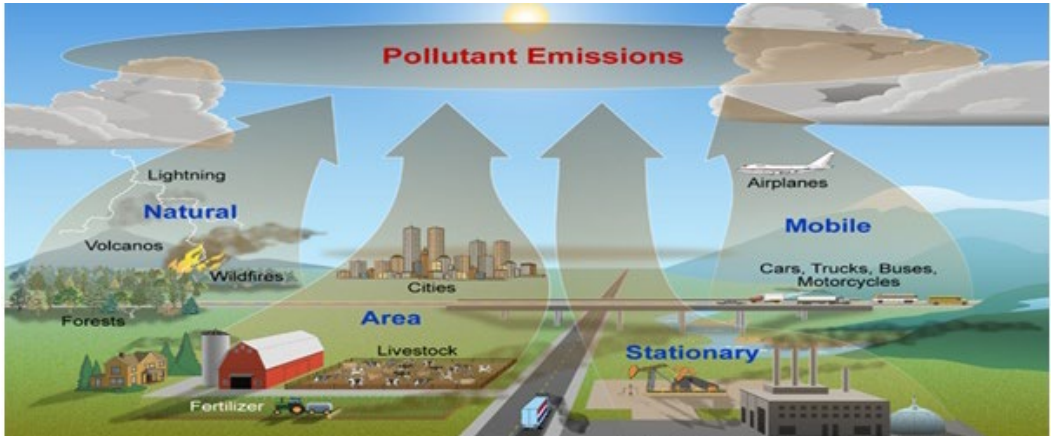
Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

Daily NOx emissions over Europe from TROPOMI

Ronald van der A, Jieying Ding, Henk Eskes, Bas Mijling
KNMI

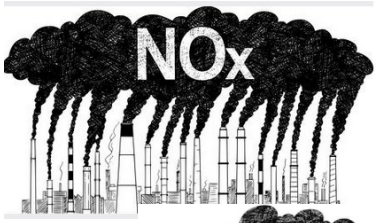
ATMOS, November 2021

Sources of NOx



Themes:

- Nitrogen cycle
- Air pollution
- Eutrophication



Anthropogenic sources:

- Industry
- Power plants
- Traffic
- Agriculture: soil

Biogenic sources:

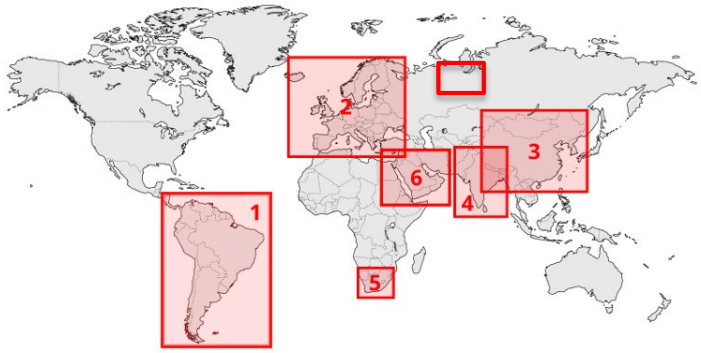
- Fires
- Nature: soil

DECSO

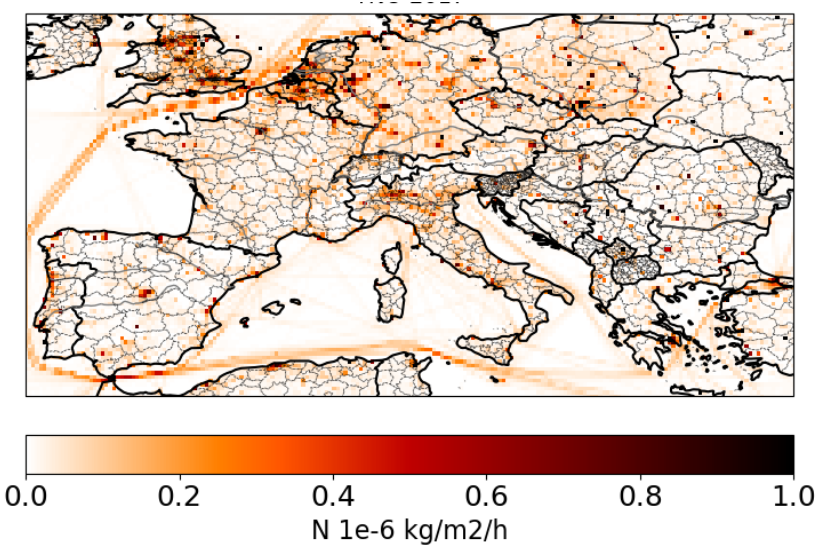
Daily Estimates Constrained by Satellite Observations

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	$\mathbf{P}^{a}(t_i) = (\mathbf{I} - \mathbf{K}_i\mathbf{H}_i)\,\mathbf{P}^{f}(t_i)$

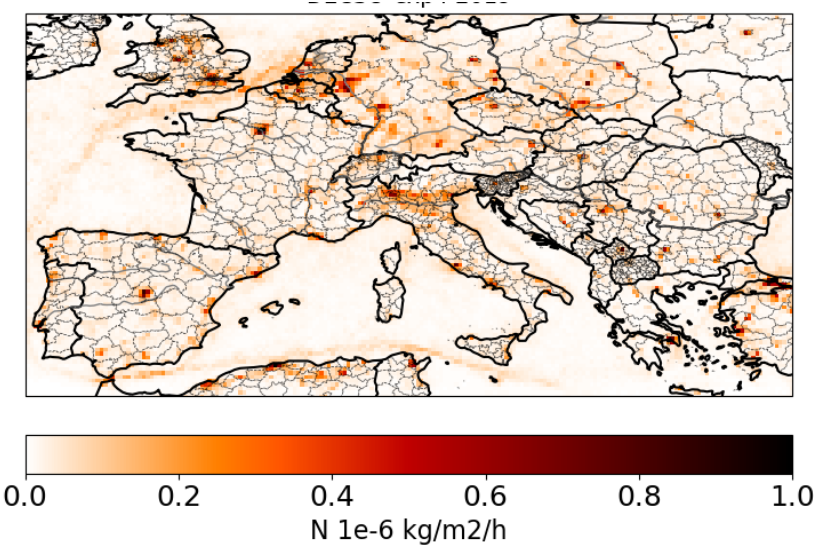
- It is fast: one model run per assimilation step of 1 day
- No *a priori* information needed.
- Emissions are updated by addition instead of scaling: new sources become visible.
- Full error estimation of new emission inventory



European NOx emissions

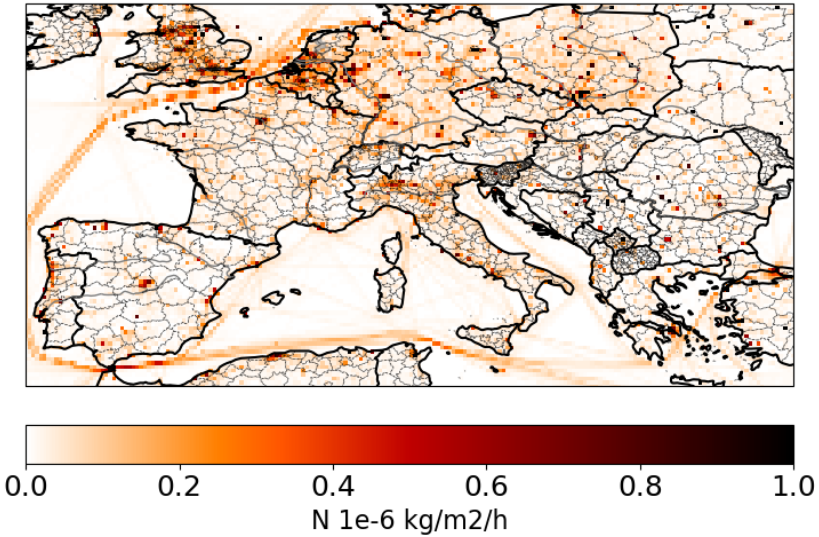


CAMS 2017

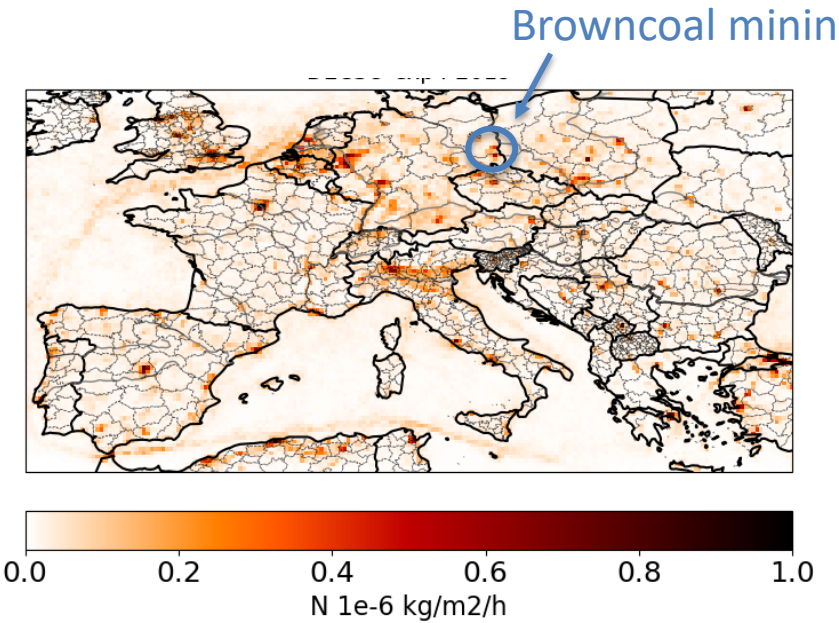


DECSO 2019

European NOx emissions



CAMS 2017



DECSO 2019

Split DECSO NOx per sector

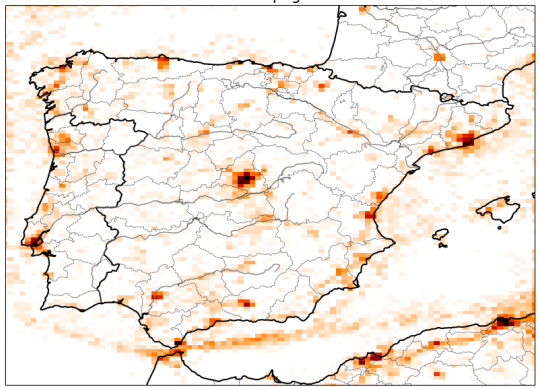
- Anthropogenic, Agricultural, Maritime -

Method:

- Anthropogenic emissions selected based on
  - landuse >1% urban (LandCover 2019 of the Copernicus Land Monitoring Service)
  - ratio summer/winter emission < 2. (eg. over the ocean)
- Agricultural emissions selected
  - Landuse categories Croplands+Grassland > 50% (LandCover 2019)
- Remaining grid cells: “nature”

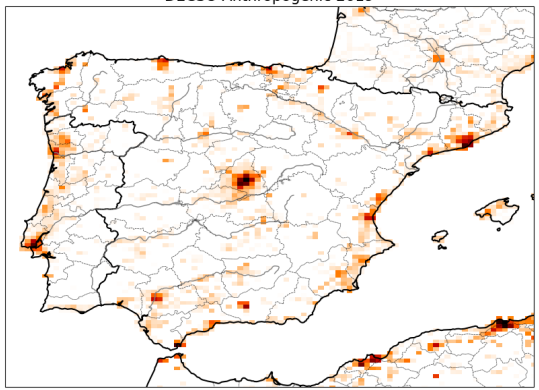
- For comparison : Anthropogenic CAMS emissions 2017 are shown

DECSO Anthropogenic 2019



Ratio summer/winter

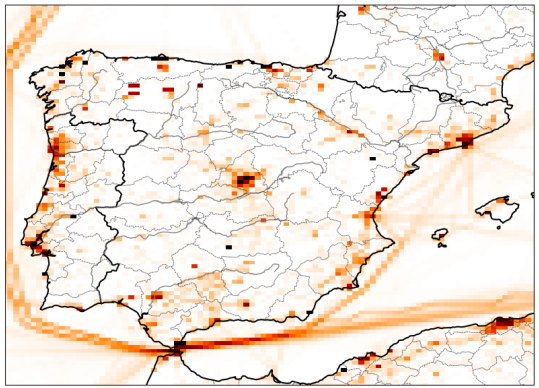
DECSO Anthropogenic 2019



LandCover 2019

CAMS emissions 2017

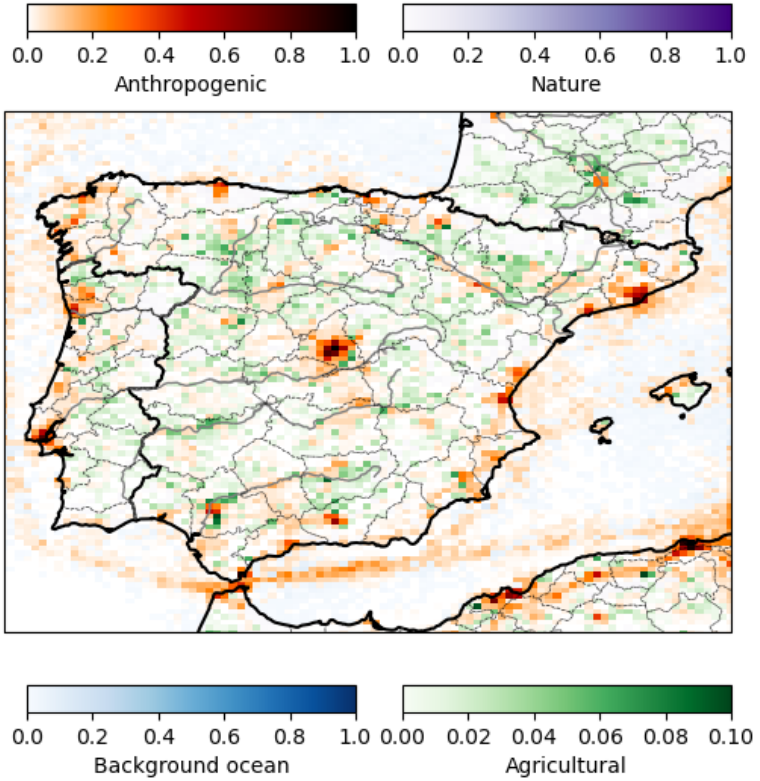
CAMS-TNO 2017



NOx emissions by DECSO

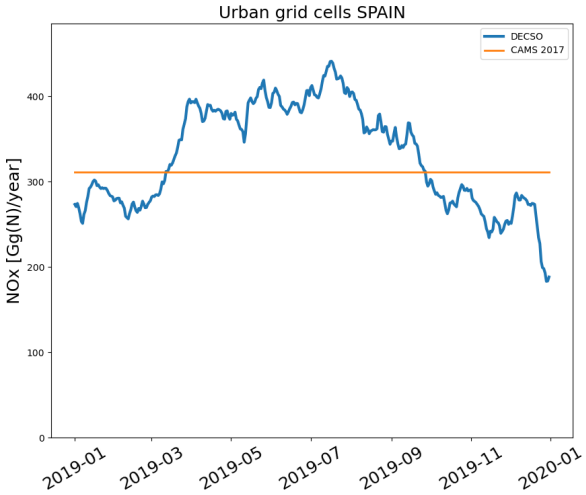
Iberian peninsula, 10x 10 km

- Land use (Copernicus) and seasonality used for split-up in main sectors.

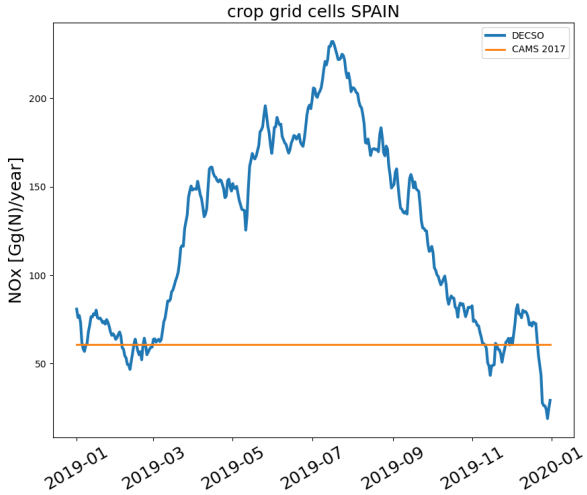


Seasonality 2019

Urban



Agricultural (crops+grassland)



Bias in seasonal cycle caused by:

- Bias between summer and winter TROPOMI-NO2 (version 2019)
- Outdated version of Chimere in DECSO needs to be upgraded

Work in progress

Verification of NOx emissions by DECSO

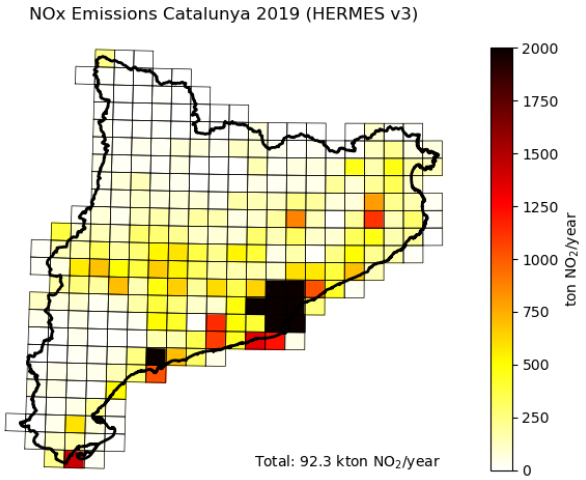
with a focus on Catalonia

Comparison:

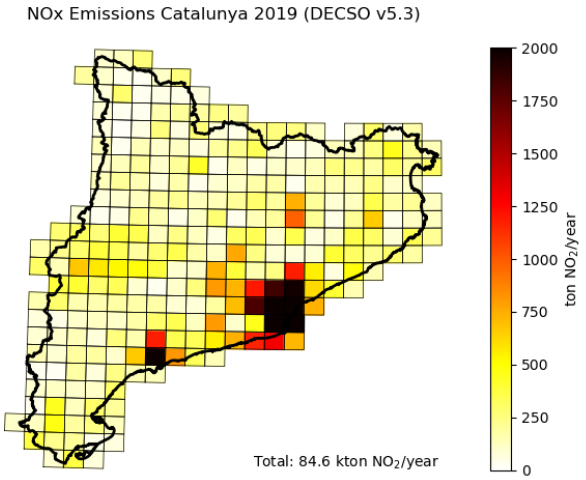
- DECSO v5.3 (2019)
- CAMS emissions (2017)
- HERMES (2019):

  High-Elective Resolution Modelling Emission System of the Barcelona Supercomputing Centre

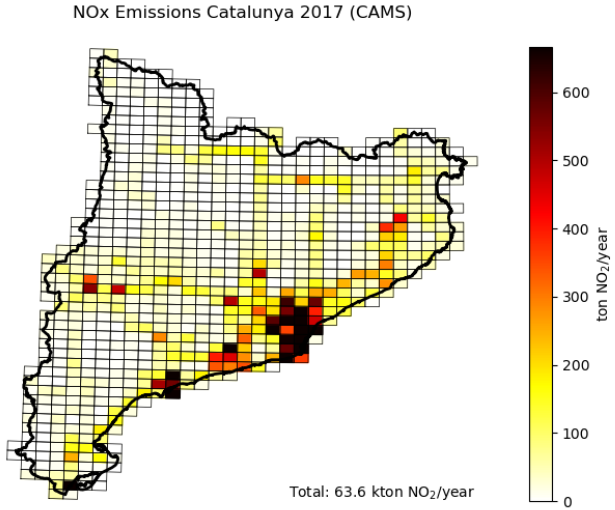
Total NO_X emissions Catalonia, 2019



HERMES
92.3 kton/yr

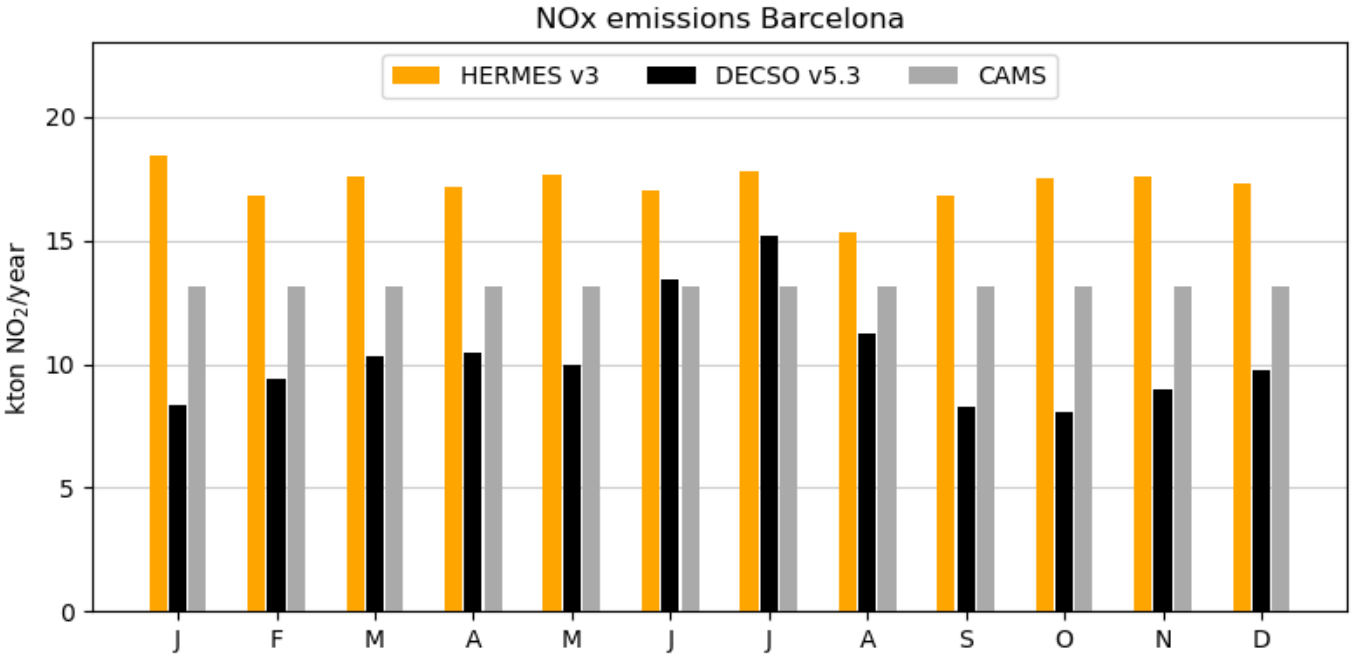


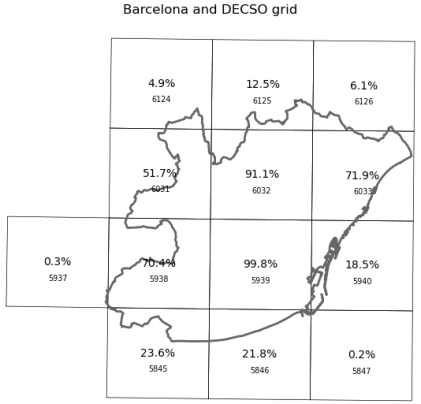
DECSO
84.6 kton/yr



CAMS
63.6 kton/yr

Monthly NO_X emissions Barcelona

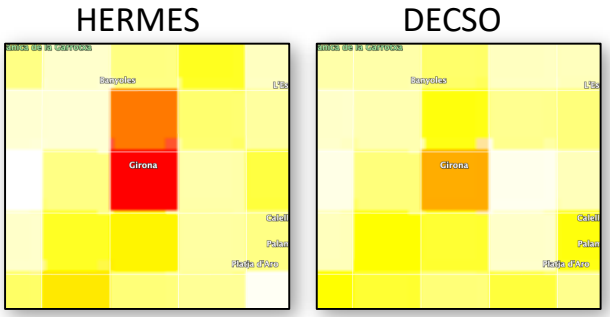


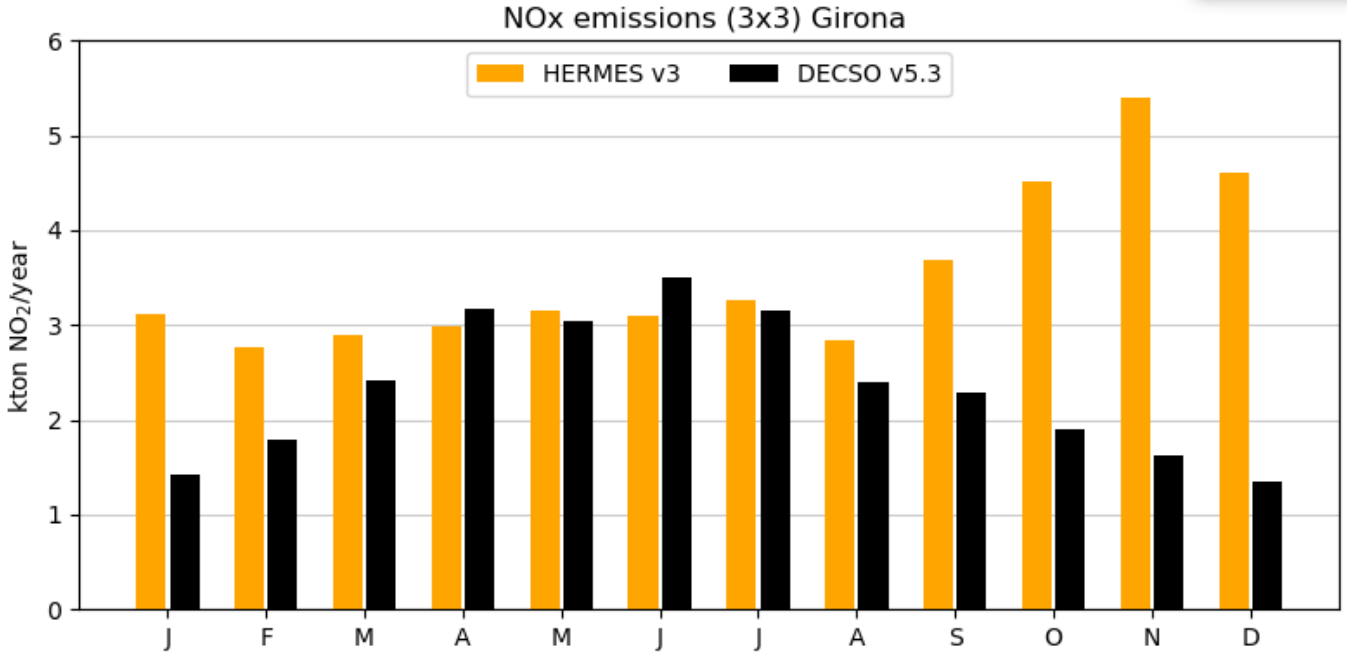


Total emissions

HERMES v3 (2019):	17.3 kton NO_2
DECSO v5.3 (2019):	10.3 kton NO_2
CAMS (2017):	13.2 kton NO_2

Monthly emissions Girona



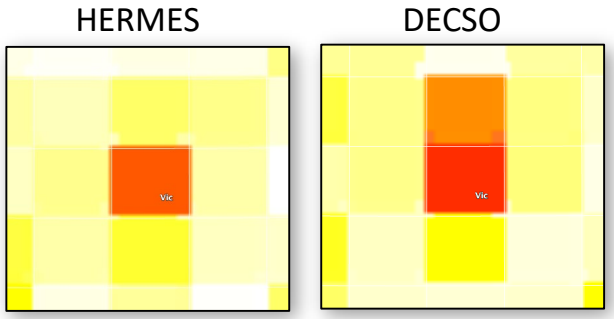


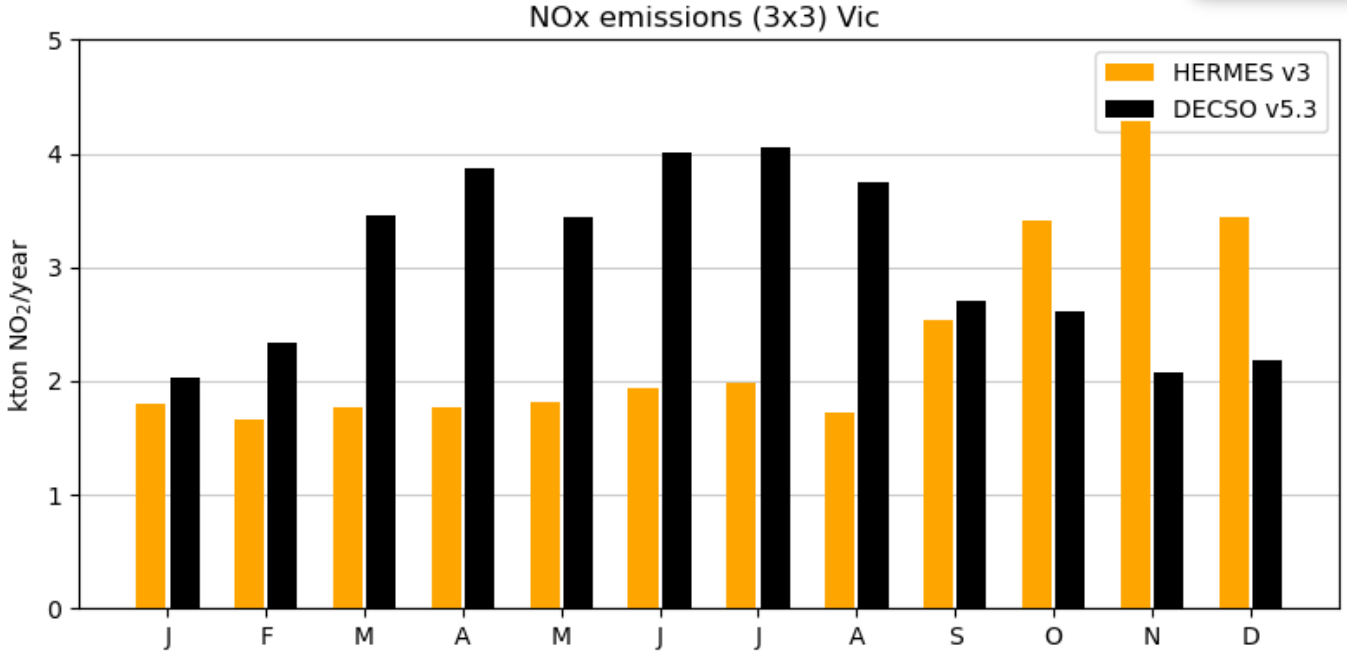
Total emissions (3x3)

HERMES v3 (2019): 3.5 kton NO_2

DECSO v5.3 (2019): 2.3 kton NO_2

Monthly emissions Vic





Total emissions (1x1)

HERMES v3 (2019): 0.88 kton NO_2

DECSO v5.3 (2019): 0.98 kton NO_2

Total emissions (3x3)

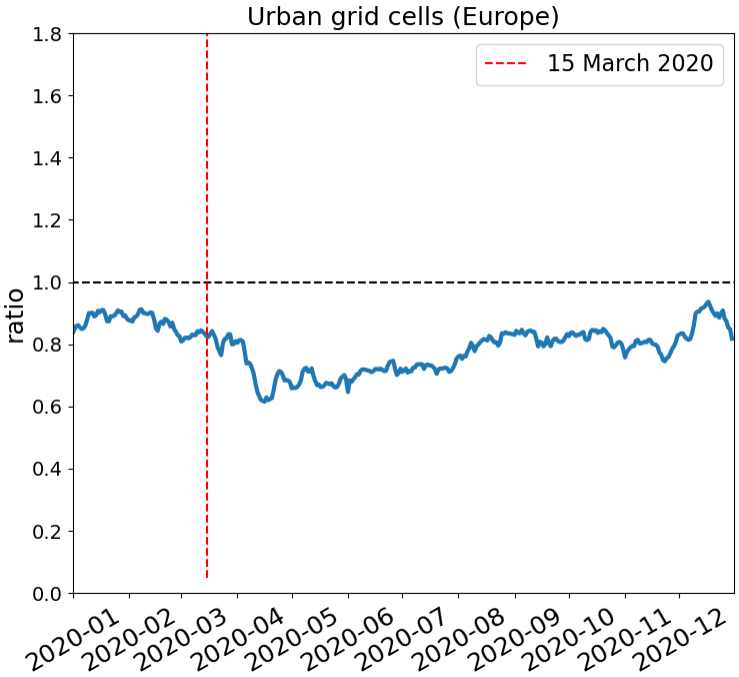
HERMES v3 (2019): 2.3 kton NO_2

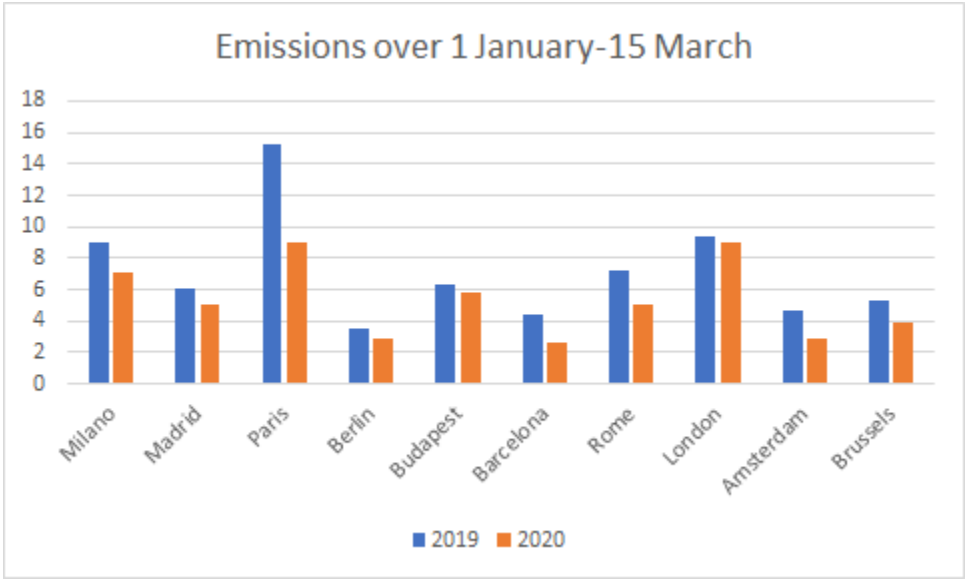
DECSO v5.3 (2019): 3.1 kton NO_2

NOx emissions time series in Europe during 2020 affected by COVID

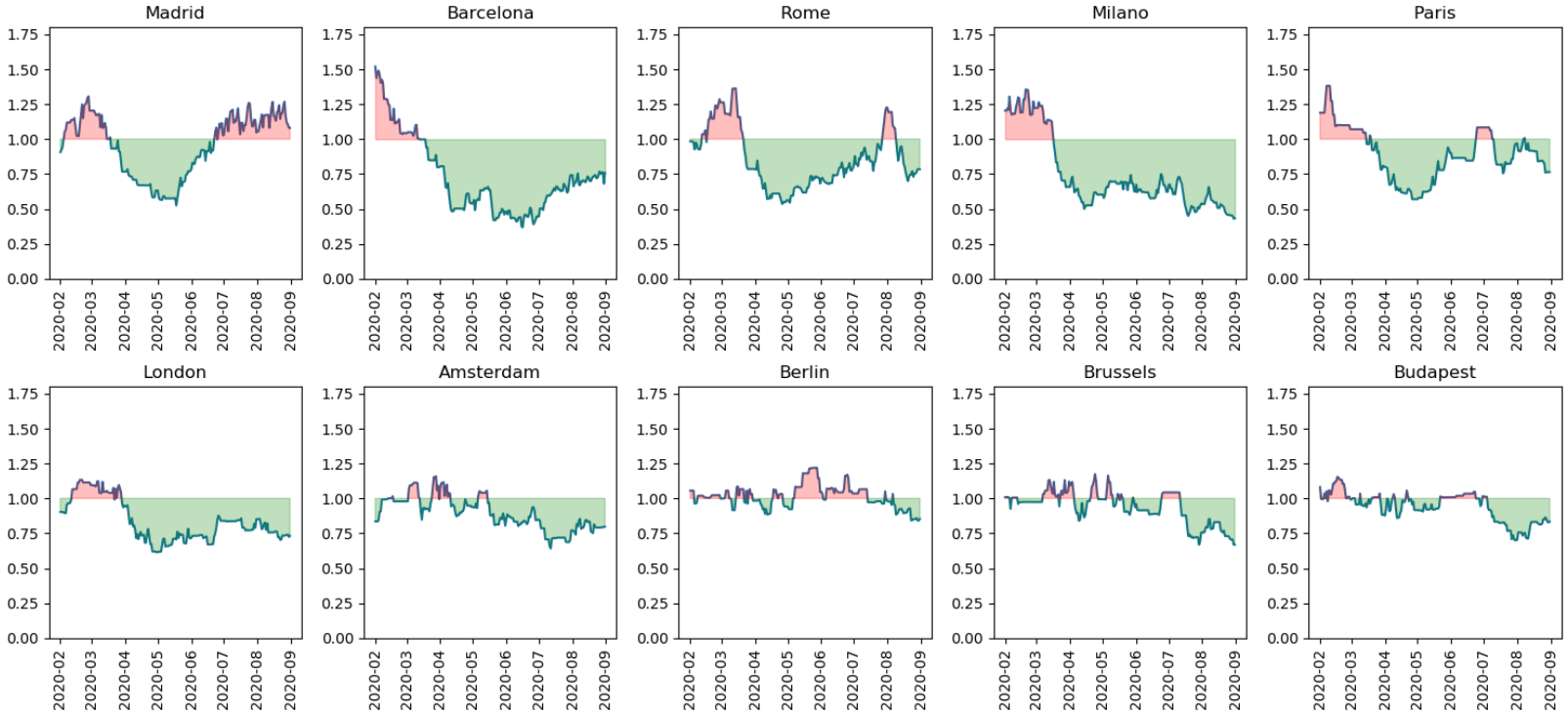
- ICOVAC project -

Trends in 2020 compared to 2019





Ratio of NOx emissions normalized with the mean of [1 Jan 2020 – 15 March 2020] :



Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

Conclusions

1) DECSO:

- Daily NOx emissions over Europe on a resolution of 10-20 km derived from TROPOMI (S5p).
- Emissions derived for anthropogenic, agricultural and maritime source sectors.

2) VERIFICATION

- Comparison over Catalonia with HERMES (2019) and CAMS (2017).
- Good agreement of spatial locations and absolute regional emissions.
- Seasonal variability of DECSO needs improvement.

3) COVID-19:

- Reductions vary strongly over the European cities and are superimposed on a general trend that should be considered when quantifying the impact of COVID-19 regulations.