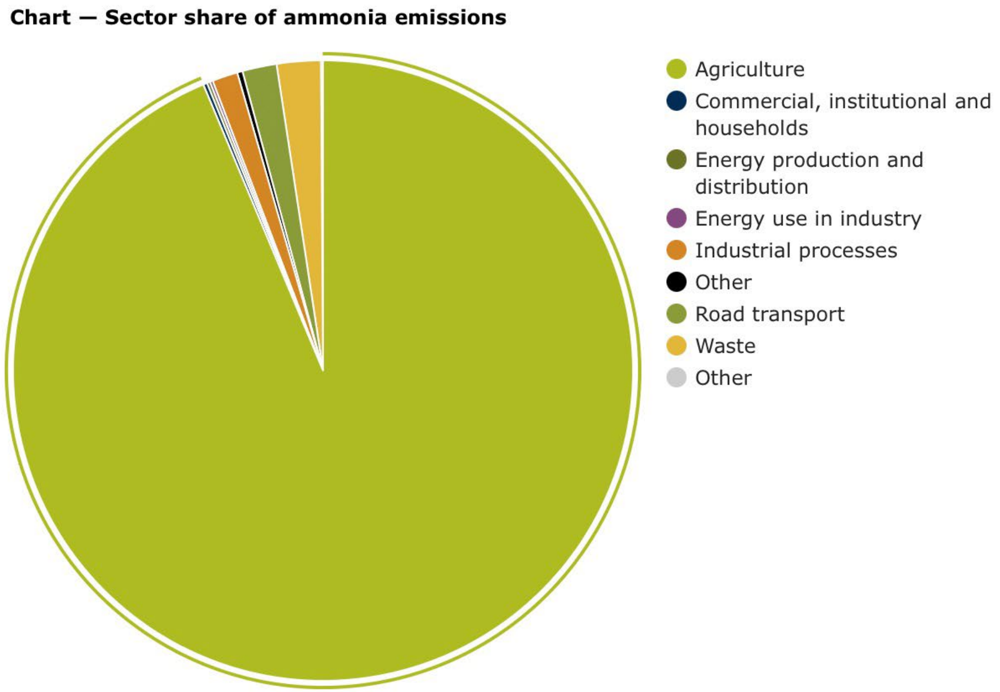
SEEDS NH_3 emissions

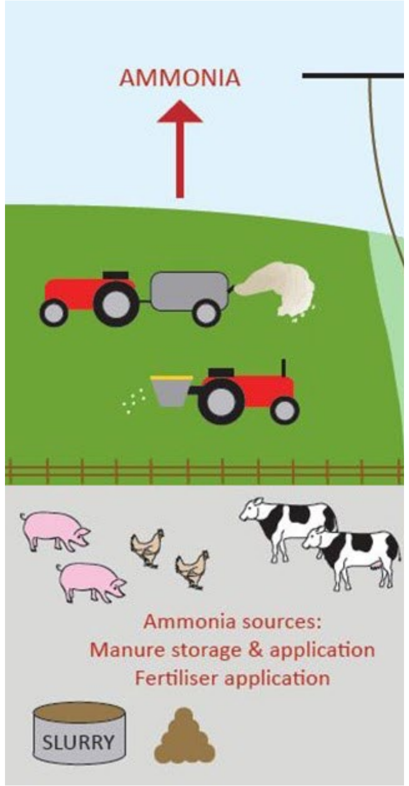
Jieying Ding, Ronald van der A, Henk Eskes

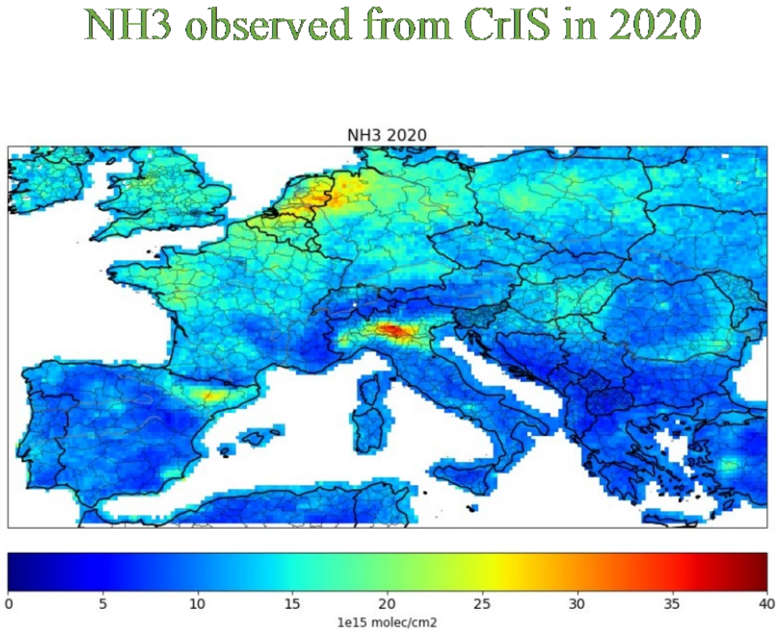
KNMI

Dec. 2023 Toulouse, France

Ammonia (NH3)

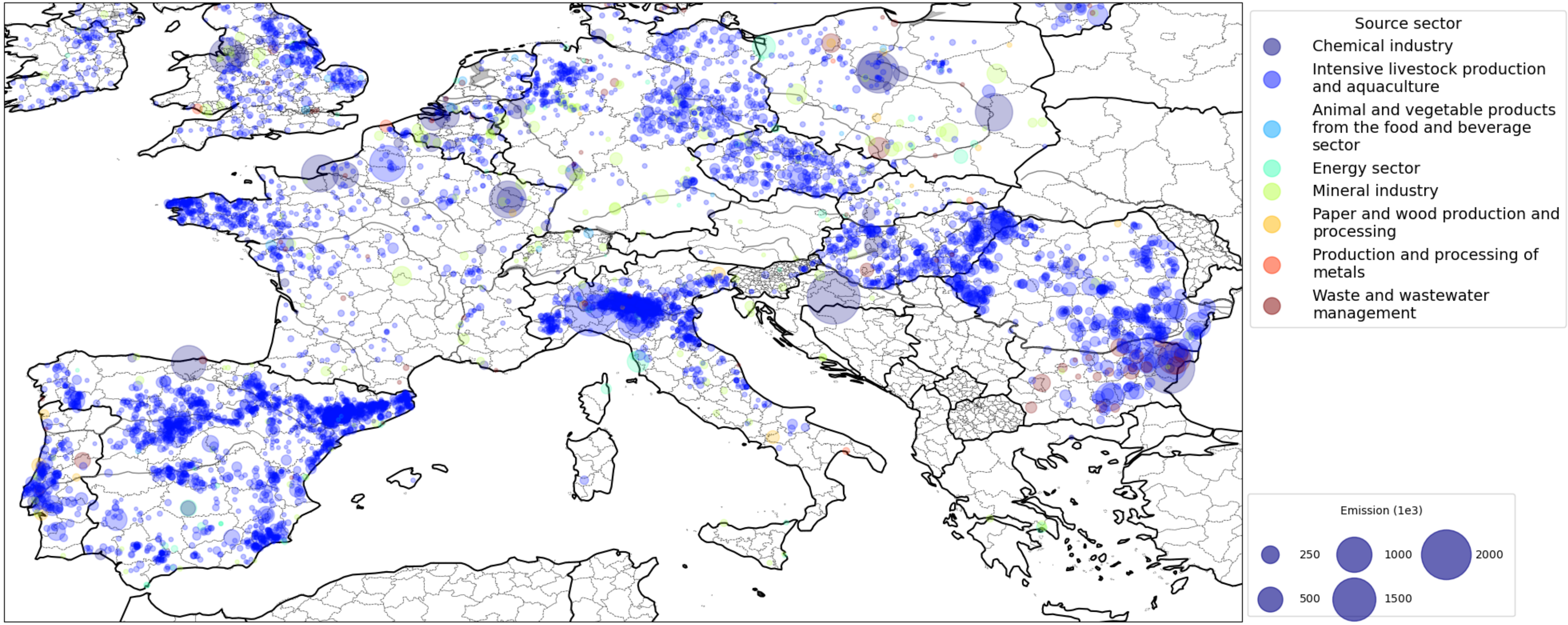






The contribution made by different sectors to emissions of ammonia in 2011. (Figure from European Environment Agency)

Ammonia sources from the European Pollutant Release and Transfer Register (E-PRTR)



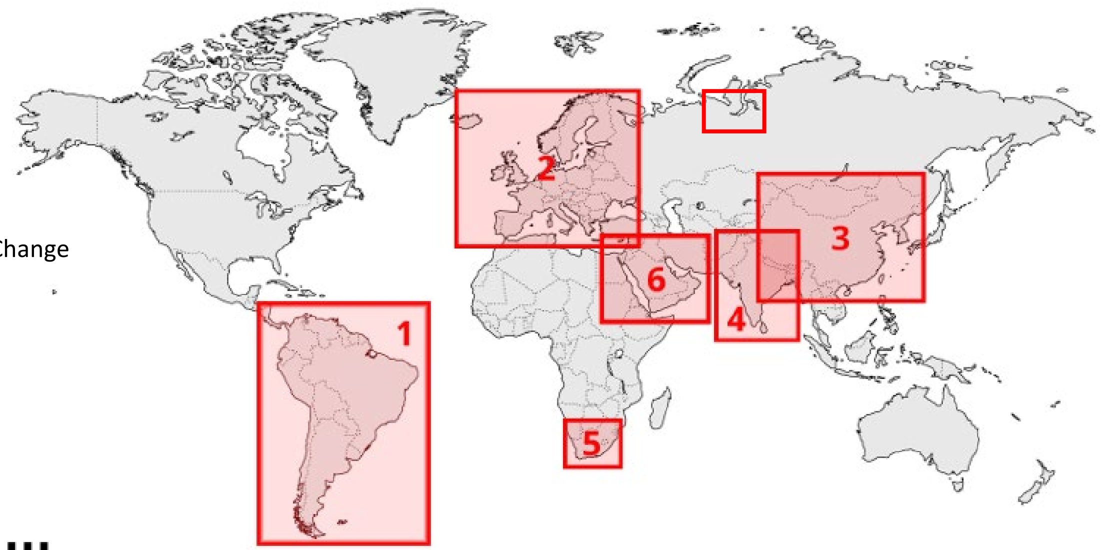
DECSO Daily Emissions Constrained by Satellite Observations

- 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

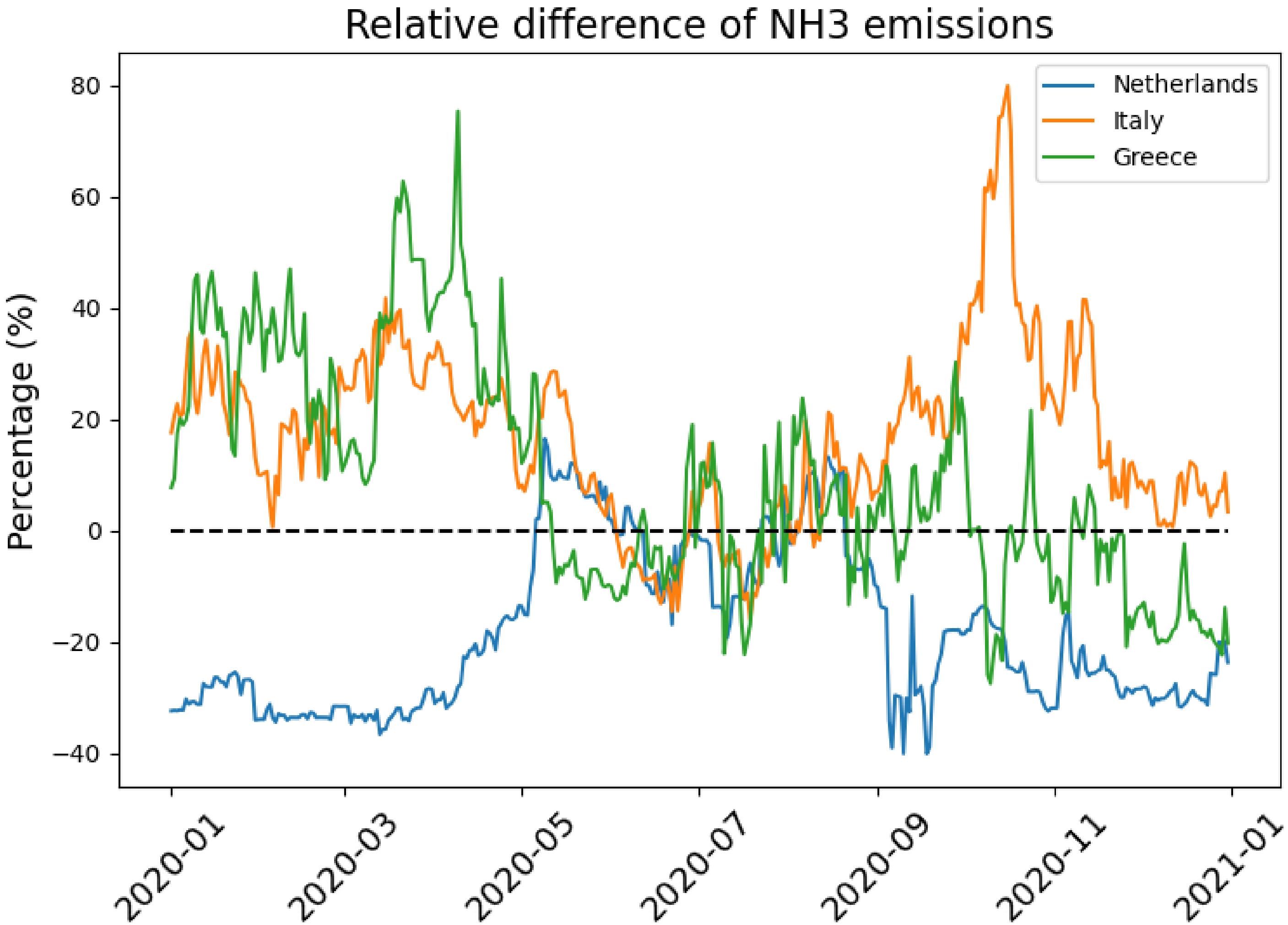
State vector forecast	$\mathbf{x}^f(t_{i+1}) = M_i\,[\mathbf{x}^a(t_i)]$
Error covariance forecast	$\mathbf{P}^f(t_{i+1}) = \mathbf{M}_i\mathbf{P}^a(t_i)\mathbf{M}_i^T + \mathbf{Q}(t_i)$
Kalman gain matrix	$\mathbf{K}_i = \mathbf{P}^f(t_i)\mathbf{H}_i^T[\mathbf{H}_i\mathbf{P}^f(t_i)\mathbf{H}_i^T + \mathbf{R}_i]^{-1}$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

- DECSO v6.2
- Model: CHIMERE 2020 r3
- Observations:
  - CrIS NH3 (provided by Mark Shephard*)
  - CrIS on SNPP and NOAA

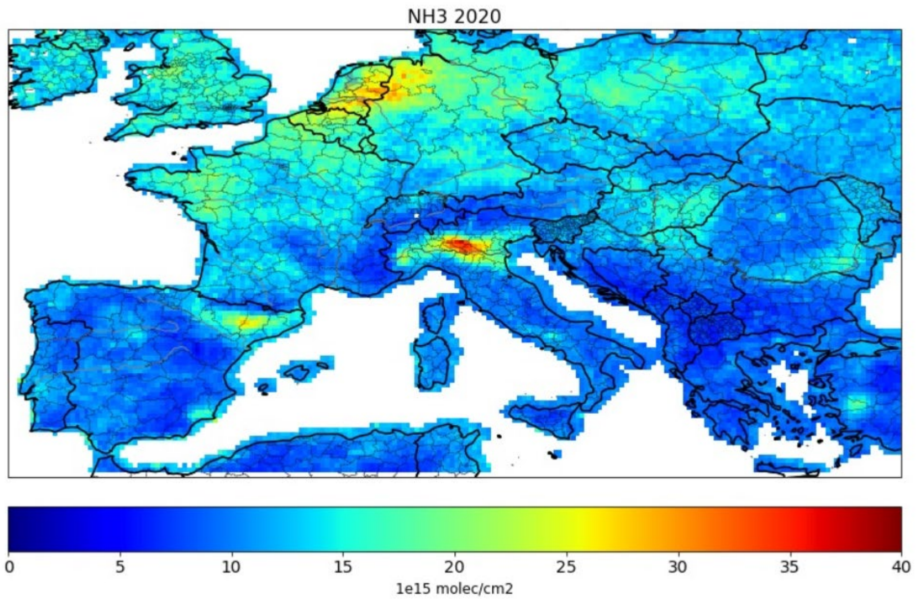
*Environment and Climate Change Canada

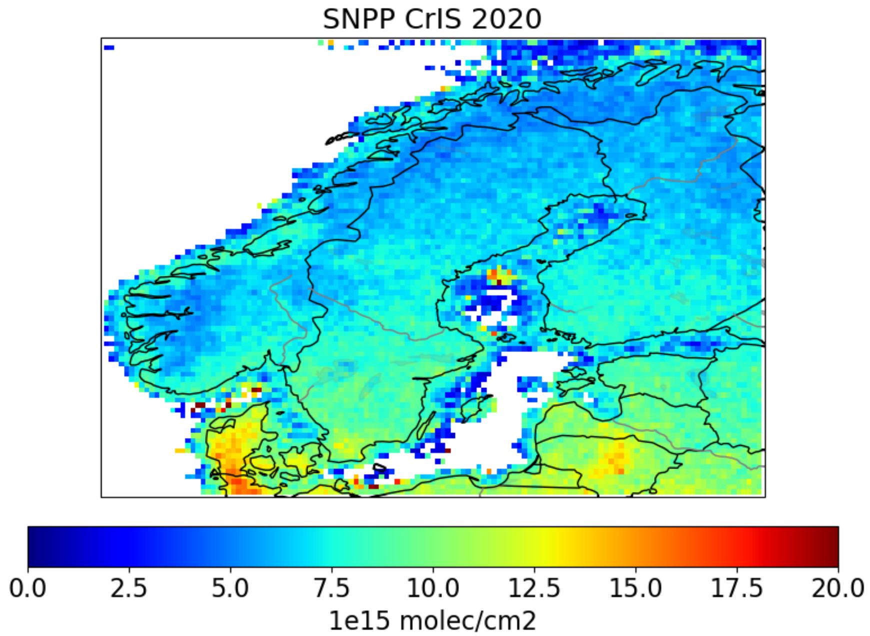


NH3 emission estimates: impact of NOx emissions on NH3 inversion:
- NOx emissions updated from TROPOMI
- No updates of NOx

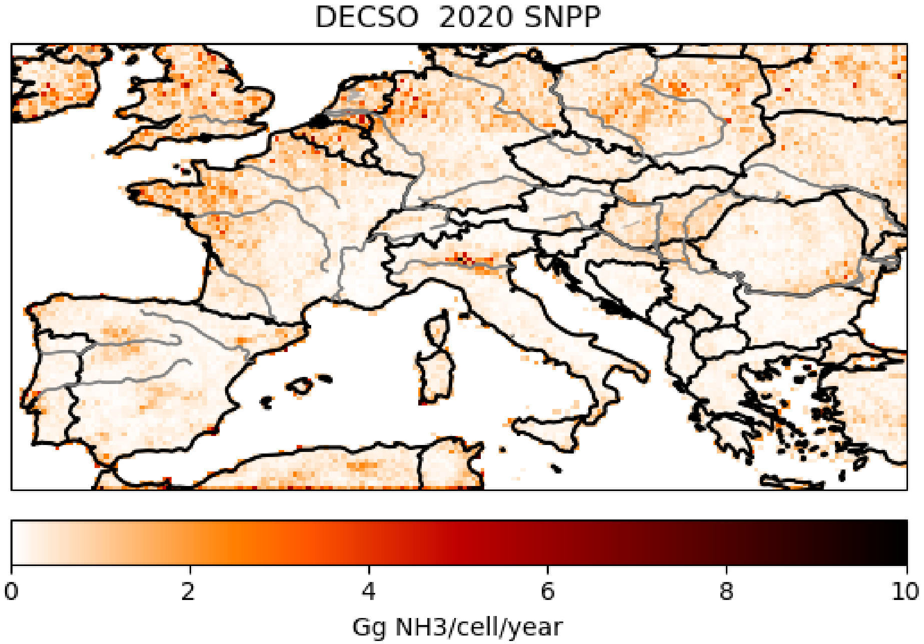


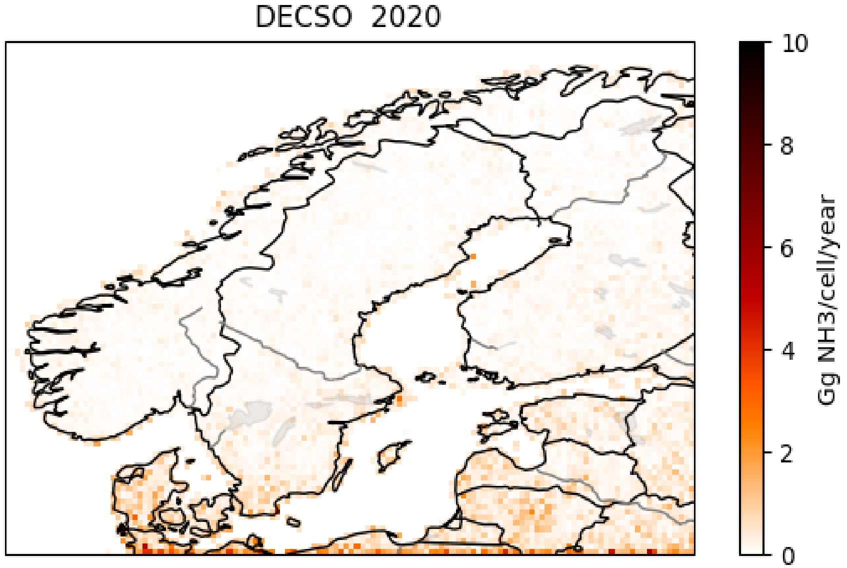
NH3 concentrations



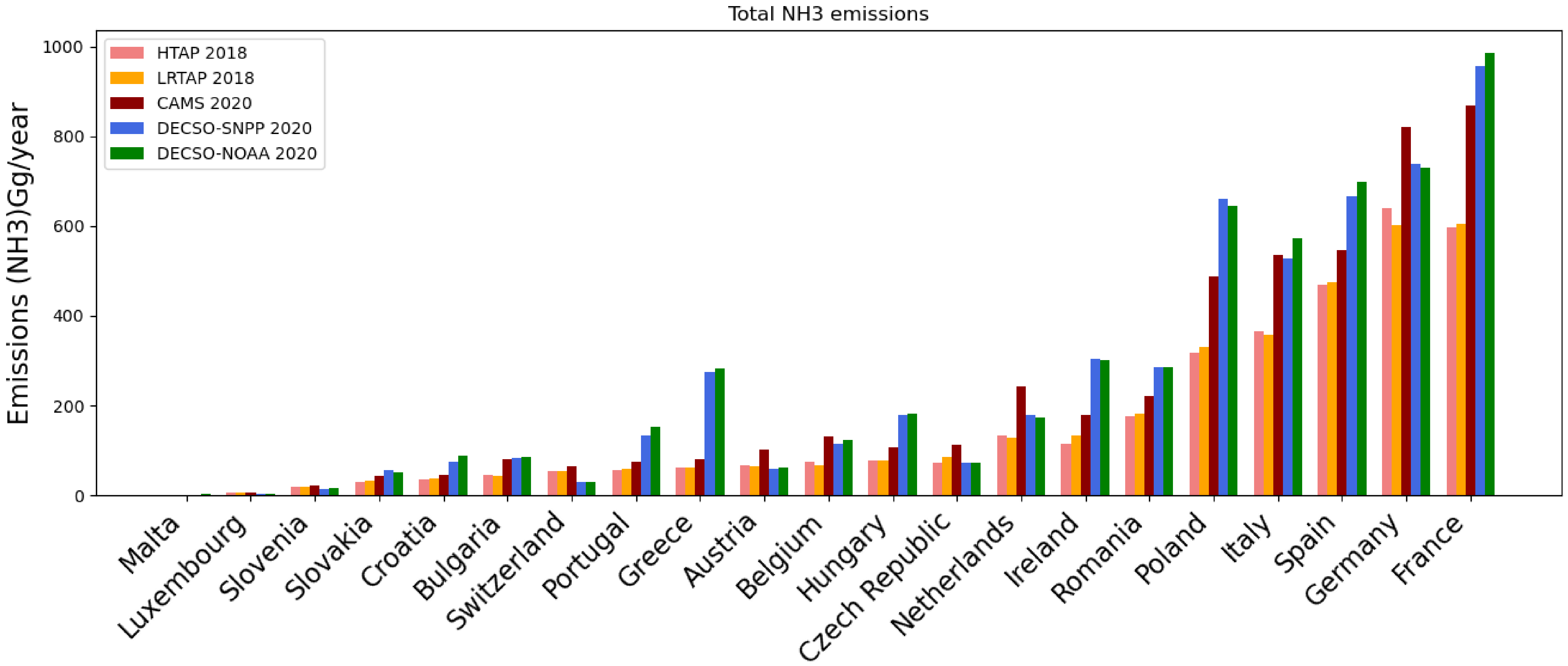


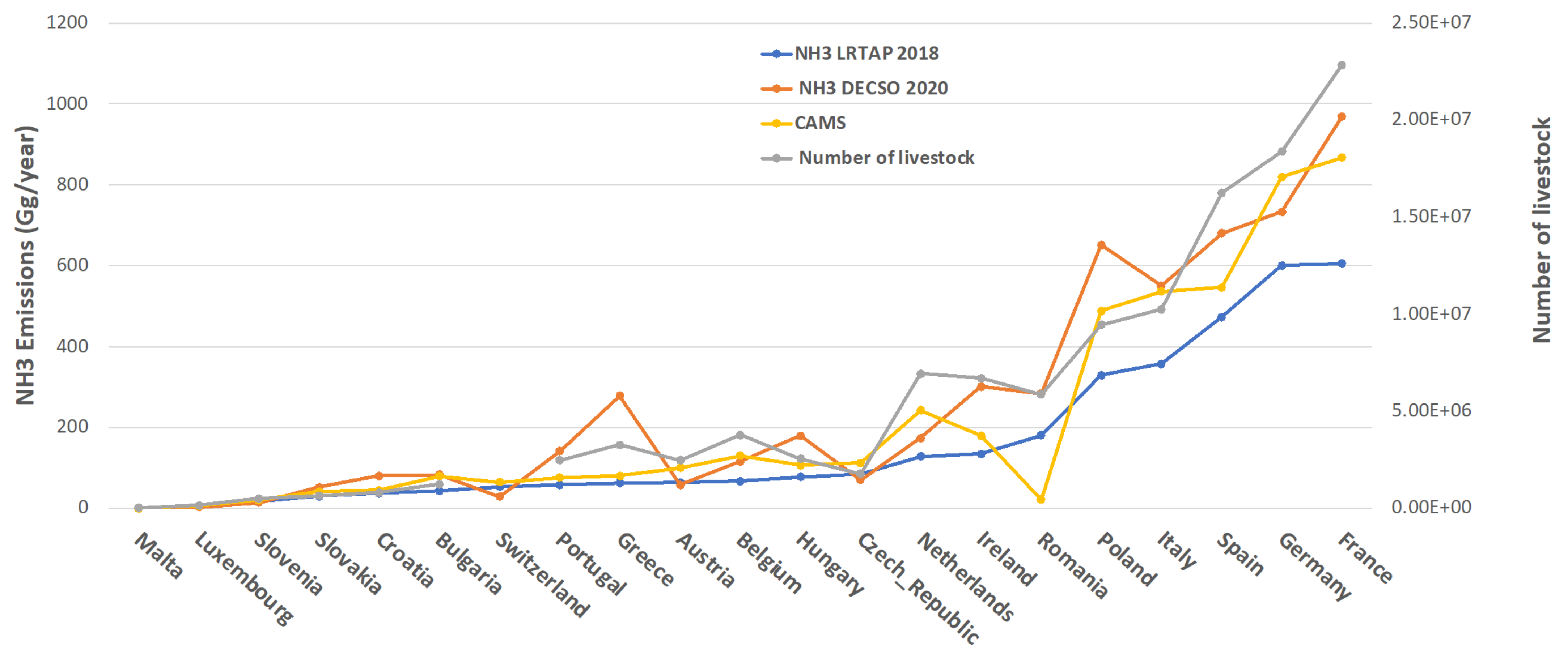
NH3 Emissions

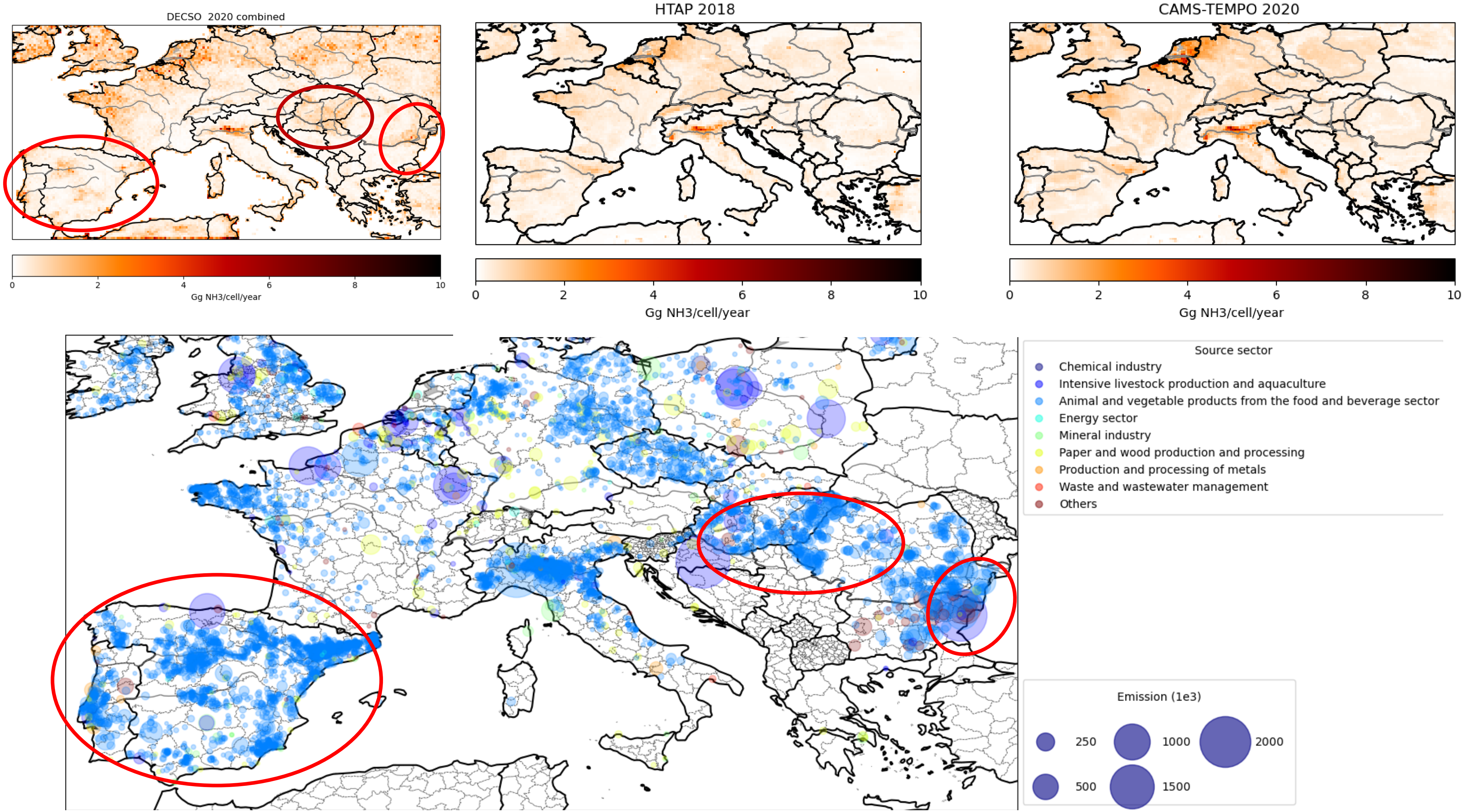




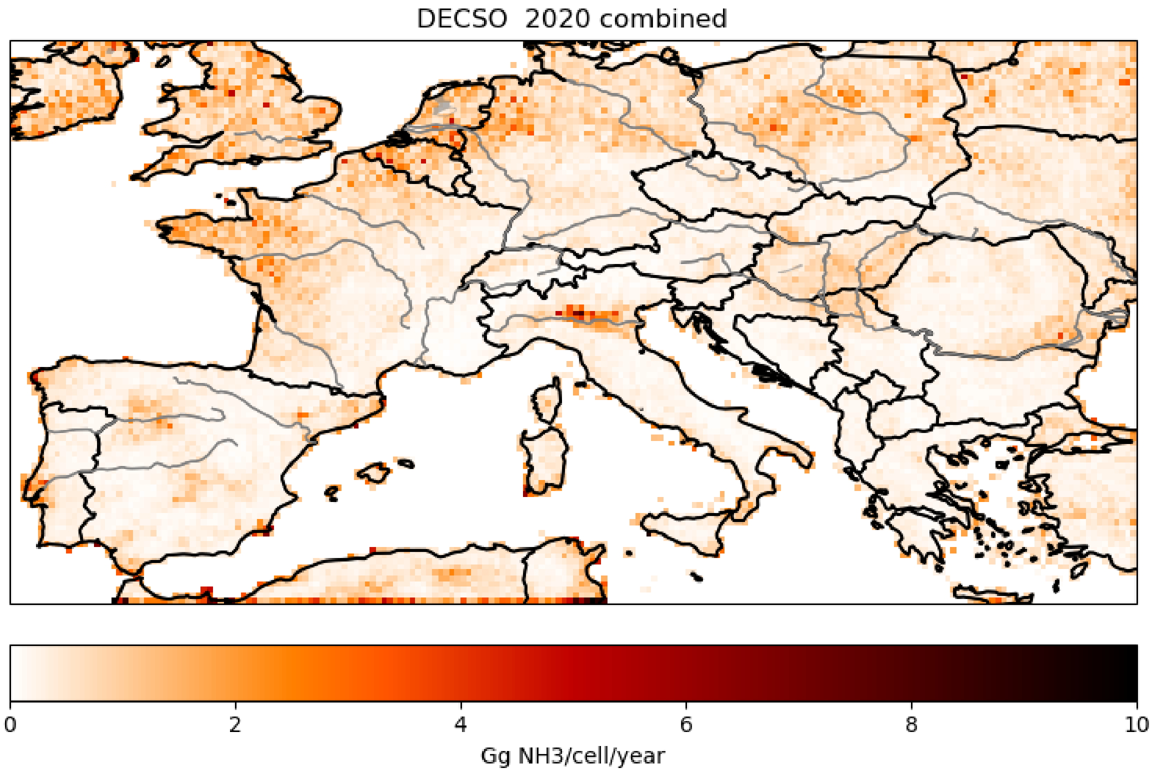
Country total comparison

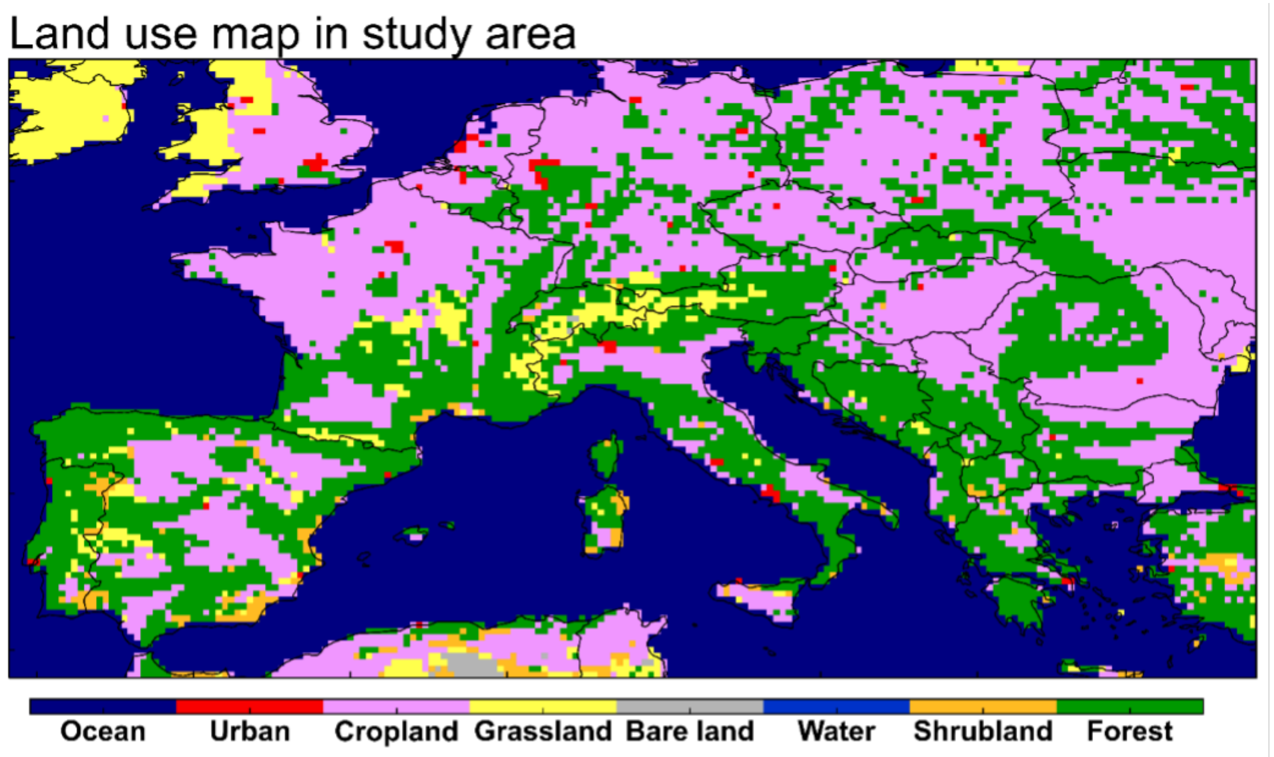



NH3 LRTAP 2018
NH3 DECSO 2020
CAMS
Number of livestock
NH3 Emissions (Gg/year)
Number of livestock
0
200
400
600
800
1000
1200
0.00E+00
5.00E+06
1.00E+07
1.50E+07
2.00E+07
2.50E+07
Malta
Luxembourg
Slovenia
Slovakia
Croatia
Bulgaria
Switzerland
Portugal
Greece
Austria
Belgium
Hungary
Czech_Republic
Netherlands
Ireland
Romania
Poland
Italy
Spain
Germany
France

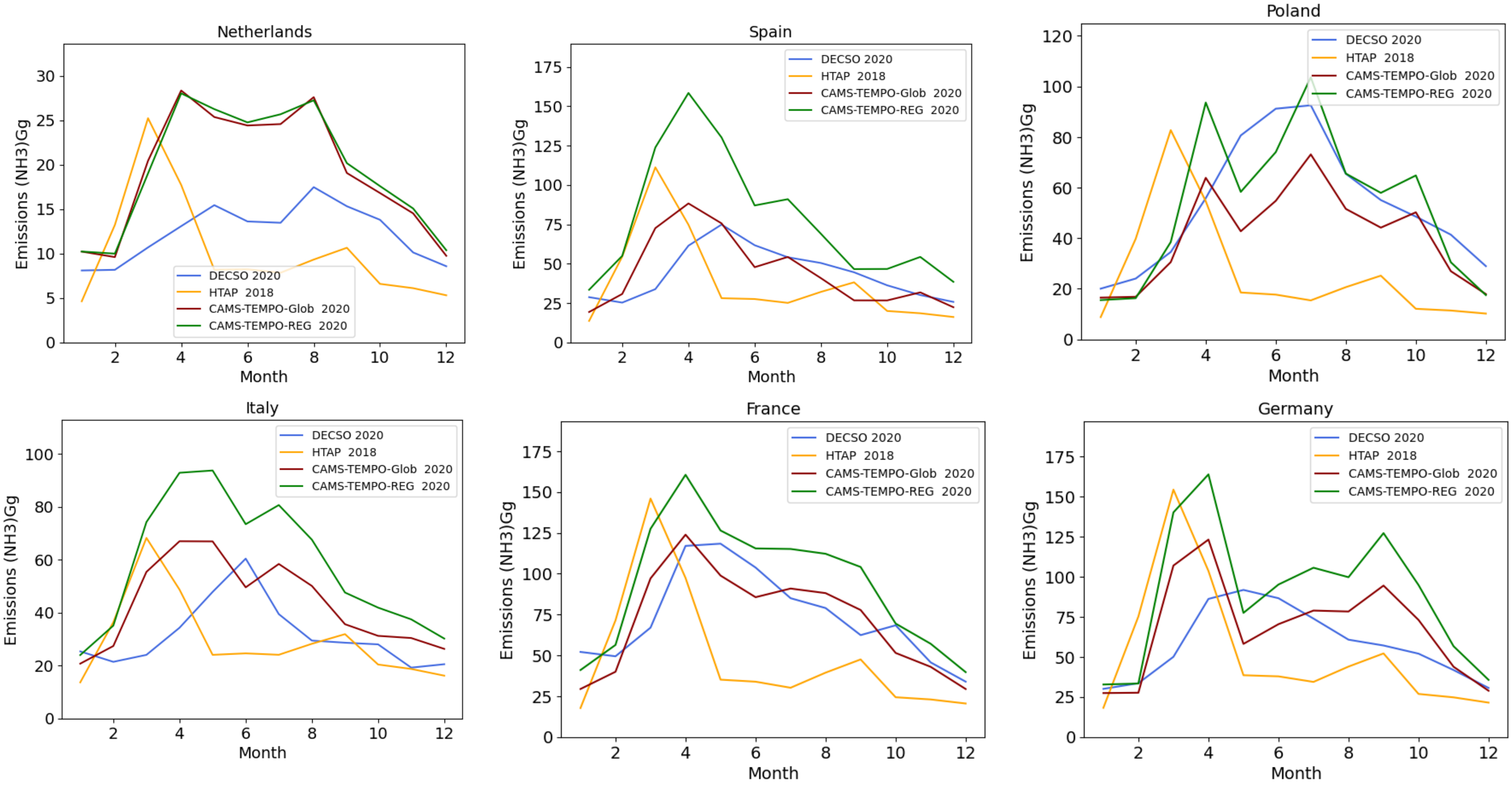

DECSO 2020 combined
HTAP 2018
CAMS-TEMPO 2020
0
2
4
6
8
10
Gg NH3/cell/year
Source sector
Chemical industry
Intensive livestock production and aquaculture
Animal and vegetable products from the food and beverage sector
Energy sector
Mineral industry
Paper and wood production and processing
Production and processing of metals
Waste and wastewater management
Others
Emission (1e3)
250
500
1000
1500
2000

NH3 emissions and land use

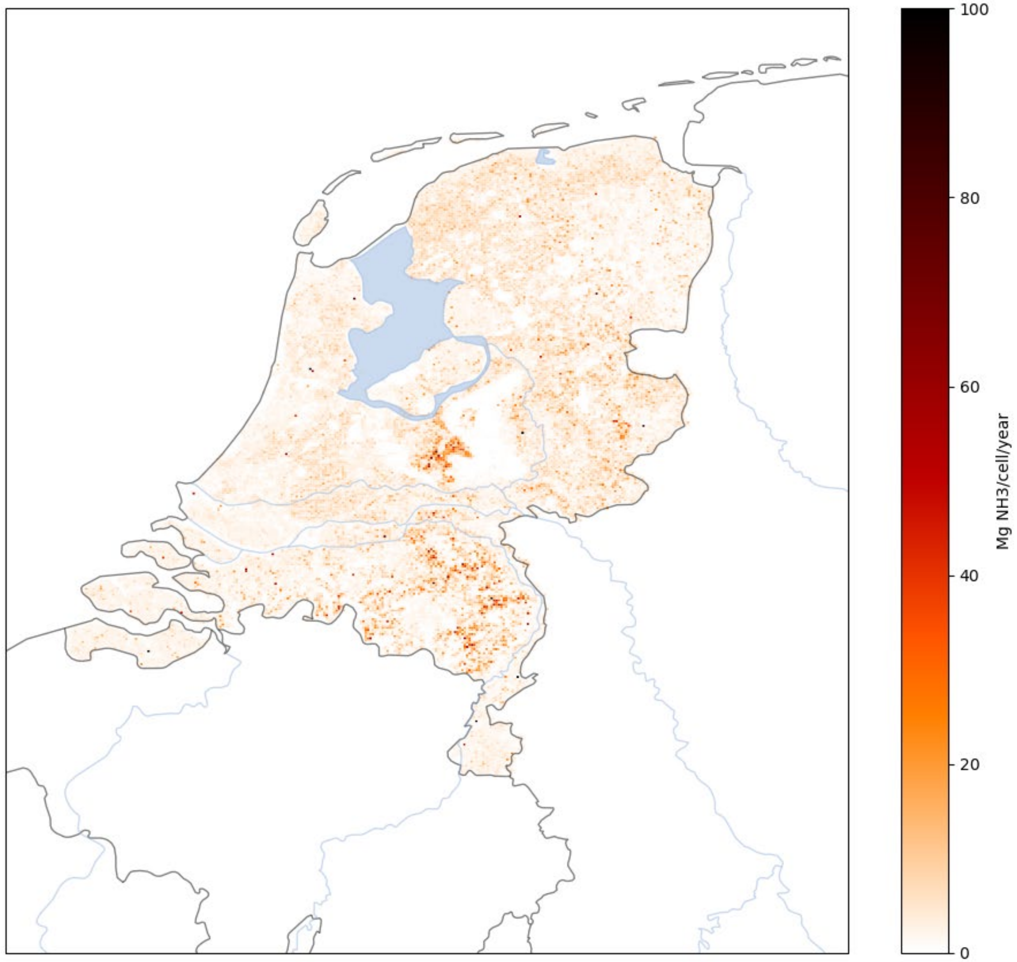




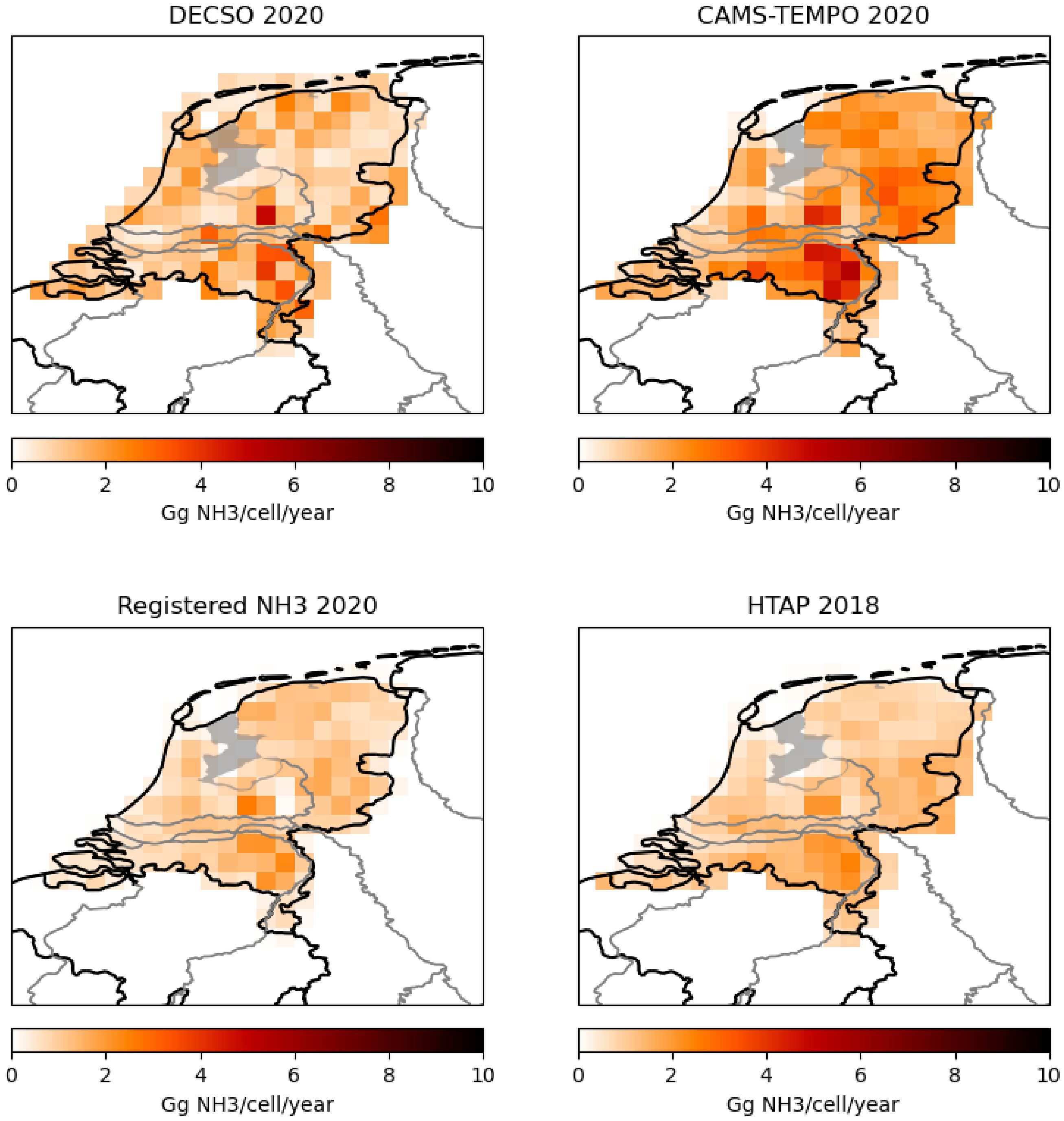
Seasonality



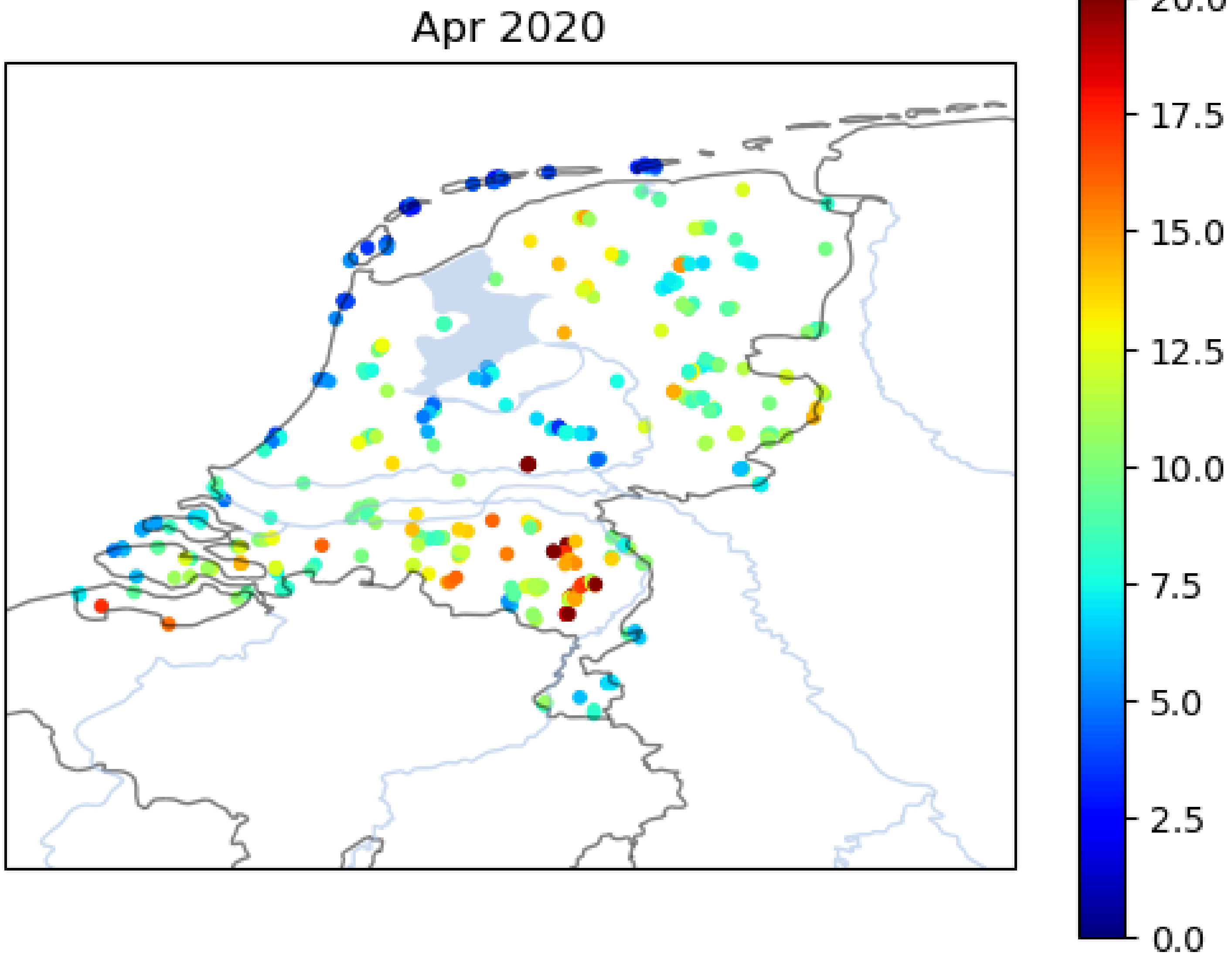
Comparison

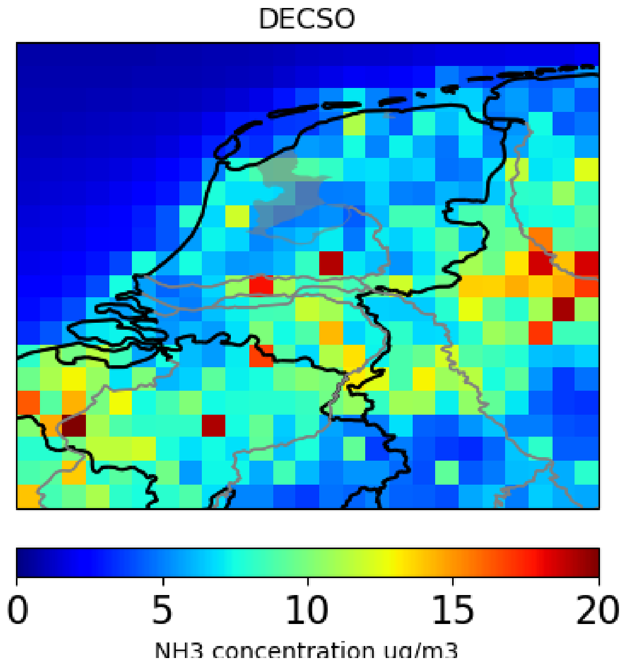


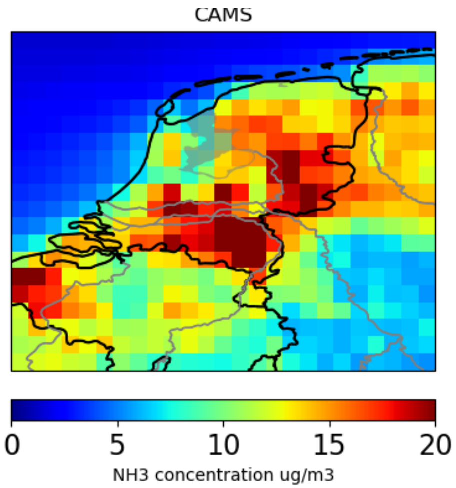
Registered NH3 emissions in NL (1km resolution)

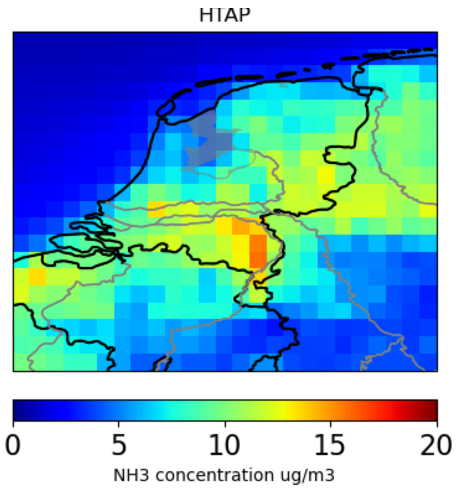


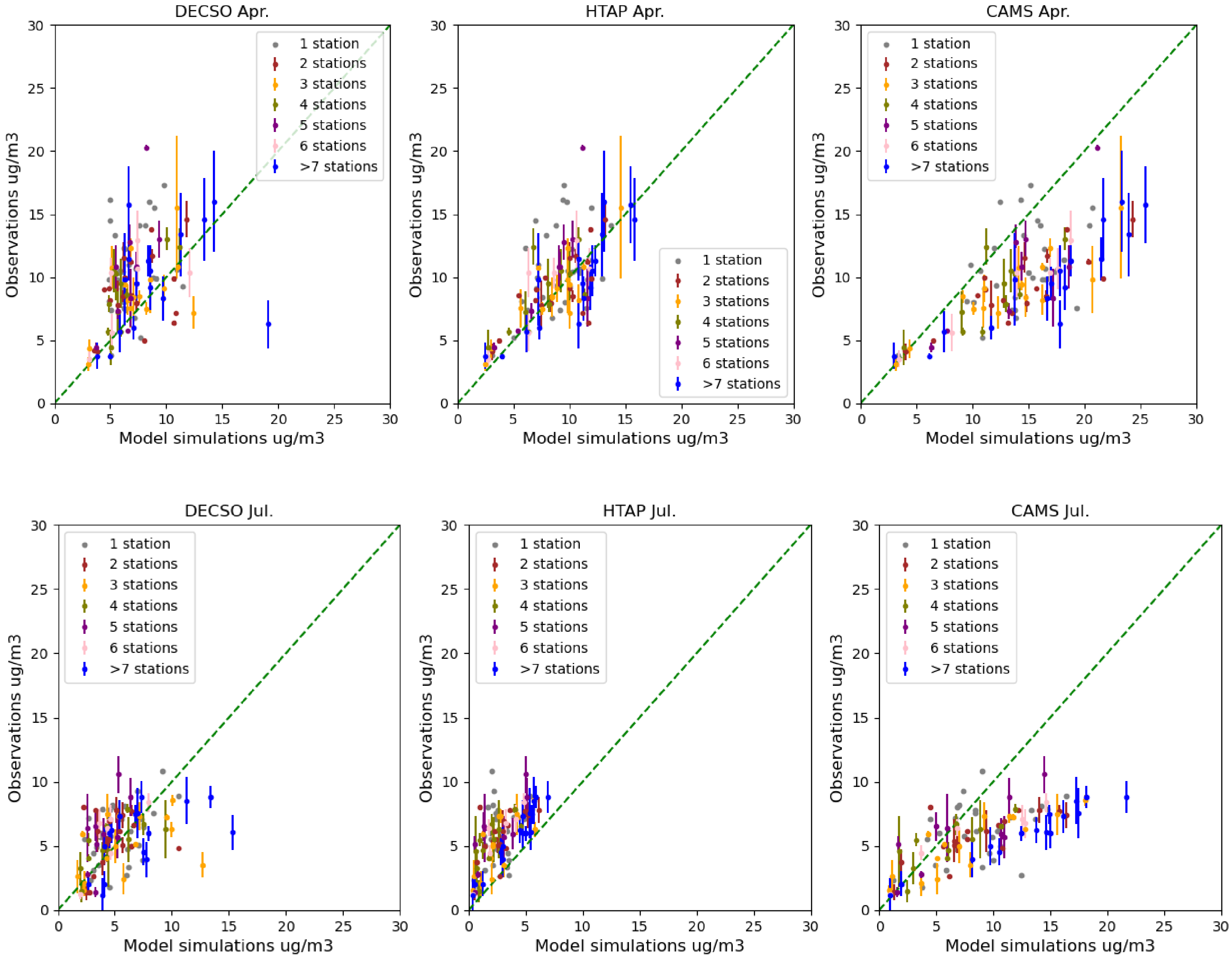
MAN network


Apr 2020
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0


DECSO
0
5
10
15
20
NH3 concentration ug/m3

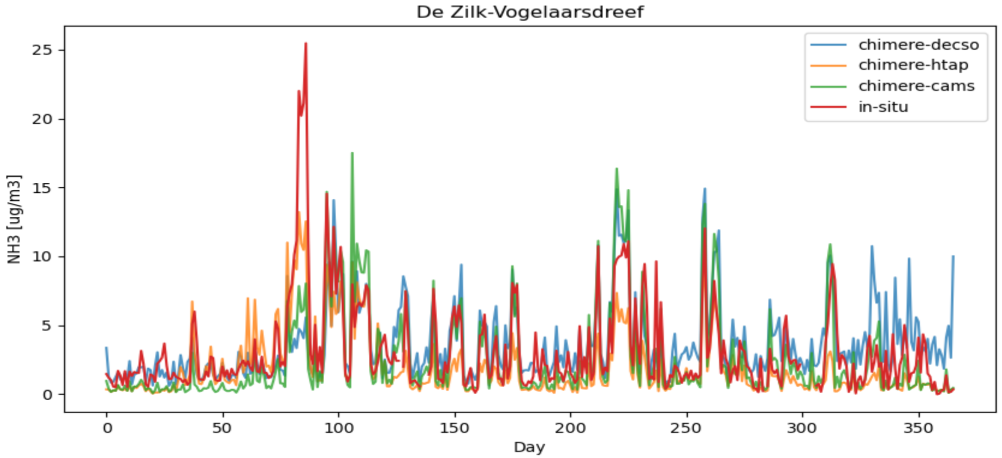

CAMS
0
5
10
15
20
NH3 concentration ug/m3

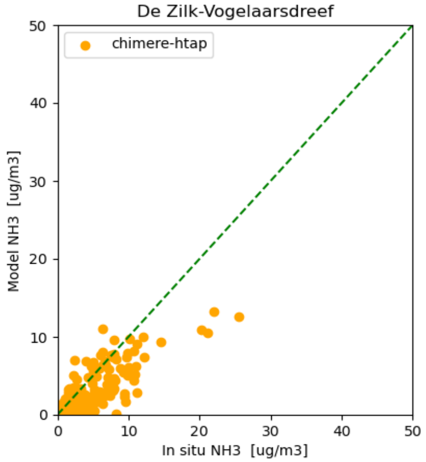

HTAP
0
5
10
15
20
NH3 concentration ug/m3

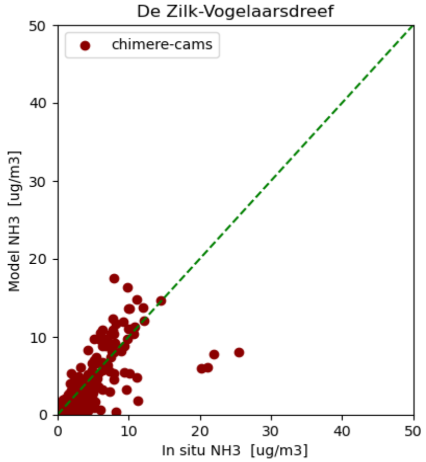


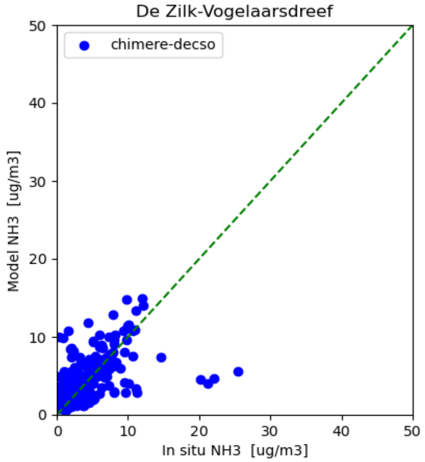
DECSO Apr.
HTAP Apr.
CAMS Apr.
DECSO Jul.
HTAP Jul.
CAMS Jul.
1 station
2 stations
3 stations
4 stations
5 stations
6 stations
>7 stations
Observations ug/m3
Model simulations ug/m3

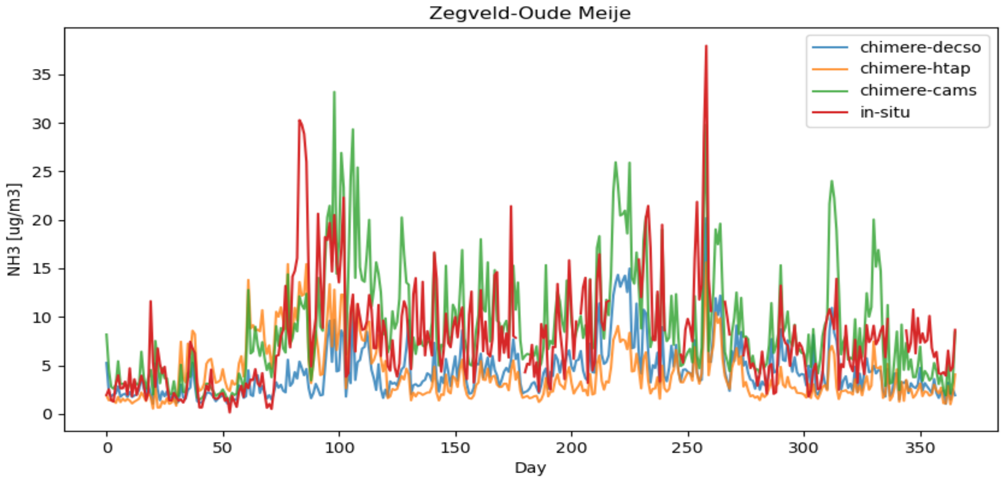
LML hourly nh3 measurement

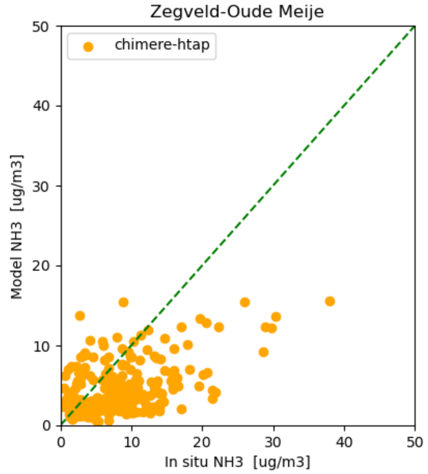


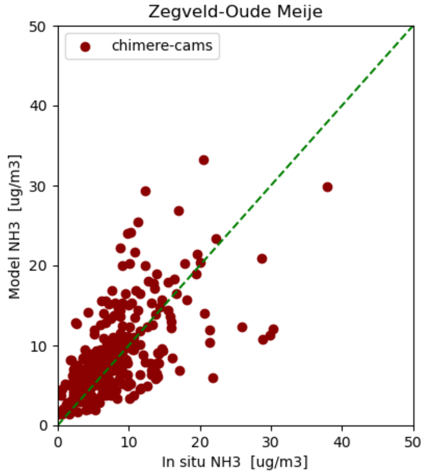


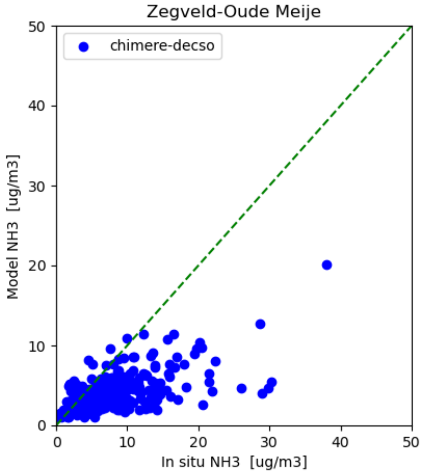




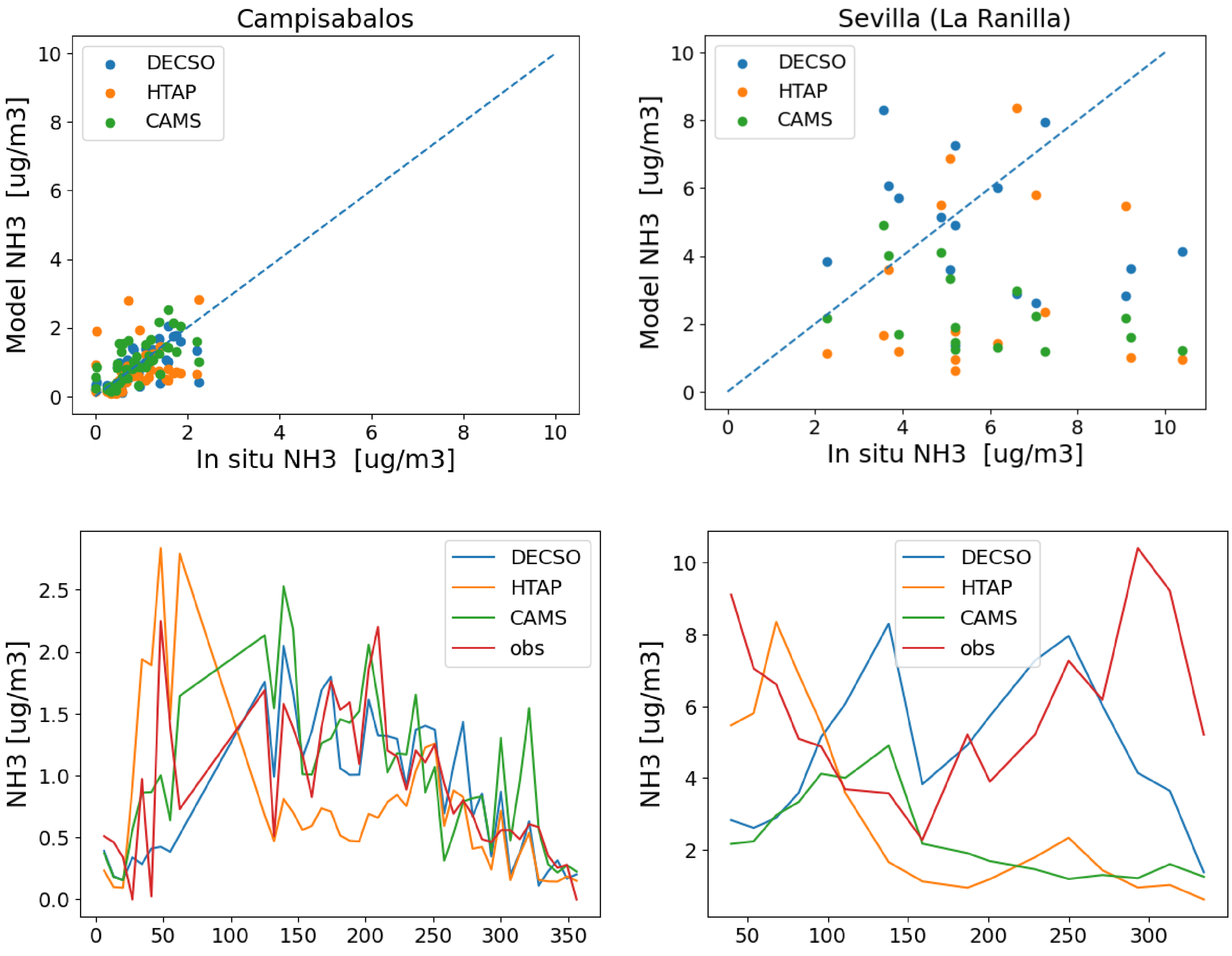




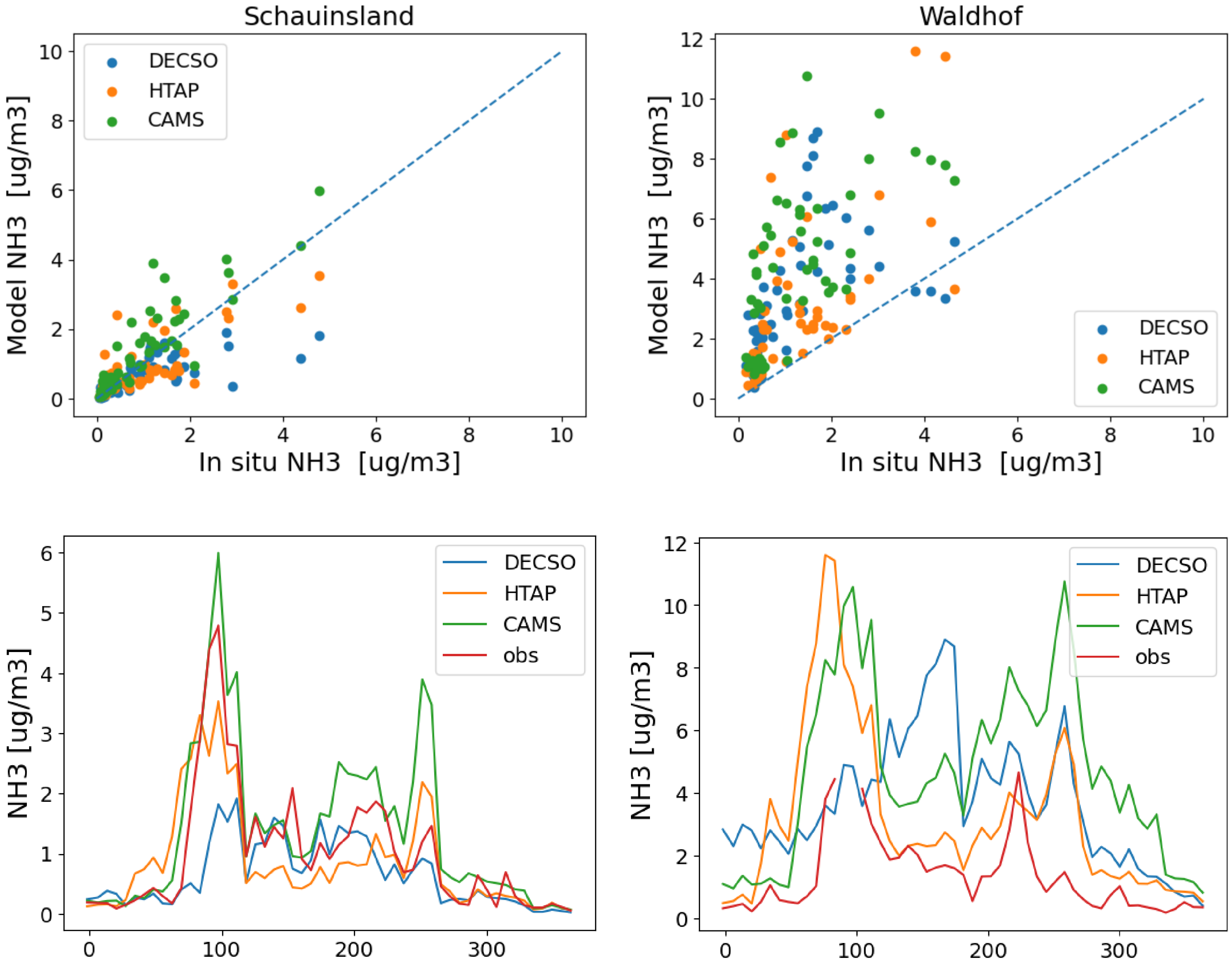




Spain


Campisabalos
Sevilla (La Ranilla)
DECSO
HTAP
CAMS
obs
Model NH3 [ug/m3]
In situ NH3 [ug/m3]
NH3 [ug/m3]

Germany



Schauinsland
Waldhof
Model NH3 [ug/m3]
In situ NH3 [ug/m3]
DECSO
HTAP
CAMS
obs
NH3 [ug/m3]
0
2
4
6
8
10
12
100
200
300

Conclusion

- The NH_3 emissions from DECSO are comparable with bottom-up emissions/ reported NH_3 emissions for country totals.
- The spatial distribution of NH_3 emissions from DECSO is reasonable. The regions with high NH_3 emissions are well detected.
- The seasonality of NH_3 emissions is different among bottom-up inventories. The results of DECSO are among the variation.
- We need do more studies on NH3 emissions especially seasonality