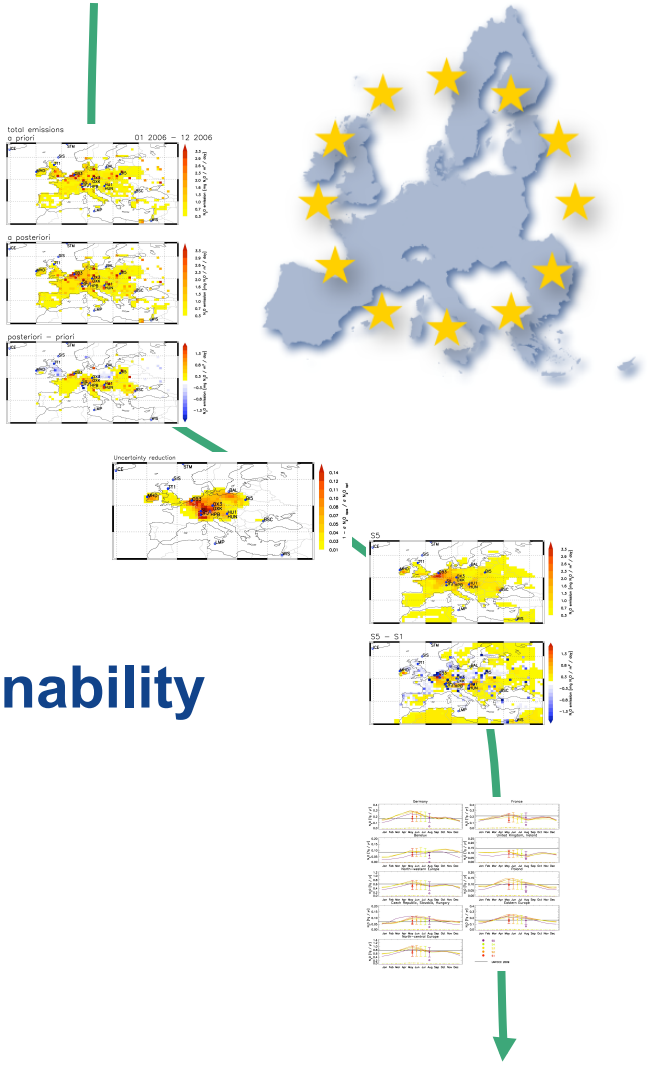
Joint Research Centre (JRC)

Matteo Corazza

Peter Bergamaschi, Arjo Segers



IES - Institute for Environment and Sustainability

Ispra - Italy

http://ies.jrc.ec.europa.eu/

http://www.jrc.ec.europa.eu/

The TM5 – 4DVar inverse modeling system for N_2O

- A very short description
- Sinks
- Initial Conditions
- A priori emission inventories
- Available Observations

Assimilating observations from different networks

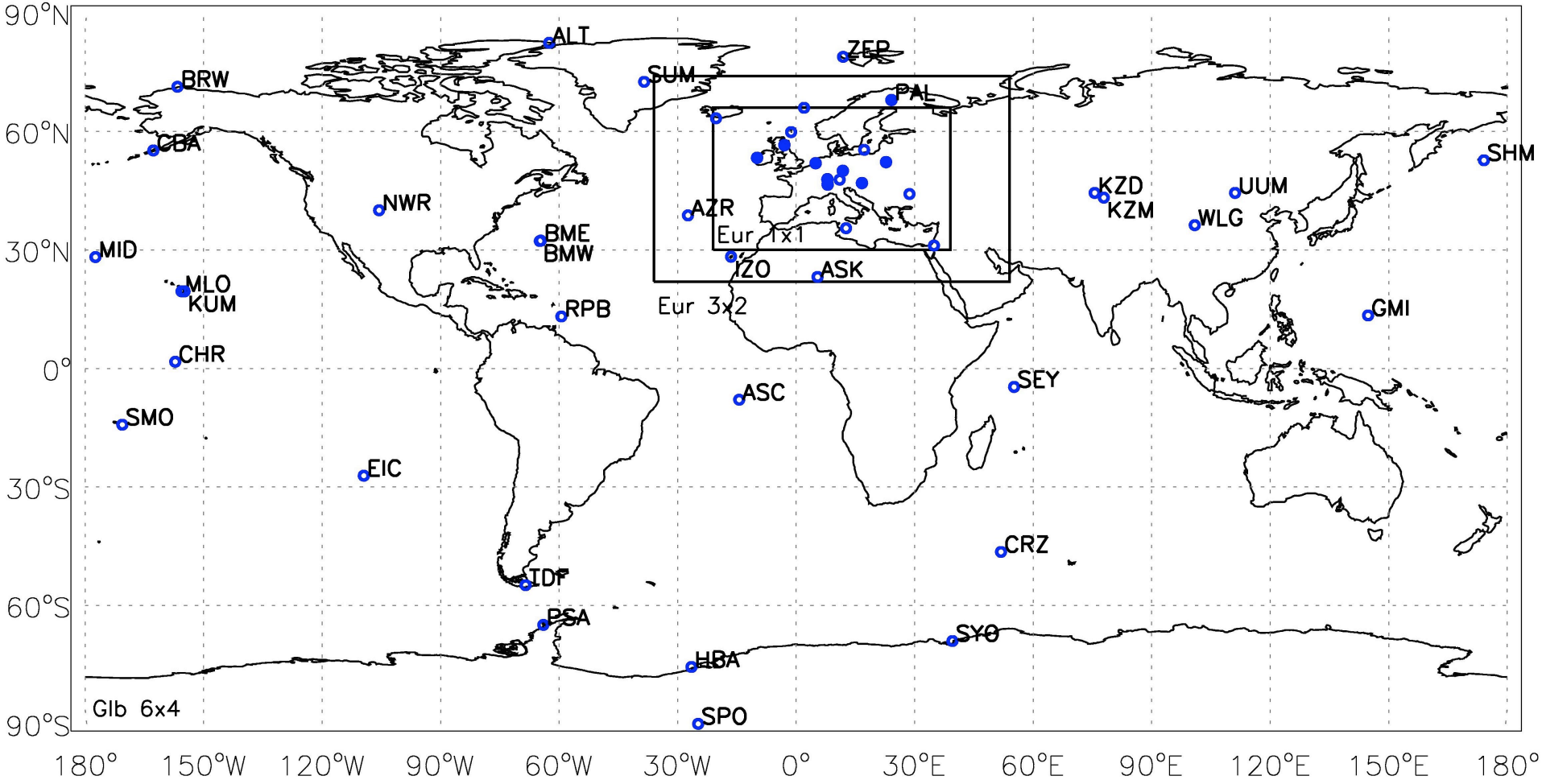
- Implementation of a bias correction scheme

Experiments

Results

Preliminary intercomparison results in the framework of NitroEurope IP

- Flask measurements (large part belonging to the NOAA network)
- Continuous measurements (from different networks over Europe)

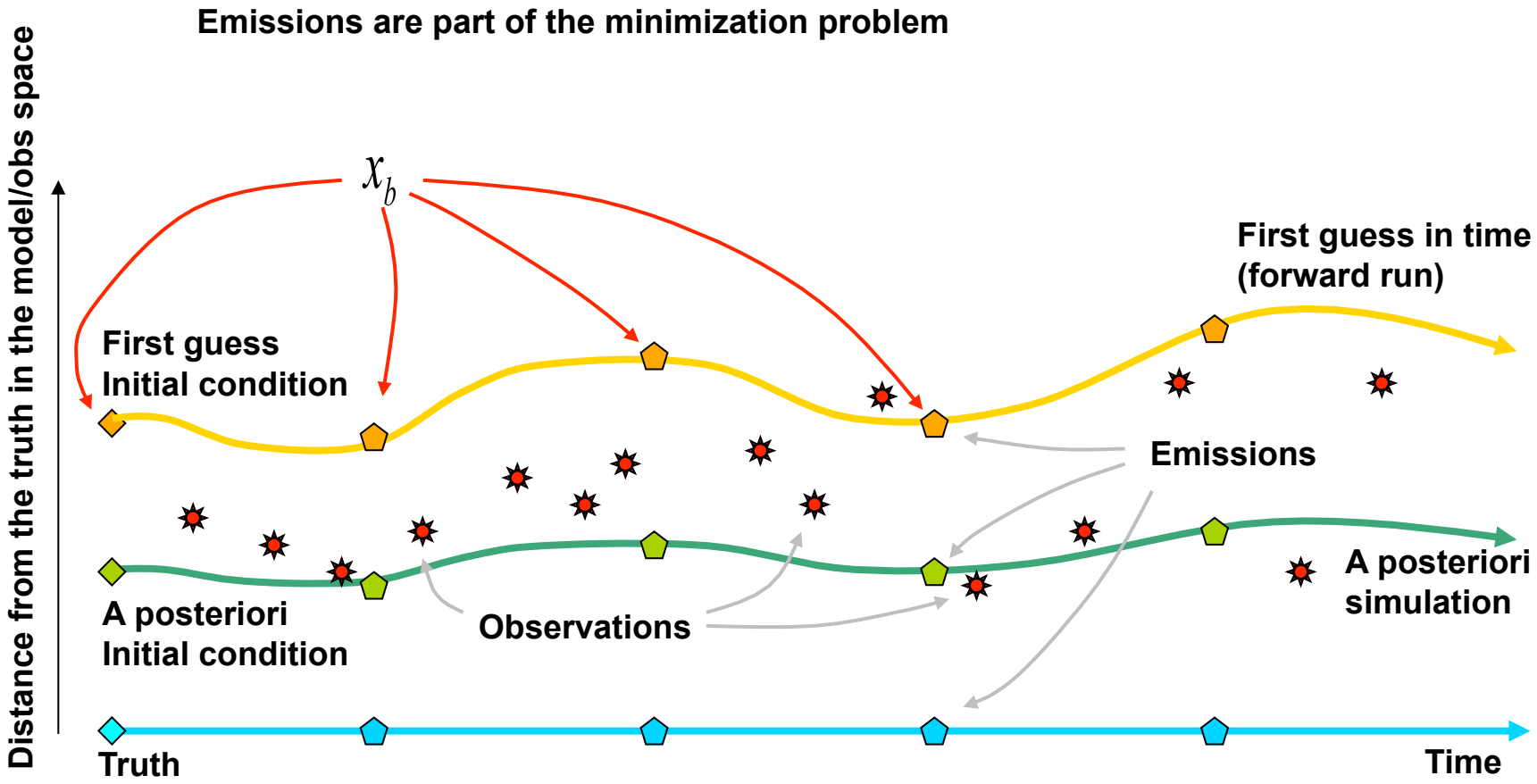


Parallel stations and Bias

In four sites parallel measurements from different networks are available: a not negligible bias for three of them is apparent both in 2006 and 2007.

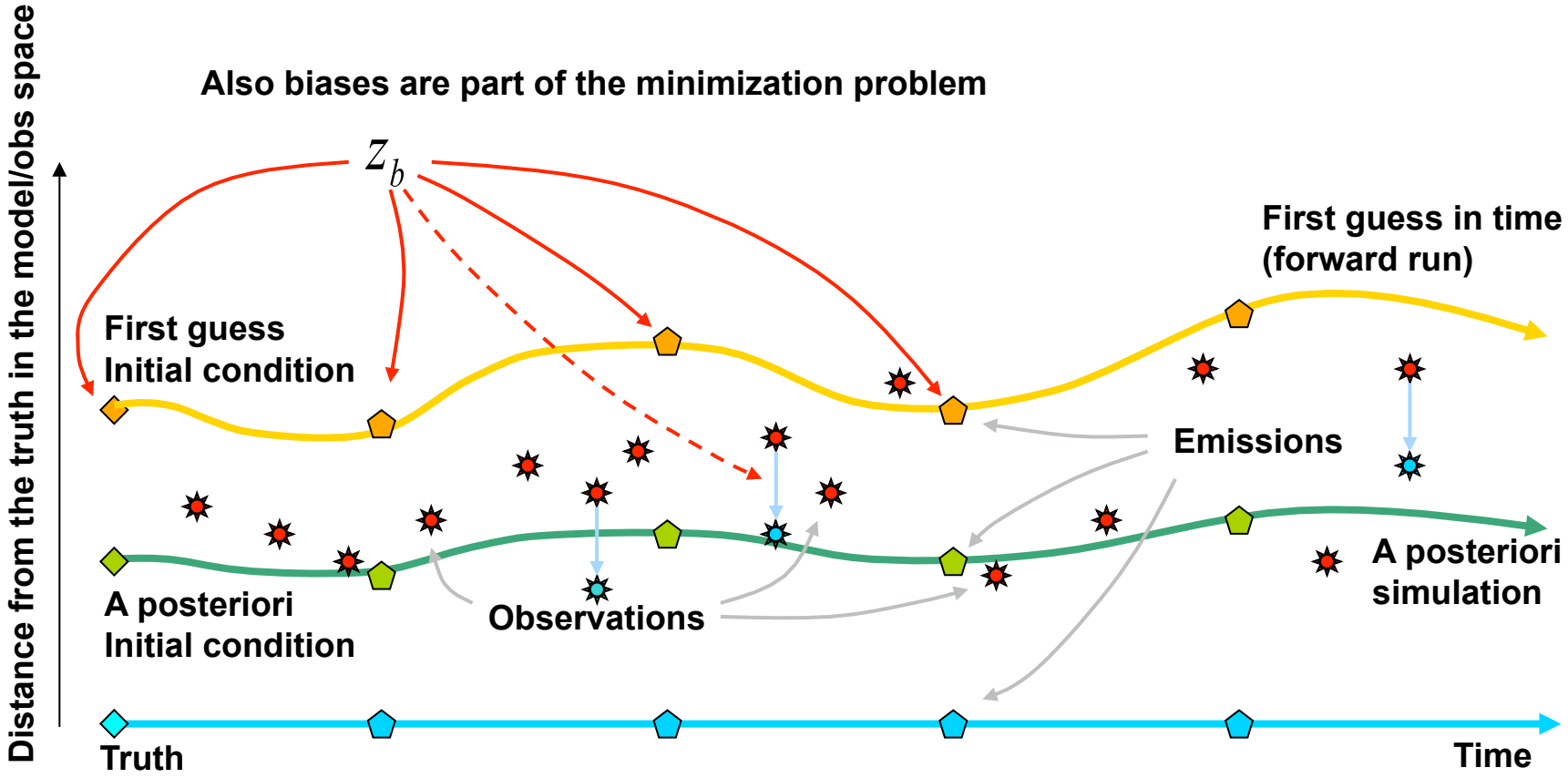
Station	Comparison with reference flask NOAA station (2006)	2007
Pallas	**0.5 ±0.3 (n=36)**	**0.4 ±0.4 (n=42)**
Mace Head	**-0.1 ±0.3 (n=36)**	**0.3 ±0.5 (n=37)**
Ochsenkopf	**1.0 ±0.4 (n=5)**	**0.2 ±0.7 (n=11)**
Hegyhatsal	**1.0 ±1.2 (n=23)**	**1.1 ±1.7 (n=21)**

$$J(x) = (x_b - x)^T B_x^{-1}(x_b - x) + [y - h(x)]^T R^{-1} [y - h(x)]$$



$$J(x) = (x_b - x)^T B_x^{-1}(x_b - x) + [y - h(x)]^T R^{-1} [y - h(x)]$$

$$\left.\begin{array}{l} \tilde{h}(z) = \tilde{h}(x, \beta) \\ z^T = [x^T \ \beta^T] \end{array}\right\} \Rightarrow J(z) = (z_b - z)^T B_z^{-1}(z_b - z) + [y - \tilde{h}(z)]^T R^{-1} [y - \tilde{h}(z)]$$



Control Simulation (S1): 2006 and 2007

- ERA Interim meteorological forcing;
- m1qn3 minimization algorithm;
- October 20, 2009 release of the NitroEurope IP modeling protocol;
- Initial conditions from long term data assimilation global experiments;
- Spatial correlation coefficient for emissions equal to 200 km.
- 4 group categories for emission (originally 13 categories):
  ocean, soil, biomass burning, remaining emissions.

Bias correction

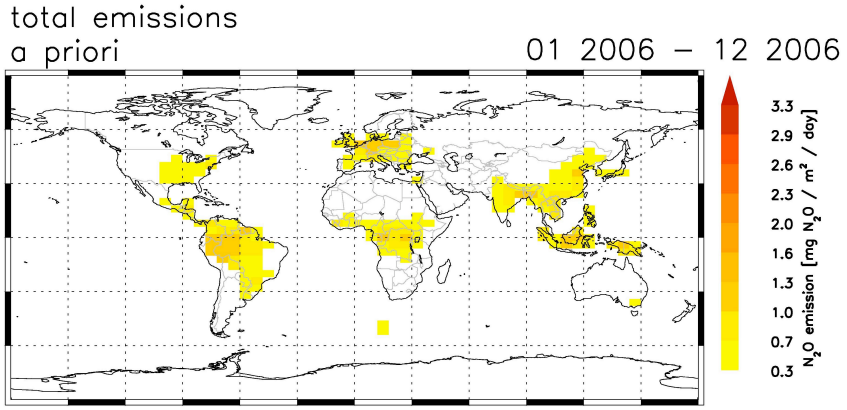
Station	network / laboratory	Comparison with NOAA	S1
Pallas	FMI	0.5 ±0.3 (n=36)	0.5
Shetland Island	MPI		0.5
Angus	CHIOTTO		0.8
Mace Head	AGAGE	-0.1 ±0.3 (n=36)	0.0
Bialystok	CHIOTTO		0.3
Cabauw	CHIOTTO		0.2
Ochsenkopf	CHIOTTO	1.0 ±0.4 (n=5)	1.1
Schauinsland	UBA		0.4
Hegyhatsal	CHIOTTO	1.0 ±1.2 (n=23)	1.0
Jungfraujoch	NABEL		-0.4

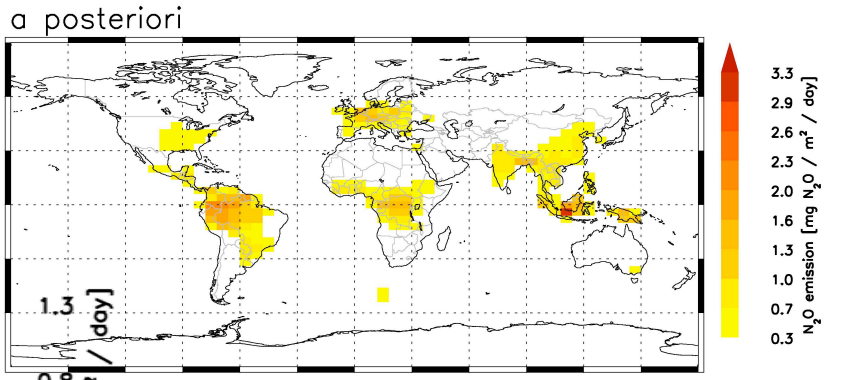
Global domain:

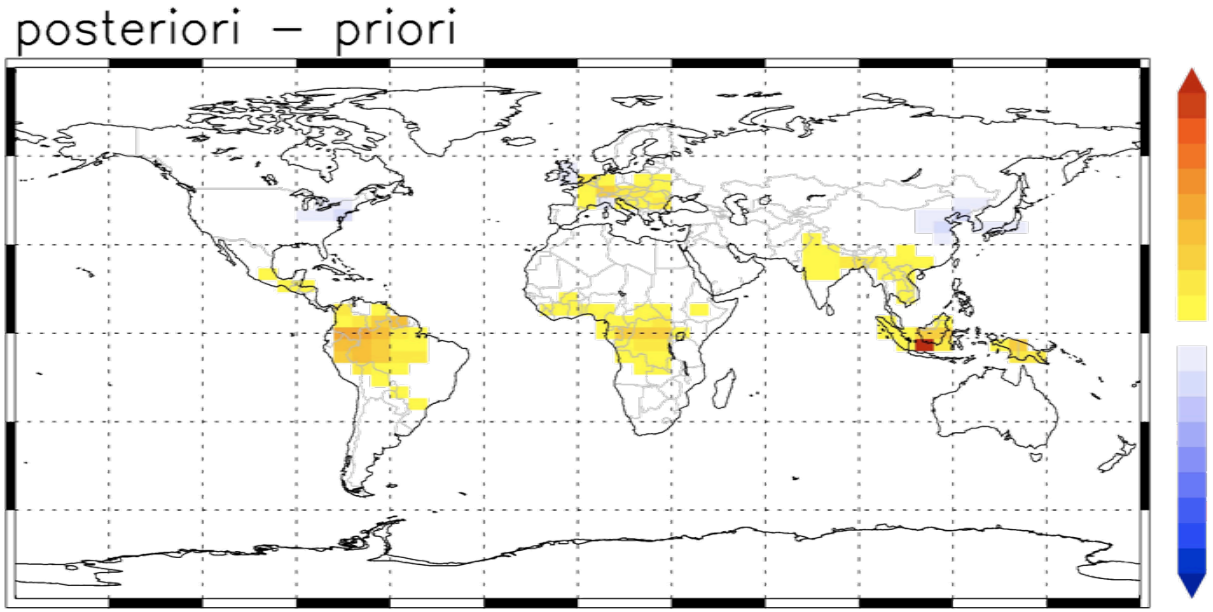
Total Emission: 16.06 Tg N_{N2O}/yr
A priori value: 13.76 Tg N_{N2O}/yr

Total sinks: 12.08 Tg N_{N2O}/yr

Resulting lifetime: ~ 127 years

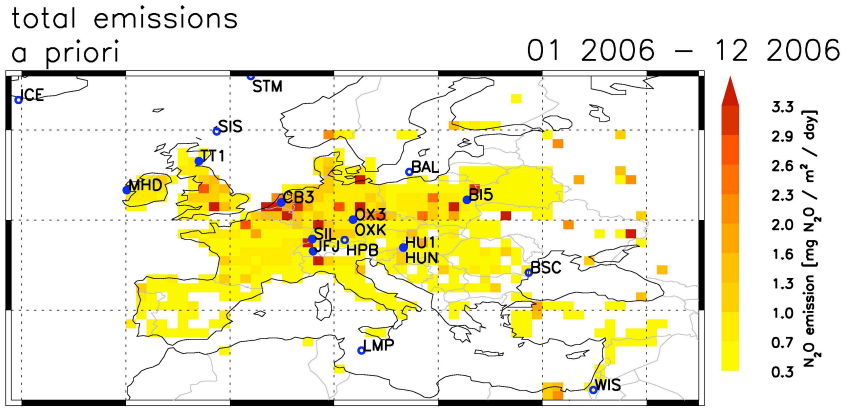


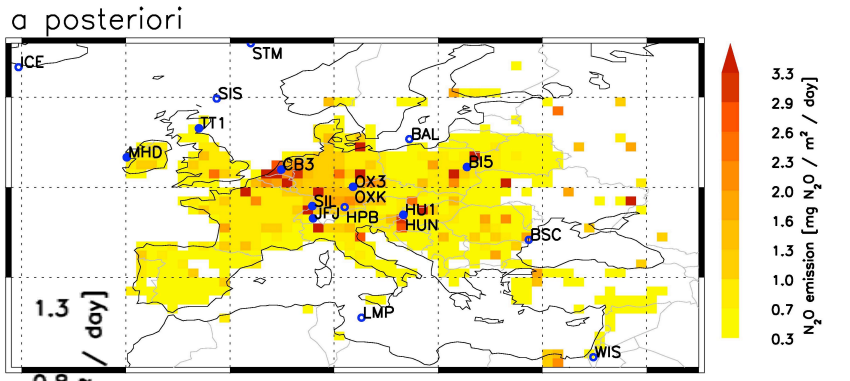


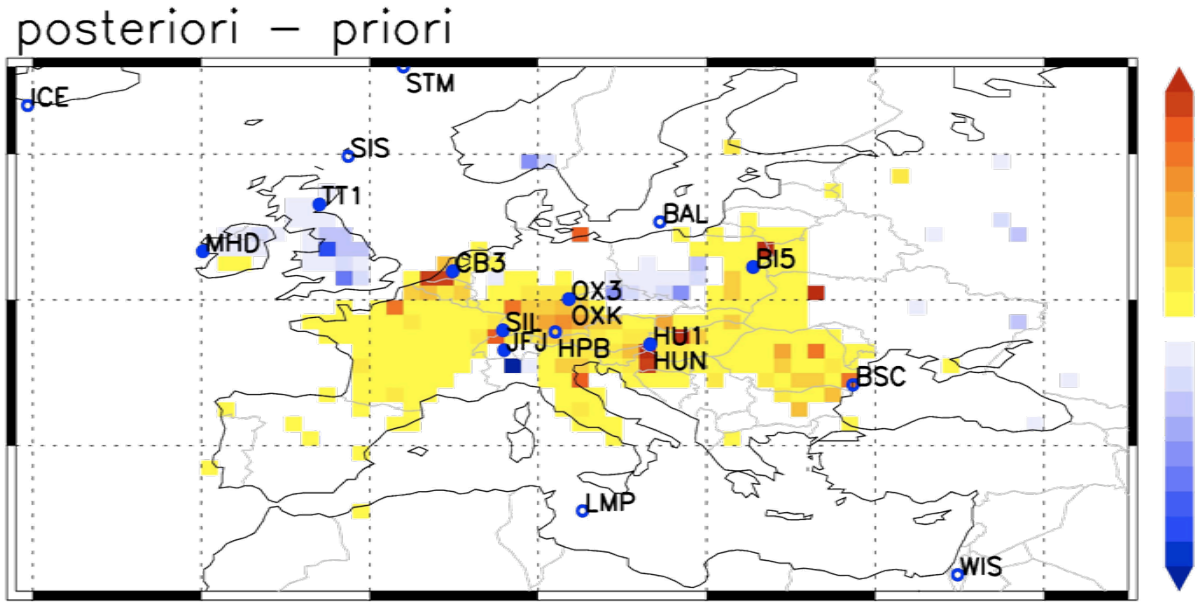


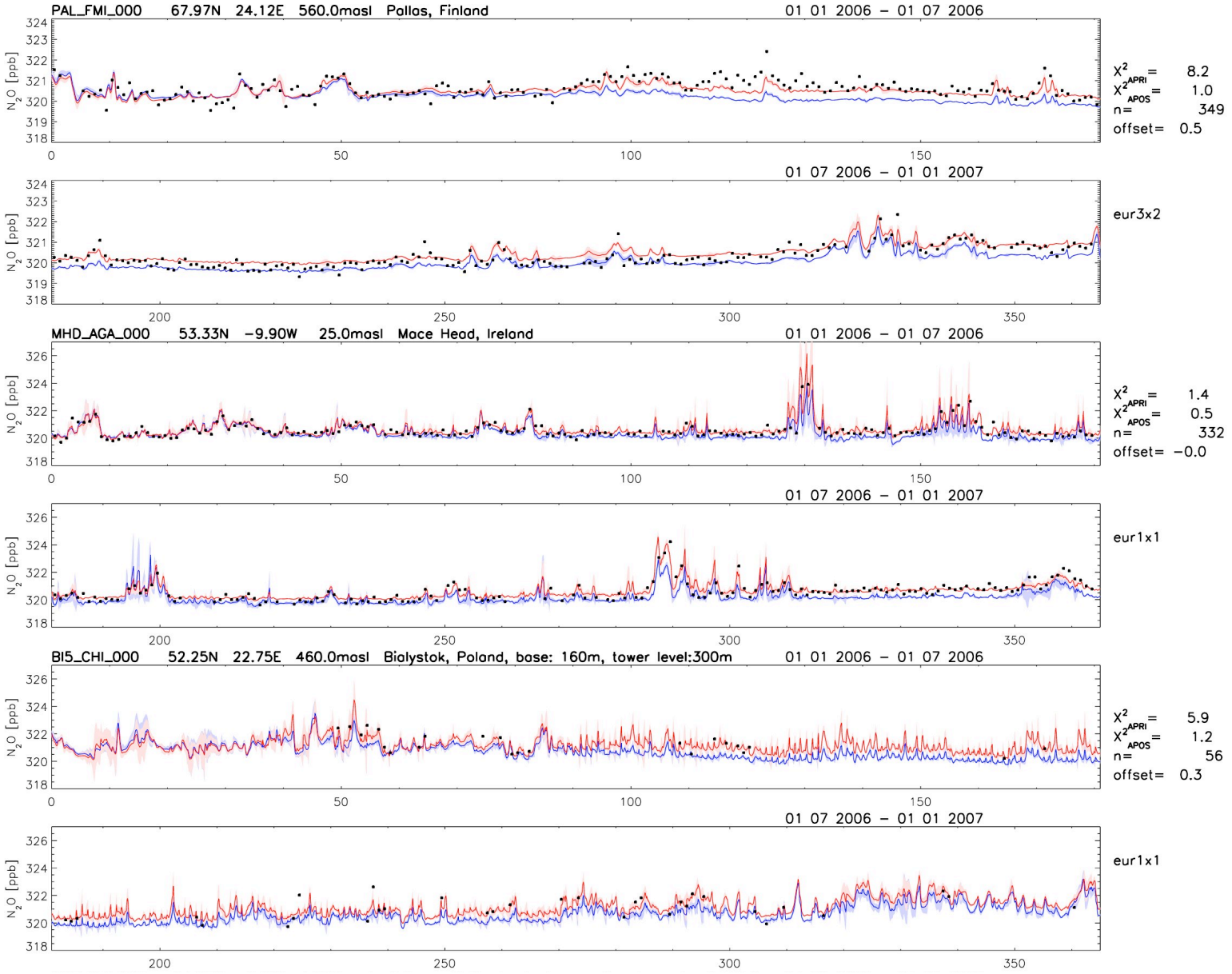
European domain:

Total Emission: 1.19 Tg N_{N2O}/yr
A priori value: 1.05 Tg N_{N2O}/yr









A priori
A posteriori

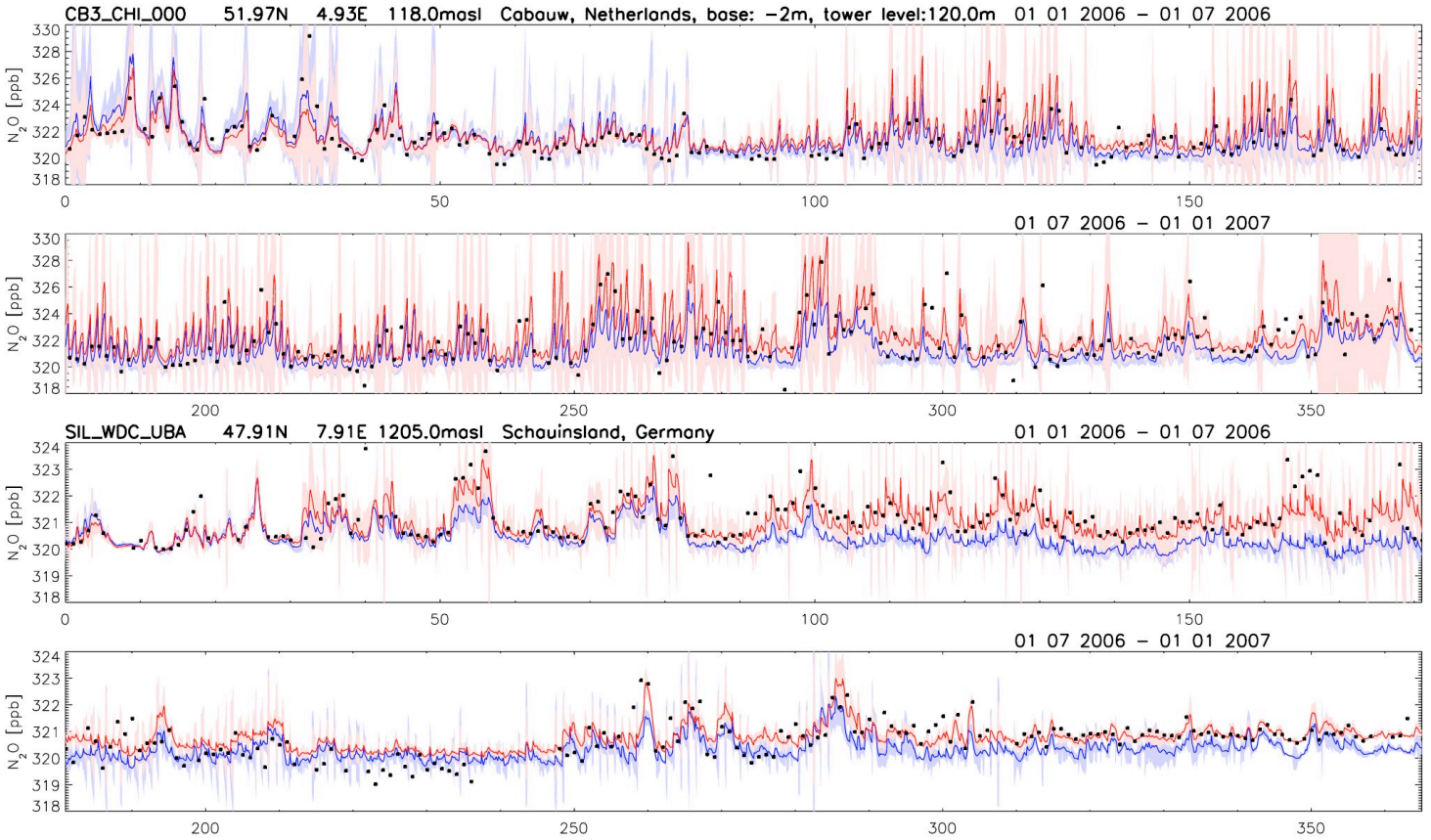
Pallas

Mace Head

Bialystok

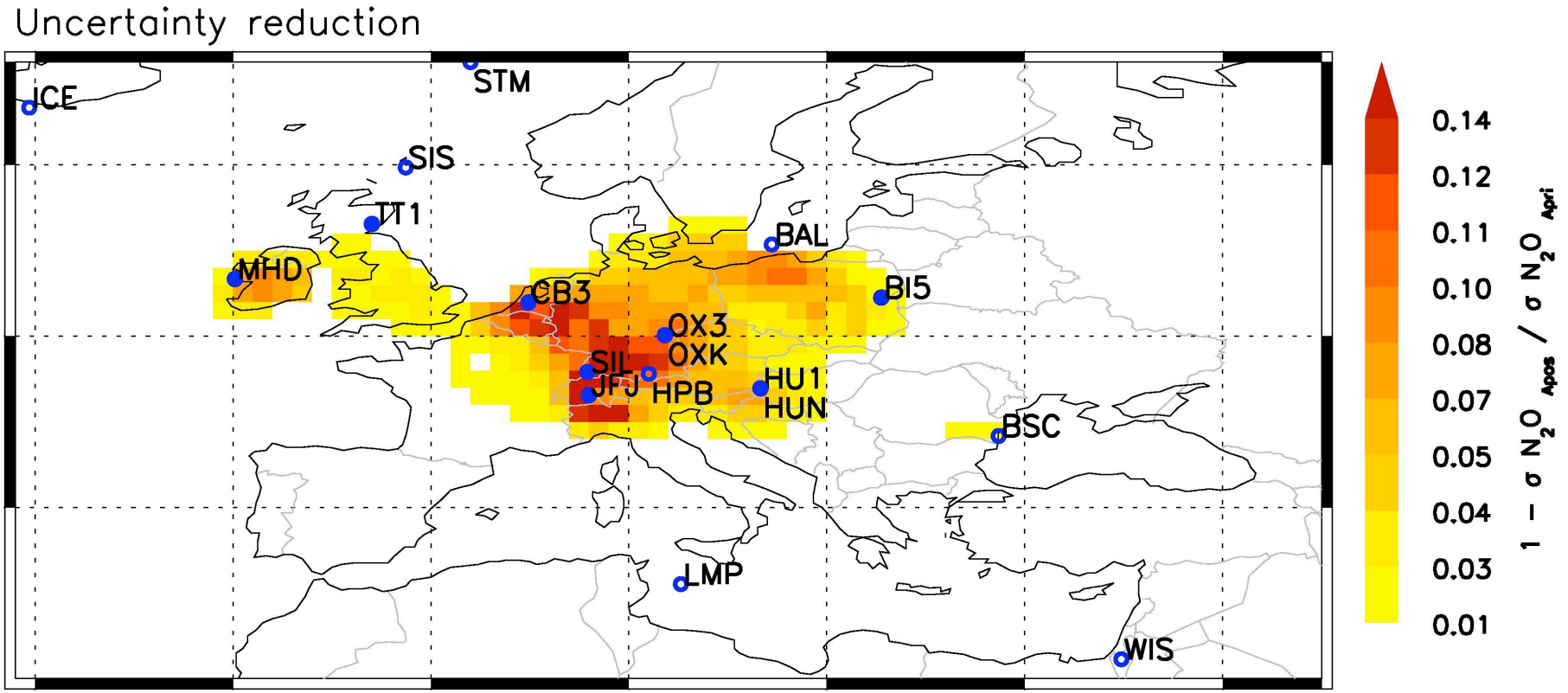
Concentration time series at stations sites

A priori
A posteriori



Cabauw

Schauinsland


Uncertainty reduction
ICE
STM
SIS
TT1
MHD
BAL
CB3
BI5
OX3
OXK
SIL
JFJ
HPB
HU1
HUN
BSC
LMP
WIS
0.14
0.12
0.11
0.10
0.08
0.07
0.05
0.04
0.03
0.01
1 − σ N2O Apos / σ N2O Apri

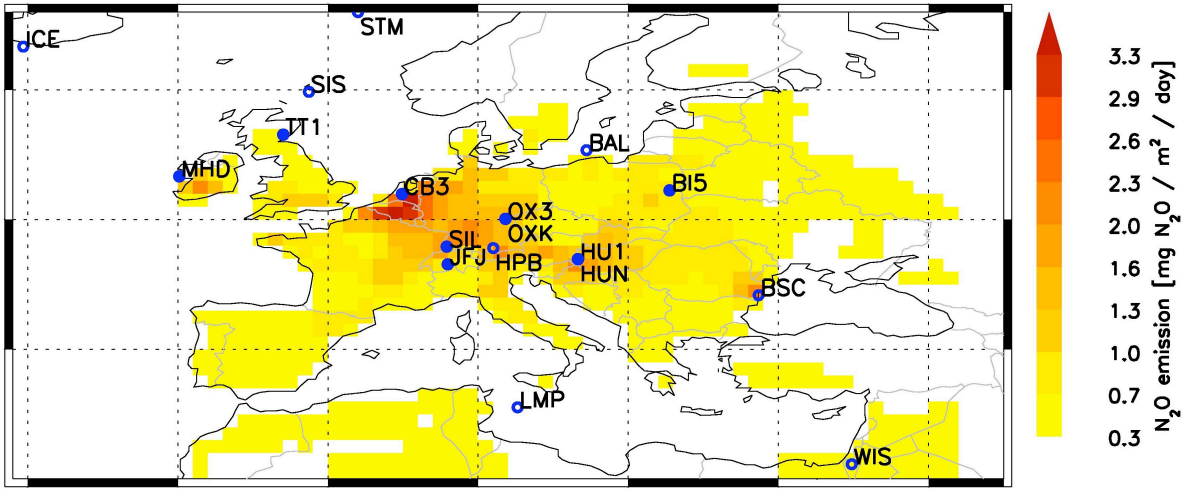
Sensitivity experiments

Inversion	L_corr	Description
S1	200 km	Reference inversion
S2	300 km	As S1, but spatial correlation length 300 km
S3	100 km	As S1, but spatial correlation length 100 km
S4	200 km	As S1, without using the parallel NOAA measurements at 4 European stations
S5	50 km	As S1, but homogeneous a priori emissions (two different values over land and over ocean, respectively). Spatial correlation length 50 km, and uncertainty of emissions set to 500%. Only total emissions optimized.

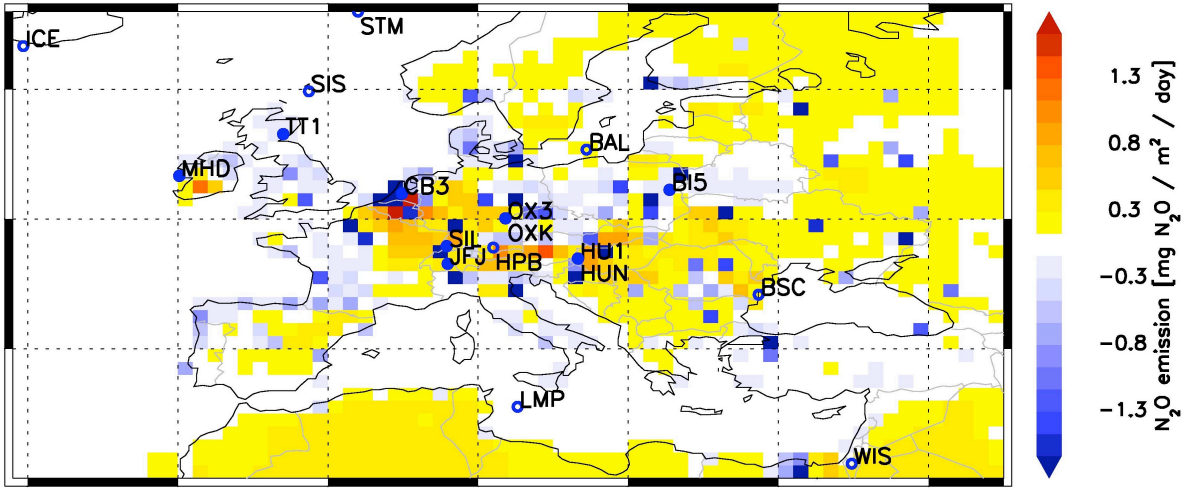
Bias correction

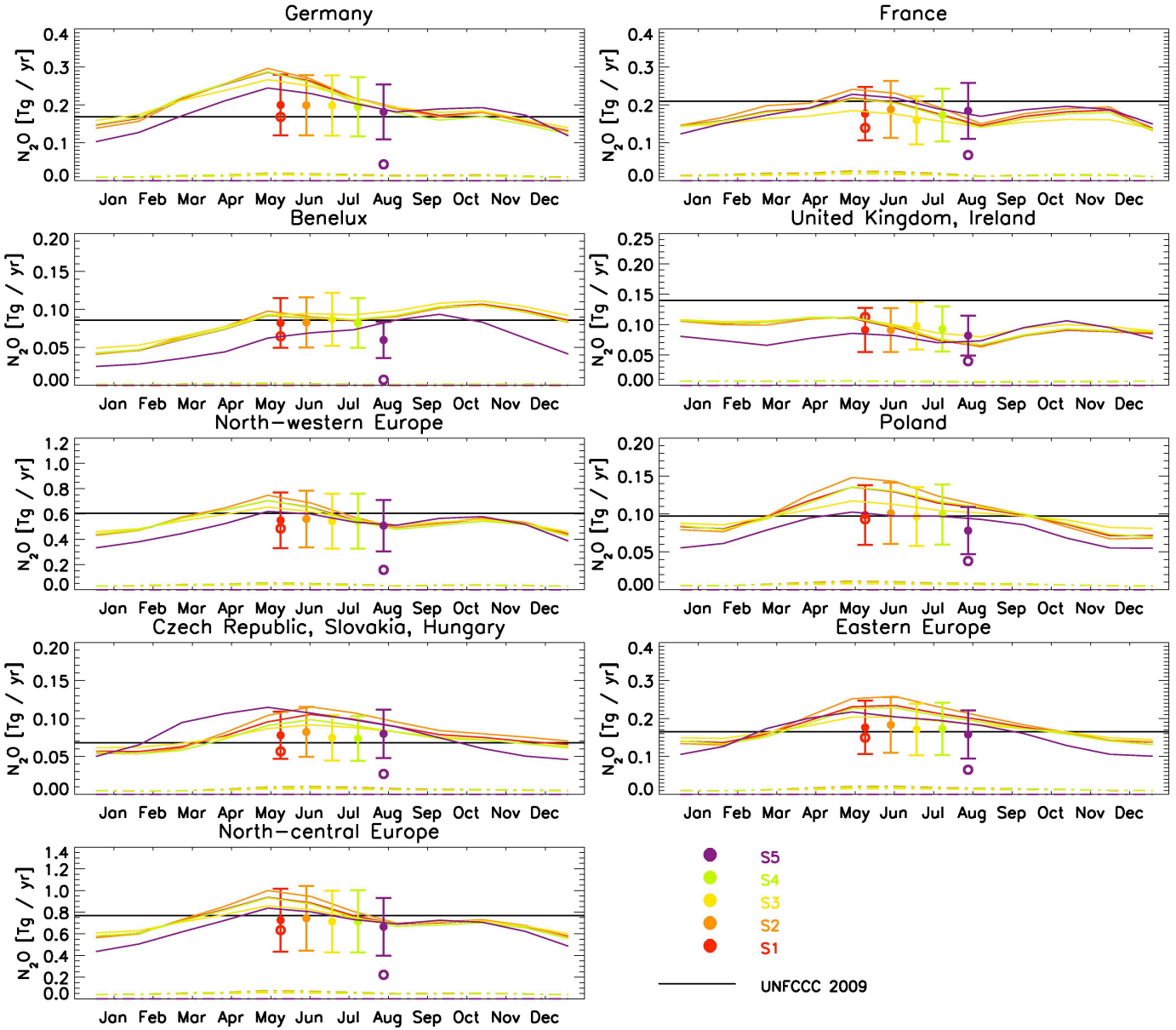
Station	network / laboratory	Comparison with NOAA	S1	S2	S3	S4	S5
Pallas	FMI	0.5 ±0.3 (n=36)	0.5	0.5	0.5	0.5	0.5
Shetland Island	MPI		0.5	0.5	0.5	0.5	0.6
Angus	CHIOTTO		0.8	0.8	0.8	0.8	0.8
Mace Head	AGAGE	-0.1 ±0.3 (n=36)	0.0	0.0	0.0	-0.1	0.0
Bialystok	CHIOTTO		0.3	0.2	0.3	0.3	0.4
Cabauw	CHIOTTO		0.2	0.2	0.2	0.2	0.6
Ochsenkopf	CHIOTTO	1.0 ±0.4 (n=5)	1.1	1.1	1.1	1.1	1.2
Schauinsland	UBA		0.4	0.4	0.5	0.4	0.5
Hegyhatsal	CHIOTTO	1.0 ±1.2 (n=23)	1.0	1.0	1.1	1.1	1.1
Jungfraujoch	NABEL		-0.4	-0.4	-0.4	-0.4	-0.4

S5


ICE
STM
SIS
TT1
MHD
BAL
CB3
BI5
OX3
OXK
SII
JFJ
HPB
HU1
HUN
BSC
LMP
WIS
3.3
2.9
2.6
2.3
2.0
1.6
1.3
1.0
0.7
0.3
N2O emission [mg N2O / m2 / day]

S5 – S1


ICE
STM
SIS
TT1
MHD
BAL
CB3
BI5
OX3
OXK
SII
JFJ
HPB
HU1
HUN
BSC
LMP
WIS
1.3
0.8
0.3
−0.3
−0.8
−1.3
N2O emission [mg N2O / m2 / day]


Germany
France
Benelux
United Kingdom, Ireland
North−western Europe
Poland
Czech Republic, Slovakia, Hungary
Eastern Europe
North−central Europe
N2O [Tg / yr]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
S5
S4
S3
S2
S1
UNFCCC 2009

NEU A6.2: "Independent inverse modelling of European N_2O and CH_4 emissions"

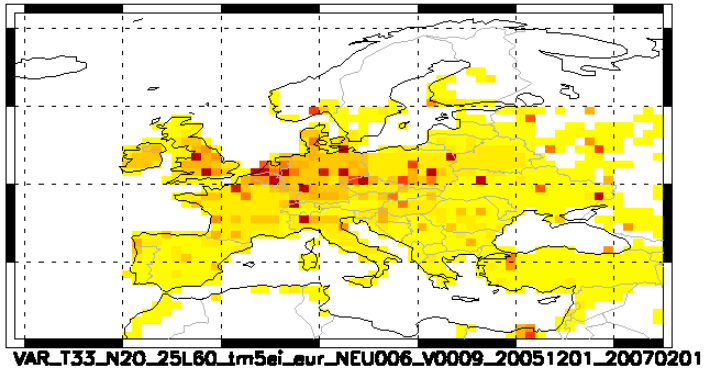
Inverse modelling:

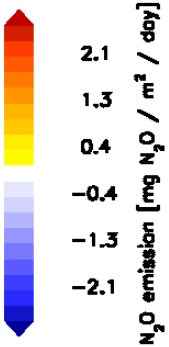
- **JRC (Peter Bergamaschi, Matteo Corazza, Arjo Segers)**
- **ECN (Alex Vermeulen)**
- **UK-MET (Alistair Manning, Maria Athanassiadou)**
- **LSCE-CEA (Philippe Bousquet, Rona Thompson, Isabelle Pison)**
- **MPI (Ute Karstens, Martin Heimann)**

Bottom-up inventories (N_2O soil emission):

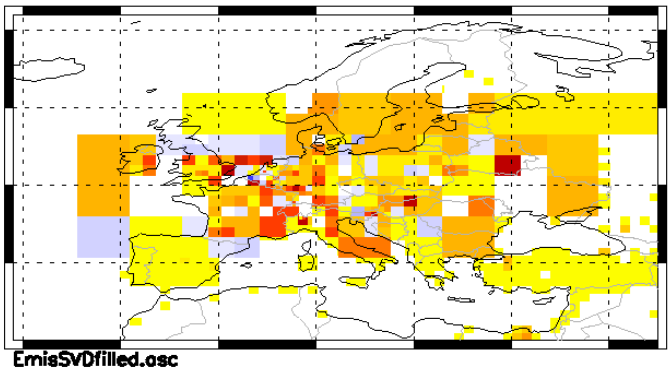
- **FZK (Christian Werner)**

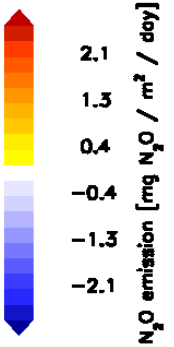
apriori 2006 Scenario S1



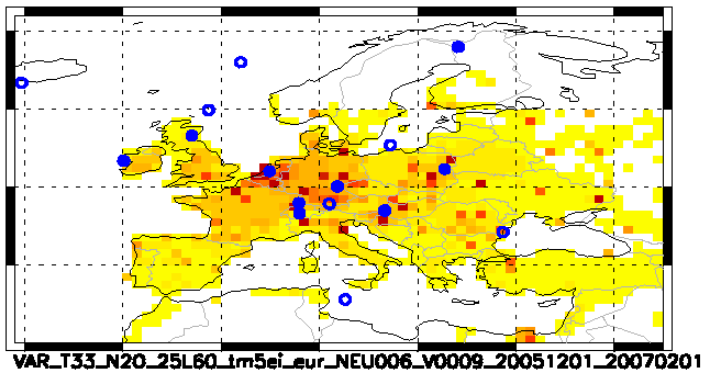


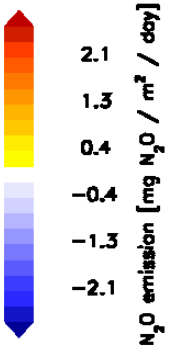
COMET 2006 Scenario S1



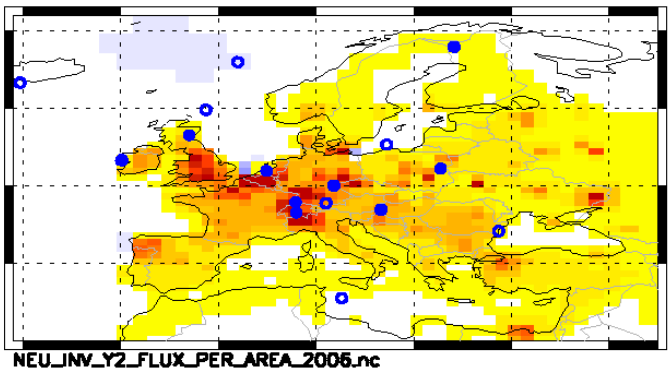


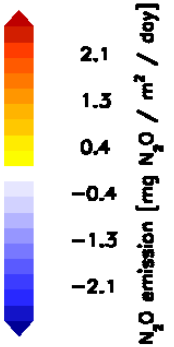
TM5−4DVAR 2006 Scenario S1



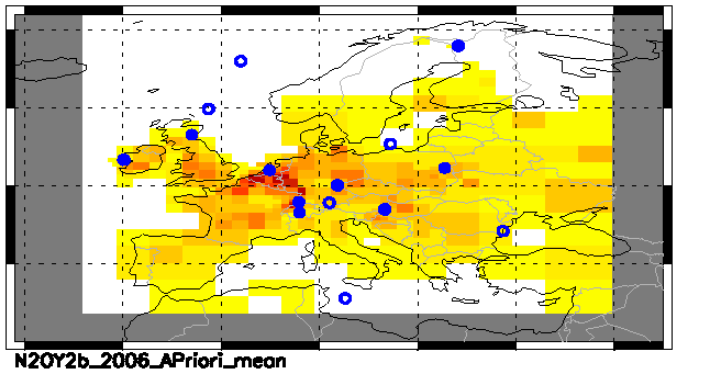


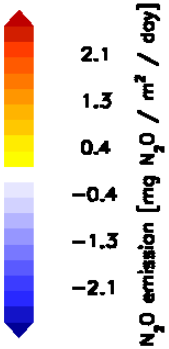
LMDZ 2006 Scenario S1



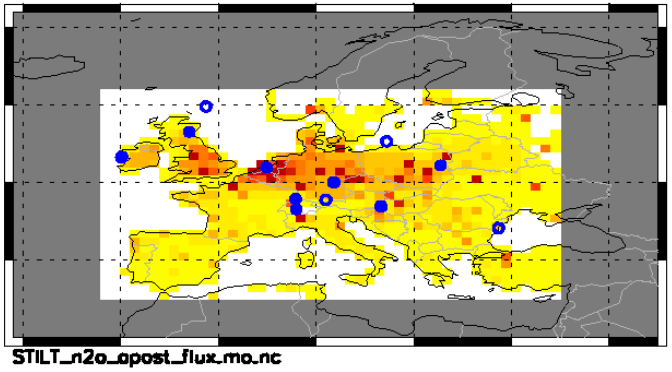


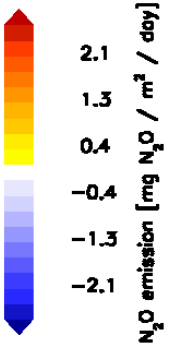
NAME 2006 Scenario S1



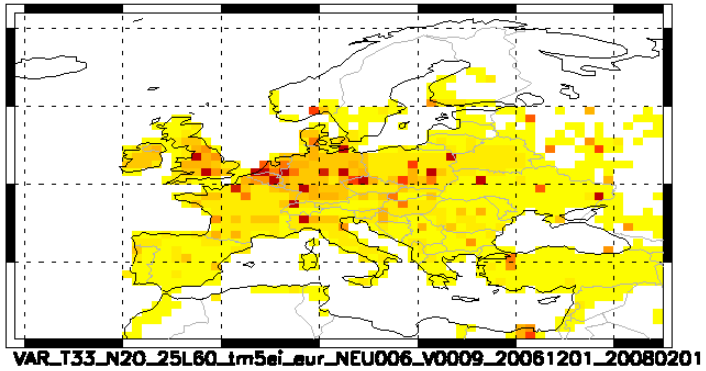


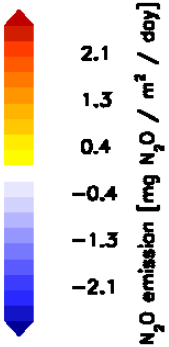
TM3−STILT 2006 Scenario S1



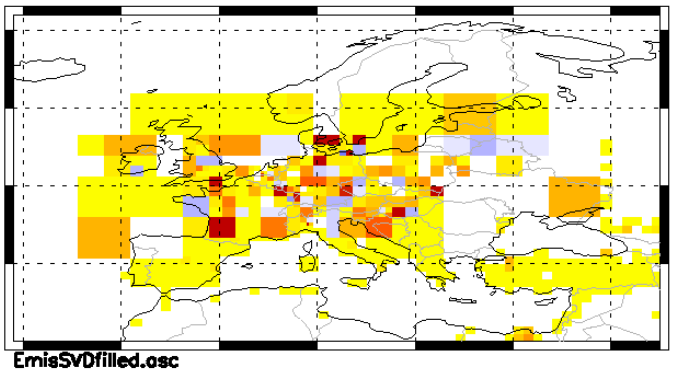


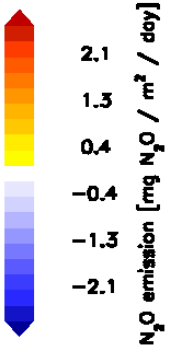
apriori 2007 Scenario S1



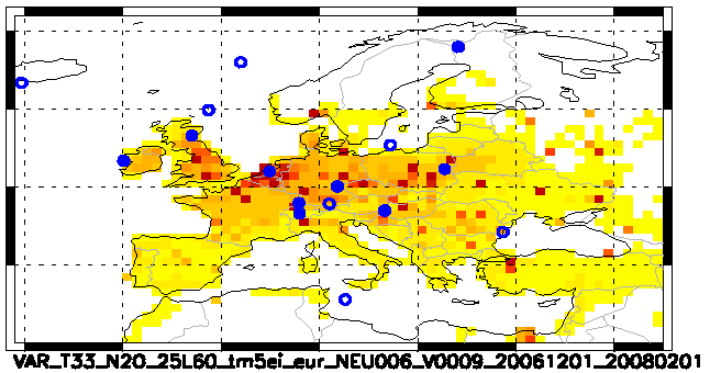


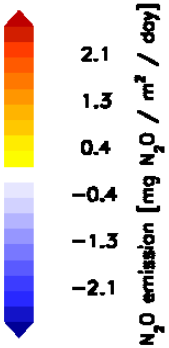
COMET 2007 Scenario S1



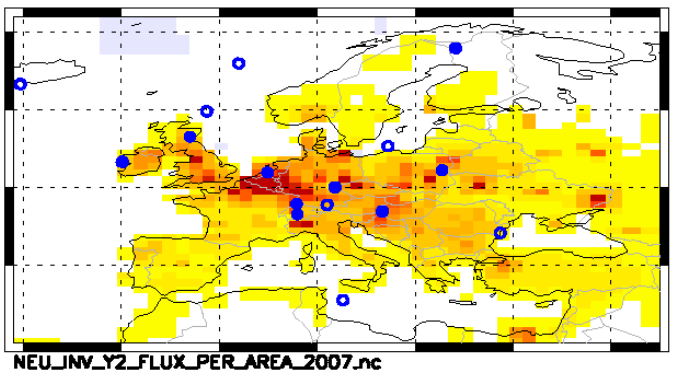


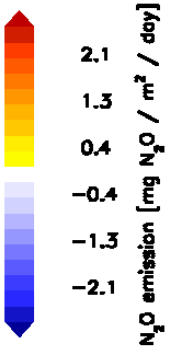
TM5–4DVAR 2007 Scenario S1



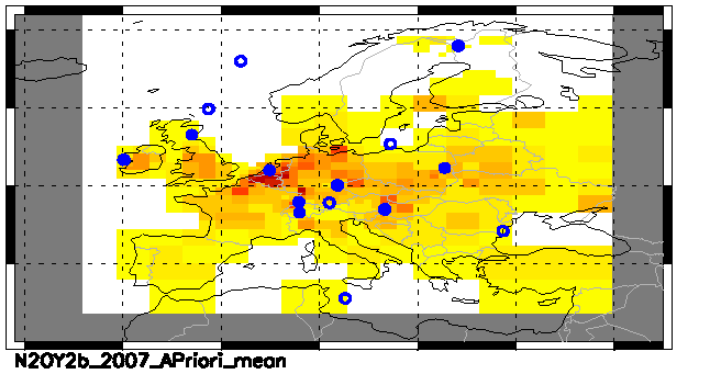


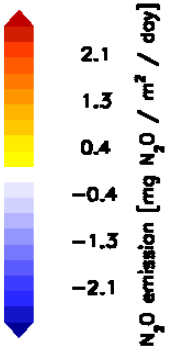
LMDZ 2007 Scenario S1



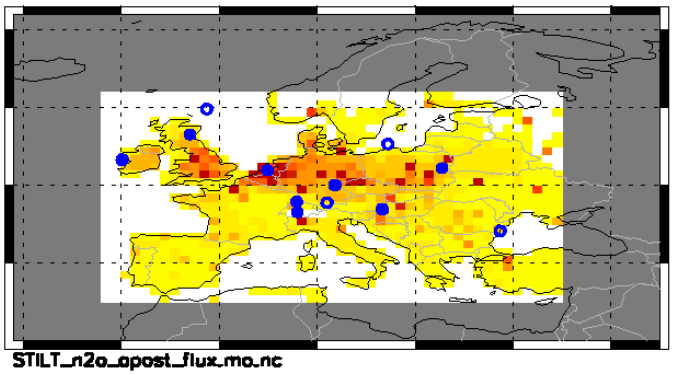


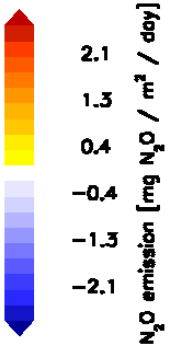
NAME 2007 Scenario S1



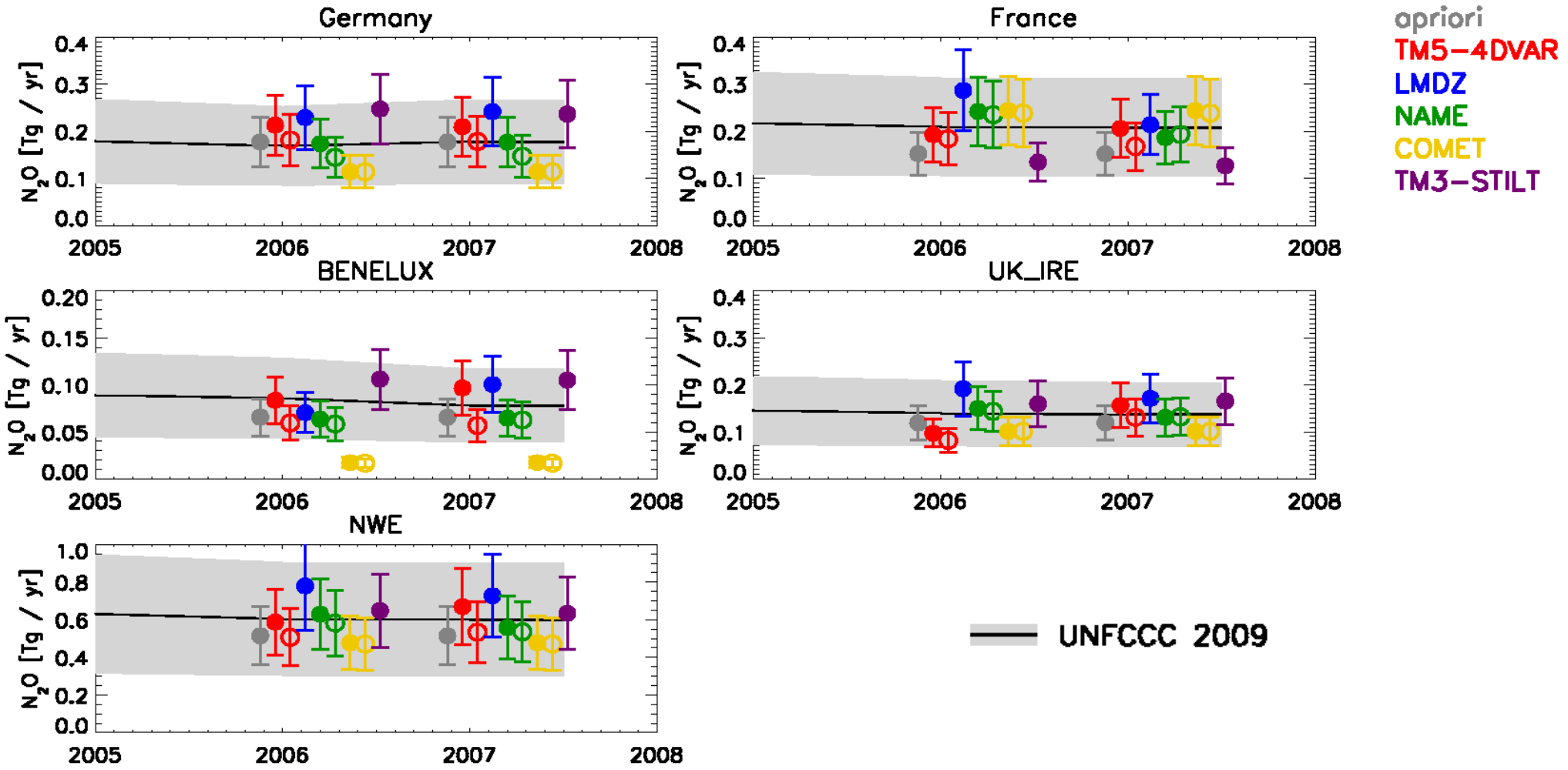


TM3–STILT 2007 Scenario S1

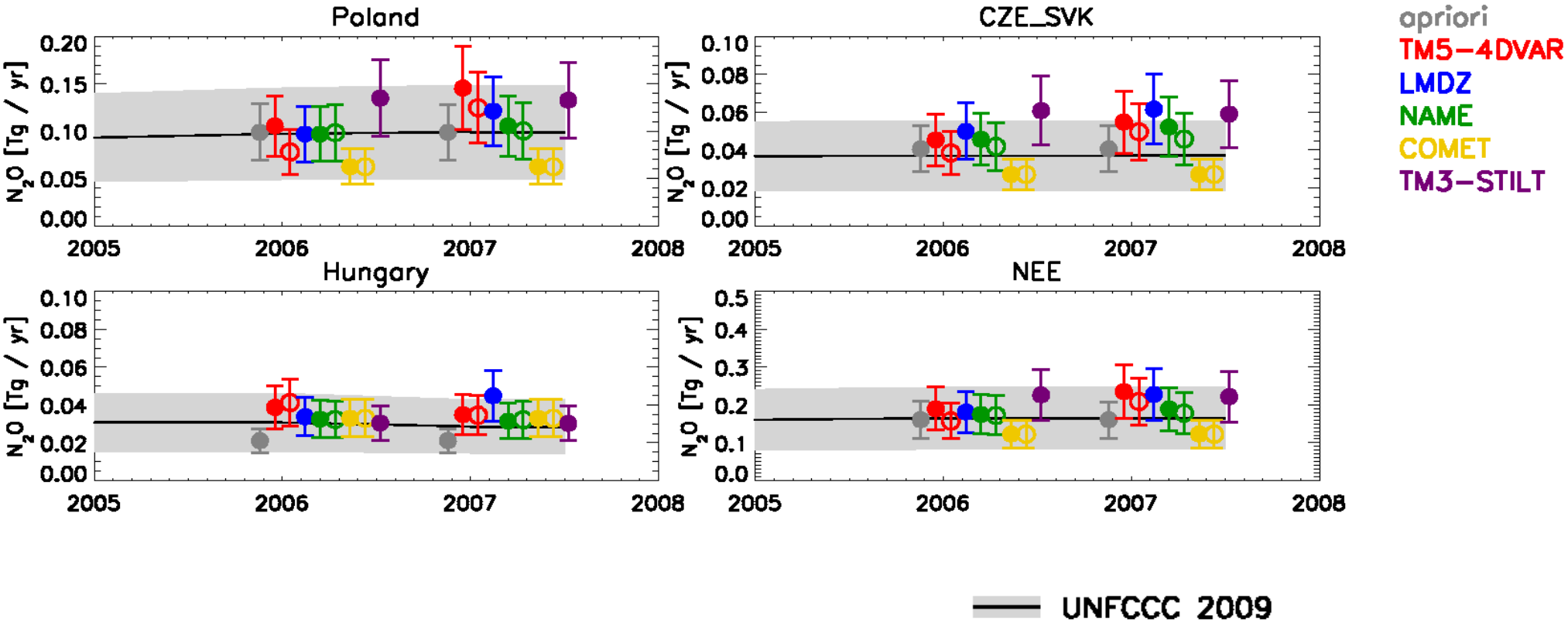




NitroEurope IP intercomparison



NitroEurope IP intercomparison



Conclusions and discussion

- Assimilating observations from different network is possible (and the path is to use schemes for bias correction);
- Total anthropogenic emissions obtained by the TM5-4DVAR compare well with the UNFCCC inventories at country scales (this in spite of very large uncertainties estimated for UNFCCC data);
- The use of a constant a priori emission inventory provides good results, showing that inverse modeling can be used as an independent top-down verification tool for bottom-up inventories;
- “Official” and more reliable results soon available in the framework of the model intercomparison carried on for NitroEurope IP
- Results using the very preliminary daily varying inventory show that the bias correction system is solid, and that future versions of the inventory are potentially capable to improve results.

What next?

- **Model intercomparison in the framework of NitroEurope IP:**
  - Verification;
  - Ensemble results;
  - Putting all together;
- **Daily varying inventory:**
  - Experiments with updated inventory;
  - Reduction of emission base timescale, weekly or daily optimizations;
- **Better characterization of errors?**
  - Model
  - Meteorological information
  - Aggregated errors (Thompson, 2010)
  - Else?