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Update on N2O Inverse Modelling at JRC

Matteo Corazza
Peter Bergamaschi

European Commission Joint Research Centre, Institute for Environment and Sustainability, Climate Change Unit, I-21027 Ispra (VA), Italy

Layout

- **Sinks and Initial conditions**

- **Correction of the calibration offsets between different station networks within the 4DVar code**

  - **Implementation**
  - **Results**

- **Sensitivity experiments**

- **Results**

Bias Correction

Different station network show to have inconsistent calibrations:

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)

Bias Correction

It is therefore necessary to introduce a bias correction for observation stations in order to take into account these differences.

Starting from the standard minimization problem,

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

Modify the observation operator to account for bias: $\tilde{h}(z) = \tilde{h}(x, \beta)$

Include the bias parameters in the control vector: $z^T = [\, x^T \;\; \beta^T \,]$

New minimization:

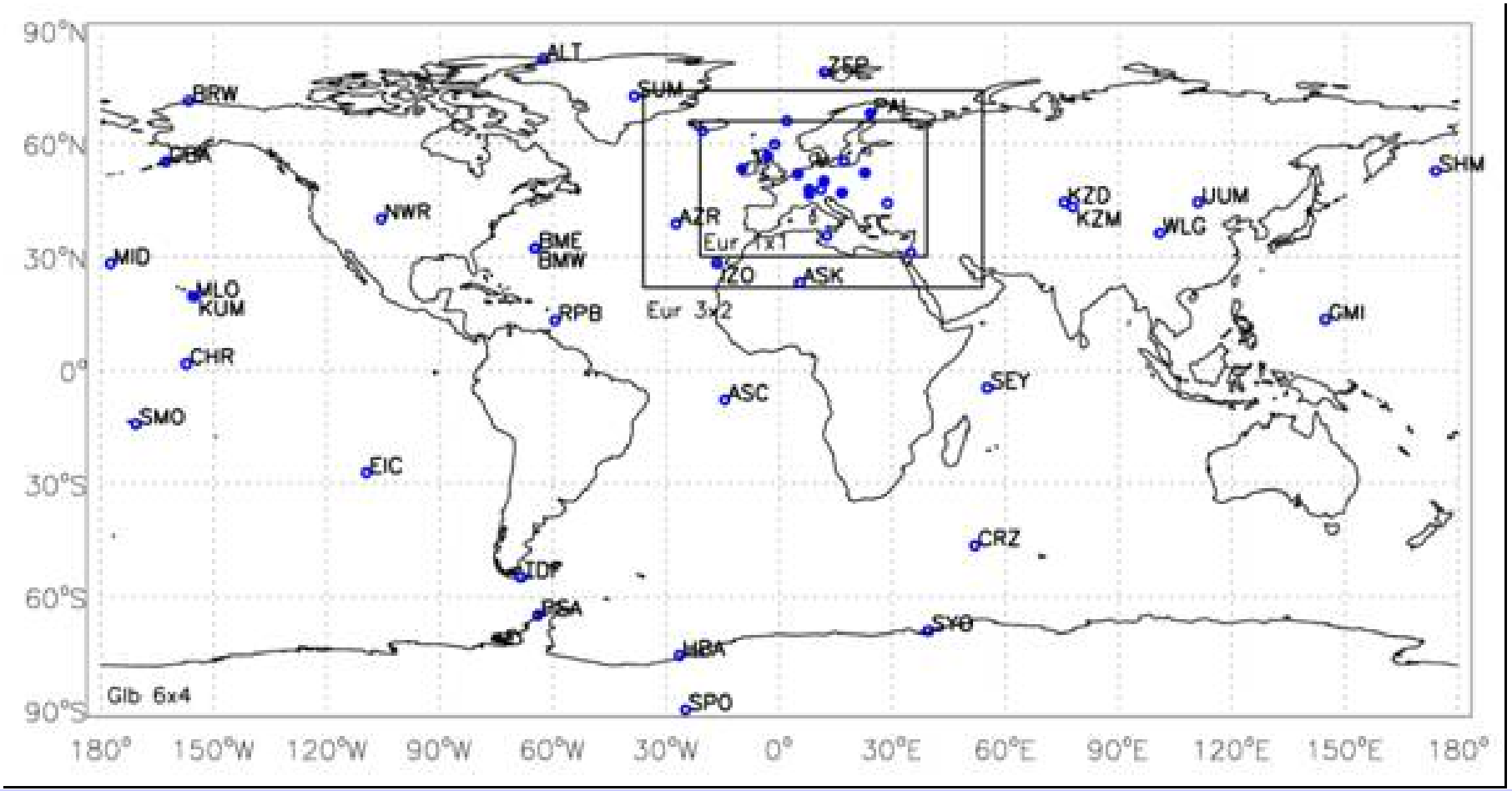
$$J(z) = (z_b - z)^T B_z^{-1} (z_b - z) + [y - \tilde{h}(z)]^T R^{-1} [y - \tilde{h}(z)]$$

Adapted from Dick Dee and Niels Bormann, ECMWF

Forward runs

Simulation period: from December 2005 to February 2007
(plots from January to December 2006)

3 nested domains (Global 6x4, Europe 3x2, Europe 1x1)

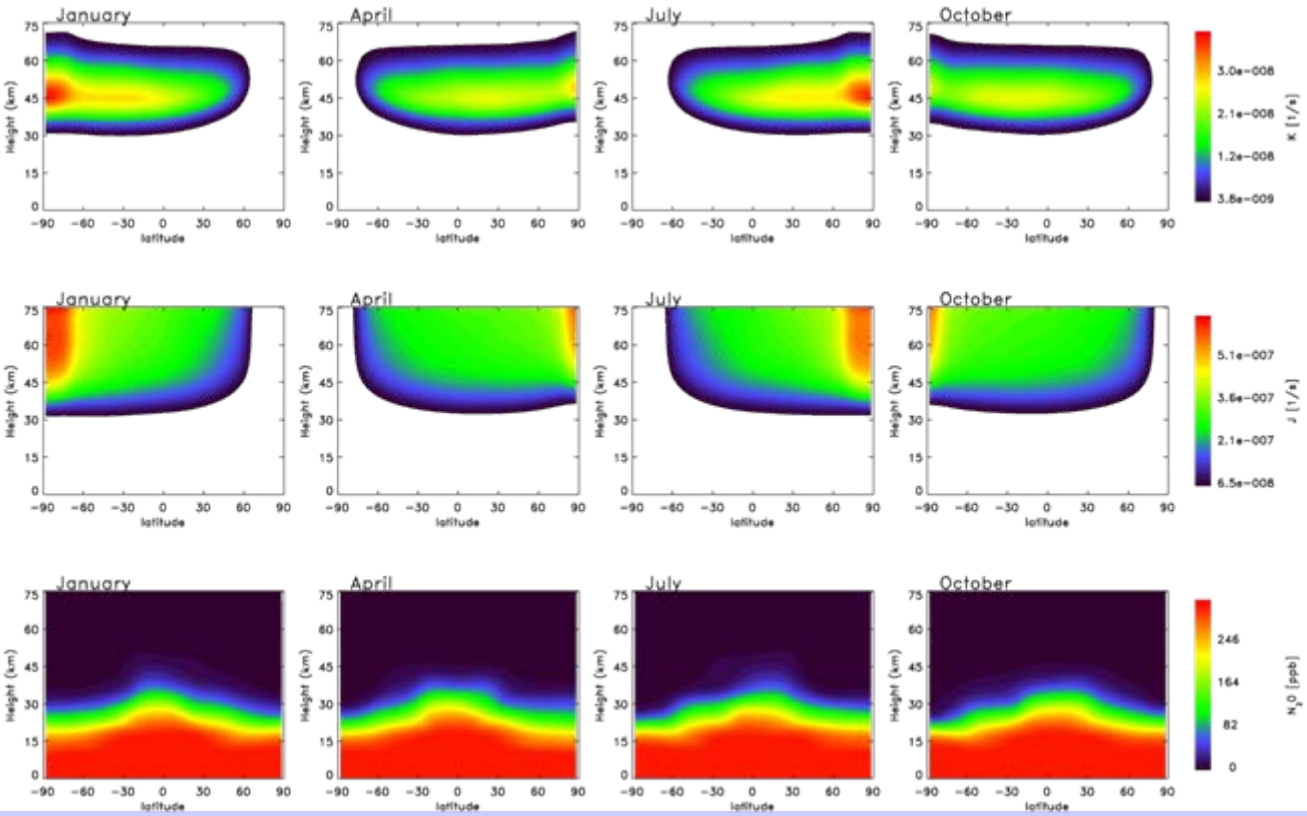


N2O Sinks and initial conditions

- **Monthly averaged values provided by Christoph Bruehl, MPI Mainz, ECHAM model, adapted to the TM5 grid.**
- **Two bulk removal processes: photolysis and reaction with excited O**

photolysis reaction with excited O

$$\frac{d}{dt}\left[\mathrm{N_2O}\right]_{j,l,t} = -J_{j,l,t}\left[\mathrm{N_2O}\right]_{j,l,t} - K_{j,l,t}\left[\mathrm{N_2O}\right]_{j,l,t}$$



Anthropogenic and Natural Emissions

Category	Source	Total (N_2O-N) Emissions	Total (N_2O) Emissions	Monthly Variations	Inversion category
Natural Soil	GEIA	4.59	7.21	N	Soil
Agricoltural Soil	EDGAR 4.0	3.24	5.09	N	Soil
Manure	EDGAR 4.0	0.21	0.33	N	Remaining emissions
Biomass Burning	GFED v2	0.65	1.02	Y	Biomass burning
Deforestation	GEIA	0.36	0.57	N	Remaining emissions
Agricoltural Burning	EDGAR 4.0	0.02	0.03	N	Remaining emissions
Transport	EDGAR 4.0	0.16	0.25	N	Remaining emissions
Residential	EDGAR 4.0	0.11	0.17	N	Remaining emissions
Industrial	EDGAR 4.0	0.38	0.60	N	Remaining emissions
Energy-Manufacture	EDGAR 4.0	0.21	0.33	N	Remaining emissions
Oil - Gas Production	EDGAR 4.0	< 0.01	< 0.01	N	Remaining emissions
Waste	EDGAR 4.0	0.22	0.35	N	Remaining emissions
Ocean	GEIA	3.60	5.66	N	Ocean
Total	-	13.76	21.62	Y	

Bias Correction

Bias (offset) correction by the different simulations (2006)

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	CHI		0.8	0.8	0.8	0.8	0.8
Mace Head	AGA	-0.1 ±0.3 (n=36)	0	0	0	-0.1	0
Bialystok	CHI		0.3	0.2	0.3	0.3	0.4
Cabauw	CHI		0.2	0.2	0.2	0.2	0.6
Ochsenkopf	CHI	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	CHI	1.0 ±1.2 (n=23)	1.0	1.0	1.1	1.1	1.1
Jungfraujoch	EMP		-0.4	-0.4	-0.4	-0.4	-0.4

Experiments

Control Simulation (S1): 2006 and 2007

- ERA Interim meteo forcing;
- m1qn3 minimization algorithm;
- October 20, 2009 release of the NitroEurope IP modelling 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.

Simulation 2 (S2): as S1 with Spatial correlation coefficient equal to 300 km.

Simulation 3 (S3): as S1 with Spatial correlation coefficient equal to 100 km.

Simulation 4 (S4): as S1 without using NOAA flask measurements at the same sites of stations affected by bias correction.

Simulation 5 (S5): as S1 with a priori emissions equal to constant values (over land and over ocean). Only one total emission category

Bias Correction

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Mace Head	AGA	-0.1 ±0.3 (n=36)	0	0	0	-0.1	0
Bialystok	CHI		0.3	0.2	0.3	0.3	0.4
Cabauw	CHI		0.2	0.2	0.2	0.2	0.6
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Jungfraujoch	EMP		-0.4	-0.4	-0.4	-0.4	-0.4

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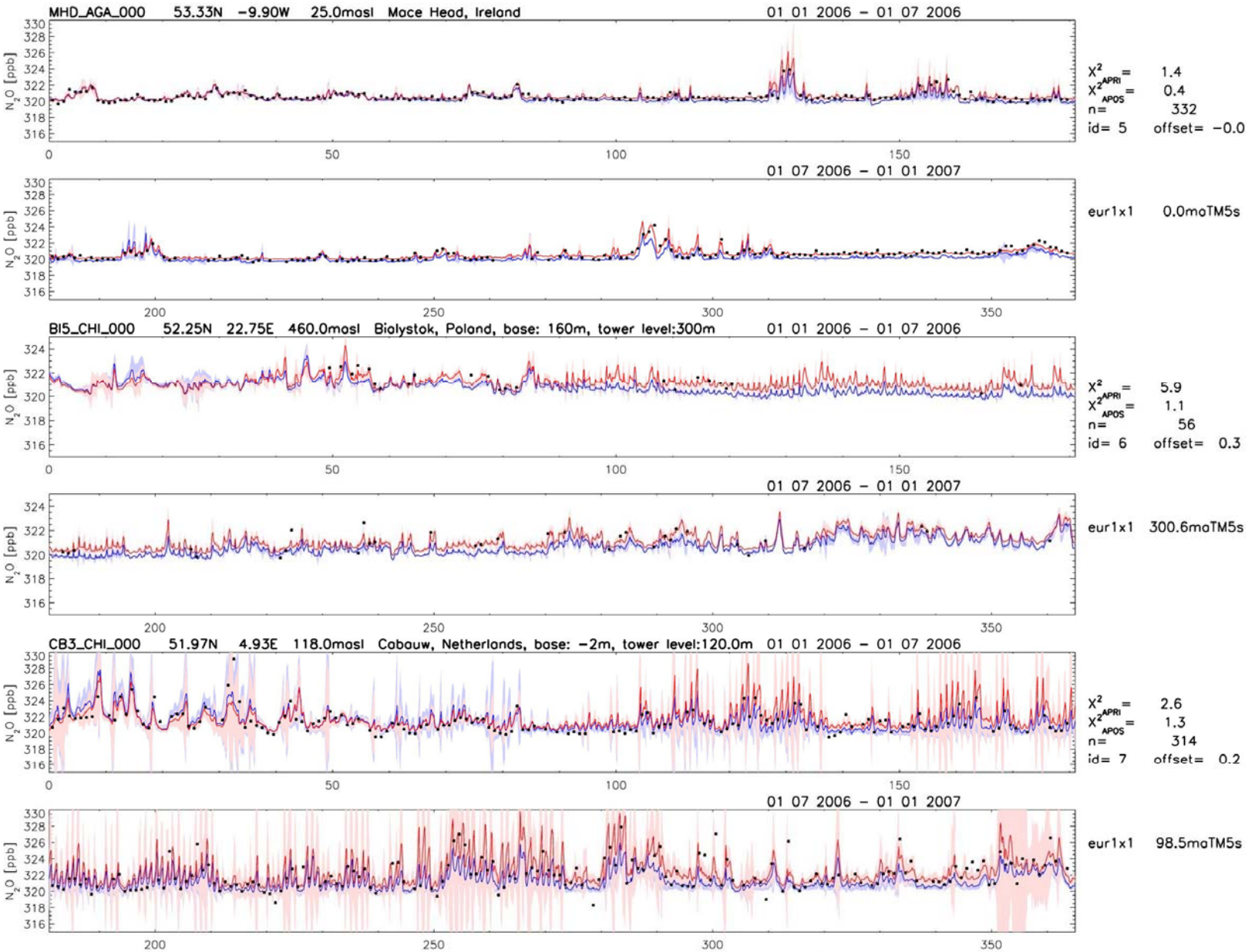
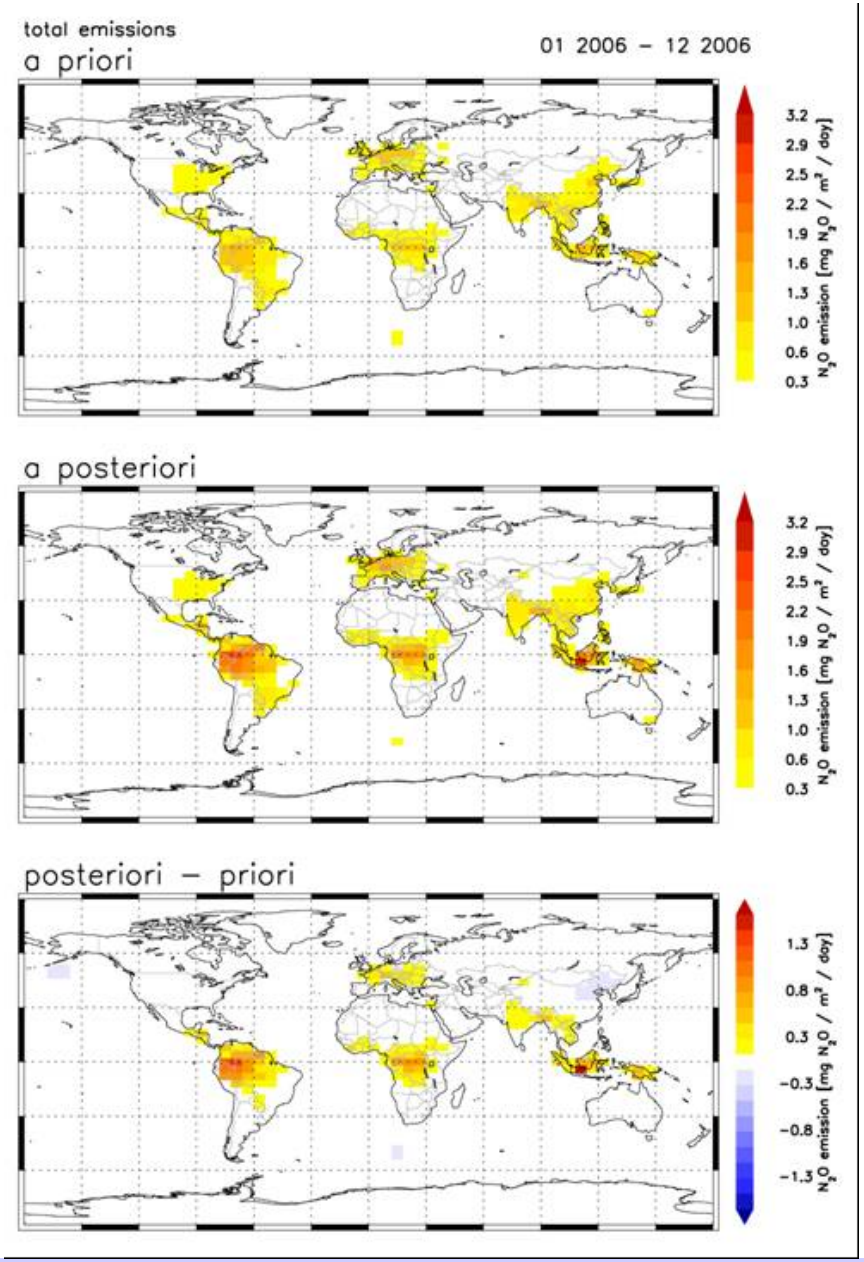
Comparison with station observations



Emission output (global)



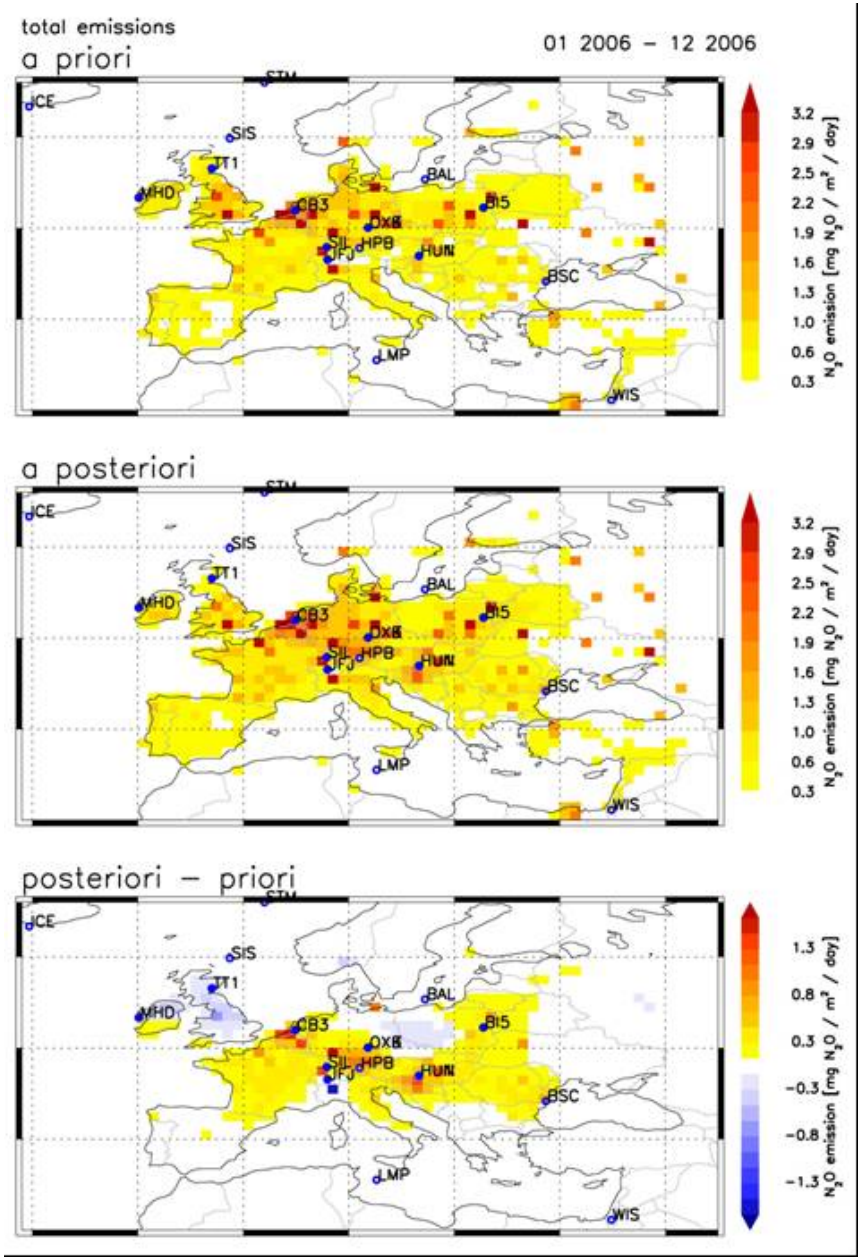
Control simulation

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

Total sinks
12.08 Tg N_{N2O}/yr

Resulting lifetime:
~ 127 years

Emission output over Europe



Control simulation

Total Emission:
1.19 Tg N_{N2O}/yr

Apriori value:
1.05 Tg N_{N2O}/yr

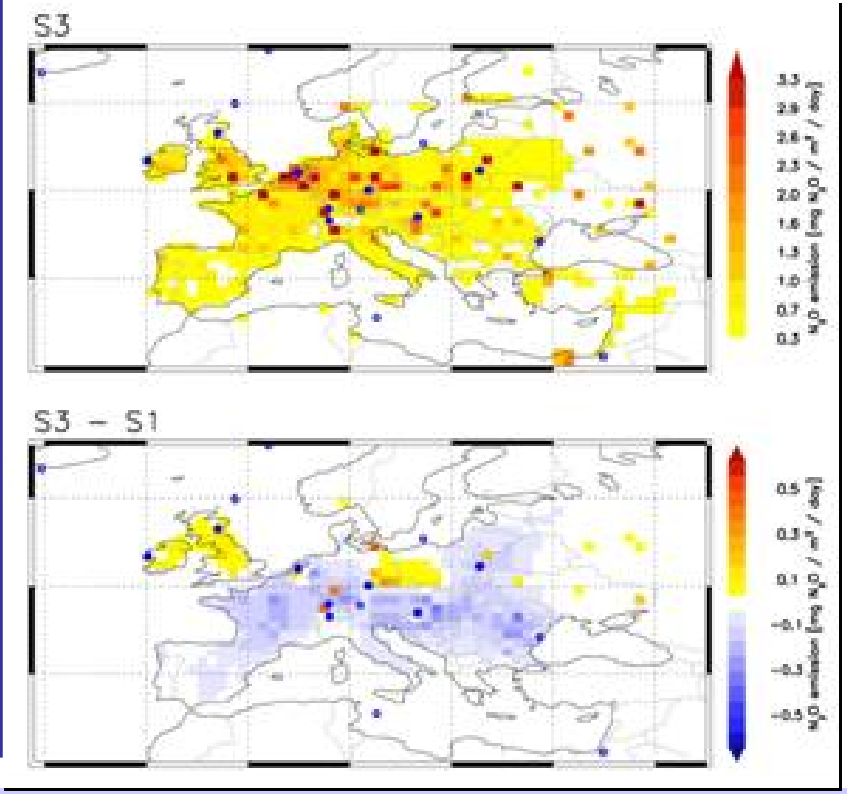
Sensitivity experiments

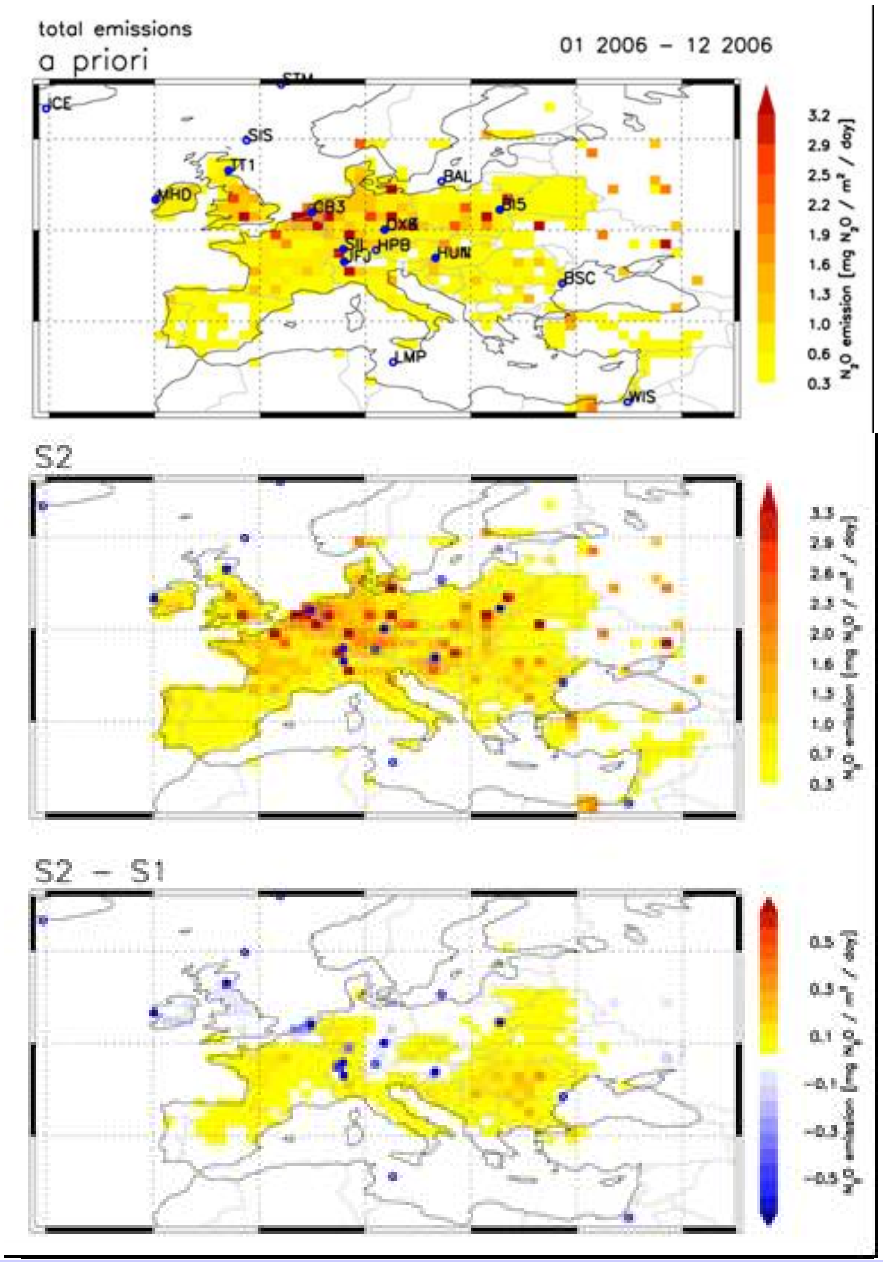
Horizontal correlation coefficients

200 km

100 km

300 km





Sensitivity experiments

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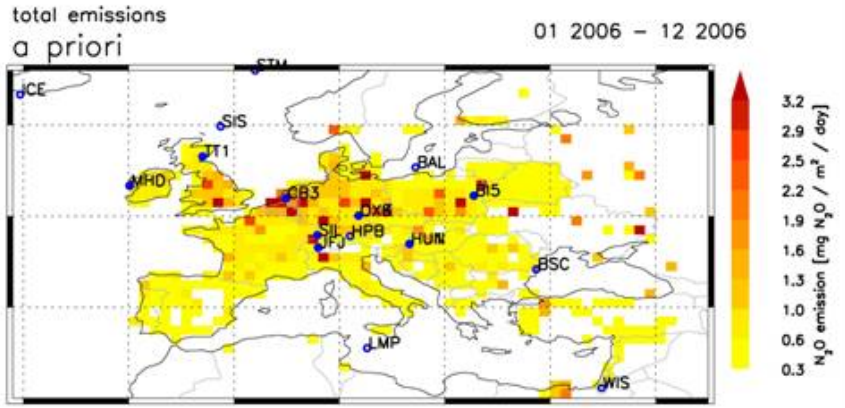
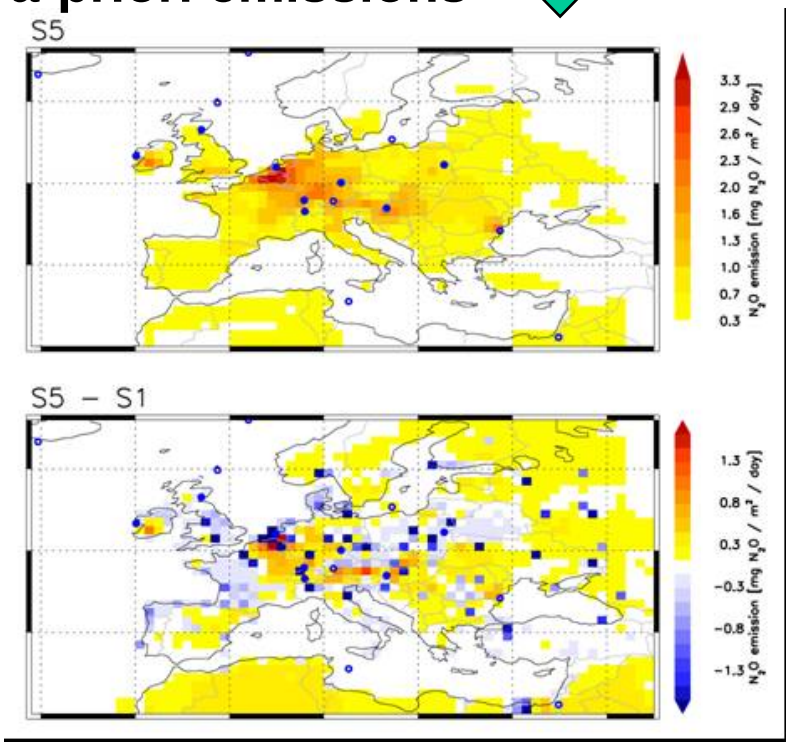
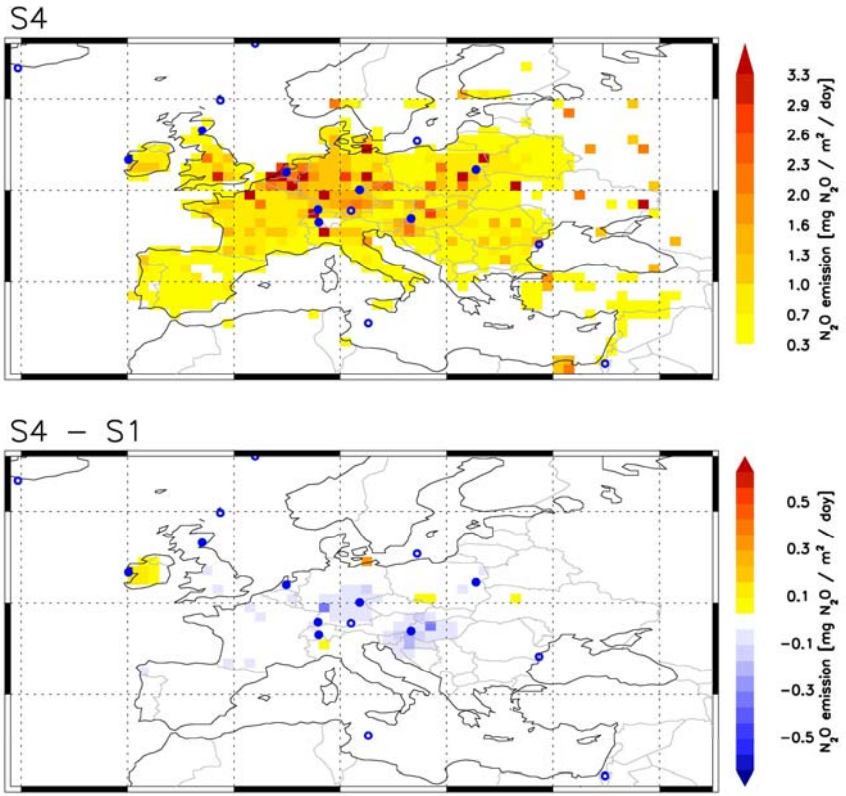
Control simulation



No flask measurements at Mace Head, Pallas, Ochsenkopf, and Hegyhatsal

Homogeneous a-priori emissions





National averages