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Joint Research Centre

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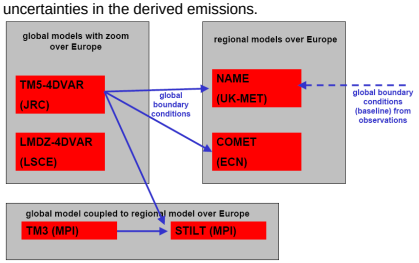
Introduction

Atmospheric measurements combined with inverse atmospheric models can provide independent top-down estimates of greenhouse gas (GHG) emissions. This is important in particular for N_2O and CH_4, for which considerable uncertainties of the bottom-up inventories exist (uncertainty estimates of bottom-up emissions reported to UNFCCC: CH_4: ~30%; N_2O >100% for annual country totals).

According to UNFCCC inventories, CH_4 and N_2O contributed 'only' ~8% and ~7%, respectively, of total GHG emissions of EU-15 countries (2007). However, the reported reductions of total GHG emissions (1990-2007: -199 Tg CO_2 eq) are mainly attributed to CH_4 (-133 Tg CO_2 eq) and N_2O (-105 Tg CO_2 eq).

Inverse Models

We used **5 independent inverse modeling systems** based on different global and regional Eulerian and Lagrangian transport models. The major objective of this model ensemble approach is to provide more realistic estimates of the overall uncertainties in the derived emissions.

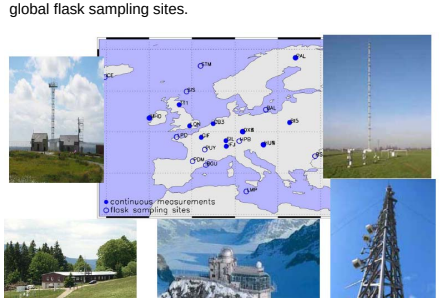


Scenario S1: Include information from bottom-up emission inventories (as a priori (TM5, LMDZ, STILT), or to redistribute emissions within regions resolved by the inversion (NAME) or to complement regions not resolved by the inversion (COMET)

Scenario S2: 'Free inversion' (TM5 and NAME)

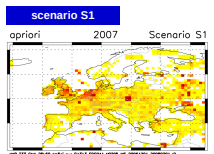
Atmospheric Observations

We use continuous observations from 10 European stations (including several tall towers) for CH_4 and 8 continuous stations for N_2O, complemented by further European and global flask sampling sites.

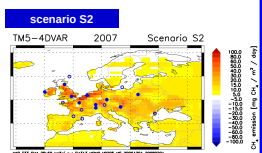


European CH_4 emissions

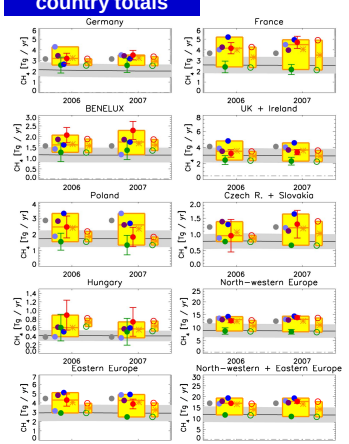
scenario S1



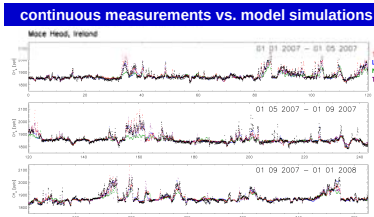
scenario S2



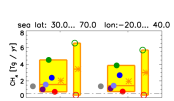
country totals



continuous measurements vs. model simulations

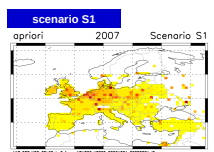


Continuous measurements provide important information on regional emissions. The figure above shows the the measurements and model simulations at Mace Head as example.

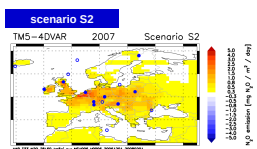


European N_2O emissions

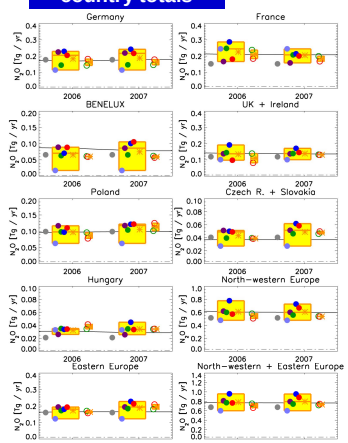
scenario S1



scenario S2



country totals



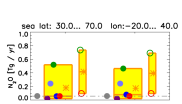
bias correction N_2O measurements

	2006 vs. NOAA flasks	2007 TM5-4DVAR vs. NOAA flasks	2007 TM5-4DVAR	2007 LMDZ[1]
PAL_FMI	0.5 ± 0.3 (n=36)	0.5	0.4 ± 0.4 (n=42)	0.3	0.5
SIS_MPI		0.5		0.7	0.6
TT1_CHI		0.8		1.0	0.9
MHD_AGA	0.1 ± 0.3 (n=36)	0.0	0.3 ± 0.5 (n=37)	0.1	0.2
BIS_CHI		0.3		0.2	0.3
CB3_CHI		0.2		0.5	0.7
OX3_CHI	1.0 ± 0.4 (n=5)	1.1	0.2 ± 0.7 (n=11)	0.3	1.0
SIL_WDC		0.4		0.2	0.7
HU2_CHI	1.0 ± 1.2 (n=23)	1.0	1.1 ± 1.7 (n=21)	1.2	1.3
JFJ_EMP		-0.4		-0.3	-0.2

[1] 2006-2007 average

unit: [ppb]

While CH_4 measurements from the different monitoring groups used in this study compare well at co-located sites (and in laboratory inter-comparisons), there are significant offsets seen for N_2O measurements. Therefore, we apply a recently developed bias correction scheme for N_2O [Corazza et al., 2011]. The bias correction derived by the 4DVAR systems agree within ~0.1 ppb with the bias derived from parallel NOAA flasks sites.



Summary

- The available observations mainly constrain CH_4 and N_2O emissions from north-western and eastern Europe.
- The different inverse models show reasonable consistency regarding the derived emissions for annual totals of countries / larger regions constrained by the observations, but show significant differences on smaller scales.
- Most inverse models yield higher CH_4 emissions for north-western and eastern Europe compared to bottom-up emissions reported to the UNFCCC (median from 5 inverse models ~40% higher than UNFCCC). Also the bottom-up estimate from EDGARv4.1 is significantly higher than UNFCCC.
- the preliminary top-down estimates of European N_2O emissions are consistent with the bottom-up inventories reported to the UNFCCC, as well as with the EDGAR bottom-up estimates. This good agreement for N_2O is rather surprising, since very large uncertainties are reported for the UNFCCC N_2O inventories (e.g. uncertainties for total N_2O emissions from north-western Europe >160%, mostly due to large uncertainties in emissions from agricultural soils). However, some models (NAME, COMET) attribute significant emissions to the sea (these emissions are not attributed to countries).
- Scenario S2 (without this a priori information) results in very similar country totals as S1. This demonstrate the significant constraints of the observations on the emissions from larger regions within the footprint area of the measurement network

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