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Inverse modelling of European CH_4 and N_2O emissions 2006-2012 using different inverse models and improved atmospheric observations

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We present top-down estimates of European CH_4 and N_2O emissions for 2006-2012, based on the new quality controlled and harmonized data set from 18 European atmospheric monitoring stations generated within the European FP7 project InGOS ("Integrated non-CO_2 Greenhouse gas Observing System"). We applied an ensemble of 7 different inverse models for CH_4 (and 4 for N_2O), and performed four different inversion experiments, investigating the impact of different sets of stations and the use of 'a priori' information on emissions.

The inverse models infer total CH_4 emissions of 28.4 $\pm$ 6.4 (2σ) Tg CH_4 yr^{-1} for the EU-28 for 2006-2012 from the 4 inversion experiments. For comparison, total anthropogenic CH_4 emissions reported to UNFCCC ('bottom-up', based on statistical data and emissions factors) amount to only 19.0 - 20.9 Tg CH_4 yr^{-1} for the same period. A potential explanation for the discrepancy between the 'bottom-up' and 'top-down' estimates could be the contribution of natural sources, such as peatlands, wetlands, and wet soils, which might have been underestimated in previous analyses. The hypothesis of significant natural emissions is supported by the finding that the inversions yield significant seasonal cycles of derived CH_4 emissions with maximum in summer, while anthropogenic CH_4 emissions are assumed to have much lower seasonal variability. Furthermore we investigate potential biases of the flux inversions by comparing model simulations with regular aircraft profiles at 4 European sites and the 'Infrastructure for Measurement of the European Carbon Cycle (IMECC)' aircraft campaign.

For N_2O, for which uncertainties of bottom-up inventories are very large - typically on the order of 100% for the total N_2O emissions per country (mainly due to N_2O emissions from agricultural soils) - our results demonstrate that atmospheric measurements and inverse modelling can significantly reduce the uncertainties. Despite the large uncertainties in the bottom-up inventories, our estimate of total European N_2O emissions (EU-28: 1.41 $\pm$ 0.54 (2σ) Tg N_2O yr^{-1}) agrees relatively well with reported total anthropogenic N_2O emissions (EU-28: 1.08-1.23 Tg N_2O yr^{-1}) and an assumed small contribution from natural soils ($\sim$0.1 Tg N_2O yr^{-1}).