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Inventories of NO and N2O soil emissions from European forest ecosystems

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The overall objective of the EU project NOFRETETE was to improve the knowledge about and to enable a better prediction of the magnitude of emissions of nitrogen oxides (N2O and NO) from European forest ecosystems growing in different climates (boreal, temperate, Mediterranean) and exposed to different levels of atmospheric N-deposition by (i) long-term continuous measurements of soil N2O and NO emissions using chamber techniques at 15 forest sites in Europe covering a wide span of different climates, forest/soil types, and nitrogen loads, (ii) quantifying and characterising microbial and physico-chemical processes involved in N-trace gas emissions, (iii) performing flux measurements at sites receiving different amounts of nitrogen to further elucidate the importance of N-deposition for the magnitude of N-oxide fluxes, (iv) using the combined results from field and laboratory measurements to improve and validate the complex biogeochemical model PnET-N-DNDC for simulating C- and N-cycling and associated processes of N-trace gas production, consumption and emission in soils of forest ecosystems, as well as a multi-layer canopy exchange model, describing deposition and photo-chemical reactions of reactive N-oxides in the canopy, (v) linking the two models to a GIS database containing all relevant information on model drivers (climate) and model parameters (e.g. forest and soil characteristics, N-deposition), (vi) using the models for upscaling emissions of N-oxides from forest ecosystems to the European scale, thereby calculating emission inventories for N2O and NO for the forested area of Europe, (vii) performing scenario studies on European scale in order to identify future changes in N-oxide emissions from forest ecosystems due to changes in climate. The soil N trace gas emission inventories show a distinct regional pattern, with N2O emissions in the range of 0-5 kg N2O-N ha-1 yr-1 and NO emissions in the range of 0-9 kg N ha-1 yr-1. High N2O emissions are especially predicted for regions with high atmospheric values of N deposition such as Germany and

the Benelux countries, and for regions with high SOC content like in Poland and the Baltic states. High NO emissions are also expected to occur in the regions with high atmospheric N load, but also in regions covered with coniferous forests and with low soil pH, like the boreal forests in Sweden. Total N trace gas emissions from European forest ecosystems in the year 2000 have been calculated to be 219 kt NO-N (span: 99-442 kt N) and 117 kt N2O-N (span: 51-235 kt N), respectively. This means that total annual N2O emissions from forest soils in Europe are approx. 20% of the sum estimated for agricultural soils, thus indicating that also forest soils are a significant, not negligible source for N2O in Europe. The predicted changes in temperature and in the seasonality of precipitation showed a significant effect on simulated N trace gas emissions. Based on our calculations with the process oriented model it is obvious that climate changes in Europe will further increase NO emissions from forest soils by in average 14%, i.e. a positive feedback will be observed. This increase is especially pronounced for parts of Scandinavia, the North Alpine region and the west coast region of the UK and Ireland, whereas slight reductions in NO emissions may occur from forest soils in Central France and NW Spain. With regard to N2O a slight decrease in emissions is predicted (in average 6%). N2O emissions are predicted to increase partly by more than 20% in Central Europe, UK and in the Mediterranean area, whereas a significant decrease in emissions is predicted for large areas of Scandinavia and the Baltic states. Within the NOFRETETE project we could demonstrate that high rates of atmospheric nitrogen deposition to forests lead to increased emission rates of nitrogen oxides, especially of NO from coniferous forests. Atmospheric N deposition does not only affect N emissions from soils but also microbial N turnover rates and microbial community structures in the soil. The project also contributed to a better understanding of the complexity of biosphere-atmosphere exchange processes of reactive N species such as NO and NO2. The strategy to use field and laboratory measurements as bases for the further development and validation of complex models capable of simulating biosphere-atmosphere exchange processes proved to be successful. Therefore, inventories of N trace gas emissions from forest ecosystems for present and future climate conditions were calculated for the entire EU by linking of such models to a detailed GIS database, holding spatial and temporal resolved model input parameters and model drivers.