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Tall tower landscape scale N2O flux measurements in a Danish agricultural and urban, coastal area

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Both technical and natural processes emit the greenhouse gas nitrous oxide (N_2O) into the atmosphere. The abundant use of nitrogen (N) as fertiliser increases the concentration of reactive nitrogen (N_r) in the atmosphere, the hydrosphere and in the biosphere, i.e. in terrestrial and aquatic ecosystems. Surplus N_r is distributed across linkages to other spheres until most of it is emitted to the atmosphere as NO, N_2O or N_2. A complete estimate of the effects from human activities on N_2O emissions must therefore include all emissions, the direct emissions and the indirect emissions that happen in interlinked spheres. For this it is necessary to assess the fluxes at least at the landscape scale.

The episodic nature and the large spatial variability make it difficult to estimate the direct and indirect emissions in a landscape. Modelling requires not only to include the highly variable microbial processes in the ecosystems that produce N_2O but as well the accurate simulation of lateral N_r fluxes and their effects on N_2O fluxes in places remote from the primary N_r sources. In this context tall tower N_2O flux measurements are particularly useful as they integrate over larger areas and can be run, continuously without disturbing the fluxes. On the other hand these measurements can be difficult to interpret due to difficulties to measure the small concentration fluctuations in the atmosphere at small flux rates and to accurately attribute the measured flux at the tower to the area that generates the flux, i.e. the source area.

The Technical University of Denmark (DTU) has established eddy covariance N_2O flux measurements on a 125 m tall tower at its Risø Campus as part of the EU research infrastructure project the 'Integrated non-CO_2 Greenhouse gas Observing System' (InGOS). The eddy covariance system consisted of a N2O/CO quantum cascade laser, Los Gatos, Mountain View, CA, USA and a 3D sonic anemometer (USA-1), Metek, Elmshorn, Germany.

The Risø peninsula lies at the eastern coastline of the Roskilde fjord on the Danish island Zealand. The tower is surrounded by the fjord, by agricultural area, forests and, in the South by the urban area of the City of Roskilde. The City of Roskilde operates a waste incinerator and a waste water treatment plant, which drains treated waste water into the fjord.

The level of the measured flux values was generally relatively low. Based on the clear definition of the lag time between N_2O concentrations and the vertical wind speed, fluxes were measureable over larger periods. The fluxes showed clear directional relationships indicating their large spatial and temporal variability in the landscape. Footprint calculations were performed to attribute source areas to the measured fluxes ...(Kormann and Meixner, 2001; Neftel et al., 2008). The footprint of the flux measurement included areas between 200 m and several kilometres distance from the tower. A preliminary approach was developed to generate monthly maps of N_2O fluxes around the tower. Here we present the results from the first seven months of flux measurements. Based on these results we discuss the potential and the limitations of tall tower eddy covariance measurements to estimate maps of N_2O fluxes and the integral value of the landscape N_2O flux.

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