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Micrometeorological measurements of ammonia and total reactive nitrogen exchange over semi-natural peatland

Christian Brümmer (1), Undine Richter (1), Frederik Schrader (1), Werner Kutsch (1,2)

(1) Thünen-Institute, Climate-Smart Agriculture, Braunschweig, Germany (christian.bruemmer@ti.bund.de), (2) Integrated Carbon Observation System (ICOS), Head Office, Helsinki, Finland (werner.kutsch@helsinki.fi)

Intensive agriculture generates a substantial atmospheric burden for nitrogen-limited ecosystems such as peatlands when the latter are located in close vicinity to arable sites and animal houses. The exchange of reactive nitrogen compounds between these bog ecosystems and the atmosphere is still not very well understood due to the lack of suitable measurement techniques. With recent advancements in laser spectrometry, we used a quantum cascade laser spectrometer as well as a custom-built total reactive atmospheric nitrogen (ΣN_r) converter (TRANC) coupled to a fast-response chemiluminescence detector to measure NH_3 and ΣN_r concentrations, respectively. The analyzers' high temporal resolution allowed for determination of the respective nitrogen exchange within eddy covariance-based setups. Field campaigns were conducted at a northwestern German peatland site that is surrounded by an area of highly fertilized agricultural land and intensive livestock production ($\sim$1 km distance). The field site is part of a natural park with a very small remaining protected zone of less than 2 km x 2 km.

Ammonia and ΣN_r concentrations were highly variable between 2 to 110 ppb and 10 to 120 ppb, respectively. Peak values coincided with main fertilization periods on the neighboring agricultural land in early spring and fall. The trend in weekly averaged ΣN_r concentrations from TRANC measurements was in good agreement with results from KAPS denuder filter systems when the latter were combined with the missing and apparently highly variable NO_x contribution. Wind direction and land use in the closer vicinity clearly regulated whether ΣN_r concentrations were NH_3 or NO_x-dominated.

Ammonia uptake rates between 40 ng N m^{-2} s^{-1} and near-neutral exchange were observed. The cumulative net uptake for the period of investigation was $\sim$700 g N ha^{-1} resulting in a dry net deposition of $\sim$4 kg N ha^{-1} when extrapolated to an entire year, whereas KAPS denuder measurements in combination with dry deposition modeling added up to 8.5 kg N ha^{-1} yr^{-1}. Values of monthly averaged diurnal flux courses of ΣN_r ranged between -40 and +20 ng N m^{-2} s^{-1} with the majority of fluxes showing net deposition of ΣN_r to the land surface. The cumulative net exchange of ΣN_r resulted in an uptake of the ecosystem of only $\sim$1.2 kg N ha^{-1} yr^{-1} with intermittent periods showing net ΣN_r release.

Our study stresses the importance of a thorough method inter-comparison, e.g. with denuder systems and dry deposition modeling. The implementation of adequate ammonia compensation point parameterizations becomes crucial in surface-atmosphere exchange schemes for bog vegetation. We found indication for an oversaturation of the investigated N-limited moorland site caused by agricultural practices such as livestock production and fertilization. Bog plants were temporarily not capable of taking up the surplus nitrogen from the atmosphere, which highlights the importance for a thorough reassessment of protection guidelines for vulnerable ecosystems such as peatlands.