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High-resolution measurement of nitrous oxide in the Elbe estuary under hypoxia: Hot-spots of biological N_2O production

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Nitrous oxide (N_2O) is one of the most important greenhouse gases. Its global warming potential exceeds that of CO_2 by a factor of $\sim$300. Estuaries, being sites of intense biological N-turnover, are one of the major natural sources of N_2O emissions.

On two ship cruises in April and June 2015, concentrations of N_2O were measured in the surface water using equilibrator laser based on-line measurements. Based on these high-resolution N_2O profiles along the Elbe estuary, N_2O saturation and N_2O-fluxes between surface water and air were calculated. Additionally, DIN concentrations and dual stable isotopes of nitrate ($\delta^{15}N$ and $\delta^{18}O$) were analyzed.

Concentration and water-to-air fluxes of N_2O were highest in the Hamburg port region and dropped quickly further downstream. Highest water-to-air fluxes were up to 800μM/m^2/d and 1600μM/m^2/d in April and in June, respectively. Downstream of the port region, an N_2O oversaturation of 150-200% was estimated over the entire estuary, with saturation approaching equilibrium (96-100%) only in the North Sea region. N_2O production was much higher in June than in April 2015, likely coupled to lower oxygen saturation in the water column in June.

Based on these measurements, the port of Hamburg region was identified as a hot-spot of N_2O production. High N_2O concentration and depleted values of nitrate isotopes suggest that nitrification is a significant source of N_2O in the estuary, especially at low oxygen concentration. In the Elbe estuary, hypoxia obviously drastically increased the emissions of the greenhouse gas N_2O.