High-resolution measurement of nitrous oxide in the Elbe estuary under hypoxia: Hot-spots of biological N\textsubscript{2}O production

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Nitrous oxide (N\textsubscript{2}O) is one of the most important greenhouse gases. Its global warming potential exceeds that of CO\textsubscript{2} by a factor of \(\sim 300\). Estuaries, being sites of intense biological N-turnover, are one of the major natural sources of N\textsubscript{2}O emissions.

On two ship cruises in April and June 2015, concentrations of N\textsubscript{2}O were measured in the surface water using equilibrator laser based on-line measurements. Based on these high-resolution N\textsubscript{2}O profiles along the Elbe estuary, N\textsubscript{2}O saturation and N\textsubscript{2}O-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\textsubscript{2}O were highest in the Hamburg port region and dropped quickly further downstream. Highest water-to-air fluxes were up to 800\(\mu\)M/m\(^2\)/d and 1600\(\mu\)M/m\(^2\)/d in April and in June, respectively. Downstream of the port region, an N\textsubscript{2}O oversaturation of 150-200\% was estimated over the entire estuary, with saturation approaching equilibrium (96-100\%) only in the North Sea region. N\textsubscript{2}O 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\textsubscript{2}O production. High N\textsubscript{2}O concentration and depleted values of nitrate isotopes suggest that nitrification is a significant source of N\textsubscript{2}O in the estuary, especially at low oxygen concentration. In the Elbe estuary, hypoxia obviously drastically increased the emissions of the greenhouse gas N\textsubscript{2}O.