N$_2$O concentrations in boreal lakes are linked to nitrate and temperature

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While regional and global estimates for carbon dioxide (CO$_2$) and methane (CH$_4$) emission from lakes are presently available, nitrous oxide (N$_2$O) evasion from lakes and streams and the primary drivers regulating the fluxes have remained poorly studied. Freshwater N$_2$O data are scarce and mostly based on short term measurements from a few lakes/rivers. The largest N$_2$O data was collected by Whitfield et al. (2011) focusing on 121 small, polymictic headwater lakes in Ireland in spring 2008.

We gathered the so-far largest seasonal/annual N$_2$O data from boreal lakes. A subpopulation of 112 lakes from the boreal zone in Finland (from 60°N to 69°N) was randomly selected from the Nordic Lake Survey (NLS) data base. Water chemistry, catchment land use, climatic drivers and variables linked to catchment topography (e.g. max depth of the lake) were determined for each lake. The lakes were sampled four times per year (before and after ice melt, at the end of a summer stratification and during a fall overturn) from four depths (1 m from the surface, middle of the lake, 1 m from the sediment and 20 cm from the sediment) at the deepest point of the lake for N$_2$O concentrations and physical and chemical characteristics. Finnish lakes are predominantly dimictic and the average length of the ice cover period ranges from about 5 months in the south to over 7 months in the north.

The variability in N$_2$O concentrations in the lake population was large in each season and depth. Although highest N$_2$O concentrations were often found in bottom water samples, N$_2$O and oxygen were poorly linked to each other (weak correlation only in winter samples). This is in contrast to CO$_2$ concentrations in the study lakes, which were strongly linked to oxygen concentrations (r^2= 0.79, n = 2740, p < 0.0001; Kortelainen et al. 2006).

In contrast, nitrate and temperature were strong predictors for N$_2$O concentrations in our data despite the large variability in lake area (from 0.04 to 63 km^2), maximum depth (from 2 m to 84 m), latitude (from 60°C to 69°C) and land use, which represents typical patterns in the boreal zone: lakes are predominantly surrounded by forests and peatlands with a lower proportion of agricultural land. Our N$_2$O data from randomly selected lakes can be used to estimate the role of freshwater ecosystems to landscape N$_2$O emission in boreal zone and the most important drivers contributing to freshwater N$_2$O concentrations.

References

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