

# Winter is an important driver for nitrous oxide emissions from boreal lakes

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Boreal lakes emit greenhouse gases, but the magnitude of the emissions is still inadequately quantified. While the emissions of carbon dioxide and methane have been addressed earlier, those of nitrous oxide ( $\text{N}_2\text{O}$ ) have received little interest. A Finnish study published in *Global Change Biology* increases significantly the knowledge on the nitrous oxide emissions from boreal lakes. A joint project of Finnish Environment Institute (SYKE), University of Eastern Finland (UEF), Natural Resources Institute Finland (Luke), and University of Helsinki (UH) focused on nitrous oxide during all four seasons in 112 Finnish lakes.

Nitrate concentration in lake water explained as much as 78 % of the variation in [nitrous oxide](#) concentration in [lake water](#). Both the concentrations and emissions of N<sub>2</sub>O from lakes increased with the increase in nitrate concentration. Nitrous oxide emissions were highest from lakes in southern Finland, in the region with intensive agriculture. In addition to methane and [carbon dioxide emissions](#), eutrophication of lakes thus also boosts nitrous oxide emissions.

Annual release of nitrous oxide from Finnish and all boreal lakes were estimated to be 0.9 and 46 Gg, respectively. For Finnish lakes the atmospheric importance of the nitrous oxide emissions was estimated to be about one third of that of diffusive methane emissions.

There was a large seasonal variation in N<sub>2</sub>O and nitrate concentrations—highest in winter and lowest in summer. Consequently, emissions after ice-out significantly contribute to the annual nitrous oxide emissions from boreal lakes. When all the four-season measurements were combined, the resulting annual emission was four-fold compared to an estimate based only on summer measurements.

Climate warming enhances the nutrient turnover in soil and the leaching of nutrients to lakes when the soil is unfrozen for longer periods. Together with the shorter ice-cover period the increased leaching will enhance [nitrous oxide emissions](#) from lakes under warming climate.

**More information:** Pirkko Kortelainen et al. Lakes as nitrous oxide sources in the boreal landscape, *Global Change Biology* (2019). [DOI: 10.1111/gcb.14928](https://doi.org/10.1111/gcb.14928)

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