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Which factors control the interannual variability of nitrous oxide fluxes in subarctic European Russian tundra?

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A decade ago, high emissions of nitrous oxide (N_2O) fluxes were discovered in upheaved permafrost peatlands in subarctic European Russian tundra. These emissions, comparable to those from tropical and agricultural soils, originate from patches of bare peat, which occur on the top of peat plateaus as a result of erosion and frost action. Discovery of these subarctic N_2O hot-spots challenged the common belief that pristine northern soils are negligible with respect to this gas. Since then, a considerable effort has been made to understand the mechanisms behind the high emissions and to explain the occurrence of the N_2O hot-spots in the otherwise N_2O neutral landscape. Now, with multiannual time-series of growing season flux measurements, it has finally become possible to analyze also the interannual variability in the N_2O fluxes.

In this study, we investigated the role of basic climatic variables as drivers of the large year-to-year variability in the N_2O fluxes. Detailed soil profile measurements of pore gas concentrations, soil moisture and temperature provided insights into soil processes underlain the net emissions to the atmosphere.

Soil moisture and temperature together were the main controls of the interannual variability: When the soil moisture content was sufficient for N_2O production by anaerobic denitrification, the emissions were strongly dependent on temperature. During dry years we observed lower N_2O emissions and accumulation of nitrate, the initial electron acceptor of denitrification, together reflecting moisture limitation of N_2O production. Depth of seasonal thaw, which is positively affected by both temperature and moisture, explained well the interannual variability in N_2O emissions.