

Submitted Abstract

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Abstract

Nitrous oxide (N₂O) is a strong greenhouse gas with a global warming potential about 300 times that of CO₂ for a 100-year timescale. Soils are sources of N₂O globally, but N₂O emissions from permafrost-affected soils underlying large parts of high-latitude and alpine regions have been considered negligible owing to nitrogen (N) limitation in these cold soils. Recent measurements of N₂O emissions have challenged this view, and a review of published studies (Voigt et al. 2020) showed that vegetated soils in permafrost regions are often small but evident sources of N₂O during the growing season ($\sim 30 \mu\text{g N}_2\text{O-N m}^{-2} \text{ day}^{-1}$). Moreover, barren or sparsely vegetated soils, common in harsh climates, can serve as substantial sources of N₂O ($\sim 455 \mu\text{g N}_2\text{O-N m}^{-2} \text{ day}^{-1}$), demonstrating the importance of permafrost-affected soils in Earth's N₂O budget. Here we will discuss N₂O fluxes from arctic, antarctic and alpine permafrost regions, including areas that likely serve as sources (such as peatlands) and as sinks (wetlands, dry upland soils), and estimate N₂O emissions from global permafrost-affected soils. The average N₂O emissions were 38 (mean) and 288 (median) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ day}^{-1}$, and were not significantly different between arctic, antarctic and alpine soils; however, data from alpine ecosystems were particularly rare and mostly restricted to the Tibetan Plateau. We outline the below-ground N cycle in permafrost regions and examine the environmental conditions influencing N₂O dynamics. Global-change-related impacts on permafrost ecosystems and how these could alter N₂O fluxes are discussed, including effects of warming, altered precipitation and snow pack, permafrost collapse, enhanced availability of mineral nitrogen and effects of management practices such as grazing on N₂O emissions from alpine soils. Finally, we will introduce first modelling efforts to simulate N₂O fluxes from permafrost regions. The need for more research to better constrain the global impact of permafrost N₂O emissions is highlighted.

Voigt, Carolina & Marushchak, Maija & Abbott, Benjamin & Biasi, Christina & Elberling, Bo & Siciliano, Steven & Sonnentag, Oliver & Stewart, Katherine & Yang, Yuanhe & Martikainen, Pertti. (2020). Nitrous oxide emissions from permafrost-affected soils. *Nature Reviews Earth & Environment* 1, 1-15.