Multi-year N_2O flux measurements reveal high temporal variation and freeze-thaw cycles in a fertile forested peatland

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The effect of soil freezing and thawing events on N_2O emissions is well known; however, the importance of these events is incompletely understood particularly in forested peatlands. Most of the studies have been made by sporadic manual measurements, or the winter-time measurements have not been made at all. The aim of this study was to measure the seasonal cycle of N_2O fluxes over several years and investigate the effect of freeze-thaw cycles on the fluxes.

Our study site was a nutrient-rich drained peatland 'Lettosuo' located in Tammela in southern Finland. The peatland, originally an herb-rich tall sedge pine fen was drained for forestry in 1969. After that, the tree stand was a mixture of Scots pine, Norway spruce and Downy birch. N_2O fluxes were measured hourly with six automatic chambers.

N_2O fluxes were highly variable both temporally and spatially. Almost all the measured N_2O fluxes were positive (emission, from the ecosystem to the atmosphere). The annual balances of the chambers varied between 130–2040 mg N_2O m^{-2} yr^{-1}. Highest N_2O emissions occurred mostly during summertime, but typically with a high temporal variation. However, during exceptionally dry summer of 2018, < 20 μg N_2O m^{-2} h^{-1} fluxes were measured by all the chambers throughout the summer except for an emission peak in the first half of July. N_2O flux during the thaw period lagged with soil moisture; when soil moisture rose, N_2O emissions also rose a few days later and vice versa. Several emission peaks outside summertime were also observed, and they were closely connected to times of soil freezing and thawing. Thawing peaks occurred during April and May, and the peaks were usually continued with high emissions during summer. Freezing peaks occurred in December in 2015 and 2016, but they were missing in winter (DJF) 2017-2018. Freezing and thawing peaks were observed by all the chambers even though the magnitude of the fluxes varied between the chambers. Outside summer and freezing and thawing peaks, the fluxes were relatively low.

Our results show that N_2O fluxes in a nutrient-rich peatland forest, measured with automatic chambers, are highly variable both spatially and temporally. However, all the chambers showed similar flux dynamics. This underlines the importance of continuous measurements for capturing the freeze-thaw events, which play a significant role when calculating N_2O balances.