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Nitrous oxide fluxes from forest floor, tree stems and canopies of boreal tree species during spring

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Boreal forests are considered as small sources of atmospheric nitrous oxide (N_2O) due to microbial N_2O production in the soils. Recent evidence shows that trees may play an important role in N_2O exchange of forest ecosystems by offering pathways for soil produced N_2O to the atmosphere. To confirm magnitude, variability and the origin of the tree mediated N_2O emissions more research is needed, especially in boreal forests which have been in a minority in such investigation.

We measured forest floor, tree stem and shoot N_2O exchange of three boreal tree species at the beginning of the growing season (13.4.–13.6.2015) at SMEAR II station in Hyytiälä, located in Southern Finland (61˚51´N, 24˚17´E, 181 a.s.l.). The fluxes were measured in silver birch (*Betula pendula*), downy birch (*B. pubescens*) and Norway spruce (*Picea abies*) on two sites with differing soil type and characteristics (paludified and mineral soil), vegetation cover and forest structure. The aim was to study the vertical profile of N_2O fluxes at stem level and to observe temporal changes in N_2O fluxes over the beginning of the growing season. The N_2O exchange was determined using the static chamber technique and gas chromatographic analyses. Scaffold towers were used for measurements at multiple stem heights and at the canopy level.

Overall, the N_2O fluxes from the forest floor and trees at both sites were very small and close to the detection limit. The measured trees mainly emitted N_2O from their stems and shoots, while the forest floor acted as a sink of N_2O at the paludified site and as a small source of N_2O at the mineral soil site. Stem emissions from all the trees at both sites were on average below 0.5 μg N_2O m^{-2} of stem area h^{-1}, and the shoot emissions varied between 0.2 and 0.5 ng N_2O m^{-2} g^{-1} dry biomass. When the N_2O fluxes were scaled up to the whole forest ecosystem, based on the tree biomass and stand density, the N_2O emissions from birch and spruce trees at the paludified site were 1.4 and 2.2 mg N_2O ha^{-1} h^{-1}, respectively, while the forest floor was a sink of -6.1 mg N_2O ha^{-1} h^{-1}. At the mineral soil site the upscaled N_2O emissions from birch trees and forest floor were 3.6 and 8.9 mg N_2O ha^{-1} h^{-1}, respectively, indicating that the emissions from trees significantly contribute to the N_2O emissions from boreal forests. The results also indicate that tree canopies contributed up to 89% of the whole-tree N_2O emissions. Our findings demonstrate that we urgently need more studies focusing on leaf-level N_2O exchange in forest ecosystems.

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