Geophysical Research Abstracts
Vol. 18, EGU2016-15443, 2016
EGU General Assembly 2016

The role of forest floor and trees to the ecosystem scale methane budget of boreal forests

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Boreal forests are considered as a sink of atmospheric methane (CH_4) due to the activity of CH_4 oxidizing bacteria (methanotrophs) in the soil. This soil CH_4 sink is especially strong for upland forest soils, whereas forests growing on organic soils may act as small sources due to the domination of CH_4 production by methanogens in the anaerobic parts of the soil. The role of trees to the ecosystem-scale CH_4 fluxes has until recently been neglected due to the perception that trees do not contribute to the CH_4 exchange, and also due to difficulties in measuring the CH_4 exchange from trees. Findings of aerobic CH_4 formation in plants and emissions from tree-stems in temperate and tropical forests during the past decade demonstrate that our understanding of CH_4 cycling in forest ecosystems is not complete. Especially the role of forest canopies still remain unresolved, and very little is known of CH_4 fluxes from trees in boreal region.

We measured the CH_4 exchange of tree-stems and tree-canopies from pine (*Pinus sylvestris*), spruce (*Picea abies*) and birch (*Betula pubescens, Betula pendula*) trees growing in Southern Finland (SMEAR II station) on varying soil conditions, from upland mineral soils to paludified soil. We compared the CH_4 fluxes from trees to forest-floor CH_4 exchange, both measured by static chambers, and to CH_4 fluxes measured above the forest canopy by a flux gradient technique. We link the CH_4 fluxes from trees and forest floor to physiological activity of the trees, such as transpiration, sap-flow, CO_2 net ecosystem exchange (NEE), soil properties such as temperature and moisture, and to the presence of CH_4 producing methanogens and CH_4 oxidizing methanotrophs in trees or soil.

The above canopy CH_4 flux measurements show that the whole forest ecosystem was a small source of CH_4 over extended periods in the spring and summer 2012, 2014 and 2015. Throughout the 2013-2014 measurements, the forest floor was in total a net sink of CH_4, with variation between high CH_4 uptake in the dominating dry upland areas and high emissions from the few wet spots of the forest. All the studied tree species emitted small amounts of CH_4 from the stems and shoots, with emission rates depending on the season, tree species and soil conditions. Especially, CH_4 emissions from birch canopies were high and can therefore contribute significantly to the ecosystem-scale CH_4 fluxes. Processes behind the canopy and stem CH_4emission remain unresolved, however, ongoing analysis of the methanogens and methanotrophs within the plant-soil systems will reveal whether CH_4 production or consumption is of microbial origin. Also, comparison of the CH_4 fluxes from trees and forest floor to sap-flow, transpiration, and NEE as well as soil parameters will help to explain the seasonality and mechanisms involved in the CH_4 emissions.