Department of Agricultural Sciences & Institute for Atmospheric and Earth System Research INAR, University of Helsinki

PLANT-MEDIATED METHANE AND CANOPY EXCHANGE IN A BOREAL UPLAND FOREST

Mari Pihlatie, Juho Aalto, Hannu Fritze, Iikka Haikarainen, Elisa Halmeenmäki, Jussi Heinonsalo, Katerina Machacova, Olli Peltola, Anuliina Putkinen, Üllar Rannik and Minna Santalahti

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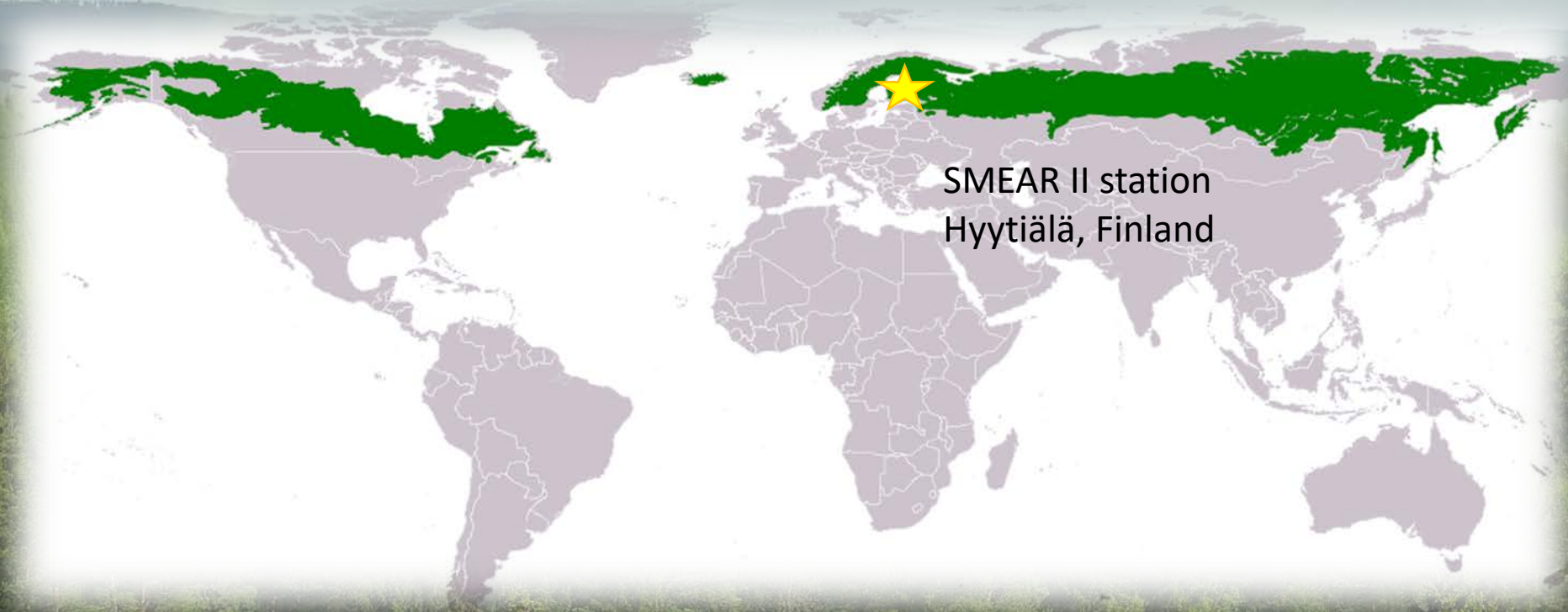

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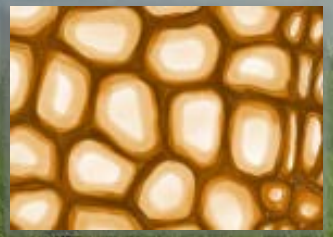
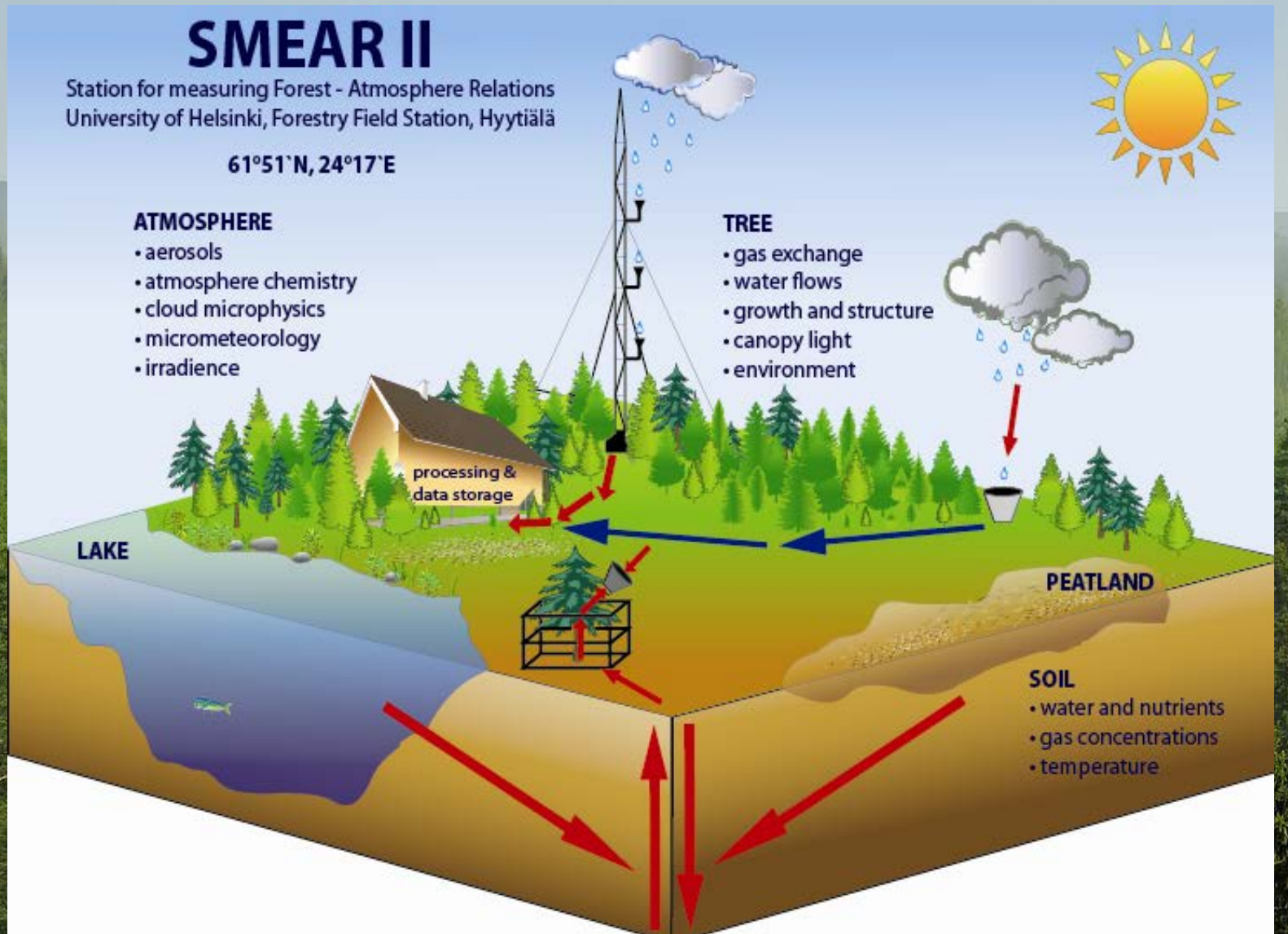
FROM MOLECULAR TO ECOSYSTEM SCALES AND FROM LABORATORY TO FIELD EXPERIMENTS





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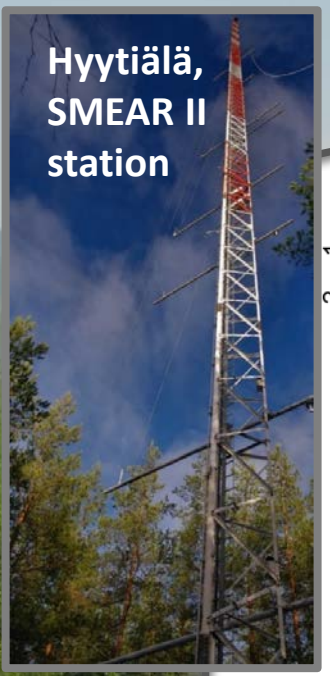
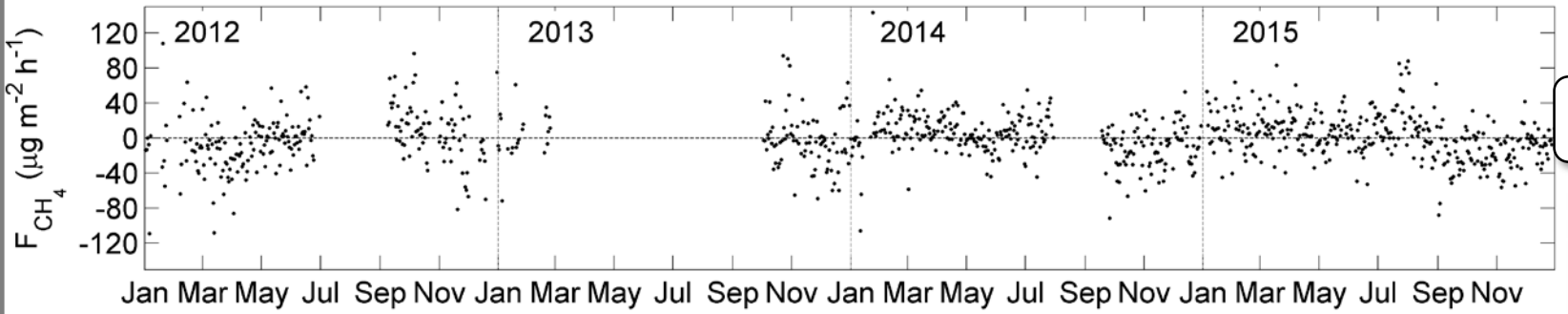
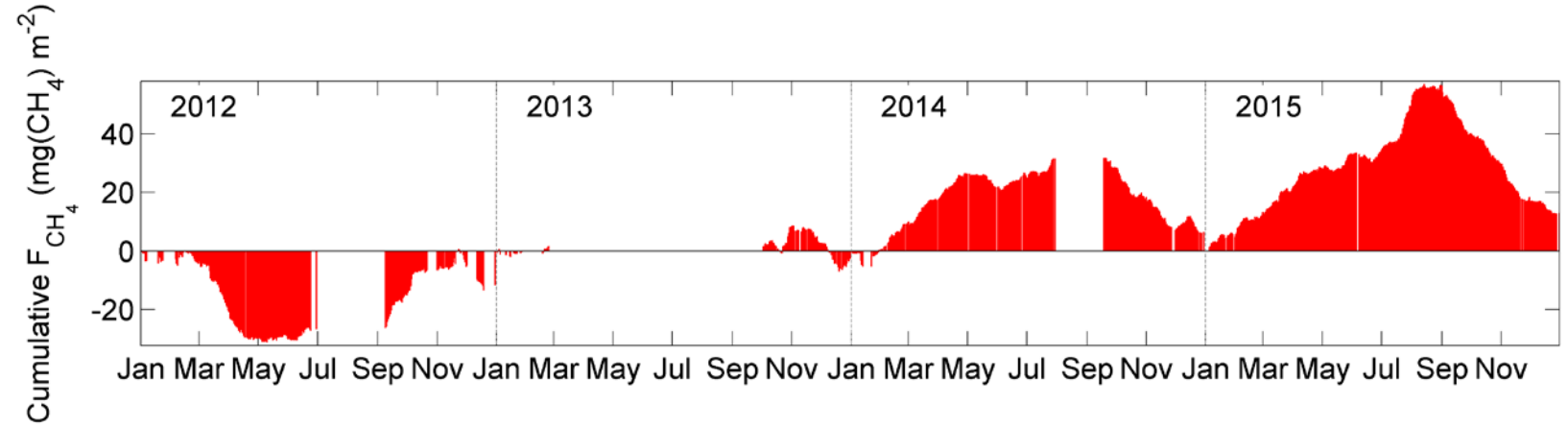
Motivation: Ecosystem-scale flux measurements indicate occasional emissions of CH_4

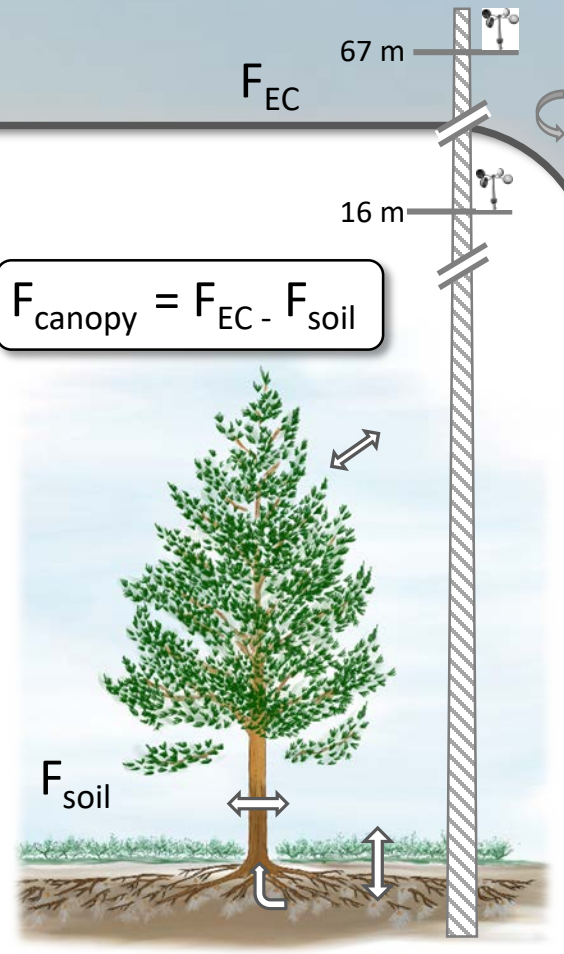


Forest floor in the upland areas acts as a sink!

Are we missing a soil source or do trees play a role?

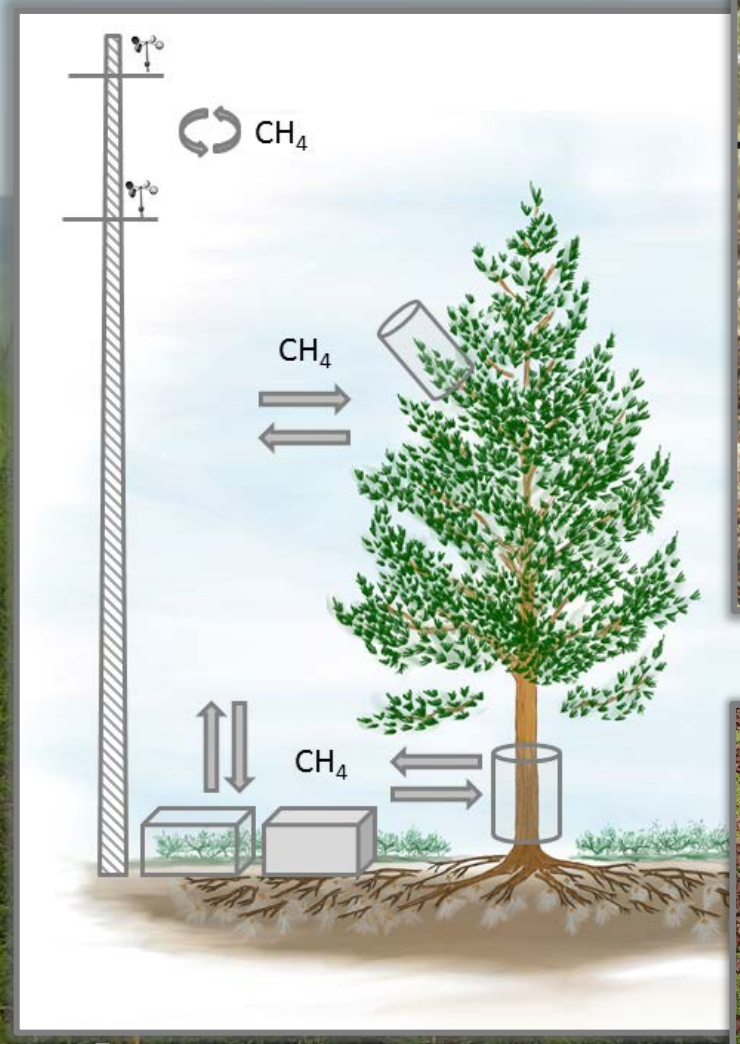




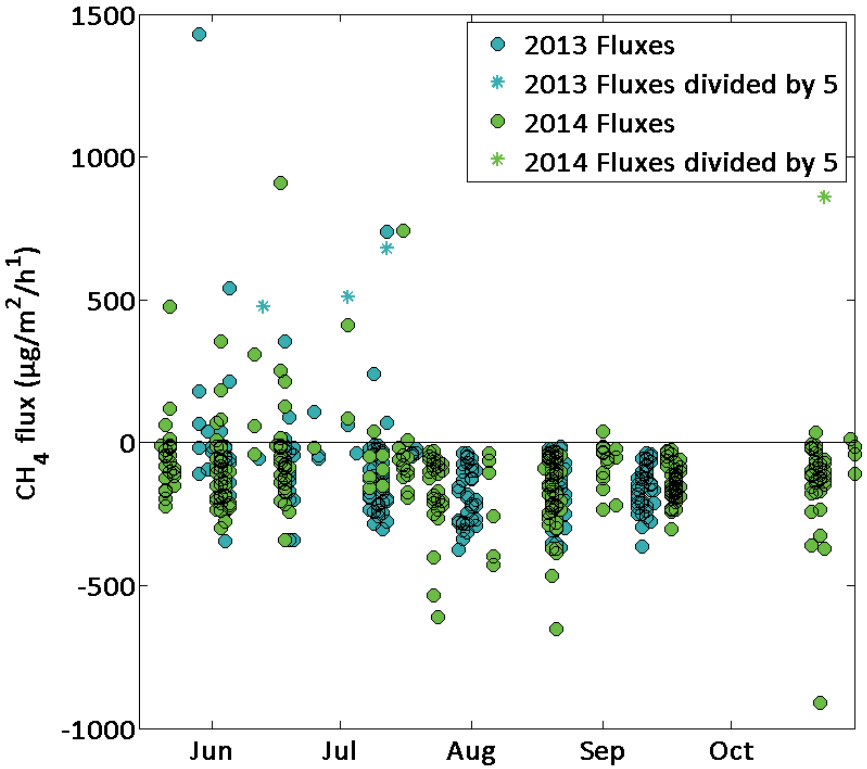


Figures: Olli Peltola & Elisa Halmeenmäki

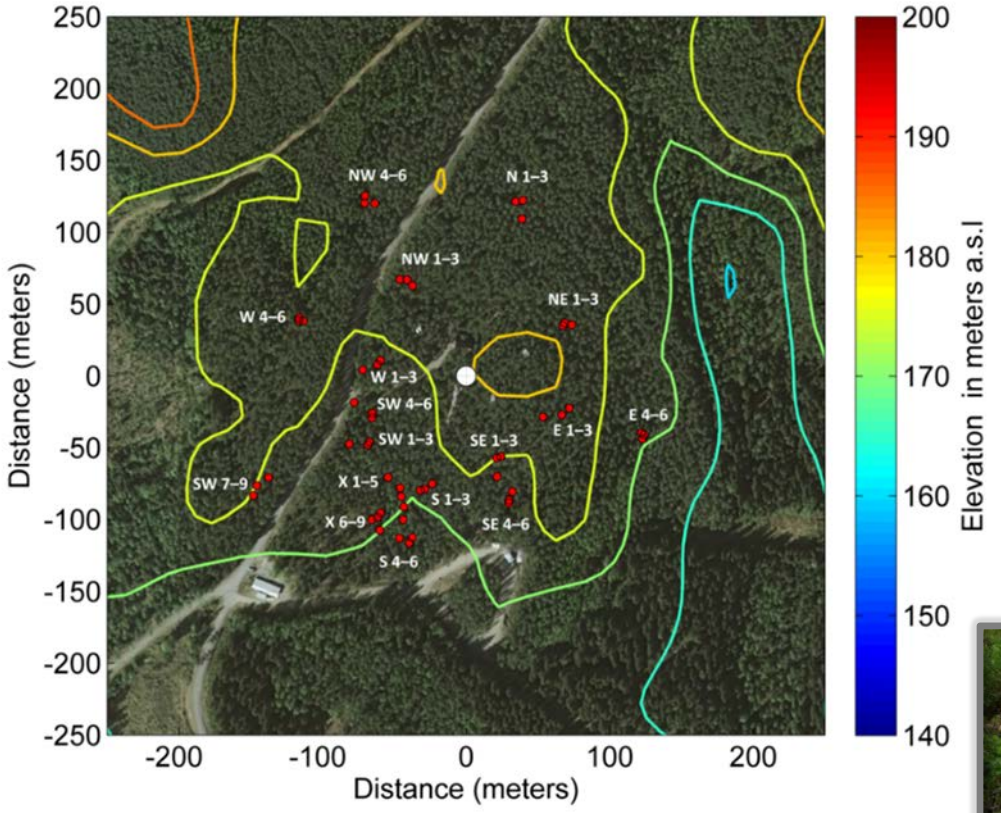
Series of experiments to quantify CH_4 fluxes in boreal forests

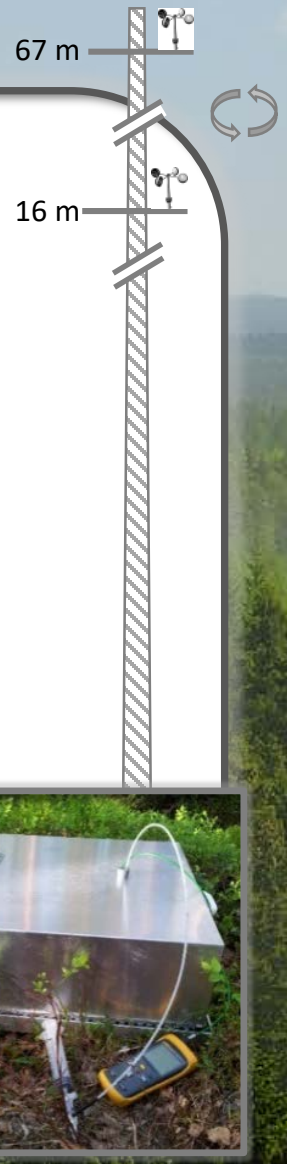


Quantifying the forest floor CH_4 fluxes in the footprint area



Halmeenmäki et al., in preparation





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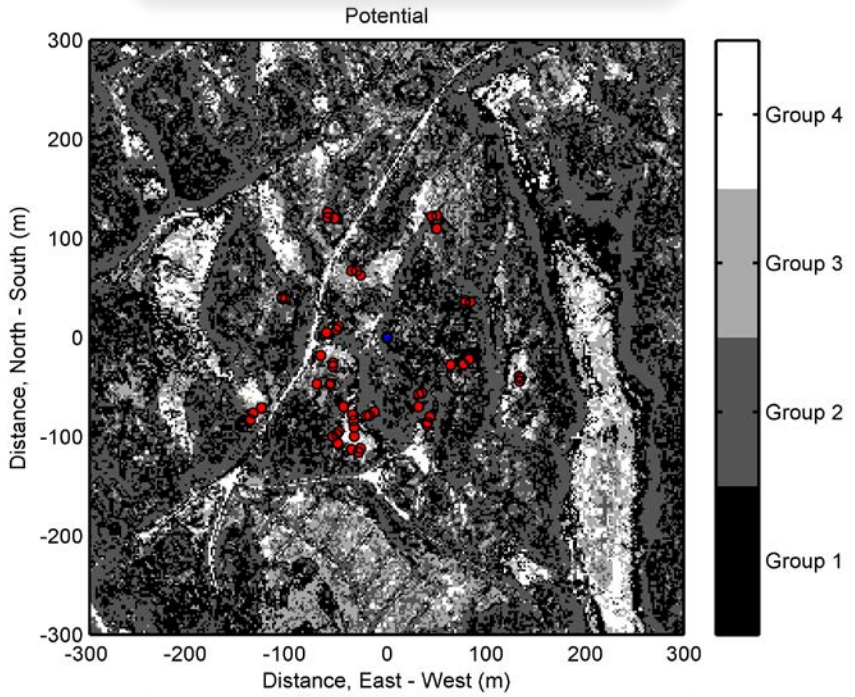
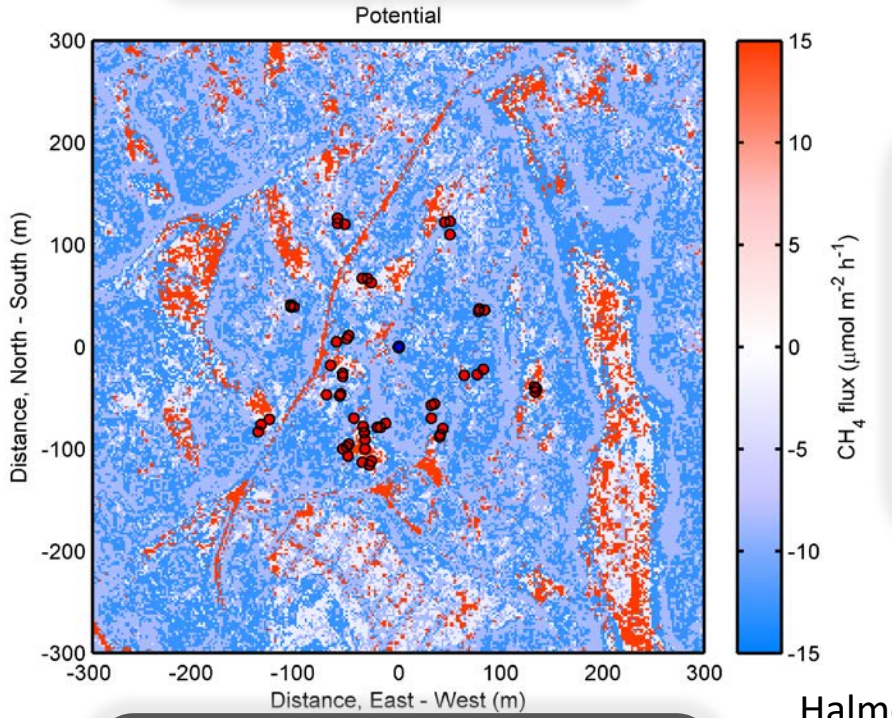
First attempt: Forest floor CH_4 fluxes do not seem to explain the above canopy emissions

Modelled soil moisture



Modelled CH_4 fluxes



Wet spots emit CH_4 while on average the forest floor is a sink of CH_4

Halmeenmäki et al., in preparation

LIDAR data => Digital elevation model (DEM) => grouping plots according to soil moisture

Based on correlation between soil moisture and forest floor CH_4 fluxes

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First tree measurements 2013: Scots pine trees growing on upland soils emit methane

SCIENTIFIC REPORTS

OPEN

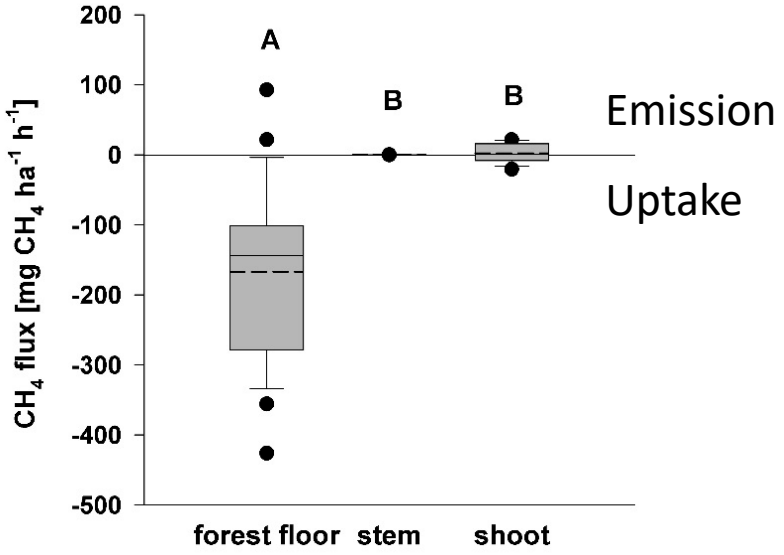
Pinus sylvestris as a missing source of nitrous oxide and methane in boreal forest

Katerina Machacova[1], Jaana Bäck[3], Anni Vanhatalo[3], Elisa Halmeenmäki[2], Pasi Kolari[2], Ivan Mammarella[2], Jukka Pumpanen[4], Manuel Acosta[1], Otmar Urban[1] & Mari Pihlatie[2,5]

Received: 10 September 2015
Accepted: 07 March 2016

Machacova et al., 2016

Stems and canopy emit CH_4, forest floor is a sink



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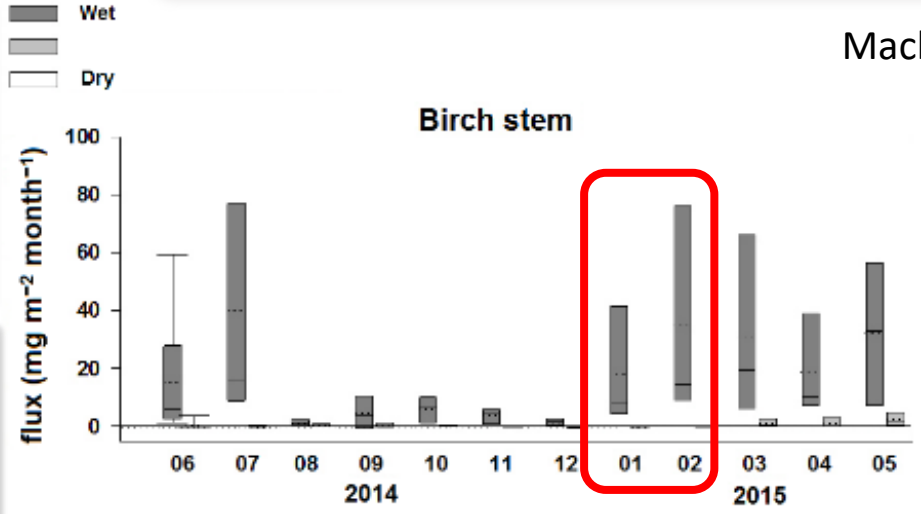
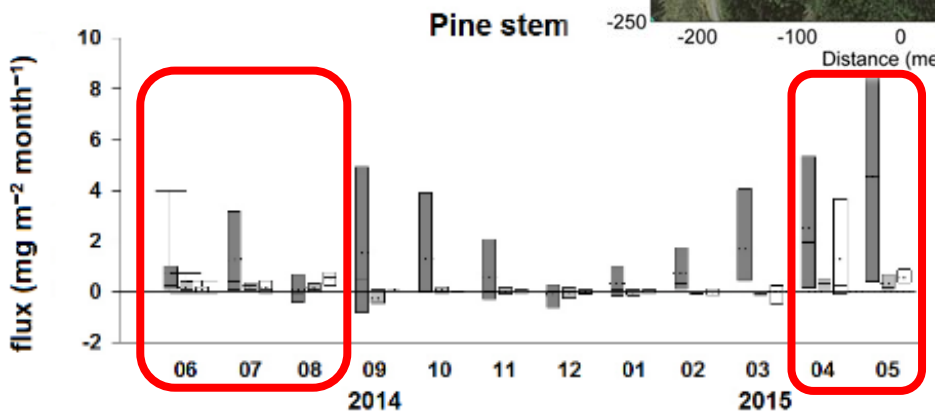
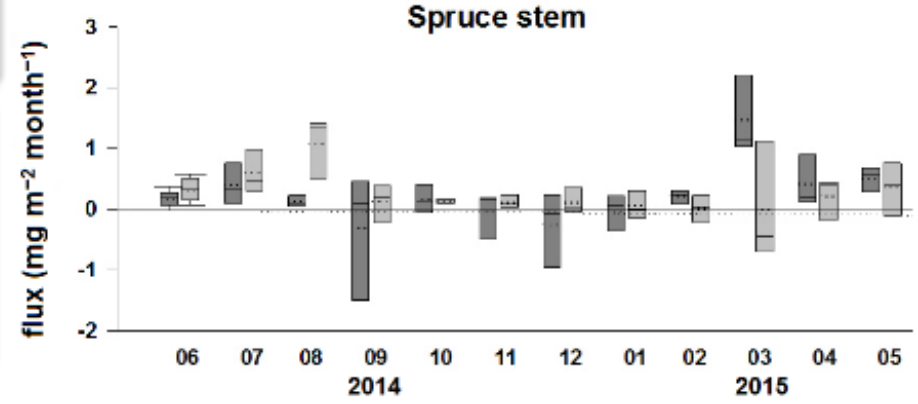
The effect of growing conditions and tree species

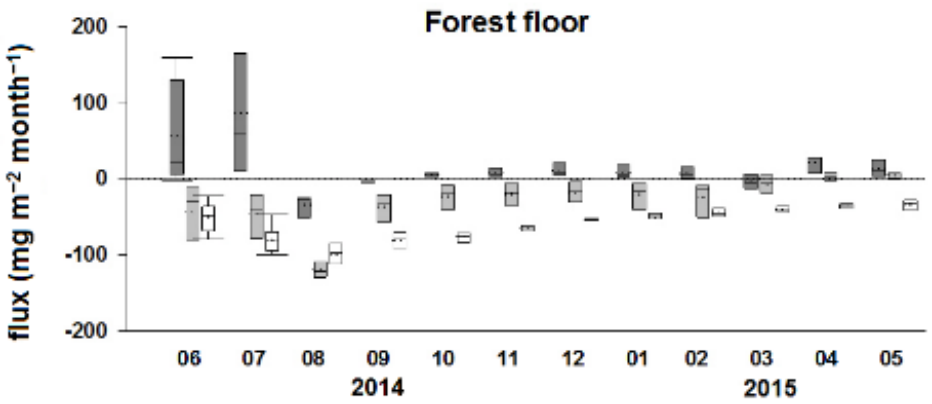
Birch growing on wet soils is the highest emitter

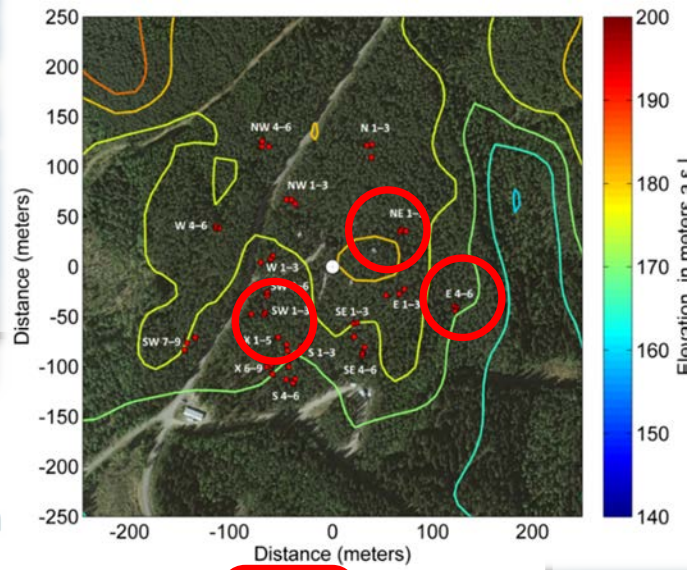
Machacova et al., in preparation





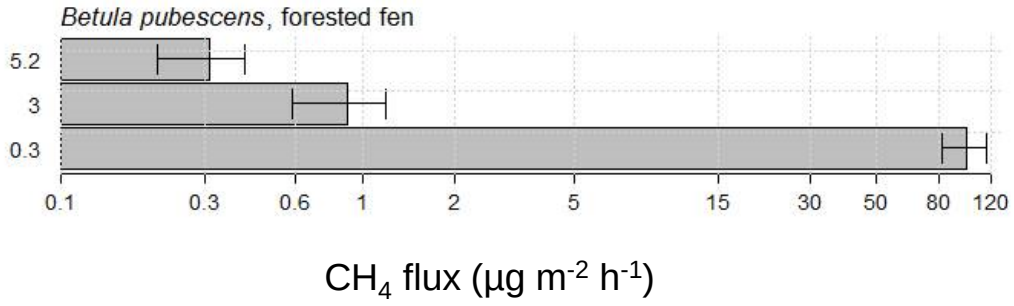






Tree stem CH_4 fluxes revisited: transport or *in-situ* production?

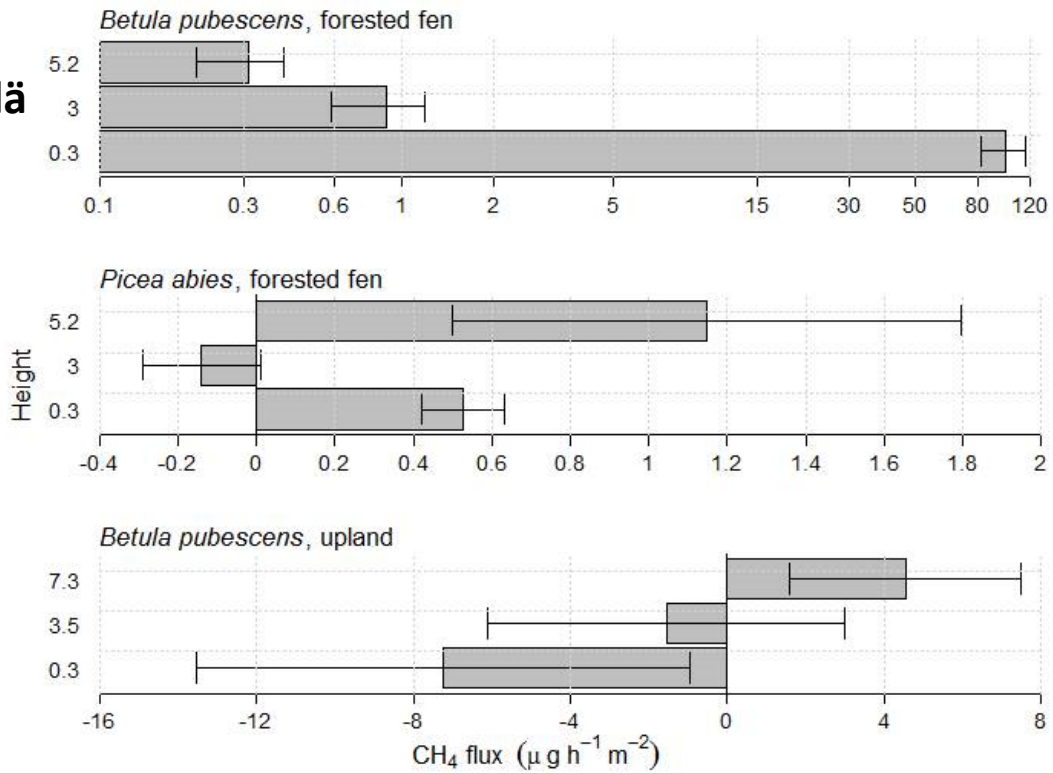
Hyytiälä



Haikarainen et al., in preparation

Tree stem CH_4 fluxes revisited: transport or *in-situ* production?

Hyytiälä

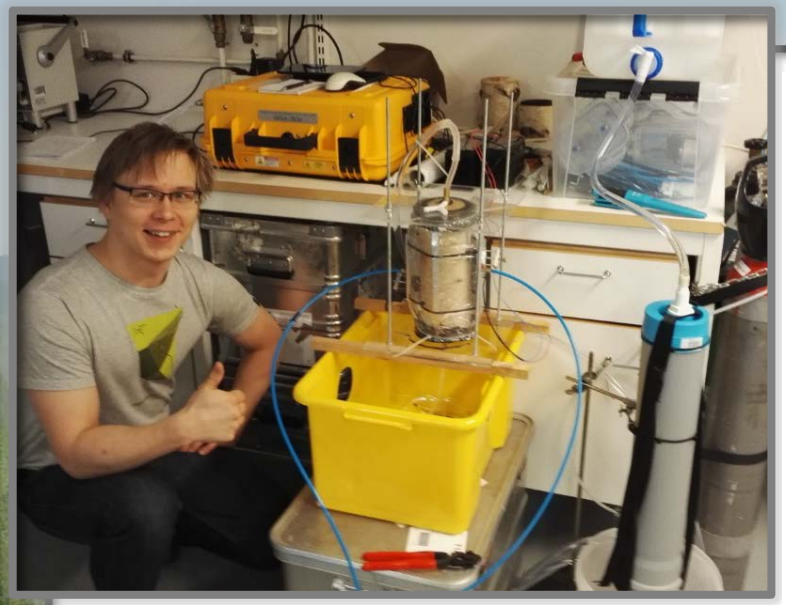


Stem fluxes highly variable between tree species and growth conditions

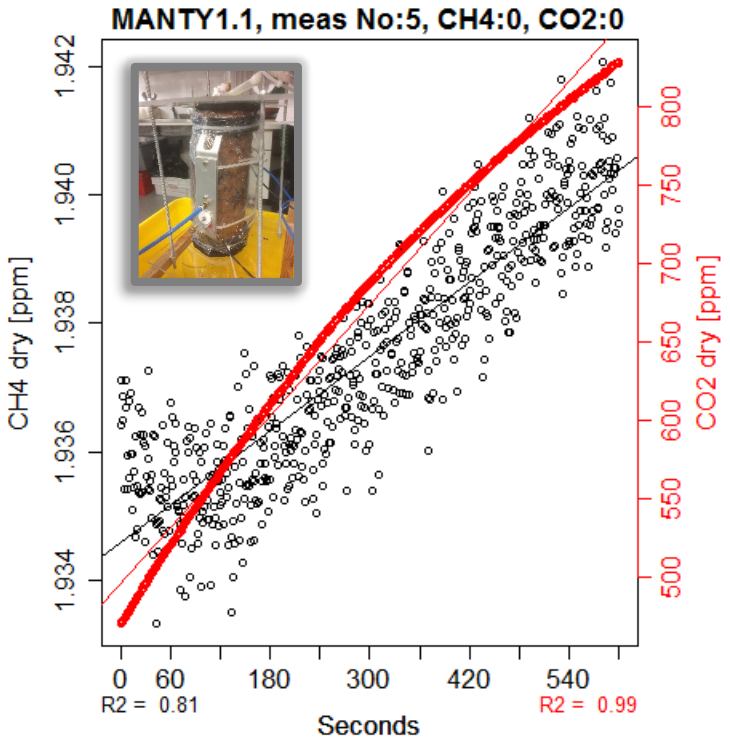
Does wood anatomy and diffusivity drive stem fluxes?

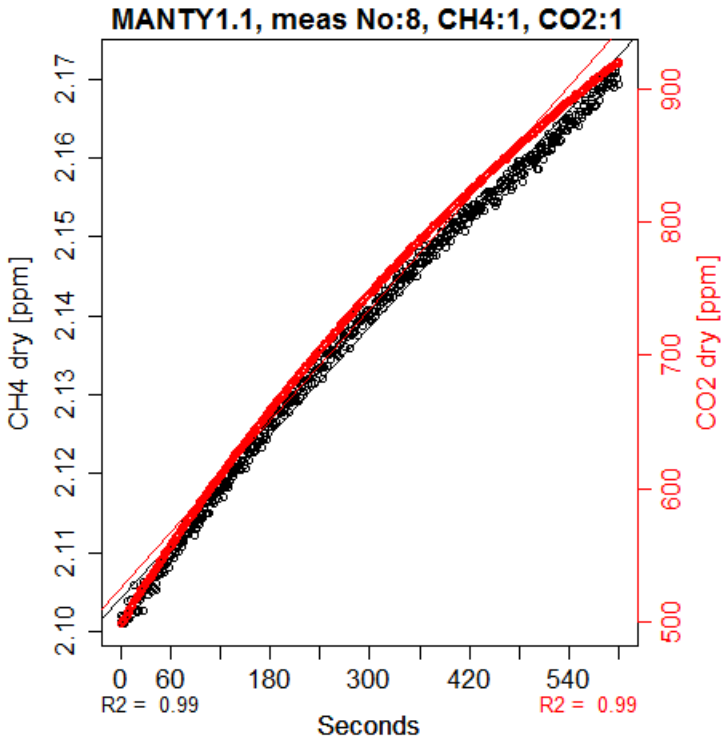
Haikarainen et al., in preparation

High soil [CH_4]: Transport of soil CH_4 via transpiration stream and emission through the stems



To obtain parameters for gas transport modelling



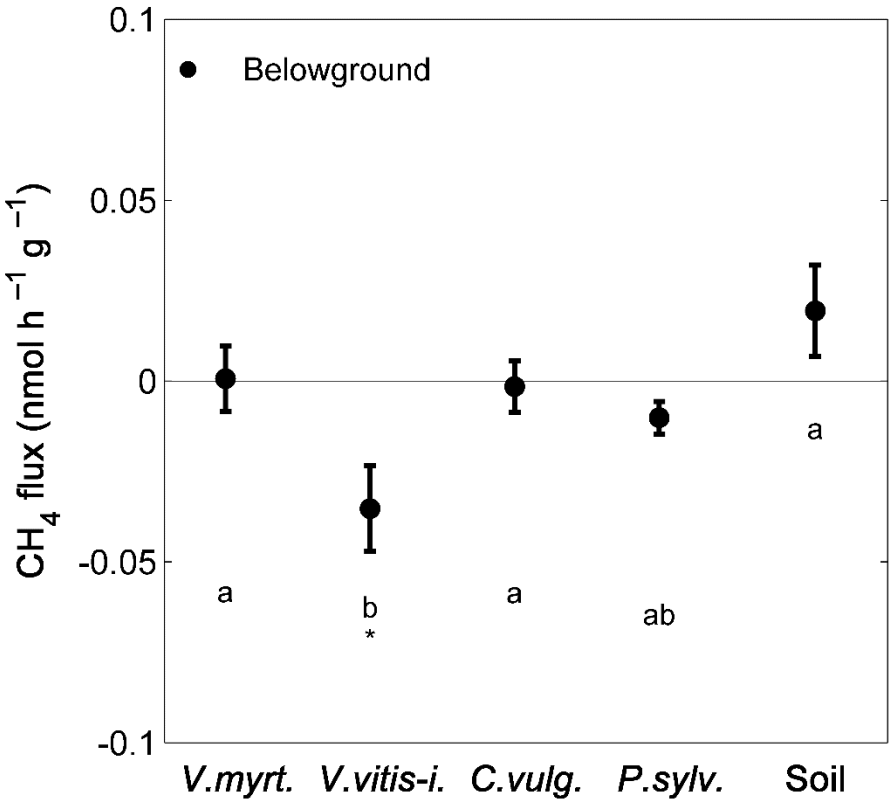


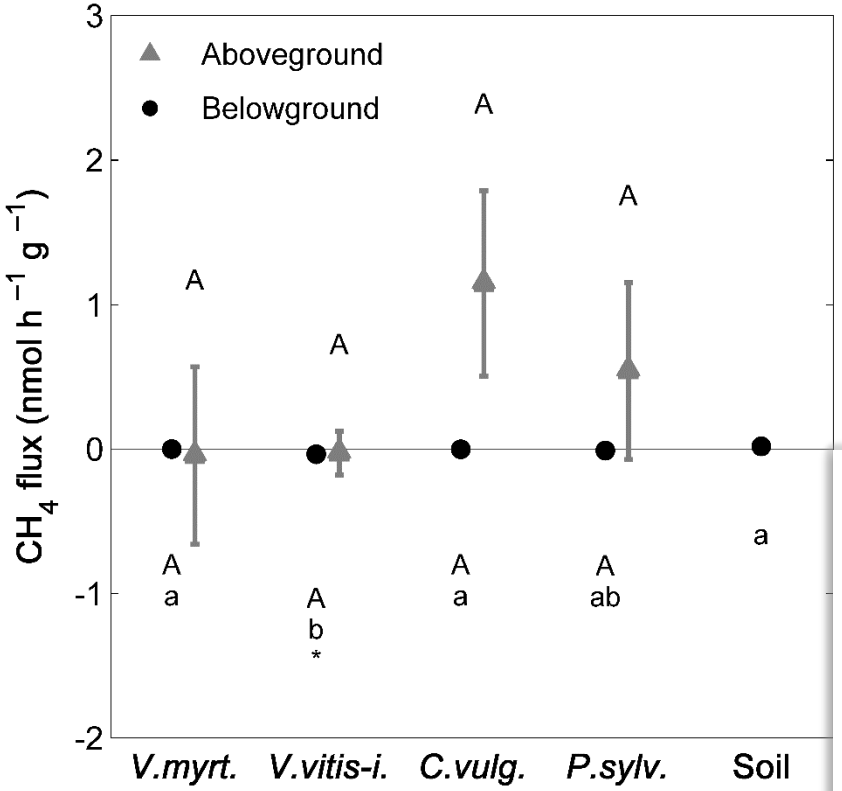
Do tree species differ in radial diffusion and gas diffusivity?

Homa Ghasemi, MSc thesis (work in progress)

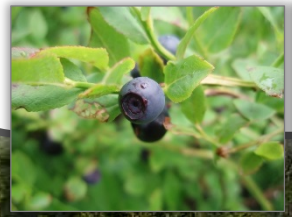
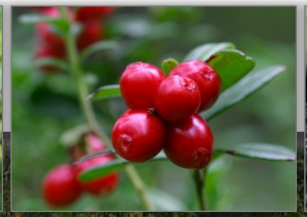
What is behind net CH_4 exchange in the forest floor?

Microcosm: to partition gas exchange of roots, soil and shoots of the plants





Aboveground plants emit CH_4, roots consume CH_4 and stimulate methanotrops

Halmeenmäki et al., 2017. Plant & Soil

What do we know of canopy exchange of methane in (boreal) forests?

Original work by Frank Keppler et al. (2006) suggests potentially high CH_4 emissions from tree canopies

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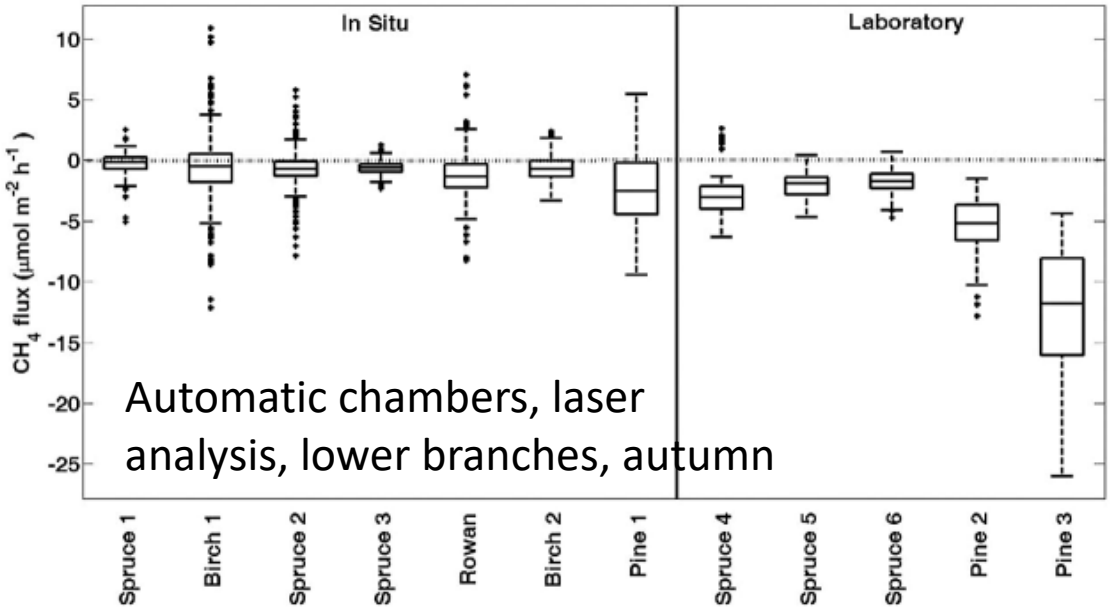
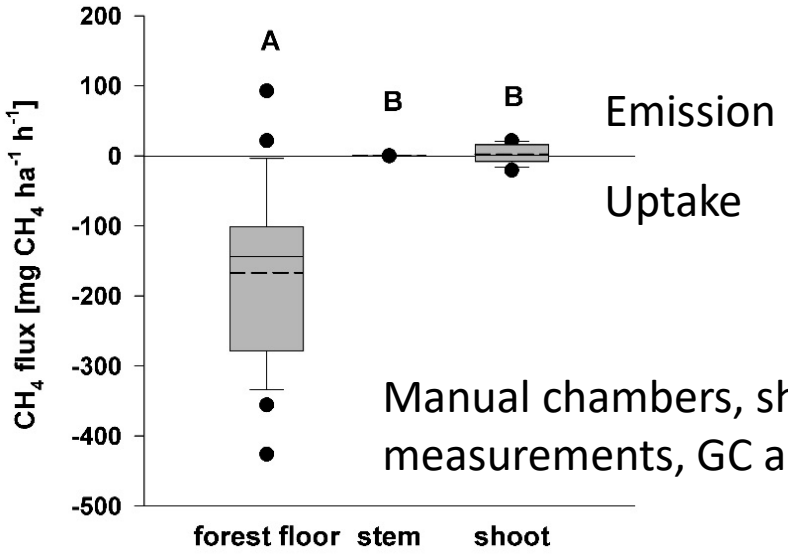
Very few studies indicate both emissions and uptake by tree shoots



Automatic chambers, laser analysis, lower branches, autumn

Sundqvist et al., 2012

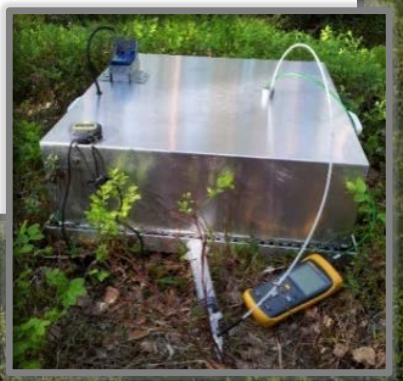


Emission

Uptake

Manual chambers, shade measurements, GC analysis

Machacova et al., 2016



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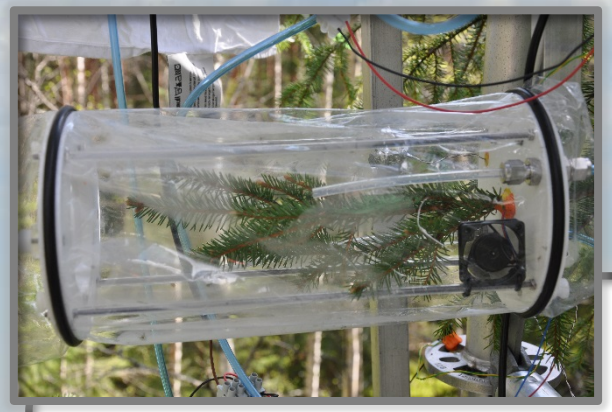
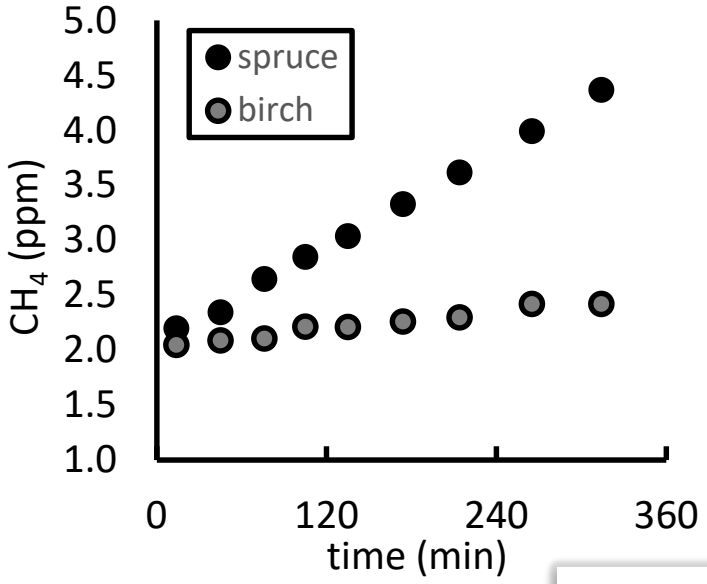
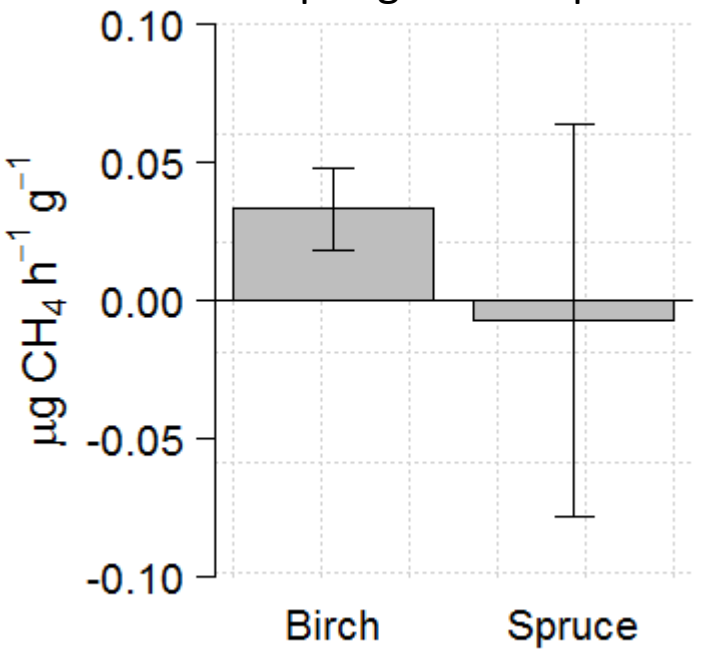
@Hyytiälä: occasional CH_4 emissions in shade

Are they significant and how to scale up?





Spring leaf out period

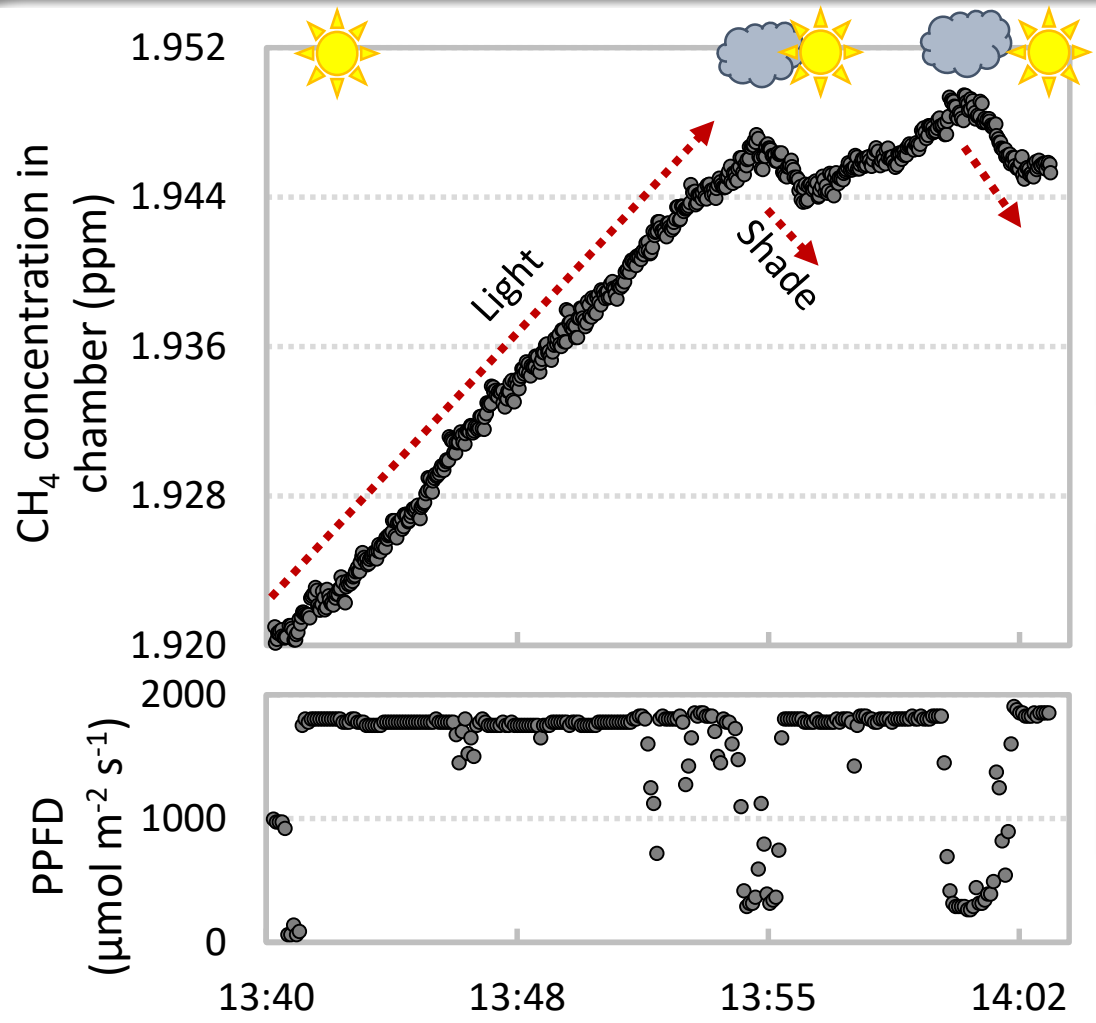


Haikarainen et al., in preparation

Long closure times, shaded shoot chambers to avoid heating

Undisturbed canopy CH_4 exchange: improved shoot enclosures?

Typically enclosures tend to disturb (Temp↑; CO_2 ↓; H_2O ↑)
How to measure under normal environmental conditions and avoid stress to the plant?



@Hyytiälä

Test measurements: CO_2 addition and temperature control

All tested trees emitted CH_4 in light. The significance remains to be solved!

Unpublished, data from June 2017

TO CONCLUDE

- **Upland boreal forests can act as a source of CH_4 even though the soil is a sink of CH_4**
- **Boreal trees emit and can consume CH_4** from stems and canopy
- **The emissions are variable** seasonally, between tree species and growing conditions
- **Processes behind still not specified: 1) Aerobic and non-microbial production, 2) Transport of soil produced CH_4, 3) Microbial production & consumption within plants** (not by **methanogens**)

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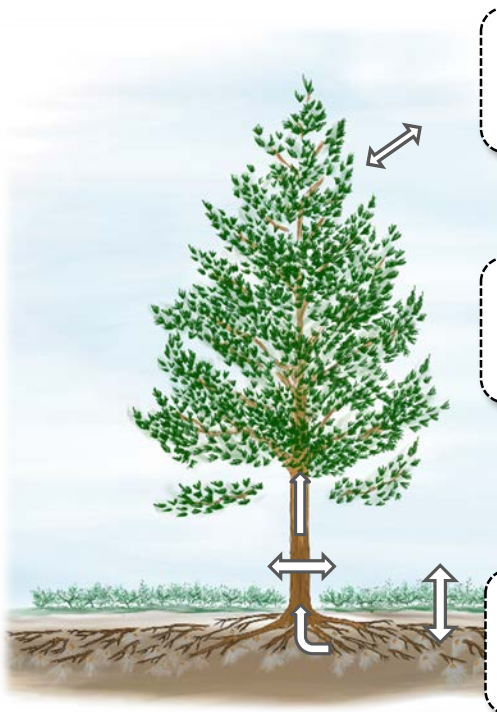
Thank you!

Open position for a modeller! Please contact me ☺

mari.pihlatie@helsinki.fi; http://blogs.helsinki.fi/Methane-forest/

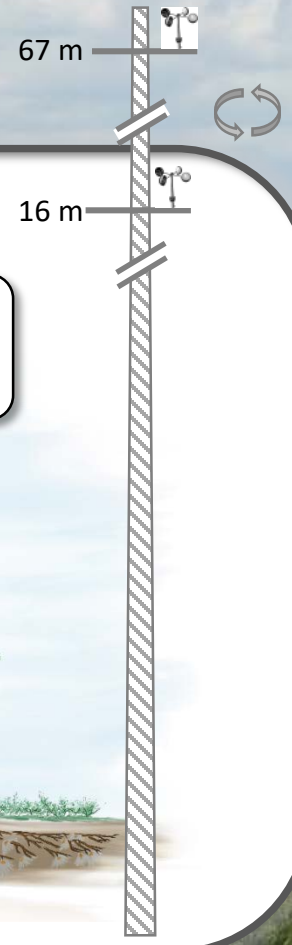


Canopy CH_4 processes

Stem CH_4 processes

Soil CH_4 processes

SOIL-TREE-ATMOSPHERE CH_4-MODEL



F_{EC}

$F_{canopy} = F_{EC} - F_{soil}$

F_{soil}

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