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Funding was provided through infrastructure grants by Universität Innsbruck via the research area Mountain Regions.

Methane flux measurements above a Scots Pine forest in Austria

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Background

Forests play an important role in the exchange of greenhouse gases like CO_2 and CH_4 between the biosphere and the atmosphere. Although fluxes vary depending on biotic and abiotic factors like ecosystem composition and climatic conditions, forests generally are a sink for CO_2. For CH_4, forests with well-drained soils are considered a sink due to the oxidation of CH_4 within those soils. However, recent study results indicate that CH_4 emissions from trees may offset this soil CH_4 sink, resulting in a lower sink strength or even source at the ecosystem level. So far, ecosystem CH_4 flux measurements at upland forest sites are sparse.

Methods

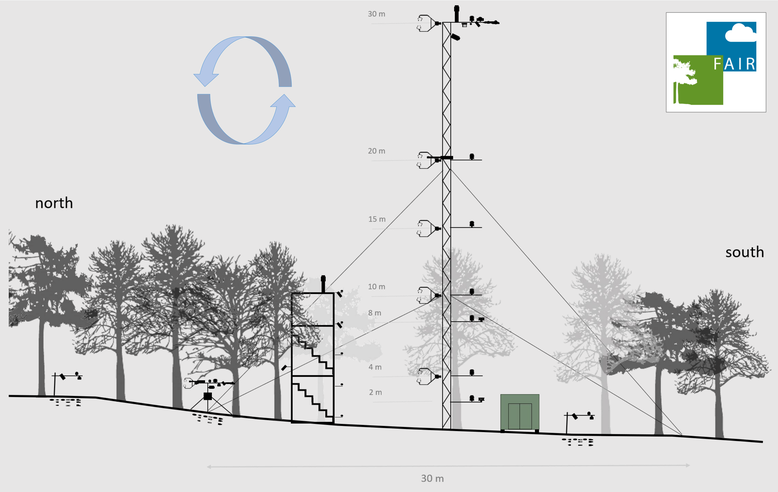
Forest-**A**tmosphere-**I**nteraction-**R**esearch (FAIR) site

-a research platform of the University of Innsbruck
-960 m a.s.l; lat: 47° 18.9938' N, lon: 10° 58.2053' E
Scots Pine forest
Major tree species: ***Pinus sylvestris***
Major shrub species: ***Juniperus communis***
Tree age: 102 +/- 31 years
Tree height: 8.3 +/- 1.7 m

Well drained calcareous bedrock; nutrient poor and shallow soils

2022: MAT =8.7 °C, TAP = 727 mm (**Fig. I**)

CH_4, CO_2, LE, and H fluxes are measured continuously at 20m height using the Eddy Covariance (EC) method. Instruments include a 3D sonic anemometer (CSAT), an enclosed infrared gas analyzer (EC155; CPEC System) and an **open path CH4 gas analyzer (Li7700)**.



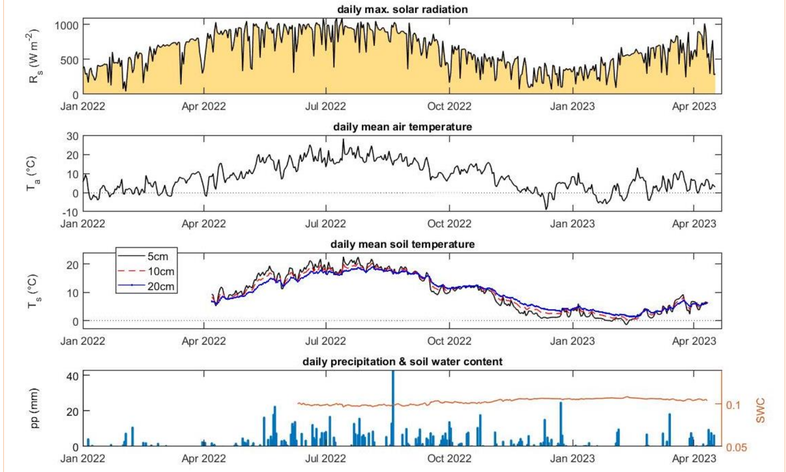


Fig. I

Results

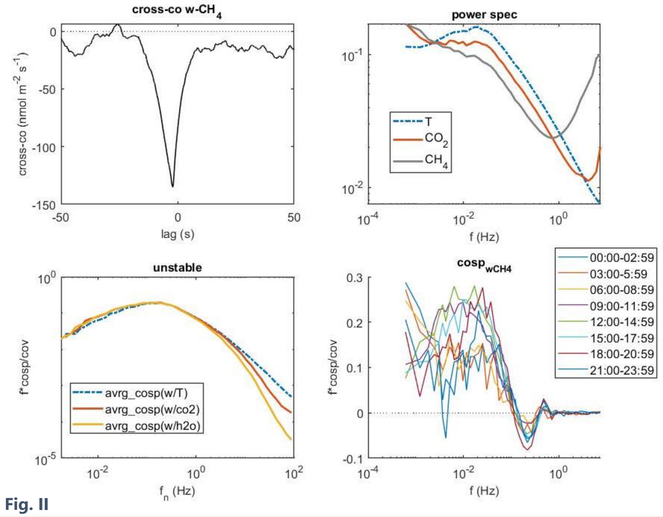


Fig. II

Questions

What is the CH_4 source / sink strength of a Scots pine forest ?

Can the challenges of measuring small CH_4 fluxes with an open path sensor be addressed reasonably ?

Fig.II: Most of the time, the time lag of CH_4 relative to the vertical wind velocity (w) could clearly be determined through a clear peak in the w-CH_4 cross-correlation.
The CH_4 power spectra showed larger attenuation and instrumental noise at high frequencies than CO_2. Total flux attenuation was estimated to about 21 % on average (compared to ~5 % for CO_2).
Normalized w-CH_4 cospectra showed unexpected behavior with negative values in the higher frequency range.
Fig.III: In general, CH_4 fluxes were small and showed higher variability during the day, especially when energy fluxes were high. As the open path CH_4 gas analyzer measures gas densities, fluxes have to be corrected for density and spectroscopic effects. At low flux environments (like our site), those corrections are larger than the actual CH_4 flux.

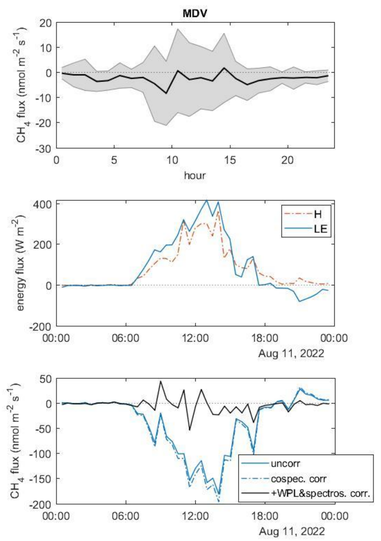


Fig. III

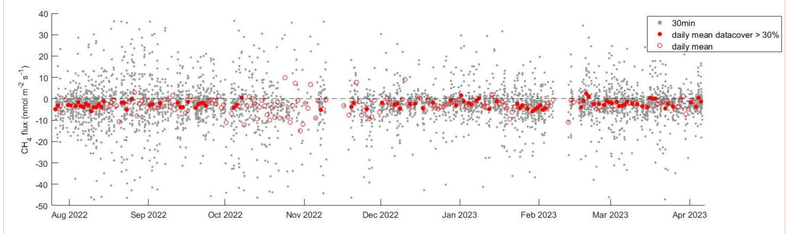


Fig. IV

After quality control, CH_4 flux **data cover was about 35 %.**
The overall **mean (±1std) CH_4 flux was -2.75 ± 9.1 nmol m^{-2} s^{-1}** (**Fig. IV**).
Flux random uncertainty was 3.4 ± 6.6 nmol m^{-2} s^{-1} (median ±1std) while flux uncertainty due to instrumental noise was estimated to be about 6 % of the random flux error.

- Fluxes were close to zero; non-zero fluxes are likely caused by random flux uncertainty or uncertainties in the density and spectroscopic corrections.
- To determine whether this very low CH_4 flux at this site is a result of counter-interacting soil and tree fluxes, soil chamber measurements are planned during 2023.