Variations of methane concentrations over two Swiss grasslands

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Introduction

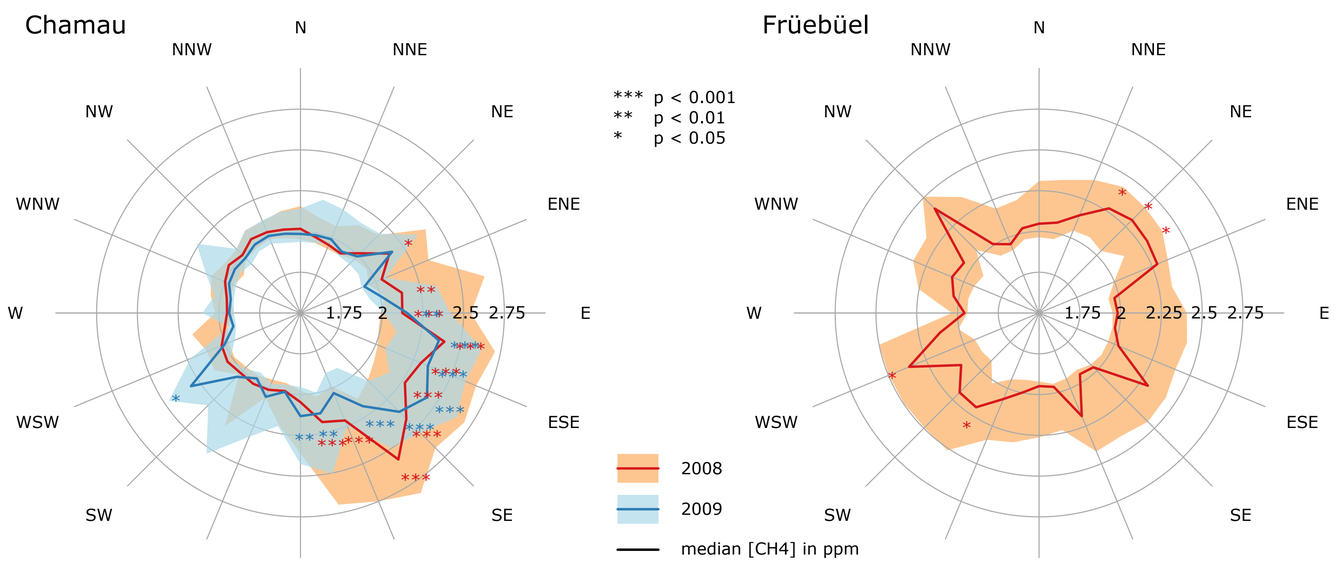
National inventory estimates of CH_4, e.g. for reporting under the Kyoto Protocol, are made at the national level without detailed knowledge about the spatial and temporal variability of CH_4 emissions. We thus started to investigate this variability first by studying temporal dynamics of CH_4 concentration time series, which will be complemented by direct eddy covariance flux measurements in the future.

Sites and methods

Measurement of 30-min averaged methane concentrations at Chamau and Früebüel (both Agricultural Research Stations of ETH Zürich) using a Fast Methane Analyzer (Los Gatos Research Inc., USA)

Chamau:
400 m a.s.l.
valley floor
Cambisol, partially Gleysol
data from Sept 2008 & Apr 2009

Früebüel:
1000 m a.s.l.
on the ridge of Zugerberg
Cambisol and Gleysol
data from Sept 2008



Windroses of methane concentrations

Chamau (left panel):

- enhanced CH_4 if prevailing wind from SE
- 2008 vs. 2009: peak SW (direction of stables) in 2009: In Aug 2008, the cows were in the Alps (Swiss traditional three stage farming system) while they were on the farm in Apr 2009.

Früebüel (right panel):

- slightly higher concentrations from NE and SW (relates to the change of wind regime over the measurement period accompanied with elevated CH_4 towards the end of the month, see Figure below)

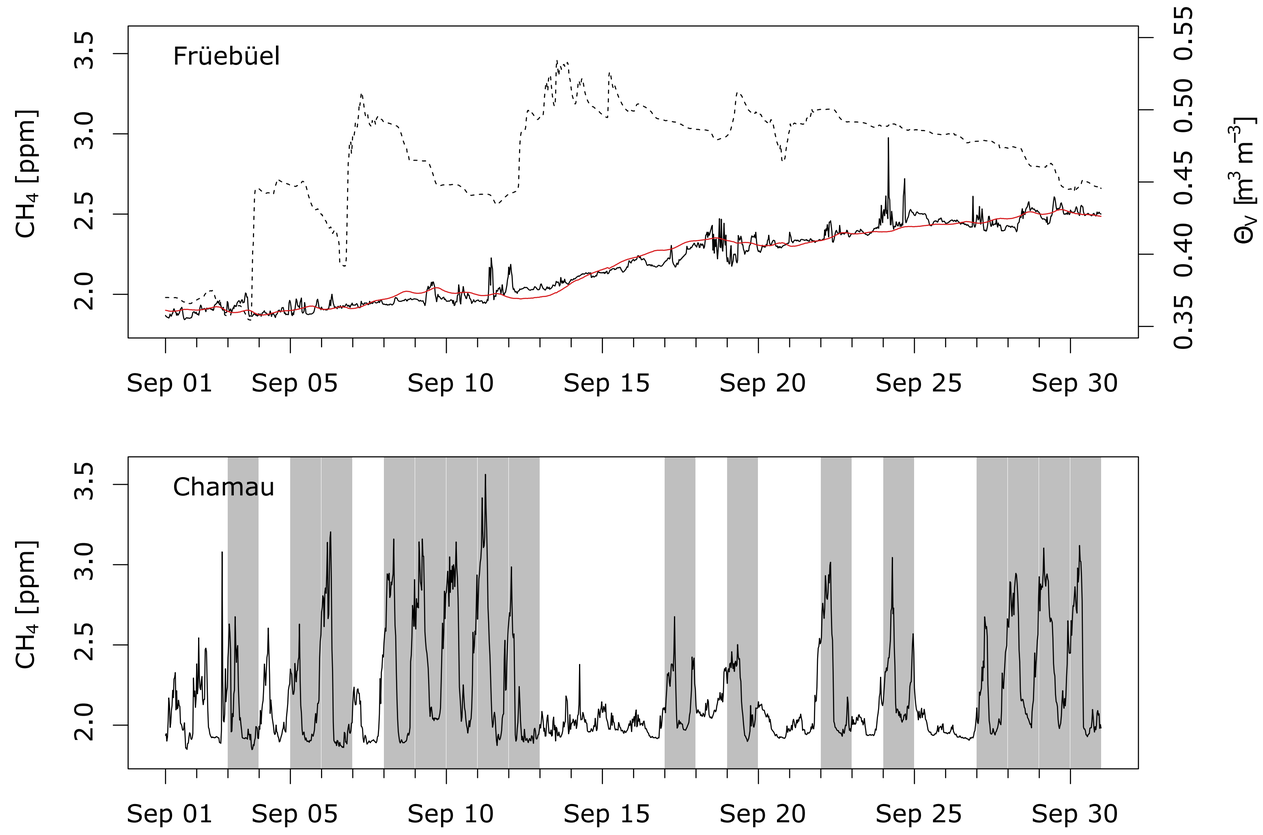
Temporal variation of methane

Früebüel (upper panel):

- steady increase of methane concentration (solid line) following soil moisture Θ_v at 5 cm (dashed line), r = 0.46
- the more humid the soil, the faster the increase in CH_4 (change of slope of CH_4 after each rain event which are indicated by a rapid increase of soil moisture)
- strong neg. correlation ($r < -0.86$) between CH_4 and T_{soil}, getting stronger with depth where diurnal cycle is less distinct (lowest measurement at 95 cm)
- model $CH_4 = T_{soil,95cm} + \Theta_{v,5cm} + T_{soil,95cm} \cdot \Theta_{v,5cm}$ (red line) explains 95.0 % of temporal CH_4 variability

Chamau (lower panel):

- strong diurnal pattern of methane concentration (solid line) on pronounced valley wind days (shaded)
- base line is rather stable



Conclusions

- Concentrations measurements over an ecosystem are strongly affected by local environmental conditions, which are influenced by both meteorological and biological processes.
- Neighboring sources can strongly influence the measured concentrations at a given locality, as concentration footprints are relatively large compared to flux footprint areas.
- If nearby sources are not dominant, changes in concentrations should be explainable by local environmental variables.

Outlook

With the progress of our project, namely by adding direct eddy covariance flux measurements to the concentration measurements, we aim at improving our understanding of spatial and temporal variability of CH_4 concentrations. Where temporal variability is well resolved at the selected research stations, we will also employ low-level aircraft measurements to address the spatial variability that is not well resolved by two surface stations alone.

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