How Relevant are Freshwater Ecosystems for the Global Methane Budget?

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Abstract

Lakes have a controversial climate footprint. In fact, they are a sink of CO2 but at the same time they can be an important source of CH4. Indeed, a global synthesis of methane emission data (Bastviken et al., 2011) suggests that freshwater ecosystems - in particular lakes - may be much larger sources of methane than previously thought, questioning current methane budgets and the general role of freshwater ecosystems in the greenhouse gas balance. The main objective of this study is to improve data availability and quality regarding methane emissions from lakes in the Alpine region - a region that presently is heavily under-represented in global data sets - in order to allow a robust assessment of their role in the global greenhouse gas balance. This is of fundamental importance for the assessment of CH4 emissions from regions particularly sensitive to an increasing climatic variability. Aiming at spatial and temporal representativeness of flux measurements, we made use of an innovative mobile eddy covariance system. We installed the instruments on a small boat, and we performed measurements while cruising. Meteorological and bio-physical data got recorded simultaneously to investigate drivers of gas fluxes by means of empirical modelling. Additionally, we made use of classical chamber measurements for validating our approach. In this fashion, we investigated a number of natural and man-made lakes across a transect of two degrees of latitude across the Alps. In fact, the alpine region provides a unique opportunity to assess the role of environmental drivers on GHG emissions over a limited latitudinal range in an altitude-for-time substitution manner. We repeatedly visited target lakes across the ice-free season during the years 2018 and 2019. We demonstrated that our method is valid for capturing methane emissions from different pathways (diffusion but also ebullition and transport through vegetation). We found that most of the lakes are supersaturated and the highest emissions were measured in shallow and eutrophic lakes at low altitude. In conclusion, with this study we were able to develop new insights on the role of freshwater ecosystems in the global methane budget. References: Bastviken D, Tranvik LJ, Downing JA, Crill PM, Enrich-Prast A (2011). Freshwater methane emissions offset the continental carbon sink. Science 331, 50.

How Relevant are Alpine Freshwater Ecosystems for the Global Methane Budget?

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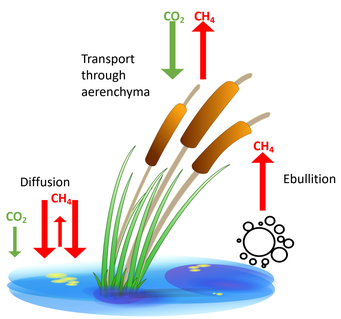
1. Overview

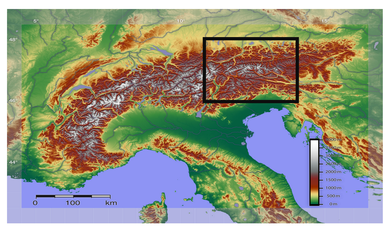
- Lakes are a sink of CO_2 but at the same time they can be an important source of methane (Bastviken et al. 2011, Holgerson and Raymond 2016, Sanches et al. 2019, Saunois et. al 2019). There is need for reducing uncertainties of our estimates. In doing this, all the pathways need to be considered.
- The main objective of this study is to improve data availability and quality about methane emissions from lakes in regions particularly sensitive to an increasing climatic variability like the Alpine region.



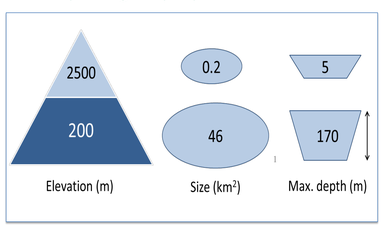
- We made use of an innovative mobile eddy covariance system. We installed the instruments on a small boat and performed measurements while cruising. Meteorological and bio-physical data got recorded simultaneously.
- We made use of chambers and dissolved gasses approaches for validation.
- We visited several natural and man-made lakes across a transect of two degrees of latitude across the Alps across the ice-free season during the years 2018 and 2019.

2. Approach

a. Area of Interest (AOI)

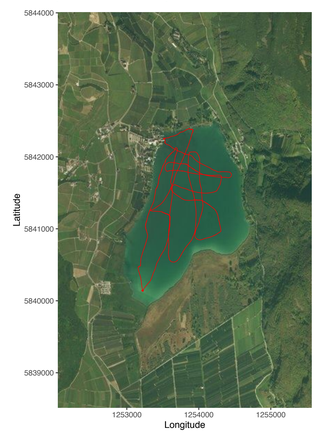


b. Morphological properties of lakes in the AOI



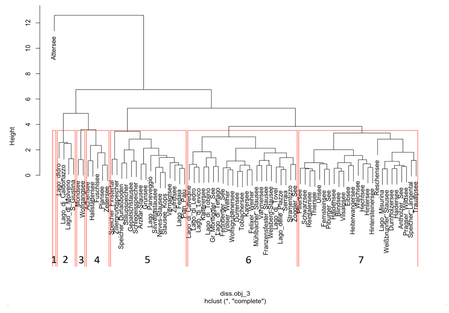
c. The platform with installed instruments

d. Example of a sampling cruise (Kalterer See)

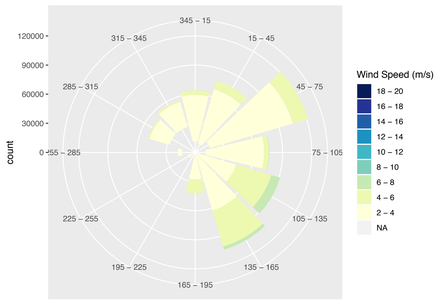


3. Results

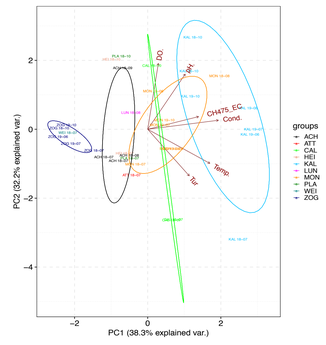
a. Clustering of geo-morphological parameters for sampling design



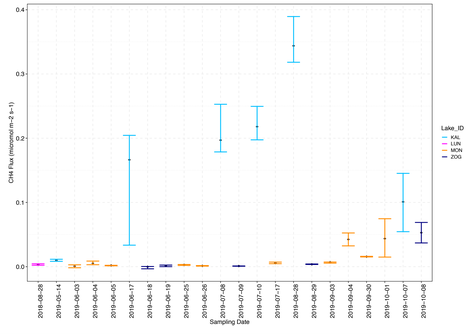
b. Corrected wind speed and direction during a sampling cruise



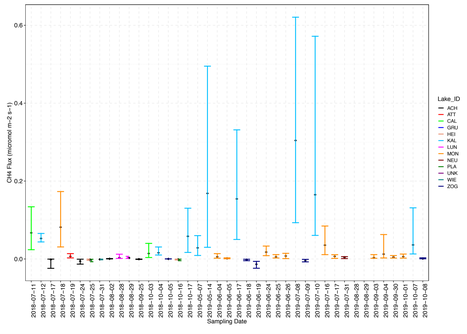
c. PCA of main predictors for high fluxes



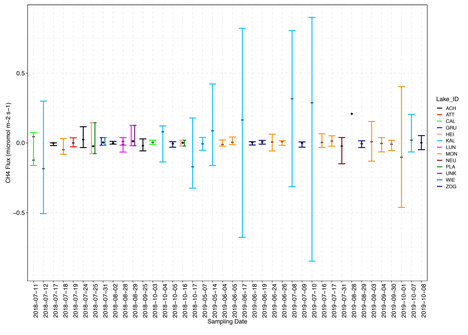
d. Fluxes and uncertainties from chamber sampling



e. Fluxes and uncertainties from dissolved gases sampling



f. Fluxes and uncertainties from eddy covariance



4. Conclusions

- Even lakes at high elevation are supersaturated with CH_4.
- Measurements across a latitudinal range of lakes show a trend towards higher CH_4 emissions from warm lakes at low elevation.
- The main predictors are dissolved oxygen, pH, conductivity, temperature and turbidity.
- Kalterer See - a shallow, small lake in the southern part of the AOI – showed the highest CH_4 concentrations/fluxes.
- The temporal variability of mobile eddy covariance measurements is consistent with other established methods.
- The spatial variability of CH_4 fluxes is caught by means of mobile eddy covariance measurements and needs to be analyzed with with ancillary data.

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