High Spatio-Temporal Methane Dynamics in Surface Waters: Between *in situ* Production and Emission

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For more than one decade, freshwater environments are considered as globally significant methane (CH_4) sources. The discovery of CH_4 accumulation in oxic marine and limnic waters led to redefine the role of aquatic environments in the global CH_4 budget. Although CH_4 accumulation in oxic surface waters became obvious over recent years, the sources are still subject to controversial discussions.

We present high-resolution simultaneous *in situ* measurements of CH_4 concentrations and its stable isotope values in a stratified oligo-mesotrophic lake. We show that CH_4 dynamics within the oxic water layer are notably stronger and faster than previously assumed. Additionally, aquatic surface water CH_4 accumulation originates from a highly dynamic interplay between CH_4 emission, oxidation and production within the oxic surface water.

Measured *in-situ* concentrations of aquatic CH_4 show remarkably good spatial and temporal coverage with cyanobacteria and diatom pigments. Laboratory incubations of different phytoplankton types and the application of stable isotope labelling techniques provide evidence that major phytoplankton classes in Lake Stechlin *per se* produce CH_4 under oxic conditions.

Combined with our field data, this implies that epilimnic CH_4 production is related to the photoautotroph community and thus drives accumulation of CH_4 in surface waters in a highly dynamic spatio-temporal manner.