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Seasonal changes in CH_4 emissions from an alpine reservoir, Lake Klöntal, Switzerland

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Abstract

Atmospheric methane (CH_4) concentration doubled since the pre-industrialized era and its potential as a greenhouse gas is 25 higher than CO_2 over a 100-year horizon. Recent studies showed an important contribution of inland waters, including hydropower reservoirs, to the global CH_4 cycle. However, the large seasonal and latitudinal variability of emissions reported in the literature highlights the necessity for a better understanding of CH_4 emission mechanisms. The aim of this study was to investigate physical factors (water level and temperature) that trigger the seasonal pattern of CH_4 emissions in a Swiss alpine reservoir, Lake Klöntal, using multiple methods. Atmospheric CH_4 flux was measured using a fast methane analyzer (FMA, Los Gatos Research) and an eddy covariance tower set on a floating platform from April to December 2011 (before ice sets). Emissions were also measured monthly via chambers and calculated from surface water concentrations using Henry's law. Methane ebullition was examined over the lake surface of 5 km^2 using a split-beam echosounder. Typical daily variations of CH_4 were measured with the eddy covariance setup within the range of 0.23 and 7.4 mg CH_4 m^{-2} d^{-1} (95% confidence interval) and were mainly related to temperature and solar radiation variability. The seasonal trend shows that average fluxes increase from 3.0 (April) to 3.7 mg CH_4 m^{-2} d^{-1} in November. Much larger fluctuations can be observed in comparison to the chamber results where the emissions typically increase throughout the day. Furthermore, highest chamber fluxes were measured in July and October, which does not correspond with the FMA results (November). This inconsistency is also observed in the flux estimates calculated from surface concentrations of which the highest fluxes were in September. Ebullition was only observed (Jul., Sep. and Nov.) in a very shallow area where it was not possible to use the echosounder. Hence, our measurements may slightly underestimate the average fluxes, but they do record the magnitude of these changes via different methods. We thus conclude that the variability of CH_4 fluxes observed throughout the literature and our study is related to both physical triggers and the method used for measurements. Eddy measurements are continuous but limited spatially, whereas chamber measurements directly spatially cover more of the lake surface but at low and intermittent frequency. The discrepancy between surface concentrations used for flux measurements and chamber emissions may also be due to the fact that sampling did not occur simultaneously at the same spot. This study highlights the necessity for future assessments of CH_4 emissions from water bodies to use a combination of methods in order to account for the various sources of CH_4 emission.