Geophysical Research Abstracts
Vol. 14, EGU2012-7837, 2012
EGU General Assembly 2012

Examination of methane ebullition in a Swiss hydropower reservoir

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Ebullition is one of the most important methane emission pathways from inland water bodies, yet the stochastic nature of ebullition complicates its monitoring. Therefore, a bubble-calibrated 120 kHz split-beam echosounder (Simrad EK60, Kongsberg Maritime) was utilized to survey the active ebullition area of a small temperate hydropower reservoir (Lake Wohlen, Switzerland), which is known for intense methane bubble release in summer. The performed bubble size calibration agreed well with the literature and the presented hydroacoustic technique to estimate methane bubble flux in the presence of non-bubble targets was determined to be the most appropriate post-processing method for this reservoir. The acoustically-determined average methane ebullition flux from the sediment to the water column from seven campaigns was 580 mg CH4 m-2 d-1 (range, 130 to 1450). Bubble size distribution, which mostly included 1 to 20 mm diameter bubbles, was strongly related to the magnitude of sediment ebullition flux. The bubble size distribution is an important consideration when calculating the resulting surface efflux using a bubble dissolution model. Using the Sauter mean diameter to represent the volume to surface area to volume ratio of the bubble size distribution in the bubble model resulted in an average atmospheric emission of 490 mg CH4 m-2 d-1. The spatially-averaged data and the standard deviation from seven sampling campaigns revealed areas of 'high' and 'low' ebullition fluxes that seemed to correlate to geomorphology of the reservoir, which still contains the former river channel. The hydroacoustic flux estimates were compared with other methods of methane flux assessments used simultaneously: the traditional chamber method and the eddy covariance technique combined with spectrometer methane measurements (Fast Methane Analyzer, Los Gatos Research). Chamber measurements on all but one day were higher than the hydroacoustic survey results (but within the same order of magnitude), which is likely due to the extended coverage of echosounder surveys identifying more areas of low fluxes. However, hydroacoustic assessments and eddy covariance measurements of methane flux were similar and both revealed a flux dependence on the time of day, which was further related to scheduled water level changes in the reservoir. While the eddy covariance technique can provide continuous data useful for correlating with external forcing factors related to emissions, echosounder surveys provide spatial-specific information and thus resolve the locations of methane ebullition. Ideally, combining these methods would allow for the best coverage of the spatiotemporal dynamics of ebullition over a given study site.