Geophysical Research Abstracts
Vol. 16, EGU2014-6824, 2014
EGU General Assembly 2014

Controls for multi-scale temporal variation in ecosystem methane exchange during the growing season of a permanently inundated fen

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Temperature and phenology trigger seasonal variation of CH4 emissions in many ecosystems. However, ecosystem CH4 exchange varies also considerably on smaller temporal scales such as days or weeks. Indeed, we are aware of many processes that control CH4 emissions on the local soil-plant-atmosphere continuum, but their interaction on ecosystem level is not well understood yet. We used a quasi-continuous Eddy Covariance CH4 flux time series and wavelet analysis to describe the temporal variation of ecosystem CH4 exchange within the growing season of a permanently inundated temperate fen. Moreover, we assigned time scale-specific controls and investigated whether their impact changes during the course of the growing season. Water/soil temperature correlated with ecosystem CH4 exchange at time scales of 6-11 and 22 days which exceeds the time scales that are typically associated with the passage of weather fronts. The low response time might be due to the high heat capacity of the water column. On a daily scale, shear-induced turbulence (presented by friction velocity) and plant activity (presented by canopy photosynthesis) caused a diurnal variation of ecosystem CH4 exchange with peak time around noon. However, this pattern was apparent only at the beginning of the growing season (April/May). In the following, convective mixing of the water column (presented by the water temperature gradient) gradually gained importance and caused high night-time CH4 emissions, thereby levelling off the diurnal CH4 emission pattern. Our study highlights the need for multi-scale approaches that consider the non-stationarity of the underlying processes to adequately describe the complexity of ecosystem CH4 exchange. Moreover, we show that CH4 release processes such as convective mixing of the water column which has been mainly known from aquatic ecosystems until recently (Godwin et al. 2013), might be also of importance in shallowly flooded terrestrial ecosystems.

Citation:
Godwin CM, McNamara PJ, Markfort CD (2013) Evening methane emission pulses from a boreal wetland correspond to convective mixing in hollows. Journal of Geophysical Research: Biogeosciences.