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Pronounced short-term temporal dynamics of methane fluxes during the snowmelt period at a boreal peatland in NW Russia

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Peatlands are one of the major natural sources of methane (CH_4), but the quantification of efflux is uncertain especially during winter, fall and the highly dynamic spring thaw period. Here we report unexpected diurnal variations in methane fluxes as measured using the eddy correlation technique lasting several days during the snow thawing period at a boreal peatland in NW Russia. The beginning of snowmelt in 2008 was characterized by moderate CH_4 fluxes of $\sim$0.5-1.8 mg m^{-2} h^{-1}. However, we found unexpected pattern in CH_4 fluxes from 21.04-3.05.2008 when fluxes showed strong diurnal variability apparently controlled by changes in the surface temperature. Hourly CH_4 fluxes were $\sim$0.5 mg m^{-2} h^{-1} during night and reached as much as $\sim$5 mg m^{-2} h^{-1} during midday. An empirical model based on linear reduced major axis regression was used to gap-fill the time series with surface temperature as a predictor. There was a lag of one hour between the diurnal maxima of surface temperature and CH_4 flux, respectively. The fluxes started to decrease earlier than the surface temperature reached its maximum. The most likely explanation is that thawing and refreezing of an ice layer at the wet peatland micro-sites due to oscillating surface temperatures above 0 °C during the days and below 0 °C during the nights, which was observed during this period of the year, led to a pronounced diurnal variability of the resistance for gas diffusion from the soil and open water bodies to the atmosphere. Apparently, physical factors influencing the gas transport processes have a stronger effect on CH_4 efflux than microbiological ones during the spring whereas the control of CH_4 efflux is dominated by biological processes during the vegetation period. The evidence of strong temporal variation on an hourly time scale is important when estimates of cold season fluxes are made to quantify seasonal or annual CH_4 emissions, especially when static chambers are applied under climatic conditions favouring these events to prevent over or underestimation of CH_4 fluxes depending on sampling time during the day.