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Upscaling methane emissions from plot- to ecosystem-scale in two boreal peatlands

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Boreal peatlands are a major natural source of methane (CH_4). They are often characterized by a heterogeneous surface, ranging from dry to wet plots at micro-scale and e.g. different vegetation units on the meso- and/or ecosystem-scale. Because the CH_4 exchange of these units can vary substantially, different methods are applied to quantify their emission rates: Usually chamber measurements are applied at microsite-scale and then upscaled to the ecosystem. Only in the last 10 years, the eddy covariance (EC) method has become applicable for CH_4 fluxes, which offers a non-intrusive, ecosystem-scale measurement of mean gas exchange of a site with high temporal resolution. Here, we present plot and ecosystem measurements of CH_4 (chambers and EC) in two boreal peatlands in Finland and Russia. While Salmisuo, Finland, is characterized by three microsite types, Ust-Pojeg, Russia, has seven different microsite types, which can be combined at larger scale to three meso-scale units. In Salmisuo, EC measurements took place from April – December 2007 and chamber measurements from April-September 2007. Maximum EC CH_4 flux measurements were $8\,mg\,m^{-2}\,h^{-1}$ in August, while the microsite emission rates decreased in following order: Flarks (mean: $5.2\,mg\,m^{-2}\,h^{-1}$), lawns (mean:$1.4\,mg\,m^{-2}\,h^{-1}$), hummocks (mean: $1.1\,mg\,m^{-2}\,h^{-1}$). In Ust-Pojeg, EC measurements took place from April 2008-February 2009 and chamber measurements from April-September 2008. Due to instrument failure, the EC measurements did not include the period of maximum emissions in July. The microsite emission rates decreased in the order flarks (mean:$9.6\,mg\,m^{-2}\,h^{-1}$ and $7.4\,mg\,m^{-2}\,h^{-1}$) and lawns (mean:$10.0\,mg\,m^{-2}\,h^{-1}$, $8.3\,mg\,m^{-2}\,h^{-1}$ and $7.0\,mg\,m^{-2}\,h^{-1}$) > hummocks (mean:$5.2\,mg\,m^{-2}\,h^{-1}$ and $2.7\,mg\,m^{-2}\,h^{-1}$).

To take into account the different characteristics of microsites and/or mesosites for the EC flux analysis, an analytical footprint model (Kormann and Meixner 2001) was combined with high-resolution aerial pictures (Becker et al. 2008) and satellite images. This approach has been developed in Salmisuo, where we did have access to high-resolution aerial photographs (Becker et al. 2008). We will test this approach in Ust-Pojeg, where the classification is based on a satellite image and the structure of the peatland is more heterogeneous.

In Salmisuo, microsite fluxes could be extracted from the EC time series which matched the plot measurements of lawns and hummocks (but not flarks) quite well. The budgets of gap-filled EC measurements and upscaled chamber measurements deviated 19%. This was most probably due to the overrepresentation of lawns in the 30 min footprints compared to the mean site conditions. When extracted microsite fluxes were upscaled, they deviated from upscaled chamber measurements due to the mismatch of flark emissions. However, this deviation did not exceed the uncertainty due to a potential misclassification (Forbrich et al., in prep.).

References:

Becker et al. (2008), Biogeosciences 5:1387-1393
Kormann and Meixner (2001), Boundary-Layer Meteorology 99: 207-224