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Process – based modeling of northern wetland methane emissions – what are the limits?

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Modeling of methane emissions in boreal and arctic wetlands is an important instrument for upscaling from plot to global scale emissions. However, the limits of this approach may have been reached with the current generation of models, which are generally based on plot-scale (semi)process based models.

The problem starts with model testing; this still largely relies on chamber flux measurements rather than eddy covariance data; testing of plot-scale models using eddy covariance data requires an upscaling step in itself. Existing models often do not capture day-to-day variability in methane fluxes very well. They perform better on seasonal variability, but sometimes only after considerable model tuning.

However, parameter uncertainty remains the largest problem. The typical wetland methane model has a high parameter demand, requiring detailed parameteriziation of hydrology, soil heat transfer, vegetation, biogeochemistry and carbon exchange. Improvements of process detail in the models leads to more parameter-hungry models, while improvement of the performance may be marginally only. Boreal and arctic environments are notoriously difficult for obtaining correct values of model parameters and other inputs. Additional complications are the role of soil freezing and snow cover. Typically there is also an extreme spatial variability of soil hydrology due to the presence of periglacial microrelief.

Therefore process-based modeling of northern wetland methane emission may have reached its limits. Advances must be sought in decrease of model data requirements, making better use of wetland spatial variability patterns and remote sensing data, rather than implementing more process detail.