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A new biogeochemical model to simulate regional scale carbon emission from lakes, ponds and wetlands

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Small aquatic systems are receiving increasing attention for their role in global carbon cycling. For instance, lakes and ponds in permafrost are net emitters of carbon to the atmosphere, and their capacity to process and emit carbon is significant on a landscape scale, with a global flux of 8–103 Tg methane per year which amounts to 5%–30% of all natural methane emissions (Bastviken et al 2011). However, due to the spatial and temporal highly localised character of freshwater methane emissions, fluxes remain poorly qualified and are difficult to upscale based on field data alone.

While many models exist to model carbon cycling in individual lakes and ponds, we perceived a lack of models that can work on a larger scale, over a range of latitudes, and simulate regional carbon emission from a large number of lakes, ponds and wetlands. Therefore our objective was to develop a model that can simulate carbon dioxide and methane emission from freshwaters on a regional scale. Our resulting model provides an additional tool to assess current aquatic carbon emissions as well as project future responses to changes in climatic drivers.

To this effect, we have combined an existing large-scale hydrological model (the Variable Infiltration Capacity Macroscale Hydrologic Model (VIC), Liang & Lettenmaier 1994), an aquatic biogeochemical model (BALTSEM, Savchuk et al., 2012; Gustafsson et al., 2014) and developed a new methane module for lakes. The resulting new process-based biogeochemical model is designed to model aquatic carbon emission on a regional scale, and to perform well in high-latitude environments. Our model includes carbon, oxygen and nutrient cycling in lake water and sediments, primary production and methanogenesis. Results of calibration and validation of the model in two catchments (Torne-Kalix in Northern Sweden and of a large arctic river catchment) will be presented.