



## **Methane and carbon dioxide evasion from Arctic lakes: A methodological review**

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Increasing line of evidence show that Arctic lakes are currently acting as an important source of greenhouse gases methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ). Recent model-based estimates suggest that  $\text{CH}_4$  and  $\text{CO}_2$  evasion from boreal lakes will significantly contribute to the greenhouse gas-climate system feedback. However, the greenhouse gas balance of boreal freshwater aquatic systems remains uncertain mainly due to poor observational data coverage and high regional spatial variability. Moreover, regional and/or global modeling do not yet capture all relevant physical and biogeochemical processes involved in the greenhouse gas balance. Here, we revise current estimates, tools and methods quantifying  $\text{CH}_4$  and  $\text{CO}_2$  emissions from Arctic lakes and suggest novel process-based biogeochemical modelling tools for quantifying the lake greenhouse gas balance at regional to global scales. We identify that in order to obtain reliable estimates of both  $\text{CH}_4$  and  $\text{CO}_2$  from Arctic lakes, a dynamic biogeochemical model for lake water and sediment coupled to the lake hydrology is required. The carbon stock and age of lake-neighbouring soils need to be accounted for when modelling the gas release from lake sediments. In addition, accurate quantification of nutrient inputs are important, in particular for mesotrophic and eutrophic lakes. Increasing the observation coverage of nutrient concentrations of boreal freshwater systems would highly improve model estimates of  $\text{CH}_4$  and  $\text{CO}_2$  emissions from Arctic lakes at a regional to global scale.