Geophysical Research Abstracts
Vol. 18, EGU2016-4713, 2016
EGU General Assembly 2016

Modelling methane dynamics from a seasonally ice-covered young boreal reservoir

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Flooding terrestrial ecosystems to form a hydroelectric reservoir submerges large amounts of terrestrial organic carbon stored in terrestrial plants and soils. Environmental conditions changing from aerobic to anaerobic could enhance methane emissions from the reservoir surface. In order to quantify the response of biogeochemical processes to such a land use change, a one-dimensional process-based reservoir biogeochemical model was developed. We simulated complex physical and biogeochemical processes of methane production, oxidation, transport, and emissions in the sediment and water column. The model was calibrated and tested against observational data from a large boreal hydroelectric reservoir, northern Quebec, Canada. The modelled methane fluxes across air-water interface were consistent with measurements. The simulated mean partial pressure of methane agreed well with observations from the generating station in the dam. The seasonal variability of methane emissions was primarily controlled by the reservoir thermal dynamic (e.g., ice-cover timing and water mixing) that is a response to climate. The decomposition of flooded terrestrial organic carbon in the sediment stimulated methane emissions of the reservoir ecosystem in the first 5-yrs after the reservoir creation. This study demonstrated that the sinking organic carbon from the water column would become the major source of substrate for methane production when the reservoir developed to be a "natural" lake. We conclude that flooding changes the biogeochemical cycles and, moreover, triggers methane emissions from the newly created aquatic ecosystem.