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Modelling vegetation dynamics and carbon fluxes in a high Arctic mire

High Arctic wetlands are an important component of the global climate system. Nevertheless estimations of their expected response to climate change and associated climate-feedbacks have large uncertainties. Improving models for vegetation and carbon dynamics of ecosystems is an important step towards making predictions more accurate.

In this study, an arctic-enabled version of the LPJ-GUESS dynamic global vegetation model (LPJ-GUESS-WHyMe) was used to conduct a local modelling study on vegetation dynamics and carbon fluxes in the high Arctic mire Rylekærene in north-western Greenland. LPJ-GUESS-WHyMe includes process descriptions of wetland hydrology, soil freezing and wetland carbon (carbon dioxide and methane) emission, as well as wetland PFTs.

The aims of this study were: 1) to assess uncertainties of parameters and process representations; 2) to assess the possibility of including grazing into the model; and 3) to lay a ground for future studies in which the response of the mire ecosystem to climate change and changes in grazing pressure can be simulated. Field data from several studies in Rylekærene were used for parameter calibration and comparison with model outputs.

The field data included carbon dioxide and methane flux chamber measurements, measurements of environmental variables and vegetation analyses. Model parameters were calibrated in the following order: 1) hydrology and permafrost; 2) vegetation; and 3) methane dynamics, using data from 2013. Data from 2011 was used for validation.

The calibration improved model performance within hydrology, permafrost and vegetation dynamics for both 2013 and 2011. For methane fluxes the calibration did not improve the model performance for 2011. Sensitivity analyses were performed for parameters related to vegetation and methane dynamics. An important finding in the sensitivity study was that increasing the fraction of vascular plant net primary production allocated to root exudates also decreased vascular plant productivity which had a net-effect of decreasing methane emissions. Main challenges for future studies were identified to be: 1) the inclusion of the effect of run-on/off from snowmelt on soil hydrology and temperature; 2) modeling competition between grasses and mosses; and 3) modeling the effect of graminoid density on methane fluxes accurately. Data from a three-year musk-ox exclosure experiment was used to build a simple module for modelling changes in grazing pressure. The results showed that improvements in the representation of model processes are needed before the effects of musk ox grazing on different parts of the ecosystem could be simulated accurately.

Key words: Geography, Physical Geography, LPJ-GUESS, Ecosystem modelling, Vegetation dynamics, Biogeochemical cycling, Methane dynamics, High Arctic wetland, Zackenberg

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