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Development of an advanced regional climate-ecosystem model for Arctic applications

Nitin Chaudhary, Benjamin Smith, and Paul Miller
Department of Physical Geography and Ecosystem Science, Lund University Sölvegatan 12 S-223 62 Lund, Sweden

Cryospheric processes together with their feedbacks play a crucial role in determining rates and patterns of future warming over high-latitude regions. Cryospheric processes including permafrost as well as peatland and associated vegetation, hydrological and biogeochemical dynamics are not well represented in land surface schemes (LSS) of most climate models. As a step in this direction, we describe a scheme to include the coupled dynamics of vegetation, hydrology and peat accumulation under climate forcing within a detailed vegetation dynamics-biogeochemistry model, LPJ GUESS (Smith et al. 2001; Miller et al., in preparation). In the first step, a one-dimensional (1D) landscape scale peat accumulation and two dimensional (2D) micro-topographical models have been developed. For the parameterisation and validation of these models, good quality datasets are being used which are collected at various locations around the Arctic. Building on these, a three-dimensional (3D) scheme will be incorporated in a version of LPJ-GUESS that already includes patch-scale vegetation dynamics and soil carbon cycling, as well as a one-dimensional hydrology scheme. The patches in the 3D model will be treated as adjacent micro-patches in a grid and depending on underlying micro-topography water will flow from higher to lower patches. The 2D and 3D models will help in simulating hummock and hollow structure which is typical for Northern peatlands based on the cyclic regeneration theory (von Post and Sernander, 1910). The resulting models will be incorporated within the biospheric component of a regional climate-ecosystem model, RCA-GUESS (Smith et al., 2010) and used to investigate feedbacks related to the dynamics of peatlands, permafrost and emissions of the greenhouse gases, mainly CO_2 and CH_4 across the Arctic region.

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