EGU2020-14992, updated on 25 Oct 2021
https://doi.org/10.5194/egusphere-egu2020-14992
EGU General Assembly 2020

Coupling an individual-based boreal forest model with a permafrost land-surface model to forecast biomass development in boreal larch forests at the Siberian treeline

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The fate of boreal forests under global warming and forced rapid environmental changes is still highly uncertain, in terms of remaining a carbon sink or becoming a future carbon source. Forest dynamics and resulting ecosystem services are strongly interlinked in the vast permafrost-covered regions of the Siberian treeline ecotone. Consequently, understanding the role of current and future active layer dynamics is crucial for the prediction of aboveground biomass and thus carbon stock developments.

We present a coupled model version combining CryoGrid, a sophisticated one-dimensional permafrost land surface model adapted for the use in forest ecosystems, with LAVESI, a detailed, individual-based and spatially explicit larch forest model. Subsequently, parameterizing against an extensive field data set of >100 forest inventories conducted along the treeline of larch-dominated boreal forests in Siberia (97-169° E), we run simulations covering the upcoming decades under contrasting climatic change scenarios.

The model setup can reproduce the energy transfer and thermal regime in permafrost ground as well as the radiation budget, nitrogen and photosynthetic profiles, canopy turbulence and leaf fluxes and predict the expected establishment, die-off and treeline movements of larch forests. Our results will show vegetation and permafrost dynamics, quantify the magnitudes of different feedback processes between permafrost, vegetation, and climate and reveal their impact on carbon stocks in Northern Siberia.