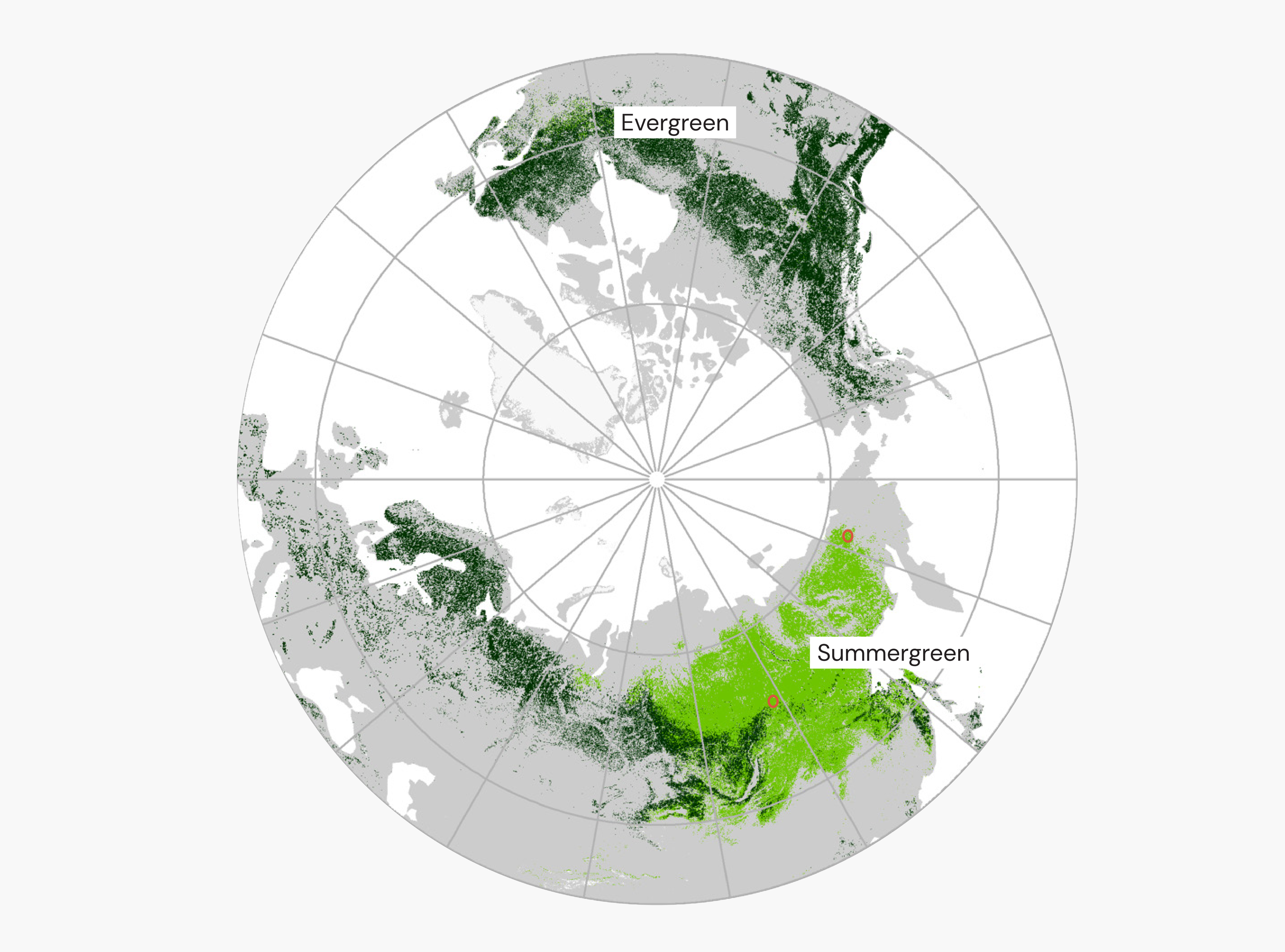

Permafrost sensitivity in high latitude forest

S. Stünzi[1,2], J. Boike[1,2], U. Herzschuh[1,3], S. Kruse[1,3], T. Schneider v. Deimling[1,2], M. Langer[1,2]

Widespread dominance of Larix in Siberia is surprising because, in mixed stands, light-demanding Larix is outcompeted by evergreen taxa. Climate is assumed to be the major distribution factor but in different boreal areas it is similar, nonetheless, many forest types can be found (Herzschuh et al., 2019). Climate change has a direct impact on the water, heat and nutrient budget of boreal ecosystems and permafrost conditions. The prediction of permafrost sensitivity to a warming climate and changing vegetation cover is highly complex with many uncertainties. It is an open question as to how Larix forests, once established, hinder their replacement by evergreen forests and thus maintain vegetation–climate disequilibrium.

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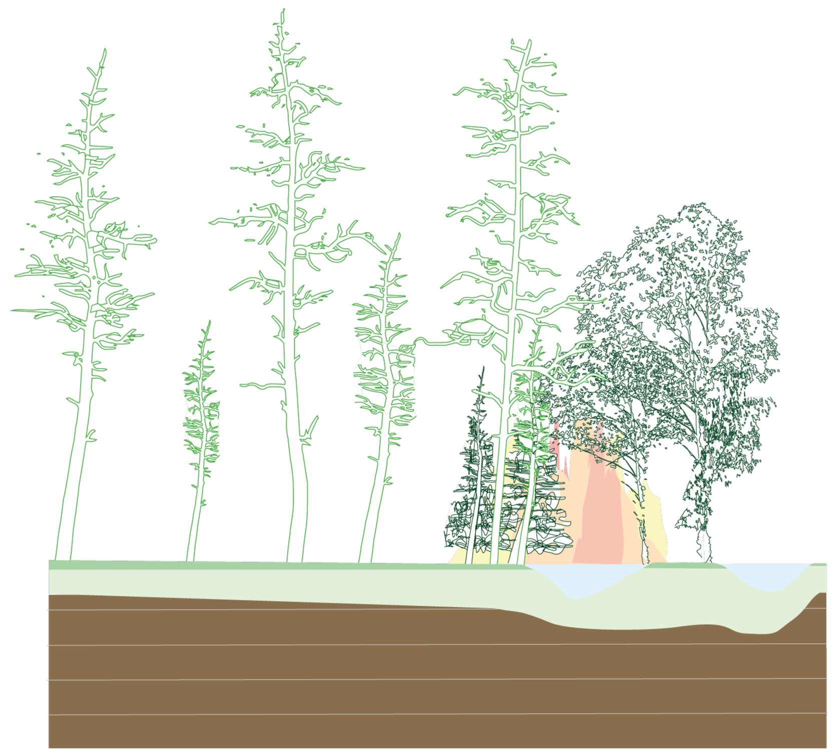
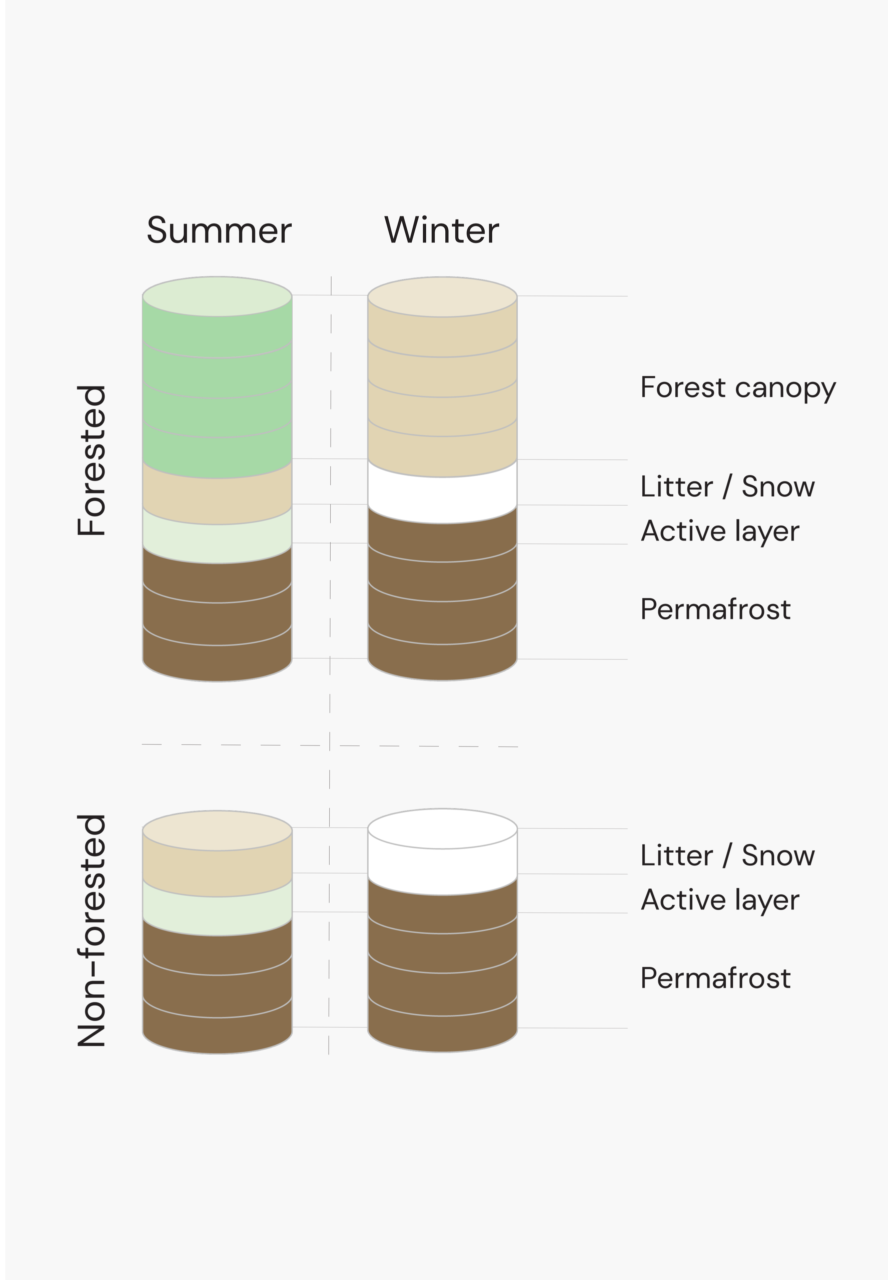
HYPOTHESIS

Larix forests self-stabilize due to vegetation-climate-permafrost-fire feedbacks and inhibit the invasion of evergreen taxa



Ecosystem components of boreal forests in Eastern Siberia (snow-free season). Larch (light green), evergreen/birch (dark green), fire, thawing (blue), permafrost (brown) and active layer (green).

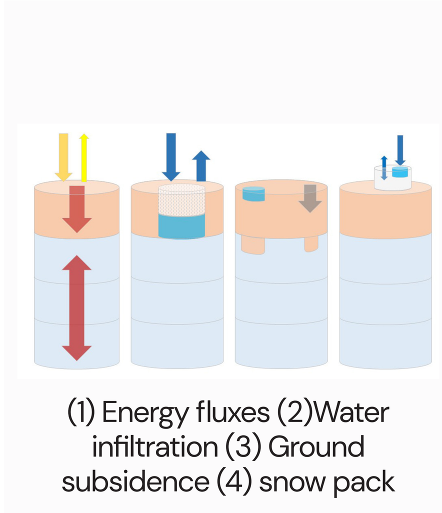


Top: Forested model realization for winter and summer. Bottom: Non-forested realizations.

METHODS

Model-based description of the role and future of boreal forests in Eastern Siberia.

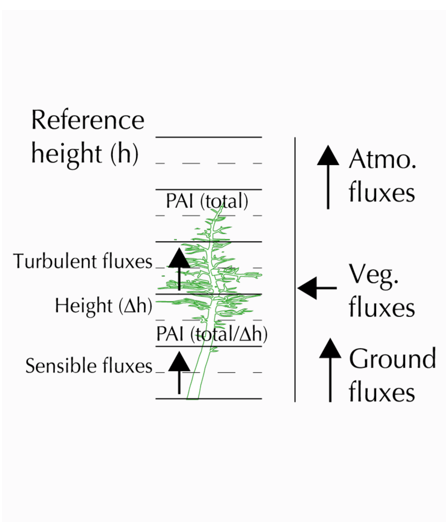
CryoGrid is a one-dimensional land surface model that can be used to simulate diverse processes in periglacial landscapes. It calculates the surface energy balance in order to represent energy transfer processes between the ground and the atmosphere (Langer et al., 2016).



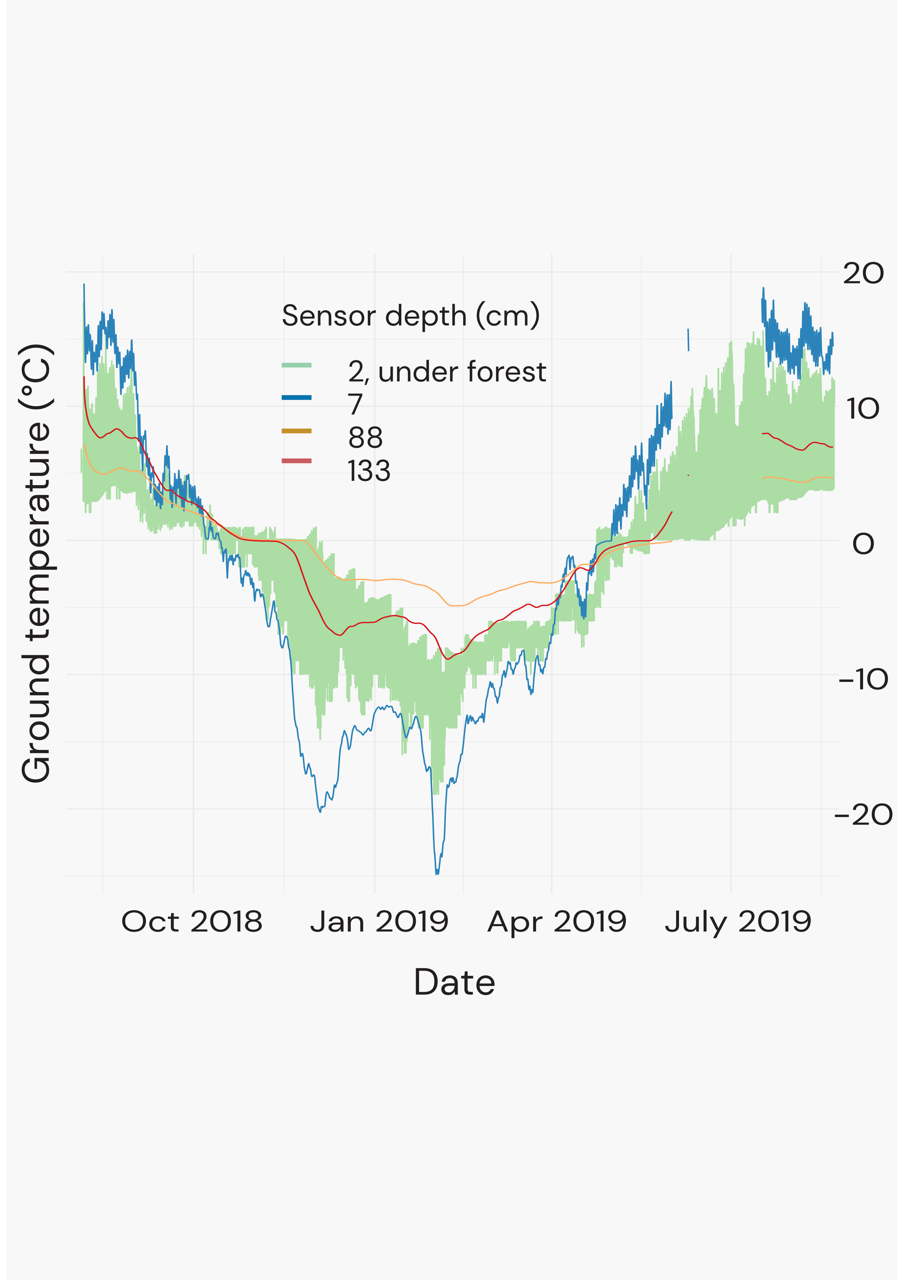
(1) Energy fluxes (2)Water infiltration (3) Ground subsidence (4) snow pack

CryoGrid components.

Multilayer canopy module.



One uncertainty factor is the insulation effect of the surface litter layer and vegetation. Therefore, it is further developed by implementing a roughness sublayer turbulence parameterization to simulate a multilayer canopy that responds to the local climate and permafrost conditions (Bonan et al., 2018 - CLM-ml).

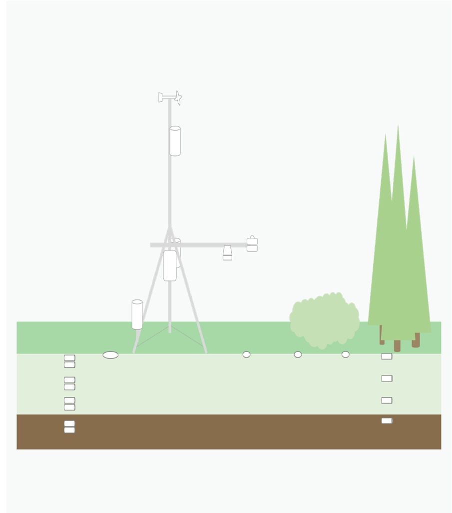


Ground temp. of 11 soil temp. sensors in *Nyurba*: (i) 8 in larch forest soils (green, stacked). (ii) 3 in open grassland (blue/orange/red).

VALIDATION DATA

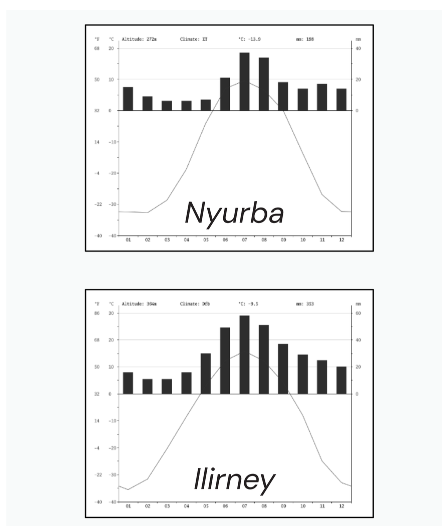
In-situ data measurements at remote study sites in Eastern Siberia.

We have two study areas (SA) in larch dominated forests to evaluate the model. The northern SA is located at *Lake Ilirney* in Chukotka (168°21′58″E, 67°24′9″N). In Yakutia the SA is south of *Nyurba* (118°11′45″E, 63°11′22″N). For these sites, we have in-situ soil and air temperature, humidity,

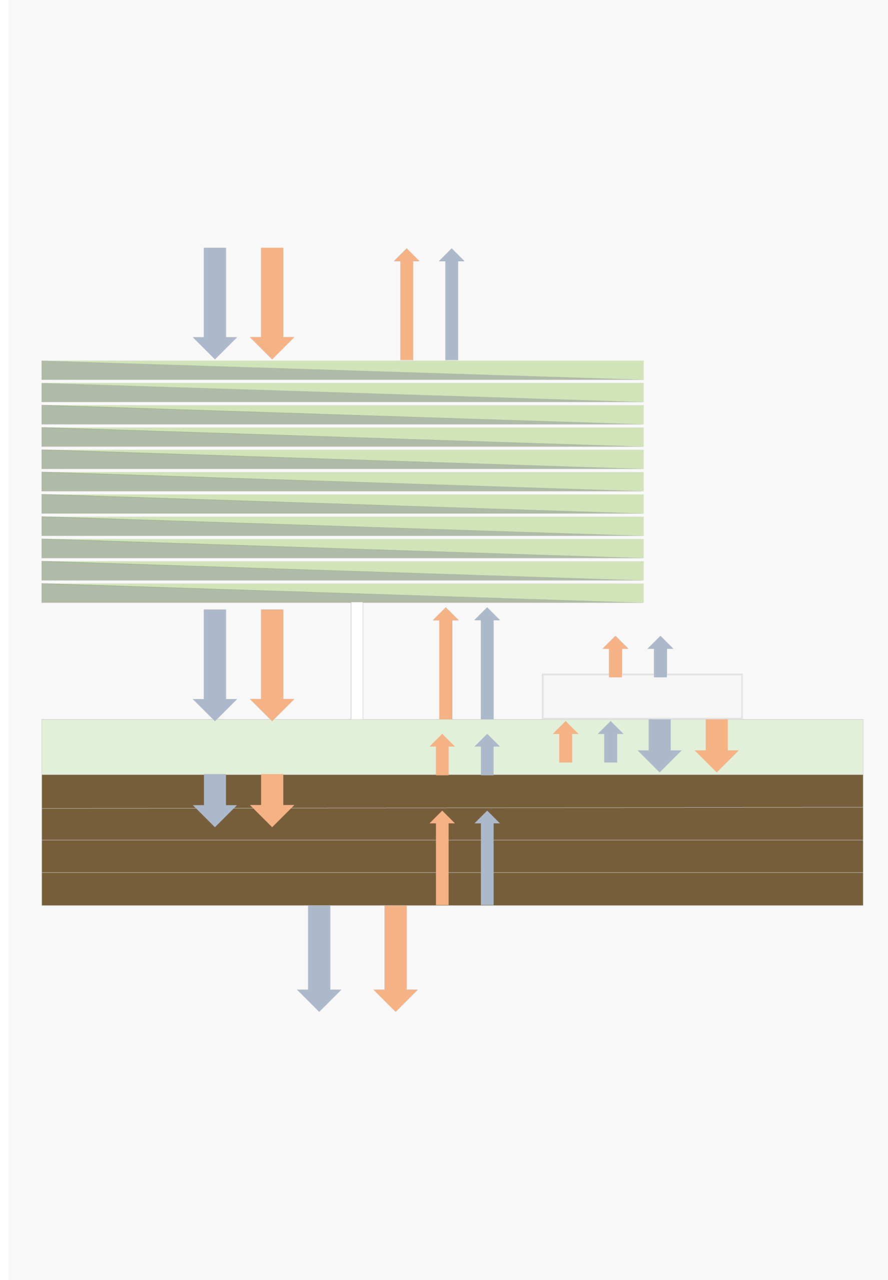


Climate station and soil temp. sensors (white)

Climate diagrams of the two study sites.



precipitation, wind and radiation measurements. Further, we conducted vegetation surveys, analyzed soil samples, measured soil moisture and temperature and acquired UAV imagery from 90 locations between *Ilirney* and South Yakutia in 2018/19 expeditions.

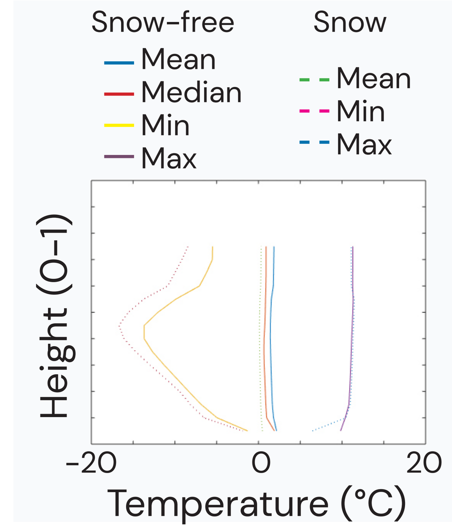


Coupled multi-layer vegetation - permafrost model with energy and water fluxes.

CURRENT WORK

The coupled model can simulate the current and future conditions of high latitude forests.

A tailored version of CryoGrid is adapted for the application in forested areas and used to reproduce the energy transfer and thermal regime of permafrost ground. The exchanged terms are the ground and snow temperature and moisture of the top layers in CryoGrid to the vegetation ground layers and vice-versa. The vegetation forms the upper boundary of the coupled model. The snow is built up in between.



Vegetation temperature profile of a two year simulation.

- Snowpack on canopy top vs. below
- LAI/PAI estimates from UAV data
- Forest type parametrizations
- Implementation of fires/disturbances

Herzschuh, U., Legacy of the Last Glacial on the present-day distribution of deciduous versus evergreen boreal forests. Global Ecol Biogeogr.:2019. **Langer**, M., S. Westermann, J. Boike, et al.: Rapid degradation of permafrost underneath waterbodies in tundra landscapes—Toward a representation of thermokarst in land surface models. JGR: Earth Surface:2016. **Bonan**, G. B., Patton, E. G., Harman, I. N. et al.: Modeling canopy-induced turbulence in the Earth system: a unified parameterization of turbulent exchange within plant canopies and the roughness sublayer (CLM-ml v0). GMD:2018. **Rogers**, B. M., A. J. Soja, M. L. Goulden, and J.T. Randerson: Influence of tree species on continental differences in boreal fires and climate feedbacks. Nature Geoscience:2015.