Project: **1117**

Project title: **Study Of the Development of Extreme Events over Permafrost areas - SODEEP**

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Model evaluation and development

The major outcome of the SODEEP project was the development of a methodology for the identification of climatic patterns that might initiate deepening of the active layer thickness (ALT) in the high northern latitudes (Fig 1.). Therefore, these climatic patterns are also relevant for permafrost degradation. The methodology was developed combining remote sensing data (ESA permafrost CCI ALT), in situ observations (Circumpolar Active Layer Monitoring Network - CALM) and meteorological reanalysis (ERA-Interim). Therefore, it can be easily applied with any gridded data set (e.g. MPI-ESM, or REMO).

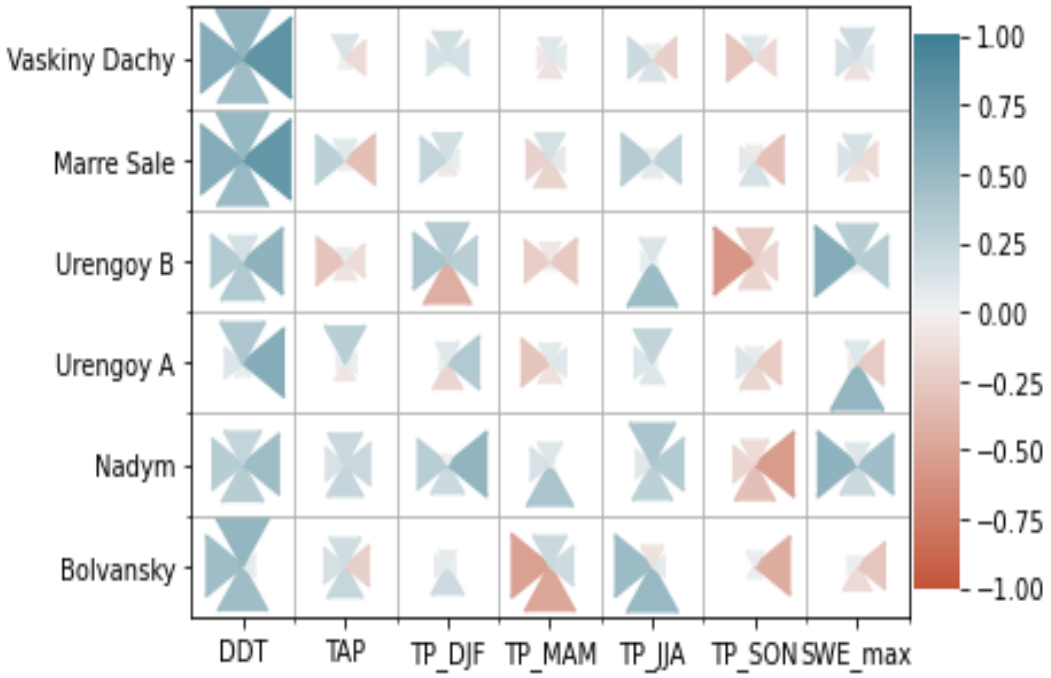

Fig 1. Correlations of ALT with climatic parameters. The upper triangle (▽) shows the correlation of MPI-ESM ALT with MPI-ESM climate parameters. The lower triangle (△) shows the correlation between CALM ALT and the climate parameters calculated from the nearby Russian hydrometeorological stations by RIHMI-WDC. The left triangle (▷) shows the correlation between CALM ALT and ERA interim reanalysis data. The right triangle (◁) shows the correlation between ESA permafrost CCI ALT and ERA-Interim.

Another major outcome of the project was the further development of the vertical soil structure of the land components of the global MPI-ESM (JSBACH) and the regional ESM ROM (REMO), in order to better represent permafrost related processes.

MPI-ESM

AMIP type simulations were conducted with MPI-ESM for the SSP126 and SSP585 shared socio-economic pathways (SSP). Fig. 2 shows the decrease in permafrost extent in the SSP585 simulation compared to SSP126. In SSP585, abrupt warming events are increasing in frequency and intensity relative to their number and severity during the first two decades of the 21st century. In SSP126 simulations, the frequency and intensity of abrupt warming events do not change significantly by the end of the 21st century compared to their frequency and intensity during the first two decades of the 21st century. As a result, the thaw depth and day-degree thaw index (DDTI) in SSP126 show permafrost extent similar to today's values, while SSP585 shows a significant decrease in permafrost extent compared to today's extent.

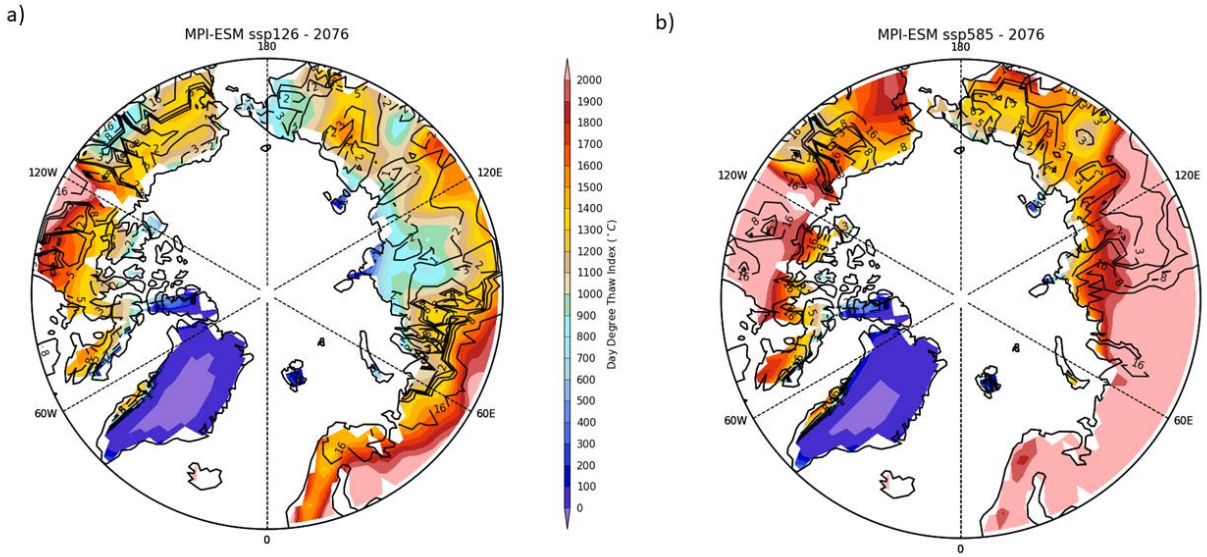

Fig 2. Thaw depth (isolines) and DDTI for two shared socioeconomic pathways simulations with MPI-ESM (permafrost enabled) simulations: SSP126 (a) and SSP585 (b).SM ROM

ESM-ROM

Fig 3. shows 2 m temperature differences between MPI-ESM, ROM and ERA-Interim for winter and summer. In winter, ROM simulations have lower temperature along the east coast of Greenland. These are the main water transport pathways from the Arctic Ocean. This indicates an overestimation of sea ice in this region. There are two areas of positive bias present in the ROM simulations - north of Canada and over the eastern part of Eurasia. Both areas appear to be reinforcements of discrepancies present in the MPI-ESM. In summer, the 2m temperature differences for MPI-ESM show strong negative values over the northern North Atlantic, reflecting the influence of the so-called Labrador Sea cold bias. In ROM simulations this bias is generally smaller. Looking at the 2m temperature, ROM clearly demonstrates "added value" of regional dynamical downscaling by improving the results of the driving model MPI-ESM in JJA.

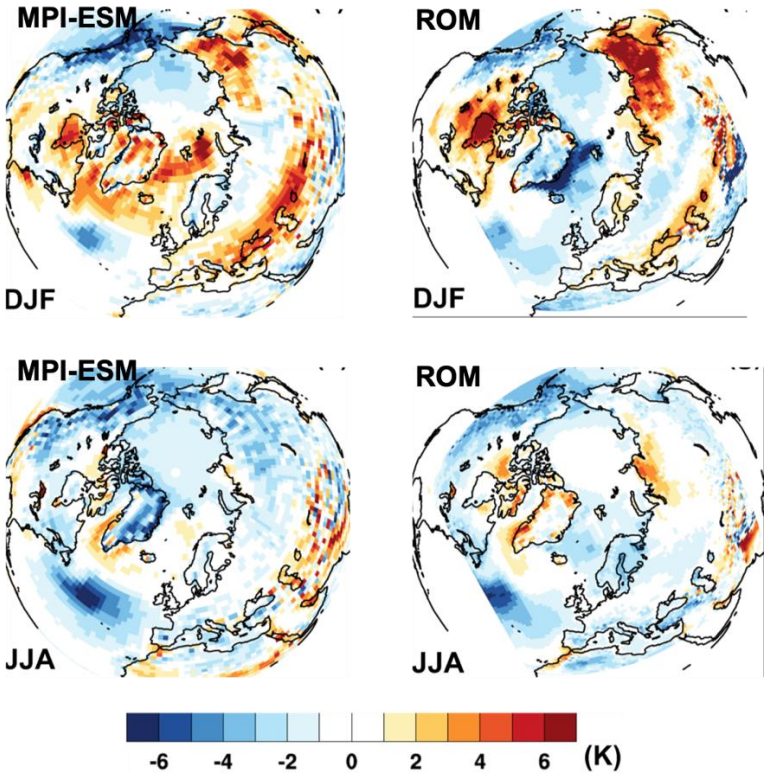

Fig 3. Bias of 2m temperature versus ERA Interim reanalysis for the driving MPI-ESM (left column) and ROM (right column) in winter (DJF, top) and summer (JJA, bottom) 1976-2005.