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Regional coherence of climatic changes in northern Eurasia: implications for predictive permafrost modeling

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The purpose of this paper was to study the spatial coherence of climatic changes in Northern Eurasia and to evaluate the impact it may have on permafrost modeling. We used data from 455 Russian weather stations and found that the spatial structure of the temperature field in Northern Eurasia may be characterized by the combination of four major patterns that correspond to specific types of atmospheric circulation. For each of these iconic patterns (and corresponding time intervals) we delineated regions with coherent changes of seasonal air temperatures.

The concept of “coherent regionalization” was used to construct the empirical climatic projection for 2025. We analyzed the interannual variability of air temperature averaged over the coherent regions, and evaluated the regional trends for the time intervals that are characterized by the same types of atmospheric circulation. Climatic norms for 1961-1990 at individual stations were overlaid with departures that were obtained through linear extrapolation of region-specific trends for various types of atmospheric circulation.

These data were used in equilibrium permafrost model to calculate the projected for the future changes of the regional permafrost temperature and active-layer thickness. To simulate the effects of variability in snow, vegetation, and soil moisture, we used an ensemble approach. In different calculations snow depth varied in the range $\pm$ 50% from the mean climatological value; vegetation (moss) height varied between 5 and 10 cm, and organic layer thickness was in the range 5–20 cm. Moisture content in the

organic layer varied between 0.3 and 0.5 m/m, and mineral soil moisture varied from 0.1 to 0.3 m/m.

The ultimate result of our study is the set of predictive probabilistic permafrost maps for the Northern Eurasia. Aside from portraying the “average” or “typical” active-layer thickness for 2025, such maps depict the probability of thaw depth exceeding given thresholds within specified regions. Such information has important implication in cold region engineering and may be used for predicting potential threats to infrastructure built upon thawing permafrost.

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