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Evaluating climate severity for human comfort in a changing climate of the 21st century in Central Siberia

In the past, human migrations were associated with climate change. As our civilization developed, humans depended less on the environment, in particular on climate, because technological and economical developments in the span of human history allowed them to adapt to and overcome environmental discomfort of the environment. Siberia is known to be sparsely populated. As can be viewed from night lights imagery, the Siberian population is concentrated along the forest-steppe zone in the south, with its comfortable climate and rich agriculture on fertile soils. In a warming climate, vast Siberian lands may be attractive for population migrations.

Our goal was to evaluate Siberia's climate severity and comfort for humans from a view point of winter conditions (degree-days below 0°C, winter duration, and presence/absence of permafrost) in the contemporary climate and to predict the potential in climate comfort in a warming climate by the 2080s. Additionally, our goal was to evaluate future crop potential that may evolve as the climate changes.

Our study area is Central Siberia within the window 85-105°E and 51-75°N including the Krasnoyarsk territory and the Republics of Khakassia and Tyva. Climate data from 100 weather stations over the study area were used to map the negative degree-days for the 1960-1990 baseline period using a digital elevation model of 1 km resolution using Hutchinson's thin plate splines. The outcomes from ten global climate models (CMIP5) and their ensemble were used to characterize a range of warming by the 2080s. The permafrost distribution in the contemporary climate was calculated as a function of the July and January temperatures and annual precipitation ($R^2 = 0.70$). Stefan's theoretical equation was used to calculate the future permafrost distribution and map its border.

The baseline 1960-1990 negative degree-days maps demonstrated that the contemporary climate should be characterized as severe and uncomfortable for humans especially over the permafrost zone. Only some lands in the forest-steppe zone over Siberia free of permafrost are characterized as mild and comfortable for humans.

As predicted from the CMIP5 models, by the 2080s, Siberia would be characterized by milder and more moderate climates with less permafrost coverage. Superimposing the climate severity, permafrost and crop potential maps onto population density maps demonstrated good correlations between them. Predicted mild climates and doubled crop production might attract the humans to migrate to Siberia during this century.