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An acceleration in soil heat storage across northern Eurasia

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Observed warming of soil temperatures across northern Eurasia have been cited as evidence of climate change. Although the warming is documented across the region, the observations present an incomplete picture because the observational network is sparse with measurements taken at different discrete depths for varying time periods, depending on the station. A more comprehensive measure of change is the heat content of the soil column because this provides an integrative measure of the changing heat stored in the soil column, accounting for changes in temperature, moisture, and latent heat effects. Heat accumulation in the soil column is an indication of a changing energy budget in the region and how the land surface is responding to atmospheric change.

We present estimates of the heat stored in the soil column from the Variable Infiltration Capacity (VIC) land surface model. The VIC model solves both the energy and water budget at the land surface and subsurface with a 50 meter soil column, but our analysis centered on the top six meters below the surface. After a 500-year model spin-up, the model is validated in that it shows the capability to replicate observed soil temperature measurements reasonably well. After validation, we show that there has been a small increase in heat storage from 1901 to 1980. Following 1980, there is an acceleration in the rate of heat accumulated in the soil column that occurs through 2006, when the model simulations end. The analysis shows spatial heterogeneity in the pattern of heat accumulation, with the permafrost zone and the southern Ob basin standing out as regions of larger accumulation. A series of model experiments isolating the factors affecting the spatial and temporal variation in soil heat accumulation point to changes in the snowpack as having a primary influence, particularly in the permafrost region. The acceleration in heat accumulation over the region is a clear indicator that the terrestrial system is in a state of transition as it responds to atmospheric climate changes.