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Increasing Soil Heat Storage across Northern Eurasia

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Recent studies have shown that the ocean, atmosphere, cryosphere, and continental land masses have gained heat over the past century [Hansen et al., 2009; Beltrami et al., 2002]. Although soil heat storage may play a lesser role than the ocean in absorbing heat, it plays an important role in identifying and understanding changes in climate, especially relating to changes in the permafrost active layer. Northern Eurasia has experienced some of the strongest warming trends over the twentieth century, and in situ measurements of soil temperature have shown that the land surface is responding by warming accordingly. The observational network presents an incomplete picture of the soil heat gain because the network is sparse and temperature does not account for latent heat effects and moisture dynamics in the soil column, which also affect the change in enthalpy. In the winter, the snowpack insulates the soil column, which may decouple the air and ground temperatures. To bridge this gap in our understanding, we use the VIC land surface model, which solves for both the energy and water budget at the land surface and subsurface with a 50 meter soil column, to calculate the change in ground heat between 1901 and 2005 after a 500-year model spin-up. We find that the heat stored in the soil column experienced a small but steady increase at the beginning of the twentieth century, with an abrupt increase in heat accumulation after 1980, indicating a possible tipping point in the system. There is heterogeneity in the spatial pattern of heat accumulation, with larger accumulation in the southern Ob River basin and the permafrost-dominated regions of Eurasia. The modeled heat accumulation in the permafrost zone confirms concerns in the scientific literature that the permafrost is particularly vulnerable to climate changes.

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