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Decreasing sensitivity of permafrost temperature to environmental change challenges monitoring and data interpretation

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Permafrost is sensitive to climate change and yet, more and more boreholes have nearly unchanging temperatures. This is a known effect of phase change that has important consequences for the communication of monitoring results and for the planning of monitoring activities. Publications, prominently including those resulting from the IPY Thermal State of Permafrost Snapshot, show many examples of near-isothermal boreholes. Near-isothermal here refers to the shape of temperature-depth profiles and to weak seasonal and inter-annual variation due to phase change. Using a mean annual ground temperature little below 0°C as an indicator and Version 1 of the IPA-IPY Thermal State of Permafrost Snapshot Borehole Inventory, one can estimate an approximate proportion of boreholes that are or may soon become isothermal. After removing boreholes flagged as having no permafrost or with above-zero or missing MAGT, 559 locations remain. Of those, 62% are warmer than -2°C, 45% warmer than -1°C, and 29% warmer than -0.5°C. The properties of warming permafrost near 0°C are investigated based on simple model experiments that approximate freezing characteristic curves as a function of soil texture. Ground temperature are considered to be a measure of two important phenomena: (a) the uptake of heat from the atmosphere, and (b) the change of liquid water content due to thaw that causes altered physical properties of the subsurface and often emergent geomorphic phenomena such as thermokarst or subsidence. In the experiments, the gradual and often sustained loss of sensitivity of temperature measurements to reveal those phenomena is demonstrated. Isothermal boreholes in permafrost are a clear indicator of drastic change in the subsurface. Near the melting point of water, temperatures in soil only have a strongly reduced value for monitoring the real phenomena of interest and forward-looking strategies for monitoring environmental change should account for the foreseeable change of character of many current boreholes.