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Vertical gradients of steady-state mean annual ground temperatures in seasonally frozen soil and permafrost explored by numerical experiments

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The mean annual ground temperature in the upper meters of the subsurface often is lower at depth than close to the surface. Especially in temperate and cold climates, this effect is results in a considerable "thermal offset" between mean ground surface temperatures and temperatures at the depth of a few meters. It is largely due to the contrast between the bulk thermal conductivity of the soil during cold and during warm periods. This is caused by variable proportions of ice, water and air in the soil due to water movement and phase change and results in a "thermal diode" effect.
This study is based on numerical experimentation with the model GEOtop that simulates the heat and water transfer in saturated and unsaturated soil. We use harmonic Dirichlet boundary conditions with diverse means as well as annual and daily amplitudes to study the effects of surface forcing. These experiments are performed on differing ground types and water saturations and spun over long time scales (decades to centuries) to approach equilibrium conditions.
The results allow an insight into the importance of a sophisticated treatment of soil freezing and thawing in permafrost models.