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Lowering the bottom boundary in Land Models: Implications for permafrost stability.

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Earth System Models (ESMs) currently use very shallow bottom boundaries (∼3-45m) for the land subsurface. These depths are an order of magnitude smaller than the depths required to fully capture thermal changes propagating from the surface for the centennial time scales associated with climate change. This depth limitation limits the propagation of energy into the subsurface, thus shallow bottom boundaries and the lack of geothermal gradient in current land surface models, could introduce uncertainties in the estimates of the land surface energy balance and the thermal evolution of the subsurface. We have modified the Community Land Model version 4.5 (CLM4.5) by introducing a crustal heat flux as bottom boundary condition and increasing the depth of the lower boundary from 42m to 342m. We have compared the thermal regime of the subsurface with that of the unmodified CLM4.5 under the atmospheric forcings for the 20th century followed by 300 years of a high emission future scenario (RCP 8.5). Our results suggest that the bottom boundary of the unmodified CLM4.5 is too shallow to fully capture the thermal signal propagating from the surface and reflects considerable energy back to the surface, resulting in higher underground temperatures, which may adversely influence the simulated stability of regions of permafrost and the associated release of stored carbon.