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Quantification of subsurface heat storage in GCM simulations: the case of ECHO-g

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Recent studies indicate that shallow bottom boundary conditions (BBCs) used in the soil components of state-of-the-art general circulation models (GCMs) impose an artificial limit to the amount of heat that can be absorbed by the subsurface. This is an important issue that needs to be understood in order to determine the energy partitioning among Earth's climate subsystems. To quantify this effect on a GCM, without running a full simulation with a causally detached BBC, the subsurface heat accumulation in the existing GCM soil model simulations is compared to the subsurface heat accumulation as determined by a finite difference land surface model (FDLSM) driven by the GCM near-surface temperature output, with a bottom boundary at a comparable depth to that of ECHO-g. We use the existing 1000-year simulation (1000-1990 CE) of the ECHO-g GCM to show that the two models' total heat accumulations are equivalent such that the FDLSM can be used as a proxy for the subsurface of ECHO-g in further experiments. An experiment is carried out using the FDLSM with a deep, causally detached BBC, forced at the surface by GCM ECHO-g output of the 1991-2100 A2 and B2 emission scenarios. Results show that the causally detached FDLSM absorbs about 6.5 times as much heat under the A2 scenario than the ECHO-g soil model. These results suggest that shallow BBCs in existing GCM simulations may prevent significant amounts of heat from being stored in the subsurface and that this effect could be relevant in assessing the magnitude of temperature change in the next century.