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Simulation of Air and Ground Temperatures in PMIP3/CMIP5 Last Millennium Simulations: Implications for Climate Reconstructions from Borehole Temperature Profiles

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For General Circulation Models (GCMs) to simulate the continental energy storage of the Earth's energy budget it is crucial that they correctly capture the processes that partition energy across the land-atmosphere boundary. We evaluate herein the characteristics of these processes as simulated by models in the third phase of the Paleoclimate Modelling Intercomparison Project and the fifth phase of the Coupled Model Intercomparison Project (PMIP3/CMIP5). We examine the seasonal differences between air and ground temperatures within PMIP3 last-millennium simulations concatenated with historical simulations from the CMIP5 archive. We find a strong air-ground coupling during the summer from 850 to 2000 CE. During the winter, the insulating effect of snow and latent heat exchanges produce a decoupling between air and ground temperatures in the northern high latitudes. Additionally, we use the simulated temperature trends as an upper boundary condition to force a one-dimensional conductive model to derive synthetic temperature-depth profiles for each PMIP3/CMIP5 simulation. The inversions of these subsurface profiles yield temperature trends that retain the surface temperature variations of the last millennium for all the PMIP3/CMIP5 simulations. These results support the use of underground temperatures to reconstruct past changes in ground surface temperature and to estimate the continental energy storage.