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Characterization of air and ground temperature relationships within the CMIP5 historical and future simulations

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The simulation of the coupling between the lower atmosphere and the ground surface, and the resultant impact on terrestrial subsurface temperatures, is important for the representation of positive climate feedbacks such as permafrost and soil carbon stability. Here, we characterize the relationship between surface air (2 m) and ground surface temperatures (SAT and GST, respectively) across North America within the historical and future projection simulations from 32 General Circulation Models (GCMs) included in the fifth phase of the Coupled Model Intercomparison Project (CMIP5). Results show that the covariability between SAT and GST is affected by simulated snow cover, vegetation, soil moisture and precipitation. At high latitudes, the differences between SAT and GST, for all CMIP5 simulations, are related to the insulating effect of snow cover. At low latitudes, the difference between the two temperatures, for the majority of simulations, is inversely proportional to leaf area index, soil moisture, and precipitation, likely due to induced-changes in latent and sensible heat fluxes at the ground surface. The representation of differences between SAT and GST differs from observations and among models depending on each GCM's land-surface model components. The large variability among GCMs and the marked dependency of the results on the choice of the land-surface model, illustrate the need for improving the representation of surface processes, which affect the coupling of the lower atmosphere and the ground surface in GCMs as a means of reducing the uncertainties across the model ensemble.