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1 The diurnal cycle, convection, and the soil moisture – precipitation feedback

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Global climate models are often employed to investigate whether and how soil moisture anomalies affect weather and climate both in the present climate and in a potentially different future climate. A recent model intercomparison (Global Land-Atmosphere Coupling Experiment, GLACE) demonstrated that the degree of land-atmosphere interaction varies widely across current state-of-the-art AGCMs. Simulations using models with different inherent coupling strengths may generate disparate conclusions about the contribution of, for example, land cover change to climate change.

Land-atmosphere coupling strength, or the extent to which a precipitation-induced soil moisture anomaly influences the overlying atmosphere and thereby the evolution of weather and the generation of precipitation, is reasonably strong in the NCAR Community Atmosphere Model (CAM3/CLM3) but is very weak in the Hadley Centre modeling system (HadAM3/MOSES2). Through direct comparison of the coupling mechanism in these two models, we can evaluate what aspects of the model control the degree of land-atmosphere coupling. In this study, key aspects of the indirect soil moisture-precipitation feedback are evaluated and compared in the two GCMs under a number of different configurations (e.g. convection schemes, land-surface schemes). It is found that differences in the simulation of the diurnal cycle as well as the sensitivity of the convection scheme to surface fluxes appear to be able to explain the large differences in coupling strength. In particular, the simulation of the diurnal evolution of boundary layer moist static energy and its relationship to moist convection are crucial factors that govern the strength of the soil moisture-precipitation feedback.

In CAM3/CLM3, over wet soils boundary layer moist static energy grows steadily during the day, fed by strong evaporation into a only slowly deepening boundary layer, leading to heavy convective precipitation. In contrast in HadAM3/MOSES2, soil moisture exerts virtually no control on boundary layer moist static energy and henceforth convection is essentially unaffected by soil moisture and land-atmosphere coupling strength is low.