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Afternoon rain more likely over drier soils

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In many regions of the world, soil moisture can affect precipitation via its control on surface fluxes of sensible and latent heat. Under certain circumstances, the occurrence and location of daytime convective storms may be influenced by soil moisture state. The importance of soil moisture feedbacks on precipitation across the world has previously been examined using coupled land-atmosphere models, notably in the GLACE experiment (Koster et al 2004). Whilst different models agree to some extent in terms of where feedbacks operate, large differences in feedback strength imply considerable uncertainty in model-based depictions of land-atmosphere coupling. Here we present a global analysis of near surface soil moisture and precipitation datasets based on remote-sensing at a spatial resolution of 0.25 degrees. For soil moisture we used retrievals from AMSR-E and ASCAT, available typically once per day, and for precipitation we tested 3 alternative 3-hourly datasets; CMORPH, TRMM3B42 and PERSIANN. By examining the difference in pre-storm soil moisture between afternoon rainfall maxima and nearby (50km) minima, we find a robust signal showing that afternoon rain is more likely to occur over a locally drier soil. The signal emerges most clearly in semi-arid regions, notably North Africa, but is also evident in continental-scale analyses elsewhere. We applied the same methodology to four CMIP-5 climate models and two reanalyses and found contrasting behaviour to the observations. The models have a strong tendency to simulate daytime rainfall maxima over wetter grid boxes, particularly in the tropics. More work is needed to understand why the models fail to reproduce the observed feedback sign. A likely cause is the convective parameterisations used in large-scale models. Spatial scale may also play a role, though repeating the observational analysis having first degraded the resolution to 1 degree (comparable to 3 of the models) still yielded a strong rain-over-dry-soil signal across the tropics. These results raise questions about the ability of large-scale models to accurately depict land-atmosphere feedbacks and their role in droughts.