Investigating soil moisture-evapotranspiration coupling in CMIP5 models

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Soil moisture–atmosphere coupling is a key process underlying climate variability and change over land. This coupling occurs when available soil moisture (SM) affects the surface energy balance, in particular the partitioning of surface energy fluxes (evapotranspiration (ET) and sensible heat flux), and when altered surface fluxes then further impact the lower atmosphere. The control of SM on ET is thus a necessary condition for soil moisture to be able to feedback onto surface climate. Here we investigate how this control manifests itself across simulations from the CMIP5 ensemble, using a simple correlation analysis focusing on the interannual (summertime) time scale. Analysis of the CMIP5 historical simulations indicates significant model diversity in terms of SM-ET coupling, both in patterns and magnitude. We investigate the relationship of this spread with model differences in background climate and climate variability. Perhaps unsurprisingly, mean precipitation is found to be a primary driver of model spread in SM-ET coupling. Compared to observations, some land regions appear consistently biased dry and soil moisture-limited. Because of feedbacks on air temperature, SM-ET coupling also induces a significant correlation between model temperature and precipitation biases. We also investigate how SM-ET coupling is affected by the partitioning of ET into its different components (plant transpiration, soil evaporation, canopy-interception). The coupling of transpiration with SM appears to be responsible for the majority of the model spread in overall SM-ET coupling. Finally, we explore the potential relationships between model uncertainties in SM-ET coupling and climate projections, and show that over mid-high latitudes continental regions of Northern Hemisphere, models that are more soil moisture-limited in the present tend to warm more in future projections.