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Land surface energy budget during dry spells: global CMIP5 AMIP simulations vs. satellite observations

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During extended periods without rain (dry spells), the soil can dry out due to vegetation transpiration and soil evaporation. At some point in this drying cycle, land surface conditions change from energy-limited to water-limited evapotranspiration, and this is accompanied by an increase of the ground and overlying air temperatures. Regionally, the characteristics of this transition determine the influence of soil moisture on air temperature and rainfall. Global Climate Models (GCMs) disagree on where and how strongly the surface energy budget is limited by soil moisture. Flux tower observations are improving our understanding of these dry down processes, but typical heterogeneous landscapes are too sparsely sampled to ascertain a representative regional response. Alternatively, satellite observations of land surface temperature (LST) provide indirect information about the surface energy partition at 1km resolution globally.

In our study, we analyse how well the dry spell dynamics of LST are represented by GCMs across the globe. We use a spatially and temporally aggregated diagnostic to describe the composite response of LST during surface dry down in rain-free periods in distinct climatic regions. The diagnostic is derived from daytime MODIS-Terra LST observations and bias-corrected meteorological re-analyses, and compared against the outputs of historical climate simulations of seven models running the CMIP5 AMIP experiment. Dry spell events are stratified by antecedent precipitation, land cover type and geographic regions to assess the sensitivity of surface warming rates to soil moisture levels at the onset of a dry spell for different surface and climatic zones. In a number of drought-prone hot spot regions, we find important differences in simulated dry spell behaviour, both between models, and compared to observations. These model biases are likely to compromise seasonal forecasts and future climate projections.