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Evaluating soil moisture constraints on surface fluxes in land surface models globally

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Soil moisture availability exerts a strong control over land evaporation in many regions. However, global climate models (GCMs) disagree on when and where evaporation is limited by soil moisture. Evaluation of the relevant modelled processes has suffered from a lack of reliable, global observations of land evaporation at the GCM grid box scale. Satellite observations of land surface temperature (LST) offer spatially extensive but indirect information about the surface energy partition and, under certain conditions, about soil moisture availability on evaporation. Specifically, as soil moisture decreases during rain-free dry spells, evaporation may become limited leading to increases in LST and sensible heat flux.

We use MODIS Terra and Aqua observations of LST at 1 km from 2000 to 2012 to assess changes in the surface energy partition during dry spells lasting 10 days or longer. The clear-sky LST data are aggregated to a global 0.5° grid before being composited as a function dry spell day across many events in a particular region and season. These composites are then used to calculate a Relative Warming Rate (RWR) between the land surface and near-surface air. This RWR can diagnose the typical strength of short term changes in surface heat fluxes and, by extension, changes in soil moisture limitation on evaporation.

Offline land surface model (LSM) simulations offer a relatively inexpensive way to evaluate the surface processes of GCMs. They have the benefits that multiple models, and versions of models, can be compared on a common grid and using unbiased forcing. Here, we use the RWR diagnostic to assess global, offline simulations of several LSMs (e.g., JULES and JSBACH) driven by the WATCH Forcing Data-ERA Interim. Both the observed RWR and the LSMs use the same 0.5° grid, which allows the observed clear-sky sampling inherent in the underlying MODIS LST to be applied to the model outputs directly. This approach avoids some of the difficulties in analysing free-running simulations in which land and atmosphere are coupled and, as such, it provides a flexible intermediate step in the assessment of surface processes in GCMs.