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Using dry spell dynamics of land surface temperature to evaluate large-scale model representation of soil moisture control on evapotranspiration

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The soil moisture control on the partition of land surface fluxes between sensible and latent heat is a key aspect of land surface models used within numerical weather prediction and climate models. As soils dry out, evapotranspiration (ET) decreases, and the excess energy is used to warm the atmosphere. Poor simulations of this dynamic process can affect predictions of mean, and in particular, extreme air temperatures, and can introduce substantial biases into projections of climate change at regional scales.

The lack of reliable observations of fluxes and root zone soil moisture at spatial scales that atmospheric models use (typically from 1 to several hundred kilometres), coupled with spatial variability in vegetation and soil properties, makes it difficult to evaluate the flux partitioning at the model grid box scale. To overcome this problem, we have developed techniques to use Land Surface Temperature (LST) to evaluate models. As soils dry out, LST rises, so it can be used under certain circumstances as a proxy for the partition between sensible and latent heat. Moreover, long time series of reliable LST observations under clear skies are available globally at resolutions of the order of 1km.

Models can exhibit large biases in seasonal mean LST for various reasons, including poor description of aerodynamic coupling, uncertainties in vegetation mapping, and errors in down-welling radiation. Rather than compare long-term average LST values with models, we focus on the dynamics of LST during dry spells, when negligible rain falls, and the soil moisture store is drying out. The rate of warming of the land surface, or, more precisely, its warming rate relative to the atmosphere, emphasises the impact of changes in soil moisture control on the surface energy balance.

Here we show the application of this approach to model evaluation, with examples at continental and global scales. We can compare the behaviour of both fully-coupled land-atmosphere models, and land surface models forced by observed meteorology. This approach provides insight into a fundamental process that affects predictions on multiple time scales, and which has an important impact for society.