[Coupling metrics to diagnose land-atmosphere interactions]

Relative Warming Rate

- Reference:
  - Gallego-Elvira, B., C. M. Taylor, P. P. Harris, and D. Ghent, 2019: Evaluation of regional-scale soil moisture-surface flux dynamics in Earth system models based on satellite observations of land surface temperature. *Geophys. Res. Lett.*, **46**, 5480–5488, doi: 10.1029/2019GL082962.

- Principle:
  - Rate of change of land surface temperature versus near-surface air temperature during dry periods (10 days after a rain event) is used to discern the transition from high to low soil moisture, Daytime data are used.
  - For each day d of a dry spell for all cases and points in a region, an average temperature difference between surface and atmosphere: $(\overline{T_S' - T_A'})_d$ is calculated – primes denote anomalies relative to a mean annual cycle at each point. Then the slope of a best-fit linear regression through this term for $d = 2 \ldots 10$ is calculated as the RWR.
  - RWR is found in models to be a function of the initial ($d = 1$) soil moisture, and this functionality is different for different land cover types.

- Data needs:
  - Daily daytime temperature data from the same time(s) each day for near-surface air and land surface (e.g., radiative skin temperature) over many years.
  - As temperature data are readily available from a variety of observational sources, RWR provides a means to verify the corresponding behavior in models over many locations, particularly in the subtropics and tropics where soil moisture and flux data are scarce.

- Observational data sources:
  - Land surface temperature is readily available from satellite – as the method focuses on drydown periods, the likelihood of cloud-free situations is enhanced. Air temperature can come from station observations or reanalyses constrained by data assimilation.

- Caveats:
  - Air temperature is not observable fully in 2-D like land surface temperature is, so there can be a difficulty in consistency among measurements.
  - When validating models there can be many sources for error in RWR, e.g., roughness length affecting turbulent heat fluxes or radiation biases. Other process-based metrics would be needed to diagnose causes of model errors in RWR.

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