

## Soil Moisture-Temperature Coupling

### • References:

- Miralles, D. G., M. J. van den Berg, A. J. Teuling, and R. A. M. de Jeu, 2012: Soil moisture-temperature coupling: A multiscale observational analysis. *Geophys. Res. Lett.*, **39**, L21707, doi: [10.1029/2012GL053703](https://doi.org/10.1029/2012GL053703).
- Miralles, D. G., A. J. Teuling, C. C. van Heerwaarden, and J. Vilá-Guerau de Arellano, 2014: Mega-heatwave temperatures due to combined soil desiccation and atmospheric heat accumulation. *Nature Geosci.*, **7**, 345-349, doi: [10.1038/ngeo2141](https://doi.org/10.1038/ngeo2141).

### • Principle:

- The metric corresponds to regions of strong land-atmosphere coupling via the energy cycle (i.e., thermally) and has been applied as a way to diagnose the degree to which land-atmosphere interactions may exacerbate heatwaves.

- Two energy balances are used to calculate sensible heat: the standard formulation:  $H = R_{Net} - \lambda E$ , and an alternative version using potential evaporation:  $H_p = R_{Net} - \lambda E_p$ .

- Daily sensible heat and *potential* sensible heat are each correlated with 2m temperature, and their difference is an index of thermal land-atmosphere coupling:

$$\Pi = r(H, T) - r(H_p, T)$$

- By decomposing the correlations into their component covariances and standard deviations, an “instantaneous” derivation for a single day  $i$  can be estimated:

$$\pi_i = \frac{T_i - \bar{T}}{\sigma_T} \left( \frac{H_i - \bar{H}}{\sigma_H} - \frac{H_{p,i} - \bar{H}_p}{\sigma_{H_p}} \right)$$

- $\pi_i$  represents the anomalous thermal coupling on day  $i$ , with positive values indicating enhancement

### • Data needs:

- Daily temperature, net radiation, evaporation; potential evaporation can be estimated from  $R_{Net}$  and  $T$  using the Priestley Taylor relation, or other formulations may be used. Applicable at a point or with gridded data. Easily applied to Earth system model output and reanalyses.

### • Observational data sources:

- Well suited to flux tower data.
- The authors tout the potential for using satellite data, and demonstrate application in Miralles et al. (2014) of the satellite-based GLEAM gridded evaporation dataset.

### • Caveats:

- Negative values of both  $\Pi$  and  $\pi$  denote no coupling.
- Despite the name, soil moisture is not part of the formulation; a strong negative relationship between soil moisture and sensible heat flux is assumed. Independent observational and model analyses suggest this is not the case everywhere.
- Note that sensible heat measurements/estimates are not directly used – ground heat flux becomes convolved into the estimate of sensible heat fluxes. This is done to derive a “saturated sensible heat flux”  $H_p$  and keep the calculation of the two terms consistent.