



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:

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

- π_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 Π and π are possible; these are set to zero to denote no coupling.
- Despite the name, soil moisture is not part of the formulation. It is assumed that soil moisture explains the difference between E and E_p , and thus H and H_p and heating of the near-surface air by the land. 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 “potential sensible heat flux” H_p that would occur along with potential evaporation (net radiation being the same), keeping the calculation of the two terms consistent.