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.
  - 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.
- 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 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.