

## Coupling Drought Index

- References:
  - Roundy, J. K., C. R. Ferguson, and E. F. Wood, 2013a: Temporal variability of land-atmosphere coupling and its implications for drought over the Southeast United States. *J. Hydrometeor.*, **14**, 622–635, doi:10.1175/JHM-D-12-090.1.
  - Roundy, J. K., C. R. Ferguson, and E. Wood, 2013b: Impact of land-atmospheric coupling in CFSv2 on drought prediction. *Clim. Dyn.*, **43**, 421–434, doi: 10.1007/s00382-013-1982-7.
- Principle:
  - CTP and  $HI_{Low}$  indices and categories from Findell and Eltahir (2003) are paired with soil moisture estimates to provide an additional dimensionality, and to account for evaporation effects.
    - A 3-D CDF is compiled for a region based on historical data.
    - In the 2D CTP and  $HI_{Low}$  space a marginal distribution of soil moisture is considered for each bin (representing a specific range of CTP and  $HI_{Low}$ . A Kolmogorov-Smirnov test between the marginal and total soil moisture distributions is applied and a “regime” is assigned.
      - Dry coupling if  $\{SM_{Bin}\} \ll \{SM_{All}\}$  where brackets indicate the distribution and double sign indicates significance
      - Wet coupling if  $\{SM_{Bin}\} \gg \{SM_{All}\}$
      - Transitional if  $\{SM_{Bin}\} \approx \{SM_{All}\}$
      - Atmospherically controlled where cases are few
    - The process is repeated for different bin counts and significance levels of the KS test to establish uncertainties, and smoothing is applied to create a final distribution of regimes in CTP -  $HI_{Low}$  space.
    - Time series of regimes at a point are then constructed
    - Coupling drought index for a period of  $N$  days:  $CDI = \frac{N_d - N_w}{N}$  where  $N_d$  and  $N_w$  are the number of days in dry coupling and wet coupling respectively.
      - Negative values near -1 indicate consistent wet coupling or drought recovery
      - Positive values near +1 indicate dry coupling or drought intensification and persistence.
- Data needs:
  - Temperature and humidity profiles through the lowest 300hPa (approx 3 km) of the atmosphere during early morning, soil moisture estimates (daily mean).
- Observational data sources:
  - Well suited to application to radiosonde profiles, namely where early morning soundings are available, but need co-located soil moisture measurements.
  - Roundy and Santanello (2017; JHM) extends to AIRS satellite profiles.
- Caveats:
  - Calibrated to the area and time period over which CDF is compiled – makes this a relative rather than absolute metric, which may be either a strength or weakness depending on the application.