[Coupling metrics to diagnose land-atmosphere interactions]

Vegetation-Atmosphere Coupling

- Reference:
  - Zscheischler, J., R. Orth, and S. I. Seneviratne, 2015: A submonthly database for detecting changes in vegetation-atmosphere coupling, *Geophys. Res. Lett.*, **42**, doi: 10.1002/2015GL066563.

- Principle:
  - Vegetation-atmosphere coupling (VAC) is a 2-dimensional categorical coupling index between temperature T and a vegetation-related variable; the original study looked at evapotranspiration and fraction of absorbed photosynthetically active radiation.
  - At any location, anomalies for each term are defined and a threshold percentile is chosen, applied to both tails (e.g., based on the magnitude of the anomaly). When both thresholds are simultaneously exceeded, a VAC category is entered depending on the signs of the anomalies:
    - $T-, Veg-$: energy limited, wettening, remaining atmospherically controlled
    - $T+, Veg+$: energy limited, drying, toward land-surface controlled
    - $T+, Veg-$: moisture limited, drying, remaining land-surface controlled
    - $T-, Veg+$: moisture limited, wettening, toward atmospherically controlled
  - VAC can be applied on a range of time scales, even daily when using flux data for the vegetation term, because it is based on anomalies. Its main use is to monitor movement within and between Budyko regimes.
  - Because the *corners* of a 2-parameter PDF are queried, the probability of occurrence of any category can vary spatially a great deal – this is actually informative regarding climate regimes, extremes, and even responses to climate change.

- Data needs:
  - Sufficiently long time series of temperature and the chosen vegetation variable to ensure an adequate removal of the seasonal cycle and reliable estimation of anomalies. Applicable to model or observational data.

- Observational data sources:
  - Can be applied to *in situ* or satellite data or a mix. Vegetation properties change slowly, so using FPAR or other vegetation variables (NDVI, SIF) necessitates a longer time scale.

- Caveats:
  - Threshold choice is arbitrary.
  - Basing thresholds on only the magnitude of the anomalies would not give the same results as treating the tails independently if the distribution of one or both variables is skewed – choose based on what is to be accomplished with this metric.

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