Soil Moisture Memory Decomposition

- References:
  - Koster, R. D., and M. J. Suarez, 2001: Soil moisture memory in climate models. *J. Hydrometeor.*, **2**, 558-570, doi: 10.1175/1525-7541(2001)002<0558:SMMICM>2.0.CO;2.
  - Seneviratne, S. I., and R. D. Koster, 2012: A revised framework for analyzing soil moisture memory in climate data: Derivation and interpretation. *J. Hydrometeor.*, **13**, 404-412, doi: 10.1175/JHM-D-11-044.1.

- Principle:
  - The land surface water balance equation can be converted into an equation for soil moisture autocorrelation or memory (persistence of anomalies) through selected linear assumptions about the relationships between the flux terms (namely runoff and evaporation) and the forcings of precipitation and net radiation. Koster and Suarez (2001) derived and interpreted four terms:
    - Non-stationarity (seasonality) in atmospheric forcing
    - Evaporation effect (dependence of ET on soil moisture)
    - Runoff effect (dependence of runoff on soil moisture)
    - Correlation of forcing with antecedent soil moisture
  - The final term conflated land-atmosphere feedbacks and "external forcing" (e.g., precipitation persistence caused by long-lived circulation anomalies). Additionally, the non-stationarity term was not clearly interpretable as it included the future (next month) variance of the predicted state (soil moisture) rather the future variance of the forcing (precipitation). Seneviratne and Koster (2012) addressed this by carefully reformulating the autocorrelation equation, arriving at five essential terms.

- Data needs:
  - Time series of soil moisture, precipitation and net radiation are needed, along with runoff and total evapotranspiration which are necessary to derive the coefficients defining linear relationships between those terms and soil moisture.
  - These studies used monthly mean data, but other time intervals could be used, provided the seasonal cycle is well resolved.
  - Well adapted to climate model output.

- Observational data sources:
  - Because of the need to derive linear regression coefficients of normalized runoff and ET terms as a function of soil moisture, multiple years of all five variables are needed at comparable spatial scales. This restricts the approach currently to long-term flux towers (runoff derived as a residual) or delicate combinations of disparate data sources.

- Caveats:
  - This approach defines a *climatology* of sources of soil moisture memory at any location, and as formulated does not address interannual variability or instantaneous departures from this climatology.

Supported by NASA/MAP Grant: NNX13AQ21G