[Coupling metrics to diagnose land-atmosphere interactions]

Soil Moisture Memory / Markov Process

- References:
  - Delworth, T. L., and S. Manabe, 1988: The influence of potential evaporation on the variabilities of simulated soil wetness and climate. *J. Climate*, **1**, 523-547, doi: 10.1175/1520-0442(1988)001<0523:TIOPEO>2.0.CO;2.
  - Delworth, T., and S. Manabe, 1989: The influence of soil wetness on near-surface atmospheric variability. *J. Climate*, **2**, 1447-1462, doi: 10.1175/1520-0442(1989)002<1447:TIOSWO>2.0.CO;2.
- Principle:
  - Soil moisture may be viewed as a red-noise process y driven by a white-noise forcing (z: precipitation), in which case the ODE: $\frac{dy(t)}{dt} = -\,/\,y(t) + z(t)$ maps to:

$$\frac{dw(t)}{dt} = -E_P\left(\frac{w(t)}{w_{FC}}\right) + P(t)$$

    where runoff is neglected; the ratio of potential evaporation to soil moisture field capacity $E\,/\,w_{FC} = /$ becomes the time scale.
    - The lagged autocorrelation of soil moisture $r(t) = \exp(-\,/\,t)$ has an e-folding time scale of $1\,/\,/$, which can be defined as the soil moisture memory.
- Data needs:
  - Time series of soil moisture – can be any time interval of daily or longer (no signal from diurnal cycle). The original studies used monthly mean soil moisture. The interval chosen will necessarily introduce a time-filtering.
- Observational data sources:
  - *In situ* or remotely sensed time series of soil moisture at one or more points, areas or gridded.
- Caveats:
  - Comparison of different sources of data (model or observed) is valid provided they are at the same time averaging interval and spatial scale (time series of area averages become redder as the area increases).
  - Random observational error introduces an extra source of variance that means the lagged autocorrelation of soil moisture will still be linear in $\ln(r)$ as a function of lag, but will not converged to $r = 1$ at $t = 0$; the magnitude of observational error of soil moisture can be estimated from the autocorrelation statistics. See Robock et al (1995) and Vinnikov et al. (1996) for more information.
    - Robock, A., K. Ya. Vinnikov, C. A. Schlosser, N. A. Speranskaya and Y. Xue, 1995: Use of midlatitude soil moisture and meteorological observations to validate soil moisture simulations with biosphere and bucket models. *J. Climate*, **8**, 15-35, doi: 10.1175/1520-0442(1995)008<0015:UOMSMA>2.0.CO;2.
    - Vinnikov, K. Ya., A. Robock, N. A. Speranskaya, and C. A. Schlosser, 1996: Scales of temporal and spatial variability of midlatitude soil moisture at different levels. *J. Geophys. Res.*, **101**, 7163-7174, doi: 10.1029/95JD02753.

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