Feedback parameter λ

- References:
  - Notaro, M., 2008: Statistical identification of global hot spots in soil moisture feedbacks among IPCC AR4 models. *J. Geophys. Res.*, **113**, D09101, doi:10.1029/2007JD009199.
  - Orlowsky, B., and S. I. Seneviratne, 2010: Analysis of land-atmosphere feedbacks and their possible pitfalls. *J. Climate*, **23**, 3918-3932.
- Principle:
  - The influence of a slowly-varying variable X at time t on a faster atmospheric variable Y at future time $t+dt$ can be estimated with a feedback parameter:

    $\lambda = \frac{\mathrm{cov}[X(t-\tau), Y(t)]}{\mathrm{cov}[X(t-\tau), X(t)]}$ where τ is a time scale > dt. The denominator is proportional to the lagged autocorrelation of X, or its memory.
- Data needs:
  - Time series of the two variables - well suited to large model output data sets. The larger the sample, the more robust and stable the results.
- Observational data sources:
  - Well suited to observational time series, but sensitive to sample size (see below).
- Caveats:
  - With finite data sets there will be sensitivity to the choice of τ.
  - As with all correlation-based metrics, causal relationships are not guaranteed. This is not a process-level metric.
  - Likewise, the metric isolates only linear relationships. Nonlinear or categorical (threshold) relationships may not be well captured.

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