Dynamical Process Network

- References:
  - Ruddell, B. L., and P. Kumar, 2009a: Ecohydrologic process networks: 1. Identification. *Water Resour. Res.*, **45**, W03419, doi: 10.1029/2008WR007279.
  - Ruddell, B. L., and P. Kumar, 2009b: Ecohydrologic process networks: 2. Analysis and characterization. *Water Resour. Res.*, **45**, W03420, doi: 10.1029/2008WR007280.
  - Ruddell, B. L., et al., 2016: Seasonally varied controls of climate and phenophase on terrestrial carbon dynamics: modeling eco-climate system state using Dynamical Process Networks. *Landscape ecology* **31**, 165-180, doi: 10.1007/s10980-015-0253-x.

- Principle:
  - DPN is an application of transfer entropy (TE) and mutual information (MI) to deduce coupled behavior and feedbacks in systems using pair-wise analysis of variables as linked nodes in an overall *process network* with directional flows of information that may act on a range of time scales.
  - The ratio of TE to MI over various lags:

$$T_z(X_t \to Y_t, \tau) = \frac{T(X_t \to Y_t, \tau)}{I(X_t, Y_t)}$$

    gives an indication of whether the two variables are uncoupled, weakly or strongly coupled ("feedback" or "forcing" dominated) or synchronized but not evidently coupled (where both terms are likely strongly driven "effects" of a common "cause" forcing).
  - Sets of pairwise relationships among a suite of variables can be assessed and jointly compared in a "network matrix" to determine linkages and information flows, defining process chains and degrees of coupling.

- Data needs:
  - Individual pairwise estimates are subject to the requirements discussed in the page on Transfer Entropy.
  - Networks can be of any number of variables, as long as each has similarly complete time series.
  - Very well suited to model output and model assessment.

- Observational data sources:
  - Highly applicable to observational data, noting that random error and missing data will have some effect on estimates; systematic error should not have an effect.

- Caveats:
  - As with TE, significance of results is established by Monte Carlo approaches.

Supported by NASA/MAP Grant: NNX13AQ21G