Robust Indicators for Tipping Points

Wish List for an indicator:

- Must be "*early enough*" -- this is a essentially a time scales sensitivity issue. Can we detect if we've gone over a tipping point? Can we alter our course if so?
- A method must be flexible wrt the *number of observable*.
- The *false alarm rate must be low* -- risk estimation feeds directly into a CBA of social and economic issues related to false positives.
- *Temporal* vs. *Spatial/Spatiotemporal*
  - limited by length of time series - higher resolution spatial data
  - time resolution - what does it mean to tip in a spatial context?
- *Topological methods* could provide global, robust (wrt noise) indicators
- Local tipping points in high-dim systems are basically saddle nodes, but a "general" indicators would be *flexible enough to handle PDE's.*
- We really would like *global* indicators. Current methods are essentially local.
- Extreme value methods, are they extendible to dimensions > 1?

A much less than exhaustive list of examples of issues we're aware when trying to "predict" tipping points:

- Noise-induced tipping (P. Ditlevsen)
- Short records miss slow variables (Zoe's Indian Monsoon research.
- Quasistatic equilibria change the shape of the attractor while trying to understand it.
- Crises at basin boundary collisions can be very complicated.
- Coupled systems (eg. Sugihara) can hide precursors to tipping: Eg.,

  A ---> B, B is the only observable, but all the "action" is in A. If A jolts B with a "spike" we may miss any precursors leading up to the spike, since they are, a priori, unobservable.