Collisions of phenomenological and dynamical models: Boom.

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1. Introduction

   (a) Dynamical (mechanistic) and statistical (phenomenological) models often focus on stationary dynamics

   (b) However, increasing evidence in dynamical systems and from empirical data suggest transient dynamics may be important

   (c) Here's some motivating examples (why this might be useful)

      i. Dynamical: Ghost, crawl-by and other exciting stuff

      ii. Empirical: Regime shifts

      iii. Empirical: Animal movement

   (d) Something about how Carl (and others?) have shown how to combine statistical and dynamical models in stationary systems, here we go non-stationary

2. Methods

   (a) Dynamic models: We're using May 1976 model (others we discussed below) that we vary in:

      i. Range of behaviour seen

      ii. sigma (noise)

   (b) The model is:

$$dx/dt = x(1-x) - \frac{\delta x^q}{\gamma^q + x^q}$$

   where we nondimensionalized from the original May model using

$$\delta = \frac{a}{rK}, \quad \gamma = \frac{H}{K}$$

   (c) Statistical methods (just a subset, we need to see data more to flesh this out)

      i. Mechanistic (May 1976)

      ii. Linear regression

      iii. Changepoint analysis

      iv. Mixture model

      v. Hidden Markov

vi. Mix of phenomenological with mechanistic

(d) Compare models (aim is see how the models do at forecasting phase shifts, and maybe at identifying transients)

(e) Could also compare how models respond to perturbations; either perturbations of the state variable, or of parameters

i. Cross-validation (k-fold, or leave-one-out) on given data

ii. Compare forecast to model predictions

3. Results

(a) We're going to get these. We think maybe mechanistic models should do well.

4. Discussion

(a) From all this, get to what you need to know about system (helping improve experiments) ... If you can observe the system at transient dynamics you can perhaps learn more.

(b) Transients can arise from inside the system (autonomous) ... so if you cannot find an exogenous factor, maybe it's autonomous to your system

Other stuff we mentioned:

1. Challenges in predicting transient behaviour from real data.

2. Coming up with new ways to describe phenomenon that perhaps could be better described with another method. For example, for animal movement data, where hidden Markov models are mostly used maybe you should be using dynamical models.

3. Focusing on phase shifts ... understanding if the behaviour is transient versus phase shift versus observing asymptotic behaviour ...

4. If you don't think about transients (by going in with a preformed idea of a system of asymptotic or a mixture model) you can miss important transient behaviour which can be critical prediction.

5. Are some dynamical models totally intractable statistically?

Some other dynamical models with transients (that we dreamed of working on):

1. Linear (matrix model)

2. Chaotic

3. Periodic (fast-slow)