Announcements: Videos up. Still learning how to grade things in canvas but will start working on getting last weeks submissions submitted. Reading and videos for next week will be up by Friday

Before we get started, I was curious about how many people had read or thought about phenology?
How about changes in phenology over time?

What kinds of long-term changes have people been exposed to before?

1. What is phenology?
   A. Timing of activity - seasonal scale, within a year, typically not across years.
2. This paper is very focused on plants, but what are some examples of phenology for non-plants?
   A. Breeding season onset and stop
   B. Migration days
   C. Emergence
   D. Hibernation dates

3. what are some of the ways that climate and phenology are linked?
A. Increasing temperature changes the temperature cues for species relative to photoperiod
B. Increasing temperature influences rates of development
C. In tropical climates (and deserts), seasonality may be linked with water availability more than temperature fluctuations

4. How big have the shifts in phenology been thus far?
   2.3-5.1 days per decade
   A. What kind of data do you need to detect and forecast that magnitude of change?
      high frequency data
   B. Think back to our discussion on data types - what types of data give us that scale of resolution? What challenge do they identify later in the paper that inhibits using that type of data collection to the study of phenology?
We're typically talking satellite data, but this often has low spatial resolution and/or low data frequency relative to the scale of phenology (2-week intervals for the processed data)
   C. Do you feel that its important or possible to forecast shifts that precisely?

5. Phenology has been studied extensively, but where are most of the long-term records from? What biases does this insert into our understanding of phenology?
A. Temperate zones
B. Often managed plants (cherry trees, vineyards)
Biases us towards the northern hemisphere (generally). Towards temperature-based phenology change. Cultivated species may not have the same pressures and constraints on their timing as wild species.

6. The paper dedicated a section to open discussion about which family of models (theoretical, statistical, process oriented) is suitable for forecasting phenology. Each family has pros and cons. Describe each of these family of models and how they differ from each other?
   Theoretical: based on theoretical trade offs of the costs and benefits of producing leaves to

optimize resource acquisition.

Statistical: Based on relationships in empirical data with climate factors. These are statistical fits to the data (i.e. linear regressions).

Process-based: formally describe known cause-effect relationships between biological processes and environmental factors.

Which approach do you feel may be best?
To answer which questions?

If time:
How often have you read the word 'uncertainty' in the paper?

* Once - wrt. Pollen transport.

Given the scale of the phenology response being measured, how important could uncertainty be?

* Given that we're detecting a few days per decade, seems like uncertainty could potentially be important to account for.

What sources of uncertainty can you think of that could be important for modeling or forecasting phenology?

* in the data -

for example, the remote sensing data which has uncertainty due to the smoothing/ filtering effect

Observation/sampling uncertainty: over long time periods (in field records) could be changes in who thinks what signals indicate the onset of a phenology stage.

* in our models: imperfections in our models, lack of details that could influence predictions on the scale of days/decade