A simple explanation for declining temperature sensitivity with warming

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December 28, 2019

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1 Outline & notes

Need to work on this, notes to date on here.

Meeting with Jonathan Auerbach & Andrew Gelman on 18 December 2019:
Fundamental issue is that we have a non-linear relationship ($y = 1/x$) being described by a linear function ($y = x$), where x is the mean temp and 1 could be the GDD. The time until you reach a threshold is inversely porportional to the speed you go at. So, at very low temperatures plants would (theoretically) never leaf out and at 200 C days it would take one day.

The classic algebra example (they tell me) is how long does it take to drive 200 miles? It depends on your miles per hour. (Side note by Lizzie while typing up these notes: the speed analogy is sort of nice, climate change is stepping on the accelerator, making this algebra problem relevant.)

- The artifact comes from the mean getting larger while the variance goes down (I think, I may have this noted wrong, but it's about the mean relative to the variance, not just the variance or the mean). If you make the variance scale with the mean you will see the issue go away (though Andrew pointed out this should be done on the SD scale, not the var).
- "The statistical artifact is that fitting a linear regression requires linearity"said Jonathan Auerbach.

- If this was all simple, we could fix it two ways: percent scale (decline relative to some base C temp) or log both axes. (Note from Lizzie: but we don't know when to start accumulating so not sure how this works, though Jonathan seemed to have insight into this.)
- An example of inferring process from an artifact is regression to the mean, though Andrew pointed out regression to the mean is more complicated compared to this as regression to the mean is a statistical issue and this is just a deterministic reality.
- Convexity in economics has had similar problems to this.

2 Tasks, milestones etc.

- Finish minimal analyses we think we need:
  - Produce simulated data where chilling is not met (Lizzie has notes on this below enddocument command ... (bucket model).
  - Do sliding windows for ... BETPEN (done) and FAGSYL from PEP725 and for simulated data.
- Chat with Rob Guy for foundational papers that many events like leafout are based on temperature accumulations.
- Review the literature
  - Cat did some of this [add LINK HERE]
  - Review beyond phenology?
- Outline the paper
- Decide on targeted journals
- Write the paper
- Submit the paper

3 Literature notes

Sagarin 2001: False estimates of the advance of spring (leap year issues).

I noticed as you go back to 2014 and before in my ISI searches, you get a lot of soil respiration lit. And in that literature they use Q_{10} for temperature sensitivities, "[t]he temperature sensitivity of soil respiration is often expressed as the Q10 value; that is, the factor by which soil respiration increases by a 10C increase in temperature (e.g., Kirschbaum, 1995; Van't Hoff, 1898)," which would avoid a good dose of the issue we're seeing.

Figures

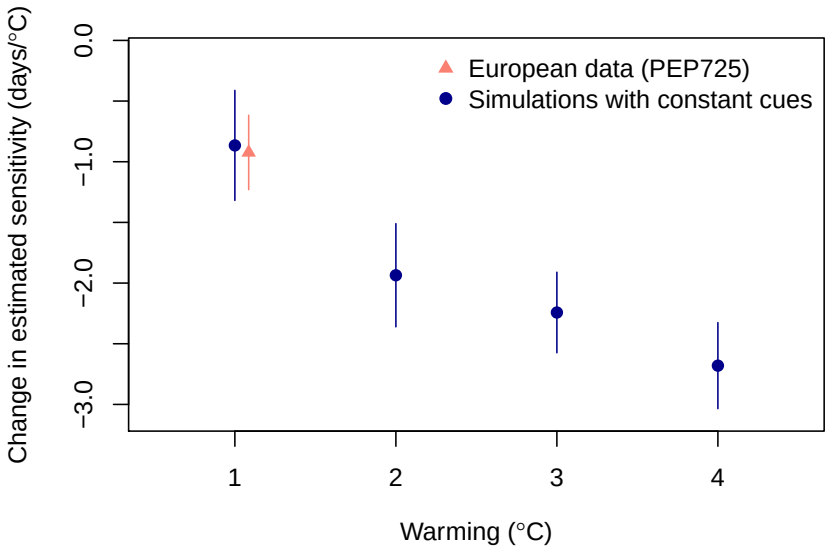

Figure 1: **Declining sensitivities observed in long-term European data for a suite of common trees may be explained by a statistical artifact.** We compared the sensitivity estimated from linear regressions of day of leafout versus mean spring temperature (estimated thus as days/°C) from PEP725 data for *Betula pendula* from 45 sites ("European data") with estimated declines in simulations where the cues were held constant but spring temperatures warmed by 1-4°C ("Simulations") and found the estimated temperature sensitivity measured as days/°C declined even though the underlying cues had not changed, see *Understanding declines in temperature sensitivity in European long-term data* for further details.