Climate Hazards: Outline

Lizzie, Isabelle Chuine, Ben Cook, Victor van der Meersch

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1 Outline

Questions for co-authors...

1. Only max temperature matters to heat extremes – unlike hardiness where plants gain/lose tolerance, this doesn't really happen for heat extremes, right?

2. What extremes to think about? Heat, cold, drought ... ?

Miscellaneous new outline bits to organize

1. Mean versus variance: lots of focus of damage due to higher means

2. Lots of interest in shifts in variance from theoretical perspective, but often not linked to empirical reality

3. Empirical reality of shifts in variance

    (a) Lots of variance patterns in temperature are narrowing:
        i. Daily temperature ranges
        ii. Elevation, latitude

4. Variance shifts in certain biological periods matter a lot more than others

    (a) Likely windows for hazards
        i. Transitional climatic periods (spring/fall) and hottest summer months
        ii. But also depend a lot on phenology (introduce PHENOFIT?)

5. Need to bridge the observational/experimental gap for heat extremes (especially)

6. Extremes and species distributions

7. Molecular studies of mean versus variability

8. What extremes?

    (a) Heat: just the max (right?)
    (b) Cold

    i. Max (hardiness at max period)

    ii. Transition periods

(c) Drought

(d) Others?

Possible headers

1. Why extremes matter

2. Why we're bad at predicting extremes

   (a) Extremes in climate science are defined statistically usually – they are rare by definition which makes them tricky

   (b) But we're not talking about that, we're talking about climate hazards, which depend on biological limits, often thermal limits

April outline

1. Introduction ...

2. Fundamental trade-off in life history of growing season length (mean) versus risk (variability often?)

   (a) Frost risk

   (b) Is there historical literature on heat damage as limiting seasons?

   (a) Introduction stuff here...

3. How much are means versus variability shifting?

4. Info from the literature

   (a) Basics from IPCC?

   (b) Refs from Ben?

   (c) Extremes versus variability

5. Case study in Europe

   (a) Variability across space (sites)

   (b) Shifts since 1950 by month

   (c) Change over time versus sites: Variability across space decreasing?

   (d) Projections

6. PHENOFIT case study

   (a) Do means versus variability shifts alone lead to increases or decreases in fitness? Or is is messier?

   (b) Additive effects...

7. From models to forecasting

   (a) Need more fitness data

   (b) Need more data on events and their impacts (crops?)

2 Manuscript text

Title: Seasonal pressure points of climate change

Abstract

Climate change is reshaping growing seasons globally with major impacts on natural and agricultural ecosystems. Yet we are uncertain exactly how, where, and when impacts will be most pronounced. Working with collaborators from France, we propose to identify the pressure points of climate change—seasonal periods when shifts in climate interact with development to lower growth, reproduction or survival. Using an integrated model of the full annual cycle of plant growth, reproduction and survival (PHENOFIT), we will compare the impacts of future warming versus shifts in frost events on the fitness of three tree species (*Fagus sylvatica, Pinus sylvestris, Quercus robur*). This framework will help identify the challenges and opportunities in adapting to climate change across European forests.