Does Timing of Weather Matter for Climate Change Impact Assessment

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INTRODUCTION

Statistical yield response models are used to explore the potential effects of climate change on crop production. Reliance on real world data presumably captures optimal farmer behavior conditional on weather. This approach can be summarized as:

Step 1: $yield_{it} = \beta \times Weather_{it} + \alpha_i + \epsilon_{it}$ (estimation)

Step 2: $\Delta yield_i = \beta \times \Delta Climate_i \pm error$ (projection)

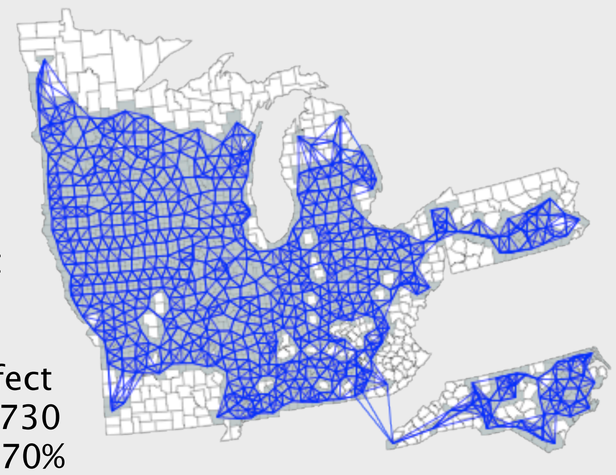
Most work in this literature (e.g. Schlenker & Roberts, 2009) use season-long time windows to capture the effect of weather. This assumption (additive separability) implies the intra-seasonal timing of the supply of weather inputs is irrelevant.

This seems at odds with conventional wisdom in the natural sciences. My goal is to develop a biophysical framework to verify whether intra-seasonal time-aggregation of weather really matters. If it does, we should expect very different effects of weather throughout the season.

METHODS

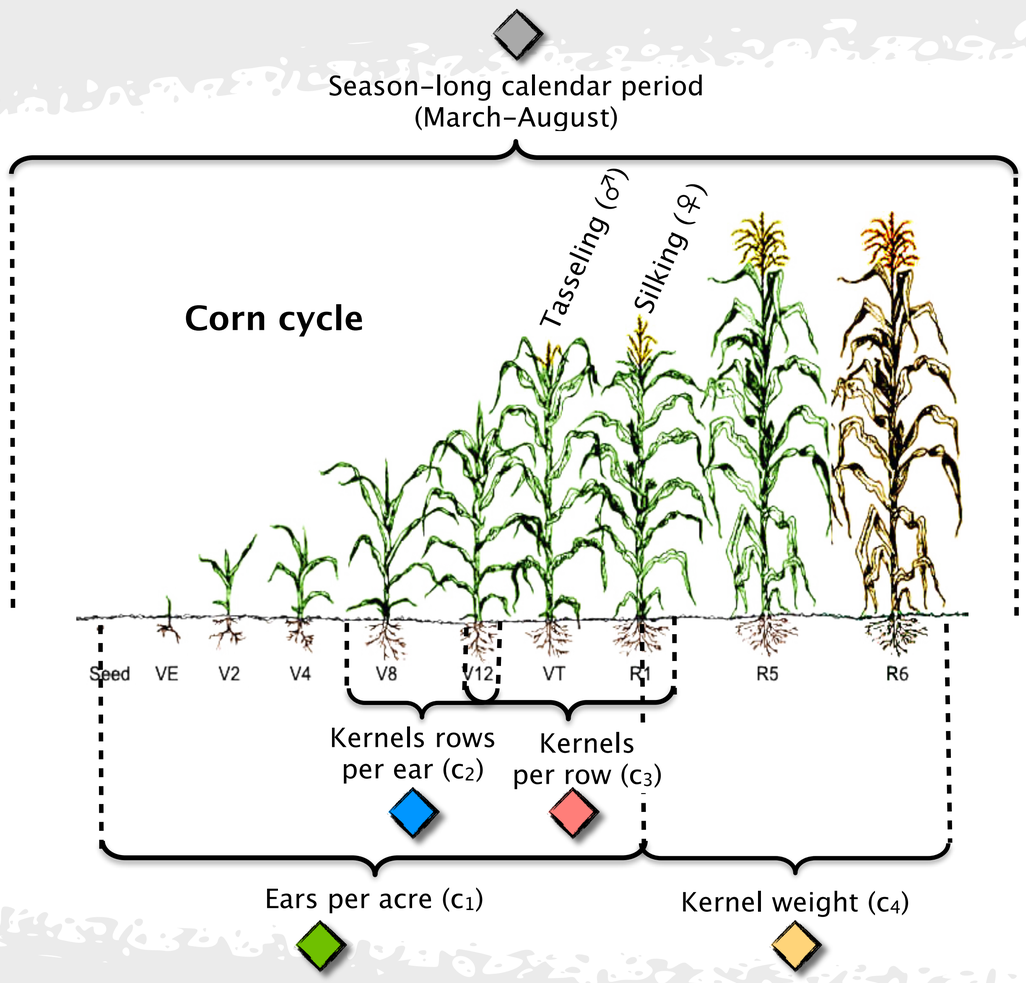
Agronomists express yield as the product of yield components ($yield = c_1 \times c_2 \times c_3 \times c_4$) which are individually determined at different periods of the growing season (c.f. corn cycle figure below).

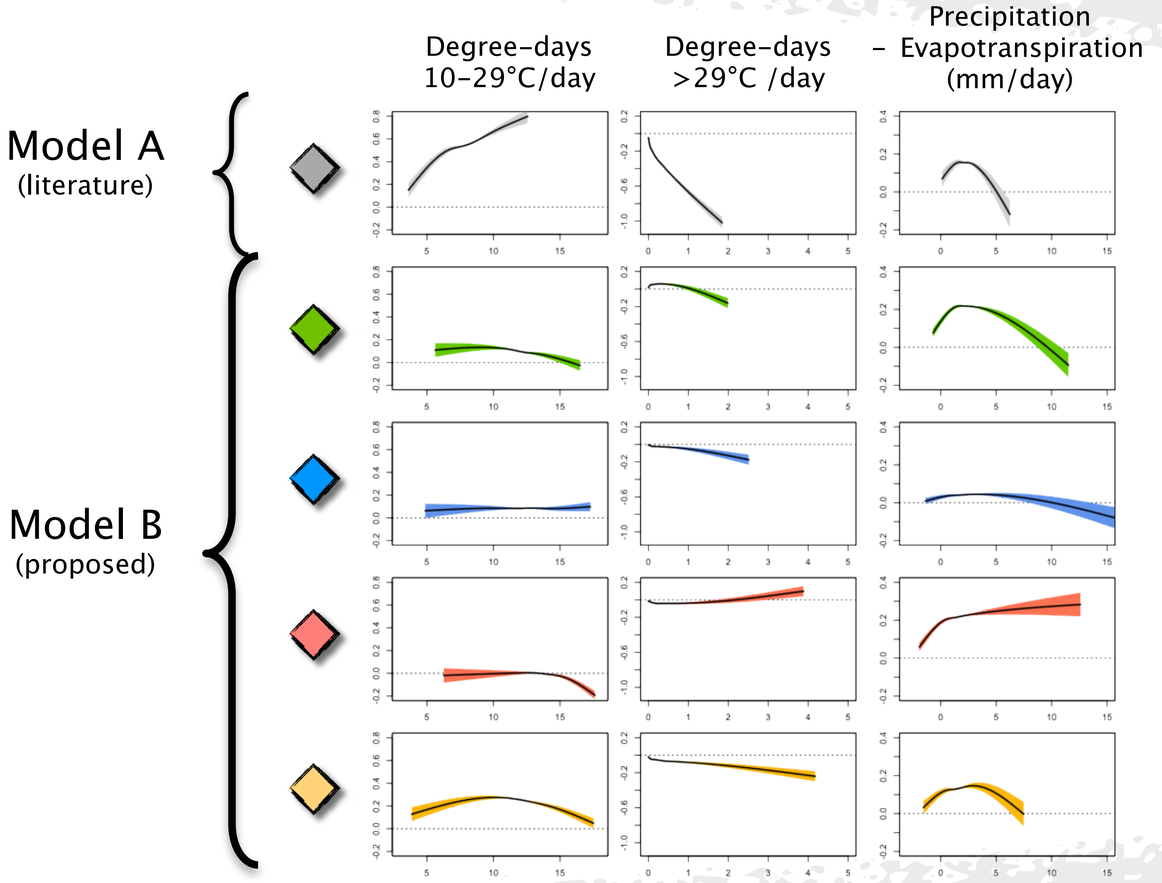
I compare models relying on weather regressors following the literature's pluri-monthly aggregation time frame for corn (Model A) and the proposed biophysical windows for each yield component (Model B).



I estimate county fixed-effect panel models of corn yields for 730 rainfed counties in 11 states (>70% of US production). I construct neighboring relationships (c.f. map) to account for spatial error correlation and improve efficiency.

- Production and progress data : USDA-NASS
- Sub-daily weather data : NOAA-NCEP-EMC-NARR





RESULTS & DISCUSSION

- While moderate (degree-days 10-29°C) and extreme (degree-days>29°C) heat exhibit positive and negative effects respectively in the literature's reference model (A), this pattern is absent when looking at sub-periods in the proposed model (B).
- The yield response to the water supply (third graph column) is different throughout the season and exhibits high returns for high levels of moisture during yield component c_3 window which occurs during flowering.
- This simple exercise shows different yield responses to weather variables for different sub-periods of the growing season. This suggests that farmers could adapt by "moving the season" to more suitable parts of the calendar (Ortiz-Bobea and Just).

CONCLUSION

The timing of weather does matter for climate change impact assessment on agriculture because the marginal effects of weather within the season seems substantially different, in particular for the heat variables. More detailed models exploring the aggregation windows and the nature of weather variables are needed.

REFERENCES

Ortiz-Bobea, A., and R.E. Just. Forthcoming 2013. "Modeling the Structure of Adaptation in Climate Change Impact Assessment." AJAE (proceedings)

Schlenker, W., and M.J. Roberts. 2009. "Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change." PNAS