Measuring Extreme Precipitation and its Effects on Agriculture in the United States

Munib Inam, University of Kentucky, and munib.inam@uky.edu
Steven Buck, University of Kentucky, and steven.buck@uky.edu

Selected Poster prepared for presentation at the 2024 Agricultural & Applied Economics Association Annual Meeting, New Orleans, LA: July 28-30, 2024

Measuring Extreme Precipitation and its Effects on Agriculture in the United States

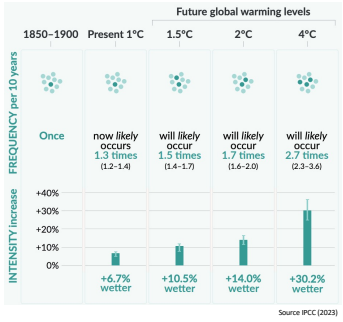
Munib Inam*, Steven Buck

University of Kentucky, Lexington, KY, USA

*Correspondence: munib.inam@uky.edu

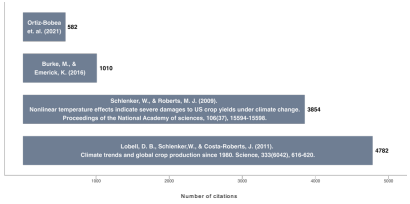
Motivation

Extreme precipitation events are projected to increase in both frequency and intensity with recent climate change projections (IPCC 2023).



Literature Review

The Effects of Climate Change on Agriculture literature has an outsized impact in the science literature:



But the literature is still relatively unexplored …

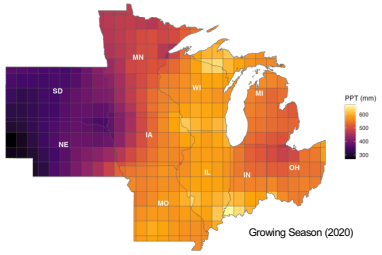
- Which extreme measures matter for which crops?
- When do extreme weather events matter in the plant growth cycle?
- Measurement error due to non-linear transformations of interpolated raw weather data.

Data

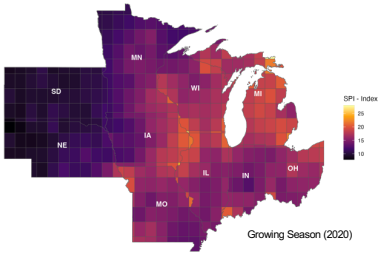
Harvested acres and planted acres: Crop yield data is sourced from the USDA-NASS.

Precipitation & temperature: Raw weather station data is from National Oceanic and Atmospheric Administration (NOAA) that is spatially interpolated.

Cropland Data Layer (CDL): This GIS data is used to merge crop yield and weather data.



The method we use to measure weather affects its spatial distribution; for example, we compare those for total growing season rainfall & the standard intensity precipitation index.



Extreme precipitation:

- Maximum precipitation over various periods (weekly, monthly, seasonally, and annually) and at different times during plant growth cycle.
- Threshold exceedance based on calendar day percentiles (90th, 95th, and 99th) and days within a specific period.

Methodology and Preliminary Results

We use a panel model of crop yields as a function of extreme precipitation measures, controlling for county and year fixed effects to account for unobserved heterogeneity such as systematic shocks, technological advancements, and policy changes.

Estimating Equation:

$$\log(yield_{ijt}) = \alpha_0 + \beta \log(X_{ijt}) + C_i + Y_t + \varepsilon_{ijt}$$

The preliminary findings (for Kentucky and years 2008-2020):

Table: Fixed Effects Model Summary (2008-2020)

	Dependent variable:	
	Log (winter wheat yield - bu/acre)	
	(95th Percentile)	(99th Percentile)
Contemporaneous	**0.3840*** **	-0.0095
	(0.0820)	(0.0579)
One year lag (t-1)	**-0.2833*** **	-0.0913
	(0.0840)	(0.0605)
Seasonal Effects:		
Fall (Planting)	-0.0550	**0.1091***
	(0.0503)	(0.0593)
Winter (Dormant)	-0.0550	0.0174
	(0.0503)	(0.0846)
Spring (Flowering)	-0.0005	**-0.2018*** **
	(0.0466)	(0.0670)
Summer (Harvest)	0.0425	0.0466
	(0.0416)	(0.0604)
Year Fixed Effects (13 years)	YES	YES
County Fixed Effects (48 counties)	YES	YES

Note: *p < 0.10; **p < 0.05; ***p<0.01

Key Findings

Extreme precipitation events do affect crop yields. Specifically, wheat yields benefit from mild to extreme precipitation up to the 95th percentile threshold, but the positive impact diminishes and becomes insignificant at higher extremes (99th percentile).

For instance, a 1% increase in precipitation intensity at the 95th percentile is associated with a 0.38% increase in winter wheat yields in the same year. However, at the 99th percentile, the effect is negative, smaller and statistically insignificant, indicating that while wheat yields benefit from intense precipitation, there is a threshold beyond which the benefits diminish.

Key Findings

Results also indicate that the positive effects of heavy rainfall can turn negative over time, for example, due to waterlogging from the previous year or soil nutrient leaching.

The timing of extreme precipitation also seems to matter. Extremely intense rainfall during the flowering phase is harmful, but results indicate that there may be potential benefits during the planting stage. This shows the importance of considering crop growth cycle when evaluating the effects of extreme weather.

Future Research

Looking ahead, we plan to extend the scope of our analysis by including more crops, regions, and years. We also plan to incorporate extreme temperature measures.

Our next primary focus is to minimize measurement error in the spatial interpolation of weather data, particularly in the context of extreme weather measures.

This will help improve the accuracy of our assessment of weather extremes on agriculture.

References

Burke, M., & Emerick, K. (2016). Adaptation to climate change: Evidence from US agriculture. American Economic Journal: Economic Policy, 8(3), 106-140.

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. Science, 333(6042), 616-620.

Ortiz-Bobea, A., Ault, T. R., Carrillo, C. M., Chambers, R. G., & Lobell, D. B. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. Nature Climate Change, 11(4), 306-312.

Schlenker, W., & Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to US crop yields under climate change. Proceedings of the National Academy of sciences, 106(37), 15594-15598.