The Impacts of Climate Change on Yields of Irrigated and Rainfed Crops:

Length, Depth, and Correlation of Damages

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Selected Poster prepared for presentation at the 2018 Agricultural & Applied Economics Association Annual Meeting, Washington, D.C., August 5-August 7

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I acknowledge support from U.S. Department of Energy, Office of Science, Biological and Environmental Research Program, Integrated Assessment Research Program, Grant No. DE-SC0005171 and Grant No. DE-SC0016162.
This poster is part of a joint study by Iman Haqiqi, Thomas W Hertel, and Wolfram Schlenker.

INTRODUCTION

Objectives:

To measure the yield response of maize by irrigation practice

To measure the impacts of climate change on maize by irrigation practice

To evaluate the impacts of adaptation strategies (irrigation and heat tolerance)

Hypothesis:

Climate change will

- increase the irrigation yield gap for maize
- increase the relative variation of rainfed to irrigated maize
- increase the relative likelihood of extreme damage
- have negative impact on US maize but positive impacts CAN, EU

MOTIVATION

Future climate will change spatial pattern of yields US (Schlenker and Roberts, 2009).

The negative impacts on irrigated yields are smaller compared to non-irrigated (Roberts and Schlenker, 2011).

Irrigation will be more profitable and more attractive to farmers under new climate (Van Dop, 2016).

Future climate will also affect year on year variation Diffenbaugh (2012).

➔What about global spatial pattern of climate impacts?

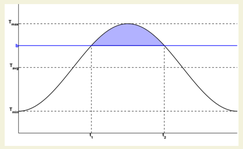
➔ What about relative advantage of irrigation?

METHODOLOGICAL APPROACH

Following Schlenker and Roberts (2009), we assume

- Temperature effects on yields are cumulative over time and plant growth depends nonlinearly on heat
- Yield depends on total precipitation
- Time trends by state will capture technological change
- Time-invariant county-fixed effect will control for time-invariant heterogeneity, such as soil quality
- We allow the error terms to be spatially correlated
- Temperature in a day follows a cosine function (Snyder, 1985)
- Bounds 10°C-29°C is beneficial heat for corn
- Above 29 °C is harmful heat for corn
- Growing season varies by location

$$\bar{t} = acos\left(\frac{2b - T_{max} - T_{min}}{T_{max} - T_{min}}\right)$$



$$\text{degree days} = \begin{cases} \frac{T_{max}+T_{min}}{2} - b & \text{if } b \le T_{min} \\ \frac{\bar{t}}{\pi}\left[\frac{T_{max}+T_{min}}{2} - b\right] + \frac{T_{max}-T_{min}}{2\pi}\sin(\bar{t}) & \text{if } T_{min} < b < T_{max} \\ 0 & \text{if } T_{max} \le b \end{cases}$$

DATA PROCESSING

Daily temperature max and min , NASA NEX-GDDP CMIP5, CCSM4, RCP8.5 Comparing 2036-2065 to 1986-2005 period

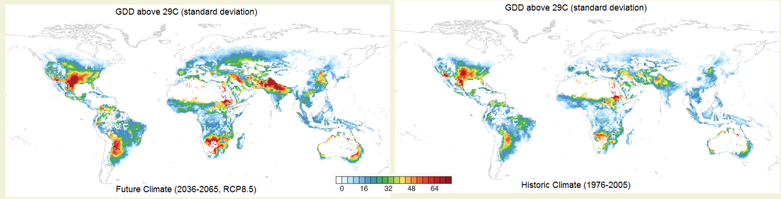
Daily precipitation, NASA NEX-GDDP

Growing period, SAGE

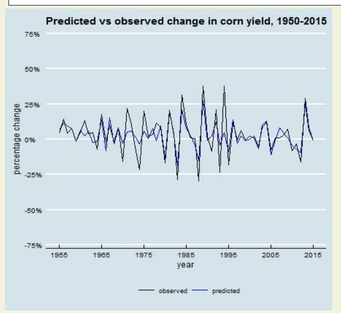
Cropland area, IIASA-IFPRI

Yields, USDA

➔ the variation of harmful heat will be changing around the world



COEFFICIENTS ARE SIGNIFICANT WITH RIGHT SIGN



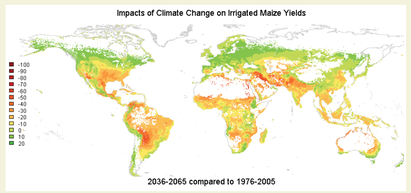
	Log CornYieldAll	Log CornYieldIrr	Log CornYieldRfd
GDD10-29C	0.00033***	0.00052***	0.00062***
GDD29C	-.00530***	-.00205***	-.00616***
Prec	0.00065***	0.00065***	0.0039***
Prec2	-5.1e-7***	-7.6e-7***	-2.4e-6***

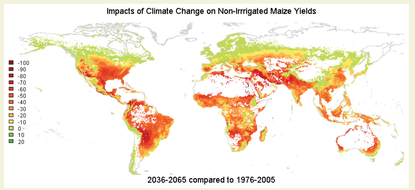
PROJECTED CLIMATE IMPACT ON MAIZE (MEAN, SD)

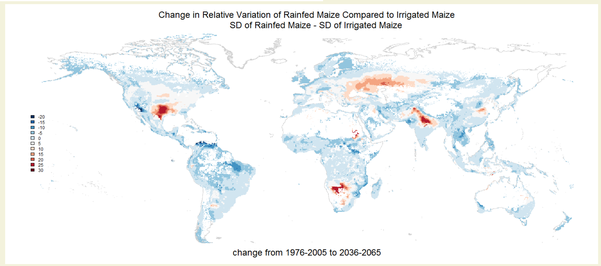
➔Climate damage on US maize is significant but smaller on irrigated maize

➔Maize in CAN, RUS, EU will benefit from climate change

➔Relative variation of rainfed maize will increase in part of US and IND





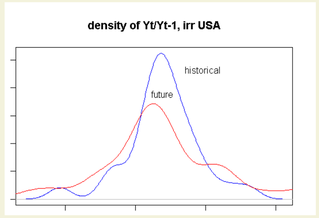


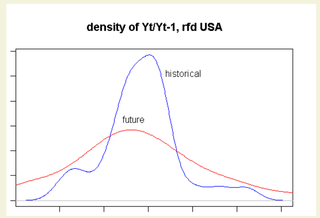
MAIZE YIELD VARIATION IN THE US

➔Keeping current maize area, variation will increase for the US

➔Variation of year on year yield will increase for both rainfed and irrigated maize

➔Relative variation of rainfed maize will increase in US

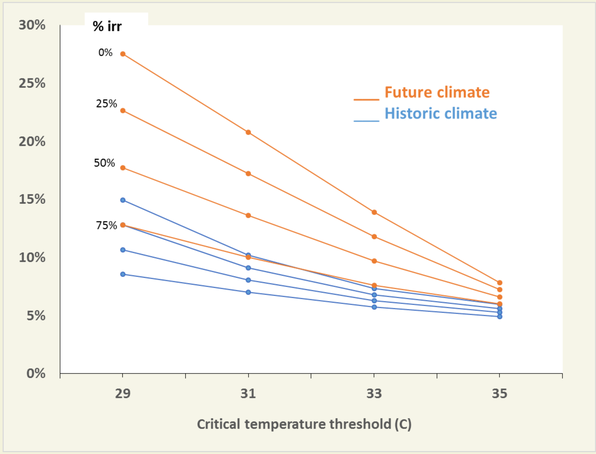




POTENTIALS FOR ADAPTATION

➔Increase in heat tolerance will reduce the yield variation

➔Expansion of irrigation can reduce the yield variation



DISCUSSIONS

For many crop growing regions in the world, there will be more than 20 years of severe damage on rainfed corn yields in a 30-year period. However, for most of the regions, the irrigated production may face less than 10 years of severe damage in this period.

These results suggest a high incentive to shift the growing region and to switch to irrigation.

In summary, looking at the change in the pattern of yield damage as well as comparative damages is a critical component of climate change analysis.