Climate impacts on food supply

David Lobell

Program on Food Security and Environment, Stanford Univ.

dlobell@stanford.edu

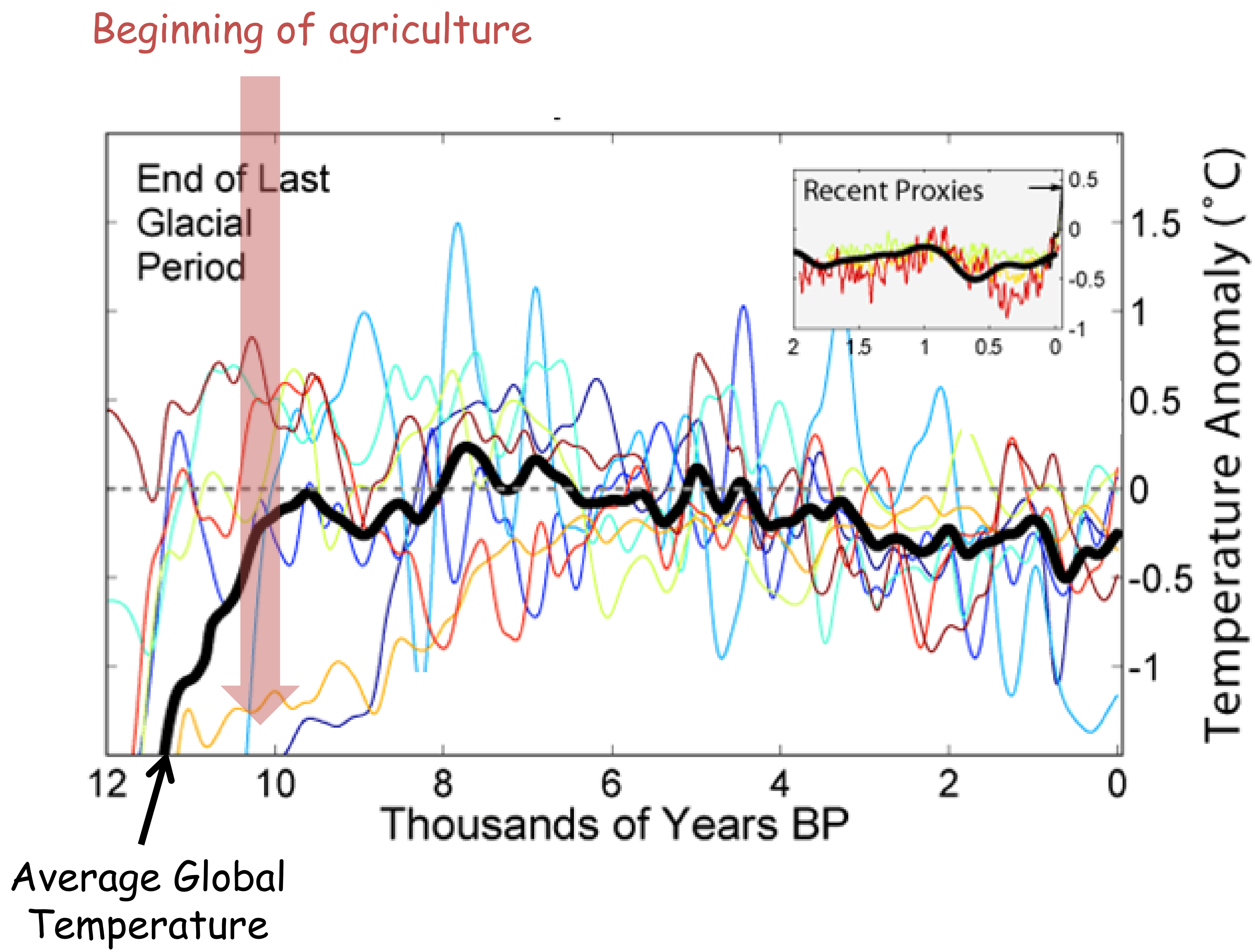
First Anniversary of the Svalbard Global Seed Vault,

26 February 2009

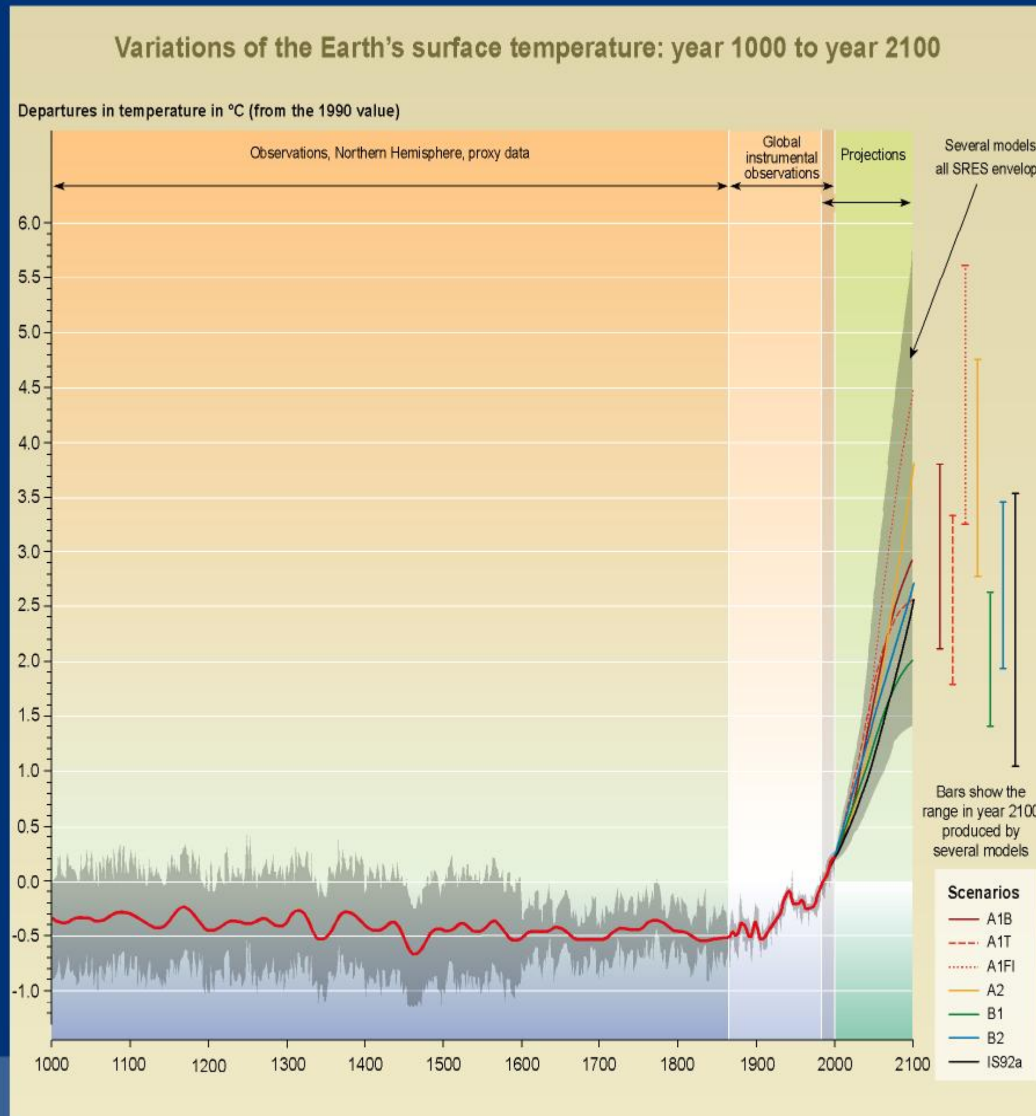
FSE

STANFORD

Agriculture has evolved in a relatively stable climate...



… but the 21st century will be different



SYR - FIGURE 9-1b

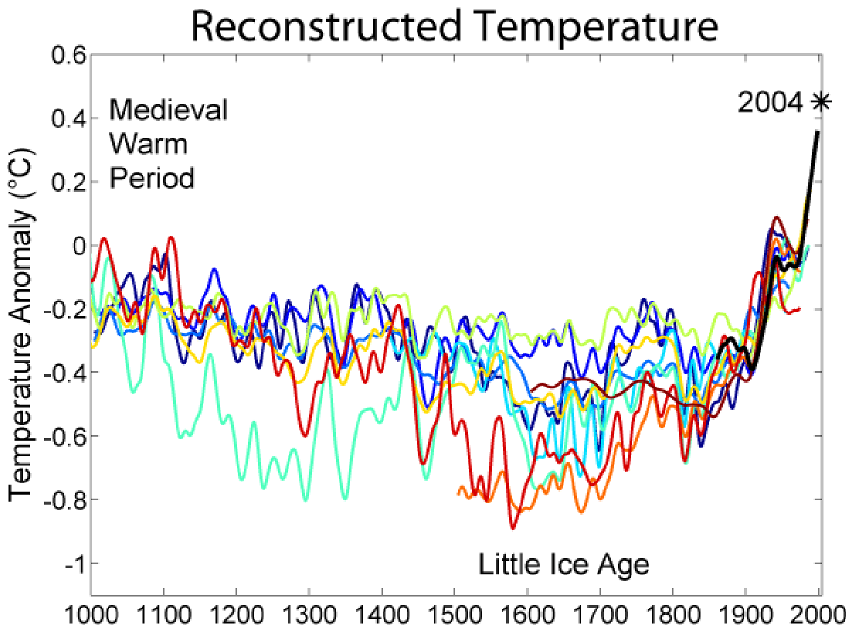
FSE
STANFORD

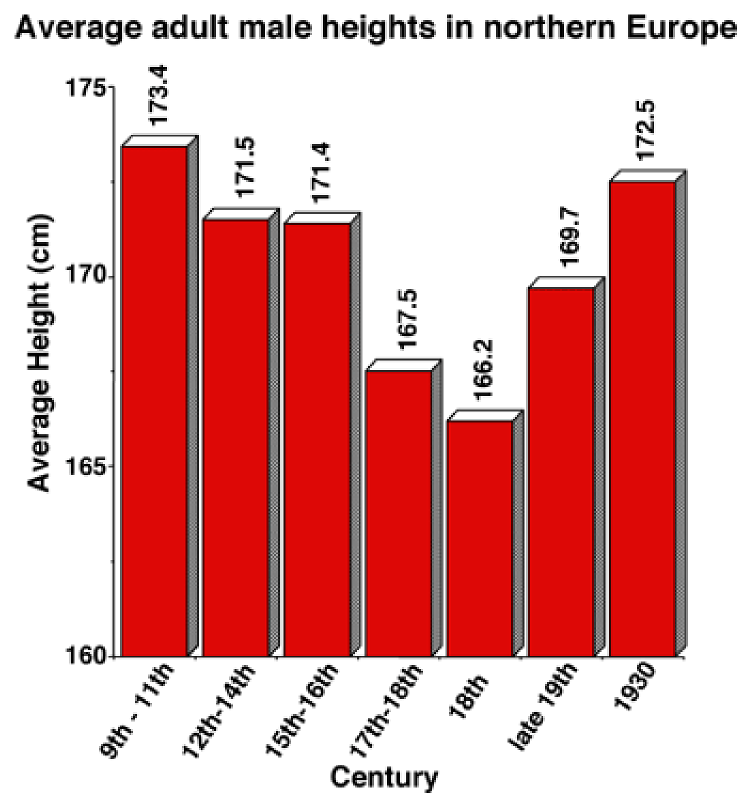
IPCC

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

Is Change, *per se*, really such a bad thing?





http://www.pbs.org/saf/1505/features/lia2.htm

FSE
STANFORD

The counter-argument (why change may not be bad)

1. We are smarter now
2. We have more international trade to buffer local impacts
3. Higher CO_2 will raise crop yields
4. Warming will open up more croplands in Northern latitudes

These are all true to some degree, but in many places the “bad” effects of change will dominate, namely greater crop stress and lower yields

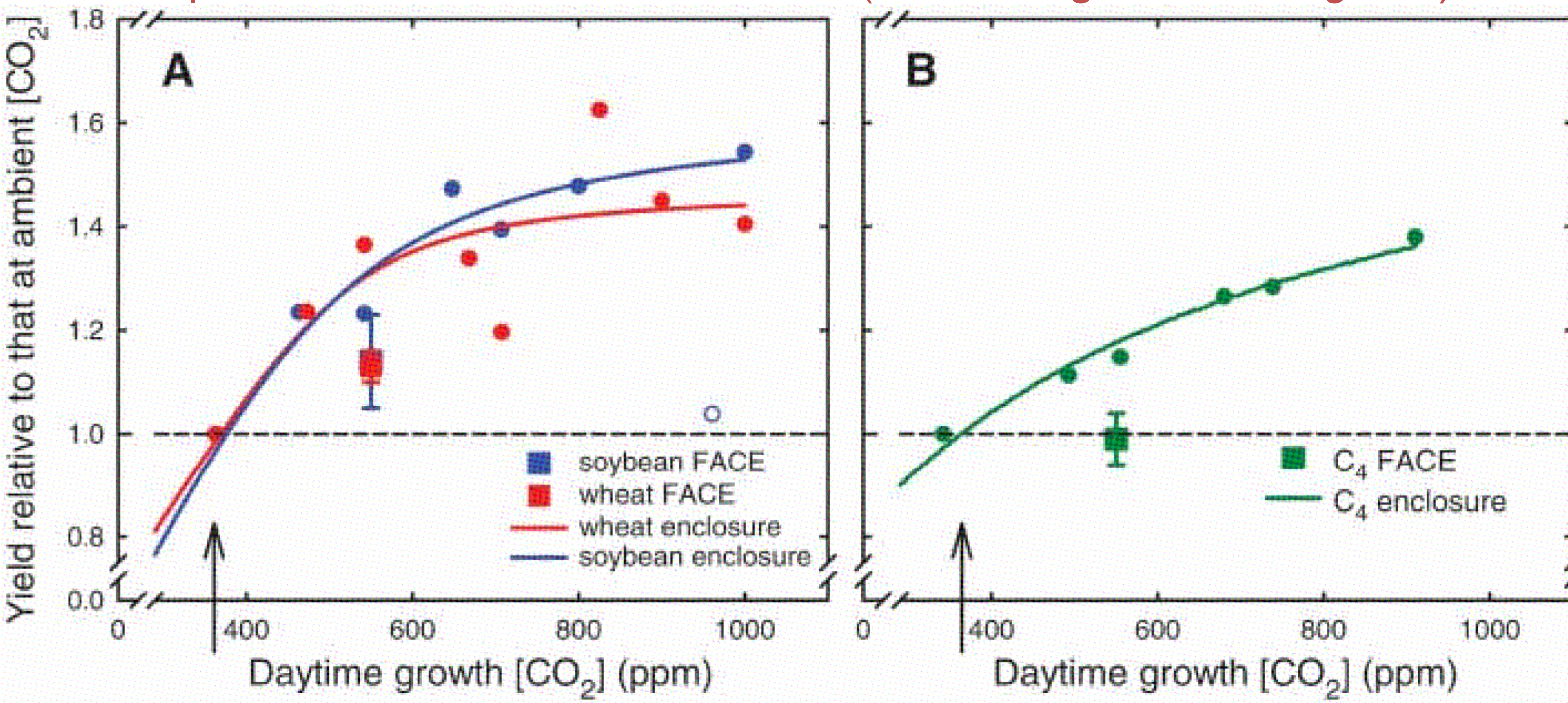
FSE
STANFORD

Impacts are largely driven by 2 opposing factors: CO_2 and Climate

-CO_2 enhances crop growth and yield

~17% increase for C3 crops at 550pm

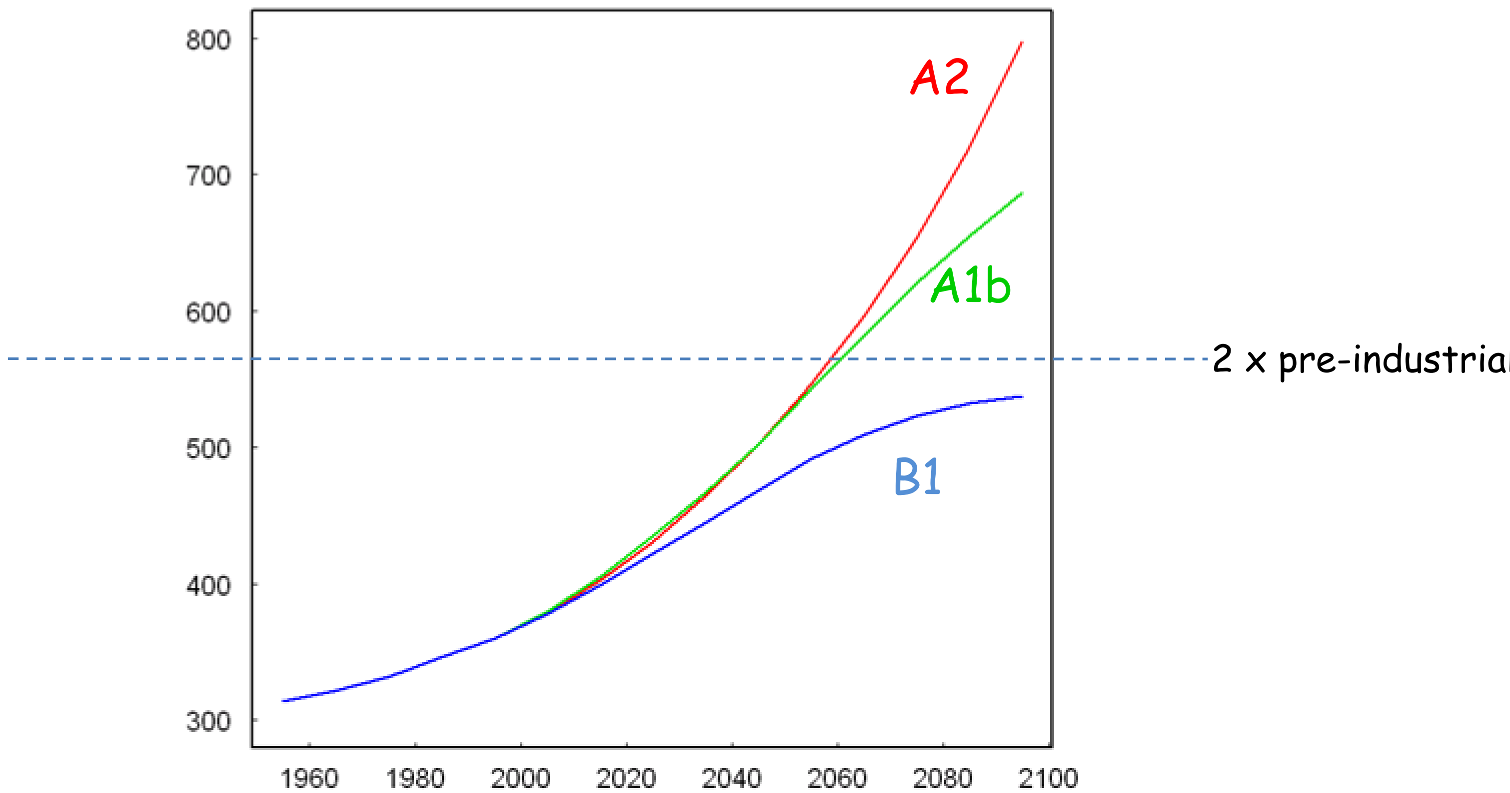
~6% increase for C4 crops (maize, sugarcane, sorghum)



Long et al. 2006, *Science*

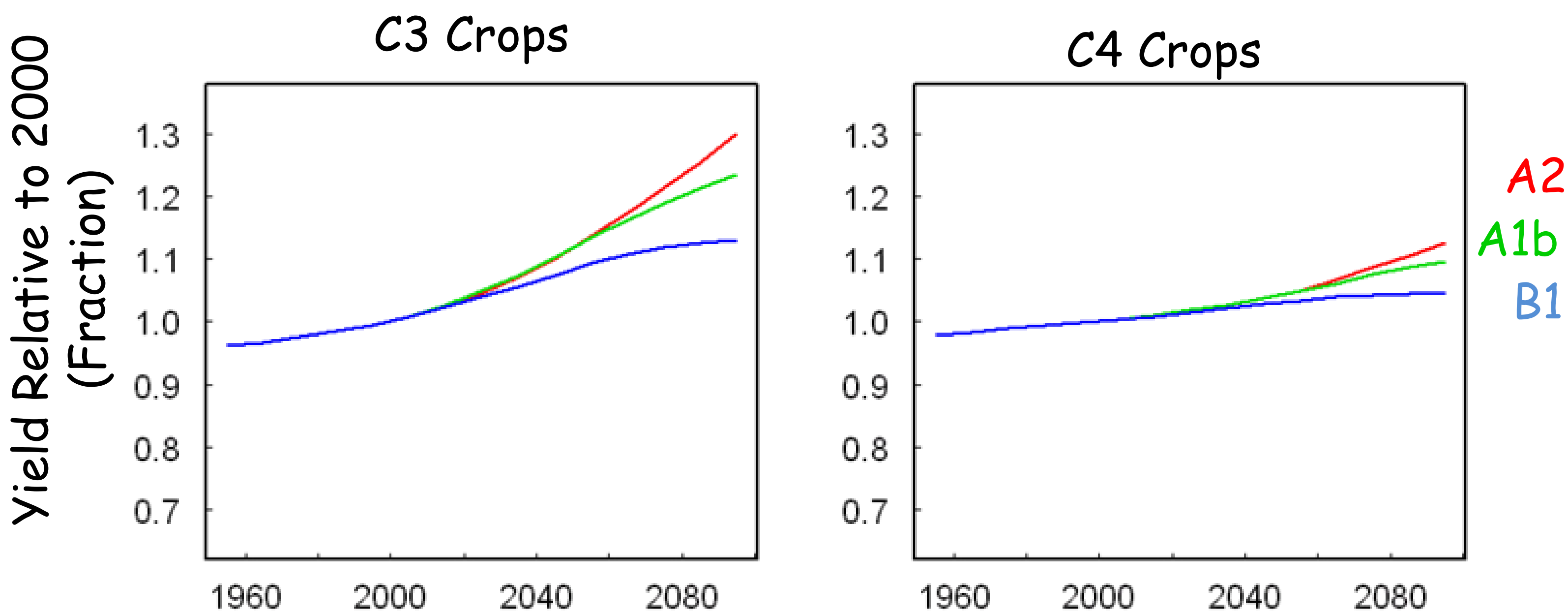
FSE STANFORD

Future CO_2 for several emission scenarios



FSE
STANFORD

Global average fertilization effect of future CO_2



FSE
STANFORD

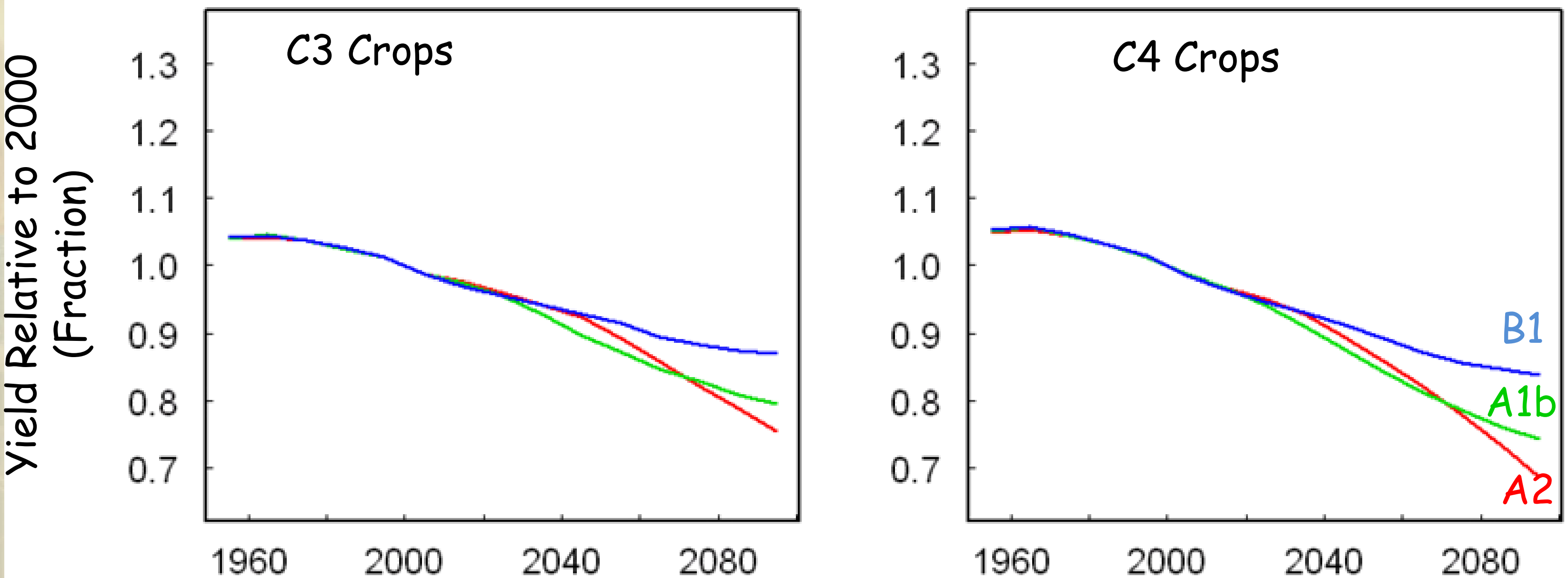
Impacts are largely driven by 2 opposing factors: CO_2 and Climate

-Warming reduces crop yields in most regions

C3 crops: ~6% yield loss per ºC

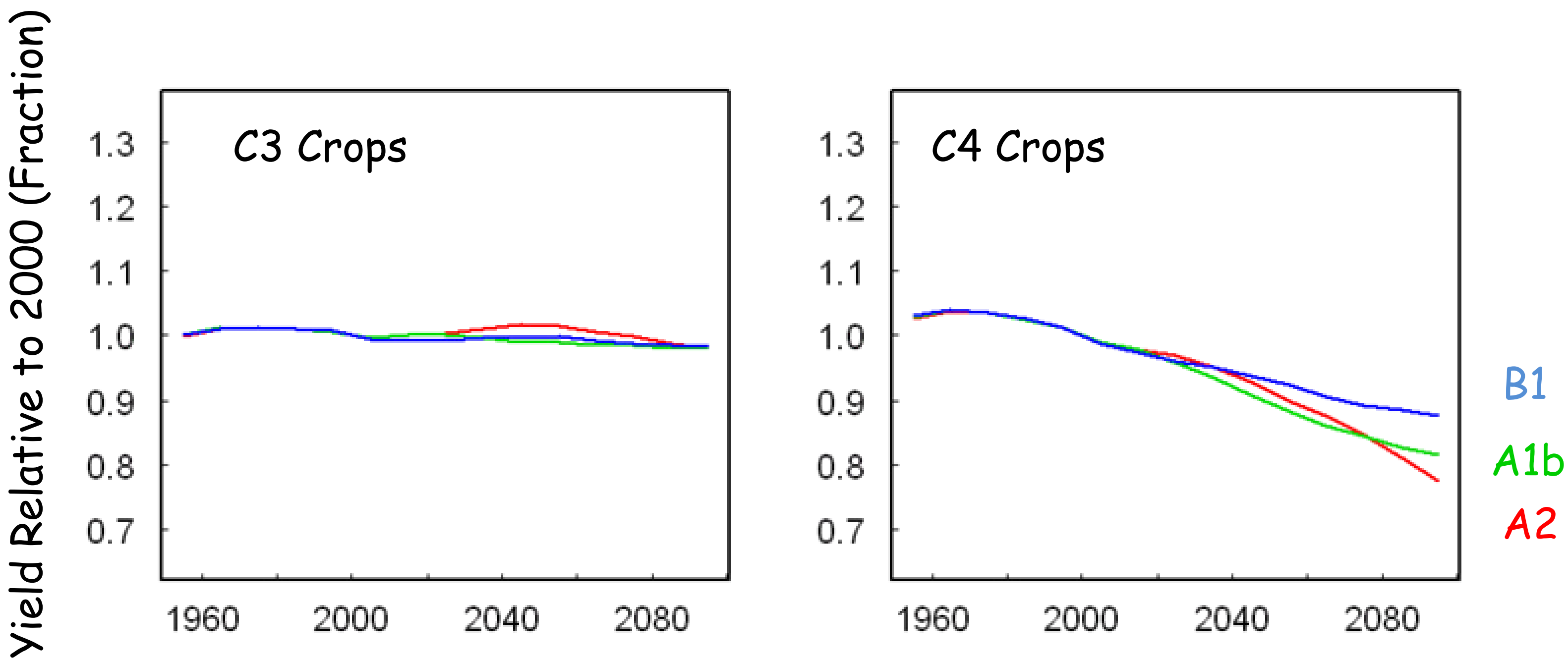
C4 crops: ~8% yield loss per ºC (Lobell and Field, 2007, *ERL*)

Global average yield effect of future warming



FSE
STANFORD

Global average combined effect of future warming + CO_2



FSE
STANFORD

This balancing of CO_2 and warming effects until ~2050 (or ~2º C) underlies most global assessment models, although assumptions about climate, crops, and adaptations can affect the details.

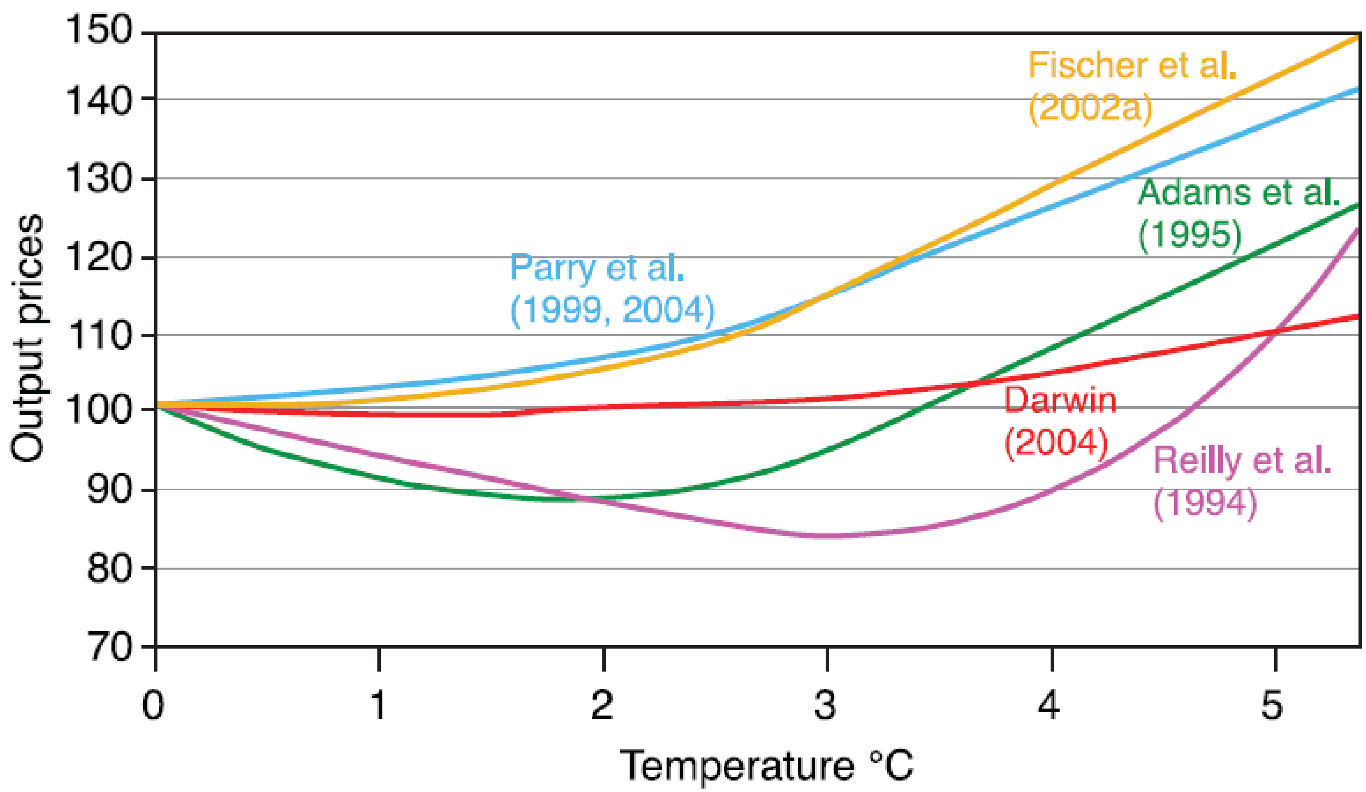


Figure 5.3. *Cereal prices (percent of baseline) versus global mean temperature change for major modelling studies. Prices interpolated from point estimates of temperature effects.*

IPCC, AR4, 2007

FSE
STANFORD

Impacts of other climate aspects are less certain and often not modeled, but probably a net negative:

-Rainfall
-Flooding
-Extreme heat events
-Pests and weeds
-Loss of irrigation water sources

"Glaciers in the Himalaya are receding faster than in any other part of the world and, if the present rate continues, the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate." IPCC AR4, WGII

Table 10.9. *Record of retreat of some glaciers in the Himalaya.*

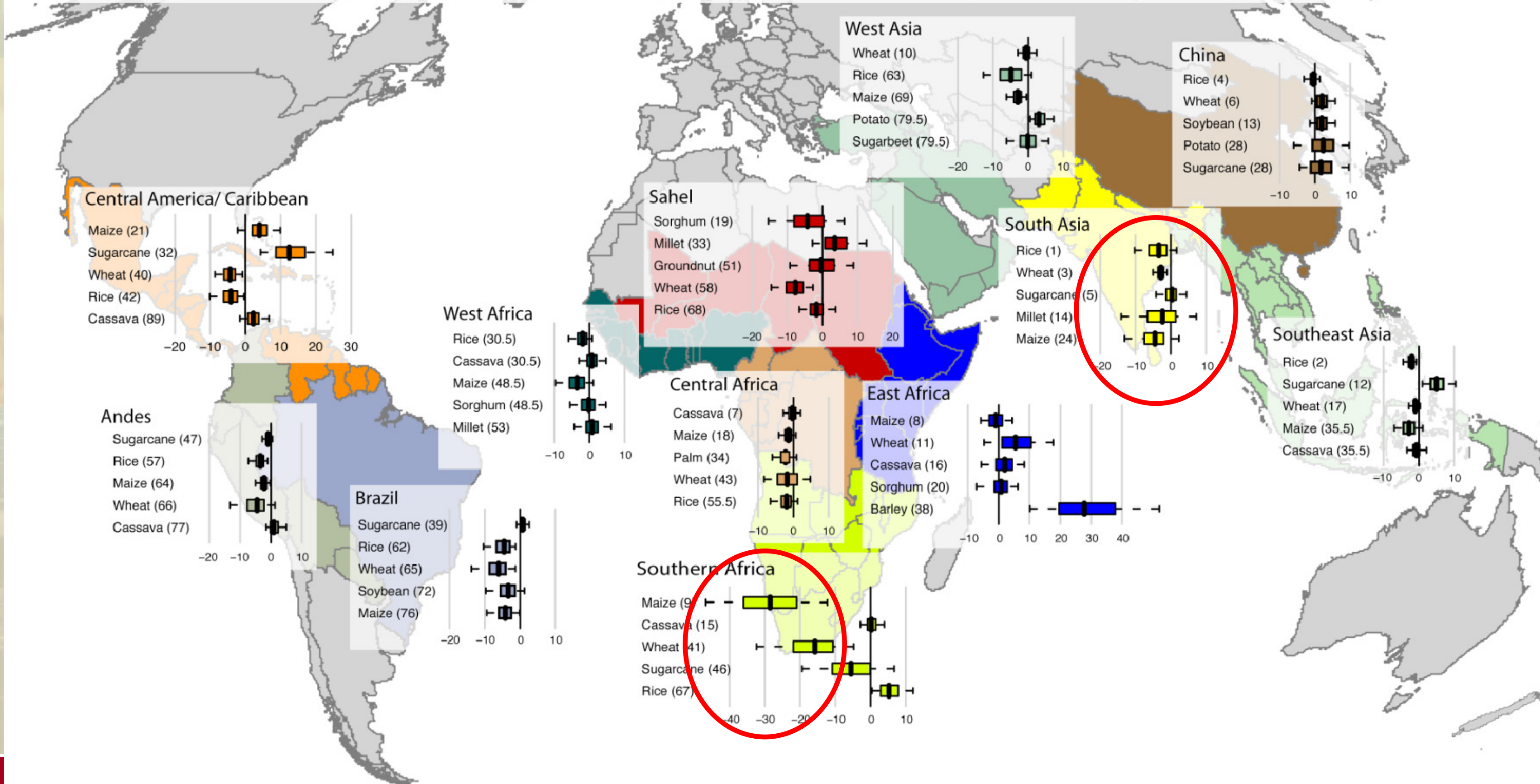
Glacier	Period	Retreat of snout (metre)	Average retreat of glacier (metre/year)
Triloknath Glacier (Himachal Pradesh)	1969 to 1995	400	15.4
Pindari Glacier (Uttaranchal)	1845 to 1966	2,840	135.2
Milam Glacier (Uttaranchal)	1909 to 1984	990	13.2
Ponting Glacier (Uttaranchal)	1906 to 1957	262	5.1
Chota Shigri Glacier (Himachal Pradesh)	1986 to 1995	60	6.7
Bara Shigri Glacier (Himachal Pradesh)	1977 to 1995	650	36.1
Gangotri Glacier (Uttaranchal)	1977 to 1990	364	28.0
Gangotri Glacier (Uttaranchal)	1985 to 2001	368	23.0
Zemu Glacier (Sikkim)	1977 to 1984	194	27.7

FSE
STANFORD

Even if global impacts are small, some regions will likely be hit hard

Projected impacts of climate change by 2030, for top 5 most important crops in each region

Boxes represent 25th-75th percentile of model projections, whiskers 5th-95th, and dark line the median projection. Number in parentheses is the overall rank of the crop/region in terms of importance to global food security.

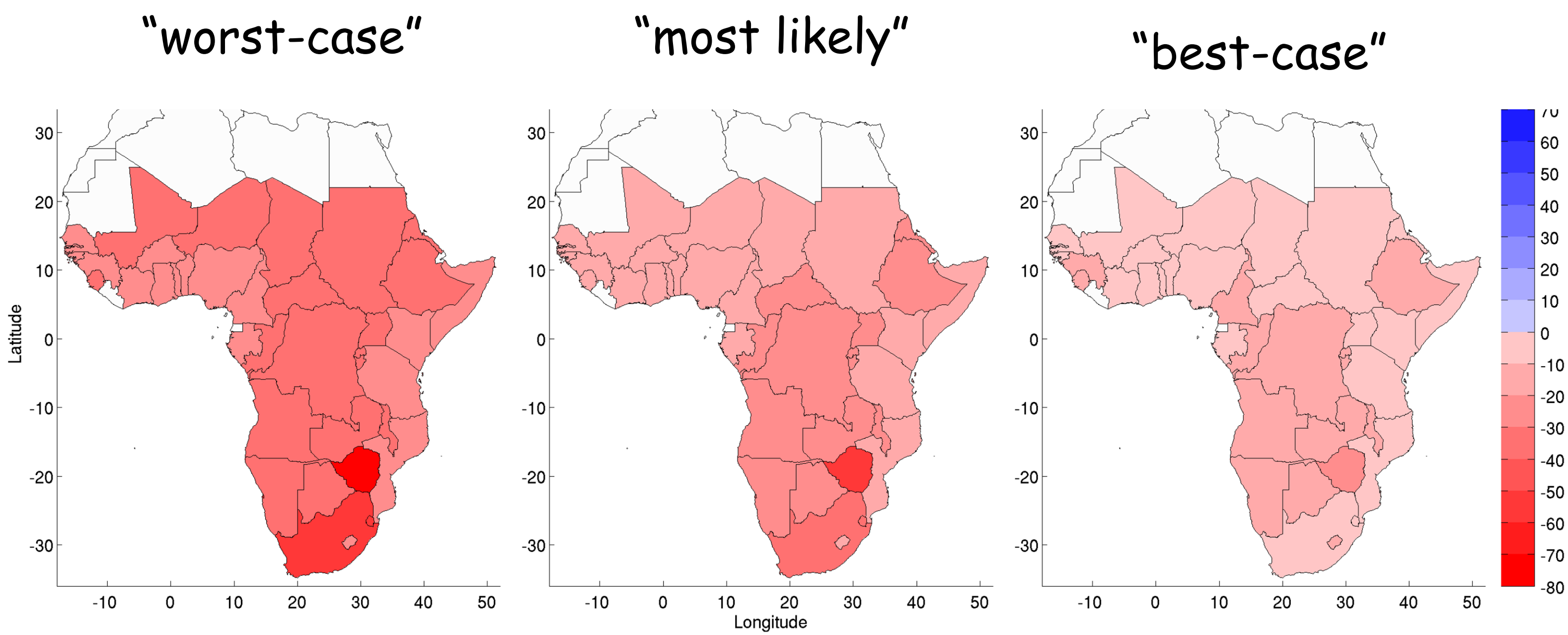


Lobell et al. 2008, *Science*

FSE
STANFORD

Even if global impacts are small, some regions will likely be hit hard

Percent Change in African Maize Yields by 2050 from Climate Change (without Adaptation)

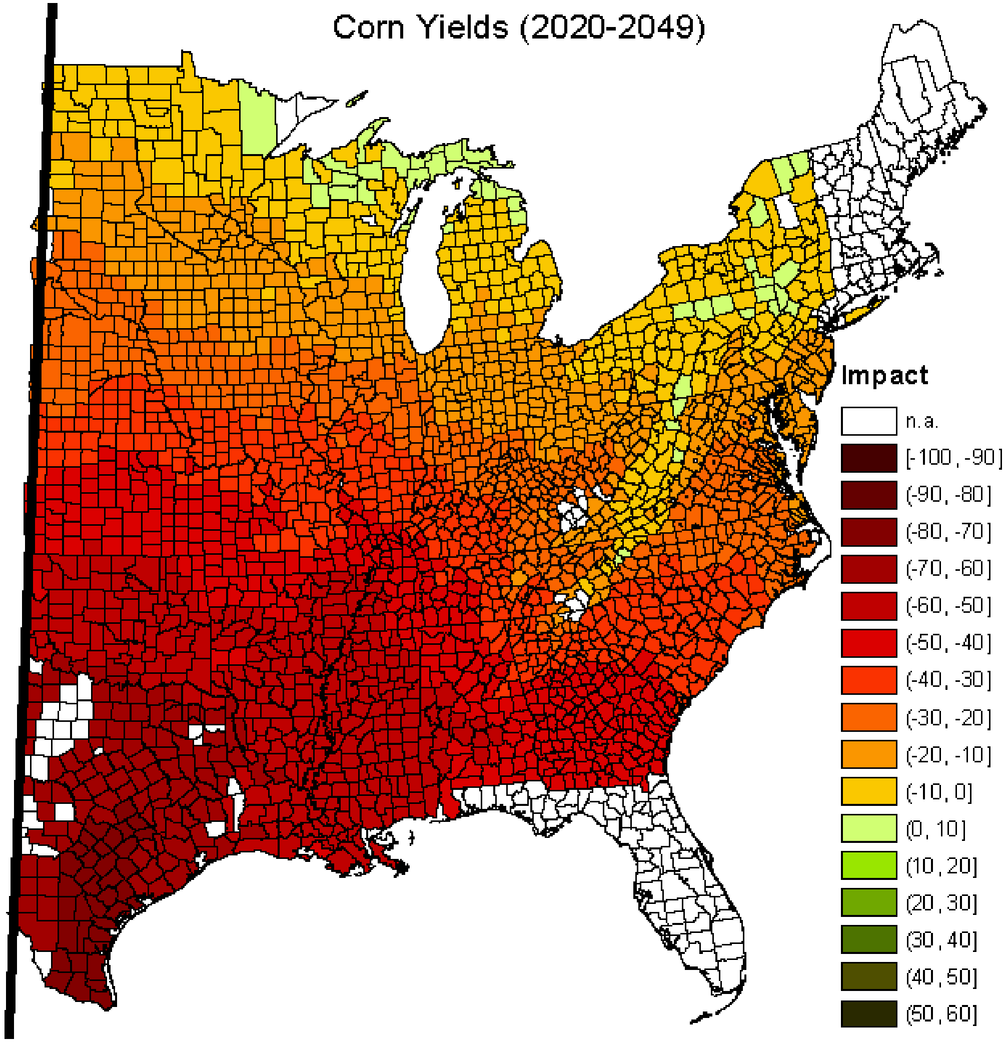


FSE
STANFORD

Schlenker and Lobell, *in prep*

Not Just Africa: U.S. maize yields also hurt

Yield impact (%) assuming current varieties



Area-weighted Average Loss ≈ 30%

FSE
STANFORD

Schlenker and Roberts, 2007

So what can we do?

- Reducing emissions is critical for how much we eventually warm, but the next 30 years are already in the pipeline. Adaptation is critical!
- Some adaptation is possible by shifting when and where existing crop varieties are grown
- But the majority of adaptation will likely be in the form of improved varieties, and for this we need genetic resources

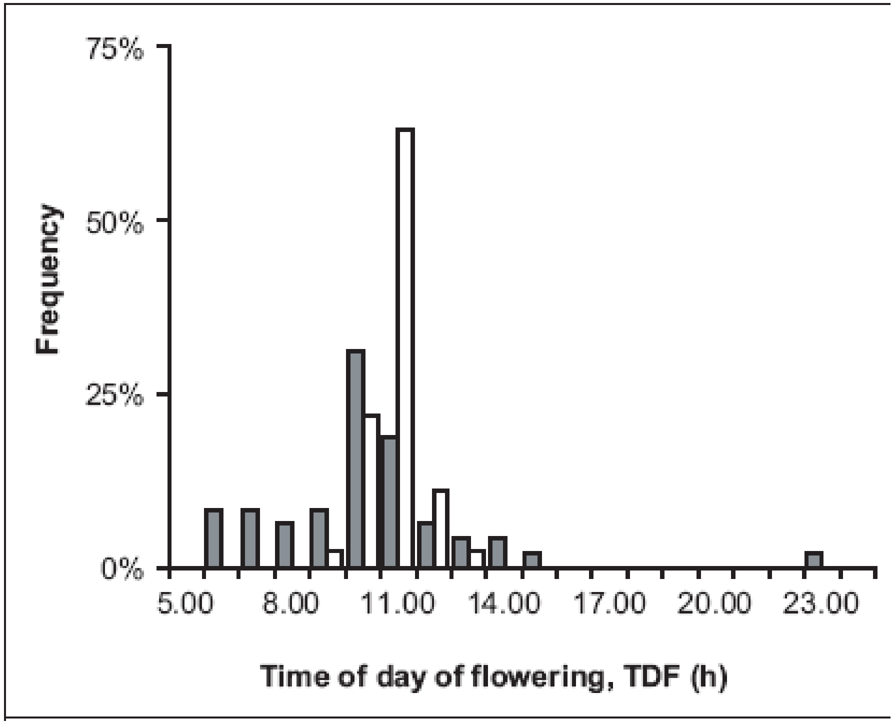
An Example of How Wild Relatives Can Help

- High temperatures (>35 C) during flowering can cause rice sterility

- One strategy is to use cultivars that flower earlier in the day

FIGURE 2

Frequency distributions of the time of day when flowering commences (TDF) in wild rice accessions (filled bars) and rice cultivars (unfilled bars) [a]



Sheehy et al. 2005

FSE
STANFORD

Summary

1. We are seeing a pace of warming that is unprecedented in the history of agriculture
2. The impacts could be severe in some places in the next two decades, with large global impacts plausible by 2050
3. Developing crops that can cope with heat, drought, flood, and other extremes will likely be the single most important thing we can do to adapt
4. "Exotic" germplasm in landraces or wild relatives will be critical to the success of these efforts

FSE
STANFORD