Growth and variability of crop production under climate change and socioeconomic pathways

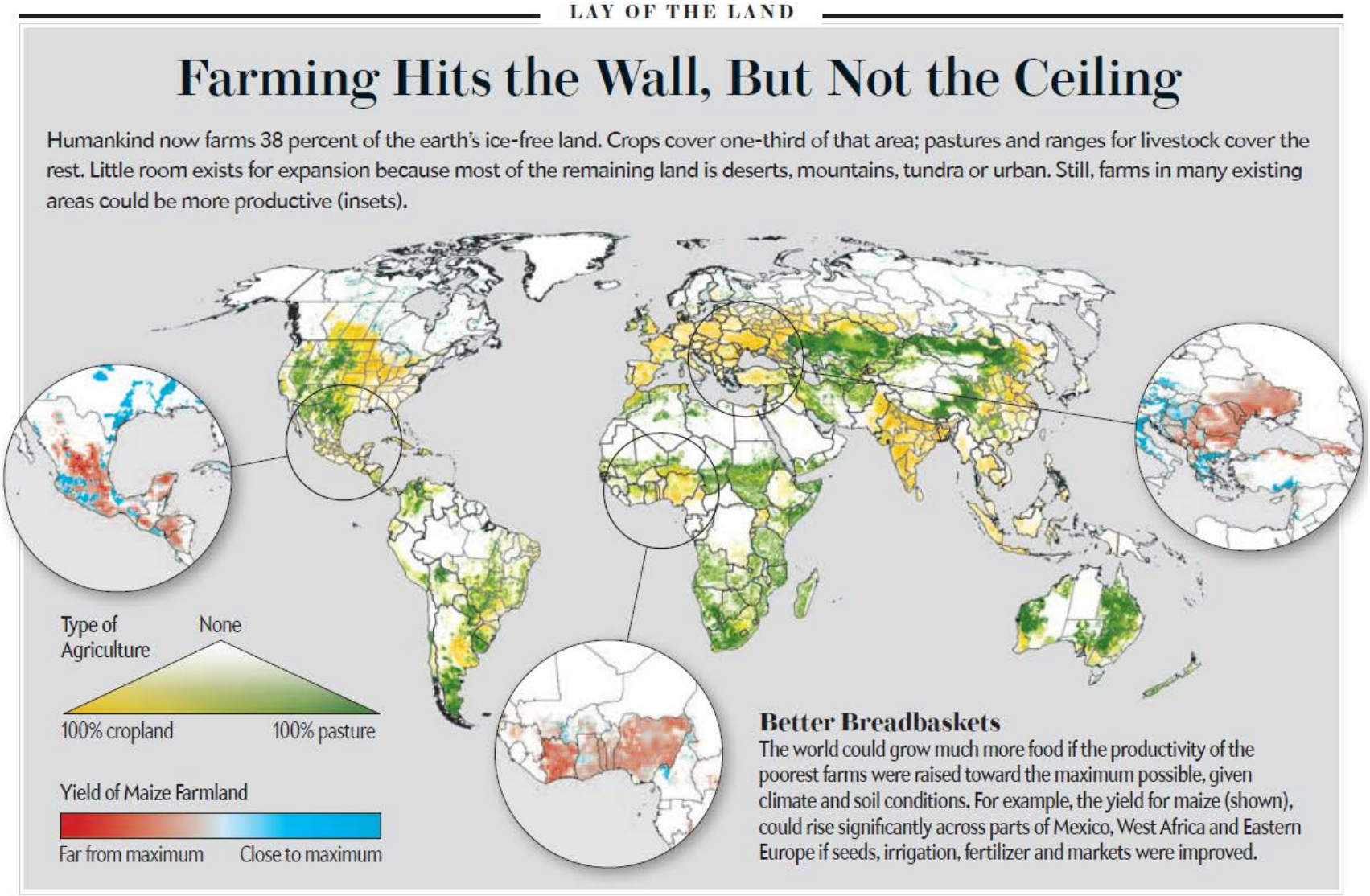
Toshichika Iizumi

National Agriculture and Food Research Organization (NARO), Japan

Contents

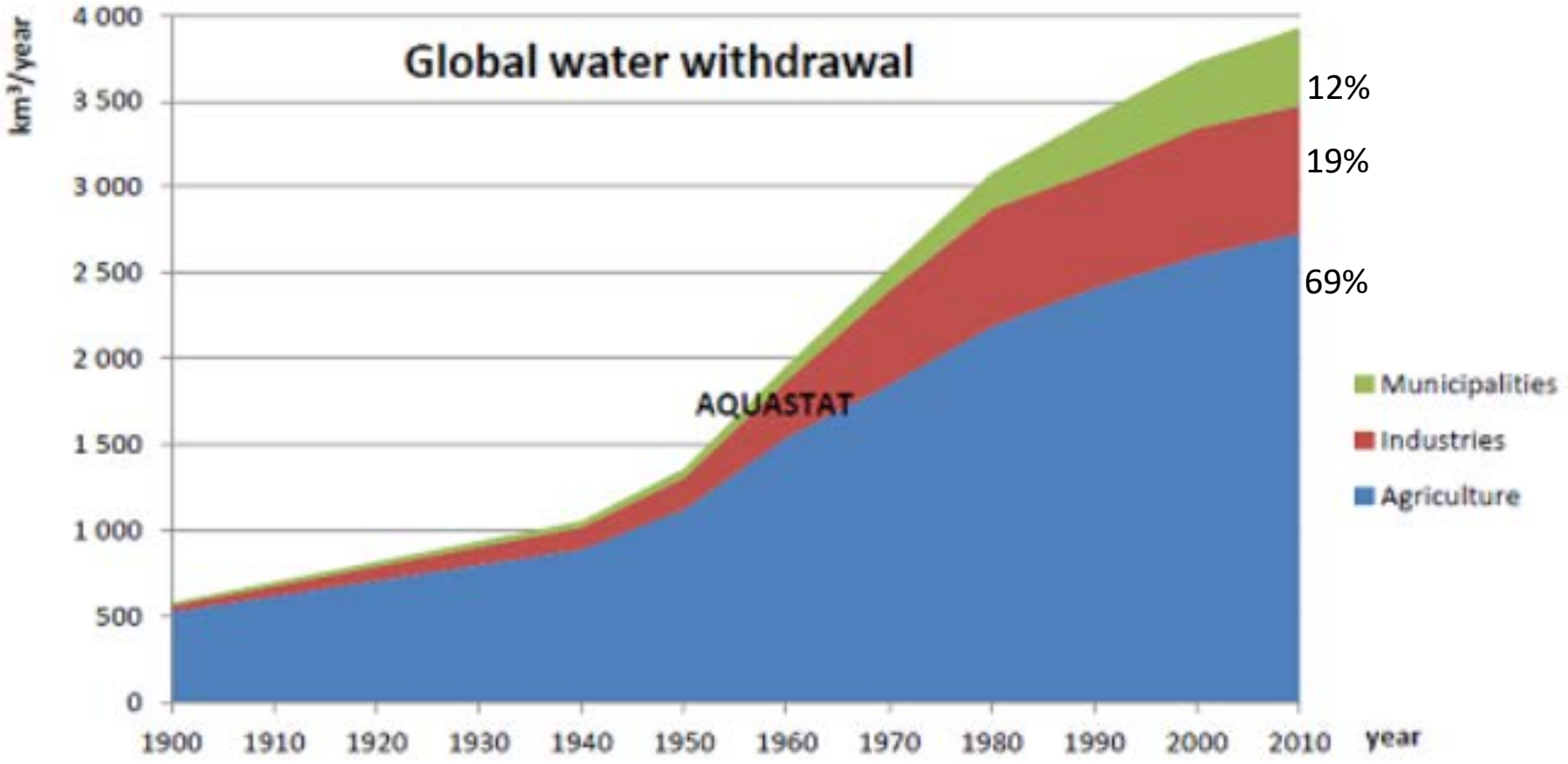
- Introduction to current status of global agriculture
- Yield growth and variability
- Two questions:
  - ✓ Have recent changes in daily temperature and precipitation extremes had a measurable influence on yield variability?
  - ✓ How crop production growth respond to climate change, particularly warming from pre-industrial levels?
- Remarks

Cropland & pasture account for 38% of the earth's ice-free land



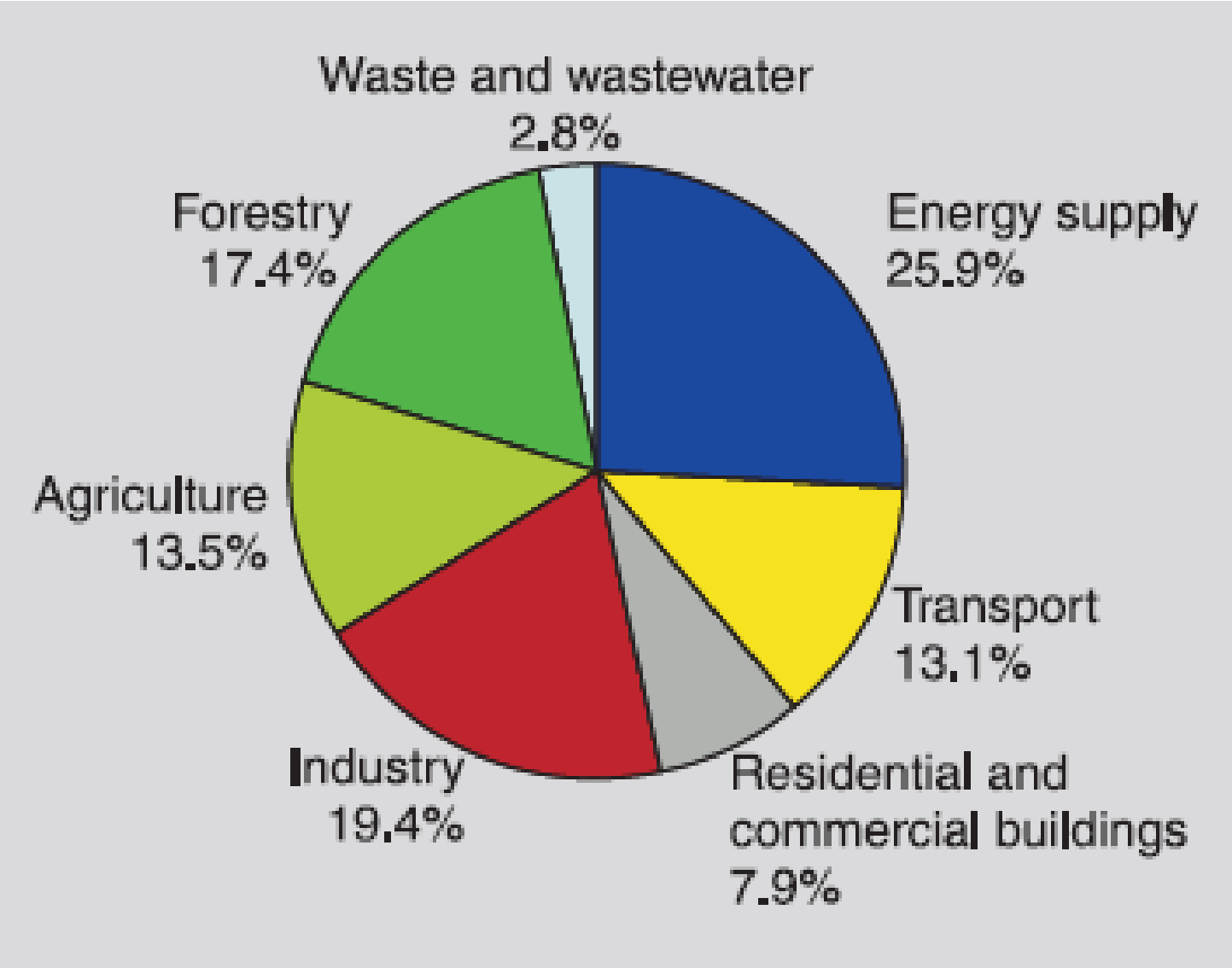
Foley (2011) *Sci Amer*

Agriculture uses 69% of water withdrawal



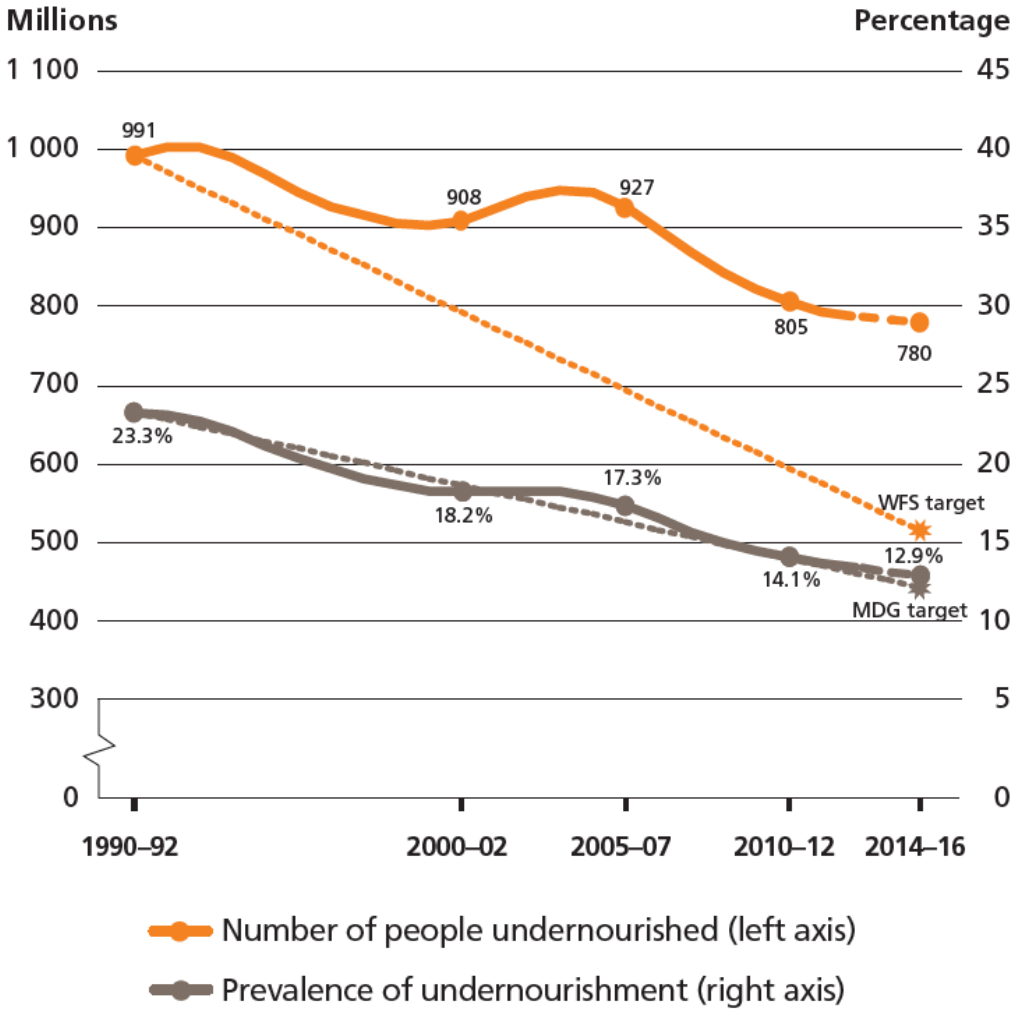
FAO (2016) *AQUASTAT* http://www.fao.org/nr/water/aquastat/water_use/index.stm

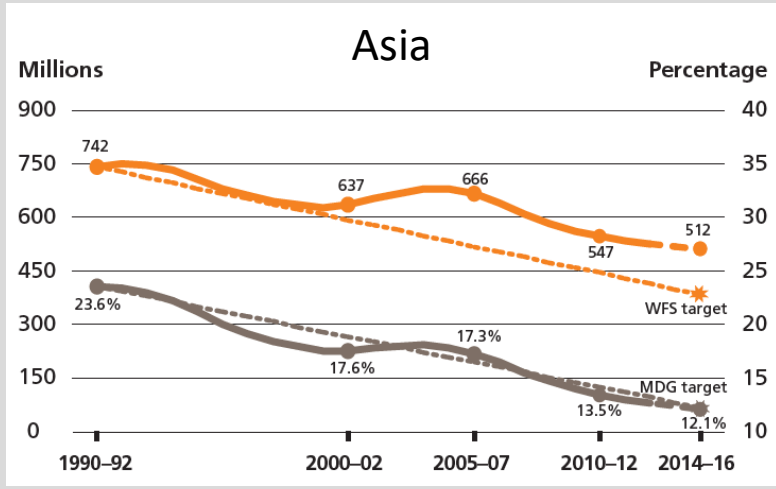
13.5% of anthropogenic GHG emissions in 2004 (CO_2-eq)

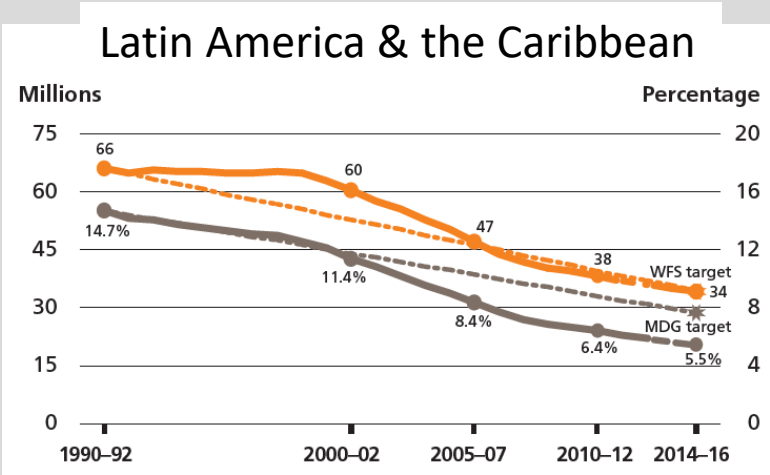


IPCC (2007) *Summary for Policymakers* in *Climate Change 2007*

Agriculture feeds 87% of the world's population in 2015



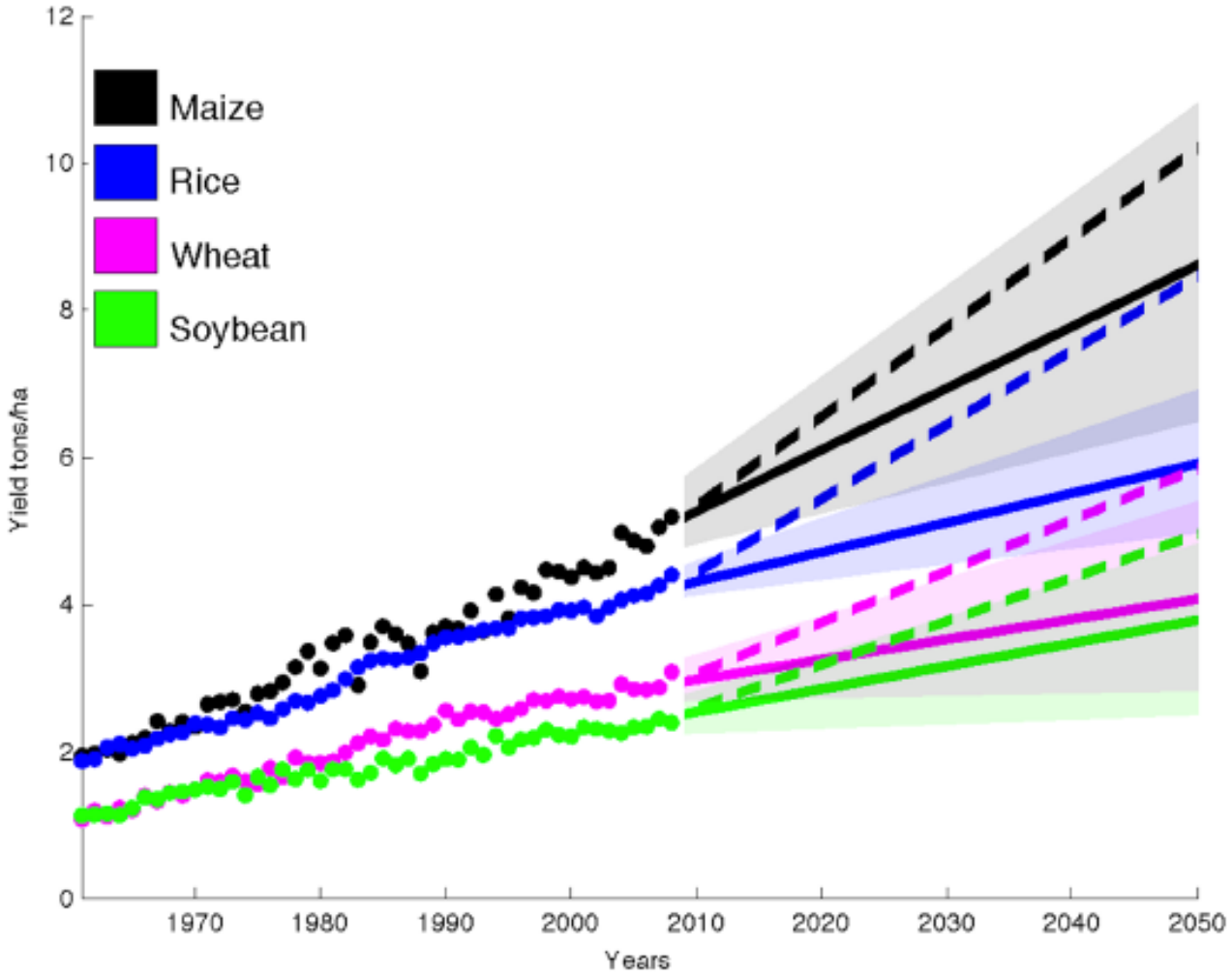




FAO, IFAD and WFP (2015) *The State of Food Insecurity in the World*

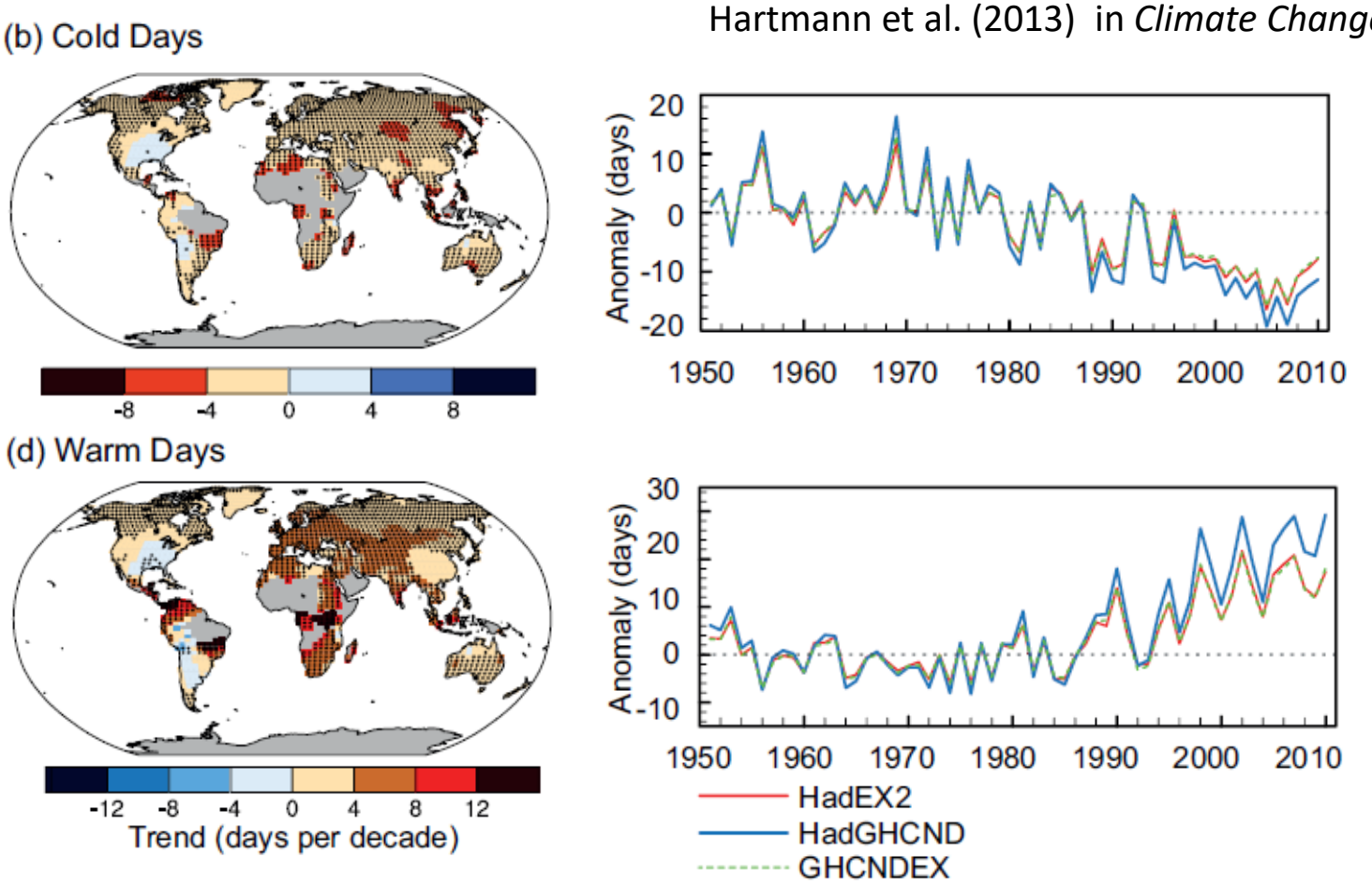
Yield growth is insufficient to double global production by 2050

"By 2050, global agricultural production may need to be increased by 60%–110% to meet these increasing demands." Ray *et al.* (2013) *PLOS ONE*



Sustaining production growth under changing climate extremes

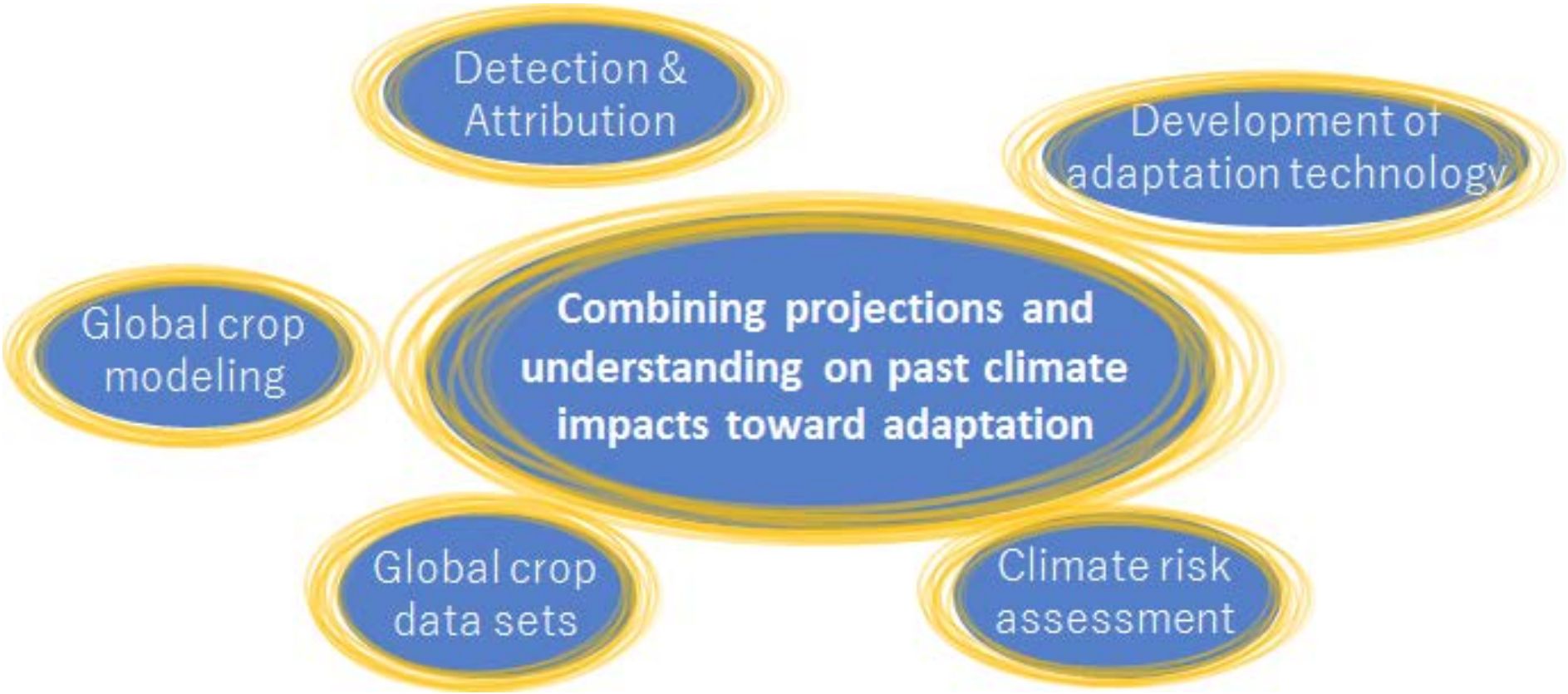
Hartmann et al. (2013) in *Climate Change 2013*



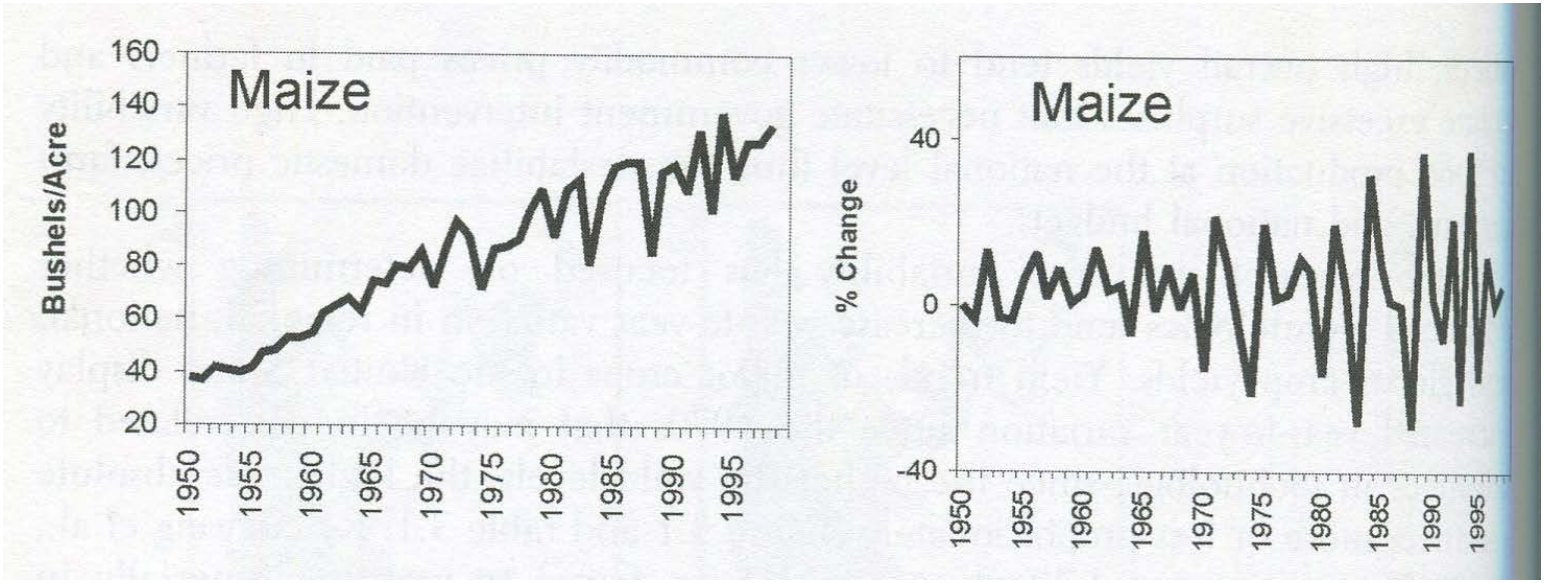
"… climate change represents a credible threat to sustaining global productivity growth at rates necessary to keep up with demand. "

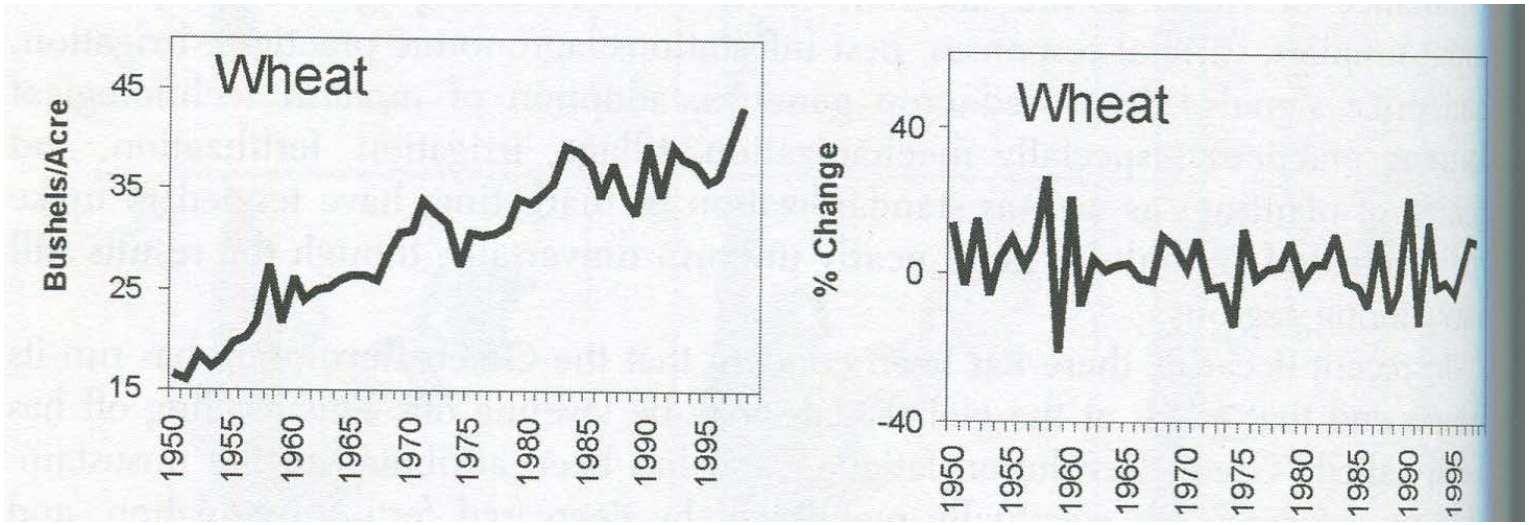
Lobell & Gourdji (2012) *Plant Physiol*

Key elements in research on agricultural climate impact



Yield trend and variability





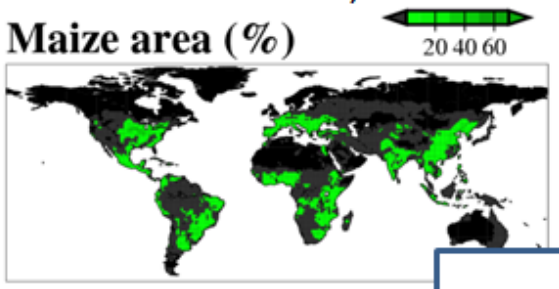
Rosenzweig & Hillel (2008) *Climate Variability and the Global Harvest*

Have recent changes in daily temperature and precipitation extremes had a measurable influence on yield variability?

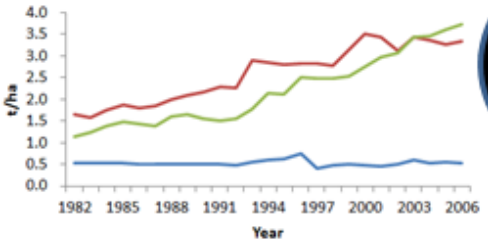
A key data set

Satellite products
(NOAA/AVHRR NPP)

Harvested area/yield in 2000
(Monfreda et al., 2008)

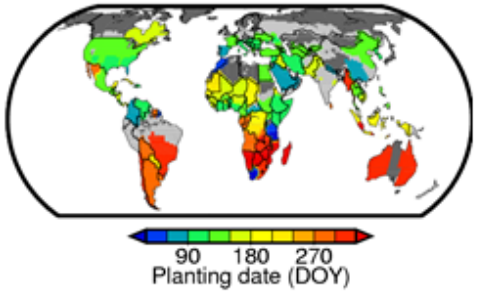


FAO country yield statistics

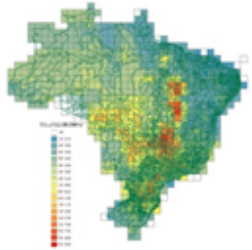


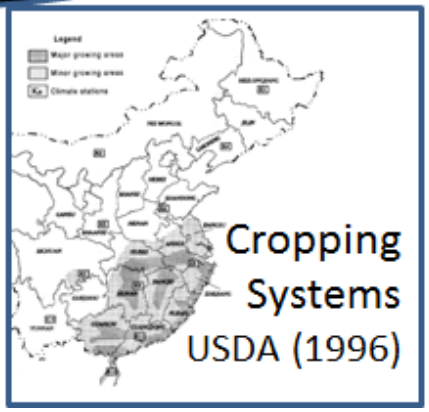
Global dataset
of
historical yields

Crop calendar
(Sacks et al.. 2010)



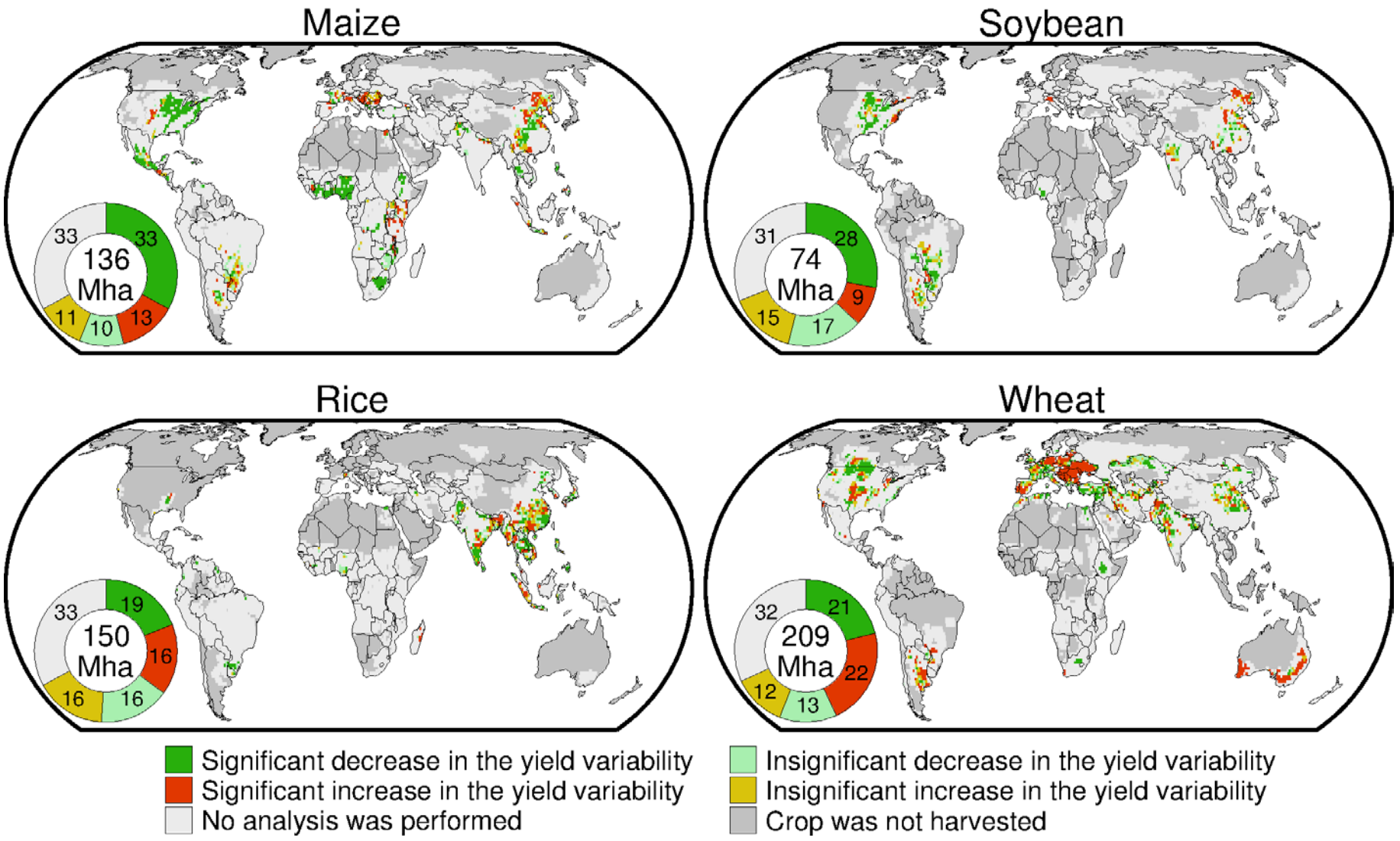
Subnational
yield statistics





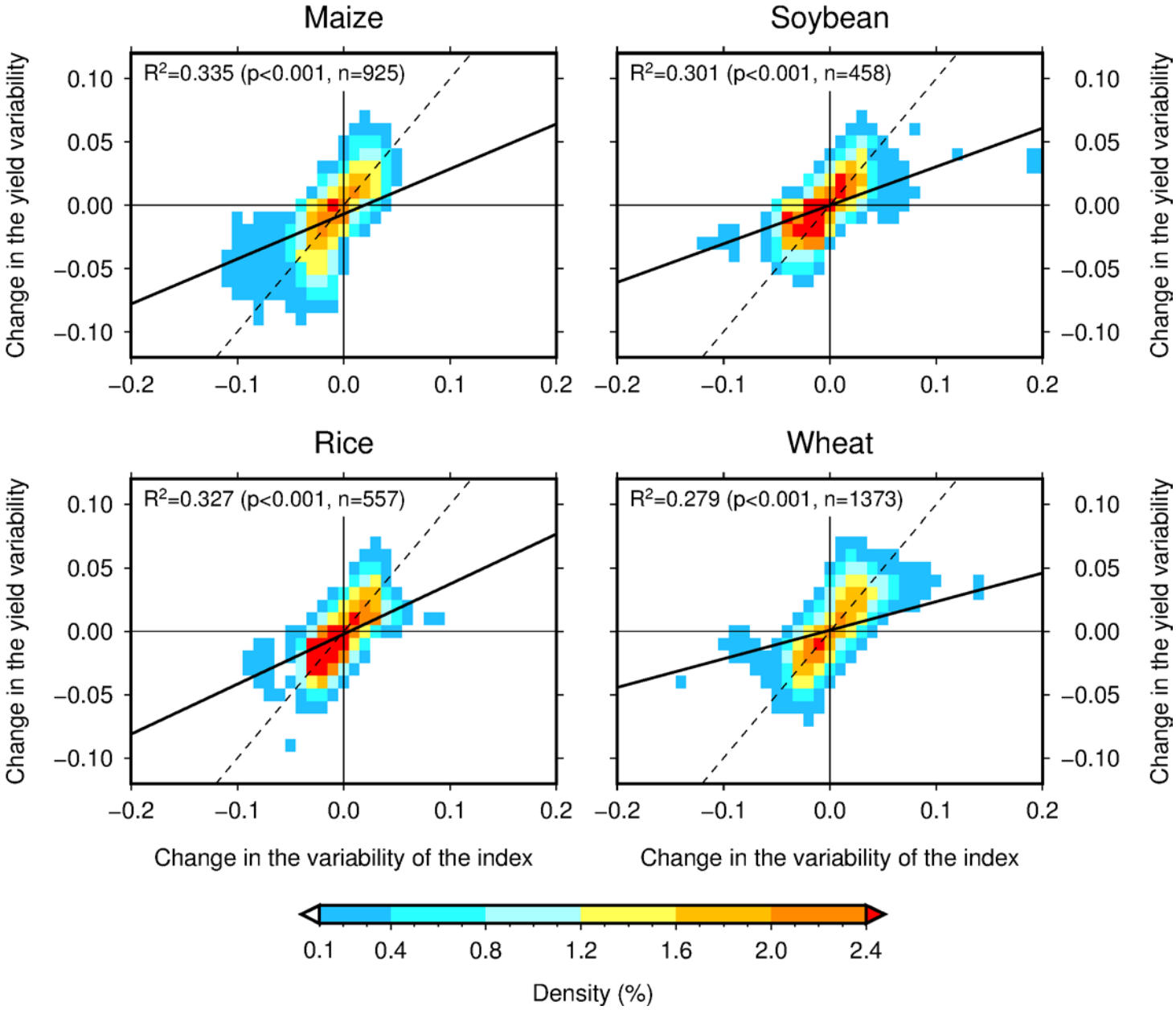
Iizumi et al. (2014)
Glob Ecol Biogeogr

Increased yield variability in 9–22% of harvested area

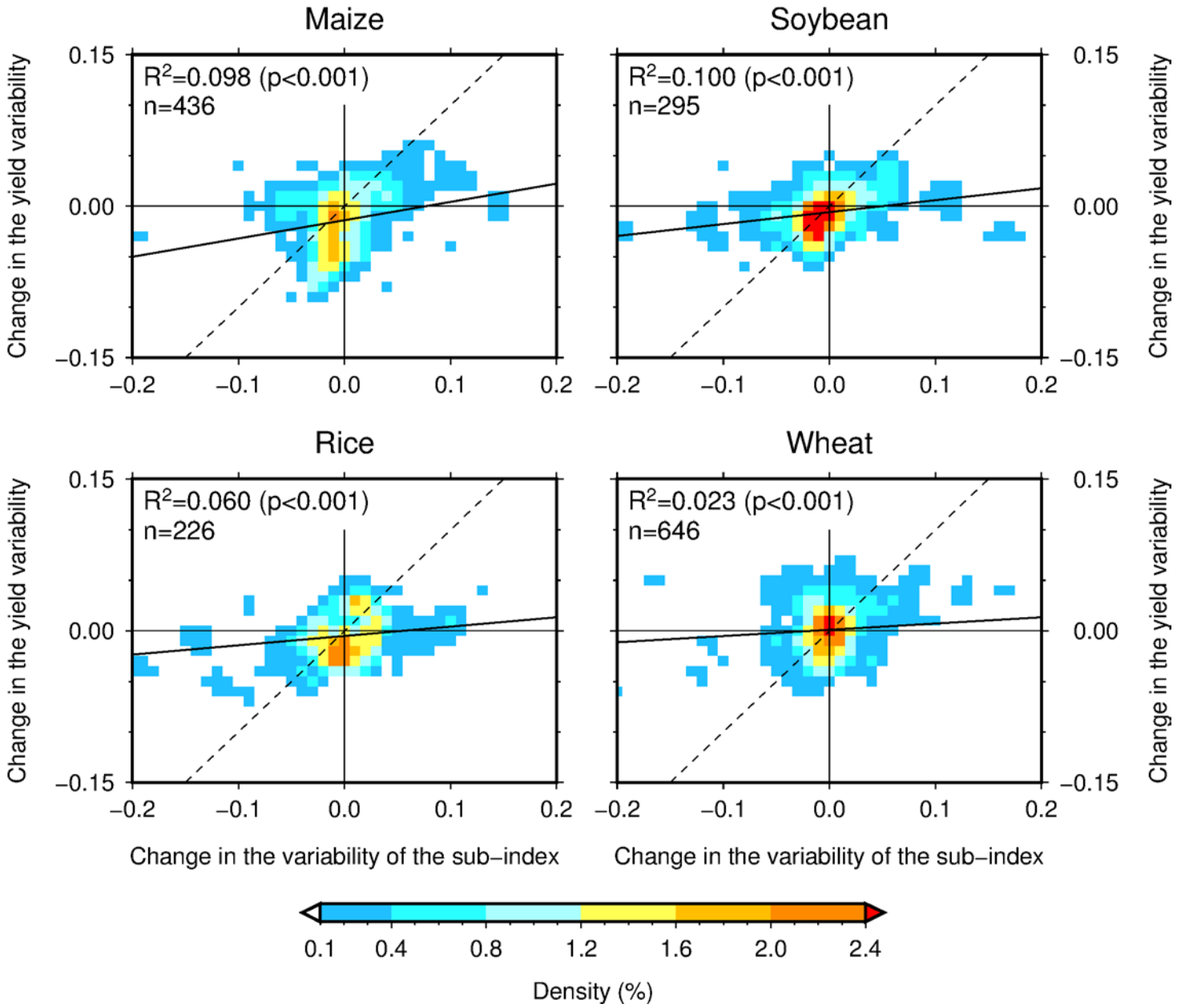


Iizumi & Ramankutty (2016) *Environ Res Lett*

Change in climate variability is a driver of yield variability change

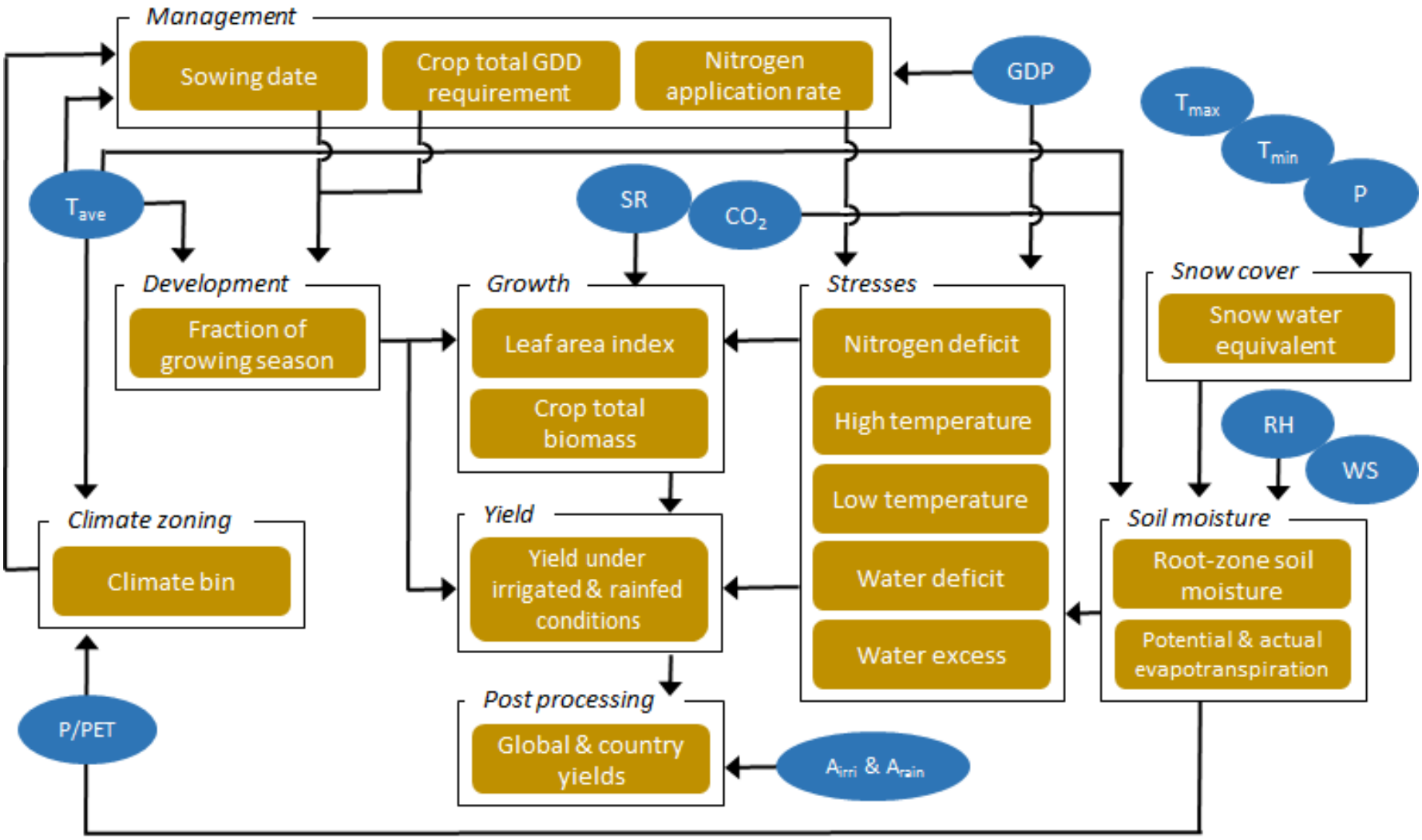


Larger contribution from increased variability in the number of hot days

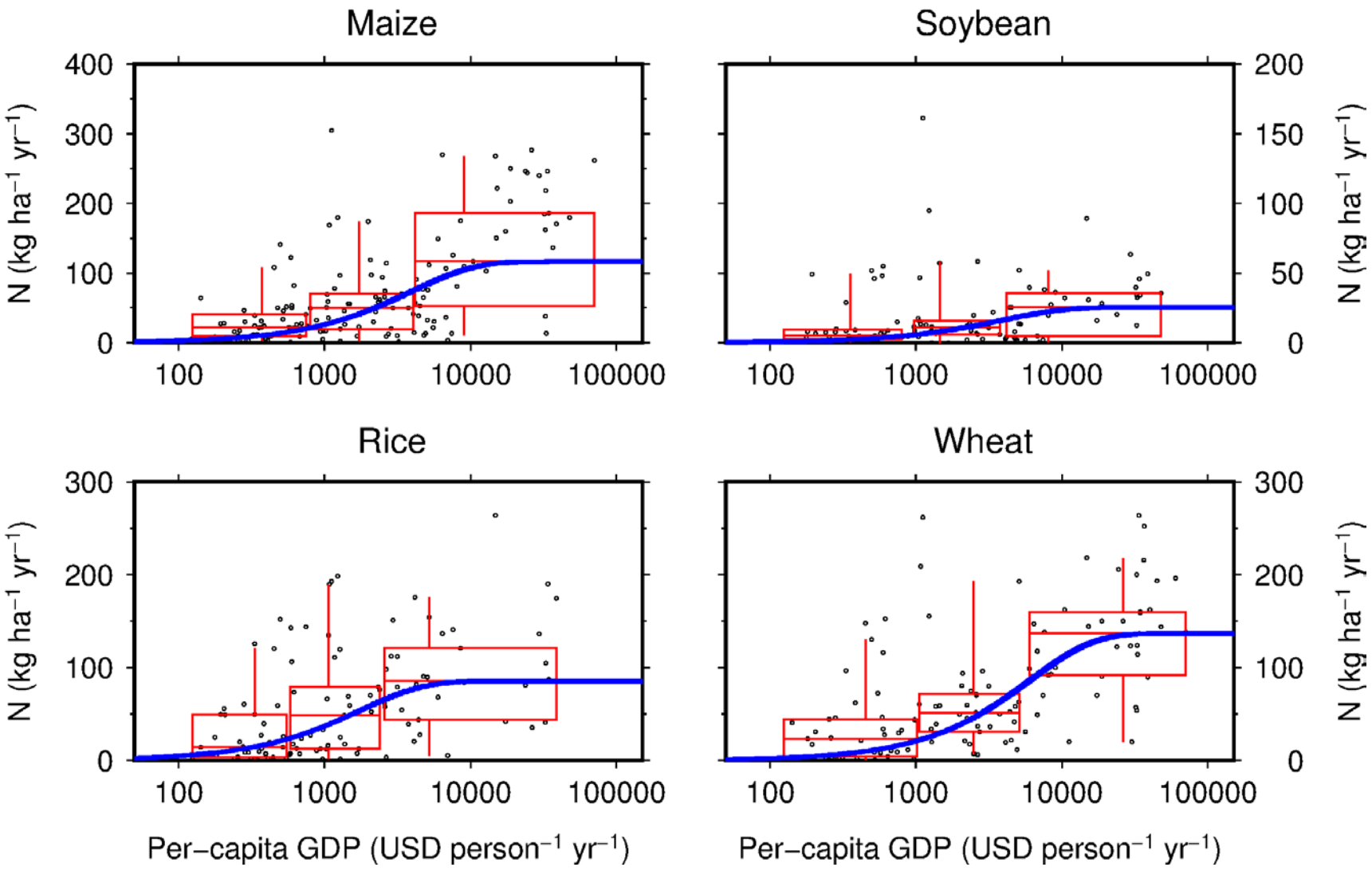


How crop production growth respond to climate change, particularly warming from pre-industrial levels?

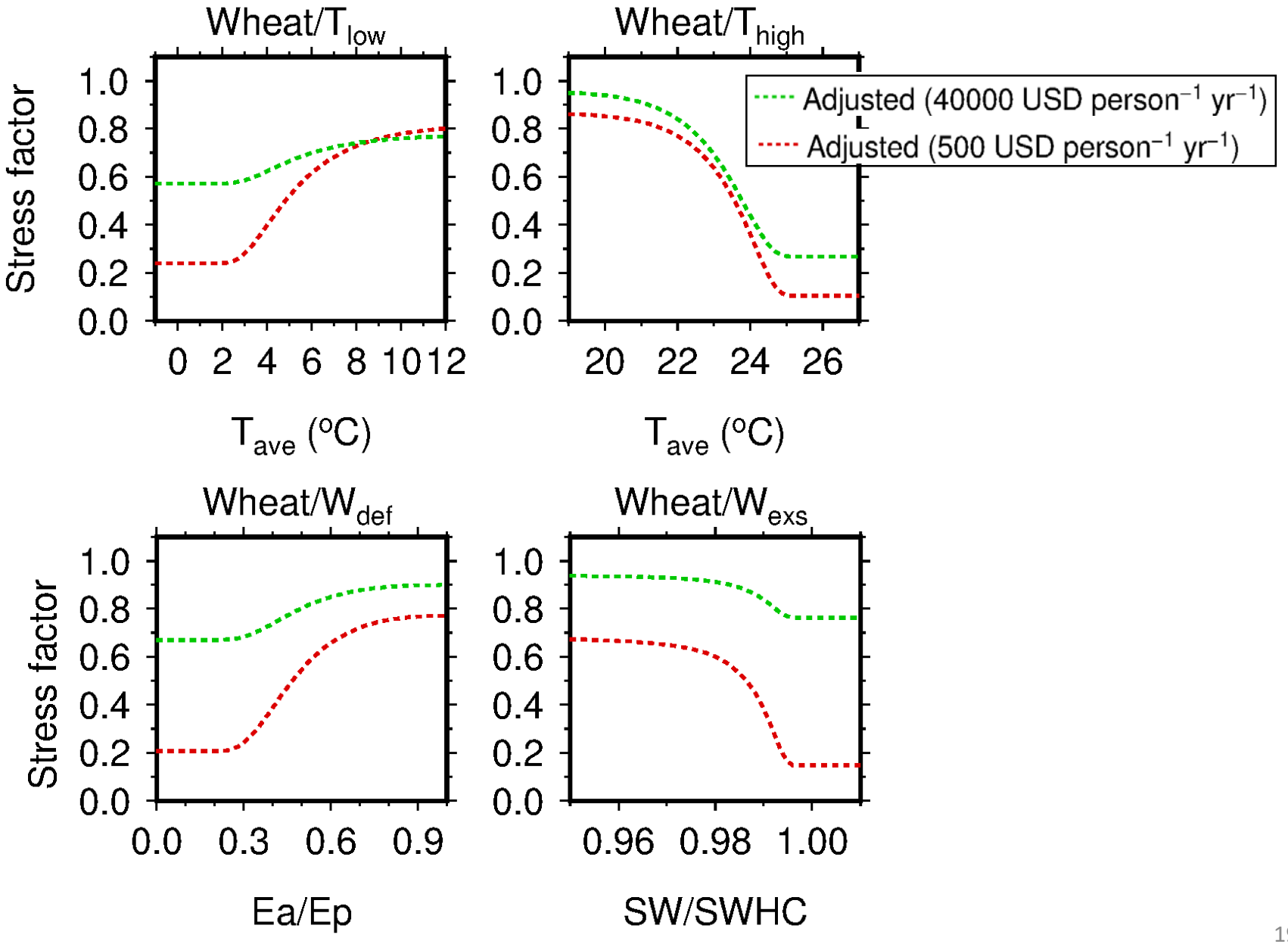
A key tool: Global gridded crop model (GGCM)



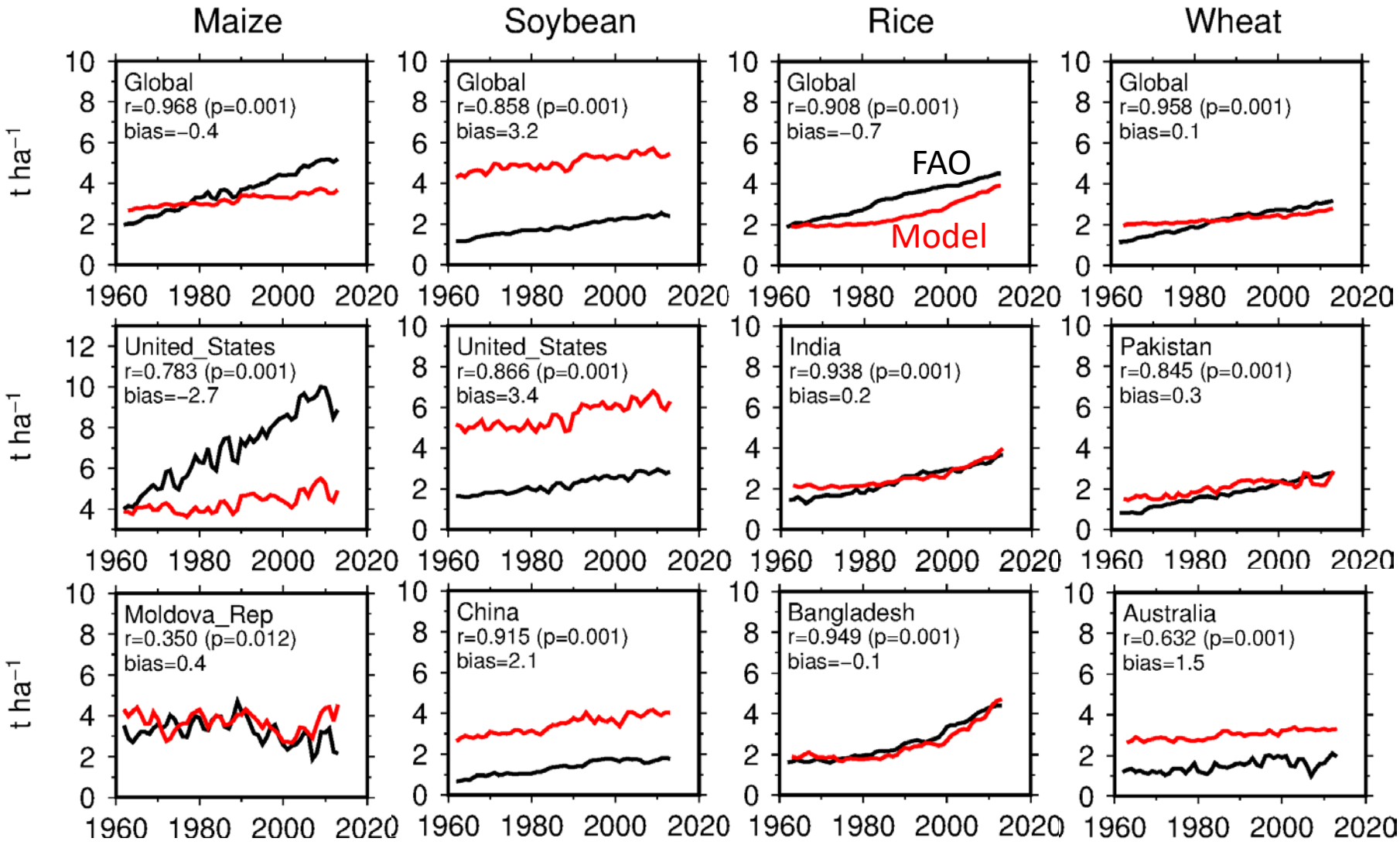
Parameterizing increased nitrogen use



Parameterizing increased use of hybrid seeds



Simulated global and country yield growth



Remarks

- While a decrease in yield variability is the main trend worldwide across crops, yields in some regions have become more unstable.
- Many low-income countries would experience the stagnation of production growth if global temperature change exceeds 1.7 ^{o}C above pre-industrial levels.
- However, many high-income countries could maintain production growth even under warming of 4.7 ^{o}C.
- Our findings suggest:
  - ✓ Agricultural development (or adaptation) in some regions in the last decades is insufficient to offset the negative impacts of observed climate change.
  - ✓ Long-term global yield monitoring and a better understanding of the contributions of technology, management, policy and climate to ongoing change in yield trend and variability are necessary to guide national agricultural adaptation

Thank you