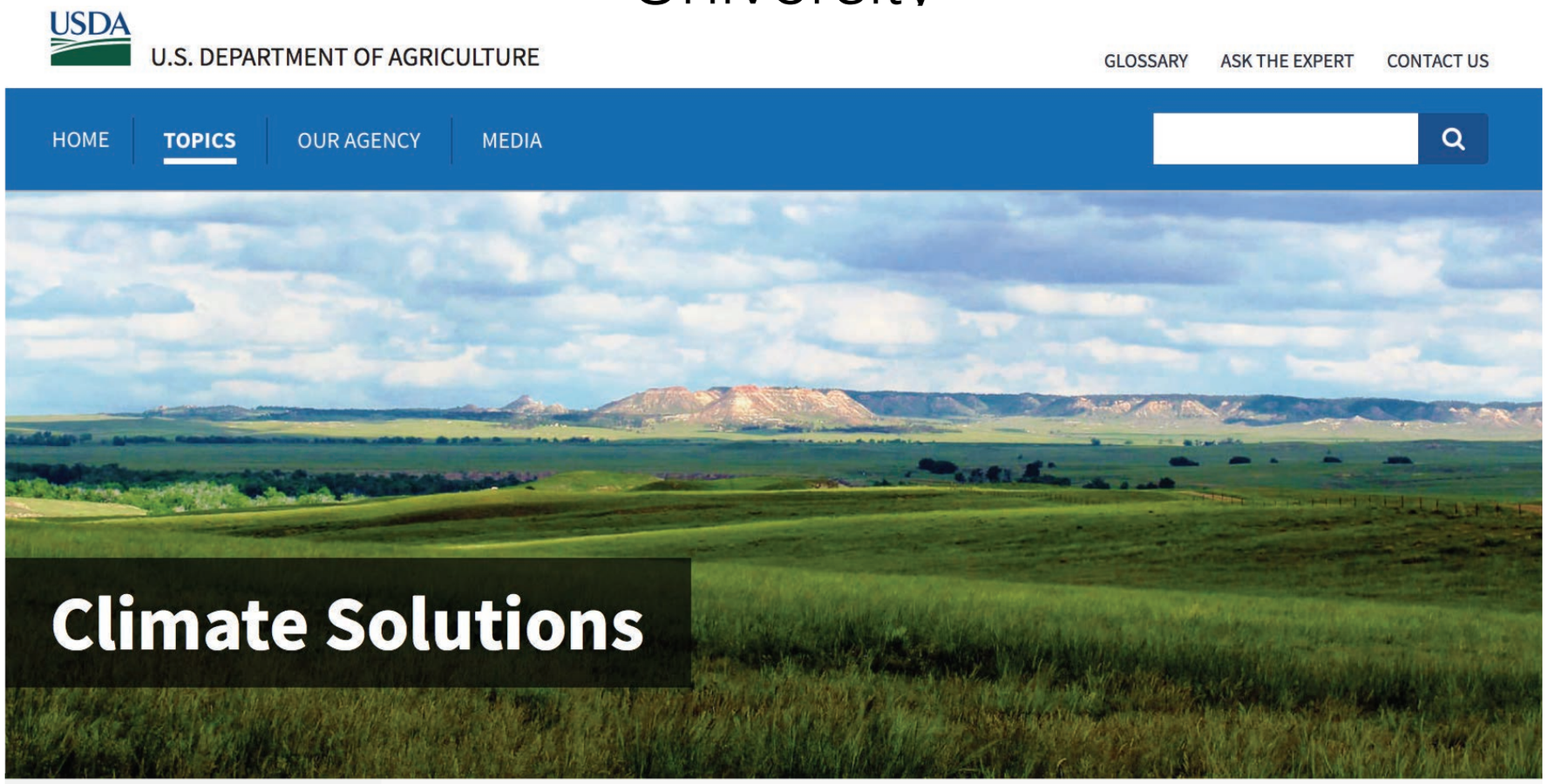
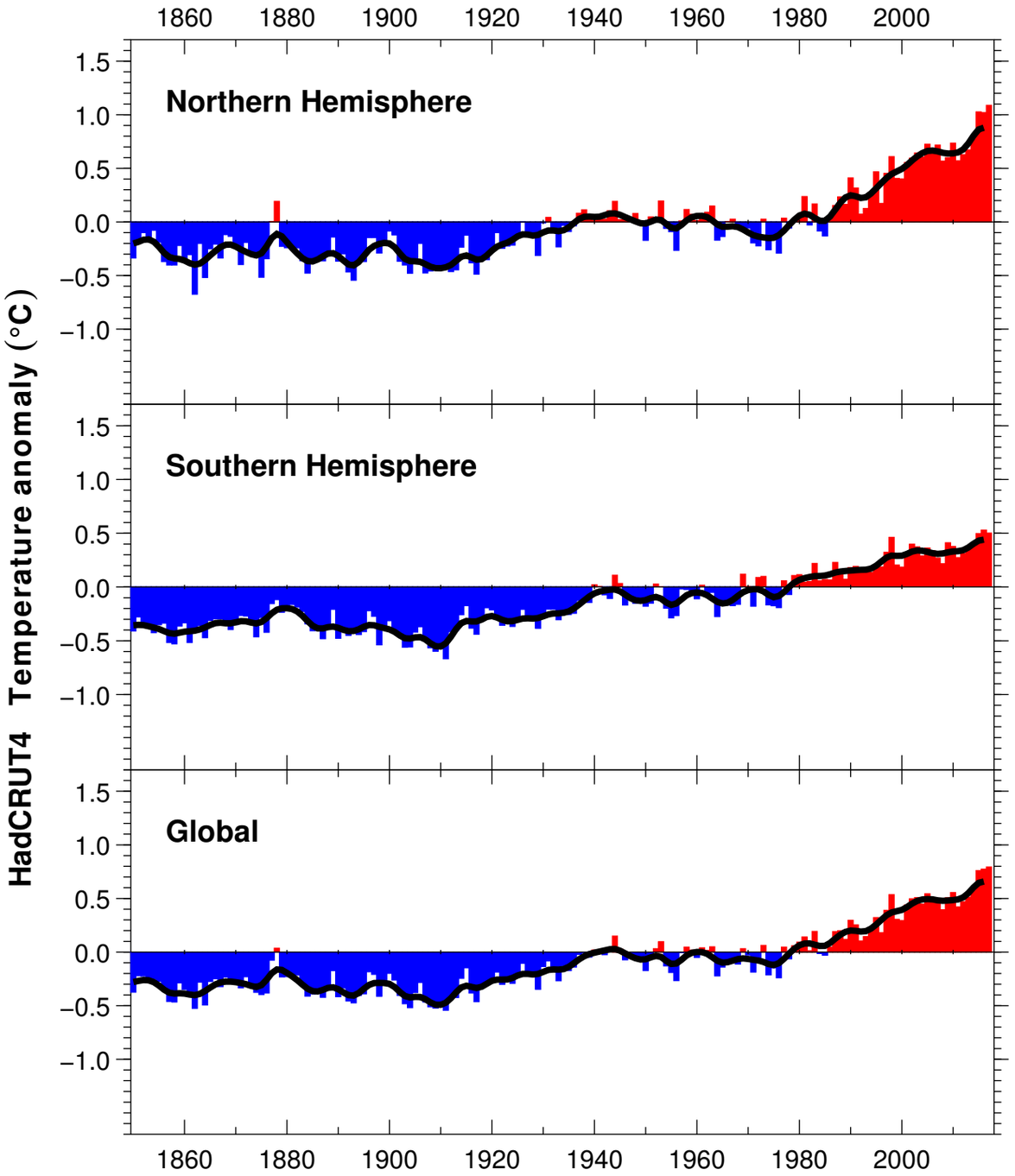
Climate variability and change, agriculture and water

Richard Seager
Lamont Doherty Earth Observatory of Columbia University



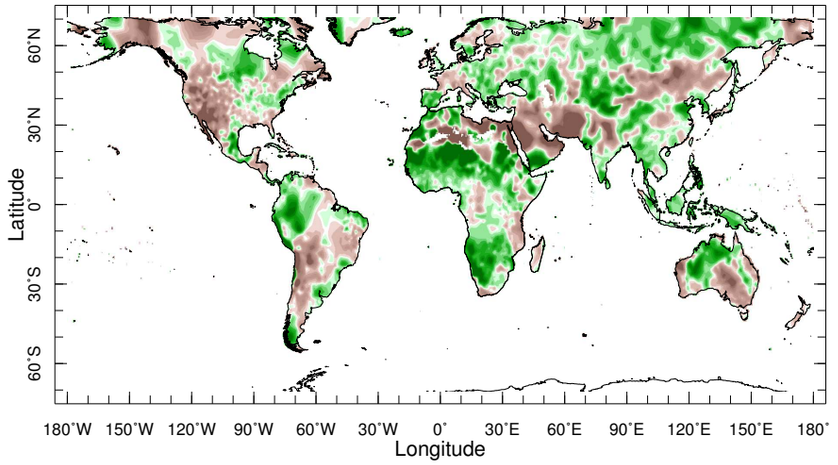
The climate is changing … and burning fossil fuels is the main reason why

Temperature

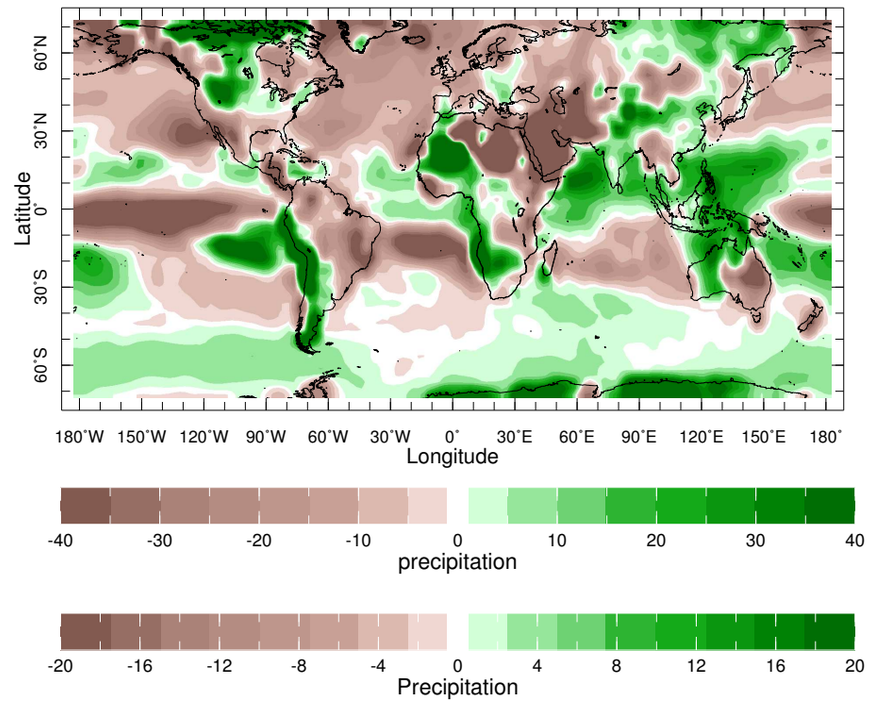


Precipitation trend 1979-2014

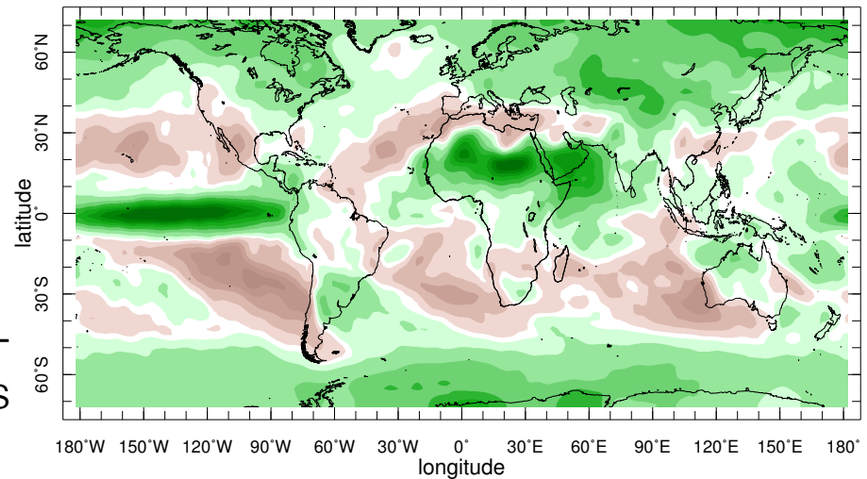
gauge



satellite



radiatively-forced models



Climate variability and change, agriculture and water

Impact of changing precipitation and temperature on crop production

Challenges to urban water supply

Globalization of local crop production anomalies by international trade

Knock-on effects of climate-induced crop production failures on migration/social stability

Many major cities are struggling to provide a reliable water supply, even without climate change, and create unrest when augmenting supply

PRI

Science, Tech & Environment

Mexico City residents brace for water cuts that will leave them dry for days

PRI's The World

January 29, 2016 · 10:45 AM EST

By Monica Campbell

Comment

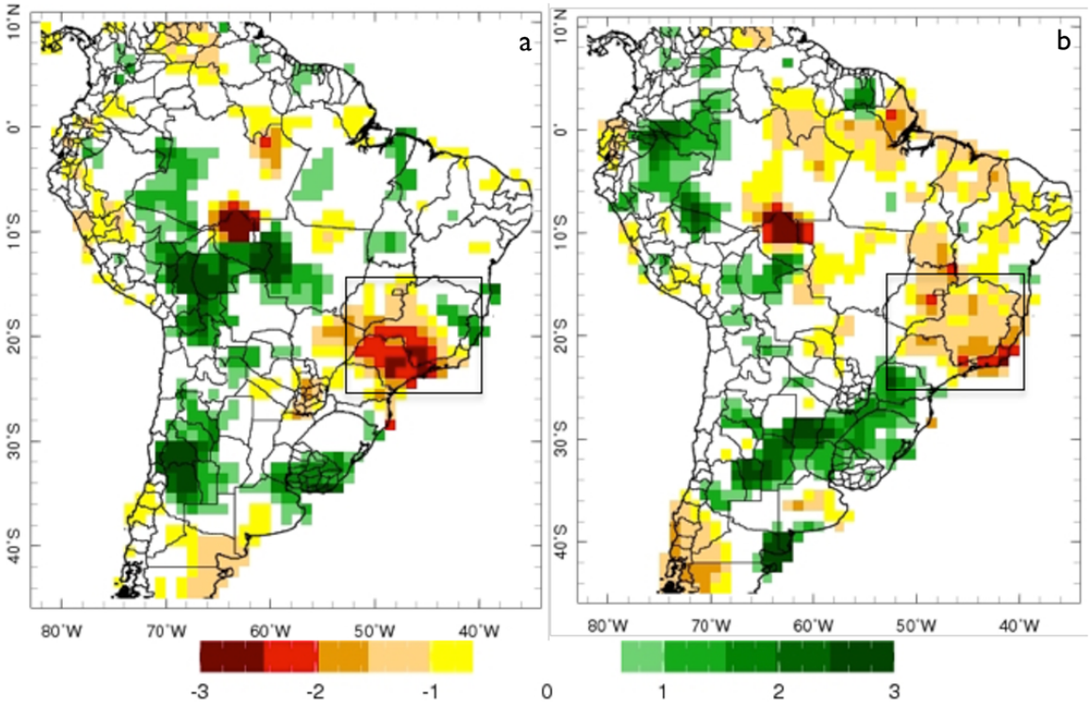
A mother and son fill a container with water collected from a public tap in Tecacalanco, on the outskirts of Mexico City. With a population of more than 21 million, Mexico City and its suburbs place huge demands on the area's water supply.

Credit: REUTERS/Henry Romero

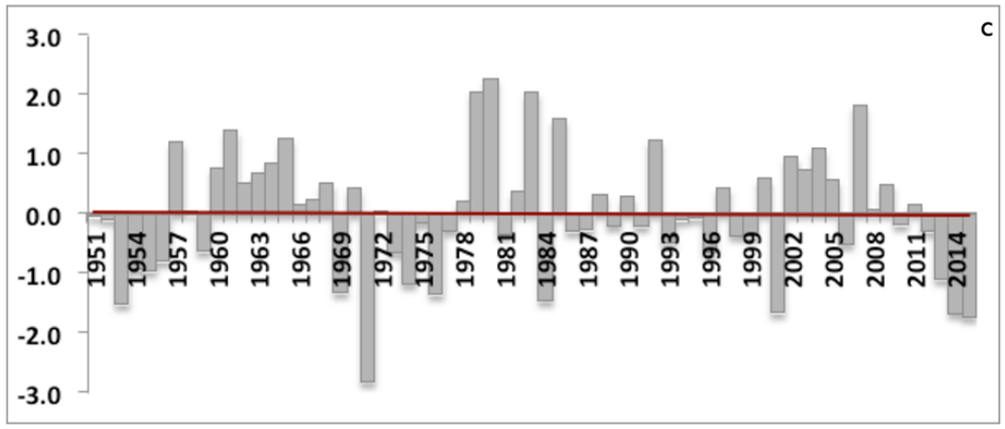
In 2015, drought plus mismanagement, disrupted water supply to residents of the largest city in the western hemisphere, causing economic losses and damaging public health

DJF precip anomaly

2013/14 2014/15



Sao Paulo precip history



Seth et al. (2015)

MENU CNBC

WORLD ECONOMY

ECONOMY | WORLD ECONOMY | US ECONOMY | THE FED | CENTRAL BANKS | JOBS | GDP OUTLOOK

Worries grow as serious drought hits São Paulo, Brazil

Marguerite Ward | @forwardist
Wednesday, 1 Jul 2015 | 9:00 AM ET

CNBC

The financial hub of one of the world's biggest economies is experiencing a water crisis so bad that experts say it could affect investors globally.

Nelson Almeida | AFP | Getty Images

The Jaguari Jacarei river dam, part of the Cantareira System of dams, is shown in Joanopolis, Brazil.

São Paulo, Brazil, is in the grips of the city's worst drought in the last half-century. The city's main water supply—called the Cantareira system—is running on emergency reserves. Normally at this time of year, the city's main supply would hold more than 155 billion gallons of water. But that water is all gone, and the government has been forced to tap into emergency reserves. (Tweet This)

"São Paulo's current drought emergency is both unprecedented and

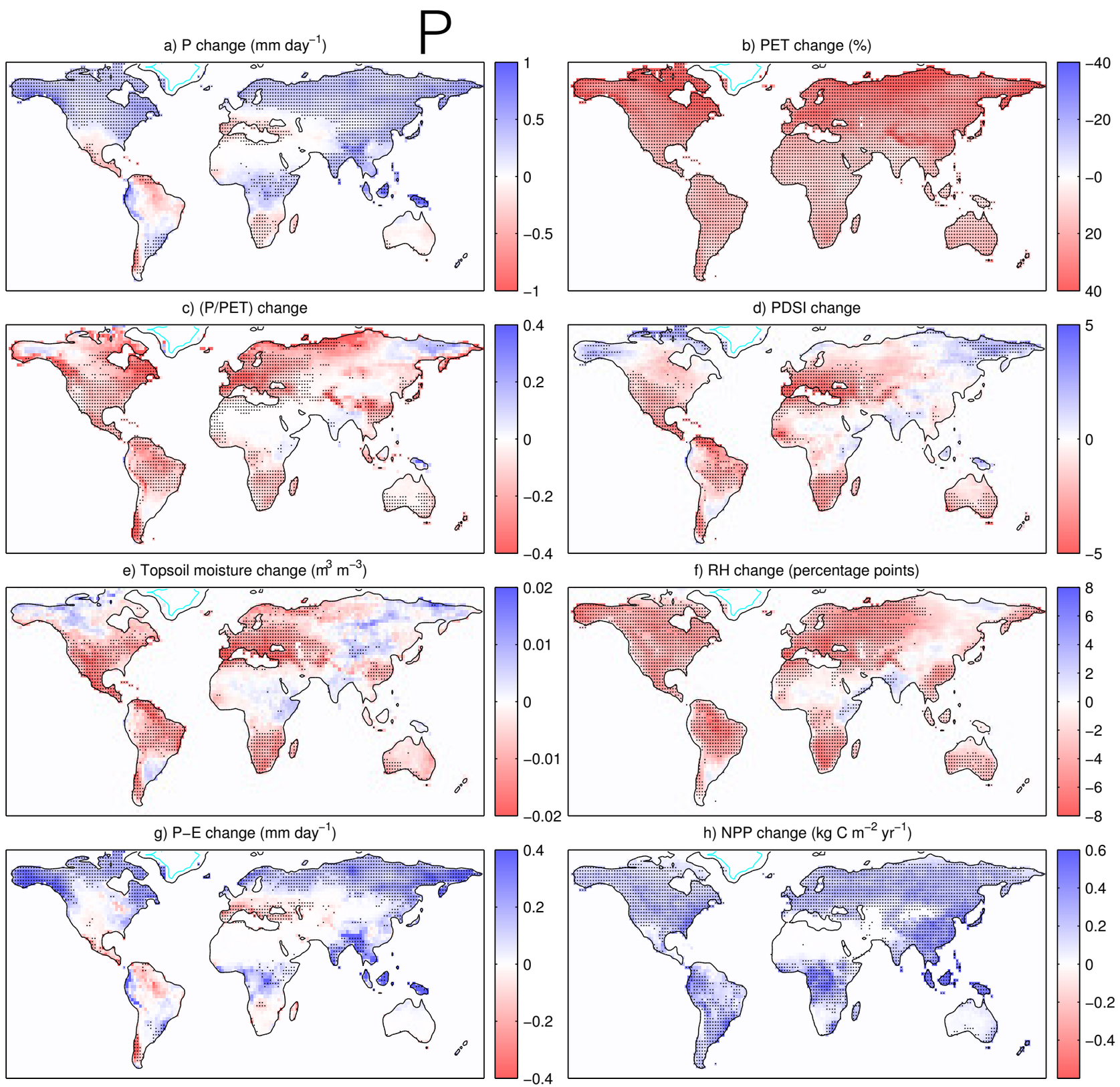
MOST POPULAR

CMIP5 multimodel mean 2070-2100 minus 1975-2004

Model-projected change in hydroclimate

Drying on all measures in:

- SW US, Mexico, Central America/ Caribbean
- Med/N. Africa/ MidEast
- Southern Africa
- Chile



Scheff, Seager, Liu, Coats (2017)

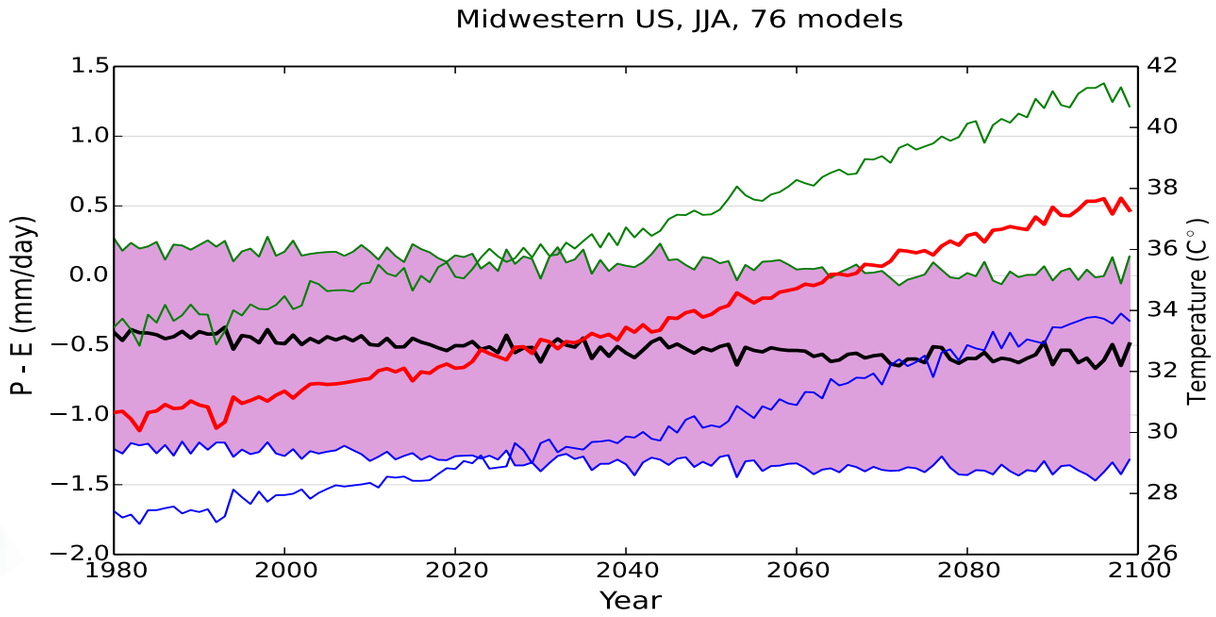
Model projected growing season hydroclimate and temperature

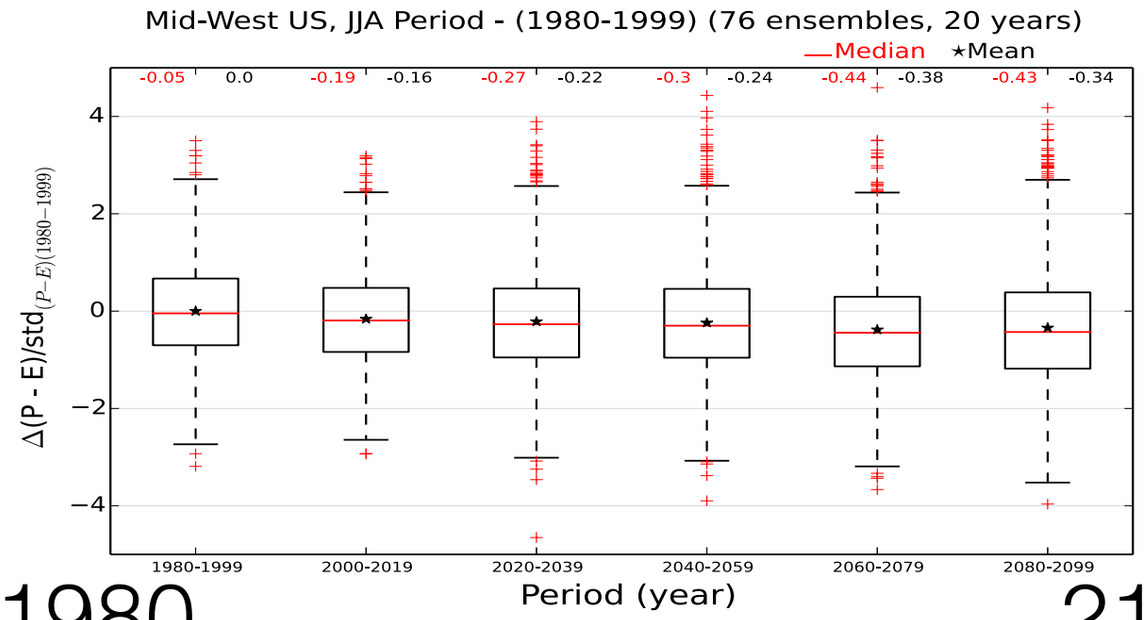
US corn belt

JJA mean P-E and T, mean and 25th, 75th %ile spread across model runs

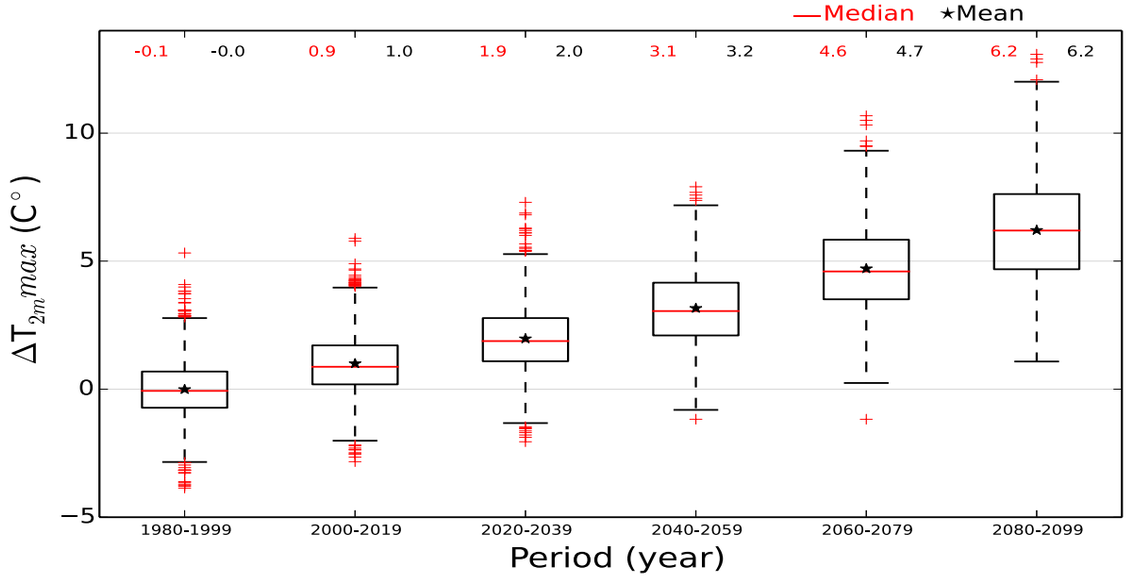
Change in JJA P-E, mean, median, spread

Change in monthly JJA Tmax, mean, median, spread





1980 2100



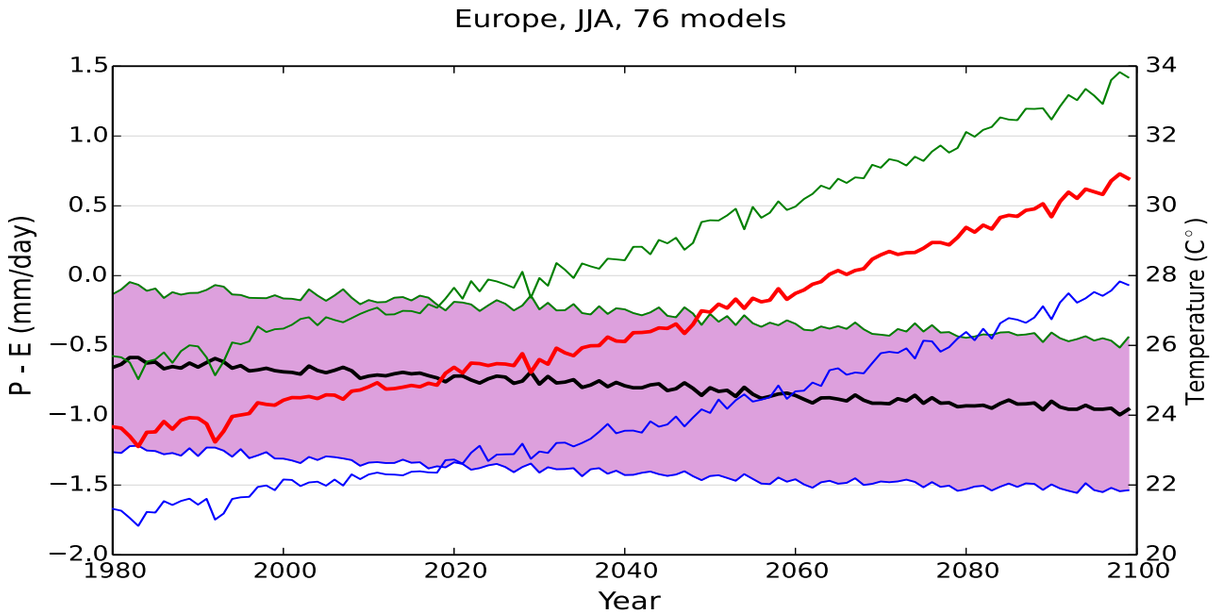
Model projected growing season hydroclimate and temperature

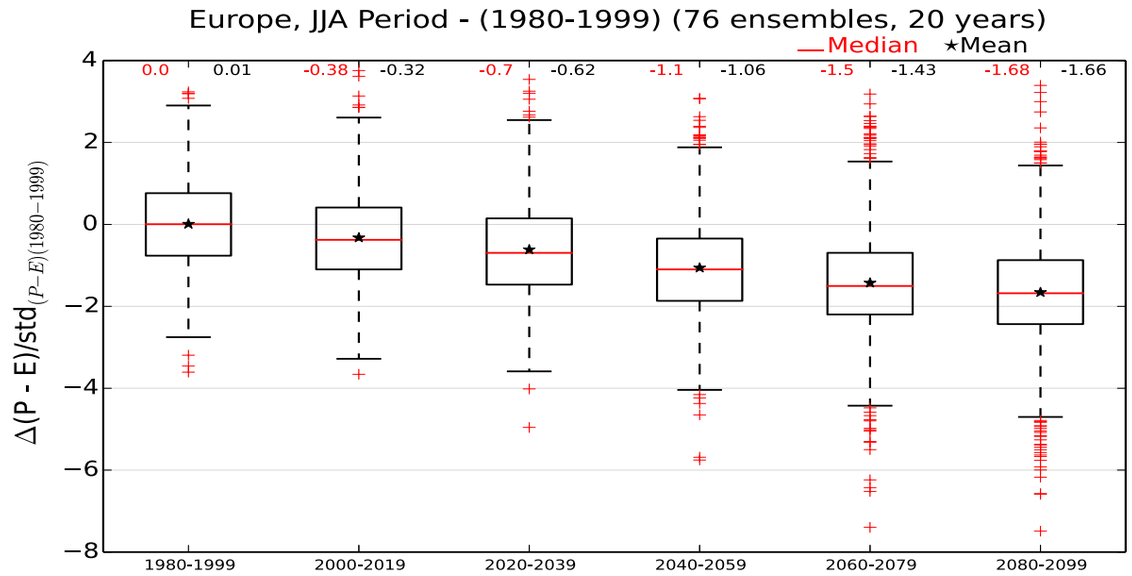
Europe

JJA mean P-E and T, mean and 25th, 75th %ile spread across model runs

Change in JJA P-E, mean, median, spread

Change in monthly JJA Tmax, mean, median, spread





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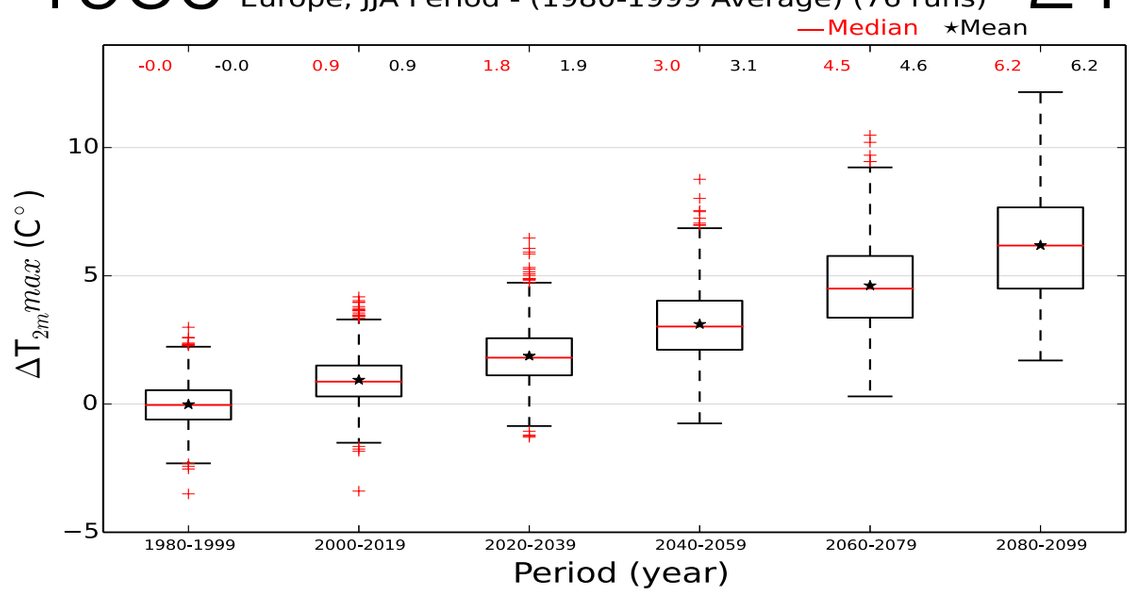


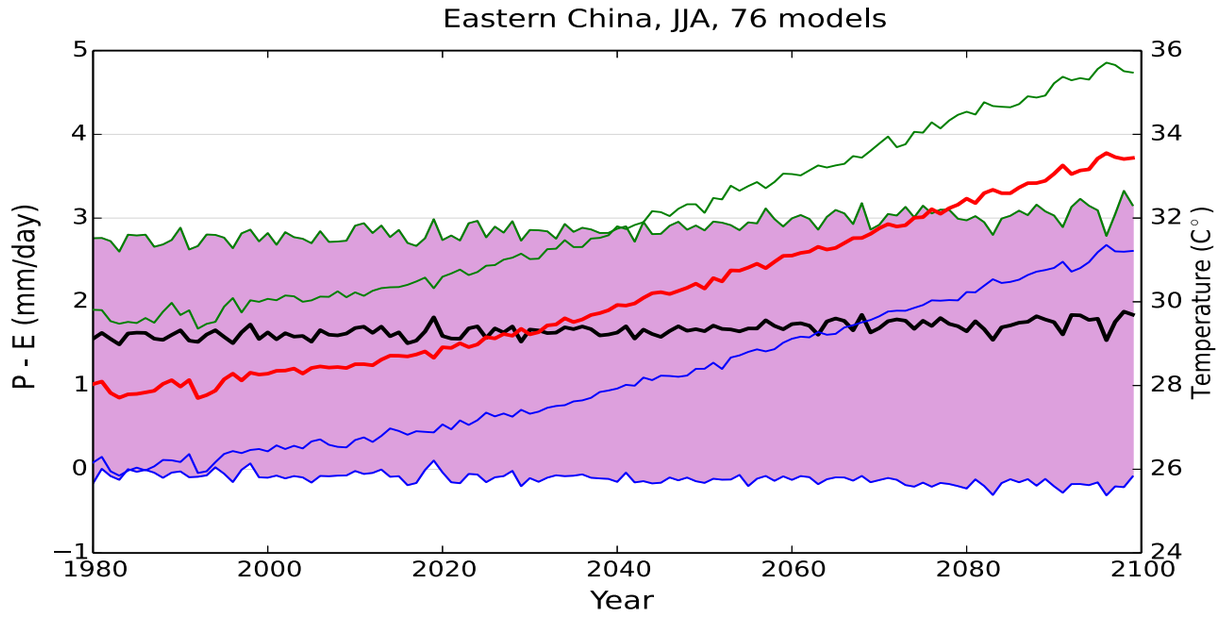
Model projected growing season hydroclimate and temperature

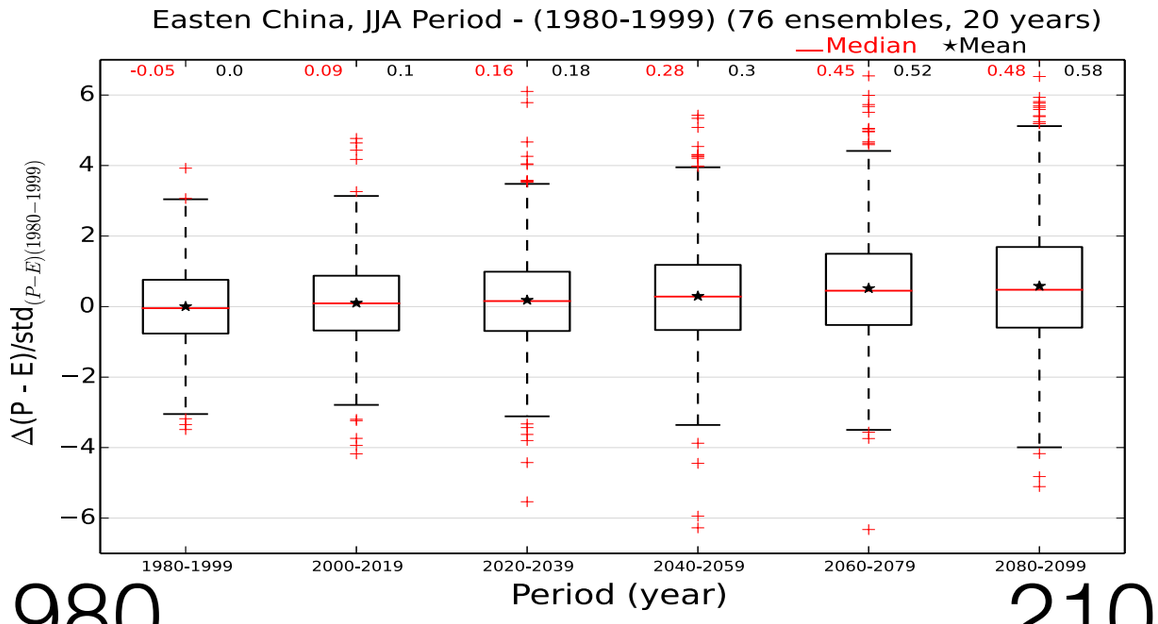
eastern China

JJA mean P-E and T, mean and 25th, 75th %ile spread across model runs

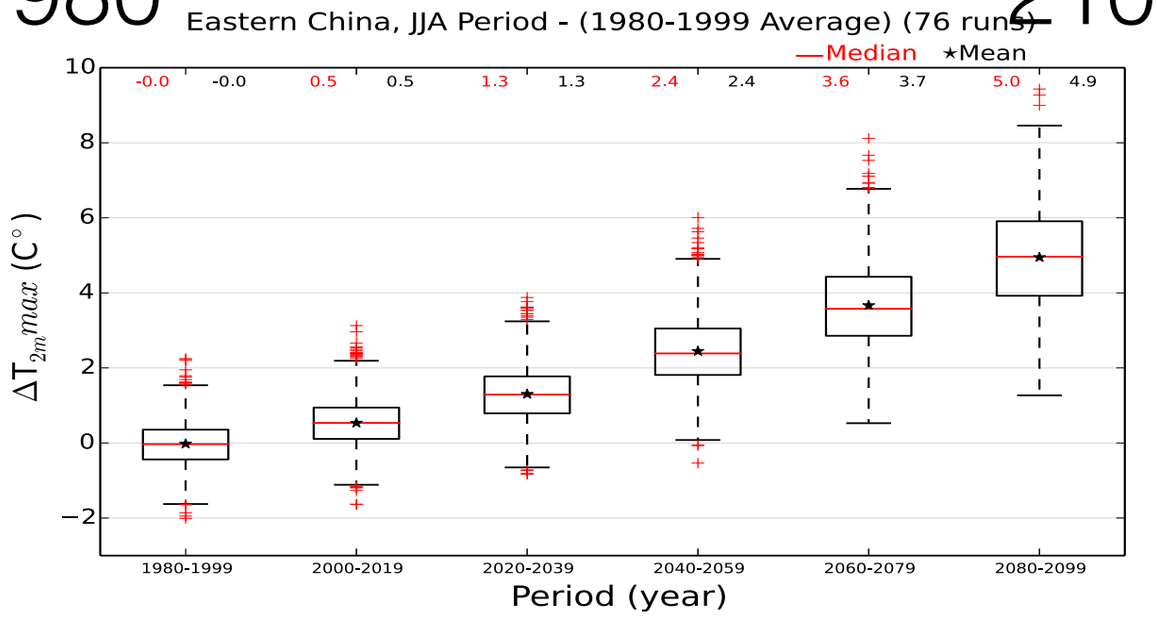
Change in JJA P-E, mean, median, spread

Change in monthly JJA Tmax, mean, median, spread





1980 2100



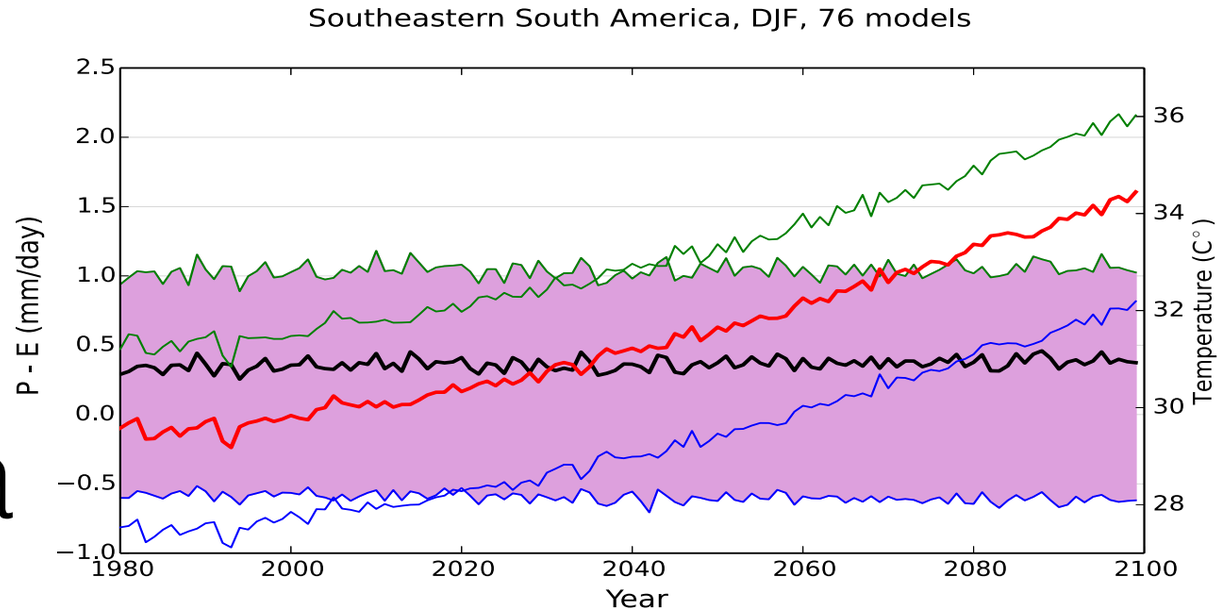
Model projected growing season hydroclimate and temperature

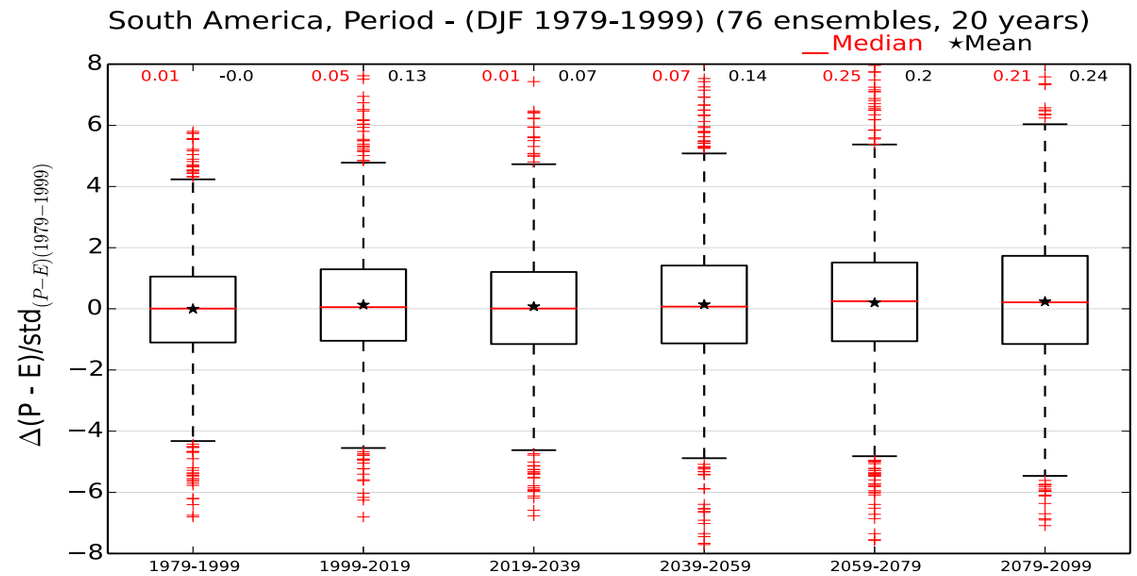
Southeast South America

JJA mean P-E and T, mean and
25th, 75th %ile spread across model runs

Change in JJA P-E, mean, median, spread

Change in monthly JJA Tmax, mean, median, spread





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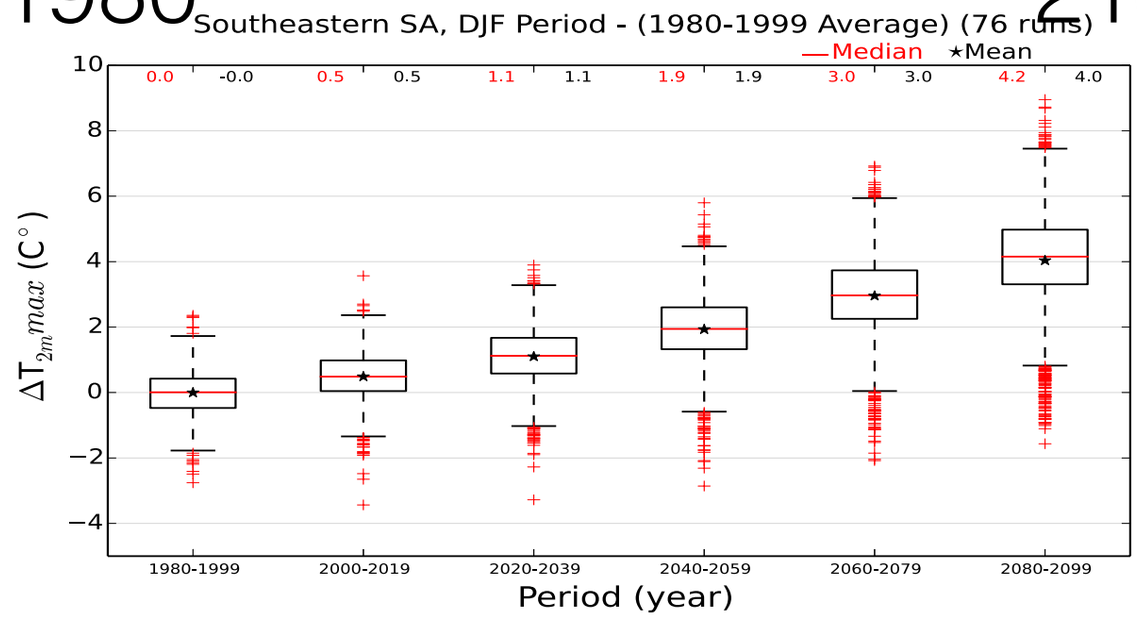


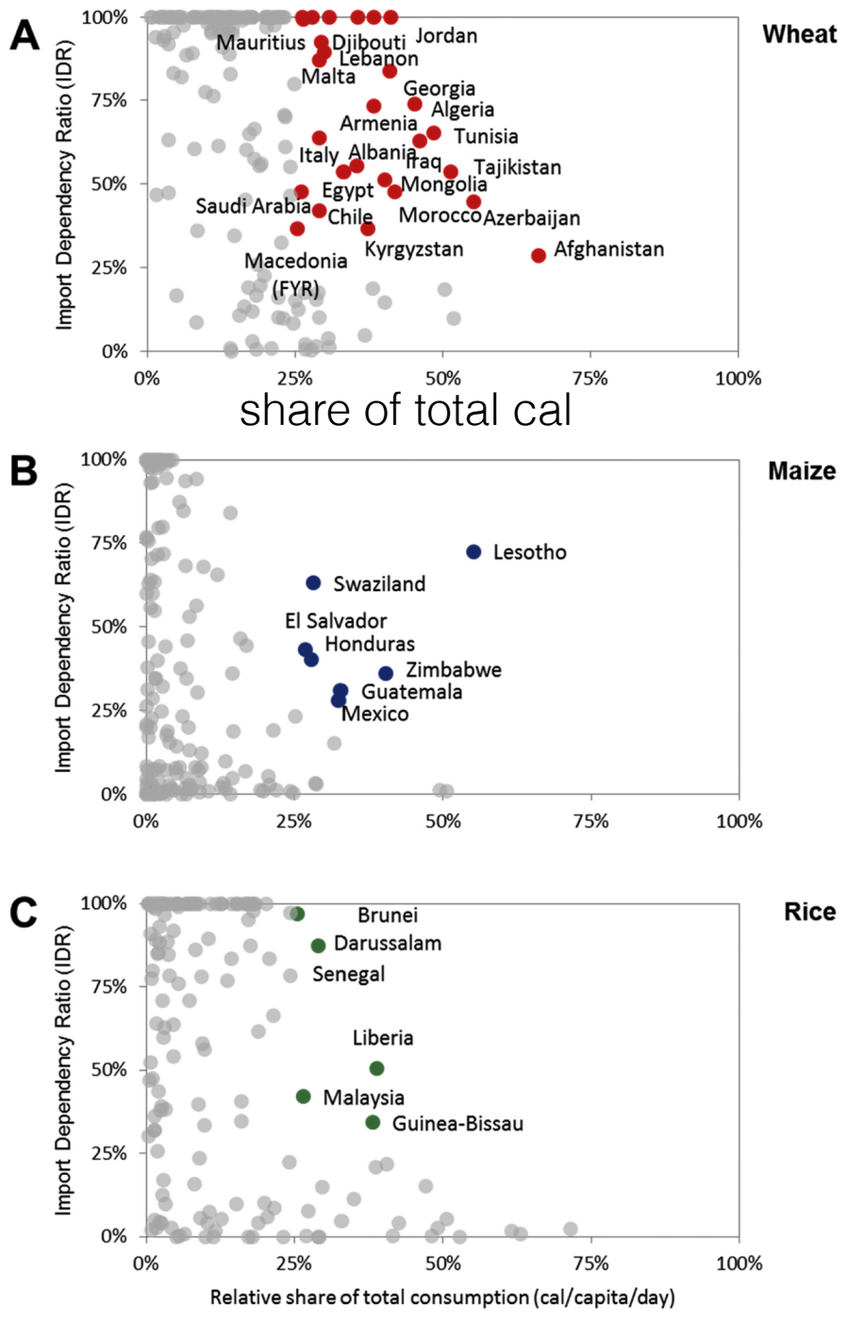
In all major grain production regions:

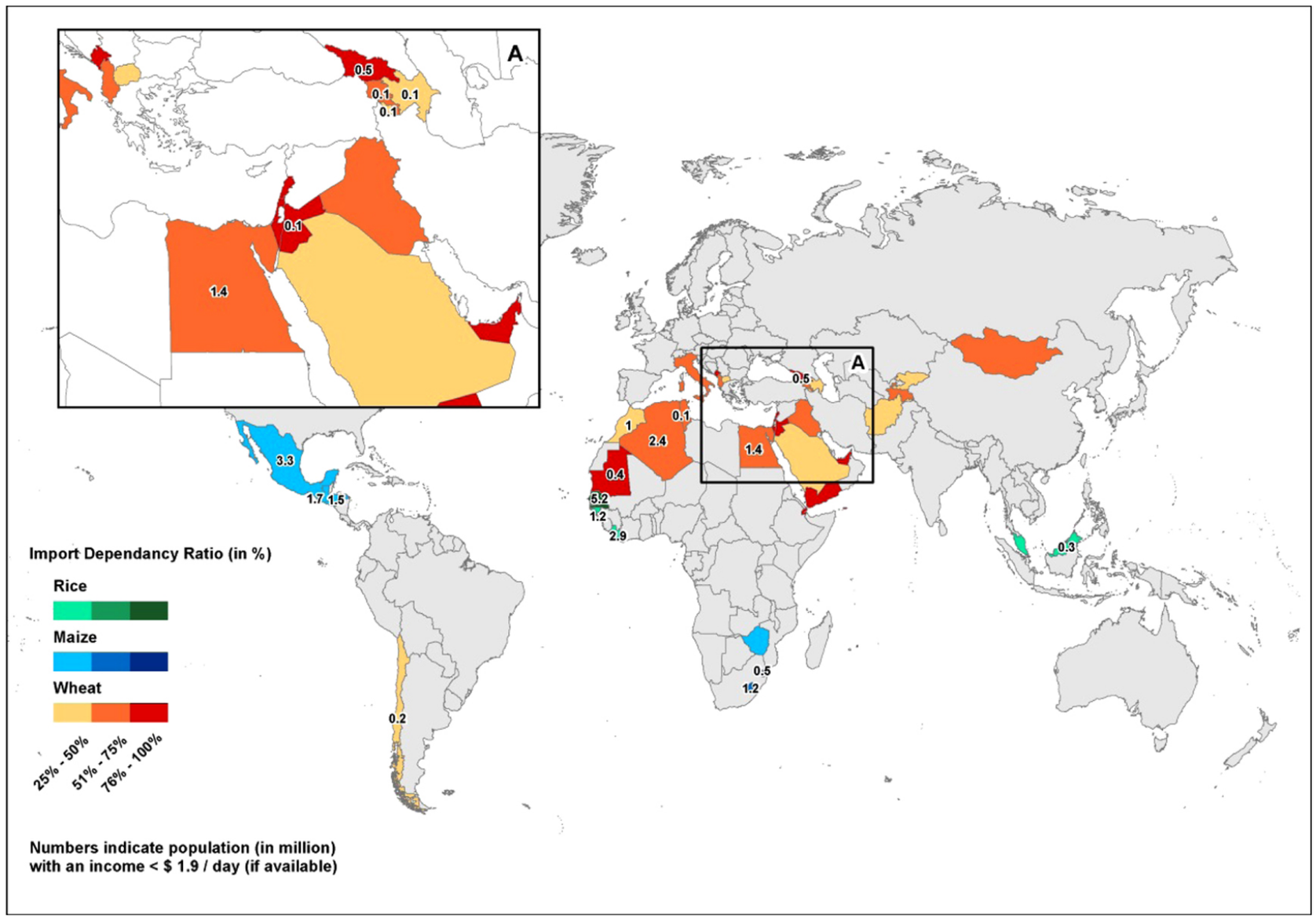
Increasingly (brutally) hot growing seasons

Hot extremes increase by even more than the mean

Drying in Midwest, serious drying in Europe

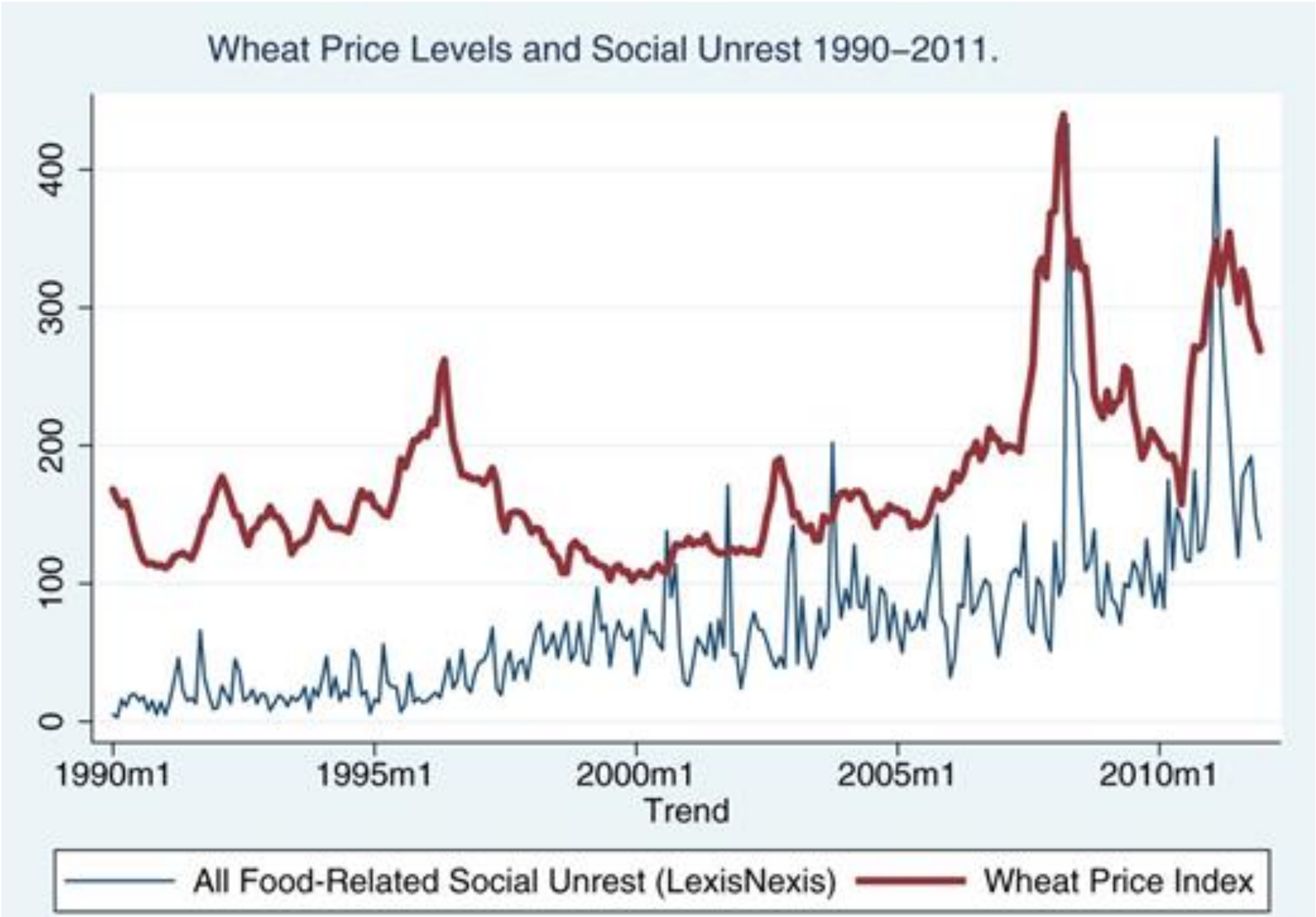
Many middle income and poor countries are highly dependent on grain imports (often of a single grain), creating vulnerability to remote crop production disruptions



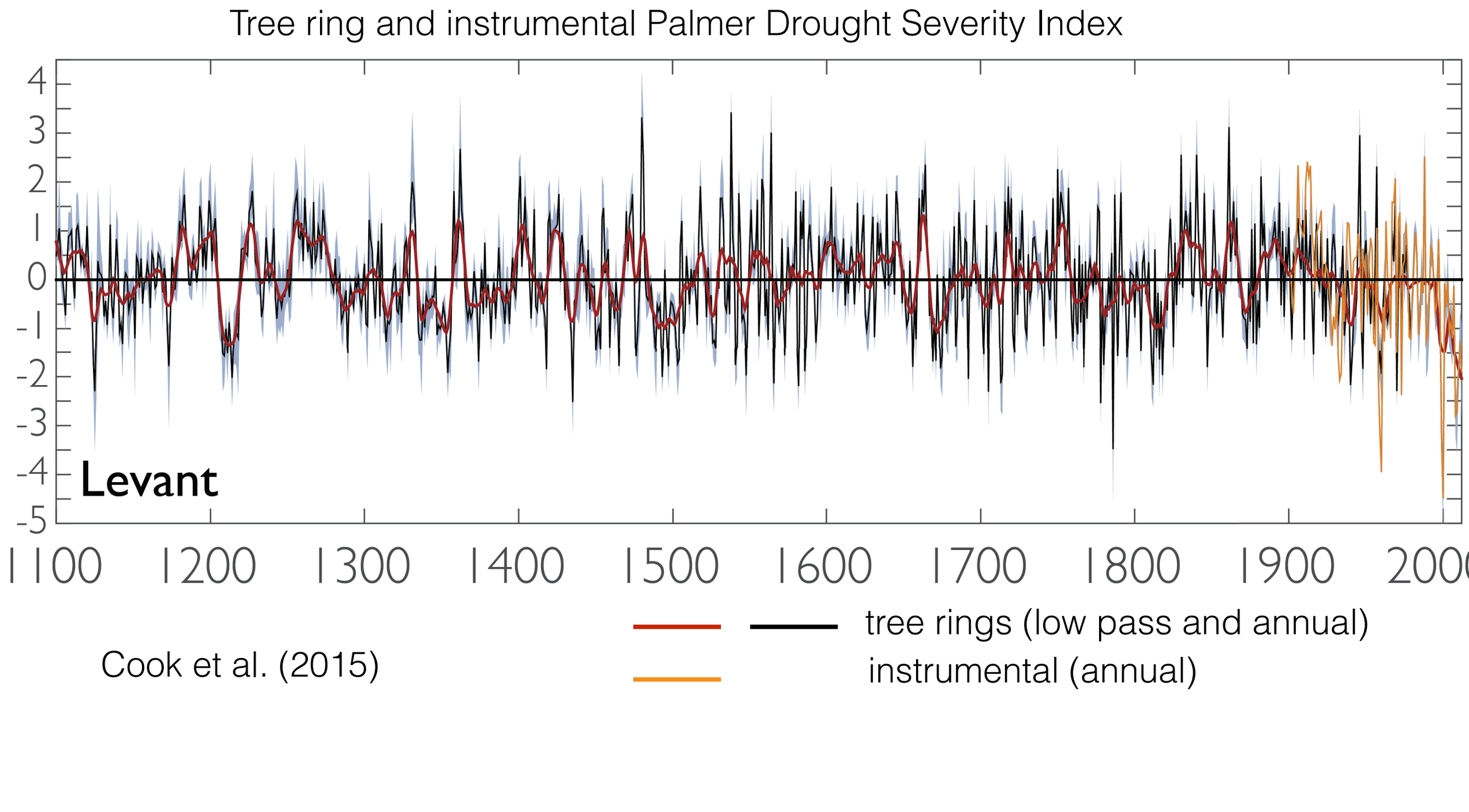


Bren d'Amour et al. (2016)

Bellemare (2015) found a statistically significant relation between grain prices and food-related social unrest



In the years preceding the uprising, Syria experienced the worst multiyear drought in the modern era and, according to tree ring records, in the last 900 years.



DROUGHT, CROP FAILURE AND MIGRATION PLAYED A ROLE IN THE EVENTS THAT LED UP TO THE BEGINNING OF THE SYRIAN REVOLT IN 2008

Timeline of Events

Prior to the 2011 Uprising

1970s-1990s
Agricultural policies promote production of staple crops, leading to increase in number of groundwater wells and use of inefficient and outdated irrigation methods

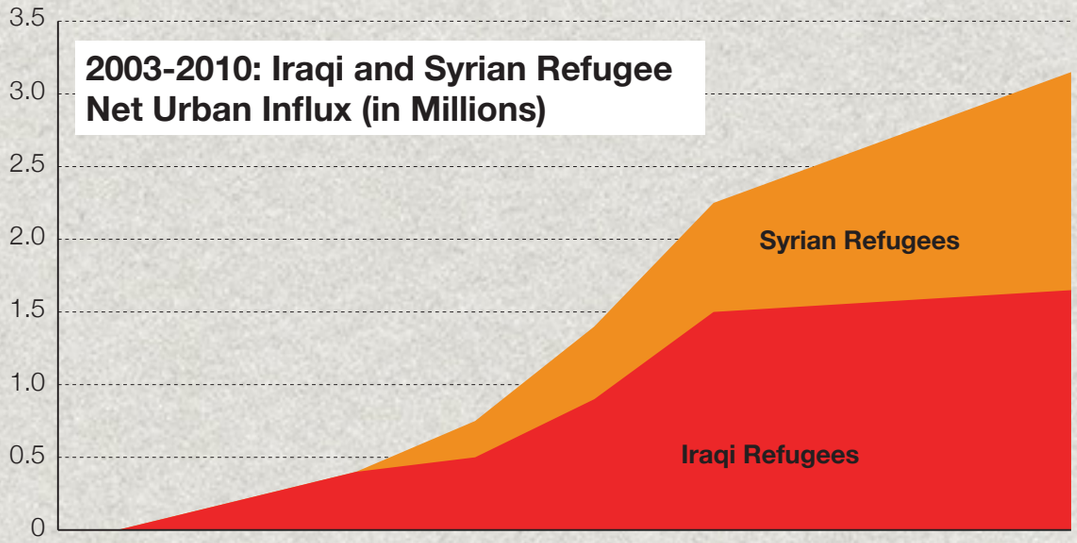
12 March, 1971
Hafez al-Assad becomes president of Syria

Syria achieves self-sufficiency in wheat production

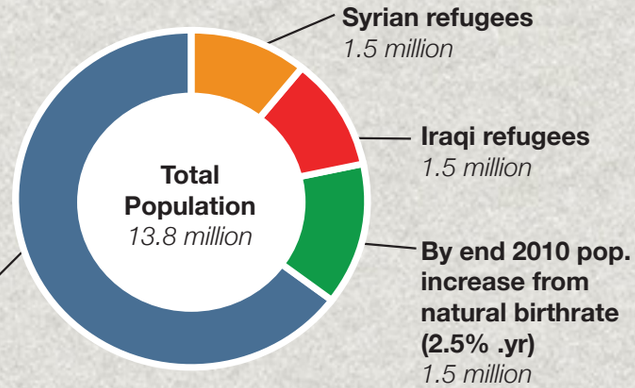
Drying of the Khabur River in NE Syria

Winter 2007-08
Driest in observed record

March 2011
Uprising in Syria



Syrian Urban Population Increase, 2003-2010



Since 2005
Apartment prices in Damascus have more than doubled

Since 2007
Wheat, rice, and feed prices have doubled

Kelley et al. (2015)

SINCE THE DROUGHT HAD A CLIMATE CHANGE COMPONENT THIS IS LIKELY A CASE OF HUMAN-INDUCED CLIMATE CHANGE CONTRIBUTING TO SOCIAL CONFLICT

Emerging problems

Climate change will exert increasing stress in major grain producing regions synchronously

Natural climate variability (e.g. El Niño-Southern Oscillation) leads to good/bad harvests in different regions at the same time

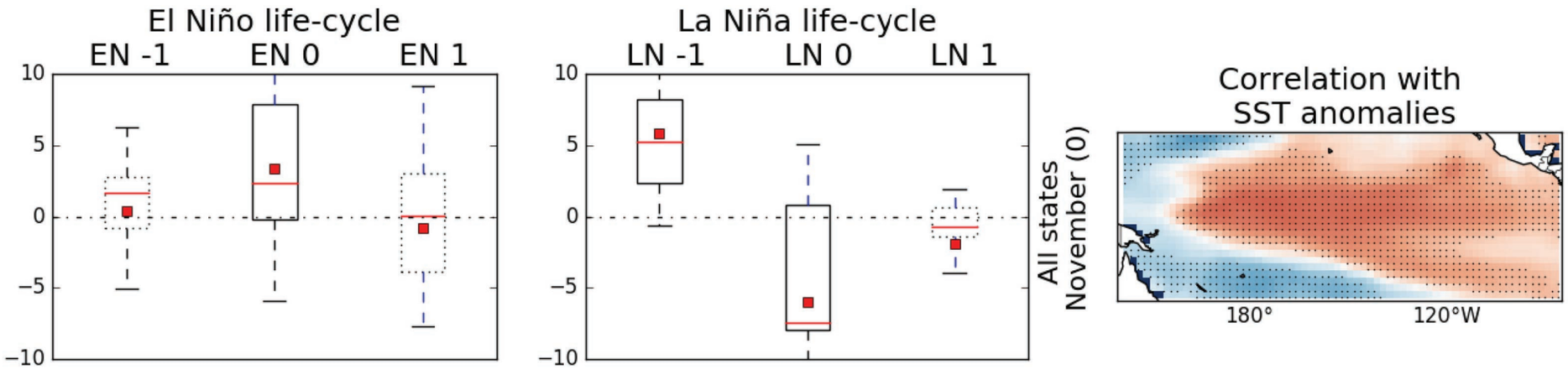
How will ***variability+change*** evolve in coming decades?

How will the odds for bad harvests in multiple grain baskets at once change? Reasonable to assume it will rise, causing increased volatility of global food supply

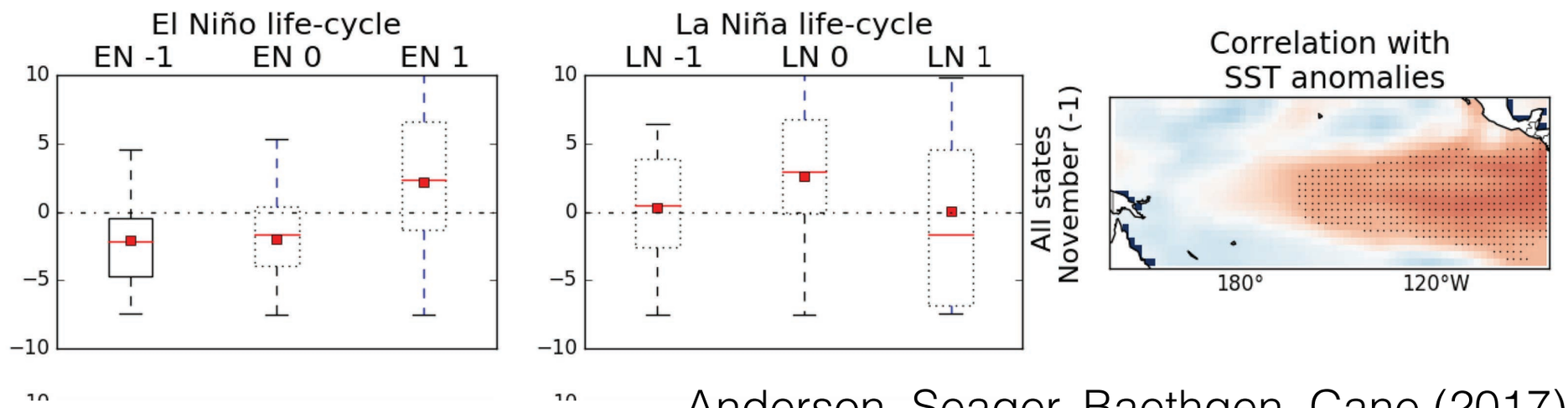
Some variations in crop production at the seasonal to interanual timescale are potentially predictable, allowing anticipation/planning/enhanced food security

El Niño and La Niña life cycles create coherent cycles of pan-Pacific grain production anomalies

maize production anomaly



wheat production anomaly



Anderson, Seager, Baethgen, Cane (2017)

Conclusions

Climate and environmental change are already stressing agriculture and water supply

Rising heat, changing precipitation, will increase challenge of providing adequate water, with negative consequences for health and the economy

Growing season temperatures in all main grain production regions will rise dangerously high in coming decades, undermining crop production

Historically, lost production is globalized into rising food prices causing social unrest, while local crop failures can lead to migration and/or conflict

Multiple knock-on effects on global economy

Scientific advance can improve prediction and anticipation of weather/climate shocks to ag and food supply, enabling planning and disaster aversion