
Climate Change and Global Food Security
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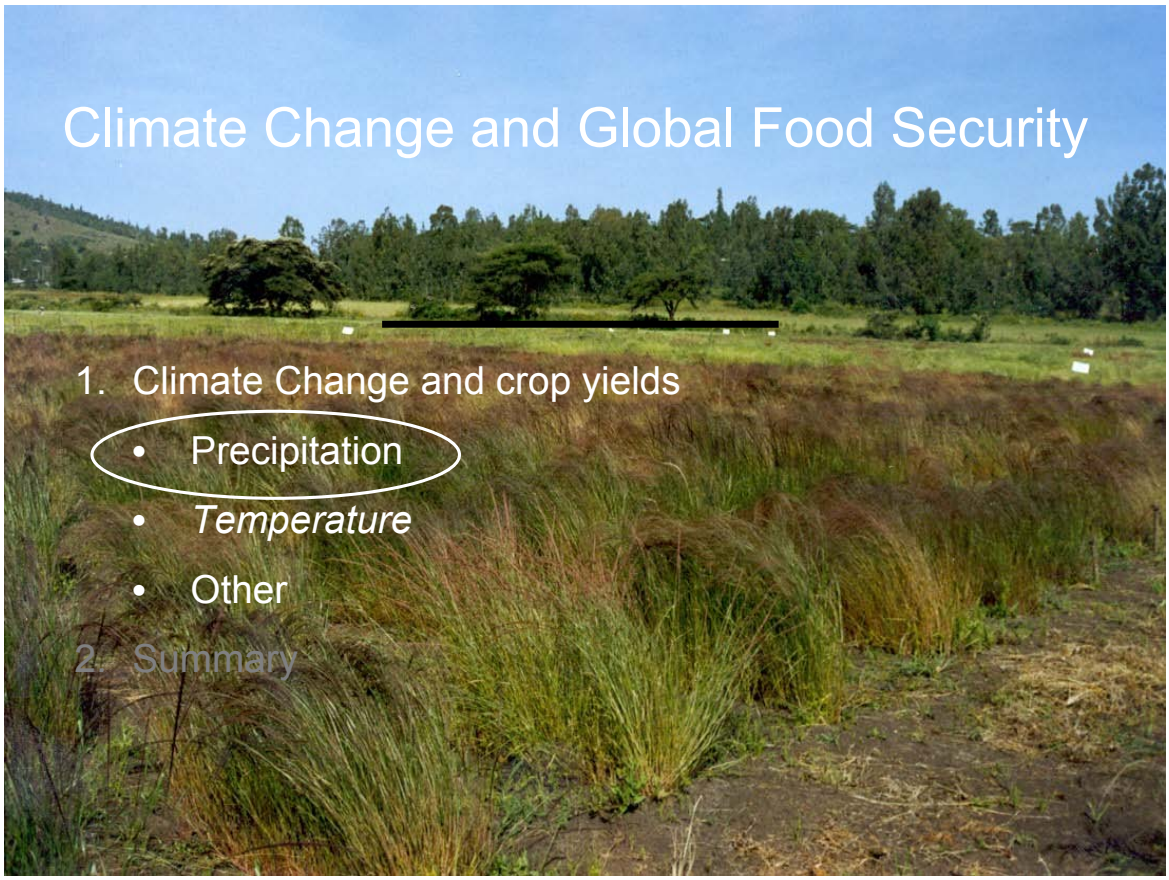
1. Climate Change and crop yields
• Precipitation
• Temperature
• Other
2. Summary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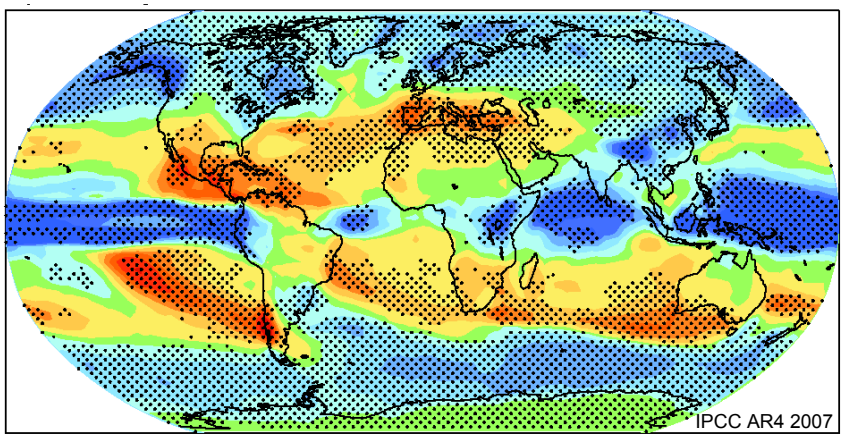
Projected Annual Average Precipitation: "2080-2099" minus "1980-1999"



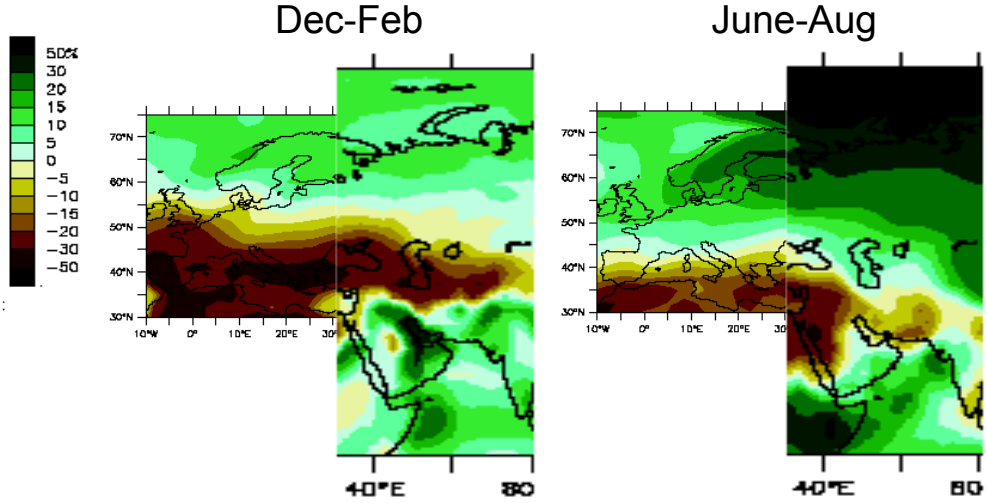
Scenario A1B

There is a *robust* drying of the subtropics, 20-35N&S.

Stippling is where the multimodel average change exceeds the standard deviation of the models

IPCC AR4 2007

Projected Precip Changes in the Central Asia: "2080-2099" minus "1980-1999"



Drying in Central Asia and Southern Europe
(~ 25% reduction of annual mean precip)

Scenario A1B

IPCC AR4 2007

The recent 1998-2001 drought in the Central Asia

~ 30% annual mean precip deficit

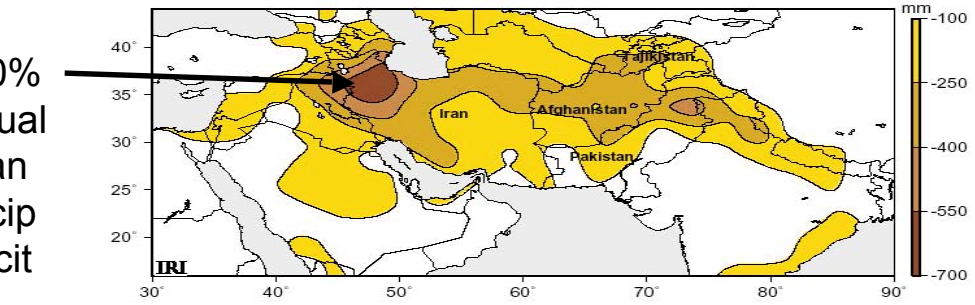


Figure 2. *Regional Drought Situation: Deficit in precipitation totaled over 1998-2001.*

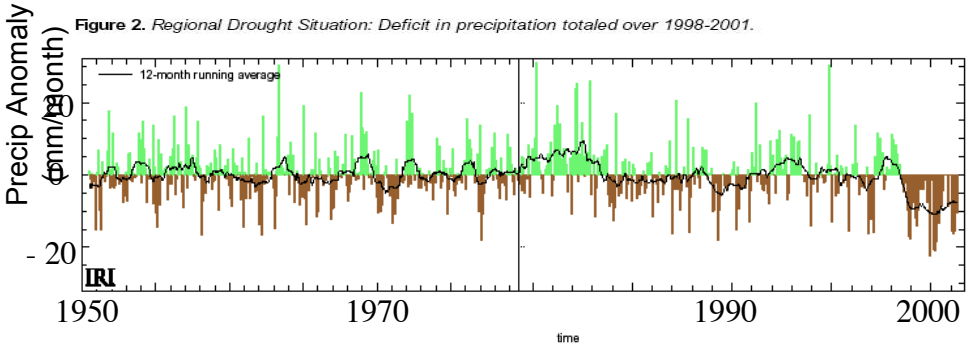


Figure 6. *Precipitation Anomalies: Monthly precipitation departures from the historical average over Central and Southwest Asia (over 25N-42N; 42E-70E), from Jan.1950 - Sep. 2001.*

The recent 1998-2001 drought in the Central Asia

- Iran: 80% of livestock lost
  35 - 75% reduction in wheat & barley
- Afghanistan: 40% of livestock lost
- Pakistan: 50% of livestock lost
- Tajikistan: 50% of grain crop lost

By the end of the century, similar *water* stress on agriculture will be the norm throughout the tropics and subtropics due to the *climate changes* associated with increasing CO_2.

Climate Change and Global Food Security

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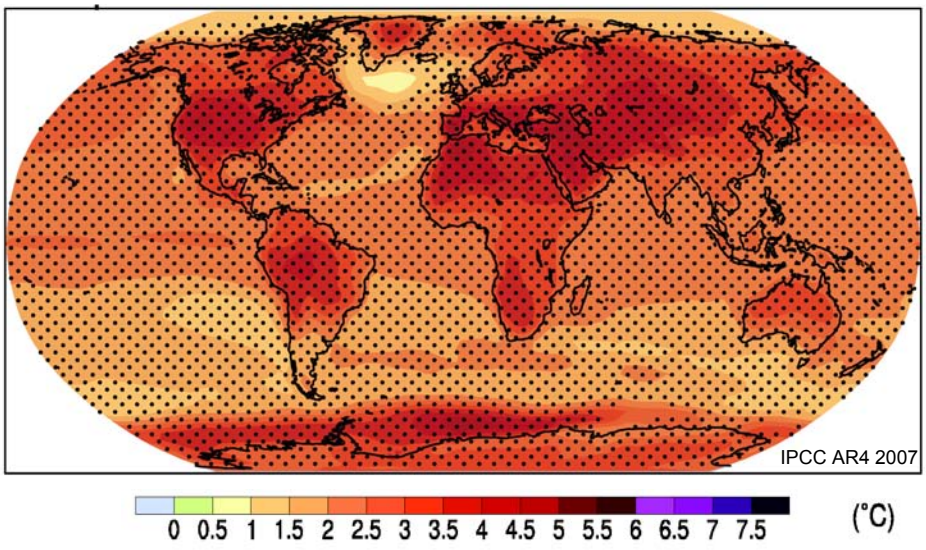
   - Precipitation
   - *Temperature*
   - Other
2. Summary

Projected JJA Average Surface Temperature Change:
"2080-2099" minus "1980-1999"



Average of 21 climate models forced by Scenario A1B.
Multiply by ~1.2 for A2 and ~0.66 for B1

Extreme Heat in Western Europe in 2003: JJA temperature 3.6°C above normal

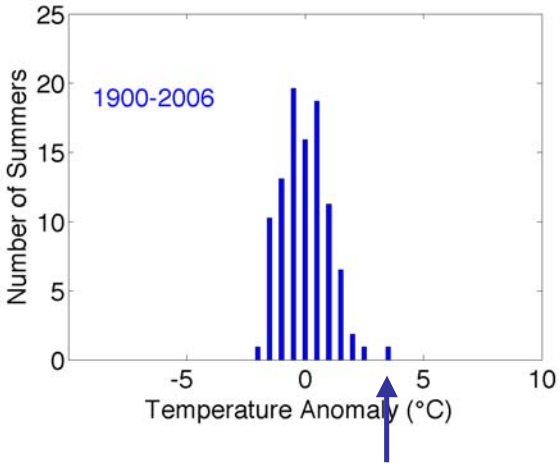
- France & N. Italy: 30,000 - 50,000 dead of heat stress
- Italy: 36% drop in maize yields
- France: 30% decrease in maize and fodder production
  25% decline in fruit harvests
  21% reduction in wheat yields

By 2100, years of similar *temperature* stress on agriculture will be the norm throughout the tropics and subtropics due to the summer *average* temperature changes.

Refs: UNEP 2007; Easterling 2007; Earth Policy Institute 2006; Eurosurveillence 2005

Growing Season Temperature

France

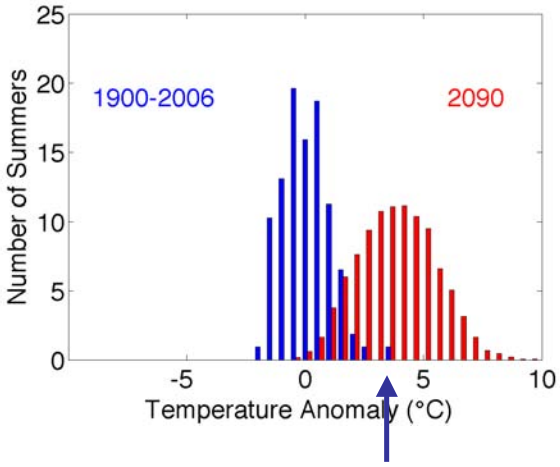


2003

Observed JJA Temp
(1900-2007)

Projections of Growing Season Temperature

France

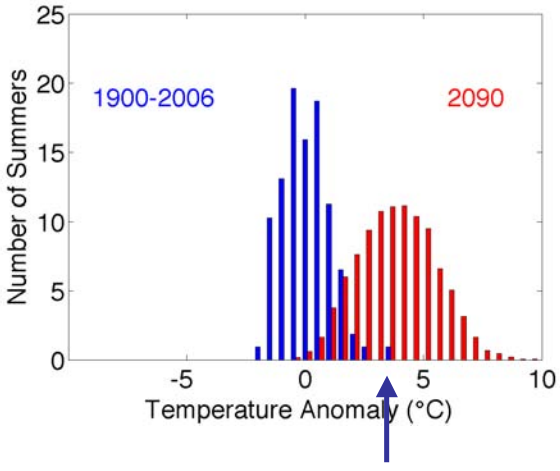


Observed JJA Temp (1900-2007)

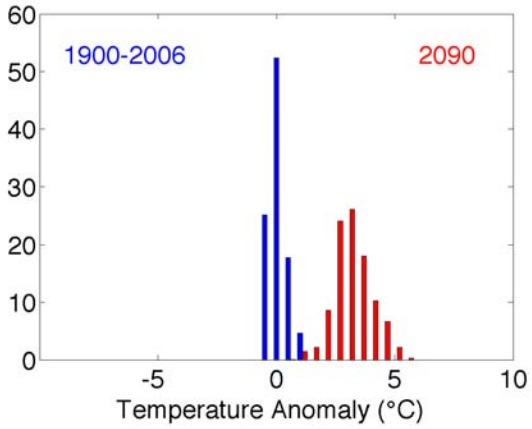
Projections use 22 climate models (IPCC AR4) forced by A1B Emission scenario. Variability taken from observations

Projections of Growing Season Temperature

France



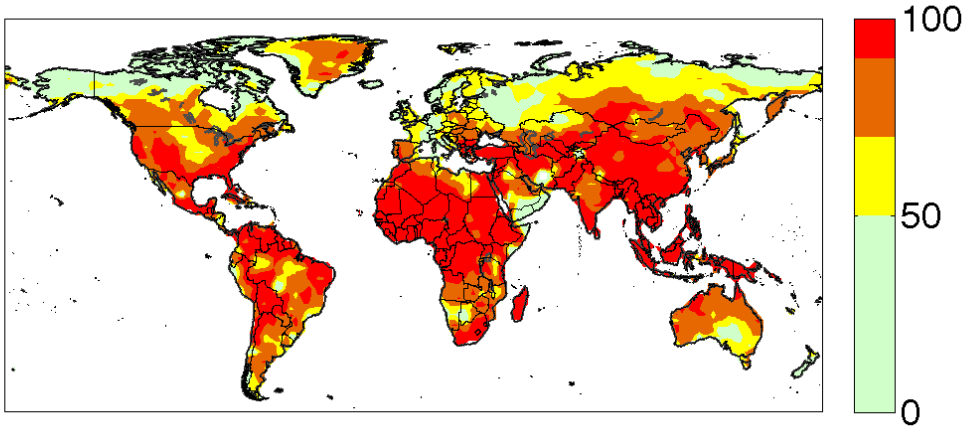
The Sahel



Battisti and Naylor 2009

Projections of Growing Season Temperature

Likelihood of Summer 2090 warmer than warmest on record



By the end of the 21st Century it will be much hotter everywhere

In most of the tropics/subtropics, the seasonal average temperature will *very likely* exceed the warmest year on record

Battisti and Naylor 2009

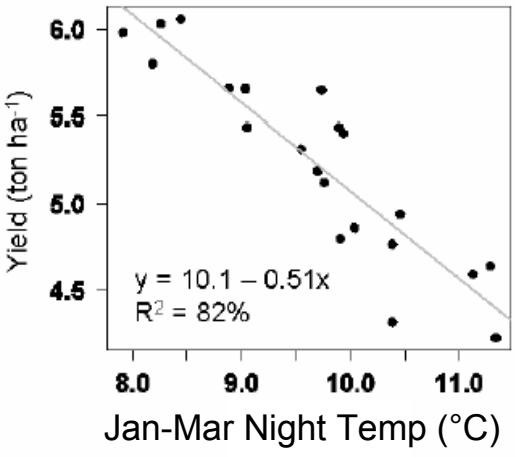
Impacts of Climate Change on Food Security

Increasing temperature over the next 50 years will cause decreases in yield:

- Decrease in grain filling
- Decrease in spikelet fertility
- Increased water stress
- Increased respiration (this case)

Important for all crops, but especially for wheat, rice and soybeans (nb, these are the C3 crops that would otherwise benefit from increased CO_2) **and maize**

Wheat Yield in Yaqui Valley, MX



Lobell 2007

Impacts of Climate Change on Food Security

Impacts of increased temperature (*only*):

- Reduced yields of wheat, rice, maize and soybeans in the tropics/subtropics (equatorward of ~35° lat.)
  - Approximately -10% per 1ºC warming
  - Est. reduction of 30-40% by 2100 in India, Africa, Middle East, Central America etc.
- Reduced nutritional content (especially protein in wheat and rice)
- Increased disease transmission rates
- Loss of water stored in snow pack and glaciers (e.g., Sierra, Himalaya)
  - Reduced duration of river supplied water, especially important for India and Bangladesh

Impacts of Climate Change on Food Security

By 2050, many countries in the subtropics will experience:

- Typically a 10 - 20% reduction in rainfall (northern and southern Africa, Caribbean, Middle East, etc.)
- Increased frequency, duration and intensity of drought

Impacts of changing precipitation:

- Reduced yields and in some places abandonment of staple crops (many of these regions are marginal for crops presently grown)
- Duration and intensity of monsoon (e.g., rice in Indonesia)
- Increase in flooding in midlatitudes and tropics (increase intensity of precipitation on drier soils)
- Leaching of nutrients in soil

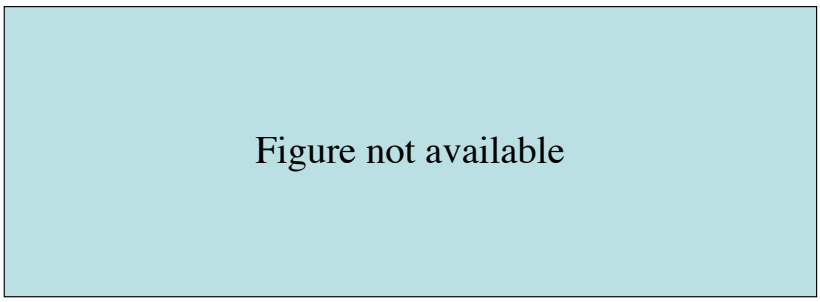
Impacts of Climate Change on Food Security

Other impacts of climate change on agriculture

- *Increased* carbon dioxide and plants
  - Enhanced growth rate for **some C3 plants** (benefits limited to < 2030AD, and to the extratropics)
  - Including *temperature* increases due to CO_2, a large net negative impact in tropics/subtropics for all crops (C3 and C4)
  - Effects on plant pathology (reduced protein content and resilience to disease)
- Effects on soil BGC (fertility/water capacity)
- Sea level rise: about 35cm by 2100
  - salinization and loss of arable land
- *Changes in pest and pathogens*

Yield loss due to impact of climate change on pests

Climate Impact on insect crop damage, 2090 - 1990: wheat



- Herbivory will change due to
  - increased metabolism (mainly): 40% in tropics, 50% in India and Russia, more than double in US
  - changes in pest fitness: increase in extratropics/decrease in tropics
- *Net impact: more than double the yield loss due to impact on pests in extratropics (wheat, maize, rice)*

(yield loss due to pests today is 5-50%)

Deutsch et al in prep.

Summary: World-wide impact on Crops

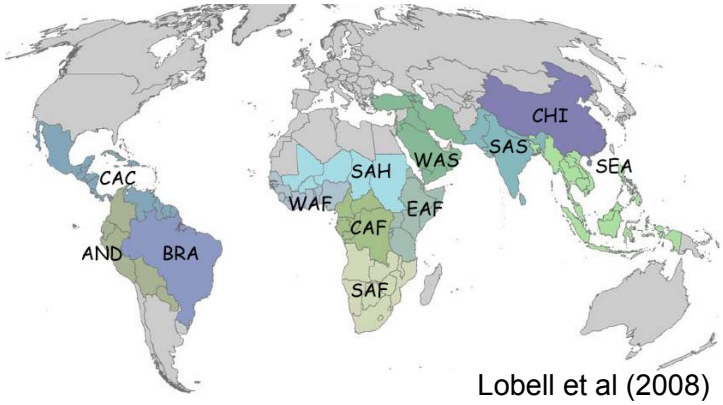
- By 2100, growing season temperatures will *very likely* exceed the warmest on record throughout the tropics and subtropics

  ⟹ 20-40% reduction in yields of major crops solely due to temperature stress alone (plant physiology)
- In subtropics, crops will be further stressed by reduced rainfall
- Increased CO_2 (fertilization) effect is small
  - About ~0 to 15% for doubling CO_2
- Pest and Pathogens

Where do the Food Insecure live?

1 B people are malnourished today

- 95% are in the tropics/subtropics



Lobell et al (2008)

Estimates: ~ 200M *more* people at risk of hunger by 2080 due to climate change

<u>The food insecure</u>

- depend heavily on agriculture for food and income

- live in regions where agriculture will be most stressed by global warming

- live in countries that have the greatest population growth rates