Climate Change and Food Supply

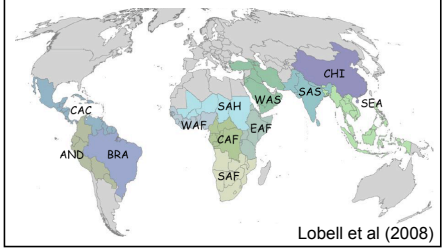
Have we understood the links?

David S. Battisti
Univ. of Washington

1. Where do the Food Insecure live?
2. Projections of climate at the end of the 21st Century
3. Climate Change and food security in developing nations

Where do the Food Insecure live?

940 M people are malnourished today
- 95% are in the tropics/subtropics



Lobell et al (2008)

What do the food insecure eat?

- Rice (26%)
- Wheat (17%)
- Sugar Cane (8%)
- Maize (6%)
- Nuts (5%)
- Casava (4%)
- Other (34%)

The food insecure are also the poor. They depend heavily on agriculture for both food an income.

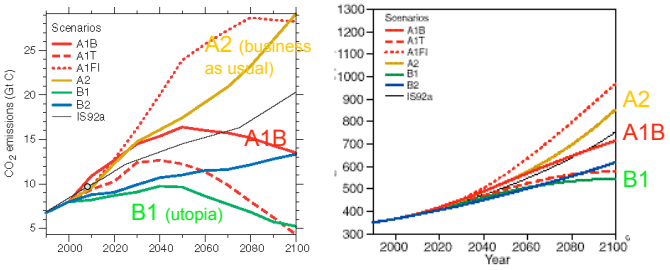
Climate Change and Food Supply

Have we understood the links?

1. Where are do the Food insecure live?
2. Projections of climate at the end of the 21st Century (from IPCC)
   - Focus on those changes that are "very likely" (i.e., those that are either deemed to have a greater than 90% chance to occur "based on quantitative analysis or an elicitation of the expert views")
3. Climate Change and food security in developing nations

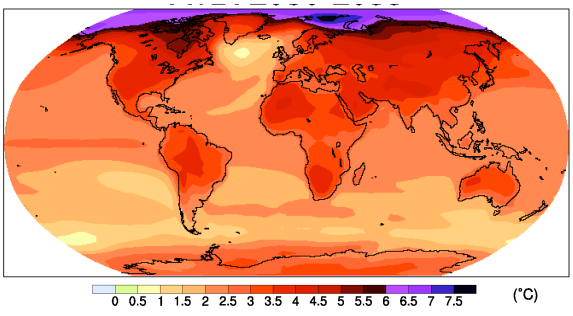
How much Carbon Dioxide will be released into the atmosphere?

Emissions



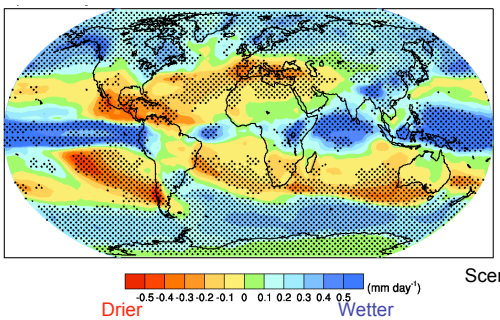
Estimates depends on population and economic projections, future choices for energy, governance/policy options in development (e.g., regional vs. global governance)

Projected Annual 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 ~0.7 for B1

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

Climate changes due to human activity

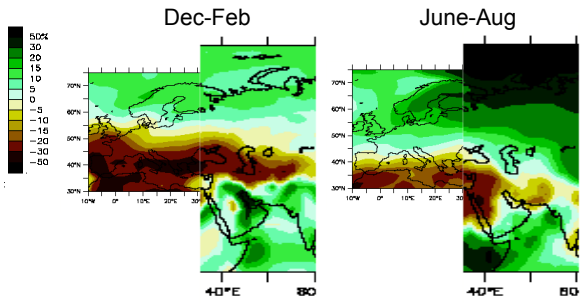
Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Virtually certain*[d]
Warm spells/heat waves. Frequency increases over most land areas	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Very likely*

Virtually certain > 99%

Very likely >90%

IPCC 2007

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



Drying in Central Asia and Southern Europe
(~ 10 - 25% reduction of annual mean precip)

Scenario A1B

The recent 1998-2001 drought in the Central Asia

~ 30% annual mean precip deficit

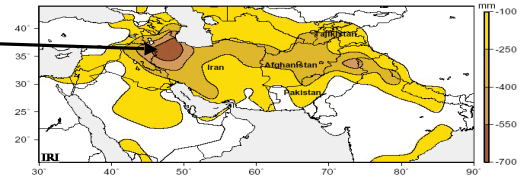


Figure 2. *Regional Drought Situation: Deficit in precipitation totaled over 1998-2001.*

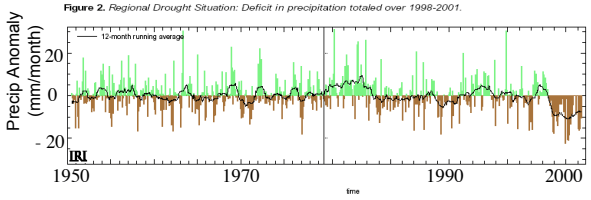


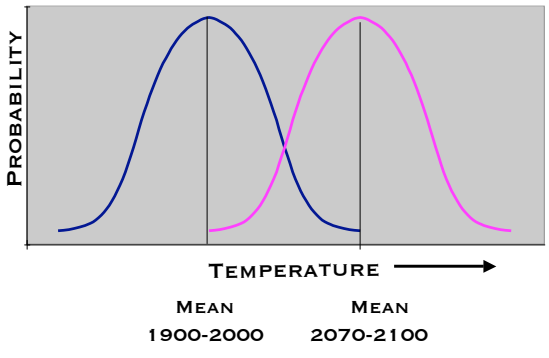
Figure 6. *Precipitation Anomalies: Monthly precipitation departures from the historical average over Central and Southwest Asia (over 25N-42N; 42E-70E), from Jan.1950 - Sep. 2001.*

The recent 1998-2001 drought in the Central Asia

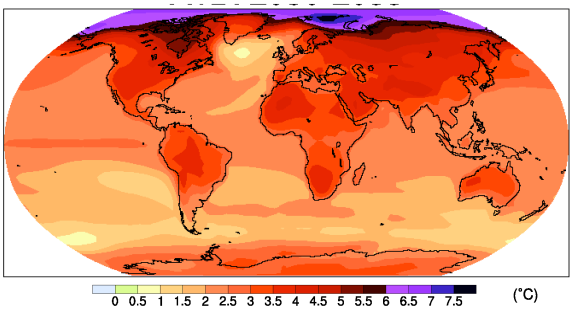
- Iran: 80% of livestock lost
  35 - 75% reduction in wheat & barley
- Afghanistan: 40% of livestock lost
- Pakistan: 50% of livestock lost
- Tajikistan: 50% of grain crop lost

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.

Projections of future temperature



Projected Annual 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 ~0.7 for B1

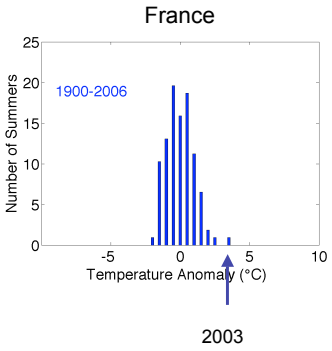
Extreme Heat in Western Europe in 2003: JJA temperature 3.6°C above normal

- 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.

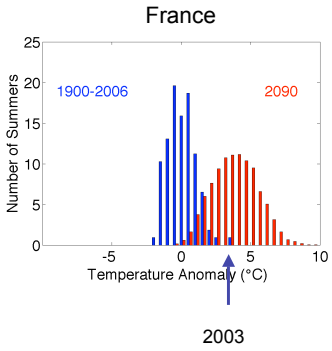
Refs: UNEP 2007; Easterling 2007; Earth Policy Institute 2006; Eurosurveillence 2005

Growing Season Temperature



Observed JJA Temp (1900-2007)

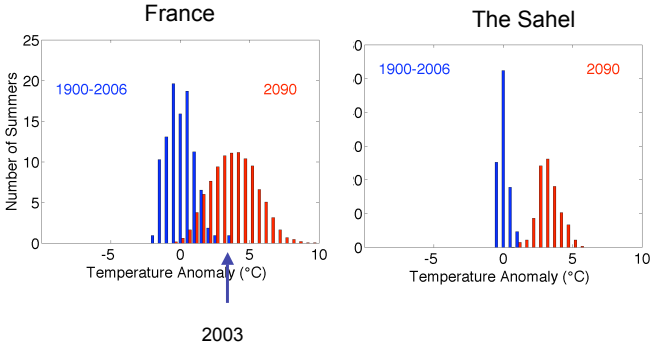
Projections of Growing Season Temperature



Observed JJA Temp (1900-2007)

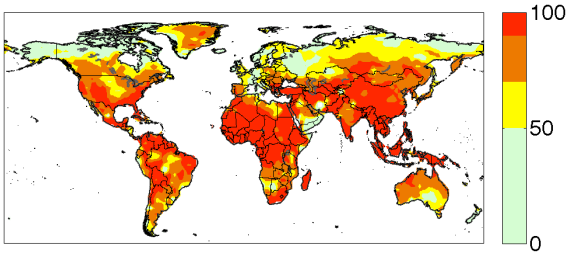
Projections use 22 climate models (IPCC AR4) forced by A1B Emission scenario. Variability taken from observations

Projections of Growing Season Temperature



Projections of Growing Season Temperature

Percent of Summers in 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

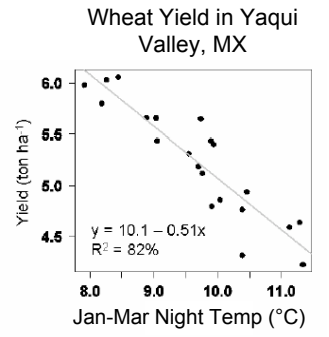
Battisti and Naylor 2008

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

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**



Lobell 2007

Impacts of Climate Change on Food Security

Impacts of increased temperature (only):

- Reduced yields of wheat, rice and soybeans in the tropics/subtropics
  - Approximately -10% per 1ºC warming
  - Est. reduction of 30-40% by 2100 in India, Southern Africa, Middle East, 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
- Increased flooding in midlatitudes and tropics (increase intensity of precipitation on drier soils

Impacts of changing precipitation:

- Reduced yields and in some places abandonment of staple crops (many of these regions are marginal for crops presently grown)
- Leaching of nutrients in soil

Impacts of Climate Change on Food Security

Other impacts of climate change on agriculture

- *Changes in pest and pathogens (yet unknown)*
- 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 net negative impact in tropics/subtropics for all crops (C3 and C4)
  - Effects on soil BGC
  - Effects on plant pathology (reduced protein content and resilience to disease)
- Sea level rise: about 35cm by 2100
  - salinization and loss of arable land

Summary: World-wide impact on Crops

- By 2100, growing season temperatures will *very likely* exceed the warmest on record throughout the tropics and subtropics
  - ⟹ 30-40% reduction in yields of major crops (plant physiology)
- In subtropics, crops will be further stressed by reduced rainfall
- Increased CO_2 (fertilization) effect is small (~10% for doubling CO_2)
- Pest and Pathogens (stay tuned)

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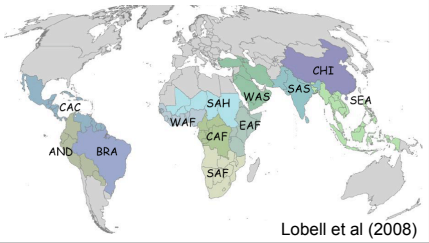
- 95% are in the tropics/subtropics



Lobell et al (2008)

Estimates: 200-400M *more* people at risk of hunger by 2080 due to climate change

The food insecure
- 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