Climate Change and Indiana Agriculture

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What is Climate Change? (and...... what it isnt!)
Weather & Climate

Some Common Definitions:

➢ Weather refers to the atmospheric conditions at a specific time and place. This includes: temperature, humidity, rainfall, and wind.

➢ Climate refers to the general weather patterns expected in some region. Often these expectation are based on 30 year or longer averages.

➢ Climate may also be applied more generally to large scale weather patterns in time or space, i.e. a tropical climate.

Climate Change & Global Warming

➢ Climate Change:
  Any systematic change in the state of the atmosphere (temperature, humidity, rainfall or winds) sustained over several decades or longer.

➢ Global Warming:
  An increase in the average temperature of the atmosphere near the Earth's surface and in the troposphere [lower atmosphere], which can contribute to changes in global climate patterns.

➢ Global warming can occur from a variety of causes, both natural and human induced.
A Brief History of “Global Warming”

Source: National Center for Atmospheric Research

Key to IPCC (Intergovernmental Panel on Climate Change) climate projections: How will CO2 levels change?

Source: IPCC 2001 SRES
Global Annual Average Surface Temperature

Referenced to the 1980-1999 Average Temperature

Solid lines: average of all models used. Number of models used varies; shaded area is the standard deviation of the models

(Source IPCC AR4 Fig 10.4)

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

(Source IPCC AR4 Fig 10.8)

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

(Source IPCC AR4 Fig 10.12)

Potential Impacts / Problems

<table>
<thead>
<tr>
<th>Phenomenon and direction of trend</th>
<th>Likelihood that trend occurred in late 20th century (physically post 1960)</th>
<th>Likelihood of a human contribution to observed trend</th>
<th>Likelihood of future trends based on projections for 21st century using SRES scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmer and fewer cold spells and nights over most land areas</td>
<td>Very likely</td>
<td>Likely</td>
<td>Virtually certain</td>
</tr>
<tr>
<td>Warmer and more frequent hot days and nights over most land areas</td>
<td>Very likely</td>
<td>Likely</td>
<td>Virtually certain</td>
</tr>
<tr>
<td>Warm spells/heat waves. Frequency increases near most land areas</td>
<td>Likely</td>
<td>More likely than not</td>
<td>Very likely</td>
</tr>
<tr>
<td>Heavy precipitation events. Frequency (or proportion of total rainfall from heavy rainfall) increases over most areas</td>
<td>Likely</td>
<td>More likely than not</td>
<td>Very likely</td>
</tr>
<tr>
<td>Area affected by droughts increases</td>
<td>Likely in many regions since 1990s</td>
<td>More likely than not</td>
<td>Likely</td>
</tr>
<tr>
<td>Intense tropical cyclone activity increases</td>
<td>Likely in some regions since 1970</td>
<td>More likely than not</td>
<td>Likely</td>
</tr>
<tr>
<td>Increased incidence of hurricanes high on land (excludes tsunami)</td>
<td>Likely</td>
<td>More likely than not</td>
<td>Likely</td>
</tr>
</tbody>
</table>
Thresholds for temperature changes

Projected impact of climate change

Global temperature change (relative to pre-industrial)

<table>
<thead>
<tr>
<th>°C</th>
<th>0°C</th>
<th>1°C</th>
<th>2°C</th>
<th>3°C</th>
<th>4°C</th>
<th>5°C</th>
<th>6°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td></td>
<td></td>
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<td>Possible rising yields in some high latitude regions</td>
<td>Falling crop yields in many areas, particularly developing regions</td>
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<tr>
<td>Water</td>
<td>Small mountain glaciers disappear - water supplies threatened in several areas</td>
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<td>Significant decreases in water availability in many areas, including Mediterranean and Southern Africa</td>
<td></td>
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<td>Data level rise threatens major cities</td>
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<tr>
<td>Ecosystems</td>
<td>Extensive damage to coral reefs</td>
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<tr>
<td>Extreme weather events</td>
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<tr>
<td>Risk of abrupt and major irreversible changes</td>
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Summary of Future Climate Change

- Higher CO₂ concentrations
- Higher Temperatures (regional changes warming/cooling possible)
- Regionally varying Precipitation changes (higher in temperate regions; lower in tropical and subtropical regions)
  - Newer climate regimes will develop
Climate Change / Agriculture Future

- Growing season change
  - Longer if temperature dominated as in Midwest; shorter if (if precipitation dependent as in tropics)

- Pests and diseases threat increases (weed migration)

- Crops grown in confined zones or horticulture crops
  - may show less capacity to adapt
  - may show less variability in available genotypes to easily adopt in new growing areas

- Crops grown over larger areas may reach extremes
  - e.g. day and night temperature, rice cultivation, possible for other crops

Projected changes in agricultural productivity due to climate change including the CO2 fertilization effect

Courtesy: Bellagio Conference/AR4
Loss in wheat production due to climate change (CO2 and temperature interactions) over India*

![Bar chart showing loss in wheat production due to climate change.](chart)

*assuming no change in area planted and irrigation availability

Source: P. Agarwal, IARI @ Bellagio

Examples of positive and negative feedbacks of climate – agriculture interactions

Examples include:
- Carbon dioxide fertilization
- Increased growing seasons
- Increased precipitation
- More frequent droughts
- Pest and heat stress
- Faster growing periods
- Increased flooding and salinization

Climate change and soil carbon sequestration (Source: Tubiello, 2002; Scientific American and C. Rosenzwig NASA/GISS Senate testimony, July 8, 2003)
MAJORITY OF OUR UNDERSTANDING IS TOP DOWN.

ARROW THICKNESS IS LOOSELY LINKED TO HOW WELL THE FEEDBACK HAS BEEN STUDIED.

- Will agriculture be controlled under climate change umbrella?
- How can agriculture help control climate change?

National Research Council report: Conceptual framework of climate forcing, response, and feedbacks
Agricultural emissions of green house gases

- Agriculture already considered a significant source of methane, nitrous oxide, carbon dioxide in current assessment
  - Animal Waste
  - Soil Emissions
  - Fertilizer Use
- (Exact emission factors, types continue to be updated)
- *Expect this to be scrutinized further.*

Emerging National Research Needs for Agricultural Air Quality

*Fig. 1. Atmospheric emissions, transport, transformation, and deposition of trace gases.*
Example of change in agricultural land use over the past century

Change in land use corresponds to change in rainfall patterns in a weather model:

Top slide: rains due to natural vegetation

Middle slide: rains due to current vegetation

Bottom slide: difference
• SW Australia, approximately 13 million hectares of native vegetation cleared for agriculture
• A 750km vermin proof fence demarcates the boundary between cleared and pristine areas
• 20% reduction observed in rainfall over agricultural areas

Courtesy: US Nair, UAH
Effect of agriculture intensification on thunderstorms

IL-IN F4 Tornado simulation (13 July 2004)
More agricultural landscape → More transpiration → more water vapor in the atmosphere → more potential for thunderstorms?

Agricultural intensification in Midwest will also lead to population and economic growth, and urbanization
Urbanization and land use change leads to regional temperature changes (warming = Urban Heat Island)

Average Temperatures in July for Urban & Rural Areas

La Porte Jul 01 Avg Temp
Midway Jul 01 Avg Temp

Urban landscape change also lead to rainfall changes!
Thunderstorms can be dangerous but they are also a major source of rainfall over the Midwest
Indiana climate data does not show much change in temperature or rainfall trends. Most changes are geographical or land use dominated. (This may change in future as CO2 levels continue to increase)

So with more agricultural intensification.....

- Two pathways depending on availability of soil moisture (and other resources)

More agricultural landscape $\rightarrow$ More transpiration $\rightarrow$ more water vapor in the atmosphere $\rightarrow$ more thunderstorms and more rain with higher variability?

OR

More transpiration $\rightarrow$ drier soils $\rightarrow$ more drought potential?
Final thought

• Temperature effect will be regional and crop specific (frost or pollination; generally possible to mitigate by adaptive techniques or technology)

• CO2 effects will lead to winners and losers HOWEVER impact also depends on rainfall changes and water availability.

• So… follow the water – If abundant, those regions may be more resilient to climate change.

• The coupled feedback of agriculture on climate is currently under represented in most assessments – expect this appreciation to grow.

• Changes in agriculture practices can affect regional climate – look for mitigation management practices as opportunities.

• Expect more scrutiny as well as opportunities in the future.

Thank you!

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