Climate Science for Agriculture
Challenges and Opportunities of Using Climate Model Projections

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Key Themes
Facing the “Practitioners Dilemma”

Data  Evaluation  Translation  Best Practice
Tools: Weather vs Climate
Trying to bridge the gap

Forecast Lead

Initial Conditions

Climate Prediction

Forecast

Weather Prediction

Outlook

Guidance

Watches

Alerts

Threats

Assessments

Months

Seasons

Years

Minutes

Hours

Days

1 Week

2 Week

Forecast Change

Climate

Boundary Conditions

Forecast Uncertainty

Space Affected

Protection of Life & Property

Flood Mitigation & Navigation

Space Operation

Transportation

Fire Weather

Hydropower

Agriculture

Reservoir Control

Recreation

Ecosystem

Energy

Health

Commerce

State/Local Planning

Environment
Weather Modeling needs good initial conditions
Tools to Study Climate
From global radiation to regional processes and impacts
Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes (Figure SPM.6 and Table SPM.1). This evidence for human influence has grown since AR4. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. {10.3–10.6, 10.9}
Projected Changes in selected Episodes

Intra-Seasonal Variability

when wet : wetter..
when dry : drier...

IPCC AR5 2013
Stage 1. **1870 control run:** 1000 years with constant 1870 forcing: Solar, GHG, Volcanic Sulfate, O3

Stage 2. **Historical:** 1870-2000 run using time-evolving, observed, Solar, GHG, Volcanoes, O3

Stage 3. **Future Scenarios:** 4 2000-2100 IPCC Scenarios from end of historical run

**Ensemble Climate Simulations**

- **1870 control run:**
  - 1000 years with constant 1870 forcing: Solar, GHG, Volcanic Sulfate, O3

- **Historical:**
  - 1870-2000 run using time-evolving, observed, Solar, GHG, Volcanoes, O3

- **Future Scenarios:**
  - 4 2000-2100 IPCC Scenarios from end of historical run

**Graphical Representation:**

- **Stage 1.** 1870 control run from 1870 to 1870 with constant forcing.
- **Stage 2.** Historical run from 1870 to 2000 using time-evolving, observed forcings.
- **Stage 3.** Future Scenarios run from 2000 to 2100 with four different scenarios (A1, A1B, B1, Commit).
But data availability is not enough
... challenges to be aware of ...

Understanding climate data and information production “chain”:
• Resolution issues - processes representation
• Key climate indices that best encapsulate impacts and vulnerabilities
• Model biases and a cascade of uncertainties, exposing assumptions
• Internal variability: “weather” vs “climate” (do ensembles)
• Limited understanding (“change in variability”) - flexible Scenarios
New Focus on Regional Climate and Impacts

Integration of data and knowledge across scales.
Global - to - Local

e.g.: Agriculture
Is there an App for that?

What data should I use? Which is the best? What does it mean? Just give me the number!
A bit like the Wild West out there...
High Resolution Modeling

**Current Nesting:** WRF
Chem, hurricane, crop, hydro...

**Next Generation:** MPAS
Model for Prediction across Scales
GFDL CM 2.1 Downscaled document differences: txx, max, July

BCCA

ARRM

ECP2

RCM3

HRM3
Data: Precipitation ≠ Precipitation
Application-specific evaluation needed

Gorakhpur: Monsoon
Nebraska: Drought
Hex River: Flash Flood
DaNang: Typhoon
USDA: From Evaluation to Translation

e.g.: Change in Number of Frost Days
#Tropical Nights (August)

ARRM

BCCA

WRF-G
Appropriate Ensembles”

How does a passenger jet look like?

- Is the average meaningful?
- Not independent information
- Better and worse information
- Does it reflect the what we think the uncertainty is?

Two issues: sampling and weighting
Internal Variability:
Temperature Trend 2006-2060
(40 member ensemble, different initial conditions)

Deser et al. 2012
But how are we going to explore all possible options, from both science and management perspectives?
Sequence of Events
(daily, season, inter annual)
Facing the “Practitioners Dilemma” through Communities of Practice
Acknowledging and Responding to Agricultural Annual Decision Cycle

from Gene Takle, U2U
Challenges to making science more useful

- **Data** accessibility, in application-oriented, useful form (format, index, resolution)

- **Evaluation**: Information about the data across the production “chain” vs observations, ensembles

- **Translation of Scientific Knowledge** for exploration of impacts of change, guidance of use, transparency of uncertainties

- **Community of Practice** that collaboratively develops data requirements and scenarios

  But often black-box hand down:

  - no standardization (indices, usefulness)
  - no regional ensemble analysis concept
  - no coupling to context

But need for: sustainable solutions, not “fixes”
Climate change poses unprecedented challenges to the U.S. agriculture industry.

Without significant adaptation measures, costs and losses will rise dramatically.

Food security will be threatened worldwide.
Climate Change and Agriculture in US Research Needs

- Improve projections of future climate conditions for time scales of seasons to multiple decades; change and duration of average and extreme temperatures, precipitation, and related variables (e.g., evapotranspiration, soil moisture).

- Evaluate and develop process level understanding of the sensitivity of plant and animal production systems, including insect, weed, pathogen, soil and water components, to key direct, indirect and interacting effects of climate change effects.

- Develop and extend the knowledge, management strategies and tools needed by US agricultural stakeholders to enhance the adaptive capacity of plant and animal production to climate variability and extremes. While existing management and agronomic options have demonstrated significant capacity for expanding adaptation opportunities, new adaptive management strategies, robust risk management approaches, and breeding and genetic advances offer much potential, but have yet to be evaluated.
Seamless Integration
Weather - Season - Climate

Observations
Weather Forecast
Seasonal Outlook
Climate Projection
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Thanks!

Building Climate Services with and for you

UCAR/NCAR CLIMATE SERVICES

Earth System Observations and Modeling
Research to understand our Planet

Translation for Impacts Understanding
Providing context for applied problems

Data Visualization and Delivery
Putting data into the hands of stakeholders

Training and Education
Preparing our nation’s workforce

Decision Support
Helping users on the ground

UCAR / NCAR Climate Services Capabilities

Who We Are
• NCAR: Hundreds of scientists; state-of-the-art ground-based and airborne research capabilities and supercomputing facilities
• UCP: Science support programs for data delivery, visualization and archiving; training and education; logistical and program support
• 104 national and international partner Universities

What We Do
• Scientific Leadership: Develop, coordinate and facilitate climate science
• Translation: Climate science interpretation and context for stakeholders
• Support for Climate Services: End-user focused approaches for data, evaluation, training and education; logistical support for national and international programs
• Standards: Establish community protocols and best practices for data, community modeling, and analysis
• Community Building: Create impactful connections between scientists and stakeholders
• Next generation: Capacity building through Universities for the global marketplace
• Decision Support: End-to-end tailored solutions and applications

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