

# Climate Extremes: The Science, Impacts, and Policy Relevance

Presented by

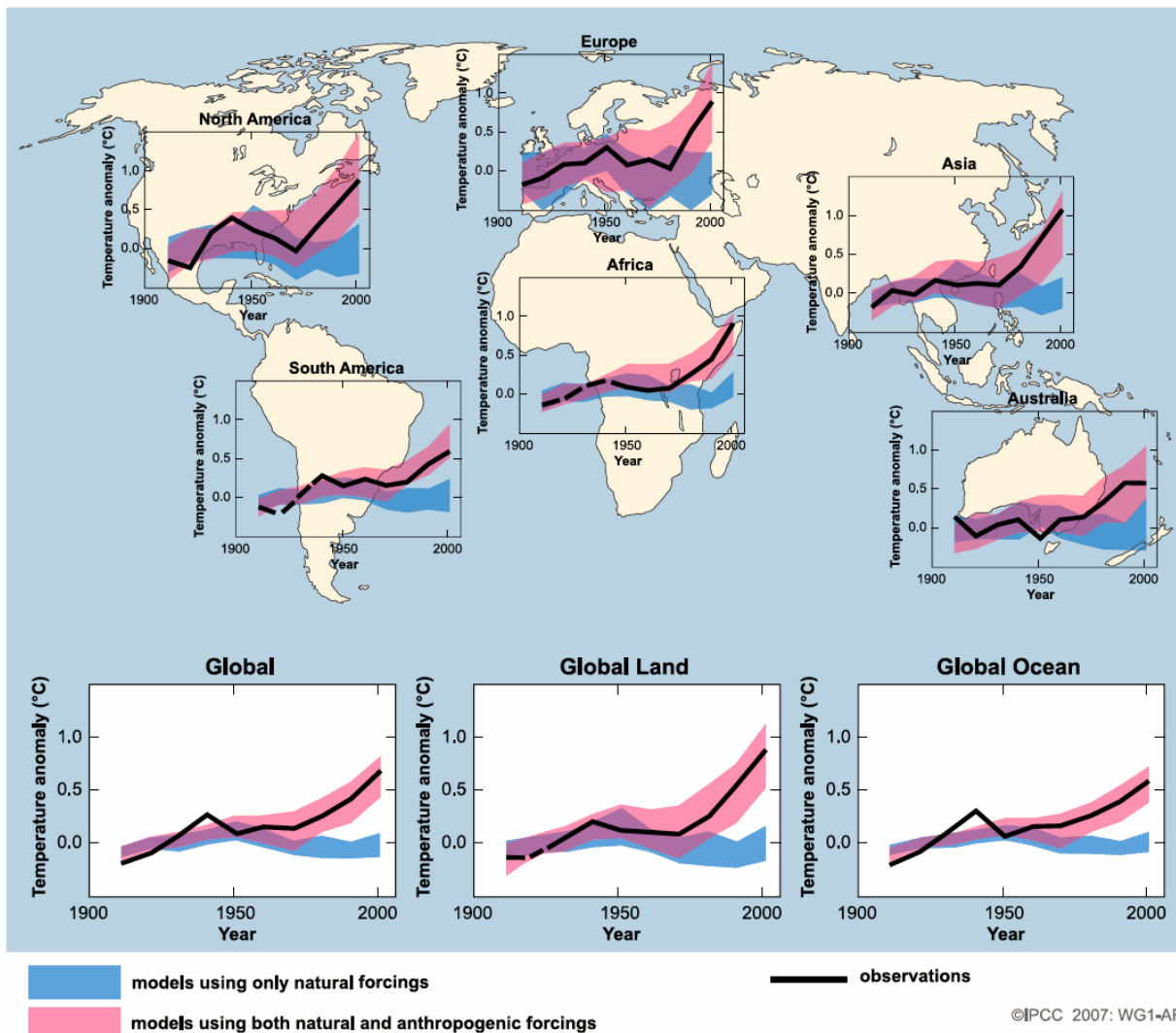
**Auroop R. Ganguly**

Geographic Information Science  
and Technology

Computational Sciences and Engineering



# Global warming is credible: Without anthropogenic emissions, we would have a slight cooling trend (IPCC AR4)



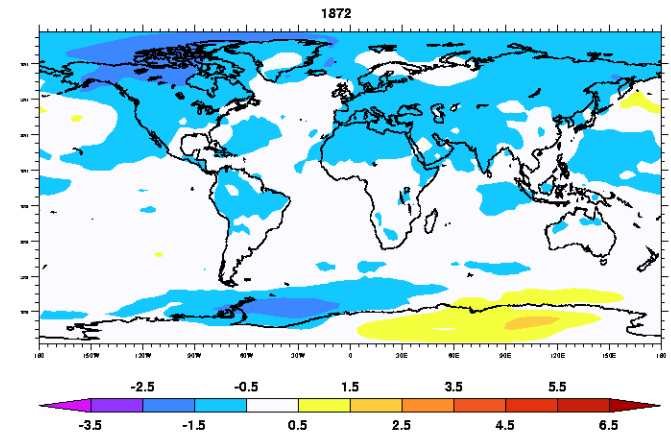
Courtesy:  
IPCC AR4

©IPCC 2007: WG1-AR4

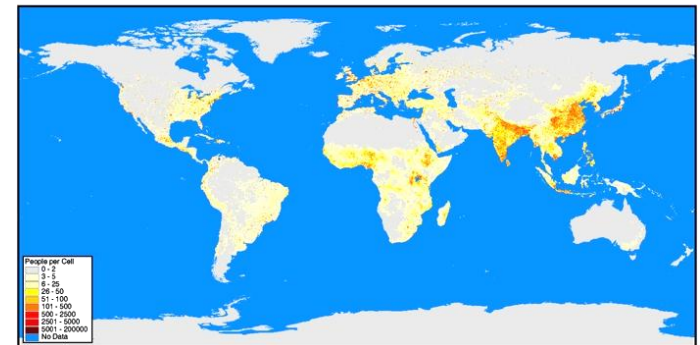
# Knowledge gaps exist in the science of climate change and impacts

- Feedback among climate, land use, and population distribution
- Climate-induced hazards and infrastructure impacts
- Spatiotemporal translation of regional climate impacts on local decisions

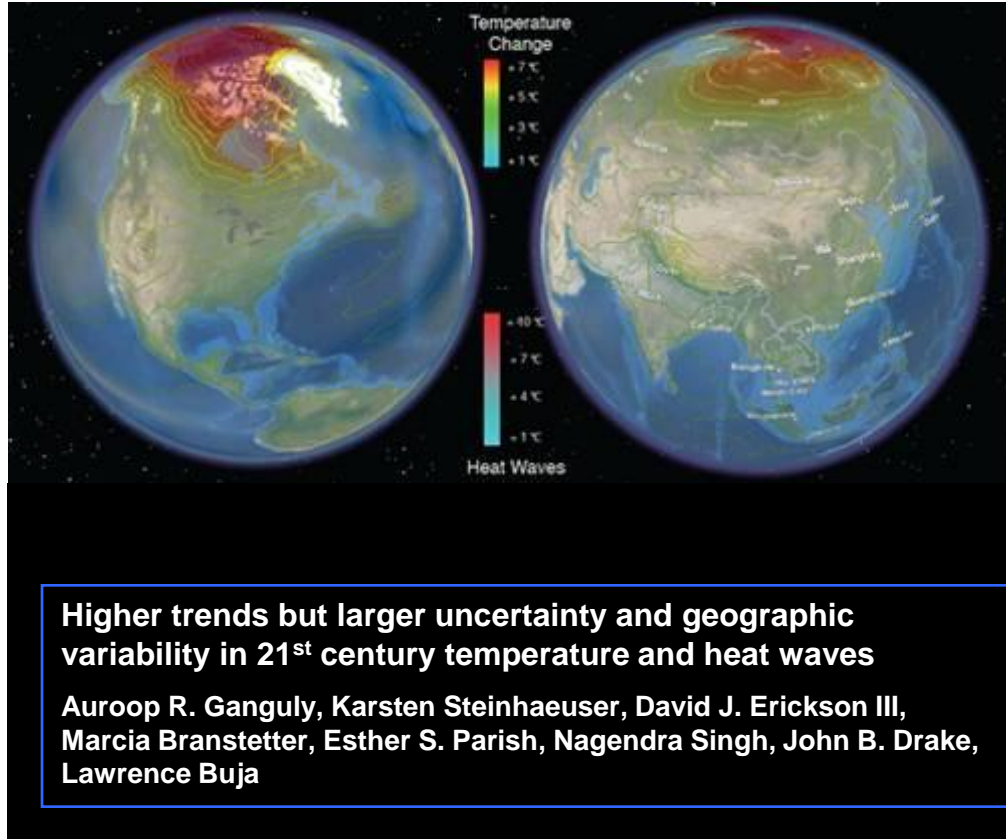
Surface air temperature change from 1980-2000 average



Population  
ORNL LandScan Global Population Project



# Predicted extremes may be larger but so is associated uncertainty



- **Comprehensive statistical analysis of climate model simulations for fossil fuel intensive scenario suggests:**
  - Higher global and regional warming trends with worsening heat wave trends
  - Worsening temperature extremes but larger uncertainty, especially at regional scales
- **Regional warming and intense heat waves concurrent with larger uncertainty point to the need for both urgency and caution in preparedness and mitigation**

PNAS

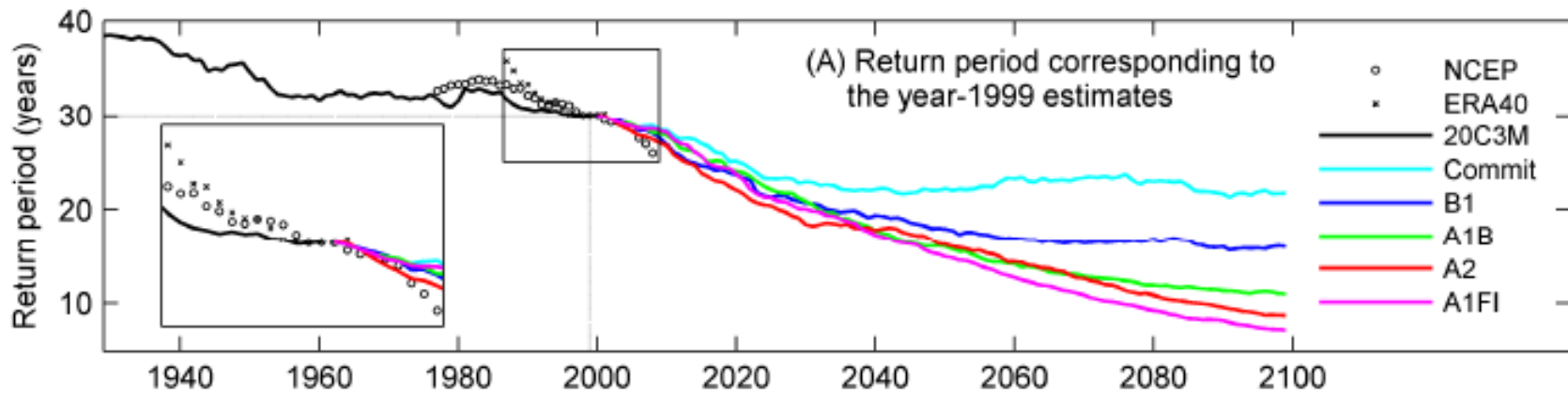
Proceedings of the National Academy of Sciences of the United States of America

www.pnas.org



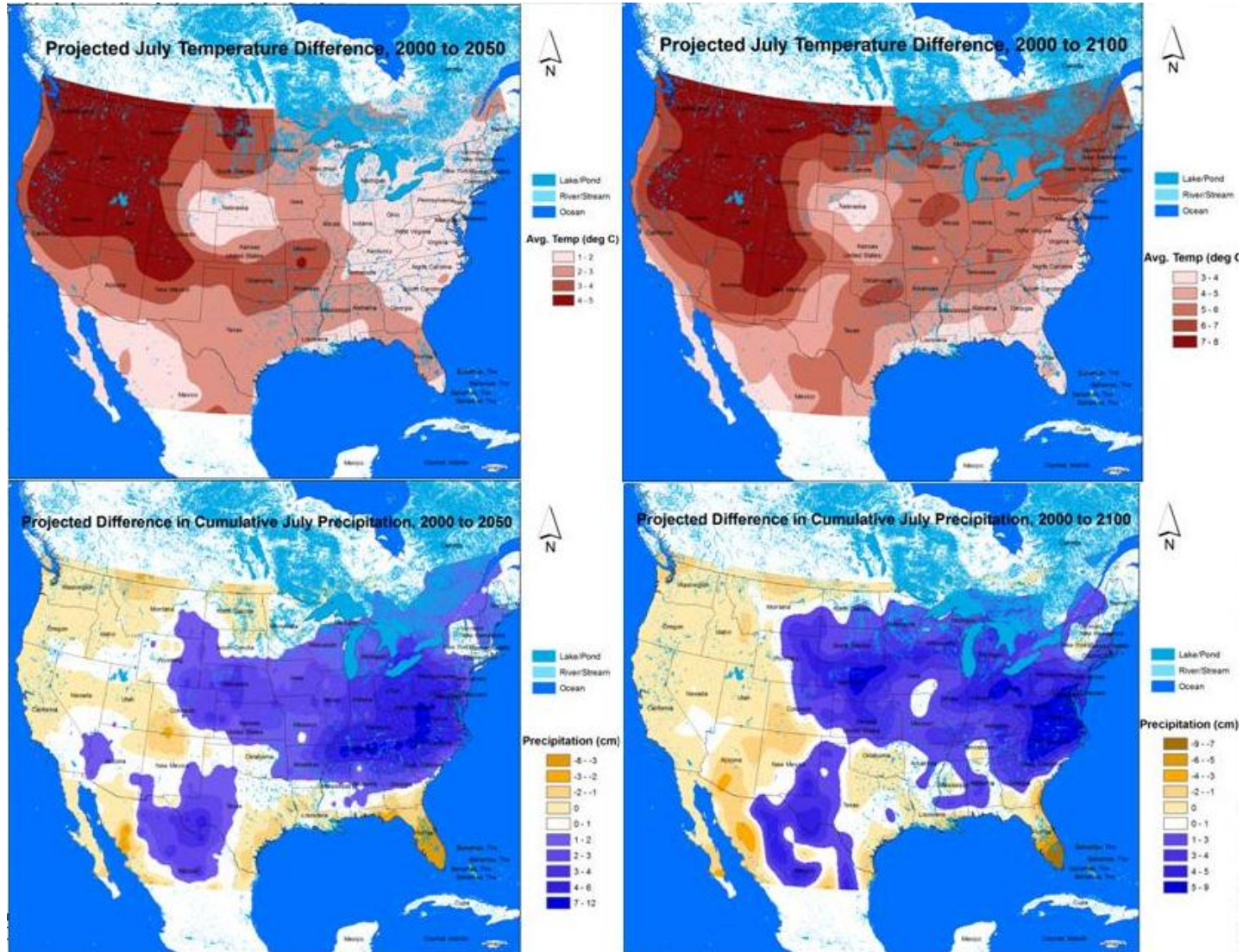
# Severe storms projected to grow more intense and frequent with changing climate

Central Tendency (Median) of Return Levels Based on All Land Grids



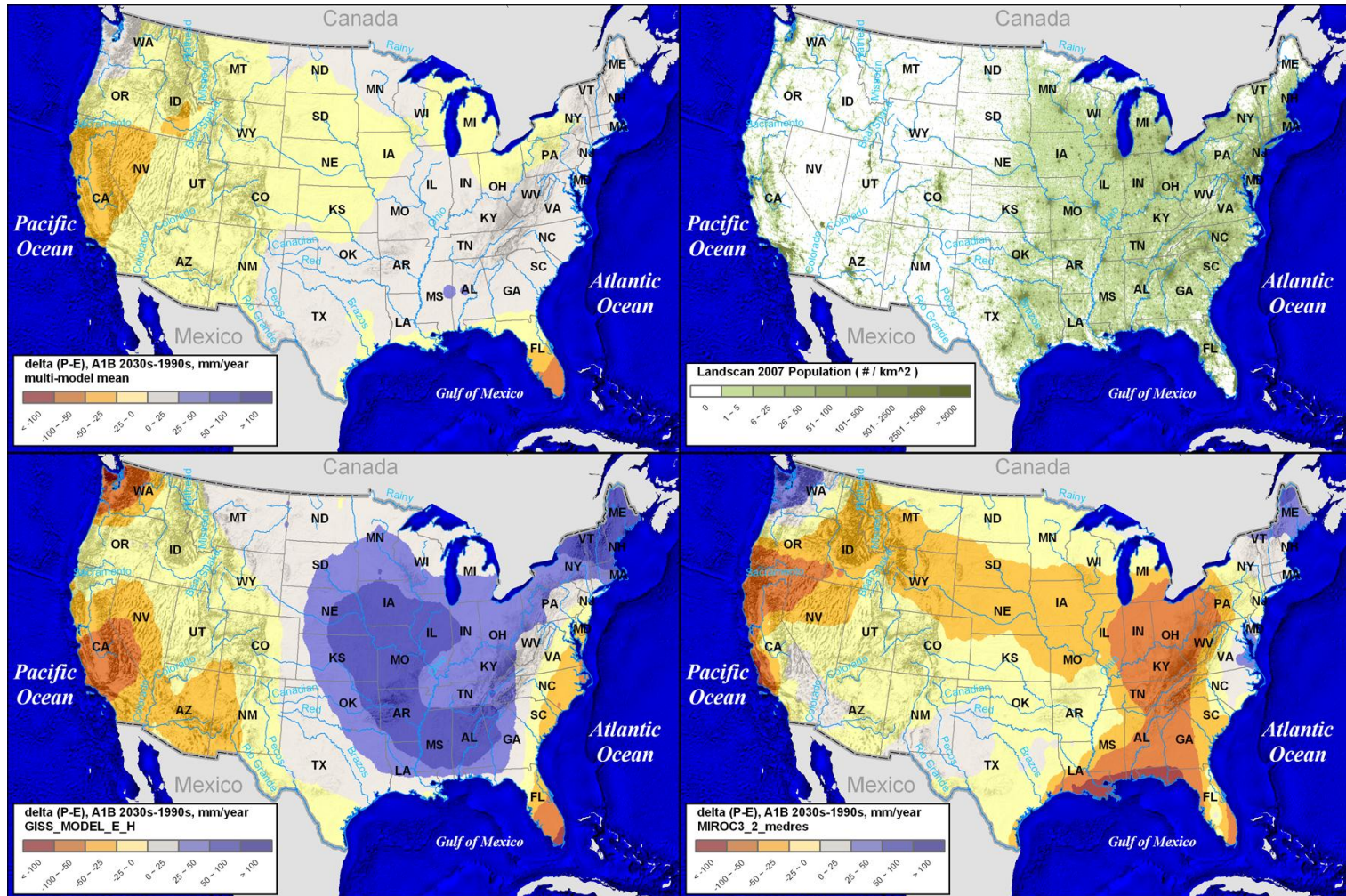
1. Observed trends match modeled trends (correlation: NCEP: 0.89; ERA40: 0.97)
2. Observed trends suggest even worse extremes than the worst case from CCSM3
3. Best case and commit project much less, showing the value of mitigation policies
  - A. Statistical checks for
    - a) Suitability of Extreme Value Theory (EVT) based on GEV
    - b) Estimation of EVT (GEV) parameters (with uncertainty)
  - B. Moving windows for nonstationary extremes
  - C. Match between modeled and observed trends

# Credible projections of local to regional scale climate extremes is a key: Dire possibilities

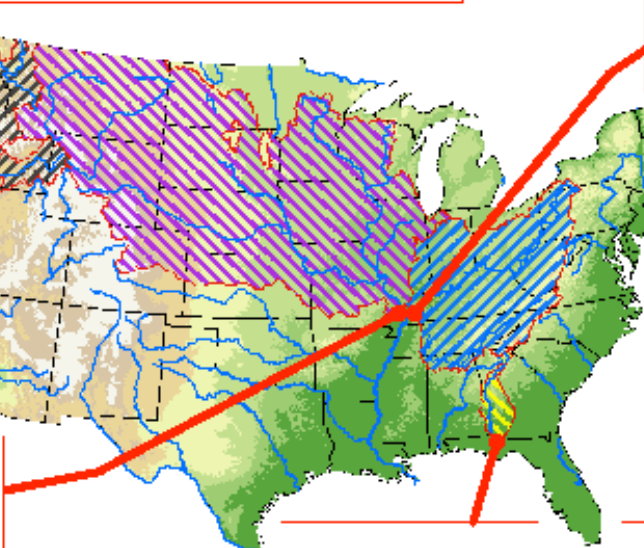
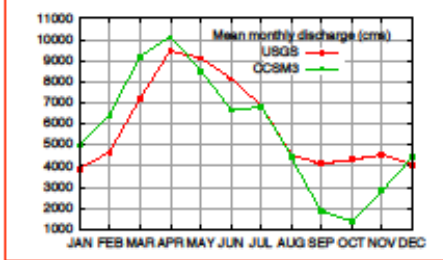
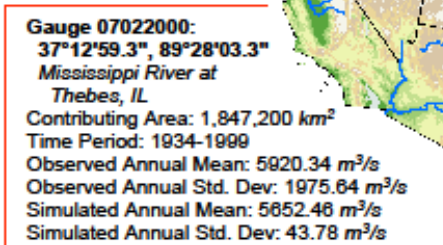
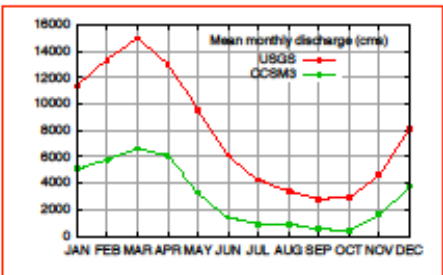
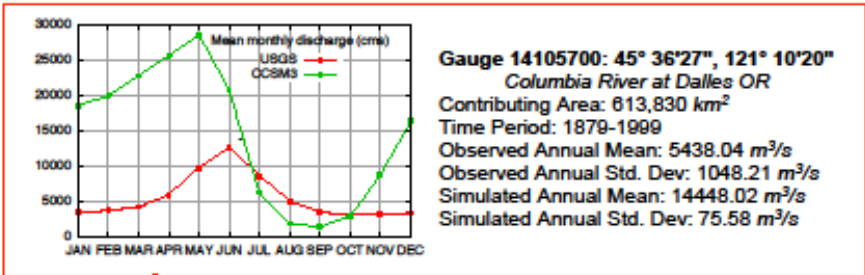




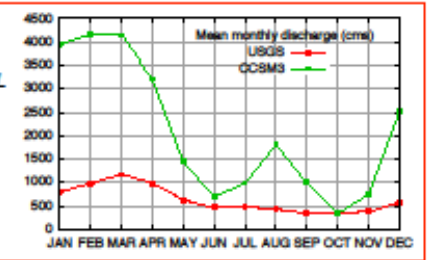
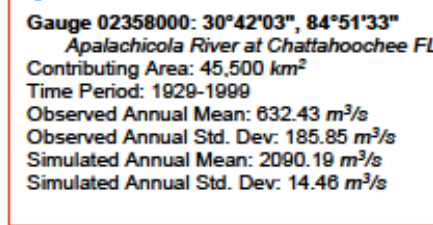
# Credible projections of local to regional scale climate extremes is a key: Large uncertainty



# River flow projections have larger uncertainties

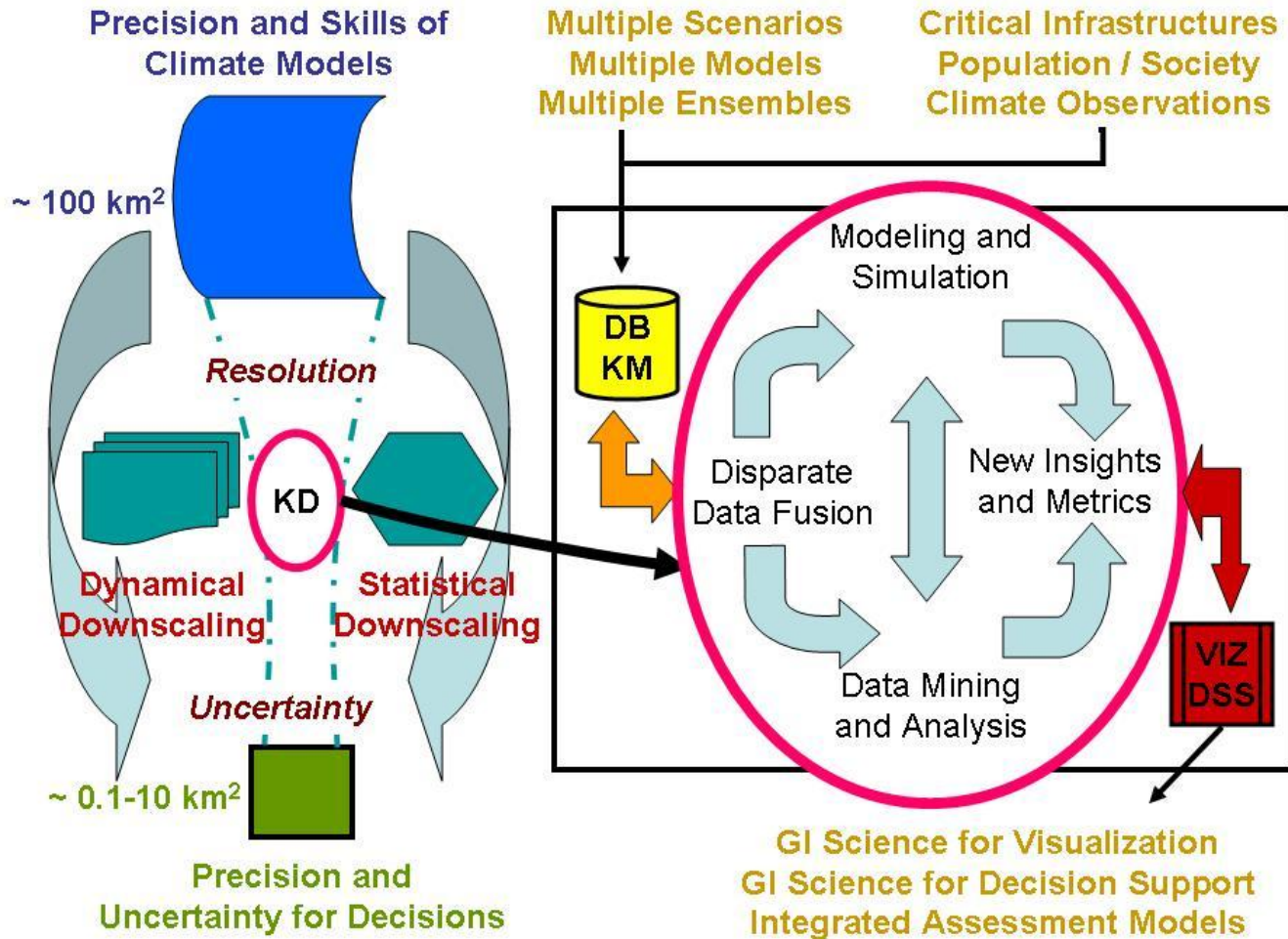


- CCSM3 Resolution: 1.4°
- CAM (Atmosphere): 1.4°
- CLM (Land - Overall): 1.4°
- CLM (Routing Only): 0.5°

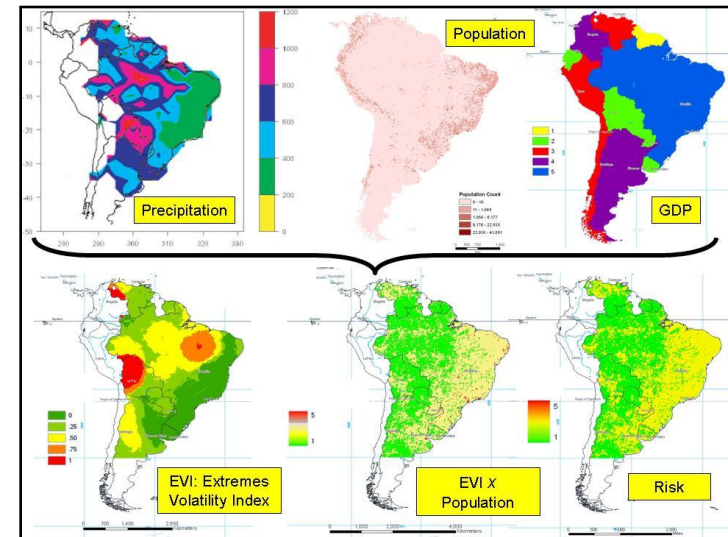
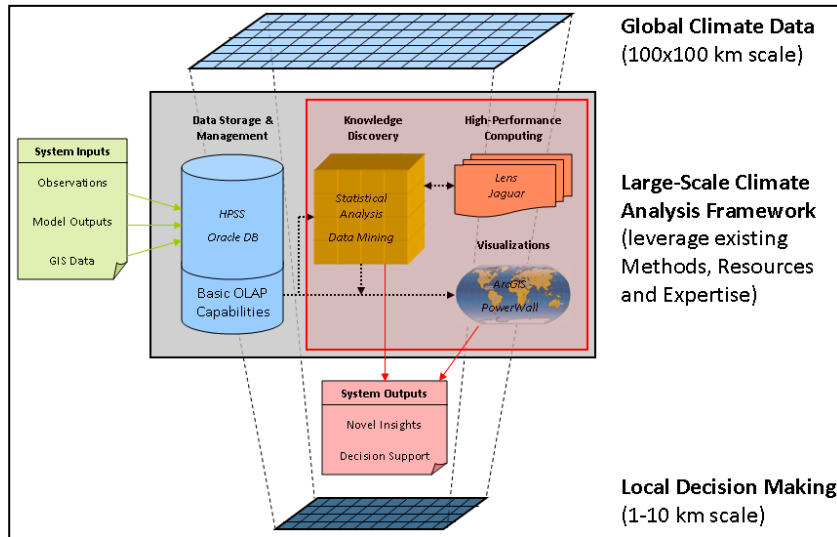




# Our goal is to translate climate model simulations to decision and policy tools

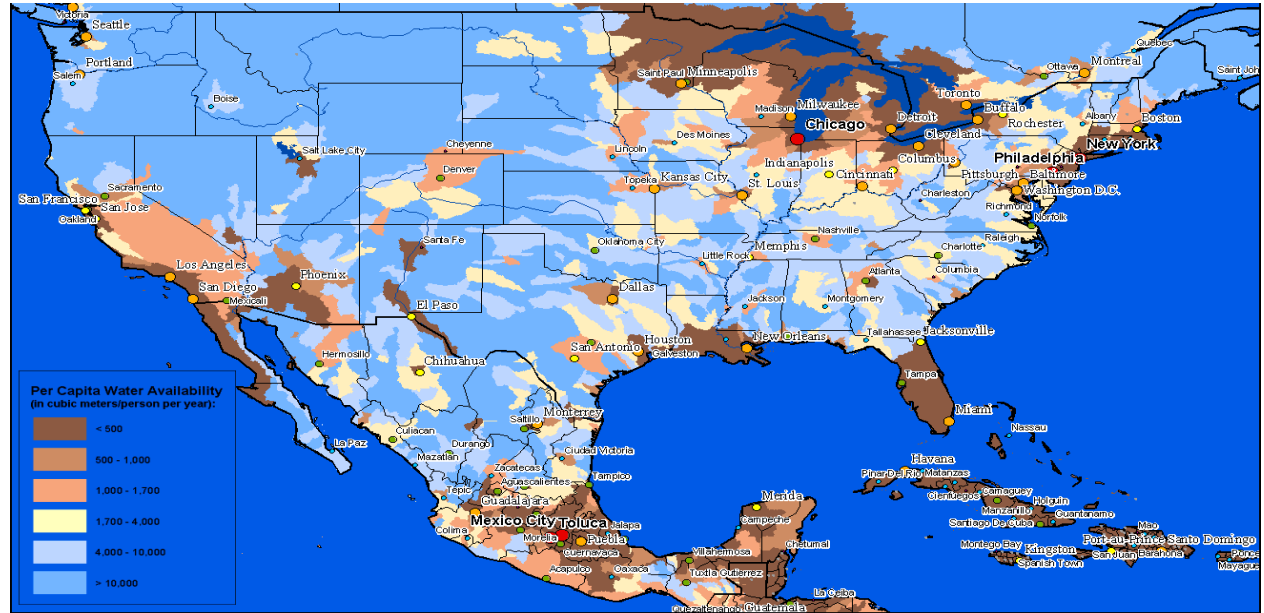
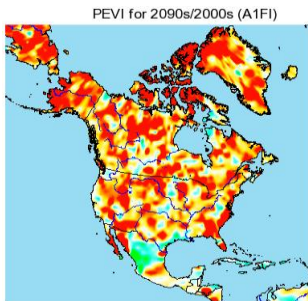
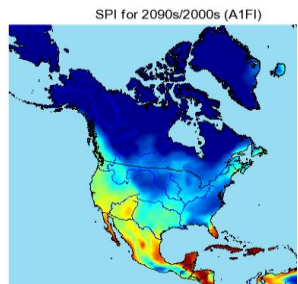
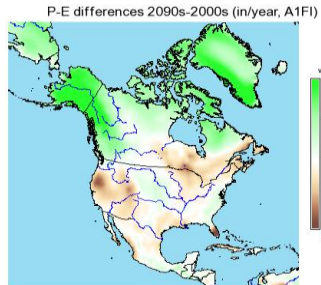


# Understanding uncertainties and formulating risk strategies for adaptation remain challenging

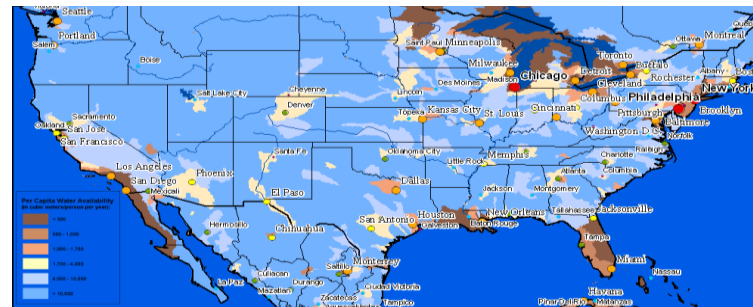


- **Current generation of climate models has significant uncertainties at regional and decadal scales of interest to decision makers**
- **Climate extremes, defined here as large shifts in regional climate patterns and changing likelihoods of severe events, may bridge the gap**
- **The challenge in going from climate prediction to integrated assessments is translation to risks or characterization of uncertainty**

# Despite knowledge gaps, credible insights can be generated: U.S. water resources in the 21st century



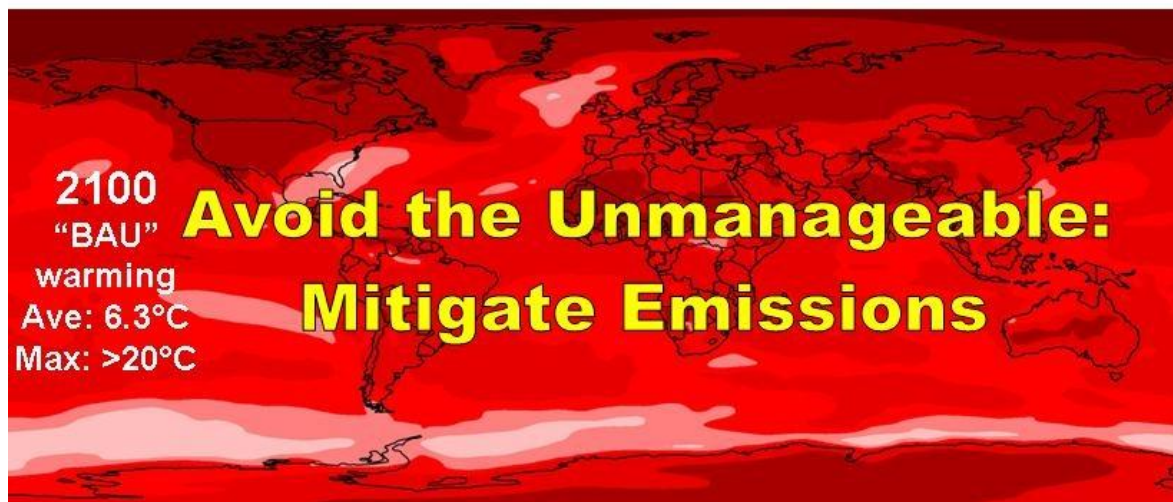
## Worst-Case Projected Per Capita Water Availability by 2100\*



## Current Per Capita Water Availability\*

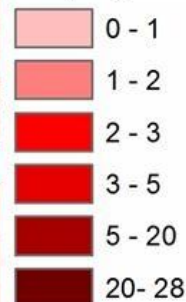


# Policy tools: Supporting a climate change war game involving international policy makers



## Nature Blogs

Temp.  
Difference  
(°C)

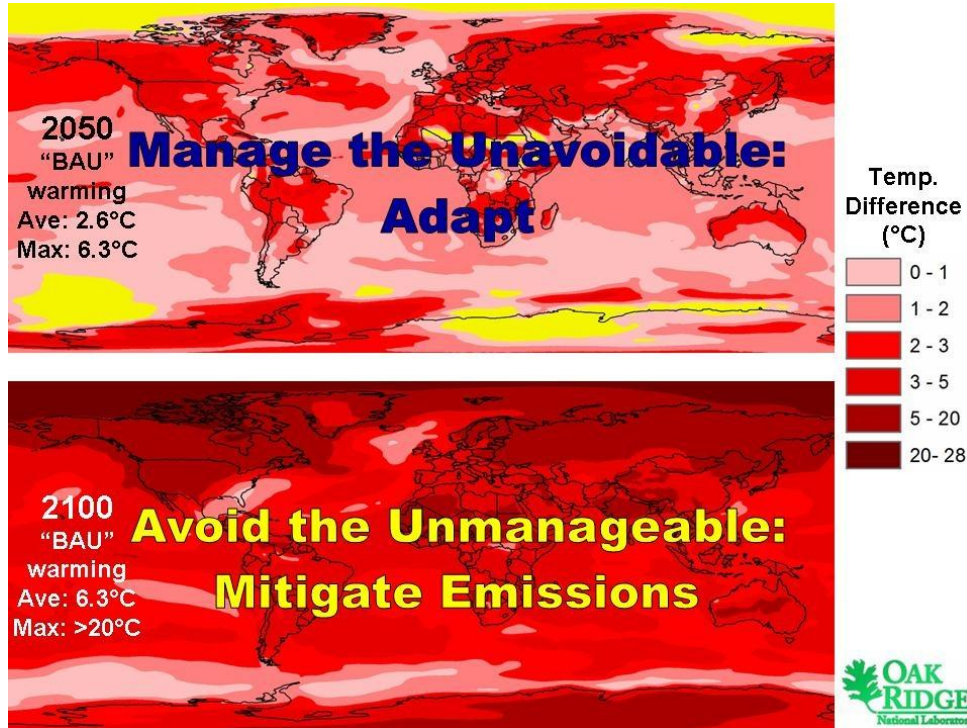


### Courtesy

Nature Blog (Tollefson)  
CNAS (John Podesta) Pew  
Center (Gulledge)  
CNAS (Sharon Burke)



# A climate change war game engaged policy makers in a role-playing exercise prior to Cop15



## Four Negotiation Areas

- Water and food resources
- Hazards and humanitarian aid
- Migration and population shifts
- Reduction of GHG emissions

## Nature Blogs

Published online 5 August 2008 | Nature | doi:10.1038/454673a

News

**nature**news

## Climate war games

Role-play negotiations test the outcomes of global warming.

[Jeff Tollefson \(/news/author/Jeff+Tollefson/index.html\)](/news/author/Jeff+Tollefson/index.html)

# Decision support: Climate Support for DOD's 2010 Quadrennial Defense Review (QDR) Report

From the FY08 National Defense Authorization Act (Section 951, "Department of Defense Consideration of Effect of Climate Change on Department Facilities, Capabilities, and Missions"):

"The first *Quadrennial Defense Review* prepared after the date of the enactment of this subsection shall also **examine the capabilities of the armed forces to respond to the consequences of climate change, in particular, preparedness for natural disasters from extreme weather events and other missions the armed forces may be asked to support inside the United States and overseas.**"

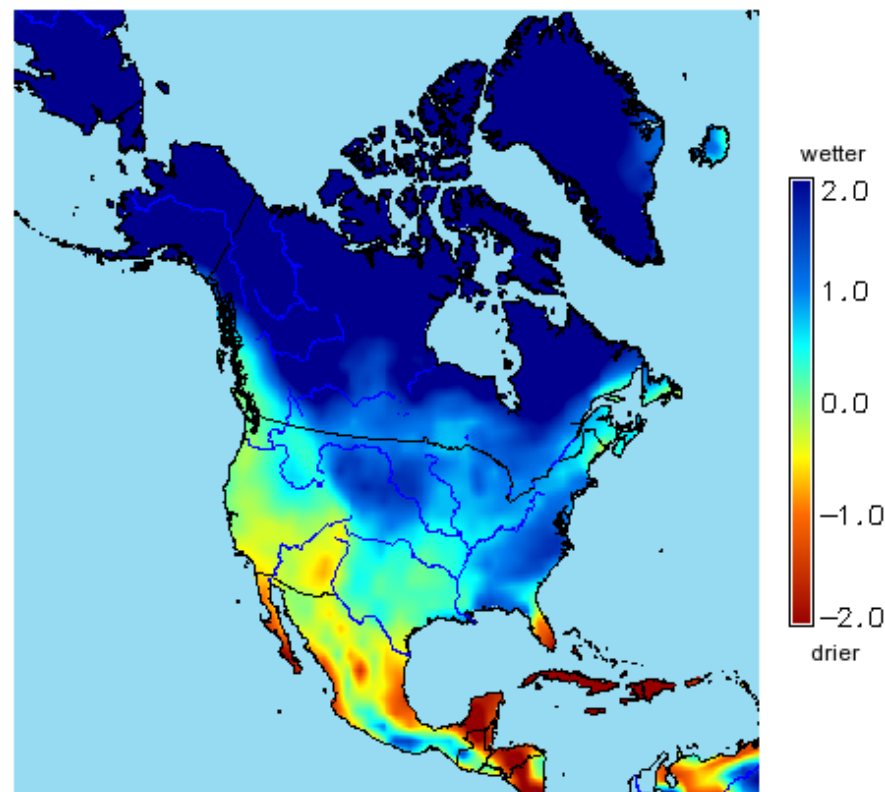


<http://www.ornl.gov/knowledgediscovery/QDR/>



# NORTHCOM: Intensification of droughts

- General shift in Atlantic hurricane intensity might be expected by 2100 for A1FI
- Desertification in the western U.S. can be contrasted with wetter conditions in the southeastern U.S.
- Warming greatest in winter
- Water scarcity and wildfires



2100 A1FI  
Water Availability Index

# Acknowledgements

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<http://www.ornl.gov/knowledgediscovery/ClimateExtremes>

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