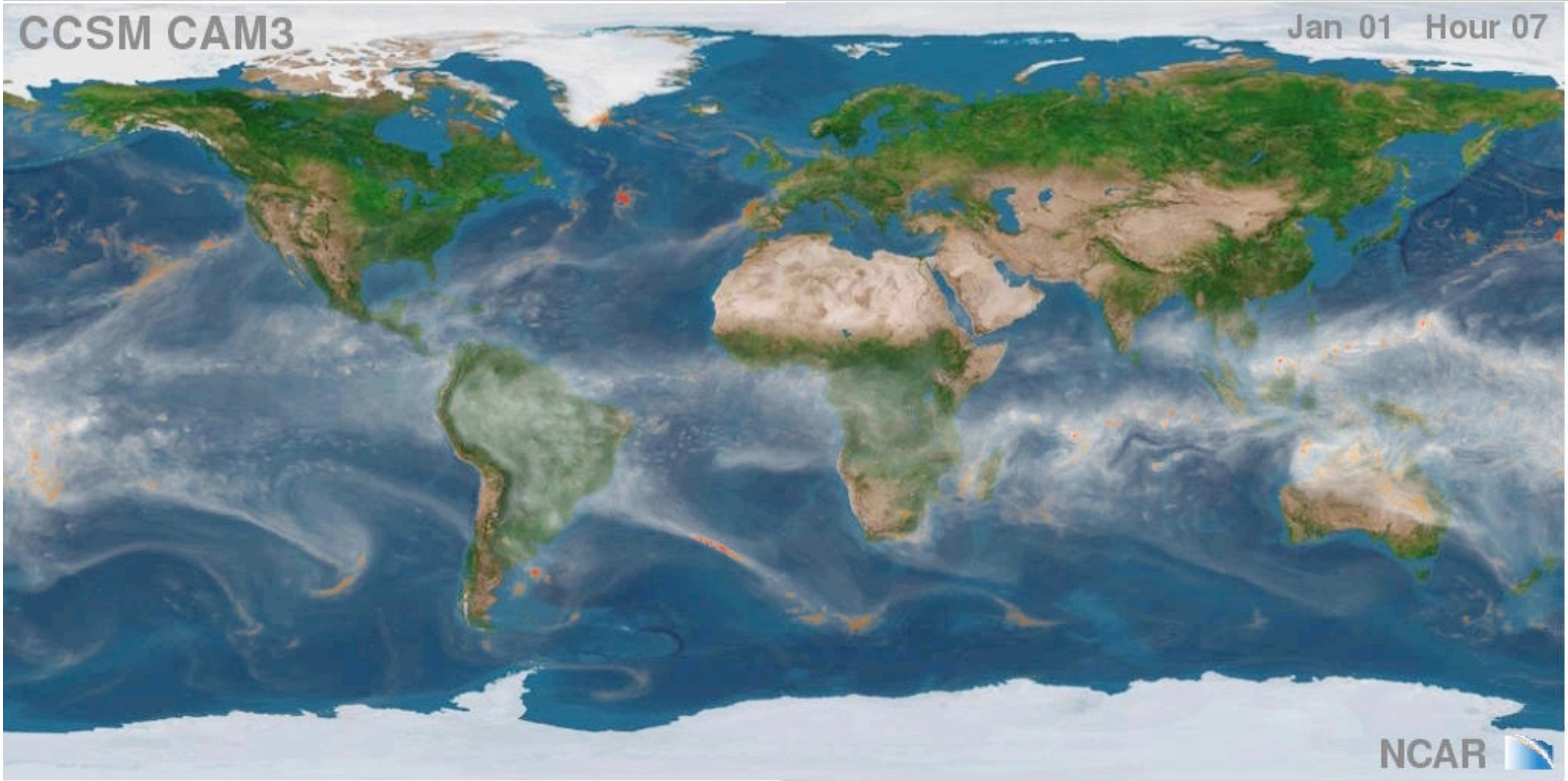
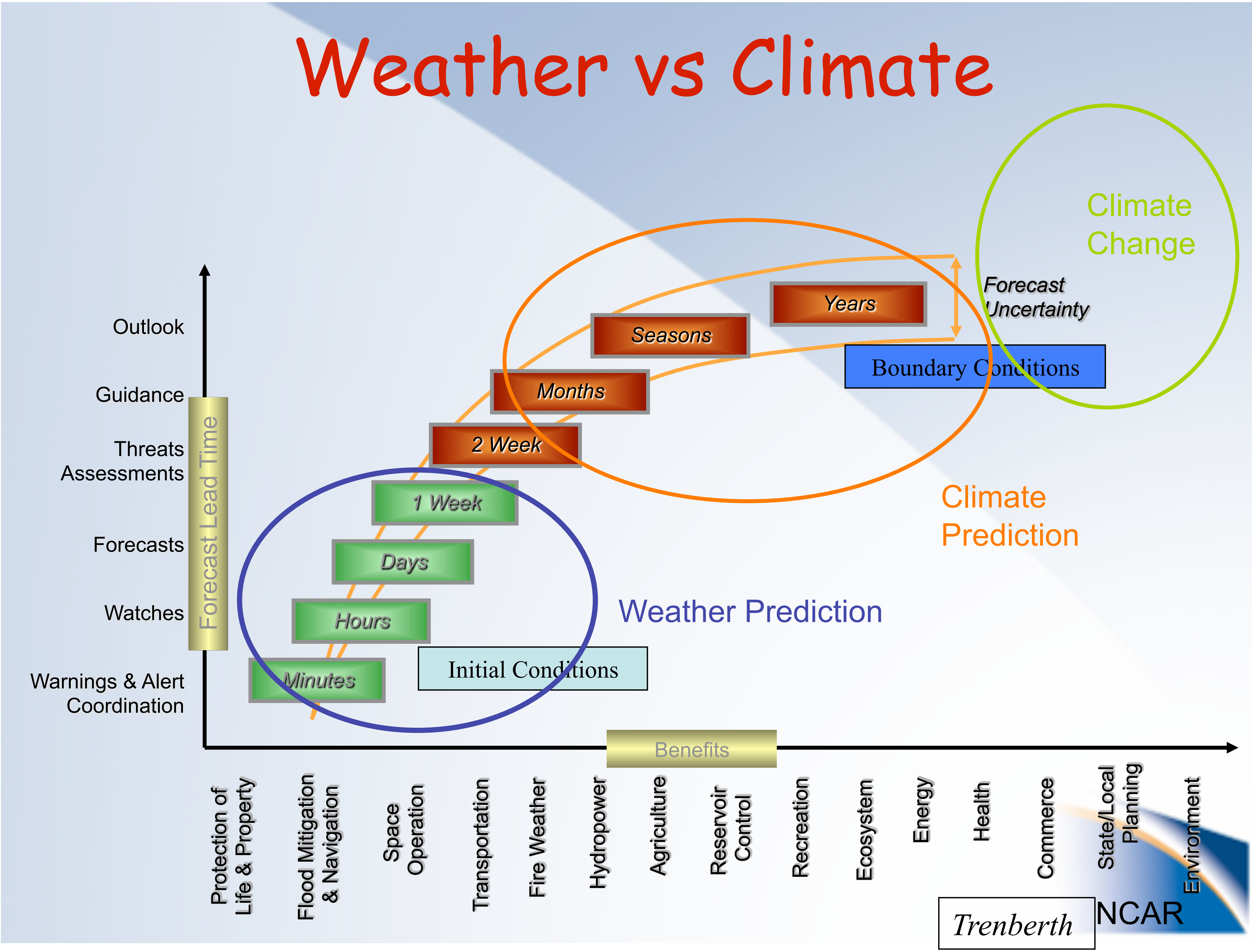
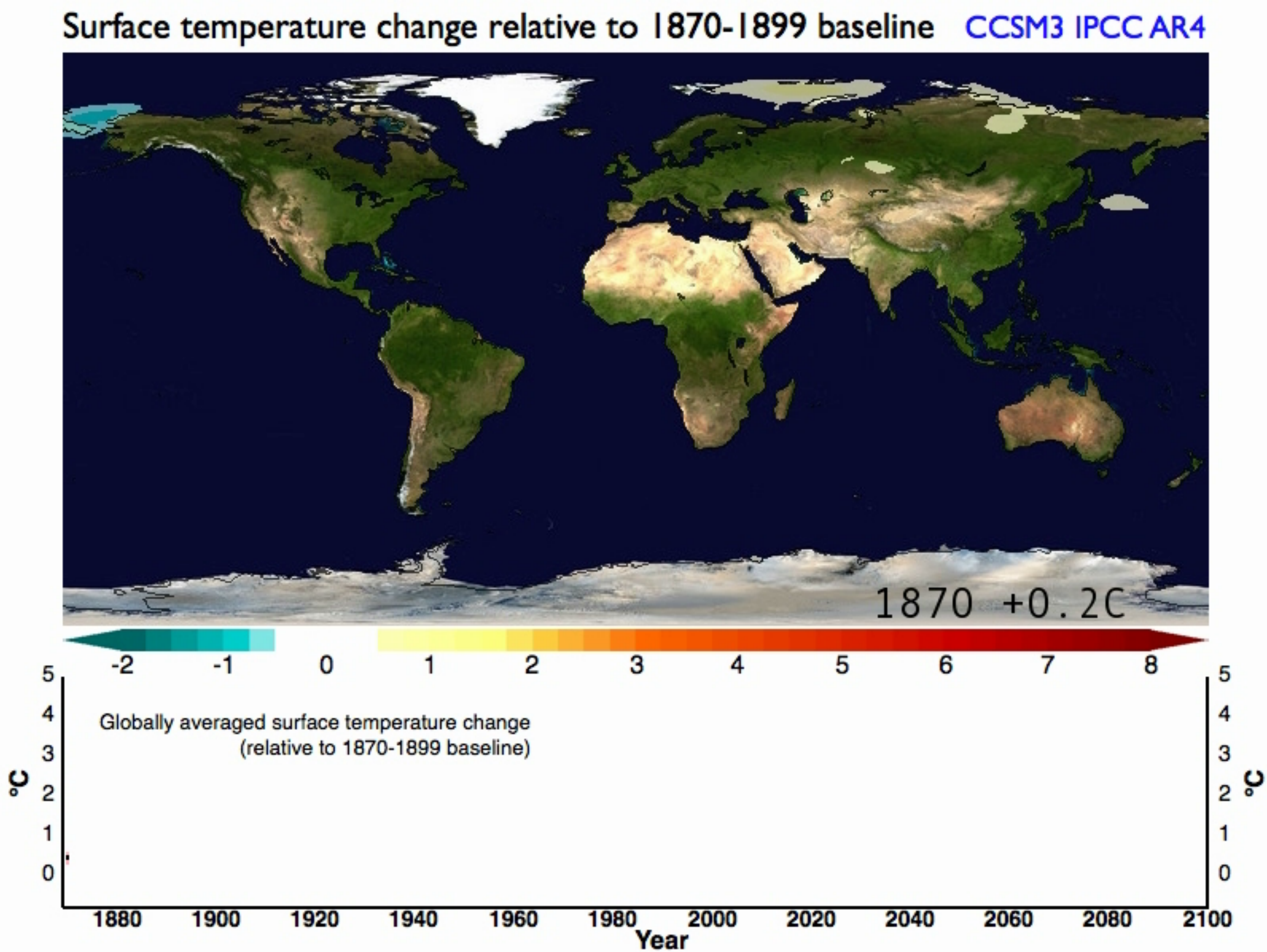
Climate Modeling in a Changed World



CAM T341- Jim Hack

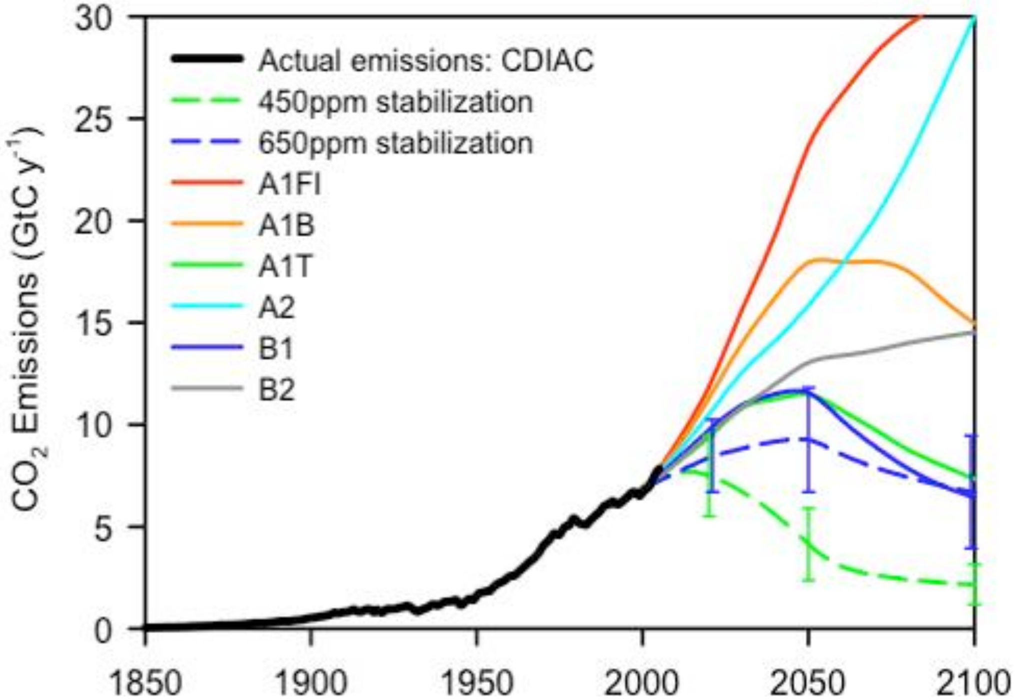
Lawrence Buja southern@ucar.edu
National Center for Atmospheric Research
Boulder, Colorado

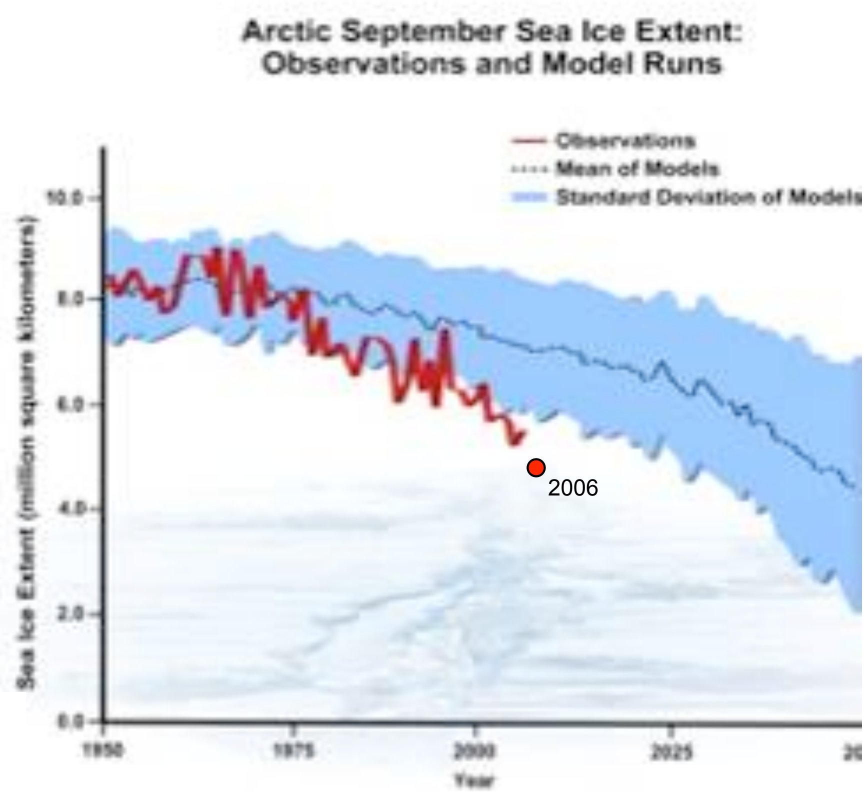

Weather vs Climate
Climate Change
Forecast Uncertainty
Years
Seasons
Boundary Conditions
Months
2 Week
1 Week
Days
Hours
Minutes
Initial Conditions
Climate Prediction
Weather Prediction
Outlook
Guidance
Threats Assessments
Forecasts
Watches
Warnings & Alert Coordination
Forecast Lead Time
Benefits
Protection of Life & Property
Flood Mitigation & Navigation
Space Operation
Transportation
Fire Weather
Hydropower
Agriculture
Reservoir Control
Recreation
Ecosystem
Energy
Health
Commerce
State/Local Planning
Environment
Trenberth
NCAR

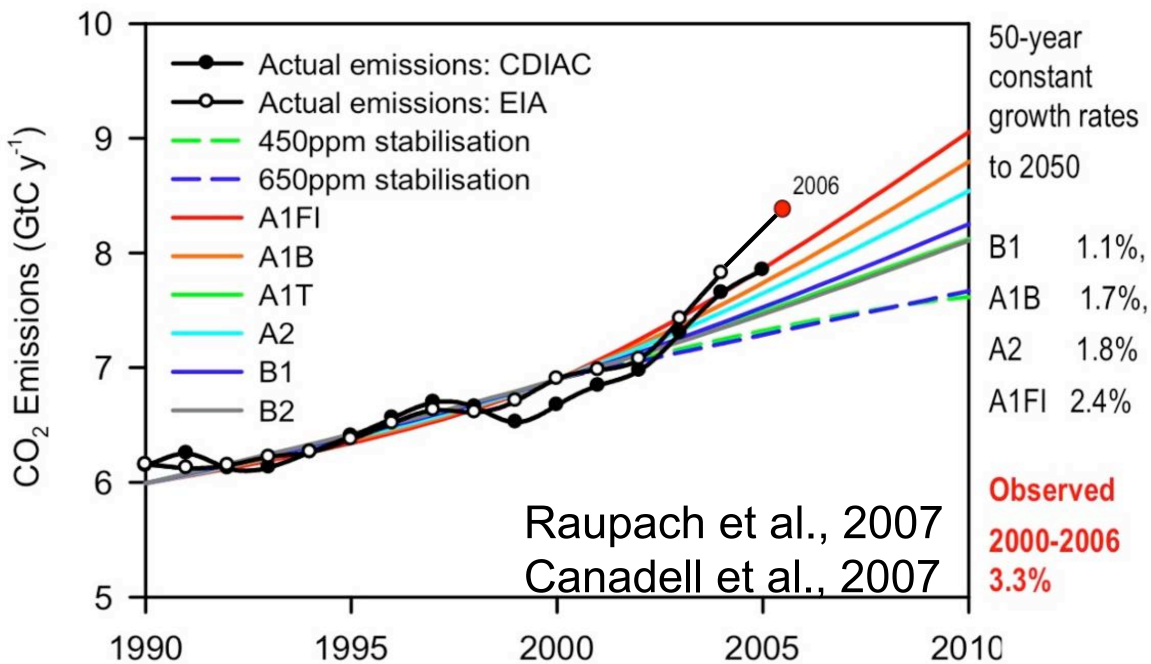


Surface temperature change relative to 1870-1899 baseline
CCSM3 IPCC AR4
1870 +0.2C
-2
-1
0
1
2
3
4
5
6
7
8
Globally averaged surface temperature change
(relative to 1870-1899 baseline)
°C
Year

Is the IPCC being too Alarmist?







If anything, we are being much too conservative!

Since AR4, the questions society is asking climate change science dramatically changed.

WAS: Is anthropogenic climate change occurring?

NOW: What will be the of impact of anthropogenic climate change on coupled human and natural systems?

- Magnitude and speed… in specific regions and sectors?
- Direct and indirect impacts?
- Adaptation vs mitigation
- What are our options & limits?

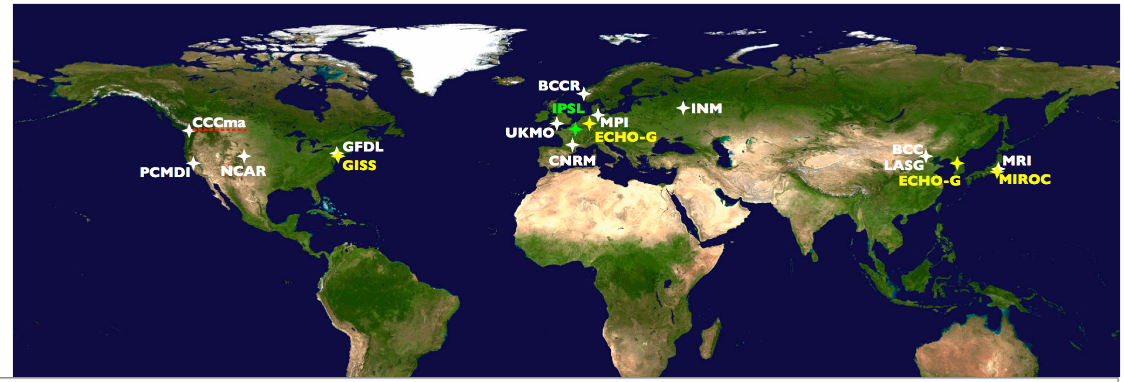
> Addressing these new, much more complex, questions requires

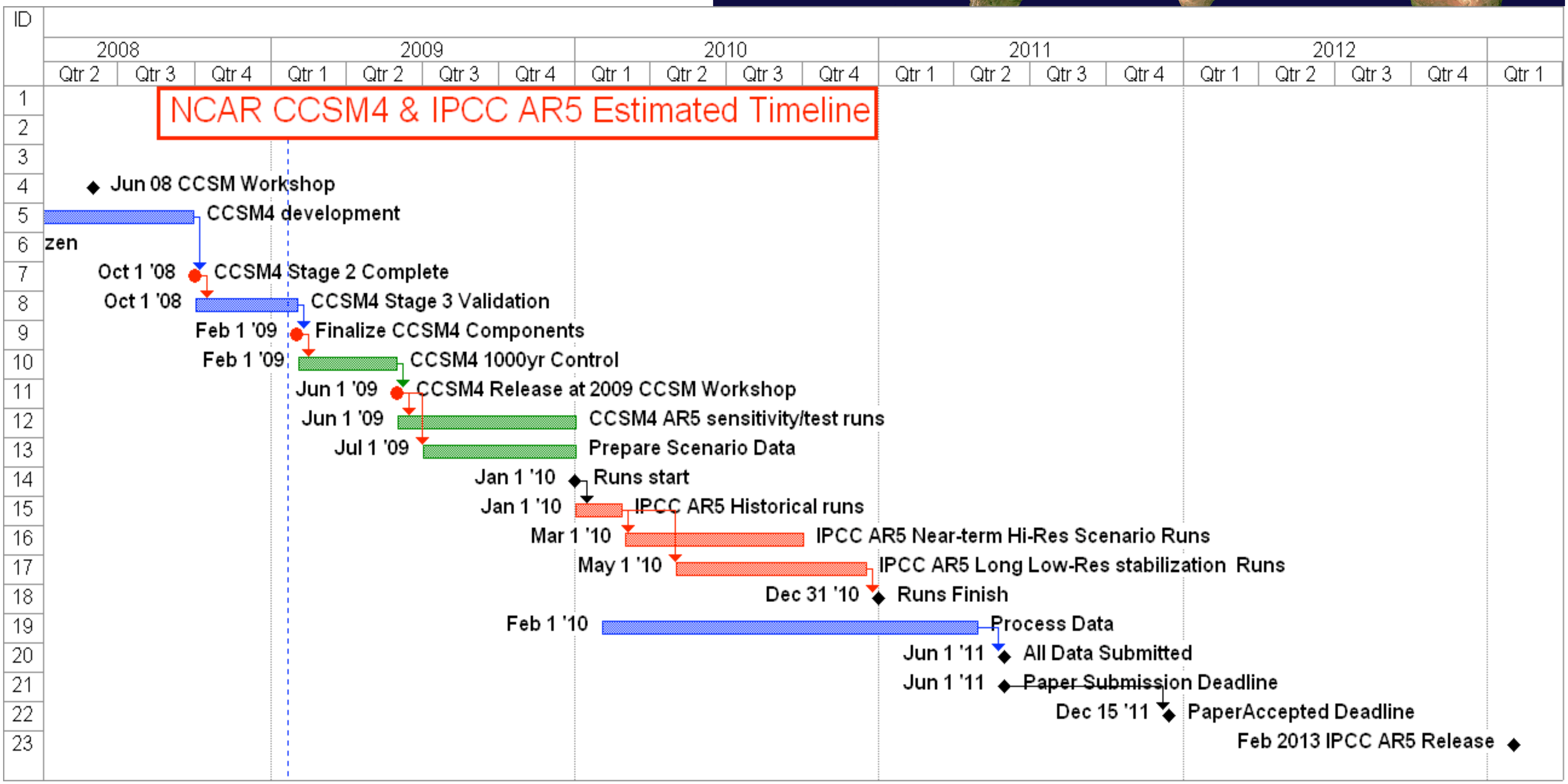
- new approaches & priorities,
- new science capabilities,
- new collaborators/partners

> Vast improvements still req'd for Climate Models & Observation

Image courtesy of Canada DND

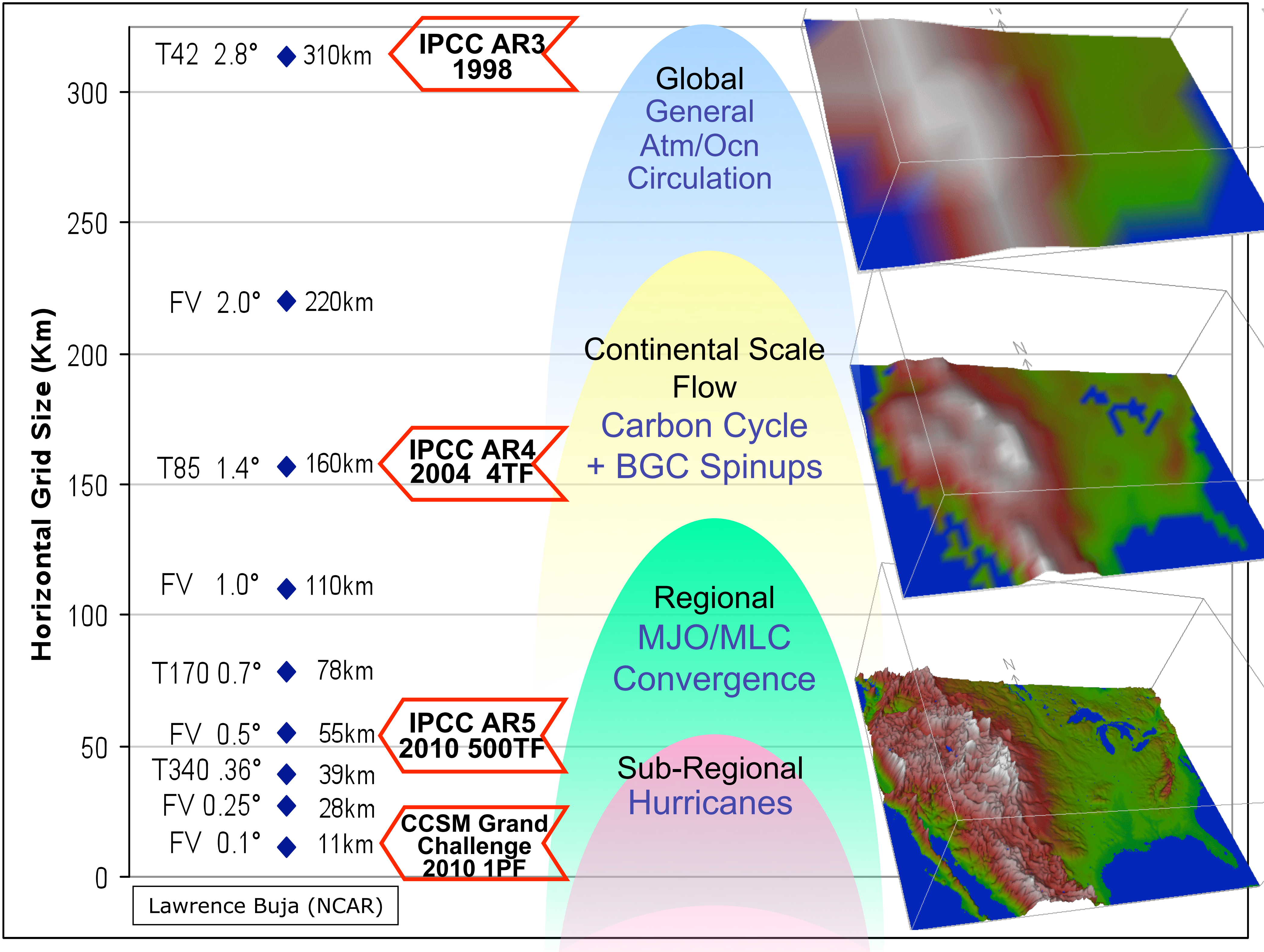
IPCC AR4 Modeling Centers & AR5 Timeline





New CCSM Components for CMIP5

- **Aerosols**
  - **Direct and indirect effects**
- **Chemistry**
  - **Radiative and air quality issues**
- **Dynamic Vegetation**
  - **Historical evolution, future paths**
- **Carbon & Nitrogen Cycle**
  - **Ocean & land biogeochemistry**
  - **Anthropogenic (transient) land use/cover**
- **Land Ice Sheets**
  - **Sea level Rise & Abrupt Climate change**


Horizontal Grid Size (Km)
300
250
200
150
100
50
0
T42 2.8° 310km
FV 2.0° 220km
T85 1.4° 160km
FV 1.0° 110km
T170 0.7° 78km
FV 0.5° 55km
T340 .36° 39km
FV 0.25° 28km
FV 0.1° 11km
IPCC AR3 1998
IPCC AR4 2004 4TF
IPCC AR5 2010 500TF
CCSM Grand Challenge 2010 1PF
Global
General Atm/Ocn Circulation
Continental Scale Flow
Carbon Cycle + BGC Spinups
Regional
MJO/MLC Convergence
Sub-Regional
Hurricanes
Lawrence Buja (NCAR)

The CMIP experience: The importance of Community

From "Climate Models: A Users Guide" Daniel Farber, Sho Sato Professor of Law and Faculty Director of the California Center for Environmental Law and Policy, University of California, Berkeley.

•[Climate] Model predictions cannot be taken as gospel. There is considerable residual uncertainty about climate change impacts that cannot be fully quantified… The policy process should be designed with this uncertainty in mind.

•Economic models are much less advanced, and their conclusions should be used with caution. Unfortunately, economists are not always carefully about incorporating uncertainty into their policy recommendations.

•Climate scientists have created a unique institutional system for assessing and improving models, going well beyond the usual system of peer review. Consequently, their conclusions should be entitled to considerable credence by courts and agencies.

CMIP Data Services: Earth System Grid

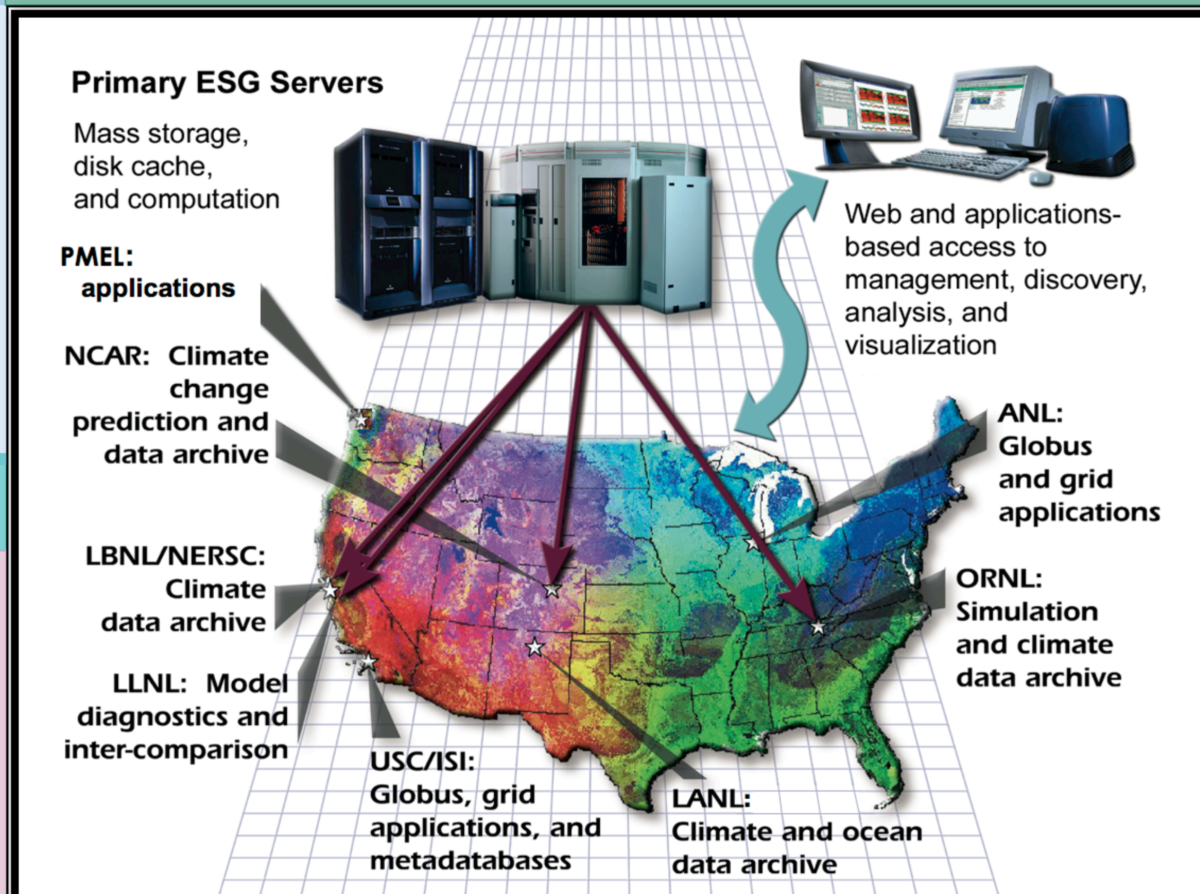
ESG Goals

- Petabyte-scale data volumes
- Globally federated sites
- "Virtual Datasets" created through subsetting and aggregation
- Metadata-based search and discovery
- Bulk data access
- Web-based and analysis tool access
- Increased flexibility and robustness

http://www.earthsystemgrid.org
http://www-pcmdi.llnl.gov

For AR5, ESG will be expanded to form a global virtual data center!

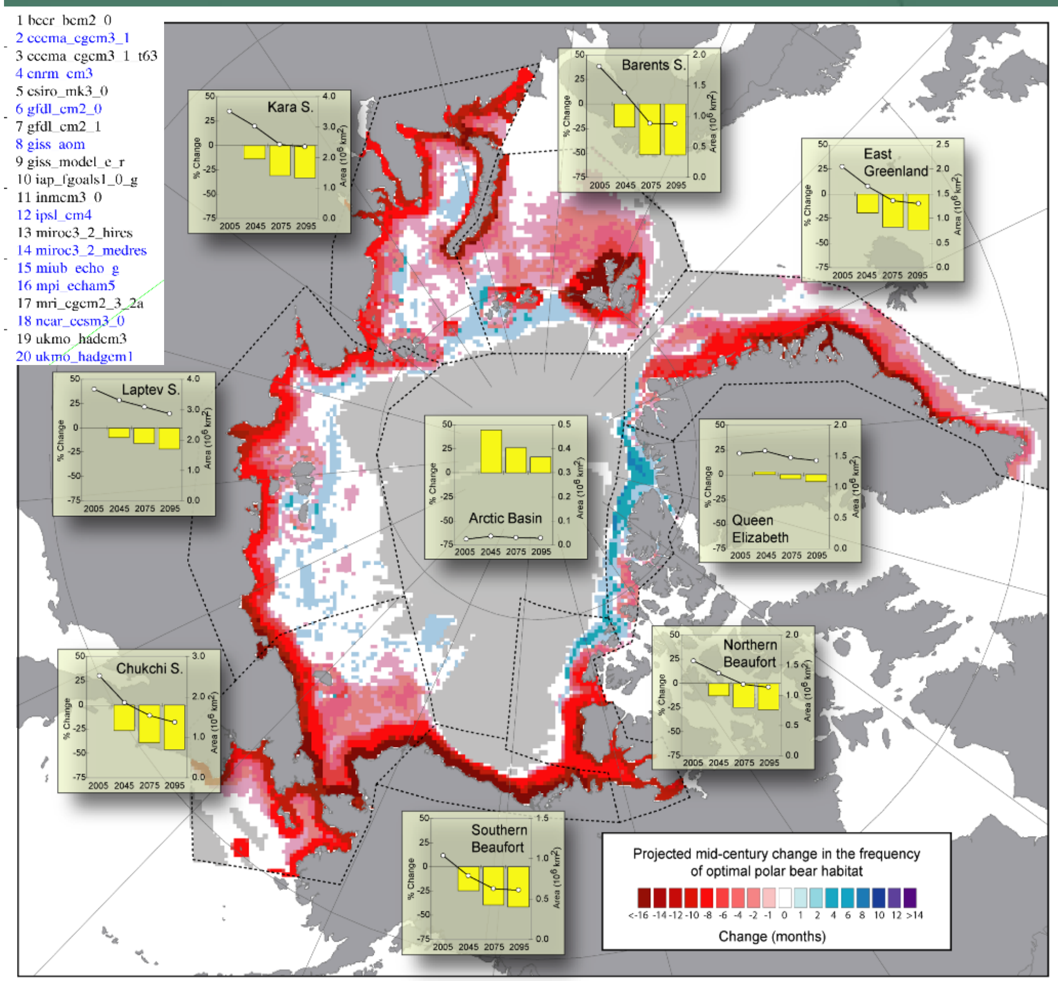
Current ESG Sites



From: Earth System Grid Center for Enabling Technologies: (ESG-CET)

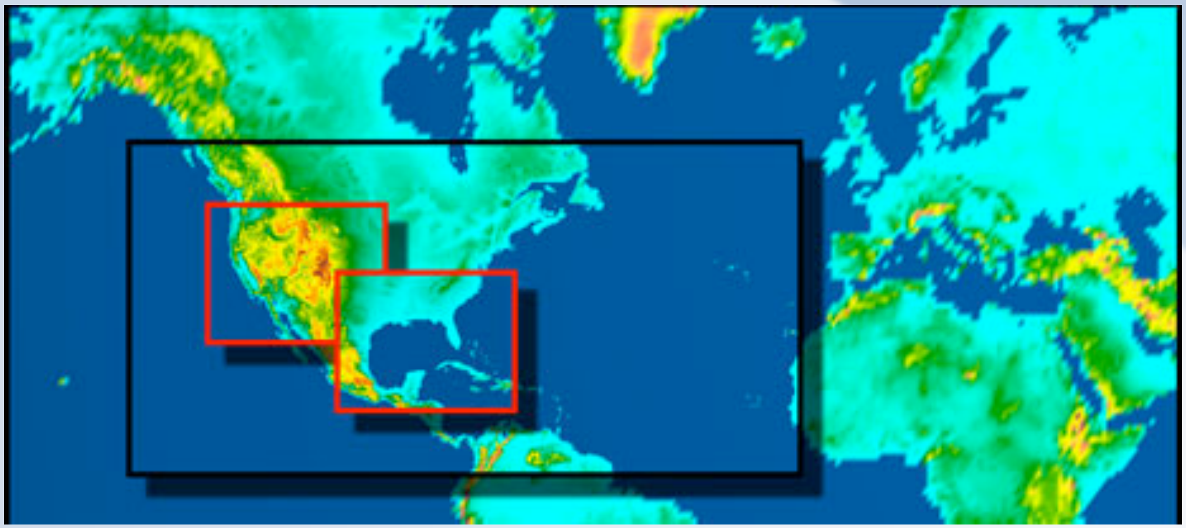
Briefing on Results:

USGS Science Strategy to Support U.S. Fish & Wildlife Service Polar Bear Endangered Species Listing Decision:



U.S. Department of the Interior
U.S. Geological Survey

North Atlantic and North American Regional Climate Changes



The goal is to simulate the effects of climate change on precipitation across the intermountain West States and tropical cyclones, with a focus on the Gulf of Mexico.

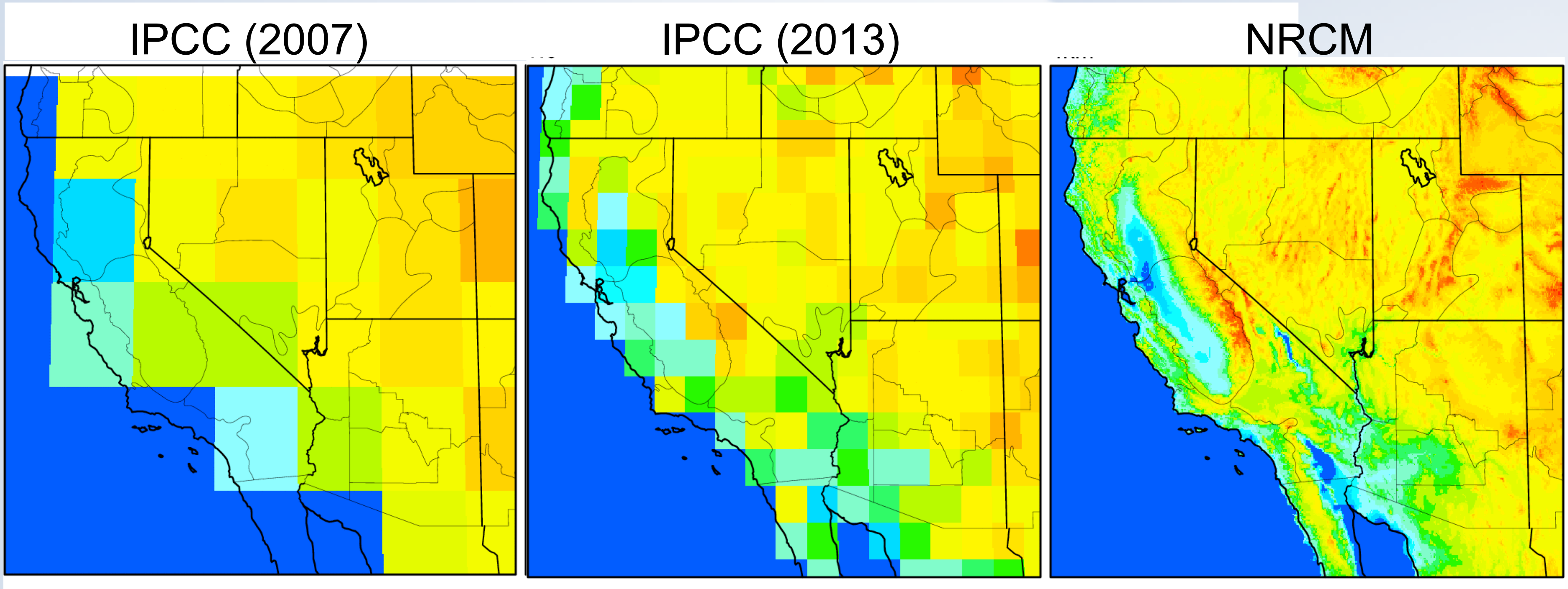
- 36, 12 and 4 km domains nested into CCSM
- 1996-2005, then time slices out to 2050
- Multi-member ensembles for each period
- Dedicated time on NCAR IBM Power 6 (Bluefire) since July:
  - 24 nodes (~20% of total number of processors)
  - 36 (12) km simulations use 128 (256) processors per job
  - Will use 3.9M processor hours through 11/08
  - ~300 Tb of data (to date); 450 Tb total (including earlier runs)

NCAR

Improving Predictions of Regional Changes in Weather and Climate

The Nested Regional Climate Model

High Resolution Climate Modeling



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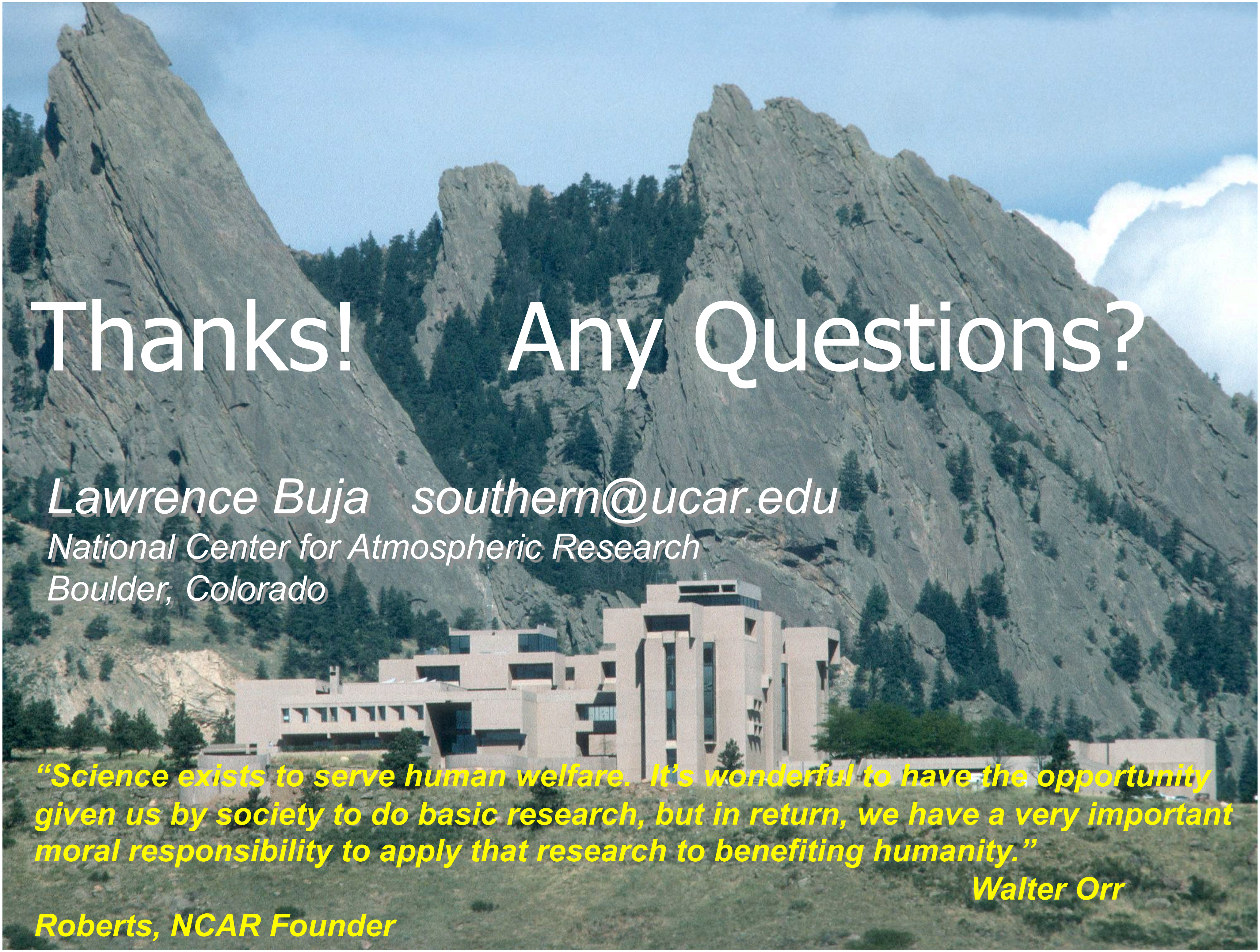
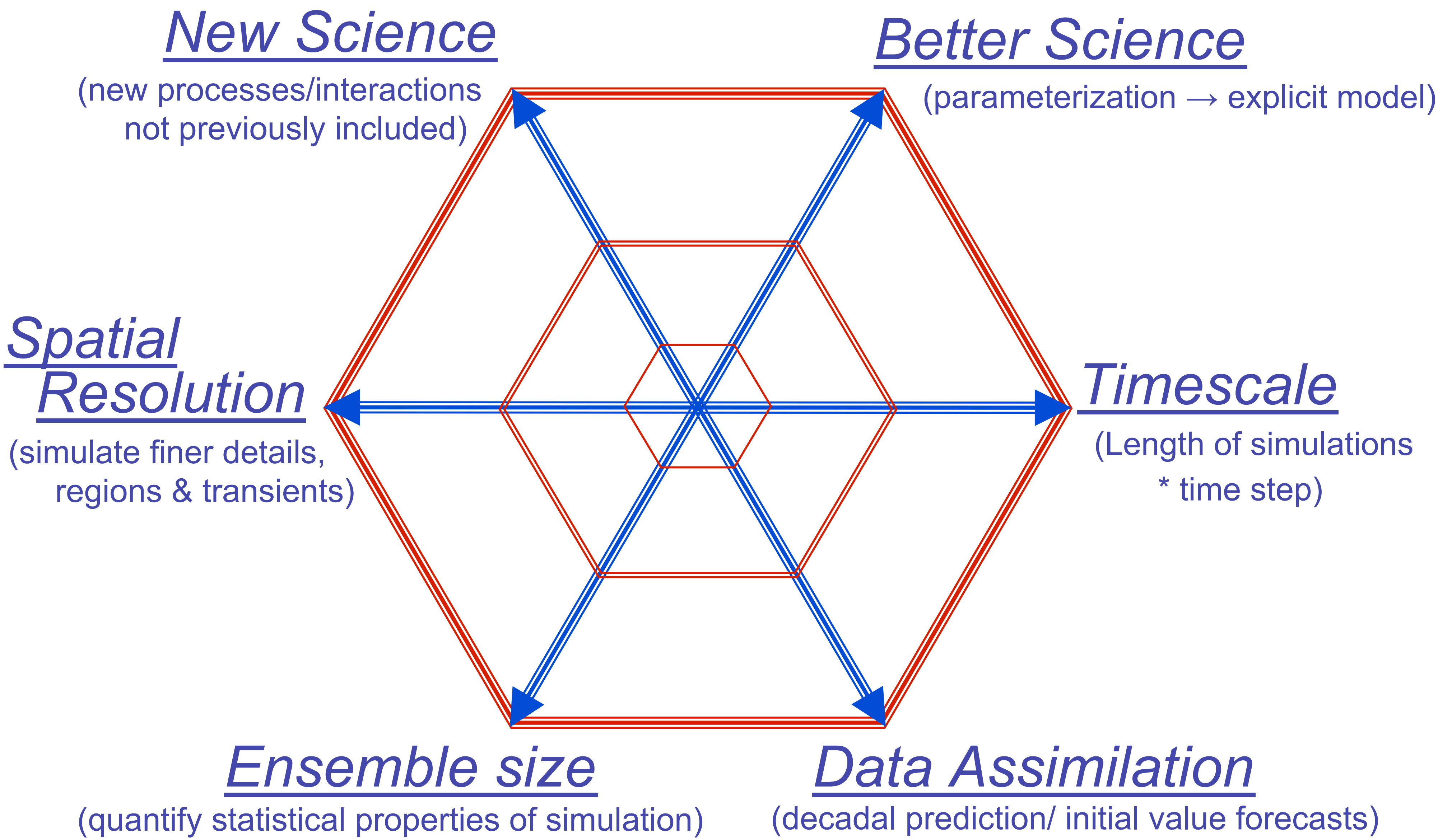
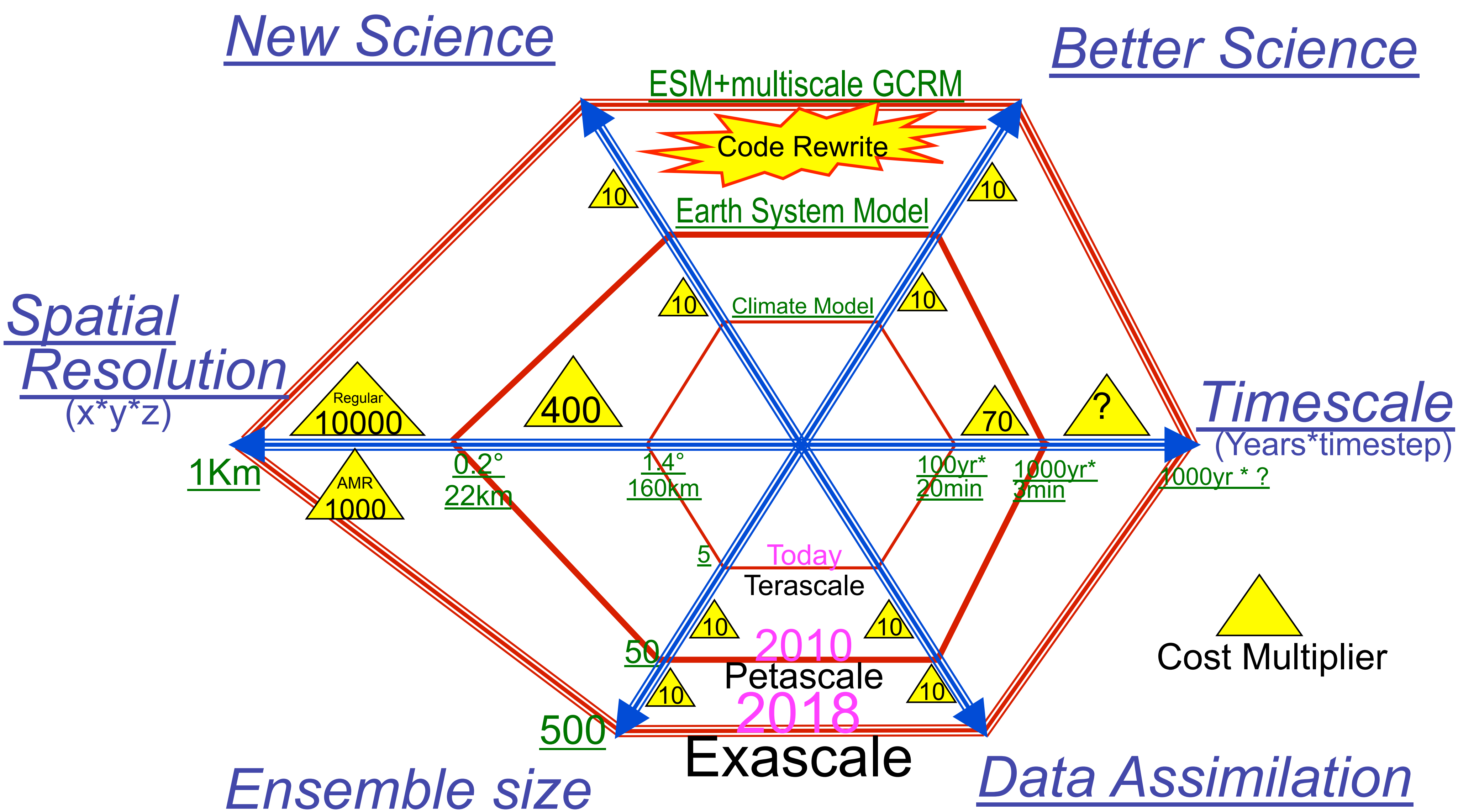

Thanks! Any Questions?
Lawrence Buja southern@ucar.edu
National Center for Atmospheric Research
Boulder, Colorado
"Science exists to serve human welfare. It's wonderful to have the opportunity given us by society to do basic research, but in return, we have a very important moral responsibility to apply that research to benefiting humanity."
Walter Orr Roberts, NCAR Founder

HPC dimensions of Climate Prediction



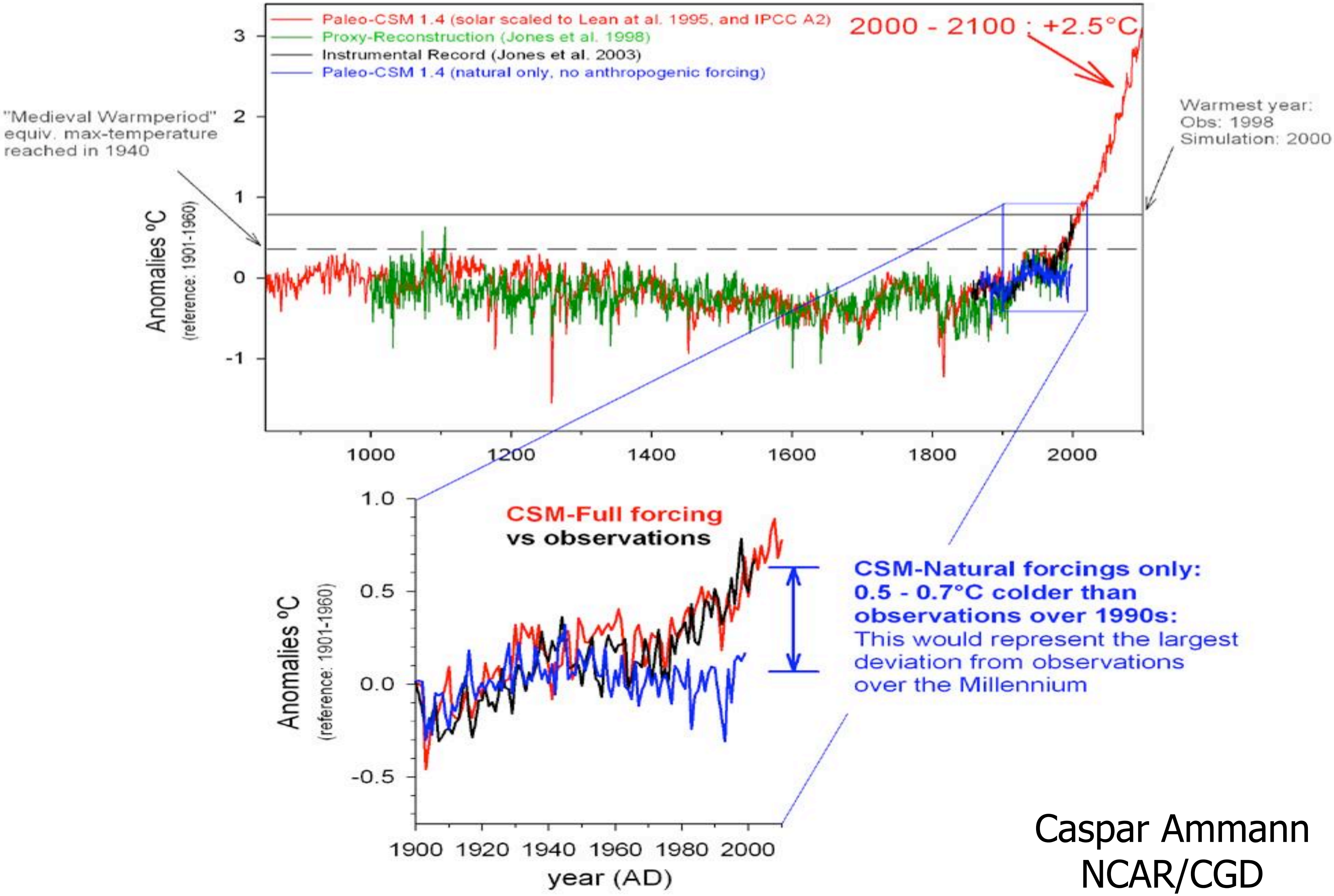
Lawrence Buja (NCAR) / Tim Palmer (ECMWF)

HPC dimensions of Climate Prediction



Lawrence Buja (NCAR)

Climate of the last Millennium



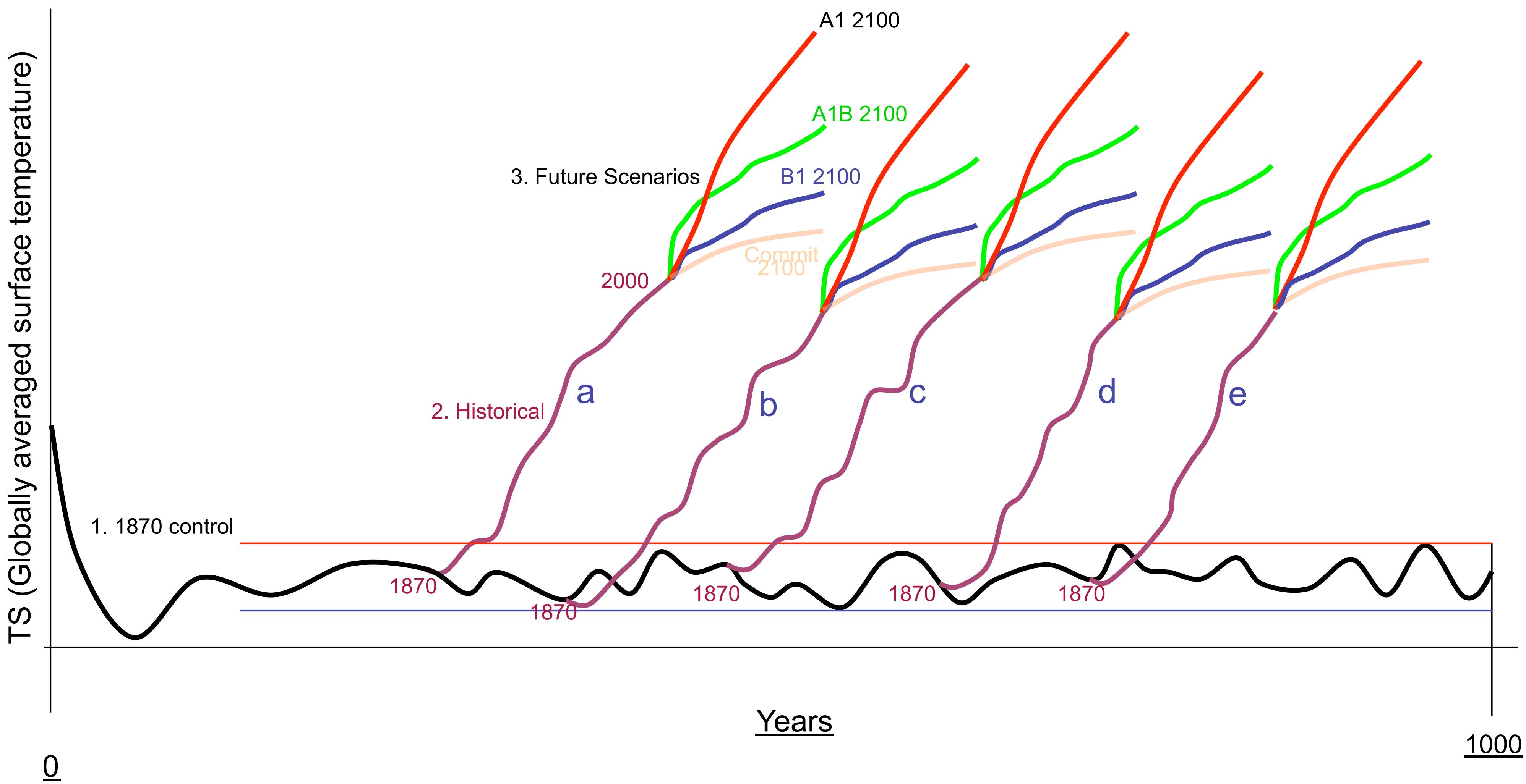
Caspar Ammann
NCAR/CGD

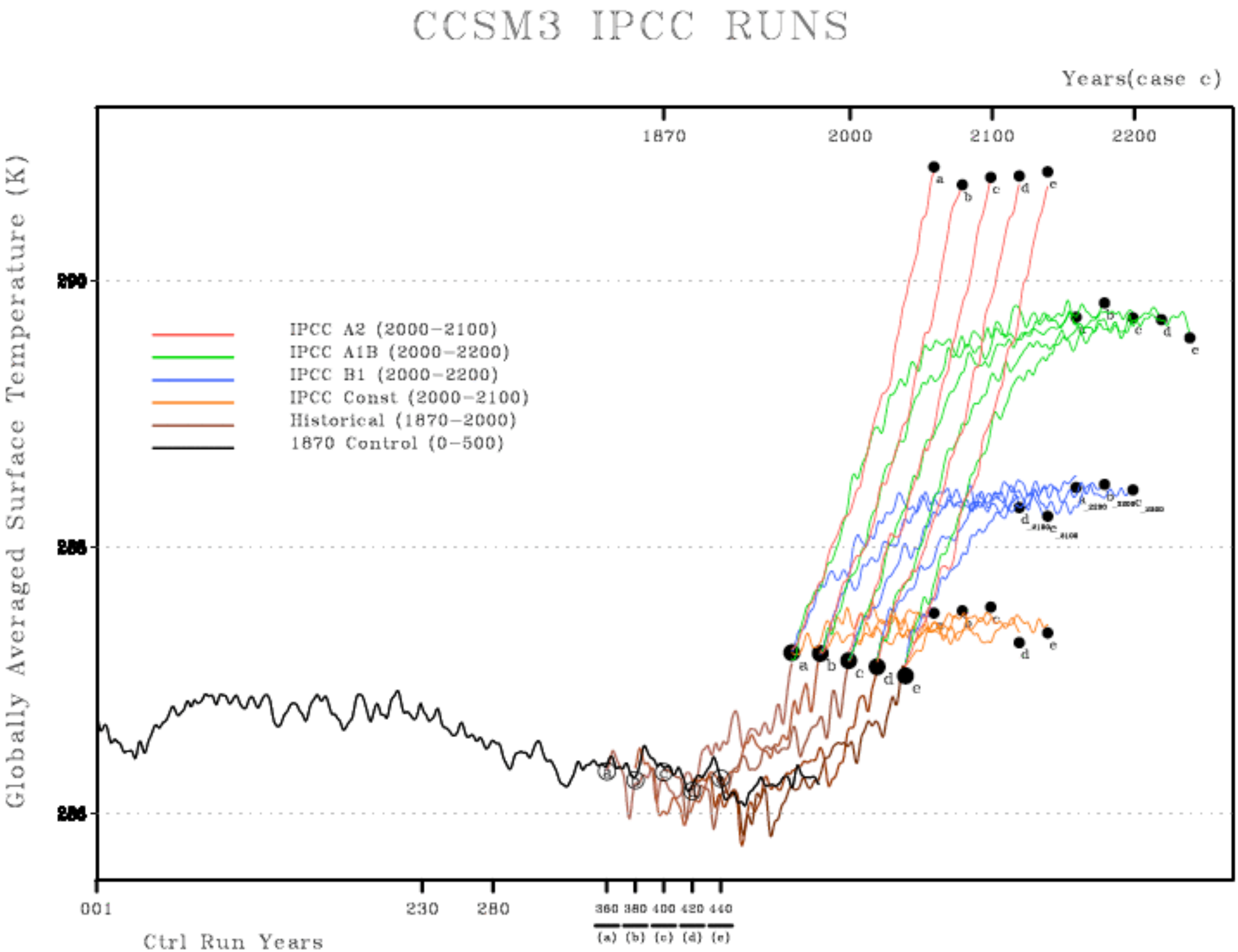
Probablistic Climate Simulations

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

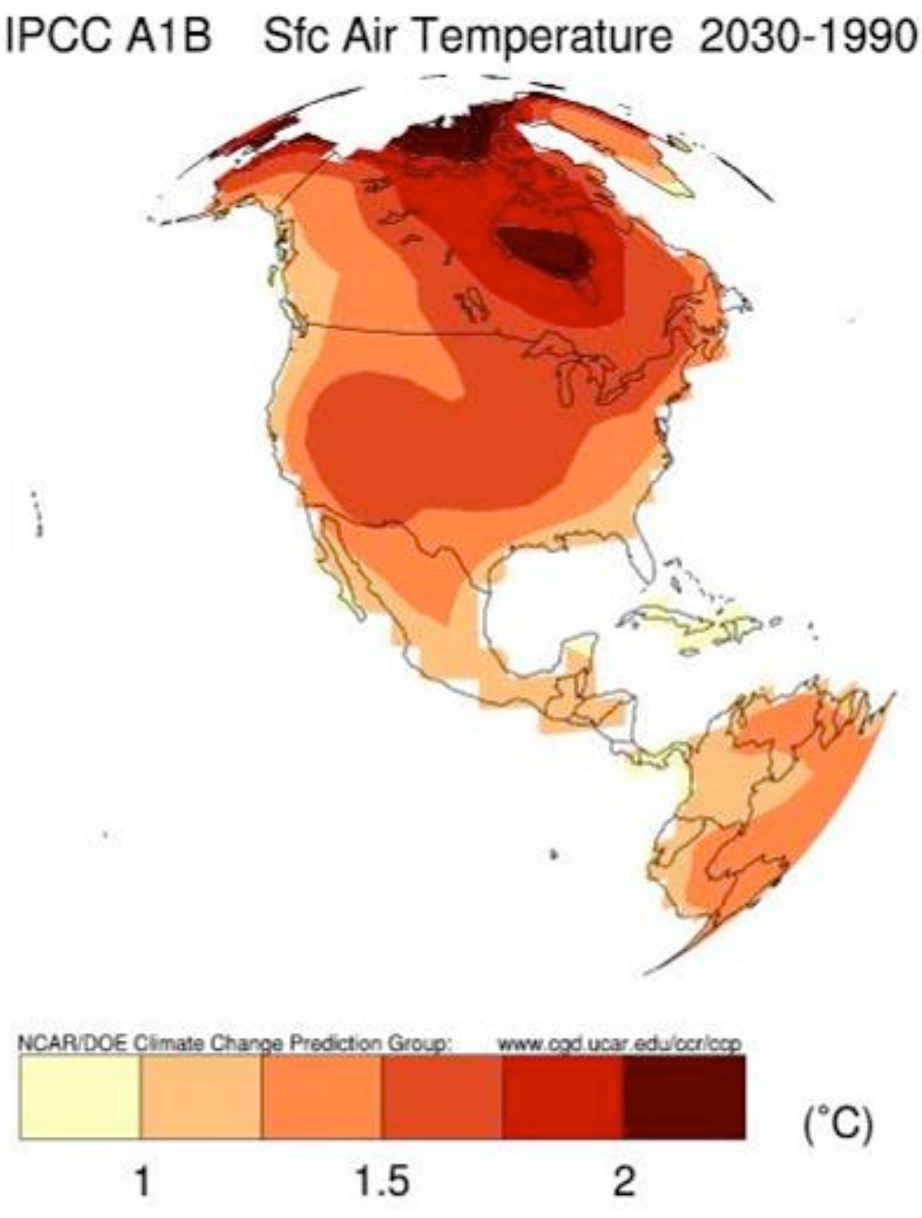
Stage 2. Historical: 1870-2000 run using time-evolving, observed, Solar, GHG, Volcanoes, O3

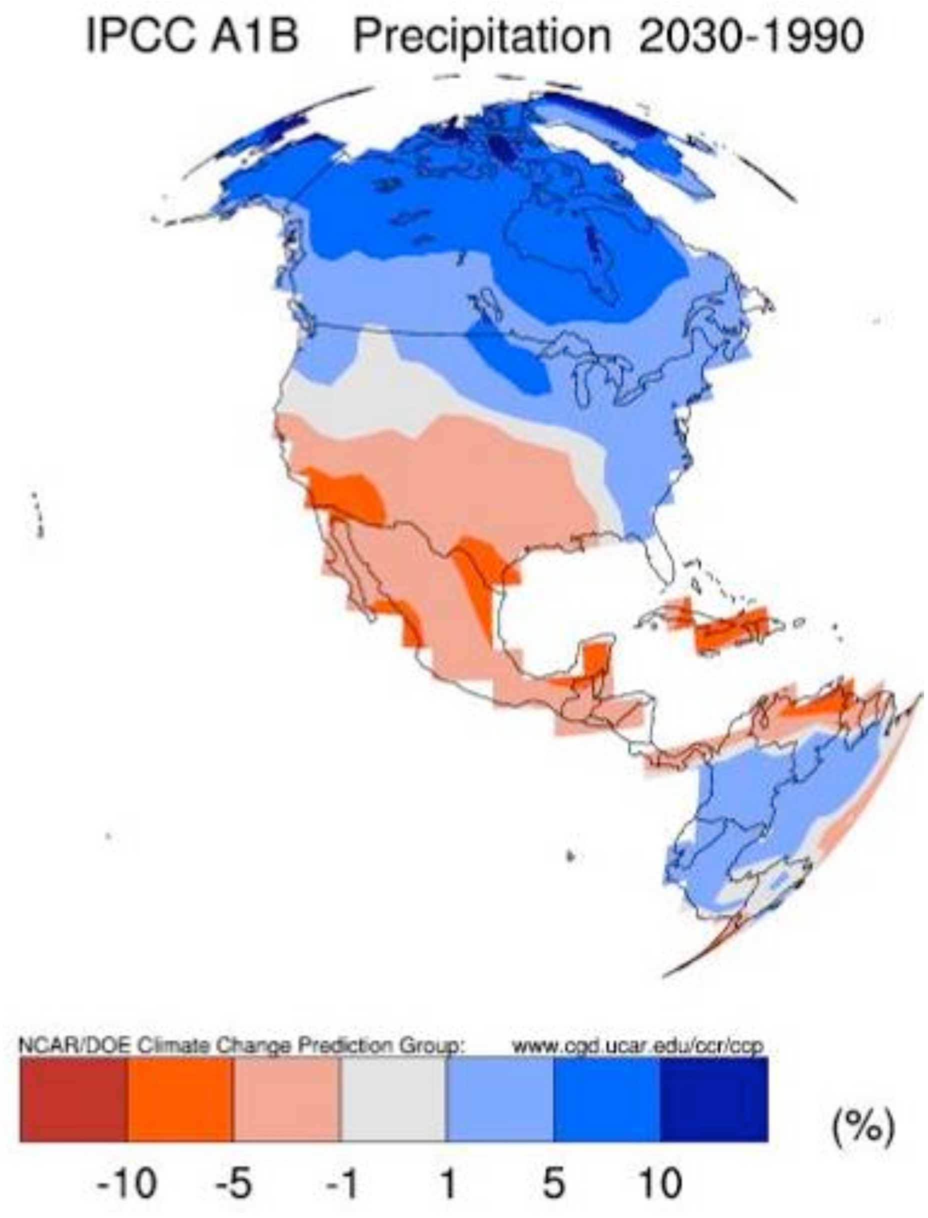
Stage 3. Future Scenarios: 4 2000-2100 IPCC Scenarios from end of historical run




CCSM3 IPCC RUNS
Years(case c)
1870
2000
2100
2200
Globally Averaged Surface Temperature (K)
IPCC A2 (2000-2100)
IPCC A1B (2000-2200)
IPCC B1 (2000-2200)
IPCC Const (2000-2100)
Historical (1870-2000)
1870 Control (0-500)
001
230
280
360
380
400
420
440
(a)
(b)
(c)
(d)
(e)
Ctrl Run Years

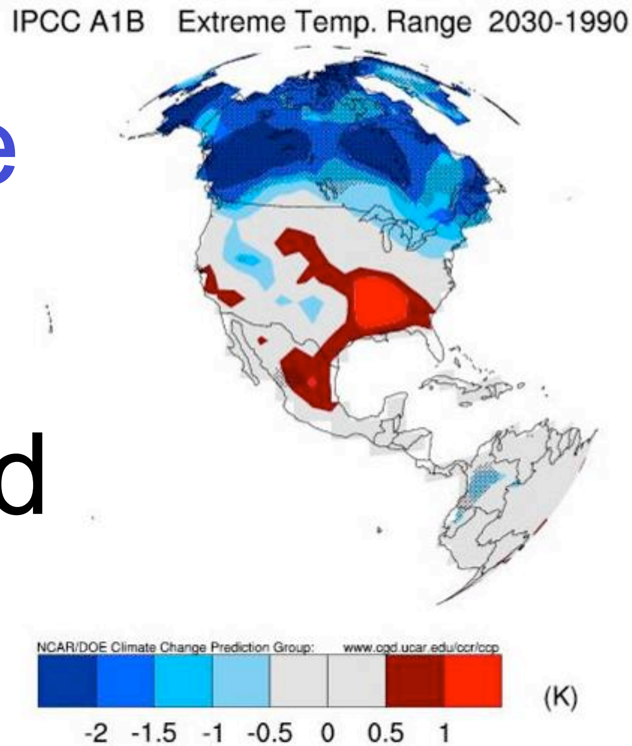
2030: A Warmer and Wetter World

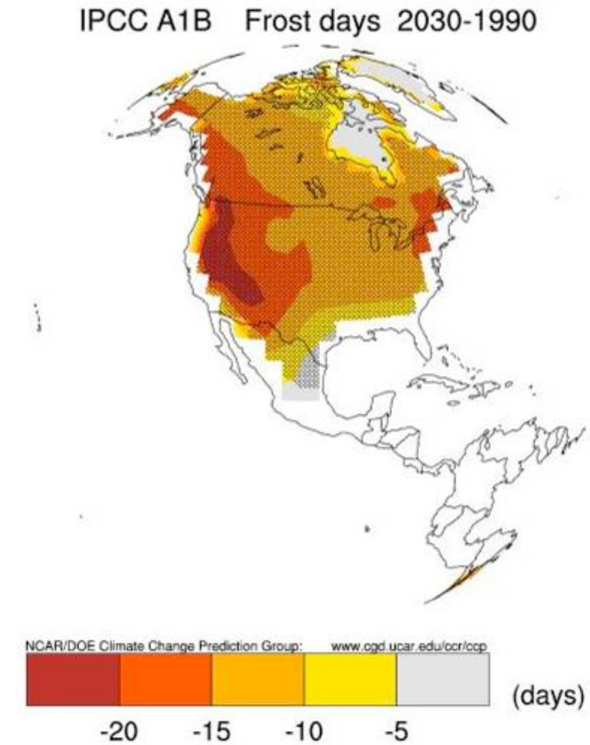


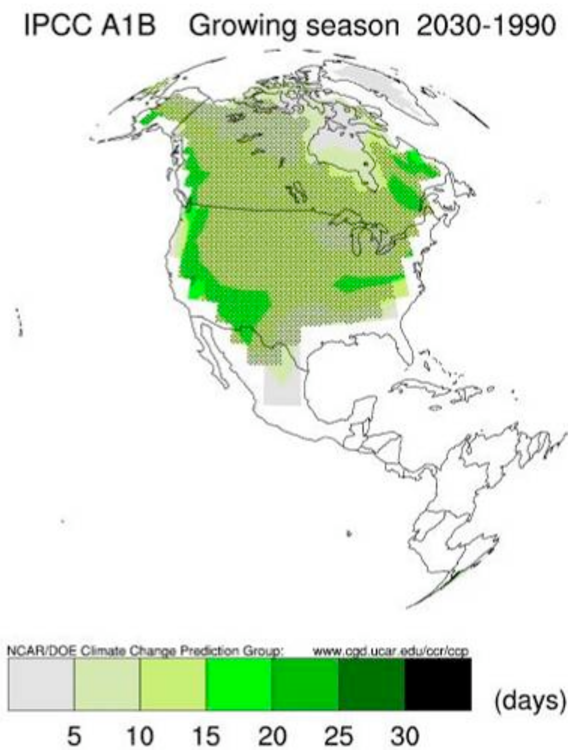


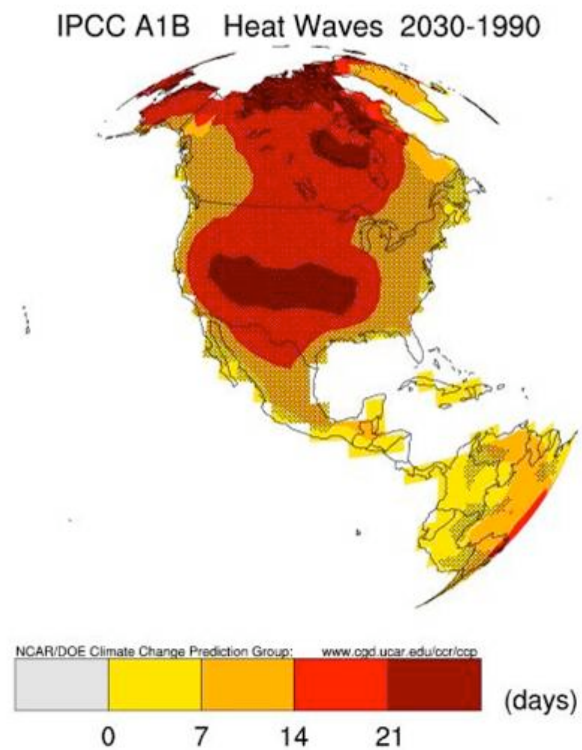
Temperature at 2030

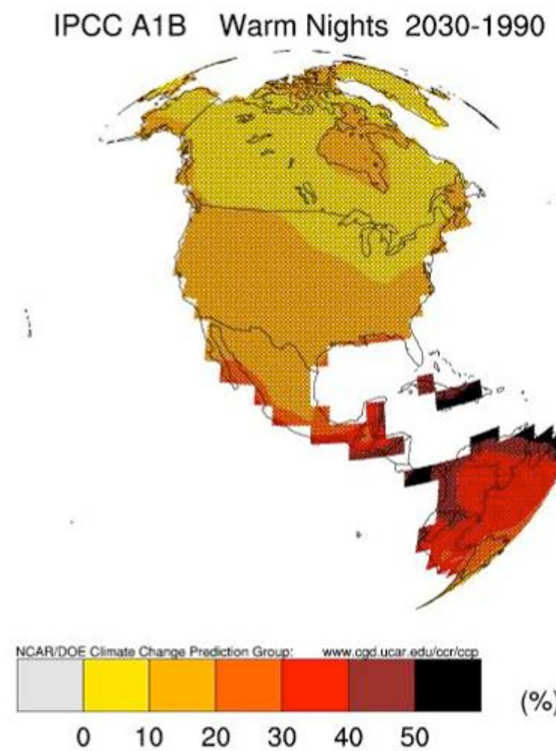
Averages and Extremes











Precipitation at 2030

Averages and Extremes