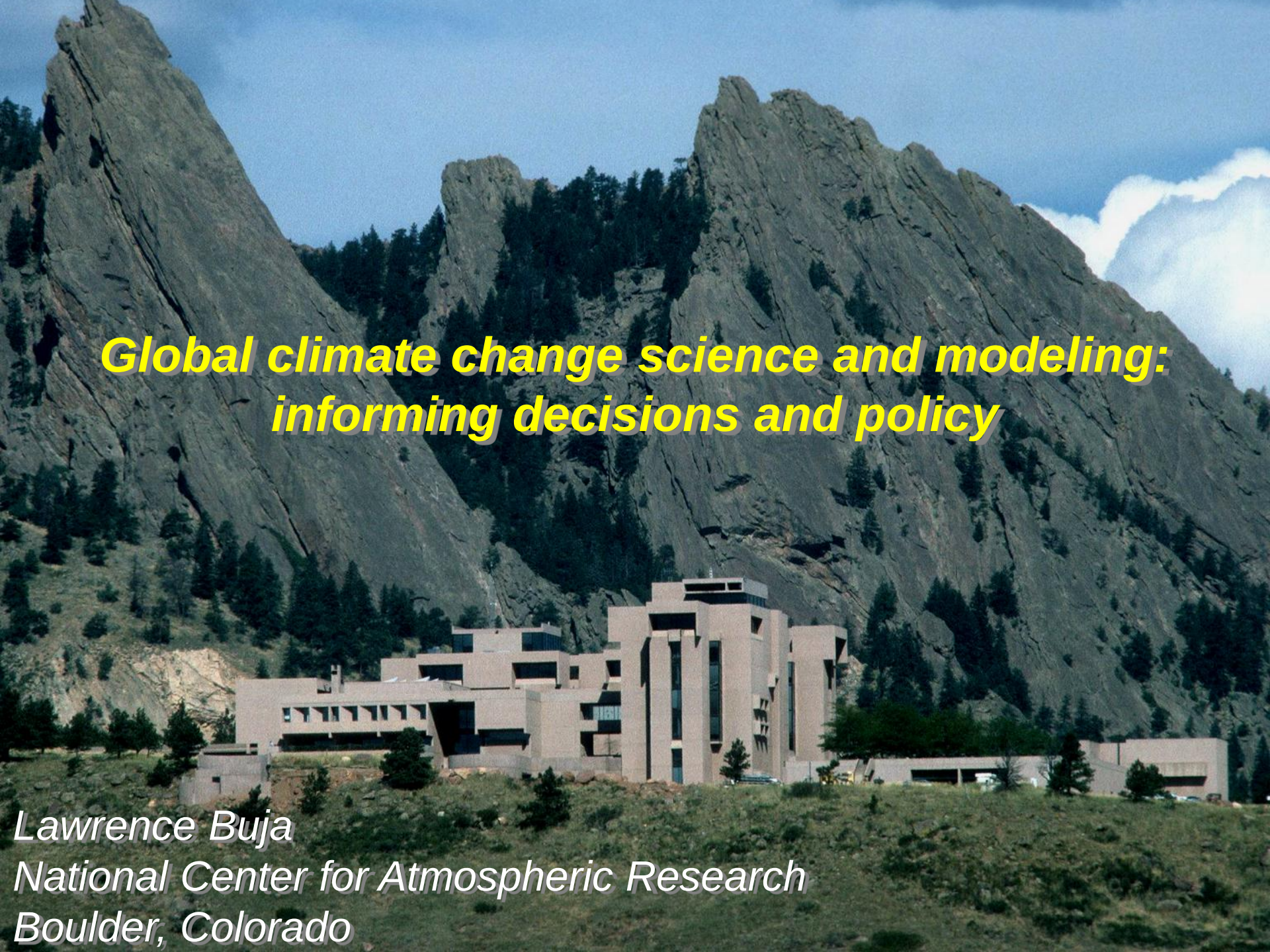
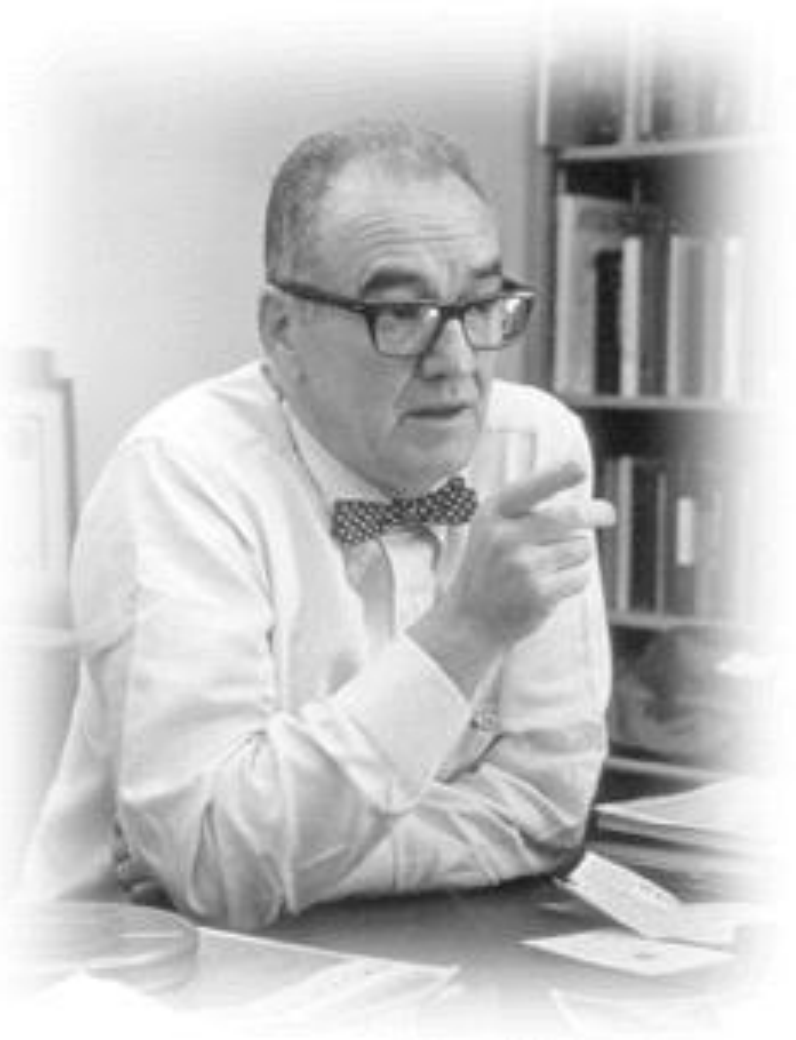


# *Global climate change science and modeling: informing decisions and policy*

*Lawrence Buja*
*National Center for Atmospheric Research*
*Boulder, Colorado*

"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.***"

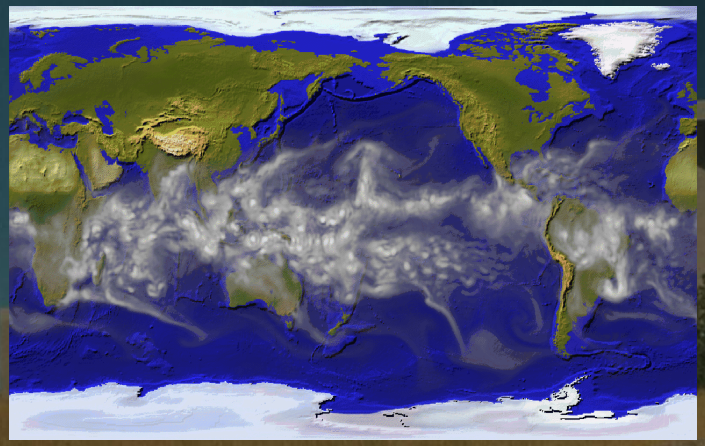
Walter Orr Roberts



# NCAR/NSF Scientific facilities

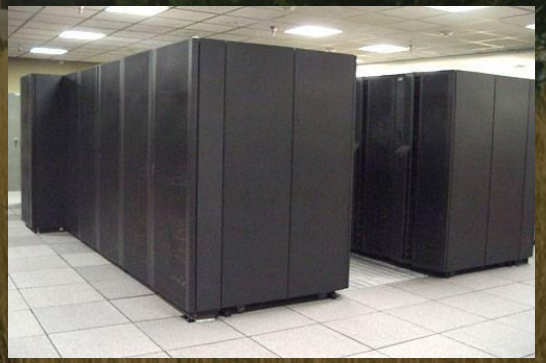
- US National Science Foundation FFRDC
- 900 Staff, 500 Scientists/Engineers, 4 Boulder campuses
- Governed by > 70 universities

## EOL
Earth Observing Laboratory



## NESL
NCAR Earth System Laboratory

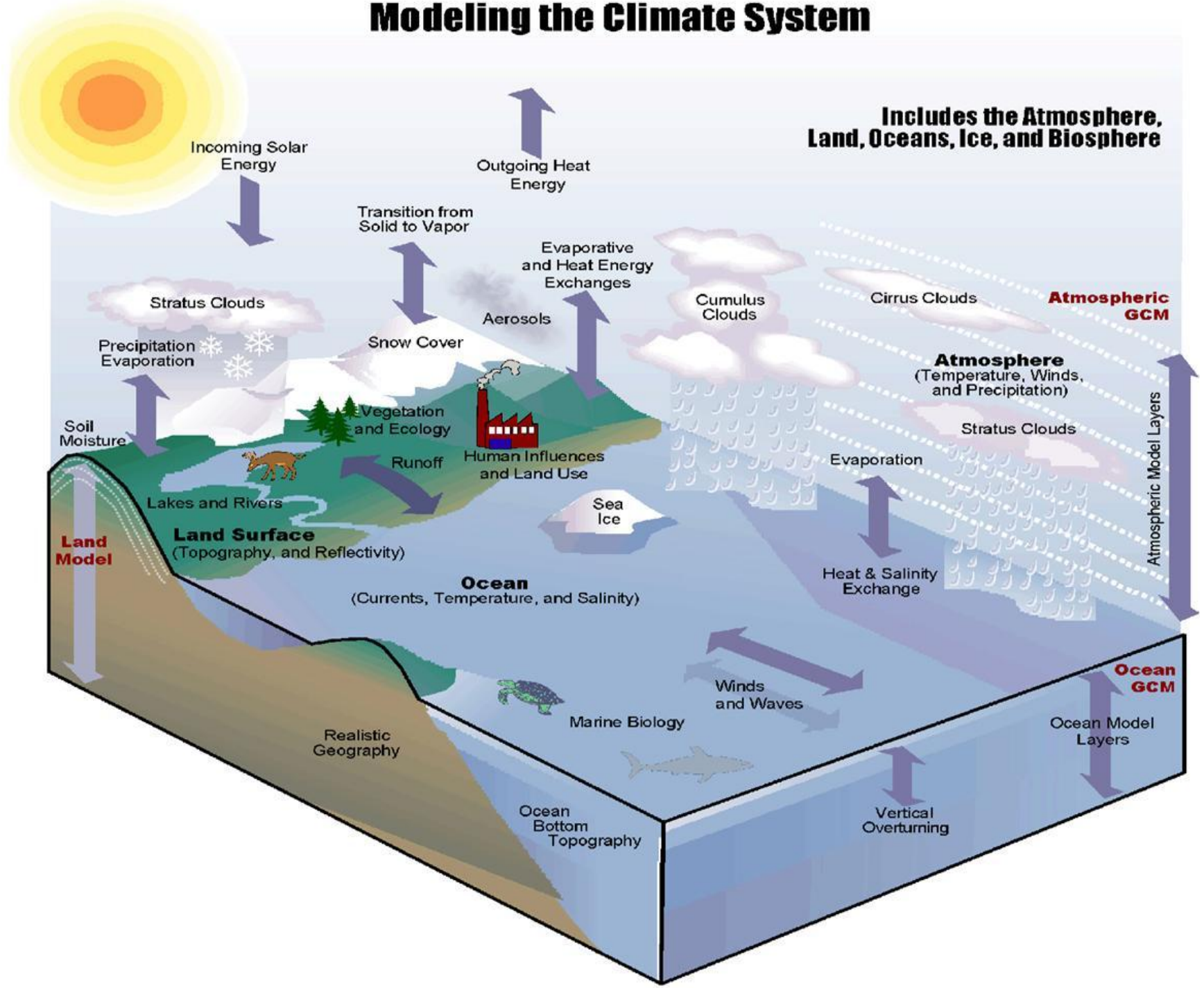
## CISL
Computational & Information Systems

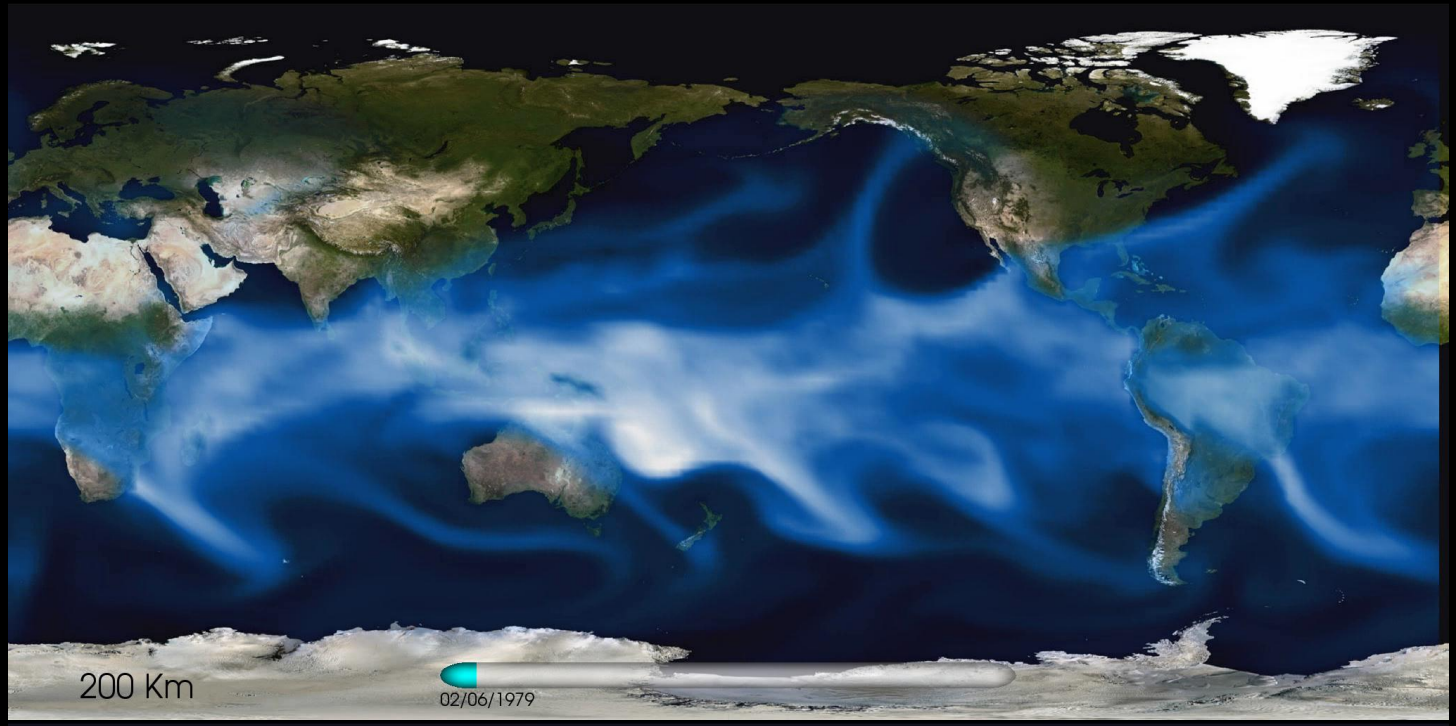


## RAL
Research Applications Laboratory

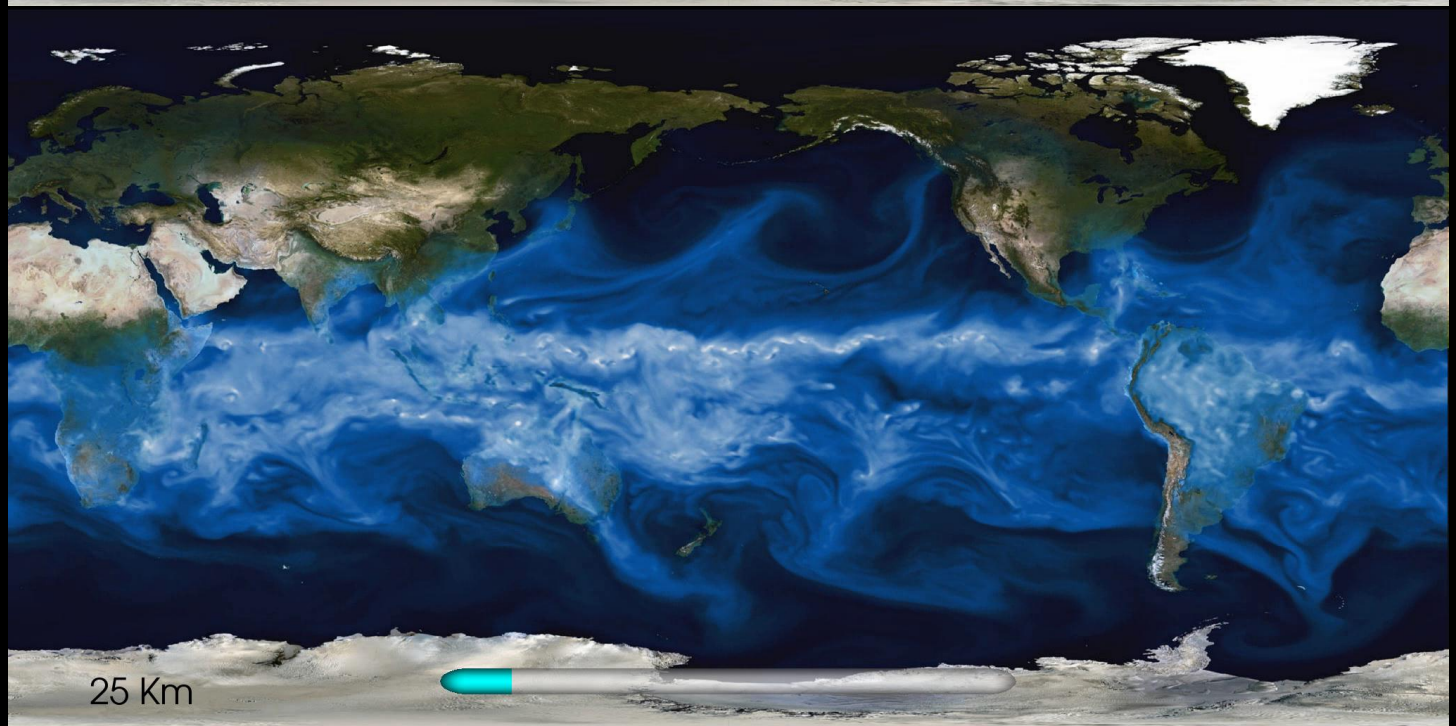
## ISP: Integrated Science Program

# Modeling the Climate System






**200 KM**




**20 KM**

Courtesy:
Michael Weiner
LBNL

# NSF/DOE IPCC AR5 Project

NCAR, LBL, ORNL, NERSC, ANL, LANL, NCSA

Observations of the Earths Climate System

Simulations Past, Present Future Climate States

**6-Year Timeline**

**2008: Climate Model/Data-systems development**

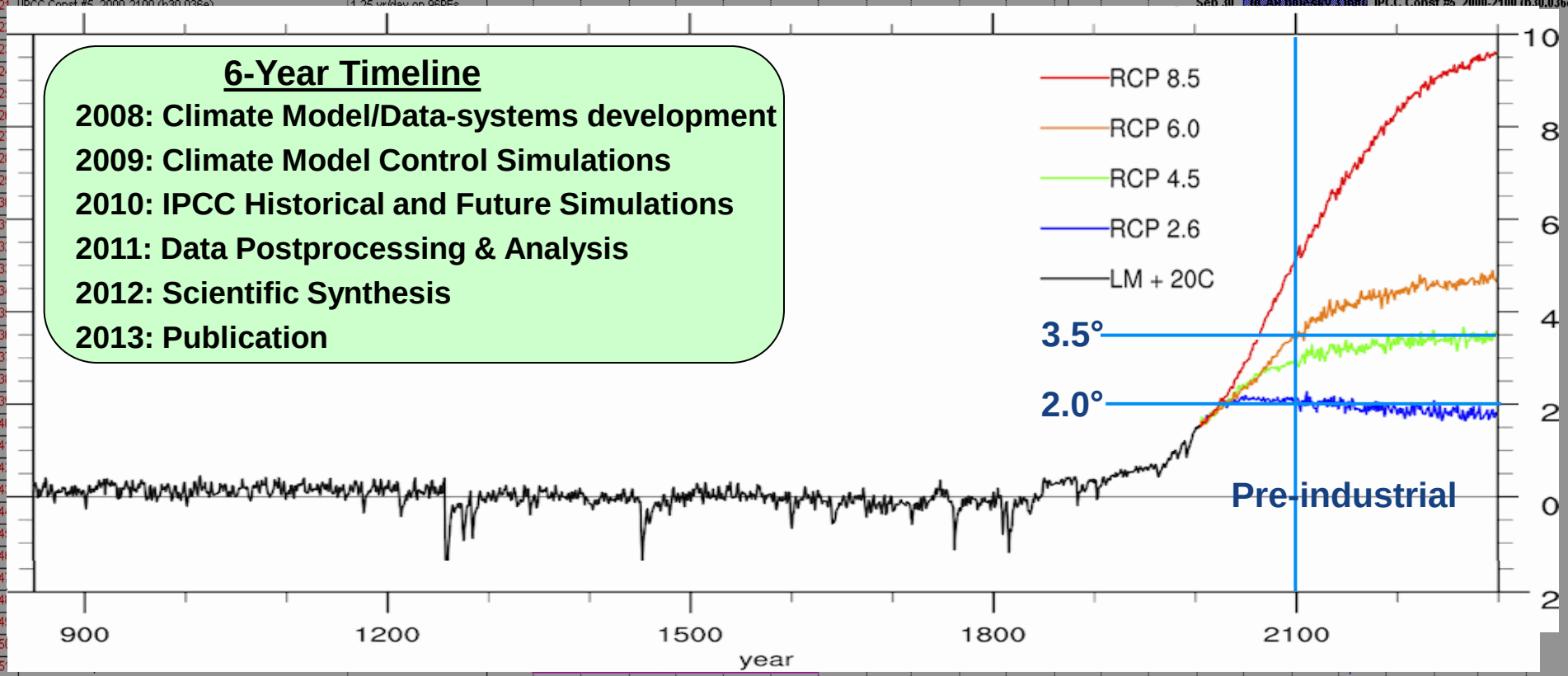
**2009: Climate Model Control Simulations**

**2010: IPCC Historical and Future Simulations**

**2011: Data Postprocessing & Analysis**

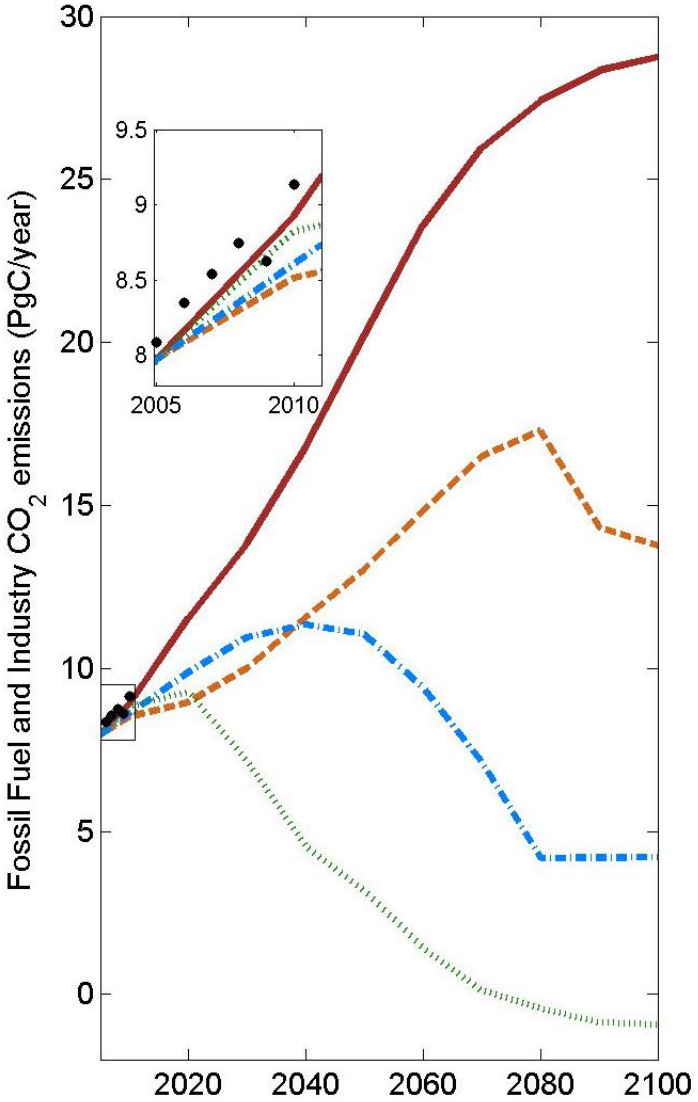
**2012: Scientific Synthesis**

**2013: Publication**

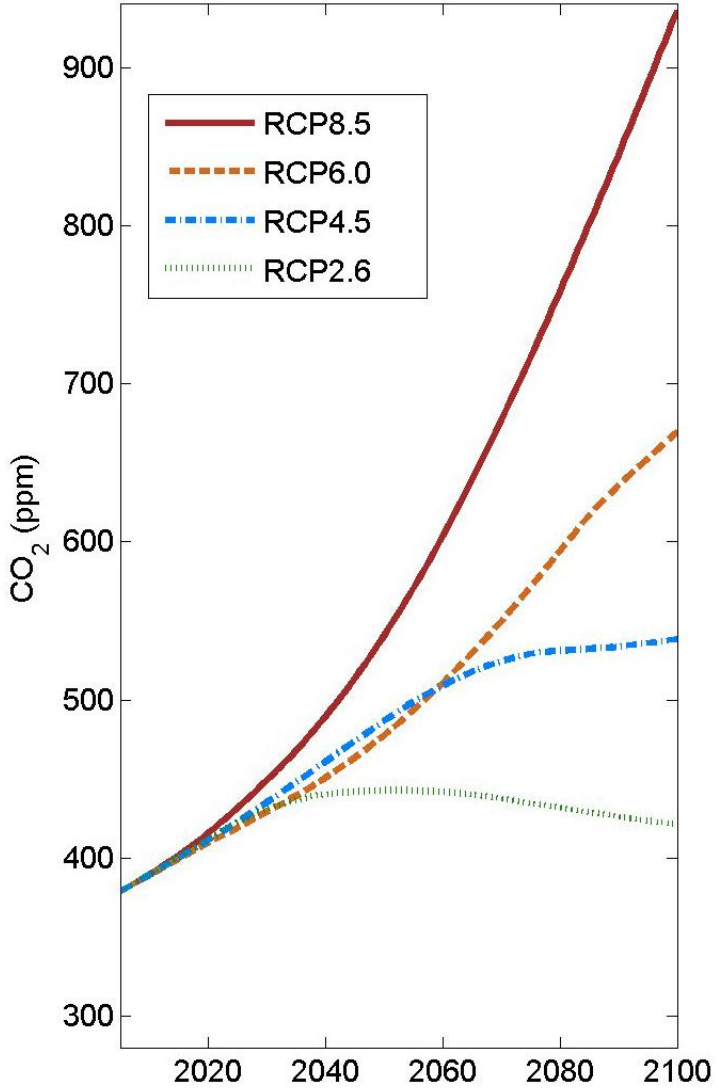


# Future scenarios of $CO_2$ for AR5

## CO2 Emissions

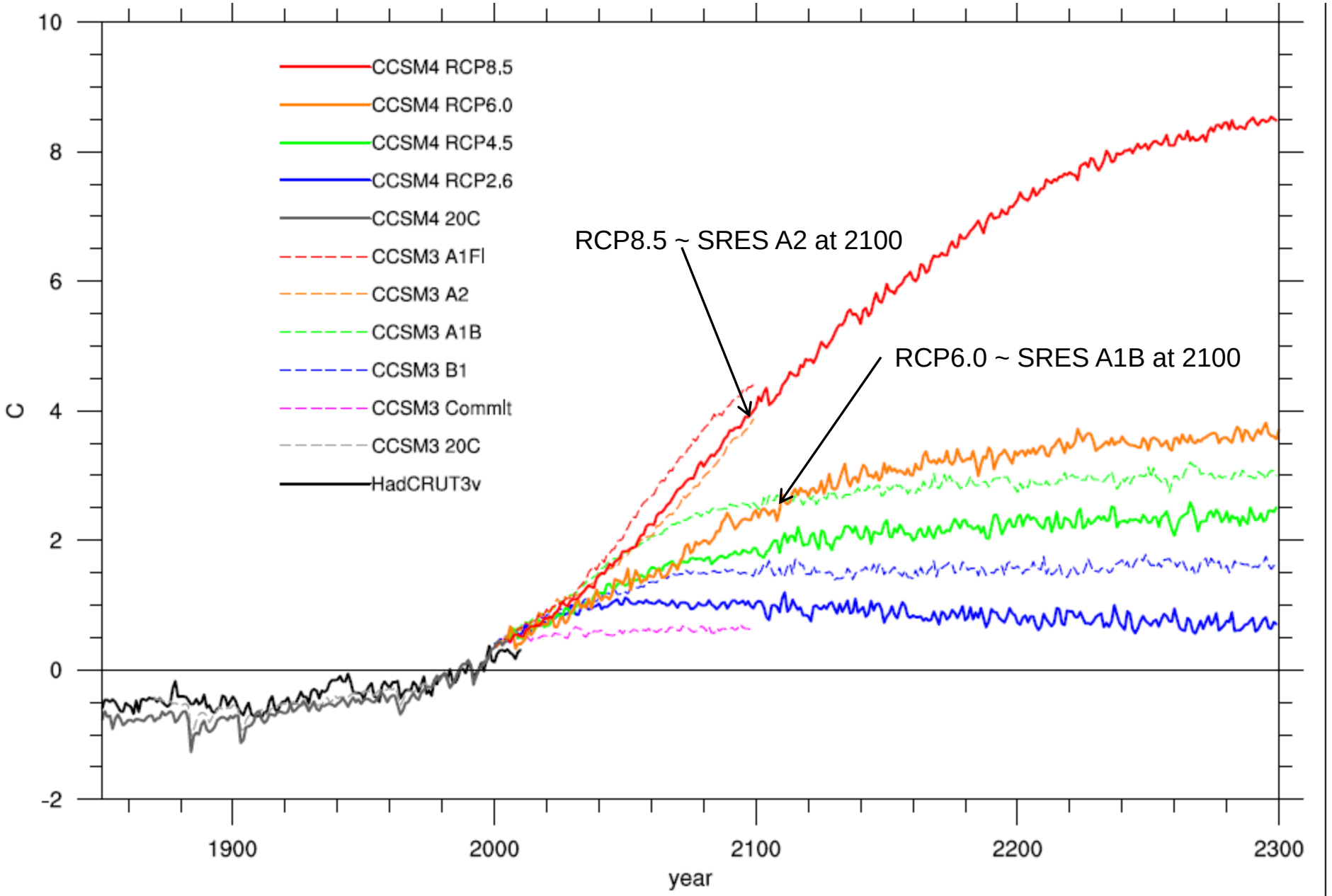


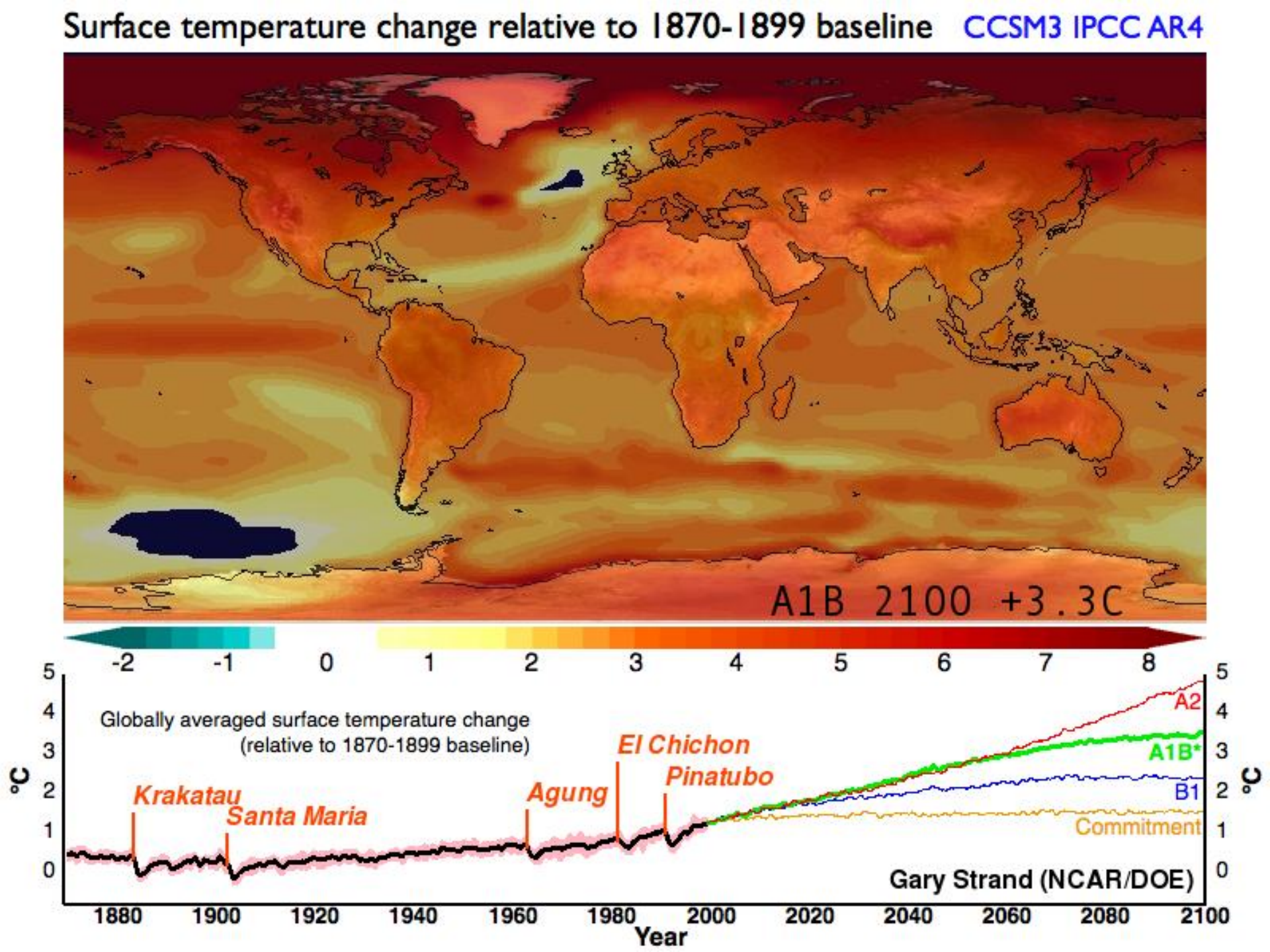

## Concentration



# Surface Temperature: RCP and SRES (dotted) comparison

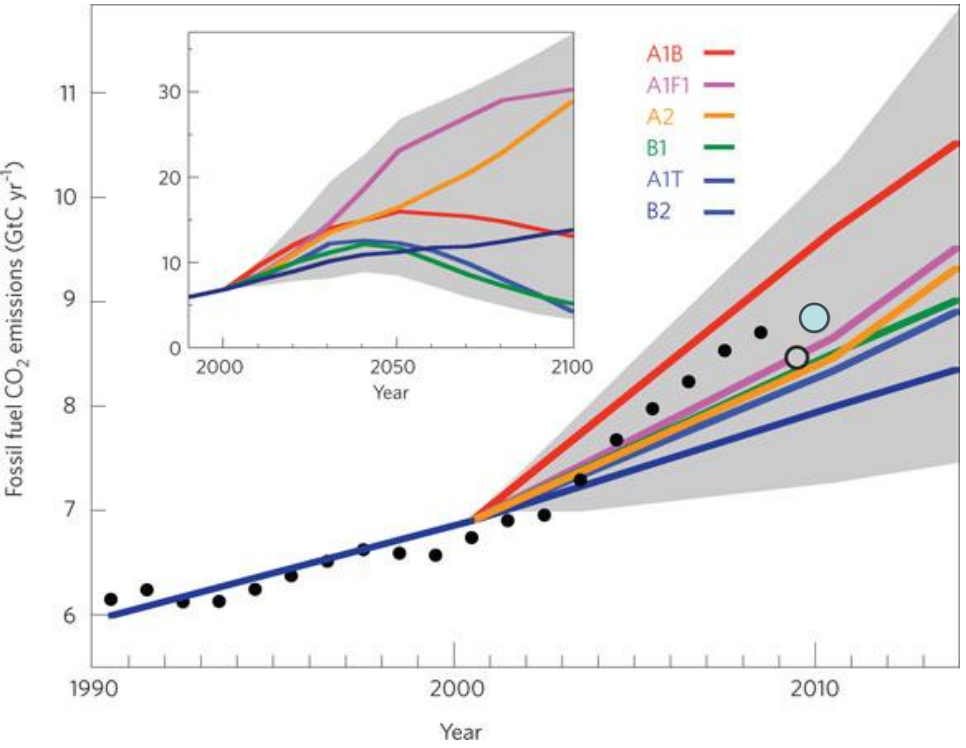
Anomaly from 1980-1999, annual and global mean




Surface temperature change relative to 1870-1899 baseline
CCSM3 IPCC AR4
A1B 2100 +3.3C
-2
-1
0
1
2
3
4
5
6
7
8
Globally averaged surface temperature change
(relative to 1870-1899 baseline)
Krakatau
Santa Maria
Agung
El Chichon
Pinatubo
A2
A1B*
B1
Commitment
°C
Gary Strand (NCAR/DOE)
1880
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Year

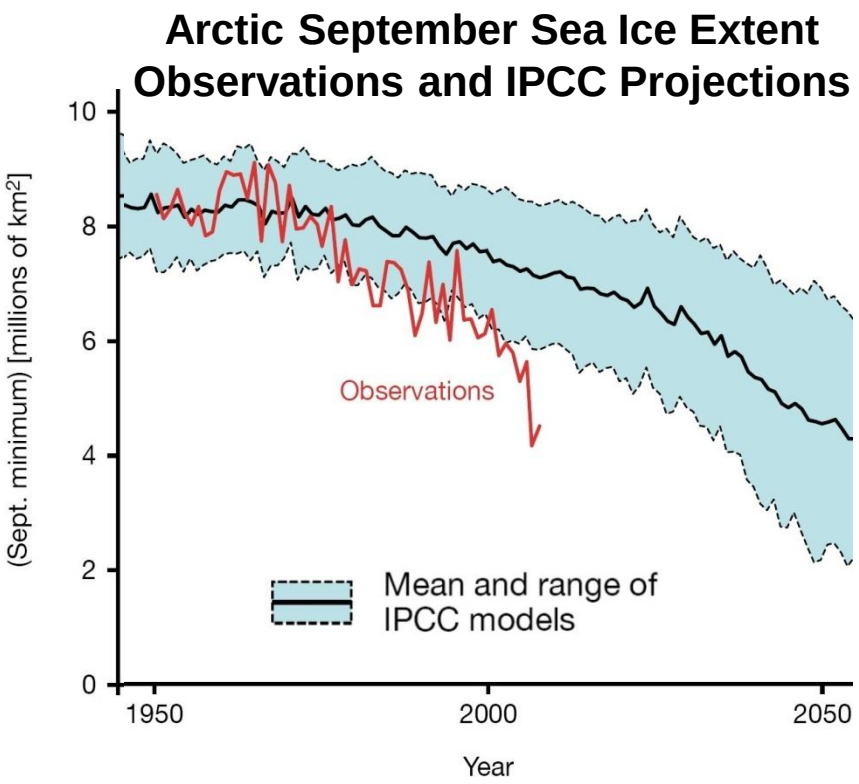
# Is the IPCC being too Alarmist?

Observed Emissions vs SRES Scenarios for IPCC AR4

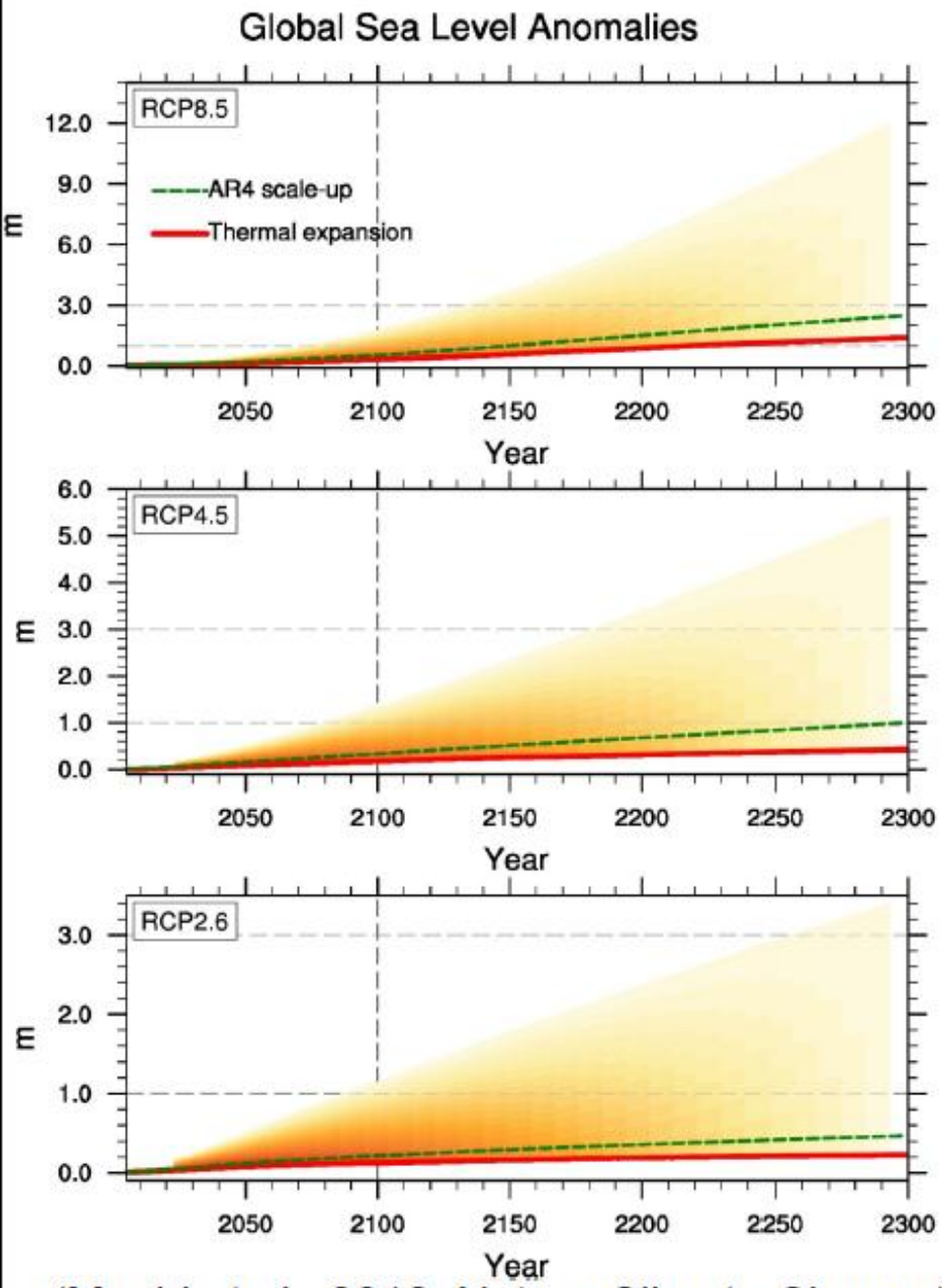



updated from

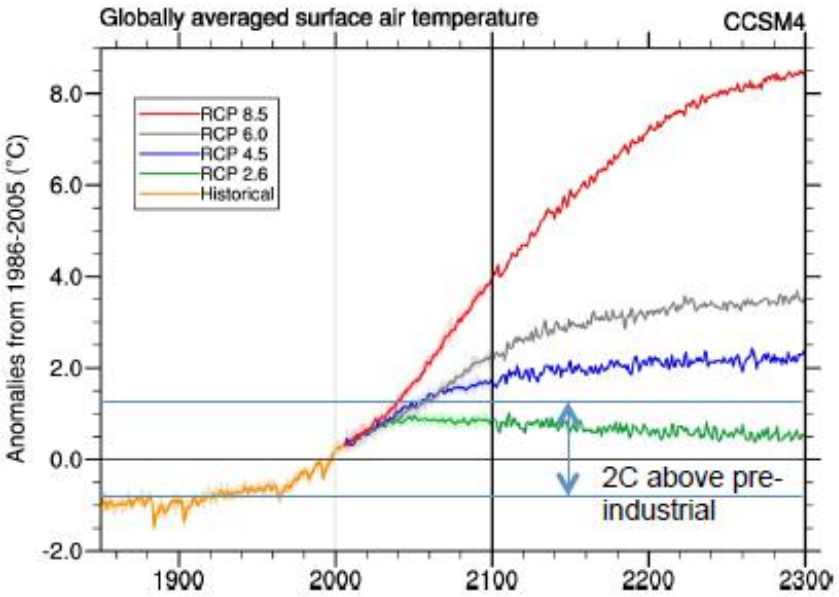
M. R. Manning, J. Edmonds, S. Emori, A. Grubler, K. Hibbard, F. Joos, M. Kainuma, R. F. Keeling, T. Kram, A. C. Manning, M. Meinshausen, R. Moss, N. Nakicenovic, K. Riahi, S. K. Rose, S. Smith, R. Swart & D. P. van VuurenNature Geoscience 3, 376 - 377 (2010)doi:10.1038/ngeo880




If anything, we are being much too conservative!




(Meehl et al., 2012, Nature Climate Change)




**In the RCP scenarios, we can mitigate temperature but not sea level rise**

(note: There are various ways to attempt to estimate what the magnitude and timing of global sea level rise will be, with the best known contribution from thermal expansion, another using the "example" in the AR4 taking into account some contribution from accelerated ice sheet discharge, and semi-empirical methods)

Gerald Meehl, NCAR

# Climate model genealogy: Generation CMIP5 and how we got there

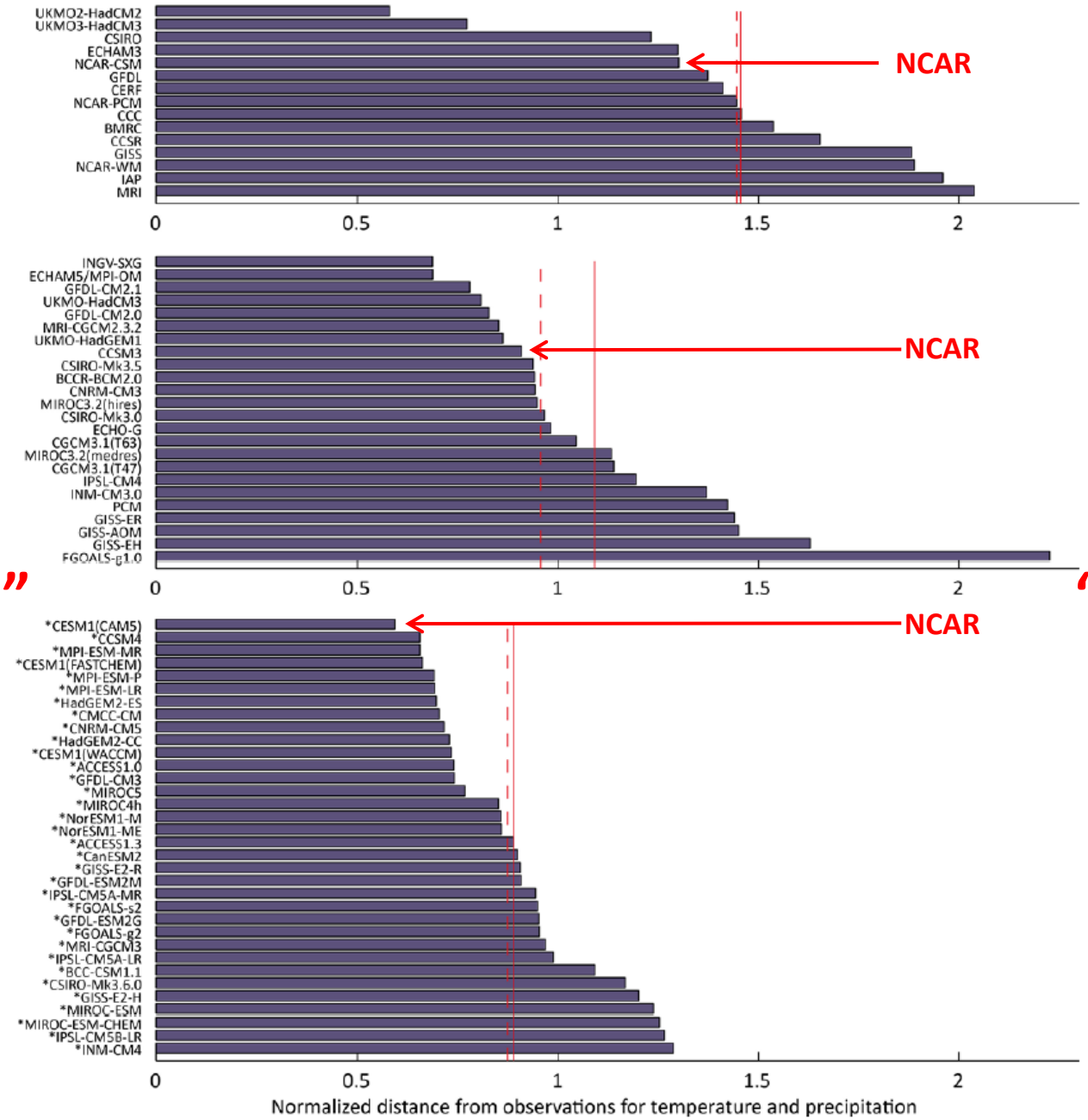
Reto Knutti, David Masson , Andrew Gettelman

June 29, 2012, submitted to GRL

CMIP2
1997

CMIP3
2006

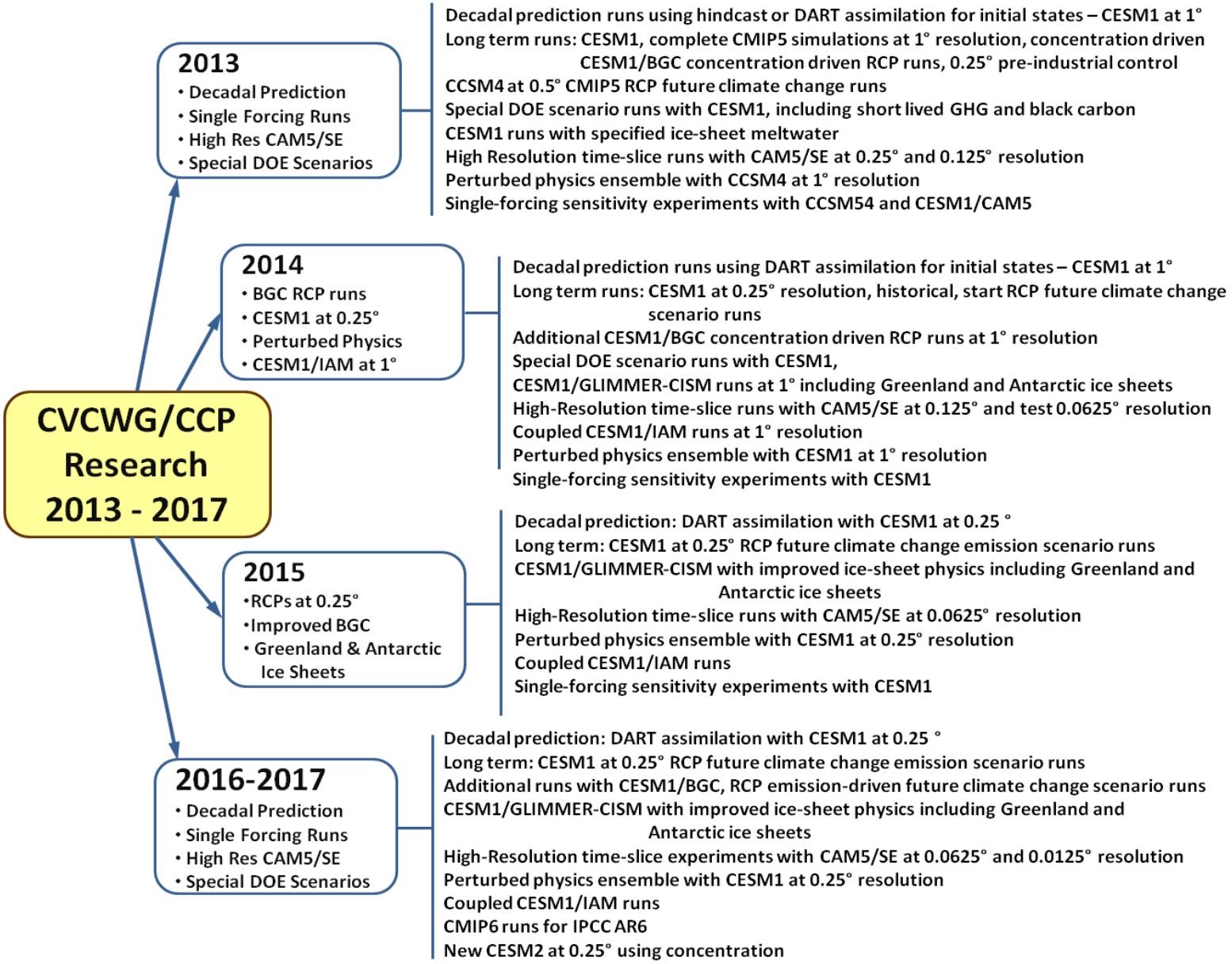
CMIP5
2012




**“Better”**

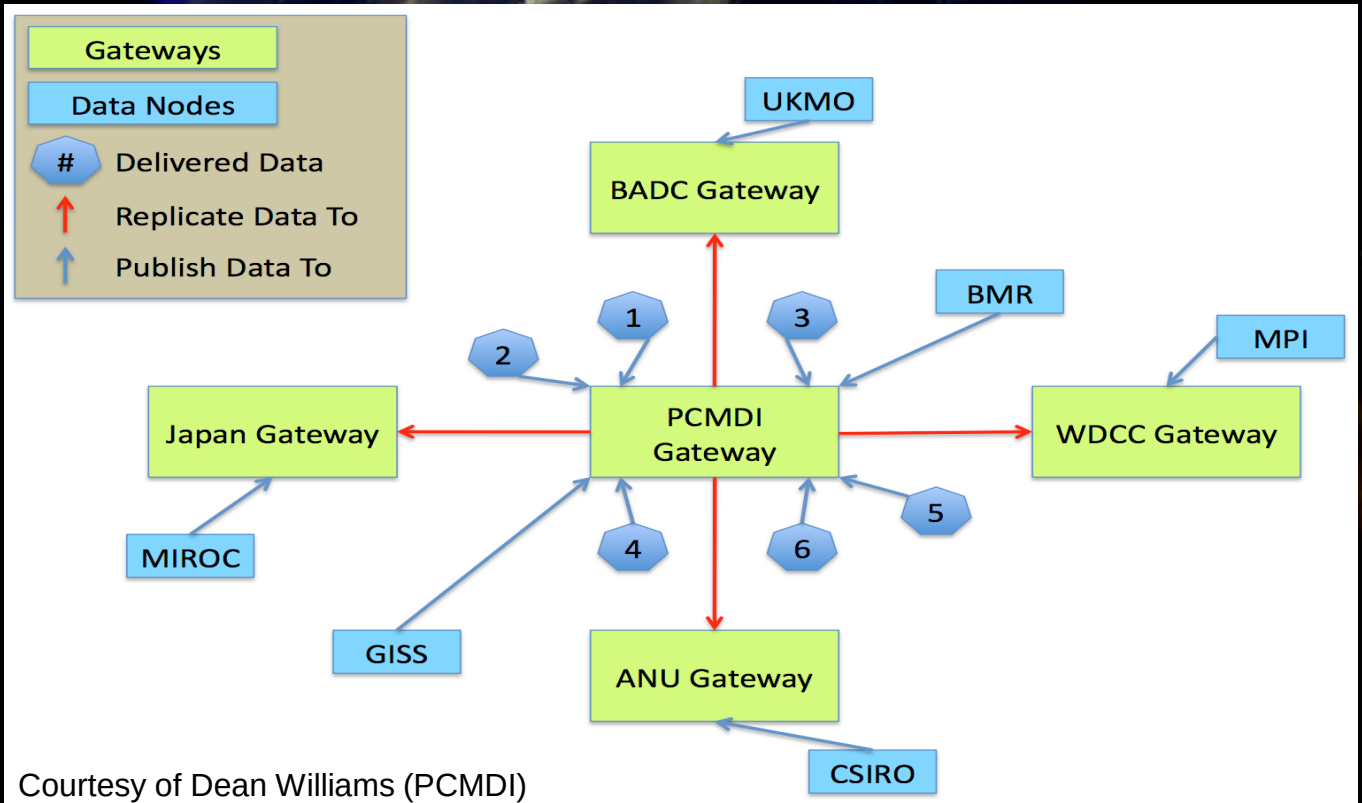
**“Worse”**

# Priority List of Simulations Planned for 2013 to 2017



**Model outputs are being accessed via the Earth System Grid Federation (ESGF, a distributed grid technology),** and most data is being archived on local or regional nodes; some groups will send their model data directly to PCMDI where it will be archived on their ESGF node; all CMIP5 data can be accessed from PCMDI web page with registration; over 300 users already registered.

**An extensive documentation of the models and of model experiments will be available for CMIP5** via EU Metafor & US Earth System Curator

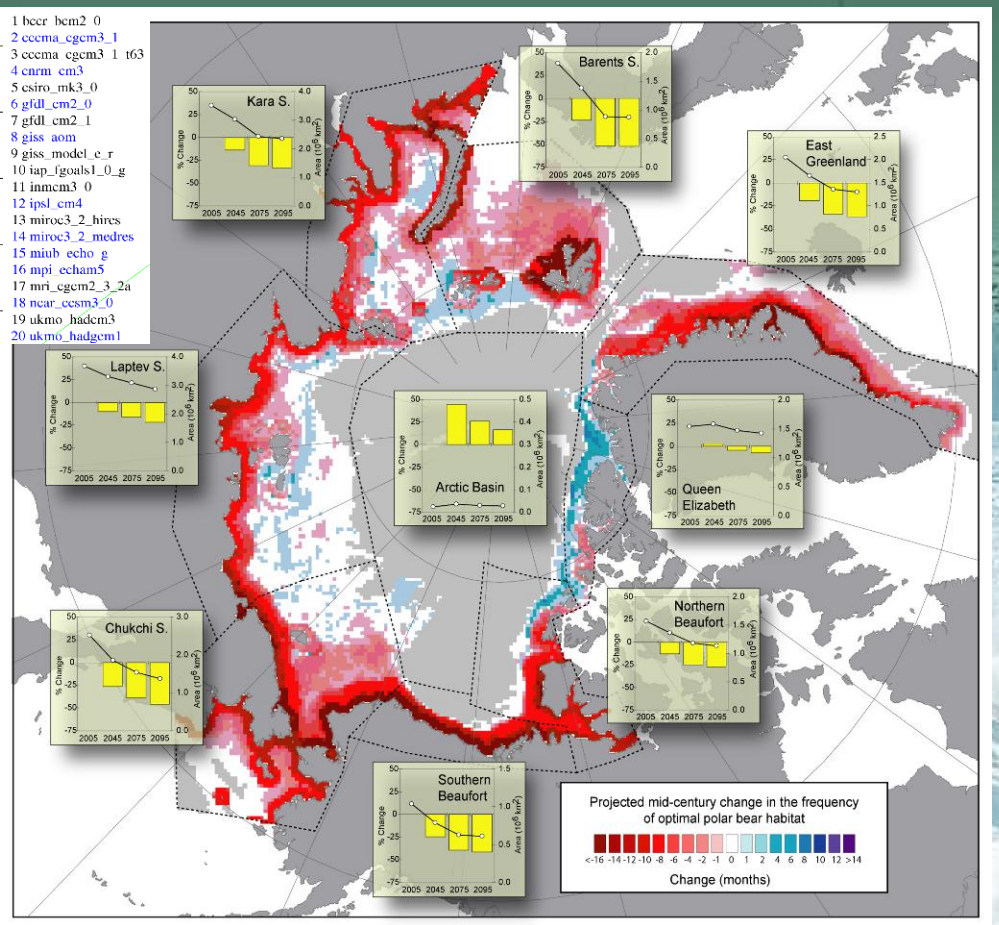



Courtesy of Dean Williams (PCMDI)

USGS
science for a changing world

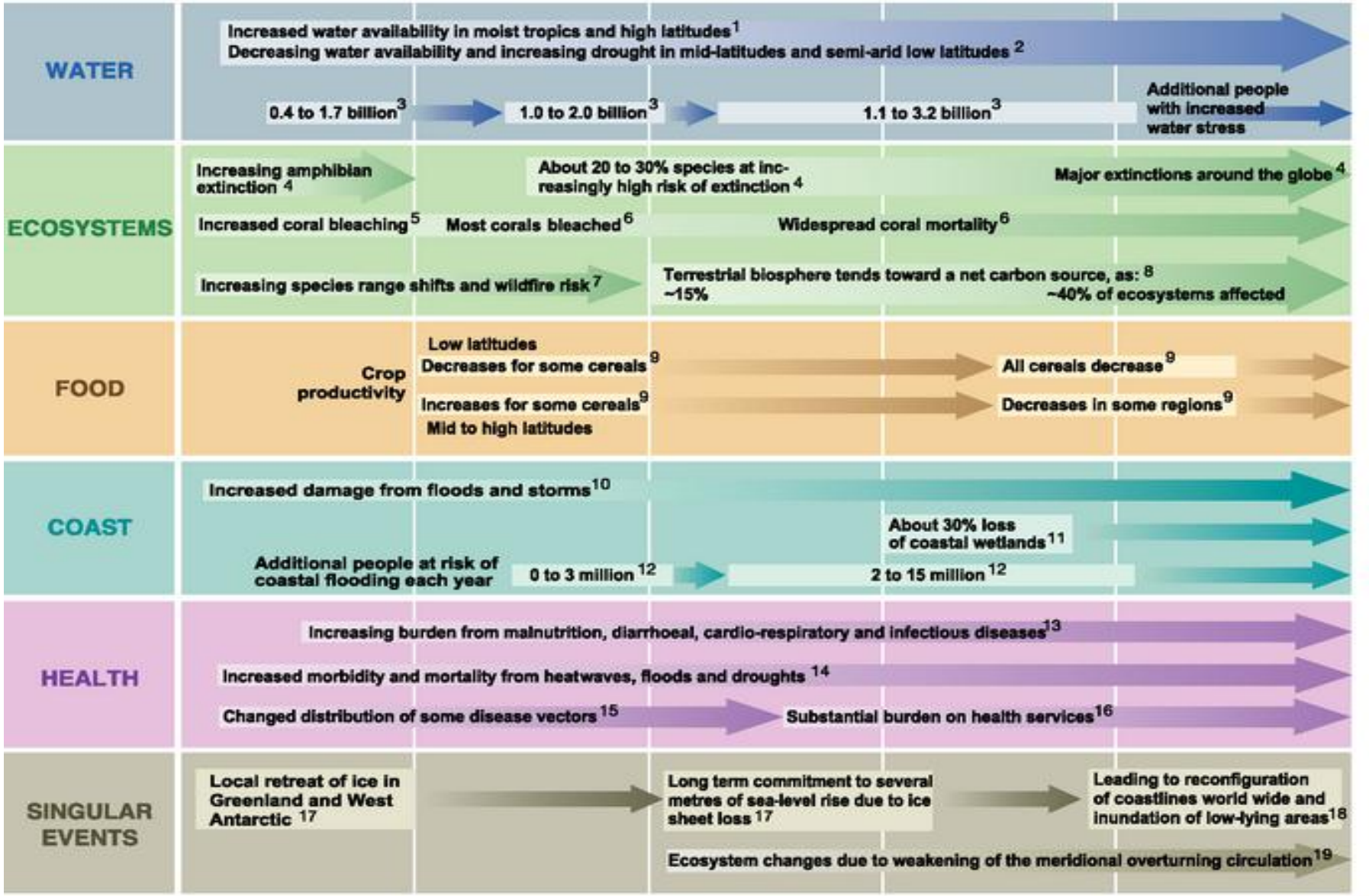
# Briefing on Results:

## 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

# IPCC AR4 WGII Table 20.8: Impacts



# Climate 2.0 - Usable Science for Society

The fundamental question that society is asking of climate science has dramatically changed.

## Climate 1.0 Is anthropogenic climate change occurring?

- Classic, low-resolution, global climate modeling (past 40 years)
- After IPCC AR4 findings, the question is now….

## Climate 2.0 What is the impact of this climate change on our coupled human & natural systems?

- Magnitude and speed? Direct and indirect impacts?
- Adaptation and mitigation - options & limits?
- Regional/Local focus on “usable” science
- Sustainable Systems: Energy, Food, Water, Health, Cities, Ecosystems
- Societal Impacts: GIS, extremes, climate services

## Addressing these much more complex, questions requires:

- Vast improvements to existing climate tools ( CESM & WRF/NRCM )
- Integrating new approaches, priorities, capabilities,
- New collaborators & partners

*Table 2.1. Some characteristics of different approaches to CCIAV assessment. Note that vulnerability and adaptation-based approaches are highly complementary.*

| | Approach | | | |
|---|---|---|---|---|
| | **Impact** | **Vulnerability** | **Adaptation** | **Integrated** |
| **Scientific objectives** | Impacts and risks under future climate | Processes affecting vulnerability to climate change | Processes affecting adaptation and adaptive capacity | Interactions and feedbacks between multiple drivers and impacts |
| **Practical aims** | Actions to reduce risks | Actions to reduce vulnerability | Actions to improve adaptation | Global policy options and costs |
| **Research methods** | Standard approach to CCIAV Drivers-pressure-state-impact-response (DPSIR) methods Hazard-driven risk assessment | Vulnerability indicators and profiles Past and present climate risks Livelihood analysis Agent-based methods Narrative methods Risk perception including critical thresholds Development/sustainability policy performance Relationship of adaptive capacity to sustainable development | | Integrated assessment modelling Cross-sectoral interactions Integration of climate with other drivers Stakeholder discussions Linking models across types and scales Combining assessment approaches/methods |
| **Spatial domains** | Top-down Global -› Local | Bottom-up Local -› Regional (macro-economic approaches are top-down) | | Linking scales Commonly global/regional Often grid-based |
| **Scenario types** | Exploratory scenarios of climate and other factors (e.g., SRES) Normative scenarios (e.g., stabilisation) | Socio-economic conditions Scenarios or inverse methods | Baseline adaptation Adaptation analogues from history, other locations, other activities | Exploratory scenarios: exogenous and often endogenous (including feedbacks) Normative pathways |
| **Motivation** | Research-driven | Research-/stakeholder-driven | Stakeholder-/research-driven | Research-/stakeholder-driven |

# Climate Science and Applications Program

***Promote societal resilience to environmental variability by conducting interdisciplinary research on the interactions among society, weather, and climate.***

**RAL**

**ISP**

***GIScience Program***
***Olga Wilhelmi***

***Governance and Adaptation***
***Kathy Miller***

***Regional Adaptation to Climate Change***
***Caspar Ammann***

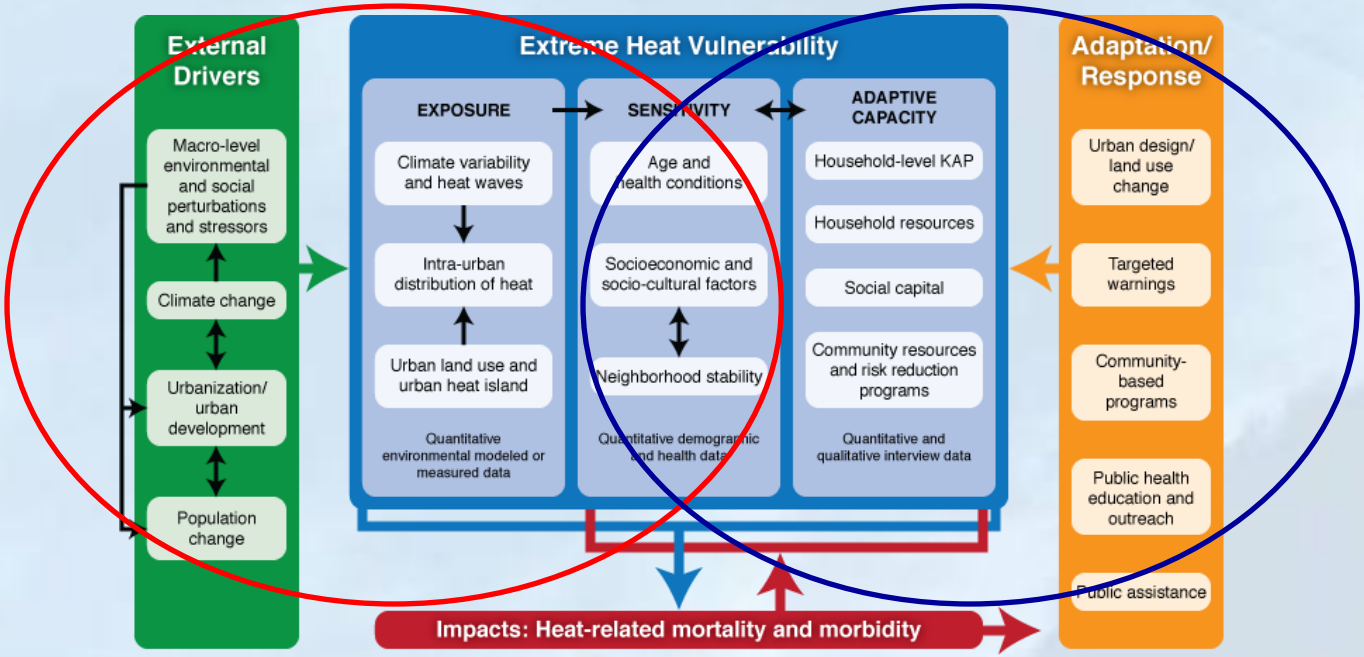
***Resilient Sustainable Cities***
***Paty Romero-Lankao***

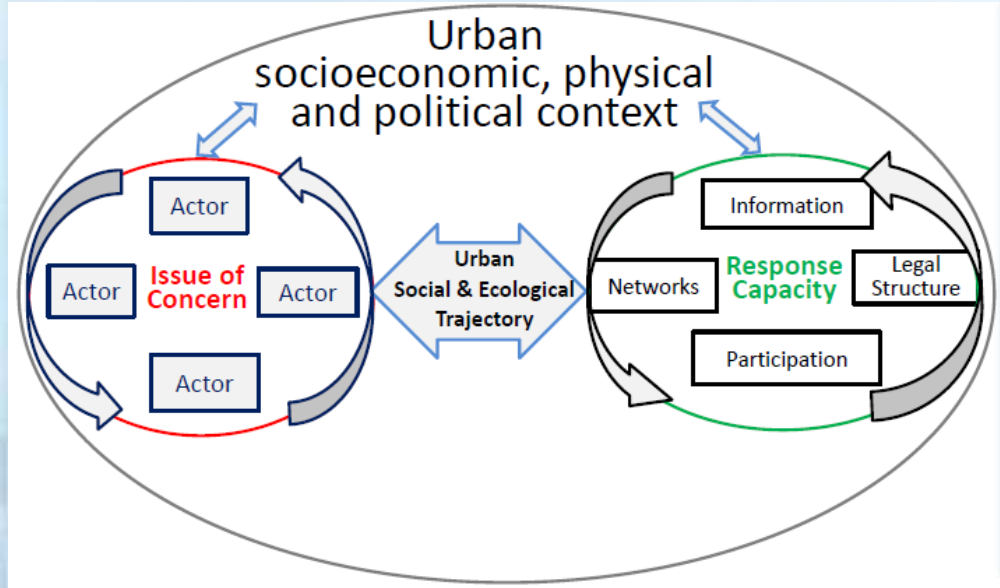
***Weather, Climate and Health***
***Mary Hayden***

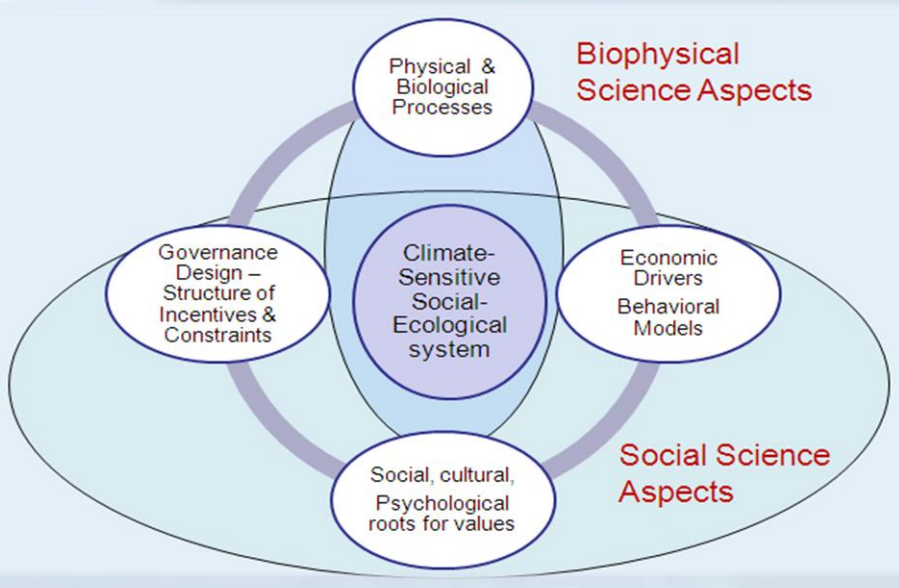
NCAR

NSF

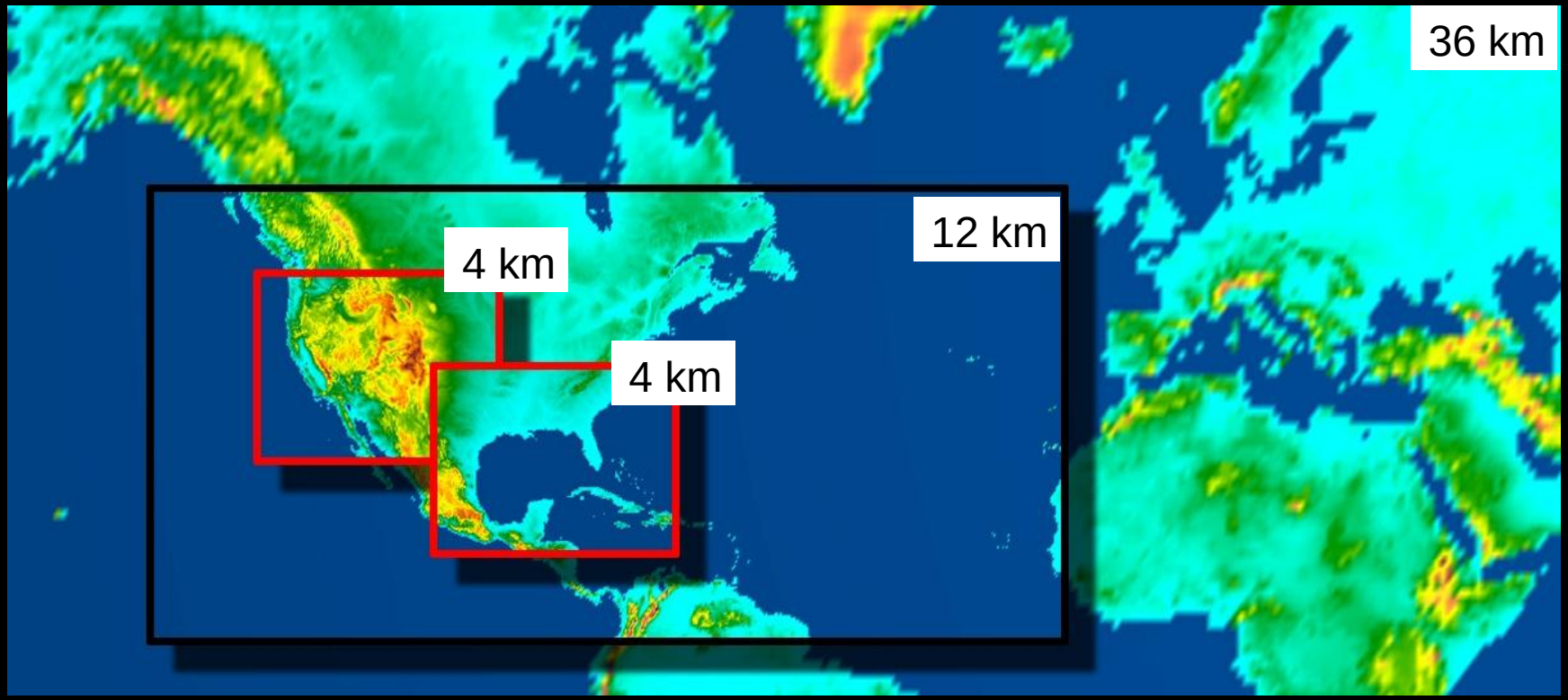
# CSAP Frameworks: Bridging Social and Physical Sciences



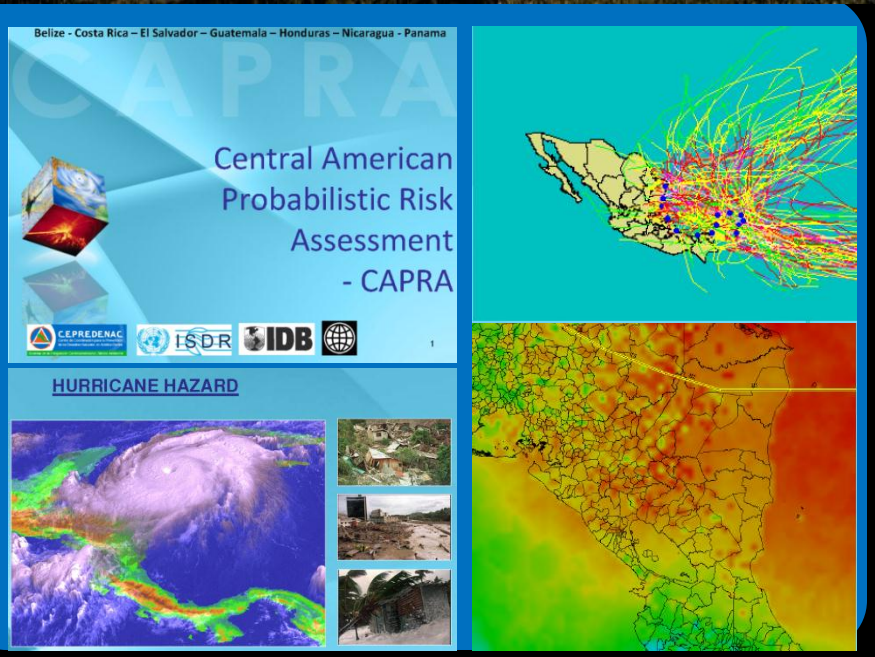
# Multi-decadal Regional Climate Predictions of High-Impact Weather Over North America & the Caribbean

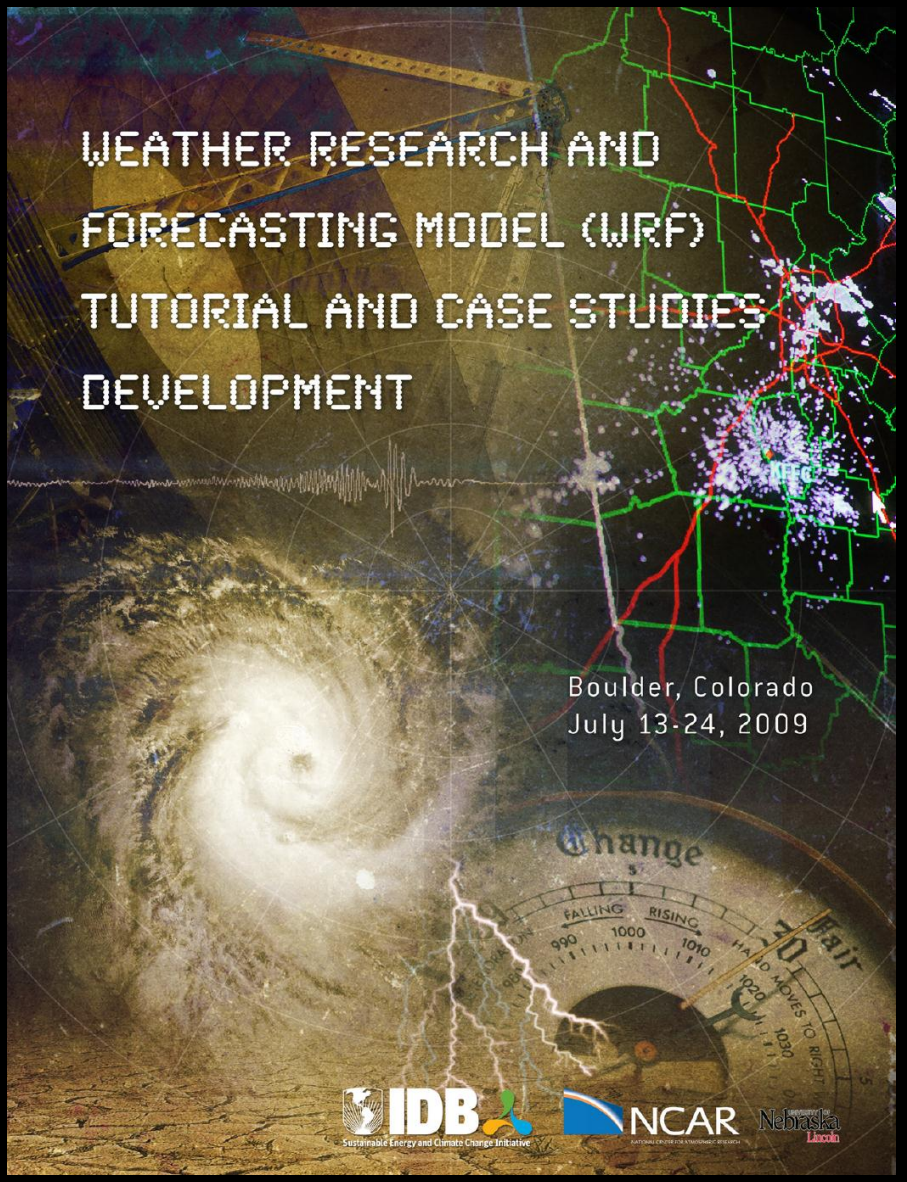



- Global Model: 3 Ensembles from 1950-2060
- NRCM: 1995-2005 Obs, 1995-2005, 2020-2030, 2045-2055,
- 3 ensembles at 36km, 1 at 12 km, specific cases at 4 km.
- Use of statistical downscaling to fill in intermediate periods

**Holland - NCAR**

# InterAmerican Development Bank
# Energy & Climate Change Initiative

# Societal Dimensions Working Group

## Connecting climate research with a major industrial sector

**Water Utility Climate Alliance**: create usable climate data with attached uncertainty at a scale that can inform WUCA hydrologic and operations models.

**CESM Climate Modelers**: Advance CESM modeling capability and evaluation of "usability" in a model development context

San Francisco Water Power Sewer

### Symbiosis

San Francisco Water Power Sewer

### The Stakes on Climate Change:
**Water and Clean Water Sector Only**

**2011-2031: Without Adaptation**

Drinking Water Infrastructure Investment
**$335 Billion** [1]

Clean Water Infrastructure Investment
**$298 Billion** [2]

**By 2050: Potential Adaptation Costs**

Drinking Water + Clean Water Sector:

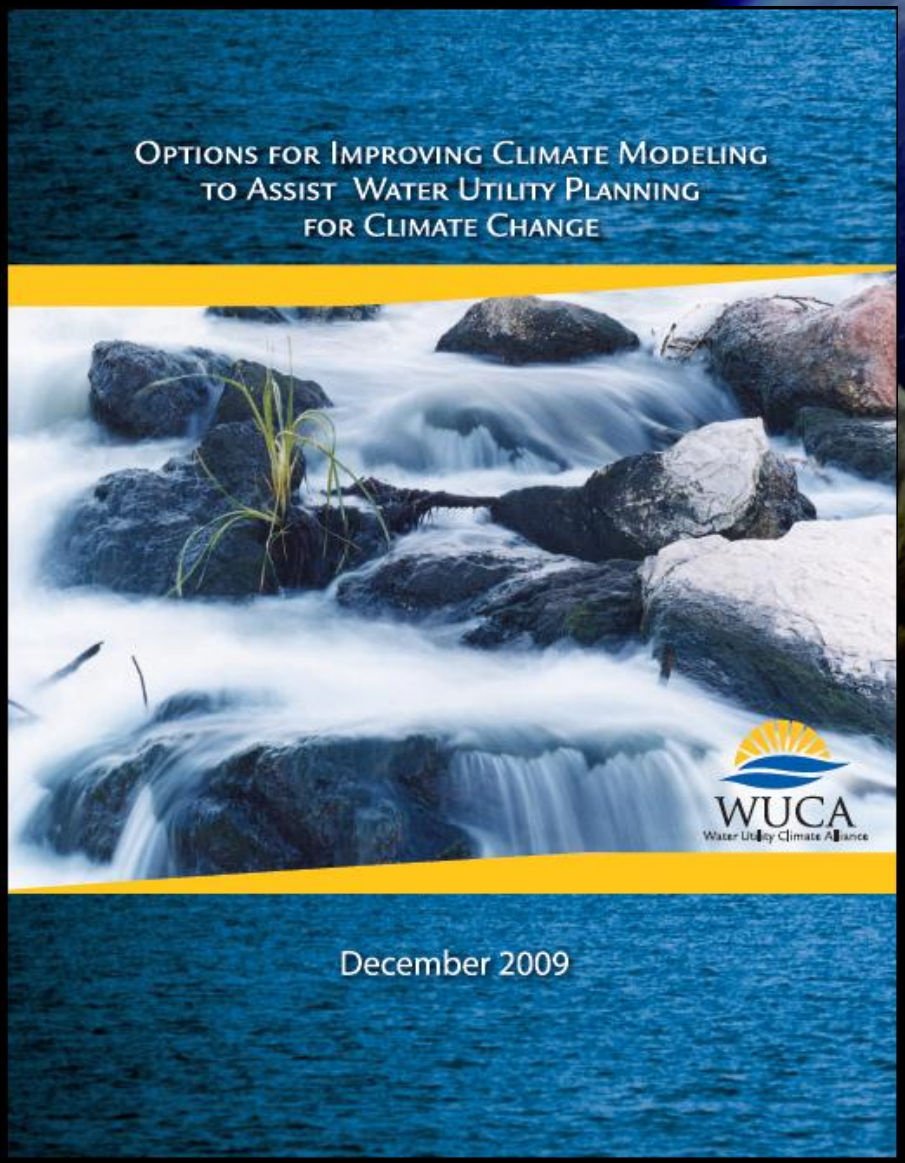
**$448 - 944 Billion** [3]

[1] "2009 Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress." USEPA Office of Water, 2005.

[2] "Clean Watersheds Needs Survey 2008: Report to Congress." USEPA, May 2010.

[3] "Confronting Climate Change: An Early Analysis of Water and Wastewater Adaptation Costs," Association of Metropolitan Water Agencies, National Association of Clean Water Agencies, 2009.

# Responding to Societal needs




***GCM Improvements:***

1. *Development and enhancement of global climate model ensembles.*
2. *Improved use of observations to constrain climate model projections.*
3. *Improved modeling of the Tropical Pacific.*
4. *Improved decadal prediction.*

***Regional Model Improvements:***

1. *Development of regional climate change ensembles*
2. *Development of RCM model components.*
3. *Development of statistical downscaling techniques for probabilistic downscaling, extremes, and daily data*

These needs integrated into 2012 CESM development plans.

# Climate Services:

*"The timely production and delivery of useful climate data, information and knowledge to decision makers"*

*(NRC, 2001)*

"Give me information in such a way that I can make decisions at a local level. What does this mean for me in the next 3-5 years"

- Jargon-free, clear, actionable, expose the uncertainties
- Science-brokers/translators are important

(Pew Report "Lost in Translation")

Goal: "Issued" climate products & processes that allow planners to move ahead with major, climate-informed, operational decisions

,,,, and get on with their real jobs

….and stay out of court.

US: NCPP, DOI NC-CSC,US NA, ESGF/

Int'l: Climate Service Partnership, ICCS series & WMO/GFCS

# The Grand Challenge of today…

Maintaining healthy national and local economies,
in a rapidly changing world of increasing population and GNP,
all accessing a finite resource base.

It's all about sustainability of Energy, Food & Water…

While maintaining your critical Human systems
- Transportation, Agriculture, Health & Quality of life…

Without disrupting your critical natural ecosystems…

"Technology alone is not enough. Faster, thinner, lighter, those are all good things. But when technology gets out of your way, everything becomes more delightful, even magical… That's when you leap forward…" **Apple iPad**


# Thanks! Any Questions?

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**southern@ucar.edu www.ral.ucar.edu/csap**