Preparing for the next probable IPCC Assessment Report: Moving to Higher Resolution and Complexity

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National Center for Atmospheric Research

CAS2K13, Annecy,France
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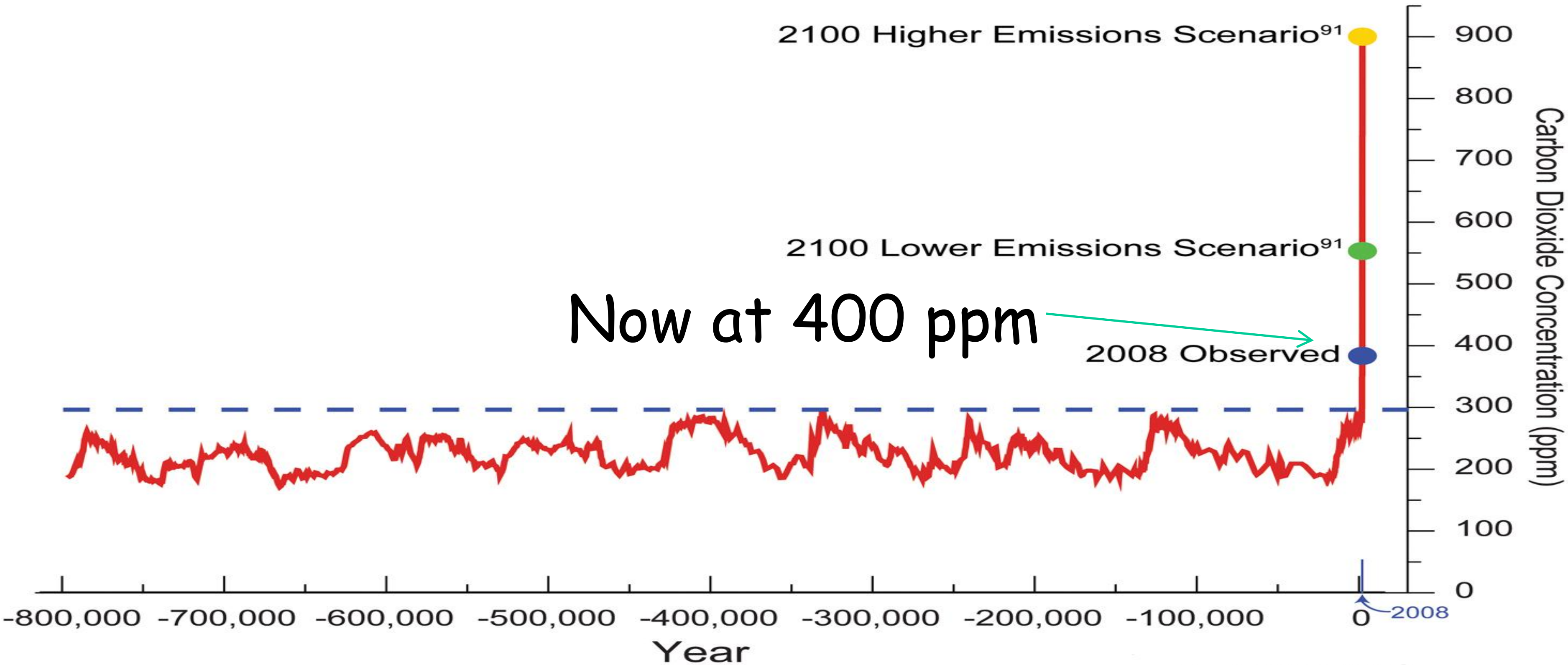
NCAR

Overview

- Brief history of observations, climate modeling and Earth system modeling
- Prediction of 20^{th}, 21^{st} century and beyond climate change and its effect on society
- Four goals: advance the science, inform decision making, conduct assessments, and communicate and educate policymakers and the public
- What will be viable resolutions and complexity of future climate and Earth system models

The Observational Story

Historical CO_2 Levels

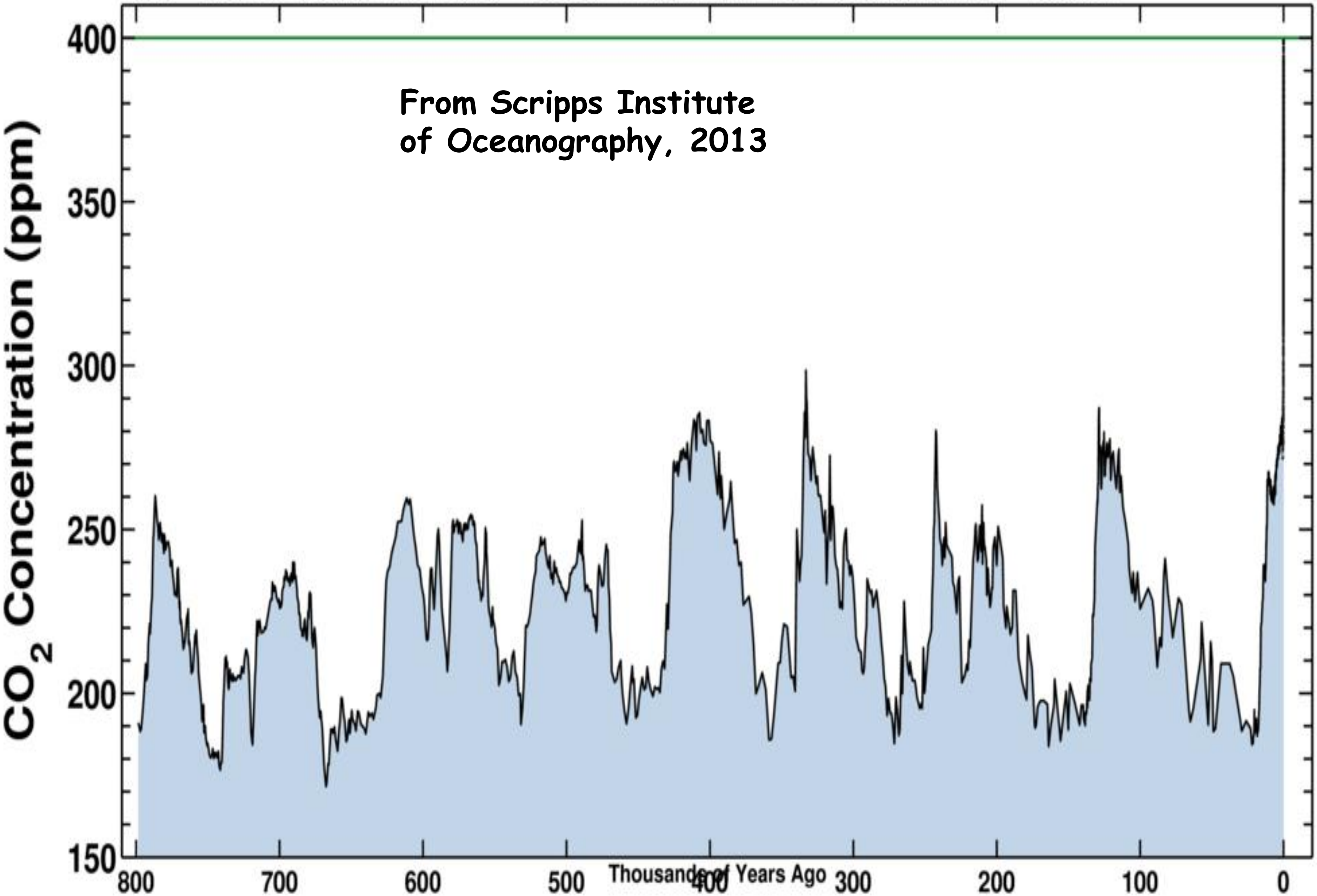


Lüthi *et al.*; Tans; IIASA[2]

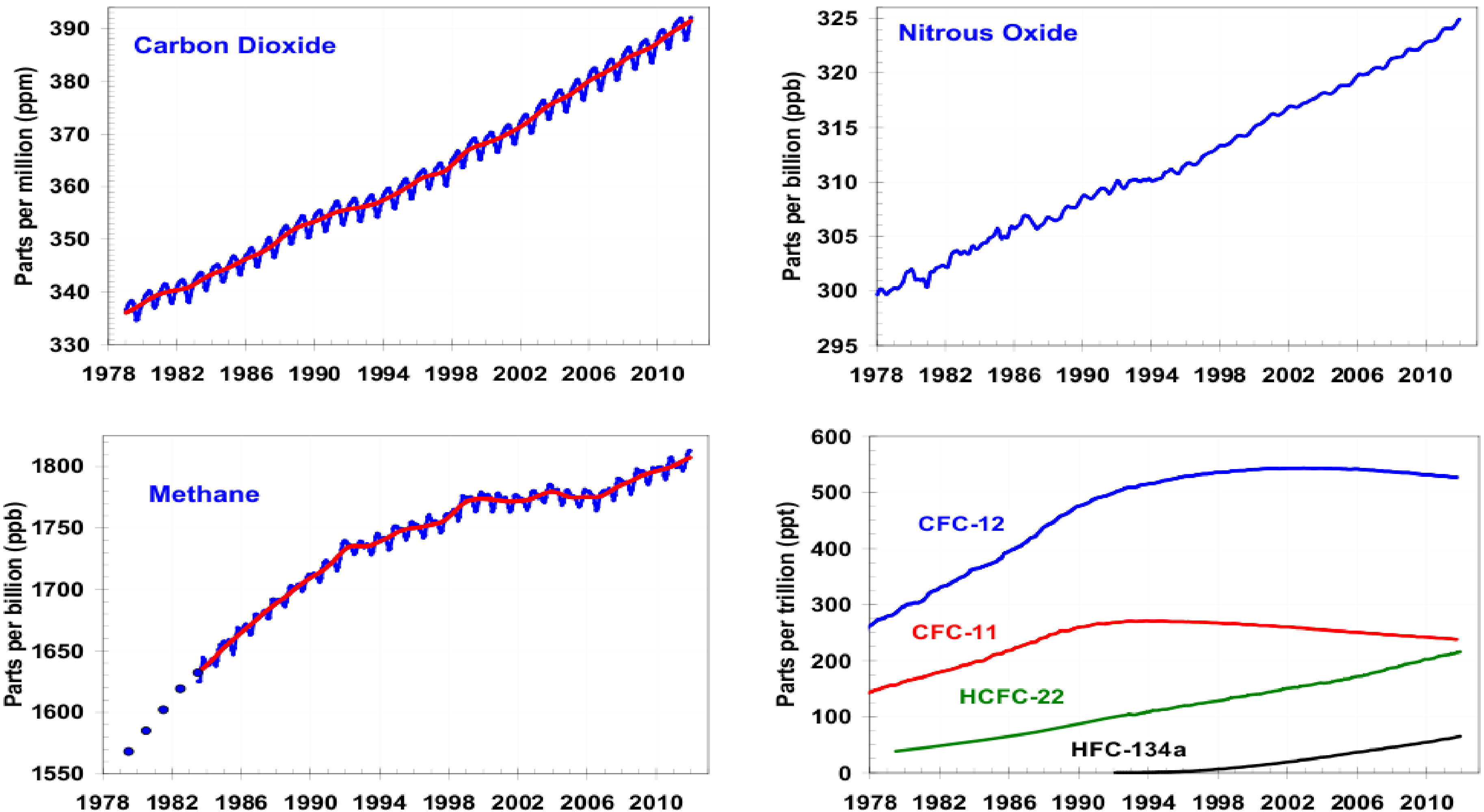
Analysis of air bubbles trapped in an Antarctic ice core extending back 800,000 years documents the Earth's changing carbon dioxide concentration. Over this long period, natural factors have caused the atmospheric carbon dioxide concentration to vary within a range of about 170 to 300 parts per million (ppm). Temperature-related data make clear that these variations have played a central role in determining the global climate. As a result of human activities, the present carbon dioxide concentration of about 385 ppm is about 30 percent above its highest level over at least the last 800,000 years. In the absence of strong control measures, emissions projected for this century would result in the carbon dioxide concentration increasing to a level that is roughly 2 to 3 times the highest level occurring over the glacial-interglacial era that spans the last 800,000 or more years.

Luthi et al:Tans

Ice–core data before 1958. Mauna Loa data after 1958.

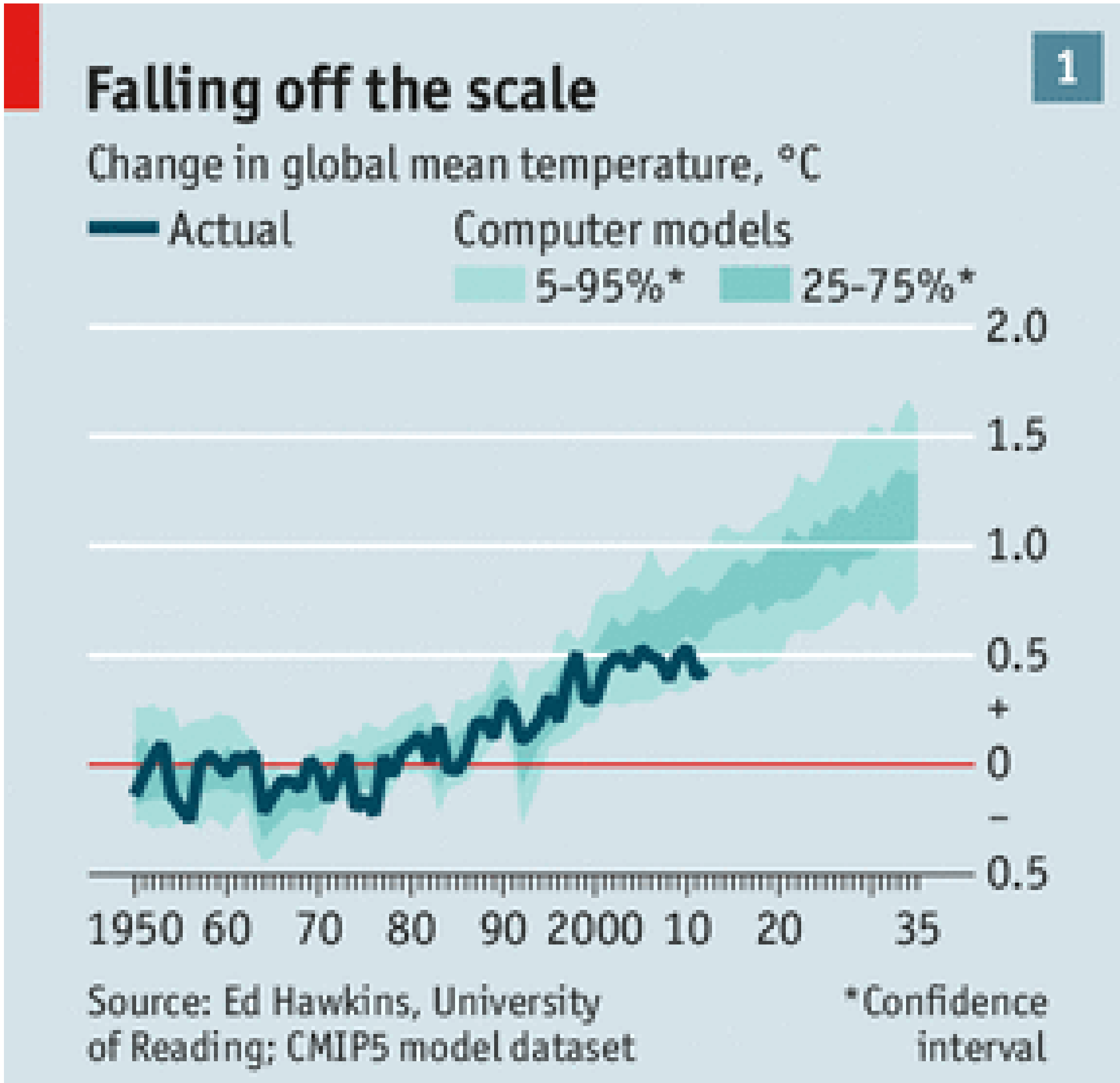


CO_2 Emissions



From NOAA

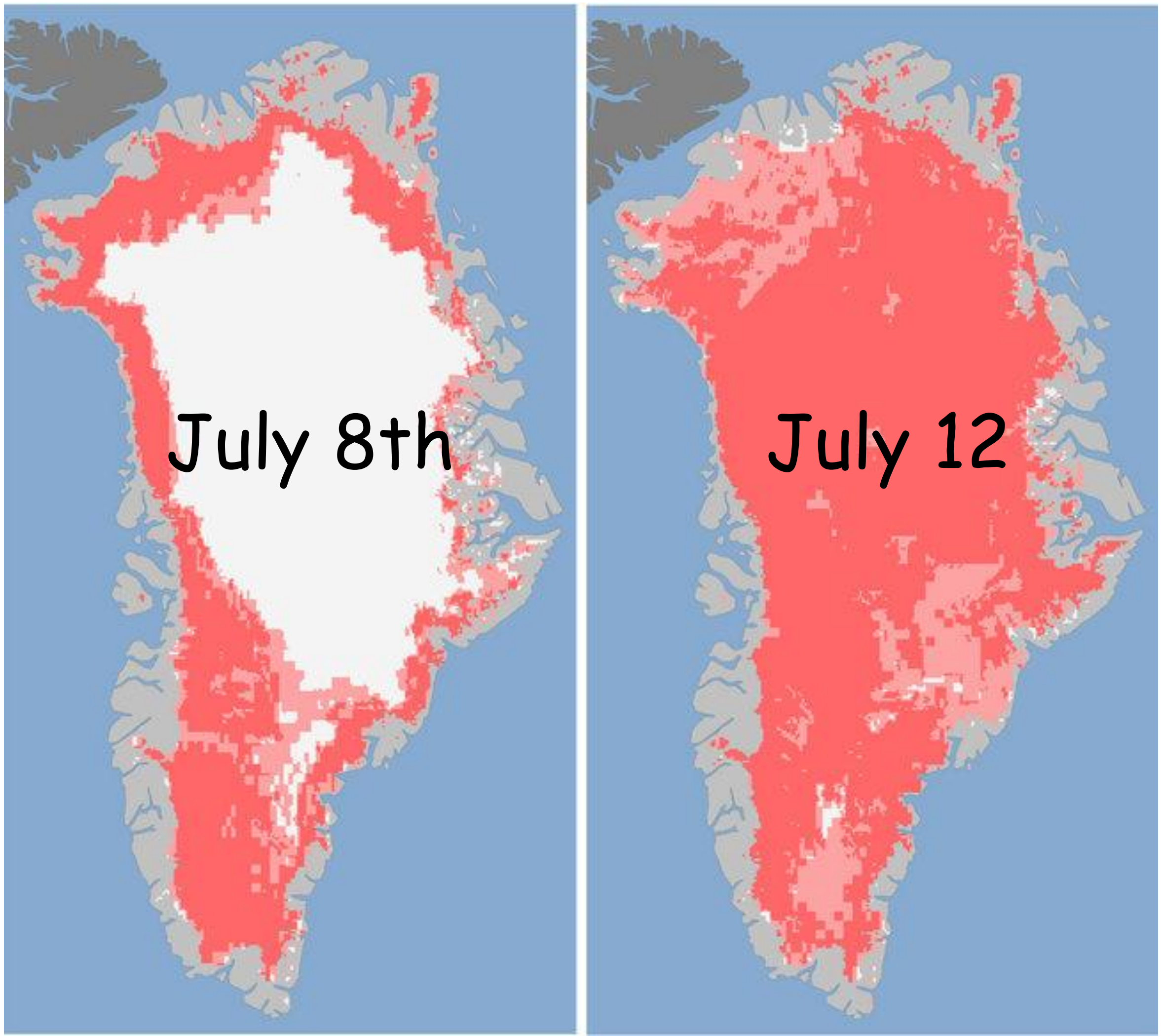
Is Global Warming Slowing Down?



Cloud feedback, heat going in deeper ocean, Volcanic aerosols, China and India, Aerosols, PDO.

Economist
1 April 2013

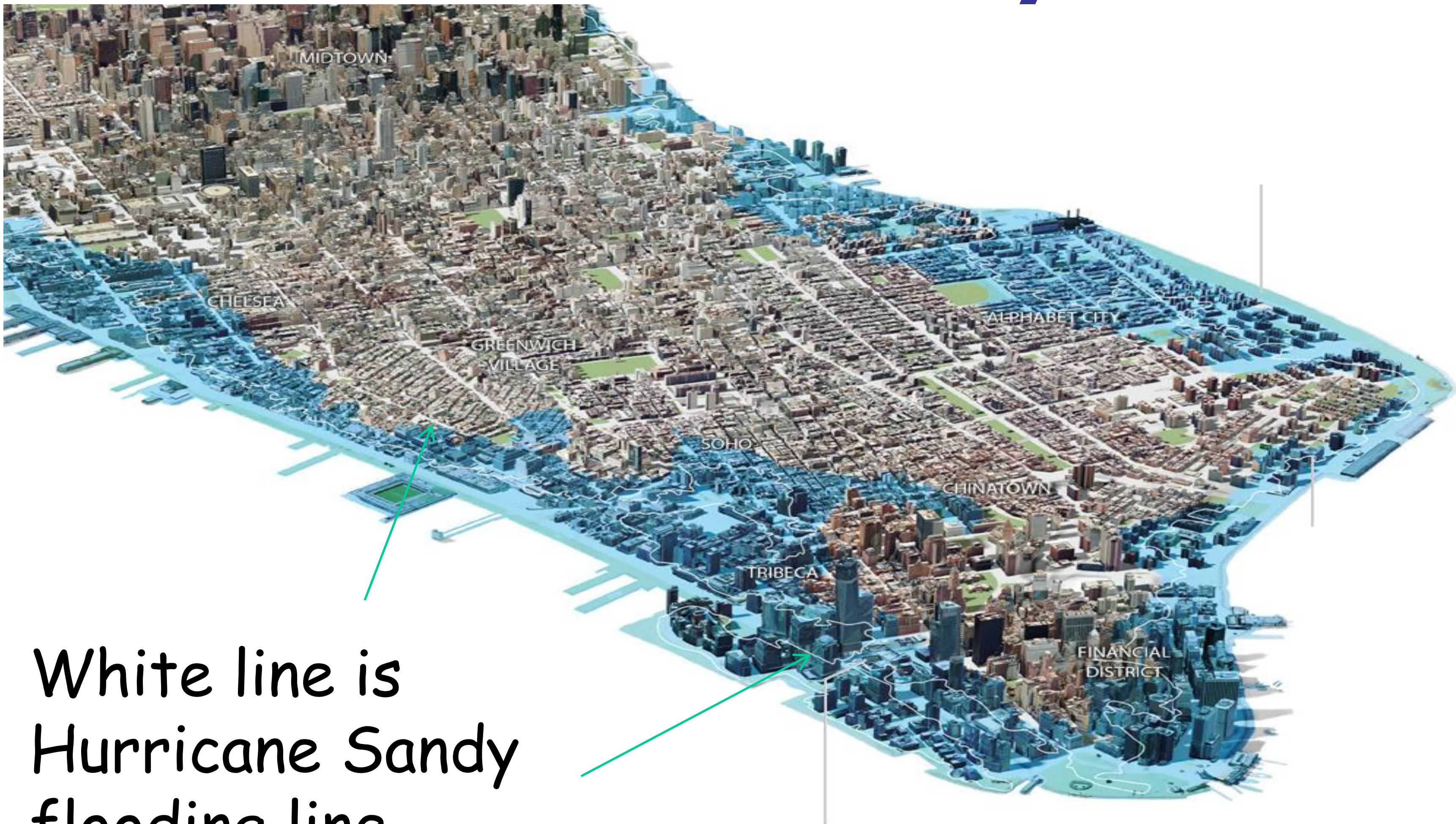
Recent melting of snow on the top of Greenland



From 3 satellites

My experience on the top Greenland

Sandy and future flooding of New York city



White line is Hurricane Sandy flooding line.

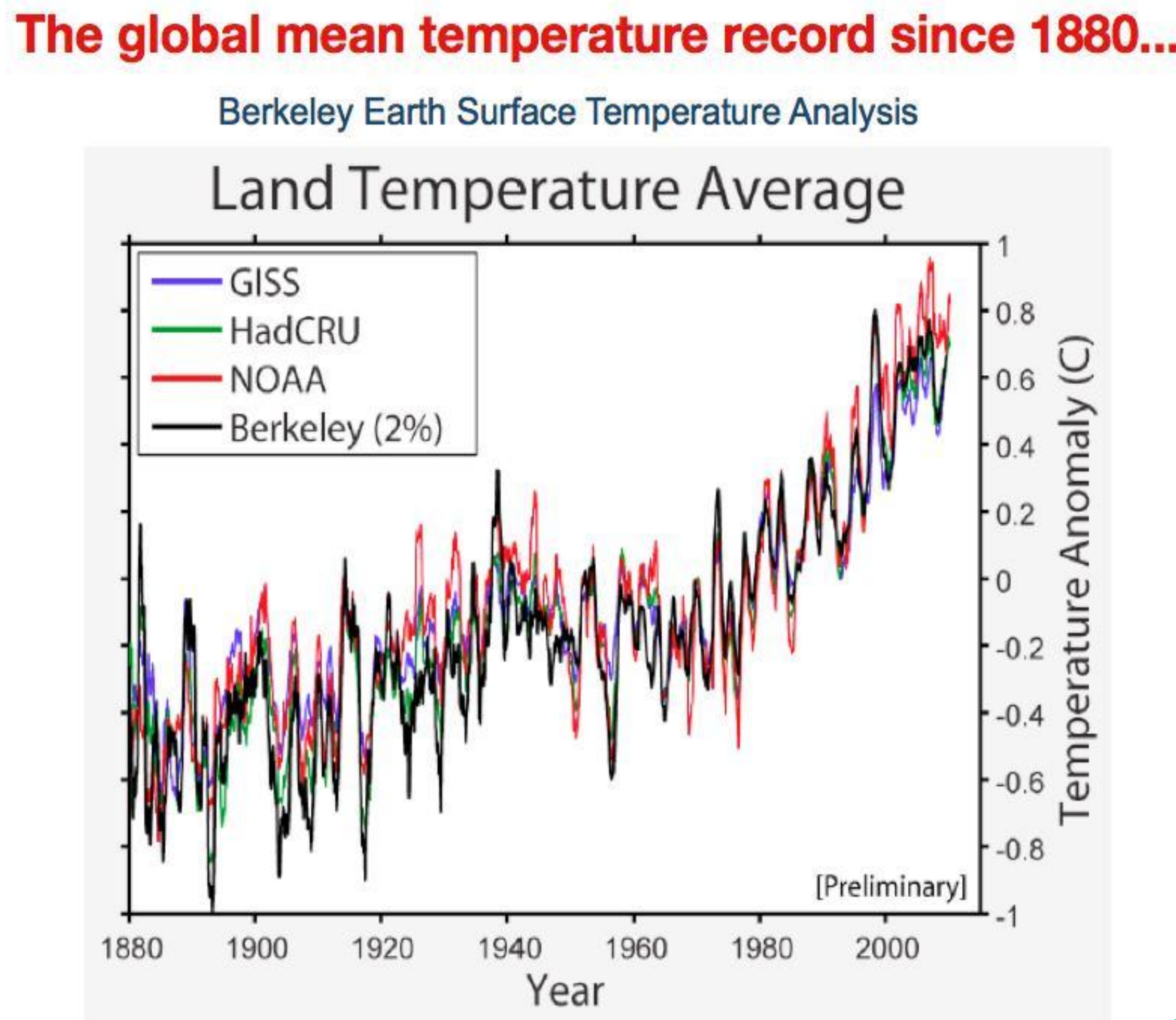
Graphic: National Geographic

The next NASA satellite video gives insight to how the climate is changing and the interaction of vegetation on the carbon cycle.

Credit to the NASA Aqua instrument:
Tom Paqano and colleagues at JPL

The atmospheric carbon dioxide and vegetation connection!

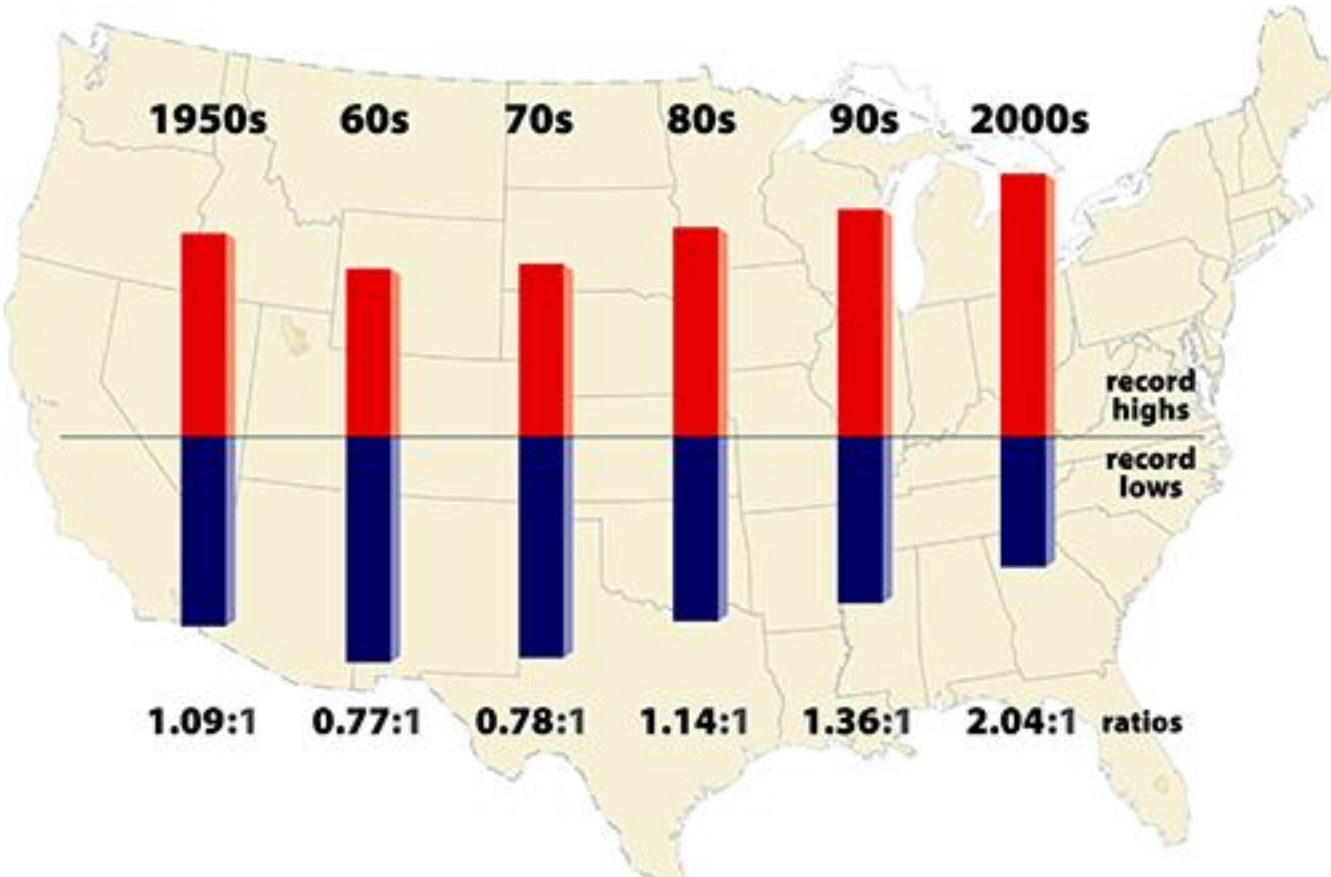
Global Temperature Trends



Former Skeptic

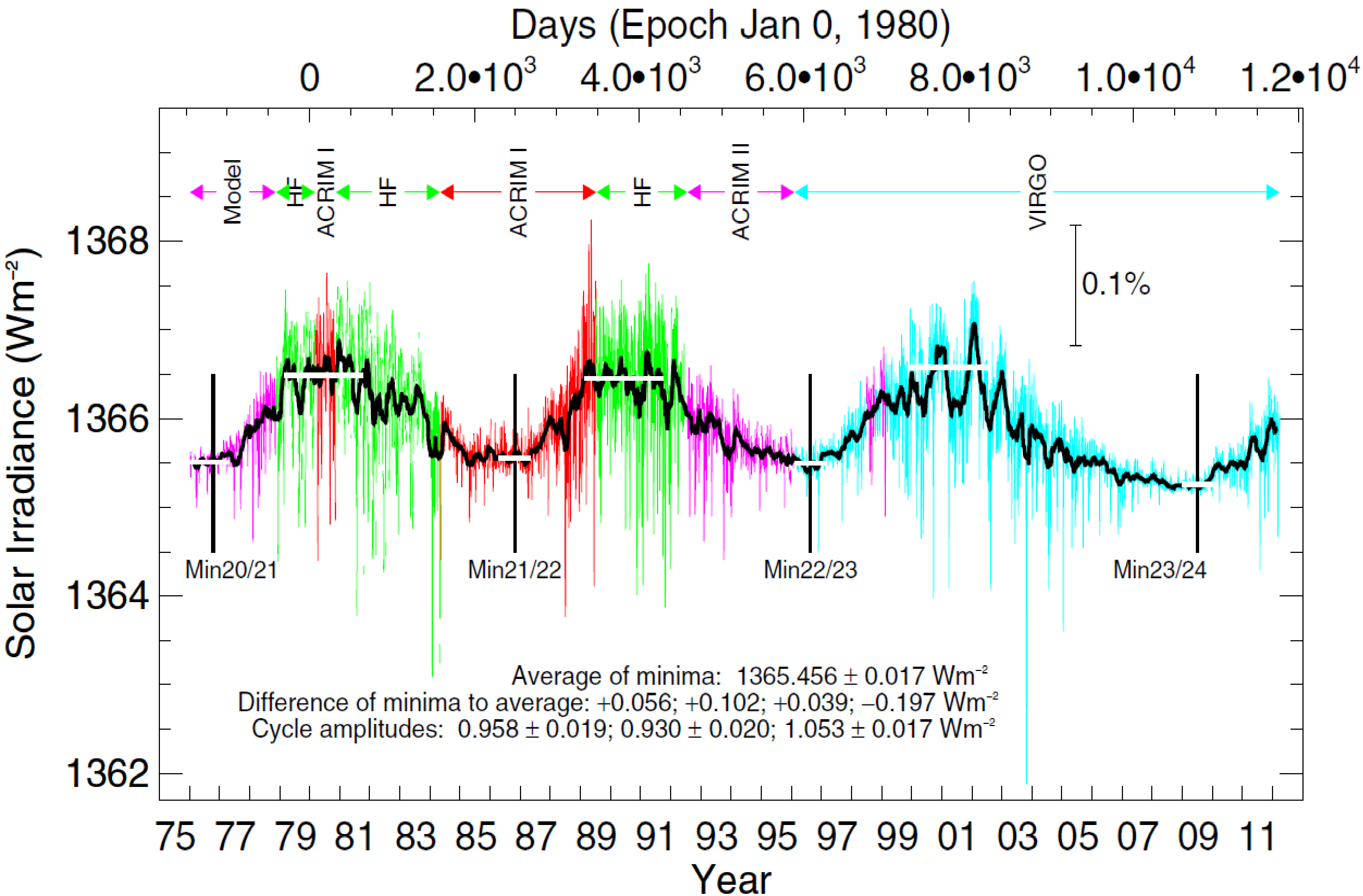
David Brillinger, Judith Curry, Robert Jacobsen, Elizabeth Muller, **Richard Muller (chair)**, Saul Perlmutter, **Robert Rohde**, Arthur Rosenfeld, Charlotte Wickham, Jonathan Wurtele

Changes in Extremes
(heat and cold records)



This graph shows the warming story!

G. Meehl et al. 2010



World Radiation Center, Davos

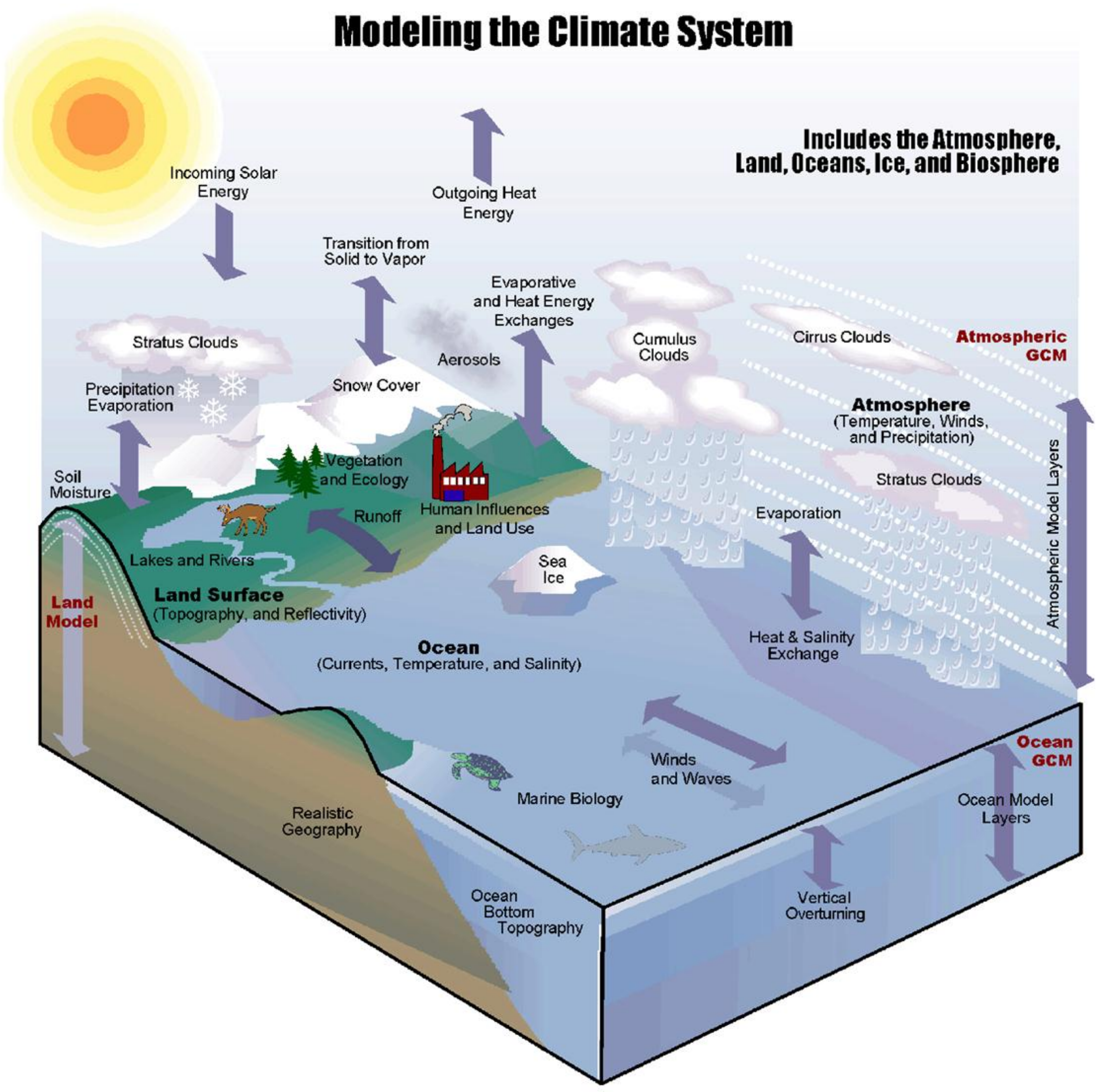
The Climate and Earth System Modeling Story

Laws of Physics, Chemistry, and Biology

- Equations govern the dynamics of atmosphere, ocean, vegetation, and sea ice
- Equations put into a form that can be solved on modern computer systems
- Physical processes such as precipitation, radiation (solar and terrestrial), vegetation, boundary transfers of heat, momentum, and moisture at earth's surface are included
- Forcings: GHGs, Volcanic, Solar variations

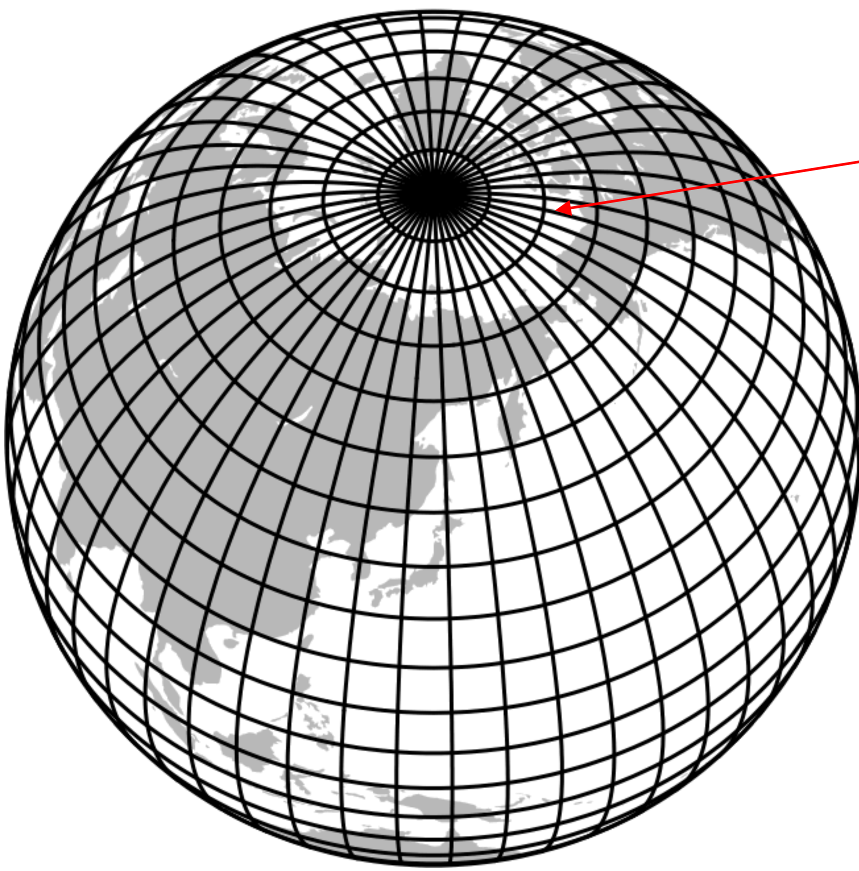
Modelers in the early 1960s

Climate and Earth System Models are Becoming More Complete



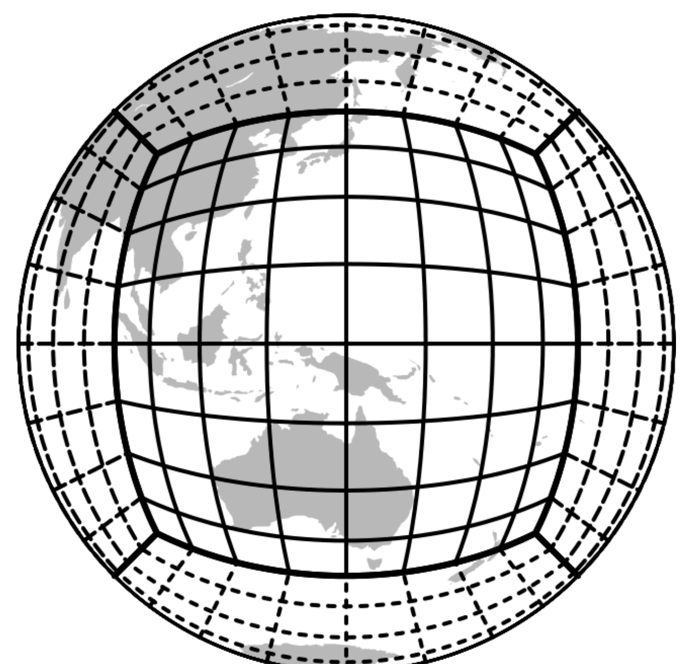
Atmospheric Grid Structure in the 1960s and 1970s

LATITUDE-LONGITUDE GRID

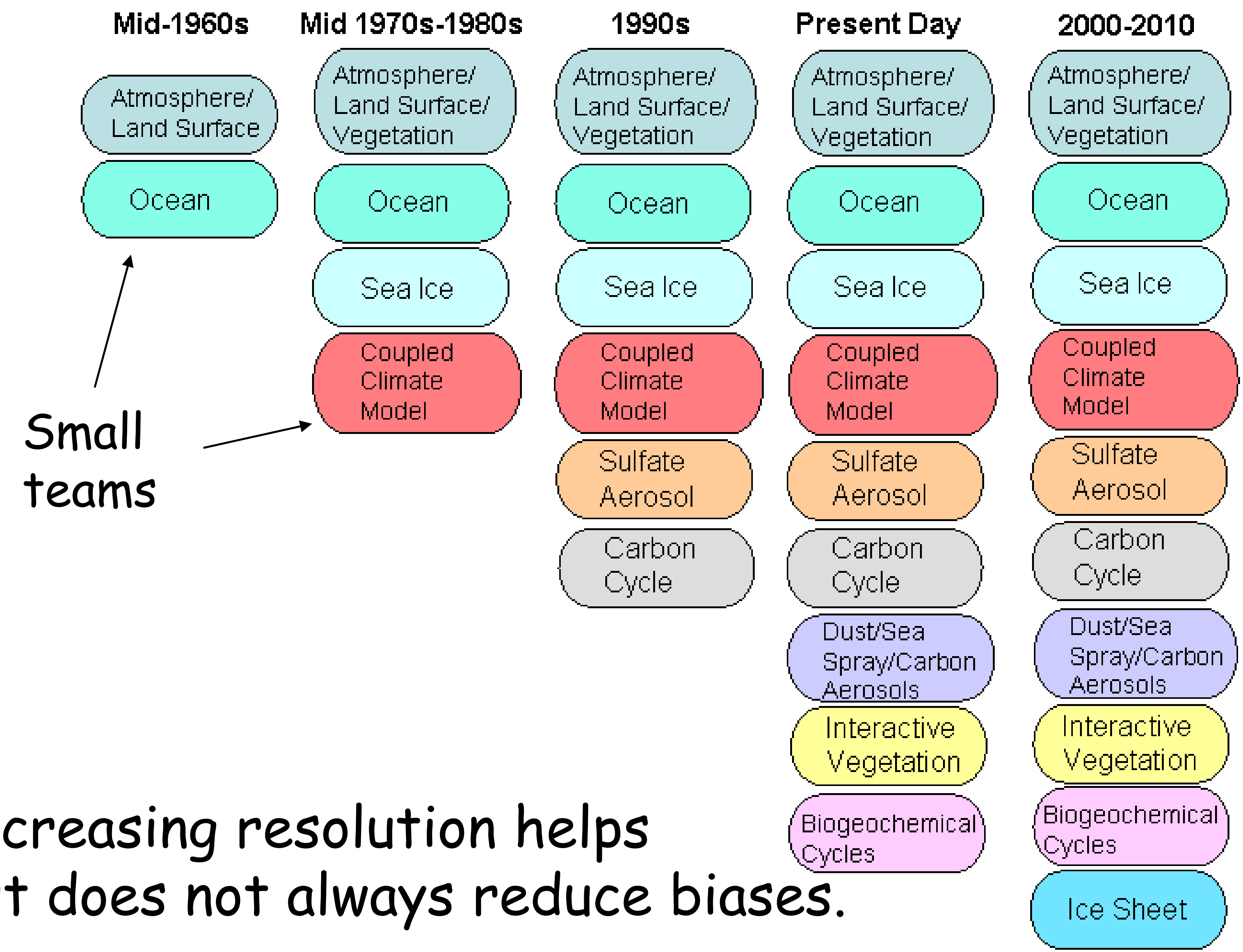


Problem near the poles where longitudes converge…models move new grid structures

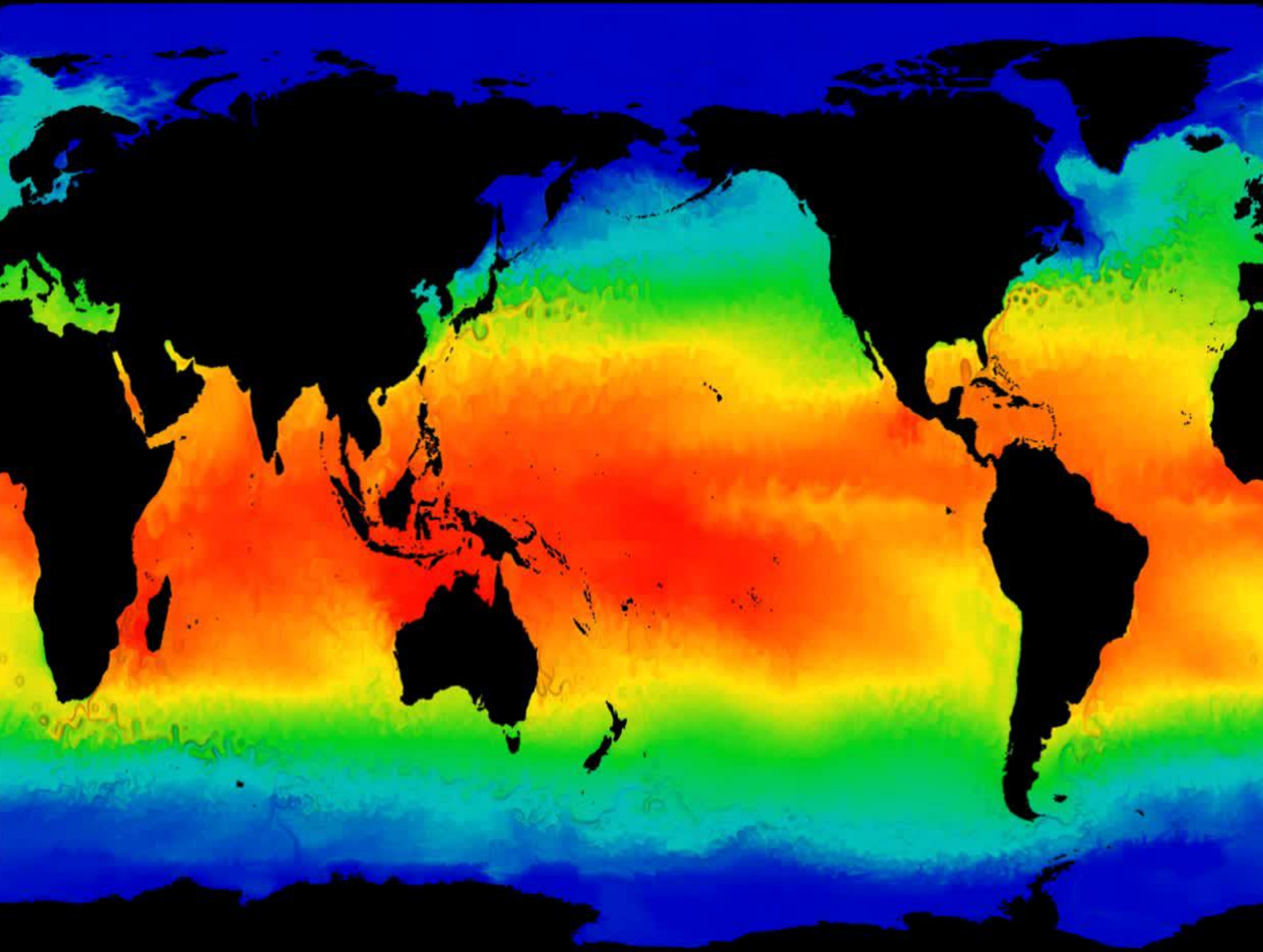
CUBED SPHERE GRID



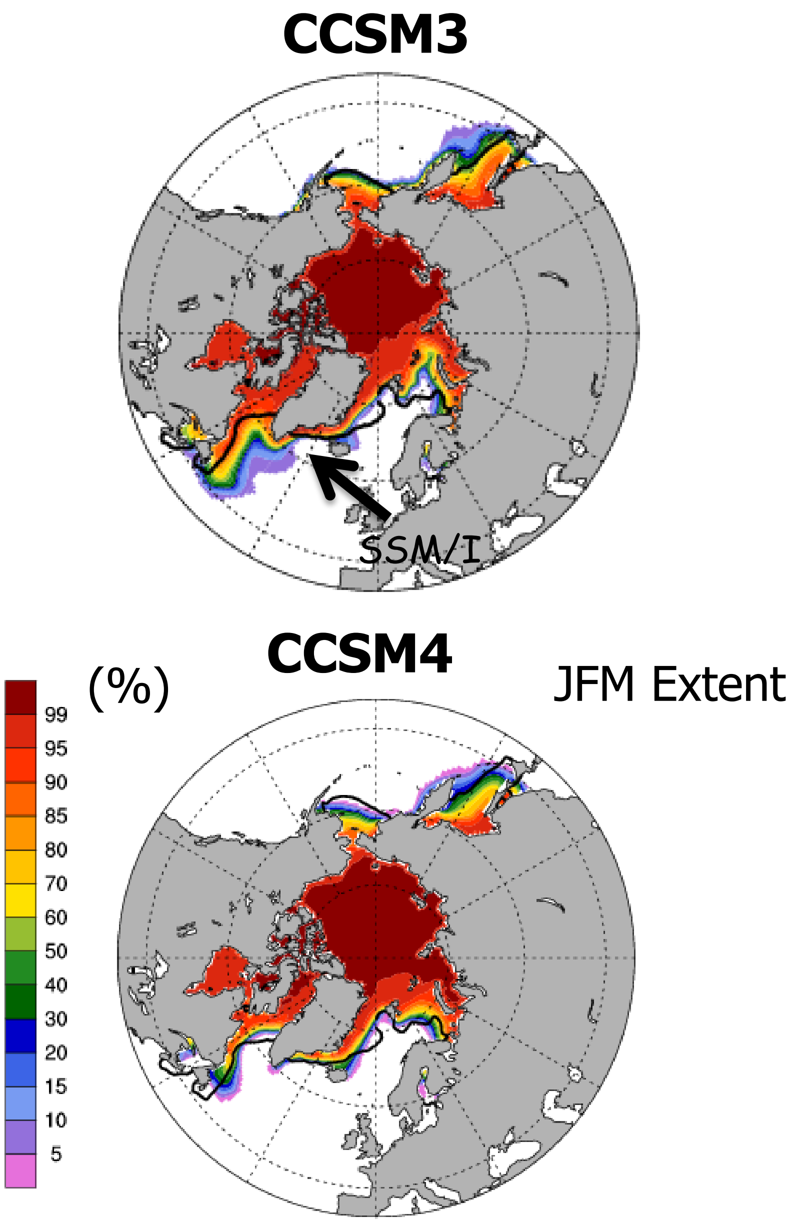
Timeline of Climate Model Development



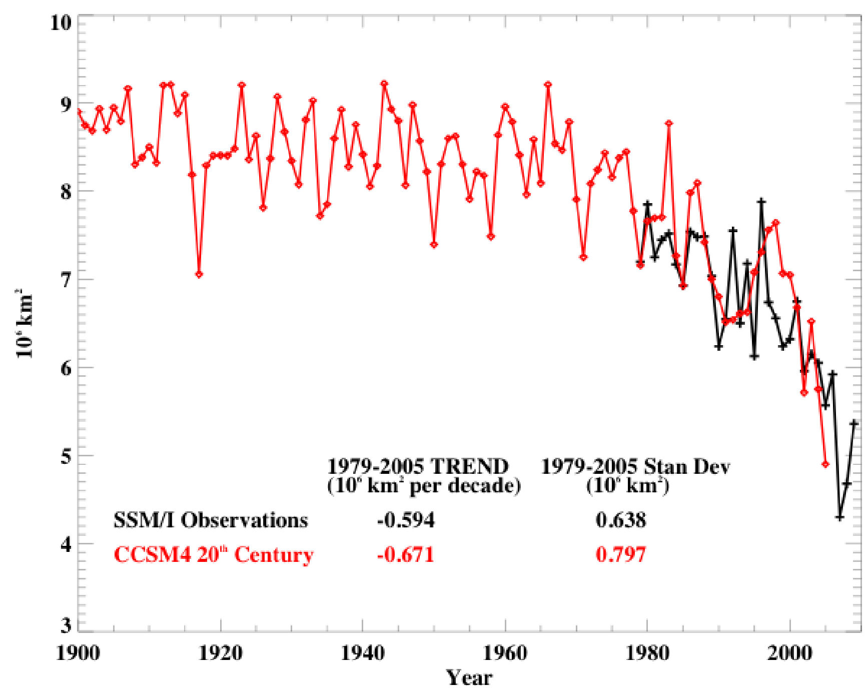
Increasing resolution helps
but does not always reduce biases.



Arctic Sea Ice
(Late 20th Century)
climate change capability

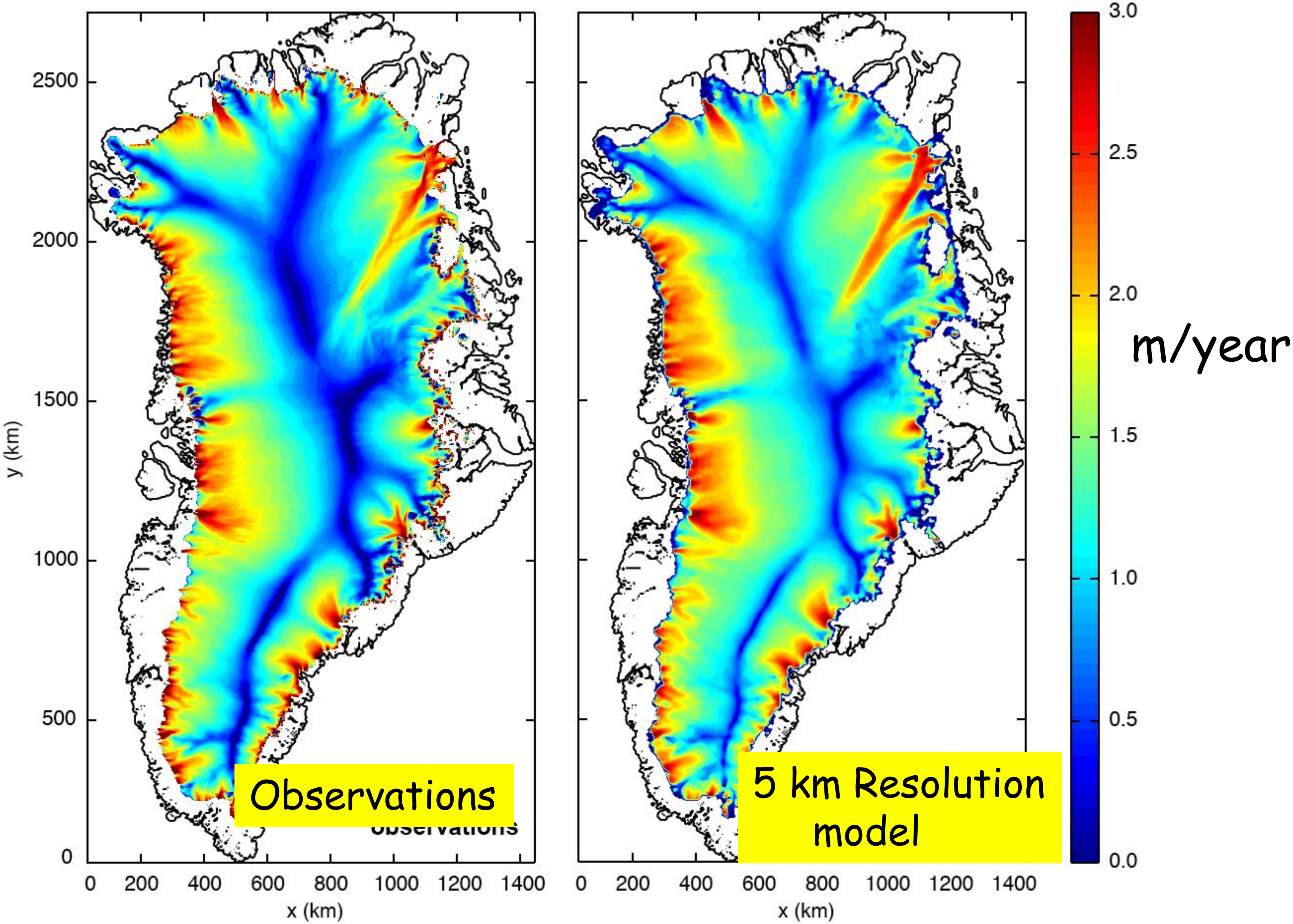


September sea-ice extent loss



DOE/NSF

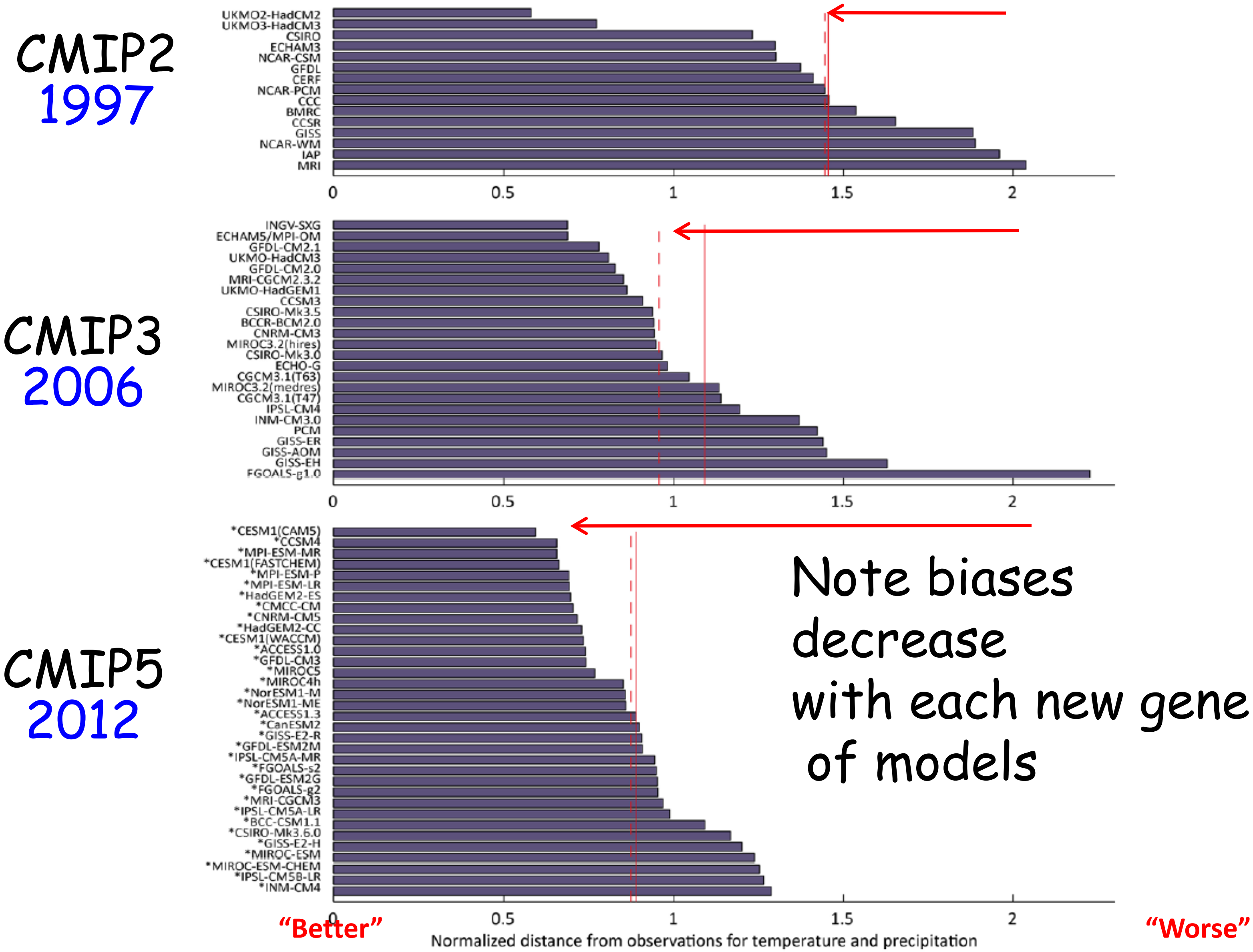
Velocities



Price, Lipscomb et al, DOE/LANL, 2010

Climate model genealogy: Generation CMIP5 and how we got there

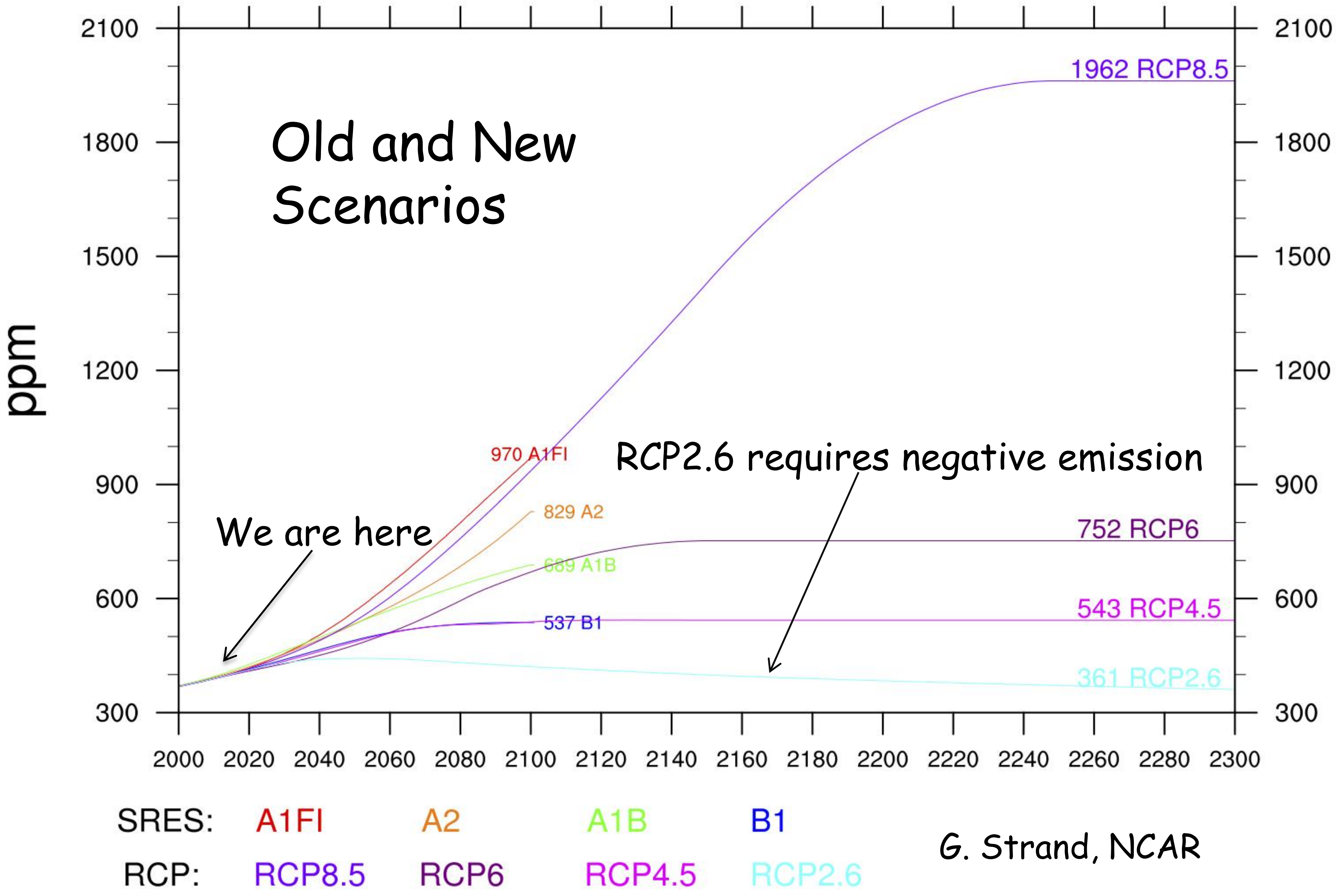
Reto Knutti, David Masson , Andrew Gettelman



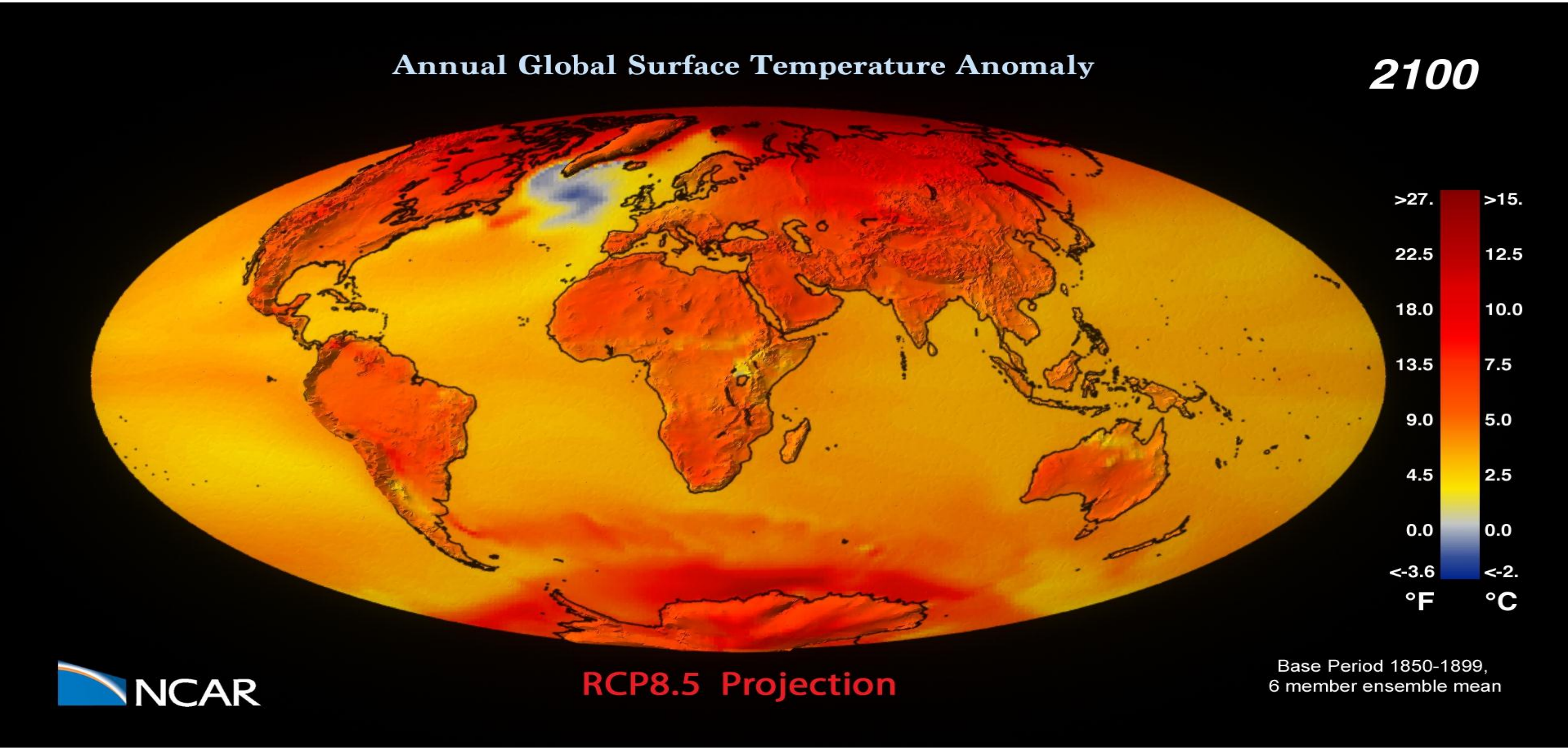
Note biases decrease
with each new generation
of models

Modeling Future Climate

CO_2 concentrations

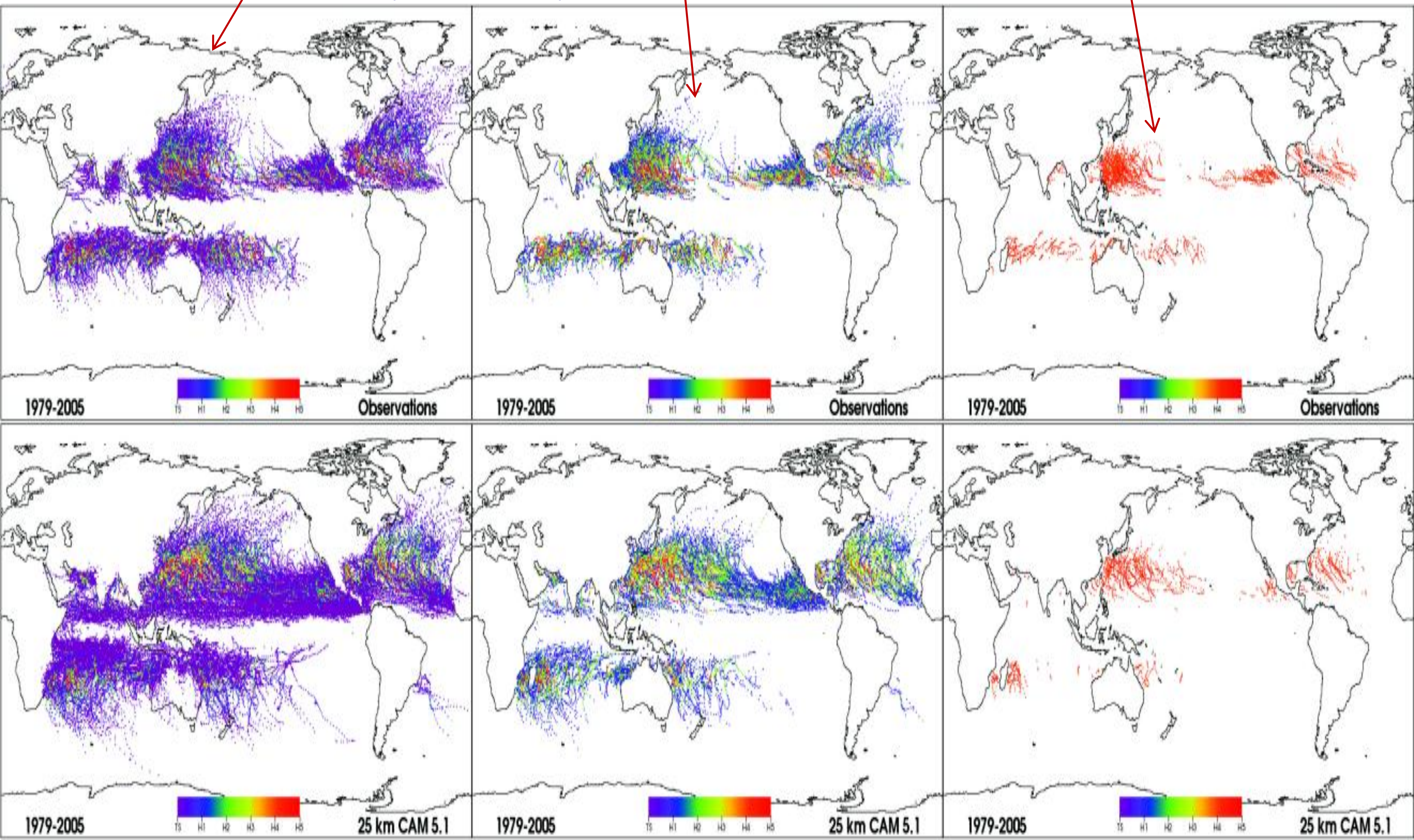


Geographical Pattern of 8.5 RCP

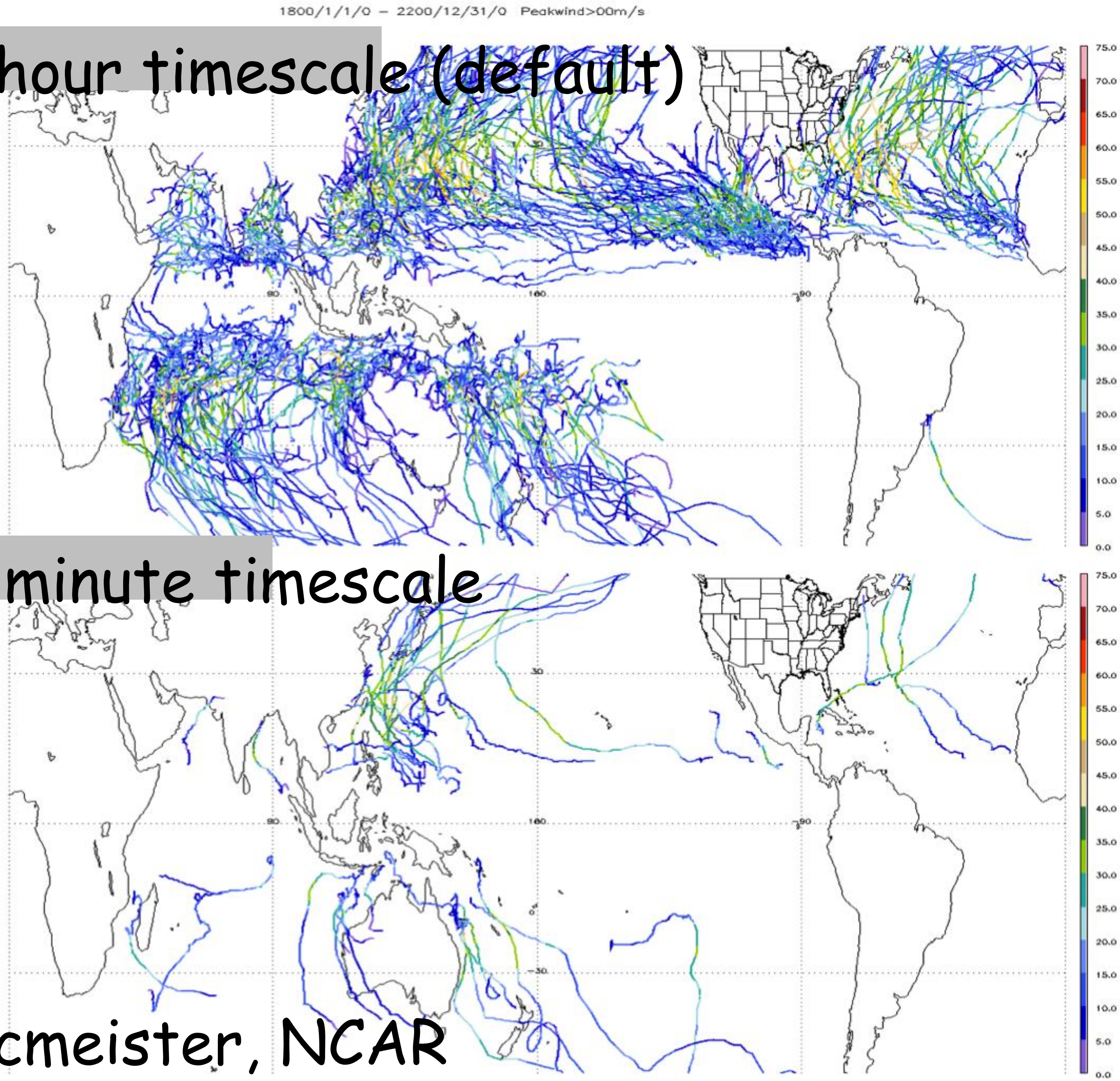


1º and 1/4º simulations - M. Wehner (DOE, LBL)

Tropical storms, hurricanes, and intense hurricanes for high resolution (25 km) atmospheric model(CAM5) M. Wehner, DOE LBL



Simulated TC tracks 2000-2005



But ...

Hurricanes disappear with shorter convective timescale

From Julio Bacmeister, NCAR

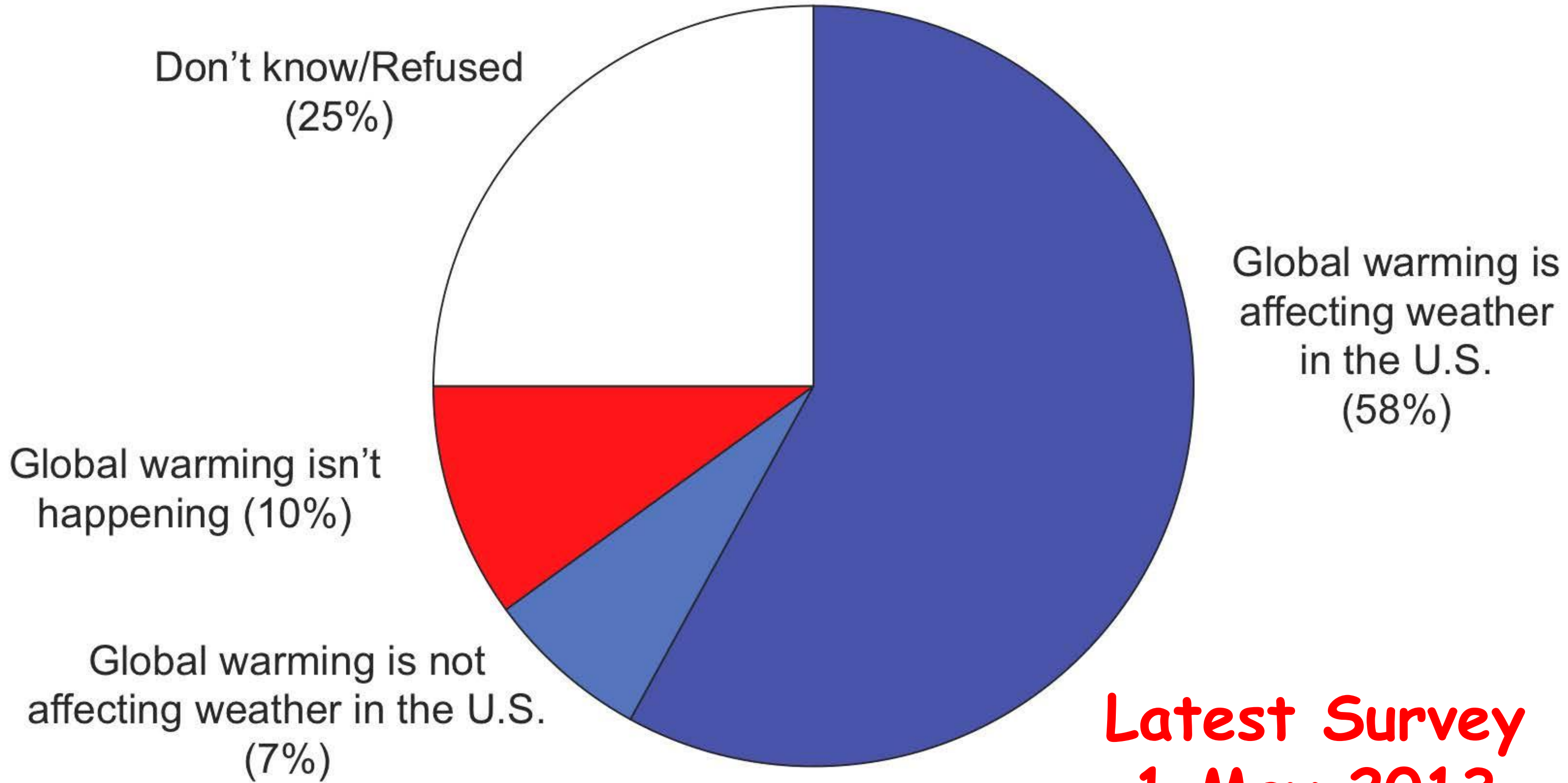
Climate and Earth System models have and continue to contribute to understanding and predicting the climate system. They allow the science community to determine objectively the possible impacts of climate change on food production, flooding, drought, sea level rise, and health as well as decision support. We need more emphasis on mitigation and adaptation. Higher resolution and more complete models will help.

From Istockphoto.com

United States Research Goals for U.S. Global Change Research Program $2.7B

- Goal 1. Advance science: Earth system understanding, science of adaptation and mitigation, observations, modeling, sharing information
- Goal 2. Inform decisions: Scientific basis to inform, adaptation and mitigation decisions
- Goal 3. Conduct sustained assessments: build capacity that improves Nation's ability to understand, anticipate, and respond
- Goal 4. Communicate and educate: Advance communication and educate the public, improve the understanding of global change, develop future scientific workforce

Majority of Americans Say Global Warming Is Affecting Weather in the United States



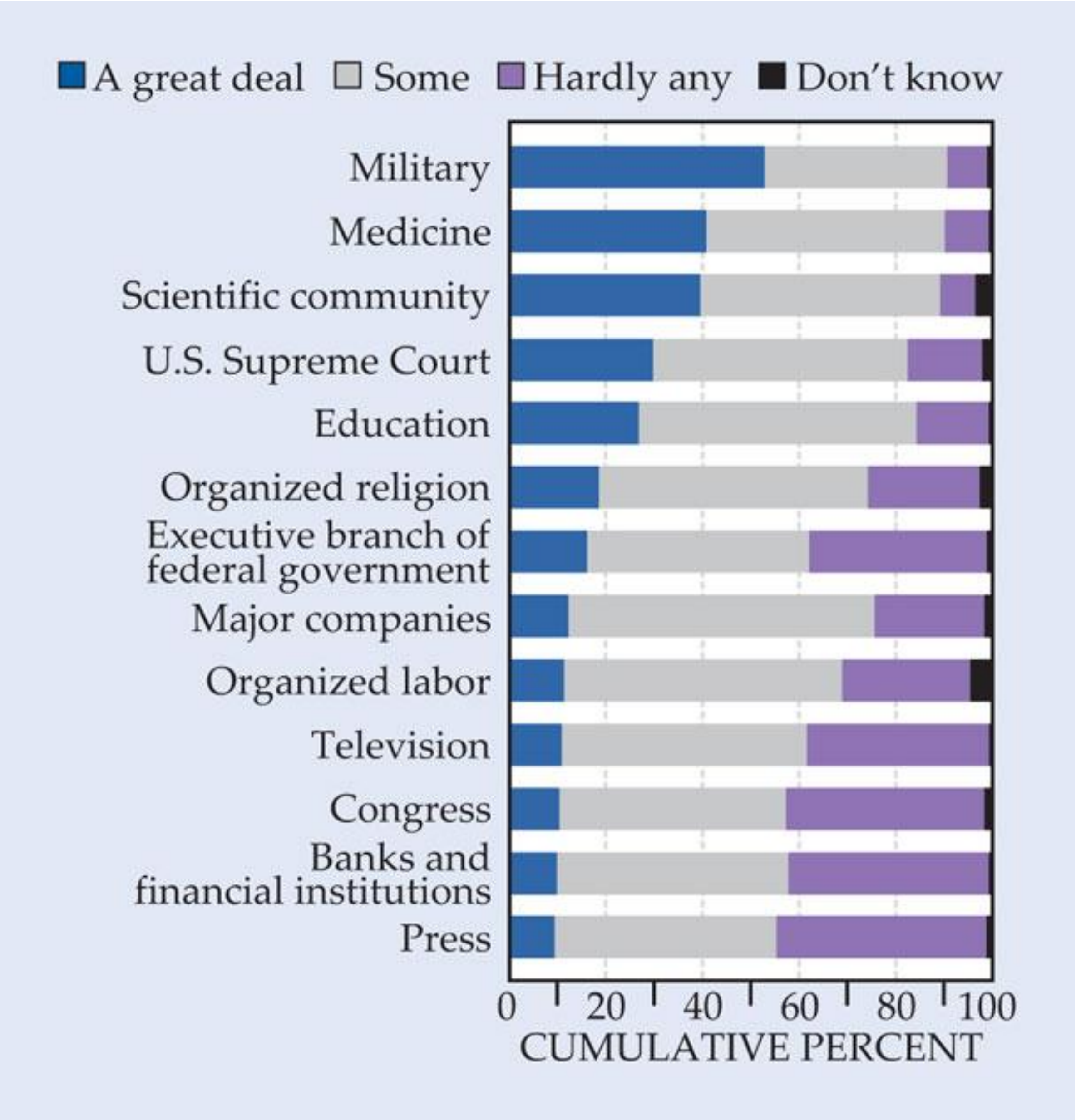
Latest Survey 1 May 2013

Which statement below best reflects your view?

Base: Americans 18+ (n=526, split sample)

YALE PROJECT ON CLIMATE CHANGE COMMUNICATION
BRIDGING SCIENCE + SOCIETY
4C
George Mason University
Center for Climate Change Communi

Professions: Public Trust



From National Science Board S & E Indicators (2012)

Where are we with respect to climate change?

- Mitigation versus adaptation…if we do nothing about greenhouse gas emissions then it is all adaptation. We need both.
- Models can provide vital information on both climate change and its impacts.
- Copenhagen, Cancun, Durban, and Doha climate change conferences suggest we have not solved the major policy aspects of future climate change.
- Where is the United States going on climate change policy? Future Earth?

photos: www.dawide.com

Future Earth
Research for global sustainability

UNEP

IGFA
International Group of Funding Agencies for Global Change Research

UNESCO
United Nations Educational, Scientific and Cultural Organization

BELMONT FORUM

ICSU
International Council for Science

ISSC
international social science council

UNITED NATIONS UNIVERSITY

The End