

Climate Change: What Does It Mean For Idaho?

Lecture by Arjan Meddens

Slides courtesy of

Dr. Jeffrey A. Hicke

Department of Geography

University of Idaho

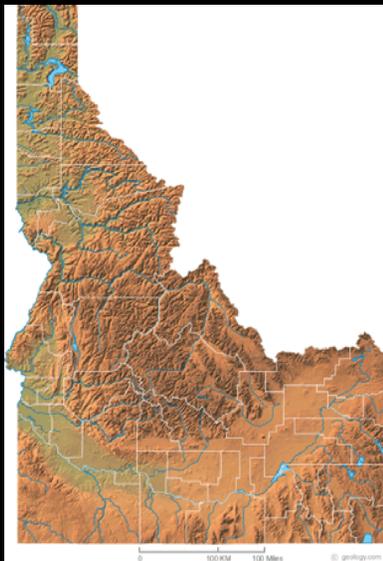
with the assistance of slides and other materials from:

Von Walden, University of Idaho

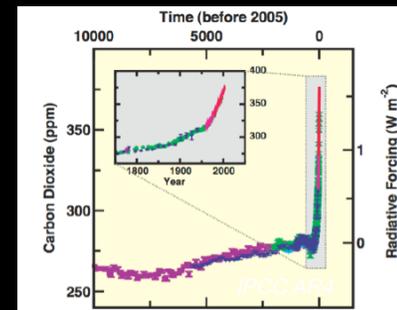
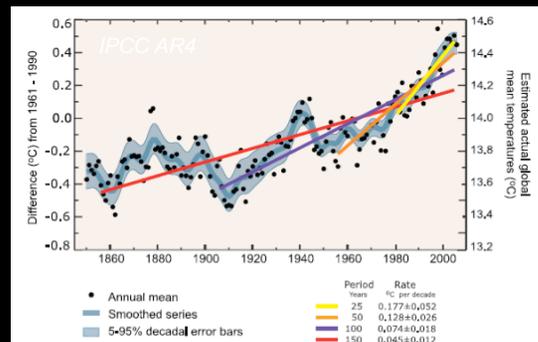
Karen Humes, University of Idaho

Lara Whitely Binder, Climate Impacts Group, University of Washington

Steve Running, University of Montana



K. Wattenmaker, firepix.blm.gov



Outline

1. Basic science of global warming

2. Recent climate change

3. Future predictions

4. Impacts in Pacific Northwest



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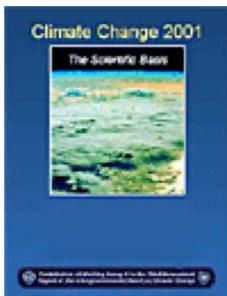


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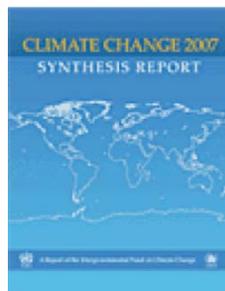
Who evaluates climate science results and produces reports for governments and the public?

- **International Panel of Climate Change (IPCC)**
 - Set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP).
 - Hundreds of scientists all over the world contribute to the work of the IPCC
 - Issue “Assessment Reports” approx every 5-6 years (1996, 2001, 2007) <http://www.ipcc.ch>

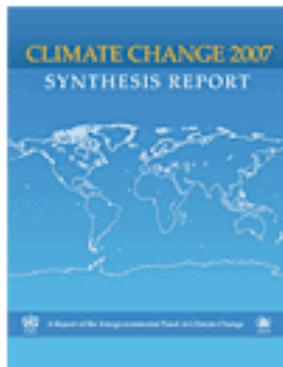


- **The 2001 report stated:**
 - Influence of human activities now evident
 - Rates of change too fast to be “just” natural cycles

- **The 2007 report:**
 - Warming of the climate system is certain as is now evident from **observations** of increases in global **temperatures**, widespread **melting of snow and ice**



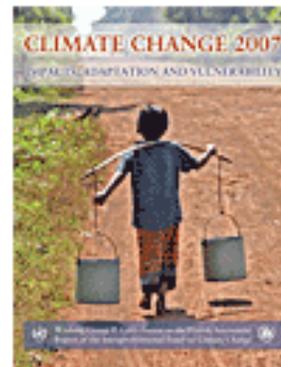
IPCC FOURTH ASSESSMENT REPORT: CLIMATE CHANGE 2007



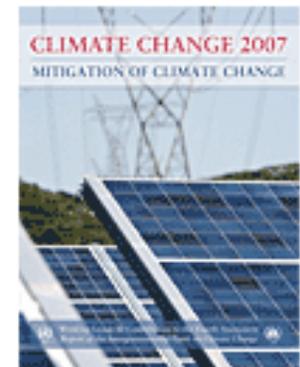
The AR4 Synthesis Report



Working Group I Report
"The Physical Science
Basis"



Working Group II Report
"Impacts, Adaptation and
Vulnerability"



Working Group III Report
"Mitigation of Climate
Change"



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



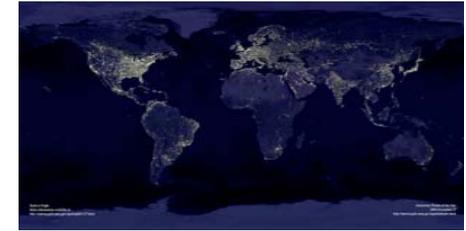
<http://www.ipcc.ch>

WEATHER: Meteorological conditions
of the next Day – Month

CLIMATE: Long term conditions of the
Meteorology over Years - Decades

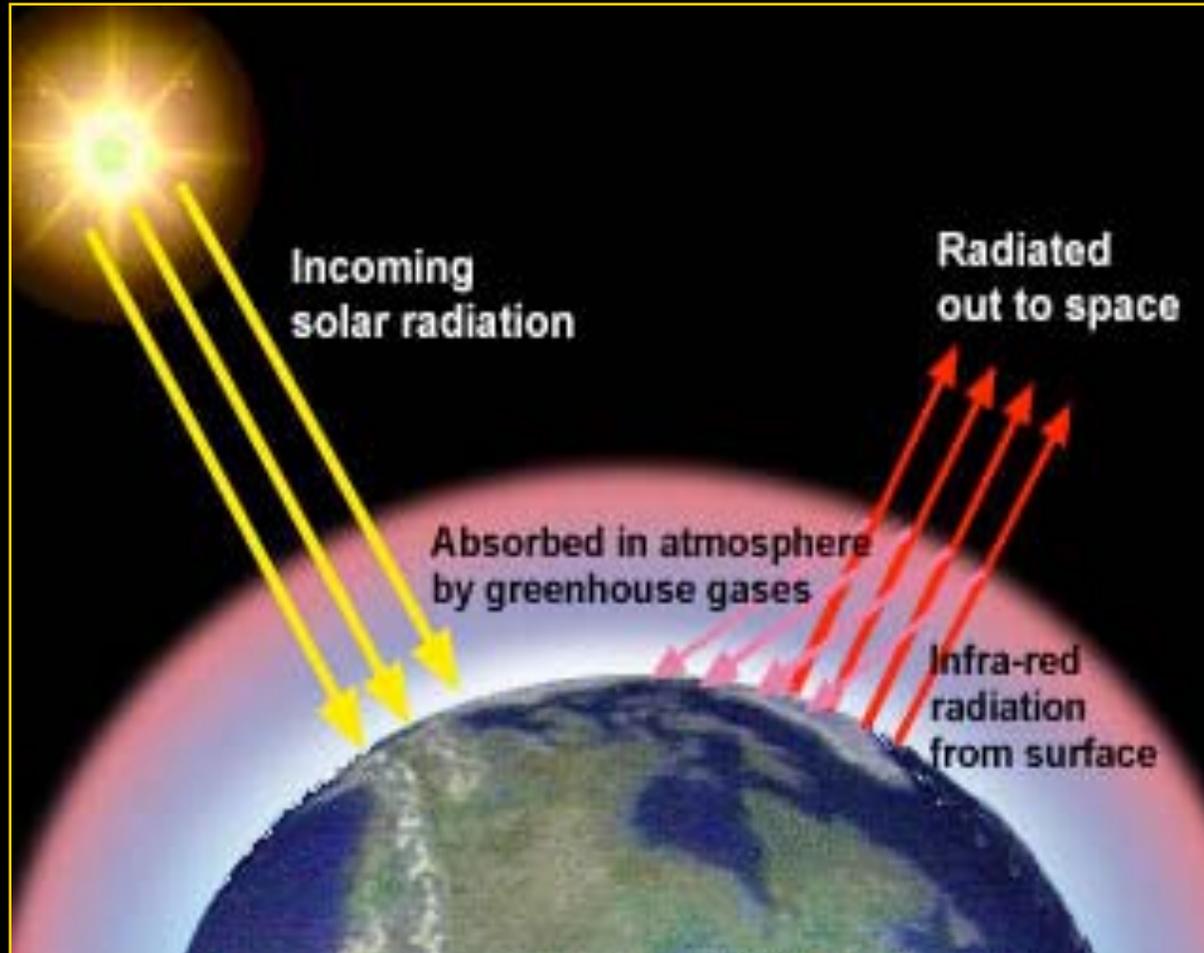
Slide courtesy S. Running, U. MT

Scientific Consensus on Climate Change



- Carbon dioxide (CO₂) and other greenhouse gases warm the planet.
- Human activities have increased the concentration of the major greenhouse gases since 1750.
- Average global temperature has increased **1.3°F** since 1906. Warming since the 1950s *very likely* (>90% chance) due to human increases in GHG.
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- Without drastic changes in current emissions trends, greenhouse gas concentrations will increase dramatically over the next century and beyond.

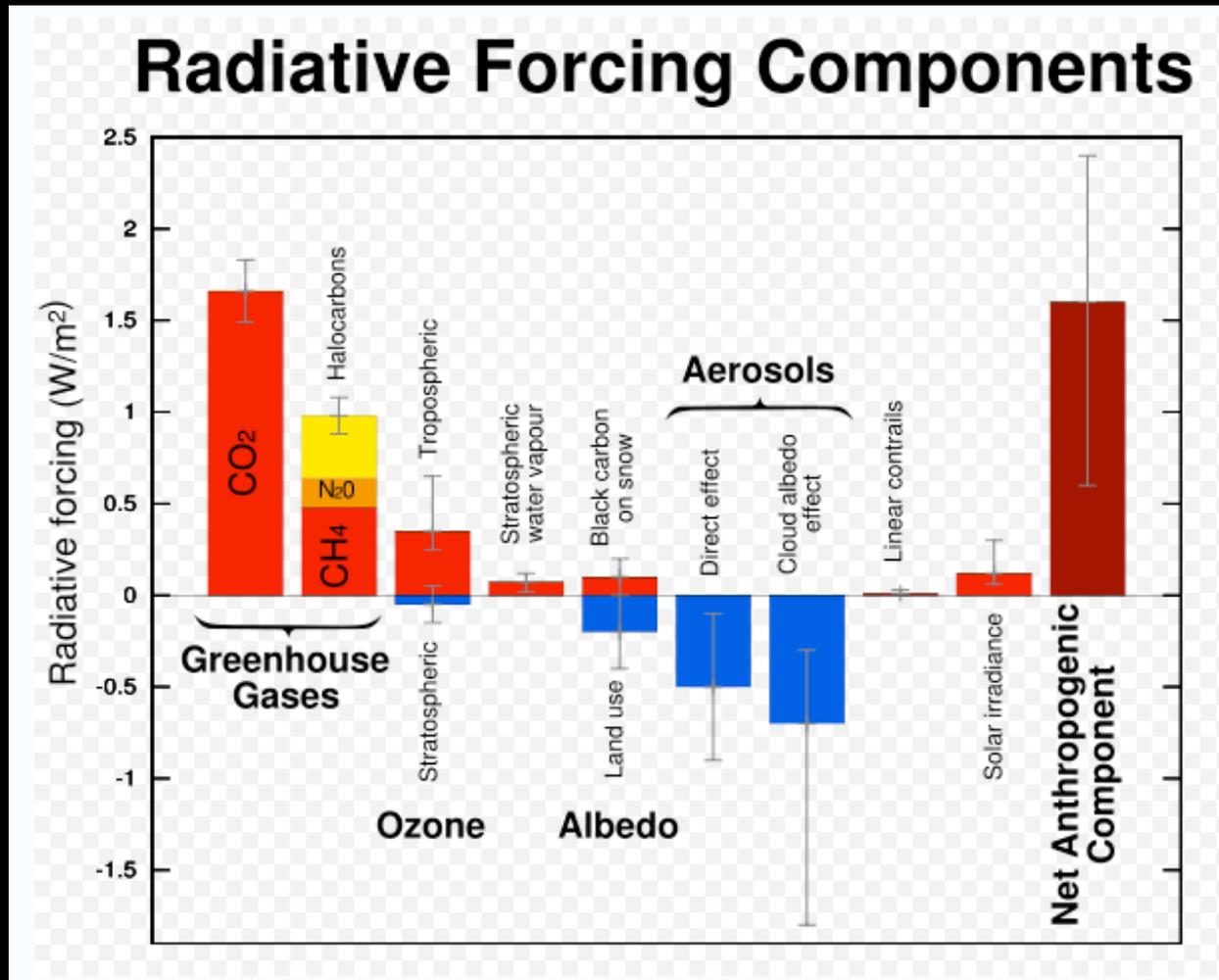
Greenhouse gases (water vapor, CO₂, CH₄, N₂O) play a critical role in determining global temperature



These special gases act like a “blanket”, trapping heat emitted by the Earth, which is warmed by the Sun

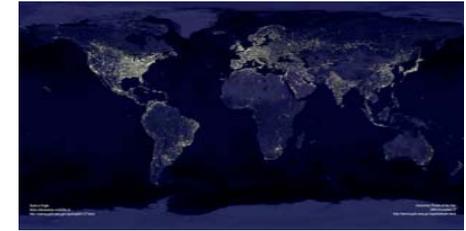
This greenhouse effect makes the Earth a livable planet, BUT....

Radiative forcing (in W/m^2) is the change in the balance between radiation coming into the atmosphere and radiation going out



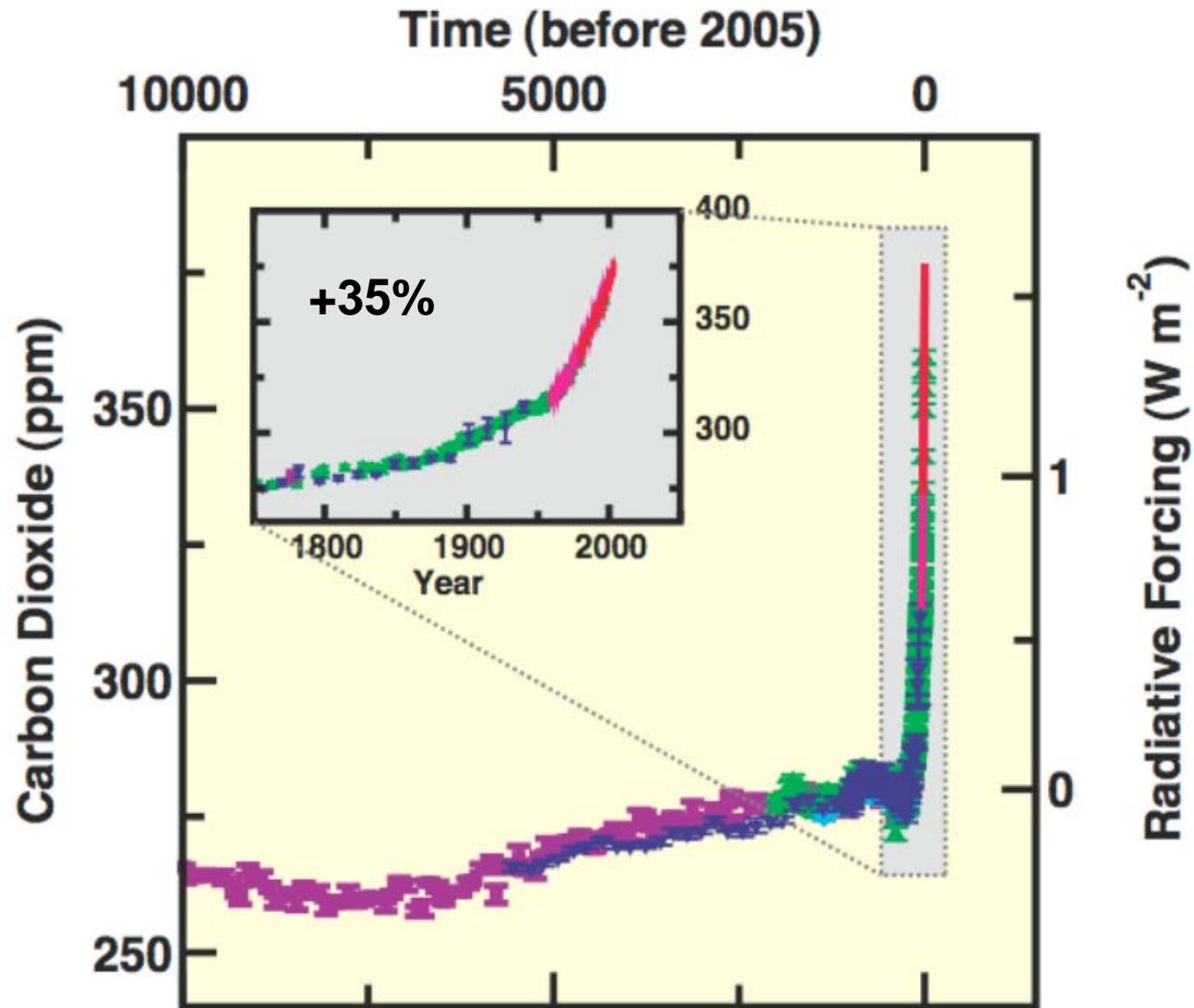
A positive radiative forcing tends to warm the surface of the Earth, and negative forcing tends to cool the surface.

Scientific Consensus on Climate Change

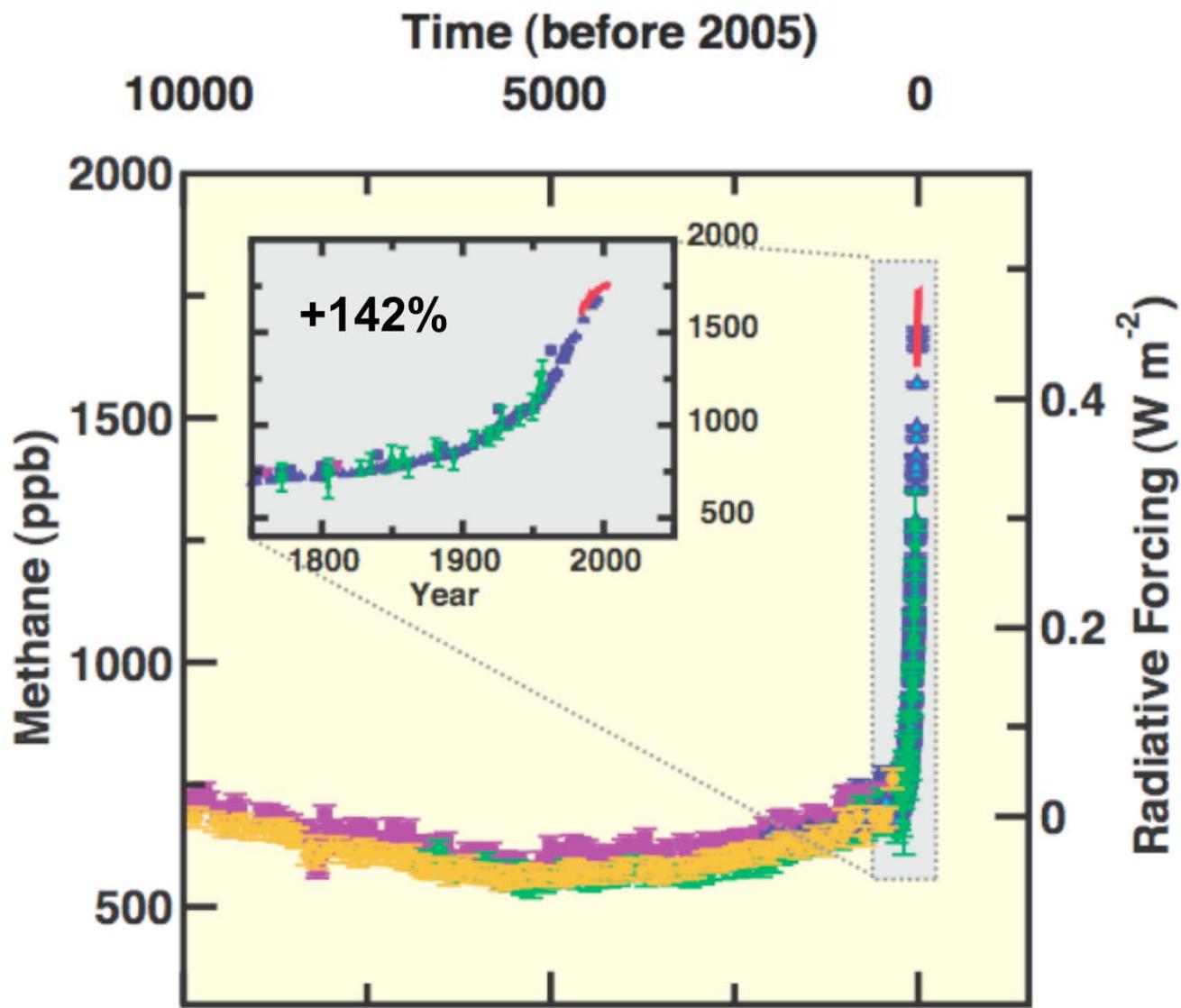


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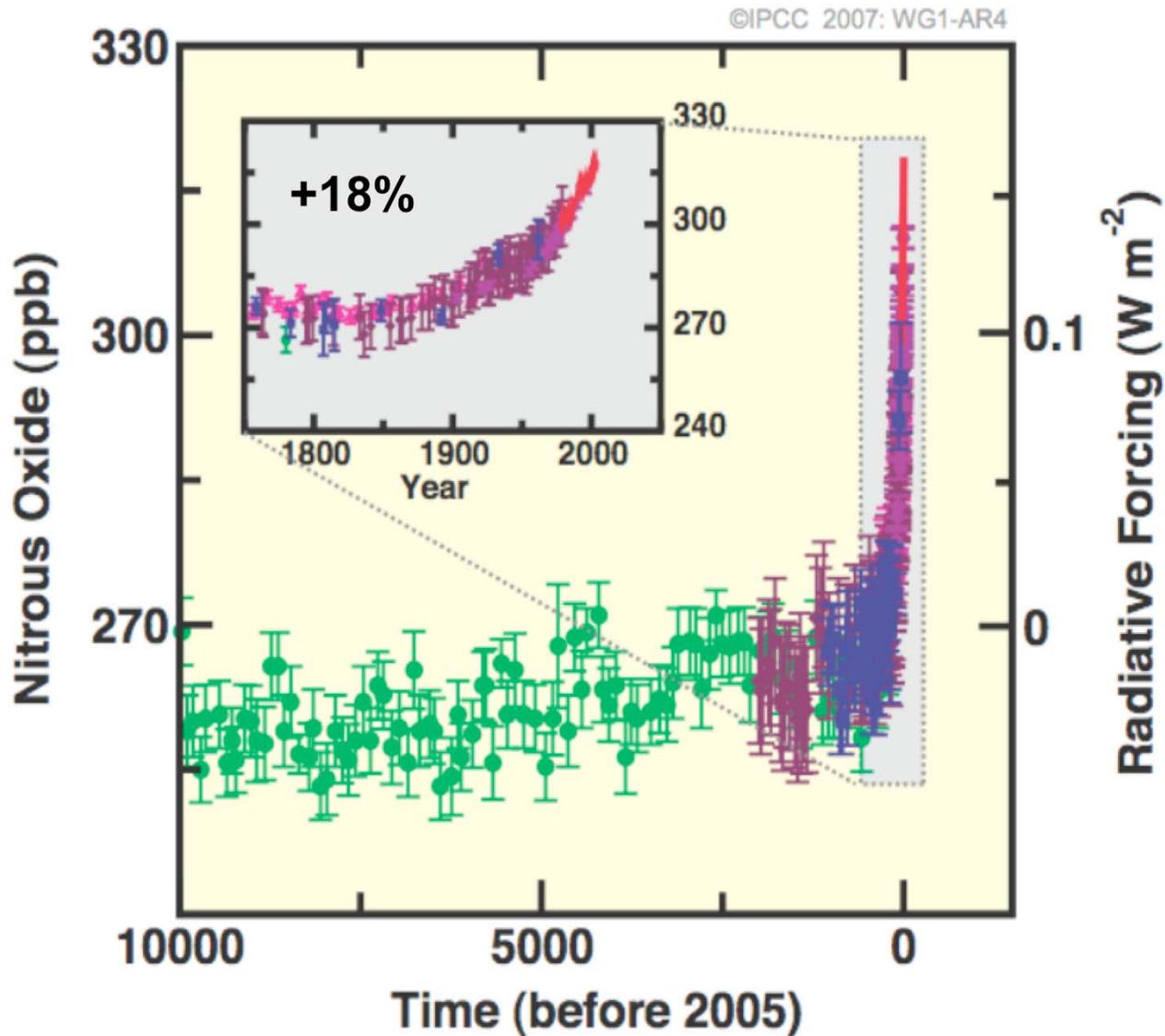
Carbon Dioxide (CO₂)



Methane (CH₄)



Nitrous Oxide (N₂O)

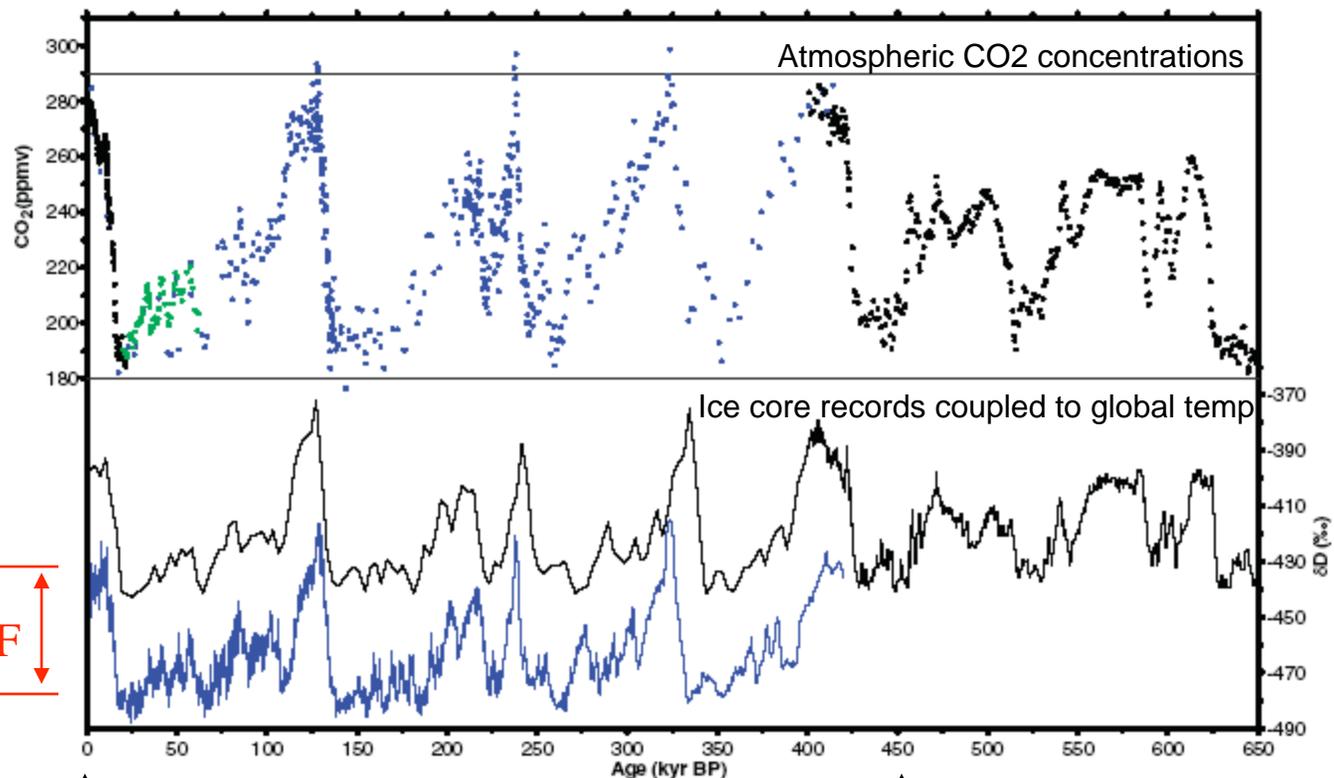


Compared to Historical Ice Core Record

CO₂ record from Dome C Ice Core

Fig. 4. A composite CO₂ record over six and a half ice age cycles, back to 650,000 years B.P. The record results from the combination of CO₂ data from three Antarctic ice cores: Dome C (black), 0 to 22 kyr B.P. (9, 11) and 390 to 650 kyr B.P. [this work including data from 31 depth intervals over termination V of (7)]; Vostok (blue), 0 to 420 kyr B.P. (5, 7), and Taylor Dome (light green), 20 to 62 yr B.P. (8). Black line indicates δD from Dome C, 0 to 400 kyr B.P. (1) and 400 to 650 kyr B.P. (18). Blue line indicates δD from Vostok, 0 to 420 kyr B.P. (7).

7 to 8 C, or 13.5 F



Present

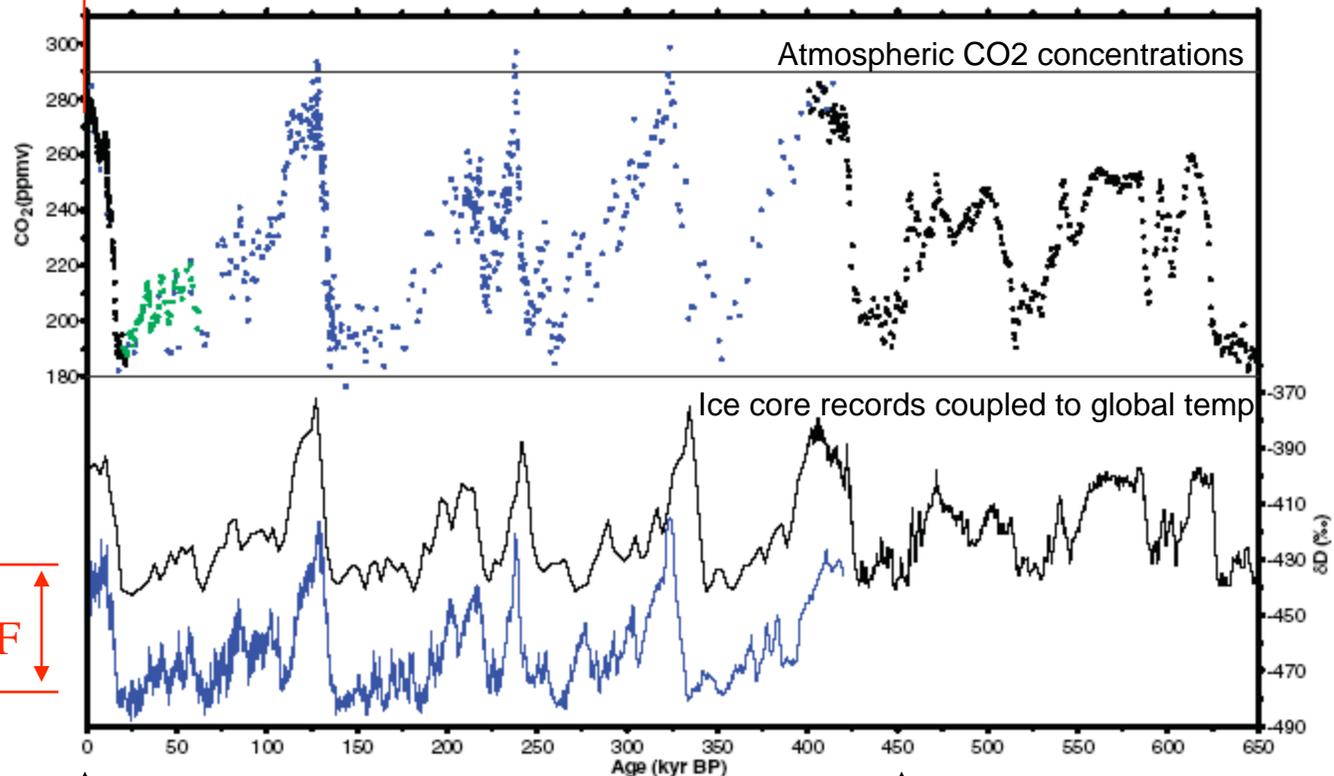
450,000 years ago

Compared to Historical Ice Core Record

Current concentration (380 ppm)

CO₂ record from Dome C Ice Core

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7 to 8 C, or 13.5 F

Present

450,000 years ago

Where Do These Increases Come From?

- **Human sources:**

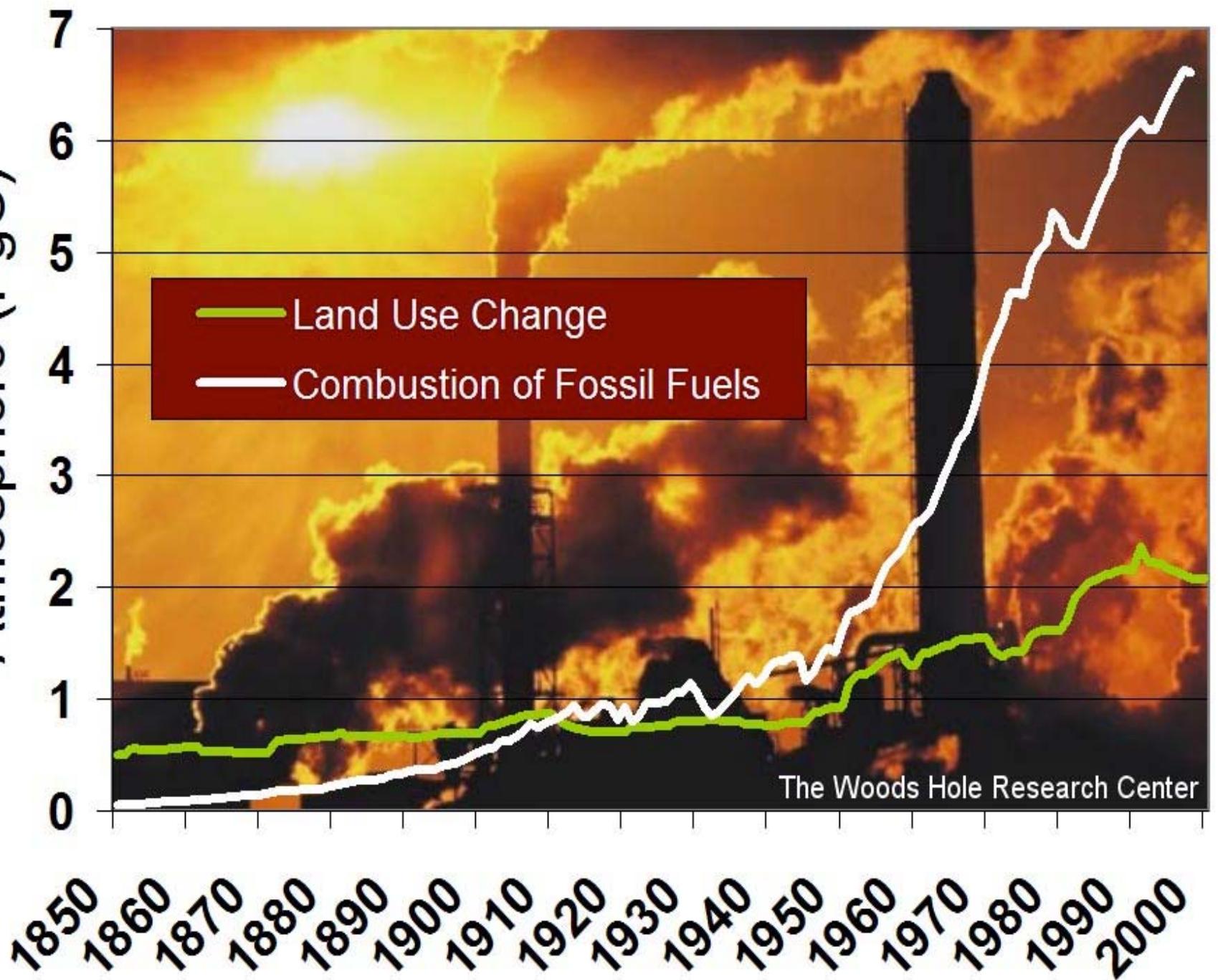
- Fossil fuel burning (oil, coal, natural gas) (CO_2 , CH_4 , N_2O)
- Deforestation and land use change (CO_2)
- Agricultural practices (CO_2 , CH_4 , N_2O)
- Energy extraction (CO_2 , CH_4)
- Ruminant (e.g., cows) (CH_4)
- Cement production (CO_2)
- Landfills (CH_4)

- **Natural sources**

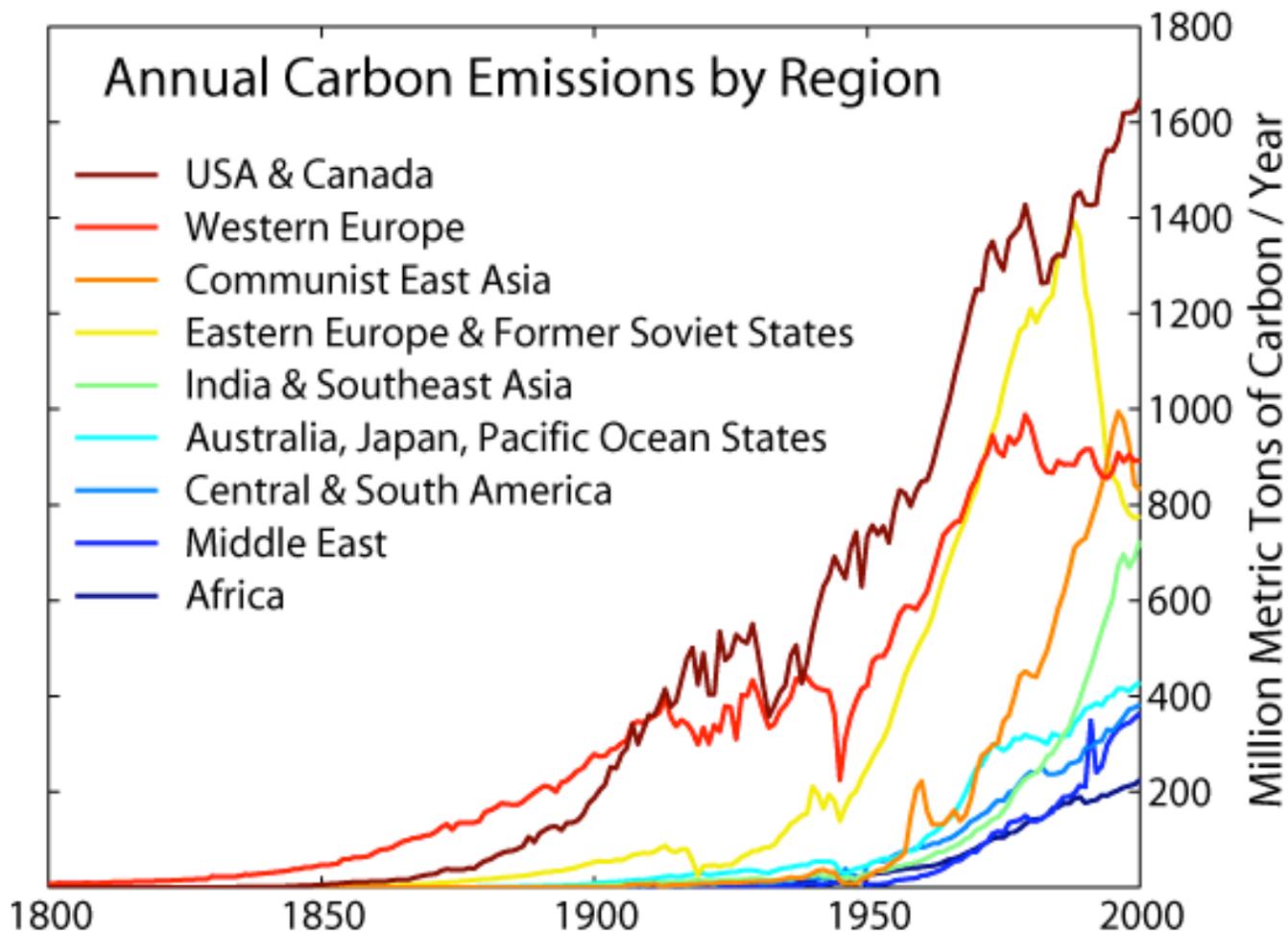
- Wetlands (CH_4)
- Oceans, soils (CO_2 , N_2O)
- Decomposition of organic matter (CO_2 , CH_4)



Annual Emissions to the
Atmosphere (PgC)



Emissions principally from US, Canada, with other regions becoming more important



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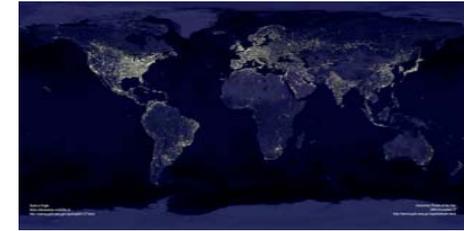
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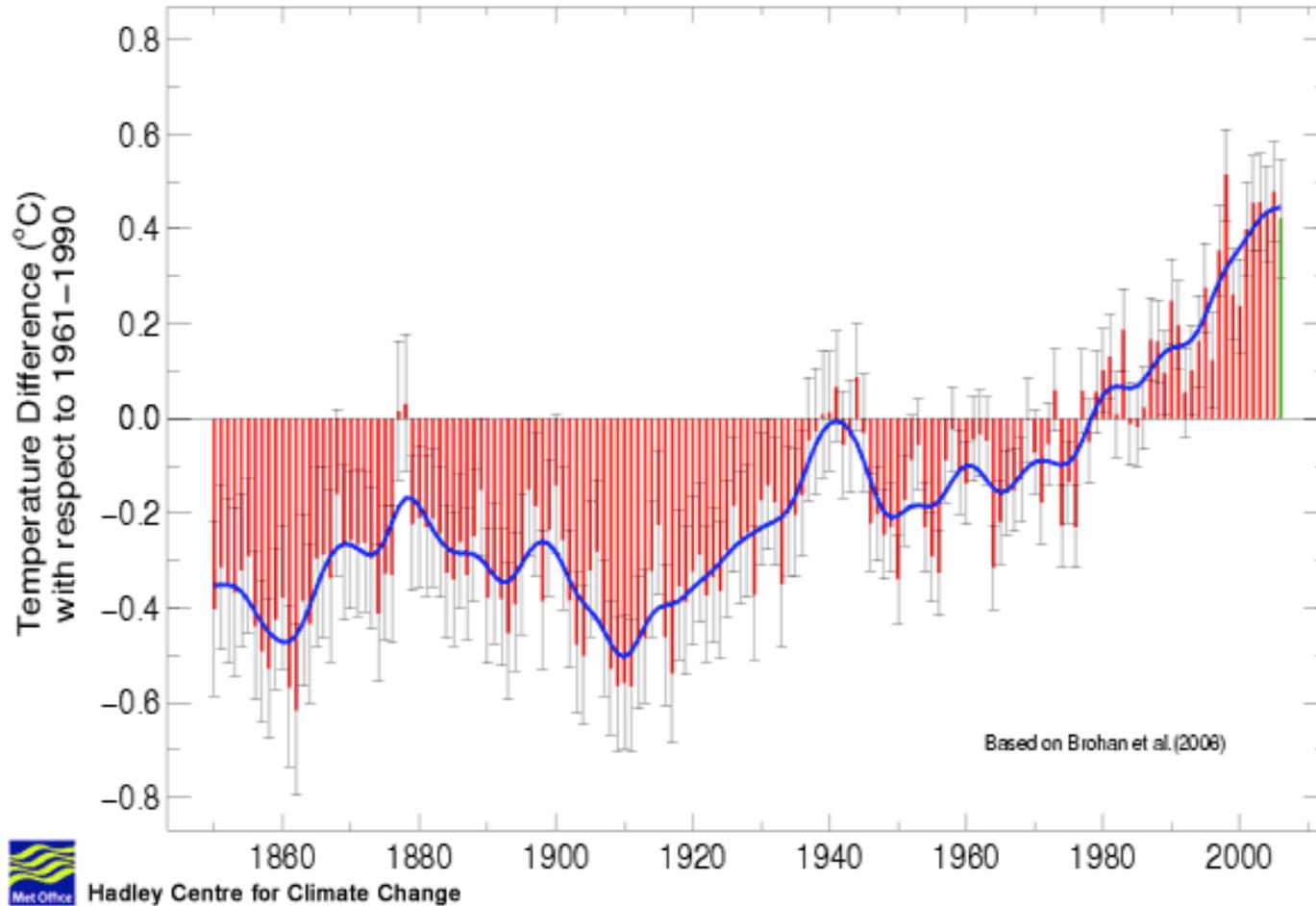
Scientific Consensus on Climate Change



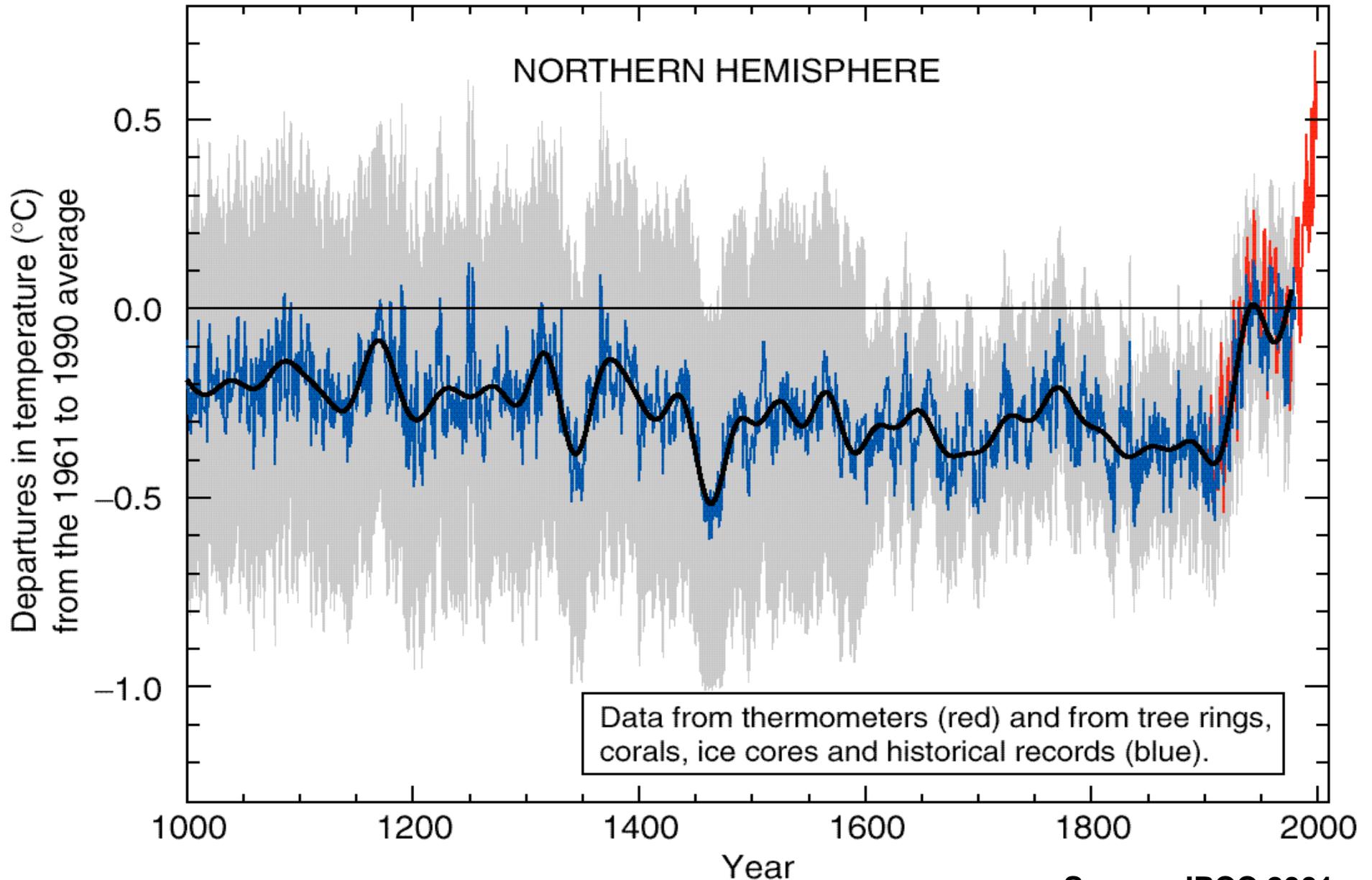
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Change in temperature over last 150 years

Global near-surface temperatures:
Annual anomalies 1850-2006

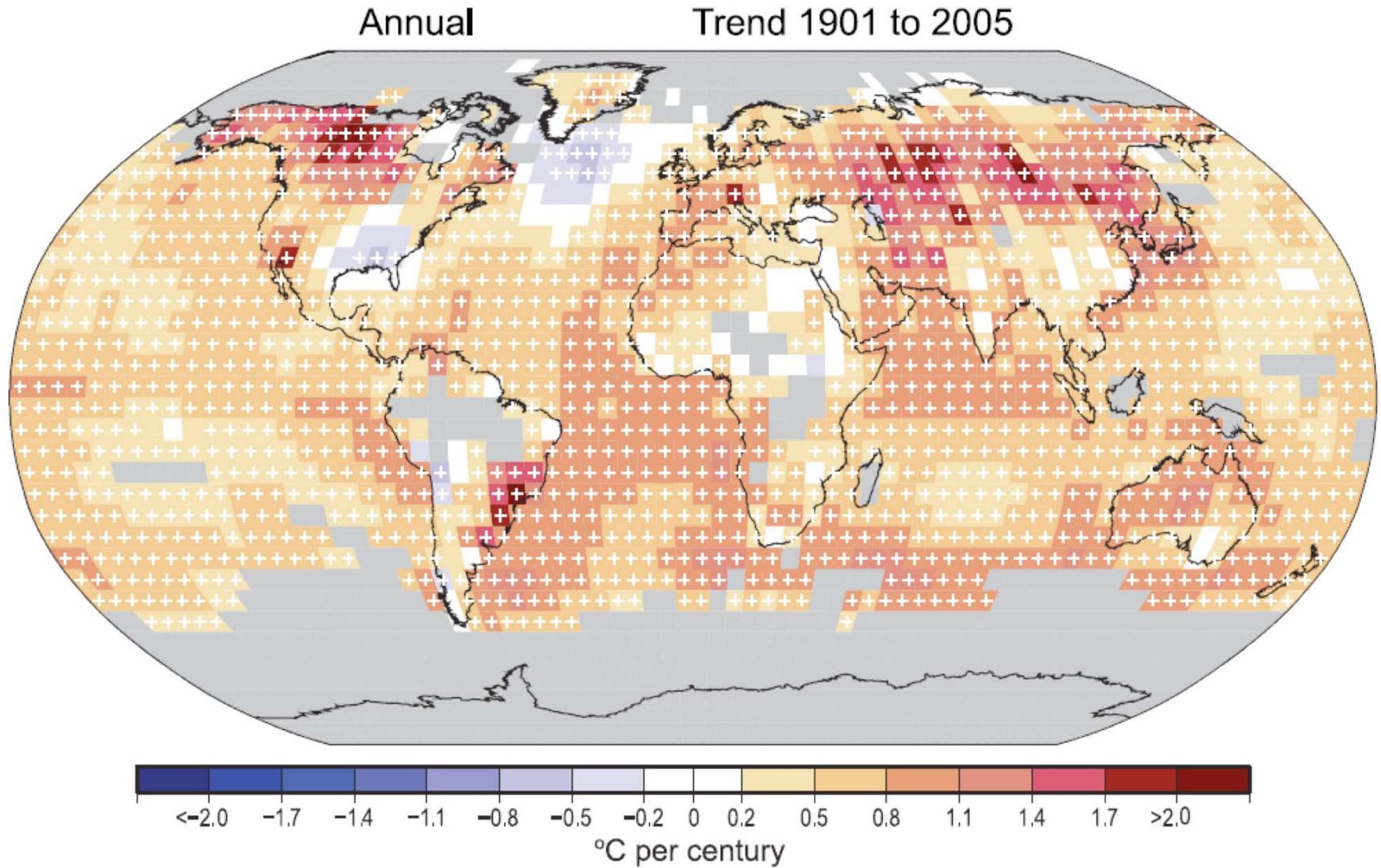


Change in temperature over last 1000 years



Source: IPCC 2001

Annual Temperature Trend 1901-2005



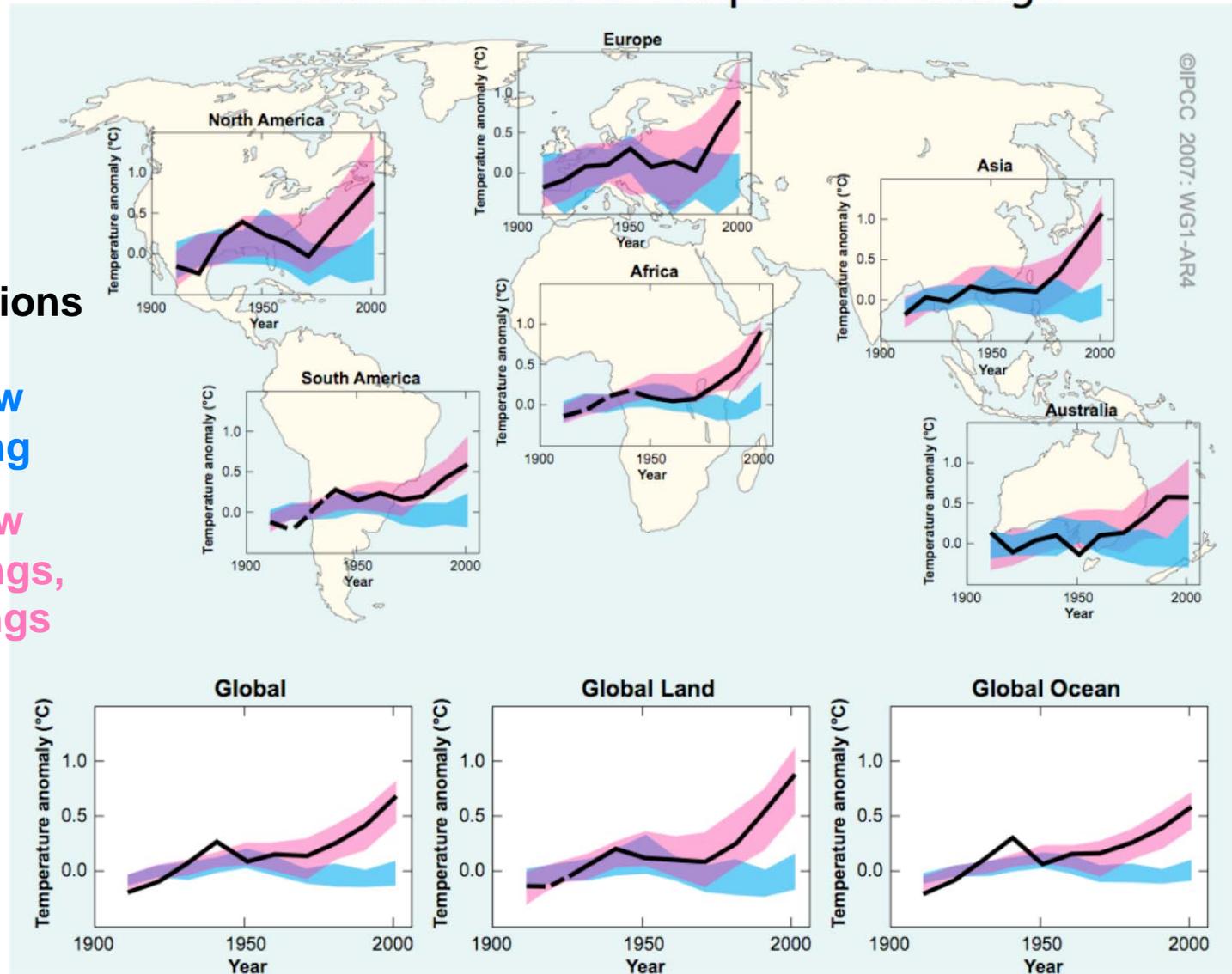
Models require both natural and anthropogenic forcings to simulate observations

Global and Continental Temperature Change

Line: Observations

Band: Models w /natural forcing

Band: Models w /natural forcings, human forcings

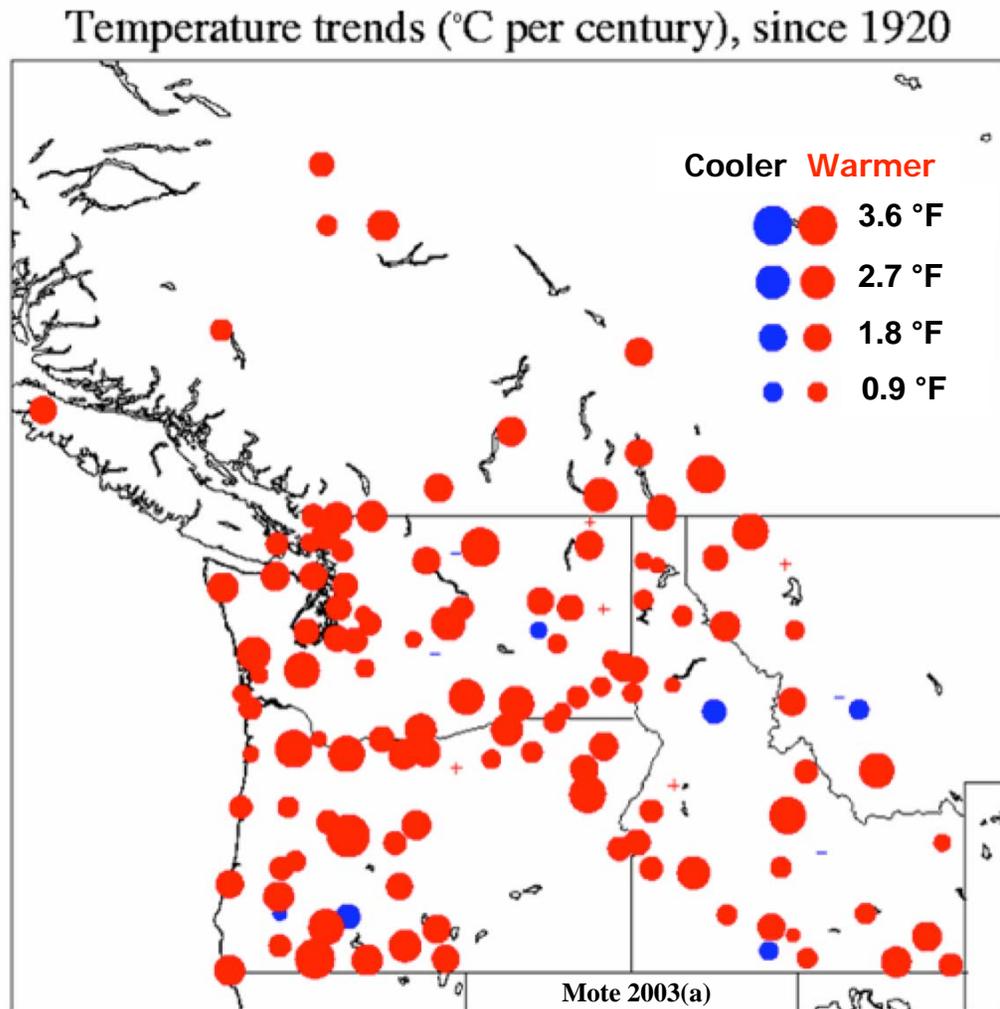


©IPCC 2007: WG1-AR4

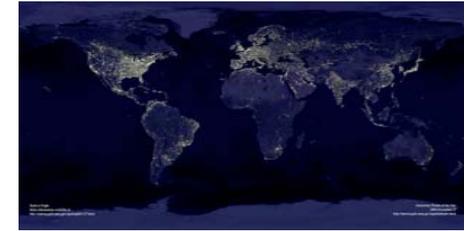
PNW Temperature Trends by Station

Average annual temperature increased $+1.5^{\circ}\text{F}$ in the PNW during the 20th century

- *Almost every station shows warming*
- *Extreme cold conditions have become rarer*
- *Low temperatures rose faster than high temperatures*



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Observed changes in natural systems (20th century)

The extent and thickness of Arctic sea-ice is declining (extent is down 10-15%; thickness is down 40%)

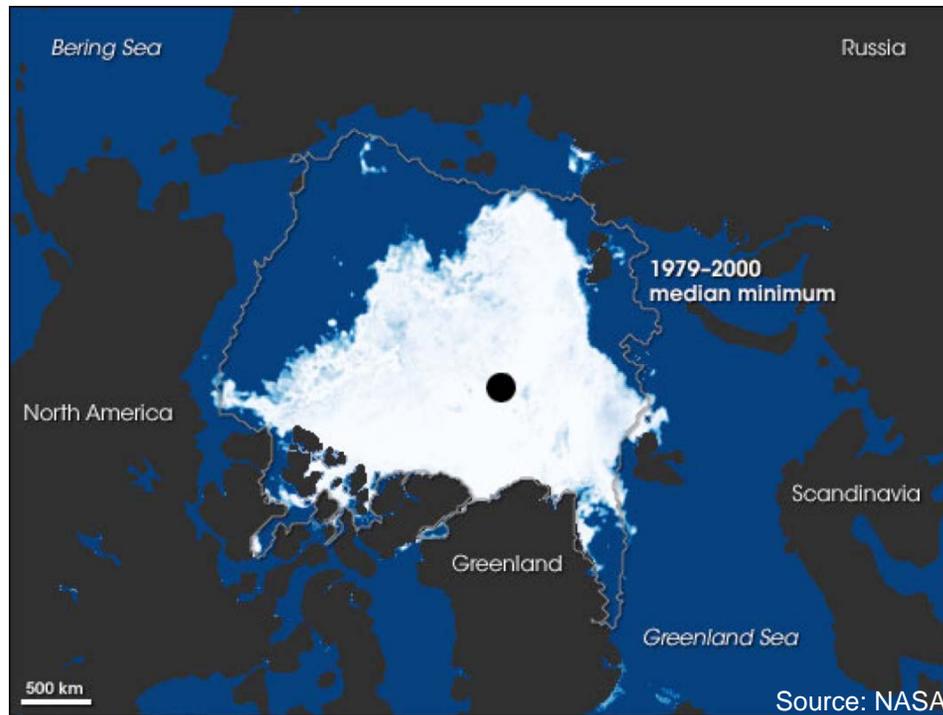


Permafrost is thawing (with major implications for the region and the globe)

In the Northern Hemisphere, plants are flowering earlier, birds are arriving earlier, insects are emerging earlier

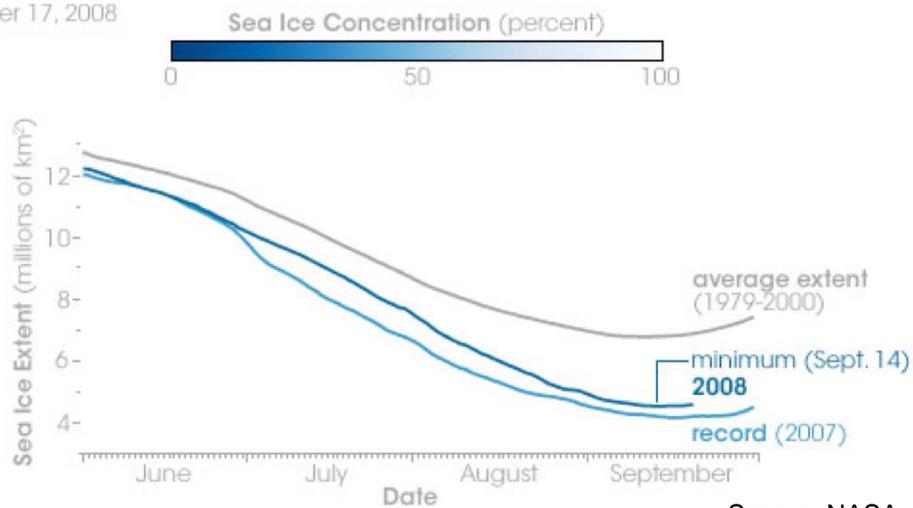


North pole – Summer sea ice extent in 1979 and 2000

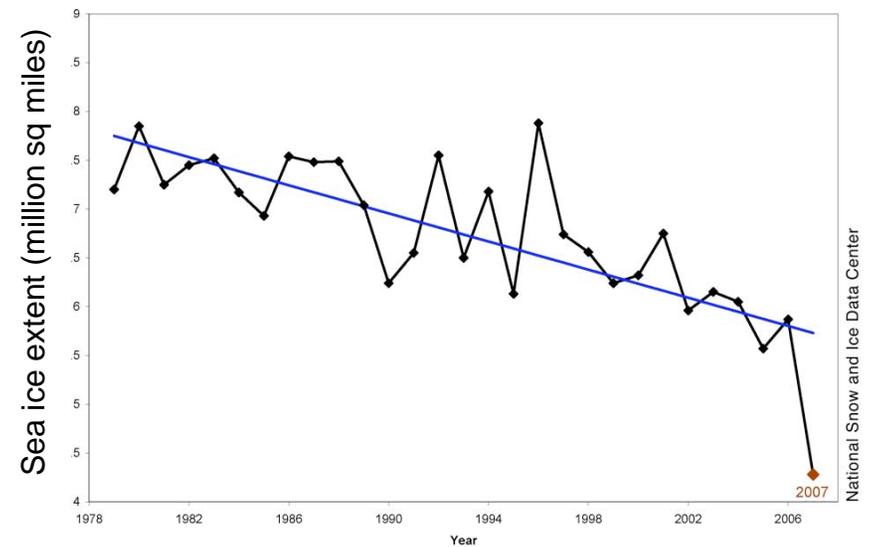


In 2007 a record low

September 17, 2008



Source: NASA



National Snow and Ice Data Center

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Observed 20th Century Changes (cont'd)

The growing season has lengthened 1-4 days per decade during the last 40 years in the Northern Hemisphere, especially at northern latitudes – earlier spring & later fall



Plant and animal ranges are shifting northward and to higher elevations



The frequency of coral bleaching is increasing, particularly during El Niño events



Mid-elevation mountain snowpack is in decline and melting earlier. Glaciers are in widespread retreat.

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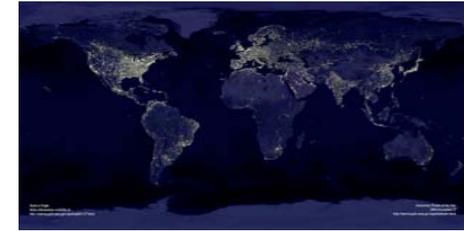
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Scientific Consensus on Climate Change

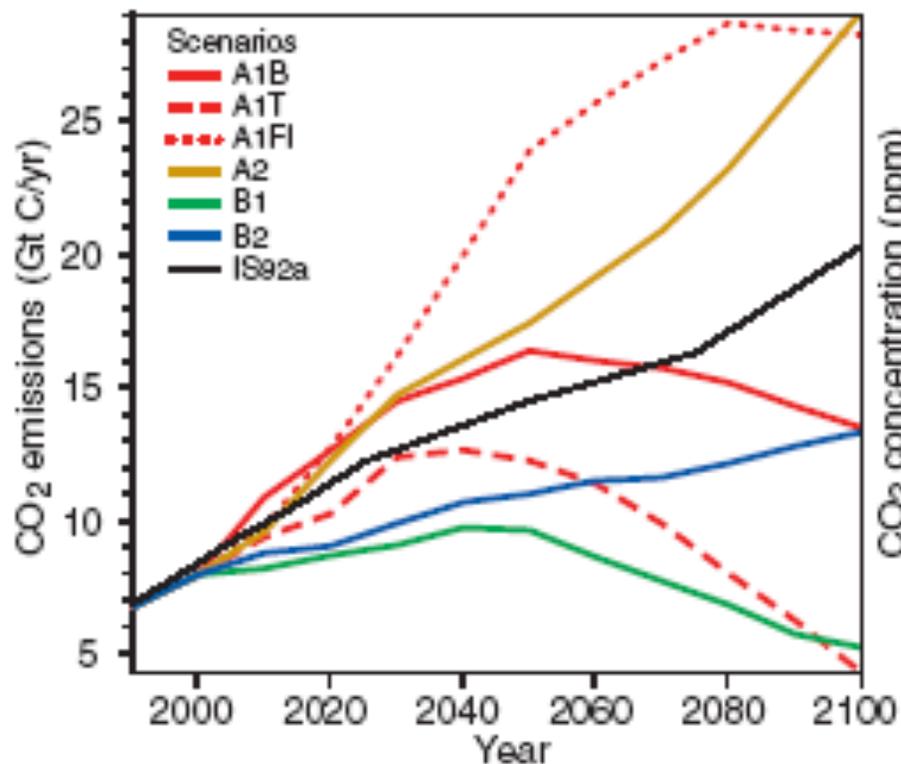


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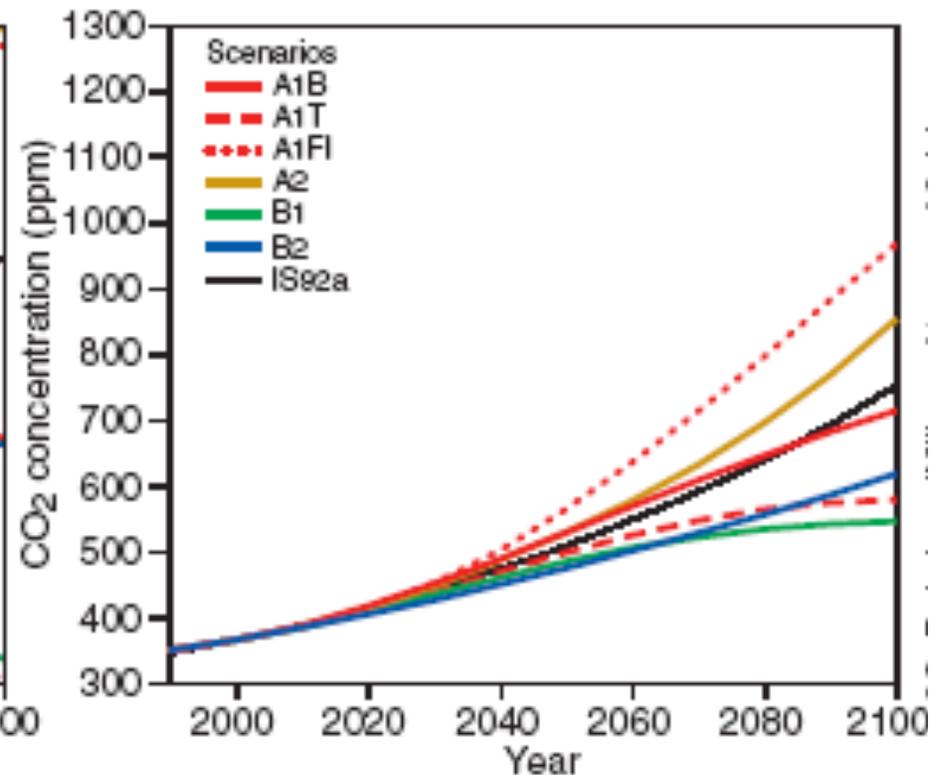
CO₂ Emissions in the 21st Century

IPCC Emission scenarios based on economical and technological assumptions about global society

(a) CO₂ emissions



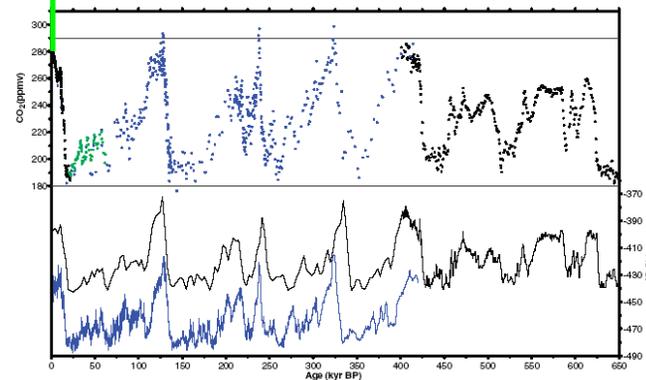
(b) CO₂ concentrations



CO₂ Emissions in the 21st Century

Green Scenario (550 ppm)

Fig. 4. A composite CO₂ record over six and a half ice age cycles, back to 650,000 years B.P. The record results from the combination of CO₂ data from three Antarctic ice cores: Dome C (black), 0 to 22 kyr B.P. (9, 11) and 390 to 650 kyr B.P. [this work including data from 31 depth intervals over termination V of (7)]; Vostok (blue), 0 to 420 kyr B.P. (5, 7), and Taylor Dome (light green), 20 to 62 yr B.P. (6). Black line indicates δD from Dome C, 0 to 400 kyr B.P. (7) and 400 to 650 kyr B.P. (18). Blue line indicates δD from Vostok, 0 to 420 kyr B.P. (7).

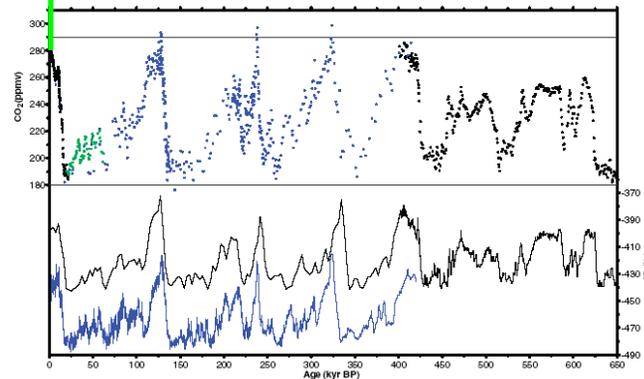


CO₂ Emissions in the 21st Century

Business-as-usual Scenario (750 ppm)

Green Scenario (550 ppm)

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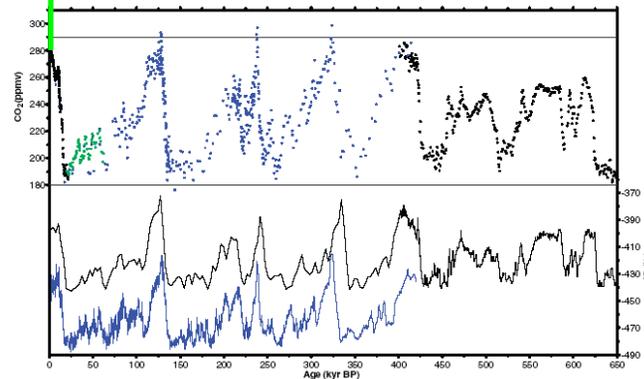
CO₂ Emissions in the 21st Century

A1FI "Aggressive" Scenario (900 ppm)

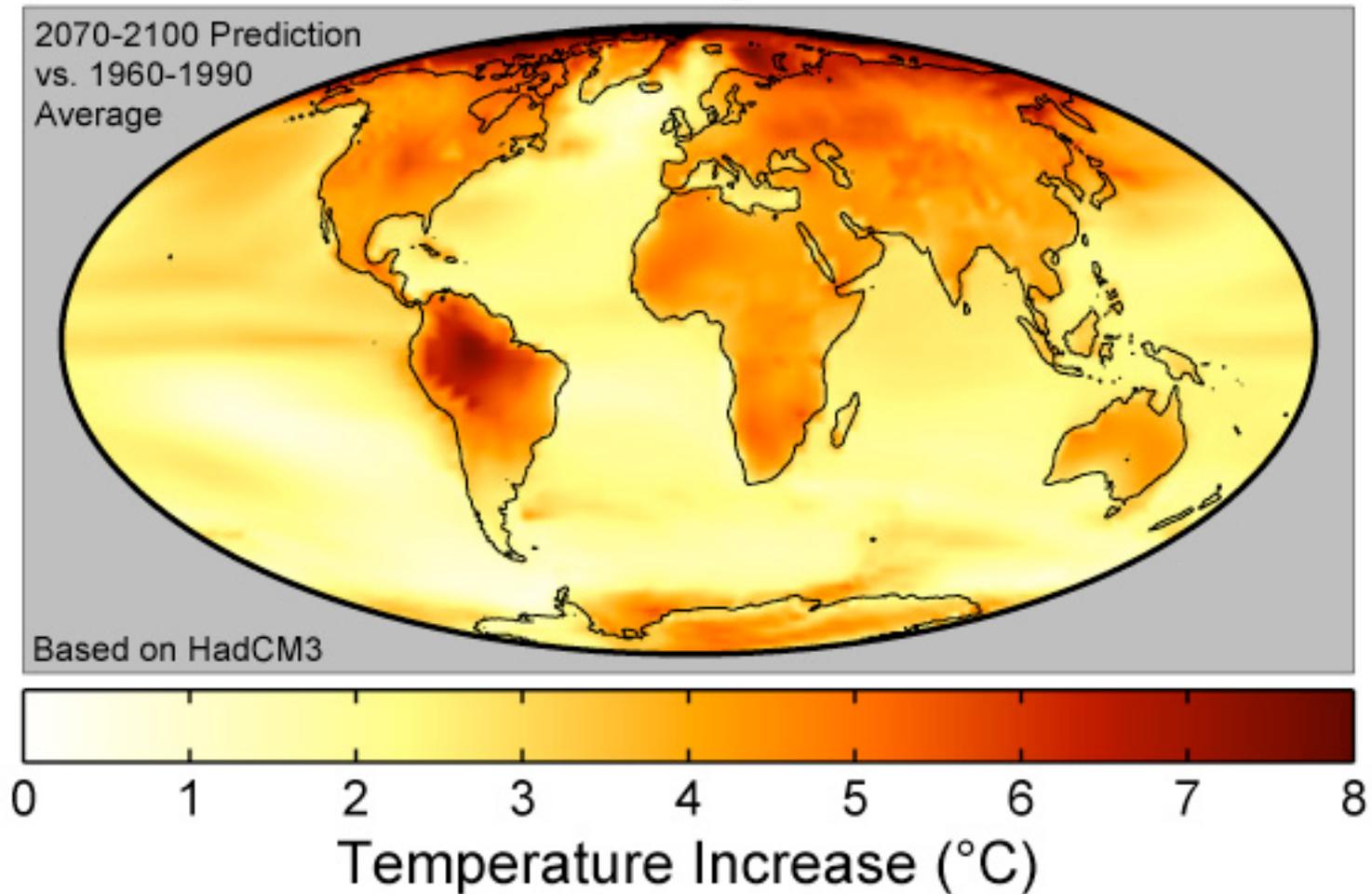
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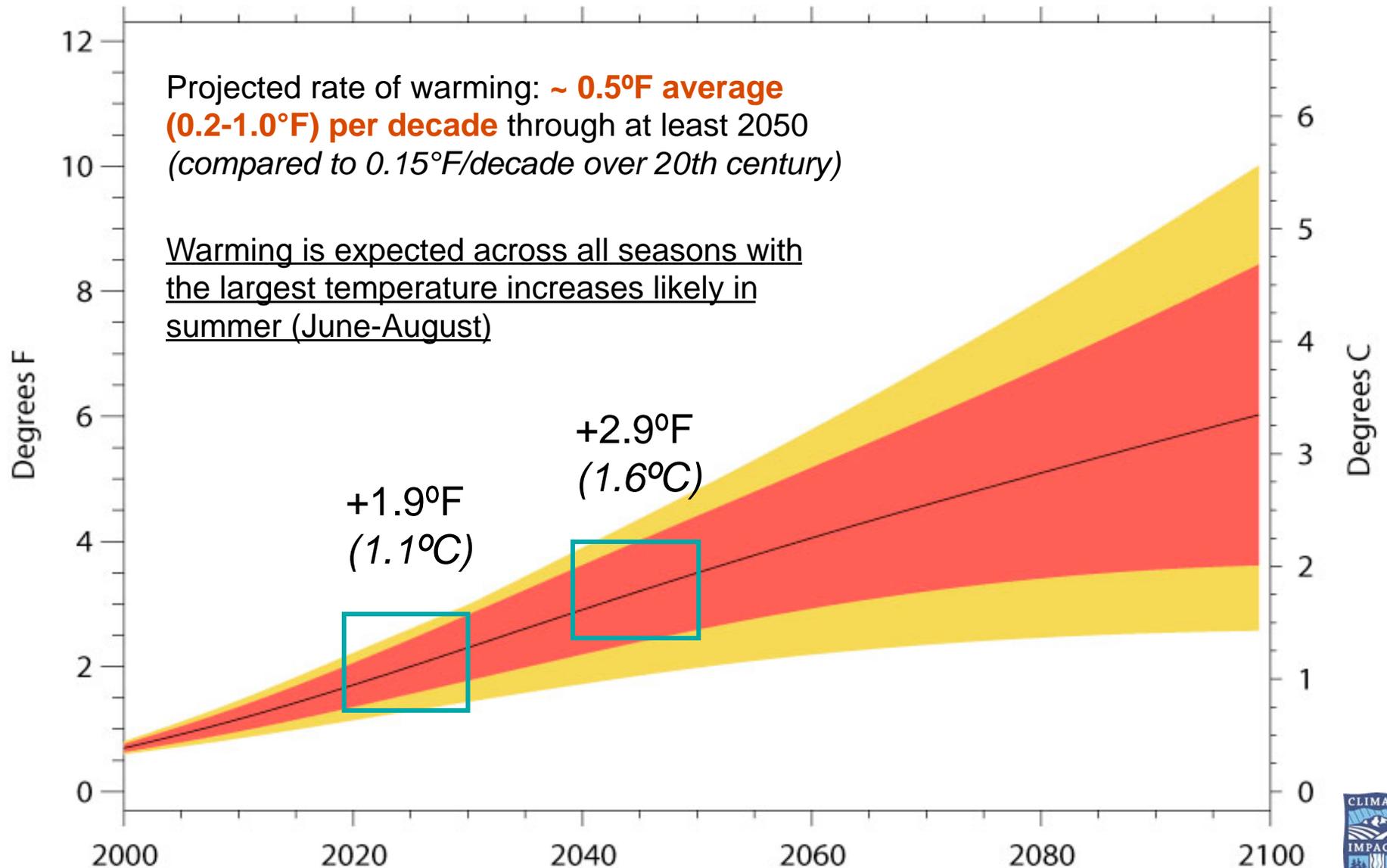


Global Warming Predictions



“Business as usual” scenario; one model (HadCM3)

21st Century PNW Warming

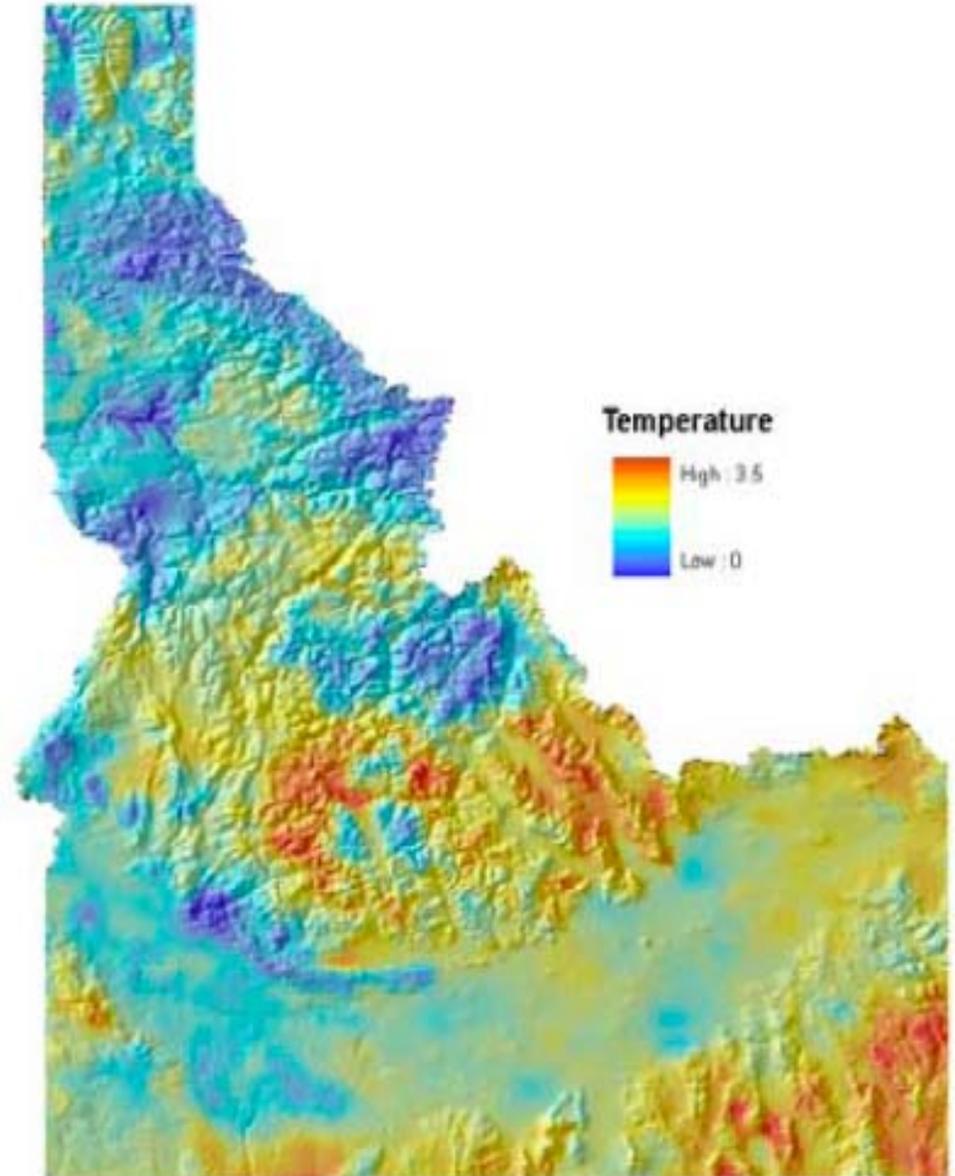


More detail on the CIG scenarios is available at: <http://www.cses.washington.edu/cig/fpt/ccscenarios.shtml>



21st Century Warming in Idaho

- “Downscaled” temperature data for a low-to-medium climate change scenario.



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IPCC 2007 report

Examples of some projected regional impacts of North America

- **Decreased snowpack, more winter flooding and reduced summer flows, and competition for water resources.**
- **Moderate climate change is projected to increase yields of rain-fed agriculture by 5 to 20%, but with variability among regions.**
- **Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources.**



Glacier retreat in Rocky Mountains and North Cascades



Photo by W.C. Alden, USGS

1913



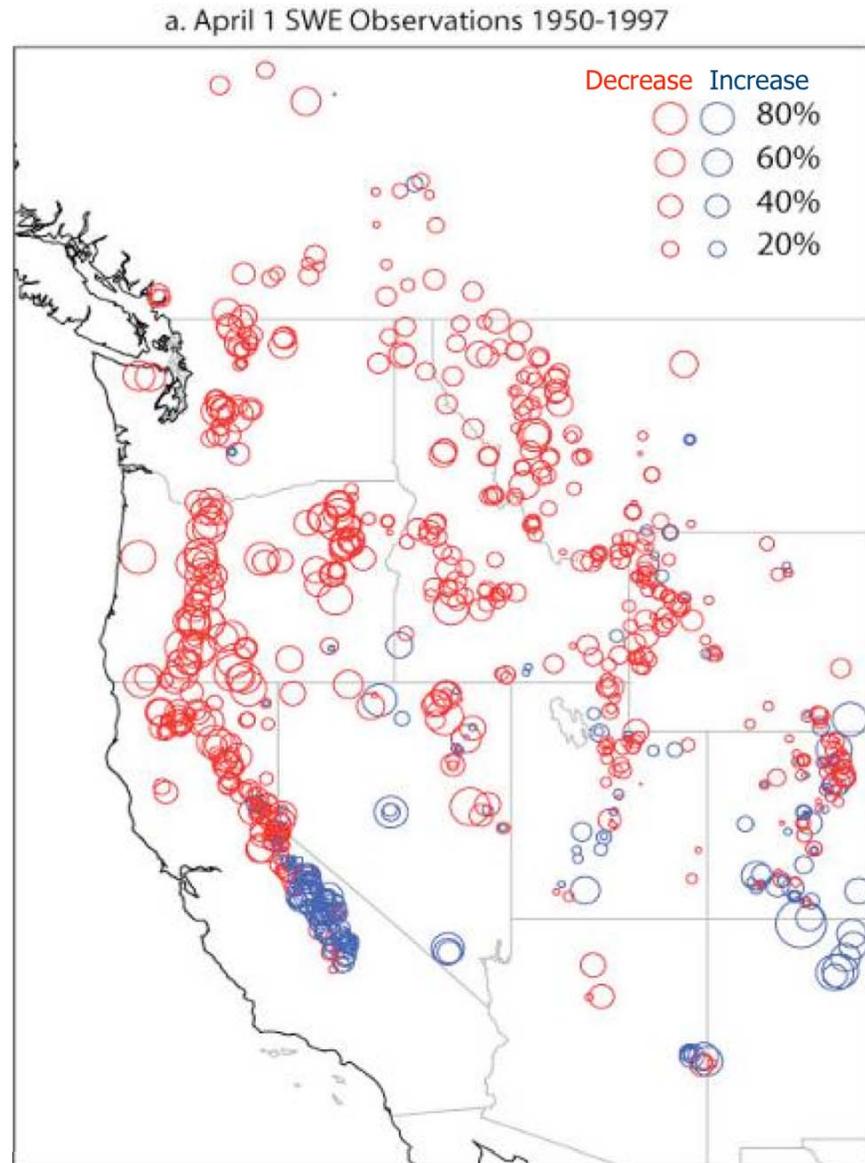
Photo by B. Reardon, USGS

2005

**Shepard Glacier
Glacier National Park**

Trends in Snow Water Equivalent

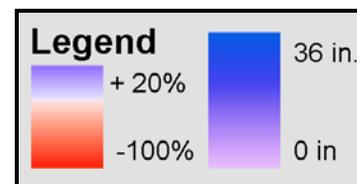
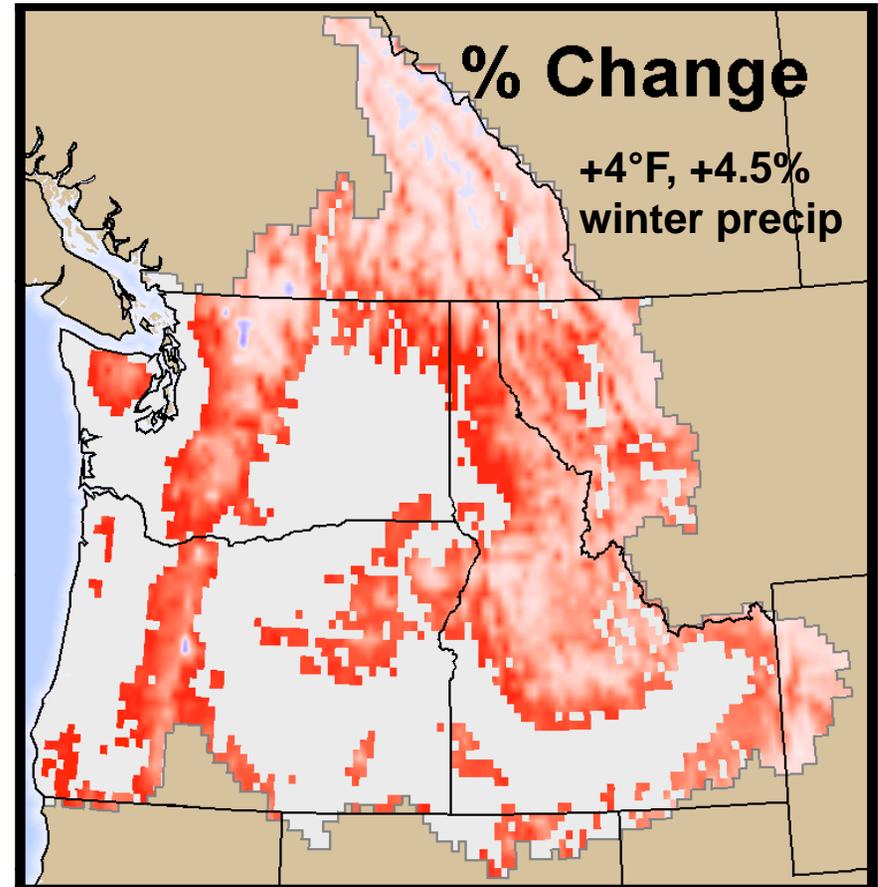
- Most PNW stations show a decline in snow water equivalent
- Numerous sites in the Cascades with 30% to 60% declines
- Similar trends seen throughout the western United States - 73% of stations show a decline in April 1 snow water equivalent



Lower Spring Snowpack

Spring snowpack is projected to decline as more winter precipitation falls as rain rather than snow, *especially in warmer mid-elevation basins*

Snowpack will melt earlier with warmer spring temperatures



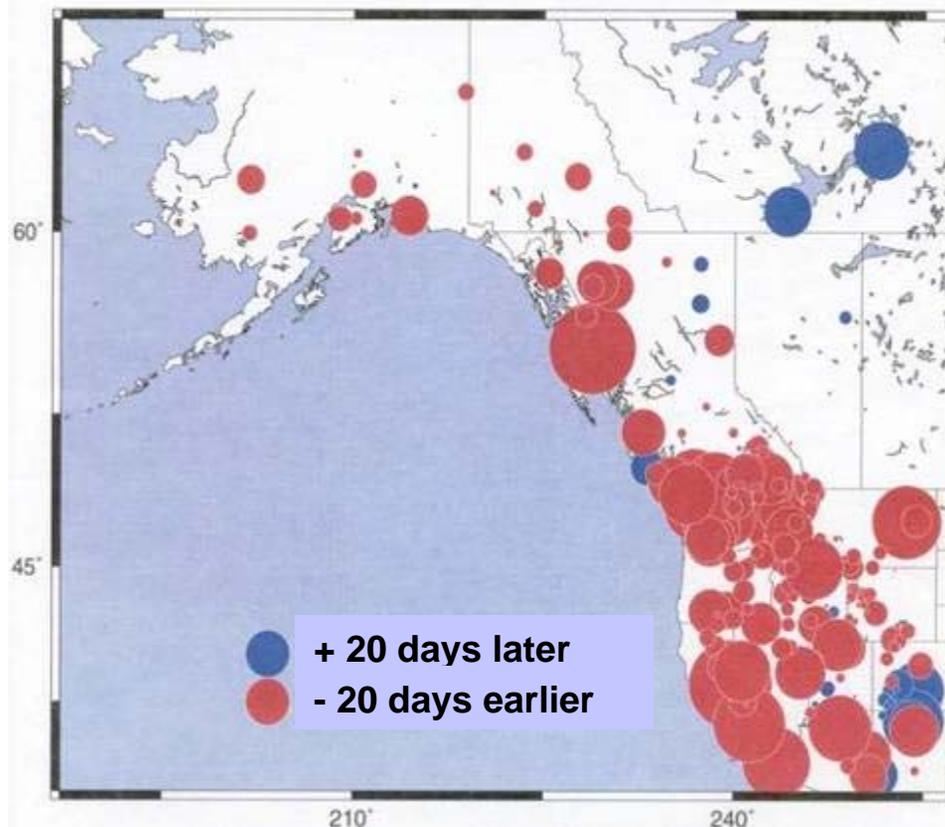
**April 1
Snowpack**



Trends in Spring Runoff

Peak of spring runoff is moving earlier into the spring throughout western US and Canada

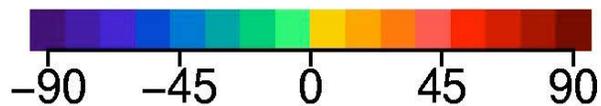
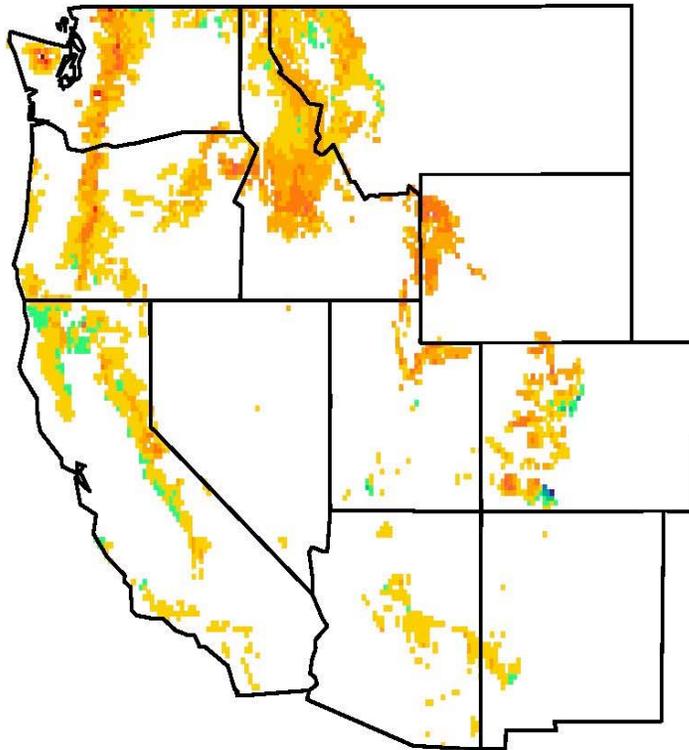
- *Advances of 10-30 days between 1948-2000*
- *Greatest trends in PNW, Canada, and AK*
- *>30% of trends are statistically significant at the 90% level, especially in the PNW*



Stewart, I., Cayan, D.R., and Dettinger, M.D., 2004, *Changes in snowmelt runoff timing in western North America under a "Business as Usual" climate change scenario: Climatic Change 62, 217-232.*

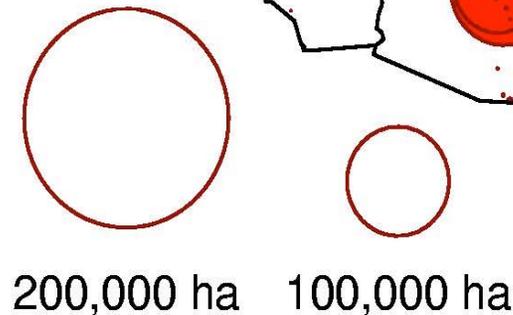
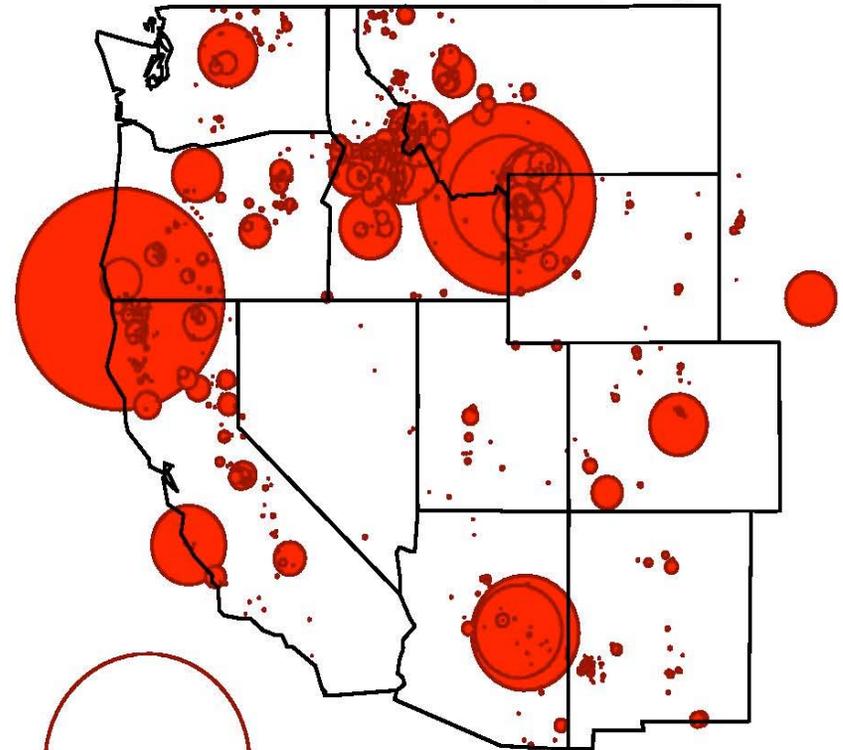
Wildfires accelerate 1970 – 2003 with early snowmelt, longer, drier summers

Change in Average Moisture Deficit 1987–2003 versus 1970–1986



percent change scaled by forest area

Large Forest Wildfires in Years with Early Spring



Tree mortality resulting from insect outbreaks

Southwestern US



Photo by Craig Allen - USGS

British Columbia



© Parks Canada/Ross MacDonald/KNP/2004



October 2004, Sylvan Pass, Yellowstone NP

Conclusions

1. **There is an increase in global temperatures due to human-caused increases in green house gasses**
2. **In the last century the average global temperature has risen with 1.3°F**
3. **Future predictions for the PNW say that temperature will increase around 5°F in the PNW by 2100**
4. **The impacts of the temperature increase in the PNW will affect agricultural and natural systems.**



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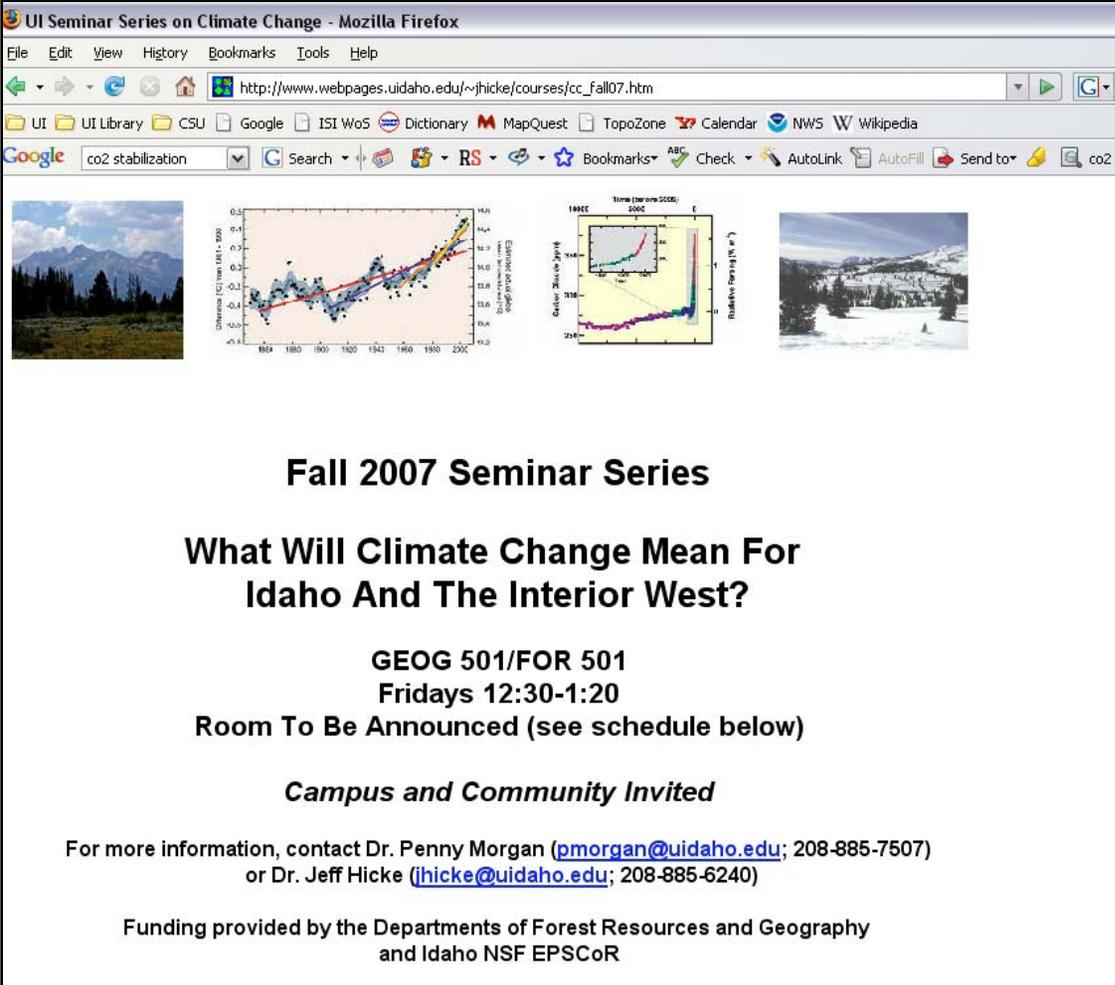


K. Wattenmaker, firepix.blm.gov



For more information...

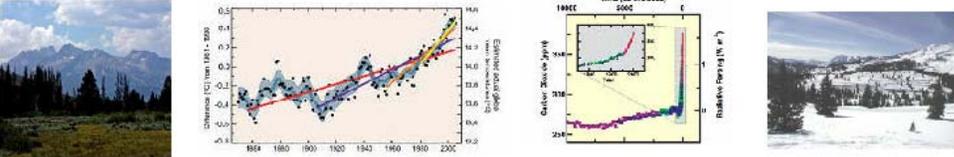
University of Idaho Fall Seminar Series on Climate Change and Idaho



UI Seminar Series on Climate Change - Mozilla Firefox

http://www.webpages.uidaho.edu/~jhicke/courses/cc_fall07.htm

co2 stabilization



Fall 2007 Seminar Series

What Will Climate Change Mean For Idaho And The Interior West?

GEOG 501/FOR 501
Fridays 12:30-1:20
Room To Be Announced (see schedule below)

Campus and Community Invited

For more information, contact Dr. Penny Morgan (pmorgan@uidaho.edu; 208-885-7507)
or Dr. Jeff Hicke (jhicke@uidaho.edu; 208-885-6240)

Funding provided by the Departments of Forest Resources and Geography
and Idaho NSF EPSCoR

Variety of topics:

- snow
- fish
- fire
- insects
- C sequestration
- etc.

Seminars recorded,
available for viewing from
WWW

www.webpages.uidaho.edu/~jhicke/courses/cc_fall07.htm

For more information...

Information on Idaho climate change is available at
<http://groups.google.com/group/idahoclimatechange>
Or contact Dr. Jeffrey A. Hicke (jhicke@uidaho.edu),
Dr. Von P. Walden (vonw@uidaho.edu),
or Dr. Karen Humes (khumes@uidaho.edu)



University of Idaho

More information on PNW climate impacts and planning
for climate change is available from

The Climate Impacts Group

www.cses.washington.edu/cig

Lara Whitely Binder

lwb123@u.washington.edu

