

# Global Climate Change: Causes and Consequences

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“The Climate Ahead: Global Change, Local Impacts”  
Douglass College Center  
September 20, 2006



## Study Ties Warming to Intense Hurricanes

By RANDOLPH E. SCHMID

The Associated Press

Monday, September 11, 2006; 6:44 PM

WASHINGTON -- Most of the increase in ocean temperature that feeds more intense hurricanes is a result of human-induced global warming, says a study that one researcher says "closes the loop" between climate change and powerful storms like Katrina.

## Discouraging Study on Global Warming

By THE ASSOCIATED PRESS

Published: September 7, 2006

WASHINGTON, Sept. 6 (AP) — Methane, a potent heat-trapping gas, is bubbling out of the thawing Siberian permafrost five times more than previously thought, researchers are reporting.

## Biofuels Come of Age as the Demand Rises



### Summer was warmest since '30s

The Boston Globe

By Margot Habiby, Bloomberg News | September 15, 2006

DALLAS -- The continental United States endured the hottest summer since the Dust Bowl era of the 1930s, and the second-warmest since recordkeeping began more than a century ago, US forecasters said yesterday.

## NASA Scientists See New Signs of Global Warming

By ANDREW C. REVKIN

Published: September 14, 2006

Scientists have long suspected that the recent melting of Arctic Ocean ice in the summer might be a result of heat-trapping gases building up in the atmosphere. But yesterday [NASA](#) scientists reported that higher temperatures and a retreat of the sea ice over the last two winters offered new evidence that the gases were influencing the region's climate.

## California, Taking Big Gamble, Tries to Curb Greenhouse Gases



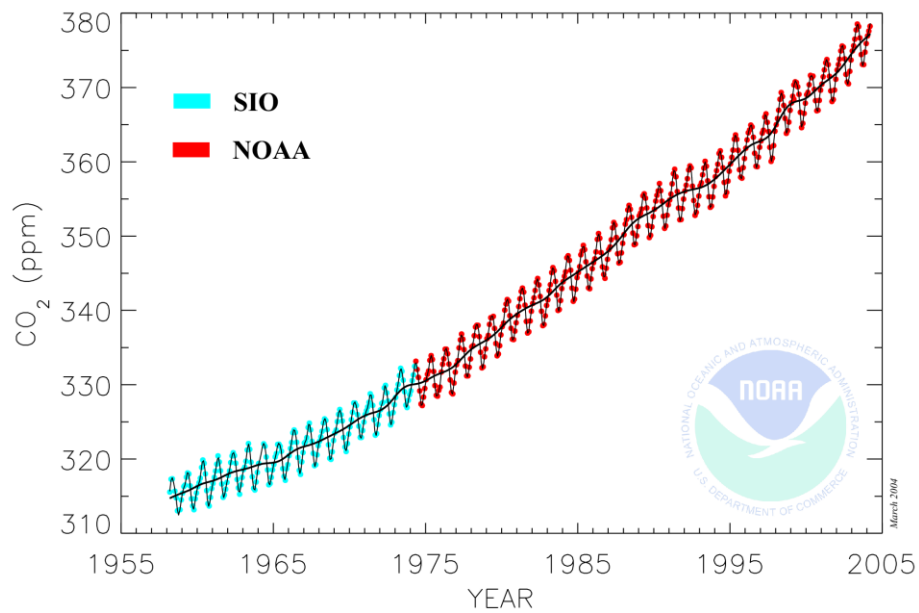
Max Whittaker for The New York Times

1 Bolden installing solar panels in a subdivision in Rocklin, Calif. A new law requires 10% of new homes by 2012.

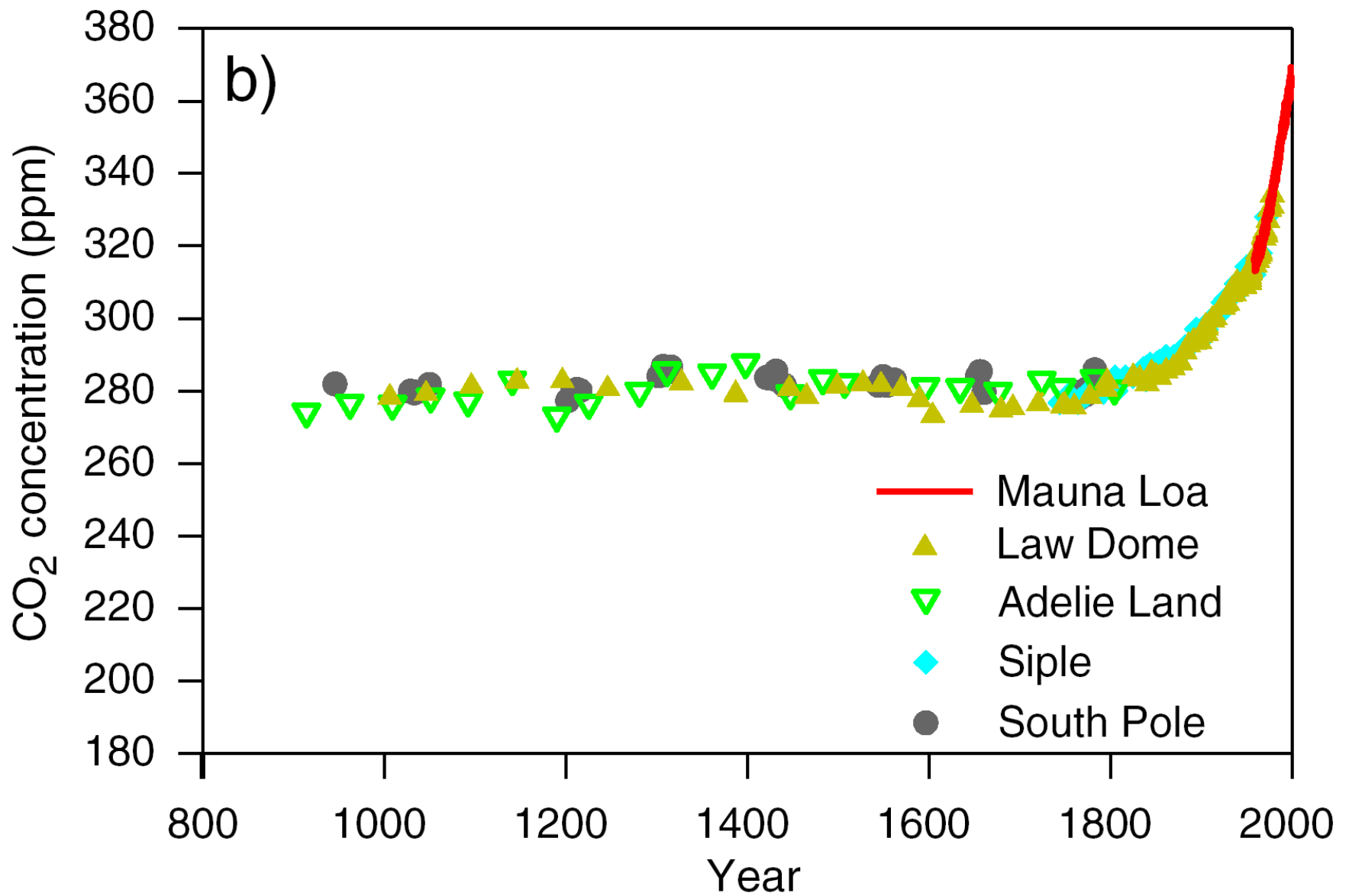




**Mauna Loa Monthly Mean Carbon Dioxide**

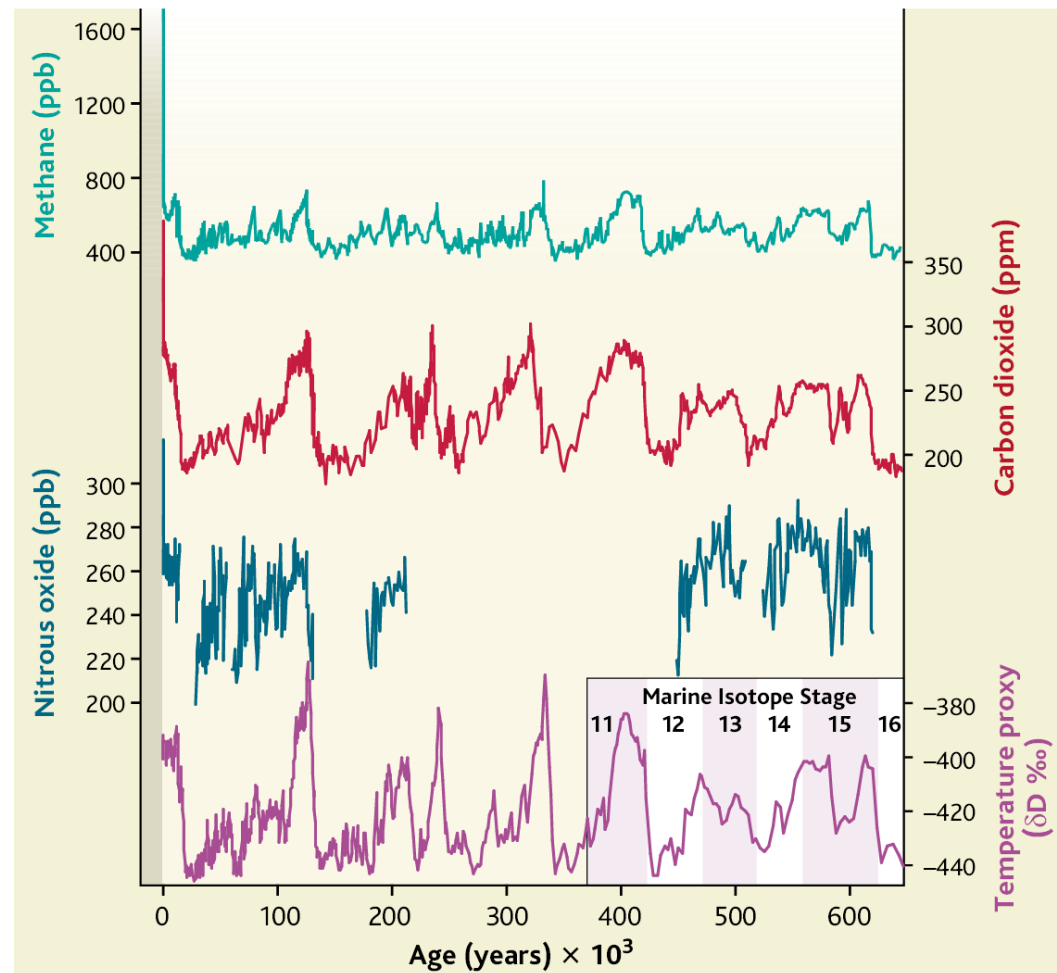
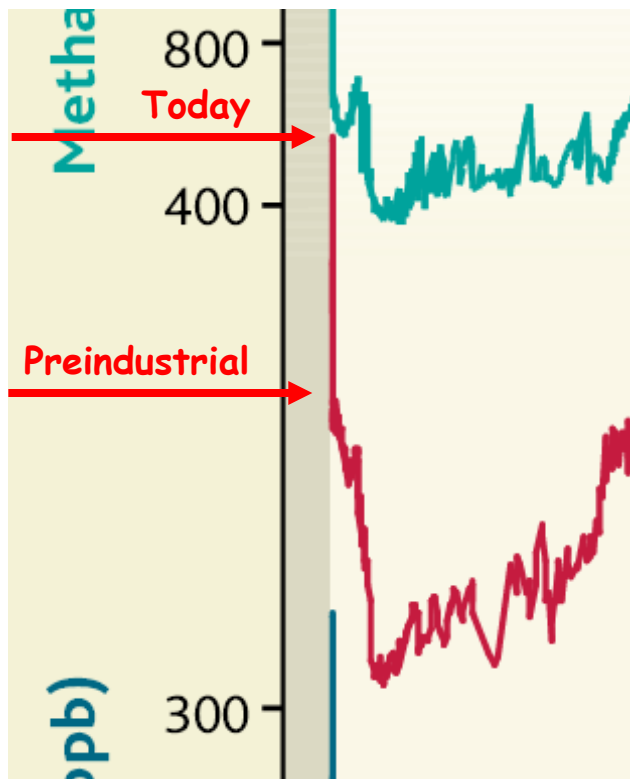








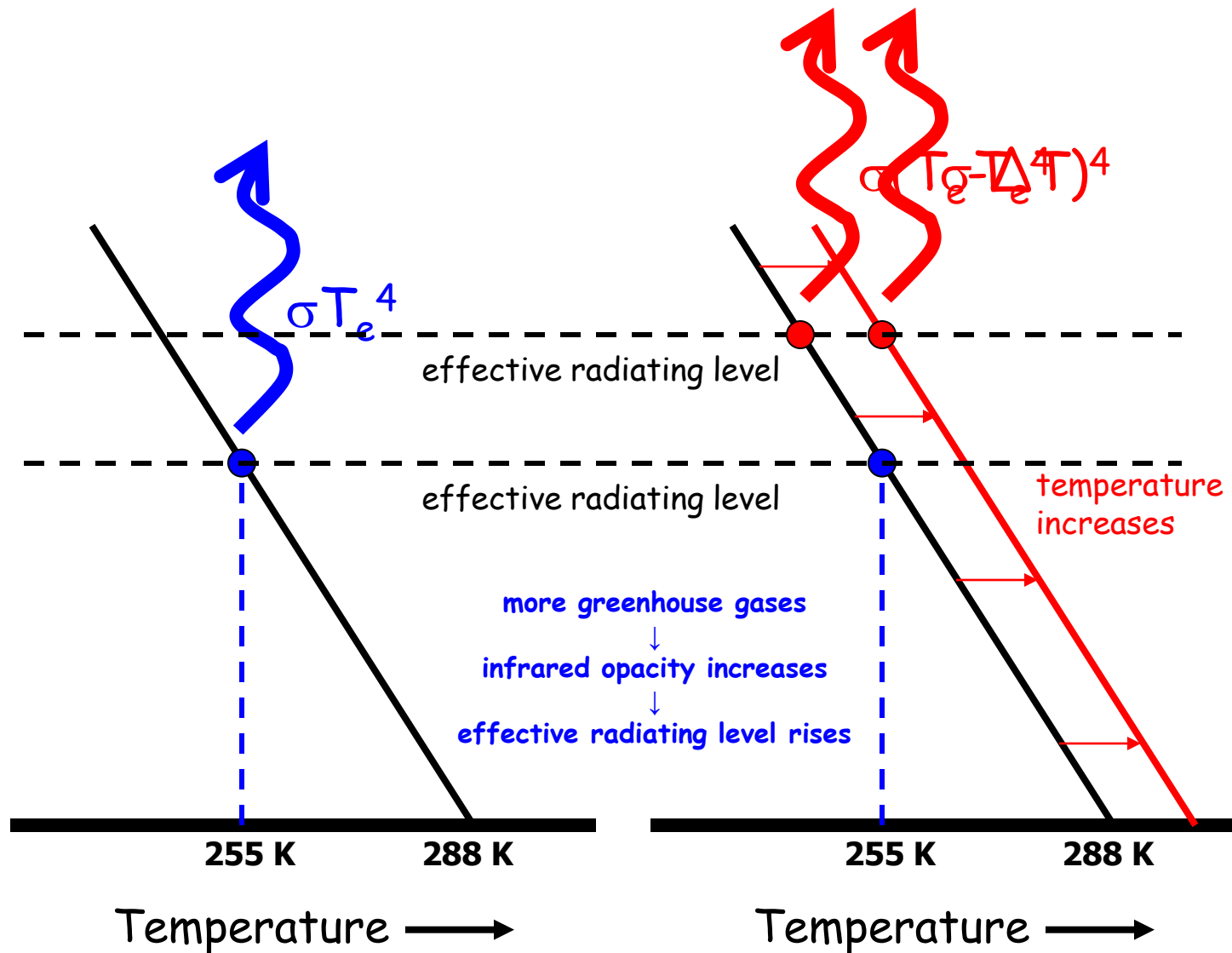
Greenhouse gases are now higher than any time in the past 650,000 years.



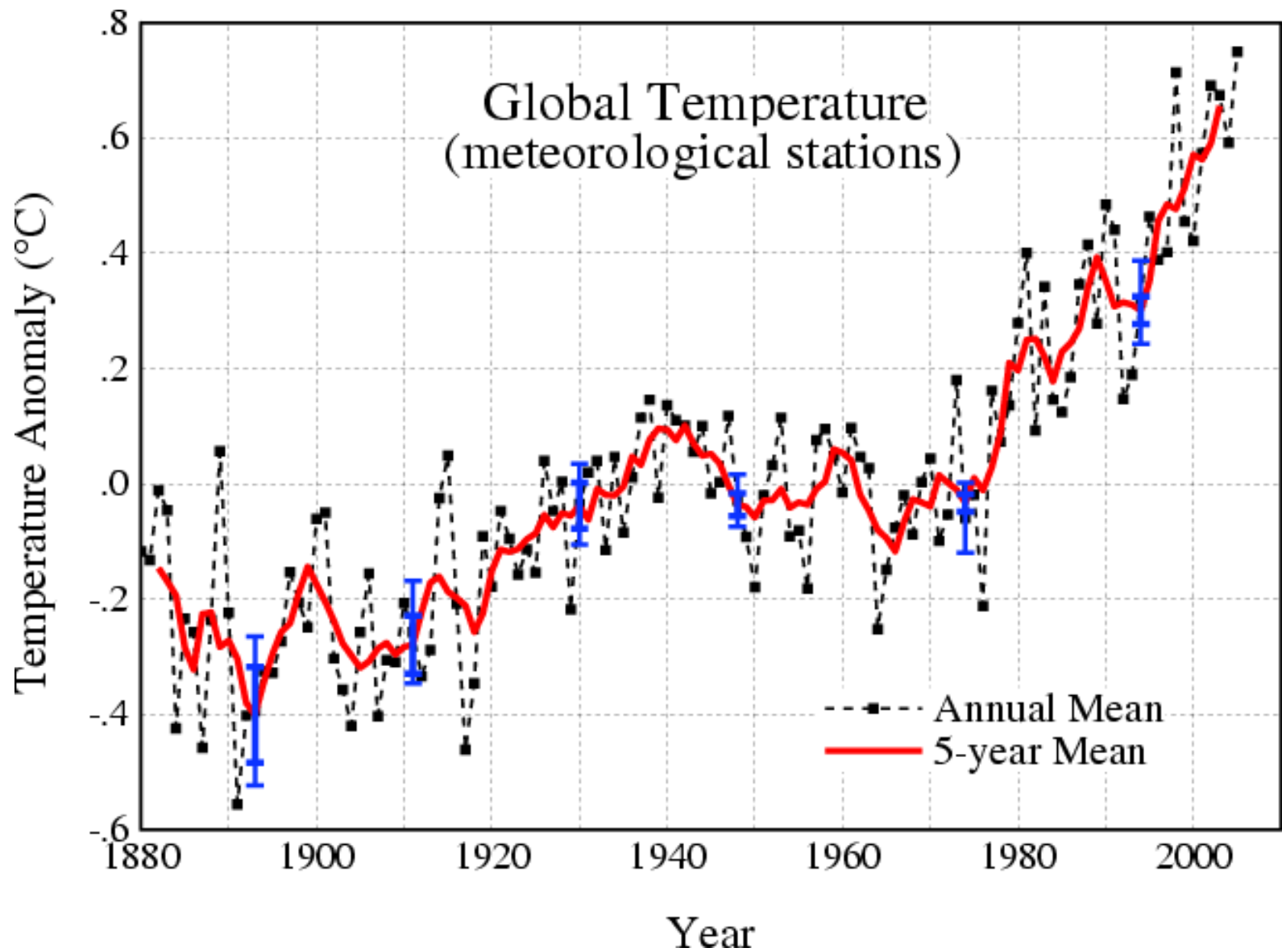
**The long view.** The greenhouse gas ( $\text{CO}_2$ ,  $\text{CH}_4$ , and  $\text{NO}_2$ ) and deuterium ( $\delta\text{D}$ ) records for the past 650,000 years from EPICA Dome C and other ice cores, with marine isotope stage correlations (labeled at lower right) for stages 11 to 16 (2, 3).  $\delta\text{D}$ , a proxy for air temperature, is the deuterium/hydrogen ratio of the ice, expressed as a per mil deviation from the value of an isotope standard (4). More positive values indicate warmer conditions. Data for the past 200 years from other ice core records (20–22) and direct atmospheric measurements at the South Pole (23, 24) are also included.

Source: Brook, E., 2005: Tiny bubbles tell all, *Science*, **310**, 1285-1287.





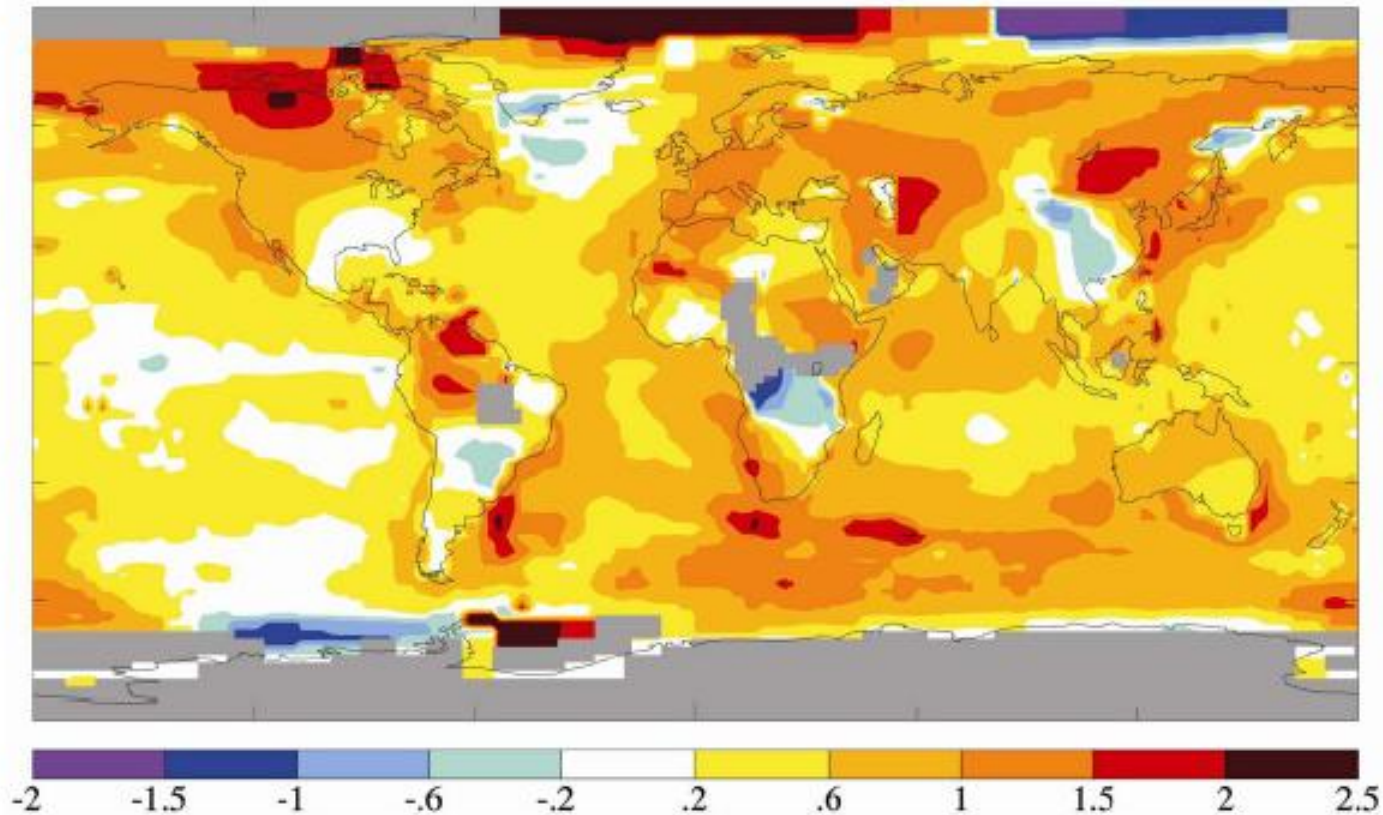






## 1900-2005 Surface Temperature Change (°C)

.61

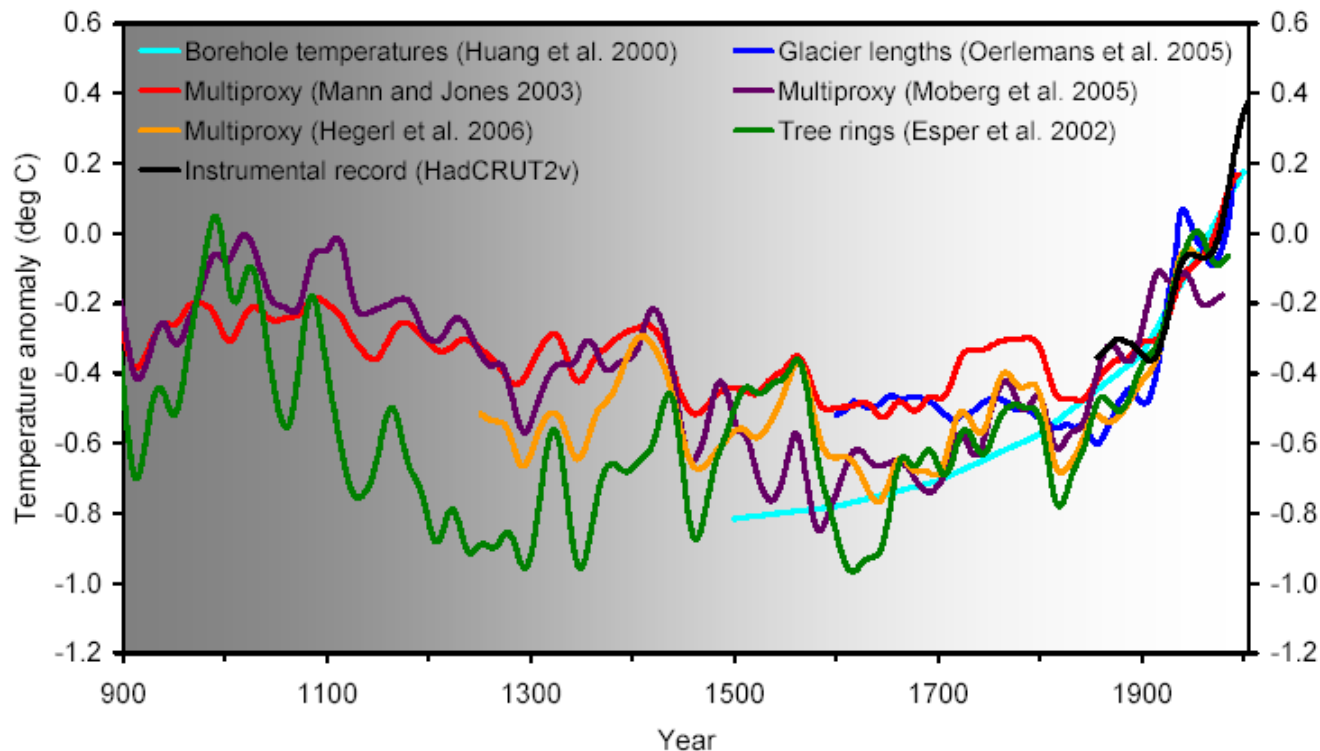


Change of surface temperature index based on local linear trends using surface air temperature over land and SST over ocean.

Sources: Hansen et al., *JGR*, **106**, 23947, 2001; Reynolds and Smith, *J. Climate*, **7**, 1994; Rayner et al., *JGR*, **108**, 2003.



# Northern Hemisphere Temperature Reconstructions

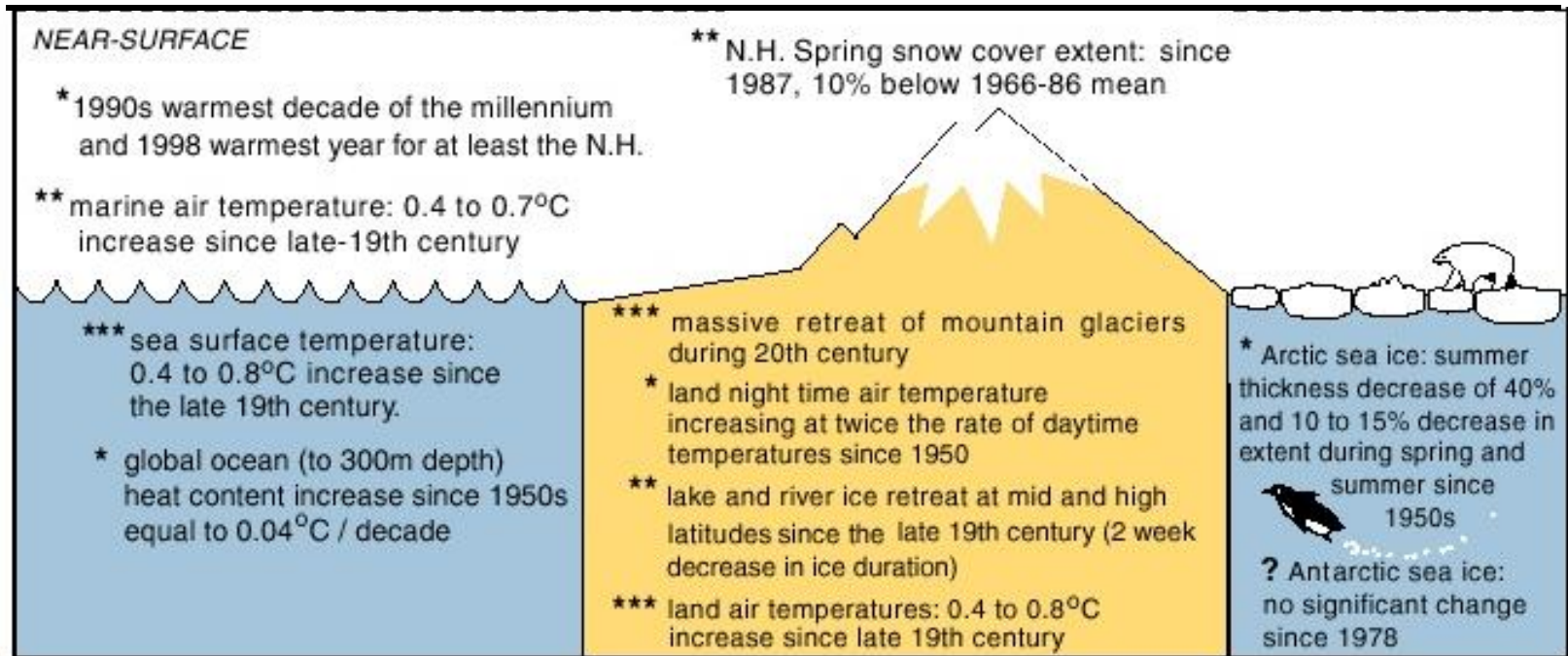


**"It can be said with a high level of confidence that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries"**

**"...the committee finds it plausible that the Northern Hemisphere was warmer during the last few decades of the 20th century than during any comparable period over the preceding millennium."** [National Research Council](#)



# Temperature Indicators

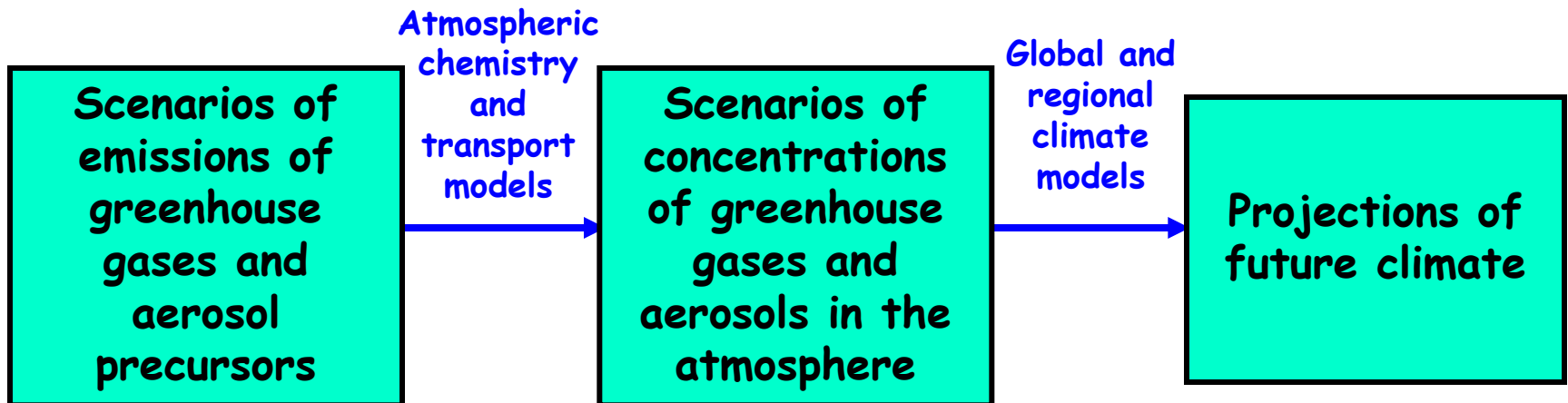


Likelihood: {

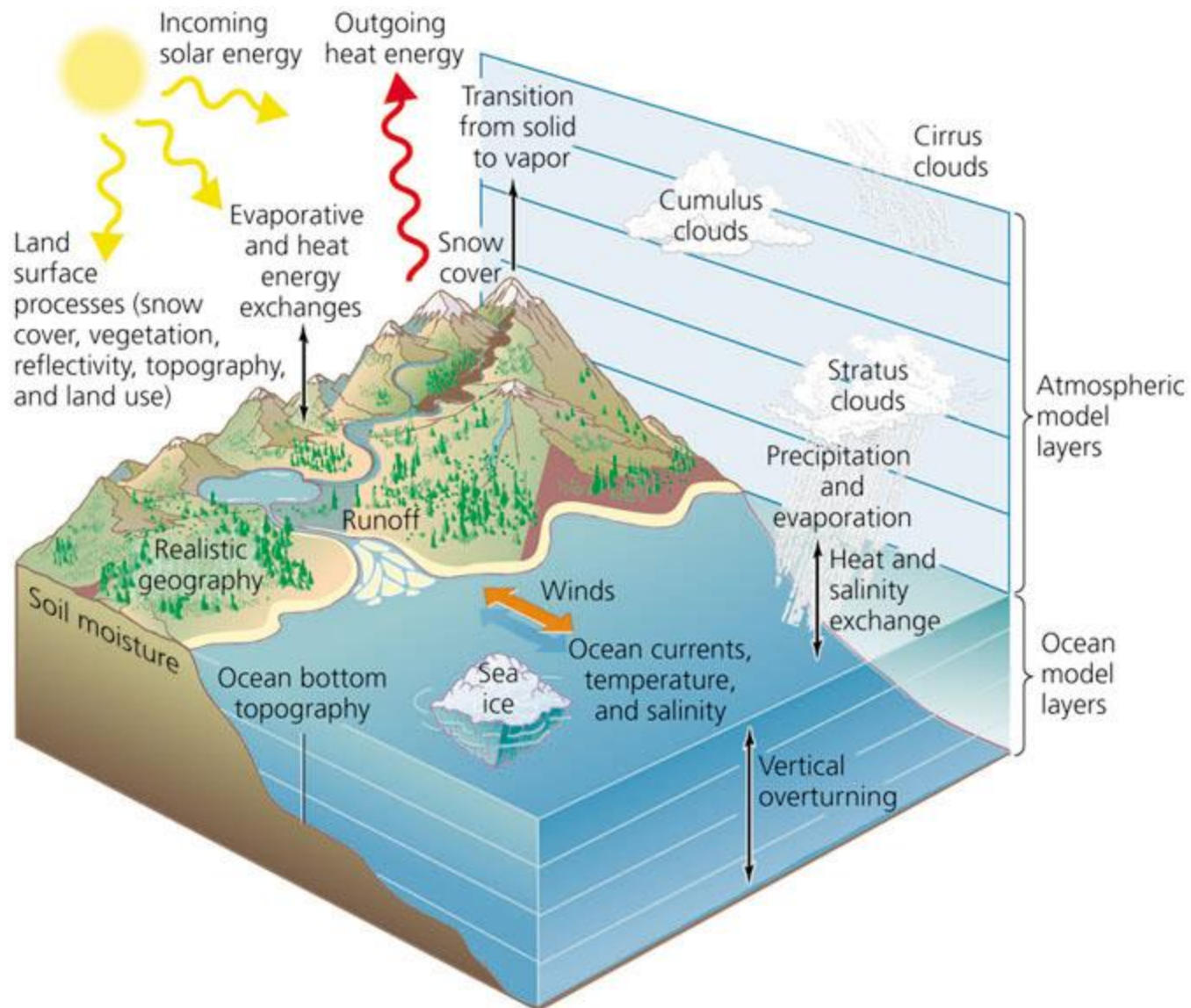
- \*\*\* Virtually certain (probability > 99%)
- \*\* Very likely (probability > 90% but ≤ 99%)
- \* Likely (probability > 66% but < 90%)
- ? Medium likelihood (probability > 33% but ≤ 66%)



# Projecting Future Climate



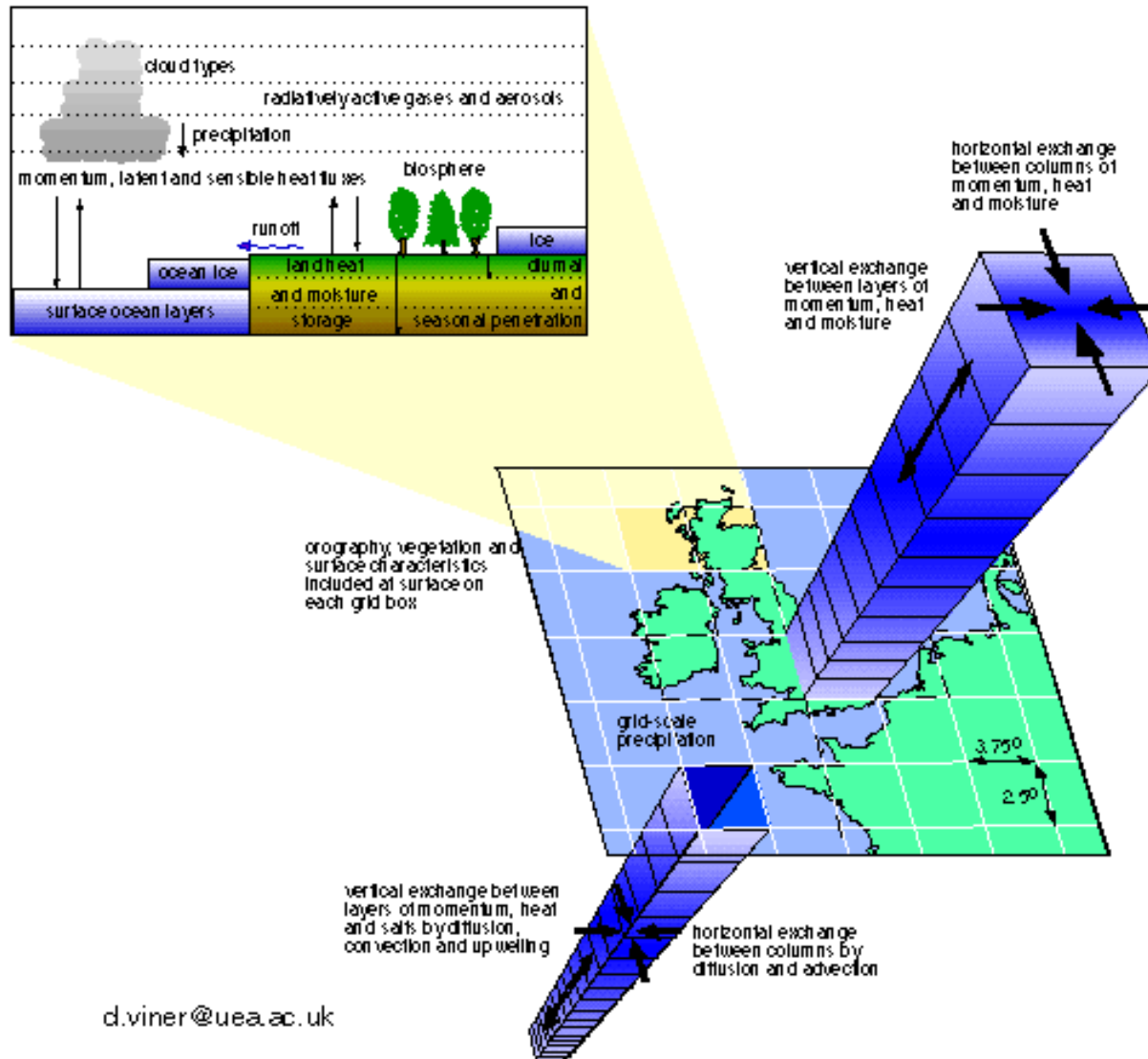




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# Coupled Climate Model Schematic

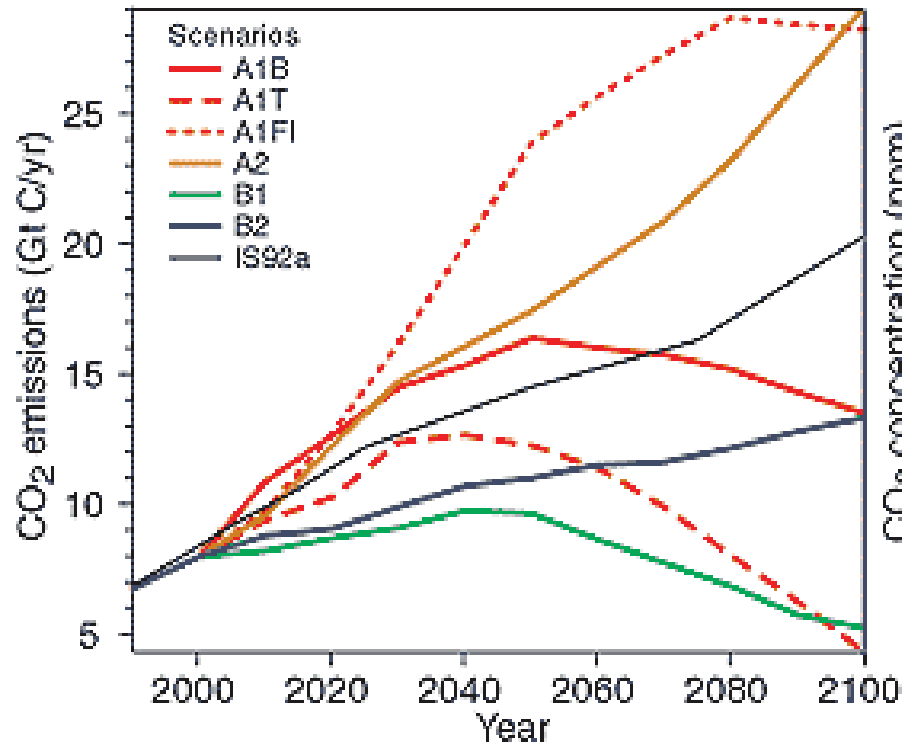


d.viner@uea.ac.uk

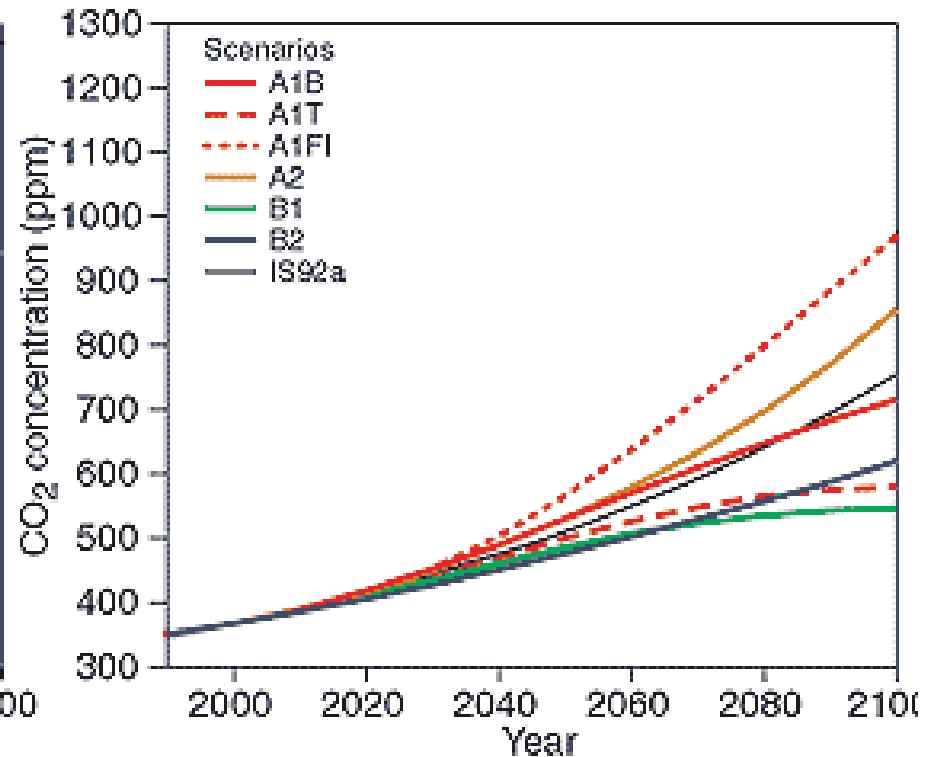


# Future Emissions Scenarios

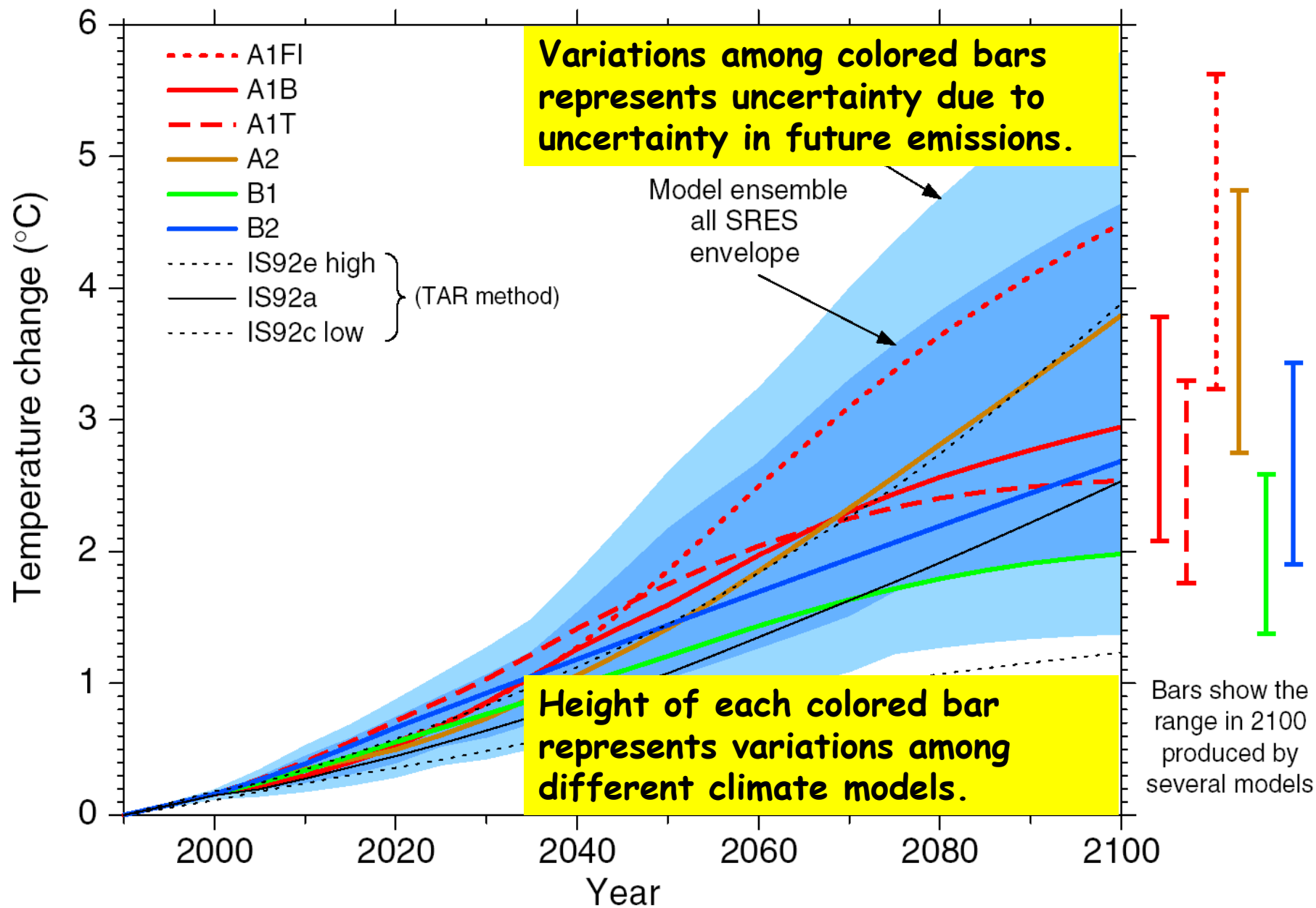
(a) CO<sub>2</sub> emissions



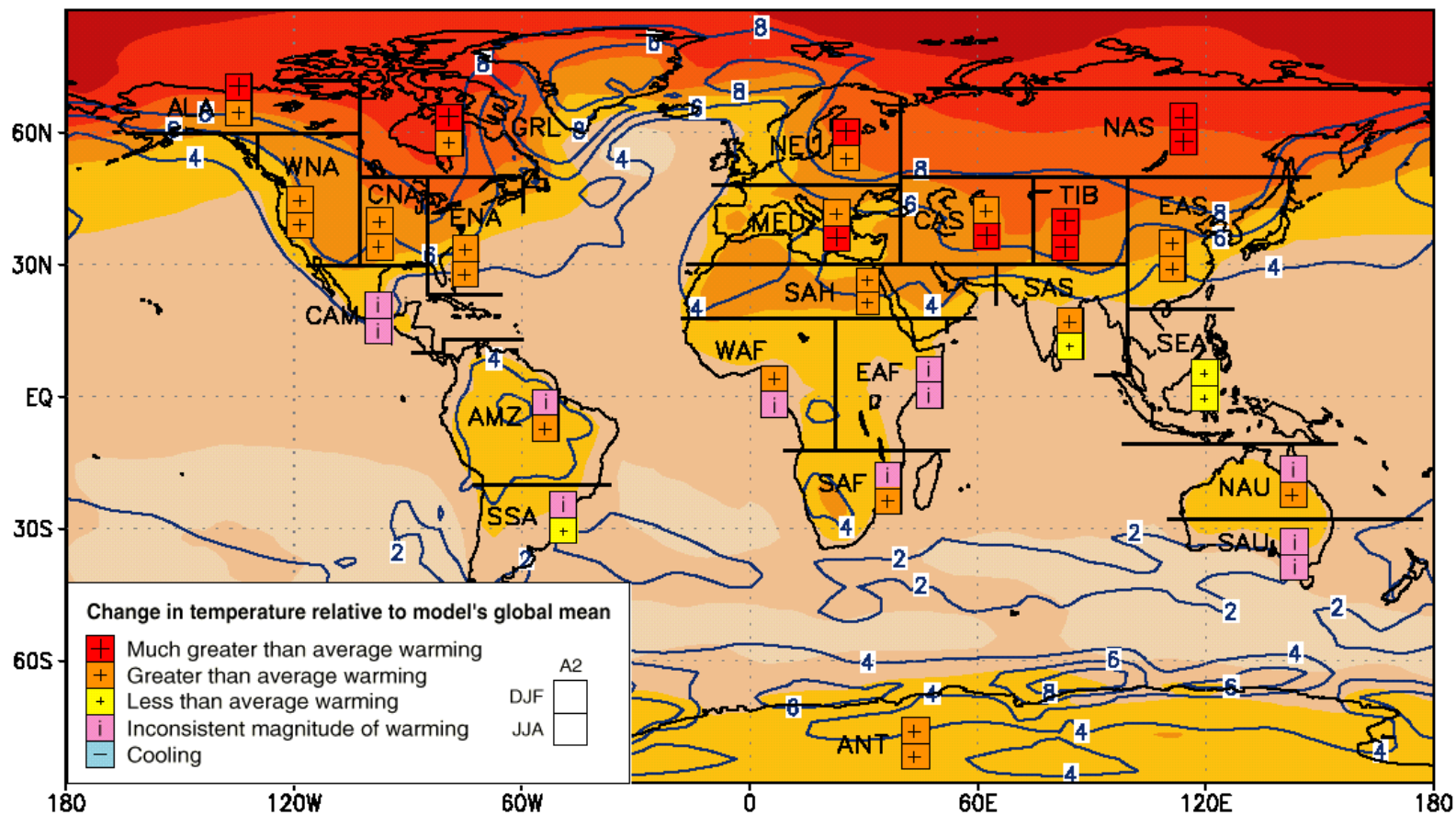
(b) CO<sub>2</sub> concentrations











**A2**



**Annual mean temperature change  
(2071-2100) minus (1961-1990), °C**

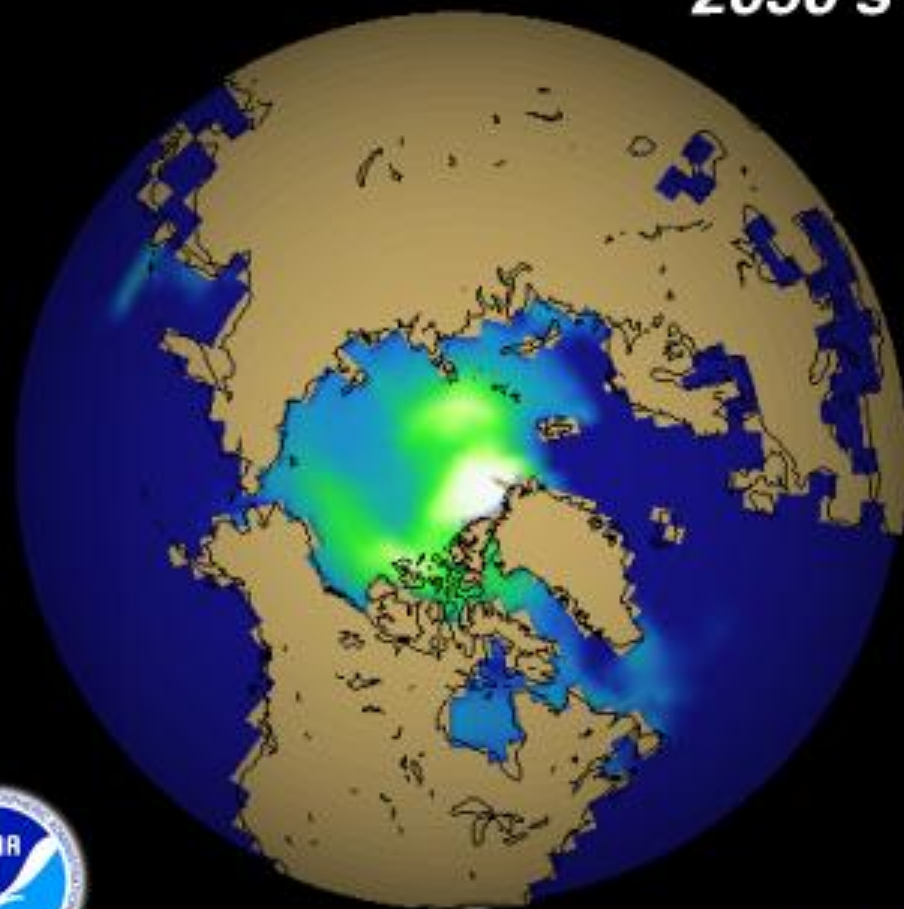
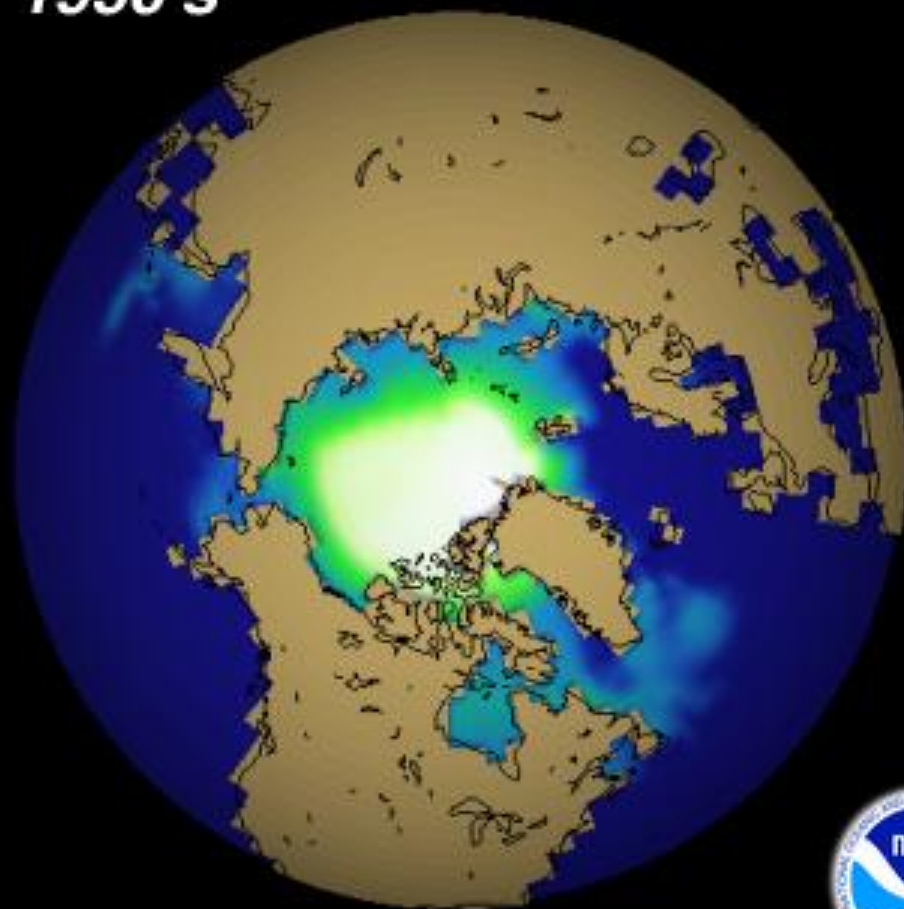
Source: IPCC Working Group I (2001)



# Sea Ice Thickness (10-year average)

**1950's**

**2050's**



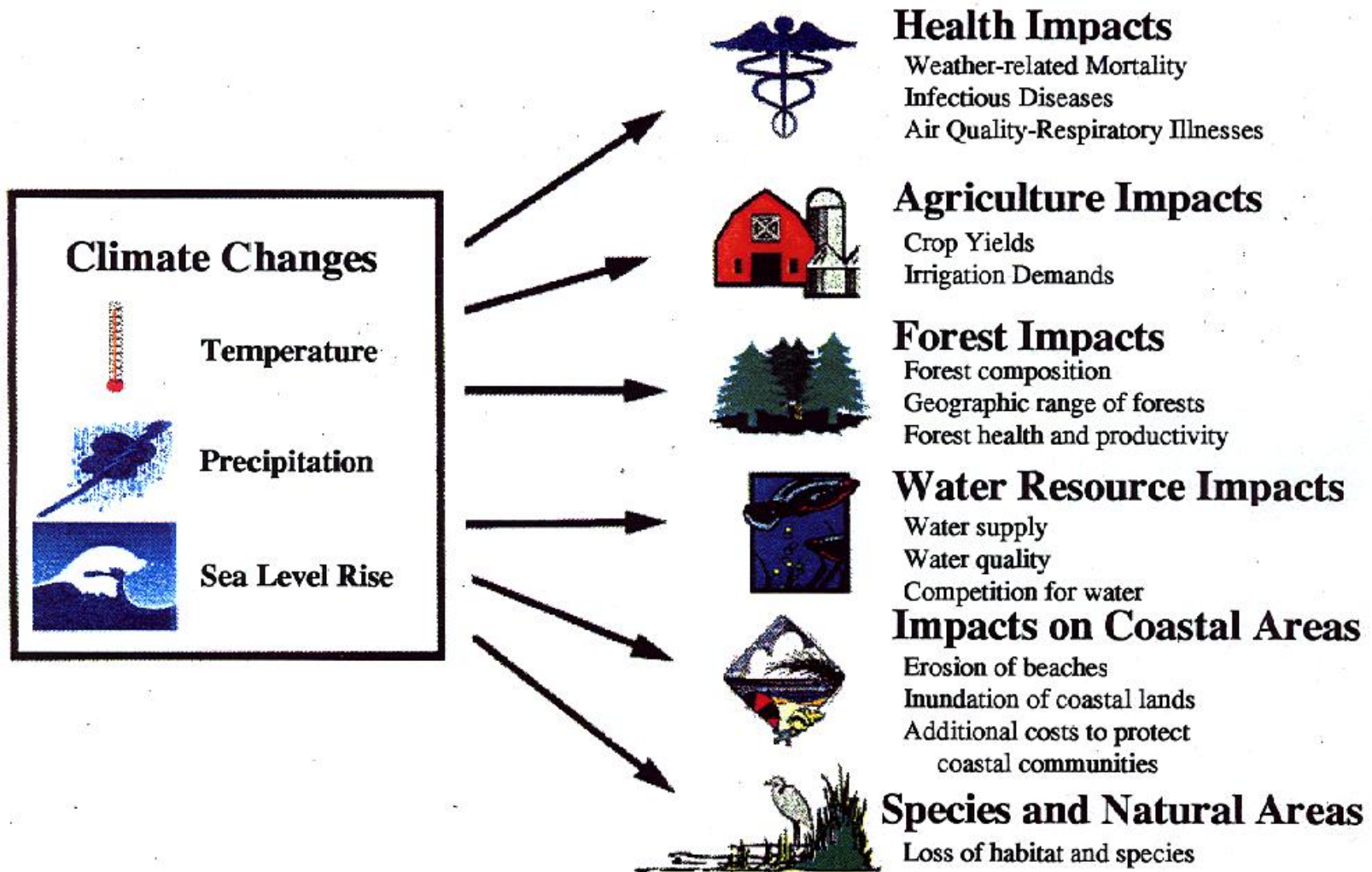
100% of  
1955 volume



54% of  
1955 volume



# Potential Climate Change Impacts







Coastal Environment



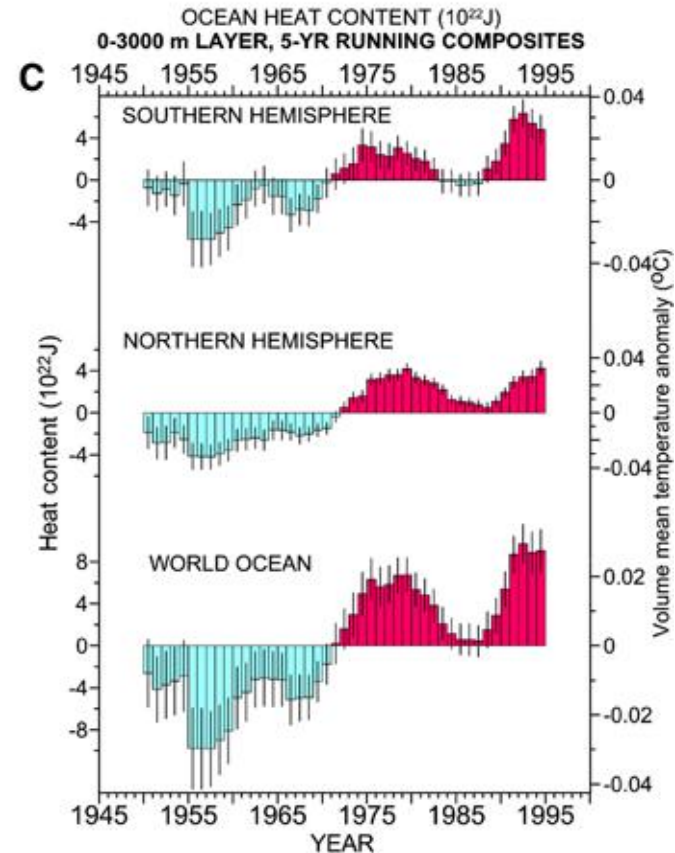
Water Resources



# Why Is Global Sea Level Rising?

## Thermal Expansion:

Warmer water is less dense than colder water.



The ocean has been gaining heat.



# Why Is Global Sea Level Rising?

## Melting Glaciers and Ice Caps:

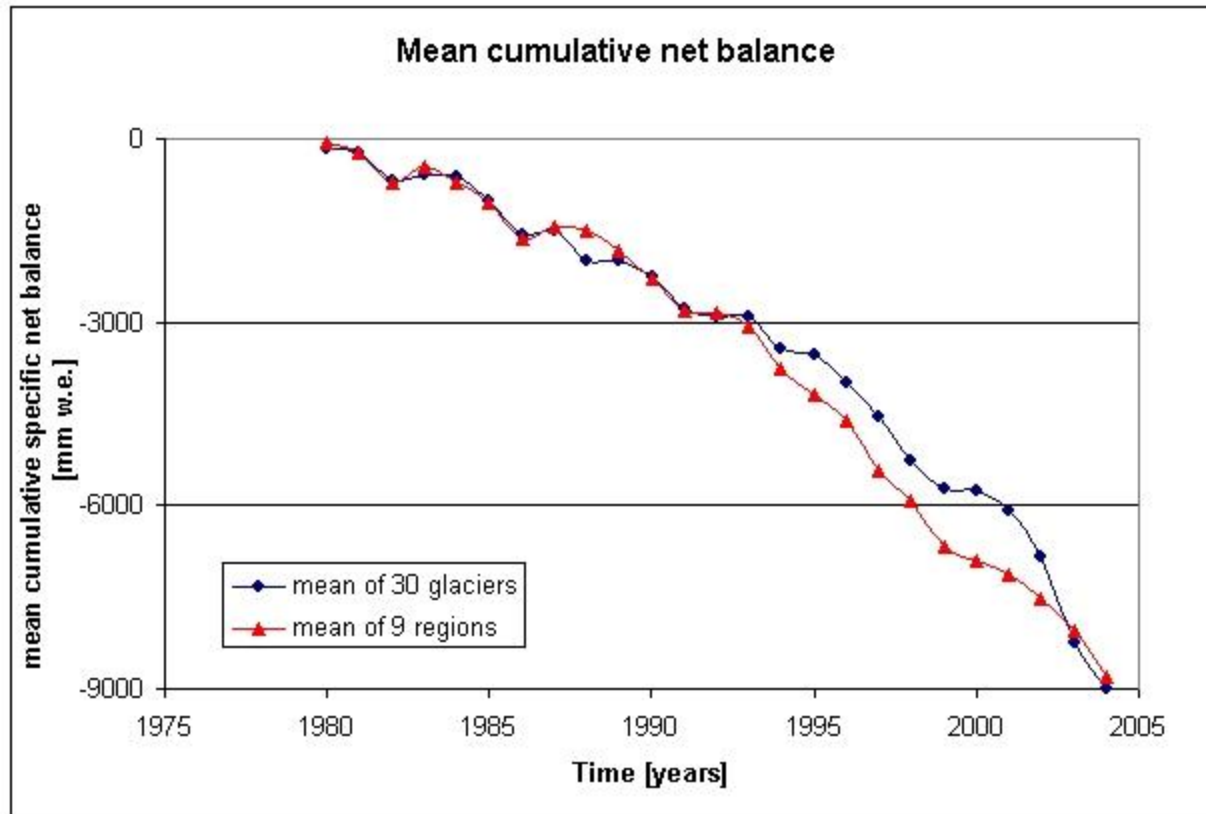
Water released by the melting of ice on land adds to the volume of the oceans.



Source: Roger Braithwaite, Univ. of Reading

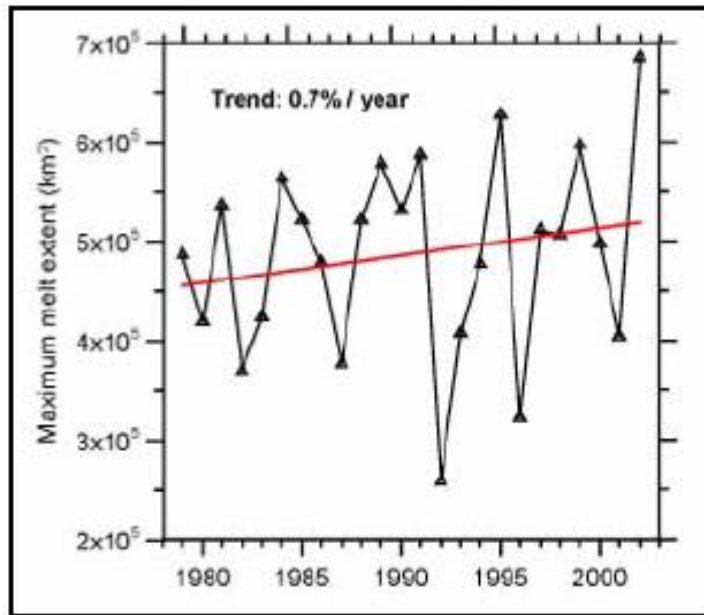


# Changes in Glacier Mass

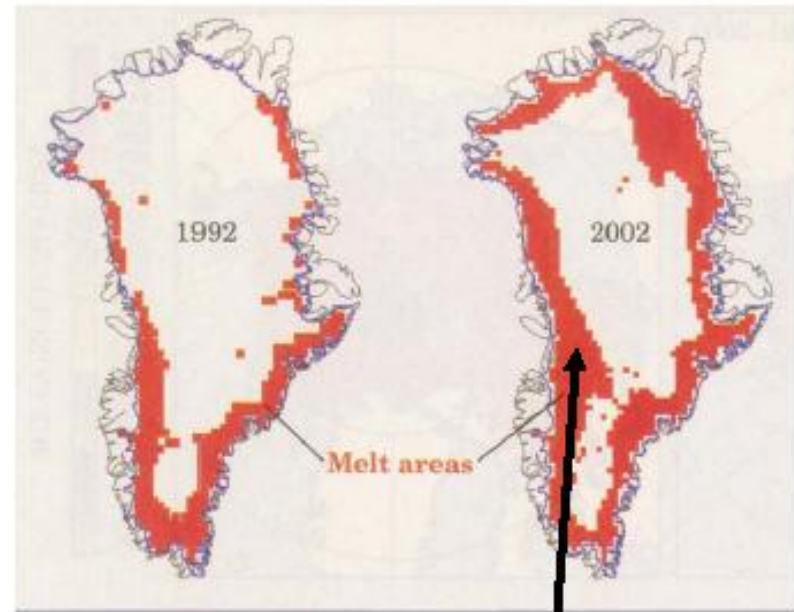




# Increasing Melt Area on Greenland



- 2002 all-time record melt area
- Melting up to elevation of 2000 m
- 16% increase from 1979 to 2002



**70 meters thinning in 5 years**

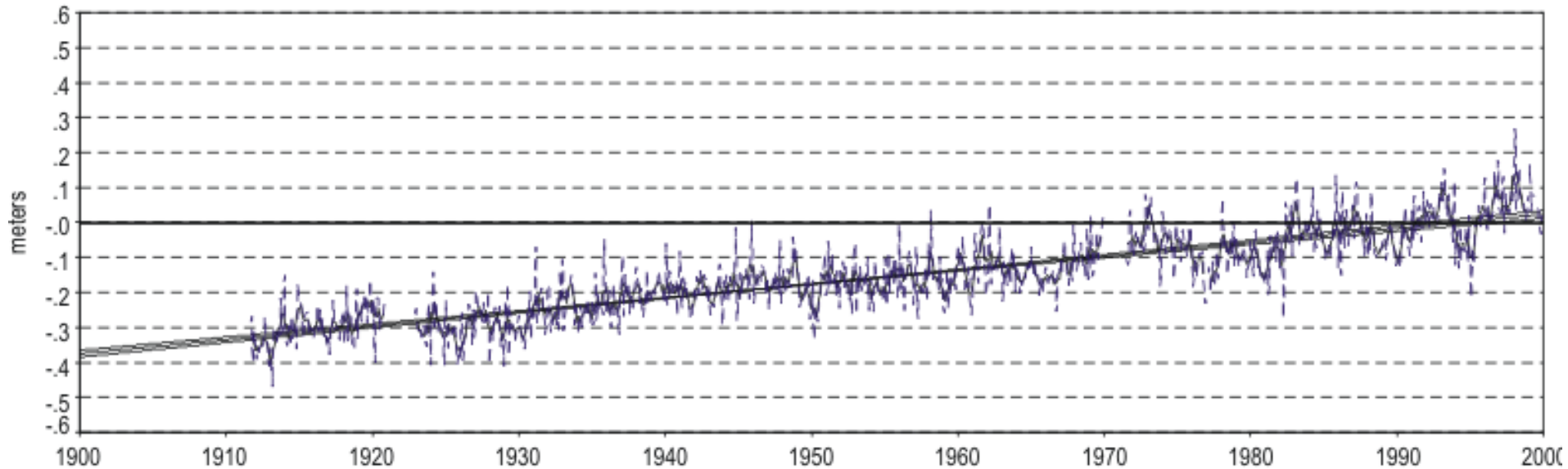
**Satellite-era record melt of 2002 was exceeded in 2005.**

Source: Waleed Abdalati, Goddard Space Flight Center



# Sea Level Trends in New Jersey

## Atlantic City, NJ



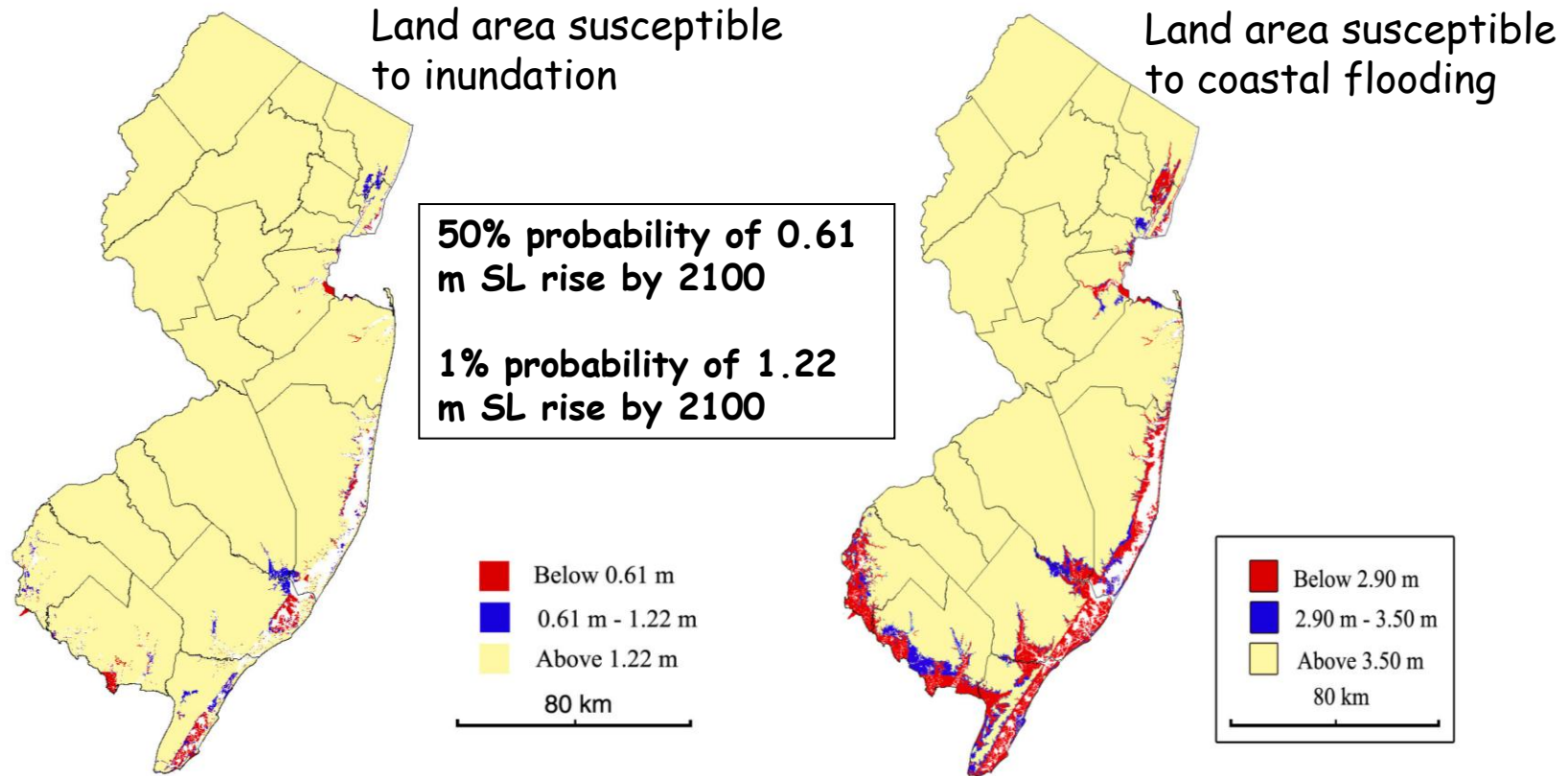
Source: National Oceanic and Atmospheric Administration







# Effects of Sea Level Rise on the Coastal Environment



Source: Cooper et al. "Future Sea Level Rise and the New Jersey Coast", Princeton University

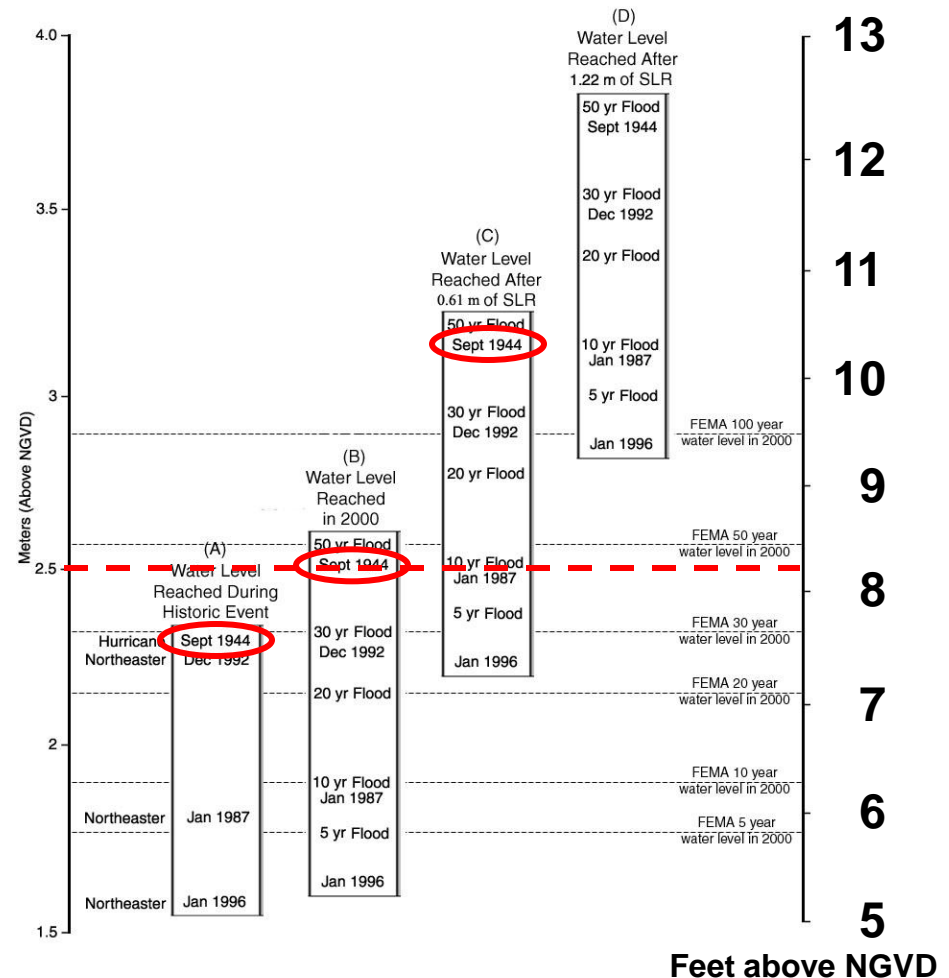


# Impact on Coastal Flooding

Highest water level recorded by Atlantic City tide gauge: ~7.6 ft. above NDVD during Sept. 1944 hurricane.

If the same storm happened today, the water level would reach ~8.2 ft. With today's sea level, the return period for this water level is ~45 years.

If sea level rises by 0.61 m by the end of the century, the same water level would have a return period of ~10 years, and a storm like the 1944 hurricane would produce a water level of ~10.3 ft.



Source: Cooper et al. "Future Sea Level Rise and the New Jersey Coast", Princeton University



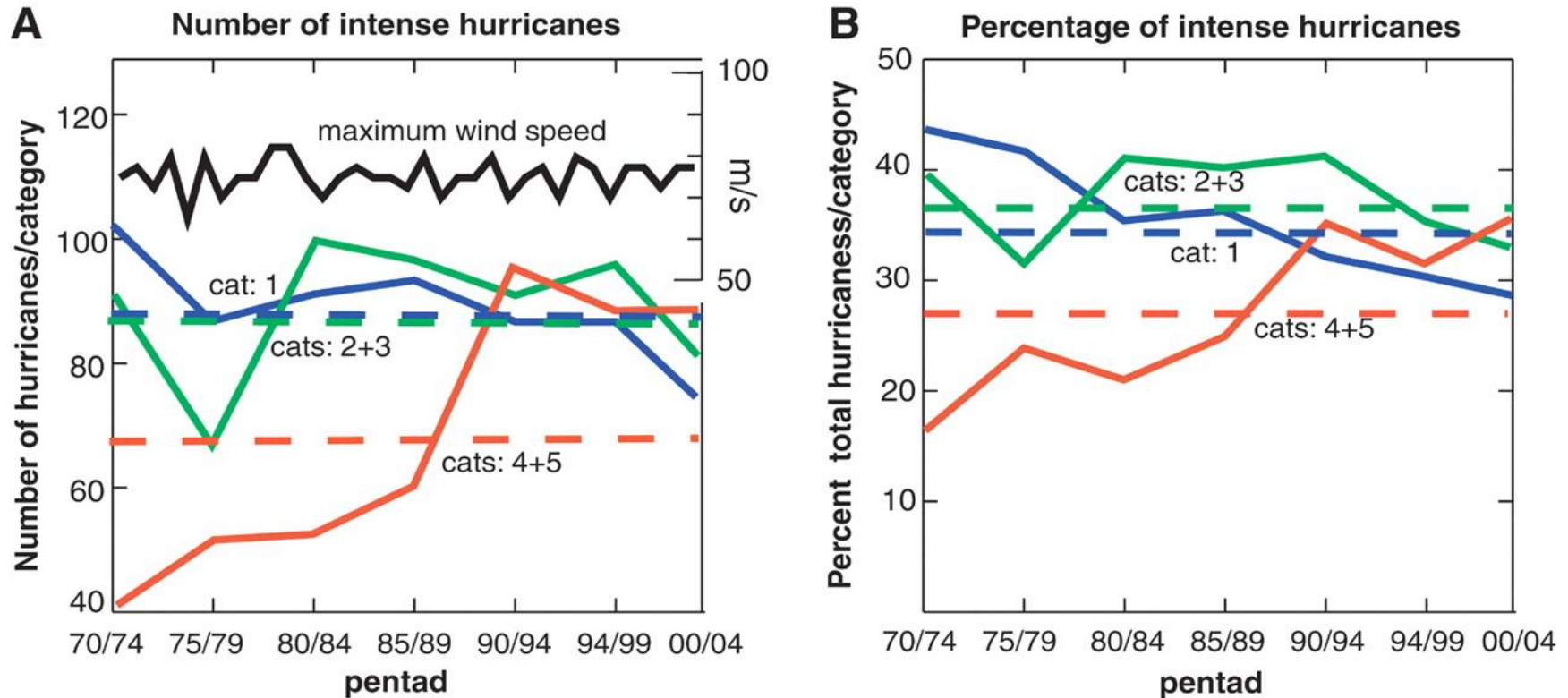
# "Ash Wednesday Storm"



Harvey Cedars, March 1962



# Are Intense Hurricanes Becoming More Frequent?



Source: Webster et al., *Science*, 16 September 2005

Warning: The direction of this trend is consistent with theory and modeling, but the magnitude appears to be larger.



# Effects of Climate Change on Water Resources: Floods and Droughts?

Cannonsville Reservoir, Dec. 2001



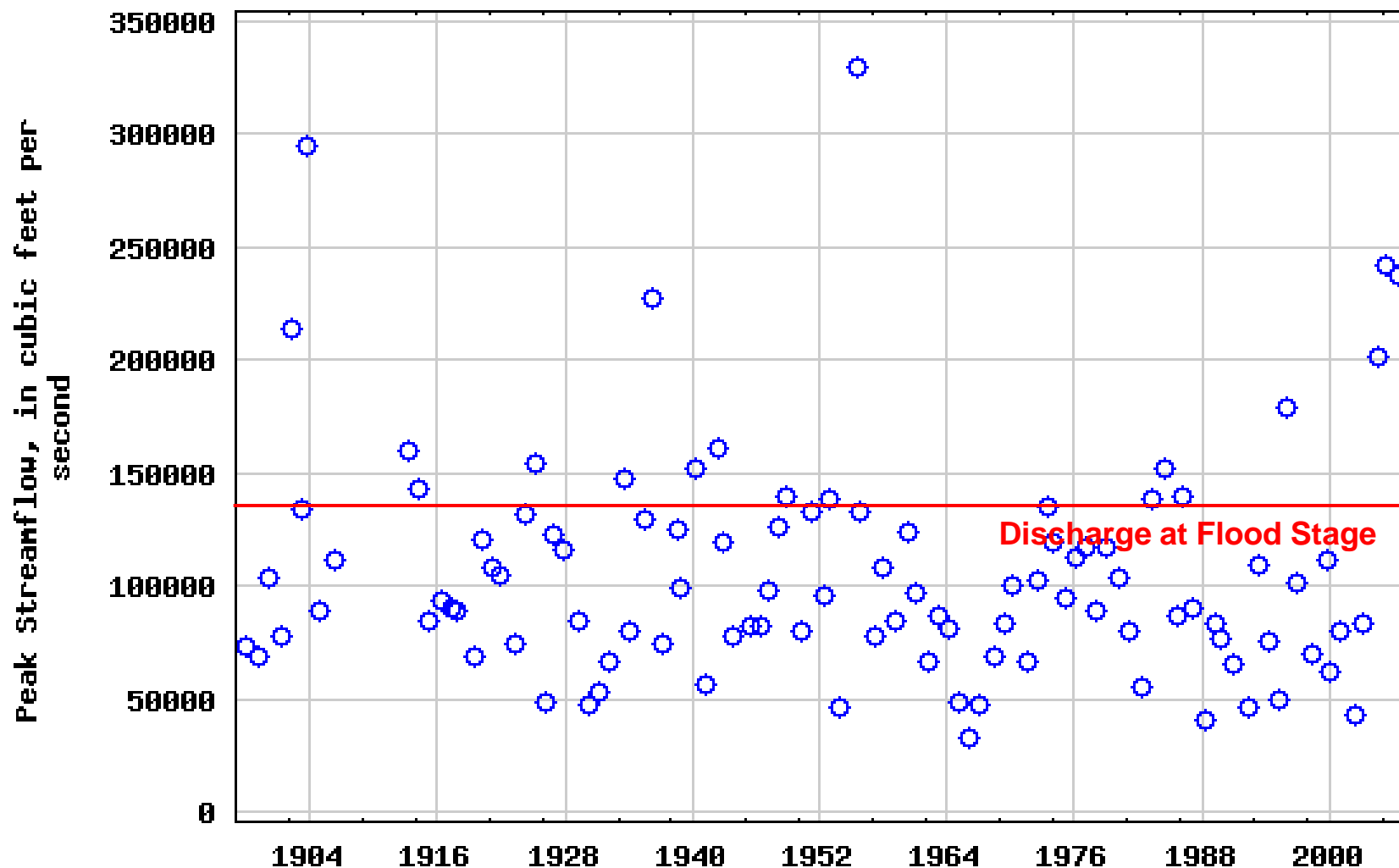
Delaware River, Sept. 2004



Easton-Phillipsburg Bridge  
June 2006

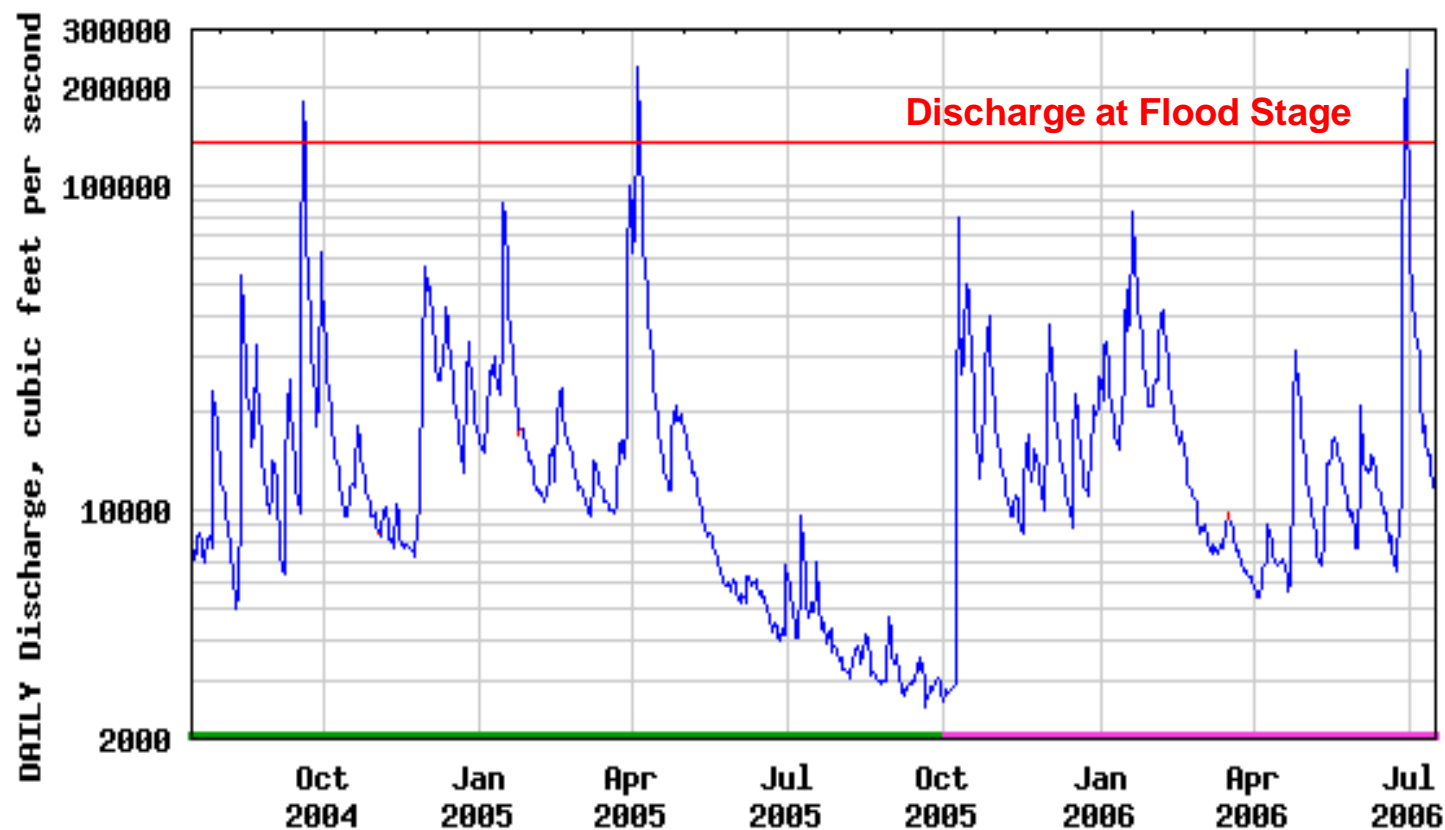


## USGS 01463500 DELAWARE RIVER AT TRENTON NJ





## USGS 01463500 DELAWARE RIVER AT TRENTON NJ

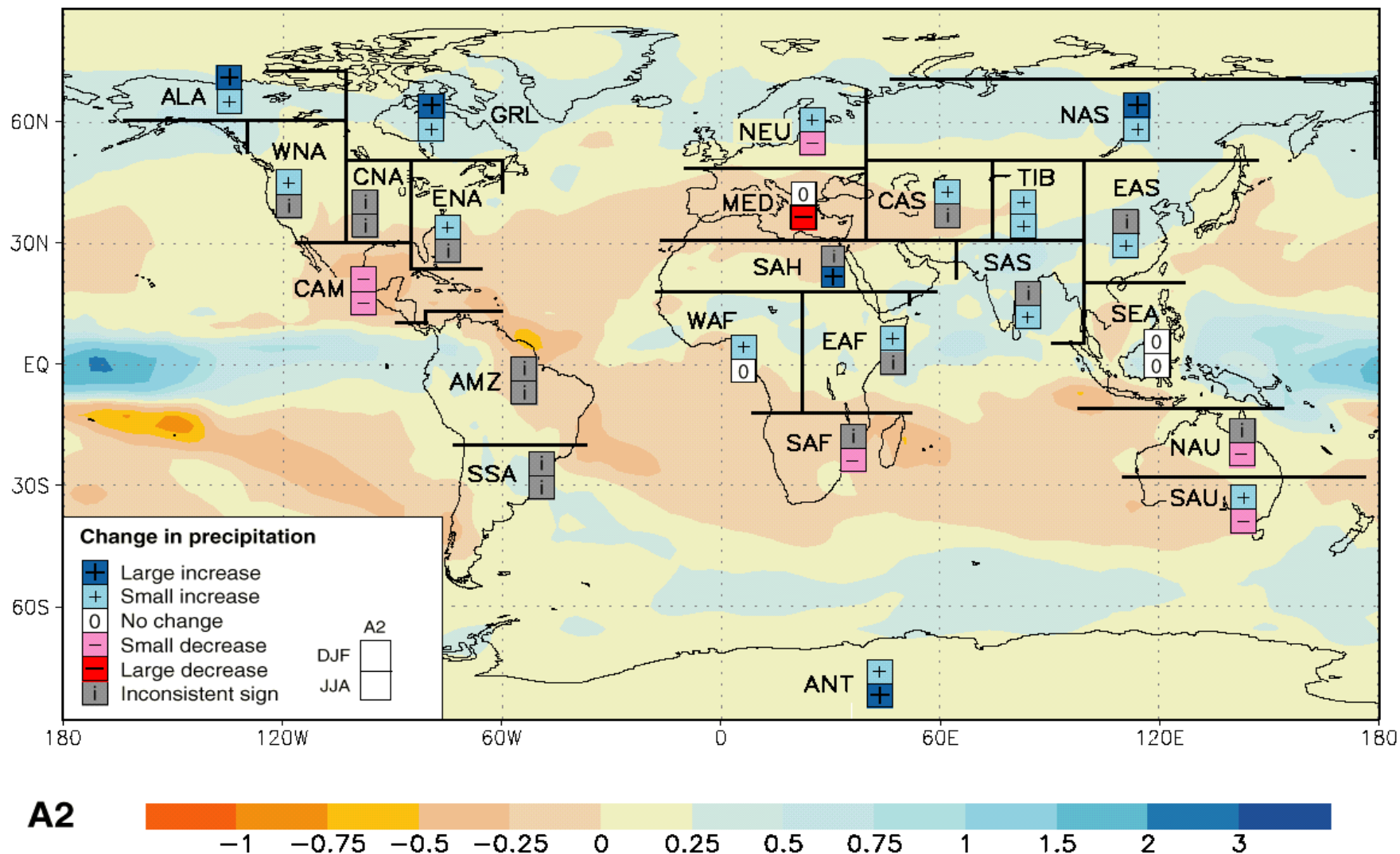




# Global Warming and the Hydrologic Cycle

- The downward flux of radiative energy (i.e., sunlight and infrared radiation) at the surface is balanced by evaporation and sensible heating of the atmosphere.
- If the downward flux of energy increases, then evaporation will increase.
- On a global basis, evaporation and precipitation must balance.
- Thus as the earth warms, both evaporation and precipitation will increase.



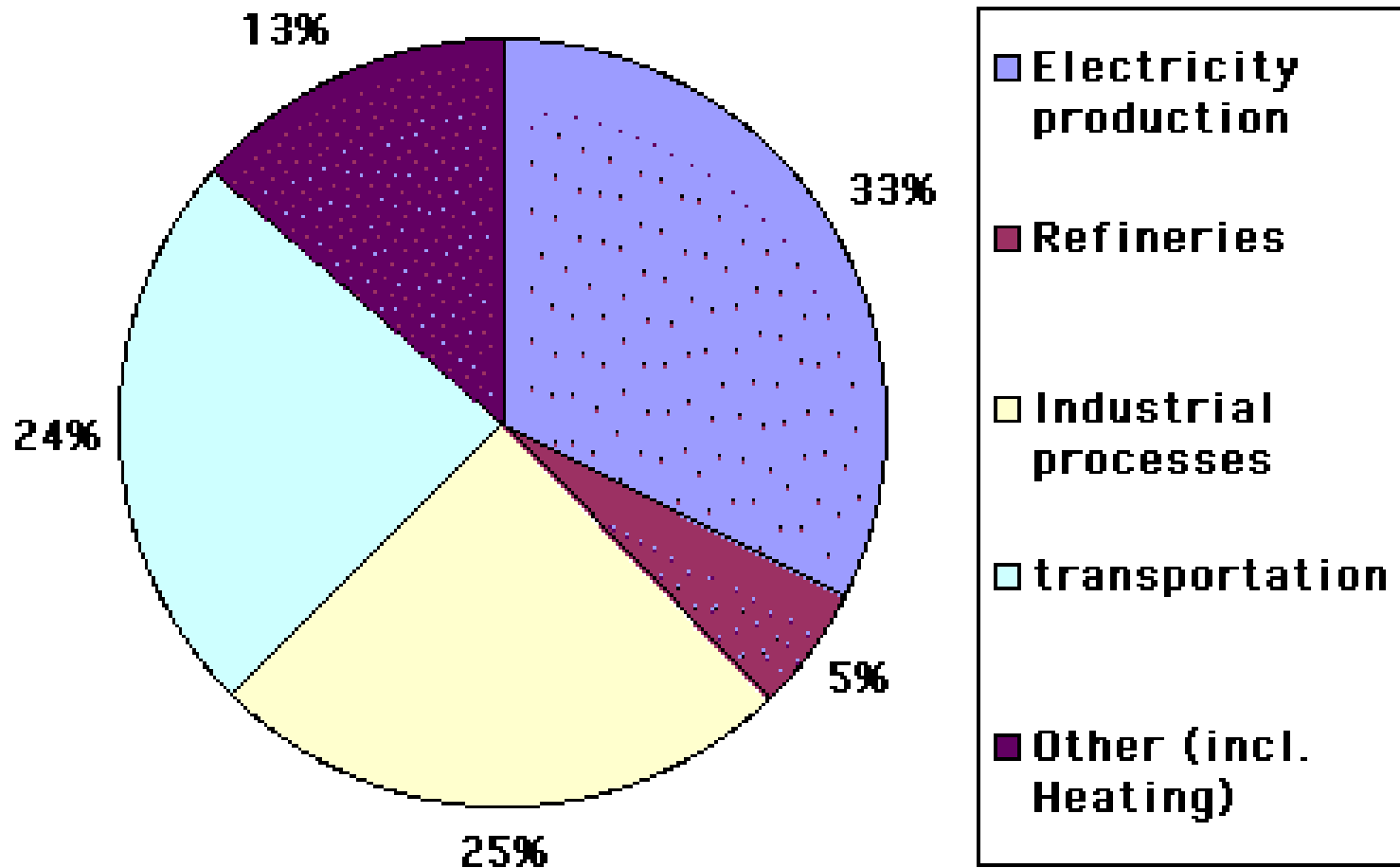


**Annual mean rainfall rate change  
(2071-2100) minus (1961-1990), mm/day**

Source: IPCC Working Group I (2001)



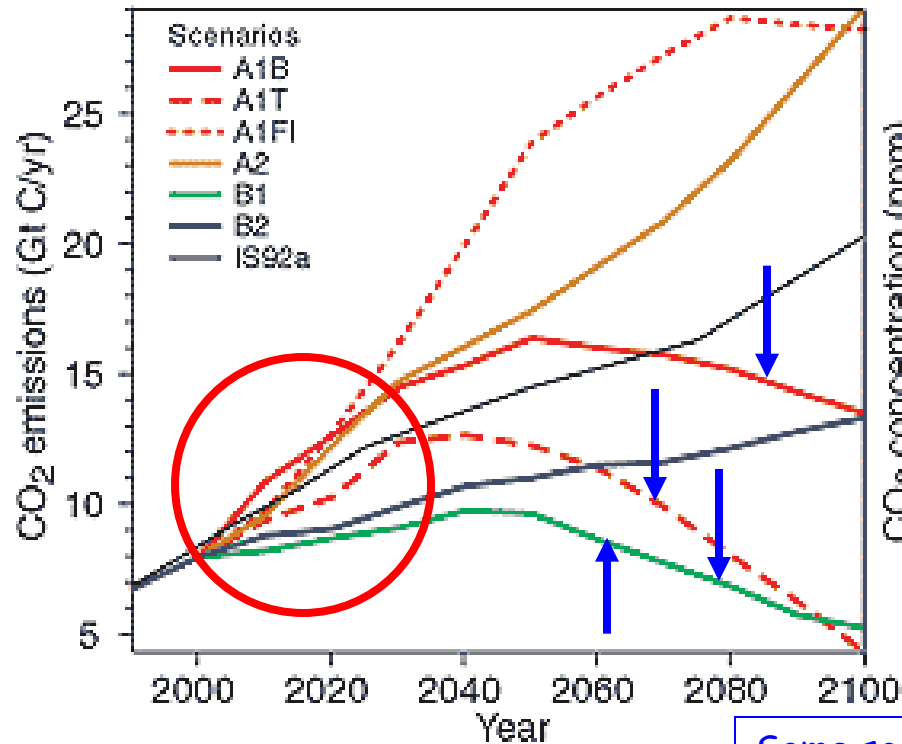
# Global CO<sub>2</sub> Emissions





# Future Emissions Scenarios

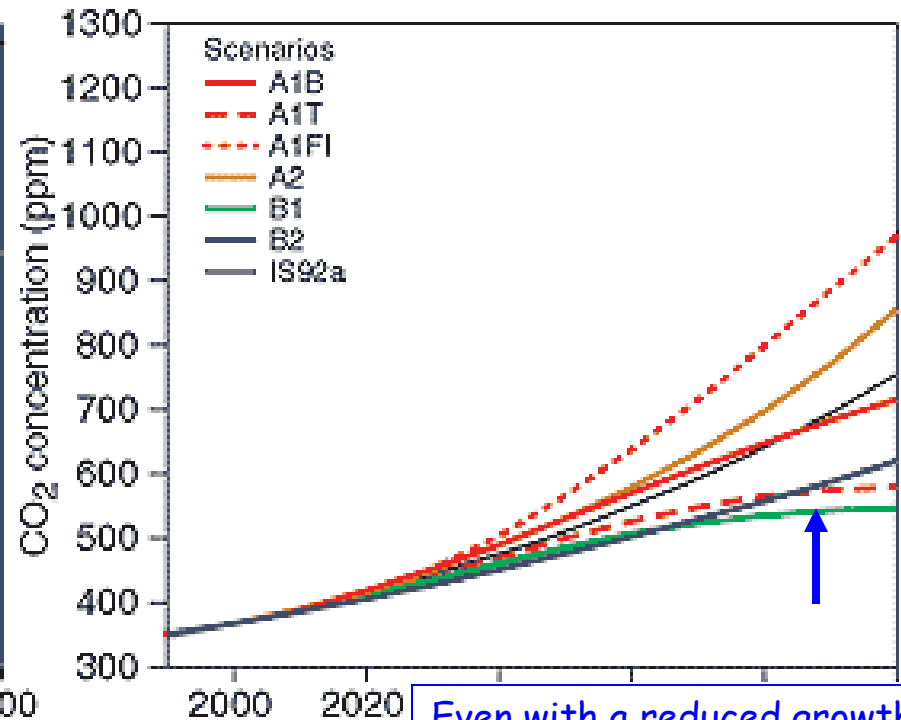
(a) CO<sub>2</sub> emissions



All scenarios show increasing emissions during next several decades

Some scenarios show decreased emissions in latter half of 21<sup>st</sup> century

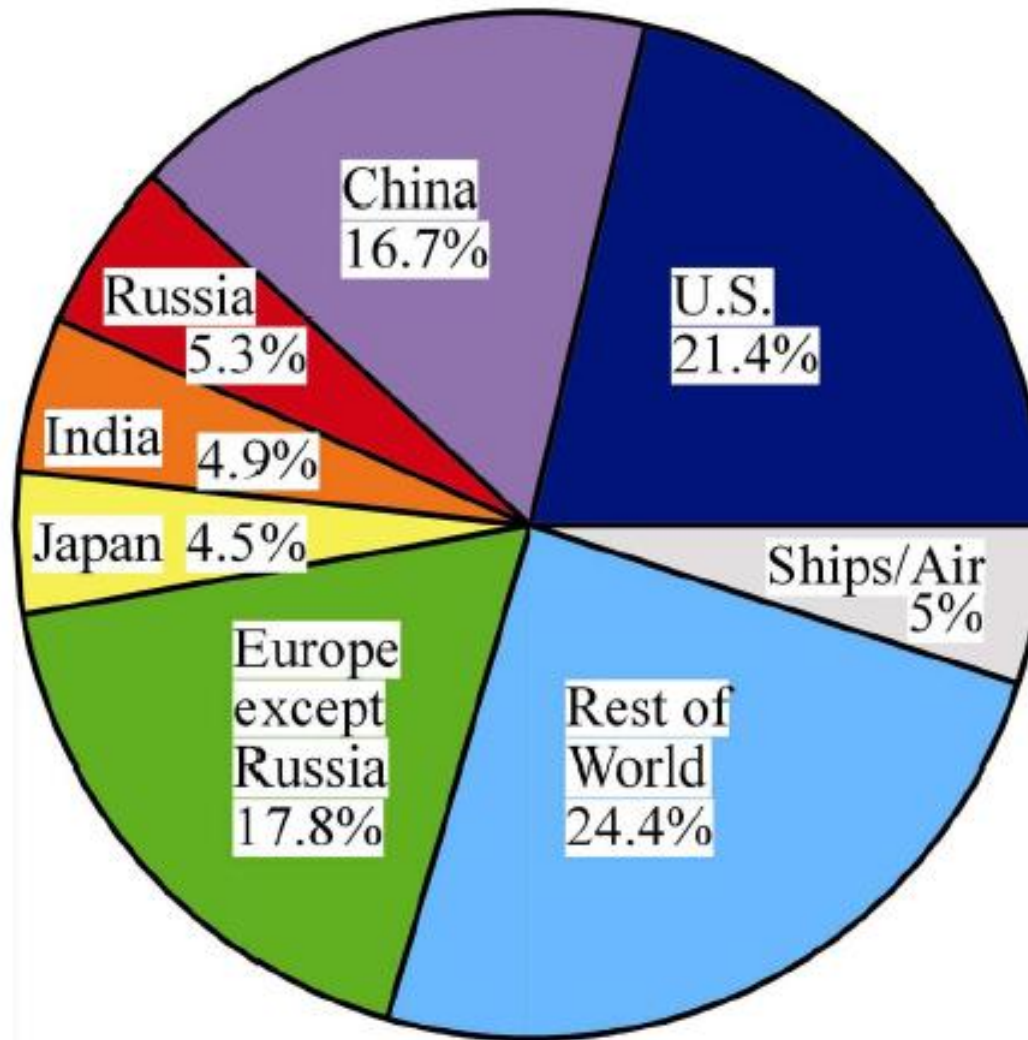
(b) CO<sub>2</sub> concentrations



Even with a reduced growth rate of emissions and their reduction later in this century, CO<sub>2</sub> would rise to 2x preindustrial levels



## 2004 Portions of CO<sub>2</sub> Emissions



Fossil Fuel CO<sub>2</sub> emissions by source country in 2004.

Source: Hansen et al, J. Geophys. Res., to be submitted



# Opinion Survey: Is There Evidence That Earth Is Warming?

Yes, solid evidence	70%
Due to human activity	41%
Due to natural patterns	21%
Don't know	8%
No, no solid evidence	20%
Don't know	10%

Source: Pew Research Center for the People and the Press, June 2006



# Global Warming Not A Top Priority

“Despite widespread agreement among survey respondents that there is solid evidence that global warming is happening, and in a broad sense that its effects can be mitigated, dealing with global warming remains a relatively low priority for the American public. Asked to rate the importance of various issues, **44% rate global warming as “very important.”** This is among the lowest of 19 issues tested, including top-ranked **education (82% very important)**, the **economy (80%)** and **health care (79%).**”

Source: Pew Research Center for the People and the Press, June 2006



# Psychological Barriers?

- Climate change is not the result of malevolence.
- Climate change does not violate our moral sensibilities.
- Climate change is perceived as a future rather than an immediate threat.
- Climate change proceeds gradually.

Source: Daniel Gilbert, Harvard University, *Los Angeles Times*, July 2006



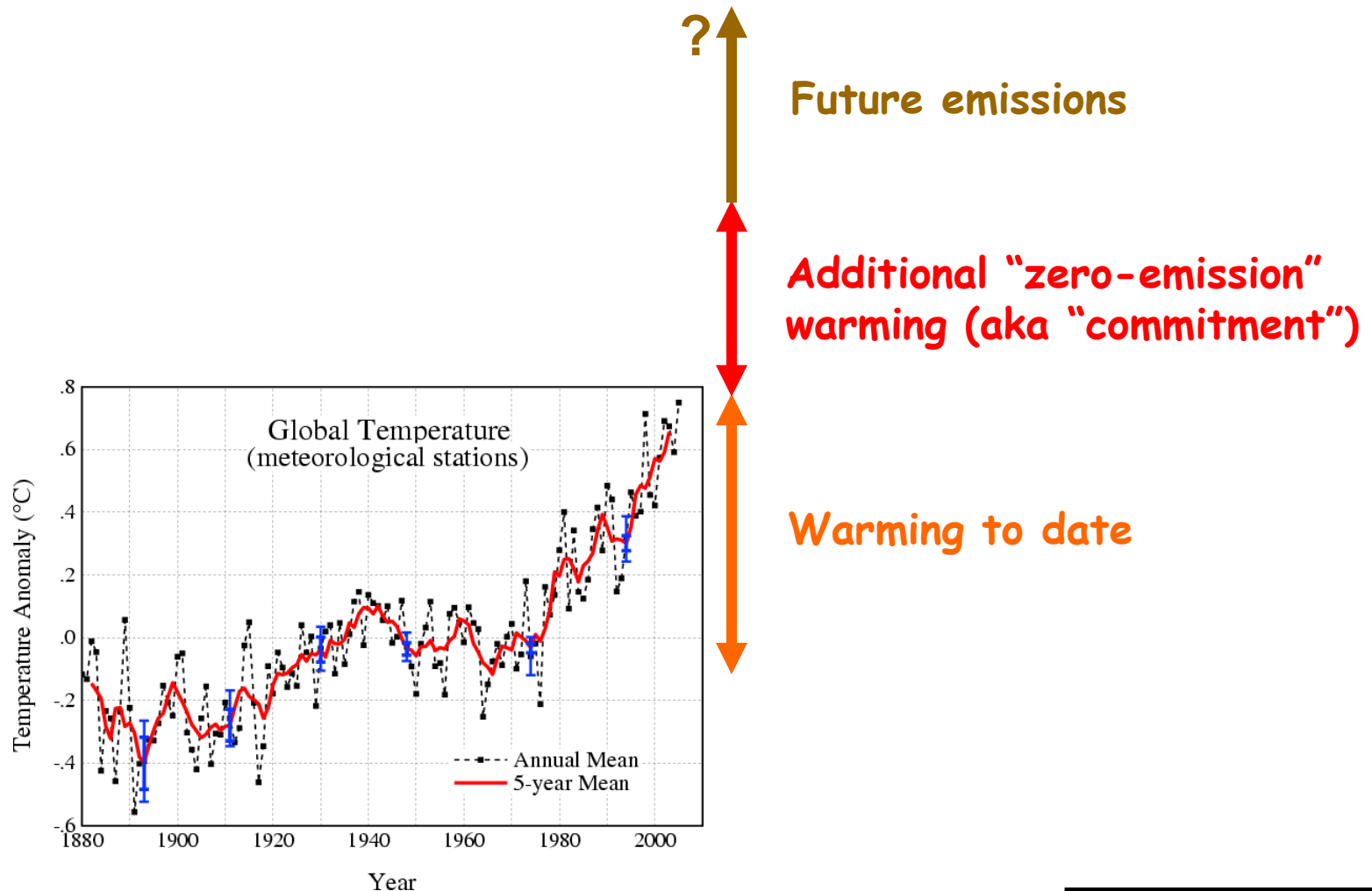
# Controversy and Politics?

- Time/ABC News/Stanford Univ. poll (March 2006) found that 64% of those surveyed think that scientists disagree about global warming.
- The same poll found interesting trends when the results were classified by political party affiliation.

Are you sure that global warming is happening?	1998	2006
Democrats	39%	46%
Independents	31%	45%
Republicans	31%	26%



# More Warming in the Pipeline





# Managing Climate Change

- **Mitigation:** Reduce emissions of carbon dioxide and other greenhouse gases.
- **Adaptation:** Increase the resilience of society to climate change.
- **Knowledge:** Develop a better understanding of the details of future climate change.
- **Leadership:** Raise public awareness of the challenges posed by climate change and the need to mitigate and adapt.



# Rutgers: “One-Stop Shopping”

- **Research:** Expertise in a broad range of disciplines relevant to understanding global climate change and its effects on the environment and society.
- **Education:** Undergraduate and graduate programs in most climate change-related disciplines; potential for strong interdisciplinary programs.
- **Outreach:** Extension service; public speakers on climate change and related issues.



# **The Global Warming Dilemma (Mahlman, 2002)**

“There are no quick policy fixes, nationally or globally. If we don't begin to chip away at the problem soon, it is very likely that serious consequences will be wired in for the world of our great-grandchildren and for their great-grandchildren....

The long time scales and robustness of the problem almost guarantees that our descendants in the 22<sup>nd</sup> century will, with historical perspective, see that we were actually confronted with a major planet-scale stewardship/ management problem.

**They will most assuredly note how we responded, or how we did not respond to the problem.”**