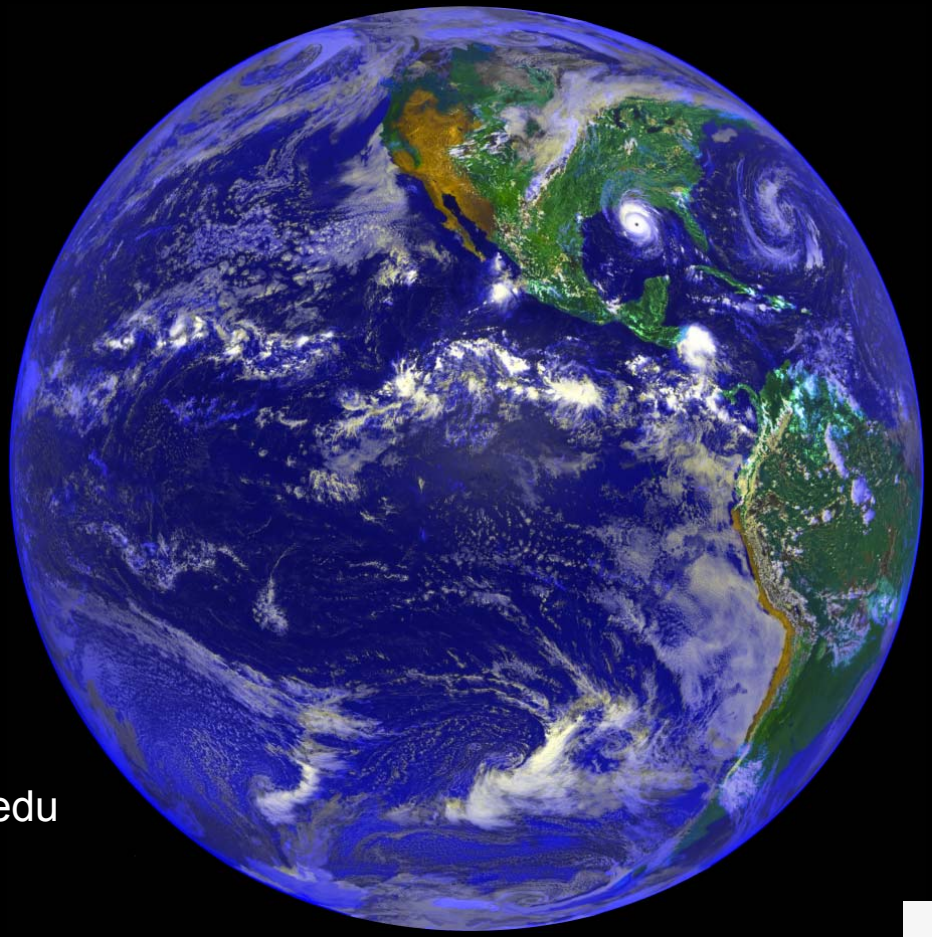
The science of global warming



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Reasons to Believe
January 25, 2007

Georgia Tech

versus

The politics of global warming

or

The economics of global warming

Which of the following are scientific statements?

1) Slowing global warming would hurt the economy.

2) Hurricane Katrina provides direct proof of global warming.

3) A warming of 1ºC over the next 50yrs should be avoided.

4) The Earth was warmer than today 100 million years ago.

5) Improved technology is the best way to mitigate global warming.

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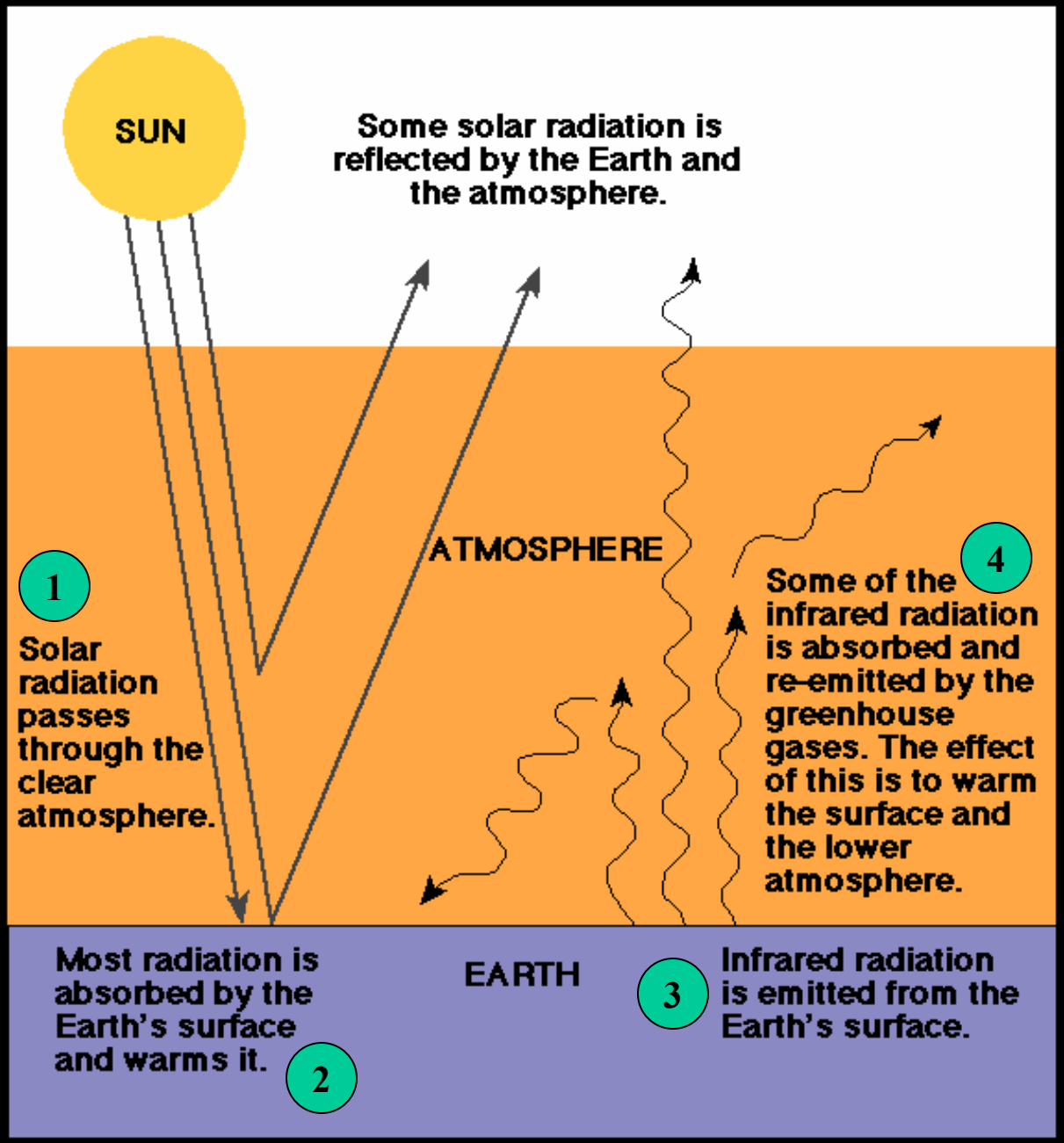
greenhouse gases in the atmosphere trap heat at the Earth's surface and prevent it from escaping.

These gases include:

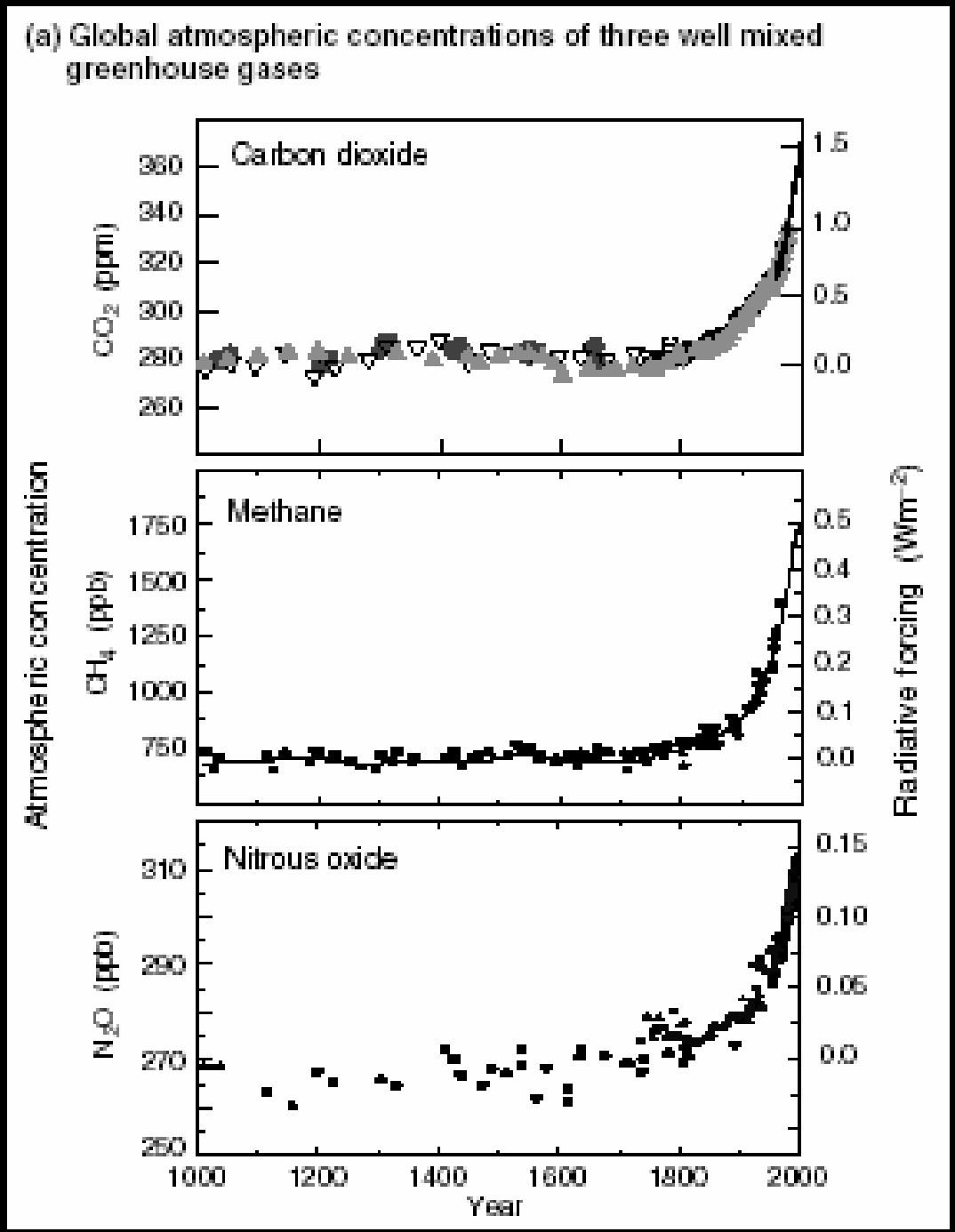
- Carbon dioxide CO_2
- Methane CH_4
- Nitrous oxide N_2O
- Chlorofluorocarbons
- *Water vapor H_2O*

  (this is the most important one, by far!)

without greenhouse gases average temp of Earth would be -18ºC instead of 15ºC



atmospheric CO2 measurements show that CO2 has been increasing since at least the mid 1950's

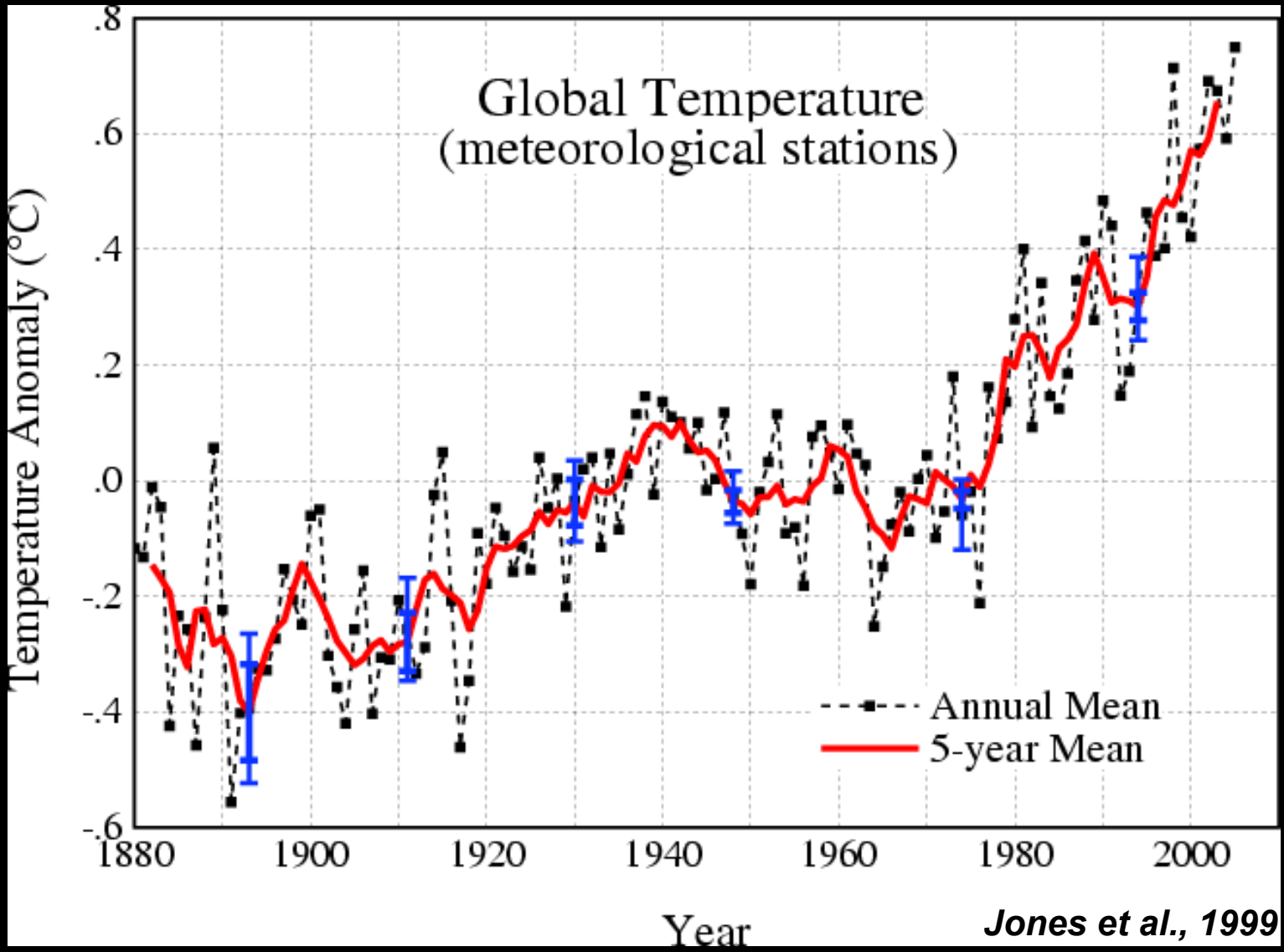


ice core CO2 records confirm that the CO2 trend began in the 1800's

-clear land for agriculture

-Industrial Revolution

IPCC, 2001



The ‘instrumental’ record of climate shows a ~1ºC warming over the last century

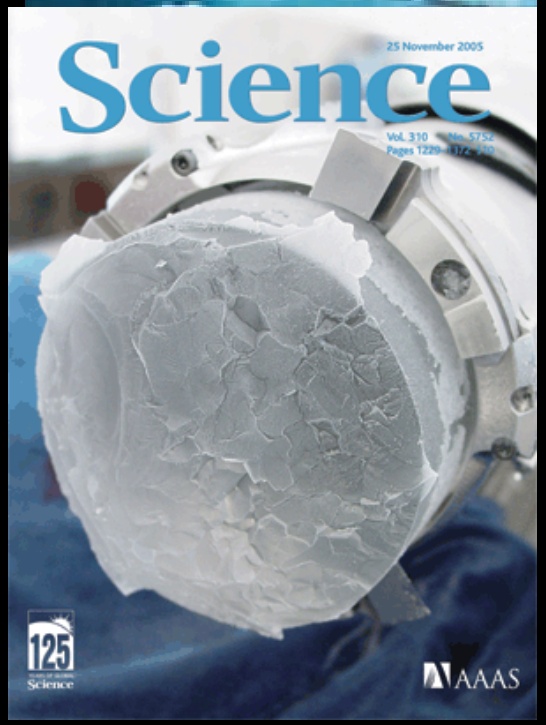
Why do 99.999% of climate scientists believe that CO_2 is warming the planet?

1. Theory predicts that increasing atmospheric CO2 should warm the planet.

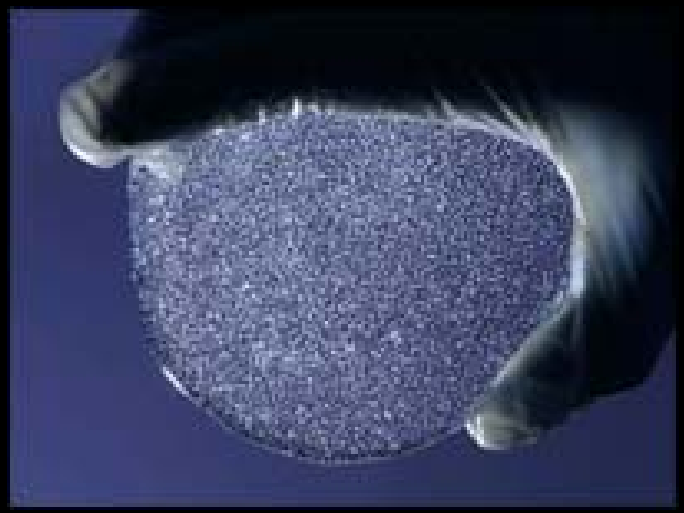
2. Geologic evidence links CO2 and temperature in the past.

3. The warming is unprecedented in the most recent centuries (dwarfs natural variability).

4. Climate models show that rising CO2 is necessary to simulate 20th century temperature trends (solar and volcanic minor players).

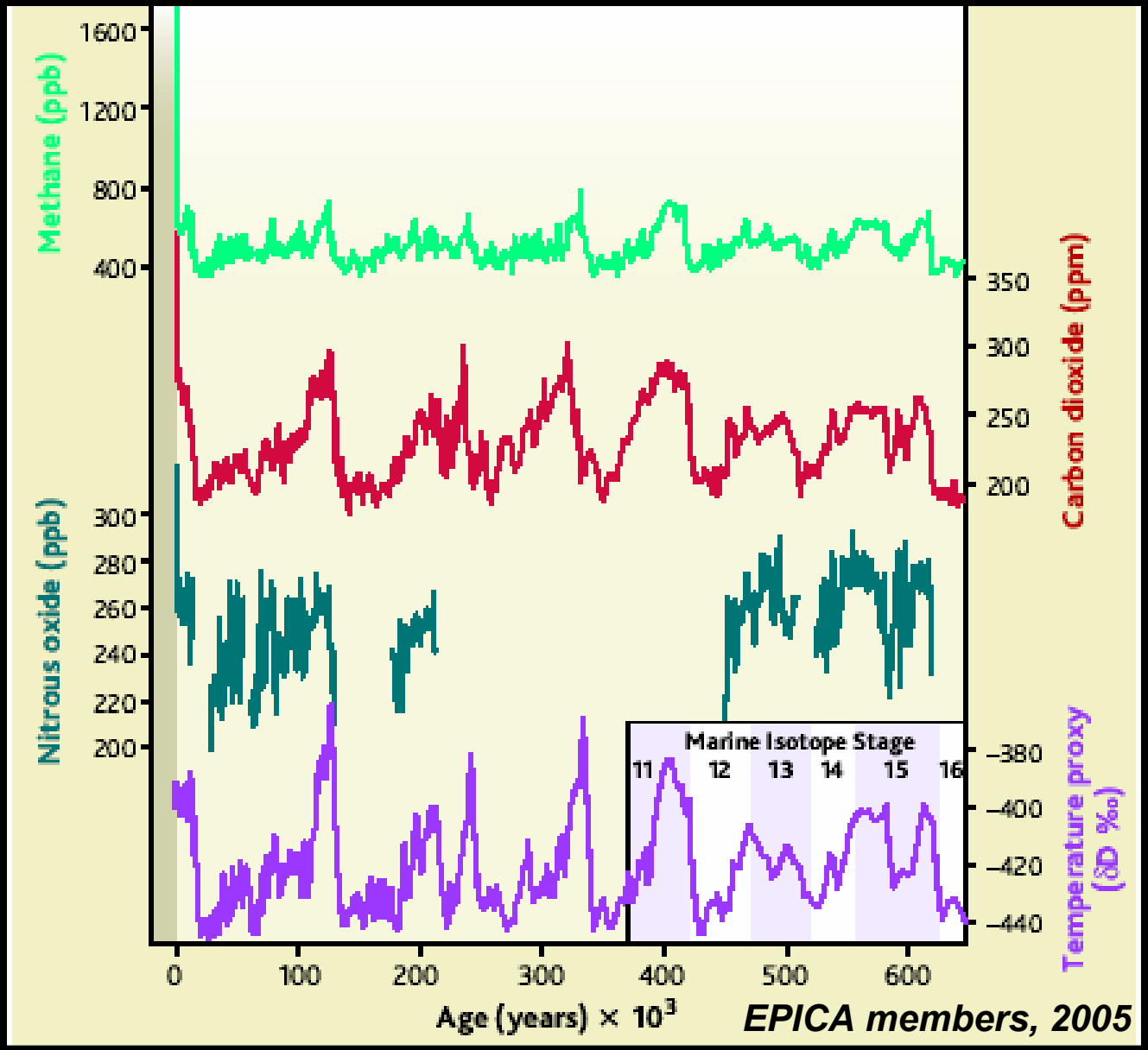


Ice core climate and CO_2 records



tiny gas bubbles
in the ice trap
ancient air samples

Atmospheric CO_2 and temperature over the past 650 thousand years

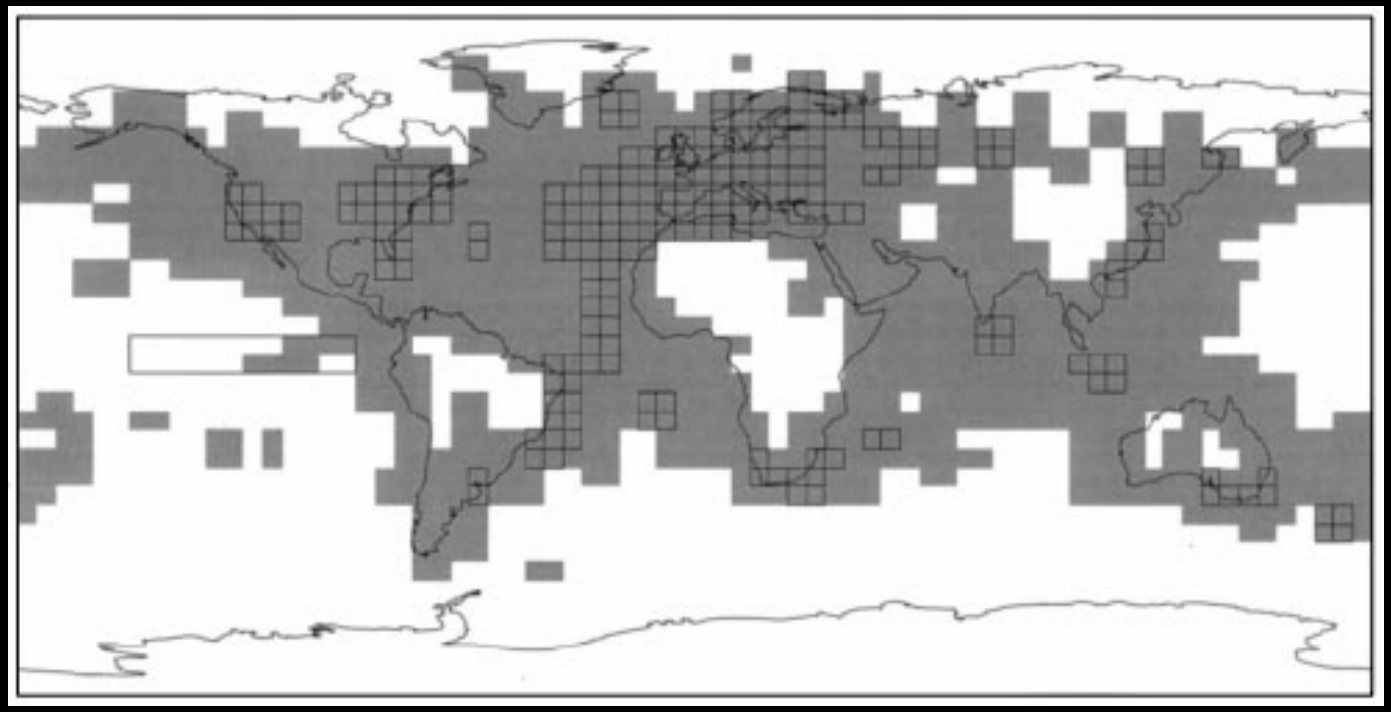


CO_2 and temperature are closely linked on geologic timescales

Quantifying recent temperature change is critical to separating natural and anthropogenic effects on climate

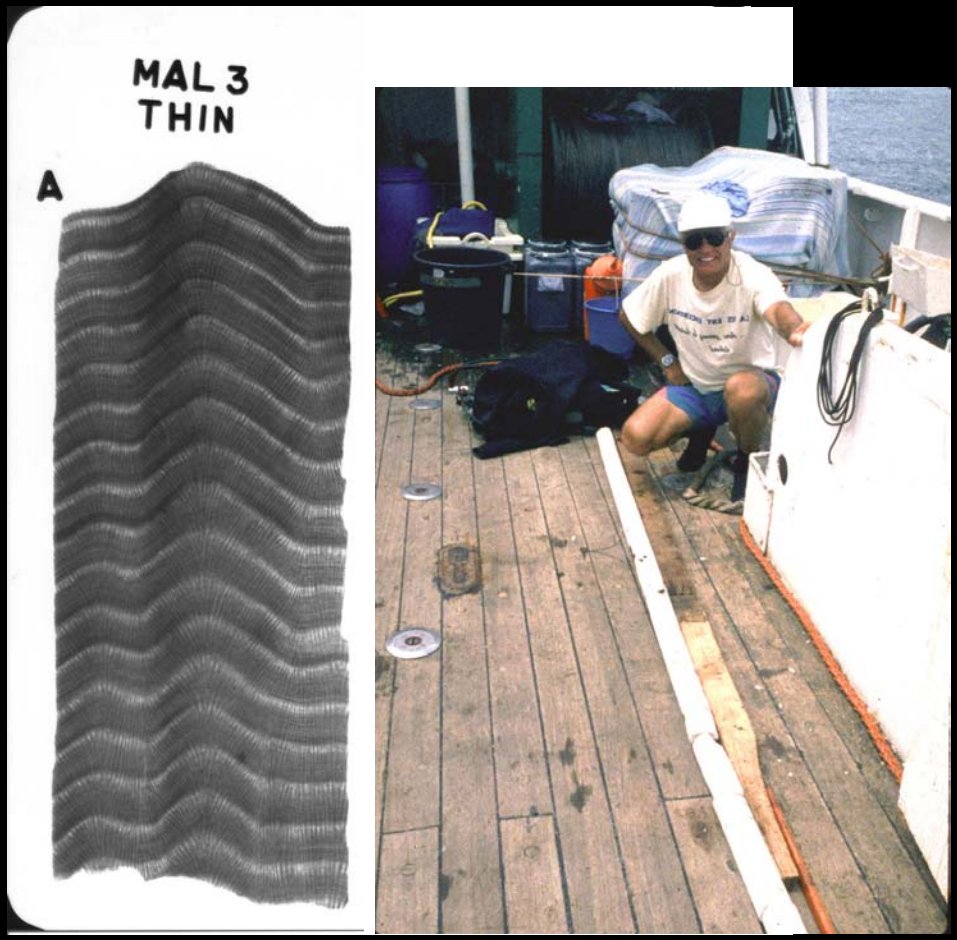
The instrumental record of climate
back to 1854 (squares)
back to 1902 (shaded area)

*so most of Pacific and southern Ocean only go back to ~1950

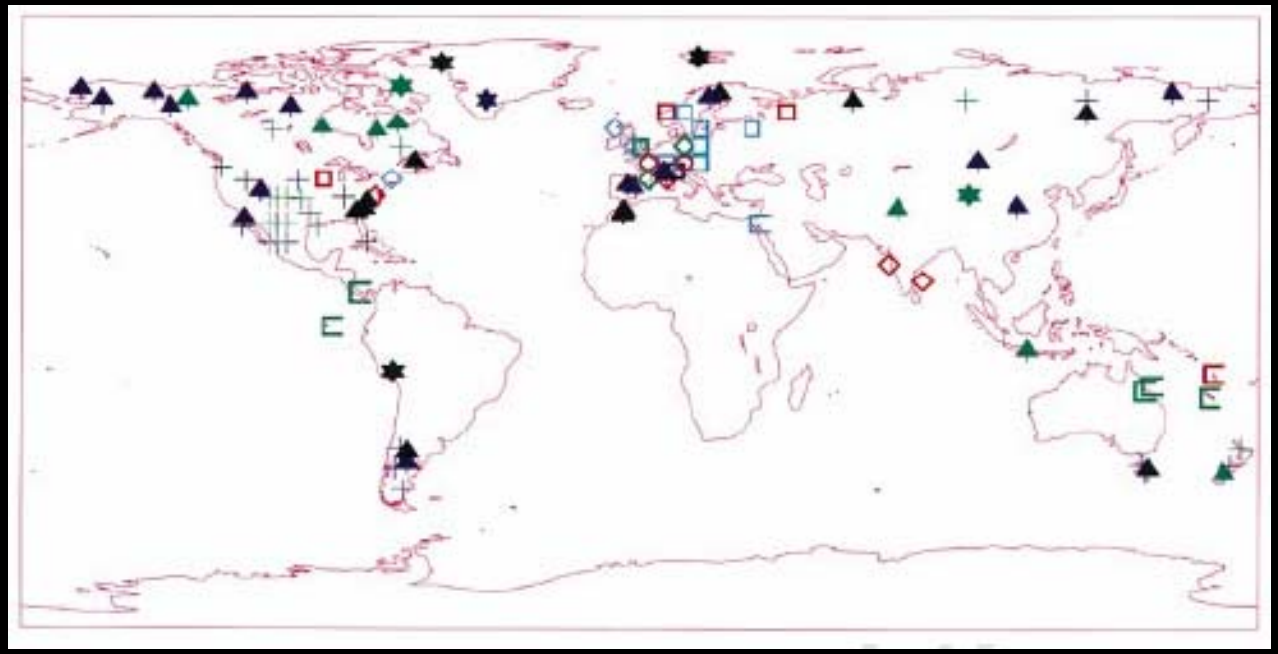


To understand how climate has changed in the past, we need to use records of climate preserved in ice cores, ancient tree rings, coral bands, and other "**paleoclimatic**" sources:

key is to CALIBRATE to temperature records



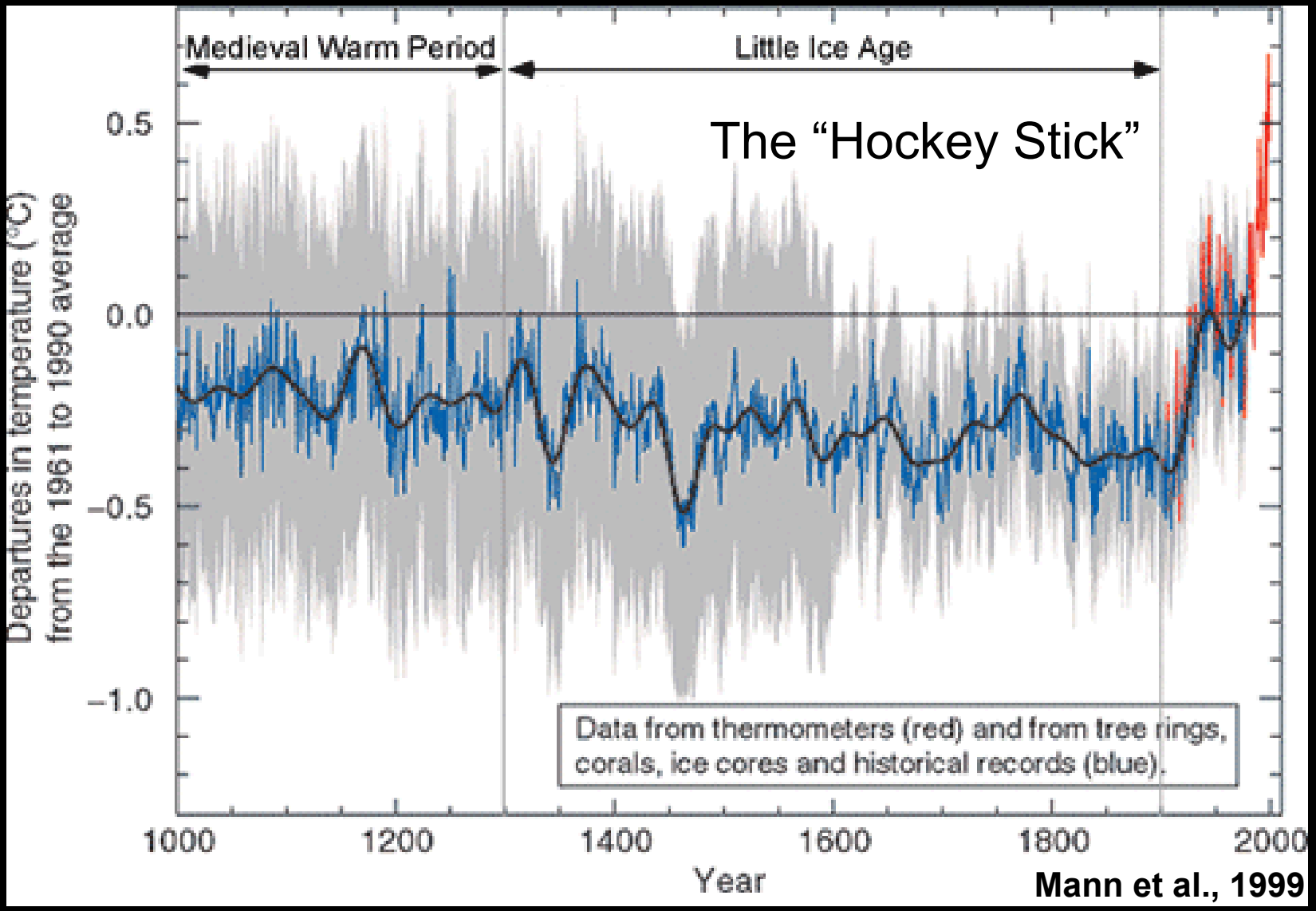
Multi-proxy temperature reconstructions



The goal: a quantitative reconstruction of temperature over a large geographic area (ex. Northern Hemisphere)

Steps:

1. calibrate each paleoclimate record to instrumental temperature
2. combine paleoclimate records back in time
3. keep careful track of error bars (depends on # of records and their ability to capture temperature changes)



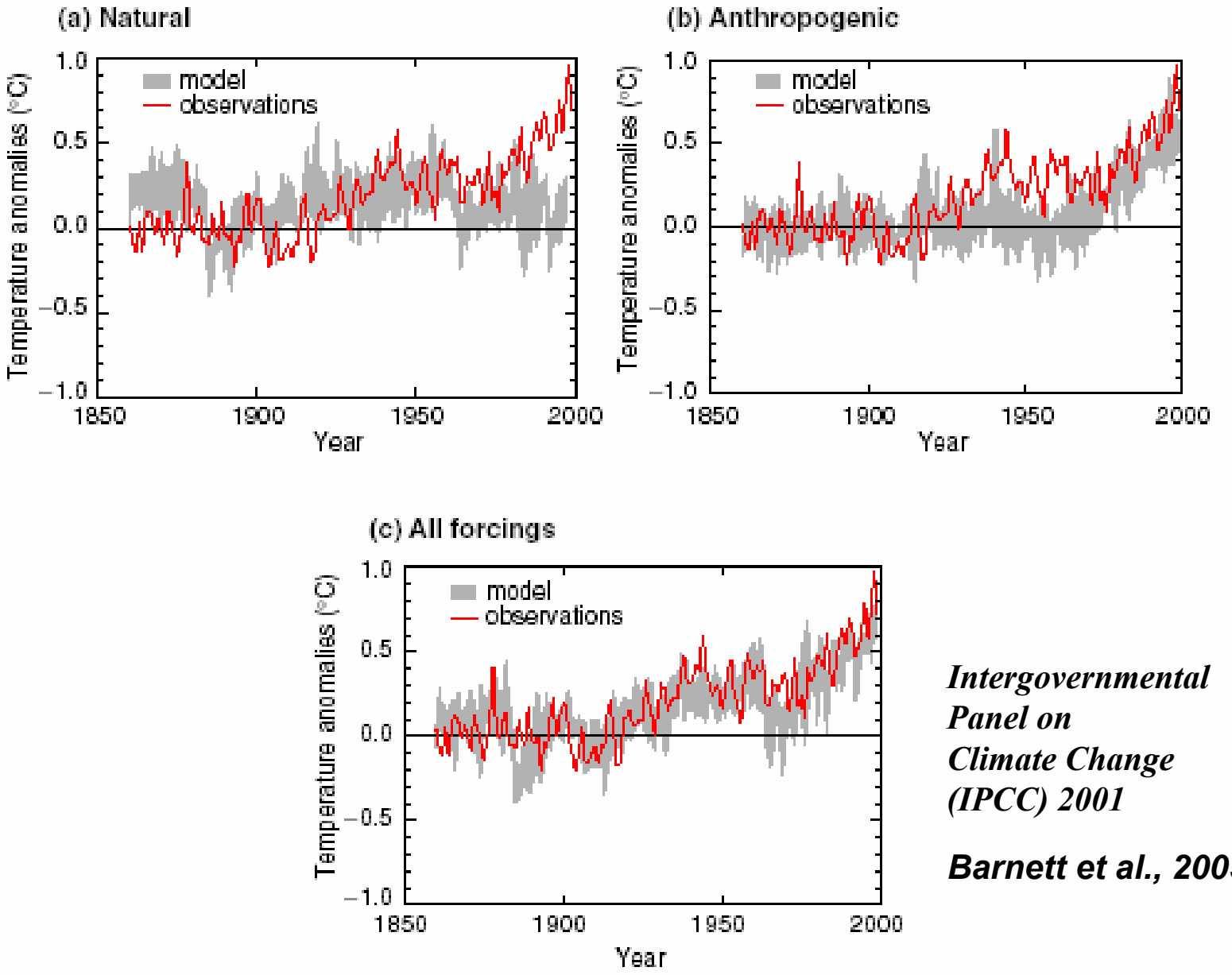
Key Points:

error bars increase as you go back in time

natural variability accounts for <0.5ºC over the last millennium

late 20th century temperature trend is unprecedented

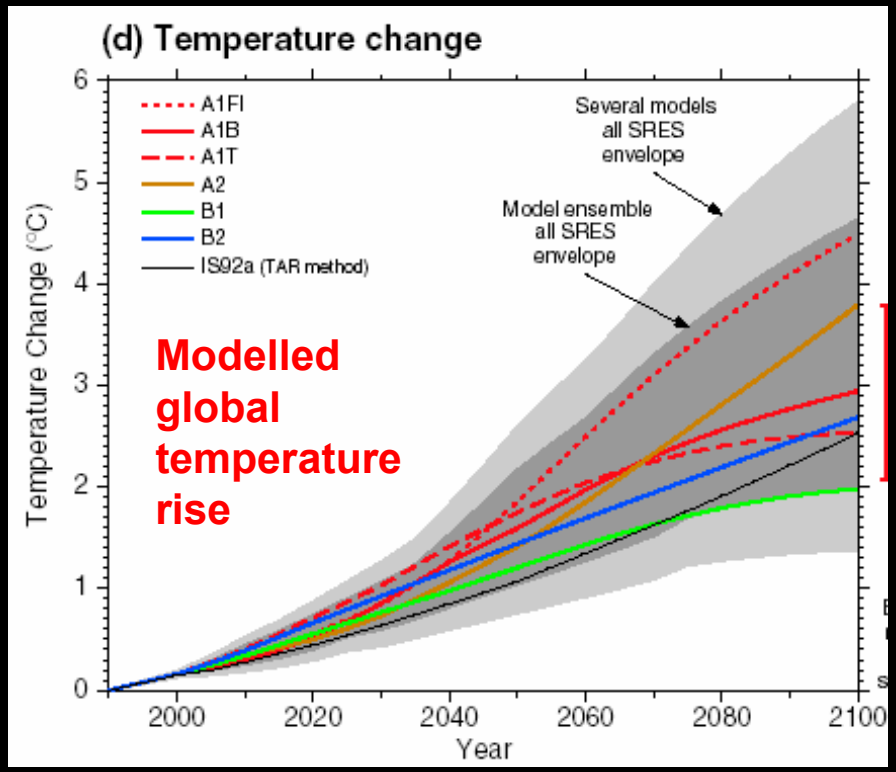
Simulated annual global mean surface temperatures

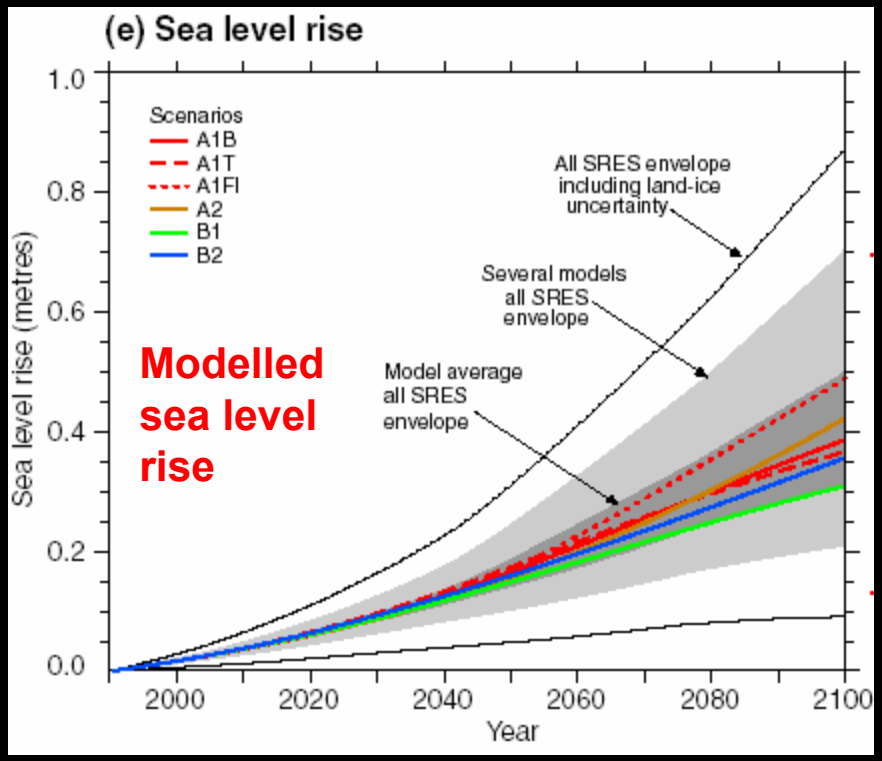


Intergovernmental Panel on Climate Change (IPCC) 2001

Barnett et al., 2005

The uncertain climate future

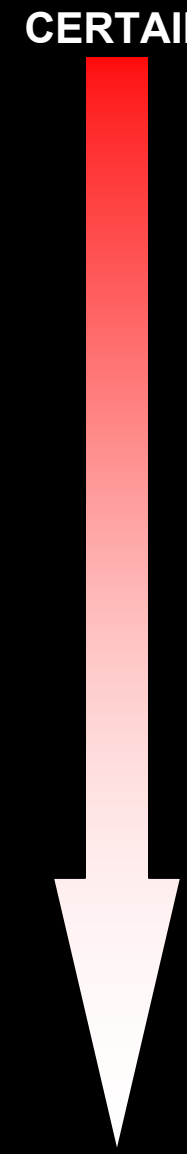




IPCC 2001

<u>The scientific challenge</u>:
no longer ‘if’
but ‘how much?’, ‘when?’, ‘where?’

A spectrum of uncertainty



Anthropogenic emissions are warming the planet. ***(1-6ºC warming by 2100)***

Sea level will rise. ***(+6 to 30 inches by 2100)***

Precipitation patterns will change. ***(need better paleoclimate data)***

Extreme events will increase. ***(short datasets; need better paleoclimate data, models)***

Prospect of 'abrupt climate change'. ***(need better paleoclimate data, models)***

Example: Hurricane Katrina (8/29/05)

Did global warming cause Katrina?

What is CLIMATE? What is WEATHER?

How can we predict temperatures 50 years from now if we can't predict temperatures 5 days from now?

CLIMATE: average of variables over 10-50years

ex: glacial-interglacial climate change
global warming
the 1930's "Dust Bowl"

WEATHER: the day-to-day or month-to-month variability about the climate state

ex: record rains in Seattle in winter 2006
European heat wave of 2003
Hurricane Katrina

Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment

P. J. Webster,[1] G. J. Holland,[2] J. A. Curry,[1] H.-R. Chang[1]

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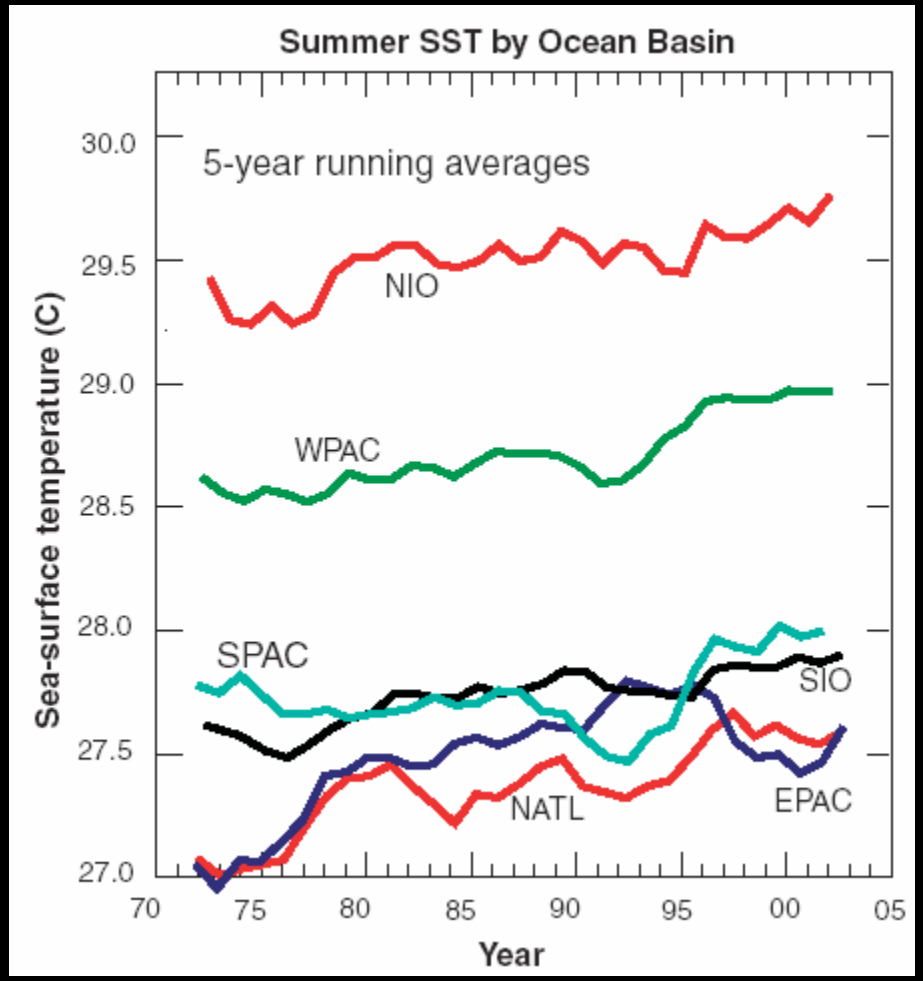

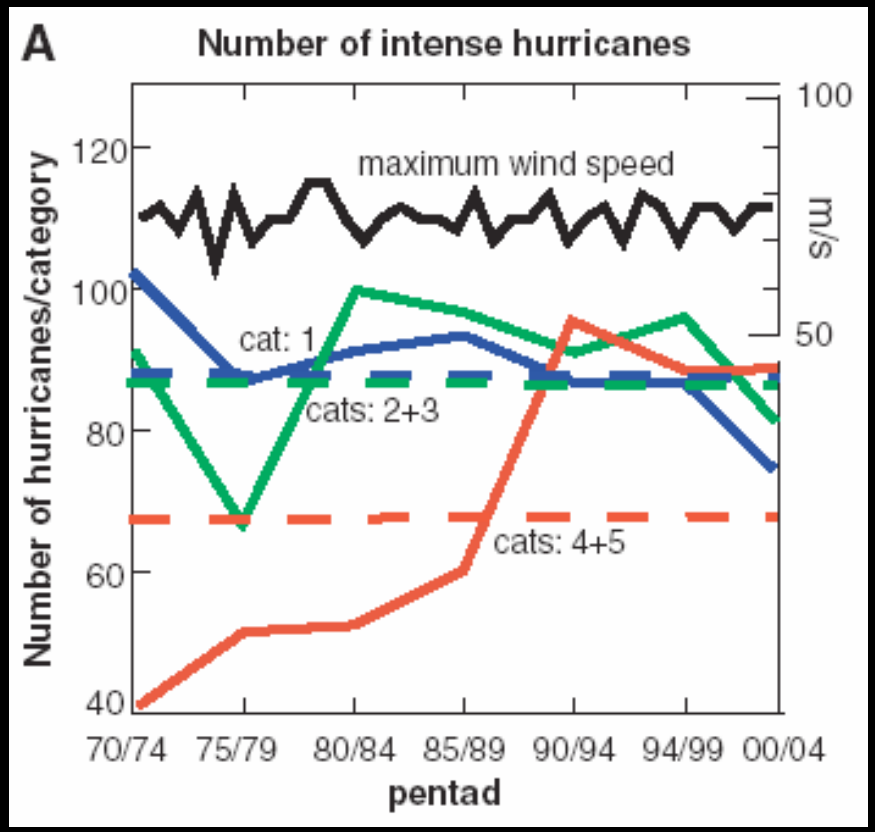

Scientific Summary

Strong evidence supports the idea that anthropogenic CO_2 is warming the planet.

Future climate changes in a warming environment are uncertain

- **sea level rise certain (how much by when?)**
- **changes in distribution of precipitation very likely (where? how much?)**
- **evidence for increasing storm activity (caused by global warming?)**
- **abrupt climate change has precedent, but our understanding is poor**

A Climate Scientist's Plea

Evaluate the scientific facts for yourselves, from a scientific source.

Distinguish between science of global warming and the politics/economics of global warming.

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