Introduction to the science of global warming

2008 MGWA Spring Conference

Earth at night - are we really doing damage?
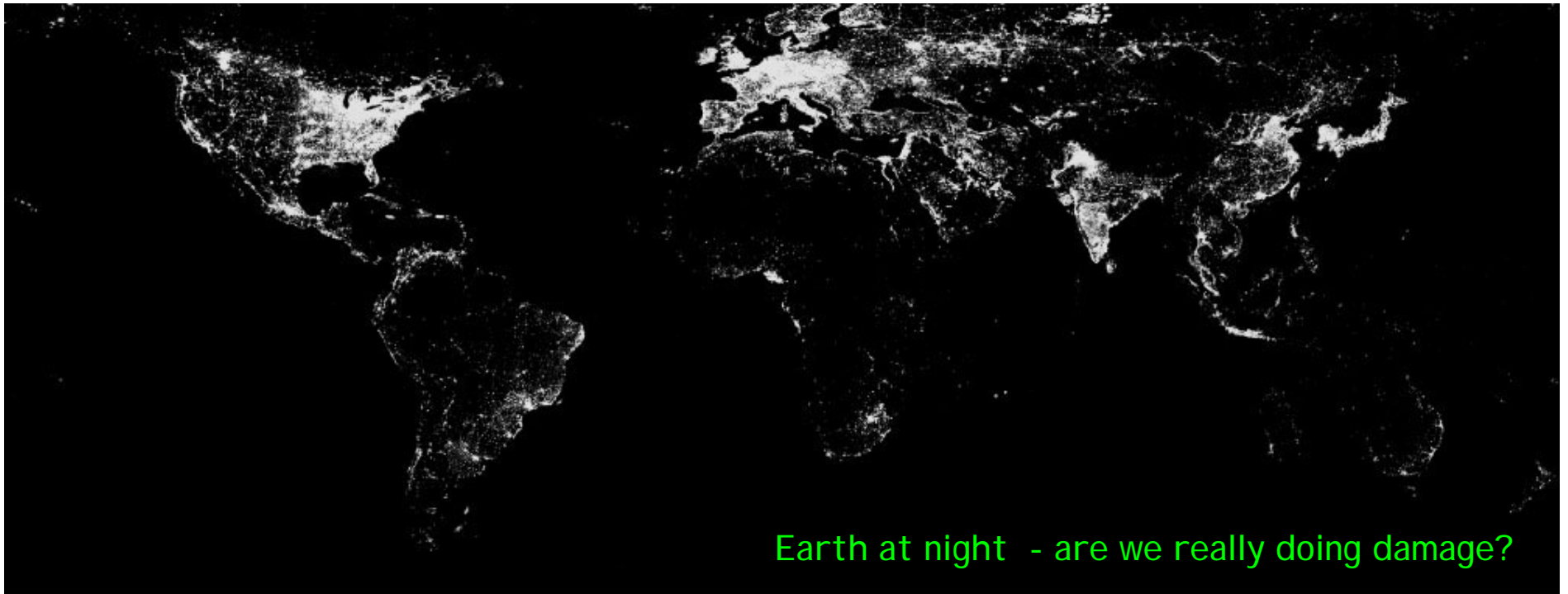
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Outline

- Detection of global warming

- Attribution of global warming

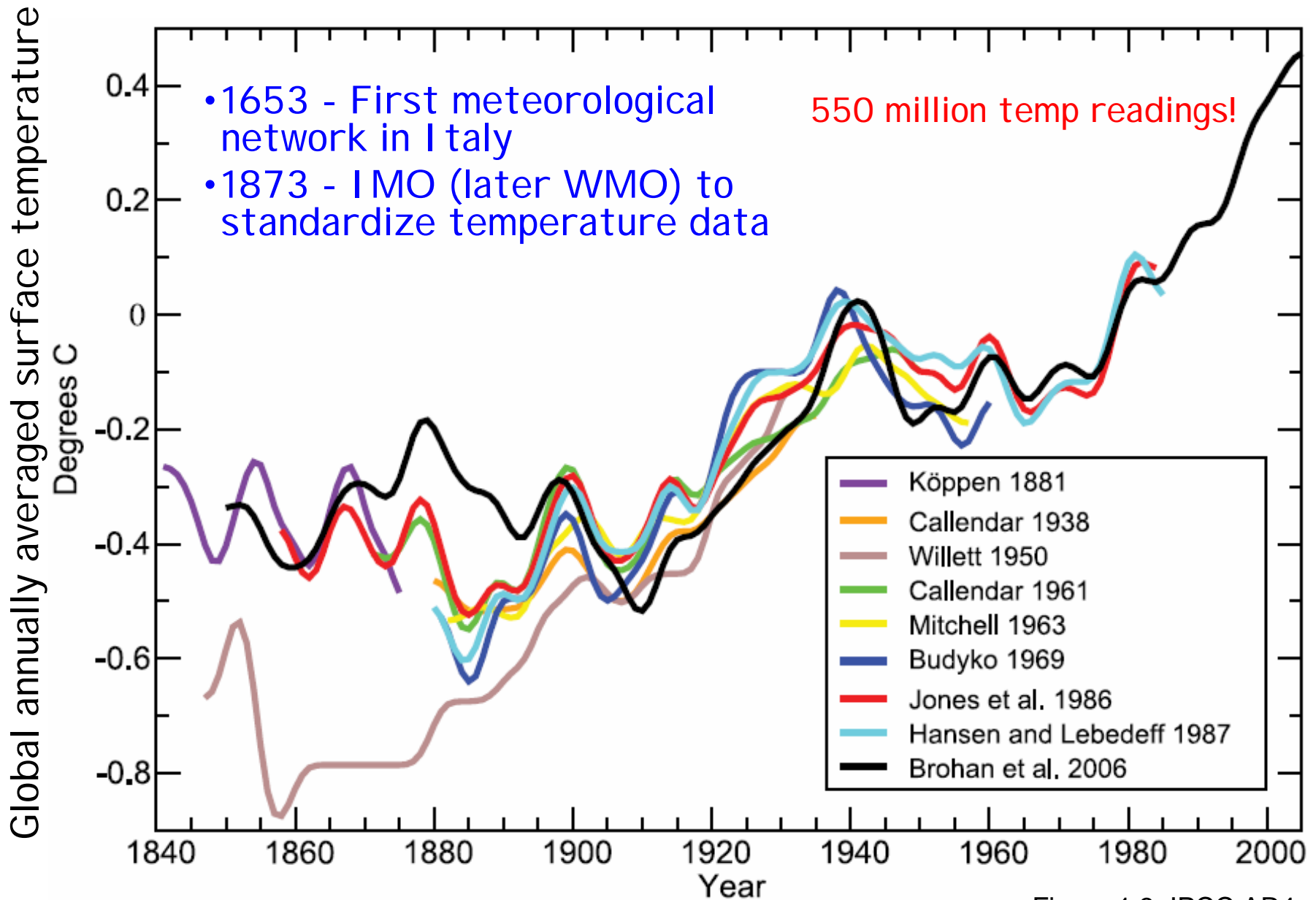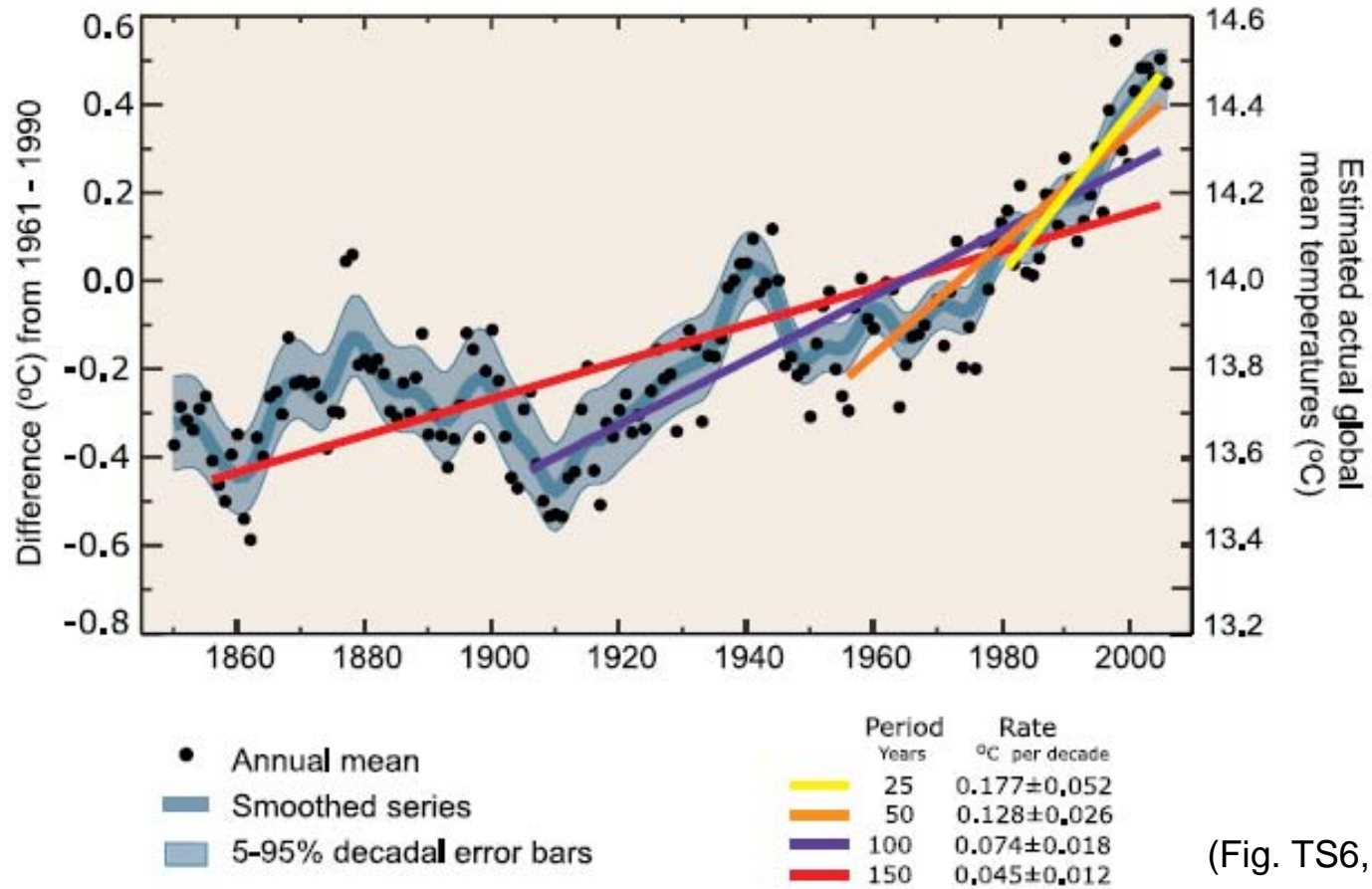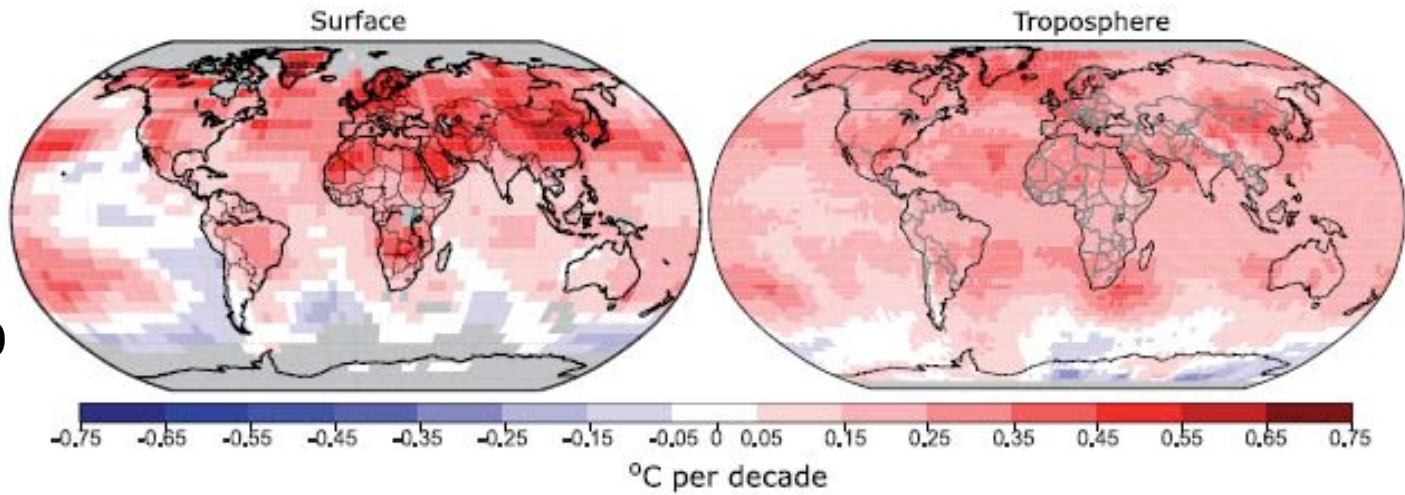- Skeptics of climate change

Instrumental records

Figure 1.3, IPCC AR4

2005 - 1979

Surface | Troposphere

°C per decade
-0.75 -0.65 -0.55 -0.45 -0.35 -0.25 -0.15 -0.05 0 0.05 0.15 0.25 0.35 0.45 0.55 0.65 0.75

Period Years	Rate °C per decade
25	0.177±0.052
50	0.128±0.026
100	0.074±0.018
150	0.045±0.012

● Annual mean
▬ Smoothed series
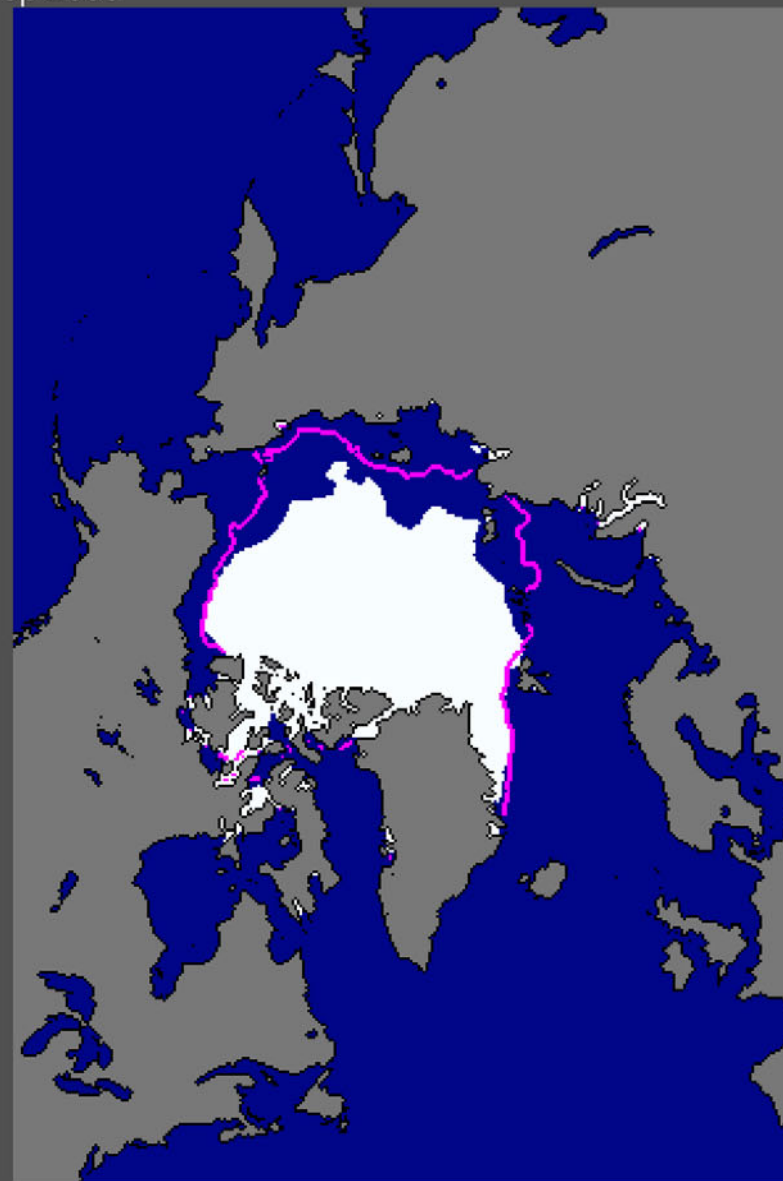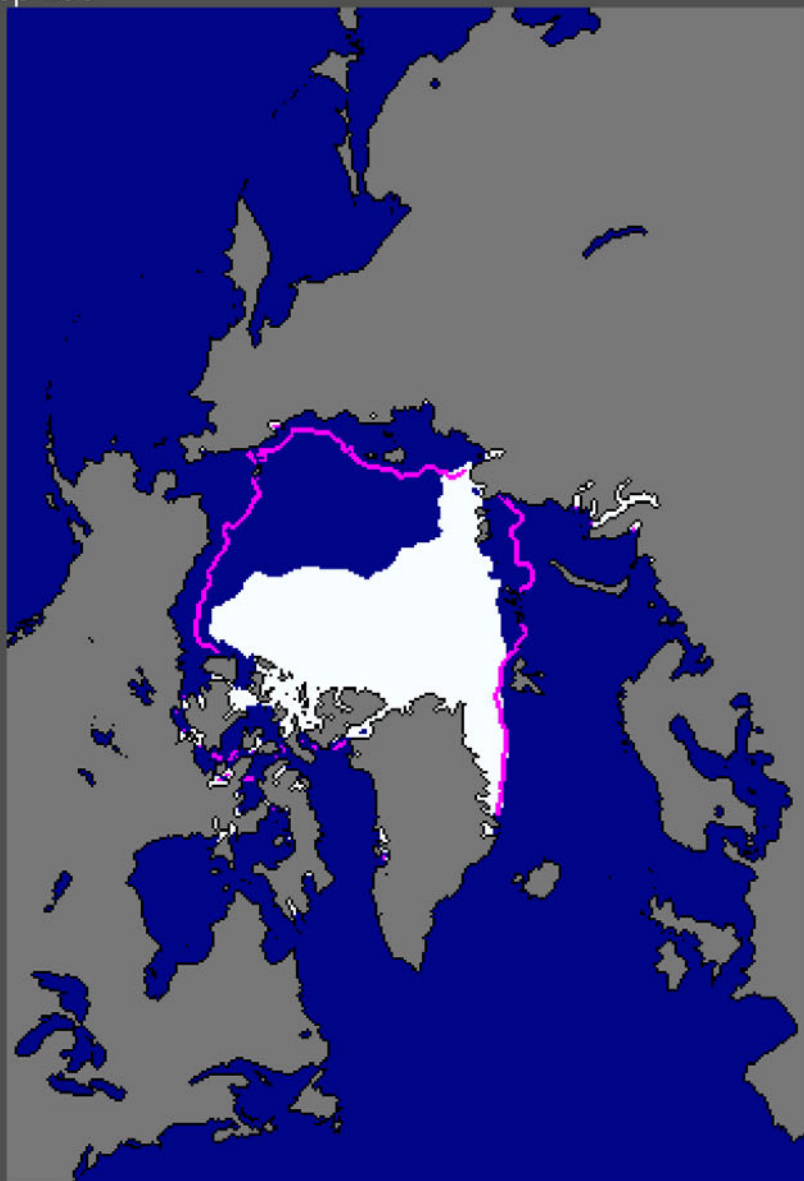▬ 5-95% decadal error bars

(Fig. TS6, IPCC AR4)

Arctic sea ice

Sea Ice Extent
Sep 2007

Sea Ice Extent
Sep 2005

NSIDC

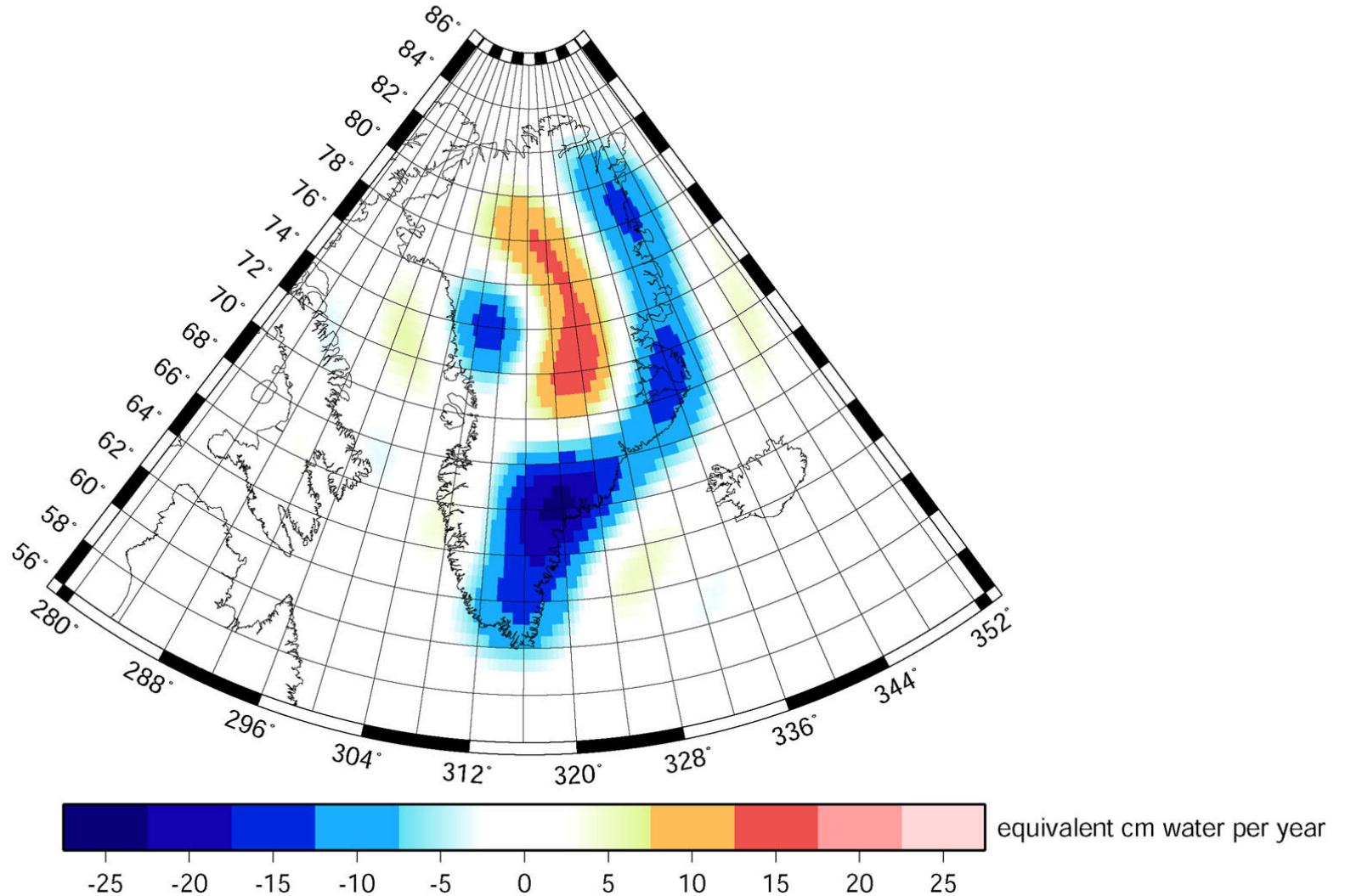National Snow and Ice Data Center, Boulder, CO

median
ice edge

Total extent = 4.3 million sq km

Total extent = 5.6 million sq km
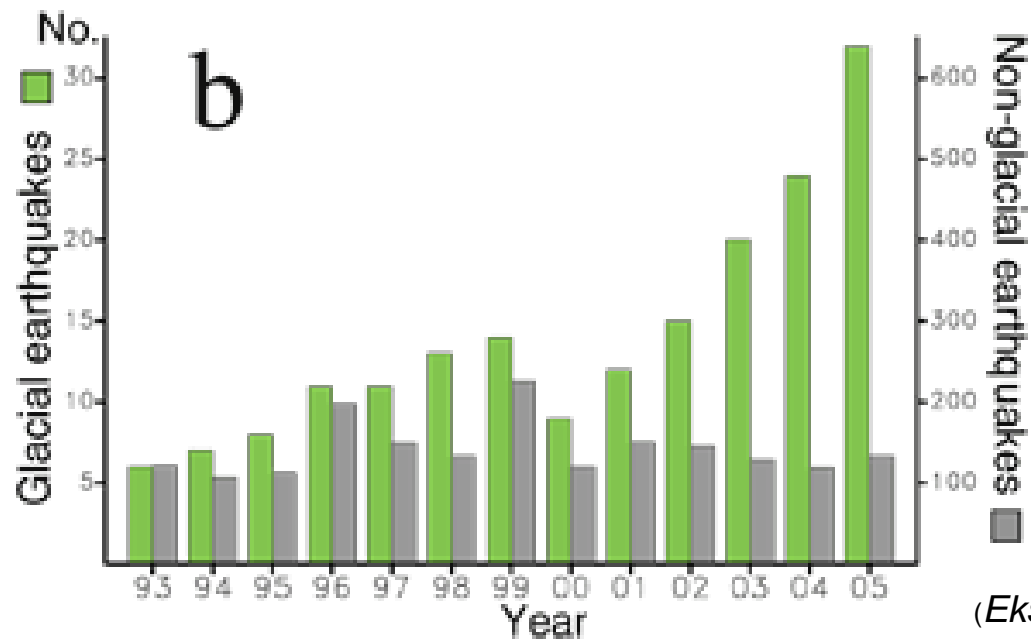
Satellite altimetry

Greenland Mass Trend from GRACE

(NASA)

Greenland is melting…

Hansen (2004)

Glacial earthquakes
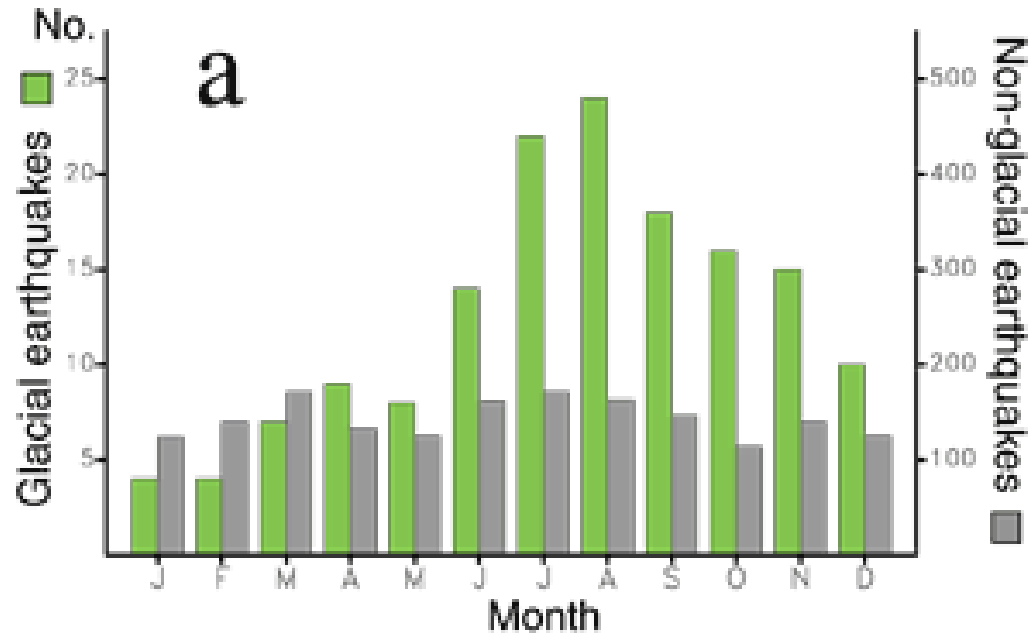
(*Ekström, Tsai, Nettles, 2006*)

Global ocean heat content
"The smoking gun" of GW

- About 90% of extra heat from GW in the ocean...but small temp change
- Reason for delay in climate response

(Fig. 5.1, IPCC AR4)

Recent Sea Level Rise

23 Annual Tide Gauge Records

— Three Year Average
— Satellite Altimetry

~1 mm/yr globally

Sea Level Change (cm)

Wikipedia – data from Douglas (1997)
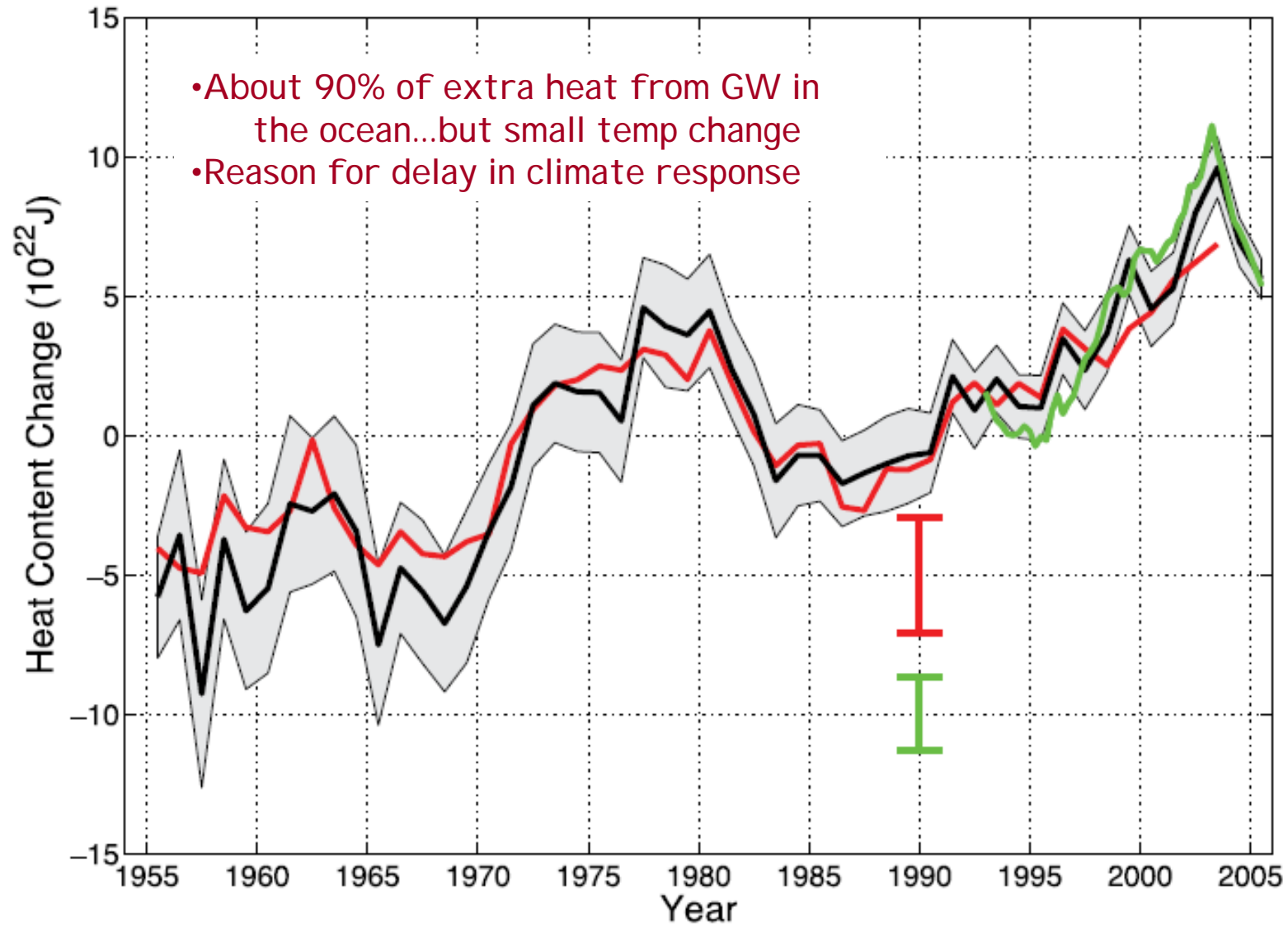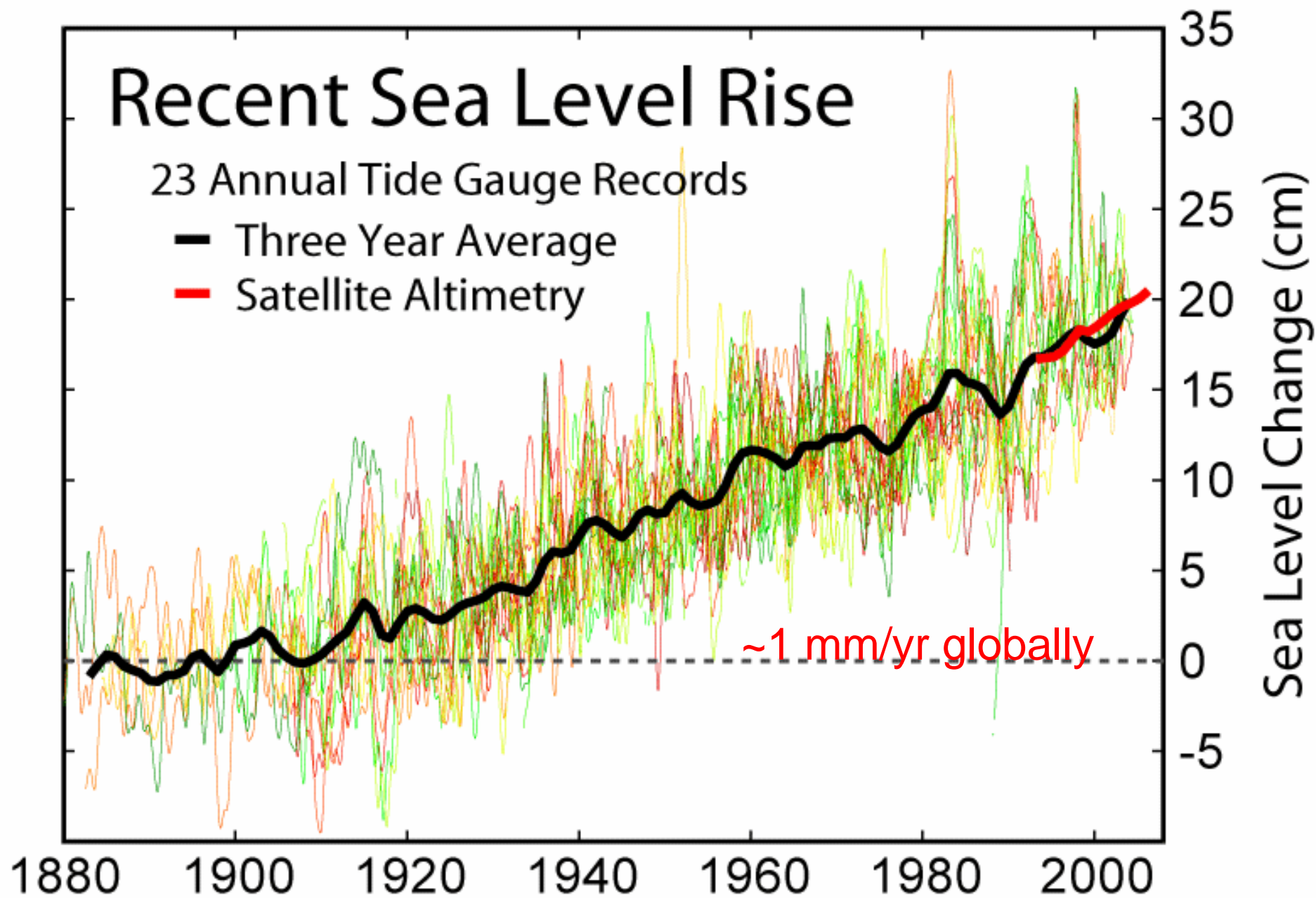
Relocation of Carteret islanders underway

If convinced of global warming, can we then advocate controlling CO_2 emissions?

CO$_2$ in the last millennium

Atmosphere: Mauna Loa
Ice core: Siple Dome
Ice core: H15
Ice core: D47 & D57
Ice core: Law Dome

Mauna Loa Observatory, Hawaii
monthly averaged concentration

Sarmiento and Gruber (2002)

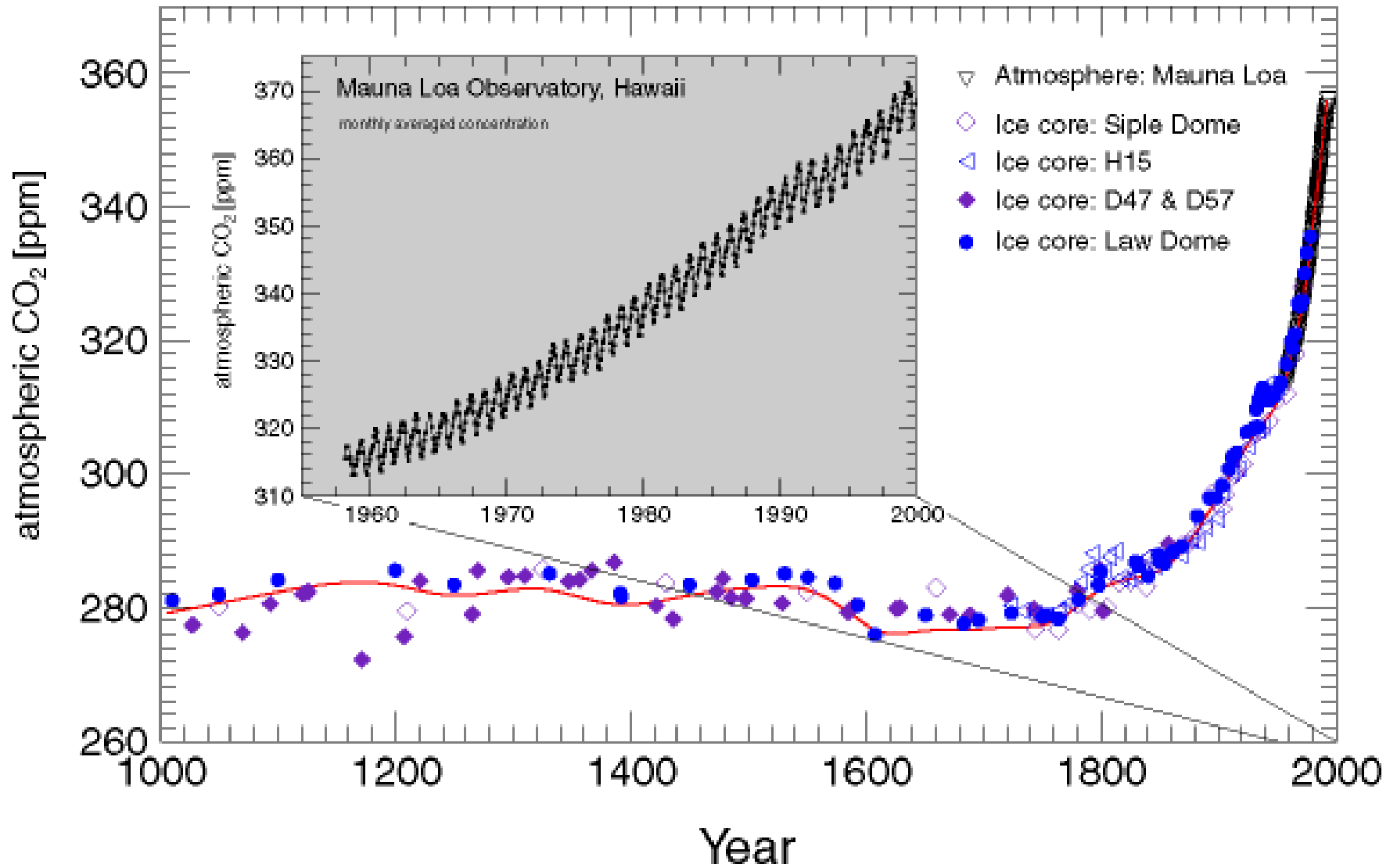# Greenhouse gases and theory of global warming (not new)

- 1681 : greenhouse effect of glass (Mariotte)

- 1827 : greenhouse effect of atmosphere (Fourier)

- 1861 : laboratory confirmation of the greenhouse properties of CO_2 and H_2O (Tyndall)

- 1895 : prediction of CO_2-induced warming (Arrhenius)

Radiative forcing of climate between 1750 and 2005
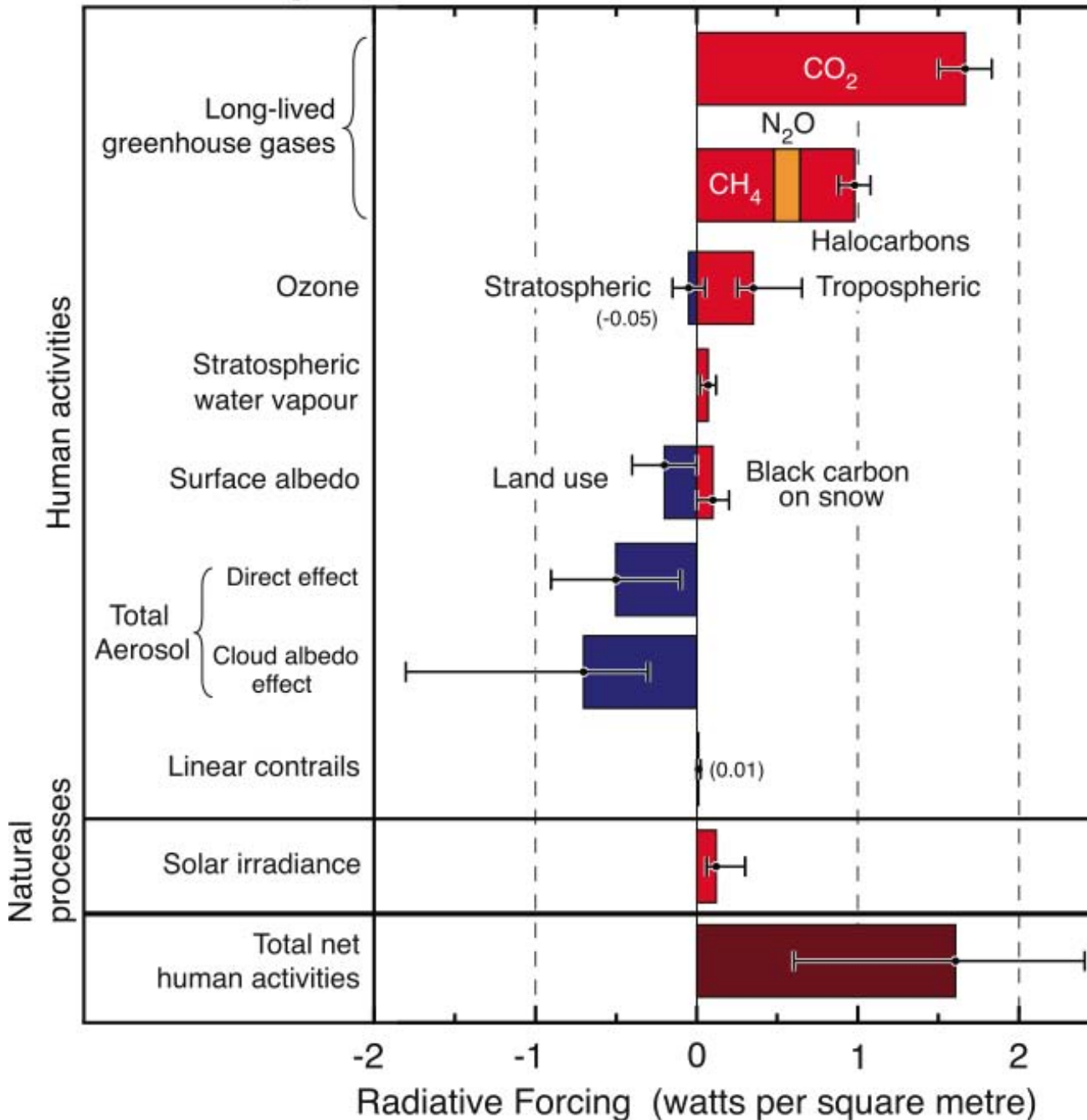
CO$_2$ is not the only one

Some aerosols have negative impact

Water vapor feedback

IPCC AR4
FAQ 2.1, Figure 2

Sum of all forcings: Two X-mas light bulbs per m^2

2 W/m2

Attribution of global warming
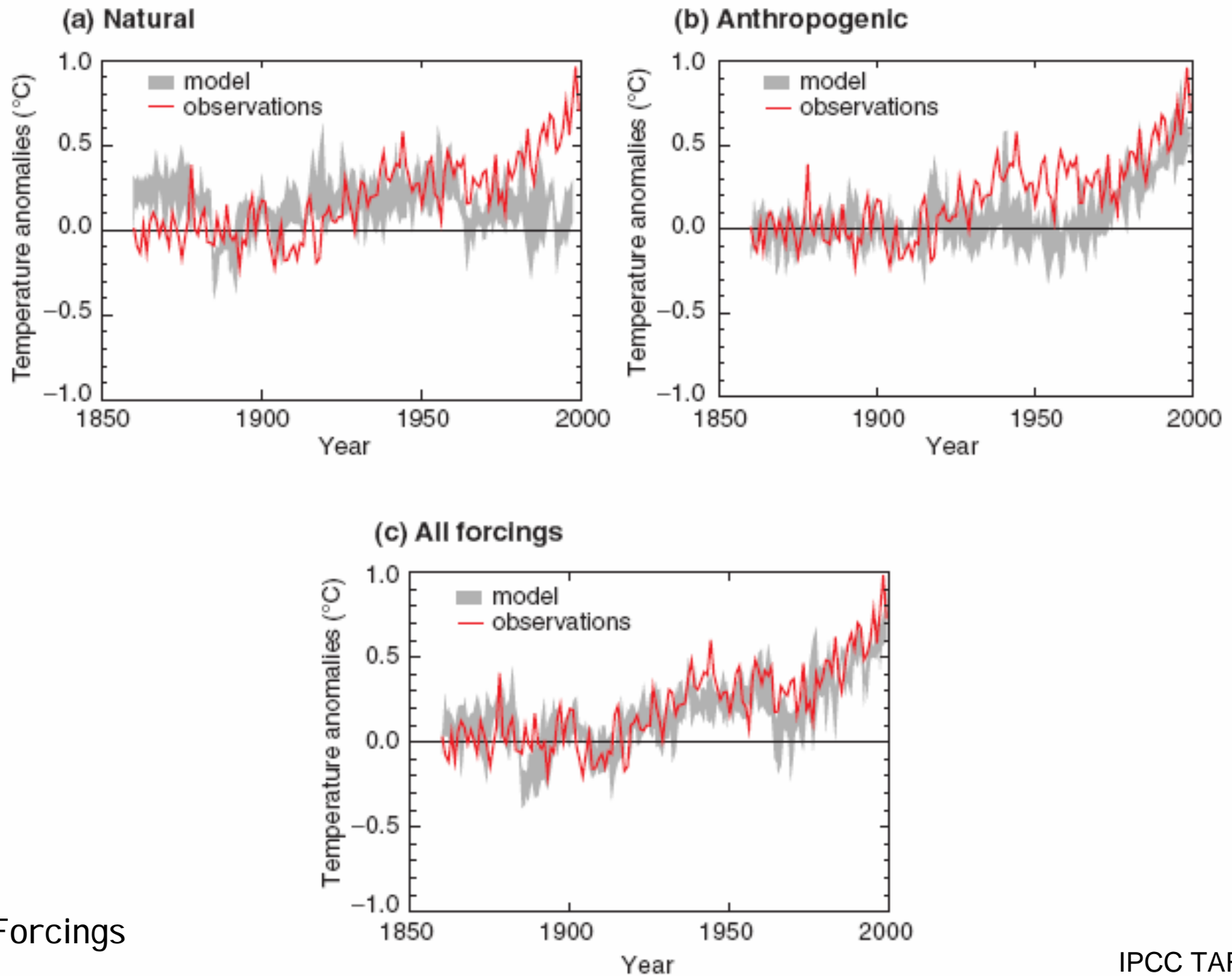
What do we need to show?
(1) Anthropogenic forcings are doing it
(2) Natural forcings are insufficient

How?
Earth science – no control experiment
Rely on climate models (show movie)

Simulated annual global mean surface temperatures

(a) Natural

(b) Anthropogenic

(c) All forcings

Forcings

IPCC TAR

How reliable are the global climate models?

1) Models based on established physical laws

2) Ability to model key aspects of current climate

large scale temperature, precipitation, radiation, wind, ocean temperatures, currents, ice cover, seasonality of monsoons and storm tracks...

3) Ability to reproduce past climates

larger warming of nighttime temperatures, larger NH warming, short-term cooling following volcanic eruptions...

Uncertainties in tropical precipitation, El Nino, representation of clouds, small scale projections

IPCC AR4 FAQ8.1

Predicting paleoclimate temperature change
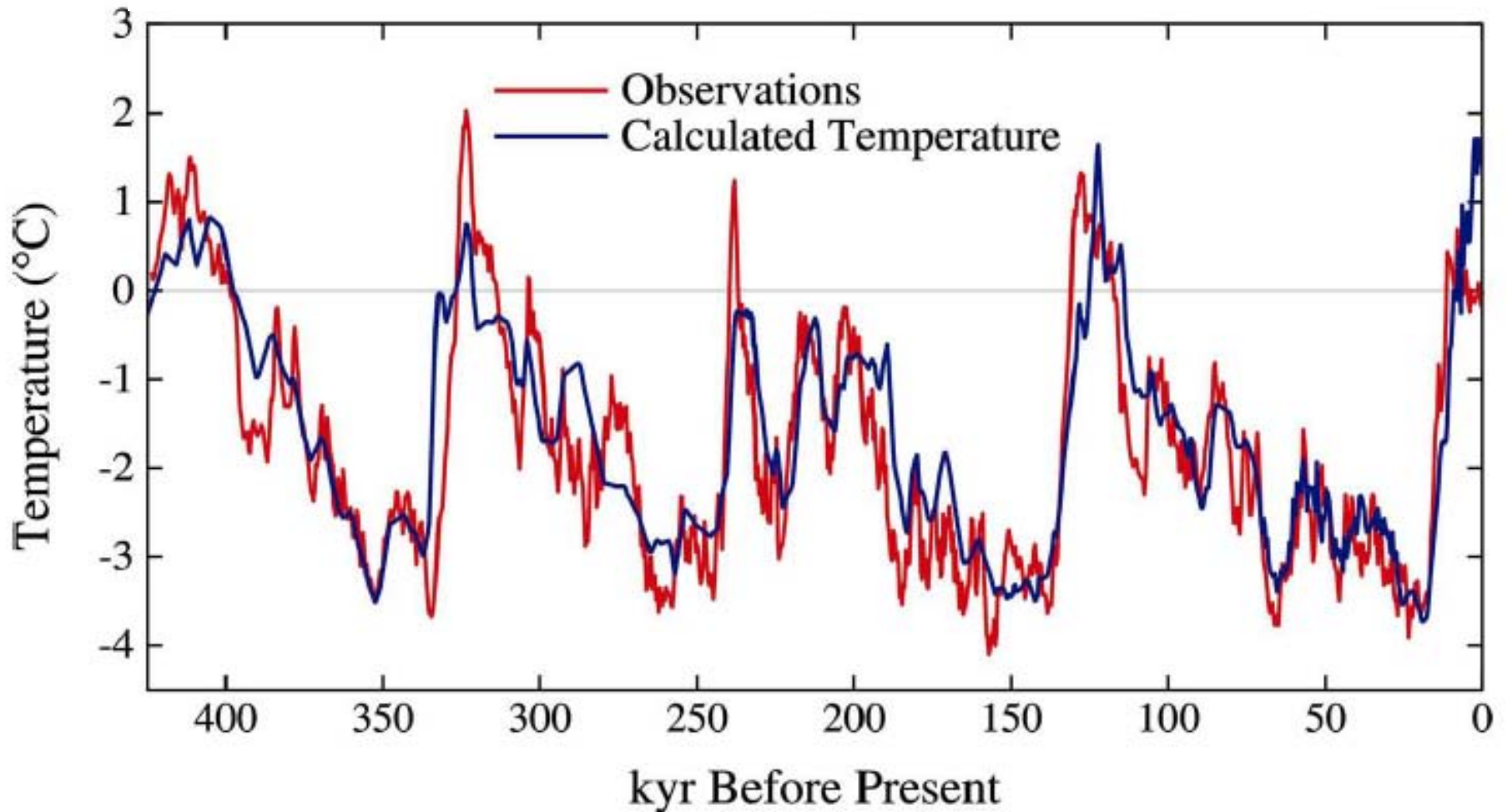
Observations = Vostok ΔT/2.
Calculated temperature = Forcing x 0.75°C /W/m²

(Hansen, 2004)

1991 Mt Pinatubo

In 1988 Hansen predicted the radiative effect of a volcanic eruption – later proved correct (-1 W m^{-2})

(Ed Wolfe, USGS, 1991)

Who are the skeptics?

Fred Singer, electrical engineer

Works with Exxon, American Petroleum Institute: "proposed a $5 million campaign... to convince the public that the science of global warming is riddled with controversy and uncertainty"

– Newsweek 2007

60 scientists' open letter to Canadian prime minister

Many non-scientists (journalists, and sociologists); most retired and not active researchers; only TWO active

Richard Lindzen, MIT professor in meteorology

gets funding from OPEC, $2500/day "consulting" fee

Michael Crichton! (invited by Congress to testify)

Who's arguing that global warming is here?

Intergovernmental Panel on Climate Change – thousands of ACTIVE scientists

- 1990 – qualitative persuasion of human interference with climate system
- 1995 – "discernable human influence on global climate"
- 2001 – "most of the warming over the last 50 yrs is likely attributable to human activities
- 2007 – "very likely" (>90% probability)

National science academies

Pretty much every *active* climate scientist

Myths and skepticisms

1. Scientists can't even predict next week's weather

2. Climate model predictions have never been tested

3. Hansen has been wrong before

5. Global warming + global dimming -> Southern warming

6. GCMs don't have clouds

7. Climate models can't explain the past

8. Climate is chaotic and thus not predictable

9. Regional and local climate predictions are bogus

Summary

- Detection by observations - warming of atmosphere, ocean, less Arctic sea ice, faster rates of Greenland melting, more ice-quakes in Greenland, sea level rise

- Primary cause – anthropogenic greenhouse gases

- Attribution to humans – use of global climate models, show observed changes due to humans, show observed changes cannot be explained without humans

- Skeptics – mostly non-scientists, lobbyists

- Journalists present "both" sides equally even though the credibility of the two sides is lopsided