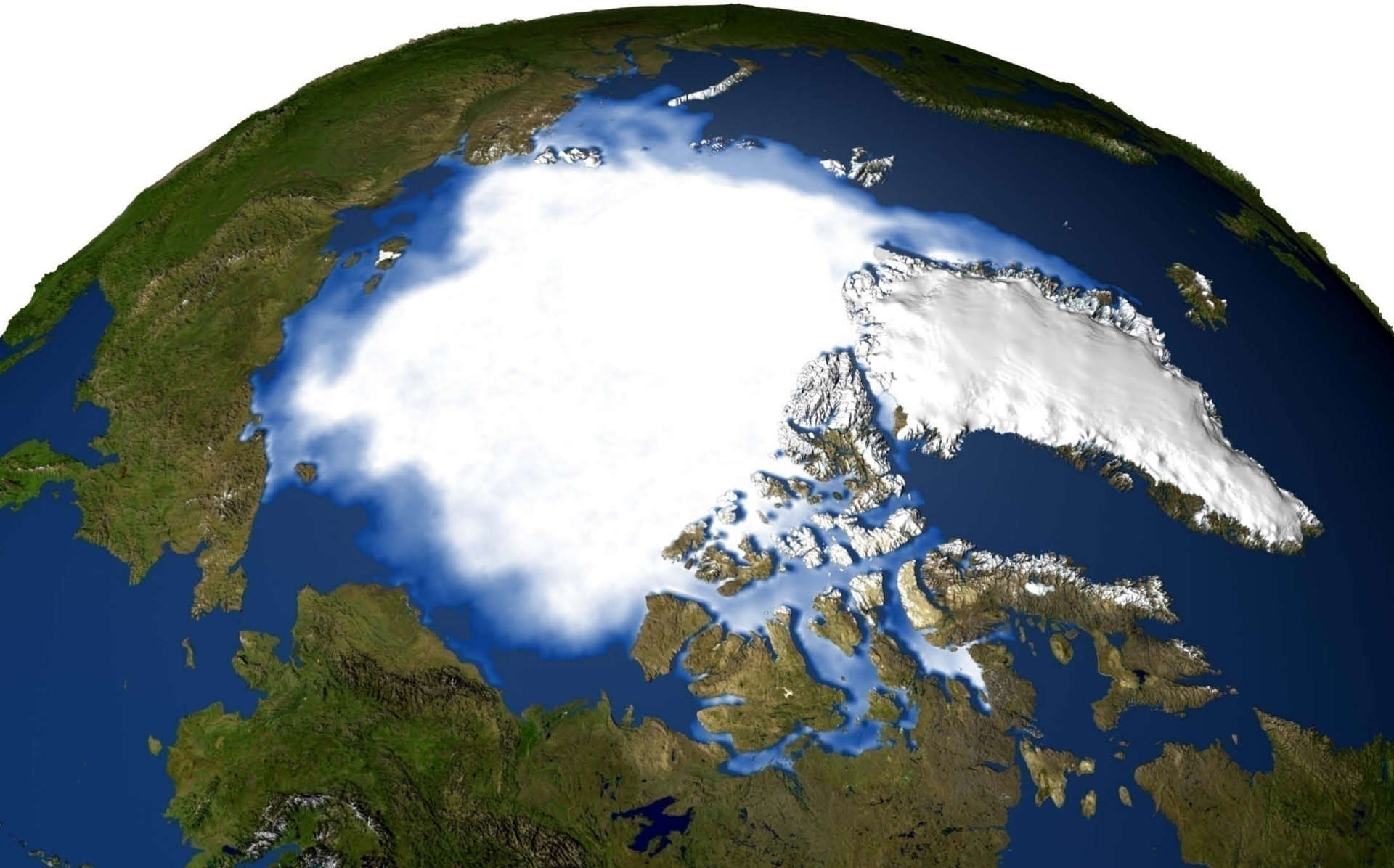
Climate Change: Cutting through the Rhetoric



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    (snow, sea ice, permafrost, glaciers, ice sheets)
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    Can we live with it? Are CO_2 reductions even possible?

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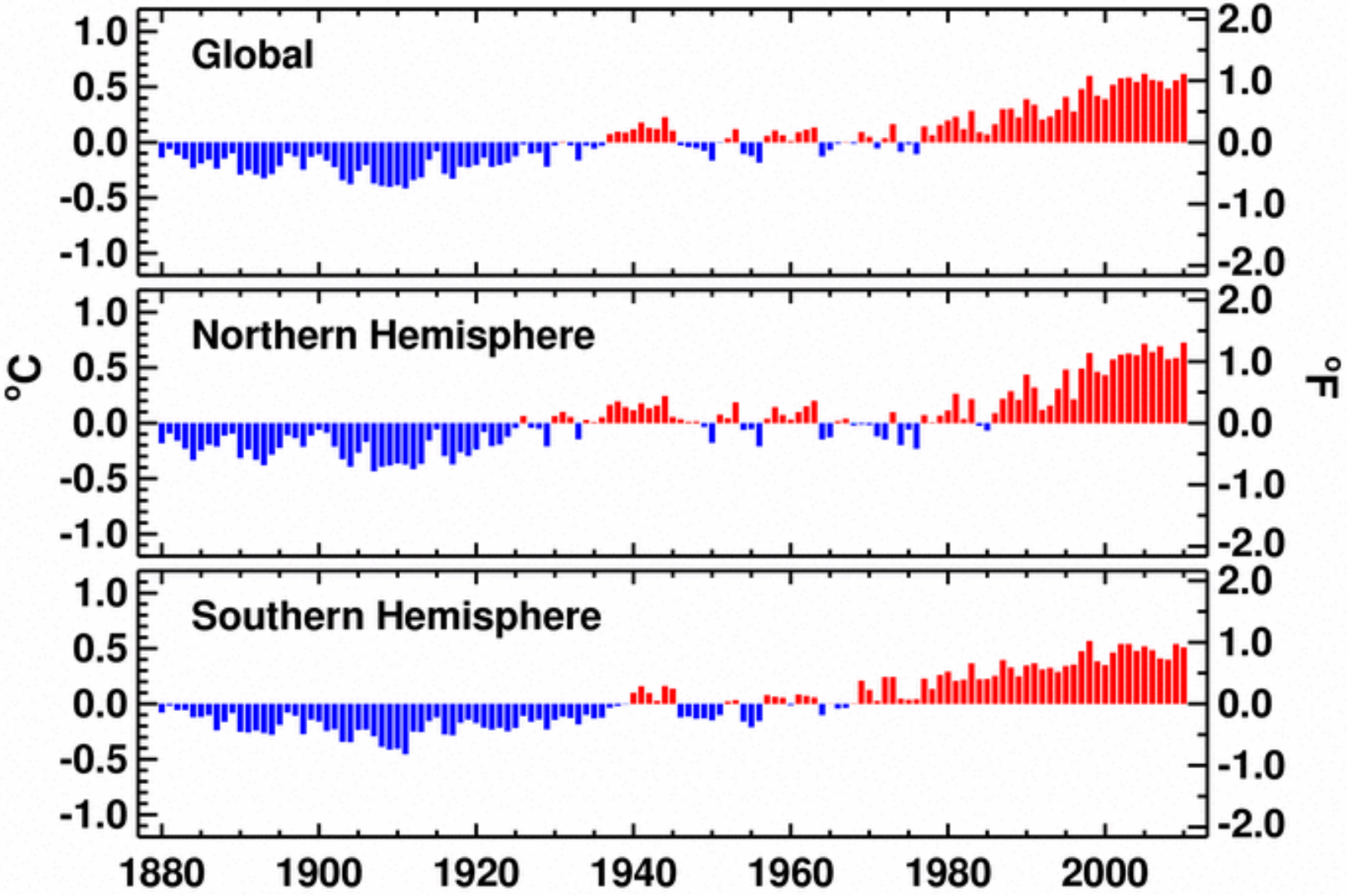
Global Top 12 Warm Years	Anomaly °C
2010	0.62
2005	0.62
1998	0.60
2003	0.58
2002	0.57
2009	0.56
2006	0.56
2007	0.55
2004	0.54
2001	0.52
2008	0.48
1997	0.48

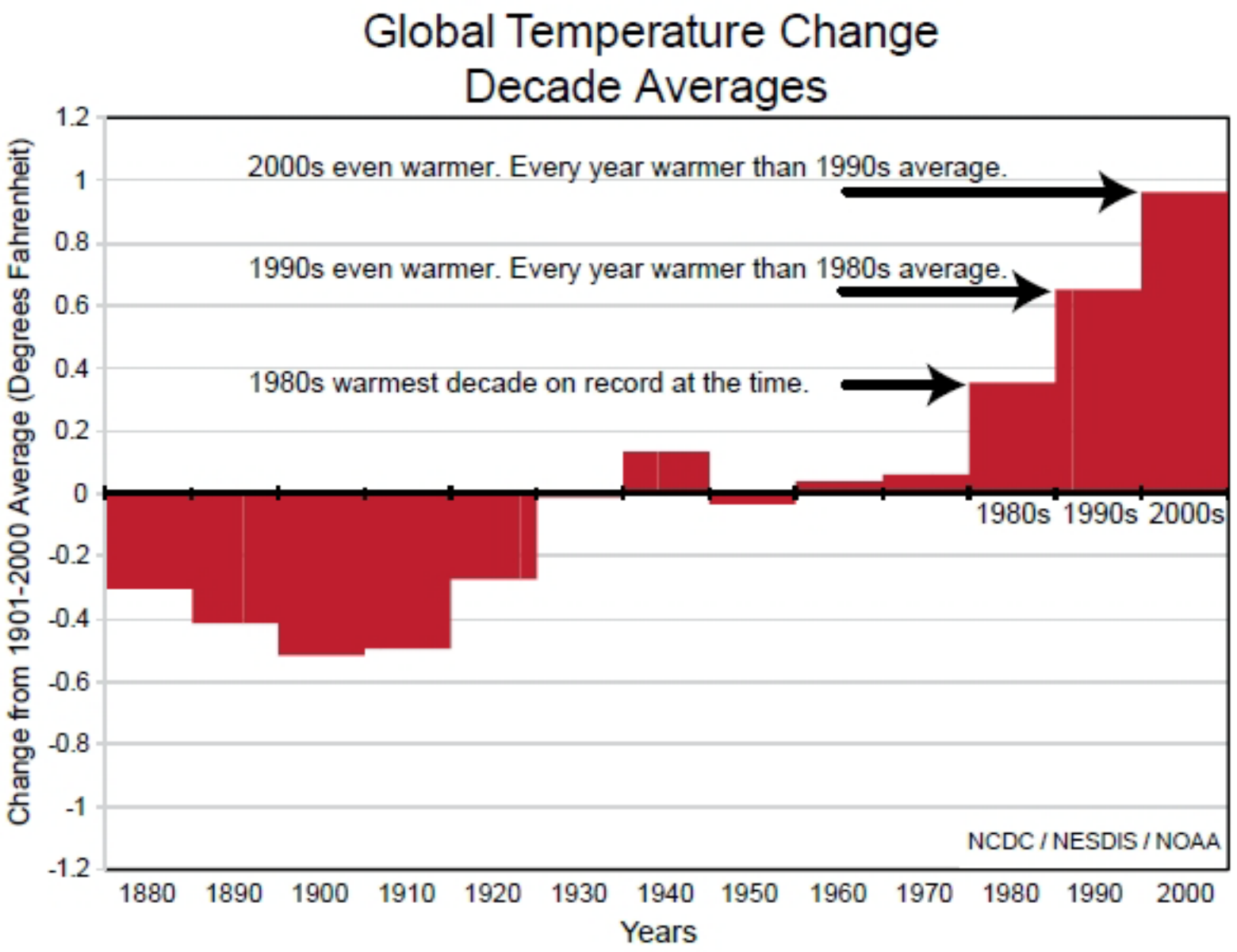
http://www.ncdc.noaa.gov/sotc/

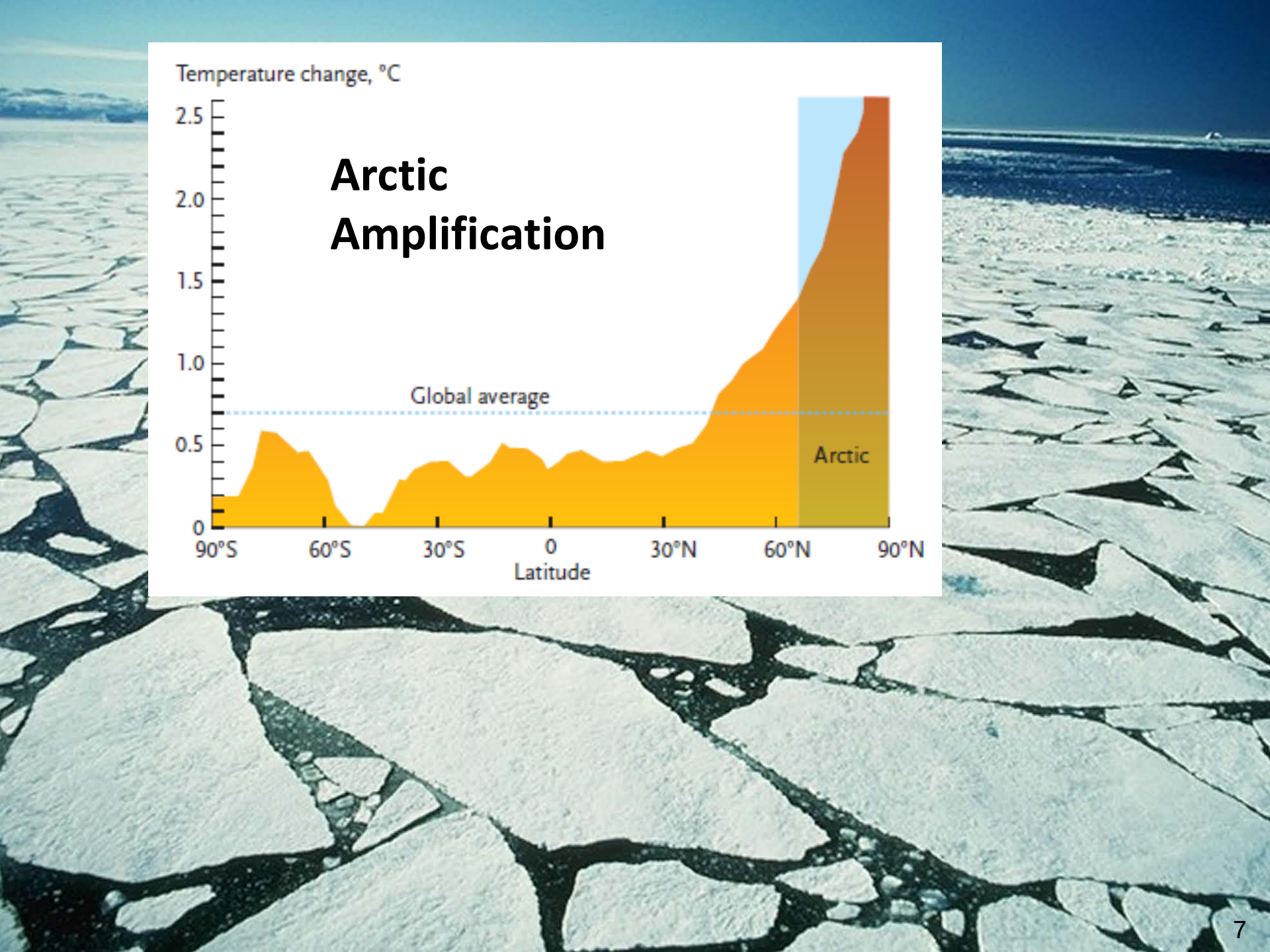
Jan-Dec Land & Ocean Surface Mean Temp Anomalies

NCDC/NESDIS/NOAA

Analysis is based upon Smith et al. (2008) methodology.




Global Temperature Change
Decade Averages
2000s even warmer. Every year warmer than 1990s average.
1990s even warmer. Every year warmer than 1980s average.
1980s warmest decade on record at the time.
1980s 1990s 2000s
NCDC / NESDIS / NOAA
Change from 1901-2000 Average (Degrees Fahrenheit)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
Years

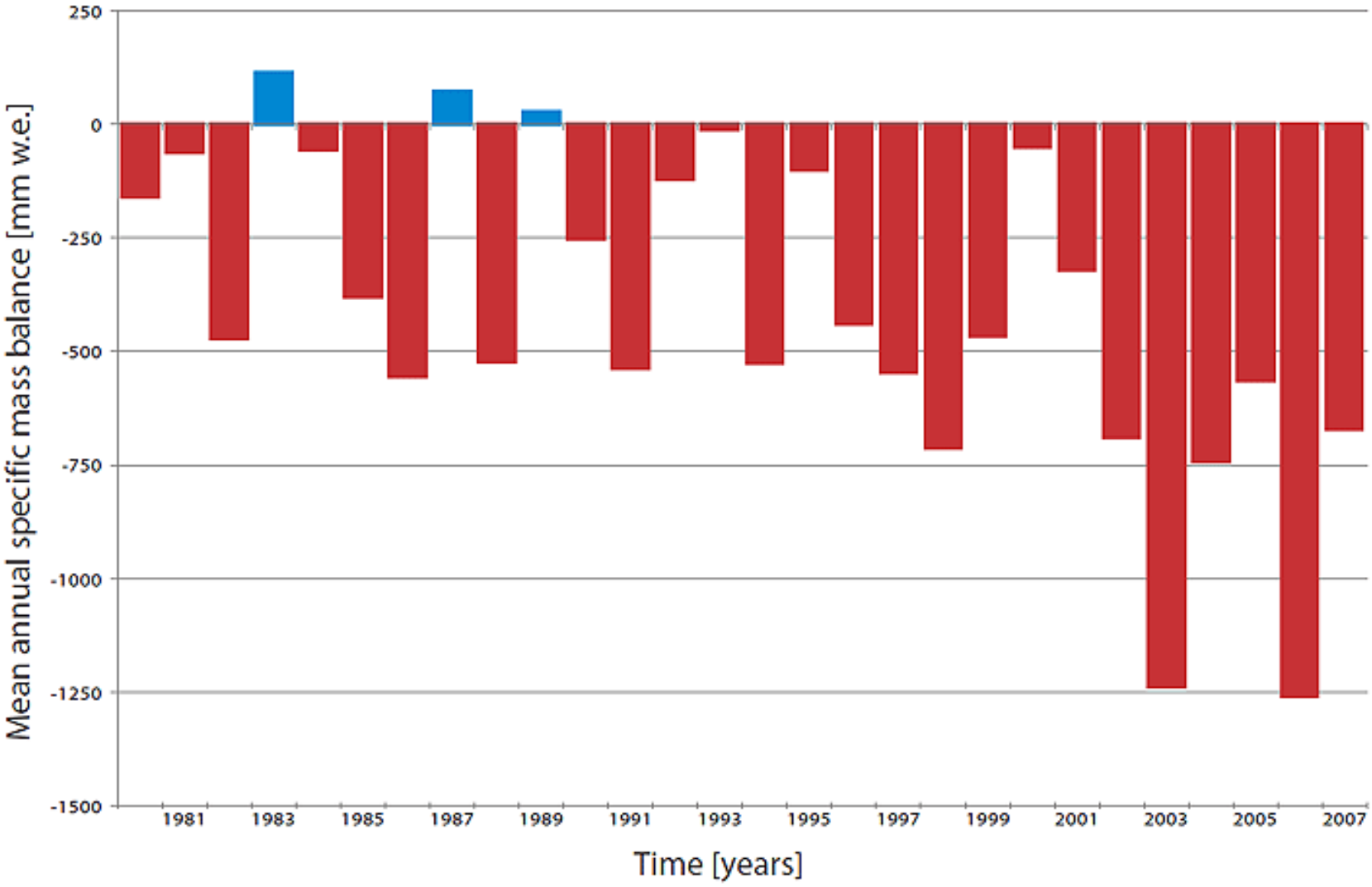

Arctic
Amplification
Temperature change, °C
2.5
2.0
1.5
1.0
0.5
0
Global average
Arctic
90°S
60°S
30°S
0
30°N
60°N
90°N
Latitude

Columbia Glacier

Saskatchewan Glacier, Canadian Rockies

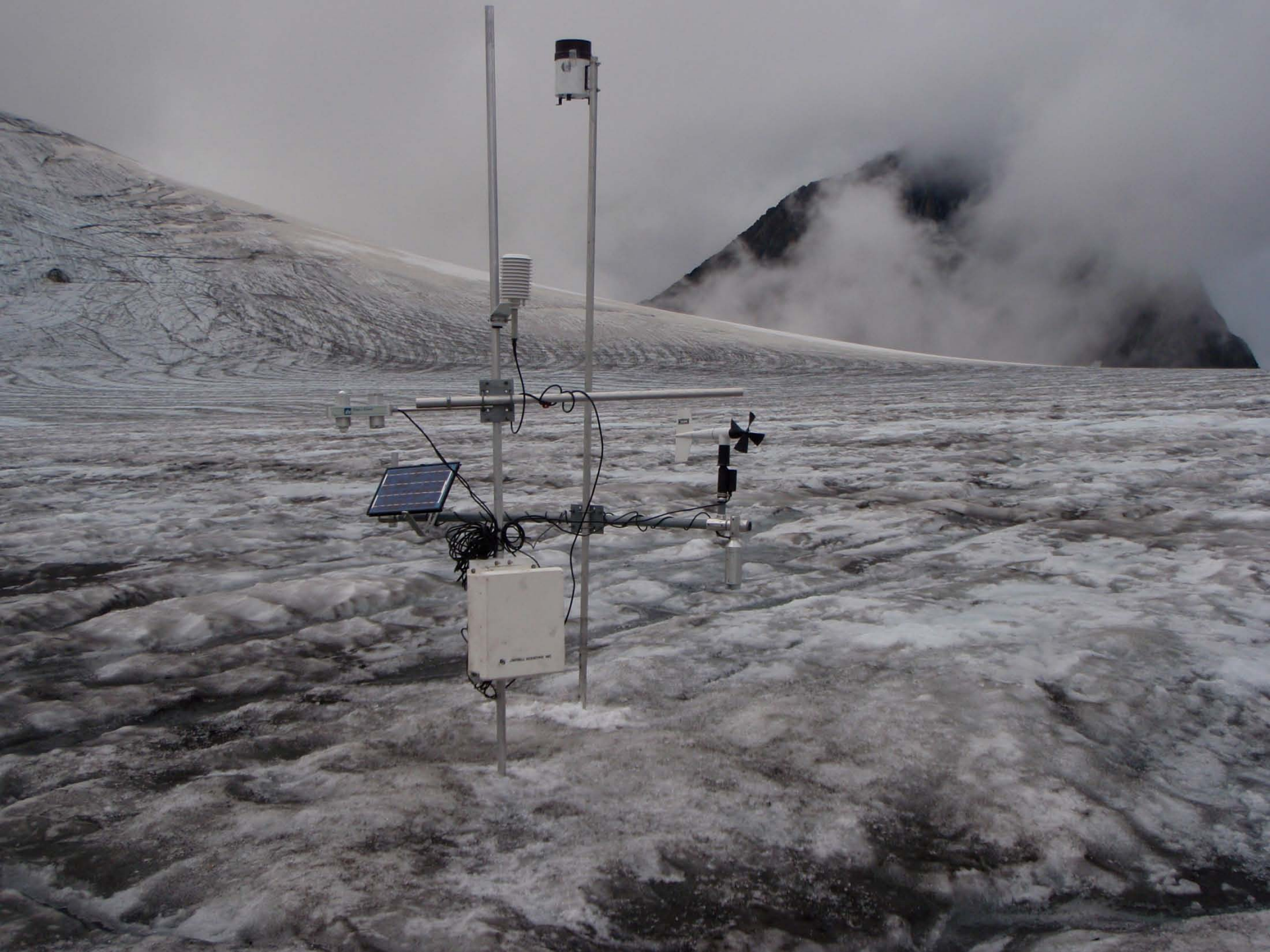
Photo credit: R. Sandford

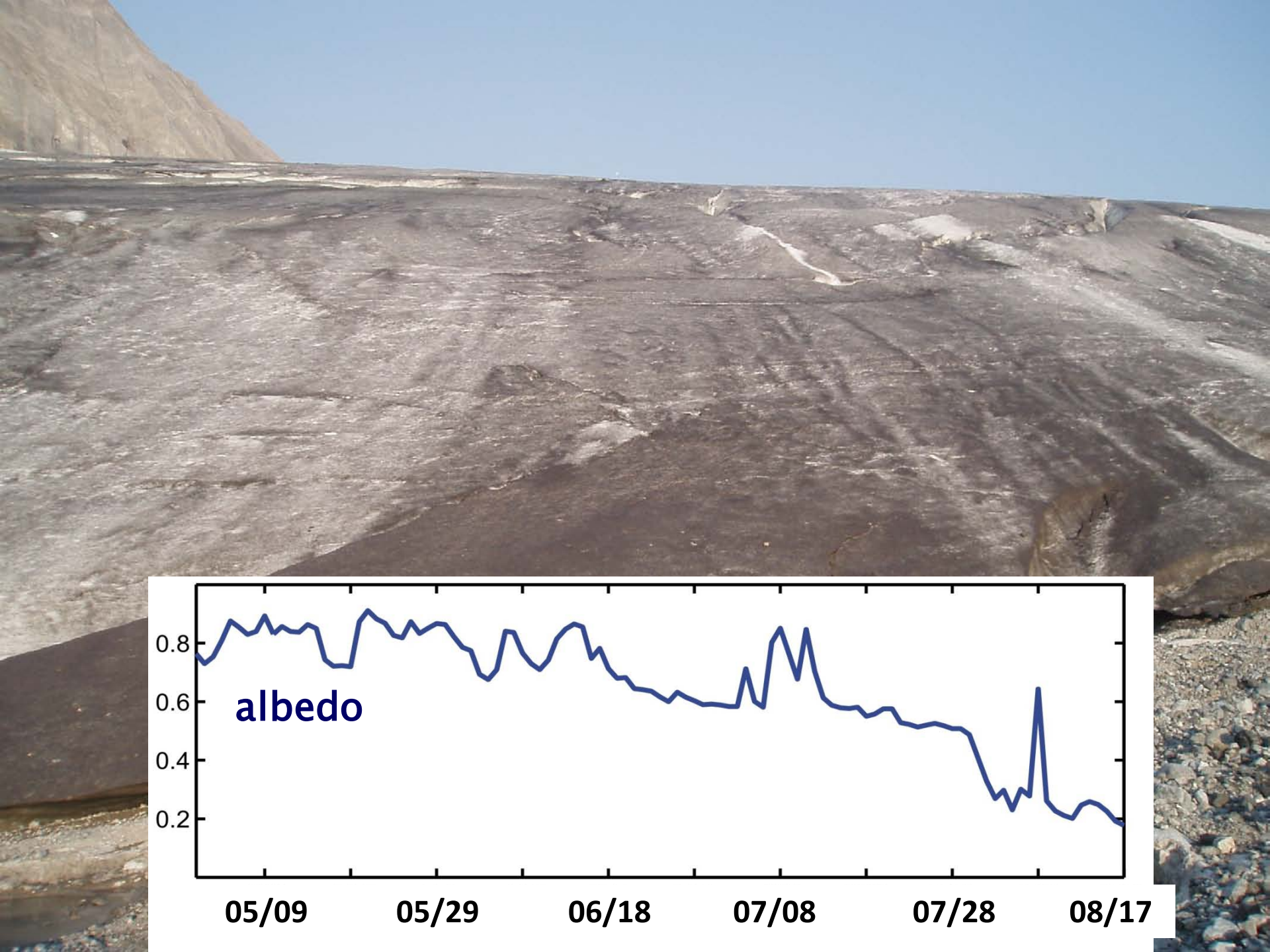
The global glacier mass balance record



Haig Glacier, Canadian Rockies
September 2009

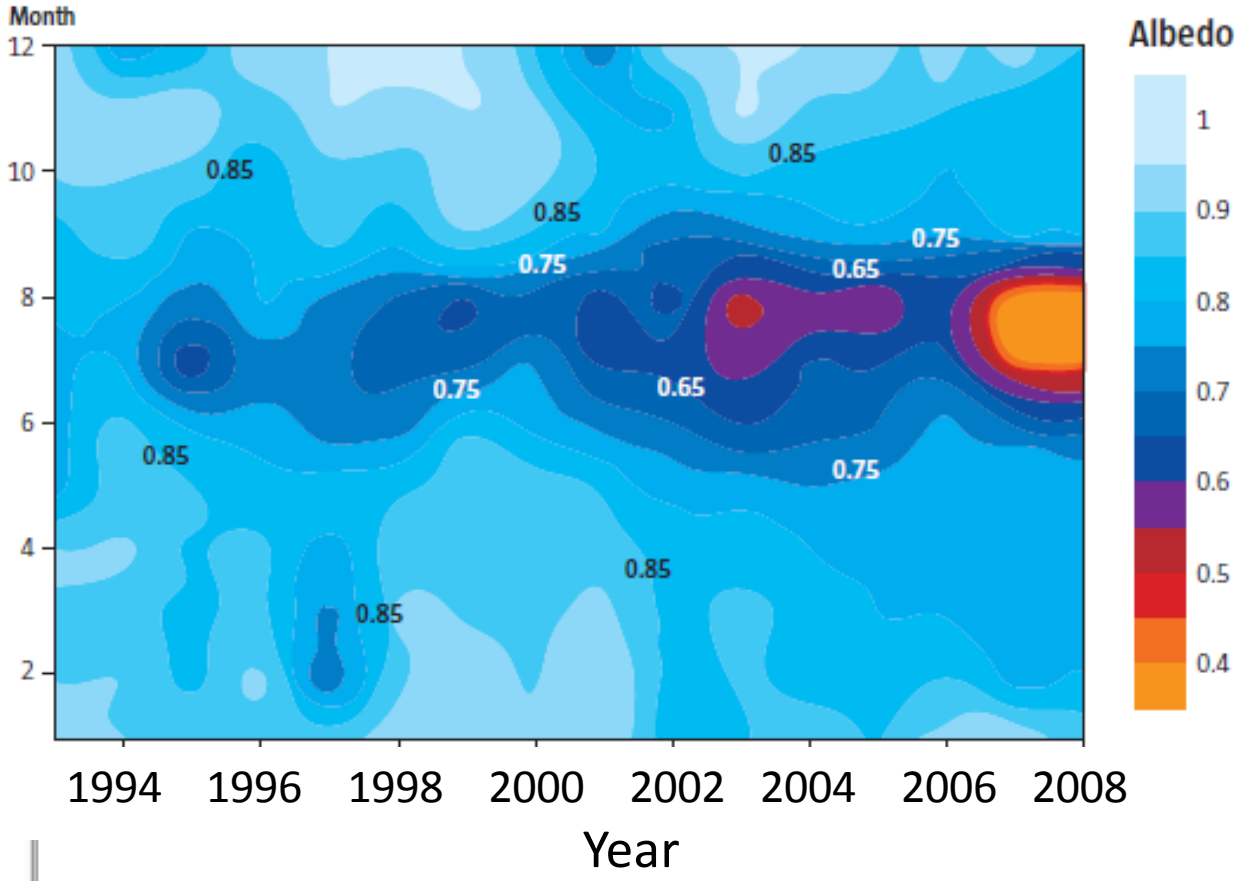

Haig Glacier, Sept 2006




albedo
0.8
0.6
0.4
0.2
05/09
05/29
06/18
07/08
07/28
08/17

Changes in Greenland

2a. Feedbacks from more melt

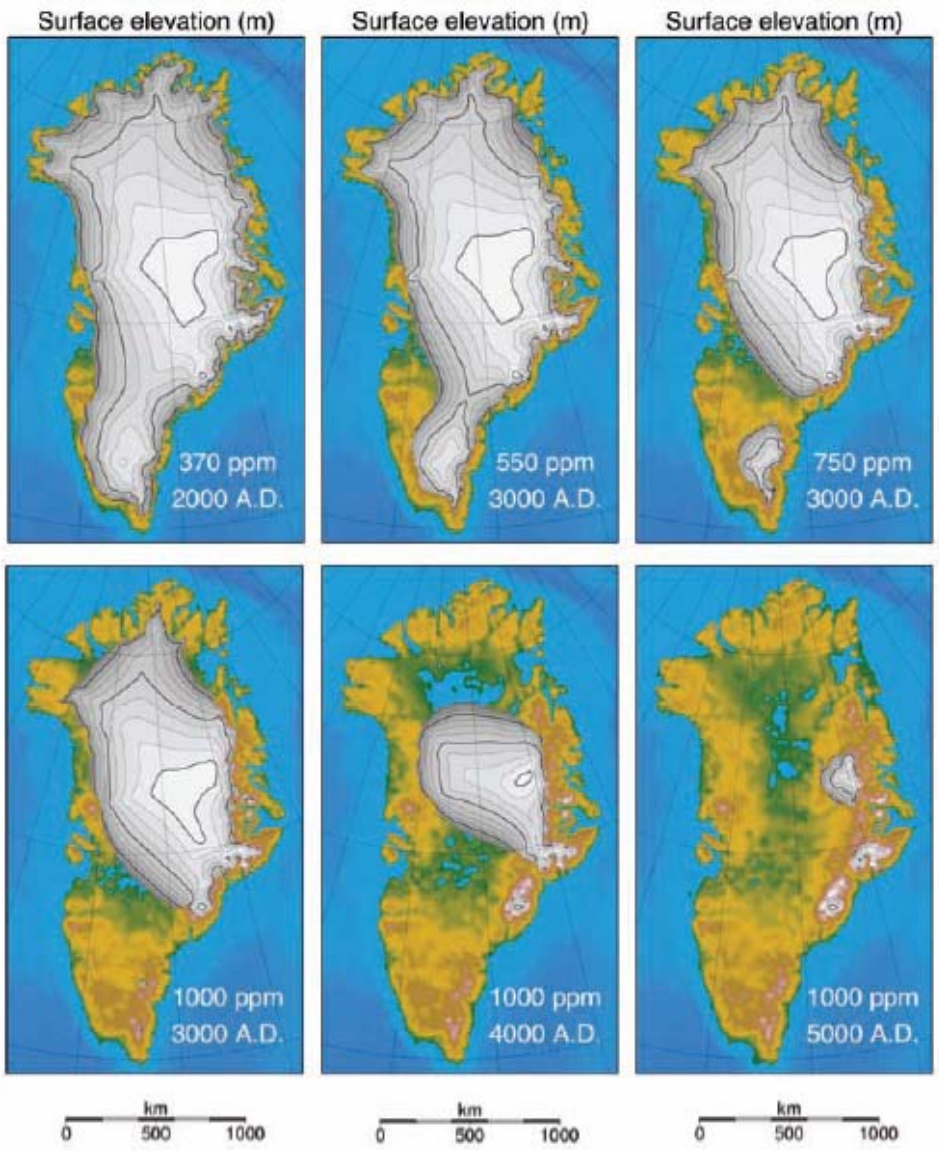


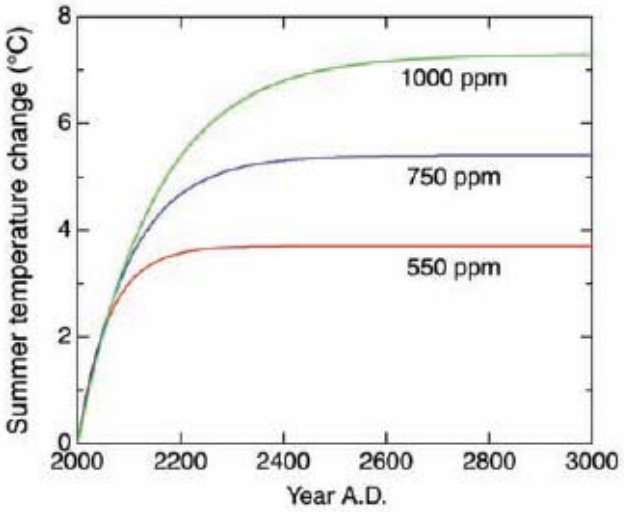
Changes in Greenland

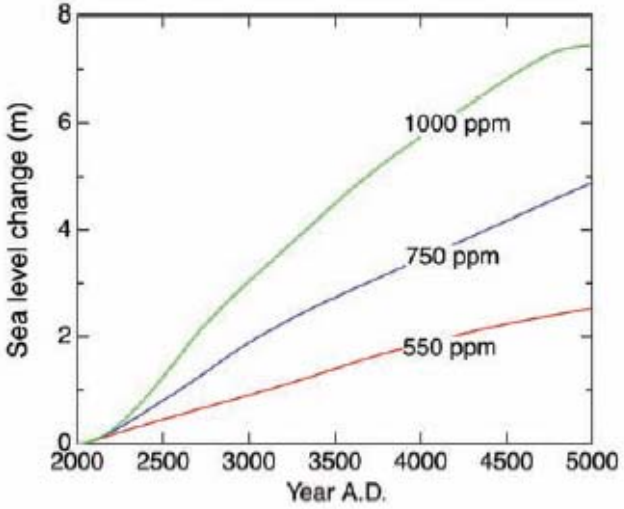
Impacts of Ocean Warming

Ice-Sheet and Sea-Level Changes

Richard B. Alley,[1*†] Peter U. Clark,[2*] Philippe Huybrechts,[3,4*] Ian Joughin[5*]







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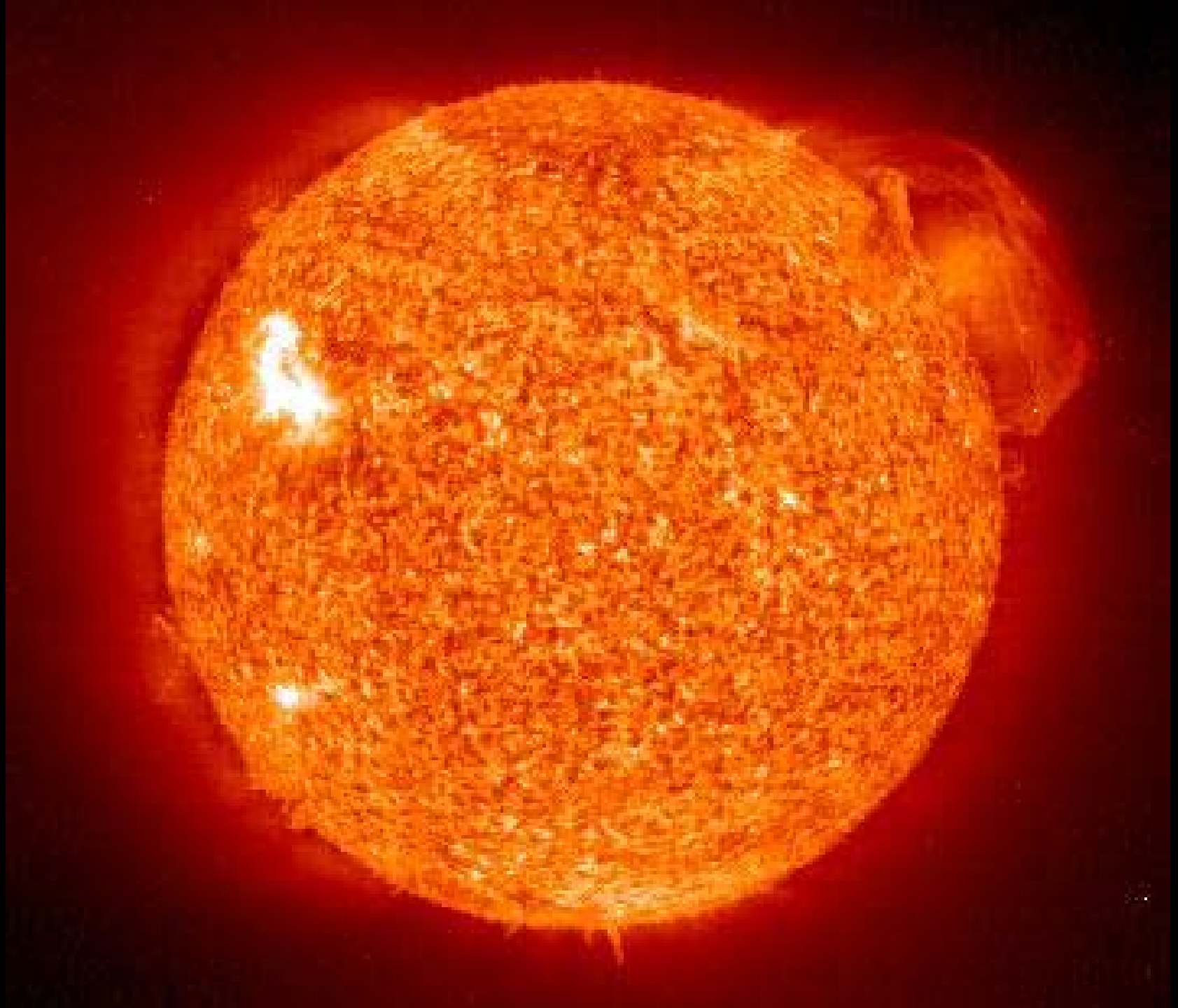
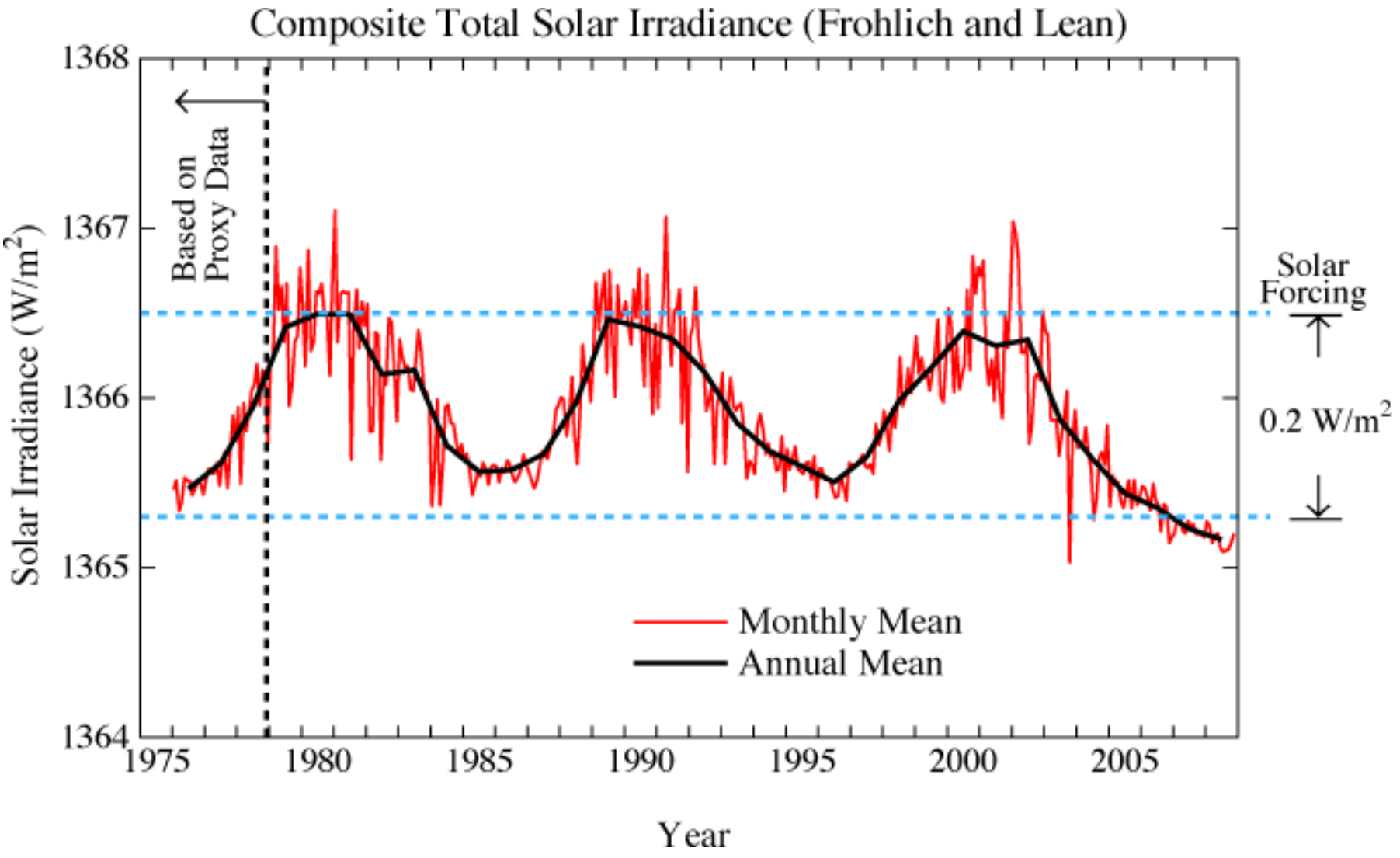
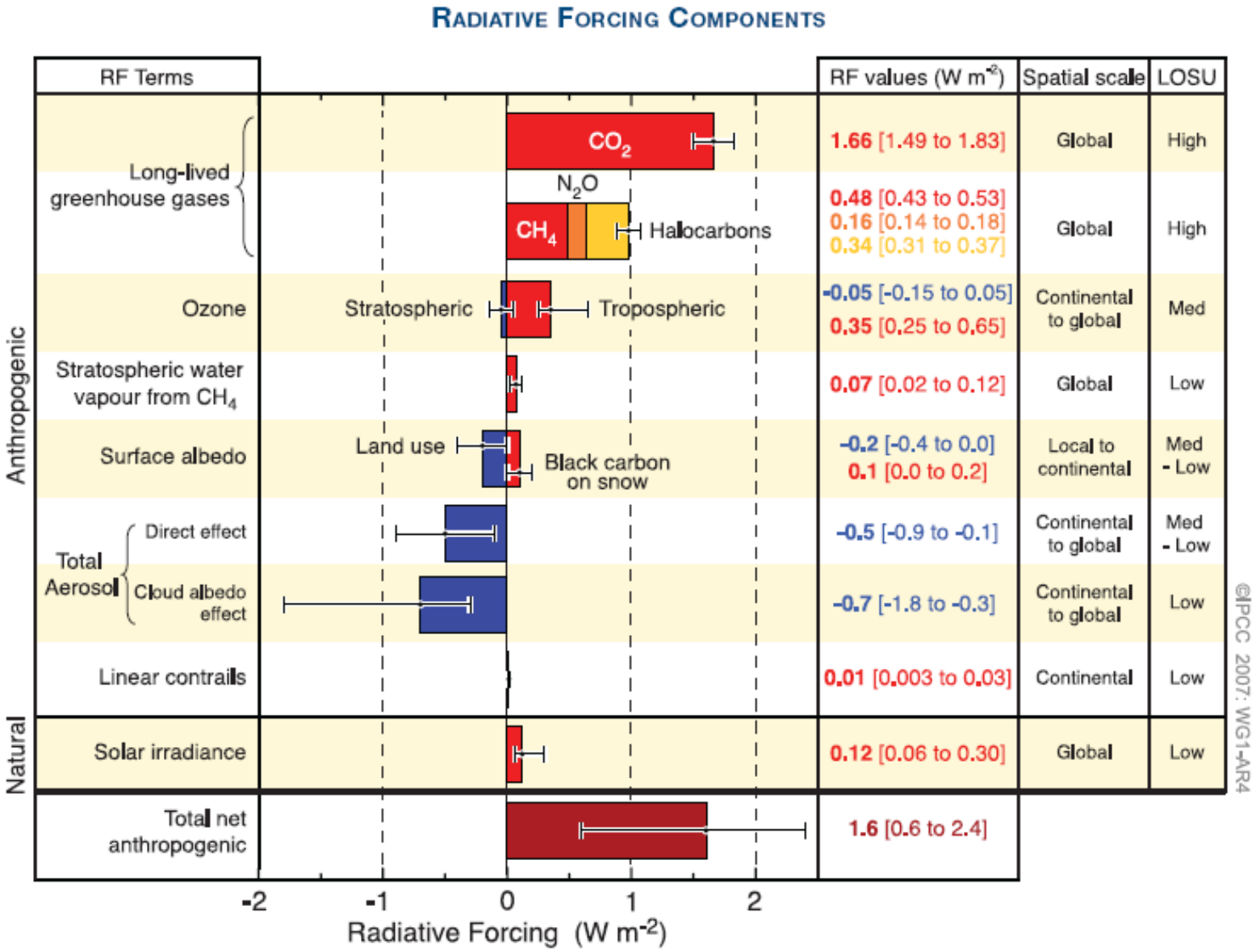



Composite Total Solar Irradiance (Frohlich and Lean)
Solar Irradiance (W/m2)
1368
1367
1366
1365
1364
1975
1980
1985
1990
1995
2000
2005
Year
Based on Proxy Data
Solar Forcing
0.2 W/m2
Monthly Mean
Annual Mean

IPCC (2007) assessment of radiative forcing



On Causality

Lots of things can push the climate around, e.g., solar variability; volcanic & industrial sulphate emissions; , land use changes; greenhouse gases other than CO_2

It is just that nothing other than CO_2 explains the warming over the last 40 years

Flipping things over: given the GHG buildup, it would be strange if the world was *not* warming

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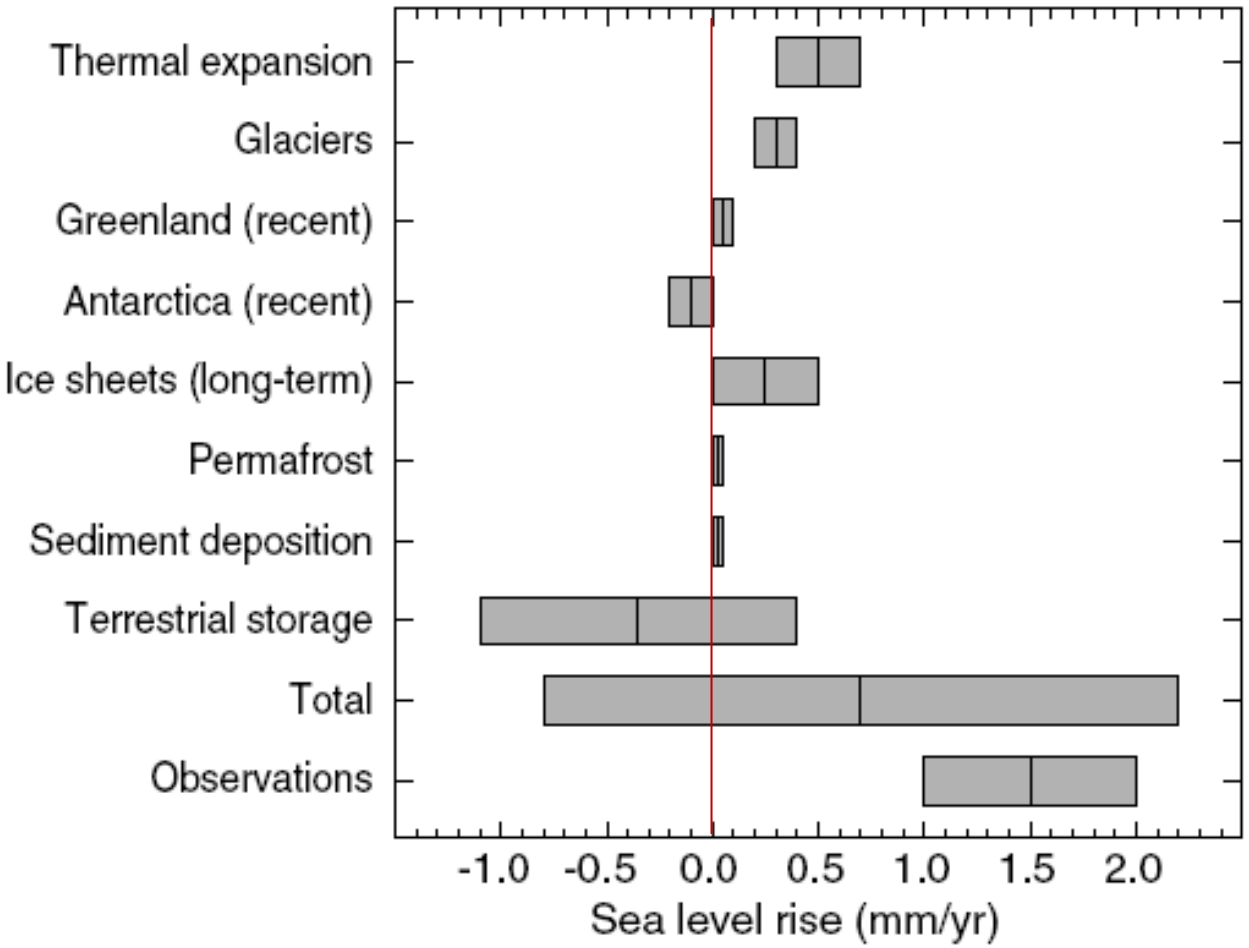
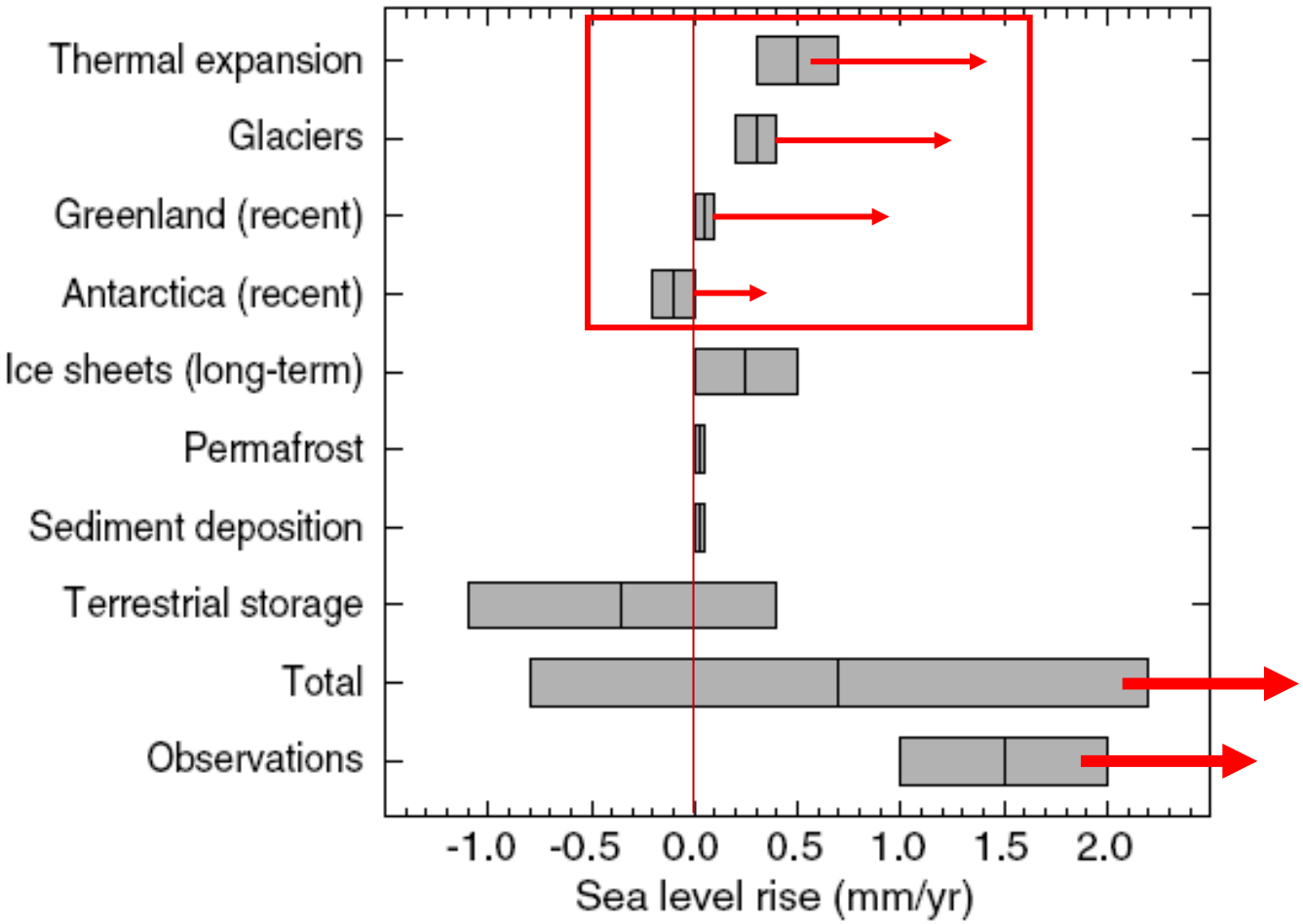


Figure 11.9: Ranges of uncertainty for the average rate of sea level rise from 1910 to 1990 and the estimated contributions from different processes.

IPCC (2001)



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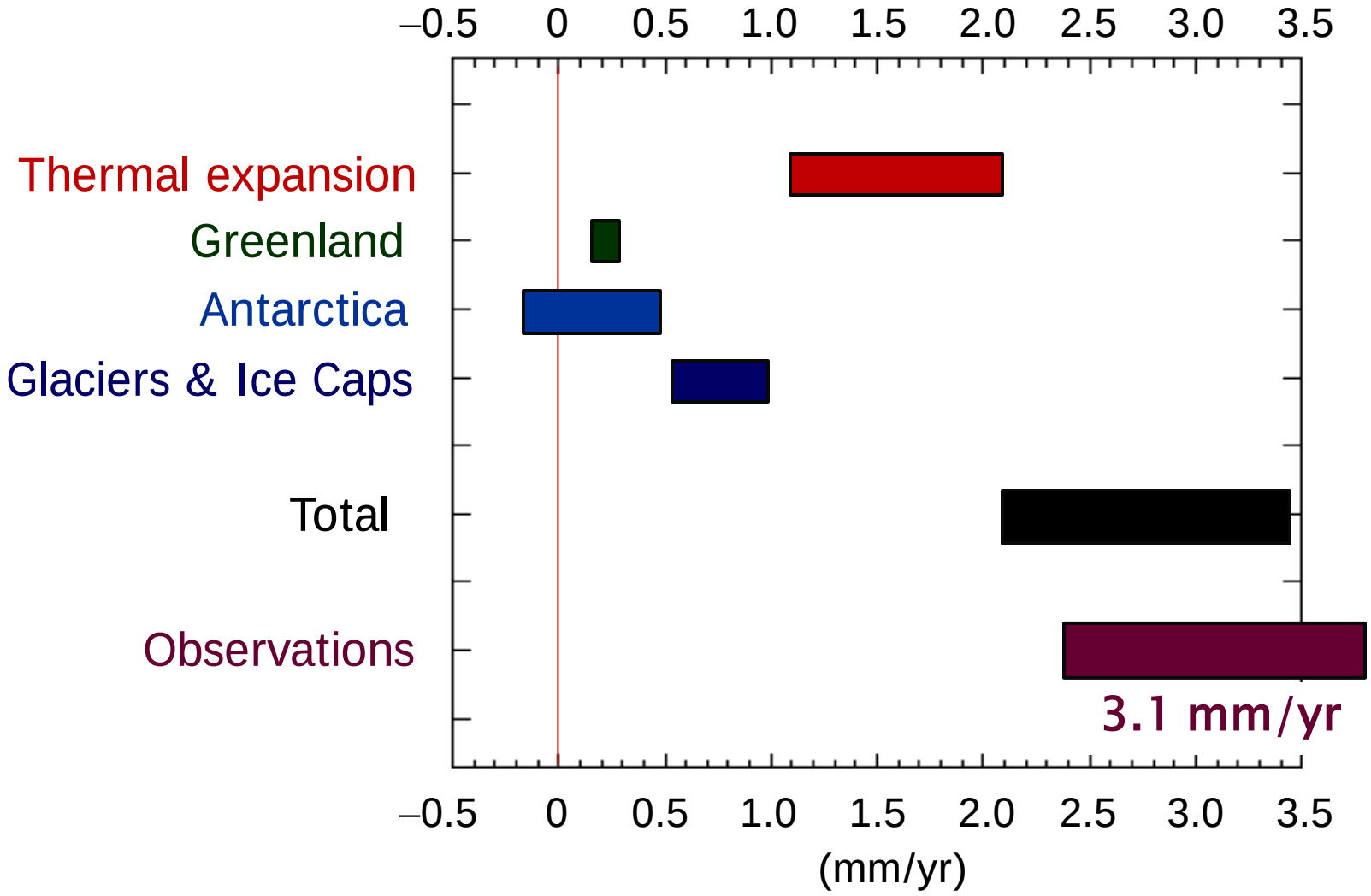
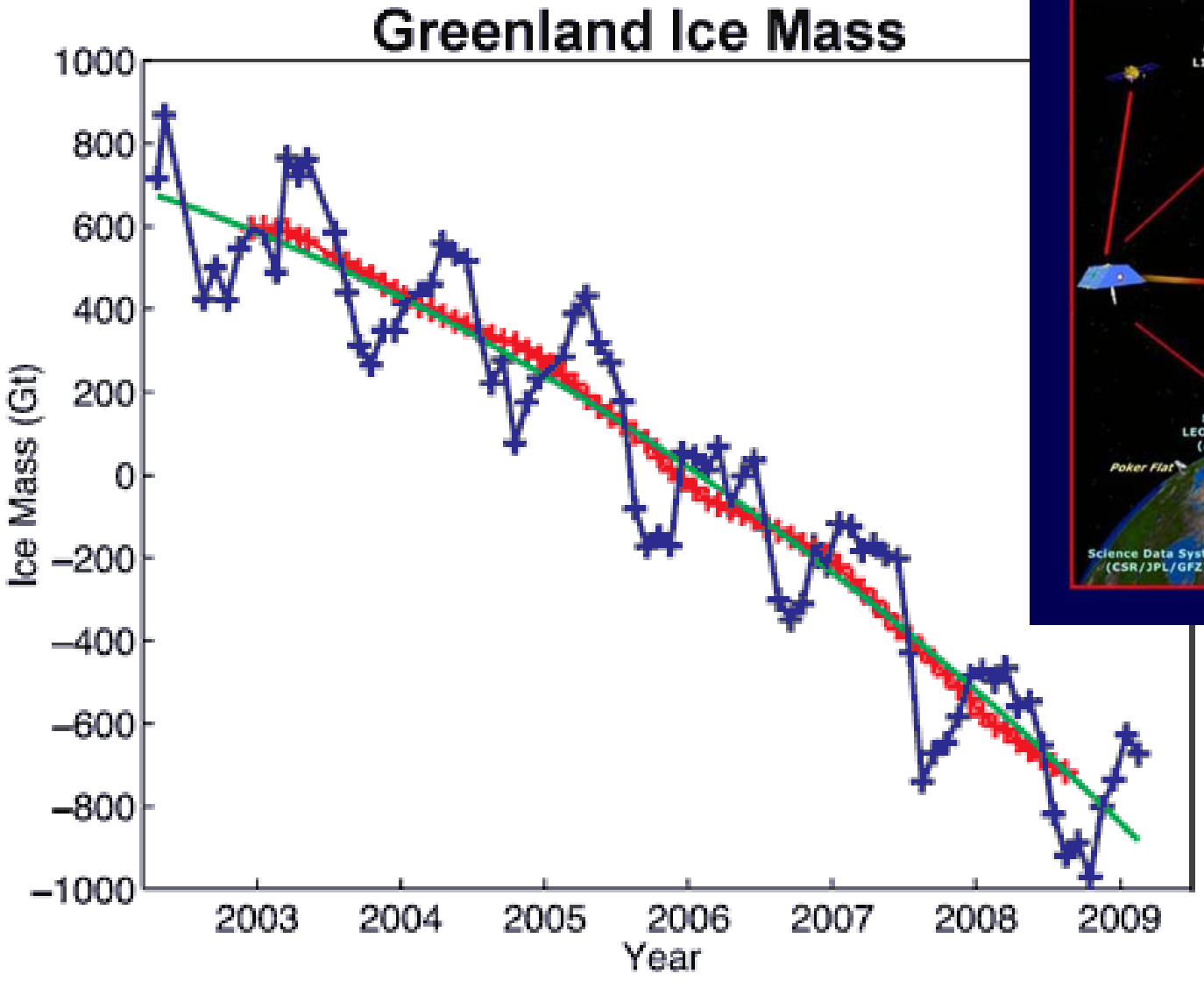
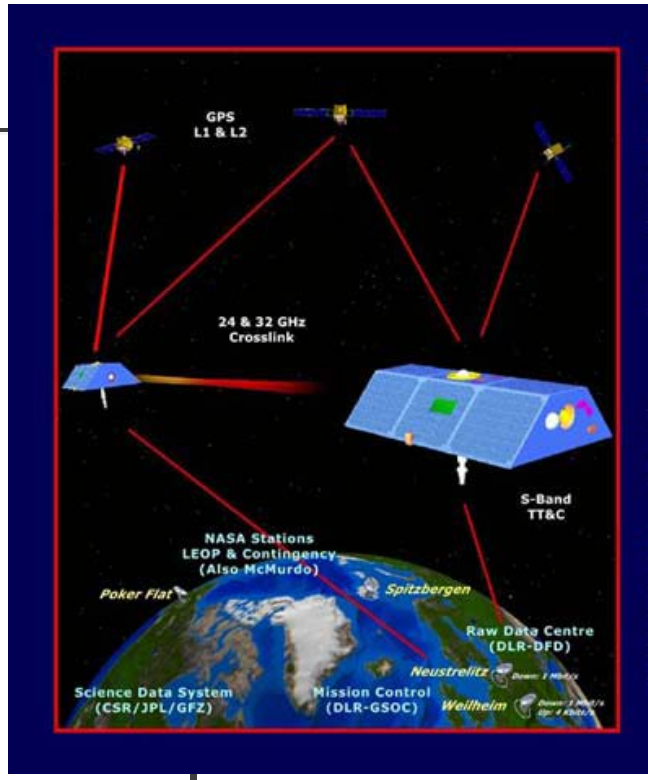
Changing Reality: From IPCC 2001 to IPCC 2007



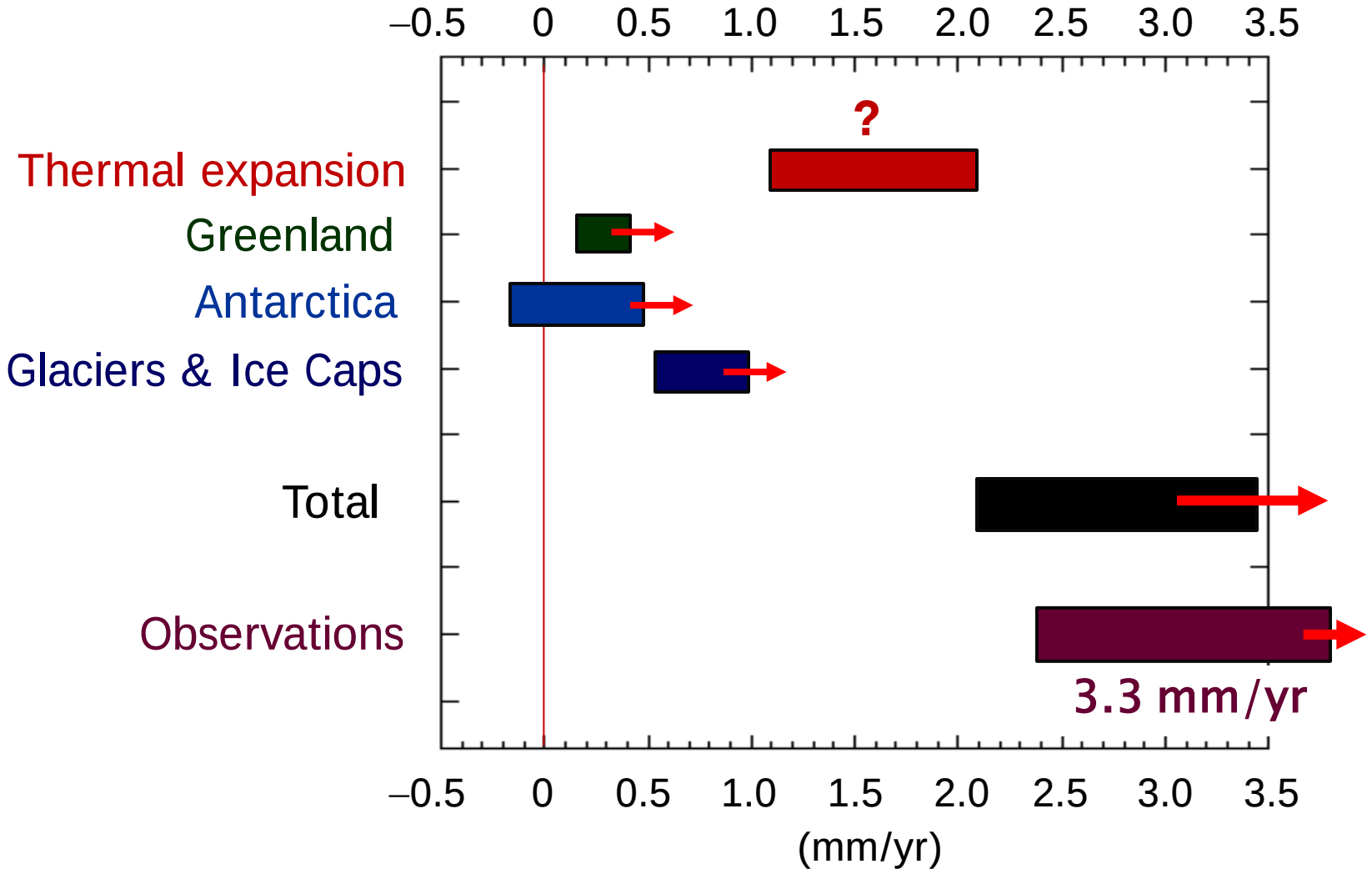
Contributions to global sea level rise, 1993-2003

Redrawn from IPCC (2007)





Velicogna (2009), GRL



Contributions to global sea level rise, 1993-2009

Prospects for IPCC (2013) ??

Concerns about sea level rise

A bit of a wild card: Published estimates vary from 20-160 cm of global eustatic sea level rise by 2100

Impacts: Very global, and most serious for tropical developing countries.

* 150 of the world's 192 sovereign nations border the ocean
* The world's 98 largest coastal cities (population > 2 million) constitute 664 million people

Potential impact of sea-level rise on Bangladesh

Today

Total population: 112 Million

Total land area: 134,000 km^2

1.5 m - Impact

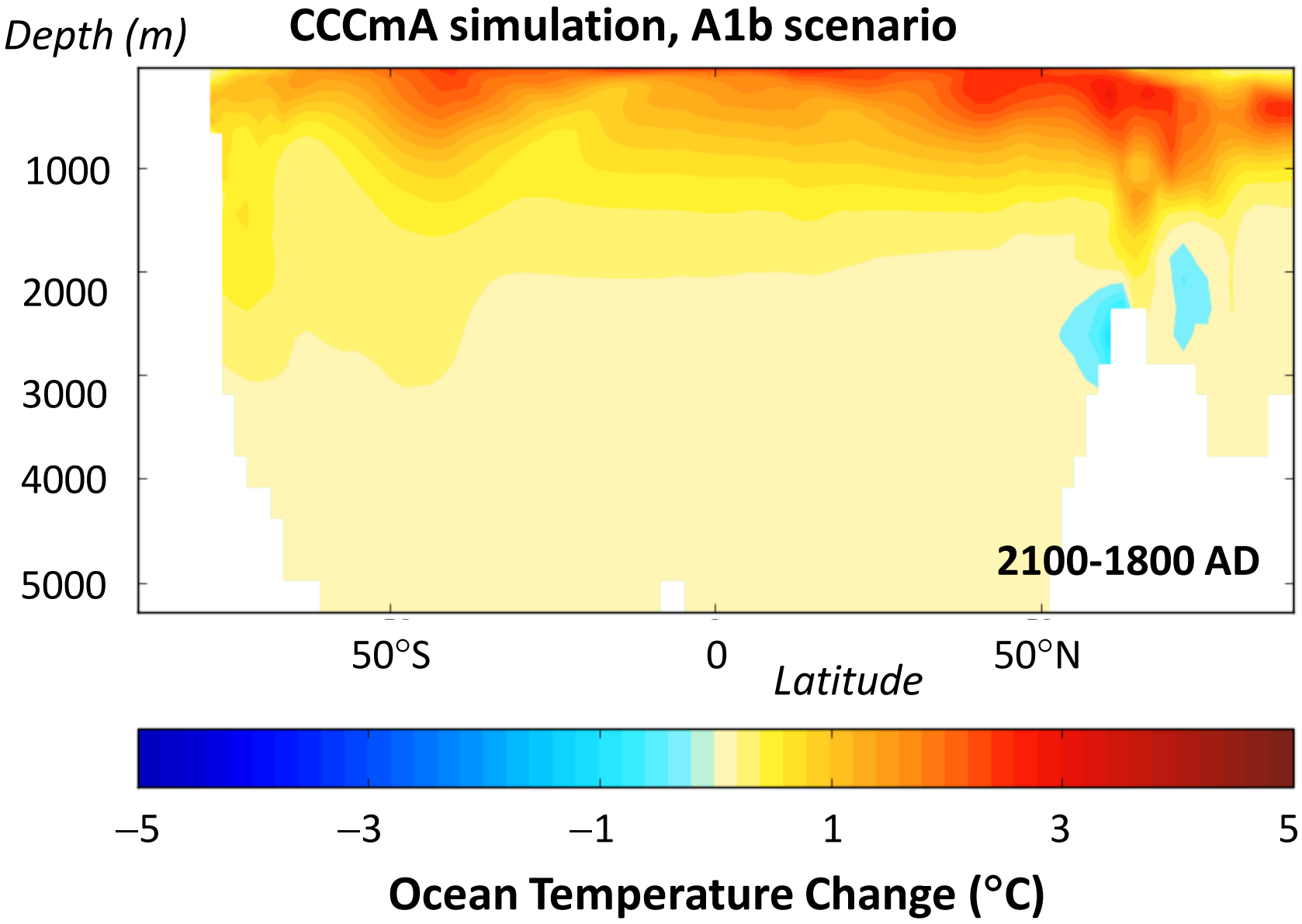
Total population affected: 17 Million (15%)

Total land area affected: 22,000 km^2 (16%)

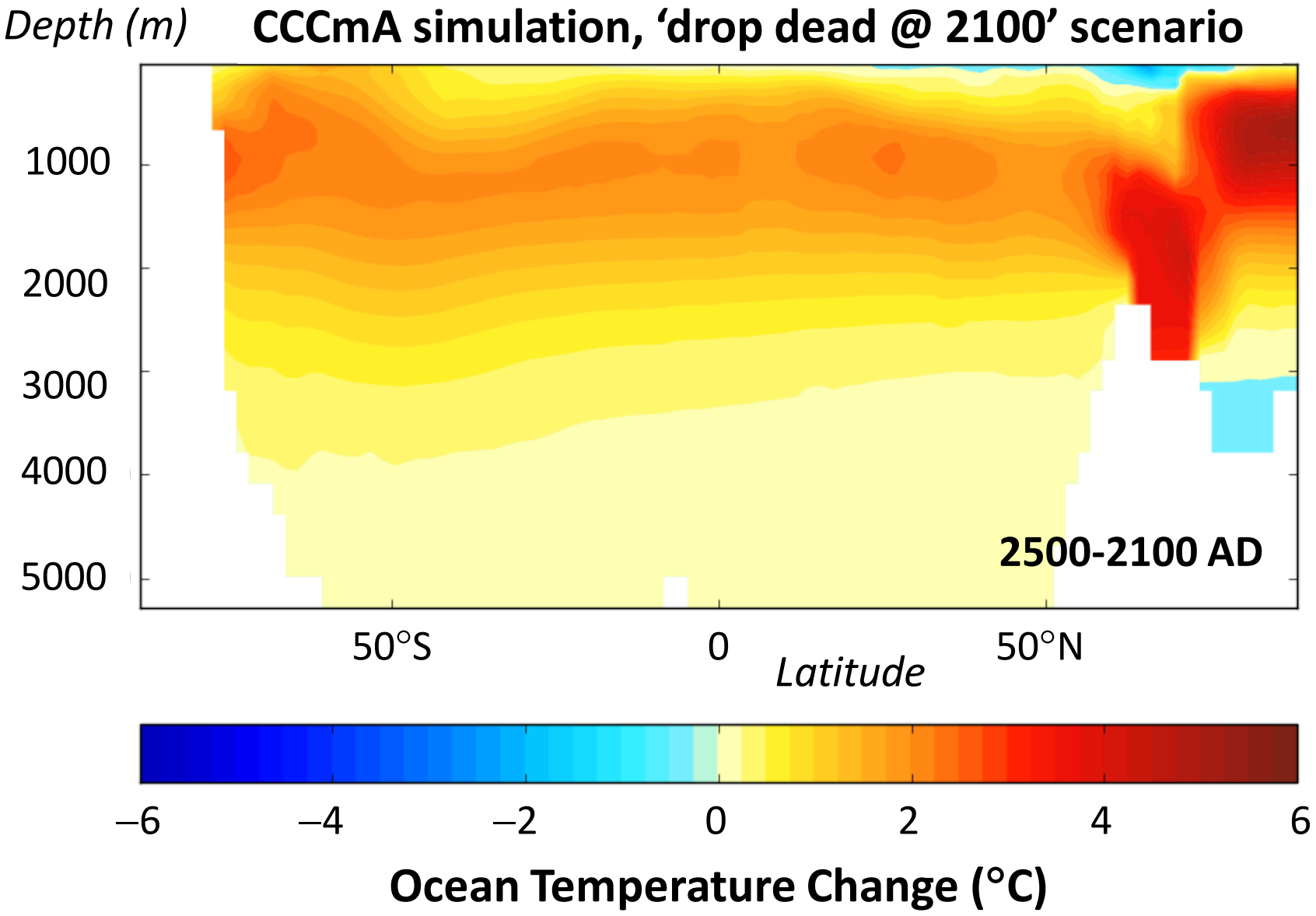
GRID Arendal UNEP

Source : UNEP/GRID Geneva; University of Dacca; JRO Munich; The World Bank; World Resources Institute, Washington D.C.

Modelled Ocean Warming, Zonally-Averaged



Implications for Sea Level Rise Commitment



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KYOTO

Climate Change Policy

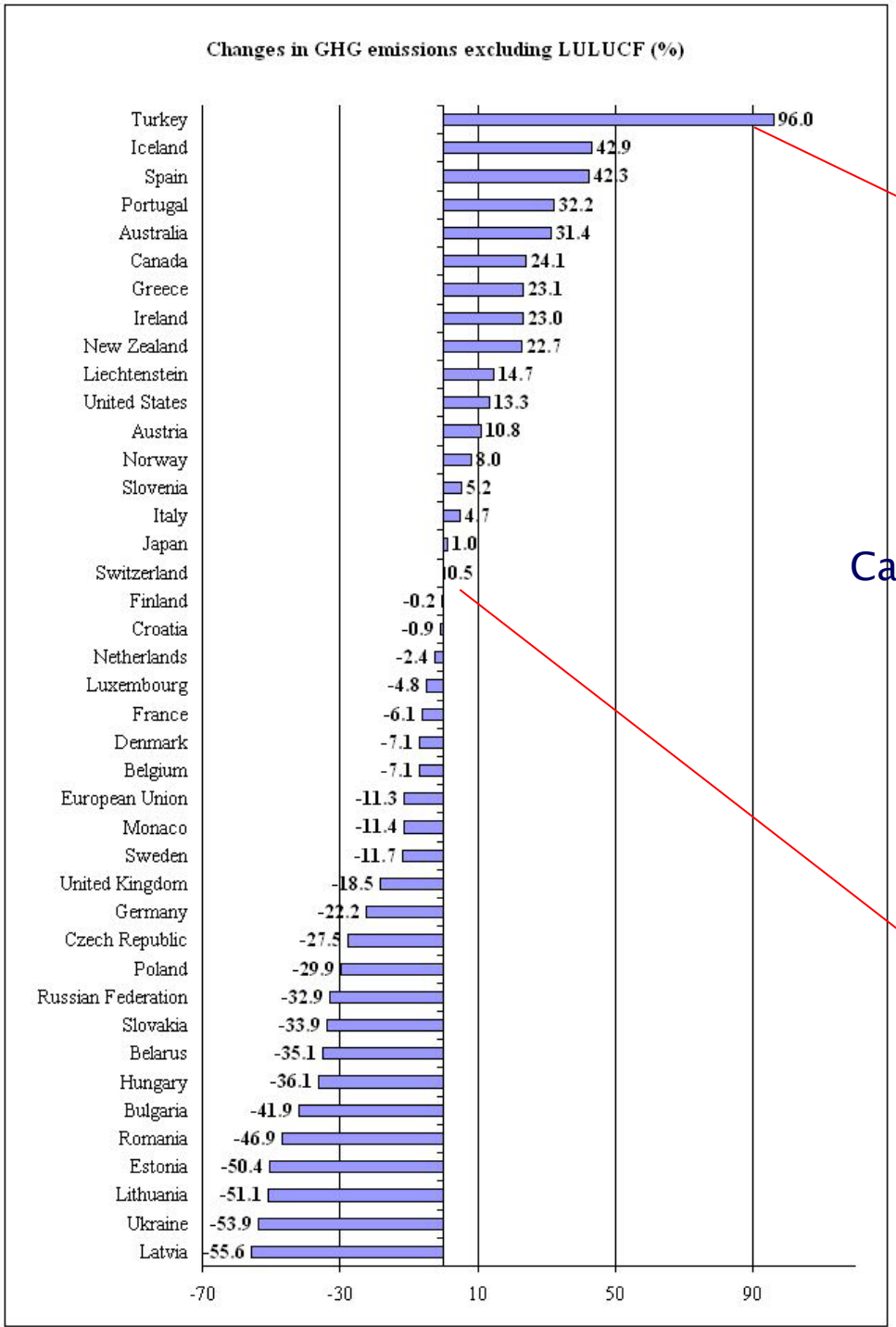
1997: COP 3, Kyoto

Mandatory targets on greenhouse-gas emissions for the world's leading economies.

Targets range from –8% to +10% of countries' individual 1990 emissions levels

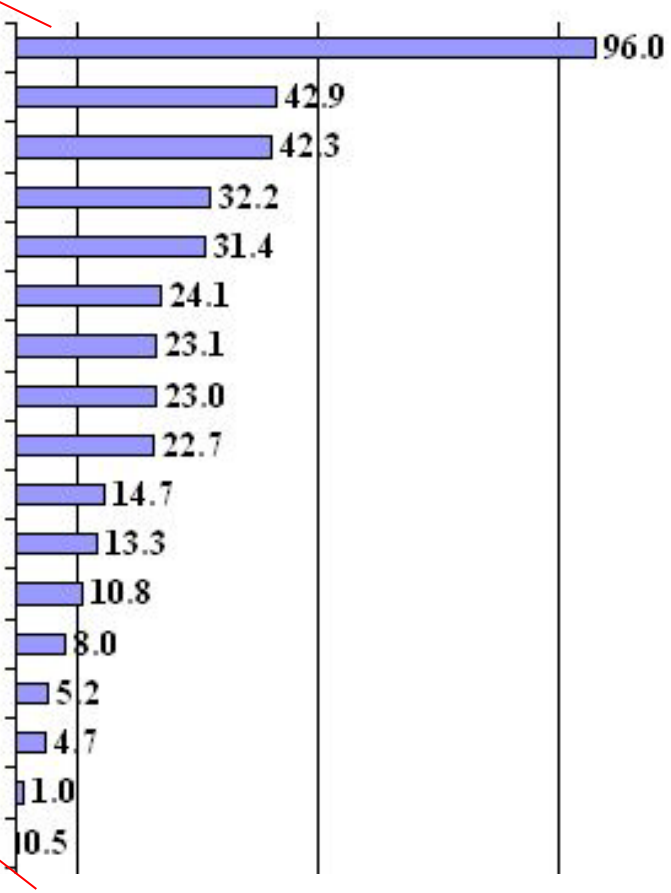
"with a view to reducing their overall emissions of such gases by at least 5 per cent below existing 1990 levels in the commitment period 2008 to 2012"

Changes in GHG emissions 1990 to 2008

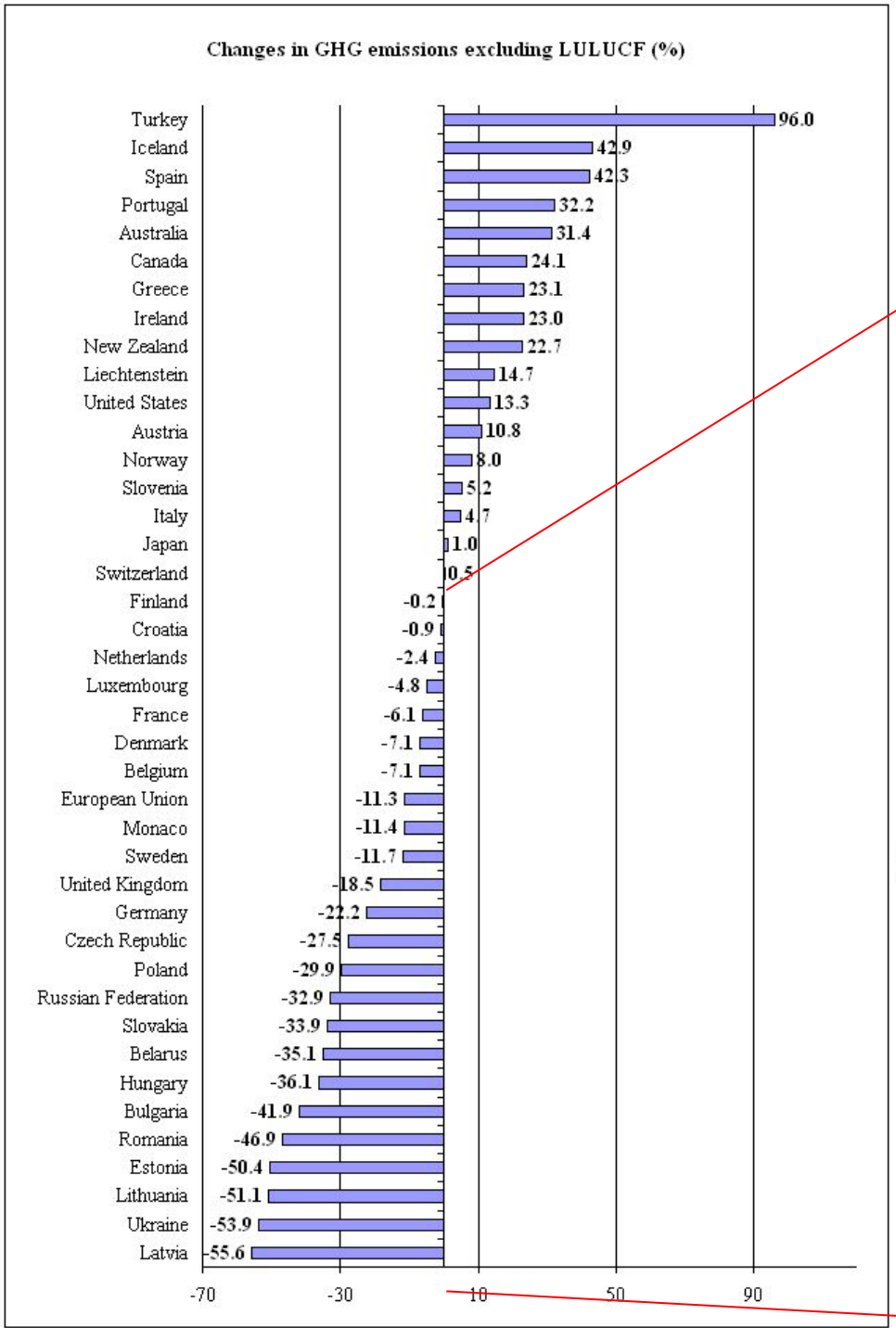


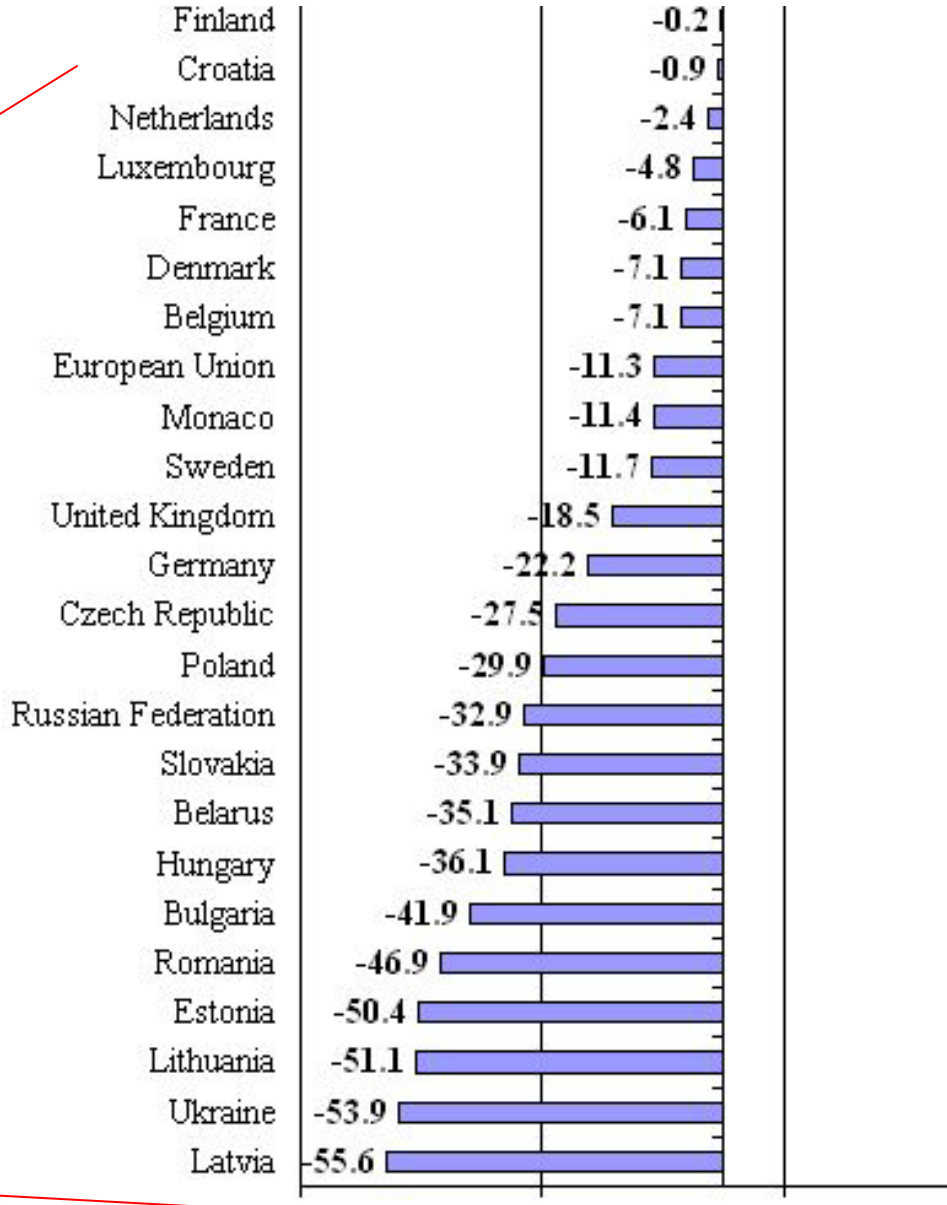
Canada

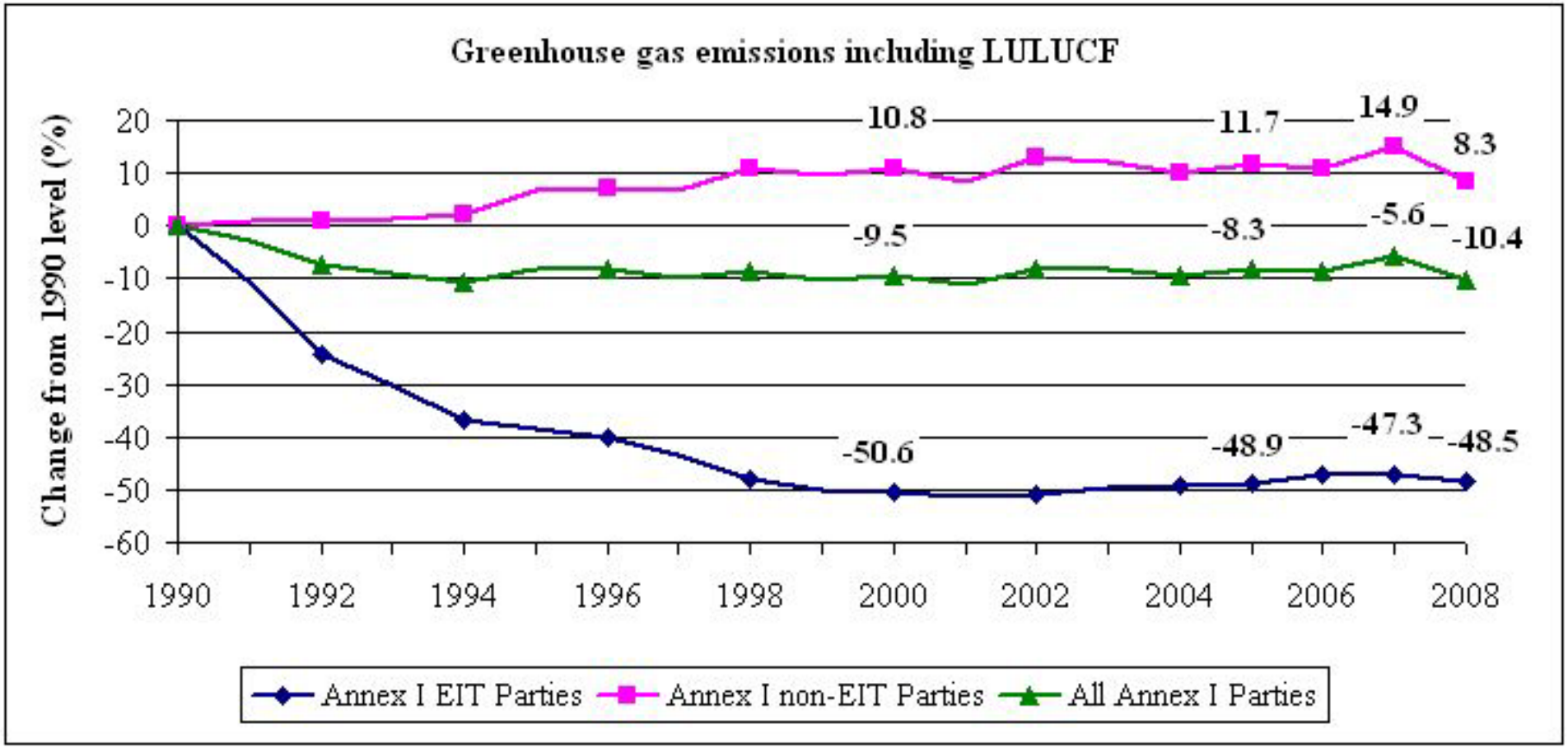
U.S.A.



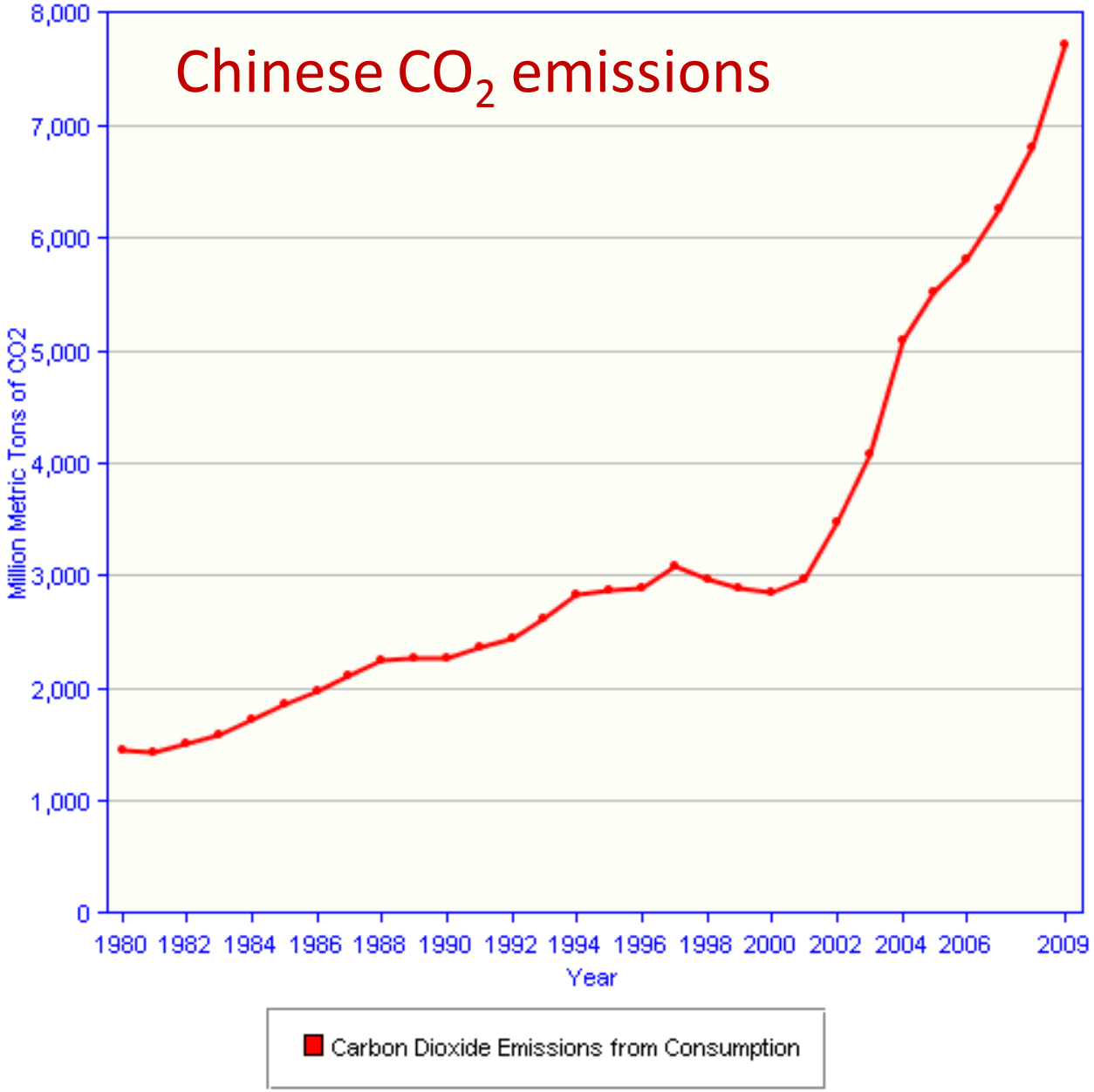
Changes in GHG emissions 1990 to 2008

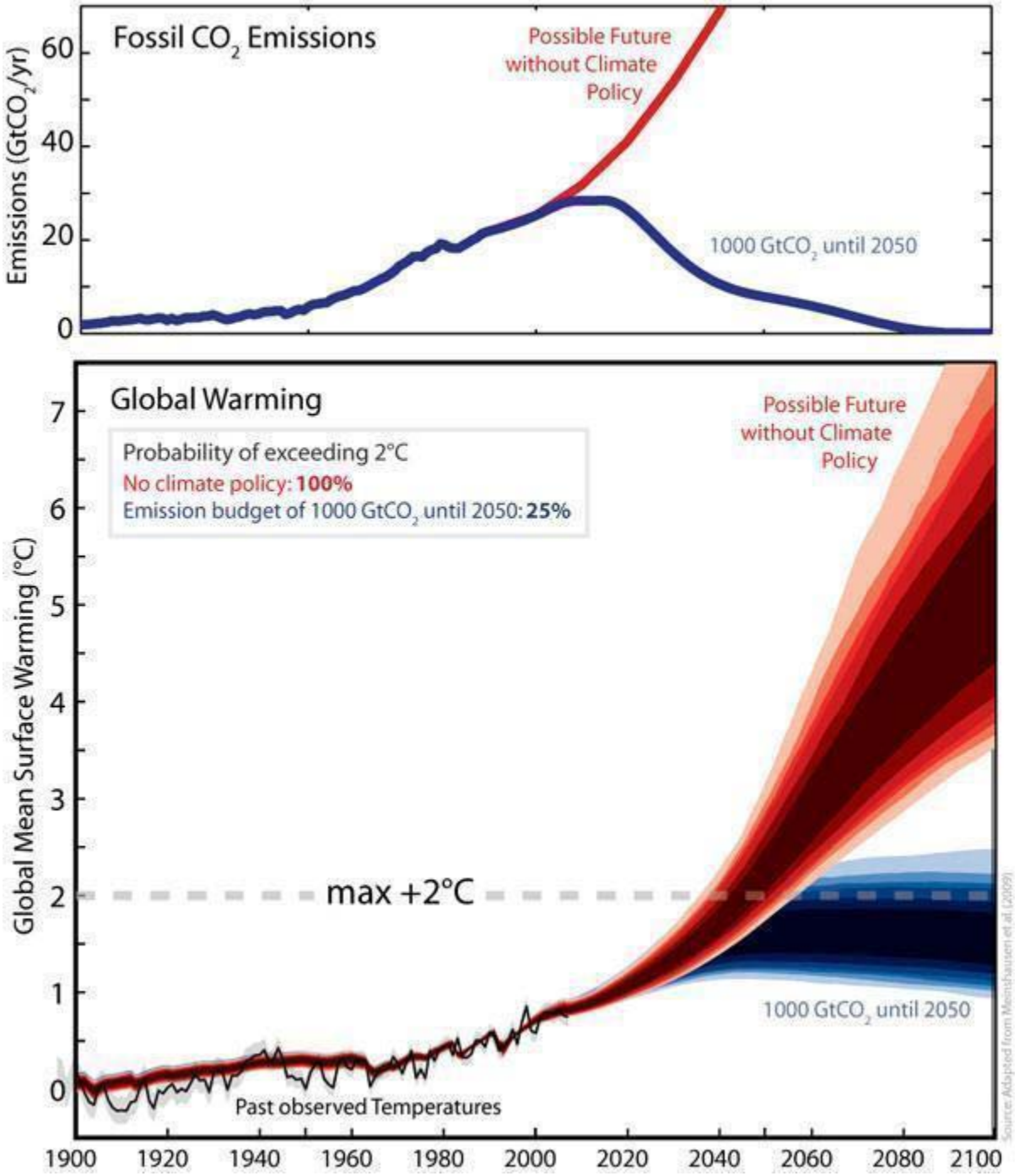


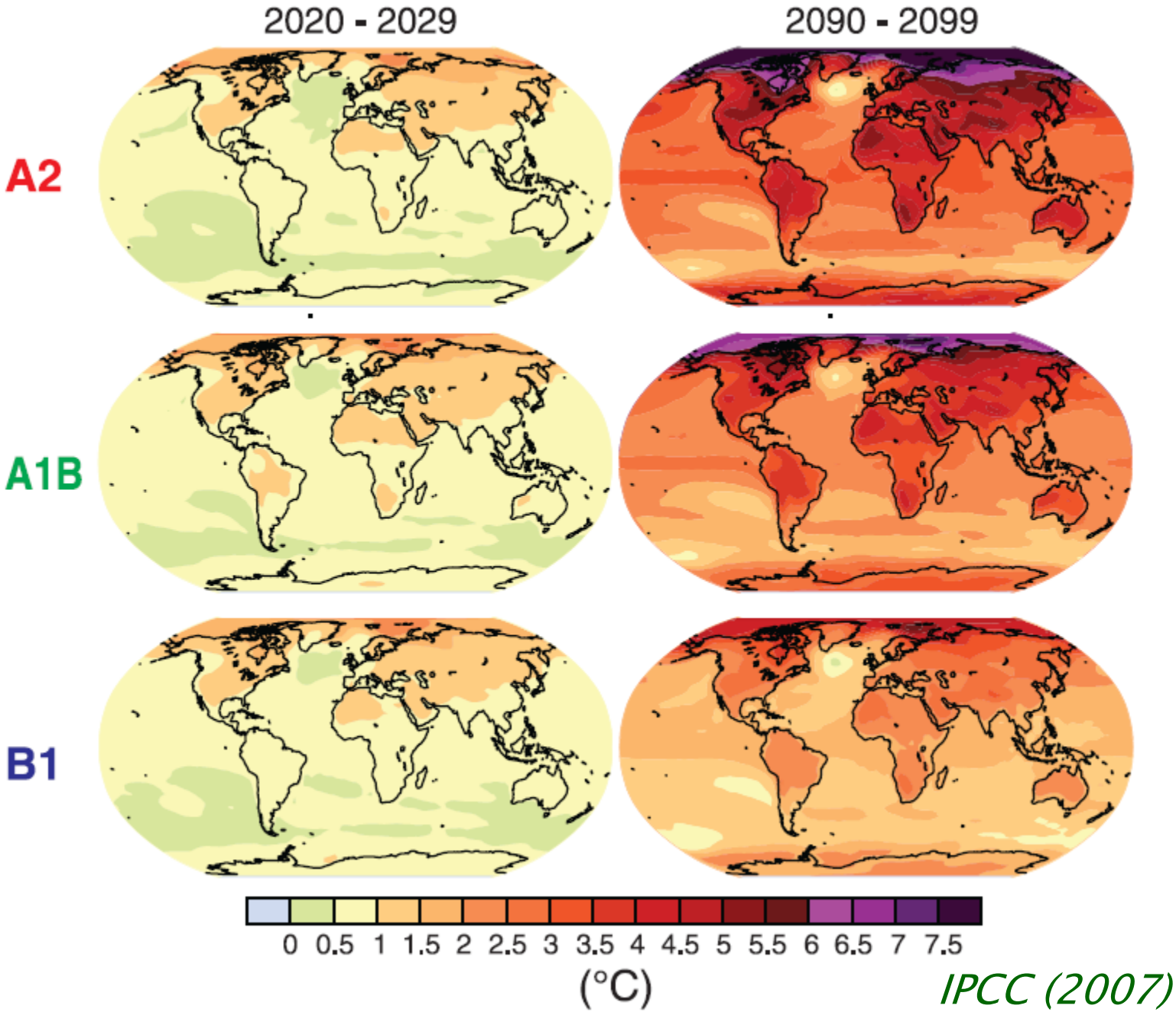




http://unfccc.int/di/DetailedByGas.do

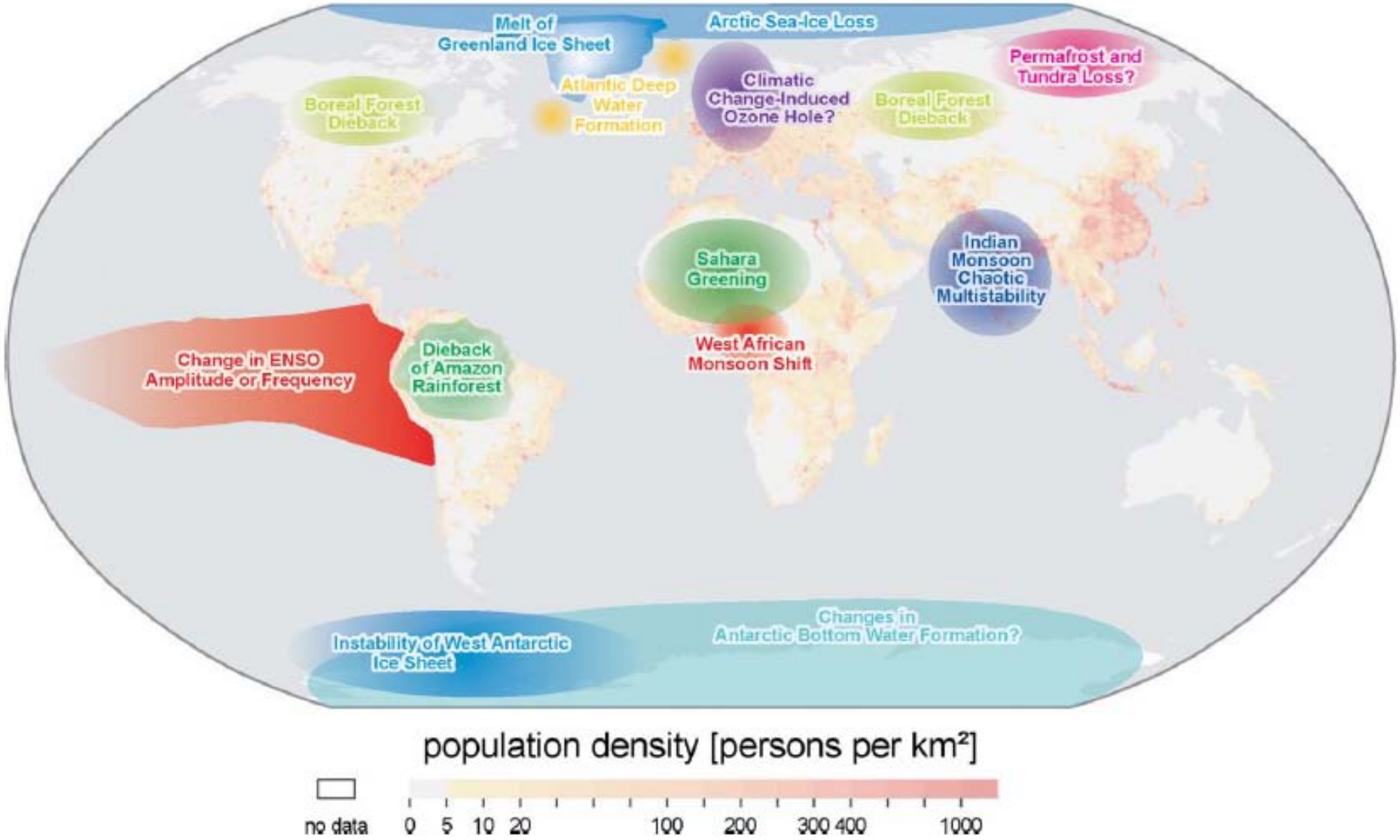

Chinese CO_2 emissions
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Million Metric Tons of CO2
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2009
Year
Carbon Dioxide Emissions from Consumption


Fossil CO_2 Emissions
Possible Future without Climate Policy
1000 $GtCO_2$ until 2050
Emissions ($GtCO_2$/yr)
0
20
40
60
Global Warming
Probability of exceeding 2°C
No climate policy: 100%
Emission budget of 1000 $GtCO_2$ until 2050: 25%
Possible Future without Climate Policy
max +2°C
1000 $GtCO_2$ until 2050
Past observed Temperatures
Global Mean Surface Warming (°C)
0
1
2
3
4
5
6
7
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Source: Adapted from Meinshausen et al. (2009)



IPCC (2007)

Potential ‘tipping elements’ in Earth’s climate



Lenton et al., 2008

General Comments On Climate Models

Like weather forecasts,
"Too speculative to trust, but too good to ignore"

A few important points:

- Good at certain things, lousy at others
- Forecasting the mean climate state is a much simpler problem than a weather forecast
- Not about the internal redistribution of energy, but the balance:

$$\rho c \frac{\partial T}{\partial t} = \text{Energy In} - \text{Energy Out}$$

Climate Change: Hedging our Bets

We don't know exactly what is ahead:

- natural forcings could make it warmer or colder than the simple GHG-driven trajectory we are on
- there are feedbacks that can go either way

But: What we *do* know about the climate system is that the basic thermodynamics make warming a good bet, and that feedbacks in the system are mostly positive.

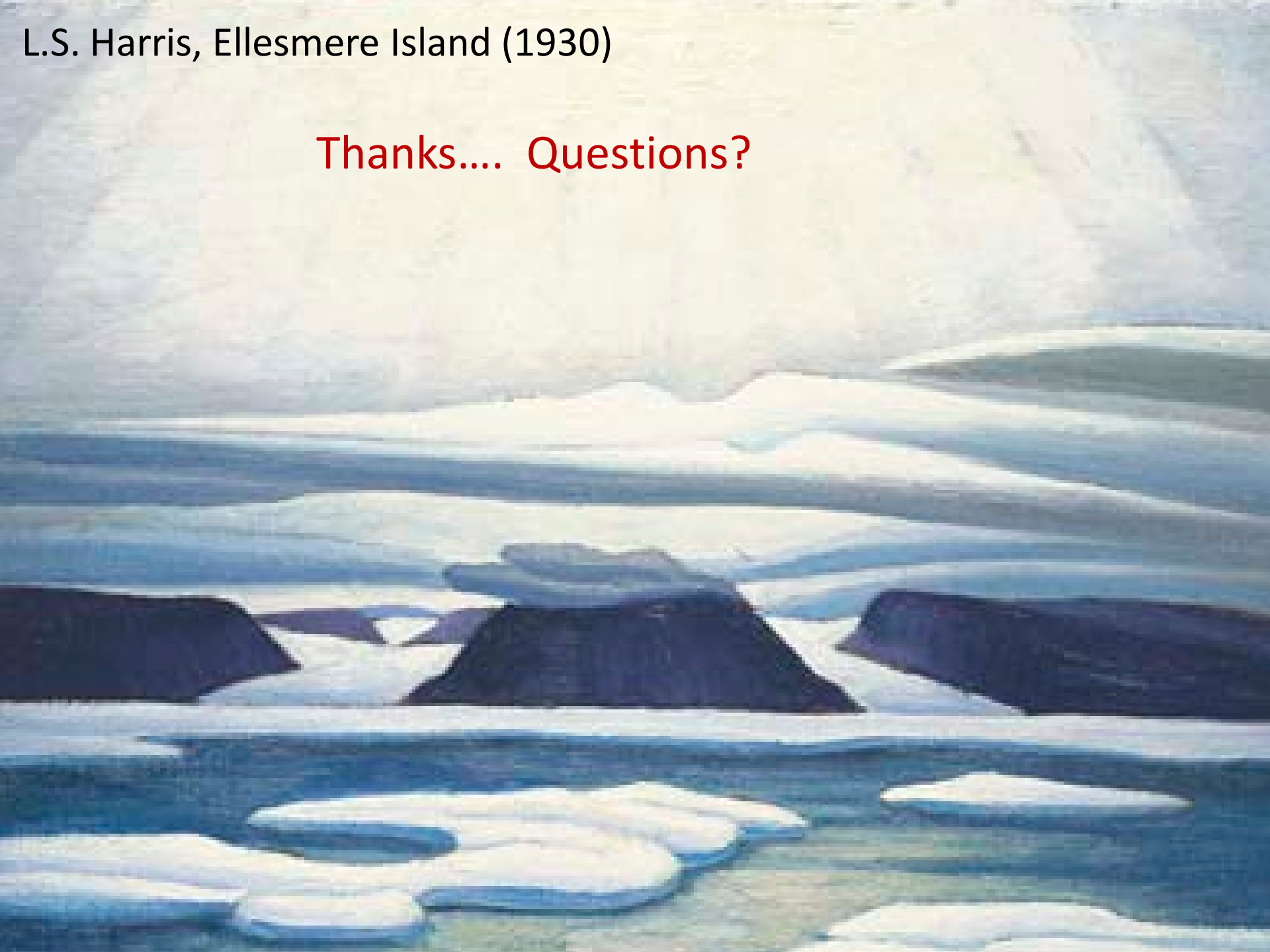
The conservative, rational thing to do is to play the odds and minimize our risks and negative impacts.

Climate Change: Cutting through the Rhetoric

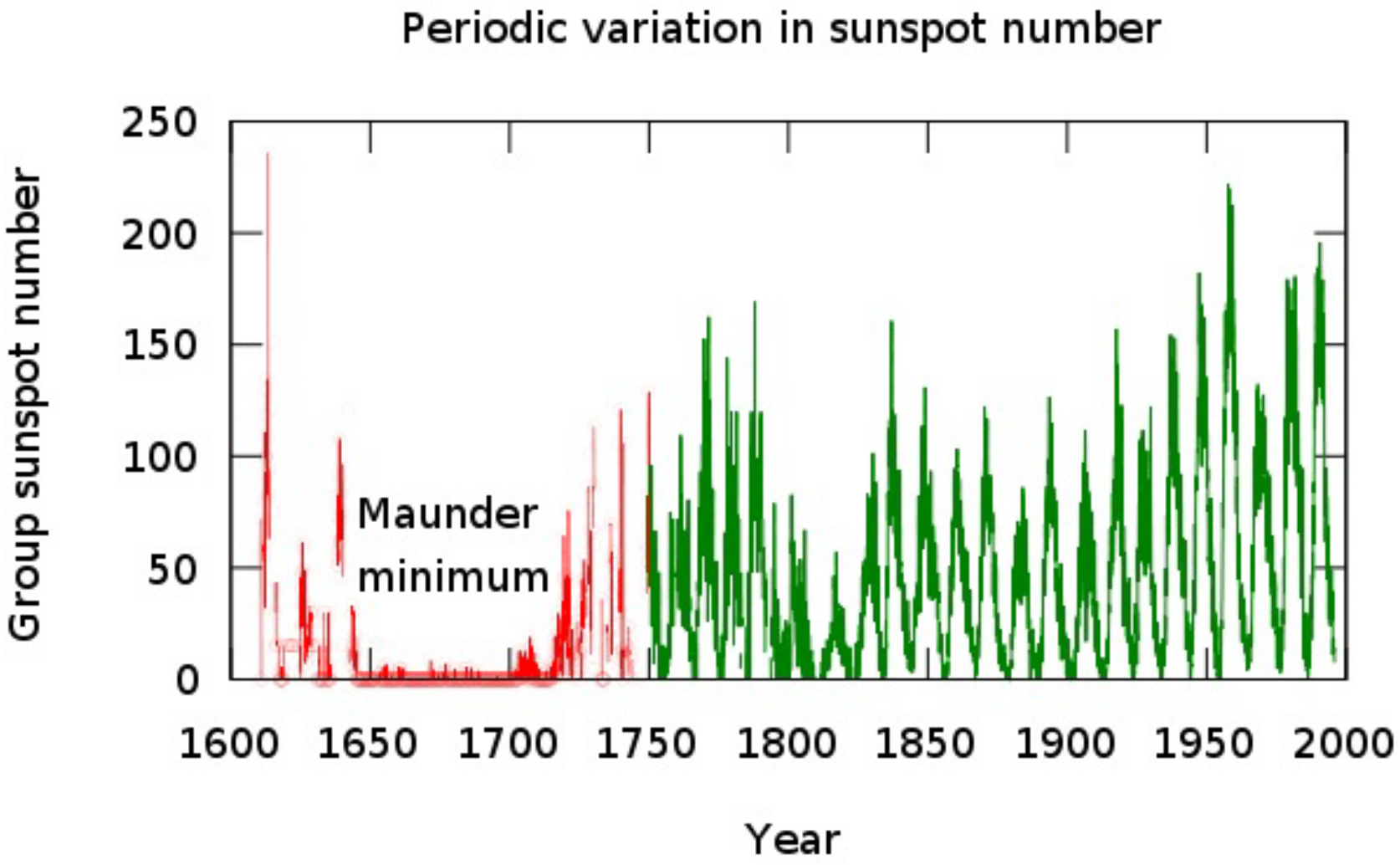
Can we reframe the question to:

"What kind of world do we want?"

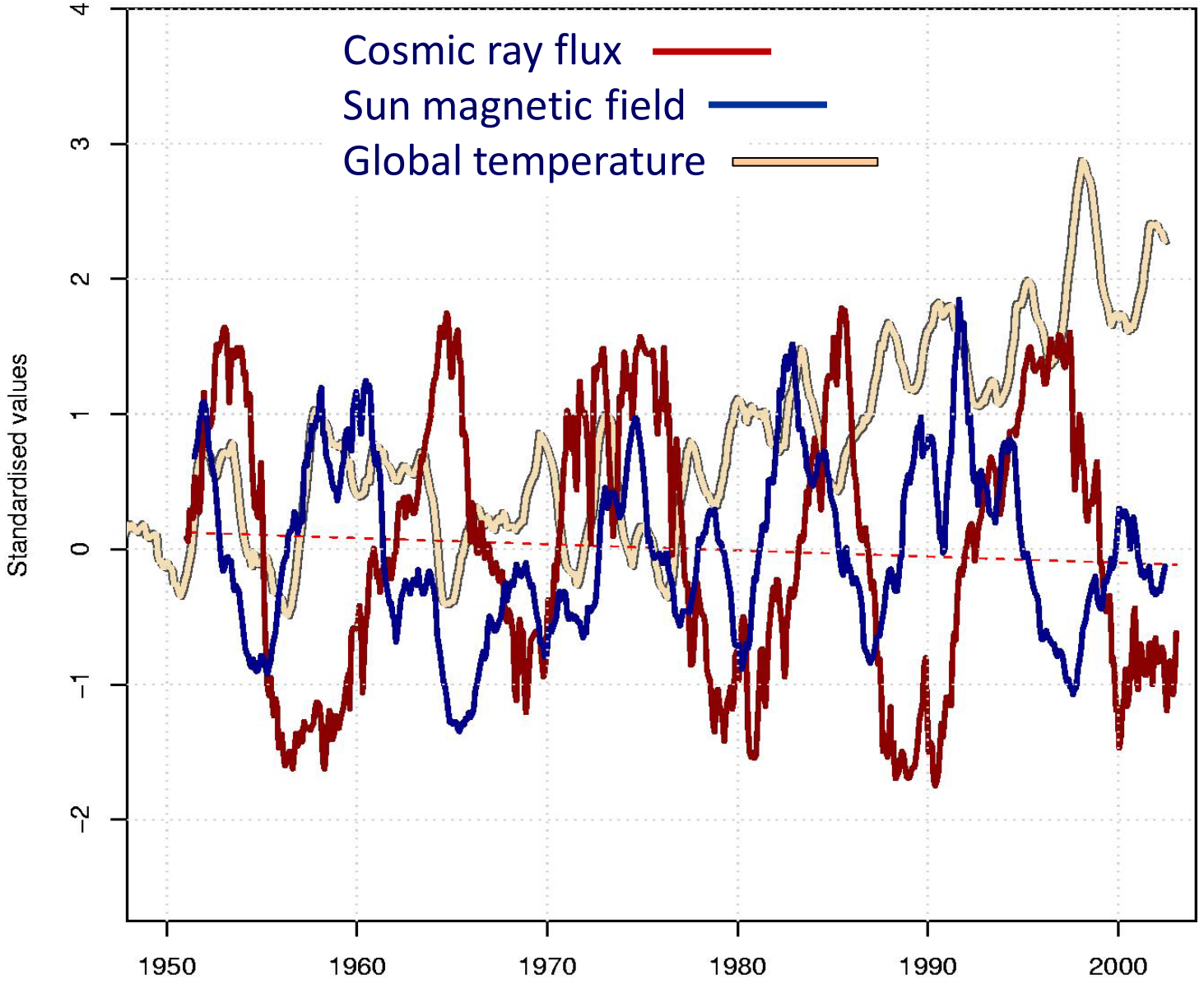

WC²N
WESTERN CANADIAN
CRYOSPHERIC NETWORK
NSERC
CRSNG
25 years
cifar
Canadian Institute for
Advanced Research
NUNAVUMMI QAUJISAQTULIRIJIKKUT - NUNAVUT RESEARCH INSTITUTE
Canadian Foundation for Climate
and Atmospheric Sciences (CFCAS)
Fondation canadienne pour les sciences
du climat et de l'atmosphère (FCSCA)


L.S. Harris, Ellesmere Island (1930)
Thanks…. Questions?

Spare slides



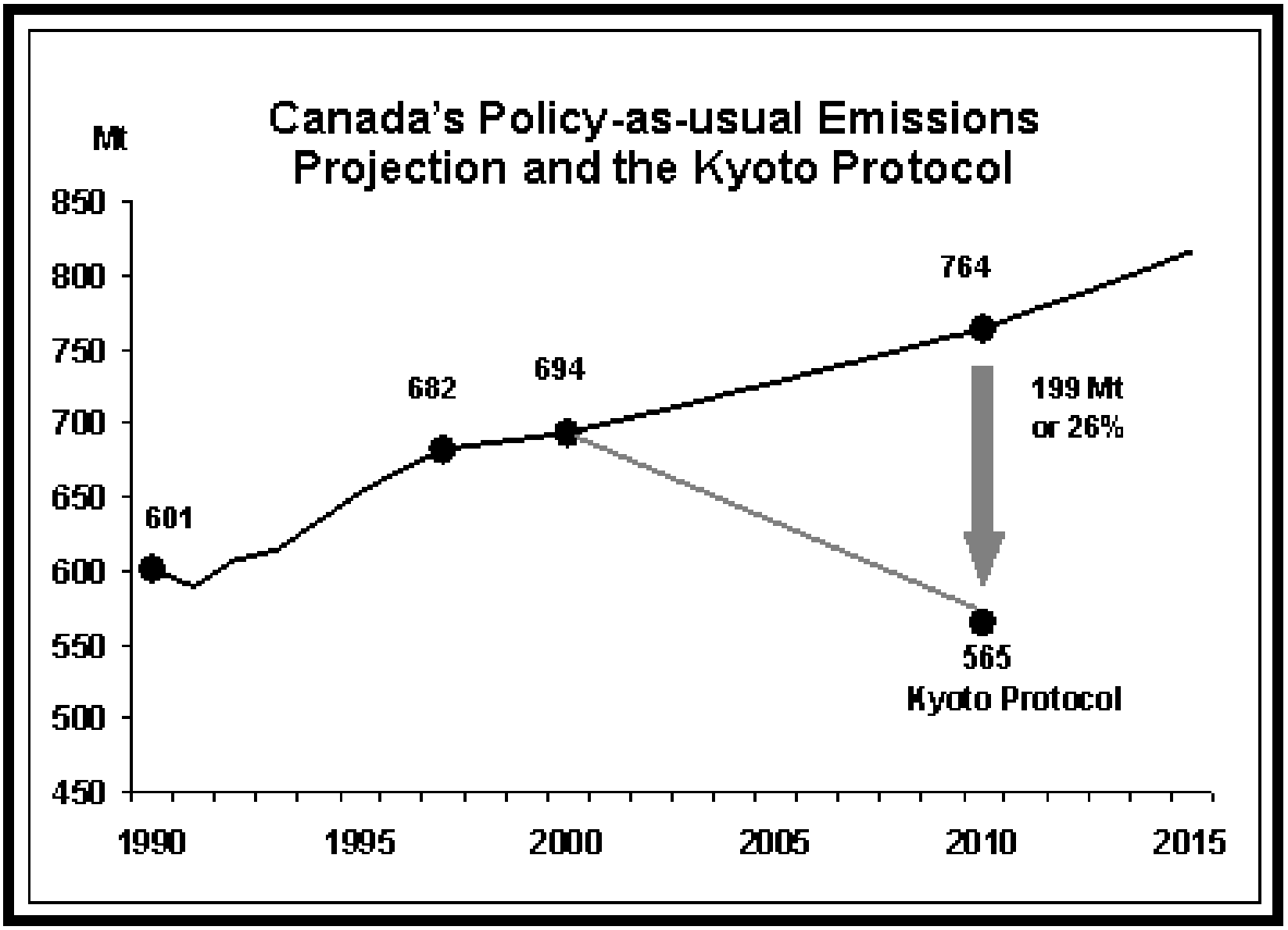
Duhau and Jager, 2010

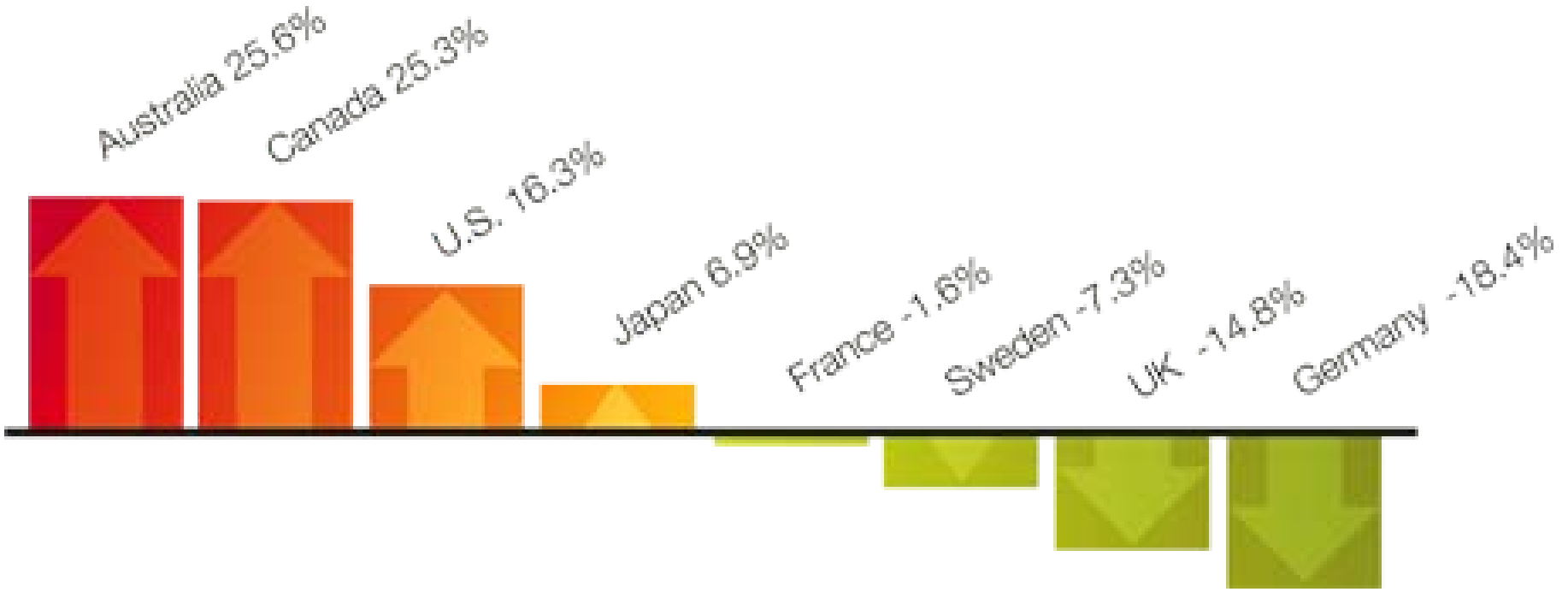


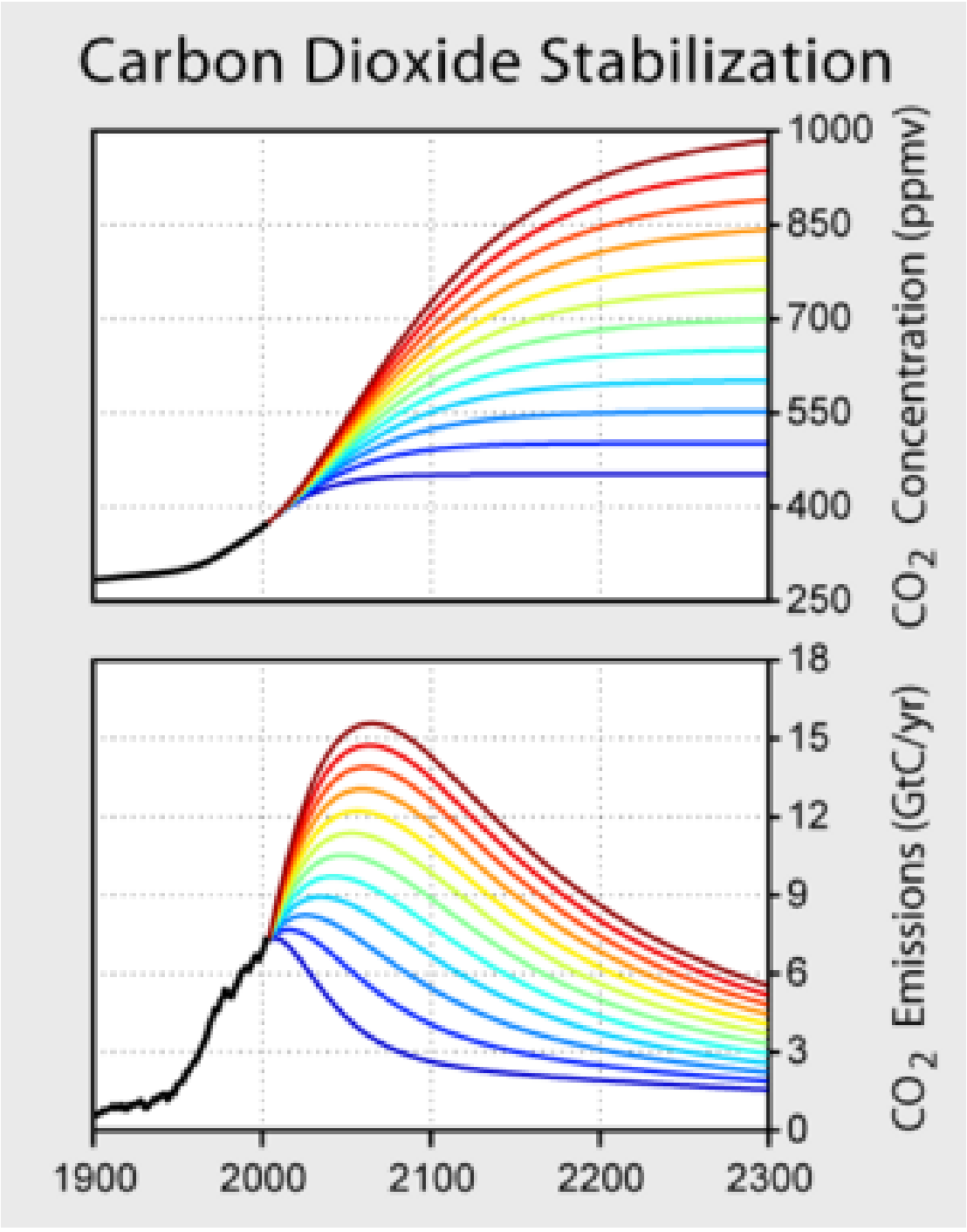
See e.g. Benestad, R.E. (2002) Solar Activity and Earth's Climate, Praxis-Springer, Berlin and Heidelberg, 287 pp.

Summary, Primary Climate Forcings (W/m^2)

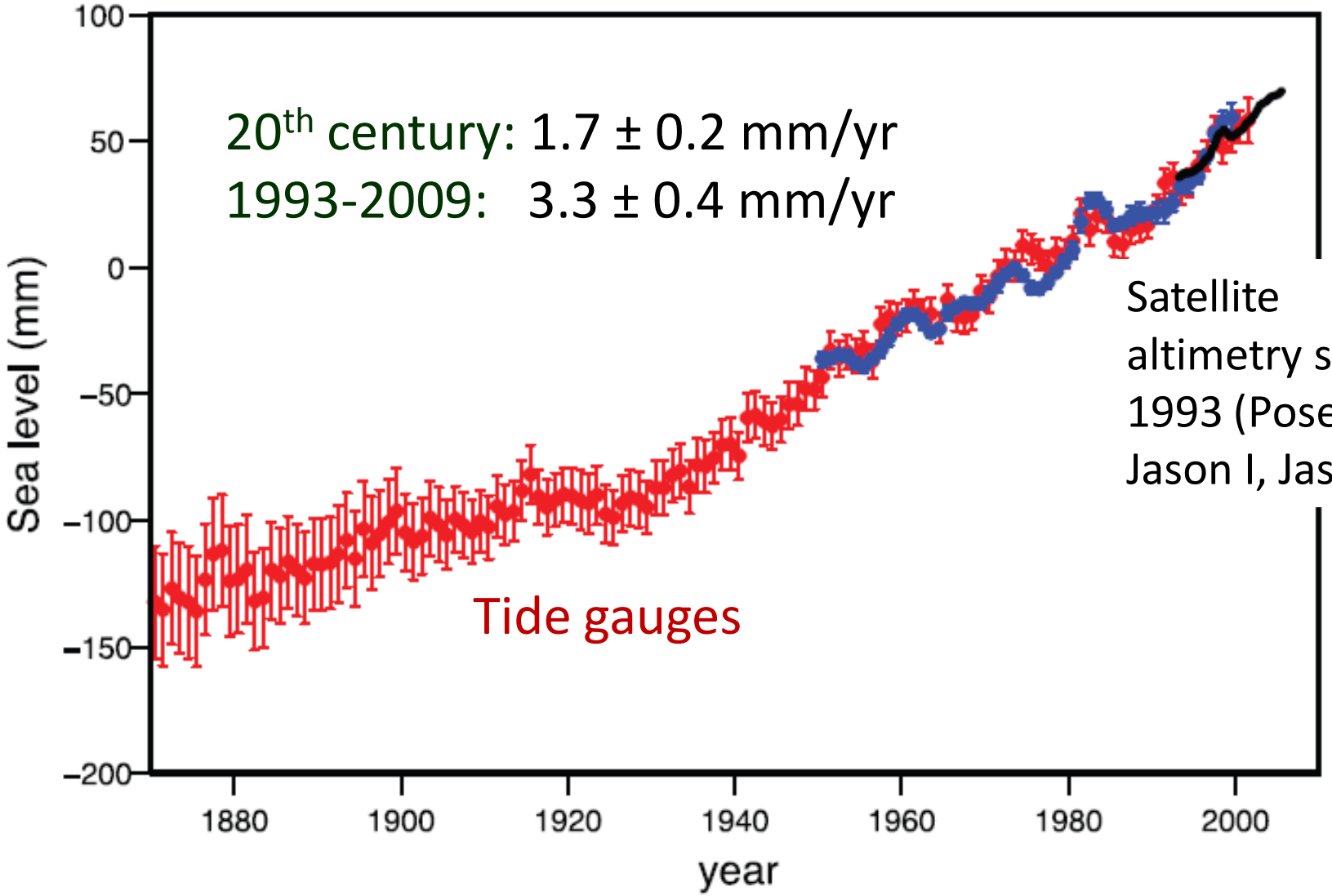
	0-2000 AD (W/m^2)	1900-2000 (W/m^2)
Volcanic	–0.21	–0.27
Aerosol	–0.03	–0.50
Solar	+0.04	+0.41
Greenhouse gases	+0.01	**+1.10**


Canada's Policy-as-usual Emissions Projection and the Kyoto Protocol
Mt
850
800
750
700
650
600
550
500
450
1990
1995
2000
2005
2010
2015
601
682
694
764
565
199 Mt or 26%
Kyoto Protocol

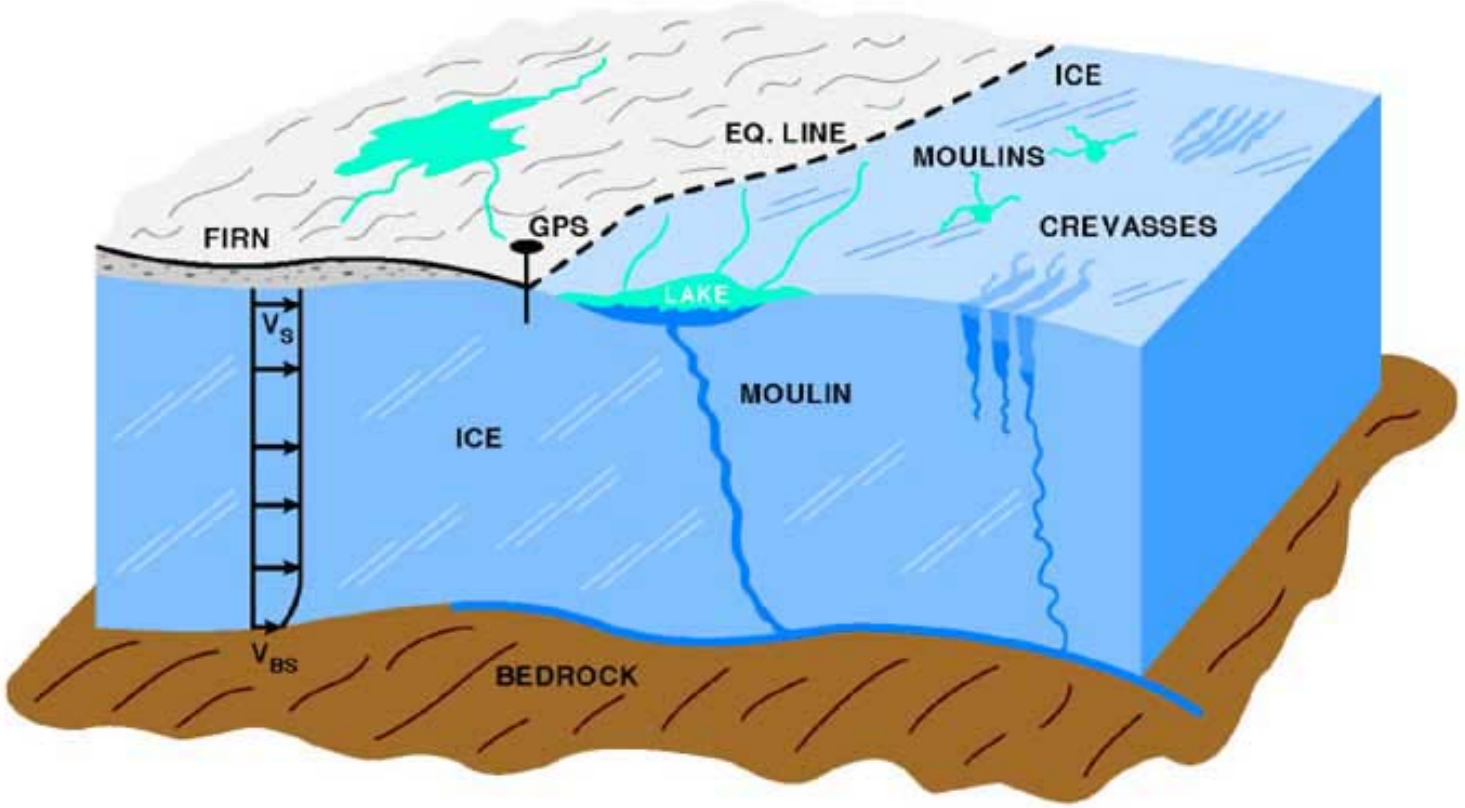

Australia 25.6%
Canada 25.3%
U.S. 16.3%
Japan 6.9%
France -1.6%
Sweden -7.3%
UK -14.8%
Germany -18.4%


Carbon Dioxide Stabilization
1000
850
700
550
400
250
CO2 Concentration (ppmv)
18
15
12
9
6
3
0
CO2 Emissions (GtC/yr)
1900
2000
2100
2200
2300

Observed sea level rise



IPCC (2007)



Wet base = potential speedup

Climate Change Policy

1997: COP 3, Kyoto

Required ratification from at least 55 parties to the Convention, representing at least 55% of global CO_2 emissions, to come into effect

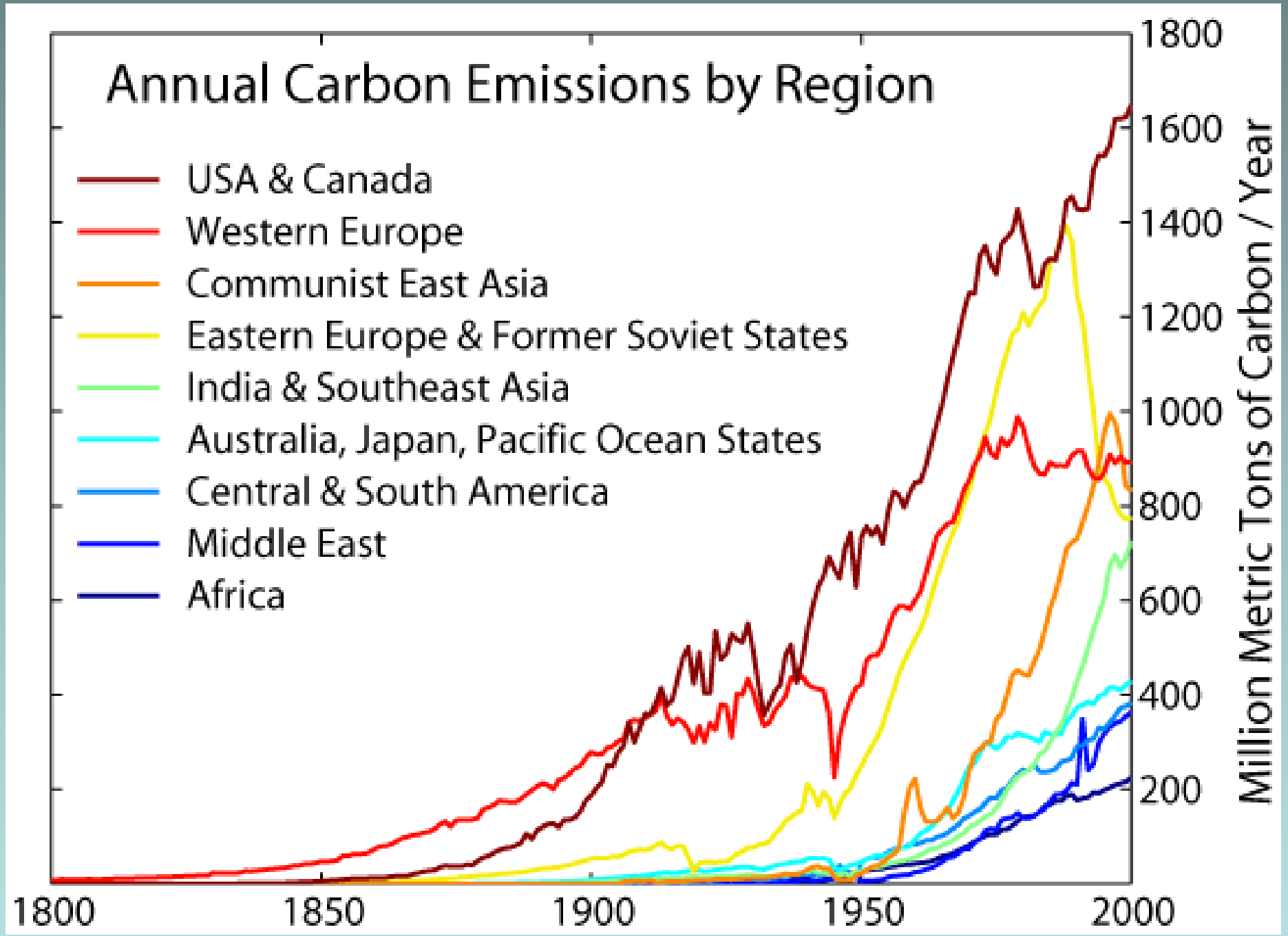
Stalled for several years. Canada (3.3%) ratified in 2002. Russia (17.6%) ratified November, 2004.

Legally came into effect, February 16, 2005

156 of 162 countries accepted, representing 61.6% of global emissions

COP15
COPENHAGEN

UN CLIMATE CHANGE CONFERENCE 2009


Annual Carbon Emissions by Region
USA & Canada
Western Europe
Communist East Asia
Eastern Europe & Former Soviet States
India & Southeast Asia
Australia, Japan, Pacific Ocean States
Central & South America
Middle East
Africa
1800
1600
1400
1200
1000
800
600
400
200
Million Metric Tons of Carbon / Year
1800
1850
1900
1950
2000