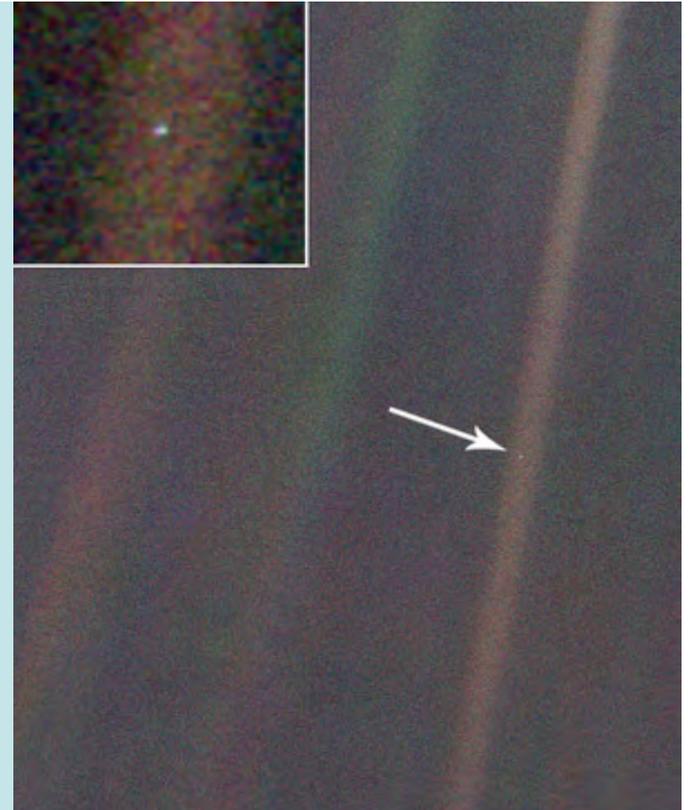


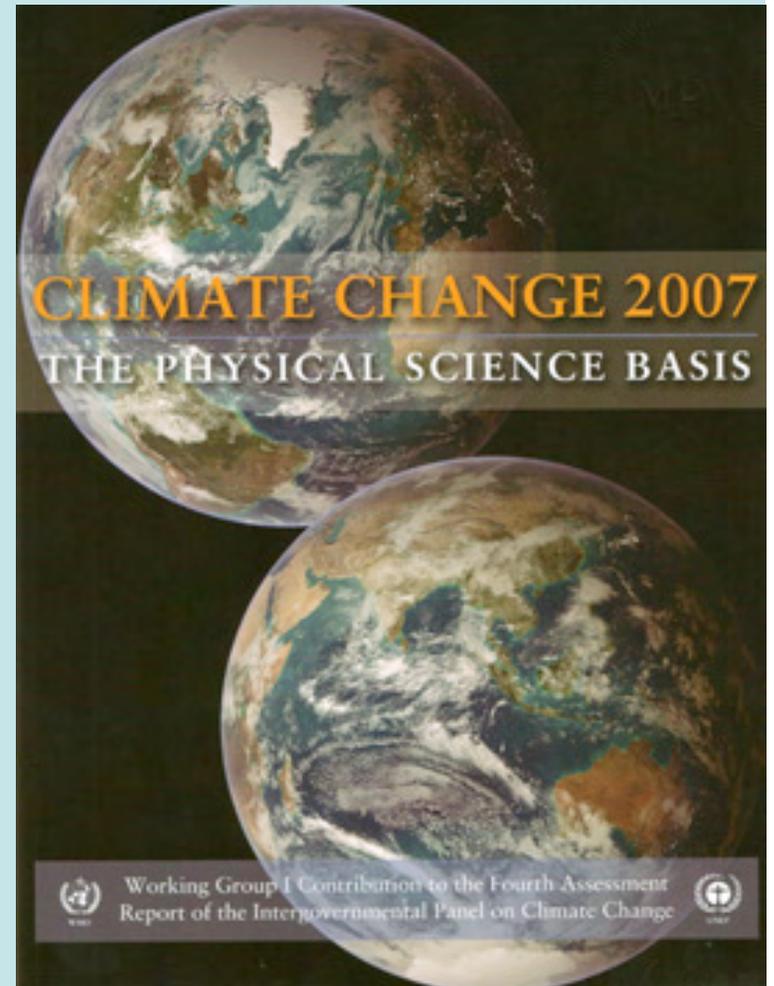
Global Warming Is “Unequivocal”

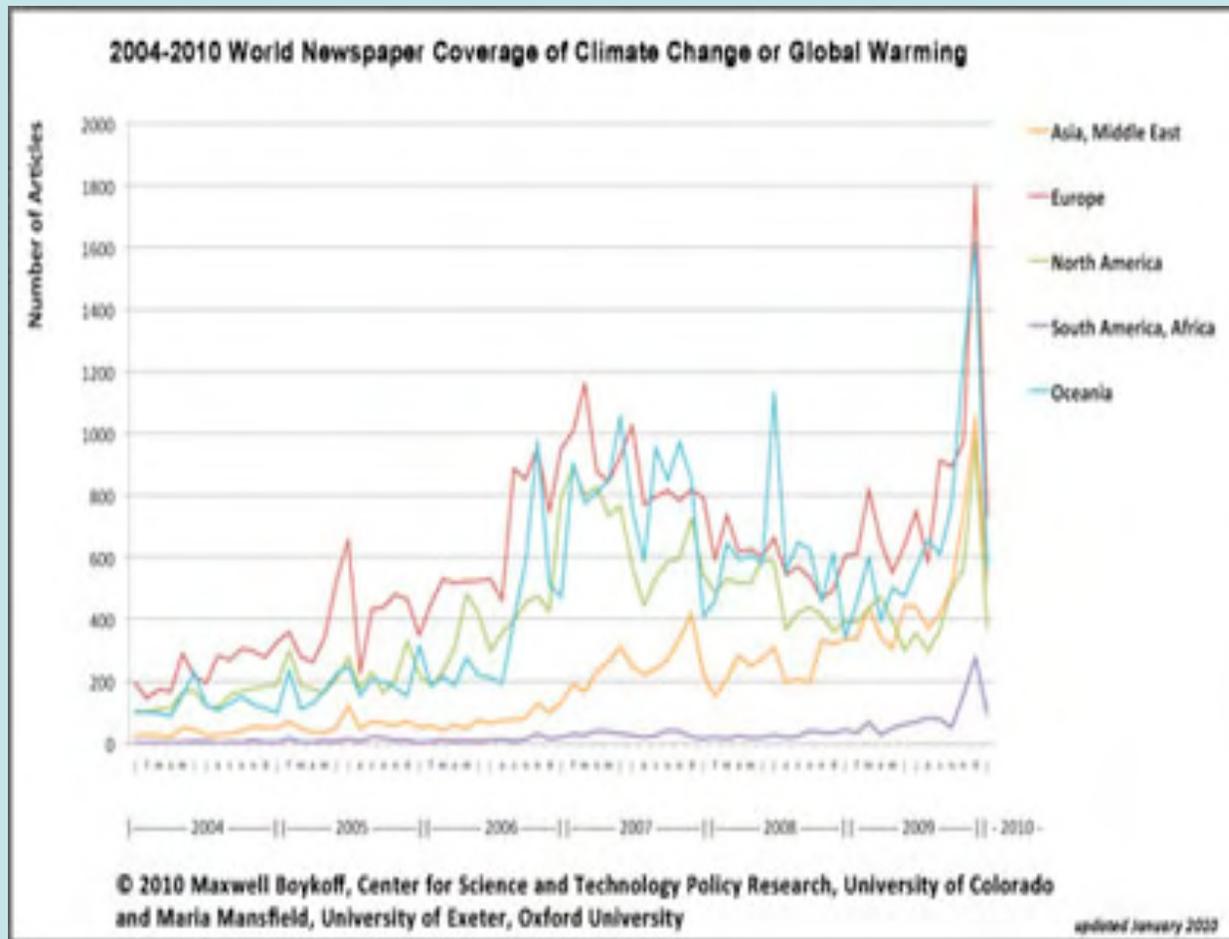
R H Gammon
University of Washington

Padilla Bay
September 16, 2010



- “Warming of the climate system is
- **unequivocal...**
- as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea...”
-
- The IPCC (‘07) finds that it is “**very likely**” (90 to 95% confidence) that emissions of heat trapping gases from human activities have caused **most** of the observed increase in globally averaged temperatures since the mid 20th century
-
- (IPCC 2007 Summary for Policymakers)



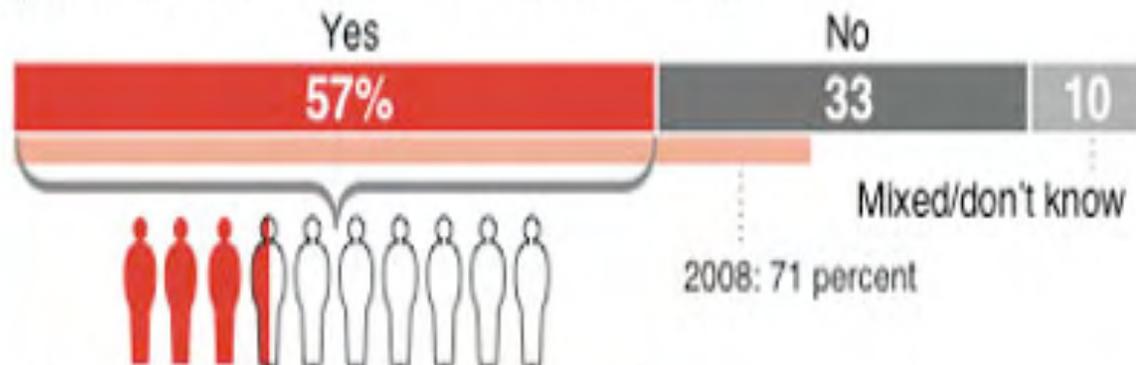


Lots of media attention (2007, 2009), but not accurate science coverage. He said, she said (false journalistic balance)

Fewer believe in global warming

In October 2009, 57 percent of Americans said there is solid evidence that the Earth is warming, down 14 percentage points from April 2008.

Q: Is there solid evidence the Earth is warming?



36 percent of those who answered yes, said temperatures are rising because of human activity

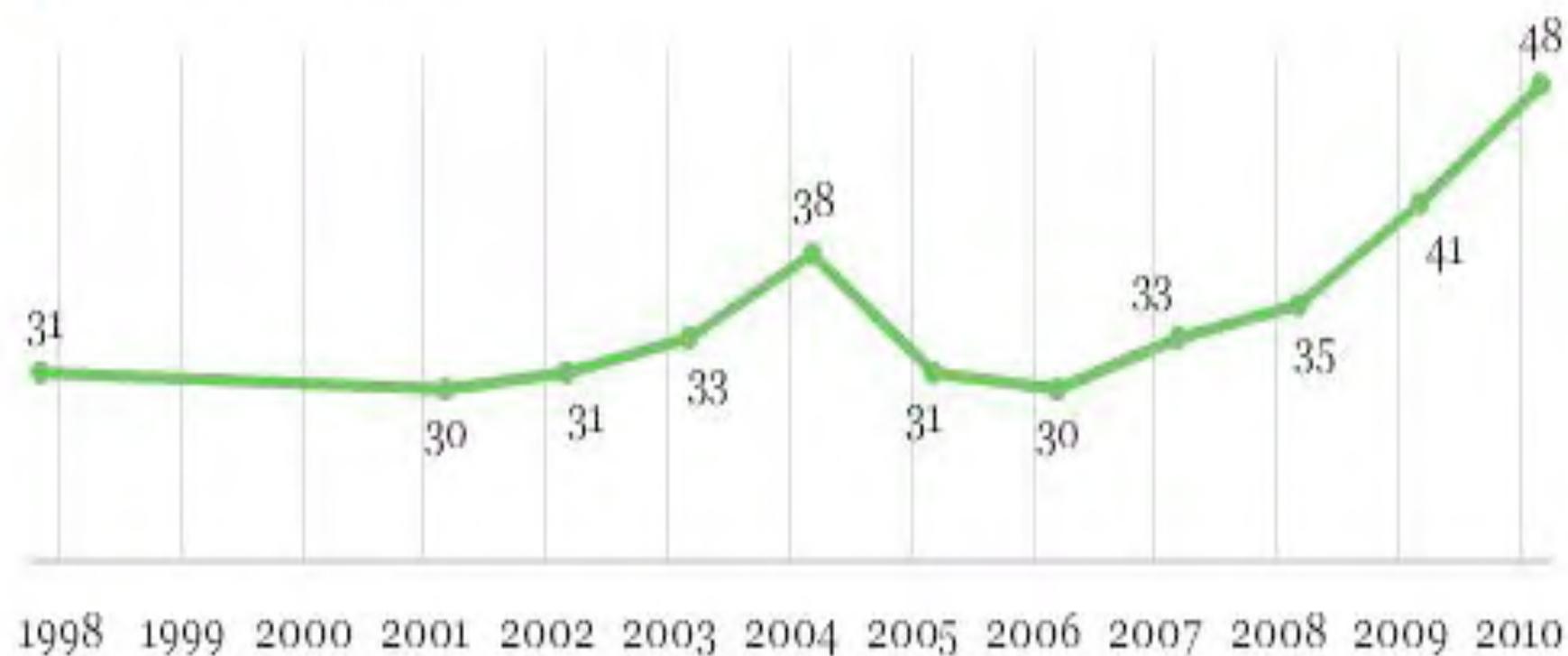
SOURCE: Pew Research Center

AP

How can this be happening?

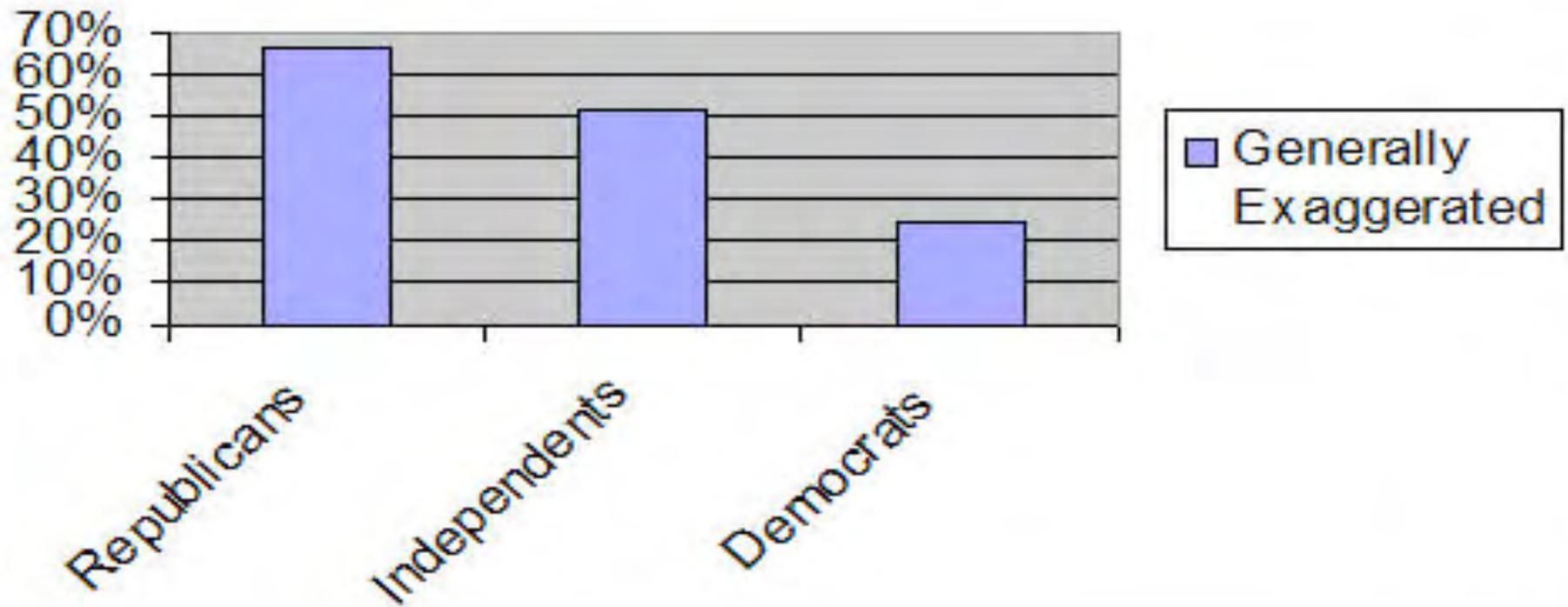
Thinking about what is said in the news, in your view is the seriousness of global warming -- [ROTATED: generally exaggerated, generally correct, or is it generally underestimated]?

■ % Generally exaggerated



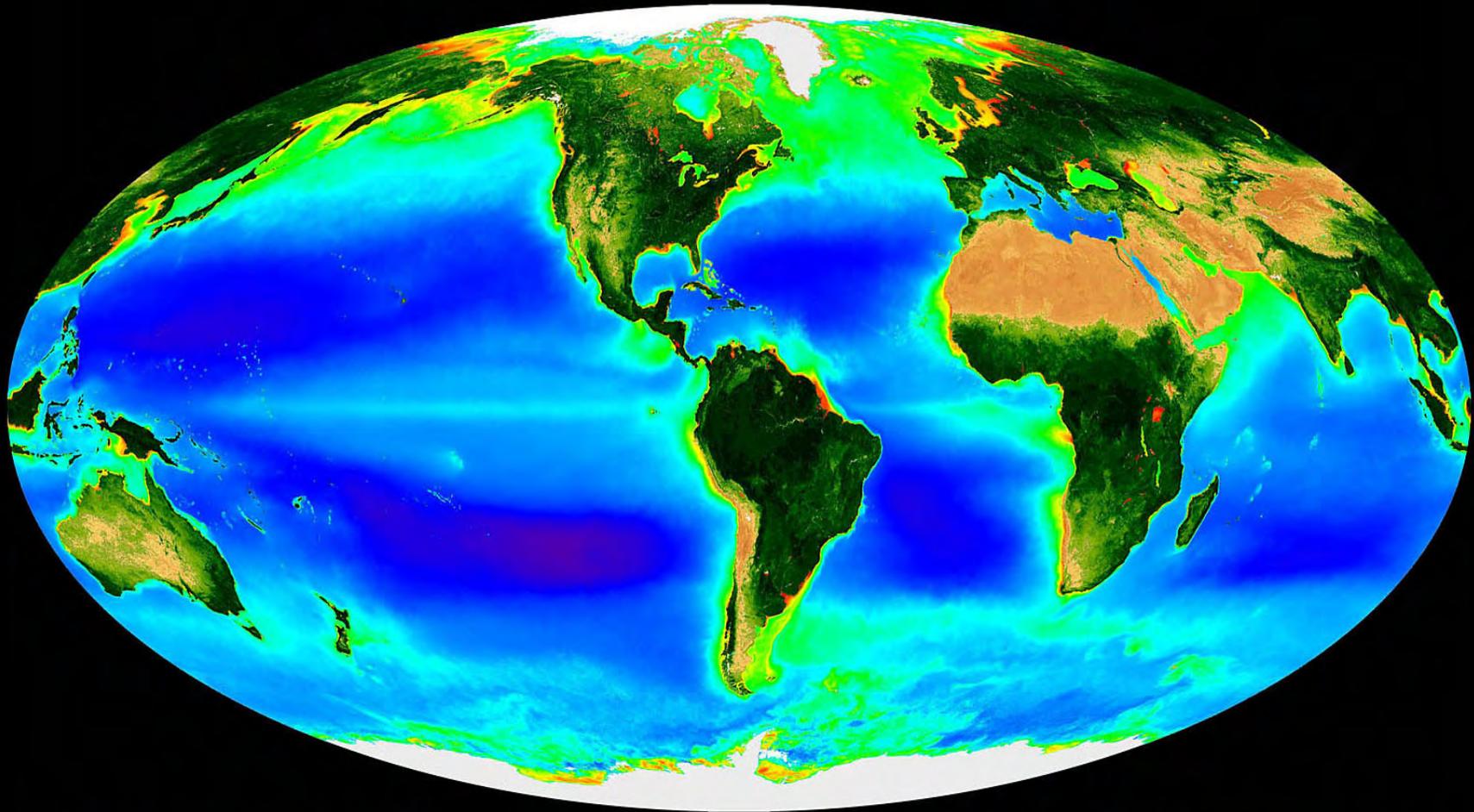
GALLUP®

Thinking about what is said in the news, in your view, is the seriousness of global warming...?



A growing partisan divide

First point: Earth is alive and responds to changing stimuli



Ocean Chlorophyll-a Concentration (mg/m³)



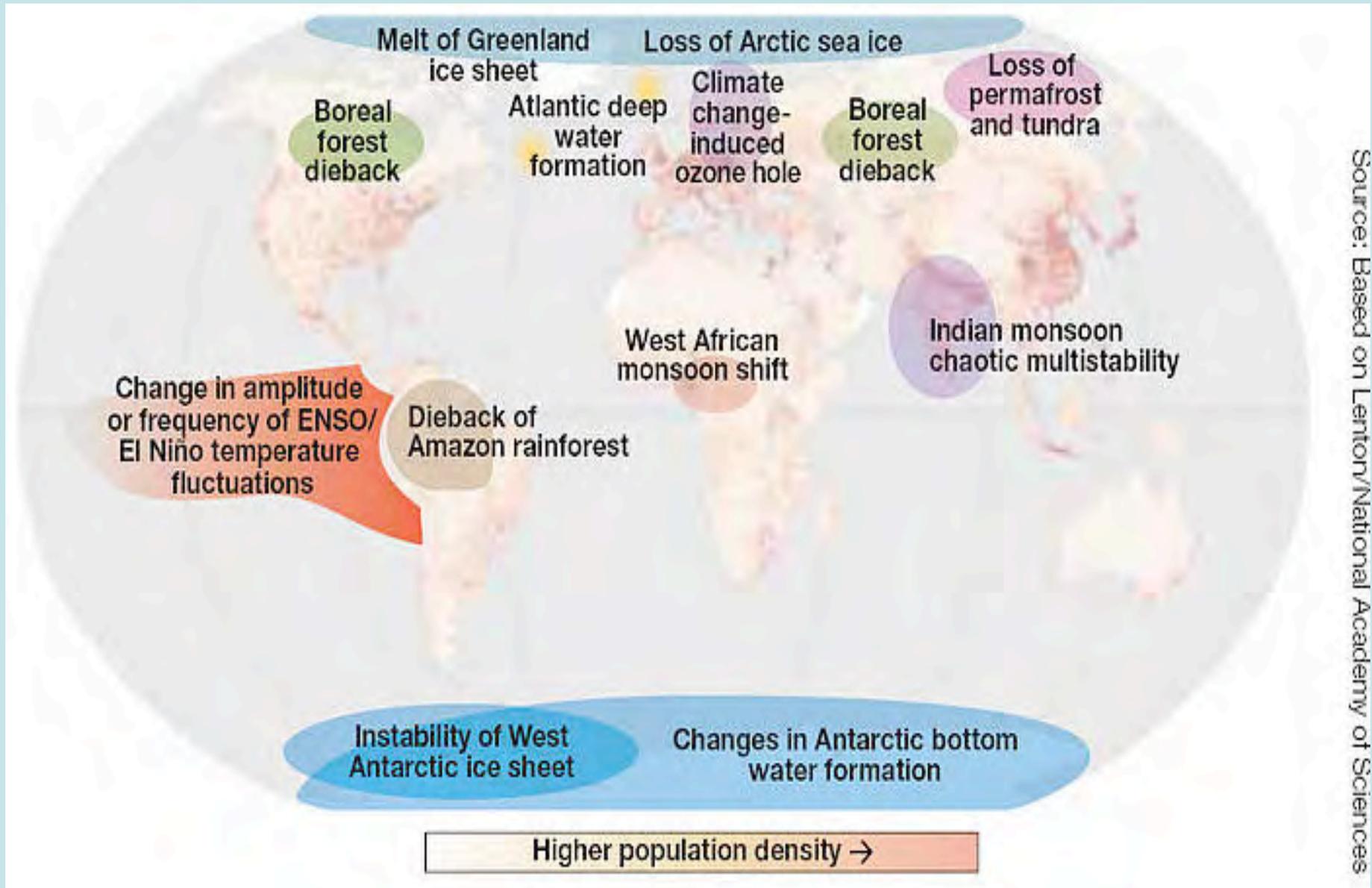
Land Normalized Difference Vegetation Index



Satellite image of the living Earth (NASA). Carbon feedbacks to climate change.

Some tipping points in the Earth System.

Q: Arctic sea-ice tipping point already passed?





CLIMATE
CHANGE
SCIENCE COMPENDIUM 2009

Managing Editor: Catherine P. McMullen
Associate Editor: Jason Jabbour



Recent climate
science update from
UN Environmental
Program ('09)

The Copenhagen Diagnosis

Updating the World on the Latest Climate Science



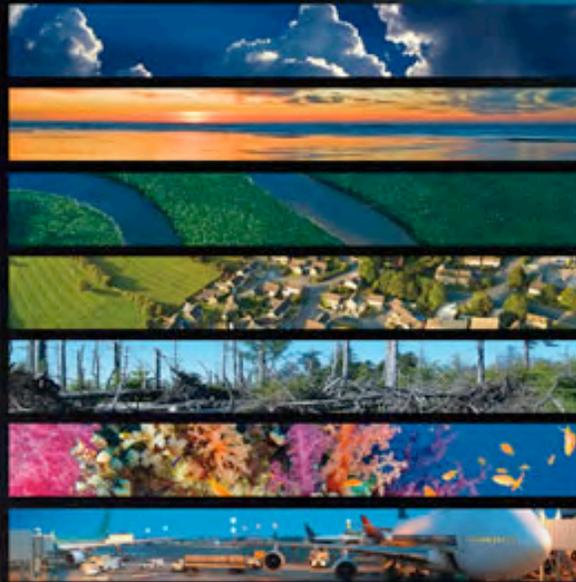
2009

Copenhagen Diagnosis (Fall, 2009)



OUR CHANGING PLANET

The U.S. Climate Change Science Program
for Fiscal Year 2009



A Report by the
Climate Change Science Program and
the Subcommittee on Global Change Research

A Supplement to the President's Budget for Fiscal Year 2009

Positive proof of global warming.



**18th
Century**

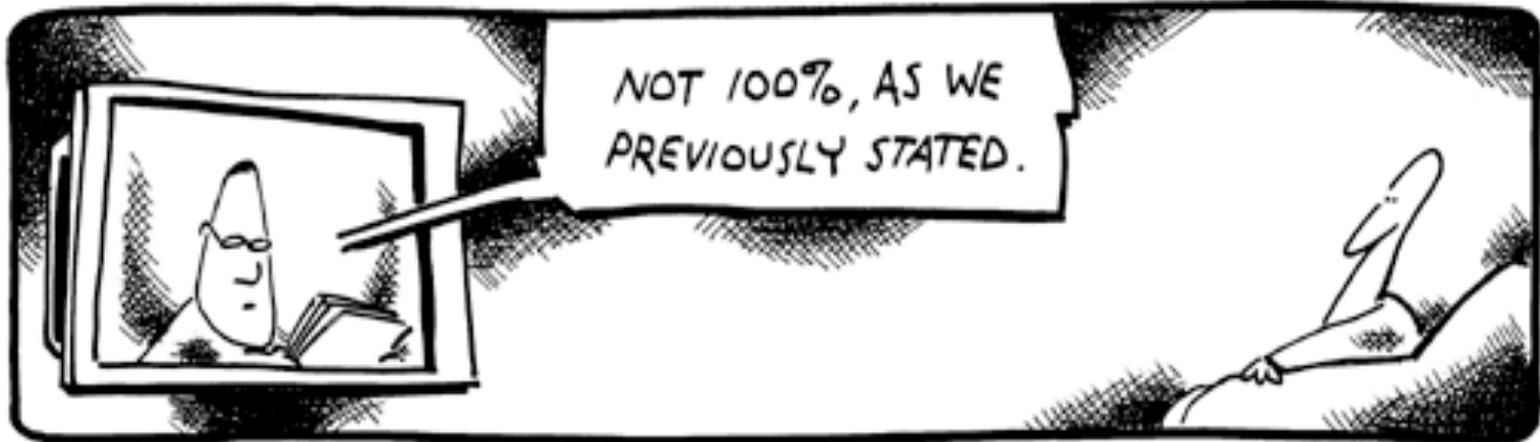
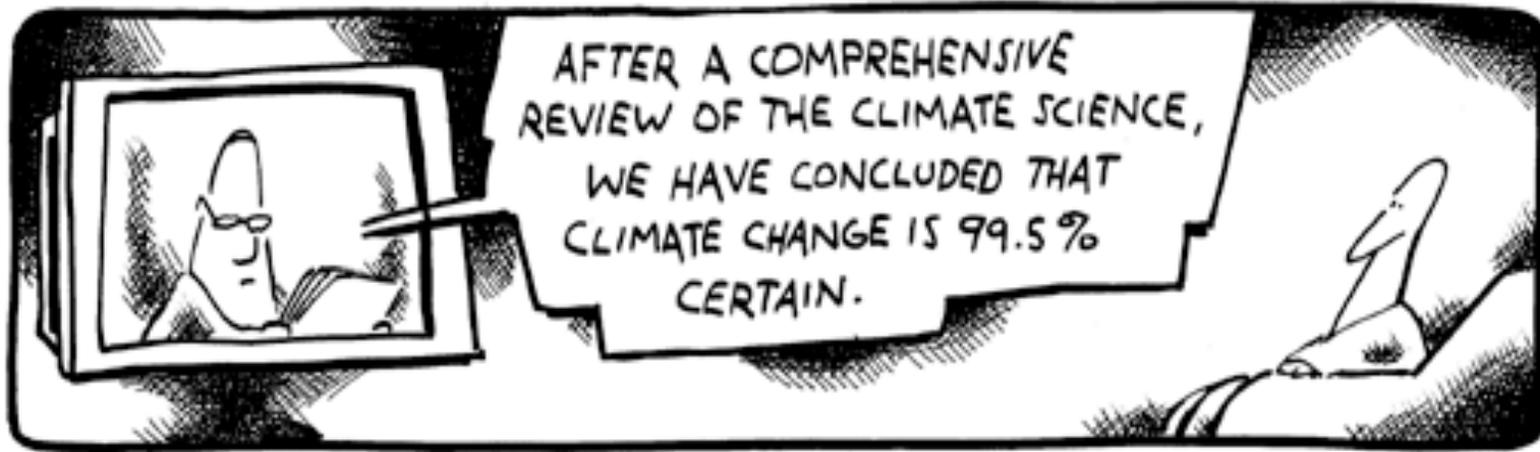
1900

1950

1970

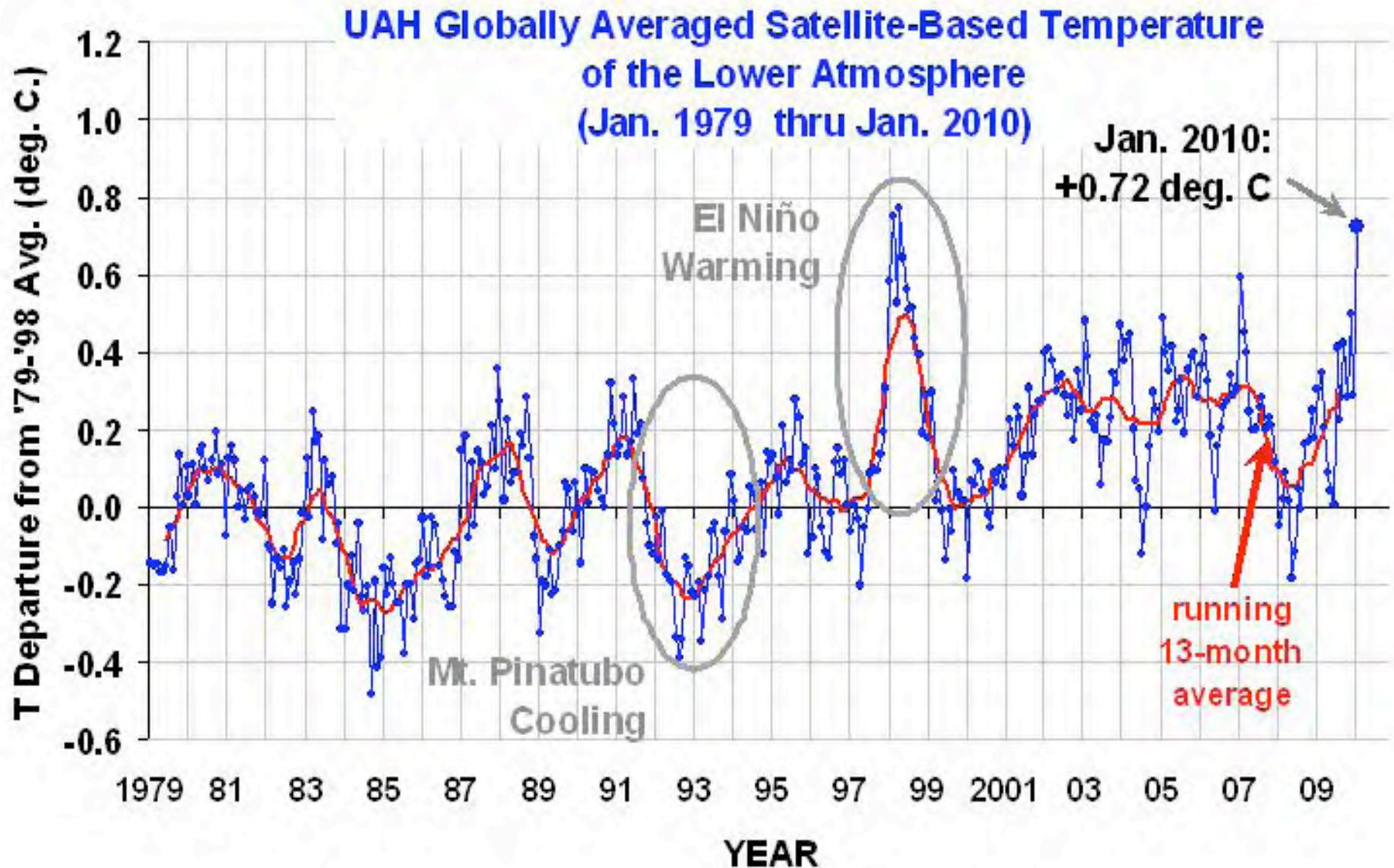
1980

1990



equivocal: having two or more meanings,
purposely ambiguous, doubtful, suspicious

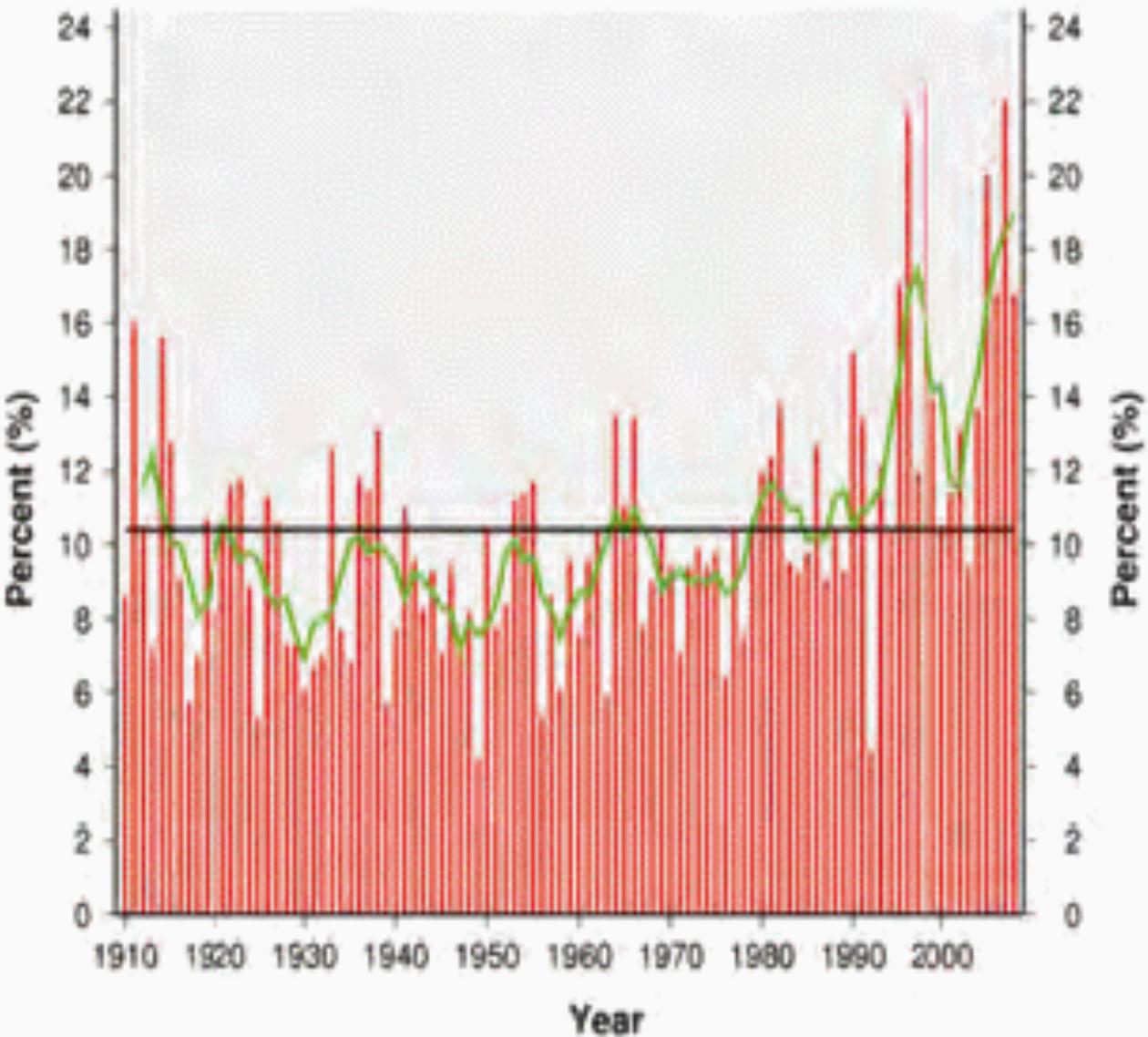
equivocate: to use equivocal terms in order
to deceive or mislead



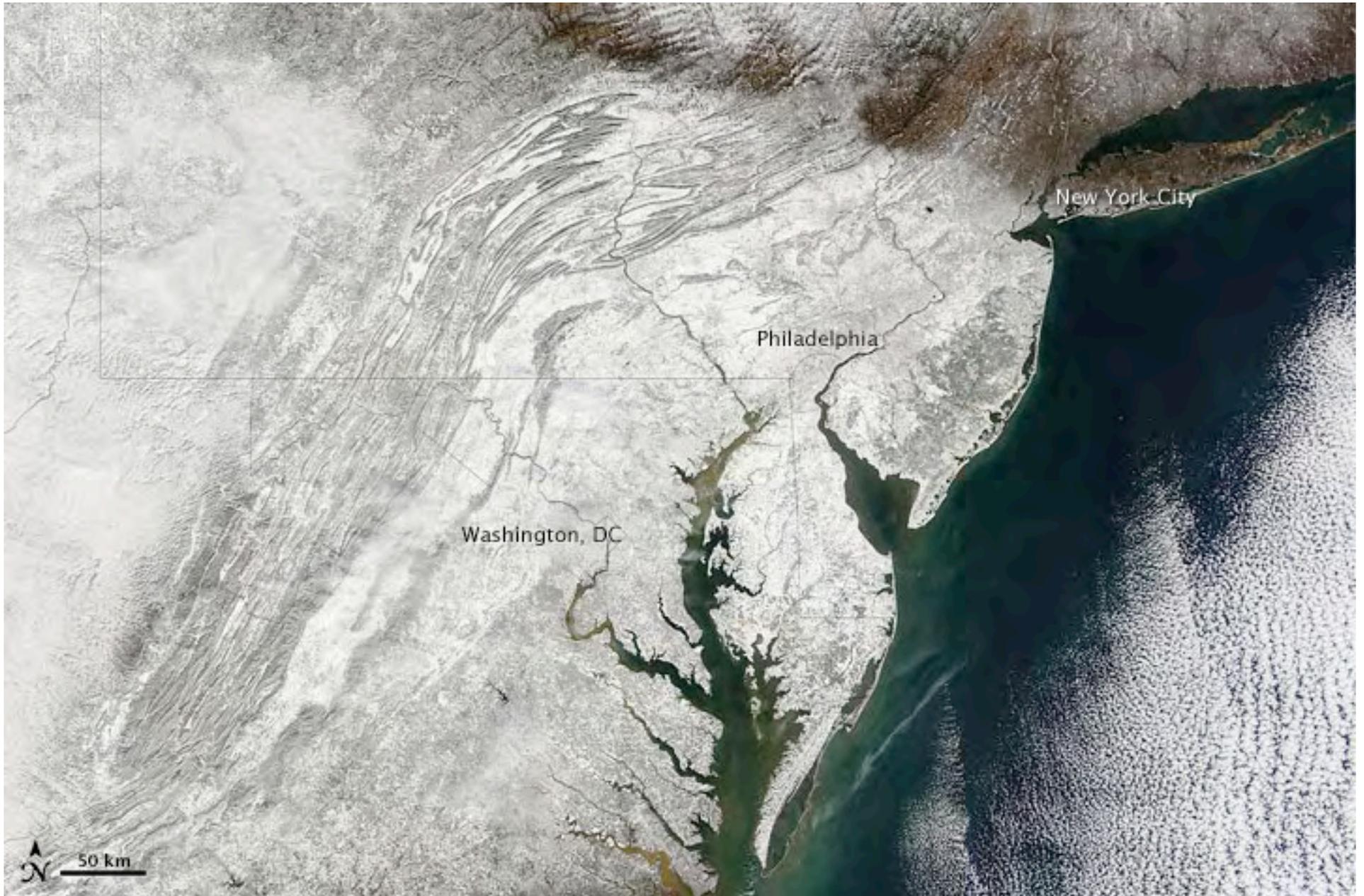
(2010) Record warmth month globally in Jan, Feb, Mar, April, May, June, ...

U.S. Climate Extremes Index: Step4

Annual (Jan-Dec)
1910-2008

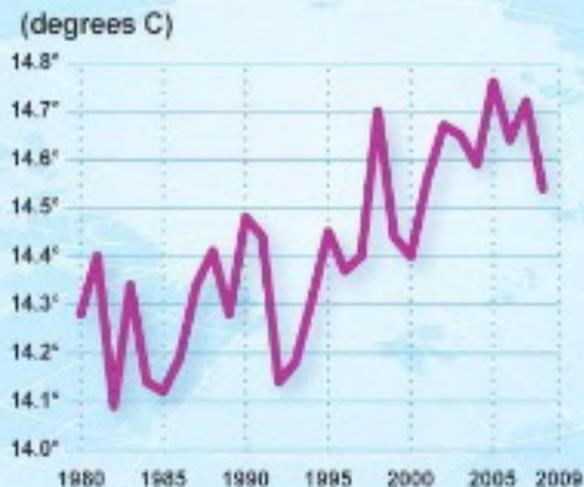


Extreme weather events are increasing, as predicted by climate models (IPCC '07)



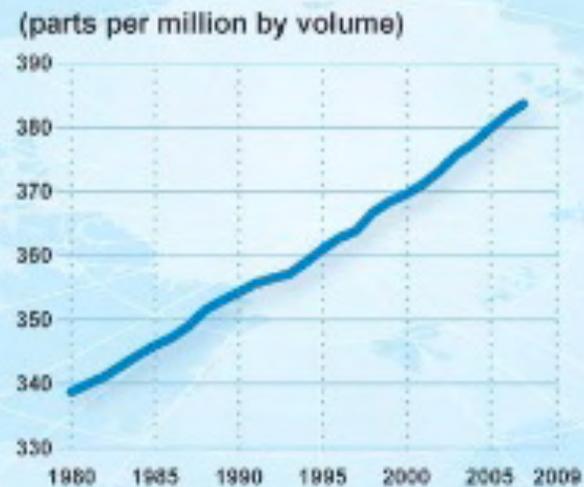
East coast snowstorms (Jan-Feb, 2010) don't disprove global climate change predictions, just the opposite!

GLOBAL AVERAGE TEMPERATURE



Source: NASA

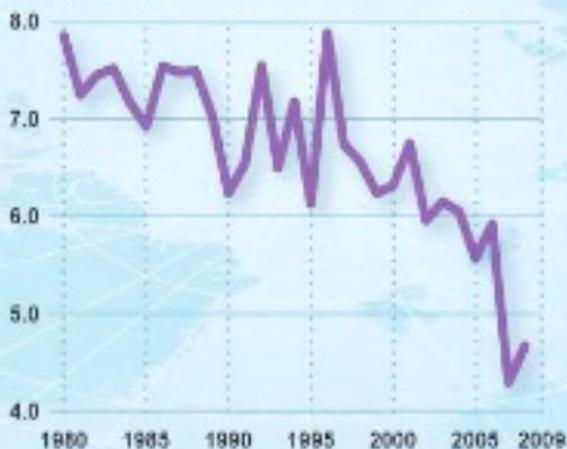
ATMOSPHERIC CO₂



Source: Carbon Dioxide Information Analysis Center, Mauna Loa

ARCTIC SEA-ICE COVER

Northern hemisphere summer sea-ice minimum
(millions of square kilometres)



Source: NOAA

SEA LEVEL

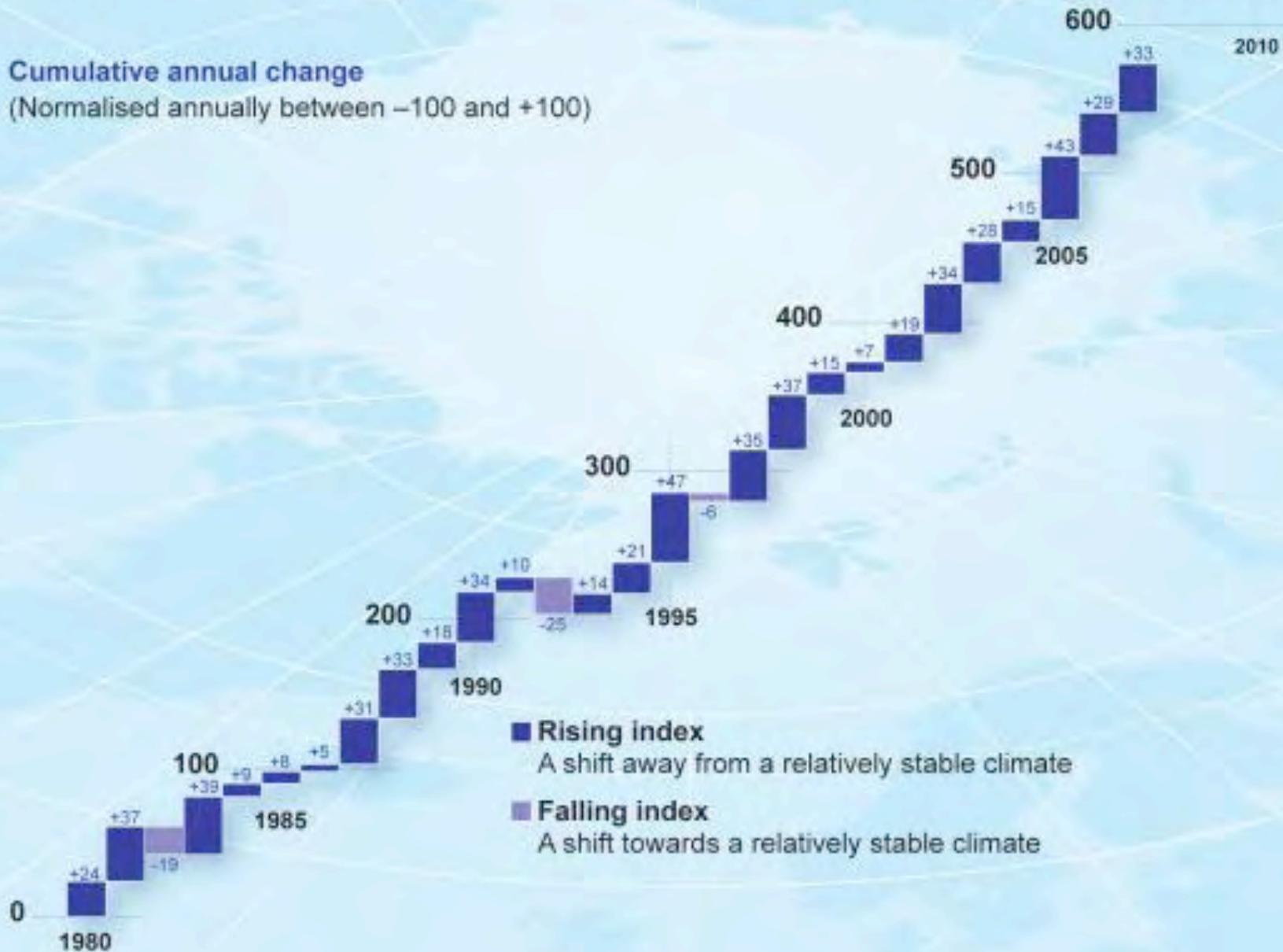
(millimetres)



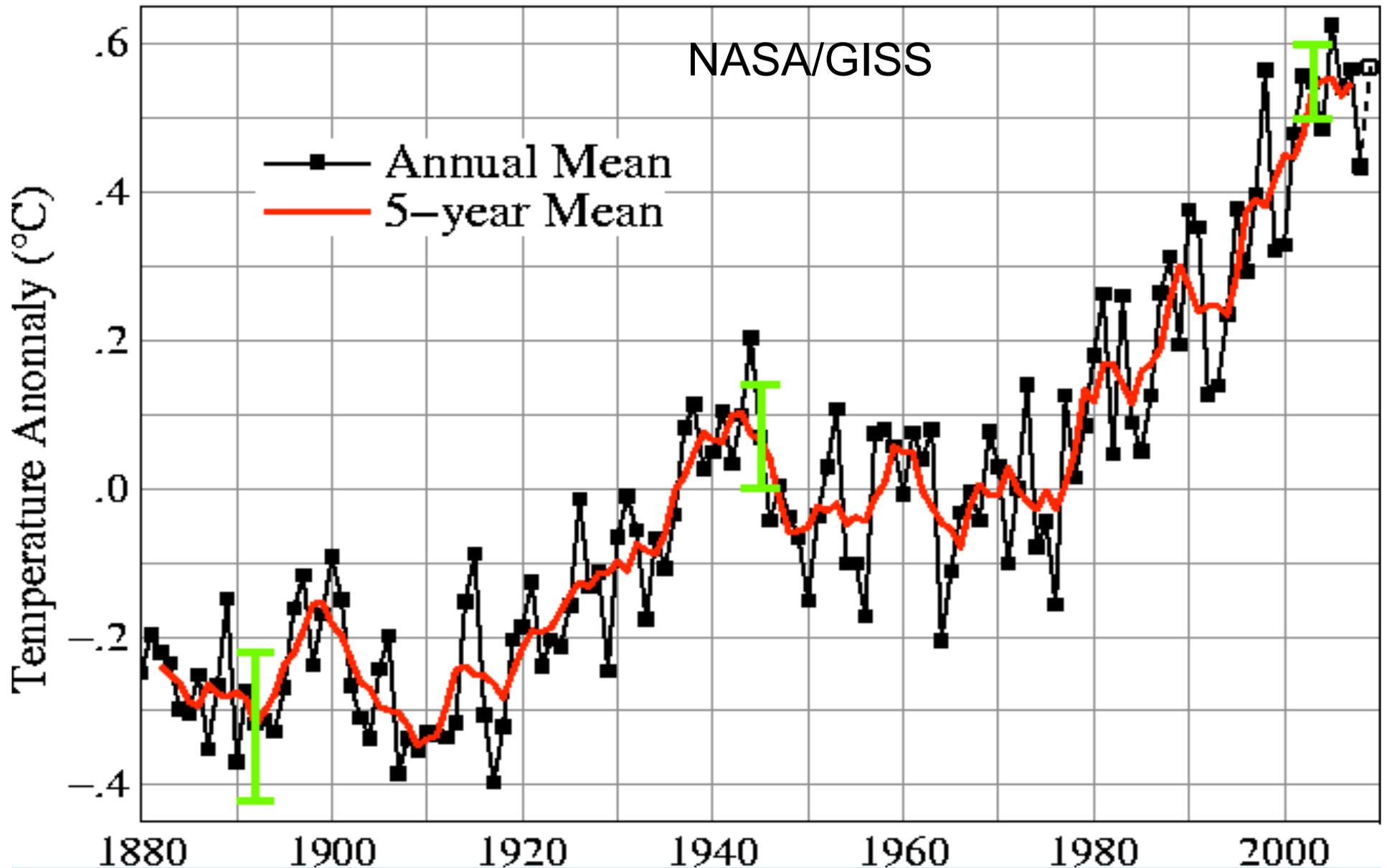
Source: Church and White global mean sea-level reconstruction (CSIRO) using data from the Permanent Service for Mean Sea Level, Proudman Oceanographic Laboratory, Natural Environment Research Council

IGBP CLIMATE-CHANGE INDEX

Cumulative annual change
(Normalised annually between -100 and +100)



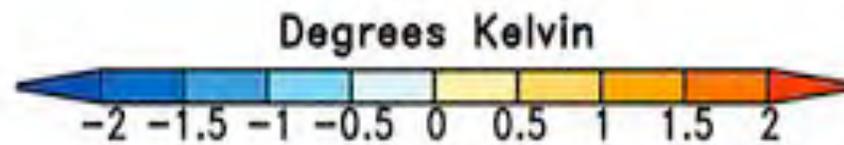
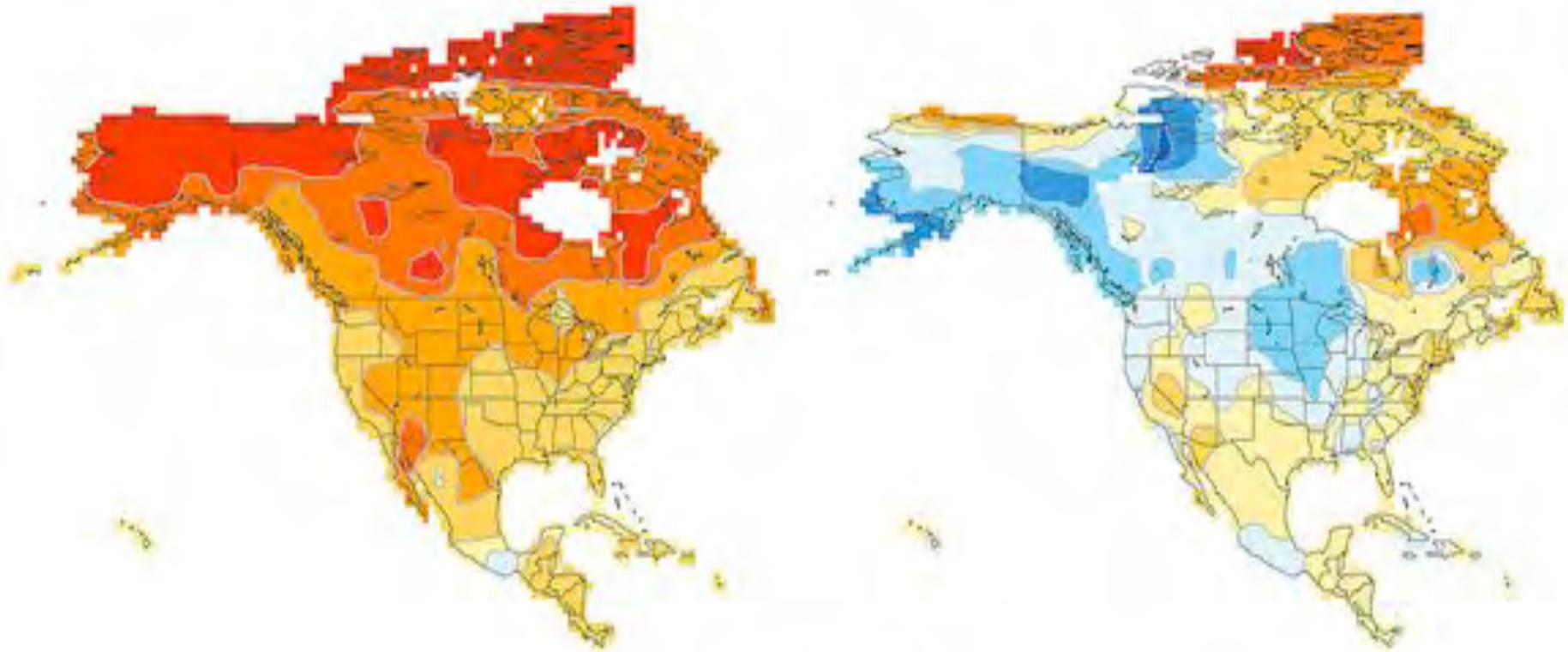
Global Land–Ocean Temperature Index



Note: 2005 warmest, (2009, 2007, 1998) tied for 2nd warmest

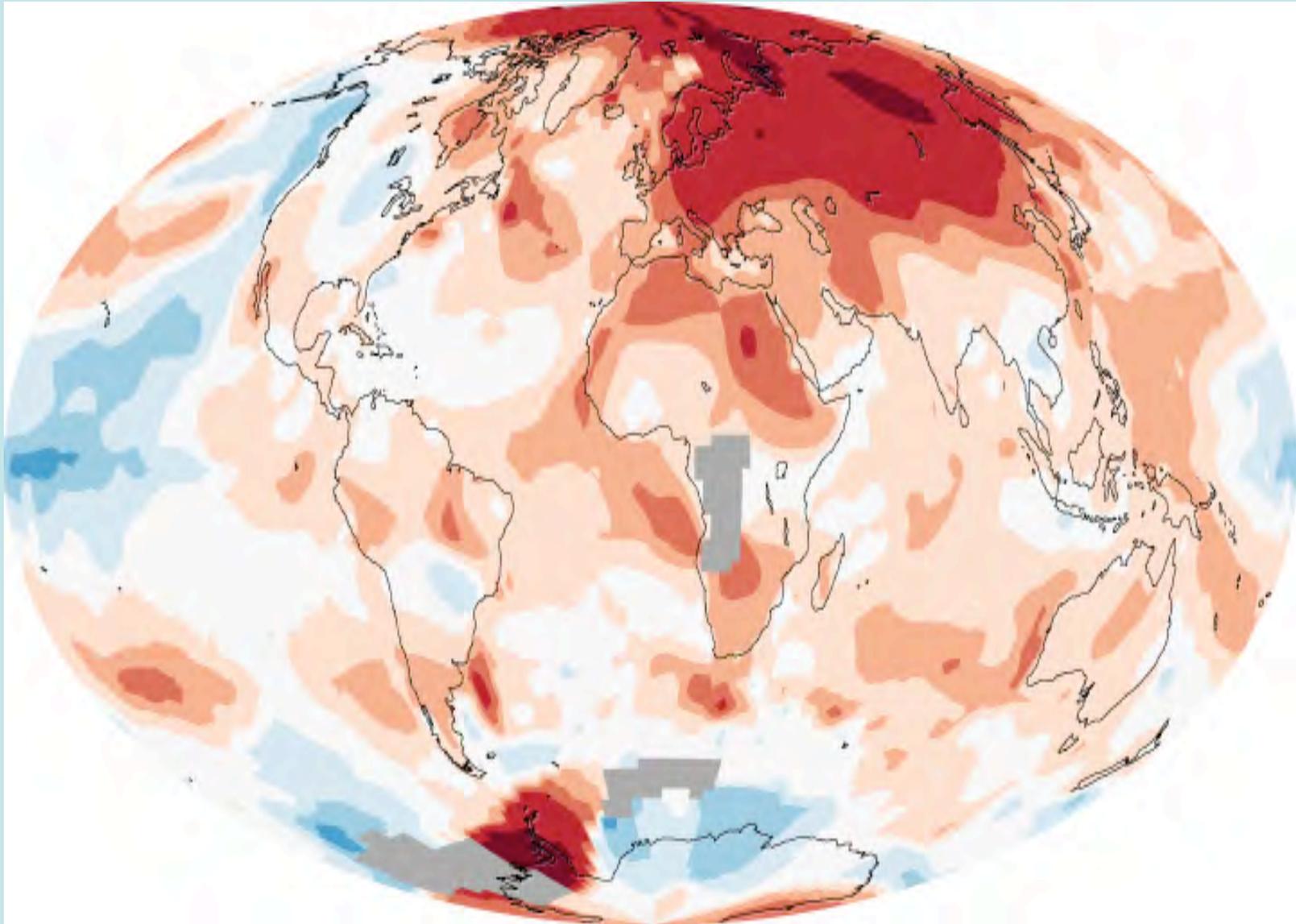
1970–2007 Trend

2008 Departure



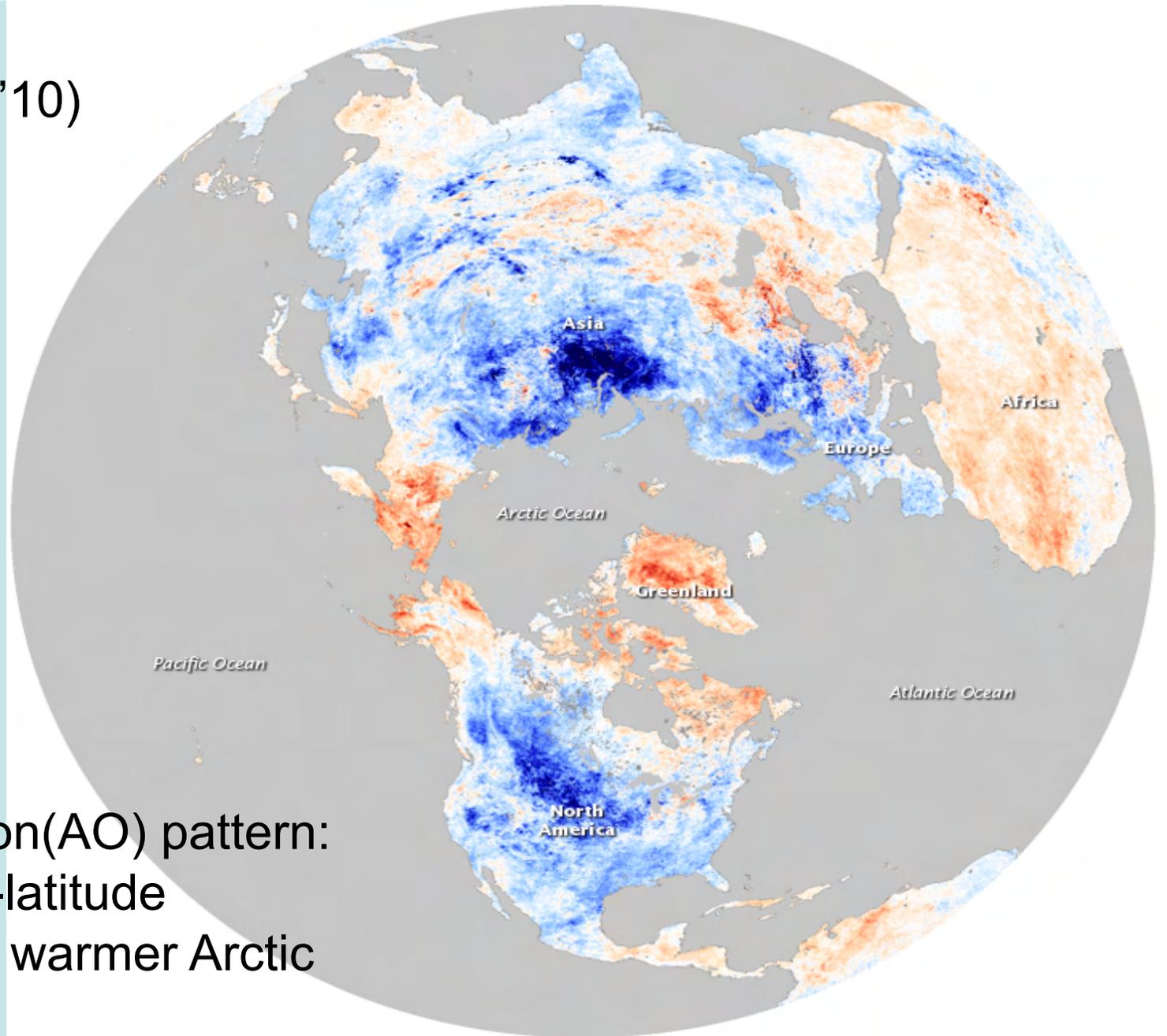
2008 was colder in the USA (~1.5% global area), but...

Global temperature anomaly 2008 (NASA/GISS)



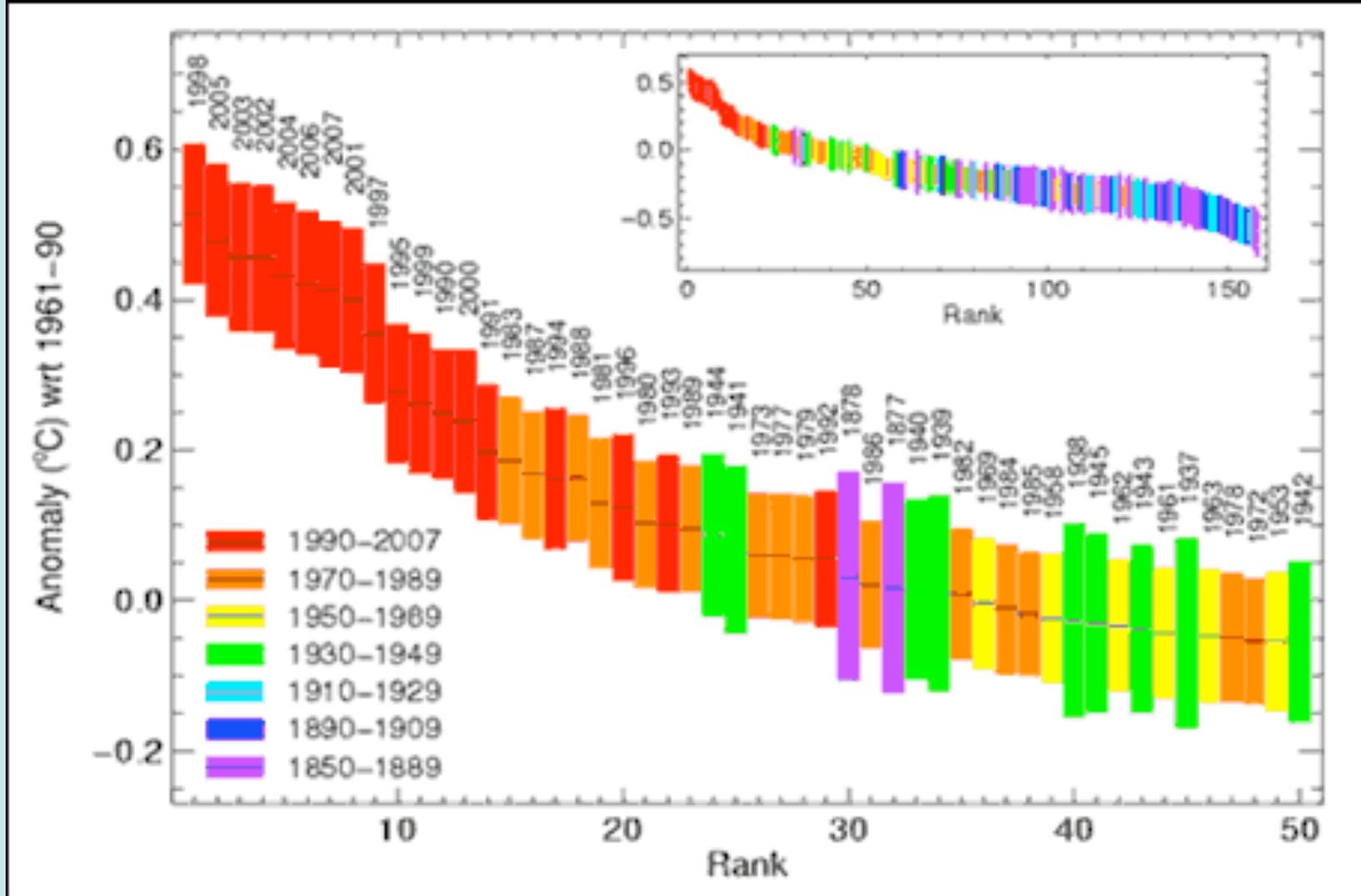
The world was still warming in 2008, especially NH high latitudes

Winter ('09/'10)

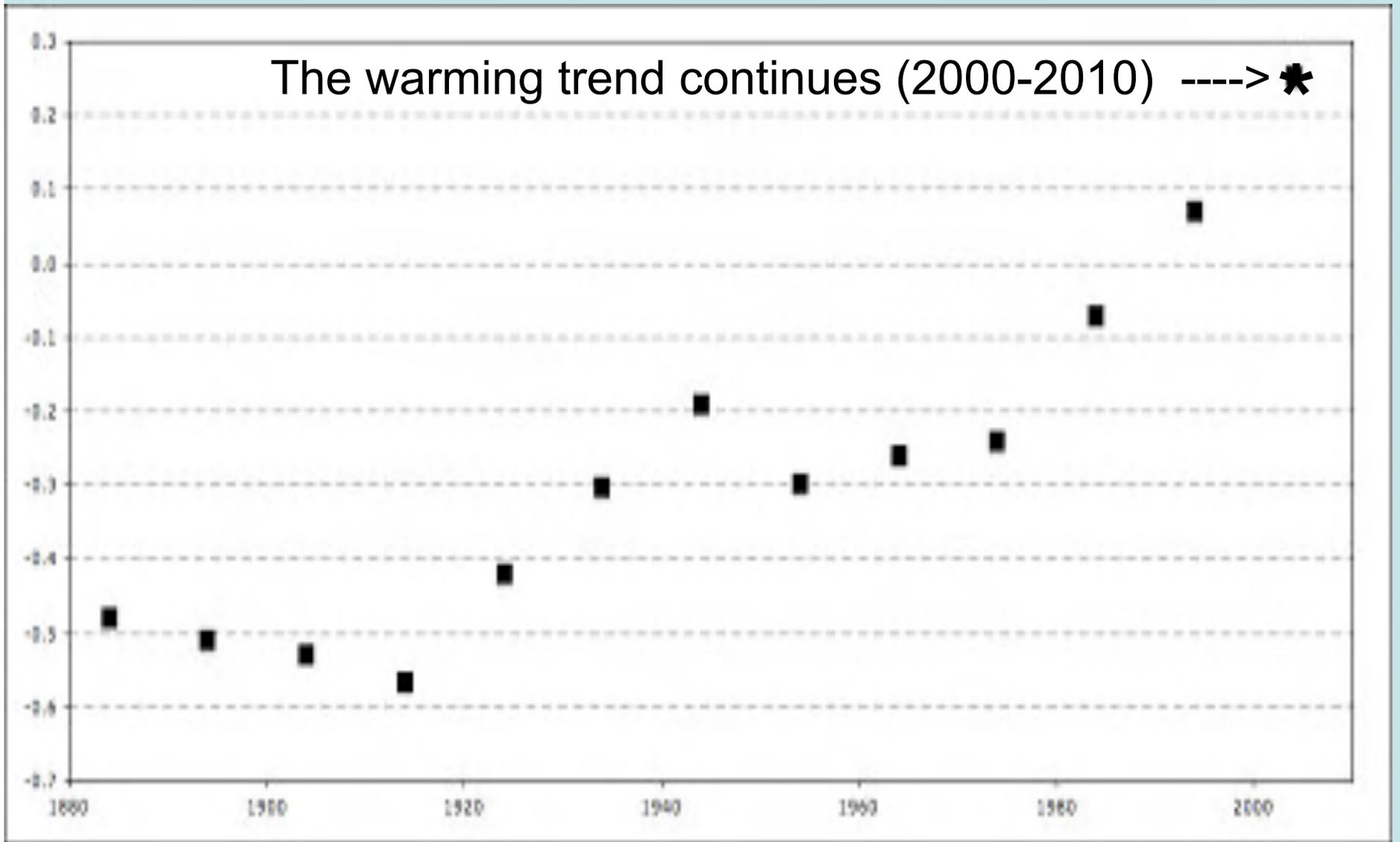


Arctic Oscillation(AO) pattern:
cooler NH mid-latitude
continents, but warmer Arctic

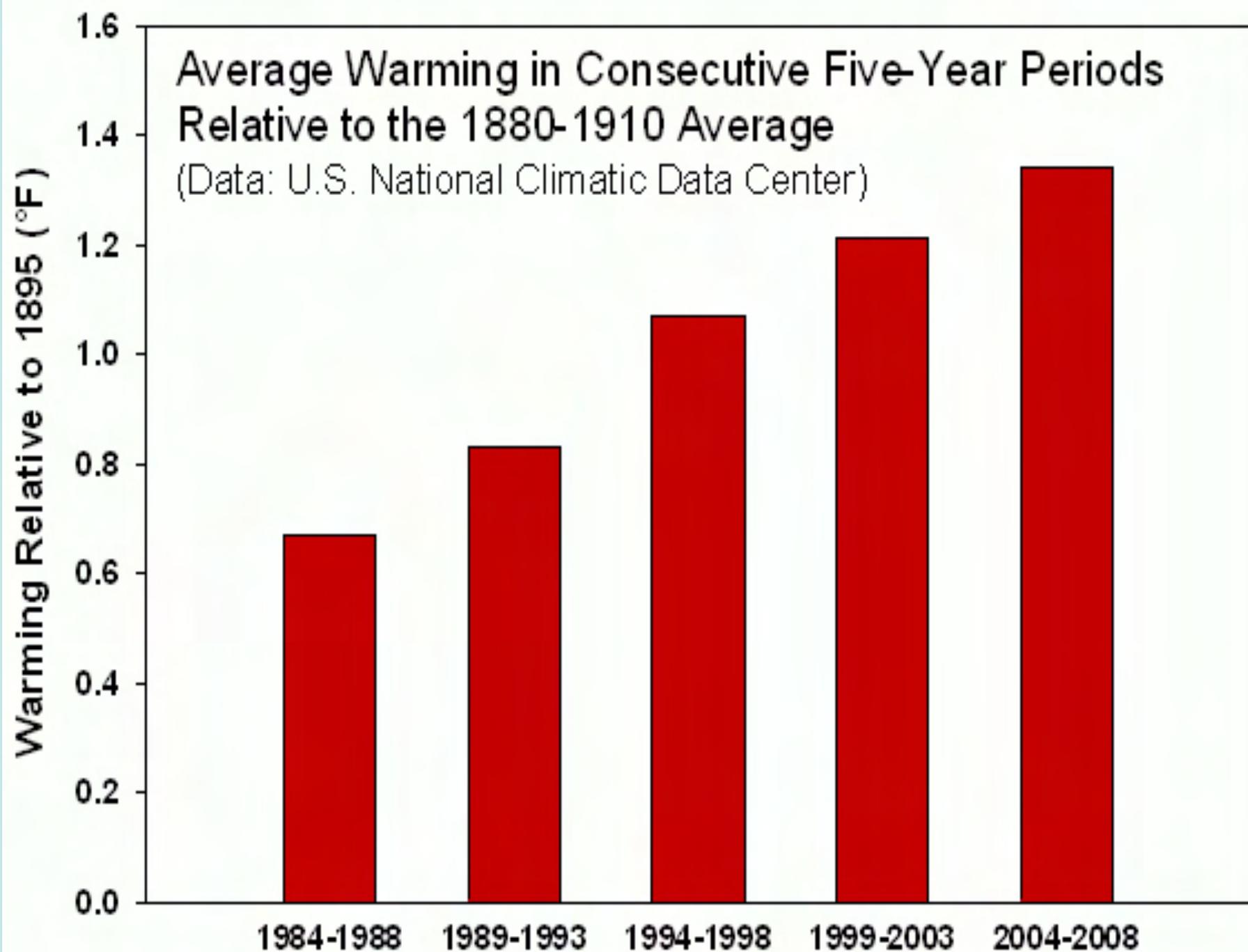
Global temperature anomaly, 1850-2007



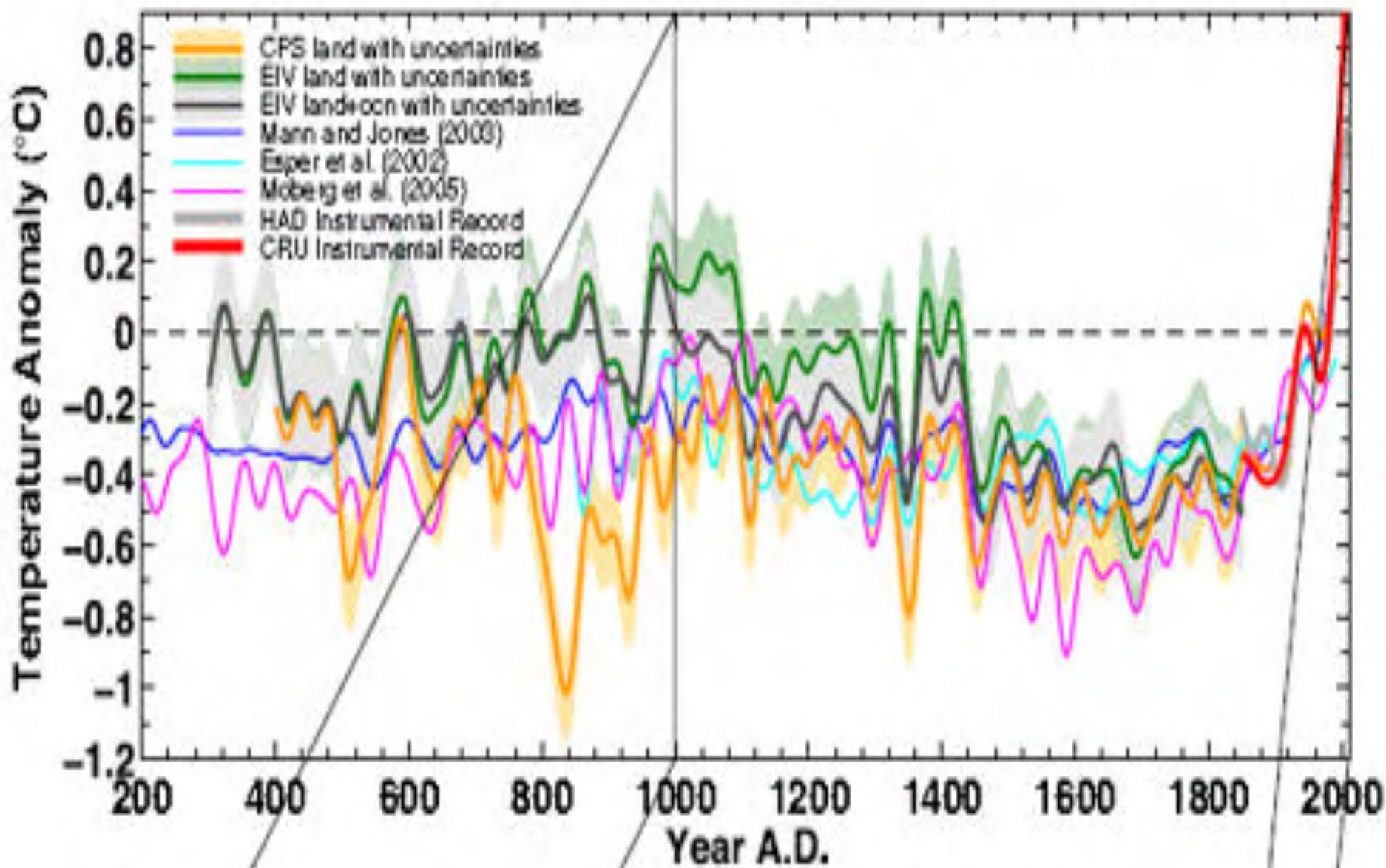
The most recent decade has been the warmest on record



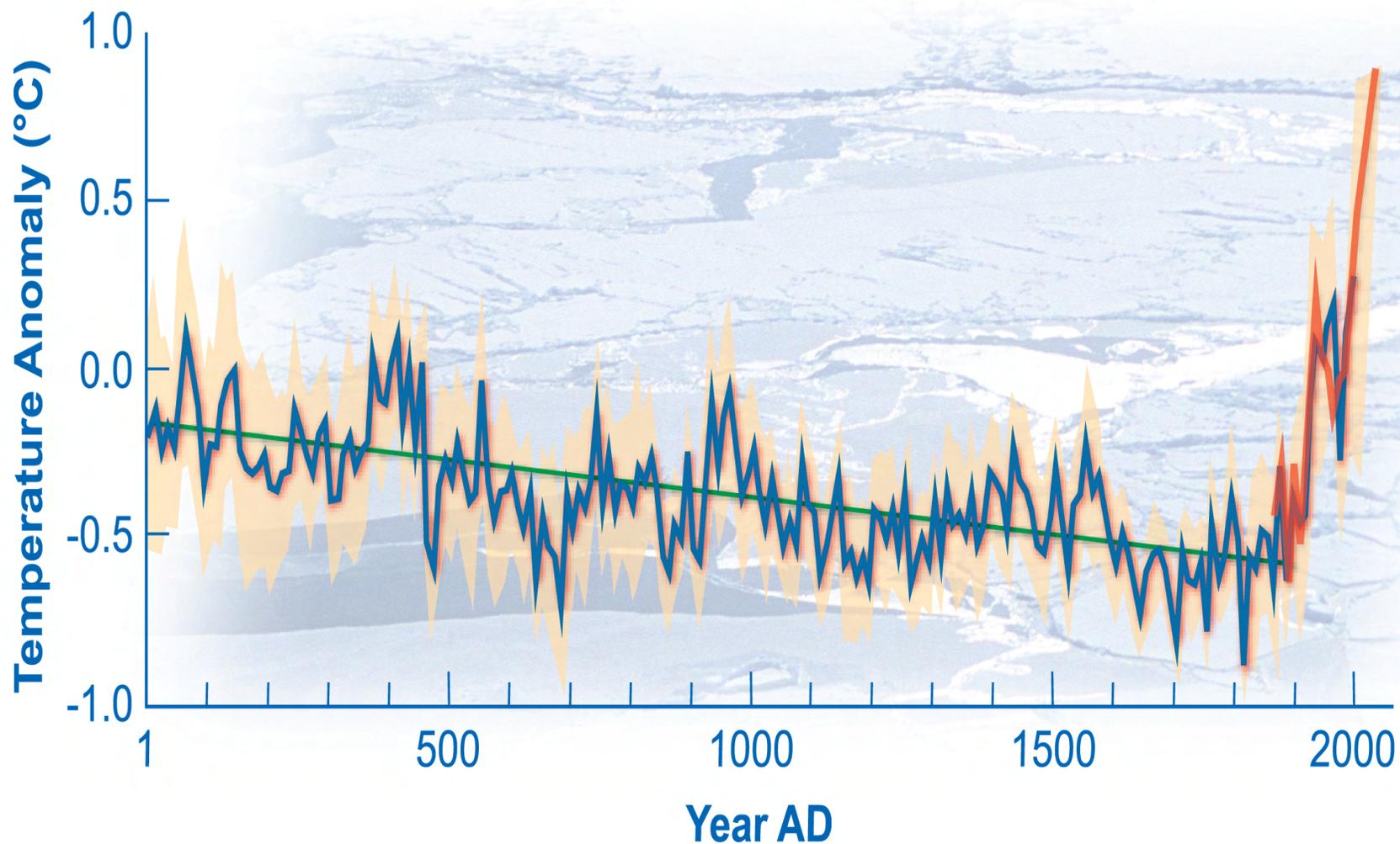
Decadal average global surface temperature



Northern Hemisphere



Dr. Mann's hockey stick is confirmed by many other subsequent studies



A new (independent) hockey stick: Arctic temperature trends for the past 2000 years (Kaufman et al, Science (Sept '09))

Past and possible future global temperatures (IPCC '07)

Global Temperature Relative to 1800-1900 (°C)

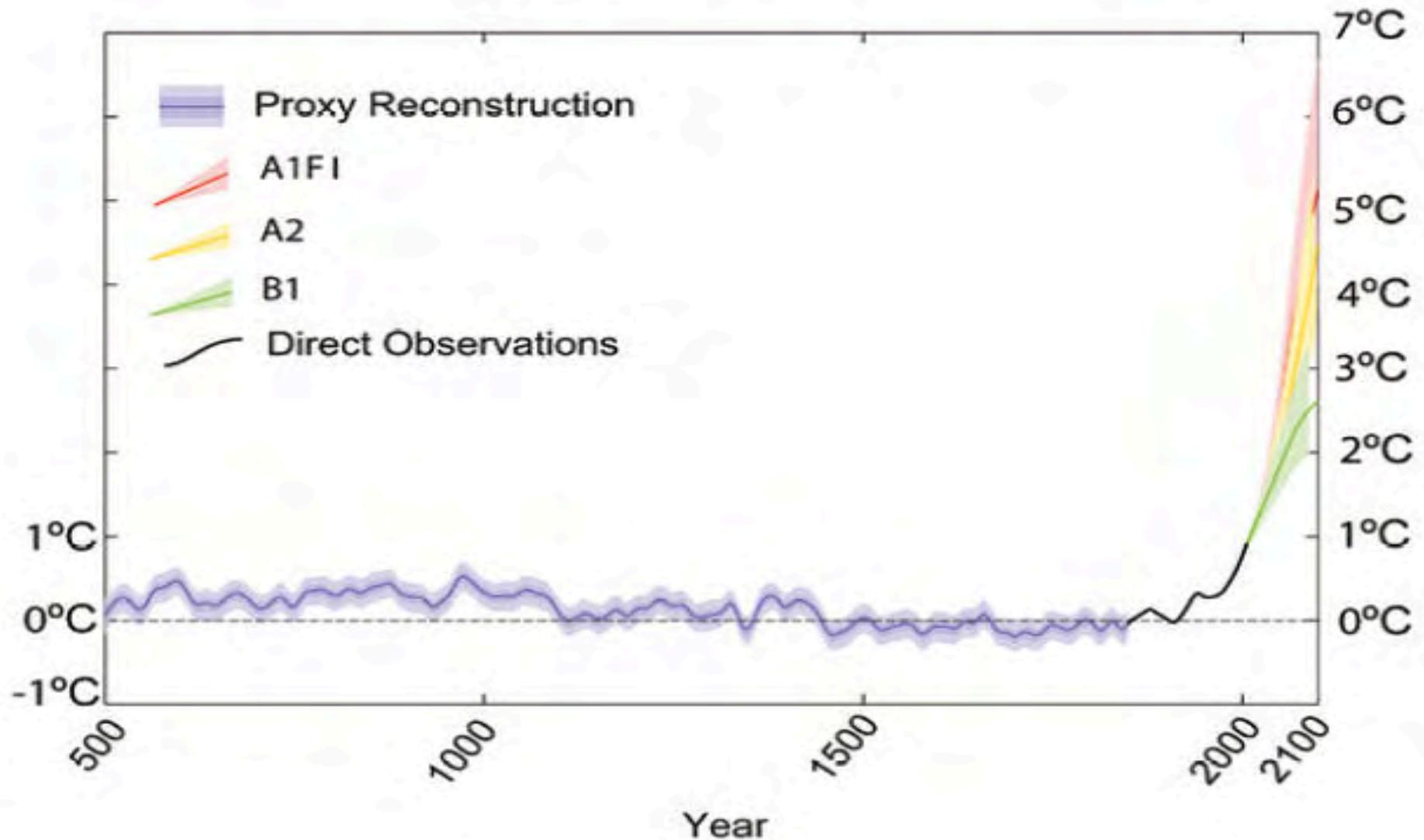
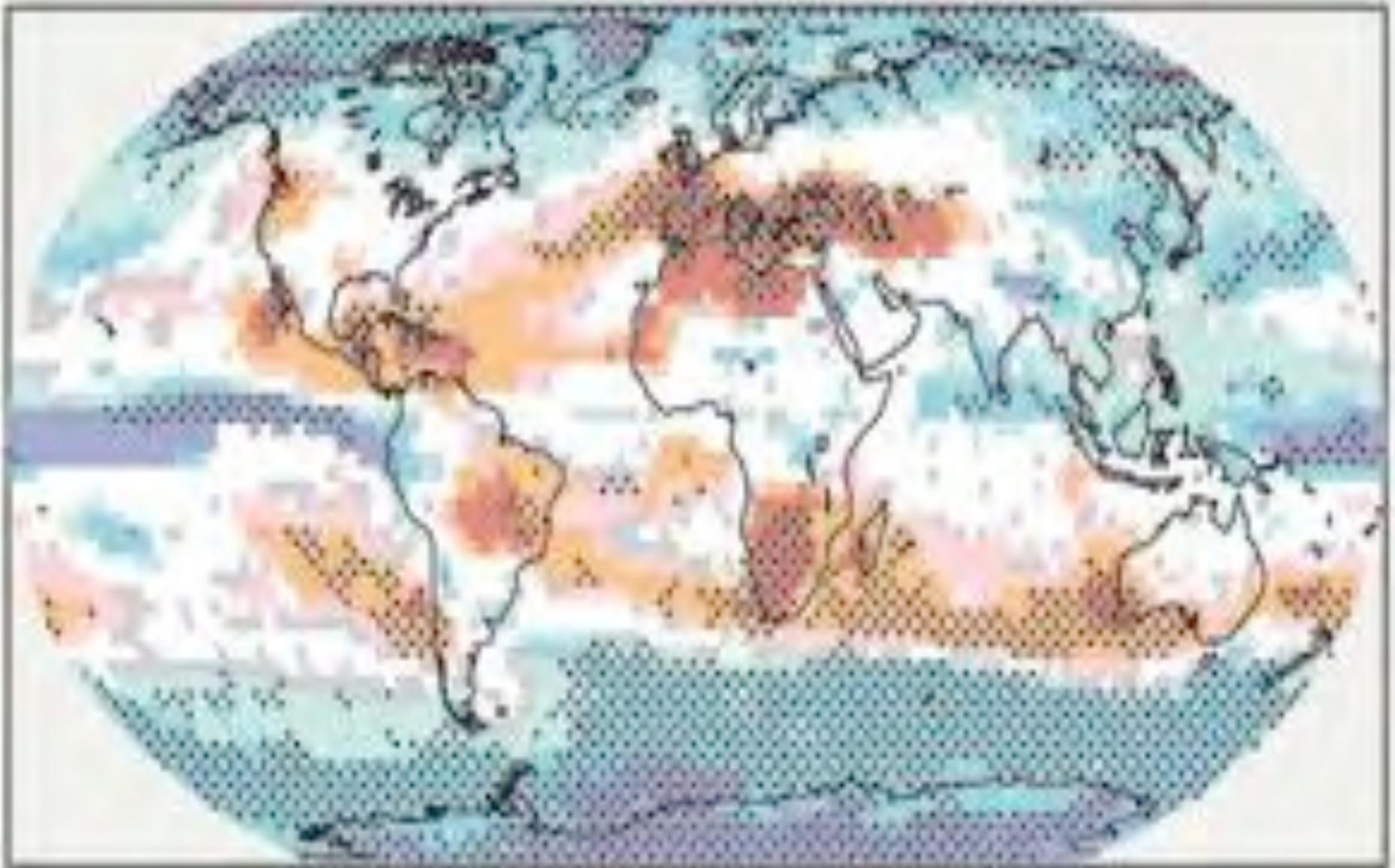
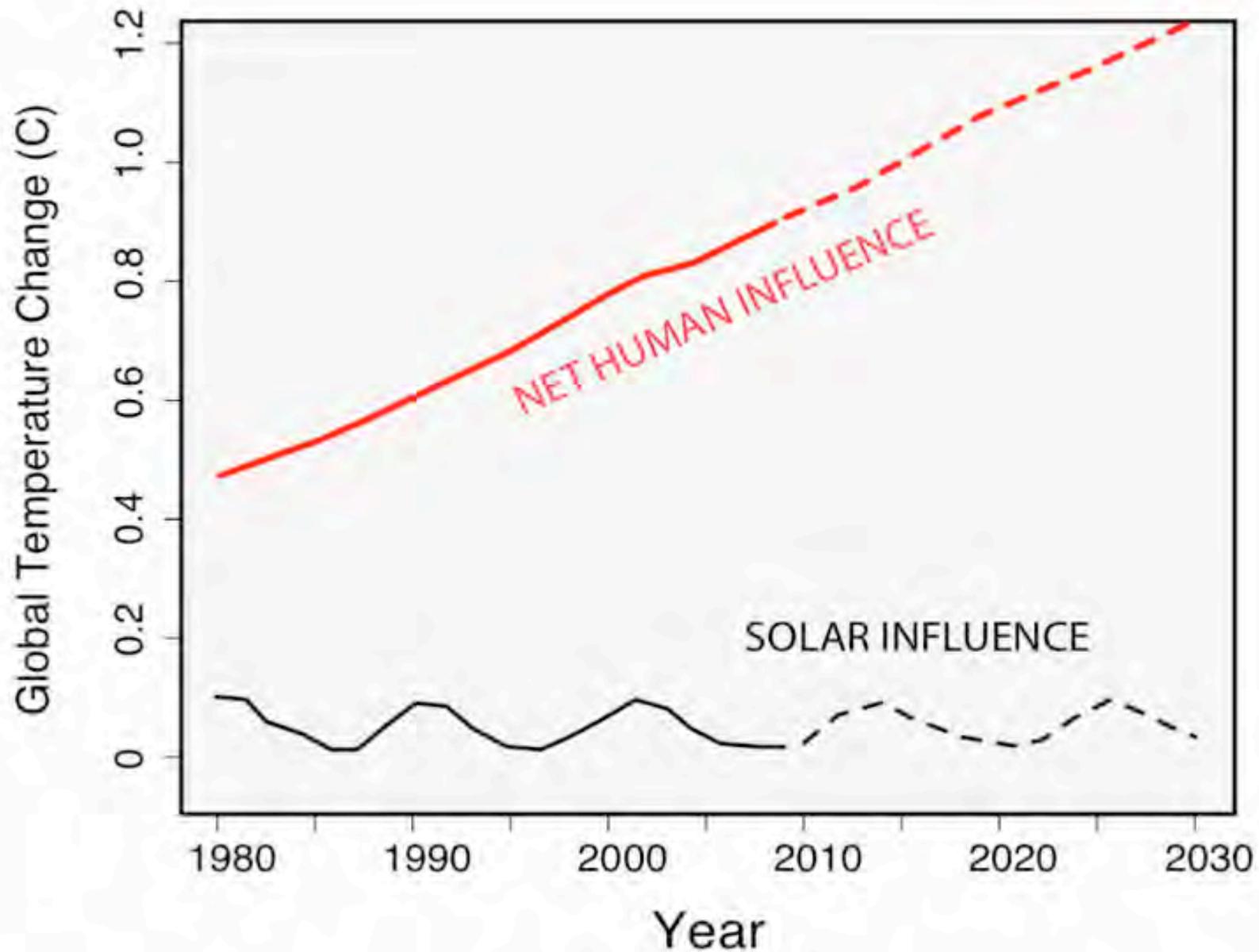


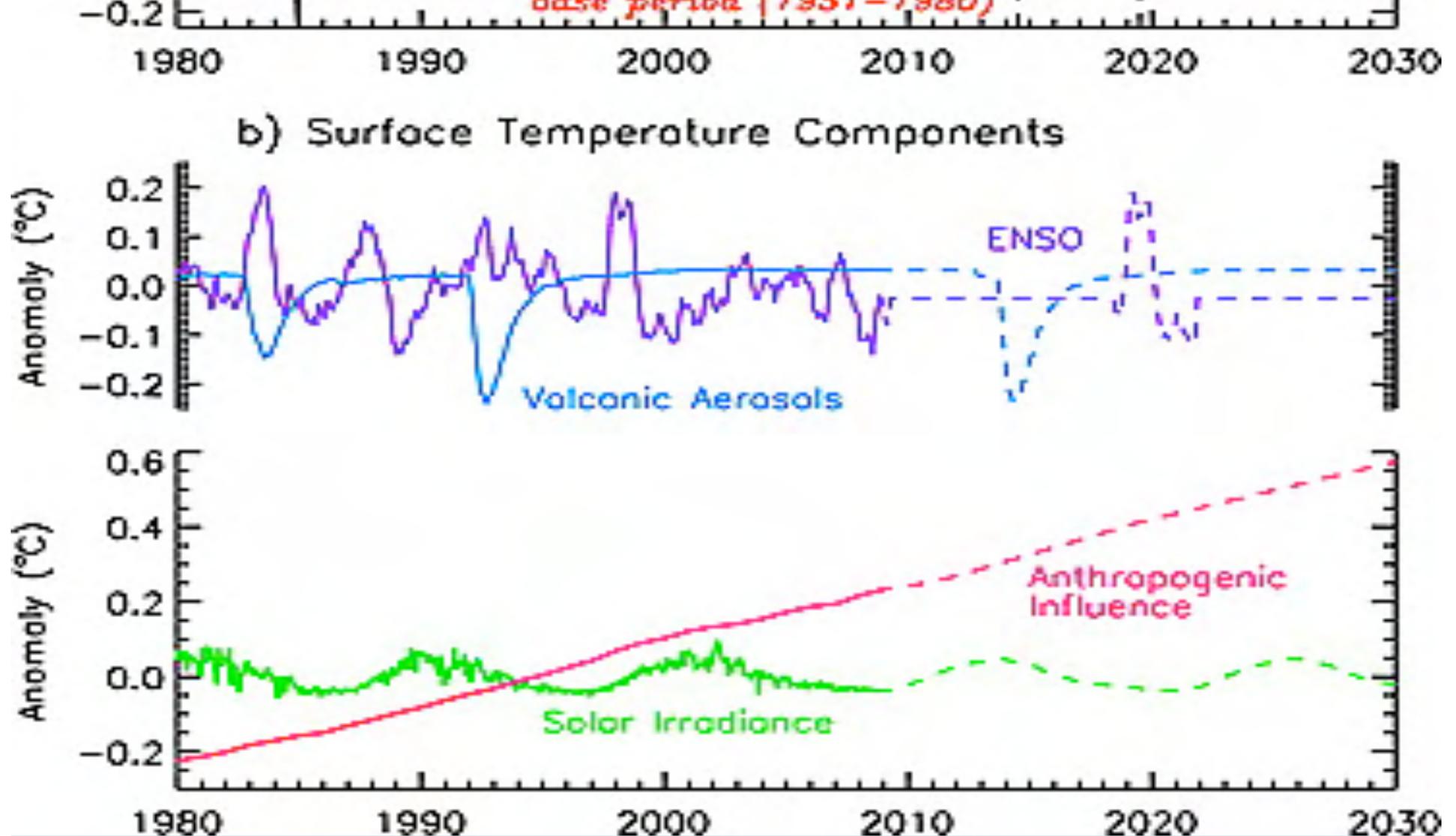
Figure 21. Reconstructed global-average temperature relative to 1800-1900 (blue) and projected global-average temperature out to 2100 (the latter from IPCC AR4). The envelopes B1, A2, A1FI refer to the IPCC AR4 projections using those scenarios. The



Projected precipitation changes by 2100 (IPCC '07):
increasing subtropical droughts, and increasing high-latitude rain

Sun: small, regular (11-yr cycle) modulation of global temperature

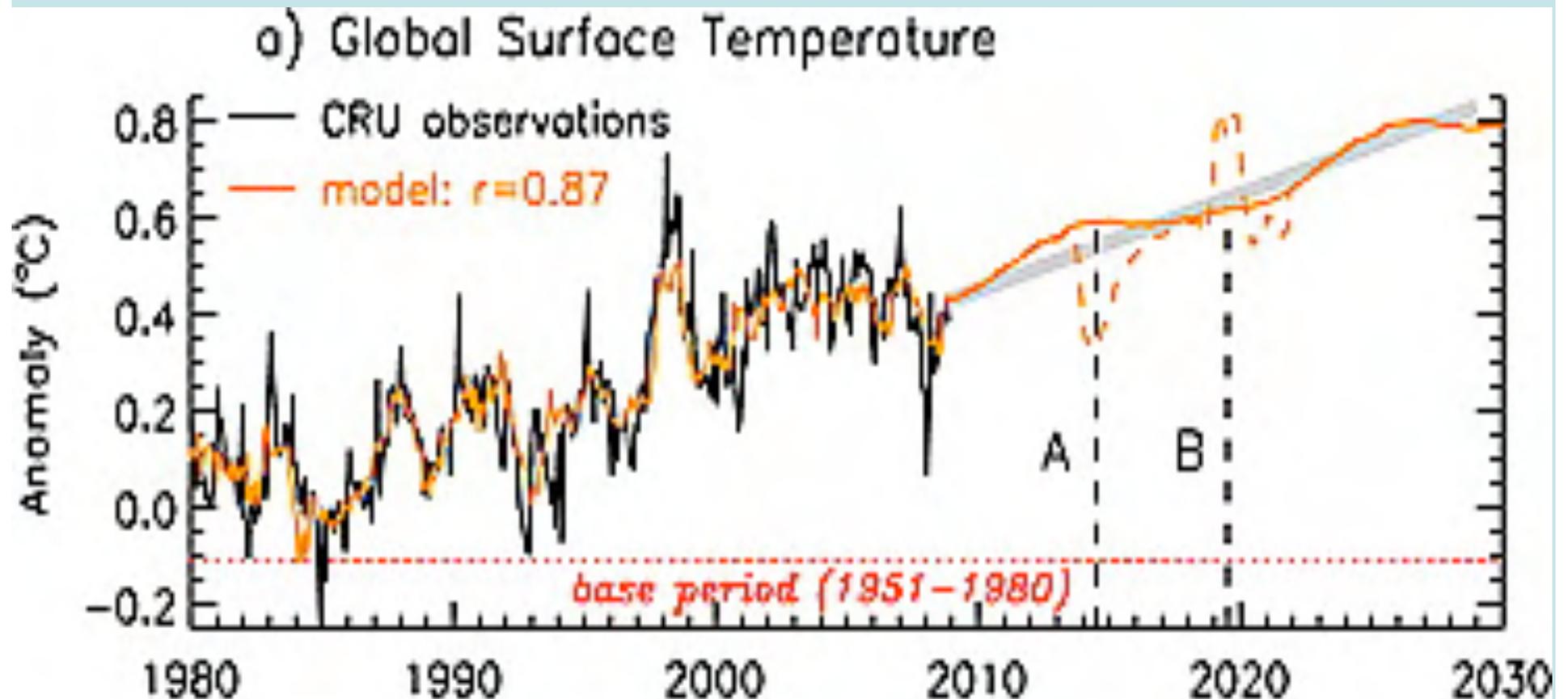




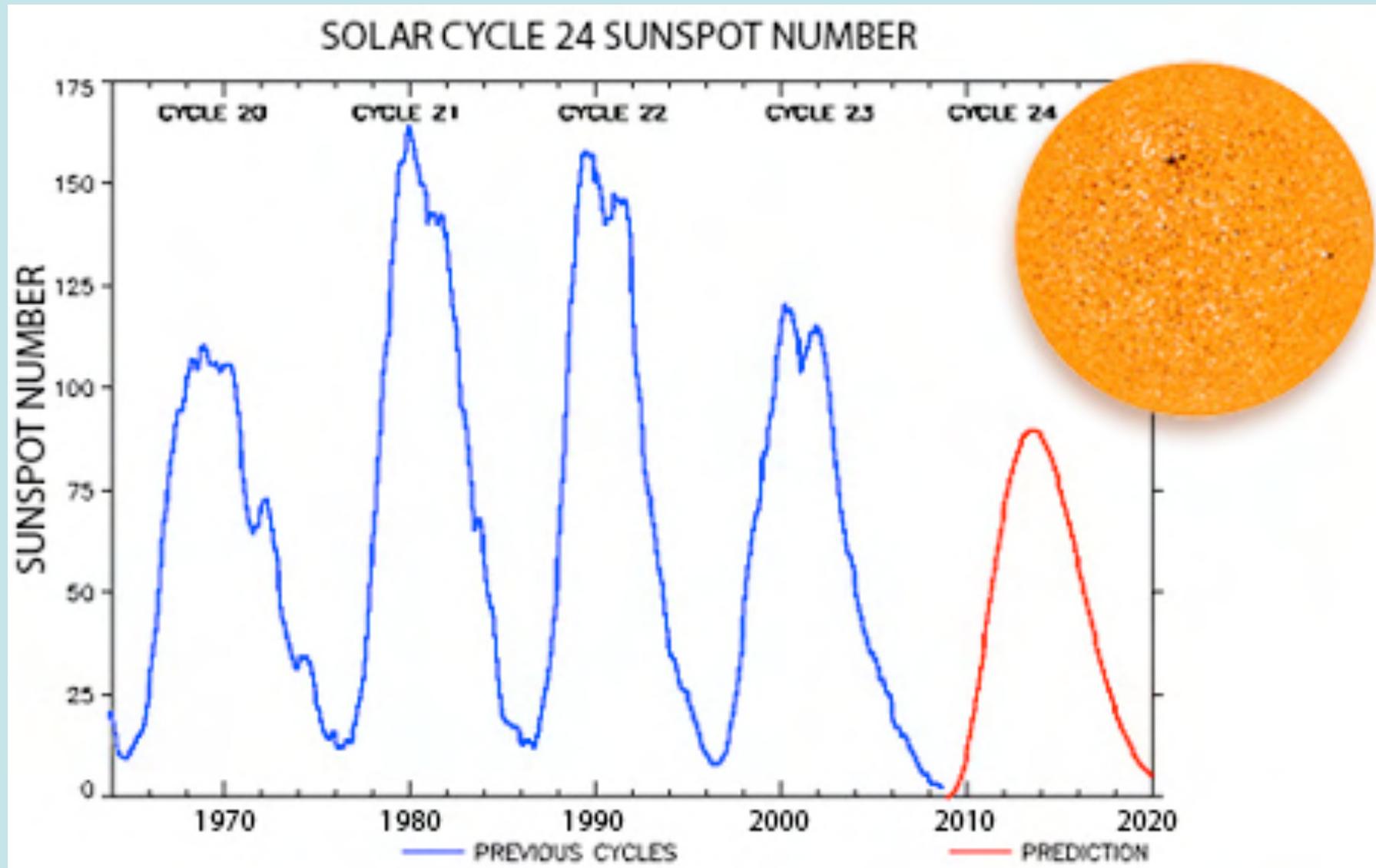
Major factors: (natural) solar variability, volcanoes, ENSO
(human) greenhouse gases

Combining all factors, fitting the record and 'predicting' to 2030

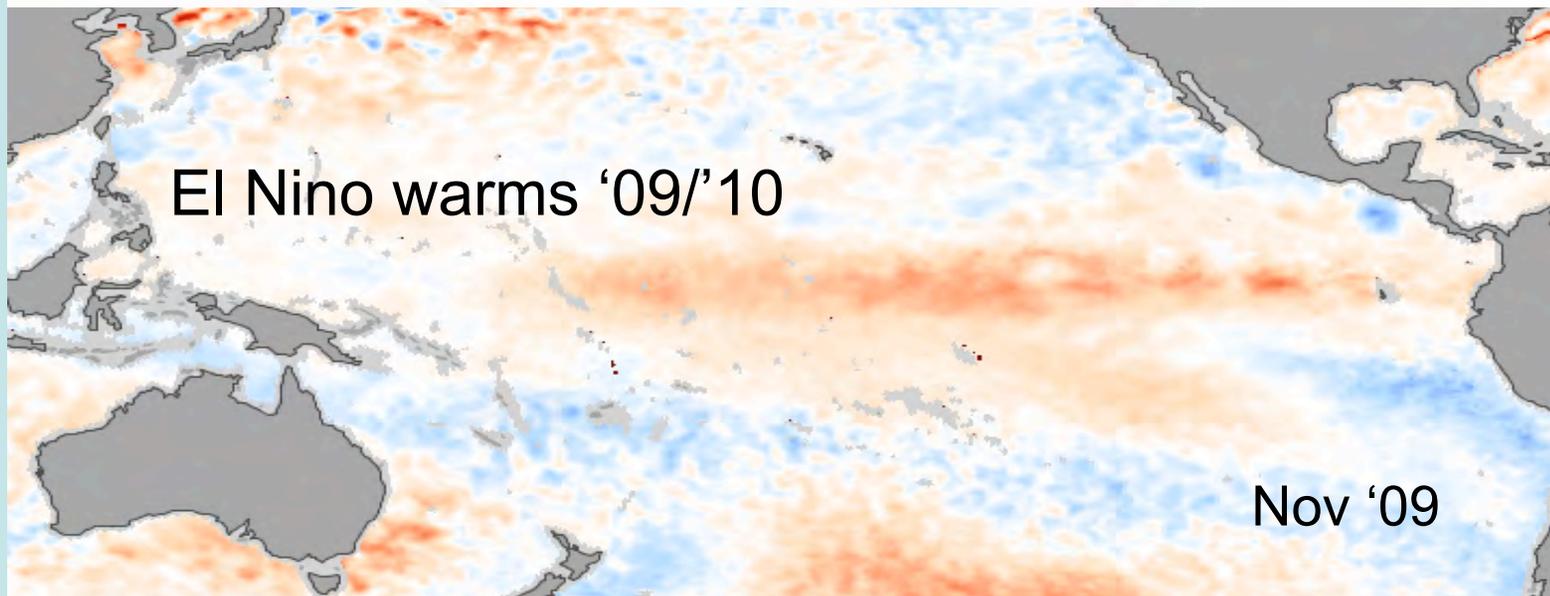
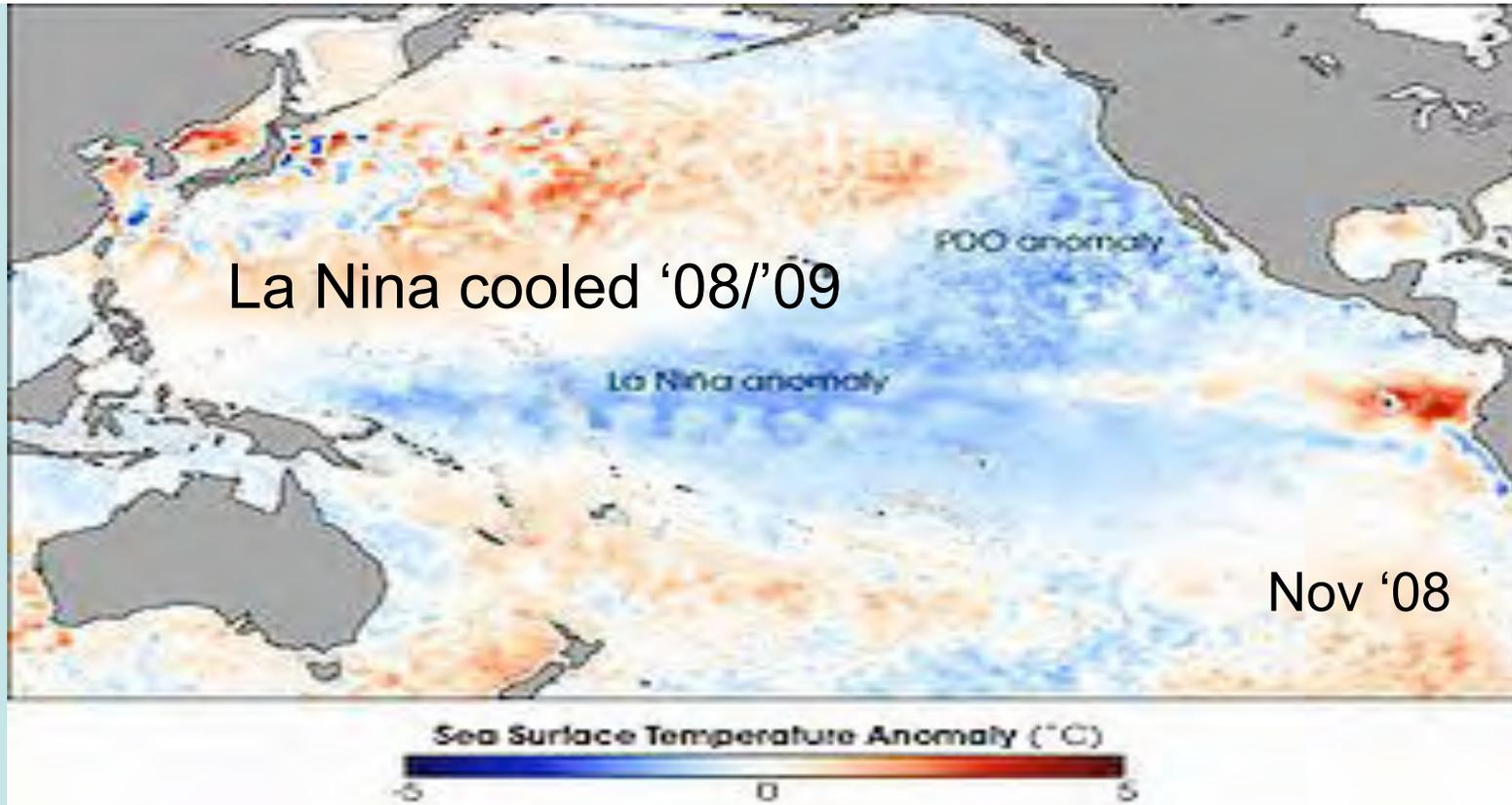
(Lean et al , GRL 2009)



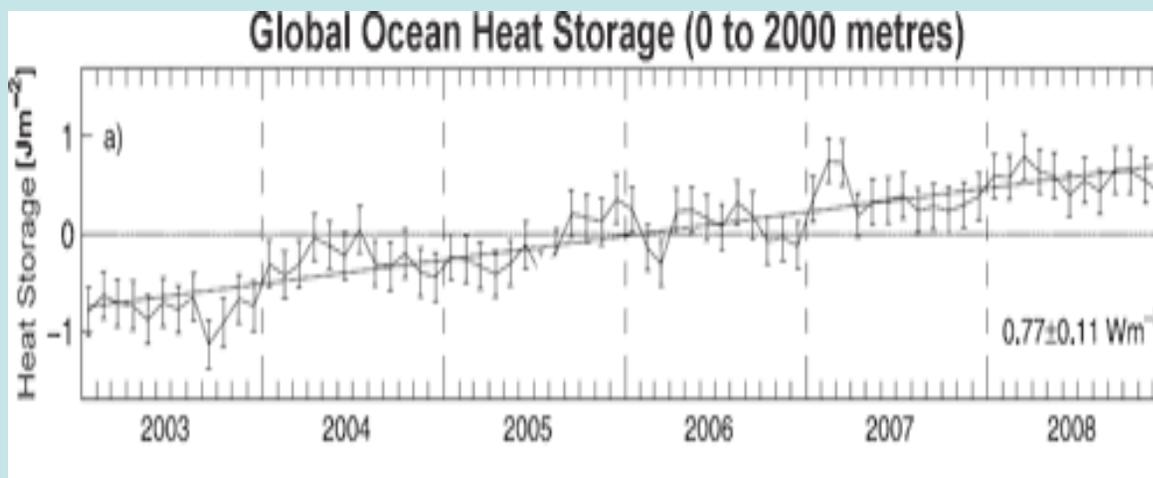
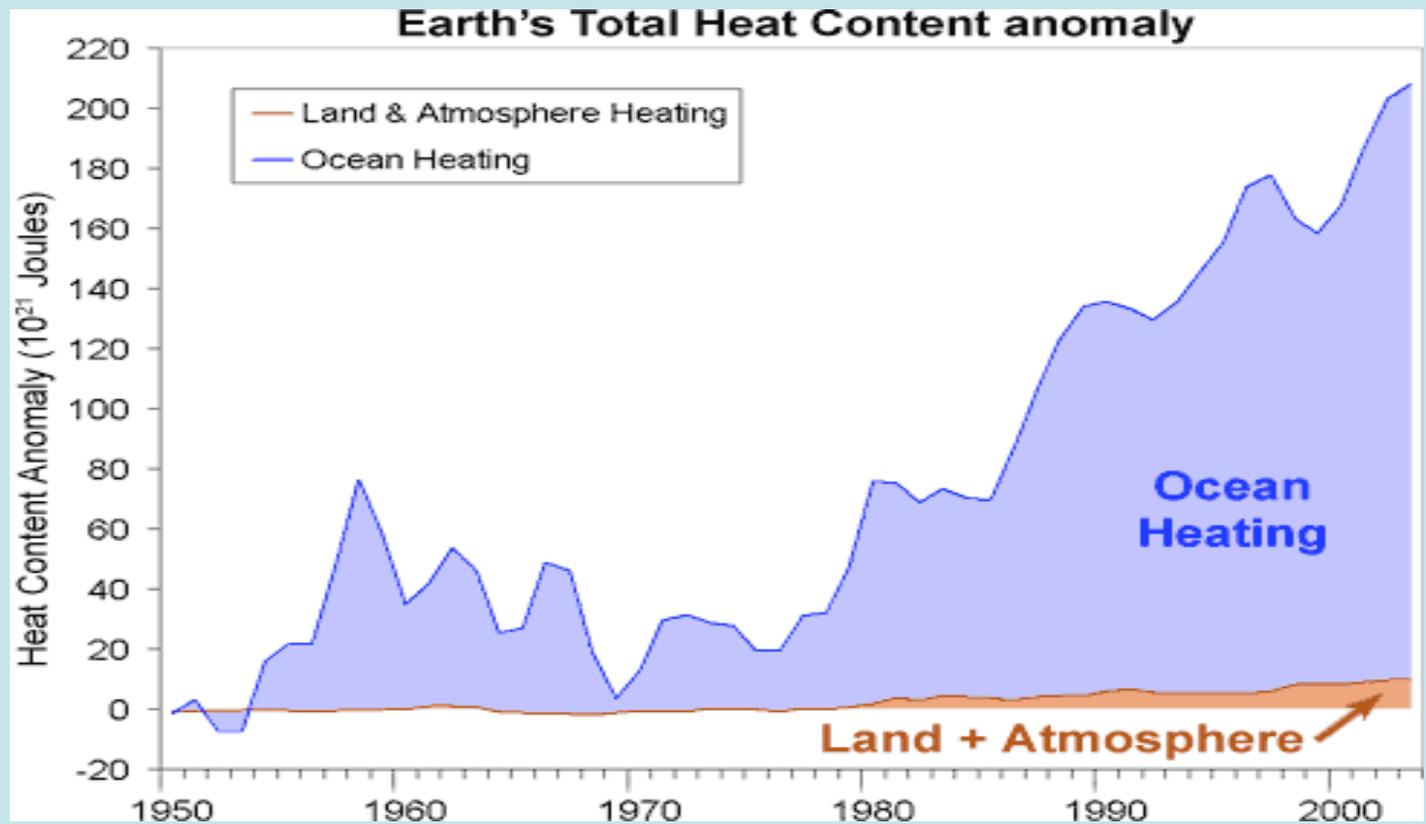
b) Surface Temperature Components



Next solar max (modest) predicted for 2013

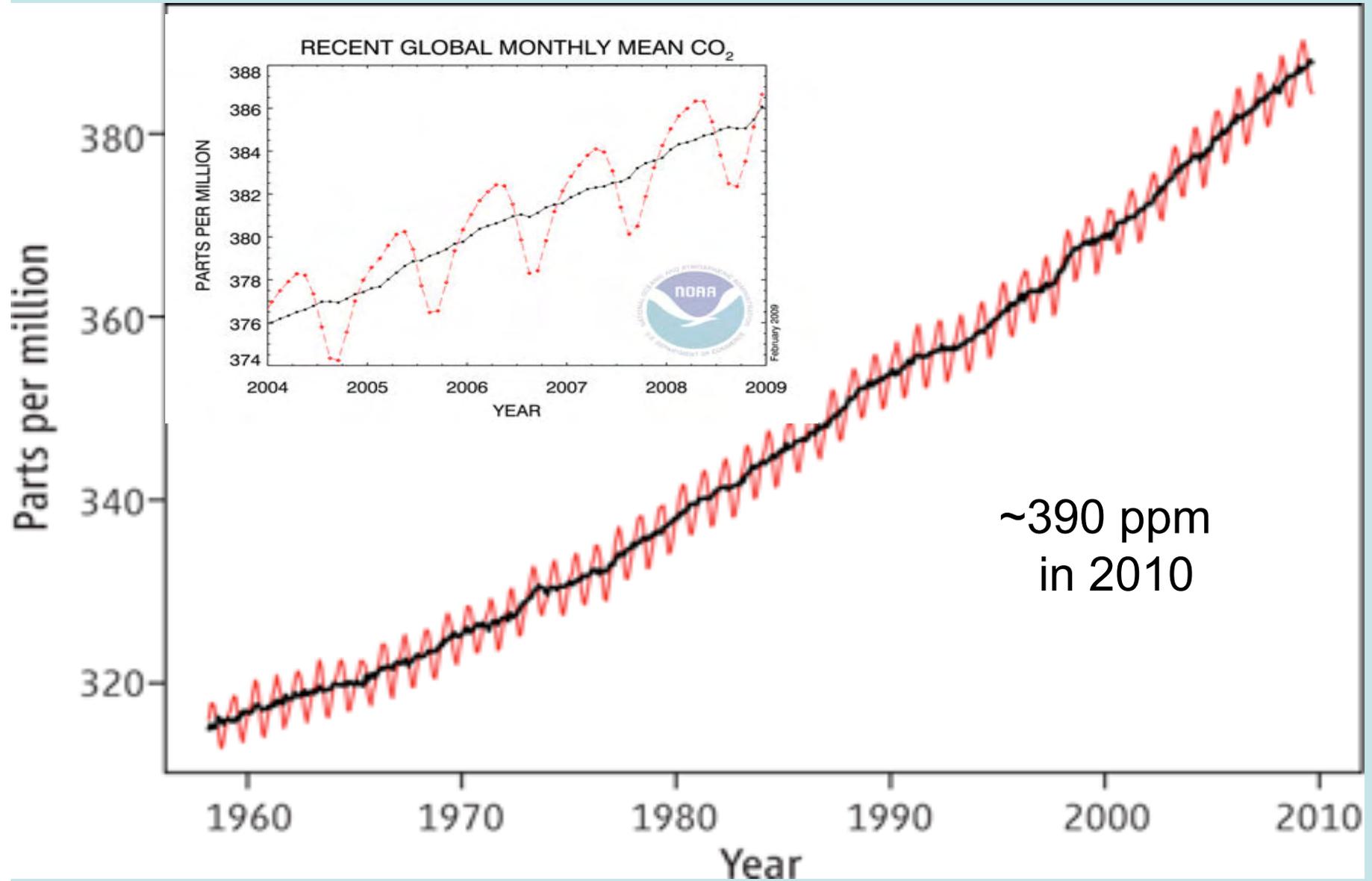


Most excess heat goes into the ocean, not the land or the atmosphere



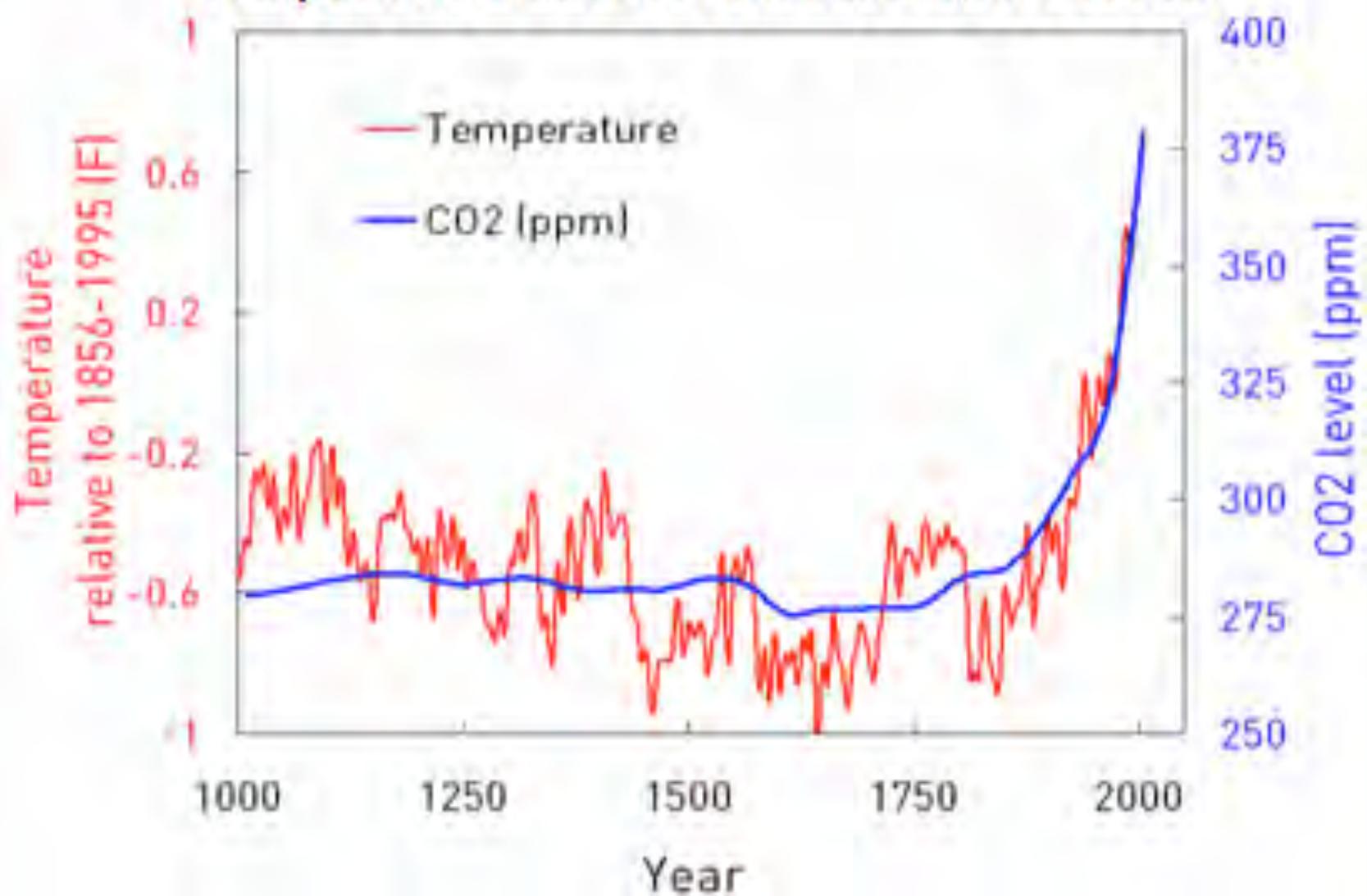
Measured increase in greenhouse heat stored in the upper ocean

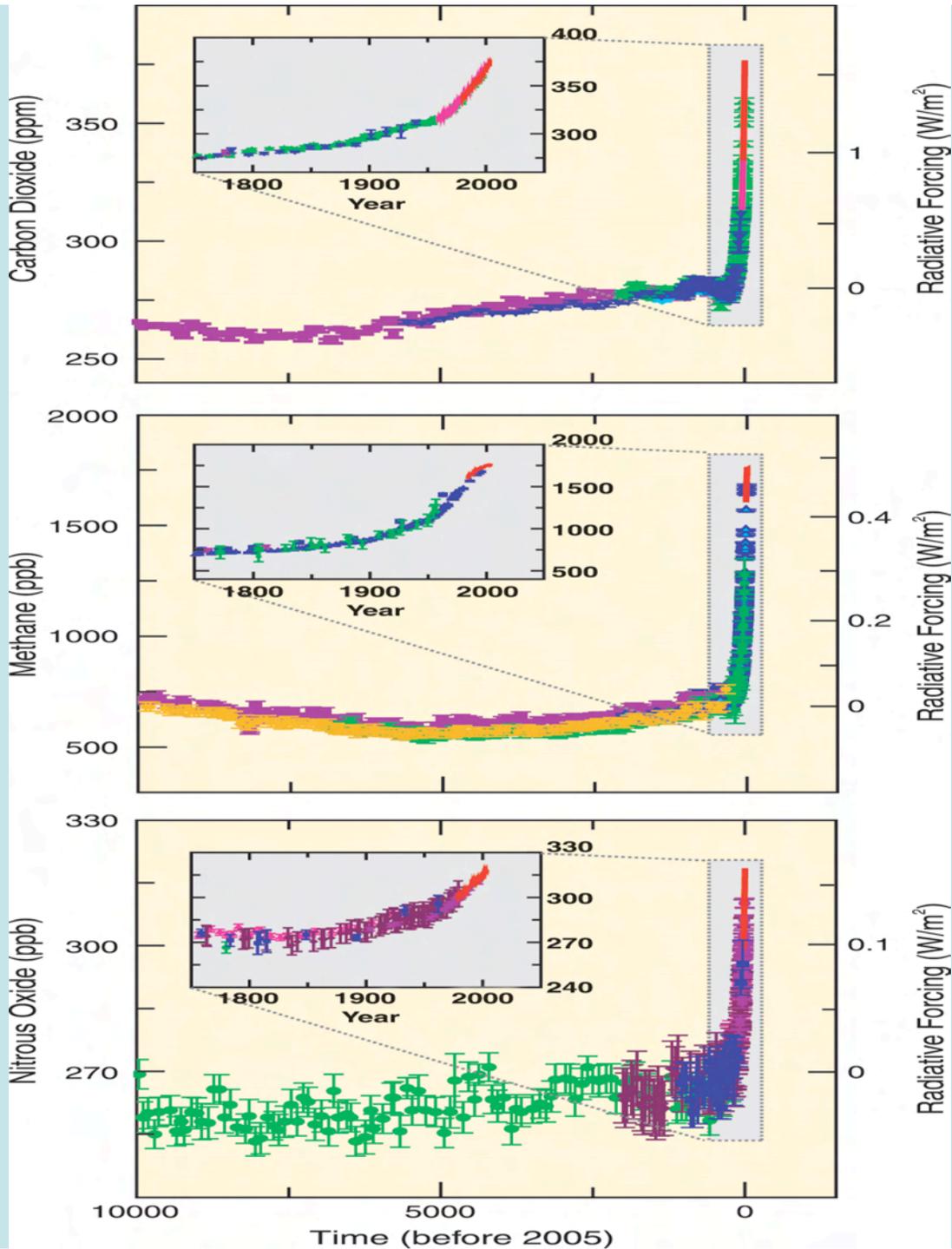
Combustion of coal, oil, natural gas, tropical forests



Increasing atmospheric CO₂ at Mauna Loa (Hawaii)

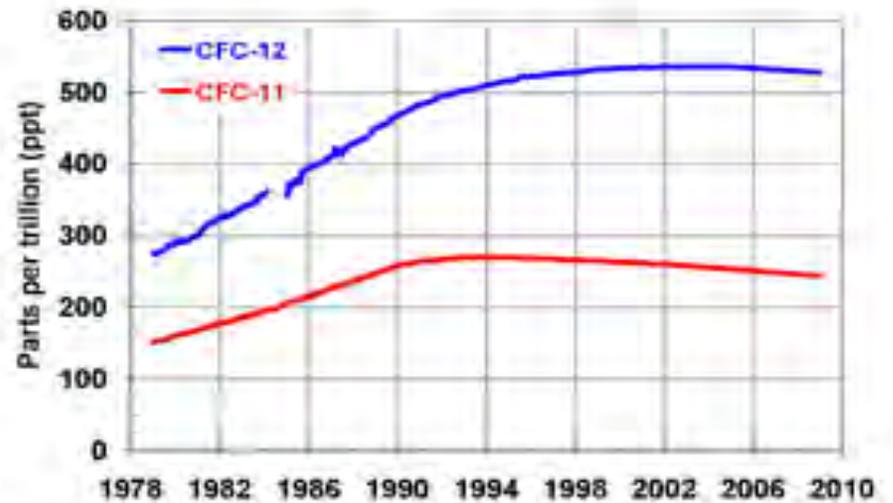
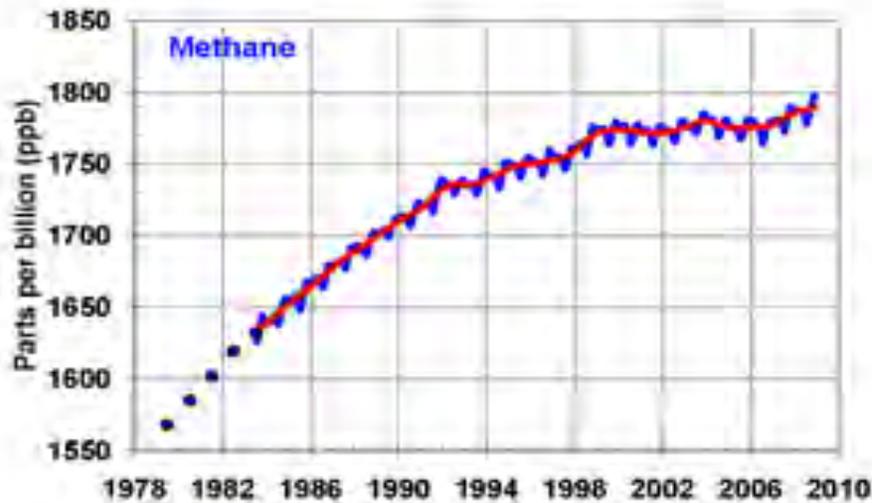
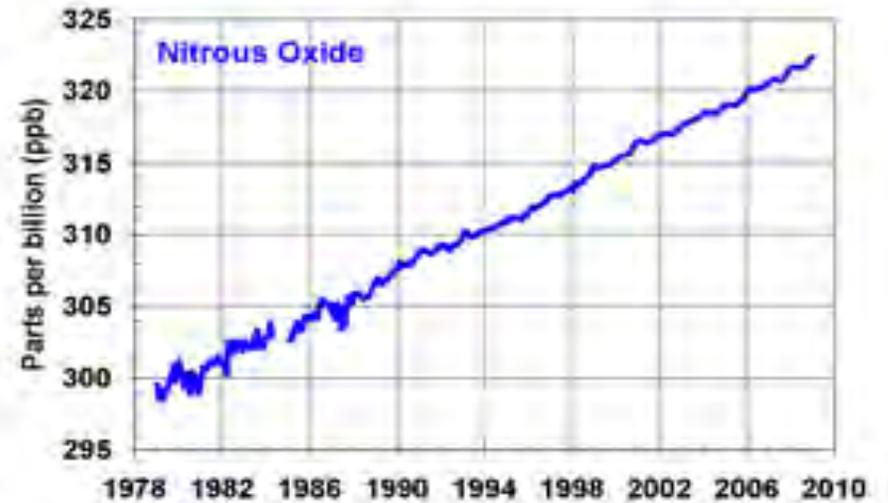
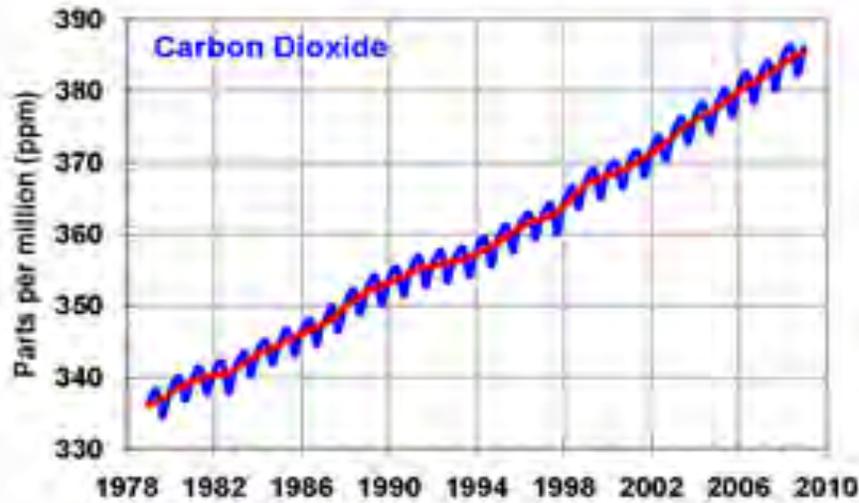
Temperature and CO2 for Last 1,000 Years



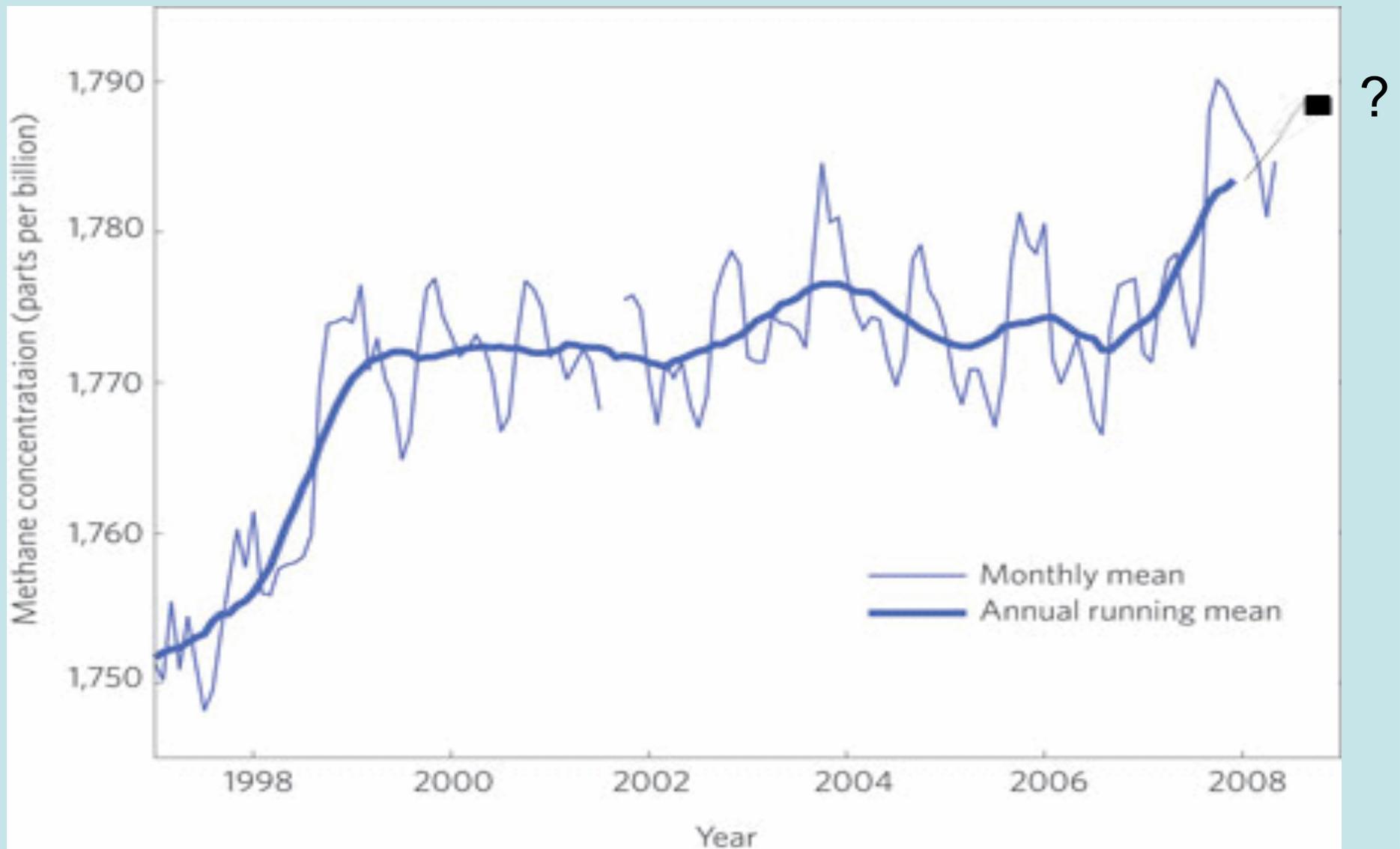


Rapid increase in greenhouse gas concentrations since 1900, relative to previous 10,000 years

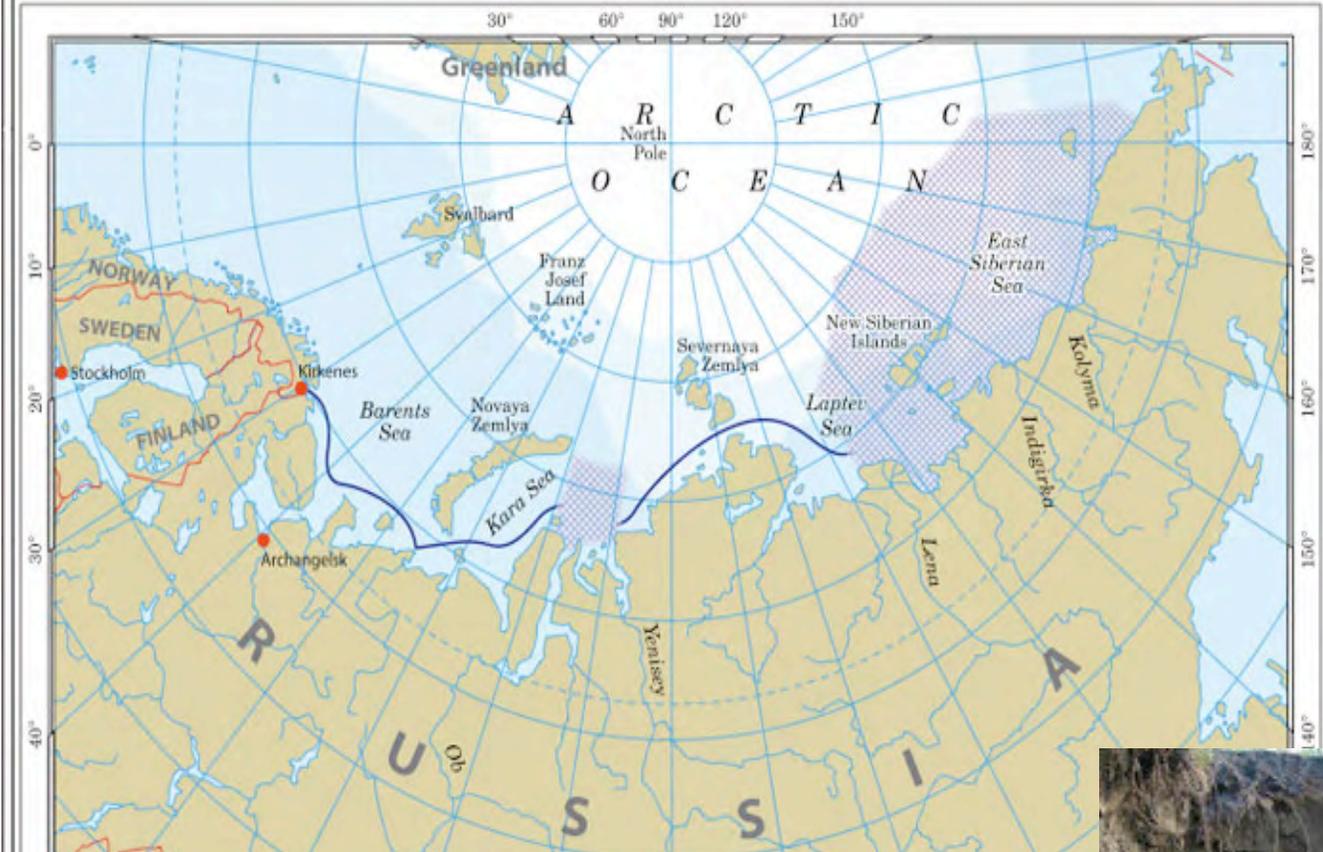
(IPCC '07)



Other greenhouse gases contribute ~30% additional warming



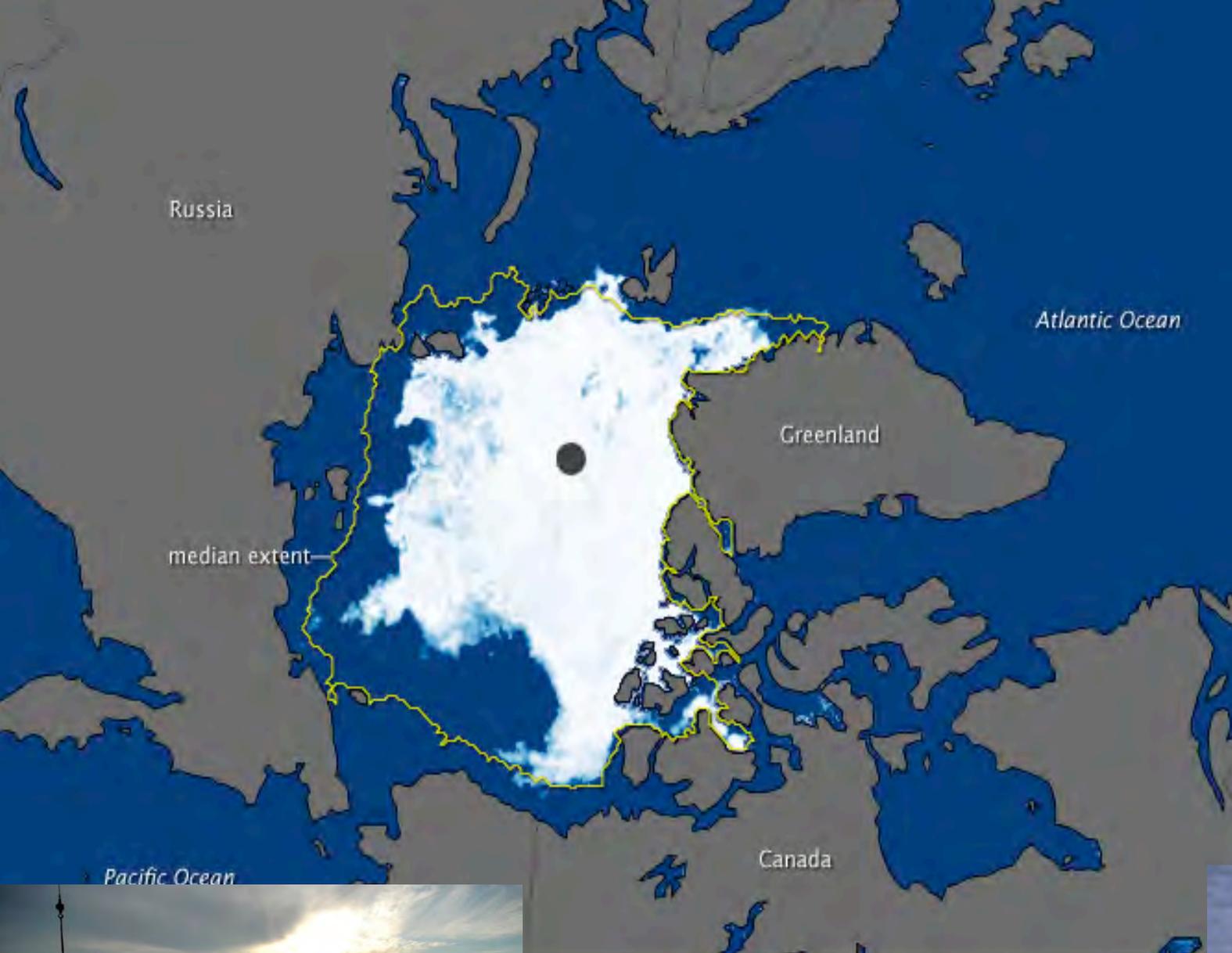
Worrisome recent increase in atmospheric methane



Arctic climate feedbacks?

Measured recent release of CH_4 from Russian boreal peatbogs, permafrost, hydrate deposits offshore





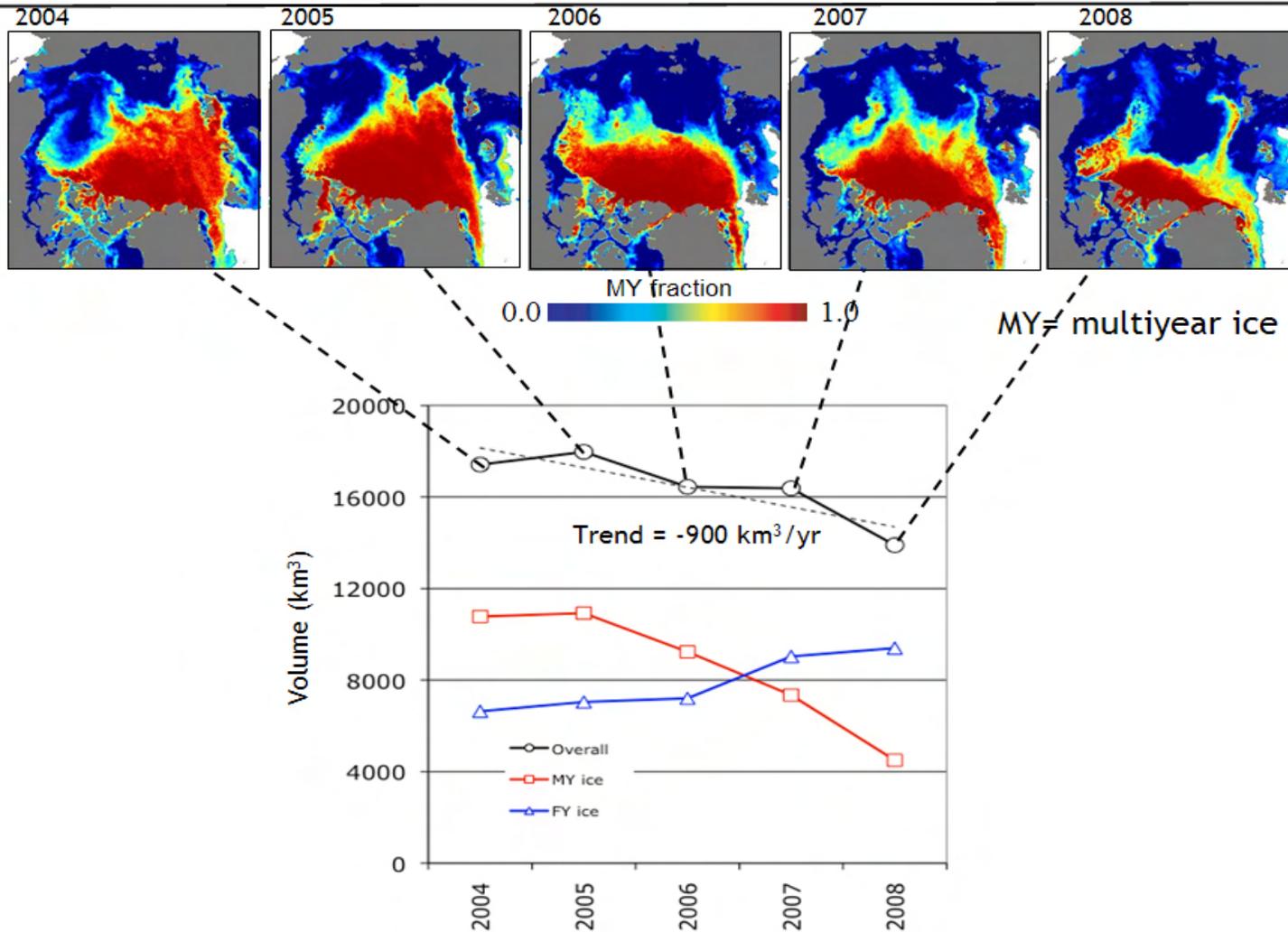
Arctic sea
ice minimum
Sept '09

NW passage
now open
for business

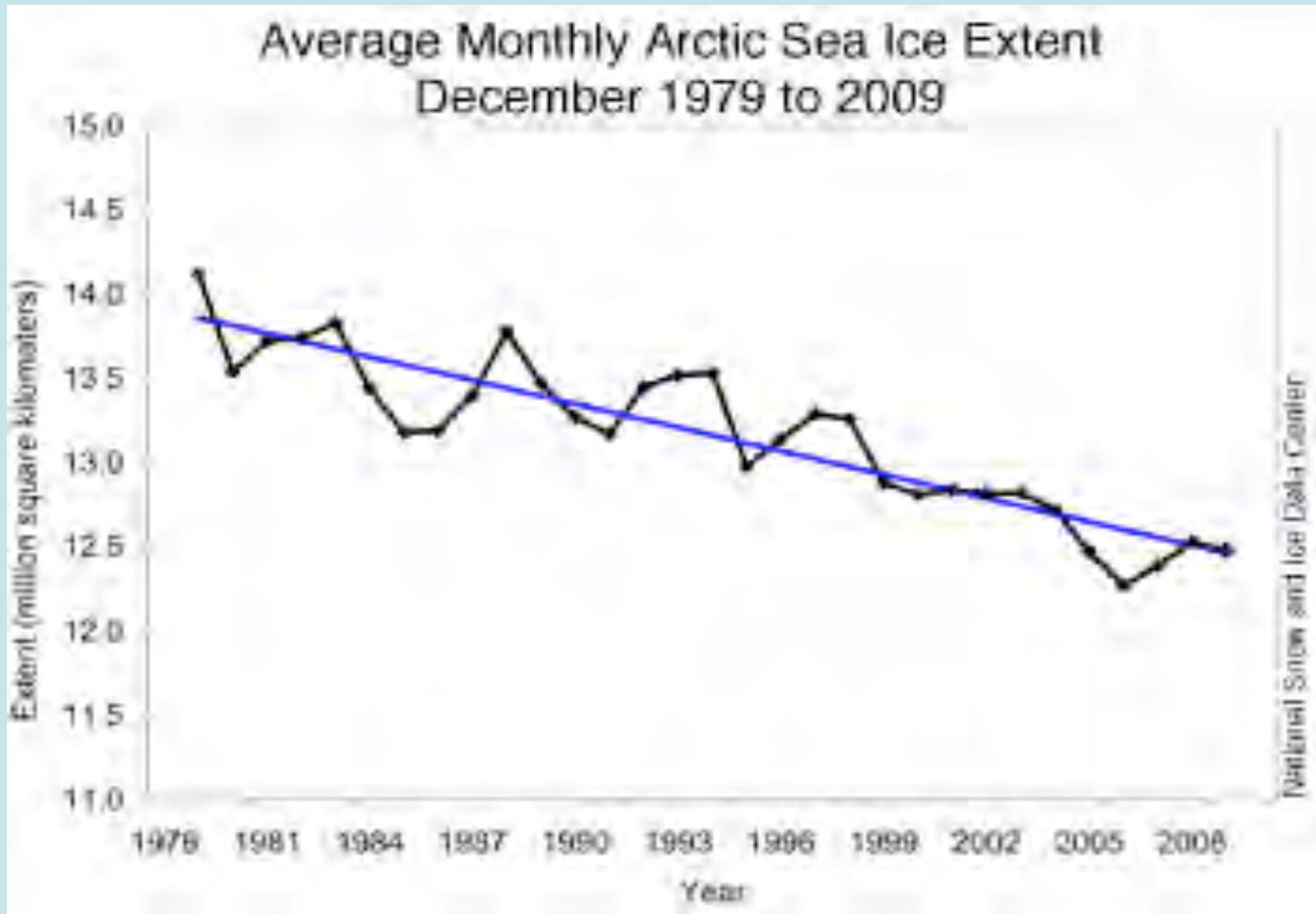




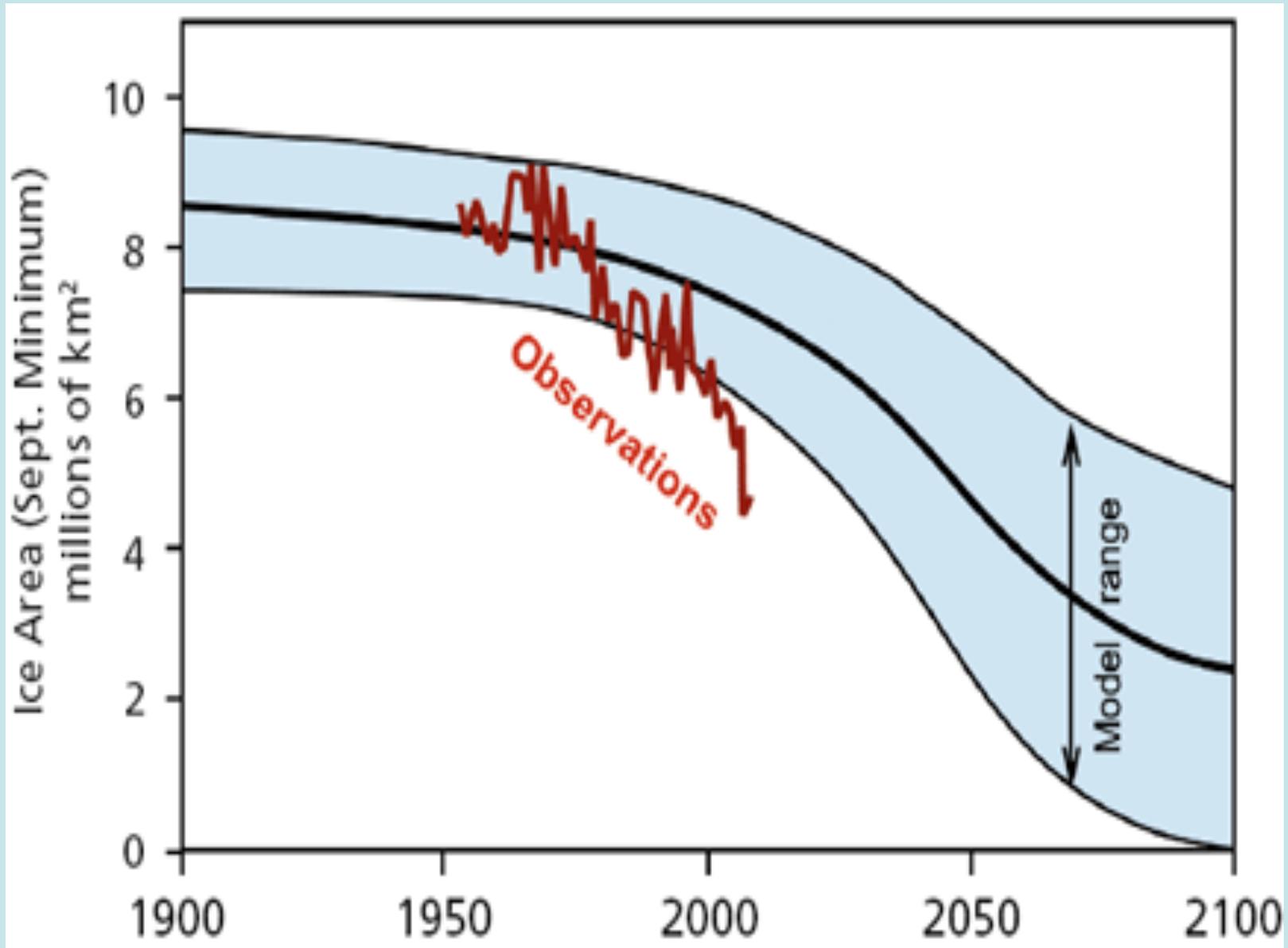
Trend in winter sea ice volume



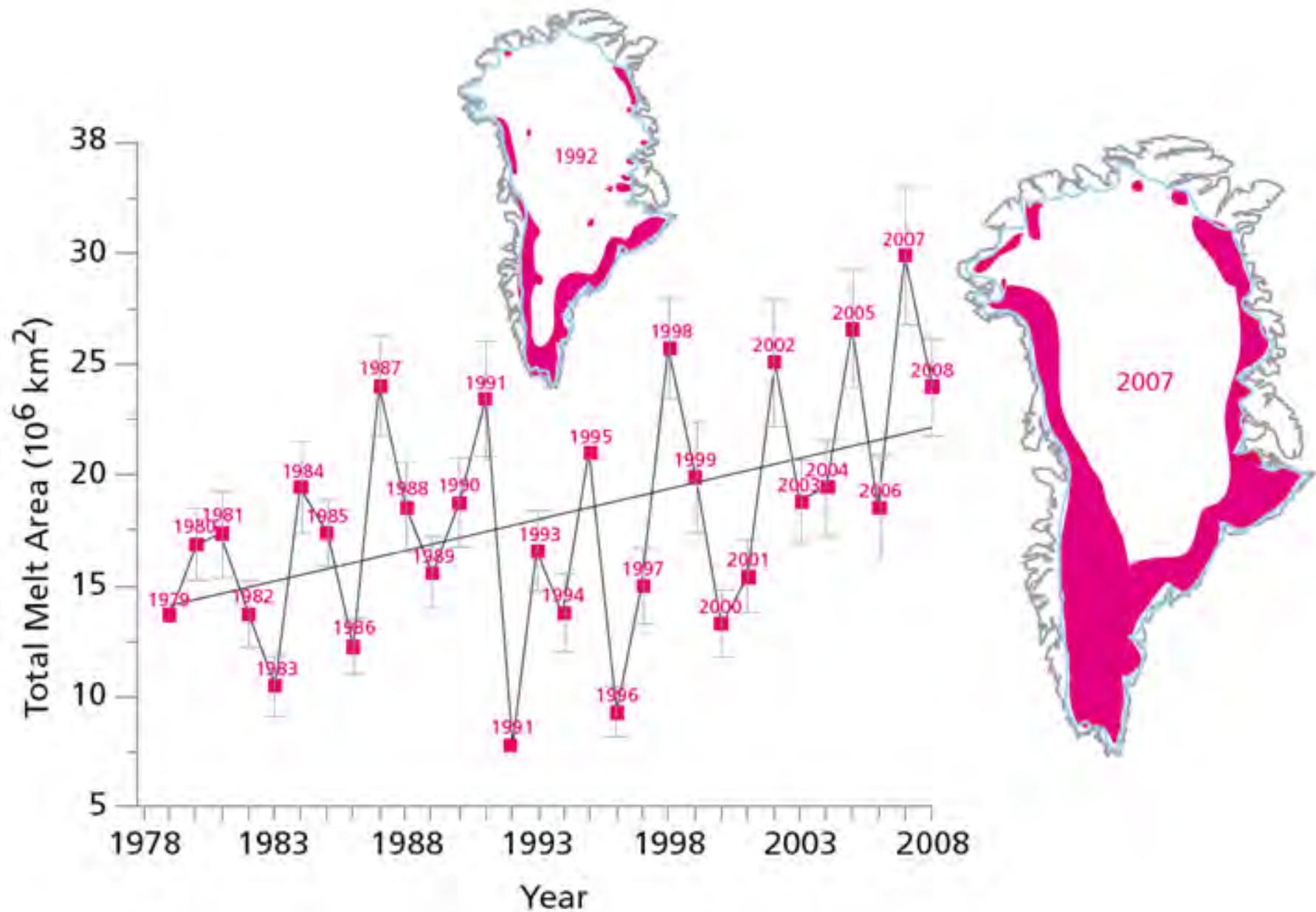
Multi-year sea ice rapidly disappearing



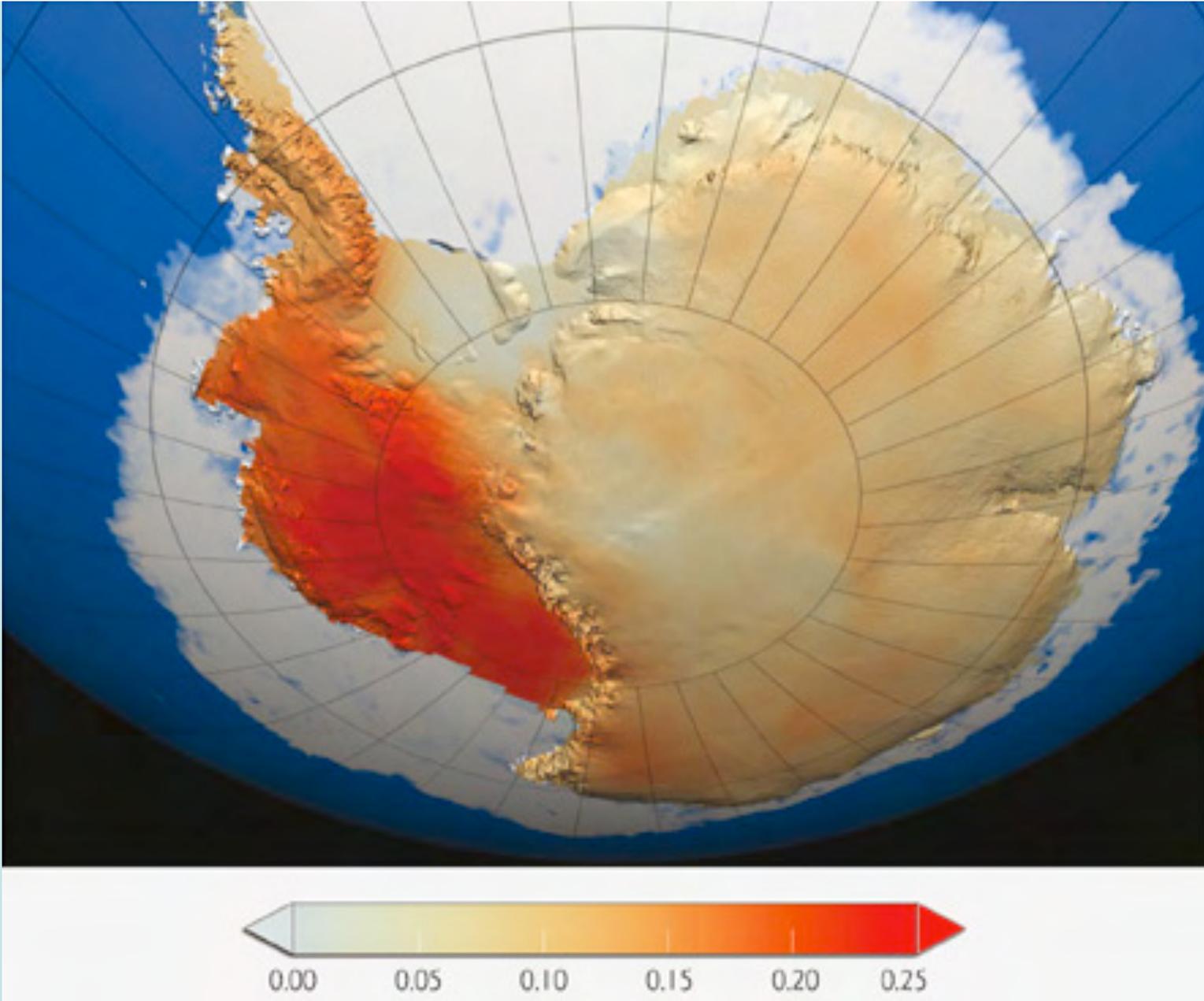
Arctic sea-ice extent declining rapidly



Observed rate of ice loss faster than any model prediction



Rapid and increasing loss of Greenland ice



Antarctica is also warming and losing ice, especially West Antarctica

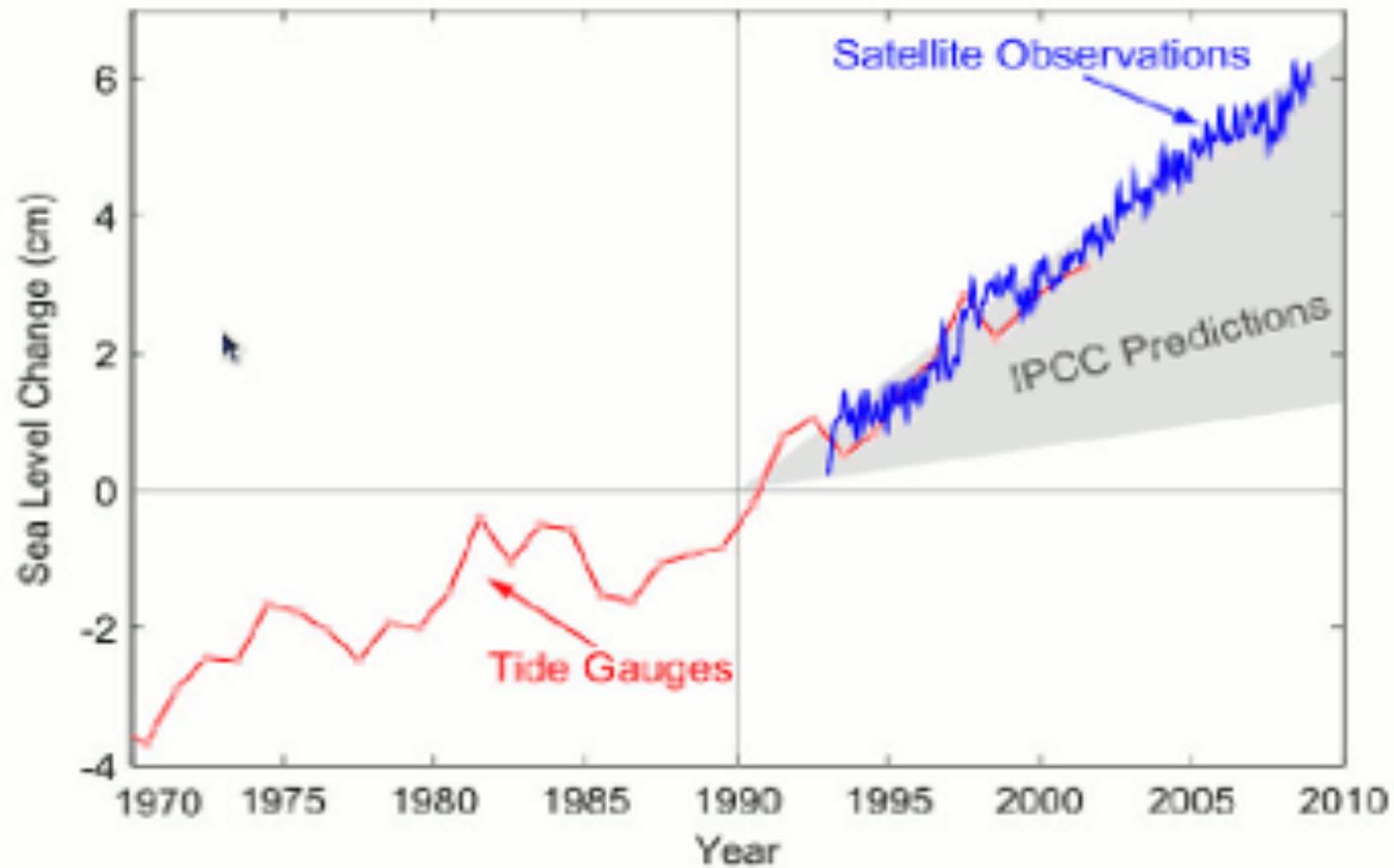
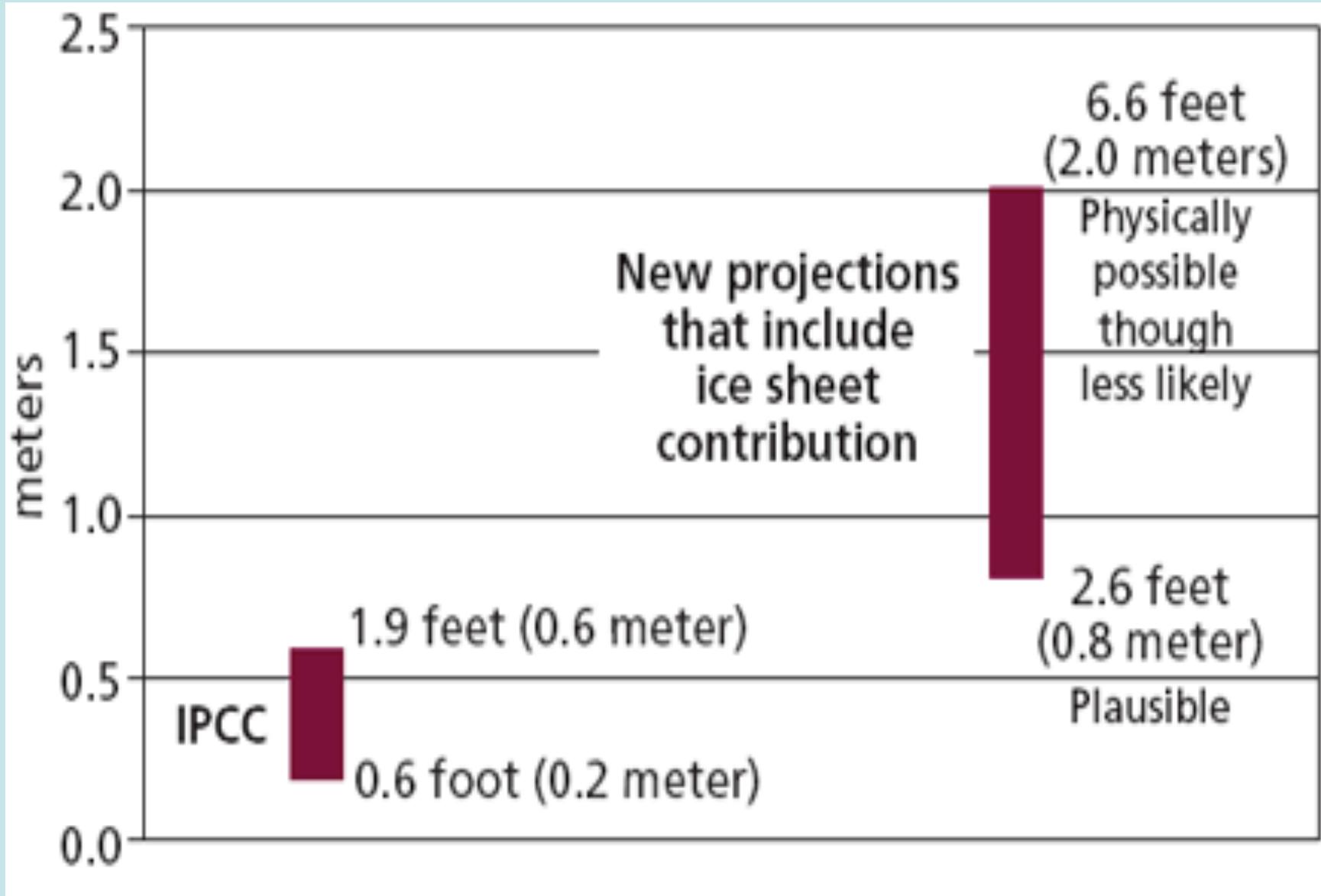


Figure 16: Sea-level change 1970-2010



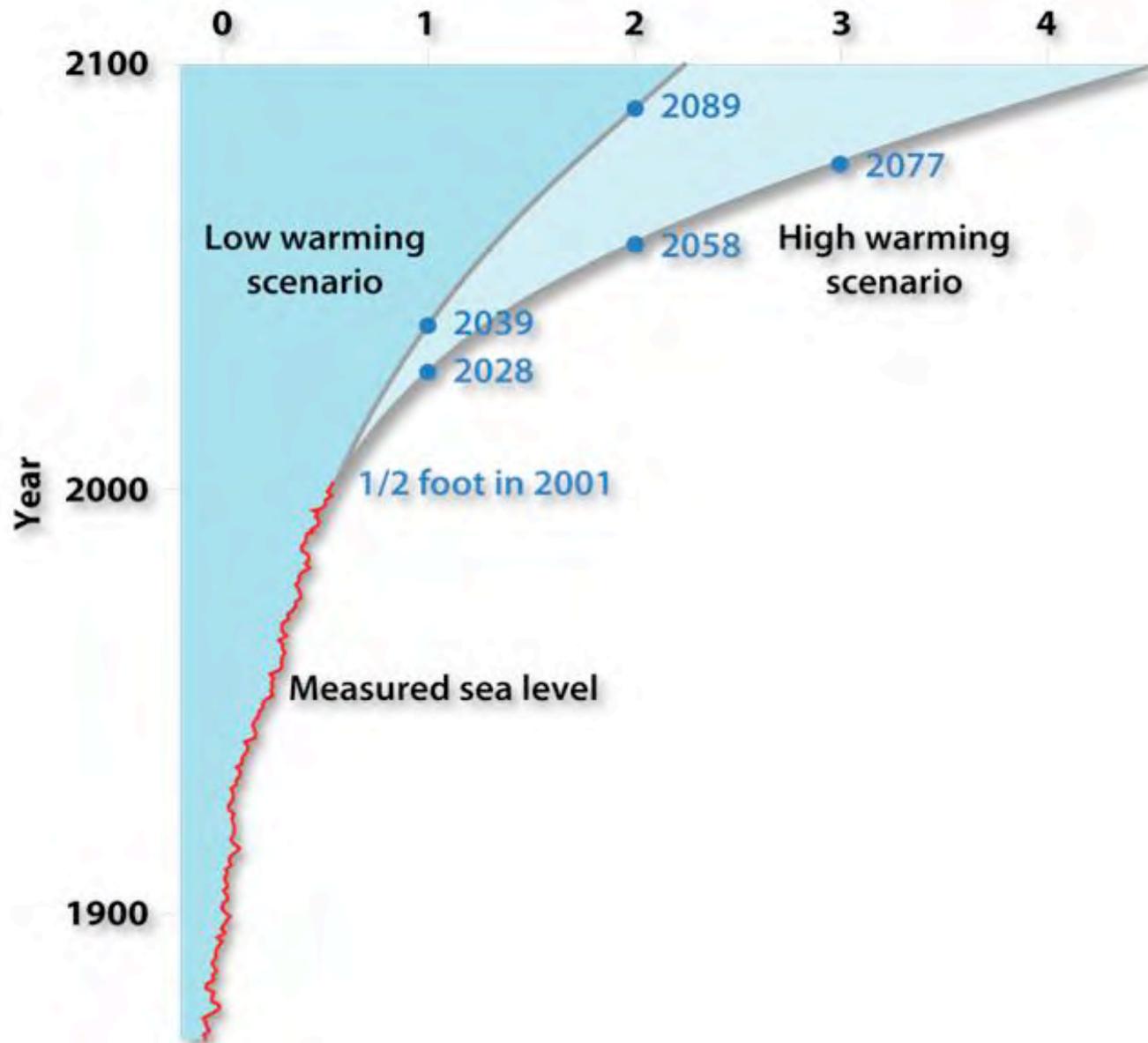
Observed sea-level rising faster than model predictions



Possible sea-level rise by 2100 of 3 to 6 feet

Sea Level Rise Projections

Relative to 1900
(feet)



Sea-level predicted to rise by 10 feet or more by 2300

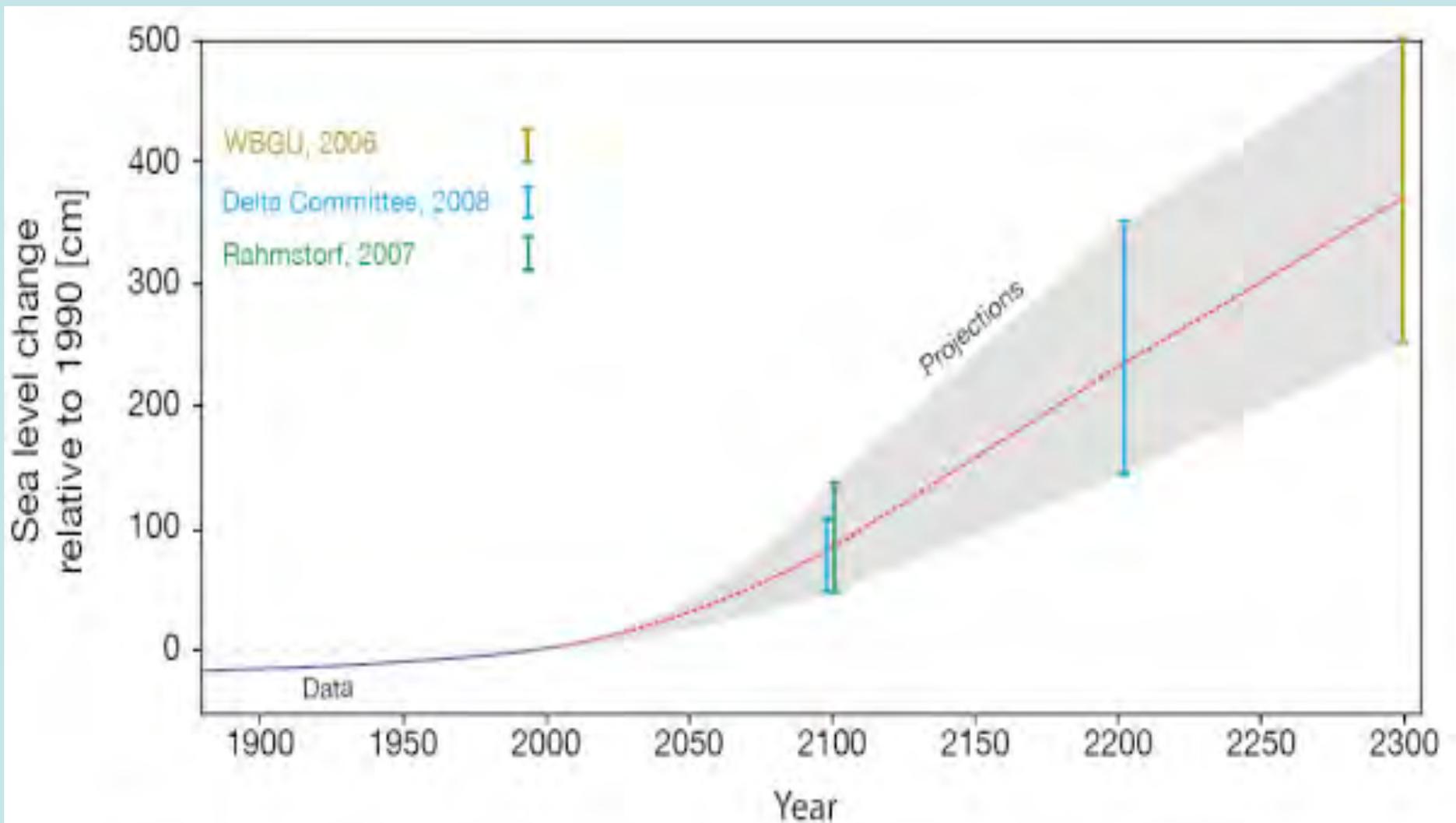


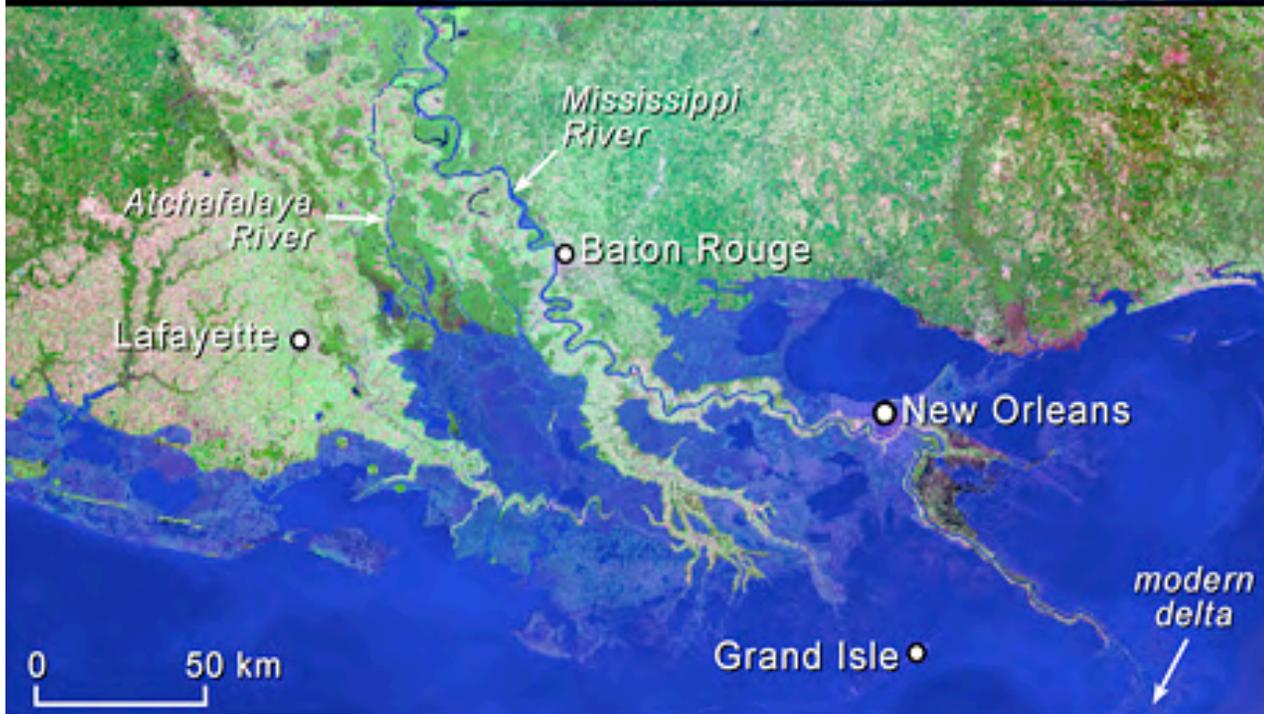
Figure 17. Some recent projections of future sea level rise. Historical data from Church and White (2006). Future projections are from Rahmstorf (2007) and WBGU (2006), while those projections represented here as 'Delta Committee' are from Vellinga et al.



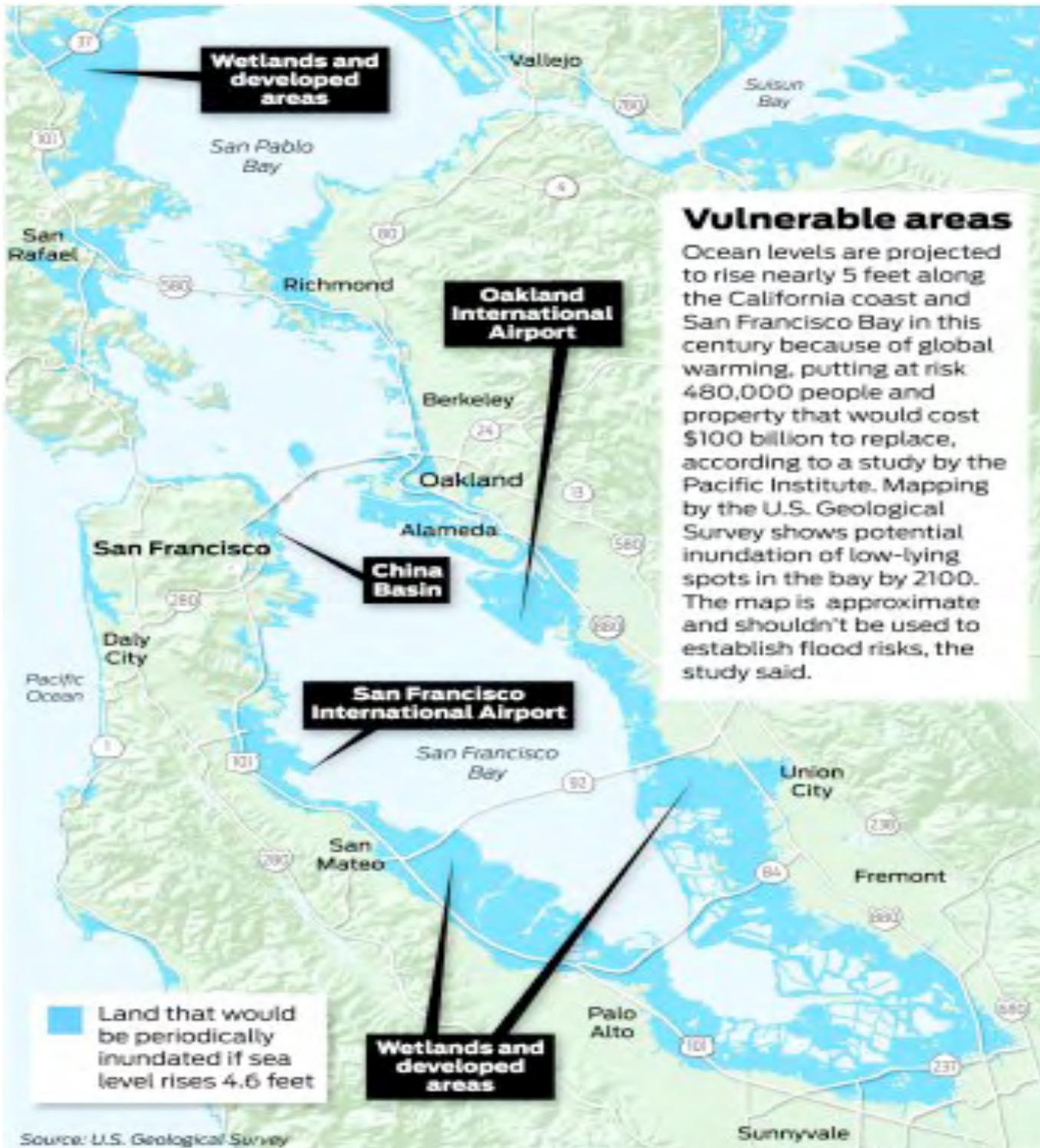
Loss of coastal US land for sea-level rise of 20 feet.



New Orleans now



Possible by 2050
(Rising sea-level,
eroding delta)



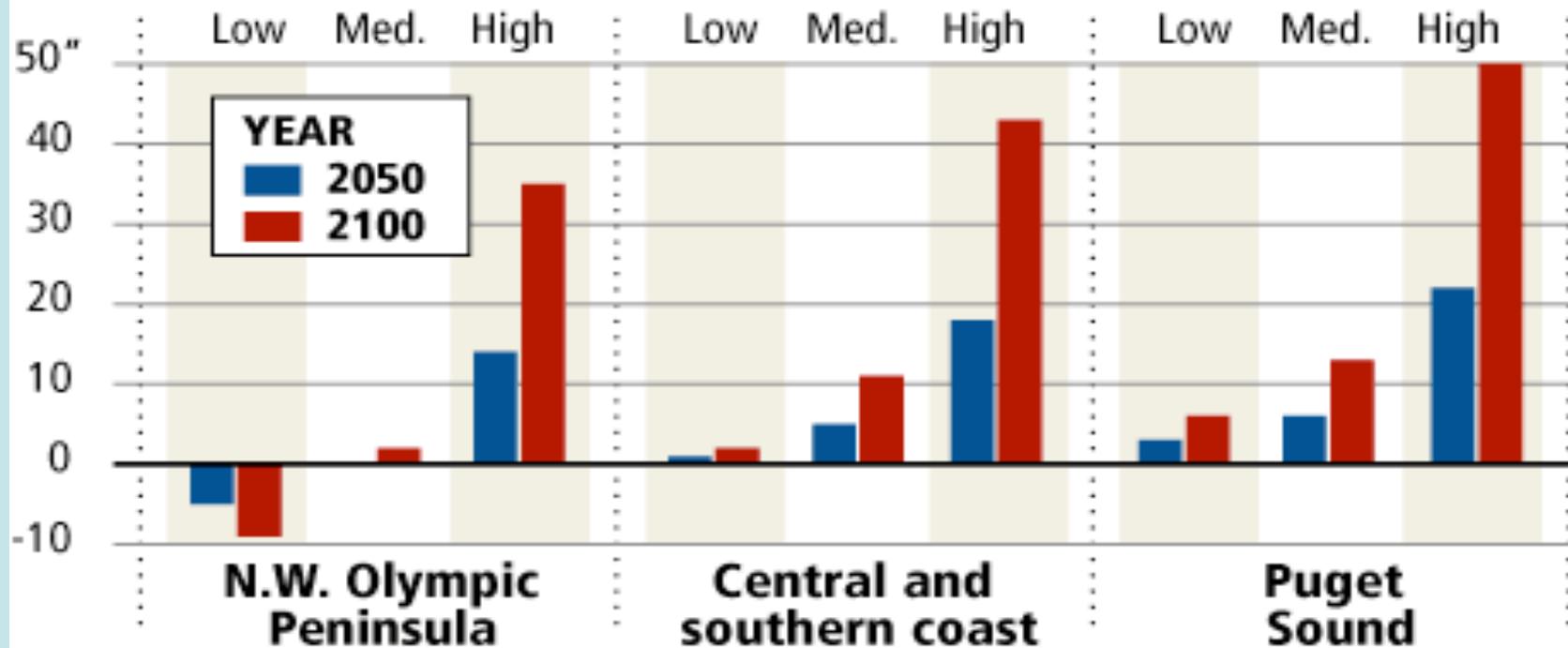
A 5-ft sea-level rise would remake San Francisco Bay, inundating Both SFO and Oakland airports

RISING SEA LEVEL

Sea level rise varies by location on Washington shorelines largely because of plate tectonics that lift or lower land masses. The estimates are influenced by the amount of greenhouse gases produced and the rate of melting for Greenland and Antarctica's ice sheets. The worst and best case scenarios are considered "low probability."

SEA LEVEL CHANGE ESTIMATES

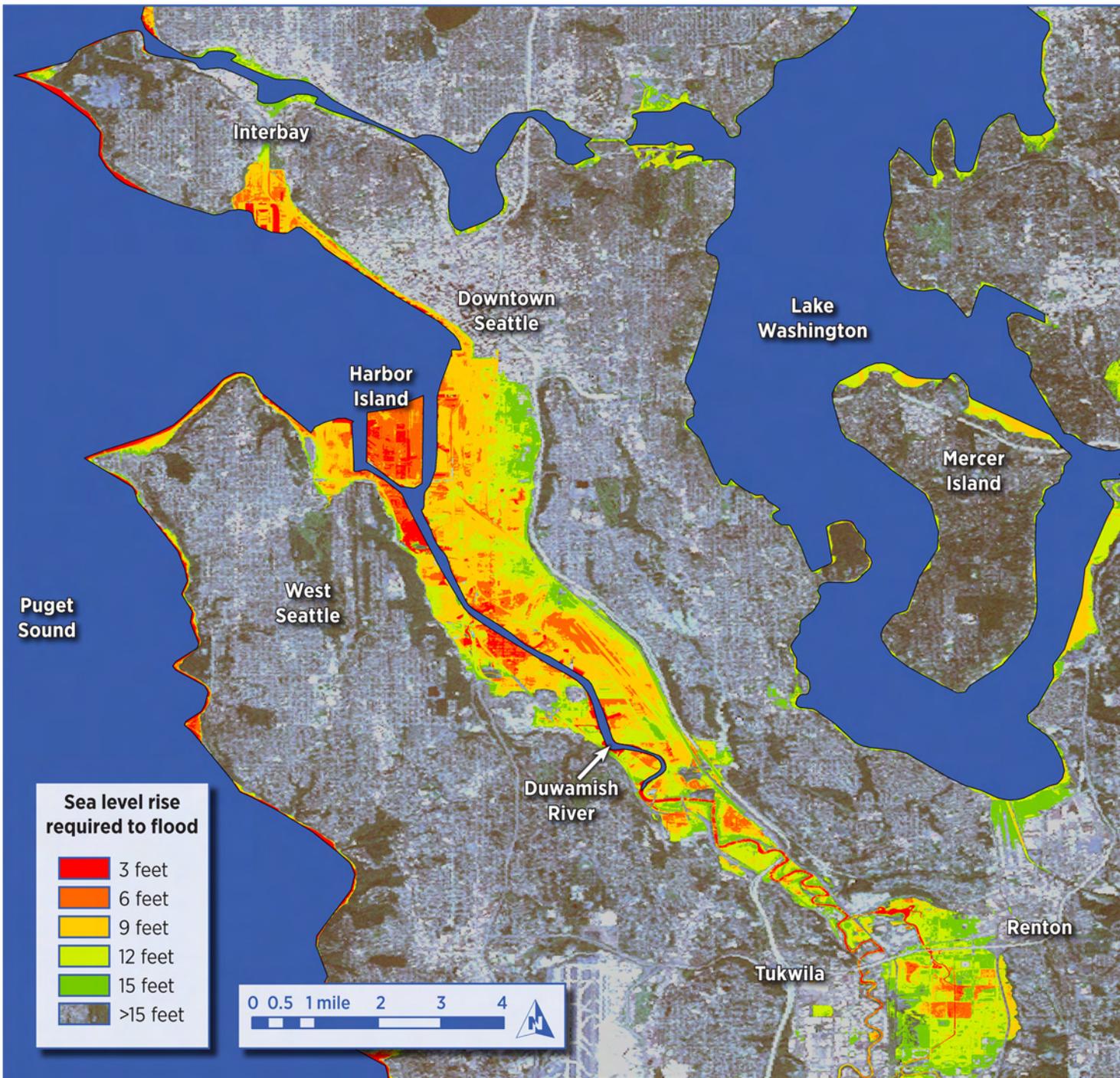
Low, medium and high estimates measured in inches



Sources: University of Washington Climate Impacts Group, Washington Department of Ecology

SEATTLE P-I

A high estimate (4 ft) for Puget Sound by 2100



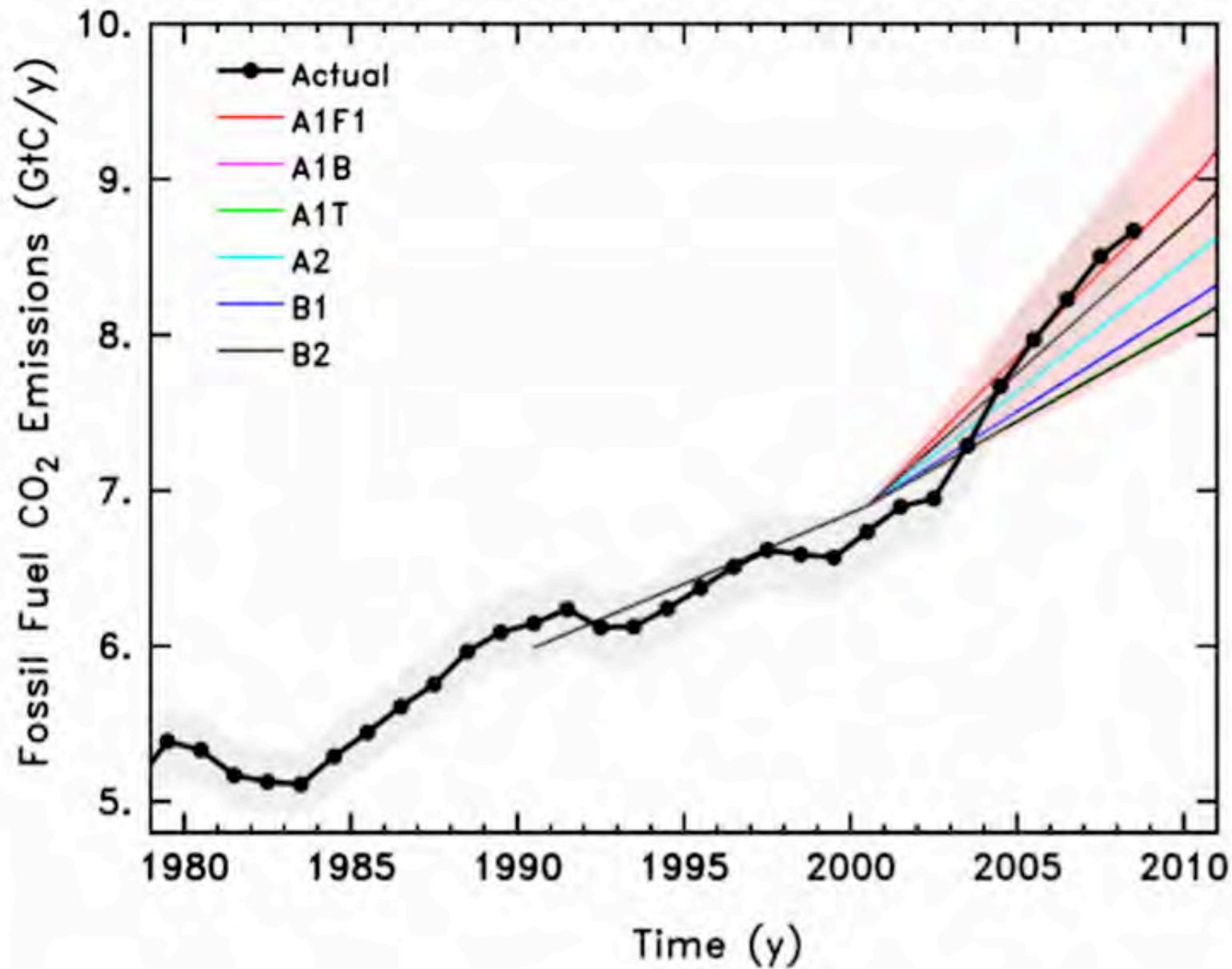
Impact of sea-level rise in Puget Sound

“Copenhagen Accord” reached in the final hours of COP-15 (Jan 2010)



Non-binding
No targets
No timetable

Not enough
to safeguard
our childrens'
world



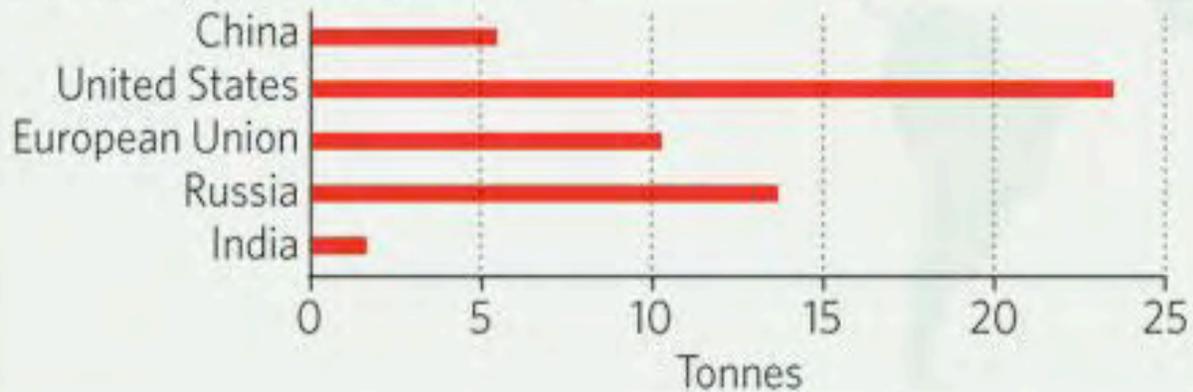
Global use of fossil fuels now exceeding all earlier predictions

FIVE BIGGEST EMITTERS

Total greenhouse-gas emissions, excluding land-use change, in millions of tonnes of carbon dioxide equivalent for 2005

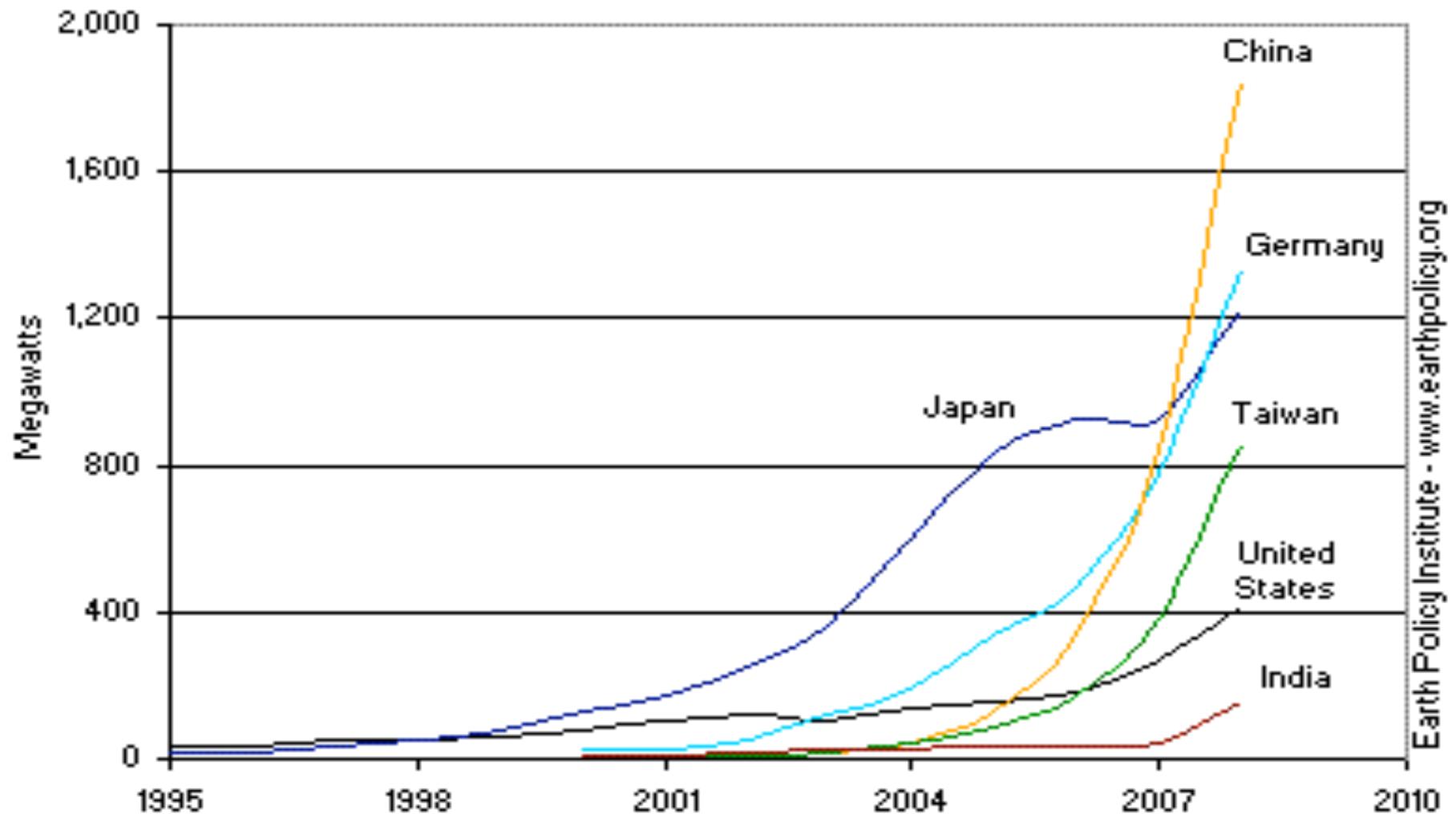


EMISSIONS PER CAPITA



China has passed the USA in country emissions, but not in per capita emissions, nor in cumulative emissions

Annual Solar Photovoltaics Production in Selected Countries, 1995-2008



Source: Worldwatch; Prometheus Institute and Greentech Media

China leads the world in wind and solar energy manufacturing

Estimated global CO₂ emission reduction pathways needed to have 67% probability of holding global warming below 2 °C. Note year of maximum global emissions in each case

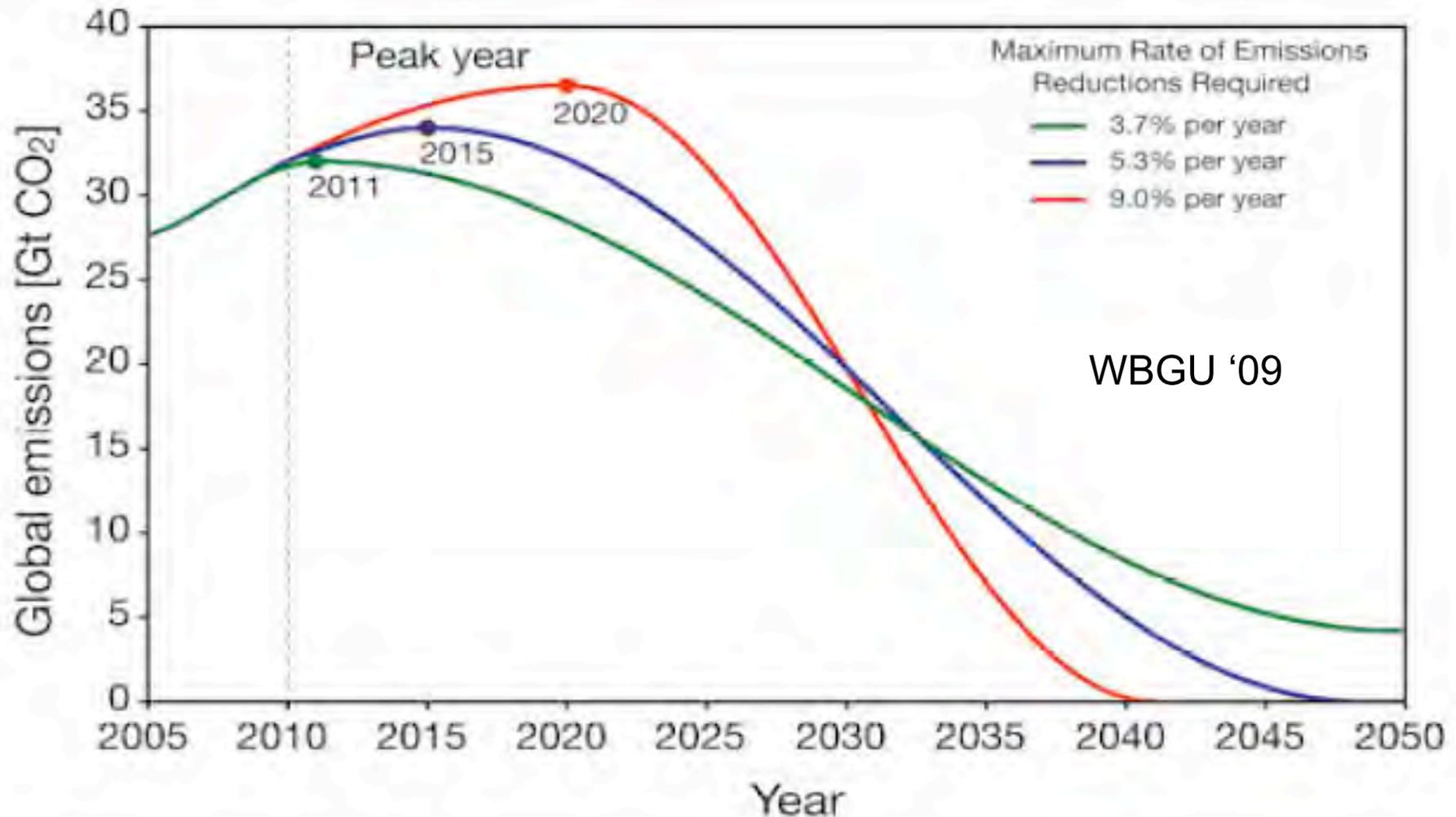
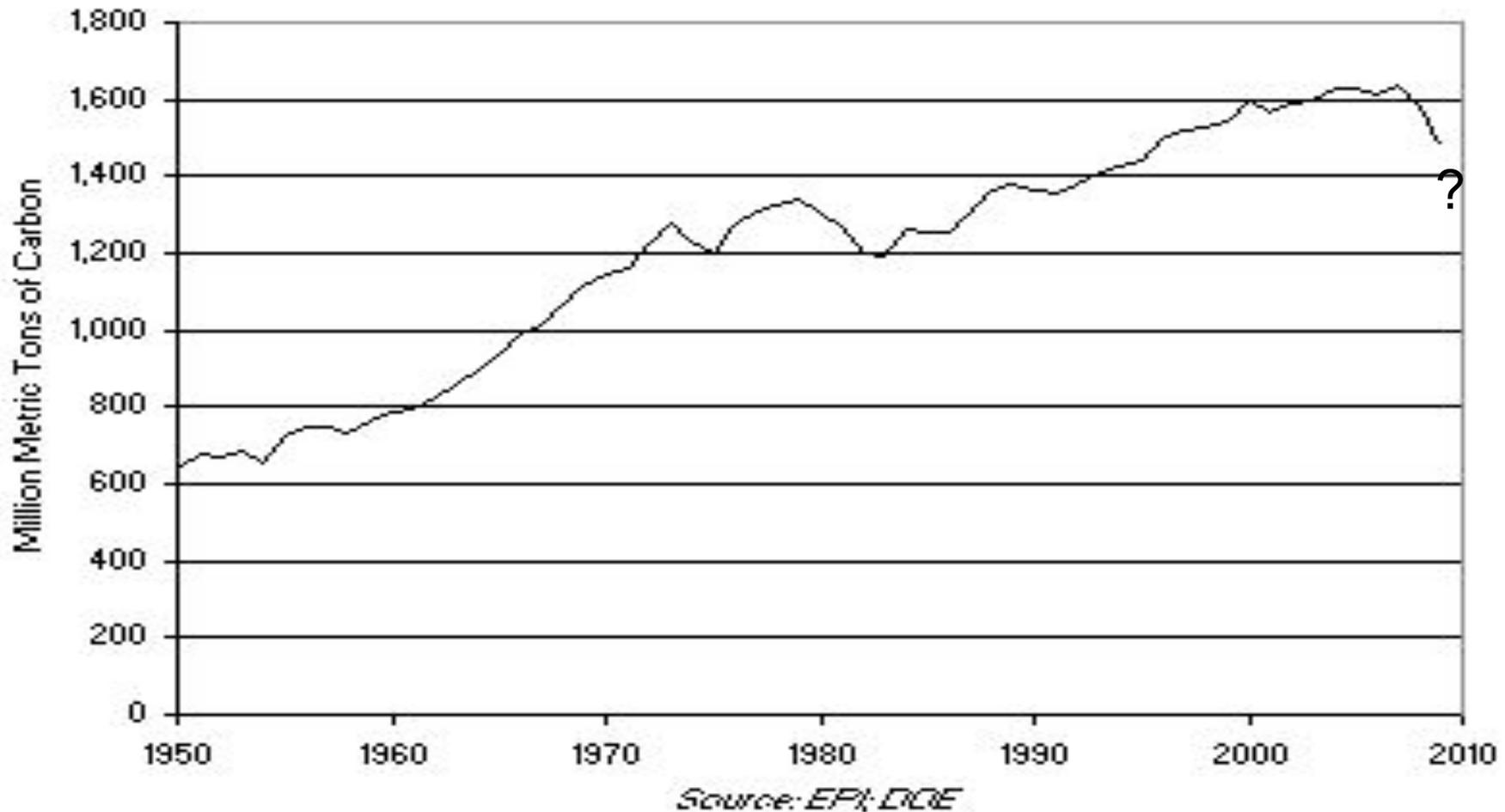


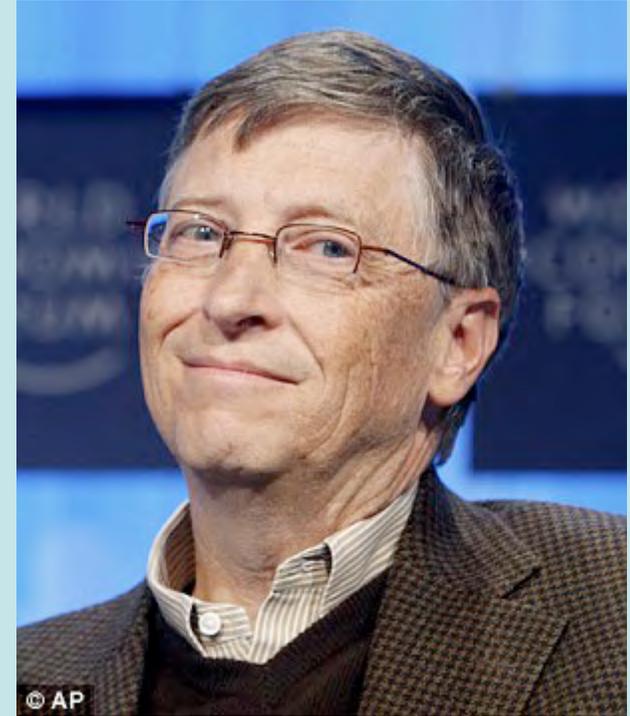
Figure 22. Examples of global emission pathways where cumulative CO₂ emissions equal 750 Gt during the time period 2010-2050 (Gt C = 3.67 Gt CO₂). At this level, there is a 67% probability of limiting global warming to a maximum of 2°C. The graph shows

U.S. Energy-Related Carbon Dioxide Emissions, 1950-2009



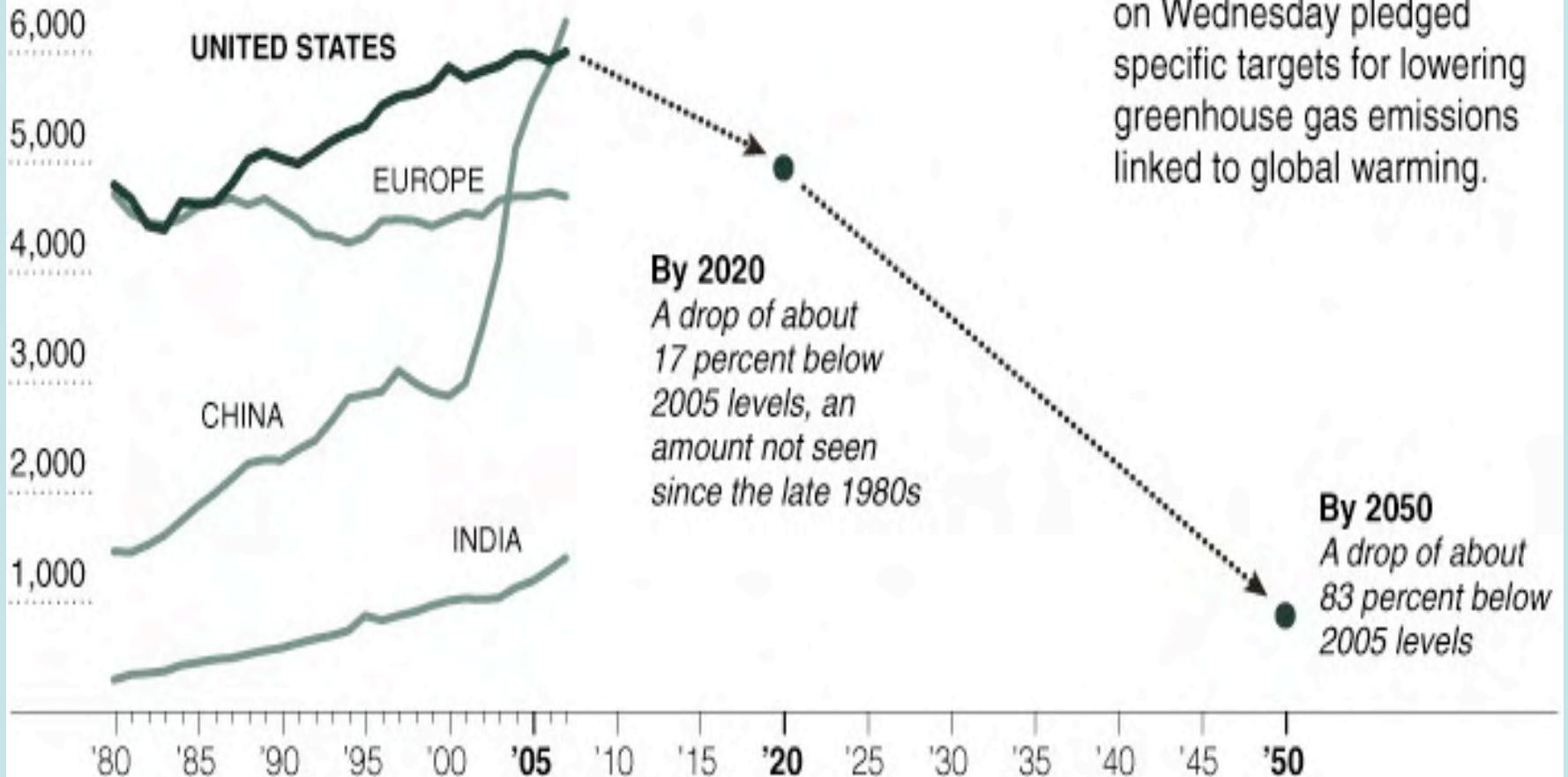
In recession, has the US turned the corner on CO2 emissions?

- The formula is a very straightforward one. More carbon dioxide equals temperature increase equals negative effects like collapsed ecosystems.
- We have to get to zero!
- (carbon dioxide emission)”
-
-
- Bill Gates ..on dealing with global climate change
(Feb, 2010)



Carbon emissions from energy consumption

Million metric tons



Source: Energy Information Administration

A Pitch to Cut U.S. Emissions

The Obama administration on Wednesday pledged specific targets for lowering greenhouse gas emissions linked to global warming.

By 2020
A drop of about 17 percent below 2005 levels, an amount not seen since the late 1980s

By 2050
A drop of about 83 percent below 2005 levels

Will we do this, will we do this in time?

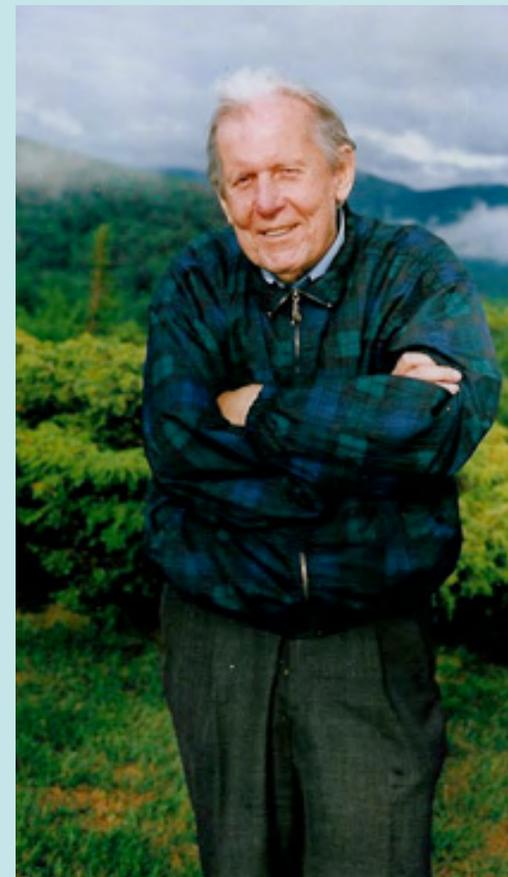
- “The choice is awesome and potentially eternal.
- It is in the hands of the present generation; a decision we cannot escape, and a choice to be mourned or celebrated through all the generations to come...”

Al Gore 2009 (Our Choice)



“Two things are needed to guide our judgment and sustain our energies for the challenges ahead: a certain alarm at what is happening at present, and a fascination with the future available to us if only we respond creatively to the urgencies of the present”

Thomas Berry



What You Can Do

- * **Learn about climate change, convince others of the challenge**
- * **Urge your leaders to pass strong climate mitigation laws**
 - * **Support clean, renewable energy**
 - * **Replace incandescent light-bulbs with CFLs**
 - * **Save energy and water at home**
 - * **Buy energy-efficient appliances**
 - * **Plant a tree, protect a forest**
 - * **Recycle, reuse, rethink (don't waste anything)**
- * **Support better public transportation, walk, ride a bike.**
- * **Drive green (take your foot off the gas!), consider a Prius**

“Start by doing what’s necessary, then do what’s possible, soon you will be doing the impossible”

St. Francis of Assisi