Overview of Global Climate Change

Barry Lefer
University of Houston
29 Jan 2007

APRIL 3, 2006

www.time.com AOL Keyword: TIME

SPECIAL REPORT GLOBAL WARMING

TIME

BE WORRIED. BE VERY WORRIED.

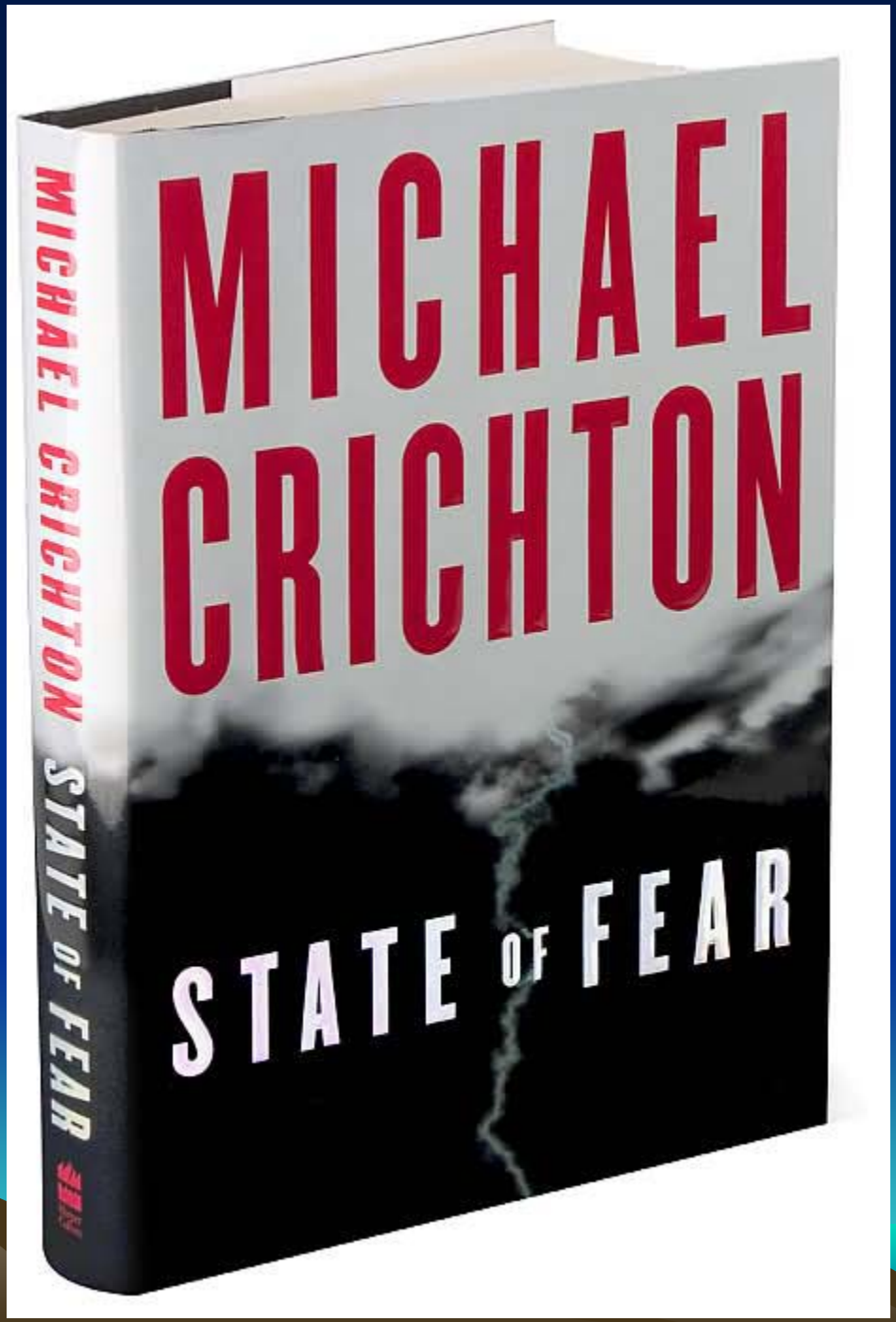
Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well

EARTH AT THE TIPPING POINT

HOW IT THREATENS YOUR HEALTH

HOW CHINA & INDIA CAN HELP SAVE THE WORLD—OR DESTROY IT

THE CLIMATE CRUSADERS


MICHAEL CRICHTON
STATE OF FEAR
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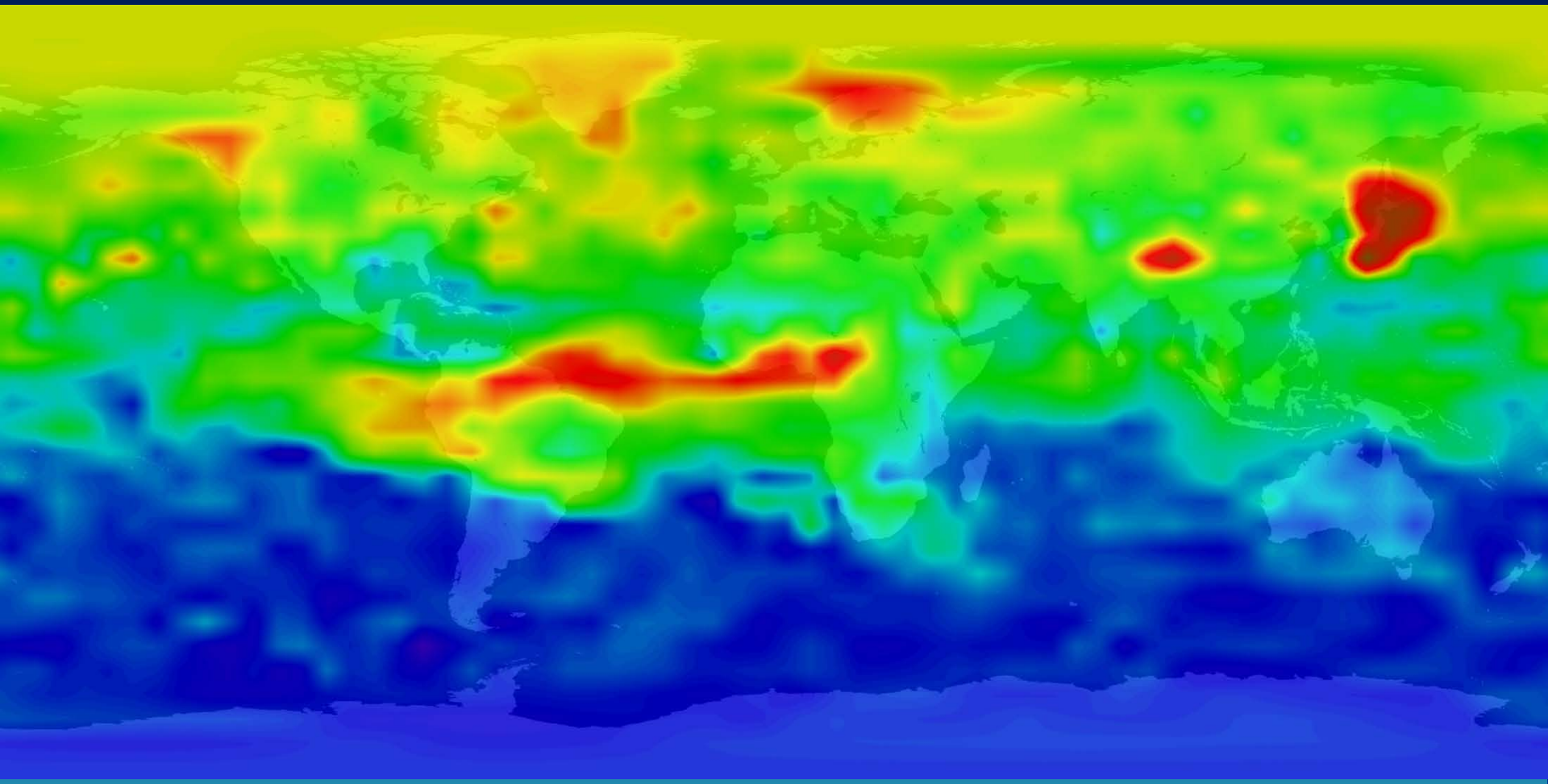
STATE OF FEAR

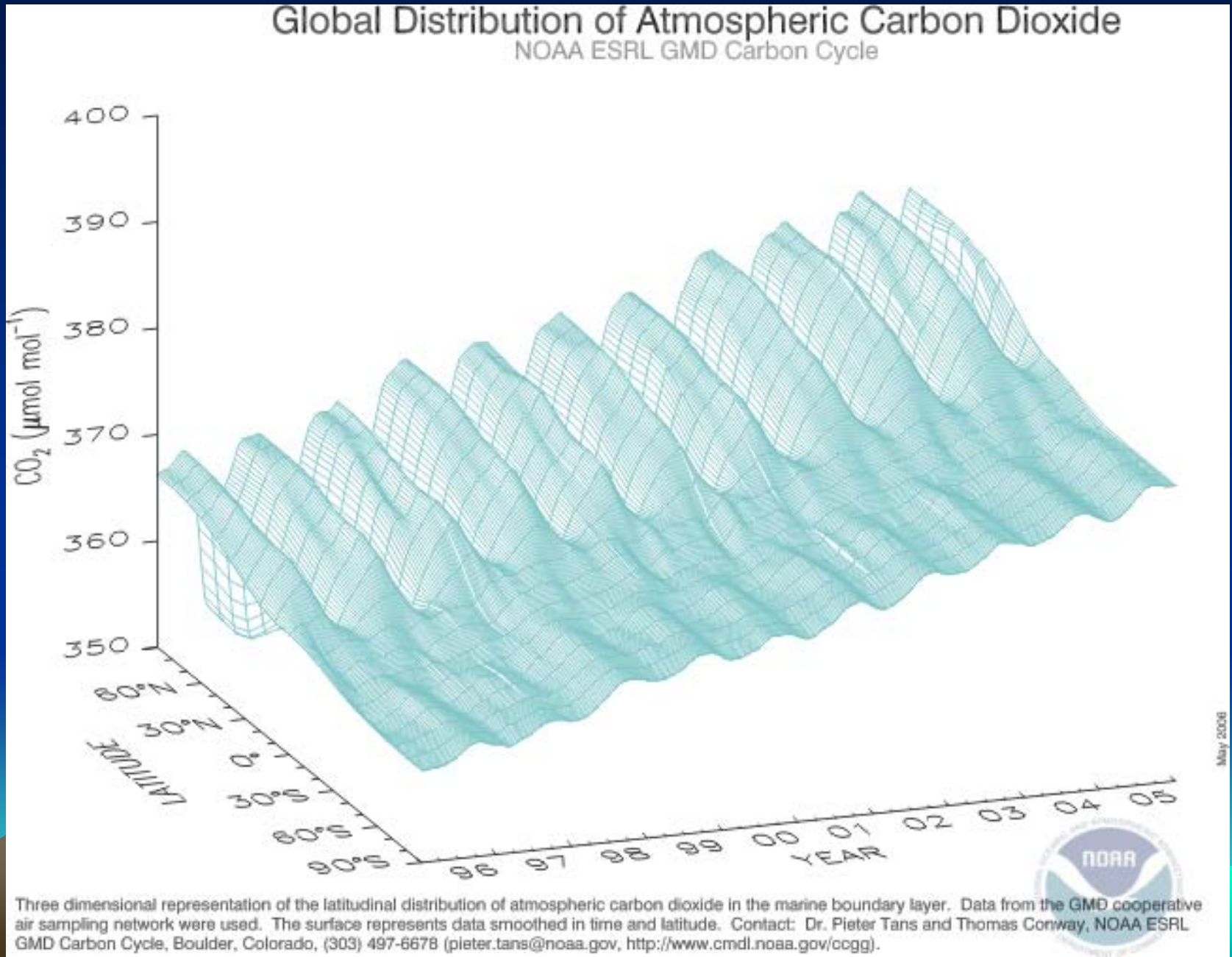

Science
24 March 2006
Climate Change
Breaking the Ice
AAAS

Global CO “snapshot”



MOPPITT satellite
October 3, 2003

More Recent carbon dioxide



Three dimensional representation of the latitudinal distribution of atmospheric carbon dioxide in the marine boundary layer. Data from the GMD cooperative air sampling network were used. The surface represents data smoothed in time and latitude. Contact: Dr. Pieter Tans and Thomas Conway, NOAA ESRL GMD Carbon Cycle, Boulder, Colorado, (303) 497-6678 (pieter.tans@noaa.gov, http://www.cmdl.noaa.gov/ccgg).

Temperature Scales

Gabriel Fahrenheit

Anders Celsius

William Thomson

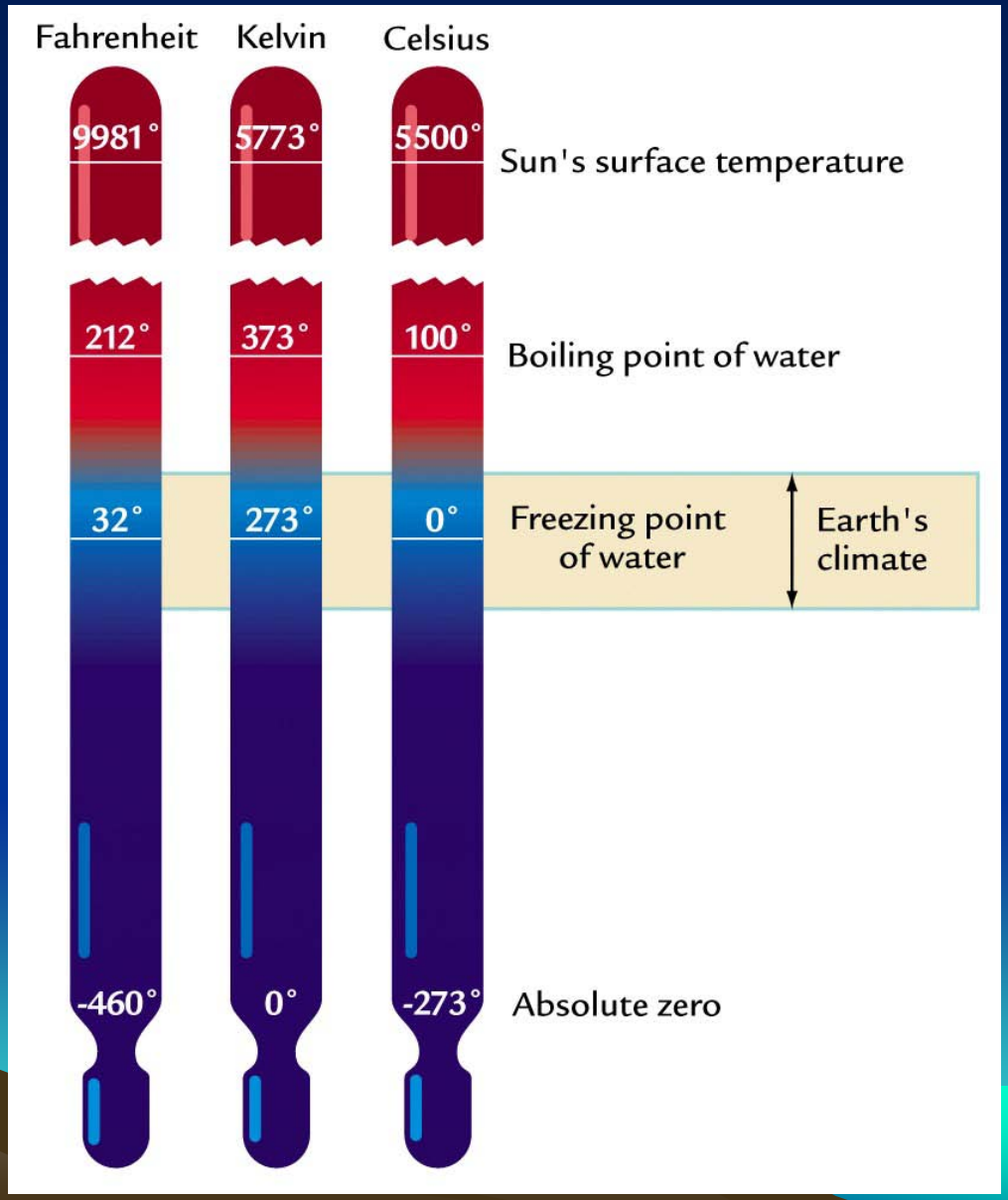
$T_C = 0.55\ (T_F - 32)$
$T_F = (1.8 * T_C) + 32$

Ave Temp = 15 C

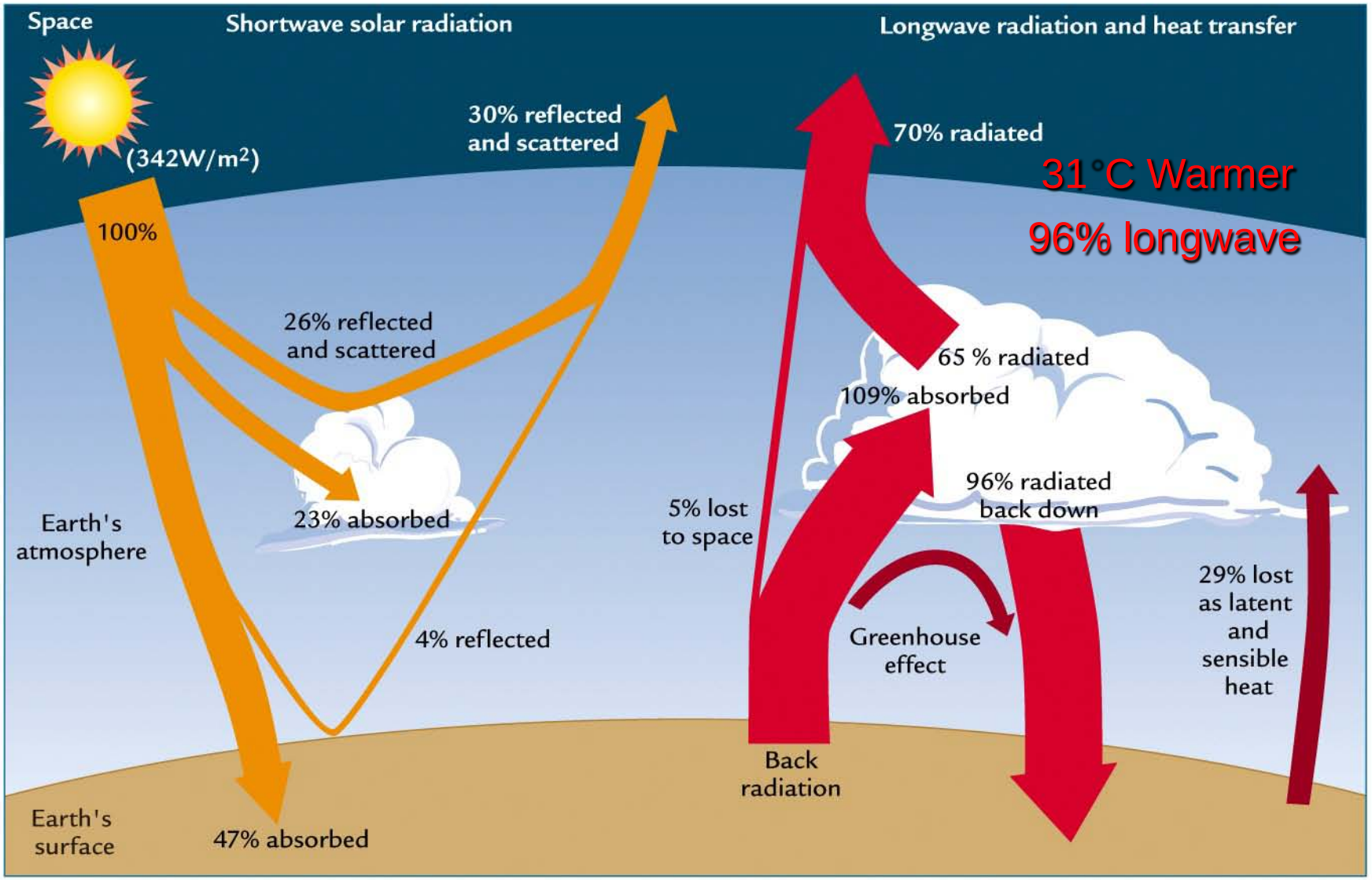
= 59 F

Typical Range = 0° - 30°C

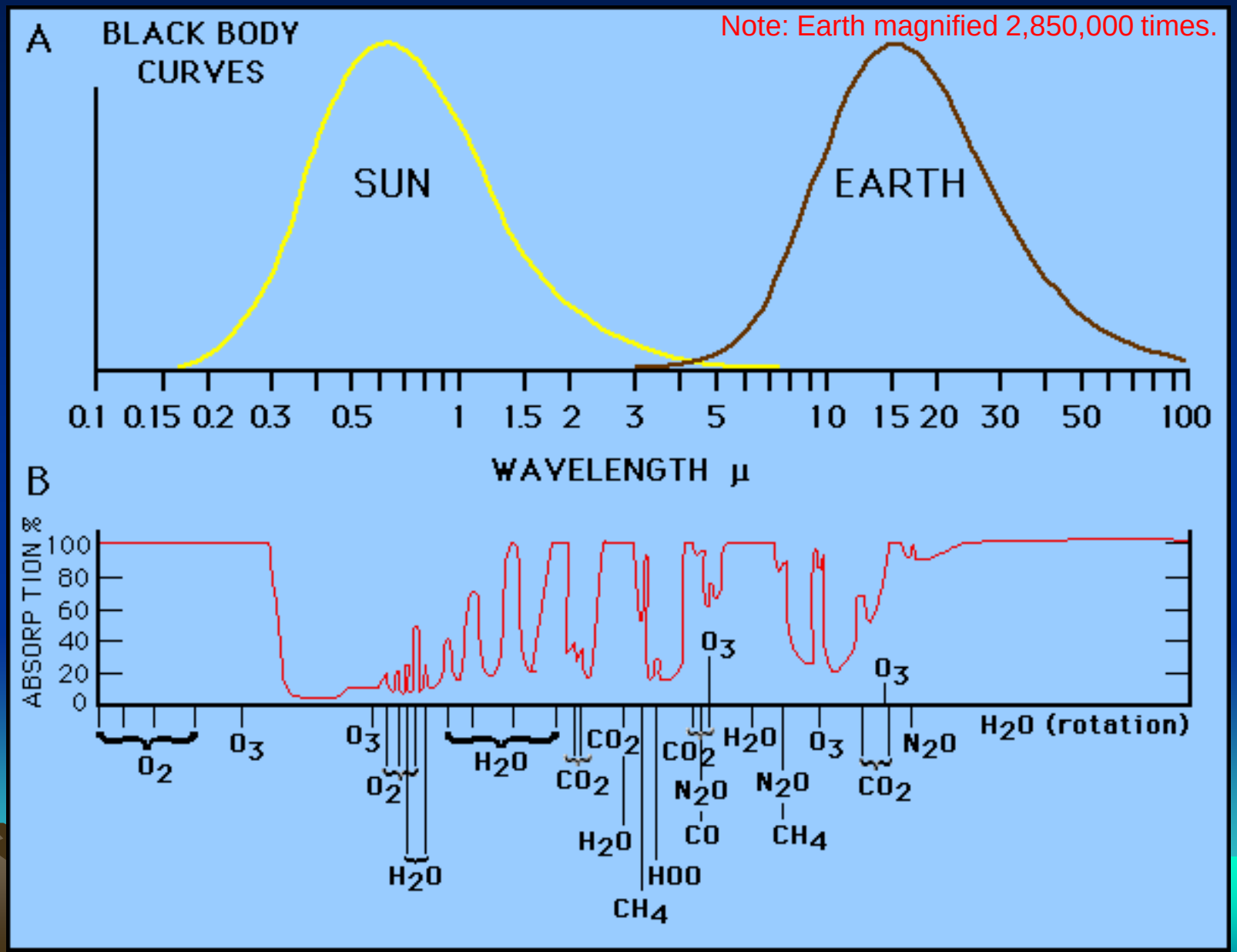
= 32° - 86°F



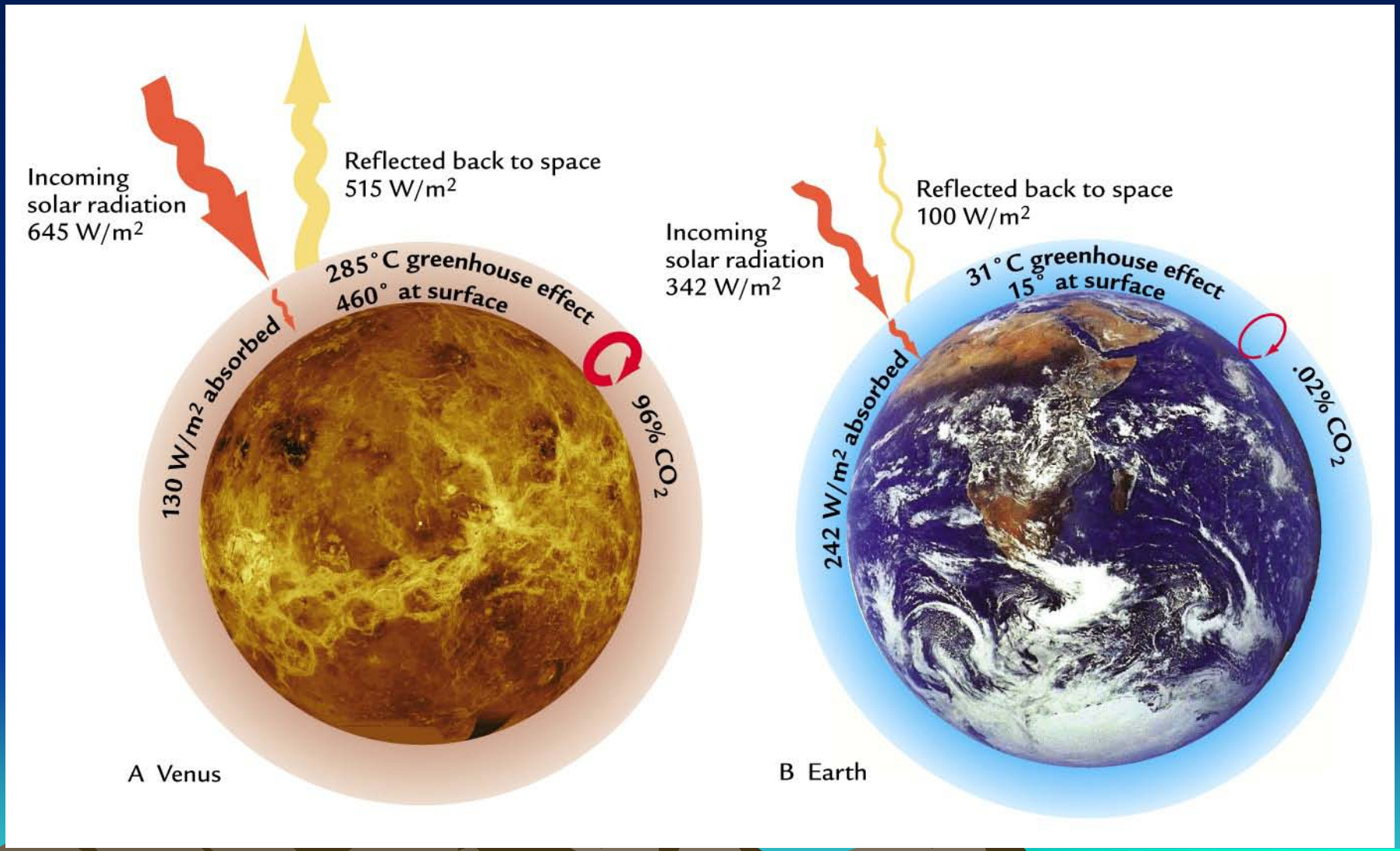
Earth's Radiation Budget



Shortwave vs. Longwave radiation



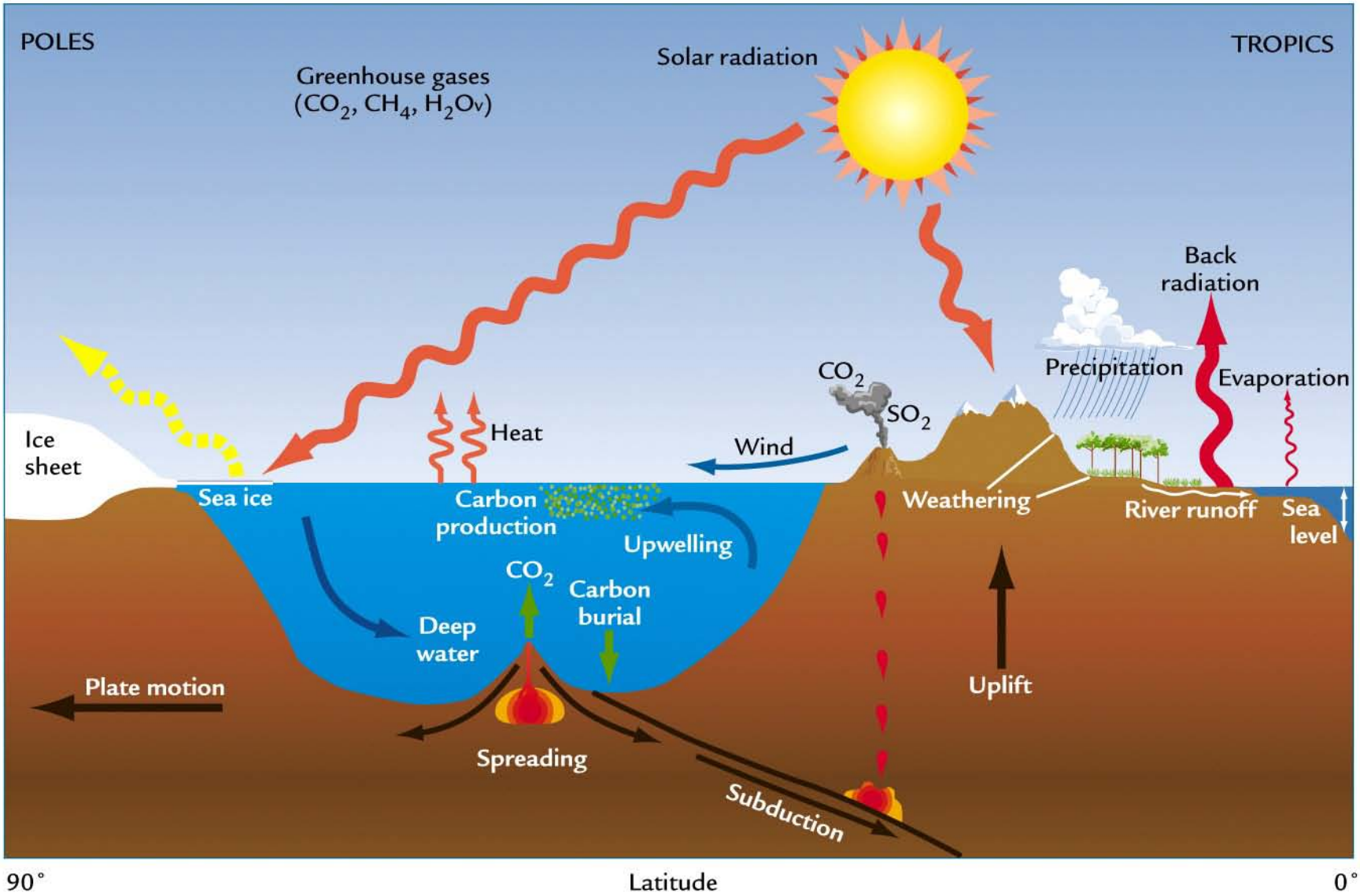
Greenhouse effect: Earth and Venus



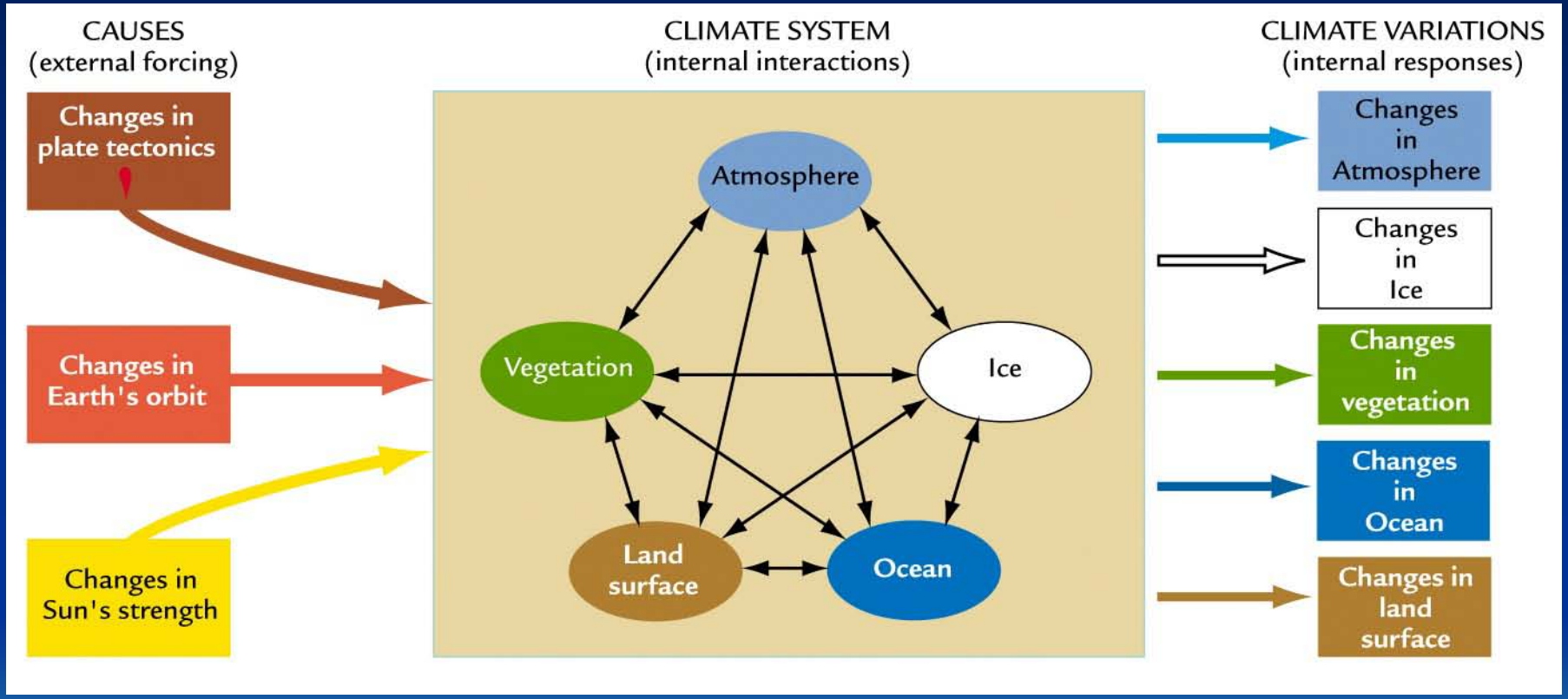
Climate vs. Weather

Weather	Climate
Shorter-term fluctuations	Longer-Term Changes
in atmospheric environment (e.g., temp, press, ws, wdir, rainfall amount, etc)	broad composite of average (or mean) condition of a region (e.g., temp, rainfall, snowfall, ice cover, winds)
Hours, Days, Weeks	Years (and longer)
Specific location for specific time	Mean state of a specific region (e.g., continent, ocean, or entire planet)

Components of Climate System



Interactions between Climate System Components



Some basic reactions

$$\text{Organic-C} + O_2 \rightarrow CO_2 + H_2O + \text{heat}$$

$$H_2O + CO_2 \rightarrow C_6H_{12}O_6 + O_2$$

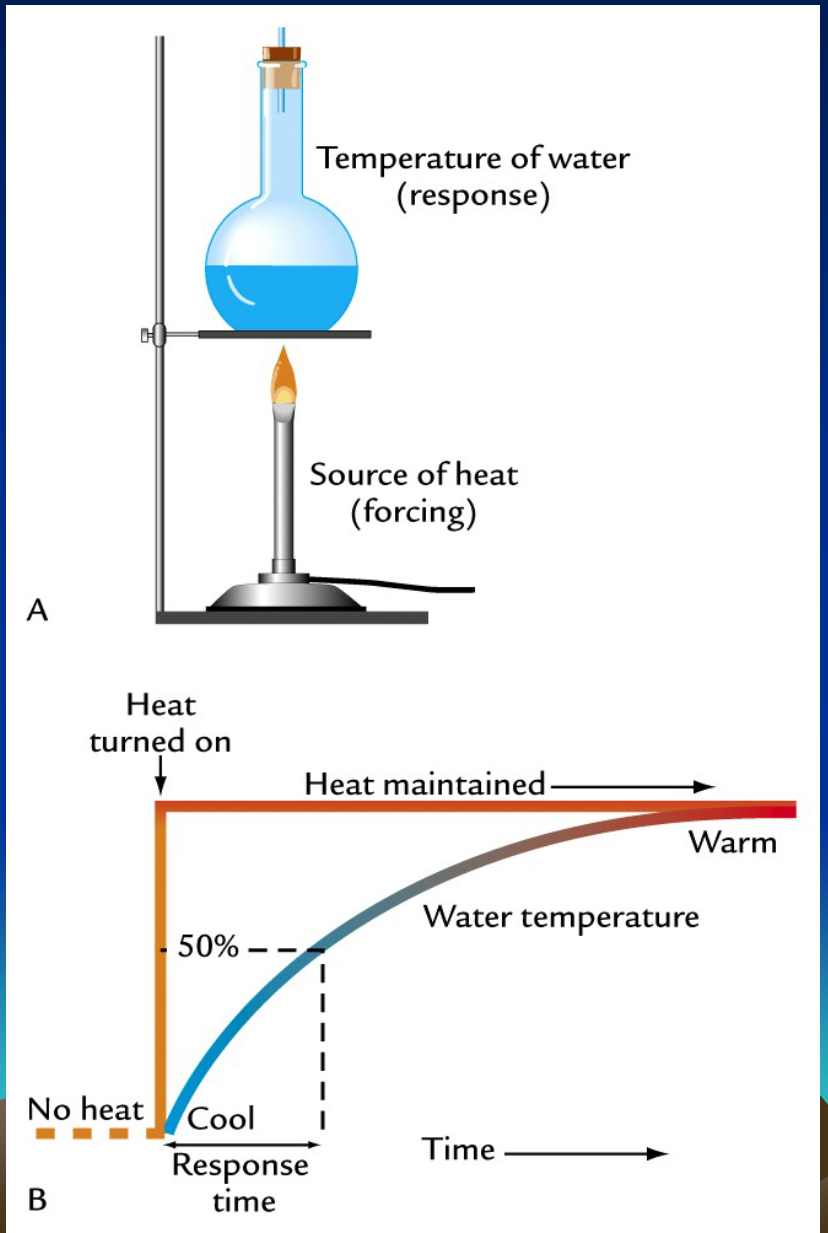
$$\text{Organic-C} + O_2 \rightarrow CO_2 + H_2O + \text{heat} + NO + SO_2$$

$$NO \rightarrow HNO_3$$

$$SO_2 \rightarrow H_2SO_4 \rightarrow \text{sulfate aerosol}$$

$$NO + \text{Organic-C} + \text{sunlight} \rightarrow O_3$$

Climate System Response

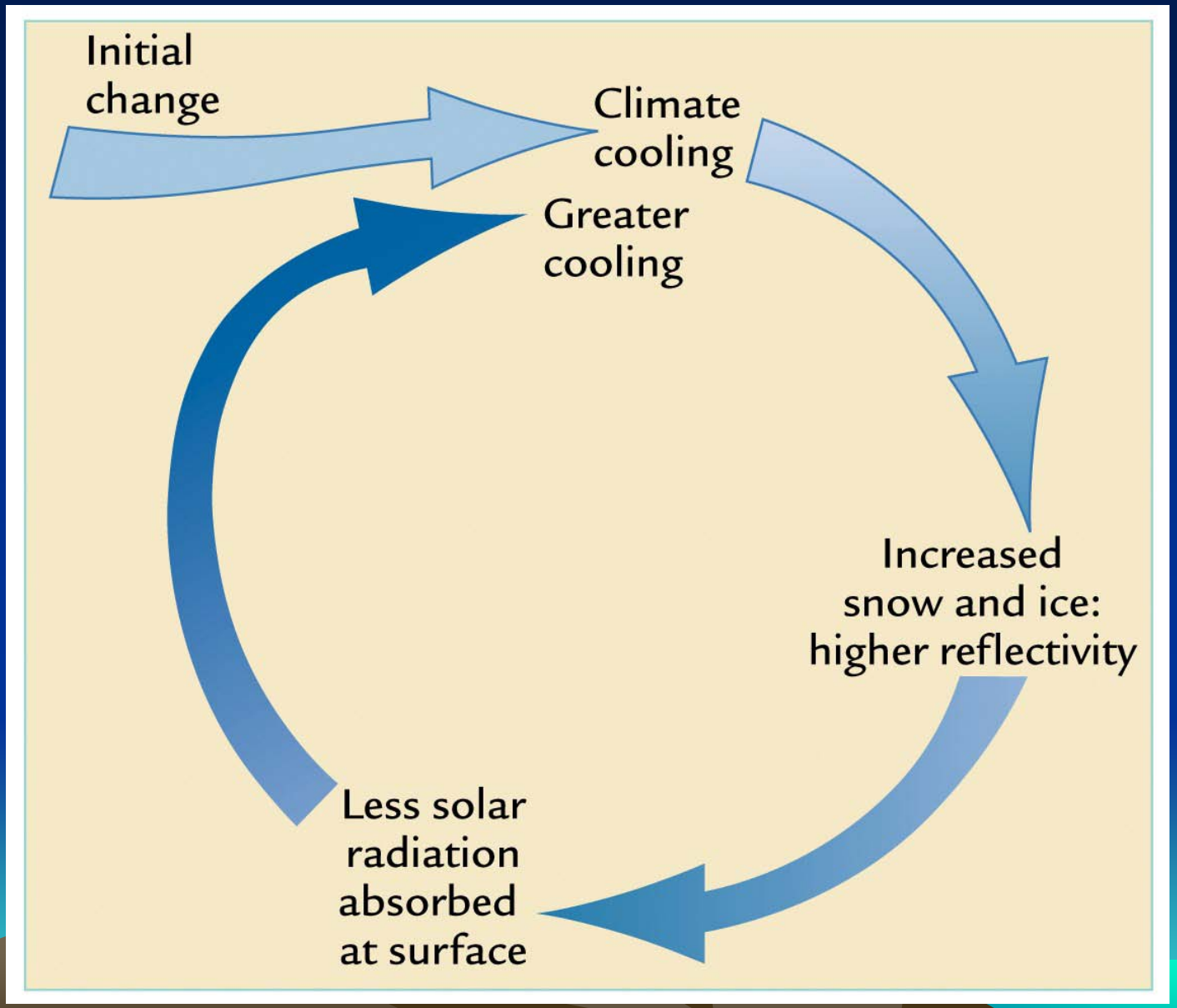


Response Times

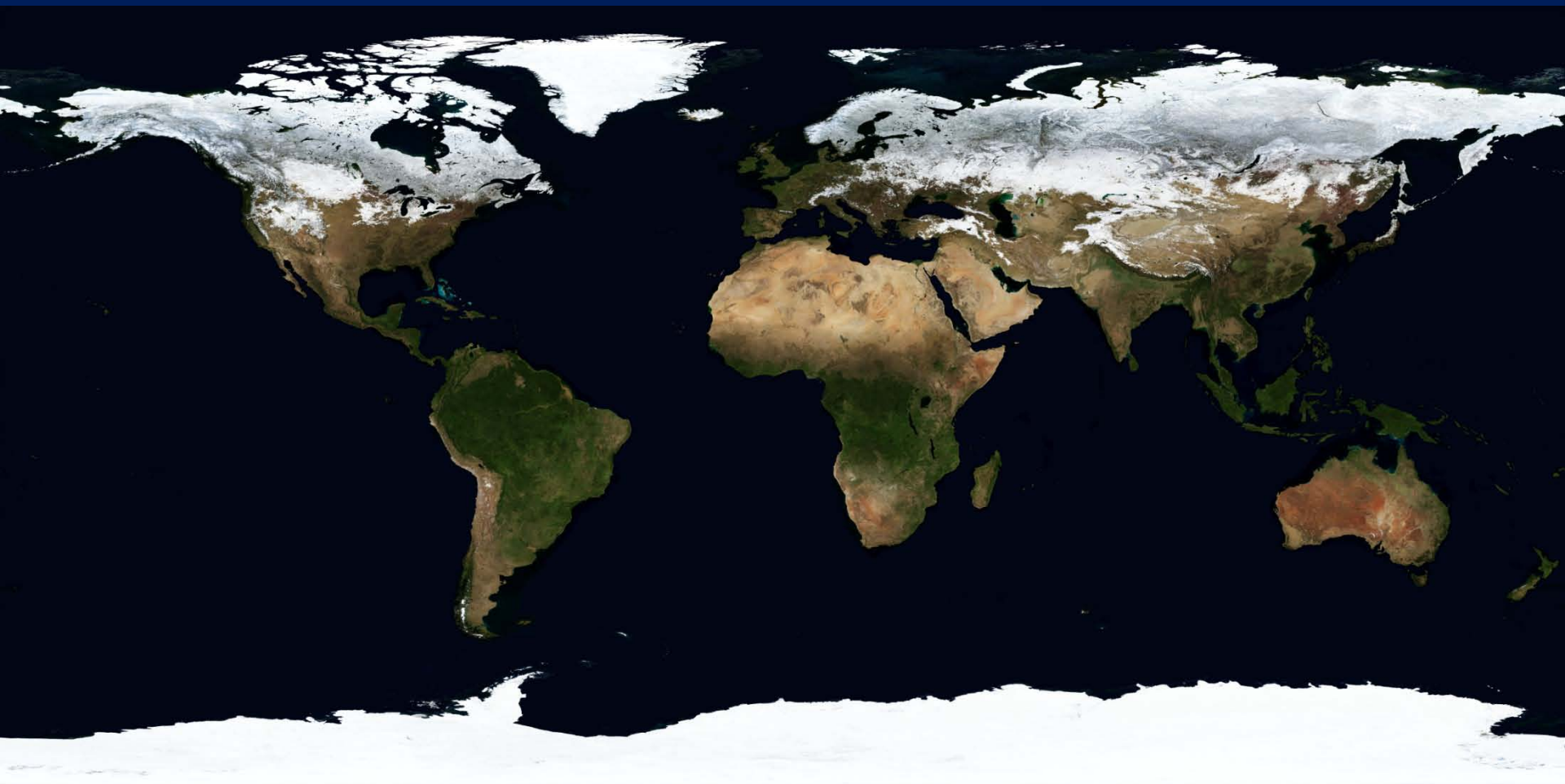
TABLE 1.1 Response Times of Various Climate System Components

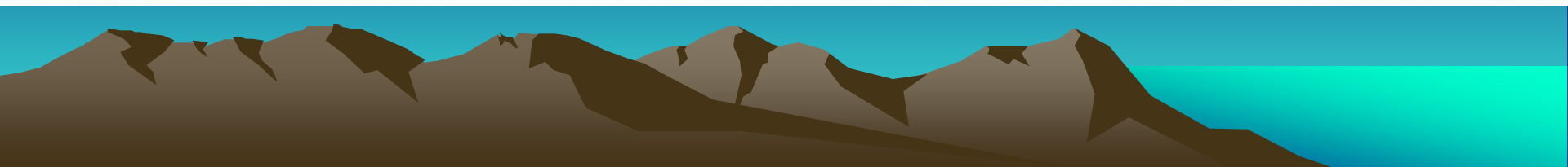
Component	Response time (range)	Example
	Fast responses	
Atmosphere	Hours to weeks	Daily heating and cooling Gradual buildup of heat wave
Land surface	Hours to months	Daily heating of upper ground surface Midwinter freezing and thawing
Ocean surface	Days to months	Afternoon heating of upper few feet Warmest beach temperatures late in summer
Vegetation	Hours to decades/centuries	Sudden leaf kill by frost Slow growth of trees to maturity
Sea ice	Weeks to years	Late-winter maximum extent Historical changes near Iceland
	Slow responses	
Mountain glaciers	10–100 years	Widespread glacier retreat in 20th century
Deep ocean	100–1500 years	Time to replace world's deep water
Ice sheets	100–10,000 years	Advances/retreats of ice sheet margins Growth/decay of entire ice sheet

Albedo-Temperature Feedback

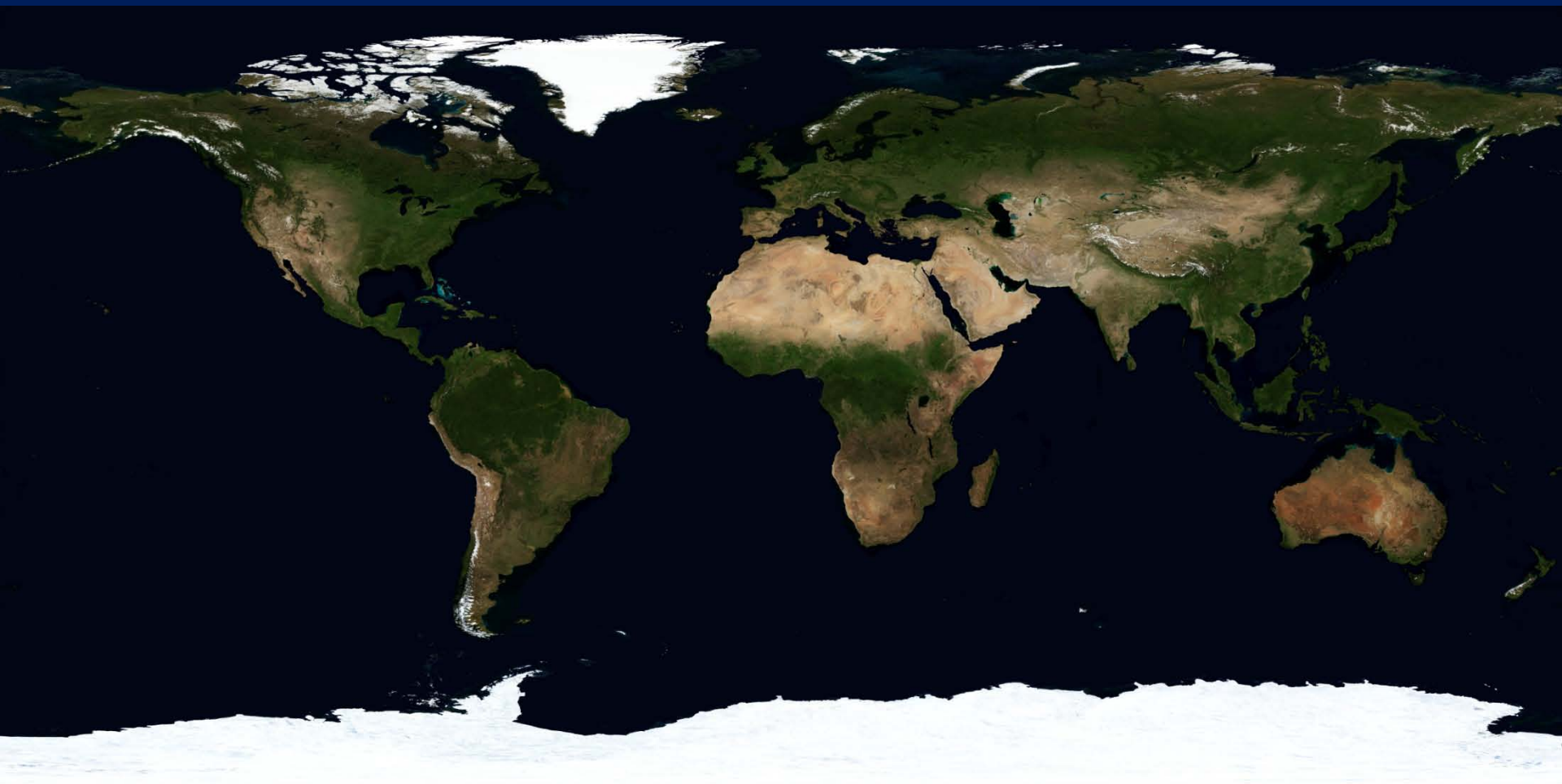


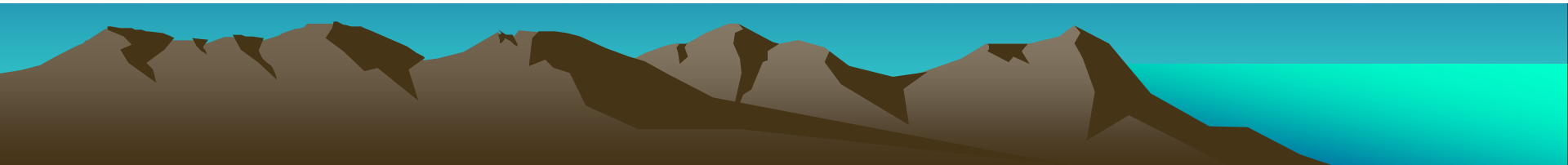
Albedo-Temperature Feedback



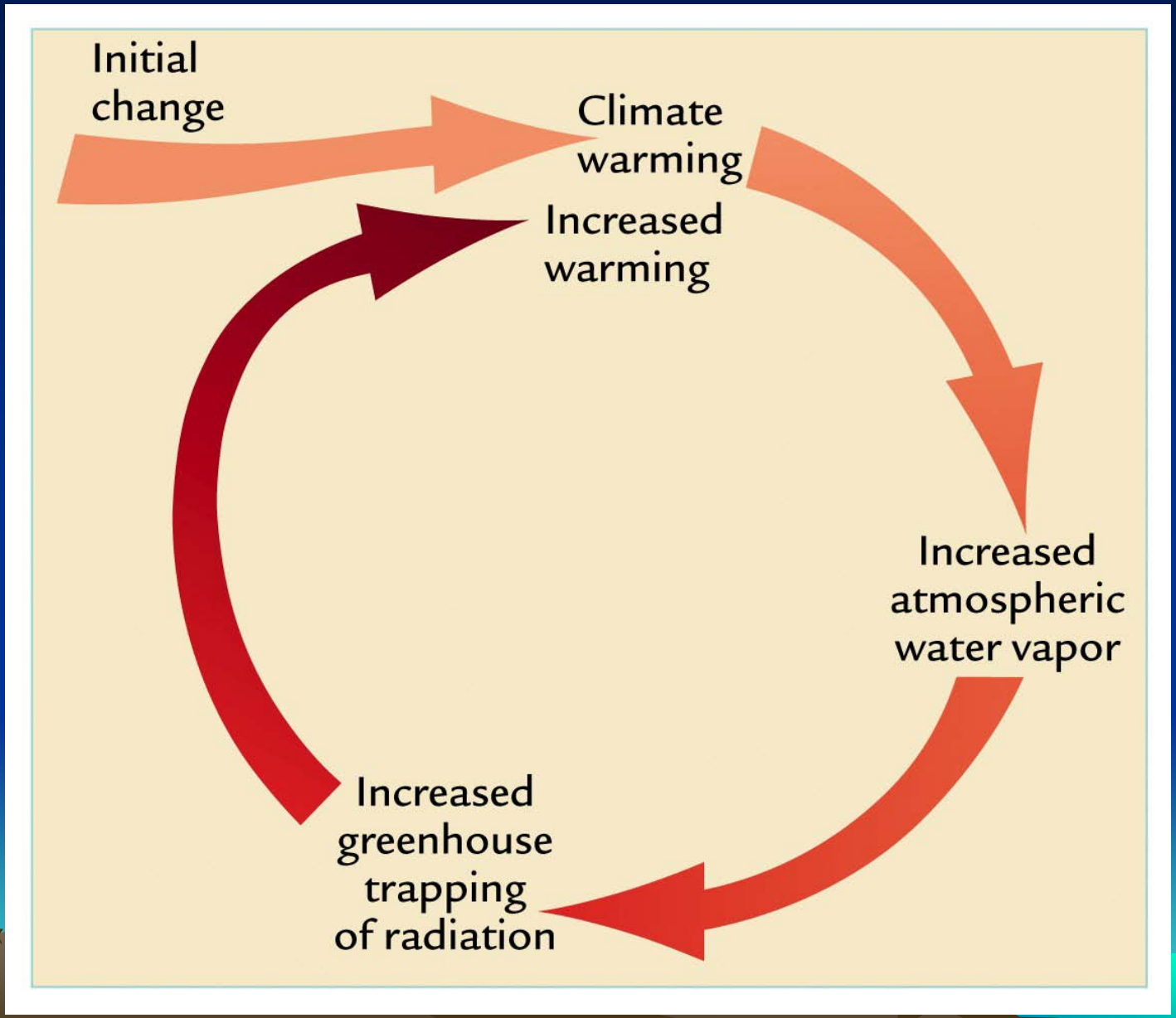


Albedo-Temperature Feedback

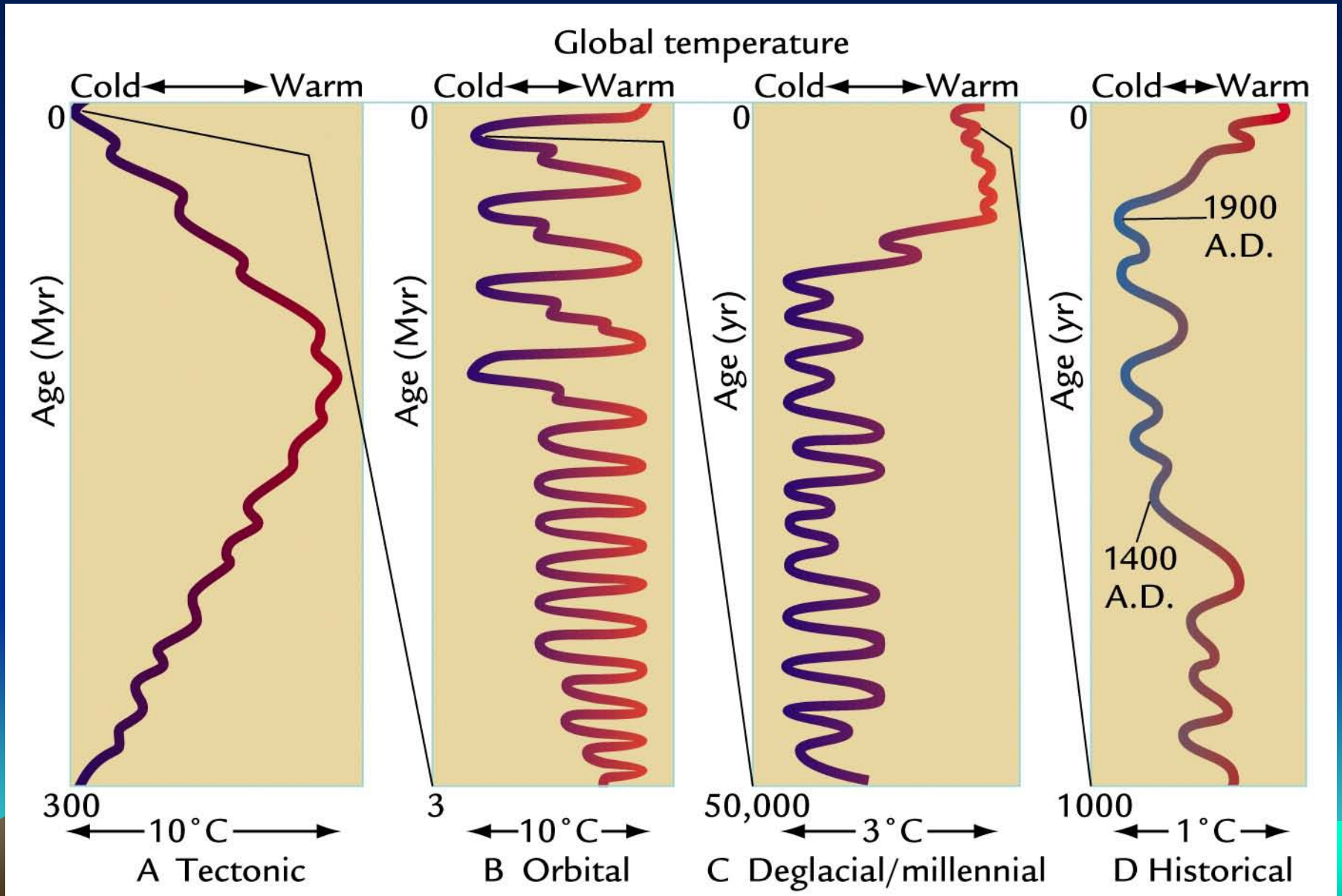




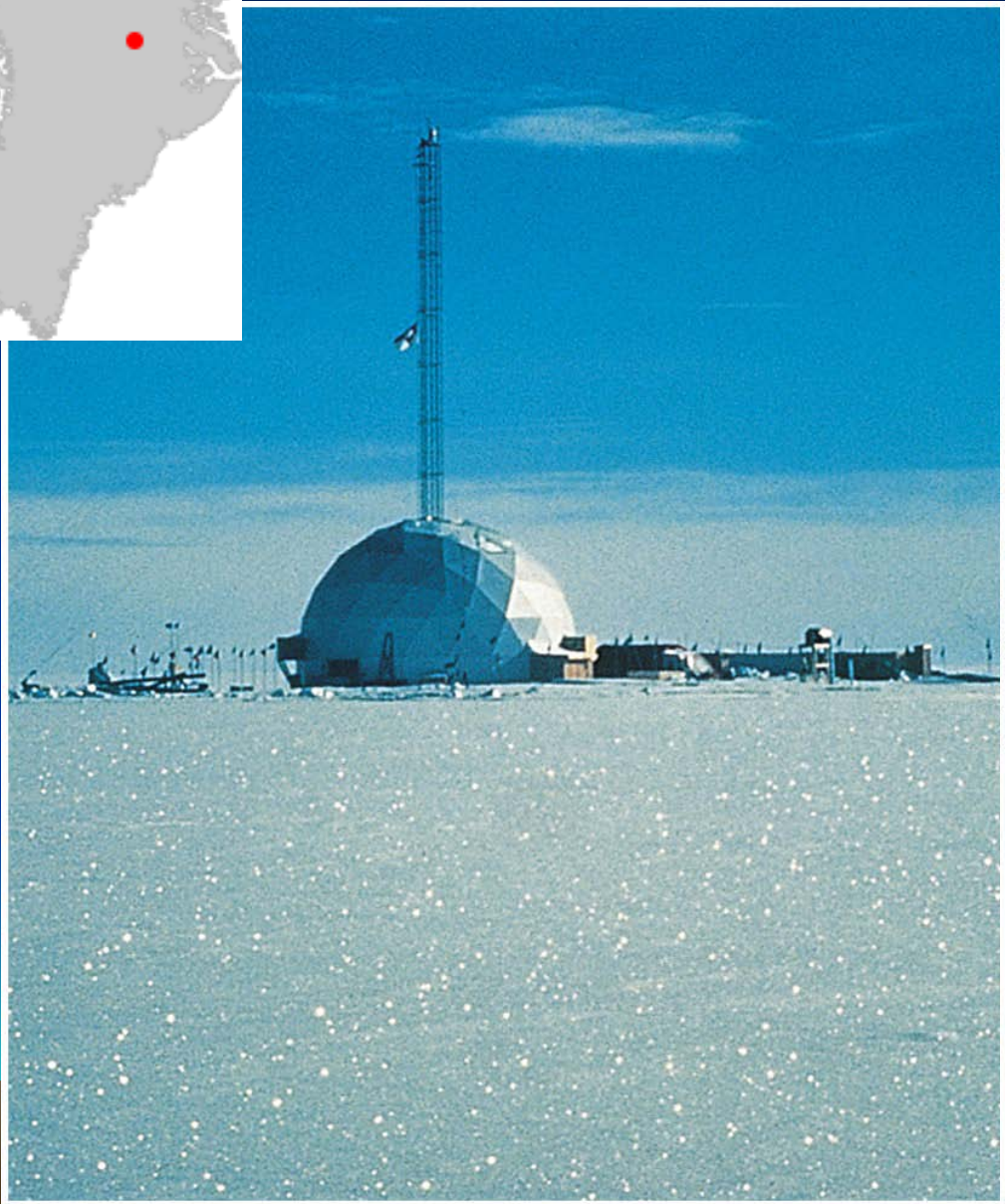
Water vapor feedback



Time Scales of Climate Change

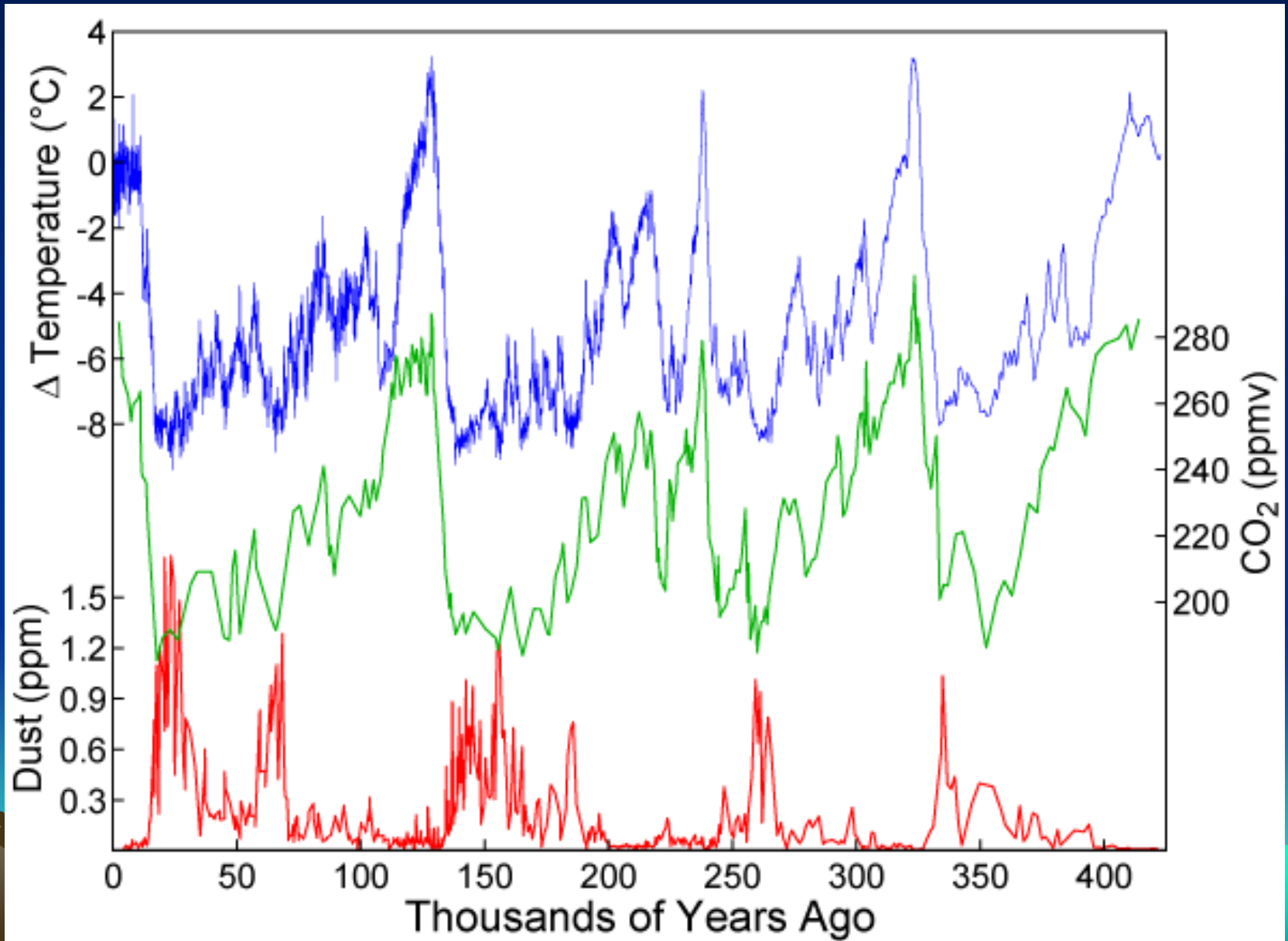


Coring Earth's ice sheets

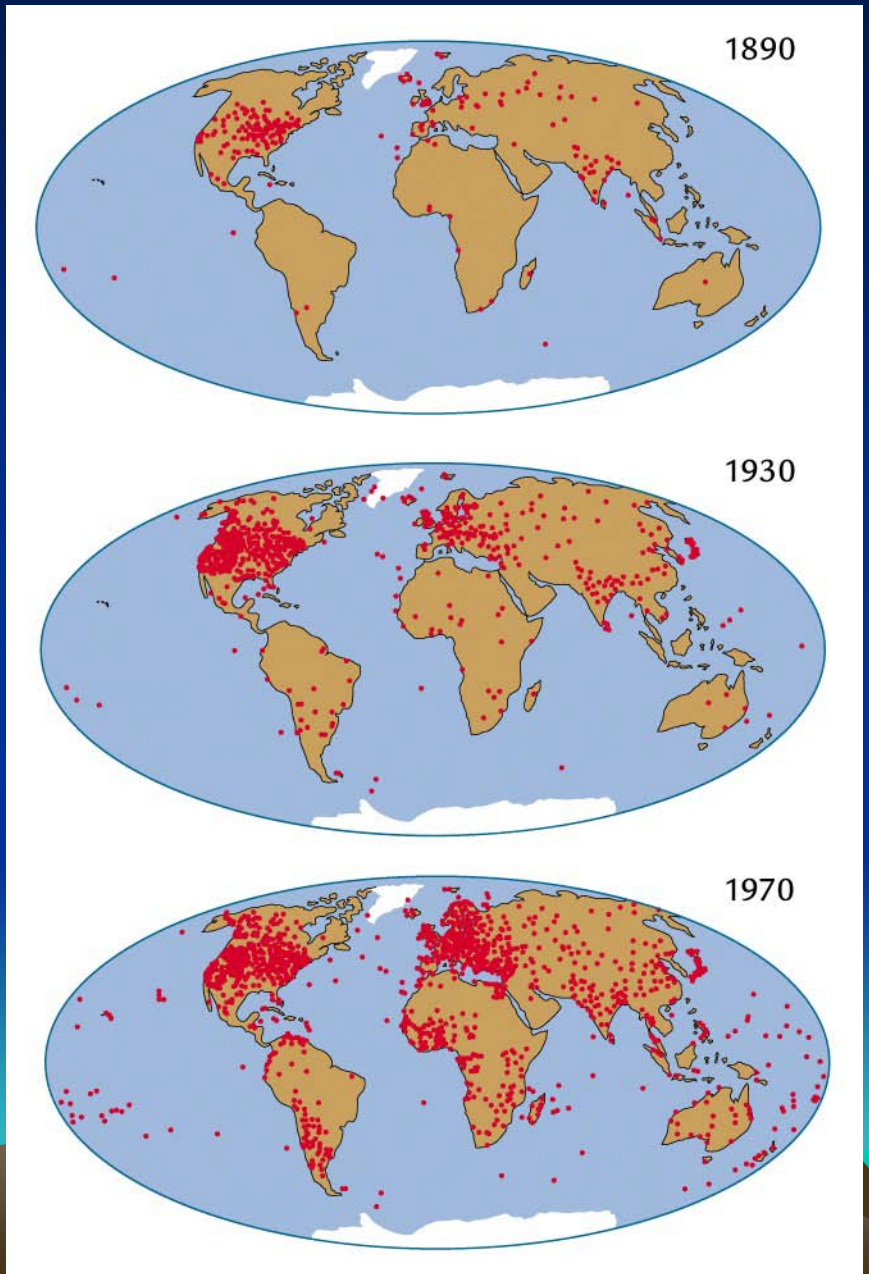


Bubbles Trapped in ice core

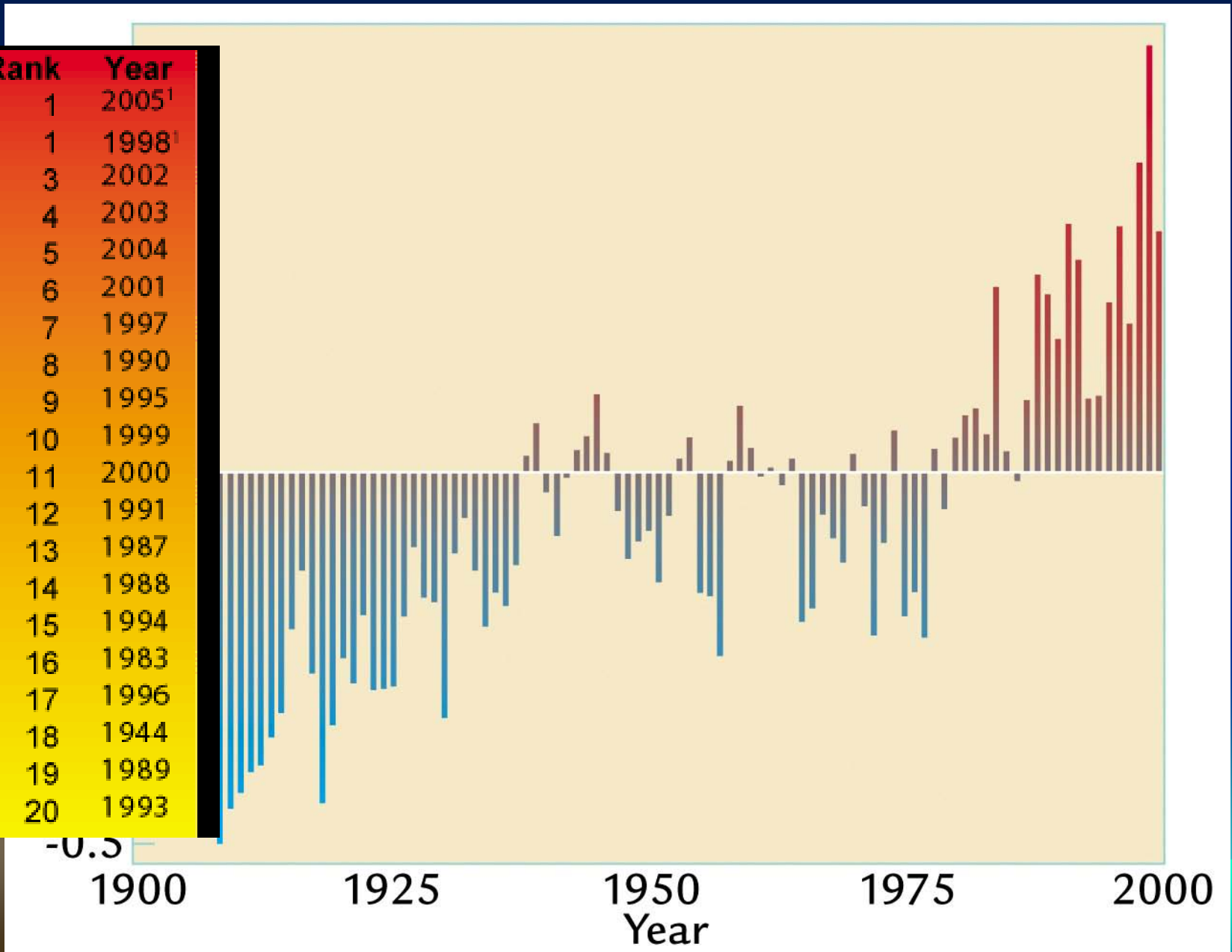
Ice core record



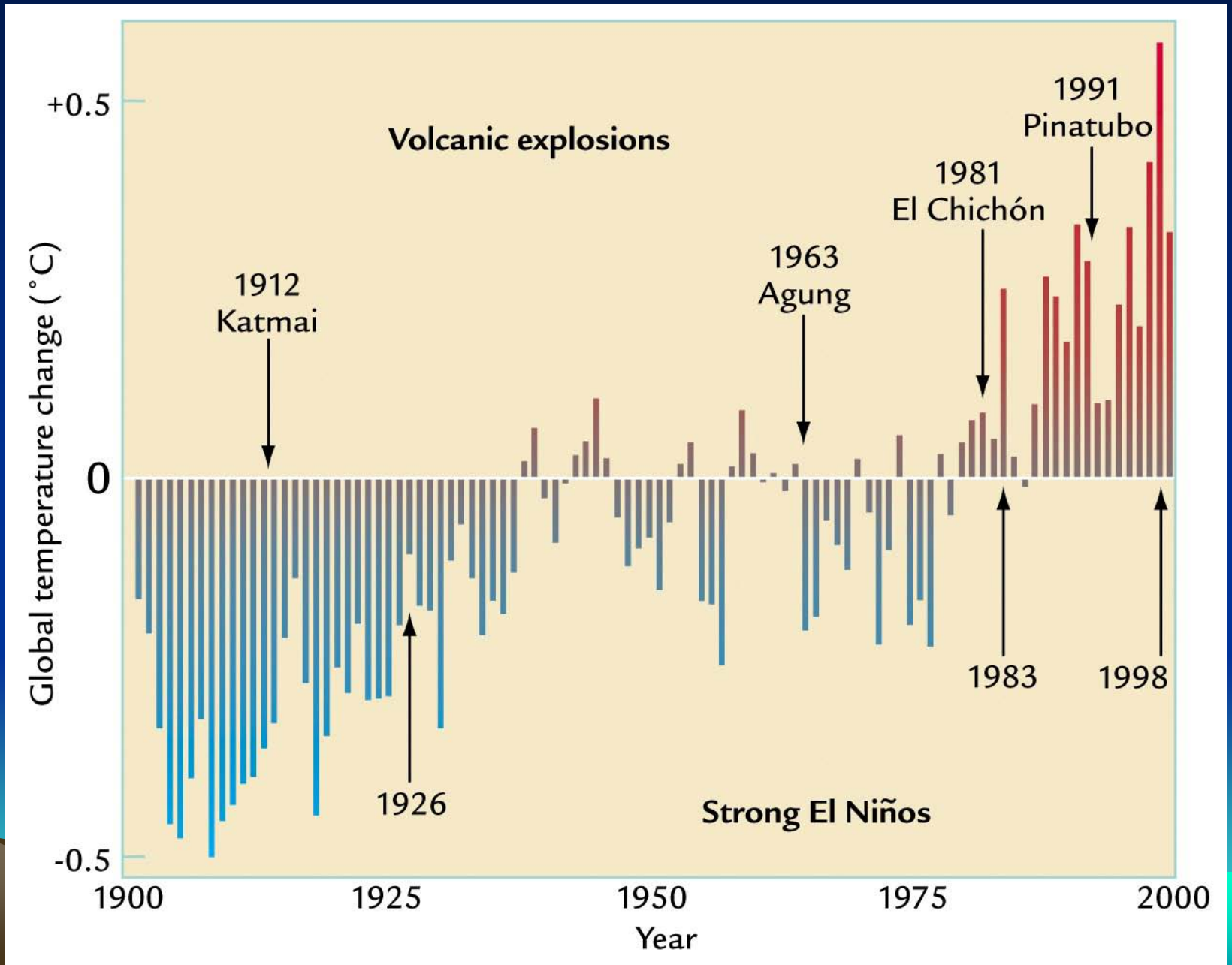
Temperature stations



Change in surface temperature in 20th century



Volcanic cooling and El Niño warming

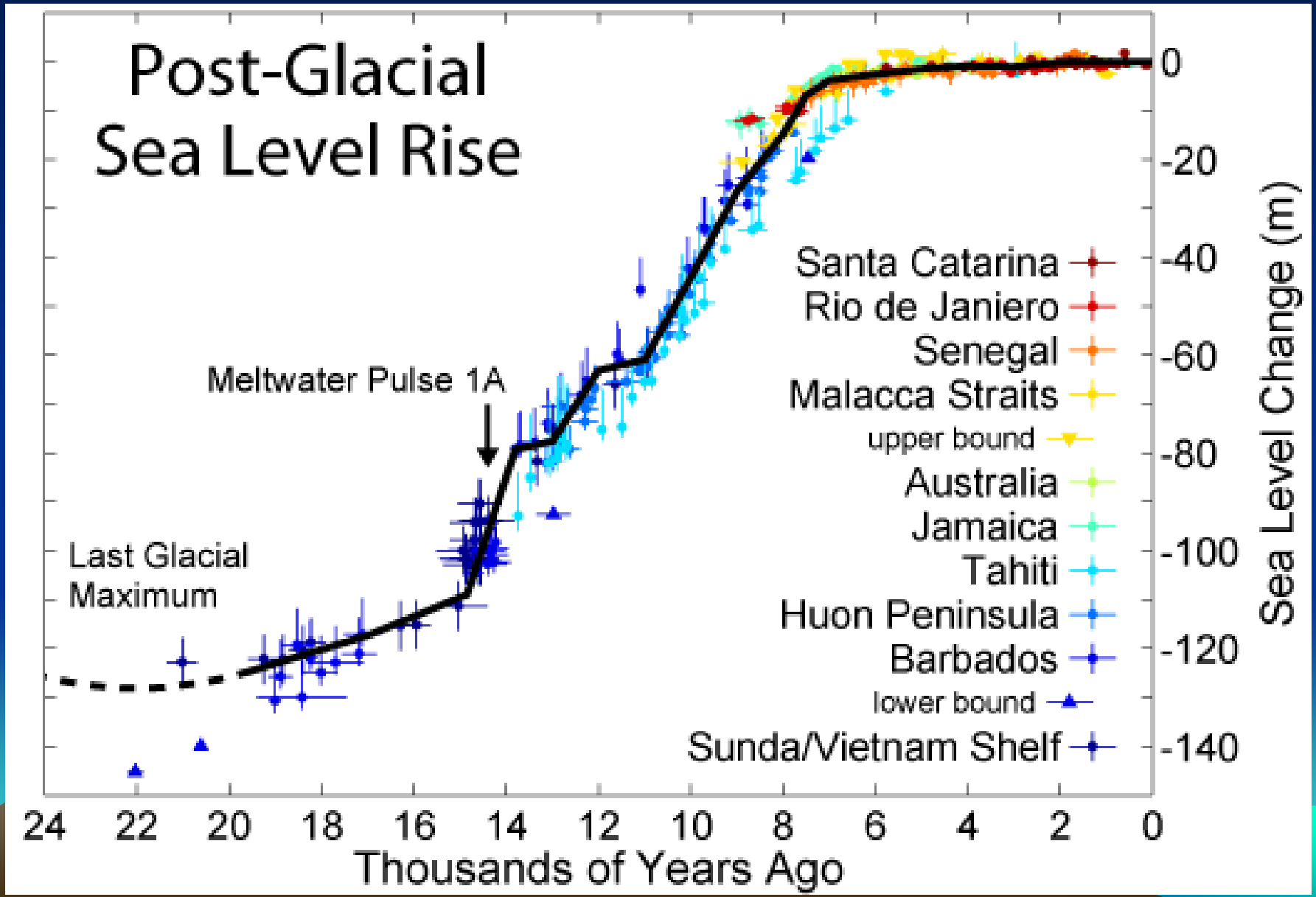


Retreat of mountain glaciers

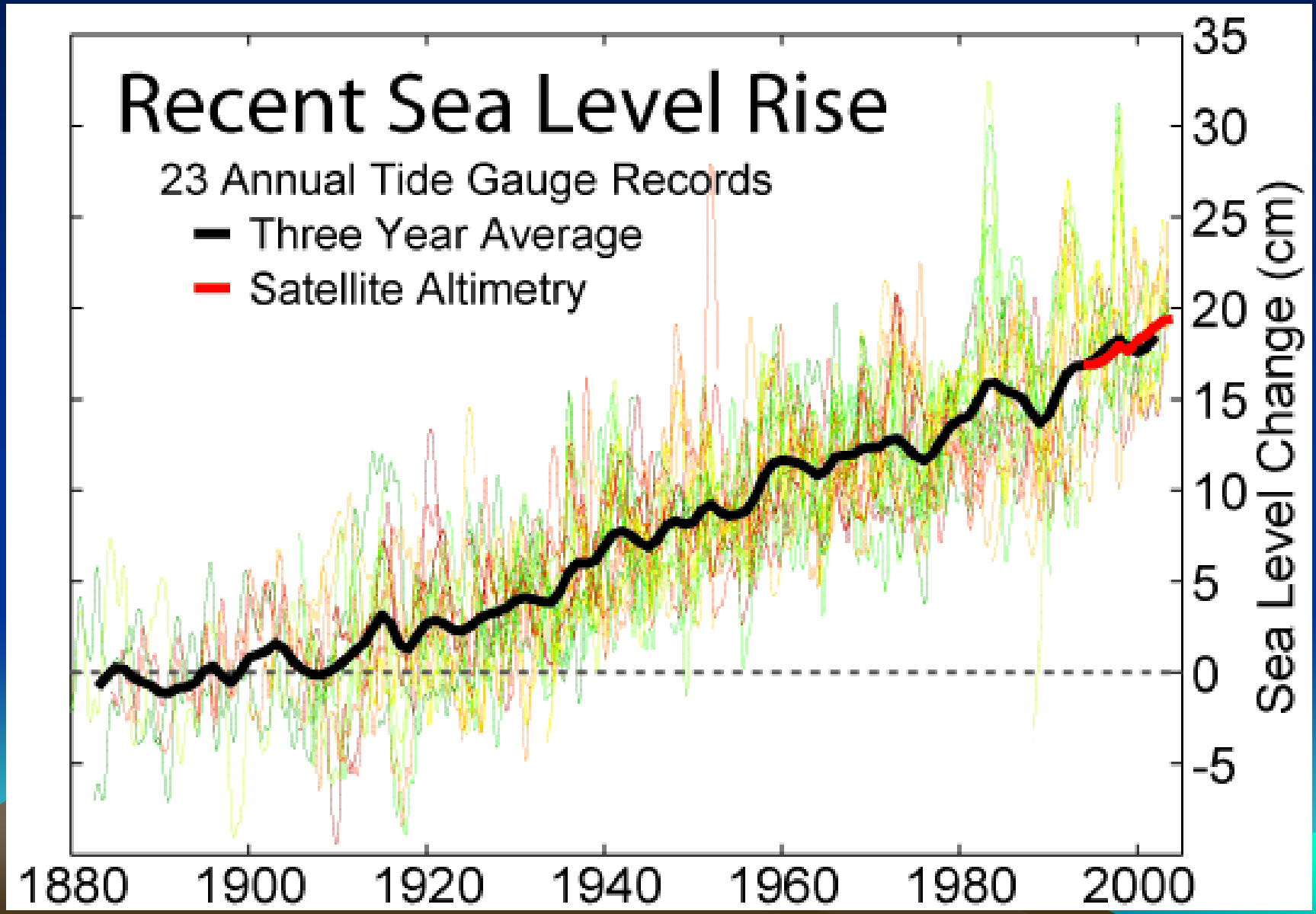
Muir and Riggs Glaciers

Melting of Greenland Icesheet

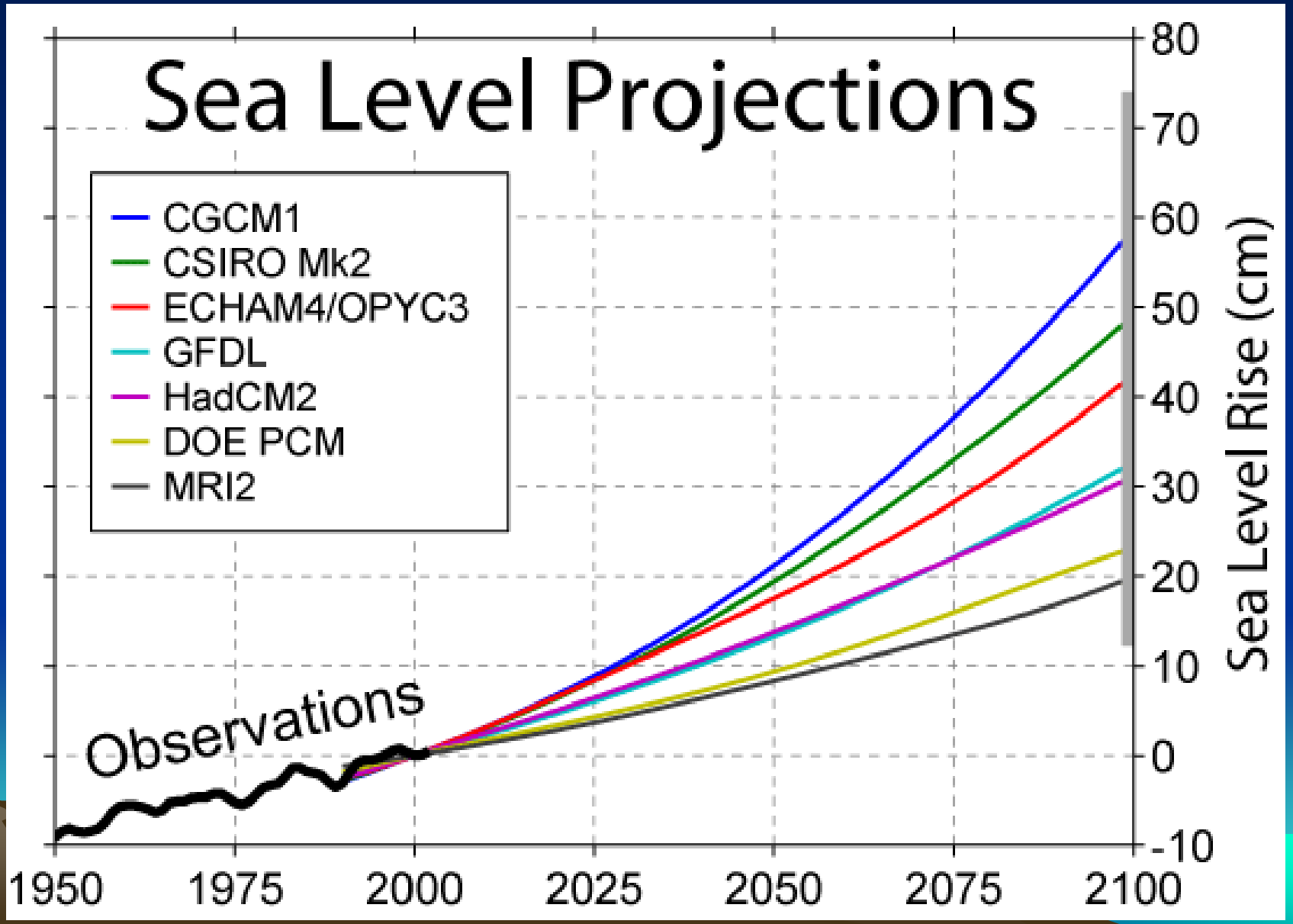
Global rise in sea level last 20,000 years



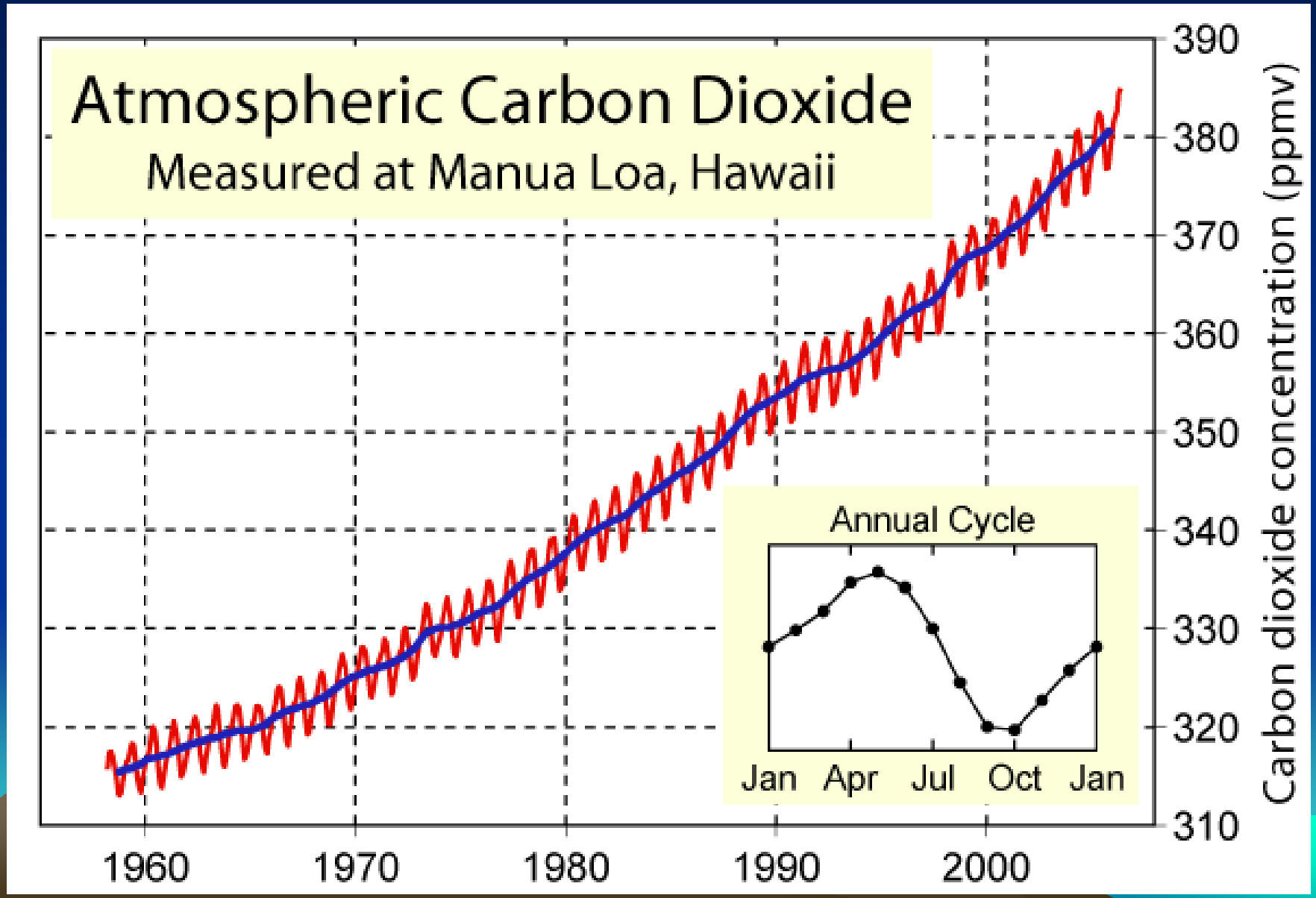
Global rise in sea level in the 20th century



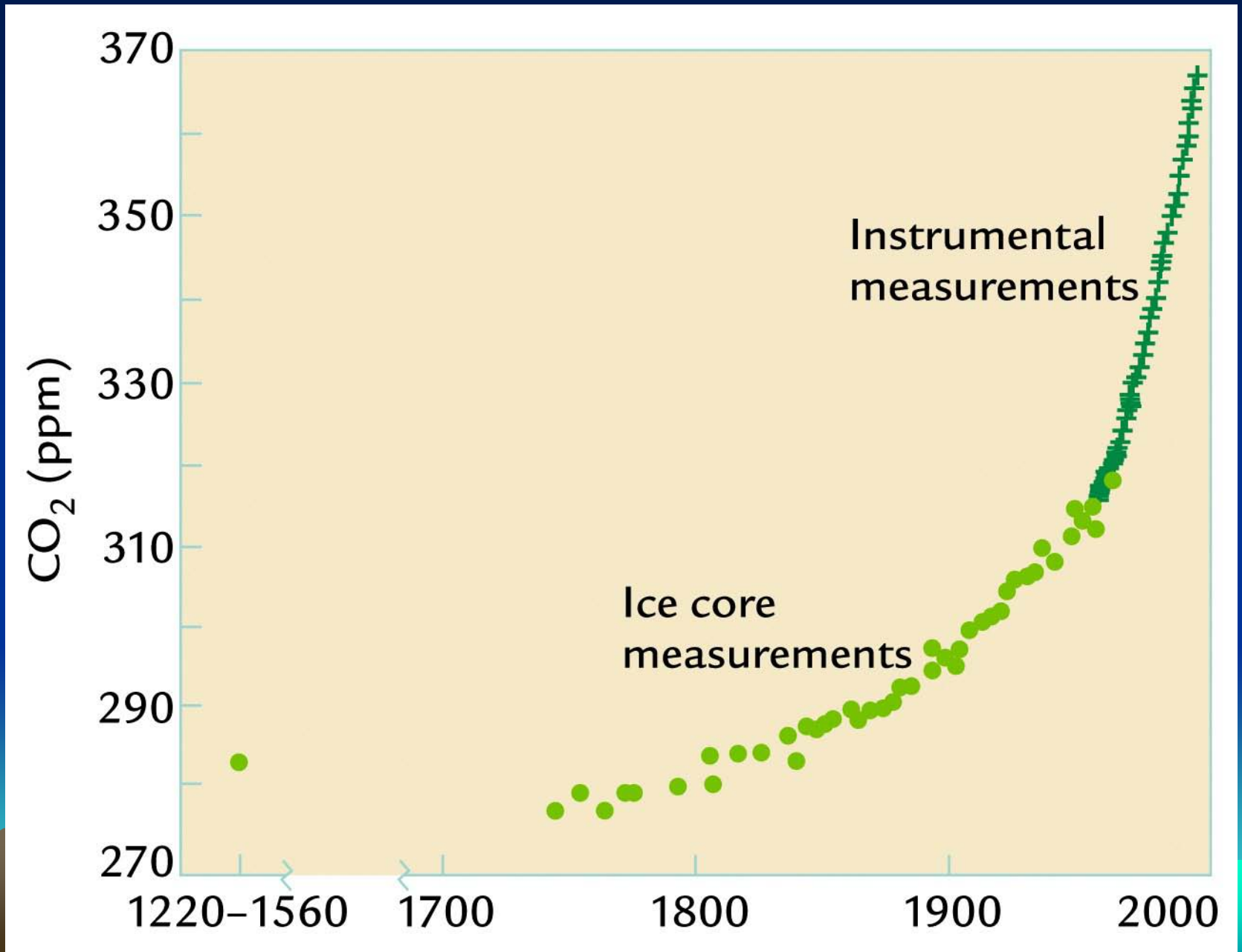
Project future rise in sea level



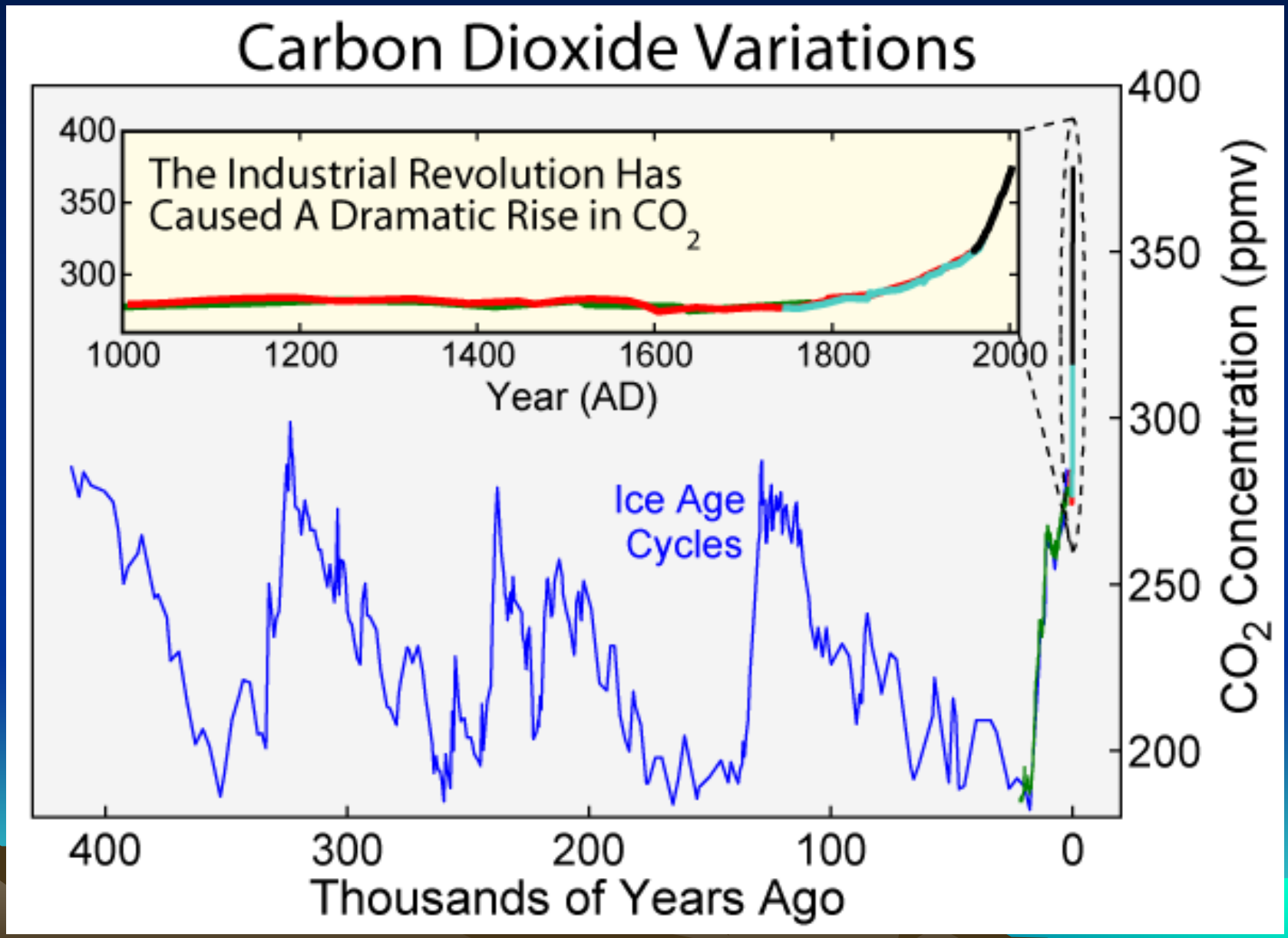
Anthropogenic CO_2



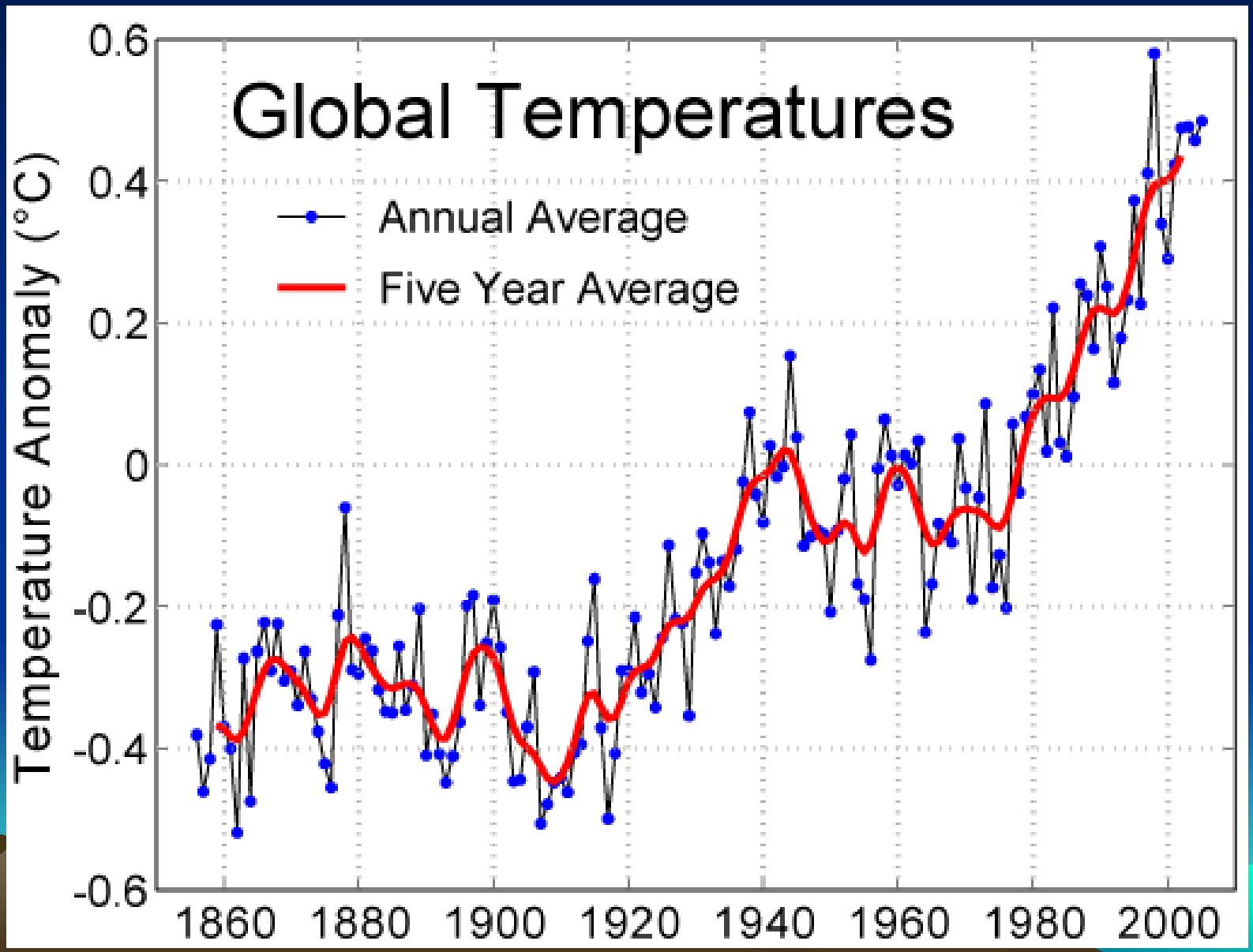
Pre-industrial and anthropogenic CO_2



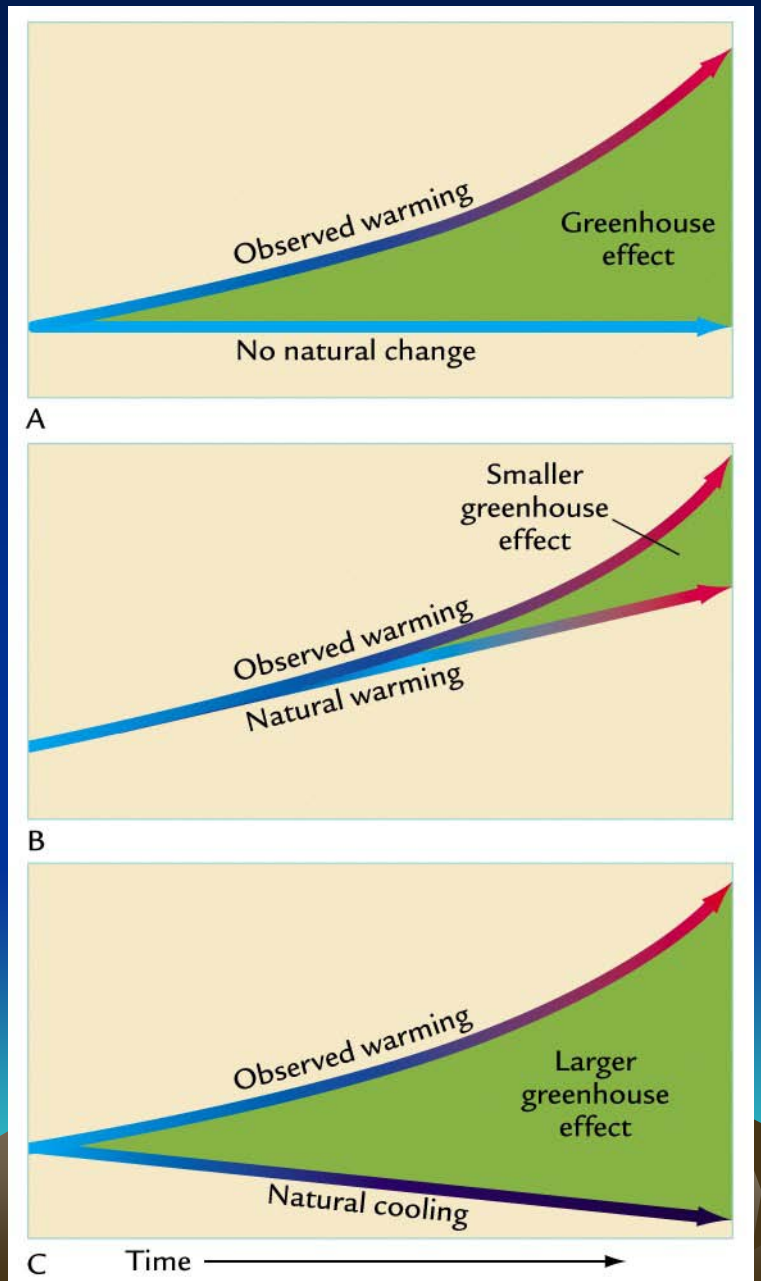
Ice core CO_2 record



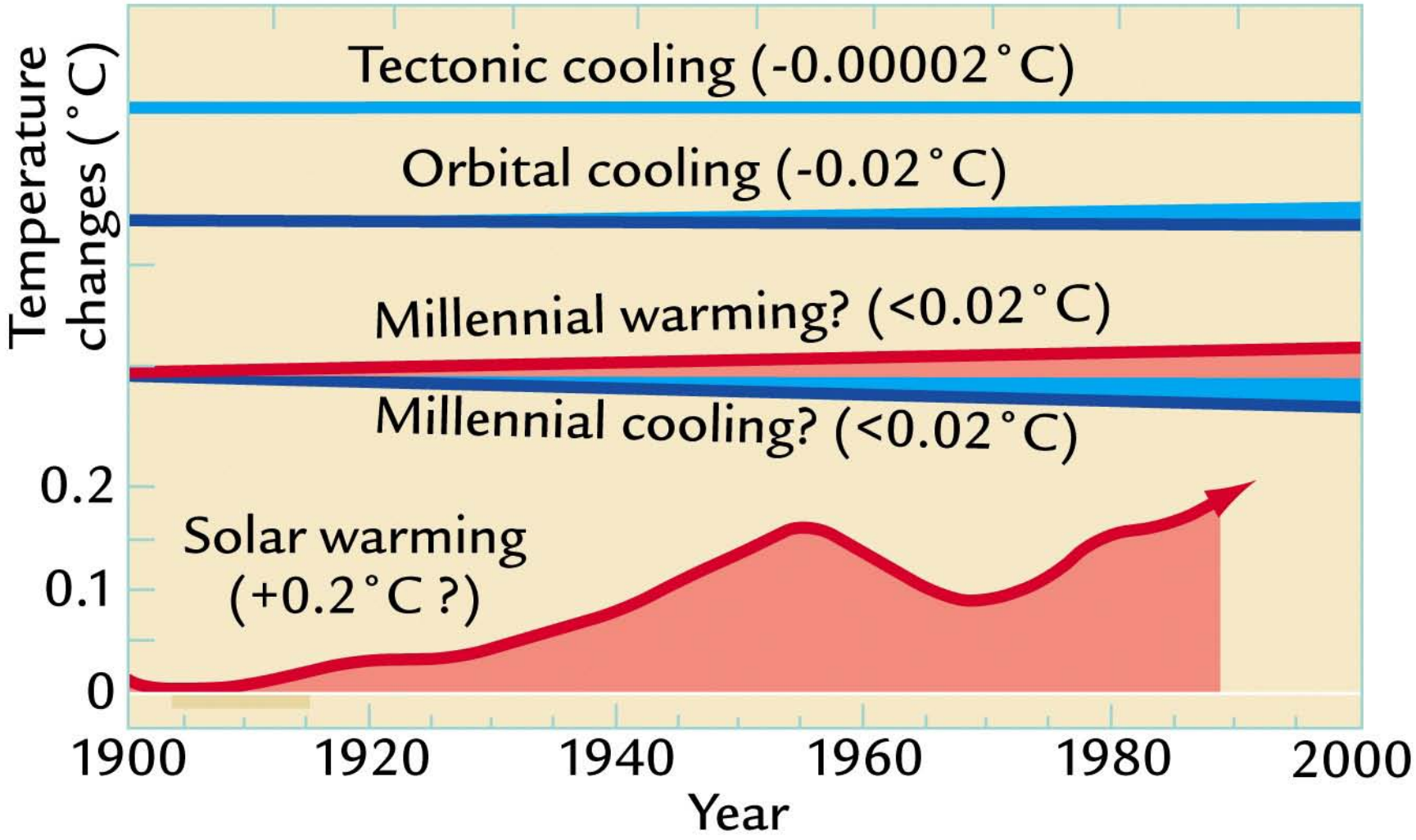
Observed temperature changes



Natural warming and greenhouse effects

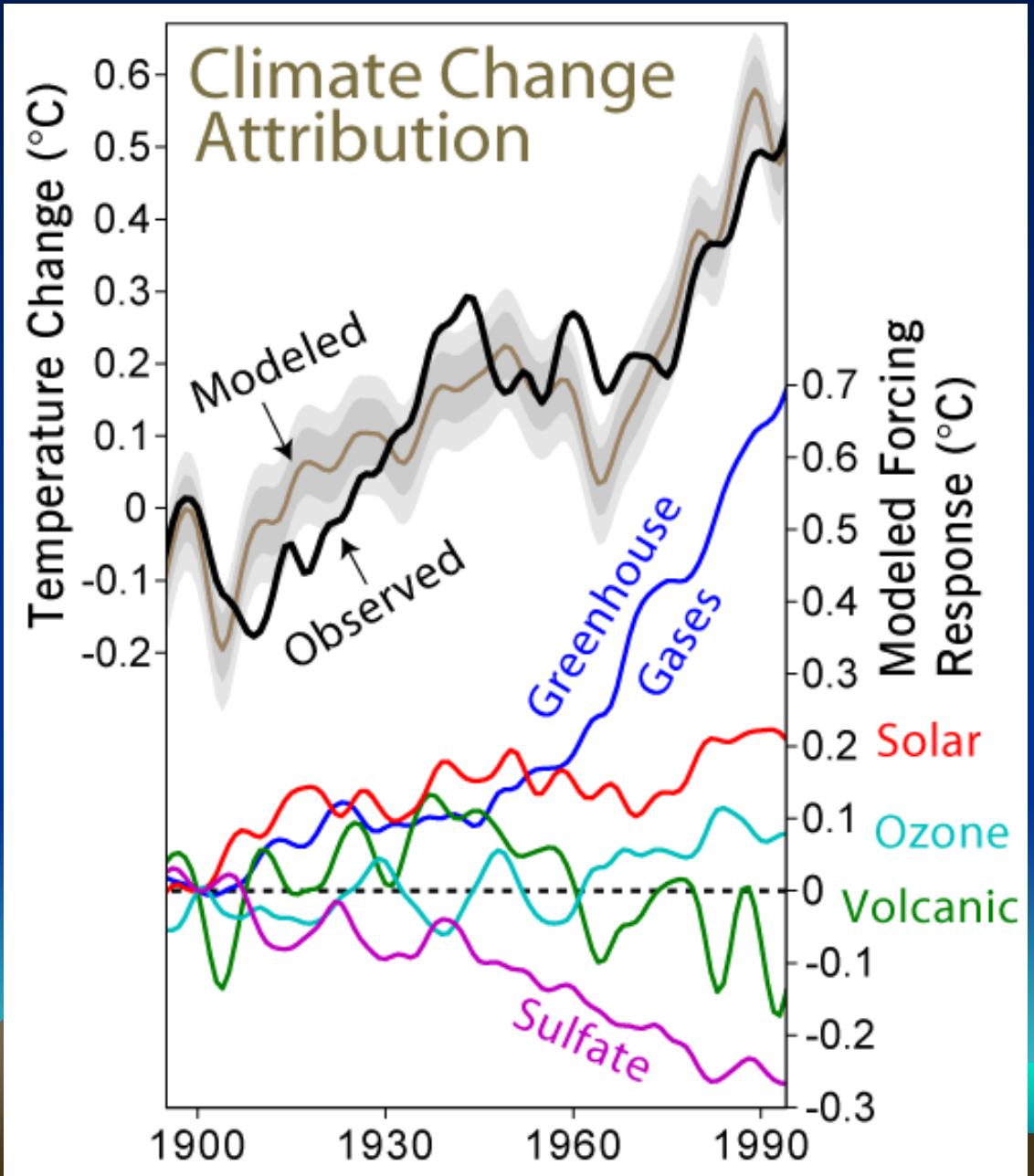


Natural temperature changes

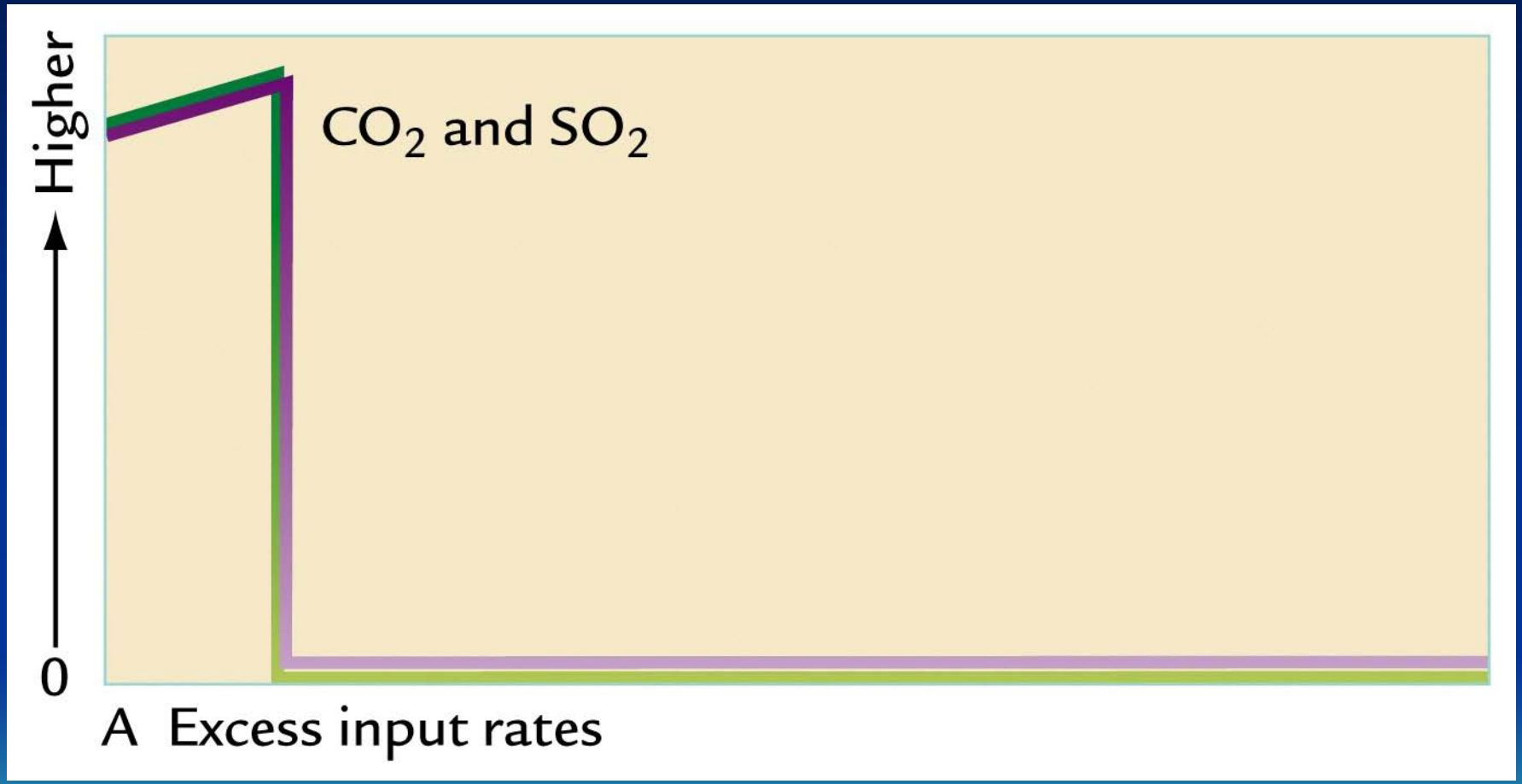


B Natural temperature changes

Temperature increases caused by humans?



Response to abrupt Δ CO_2 and SO_2 emissions?



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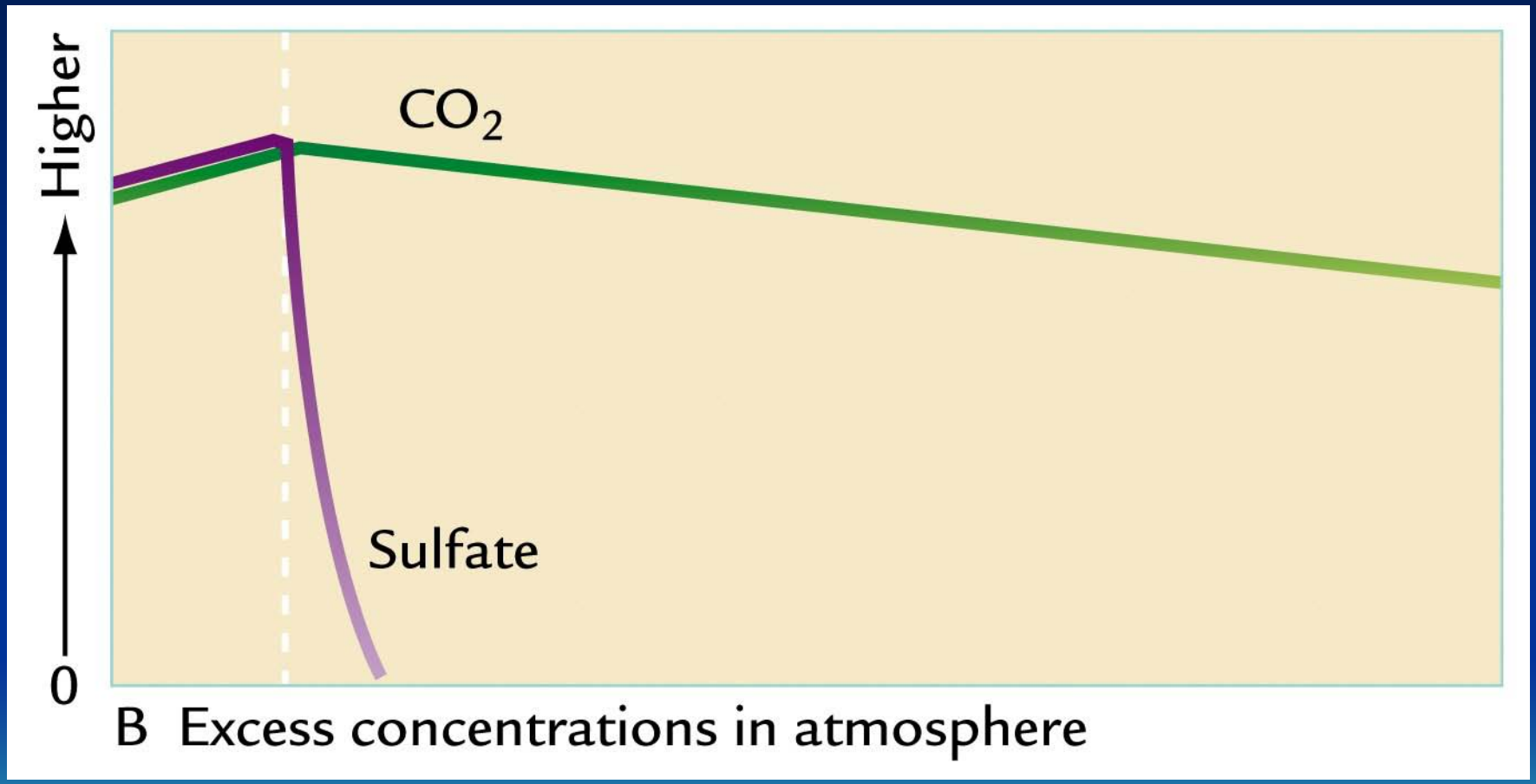

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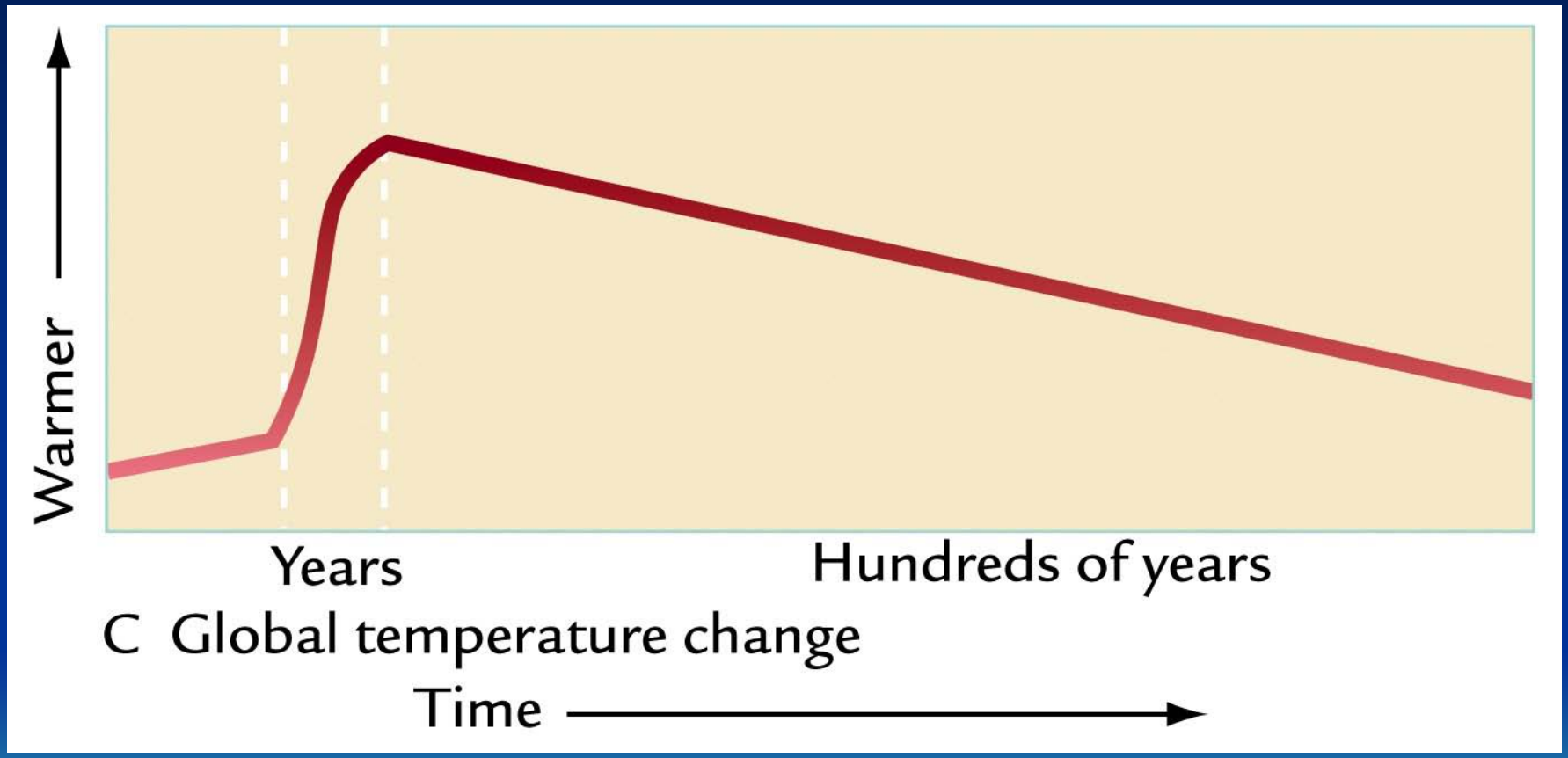
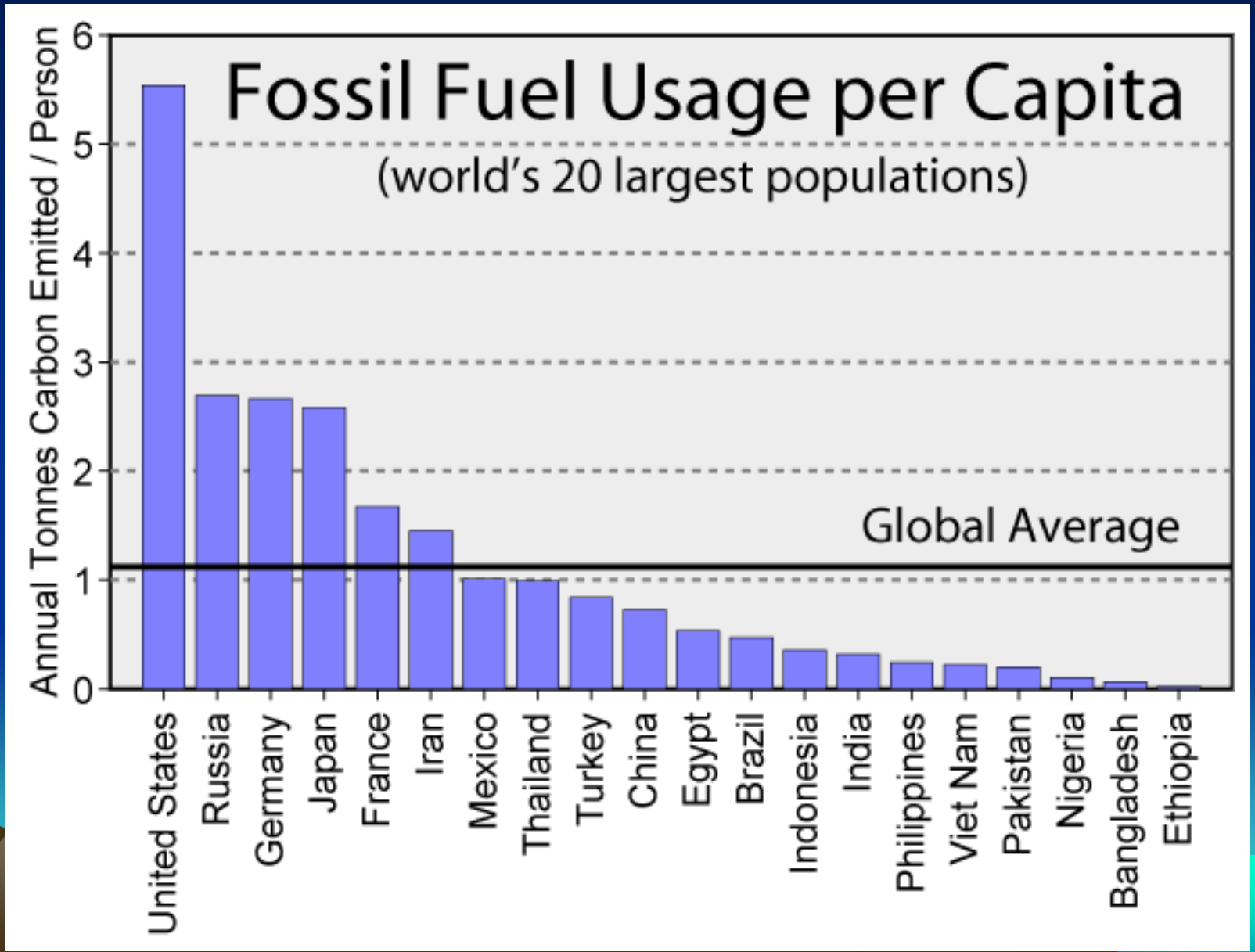


How does the U.S. rank?



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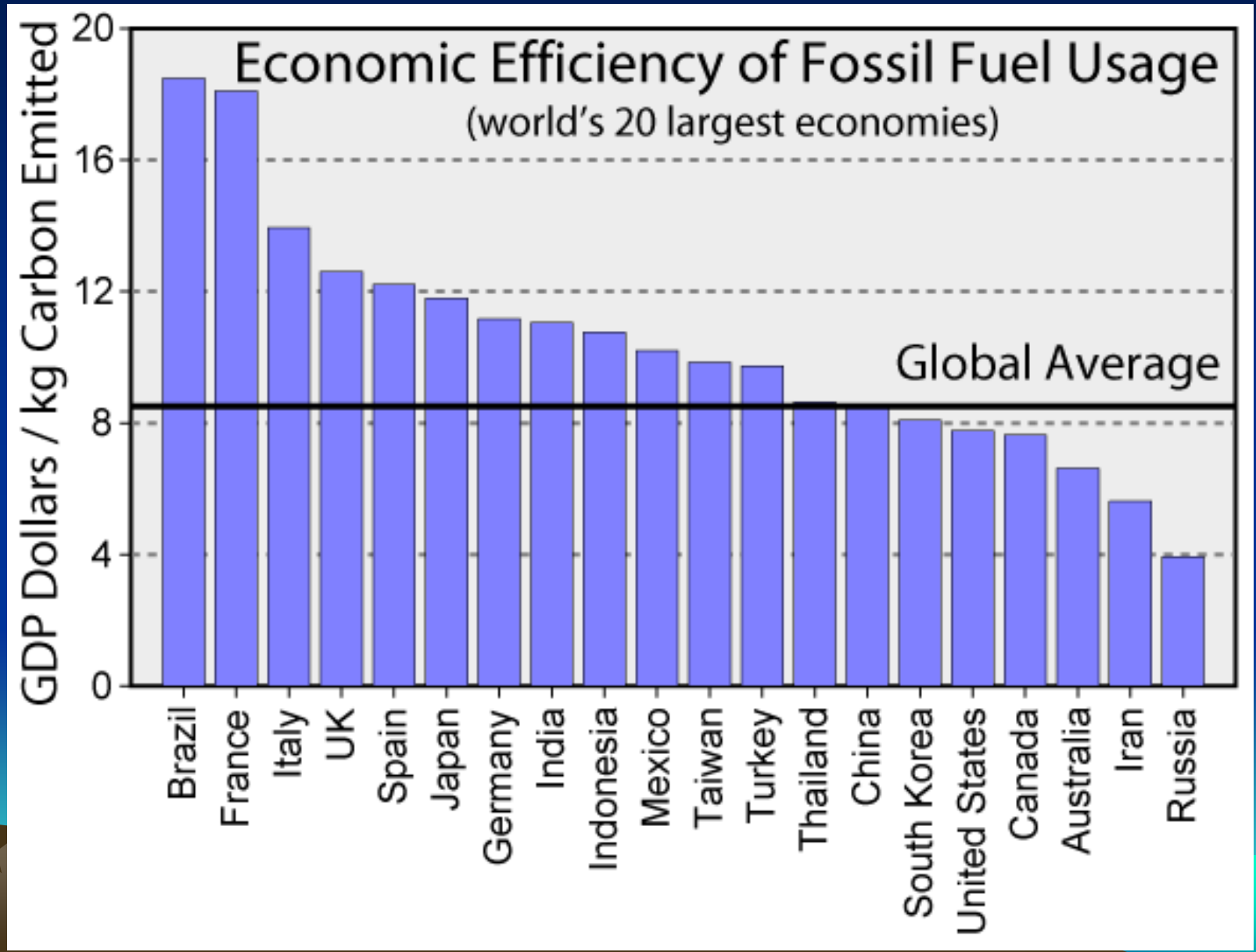


Climate change in the next 100 to 1000 years

Estimated present-day reserves of fossil fuels (mainly coal) should last for another few hundred years and will add far more CO_2 to the atmosphere than has accumulated so far.

Unless technology or conservation efforts reduces this excess emission of CO_2 to the atmosphere, atmospheric CO_2 will increase within the next 200 years to levels 2X – 4X pre-industrial levels.

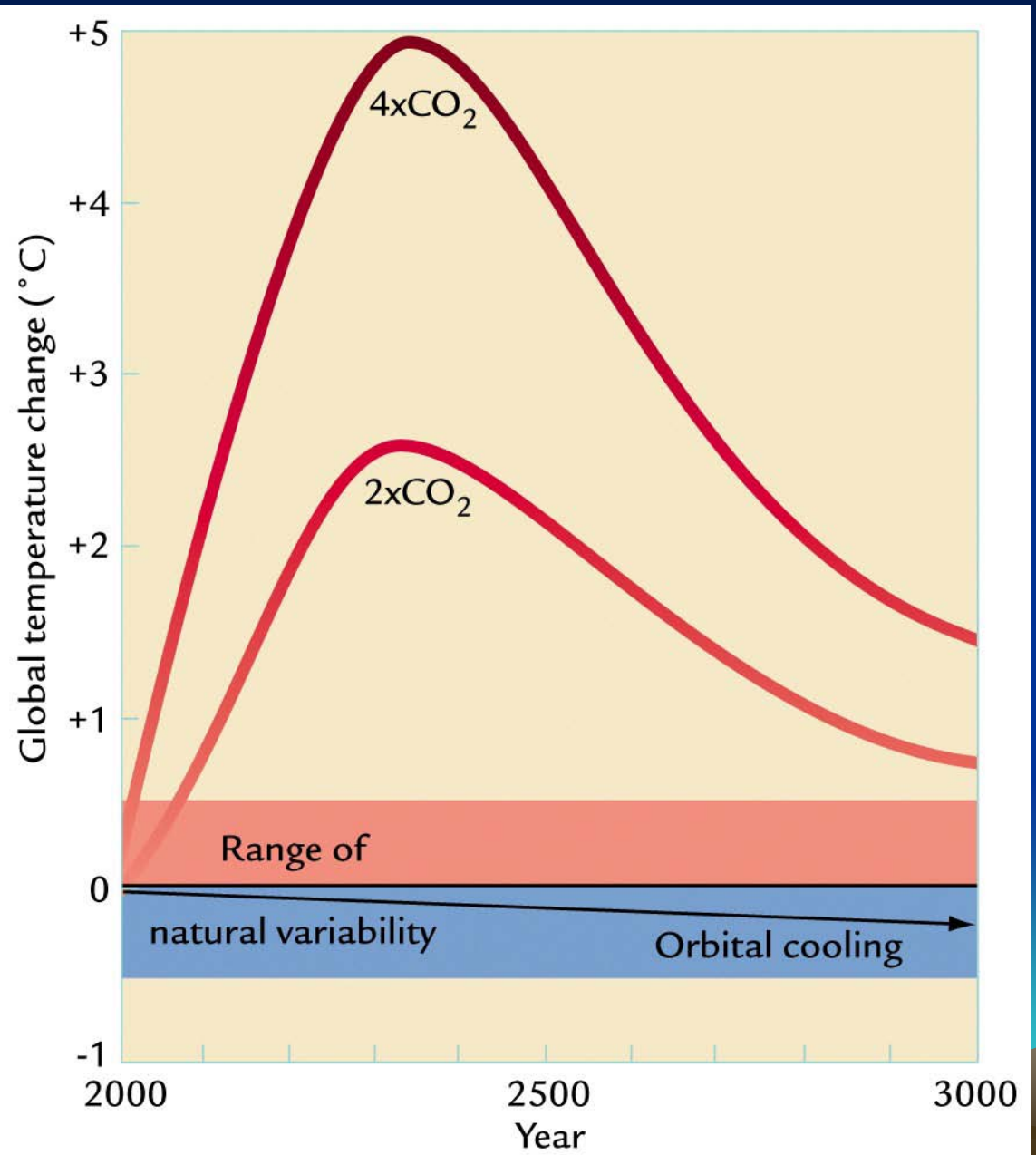
Resulting in CO_2 levels comparable to 10s of millions of years ago in warmer greenhouse worlds.

This warming will overwhelm natural variations in climate and could cause climatic and environmental changes unprecedented in human experience.

As regional patterns of temperature and precipitation change, impacts on human populations will vary from favorable to unfavorable by region and season.

Atmospheric CO_2 levels will remain high for 1000 years or more, until the ocean absorbs the excess CO_2.

Greenhouse and natural changes

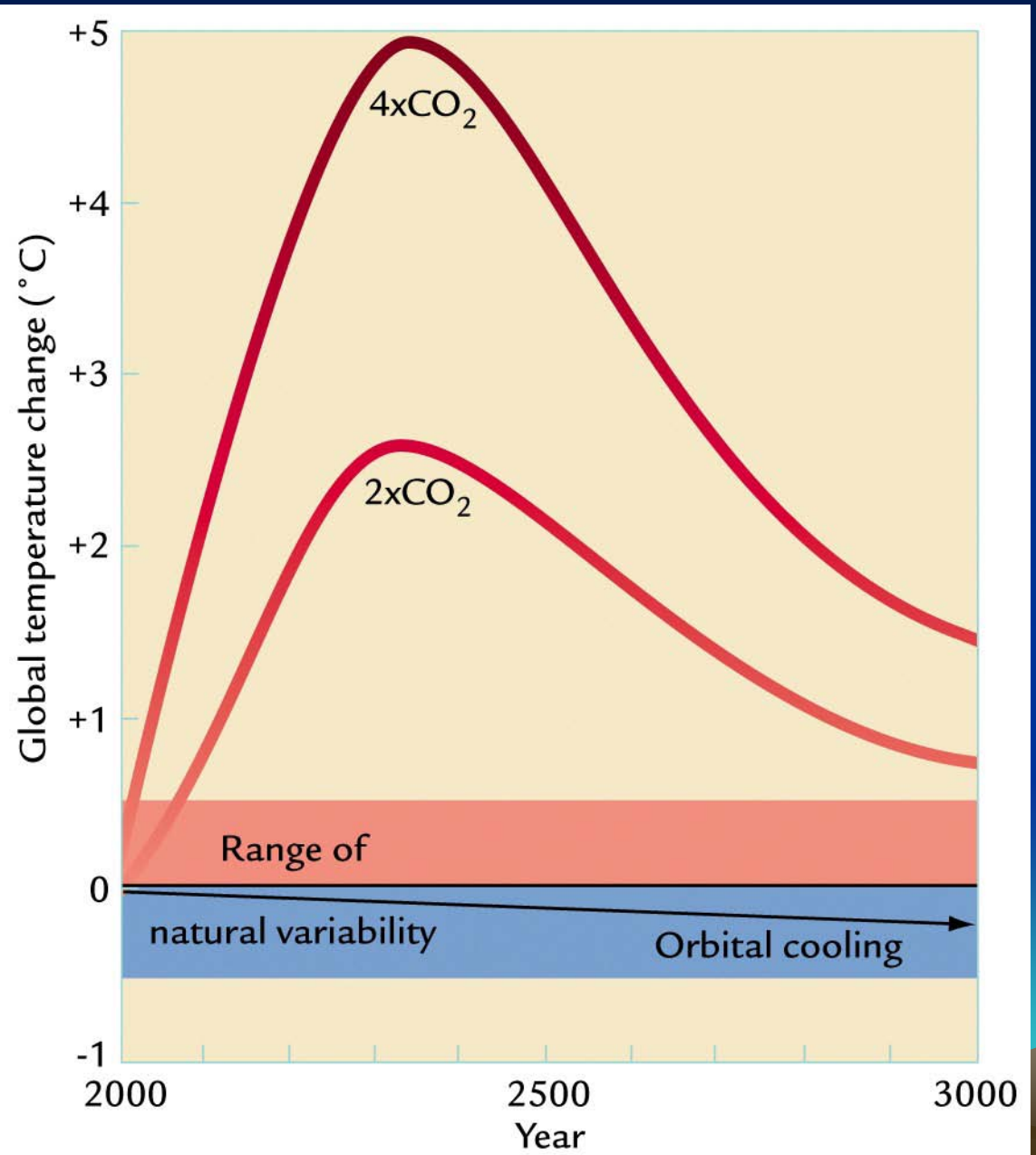


Inherent uncertainties make it difficult to predict climate over the next few decades.

However, 50 yrs from now, as equivalent-CO_2 concentrations approach 2X the pre-industrial value, climate change will have overwhelmed natural variability.

Impact of our unintended experiment should be obvious, and debate over Earth's sensitivity to ghg will have been settled.

Greenhouse and natural changes



Natural climatic variability over a few years (i.e., El Nino, volcanic eruptions), represent only brief departures from longer-term underlying trends.

These short oscillations are irrelevant to projections over next 1000 years.

Global temp. changes produced by all natural causes unlikely to reach 1 C over next 1000 years.

Projected ghg warming for same interval is between 2 -8 C, with a likely value of 4°-5°C.

Projected Carbon Emissions

Atmospheric CO_2 levels continue to rise at rate of 1.5 ppm (0.4%) per year because of fossil fuel combustion and clearing of forests.

Rate of increase will probably accelerate in future, but at unknown rates.

Uncertainties center on two issues:

1) How much carbon will human activities emit?

2) How will Earth system distribute this additional CO_2 among its atmospheric, oceanic and terrestrial reservoirs of carbon?

Projections of future carbon emissions based on three factors:

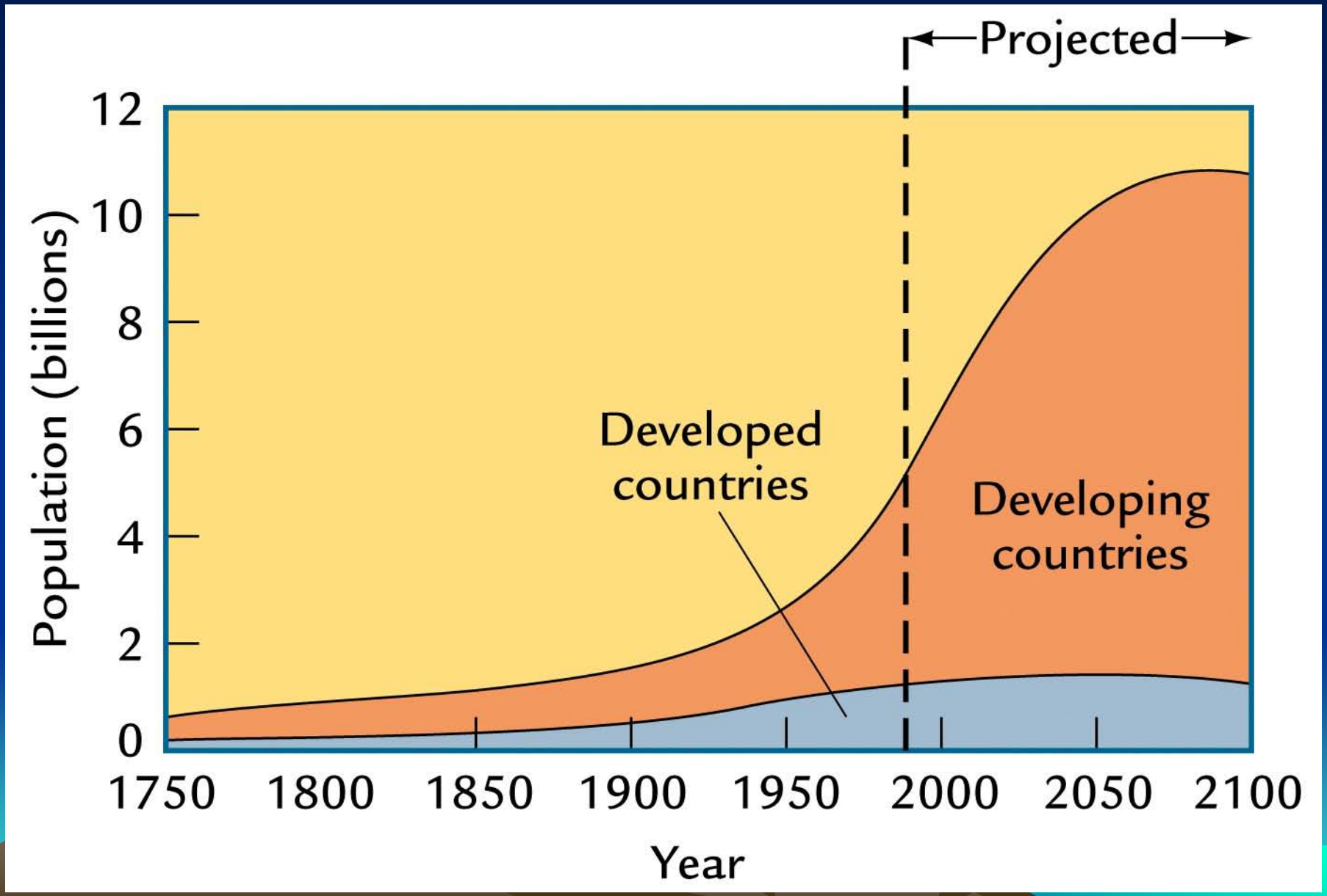
1) Population

2) Emissions per person

3) Carbon use efficiency (CUE)

$\%\Delta$ carbon emissions = $\%\Delta$ population x $\%\Delta$ emissions/person x $\%\Delta$ CUE

Future Population



Emissions per person

Emissions per person is linked to the average standard of living.

In many nations, standards of living increase over time, and in the past this process has required more carbon-based fuel for industrialization and day-to-day individual consumption (for cars and home heating or cooling).

In the near term, largest changes will occur in SE Asia as nations moving from semi-industrialized economies to join industrialized nations.

Some developing countries will also move from farm-based economies to semi-industrialized status.

What can you do?

Buy a fuel-efficient car

Take mass transit (bicycle or walk) to work

Car-pool

Take a look at other ways in which you waste energy at home or at work

Education: Learn more about this issue.

What can you do?

Buy products from companies that are trying to reduce their own impact on the climate

(e.g., Wal-Mart, Green Mountain Energy)

In October 2005, CEO H. Lee Scott announced a goal to transform Wal-Mart into a company that runs on 100 percent renewable energy and produces zero waste.

In addition, he recently articulated commitments:

- to cut the corporation's greenhouse-gas emissions by 20 percent over the next seven years,

- double the fuel efficiency of its truck fleet within 10 years,

- reduce solid waste from U.S. stores by 25 percent in the next three years

- double offerings of organic foods this spring, selling them at prices more affordable to the masses.

Websites for more information

www.realclimate.org

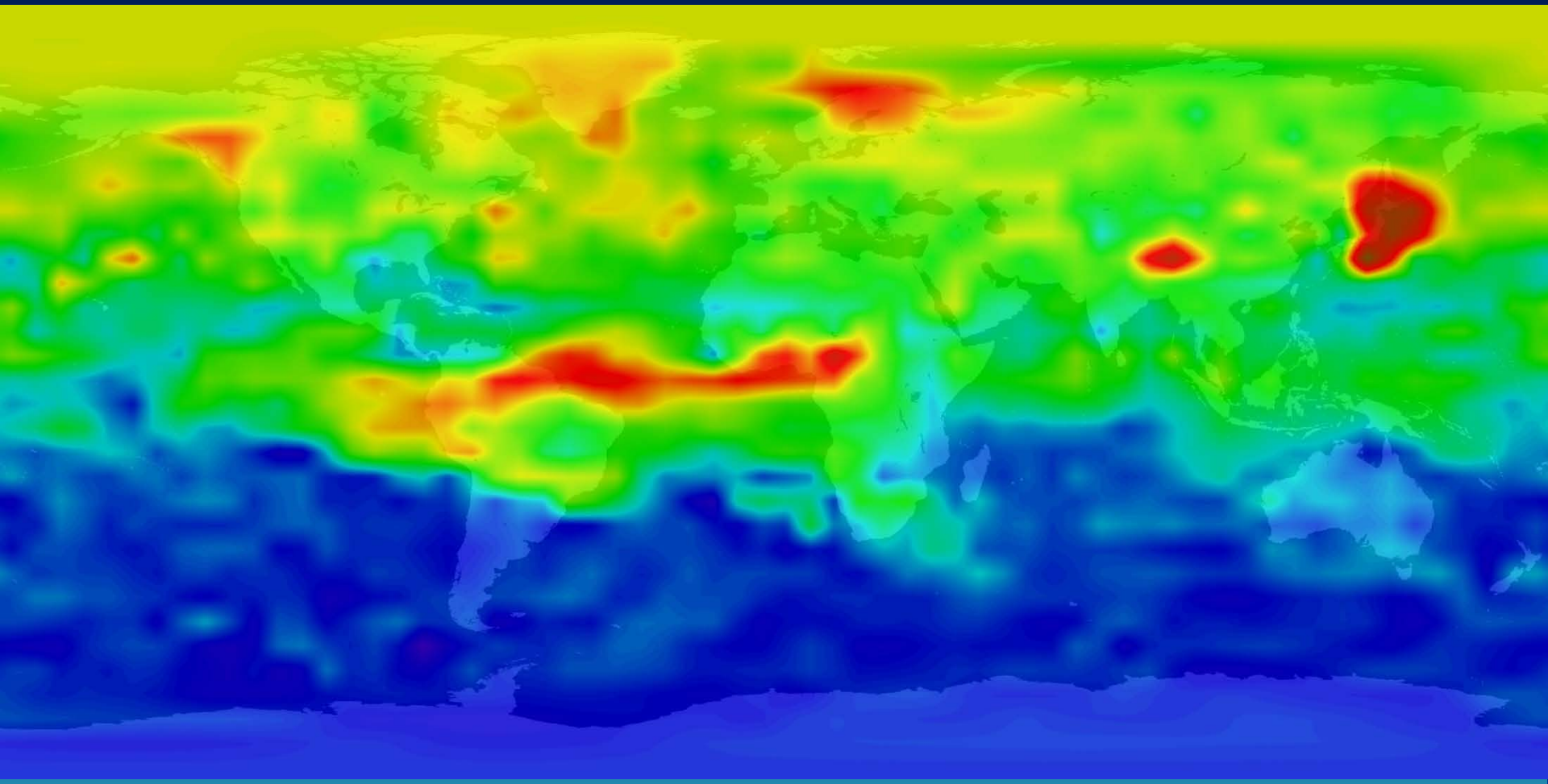
www.ipcc.ch Feb 2nd 2007 Assessment

www.climateark.org

gcmd.gsfc.nasa.gov Global Climate Change Master Directory

www.globalchange.gov U.S. Global Change Data and Information System

Global CO “snapshot”

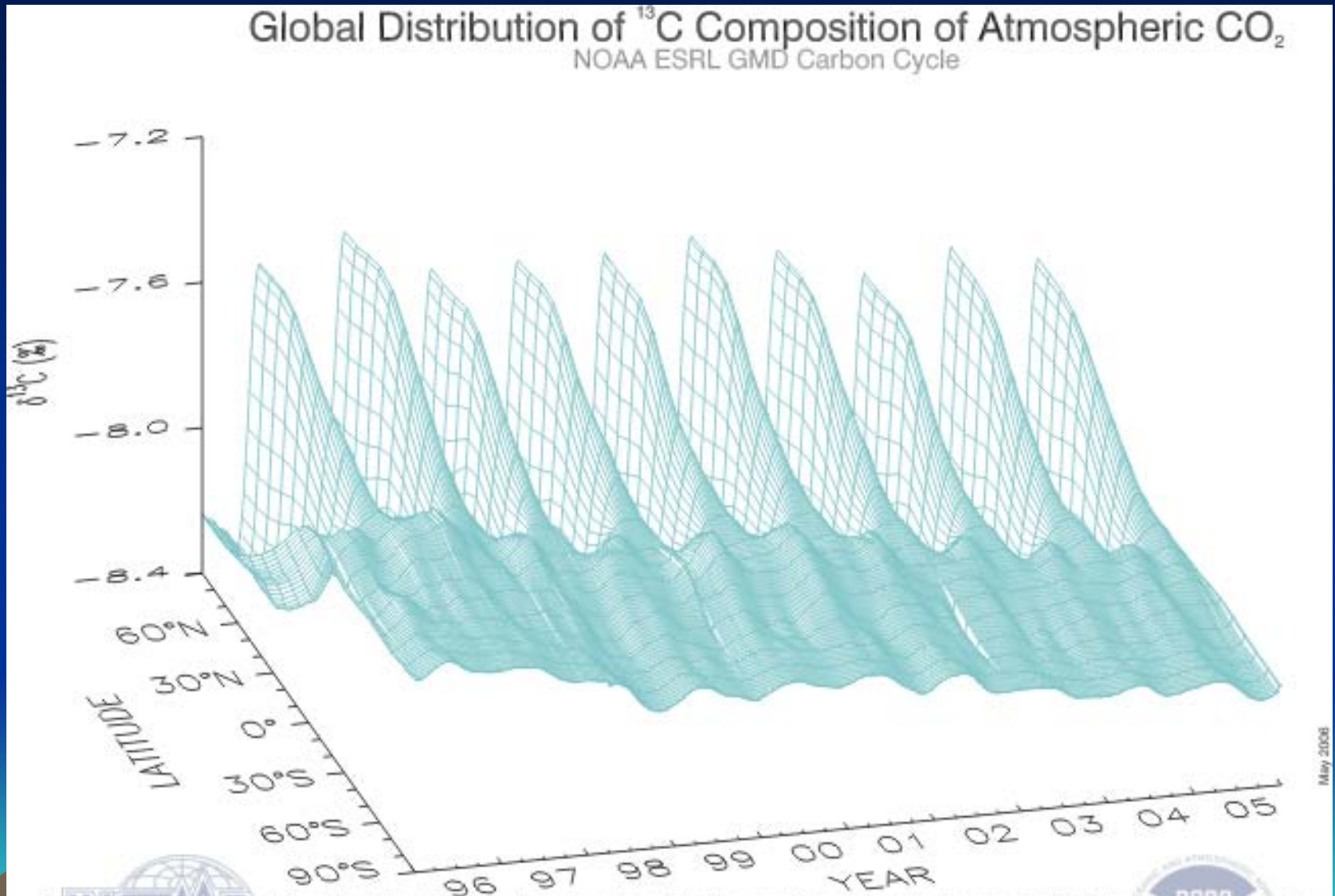


MOPPITT satellite
October 3, 2003


GEOGRAPHIC
SOUTH POLE
ROALD AMUNDSEN
ROBERT F. SCOTT

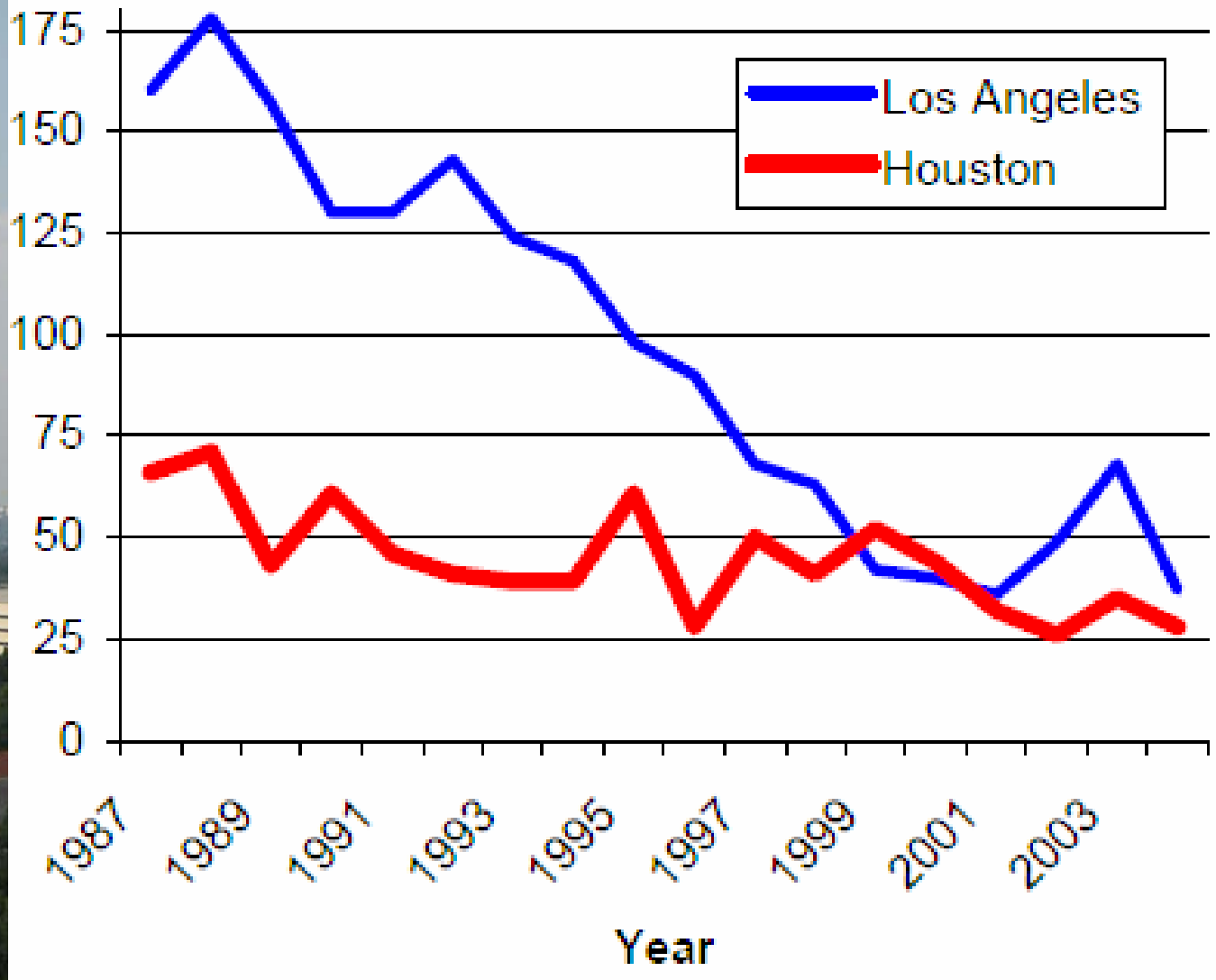

Automatic Weather Station (AWS)
Location Map
See http://uwamrc.ssec.wisc.edu/aws/
and ftp://ice.ssec.wisc.edu/pub/biglist
for more details
AVHRR Image Mosaic from
USGS Map I-2560
Merge by C.A. Shuman
UMD-ESSIC
Racer Rock
Larsen Ice
Bonaparte Point
Dolleman Island
Butler Island
Santa Claus Island
Rothera
Uranus Glacier
Limbert
Cape Adams
Ski Hi
Siple
Halley Bay
AGO Site
Recovery Glacier
AGO-A81
AGO-3
AGO-A84
AGO-2
Relay Station
Dome F, Dome Fuji
AGO-4
AGO-1
AGO-5
Dome C II
Dome C
Henry
Patrick
Nico
Clean Air
Kelly
Allison
Lindsay
Theresa
Erin
Mount Howe
Doug
Harry
J.C.
Brianna
Bowers
Inland
Byrd
Elizabeth
Swithinbank
Siple Dome
Elaine
Lettau
Marilyn
Schwerdtfeger
Byrd Glacier
Mount Siple
Gill
Martha II
Martha I
Asgard
Marble Point
Pat
Shristi
Sandra
Lynn
Sushila
Whitlock
Manuela
Possession Island
AGO-6
D-80
D-57
D-47
D-17
D-10
Port Martin
Sutton
Cape Denison
Cape Webb
Penguin Point
Buckle Island
Young Island
Scott Island
Active AWS
Inactive AWS
Planned AWS
Key for McMurdo Area
1 Cape Bird
2 Ferrell
3 Fogle
4 Jimmy1
5 Jimmy2
6 Laurie
7 Linda
8 Manning
9 Meeley
10 Minna Bluff
11 Mount Erebus
12 Nancy
13 Pegasus
14 Pegasus North
15 Pegasus South
16 Tiffany
17 White Out
18 White Island
19 Willie Field
20 Windless Bight1
21 Windless Bight2

More Recent carbon dioxide



Three dimensional representation of the latitudinal distribution of the carbon isotopic composition of atmospheric carbon dioxide in the marine boundary layer. The measurements of stable isotope ratios were made at the University of Colorado INSTAAR using air samples provided by the GMD cooperative air sampling network. The surface represents data smoothed in time and latitude. The isotope data are expressed as deviations of the carbon-13/carbon-12 ratio in carbon dioxide from the VPDB-CO2 standard, in per mil (parts per thousand). Contact: Dr. Jim White, CU/INSTAAR, Boulder, Colorado; (303) 492-5494, (James.white@colorado.edu, http://www.cmdl.noaa.gov/ccgg).

Number of Days Exceeding One-Hour Ozone Standard



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