The Real Science of Global Warming

By

Sandra Kirtland, Lauren Rafelski, Tim Ray, and Daniel Richter.

GHGs Do Trap Heat

- John Tyndall discovered CO_2 is a greenhouse gas in 1859!
- In terms of the atmosphere, water is the strongest greenhouse gas.
- But, since we can't control water, it is not necessarily the most important greenhouse gas.

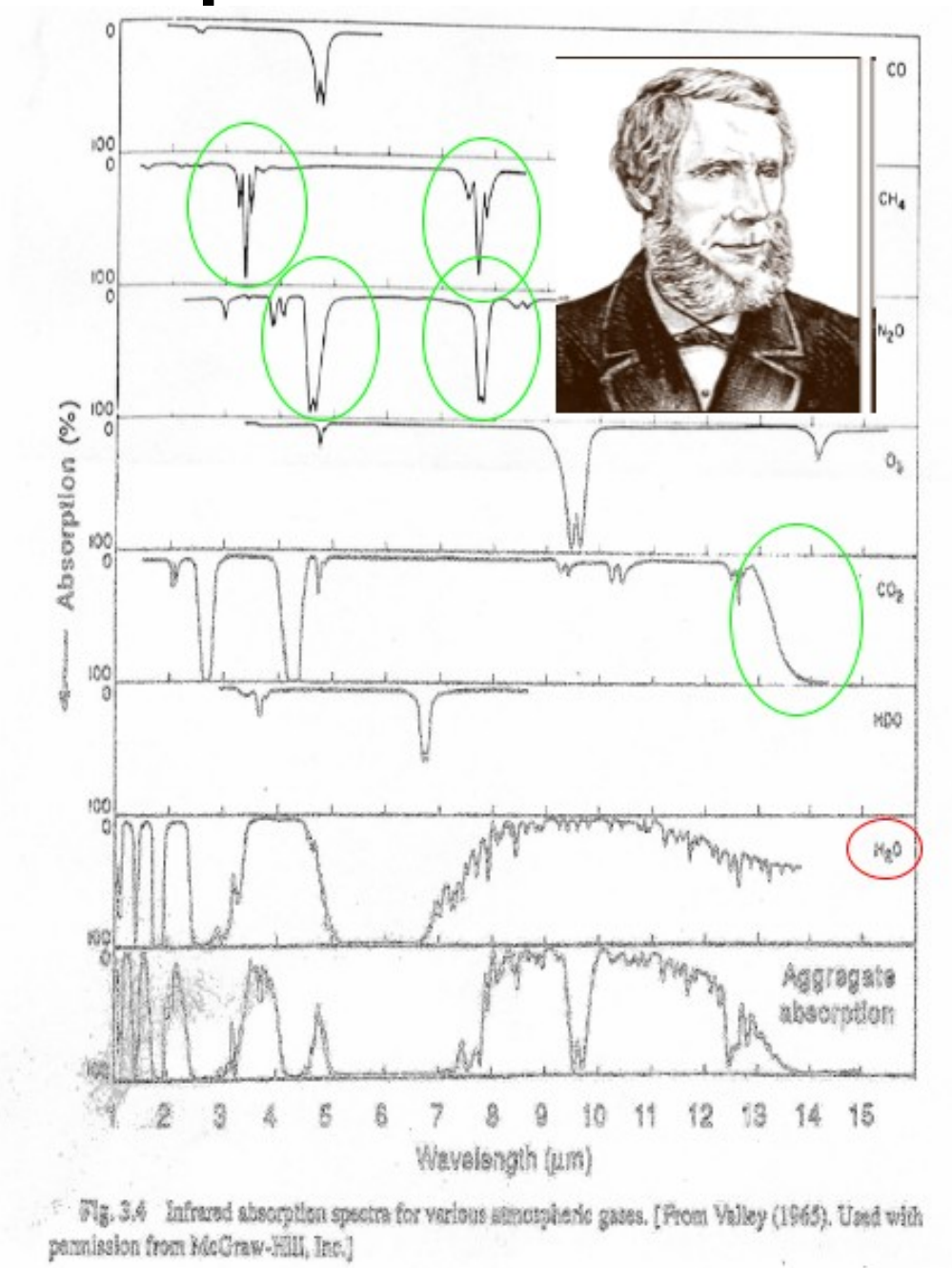
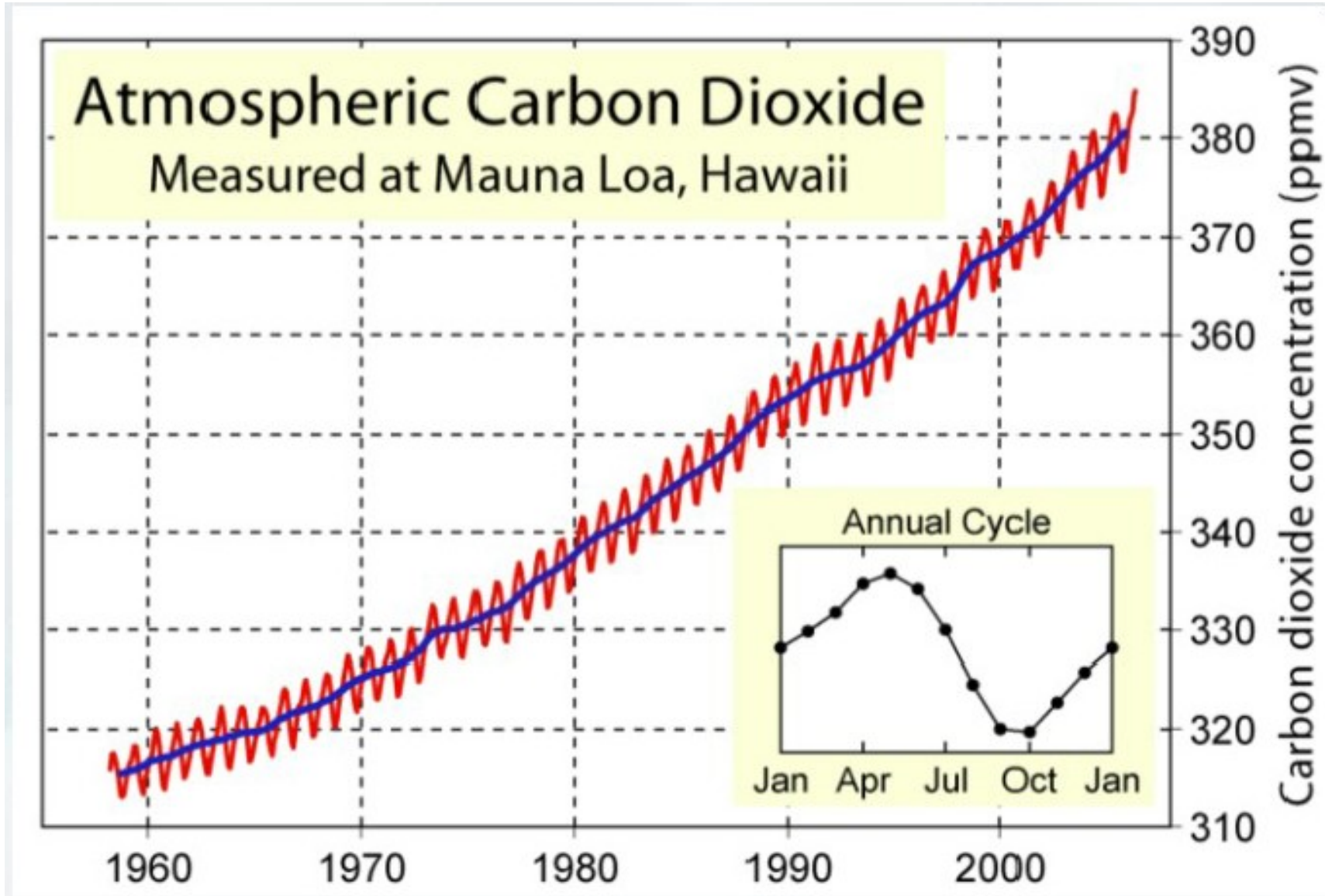


Fig. 3.4 Infrared absorption spectra for various atmospheric gases. [From Valley (1965). Used with permission from McGraw-Hill, Inc.]

CO_2 Concentrations are Rising



Carbon Budgets

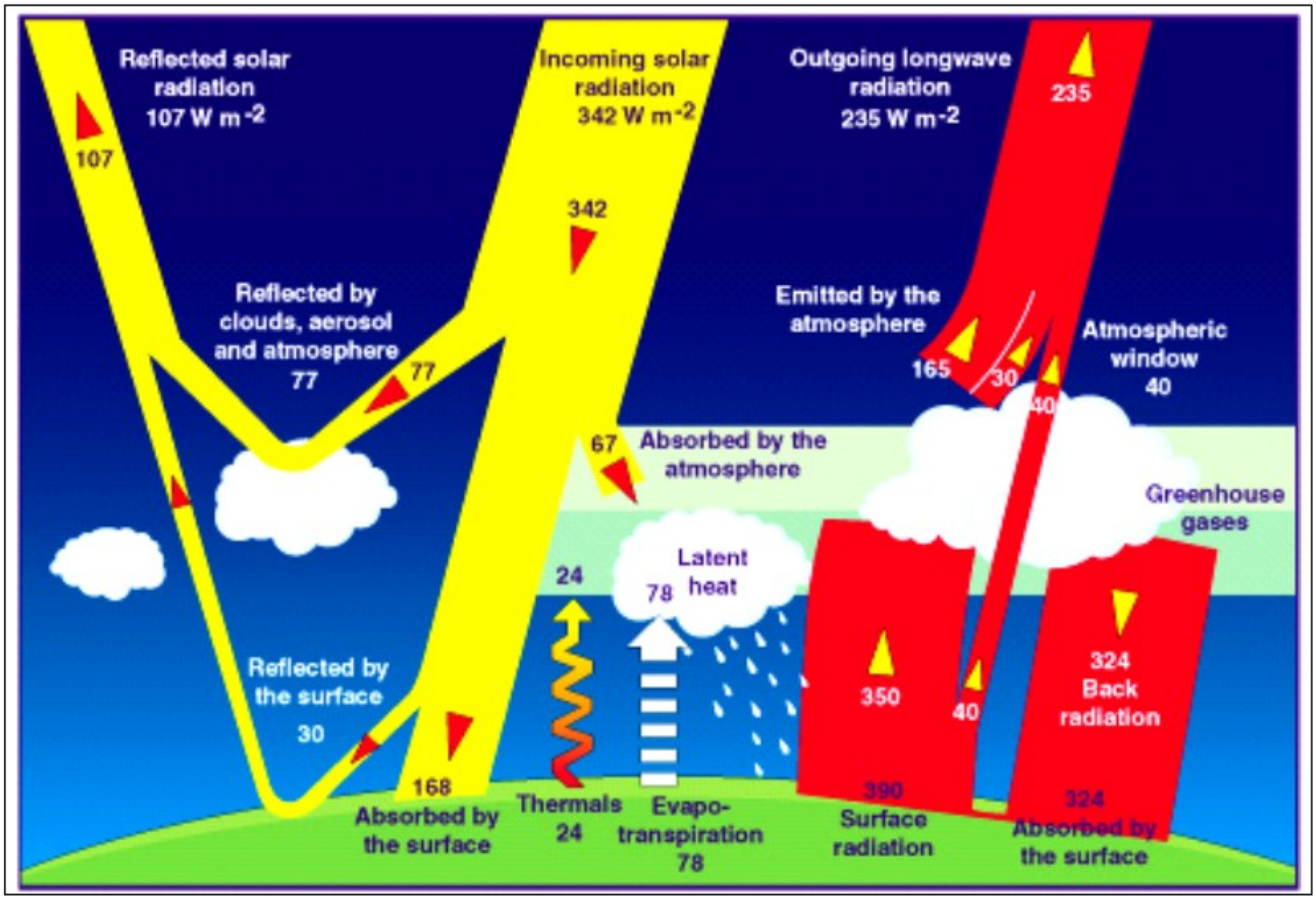
- We've emitted twice as much CO_2 as is needed to account for the rise we've seen to 390 ppm.
- The other half has mostly gone into the ocean.

Table 1. Anthropogenic CO_2 budget for the anthropocene (1800 to 1994) and for the decades of the 1980s and 1990s.

CO_2 sources and sinks	1800 to 1994 (Pg C)*	1980 to 1999 (Pg C)¶
Constrained sources and sinks		
(1) Emissions from fossil fuel and cement production	244† ± 20	117 ± 5
(2) Storage in the atmosphere	−165‡ ± 4	−65 ± 1
(3) Uptake and storage in the ocean	−118§ ± 19	−37 ± 8
Inferred net terrestrial balance		
(4) Net terrestrial balance = [−(1) − (2) − (3)]	39 ± 28	−15 ± 9
Terrestrial balance		
(5) Emissions from land-use change	100 to 180‖	24 ± 12
(6) Terrestrial biosphere sink = [−(1) − (2) − (3)] − (5)	−61 to −141	−39 ± 18

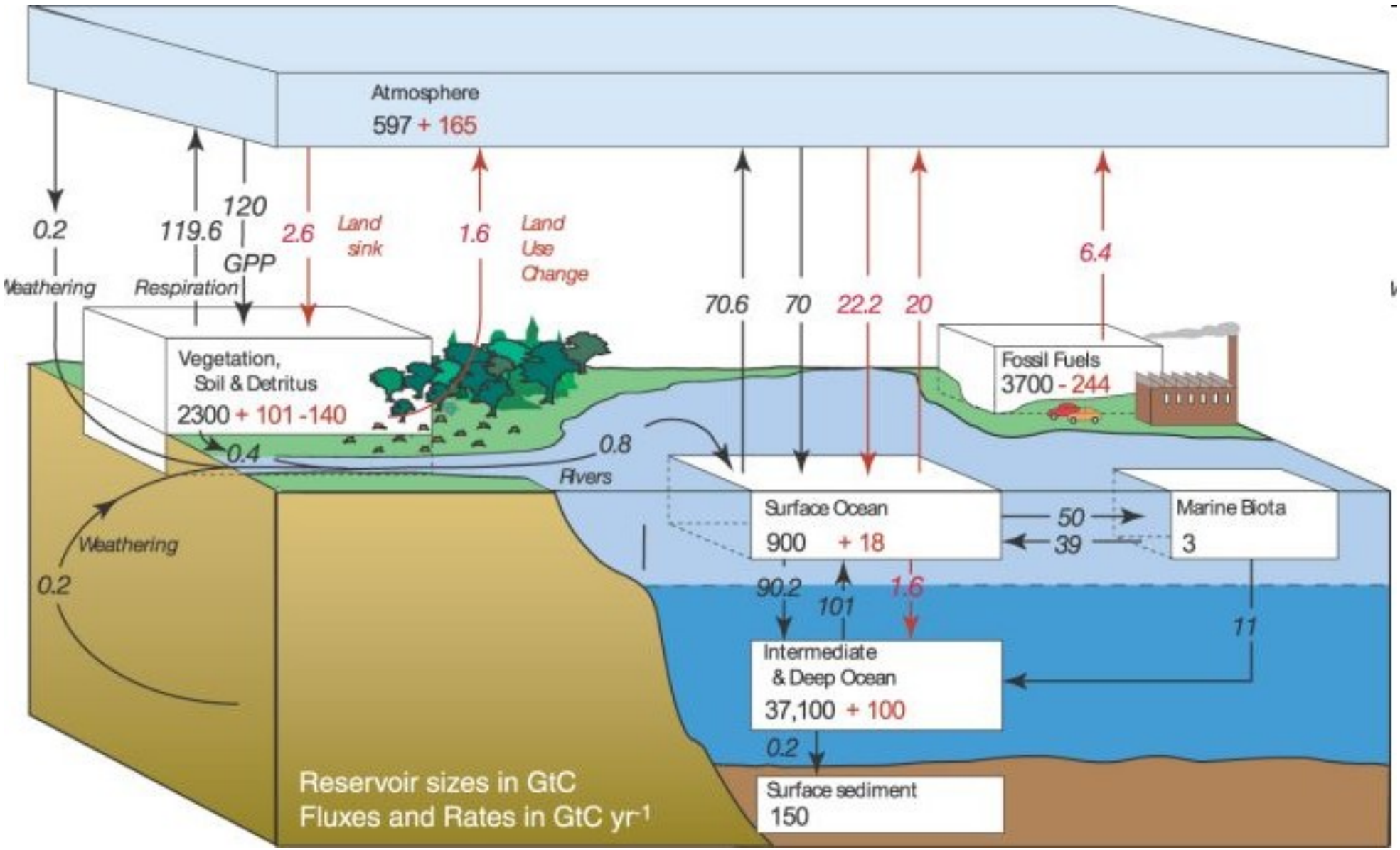
*Errors as estimated by respective sources; errors of sums and differences are calculated by quadratic error propagation. †From (*19*), with an error estimate of ±8%. ‡Calculated from the change in atmospheric PCO_2 (1800: 281 ± 2 ppm; 1994: 359 ± 0.4 ppm). §This study includes anthropogenic CO_2 storage in marginal seas and the Arctic Ocean. ‖Based on (*2*); see text for details. ¶From (*23*), integrated for the period 1980 to 1999.

Earth's Radiative Balance



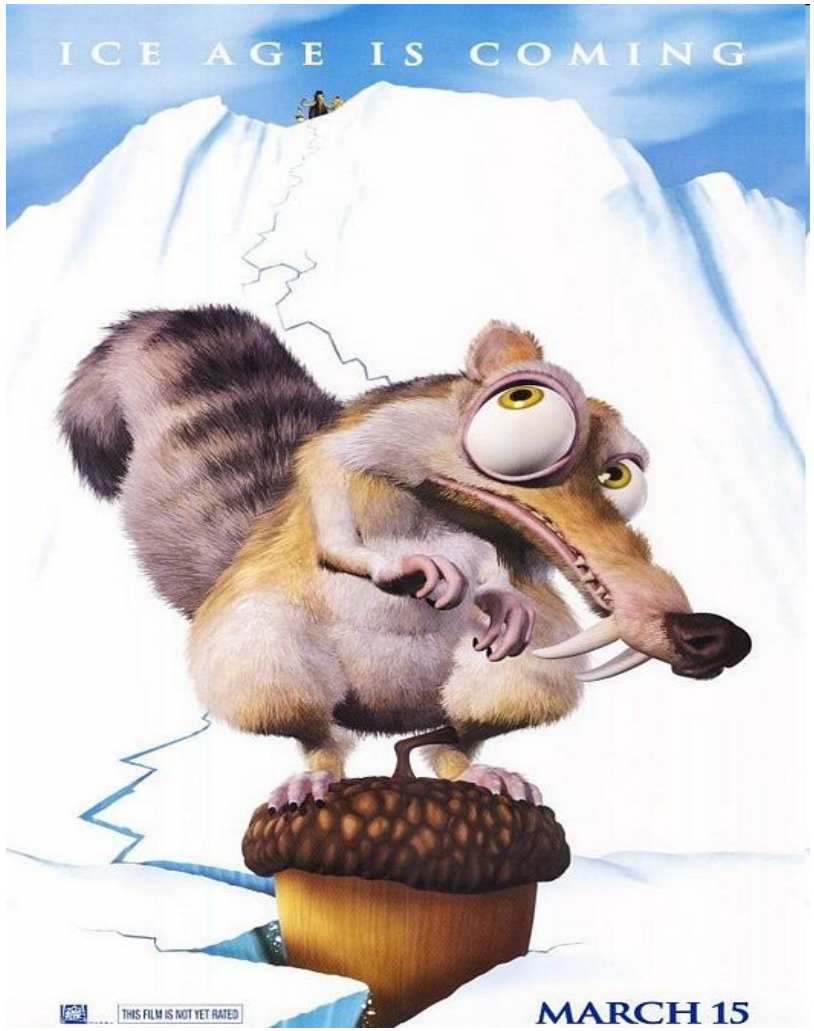
T without Greenhouse Effect = 235W/m^2 = 255K = -18^{o}C = -0.4^{o}F.
Current average = 324 W/m^2 = 14^{o}C = 57^{o}F

Carbon Sources and Sinks



Skeptics Under The Magnifying Glass

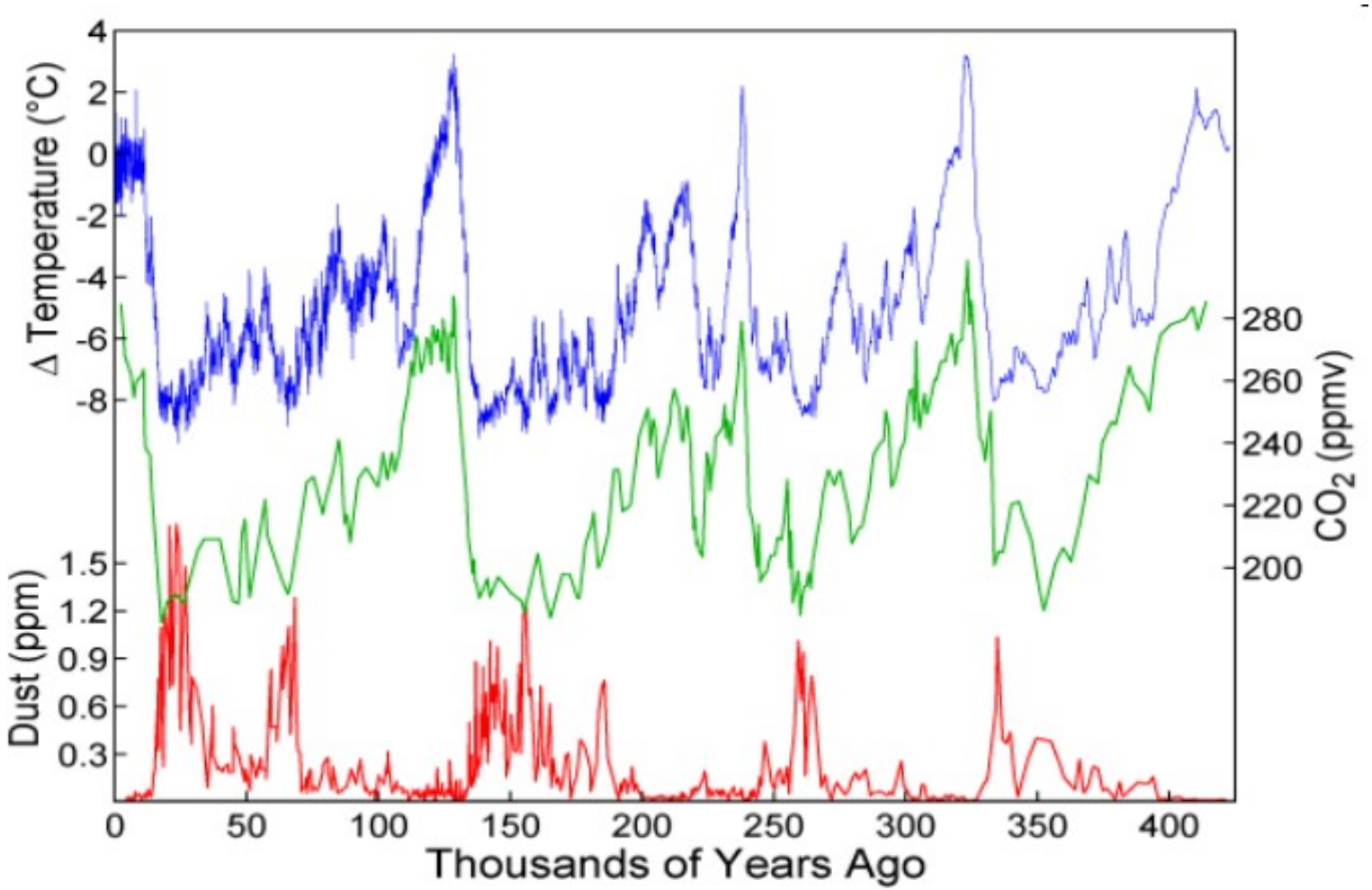
Argument: The Earth is Going into an Ice Age



Basis for the Argument

- Earth's climate system is cyclical, and it's time for an ice age!
- Back in the 70's, scientists were predicting an ice age, now they're predicting global warming!

Earth's Climate Cycles



Note slow decent into glaciation, and “rapid” return to warm periods.

History:
Predictions of an Ice Age in the 70's

Arguing for an ice age:

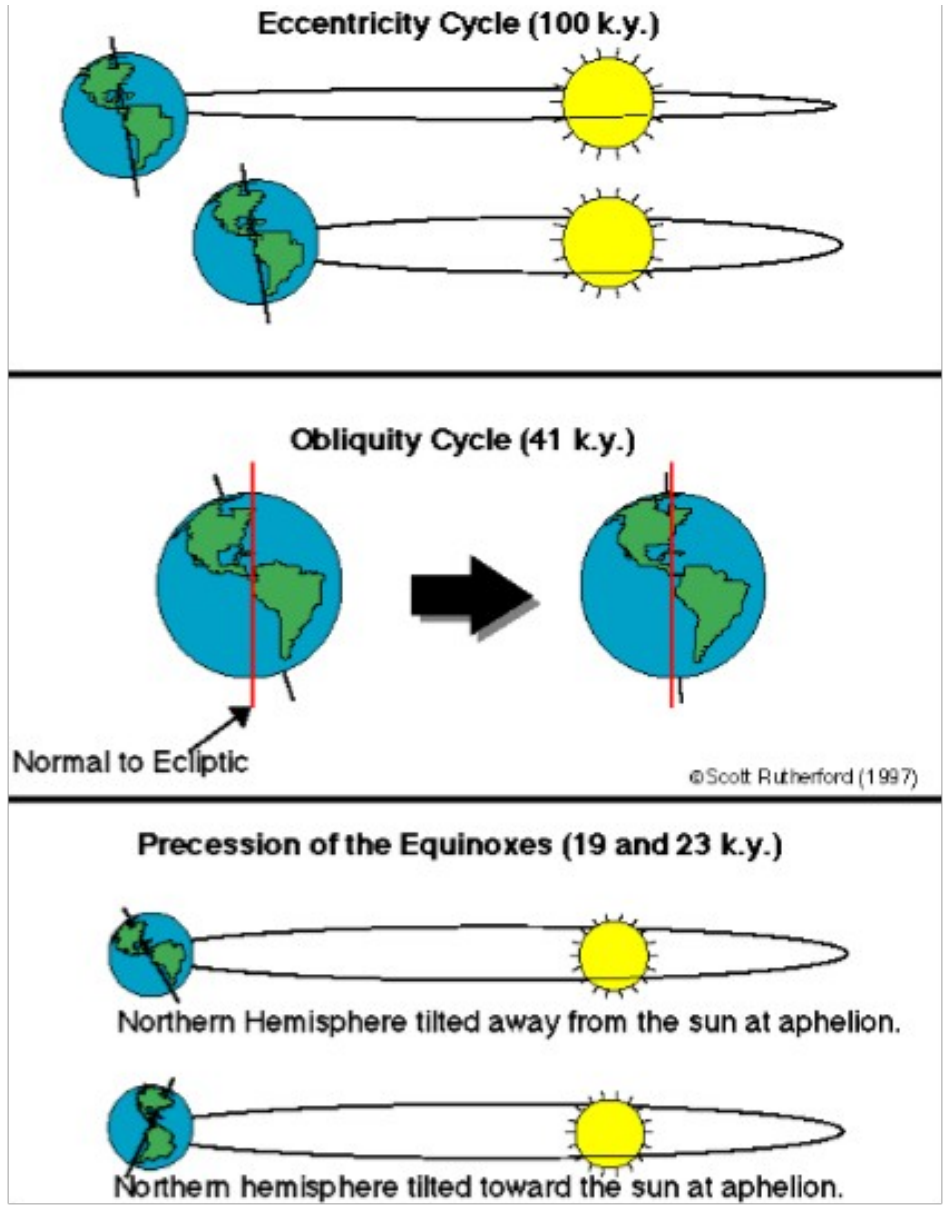
- Deep sea cores

(But, there was poor timing for how long there was between ice ages)

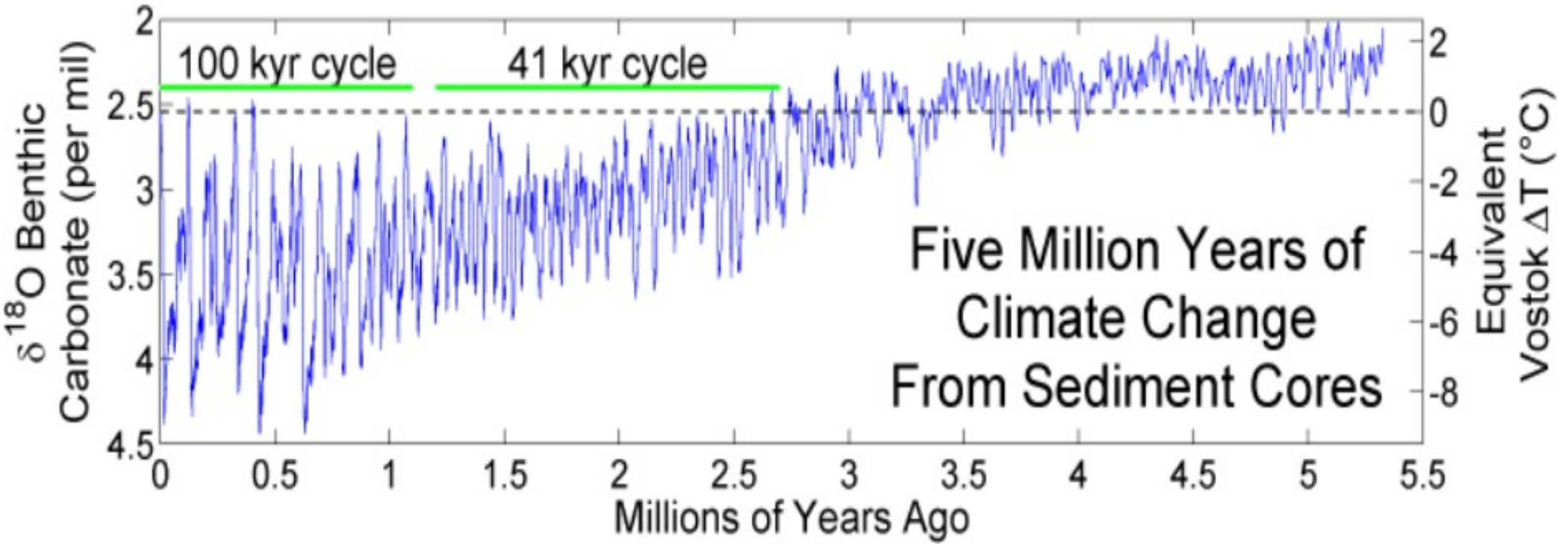
- Analysis of 1940-1970 temperatures showed 0.3^{o}C decline.

(But these data were based only on temperatures from 20-90^{o} North latitude. A 1981 analysis of GLOBAL temps from 1880-1978 showed 0.4^{o}C warming, and only 0.1^{o}C cooling from 1940-1970)

Milankovitch Cycles



Milankovitch Cycles

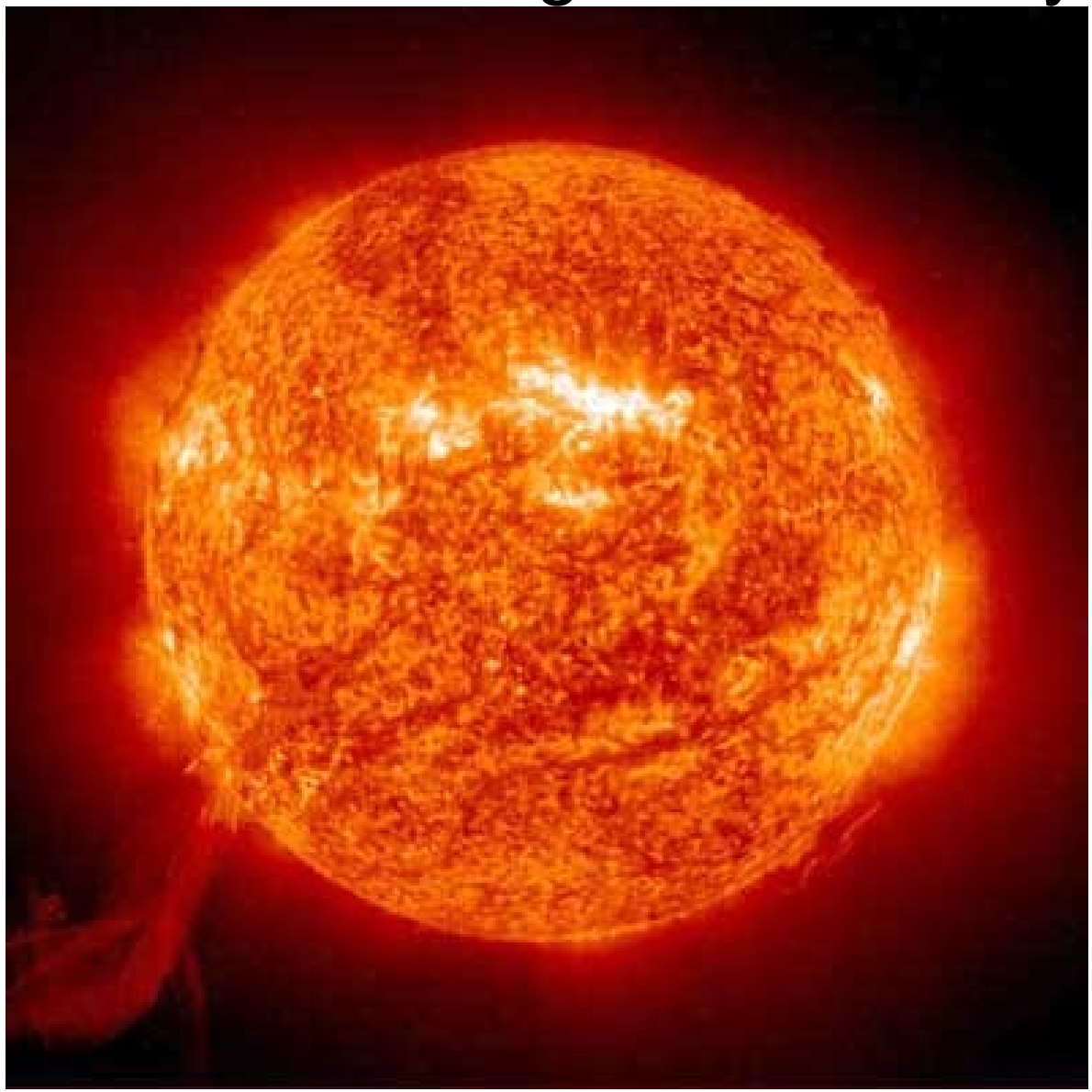


- Combined, the max global effect of Milankovitch cycles is only 0.5 W/m^2.
- By contrast, the glacial to interglaical difference by combined GHGs was 3 W/m^2.
- The effect of doubling CO2 is 4 W/m^2.

Lisiecki, L. E., and M. E. Raymo (2005)

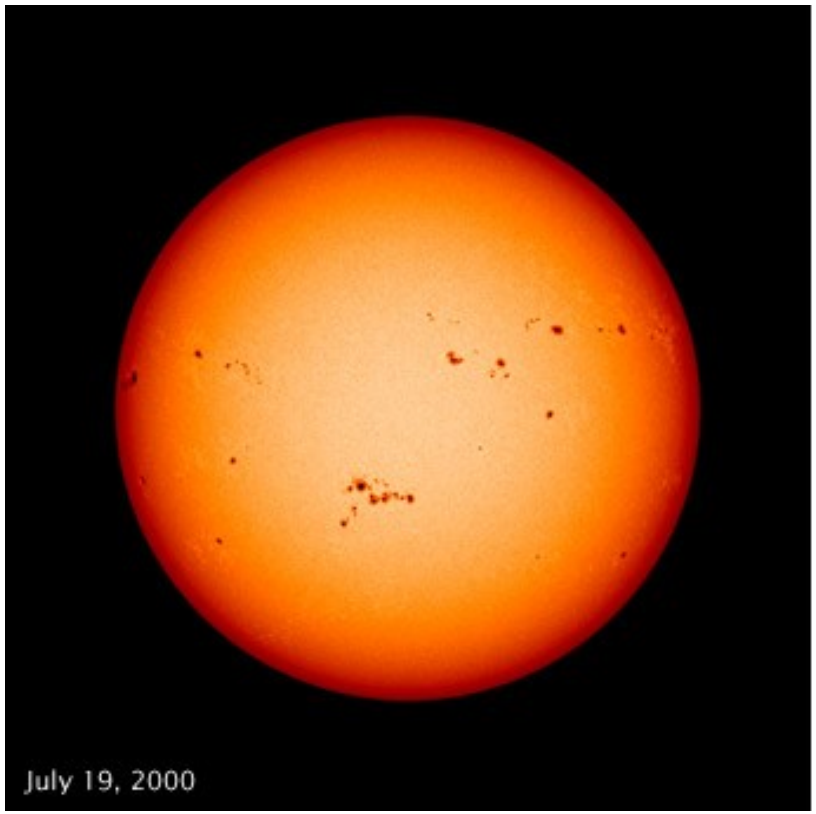
The Little Ice Age?

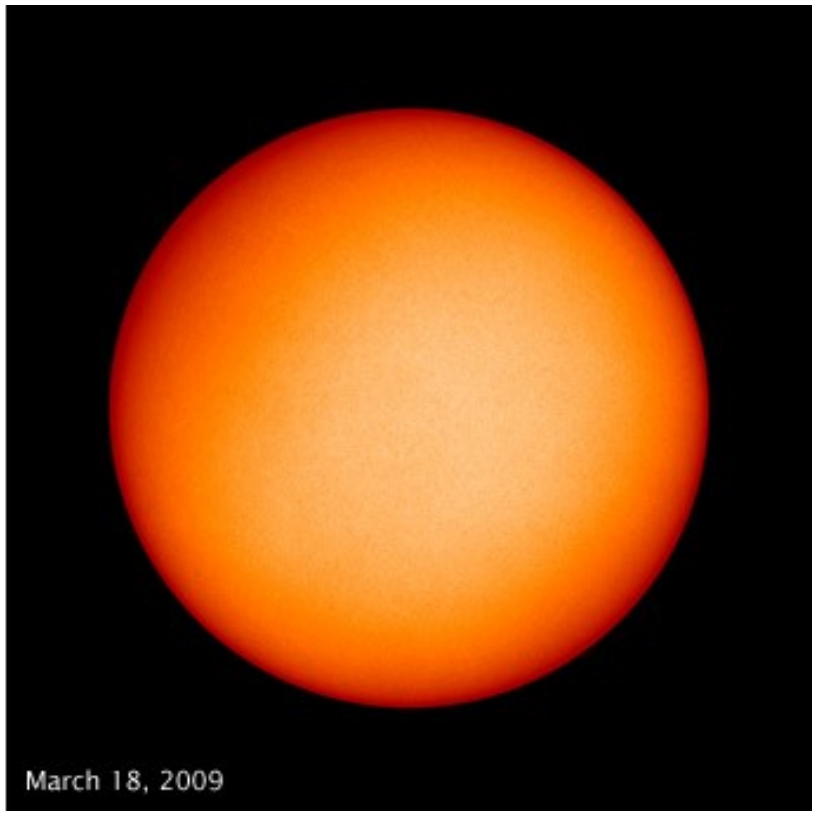
Argument: Climate change is caused by the sun

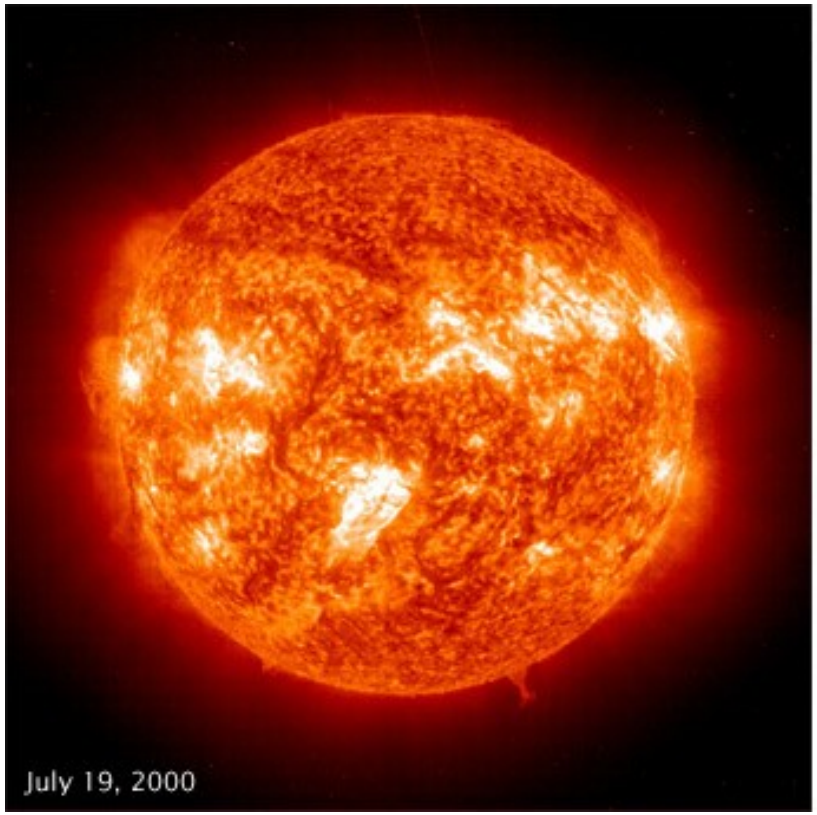


Basis for this claim:

- The sun does heat the Earth
- Changes in solar radiation reaching Earth triggered ice ages (Milankovitch Cycles)
- Connection between sunspots and climate


July 19, 2000


March 18, 2009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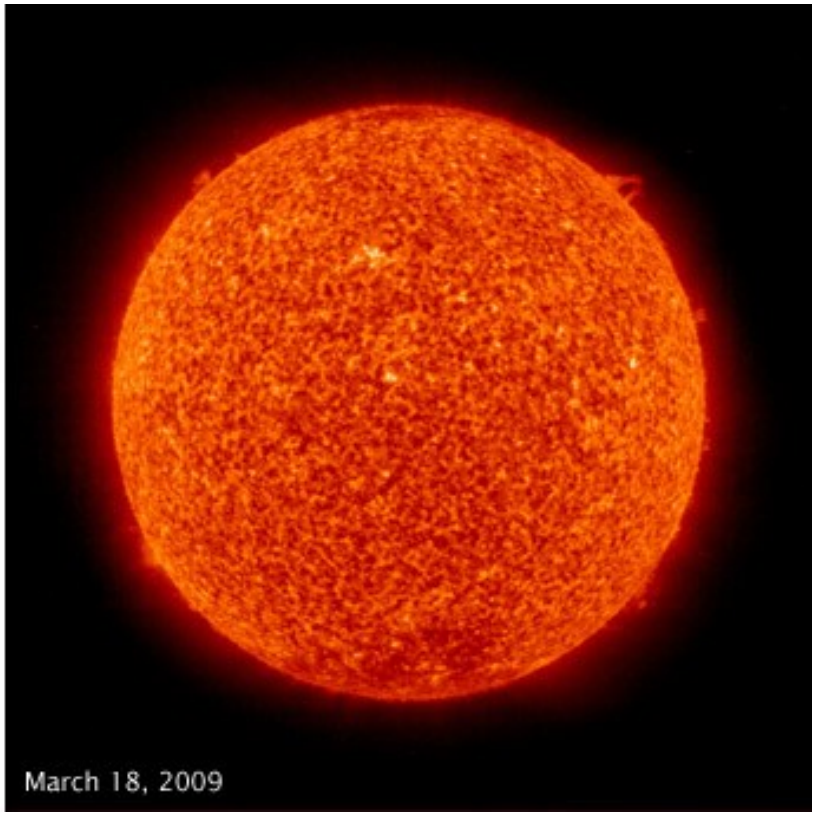
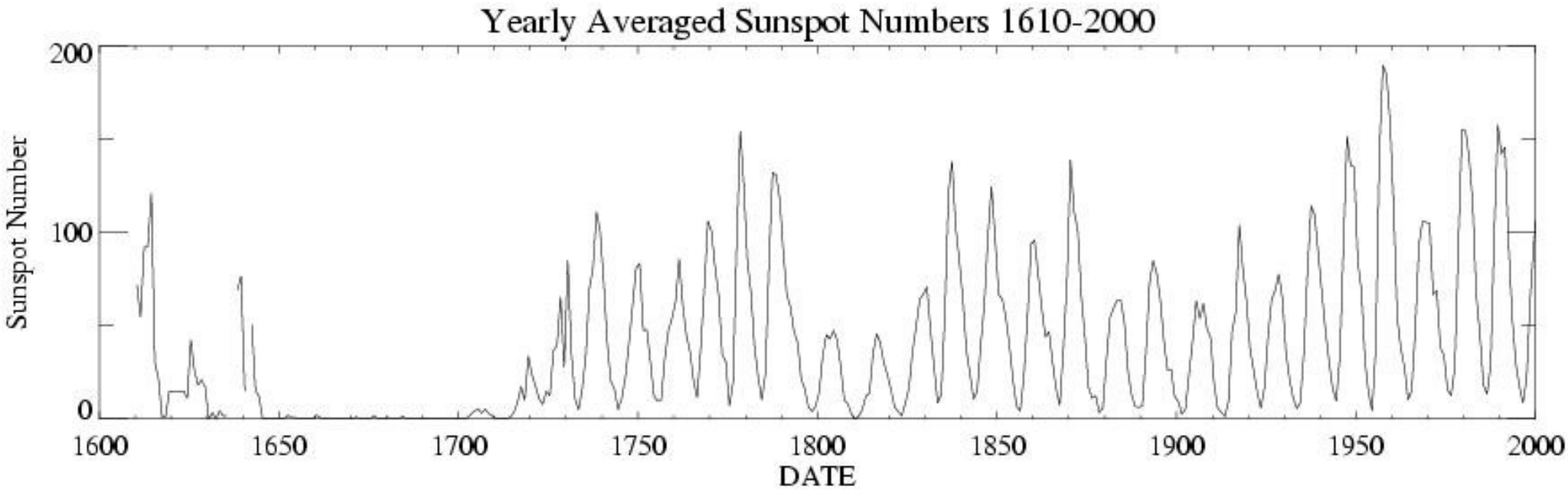

March 18, 2009

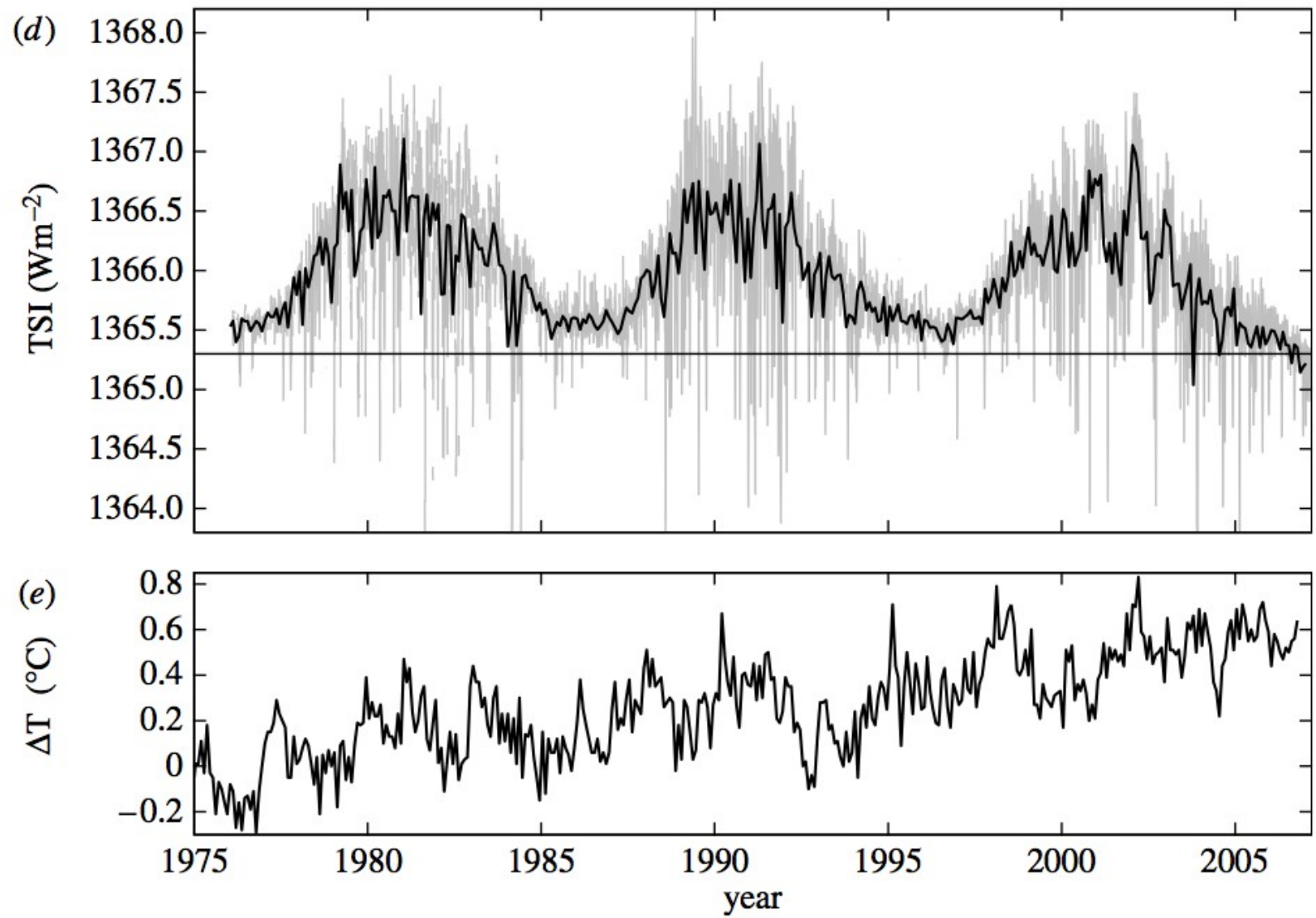
Maunder minimum



Maunder minimum coincides with the Little Ice Age: very cold winters in Europe

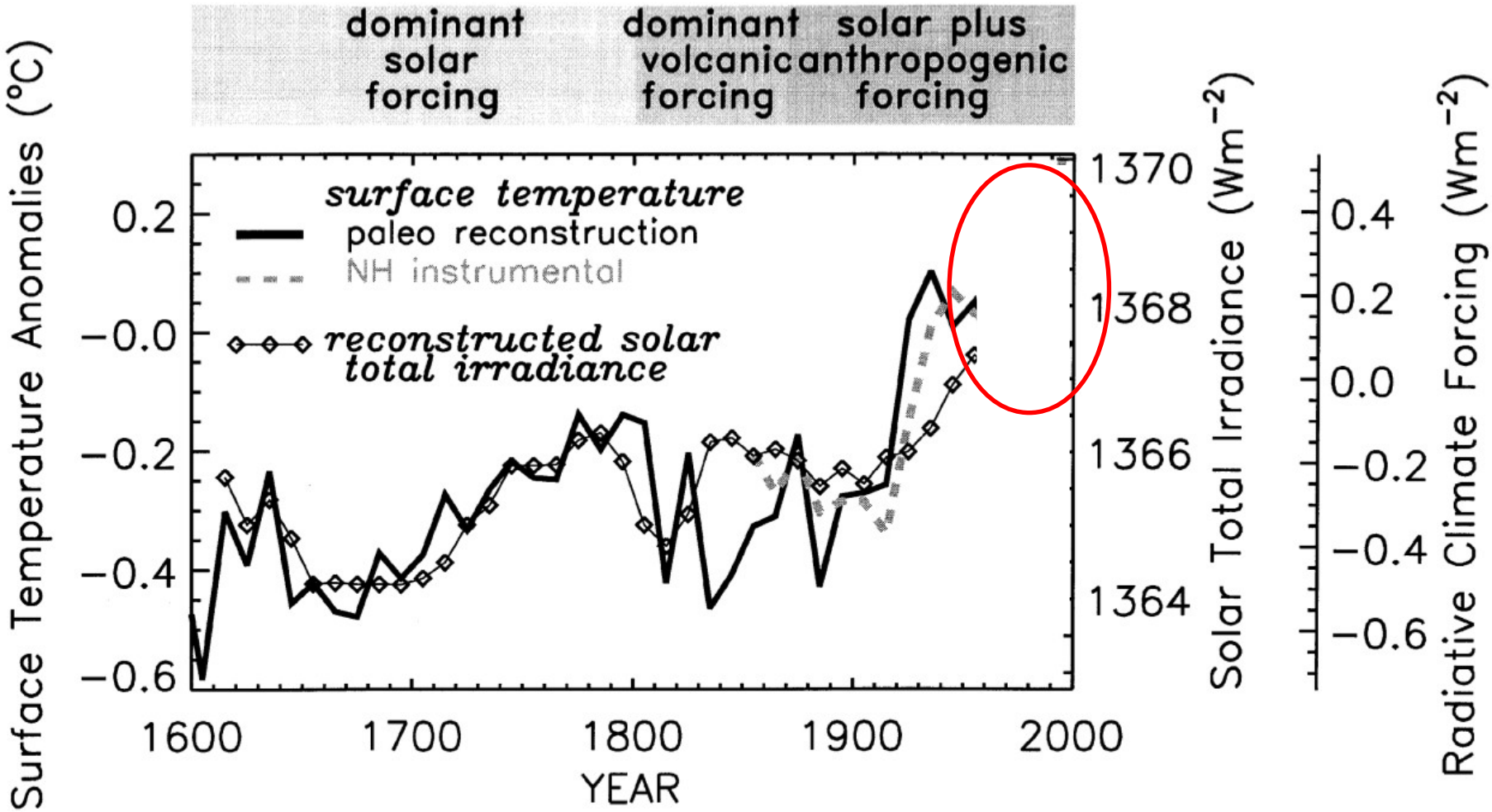
Sunspot numbers from NASA: http://solarscience.msfc.nasa.gov/SunspotCycle.shtml

Solar observations



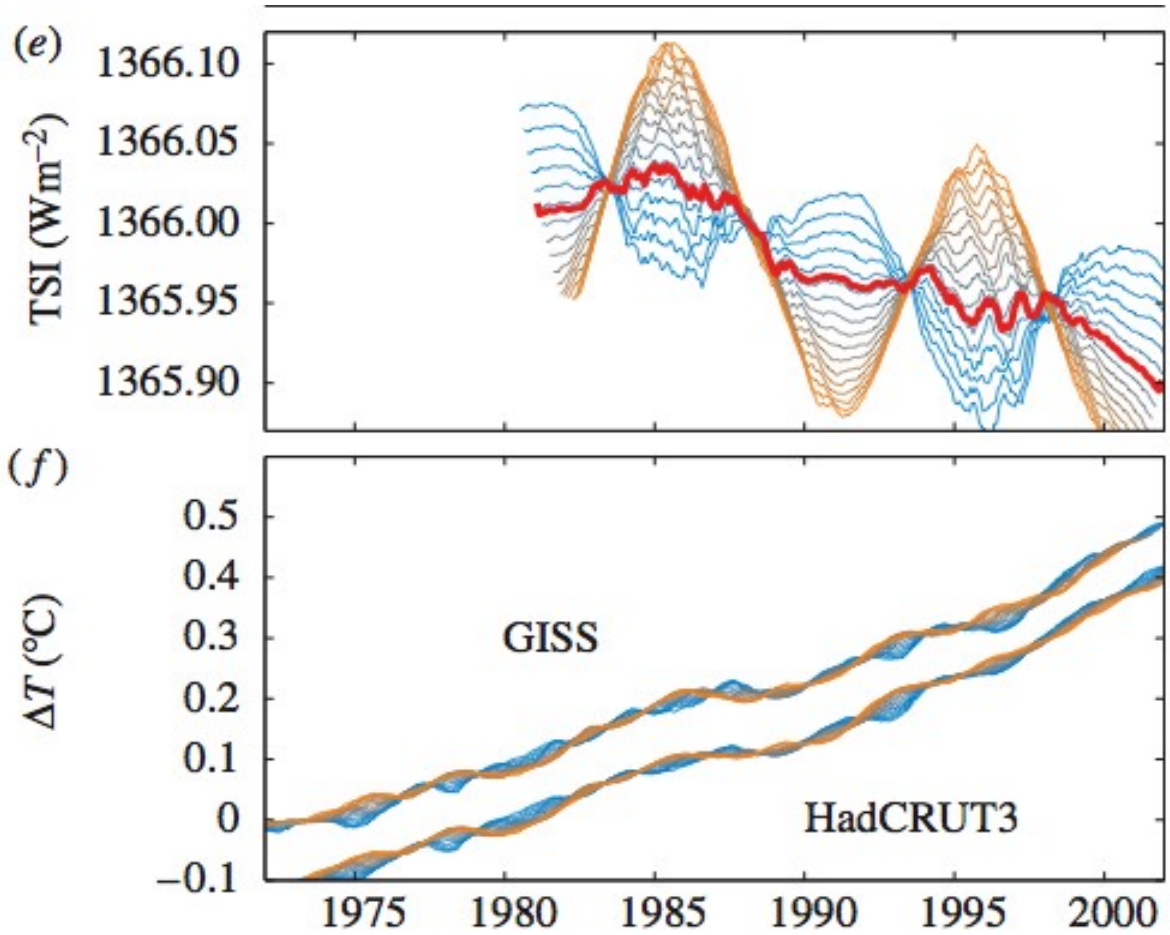
Lockwood, M. and C. Frohlich, Proc. R. Soc. A, 2007, doi:10.1098/rspa.2007.1880

Long term solar forcing



Lean, J. and D. Rind, Journal of Atmospheric and Solar Terrestrial Physics, 61, 1999 pp.25-36

Recent solar radiation



Lockwood, M. and C. Frohlich, Proc. R. Soc. A, 2007, doi:10.1098/rspa.2007.1880

Summary

- Changes in the sun may have caused changes in past climate, but it is not causing current changes in climate
- Temperature observations do not show cycles that correspond to sunspot cycles
- Radiation from the sun has decreased over the past few decades, which could not have caused warming

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ISSUES

Climate Change and Policy Implications

Much research has been conducted by various organizations and universities on the subject of climate change, resulting in a wide range of conflicting conclusions. The Energy and Commerce Committee, of which I am the Ranking Member, is responsible for overseeing the debate on most environmental policy that moves through the House of Representatives. It is my belief that for the best possible policy to be written, all known facts must be considered as well as the impact of legislation.

Fluctuations in Temperature:

There is no dispute that average world temperatures have risen over the past 100 years. While a precise measurement is difficult to pinpoint, most scientists believe the temperature increase to be within the two to three degrees Fahrenheit range. The documented increase in temperature since the 1800's, and the projected increase over the next hundred years, appears well within the range of natural variation. In light of research conducted by numerous scientists on both sides of the debate, the theory that human actions are responsible for changes in global temperatures is a serious one, and worthy of continued research. I have, however, not been convinced the theory is strong enough to warrant the immediate and draconian measures called for by some segments of the environmental community.

Relevant Facts to Put the Theory of Manmade Global Warming Into Perspective:

1) The air we breathe is composed almost entirely (99.88%) of Nitrogen (N2), Oxygen (O2), and Argon (Ar). Carbon Dioxide (CO2) and other variable gases including water vapor (H2O and clouds), Ozone (O3), and other trace gases make up the remainder.

2) Of all the greenhouse gasses, water vapor (H2O and clouds) is the most dominant and abundant greenhouse gas in the atmosphere and, by far, exceeds the total effects of increased carbon dioxide, methane, ozone and all other greenhouse gases combined [i].

3) As a percentage of the total atmosphere, carbon dioxide represents only 0.0386% [ii]. The entire increase in CO2 since before the industrial revolution represents only .0091% of the total atmosphere. Not very much, is it? Laid out on a 100 yard football field, this would equal a distance of less than 3/8 of an inch. It is also important to remember that CO2 is not a pollutant, it is an indispensable part of life. Your body creates and emits CO2 every time you take a breath.

4) Scientists base many of their predictions concerning the future effects of climate change on models. However, these climate models are unable to accurately model clouds (water vapor) – the most dominant greenhouse gas. They are also unable to accurately model the past, much less predict the future [iii].

5) Current CO2 levels are around 380 parts per million (ppm); in the past, CO2 levels have exceeded 1,000 ppm [iv]. An article in *Science* magazine illustrated that a rise in carbon dioxide did not precede a rise in temperatures, but actually lagged behind temperature rises by 200 to 1000 years [v]. A rise in carbon dioxide levels could not have caused a rise in temperature if it followed the temperature. The president of the National Academy of Sciences also testified under oath before the Energy and Commerce Committee on this very issue.

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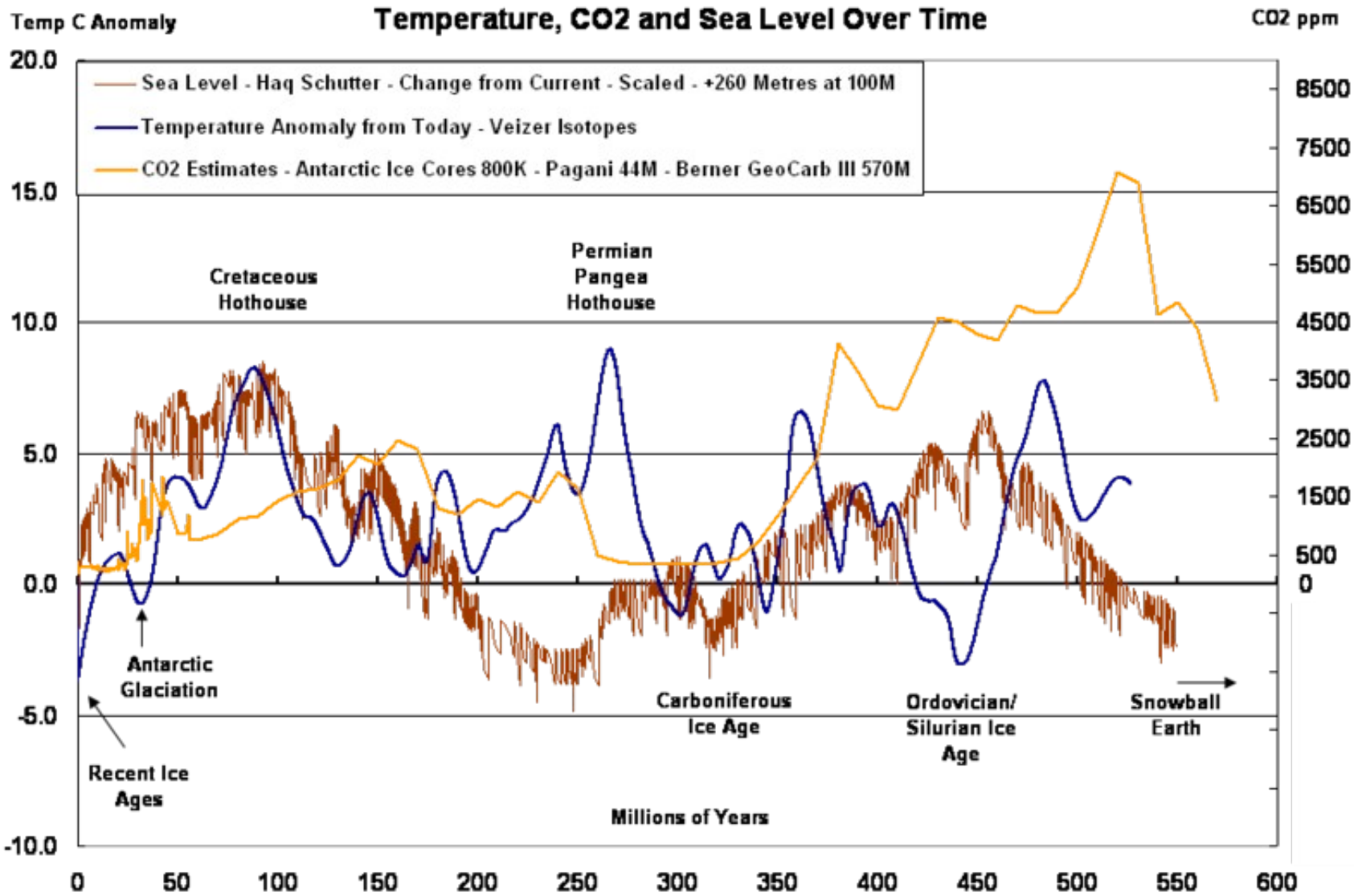
"in the past CO_2 levels have exceeded 1000 ppm(v). An article in Science magazine illustrated that a rise in carbon dioxide did not precede a rise in temperatures, but actually lagged behind temperature rises by 200 to 1000 years. A rise in carbon dioxide levels could not have caused a rise in temperature if it followed the temperature."

#1 in the past CO_2 levels have exceeded 1000 ppm(v)….

True! CO_2 55 Ma ranged from 1000 to 1500 ppm, then rapidly decreased to modern levels of 200 to 300 ppm 45 to 25 Ma



Data compiled and plotted by Bill Illis, posted on Watts up with That

#1 in the past CO_2 levels have exceeded 1000 ppm(v)….

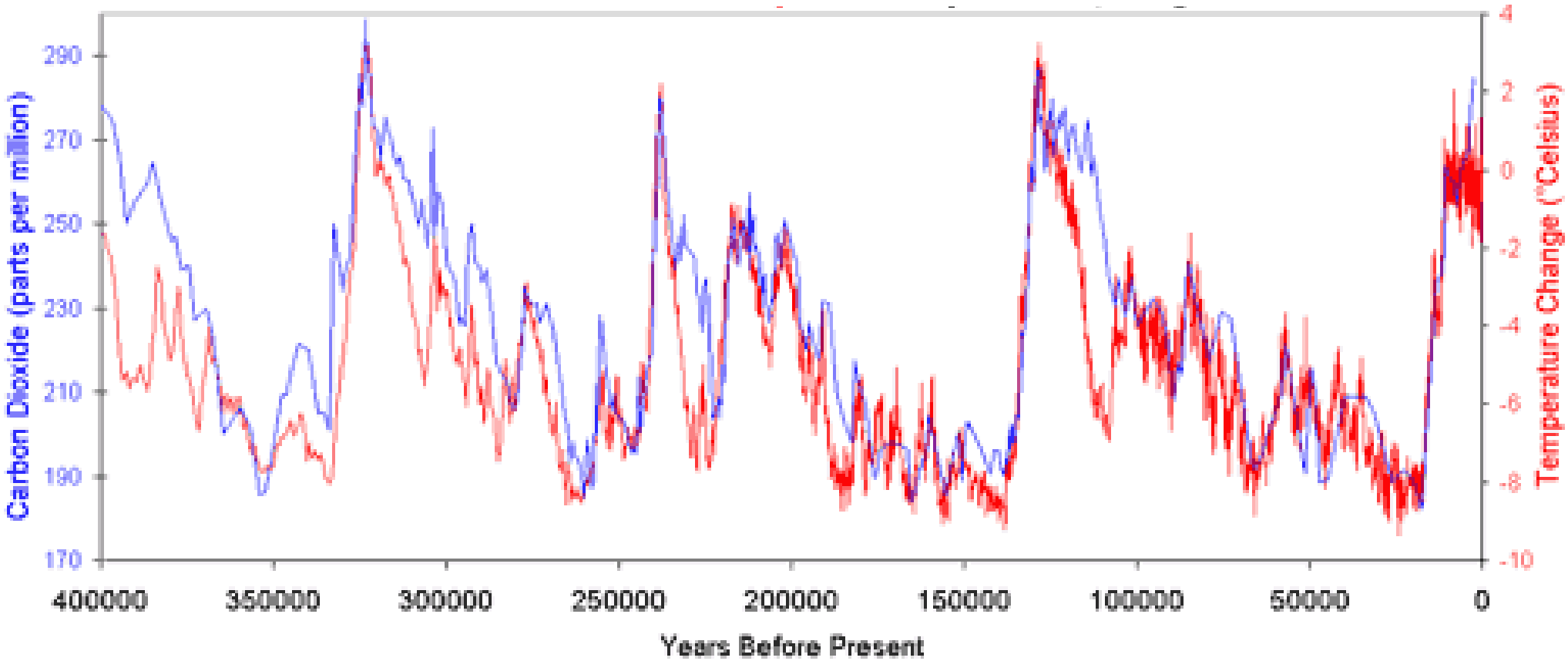
But there's more: put CO_2 levels in context

- Atmospheric CO_2 concentrations was last at 390 ppm **20 million years ago**
  - temperatures were 3° to 6°C warmer
  - sea level was 25 to 40 meters higher

(Arhadna, et al, 2009)

#2 A rise in carbon dioxide levels could not have caused a rise in temperature….

True! CO_2 concentration initially lags temperature in the **natural** cycle.



Vostok ice core records for carbon dioxide concentration (Petit 2000) and temperature change (Barnola 2003).

#2 A rise in carbon dioxide levels could not have caused a rise in temperature….

But there's more: Feedback in the climate system

Warmer oceans and soils hold less CO_2

Changes in atmospheric CO_2 content ... amplify the relatively weak orbital forcing (Hansen, 1990)

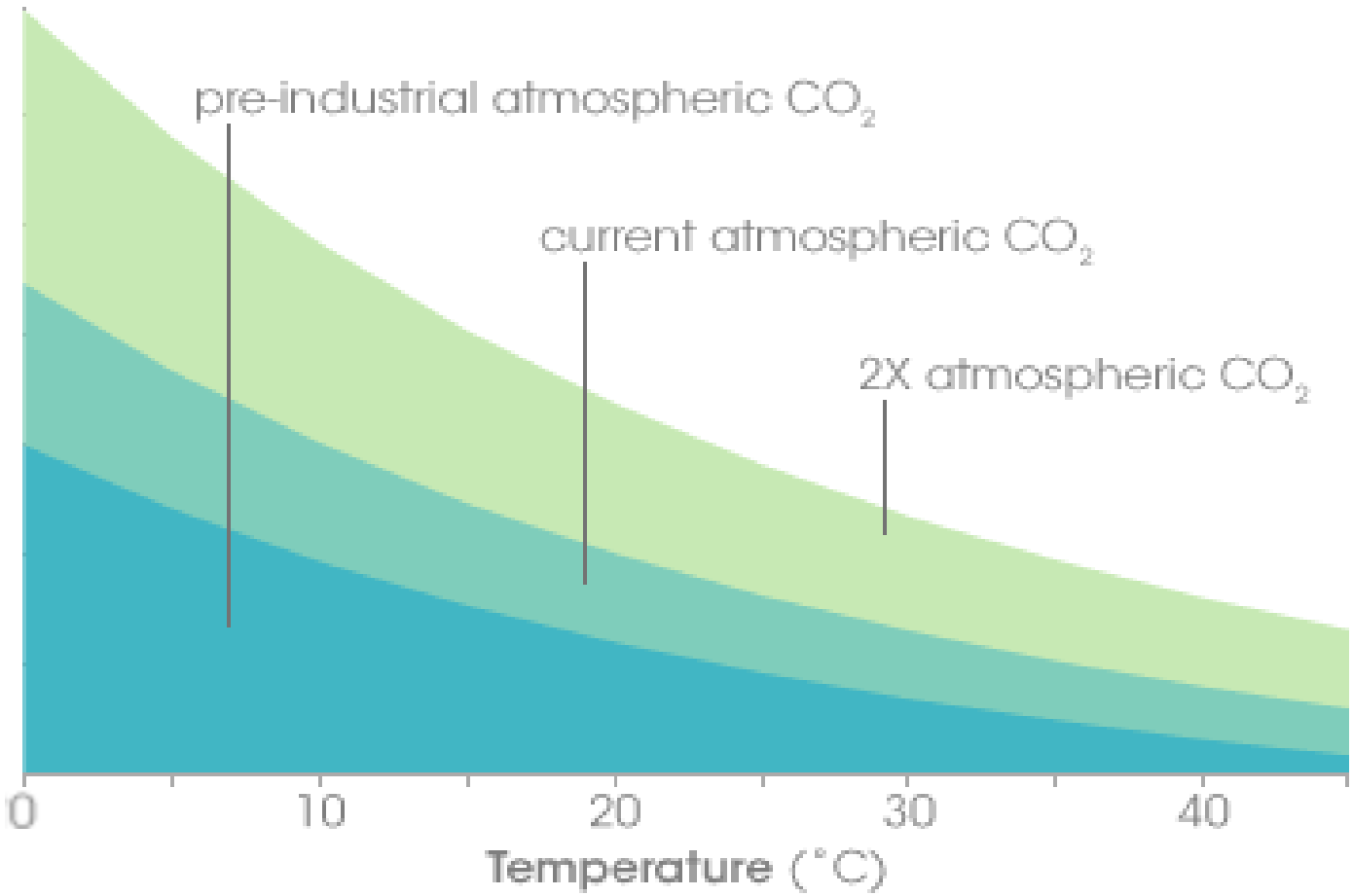


Image Credit and Location: NASA. Graph by Robert Simmon. http://earthobservatory.nasa.gov/Study/OceanCarbon/

#2 A rise in carbon dioxide levels could not have caused a rise in temperature….

But there's more: Feedback in the climate system

The natural cycle:

-Orbital factors begin a long slow warming trend which causes the out-gassing of CO_2

-CO_2 plays a key role of amplifying the initial orbital forcing

-Greenhouse effect increases global temperature

The recent anthropogenic CO_2 increase:

-Greenhouse effect increases global temperature

(Caillon, et al 2003)

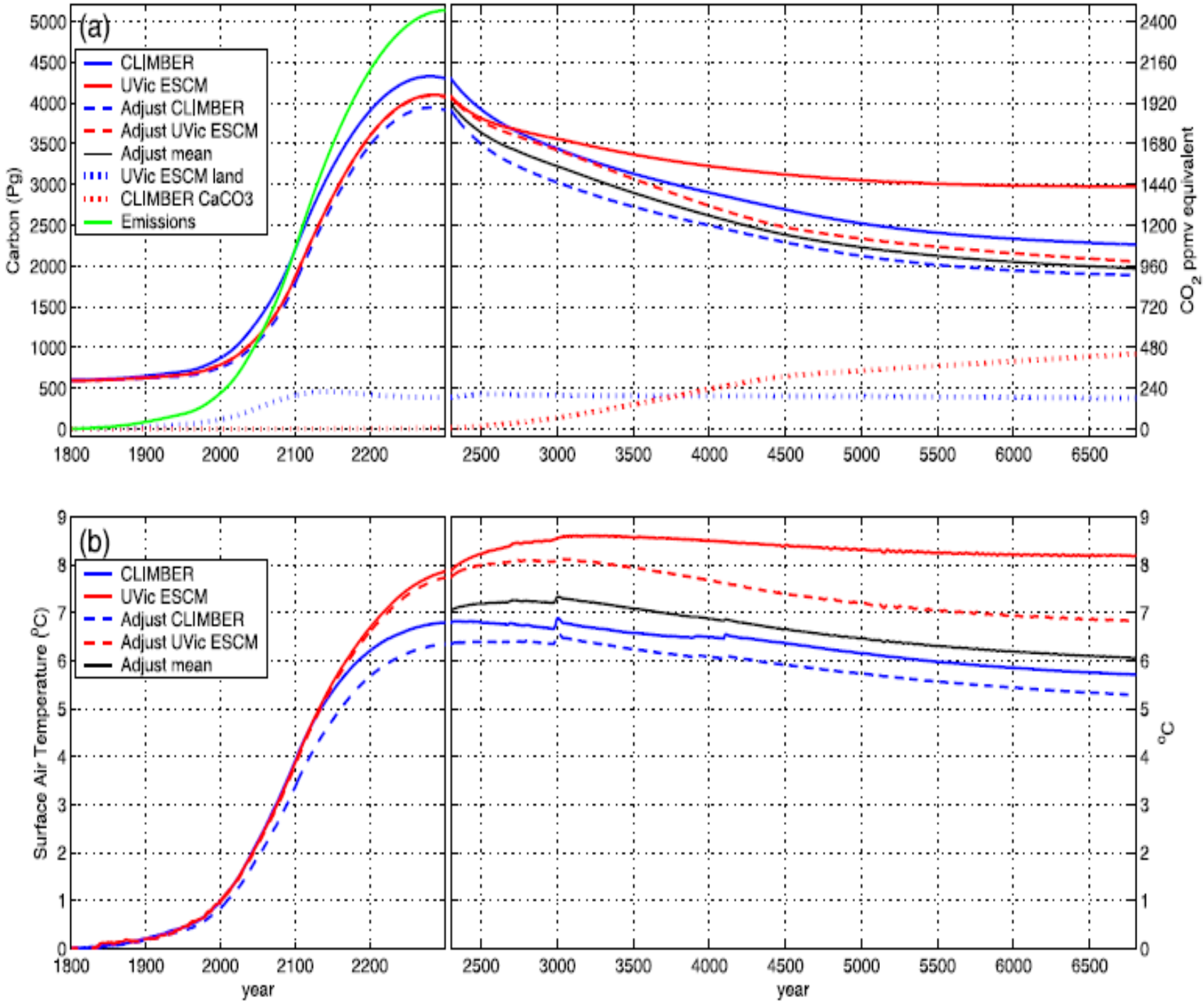
#2 A rise in carbon dioxide levels could not have caused a rise in temperature….

But there's more: Feedback in the climate system

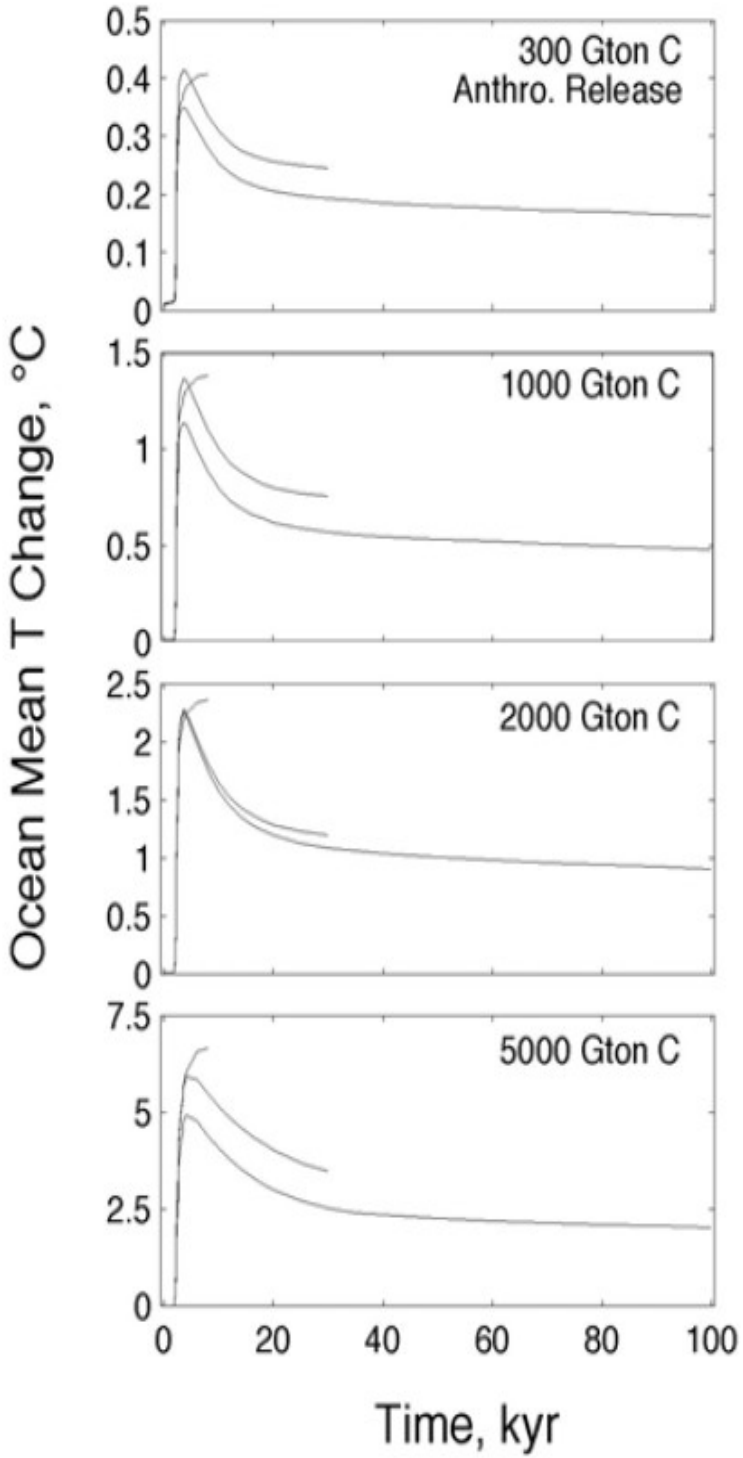
"we should distinguish between internal influences (such as the deglacial CO_2 increase) and external influences (such as the anthropogenic CO_2 increase) on the climate system.

"Although the recent CO2 increase has clearly been imposed first, as a result of anthropogenic activities, it naturally takes, at Termination III, some time for CO_2 to outgas from the ocean once it starts to react to a climate change that is first felt in the atmosphere." (Caillon, et al 2003)

“Runaway” Warming and the long-term fate of fossil fuel CO_2



Motenegro et al. 2007

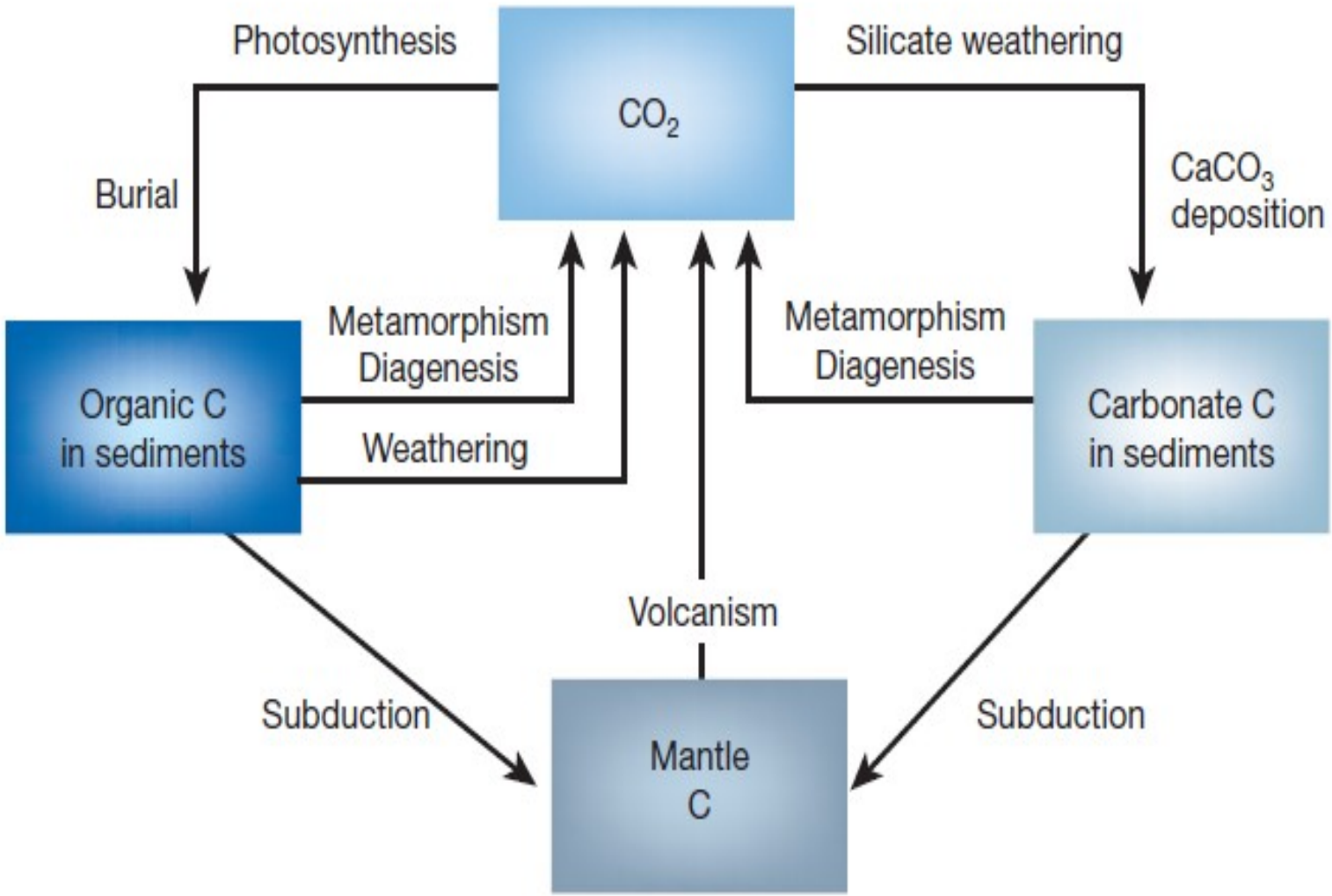


1 Gton (gigaton) is one billion metric tons of carbon

Current rates of carbon release are about 8 Gton per year

Archer 2005

Where is the carbon going?



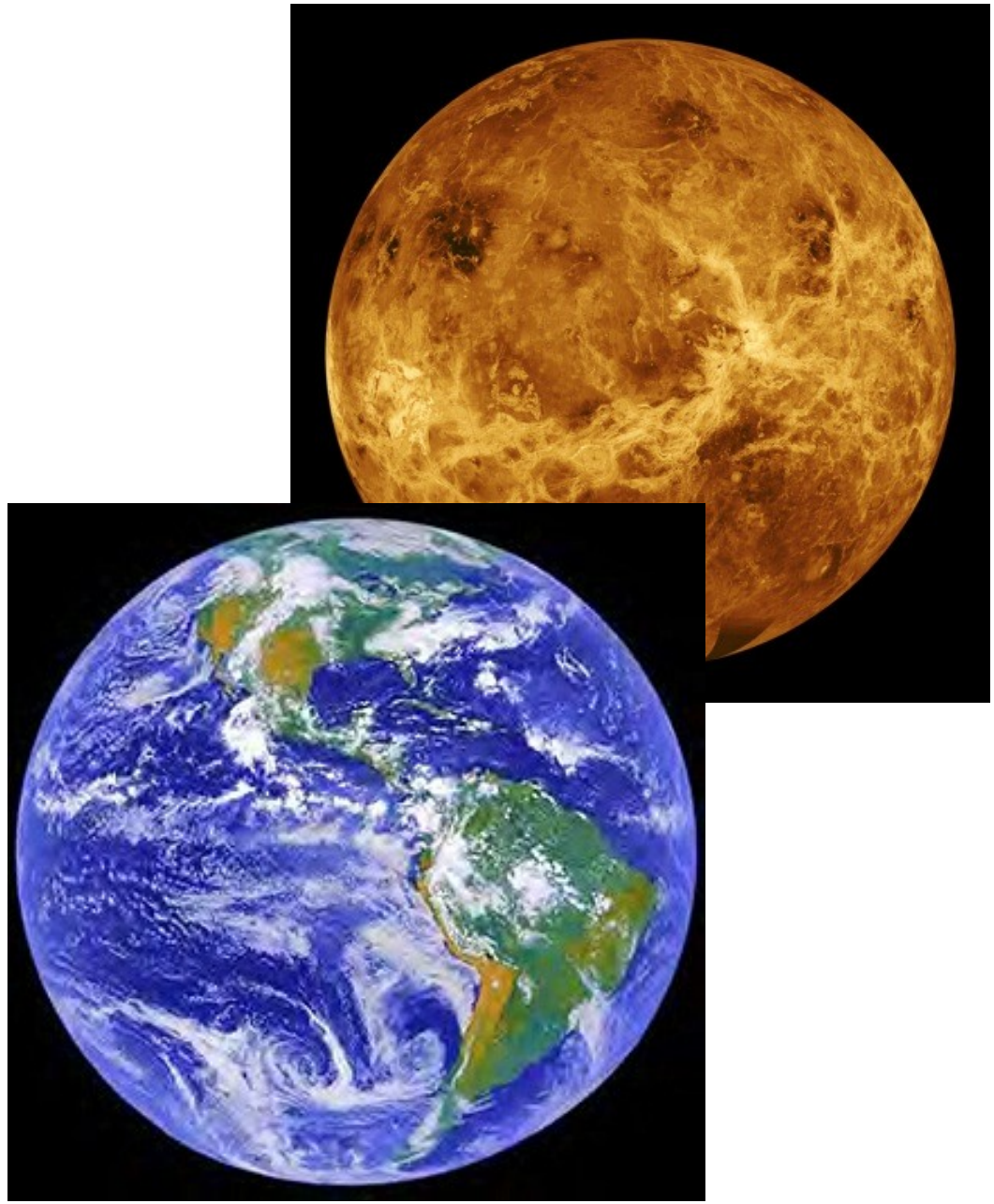
Berner 2003

What is “runaway” warming?

- Large positive feedback within the climate system
- A feedback is when a change in temperature causes an event to occur which amplifies the temperature change

Earth is NOT Venus

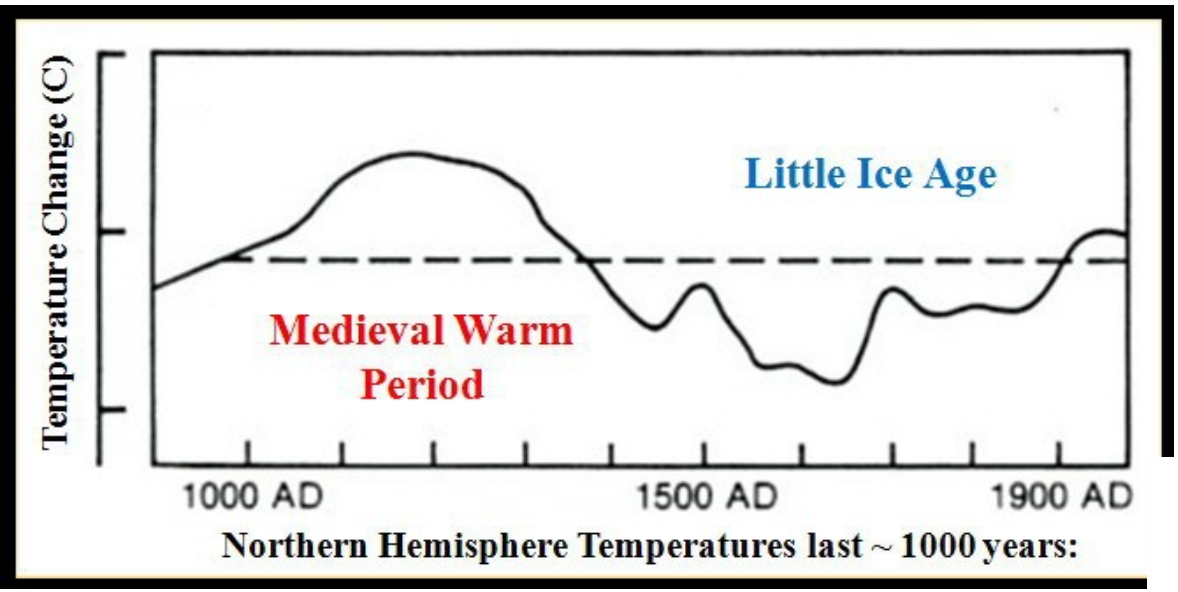
- Venus' atmosphere is about 97% CO_2.
- Earth's atmosphere is less than 1%
- Even burning all the fossil fuels on Earth is NOT sufficient to make CO_2 more than a trace gas in the atmosphere



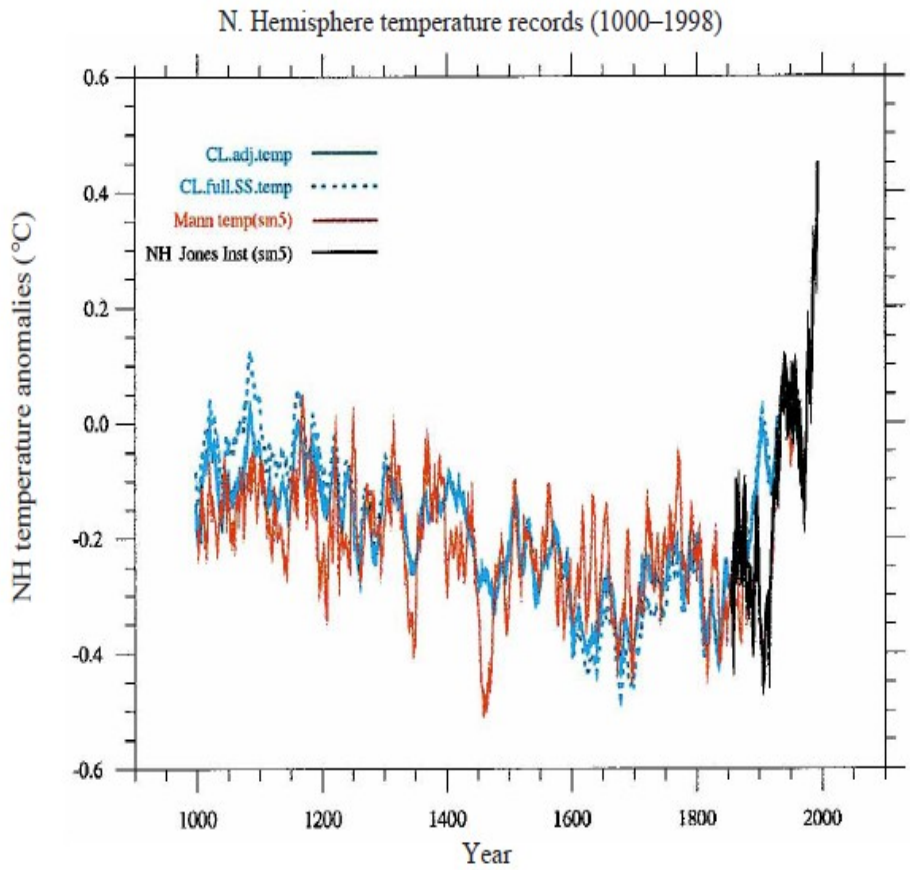
Climate Skeptics “Tricks of the Trade”

- Take a kernel of scientific truth and manipulate it
- Deliberately visually misrepresent legitimate scientific results
- Go for the details--not the big picture

Kernel of scientific truth

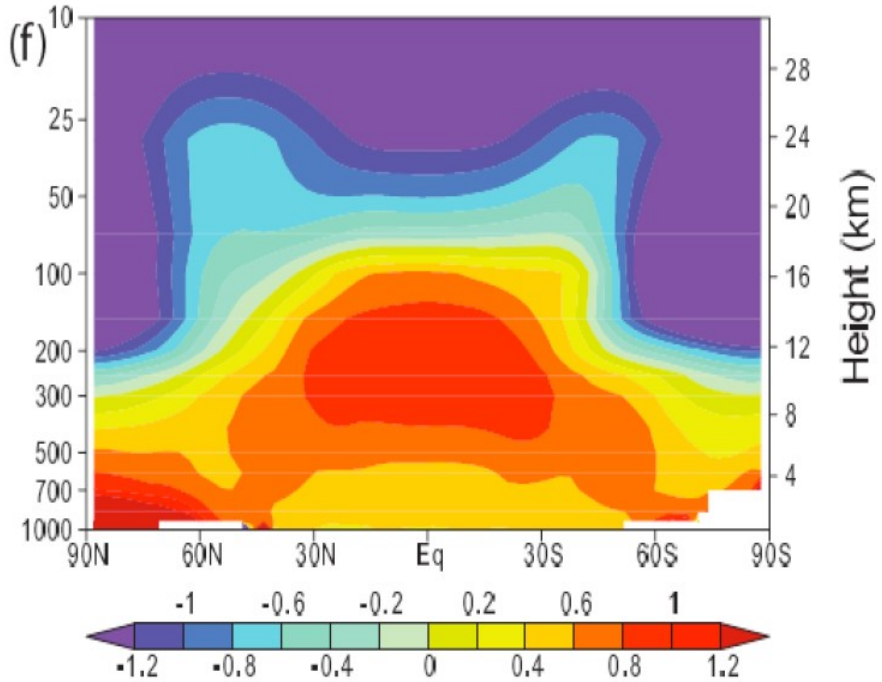


IPCC graph, regularly used to demonstrate that the Medieval Warm period was warmer than today

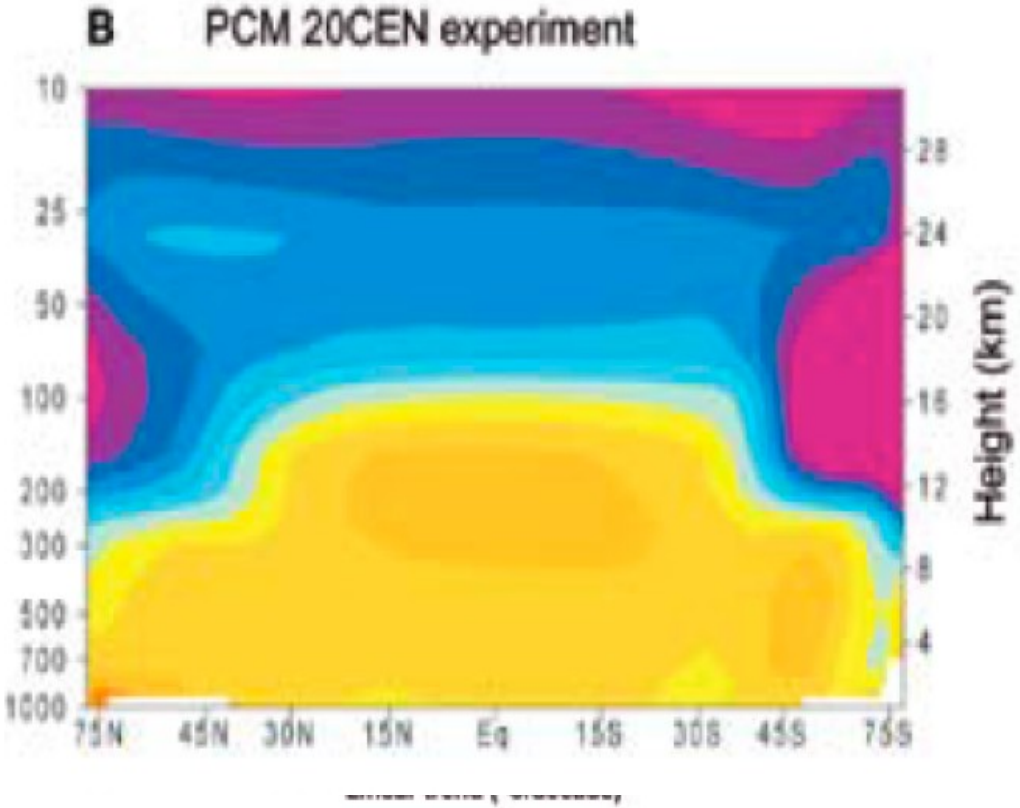


Crowley, 2000

Misrepresent legitimate data



IPCC, 2007



Climate Change Science Program Synthesis Report, 2006

Tips for addressing climate skeptics arguments

- www.skepticalscience.com (or their phone app)
- Ask for the source of the data/argument and go look it up yourself!
- Emphasize the basics--don’t get bogged down in details!