Climate Change

1. Is it real?
2. Are humans responsible?

-a physicist's perspective

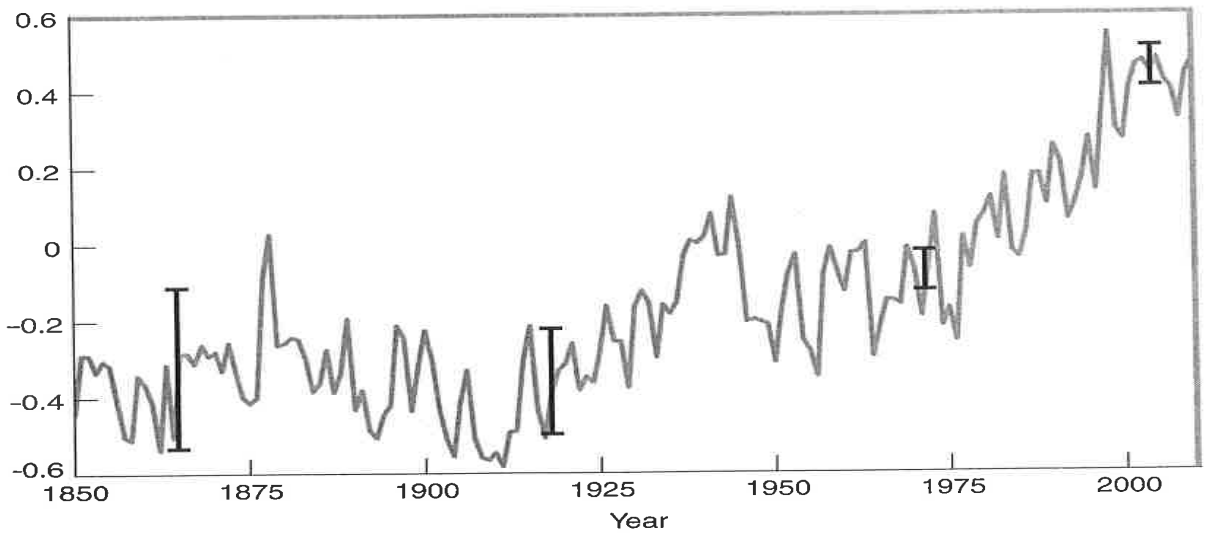
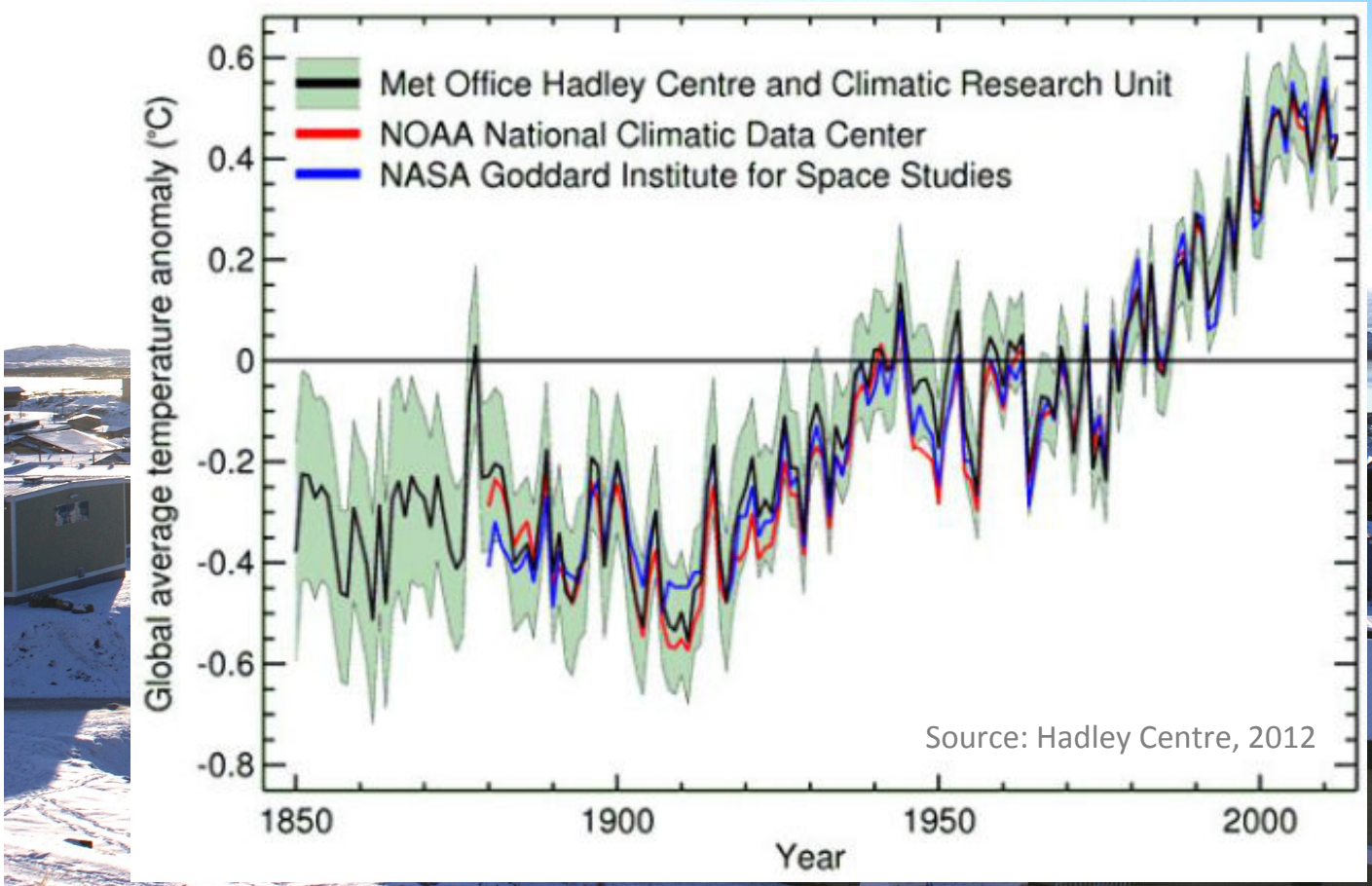
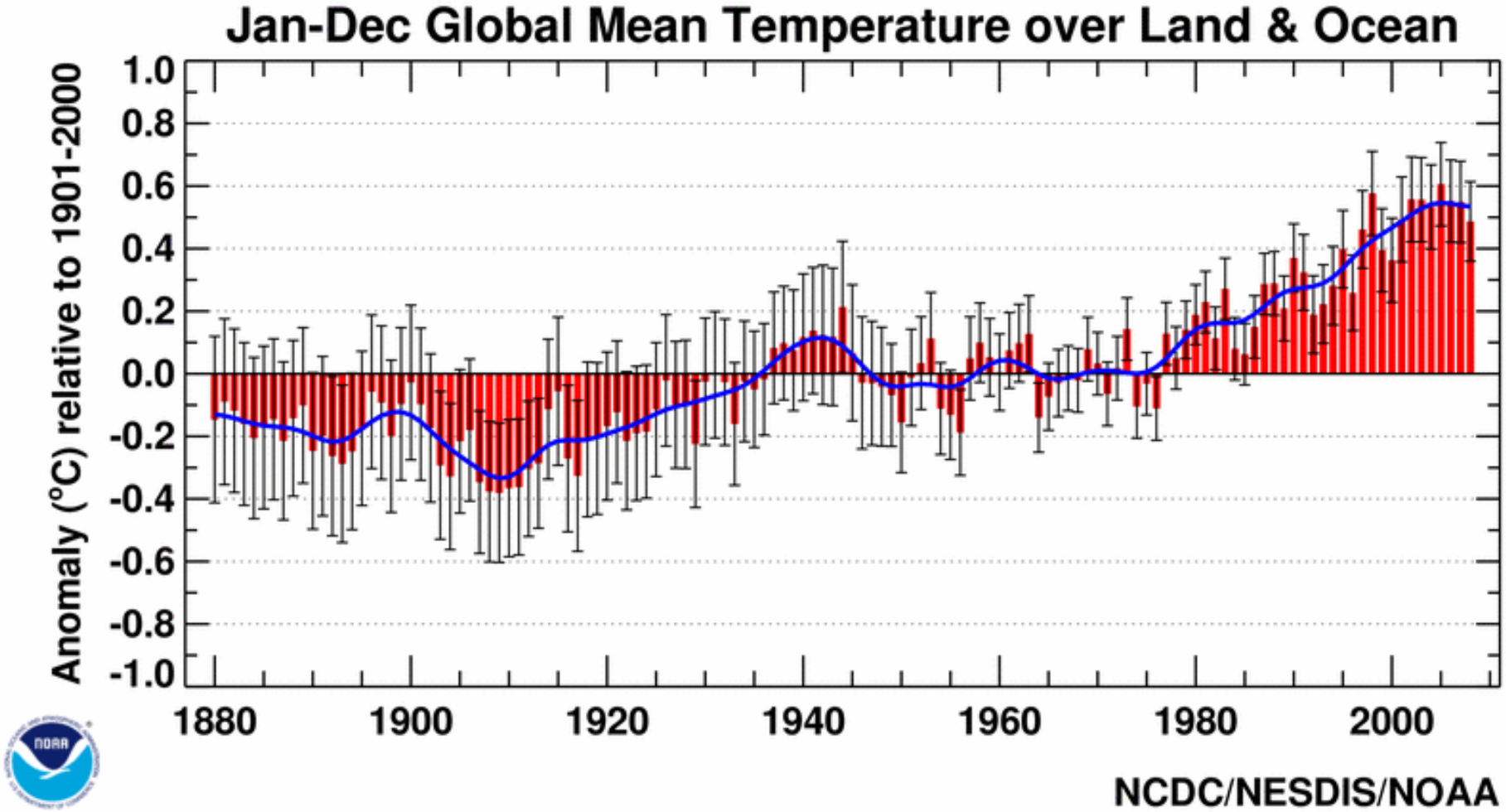
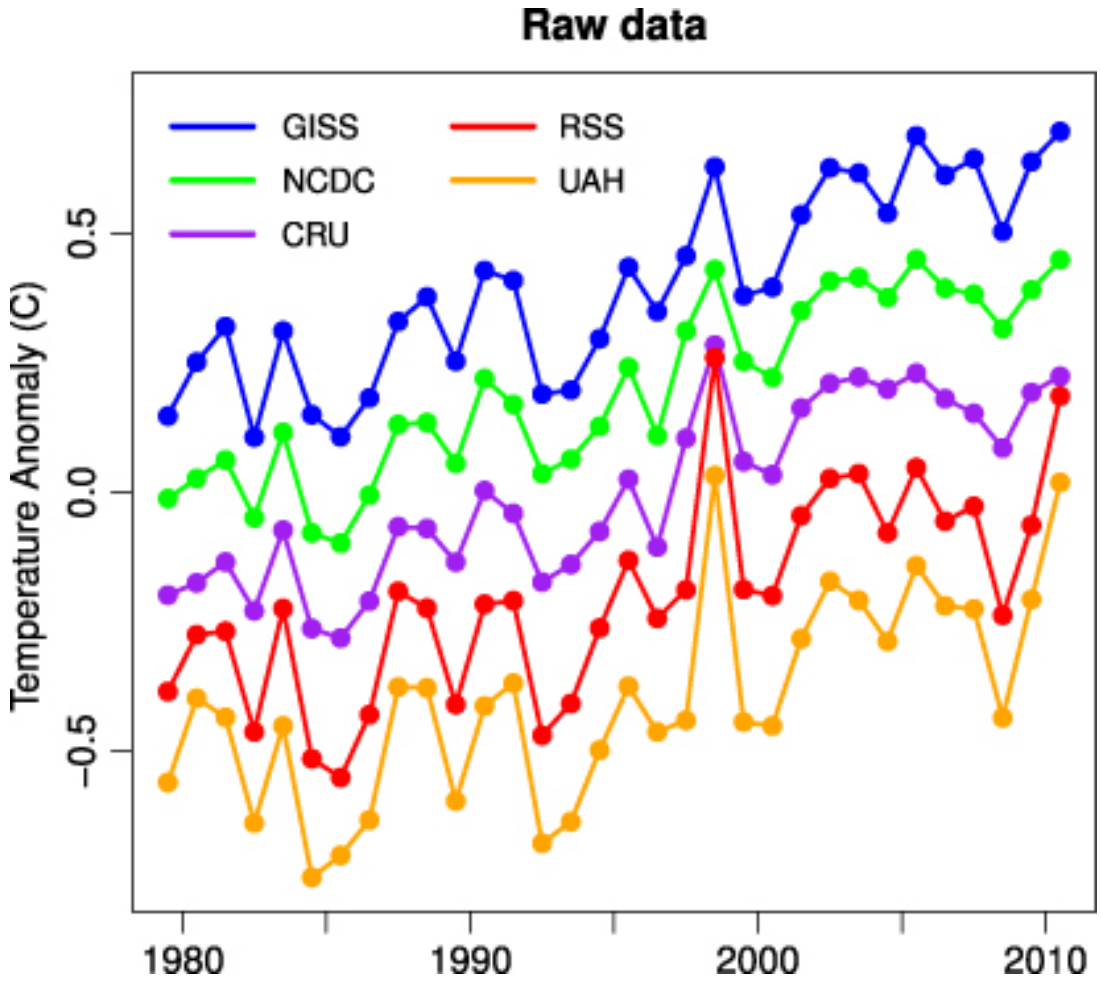


FIGURE 14.1
Global temperature variation from 1850 through 2010, using the 1960–1991 average as a baseline. Error bars show approximate uncertainty at four different times. Data are from the University of East Anglia's Climatic Research Unit; Box 14.1 and Research Problem 4 compare other temperature records.

Our changing climate and the implications




Jan-Dec Global Mean Temperature over Land & Ocean
Anomaly (°C) relative to 1901-2000
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1880
1900
1920
1940
1960
1980
2000
NCDC/NESDIS/NOAA



Annual averages of the monthly data from all five sources are shown.

All have been set to the same baseline (the entire time span, January 1979–December 2010), then offset by 0.2 °C for plotting. (IOP Science 2011)

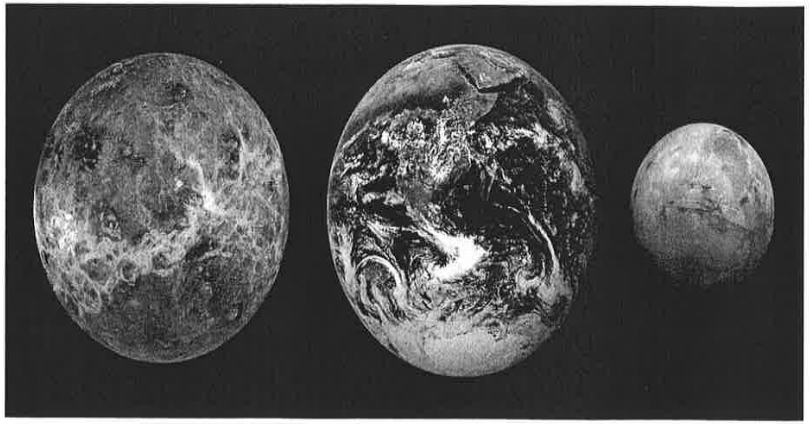


FIGURE 12.6
Venus, Earth, and Mars are different distances from the Sun and have different atmospheric compositions. Together they provide a natural "experiment" that verifies the theory of the greenhouse effect.

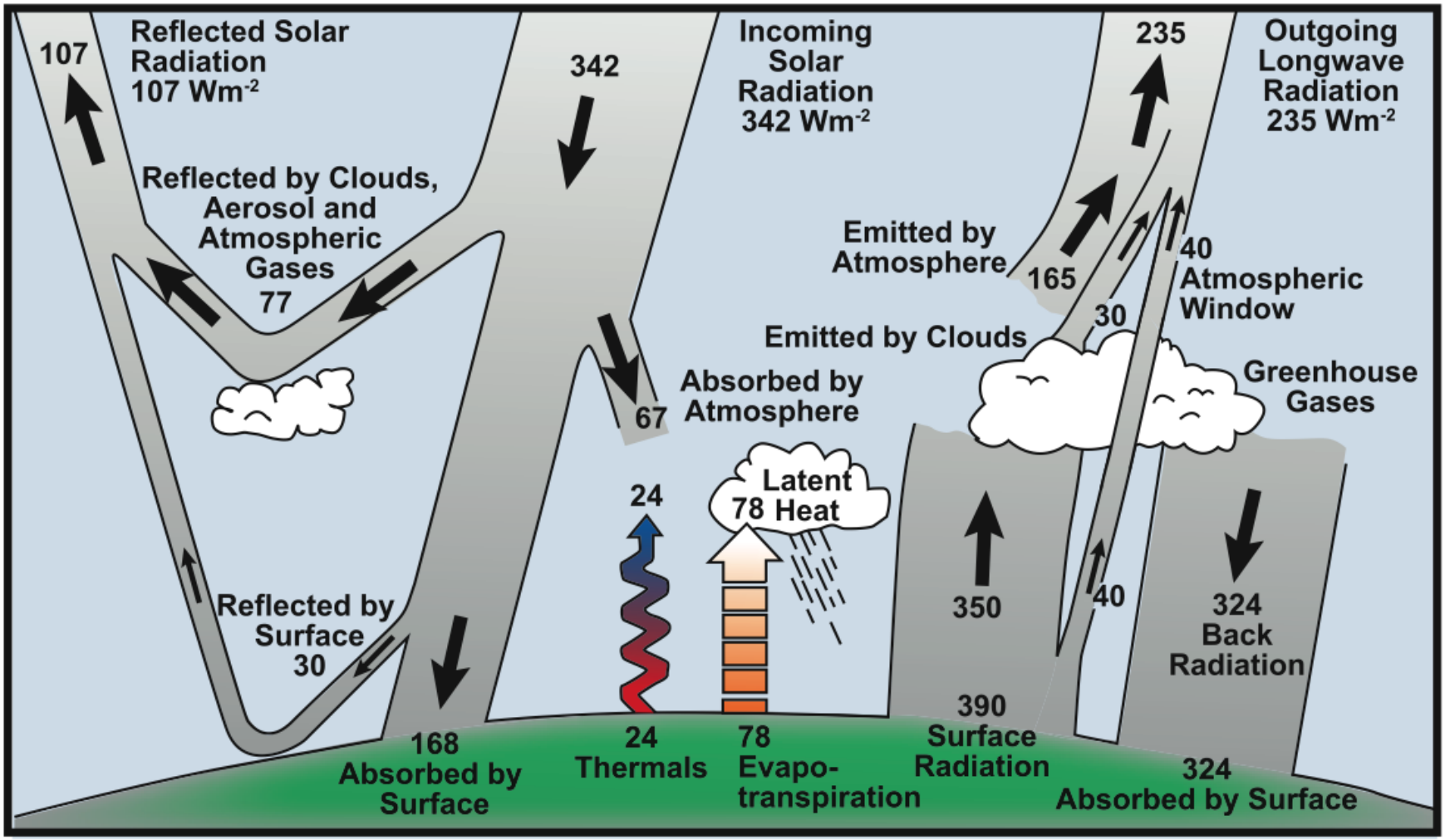
temperature by 33°C. Mars, in contrast, has an atmosphere with only 1% the density of Earth's. Mars' atmosphere is mostly CO_2, but it's so diffuse that the Martian greenhouse effect is negligible. Venus, on the other hand, has an atmosphere 100 times denser than Earth's, and it's 96% CO_2. Venus' surface temperature is a sizzling 735 K—way beyond the boiling point of water and hot enough to melt lead! Table 12.1 summarizes the very different conditions on these three neighboring planets. I've listed predicted temperatures that include the effect of reflection as calculated from the tabulated planetary albedo, since that's how we did the calculation for Earth.

The huge greenhouse effect on Venus demands a closer look. How did a planet that in many ways is much like Earth end up with such a huge surface temperature? The answer lies largely in two factors: Venus' proximity to the Sun and a positive feedback that enhanced its greenhouse effect. I've shown that Venus'

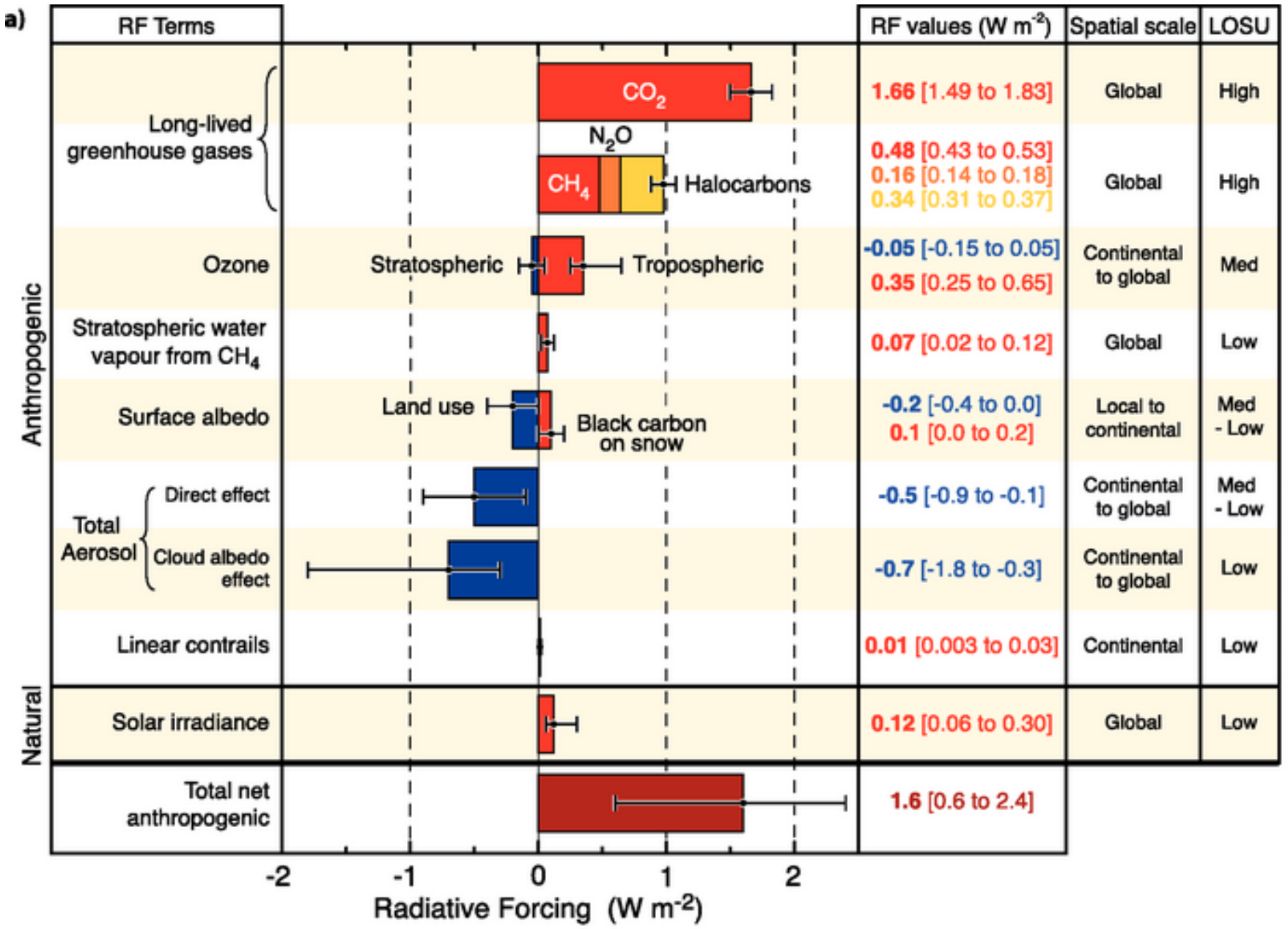
TABLE 12.1 | **THREE PLANETS**

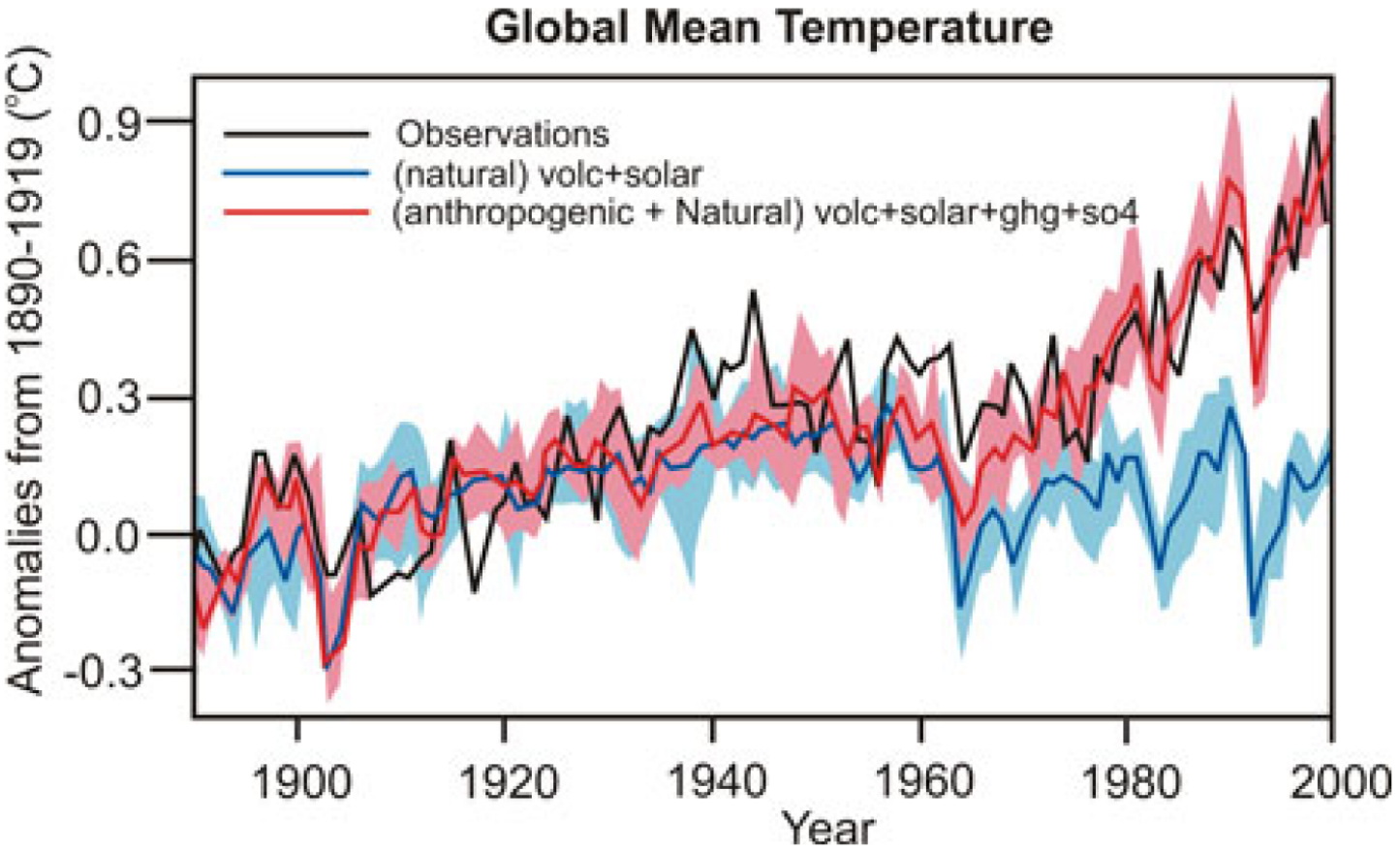
Planet	Albedo	Calculated temperature	Actual temperature	Greenhouse effect*
Venus	0.75	232 K −44°C	735 K 462°C	503°C
Earth	0.31	255 K −18°C	288 K 15°C	33°C
Mars	0.25	210 K −63°C	210 K −63°C	0°C

* The greenhouse effect is listed in °C only because it's a temperature *difference*, and so has the same numerical value in both K and °C.

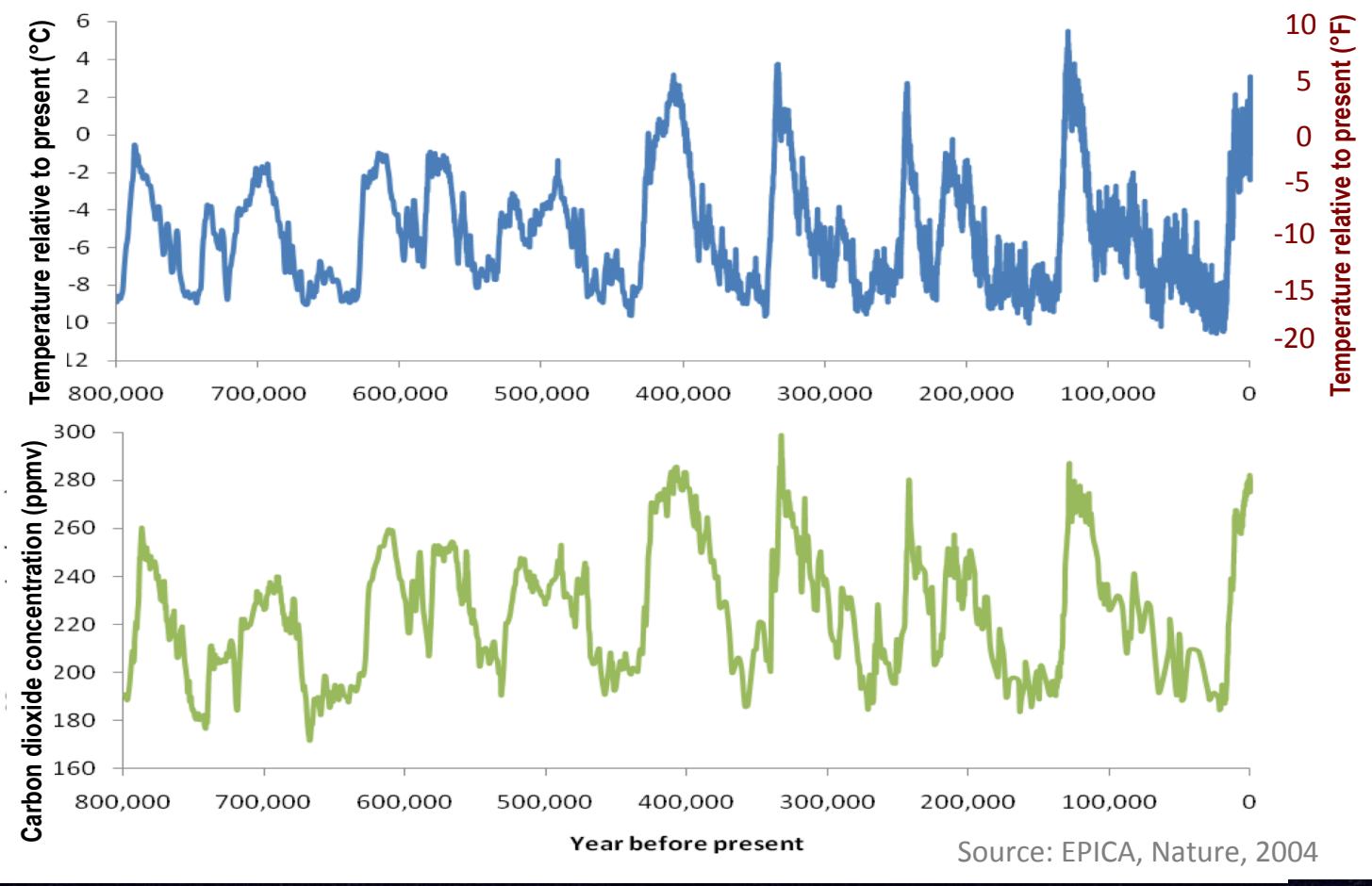


Intergovernmental Panel on Climate Change (IPCC), 2007

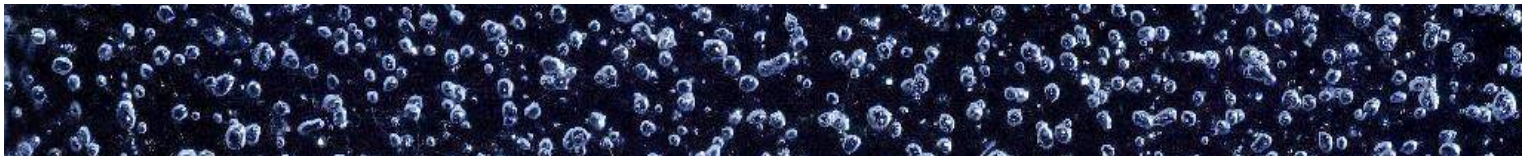


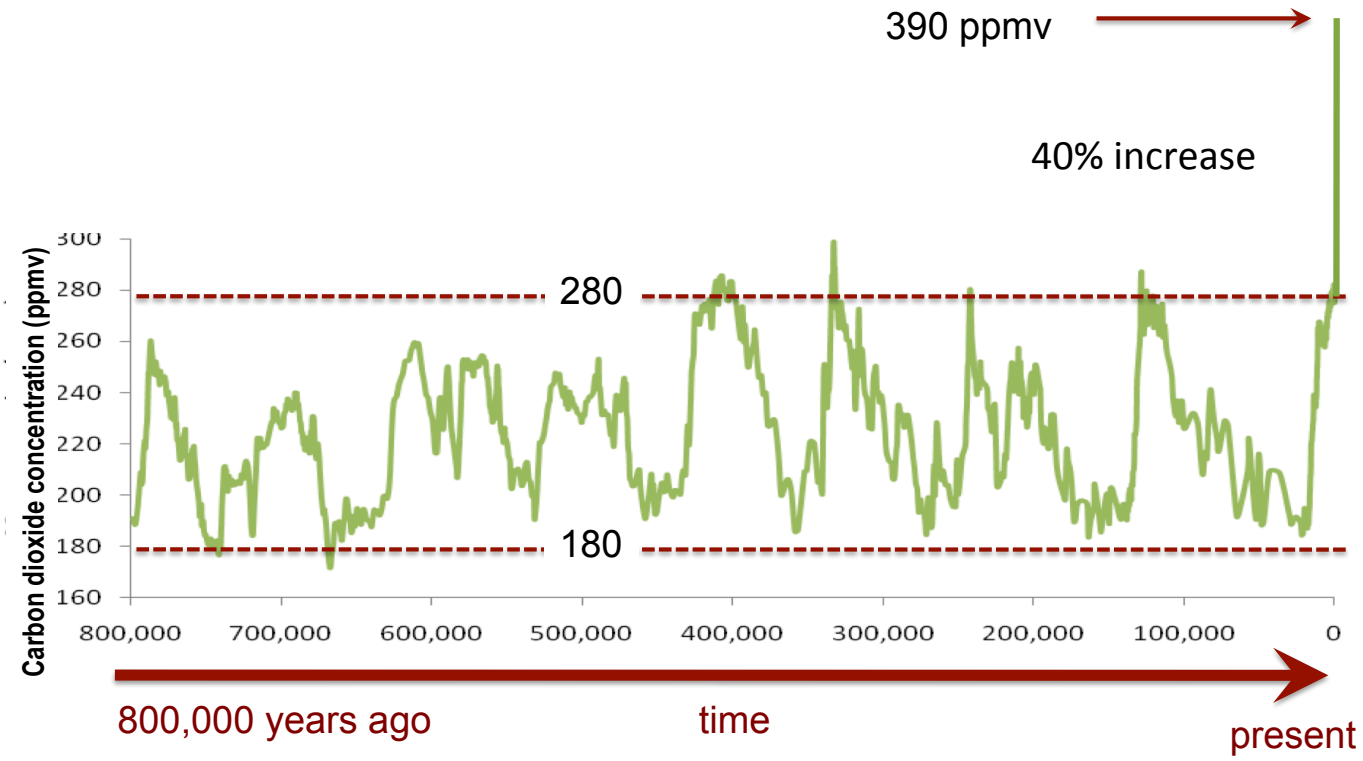


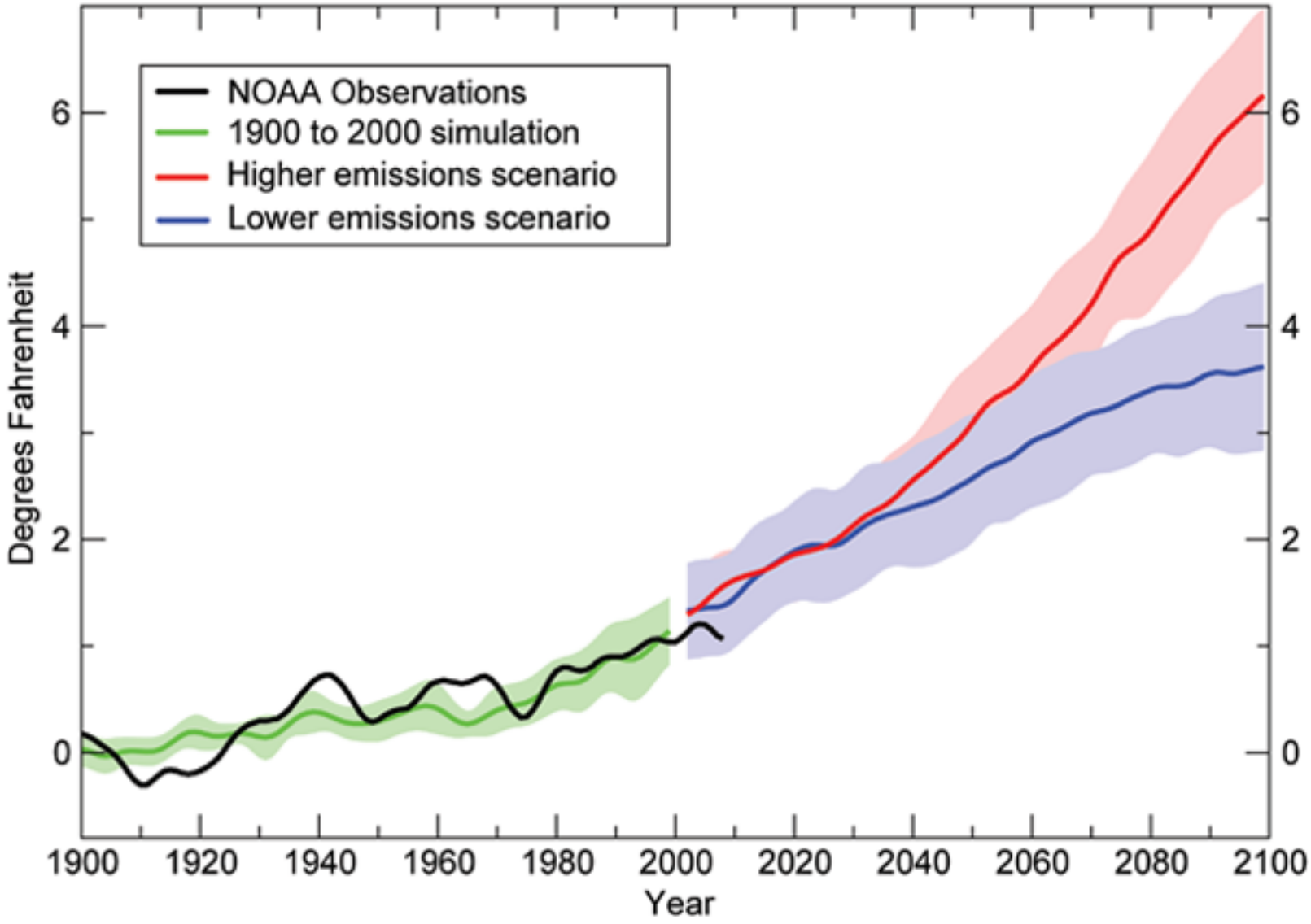
from “Phaeton’s Reins” – Kerry Emanuel



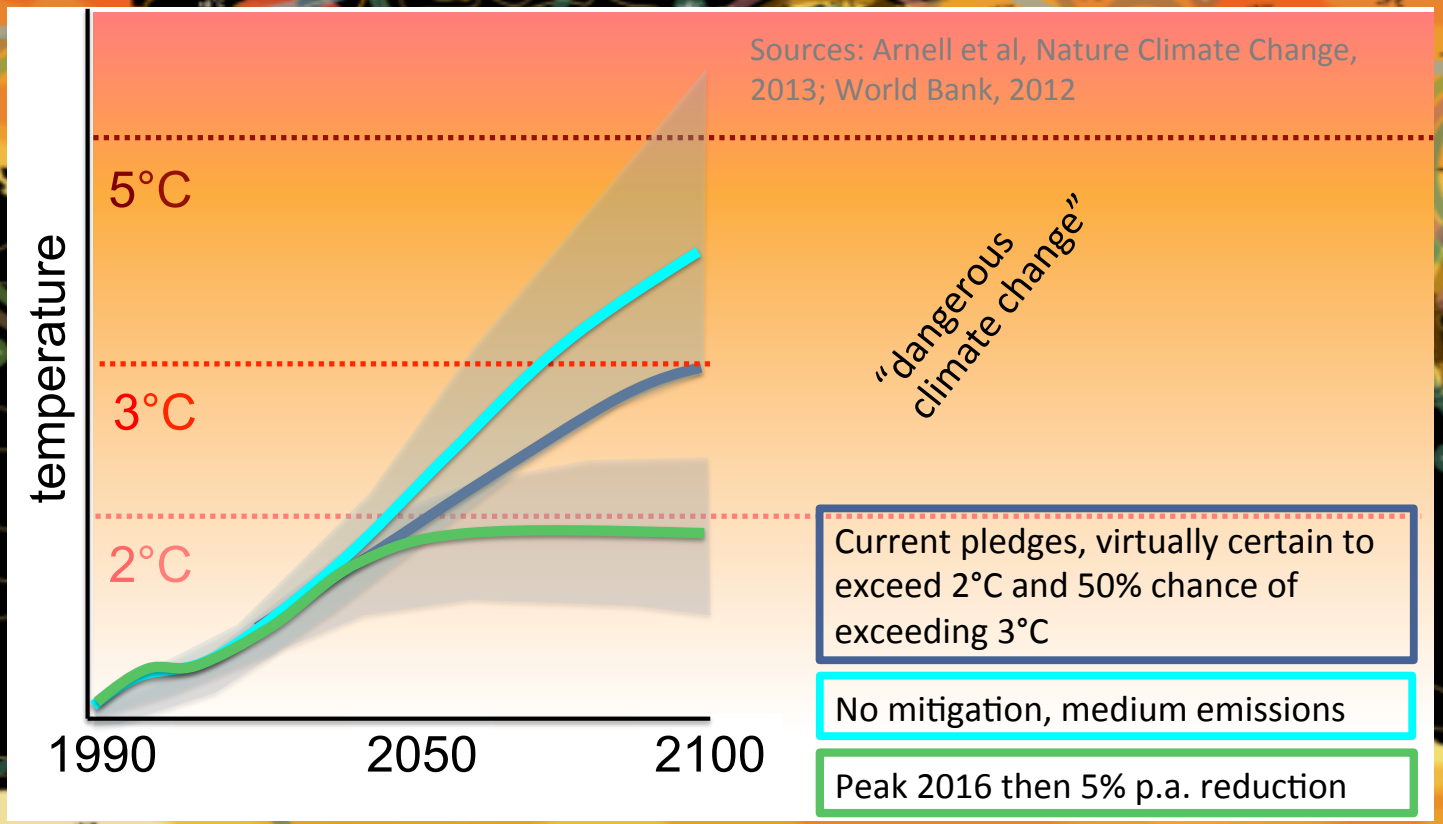
Source: EPICA, Nature, 2004

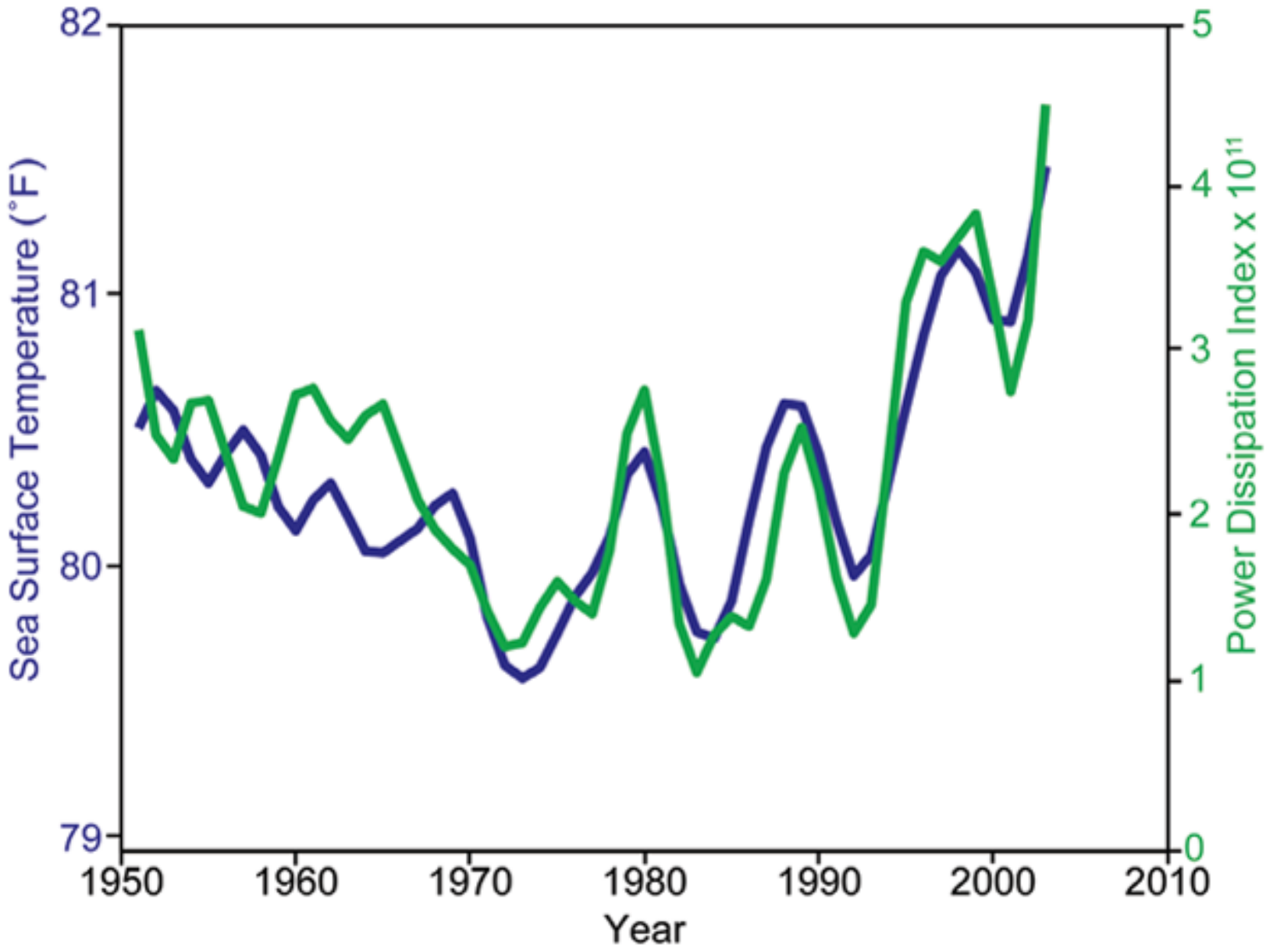



390 ppmv
40% increase
Carbon dioxide concentration (ppmv)
300
280
260
240
220
200
180
160
280
180
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
800,000 years ago
time
present


NOAA Observations
1900 to 2000 simulation
Higher emissions scenario
Lower emissions scenario
Degrees Fahrenheit
0
2
4
6
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Year

Mitigation strategies




82
81
80
79
Sea Surface Temperature (°F)
5
4
3
2
1
0
Power Dissipation Index x 10^11
1950
1960
1970
1980
1990
2000
2010
Year