Where is Public Opinion?  
Mired in politics.

Is the globe warming?  
Yes, but, from a geologic perspective, not so much.

What determines the Earth’s temperature?  
What is the role of human activity?  
How big is the problem?

**Anthropogenic Warming**

Heat Balance

\[ \sigma T^4 = (1 - \alpha)S \]

where 
- \( T \) = surface temperature (ºK) 
- \( S \) = solar influx (W/m²) 
- \( \alpha \) = albedo (reflectivity) 
- \( \sigma \) = the Stefan-Boltzmann constant

For current values, 
\[ T = 255K = -18ºC \]

Why isn’t the Earth a Snowball?

**Anthropogenic Warming**

What Determines the Earth’s Temperature?

Why isn’t the Earth a Snowball?  
*The Greenhouse Effect!*


Anthropogenic Warming
What Determines the Earth's Temperature?

Heat Balance

Historical Overview of Climate Change Science, IPCC AR4, p.96
http://ipcc-wg1.ucar.edu/wg1/report/AR4WG1_Print_CH01.pdf

Anthropogenic Warming
What Determines the Earth's Temperature?

Remember Lake Vostok?

http://svs.gsfc.nasa.gov/vis/a000000/a000900/a000996/index.html

Anthropogenic Warming
What Determines the Earth's Temperature?

Antarctic Temperature Data


Anthropogenic Warming
What Determines the Earth's Temperature?

Atmospheric CO₂ (Vostok data)

Anthropogenic Warming
What Determines the Earth’s Temperature?

Atmospheric CO₂ & Temperature (Vostok data)

-10 -8 -6 -4 -2 0 2
150 200 250 300 350 400
CO₂ (ppm)

Boron Isotope Data


http://www.carleton.edu/departments/geol/DaveSTELLA/Carbon/long_term_carbon.htm

Vostok Data
Current conditions are well outside the range recorded in the ice core data.

Ice Core
Today
Silicate Weathering

Rainwater containing dissolved CO₂ falling on silicate rocks replaces a silicon atom with a carbon atom, ultimately producing calcium carbonate (limestone) and silicon dioxide (quartz). For example, calcium silicate (Wollastonite):

$$CaSiO_3 + CO_2 \rightarrow CaCO_3 + SiO_2$$

Under volcanic conditions, the carbon atom is replaced by a silicon atom, completing the long term carbon cycle.

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$$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$$
Carbon isotope ratios and atmospheric oxygen depletion indicate that the increase in atmospheric CO\textsubscript{2} comes from burning fossil fuels.

Changes in atmospheric constituents and in Radiative Forcing, IPCC AR4, Chap. 2, p.138
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH02.pdf

Models with and without human activity.
Understanding and Attributing Climate Change, IPCC AR4, Chap. 9, p.684
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch09.pdf

Where is Public Opinion?  Mired in politics.
Is the globe warming?  Yes, but, from a geologic perspective, not so much.
What determines the Earth’s temperature?  Physics!  Solar heating plus the carbon cycle.
What is the role of human activity?  We are adding CO\textsubscript{2} to the atmosphere.
How big is the problem?
Global average sea level was likely between 4 and 6 m higher during the last interglacial period, about 125,000 years ago, than during the 20th century, mainly due to the retreat of polar ice. Ice core data suggest that the Greenland Summit region was ice-covered during this period, but reductions in the ice sheet extent are indicated in parts of southern Greenland. Ice core data also indicate that average polar temperatures at that time were 3°C to 5°C warmer than the 20th century because of differences in the Earth’s orbit. The Greenland Ice Sheet and other arctic ice fields likely contributed no more than 4 m of the observed sea level rise, implying that there may also have been a contribution from Antarctica.
Anthropogenic Warming

How big is the problem?

Vostok Data

![Vostok Data Chart]

The USA in the Ice Free Earth

Computer Simulation, Clarence Lehman, Univ. Mn. 2006

Sea level rises 63 meters.

Anthropogenic Warming

The Modern Ice Free Earth

Computer Simulation, Clarence Lehman, Univ. Mn. 2006

Sea level rises 63 meters.

Anthropogenic Warming

Summary

Where is Public Opinion?

Mired in politics.

Is the globe warming?

Yes, but, from a geologic perspective, not so much.

What determines the Earth’s temperature?

Physics! Solar heating plus the carbon cycle.

What is the role of human activity?

We are adding CO2 to the atmosphere.

How big is the problem?

Not big. Yet...

Anthropogenic Warming

Solution

I’z abouts to eliminate ur carbon footprint