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 (°K)
- \( S \) = solar influx (W/m²)
- \( \alpha \) = albedo (reflectivity)
- \( \sigma \) = the Stefan-Boltzmann constant

For current values, \( T = 255K = -18°C = 67°F \)

Why isn’t the Earth a Snowball?


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

Petit, et al., Nature 399 (June 3 1999), pp.429-436

Anthropogenic Warming
What Determines the Earth’s Temperature?

Antarctic Temperature Data

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Anthropogenic Warming
What Determines the Earth’s Temperature?

Atmospheric CO₂ (Vostok data)

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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)

- Extrapolate linear regression to 400 ppm CO₂.

Anthropogenic Warming
What Determines the Earth's Temperature?
Vostok Data


Anthropogenic Warming
What Determines the Earth's Temperature?


Anthropogenic Warming
What Determines the Earth's Temperature?

The Earth's Carbon Cycle


What Determines the Earth's Temperature?

Anthropogenic Warming

Silicate Weathering

Rainwater containing dissolved CO$_2$ 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.

\[
CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2
\]


Anthropogenic Warming

What Determines the Earth's Temperature?

Silicate Weathering

What Determines the Earth's Temperature?

The Short-Term Carbon Cycle

Couplings Between Changes in the Climate System and Biogeochemistry, IPCC AR4, p.513

http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH07.pdf

Anthropogenic Warming

Where is Public Opinion?

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What determines the Earth's temperature?

Physics! Solar heating plus the carbon cycle.

What is the role of human activity?

How big is the problem?
Anthropogenic Warming

Changes in atmospheric constituents and radiative forcing, IPCC AR4, Chap. 2, p.138

http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH02.pdf

Carbon isotope ratios and atmospheric oxygen depletion indicate that the increase in atmospheric CO₂ comes from burning fossil fuels.

http://scrippsco2.ucsd.edu/data/data.html

Anthropogenic Warming

Where is Public Opinion?
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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?


Anthropogenic Warming

The IPCC Fourth Assessment Report

Understanding andAttributing Climate Change, IPCC AR4, Chap. 9, p.684

http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch09.pdf

Models with and without human activity.
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.

Petit, et al., Nature 399 (June 3 1999), pp.429-436
Anthropogenic Warming

How big is the problem?

Vostok Data

![Graph showing CO₂ vs. temperature change](image)

Anthropogenic Warming

How big is the problem?

The USA in the Ice Free Earth

Computer Simulation, Clarence Lehman, Univ. Mn. 2006

![Map showing the USA in the Ice Free Earth](image)

Anthropogenic Warming

How big is the problem?

The Modern Ice Free Earth

Computer Simulation, Clarence Lehman, Univ. Mn. 2006

![Map showing the modern ice-free earth](image)

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

![Image of a person with a caption about eliminating carbon footprint](image)

http://icanhascheezburger.com/2009/01/13/funny-pictures-eliminate-your-carbon-footprint/