Skeptics have no clothes

"Man-made global warming is the greatest hoax ever perpetrated on the American people."
Senator James Inhofe (R-OK)

You’re entitled to your own opinion but not your own facts
Patrick Moynihan

What do scientists know that the rest of us don’t?

![Bar graph showing percentage of scientists' views on climate change](chart.png)
Comparing Science and Policy people

**Scientific enterprise**
- Inquisitorial system
  - Data collection, interpretation, revision
  - Data → hypothesis → theory → law
  - Search for “truth”, following physical “laws”
  - “Truth” through data collection, estimates of certainty
- Medium: Published papers
- Motivation: Recognition and advancement
- Accountability: Peer review
- Time-frame: Open-ended

**Policy-makers**
- Adversarial system
- Search for compromise, not “truth”
- Compromise through negotiation
- Medium: Instruments: Convention, Protocol, Frameworks, MOU’s
- Motivation: Legal compliance, achieving settlement
- Accountability: Legal and public opinion
- Time-frame: Usually fixed, rigid
A recent experience

Prof. William Happer
Cyrus Fogg Prof. of Physics, Princeton
NAS member, former DOE Director of Research

“friend of Columbia” send me his talk and asked for my comments.

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Claim: The temperature of the earth is mainly determined by CO2.

Fact: In the past, the temperature of the earth was only weakly correlated with atmospheric CO2 levels.

Fact: Temperature changes seem to cause CO2 changes, not vice versa.

Happer - Slide (April 2010)
Ice core record of CO₂ and Climate

Vostok (Antarctica)

CO₂ and CH₄ measured in Antarctic ice gas bubbles

Temperature from δD isotopic composition of Antarctic ice water.

This is “weak”?

Antarctic temperature leads CO₂ by several hundred years - so what?
**Claim:** The temperature of the earth has risen at an alarming rate in the last century.

**Fact 1:** Some of the claimed temperature rise is natural

**Fact 2:** Some of the temperature rise is bogus

**Fact 3:** What's left is due to CO2

You guys answer this one …

**Climategate CRU record** from merging surface temperature data sets from across the world. Raw data not available, lost or destroyed.

**US data (public record)** shows 1930’s about as warm as the last decade.
Deconstruct this one too
Willie Soon (Harvard)

But where is the winter warming impact of the high CO₂ levels at SLC in 2001-2010?

Winter surface temperatures at Salt Lake City, 1985-2018

Congressional Staff Briefing (April 13, 2010)

Take your pick of four independent data compilations


What global warming really looks like

Data source: NASA / GISS
Claim: At 390 ppm we are already above the optimal level of atmospheric CO2

What is the optimal level?

the 280 ppm pre-industrial level?

the 1000 ppm used in greenhouses?

the 2000 ppm of the eocene?
You guys answer this question: What is the “optimal CO₂ level”? It’s a false premise.

When was the last time CO₂ was near 600 - 1000 ppm? A long, long time ago... 25-35 million years.

Data source: Zachos et al., 2001

35 million years ago
- Arctic: Ice free
- Antarctic: Ice
6-8°C warmer; Sea level was +60 meters

Today
- Arctic
- Antarctic

Greenhouse gases recorded in the Vostok ice core.
**Claim:** CO2 increases will cause catastrophic global warming.

**Fact:** The alleged catastrophic warming from CO2 is due to large positive feedback from water vapor and clouds. The feedback is probably small or negative.

Happer - Slide 4 (April 2010)

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**Claim:** We can already see the world coming to an end because of CO2

**Fact:** None of the claims are true
- Sea level continues its historical rise
- No increase in storms
- No increase in droughts
- No trend in sea ice

Happer - Slide (April 2010)
What happens when you show all the data
Arctic Sea ice: three independent estimates

Why September?

Nearly 50% sea ice loss in 40 years

Arctic sea ice
Models vs. Observations

Amuses-bouche of other skeptic challenges

1) The Hockey stick is broken.
2) It’s the Sun.
3) Global warming ended in 2000, no rise since then.
4) Fraud and deception: ClimateGate

The Hockey Stick

Mann, Bradley, Hughes (1998)
“Proxies” - getting temperatures from trees

a) Measure ring widths

b) Calibrate ring widths

C) Validate and Apply

The Hockey stick isn’t broken, and there are 10 others based on tree-rings, ice cores, lakes, corals, ground temperatures.

It’s the Sun.

Sunspots!

More sunspots = “brighter” sun

Small effect: 1-2 W/m² of 1360 W/m²

Sunspot cycles occur over decades to hundreds of years
Very modest forcing, but significant climate responses to it.

What if the solar radiation changes by +2 W/m²?

Recalling \( I_{\text{solar}} = 1365 \text{ W/m}^2 \)

Set \( I_{\text{solar}} = 1367 \text{ W/m}^2 \)

\( \alpha = 0.3 \)

Solve for \( T_{\text{earth}} \)

\[
\frac{((1-\alpha) I_{\text{solar}})}{4} = \alpha T_{\text{earth}}^4
\]

\( \Delta T = 0.1 \degree \text{C} \) (Small!)

Hypothesis testing: Natural or manmade?

- Natural forcing
  (Sun + Volcanoes)
- Natural + Human
  (Sun + Volcanoes + GHGs)

Most of current warming is due to humans.
2010 Update

The Earth is clearly warming.

2010 may be warmest year on record (130 years).

17 of the last 20 years were record-breakers.


Did global warming end in 2000?

Global cooling?

Willie Soon (Harvard)

But global temperature isn’t rising!

CO₂ Concentration (ppm)

YEAR

Doubt it

- 2010 on track to be the warmest on record (131 years)
- Sea ice in Sept. 2010 was 3rd lowest on record
- Record ice loss in Greenland this summer
- What other reasons would you add?

Top 10 skeptic arguments

<table>
<thead>
<tr>
<th>Skeptic Argument</th>
<th>What the Science Says</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. “It’s the sun”</td>
<td>The sun’s output has hardly changed since 1979 and is irrelevant to recent global warming.</td>
</tr>
<tr>
<td>2. “Climate’s changed before”</td>
<td>Climate reacts to whatever forces it to change at the time; humans are now the dominant forcing.</td>
</tr>
<tr>
<td>3. “There is no consensus”</td>
<td>97% of climate experts agree humans are causing global warming.</td>
</tr>
<tr>
<td>4. “It’s cooling”</td>
<td>The last decade 2000-2009 was the hottest on record.</td>
</tr>
<tr>
<td>5. “Models are unreliable”</td>
<td>Models successfully reproduce temperatures since 1900 globally, by land, in the air and the ocean.</td>
</tr>
<tr>
<td>6. “Temp record is unreliable”</td>
<td>The warming trend is the same in rural and urban areas, measured by thermometers and satellites.</td>
</tr>
<tr>
<td>7. “We’re heading into an ice age”</td>
<td>Worries about global warming refer to the next 100 years, not to ice age in over 10,000 years.</td>
</tr>
</tbody>
</table>

http://www.skepticalscience.com/argument.php
Earth’s energy imbalance  
(1850 to Present)

Radiative Forcing Components

- Net: +1.6 W/m²

About 3-4 of these per square meter

What does the future hold?

Global Warming Projections

2xCO₂ = +3°C

Assumes “business as usual” emissions scenario
Recent warming is unusual, future warming is “another world”

+3°C warming

Is there a “Dangerous” CO₂ limit?

Changes approaching +2 °C pose irreversible risks.

Key concerns are sea-level and water availability.

Positive Feedback processes accelerate change:
- Ice - Albedo Feedback
- Ice sheet - sea level feedback
- Ocean circulation - salinity feedback

The “Tipping Point” CO₂ level is estimated to be ~450 ppm
- or about 30±10 years from now

How much CO₂ is too much?

CO₂ emissions will likely peak in this century.

Data source: Wiggley, 1993
Ocean Acidification
The other CO₂ problem

Oceans have taken up 30% of our emissions.
The oceans are acidifying.
CO₂ and water make acid (protons)

\[ \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}^+ + \text{HCO}_3^- \]

Why care? 20% of world's food from the oceans. This affects the base of the food chain.

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I'm on “The List”
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