

OLLI WEST: EARTH CLIMATE – WEEK 6

Future Promise:

- Fusion**
- Geoengineering (SRM, CDR, Carbon negative technologies);**
- economics**

Tuesday October 21st, 2014

Paul E. Belanger, Ph.D.

- **Fusion breakthrough**

- <http://www.lockheedmartin.com/us/products/compact-fusion.html>
- <http://aviationweek.com/blog/high-hopes-can-compact-fusion-unlock-new-power-space-and-air-transport>
- [**http://aviationweek.com/fusion-podcast**](http://aviationweek.com/fusion-podcast)

Naomi Oreskes

Slides excerpted from:

Changing Planet: Past, Present, Future

Lecture 4 – Climate Change: How Do We Know We're Not Wrong?

by Naomi Oreskes, PhD

<http://www.hhmi.org/biointeractive/climate-change-how-do-we-know-were-not-wrong>

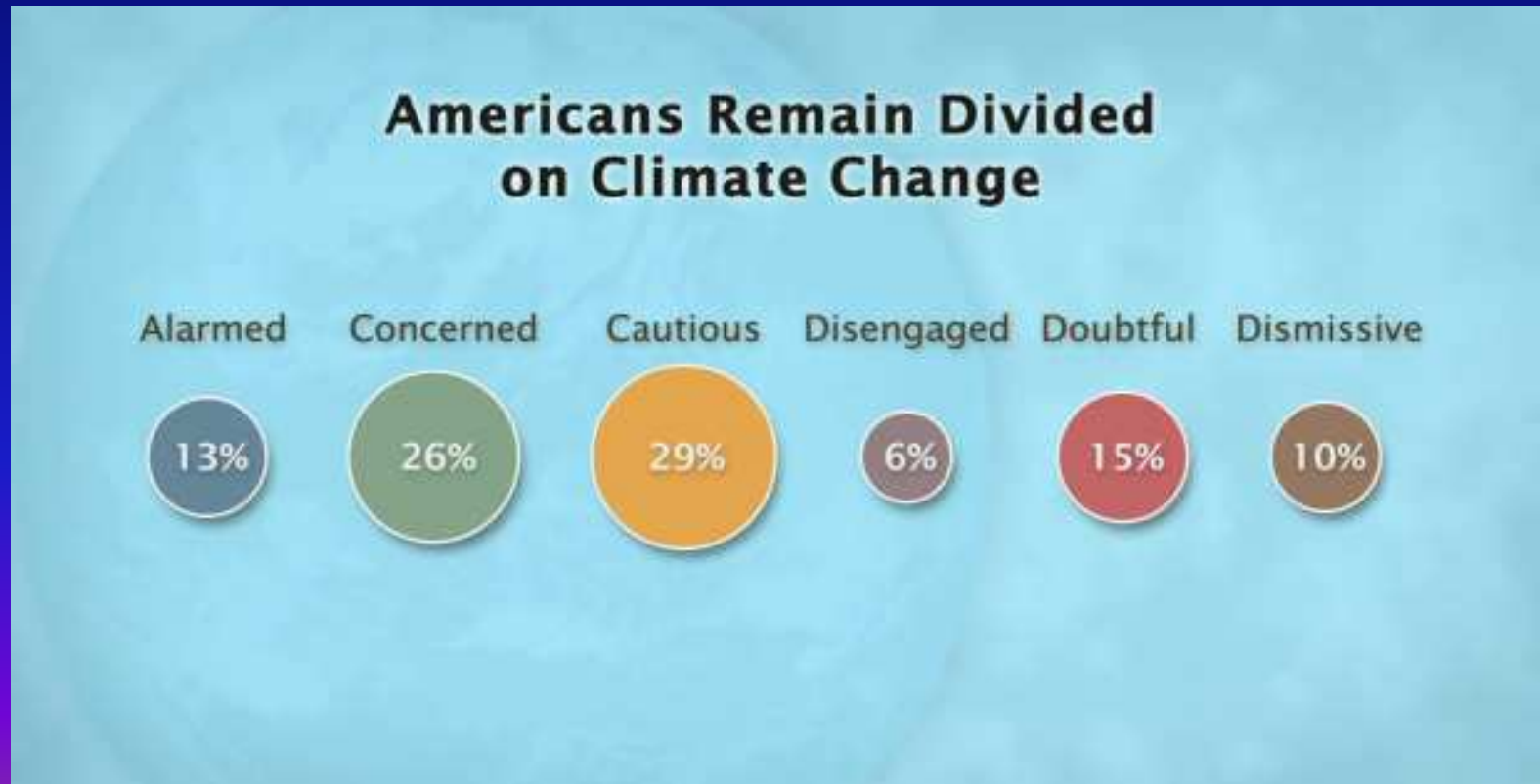
<http://media.hhmi.org/hl/12Lect4.html>

Polls on climate change:

(on evolution ~ half don't believe in evolution)

See National Center for Science Education (NCSE):

<http://ncseprojects.org/> on climate: <http://ncseprojects.org/climate>



Got to ask why, no?

Furthermore, Americans Are Less Concerned Than People in Other Countries



Do We Have an Information Deficit?



We try!

Community Response to Perceived “Information Deficit”

K-12 science education

Public outreach and informal efforts

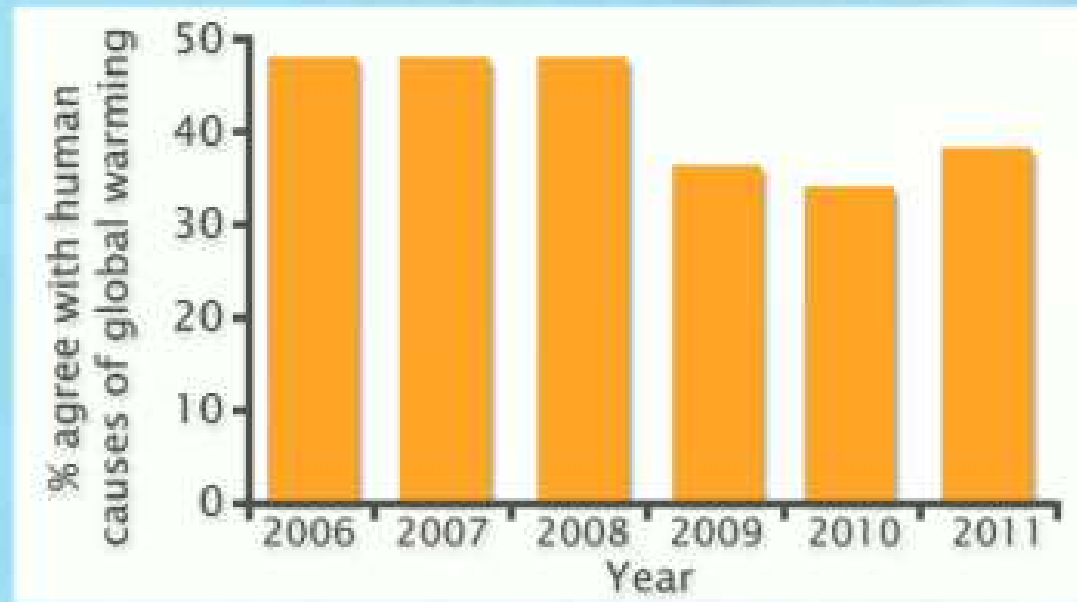
Statements on web pages

Improved uncertainty estimation (IPCC, NRC, etc.)

Howard Hughes Medical Institute lectures

Got to ask why, no?

American Views of Global Warming

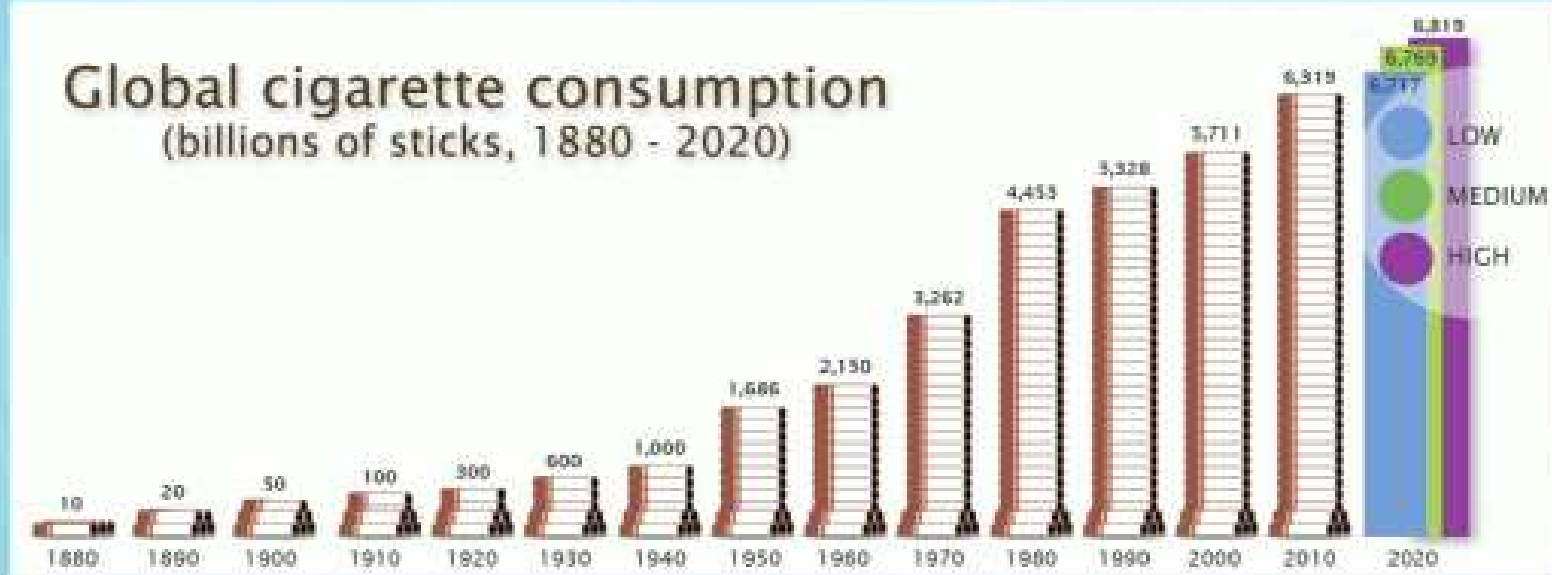


Increased education and outreach has *not* led to broader acceptance of scientific conclusions.

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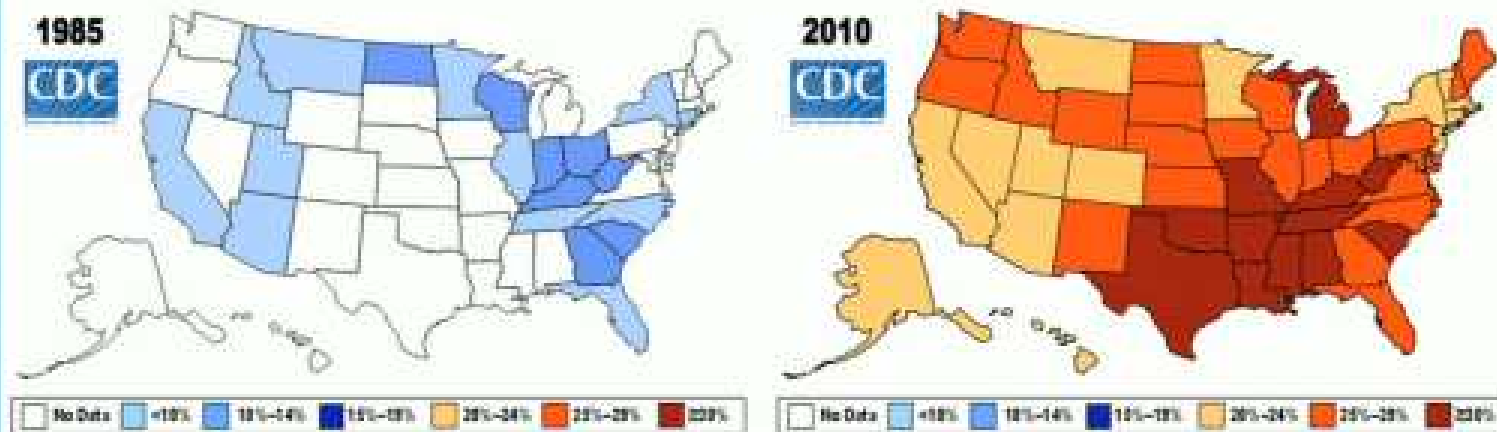
More Examples of Knowledge \neq Action

Global cigarette consumption
(billions of sticks, 1880 - 2020)



More Examples of Knowledge \neq Action

Percent of Obese (BMI ≥ 30) in U.S. Adults



There must be another explanation for why people have rejected climate science.

It started with the Marshall Institute

Organized Resistance: George C. Marshall Institute

William Nierenberg



Nuclear physicist and
long-time director of
Scripps Institution of
Oceanography

Frederick Seitz



President of NAS,
Rockefeller University,
and consultant to R J
Reynolds Tobacco

Robert Jastrow

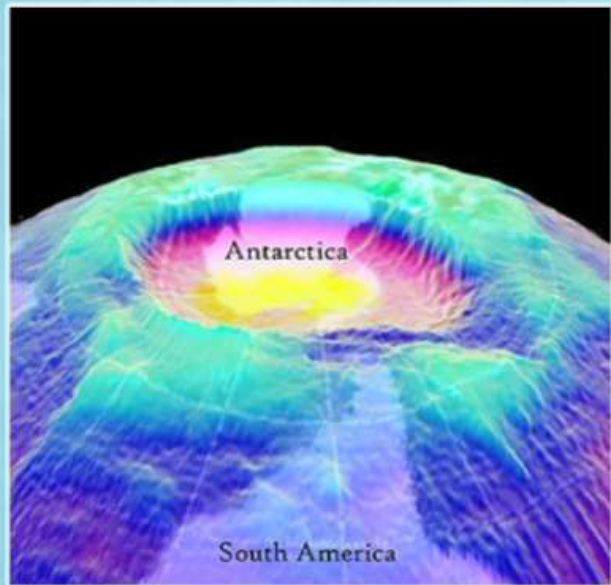


Astrophysicist, head
of Goddard Institute
for Space Studies

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**After the cold war ended, they went after
perceived internal “threats”**

**Over Twenty Years Challenged Scientific
Evidence on a Host of Issues**



Ozone depletion



Harmful effects of
tobacco smoke



Acid rain

We Can Prevent These Harms in a Variety of Ways

Tobacco: Heavy taxation, limits on advertising (free speech), and in some cases, outright bans

Acid Rain: An Emissions Trading Scheme Under Clean Air Act Amendments (1990)

Ozone Hole: International Treaty to Ban CFCs

These are all government interventions in the marketplace, which put limits on business activities and personal freedom.

It comes down to ideology, not science!

The Marshall Institute Opposes These Form of Government Interventions

Their method: challenge the scientific evidence that demonstrates the need for these interventions.

In some cases, they even attacked the *scientists*.

And it “mushroomed”

Network of Think-Tanks and Organizations Who also Spread Doubt About Climate Science

American Enterprise Institute
Competitive Enterprise Institute
Heartland Institute
Alexis De Tocqueville Institute
Heritage Foundation
Acton Institute
Hudson Institute
Atlas Economic Foundation
Americans for Prosperity
Frontiers of Freedom
Committee for a Constructive Tomorrow
Institute for Public Affairs (Australia)
Let Freedom Ring

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The Marshall Institute and More Than Two Dozen Other Think Tanks

These think tanks don't do scientific research.

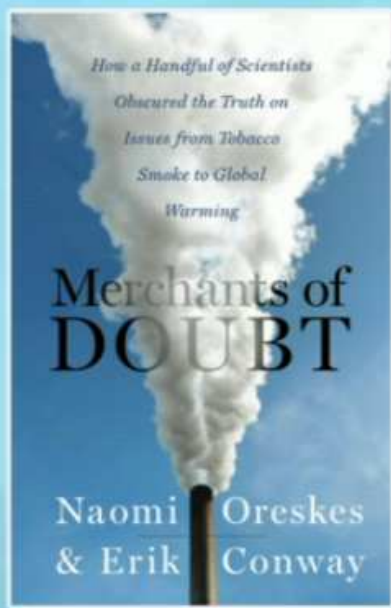
None of them are scientific research organizations.

It is legitimate to have a conversation about policy issues.

It is not legitimate to fabricate evidence or make claims without any evidence.

Implicatory Denial

Rejection of climate science—like acid rain, ozone depletion, tobacco use—was not about science.



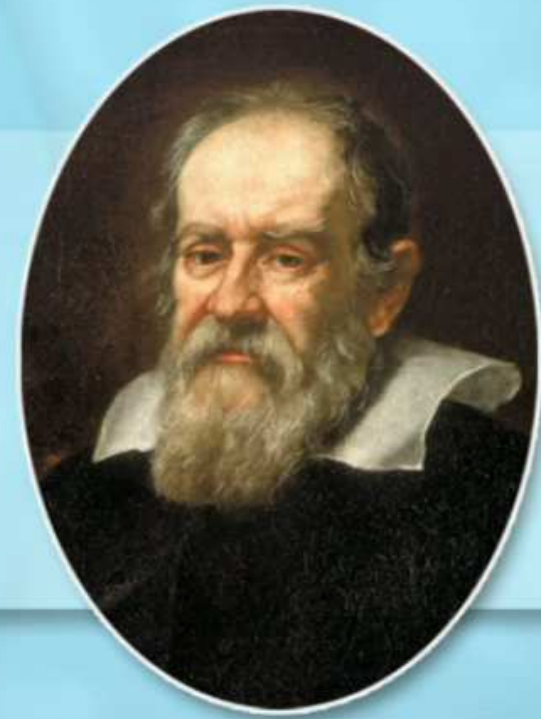
It was about its implications.

1. Free market capitalism had produced serious problems that the “invisible hand” was not solving.

2. The American way of life might need adjustment.

Catholic Church Rejected Galileo Because They Did Not Like the Implications

Not because his science wasn't right, but because it implied that the Catholic Church wasn't infallible



Dealing with Climate Change Will Require Big Decisions



Therefore, it is appropriate to turn a critical eye to the science to try to make sure it is not wrong.

Criteria By Which We Can Judge the Science

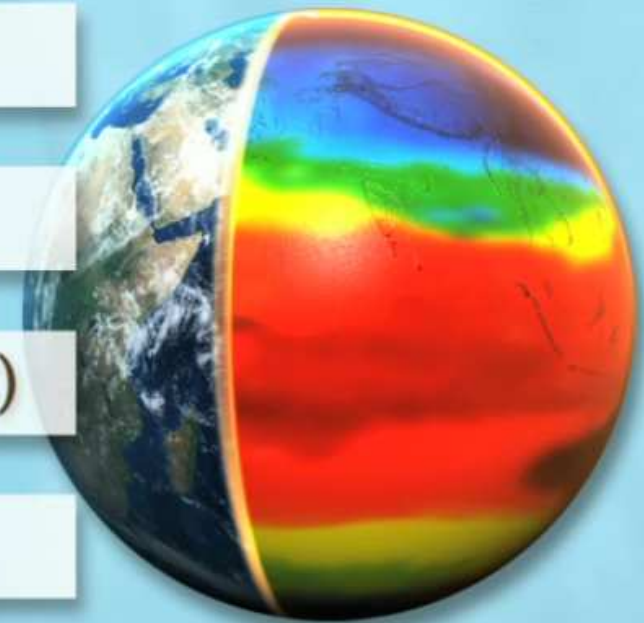
Methodological standards

Evidential Standards

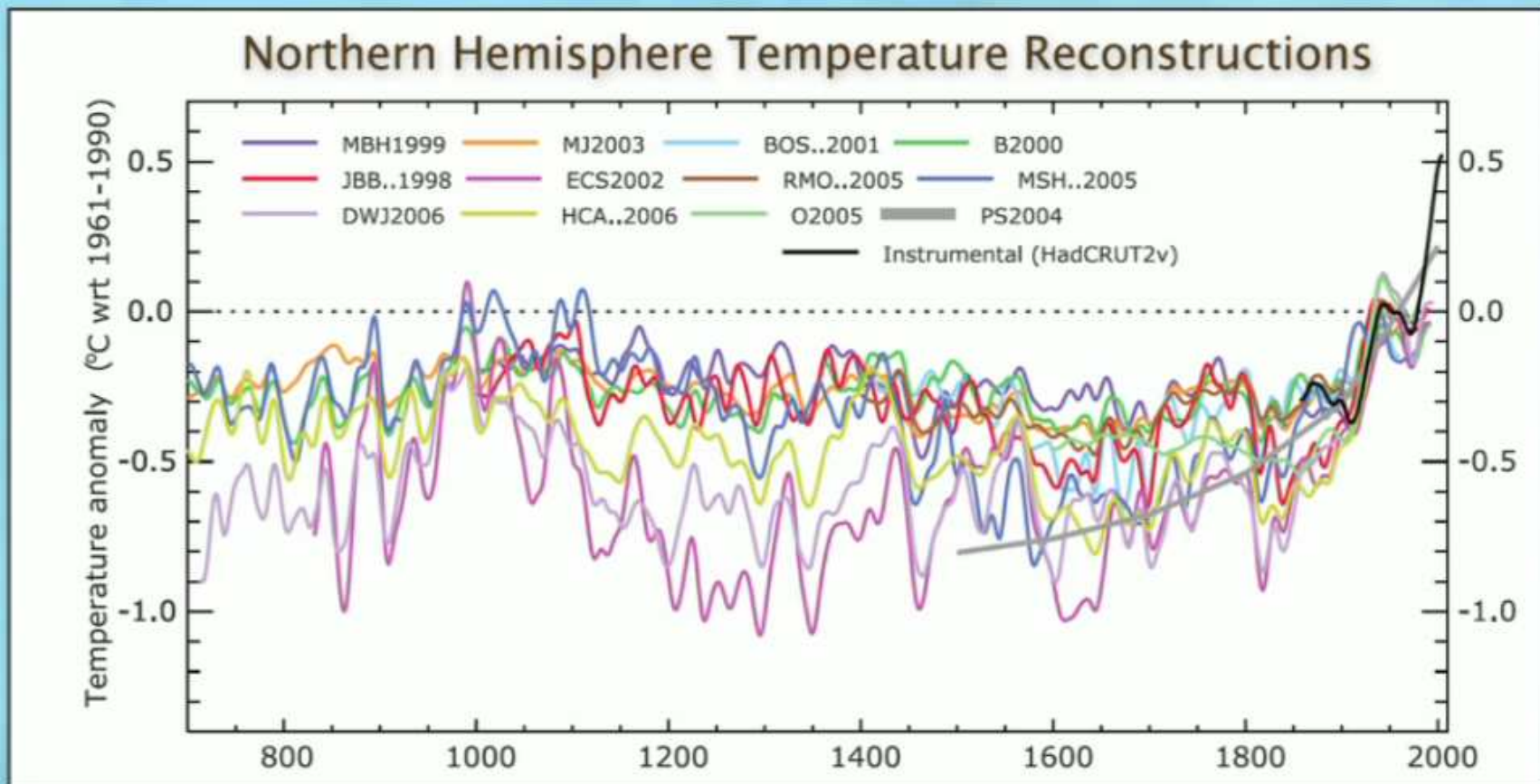


Performance standards (models)

Is there an expert consensus?



Independent Corroboration



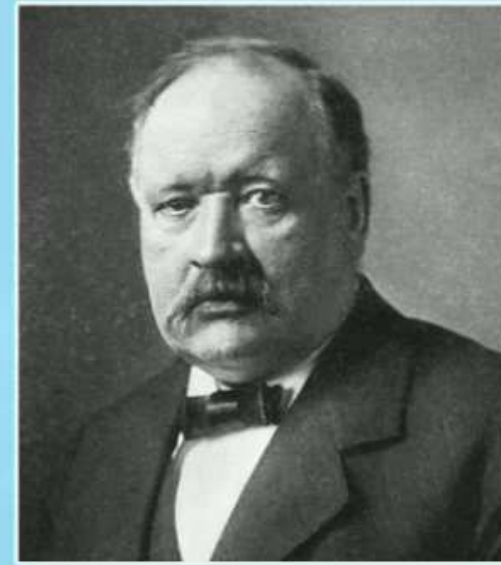
Multiple data sets show the same general trends.

Alternatively, Start with a Theory and See If Observations Fit

Example

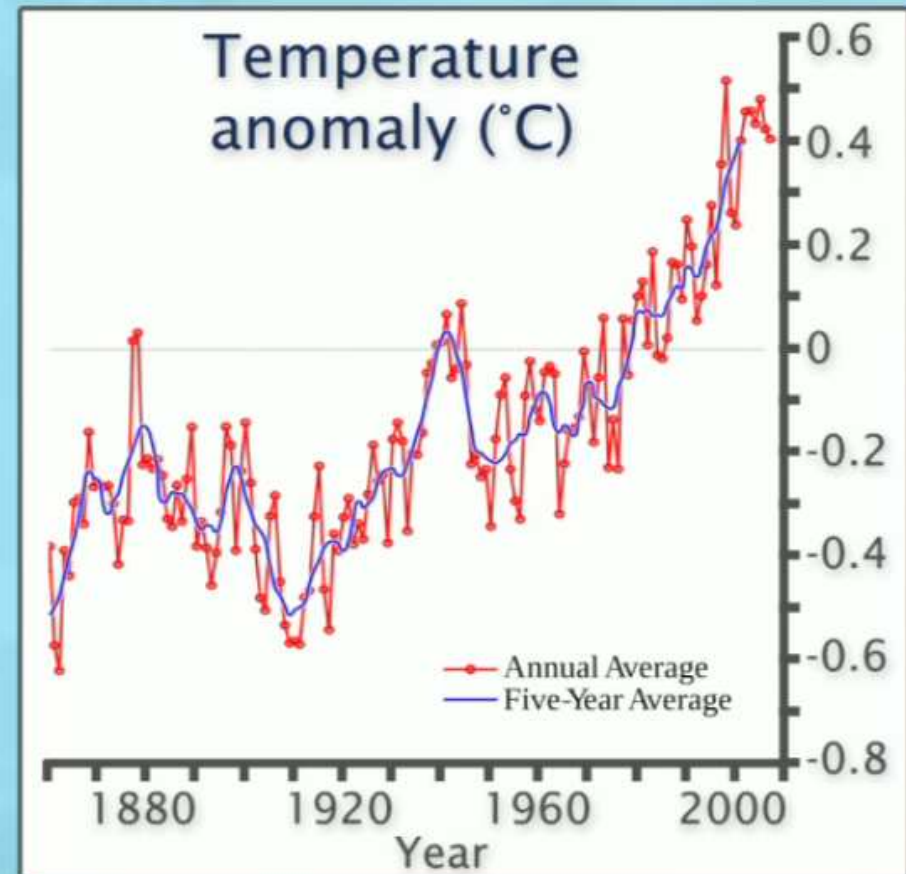
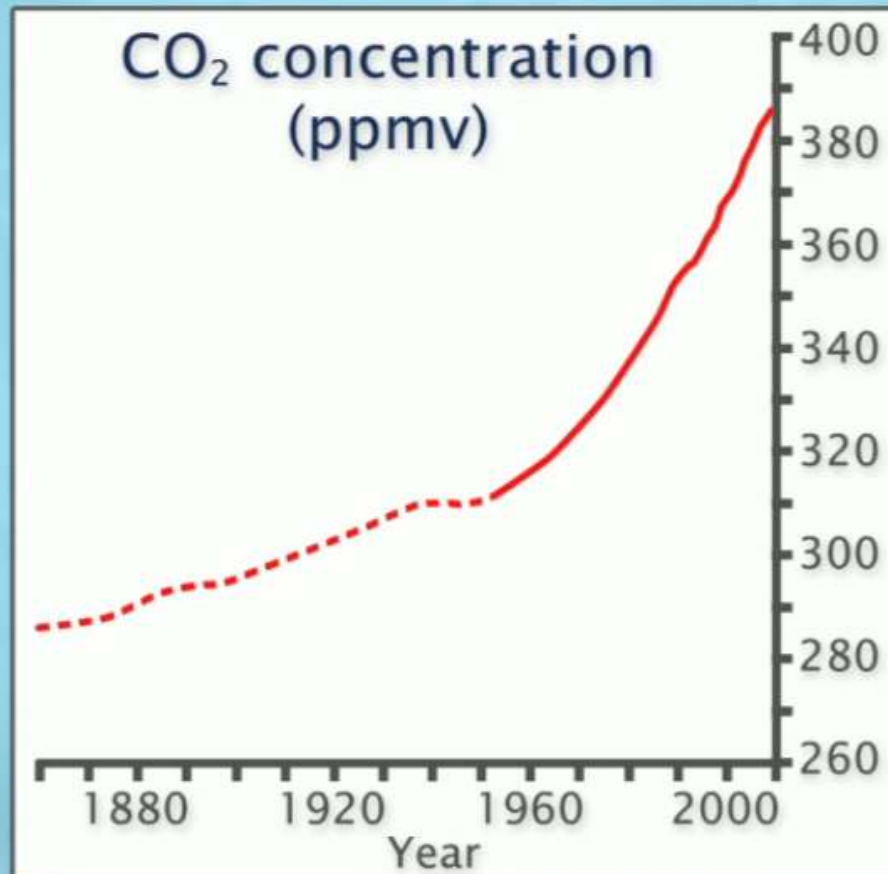
CO₂ is a
greenhouse gas.

If CO₂ rises, then
temperature
should also rise.



Arrhenius made this
prediction in 1896.

As CO₂ Level Rose, Temperature Rose



Science Is Falsifiable

This means that if the claim is false, then that can be demonstrated by experiment and/or observation.



Example

Observation:
CO₂ levels are rising

Hypothesis:
Volcanoes are the
source of that CO₂

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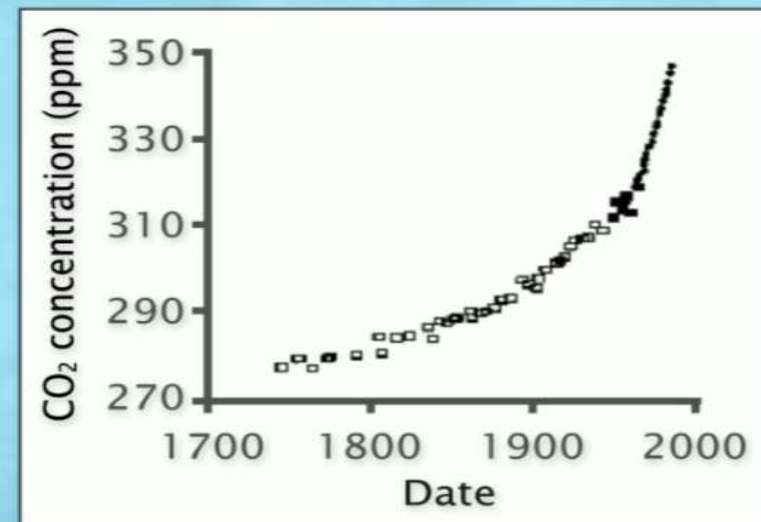
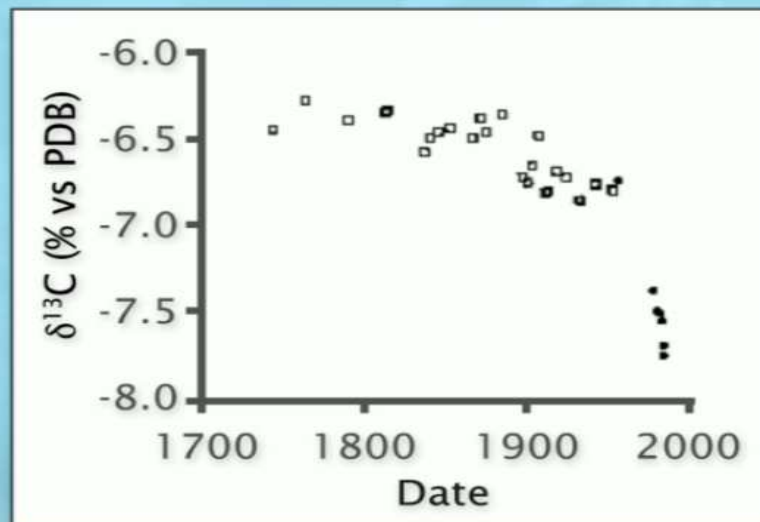
How to test the hypothesis

**Inorganic CO₂ from volcanoes are isotopically more positive;
organic matter depleted in C13 = Fossil carbon is negative**

“To claim otherwise:

Confused, ignorant or lying”

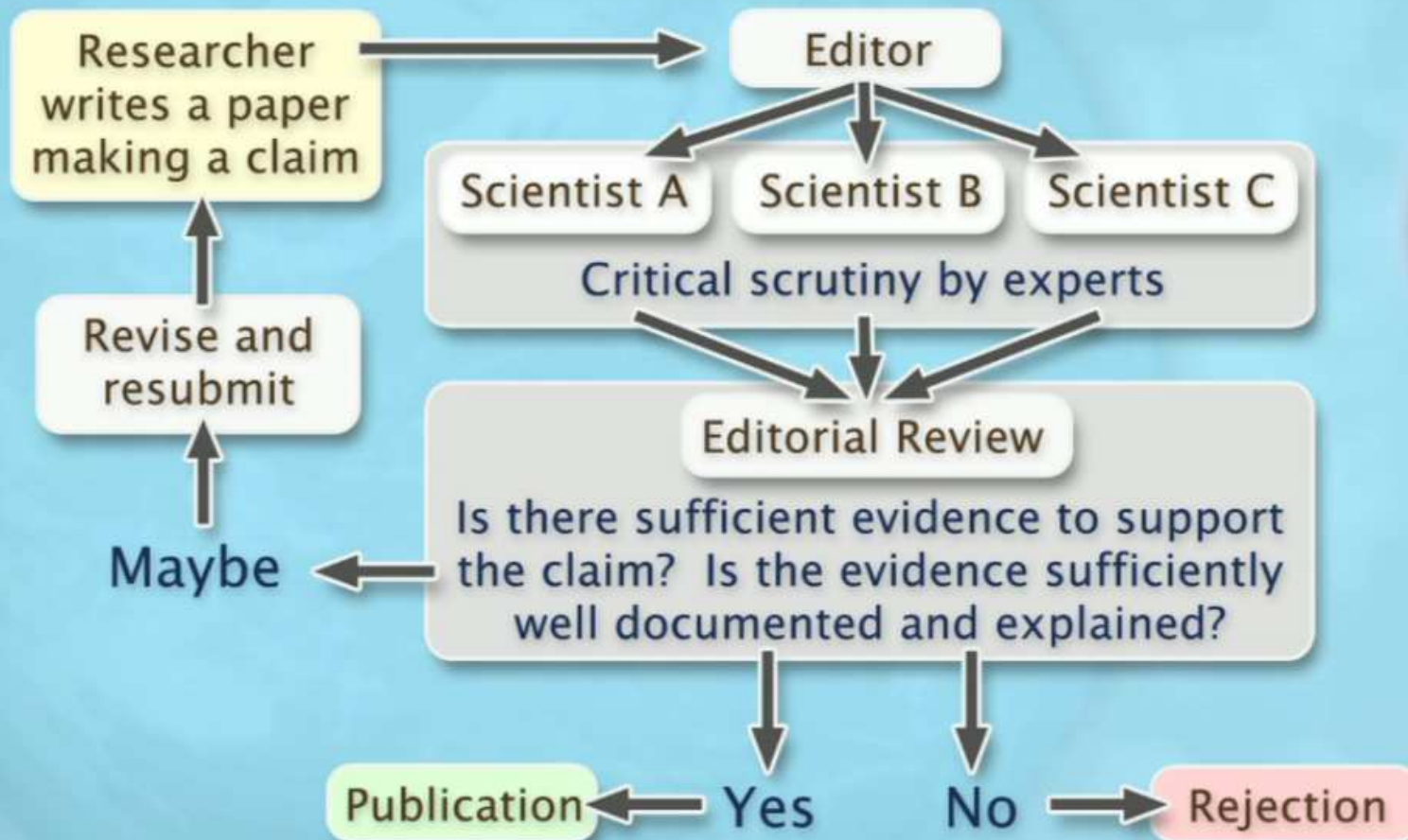
**Data Clearly Show That CO₂
Increase Is Not from Volcanoes**



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How peer review works

Has Evidence Passed Peer Review?



Intergovernmental Panel on Climate Change (IPCC)

Thousands of scientists

195 countries

Open process

An unprecedented level of review and inclusivity



Climate science has passed an unprecedented level of peer review.

<http://media.hhmi.org/hl/12Lect4.html>

Performance



Global climate model
geodesic grid

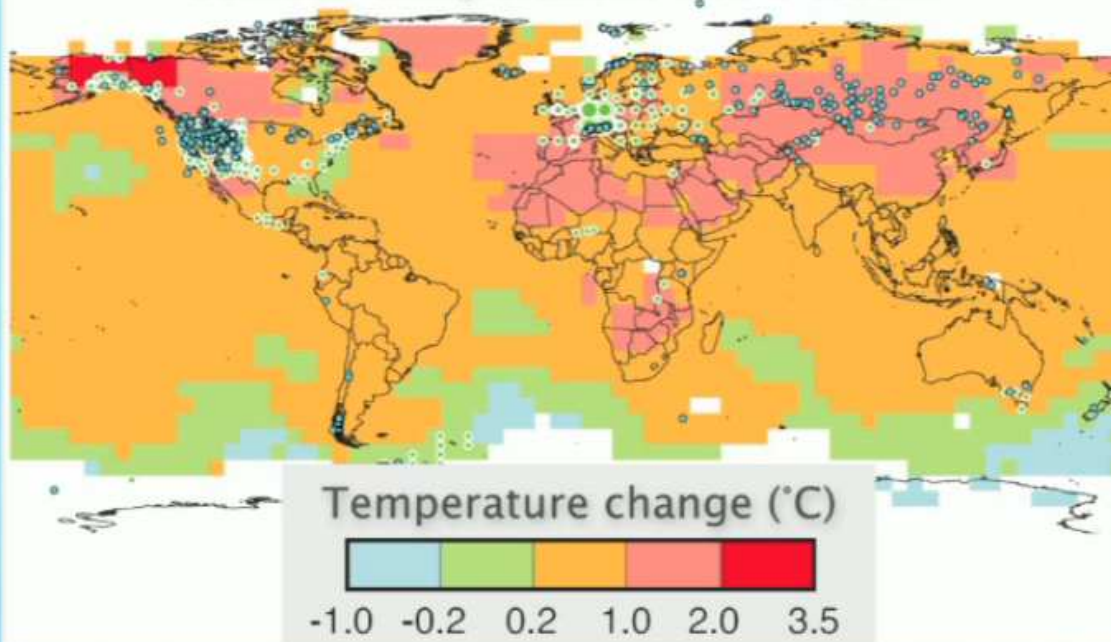
Climate models are extremely complex systems.

A good model should be consistent with what we see in the real world.

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IPCC Summary: A Vast Number of Observations Fit the Climate Models

Change in physical and biological systems and surface temperature 1970–2004



Global

Physical

765
significant
observed
changes

94%
significant
changes
consistent
with warming

Biological

28,671
significant
observed
changes

90%
significant
changes
consistent
with warming

Consensus

ESSAY

BEYOND THE IVORY TOWER

The Scientific Consensus on Climate Change

David Orvik

Policy-makers and the media, particularly in the United States, frequently assert that climate science is highly uncertain. Some have used this as an argument against adopting strong measures to reduce greenhouse gas emissions. For example, while discussing a major U.S. Environmental Protection Agency report on the risks of climate change, then-EPA administrator Christine Whitman argued, "In [the report] went through review, there

was little consensus on the science and conclusions on climate change."

(1) Some corporations whose operations might be adversely affected by controls on carbon dioxide emissions have also alleged major uncertainties in the science (2). Such statements suggest that there might be substantial disagreement in the scientific community about the reality of anthropogenic climate change. This is not the case.

The scientific consensus is clearly expressed in the reports of the Intergovernmental Panel on Climate Change (IPCC), created in 1988 by the World Meteorological Organization and the United Nations Environmental Programme. IPCC's purpose is to evaluate the state of climate science as a basis for informed policy action, primarily on the basis of peer-reviewed and published scientific literature (3). In its most recent assessment, IPCC states unequivocally that the consensus of scientific opinion is that Earth's climate is being affected by human activities: "Human activities ... are modifying the concentration of atmospheric constituents ... that absorb or scatter radiant energy ... [M]ost of the observed warming since the last 50 years is likely to have been due to the increase in greenhouse gas concentrations" (p. 2140 (4)).

IPCC is not alone in its conclusions. In recent years, all major scientific bodies in the United States whose members' expertise have directly on the matter have issued similar statements. For example, the National

Academy of Sciences report, *Climate Change Science: An Analysis of Some Key Questions*, begins, "Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise" (p. 1 in (5)). The report explicitly asks whether the IPCC assessment is a fair summary of professional scientific thinking, and answers yes: "The IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue" (p. 7 in (5)).

Others agree. The American Meteorological Society (6), the American Geophysical Union (7), and the American Association for the Advancement of Science (AAAS) all have issued statements in recent years concluding that the evidence for human modification of climate is compelling (8).

The drafting of such reports and statements involves many opportunities for comment, criticism, and revision, and it is not likely that they would diverge greatly from the opinions of the scientific community. Nevertheless, they might diverge legitimately, discussing options. That hypothesis was tested by analyzing 928 abstracts, published in national scientific journals between 2001 and 2005, and listed in the ISI database with the keywords "climate change" (9).

The 928 papers were divided into six categories: explicit endorsement of the consensus position; evaluation of impacts, mitigation, geoengineering, methods, paleoclimatic analysis, and rejection of the consensus position. Of all the papers, 75% fell into the first three categories, either explicitly or implicitly accepting the consensus view; 25% dealt with methods or paleoclimatic analysis on position on current anthropogenic climate change. Remarkably, none of the papers disagreed with the consensus position.

Admittedly, authors evaluating impacts, developing methods, or studying paleoclimatic change might believe that current

climate change is natural. However, none of these papers argued that point.

This analysis shows that scientists publishing in the peer-reviewed literature agree with IPCC, the National Academy of Sciences, and the public statements of their professional societies. Politicians, academics, journalists, and others may have the impression of confusion, disagreement, or dissent among climate scientists, but that impression is incorrect.

The scientific consensus might, of course, be wrong. If the history of science teaches anything, it is humility, and no one can be faulted for failing to act on what is not known. But one grandchild will surely blame us if they find that we underestimated the reality of anthropogenic climate change and failed to do anything about it.

Many details about climate interactions are not well understood, and there are ample grounds for continued research to provide a better basis for understanding climate dynamics. The question of when to disband climate change is also still open, but there is a scientific consensus on the reality of anthropogenic climate change. Climate scientists have repeatedly tried to make this clear. It is time for the rest of us to listen.

- References and Notes**
1. D. J. Baker, *N. Y. Times*, New York Times, 19 June 2005, A1.
 2. J. L. S. Baker, *N. Y. Times*, New York Times, 19 June 2005, A1.
 3. Intergovernmental Panel on Climate Change (IPCC), *Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, 2007).
 4. Intergovernmental Panel on Climate Change (IPCC), *Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, 2007).
 5. National Academy of Sciences, *Climate Change Science: An Analysis of Some Key Questions* (National Academy Press, Washington, DC, 2005).
 6. American Meteorological Society, *Statement on the Science of Climate Change* (American Meteorological Society, Boston, MA, 2005).
 7. American Geophysical Union, *Statement on the Science of Climate Change* (American Geophysical Union, Washington, DC, 2005).
 8. American Association for the Advancement of Science, *Statement on the Science of Climate Change* (American Association for the Advancement of Science, Washington, DC, 2005).
 9. D. Orvik, *Journal of Climate Change*, 2006, 17, 1000-1005.

Review of 928 papers

75% supported the conclusion that anthropogenic climate change was under way

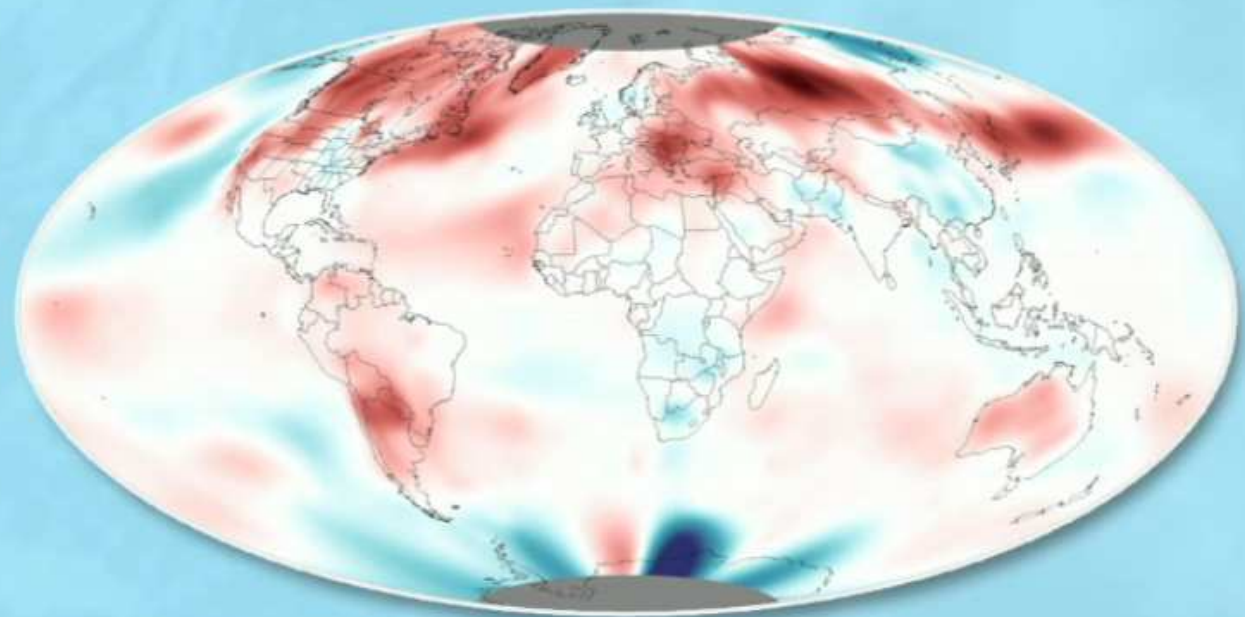
25% focused on paleoclimate or other technical aspects and took no position

No peer-reviewed papers refuted the consensus view

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The Science Is Settled and Passes All the Tests That We Can Subject It To

The globe is warming and the climate is changing.



Difference from average temperature (°F)



**The Debate Should Not Be About Whether
Climate Change Is Happening...**



...Rather, What Are We Going to Do About It?

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Obama quoted in episode of Years of Living Dangerously (paraphrased): “It’s difficult in a Democracy to do something/pass something where the pay-back is 10 or more years out”

End of class PowerPoint week 6;

Go back to syllabus