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Prepared for the Tompkins County

Climate Change Salons and Community Circles

Organized by Sustainable Tompkins

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At the end of this slideshow

is a complete list of the books

and articles from which the

information was derived.

Particular citations are given

on individual slides where appropriate.

This slideshow can be accessed online at:

http://msuweb.montclair.edu/~franker/SustainableTompkins/FrankeGlobalWarmingBasicsST.pdf

Topics for this Slideshow

1. What is global warming?
2. Why do almost all scientists think human activity is causing it?
3. What is the danger?
4. What can we do about it?

Topic 01

What is global warming?

What Is Global Warming?

Some slides courtesy of Jason Hamilton

Department of Biology & Environmental Science

Ithaca College

1. What Is Global Warming?

- Increase in average temperature at earth's surface
- Can include increase in ocean temperatures
- Not same all over – some regions might warm more than others
- Even selected cooling possible in some areas due to effects of "thermohaline circulation" - see slides 121 – 124 later in the slideshow

Global Warming or Climate Change?

Because warming of the earth could cause various other changes in the climate besides higher temperatures – droughts, excessive rainfall, even limited area cooling – scientists now use both the terms global warming and climate change, depending on the focus of their research. The warming of the earth's surface and lower atmosphere, however, are thought to be the "drivers" of any "climate change."

See slides 25 and 124 later in this show for examples

To see the historical background on these terms and an explanation of the distinction from the NASA website, click here.

1. What Is Global Warming?

For now, we focus on global warming only.

Two major ways to measure –

- Use average surface temperatures in Centigrade or Fahrenheit, OR;
- Use 14° C or 57.2° F as "zero" and measure anomaly up or down from it over time

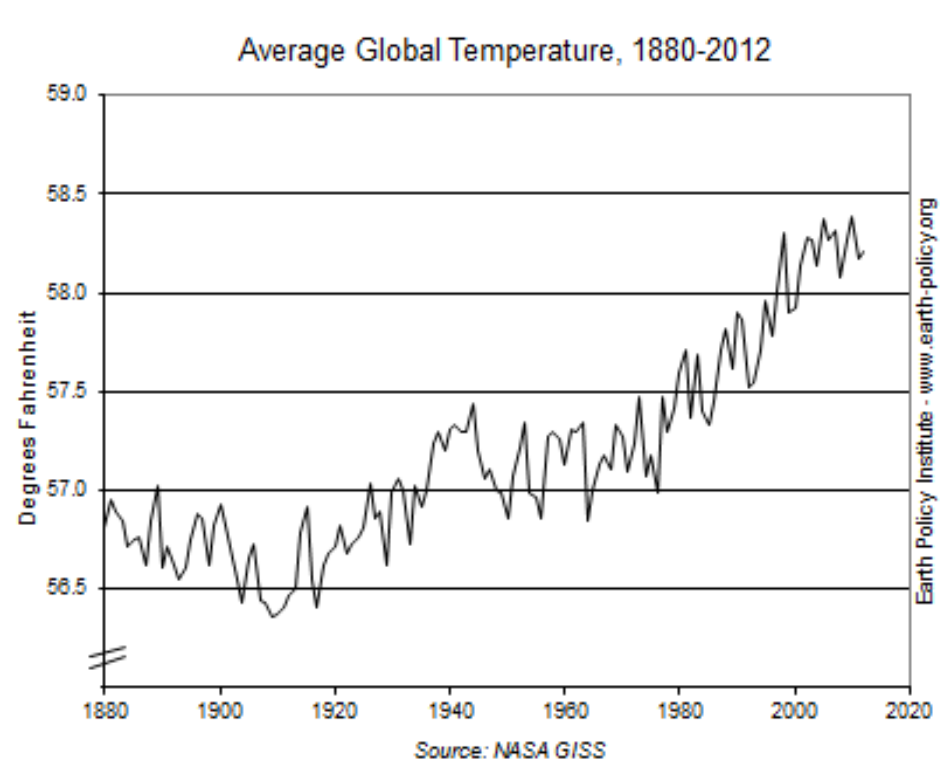
Ways to Measure

First –
use average surface temperatures in Fahrenheit…

What the Measure Shows

Average temp has gone up from about 57.0 F (13.9 C) in 1880 to about 58.3 F (14.6 C) in 2013, an increase of 1.3° F (0.7° C)

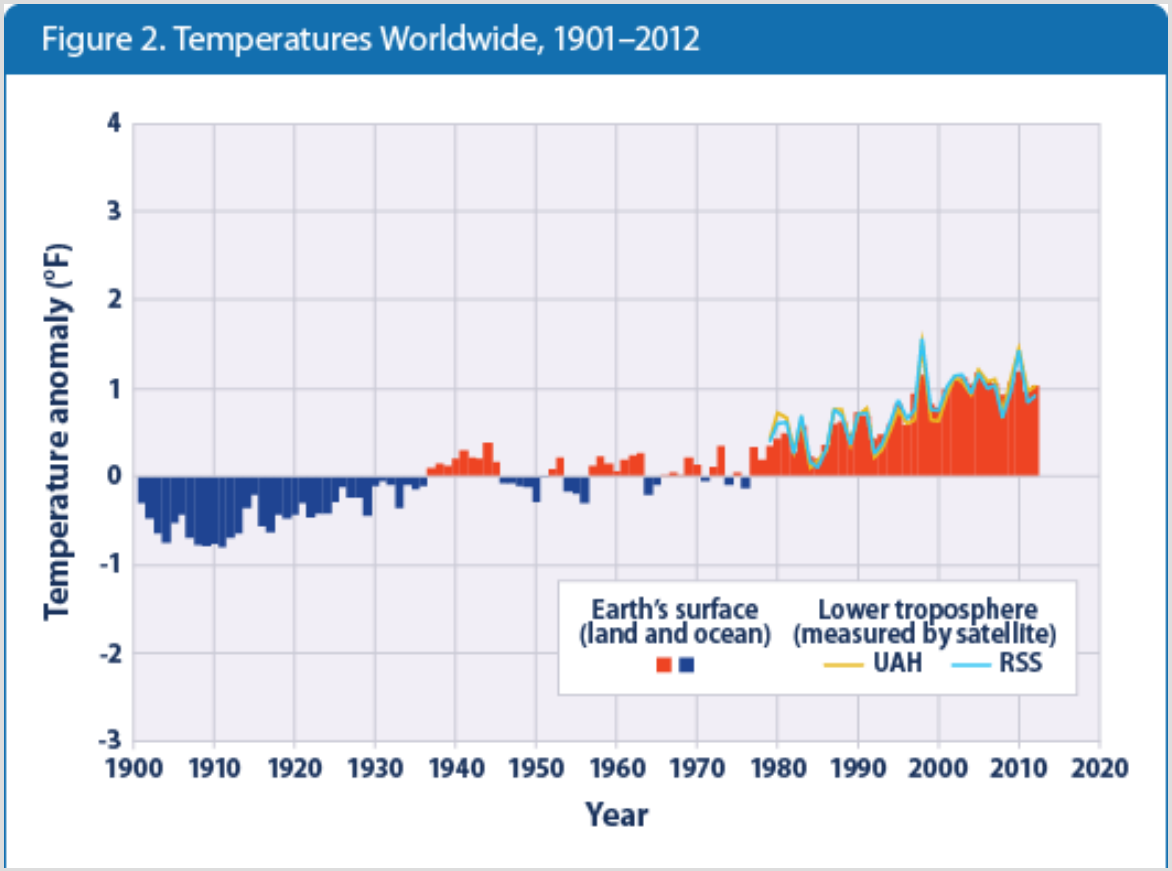
Source for the numbers above: http://earthsky.org/earth/2013-sustained-long-term-climate-warming-trend-says-nasa-report



Source for graph: http://www.earth-policy.org/indicators/C51/temperature_2011

What the Measure Shows

Anomaly measure-ment example

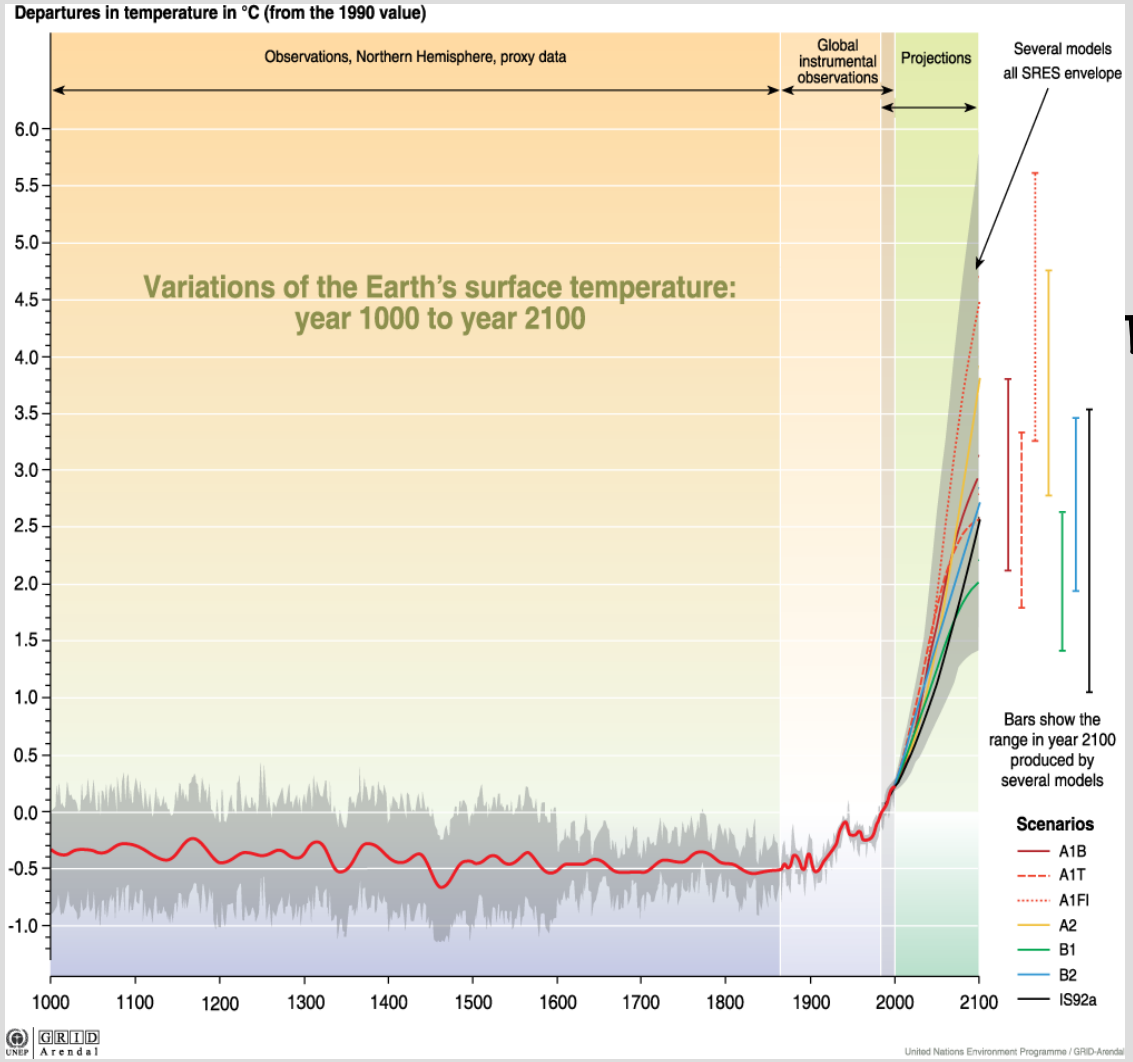


http://www.epa.gov/climatechange/science/indicators/weather-climate/temperature.html

What the Measures Show

Both absolute and anomaly type measures show same trend – up from avg in recent decades

What if we use a longer time scale?



Source: http://iefworld.org/ddahl09e.html

The Hockey Stick Graph

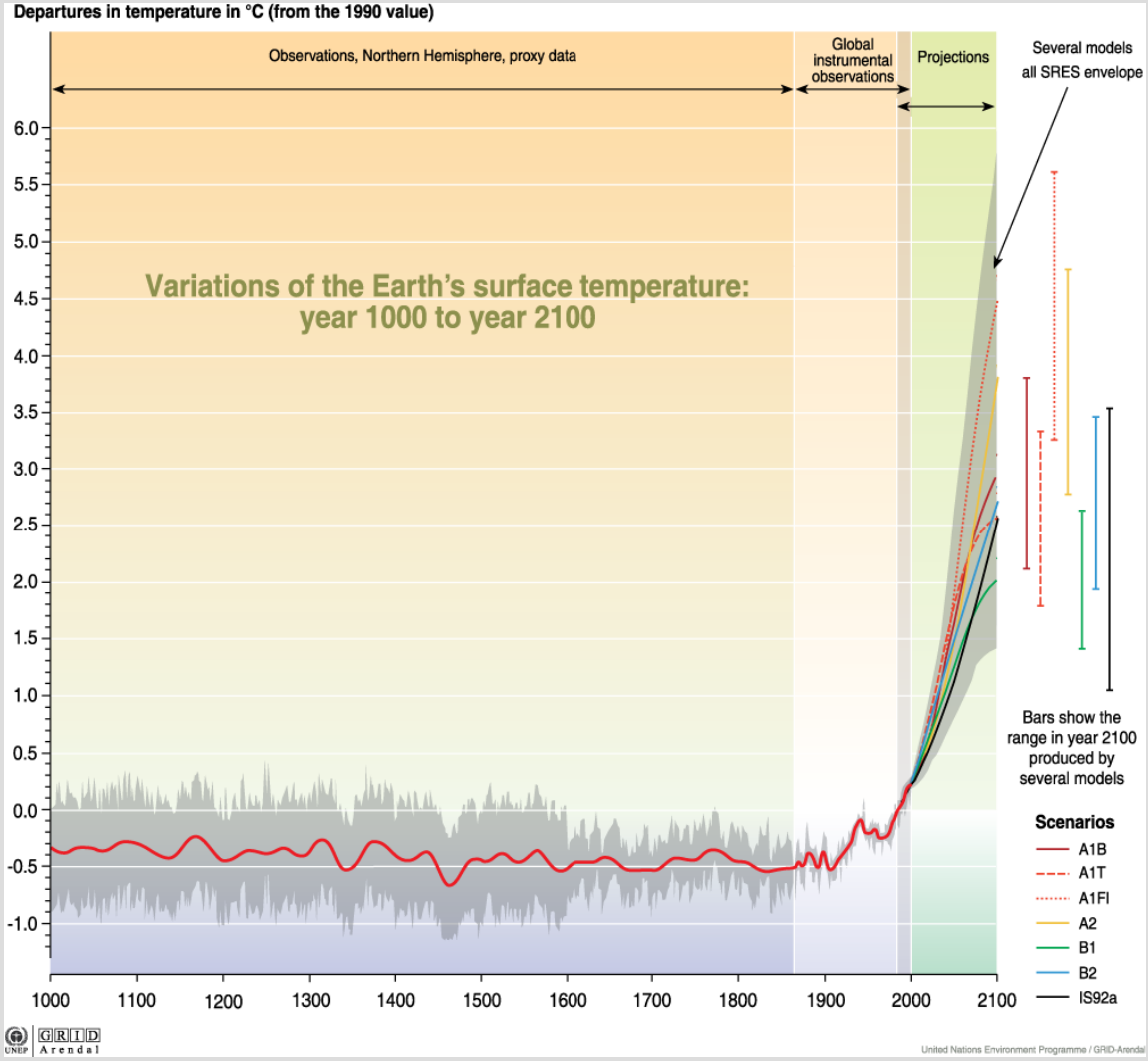
This is one version of the "hockey stick" graph made famous in the Al Gore movie *An Inconvenient Truth*.

It shows projections of global warming to the year 2100 based on trends of the last 50 yrs as contrasted with the previous 950 years

The Hockey Stick Graph

Note that the graph uses the year 1990 as a "zero" point and measures deviations from that – that is, it's an anomaly graph.

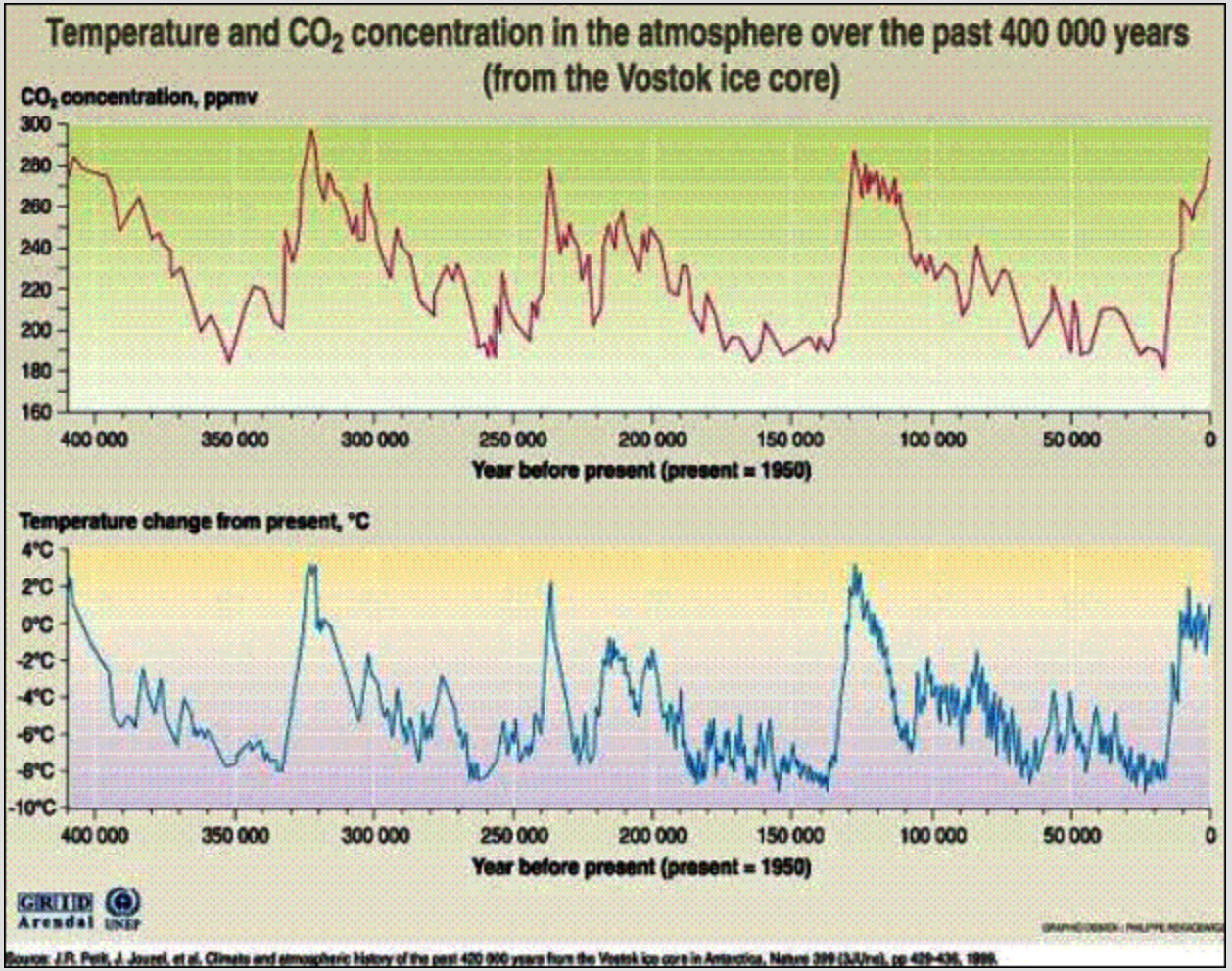
Note also how dramatic the temperature rise appears to be when the time scale changes from 1880 to the year 1000.

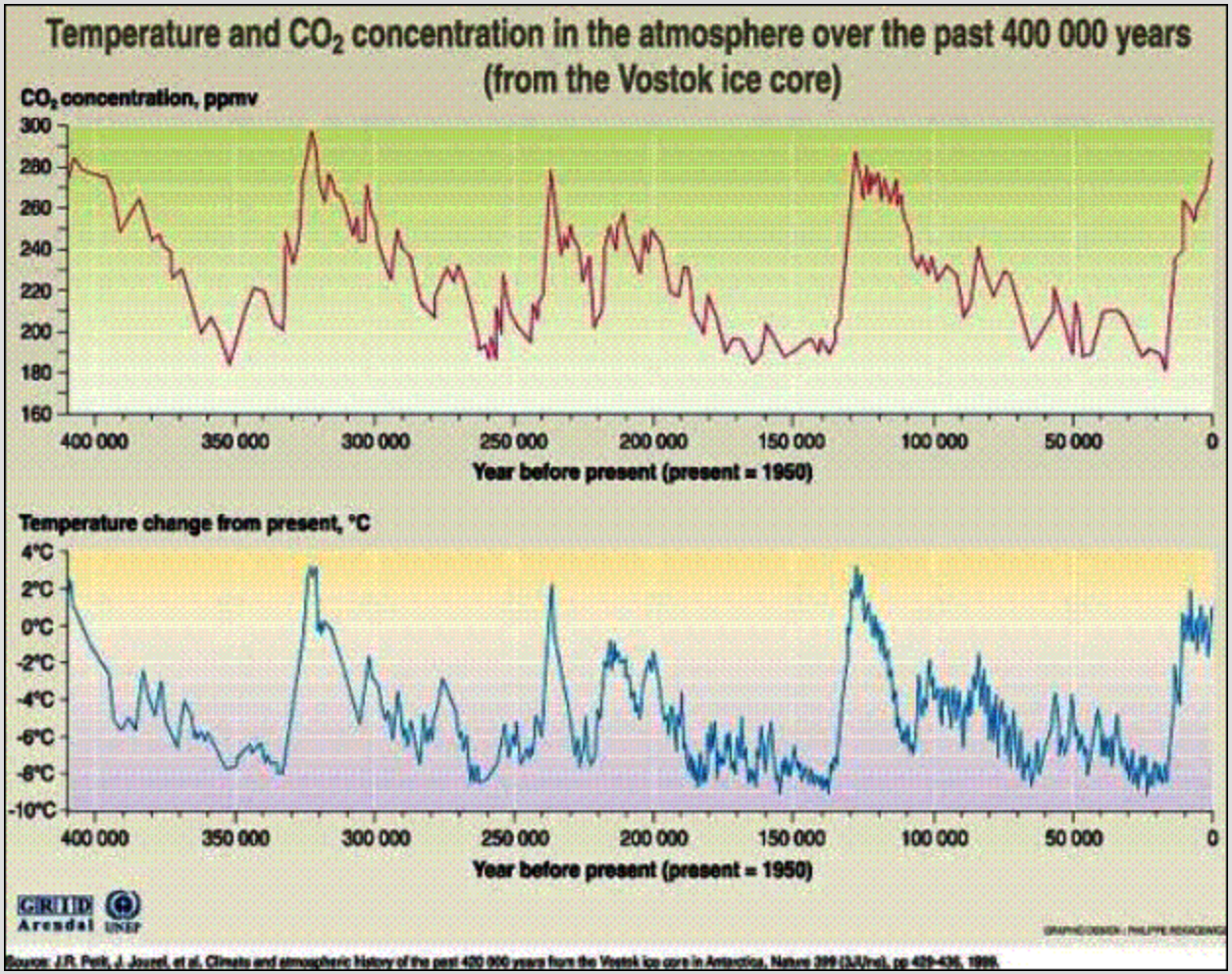


Some (Geological) History

When we make the timescale 400,000 years, we see regular cycles. We'll explain these a bit more later.

Source: http://www.appinsys.com/GlobalWarming/GW_Part1_HistoricalRecord_files/image020.gif





Some (Geological) History

It's important to note that human civilization was not around for most of the time on this graph.

These are part of earth's natural carbon and temperature cycles except for the little upward blip on the far right.

Another of the many possible indicators appears on this map – which shows how the frost-free season has lengthened in number of days from 1970 to 2013 in different parts of the U.S. Here we are seeing how global warming causes climate change, bringing the two concepts together.

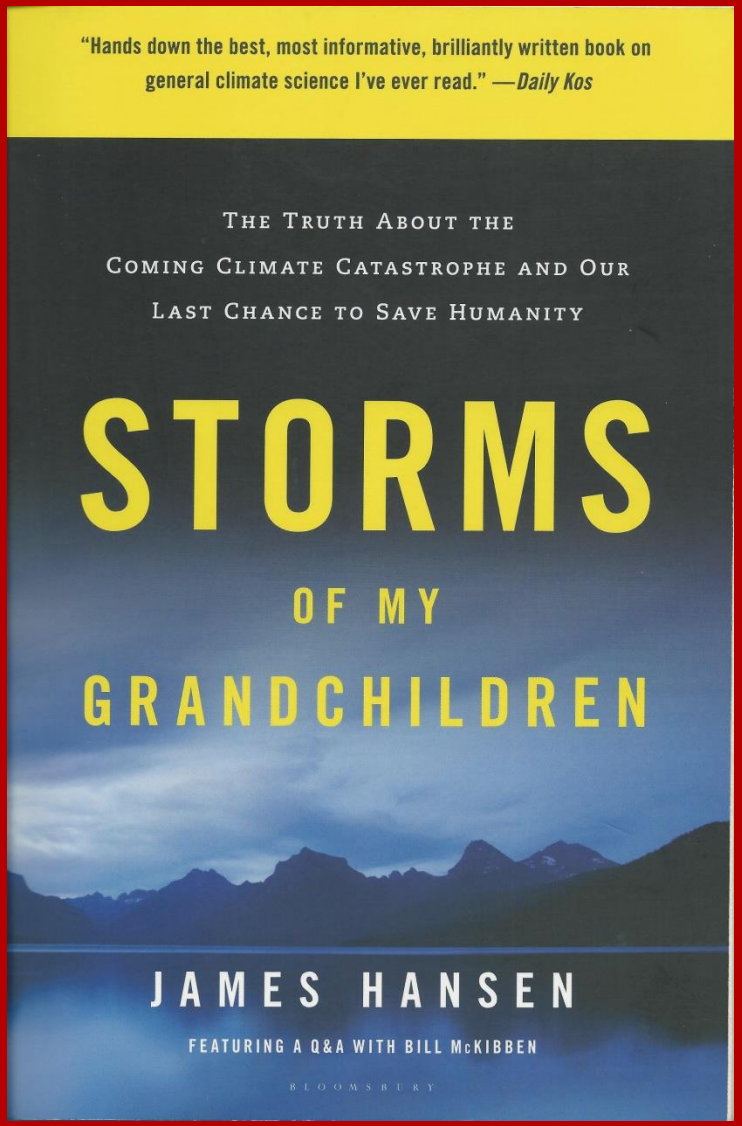
Source: http://www.climatecentral.org/gallery?page=2

Quick Read

Only have time for one book?

Former director of the NASA Goddard Space Institute and probably America's most famous global warming scientist provides an overview of the main dimensions of global warming and climate change.

Text is a bit challenging in places, but you'll know a lot after reading it even if you have to skip a few sentences.



Topic 02

Why do almost all scientists think human activity is causing global warming?

Topic 02

(And why you should think so too)

2. Human Causes?

Substantial evidence from various observations has convinced nearly all scientists that most, maybe all of global warming and the climate changes it is bringing are a result of recent human activity.

2. Human Causes?

According to NASA, 97% of scientists agree that "climate-warming trends over the past century are very likely due to human activities."

Source: http://climate.nasa.gov/scientific-consensus

2. Human Causes?

In a 2004 article in *Science* magazine, science historian…

2. Human Causes?

…Naomi Oreskes found that scientists have reached a consensus that global warming is real and that it is "anthropogenic" or human caused.

Richard W. Franke and Barbara H. Chasin
2/10/2014

ESSAY

BEYOND THE IVORY TOWER

This year's essay series highlights the benefits that scientists, science, and technology have brought to society throughout history.

The Scientific Consensus on Climate Change

Naomi Oreskes

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, "As [the report] went through review, there was less consensus on the science and conclusions on climate change" (*1*). Some corporations whose revenues 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 substantive disagreement in the scientific community about the reality of anthropogenic climate change. This is not the case.

Without substantial disagreement, scientists find human activities are heating the Earth's surface.

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 over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations" [p. 21 in (*4*)].

IPCC is not alone in its conclusions. In recent years, all major scientific bodies in the United States whose members' expertise bears 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. 3 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 societies' members. Nevertheless, they might downplay legitimate dissenting opinions. That hypothesis was tested by analyzing 928 abstracts, published in refereed scientific journals between 1993 and 2003, 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 proposals, methods, paleoclimate 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 paleoclimate, taking no 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, economists, journalists, and others may have the impression of confusion, disagreement, or discord 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 our grandchildren will surely blame us if they find that we understood 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 what to do about 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.

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References and Notes

1. A. C. Revkin, K. Q. Seelye, *New York Times*, 19 June 2003, A1.
2. S. van den Hove, M. Le Menestrel, H.-C. de Bettignies, *Climate Policy* **2** (1), 3 (2003).
3. See www.ipcc.ch/about/about.htm.
4. J. J. McCarthy *et al.*, Eds., *Climate Change 2001: Impacts, Adaptation, and Vulnerability* (Cambridge Univ. Press, Cambridge, 2001).
5. National Academy of Sciences Committee on the Science of Climate Change, *Climate Change Science: An Analysis of Some Key Questions* (National Academy Press, Washington, DC, 2001).
6. American Meteorological Society, *Bull. Am. Meteorol. Soc.* **84**, 508 (2003).
7. American Geophysical Union, *Eos* **84** (51), 574 (2003).
8. See www.ourplanet.com/aaas/pages/atmos02.html.
9. The first year for which the database consistently published abstracts was 1993. Some abstracts were deleted from our analysis because, although the authors had put "climate change" in their key words, the paper was not about climate change.
10. This essay is excerpted from the 2004 George Sarton Memorial Lecture, "Consensus in science: How do we know we're not wrong," presented at the AAAS meeting on 13 February 2004. I am grateful to AAAS and the History of Science Society for their support of this lectureship; to my research assistants S. Luis and G. Law; and to D. C. Agnew, K. Belitz, J. R. Fleming, M. T. Greene, H. Leifert, and R. C. J. Somerville for helpful discussions.

10.1126/science.1103618

Global Warming is Caused By People

Not one of the 928 peer reviewed articles published between 1993 and 2003 disagree with the consensus position.

Naomi. Oreskes, Science 2004

The Denial Industry

Even so, each year the "Heartland Institute" sponsors conferences attacking the scientific consensus

IONAL THURSDAY, MARCH 5, 2009 N A21

INTERNATIONAL CONFERENCE ON CLIMATE CHANGE

MARCH 8 - 10, 2009 · NEW YORK CITY

Is the global warming crisis over? Was it ever really a crisis? Tens of thousands of scientists now say the media and environmental advocacy groups have it all wrong, that global warming is not a crisis. They point to a cooling trend in global temperatures since 2000, past warming and cooling cycles that were not man-made, and new evidence that carbon dioxide is not a very powerful greenhouse gas.

On March 8-10, 2009, the 2009 International Conference on Climate Change will provide a platform for scientists and policy analysts from around the world who question the theory that global warming is a crisis.

For more information about this exciting conference or to register online, please visit www.heartland.org or www.globalwarmingheartland.org, or call 312/377-4000. Audio and video recordings of presentations made at the 2008 International Conference on Climate Change are also available online at both Web sites.

KEYNOTE SPEAKERS

Vaclav Klaus, President Czech Republic European Union

Richard S. Lindzen, Ph.D. One of the world's most respected atmospheric physicists

Harrison "Jack" Schmitt, Ph.D. Former U.S. Senator Apollo 17 Moonwalker

Nir Shaviv, Ph.D. A world-renowned scientist studying astrophysics and climate change

Willie Soon, Ph.D. A physicist at the Harvard-Smithsonian Center for Astrophysics

73 CONFERENCE SPEAKERS, INCLUDING:

J. Scott Armstrong, Ph.D. University of Pennsylvania

Syun Akasofu, Ph.D. University of Alaska Fairbanks

Frank Clemente, Ph.D. Penn State University

David Douglass, Ph.D. University of Rochester

Christopher Essex, Ph.D. University of Western Ontario (Canada)

Michaelle Fess, Ph.D. University of Texas, Center for Energy Economics

William Gray, Ph.D. Colorado State University

Fred Goldberg, Ph.D. Royal School of Technology (Sweden)

Kesten Green, Ph.D. Monash University (Australia)

Craig Idso, Ph.D. Center for the Study of Carbon Dioxide and Global Change

David Legates, Ph.D. University of Delaware

Joy Lehr, Ph.D. Science Director The Heartland Institute

Ross McKitrick, Ph.D. University of Guelph (Canada)

Patrick Michaels, Ph.D. Senior Fellow Cato Institute

Lord Christopher Monckton Former advisor, Prime Minister Thatcher

Jim O'Brien, Ph.D. Florida State University

Tim Patterson, Ph.D. Carleton University (Canada)

Benny Peiser, Ph.D. Liverpool John Moores University (United Kingdom)

Arthur B. Robinson, Ph.D. Oregon Institute of Science and Medicine

S. Fred Singer, Ph.D. Science and Environmental Policy Project

Lawrence Solomon Canadian environmentalist and author of *The Deniers*

COSPONSORING ORGANIZATIONS (PARTIAL LIST)

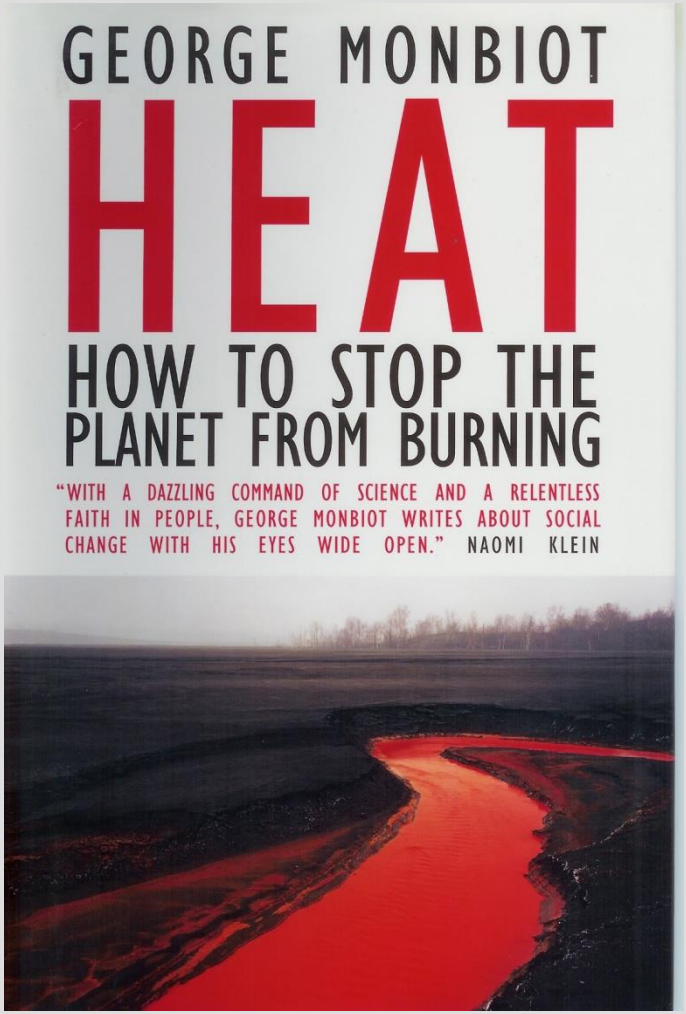
Accuracy in Media
Alternate Solutions Institute
American Policy Center
Americans For Prosperity
Atlas Economic Research Foundation
Australian Libertarian Society
Business & Media Institute
Carbon Sense Coalition
Cascade Policy Institute
Center for the Study of Carbon Dioxide and Global Change
Climate Strategies Watch
Committee for a Constructive Tomorrow
Competitive Enterprise Institute
Cornwall Alliance
Freedom Foundation of Minnesota
Frontiers of Freedom
The Heritage Foundation
International Climate and Environmental Change Assessment Project
Initiative for Public Policy Analysis (Nigeria)
Institute for Private Enterprise
Institute of Public Affairs (Australia)
Instituto Liberdade
International Climate Science Coalition (New Zealand)
Istituto Bruno Leoni
John Locke Foundation
Liberty Institute (India)
Mannkal Economic Education Foundation
Minimal Government Thinkers (Phillipines)
Oregon Institute of Science and Medicine
Science and Environmental Policy Project
Science and Public Policy Institute

GLOBAL WARMING WAS IT EVER REALLY A CRISIS?

More than 34,000 scientists have signed a petition saying global warming probably is natural and not a crisis. See the complete list at www.oism.org/pproject.

For more information about global warming, visit www.globalwarmingheartland.org.

The Heartland INSTITUTE WWW.HEARTLAND.ORG



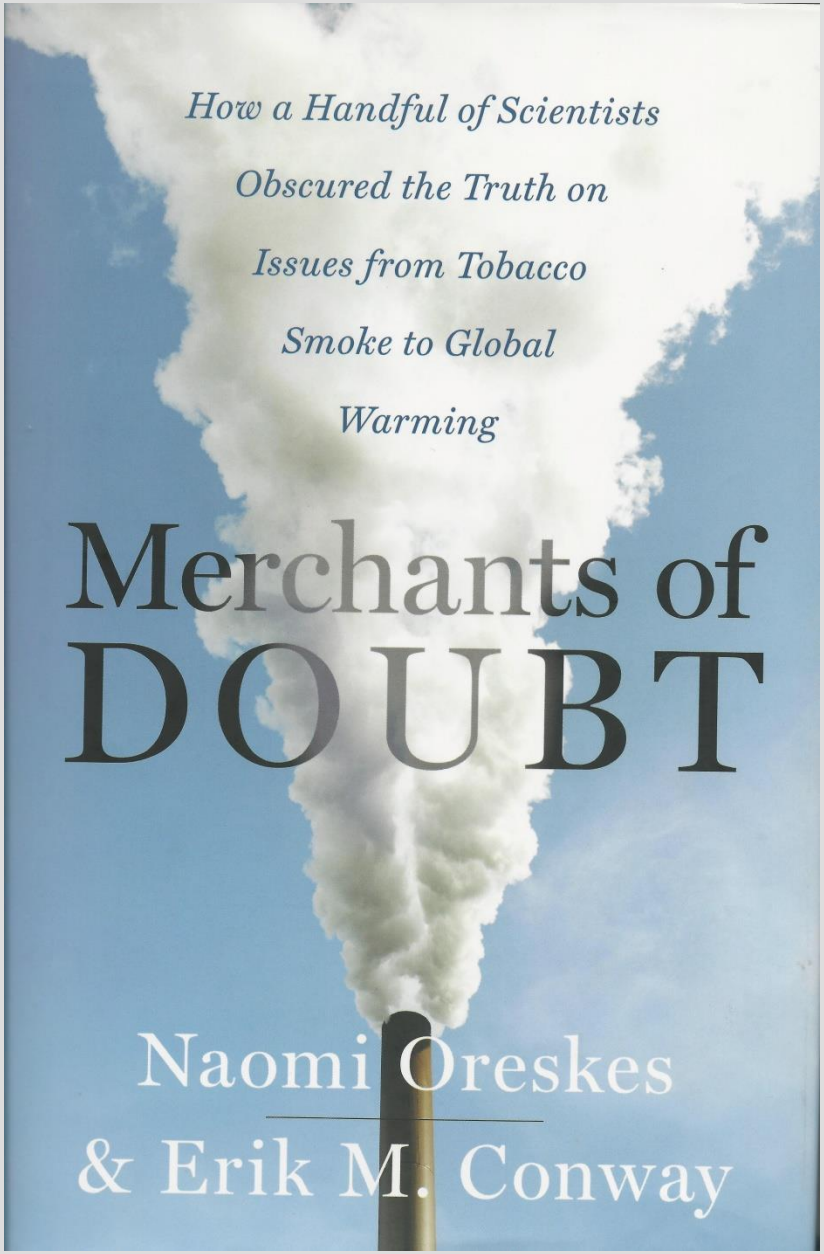
The Denial Industry

British journalist and environment watcher George Monbiot calls this the "denial industry."

(This entire book is also a good and readable introduction to most of the issues involved in global warming and climate change.)

The Denial Industry

Oreskes and colleague Eric Conway call the deniers *Merchants of Doubt* in their 2010 book of that title.



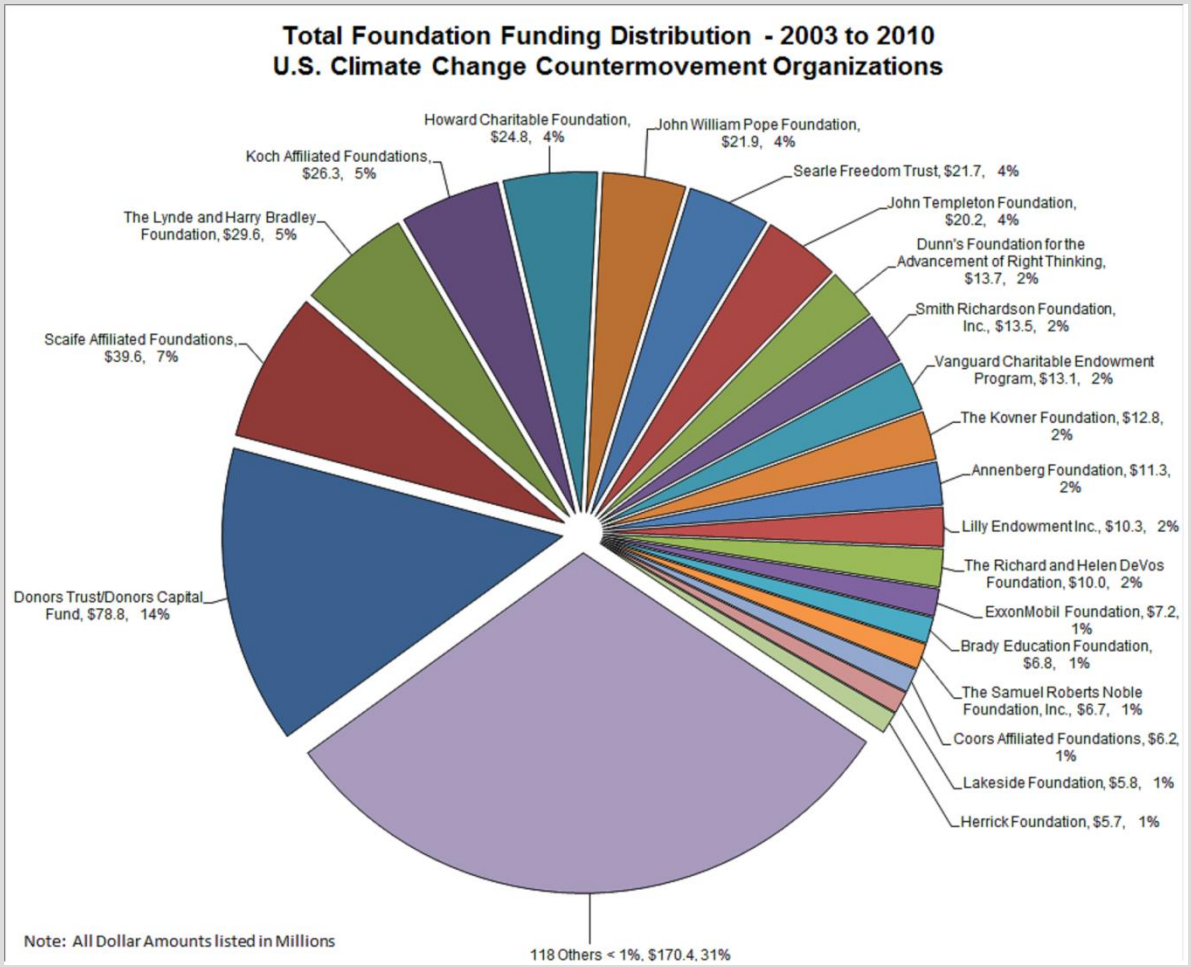
The Denial Industry

Many of the deniers and doubters have received substantial corporate backing for their activities – often via right wing family foundations…

The Denial Industry

…as Drexel University Professor Robert Brulle has shown…

Source: http://drexel.edu/now/news-media/releases/archive/2013/December/Climate-Change/



The Scientific Consensus

But the consensus remains that…

The Scientific Consensus

Global warming and climate change result from human activities such as the burning of fossil fuels, and some related developments…

The Scientific Consensus

…including the invention of mass artificial fertilizer, deforestation, the spread of cattle, and several "positive feedbacks" resulting from the main causes…

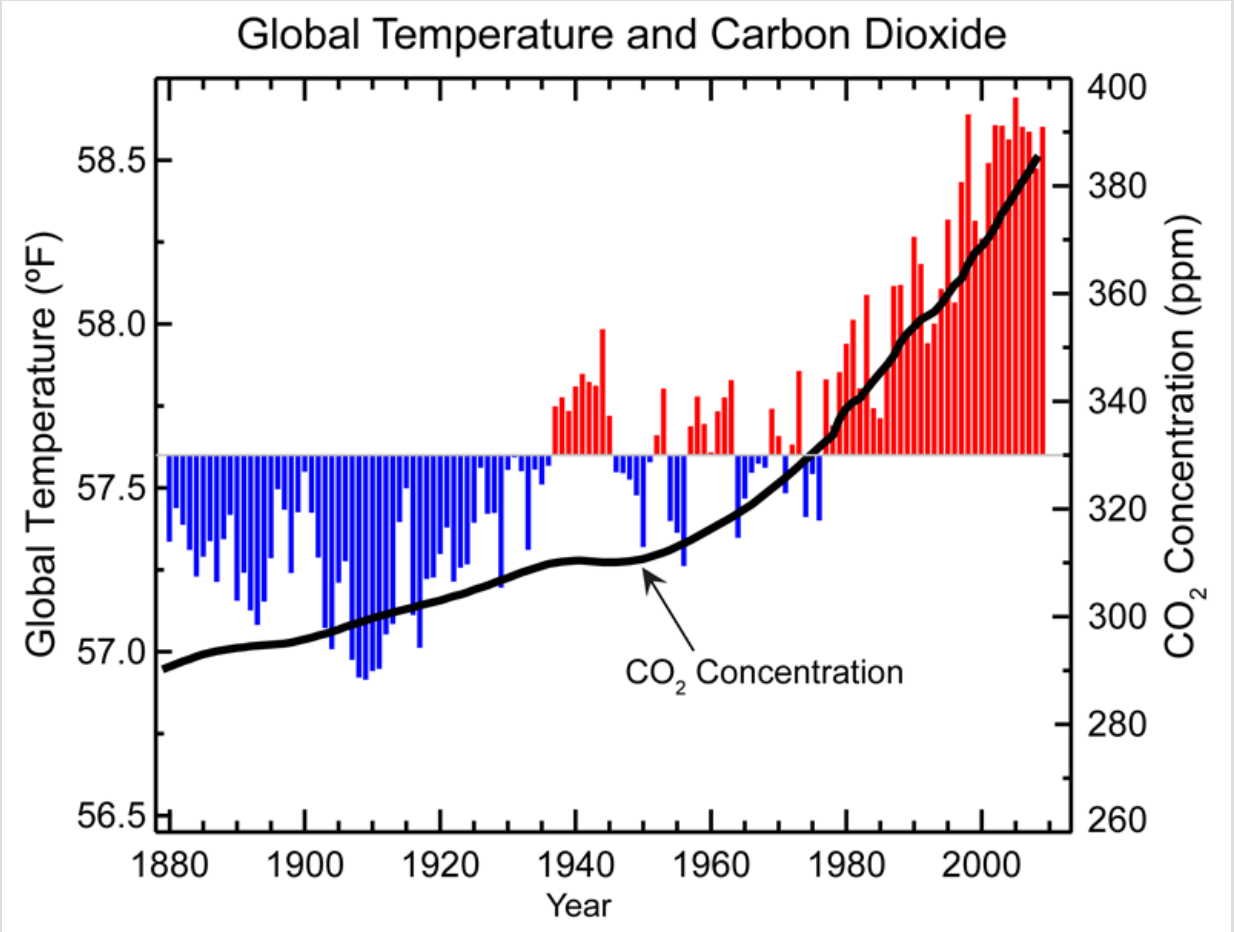
CO_2

The single most important factor is the burning of the fossil fuels coal and oil which result in huge increases in the amount of CO_2 (carbon dioxide) in the atmosphere.

CO_2

Note how closely the pattern of temperature increases follows the line of increases in the concentration of CO_2

Source: http://www1.ncdc.noaa.gov/pub/data/cmb/images/indicators/global-temp-and-co2-1880-2009.gif



CO_2

You may notice that from 1880 to about 1920 temperatures were below average even though CO_2 was increasing…some believe this resulted from unusual volcanic activity such as the gigantic Krakatoa volcanic eruption in Indonesia in 1883 that spewed ash into the atmosphere and cooled temperatures.

CO_2

In any case, the close association of CO_2 and temperature becomes definitive and pronounced after 1960.

Observations → Explanation

The scientific consensus is based on three main observations:

1. The statistical correlation of Co_2 and temperature is very strong, and;
2. There is a plausible anthropogenic mechanism to explain the statistics using CO_2 as the causal variable; and…
3. There is no known plausible alternative – non-anthropogenic mechanism.

Observations → Explanation

Here's the consensus explanation in a simple form…

****

[Want more detail and more scientific depth? Go to the Intergovernmental Panel on Climate Change 2014 Climate Change Update:]
http://www.greenfacts.org/en/climate-change-ar5-science-basis/index.htm?utm_medium=email&utm_campaign=2014-03-24-Newsletter&utm_content=2014-03-24-Newsletter+CID_61e16bfb29596c786b18030ae3c2de6d&utm_source=Newsletter&utm_term=Climate%20Change%202013%20The%20Physical%20Science%20Basis

Observations → Explanation

Earth's climate results from 3 main factors:

-The sun's energy output

-The earth's distance from and angle to the sun

-The mix of gases in the earth's atmosphere

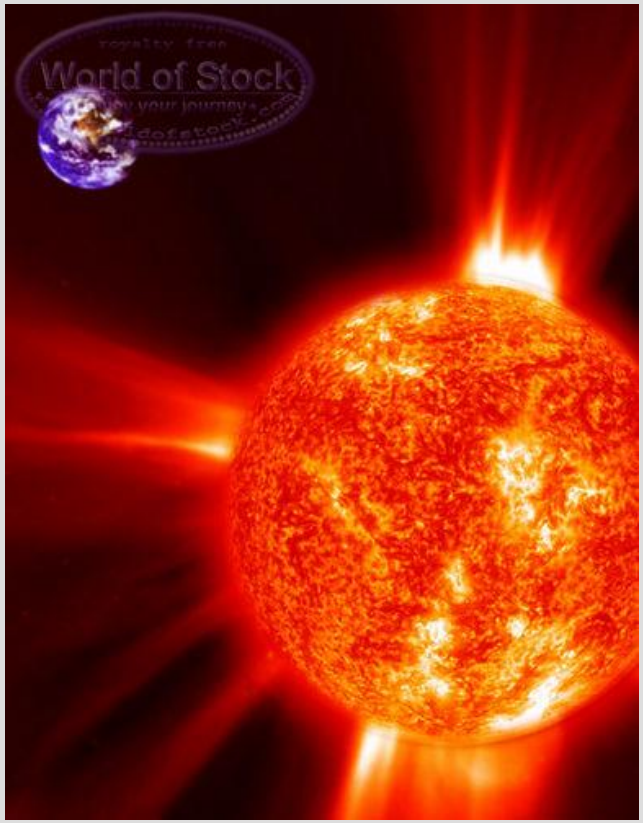
Observations → Explanation

In general, solar energy output can be considered constant…

****

Although – (footnote)

Gradually over the 4 billion years of life on earth heat from the sun has increased by about 25%. Yet – earth's temperature has oscillated within a fairly narrow range.



Sources: Capra, Fritjof. 1996. *The Web of Life: A New Scientific Understanding of Living Systems*. New York: Anchor Books. Page 102. Hansen, James. 2009. *Storms of My Grandchildren: The Truth About the Coming Climate Catastrophe and Our Last Chance to Save Humanity*. New York: Bloomsbury. Page 225.

Astronomy of Earth's Climate

Earth's distance from the sun and its angle of tilt are governed by three processes called "Milankovitch cycles" after a Serbian astronomer and mathematician who first described them.

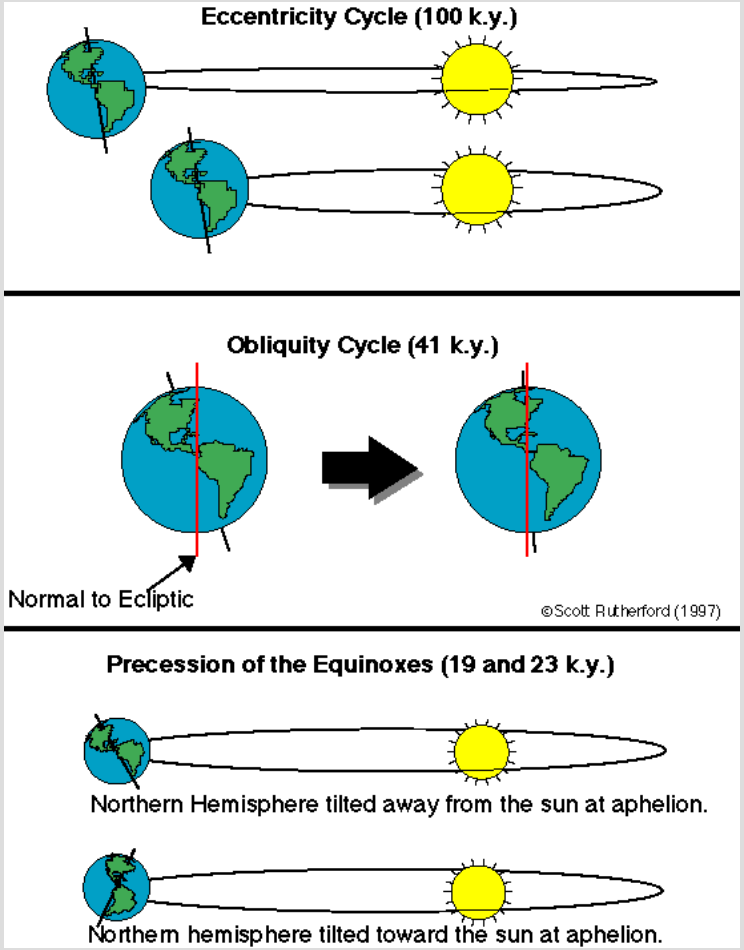
Astronomy of Earth's Climate

They operate over periods of

100 thousand yrs

41 thousand yrs, and

19–23 thousand yrs…

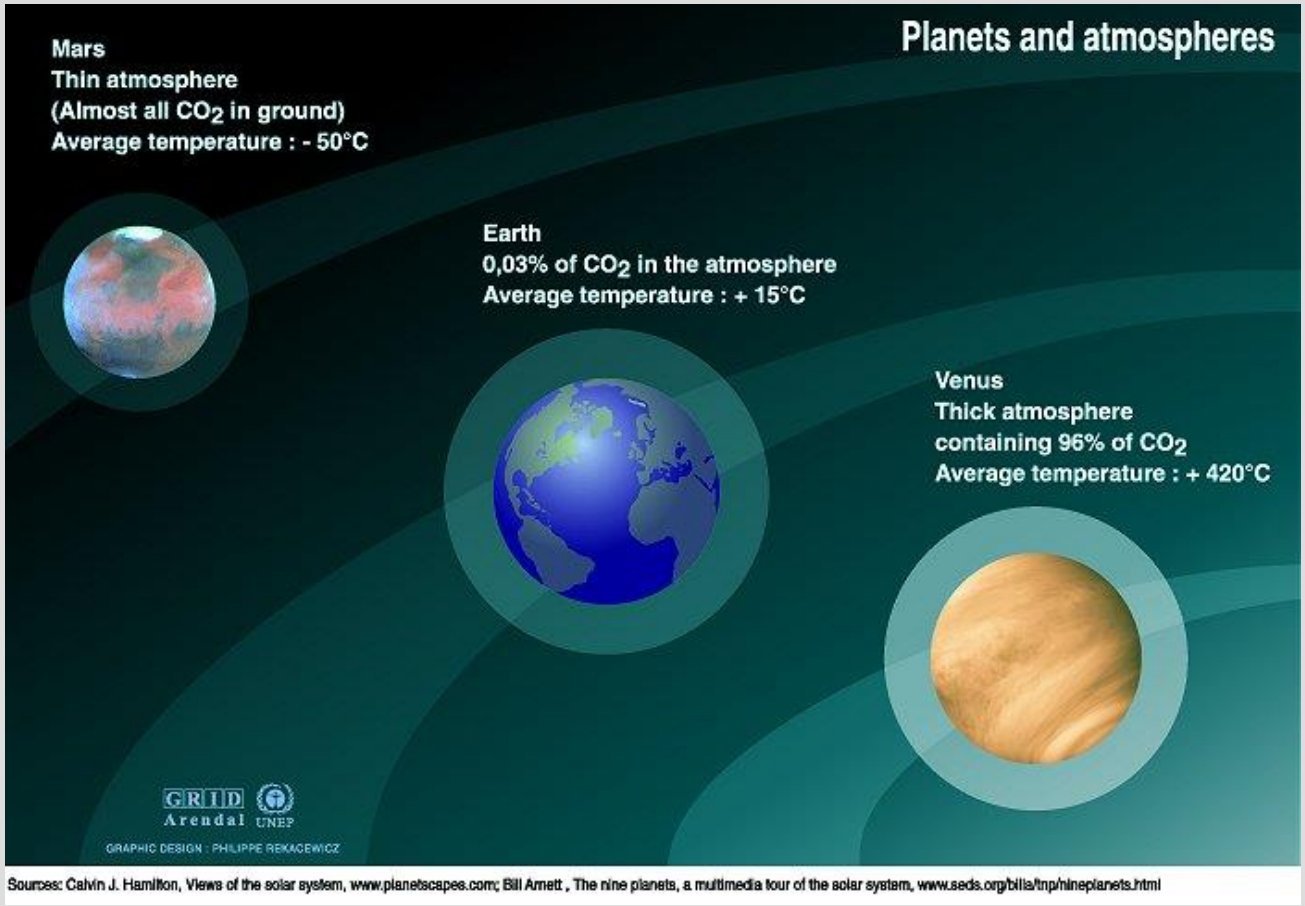


Astronomy of Earth's Climate

…and are thus possibly important for understanding long term ice ages and warming periods of the earth such as we saw in slides 19 and 20, but not the sudden rise in temperatures beginning in the 19th and 20th centuries

Earth's Atmosphere

This leaves the mix of gases in earth's atmosphere as the only likely mechanism to explain recent warming trends.

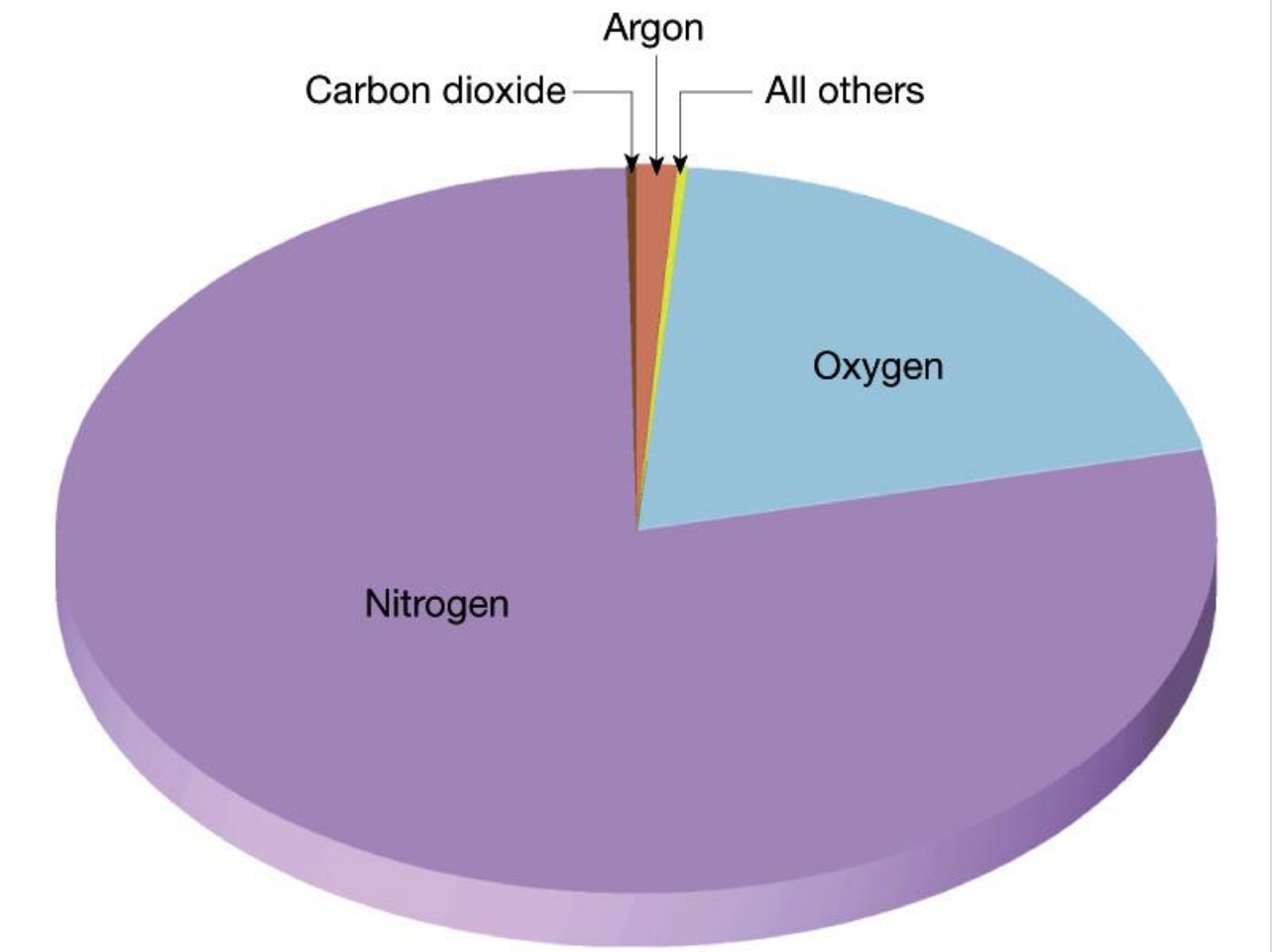


Earth's Atmosphere

Earth's atmosphere is unusual and so is its average temperature.

Earth's Atmosphere

Earth's atmosphere near the surface (up to about 18 km or 11 mi) is 78% nitrogen and 21% oxygen.

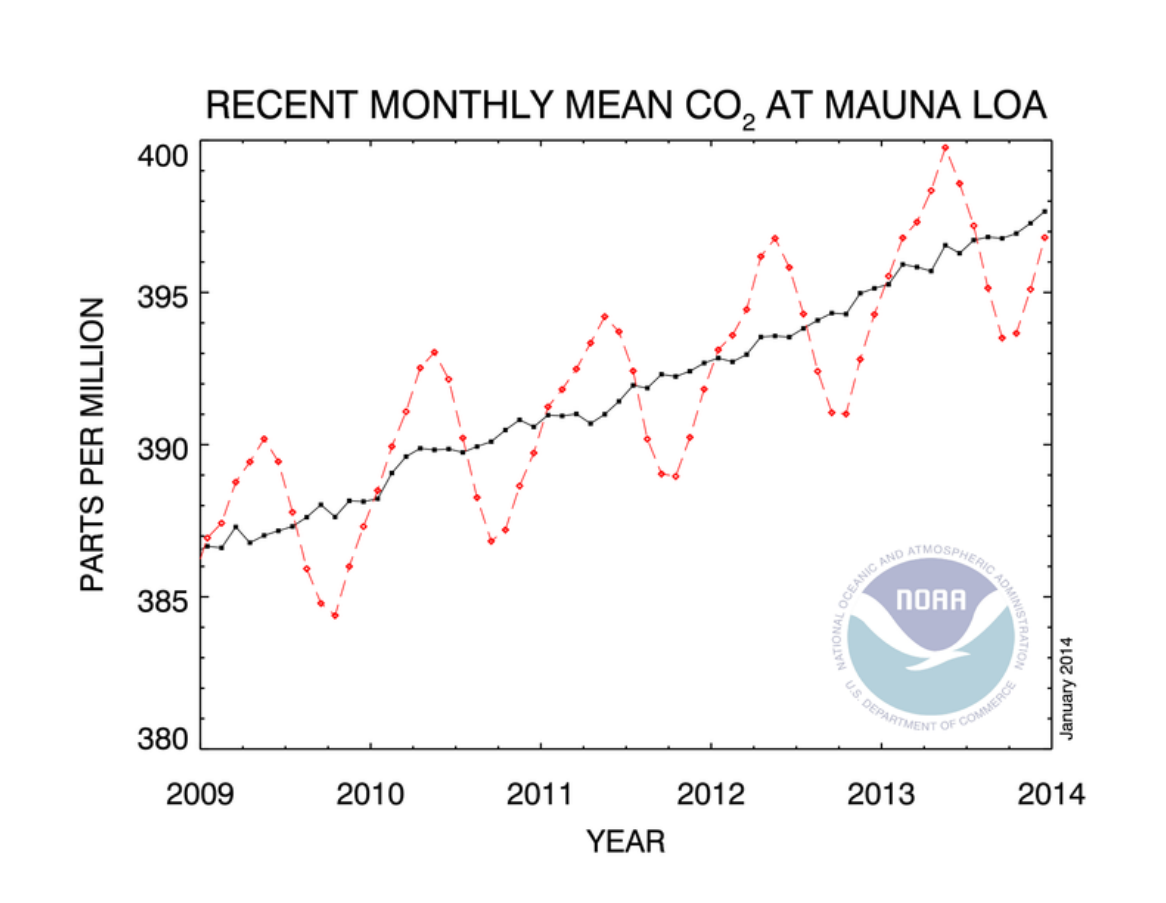


CO_2

Only 0.04% (≈ 400 parts per million) of the earth's lower atmosphere is carbon dioxide (CO_2), but that small trace amount appears to have a big impact on the earth's temperature.

The amount is going up regularly…

Footnote: The atmosphere of Venus is 97% CO_2 and the surface temp is 850˚ F.
Source: Hansen, James. 2009. *Storms of My Grandchildren: The Truth About the Coming Climate Catastrophe and Our Last Chance to Save Humanity*. New York: Bloomsbury. Page 225.



CO_2

CO_2 concentrations at Mauna Loa, Hawaii Research Station

Source:

http://www.esrl.noaa.gov/gmd/ccgg/trends/

2. Human Causes?

Before the industrial revolution

the CO_2 level was about

280 parts per million.

Greenhouse Effect

In 1859 the Irish scientist John Tyndall discovered that nitrogen and oxygen – the two most common gases in earth's atmosphere – were transparent to both visible and infrared radiation.

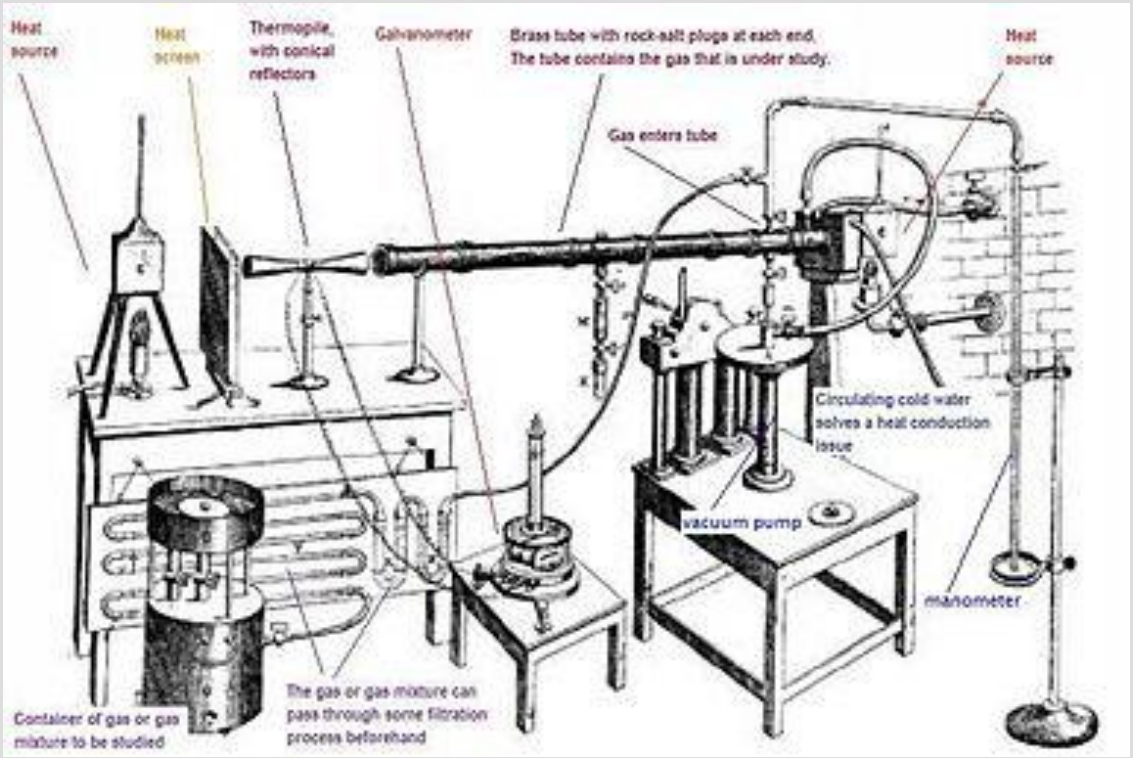
Greenhouse Effect

But water vapor – which occurs in varying amounts – and carbon dioxide – or CO_2 – were partly opaque to the infrared light energy

As heat bounces from the earth back towards space, the CO_2 bounces it back into earth's atmosphere.

Tyndall's lab →

Source: Wikipedia

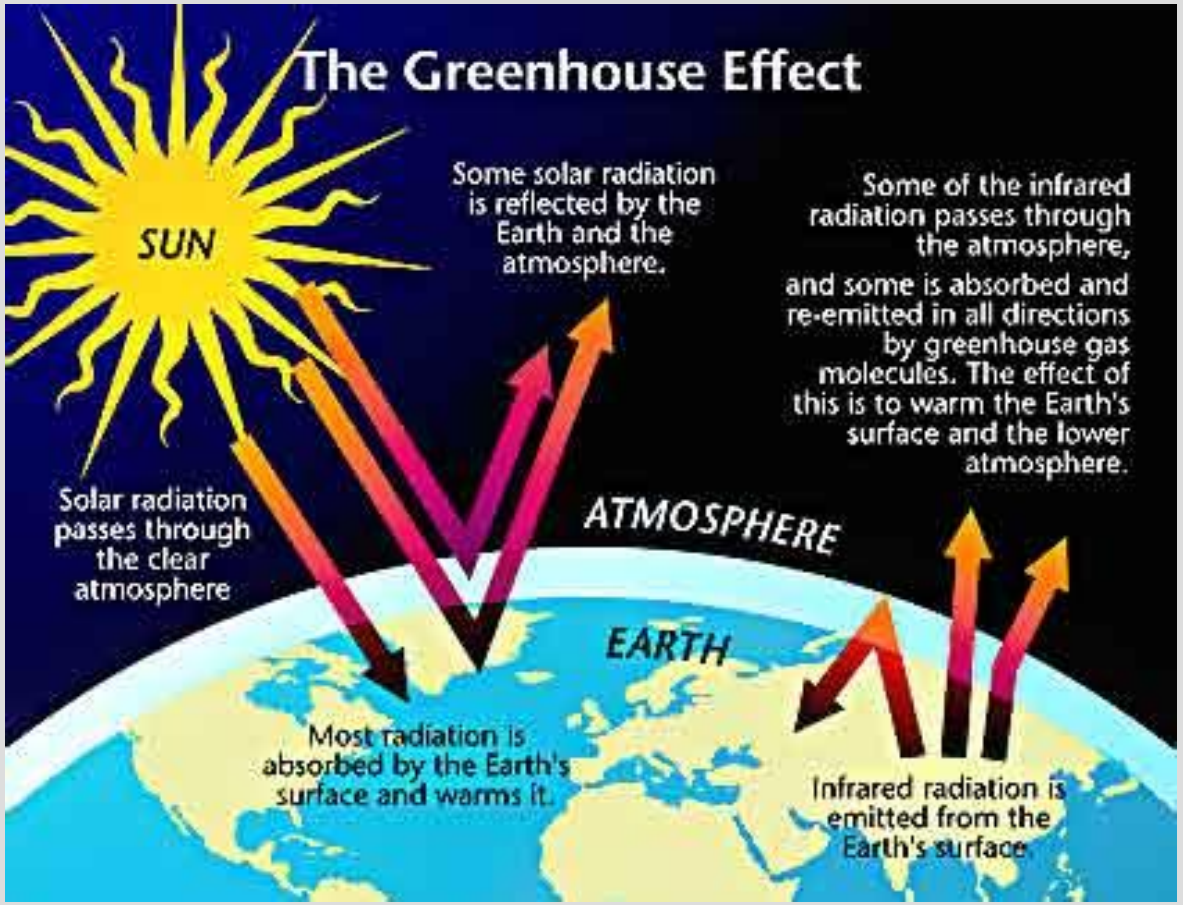


Greenhouse Effect

This is now known as the "natural greenhouse effect"

…and…

…even the pre-industrial era the 0.028% CO_2 in the atmosphere was enough to raise the avg temperature from near absolute zero to 57.2° F (or 14° C)



Greenhouse Effect

In 1894 a Swedish scientist named Svante Arrhenius made the first calculations of the relations between the amount of CO_2 , the refraction of infrared heat back to earth, and the earth's temperature. His predictions were pretty close to those of modern scientists, but…

Greenhouse Effect

…Arrhenius thought global warming would take 3,000 years to have much effect because he believed – incorrectly it appears – that the oceans would absorb most of the excess CO_2 being emitted from the coal burning furnaces of the industrial revolution.

Source: Materials on Tyndall and Arrhenius from Kolbert, Elizabeth. 2006. *Field Notes from a Catastrophe: Man, Nature, and Climate Change*. New York: Bloomsbury Publishing. Esp. pp. 35–42.

The Keeling Curve

Arrhenius's 3,000 year period of adjustment led to a drop in scientific and policy interest in global warming until 1959 when the American scientist Charles Keeling made a startling and unexpected discovery…

2. Human Causes?

Keeling began measuring CO_2 levels for "fun" at 11,000 ft above sea level at Mauna Loa, Hawaii. He discovered two astonishing facts:

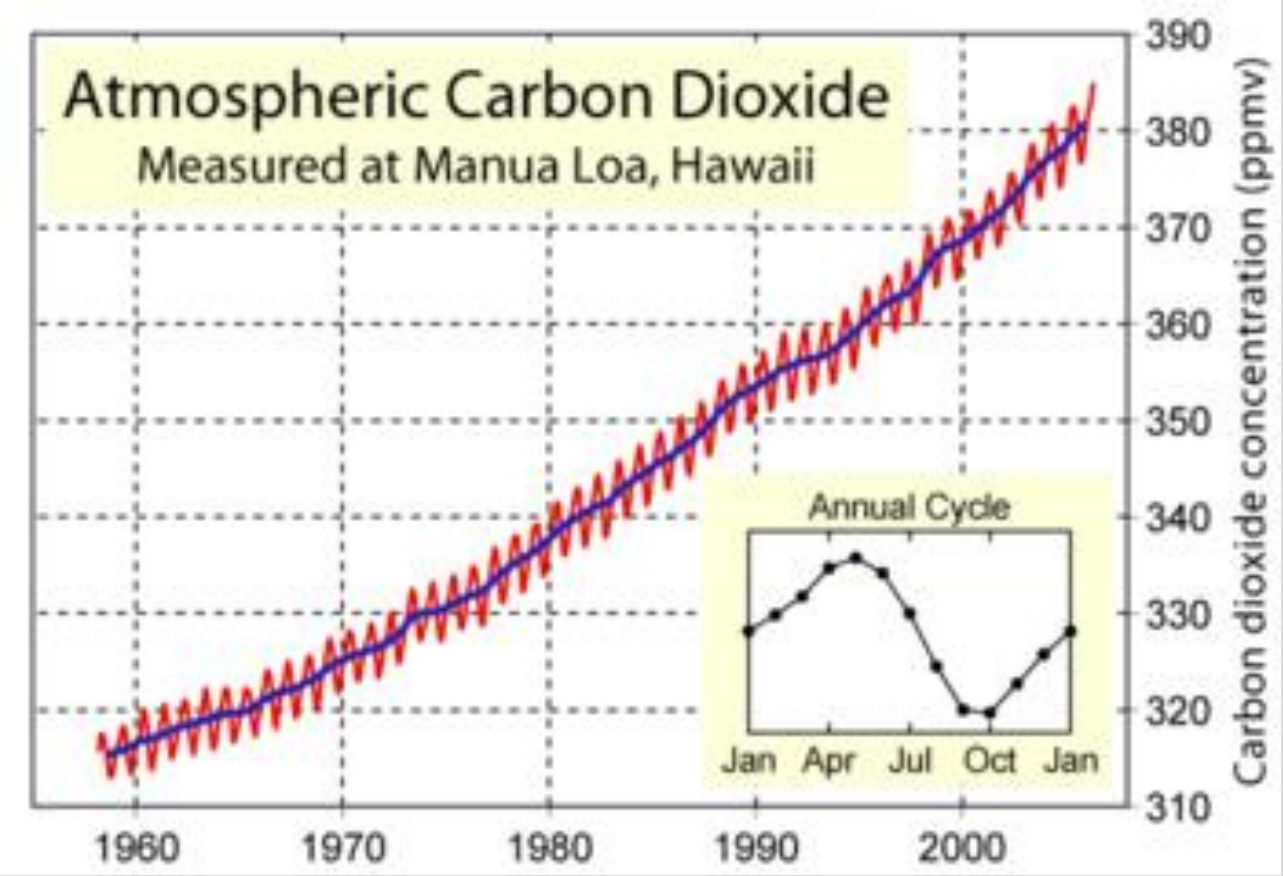
-CO_2 levels go up in winter and down in the summers of the Northern Hemisphere. This is where most of the worlds deciduous forests are found and the tree leaves pull up the carbon in summer taking it out of the atmosphere and putting it back in winter when their leaves fall off.

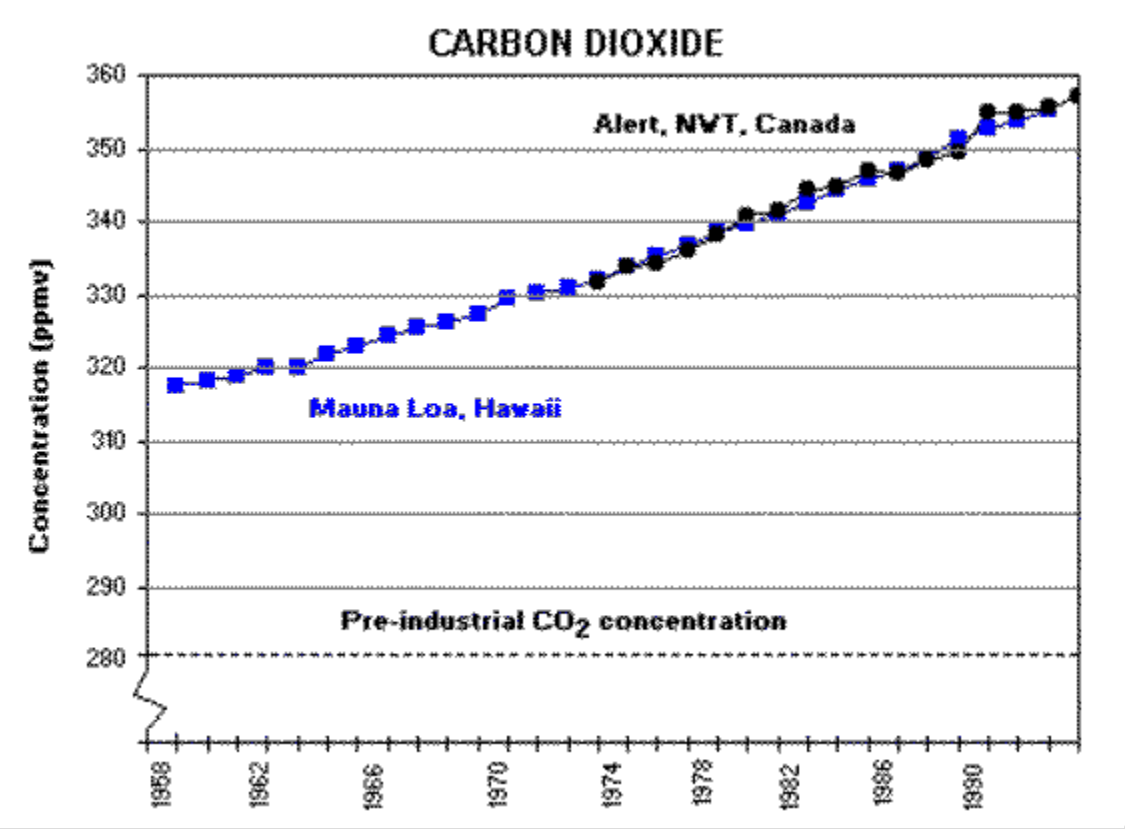
2. Human Causes?

Keeling's other discovery was that overall levels of CO_2 were rising steadily year after year. No known process of nature was evident to explain this.

Keeling's findings are now known as the "Keeling Curve," and are among the most famous discoveries of modern science.

The Keeling Curve

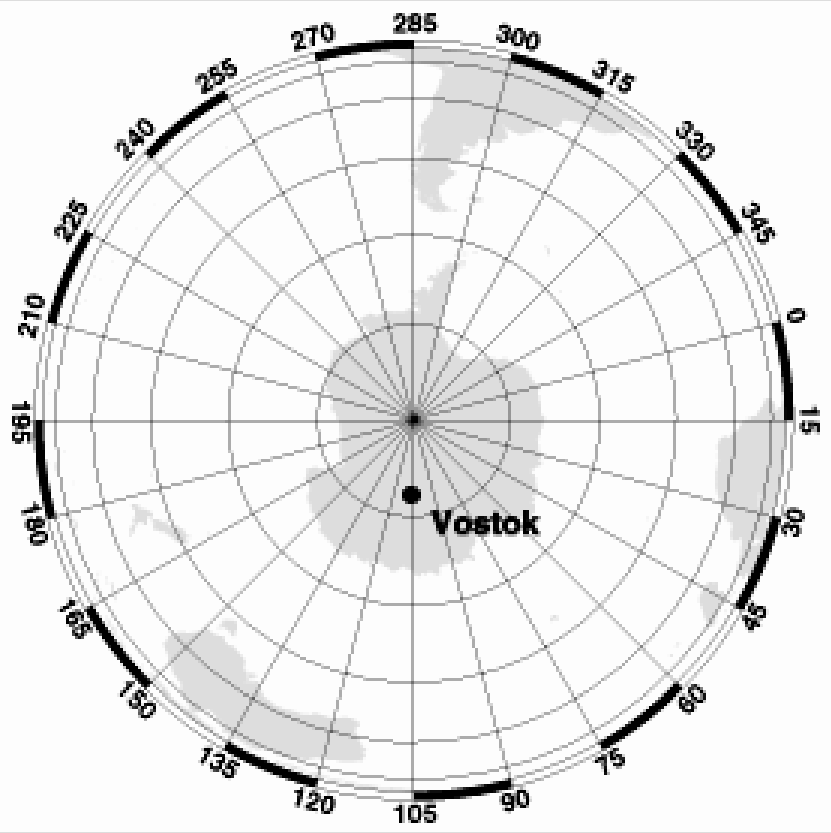




The Keeling Curve

superimposed on pre-industrial CO_2 concentrations

← Pre-industrial level of 280 ppm



Learning from Antarctica

More recently, ice cores from the Vostok station in Antarctica have allowed scientists to measure the amount of CO_2 in the atmosphere for hundreds of thousands of years.

Learning from Antarctica

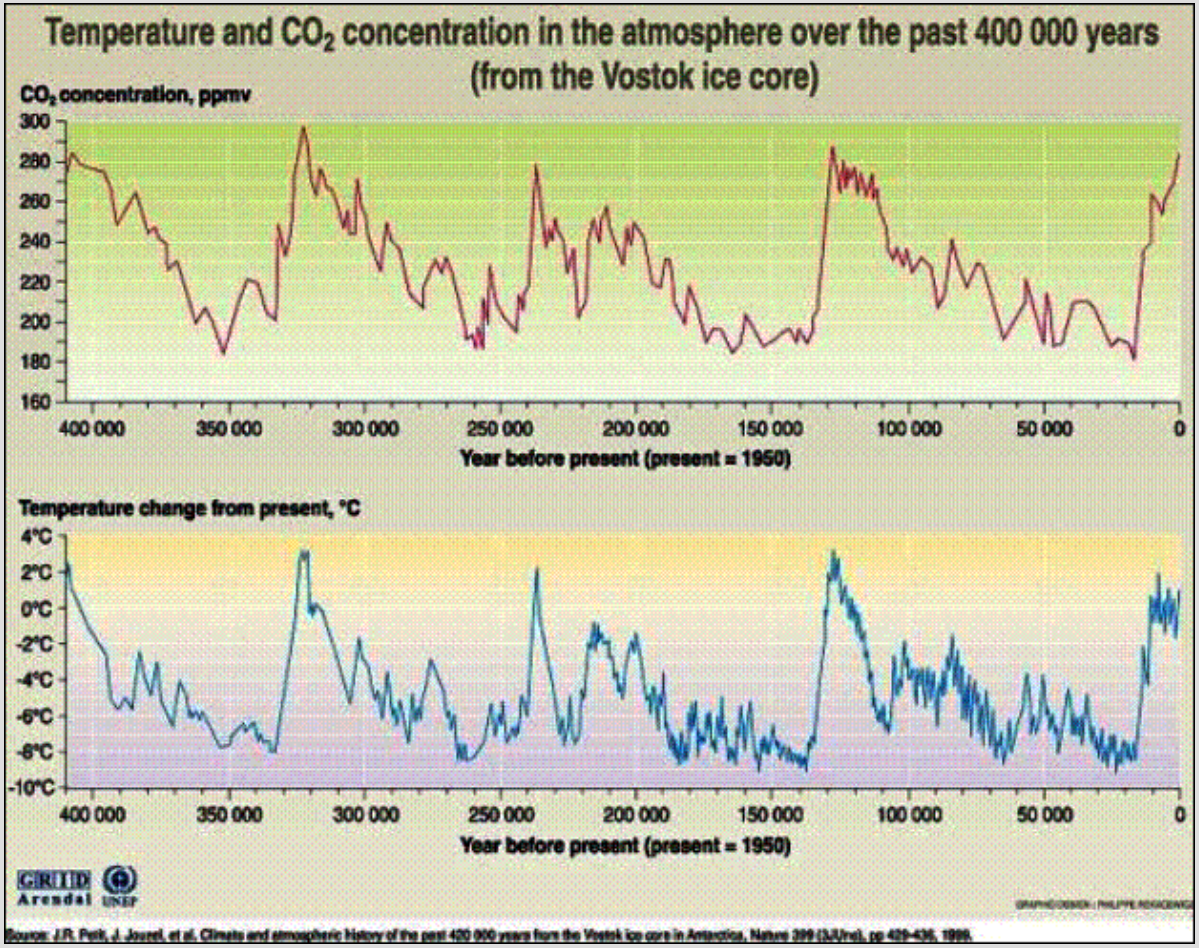
Ice cores capture the concentration of atmospheric gases as bubbles in ice that accumulates at the coldest parts of the earth such as Antarctica.

Learning from Antarctica

These sites are presumed to have been free of human interference until the very last few years.

Learning from Antarctica

The Vostok core shows that CO_2 has gone up and down in cycles that exactly match the ice ages (down) and "inter-glacials" or warm periods (up).



Source: Same as Slide 19

ESSAY

BEYOND THE IVORY TOWER

The Scientific Consensus on Climate Change

Naomi Oreskes

This year's essay series highlights the benefits that scientists, science, and technology have brought to society throughout history.

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, "As [the report] went through review, there was less consensus on the science and conclusions on climate change" (*1*). Some corporations whose revenues 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 substantive disagreement in the scientific community about the reality of anthropogenic climate change. This is not the case.

Without substantial disagreement, scientists find human activities are heating the Earth's surface.

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 over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations" [p. 21 in (*4*)].

IPCC is not alone in its conclusions. In recent years, all major scientific bodies in the United States whose members' expertise bears 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. 3 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 societies' members. Nevertheless, they might downplay legitimate dissenting opinions. That hypothesis was tested by analyzing 928 abstracts, published in refereed scientific journals between 1993 and 2003, 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 proposals, methods, paleoclimate 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 paleoclimate, taking no 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, economists, journalists, and others may have the impression of confusion, disagreement, or discord 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 our grandchildren will surely blame us if they find that we understood 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 what to do about 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.

The author is in the Department of History and Science Studies Program, University of California at San Diego, La Jolla, CA 92093, USA. E-mail: noreskes@ucsd.edu

References and Notes

1. A. C. Revkin, K. Q. Seelye, *New York Times*, 19 June 2003, A1.
2. S. van den Hove, M. Le Menestrel, H.-C. de Bettignies, *Climate Policy* **2** (1), 3 (2003).
3. See www.ipcc.ch/about/about.htm.
4. J. J. McCarthy *et al.*, Eds., *Climate Change 2001: Impacts, Adaptation, and Vulnerability* (Cambridge Univ. Press, Cambridge, 2001).
5. National Academy of Sciences Committee on the Science of Climate Change, *Climate Change Science: An Analysis of Some Key Questions* (National Academy Press, Washington, DC, 2001).
6. American Meteorological Society, *Bull. Am. Meteorol. Soc.* **84**, 508 (2003).
7. American Geophysical Union, *Eos* **84** (51), 574 (2003).
8. See www.ourplanet.com/aaas/pages/atmos02.html.
9. The first year for which the database consistently published abstracts was 1993. Some abstracts were deleted from our analysis because, although the authors had put "climate change" in their key words, the paper was not about climate change.
10. This essay is excerpted from the 2004 George Sarton Memorial Lecture, "Consensus in science: How do we know we're not wrong," presented at the AAAS meeting on 13 February 2004. I am grateful to AAAS and the History of Science Society for their support of this lectureship; to my research assistants S. Luis and G. Law; and to D. C. Agnew, K. Belitz, J. R. Fleming, M. T. Greene, H. Leifert, and R. C. J. Somerville for helpful discussions.

10.1126/science.1103618

A Reminder

The various findings lead scientists to the only plausible conclusion: that human activities in burning fossil fuels – and perhaps other activities that raise CO_2 levels in the lower atmosphere – are beginning to push up temperatures.

Human Causes?

Human-induced* greenhouse effect

*anthropogenic

Fossil Fuels

You can watch an animated film of the natural and anthropogenic greenhouse effects at:

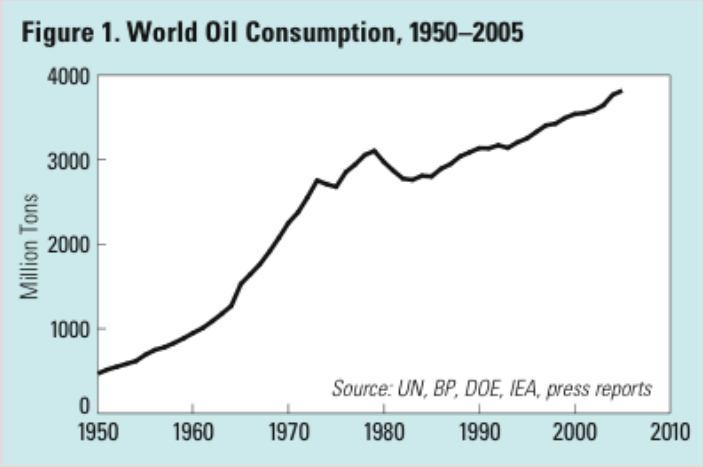
http://earthguide.ucsd.edu/earthguide/diagrams/greenhouse/

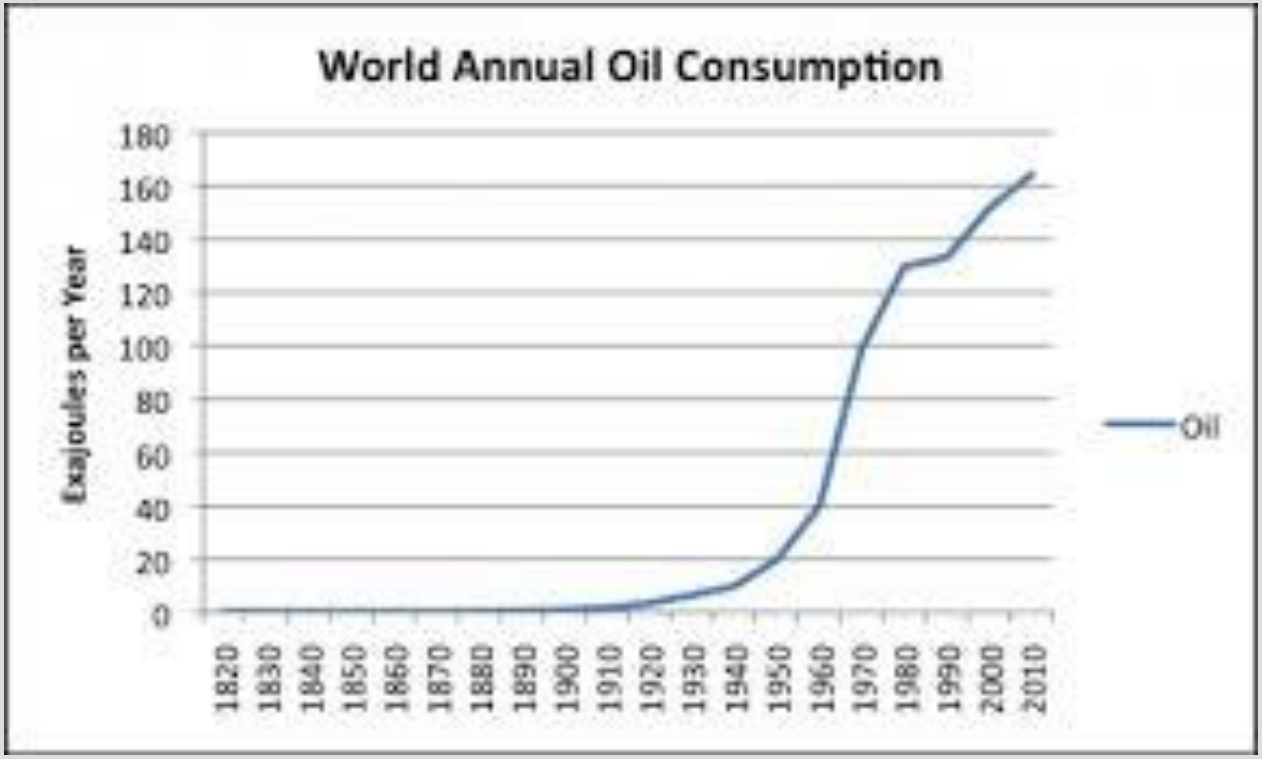
Fossil Fuels

Anthropogenic greenhouse effect – one major contributor is fossil fuel use.

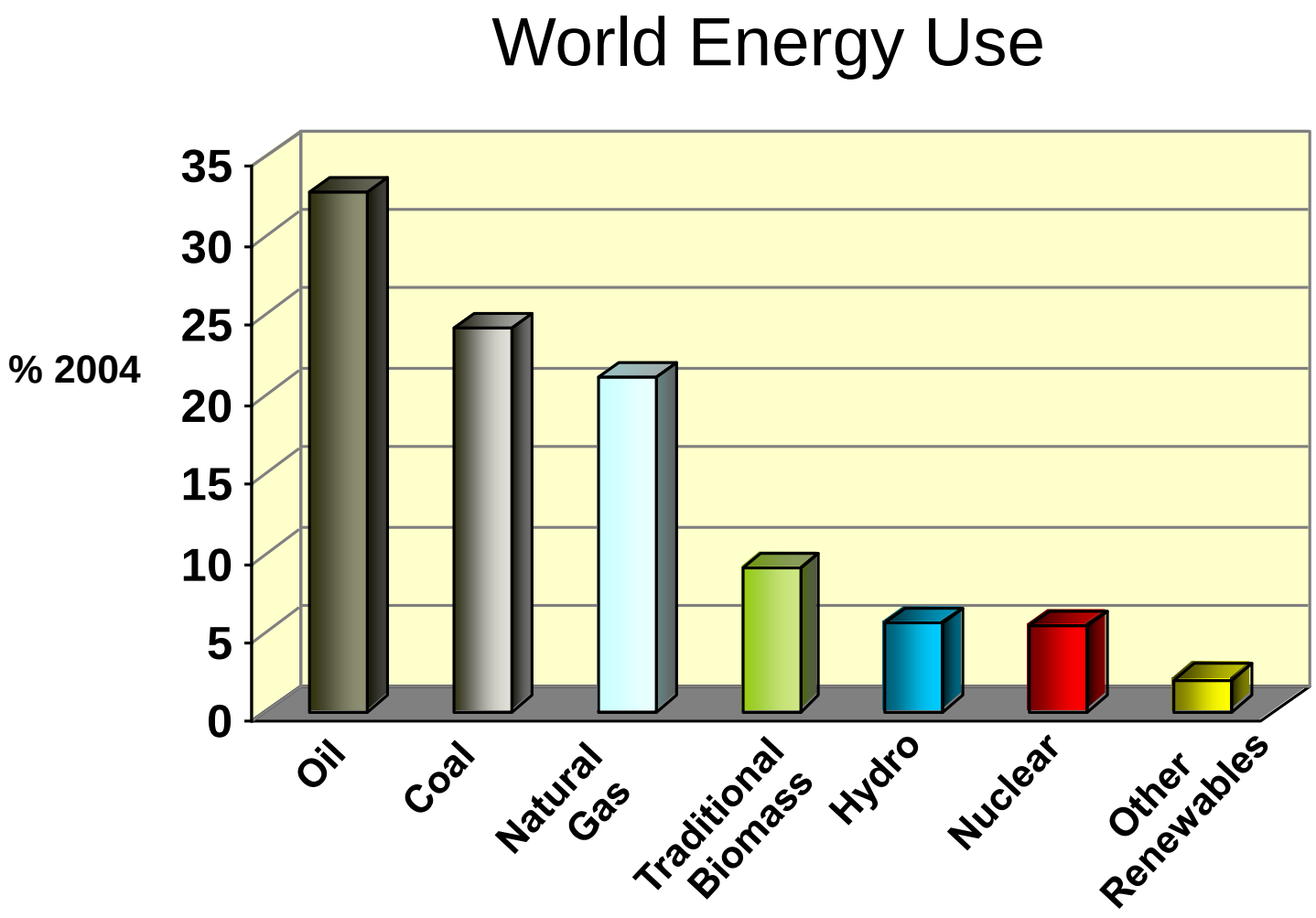
Puts 5.5 billion lbs of CO_2 into the atmosphere each year.

Source: for graph to right
http://rethinksurvival.com/posts/the-charts-dont-lie-somethings-got-to-give/



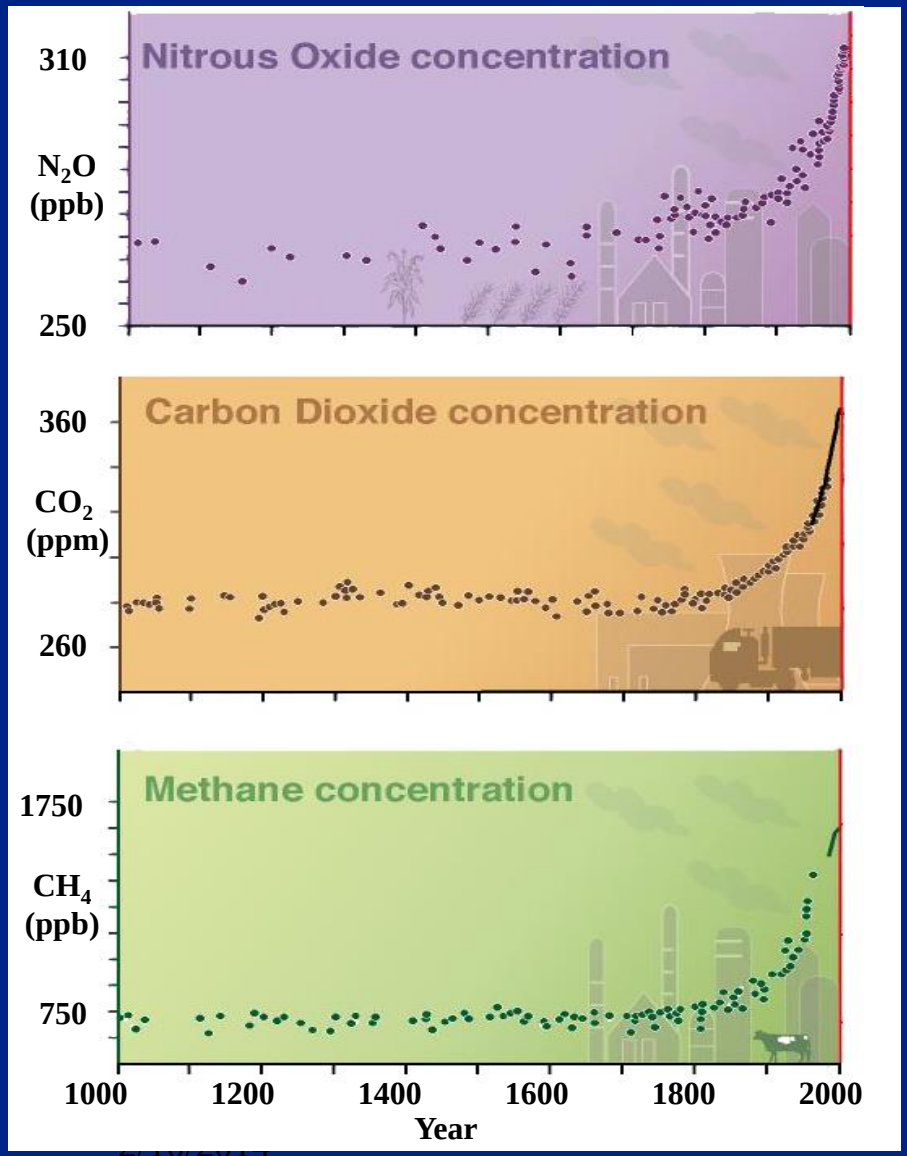


Fossil Fuels Still Dominate



Source: Martinot, BP

Methane and Nitrous Oxide add to Greenhouse Effect



Data from www.ipcc.ch

Richard W. Franke and Barbara H. Chasin

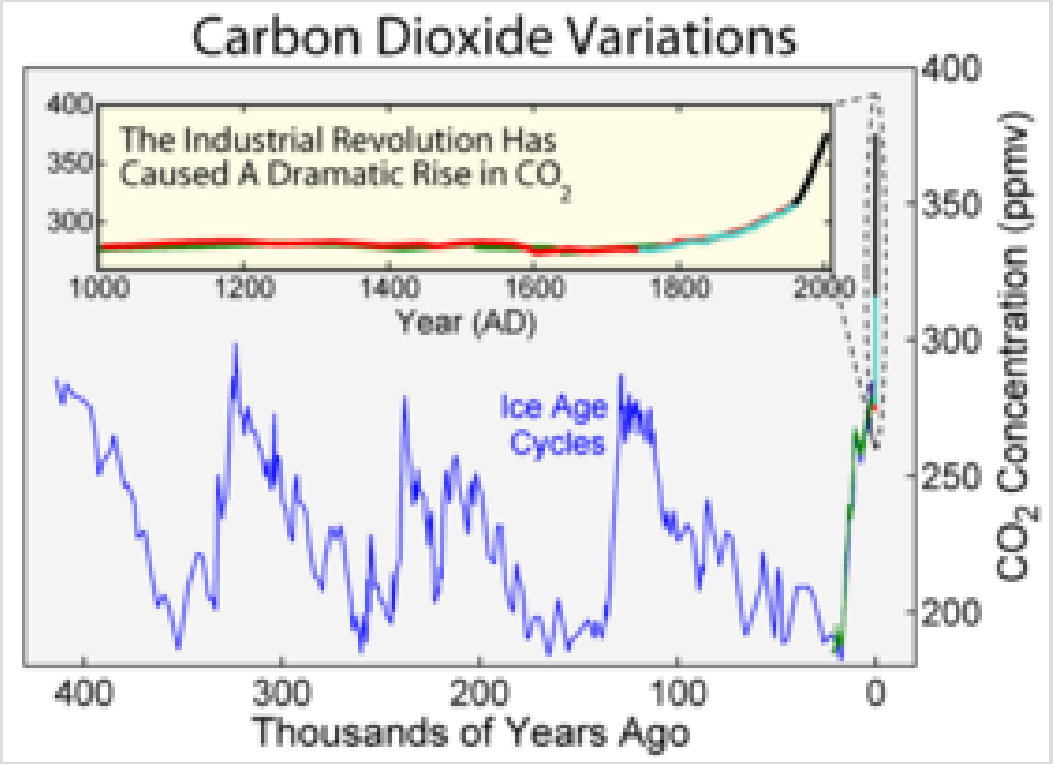
Photograph: http://www.maricopa.gov/envsvc/PHOTOS/carpollution.jpg

Human Causes?

(Unfortunately) …**There's more…**

Why Worry?

The Vostok core combines with the Keeling curve to reveal three worrisome apparent relationships:



Why Worry?

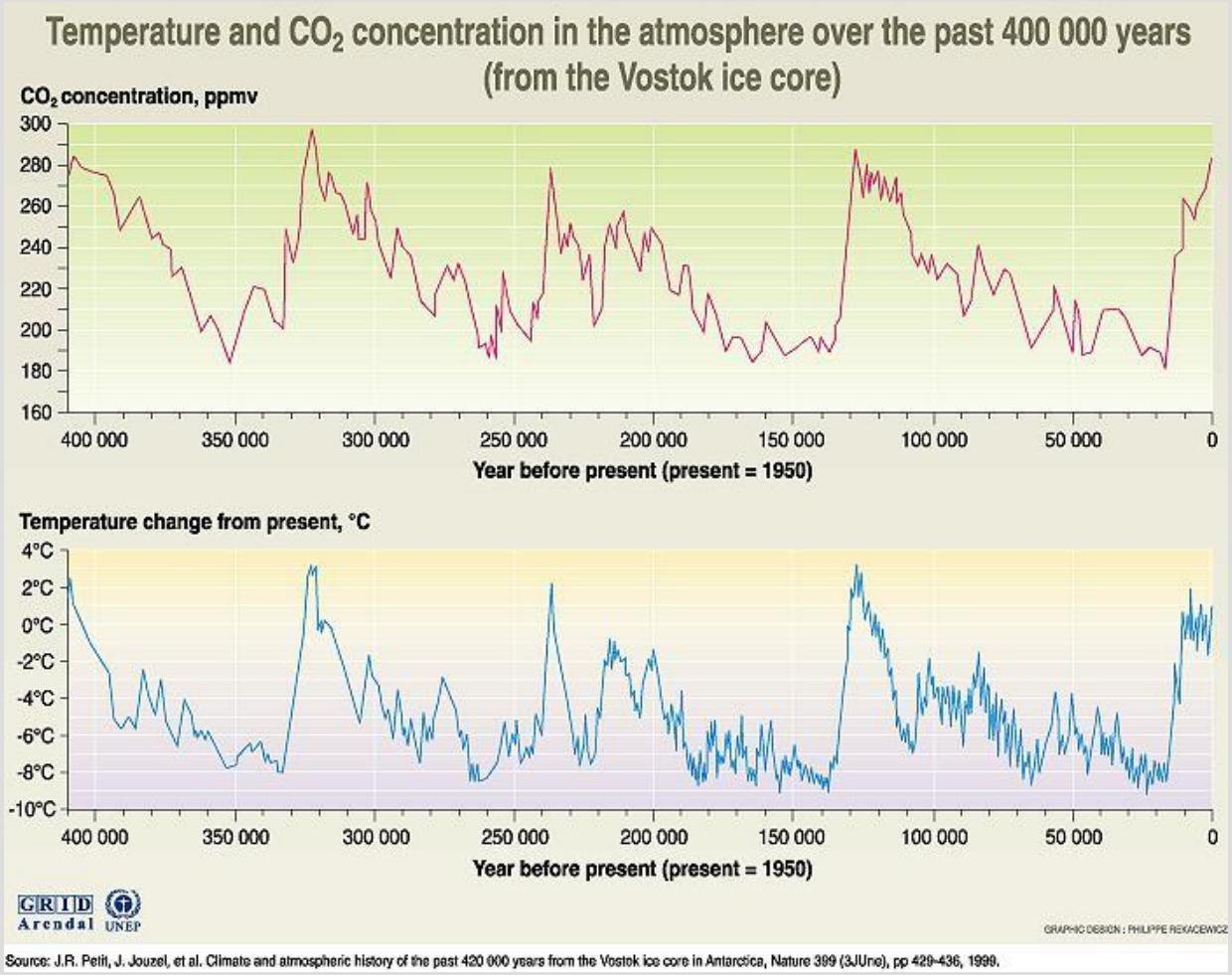
1. Increasing CO_2 levels associate with rising temperatures and almost certainly cause them – recall the discoveries by Tyndall and Arrhenius.

2. "Unnatural" increases of CO_2 have been occurring since the beginning of the industrial revolution with the burning of coal and petroleum – first measured by Keeling in the 1960s…**and**…

Why Worry?

3. The increase in CO_2 associated with the industrial revolution (ie the anthropogenic greenhouse effect) occurred at a time when the earth was already at a historic (and prehistoric) high temperature

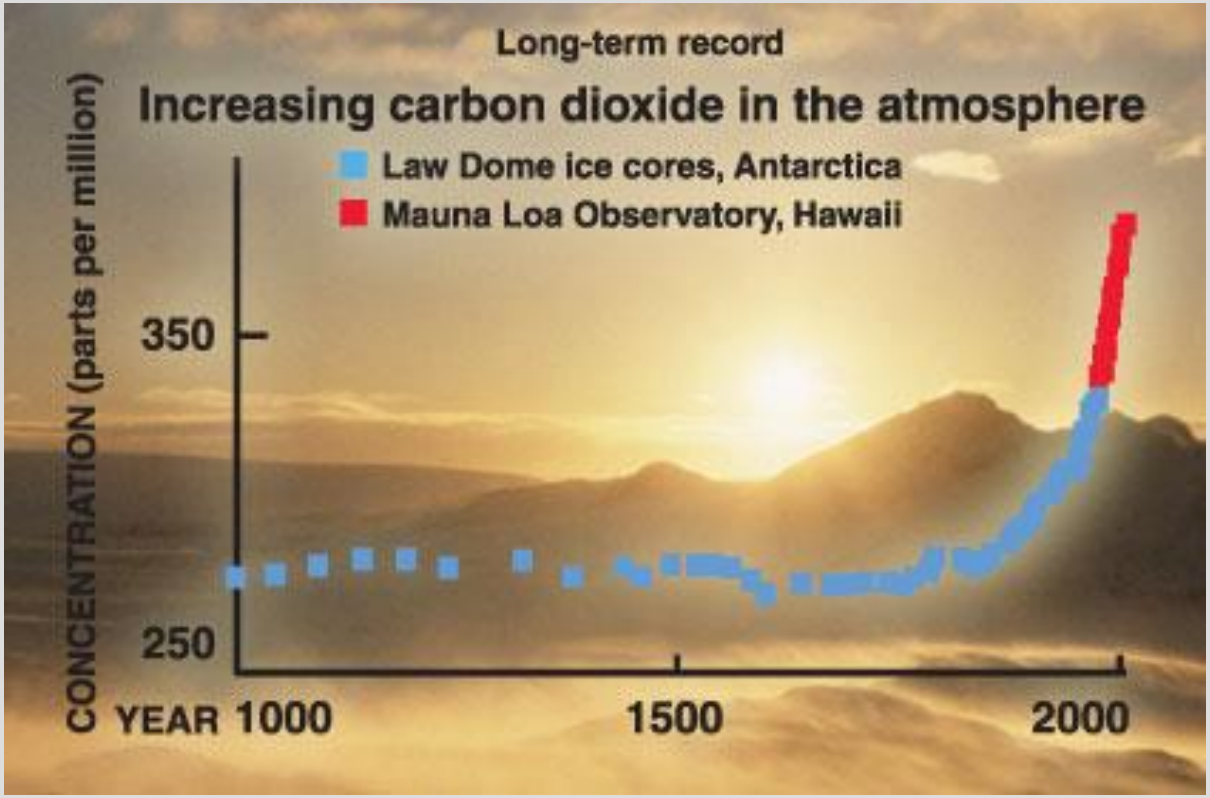
Look at the graph again…



Why Worry?

←Increases begin when it's already pretty warm

Why Worry?



As for Co_2

← Increases begin when it's already quite a lot

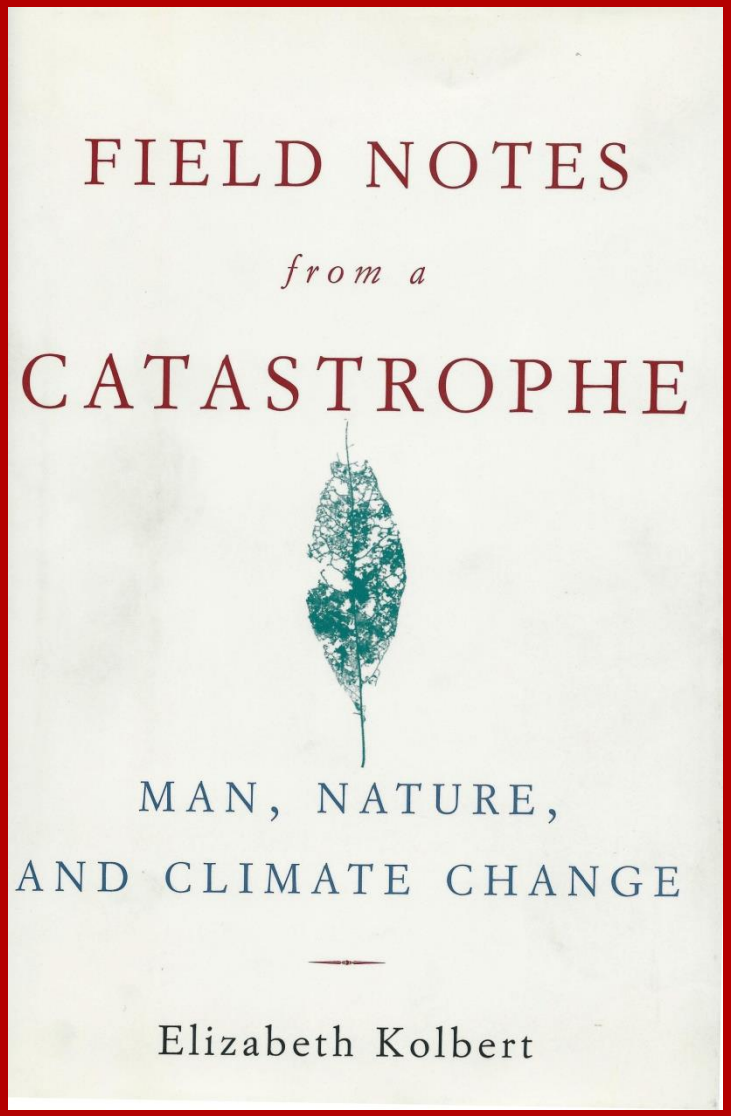
Source:
http://www.climatecentral.org/history.html

Quick Read

Only have time for one book? Elizabeth Kolbert covers the history of the discovery of global warming and many of its salient features in this 187-page easy to read intro.

Especially good on explaining the reasoning behind the scientific consensus on the role of human activities.

Based on a *New Yorker* series in 2006.



Topic 03

What is the danger?

3. Dangers of Global Warming?

Could have positive or negative consequences or both

3. Dangers of Global Warming?

Better for farmers

in central Canada

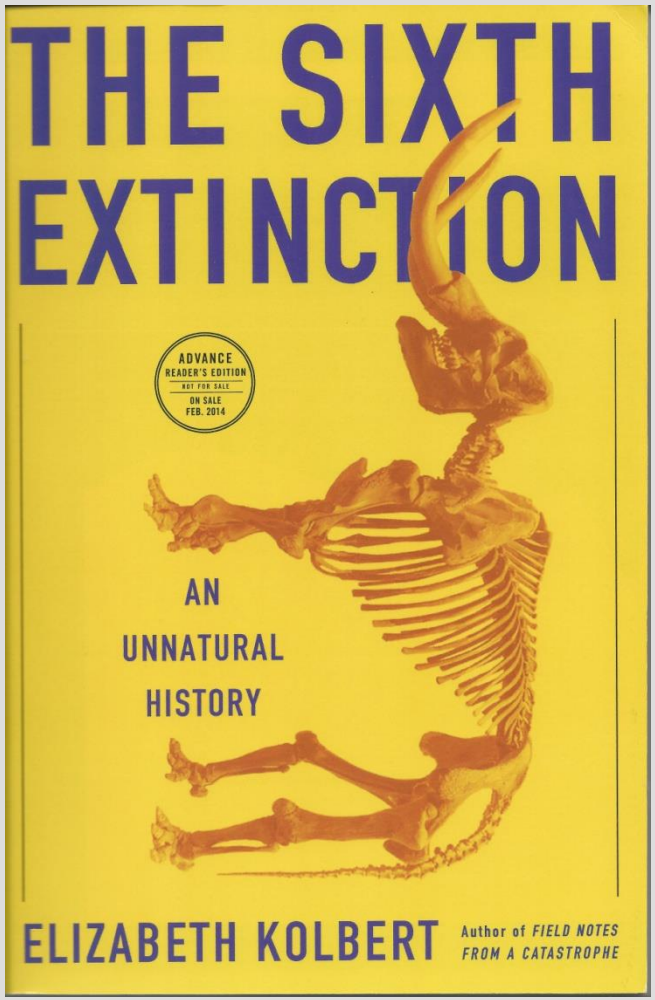
3. Dangers of Global Warming?

Most scientists consider
the dangers overall
greater than the benefits

What Consequences?

Based on what physicists and climatologists now know, they predict –

- Continued, possibly accelerated warming
- Greater over land than over oceans
- Greater over higher latitudes than tropics
- Greater in continental interiors than coastal regions.



The Sixth Extinction?

Further substantial increases of CO_2 could push earth beyond the warmest it's been in hundreds of thousands of years and thus beyond the adaptive range of many of the plants and animals that live here now – the speed of the increase may occur faster than many plants and animals can adapt to genetically through natural selection.

Five mass extinctions or "great dyings" known in fossil record:

- 444 million years ago (mya) Ordovician-Silurian
- 360 mya Late Devonian
- 251 mya Permian-Triassic (up to 95% die off)
- 200 mya Triassic-Jurassic
- 65 mya Cretaceous – extinction of dinosaurs
    - 50% of all species extinct in Cretaceous

Sources: http://www.bbc.co.uk/nature/extinction_events
http://www.nhm.ac.uk/nature-online/life/dinosaurs-other-extinct-creatures/mass-extinctions/index.html

The Sixth Extinction?

Rapid loss of species diversity is currently uncharted territory

Don't know what the consequences might be, but could be dangerous for humans who depend on biodiversity in all kinds of ways

Could pass a "tipping point" beyond which we could not stop runaway extinction

Feedback Loops?

…danger of "positive feedback loops" → "runaway greenhouse" → "Venus syndrome" (a way overheated planet)

-Melting arctic ice creates open water – less heat reflected, more absorbed – speeds up warming

-Melting of permafrost – unknown amounts of carbon that could be released as CO_2, significantly increasing speed of warming

-Thermal expansion of oceans compounds sea level rise

All three already happening somewhat

"Venus syndrome" source: Hansen, James. 2009. *Storms of My Grandchildren: The Truth About the Coming Climate Catastrophe and Our Last Chance to Save Humanity*. New York: Bloomsbury. Pages 223–236. See also slide 52

Dire Consequences?

According to Earth Policy Institute President Lester Brown –

- Increased wildfires in Western US states
- Extinction of more than a quarter of all land animals and plants (massive decrease in world biodiversity)
- Caused by extent and speed of the warming – too fast for many species to adapt to (see also slide #87)

Source: Brown, Lester. 2003. Rising Temperatures and Rising Seas. Chapter 4 of *Plan B: Rescuing a Planet under Stress and a Civilization in Trouble*. Page 63.

Sea Levels Rise

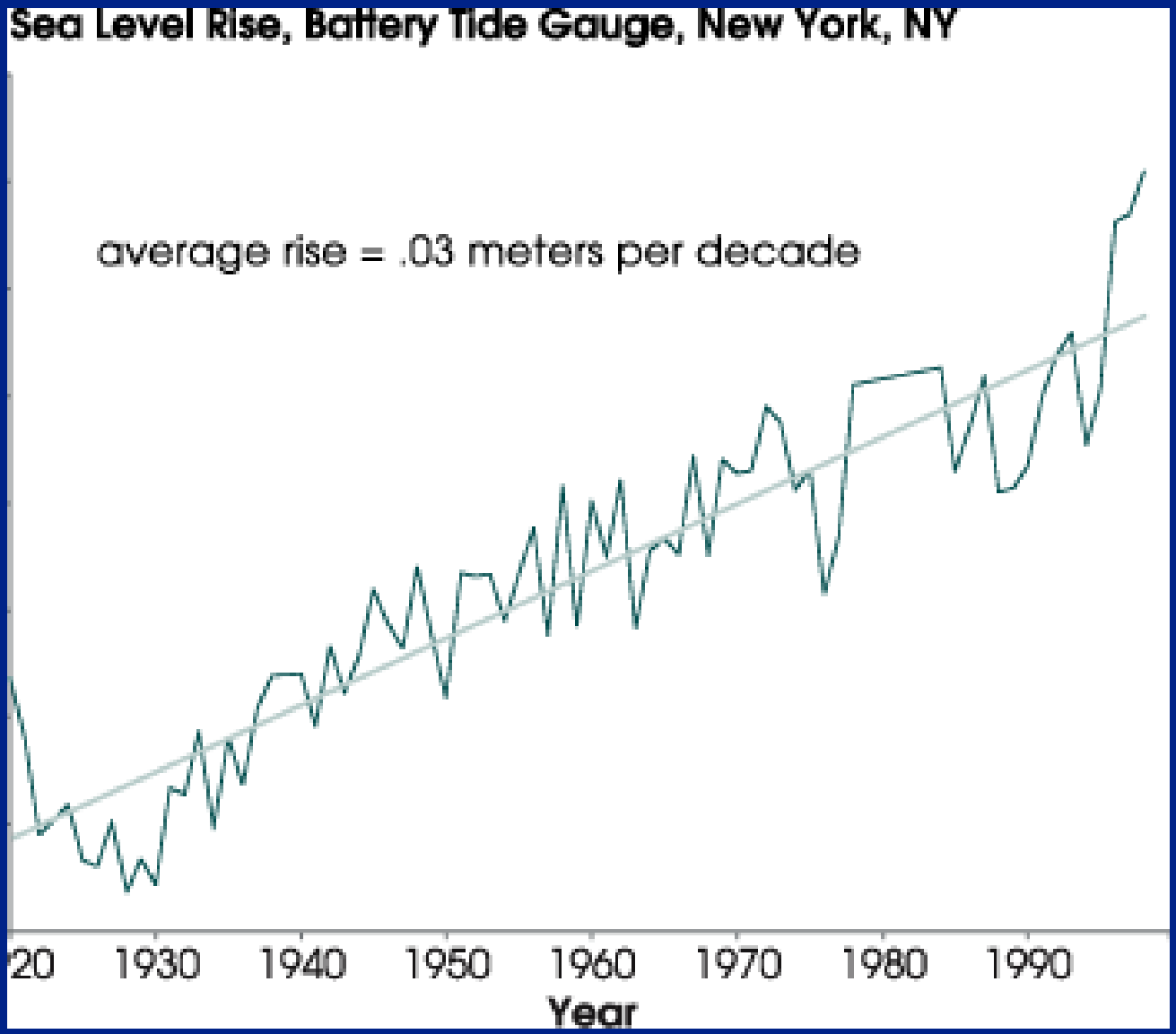
According to Lester Brown –

If rise in sea level of just one meter ($3\frac{1}{4}$ ft)

- Loss of shoreline to nearly one mile inland in US
- Loss of 14,000 square miles of US land surface
- One-third of Shanghai under water – 3–4 million affected
- Much of Bangladesh flooded – tens of millions affected

Source: Brown, Lester. 2003 Rising Temperatures and Rising Seas. Chapter 4 of *Plan B: Rescuing a Planet under Stress and a Civilization in Trouble*. Page 73.

Sea Level is Rising



ITHACA C N Sustainability Group

http://earthobservatory.nasa.gov/Study/Adapting/adapting_2.html

Stormy Weather

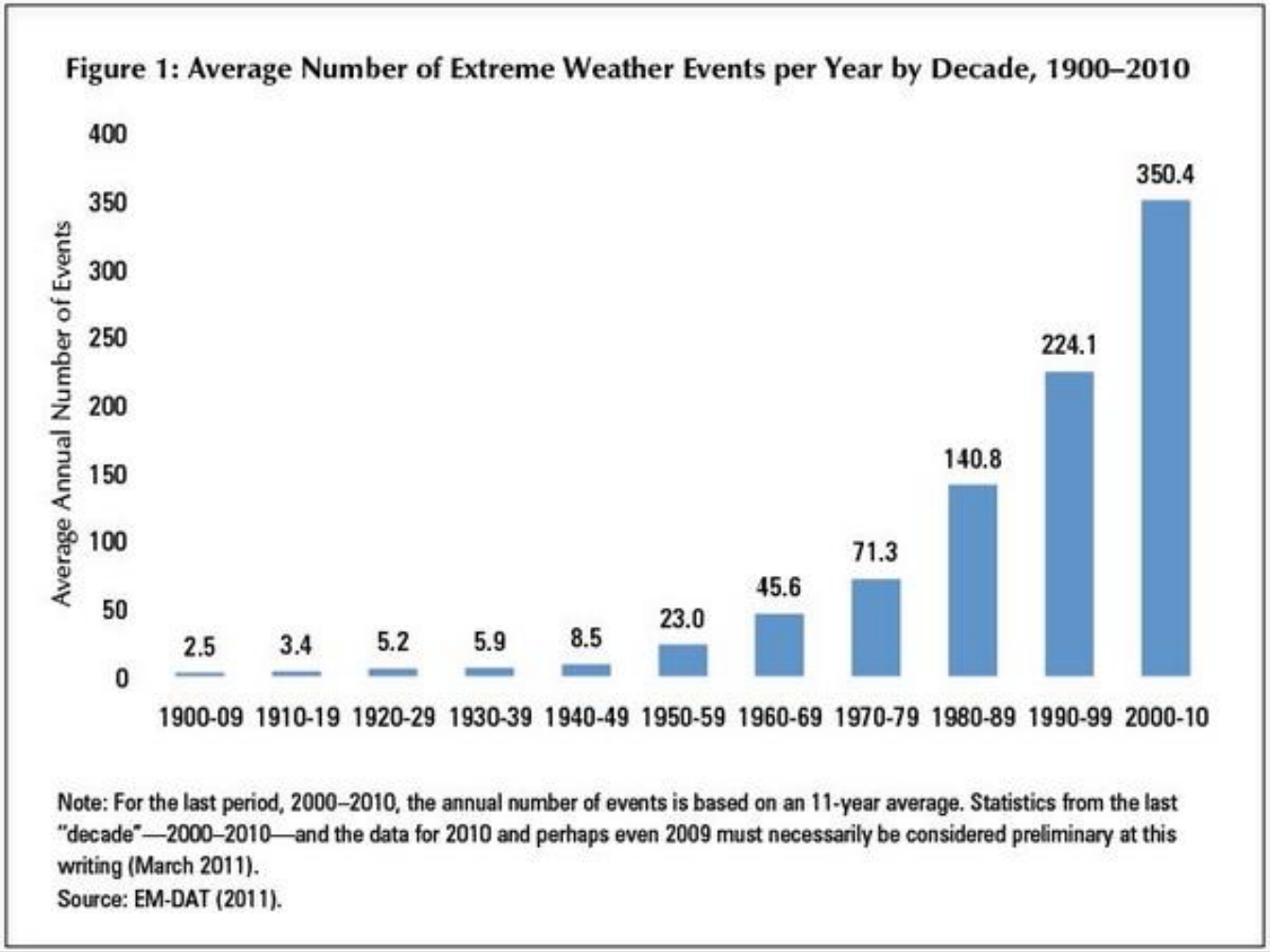
- More frequent and more destructive storms – that is, more "extreme weather events."

- Floods, hurricanes, droughts

Sources: Brown, Lester. 2003 Rising Temperatures and Rising Seas. Chapter 4 of *Plan B: Rescuing a Planet under Stress and a Civilization in Trouble*. Page 73.

Meadows, Donella, Jorgen Randers, and Dennis Meadows. 2004. *Limits to Growth: The 30-Year Update*. White River Junction VT: Chelsea Green. Page 117.

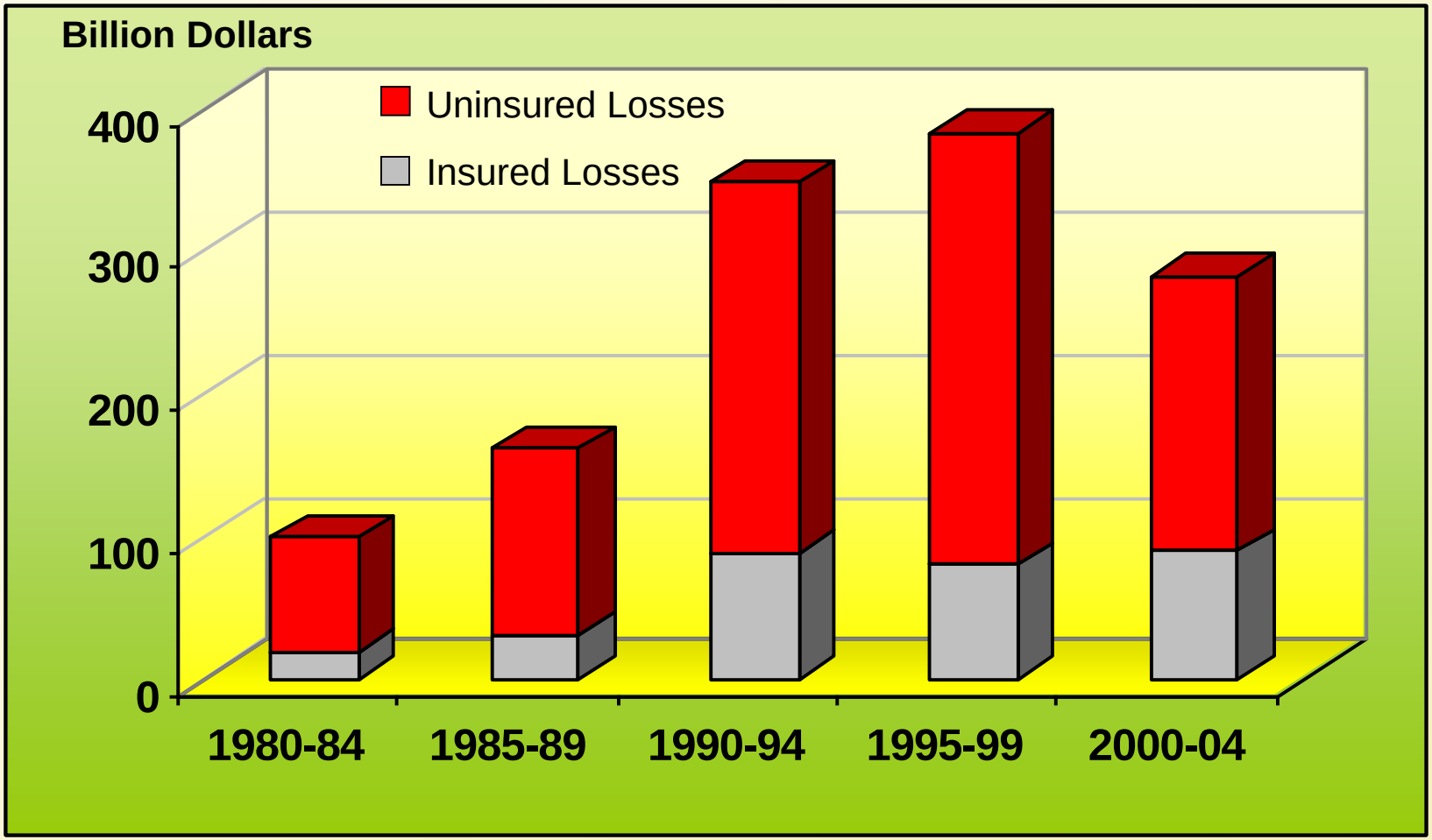
Stormy Weather



Source: http://www.intellectualtakeout.org/library/chart-graph/extreme-weather-escalation-1900-2010

Weather Disasters

The economic cost of weather-related catastrophes – Katrina not included



Source: Munich Re

Food and Water

The two most threatening consequences of global warming may be

- Sharp drop in food supply
- Sharp drop in fresh water supply

Food and Water

Most vulnerable crops are:

- Rice
- Wheat
- Especially corn – can't reproduce in hot, dry climates

These are the three most important food crops on earth.

Source: Brown, Lester. 2011. *World on the Edge: How to Prevent Environmental and Economic Collapse*. New York: W. W. Norton and Company. Pages 47–48.

Food and Water

Virtually all energy available to humans derives from the photosynthesis of plants (even oil is ultimately from plants)…but…

- at 35° C (95° F) photosynthesis begins to decline
- For each 1 degree Celsius rise in temp, yields decline by 10%
- at 40° C(104° F) it ceases entirely (called "photosynthesis shock")

Source: Brown, Lester. 2011. *World on the Edge: How to Prevent Environmental and Economic Collapse*. New York: W. W. Norton and Company. Page 47

Where Have All the Glaciers Gone?

- Second major threat – fresh water supply
- Loss of "reservoirs in the sky" (Brown 2011, p. 50)
- 1. Less pack ice in mountains
- 2. Faster melting of glaciers

Where Have All the Glaciers Gone?

Even slight temp increase changes much mountain snowfall to rain – increases flooding in rainy season and deprives lowlands of runoff from melting snow at other times.

Where Have All the Glaciers Gone?

For example: Colorado River, which depends on Rocky Mtn snowfall for its flow…but…

Not Many Drops…to Drink

MSNBC staff and news service reports

Updated: 1:25 p.m. ET Feb 22, 2007

PHOENIX –

"The 25 million Americans who rely on the Colorado River for water should expect continued — and even worsening — drought spells and water shortages as rising temperatures and growing populations create a double whammy, experts warned in a new report."

Not Many Drops…to Drink

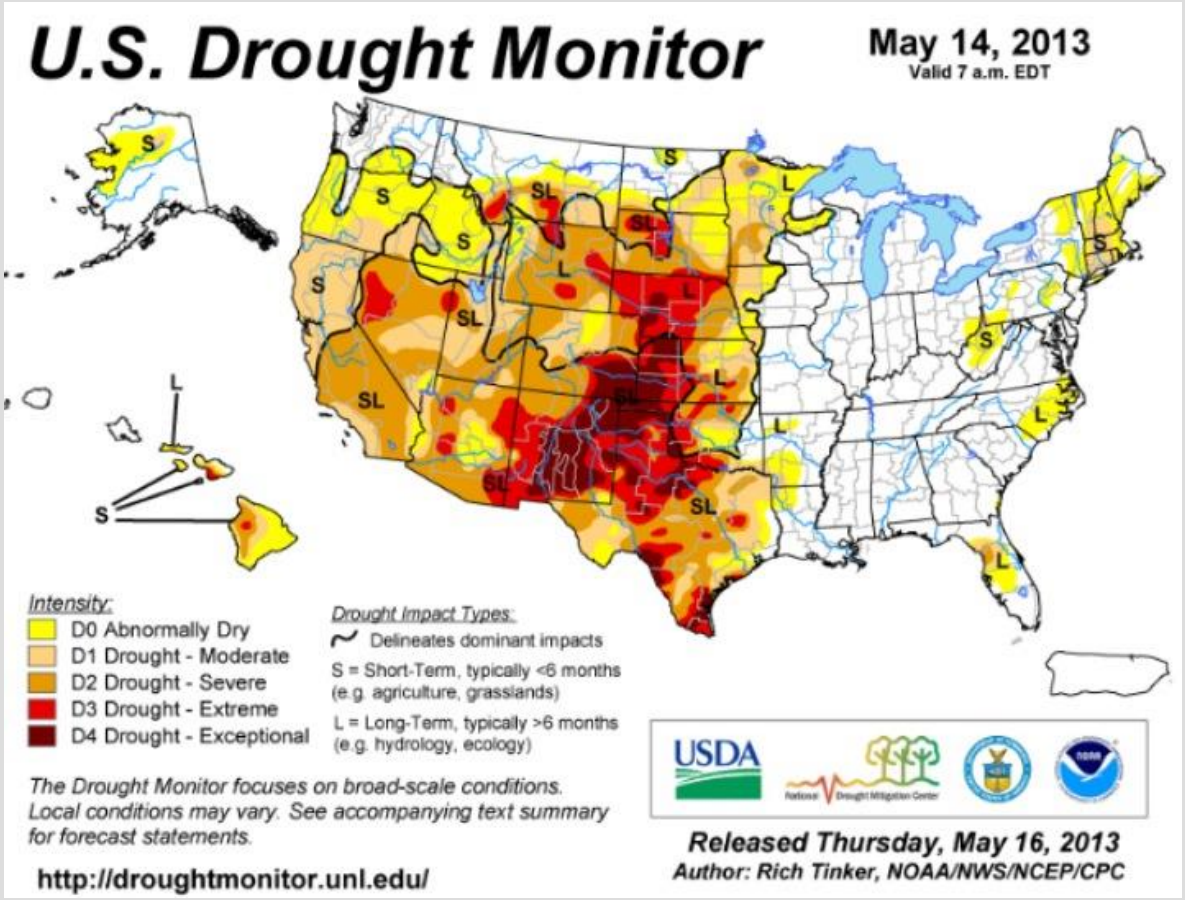
"Much of the region has seen severe drought since the late 1990s, with 2002 and 2004 being among the 10 driest years on record in the upper basin states of Colorado, New Mexico, Utah, and Wyoming.

"Water storage in basin reservoirs dropped sharply during that time due to very low stream flows, the experts noted. For example, 2002 water year flows into Lake Powell were roughly 25 percent of average."

Not Many Drops…to Drink

On 1 February, 2014 *The New York Times* reported on the possible once-in-500-years drought now afflicting the Western US. Might not be once in 500 years any more.

To read the article and view a 10-slide photo show, click here.



↑

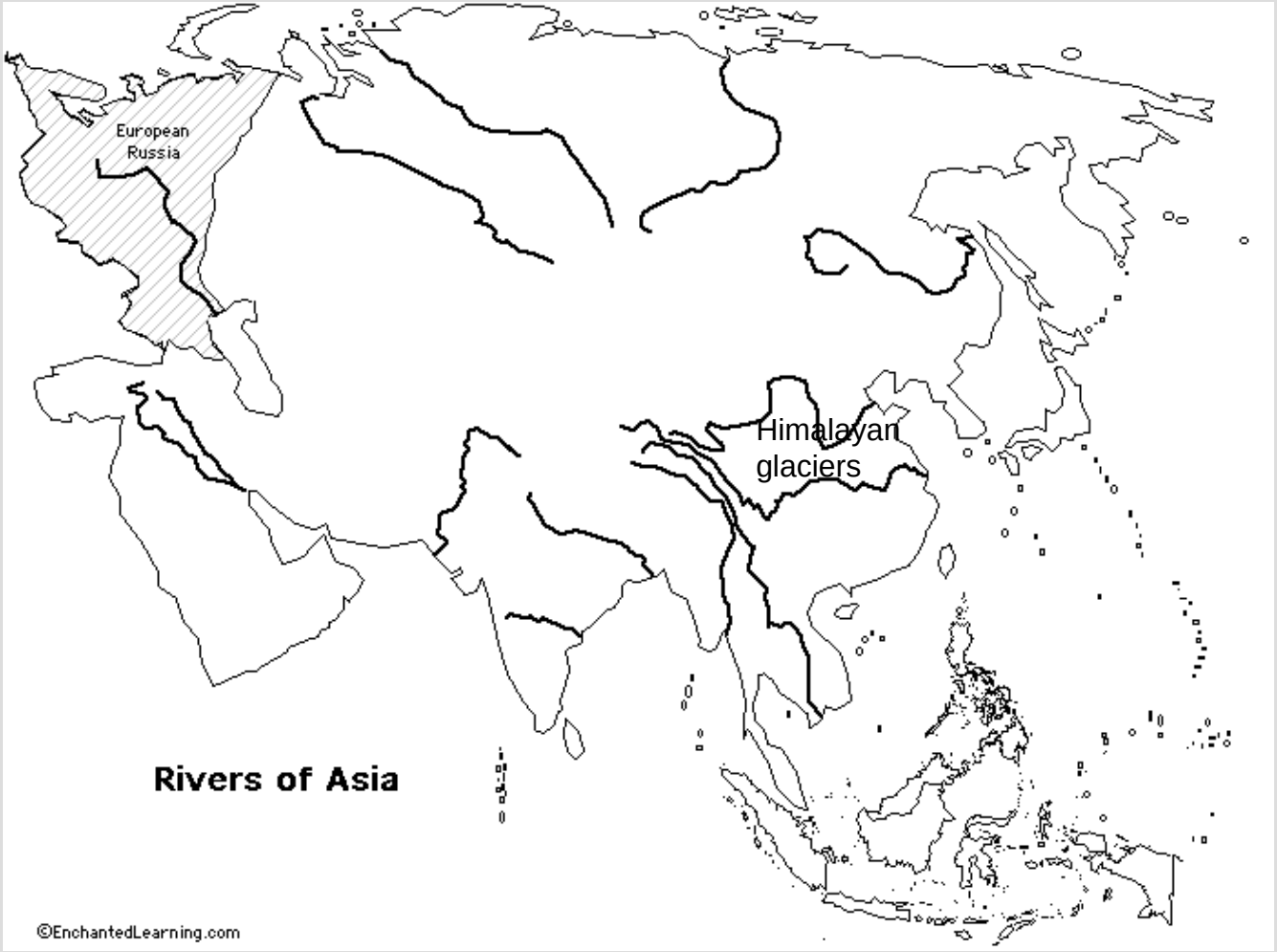
Source for the map, PBS 16 May, 2013 – http://www.pbs.org/newshour/rundown/latest-forecast-shows-the-us-drought-moving-west/

Where Has All the Water Gone?

Half of world's people live in Asia…

Most major rivers in Asia originate in the Himalayas

- Shrinking glaciers and
- Lowering of annual snowfall
- Could bring massive drinking water and irrigation water shortages



Shrinking Himalayan Glaciers

Evidence of shrinking glaciers worldwide is now overwhelming…

Global Ice Cover is Shrinking

Argentina's Upsala Glacier was once the biggest in South America, but it is now disappearing at 200 meters per year.

Where Have All the Glaciers Gone?

The Blomstrandbreen Glacier on Spitsbergen in the arctic –

1918 →

2002 →

Source:

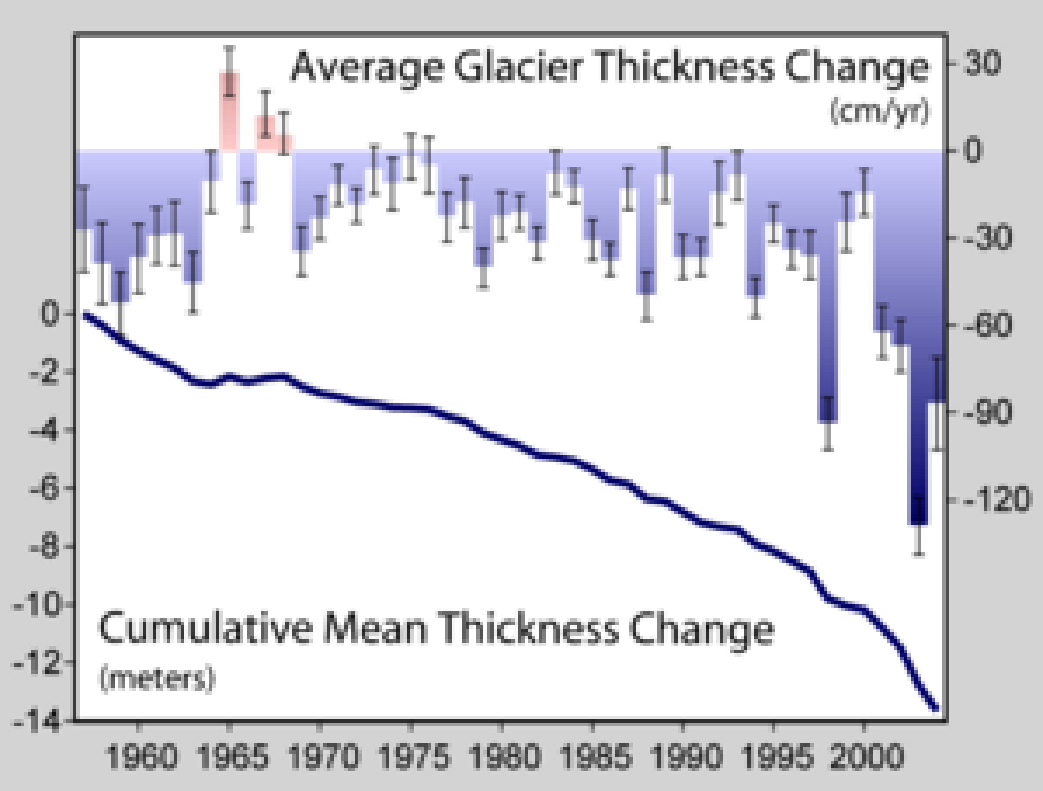
http://www.theguardian.com/environment/2002/aug/08/climatechange.climatechange

Thinning Ice

Remaining glaciers are losing their ice…

Source for the graph →

http://www.globalwarmingart.com/wiki/File:Glacier_Mass_Balance_Map_png



Overall global ice cover

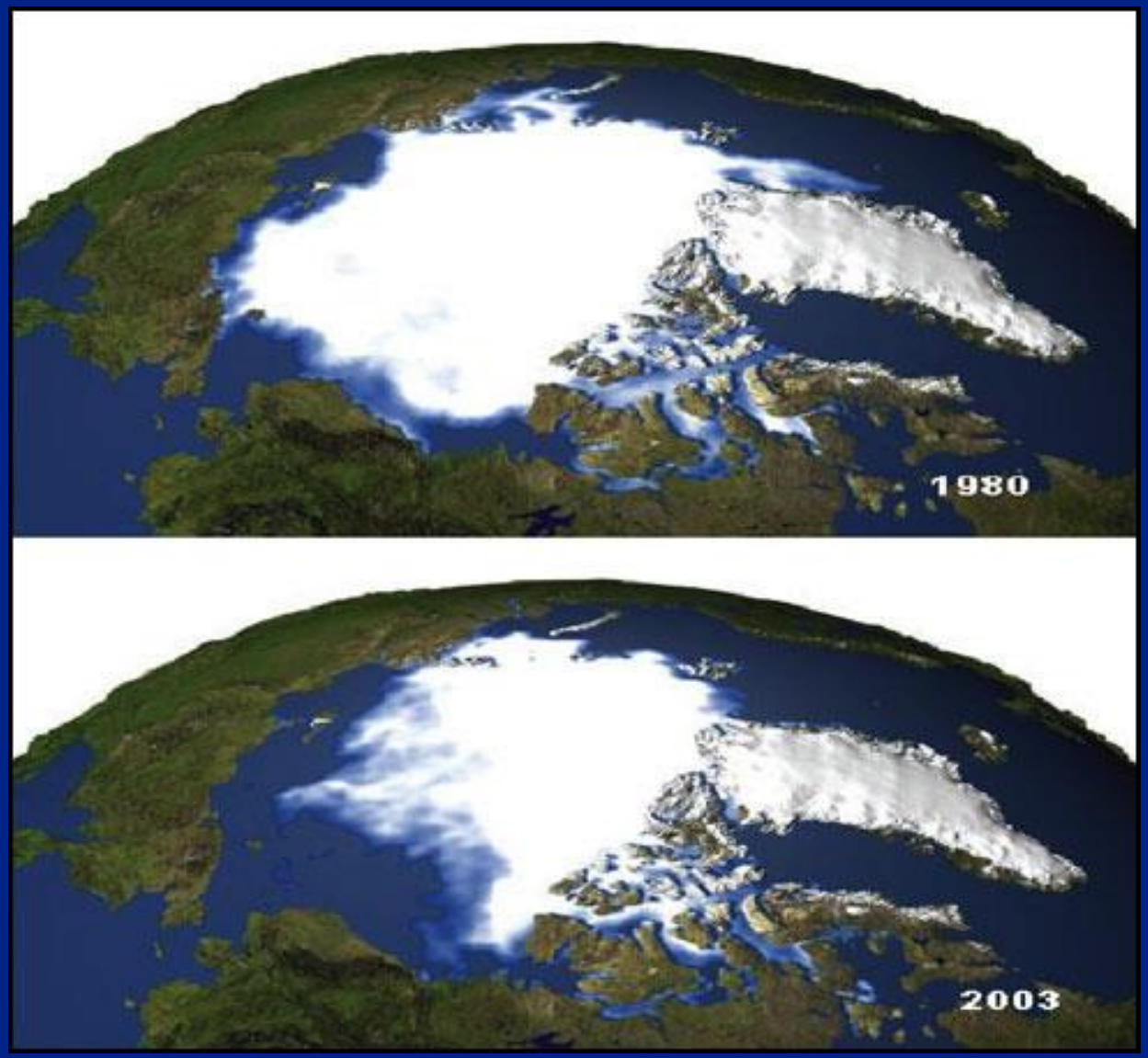
is diminishing rapidly…

3. What Consequences?

From 1979 to 2005 the area of perennial sea ice in the arctic shrank by 250 million acres – equal to New York, Georgia and Texas combined

Source: Kolbert, Elizabeth. 2006. *Field Notes from a Catastrophe: Man, Nature, and Climate Change*. New York: Bloomsbury. Page 26.

Global Ice Cover is Shrinking: Arctic



http://science.hq.nasa.gov/directorate/04review.html

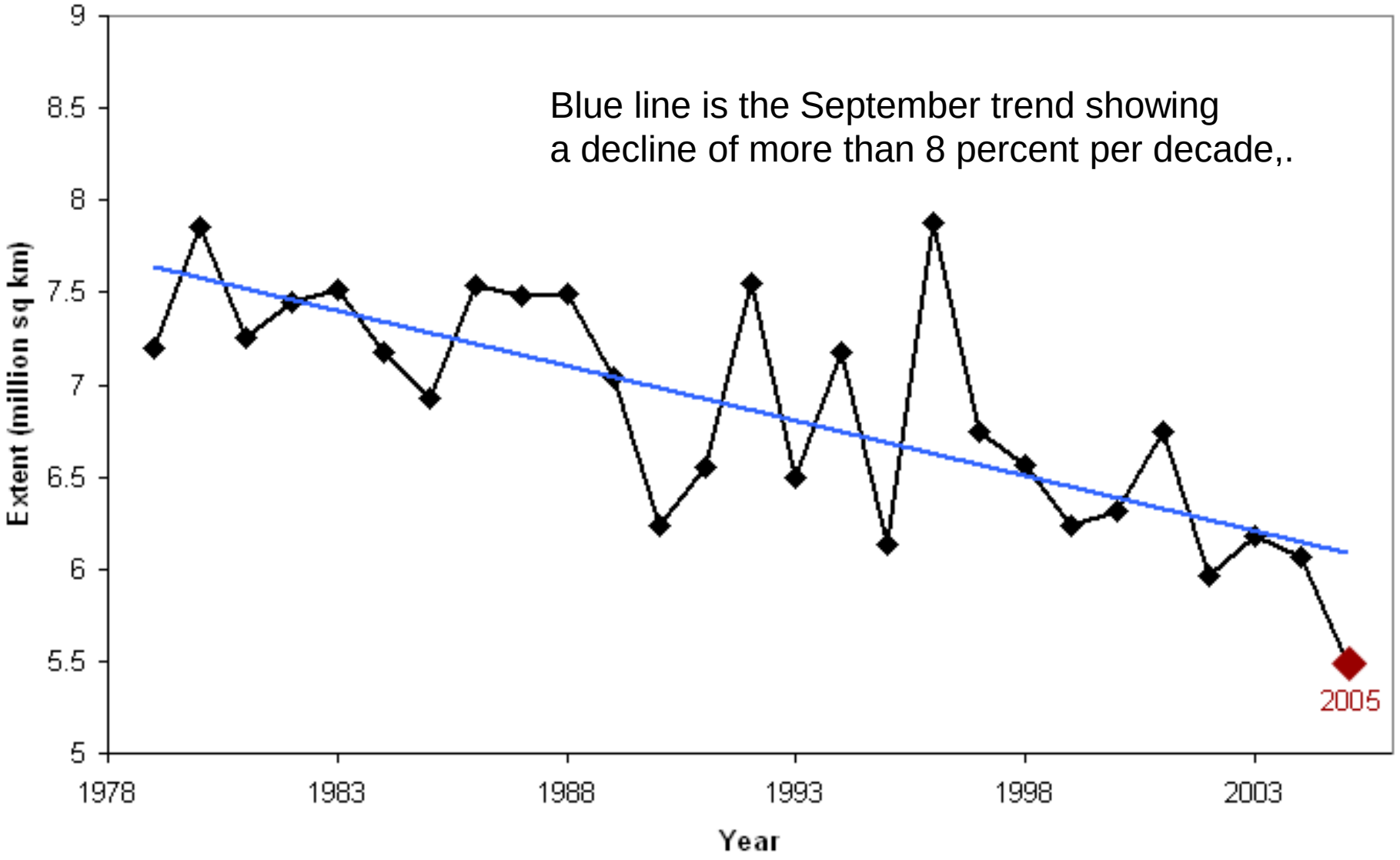
Positive Feedback with Negative Consequences

Loss of perennial sea ice speeds up global warming because ice and snow reflect about 80% of sunlight (albedo = 0.8)

Open ocean water reflects less than 1% (albedo 0.07) – so more heat is absorbed which melts more ice which…

Source: Kolbert, Elizabeth. 2006. *Field Notes from a Catastrophe: Man, Nature, and Climate Change*. New York: Bloomsbury. Page 30.

Global Ice Cover is Shrinking



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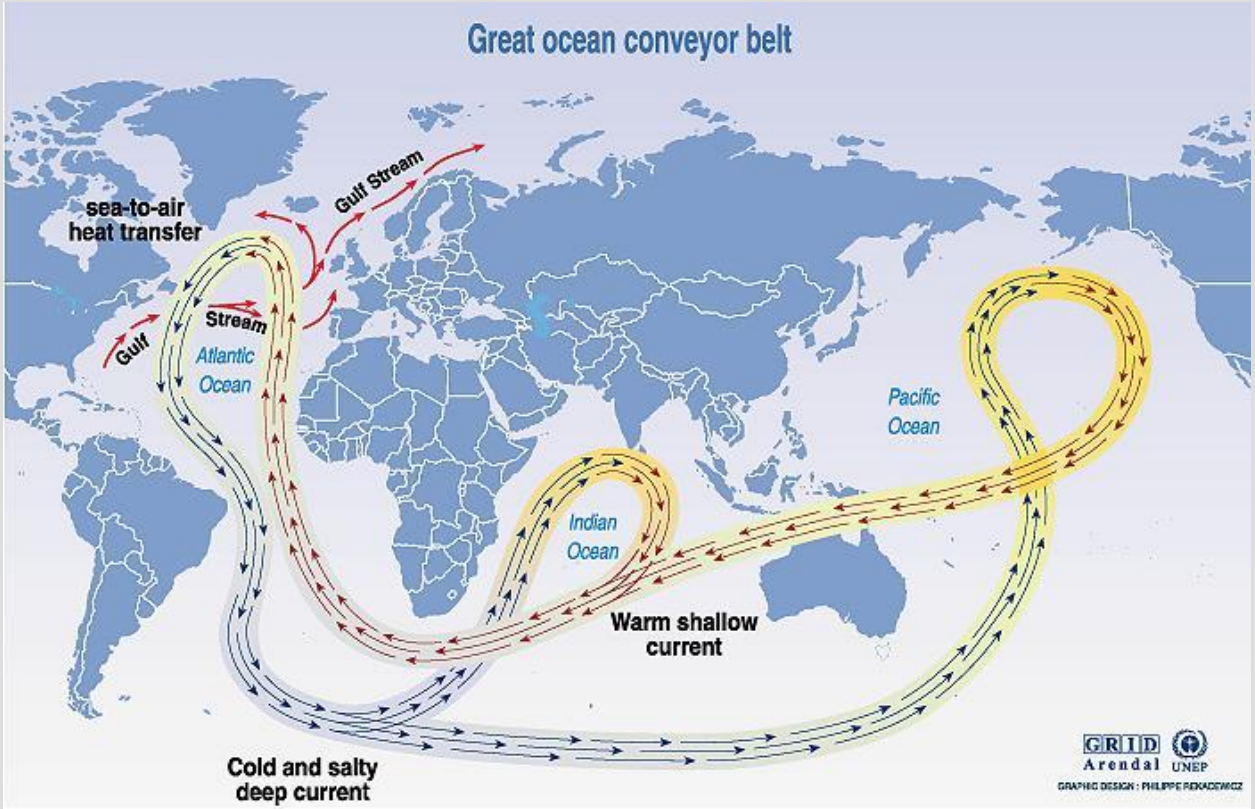
http://nsidc.org/news/press/20050928_trendscontinue.html

The strange "thermohaline circulation" effect:

- Oddly, it appears possible global warming could cause a major cold spot in Europe and/or North America.
- Europe is now unusually warm for its latitude
- Result of warm ocean currents from tropical Atlantic

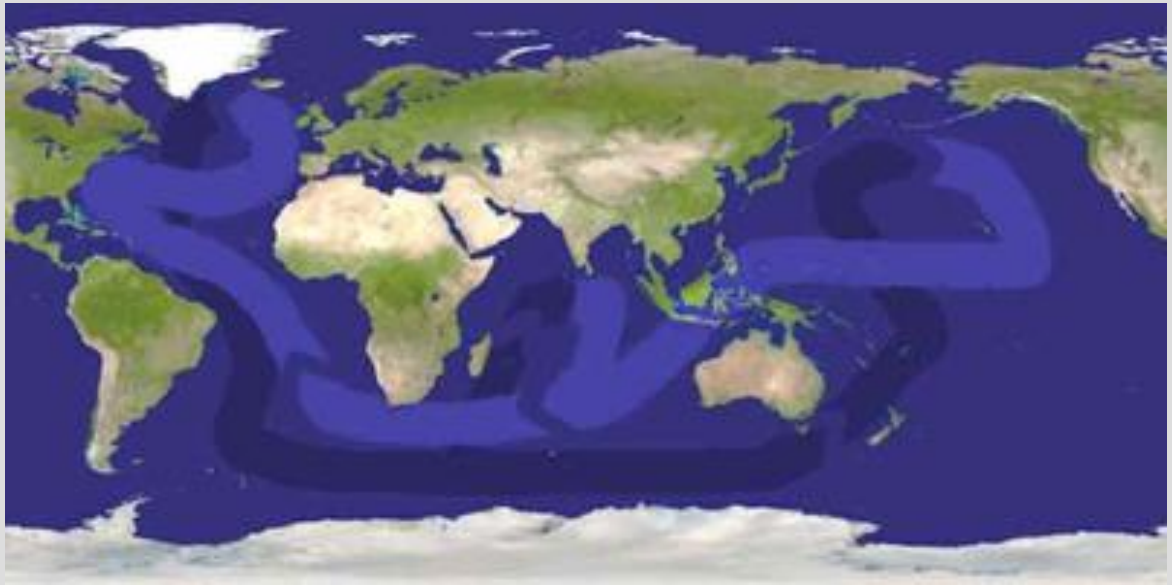
Thermohaline Circulation

Also known as the "ocean conveyer belt"



Source: Broecker, 1991, in Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Melting Greenland ice sheet could cause too → much fresh water in North Atlantic



Heavier warm salty water sinks near Greenland – but if ice melts, less salty water won't sink – whole system could collapse

Source: http://oceanservice.noaa.gov/education/tutorial_currents/05conveyor2.html

Why the Thermohaline Matters

Worldwide consequences of collapse of the thermohaline circulation difficult to speculate on – but likely to be significant

- would be another example of climate change caused by global warming (See slides 9 and 25)

Source: http://www.news.illinois.edu/news/05/1206climate.html

See also: Pearce, Fred. 2007. *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change.* Boston: Beacon Press. Especially pages xix–xxi and 141–154.

Why Worry?
A Summary

- Biodiversity loss – possibly up to 25% of species worldwide
- More – and more intense – fires, hurricanes, floods
- Land loss to sea
- Food supply threatened
- Fresh water supply threatened
- Positive feedback loops → runaway, unstoppable global warming
- Possible mini-ice ages in Europe and parts of North America

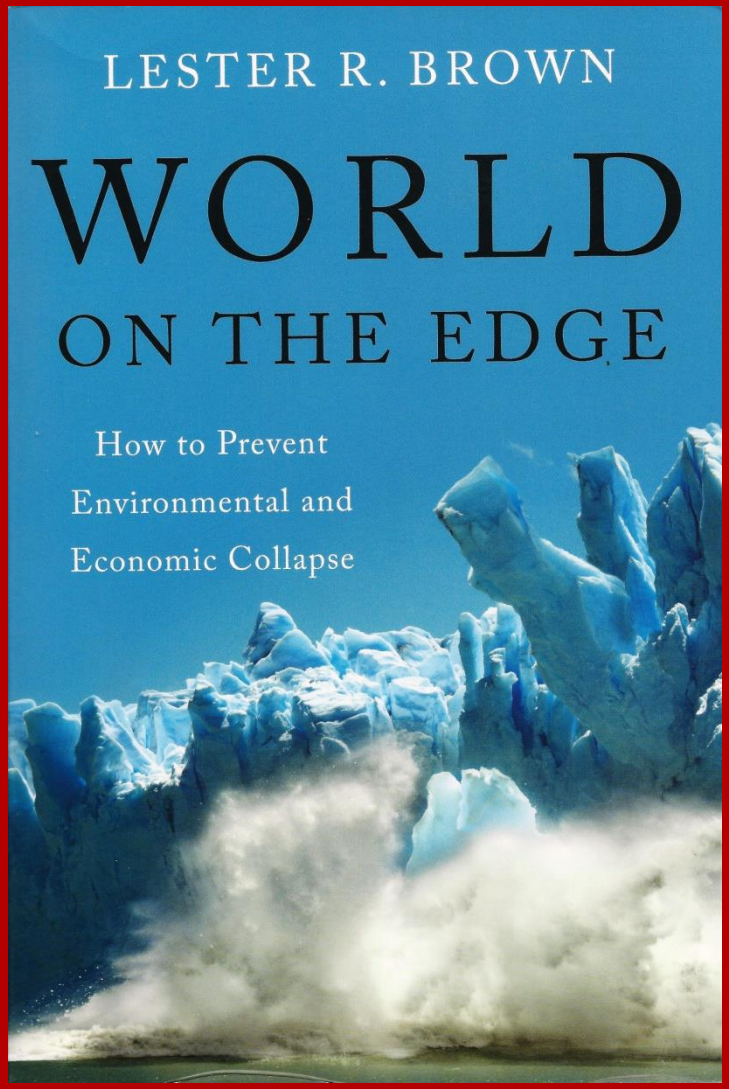
Quick Read

Only have time for one book?

Earth Policy Institute President Lester Brown summarizes the main consequences of global warming and climate change in chapter 4, pages 45–55, of his 2011 book *World on the Edge.*

Download the book free at:
http://www.earth-policy.org/books/wote

Same link has a link to a slideshow overview of the book's contents – also a free download.



Update: 2014 U.S. National Climate Assessment

On May 6, 2014 the Obama Administration released the congressionally mandated every four years climate assessment. This 841 page report contains a wealth of details including a summary of climate science and predictions for various regions of the U.S. Click to download:

The downloads page to access the full report and all the sections separately

The highlights/overview of the report

The section on likely effects in the Northeast USA that includes upstate New York.

Topic 04

What Can We Do?

4. What Can We Do?

We can think of taking three main types of actions…

4. What Can We Do?

-Political actions to reduce fossil fuel production;

-Actions individually or in our communities to improve energy efficiency;

-Actions to expand renewable, fossil-fuel free energy production

4. What Can We Do?

We can think of taking actions at 4 levels…

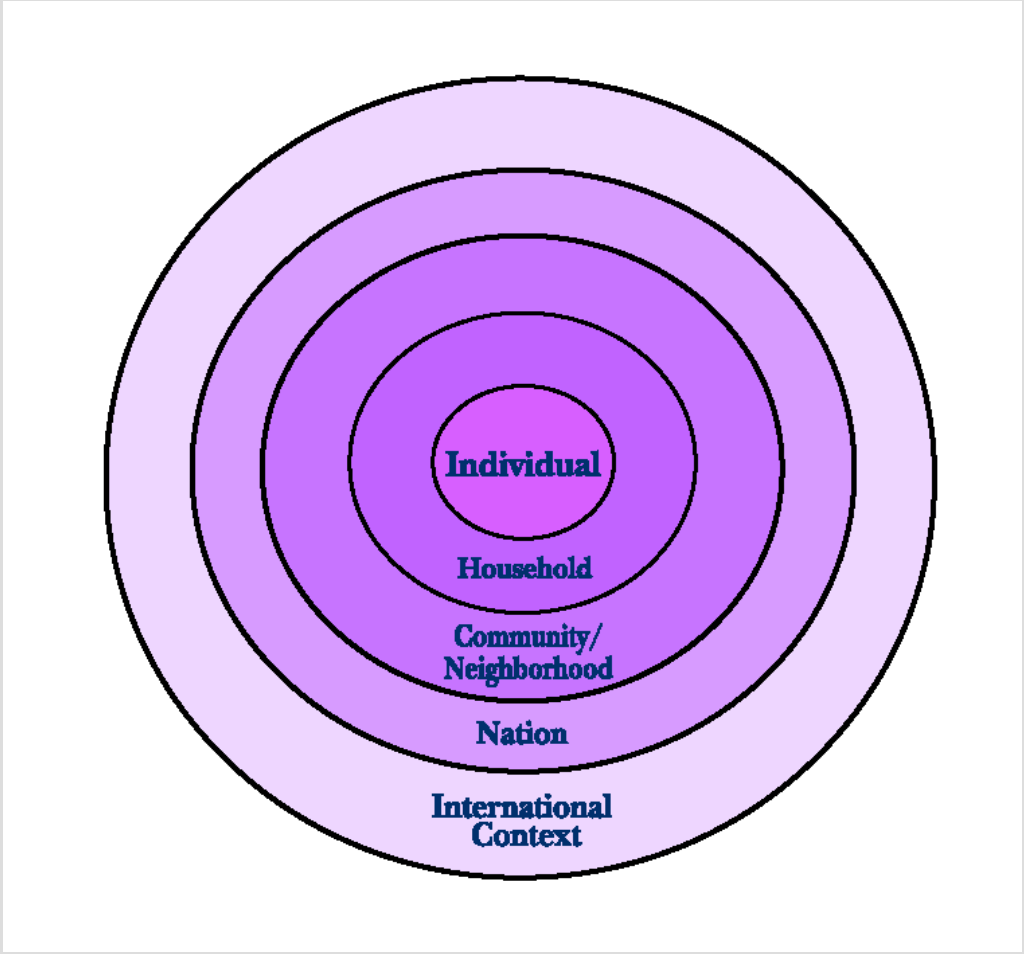
Action Levels

Individual or
houshold level

Community level

National level

International level



4. What Can We Do?

This creates a matrix

of 12 possibilities…

4. What Can We Do? Levels of Action

Level	Increase Energy Efficiency	Switch to Alternative Energy	Political Action
International	Learn from other countries	Renew and enforce Kyoto type agreements	Work to get US government to take more active role
National	National auto mileage requirements	Federal tax incentives for solar heat/electric	Support actions in boxes to left
Community	Support Finger Lakes Climate Fund ↓	Join solar buying club; invest in local wind farm	Join a Sustainable Tompkins Community Circle
Individual	Upgrade home insulation	Buy local food; eat less beef	Write letters; attend meetings; vote

4. What Can We Do?

Many other examples
can be put into the boxes.
What are *your* ideas?

Connections

Note also that the various boxes often connect to one another: an action in one has effects in another.

4. What Can We Do?

Earth Institute President

Lester Brown has a similar list…

Let's Get to Work

Saving civilization is not a spectator sport.

Lester R. Brown

- Lifestyle changes such as using more-efficient light bulbs are important, but not nearly enough
- Preventing environmental and economic collapse requires political action from all of us in order to effect broad social change
- Make sure your elected officials know what's important
- Note the successes of the U.S. grassroots movement in closing coal-fired power plants
- Take action in an area that concerns and excites you

Source: http://www.earth-policy.org/books/wote Slide #58

Wartime Footing?

He also calls for a "wartime" emergency type of mobilization of our society's resources…

A Wartime Mobilization

- We have the technologies necessary to implement the needed changes – what is needed now is the political will to do so
- Saving civilization will require urgent action on a large scale, but we've mobilized quickly before:
- Upon entering World War II, the U.S. mobilized resources and completely restructured its economy within months

Source: http://www.earth-policy.org/books/wote Slide #57

Photo Credit: Yann Arthus-Bertrand

Disinvestment

Journalist and climate activist Bill McKibben focuses on mobilizing people to withdraw investment from fossil fuel corporations…

http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719

Disinvestment

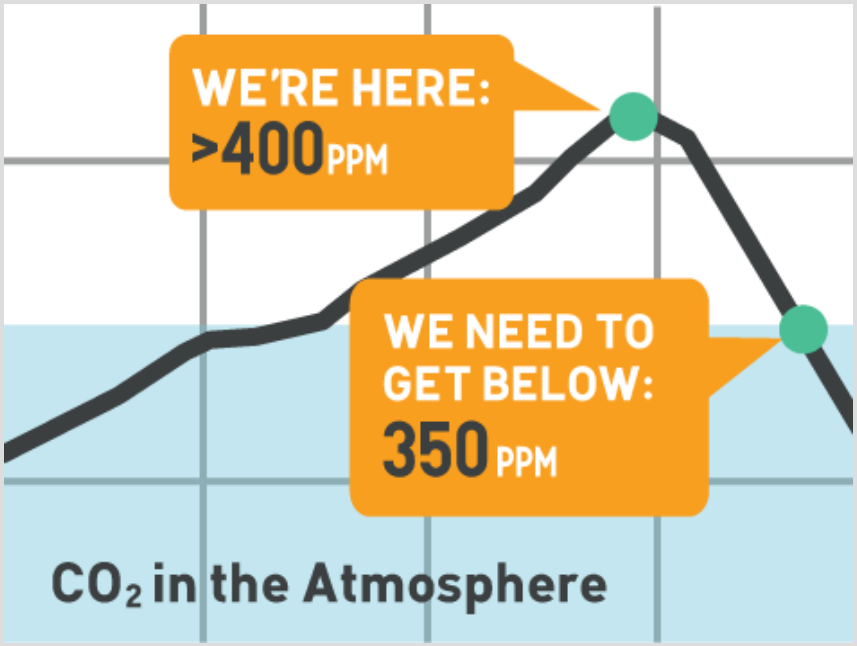
…and…to pressure
their universities, pension funds
and friends to do the same.

350.org

Is based on the number 350 ppm (parts per million) that we need to get down to – from about 400 today – to keep the earth cool enough to avoid catastrophic climate changes

McKibben's organization:

350.Org



4. What Can We Do?

In an essay in *Rolling Stone* – July 19, 2012 – McKibben laid out what he believes are "three simple numbers" that indicate how serious our climate change challenge is:.

He called the essay:

Source:
http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719

"Global Warming's Terrifying New Math: Three simple numbers that add up to global catastrophe – and that make clear who the real enemy is"

Source:

http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719

Why Disinvestment?

Terrifying Number One:

2° Celsius (3.6° Fahrenheit)

The maximum we can allow the earth to warm without catastrophic consequences (see slides 81 to 119) – we've already caused 0.8 C.*

* Maybe 0.7, see slide #17

Why Disinvestment?

Terrifying Number Two:

565 Gigatons

(Giga = billion or 10^9)

The amount of CO_2 we can still put into the atmosphere and stay below 2° C average temp increase.

http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719

Why Disinvestment?

Terrifying Number Three:

2,795 Gigatons

(Giga = billion or 10^9)

The amount of carbon in "already proven coal and oil and gas reserves…" in short "ready to burn"

http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719

4. Why Disinvestment?

Terrifying Number Three: is 5 times the size of Terrifying Number Two…and the world's main energy companies are eager to burn it all.

http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719

Why Disinvestment?

These tons of carbon can only be kept in the ground if…

1. A mass disinvestment movement makes it uneconomic for companies to exploit these reserves…

4. What Can We Do?

…and…

4. What Can We Do?

(1. Divestment plus…)

2. Individuals, communities, and nations…

   …reduce energy consumption while installing renewable, carbon-free energy systems

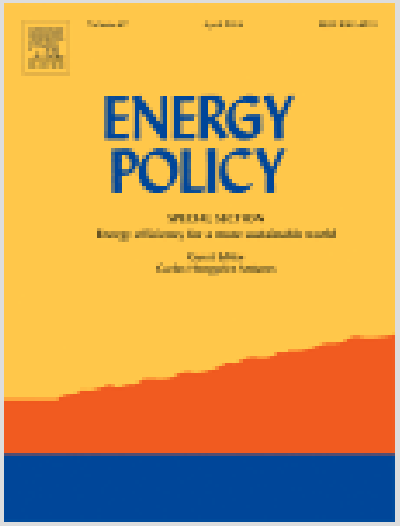
Is This Possible?

Carbon Free New York in 2030?

In March of 2013 Stanford University engineering and atmospheric sciences professor Mark Z. Jacobson and 12 other scientists published an article in the academic journal *Energy Policy* arguing that New York State's entire "energy infrastructure" could be 100% powered by wind, water and sunlight by the year 2030.

Source: Jacobson, Mark Z. *et al*. Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight. *Energy Policy* 57(2013):585-601.

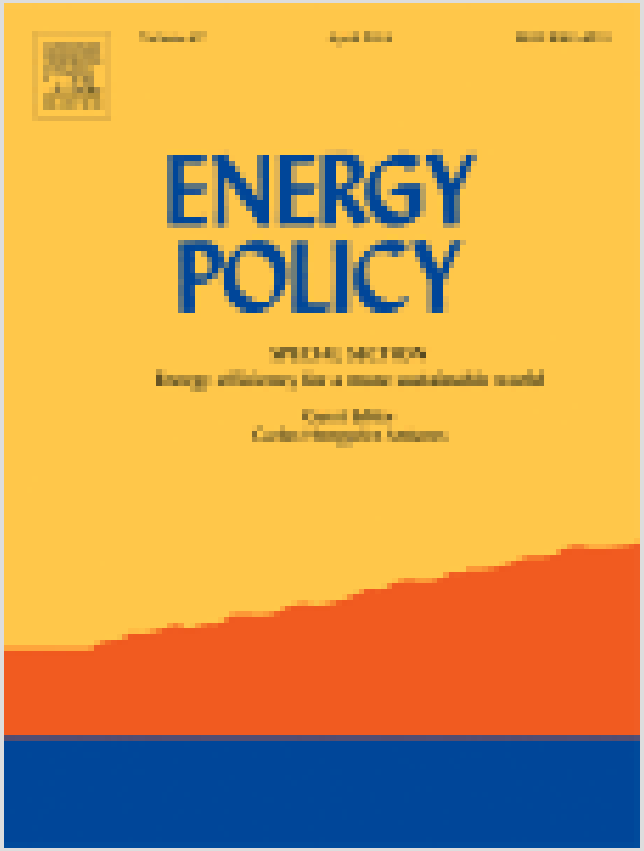
Carbon Free New York in 2030?



This would mean no fossil fuels – no coal, no natural gas, no petroleum – no ethanol or other biofuels and no nuclear power plants.

Carbon Free New York in 2030?

There would be approximately 37% less energy requirements (from higher efficiencies) but no decline in quality of life.



Carbon Free New York in 2030?

It would mean cleaner air, cleaner water, fewer pollution related deaths and an overall healthier New York State population.

Source: Jacobson, Mark Z. *et al*. Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight. *Energy Policy* 57(2013):593-94.

Carbon Free New York in 2030?

Implementing the project could add up to 4.5 million jobs of which up to 58,000 would be permanent – would remain after construction.

Source: Jacobson, Mark Z. *et al*. Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight. *Energy Policy* 57(2013). Page 595.

Is This Possible?

Carbon Free New York in 2030?

Here are a few highlights of the authors' proposal for those without the time or inclination to read the detailed scientific paper.

Carbon Free New York in 2030?

The infrastructure to be built…

Carbon Free New York in 2030?

- ✓4,020 onshore 5-megawatt wind turbines
- ✓12,770 offshore 5-megawatt wind turbines
- ✓387 100-megawatt concentrated solar plants
- ✓828 50-megawatt photovoltaic power plants
- ✓5 million 5-kilowatt residential rooftop photovoltaic systems
- ✓500,000 100-kilowatt commercial/government rooftop photovoltaic systems
- ✓36 100-megawatt geothermal plants
- ✓1,910 0.75-megawatt wave devices
- ✓2,600 1-megawatt tidal turbines
- ✓7 1,300-megawatt hydroelectric power plants, of which most (already) exist

Sources: Jacobson et al, page 589; http://news.stanford.edu/news/2013/march/new-york-energy-031213.html

Carbon Free New York in 2030?

Perhaps the most politically difficult part of the proposal is to replace cars, trucks, ships, and locomotives with electric battery motors or hydrogen fuel cells.

Source: Jacobson, Mark Z. *et al*. Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight. *Energy Policy* 57(2013). Esp. pages 586 and 598.

Carbon Free New York in 2030?

This would require significant political organization and action…

Carbon Free New York in 2030?

…On the other hand, what is our sustainability movement for?

Carbon Free New York in 2030?

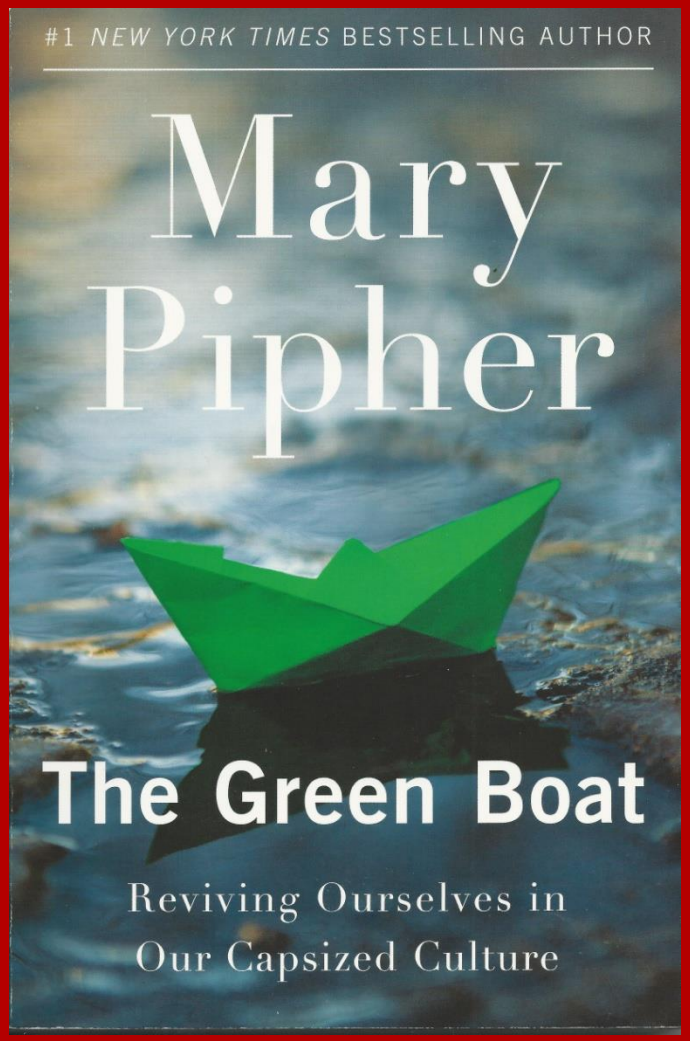
Is it worth noting that at least two of Jacobson's co-authors, Robert Howarth and Anthony Ingraffea, are at Cornell and thus are locally available…

A Carbon Free Tompkins County in 2030?

What about seeing how much of the Jacobson et al plan could be implemented locally within Tompkins County?

Carbon Free New York in 2030?

What are we waiting for?



Join the Discussion;
Consider Taking Action

Sustainable Tompkins and the Tompkins County Sustainability Center are hosting a series of four climate change salons on various aspects of the climate threats – starting with Mary Pipher's *The Green Boat which* deals with psychological elements of "climate disruption and denial."

Attend one or all – see the next two slides for the other topics and dates…all will take place on Thursday evenings at 7 pm at the Sustainability Center, 111 South Albany, Ithaca.

All will take place on Thursday evenings at 7 pm at the Sustainability Center, 111 South Albany, Ithaca.

The conversation salons will begin with brief sketches by thoughtful citizens of some of the main perspectives on each topic before we open up the discussion to all salon attendees. Come prepared to listen, to be challenged, and to make your voice heard. Watch for our column in Tompkins Weekly and on the Sustainable Tompkins website for a briefing on each salon's topic.

Join the Discussions

Session 1 April 17

Session 2 May 8

Session 3 May 29

Session 4 June 19

Consider Taking Action

- Why are we stuck in climate denial?
- Can business and technology save us?
- Will government intervene?
- Is it up to the citizenry?

The conversation salons will begin with brief sketches by thoughtful citizens of some of the main perspectives on each topic before we open up the discussion to all salon attendees. Come prepared to listen, to be challenged, and to make your voice heard. Watch for our column in Tompkins Weekly and on the Sustainable Tompkins website for a briefing on each salon's topic.

For more information, email gay@sustainabletompkins.org.

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End of Slides on
Global Warming Basics