

The Science on Global Warming / Climate Change

V0.10 7 Feb/2008 by Corrie Kost

For good, up-to-date (2007), comprehensive, science based overviews, please see

http://en.wikipedia.org/wiki/Global_warming

and http://en.wikipedia.org/wiki/Global_warming_controversy but especially also the highlights document by the NAS (National Academy of Sciences) “Understanding and Responding to Climate Change” at <http://dels.nas.edu/basc/Climate-LOW.pdf>

On a world-wide scale, glaciers are in retreat – even in Garibaldi park

<http://www.sciencedaily.com/releases/2007/10/071030092705.htm>

there are minor exceptions – see

<http://www.sciencedaily.com/releases/2005/05/050507094531.htm>

but as the paper concludes – “on the average, the whole West is heating up”

A web site by the Union of Concerned Scientists –

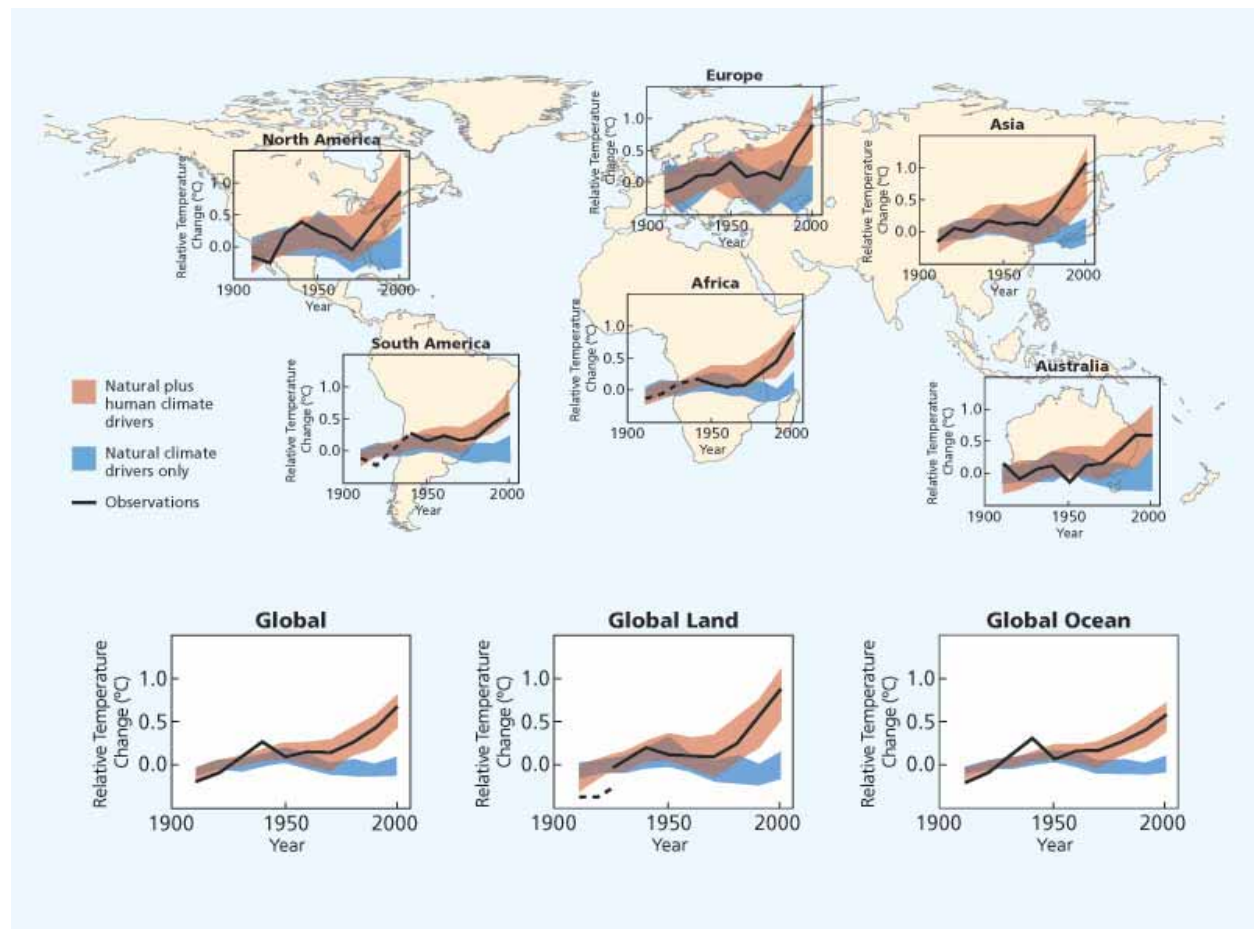
http://www.ucsusa.org/global_warming/science/science-of-global-warming.html

is a good resource. See also <http://www.realclimate.org/> and especially

<http://www.realclimate.org/index.php/archives/2007/05/start-here/>

The IPCC (Intergovernmental Panel on Climate Change) publications of Feb 2007 leave very little doubt that

“emissions of heat-trapping gases from human activities have caused “most of the observed increase in globally averaged temperatures since the mid-20th century.” Evidence that human activities are the major cause of recent climate change is even stronger than in prior assessments.” http://www.ucsusa.org/global_warming/science/ipcc-highlights1.html



The **black line** represents observed surface temperature changes for the globe and each continent (based on temperatures recorded by measuring stations around the world). The **blue band** represents how the climate would have evolved over the past century in response to natural factors only (according to 19 computer simulations derived from five different climate models); the **brown band** represents how the climate would have changed in response to both human and natural factors (according to 58 computer simulations derived from 14 different climate models). The overlap of the brown band and black line suggests that human activity very likely caused most of the observed increase since the mid-20th century. Temperature change is plotted relative to the corresponding average for the 1901 to 1950 time period.

The scientific consensus is clear that the rise in temperature and change in climate are being caused in part by human activities. Mainstream media are beginning to reflect this scientific consensus. But after a decade of controversial reporting and public debate, some skepticism lingers in the public at large and is still rampant among industry groups and their proponents who fear adverse economic impacts from taking action on global warming. While their main tactic now is to dismiss potential solutions to the problem -- in particular the 1997 Kyoto Protocol to the UN Framework Convention on Climate Change -- climate skeptics continue to attack the science in order to undermine an essential and rational basis for cost-effective, sustainable action on this global problem.

A **review** of the Nov/2007 report by IPCC - **Risks And Rewards Of Combating Climate Change** can be found at

<http://www.pollutiononline.com/content/news/article.asp?docid=6a59aa4a-42da-4a39-a3fe-bada6c160676>

with the full (23 page) report at

http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

Caveat #1: There seems to have been some legitimate concerns about the objectivity of the IPCC

See for example <http://ff.org/centers/csspp/library/co2weekly/2005-03-24/ipcc.htm>

Caveat #2: The Union of Concerned Scientists appears to support the work of the IPCC

See http://www.ucsusa.org/global_warming/science/the-ipcc.html

Climate change is a SERIOUS matter. For a summary of future impacts see

http://www.pewclimate.org/global-warming-basics/basic_science

To see impacts on ocean levels see

<http://www.pewclimate.org/global-warming-basics/slr.cfm>

The excellent web site at the National Academy of Sciences

<http://www.koshland-science-museum.org/exhibitgcc/index.jsp>

is both informative and entertaining. Well worth spending an hour or more just browsing the site!

An excellent “teacher’s guide” – top 10 things one needs to know can be found at

<http://hdgc.epp.cmu.edu/teachersguide/teachersguide.htm>

An excellent FAQ has also been written by government of Australia at

<http://www.greenhouse.gov.au/science/faq/> and

<http://www.greenhouse.gov.au/science/faq/pubs/science-faq.pdf>

CO₂ and You:

The US EPA sets a limit of 1000ppm for continuous exposure. See for example,

<http://www.inspect-ny.com/hazmat/CO2gashaz.htm>

The level has steadily increased from about 315ppm in 1958 to a level of about 380ppm today. So we have a number of years to go to get to 1000ppm unless...and here comes the rub...the increase goes up rapidly due to some runaway effect.

Canadian Government Information:

For the climate change overview see the very readable web site.

http://www.ec.gc.ca/climate/overview_science-e.html

- *as a direct result of human activity concentrations of carbon dioxide have increased by 30 per cent, methane by 145 per cent, and nitrous oxide by 15 per cent.*
- *the average global temperature has increased by about 0.5° C in the past 100 years, and temperature increases over the next 100 years are expected to significantly surpass any such change of the past 10,000 years.*
- *global sea levels have risen 10-25 cm over the past 100 years, and are expected to continue to rise due to increases in temperature*

To illustrate that within the broad scientific community the debate is over...

From http://www.msc.ec.gc.ca/education/scienceofclimatechange/understanding/FAQ/sections/7_e.html

G.1 From one week to the next, media reports appear to tell vastly different stories about the importance of climate change. Do climate change scientists constantly change their minds?

Response: No. The vast majority of scientists studying climate change agree that the basis for concern is scientifically sound. Media reports often tend to focus on the more controversial elements of the science related to the details of climate change, and to talk to those scientists who represent polarized views of scientific understanding. They also frequently fail to place new science within the context of the large body of existing knowledge, hence ignoring the considerable agreement within the expert science community on the fundamental principles and processes involved. Hence such reports are not a good representation of the understanding of the expert science community.

G.3 I understand there are thousands of scientists who argue that we know too little about climate change, and that it is therefore premature to respond. Who are these dissenters and are they credible?

Response: The dissenting scientists are primarily located in the United States, although there are some in the UK, Germany, Australia and other countries. A few have sound academic credentials relevant to climate change, but most have backgrounds in nuclear physics, energy, oceanography, and earth sciences rather than atmospheric sciences. Their primary argument is that the human influence on climate is not yet apparent, and that the results of climate modeling are exaggerated. However, most generally agree with the fundamental science underlying the concern about climate change.

G.4 With so much uncertainty about what we know about climate change, why don't we hold off any reductions in carbon dioxide emissions until we are better able to understand the global climate system?

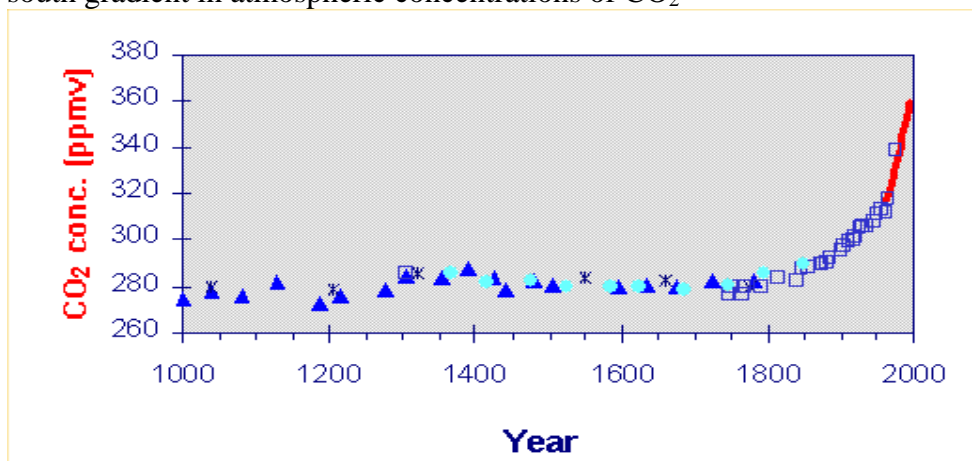
Response: Much of the uncertainty is related to the details of the consequences of global climate change. Scientists are in general confident that the basis for concern about climate change is scientifically sound and that the risks of danger are real and significant. Such risks make it prudent that we begin precautionary action now.

G.6 Is it too late to stop climate change?

Response: Scientists agree that the current warming trend cannot be stopped or reversed, but that it can be slowed down to allow biological systems and human society more time to adapt.

B.2 How do scientists know that the atmospheric buildup of greenhouse gases is due to human activity?

The rapid rise in greenhouse gas concentrations during the past century is consistent with trends in human emissions, and unprecedented in at least the last 420,000 years and likely in the past 20 million years. Furthermore, the concentration of CO₂ molecules in the atmosphere containing the radioactive carbon 14 atom (after adjustment for atomic explosion testing activities in the 1950s) is declining. This is consistent with increased concentrations of burning of coal, oil and natural gas, all of which contain 'old' carbon that has no carbon 14. Changes with time in ratios of carbon 13 and carbon 12 in oceans are also consistent with human emissions, as is the north-south gradient in atmospheric concentrations of CO₂



B.4 Don't volcanoes naturally release far more CO₂ into the atmosphere each year than humans?

Response: No. On a global scale, volcanoes release less than 1% of human emissions of carbon dioxide and hence are a minor contributor to changes in its atmospheric concentrations. Furthermore, emissions from volcanoes have always been part of the natural cycle, which has been in approximate balance for many millennia, until the industrial revolution

B.7 I understand water vapour dominates the natural greenhouse effect. Doesn't this make changes in the concentrations of other greenhouse gases insignificant?

Response: No! While water vapour represents about two-thirds of the natural greenhouse gases, changes in its concentrations are determined primarily by changes in atmospheric temperature and related effects on the hydrological cycle. As increases in other greenhouse gases warm the atmosphere and surface, the amount of water vapour also increases, amplifying the initial warming effect of the other greenhouse gases.

C.6 Doesn't the substantial cooling in places like the eastern Canadian Arctic, Greenland and in eastern Antarctica over the past few decades contradict model predictions of global warming?

Response: No. A regional cooling can be fully consistent with a warmer world. Although increasing greenhouse gas concentrations apply a rather uniform global forcing, other factors such as natural variability, local feedbacks and regional changes in atmospheric and oceanic circulation can enhance their effects in region while reducing them in another. For example, in the Arctic, some regions, such as the western Canadian Arctic and Siberia, have warmed dramatically. Although the eastern Arctic also warmed slightly during the past 50 years, some regions within it have cooled somewhat. Despite these regional variations, the average temperatures across the Arctic are becoming considerably warmer in a manner largely consistent with recent model projections. Likewise, while some regions of east Antarctica have cooled over the past few decades, the Antarctic Peninsula has warmed dramatically. Advanced climate models are now able to capture this variability quite well, and can simulate regional changes that are broadly similar to that observed.

E.6 Can scientists prove that recent extreme weather events are due to global warming?

Response: No. Although by definition extreme events occur very rarely, most of the recent events have likely happened before. Furthermore, because of their complexity, it is still difficult to assess the natural probability of occurrence for many of these events. However, in many respects, many of the recent events are also consistent with what is expected more frequently in the future, and could therefore already have been influenced by warmer climates. At minimum, many of these provide a good reminder of what may happen more frequently in the future.

E.7 Will global warming take place gradually or rapidly?

Response: Climate model studies suggest that the response of the climate to human influences will be gradual. However, there is evidence that the Earth's climate has occasionally made abrupt shifts in the distant past, primarily during periods of glacial climates or of climate change. Hence, similar abrupt changes, although unlikely, cannot be ruled out.

Global warming has both positive and negative aspect⁽⁵⁾. **Some** are listed in the table below.

Positive aspects of global warming	Negative aspects of global warming
Increases in crop yields in some mid-latitude regions	Reduction in crop yields around tropics and subtropics
Increase in timber supplies from some forests	Decrease water availability in areas short of water
Increased water availability in some regions	More endangered/at risk species
Reduced winter mortality in high latitude regions.	Negative impacts on coral reefs and alpine regions
Increase in some economic activity due to less disruptions from cold weather	Increased flooding with more intense rains.
	Increased flooding due to rise in ocean level

For a good general guide on “How to talk to a Climate Skeptic” see <http://gristmill.grist.org/skeptics>

For example, a question that is sometimes asked – **why during a mid-century rise on CO2 was there cooling?** To those skeptics of climate change see <http://gristmill.grist.org/story/2006/11/4/14560/6189>

Some may view this site as just PR. Still, it does engage the many questions put forth by skeptics.

GRACE (Gravity Recovery and Climate Experiment) in Space

A mission that's improved our knowledge of Earth's gravity field by more than 100 times and is helping to revolutionize our understanding of Earth's climate.

<http://www.csr.utexas.edu/grace/>

Recently this tool was used to demonstrate the complex water circulation in the arctic.

<http://www.jpl.nasa.gov/news/news.cfm?release=2007-131>

Many scientists viewed the changes as evidence of an ongoing climate shift, raising concerns about the effects of global warming on the Arctic. Unfortunately the spin doctors have used this to deny global warming!

See <http://globalwarmingtrends.blogspot.com/>

Solutions to the “Problem”:

Sadly, many of our “solutions” are at the root of our current problems. Thus solutions like “Engineered Weathering Process Could Mitigate Global Warming”⁽²⁾, in which the capacity of the oceans to sequester CO₂ is chemically enhanced, need careful study before being implemented.

The US Position: The first cut...

“For the first time, the US Congress has begun crafting comprehensive legislation to tackle global warming.”

<http://www.nature.com/news/2007/071114/full/450342a.html> and

http://www.nature.com/news/2007/071114/pdf/450342a_full.pdf

Politics being what it is, it means *“the debate has shifted among those who are opposed to action from the question of science to now questioning the solution.”*

View of National Academy of Scientists (NAS)

To quote <http://bookwormroom.wordpress.com/2007/11/08/global-warming-panic-continues-to-come-under-attack/> **(and the debate there is worth a read – it starts as...)**

The continuing problem here is that few non-scientists understand the process by which science is done. Scientists cherish diversity of opinion because they know that it's what keeps them honest. The claims of suppression of knowledge are false. There are honest differences of opinion, and in some cases a scientific group will overrule a minority and publish results that a strong majority feels confident in. That is not censorship or suppression — that is pragmatic. And scientists have a far higher standard of agreement than most other areas of policymaking. A 5 to 4 decision in the Supreme Court is considered definitive. A 51 to 49 vote in the Senate is final. But in most scientific councils, they don't decide on a conclusion unless they've got at least 80-20 or even 90-10. Then people point to the 10% dissenters and say “Scientists don't know what they're talking about”.

The NAS is a truly elitist organization; membership is by invitation only; invitations are extended only to scientists who have distinguished themselves with excellence. The NAS is also very conservative; knowing how important their credibility is, they don't include anything in a report that they're not highly certain of.

Thus, the NAS is to science as the Supreme Court is to law. There are some differences: the Supreme Court has only 9 justices, where the NAS has hundreds of distinguished scientists to consider the issues. The Supreme Court decides issues on a simple majority basis, while the NAS requires a huge supermajority. The Supreme Court has to make its decisions in a single term; the NAS will take as long as it thinks it needs. The result of this much more careful approach is that, in its entire history, the NAS has NEVER issued a single report that was later shown to be incorrect. Not once in 140 years. Can you name ANY government institution with that kind of track record?

So, what does the NAS have to say about climate change? Here is the first paragraph of their [report] on climate change:

“Greenhouse gases are accumulating in Earth’s atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising. The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes is also a reflection of natural variability. Human-induced warming and associated sea level rises are expected to continue through the 21st century. Secondary effects are suggested by computer model simulations and basic physical reasoning. These include increases in rainfall rates and increased susceptibility of semi-arid regions to drought. The impacts of these changes will be critically dependent on the magnitude of the warming and the rate with which it occurs.”

They also prepared a [short brochure] on the subject for easy public consumption. Here are some quotes from that brochure:

“there is now strong evidence that significant global warming is occurring.”
“It is likely that most of the warming in recent decades can be attributed to human activities. This warming has already led to changes in the earth’s climate.”

Thus, the reference to “global warming hysteria” is “extremely false”. It is not hysteria, it is well-developed and documented science. There is no basis for honest skepticism of the general contours of climate change — that skepticism is, in the vast majority of cases, predicated upon political attitudes, not rational analysis.

Lastly, I offer a simple, unbeatable challenge: if you are skeptical of climate change science, then cite a statement in the latest IPCC report⁽³⁾ that you can refute. And if you haven’t even read the IPCC report, how can you deny its truth?

To follow the rest see link above....

The “Hockey stick” controversy:

The best overview is at http://en.wikipedia.org/wiki/Hockey_stick_controversy

Having read all the material there I can only conclude that the validity of the “Hockey stick”, stands (with a 2:1 probability)

The non-scientific based controversy:

The left says global warming is a real-time crisis requiring swift curbs on smokestack and tailpipe gases that trap heat, and that big oil, big coal and antiregulatory conservatives are trashing the planet.

The right says global warming is somewhere between a hoax and a minor irritant, and argues that liberals' thirst for top-down regulations will drive American wealth to developing countries and turn off the fossil-fueled engine powering the economy⁽¹⁾

Credible Doubters

In Canada there is Timothy Ball – who holds a PhD in Climatology

<http://canadafreepress.com/2007/global-warming020507.htm>

Those who are skeptical of the majority view can follow the above link.

Not so credible doubters

See the many non-scientific articles by Lawrence Solomon at

<http://www.urban-renaissance.org/urbanren/index.cfm?DSP=larry&SubID=163>

Other doubters

<http://www.friesian.com/crichton.htm> - a review of the book by S. Fred Singer and Dennis T. Avery, Unstoppable Global Warming, Every 1,500 Years

The COSTS:

A free report titled “*Reducing US Greenhouse Gas Emissions: How Much at What Cost?*” is available from the Conference Board of Canada at

<http://sso.conferenceboard.ca/e-Library/LayoutAbstract.asp?DID=2341>

Among the main findings:

- Opportunities to reduce greenhouse gas emissions are highly fragmented and widely spread across the economy. The largest single option — carbon capture and storage (CCS) for coal-fired power plants — offers less than 11 percent of total potential identified. The largest sector, power generation, accounts for less than one third of the total.
- Reducing emissions by 3 gigatons of CO₂e in 2030 would require \$1.1 trillion of additional capital spending, or roughly 1.5 percent of the \$77 trillion in real investment the U.S. economy is expected to make over this period.
- Investment would need to be higher in the early years, in order to capture energy efficiency gains at lowest overall costs and accelerate the development of key technologies, and would be highly concentrated in the power and transportation sectors.
- If pursued, such investment would likely put upward pressure on electricity prices and vehicle costs. Policymakers would need to weigh these added costs against the energy efficiency savings, opportunities for technological advances, and other societal benefits.

Final Words:

Some still argue that man's activity is not the cause of global warming / climate change. There is an excellent counter example. Immediately after 9-11 the North American flights were grounded. The contrails disappeared and the temperature range across North America changed 1.1 degrees until the flights resumed. Something to ponder...

Some studies of the impact of plane contrails are available⁽⁴⁾ with little conclusion, but with some concerns so far.

For a nice animation of North American air travel see

<http://dotearth.blogs.nytimes.com/2007/11/21/come-fly-with-me-and-me-and-me-and-me/>
and especially the youtube movie at http://www.youtube.com/watch?v=H2qTwvaQ_F4

With the science at hand – can we afford such divisiveness? There is an old and apt saying
– **an ounce of prevention is worth a pound of cure**

- (1) http://www.nytimes.com/2007/11/13/science/earth/13book.html?_r=1&n=Top/News/Science/Topics/Global%20Warming&oref=slogin
- (2) <http://www.pollutiononline.com/content/news/article.asp?docid=6550ad7e-4cf6-4b60-be57-3e8db48c91cd>
- (3) <http://ipcc-wg1.ucar.edu/wg1/wg1-report.html>
- (4) <http://www.contrails.nl/contrails-research/temperature%2002.htm>
- (5) <http://www.greenhouse.gov.au/education/factsheets/planet.html>