Global Warming
What is it all about?

EPA

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pdf file of slides available upon request from rlindzen@mit.edu

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The issue of global warming has three distinct components:

Global Warming Itself

Catastrophic Climate Alarmism

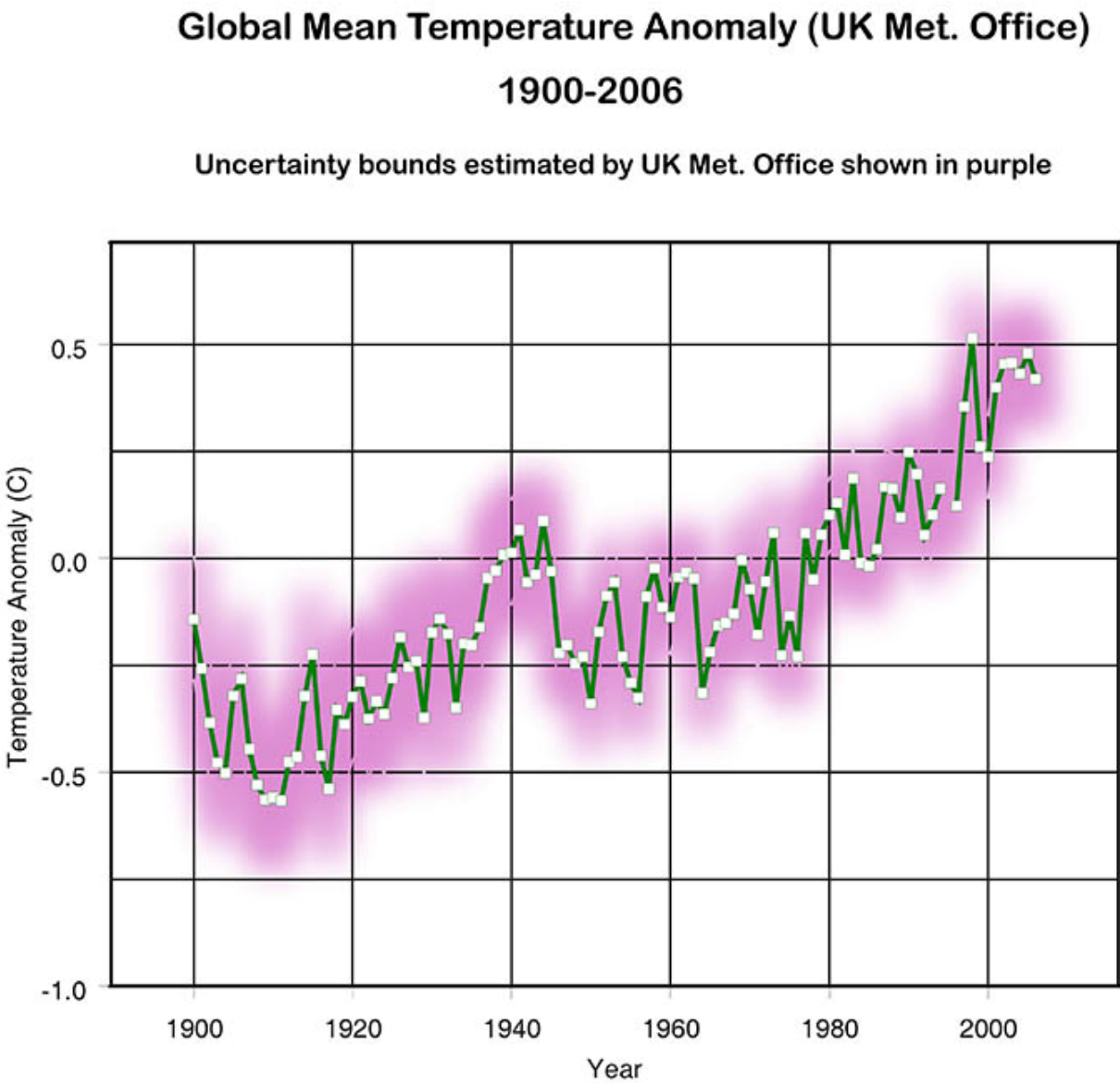
Climate Mitigation Policy

Each of these components is complex and uncertain.

The connections between the components are weak to the point of non-existence. However, it is characteristic of this topic to treat them all as equivalent.

What is Global Warming?

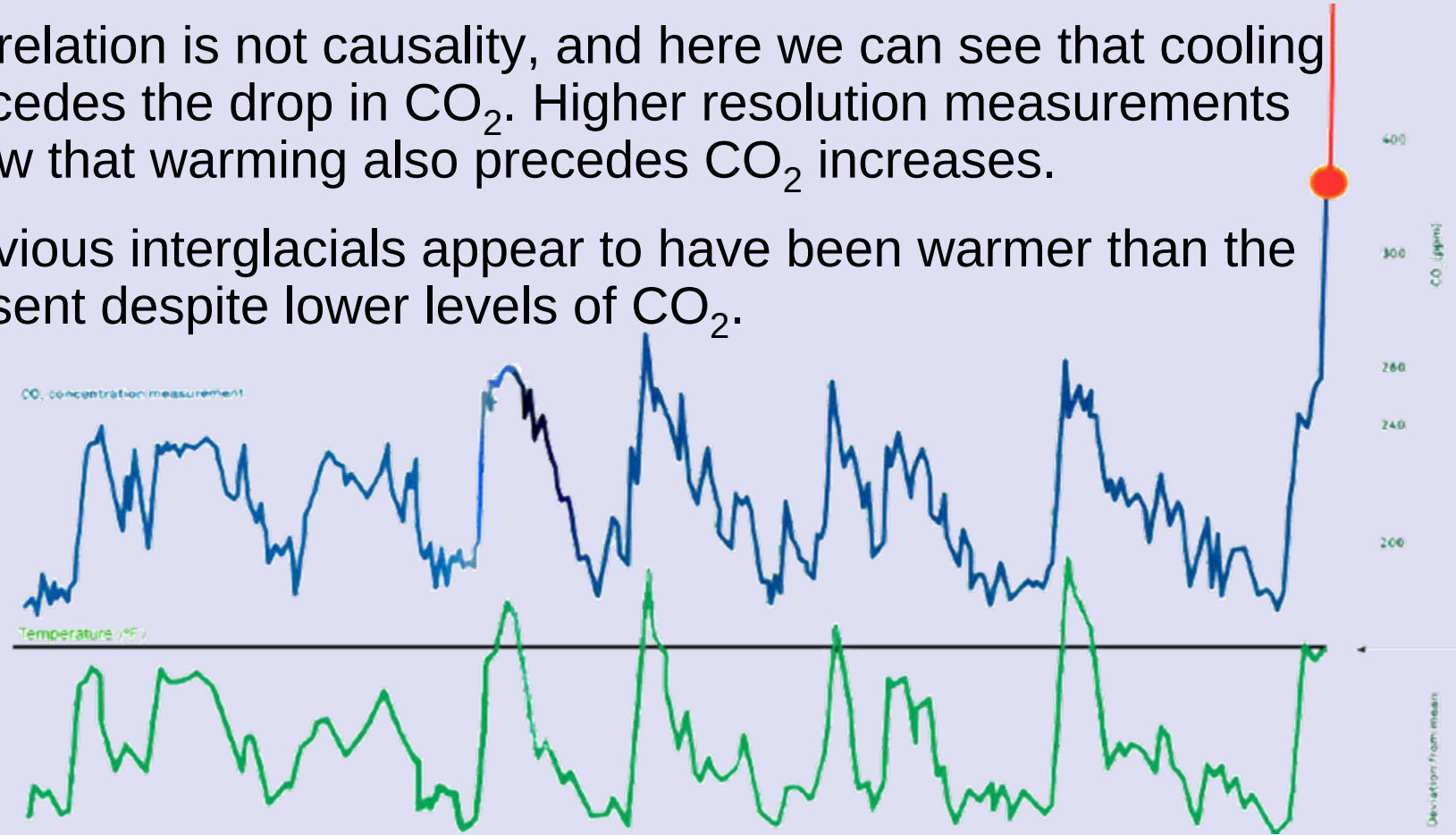
The line represents the actual measurements; the purple fuzz represents the stated uncertainty. Note the small (order 0.6C) overall but irregular warming since 1900.



Is this about Global Warming?

CO_2 and temperature records over the past 650K years as inferred from ice cores in Antarctica are often cited as evidence for the role of CO_2 in global climate, but the example is faulty on several grounds:

1. Correlation is not causality, and here we can see that cooling precedes the drop in CO_2. Higher resolution measurements show that warming also precedes CO_2 increases.
2. Previous interglacials appear to have been warmer than the present despite lower levels of CO_2.

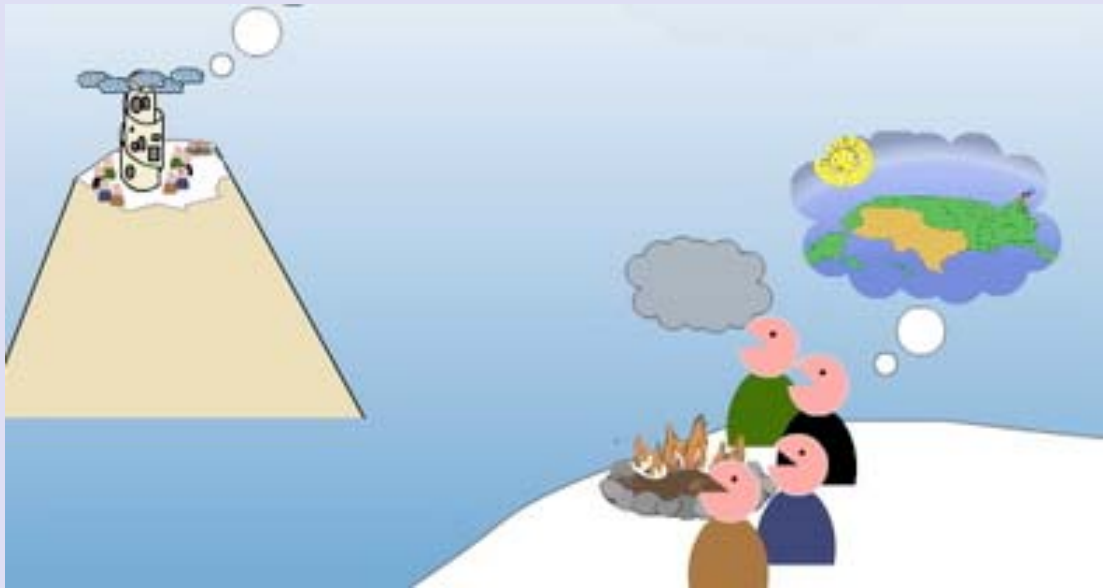


Is this what the public discourse is about?

In part – but only in relatively small part.

In fact, as I have already mentioned, there are three crucial aspects of the public discourse, and they are largely **disconnected.**

Understanding the nature of these disconnects is more important, I suspect, than understanding the science. However, we need to deal with the components first.

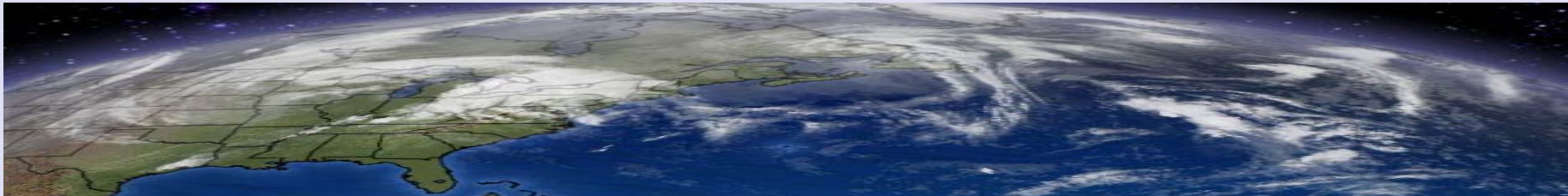


Aspect 1: Global warming itself

Global Warming is, itself, the product of many factors, and its relevance to anything else depends on its **magnitude**. Emissions of minor greenhouse gases is a factor, but only one factor (and probably not the most important) among several.

What are other factors?

The sun is commonly mentioned, but the fact of the matter is that ***the climate system does not need any external forcing to fluctuate on the scale that has been observed***. The ocean, by constantly but irregularly exchanging heat between deeper and shallower regions is always out of equilibrium with the surface, thus serving as a large source or sink of energy for the atmosphere. In the literature, this variability goes by names like El Niño, the Pacific Decadal Oscillation, and the Atlantic Multi-Decadal Oscillation – all indicative of time scales on the order being considered.



Don't forget that climate is always changing – and on virtually all time scales.

Here is a recent paleoreconstruction for the past 2000 years.

Most presentations focus on the last 100 years or so (and show the modest warming that we are talking about), but in the context of the past 2000 years, the last 100 years do not appear exceptional.

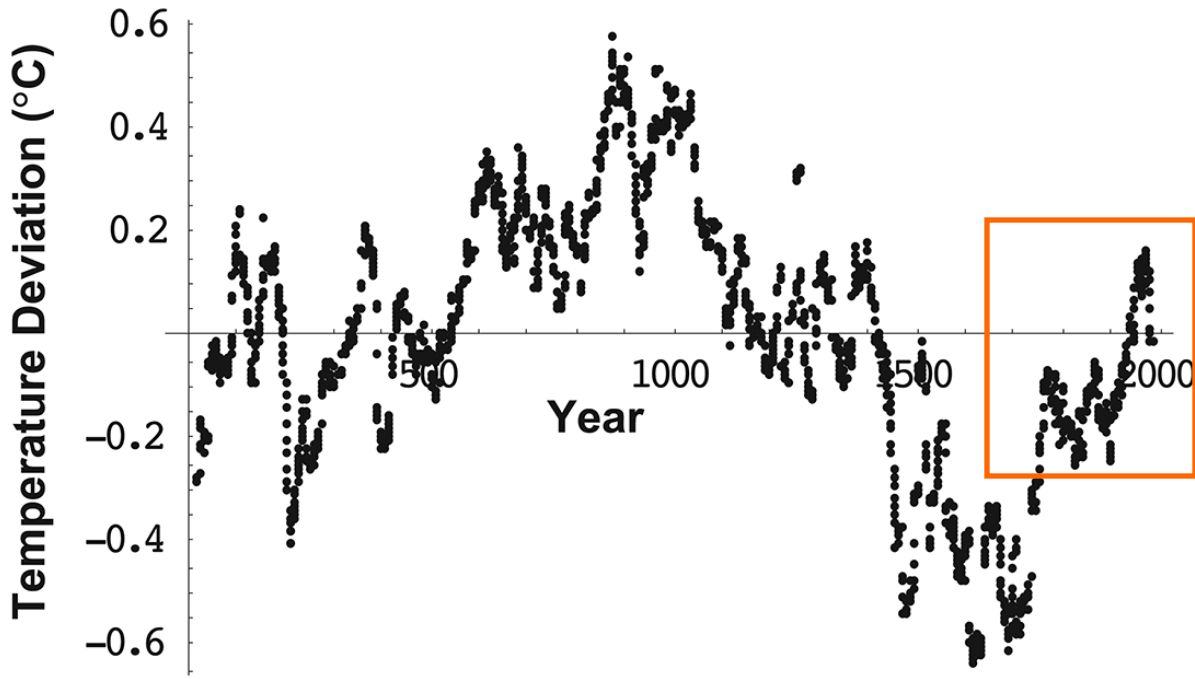
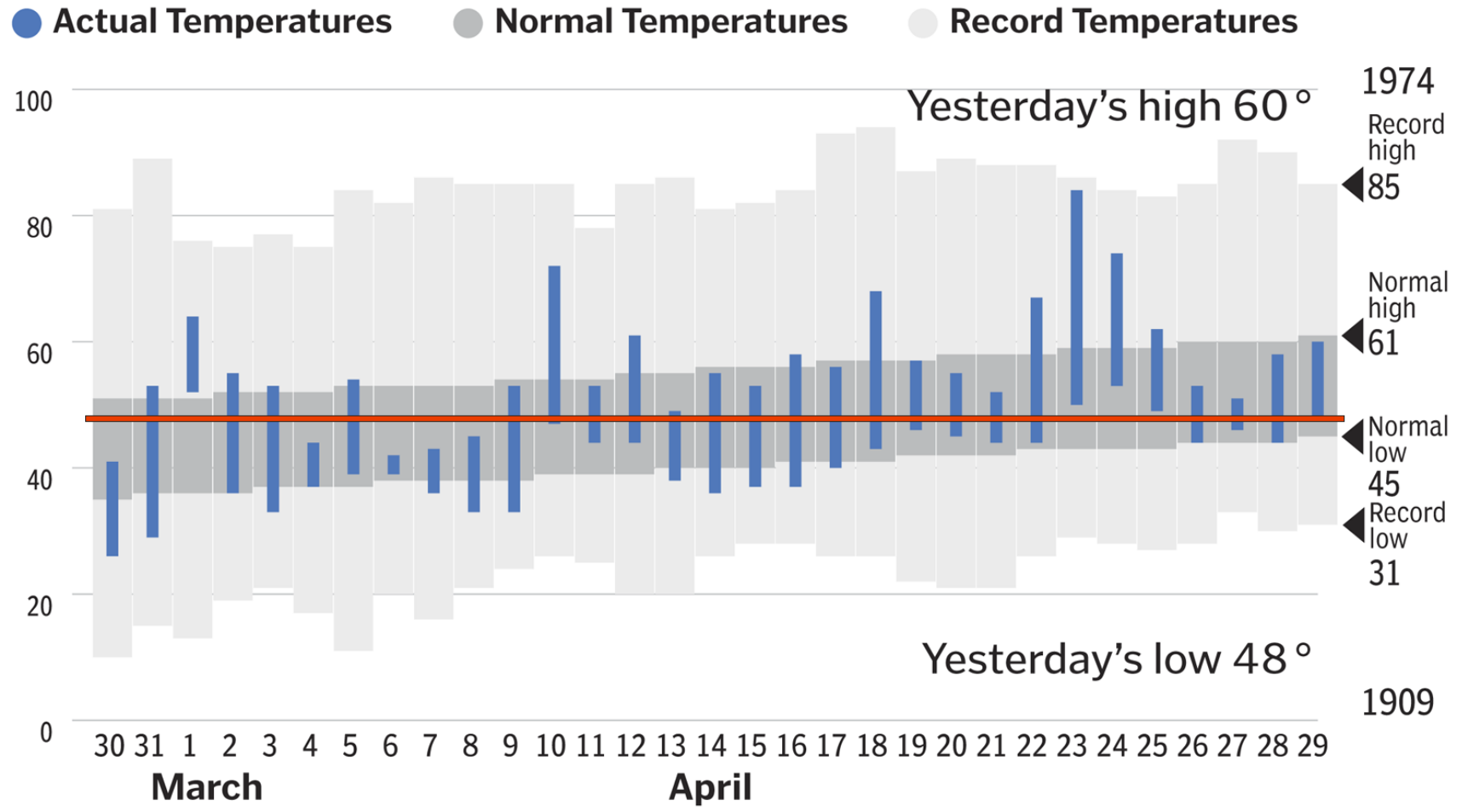


Figure 1. Mean of temperature data for 18 series.
Data archived at http://www.ncasi.org/programs/areas/climate/LoehleE&E2007.csv

Note that we are still talking about small changes: much smaller then the normal change in Boston from the beginning to the end of April, for example.

April 30, 2008



What is actually emphasized.

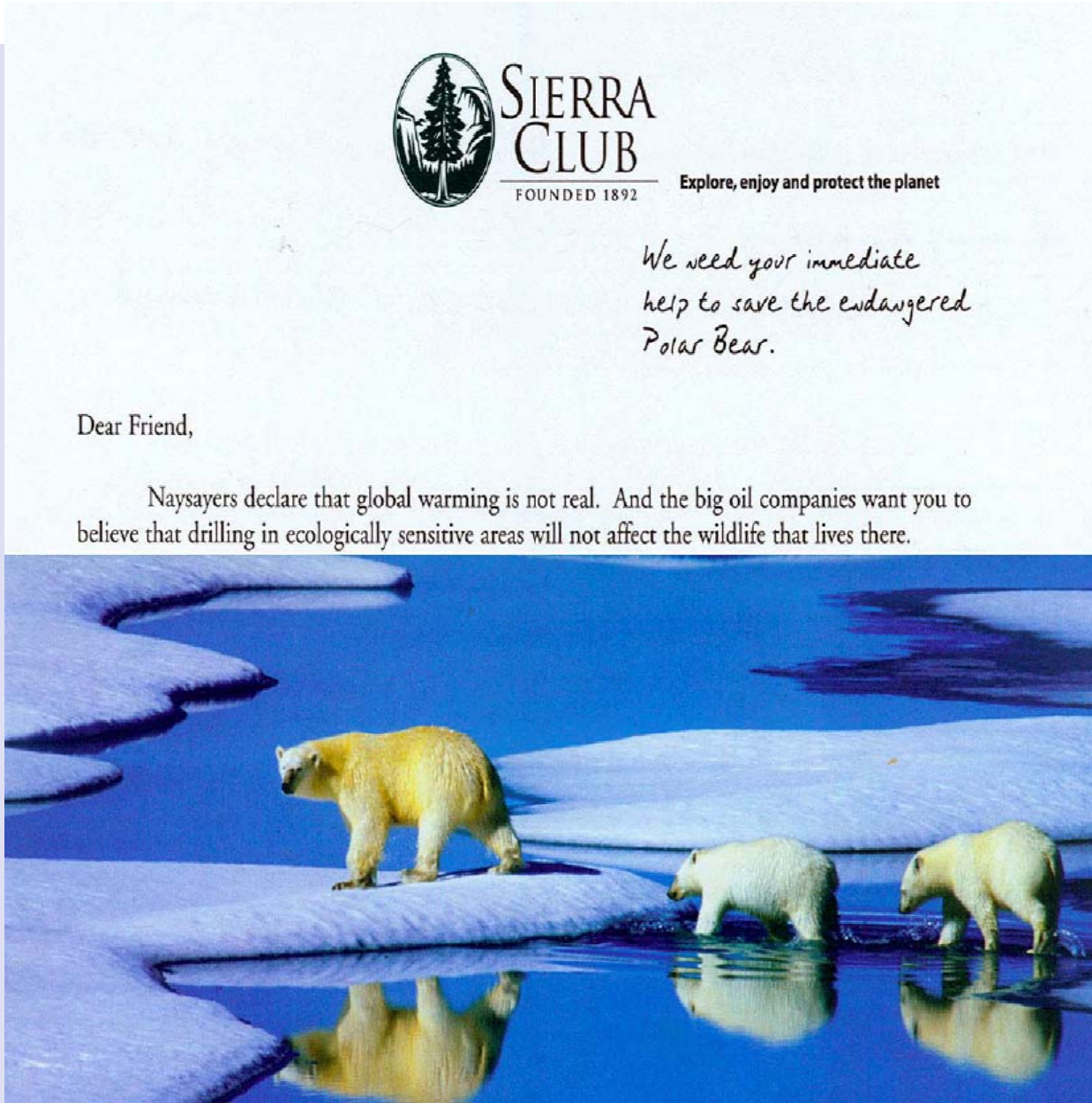
While Global Warming is sometimes what we hear about, what is usually stressed are ‘catastrophic’ or emotionally affecting alleged consequences of warming.

Geneva (Reuters) – Obesity contributes to global warming, too. May 15, 2008

ScienceDaily – Global Warming may lead to increase in kidney stones disease. May 15, 2008

AP- Earthquakes stronger due to global warming. June 18, 2008

NIA- Global warming could lead to increased terrorism. June 26, 2008.



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We need your immediate help to save the endangered Polar Bear.

Dear Friend,

Naysayers declare that global warming is not real. And the big oil companies want you to believe that drilling in ecologically sensitive areas will not affect the wildlife that lives there.

Climate change causes lemming decline. Boston Globe, November 10, 2008

PHOTO BY ERIKA LESLIE

LOSING LEMMINGS — Norway's lemming population is declining and it's not because the rodents are making a mad rush off a cliff. Climate change is the suspected cause, according to a study published online last week in Nature. Researchers presented evidence that unseasonable increases in temperature and humidity are altering snow conditions — reducing the insulated zone underneath the snow layer that provides small rodents with the essentials of survival: warmth, access to food plants, and protection from predators. Without that refuge, it is difficult for young lemmings to survive.

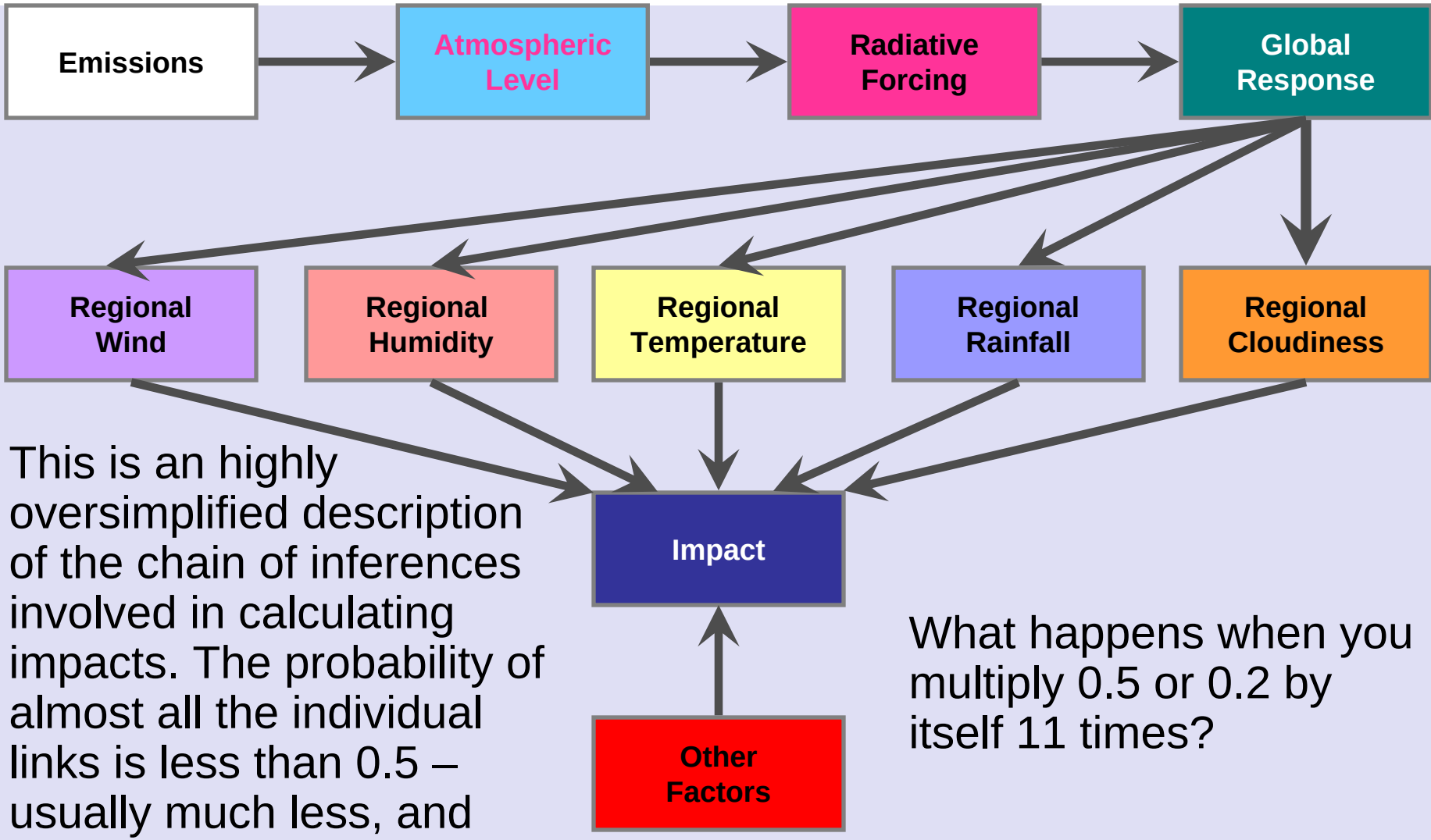
Aspect 2: Catastrophes

Putative catastrophes associated with global warming never result from global warming alone, but depend on the confluence of many factors almost all of which are essentially unpredictable.

The catastrophes emphasized in the environmental literature are selected on the basis of marketing research and focus groups – not climate science. Catastrophic forecasts are essentially always wrong (viz predictions of resource depletion, mass starvation, global cooling, Y2K, etc.).

Why is this so?

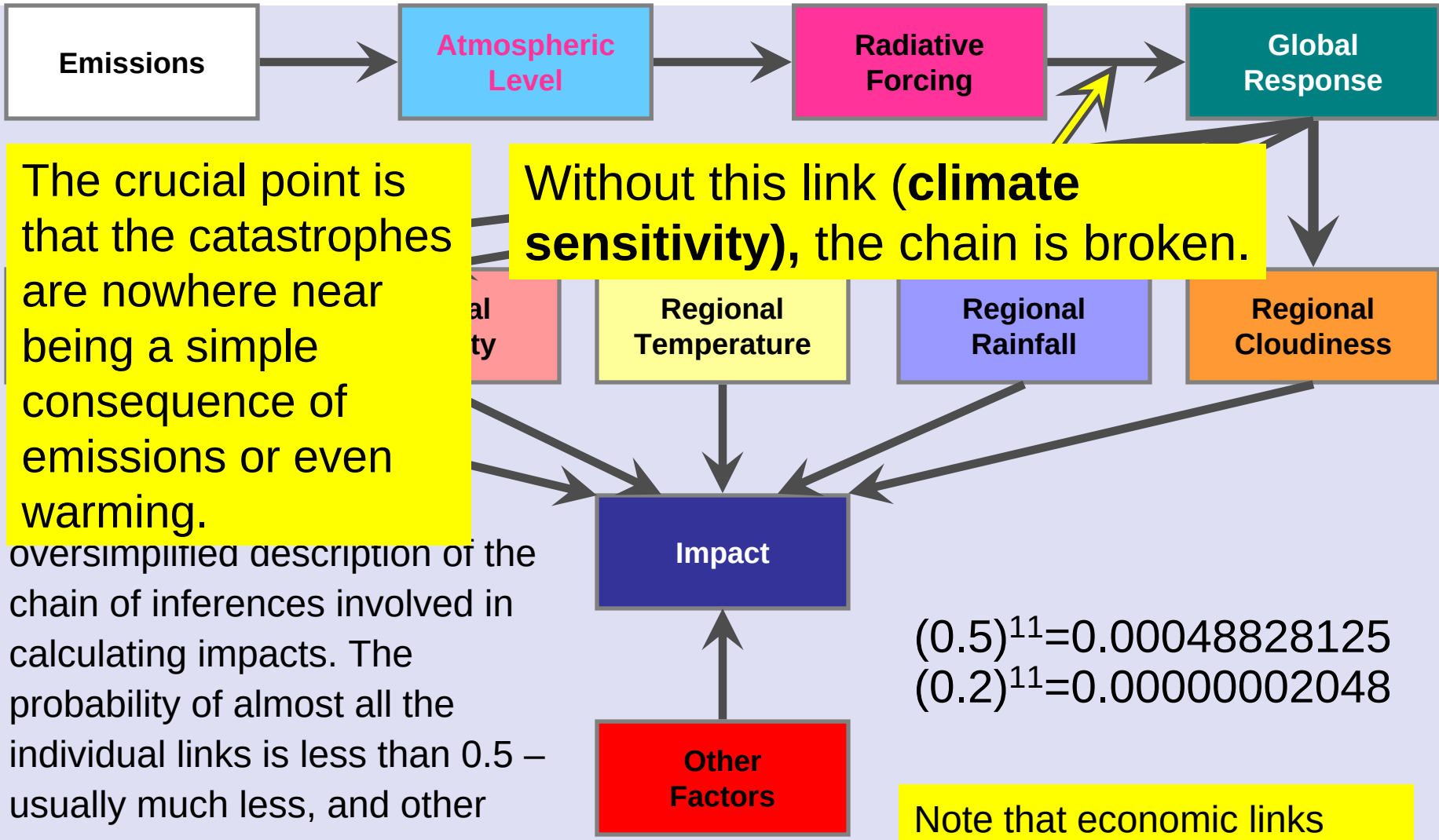
Impacts as a Chain of Inferences



This is an highly oversimplified description of the chain of inferences involved in calculating impacts. The probability of almost all the individual links is less than 0.5 – usually much less, and other factors can interfere with and confuse results.

What happens when you multiply 0.5 or 0.2 by itself 11 times?

Impacts as a Chain of Inferences



The crucial point is that the catastrophes are nowhere near being a simple consequence of emissions or even warming.

Without this link (**climate sensitivity),** the chain is broken.

oversimplified description of the chain of inferences involved in calculating impacts. The probability of almost all the individual links is less than 0.5 – usually much less, and other factors can interfere with and confuse results.

$(0.5)^{11}=0.00048828125$
$(0.2)^{11}=0.00000002048$

Note that economic links have not been included.

Model uncertainty does allow some model to predict anything.

Tim Palmer, a prominent atmospheric scientist at the European Centre for Medium Range Weather Forecasting, is quoted by Fred Pearce (Pearce, 2008) in the *New Scientist* as follows: "Politicians seem to think that the science is a done deal," says Tim Palmer. "I don't want to undermine the IPCC, but the forecasts, especially for regional climate change, are immensely uncertain." Pearce, however, continues “Palmer .. does not doubt that the Intergovernmental Panel on Climate Change (IPCC) has done a good job alerting the world to the problem of global climate change. But **he and his fellow climate scientists are acutely aware that the IPCC's predictions of how the global change will affect local climates are little more than guesswork**. They fear that if the IPCC's predictions turn out to be wrong, it will provoke a crisis in confidence that undermines the whole climate change debate. On top of this, some climate scientists believe that even the IPCC's global forecasts leave much to be desired. ...”

Catastrophic claims *never* involve a consensus among scientists.

Most scientists working on climate physics agree that storminess will decrease in a warmer world. Most scientists working on hurricanes agree that Katrina cannot be attributed to global warming.

Epidemiologists have noted that more lives will be saved from reduced cold than will be lost to increased warmth. Insect borne disease specialists note that diseases like malaria were once endemic to Siberia. Alpine glaciologists largely agree that the diminution of Kilimanjaro's glacier is not due to warming.

Indeed, even the environmental literature switches from claims of **'consensus'** to claims that **'scientists say'.** The difference is important but largely missed by most outsiders. In fact the scientists who say such things amount to no more than a handful, and even they usually qualify their statements. In particular, 'could' generally replaces **'will.'**

Aspect 3: Mitigation Policies

Almost all suggested 'mitigation' policies are essentially irrelevant to climate or practically and some are morally impossible.

Kyoto – even if perfectly adhered to – delays whatever warming might be expected by 2100, by a year or two.

No currently known energy source can replace fossil fuels to the extent required to reduce emissions by 80%. Nuclear provides a partial out as might currently unknown approaches.

Current approaches like biofuels, cap and trade, and carbon offsets may already be leading to hunger, societal instability, and corruption – without reducing emissions at all. Efficiency may be more an aesthetic issue than a means of reducing emissions.

Night time satellite image of the Korean Peninsula

South Korea has about the same per capita emissions as the UK; North Korea's are about 80% less. Is this what we want?

Climate change ‘mitigation’ and the developing world

It has long been recognized that reducing carbon dioxide would ultimately prevent the developing world from achieving its legitimate goals.

To avoid this in the first instance, developing countries were excused from the Kyoto constraints.

Nevertheless, the developing world remains sensitive to the dangers of western climate policy, and cynical of its real purposes.

Thus, Rajendra Pachauri simultaneously endorsed a climate report for the Government of India that argues that climate change will not be a problem for India, while, as head of the IPCC, he preaches that climate change will bring doom and disaster to the rest of the world, and urges the west to become vegetarian. Somehow, the cynicism seems remarkably clear to many – even if the Nobel Peace Prize Committee fails to notice it.

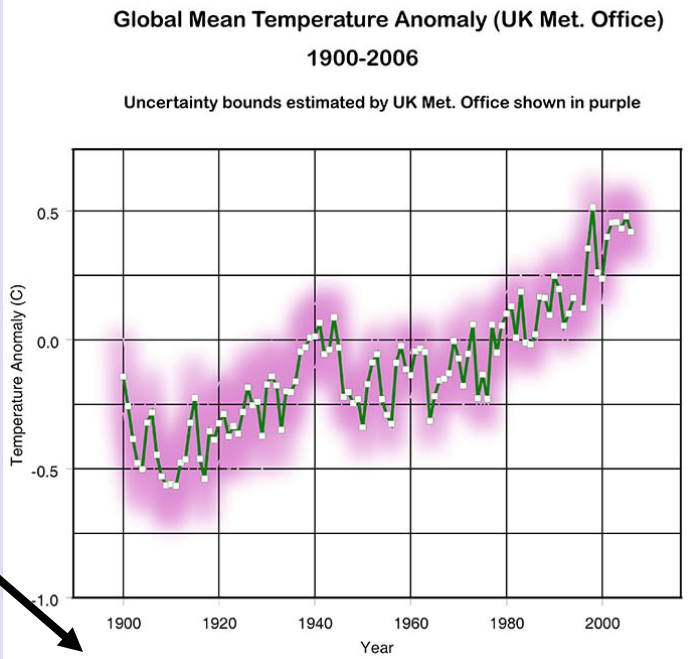
Combining these three independently complex and uncertain aspects – aspects in large measure unrelated to each other – into a single Climate Question – and claiming the agreement of all scientists on the matter, is clearly absurd. Equally absurd is the claim that this science is settled.

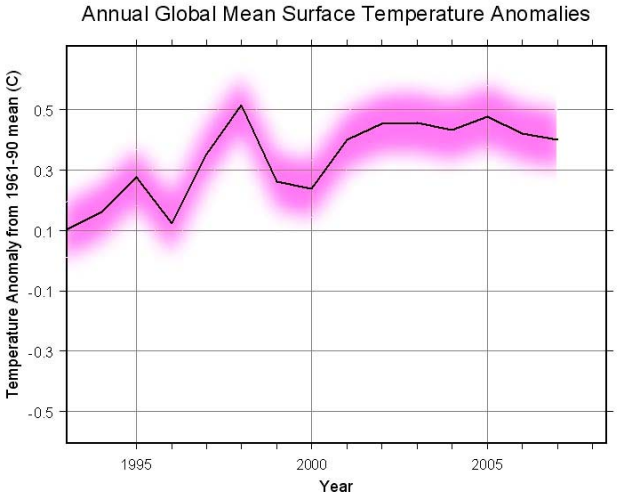
Whether claims that are so obviously absurd can be considered to be dishonest is a matter of judgment that I leave to you. It is not always an easy call. But, there are things you can look for.

Misuse of language is central to the public discourse

For example, we are currently in a warm period, but there has been no warming trend for over ***ten years***. Normal year to year fluctuations in temperature do cause some of the years to be among the warmest in the record, but this has nothing to do with trends.

Keep this in mind the next time you hear someone respond to the fact that there has been no trend over the past ten years with the assertion that x of the last y warmest years occurred since 1996.





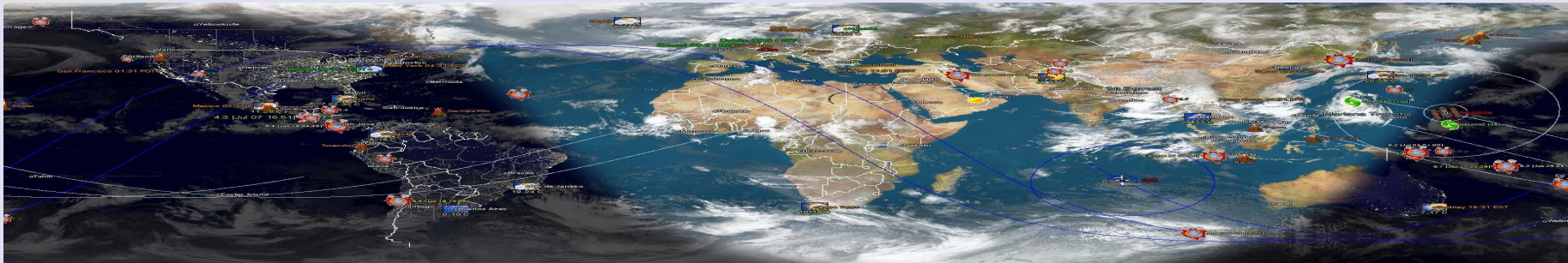
I suspect that this cessation of warming may also be responsible for the tsunami of hysterical climate propaganda of the past 3 years. The issue has been prominent for almost a generation, during which time many agendas have developed. There may be a fear that these agendas must be achieved now or never.

Another example of semantic confusion.

Similarly, it is often claimed that we are now warmer than we have been for the past thousand years. Though the claim is almost certainly false, even if it were true, it would not alter the fact that current warming is small (indeed much smaller than the models that are used to project alarm say it should be).

Important points to note:

1. It is not the amount of CO_2 that is important, but the contribution of all anthropogenic greenhouse gases to greenhouse forcing. We are already at about 80% of the forcing that would be produced by a doubling of CO_2.
2. There is a pronounced diminishing return for added CO_2. Each addition produces less forcing than its predecessor.
3. There is no physical evidence for a threshold in such a system.



Some Explanatory notes:

1. Diminishing returns for added CO_2: As one adds CO_2, one rapidly saturates the centers of radiative absorption bands (akin to the effect of painting an already blackened window with additional paint). The impact of further additions depends more and more on the weak wings of the absorption bands, leading to a logarithmic relation whereby each doubling of CO_2 leads to the same increase in greenhouse forcing. That is to say adding 280ppmv to 280ppmv leads to radiative forcing of about 3.5 Watts/square meter. At 560ppmv, one would need to add another 560ppmv to get another 3.5 Watts/square meter.
2. Ever more gradual increases in forcing generally are not associated with tipping points. More to the point, regional climate changes are generally much larger than (and significantly decorrelated from) global means. Tipping points will therefore show up long before global conditions are appropriate. The absence of such events argues against such points for the range of variability being considered.

Deconstructing the scientific consensus.

In support of the assertion of consensus, it is claimed that almost all scientists agree that the earth is warming and that man's activity causes warming.

If these two items are carefully separated, they do describe what is agreed on:

1. **There has *probably* been warming on the order of 0.5-0.8C over the past century.**
2. **CO_2 is a minor greenhouse gas, whose increase should lead to *some* warming.**

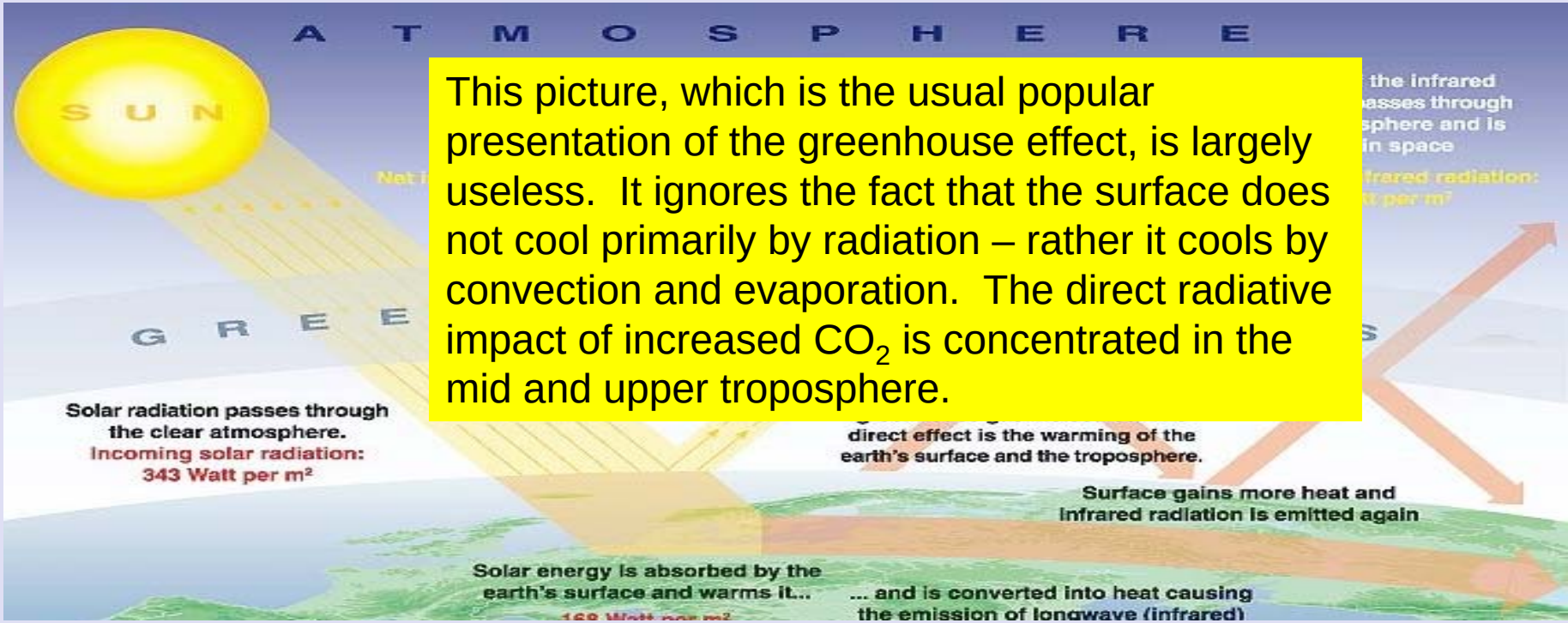
This agreement says nothing about

1. Whether items 1 and 2 are significantly related,
2. Whether the points of agreement have any relation to catastrophic expectations.

Some science.

For those of you interested in the science, here is an attempt to actually determine **the contribution of greenhouse warming** to the temperature record.

One begins with the model expectation for the pattern of warming, and then compares this with observations.



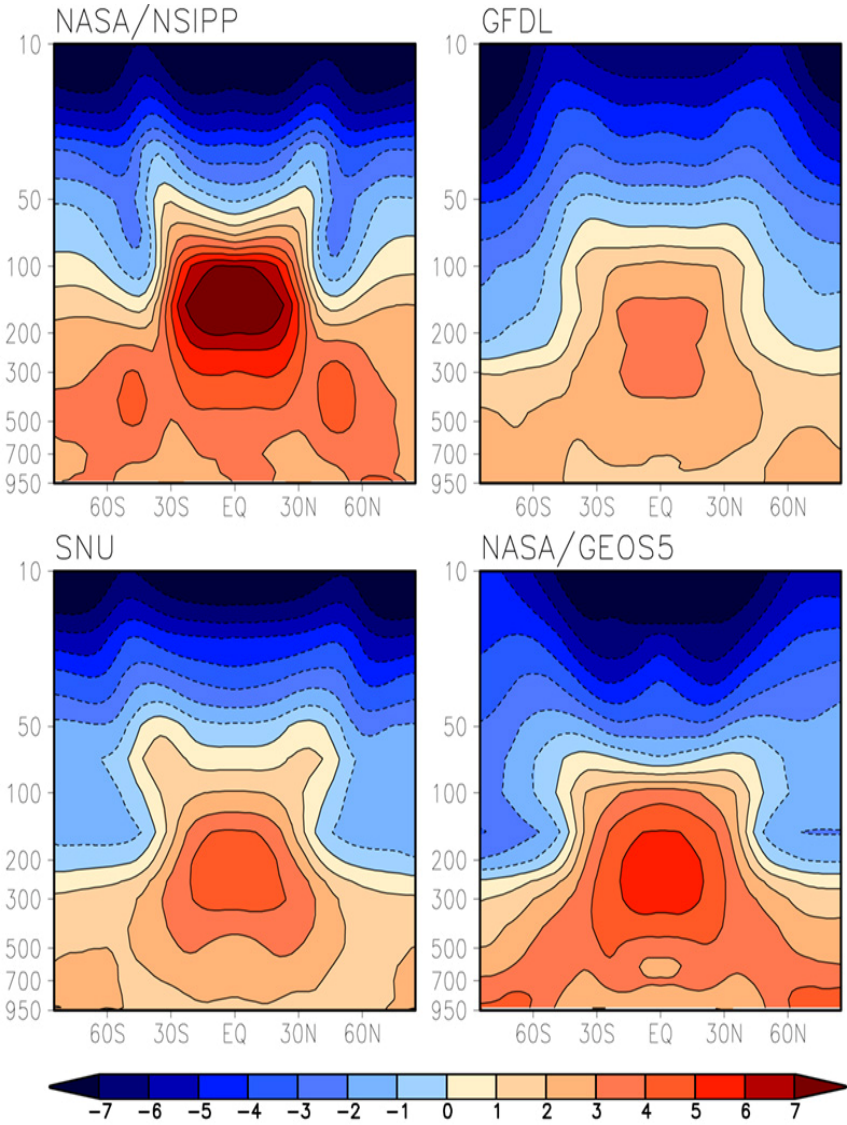
This picture, which is the usual popular presentation of the greenhouse effect, is largely useless. It ignores the fact that the surface does not cool primarily by radiation – rather it cools by convection and evaporation. The direct radiative impact of increased CO_2 is concentrated in the mid and upper troposphere.

Possible purpose of previous diagram.

What models show.

Here are very recent results for four state of the art models subject to a doubling of CO_2 (Lee et al 2007). Despite differences between the models, all show that warming is strongly concentrated in the tropical troposphere rather than at the surface. This is, in fact, **the real fingerprint of greenhouse warming**.

Although each model has a different sensitivity, **they all show about 2.5 times as much warming at the characteristic emission level than at the surface.** This is far more robust than the oft claimed polar magnification.



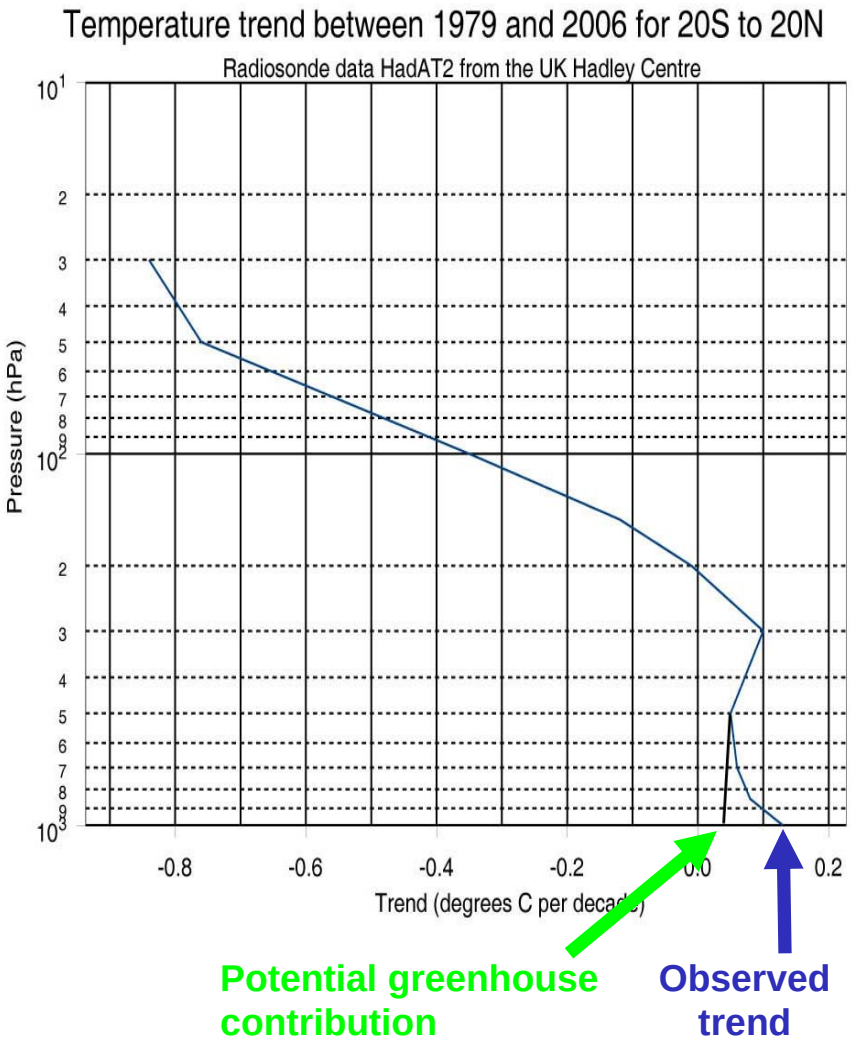
Zonal mean distributions of temperature change (2×CO2–Control). Units are Kelvin.

What does the data show?

Here are the measured trends from balloon data analyzed by the Hadley Centre in the U.K.
We do see a local maximum near the characteristic emission level (of about 0.1C/decade, but the trend at the surface is larger (about 0.13C/ decade) rather than smaller.

The correct theory tells us that no more than about a third of the surface warming can be greenhouse warming.

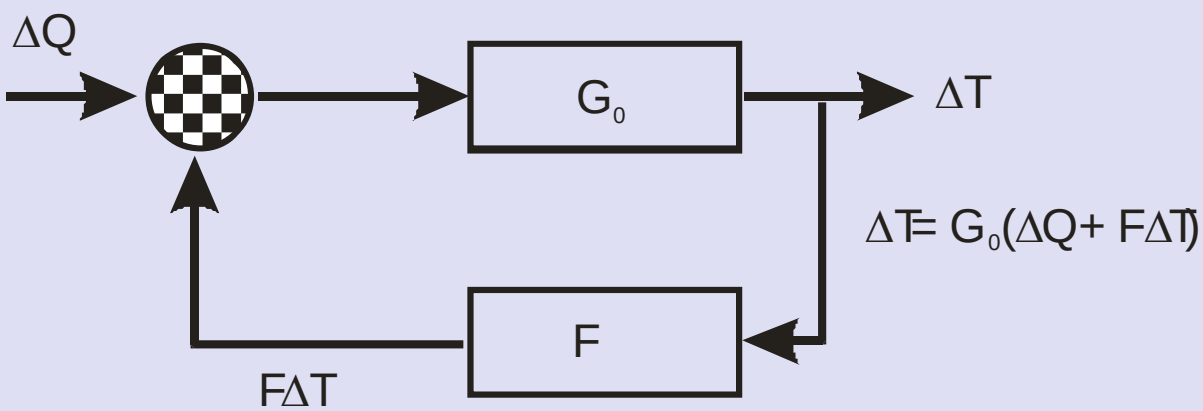
Note that this provides a bound for climate sensitivity: namely, about 0.4C for a doubling of CO_2. This is much below the bottom of the IPCC guesstimates.



Some explanatory notes

Climate sensitivity has come to be defined as the change in global mean temperature associated with a doubling of CO_2. A doubling of CO_2 produces a radiative forcing of about 3.5 Watts/square meter which is roughly a 2% perturbation to the total radiative budget of the earth. The previous illustration, by separating, greenhouse forcing from other forcing (most notably forcing by the ocean which is never quite in equilibrium with the surface), allows an immediate estimate of climate sensitivity.

In the absence of feedbacks from other greenhouse substances (like water vapor and clouds), a doubling of CO_2 will produce about 1C warming. The role of feedbacks is somewhat subtle.



$$\Delta T = \frac{G_0 \Delta Q}{1 - F}$$

or more generally,

$$\Delta T = \frac{G_0 \Delta Q}{1 - \sum_i F_i}$$

Some explanatory notes (continued)

Consider the last equation a little more carefully.

$$\Delta T = \frac{G_0 \Delta Q}{1 - \sum_i F_i}$$

$G_0\Delta Q$=1C. In current models, the response, ΔT, is always greater than this which implies that the models have positive feedbacks. Such a situation is unusual for long-lived natural systems, and our result suggests that the net feedback is negative.

Let F_1=0.5. If this is the only feedback, then ΔT=2C. Now let there be a second feedback for which F_2 also =0.5. ΔT will now be infinite! In models, F_1 is due to water vapor, while F_2 is due to clouds. F_2 is considered completely uncertain, and this accounts for the persistent wide range of model sensitivities. However, if the net feedback is negative, then the system is much more robust.

Science to the rescue of global warming.

It has become almost standard operating practice in the world of climate science for observations that imply reduced alarm to be ‘corrected.’

With respect to the preceding example, papers have come out that have attempted to do exactly that.

Allen and Sherwood (2008) simply threw out the thermometric balloon data and the satellite data, and argued that one could infer temperature changes from balloon wind data, and that these temperature changes agreed with the models. This approach was obviously dubious.

There followed a paper by Santer and 16 other authors (2008)(many of whom had no expertise in the issue – judging by their previous publications) who proceeded to greatly exaggerate the uncertainty of the data, and to consider the full range of results for all models regardless of quality. Using a couple of outliers among models, they were able to argue that the uncertainty of the data and the range of model results permitted some overlap. Hence the models and data were now ‘consistent’ with each other.

To be sure, models and data are often uncertain, but that correcting data always leads to consistency with models is highly unlikely.

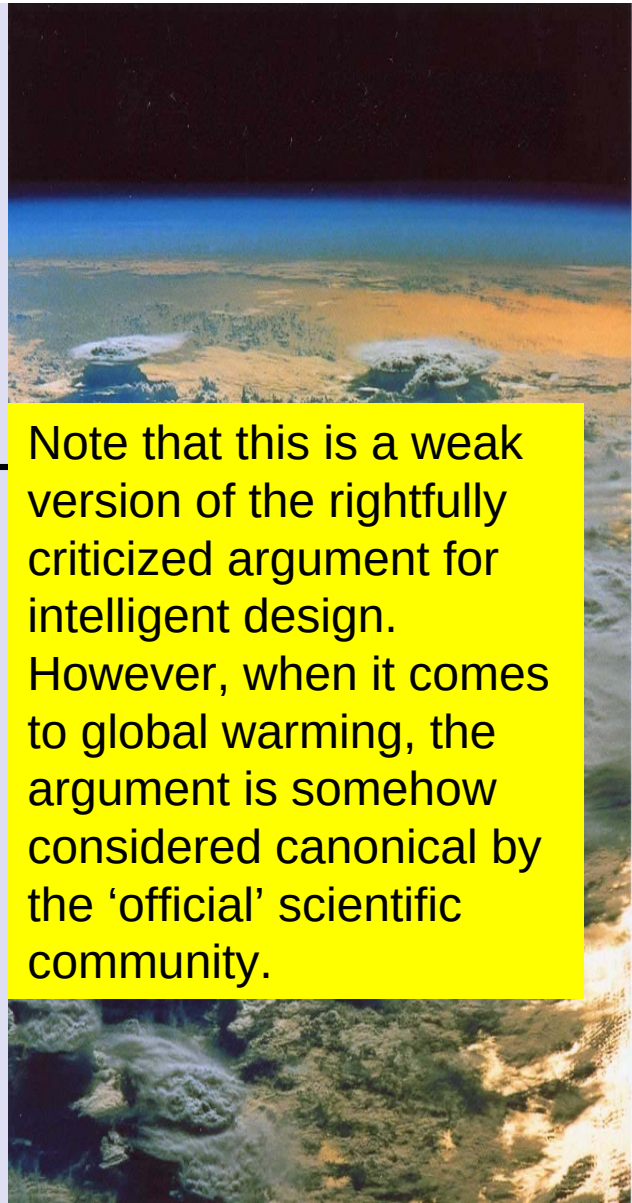
How did the IPCC justify its contrasting claims?

The IPCC claim that man is responsible for most (ie more than 50%) of recent warming is not so different from our finding of about 30%, but the IPCC justification is logically far more questionable.

The basis for the claim is, ultimately, that modelers cannot think of any other cause for the surface temperature rise of the past 50 years.

Moreover, the IPCC WG1 report acknowledges this – though the press release does not. Further, the change has been small, and the IPCC claims that it is merely probable that most (51%) is due to man.

To put it simply, consensus is invoked because arguments are unavailable.



Note that this is a weak version of the rightfully criticized argument for intelligent design. However, when it comes to global warming, the argument is somehow considered canonical by the 'official' scientific community.

Actual quote from IPCC WG1 Summary for Policymakers

"*Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations*."

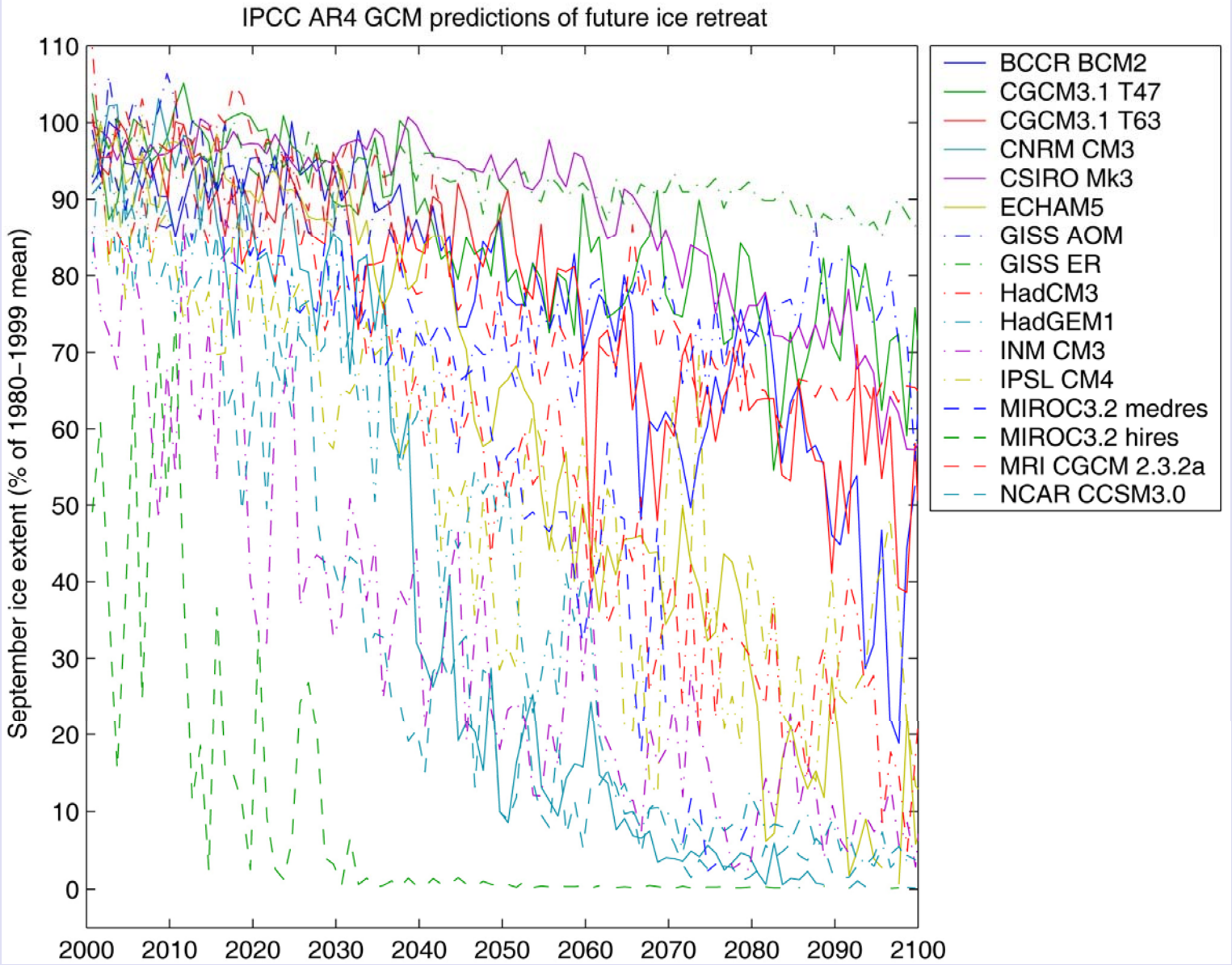
As already noted, this statement, itself, is far from alarming, and its connections to catastrophic projections is remote at best.

Results since AR4

The situation is actually worse than this. IPCC WG1 acknowledges that their iconic attribution depends on the assumption that the models used, adequately accounted for natural internal variability. However, papers from the Hadley Centre (Smith et al, 2007) and from the Max Planck Gesellschaft (Keenlyside et al, 2008) show that this assumption is incorrect.

Judging from the common response to the new findings, one has to conclude that climate science is quite unique in that its results appear to be strengthened as their foundations are eroded.

Important example of model 'uncertainty.'

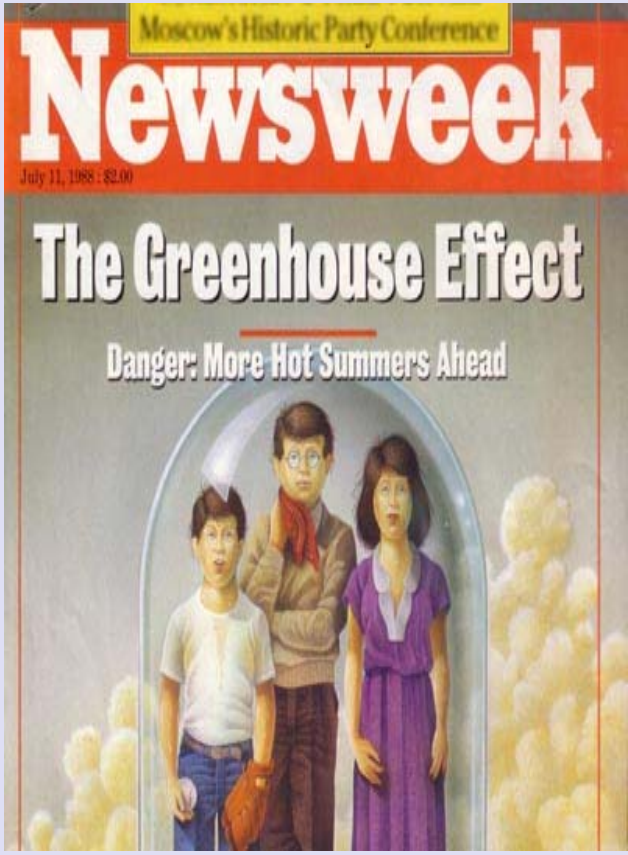


Societal observations (I)

Consensus in climate always refers to the agreement over relatively simple items that are completely consistent with the absence of any alarm.

However, claims of consensus are powerful tools for propaganda:

First, laymen who have neither the background nor the time to probe deeply into the issue, are comforted by the thought that all scientists agree so that there is no need for them to try to understand the issue themselves. For example, in 1988, *Newsweek* already reported that all scientists agreed that catastrophic climate change due to man was coming soon.



Moreover, the commonly claimed consensus is NOT the IPCC claim!

What is usually claimed by the media, politicians, alas some scientists, and others is

It is warming, the warming is due to man's emissions, and the consequences will be catastrophic.

Once consensus is accepted as a criterion, consensus is claimed for anything and everything.

Societal observations (II)

Second, the instinctive drive to conform encourages people to believe what they believe others believe.

Schopenhauer: ***There is no opinion, however absurd, which men will not readily embrace as soon as they can be brought to the conviction that it is generally adopted.***

Einstein: ***Few people are capable of expressing with equanimity opinions that differ from the prejudices of their social environment. Most people are even incapable of forming such opinions.***

Societal observations (III)

The use of climate to frighten people is hardly new: The Bible does so, and the *New York Times* has issued such warmings at least a half dozen times over the past century.

However, it is crucial to understand that there is no consensus for such alarm, and indeed the science often points in the opposite direction. Current climate hysteria simply represents the scientific illiteracy of much of the educated public (interestingly, most polls in the US and UK show that working people remain largely unconcerned), the susceptibility of the public to the substitution of repetition for truth, and the exploitation of these weaknesses by politicians, environmental promoters, and, after 20 years of media exploitation, many others as well. **The dangers of some of their agendas are likely to be far greater than the dangers of man-made climate change.**

Remember the following sage observation:

Politics is the art of looking for trouble, finding it whether it exists or not, diagnosing it incorrectly, and applying the wrong remedy.

--Sir Ernest John Pickstone Benn

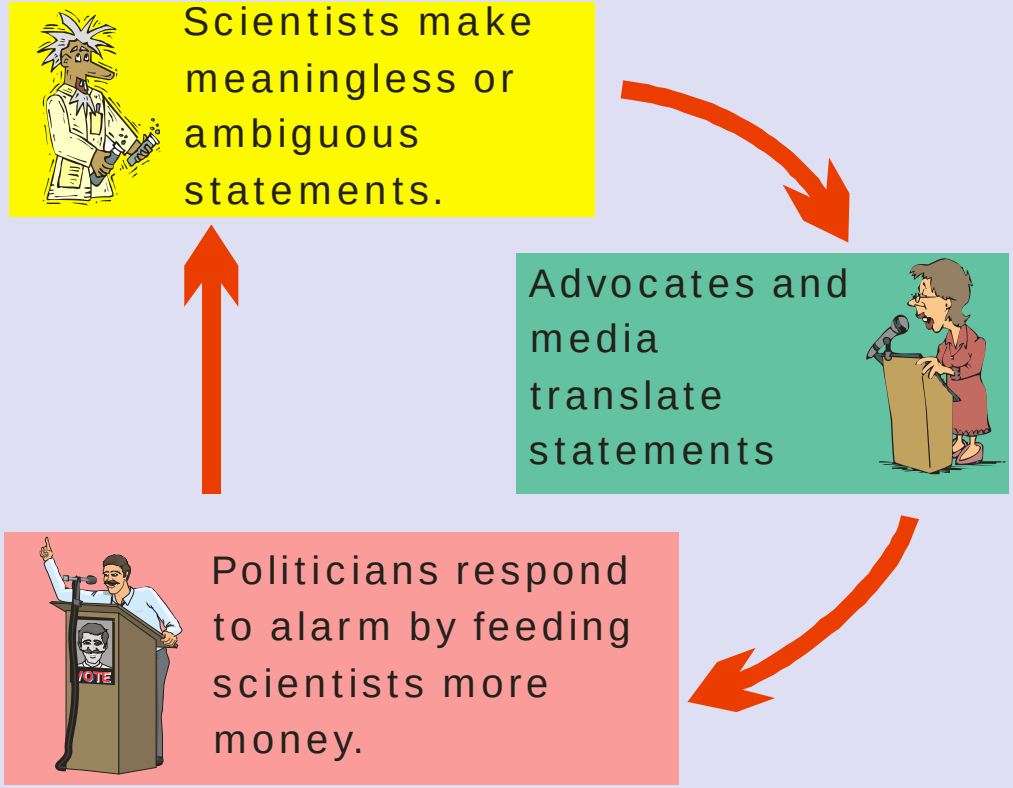
We appear to be well on our way to providing Sir Ernest with another example.

Industry, for its part, takes a simpler view:

"All we want is to be loved while making obscene profits."

And what about science?

The benign view is given by the following cartoon:



For example, the IPCC, though clearly biased, provides, in the WG1 text sufficient qualifications to make clear the presence of great doubt. Nevertheless, the IPCC provides a press release designed to be exploited – and it is! Politicians never go back to the WG1 text to see what the IPCC really says. Instead they try to 'do something.'

The situation depicted demands no conspiracy (and is particularly appropriate to a world where fear forms a primary basis for support of science).

The Holdren-Ehrlich IPAT Formula

A wonderful example of the disingenuousness of some scientists is the Holdren-Ehrlich IPAT formula. It is universally held by environmentalists to be a rigorous statement which shows what we are up against:

I (environmental Impact) = P (population) x A (affluence) x T (technology)

How does one derive such a mean spirited and totally counter-intuitive and counter-factual result?

Holdren simply suggests that the formula is only a trivial identity, where I and P have the above definitions, where A=GDP/P and T=I/GDP (which has nothing to do with technology). Of course, the choice of ‘T’ was hardly accidental.

Unfortunately, there has been an organized campaign .

This is a long story that requires at least a lecture of its own. Numerous examples are presented in Lindzen (2008): http://arxiv.org/abs/0809.3762v3. I should add that I barely scratch the surface.

I go over several aspects:

1. The unpublicized takeover of a large number of scientific professional societies and major laboratories and organizations by environmental activists.
2. The modification of data so as to always bring it closer to models – despite the poor predictive records of the models.
3. The insistence that papers disagreeing with alarming scenarios nonetheless pay lip service to these scenarios while subduing disagreement.
4. The ‘discreditation’ of papers that are contrary to the ‘consensus’ that somehow manage to get published.

Item 1 does not include the common, open, but questionable cooperation of government agencies with highly political advocacy groups.

Where does science end and politics begin?

NCSE Conference, 02:09 PM 11/6/2008, Register Now for NCSE's 9th National Conference - Biodiversity

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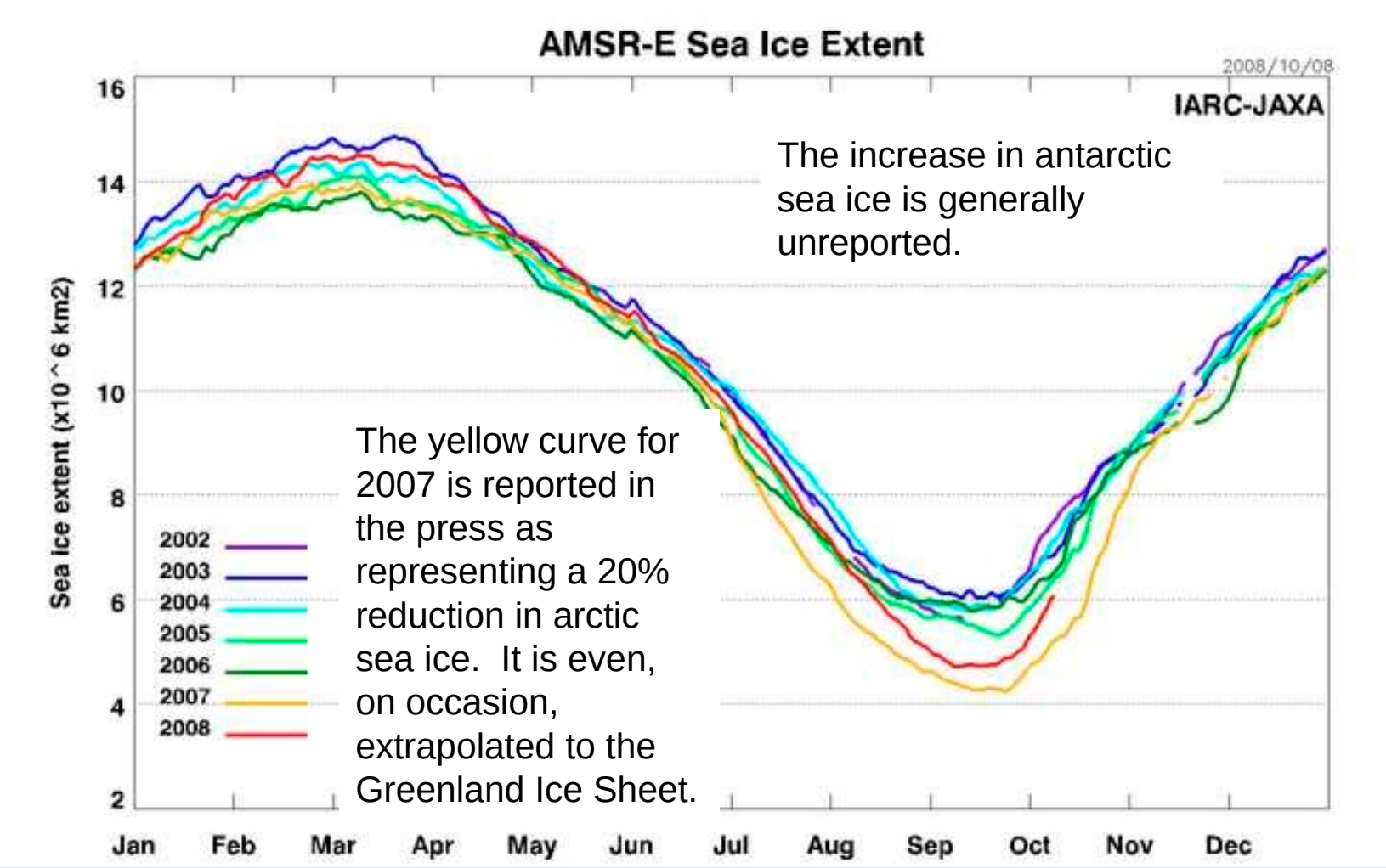
Obvious fantasy is treated with apparent seriousness

Examples:

1. Polar bears, whose population is about 4 times greater than it was 50 years ago, are declared to be endangered because some climate models suggest that they will be stressed in the future.
2. Global mean temperatures are claimed to be rising at an unprecedented rate, despite the fact that they have not changed in over a decade, because climate models say that they should have been rising.

There appears to be a substantial divorce from reality.

Normal variability is treated as evidence of disaster.



What is to be done? (with apologies to Lenin)

Science has been compromised if not corrupted. For the moment, institutional science is part of the problem rather than part of the solution.

Science, itself, however, remains crucial.

Serious ‘stakeholders’ must devote effort to independently understand the science or at least recognize the frequent departure from logic (which shouldn’t be a matter of opinion). This will make it clear that institutional science cannot, at present, provide a reliable basis for policy decisions. They should, nonetheless, find out exactly what the IPCC full report of WG1 actually says since it is frequently more reasonable than many of the numerous official pronouncements. Such stakeholders are, in my opinion, the ultimate defense against the current hysteria that is leading to policies of major and potentially detrimental impact.

Maimonides understood this long ago.

"If anybody tells you in order to support his opinion that he is in possession of proof and evidence and that he saw the thing with his own eyes, you have to doubt him, even if he is an authority accepted by great men, even if he is himself honest and virtuous. Inquire well into what he wants to prove to you. Do not allow your senses to be confused by his research and innovations. Think well, search, examine, and try to understand the ways of nature which he claims to know. Do not allow yourself to be influenced by the sayings that something is obvious, whether a single man is saying so or whether it is a common opinion, for the desire of power leads men to shameful things, particularly in the case of divided opinions."

--Moses Maimonides (1135 - 1204), *Medical Aphorisms*

It is hard to be optimistic on this count, but quite a lot depends on it.