Response to Climate Skeptic William Happer's Sept. 12, 2017 Presentation from a Mainstream Climate Scientist

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William Happer presented on Sept. 12, 2017 in Chapel Hill, NC.

A video of his presentation is here: https://www.youtube.com/watch?v=u-KZhkxRf3A

His slides (not on the video) are found on my website with this document (www.unc.edu/~jjwest/climatechange).

Synopsis

Happer argues that the current concern over human-caused greenhouse gases is overblown. Although he clearly understands basic climate science, his presentation includes claims that are exaggerated, misleading, or incorrect regarding human-caused climate change. His presentation is entertaining, but he argues in many places against claims that climate scientists do not make. He acknowledges that CO_2 has an influence on climate, but emphasizes that the influence is small. Yet he gives no physical reason to conclude that the current scientific understanding on the response of climate system to CO_2 (the "climate sensitivity") is wrong, other than to say that he does not trust climate models. His claims that climate models do not work are exaggerated and misleading. He also claims that increased CO_2 will be beneficial by increasing plant growth – it is true that plant growth will increase by the CO_2 increase alone, but he does not show that it will be beneficial, especially when climate is changing at the same time as CO_2. His presentation ignores the large number of studies available that show that through climate change, CO_2 will be detrimental to agricultural productivity as well as to human well-being generally.

Since Happer has been giving similar lectures elsewhere, I was motivated to respond with what current science shows regarding his arguments – to encourage those who agree with Happer to consider what climate science tells us, and to give a stronger basis for those who agree with the scientific consensus on climate change to respond to his arguments.

Slides 2-4 – William Happer is an accomplished physicist, but apart from the 1982 book chapter he mentions, I am not aware that he has published any other research on climate change.

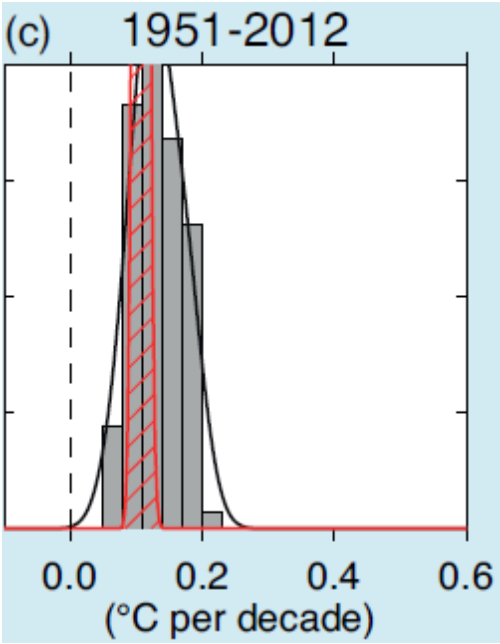
Slides 6-7 (4:00) – "Global Warming Models Don't Work". This claim is exaggerated by Happer. Climate models simulate atmospheric dynamics like weather forecasting models. Most people understand that while weather forecasts do not predict perfectly, the information they provide is very important and those forecasts are getting much better.

In the top graph of slide 7, the comparison is with satellite observations of temperature for the tropical mid-troposphere (well above the surface of the Earth). For more on the satellite observations, see the discussion of slide 33. It is also over a relatively short period of time (since 1979), whereas climate changed through the whole 20th Century. This discusses the particular graph that Happer shows, saying that choices in how the data are plotted (against good scientific practice) significantly influence the perception of a discrepancy:

http://www.realclimate.org/index.php/archives/2016/05/comparing-models-to-the-satellite-datasets/

In the bottom graph of slide 7, Happer focuses on an even shorter period of time (1993-2012 and 1998-2012). This period includes what some people call the climate "hiatus" from 1998-2014 where it appears that the rate of global warming slowed down. But after 2014, the world has again warmed as shown in Happer's slide 33 (see also the surface temperature record I posted in response to slide 33), which would bring the models in better agreement with the observations.

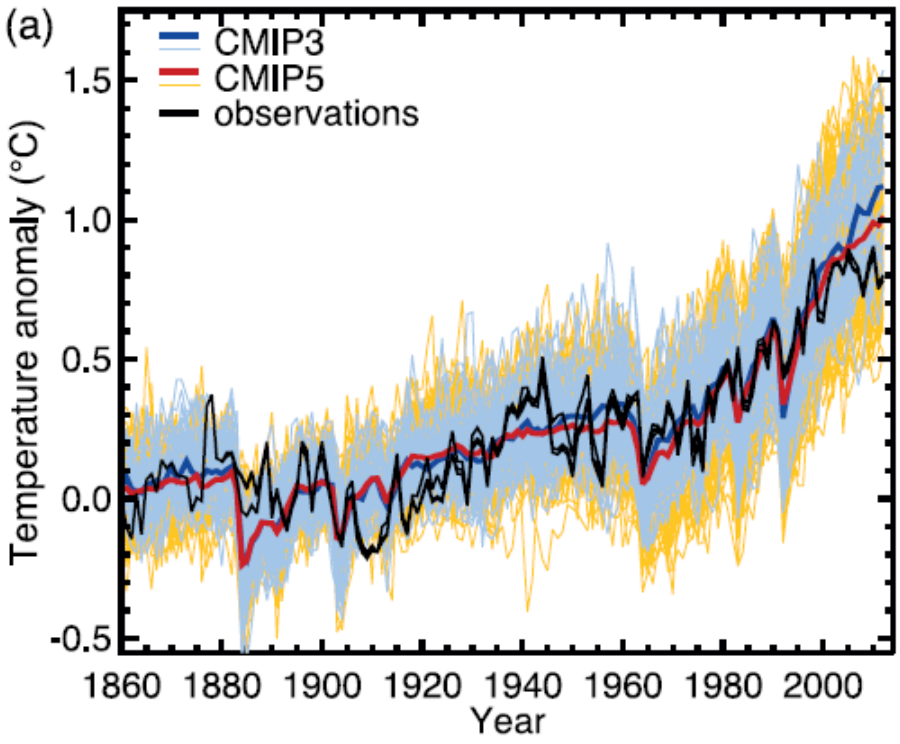
Most importantly, the time scale for these two comparisons is shorter than what is really relevant for climate change. Climate is weather over a long period, typically taken as at least 30 years. To evaluate the models for their performance in reproducing climate change, we should look over longer periods of time. Here is Happer's bottom graph over a longer period that is more relevant for long-term climate change:



From IPCC (2013) Technical Summary Box TS.3

Below is the record over the whole period of weather station observations, where the bold red line is the average of the most recent generation of climate models and the full range of models is given by the yellow lines (the blue lines show the earlier generation of models). Note that after 1998, the observed temperature flattens off somewhat, but the observations here do not include 2015-2017, which were years of record high temperature. The discrepancy between the model and observations since 1998 can be seen similarly at other points in this graph, such as around

1910 when the models were too high, or 1940 when the models were too low. Despite those short-term discrepancies between the models and observations, the models do a good job of reproducing the temperature change over this whole period, and that is what is ultimately most important for climate change. This point is also made nicely here: climatefeedback.org/claimreview/cnn-interview-william-happer-incorrectly-claims-temperatures-dont-match-climate-model-projections/



IPCC (2013) Technical Summary Figure TS.9

Finally, while climate models are important for allowing projections of future climate, they are not the only way this can be done. We also look at relationships between CO_2 and climate from past changes in climate (see discussion of slides 31-32) to estimate this relationship, and in doing so we come up with estimates that are broadly consistent with what current models estimate. Even if we distrust models, we would have to acknowledge the clear historical relationships between CO_2 and climate, and use that as a basis for understanding future climate change. Decisions about responding to future climate change should be informed by the best science available, including models, but even if one argues that the models are uncertain, that uncertainty includes possibilities of both very mild and very severe climate change. Arguing uncertainty does not preclude making decisions – it is the responsibility of decision-makers to make decisions in the face of uncertainty.

Slides 8-10 (6:15) – "Climate change happens naturally". It is certainly true that climate has changed naturally in the past. As Happer says later in his presentation, some of those changes have been large. The focus of interest on climate change today is whether human activities – principally the emissions of greenhouse gases – are changing climate and will change climate in the future. And the magnitude of human-caused climate change in the coming centuries may be as great as past natural changes that occurred before human civilization flourished (the past 10,000 years).

Nobody is arguing that we can or should stop all climate change, so in slide 9 Happer is again arguing against a claim that is not made. Today's discussion is about lessening the influence of human activities on the climate of today and the next several centuries, not about stopping climate change. Even more than lessening the influence of human activities, the discussion today is about keeping human-caused climate change from getting out of control.

Slides 11-12 (8:00) – "CO_2 is not a pollutant". Happer is once again arguing against a claim that nobody is making. There have been very few suggestions that increased CO_2 is harmful to human health, and it is generally treated as not being harmful to health when inhaled directly.

Let's consider what a pollutant is. To most people, an air pollutant has two characteristics: it exists in concentrations higher than what would naturally occur (presumably because of human activities), and it causes some adverse consequence. Both are true for CO_2 – current CO_2 concentrations are elevated because of human activities from what they were before the Industrial Revolution, and as a greenhouse gas CO_2 contributes to climate change and adverse consequences from that. Both of these points Happer acknowledges, although he claims (without much support) that the CO_2 increase will be beneficial.

In legal terms, the EPA in 2009 systematically reviewed the evidence and concluded that CO_2 and other greenhouse gases "threaten public health and welfare of current and future generations". This has given EPA the legal authority to regulate greenhouse gases as pollutants under the Clean Air Act.

Finally in looking at Alice's breath versus a power plant, Happer does not mention the difference in scale of exhaust. Emissions from power plants are sufficiently large to change the concentration of CO_2 in the atmosphere, and are doing so now. Humans exhaling have a negligible effect on atmospheric CO_2.

Slide 13 (9:55) – I am happy that Happer acknowledges the importance of air pollution for human health. But again, nobody is claiming that the air pollution he is discussing here is a result of CO_2. Interestingly, research in my lab and many others has shown that taking action to reduce CO_2 emissions will also reduce emissions of major air pollutants.

Slide 14 (11:10) – The problem with how he presents this is that most pollutants emitted by power plants are entirely invisible. Modern power plants can remove much of conventional air pollutants (particulates, NO_x, SO_2, but not CO_2), but certainly not all of it. Although you cannot see the pollutants as they are emitted, NO_x and SO_2 react in the atmosphere to form air pollutants hundreds of miles downwind, where they affect health and visibility, and cause acid rain. Power plants remain one of the most important sources of air pollutant emissions in the US. But this discussion is not directly relevant for climate change.

Slides 15-17 (12:10) – It is true that more CO_2 makes plants grow faster, but only if they also have sufficient water and nutrients and grow in areas with tolerable temperatures. The pine trees must have had those conditions.

Climate change is expected to change the availability of water for plants so that at least in certain places that will be water-stressed, the more rapid growth of plants due to increased CO_2 will be curtailed.

Happer implies (without much evidence) that a world in which plants grow faster (because of increased CO_2) would be beneficial for humans. Even if we considered the CO_2 increase alone, that would not only promote plant growth but would do so differentially among plants, with some plants growing much faster than other plants – resulting in changing competition within the ecosystem that would be difficult to predict. Now compound that stress on ecosystems by considering changes in climate at the same time, as well as changes in land use such as deforestation, and we see that ecosystems are experiencing several stresses at the same time.

In the context of agriculture, many studies have now evaluated the increased growth due to CO_2 alongside the other effects of climate change, and have found that global agricultural productivity is expected to decrease. It has also been shown that even though increasing CO_2 causes plants to grow faster, it also decreases the nutritional content of grains (http://environment.harvard.edu/sites/default/files/myers_2014_increasing_co2_threatens_human_nutrition_aop_version.pdf). While in some regions, like Canada and Russia, the growth in CO_2 together with a warmer climate would increase agricultural productivity, that increase is more than offset by the decrease in productivity in the tropics and sub-tropics (http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap7_FINAL.pdf). Agricultural productivity will be decreased most where the population is the poorest, and where subsistence farming is the main occupation of a large fraction of the population – Africa, South and Southeast Asia, and Latin America. Happer mentions next a moral argument for the world's poor, and it would seem that a moral argument would support slowing climate change to protect food security and livelihoods in the poorest nations.

More on this discussion here: climatefeedback.org/claimreview/cnn-interview-william-happer-misleads-impact-rising-carbon-dioxide-plant-life/

Slides (18-20) (15:15) – "It is immoral …" This is an interesting argument, and I'm certainly happy that Happer shows concern for the world's poor. However, he implies that poor nations of the world are reducing their fossil fuel use significantly in the name of climate change. That has generally not been the case so far, as even under the Paris Agreement, poor nations of the world have agreed to emission reductions generally more than a decade from now. These same arguments have been used effectively to suggest that wealthy nations have a moral obligation to lead the world in reducing carbon emissions.

More importantly, he is leaving out the adverse effects of climate change affecting the poor – and it is the poor who are the most vulnerable to the effects of climate change. Subsistence farmers in regions already stressed by hot temperatures, floods and droughts, and poor people living in the most flood-prone areas are among the most vulnerable people in the world to climate change. Nobody articulates this better than the Pope, who says that slowing climate change is a problem intertwined with helping the world's poor – the world must "hear both the cry of the earth and the cry of the poor" (laudatosi.com/watch).

Slides 21-27 (16:55) – This is a good description of the energy budget of the Earth, which determines the Earth's average temperature, and of atmospheric circulation. There isn't much discussion of climate change here.

Slides 28-30 (27:20) – Happer shows the absorbance of heat from the Earth by water vapor (H_2O) and CO_2 in the atmosphere. The discussion is good to clarify that H_2O and CO_2 are the most important greenhouse gases, and Happer is right that H_2O is naturally the most important greenhouse gas, more important than CO_2.

However, he says that "the main control" of the greenhouse effect is water vapor and clouds. This claim is misleading. Even though H_2O is more important as a greenhouse gas than CO_2, H_2O does not vary on climate timescales of its own accord. Rather it is CO_2 that drives changes in H_2O that amplify climate change. This is known as the "water vapor feedback" – as a result of warming, the atmospheric holds more H_2O which is a greenhouse gas, which causes more warming. Basically, water vapor in the atmosphere responds to changes in temperature, and does not drive changes in temperature. Changes in CO_2 and other greenhouse gases drive changes in temperature that are amplified by the water vapor feedback. For more on this:

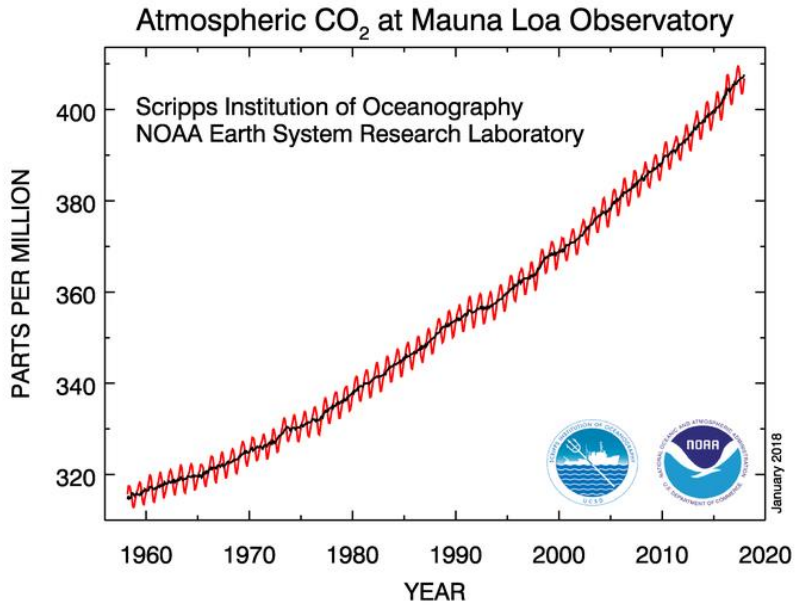
https://www.acs.org/content/acs/en/climatescience/climatesciencenarratives/its-water-vapor-not-the-co2.html

https://www.newscientist.com/article/dn11652-climate-myths-co2-isnt-the-most-important-greenhouse-gas/

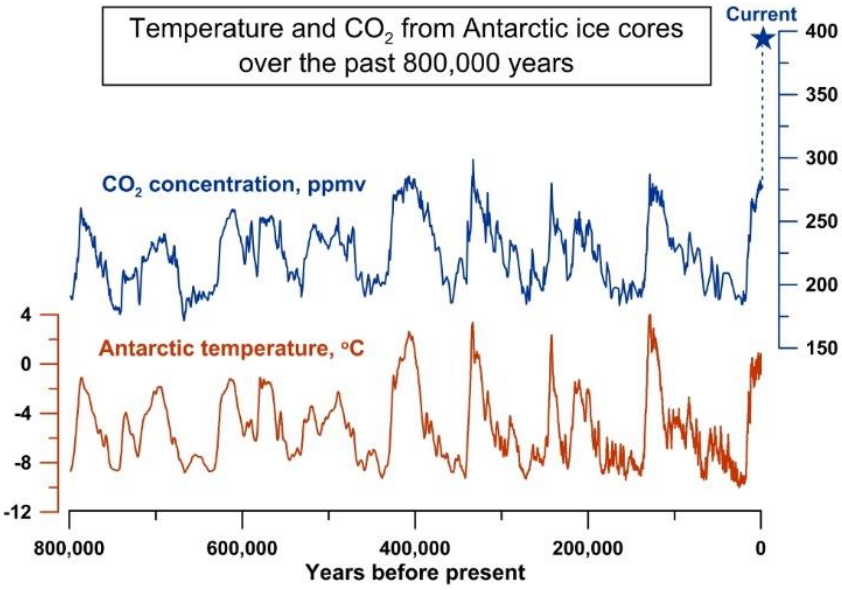
http://science.sciencemag.org/content/330/6002/356?maxtoshow=&hits=10&RESULTFORMAT=&fulltext=gavin+schmidt&searchid=1&FIRSTINDEX=0&resourcetype=HWCIT

Slide 31 (31:45) – This is a good presentation acknowledging CO_2's increase in the atmosphere, and although he does not say it verbally, his slide says correctly that this increase in CO_2 is about half of the total human input of CO_2 to the atmosphere. That is to say, it is certain that this CO_2 increase is caused by human emissions.

Happer only shows a small time period, and I think it is also worthwhile to show the whole record of CO_2 growth here:



and in longer historical context together with temperature:



J. Shakun, Harvard

Slide 32 (33:00) – Happer is right that CO_2 was higher in the geologic past, but he leaves out important discussion of the Earth's climate over this period. When CO_2 has been higher, temperature has also been higher, such as when the dinosaurs existed, showing the relationship between CO_2 and temperature historically. He says that the Earth was verdant in the past, implying that shifting to a warmer climate would be beneficial. In saying that he leaves out important details. For example, Florida was entirely under water.

It is worth noting that humans were not present on Earth for most of the period of this graph. CO_2 is currently higher (due to human emissions) than at any time in human history.

The important point is that human civilization is currently planned and organized around the current climate, which has been stable for the past 10,000 years, through our use of water, agriculture, infrastructure etc. There is now a huge number of studies documenting how current climate change is affecting human society, and is projected to do so in the future. These impacts are understood to be overwhelmingly negative. By saying climate change would be largely beneficial, Happer provides little evidence for this claim and seems to dismiss this entire literature on the impacts of climate change without even discussing it.

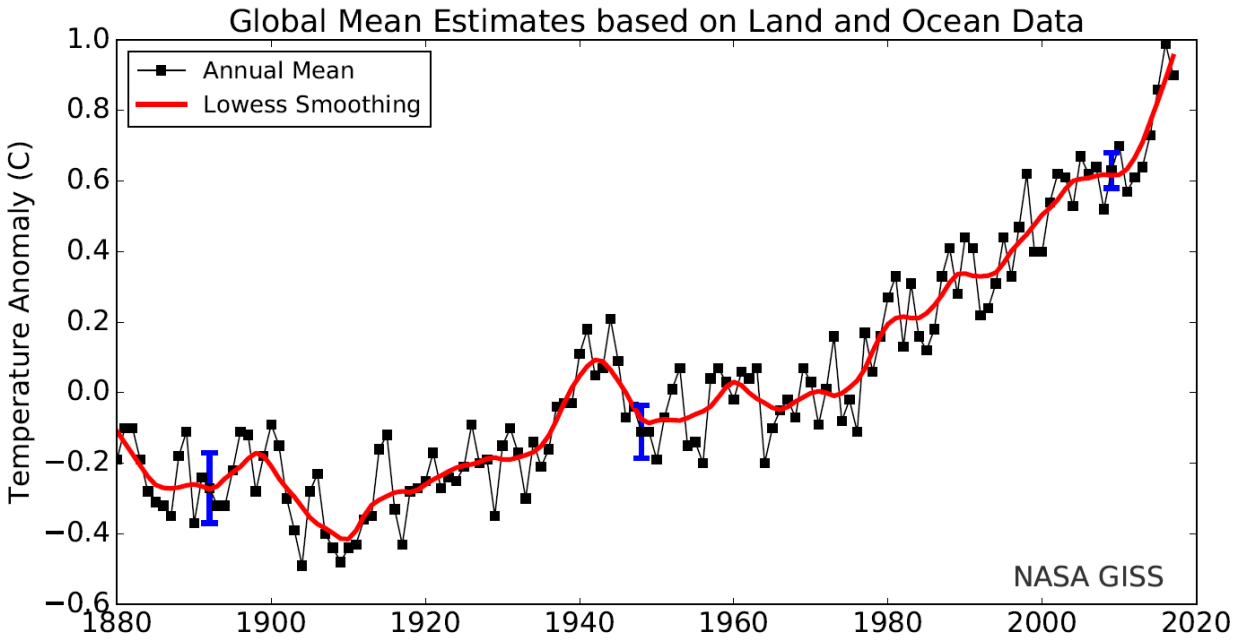
Slide 33 (34:00) – Happer emphasizes how small a change is observed – "tenths of a degree". The slide shows that the last point (Aug. 2017) is 0.41°C warmer. But that is relative to the zero on the graph, which is an average of 1981 to 2010. Over the whole period of this record (1979-2017) the increase is temperature is about 0.73°C, which is 1.3°F. That's more than a few tenths of a degree. I consider it worthy of attention that the world's average temperature warmed by 1.3°F in less than 40 years. Happer focuses on the effects of El Nino to cause the two large spikes, but he does not acknowledge the underlying upward trend that you can see even if you remove the two El Ninos, and which is more apparent over the longer record I show below.

The other point is the data that he chooses to show. This is a plot of the lower atmosphere temperature as measured by satellites, and produced by John Christy and colleagues. There are other groups that have more reliably analyzed the satellite record, and there is an abundance of temperature data from weather station thermometers and radiosondes that Happer chooses not to present, but which also provide valuable information.

For a mainstream scientist view of Christy's dataset, this video explains the issues nicely:

https://skepticalscience.com/print.php?r=466

He also limits his view of temperature change to the period over which satellites record temperature (since 1979), when longer records of temperature are also available. Most mainstream scientists would show the more reliable and longer temperature record based on weather stations – after all, it is the ground-level temperature that we have daily experience with and that shows up in weather reports, not the satellite average of the lower atmosphere. Here is one from NASA including 2017, and all other groups who have analyzed these data essentially agree with it:



Slide 34 (35:40) – A fine discussion of El Nino – he doesn't say anything about climate change here.

Slides 35-36 (37:30) – Sea level has risen since the last Ice Age, but one cannot tell from Slide 35 whether sea level is now continuing to rise at the rate shown for the last 10,000 years, or if that rise has accelerated in the past 100 years.

In slide 36 there is a correlation because both curves are going up. Sea level rise is significantly lagged behind the rise in CO_2 because of the long time it takes to heat up the oceans and melt ice, and so that delay can make it difficult to see clear relationships. But a clear relationship between CO_2 and sea level exists when we look over the longer time scale – CO2, temperature, and sea level are all lower during Ice Ages, and higher during warm periods (see his slide 35 and the graph of CO_2 through the Ice Ages that I added for Slide 31). Looking at the whole record of modern sea level rise, climate science concludes that it is likely that sea level rise has accelerated in the 20th Century, and of course it is expected to rise faster over the coming century as climate changes.

Slides 37-39 (39:10) – Happer is right that the number of hurricanes does not seem to have changed over the past several decades. But the frequency and intensity of the strongest hurricanes has been observed to have increased since the 1970, and he does not mention that.

More broadly, there are extensive observations that show that climate is changing, particularly over the past few decades. Among the most apparent changes is the rapid melting of ice in the

past few decades in the Arctic, for example nsidc.org/arcticseaicenews/2018/03/arctic-sea-ice-maximum-second-lowest/. Reviewing all available data on air and ocean temperatures, ice cover, and sea level, the IPCC (2013) concluded that "the warming of the climate system is unequivocal".

Slides 40-44 (42:30) – It is remarkable how much Happer is pandering to his conservative audience. I think it would be hard to find examples of mainstream climate scientists being so overtly political.

Happer likens climate researchers to pigs in pursuit of money. But Happer himself led a scientific career that was also funded by tax dollars (I presume, since most scientific research is government-supported), except for the few years he spent working as a Washington bureaucrat. He provides no evidence that climate scientists are any more motivated by money than scientists in his own field, and I would be surprised if they are. Scientists universally are committed, with only a few exceptions, to understanding the world. By painting climate science in this way, Happer not only weakens public trust in climate science, but also in science in general. It is a slippery slope from "climate science is corrupt" to "all science is corrupt," and Happer seems willing to give fodder to conspiracy theorists even when he clearly cares about science.