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COMMENTARY

Notes on the Essay Review by Henry Bauer of *Climate Change: Evidence and Causes*

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Abstract—The National Academy of Sciences and the Royal Society have produced a booklet (the text) for the lay person on the current state-of-the-art understanding of climate change. Our esteemed reviewer of the text has accused the eminent climate scientists of 'propaganda'. The *Journal of Scientific Exploration* requested a Commentary on the Essay Review. Let us attempt to objectively assess both documents. These Notes start with a few comments on climate change issues that may set some aspects straight, and then go through the Essay Review point by point to discuss its concerns in the light of the text.

Background

Since there is so much heated debate on climate change, it would serve us by beginning with the facts over which there is no dispute among the learned.

1. Burning fossil fuels releases carbon dioxide.
2. Carbon dioxide is a greenhouse gas and many other greenhouse gases are being released by our modern society as a result of various activities.
3. Greenhouse gases trap heat, so ocean and/or atmospheric temperatures have risen and/or will rise due to their presence.
4. The carbon dioxide levels in the atmosphere have risen since the start of the industrial revolution, after a long period of stability.
5. CO_2, methane, and nitrous oxide levels are higher now than at any time in the last 800,000 years (see text, also *Wikipedia* Milankovitch Cycles, and Rignot, Fenty, Xu, Cai, & Kemp 2015).
6. The global temperature has risen primarily over the last 100 years coincidental but not exactly correlated with the 'hockey-stick' shaped rise in CO_2, NO, and methane (e.g., see Rignot, Fenty, Xu, Cai, & Kemp 2015, and Figure 1).
7. Insolation, the Sun's contribution to global heating, is currently at a low. While it oscillates, with three peaks and three troughs in the last 100 years, overall it has been declining for the last 6,000 years.

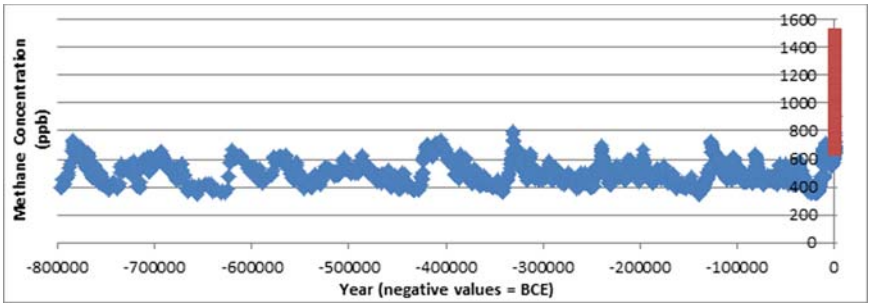

Figure 1. Atmospheric methane levels for the last 802,000 years. Levels first exceeded 850 ppb in 1894 having risen above 800 ppb in 1871 (Rignot, Fenty, Xu, Cai, & Kemp 2015). CO_2 and NO graphs follow the same overall hockey-stick pattern.

> Calculations show it is expected to start a short-term cyclical rise about now after a period of about 20 years of decline (*Wikipedia* Milankovitch Cycles).

CO_2 levels have risen unremittingly since around 1800, exhibiting a near-exponential curve and closely tracking our thirst for fossil fuels and our burgeoning population. However, temperature has not exhibited such a satisfyingly simple trajectory. No one can argue that the temperature has not risen, but there is clearly much enthusiasm for arguing about the details and causes. While the text argues that the temperature rise is most likely due to rising greenhouse gas levels, the Essay Review prefers to see these as a coincidence. Several of those holding this view have turned out to be connected in some way to the energy industry, suggesting that this is more about corporate profits than science. However, scientists like to debate, and any rigorous or at least well-founded argument deserves consideration. Below, we look in the present review for such arguments.

If one studies Figure 1a of the text, one can see that the global temperature only started rising around 1910. From about 1945 to 1980 it flat-lined only to track strongly upward until about 2000 when it flat-lined again. Purely from looking at the curve, without testing the significance of the trends, one might assert that there has been a slight downward trend in the periods 1880 to 1910, 1945 to 1980, and 2000 to the present. In short, there appears to be a 30-year cyclic trend between warming and cooling, with a strong overall upward trajectory that started during the industrial revolution. If this is a real and persistent trend, then we can expect potentially devastating warming to set in starting about 2030.

It should be noted that these periods when global temperatures have flat-lined or retreated appear to coincide approximately with declines in insolation (see point 7 above). Similarly, the recent periods in between coincide approximately with increased insolation. However, insolation does not explain the overall sharp rise in temperatures as no such phenomenon was occurring in the 19th century and the cyclic nature of insolation is a long-term astronomical phenomenon. Had the temperature changes been driven by insolation as the primary factor, then the overall trend would be downward.

One prime cause for concern, highlighted in the text, is that the ocean heat content anomaly is rising unremittingly, which many scientists think is a prime explanation for where the extra heat is currently going. If there is a cyclic trend of heat exchange with the oceans, then a decadal scale oscillation in the surface temperatures is only to be expected. The steady rise in the ocean levels during the same period (around 1970 to the present) as the rise in the heat anomaly supports this concern. The main contributer to this rise is the fact that water expands with temperature above 4 °C.

Reviewing the Essay Review

Now, let us review the points raised by Dr. Bauer. The first is that he accepts that CO_2 absorbs radiation but doubts that the re-radiation of that heat warms the surrounding atmosphere or the land or ocean below it. The only way that a body subjected to heat does not warm is if it is a super-fluid, a resistance-less heat conductor. Super-fluids can be observed in the lab, but neither the atmosphere nor any part of the Earth's surface are super-fluids.

Second, aside from his doubts that humanity is capable of modeling the climate, he raises the standard concern that temperature is not perfectly tracking CO_2 levels and is sometimes going down when CO_2 is rising. This we have discussed above. Aside from insolation, the text discusses heat exchange between the atmosphere and the oceans. Anyone who follows ocean temperature maps cannot miss the remarkable rise in ocean temperatures.

One of Dr. Bauer's main arguments relates to the difficulty of measuring global temperatures for the time before modern instrumentation, thus casting an element of doubt on all science that relies on historic records such as ice cores, tree rings, etc. No doubt thousands of academics would object strongly to this and argue much more convincingly for their results than is possible in this short piece. However, the reviewer might like to compare the studies that compare astronomical phenomenon with the historical temperature records. Since the work of Milankovitch, it has been widely accepted that long-term climate changes are being driven by varying

levels of solar insolation due to astronomical cycles, and the long-term temperature records are the main evidence (see *Wikipedia* Milankovitch Cycles for references). If these were of little use, why would they agree with such an obvious source of heating? This is not suggesting that we fully understand why some astronomical cycles are more evident than others during different epochs, but to dismiss the temperature records that have been built up by a vast and disciplined effort of scientists from all over the globe using multiple sources is rather too extreme to accept. Besides, the Essay Review makes its own arguments based on historic temperature variations and thus on the temperature records that we have.

Having expressed a lack of confidence in computer models and the underlying historical data, he addresses some of the wording in an IPCC report. He objects to assigning an approximate numerical value to the confidence of a scientific research finding. This is perplexing because virtually all science, certainly including climate science, involves error bars or ranges and/or statistical significance values, both of which do exactly that. In essence, his objection appears to be that climate science is a collection of purely subjective opinions that cannot be quantified. In any case, what this has to do with the text being reviewed is not clear. The text does not use the IPCC system of assigning levels of confidence, while making plain where uncertainties exist.

Having dismissed computer modeling, the underlying data, and the conclusions drawn thereupon, without unpicking even one study to demonstrate this, Professor Bauer arrives at the conclusion that the whole thing is a sham. This is a profound tautology. My question is, how does this advance our understanding? Our knowledge of the human body is far from complete but does that mean that we can have no confidence in modern medicine? Or should we withhold medicines that have shown promise until our knowledge becomes perfect? Some medicines get withdrawn because they prove toxic or ineffective, but, as a society, we accept that for the good that is achieved overall.

In his “Just so” section, Professor Bauer suddenly puts forward a powerful argument for why increased temperatures will give rise to more extreme weather. As he explains, heat tends to even itself out, so more heat means more movement; that means, of course, stronger winds carrying increased water loads due to greater evaporation and so more severe storms, flooding, tornadoes, etc. This is all logical and well-known theory, but what is not clear is how he then concludes that this amounts to *fewer* unusual events (his italics).

His next concern is that we have “no evidence” for extreme weather in the time of the dinosaurs when it was much hotter than today. He has

already asserted that what evidence we have about the climate in the distant past is unreliable and, as he knows, what data we have is not sufficient to tell us about day-to-day climate events. Certainly the text is not making claims about the era of the dinosaurs.

He objects to the arguments about the relative rates of melting at the Earth's poles, but while the text does make a brief attempt to address a complex issue the reviewer declines to argue against the points made. It may be worth noting that the alarm bells about Greenland and the Antarctic appear to have been ringing this year as a batch of new studies indicate that some of the glaciers may be more prone to discharging into the sea under current conditions than even the previous science had indicated (e.g., Rignot, Fenty, Xu, Cai, & Kemp 2015). Melting of ice from the land is much more serious for us because it leads to rising sea levels.

His next point is that there is "no empirical evidence for an increase in extreme weather events in the last several decades." Perhaps he would like to review, for example, the figures published by reinsurance underwriters (e.g., Swiss Re 2014). It might help to quote here from the website of Swiss Re, one of the top global underwriters:

> Given Swiss Re's role as an ultimate risk-taker, we are uniquely exposed to the impacts of climate change. We identified climate change as an emerging risk some 20 years ago. . . . If unmitigated, climate change could cost the world economy around 20% of Global GDP by the end of this century. (Swiss Re 2015)

The pullback on flood insurance in the U.S. and elsewhere is well-known. Many homes have lost significant value as they have become uninsurable for flood risks and therefore cannot be mortgaged. Simply quoting the number of hurricanes that have affected the U.S. means little in this regard.

At this point he makes a genuine complaint against the text. He is right that if one says that short-term effects cannot be ascribed to climate change, then one cannot cite individual heat waves, etc., as evidence. However, it is entirely valid for the text to assert that heat waves have become more common over recent decades as the evidence supports that (see Climate Communication Science and Outreach 2015 for a good summary with many references). It should be noted that it is possible to assess the probability of a single heat wave being due to climate warming.

Dr. Bauer expresses concern about the periods of warming that have occurred over the last few thousand years. The implication is that this is just another one of those warming periods that occurred in the absence of any substantial rise in greenhouse gas levels. For example, the Medieval Warm

Period (MWP) was a little warmer than the surrounding periods (about 0.1 to 0.2 °C, though this depends on which temperature reconstruction series you pick), but never reached the current temperature globally and did not show any of the rapid rise we currently observe (see the references listed in *Wikipedia* Medieval Warm Period). Insolation was higher then, and other regional factors likely played a major role as certain areas were much warmer than others.

It is noteworthy that Bauer cites Dilley in this regard. David Dilley is a meteorologist who developed a theory based on the Milankovitch cycles and a gravitational theory to model the historical temperature fluctuations. He also chose to ignore the effect of rising greenhouse gases. In 2008, he claimed that his model had "a near 100% correlation" to global warming cycles, including the recent warming, and made a firm prediction that 2008 was the beginning of a strong cooling that would see a "climate similar to the 1800s within the next 15 years" (Icecap blog). The complete failure of this prediction, which had been feted by the skeptic community at the time, should have given them pause.

Our nearest neighbor Venus is our best example of a runaway greenhouse effect. One reason why it will be difficult to find advanced life forms in our galaxy is that, within the habitable zone of a solar system, there is a very slim chance of finding a planet that is not in 'ice box' or 'hot house' mode. Our planet sits right on the cusp and thus oscillates between these modes. Climatic periods as benign as the current climate are rare even for Earth.

Our reviewer objects to the concern about sea level rise because sea levels have changed faster in the geologic past. However, if he lived near the beach, he might retract his words. Being told that the water level was 5 m higher 125,000 years ago does not help when you are facing a rising threat of inundation. His point is that the sea level rise might not be due to anthropogenic causes so let's not do anything to change our behavior. However, human nature is to try to adapt, so such appeals, presumably on behalf of the energy and related industries, may not succeed despite their deep pockets. It might succeed, however, in delaying action beyond the point that things can be turned around. Perhaps it already has. His reference (Gornitz 2007) states that

> Over the past few thousand years, the rate of sea level rise remained fairly low, probably not exceeding a few tenths of a millimetre per year. . . . Twentieth century sea level trends, however, are substantially higher. . . . The current phase of sea level rise appears to have begun in the mid/late 19th century to early 20th century. . . . (Gornitz 2007)

The next section makes arguments about the use of this or that word in the text and falls back on the 'no recent warming' issue. In every war there are periods of quiet, so are we to unilaterally declare the war is over and lay down our arms? Is this a smart approach to cyclical phenomena when the overall trend is so clear and the likely cause of it is also rather evident? If Dr. Bauer could put down his temperature graph for a moment and study the greenhouse gas graphs, he might have a change of heart.

His section on 'misdirection' repeats his lack of confidence in the computer models and the explanations of the climate science world for the apparently cyclic variations in temperature as already repeatedly discussed. He returns to the issue of the MWP saying it was warmer than the present, which is disputed as the global average was lower (see Climate Communication Science and Outreach 2015). His problems with the Little Ice Age (LIA) are even harder to fathom, as declining insolation can be expected to lead to cooling. According to the studies on the LIA period, the degree of cooling was very varied by locale so there are reasons to even assert that no global phenomenon was in play (*Wikipedia* Little Ice Age). There is also evidence to suggest that the LIA was the result of aerosols due to volcanism (Miller et al. 2012). Aerosols both from increased evaporation due to hotter ocean surfaces and human industrial activity are likely playing a role in moderating recent global temperatures.

Dr. Bauer may be telling us that current climate change is just another fluctuation in a history of fluctuations, but the graphs suggest otherwise. We have not seen such an accelerated rise in temperature at any time over the recent historical period he is discussing. Besides, he is not offering any alternative explanation for the cool and warm periods.

Amazingly, he starts comparing the change in global temperatures to the total change since the peak of the last glacial maximum. Surely he must understand why that makes no sense? Each interglacial starts with a multi-degree rise in temperature followed by a long period of relative stability. This is where we are now, and the current sharp change in the temperatures cannot by any stretch of the imagination be dismissed as negligible on the grounds that larger changes have occurred in the geologic past under entirely different circumstances. People are concerned because we inherited an Earth with a very benign climate that we are seeing sliding away from us.

The same applies to his comment about seashells. Marine biologists are not sounding the alarm for no reason, they are measuring what happens when CO_2 is dissolved in water. This shows that the shells of some creatures thin while others thicken (Ocean Acidification). Thus, finding evidence of marine creatures with shells from periods in the past with higher CO_2 levels is prima facie a non-issue.

The notion that there is no correlation between CO_2 and temperature over the history of the Earth is another peculiar suggestion. Long-term plots of the two series show remarkable correlations but skeptics pounce on the lags that can be picked up. In the past, when interglacials start, temperatures rise first for a while before CO_2 starts to lead. This is standard climate theory, where warming leads to the release of reservoirs of greenhouse gas which then accelerate the warming. Skeptics argue that the initial impulse of warming was not caused by CO_2, which is true at those moments when factors such as peak insolation were driving a major shift in the climate. These occasions have shown us how powerful greenhouse gases are in intensifying climate change, and this is a key reason for the concern of climate scientists.

The reviewer asserts that all authors to a paper have to specify exactly which words or sections they wrote. One might ask the reviewer if he ever did that in any of the papers he published with co-authors?

It is a pity he does not properly develop his point about water vapor as a greenhouse gas. Obviously if water heats up, evaporation increases. However, what role this plays in climate change is not addressed either in the text or the review. The implication is that the scientists are hiding something, but it could be just as possible that the intensified cycle of evaporation and precipitation is not playing a clear role in modifying temperatures. After all, clouds may trap heat but they also reflect incoming radiation back into space.

Summary

We have sincerely worked through all the points of the reviewer and given his due where earned. However, he has not shown any evidence that the text has done more than state the current view of published peer-reviewed climate science. He is right to say that we do not perfectly understand climate, but his only real argument against the main concern, the consequences of rising greenhouse gases, is that even though he accepts that they trap and re-radiate heat, he believes that there is no evidence that this warmth is being retained by either the atmosphere or the Earth's surface.

The text with its cautious presentation of data without pressing for any particular response hardly fits the definition of 'propaganda'. The reviewer expresses a lot of anger but fails to take up any issue in adequate detail to advance our understanding either of the science or the real source of his concerns.

Afternote

Both the climate science report and the skeptics such as Dr. Bauer are ignoring the third group that has a point to make about this debate. This group consists of oil industry geologists and analysts who have for many years been telling us that we are approaching the time when half of all Earth's readily extractable fossil fuels will have been consumed. For a while it seemed that their view was becoming widely accepted, and then the shale oil and gas boom started and public attention was diverted (U.S. Energy Information Administration). Shale oil companies, seeking investors, touted the boom as supplying hundreds of years of energy needs. However, the reality has proved quite different as whole shale plays turned out to have a useful life of little more than 10 years with rapidly declining production from all but the newest wells (Hughes 2013). While there is scarcely any talk of peak oil these days, it is obvious that government and industry leaders are fully factoring this in to their plans. They appear to be scaling their announcements about going 'carbon-free' with what the experts are telling them about when there will be very little carbon left to burn. There seems to be a well-coordinated plan to gradually condition public awareness to an electric world powered by windmills without stirring up a hornets' nest of rage about having our SUVs 'taken away' from us.

In 2010, we noticed that no online report considered the run-down of all types of fossil fuels—oil, gas, coal, and uranium. People would write articles saying the 'answer' was more nuclear power without any due consideration about the availability of fuel, not to mention the disposal of the spent fuel. Thus it was decided to collect the best statistics on reserves, additions to reserves, and consumption and apply a business-as-usual model to estimate how long our supplies would last. This simple approach, which assumes that those with resources will sell them to whoever can pay, yielded a date around 2050 when global oil, coal, and natural gas stocks would be largely exhausted, and uranium, assuming no significant increase in consumption, would run out around 2090. Of course, from a local perspective the view is different; for example, if the U.S. keeps its coal exports low then it has more than 200 years' supply.

Since then, the flattening of the global economy led by China, which we predicted, has slowed the growth of consumption, and the reserves of coal and especially natural gas have been revised upward. This pushes these exhaustion dates somewhat further into the future (depending on one's confidence in the reserve figures). However, from a longer-term perspective it makes little difference and the total potential for greenhouse gas emissions is not very substantially increased.

Based on the text (page 20), if we emit as much carbon in the future as we have since 1870, there is a chance, albeit small, that the rise in global average temperatures can be kept to within the target 2 °C. Further, if one studies their graphs on page 22 and applies the apparently inevitable run-down of fossil fuel consumption over the next 30 to 60 years, then CO_2 levels, temperature, and ocean rise will be contained within tolerable limits and return to year 2000 levels by 2400 or so. This won't save us from many years of extreme weather events that we are already starting to experience, but, overall, we have to admit to being quite relieved seeing all the science come together and a somewhat more benign scenario emerge than we had expected.

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