Global Warming Acceleration and Recovery

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Here we make available "Global Warming Has Accelerated," including the Supplementary Material (SM), in one document and the webinar discussing the paper.

The SM shows that the rate of freshwater injection on the North Atlantic Ocean assumed in "Ice Melt, Sea Level Rise, and Superstorms" was realistic, averaged over the past two decades, but the rate of ice melt did not increase in the past decade. The present acceleration of global warming, which is especially great in the North Atlantic and North Pacific, makes it likely that the rate of ice melt will now accelerate, thus affecting the likelihood of shutdown of the Atlantic Meridional Overturning Circulation (AMOC) and, in turn, the threat of large sea level rise.

The SM, see below, also addresses reactions to our paper. One more comment may be helpful. Why do we say that global temperature will not go down much (i.e., the world is already at +1.5°C and 2025 will be warmer than the kibitzers expect) is only partly due to the ship aerosol forcing – it is due more to high climate sensitivity. We evaluated the 1.7 W/m^2 darkening of Earth as about 0.5 W/m^2 ship aerosols, 0.15 W/m^2 sea ice albedo, but mostly cloud feedback. The cloud feedback operates in both hemispheres and is the main reason that global SST will not fall much and will soon be rising further. The ship aerosol forcing and cloud feedback work together in the North Pacific and North Atlantic, so warming is fastest there, but warming is a global phenomenon.

We have been cooperating with David Beerling and colleagues for years on one the many things that eventually may help restore a propitious climate: actions to accelerate weathering removal of atmospheric CO_2. A new paper on that is just published; we briefly discussed this once and will try to write more soon, but further information is available from the University of Sheffield.

Here are some comments from page 15 of SM:

Reactions to these papers. Given that our papers disagree with IPCC conclusions, it is not surprising that they generate reactions on social media. We generally have not responded, as it is very time consuming to respond and debate when we are outnumbered – it seems a better use of time to work on the next paper and include responses in it, if warranted, as we do here.

The first reaction was that there was no significant acceleration of global warming. This is an issue where it seems best to let others and the real world provide the response.

A second reaction was that, if there is acceleration, it is captured in the GCM simulations that IPCC employed, therefore accelerated global warming does not support our assertion that IPCC underestimated ship aerosol forcing. That reaction exposes the problem with lumping CMIP/IPCC model results into a model fog, and then treating that fog as if it is a probability distribution for the real world or even a sharp tool useful for climate analysis. The problem in this case is that many of the models in the fog did not use the IPCC aerosol forcing. For example, the fog includes GISS model runs that used Susanne Bauer's aerosol modeling, with both her Matrix and OMA aerosol models;[1] the latter model has an even greater aerosol forcing change than the aerosol scenario that we employed. A subset of the model runs consisting of only those that use the IPCC aerosol forcing (not precursor emissions) would likely produce only a slight acceleration (due to growth of the annual GHG forcing in the past several years, which exceeds that in the prior two decades; see Fig. 15), much smaller than the observed acceleration of global warming.

A third reaction was that our estimate of high climate sensitivity is an outlier. However, many recent climate sensitivity studies include a key role for an "emergent constraint." What is an emergent constraint, you may ask? The emergent constraint on climate sensitivity emerges from a desire to keep global warming similar to observations. Our present paper shows that there is a one-to-one relation between the trend of late 20th century aerosol forcing and the climate sensitivity required to match observed warming. Specifically, for the IPCC aerosol scenario, the climate sensitivity required to match observed warming is near 3°C for doubled CO_2. If one accepts the IPCC aerosol scenario, the emergent constraint is that climate sensitivity cannot be far from 3°C for doubled CO_2. Thus, given the one-to-one relation, the emergent constraint amounts to "if we assume that climate sensitivity is near 3°C for doubled CO_2, we find that climate sensitivity is near 3°C for doubled CO_2." Not many people question the IPCC aerosol scenario, leading to a seeming consensus that sensitivity is near 3°C for doubled CO_2. However, as we show in the paper, there are reasons to believe that the real-world aerosol forcing change exceeds IPCC's estimate.

A fourth reaction, made in the New York Times and elsewhere, is that the current rapid warming falls within the range of all CMIP/IPCC climate simulations, so there is no good reason to believe that something is occurring outside of IPCC assumptions. This claim draws more attention to the big model range produced by CMIP/IPCC simulations and the assumption that it is a probability function for the real world. The problem is that the range is a combination of apples and oranges, as shown by the example above, but also of bananas and figs, because of a range of assumptions or treatments of different physical processes in the models – and, to be brutally honest, some pretty awful models. A scientist who wishes to help science writers understand the situation should do more than note that some model produces a response even more extreme than the real world; it would be more useful if the scientist looked at that model to see what caused the extreme response and assessed its plausibility.

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[1] S.E. Bauer, K. Tsigaridis, G. Faluvegi et al., "Historical (1850-2014) aerosol evolution and role on climate forcing using the GISS ModelE2.1 contribution to CMIP6." *J. Adv. Model Earth Syst.* 12(8) (2020): e2019MS001978