Comment on: Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that global warming is highly dangerous

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General comments

This manuscript submitted by Hansen et al. has drawn considerable attention in both the media and among peers and scientists across disciplines. This is not a surprise, given the importance of this topic for the planet. However, to our opinion the paper and its framing in the public arena sometimes tend to cross the thin line between opinion and scientific evidence. On one hand, the evidence compiled by Hansen et al. to conclude that global warming is highly dangerous is based on rational arguments. The analysis does not contain any process that is physically impossible (albeit sometimes unlikely), nor present principally flawed interpretations of the paleo data (albeit often biased to the upper end of uncertainty measures). As such we can support the conclusions that the scenarios sketched in this paper could be interpreted as an extreme high-end scenario that describes the upper bound of what one might expect in the coming centuries to happen with our current climate if carbon emissions continue at present-day rate. The philosophy on which the construction of this "upper-end" scenario is funded does not fundamentally differ from the previously released "Delta-committee" scenario that was published by Katsman et al. (2011), with the notion that the Hansen et al. scenario is even more extreme and unlikely to occur, that is, it resides in the end of the tail of the probability distribution of future climate change.

The title of the paper is more suggestive than is justified by the scientific evidence. The conclusions cannot be regarded as being robust, as they are insufficiently supported by both modeling results and observations. Our arguments for inferring this assessment are based on four points, namely:

1) The climate model used possesses large biases, cannot be considered to be state-of-the-art and misses essential processes.

2) There are issues with timing of the events inferred from the paleodata.

3) The Eemian cannot be directly compared to any future climate that we might anticipate.

4) Even if all these issues would not exist, the extreme, abrupt events reported in this article need some preconditioning and would be much more likely to occur after 2100 or even after 2200 than in the coming century.

Therefore, we would recommend present this work with a lower level of "alarmism", and avoid terminology as "dangerous" in the title and upfront displays of the paper. Below we discuss in more detail the points that in our view make this scenario unlikely and not fit for a more realistic, best-estimate projection of future climate change in the coming centuries.

Specific comments

Sea level rise

In Section 2.1 the authors discuss literature on Eemian sea level variations, and conclude that there have been 2 peaks, separated by one sea level fall (implying ice sheet growth). To our understanding, this is not as evident as the authors suggest: various evidence for either one, two, three or even four peaks exists (see for a review Dutton et al, 2015). Related to this subject, the explanation for a mid-Eemian sea level minimum they provide is not sound (page 20074-20075):

"We suggest that the explanation for a mid-Eemian sea level minimum is a substantial late-Eemian collapse of the Antarctic ice sheet facilitated by the positive warm-season insolation anomaly on Antarctica and the Southern Ocean during the late Eemian (Fig. 3b)."

A collapse of the Antarctic ice sheet can explain a sea level rise, however it cannot explain a mid-Eemian sea level minimum. Ice sheet growth is needed for a sea level minimum, but physical mechanisms for such regrowth are not discussed explicitly. It is mentioned that Eemian sea level fluctuations are the result of a combination of processes including NH cooling due to the solar forcing, and feedbacks affecting the Antarctica ice sheet. But the degree to which this leads to a sea level minimum is unclear.

For Sections 3.2, 3.3 and 4.1 we have noticed that the freshwater forcing scenarios seem somewhat unrealistic, being 360 Gt yr-1 (1 mm yr-1 SLR, over 2003-2015), then growing with 5, 10 and 20 yr doubling times. The problem is not on the initial value, but lies in the exponential growth that is assumed. It implies that values in the order of 1 Sv are reached, which equals 30,000 Gt yr-1. It is not likely that these magnitudes of ice loss can be reached. The choice for this extreme freshwater forcing scenario is not extensively motivated, apart from some notions that ice in Greenland and Antarctica is widely connected to the ocean via outlet glaciers and basins with bedrock below sea level, and that feedbacks like albedo and surface lowering can increase the ice melt. Later in the paper (section 7.3) a review on recent ice sheet changes is given, but no direct physical justification is given for a continuous exponential growth of ice sheet mass loss, apart from a fairly loose statement:

"We do not argue for this specific input function, but we suggest that rapid meltwater increase is likely if GHGs continue to grow rapidly." (page 20078)

In fact, there are estimates of how much ice can be melted from Antarctica via a WAIS collapse: Bamber et al. (2009) estimate this to be 3.5 m. With this as upper limit an exponential growth rate is not realistic. Furthermore, the authors argue that paleoclimate data reveals that sea level rise of several meters in one century have occurred before. But this occurred during terminations of glacial periods, hence with much more ice available on the planet. To put the scenarios used here in context of the recently published assessment by Church et al. (2013): the lowest scenario by Hansen et al. is still 2-3 times higher than the Church et al. estimate in 2100, and Hansens highest estimate is more than 3000 times higher.

Referring to the comment on page 20079, line 17-19: "*Actual current freshwater flux may be about a factor of four higher than assumed in these initial runs, as we will discuss, and thus effects may occur ~20 years earlier.*": The suggestion that the simulated effects of an exponentially growing freshwater flux may occur ~20 yr earlier is only based upon a possible underestimation of the initial freshwater flux. This is strange reasoning, because the timing of the effects strongly rely on the exponential growth curve, which is highly uncertain (see above), not on the initial value. As a consequence of these over the top melt scenarios, an unrealistic fresh water flux is generated leading to a strong response in the ocean. Model results with more realistic ice melt fluxes don't show this behaviour. In other words, a large part of the results depends on the extreme ice melt down scenarios for which support lacks.

The intensity and frequency of storm tracks

Examining Figure 13 (which is extended in the supplementary material by Figure S11) shows that for the Atlantic region an anomalous high pressure occurs over the storm track region (Upper panel left). This agrees with reduced westerlies over the storm track region. For the Pacific a poleward shift of the storm tracks is visible, that might also contribute to the proposed enhancement in the frequency of stronger storms. The simulated changes in wind speed in the simulation is rather moderate, for most of the regions less than 2 m/s, along with the changes in the Eddy Kinetic energy shown in Figure 26. How the simulated perturbation in these variables translates to a drastic change in the storm climate is rather unclear in the present manuscript. Therefore we suggest that the authors increase the robustness of this conclusion using the technique of dynamical downscaling of the wind speed data in order to produce a PDF of the changes in wind speed over storm track regions from their simulations, which were performed at the rather coarse resolution of 4° x 5° which fails to capture intense storm activity accurately.

For the hurricane season (Aug-Nov) the main impact of the Atlantic high would be to deflect the hurricane tracks. How this would affect the possibility of landfall depends on the genesis location of the Hurricanes. For storms that originate in the eastern tropical Pacific (which becomes more probable in a warmer climate), the chance of landfall would probably diminish, whereas storms that originate in the western Pacific might have enhanced probability of US landfall. However simulating the changes in hurricane intensity, frequency and the tracks is a complicated process with competing factors, such as SST, vertical stability, wind shear, moisture, dust and large scale circulation including subsidence. Without a detailed analysis of these factors supported by high-resolution modeling any statement is rather speculative. The current state-of-the-art knowledge based on these models indicates that indeed hurricanes will become more intensive, but less frequent (Bender et al., 2010; Knutson et al., 2010). A thorough analysis of the skill of the applied model with respect to storm statistics fails, but is requested before such strong conclusions can be warranted.

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