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Interactive Comment

Interactive comment on "Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming is highly dangerous" *by* J. Hansen et al.

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The fundamental assertion in this paper is that the Greenland and Antarctic ice sheets might melt or collapse sufficiently rapidly as to discharge freshwater over the coming decades at a rate that is much larger than presently observed. The direct consequence would be rapid sea-level rise. The indirect consequences would be changes in ocean circulation and sea-ice extent, and perhaps surprisingly to most readers, rapid climate cooling (though this is not explicitly mentioned in either the abstract or summary section of the paper, it is shown in the figures and discussed briefly in the paper).

The authors appeal to evidence from the late Eemian of 2-3m sea-level rise to support their prescribed scenarios of rapidly increasing freshwater input to the ocean from ice sheets. However, given the way the paper is organized, it is difficult for a reader to connect assumptions made in the model forcing (sections 3.2 and 4.3) to their justification based on paleo-climate reconstructions (section 2.1) and modern observations (section 7.3). What is important is that the prescribed freshwater forcing scenarios have an exponentially increasing form with doubling times of 5, 10 and 20 years. The most extreme of these has sea level rising 5m by the year 2060. This assumes freshwater flux could rapidly reach values up to 8Sv. To put this in perspective, it is about 1800 times the currently observed melt rate for west Antarctica (Shepherd et al., 2012) and about 600-700 times the total grounded ice and ice-shelf melt estimated by Rye et al. (2014). Prolonged exponentially increasing ice-sheet loss is clearly unphysical and so the authors arbitrarily terminate freshwater input once the associated sea-level rise reaches 5m – it is zero thereafter. (Other simulations are performed with freshwater input terminated upon reaching 1m or 3.8m sea-level rise). The authors note that "termination of freshwater injection is imposed only for the sake of analyzed climate mechanisms, not with the expectation that a sudden halt of ice sheet disintegration is realistic".

The authors provide no assessment of the likelihood of any of their scenarios, and do not cite most of the previous studies that have explored the response of the climate system to much less dramatic freshwater input (e.g. Swart and Fyfe, 2013; Bintanja et al., 2013; Aiken and England, 2008; Stouffer et al. 2007; Hellmer, 2004; Weaver et al., 2003). Indeed they state that: "We do not argue for this specific input function" (pg. 20078), and that "the critical issue is whether human-spurred ice sheet mass loss can be approximated as an exponential process during the next few decades"

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(pg. 20092). They also do not justify the manner in which this freshwater is introduced into the ocean (as liquid water with a temperature of -15°C, pg. 20079). There are apparently no negative feedbacks allowed between simulated climate and ice-sheet-derived freshwater flux, and so the freshwater discharge accelerates regardless of how rapidly the surface climate cools.

The result of a very large forcing perturbation is necessarily a very large response. For the most extreme scenario (5-year doubling time), simulated global temperature drops to roughly 1.4°C below preindustrial levels by mid-century (then rapidly jumps back up when the freshwater forcing is abruptly terminated). This is in striking contrast to essentially all published projections of 21st century climate change, and so places a very large burden on the authors to provide evidence in support of rapid global cooling in the face of rising greenhouse gas concentrations. In sections 2.1, 2.3 and 5.5 there is some evidence provided for cooling events toward the end of the Eemian, but due to large dating uncertainty it is not entirely obvious that they are coincident with the late Eemian sea-level rise, and in any case they occur against the backdrop of a climate that is slowly cooling toward glacial conditions rather than one experiencing greenhouse-gas-driven warming.

In summary, this paper's projection of rapid, near-term global cooling is at odds with essentially all peer-reviewed literature on future climate projections and would suggest to most readers that the state of climate science is such that even the sign of future climate change is uncertain (let alone the magnitude). The suggestion of such fundamental uncertainty demands extraordinarily compelling evidence and a careful evaluation of plausibility and likelihood.

References:

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