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Atmospheric Chemistry and Physics Discussions

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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It is amazing what we can learn from the Eemian. I agree with David Archer that the main point of the paper is about the mechanism by which rapid sea-level rise could arise from the West Antarctic Ice Sheet (WAIS), following sea-level rise originating from the Greenland Ice Sheet (GIS). However, I also agree with him to question why GIS should not have been subject to the same kind of non-linearity as WAIS. One can observe plenty of non-linearity in current GIS melting: with its contribution to sea level

rise having risen 5-fold in twenty years (Shepherd et al, 2012 “A reconciled estimate of ice-sheet mass balance”) and with its downward trend in ice mass (Hansen and Sato, 2012, “Update of GIS ice loss – exponential?”).

A surprise from the paper was the suggestion of acute storms. But for those giant boulders to be thrown high up on Eleuthera, it seems likely that the power of a mega-tsunami would be needed. The mega-tsunami or tsunamis would have had to come from the north-east and this suggests an Arctic origin. GIS is a possibility. The ejection of huge chunks of ice sheet into the sea off the north-west coast of Greenland would have sent deep pressure waves towards the North Atlantic Ridge, where they would be reflected directly towards Eleuthera which itself has an off-shore funnel to amplify the wave. Scouring of the sea bed, up to 1000 metres down, has been observed off Greenland, suggesting there had been huge icebergs (Bennett, 2012, “Distribution of seabed ice scour caused by grounded icebergs on the Canadian Baffin continental margin”).

Now we can consider a possible sequence of events in late Eemian. For some reason, not explored in the paper, there was a dramatic temperature rise marking the start of a D-O event. This would have destabilised the GIS, with great chunks of ice sliding into the sea, creating giant icebergs and tsunamis. The icebergs would carry rocks to be later deposited across the North Atlantic – a Heinrich event. The release of vast quantities of cold freshwater onto the surface of the Atlantic could have started the cooling phase of the D-O. The meltwater from GIS would have caused the sea level to rise under the termination of the glaciers in WAIS, making them more sensitive to melting from warm water. The Heinrich event would have turned off or severely reduced the AMOC. The reduction in NADW would have had a subsequent warming effect at the terminations of glaciers in WAIS, promoting an acceleration of their discharge, already primed by the sea level rise from GIS. This warming would have been supplemented by increased summer insolation from the Milankovitch cycles.

This sequence of events seems to be consistent with the data, excepting for the timing

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of the Heinrich event. But Heinrich events are notoriously difficult to date precisely because of movement of debris and similar effects. It seems to be counter-intuitive to have Heinrich events during a cold or cooling period, and far more likely for them to be the consequence of rapid warming.

Now, if the above sequence is valid, we can see an extraordinary parallel with the current situation. We have had a dramatic non-linear temperature rise in the Arctic, primarily due to positive albedo feedback from loss of snow and sea ice. The Arctic amplification has changed the polar jet stream behaviour such that Greenland can be subject to warm winds from the south and extreme melt events, as occurred in July 2012. The GIS is riddled with moulins. Huge quantities of melt water have percolated through the ice and could be lubricating its base. There are an increasing number of icequakes indicating large-scale movement of the ice sheet. There is accelerated discharge of meltwater into the sea. Could these be the pre-conditions for the creation of giant icebergs and tsunamis, accompanied by intolerable sea level rise? Is this the lesson we should learn from the Eemian: that these things could happen to us? Those who do not learn from history are doomed to repeat it. Even though it may seem an almost impossible challenge, shouldn't we be trying to cool the Arctic and halt the ice melt now – as a top priority - before it is too late? Or should we sit back, see what happens and trust to luck? Reticence by scientists now would be unforgivable – we have seen what quite plausibly happened in the Eemian.

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