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The influence of Greenland melt water on climate during past and future warm periods: a model study

Michael Blaschek, Pepijn Bakker, and Hans Renssen
VU Amsterdam, Climate Change and Landscape Dynamics, Amsterdam, Netherlands (m.blaschek@vu.nl)

"Can past climates teach us something about the future?" Under this general question of interest to most palaeoclimate-modeller we specified it more to "Can past changes in the strength of the Atlantic Meridional Overturning Circulation (AMOC) related to melt water from the Greenland Ice Sheet (GIS) teach us something about future changes in the AMOC forced by predicted partial melting of the GIS?" To address this question, we developed a series of sensitivity experiments with the global atmosphere-ocean-sea-ice model LOVECLIM to better understand the relationship between the strength of the Atlantic Meridional Overturning Circulation (AMOC) and Greenland Ice Sheet (GIS) melt over the last and present interglacials (the Eemian and the Holocene, respectively) and put these into perspective of future greenhouse gas emission scenarios. In terms of radiative forcing, future emission scenarios are different from past orbitally-forced warm periods, as past insolation varied per season and per latitude, whereas radiative forcing due to future greenhouse gas emissions has no seasonal component (i.e. it is an annual forcing) and shows little variation per latitude. However, the two can be compared when we consider the radiative forcing regimes of the different considered warm climates, by focusing on the energy that is potentially available from radiative forcing to melt the GIS. In a similar approach, Swingedouw et al. (2009) have shown in simulations with an AOGCM that the AMOC sensitivity relates non-linear to freshwater input and that under Last Glacial Maximum (LGM) conditions the climate is more sensitive compared to warmer climates. They conclude that different climatic conditions share similar patterns in response and that past climates are useful for models to evaluate their abilities in reproducing past events. The authors encourage further model sensitivity testing to gain a better understanding of this highly important question.
In order to test this approach we performed a series of experiments in which we applied different versions of our model that differ in the sensitivity to freshwater forcing. These experiments cover all three periods considered: the Eemian, the Holocene and the 21st Century. We used different amounts of GIS melt fluxes that correspond to a wide range of changes in percent from modern-day ice sheet volume, ranging from as little as 5% to 100%. The GIS extent and topography was kept at present-day conditions. The future greenhouse gas emissions are taken from the Representative Concentration Pathways (Meinshausen et al. 2011), the new scenarios for climate change research.
Our first results suggest that the warmer Eemian and the less warm Holocene test cases have a quite linear relationship in terms of AMOC sensitivity to GIS melt. In all our sensitivity experiments the Eemian is more sensitive to freshwater forcing than the Holocene.

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