Geophysical Research Abstracts
Vol. 14, EGU2012-8705, 2012
EGU General Assembly 2012

Did Greenland Ice Sheet melting weaken the AMOC during the early part of the last interglacial? A model analysis of the uncertainties.

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Proxy data suggests that during the early part of the last interglacial, the climate was characterized by a warmer than modern-day climate and a shrinking Greenland Ice Sheet. This may resemble future conditions under the influence of anthropogenic forcings. In addition, for the first several thousand years of the last interglacial period, a weakened overturning circulation has been reconstructed. However, it has not yet been established if there is a causal relationship between the partial melting of the Greenland Ice Sheet and the millennial-scale weakening of the overturning circulation.

This intriguing palaeoclimatic setting provides us with the opportunity to investigate with a climate model whether Greenland Ice Sheet melting was the most likely cause of the weakening of the overturning. Concurrently, we can investigate if climate models are capable of realistically simulating the sensitivity of the overturning circulation to Greenland Ice Sheet melting.

We performed transient climate simulations for the early last interglacial with the LOVECLIM global climate model of intermediate complexity (Goosse et al., 2010), to investigate if Greenland Ice Sheet melting could have caused the overturning circulation to be substantially weakened for several thousand years. The impact of the uncertainties in the reconstructed volume changes of the Greenland Ice Sheet and the associated melt rates where discussed already in Bakker et al. (2012). In this study we focussed on the importance of the many other uncertainties surrounding this topic: the age constraints, the impact of the preceding deglaciation, high frequency variability in the melt rates, geographical distribution of the melt water into the surrounding oceans and lastly the importance of the model-dependent sensitivity of the overturning circulation to a perturbation of the freshwater budget.

Based on our findings we constructed a specific Greenland Ice Sheet melt scenario and show that, within the full uncertainty range, it is physically possible that last interglacial Greenland Ice Sheet melting kept the overturning weakened for 3 to 4 thousand years.

However, this scenario is at the very extreme end of the uncertainty envelope. As proxy-based reconstructions are not yet conclusive, this result leads us to propose two different interpretations: If indeed Greenland Ice Sheet melting weakened the overturning, our findings imply that the overturning in most climate models is too stable. The other interpretation however is, that it is not very likely that melting of the Greenland Ice Sheet was the sole reason for the weakened overturning during the early LIG.

References:

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