Antarctic ice sheet during the Last Interglacial: Thresholds and Feedbacks

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Abstract

Understanding the dynamics of warm climate states has gained increasing importance in the face of anthropogenic climate change. During the Last Interglacial (LIG, ~128 to 116 ka), greenhouse gas concentrations and high latitude insolation were higher than pre-industrial levels, causing a high-latitude warming (Turney and Jones, 2010; Pfeiffer and Lohmann, 2016). As a result of this modestly warmer climate, polar ice sheets were smaller and estimates report that the global mean sea level was 6-9 meters higher than today (Dutton et al., 2015). However, proxy reconstructions indicating a high-stand of LIG sea level are subject to uncertainties in timing and magnitude (Rovere et al. 2016). Here, we utilize a stable water isotope equipped climate model to simulate different stages during the LIG. Furthermore, we present a suite of model results to evaluate the thresholds and feedbacks in the system, and will compare the simulations with paleoclimate reconstructions from high southern latitudes. Our main findings can be summarized as

- Our fully-coupled atmosphere-ocean isotopic simulation of the LIG indicate that the temporal and spatial gradients in $\delta^{18}O$ do not match.
- One isotopic simulation using a reduced West Antarctic Ice Sheet (WAIS) is consistent with the isotopic signature found in ice core data (Masson-Delmotte et al., 2011)
- A reduction of the Greenland Ice Sheet height causes an additional remote warming over the WAIS via atmosphere-ocean teleconnections (Pfeiffer and Lohmann, 2016).
- Ice sheet model simulations indicate that a pronounced subsurface oceanic warming can destabilize the WAIS, resulting in an oceanic gateway between the Ross and Weddell Seas (Sutter et al. 2016).
- Our ice sheet model indicates a threshold behavior of the WAIS in the range of 2-3°C warming (Sutter et al. 2016).
- A sensitivity study using the new oceanic gateway between the Atlantic and Pacific Oceans as bathymetrical boundary condition, indicates that this region would be covered by sea ice. Mixing due to sea-ice formation prevents a pronounced warming around the WAIS and would stabilize the WAIS.

Past sea-level records located far from Antarctica and hence relatively unaffected by isostatic changes, show that it is possible that the end of the LIG was characterized by a sudden meltwater pulse (O'Leary et al., 2013), that made the sea level rise abruptly about four meters in 1 kyr. There is the possibility that a sudden, late-MIS 5e sea level rise was triggered by a collapse of either West or East Antarctica, as it appears that the Greenland Ice Sheet had been already completely melted early in the interglacial. A destabilizing feedback of the WAIS might be related to a pronounced subsurface warming caused by changes in vertical stratification (Weber et al., 2014).

Keywords: Last Interglacial, Antarctica, sea level, sea ice

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