Geophysical Research Abstracts
Vol. 13, EGU2011-12994, 2011
EGU General Assembly 2011

Simulating the Southern Hemisphere high-latitude climate impact of West-Antarctic Ice Sheet melt during the early-Holocene

Cedric Van Meerbeeck and Hans Renssen
VU University Amsterdam, Earth Sciences, Amsterdam, Netherlands (cedric.van.meerbeeck@falw.vu.nl, +31 2059 89941)

Little is known on the Southern Hemisphere (SH) high-latitude climate impact of West-Antarctic Ice Sheet (WAIS) melt during the Holocene. Grounding line data and ice sheet modelling suggest that, after the last glacial period, the WAIS decreased in size until around 3ka BP, when it reached near present-day configuration. Previous modelling efforts further suggested that with the fastest decay occurred between 12ka BP and 6ka BP amounting to 4-7 106 km3 ice volume. A resulting meltwater flux of the order of 0.05 106 m3 s-1 (=0.05Sv) to the Southern Ocean in the latter interval may have perturbed the Southern Ocean circulation through surface freshening. Notably, the freshening could facilitate sea-ice formation, thus cooling climate, and affect deep water formation.

To quantify the SH high-latitude climate impact of WAIS melting during the early-Holocene, we performed transient 9-0ka BP simulations in the LOVECLIM 3-D earth system model. The first was forced with orbital insolation and atmospheric greenhouse gas concentration changes only (OG). The second simulation contains this forcing plus an additional freshwater flux from the decaying Laurentide Ice Sheet (OG-LISF) until 7ka BP. The third simulation adds the ice volume and extent changes of the Laurentide (OG-LISFI), while the fourth further includes WAIS freshwater forcing (OG-LISFI-WAISF).

Orbital forcing causes a negative temperatures trend over and around Antarctica throughout the Holocene in the OG simulation, consistent with data and simulations with other climate models. This is exemplified by a 10% decrease of annual mean SH sea-ice extent between 9ka BP and 0ka BP. Furthermore, a 9-7ka BP cooling interval (air surface temperature decrease of 1-2°C) may be accounted for by LIS deglaciation, as seen in the OG-LISF and OG-LISFI simulations. These findings are in quantitative agreement with similarly setup simulations using a previous version of the model, suggesting independence to slight parameterisation changes.

Introducing the 0.05Sv WAIS melt flux at the Southern Ocean surface between 9ka BP and 6ka BP, however, appears to counteract the orbitally forced warmer conditions then. For instance, compared to OF, a ∼20% decrease in annual mean SH sea-ice extent together with a cooling of 2-3°C between 55 and 70°S, 90°W-150°E is noted at 9ka BP in OG-LISFI-WAISF. This marks an additional decrease of 10% in sea-ice and 1-2°C in temperatures compared to OG-LISFI. However, the WAIS melt does not lead to a remarkable decrease in deepwater formation around Antarctica, leavind the Atlantic Meridional Overturning Circulation strength unaffected.

These modelling results imply that the 9-7ka BP reconstructed high-latitude SH cooling may to a large part be the result of surface freshening promoting sea-ice formation there. The recently suggested deep ocean pathway feedback – where colder than present North Atlantic Deepwater resurfaces in the Southern Ocean, thus cooling surface waters there – may have enhanced this cooling.