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The role of ice shelves in the Holocene evolution of the Antarctic ice sheet

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Using the continental-scale ice sheet-shelf model SICOPOLIS (Greve, 1997 [1]; Sato and Greve, 2012 [2]), we assess the influence of ice shelves on the Holocene evolution and present-day geometry of the Antarctic ice sheet. We have designed a series of paleoclimate simulations driven by a time-evolved climate forcing that couples the surface temperature record from the Vostok ice core with precipitation pattern using an empirical relation of Dahl-Jensen *et al*., (1998) [3]. Our numerical experiments show that the geometry of ice shelves is determined by the evolution of climate and ocean conditions over time scales of 15 to 25 kyr. This implies that the initial configuration of ice shelves at the Last Glacial Maximum (LGM, about 21 kyr before present) has a significant effect on the modelled Early Holocene volume of ice shelves (up to 20%) that gradually diminishes to a negligible level for the present-day ice shelf configuration. Thus, the present-day geometry of the Antarctic ice shelves can be attained even if an ice-shelf-free initial condition is chosen at the LGM. However, the grounded ice volume, thickness and dynamic states are found to be sensitive to the ice shelf dynamics over a longer history spanning several tens of thousands of years. A presence of extensive marine ice at the LGM, supported by sediment core reconstructions (e.g. Naish *et al*., 2009 [4]), has a clear buttressing effect on the grounded ice that remains significant over a period of 30 to 50 kyr. If ice-shelf-free conditions are prescribed at the LGM, the modelled Early Holocene and present-day grounded ice volumes are underestimated by up to 10%, as opposed to simulations incorporating ice shelf dynamics over longer periods. The use of ice-shelf-free LGM conditions thus results in 50 to over 200 meters thinner ice sheet across much of East Antarctica.

References

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