Antarctic Ice Sheet Dynamic and its response to ocean forcing

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Abstract

Ice sheet dynamics describe the motion within large bodies of ice, such those currently on Greenland and Antarctica. Ice motion is dominated by the movement of glaciers, whose gravity-driven activity is controlled by two main variable factors: the temperature and strength of their bases. A number of processes alter these two factors, resulting in cyclic surges of activity interspersed with longer periods of inactivity, on both hourly and centennial time scales. Ice-sheet dynamics are of interest in modelling future sea level rise. The Antarctic Ice Sheet (AIS) plays a major role in the evolution of Quaternary glacial-interglacial cycles and in the global climate system in general. By a variety of ice-ocean and ice-atmosphere feedback processes, changes in the dynamics of the southern ice giant are felt throughout the globe. Ice cores drilled down to the bedrock of the East Antarctic Ice Sheet provide a glimpse into the climate history of the past one million years via water stable isotopes and trapped gasses conserved in the slow flowing ice (climate proxies). Dramatic changes in ice volume and extent characterize the evolution of the AIS during the last 130.000 years, affecting both Southern Hemisphere and global climate. A central protagonist in this history of the AIS is the West Antarctic Ice Sheet (WAIS), due to its unique setting extending into several ocean basins and thus being prone to destabilization triggered by warming of the Southern Ocean. The objective of this thesis is to shed light on the glacial-interglacial dynamics of the AIS by means of 3D ice sheet modeling. The dynamic evolution of the WAIS during the Last Interglacial (LIG) and in the future is investigated and potential climate thresholds for an marine ice sheet collapse identified. Special attention is given to the role of basal melting underneath the ice shelves in the growth and decay of the WAIS. Our results identify that fast-flowing glaciers in the eastern Weddell Sea, the Amundsen Sea, central Ross Sea, and in the Amery Trough respond most rapidly to ocean forcings, in agreement with empirical data. Most significantly, we find that although ocean warming and sea-level rise bring about mainly localized glacier acceleration, concomitant drawdown of ice from neighboring areas leads to widespread thinning of entire glacier catchments-a discovery that has important ramifications for the dynamic changes presently being observed in modern ice sheets.

Keywords: Ice sheet, Dynamics, Climate change