Geophysical Research Abstracts, Vol. 9, 03892, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03892

The sensitivity of the Antarctic ice sheet to orbital variations and atmospheric CO_2 in the Middle Miocene

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One of the largest global cooling events of the Cenozoic occurred in the Middle Miocene (around 14 million years ago). Possible causes for this event include changes in atmospheric CO_2 content, vegetation, orbital forcing and uplift of mountain ranges. Yet, none of these provide a satisfactory solution. Associated with this climate event, the Antarctic ice cap developed from a small into a large continental ice sheet. As yet, changes in temperature and ice volume have mainly been inferred from oxygen-isotope records. However, the oxygen-isotope ratio of the Antarctic ice sheet has a large effect on the oxygen-isotope composition of seawater, as documented in deep-sea carbonate sediments.

We use an axially symmetric representation of the Antarctic ice sheet to model the potential extent of the ice-volume variations as well as the temperature, oxygen-isotope and velocity distributions within the ice sheet. The model is forced by insolation variations, using physical parameterizations for energy and mass balances. Because of the high computational efficiency of the ice-sheet model, various runs spanning several 100 kyrs can be computed. The impact of the specific orbital configuration and its transition from an obliquity-dominated to an eccentricity-paced signal will be presented. These experiments will be combined with different CO_2 parameterizations, in order to test possible scenarios for the transition towards a large continental Antarctic ice sheet. In addition, the potential of the associated variations in the average oxygen-isotope ratio of the ice cap on the mean oxygen-isotope composition of seawater will be discussed.