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Antarctic glaciations under Pliocene climate conditions from numerical modeling and compilation of local field-based reconstructions

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The mid-Pliocene (3.15 to 2.85 million years before present) is the most recent period in Earth's history when temperatures and CO_2 concentrations were likely sustainedly higher than pre-industrial values. Furthermore, the positions of the continents and their sea-land distributions had already reached their present configuration, sharing some similarities with today's patterns of ocean circulation and vegetation distributions. Although significant differences exist —such as a peak sea level that could have been 22 ± 10 m higher than it is today and sea surface temperatures particularly warmer at higher latitudes, mid-Pliocene has been identified as an ideal interval for studying the climate system under conditions similar to those projected for the end of this century. Among the sources of uncertainty in the projections, the response of the Antarctic ice sheet (AIS) to warmer-than-today conditions seems to play a central role. Therefore, a better understanding of AIS's behavior during periods like the mid-Pliocene will provide valuable information that could help improve future predictions. For this purpose, we have compiled a wide range of local field-based reconstructions of the ice-sheet margin from Pliocene sediments (with the inclusions of organic matters such as, for instance, diatoms or palynoflora, or ice rafted debris), geochemical records, volcanic ashes and rocks, and geomorphology, and designed numerical experiments of the AIS dynamics during the mid-Pliocene warm period using the large-scale polythermal ice sheet-shelf model SICOPOLIS (Greve, 1997 [1]; Sato and Greve, 2012 [2]). The model is run with a horizontal resolution of 40×40 km by the climatology obtained from the PlioMIP Atmosphere Ocean Global Circulation Model experiments (Dolan *et al.*, 2012 [3]). Parameters of the AIS model (e.g. ice calving, sub-ice shelf and surface ice melt, basal sliding, etc.) have initially been estimated using ice-sheet simulations driven by the present-day climate and ocean conditions and calibrated against available remote-sensed and in-situ observations. In our Pliocene experiments, we employ alternative parameterizations of sub-ice shelf and ice surface melting processes to test the likelihood of numerous controversial theories and reconstructions arguing for or against significant retreat of the East Antarctic ice sheet from the coasts (locally up to 450 km) in the mid-Pliocene. Finally, we assess the sensitivity of the modeled West Antarctic/Antarctic Peninsula ice geometry to the above parameters and emphasize a crucial role of surface mass balance model parameters in modeling the Pliocene ice sheet configuration in agreement with existing reconstructions on a regional scale.

References

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