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The effects of climate uncertainty on the stability of the Antarctic ice sheet during the mid-Pliocene warm period

Jorge Bernales (1), Tonio Häfliger (2), Irina Rogozhina (1), Maik Thomas (1,2)

(1) Deutsches GeoForschungsZentrum Potsdam, Section 1.3, Potsdam, Germany, (2) Institut für Meteorologie, Freie universität Berlin, Berlin, Germany

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 sustainedly higher than pre-industrial values [1], representing an ideal interval for studying the climate system under conditions similar to those projected for the end of this century. In these projections, the response of the Antarctic ice sheet (AIS) remains uncertain, including areas generally considered stable under a warming climate. Therefore, a better understanding of AIS's behaviour during periods like the mid-Pliocene will provide valuable information on the potential vulnerability of the composite parts of the AIS in the future. For this purpose, we have designed numerical experiments of the AIS dynamics during the mid-Pliocene warm period using the continental-scale ice sheet-shelf model SICOPOLIS [2]. To account for the uncertainties in the configuration of the AIS and climate conditions prior to this period, we employ a wide range of initial ice sheet configurations and climatologies, including modern observations, the results from the Pliocene Model Intercomparison Project (PlioMIP) climate experiments [3], and perturbations to single climatic fields, allowing us to assess the vulnerability of different AIS sectors to specific forcing mechanisms. Our simulations show that the West Antarctic ice sheet remains largely ice-free under the chosen range of climate conditions, except for small portions grounded above sea level. On the contrary, the East Antarctic ice sheet (EAIS) shows no signs of potential collapse, with an ice loss over a few peripheral sectors largely compensated by an increase in ice volume over the interior due to increased precipitation rates and surface temperatures remaining well below the freezing point. Furthermore, our results contrast with existing hypotheses that cast doubt on the stability of the EAIS during the mid-Pliocene warm period.

References

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