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Disentangling the drivers of future Antarctic ice loss with a historically-calibrated ice-sheet model

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Recent observations show that the Antarctic ice sheet is currently losing mass at an accelerating rate in areas subject to high sub-shelf melt rates. The resulting thinning of the floating ice shelves reduces their ability to restrain the ice flowing from the grounded ice sheet towards the ocean, hence raising sea level by increased ice discharge. Despite a relatively good understanding of the drivers of current Antarctic mass changes, projections of the Antarctic ice sheet are associated with large uncertainties, especially under high-emission scenarios. This uncertainty may notably be explained by unknowns in the long-term impacts of basal melting and changes in surface mass balance. Here, we use an observationally-calibrated ice-sheet model to investigate the future trajectory of the Antarctic ice sheet until the end of the millennium related to uncertainties in the future balance between sub-shelf melting and ice discharge on the one hand, and the changing surface mass balance on the other. Our large ensemble of simulations, forced by a panel of CMIP6 climate models, suggests that the ocean will be the main driver of short-term Antarctic mass loss, triggering ice loss in the West Antarctic ice sheet (WAIS) already during this century. Under high-emission pathways, ice-ocean interactions will result in a complete WAIS collapse, likely completed before the year 2500 CE, as well as significant grounding-line retreat in the East Antarctic ice sheet (EAIS). Under a more sustainable socio-economic scenario, both the EAIS and WAIS may be preserved, though the retreat of Thwaites glacier appears to be already committed under present-day conditions. We show that with a regional near-surface warming higher than +7.5°C, which may occur by the end of this century under unabated emission scenarios, major ice loss is expected as the increase in surface runoff outweighs the increase in snow accumulation, leading to a decrease in the mitigating role of the ice sheet surface mass balance.