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Decreasing Antarctic surface mass balance due to runoff-dominated ablation by 2100

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The surface mass balance (SMB) of the Antarctic ice sheet is often considered as a negative contributor to the sea level rise as present snowfall accumulation largely compensates for ablation through wind erosion, sublimation and runoff. The latter is even almost negligible since current Antarctic surface melting is limited to relatively scarce events over generally peripheral areas and refreezes almost entirely into the snowpack. However, melting can significantly affect the stability of ice shelves through hydrofracturing, potentially leading to their disintegration, acceleration of grounded ice and increased sea level rise. Although a large increase in snowfall is expected in a warmer climate, more numerous and stronger melting events could conversely lead to a larger risk of ice shelf collapse. In this study, we provide an estimation of the SMB of the Antarctic ice sheet for the end of the 21st century by forcing the state-of-the-art regional climate model MAR with three different global climate models. We chose the models (from both the Coupled Model Intercomparison Project Phase 5 and 6 - CMIP5 and CMIP6) providing the best metrics for representing the current Antarctic climate. While the increase in snowfall largely compensates snow ablation through runoff in CMIP5-forced projections, CMIP6-forced simulations reveal that runoff cannot be neglected in the future as it accounts for a maximum of 50% of snowfall and becomes the main ablation component over the ice sheet. Furthermore, we identify a tipping point (ie., a warming of 4°C) at which the Antarctic SMB starts to decrease as a result of enhanced runoff particularly over ice shelves. Our results highlight the importance of taking into account meltwater production and runoff and indicate that previous model studies neglecting these processes yield overestimated SMB estimates, ultimately leading to underestimated Antarctic contribution to sea level rise. Finally, melt rates over each ice shelf are higher than those that led to the collapse of the Larsen A and B ice shelves, suggesting a high probability of ice shelf collapses all over peripheral Antarctica by 2100.