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Assessing the role of ice-shelf damage on a three-dimensional ice-sheet model

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As stated in the latest IPCC report, sea level will continue to rise at the end of this century and most likely well beyond, depending on future emission pathways. The Antarctic ice sheet plays an important role, as it is the largest ice sheet and thus the largest source of water storage on Earth. However, projections for Antarctica from ice-sheet models yield very mixed results due to ice-sheet-related processes that are difficult to assess. One of the main sources of uncertainty is the stability of floating ice shelves. Although ice shelves do not directly contribute to sea-level rise, they have been shown to play an important role, as they modulate the grounded ice flow via their buttressing effect. Therefore, it is necessary to assess the stability of ice shelves in a warmer climate to make more accurate predictions and define safe trajectory scenarios. Satellite images show the formation of crevasse in regions with a high deformation rate. These crevasses weaken the stability of the ice shelf, as damage enhances inland ice acceleration and promotes further shearing and retreat. However, most continental-scale ice-sheet models do not account for ice shelf damage and its consequent potential feedback mechanisms. Part of this statement is due to the fact that ice shelves at coarse resolutions show low stability to damage implementation even in simple domains. Here we force a three-dimensional ice-sheet-shelf model with various damage formulations from the literature. Given the high uncertainty in damage formation and propagation, several parameters affecting the stability of the ice shelf are evaluated. Experiments are performed in different domains to test their influence in simple and symmetric cases, such as MISMIP+, as well as in the Amundsen-Sea Embayment. Our results highlight the importance of further research on ice damage, as it has strong implications for projections but is poorly accounted for in ice-sheet models.