

Treatments of ice-ocean interaction in ice sheet models and implications for Antarctic ice sheet retreat in the past and future

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Basal melting beneath ice shelves is an important factor in the retreat of grounding lines of Antarctic ice sheet, and it may significantly affect the volume of Antarctic ice sheet. Physically, basal melting of ice shelf is determined by upward heat transfer across ice shelf-ocean boundary, that is determined by ocean circulations beneath ice shelves and Antarctic continental shelf seas. Recent ocean modeling (includes ice shelf cavity component) studies suggest a climate change affect basal melting rate by not only increasing ocean temperature itself but also by changing water mass formations and ocean circulations in the Antarctic continental shelf seas, which may lead to drastic increase in basal melting (Hellmer et al. 2012; Obase et al. 2017). In turn, basal melting of ice shelves is an essential mass balance term for ice sheet models. However, as it is difficult to conduct long-term simulation using such ocean models, basal melting rate of ice shelves are often parameterized with ocean temperature, which is derived from outputs of GCMs (without ice shelf component) or reconstructions near Antarctic continent (e. g. Deconto and Pollard 2016).

In the present study, at first, we review formulations of basal melting in the previous ice sheet modeling studies and discuss current limitations of such parameterizations, using perspectives from oceanographical and glaciological observations, and ocean modeling studies. Second, using a 3-dimensional Antarctic ice sheet model (SICOPOLIS), we investigate the responses of grounding lines of Antarctic ice sheet to simplified atmospheric surface mass balance and oceanic basal mass balance changes, similar to Golledge et al. (2017). Based on Southern Ocean temperature reconstructions in the past and climate model simulations, we discuss uncertainties in the treatment of basal melting and its implications for the retreats of Antarctic ice sheet in the past and future.

References

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