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LADDIE: a one-Layer Antarctic model for Dynamical Downscaling of Ice-ocean Exchanges

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A major source of uncertainty in future sea-level projections is the ocean-driven basal melt of Antarctic ice shelves. Remote sensing estimates of basal melt shows kilometer-scale features, and ice sheet models require kilometer-scale resolution to realistically resolve ice shelf stability and grounding line migration. Yet 3D numerical ocean models are computationally too heavy to produce melt rates at this resolution. To bridge this resolution gap, we here present the 2D numerical model LADDIE which allows for computationally efficient downscaling of basal melt rates, based on coarse 3D ocean model output. As a test case, we apply the model to downscale basal melt rates of the Crosson-Dotson ice shelf in the fast-melting Amundsen Sea region. Due to the model's computational efficiency, parameters can be tuned extensively. We have tuned the model to a range of parameters, namely average basal melt, melt in the Kohler West grounding zone, melt along the Dotson Ice Shelf Channel, and the overturning circulation of the cavity waters. These tuning targets are taken from a range of remote sensing products and in situ ocean observations. We show that the model can be tuned to agree with all observations, providing confidence that the model contains the essential physical processes governing basal melt. We propose that (sub-)kilometer resolution basal melt rates can be used to improve the realism of ice sheet models and their simulations of contemporary and future mass loss. Here we show that LADDIE can provide these boundary conditions in a computationally efficient way.