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Buoyant-plume parameterization applied to basal melt beneath Antarctic ice shelves

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Oceanic basal melting contributes significantly to the total melt rates of the Antarctic ice shelves. However, various parameterizations used in ice-dynamical models typically underestimate the basal melt rates, require significant tuning and have a limited physical basis. Therefore, we developed a new basal-melt parameterization, derived from a simple 1-D model of a buoyant plume of meltwater moving up from the grounding line along the ice-shelf base. The new parameterization takes into account both the ice-shelf geometry and the temperature of ambient ocean water flowing into the ice-shelf cavity. Regarding the geometry, we present a method that translates the original 1-D model to a full 3-D cavity. It results in a large spatial variation of basal melt, with high values typically concentrated near the grounding line, in line with observations. The resulting melt rates are shown to be more sensitive to the ambient temperature than the output of simpler models based solely on a local balance of heat. In addition, a suitable ocean temperature field is required for forcing the parametrization in conjunction with ice-dynamical models. This is problematic due to the lack of observational data beneath the ice shelves. Therefore, an effective ocean temperature field is constructed from available data, which is calibrated in such a way that the modelled melt rates agree with observed melt rates around Antarctica. The resulting 2-D field of basal melt rates is compared to simpler parametrizations and can be considered a starting point for more advanced simulations of the ice-shelf dynamics around all of Antarctica.