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The influence of coastal polynyas on the basal melting of ice shelves.

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The dense water production from coastal polynyas can strongly modify local circulation patterns with implications for both net basal melting of ice shelves and dense water formation. Results are presented from two different ice-shelf/ocean models: one of the Amery Ice Shelf/Prydz Bay region; and one of the Mertz Glacier Ice Tongue region. The models are based on the Regional Ocean Modeling System (ROMS). Two important modifications have been made to improve the simulation of thermodynamic processes beneath ice shelves: the inclusion of direct basal melt/freeze processes; and the inclusion of frazil ice dynamics. The models are forced with tides and with a smoothy varying seasonal cycle of winds. Thermohaline and circulation fields are relaxed to a smoothly varying seasonal climatology at the lateral boundaries. The open ocean surface fluxes are modified by an imposed climatological sea-ice cover that includes the seasonal effect of polynyas. It was found that the Prydz Bay gyre and Mertz gyre are summertime features. Both the strength and direction of the gyres are controlled by the production of dense water from local coastal polynyas. The production of dense water creates a current that blocks the westward flowing coastal current and diverts it northward away from the coast. For the Amery region, the coastal current bypasses the Amery Ice Shelf and flows out of the Prydz Bay channel and westward along the slope front. During summer, when the polynyas in Prydz Bay are inactive, Modified Circumpolar Deep Water (MCDW) is entrained with the eastward flowing coastal current as part of the gyre circulation. Observations of sea-ice confirm the presence of the Prydz Bay gyre under these conditions. The melt rates are higher in winter ($\sim$0.8 m ice per year) compared with summer ($\sim$0.7 m ice per year). The melting is primarily driven by dense shelf waters, with sufficient negative bouyancy, that drain to the deepest parts of the ice shelf at $\sim$2500m below mean sea level. Preliminary studies of the Mertz region show that times of highest basal melting correspond to the summertime movement of MCDW onto the shelf from the deep ocean. The model shows that the circulation in the Mertz depression is controlled seasonally by the formation of dense water that is formed in the polynya. The Mertz polynya also acts to block the movement of MCDW onto the shelf region and thus leads to lower melt rates during winter. Simulations that include a dynamic sea-ice model, without accounting for the effect of subgrid scale features, such as coastal polynyas, can potentially underestimate the production of dense shelf water, which has consequences for the basal melting of ice shelves. This research contributes to understanding how interaction between ice shelves and various forcing mechanisms can lead to changes in basal melt/freeze and dense water formation, which has major implications for the stability of ice shelves, sea level rise, and the salt budget of the global oceans.