A model of tidally-dominated ocean processes near ice-shelf grounding lines

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Glaciological processes at grounding lines may play a crucial role in controlling the dynamics of inland ice. Therefore, understanding the oceanic forcing on ice shelves in this region is of great importance to successful predictions of cryospheric change and sea level rise. As the ocean cavity shallows toward the grounding line, the effects of tidal mixing become proportionately more important until a point is reached, called the tidal front, beyond which the water properties are completely vertically homogenized. The extent of the vertically-mixed zone shoreward of the tidal front is of importance to several scientific questions because the mixed ocean behaves in a fundamentally different manner to the stratified region offshore. In this study a highly simplified one-dimensional model is used to examine the size, properties, and sensitivities of this mixed zone. The model suggests that most tidally-mixed zones are negligibly small, implying that the usual models representing a stratified ocean are generally valid. It therefore seems that in most cases upwelling of warm water, rather than tidal mixing, maintains ice-shelf basal melting. The mixed region can be significant, particularly where tidal flows are more vigorous and gradients in water-column thickness are small, but the model predicts that even these areas are smaller than previously proposed. The model also elucidates the pattern of melting near grounding lines, illustrates the birthplace of Ice Shelf Water plumes, and confirms that, unlike elsewhere in the cavity, melting in the small mixed zone increases linearly in response to ocean warming.