The response of ice-shelf basal melting to variation in ocean temperature

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A three-dimensional ocean General Circulation Model is used to study the response of idealized ice shelves to a series of ocean-warming scenarios. The model predicts that the total ice-shelf basal melt increases quadratically as the ocean offshore of the ice front warms. This occurs because the melt rate is proportional to the product of ocean flow speed and temperature in the mixed layer directly beneath the ice shelf, both of which are found to increase linearly with ocean warming. The behavior of this complex primitive-equation model can be described surprisingly well with recourse to an idealized reduced system of equations, and it is shown that this system supports a melt rate response to warming that is generally quadratic in nature. The results of this study confirm and unify several previous examinations of the relation between melt rate and ocean temperature but disagree with others, for which explanations are proposed. The hypothesized warming does not necessarily require a heat input to the ocean, as warmer waters (or larger volumes of 'warm' water) may reach ice shelves purely through a shift in ocean circulation. Since ice shelves link the Antarctic Ice Sheet to the climate of the Southern Ocean, this finding of an above-linear rise in ice-shelf mass loss as the ocean steadily warms is of significant importance to our understanding of ice-sheet evolution and sea level rise.