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Tidal Modulation of Antarctic Ice Shelf Melting

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Tides influence basal melting of individual Antarctic ice shelves, but their net impact on Antarctic-wide ice-ocean interaction has yet to be constrained. Here we quantify the impact of tides on ice shelf melting and the continental shelf seas by means of a 4 km resolution circum-Antarctic ocean model. Activating tides in the model increases the total basal mass loss by 57 Gt/yr (4 %), while decreasing continental shelf temperatures by 0.04 °C, indicating a slightly more efficient conversion of ocean heat into ice shelf melting. Regional variations can be larger, with melt rate modulations exceeding 500 % and temperatures changing by more than 0.5 °C, highlighting the importance of capturing tides for robust modelling of glacier systems and coastal oceans. Tide-induced changes around the Antarctic Peninsula have a dipolar distribution with decreased ocean temperatures and reduced melting towards the Bellingshausen Sea and warming along the continental shelf break on the Weddell Sea side. This warming extends under the Ronne Ice Shelf, which also features one of the highest increases in area-averaged basal melting (128 %) when tides are included. Further, by means of a singular spectrum analysis, we explore the processes that cause variations in melting and its drivers in the boundary layer over periods of up to one month. At most places friction velocity varies at tidal timescales (one day or faster), while thermal driving changes at slower rates (longer than one day). In some key regions under the large cold-water ice shelves, however, thermal driving varies faster than friction velocity and this can not be explained by tidal modulations in boundary layer exchange rates alone. Our results suggest that large scale ocean models aiming to predict accurate ice shelf melt rates will need to explicitly resolve tides.