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Antarctic meltwater spread pattern and its duration modulate abyssal circulation

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The abyssal ocean circulation is a key climate component that enables the ventilation of heat, carbon, and nutrients. Under global warming, the melting of the Antarctic ice sheet has the potential to contribute to the slowdown of the abyssal overturning circulation, with far-reaching implications on global climate patterns and marine ecosystems. However, the impact of Antarctic meltwater on abyssal circulation under diverse melting scenarios remains underexplored. In this study, we investigate the sensitivity of abyssal circulation to the location, rate, and duration of meltwater input using an Earth system model of intermediate complexity. The horizontal distribution of negative surface ocean density anomalies varies depending on the regions and rates of meltwater input, with the weakening of circulation being most pronounced when meltwater effectively spreads into deep convection areas. Moreover, when comparing experiments with different rates and durations of meltwater input while keeping the total amount of meltwater constant, more gradual input has a greater impact on reducing abyssal circulation. These findings highlight the critical role of both the spatial extent and temporal duration of meltwater influence over deep convection areas in shaping abyssal circulation.

Keywords: Abyssal circulation, Abyssal overturning, Antarctic Bottom Water (AABW), Antarctic meltwater, Freshwater hosing experiments