On the delay in halting ocean-driven ice-shelf melting and glacial meltwater pathways in the Amundsen Sea Embayment, Antarctica

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Ice shelves (the floating extensions of the grounded ice sheets) are in the forefront of the ice sheet-ocean interactions in Antarctica, mediating the release of ice from the land to the ocean. Unsteady ocean-driven melting of the ice shelves will not only reduce the restrains on the flow of ice sheets upstream but also structurally weaken the ice shelves by carving channels into the undersides of ice shelves, leading to a rapid discharge of ice to the ocean. This implies that the state of individual ice shelves has an ability to alter the evolution of the Antarctic Ice Sheets as a whole and therefore underpins our prediction of sea-level rise, freshening of the ocean and changing the rate of global deep-water ventilation. Many of the rapidly thinning ice shelves in Antarctia are located in the Amundsen Sea Embayment. In particular, Pine Island Glacier and its neighbour Thwaites Glacier have been highlighted as among the fastest thinning ice shelves and major drainage pathways for the West Antarctic Ice Sheet. The origin of the imbalance in these ice shelves is almost certainly due to unsteady ocean-driven melting. Here, we assess the temporal variability of the ice-ocean interactions and its connection to the pathways of glacial meltwater using an eddy-permitting ocean model, forced with two different sets of atmospheric boundary conditions (ERA-Interim and RACMO2.3) from 1991 to 2014. We show that halting the ocean-driven melting takes longer than initiating the accelerated melting, and the strength of melting determines the fate of glacial meltwater pathways to the ocean. Our findings demonstrate that the present interaction of ice-shelf melting and ocean dynamics plays a key role in shaping the future state of ice shelf and the freshwater distribution in the open ocean.