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Effect of mesh resolution on accurate grounding line definition using 2D finite element software, Elmer/ice

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Marine ice sheet dynamics plays a key role in the mechanical interaction between glaciers and the ocean. A steady-state marine ice sheet, due to the buttressing force of ice shelves, suppresses the glaciers from discharging into the ocean. Various atmospheric-oceanic-glacial mechanisms such as ice melting, buttressing, and snow accumulation lead to the instability of marine ice sheets. The unstable marine ice sheet cause thinning ice thickness and the resultant ice shelf collapse. Ice shelf collapse accelerates the rapid glaciers discharge and retreats, directly affecting sea level rise. The positive feedback loop of these processes significantly influences the ice sheets dynamics, especially the advance and retreat of the grounding line. The grounding line can be defined as a transition zone between the grounded ice sheet in bedrock and the floating ice shelf due to water buoyancy. Understanding grounding line dynamics may help us predict marine ice sheet instability and future sea level rise. It has been challenging to determine an accurate grounding line in the numerical simulation of the marine ice sheet due to mesh resolution. Here we performed two-dimensional ice flow modeling using open-source finite element software (i.e., Elmer/ice), to quantitatively evaluate the effect of diverse mesh sizes on the position of the grounding line. We tested a series of numerical models to precisely define varying the grounding line position influenced by bedrock topography, snow accumulation, and ice melting. The models with high mesh resolution required short time steps to obtain the accurate grounding line position. To consider both calculation efficiency and the accuracy of the position of the grounding line, we found adequate time steps corresponding to each mesh size ambient the grounding line. Our systematic results can provide inspiration for choosing a suitable mesh size and time step to determine a more accurate grounding line position.