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Submarine melt rates under Greenland's ice tongues

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The few remaining ice tongues (ice-shelf like extensions) of Greenland's glaciers are undergoing rapid changes with potential implications for the stability of the ice sheet. Submarine melting is recognized as a major contributor to mass loss, yet the magnitude and spatial distribution of melt are poorly known or understood. Here, we use high resolution satellite imagery to infer the magnitude and spatial variability of melt rates under Greenland's largest remaining ice tongues: Ryder Glacier, Petermann Glacier and Nioghalvfjerdsbræ (79 North Glacier). We find that submarine plus aerial melt approximately balance the ice flux from the grounded ice sheet for the first two while at Nioghalvfjerdsbræ the total melt flux exceeds the inflow of ice indicating thinning of the ice tongue. We also show that melt rates under the ice tongues vary considerably, exceeding $60\,\mathrm{m\,yr^{-1}}$ near the grounding zone and decaying rapidly downstream. Channels, likely originating from upstream subglacial channels, give rise to large melt variations across the ice tongues. Using derived melt rates, we test simplified melt parameterizations appropriate for ice sheet models and find the best agreement with those that incorporate ice tongue geometry in the form of depth and slope.