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Terminus Geometry as Main Control on Outlet Glacier Velocity

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Ice flow velocities close to the terminus of major outlet glaciers of the Greenland Ice Sheet can vary on the time scale of years to hours. Observations at Jakobshavn Isbræ show that slowing in winter and speedup in spring are related to the formation and disintegration of a floating terminus, and that removal of 400 m long parts from the terminus in big calving events leads to immediate increase of glacier flow velocity. Such flow speed variations can be explained as the reaction to changes in terminus geometry with help of a 3D full-Stokes ice flow model on a fjord topography that is typical for Greenland outlet glaciers. Starting from an initial steady state geometry, parts of an initially 7 km long floating terminus are removed. Flow velocity increases everywhere up to 4 km upstream of the grounding line, and complete removal of the floating terminus leads to a doubling of flow speed. The model results conclusively show that the observed velocity variations of outlet glaciers is dominated by the terminus geometry, even in absence of friction or pinning of the floating terminus. Since terminus geometry is mainly controlled by calving processes and melting under the floating portion, changing ocean conditions most probably have triggered the recent geometry and velocity variations of Greenland outlet glaciers.