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Modelling the evolution of Jakobshavn Isbrae between 2009 and 2017 by the application of a calving rate derived from observations

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Since the late 1990s Jakobshavn Isbrae, a major outlet glacier of the Greenland Ice Sheet, has dramatically accelerated, thinned and retreated. The causes of this retreat and acceleration have been the focus of much scientific activity. Previous studies have shown that the loss of buttressing due to retreat of the calving front is the main driver of upstream acceleration and thinning, however the controls on the timing and magnitude of the retreat remain unclear.

Ice flow velocities peaked in 2012 and 2013 in excess of 18 km yr-1, and a position of maximal retreat of the calving front was reached between 2013 and 2015. Since then, ice flow has decelerated by ∼3 km yr-1, and the calving front has readvanced from its most retreated position by ∼2 km. An estimation of the annual calving rate from 2009 to 2017 shows that the strong retreat of 2009 was the result of a very high calving rate. Meanwhile the recent readvance resulted from a ∼3 km yr-1 reduction in the calving rate between 2015 and 2016, which was closely followed by a deceleration of ice flow by a similar magnitude.

We use the BISICLES ice sheet model to simulate the evolution of Jakobshavn Isbrae over the past decade, from an initial state replicating the geometry and flow structure from early 2009. In our simulations, the glacier evolution is driven by the application of the estimated calving rate. In one branch of experiments, we apply a basal friction parameter and ice stiffening factor calculated for early 2009 while in a parallel series of experiments we apply an evolving set of these parameters calculated quarterly. The results of these experiments, which we will present, will provide insight into the extent to which the dynamical evolution of the glacier is driven by changes to calving occurring at the front, as well as the strength of the influence on the glacier evolution of environmental inputs, parameterised within the basal friction and ice stiffening factors.