Supplementary Material

Results – Buttressing number

To test which of the two buttressing quantifications gives the most physically reasonable results, and how well they compare, we first calculated them for an idealized case, the MISMIP+ Ice1r experiment. The geometry is a downward-sloping channel with the ice divide on the left side, and the ocean on the right. Under the ice shelf, there is a bedrock heightening, functioning as a pinning point for the grounding line. This setup is described in detail in Asay-Davis et al. (2016), and roughly resembles an idealized version of PIG. The Ice1r experiment is a 100-year continuation experiment with large basal melt rates close to the grounding line. We chose year 50 of the simulation as a snapshot for the buttressing calculations, to include a dynamic response. Some characteristics of this modelled ice sheet are shown in Figure 7.

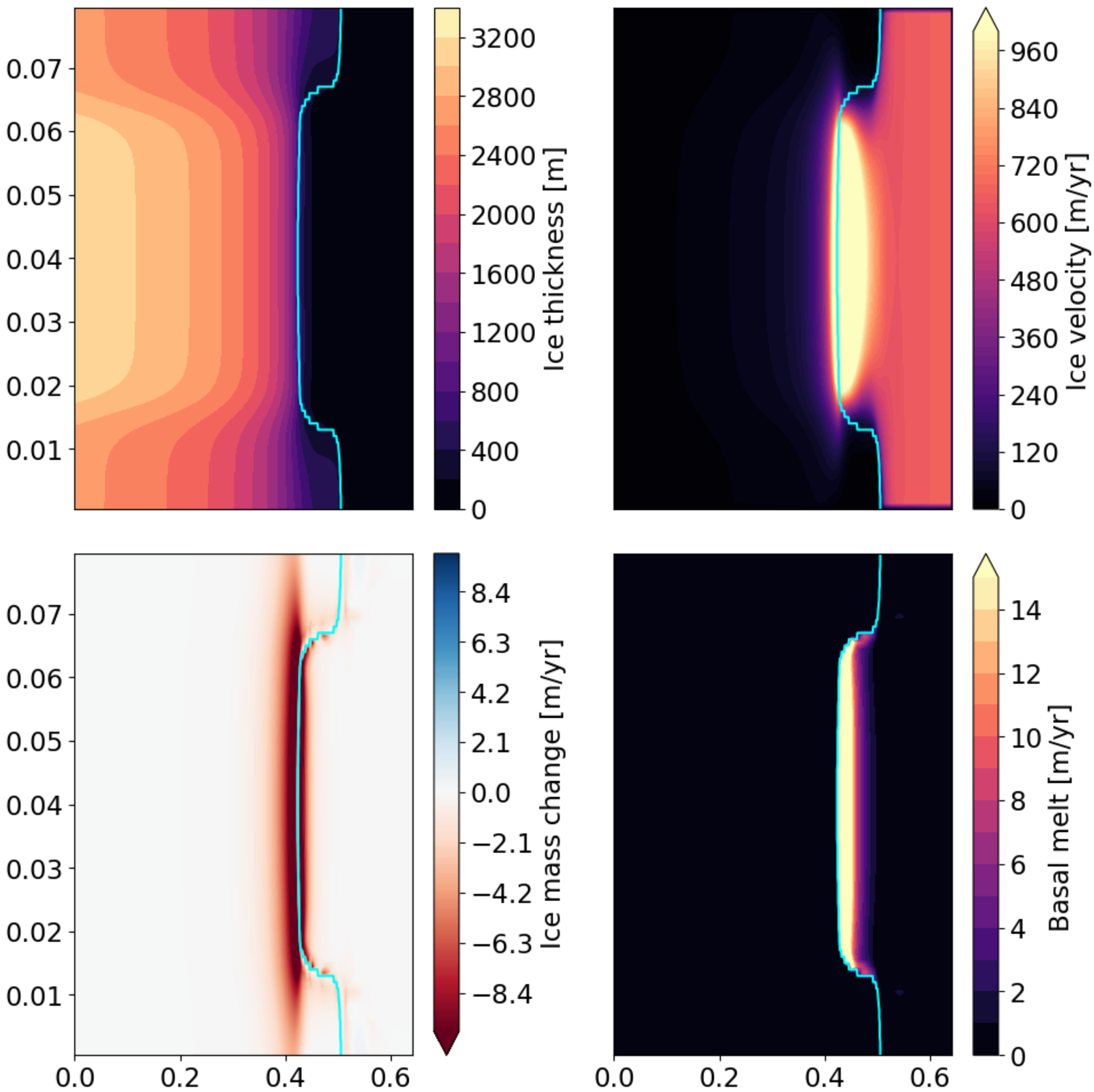

Fig S1 Characteristics of the modelled state of the MISMIP+ Ice 1r experiment after 50 years. (Top left) Modelled ice thickness, (top right) modelled ice surface velocity, (bottom left) ice mass change and (bottom right) basal melt rates. The modelled grounding line is shown in cyan.

The result after 50 years of Ice1r for the buttressing and acceleration numbers are shown in Fig. 8. A high buttressing number is found in places where the grounded ice speeds up the most when the shelf is removed, such as in the heavily buttressed center of the channel. In this idealized case, the buttressing and the acceleration number correlate well (R = 0.91). They both identify strongly buttressed ice in the center of the channel and a tensile regime at the outer margins close to the lateral domain boundaries. Since the setup and topography of the MISMIP+ experiments facilitates the formation of an ice stream with lateral margins (similar to PIG), it could be expected that the grounding line would feel the most back stress in the center of the grid. A minor discrepancy when using the buttressing number is the spatial inhomogeneity when moving towards the lateral domain boundaries: it could be expected that the buttressing smoothly decreases with distance from the center of the flow line as is the case for the acceleration number.

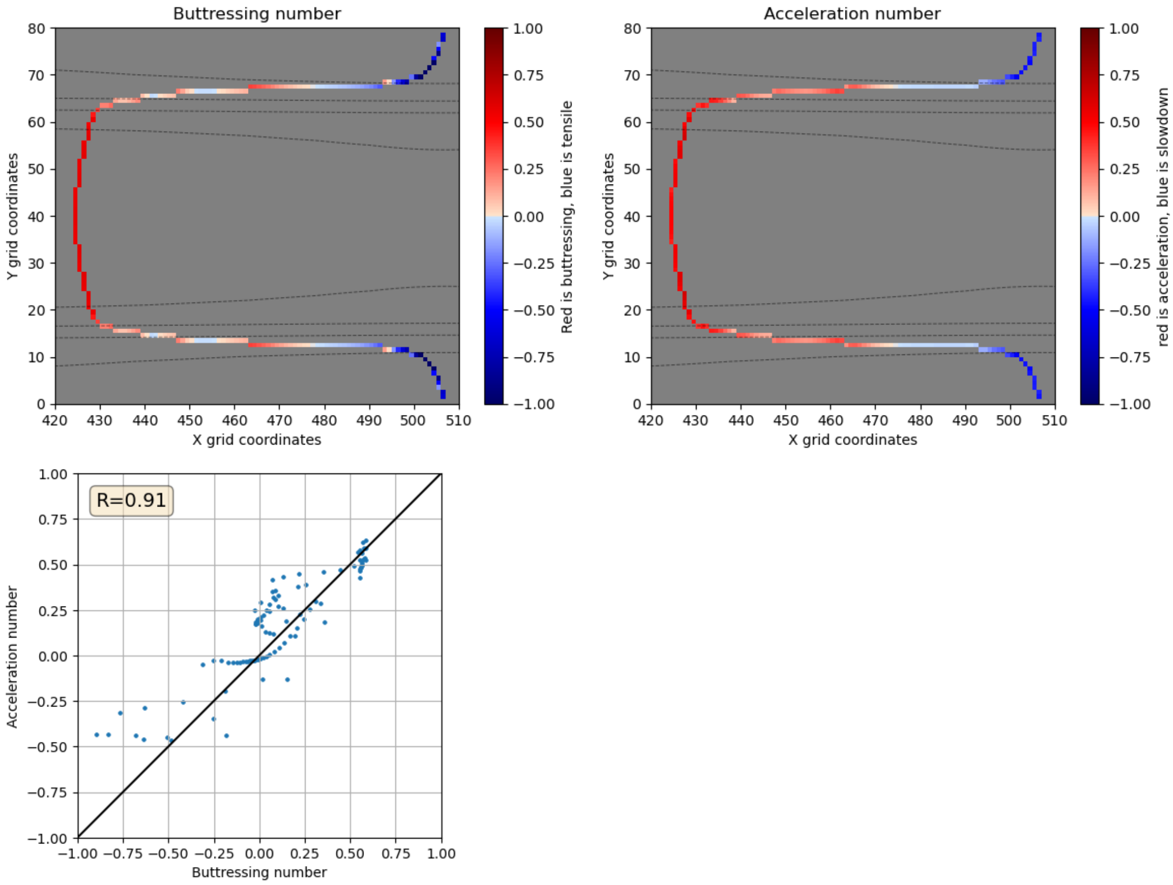

Fig S2 buttressing and acceleration numbers for the MISMIP+ Ice1r experiment. (Top row, left) the buttressing number at the grounding line after 40 years of the MISMIP+ Ice1r experiment. (Top row, right) the acceleration at the grounding line when the shelf is instantly removed. Black dashed lines represent the bedrock topography contour, from -750 meters in the centre of the plot with increments of 150 meters in the directions of the lateral margins. (Bottom row) correlation between the acceleration and buttressing number, with 208 data points.

This comparison is repeated on the whole AIS, ASE region and the Ross and Filchner-Ronne shelves. This resulted in the correlation plots shown in Figure S3. In none of these cases does the buttressing number correlate significantly with the acceleration number. Apparently, a high buttressing number calculated in a complex and realistic setting does not necessarily mean that the upstream glacier will speed up after removing all floating ice. The buttressing number can still be useful as a quantification of the stresses compared to a common benchmark, the stress boundary condition of a column of ocean water.

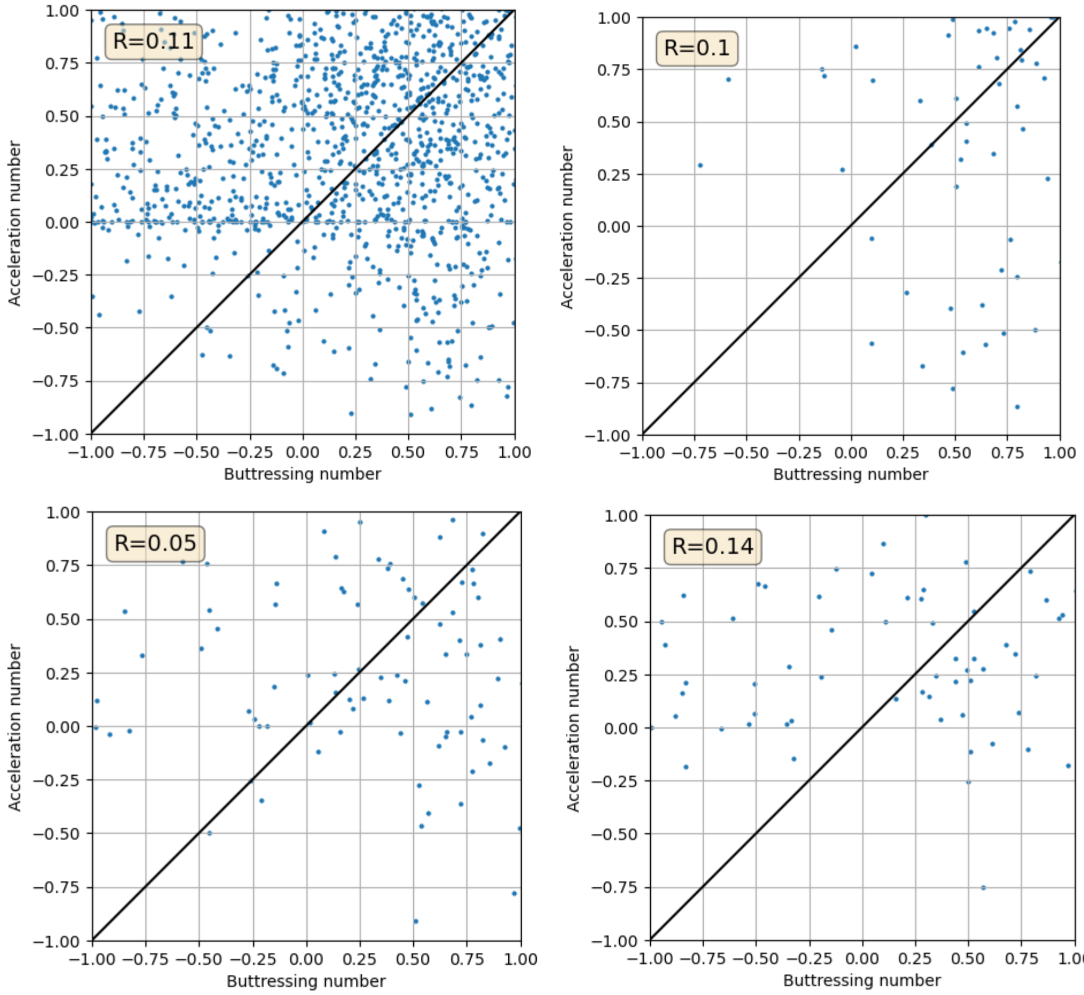

Fig S3. Acceleration number and buttressing number for (top, left) the whole Antarctic ice sheet (top, right) ASE region (bottom, left) the Ross shelf and (bottom, right) the Filchner-Ronne.