Supplementary material: The effect of melt-channel geometry on ice-shelf flow

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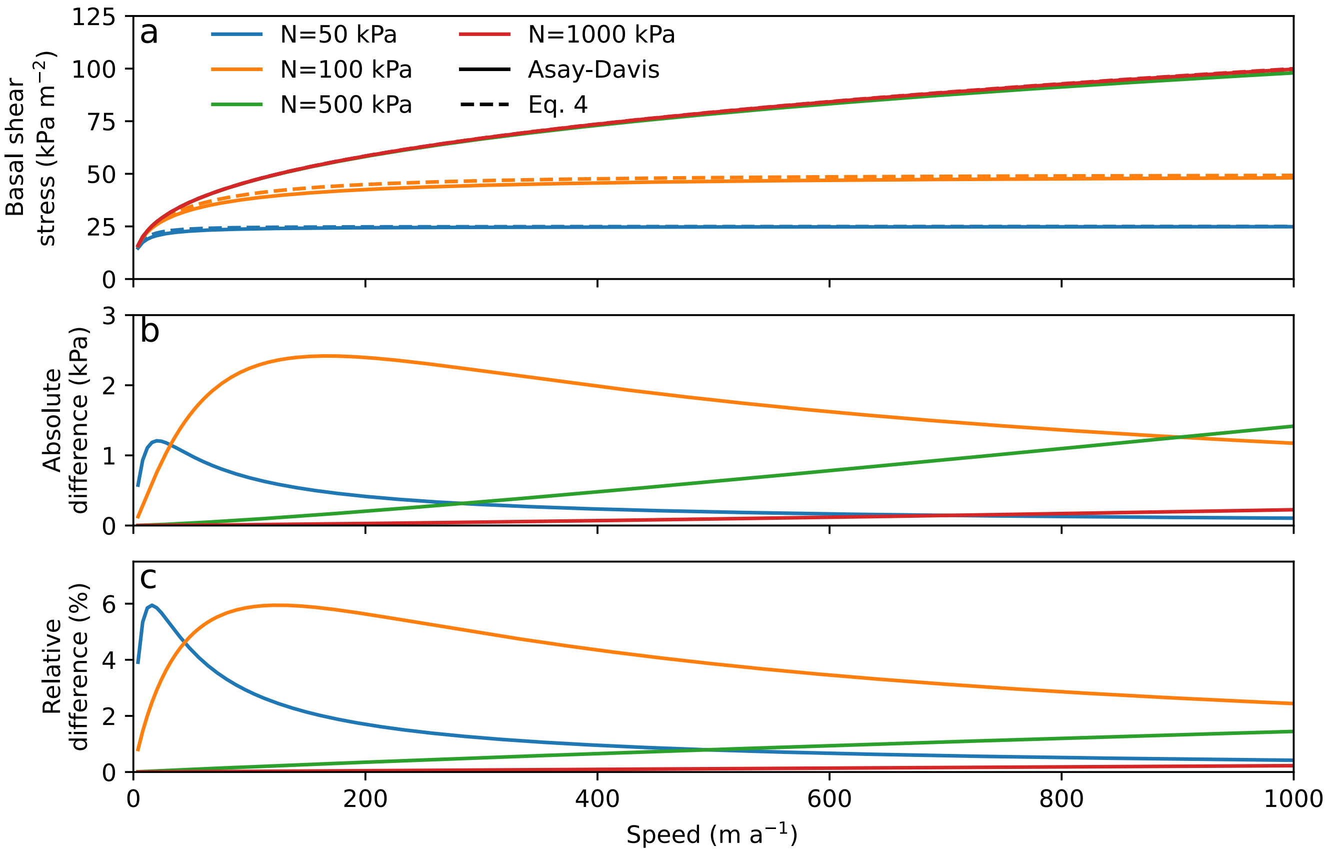

Fig. S1. Difference between regularized Coulomb sliding law used here (Joughin et al., 2024) and that recommended by Asay-Davis et al. (2016). (a) Basal shear stress as a function of flow speed for different effective pressures. Solid lines show values using the sliding law from Asay-Davis et al. (2016) while dashed line shows that used here. Color of line indicates effective pressure. (b) Absolute difference between basal shear stress with the two laws. (c) Relative difference between basal shear stress with the two sliding laws.

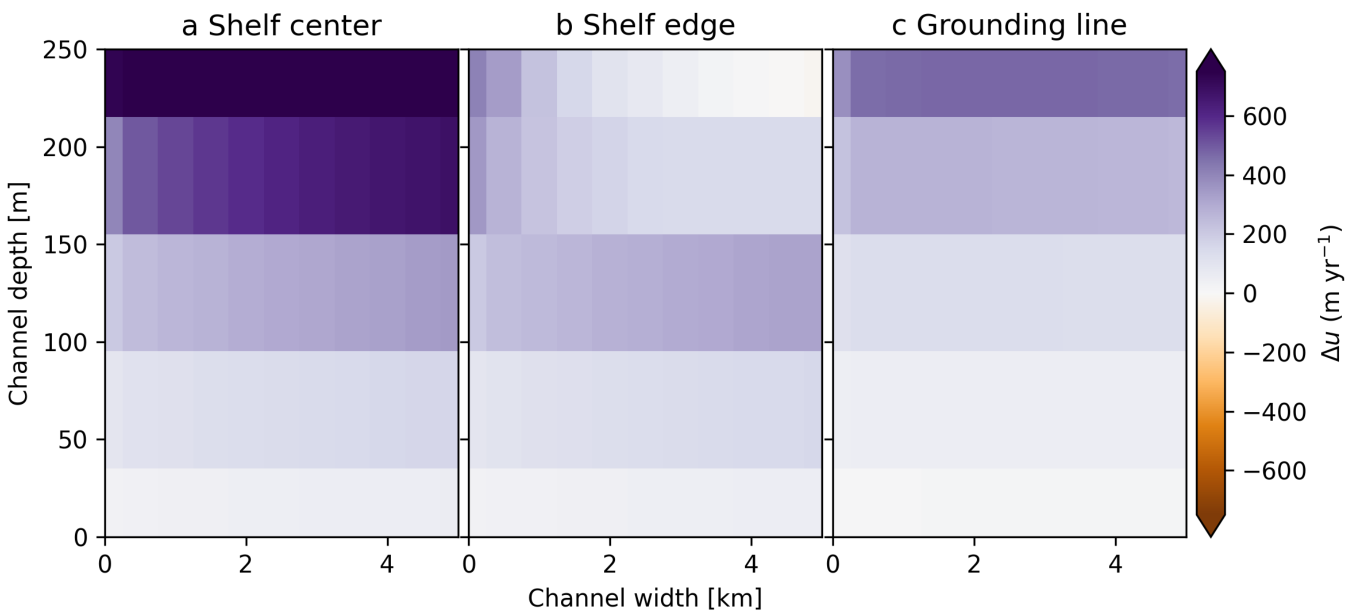

Fig. S2. Change in flow speed after channel incision at three points on shelf shown in Fig. 4 of the main text (at the circle, diamond, and square, respectively), as a function of channel width and depth. Positive numbers indicate speedup as result of channel incision. Note that the only slowdown is minor, at the shelf edge with deep, wide channels.

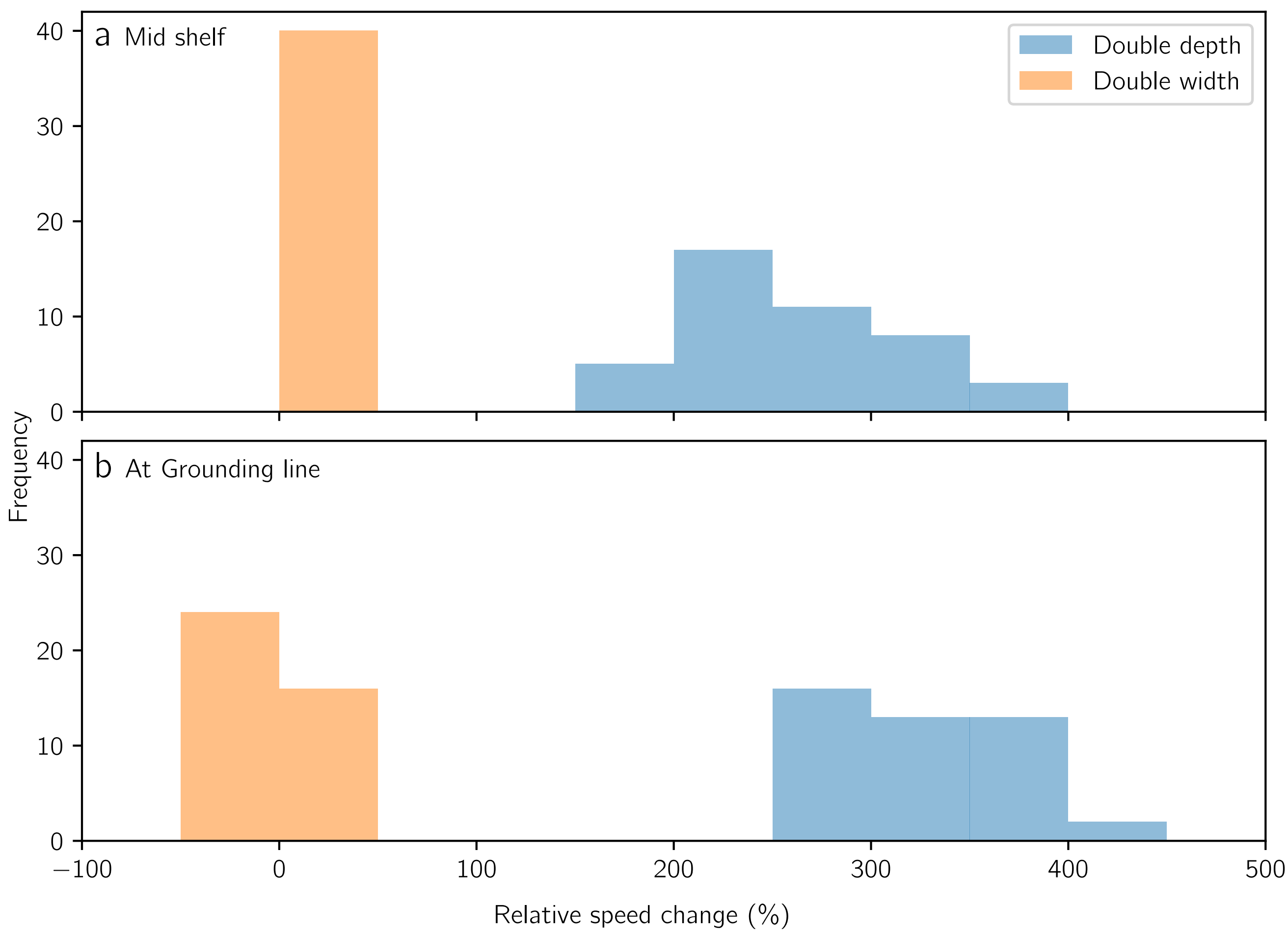

Fig. S3. Change in flow speed compared to channel width and depth. (a) Histogram of relative change in speed at the shelf center if channel width is doubled (orange) or channel depth is doubled (blue). (b) as in a, but at the grounding line.

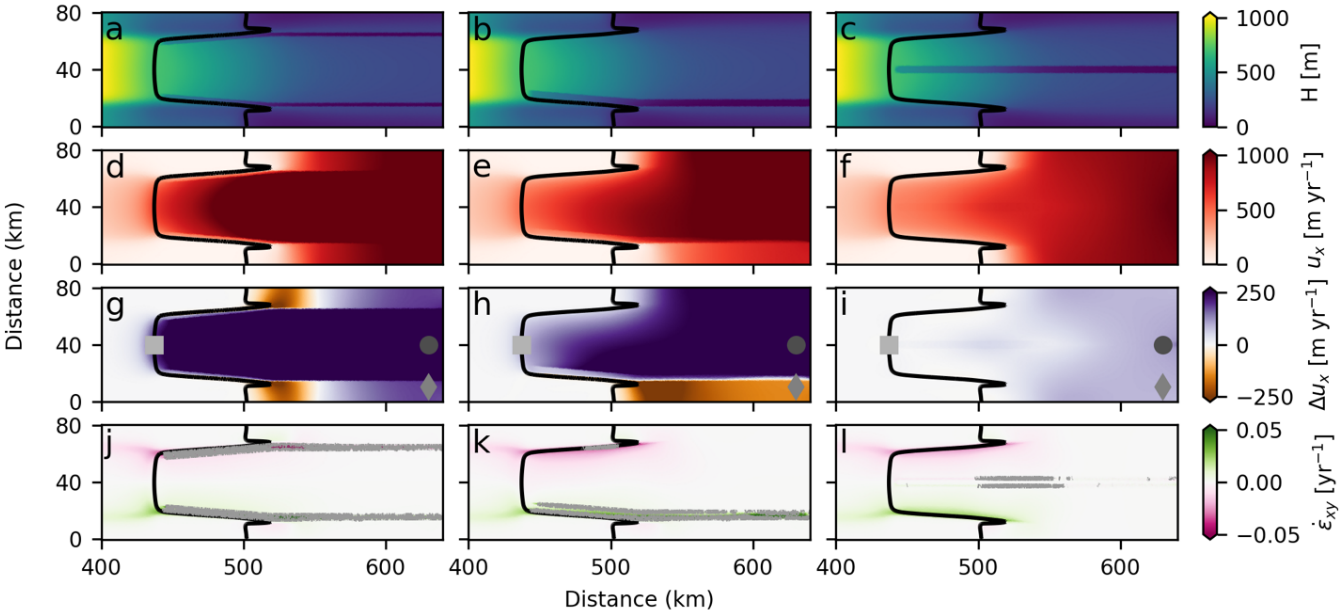

Fig. S4. Effect of single-channel incision on MISMIP+ setup. (a–c) Ice thickness with two marginal channels, one marginal channel, and one central channel, respectively. Width varies so that simulations have nearly equal incised volume (within 4%) for fair comparison. (d–f) Horizontal speeds with channels as in a–d. (g–i) Change in flow speed due to channels in a–d. Gray square and circle show grounding line and mid-shelf locations plotted in Fig. 5 of the main text. (j–l) Horizontal shear strain rate, with channels as in a–c. Gray contour shows τ_{vM}=265 kPa, a threshold for failure (Grinsted and others, 2024).

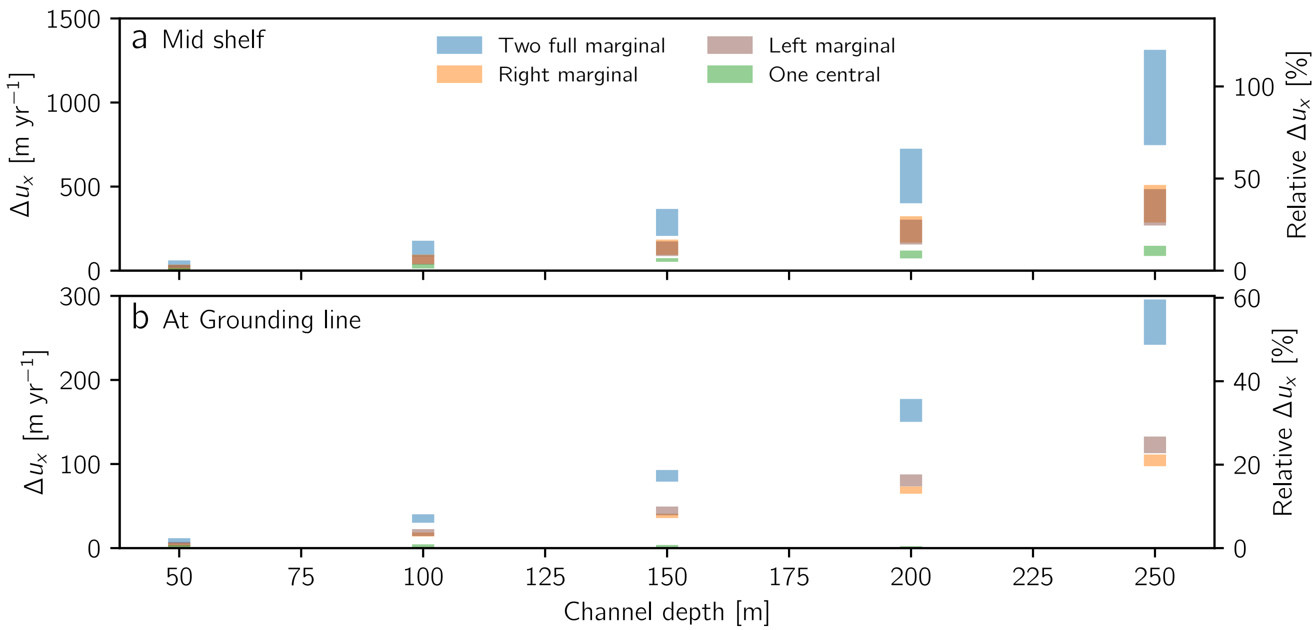

Fig S5. Change in flow speed due to channel incision (a) in the middle of the shelf near the calving front and (b) at the grounding line for the partial stream setup. Locations are shown in Fig. 7 of the main text by circle and square, respectively. Color indicates the channel number and location. Bar size encapsulates the range of speed change for various channel widths (from 500 m wide at the lowest speed change to 5 km at the largest).

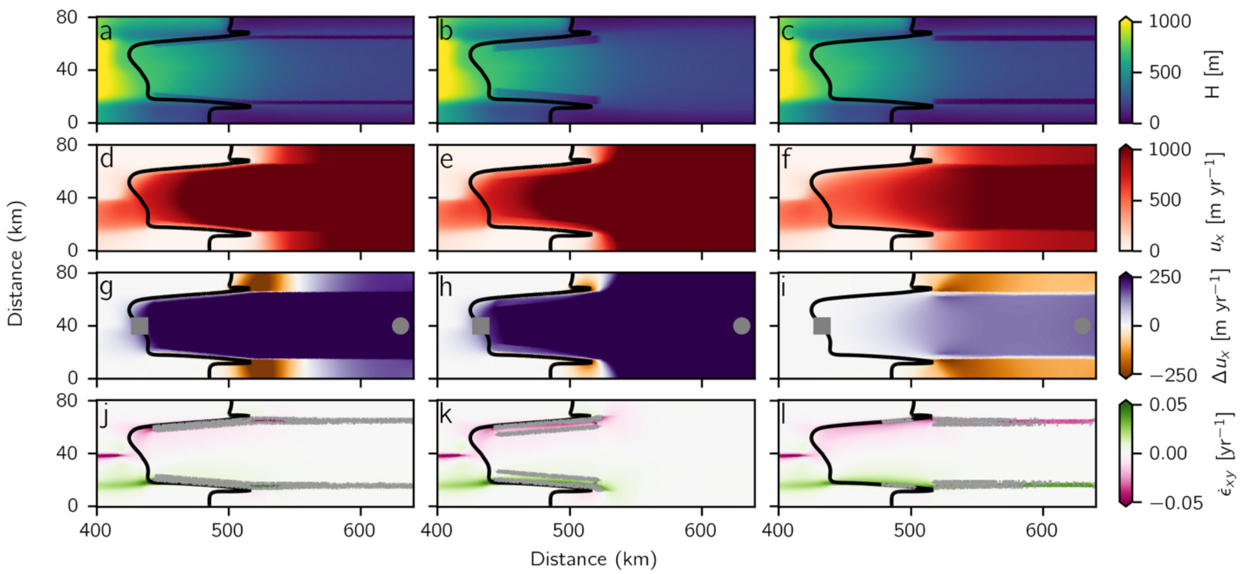

Fig. S6. Effect of channel incision of partial stream setup. (a–c) ice thickness with two full, inner, and outer marginal channels, respectively. (d–f) Horizontal speeds with channels as in a–c. (g–i) Change in flow speed due to channels in a–c. Circle and square show mid-shelf and grounding line locations plotted in Fig. S4 above. (j–l) Horizontal shear strain rate, with channels as in a–c. Gray contour shows τ_{vM}=265 kPa, a threshold for failure (Grinsted and others, 2024).

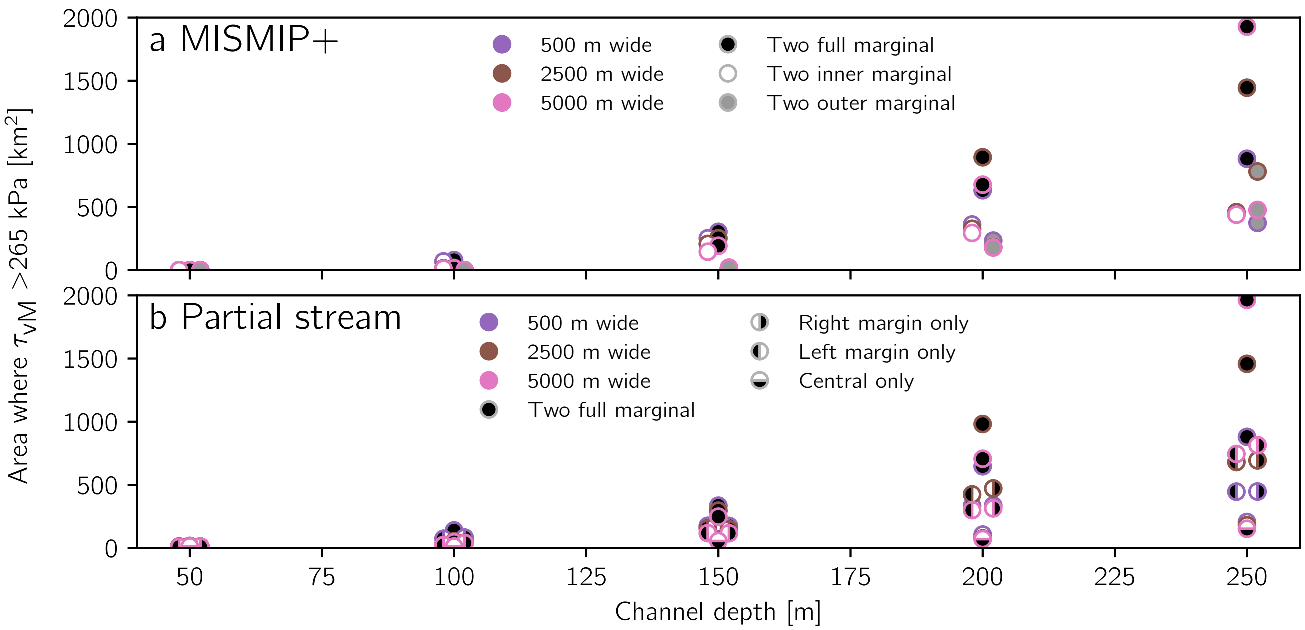

Fig. S7: As in Fig. 8 of the main text, but showing dependency on depth. Area where τ_{vM} exceeds 265 kPa for (a) MISMIP+ setup and (b) partial stream setup. Color of marker indicates channel width, with up to 2 m offset for visibility. Marker shape indicates location of channel(s).