Supplementary Information for "Velocity response of Petermann Glacier, northwest Greenland to past and future calving events"

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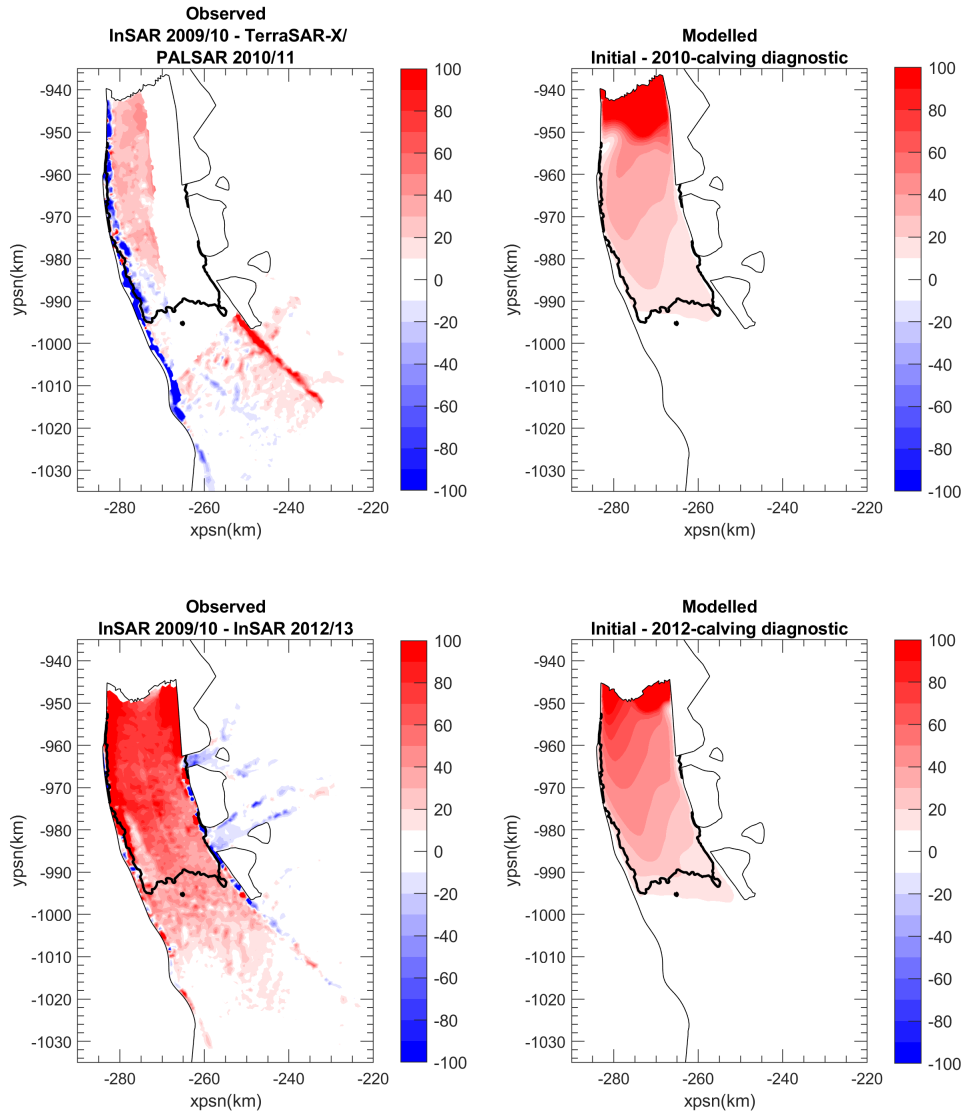
Figure S1. Spatial distribution of observed and modeled changes in flow speeds across the Petermann Glacier ice tongue after calving events in 2010 and 2012. Left two plots show the observed changes in speed between initial pre-calving observed speed (winter 2009/10, MEaSUREs Joughin et al. (2010) and observed speeds after the 2010 calving event (top) and 2012 calving event (bottom). Right hand plots show the corresponding modeled change in speed between initial modeled flow speeds and speeds after removing sections of the ice tongue in 2010 (top) and 2012 (bottom).
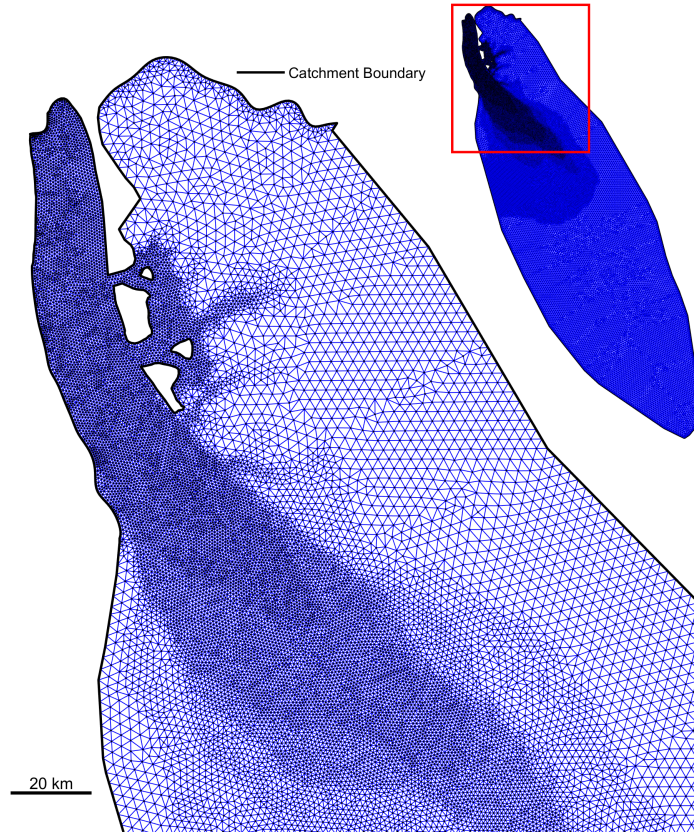
Figure S2. Finite element mesh for Petermann Glacier. The inset shows the mesh across the entire Petermann catchment and the red square highlights the areas shown in the main figure. Element sizes are smallest in the areas of fastest flow (see Figure **??**), and larger towards the slower flowing inland regions of the glacier catchment. The thick black line is the model domain.

S1. Diagnostic experiments varying the slipperiness exponent m

Úa inverts for the basal slipperiness parameter C by employing a Weertman sliding law which takes the form

$$\tau_b = C^{-1/m}|\nu_b|^{1/m-1}\nu_b \tag{1}$$

where C is the basal slipperiness, τ_b is the tangential basal traction, ν_b is the basal velocity, and m is the stress exponent.

5   The flow of fast flowing glaciers and ice streams are primarily controlled by basal motion i.e. deformation. However observational estimates of basal slipperiness (C) and the stress exponent (m) are limited, and we rely on indirect estimates, often derived from numerically inverting surface velocity measurements. In particular there is ambiguity on the most appropriate value of m. For this reason, we assessed the impact of varying the value of m on the velocity response of Petermann Glacier to two perturbations of its calving front: 1) removing the iceberg that calved in 2010, 2) removing the entire ice tongue. First, we

10   invert pre-calving observed velocities (winter 2009/10) for basal slipperiness where we varied the stress exponent (m) between 1 and 9 ($m = 1, 2, 3, 5, 7, 9$). We then input each estimate of basal slipperiness into a diagnostic forward experiment. To assess the impact of different slipperiness distributions on inland ice flow speeds, we look at the normalized change in speed across a centerline profile from the grounding line to 40 km inland for each value of m and for both 2010 calving and entire ice tongue loss (left and middle panels of Figure S3). In both cases, velocity increases are greatest at the grounding line and decrease with

15   distance inland. The final panel shows the percentage change in speeds at the grounding line relative to initial flow speeds for both experiments. Importantly the impact of removing the entire ice tongue is distinctly different to removing the 2010 iceberg. Therefor we can conclude that varying the value of m does not impact the results of our diagnostic experiments.
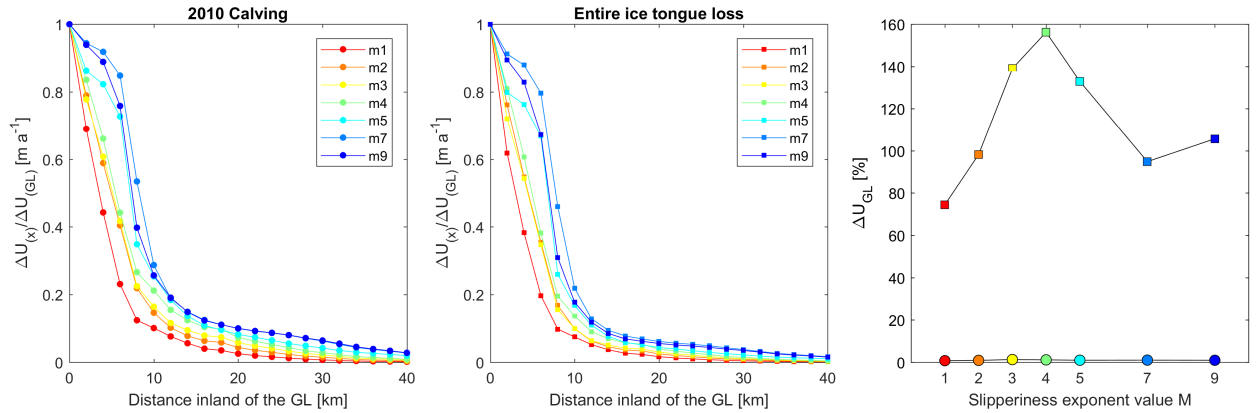
Figure S3. Left two panels show normalized increase in speed along the Petermann Glacier centerline from the grounding line to 40 km inland where $\Delta U_{(x)}$ is the change in velocity at each point along the transect and $\Delta U_{(GL)}$ is the change in speed at the grounding line. Each colored line is a different value of m. The final panel shows the percentage change in speed at the grounding line $\Delta U_{(GL)}$ for each slipperiness exponent value of m. Circles show percentage change after the 2010 calving event and squares after removing the entire ice tongue

References

Joughin, I., Smith, B. E., Howat, I. M., Scambos, T., and Moon, T.: Greenland flow variability from ice-sheet-wide velocity mapping, Journal of Glaciology, 56, 415–430, https://doi.org/10.3189/002214310792447734, 2010.