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Basal friction of Fleming Glacier, Antarctica – Part 2: Evolution from 2008 to 2015

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Supplementary Materials

S1. Sensitivity to velocity changes

Figure S1 shows the results from the inversion for basal shear stress in 2008 (Fig. S1a), 2015 (Fig. S1b), and from another additional inversion with the geometry from 2008 but using surface velocity from 2015 (Fig. S1c). The basal shear stress of this hybrid simulation shows patterns and magnitudes between those of the standard 2008 and 2015 simulations. This suggests that changes in both ice geometry and velocities have comparable impact on the inferred basal shear stress distribution, with the implication that an inversion study based on a change in either velocity or geometry alone would underestimate the change in basal drag.

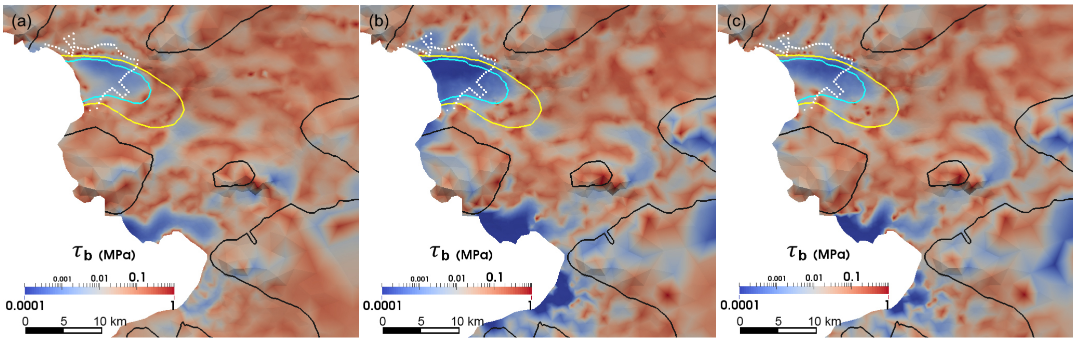

Figure S1. Basal shear stress, τ_b, for (a) 2008, (b) 2015, and (c) a simulation using topography from 2008 and velocity from 2015. The white dotted line represents the grounding line in 2014 estimated by Friedl et al. (2018). The black, yellow and cyan solid lines represent the 2008 surface speed contours of 100 m yr^{-1}, 1000 m yr^{-1}, and 1500 m yr^{-1}, respectively.

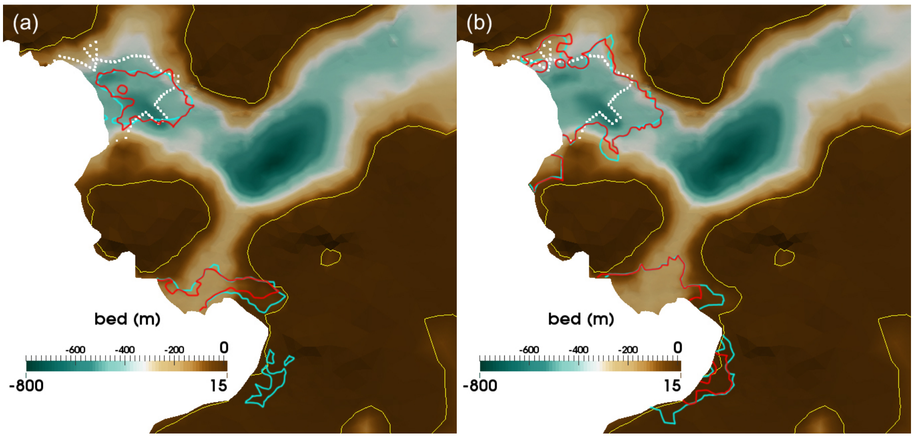

Figure S2. The boundaries of area with τ_b<0.01 MPa (blue lines) and RBD < 0.1 (red lines) in (a) 2008 and (b) 2015. The background image is the bed elevation data in this study. The white dotted line represents the deduced grounding line in 2014 from Friedl et al. (2018). The yellow contour is the sea level of 15 m.

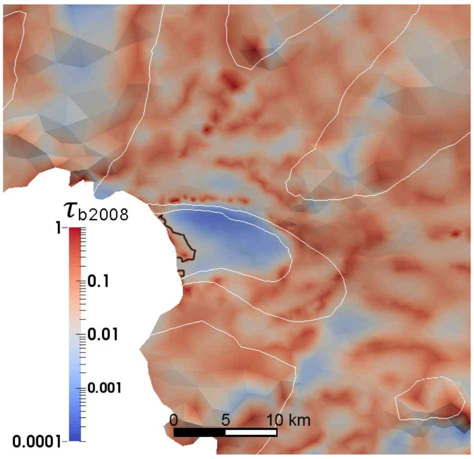

Figure S3. The basal shear stress of the fast flowing region of the Fleming Glacier in 2008. The black solid line represents the boundary of area with τ_b>0.01 MPa and surface speed higher than 1500 m yr^{-1}. The white solid lines represent the 2008 surface speed contours of 100 m yr^{-1}, 1000 m yr^{-1}, and 1500 m yr^{-1}, respectively.

S2. Basal meltwater calculation

The basal meltwater rate, m_b, is calculated for 2008 and 2015 with equation:

$$m_b = \frac{-Q_r}{LS\rho_{pw}} \quad \text{(S1)}$$

where Q_r is the residual of the heat transfer equation at each basal node, which represents the amount of energy extraction per node per year given that node temperature is at pressure melting point, L is the latent heat of fusion of ice (~33400 J kg^{-1}), S is the area of each mesh element, and ρ_{pw} is the pure water density (1000 kg m^{-3}). The basal friction heating provides the dominant heat source, being orders of magnitude higher than geothermal heating or diffusion through the ice for the fast flowing regions.

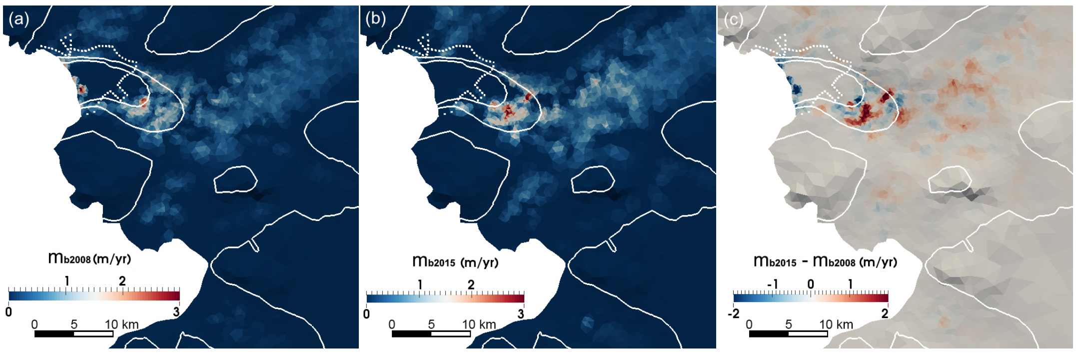

Figure S4. The simulated basal melt water (metres per year) in (a) 2008 and (b) 2015, respectively. (c) The difference of basal melt water between 2008 and 2015 (2015 minus 2008). The white dotted line represents the grounding line in 2014 estimated by Friedl et al. (2018). The white solid lines represent the 2008 surface speed contours of 100 m yr^{-1}, 1000 m yr^{-1}, and 1500 m yr^{-1}, respectively.

References

Friedl, P., Seehaus, T. C., Wendt, A., Braun, M. H., and Höppner, K.: Recent dynamic changes on Fleming Glacier after the disintegration of Wordie Ice Shelf, Antarctic Peninsula, The Cryosphere Discuss., 2017, 1-26, 2018.