Supplementary Information for: Stratified suppression of turbulence in an ice shelf basal melt parameterisation

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S1 Tidal Velocities

Fig. S1 shows the velocity variation at the ice-ocean interface in the explicit tide experiments.

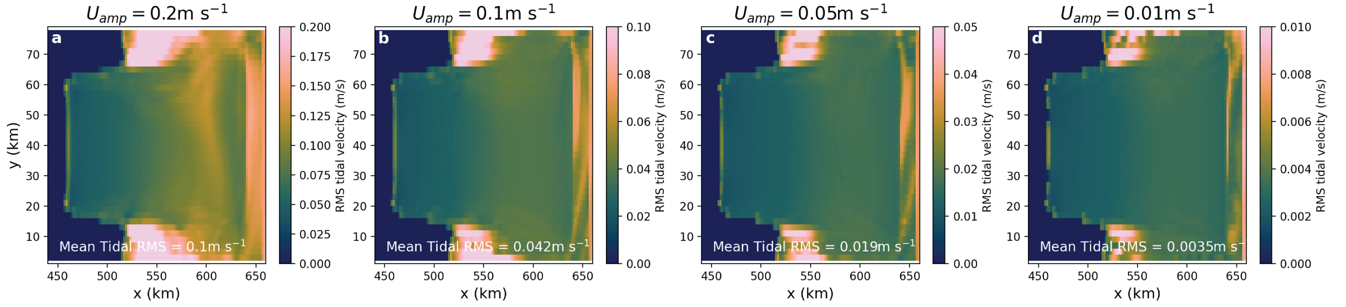

Figure S1. RMS tidal velocity at the ice-ocean boundary, computed as $\sqrt{(u-\overline{u})^2+(v-\overline{v})^2}$ from hourly averaged velocities in the last 180 days of the experiment (u, v), where the overline indicates an average over the 30 days. This was computed for each of the ConstCoeff warm tidal MOM6 experiments with prescribed boundary amplitudes of (a) $0.2\,\mathrm{m\,s^{-1}}$, (b) $0.1\,\mathrm{m\,s^{-1}}$, (c) $0.05\,\mathrm{m\,s^{-1}}$, and (d) $0.01\,\mathrm{m\,s^{-1}}$. Values averaged over the ice shelf cavity are listed in each panel.

S2 Pine Island Glacier Simulation Additional Figures

Fig. S2 shows the melt rates (as in Fig. 9a) of the Pine Island Glacier experiment when drag coefficient tuning is not performed. Fig. S2a therefore matches the Nakayama et al. (2021) control simulation.

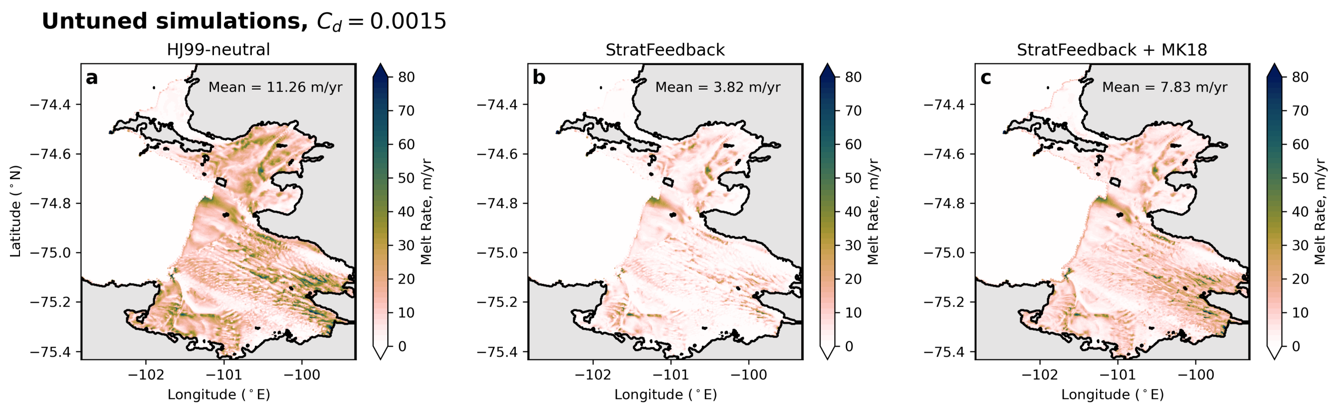

Figure S2. Melt rates averaged over days 20-50 of the untuned Pine Island Glacier simulations with $C_d = 0.0015$ for a) HJ99-neutral, b) StratFeedback and c) StratFeedback+MK18. Values of the melt rates averaged over the ice shelf are printed.

Below, we present further supplementary figures of the Pine Island Glacier simulation and compare the hydrography and ocean circulation between experiments with different melt parameterisations. We focus on the Tuned HJ99-neutral, Tuned StratFeedback and Tuned StratFeedback+MK18 experiments since they have similar mean melt rates; anomalies between untuned simulations are larger and can mostly be explained by large changes in melt rate.

Fig S3a demonstrates the large thermal driving present at Pine Island Glacier, as well as a significant difference in surface water properties between the ice shelf cavity and open ocean (Fig S3b-d). With the Tuned StratFeedback parameterisation, the ice shelf boundary layer generally warms and becomes more saline, though there is spatial variability. The AB transect along the cavity shows regions of the ice shelf with both cooler and warmer boundary layers, with changes in the open ocean also visible (Fig. S4c,f). The CD transect across the cavity also shows spatial variability in water properties (Fig. S5c,f), with warming and salinification near the sides of the cavity where flows beneath the ice shelf are generally weaker (e.g. friction velocity in Fig. 9d) and melt rates are reduced (Fig. 10b) compared to the HJ99-neutral simulation. There are minor differences in the east-southeastern velocity (which approximates the across-CD velocity) compared to HJ99-neutral (Fig. S5i). Changes with the Tuned StratFeedback+MK18 simulation are similar, though there is a large warm and salty anomaly in the AB transect subsurface open-ocean (Fig. S4c,f) and cooling and freshening at the south-east boundary of the CD transect (Fig. S5c,f), possibly associated with increased meltwater from the grounding line (Fig. 9c).

Nakayama et al. (2019) compared a similar MITgcm model (same resolution but larger domain) to *in situ* observations along a path similar to our AB transect, finding the simulated Circumpolar Deep Water to be ∼0.3°C warmer than observations and

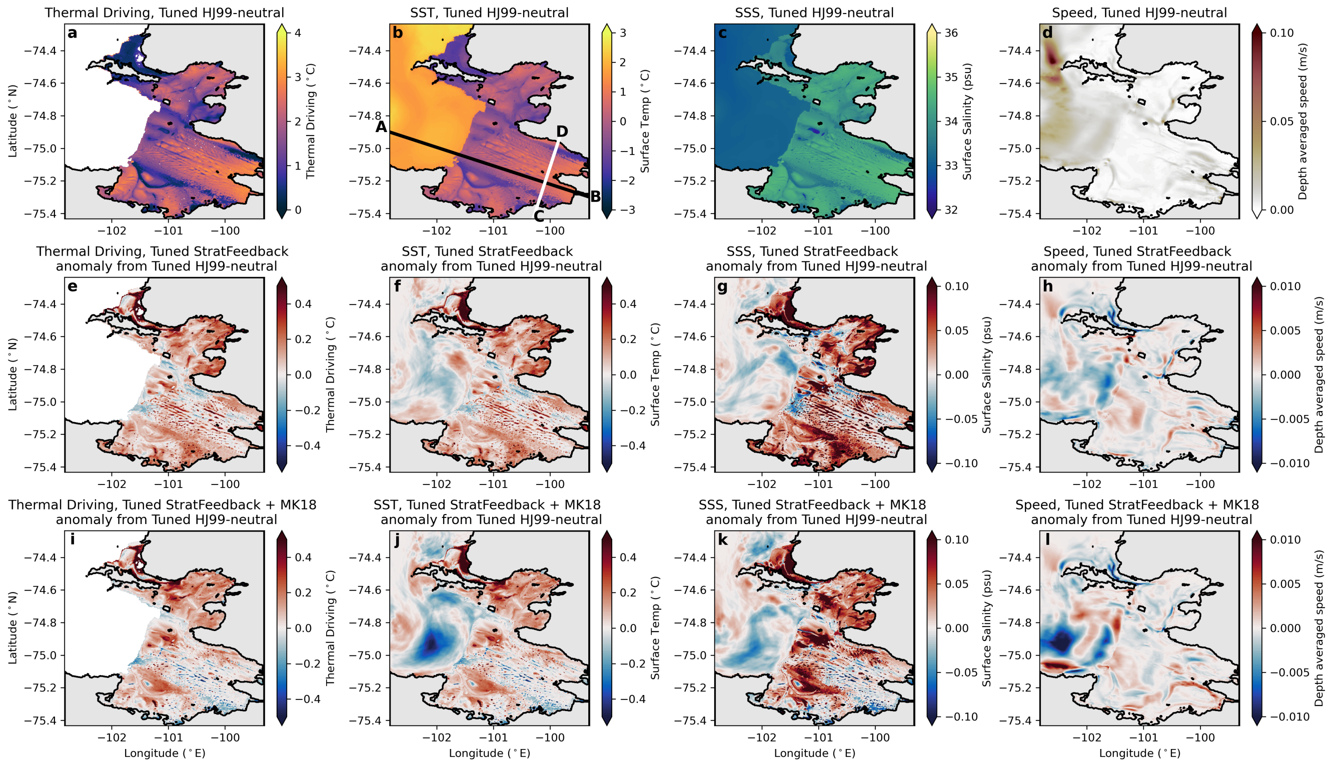

Figure S3. Pine Island Glacier model hydrography, showing results averaged over days 20-50 for the Tuned HJ99-neutral simulation (top) and average anomaly of the Tuned StratFeedback compared to the Tuned HJ99-neutral (middle) and Tuned StratFeedback+MK18 anomaly (bottom). The first column shows the thermal driving T^*, second the sea surface temperature (using the uppermost cell in the cavity), third the sea surface salinity, and fourth the vertically averaged speed. The black and white lines in panel b are used for Figs. S4 and S5 respectively.

the thermocline depth ∼100m shallower than observations. Neither metric appears to have significantly improved with the tuned StratFeedback parameterisation (Fig. S4).

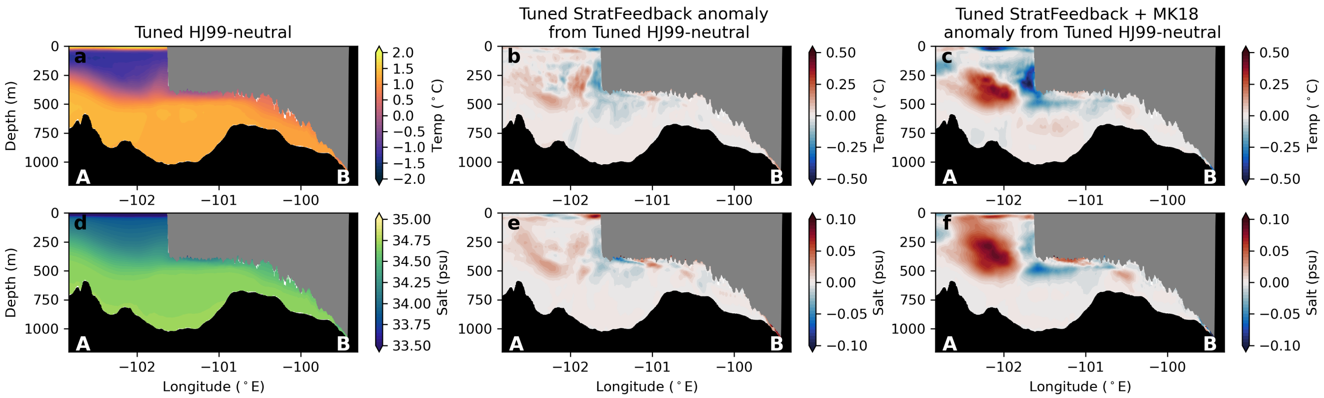

Figure S4. Transect along the black AB line of Fig. S3b, averaged over days 20-50 of the simulation. The left column shows the mean for the Tuned HJ99-neutral simulation, and the second and third columns show the anomalies for the Tuned StratFeedback parameterisation and Tuned StratFeedback+MK18 parameterisation. Panels a-c show temperature and d-f salinity.

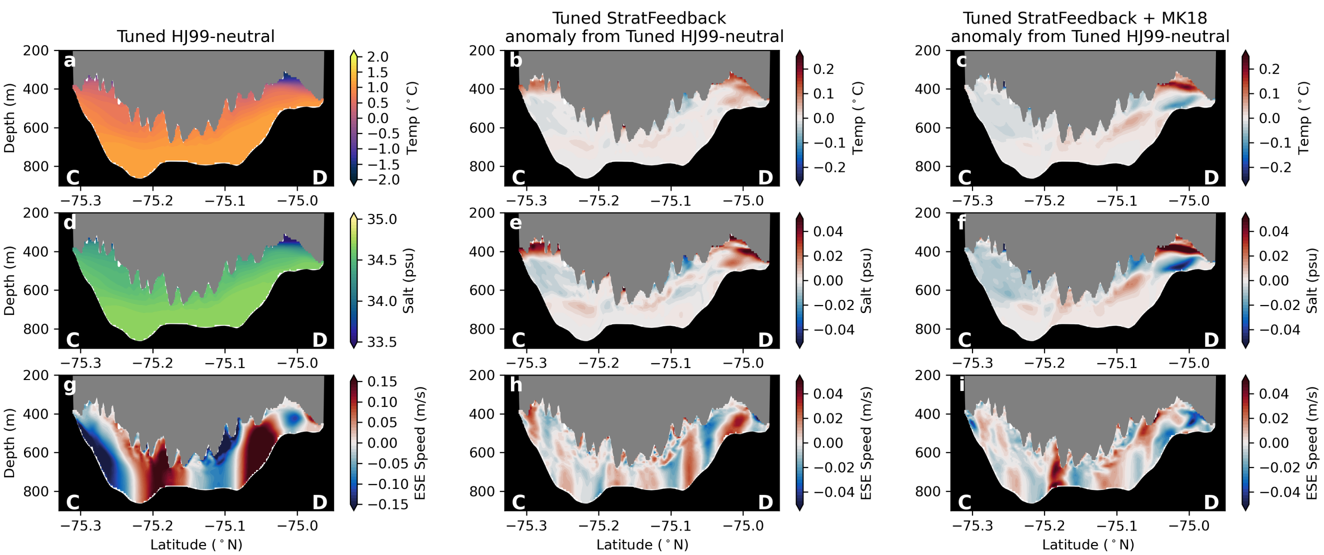

Figure S5. Transect along the white CD line of Fig. S3b, averaged over days 20-50 of the simulation. The left column shows the mean for the Tuned HJ99-neutral simulation, and the second and third columns show the anomalies for the Tuned StratFeedback parameterisation and Tuned StratFeedback+MK18 parameterisation. Panels a-c show temperature, d-f salinity and g-i east-southeastern velocity (as in Nakayama et al., 2021)

References

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