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Sensitivity of ice loss to uncertainty in flow law parameters in an idealized one-dimensional geometry

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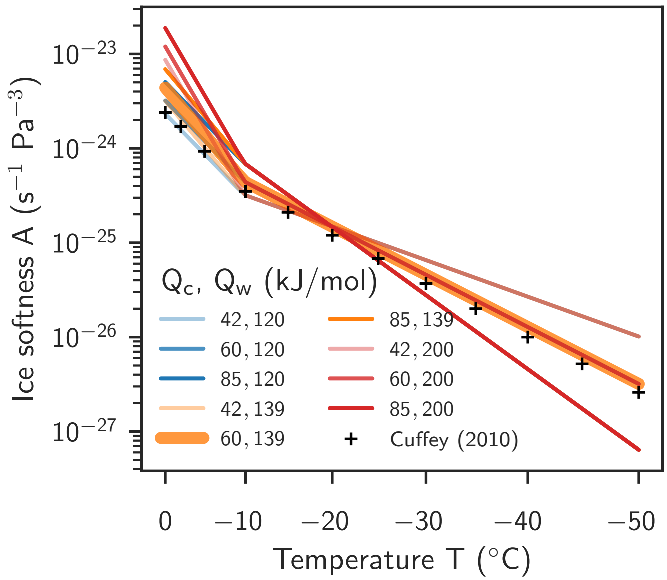

Figure S1. Effect of activation energy parameters on the temperature dependence of the softness A. The temperature dependence of the ice softness A is usually shown in an *Arrhenius plot*, where the softness is shown on a semi-log scale over the inverse temperature. Two parameters for the activation energy Q_c and Q_w for $T \leq -10\,^\circ\mathrm{C}$ and $T > -10\,^\circ\mathrm{C}$ parametrize the relationship of ice softness to pressure adjusted temperature. Here the softness is fixed at a reference temperature of $T = -20\,^\circ\mathrm{C}$. The softness at cold temperatures depends only on the choice of Q_c. Softness at pressure melting point is most sensitive for variations in the Q_w, but varies slightly with Q_c. At pressure melting point the softness increases 8-fold between the limits of parameter combinations, from -47% to + 335% compared to standard parameters. For comparison we show the textbook values of the softness for different temperatures (black crosses) (Cuffey and Paterson, 2010).

References

Cuffey, K. M. and Paterson, W. S. B.: The Physics of glaciers, Elsevier Inc., 4 edn., http://linkinghub.elsevier.com/retrieve/pii/0016718571900868, 2010.

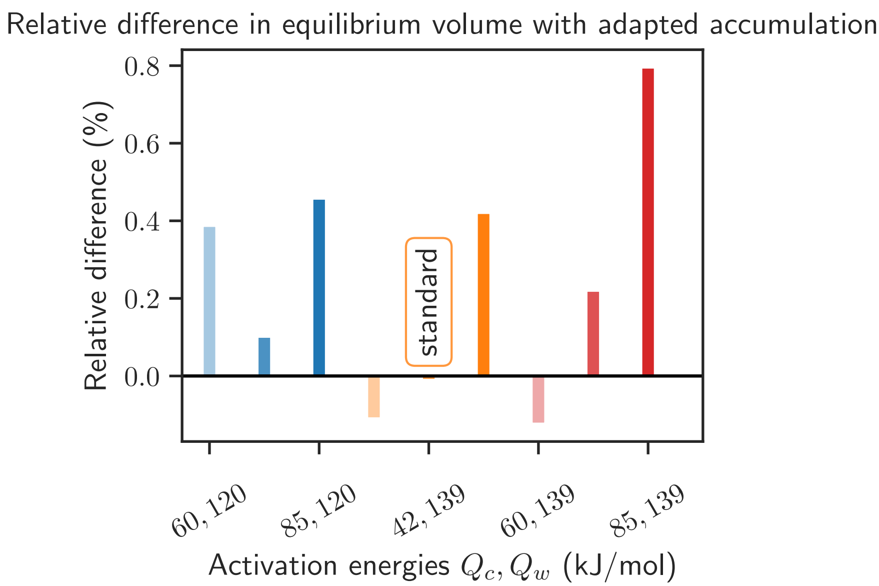

Figure S2. Relative difference in equilibirium volume with adapted accumulation rates compared to the equilibrium state of the simulation with standard parameters and an accumulation rate $a = 0.5\,\mathrm{m/yr}$.

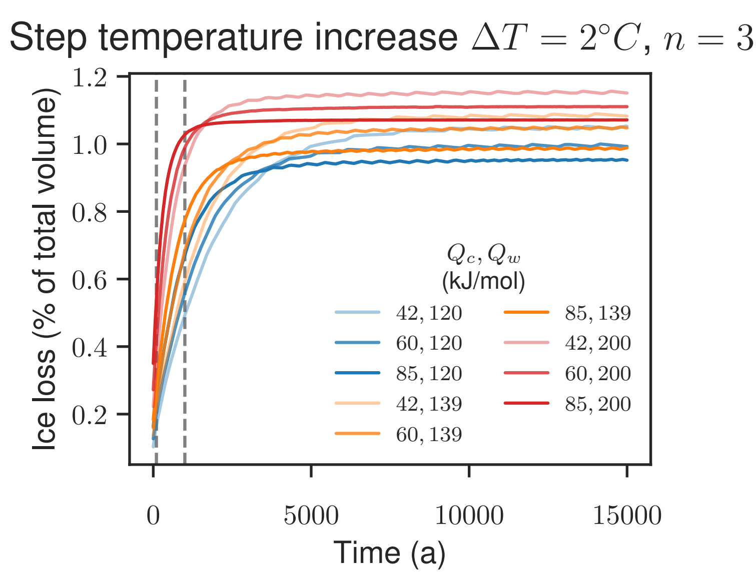

Figure S3. Effect of activation energy and flow exponent on flow-driven ice discharge : Ice loss in a conceptual flowline setup subject to a temperature anomaly forcing of $\Delta T = 2°\mathrm{C}$ and $n = 3$ in percent of the initial volume.

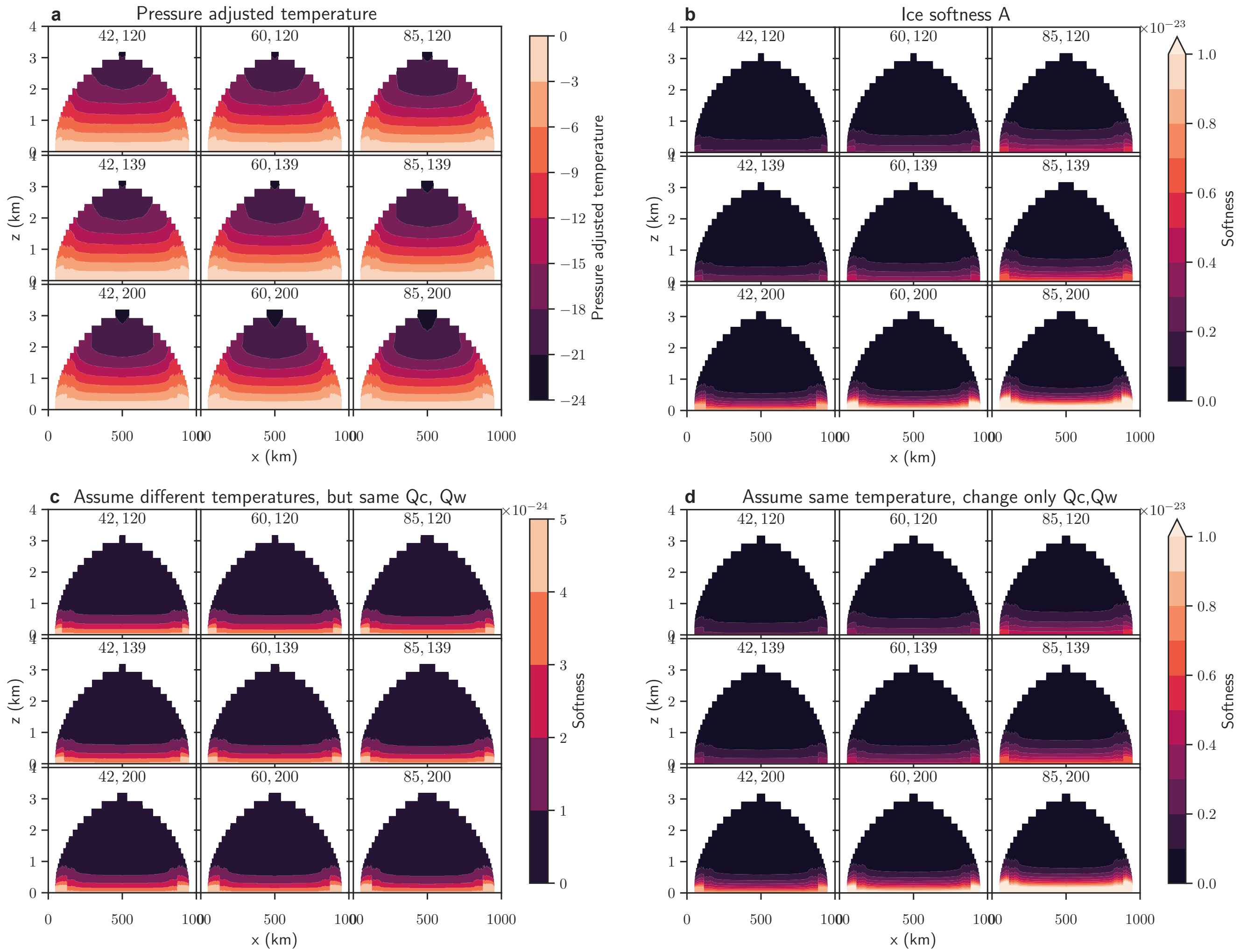

Figure S4. Effect of differences in temperature and different activation energies on ice softness in equilibrium: (a) Pressure adjusted temperature of the ice sheet in the equilibrium state for different combinations of activation energies $Q_{\mathrm{c}}, Q_{\mathrm{w}}$ (see title of each tile) with a flow exponent $n = 3$. Note that the accumulation rates are adjusted to keep the equilibrium volume fixed, with decreased accumulation rates for low activation energies and increased accumulation rates for high accumulation energies. The increase in accumulation leads to cooler temperatures at the top of the ice sheet. **(b)** Ice softness A in equilibrium for different combinations of activation energies Q_{c} and Q_{w}. A clear increase in softness, in particular at the base of the ice sheet is observed for high activation Q_{c} and Q_{w}. **(c)** Ice softness calculated from the pressure adjusted temperatures shown in **(a)** but fixing Q_{w} and Q_{c} at the reference values. The changes in temperature distribution alone are not sufficient to reproduce the softness shown in panel **(b)**. **(d)** Ice softness calculated from a fixed pressure adjusted ice temperature and different Q_{c} and Q_{w} parameters. The change in activation energies alone can reproduce the softness shown in panel **(b)**. Here we show equilibrium values without a warming anomaly. A very similar behavior is observed for the equilibrium states with increased temperatures.