Supplementary Material to the paper 'A fast and unified subglacial hydrological model applied to Thwaites Glacier, Antarctica'

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February 2024

Supplementary 1 : Initial conditions of Thwaites Glacier

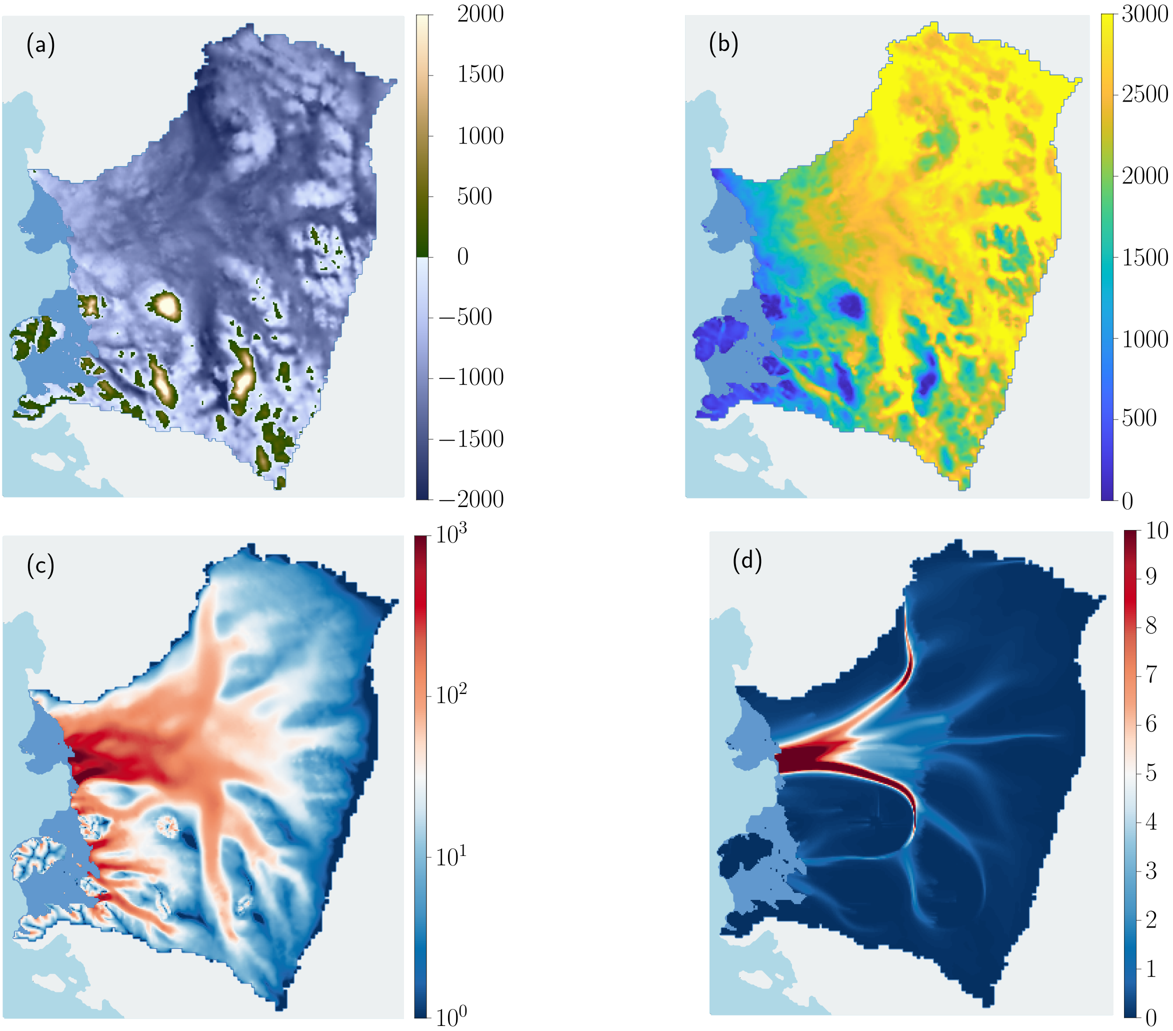


Figure S1: (a) Thwaites Glacier bedrock elevation (m), (b) ice thickness (m), (c) observed surface velocity (logarithmic scale, $\mathrm{m\,a^{-1}}$), and (d) subglacial water flux ($10^4\ \mathrm{m^2\,a^{-1}}$). The bedrock elevation and ice thickness come from Morlighem et al. (2020); Morlighem (2022), while the surface velocity and subglacial water flux are computed with the Kori-ULB model. Ice shelves are in blue, the Amundsen Sea in light blue, and grounded ice outside of Thwaites Glacier is in light grey.

Supplementary 2 : Friction coefficients after model initialization

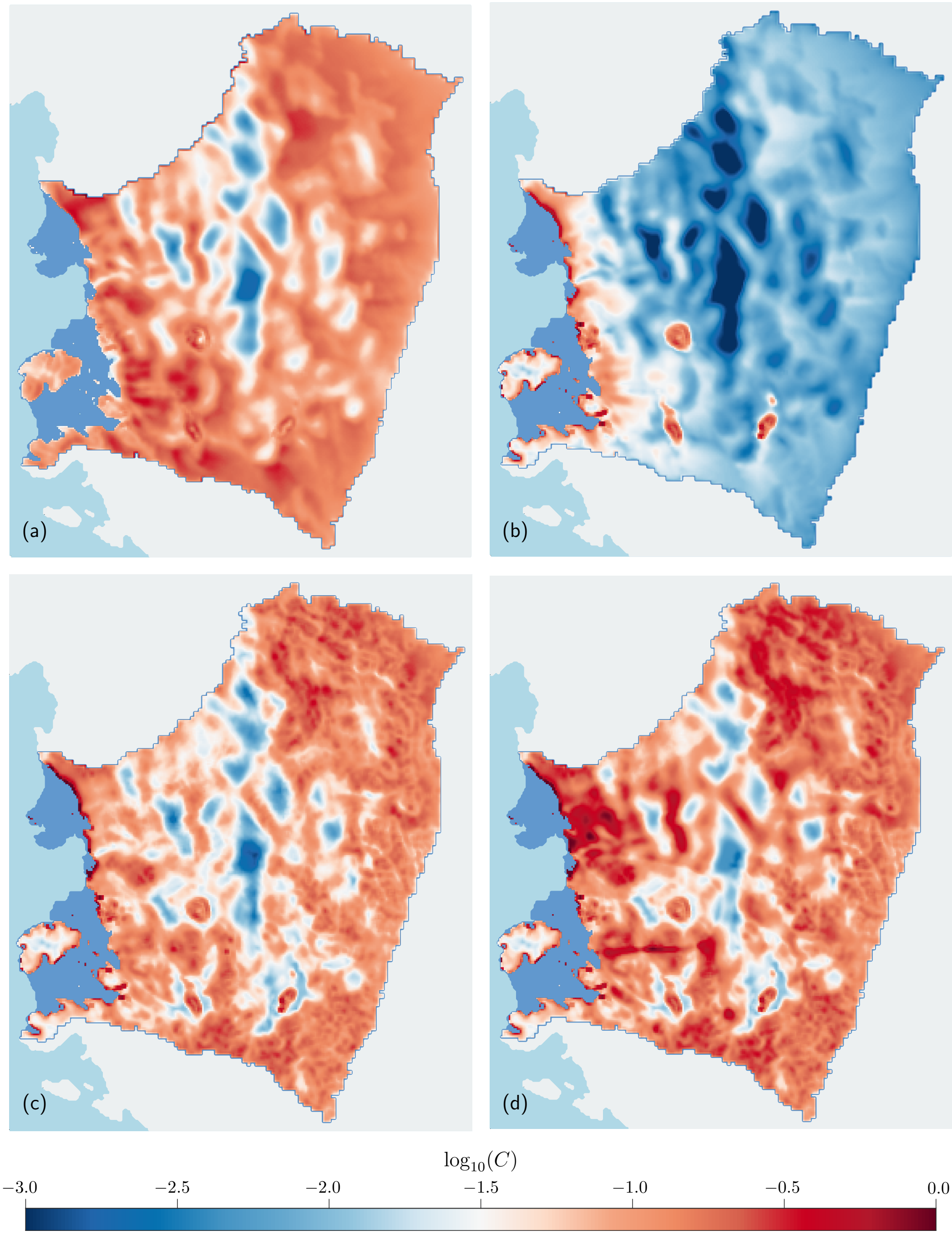


Figure S2: Friction coefficient C for (a) NON, (b) HAB, (c) HARD and (d) SOFT hydrological models, obtained after model initialization. Note that a logarithmic scale is used. For NON, N is set to 1 MPa to keep C dimensionless and comparable to the other friction fields.

Supplementary 3 : Effective pressure fields for HAB, HARD and SOFT models.

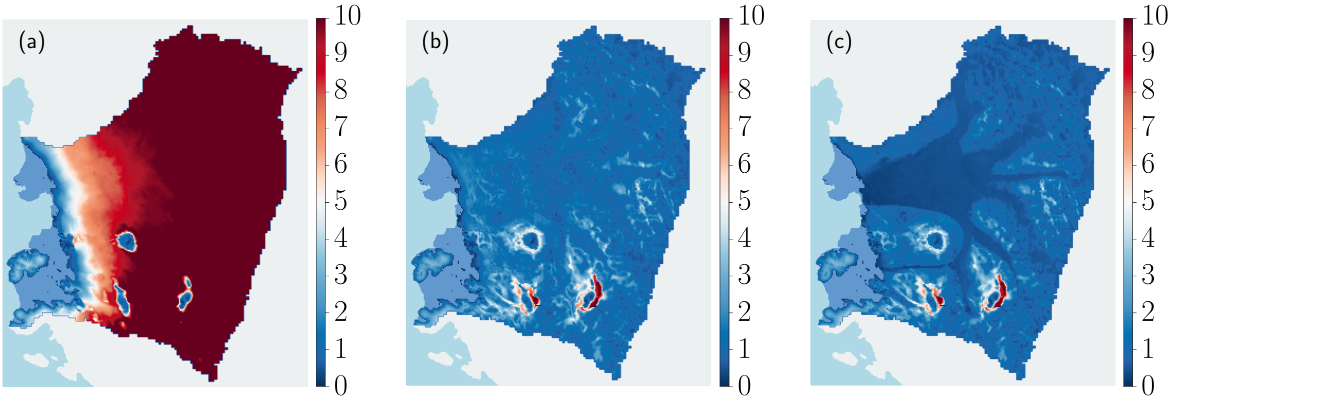
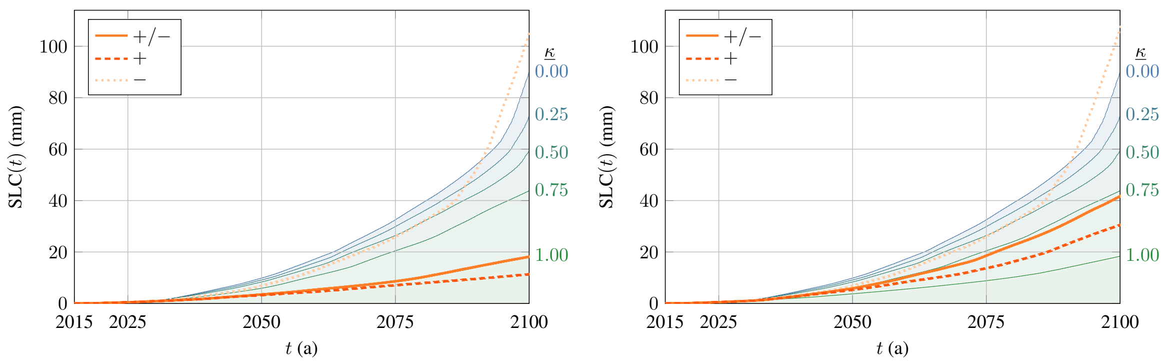


Figure S3: Effective pressure (MPa) for (a) HAB, (b) HARD and (c) SOFT hydrological models, in the initial configuration.

Supplementary 4 : Exchanging soft and hard bed regions



(a) Sharp transition.

(b) Smooth transition.

Figure S4: Sea-level contribution of Thwaites Glacier from 2015 to 2100 under present-day climate conditions when a sharp (a) and a smooth (b) transition is made between a hard (in depressions) and a soft (on topographic highs) bed for combined inefficient and efficient (orange continuous line; default), entirely efficient (orange dashed line) and entirely inefficient (orange dotted line). Sea-level contributions in the case of homogeneous hard (blue), soft (green) and mixed (with $\kappa = 0.25$, $\kappa = 0.50$, and $\kappa = 0.75$; in a gradient of blue and green) beds are also shown.

To confirm the hypothesis made in the results section of the paper, we inverted the location of hard and soft bed zones for heterogeneous beds, i.e., with hard beds occupying the depressions and soft beds on topographic highs. Although it sounds nonphysical and contradicts the data given in the literature, the idea is to test whether such configuration confirms our conclusions. Obtained sea-level contributions are similar to those obtained for a soft-bed system because the retreat of the grounding line has not yet reached the hard-bed zone. If we were to continue the simulation further in time, we would actually observe an acceleration when the grounding line would reach the hard-bed area, as expected.

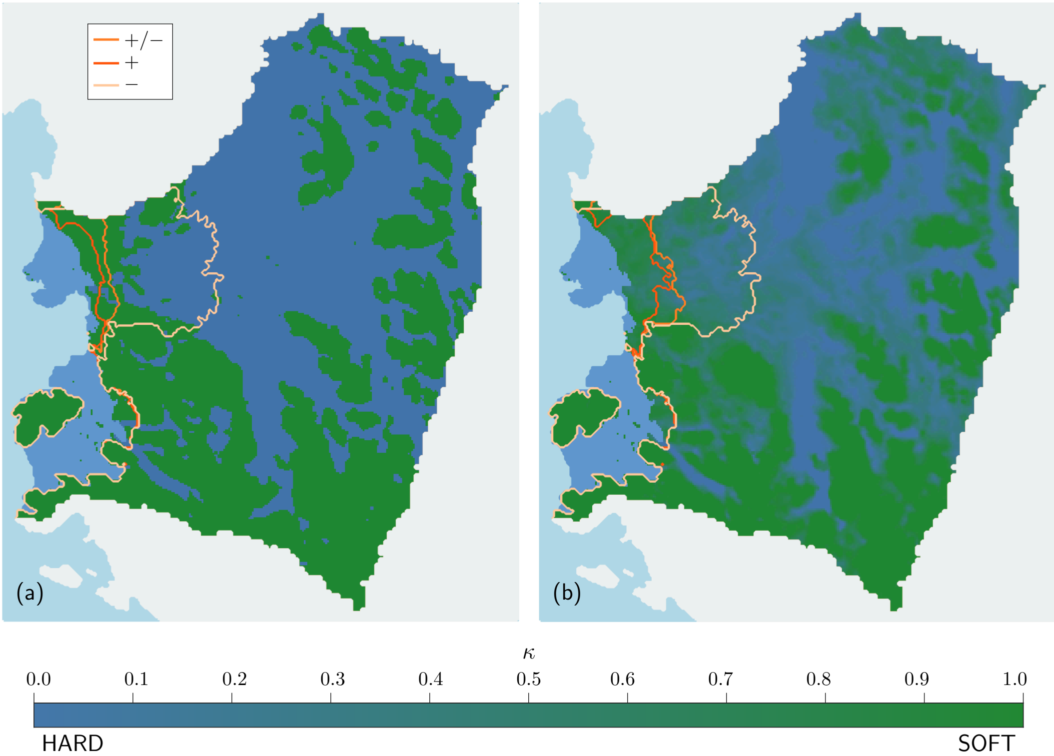


Figure S5: Grounding line position of Thwaites Glacier from 2015 to 2100 under present-day climate conditions when a sharp (a) and a smooth (b) transition is made between hard (blue,in depressions) and soft (green,on topographic highs) beds. Combined inefficient and efficient (orange), only efficient (red) and only inefficient (light orange).

References

Morlighem, M.: MEaSUREs BedMachine Antarctica, Version 3, https://doi.org/10.5067/FPSU0V1MWUB6, 2022.

Morlighem, M., Rignot, E., Binder, T., Blankenship, D., Drews, R., Eagles, G., Eisen, O., Ferraccioli, F., Forsberg, R., Fretwell, P., et al.: Deep glacial troughs and stabilizing ridges unveiled beneath the margins of the Antarctic ice sheet, Nature geoscience, 13, 132–137, 2020.