Supplement of The Cryosphere, 19, 3631–3653, 2025
https://doi.org/10.5194/tc-19-3631-2025-supplement


The Cryosphere
Open Access

*Supplement of*

# Simulating the Holocene evolution of Ryder Glacier, North Greenland

**Jamie Barnett et al.**

*Correspondence to:* Jamie Barnett (jamie.barnett@geo.su.se)

**Sect. S1**

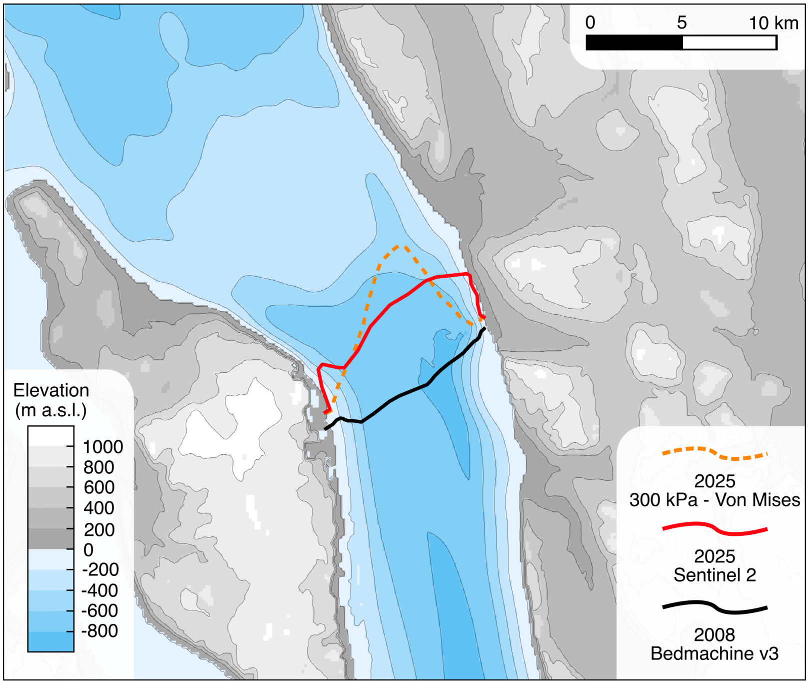


**Figure S1.** A comparison between the recent observed evolution of Ryder's calving front with a simulated front using the Von Mises calving law. The 2008 position of Ryder's terminus (black) is sourced from BedMachine v3 (Morlighem et al., 2017) and is taken as the initial ice front position for our comparison simulation. The 2025 position of Ryder's terminus (red) is taken from a Sentinel 2 satellite image dated 19-05-2025. The simulated 2025 position of Ryder (dashed orange) uses the Von Mises calving law with a threshold of 300 kPa. Surface topography and ocean bathymetry are from BedMachine v5 (Morlighem et al., 2022).

Here we test whether the Von Mises calving law with $\sigma_{max}$ value of 300 kPa (Eq. 4), found to be a suitable tuning value for the neighbouring Petermann Glacier (Åkesson et al., 2022), reproduces the contemporary evolution of Ryder Glacier's terminus. To do this, we run our ice sheet model from 2008 forward to 2025 and compare the position of the ice front to observations. The initial ice front position and ice geometry are taken from BedMachine v3 which has a nominal date of 2008 (Morlighem et al., 2017). Figure S1 shows the position of the observed front in 2025 against our simulated front using the Von Mises law with a $\sigma_{max}$ value of 300 kPa. The calving law reproduces the 2025 position well capturing the overall trend of glacier advance during the 17 years. Although the centre of the ice tongue terminus is slightly too advanced, its margins, and their connection to the fjord walls which offer buttressing, terminate in a similar position to that observed in 2025.

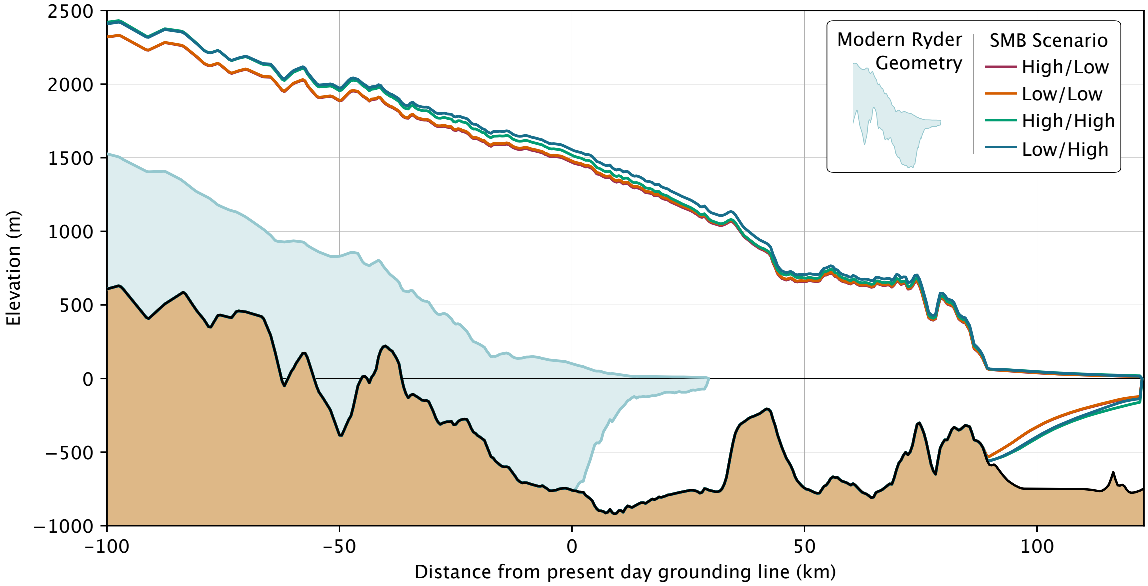


**Figure S2.** A comparison between the geometry of the present day Ryder Glacier (light blue) and that of the glacier after running a 20,000 year spin-up forced with a YD climate for the differing SMB scenarios: High/Low (red), Low/Low (Orange), High/High (Green) and Low/High (Blue). Bedrock data and the present day ice surface is from BedMachine v5 (Morlighem et al., 2022).

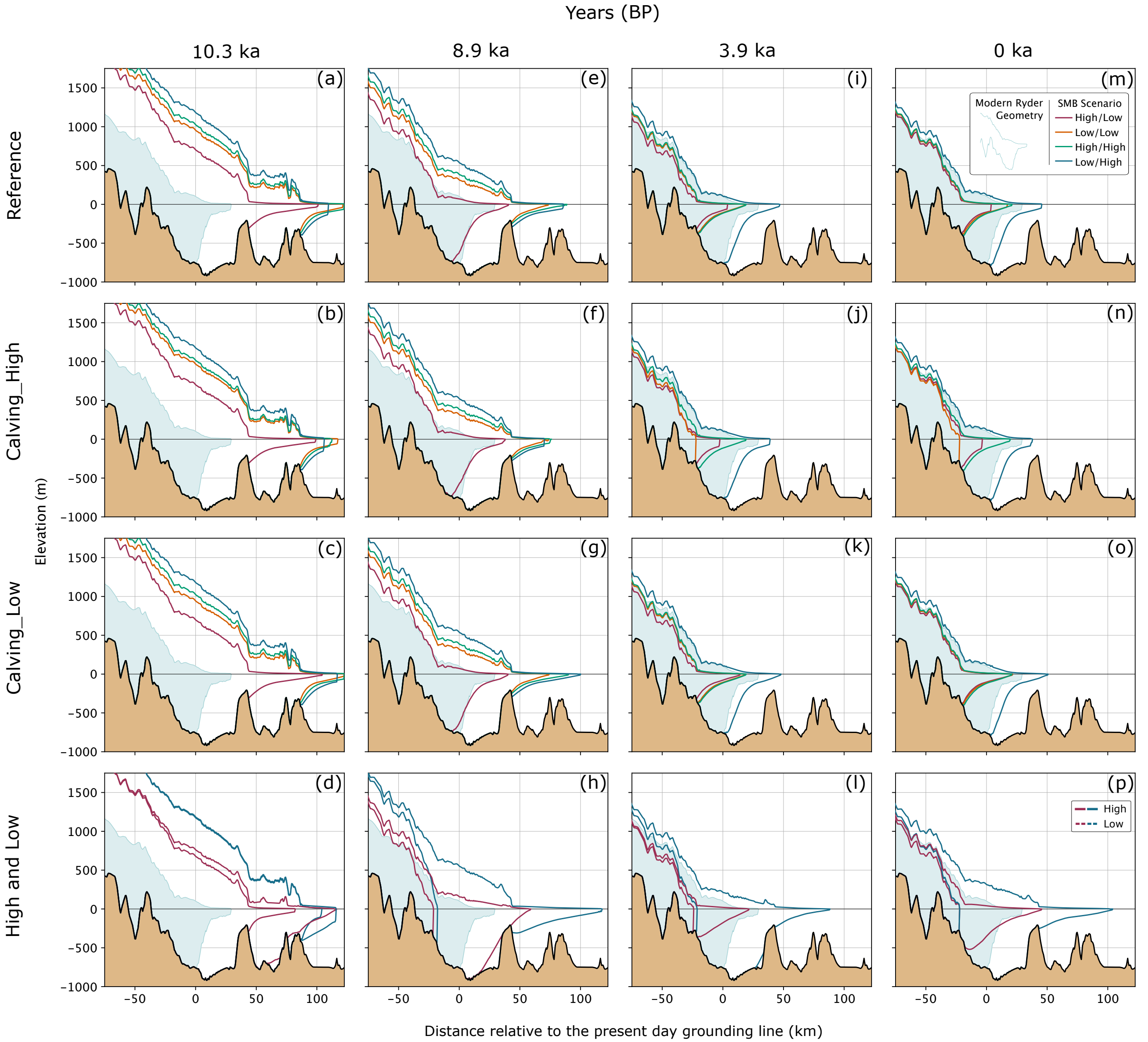


**Figure S3.** Evolution of Ryder Glacier in 2D cross section views along the centre flowline during the Holocene at specific time stamps. Dates of 10.3 ka **(a-d)**, 8.9 ka **(e-h)**, 3.9 ka **(i-l)** and 0 ka **(m-p)**, represent specific landmarks in the evolution of Ryder as discussed in O'Regan et al. (2021). Each row represents a different ocean forcing used in the transient simulation (Table **??**), from top down this includes: *Reference*, *Calving_High*, *Calving_Low* and both extreme *High* and *Low* Scenarios. Each plot contains the 4 different SMB scenarios: High/Low (red), Low/Low (Orange), High/High (Green) and Low/High (Blue).

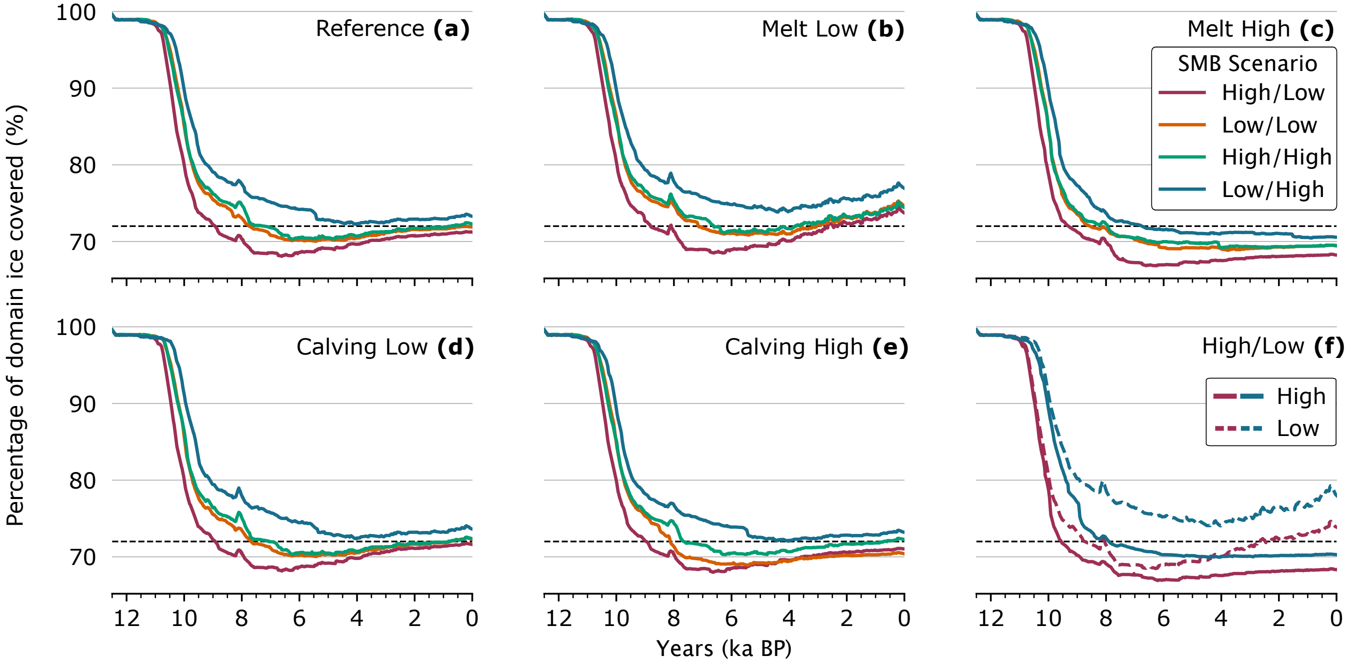


**Figure S4.** Evolution of ice cover in the model domain during the Holocene simulations. Line colour defines the SMB scenario for the transient runs: High/Low (red), Low/Low (Orange), High/High (Green) and Low/High (Blue). Each subplot represents a different ocean scenario: **(a)** *Reference*, **(b)** *Melt_Low*, **(c)** *Melt_High*, **(d)** *Calving_Low*, **(e)** *Calving_High* and **(f)** both the extreme *High* and *Low* ocean forcings. The dashed black line represent the contemporary percentage of the domain covered with ice, 72%.

## References

Morlighem, M., Williams, C. N., Rignot, E., An, L., Arndt, J. E., Bamber, J. L., Catania, G., Chauché, N., Dowdeswell, J. A., Dorschel, B., Fenty, I., Hogan, K., Howat, I., Hubbard, A., Jakobsson, M., Jordan, T. M., Kjeldsen, K. K., Millan, R., Mayer, L., Mouginot, J., Noël, B. P. Y., O'Cofaigh, C., Palmer, S., Rysgaard, S., Seroussi, H., Siegert, M. J., Slabon, P., Straneo, F., van den Broeke, M. R., Weinrebe, W., Wood, M., and Zinglersen, K. B.: BedMachine v3: Complete Bed Topography and Ocean Bathymetry Mapping of Greenland From Multibeam Echo Sounding Combined With Mass Conservation, Geophysical Research Letters, 44, 11,051–11,061, https://doi.org/10.1002/2017GL074954, 2017.

Morlighem, M., Williams, C. N., Rignot, E., An, L., Arndt, J. E., Bamber, J. L., Catania, G., Chauché, N., Dowdeswell, J. A., Dorschel, B., Fenty, I., Hogan, K., Howat, I., Hubbard, A., Jakobsson, M., Jordan, T. M., Kjeldsen, K. K., Millan, R., Mayer, L., Mouginot, J., Noël, B. P. Y., O'Cofaigh, C., Palmer, S., Rysgaard, S., Seroussi, H., Siegert, M. J., Slabon, P., Straneo, F., van den Broeke, M. R., Weinrebe, W., Wood, M., and Zinglersen, K. B.: IceBridge BedMachine Greenland, Version 5, https://doi.org/10.5067/GMEVBWFLWA7X, 2022.

O'Regan, M., Cronin, T. M., Reilly, B., Alstrup, A. K. O., Gemery, L., Golub, A., Mayer, L. A., Morlighem, M., Moros, M., Munk, O. L., Nilsson, J., Pearce, C., Detlef, H., Stranne, C., Vermassen, F., West, G., and Jakobsson, M.: The Holocene dynamics of Ryder Glacier and ice tongue in north Greenland, The Cryosphere, 15, 4073–4097, https://doi.org/10.5194/tc-15-4073-2021, publisher: Copernicus GmbH, 2021.

Åkesson, H., Morlighem, M., Nilsson, J., Stranne, C., and Jakobsson, M.: Petermann ice shelf may not recover after a future breakup, Nature Communications, 13, https://doi.org/10.1038/s41467-022-29529-5, 2022.