Supplementary Material for The Impact of Ice Structures and Ocean Warming in Milne Fiord

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S1. Climate Scenarios

To estimate the ocean temperature increase offshore from Milne Fiord for now until 2100, the output from six different climate models were analysed. Three models from the CMIP5 (Climate Model Intercomparison Project 5) and three models from CMIP6 were randomly chosen. Three different climate scenarios were also chosen. RCP2.6/SSP126 which is equivalent to an additionnal radiative forcing of 2.6 W/m^2 in 2100, is an optmistic scenario. RCP4.5/SSP245 which is equivalent to an additionnal radiative forcing of 4.5 W/m^2 in 2100, is a moderate scenario. RCP8.5/SSP585 which is equivalent to an additionnal radiative forcing of 8.5 W/m^2 in 2100, is the business as usual scenario. The four temperature increases used for modelling represent final or intermediate states for these three scenarios according to the multimodel mean (thick black line Figure S1).

We note that comparing our results to an analysis or the Arctic Ocean using 13 CMIP6 model ensembles shows a difference smaller than 0.1°C between the model mean for 2055 (Langehaug et al. 2023), providing confidence our relatively low number of model analysed did not skew our predictions.

A caveat of the ocean temperature predicitons used (and also from Langehaug et al. 2023) is the minimal presence of Pacific Summer Water (e.g. Timmermans et al. 2014) compared to recent (after 2020) observations. For example, an ice thetered profiler 400 km west from Milne Fiord shows a 1.5°C warming at 50 m since 2022 (https://www2.whoi.edu/site/itp/data/active-systems/itp-131/) . Such warming, not modelled by the CMIP models except HadGEM2-ES, would significantly increase the melting of the ice shelf and glacier tongue in Milne Fiord.

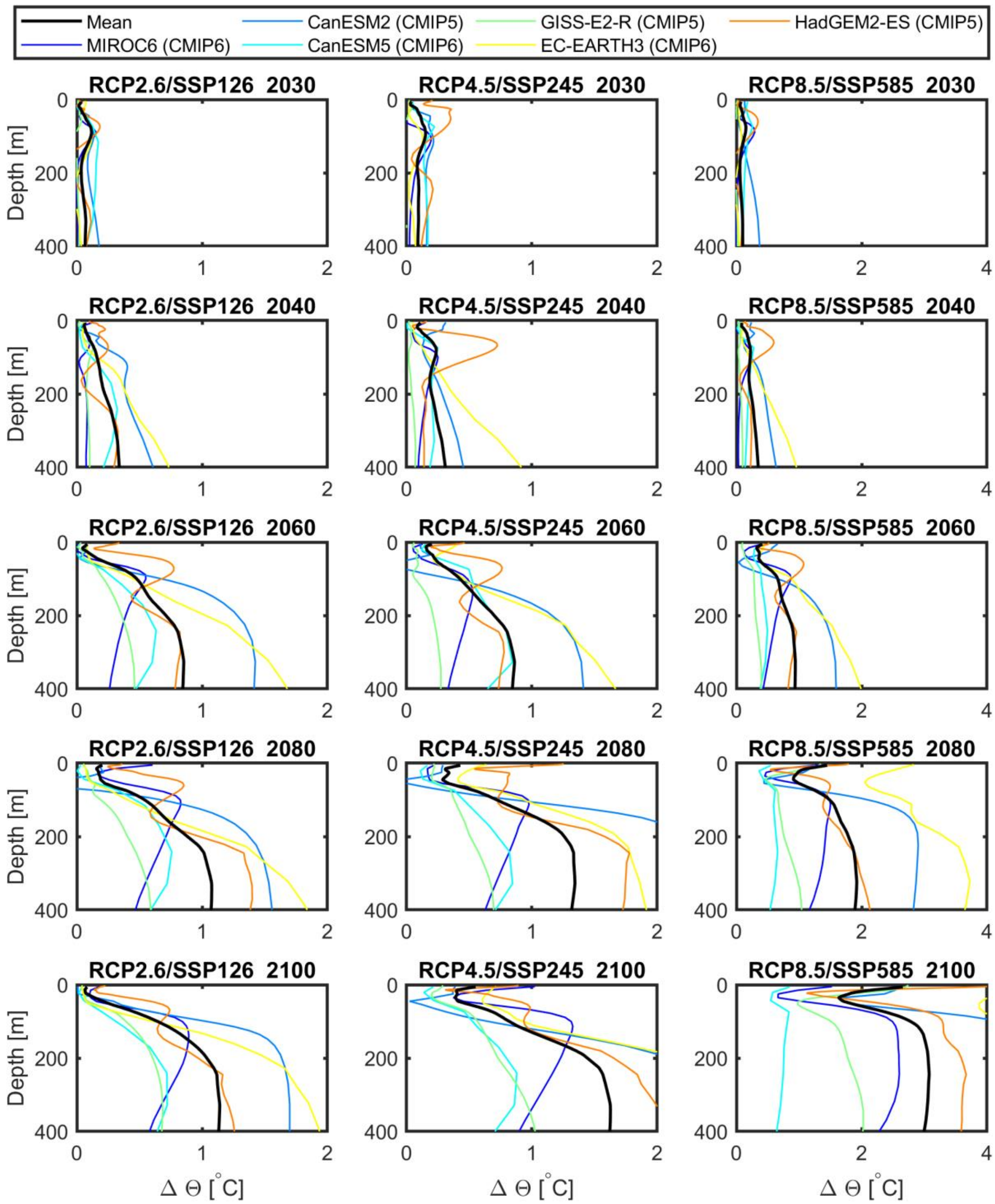

Figure S1. Ocean temperature increase (Δθ) according to different model ensembles (from CMIP5 and CMIP6) and different climate scenarios. Color lines are model ensembles and thick black lines are the mean of model ensembles. Note the different temperature scale for RCP8.5/SSP585 predictions (right column).

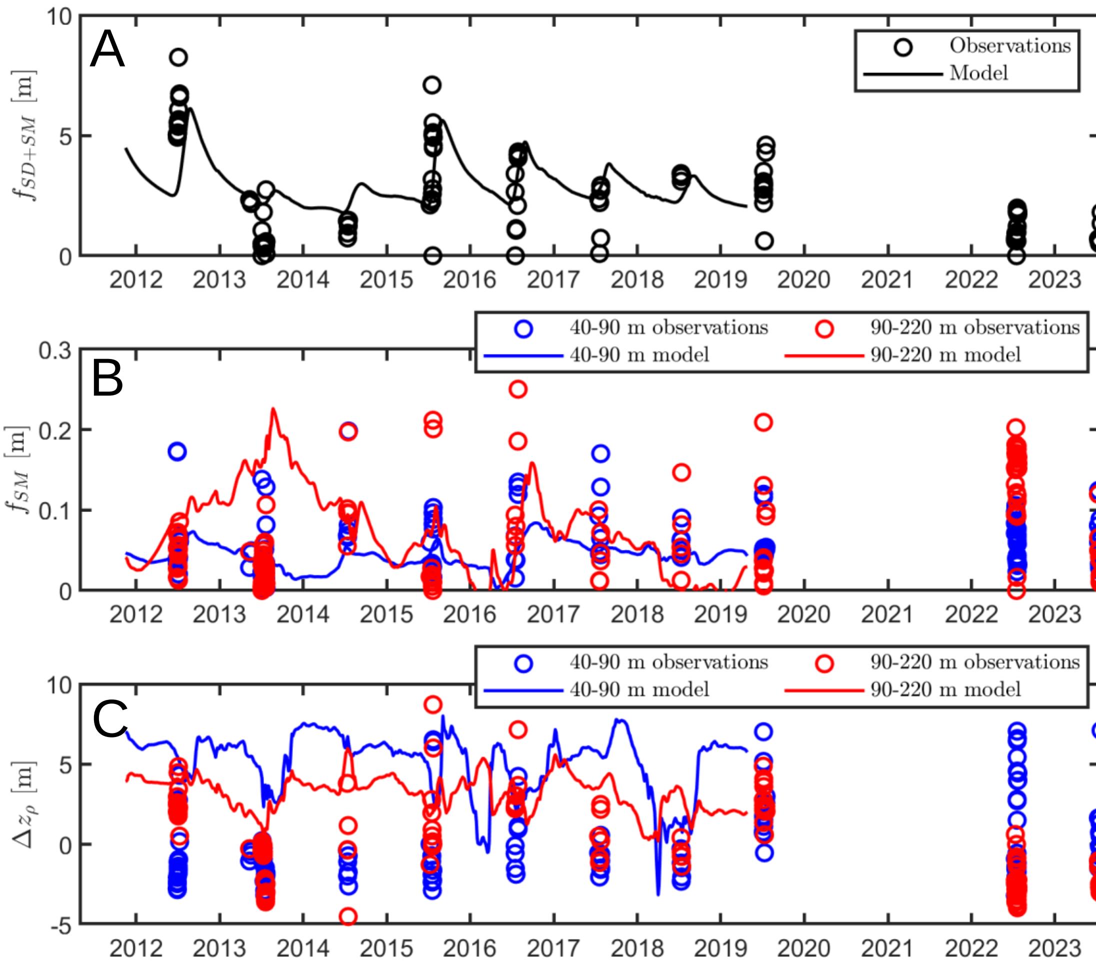

Figure S2. A: Fraction of subglacial discharge and submarine meltwater in the 10-40 m layer from observations and from the model. B: Fraction of submarine meltwater in the 40-90 m and 90-220 m layer from observations and from the model. C: Upwelling in the 40-90 m and 90-220 m layer from observations and from the model. Observations are calculated by comparing an offshore CTD profile to one inside the fjord. 212 CTD profiles are used in this figure. The variability within each field season is higher than the interannual variability.

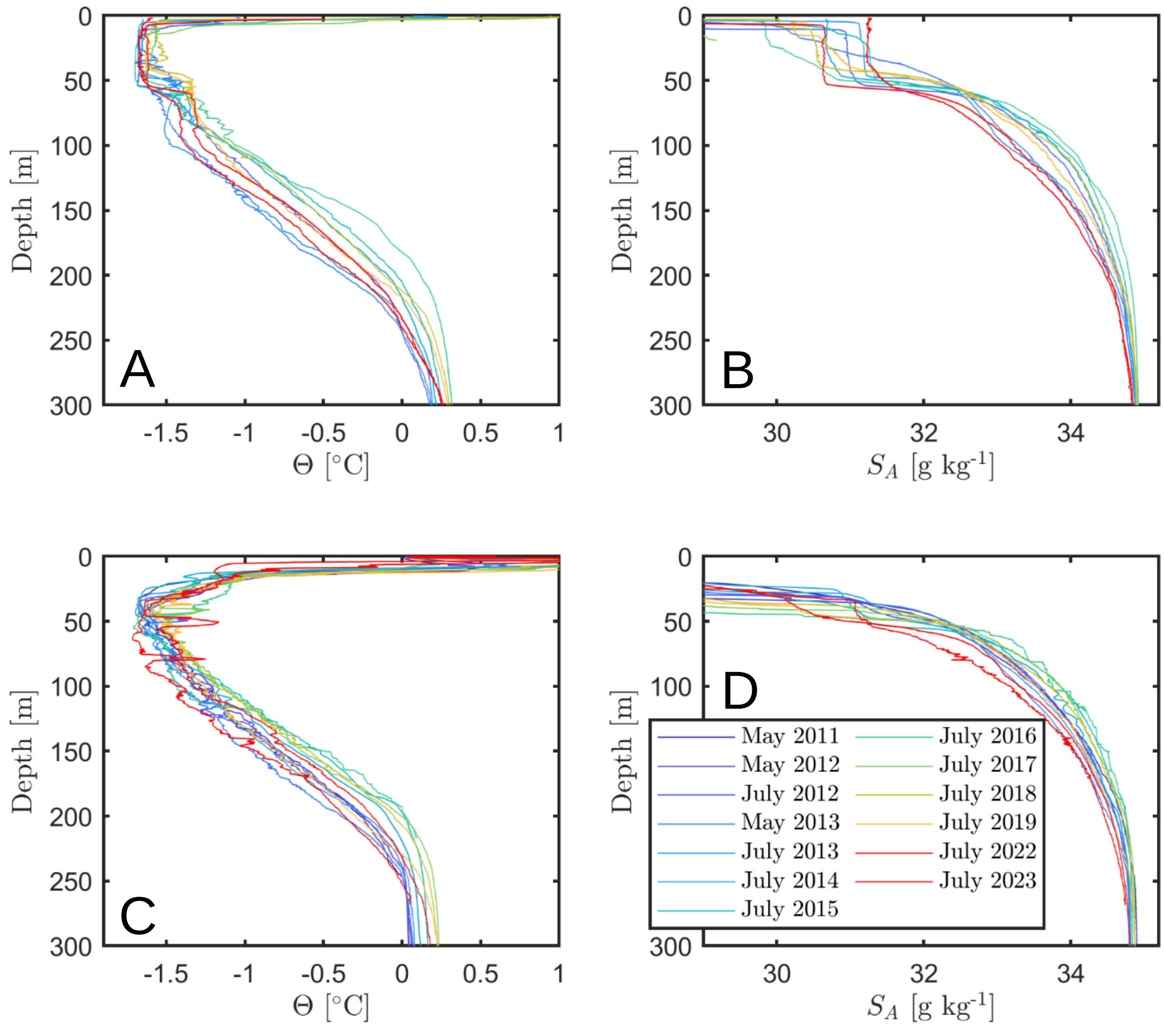

Figure S3. Temperature and salinity profiles offshore (A, B) and in the middle of the fjord (C, D) from 2011 to 2023. There is no obvious change following the July 2020 calving event. The fresher profiles in July 2022 and 2023 (D) are due to fresher offshore conditions (B).

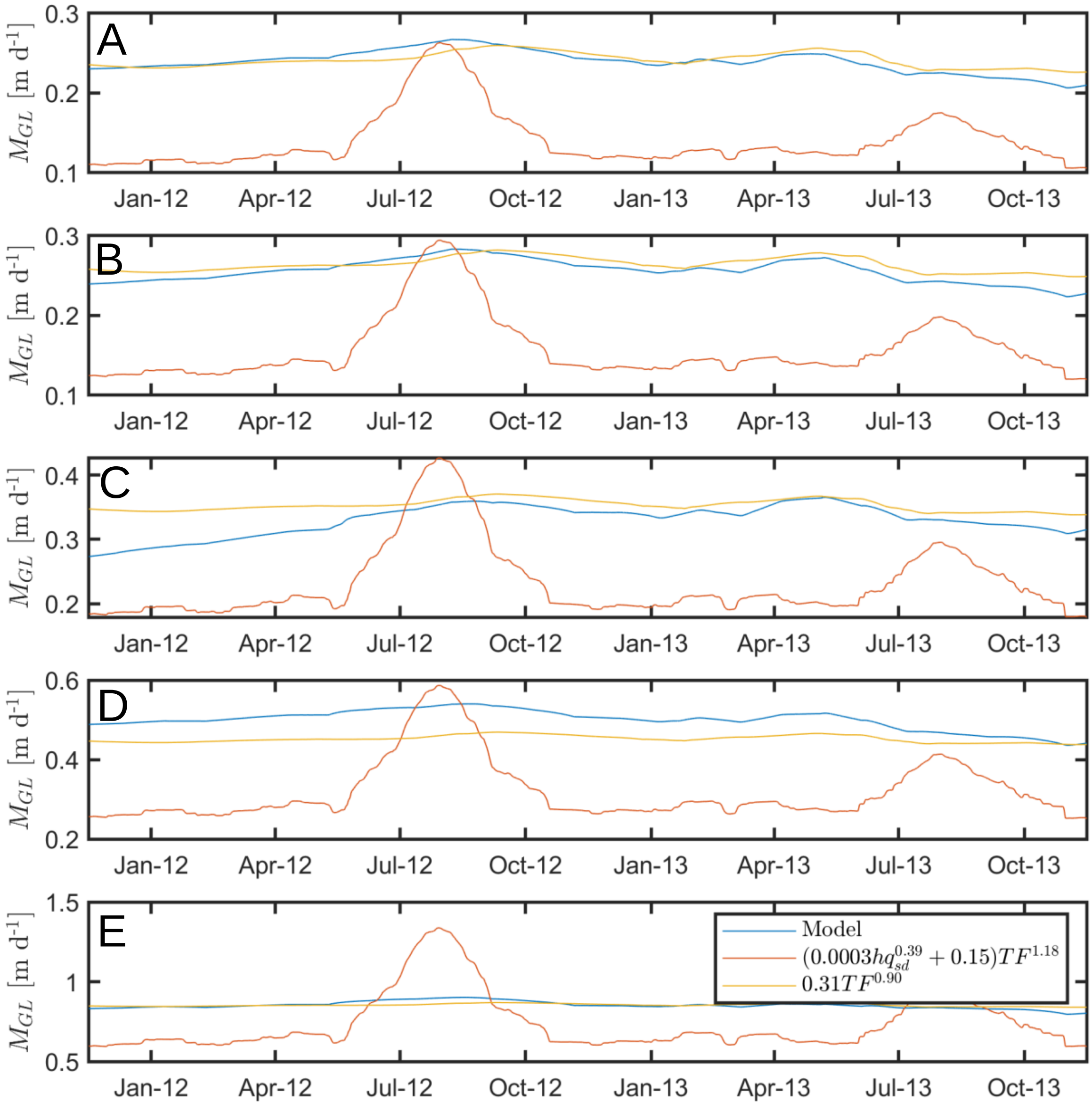

Figure S4. Comparison of submarine melting at 187 m depth from the model and parameterizations from Rignot et al (2016) (orange) and this study (yellow). A: for the *nogt* simulation. B: *T03*. C: *T09*. D: *T16*. E :*T30*.

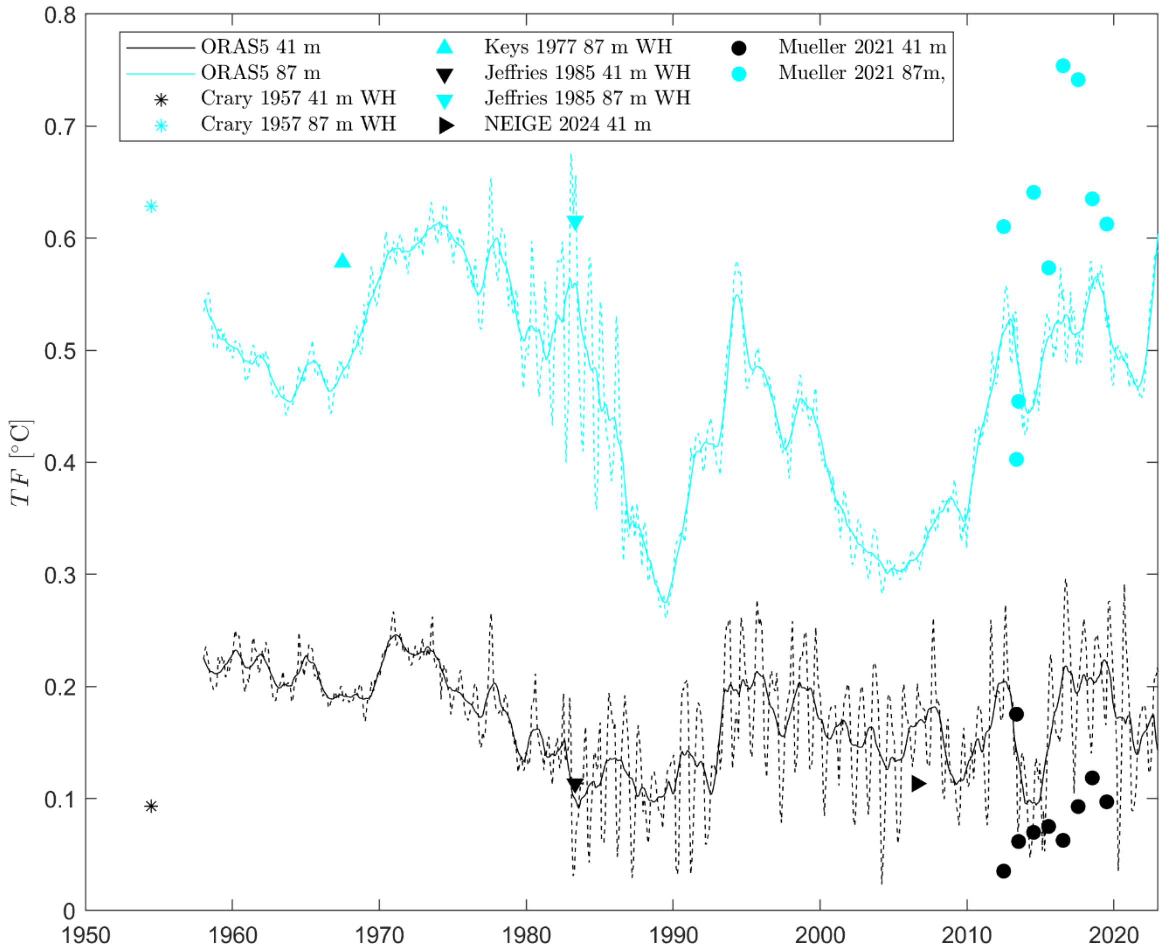

Figure S5. Ocean water thermal forcing at 41 m and 87 m. Monthly reanalysis data from ORAS5 (dashed lines) and annual average (solid lines). The data is from the grid point at 82.6°N, -96.6°W which is where the agreement between offshore CTD profiles in front of Milne Fiord and ORAS5 is the best. Individual markers represent observations in front of Milne Fiord or around Ward Hunt Island (WH, 80 km east). There is no warming or cooling trend, indicating the ocean forcing on ice shelves along the northern coast of Ellesmere has remained unchanged since 1958. Observations reference: Crary 1956; Keys 1977; Jeffries 1895; Mueller et al. 2021 and NEIGE 2024.

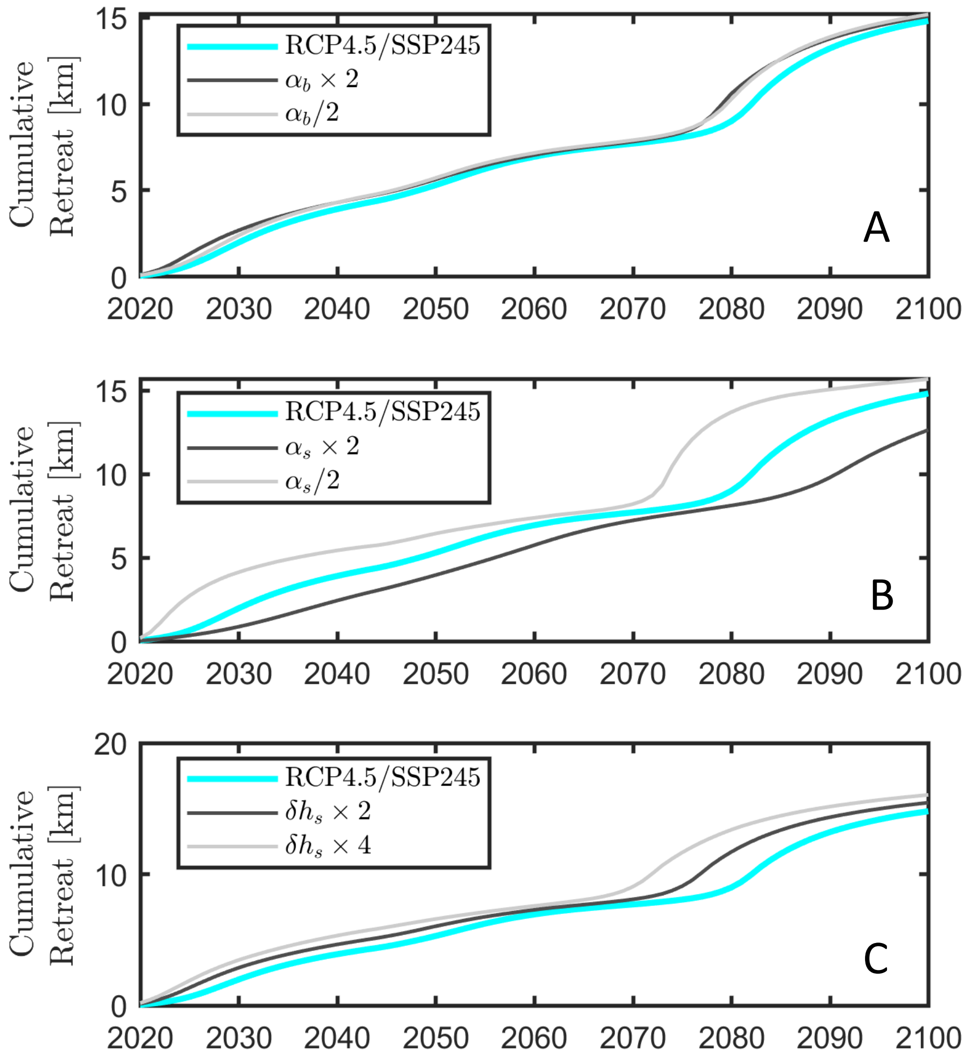

Figure S6. Sensitivity analysis of the glacier retreat to the basal slope (A), to the surface slope (B) and to the surface mass balance (C). All cases use the thermal forcing from the RCP4.5/SSP245 climate scenario. This analysis shows that results are not sensitive to these three parameters; Milne Glacier grounding line will retreat regardlesss of their (possible) values.