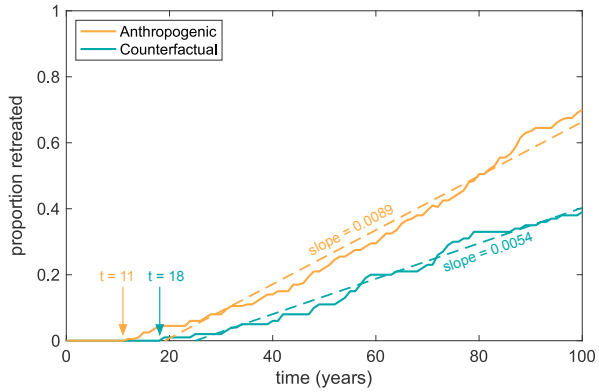
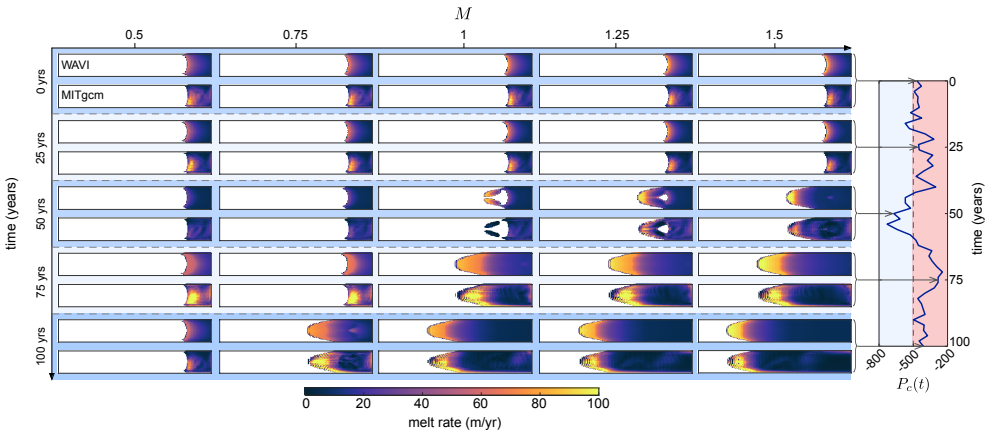
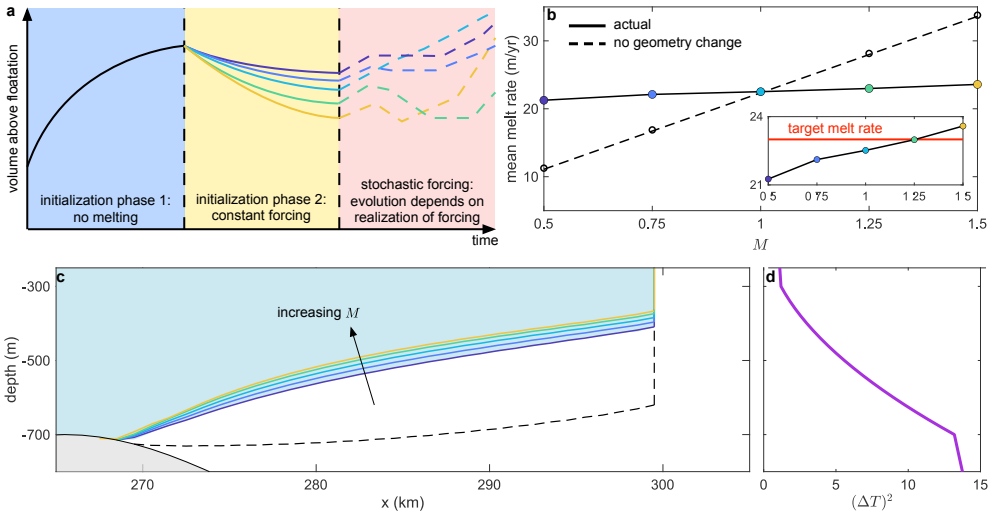
Supplementary Figures



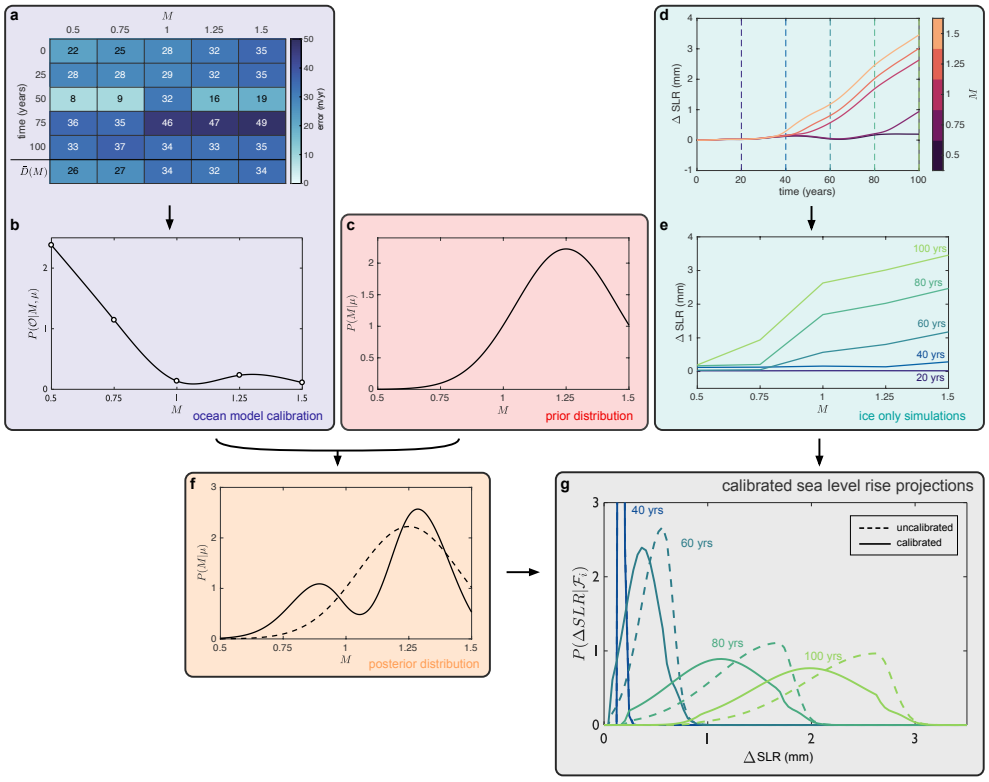
Supplementary figure 1. Time evolution of retreats. Time evolution of the number of retreats (defined as a SLR contribution greater than 0.2 mm) for all simulations from the anthropogenic ensemble (yellow) and counterfactual (green). Arrows indicate the time at which the first retreat is initiated.



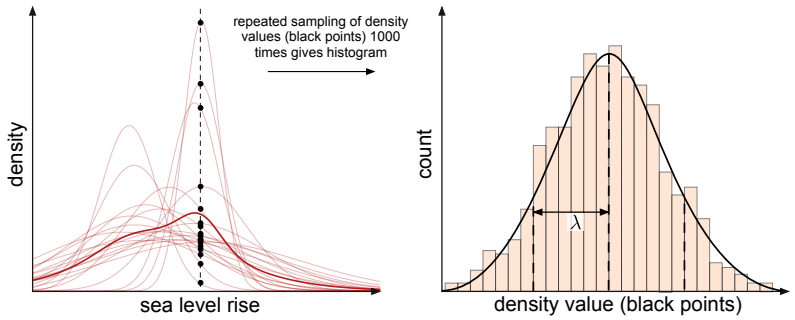
Supplementary figure 2. Calibrated retreat of ice sheets under stochastic forcing. Ice shelf melt rates (colors) computed using parameterized melting in the WAVI ice sheet model (top of each sub-panel) and the MITgcm ocean model (bottom of each panel). Data are shown for different calibration timeslices (rows) and different melt rate parameter values M (columns). Note that the x- and y-axes are the same in each, and zoomed in on the ice shelf (100 km $< x <$ 300 km, -25 km$< y <$ 25 km). The side-panel indicates the realization of forcing corresponding to the main panel, showing pycnocline depth (abscissa) as a function of time (ordinate). Red (blue, respectively) indicates where the pycnocline is shallower (deeper) than its initial position, $P_c(0) = -500$ m.



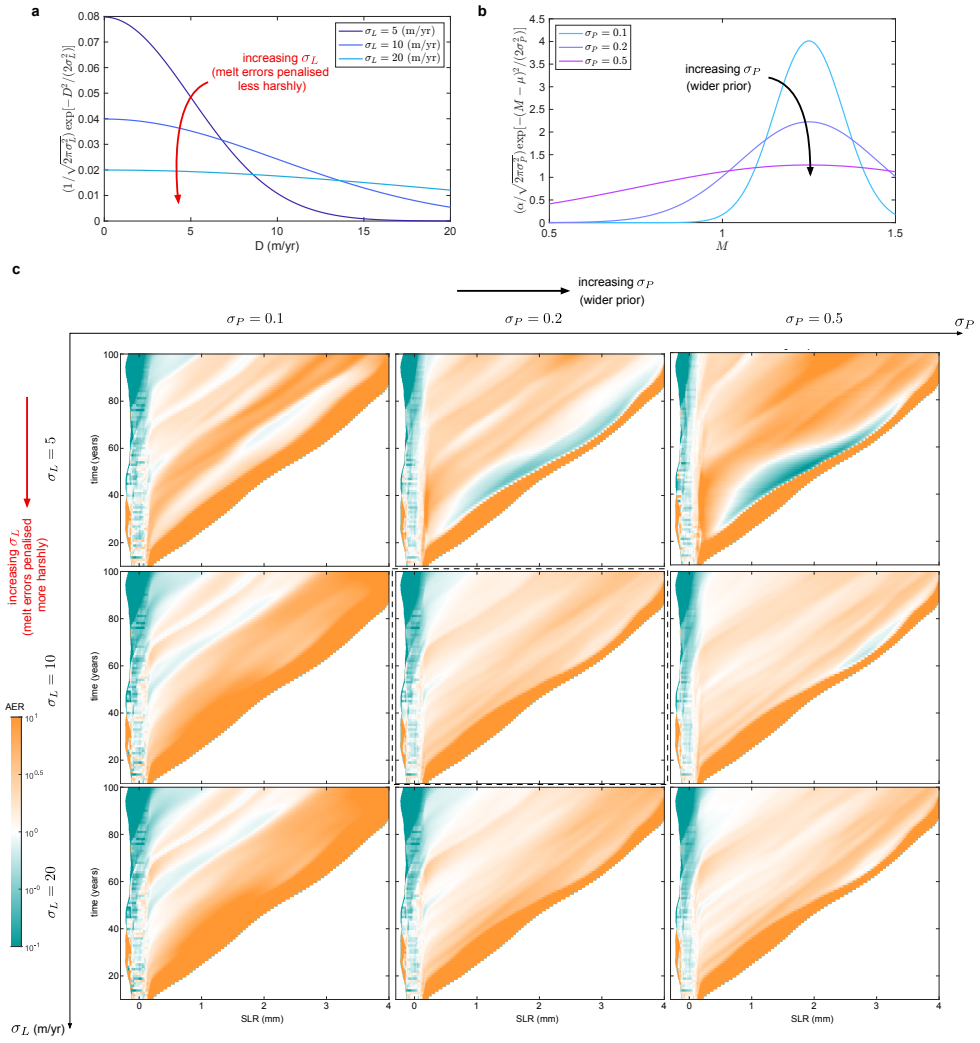
Supplementary figure 3. Two stage initialization procedure. (a) Schematic diagram of the initialization procedure, described in 'Ice Sheet Model Initialization'. Colors in the second initialization phase correspond to different values of M, as indicated by points in (b). (b) Mean melt rate after the second initialization phase as a function of M (solid line). The dashed line indicates what the mean melt rate would be if the same geometry (that of the $M = 1$ case) were used for each value of M. Inset: as in main panel with a zoomed ordinate axis. The red line is the target value of 23 m year^{-1}, which sets the prior hyperparameter μ. (c) Ice shelf geometry after the first (black) and second (colors, according to colors in (b)) initialization stages. (d) Squared thermal forcing $(\Delta T)^2 = (T_a - T_f)^2$ as a function of depth (note that (c) and (d) share an ordinate axis).



Supplementary figure 4. Producing parametrically calibrated distributions for a given realization of forcing. (a) Likelihood values at each calibration timeslice (rows) as a function of M, for the realization of forcing shown in figure 2e and supplementary figure Supplementary figure 2.. Dark (light, respectively) colors indicate high (low) errors in melting. The final row indicates the discrepancy D as a function of M, computed as the mean over calibration timeslices. (b) Likelihood function $P(\mathcal{O}|M,\mu)$ (given by equation 6), describing how the prior distribution is updated to account for information introduced by the ocean model. Here, $\sigma_L = 10$ m year^{-1}. (c) Prior distribution, given by equation 3, representing the state of knowledge of parameters M prior to calibration. Here, $\sigma_P = 0.2$. (d) SLR as a function of time for different values of M (indicated by colors), for the realization of forcing shown in figure 2e. (e) SLR at fixed times (indicated by colors, corresponding to dashed vertical lines in (d)) as a function of M. (f) Posterior distribution of M (solid black line), obtain by combining the prior and likelihood according to equation 2. The dashed black line shows the prior distribution for M for reference. (g) Combining the posterior distribution with SLR data yields calibrated probability distributions, for the forcing profile shown in figure 2e. Data are shown for different times, as labelled.



Supplementary figure 5. Schematic diagram of the bootstrapping procedure. (left) For any given time, we obtain a unique distribution of SLR for each realization of forcing (faint lines), whose ensemble mean (solid line) is the central distribution after accounting for aleatory uncertainty. For a given SLR value, an estimate of the variance λ is determined by sampling the values of the individual PDFs 1000 times and taking the standard deviation of the resulting distribution (right).



Supplementary figure 6. Sensitivity of AER to Bayesian parameters. (a) Plot of the exponential error model $P(\mathcal{O}|M,\mu)$ as a function of the melt error D. Individual curves correspond to different values of σ_L, as indicated by the legend. (b) Plot of the prior distribution $P(M|\mu)$, defined in equation 3, as a function of M. Individual curves correspond to different values of σ_P, as indicated by the legend. (c) Plots of AER as a function of SLR and time (i.e. as in figure 4 of the main text) for different values of σ_L (rows) and σ_P (columns). Values of σ_L and σ_P correspond to those shown as individual lines in (a) and (b), respectively. Each panel has the same abscissa and ordinate axis labels as those in the final row and first column and uses colours corresponding to the single colourbar. The panel highlighted in the dashed box corresponds to figure 4 of the main text. Red and black arrows indicate the direction of increasing σ_L and σ_P, respectively, and correspond to arrows of the same colour in panels (a) and (b), respectively.