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Miocene Antarctic Ice Sheet area adapts significantly faster than volume to CO_2-induced climate change

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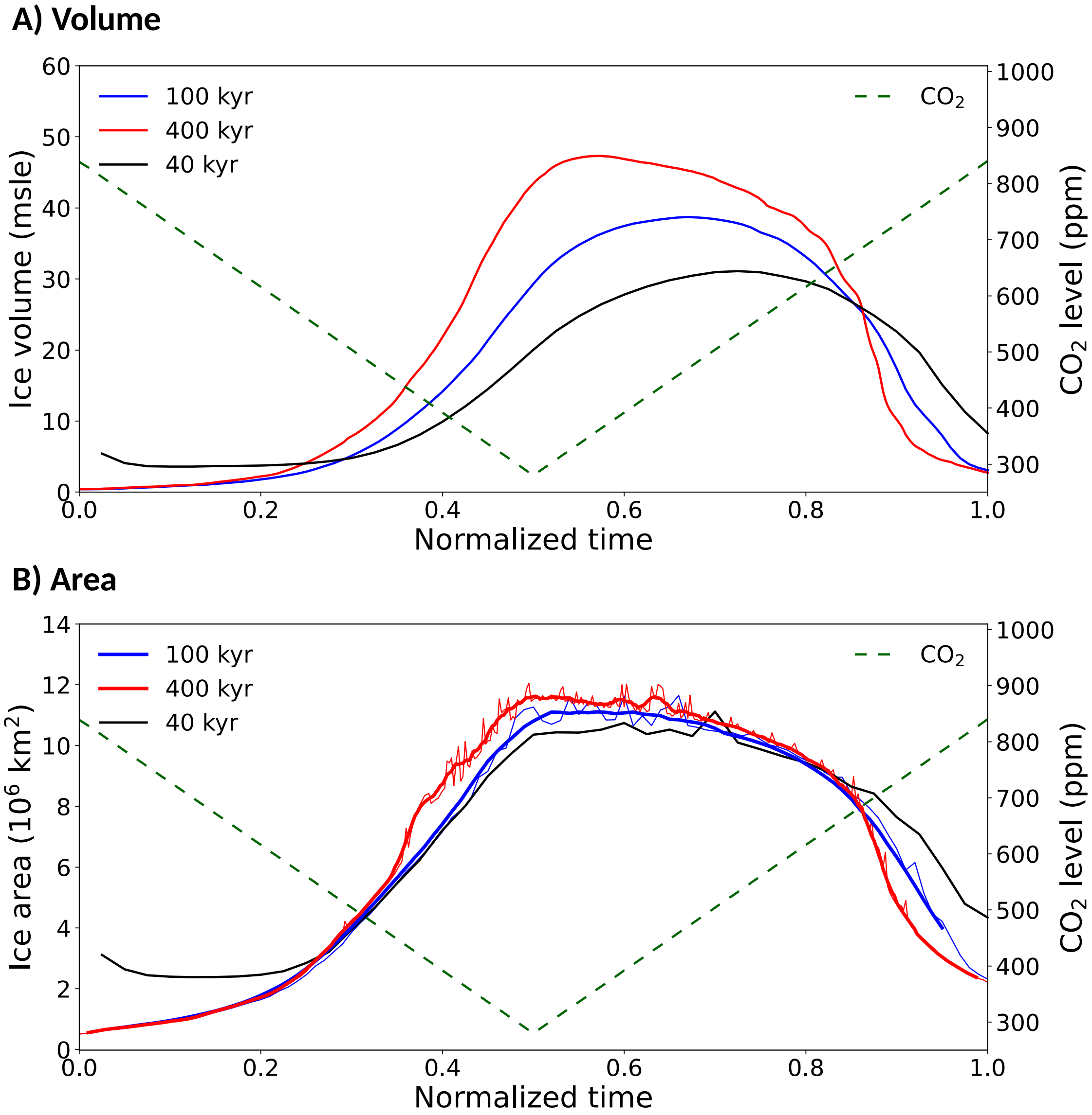

Figure S1. (A) Transient evolution of the forcing CO_2 level (green dashed) and the resulting ice volume over time, normalized with respect to the maximum integration time, for the 100-kyr (blue), 400-kyr (red) simulations, and the final cycle of the 40-kyr simulation (black).
(B) Same for CO_2 and ice area. For the 100-kyr and 400-kyr simulations, we show the 10-kyr moving average (thick lines) in addition to the 1-kyr output (thin lines).

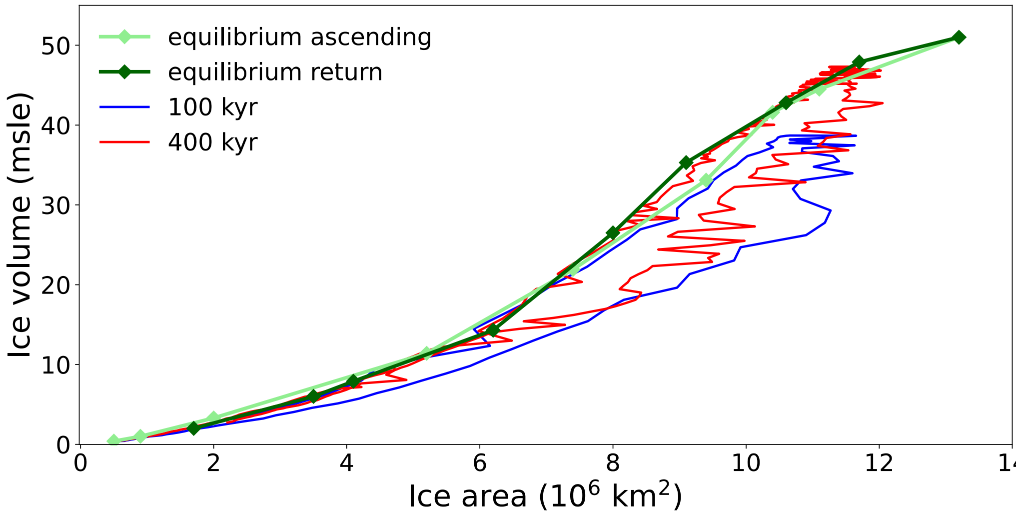

Figure S2. Ice volume plotted against ice area, for the 100-kyr (blue) and 400-kyr (red) simulations. The progression direction is counterclockwise. The connected symbols indicate the ascending branch (lightgreen) and return branch (darkgreen) equilibrium ice volume and area.

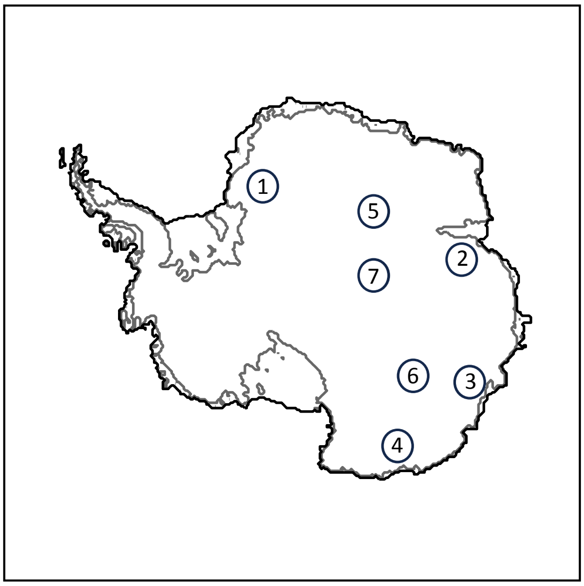

Figure S3. Map of present-day Antarctic grounding lines and coastlines (Morlighem et al., 2020). Indicated are the locations where ice sheet collapse occurs in successive order: 1) Coats Land, 2) Princess Elizabeth Land, 3) Wilkes Land, 4) George V Land, 5) Dome Fuji, 6) Dome Circe, and 7) Dome Argus.

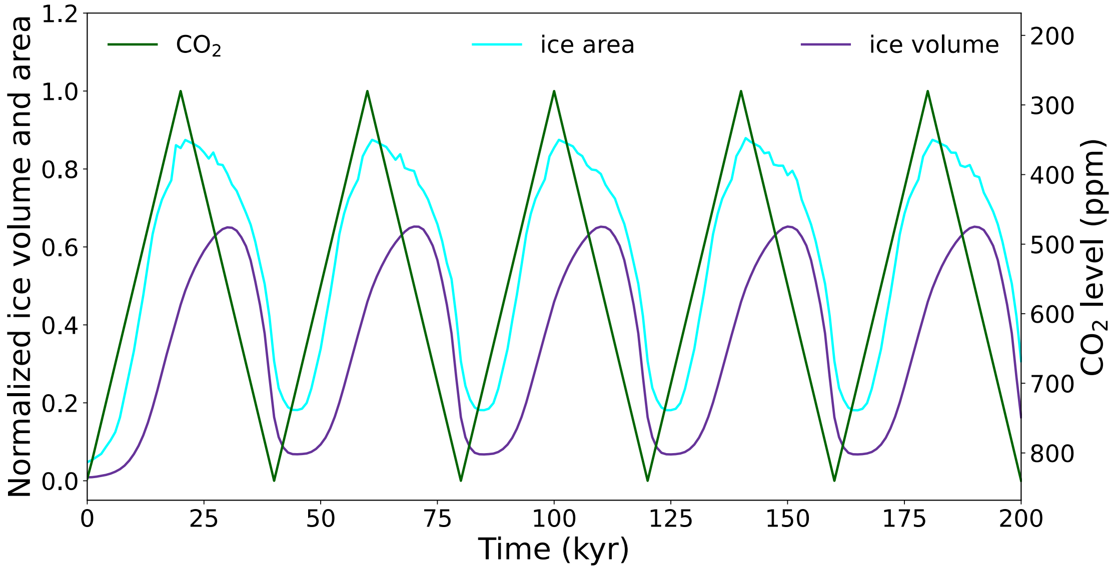

Figure S4. Results for the 40-kyr simulation using an index method in which the interpolation of the climate forcing is solely based on the CO_2 level (NOFEEDB experiment in Stap et al., 2022). Transient evolution over time of ice area (cyan) and ice volume (purple) relative to their maximum sizes as obtained from the 280-ppm equilibrium simulation, 14.4 x 10^6 km^2 and 60.1 msle respectively. The green line shows the forcing CO_2 level. The right y-axis is reversed because CO_2 is generally negatively related to the benthic $\delta^{18}O$ signal.

Section S1

We perform an additional experiment using a model set-up representative for Pleistocene glacial-interglacial variability of the North American ice sheet, that is described in detail in Scherrenberg et al. (2023). Briefly, we deploy the updated version 2.0 of IMAU-ICE. This version uses the DIVA approach - which is slightly different from the hybrid SIA/SSA approach - to calculate the dynamics of grounded and floating ice (Berends et al., 2022). The grid covers the North American continent on a 40x40-km resolution. We carry out an equilibrium and a transient simulation like those for the Miocene Antarctic ice sheet. An equilibrium simulation is conducted at a CO_2 level of 190 ppm. In the transient simulation, the CO_2 level is linearly decreased from 280 to 190 ppm, and then increased back to 190 ppm. In Fig. S4, we show the forcing CO_2 level and the resulting ice area and volume.

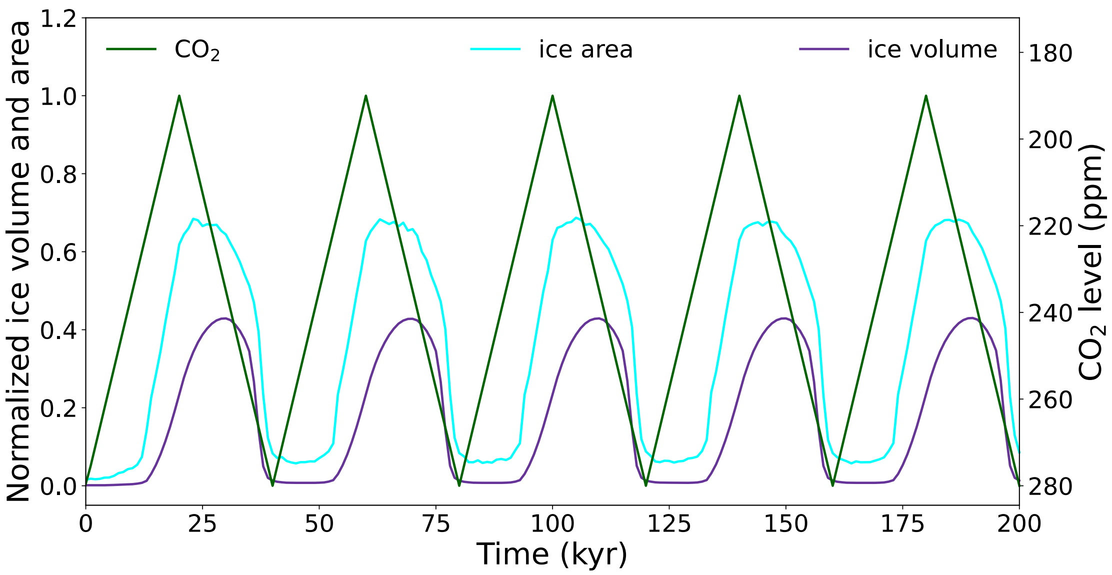

Figure S5. Results for the 40-kyr simulation of the North American ice sheet in settings representative for Pleistocene glacial-interglacial variability. Transient evolution over time of ice area (cyan) and ice volume (purple) relative to their maximum sizes as obtained from the 190-ppm equilibrium simulation, 15.5 x 10^6 km^2 and 98.9 msle respectively. The green line shows the forcing CO_2 level. The right y-axis is reversed because CO_2 is generally negatively related to the benthic $\delta^{18}O$ signal.

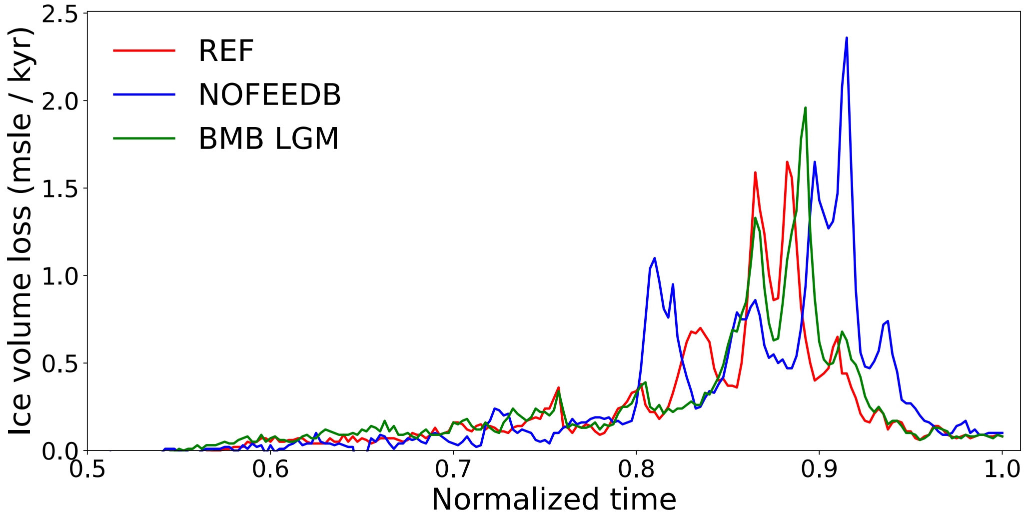

Figure S6. Decay rate over normalized time, for the 400-kyr simulations of the reference experiment (red), an experiment using a simpler index method for the climate interpolation (excluding the albedo-temperature feedback; blue), and an experiment using Last Glacial Maximum sub-shelf melt rates (green).

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