

Supplement to "Stability and basal thermal conditions of East Antarctic divide regions during the last glacial cycle"

Olivia Raspoet¹, Violaine Coulon¹, and Frank Pattyn¹

¹Laboratoire de Glaciologie, Université libre de Bruxelles

Correspondence: Olivia Raspoet (olivia.raspoet@ulb.be)

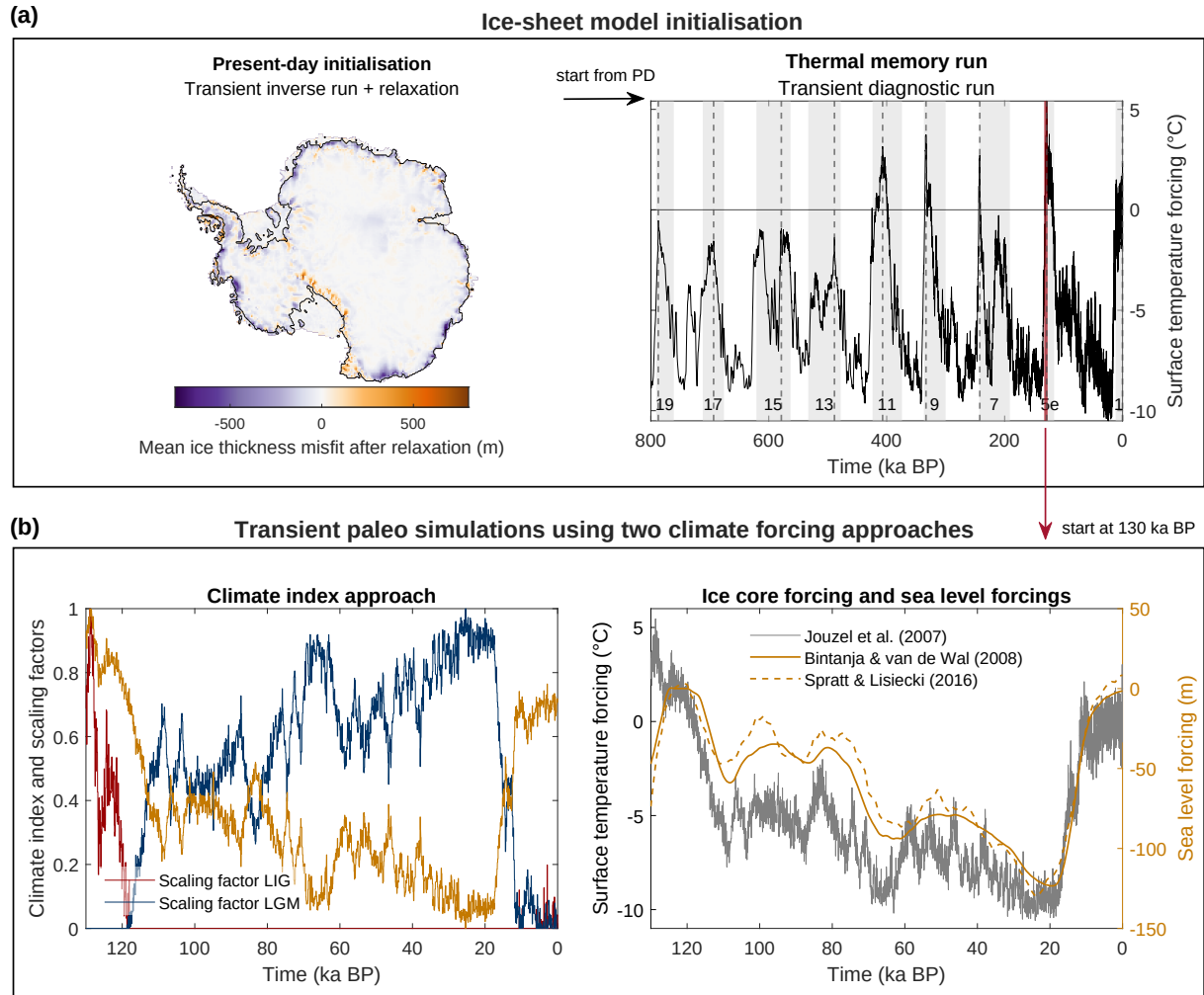


Figure S1. Experimental set-up for the ensemble of simulations. (a) The ice-sheet model initialisation starts with a long-term transient inverse run under present-day (PD) conditions during which basal sliding coefficients and subshelf melt rates are iteratively adjusted to minimise misfits between modelled and observed ice thickness (Pollard and DeConto, 2012; Bernalles et al., 2017). This transient inverse run is followed by a short relaxation run (20 years) to limit the impact of transitioning from optimised sub-shelf melt rates to those calculated with the PICO model (Coulon et al., 2025). The obtained present-day ice sheet configuration is used as an initial state for a transient diagnostic run (fixed ice sheet geometry) over the last 800 ka to capture the thermal memory of the Antarctic ice sheet (Raspoet et al., 2026). The obtained ice-sheet state at 130 ka BP is used as an initial state for the ensemble of transient palaeo ice-sheet simulations. Note that a new initialisation is performed for all combinations of boundary conditions. (b) The transient palaeo simulations are conducted using two climate forcing approaches: a climate index approach (Sutter et al., 2019) or an ice-core forcing based on surface temperature anomalies reconstructed from the EPICA Dome C (EDC) ice core (Jouzel et al., 2007). Note that the climate index is derived from the deuterium record of the EDC ice core (Jouzel et al., 2007). This panel also illustrates the two sea level forcings used in this study (Bintanja and Van de Wal, 2008; Spratt and Lisiecki, 2016). LIG: Last Interglacial. LGM: Last Glacial Maximum. BP: Before Present.

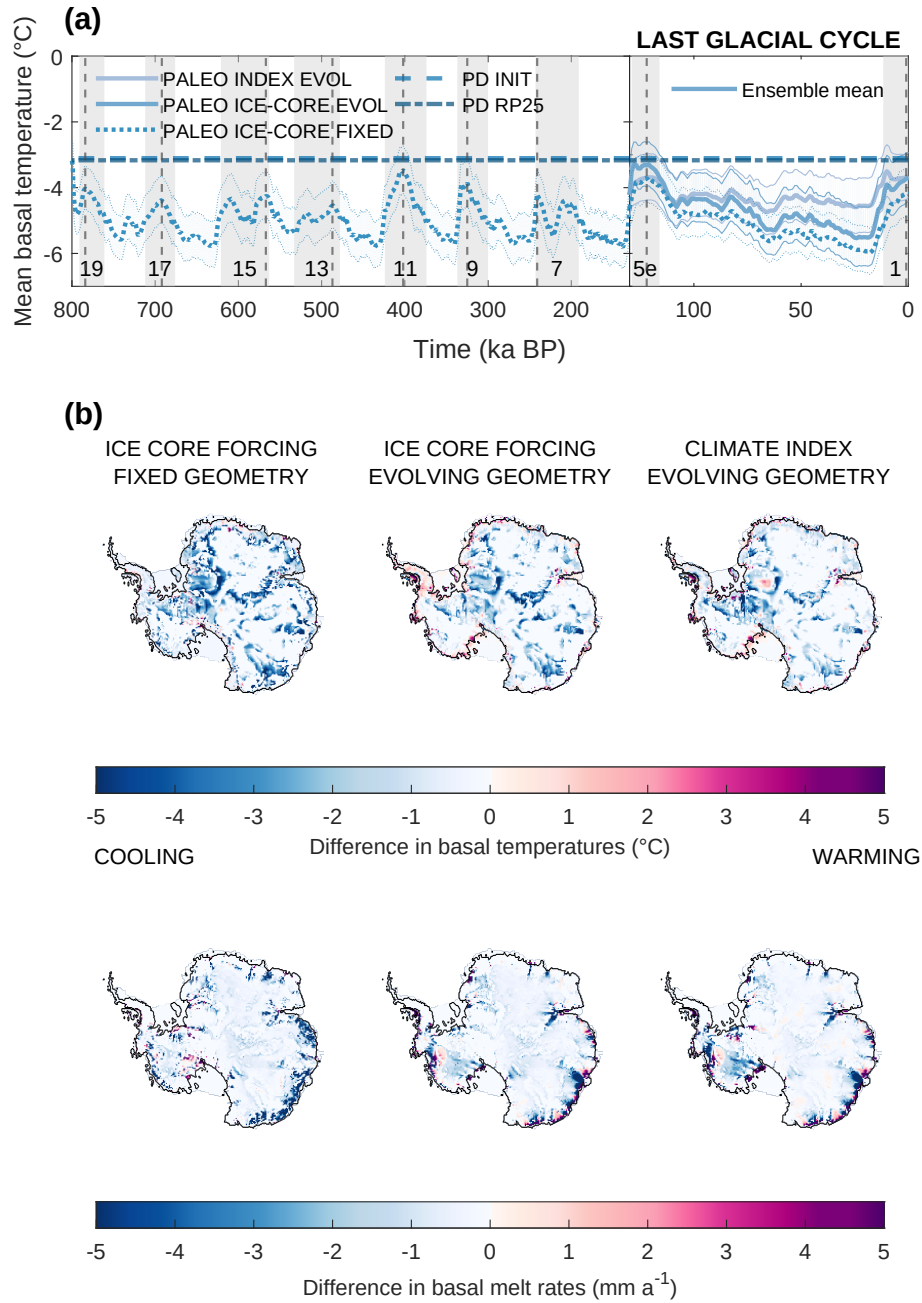


Figure S2. The thermal memory of the Antarctic ice sheet (AIS) and its influence on subglacial thermal conditions (Raspoet et al., 2026). (a) Evolution of the mean basal temperature of the Antarctic ice sheet over the last 800 ka conducted with the ice core forcing and fixed ice sheet geometry (diagnostic) experiments (PALEO ICE-CORE FIXED), and over the last 130 ka with the palaeo simulations with evolving ice sheet geometry presented in the main manuscript (PALEO ICE-CORE EVOL, PALEO INDEX EVOL). Results are compared with simulations considering a thermal steady state (PD INIT; RP25; Raspoet and Pattyn, 2025). (b) Differences in present-day basal temperatures and melt rates between results from the palaeo simulations (at 0 ka BP) and corresponding thermal steady state estimates. Results show that significant cooling can occur in some regions inland of the ice sheet, challenging the thermal steady-state assumption. Transient diagnostic model runs with fixed ice sheet geometry satisfactorily reproduce the spatial pattern and magnitude of changes in both basal temperatures and melt rates at reduced computational costs and with limited misfits in the present-day geometry compared to full evolving palaeo simulations, making it a promising palaeo spin-up approach to combine with present-day inversion-based ice sheet model initialisations (Raspoet et al., in prep).

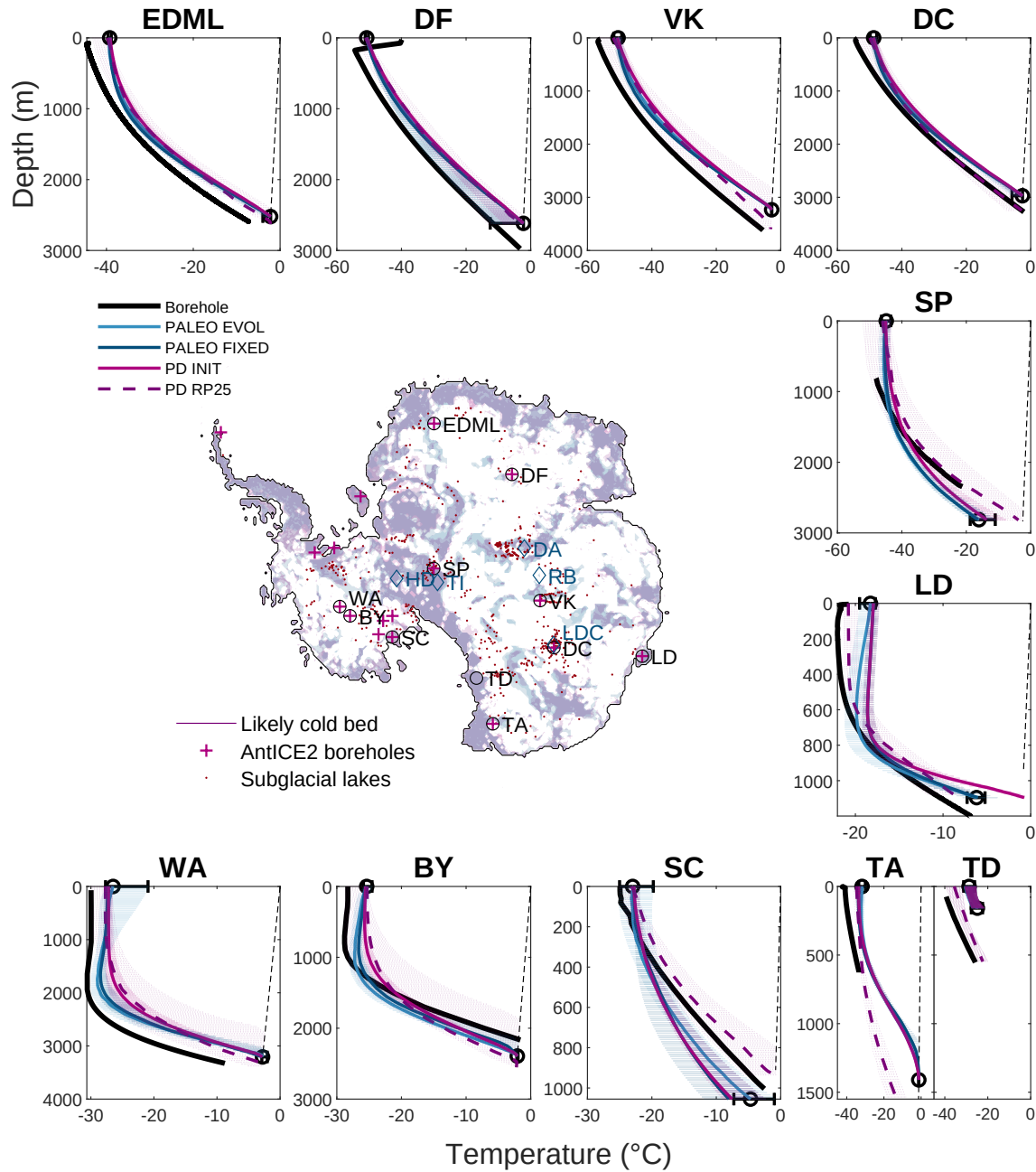


Figure S3. The thermal memory of the Antarctic ice sheet and its influence on englacial temperatures (Raspoet et al., 2026). Comparison of modelled temperature profiles (coloured profiles) with borehole measurements (black profiles). The panel with the Antarctic map highlights likely cold-based areas for present-day (PD; 0 ka BP) estimated by simulations assuming a thermal steady state (PD INIT; PD RP25) or accounting for the influence of transient palaeo-climatic evolution (PALEO EVOL; PALEO FIXED). Results are compared with those of Raspoet and Pattyn (2025) (RP25). Subglacial lakes (Livingstone et al., 2022) are indicated by red dots and represent likely temperate basal conditions (i.e., ice-bed interface at the pressure melting point). The location of borehole measurements from AntICE2 (Lecavalier et al., 2023, 2022) are indicated by pink crosses. Results show that results from the palaeo simulations are associated with more areas exhibiting likely cold basal conditions. However, some location seems to be close to thermal steady-state (e.g., Dome Fuji). Overall, the ensemble of modelled temperature profiles aligns well with those from borehole measurements. Results are shown by the ensemble median along with the 5-95% interval (bounded profiles). The thin dotted black lines represent the pressure melting point temperatures for each profile given the local ice thickness. (Raspoet et al., in prep)

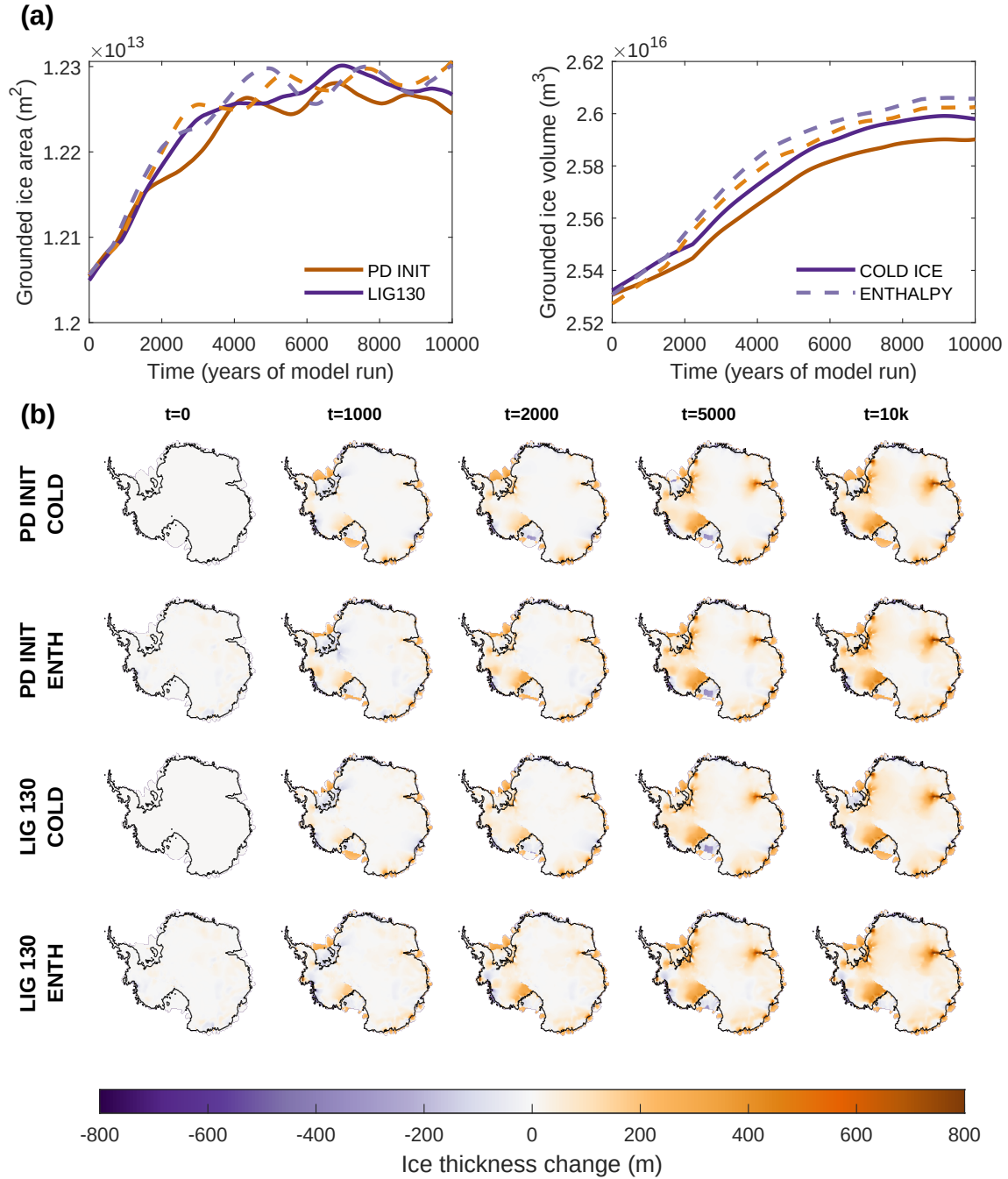


Figure S4. Evaluation of model drift under a control run (constant climatic condition during 10 ka) conducted after a present-day initialisation (PD INIT) and after the LIG snapshot at 130 ka BP from the diagnostic palaeo spin up (LIG 130). (a) Evolution of the grounded ice area and volume during control simulations. (b) Ice thickness change relative to the present-day ice sheet geometry from the initialisation runs. Results show similar model drift under both initialisation approaches, as well as with enthalpy (ENTH) and cold-ice (COLD) thermodynamic solvers. The control simulations are conducted without bedrock adjustment (no GIA), with initial surface climatic conditions from MAR v3.11 (Kittel et al., 2021), and the GHF of Stål et al. (2021).

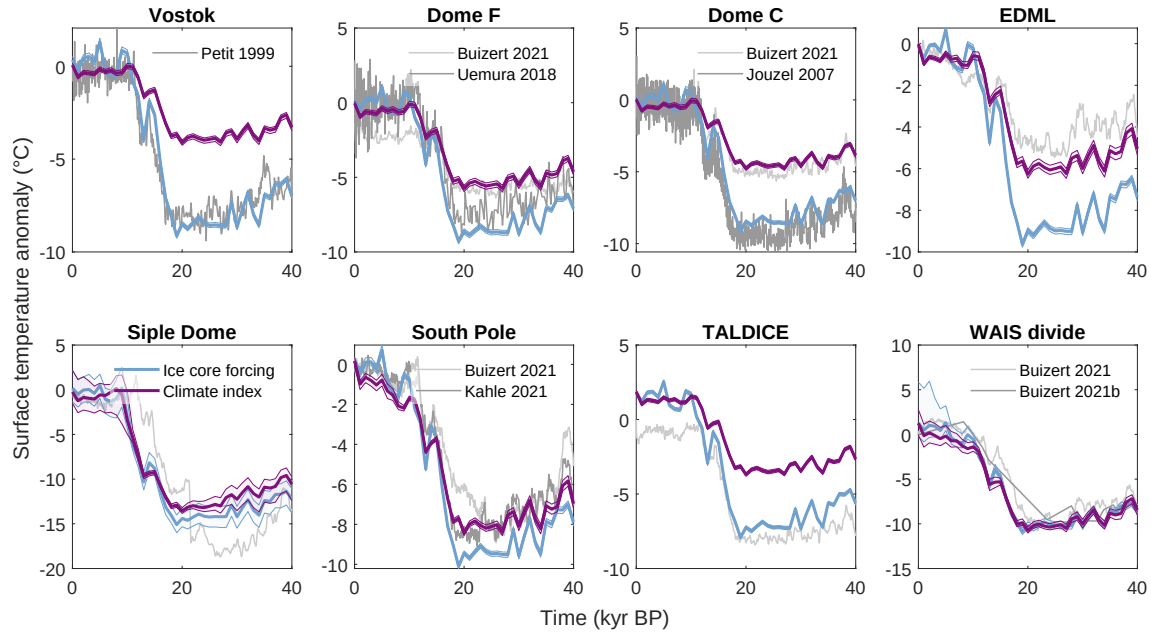


Figure S5. Comparison of surface temperature anomalies (corrected for elevation changes) derived from simulations using the ice core forcing and climate index approaches with ice core reconstructions (Buizert et al., 2021; Buizert, 2021; Kahle et al., 2021; Uemura et al., 2018; Jouzel et al., 2007; Petit et al., 1999). The ice core forcing approach tends to generate surface temperature changes exhibiting an higher amplitude between glacial and contemporary conditions than the climate index approach does.

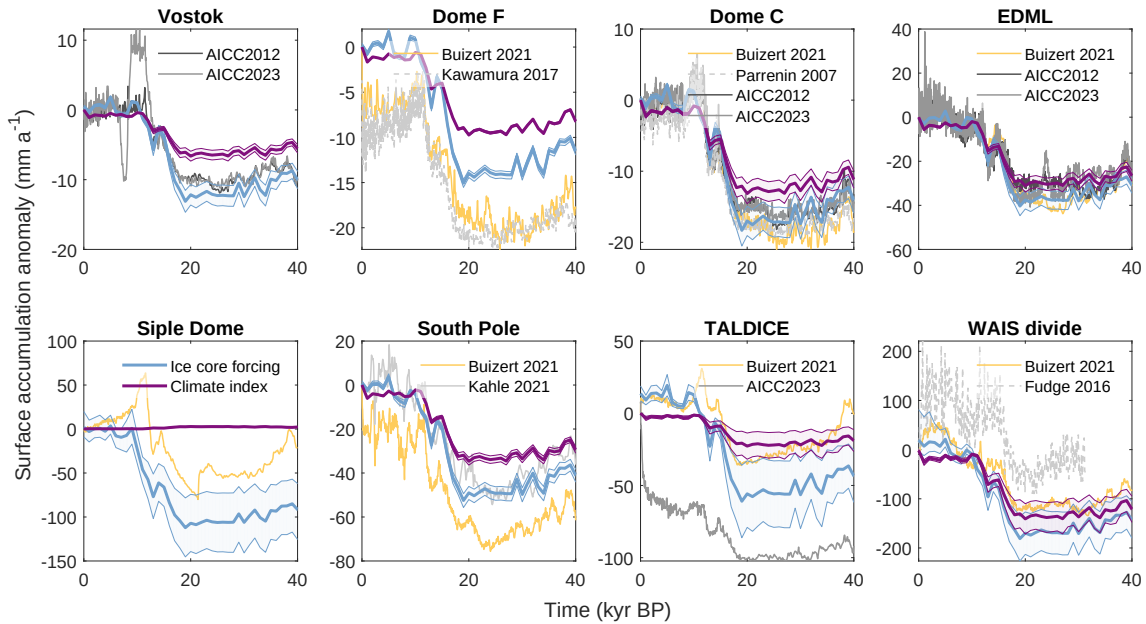


Figure S6. Comparison of surface accumulation rate anomalies derived from simulations using the ice core forcing and climate index approaches with ice core reconstructions (Bouchet et al., 2023; Buizert et al., 2021; Kahle et al., 2021; Kawamura et al., 2017; Fudge et al., 2016; Bazin et al., 2013; Parrenin et al., 2007). Note that the references for AICC2012 and AICC2023 are Bazin et al. (2013) and Bouchet et al. (2023), respectively.

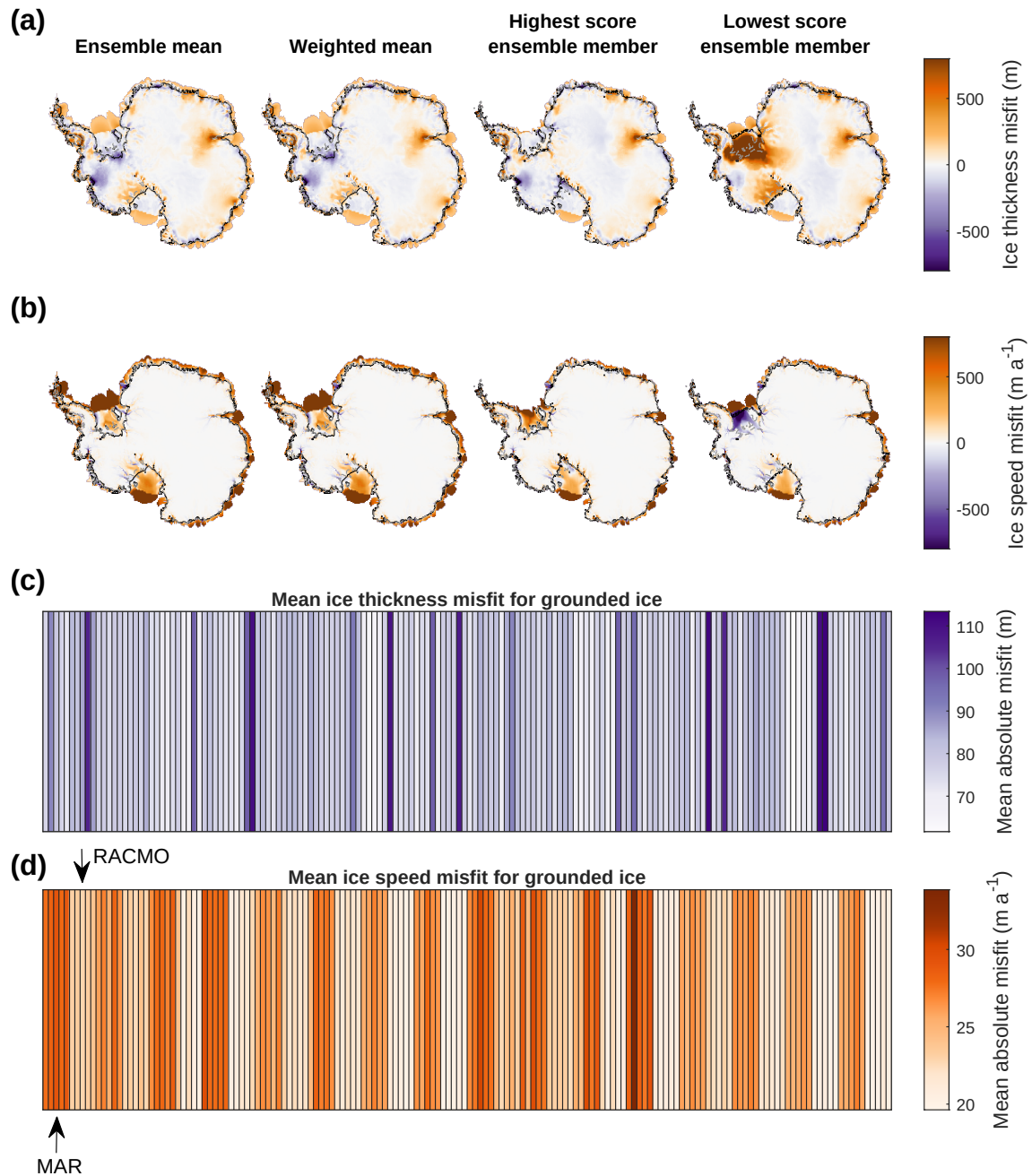


Figure S7. Misfits between modelled results and observational constraints for present-day conditions (i.e., 0 ka BP). (a) Ice thickness misfit with respect to BedMachine v3 (Morlighem, 2022; Morlighem et al., 2020). (b) Ice speed misfit with respect to MEaSUREs surface velocities (Mouginot et al., 2019a, b). (c-d) Absolute misfit between modelled and observed ice thickness and speed, used to compute M_3 and M_5 , respectively (Appendix A). Simulations in the heatmap are ordered as follows: the five GHF datasets are alternated every simulations (Shen et al., 2020; Martos et al., 2017; Stål et al., 2021; Lösing and Ebbing, 2021; Haeger et al., 2022), the surface climatic conditions are changed every 5 simulations (Kittel et al., 2021; van Wessem et al., 2018, MAR and RACMO); the thermodynamic model is changed every 10 simulations (cold-ice and enthalpy models), the climate forcing approach is changed every 20 simulations (climate index and ice core forcing approaches), the sea level forcing is changed every 40 simulations (Spratt and Lisiecki, 2016; Bintanja and Van de Wal, 2008), and the GIA relaxation times are varied every 80 simulations (GIAS and GIAW).

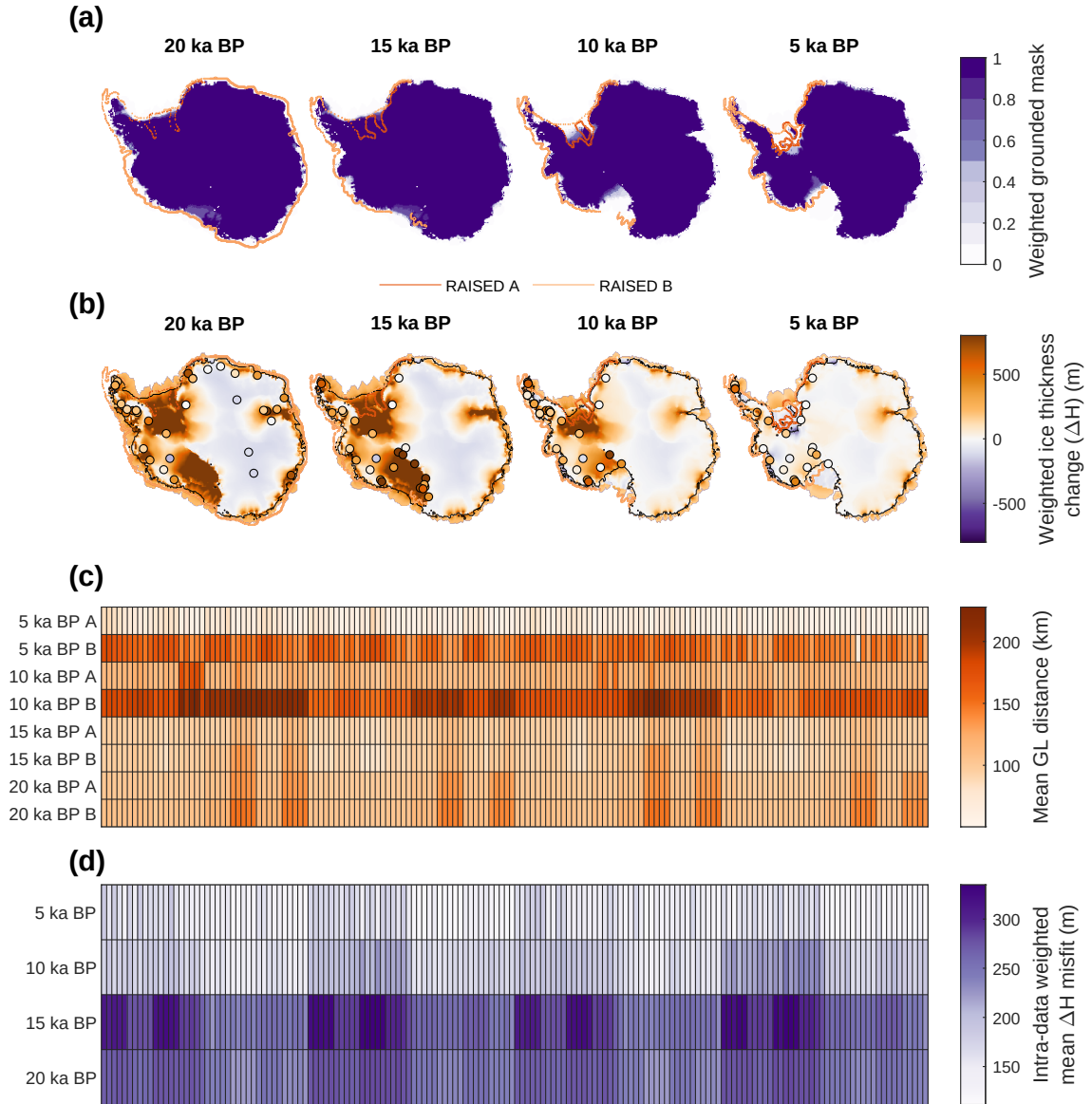


Figure S8. Comparison of the ensemble with the reconstruction of the Antarctic ice sheet deglaciation (RAISED consortium; Bentley et al., 2014). (a) Grounding line extent for scenarios A and B superposed on the weighted grounded mask. A value of 1 indicates that all simulations predict the presence of grounded ice at that location. (b) Ice thickness change above present-day elevation (m) for the ensemble weighted mean compared to reconstructions from the RAISED consortium. (c) Absolute distance between modelled and reconstructed grounding line positions from RAISED, used to calculate M_6 (Appendix A). (d) Absolute misfit between modelled and reconstructed ice thickness changes, used to calculate M_7 (Appendix A). Simulations in the heatmap are ordered as explained in the legend of Figure S7.

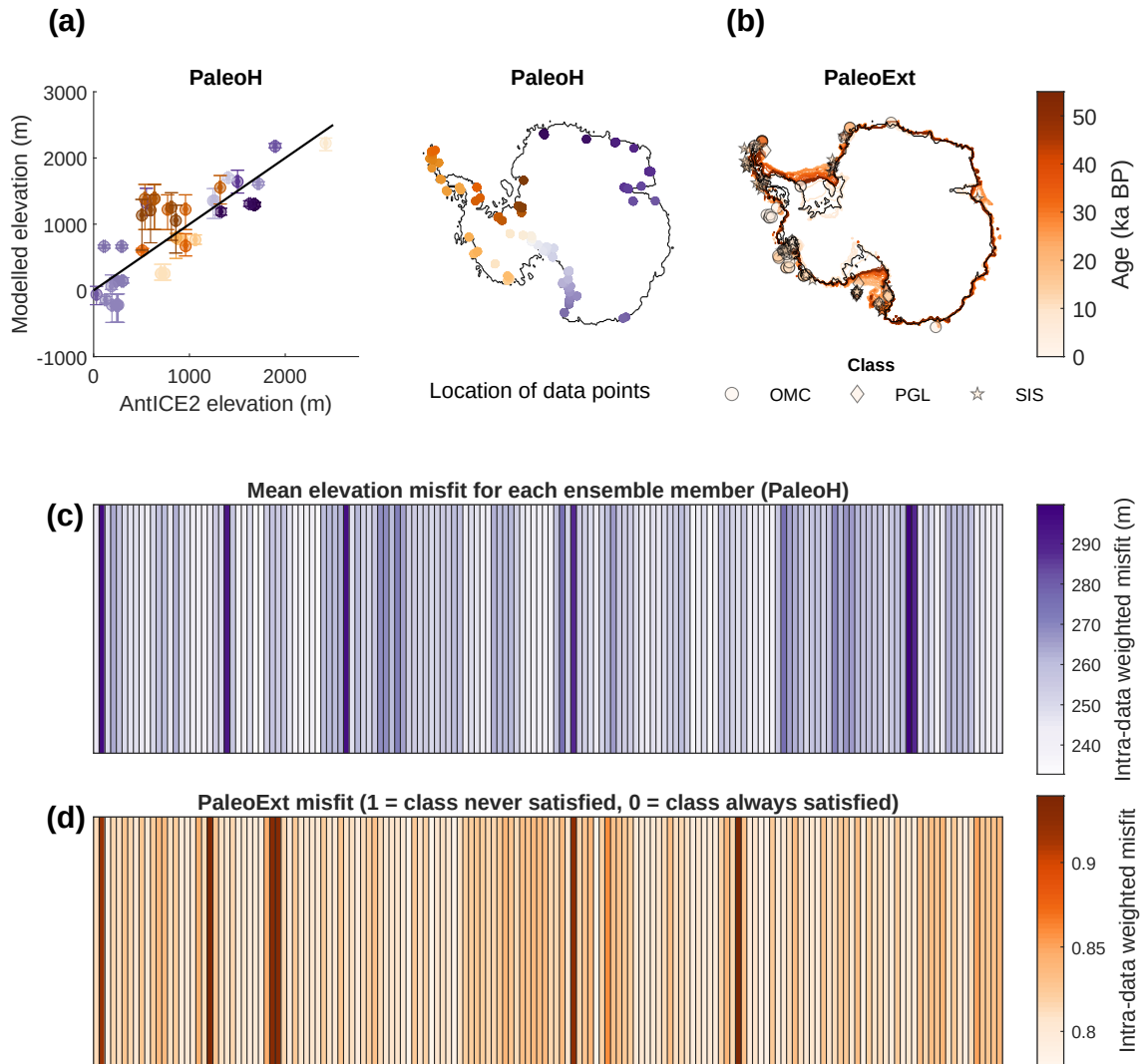


Figure S9. Comparison of modelled results with observational constraints from PaleoH (a) and PaleoExt (b) AntICE2 databases (Lecavalier et al., 2023, 2022). (a) Modelled and observed elevations from AntICE2 for all data points of various ages. The error bars represent the model spread (vertical) and the observational uncertainty (horizontal). (b) Proxy records for various conditions (OMC: Open Marine Conditions, PGL: Proximal Grounding Line, SIS: Sub Ice Shelf) and ages. Comparison with the ensemble weighted mean grounding line position over time. (c-d) Absolute misfits with respect to the observational constraints, used to calculate M_8 and M_9 , respectively (Appendix A). Simulations in the heatmap are ordered as explained in the legend of Figure S7.

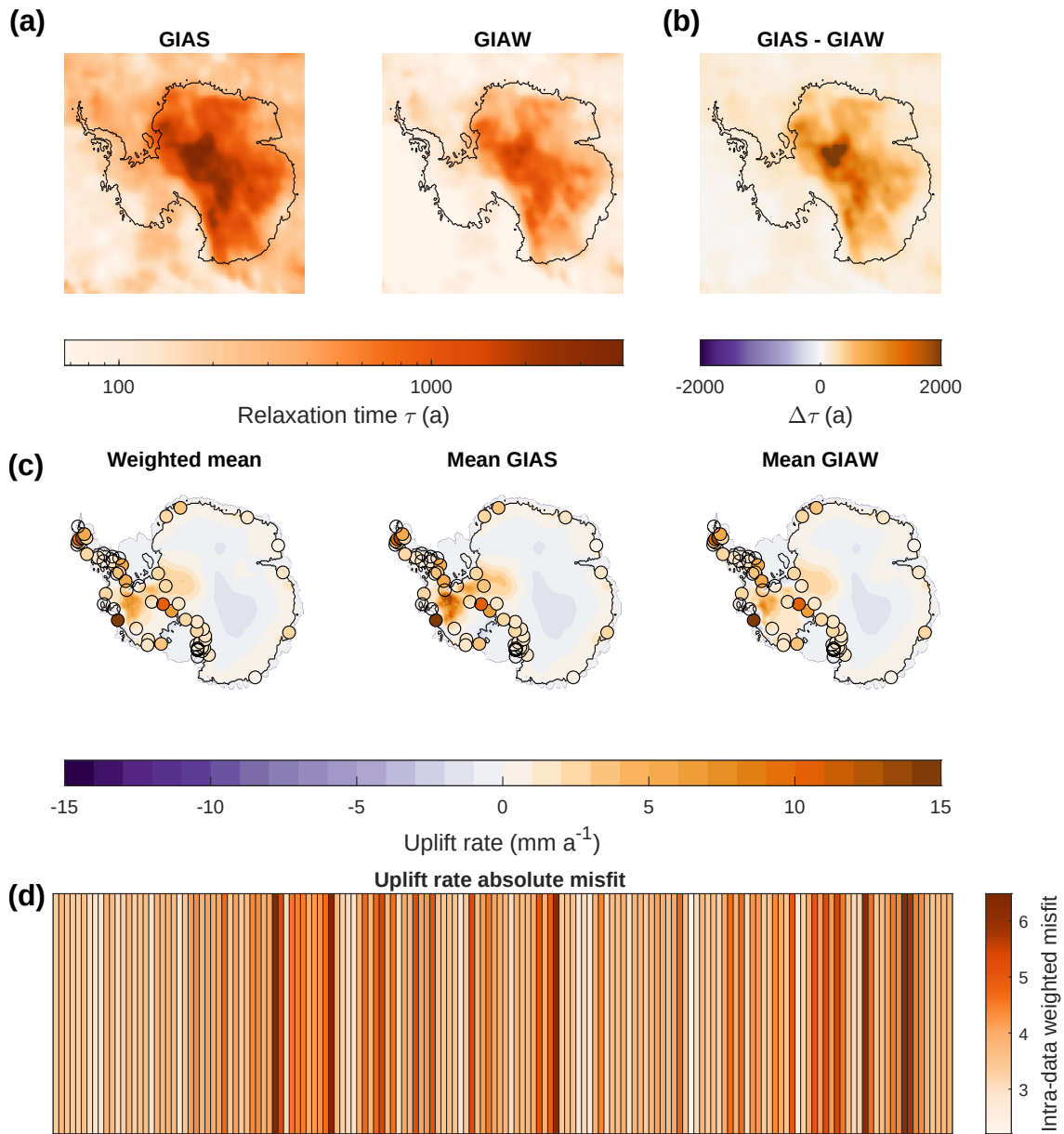


Figure S10. Glacial isostatic adjustment (GIA). (a) Relaxation times (years) from van Calcar et al. (2026) used in the ELRA model (Coulon et al., 2021). (b) Differences in relaxation times between stronger (GIAS) and weaker (GIAW) Earth structures. (c) Comparison of modelled uplift rate and observational constraints from AntICE2 (Lecavalier et al., 2023, 2022). (d) Absolute misfit with respect to the AntICE2 database used to calculate M_{10} (Appendix A). Simulations in the heatmap are ordered as explained in the legend of Figure S7.

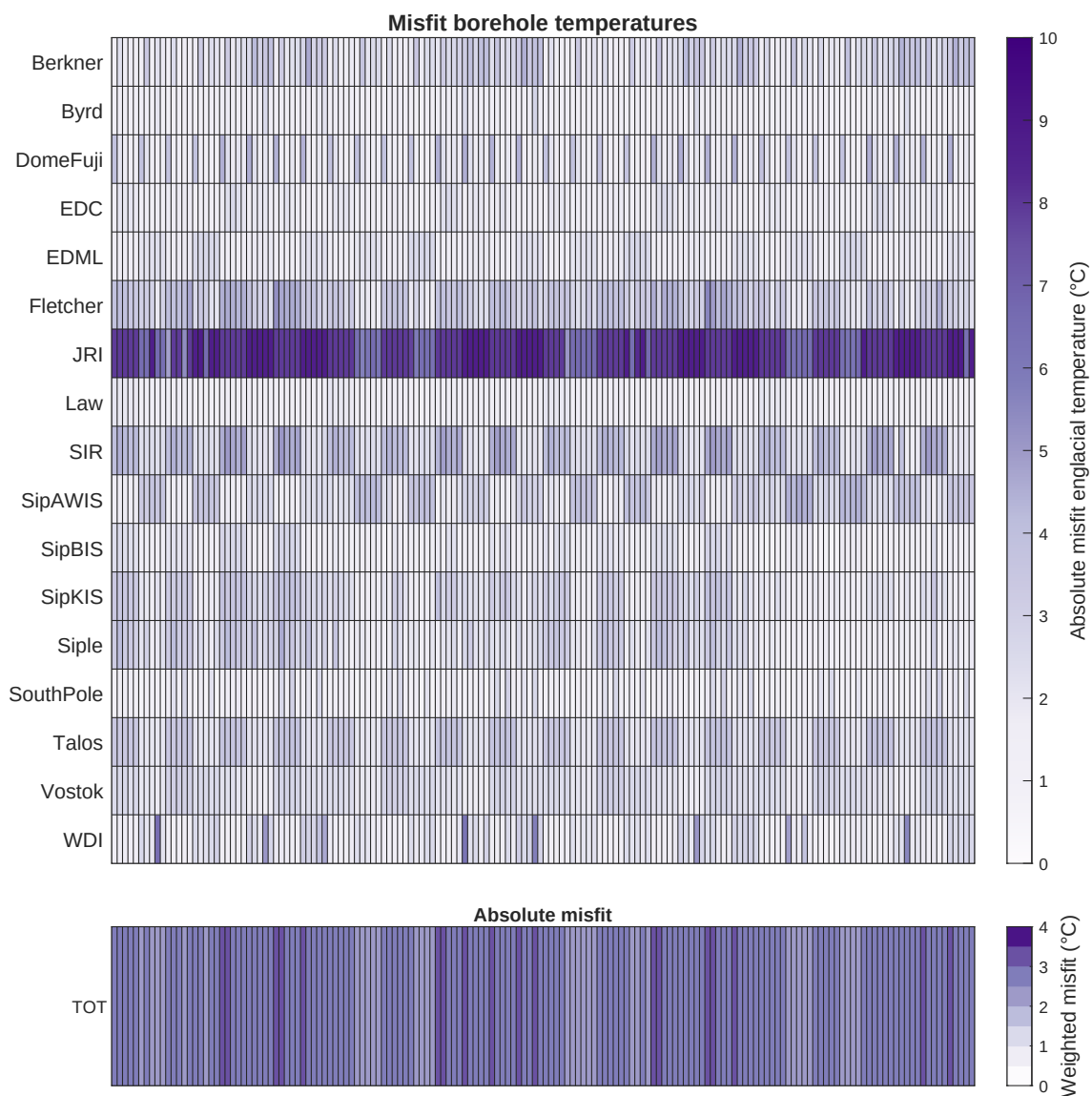


Figure S11. Vertically-integrated misfits between modelled temperature profiles and borehole measurements from AntICE2 (Lecavalier et al., 2023, 2022). Absolute misfits are presented for each profile along with the total absolute misfit used to calculate M_{11} (Appendix A). The location of AntICE2 boreholes are also displayed in Figure S3. Simulations in the heatmap are ordered as explained in the legend of Figure S7.

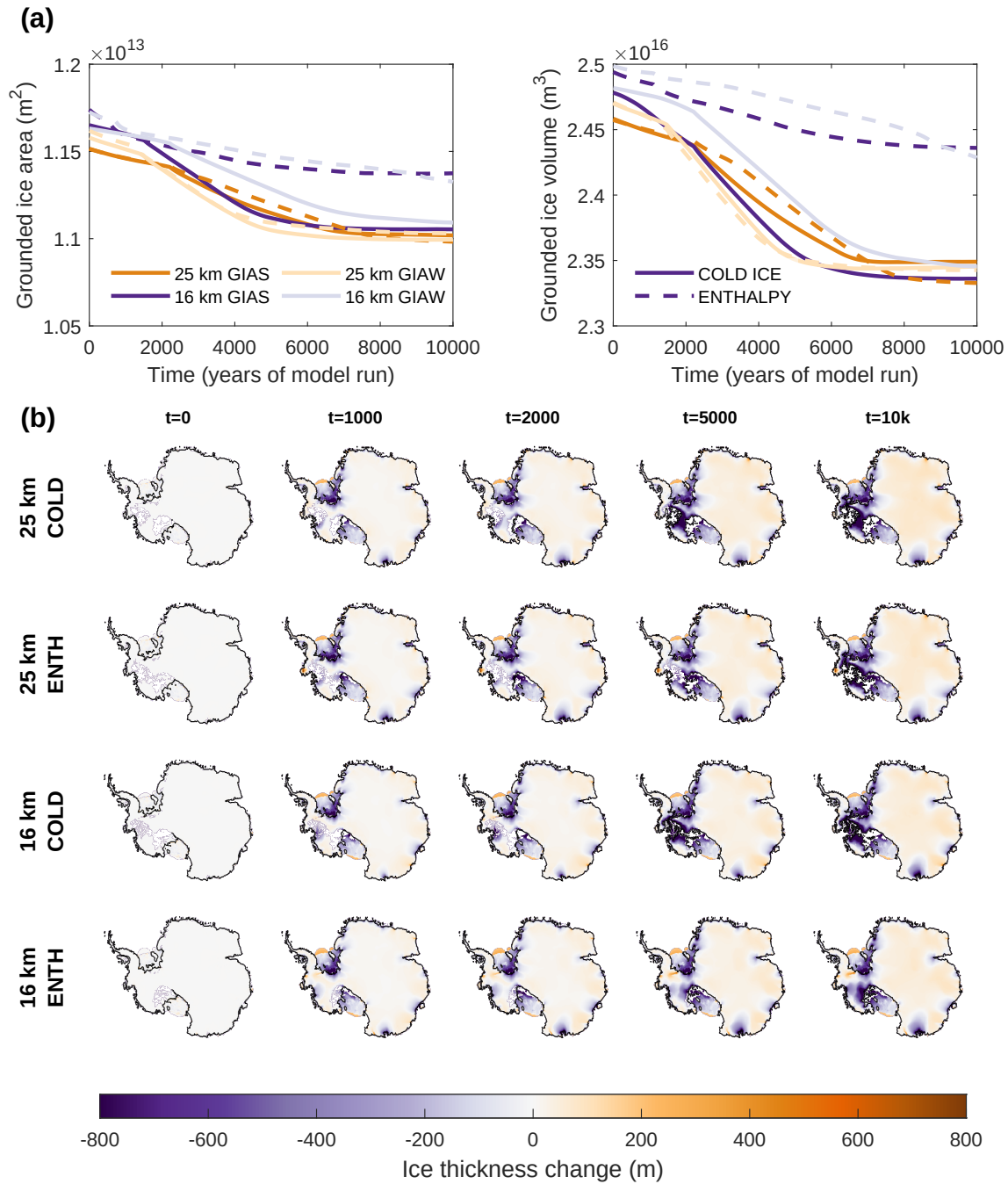


Figure S12. Results from the spatial-resolution-sensitivity experiments. Simulations are conducted for 10 ka using both 25 and 16 km resolution and forced by constant LIG (Last Interglacial) conditions ($\Delta T_s = 5^\circ\text{C}$, $\Delta SL = 2$ m, representing the maximum amplitude changes recorded for the LIG in our forcing framework, e.g., Figure S1). The experiments start after the relaxation run performed after the inverse run of the initialisation procedure. Simulations are conducted with the initial surface climatic conditions from MAR v3.11 (Kittel et al., 2021), the GHF of Stål et al. (2021), and both GIAS and GIAW (van Calcar et al., 2026), though only runs using the GIAS configuration are shown in (b) for conciseness.

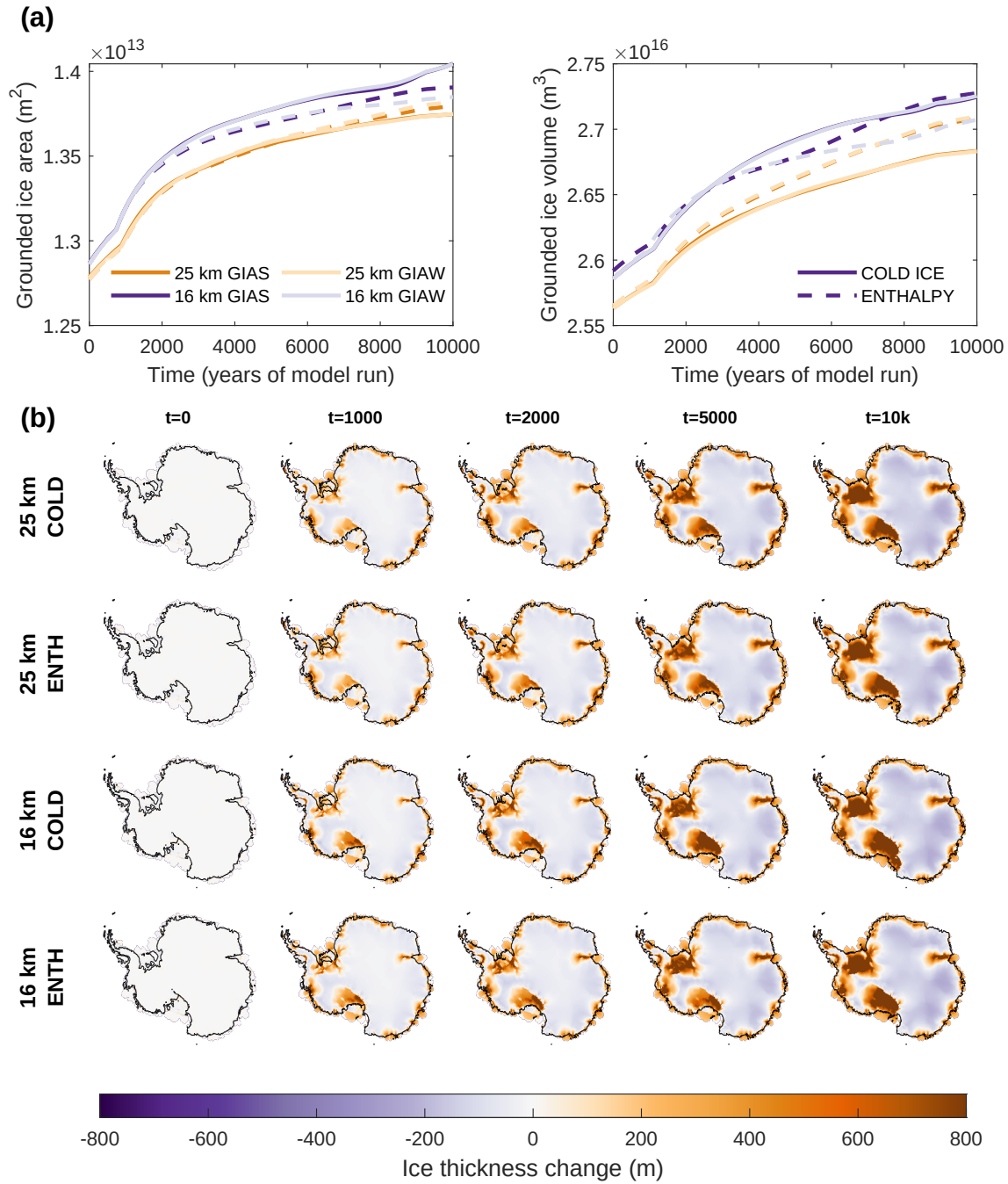


Figure S13. Results from the spatial-resolution-sensitivity experiments. Simulations are conducted for 10 ka using both 25 and 16 km resolution and forced by constant LGM (Last Glacial Maximum) conditions ($\Delta T_s = -10^\circ\text{C}$, $\Delta SL = -120$ m, representing the maximum amplitude changes recorded for the LGM in our forcing framework, e.g., Figure S1). The experiments start after the relaxation run performed after the inverse run of the initialisation procedure. Simulations are conducted with the initial surface climatic conditions from MAR v3.11 (Kittel et al., 2021), the GHF of Stål et al. (2021), and both GIAS and GIAW (van Calcar et al., 2026), though only runs using the GIAS configuration are shown in (b) for conciseness.

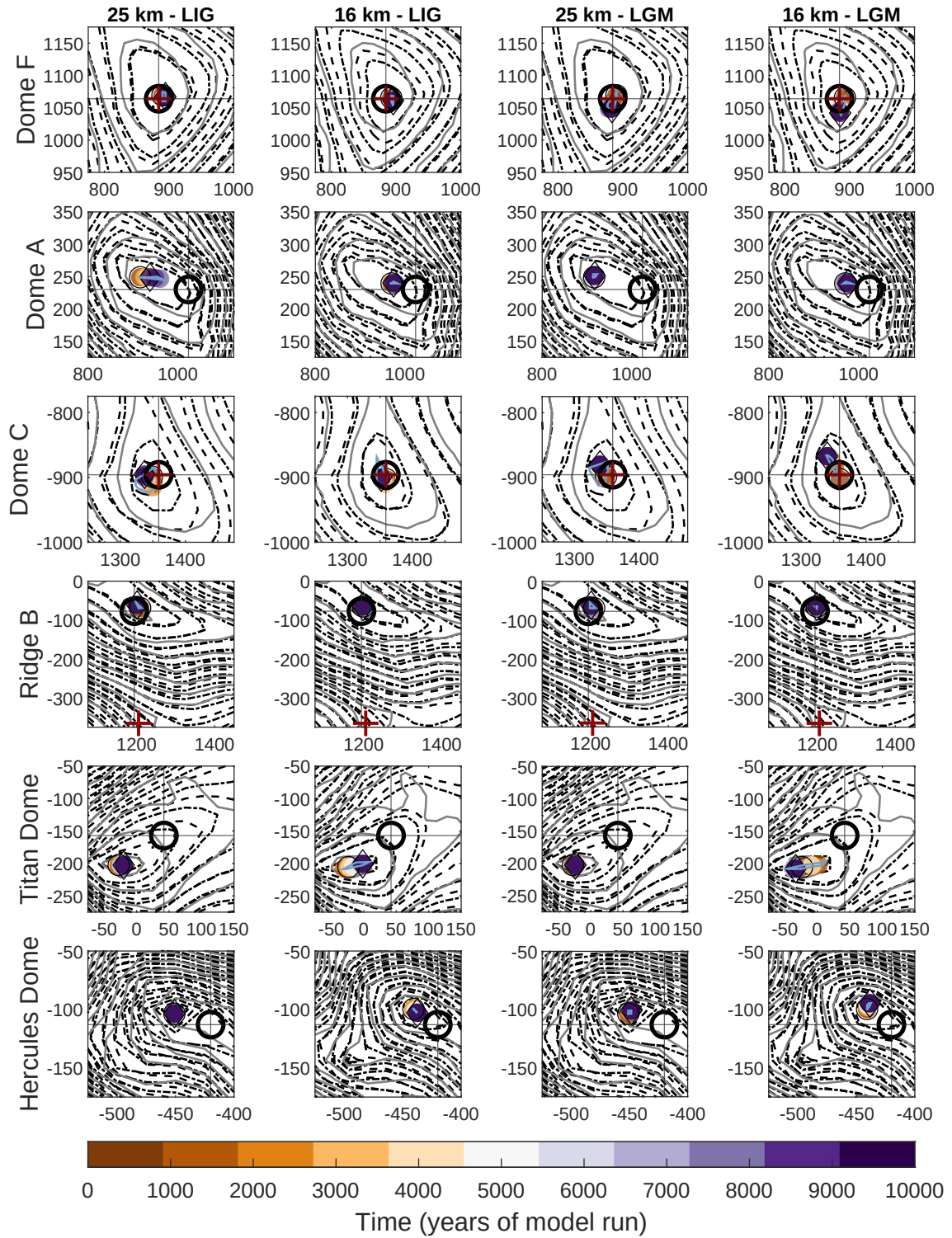


Figure S14. Dome migration resulting from the 25 and 16 km spatial resolution experiments. Similar to Figure 2 (in the main manuscript), the grey contour shows the present-day surface elevation (BedMachine v3; Morlighem et al., 2020; Morlighem, 2022), the dotted and dashed black contours indicate initial (at 0 ka BP) and final elevations, respectively, and the evolution of the dome position in time is shown in colours. The experimental setup of the spatial-resolution sensitivity experiments is explained in the captions of Figures S12–S13.

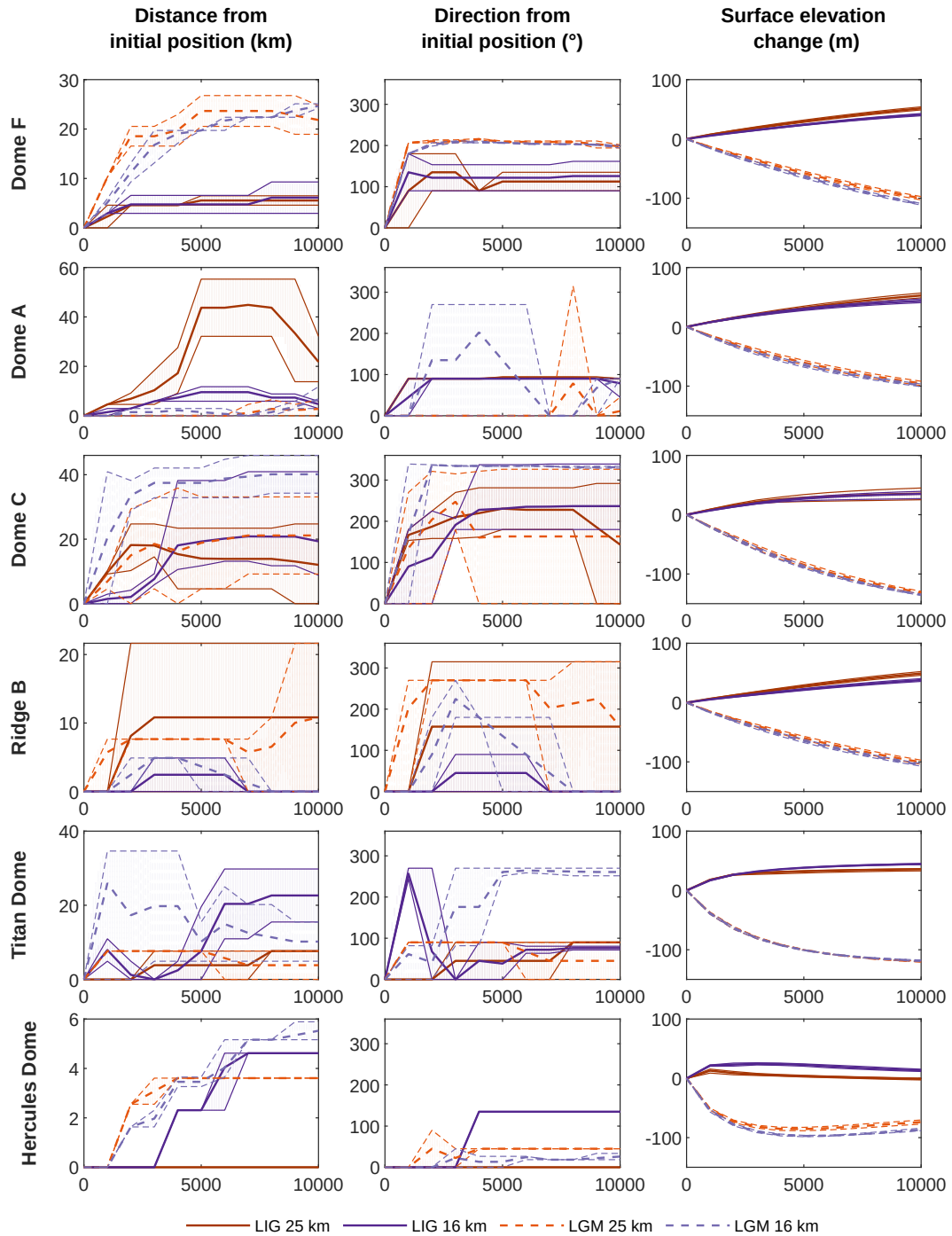


Figure S15. Dome migration and elevation changes at each dome location for 25 and 16 km spatial resolution experiments (shown in orange and purple, respectively). The experimental setup of the spatial-resolution sensitivity experiments is explained in the captions of Figures S12–S13. While results show convergence in surface elevation changes, the distance and direction from the initial dome position at 0 ka BP vary between the 25 and 16 km experiments, although they remain mostly of the same order of magnitude.

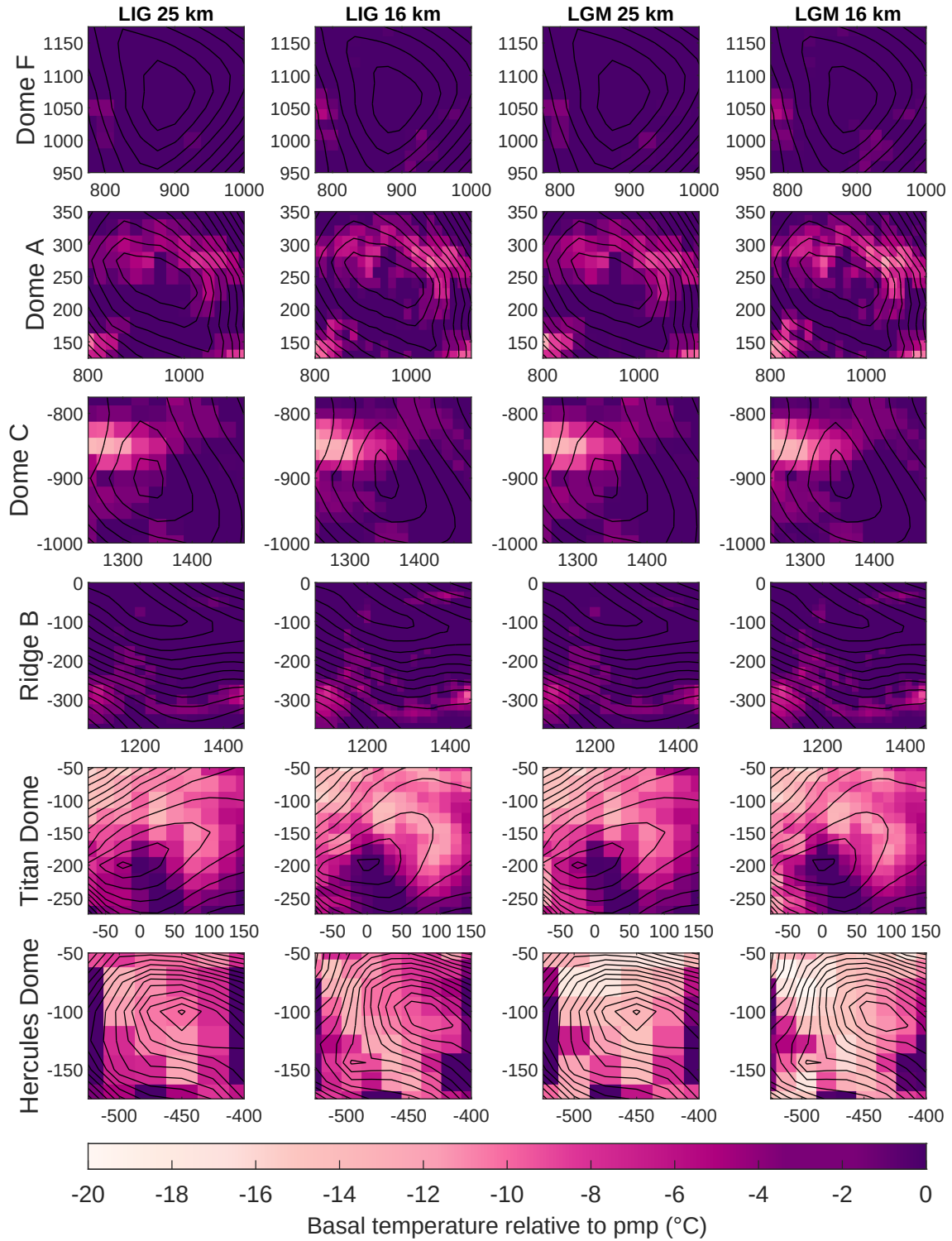


Figure S16. Basal temperatures relative to the pressure melting point (pmp) at the end of the 25 and 16 km spatial resolution sensitivity experiments. Simulations are conducted with the initial surface climatic conditions from MAR v3.11 (Kittel et al., 2021) and the GHF of Stål et al. (2021). The experimental setup of the spatial-resolution sensitivity experiments is explained in the captions of Figures S12–S13.

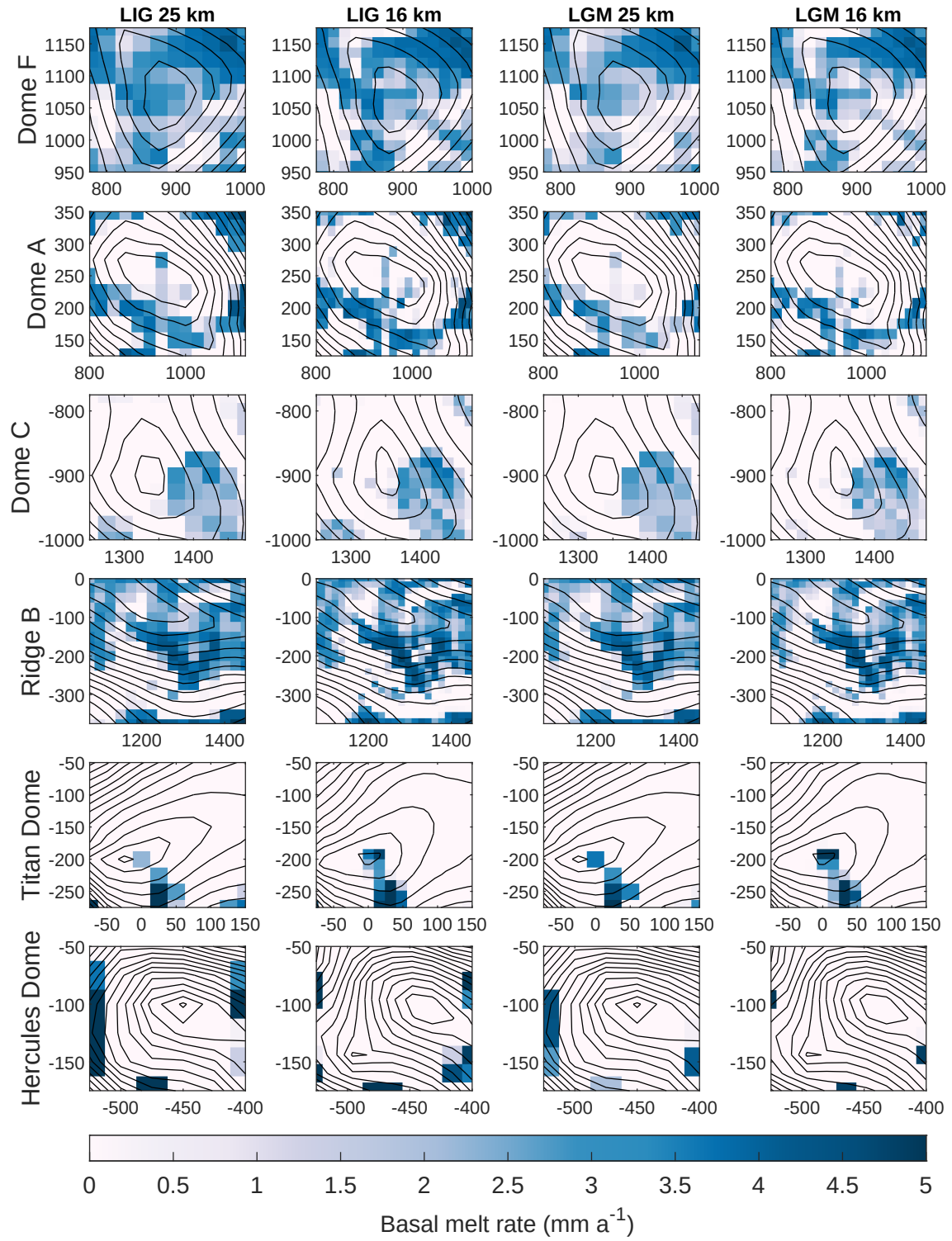


Figure S17. Basal melt rates at the end of the 25 and 16 km spatial resolution sensitivity experiments. Simulations are conducted with the initial surface climatic conditions from MAR v3.11 (Kittel et al., 2021) and the GHF of Stål et al. (2021). The experimental setup of the spatial-resolution sensitivity experiments is explained in the captions of Figures S12–S13.

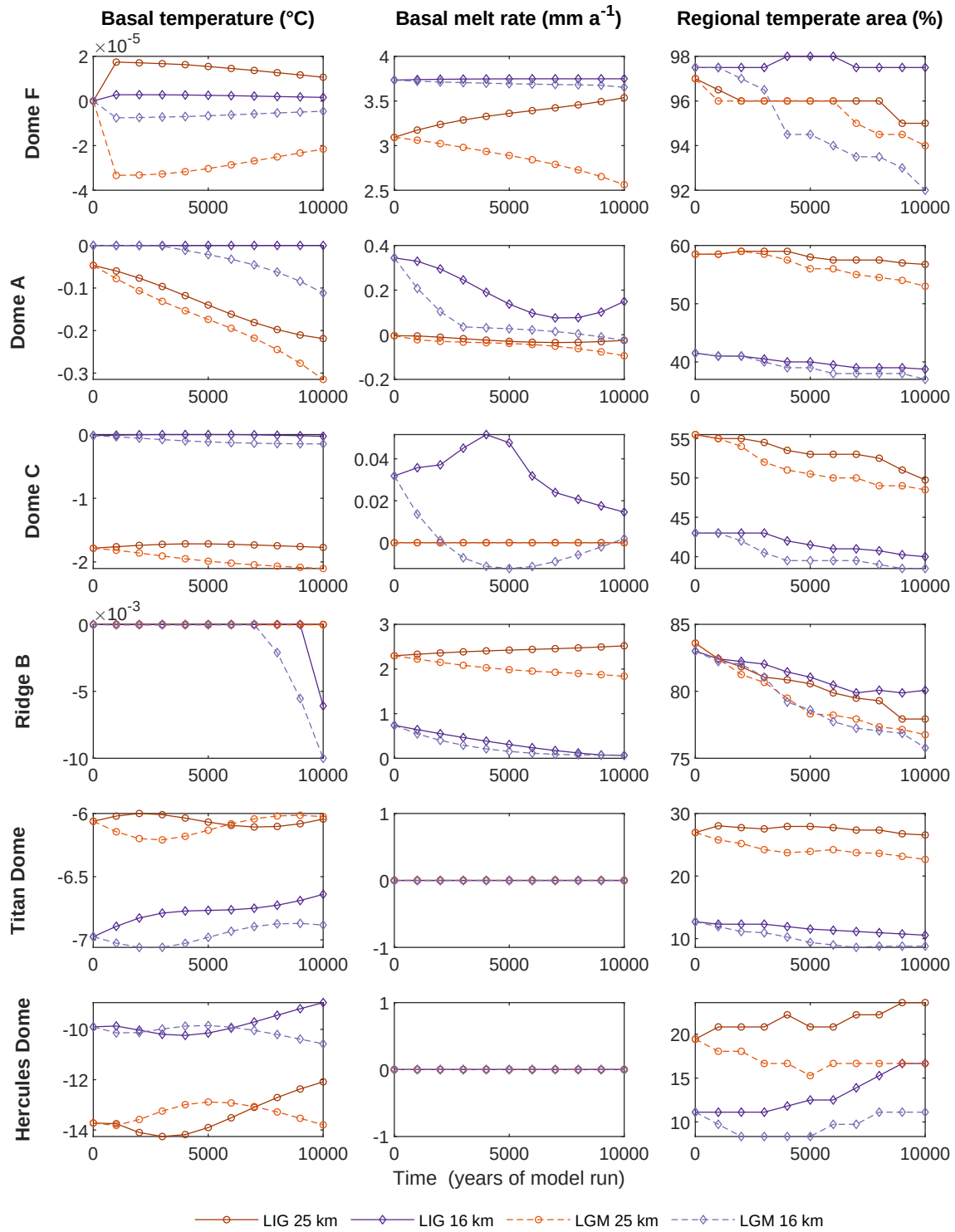


Figure S18. Evolution of basal thermal conditions at dome locations for the 25 and 16 km spatial resolution sensitivity experiments. Simulations are conducted with the initial surface climatic conditions from MAR v3.11 (Kittel et al., 2021) and the GHF of Stål et al. (2021). The experimental setup of the spatial-resolution sensitivity experiments is explained in the captions of Figures S12–S13.

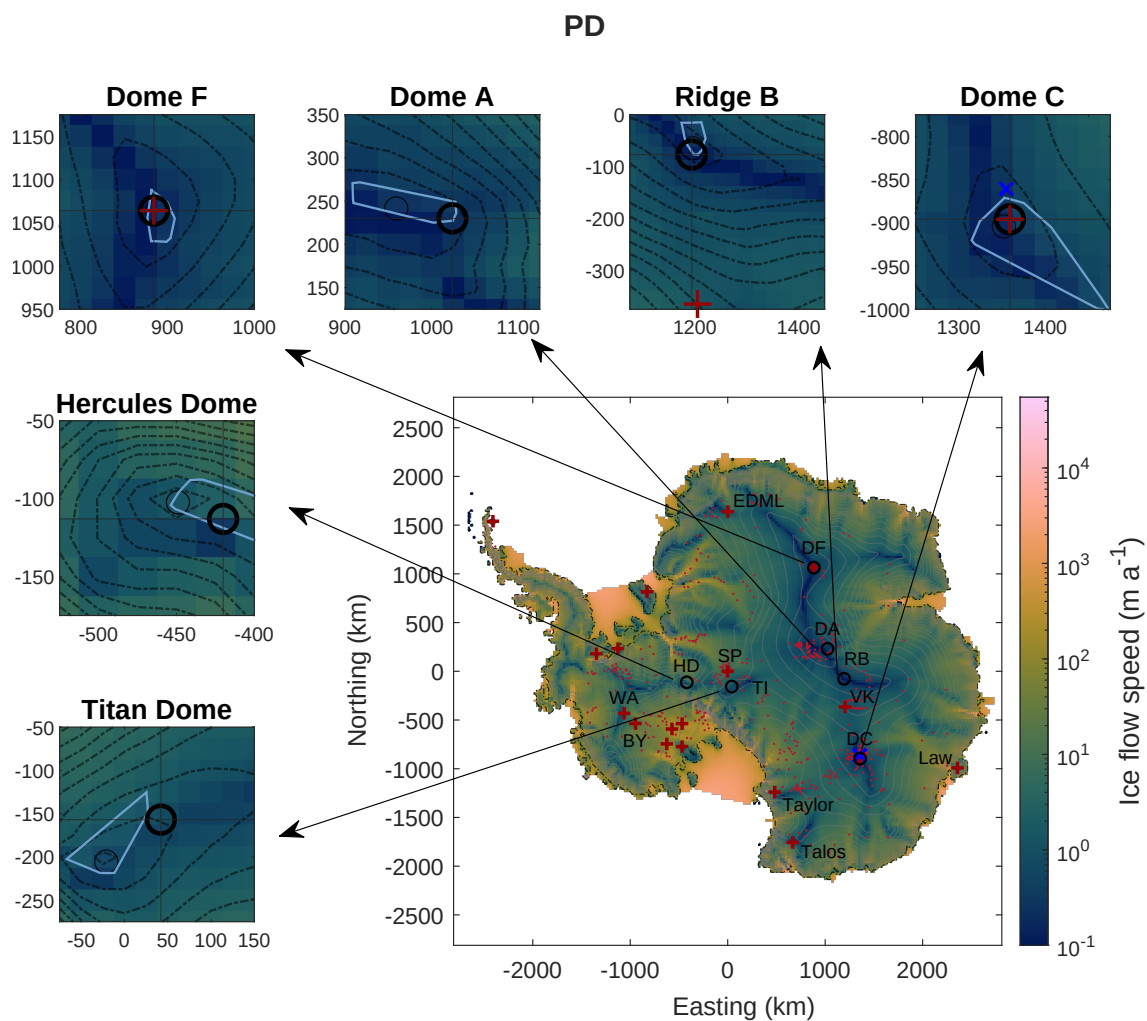


Figure S19. Ensemble mean ice-flow speed obtained from the present-day (PD) initialisation procedure (after relaxation). Results show that the topographic dome coincides closely with the ice divide flow pattern in the studied regions. Red dots highlight the presence of subglacial lakes (Livingstone et al., 2022).

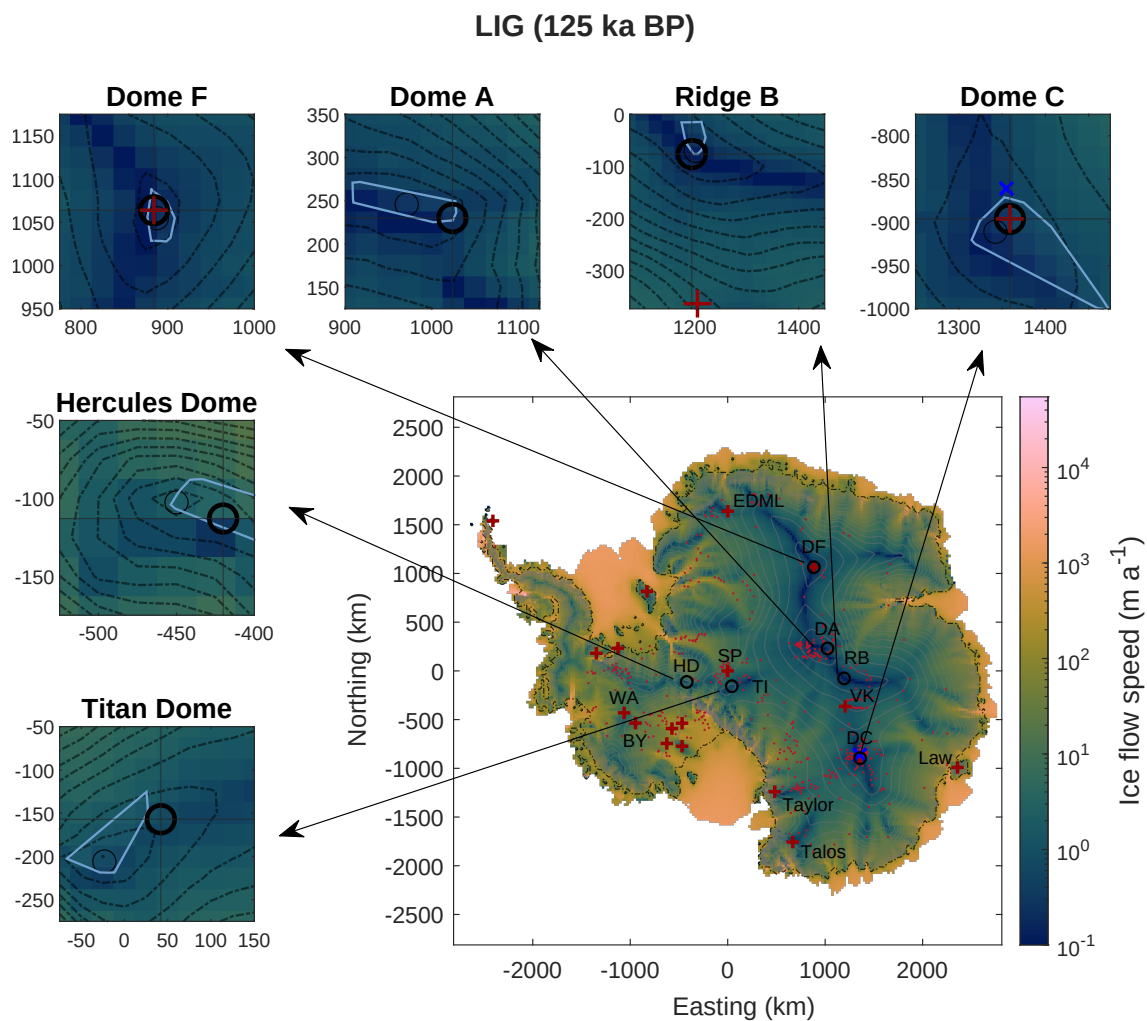


Figure S20. Ensemble mean ice-flow speed at 125 ka BP (i.e., after 5000 years of model run). Results show that the topographic dome coincides closely with the ice divide flow pattern in the studied regions. Compared with the present-day results presented in Figure S19, one can observe a slight migration in the ice flow pattern at Dome A and Dome C. Red dots highlight the presence of subglacial lakes (Livingstone et al., 2022).

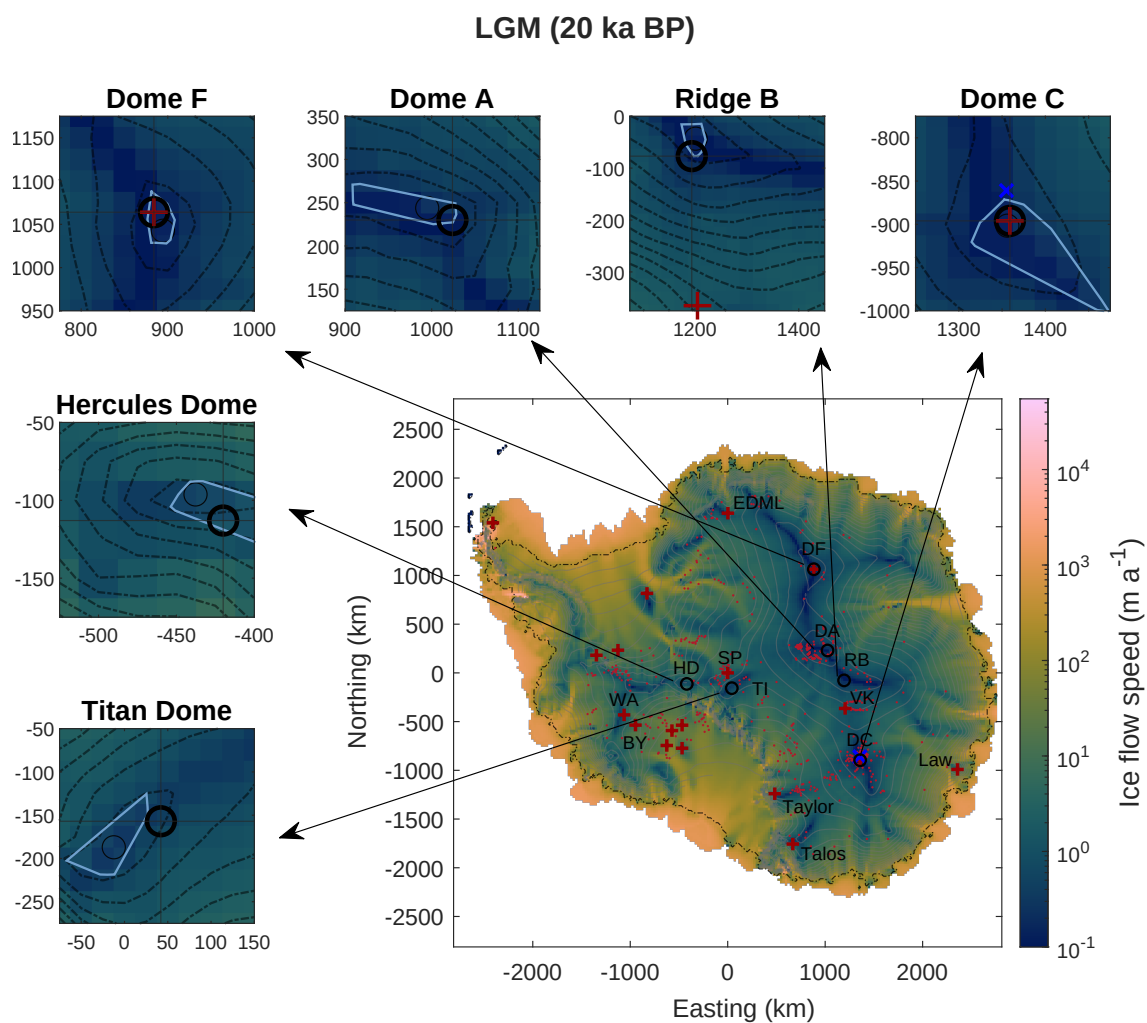


Figure S21. Ensemble mean ice-flow speed at 20 ka BP (LGM). Results show that the topographic dome coincides closely with the ice divide flow pattern in the studied regions. Compared with the LIG results presented in Figure S20, one can observe changes in the ice flow pattern in most of the regions. This change is more pronounced for Titan Dome and Hercules Dome, which are influenced by the migration of the grounding line toward the continental shelf in the WAIS. Red dots highlight the presence of subglacial lakes (Livingstone et al., 2022).

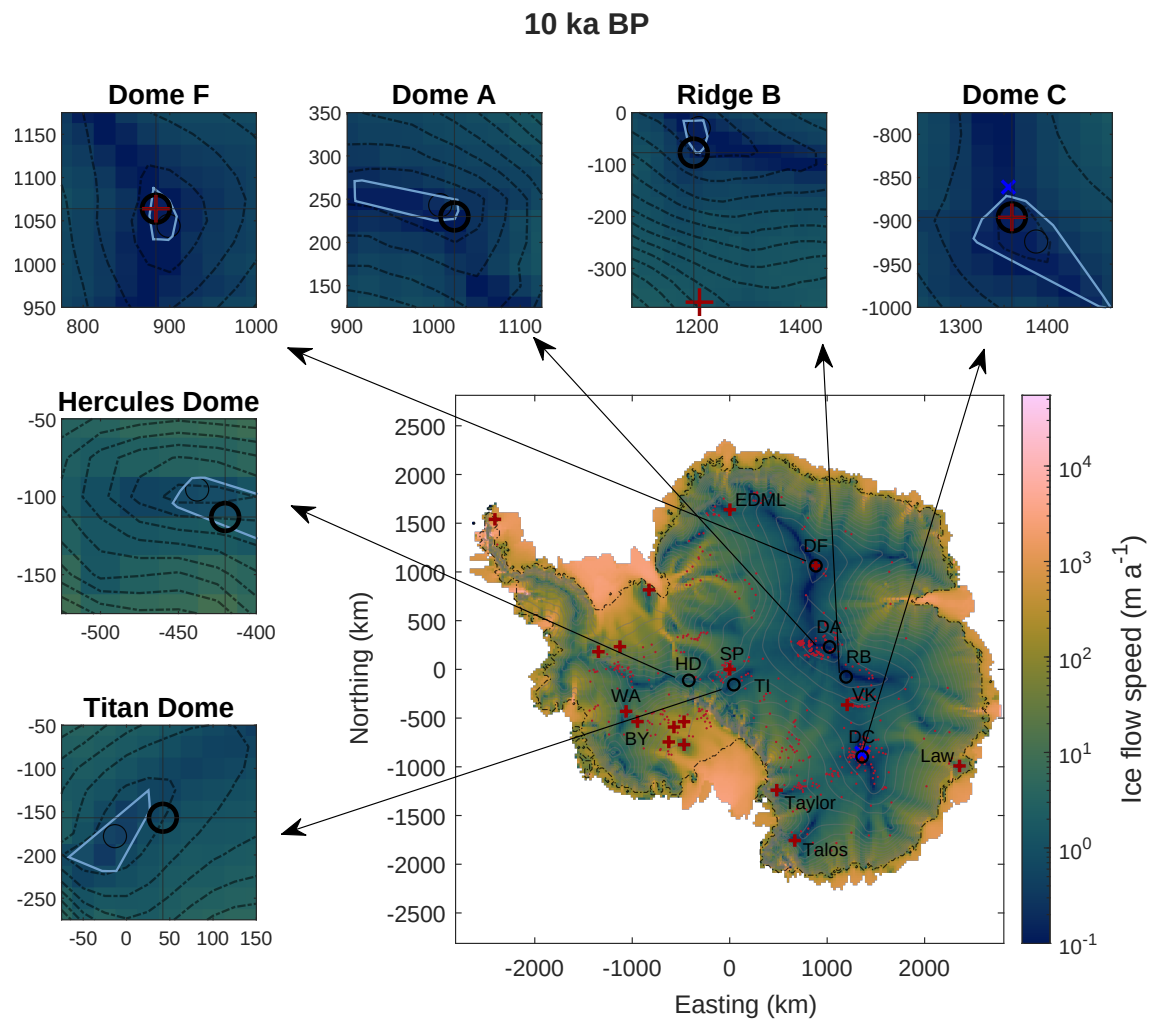


Figure S22. Ensemble mean ice-flow speed at 10 ka BP (Holocene). Results show that the topographic dome coincides closely with the ice divide flow pattern in the studied regions. Compared with the LGM results presented in Figure S21, one can observe changes in the ice flow pattern, notably at Dome C, Ridge B, and Dome A. Red dots highlight the presence of subglacial lakes (Livingstone et al., 2022).

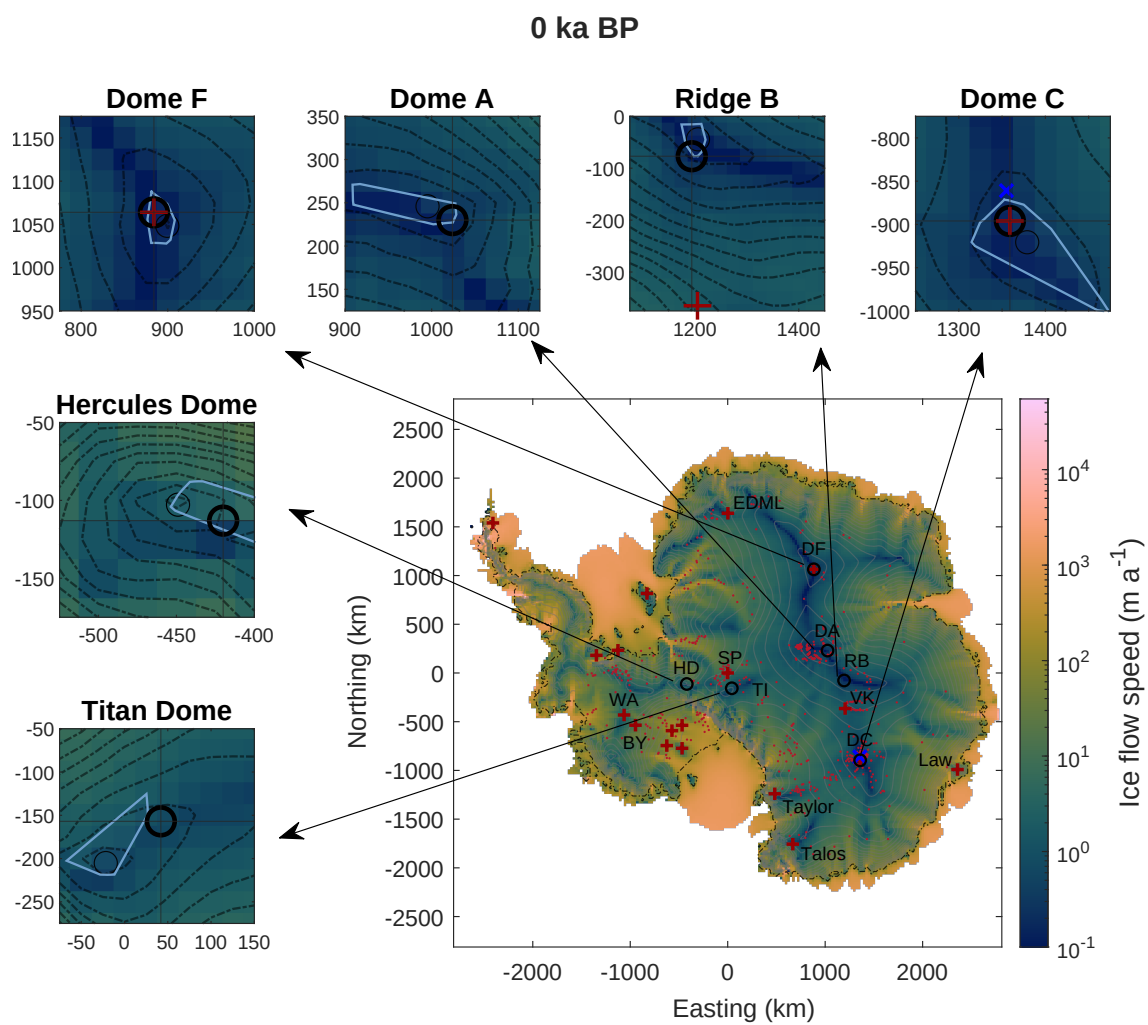


Figure S23. Ensemble mean ice-flow speed at 0 ka BP. Results show that the topographic domes coincide closely with the ice flow divergence pattern in the studied ice-divide regions. Red dots highlight the presence of subglacial lakes (Livingstone et al., 2022).

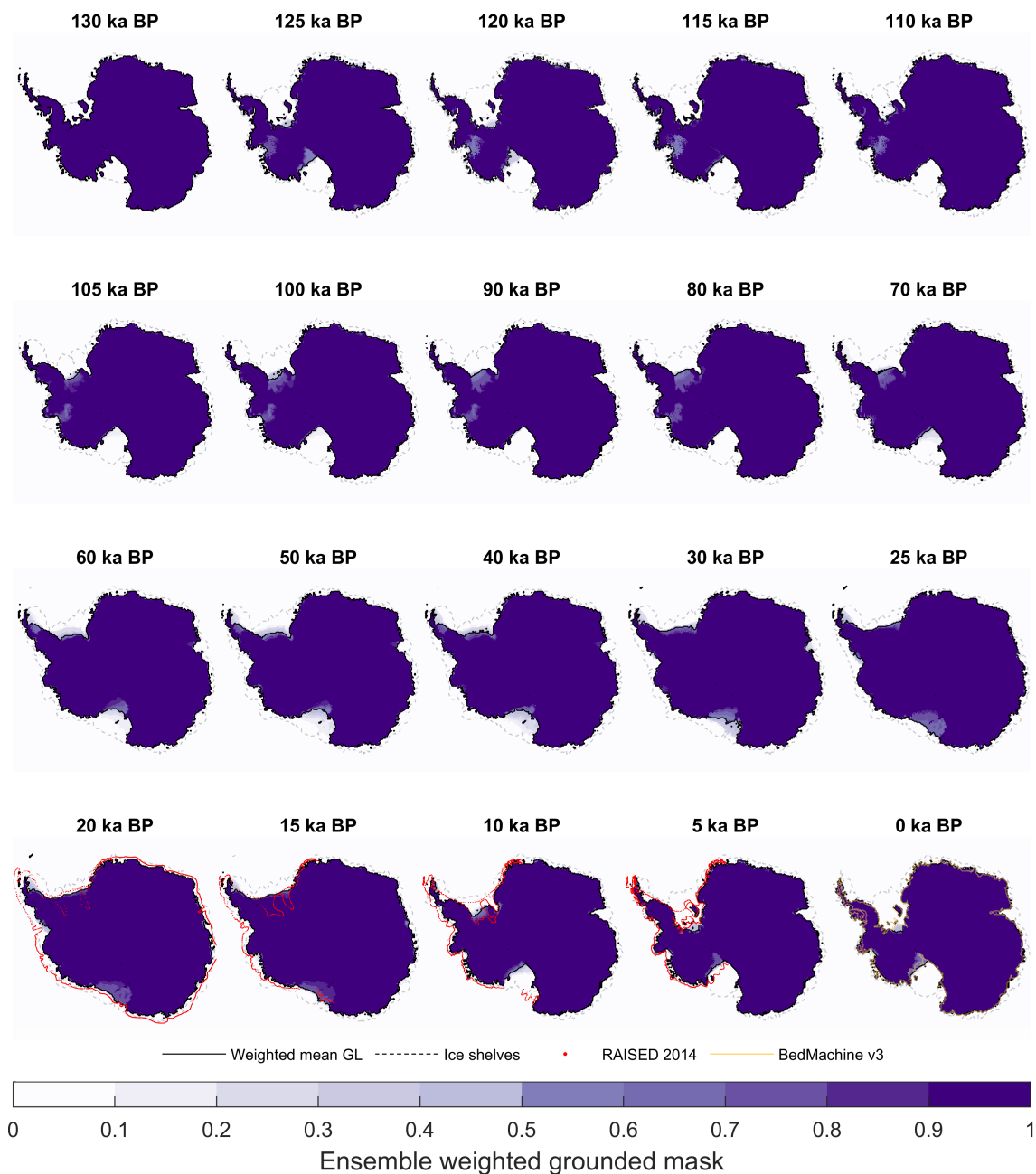


Figure S24. Weighted grounded ice mask. A value of 1 indicates that all simulations predict grounded ice at that location. The plain lines represent the weighted mean grounding line (GL) while the dashed lines represent the weighted mean calving front (delineating ice shelves). Reconstructions from the RAISED (Bentley et al., 2014) are shown in red. Grounding lines from BedMachine v3 (Morlighem et al., 2020; Morlighem, 2022) are shown in yellow.

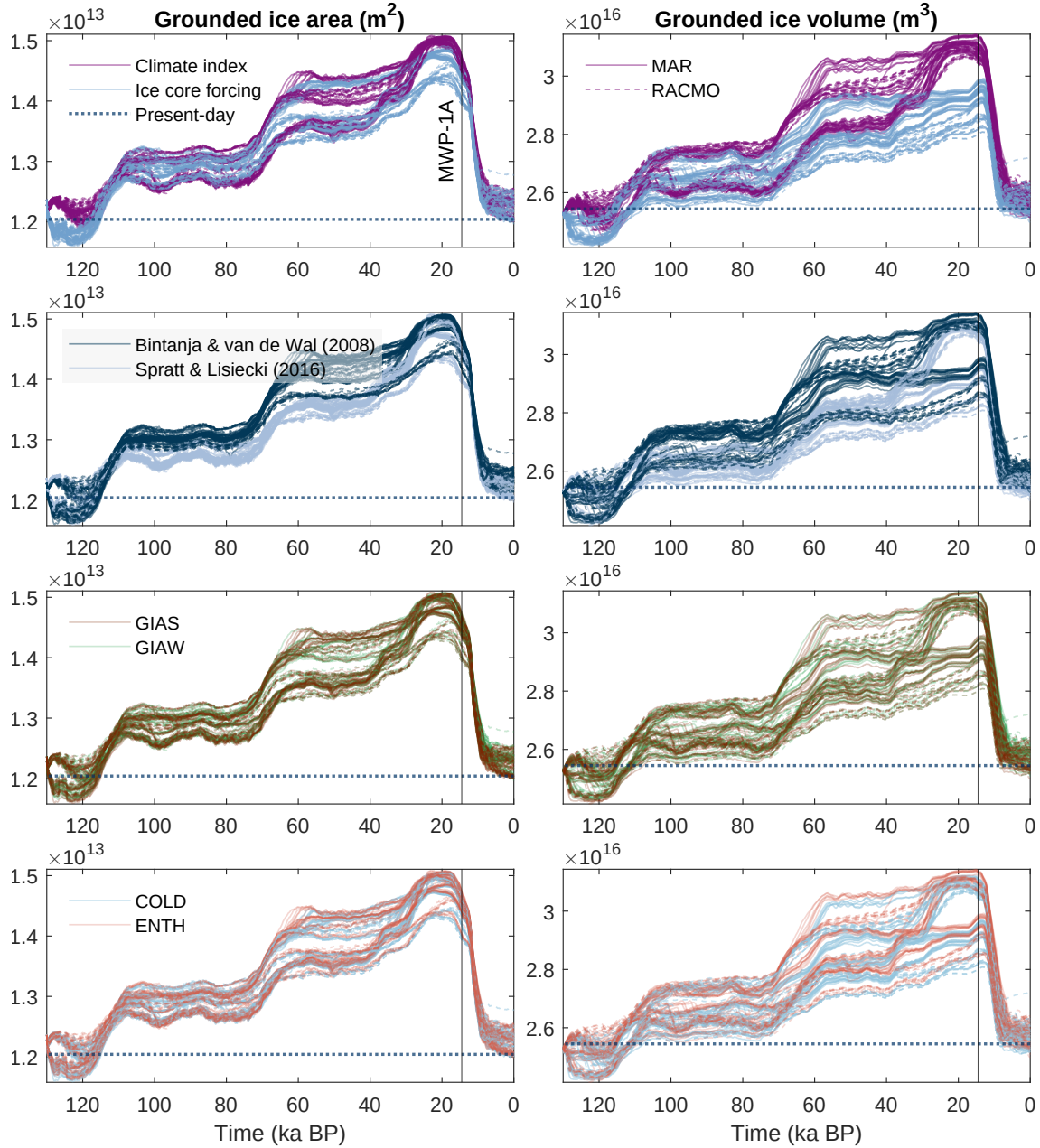


Figure S25. Sensitivity of the modelled grounded ice areas and volumes to the different factors of uncertainty considered in this study (Table 1), which include: climate forcing approach, initial climatic conditions, sea level forcing, relaxation times in the GIA model, and the thermodynamic model. The sensitivity to each GHF dataset is not shown, as GHF exerts minimal influence on the large-scale behaviour of the ice sheet, as shown by the ANOVA analysis presented in Figure 1 of the main manuscript.

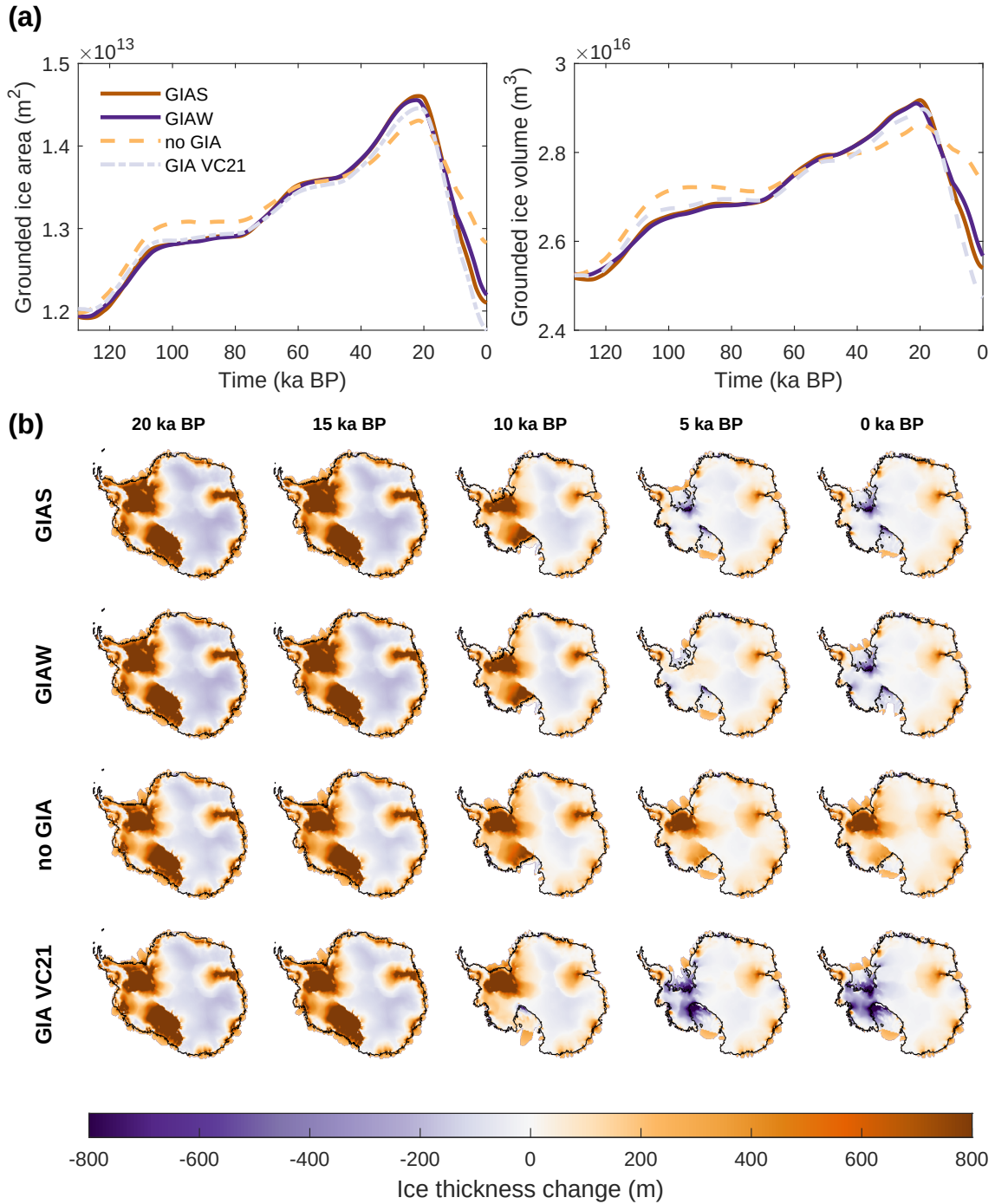


Figure S26. Sensitivity to Glacial Isostatic Adjustment (GIA). (a) Grounded ice areas and grounded ice volumes resulting from experiments using different relaxation times in the ELRA model (Coulon et al., 2021). (b) Snapshots of ice thickness changes relative to the present-day during the deglaciation (20–0 ka BP). GIAS and GIAW correspond to relaxation times derived from the stronger and weaker Earth structures in van Calcar et al. (2026). GIA VC21 refers to the relaxation times used in Coulon et al. (2021), and no GIA refers to simulations that do not consider glacial isostatic adjustment (constant bedrock elevation in time). Simulations are conducted with the initial surface climatic conditions from MAR v3.11 (Kittel et al., 2021), the GHF of Stål et al. (2021), the enthalpy solver, and the ice core forcing approach. Results highlight that relaxation times in the ELRA model strongly influence the evolution of the ice sheet during the deglaciation.

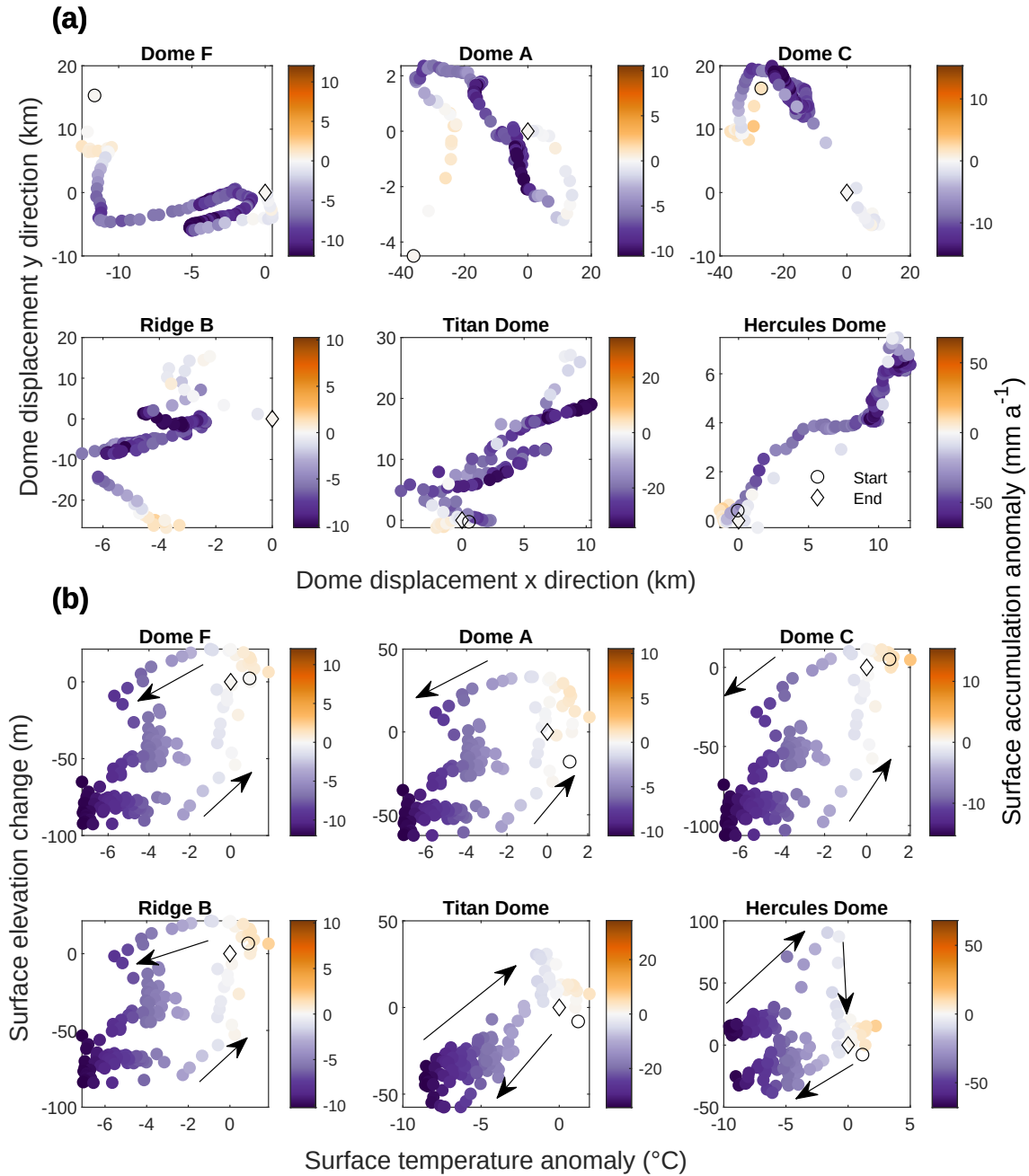


Figure S27. Dome displacement as a function of the atmospheric forcing. (a) Evolution of the position of the topographic domes relative to the final position (0 ka BP). (b) Surface elevation changes as a function of surface temperature anomalies. In all panels, colours indicate the surface accumulation anomalies at a given time. The start and final positions/elevations are indicated by circles and diamonds, respectively. The arrows highlight the trajectory in time. Results are shown for the ensemble weighted mean.

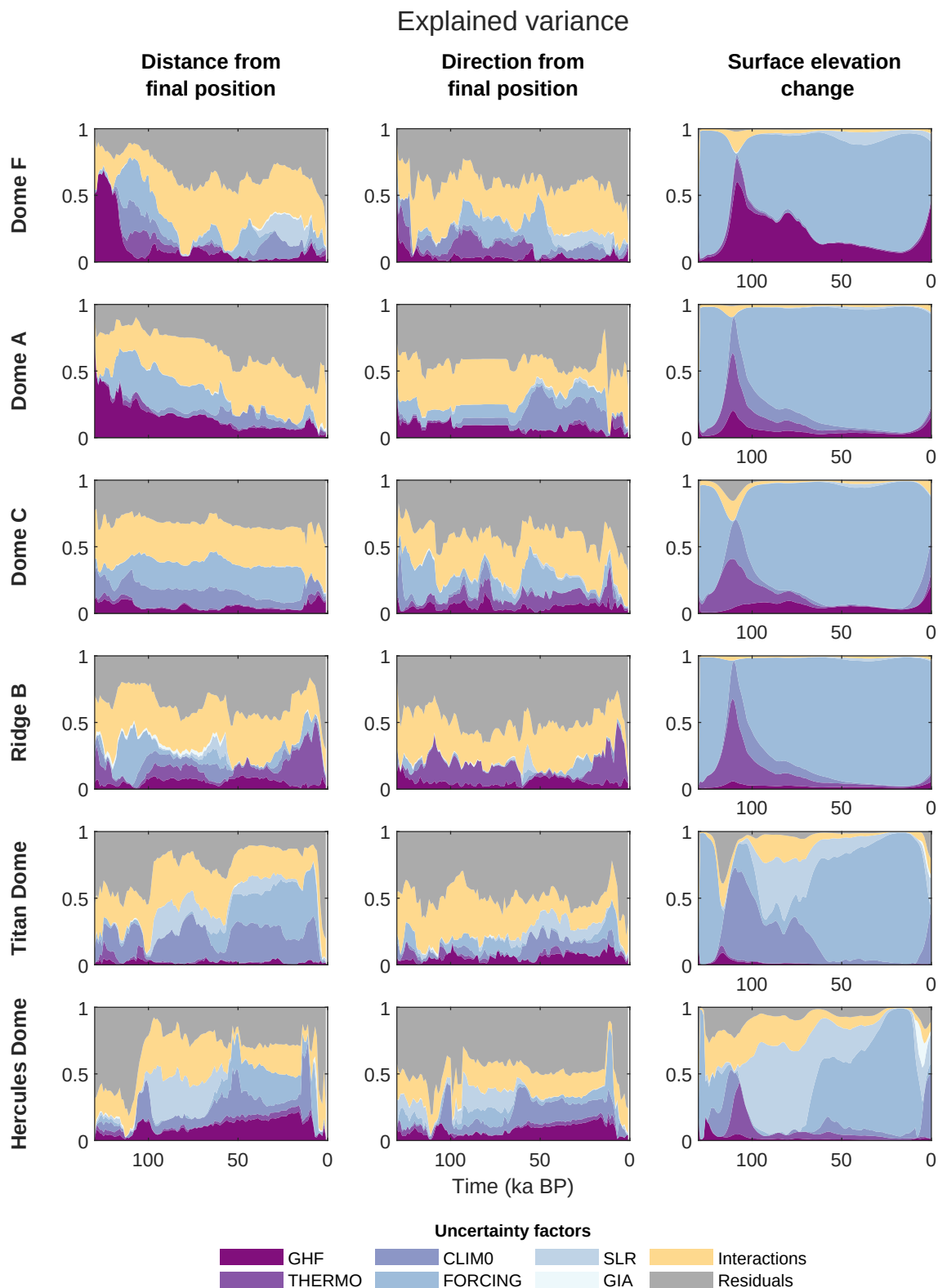


Figure S28. Analysis of variance (ANOVA) for dome migration (distance and direction from the final position at 0 ka BP) and surface elevation changes. The factors of uncertainty are presented in Table 1 and discussed in the main manuscript.

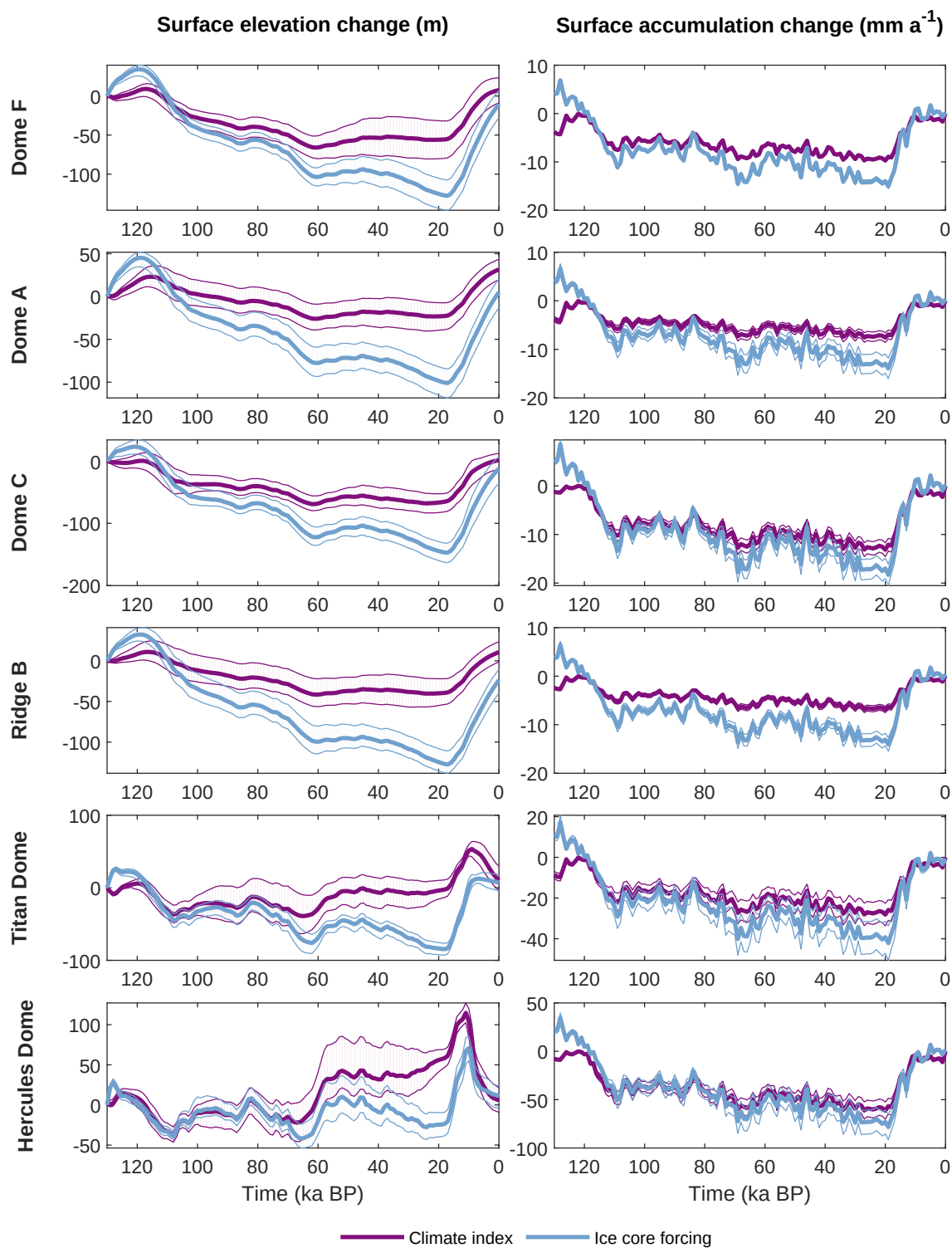


Figure S29. Surface elevation changes and surface accumulation changes at each dome location. Simulations forced by the climate index approach exhibit lower amplitude of changes in both surface elevations and accumulation rates compared to simulations forced by the ice core forcing approach. Dome F, Dome A, Dome C and Ridge B exhibit a lagged response to the atmospheric forcing, in contrast to Titan Dome and Hercules Dome, which display a faster response.

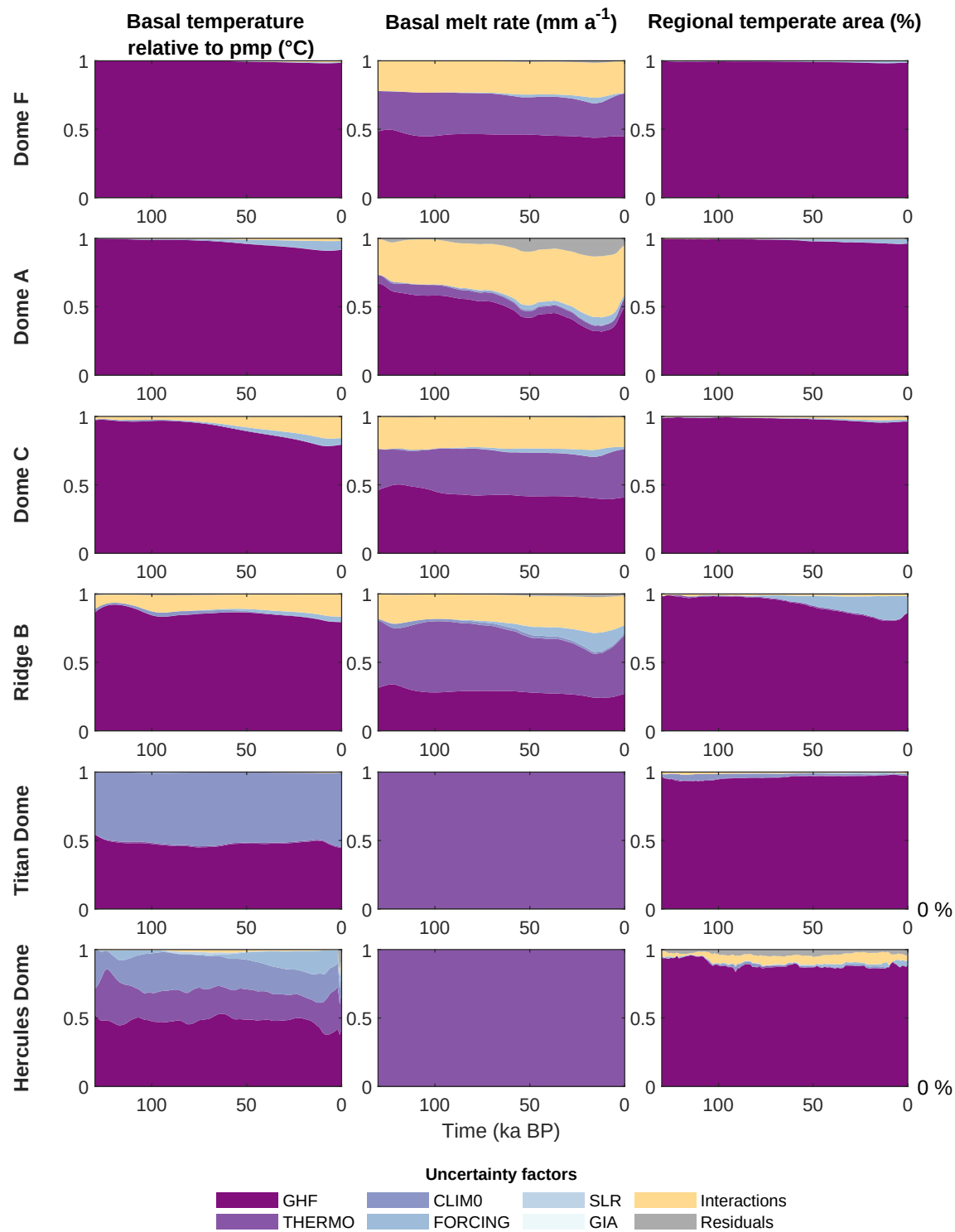


Figure S30. Analysis of variance (ANOVA) for basal thermal conditions. The factors of uncertainty are presented in Table 1 and discussed in the main manuscript.

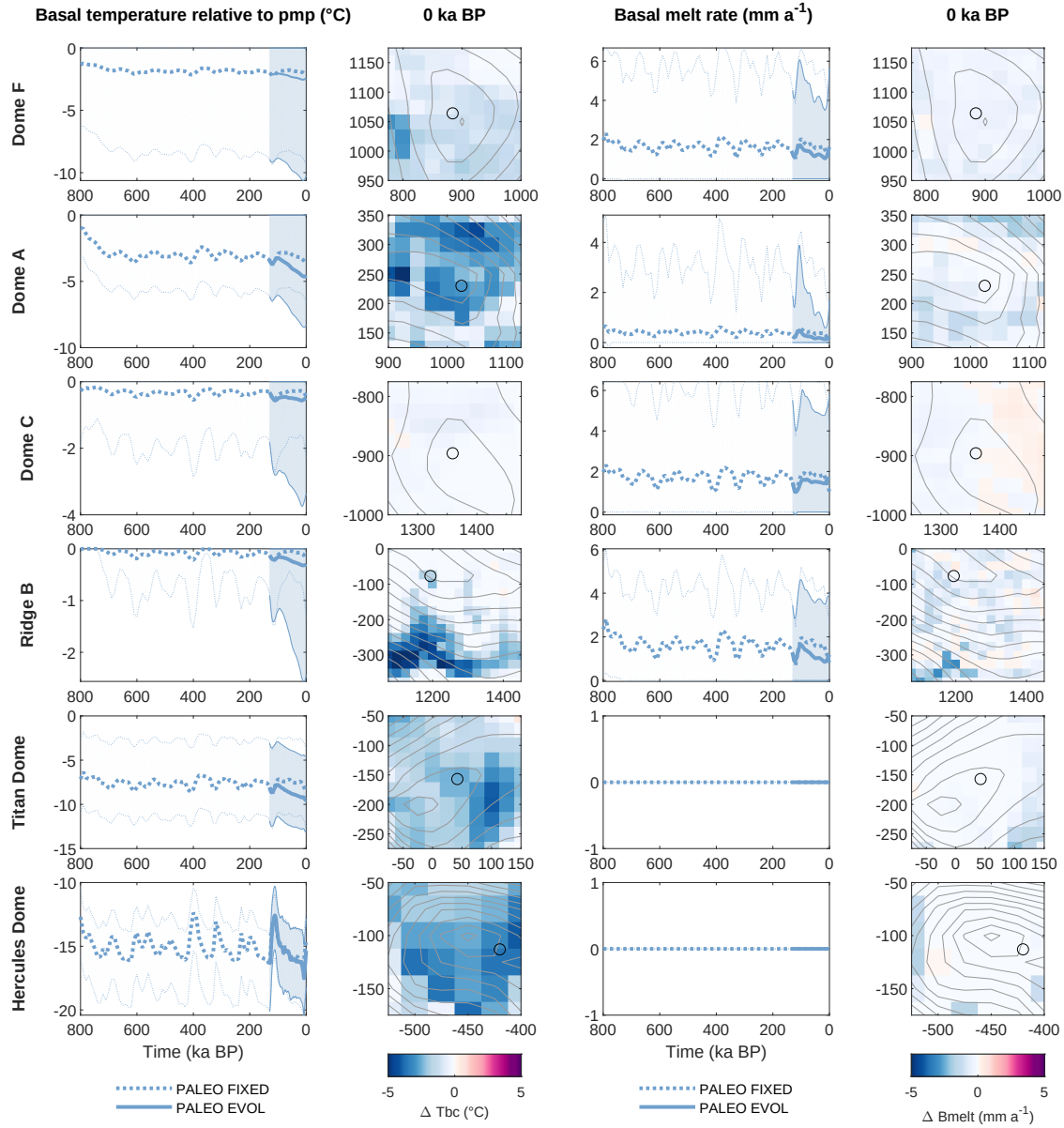


Figure S31. Evolution of basal temperatures and melt rates during the last glacial cycles from (i) the diagnostic palaeo run with a fixed ice sheet geometry (PALEO FIXED) used in the initialisation procedure to account for the thermal memory of the ice sheet, and (ii) the palaeo simulations performed to investigate dome migration patterns (PALEO EVOL). Results highlight a similar evolution of basal thermal conditions for evolving and fixed geometry experiments. The evolving geometry experiment leads to more pronounced cooling during the glacial period and LGM, because the ice thickness decreases over the EAIS plateau during the glacial period (e.g., Figure S8). However, the results converge again at 0 ka BP (present-day). The figure further shows the mean difference in basal temperatures (ΔT_{bc}) and melt rates (ΔB_{melt}) at the end of the palaeo simulations (0 ka BP) relative to thermal steady-state estimates.

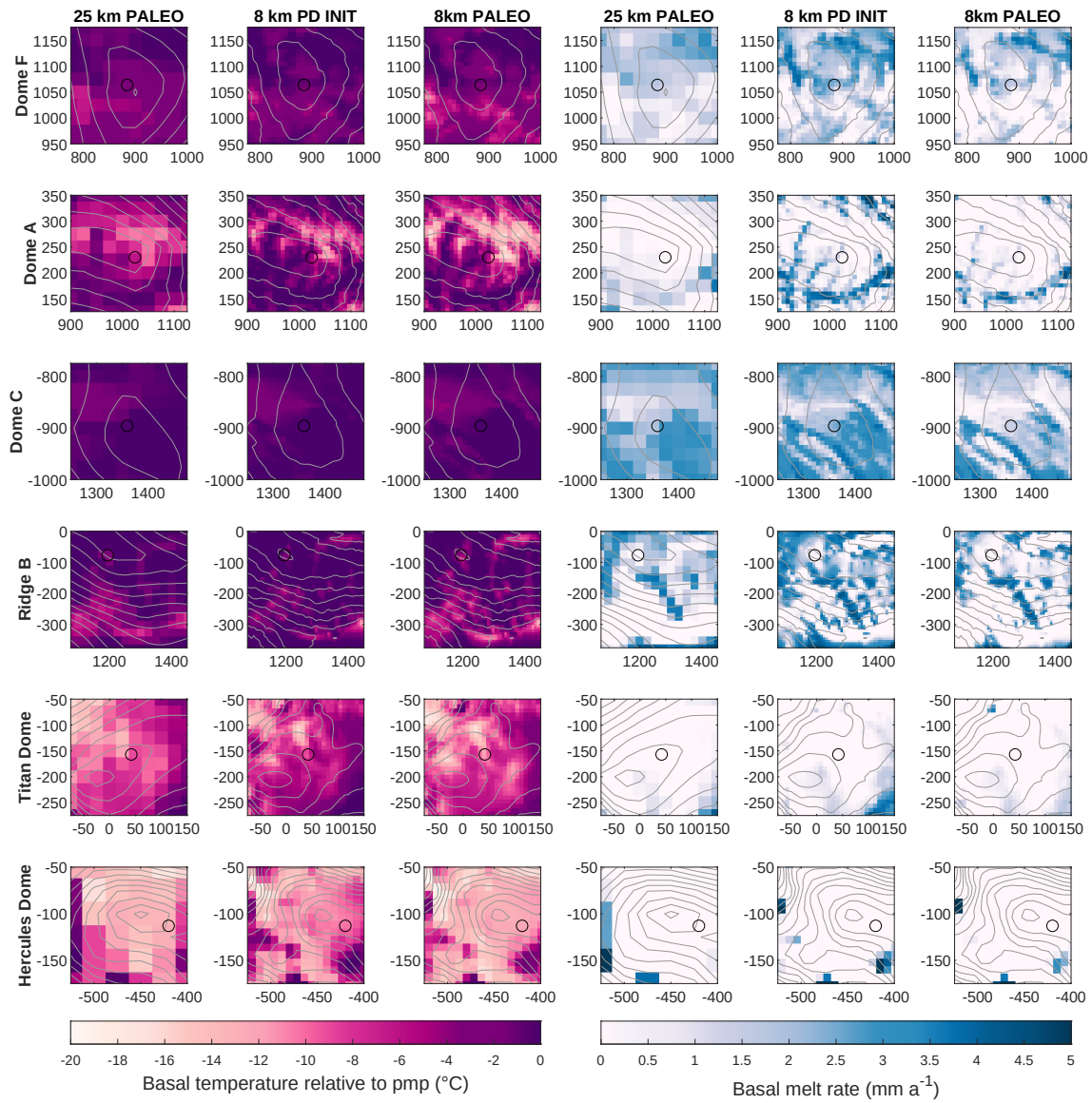


Figure S32. Comparison of the ensemble mean basal temperatures and melt rates presented in this study (25 km PALEO) with a subset of the ensemble presented in Raspoet and Pattyn (2025) that use the same ice-sheet model and boundary conditions as in this study (8 km PD INIT). The latter is used to conduct diagnostic palaeo simulations at higher resolution to account for the thermal memory of the ice sheet (8 km PALEO).

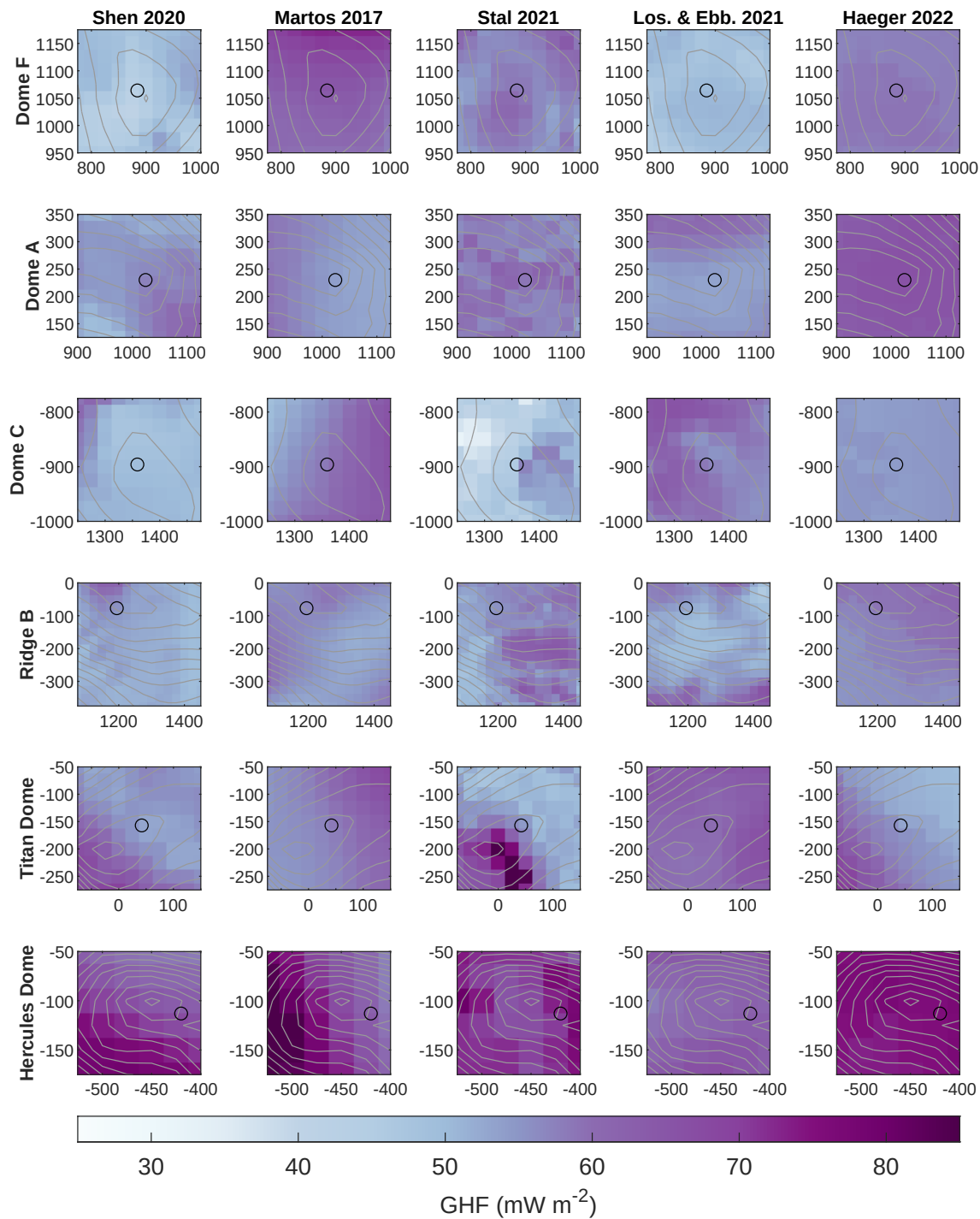


Figure S33. Geothermal Heat Flow (GHF) across all dome regions estimated by different GHF datasets: Shen et al. (2020), Martos et al. (2017), Stål et al. (2021), Lösing and Ebbing (2021), Haeger et al. (2022). The contours highlight surface elevations at 0 ka BP. The black circles show the current dome positions.

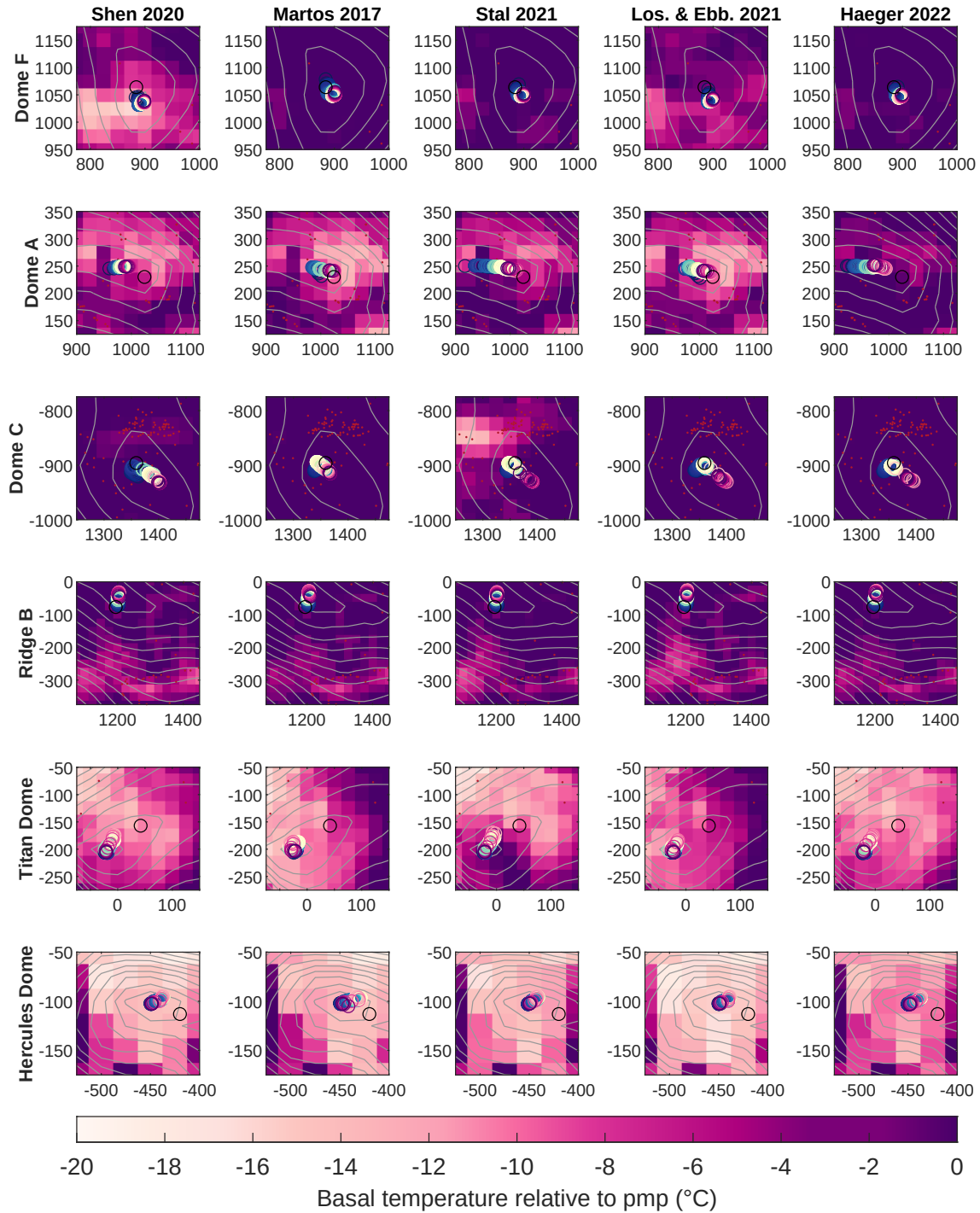


Figure S34. Mean basal temperatures at 0 ka BP for all dome regions estimated by different GHF datasets: Shen et al. (2020), Martos et al. (2017), Stål et al. (2021), Lösing and Ebbing (2021), Haeger et al. (2022). The contours highlight surface elevations at 0 ka BP. The black circles indicate the current dome positions. The coloured scatter plots show the mean dome migration for each GHF following the colorbar of Figure 2.

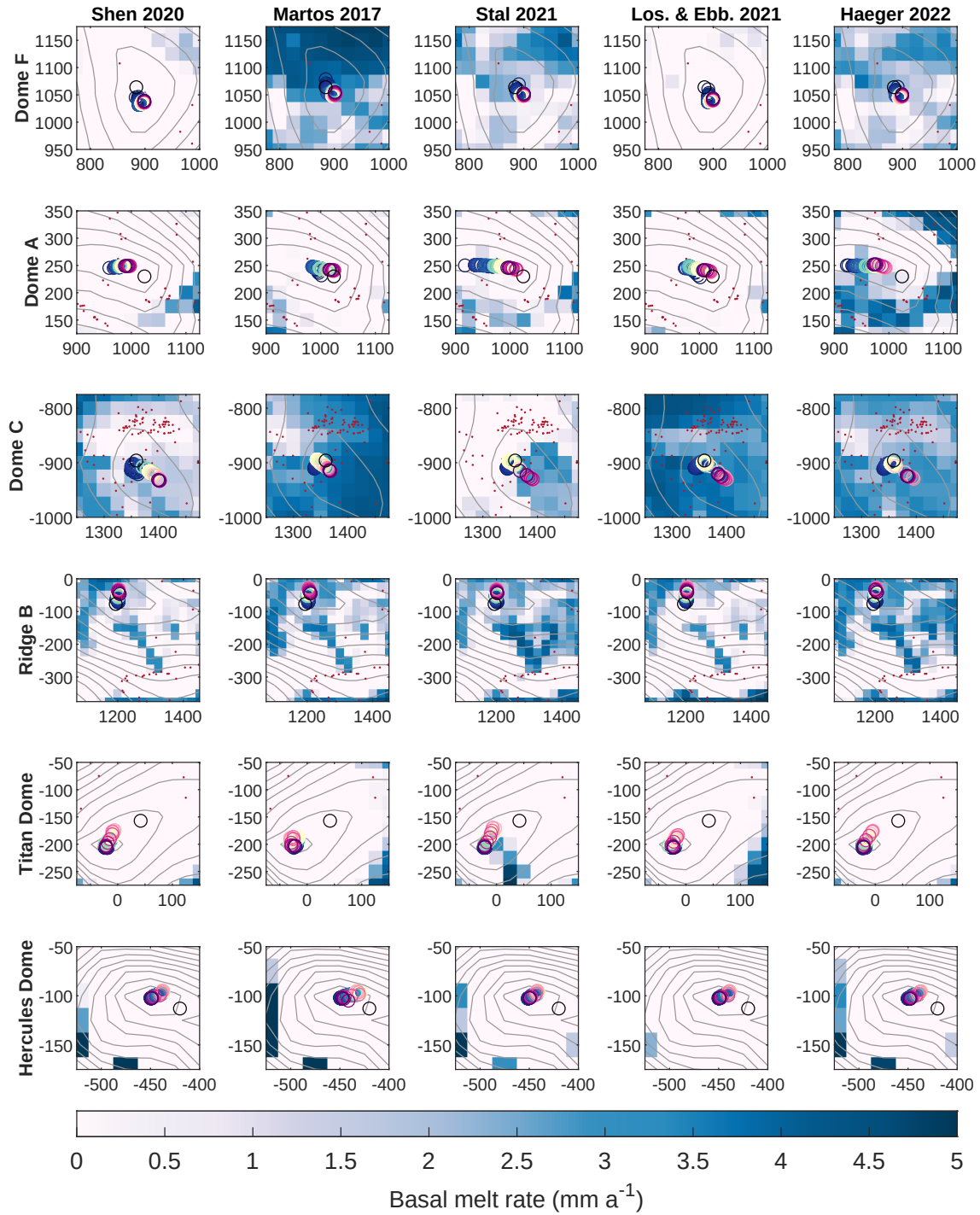


Figure S35. Mean basal melt rates at 0 ka BP for all dome regions estimated by different GHF datasets: Shen et al. (2020), Martos et al. (2017), Stål et al. (2021), Lösing and Ebbing (2021), Haeger et al. (2022). The contours highlight surface elevations at 0 ka BP. The black circles indicate the current dome positions. The coloured scatter plots show the mean dome migration for each GHF following the colorbar of Figure 2.

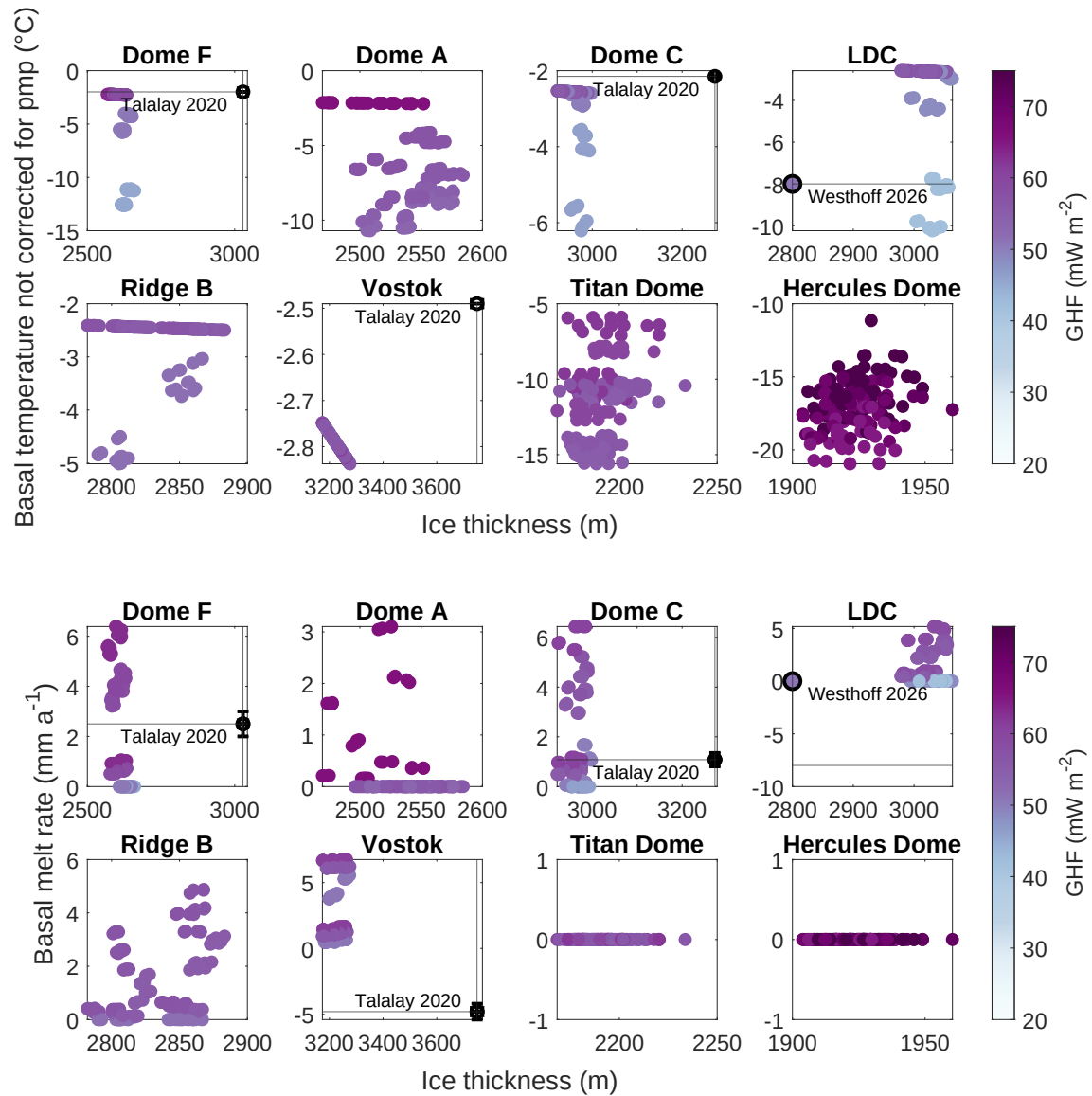


Figure S36. Basal temperatures and melt rates as a function of local ice thickness and geothermal heat flow (GHF). Results are compared with borehole-derived estimates from Talalay et al. (2020) and Westhoff et al. (2026) for LDC (Little Dome C).

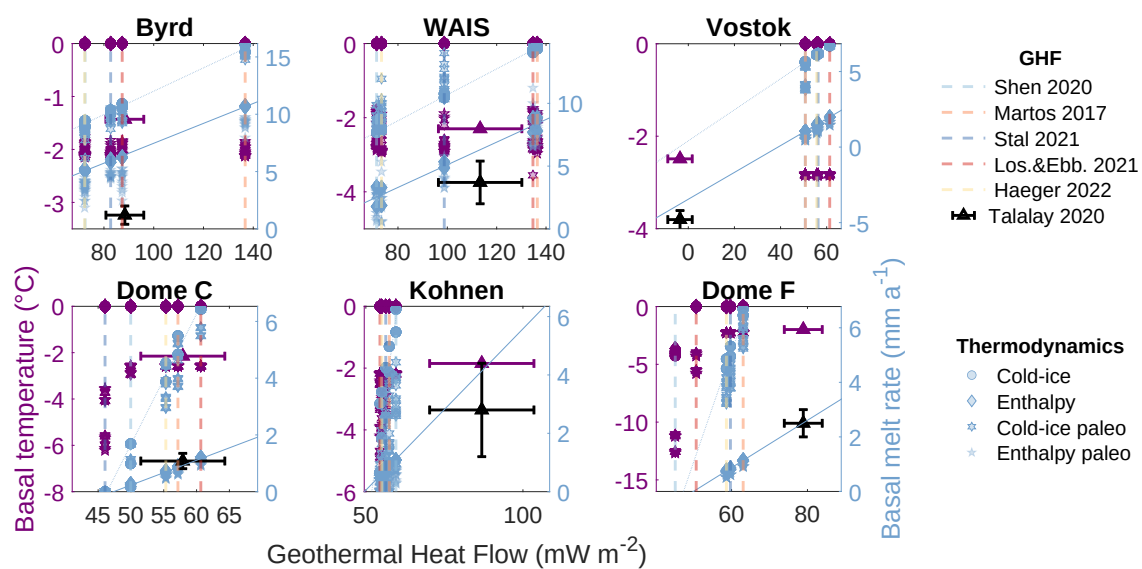


Figure S37. Comparison of modelled basal temperatures and melt rates at 0 ka BP as a function of GHF with data derived from borehole measurements by Talalay et al. (2020). Results for basal temperatures (not corrected for the pressure melting point) are shown in purple, and basal melt rates in blue. The coloured lines inside the panels indicate the GHF at a given location for the different GHF datasets. The purple and black error bars show results from Talalay et al. (2020).

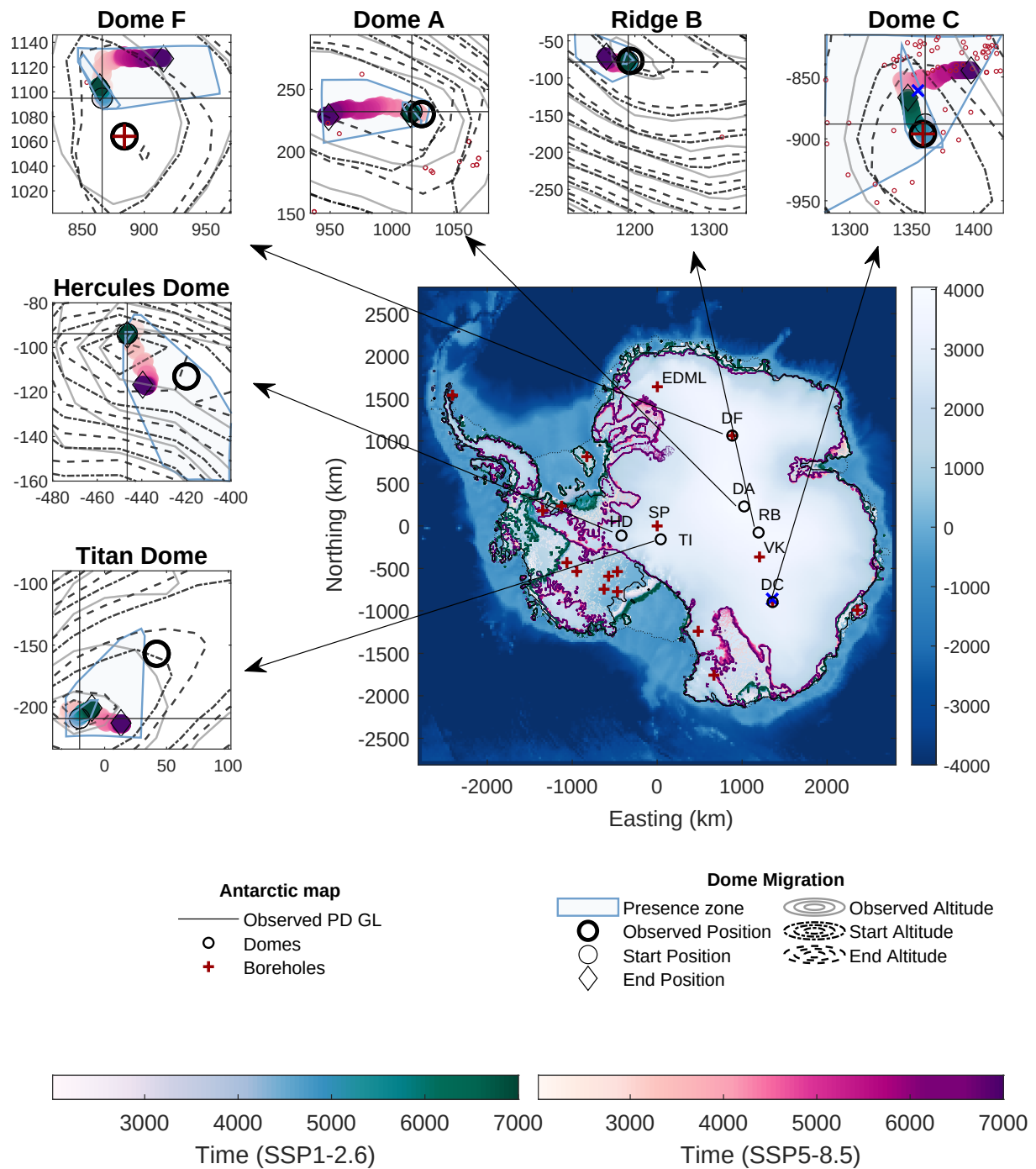


Figure S38. Migration of East Antarctic domes in response to extensive grounding line retreat under SSP1-2.6 and SSP5-8.5 scenarios. These results are taken from the Kori-ULB simulations by Coulon et al. (2024) and Klose et al. (2024).

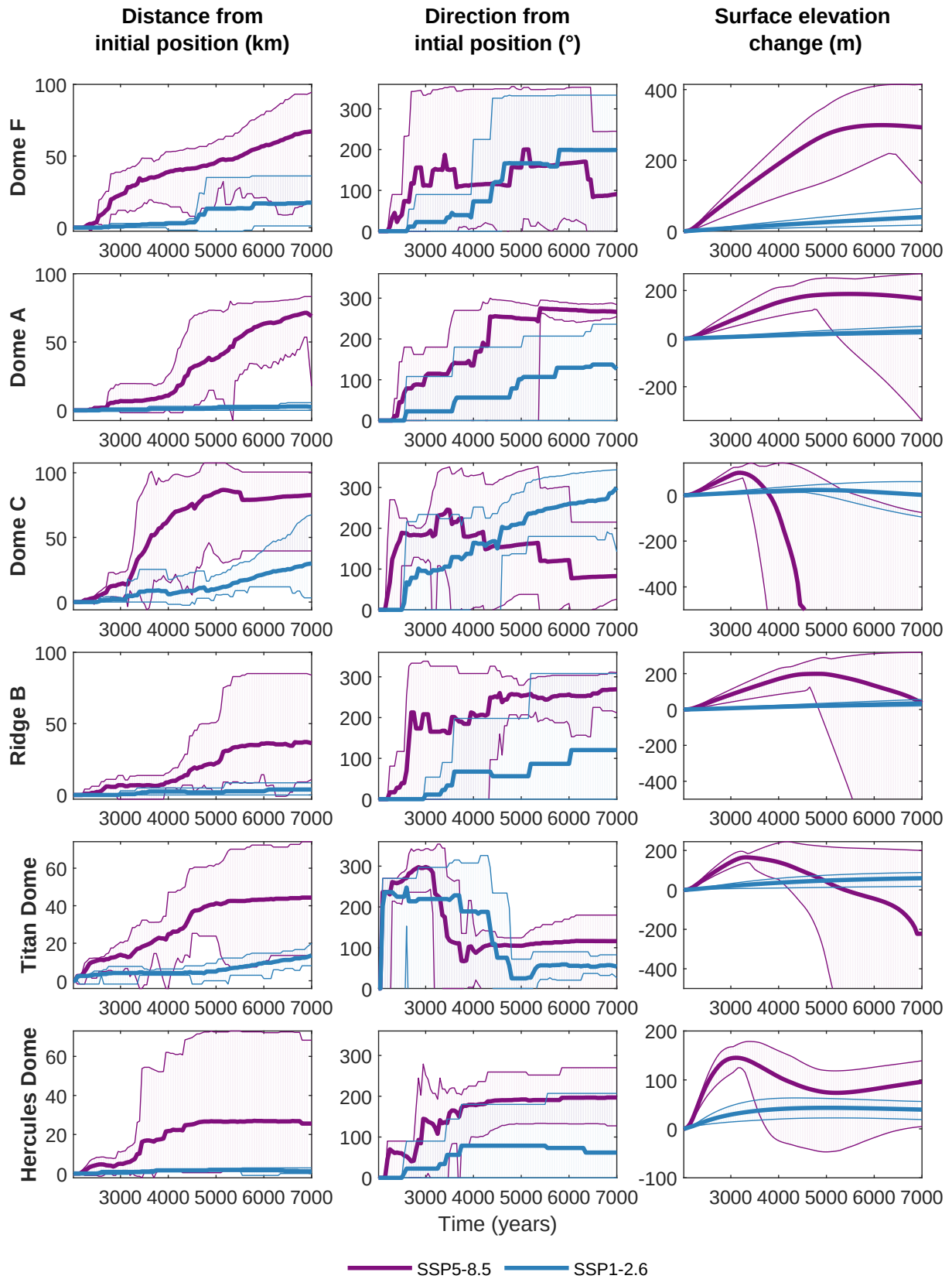


Figure S39. Distance and orientation from initial dome positions and elevations changes under SSP1-2.6 and SSP5-8.5 scenarios. These results are taken from the Kori-ULB simulations by Coulon et al. (2024) and Klose et al. (2024).

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