Multi-phase, transient spin-up for the Antarctic ice sheet with the SICOPOLIS model

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Ice sheets play a critical role in the Earth's climate system, and their evolution is closely linked to the global temperature and sea level. Numerical modelling has become an important tool for estimating the contribution of the Earth's ice sheets to sea-level rise over the coming centuries. Such simulations depend on reasonably accurate initial conditions of the recent 3D dynamic/thermodynamic state of the ice sheet in question. Since observational data are limited, numerical tools are required to obtain these initial conditions, which can be classified into assimilation methods and spin-up methods.

Here, we conduct a multi-phase, transient spin-up for the Antarctic ice sheet (Berends et al. 2023), simulated with the SICOPOLIS model (https://www.sicopolis.net). The spin-up consists of the following steps: (1) a 100-ka steady-state calibration phase that includes preliminary tuning of the basal sliding coefficients for the 18 different IMBIE regions (Rignot and Mouginot 2016), (2) a freely evolving glacial phase from the Eemian interglacial until the Last Glacial Maximum (LGM), (3) a deglaciation phase from the LGM until the early Holocene with topography-nudging to produce an ice-sheet configuration close to present day, (4) a Holocene phase from the early Holocene until today that continues the topography-nudging and involves further tuning of the basal sliding coefficients. The results for the ice volume are shown in Figure 1. At the LGM, the volume is about 6 metres of sea-level equivalent larger than today's, along with a significant advance of the grounding line in the area of the Filchner-Ronne ice shelf. During the deglaciation phase, the ice volume drops closely towards today's value and remains fairly constant during the Holocene. Further, a good agreement between observed and simulated present-day surface velocities is achieved. The simulated ice sheet includes the thermal and glacial-isostatic-adjustment histories and is well suited as an initial condition for simulations of the future of the ice sheet.

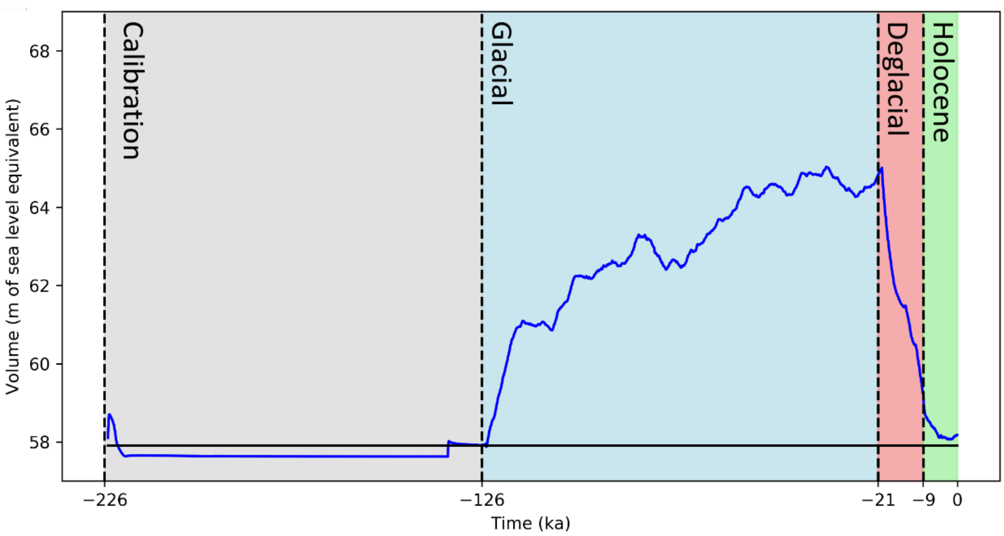

Figure 1. Simulated volume (expressed in metres of sea-level equivalent) of the Antarctic ice sheet for the four phases of the transient spin-up.

References

Berends, T., J. Bernales, C. van Calcar, and R. van de Wal. 2023. Sensitivity of future projections of ice sheet retreat to initial conditions. EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-14236, doi: 10.5194/egusphere-egu23-14236.

Rignot, E. and J. Mouginot. 2016. Antarctica and Greenland drainage basin and ice sheet definitions. IMBIE 2016, URL http://imbie.org/imbie-2016/drainage-basins/.