Long-term future projections for the Greenland ice sheet with the model SICOPOLIS

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The Coupled Model Intercomparison Project Phase 6 (CMIP6) is a major international climate modelling initiative [1]. As part of it, the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) was devised to assess the likely sea-level-rise contribution from the Greenland and Antarctic ice sheets until the year 2100 [2,3]. This was achieved by defining a set of future climate scenarios by evaluating results of CMIP5 and CMIP6 global climate models (GCMs, including MIROC) over and surrounding the Greenland and Antarctic ice sheets. These scenarios were used as forcings for a variety of ice-sheet models operated by different working groups worldwide [4,5]. Results obtained with the model SICOPOLIS for the Greenland ice sheet are summarized in Ref. [6].

Here, we use the model SICOPOLIS to carry out extended versions of the ISMIP6 future climate experiments for the Greenland ice sheet until the year 3000. We employ two different ice-dynamics schemes, SIA (shallow-ice approximation) and HYB (hybrid shallow-ice–shelfy stream dynamics [6,7]). For the atmospheric forcing (anomalies of surface mass balance and temperature) beyond 2100, we sample randomly the ten-year interval 2091–2100, while the oceanic forcing (prescribed retreat due to ocean thermal forcing) beyond 2100 is kept fixed at 2100 conditions. Twelve experiments are for the pessimistic, "business as usual" pathway RCP8.5 (CMIP5) / SSP5-8.5 (CMIP6), and two are for the optimistic RCP2.6 (CMIP5) / SSP1-2.6 (CMIP6) pathway that represents substantial emissions reductions. Results are shown in Fig. 1. For the control run with a constant, 1960–1989 average climate, the ice sheet is stable until the year 3000. For RCP8.5/SSP5-8.5, it suffers a severe mass loss, which amounts to ~1.7 m SLE (sea-level equivalent), or ~25% of its entire mass, for the twelve-experiment mean, and ~3.5 m SLE (~50% of the entire mass) for the most sensitive experiment. For RCP2.6/SSP1-2.6, the mass loss is limited to a two-experiment mean of ~0.26 m SLE. Climate-change mitigation during the next decades will therefore be an efficient means for limiting the contribution of the Greenland ice sheet to sea-level rise in the long term.

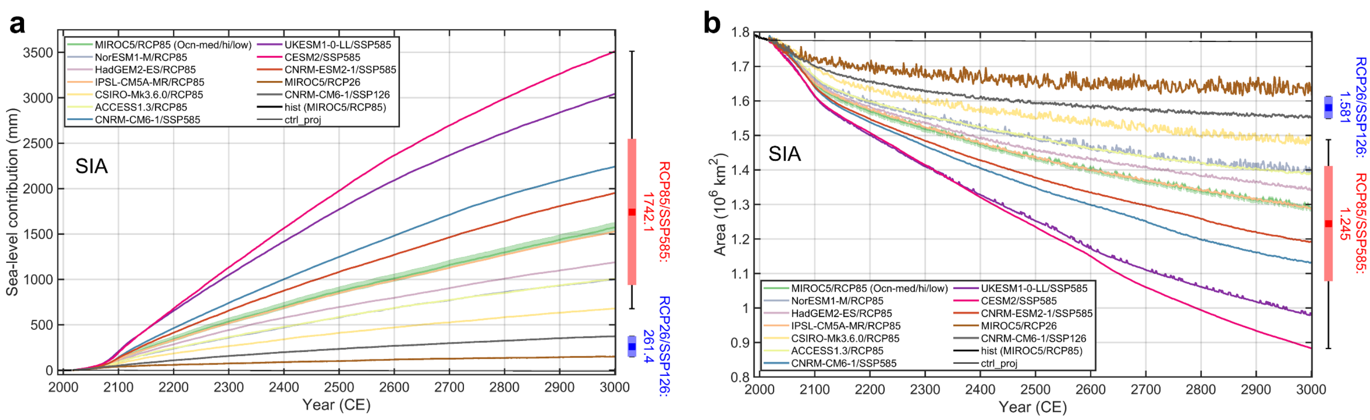

Figure 1. Historical run (hist), projection control run (ctrl_proj), and extended ISMIP6 future climate experiments for SIA dynamics: (a) Simulated ice mass change, counted positively for loss and expressed as sea-level contribution. (b) Simulated ice area. The red and blue boxes to the right show the mean ± 1-sigma ranges for RCP8.5/SSP5-8.5 and RCP2.6/SSP1-2.6, respectively; the whiskers show the corresponding full ranges.

References

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