EGU2020-14565
https://doi.org/10.5194/egusphere-egu2020-14565
EGU General Assembly 2020

Sensitivity of Greenland ice sheet projections to spatial resolution in higher-order simulations: the AWI contribution to ISMIP6-Greenland using ISSM

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Projections of the contribution of the Greenland ice sheet to future sea-level rise include uncertainties primarily due to the imposed climate forcing and the initial state of the ice sheet model. Several state-of-the-art ice flow models are currently being employed on various grid resolutions to estimate future mass changes in the framework of the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6). Here we investigate the sensitivity to grid resolution on centennial sea-level contributions from the Greenland ice sheet and study the mechanism at play. To this end, we employ the finite-element higher-order ice flow model ISSM and conduct experiments with four different horizontal resolutions, namely 4, 2, 1 and 0.75 km. We run the simulation based on the ISMIP6 core GCM MIROC5 under the high emission scenario RCP8.5 and consider both atmospheric and oceanic forcing in full and separate scenarios. Under the full scenarios, finer simulations unveil up to 5% more sea-level rise compared to the coarser resolution. The sensitivity depends on the magnitude of outlet glacier retreat, which is implemented as a series of retreat masks following the ISMIP6 protocol. Without imposed retreat under atmosphere-only forcing, the resolution dependency exhibits an opposite behaviour with about 5% more sea-level contribution in the coarser resolution. The sea-level contribution indicates a converging behaviour ≤ 1 km horizontal resolution. A driving mechanism for differences is the ability to resolve the bed topography, which highly controls ice discharge to the ocean. Additionally, thinning and acceleration emerge to propagate further inland in high resolution for many glaciers. A major response mechanism is sliding (despite no climate-induced hydrological feedback is invoked), with an enhanced feedback on the effective normal pressure N at higher resolution leading to a larger increase in sliding speeds under scenarios with outlet glacier retreat.