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Modelling glacial inception with GENIE

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Glacial inception is difficult to capture accurately in Earth-system models. It has been suggested that inception can occur either when a wide area gains snow cover which persists from year to year, enhanced by the albedo feedback effect, or when mountain glaciers merge to form larger volumes of ice (the mass balance-elevation effect). Insufficient horizontal resolution may explain the difficulty of simulating the latter process, though it is unclear how it would impact on the former. In this study, we consider the problem in the context of a new, modular Earth-system model (GENIE). In the present configuration, GENIE is run with an intermediate-complexity, fully-dynamical atmosphere (T21, seven levels), a high-resolution thermo-mechanical ice-sheet model, a slab ocean and sea-ice model. A novel feature of the ice-sheet model is that it may be configured to run on any number of arbitrary domains simultaneously, and at different resolutions. This enables small-scale topography to be captured within the ice model over particular regions of the Earth's surface, without compromising performance unduly.

Because of these difficulties, and specifically because it requires an accurate calculation of mass-balance, the modelling of glacial inception is a stringent test of the model. It also exploits its particular strengths, namely the flexible coupling of a high-resolution ice sheet model with a dynamical atmosphere. The coupling is achieved via a degree-day method mass-balance scheme, forced by daily temperatures and precipitation from the atmospheric model. The ice model performs a lapse-rate correction to account for the high-resolution topography, and returns albedo and topography to the global model annually. The study considers the effects on modelled inception of orbital parameters and CO2 levels, with conditions 115kyr ago serving as a starting-point. A range of sensitivity studies are performed; these results are presented and interpreted in the light of the characteristics of the model.