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Simulating grounding line migration in a 1D adaptive mesh ice sheet model

R.M. Gladstone (1), V. Lee (1), A.J. Payne (1), and A. Vieli (2)

(1) Bristol Glaciology Centre, Geographical Sciences, University of Bristol, UK, (2) Department of Geography, Durham University, UK

Grounding line migration is a key process affecting the stability of marine ice sheets such as the West Antarctic ice sheet (WAIS). Recent studies have shown that standard models employing a fixed spatial grid can not be used to solve this problem in a robust manner but that moving-grid models (which explicitly track grounding line migration) show a great deal of promise. While the latter type of model is relatively easy to implement in one dimension, it would be very difficult to employ in full, three-dimensional ice sheet models. Here we use the AMR (adaptive mesh refinement) technique, which is based on a nested set of fixed-grid models. We have developed a 1D ice sheet model in which sub regions of the whole model domain (and sub regions thereof, etc) are run at higher resolutions, forced at their boundaries by data from the encompassing lower resolution region, allowing very high resolution where it is needed without the high computational costs of running the whole domain at high resolution. The higher resolution regions evolve during the simulation according to predefined criteria (e.g. crossing a given threshold in estimated truncation error or proximity to grounding line). We also use linear interpolation to determine an exact grounding line position between grid points. We show that using either the AMR approach or grounding line interpolation give improvements in modelling grounding line migration as compared to the standard fixed grid model, but that using both together (i.e. linear interpolation of the grounding line within the highest resolution nest) is required in order to give a result that is truly robust to changes in model resolution.