Evaluating a model of the current dynamical state of the Antarctic ice sheet using the Parallel Ice Sheet Model

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We present a complete Antarctic ice sheet, stream and shelf model, and show that there is a close match of model output to observed surface velocities. The model is high resolution, with the entire ice sheet resolved on a 10 km grid. This resolution, and the immediate prospect of higher resolution, is possible because the Parallel Ice Sheet Model ("PISM"; www.pism-docs.org), an open source code, is used with hundreds of processors. The model is a shallow hybrid which includes ice stream and ice shelf flow based on the shallow shelf approximation and a plastic model for the subglacial till (Bueler and Brown, 2008; Schoof, 2006). A distributed map of till friction angle, in combination with a pore water pressure model, determines the till yield stress. The model is prognostic and thermomechanically coupled.

It is initialized by time-stepping through a paleoclimate history of several ice age cycles. Initialization uses publicly-available data including BEDMAP geometry, surface temperature from (Comiso, 2000), net surface mass balance from (Vaughan and others, 1999), and geothermal flux from (Shapiro and Ritzwoller, 2004). Critically, till friction angle is a function of the bed elevation instead of inverse modeling of surface velocities, for instance. This reinterprets an idea used by Huybrechts and de Wolde (1999) in a shallow ice approximation model, but in our using membrane stress balance model. Our reinterpretation is effective in generating ice streamflow distributed appropriately throughout WAIS. The result is a qualitative and quantitative fit to observed surface velocities. We measure the difference relative to interferometry-derived data from the Modified Antarctic Mapping Mission (Jezek, 2003). We also "zoom in" and compare to RIGGS velocities for the Ross Ice Shelf, and we compare other model outputs to observations. To obtain optimal fit we adjust only three scalar parameters. A parameter study is given. The evaluation of the model done here is a preamble to inverse modeling using these data and prognostic determination of sea level rise using the model coupled to a GCM.

References

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