Accurate and stable time stepping in ice sheet modeling

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ABSTRACT

The efficiency, stability and accuracy are the three major issues in the numerical simulation of paleo ice sheet modeling. We introduce adaptive time step control for simulation of evolution of ice sheets. The discretization error in the approximations is estimated using Milnes device by comparing the result from two different methods in a predictor-corrector pair. The time step is changed in an efficient way that the velocity field equation is only solved once per time step. The stability of the numerical solution is maintained and the accuracy is controlled by keeping the local error below a given threshold using PI-control. Our method takes a shorter time step than an implicit method but with less work in each time step and the solver is simpler. The method is analyzed theoretically with respect to stability and applied to the simulation of a 2D ice slab and a 3D circular ice sheet. The stability bounds in the experiments are explained by and agree well with the theoretical results.