Verifying thermocoupled ice sheet models: whence the warm spokes

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ABSTRACT: We describe exact solutions to the thermocoupled shallow ice approximation in three spatial dimensions. Though artificially constructed, these solutions are very useful for testing numerical methods. In fact, they allow us to verify (Roache 1998; Bueler and others, 2005) a finite difference scheme, that is, to show that the results of our numerical scheme converge to the correct continuum values as the grid is refined in three dimensions. Comparison of numerical results to exact solutions has helped us to precisely identify and understand a number of numerical instabilities and inaccuracies. Nonetheless our verified numerical scheme shows a version of the basal temperature spokes which arose in the EISMINT II intercomparison (Payne and others, 2000). A careful error analysis identifies the warm spokes as numerical errors which occur when the derivative of the strain-heating term with respect to the temperature is large. This fact motivates smoothing the strain-heating term, a numerical technique which eliminates the spokes. The appearance of spokes for a verified numerical scheme is strong evidence for the effective or actual ill-posedness of the particular EISMINT II experiment F thermcoupled steady state free margin problem.

Reference:

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