SIA vs Higher Order: Greenland tests, and thoughts on Antarctica

Byron Parizek[1], Patrick Applegate[2], Klaus Keller[2], and Richard Alley[2]

[1]*Mathematics and Geosciences, the Pennsylvania State University, DuBois, PA, USA*
[2]*Department of Geosciences and Earth and Environmental Systems Institute, the Pennsylvania State University, University Park, PA, USA*

With large spatiotemporal uncertainties remaining in controlling variables, processes, and boundary conditions, ensemble simulations are often utilized to provide a range of possible outcomes and to assess ice-sheet sensitivity to combinations of poorly constrained parameters. Due to their computational efficiency, models based on the traditional shallow ice approximation (SIA) enable whole ice sheet glacial-cycle runs as well as large suites of perturbation experiments. However, with the development of higher-order and full-Stokes physics cores, the validity and continued utility of SIA ice sheet models are increasingly questioned. This motivates the need to gain a better understanding of the impact of incorporating more accurate, but less-efficient, higher-order physics on model results. To this end, we conducted a suite of five Greenland stepped-warming experiments (ΔT = 0, 3, 4.5, 6, and 12 K) with both a SIA and higher-order model. In settings such as this, we find that: i) process inclusion matters as much as the physics core, ii) higher-order physics initially delays volume loss for more moderate warming and accelerates loss with additional warming, and iii) the rate and magnitude of warming matter not only to the quantity of mass loss, but also to the rate of loss.