MISMIP+ summary of PSU3D ice sheet model.

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Model Details:

1. Model: PSU3D

   Pollard, D. and R.M. DeConto. 2012. Description of a hybrid ice sheet-shelf model, and application to Antarctica. Geosci. Model Devel., 5, 1273-1295. (Main model description).

   Pollard, D., R.M. DeConto and R.B. Alley. 2015. Potential Antarctic Ice Sheet retreat driven by hydrofracturing and ice cliff failure. Earth Plan. Sci. Lett., 412, 112-121. (Some updates).

2. Source code available on request from pollard@essc.psu.edu

3. Englacial stresses: for SIA and SSA, Glen's law, n=3, A=3.5 x 10^{-17} Pa^{-3} a^{-1} for MISMIP+.
   A was adjusted so that the Ice0 central grounding line is at $x \approx 450$ km.

4. Basal traction: power law, $|\tau_b| = \beta^2\ |u_b|^{1/3}$, $\beta^2 = 10^4$ Pa $m^{-1/3}$ $a^{1/3}$ for MISMIP+.

5. Space discretization: Finite difference, Arakawa C grid (i.e., u-grid is staggered 1/2 grid box in the x direction, v-grid is staggered 1/2 grid box in the y direction, both relative to the h-grid).

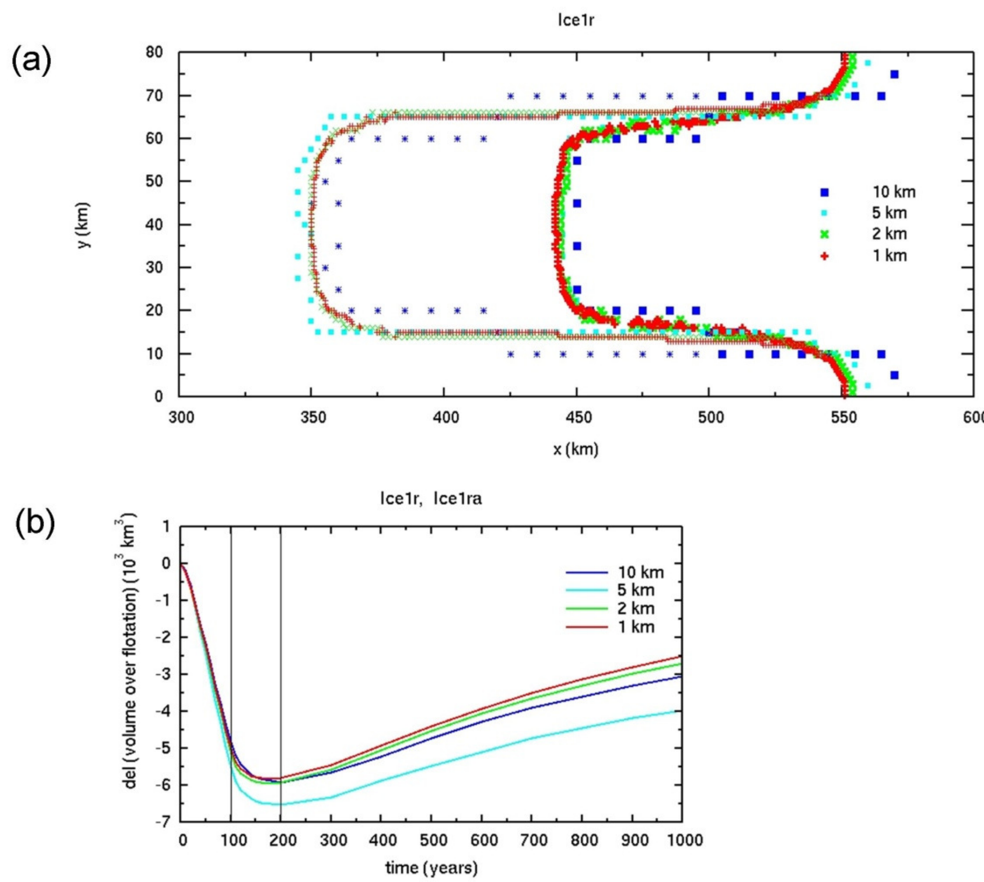
6. Tine stepping: Runge-Kutta outer iteration with Newton-Raphson time-implicit terms for SIA, Picard inner iteration for SSA.

7. Grounding line: Ice thickness at the grounding line is sub-grid interpolated, based on volume over/under flotation. Ice velocity across grounding line is specified as function of g.l. ice thickness as in Schoof (JGR, 2007), in the across-g.l. direction.

   The grounding line is specified as contiguous segments in the x or y directions, each one cell in length, at the interfaces of h-grid cells. The center of y-direction segments coincide with the center of a u-grid cell (with one defined u velocity), and the center of x-direction segments coincide with the center of a v-grid cell (with one defined v velocity). This makes our along-grounding-line velocity output for MISMIP+ somewhat blocky and noisy, because (1) a real grounding line with a gradual slope in x,y space can only be represented by perpendicular along-domain and across-domain segments, and (2) in certain places and times, our grounding line can fluctuate stochastically in time ("wiggles") by 1 grid cell. Also, at each model grounding-line point (the center of segments described above), there is only one model u or v velocity component available at that point; for MISMIP+ output, I interpolated the other velocity component from the 4 surrounding u or v-grid centers, which can cause noisiness in the reported velocities in the vicinity of wiggles.

8. MISMIP+ names: PSU1, PSU2, PSU5, PSU10, for resolutions 1 km, 2 km, 5 km and 10 km, respectively.

Convergence vs. resolution:



These figures show runs at resolutions of 10, 5 , 2 and 1 km. **(a)** shows grounding line positions at the beginning and end of Ice1r experiments; larger dots for the beginning, smaller dots for the end. (Dots show the u or v-grid centers of 1-cell-long segments comprising the model's grounding line, as described above.) **(b)** shows change in total volume above flotation for experiments Ice1r (years 0 to 100), and Ice1ra (years 100 to 1000).

The results for 1 km and 2 km lie much closer to each other relative to the coarser resolutions, i.e., are close to convergence. Note that even with the coarsest 10-km resolution (only 8 grid cells in the y-direction), the results are still quite close to the finer resolutions, and could be adequate for some large-scale applications; at 10 km, long-term runs on an all-Antarctic domain are feasible with the model.