Simulations of Ocean Circulation under Static and Dynamic Ice Shelves

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Abstract
We present a method for performing simulations of dynamic ice shelves within a dynamical ocean model (the Parallel Ocean Program, POP) using an immersed boundary method (IBM) to represent the geometry of the ice/ocean interface. IBM allows for geometrically correct representation of the boundary conditions at the ocean/ice interface without the need for a grid that conforms to the boundary or changes in time. The interface is free to move in time as the ice sheet evolves.

Background
Many Antarctic ice shelves: • Steady state • Both melting and freezing

Vulnerable ice shelves (Amundsen and Bellingshausen Embayments): • Accessible to warm circumpolar deep water (CDW) • Only melting; ice shelf retreats • Instability, further retreat?

Immersed Boundary Method (IBM)
• Enforce boundary conditions on u, T and S
• Fictitious ocean flow in ice shelf/ice sheet

Forcing at “ghost point” in fictitious flow • Find u, T, S values that produce desired mass, heat and salt fluxes

Turbulent Boundary Layer Physics
• Analytic sub-grid-scale model • Based on McPhee (2008)
• Balance of turbulent diffusion and Coriolis force • Accounts for stratification (p-)
• Fit to rational polynomials for comp. efficiency

The IBM: blue areas are “true” or “fictitious” ocean

In blue, bedrock below sea level

In black, current ice sheet/ice shelf extent

Future Work
Development of the IBM is nearing completion, with a series of tests on simplified problems (e.g., the Ice-Ocean Model Inter-comparison Project, ISMIP, experiment) currently in progress. Coupling of the ice sheet and ocean models in the Community Earth System Model (CESM) is also in progress.

References


