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Design of the MISMIP+, ISOMIP+, and MISOMIP ice-sheet, ocean, and coupled ice sheet-ocean intercomparison projects

Xylar Asay-Davis (1), Stephen Cornford (2), Daniel Martin (3), Hilmar Gudmundsson (4), David Holland (5), and Denise Holland (5)

(1) Potsdam Institute for Climate Impact Research, Potsdam, Germany, (2) Bristol University, Bristol, UK, (3) Lawrence Berkeley National Laboratory, Berkeley, CA, US, (4) British Antarctic Survey, Cambridge, UK, (5) New York University, New York, NY, US

The MISMIP and MISMIP3D marine ice sheet model intercomparison exercises have become popular benchmarks, and several modeling groups have used them to show how their models compare to both analytical results and other models. Similarly, the ISOMIP (Ice Shelf-Ocean Model Intercomparison Project) experiments have acted as a proving ground for ocean models with sub-ice-shelf cavities.As coupled ice sheet-ocean models become available, an updated set of benchmark experiments is needed. To this end, we propose sequel experiments, MISMIP+ and ISOMIP+, with an end goal of coupling the two in a third intercomparison exercise, MISOMIP (the Marine Ice Sheet-Ocean Model Intercomparison Project).
Like MISMIP3D, the MISMIP+ experiments take place in an idealized, three-dimensional setting and compare full 3D (Stokes) and reduced, hydrostatic models. Unlike the earlier exercises, the primary focus will be the response of models to sub-shelf melting. The chosen configuration features an ice shelf that experiences substantial lateral shear and buttresses the upstream ice, and so is well suited to melting experiments. Differences between the steady states of each model are minor compared to the response to melt-rate perturbations, reflecting typical real-world applications where parameters are chosen so that the initial states of all models tend to match observations.
The three ISOMIP+ experiments have been designed to to make use of the same bedrock topography as MISMIP+ and using ice-shelf geometries from MISMIP+ results produced by the BISICLES ice-sheet model. The first two experiments use static ice-shelf geometries to simulate the evolution of ocean dynamics and resulting melt rates to a quasi-steady state when far-field forcing changes in either from cold to warm or from warm to cold states. The third experiment prescribes 200 years of dynamic ice-shelf geometry (with both retreating and advancing ice) based on a BISICLES simulation along with similar flips between warm and cold states in the far-field ocean forcing.
The MISOMIP experiment combines the MISMIP+ experiments with the third ISOMIP+ experiment. Changes in far-field ocean forcing lead to a rapid (over ∼1-2 years) increase in sub-ice-shelf melting, which is allowed to drive ice-shelf retreat for ∼100 years. Then, the far-field forcing is switched to a cold state, leading to a rapid decrease in melting and a subsequent advance over ∼100 years.
To illustrate, we present results from BISICLES and POP2x experiments for each of the three intercomparison exercises.