

Using supercomputers to explore ice sheet dynamics

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Ice sheets in Glacier Bay National Park are subject to dynamics that SEACISM researchers simulate on leadership-class supercomputers. Credit: Kate Evans

Recently, Rhode Island-sized chunks of ice have separated from Greenland and Antarctica, garnering worldwide attention. But is this calving due to typical seasonal variations or a long-term warmer world? Climate scientists already use ice sheet models to better understand how ice loss affects sea levels; however, those models are not easily adapted for use in global climate models. In August the Scalable, Efficient, and Accurate Community Ice Sheet Model project began on Jaguar, one of the world's fastest supercomputers, at Oak Ridge National Laboratory. SEACISM's aim is to use state-of-the-art simulation to predict the behavior of ice sheets under a changing climate by developing scalable algorithms.

"Right now we don't know enough to predict the dynamics of the ice sheets," said ORNL computational Earth scientist Kate Evans, who leads the SEACISM project. Included in the team are other scientists from ORNL, Los Alamos National Laboratory, Sandia National Laboratories, New York University and Florida State University. Their goal is to address this lack of understanding by reducing uncertainties about climate and sea-level predictions through high-fidelity simulations that resolve important ice sheet features.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change did not provide a prediction of ice sheet fate due to a lack of data. Given the importance of building a predictive capability, the Department of Energy's Office of Advanced Scientific Computing Research created an initiative to meet that need. ASCR's Scientific Discovery through Advanced Computing program funded the Ice Sheet Initiative for CLimate ExtremeS to yield high-fidelity, high-resolution ice sheet models.

SEACISM is one of six projects launched from ISICLES, all of which respond to the national and international need to include better ice sheet [dynamic simulations](#) in Earth system models. Among other objectives, the projects will quantify uncertainties of dynamic predictions and develop models to efficiently use supercomputers. ASCR's Leadership Computing Challenge program granted SEACISM researchers 5 million processor hours on Jaguar, a leadership computing facility system capable of up to 2.3 quadrillion calculations per second. Another 1 million hours for SEACISM were allocated on Argonne National Laboratory's LCF [supercomputer](#) Intrepid, with a peak speed of 557 trillion calculations per second.

The scientists working on SEACISM are collaborating to extend Glimmer-CISM, a three-dimensional thermomechanical ice sheet [model](#) that has recently been incorporated into the Community Earth System

Model. CESM is a coupled global climate model comprised of atmosphere, land-surface, ocean, and sea-ice model components. SEACISM researchers are using the hours allocated in 2010 to prepare for the inclusion of the ice sheet model in simulations run as part of the Climate-Science End Station, an Innovative and Novel Computational Impact on Theory and Experiment, or INCITE, project that runs on the LCF systems.

"We need SEACISM to be working efficiently on LCF systems by next year," Evans said. The team is running test cases to validate newly developed model features. Once the code reproduces previous results, the team will move on to cases of increasing size and complexity. More detailed equations and finer grids build more complexity into the model, which allows better resolution of features such as the grounding line, a crucial juncture at which the floating ice shelf meets the land surface below it.

The SEACISM team is working on several journal articles about its research and will present intermediate results to the CESM's Land Ice Working Group in Boulder, Colo., in January. It hopes the model improvements will allow [climate scientists](#) to provide simulation data about [ice sheet](#) dynamics that will inform the next IPCC assessment report, expected in 2013.

Provided by Oak Ridge National Laboratory

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