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RAPID DEVELOPMENT OF AN ICE SHEET CLIMATE APPLICATION USING THE COMPONENTS-BASED APPROACH

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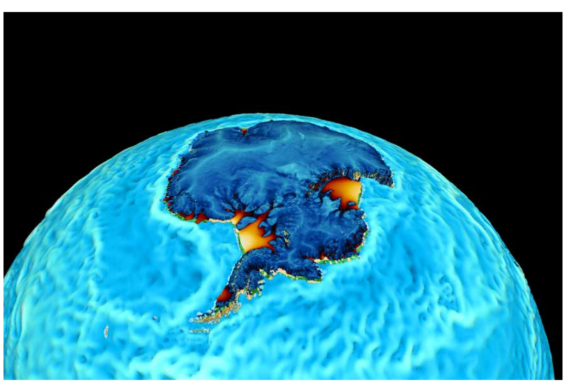
"As computational scientists with expertise in math and algorithms, it is challenging to get deep enough into a new science application area to make an impact. This team has made a sustained effort in learning about ice sheets and building relationships with climate scientists, and has been rewarded seeing our code on the critical path of DOE's climate science program."

– Andy Salinger

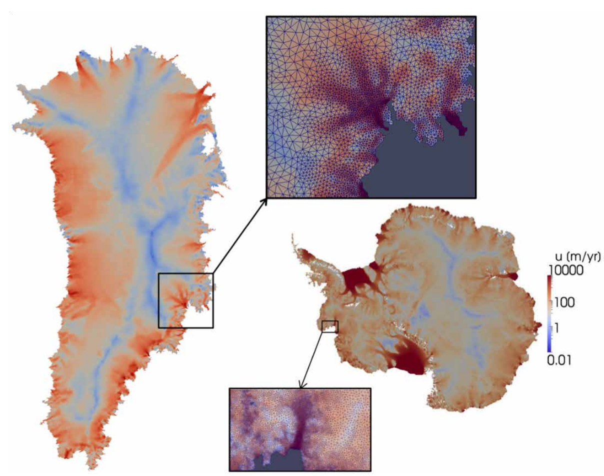
In the third year of a five-year jointly funded project, Sandia's Albany/FELIX simulation code for ice sheet dynamics is being developed to be run in two modes: (1) as a stand-alone model for scientific investigations, and (2) as part of the land-ice component of coupled climate simulations in the Department of Energy's (DOE's) earth system model. The land-ice component simulates changes to the Greenland and Antarctic ice sheets, including their contributions to global sea-level rise. Using high performance computing (HPC), Sandia has recently completed a controlled mesh convergence study to compute the rate at which the Greenland ice sheet is flowing. The study demonstrated that the HPC code is capable of working accurately, efficiently, and reliably on larger scales (over 1 billion unknowns). The study also identified, for the first time, the minimum number of vertical levels needed in the mesh to maintain accuracy.

The rapid development of this impressive simulation capability was enabled by our components-based approach to computational science. Under our "Agile Components" strategy, small teams of experts develop independent math libraries, which are designed to be interoperable through software interfaces, and maintained and deployed for subsequent application by following software engineering best practices. The Albany code benefited from dozens of previously developed capabilities, and in turn, has improved the foundational code base for other applications.

Funded by the DOE Office of Science Scientific Discovery through Advanced Computing program (SciDAC), this project is a collaborative effort between the Climate (BER) and Applied Math (ASCR) programs. Partnering with Los Alamos National Laboratory, Sandia National Laboratories analysts have recently integrated the Albany/FELIX code into LANL's MPAS-LI code, the land ice component of DOE's Accelerated Climate Model for Energy (ACME) earth system model. In ACME, the Albany code will be coupled with the atmospheric, ocean, land, and sea ice components, and used in climate projections in support of DOE's energy and security missions. Demonstrating the capability for interagency computing, this work primarily uses the computing systems as National Energy Research Scientific Computing Center (Hopper) and Oakridge Leadership Computing Facility (Titan).



Visualization of the computed surface velocity of the Antarctic ice sheet, which clearly shows the fast-moving ice shelfs (red-orange colors). For visualization, the vertical dimension of the ice sheet is stretched and the figure is superimposed on an ocean model simulation result, foreshadowing our ongoing work in integrating the ice sheet model into global earth system models. (Graphic by P. Wolfram [LANL]).



Computed surface velocities for both the Greenland and Antarctic ice sheets. The insets show how our unstructured-grid approach allows for enhanced resolution in the critical locations of fast-moving ice streams at greatly reduced computational costs over uniform grid approaches.