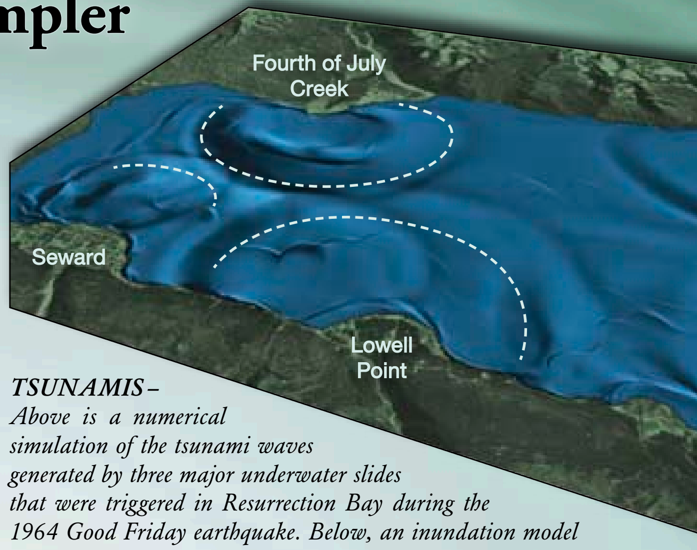
Geophysical Institute Quarterly
Volume 22, No. 4, 2010

Tsunami Mapping Made Simpler

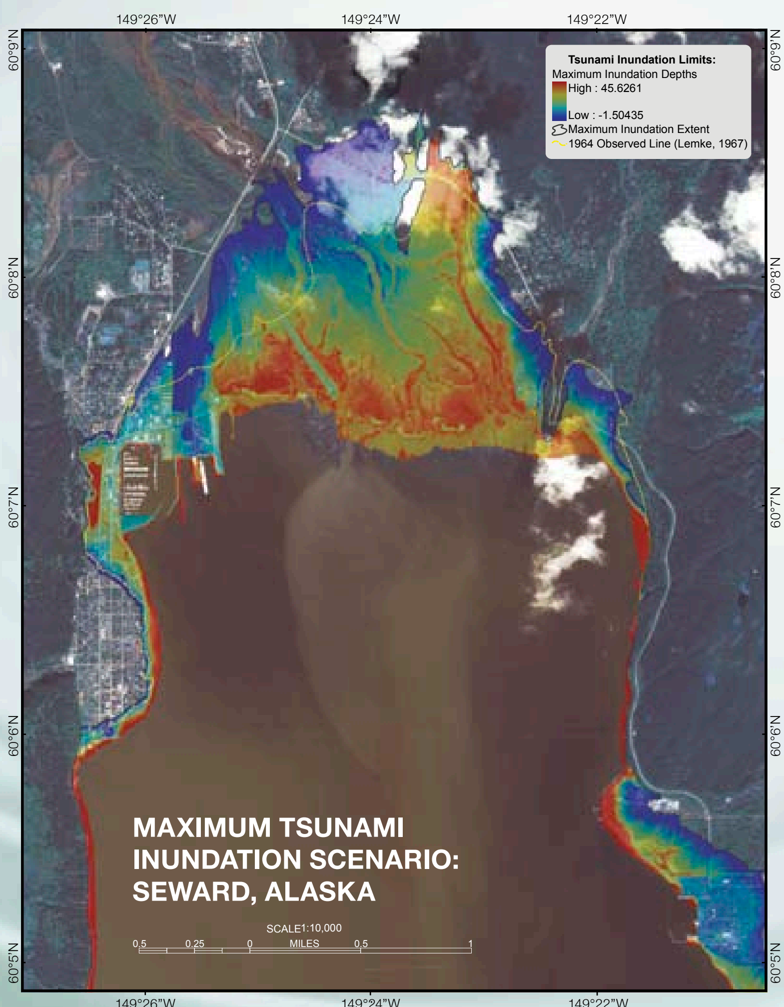
When the Alaska Earthquake Information Center became a National Tsunami Hazard Mitigation Program member in 1998, there were only 11 coastal communities in Alaska that expressed interest in having a tsunami inundation map. After the 2004 Sumatra tsunami killed more than 230,000 people, Alaskans had a renewed interest in tsunami mapping. Researchers at AEIC are now producing inundation maps for more than 75 coastal Alaska communities, a job made easier by the capability of the Arctic Region Supercomputing Center.

Geophysical Institute tsunami numerical modelers Elena Suleimani and Dmitry Nicolsky will produce 76 tsunami inundation maps by 2013. They already have produced maps for Seward, Whittier, Kodiak, Homer and Seldovia, with Cordova, Sitka and Valdez up next.

Producing maps with lines that represent inundation levels for different tsunami events requires numerical simulation of waves generated by different earthquake scenarios. This process, formerly very time consumptive, has become easier with the power of ARSC and with new software Nicolsky developed to interact with computers at the center. He created the Alaska Tsunami Online Mapping Interface "to speed up computations and archive calculations, and to facilitate sharing with people," said Nicolsky. "It's a point and click system."



TSUNAMIS – Above is a numerical simulation of the tsunami waves generated by three major underwater slides that were triggered in Resurrection Bay during the 1964 Good Friday earthquake. Below, an inundation model for Seward shows areas with the greatest potential impact from a tsunami.



"The ARSC consult desk provided a lot of support, answered many questions, developed some pieces of code, and generated ideas how to optimize data flow," Nicolsky added. "It would be much harder to develop (the interface) without their help."

Before Nicolsky developed the software to better communicate with the AEIC tsunami model that runs on ARSC supercomputers, Suleimani, who has worked on the mapping since 1998, had to manually change all the input parameters for each tsunami scenario, for each coastal community.

"It was a very labor-intensive process," she said.

Now, Nicolsky's web-based software, combined with supercomputing power, allows the researchers to get tsunami inundation maps to communities much sooner.

"The important thing is the speed of the process," Suleimani said. "Now we get the map results right after calculations are done."

Supercomputers Model The Future of Greenland

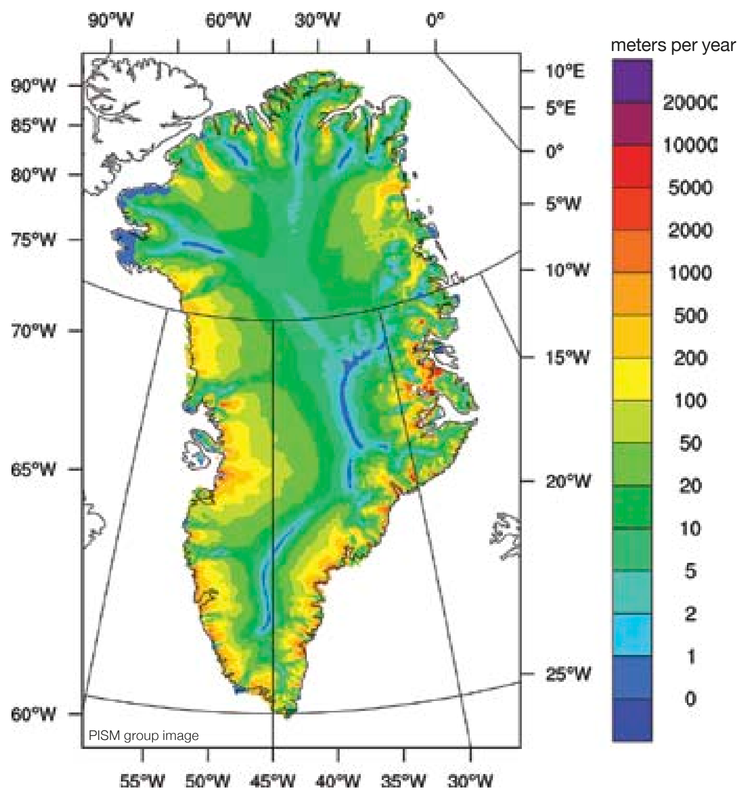
Researchers at the University of Alaska Fairbanks are using the massive computing power of the Arctic Region Supercomputing Center to model future behavior of the Greenland Ice Sheet, work that may give the scientific community a much-needed, comprehensive picture of the potentially dramatic changes in store for the world's biggest island. The researchers' goal is to develop the Parallel Ice Sheet Model into a tool that can effectively simulate changes to the ice sheet and predict resulting impacts to sea level rise.

The collaborative project draws on fieldwork done by Geophysical Institute Associate Professor Martin Truffer, who has taken detailed measurements of the Greenland Ice Sheet's glaciers. Geophysical Institute Associate Professor Regine Hock and Research Professional Constantine Khroulev also contribute glacial surface science and programming to the PISM team, respectively.

Because researchers in the field can't see the bottom of glaciers, they use inverse modeling—applying an understanding of the physical process of glacial flow to the model in lieu of data inputs. Computer modelers like University of Alaska Fairbanks Associate Professor of Mathematics Ed Bueler can then program PISM to use the physics of glacial flow along with remote-sensing data to produce more accurate simulations.

The research group began using supercomputers in 2004. The supercomputers, a 2,290-processor Sun Opteron Cluster dubbed Midnight and a 3,456-processor Cray XT5 called Pingo, allow researchers to combine and analyze satellite data and ice sheet data in a grid of 3-kilometer squares. The supercomputers give the team the processing power to model the ice flow in each square. Dividing Greenland data into such small pieces means working with about 200 million grid cells, and, according Bueler, "There is a fair amount of computation to be done in one cell." The researchers combine results for each square to get a picture—a model—of the dynamics and future behavior of the entire ice sheet. It is a task that demands the kind of processing ability available at ARSC.

According to Andy Aschwanden, postdoctoral fellow with ARSC and member of the PISM team, the model will increase in sophistication as it takes advantage of new



FLOWING ICE– Modeled ice surface velocity for the present conditions of the Greenland Ice Sheet is shown above. Surface velocities vary from zero (shown in blue) to more than 10 kilometers (shown in red) per year in a few outlet glaciers.

high-resolution data for Greenland. The team has recently performed runs on a 1-kilometer grid, a feat Aschwanden calls “unprecedented.”

The PISM project responds to an urgent need in the climate-science community. The Intergovernmental Panel on Climate Change is compiling a new report for 2013, and the panel wants to include this understudied area of research.

“A lot of global climate models don’t include ice sheets,” Bueler said. “They don’t take ice sheet flow into account.”

Ice sheets were once modeled as static entities–big blocks of ice that didn’t change much. Scientists have now learned that Greenland is losing ice mass much more quickly than previously thought. According to Truffer, ocean-outlet glaciers in the last decade are moving faster, losing more mass through calving and melting, and retreating at rapid rates.

Scientists speculate that rising temperatures could cause the Greenland Ice Sheet to pass a tipping point, so that it falls into “irreversible destabilization,” meaning that it will lose more ice than snowfall can replace until the ice sheet melts entirely.

“The question is,” Truffer said, “What is the point of no return?”

Truffer traveled to Greenland in April to study heat flux in ocean-glacier interaction, an area of research that points to one of the challenges of ice sheet modeling. In order to get meaningful, useful data, scientists need to better understand ocean-glacier interaction, the physical processes at the bed of glaciers, and the behavior of water features, such as lakes on the ice sheet’s surface. Once scientists better understand how the ice sheet loses mass, modelers will be able to use the supercomputers to learn about the consequences of that change.

“The goal we are trying to achieve,” Bueler said, “is a better estimate of how much ice sheets can and will contribute to sea level in a warmer climate.”

One innovative aspect of PISM is that it is a completely open and public project. Users from anywhere in the world can download the program, and because the program is open-source they can modify it to suit their needs. A German group, for one, has modified the program to model the Antarctic Ice Sheet.

The UAF group will contribute its findings to the IPCC in 2012, in advance of the 2013 report. Bueler believes that they will continue to make discoveries about ice sheets and ice sheet modeling.

“Once you understand something, you always find something else you don’t understand, so we could keep building this model forever.”

THINNING ICE *– Below, Martin Truffer puts an ablation stake into a shallow borehole in the Greenland Ice Sheet to measure how much ice will melt during the summer. Ocean-calving outlet glaciers in Greenland, like that pictured at right, have been retreating at rapid rates in the last decade.*

photos courtesy of Martin Truffer

Supercomputer Essential for Permafrost Modeling

Geophysical Institute permafrost researchers rely on the Arctic Region Supercomputing Center to help create simulations predicting the future of permafrost in both Alaska and Siberia.

"We can expect degradation of the current permafrost," Geophysical Institute Research Associate Professor Sergei Marchenko said of a modeled scenario for Alaska.

Using what researchers know as the GIPL2-MPI parallel transient model for the Alaska permafrost study, Marchenko was part of a team including the institute's Vladimir Romanovsky, Ronald Daanen, graduate student Elchin Jafarov, John Walsh of the International Arctic Research Center, and Nancy Fresco and Scott Rupp of the Scenarios Network for Alaska Planning at the University of Alaska Fairbanks.

The researchers used a high-resolution dataset that included results from five global climate models and performed a simulation for Alaska (with 2 by 2 kilometer resolution) and another for northern Russia (known as the GIPL2, with 4 by 4 kilometer resolution).

"The supercomputer is a very important part for our modeling result," Marchenko said. "It's a huge amount of data, a huge amount of computation."

***PERMAFROST** – A thermokarst ground collapse near Toolik Lake on Alaska's North Slope is shown above. Photo by Sergei Marchenko.*

Geophysical Institute Quarterly: Volume 22, No. 4, 2010
The Geophysical Institute Quarterly is published as a public service by the University of Alaska Fairbanks Geophysical Institute Outreach Office: **Kathryn Bertram**, supervisor; **Vicki Daniels**, designer and editor; **Amy Hartley**, editor; and **Ned Rozell** and **Brian Keenan**, writers. Free subscriptions to the Quarterly are available by e-mail at info@gi.alaska.edu, by phone at (907) 474-7558; by fax at (907) 474-7290, from the address above, or online at http://www.gi.alaska.edu. UAF is an affirmative action/equal opportunity employer and educational institution.

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