

Taking the pulse of an iceberg -- scientists simulate laser imaging for NASA missions

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Monitoring glaciers and ice sheets is complicated work. They move and change shape. They melt.

A scientist at Rochester Institute of Technology is giving NASA better tools for assessing changes in the fragile polar region. John Kerekes won a three-year, \$561,130 grant from NASA to help the space agency's scientists better interpret remotely sensed data collected with laser light.

The technology -- known as lidar or "light detection and ranging" -- measures altitude by shooting pulses of laser light, or photons, at a target. The light pulses reach the surface and bounce back to the sensor. The detector measures the distance traveled and forms an image of the shape pulse by pulse. The processed data creates three-dimensional renderings or digital elevation maps that scientists can use to measure changes in the [polar ice](#). Future NASA missions, such as the upcoming Ice, Cloud and land Elevation Satellite-2, or ICESat-2, will use lidar devices. Slated for launch in 2016, ICESat-2 will measure ice-surface topography and assess changes to Greenland and [Antarctic ice sheets](#) and sea ice.

"The ICESat-2 science team wants to be able to measure annual changes in ice-sheet thickness to within a few millimeters, averaged over the entire ice sheet," says Kerekes, an associate professor in the Chester F. Carlson Center for [Imaging Science](#) at RIT.

"Take a flat mirror -- a pulse of light comes down, bounces off the mirror and you know exactly how long it took," he explains. "But real ice

sheets and glaciers have narrow crevasses that may be only a few meters wide and tens of meters deep. And the laser pulse is going to interact with that complex surface in a way that will be very different than if it were just a flat surface."

Kerekes' team will give lidar a trial run in a simulated [arctic environment](#) well before NASA launches the technology on its future mission. They will use the Digital Imaging and Remote Sensing Image Generation tool, developed at RIT, to model the light-scattering radiometric behavior of the Earth and its atmosphere in a computer-coded world of glaciers and icebergs orbited by a simulated ICESat-2.

"DIRSIG is capable of simulating scenes that reflect the physics and radiometry found in the real world as compared to simulations that were designed for a movie, where it doesn't have to have the right physical units; it just has to look good," Kerekes says.

The polar scene is a stage for working out the complicated geometry of ice nooks and crevasses, dusted with snow or completely covered. It allows the team to trace the light pulses and write algorithms accounting for the multiple scattering that delays the photons' return to the sensor. Modeling how the detector works on a computer will advance the science of using laser data to interpret the shape of an [ice sheet](#) in the real world. The simulation also doubles as an inexpensive way to test potential design changes or shortfalls in component performances.

Input from geophysicist Beata Csatho, associate professor of geology at University at Buffalo, will provide essential details to the mini-Arctic world. Her expertise in polar topics with a remote-sensing perspective will layer the scenes with realistic physical details of ice sheets and glaciers and lend relevance to testing the laser sensor's signal processing methods via computer software. Csatho, who is also the leader of the NASA ICESat-2 Science Definition Team, understands the challenges of

interpreting data collected from airplanes and satellites.

"Ice sheets and glaciers play a critical role in the Earth's climate system and they are major contributors to global sea level rise," Csatho says.

"Ice sheets and outlet glaciers often change rapidly exhibiting a complex pattern, controlled by interactions with climate, oceanographic and geological processes. Simulations will allow us to develop and test algorithms to process ICESat-2 data for mapping the surface as accurately as possible, even in adverse conditions such when blowing snow or ice fog restrict the visibility or the lidar beam is reflected from a surface covered by melting snow or large snow crystals."

"It's a complementary collaboration," Kerekes adds. "We're working on modeling the instrument -- how it works; how the light interacts with the surface. The UB team is providing an understanding of how we should construct a surface model and what are the most important issues in terms of the NASA science community."

Provided by Rochester Institute of Technology

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