Researcher develops more accurate method to measure surface meltwater volume of Greenland ice sheet

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Carl Legleiter, a UW assistant professor of geography, readies an unmanned drone boat before sending it out to record depth and brightness of a water body on the surface of the Greenland ice sheet. Fellow researchers Alberto Behar (left) and Larry Smith also are pictured. Credit: Marco Tedesco

(Phys.org) —A University of Wyoming researcher discovered that using satellite imagery to map the depth of melt ponds and melt-water stream channels on the surface of the Greenland ice sheet could become a new and more accurate way to keep close watch on that ice sheet's accelerated rate of melting.

Carl Legleiter, a UW assistant professor in the Department of

Geography, was lead writer on a study that demonstrated, for the first time, the feasibility of using spectrally based depth retrieval from high-spatial resolution commercial satellite images of supraglacial (meaning on top of the ice) lakes and streams. Given instrumentation with sufficient spatial resolution, optical remote sensing can be used to accurately estimate the volume of water stored in large lakes and smaller melt ponds that might go undetected by sensors with larger pixel sizes.

"This paper seeks to establish the method of estimating the depth of lakes and streams on the surface of the ice sheet," Legleiter says. "This remote sensing approach could be a powerful tool for understanding the hydrology of the ice sheet and constraining estimates of sea level rise."

Although several previous studies have mapped the locations and depths of relatively large supraglacial lakes from optical image data, none have attempted to retrieve water depth in supraglacial streams.

"There have been some previous remote sensing studies, but those used larger pixels. There was not as much detail," Legleiter says. "To our knowledge, ours was the first to look at stream channels. We could see enough detail to map those smaller streams and ponds."

Breaking the ice

Research was conducted during July 2012 in southwestern Greenland during the summer melt season. Field data and satellite images were acquired from three primary field sites—the Olsen River, Lake Napoli and Cold Creek. The names of these water bodies were bestowed by the research team.

The Olsen River consisted of a broad, shallow channel where melt water exited a lake that transitioned to a narrower, deeper body of water confined by high banks of ice. Lake Napoli was circular with a depth

just past 31 feet. Cold Creek was a shallow, wide and slow-flowing outlet channel from a small lake.

Carl Legleiter (right) and Brandon Overstreet, a UW doctoral student, stand in front of a melt-water stream channel on the Greenland ice sheet. (Larry Smith Photo)

In addition to satellite images, the research team employed an unmanned motorized drone boat that was used to deploy an instrument called a spectroradiometer. The instrument measures reflectance, or the inherent color and brightness of an object, such as the water in the ponds and channels as well as the ice beneath. The boat's instrument payload also included an echo sounder, used to measure water depth.

"It was a way of conducting remote sensing on the ground, so we could develop a relationship between an image-derived quantity, the ratio of two spectral bands, and the water depth," Legleiter says.

The unmanned boat was used in the event that a stream would suddenly

disappear into a moulin, a large pit that serves as an opening into the ice sheet.

A new area of research

This was Legleiter's first foray into studying water bodies on the surface of an ice sheet. Legleiter, who primarily studies terrestrial rivers, including the Snake River, was contacted by Laurence Smith, a professor and chair of the Department of Geography at UCLA, to participate in the study.

"He called me and asked if we could do this (type of measurement) for rivers on the surface of the Greenland ice sheet," Legleiter says. "This is a new field of study for me."

Legleiter, who was in Greenland for only a week, says he particularly enjoyed the 45-minute helicopter rides originating from Kangerlussuaq and traveling over breath-taking vistas en route to the measurement study site.

"It was an adventure. It's one of the most exciting things I've ever done," he says.

And dangerous. Each day, the helicopter delicately touched its landing pads on the ice to probe for a safe spot and avoid crevasses, while a flight crew member used an ice axe to test the ice as well.

"We took a lot of precautions," Legleiter says.

Legleiter hopes to return to Greenland for more research, perhaps in summer 2015. He is one member of a large scientific team that has submitted a proposal to NASA to conduct further work on the Greenland ice sheet. If the proposal is successful, it would include funding for

unmanned aerial vehicles (UAVs), also referred to as drones.

"They would fly back and forth over the ice sheet all summer long, and provide broader spatial coverage," he says. "The drones would make repeated movements over the ice sheet during the melt season, and record changes as the melt season goes on."

More information: Legleiter, C. J., Tedesco, M., Smith, L. C., and Overstreet, B. T.: "Mapping the bathymetry of supraglacial lakes and streams on the Greenland Ice Sheet using field measurements and high resolution satellite images," *The Cryosphere* Discuss., 7, 4741-4773, DOI: 10.5194/tcd-7-4741-2013, 2013.

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