Greenland Ice Sheet
Surface melting and a slippery bottom

Sarah Das, Geology & Geophysics
Mark Behn, Geology & Geophysics
Dan Lizarralde, Geology & Geophysics

Should the polar ice sheets melt in response to rising global temperatures, dramatic effects are predicted in the form of higher sea-level and the alteration of ocean circulation patterns. The Greenland Ice Sheet is more than a kilometer thick in most places, and until recently, many believed that it would take over a thousand years for temperature variations at the surface to reach the bed of the ice sheet.

Recent observations from Greenland, however, suggest that ice sheets have the potential to respond much more rapidly to climate change than was previously believed. New data show that ice-flow acceleration can occur within hours or days following the onset of melting at the surface. This surprising finding suggests that meltwater might be draining through the ice sheet rather than running off the surface, thereby rapidly lubricating and warming the bed. This would result in a quicker movement of the ice sheet toward the coast and ultimately into the ocean. If we are to fully grasp the effects of increased ice melting on ice sheet flow and its effects on sea-level change, we need to understand where and how the meltwater gets to the ice sheet bed.

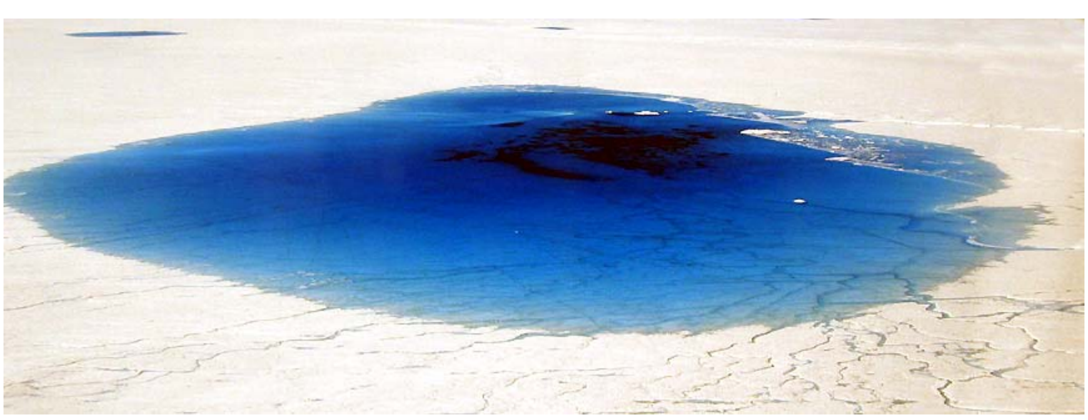
Sarah Das and Mark Behn drilling to install a seismometer on the Greenland Ice Sheet.

One mechanism that has been proposed to quickly transport meltwater from the surface to the bed of an ice sheet is the propagation of water-filled fractures beneath lakes that form annually on the surface of the ice sheet. While theoretical models suggest that the draining of supraglacial lakes through fractures in the ice is a plausible transport mechanism, water-filled cracks that reached the bed had never been observed in the thick, subfreezing ice sheets. New results in 2006 & 2007 from our National Science Foundation-funded project to study the behavior of supraglacial lakes (see Oceanus article: Tracking an Ocean of Ice Atop Greenland) have revealed that large lakes do in fact drain rapidly—some in a matter of hours—through an apparent fracture-driven process (see front cover). This study represents the first glimpse into the pathways and time scales of surface-to-bed water flow.

Our next step, supported by the Ocean and Climate Change Institute, will be to monitor the fracture process with field-based measurements to determine the location and timing of fracture events and test our numerical model results. To accomplish this, we have designed an observational network to measure seismicity around seasonally draining supraglacial lakes. Our experiment is designed to determine the rate and extent of water-filled crack propagation. We expect that crack propagation will be accompanied by enhanced seismicity near the crack tip.

During our field expedition in July 2007, we deployed a network of seismometers around two lakes on the Greenland Ice Sheet. We will retrieve the instruments and data in July 2008. With this seismic network we should be able to determine the strength of the “icequakes” associated with lake drainage and establish: 1) whether crack propagation coincides with drainage and 2) the location and maximum depth extent of crack penetration. These measurements will provide some of the first direct observations of the mechanisms behind rapid meltwater transport from supraglacial lakes to the bed of theGreenland Ice Sheet.

—Sarah Das and Mark Behn



Large lakes form as ice melts and pools on the surface of the Greenland Ice Sheet. The lake shown above is 1 kilometer wide by 1.5 kilometers long. These “supraglacial” lakes drain seasonally through cracks in the ice.