The researchers lower the fiber-optic and sensor cables down a hole drilled through the ice to the ocean in 2011. The data from this equipment revealed details of the interactions between ocean water and the base of the ice sheet.

Fiber optics in Antarctica will monitor ice sheet melting

By Carolyn Gramling (author/carolyn-gramling)  21 October 2014 1:15 pm  0 Comments (climate/2014/10/fiber-optics-antarctica-will-monitor-ice-sheet-melting#disqus_thread)

Earth is rapidly being wired with fiber-optic cables—inexpensive, flexible strands of silicon dioxide that have revolutionized telecommunications. They've already crisscrossed the planet's oceans, linking every continent but one: Antarctica. Now, fiber optics has arrived at the...
continent, but to measure ice sheet temperatures rather than carry telecommunication signals. A team of scientists using an innovative fiber-optic cable–based technology has measured temperature changes within and below the ice over 14 months. This technology, they say, offers a powerful new tool to observe and quantify melting at the base of the West Antarctic Ice Sheet, the collapse of which may help drive a worldwide increase in sea levels of more than 3 meters (http://www.sciencemag.org/content/344/6185/735.abstract).

The oil and gas industry has been using fiber-optic cables to measure temperatures in boreholes for decades, says Scott Tyler, a hydrologist at the University of Nevada, Reno (UNR). Tyler has been adapting this technology for his own environmental monitoring in places ranging from Chile’s Atacama Desert to Switzerland, ramping up the sampling speed and resolution in order to measure small temperature changes in lakes, streams, and the atmosphere.

Recently, he began hearing from scientists working in Antarctica who were interested in deploying the technology there. The hope is that the cables could reveal secrets about what’s happening underneath the ice sheets, especially about melting at the so-called grounding line, the place where the bottom of an ice sheet meets the slightly warmer ocean. This junction is where much of the melting is taking place (http://www.nature.com/nature/journal/v484/n7395/full/nature10968.html). Driven by stronger winds resulting from climate change, ocean waters in the Southern Ocean are mixing more powerfully, so that relatively warm deep water rises to the surface and eats away at the underside of the ice (http://www.sciencemag.org/content/341/6143/266).

Tyler and his colleagues, including David Holland, an oceanographer at New York University, and Victor Zagorodnov, a glaciologist at Ohio State University, Columbus, installed the technology from November to December 2011. They drilled through about 200 meters of ice, unspooled a length of optical fiber into the borehole, and then extended the cable through the hole and down about a kilometer into the ocean beneath. To measure temperatures along the cable’s length, the team sends pulses of light down the fiber and observes how the fiber backscatters the light, returning it in the direction from which it came. “It’s like shining a flashlight into a dusty room and you can see specks of
dust," Tyler says. As the temperature changes down the length of the borehole, the light travels at slightly different speeds, and the color of the backscattered light changes slightly as well. The frequencies of the backscattered light are measured by an optical receiver and those signals are processed to determine temperatures. “It’s a really subtle change in color that your eyes can’t see but our instruments can,” Tyler says. “The color of that light tells me the temperature of that place along the fiber.”

The power of this “distributed temperature sensing” is that it provides more than just a snapshot of a temperature at a particular depth—instead, the technique allowed the researchers to measure temperatures all along the length of the fiber. What they observed, they reported online this month in *Geophysical Research Letters*, was a rich time series showing the interplay of ice and ocean water. “We can actually see the bottom of the shelf moving up over time” as the ice melts, Tyler says. “Instead of an average annual melt rate, we can get the melt rate almost on a daily basis, which is pretty hard to do,” Tyler says. “We were pretty sure we’d see temperature changes—and we did, we saw a beautiful influx of warm water,” a pulse that was about –1.3°C, just slightly above freezing for sea water, which is about –1.9°C, he says.

Recording these temperatures continuously can help scientists develop a detailed picture of the physics by which the ocean melts the ice shelves from below, says oceanographer Laurence Padman of Earth & Space Research in Corvallis, Oregon. Researchers can measure annual changes in how the melt rate occurs, for example, or the effects of a single pulse of warm deep-ocean water. “It allows us to know what the ocean is doing at the same time the ice is responding to it,” says Padman, who was not connected with the study. “It’s a neat extra tool to have in our toolbox for looking at how ocean and ice shelves interact.”

One disadvantage to using fiber-optic temperature sensors to study ice shelves, Padman notes, is that they aren’t particularly easy to deploy, requiring drilling through ice that can be as much as 2 kilometers thick. So although it offers the opportunity to collect a continuous time series,
it’s unlikely to offer broad spatial coverage. But “we’re used to that in the Antarctic, not being able to get everything we want,” he says.

Although Tyler’s team pulled its instruments out of the borehole in January 2013, the mooring that held the cable in place remains frozen into the ice shelf, he says—and the team hopes they can get back to it for a longer term monitoring project. Tyler’s lab has also been working with a U.S. team that drilled into Antarctica’s subglacial Lake Whillans (http://news.sciencemag.org/2013/01/u.s.-team-retrieves-samples-buried-antarctic-lake) in 2013, installing a fiber-optic cable to measure heat flux in the lake.

Meanwhile, he says, other researchers are becoming interested in how they might be able to use fiber optics. The National Science Foundation supports a joint center at UNR and Oregon State University (http://www.ctemps.org) that makes fiber-optic equipment available to the research community. “Our goal is to keep these instruments in the field,” Tyler says.

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