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Inductive Modems on Ice:

Mooring with Inductive Telemetry Operating on the Ross Ice Shelf

Mike Brewer of NIWA servicing the mooring.

Words by Darius Miller, president and principal engineer of Soundnine Inc.

Just over a year ago a large team of New Zealand scientists mobilized for one of the most ambitious projects carried out in Antarctica. This was a multi-disciplinary team involving a dozen separate studies, three New Zealand Universities, and two Crown research institutions. Their goal was to monitor conditions at the Ross Ice Shelf and study how this vast ice shelf might respond to future global warming.

The Ross Ice Shelf is the largest ice shelf in the world. It is hundreds of meters thick and larger than California. The cold cavity under the ice contains more water than the entire North Sea. This system is important to climate models but remains poorly understood. Scientists estimate melting under the ice shelf accounts for about half the mass loss on the Ross Sea side of West Antarctica.


A current profiler starts a 700 meter journey to the ocean under the ice.

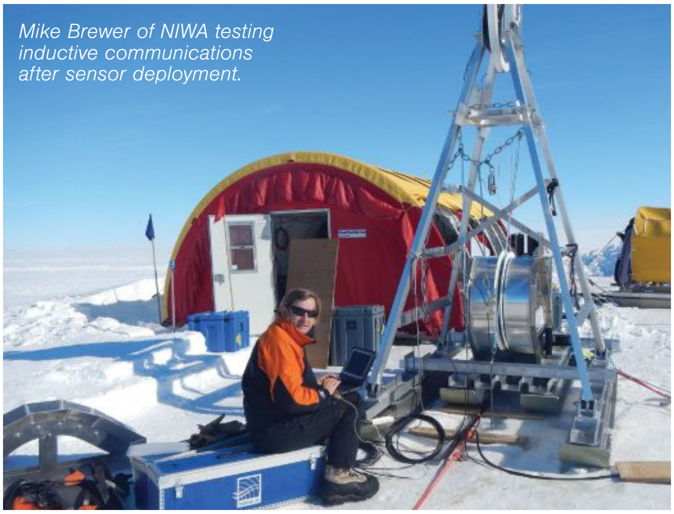
The team camped on the Ross Ice Shelf in November, 2017 – after a series of weather delays typical of Antarctic operations. They were about 350 kilometers from the Kiwi Antarctic headquarters at Scott Base. The expedition was supported by two aircraft and tracked vehicles. Aircraft were often grounded due to weather conditions. The temperature was a balmy minus 18 degrees Celsius in the Antarctic spring.

Moorings technician Mike Brewer, from New Zealand science research organization NIWA, was part of the team installing sensors under the ice shelf. This required first opening a hole in 400 meters of ice to reach the ocean beneath, then passing about a kilometer of mooring cable with instruments through the hole before it froze. The hole was melted with an impressive hot water drill equipped with cameras and sensors.

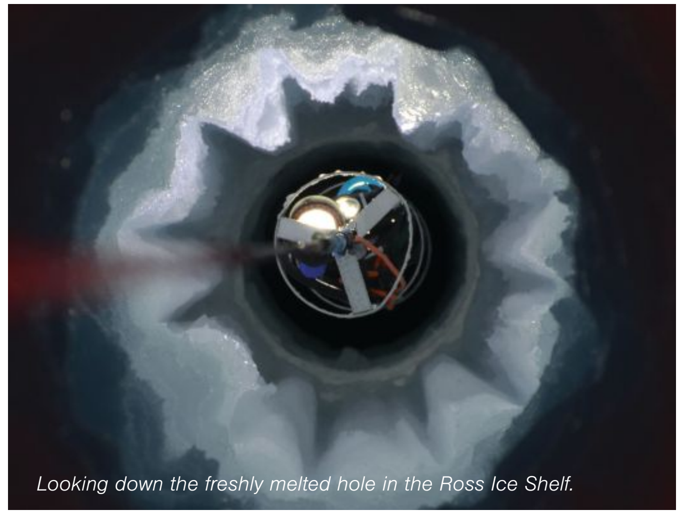
Sensors deployed on the cable measure temperature, salinity, and currents at five depths of up to 350 meters in the ocean under the ice. Expendable temperature sensors were placed at the ice-water boundary. The sensor payload included Sea-Bird Scientific SBE37IM CTD's, Nortek Aquadopp current meters, and Soundnine Inc XTP temperature & pressure sensors. All these instruments were passed through a hole in the ice only 25 centimeters wide.

The sensors communicate using electrical signals inductively coupled through the mooring cable. A DANTE buoy controller and Ultimodem inductive modem from Soundnine Inc poll the subsurface instruments every thirty minutes and transmit data via Iridium RUDICS satellite connection every two hours. Satellite communication uses a small antenna mounted on a tripod over the snow.

The DANTE controller was a late addition to the project, ordered just a month before the team's scheduled departure. While the unit performed admirably, it had a dramatic beginning. The Iridium transmitter was damaged on the ice, probably by connecting the wrong kind of antenna. In an episode both surreal and ironic, as Mike Brewer worked on the ice at minus 18 degrees, Soundnine Inc engineer Darius Miller helped diagnose the problem while suffering from heat exhaustion in a hotel in Mexico. After many days waiting for a re-



Mike Brewer of NIWA testing inductive communications after sensor deployment.



Looking down the freshly melted hole in the Ross Ice Shelf.

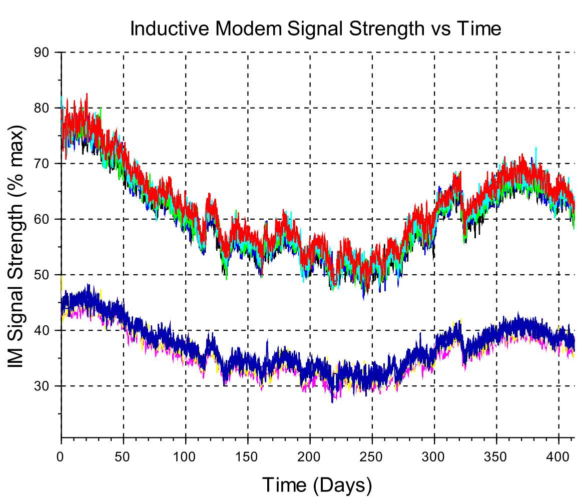
placement modem to arrive, Mike swapped the modem, connected a new antenna, and buried the unit in the snow with just minutes to spare before the last plane left for Scott Base – not knowing if the transmitter was working or if he would have to return to retrieve data.

In addition to logging CTD and current profiler data, the controller also collects performance data for the inductive telemetry. It records the background noise level on the mooring cable and the signal strength of each transmission from each underwater sensor. These data show the inductive communications system has much lower noise than typical surface buoys and the signals from the subsurface instruments are both very strong and very consistent over the entire year. The current meters transmit stronger signals than the CTDs. The only significant variations in signal strength of inductive telemetry to date are strongly correlated with surface controller temperature and servicing of the mooring. The system shows a margin of several hundred times the minimum required signal strength for reliable communications.

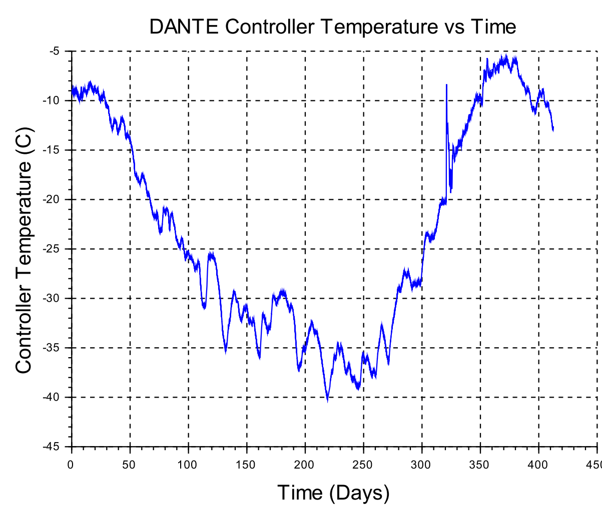
The Antarctic is a harsh environment for electronics. Over the year the temperature in the controller ranged from minus 8 degrees to minus 40 degrees C. Most electrical components are not characterized for operation below minus 40C. This doesn't mean they won't operate – but each unit must be tested below the minimum expected temperature. The controller and inductive modem were packed in a shipping container with batteries and buried in the snow for protection from the worst of the weather. The electronics are extremely power efficient, so they generate almost no heat and remain at the temperature of the snow and ice.

Mike returned to the ice in November, 2018 to carry out maintenance work on the surface unit and replace batteries. The controller has enough power to transmit for several years – well after the underwater instruments run out of battery power. The team hopes to recover the instruments from under the ice in a future expedition. Since they already have the data, any recovery effort may be much less exciting than the next deployment.

With just over a year of data collected, a great deal of analysis is in progress. Already the findings have surprised scientists who have found the underside of the ice covered in flat ice crystals, showing that sea water is freezing on to the base of the ice. We're looking forward to hearing more from the scientists as they review the data.



Inductive communication signals through the ice are surprisingly stable. Signal strengths of all instruments change as a group with the surface temperature.



The surface controller temperature reached -40C while buried in the snow.