University of Utah

University of Utah Goes to Extremes to Investigate the Characteristics of Polar Ice

Barrow, Alaska and Scott Base, Antarctica are just two of the far-flung locations visited by mathematicians and electrical engineers at the University of Utah.

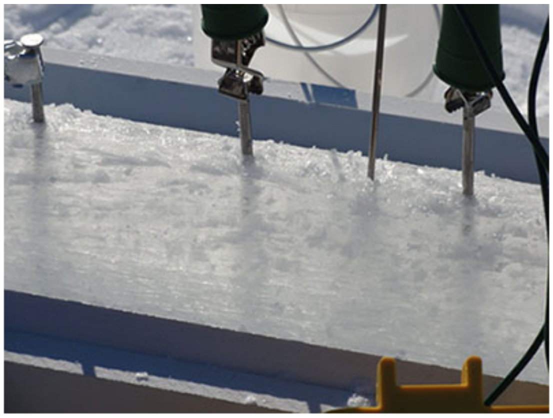
Why the lengthy trips?


Professors Ken Golden and Cynthia Furse and colleagues from the University of Utah have ventured to both the Arctic and Antarctic Polar Regions to study sea ice and understand what variables should be measured to better understand climate change. Dr. Golden, Professor of Mathematics and Dr. Furse, Associate Vice President for Research and Professor of Electrical & Computer Engineering, have made multiple treks to determine why ice loss in those regions has been worse than expected. "Just as meteorologists have excellent models for predicting the weather, we need models for predicting how climate is changing," notes Furse. Professor Golden has been to the Polar Regions seventeen times and is developing mathematical models to predict how sea ice is impacted by global warming.

Understanding how freezing and melting ice factors into climate change models

To identify what parameters are needed to predict how climate change will impact the environment, Golden and Furse have focused some of their research on the effects of melt ponds. "When sea ice freezes, the pure water freezes first, leaving behind the extra-salty brine in little pockets throughout the ice," explains Furse. "As the ice warms, the tiny inclusions link up, creating channels of salty brine. Meanwhile, when the sun melts the ice in the spring, it creates 'melt ponds' of water that sit on top of the ice. Melt ponds absorb heat from the sun, because they are dark colored. If the channels in the ice created by the brine pockets are big enough and connected enough, water from the melt ponds can percolate down through the ice to the ocean below, draining the melt pond. The more brine channels in the ice, the more drainage can occur." Golden and Furse, and their research teams are very interested in these channels and their impact on sea ice.

Measurement techniques



Measuring the conductivity of sea ice using a four-probe setup. A thermistor probe in between measures the temperature of the ice near Scott Base in Antarctica, 2010. Photo Credit Cynthia Furse 2010

The Utah team used two ways to measure the brine channels. One method is to measure actual fluid flow by removing a partial core from the ice and measuring how fast the water rises into the hole. This gives the fluid permeability of the ice at the bottom of the hole. Another method is to measure the electrical properties of the ice. The brine phase has a higher electrical conductivity than pure ice, and by correlating electrical measurements with the percolation properties of the ice, researchers can make estimates of how quickly a melt pond might drain in that region.

Keysight Technologies in the field

Multiple test instruments were taken on the polar expeditions, which proved useful in capturing invaluable data. For example, a FieldFox handheld analyzer from Keysight (formerly Agilent's Electronics Measurement Group) was instrumental in measuring the electromagnetic properties of the ice.


Left photo: Professor of Mathematics Ken Golden taking a core sample of sea ice in McMurdo Sound, Antarctica near Scott Base. Mt. Erebus looms in the background. Photo Credit: David Lubbers 2010

Right photo: Graduate student in electrical and computer engineering David Lubbers uses the Field Fox to measure the AC conductivity of a sea ice core in the Arctic Ocean off the coast of Barrow, Alaska. Photo Credit Cynthia Furse 2011

These ice core samples, taken with an ice corer, measured 1 meter long by 9 centimeters in diameter. Nails were placed into the cores which allowed for 4-wire measurements of the ice. The Keysight FieldFox analyzer provided the low frequency AC impendence magnitude and phase measurements as well as complex permittivity (high frequency equivalence of resistance) from related waveguide experiments.

Graduate student in electrical and computer engineering David Lubbers uses the Field Fox to measure the AC conductivity of a sea ice core in the Arctic Ocean off the coast of Barrow, Alaska. Photo Credit Cynthia Furse 2011

The environment that the Utah team experienced was tough on their instruments. Antarctica was particularly harsh on the team with blowing needle-like snow that had a sandblasting effect. These salty particles threatened to get into the instruments. Fortunately, the ruggedized Keysight FieldFox is weather resistant and designed to withstand both salty and humid environments, and performed well in the extreme conditions.

Wind, snow, penguins, and bears

The polar trips, which included University of Utah undergraduate, graduate and post-doctoral research assistants, provided a unique opportunity for the engineering and math students to participate in important discoveries and make immediate contributions. In this case, the working conditions for both professors and assistants were far from typical. Their research programs took them to locations that had significant logistical challenges.
More than one trip required the help of icebreaking ships to get the researchers to their remote locations. Once there, they often encountered harsh working conditions including sub-zero temperatures, wind, and howling snow. And if that wasn't enough, while taking measurements in the Artic, the team took along a rifle-toting guard to watch for polar bears while they worked in the field. "I've always found engineering exciting, fascinating, and never ever boring … but I hadn't exactly planned on this much adventure," exclaims Professor Furse.


Left photo: Graduate student in electrical and computer engineering David Lubbers takes a break to greet some curious onlookers during the SIPEX II cruise off the co east Antarctica. Photo Credit: Ken Golden 2012

Right photo: Engineering is not your average desk Job. Dr. Cynthia Furse (with ice core), ECE undergraduate David Lubbers (with ice axe), and their bear guard, Glenro Barrow, Alaska 2012.

Tackling important questions

There are still many questions to be answered. Going forward, Dr. Furse and her colleagues will be doing extensive analysis on the large amount of data that has been collected from the Arctic and Antarctic regions. Meanwhile, Dr. Golden is continuing his work to develop theoretical models that will improve predictions of how sea ice will respond to planetary warming. This research will help provide insight into how our environment is changing. "I believe it is important to understand something as critical to us as our planet's climate," states Professor Furse. "There are many questions about climate change, and my job as a scientist is to help understand and answer those questions. Fortunately, I am not alone in that endeavor and great progress is being made."

University of Utah Resources:

- Kenneth Golden's webpage
- Cynthia Furse's webpage
- University of Utah Electrical & Computer Engineering
- University of Utah Mathematics
- Antarctica Blog
- Arctic Blog

Keysight Technologies Resources:

- Keysight Home Page
- FieldFox Handheld RF Analyzer
- Keysight Educators' Corner
- Keysight Researchers' Corner
- Additional Spotlight Articles