Research Highlight

GNSS Reflections: the future of observational sea level and ice sheet research?

Prof. Natalya Gomez *is an Assistant Professor of Earth and Planetary Sciences in the McGill Space Institute. Her research centres around the interactions between ice sheets, sea level and the solid Earth, and the response of these systems to past, present and future climate changes.* **David Purnell** *is an MSI fellow and a Ph.D. student in Prof. Gomez's group. His research focuses on observations of sea level and ice sheet interactions in Greenland using remote sensing techniques.*

Why this is important

GNSS-R is a promising new technique for measuring changes in sea level near ice sheets. Said measurements could be used to inform our understanding of how the ice sheets respond to changes in climate on Earth. The remote sensing techniques (and associated algorithms) developed in this project would help guide future endeavors to other ice-bearing planetary bodies.

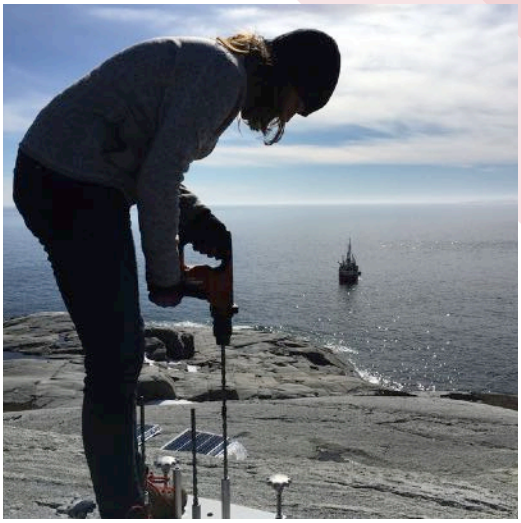
In June 2018, MSI Professor Natalya Gomez and MSI fellow David Purnell travelled to the west coast of Greenland, joining a team from New York University Abu Dhabi's Center for Global Sea Level Change to install instruments near Jakobshavn Glacier, one of the largest and most rapidly changing outlet glaciers of the Greenland ice sheet. Global Navigation Satellite System antennas (GNSS, a general term for satellite networks such as the familiar GPS) will be used to monitor local sea level using a new technique called GNSS Reflectometry (GNSS-R), along with various other instruments to monitor properties of the atmosphere and ocean to isolate changes in sea level due to ice mass changes at Jakobshavn.

When an ice sheet melts, the meltwater is redistributed around the oceans causing, on average, a rise in global sea levels. However, the oceans do not fill up evenly like in a bathtub; instead, sea level actually falls near the ice sheet and rises at a greater distance from the ice sheet. This pattern is caused by the solid earth rebounding elastically (popping up) in response to the reduced weight of the ice sheet and a weaker gravitational attraction of the ocean towards the ice sheet. The combination of these effects causes a local fall in sea level that is much larger in magnitude than the rise that occurs farther away. Therefore, sea level measurements near an ice sheet could theoretically be used to improve estimates of ice mass changes, a key challenge in observational ice sheet and sea level research.

A GNSS antenna in a Fjord near Jakobshavn glacier in Greenland, installed by Natalya Gomez, David Purnell and collaborators at NYU as part of field work in June.

Traditionally, sea level has been monitored using instruments called tide gauges, which are difficult and expensive to maintain in harsh polar climates. There are currently very few tide gauges in polar regions, which has limited the possibility of using sea level measurements to estimate ice mass changes. By contrast, multiple networks of GNSS instruments currently exist in polar regions. It has recently been proposed that a GNSS antenna installed on the coast could be used as an alternative to traditional tide gauges. GNSS-R sea level measurements are obtained by analyzing the interference between microwaves emitted from satellites that reach an antenna directly and indirectly after reflecting off the sea surface.

The purpose of the fieldwork was both to test the capability of GNSS instruments to monitor sea level and to test the hypothesis that sea level measurements near an ice sheet could be used to improve estimates of ice mass changes. If the project is a success then these stations may be the first members of a larger network of GNSS-R stations in similar polar regions. The remote sensing techniques (and associated algorithms) developed in this project would help guide future endeavors to other ice-bearing planetary bodies.



From top right: Natalya Gomez drilling the foundations for a GNSS antenna at a site in Disko Bay; David Purnell and Professor David Holland (NYU) preparing an ocean mooring; David Purnell and Natalya Gomez in Disko Bay, Greenland, with a large iceberg originating from Jakobshavn glacier that can be seen behind.