Monitoring the changes of our lifetime

by Farouk Kadded and Luc Moreau

Greenland, rugged and wild, is covered by a massive ice sheet that represents roughly 80% of its surface. Glaciers break free of this ice sheet and become slow flowing rivers of ice that are constantly moving, being pushed by their own massive weight towards the sea. There are many reasons why researchers have recently taken an enormous interest in studying the secrets of Greenland's ice. One is that Greenland is especially vulnerable to climate change; the ice sheet is melting faster than any other body of ice in the world and the glaciers are moving ten times faster towards the sea than they did just five years ago. Another reason is that this country's ice represents roughly eight percent of all freshwater found on Earth. Should these glaciers melt, the meltwater would be enough to raise the sea level by over seven metres (20 feet), displacing millions of people on this planet. This will have serious consequences on our environment, making it extremely important to monitor these changes, which are occurring during our lifetime.

Luc Moreau, a glaciologist based in Chamonix, France, has been studying the impressive four kilometre (two and a half miles) wide Eqip Sermia glacier in West Greenland for over three years. Luc, along with, the SPELEICE association and the MONALISA production company, recently organised an expedition to collect data on the speed of this glacier's melt flow and to understand how this glacier's ice moulins (deep holes that transport meltwater through glaciers) affect the speed of its melting. Accompanying them was Farouk Kadded, product manager of Geomatics at Leica Geosystems France, and together they set out using the state-of-the art Leica Nova MS50 MultiStation and real-time GNSS positioning instruments Leica

The melting glacier, Eqip Sermia, in Greenland is moving alarmingly fast.

GS14 antenna and Leica GS10 receiver. The MultiStation was chosen because it was capable of making accurate, reflectorless 3D scans from a distance of 1 – 2 km (0.6 – 1.2 mi), was lightweight and compact enough to be carried in a backpack and was proven to be reliable and rugged. It was also the only scanner on the market that offered all four technologies needed: total station, scanning, GNSS and imaging.

Measuring the Eqip Sermia's movement flow

During his last expeditions, Luc set up a camera that took pictures daily over the last few years. He was able to identify the changes in the glacier size by piecing together a "timelapse" film from the images taken by this camera. This film, when accompanied by the collected topographic data of the Leica Geosystems equipment, could be used to calculate the length and speed of the flow of the Eqip Sermia glacier.

After Luc and Farouk found stable ground for the GS10 receiver to serve as a reference point, they started out looking for the ideal measuring positions on the glacier. This was a dangerous task on the quickly shifting glacier surface with its deep and deadly ice chasms. Carrying the MultiStation, a tripod, a reflector target, the rugged Leica GS14 antenna and a pole, they first set up the MultiStation on the stable left bank with the Leica GS14 GNSS antenna on top to get the exact coordinates for the MS50 to measure the selected points at a range of 1.3 kilometres (0.8 miles). After this, they perilously crossed the glacier to position a reflective target. For four consecutive days, they collected position data at the same time of day to calculate the glacier melt flow over a 24-hour period.

The glacier moved at a rate of up to 30 centimetres (12 inches) an hour, so the team had to work fast. Images were first taken by the MultiStation of several seracs, or ice towers, to help Luc and Farouk easily relocate the same points the next day.

The results proved that the glacier's movement was up to 7 metres (23 feet) a day. The last measurements taken in 2012, revealed the Eqip Sermia moved 3 metres (10 feet) daily. This flow, when compared with other glaciers around the world, moving roughly 30 centimetres (12 inches) a day, is alarmingly fast. The team also proved the glacier lost roughly 500 metres (1,640 feet) in just the previous month. Another goal the team had set out to accomplish, that of using the Leica MultiStation to make a 3D scan for posterity of the historic cabin that French polar explorer Paul-Émile Victor used as a base for his expeditions, was also successfully completed. Also, a large lake several kilometres inland on the Eqip

■ **A bracket on the ice wall carries the MS50 to scan the moulin.**

Sermia's surface was discovered. Should this water somehow find its way into a crack, it could cause a glacier meltdown. Finally results also proved that the glacier is melting 100 times faster below the surface of the ocean than above.

Measuring the inside the ice moulin

After making the same, day long trek on the path explorer Paul-Émile Victor took to reach the glacier's ice cap 60 years ago, the team set up camp and searched for a "moulin" to make the 3D scan. This scan would determine if the water inside a moulin did indeed reach the rock bed below the glacier. Why are these moulins so important to researching glaciers? With Greenland feeling global warming much more than the rest of the world, lakes of meltwater appear on the surfaces of the glaciers on very warm days. The excess lake water produces rivers that melt the ice at an alarmingly rate. If this water gets into a moulin, it will begin to swirl and erode the ice and find its way to the bottom of the glacier on Greenland's bedrock. This water builds up under the glacier and works like a lubricant. The glacier easily slides on this water surface and the forces of gravity push the massive weight of the ice even faster, towards the ocean.

The meltwater's journey

Luc and Farouk managed to set up the MultiStation on the tribach inside an ice moulin to scan the details of the ice crevasse. With some moulins reaching depths of up to 200 metres (650 feet) , it was truly exciting. Never before has such an accurate scan be done of how the water's flow formed nooks and crannies inside a glacier moulin, recording its progress to the bottom of the ice.

Working inside this hole is not without its dangers. Should the surface temperature fluctuate as much as 1-2°C (34-36°F), glacier water could start to melt and flow into the moulin, flooding everything. Scanning took an entire day, but they were able to scan the moulin in its entirety, measuring vertically, bit by bit, from the river that created it to its deepest part, collecting roughly 500,000 highly detailed points. Depth, circumference and width can all be provided by a 3D scan taken by the Leica MS50 MultiStation and the results were fascinating.

"The idea of measuring this way was to have all the dimensions of a moulin in order to appreciate its development over time and the deformation of the ice. The results proved very effective, the model visuals are excellent and the device well suited for this type of opening – provided you have good weather!" says Luc Moreau excitedly.

The 3D scan proved the Leica MS50 MultiStation's versatility and its robustness under extraordinary circumstances. Its new programs and features that work together, integrate new technologies, making measuring far more reliable, quicker and complete, enabling researchers to receive the information they require. Working together with companies that are at the forefront of their fields, can only help researchers to advance in their understanding the changing climate. ■

About the authors:
Farouk Kadded is a land surveying engineer and works as Product Manager of Geomatics at Leica Geosystems France.
farouk.kadded@leica-geosystems.fr
Luc Moreau is a glaciologist. He holds doctor's degree in alpine science and is an associate member of the research team of CNRS Laboratory Environment and Dynamics of Mountain Territories.
moreauluc@club-internet.fr