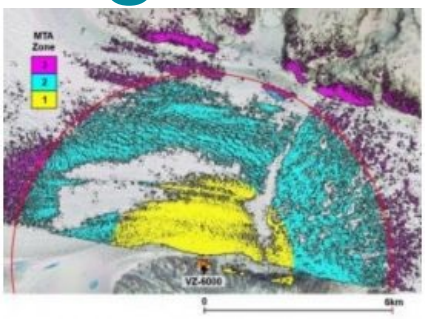
PUSHING THE LIMITS

Scanning Glaciers with a Long-range Scanner



Scan data displaying MTA zones for 50kHz measurement rate overlaid onto Google Earth.

A team of scientists recently completed a research visit to Helheim Glacier in Southeast Greenland. The purpose of their research was to characterise the behaviour of the glacier using the latest technology in ground-based remote sensing, a long-range Terrestrial Laser Scanner (TLS). The team monitored the glacier over the course of a few days using a Riegl VZ-6000 Ultra-Long Range which enabled fixed-time interval scans of the glacier to be completed automatically. This automation gave the team a time-lapse 3D dataset, which can be referred to as a 4D dataset. One of the key breakthroughs was their ability to safely measure the entire width of the glacier from one side of its 6km-wide fjord. Glaciers are some of the most powerful forces on Earth, so the ability to monitor them while remaining at a safe distance is essential.

Retreat, acceleration and thinning of tidewater outlet glaciers around the margins of the Greenland Ice Sheet have continually been observed over the last two decades. These changes coincide with an increase in surface melting and, together, have doubled the ice sheet's contribution to equivalent global mean sea-level rise. Specifically Helheim Glacier, located in Southeast Greenland, has exhibited significant change in the last decade and is typical of Greenland's large outlet glaciers which terminate in narrow and deep fjords (~5-10km wide, ~100km long and >500m deep). Between 2002 and 2005, Helheim Glacier retreated more than 7km, accelerated its near-terminus flow speeds from ~7km/yr to ~11km/yr, and thinned by ~200m. The glacier has since slowed down, although speeds have not returned to pre-2002 levels and they show considerable interannual variability. Characterising the flow speeds of such a glacier at safe stand-off distances is a significant challenge. Yet it is essential to acquire these data to better understand the daily and interannual variations so that they may be included in the next generation of coupled Earth system models being developed which seek to better predict sea-level rise.

Background

This is not the first time that the team has made a trip to conduct this kind of work. On previous trips to Helheim Glacier, they have performed precarious on-ice high-resolution GNSS surveys, and installed climate stations and time-lapse cameras to capture multi-temporal images of the glacier's behaviour. Along with these visual and spatial glimpses into the workings of the glacier, researcher David Finnegan from CRREL has previously utilised TLS in an attempt to determine flow velocities at numerous glaciers around the world, albeit with limited success. These previous efforts with existing technology had resulted in datasets with a maximum useful range of 3-4km. Although these data were groundbreaking for cryospheric sciences, they were of limited use since acquisition times were significant and, in the case of Helheim Glacier, the glacier was moving faster (>1m/hour) than the laser scanner was able to acquire data. An additional requirement was the necessity of acquiring the TLS data from a fixed, off-ice position to ensure the safety of the research team and to maintain confidence that any movement logged by the TLS was movement of the glacier only. One of the alternative methods considered was the use of airborne Lidar which would provide timely and comprehensive coverage of the glaciers. Using airborne Lidar in Greenland would require mobilisation and constant loitering by an aircraft equipped for Arctic missions, which is not cost efficient. Therefore a TLS with a range of at least 6km on snow and ice would provide the optimum balance between performance and cost efficiency. As no system existed which could address these requirements, a new instrument would need to be developed which could not only reach much longer ranges, but would also acquire data much faster. Riegl Laser Measurement Systems took up the challenge of developing a system to meet these demanding specifications.

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