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Measuring a Changing Mountain
A Challenging Mission to New Zealand’s Highest Peak

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Worthy of the Mountain: A GNSS Survey of New Zealand’s Aoraki/Mt Cook

“Aoraki/Mount Cook is the highest peak in all of New Zealand, a mountain with tapu (sacred) status and of supreme importance to local Maori. And our team follows in the footsteps of many dedicated surveyors before us. This mountain deserves the effort that it took to validate its height to the best possible accuracy.”

– Dr. Pascal Sirguey, Research Team Leader

In late 2013, researchers from the Survey School at New Zealand’s Otago University embarked on a physically demanding survey to validate the height of New Zealand’s highest mountain and confirm the accuracy of a photogrammetric 3D model.

Rock Avalanche!
On December 13, 1991, Aoraki/Mt Cook measured 3,764 m (12,349 ft). But the very next day a massive avalanche of approximately 14 million m³ (490 million ft³) of rock travelling up to 200 km per hour (120 mph) plunged down the mountain’s eastern face. The cascade carried with it a portion of the mountain’s summit.

Following the avalanche, new aerial photos were taken of the summit area. The Department of Survey & Land Information, now Land Information NZ (LINZ), reassessed the height of the summit by tying the updated photos to the triangulation of a comprehensive 1986 aerial survey that included ground points. A new official height of 3,754 m (12,316 ft) was estimated.

In 2013, Otago MSc student Sebastian Vivero, supervised by Dr. Pascal Sirguey and Prof. Sean Fitzsimons, embarked on a project to measure changes in Tasman Glacier. With support from GNS Science of NZ, Vivero collected GPS coordinates from all climbing shelter huts in the area. These ground control points enabled the team to triangulate a 2008 aerial survey and generate a photogrammetric 3D model of the area.

The model had sub-meter accuracy and the team made a surprising discovery—that the summit of Aoraki/Mt Cook was now just 3,724 m (12,218 ft)—30 m (98 ft) lower than the 1991 post-avalanche estimate.

A Daunting Climb
The research team met with local Maori to propose an ambitious project to validate the newly discovered height. It would involve a physically demanding ascent of the mountain in order to perform a GNSS survey at its peak. Following the consultation, the team agreed to not step on the tapu (sacred) summit of Aoraki. Instead they would measure a control point about 45 m (150 ft) north from the highest point to validate the 3D photogrammetric model.

Aoraki/Mt Cook is a challenging, often dangerous peak with dynamic glaciers and steep ice and rock faces. New Zealand’s temperate maritime climate and the geography of the Southern Alps create changeable alpine weather. And because Aoraki/Mt Cook’s summit is less than 20 km (12 mi) from the Tasman Sea, sudden, severe storms are common.
Dr. Sirguey created two teams of two, with each team comprising one professional mountain guide and one person—also an experienced mountain climber—responsible for gathering the data. If one team could not perform the ascent—due to, for example, inclement weather or injury—the other should still be able to complete the survey. The National School of Surveying, GNS Science, LINZ and the Federated Mountain Clubs of NZ provided financial support for the climb, while sponsor Southern Approach Ltd. provided each team with a GoPro camera to document the attempt.

The research team flew by helicopter to Plateau Hut, which is situated on Mt Aoraki at 2,200 m (7,200 ft). Shortly after midnight on November 23, 2013 the four climbers left the hut to begin the 1,500 m (4,900 ft) climb to the summit.

**A Unique Survey for the Mountain’s Unpredictability**

Each team carried a lightweight Trimble R10 GNSS receiver programmed to log data every five seconds from the moment it was powered on until its batteries died. No controller or other equipment was required.

Says Dr. Sirguey, “Due to the risks of bad weather and injury, we had no idea how long our guys would be able to stand on the summit, or if they would even make it. So we planned for each team to simply set the receiver in place at the top of the mountain for a minimum of 20 minutes, and then again at one backup point on their downward climb. In between, the receivers would continuously log data, even while our guys descended, to ensure that a long enough session was captured for postprocessing.”

Aoraki/Mt Cook granted the teams good weather and a trouble-free climb, with all four men safely reaching their destination 10 hours after leaving the hut. Nicolas Cullen and Jim Anderson immediately spiked the two Trimble R10 receivers into the ice cap then powered them on for the static survey.

Once complete, the team carefully negotiated their descent, eventually reaching the Plateau Hut 18 hours after first heading out and with two successful static surveys completed.

**A Trigonometric Tribute**

The Aoraki/Mt Cook project included a trigonometric survey performed as a tribute to the surveyors who came before. Second-year surveying student Tyler Hager, with sponsorship from LINZ, used a precision theodolite to gather trigonometric observations from several locations with a line of sight of the summit.

Hager took advantage of new technologies such as GIS and geo-visualization to help identify appropriate viewing points. Even so, Hager’s measurements reproduced some of the complexities that the early surveyors encountered when estimating the height of a prominent peak.

Hager’s final height assessment was 3725.14 ± 1.38 m (12,221.6 ± 4.5 ft), which is consistent with the GNSS/photogrammetry estimate.
The full team (left to right): Jim Anderson, a recent graduate from the School of Surveying and now a surveyor at Survey Waitaki; Brian Weedon, mountain guide of Mountain Recreation Ltd; Julian Thomson of GNS Science, who contributed to a visual record of the project; Pascal Sirguey (project leader) a Senior Lecturer at the National School of Surveying at Otago University; Nicolas Cullen, a Senior Lecturer in the Department of Geography at Otago University and expedition leader; and Geoff Wayatt, mountain guide of Mountain Recreation Ltd. Geoff, Brian, Nicolas and Jim made up the climbing team.

### A New Official Height

Back at Otago University the data was post-processed using Trimble Business Center office software. Using reference signals from nearby stations in the LINZ PositionNZ continuous GNSS network, the team achieved decimeter accuracy. The highest point the team measured on Aoraki/Mt Cook was 3,719 m (12,201 ft), which differed by less than one meter from the 3D model and was consistent with the height from the computer model. They calculated and confirmed the height of the high peak as 3,724 m (12,218 ft) above mean sea level.

Says Dr Sirguey, "It extremely satisfying to have our photogrammetric calculations validated by GPS." He suggested that the new height can be explained by a two-decades-long reshaping process of the thick ice cap following the avalanche.

Despite its new height, Aoraki/Mt Cook remains the highest mountain in New Zealand, still towering above neighboring Mt. Tasman, New Zealand’s second highest peak, which is just 3,497 m (11,473 ft).

See the feature article in The American Surveyor, July 2014: www.amersurv.com