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Measuring the Great One

From as far back as 1897, Alaska's Denali mountain has been considered to be the highest peak in North America. And at 20,310 ft (6,190 m) above sea level—a measurement derived from a 2015 GNSS survey—that title still holds true today.

Apart from being the highest peak in North America, the "Great One" is also the third most prominent peak in the world and is one of the Seven Summits, the elite ranking of the highest mountains of each of the seven continents. With such superlatives attached to it, Denali is a particular point of pride for Alaskans.

So when published results of an Interferometric Synthetic Aperture Radar (IFSAR)-based survey, sponsored by the U.S. Geological Survey (USGS) in 2013, indicated Denali's height was 20,237 ft (6,168 m), 83 ft (25 m) lower than the long-accepted, published height, people took notice. That renewed interest ultimately led to a GNSS summit expedition to definitively resolve the true height of the mountain.

Under a Dewberry contract that received financial and technical support from the USGS and National Geodetic Survey (NGS), GNSS equipment support from Trimble, in-kind support from the University of Alaska Fairbanks (UAF) and the critical support of the National Park Service and Alaskan mapping, mountaineering and resident communities, a four-person expedition team flew to Alaska to set the height record straight.

Compiled and led by Blaine Horner, a former mountain guide on Denali and a survey account executive with CompassData, a geospatial data and services provider based in Centennial, Colo., the team included Tom Heinrichs, the director of the Geographic Information Network of Alaska at the UAF; and Augustin Karriere and Rhett Foster, experienced climbing guides.

Scaling for a number

After arriving in Talkeetna, Alaska, on June 15, the team flew to Camp 1 at 2,377 m (7,800 ft) on the Kahiltna Glacier and spent the next several days moving gear and supplies up the mountain, eventually basing themselves at 14 Camp, the upper-mountain main base camp at 4,328 m (14,200 ft). The team used their time there to acclimatize, ensure their technology and gear were functioning correctly in the sub-zero temperatures and to cache the equipment at 17 Camp at 5,242 m (17,200 ft), the last camp before the summit.

At 6:30 AM on June 24, Horner and Karriere set off from 14 Camp and took the standard West Buttress route to 17 Camp to dig up the stored survey equipment, which included one Trimble R10 GNSS receiver, one Trimble NetR9™ GNSS receiver, a Trimble Zephyr™ Model 2 antenna, two sets of batteries and an avalanche probe. The two began their climb about 9:30 and by 3:30 that afternoon, Horner and Karriere were standing on top of a serene and surprisingly warm Denali.

Horner's first task was to find the highest point on the summit. Moving about 50 cm (19.7 in) northeast from that point, he hammered a 1-m range pole 86 cm (34 in) into the snow pack, leveled the top of the range pole from that point and installed the Zephyr Model 2 antenna on the pole. He dug a small pit at the pole's base and placed the NetR9 and its battery

The CompassData summit survey team. L-R: Blaine Horner, Rhett Foster, Augustin (Udi) Karriere and Tom Heinrichs.

inside, connected the two and immediately began acquiring static data. At a 2.5-m (8.2-ft) distance southeast of the NetR9, Horner pounded another 1-m range pole down 56 cm (22 in) and leveled that to the top of the other range pole, ensuring that both GNSS units were at the same elevation. He mounted the R10 on the range pole, dug a small pit for its battery and connected the antenna to the battery, initiating the R10's data collection. Both pits were then backfilled with snow to protect the gear from the elements.

While the two GNSS receivers were collecting data, Horner used a 10-pound, steel avalanche probe to penetrate the snow pack around the two instruments in an effort to estimate the snow pack depth—a value never before measured. Around the R10 he was able to probe to a depth of 394 cm (155 in) and near the NetR9 he went to 415 cm (163 in) before hitting definitive resistance. However, Horner cannot state with 100 percent certainty that he hit rock.

One hour after summiting, Horner and Karriere descended, leaving the two GNSS instruments to collect data for the next 18 hours.

In addition to the summit survey, the team established a third survey site at "Windy Corner," a flatter area at 4,084 m (13,400 ft), to

Blaine Horner checks the survey gear that was cached at 17 Camp at 17,200 feet.

Udi Karriere levels the two range poles to ensure both the R9 and R10 are at the same elevation.

Survey team member Tom Heinrichs approaches Windy Corner at 13,400 feet.

The survey gear on the summit: NetR9's Zephry-2 antenna (R) and R10 (L).

both collect data in parallel with the summit collection and to help establish a baseline for researchers to determine Denali's velocity of change over time.

Prior to summit day, Horner had gone to Windy Corner, found exposed bedrock and placed a second R10 on the rock several hundred meters away from the main high-traffic trail. Located about 2 km (6,560 ft) below the peak, the R10 recorded continual observations for six days total, the last two coinciding with the summit survey, enabling them to strengthen the elevation measurement. During the summit climb, Heinrichs and Foster checked the GNSS instrument to ensure it was logging data.

Survey says?

To ensure consistency and confidence in computing the new height of Denali, the expedition partners created their own "data-redundancy triangle"—experts from CompassData, UAF and the NGS would process the same GNSS data independently using their own software solutions.

Philipp Hummel, a professional land surveyor and CompassData's technical director, led the GNSS data processing using the Trimble Business Center software suite of geospatial data analysis, processing and editing tools.

Based on nearly 18 hours of observations, Hummel first calculated independent network adjustments for the R10 summit data and NetR9 summit data based on ten permanent CORS stations located 40-150 km (25-93 mi) away from Denali. He used the Windy Corner data as another reference point to strengthen the geometry of the network. Hummel says the results of the two independent calculations were accurate enough that he could combine the summit data and the Windy Corner data together, and process one single network adjustment using Trimble Business Center. The result was a network adjustment with an accuracy of plus/minus 5 mm.

By mid-August, all three expedition partners had processed the GNSS data and compared their results. And all of them were within 3 cm (1.2 in) of each other. Based on comprehensive analysis and review of their methods and results, CompassData, UAF, NGS and the USGS determined a final above-sea-level height for Denali of 20,310 ft (6,190 m) (NAVD88), just 10 ft (3 m) lower than the 1950's survey. The new, top-of-snow elevation was officially recognized by the USGS in September. The survey information can be accessed through NGS' Online Positioning User Service.

While measuring at 20,000 feet isn't every day survey work, successfully climbing Denali to determine its elevation does finally put to rest any lingering questions about the height of the highest peak in North America—for a while at least.

See feature in American Surveyor's November 2015 issue: http://amerisurv.com/emag/