



A Lesson In GIS— at 19,000 Feet

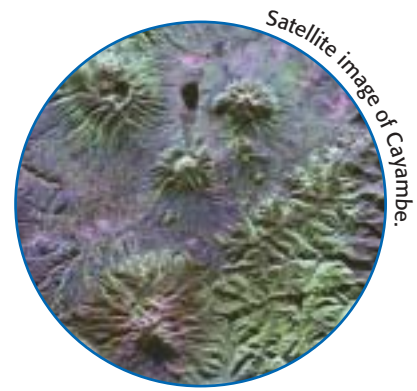
by Howard James

Most agree that education is critical in sustaining a steady flow of bright, motivated, well-prepared young people into the geomatics professions. A key element to this sustainability (and potential growth) is getting more students interested in surveying and GIS technology during their high school years so they seek to study these subjects at the university level and beyond.

Last summer, nine high school girls had an extraordinary opportunity to get real-world experience in GIS and mapping in a not-so-common setting: a mountain glacier in Ecuador in Western South America, bordering the Pacific Ocean at the equator between Colombia and Peru.

The nine students were part of an all-girls scientific mountaineering excursion coordinated by the co-founders and supporters of the International Non-Traditional Teaching (INTI) concept, an educational approach supported by experiential teachings. A natural fit for such an approach is Oldfields School of Glencoe, Md., an all-girls college preparatory school that includes concentrated learning experiences during the month of May through its May Program. In May and June of 2003, nine girls from Oldfields traveled to Ecuador's Nevado Cayambe to study glacial recession in the Tropics. Cayambe, a heavily glaciated active (but yet to erupt) volcano, is the third highest peak in the

How an all-girl expedition collected GIS data on a tropical glacier in Ecuador.



northern hemisphere of the Americas. There, the girls learned many lessons including survival techniques and the proper logistics to collecting hydrologic data from tropical glaciers.

Paramount among the expedition's many tangible successes was the data collected, which included meteorological data, glacial mass balance data and glacial geometry data. In the process of climbing the mountain and collecting the data, the girls achieved numerous other academic and non-academic goals. The work that the girls accomplished, which attracted the attention of both national and international media, has the potential to have a real and significant impact at both the local and global level. What is already evident is that the 2003 Expedition is an educational experience they will never forget.

A Classroom Without Walls

In addition to being one of the highest points in the northern hemisphere of the Americas, Nevado Cayambe has the distinction of being the highest point through which the equator passes anywhere on the face of the Earth. This fact, combined with the fact that no serious effort has ever been made to study Cayambe's glaciers, made it the ideal classroom without walls for the INTI Expedition. Conventional wisdom suggests that the Tropics should have the most stable climate on Earth, however, indicators like glacial recession in the Tropics suggest that the climate may not be as stable as was once thought. Today, according to some experts, glacial recession in the Tropics is the most significant and alarming indicator of global warming. In addition to being an important indicator of global climate fluctuations, glacial recession in the Tropics could have a major impact on water resources in the region—a region that has a disproportionate amount of the world's readily available freshwater resources.

"Cayambe is a great classroom," says Expedition leader and INTI Co-founder Ret Talbot. "For INTI expeditions, we seek out locations we know will present significant challenges. Cayambe is a very big mountain with many objective hazards like avalanches, rockfall and large crevasses (deep cracks) that must be crossed countless times. One could look at these hazards as a liability, but the INTI faculty chooses to view them as a curricular asset. The presence of such dangers makes the curriculum very relevant to each and every student."

Although much of the INTI teaching focuses on what Talbot calls "hard" skills—things such as rope handling and self-arrest with an ice axe—a key INTI philosophy is to address traditional academic objectives at every opportunity. "For example, teaching a student how to rescue a fellow student after a crevasse fall requires the instructor to, in

essence, teach the traditional physics lesson plan on mechanical advantage," Talbot says. "My experience has been that a student's understanding and retention [of a concept] is a whole lot better after the crevasse rescue lesson—for the obvious reason that it could, quite literally, be a matter of life or death."

A cornerstone of the INTI Expedition's brand of experiential education is that nothing is artificial. "Being on a big mountain like Cayambe means we don't have to contrive anything," says Brad Bond, the INTI 2003 Expedition's scientific coordinator and the INTI program's other co-founder. "We can rest assured that Mother Nature is going to throw enough real challenges at us to keep it exceedingly real."

A telling example of this is that Cayambe delivered an impressive show when it came to weather. "The HOBO weather station at base camp regularly recorded sustained winds of 30-50 mph," Bond says. "But it's a lot more than the weather that makes the INTI experience so real. The fact that no other Expedition has seriously studied glacial recession,



Felicitas Scholten and Ret Talbot plan the day's mapping objectives in the foreground of the Expeditions' study glacier.



sion on Cayambe makes our scientific work all the more significant to the students.”

Not Like a Lab in Science Class

“It’s not like doing a lab in science class at school,” says Catherine Ford, an Expedition member. “In science class, you’re so often doing an experiment from the book, and you know that thousands of other students have already done it and that thousands more will do it that year or the next. It’s hard to get too excited about that. But on Cayambe, the science we were doing was real, and our teachers were right there beside us as team members. How many high school students get that opportunity, not to mention the opportunity to contribute to scientific research that is significant on both a local and global level?”

Nevado Cayambe is located in the Condor Bioreserve, which encompasses 15 ecoregions and four protected areas: Cayambe-Coca Ecological Reserve, Antisana Ecological Reserve, Cotopaxi National Park and Sumaco Napo Galeras National Park.

“We’re particularly interested in studying Cayambe’s role in the hydrologic cycle,” says Annie Dickerson, a junior at Oldfields School. “The ecosystem that Ecuador depends on for its water—a region called the paramo—is very threatened right now because of unsustainable land management poli-

cies. We want to answer the question of how glacial recession might also affect the paramo through changes to annual runoff patterns.”

Tracing Glacial Recession with GIS

Beyond providing a unique educational experience for the girls, the INTI 2003 expedition had ambitious scientific goals aimed at laying the groundwork for a serious analysis of tropical glacier recession. Nevado Cayambe is characterized by a significant ice cap with 20 different outlet glaciers extending from it. The entire glaciated area on Cayambe is 17.73 sq km.

“Although it is generally assumed that there has been significant reduction in the glacial geometry of Cayambe’s glaciers since the middle of the 19th century, no documented study until INTI 2003 has set out to reconstruct the history of mass balance change to this important mountain’s glaciers,” Talbot says.

A central focus of the INTI Expedition was therefore to study and catalog the history of mass balance change on Cayambe. Because no mass balance data existed, it had to be reconstructed using historical records made of anecdotal evidence, artistic representation and photogrammetry. Satellite imagery, like Landsat multispectral scanner images and low-tech imagery such as simple tourism postcards were particularly useful. A geographic information system (GIS) was used



Expedition leader Ret Talbot gathers data with a Leica GS20 Professional Data Mapper.

to model visually in two and three dimensions mass balance change from the 16th century to the present.

The Expedition also set up a quantifiable study area on Cayambe and established a transect of ablation stakes (stakes that erode) to form the basis of a long-term mass balance study. As a part of establishing the study area, the team initiated the most significant mapping project ever undertaken on Cayambe. Of course, the INTI Expedition's work and adventure couldn't happen without instrumentation and technology.

"The INTI 2003 Expedition relied significantly on the support of four major partners," Talbot says. "Both HOBO, a division of Onset Computer Corporation (Bourne, Mass.) and Leica Geosystems (Norcross, Ga.) provided technology that made the depth and breadth of the Expedition's scientific work a reality. Golite, an outdoor equipment and clothing manufacturer (Boulder, Colo.), provided critical in-kind support to the Expedition, allowing them to work under some extraordinarily challenging conditions. Finally, Hewlett-Packard (HP, Palo Alto, Calif.) provided the essential integrated technology solution that pulled all of the Expedition's various objectives together into a unified whole. It was as a result of these title partners' commitment to the INTI Expedition's innovative educational model that the girls were able to accomplish so much."

Using a Leica Geosystems GS20 PDM (professional data mapper), the students mapped with sub-meter or better accuracy the location of each ablation stake, the perimeter of the study glacier, and geographic features that are inconsistent with the available 1:25,000 topographical maps created by the Ecuadorian government in the 1950s. All of the data mapped was then added to the GIS for the purpose of comparing with the reconstructed historical record and as a base line for comparison with data that will be collected from the study area in the future.

"Because the GS20 geographical data is accurate to within a meter or better, next year's expedition will be able to return to Cayambe and have a very good idea of exactly how much the glacier has changed," says Oldfields senior Lauren Park.

"The ablation stakes are three-meter wood or fiberglass poles that we placed two meters into the ice," says Alison Jeanes, another senior at Oldfields. "After drilling each hole in the glacier and placing the stake, we documented its exact location, as well as both the snow line from recent accumulation and the precise depth of the glacial ice using the GS20. Future expeditions will be able to go back and assess and document any changes. We hope that the record of the changes over time will tell us something about the health of this glacier."

"The generous support we received from Leica Geosystems in supplying one of its first production-model GS20s played a major role in the success of the expedition," Talbot says, who noted that the GS20 worked flawlessly and proved to be surprisingly easy for the girls to learn to use without previous training. "The professional data mapper was extensively used around the clock by the girls for a wide range of mapping tasks under extremely difficult environmental conditions."



Felicitas Scholten and Lauren Park receive basic instruction in using the GS20 from Ret Talbot before mapping a glacial pond at nearly 16,000 feet.

"The cable-free operation facilitated by the GS20's Bluetooth wireless technology made data collection efficient and streamlined. In a high-altitude mountaineering environment where efficiency means safety, the GS20's wireless capability gave us peace of mind. Knowing that we could rely on the GS20 to do its job of collecting data permitted us to focus on risk management and gave us the confidence to map portions of the glacier we had previously categorized as inaccessible."

Mapping the Watershed

The glaciated portion of the Expedition's study area was established on the western flank of Cayambe above the Rio Blanquillo. This stream was selected because it flows into the Rio Blanco and in turn provides a significant environmental service to the village of Cayambe some 15 km north-west of the mountain. The study area is defined to the north by a rock ridge terminating in the point known as Picos Jarrin, to the east by a large bergschrund (crevasse), to the south by the glacial margin above a tarn (pond formed through glaciation) and to the west by the glacial terminus above the Rio Blanquillo. More specifically, because the study area includes both the well-defined outlet glacier directly above the headwaters of the Rio Blanquillo and the portion of the larger ice cap above, the team further defined the study area as the Rio Blanquillo watershed.

The ESRI (Redlands, Calif.) Arc Hydro data model was used to delineate the Rio Blanquillo's watershed. Arc Hydro is a computer-based comprehensive geospatial and temporal



An Expedition member sought out the source of the Rio Rosachurpa on the snout of the Hermosa Glacier where it flows out of an ice cave (that happened to collapse the night before).

data model designed for studying and analyzing water resources devised to operate within ArcGIS. Using the Arc Hydro toolset, the team members were able to utilize digital elevation models of the land-surface terrain to delineate the river's watershed, and also to delineate the larger Rio Blanco basin, which will prove essential to understanding how streamflow in the region may be impacted by glacial ablation.

Because of the link between climate and mass balance change, the INTI team also deployed a World Meteorological Organization certified weather station near the base camp at more than 4,500 meters. The meteorological data collected during the course of the expedition, and data that continues to be collected by a logger deployed at a remote site higher on the mountain, will provide valuable base line data for future study.

At the base camp, the weather data was downloaded directly to a Hewlett-Packard iPAQ laptop computer running BoxCar Pro, Onset's data graphing and analysis software program. With a few clicks of the mouse, the software translated the collected data into graphs that clearly marked out spikes and drops in the various weather parameters that were measured, and printouts were made on HP color printers.

"It was always amazing to look at the color printouts of the weather station data," says Oldfields senior Jennifer Wolf. "It's one thing to be up all night trying to keep your tent up in a storm, but to be able to look at the wind graphs on the laptops the next morning was really cool and made the experience so much more educational. To say something like 'I think it blew hardest between 2 and 3,' and then to see it on the computer or on the printout was an incredible thing. Now when the weatherman says to expect 50 mph gusts, I guess I'll know exactly what he means."



Lauren Park sets out to map in difficult conditions.

Jason Dittmer, a mountaineering expert, team advisor and film-maker, expressed his admiration for the girls' accomplishments under horrifying

conditions. "It's truly incredible what these girls accomplished. Just the fact that they endured in such an inhospitable environment is a testament to their mental and physical strength. I've climbed in a lot of places known for ferocious weather, such as Denali and the Himalaya, and what we saw on Cayambe was about the most sustained bad weather I've ever seen. The fact that the girls did so much more than simply endure is the real story that needs to be told here. Day after day, they came out of their tents regardless of how hard it was blowing or what was coming out of the sky, strapped crampons on and tied onto a rope. The fact that they did it for school and because they had the opportunity to make a difference in the lives of people they will probably never meet is the crown jewel of the INTI program."

Preliminary analysis of the data collected during the INTI 2003 expe-

dition suggests that Cayambe's glaciers are subject to the same trend of significant glacial recession as other tropical glaciers around the world. This analysis was reached by using a GIS to map the historical record of glacial extent on the mountain. The team was then able to graphically model the physical appearance of Cayambe and its glaciers and compare those models with data collected on other nearby peaks. The analysis was also reached through the dedicated efforts of several strong girls, a progressive educational team and quality precision equipment from supportive sponsors. A second student expedition hopes to return to Cayambe in May 2004 to continue the work and gather fresh data. 🌐

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