# Polar Applications of Geodetic Field Methods: A St. Mary's Glacier Case Study

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## Introduction

The UNAVCO Polar Team provides GPS equipment and support to university researchers working in the Arctic and Antarctic. As UNAVCO Polar Services interns we evaluated the difference between Real Time Kinematic (RTK) and Post-Processing Kinematic (PPK) GPS survey methods. The two methods can be used for similar purposes, but require different equipment, setup, and processing. We precisely mapped the edge of snowpack at St. Mary's Glacier, Colorado and compared the measurements to last year's results in order to monitor changes in snowpack extent. We were also able to assist in preparing and testing the equipment that will be used by field engineers during the upcoming Antarctic season.

## Differential GPS

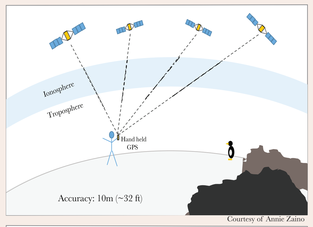



Figure 1: An example of using a handheld GPS receiver. The device receives transmitted signals from at least four satellites to obtain a general location.

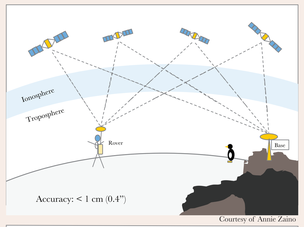



Figure 2: An example using differential GPS, allowing the base and rover receivers to communicate with satellites simultaneously, thus greatly increaseing accuracy.

Traditional handheld GPS devices receive signals transmitted from at least four GPS satellites, and triangulate position based on signal travel time. Most of the error in location is the result of atmospheric distortion of these signals, which either increase or decrease the travel time. Differential GPS adds a base station to the handheld method, for which position is already precisely known. By calculating offset between actual and recorded position, the same offsets can be applied to the rover station to correct the errors and precisely locate points of interest.

## RTK vs. PPK

| Method | Pros | Cons |
|---|---|---|
| RTK (Real Time Kinematic) GPS | ✧ Shorter initialization period, <2minutes<br>✧ Measure points in ~5 seconds<br>✧ No need to post process data<br>✧ Ability to stakeout and return to a known set of coordinates | ✧ Radio set up is often difficult<br>✧ Requires direct line of sight between rover and base station<br>✧ Base station takes longer to set up<br>✧ Requires more battery use |
| PPK (Post Processing Kinematic) GPS | ✧ Quick set up<br>✧ Do not need to use radios<br>✧ Not limited to direct line of sight with base station, can be up to ~60 km with accurate results | ✧ Must reinitialize if satellite link is lost, adding ~8 minutes<br>✧ Measure points in ~15 seconds<br>✧ Data processed post survey |

Figure 3

Both RTK and PPK surveys have many similarities, but it is their differences that are important when deciding which method will best achieve the goals of a project. RTK continually corrects the data via radio, however the radio requires a direct line of sight with the base receiver. PPK is quicker to the set up, and the survey area can be larger (up to 60km from base station), but it is not possible to navigate to previously surveyed coordinates.

## Methods

We measured the extent of the snowpack at St. Mary's Glacier, using both RTK and PPK methods. With RTK we measured 1 point per second and with PPK we measured one point every meter. We conducted this survey as outlined in UNAVCO's differential GPS field manual1. To maintain line of sight for RTK, we installed the base receiver on a rock outcrop on the north side of the glacier. The baseline ranged from 10 meters to 150 meters.

Photo courtesy of Spencer Niebuhr

Eric Sheley and Bradley Norman wearing roverpacks to measure the edge of snow line at St. Mary's Glacier.

Photo courtesy of Ian Lauer, UNAVCO

Bradley Norman and Annie Zaino deploying the base station on St. Mary's Glacier, near Idaho Springs, CO.

## St. Mary's Glacier

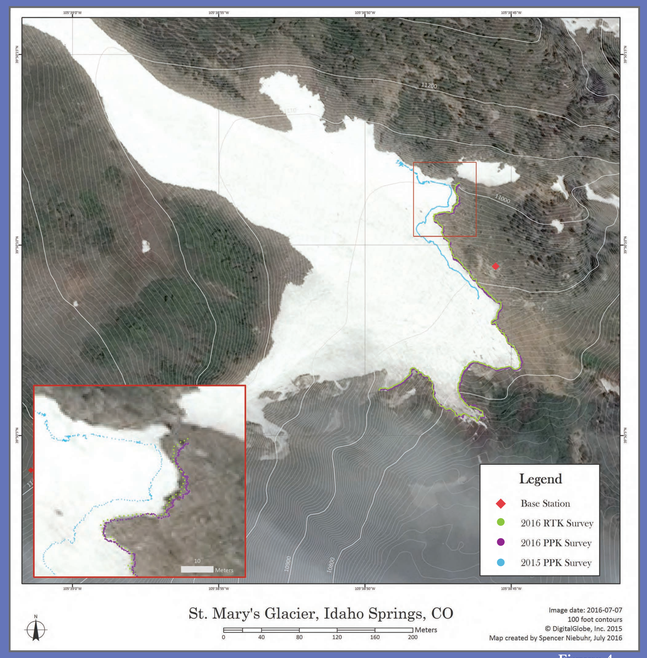



Figure 4

After deploying the base station on a ridge (depicted as a red diamond) we proceeded to the northernmost edge of the ice to begin surveying. We walked the edge of the glacier from north to south while both PPK (purple) and RTK (green) measurements were being taken. Above the data is compared to the last year's results (blue).

Figure 1: Looking NNW at St. Mary's Glacier to show snowpack levels on July 7th, 2016.

## Discussion

### Survey Methods

We performed both PPK and RTK surveys at this site, both with the intention of evaluating the effectiveness of each and to maximize the likeliness of obtaining a valuable data set. The terrain was steep and uneven in some areas, which affected the surveyors ability to keep the antenna level and oriented precisely over the glacier to rock transition. When the antenna is tilted it can alter or lose signal with the satellites. In the case of PPK, if the antenna is tilted too much initialization lock can be lost, requiring the operator to reinitialize before proceeding. Additionally, due to the varied topography, it was not possible to determine prior to the site visit whether a single base location would have line of sight at all survey locations. Neither of these obstacles were insurmountable for this particular survey. In this situation both of these survey methods were suitable, however in other circumstances one is often preferable over the other.

Photo courtesy of Ian Lauer, UNAVCO

Bradley Norman and Eric Sheley measuring around the edge of St. Mary's Glacier, Idaho Springs CO

### Future Recommendations

Future Geo-Launchpad Polar intern groups could repeat the current survey to expand the data set and obtain more info about longer-term trends. It may also be valuable to gain information on snowpack thickness. This could be determined using RTK and reoccupying known mid-snowpack locations, year-to-year and comparing elevation data.

It would also be interesting to compare precipitation and temperature records with each respective dataset, but further analysis is outside of the scope of this project.

### Comparison

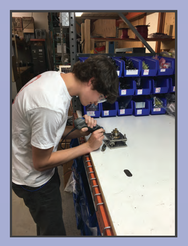
We were able to collect significantly more data during our 2016 survey than what was collected in 2015, largely due to more conducive weather conditions this year. From comparing the areas that overlapped, as seen in Figure 4, we were able to see a fairly significant increase in the snowpack in 2016. This survey was performed with the intention of tracking the long-term trends of the snowfield, however many years of data will be collected before any trends will become apparent. Many factors can affect the variability of snow pack levels at any given year, local weather effects and shorter-term climate cycles such as El Niño. It is important to remember that short-term changes from year to year are not necessarily reflective of climate changes, but instead are observations to be taken into consideration while looking at the big picture. As we only have two years of data to compare, there is no way to state conclusive results, apart from noting the difference and looking toward the results in coming years.

Photo Courtesy of Spencer Niebuhr

Eric Sheley and Bradley Norman measuring around the edge of St. Mary's Glacier

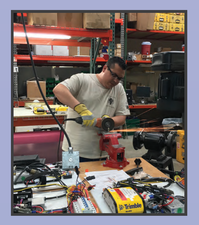
## Support for Field Engineers

A significant part of the Geo-Launchpad experience was assisting Antarctic field engineers with gear preparation for the 2016 Antarctic season. The UNAVCO Polar Team provides geodetic support to NSF-OPP funded scientific investigators working in the Arctic and Antarctic.



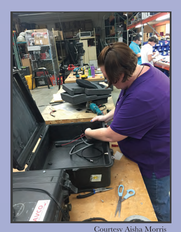
Brad Norman assigning an identification number on a level mount.

- Updating firmware and configuration files on GPS receivers
- Calibrating antenna mounting systems
- Issuing identifcation numbers and documenting antenna mounting systems



Eric Sheeley working to remove obsolete numbers in order to properly assign an identification number.

- Updating and testing Pelican cases used for static GPS kits
- Reterminating antenna cables
- Assembling guylines
- Calibrating and restamping spike mounts



Courtesy Aisha Morris

Kelly Billings installing a solar charge controller into a campaign station Pelican case.

- QC testing GPS gear for upcoming Antarctic deployment
- Organizing tool kits
- Building solar panel cases
- Building permanent station control boards

Courtesy Aisha Morris

Eric Sheely and Bradley Norman building GPS permanent station boards.

## Acknowledgements

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Geo-Launchpad
Internship Program