University Centre in Svalbard

AT-329 Cold Regions Field Investigations

23.02.2012

Borehole Coordinates at Hotellneset Quay: Directed toward Store Norske

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Summary

On 22.02.2012 a survey for Store Norske Spitsbergen Coal Company was conducted at Hotellneset Quay to obtain the point coordinates for several boreholes. The purpose was to verify the coordinates using differential global positioning systems (DGPS). Please find the fact sheet and results below, followed by more information regarding methods.

Fact Sheet for Obtained Point Coordinates

Date: 22.02.2012
Time: 14:00-16:00
Region: Longyearbyen, Svalbard
Unit Used: Leica Geosystems© Vivo Uno
Horizontal Reference System: EUREF89
Map Projection: UTM
Axis/Zone: 33N
Vertical Reference System: WGS84/EUREF89
Base Antenna Height: 0.737 m
Rover Antenna Height: 2 m

Borehole Coordinate Point Results:

Borehole Point	Easting	Northing	Ellipsoidal Height (m)	Height (masl)
P1	512332,2721	8685559,908	34,00103333	2,166
f2	512391,5331	8685712,091	32,13603333	0,301
10	512351,4501	8685636,813	31,78503333	0,05
9	512337,8301	8685615,374	33,74503333	1,91
6	512349,0271	8685610,391	33,45703333	1,622
5	512362,0271	8685598,148	33,29803333	1,463
3h	512308,7541	8685568,454	33,02203333	1,187

Table 1: Borehole coordinates and elevation data for Hotellneset.

Calculation Methods:

The ellipsoidal height of base point P1 was determined by averaging three ellipsoidal heights from established ground control points measured on February 21, 2012: NP 124 - P1, 9402 - P1 A, and 9402 - P1 B. The resulting average gave an ellipsoidal height of 29.016 metres.

Some miscalculations with the initial baselines measured on the 21 of February resulted in an ellipsoidal height error and therefore required a baseline shift. To find the shift we used the average of the northing, easting, and height of the NP124 P1, 9402 P1 A, and 9402 P1 B to establish the coordinate from the previous day. We then subtracted those values from the coordinates we had taken for our P 1. The resulting differences for the easting, northing, and height values gave us the shift value we needed to apply to each transformation of our borehole coordinate points. The easting shift value was 9.4961 m, northing was -0.2316 m, and height was 4.9850 m.

After the new coordinates were established, the next step was to change the ellipsoidal height to the height above mean sea level, in order to make the height usable. To do this we needed to find the local geoidal height and subtract it from the ellipsoidal height. To find the geoidal height we averaged the ground control point from three known geoidal heights for the area, giving the result of 31.8347 m. This number allowed us to determine the actual height of our points above mean sea level.

Quality

Three measured points, two known and one unknown, were used to form a baseline and establish a local base point, P1. These points were used placed in the following order to form triangle, NP124-P1-9402. A field check was performed by summing the geocentric coordinates along with the ellipsoidal heights to ensure that the triangle was closed (Table 2).

	dX	dY	dZ	dHgt
N124 to P1	-1727,59	-2480,8	453,4707	-31,3579
P1 to 9402	1180,411	1799,44	-338,529	1,088
9402 to N124	547,1788	681,3598	-114,945	32,4414
	-0,0043	-0,0005	-0,0037	2,1715

Table 2: Field check of coordinates by triangulation.

Fieldwork Methods

Fieldwork was executed on February 22, 2010 between 14:00 and 16:00 hours at Hotellneset in Longyearbyen, Svalbard. Measurements were completed after having set up a Base Station on local base point, P1. Real Time Kinematic (RTK) measurements were used to process coordinate data at time of collection thereby avoiding post processing hassles. Cellular phone communication rather than radio or internet connections were used to transmit data between the base station and rover. One problem originating from this form of communication is that only one rover could be measuring points at a single time, if more rovers were wanted to increase efficiency, then another cell phone would have been needed at the base station or another device used instead.

Rover measurements were “stop-and-go” in that points were only collected when initiated by the surveyor. Measurements took approximately 10 seconds to produce results with an ambiguity status of “yes” suggesting that activity within the ionosphere was not hindering results. Orthometric heights were not measured in the field, but were calculated through post-processing because there is no local datum for Svalbard. This may influence the final results, but likely not significantly.

Discussion of Methods

As a phase receiver, DGPS is capable of millimeter accuracy through both post processing and real time kinematic (RTK) processing. The system uses two receivers, a base station and a rover to construct baselines between known and unknown coordinates, thereby producing relative results.

This is advantageous in comparison to absolute measurements with one code receiver (handheld GPS) which will produce results in metre accuracy.

For the cut-off angle, we used an angle of 10°. This angle is suitable because then we are able to avoid any obstacles in the horizon which might interfere with the connection between the dgps and satellites in the sky.

The Real time kinematic (RTK) method of processing data operates under the main principle of data connection transfer between the base station and rover through a communication device. This can be cellular phone, radio, or internet. It requires a minimum of two receivers and the observation time only requires 10 seconds. The accuracy of results can be in the order of 10 to 20 mm. The results are relative rather than absolute as systematic errors are accounted for by the presence of the base station which runs simultaneously to the rover on a known point. Short time static observations are similar to RTK in that they also require two receivers, however they require post-processing, two to ten minutes of observation time, have an accuracy of 10 mm plus 1 Ppm and baselines which are less than 10 km. Therefore, it is most preferable on a field site such as at Hotellneset to use RTK for measuring points.

Relative results allow for ionospheric noise to be taken into consideration and systematic error to be observed and corrected for. Real time kinematic measurements inform the surveyor at the time of data collection whether activity in the atmosphere is too high and ambiguity status is acceptable “Yes” or not “No”. Without RTK, one would have to wait until post-processing is completed back in the lab to discover if the ionosphere interrupted measurements significantly and need to be re-measured. In this exercise cellular communication was applied between the base and rover to establish a data connection. This allows for direct, uninterrupted communication between the devices. The disadvantage with using a cell phone is that only one rover can be in communication with the base at a single time. Also, one must be within cell service range, therefore if too far away from civilization, it may not be the optimal method of communication.

For best results, satellite geometry should be well spread out with good intersection of spheres and low Dilution of Precision (DOP) values (for example: the GDOP, geometry dilution of precision, should be less than 5 for good measurements). With a minimum of four satellites three dimensional solutions can be found for any point. Unfortunately, because of poor geometry, elevation will always be less precise by about 50% than plane measurements. This is because there are no satellites “in the Earth” or below the horizon to measure the point from all sides.

To use RTK, a local base is often established at the field site, as is the case in Hotellneset. This is completed by using a minimum of two receivers measuring simultaneously to compute baselines between them. With this field site, three receivers were used; two with known coordinates and one collecting coordinate data to construct the new base point. The minimum measuring time for a baseline is 30-60 min. The average of the values measured from the baselines will be used as the new base point. Triangulation should be done to test for errors by calculating the misclosures. Good geometry is required to produce good points; therefore it is best to have the ground control points from all directions around the point that is being measured.

There are some permanent commercial networks of known base points in Norway and globally; Statens Kartwerk (C-pos, Satref), Leica (SMARTnet/SpiderNET) and Blinken (NTRIP) to name a few.

These can be used as an alternative to one local base station as described in the previous paragraphs. Leica has a network of base stations around Norway, mostly surrounding the larger cities and with three main control centers in Oslo, Bergen and Trondheim. These have a network of baselines that are permanently linked and are therefore always available to use and no local base is necessary to make. But, a disadvantage to it is that baselines are long and therefore accuracy is about 6 mm plus ½ mm/km. CPOS, used by Statens kartwerk has an accuracy on the cm level and can be used in real time. GPS base stations are linked together in a network that reduces the need for additional base stations while surveying. Base stations cover the entire mainland of Norway, and also have five stations on and around Svalbard at Longyearbyen, Ny-Ålesund, Svea, Bjørnøya and Hopen. These log data continuously but cannot be used in real time, but rather need post processing. Statens kartwerk also uses DPOS which can be used in realtime but has less accuracy, at the 10-50 cm level, and also ETPOS, post-processing but with accuracy less than 1 cm.

Ground Profile

A 41m long ground profile was taken on the quay starting from [512375.843, 8685688.980, 31.579] and ending at [512400.046, 8685721.856, 31.576]. When the geoidal height was calculated the profile is seen to be below sea level. This error is the result of using an approximate height above the geoid, the fact that the uncertainty associated with the geoidal height in Svalbard is ±1m and due to the relative imprecision with height measurements mentioned earlier.

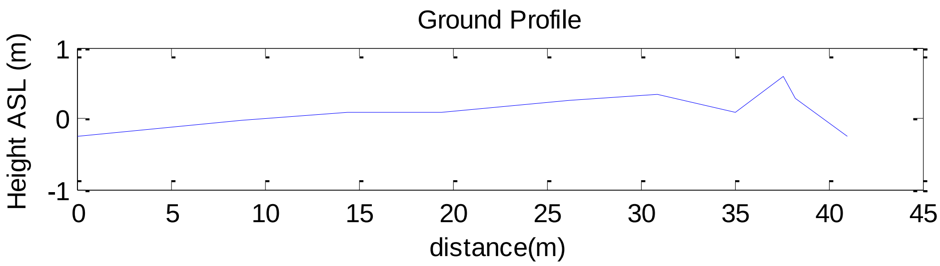

Fig. 1: Ground profile