<u>**GPS Project Report – March 5 & 8, 2006**</u>

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Introduction

On March 5th, 2006, differential GPS profiles were acquired in the flats of Sassendalen in order to test and learn the technology of differential GPS. A second survey was completed on March 8th upon Longyearbyen, in combination with GPRadar, to acquire exact positions upon the 4 radar transect driven.

Data and Methods

Data was collected using Leica Recievers, system 500. One base station was set up upon a local hill, although exact coordinates were not available. The base station acquired data using a static survey set at a 2 second interval. Kinematic GPS profiles were acquired by attaching the antennae to the back of a snow scooter or band wagon and driving profiles at a speed of 5-30 km\hr. These profiles were combined with stop-and-go surveying to further confirm the positions at the start and end of each kinematic profile.

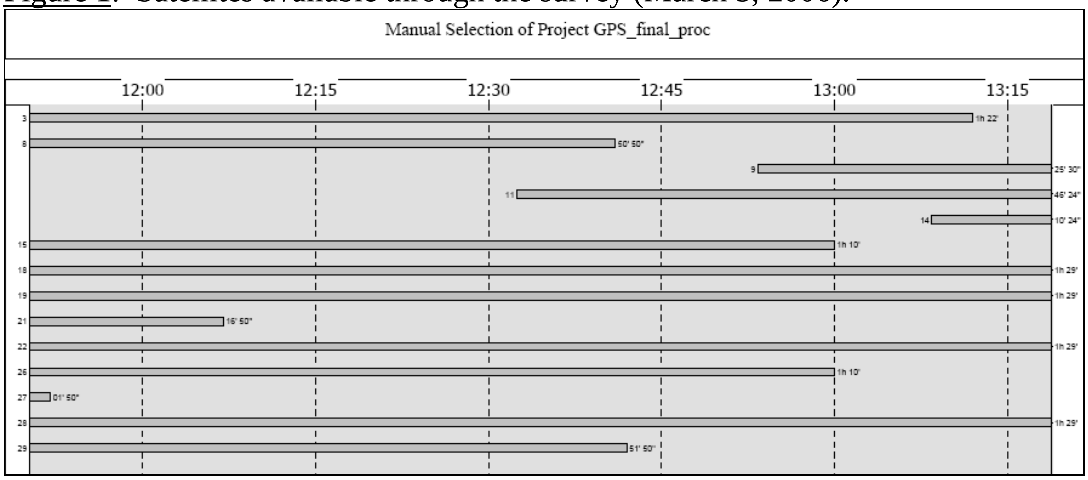
After the surveying was finished, the data was brought into the computer lab where it was processed using Leice Ski-Pro. The resulting profiles and coordinates were exported in EUREF89 datum with geodetic positions and heights. WSKTrans (a coordinate converting program created for the mainland Norway by Statens Kartverk) was used to convert the coordinates to UTM (zone 33).

Results

MARCH 5, 2006

To derive good coordinates and heights from the GPS instruments, a number of factors are responsible for the accuracy of positions. Directly related to the GPS technology, the accuracy is highly dependent upon the number of satellites (Figure 1) and the geometry of the satellites in the sky. These factors make up the relative DOP values linked to the survey measurements. During the transect for Team 4, the GDOP, or dilution of precision based upon geometry, is relatively low ranging from 2.5 to 3.2 confirming a good satellite configuration (i.e. the equal distribution of satellites within the sky view). The PDOP values range from 2.2 to 2.9, confirming the relative good quality for horizontal and vertical measurements relative the to the satellite geometry. Another criteria for retrieving good coordinates involves the use of a known base station, which was not available thus decreasing the accuracy (slightly) of our survey, although not significantly.

<u>Figure 1</u>: Satellites available through the survey (March 5, 2006).



The four profiles driven are seen in figure 2a, while Team 4's profile is shown in figure 2b. It is clear that the profiles were not driven in a perfect straight line although the different scales between figure 2a and 2b over-emphasize the curvature of the driven profile. To analyze the accuracy of the differential GPS system, elevation profiles were compared for the two driven transects (Figure 3). There is a clear difference between the two profiles, although the difference is smaller than a couple of centimeters. This reflects the accuracy of the differential GPS system, even if a known base station is not used. Furthermore, the variation between the profiles can be considered noise from instability in the height of the antennae caused by the snow scooter.

Figure 2: a) All Profiles (left); b) Team 4 profile (right)

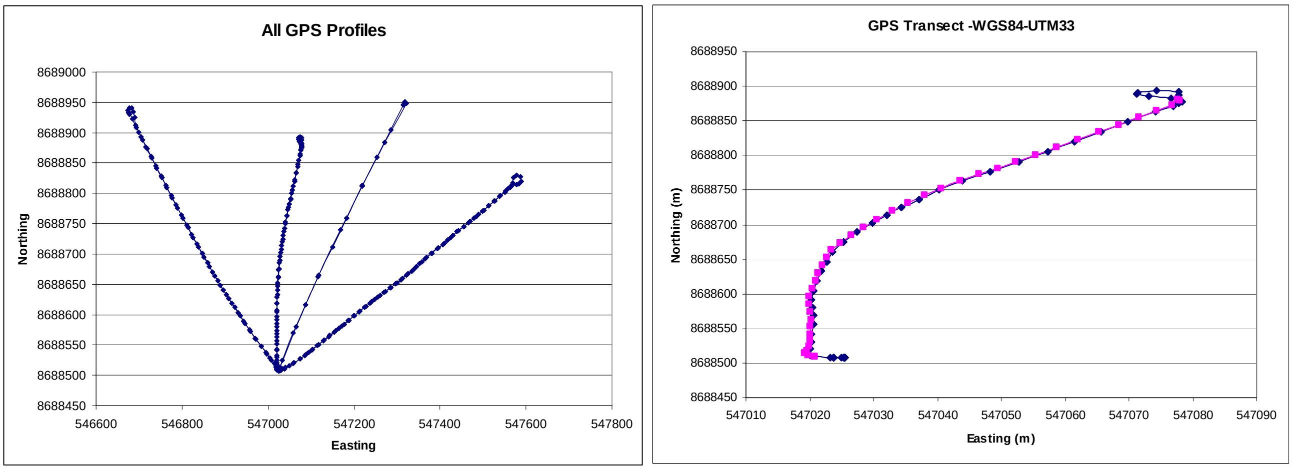
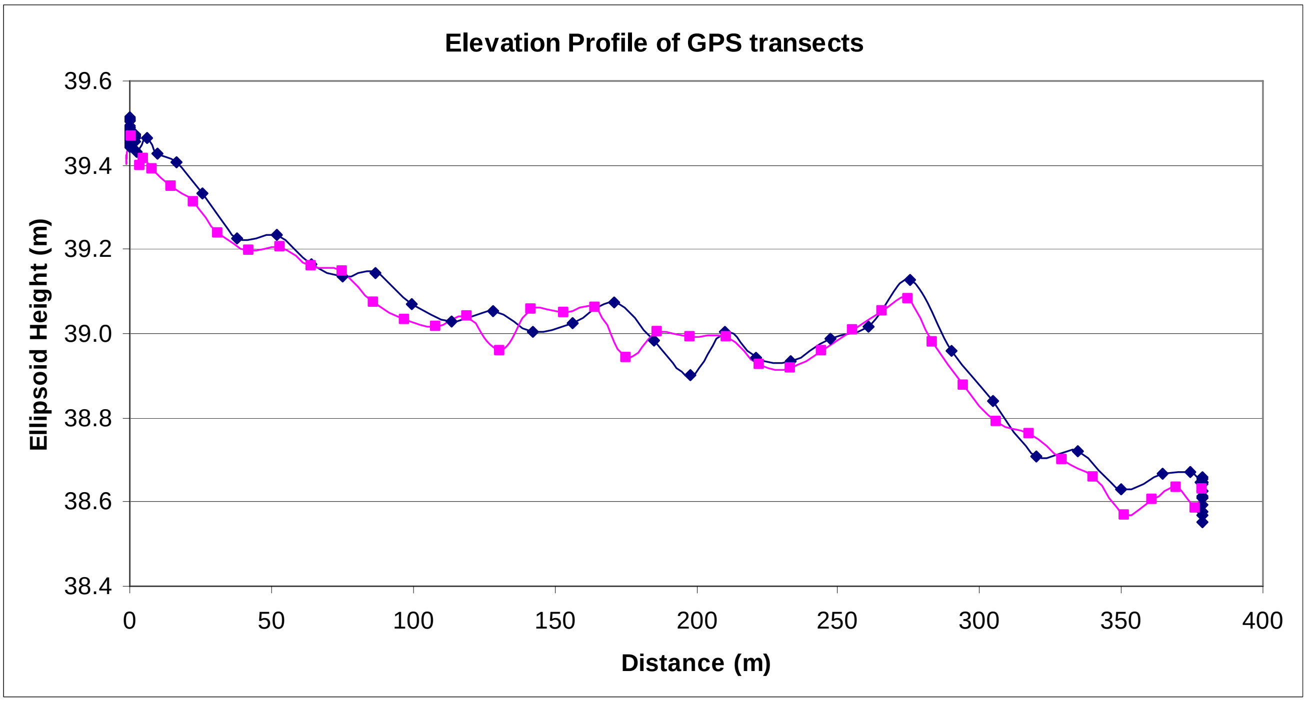


Figure 3: Elevation profile comparison from the



MARCH 8, 2006

GPS receivers were surveying while acquiring GPR radar profiles across Longyearbreen. The GPS was mounted on a rod over a sledge pulled by a bandwagon. The number of satellites during the survery range from 8 to 11. The GDOP values range from 3.1 to 5.7 while the PDOP values range from 2.7 to 4.9. Therefore, it can be stated that the quality of the GPS measurements is fairly high with mediocre DOP values. Moreover, since a known control point was not used within the survey (i.e. NP124), the accuracy of the measurements is slightly decreased. Instead, an average coordinate over the total logging time is used for the local base station.

Figure 4: Number of Satellites available during survey on March 8, 2006

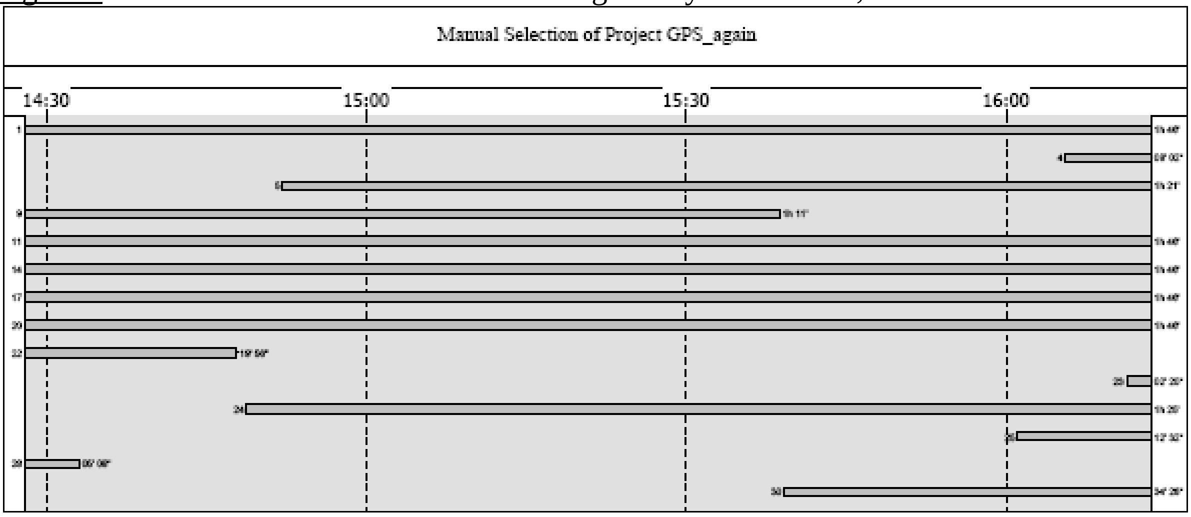


Figure 5: GPS profiles on Longyearbreen

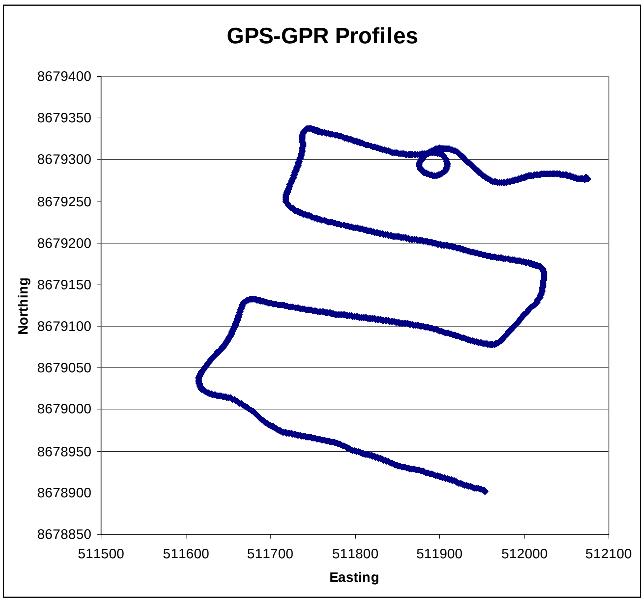


Figure 6: NTNU Geoid Model

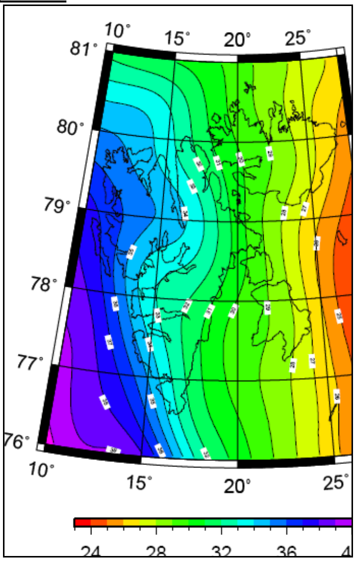


Figure 5 shows the GPS transects driven over Longyearbyen in conjunction with GPR measurements. Moreover, Table 1 shows examples of the GPS measurements and the following transformations performed. First, ellipsoid heights were converted to geoid heights (elevation above sea level) using 2 conversion factors based upon the NTNU model (figure 6), as well as that calculated from the known control point, NP124 (table 1). The adjustment factors were 33 and 31.901 meters respectively. Furthermore, the UTM coordinates were transferred from the Euref89 datum to ED50 using two transformations. The first, from WSKTrans, a program created for conversions within the mainland Norway, and through a conversion based upon NP124. The differences between the resulting ED50 coordinates are shown in the last two columns of Table 1. It is apparent that a systematic difference of -4.8 and 11.58 meters (for northing and easting, respectively) results from using the WSKTrans program. Conclusively, this program should not be used for conversions in Svalbard, and thus an adapted conversion using NP124 is more desirable.

Table 1: Sample GPS measurements and transformations

		Euref89- UTM33N			Height from Geoid Model	Height from NP124	ED50-UTM(zone33): From WSK_Trans		ED50-UTM(zone33): NP124		Differences in ED50 transformation	
Point ID	Time	Northing	Easting	Ellip. Height			Northing	Easting	Northing	Easting	Northing - diff	Easting - diff
sag1		8679279	512073	350.408	317.408	318.508	8679486	512137	8679481	512148	-5.043	11.518
6.9E+07	1346480	8679279	512073	350.414	317.414	318.514	8679486	512137	8679481	512148	-5.037	11.517
6.9E+07	1346500	8679279	512073	350.422	317.422	318.522	8679486	512137	8679481	512148	-5.034	11.517
6.9E+07	1346520	8679279	512073	350.428	317.428	318.528	8679486	512137	8679481	512148	-5.035	11.516
6.9E+07	1346540	8679279	512073	350.433	317.433	318.533	8679486	512137	8679481	512148	-5.032	11.516
6.9E+07	1346560	8679279	512073	350.43	317.43	318.53	8679486	512137	8679481	512148	-5.023	11.513
6.9E+07	1346580	8679279	512073	350.424	317.424	318.524	8679486	512137	8679481	512148	-5.034	11.511
6.9E+07	1347000	8679279	512073	350.417	317.417	318.517	8679486	512137	8679481	512148	-5.031	11.526
6.9E+07	1347020	8679279	512073	350.4	317.4	318.5	8679486	512137	8679481	512148	-5.029	11.513
6.9E+07	1347040	8679279	512073	350.416	317.416	318.516	8679486	512137	8679481	512148	-5.04	11.517
6.9E+07	1347060	8679279	512073	350.4	317.4	318.5	8679486	512137	8679481	512148	-5.033	11.52
6.9E+07	1347080	8679279	512073	350.423	317.423	318.523	8679486	512137	8679481	512148	-5.026	11.516
6.9E+07	1347100	8679279	512073	350.429	317.429	318.529	8679486	512137	8679481	512148	-5.034	11.515
6.9E+07	1347120	8679279	512073	350.412	317.412	318.512	8679486	512137	8679481	512148	-5.029	11.517
6.9E+07	1347140	8679279	512073	350.431	317.431	318.531	8679486	512137	8679481	512148	-5.037	11.52

Discussion

Three different GPS surveying techniques were performed: static, stop-and-go, and kinematic. Static surveys are typically used for measuring control points and base stations. Stop-and-go surveying is a common approach when a larger amount of points need to be measured within a relatively short time. Kinematic profiling is used when creating transects of coordinates and heights across the surface. All three methods require a minimum of 2 receivers while all methods retrieve similar accuracy of 10-20 mm. The underlying difference between the methods is in the application. Static surveys typically result in the best accuracy given a long total logging time that allows different satellite geometries. Stop-and-go surveys require longer *initializations* as well as constant contact with at least 4 satellites. Kinematic surveys are dependent upon the logging interval in order to acquire the best resolution for the purpose of the survey.

A number of other parameters, previously mentioned, are also important in terms of data accuracy and precision. The cut-off angle is the angle at which the GPS receivers stop looking for satellites. Satellites are removed lower than this angle since these satellites are more prone to atmospheric distortions which result in cycle slips and/or mis-calculation of the wavelength periods that are required to estimate satellite-gps distances. Moreover, the logging interval is mostly important for kinematic surveys and will be dependent upon the application of the survey. The total logging time is an important criterion specifically for static surveying since the longer the total logging time, the better the results because of changing satellite geometries. This total logging interval also plays an important role when considering GPS *initialization*, which provides the initial estimates of wavelength, period, and thus coordinates. If the *initialization* is wrong, then a systematic difference will result in all following retrieved positions and elevations.

In terms of post processing, the geographic datums and projections are important to determine accurate coordinates. Since most GPS receivers acquire data within the WGS84 –UTM datum/projection, transformations may be necessary to plot them accurately upon a map. These transformations are not similar across the surface. For example, when using a transformation program (WSKTrans) based from mainland Norway to transform Euref89 to ED50 in Svalbard, an offset occurs of approximately 5 and 11 meters in northing and easting, respectively. A more appropriate approach involves using a known control point on Svalbard, and applying the offset between the known coordinates in both projections. Moreover, mean sea level elevations require a geoid model, and varies significantly across the surface. Using a geoid model from NTNU results in a constant transformation of 33 meters while using the measured control point results in a difference of 31.9 meters. The difference in elevation acquired from using these offsets is 1.1 meters, which then emphasizes the ultimate accuracy of derived elevations (above sea level) from ellipsoid heights.

Conclusion

In summary, both GPS surveys were successful, although known control points were not used. Instead, averages of the static surveys at the local references were used as a control. In spite of this, one can see that the accuracy of positions and heights as retrieved through the GPS is more than high enough for the methods used. It is the methods of retrieval and transformations that limit the accuracy of positions and geoid heights retrieved. For example, elevations retrieved via kinematic profiles will be strictly dependent upon the variation of the local surface topography as the vehicle drives over it (and thus dependent upon speed as well). Moreover, although ellipsoid height will be accurate, the transformation to geoid heights requires a constant parameter for conversion, in which two different models (parameters) will lead to a difference in the resulting elevation of over a meter. Therefore, in conclusion, the accuracy and precision of a GPS survey, although dependent upon the gps technology including logging time and interval, number of satellites, and satellite geometry, is inherently limited by the direct methods used to survey in the field (i.e. scooter driving) and transformations performed during the post processing.