Evaluating the Performance of Kinematic PPP and Differential Kinematic Methods in Rural and Urban Areas

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SUMMARY

This study examines the performance of post-processed Kinematic GNSS-PPP and differential Kinematic GNSS methods in rural and urban areas. For this purpose, three different routes were selected. They are Campus, Campus-Ardicli village and Bosna-Hersek district route. Campus route has no large number of high buildings but signal loss may be possible. While the Campus-Ardicli village route is suitable for satellite based positioning because of open-sky, Bosna-Hersek district route has a lot of high buildings that may cause signal loss and decrease the number of visible satellites. Dual-frequency GNSS receivers was used for data collection. Cut of angle and epoch interval was chosen 10º and 1 second, respectively. Collected data were processed by using CSRS-PPP and Leica Geo Office 5.0 software for kinematic PPP and differential kinematic methods respectively. PPP and Differential Kinematics' results were compared with respect to rural and urban regions separately, based on three routes.

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1. INTRODUCTION

Precise Point Positioning (PPP) is a special case of zero difference processing and viable alternative to differential technique. PPP is cost effective since the point positioning is performed using a single GNSS receiver (at the user's position) and it is not require accessing to the observations of reference station with known coordinates (Rizos et al. 2012, Gao and Shen 2002). While the PPP method dates back to Anderle 1976 increased attention has focused on since 1990's. PPP was first developed for static applications, however with the development of final, new real time or real time satellite orbit and clock products, kinematic PPP is being increasingly used in research and applications (Anquela et al 2013). Over the last few years several PPP software packages have been developed. PPP post processing services such as CSRS-PPP, MagicGNSS, GAPS, APPS provide converged float solutions at the centimeter level in static mode (Grinter and Janssen 2012) and at the decimeter level of accuracy in kinematic mode depending on observation duration (Ocalan et al 2013, Alkan and Ocalan 2014). CSRS-PPP employs GNSS orbit and clock products provided by IGS and estimates positioning of the single GNSS receiver in static and kinematic mode. CSRS use both phase and code observations and has an option for users to select data in results including NAD83 and ITRF 2008. Ebner and Featherstone (2008) compared the DD network solution estimated by Bernese 5.0 with CSRS-PPP results was found that differences are generally insignificant. Detailed information about PPP based software packages are given in (Ocalan et al 2013). In this study, performance of the kinematic PPP and Differential Kinematic methods were compared in three different routes including rural and urban regions. For the kinematic PPP process NRCan's CSRS-PPP online service and for the post process kinematic PPP application Leica Geo Office commercial software was used (URL-1).

2. EXPERIMENTAL WORK

In order to compare kinematic PPP and differential kinematic methods three routes have different topographical conditions and satellite visibilities were selected. They are Campus-Ardicli Village, Campus and Bosna-Hersek District routes. Campus-Ardicli Village is in the plain rural area and there isn't any buildings or forest near the route that could be interfered with GNSS signal (Figure-1). It is 8.9 km long. As given in figure-2, the Campus is the shortest route (3.8 km) including few high buildings that may possibly bloke the signals path.

However Bosna-Hersek District is the longest route that has a lot of high buildings which may cause signal loss and decrease in the number of visible satellites (Figure-3). This route is 13.7 km long.

Figure 1. Campus-Ardicli Route

Figure 2. Campus Route

Figure 3. Bosna-Hersek District Route

In order to estimate differential kinematic coordinates, a reference station was located inside the campus area denoted as a red star in figure 2. In addition a receiver, placed on the vehicle (Figure-4), used as a rover. GPS data were collected at 1 second intervals with a maximum vehicle speed of 30 km/h and 10 degree cut off angle. Unlike other routes in order to investigate consistency of the results campus route was made 7 laps. The data obtained from the routes was prepared to use in the processes. The total number of observation data obtained for each route are 2100, 4700 and 2200 for Campus-Ardicli, Campus and Bosna-Hersek District respectively. In order to eliminate datum difference between differential kinematic and kinematic PPP applications, observation data of the reference station was processed by the static module of the CSRS-PPP software and estimated coordinates was used as a fixed coordinates of reference station for differential kinematic applications. Using Leica Geo Office 5.0 Software for differential kinematic processes, differential kinematic coordinates of the rover according to the reference station was estimated for three different routes. However some meaningless coordinates corresponding to Bosna-Hersek District route was determined beacuse of signal loss and multipath.

Besides diferential kinematic applications, kinematic PPP processes were made using kinematic module of CSRS-PPP software. While doing this, only observation files corresponding to each route were uploaded to the system and process results were received by e-mail. Unlike the differential results, there was no meaningless results was found in the estimated coordinate files. After eliminating outlier coordinates of the differential results, their corresponding parts in the kinematic PPP results were also extracted for the comparison.

Coordinate results estimated by two methods for the Campus-Ardicli route, which is in the rural area, are highly consistent in all directions (Figure-5).

Figure 4 Receiver (Rover) Located on the Car

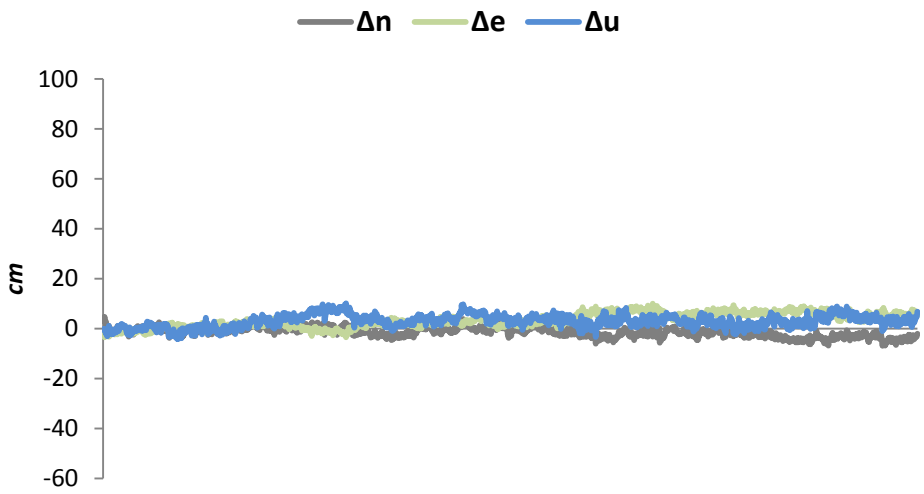

Figure 5 Coordinate Differences of Capmus-Ardicli Village Route

As can be seen in figure-6, maximum difference can reach 40 cm level in up components for Campus-Route which includes 7 laps. Coordinate differences are similar for each laps. However when the Bosna-Hersek results were examined it can be seen in figure-7 that differences are very high for all coordinate components. In addition there are meaningless leaps in the figure. These are associated with the differential kinematic coordinates.

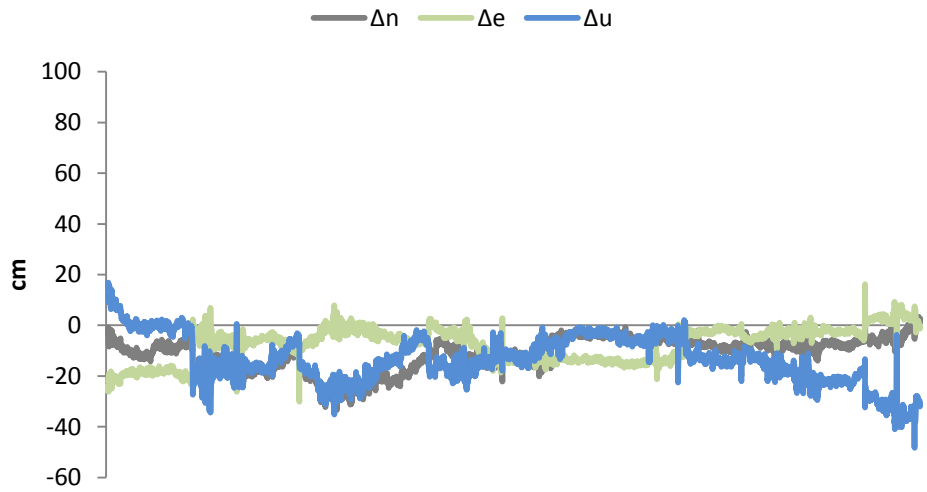

Figure 6 Coordinate Differences of Campus Route

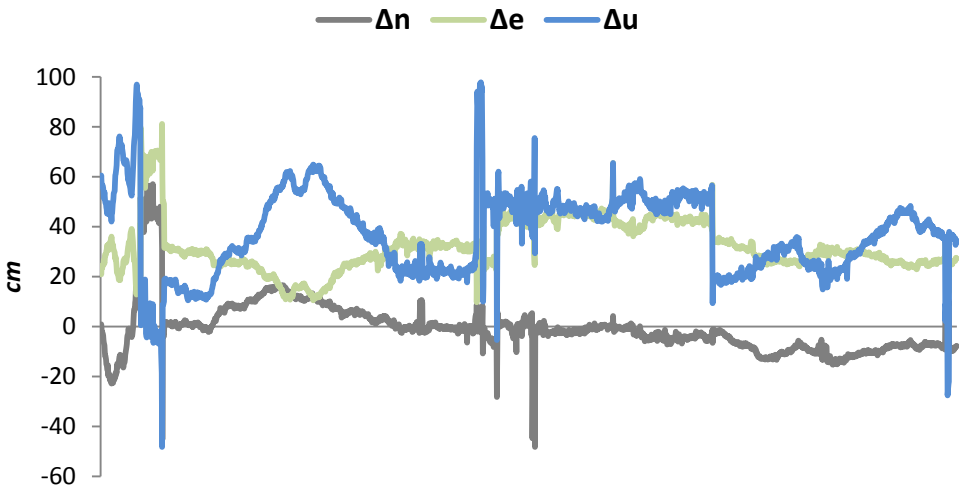

Figure 7 Coordinate Differences Bosna-Hersek District Route

Besides coordinate differences, standard deviations of the coordinate components were also examined. Figure-8 illustrated that standard deviations of Campus route for 7 laps are similar in general. However they are a little larger in the first lap reaching 10 cm for up component. Standard deviations are 5 cm level in general. In addition standard deviations corresponding to 7 laps are 6.6 cm, 6.7 cm and 9.4 cm for north, east and up directions respectively.

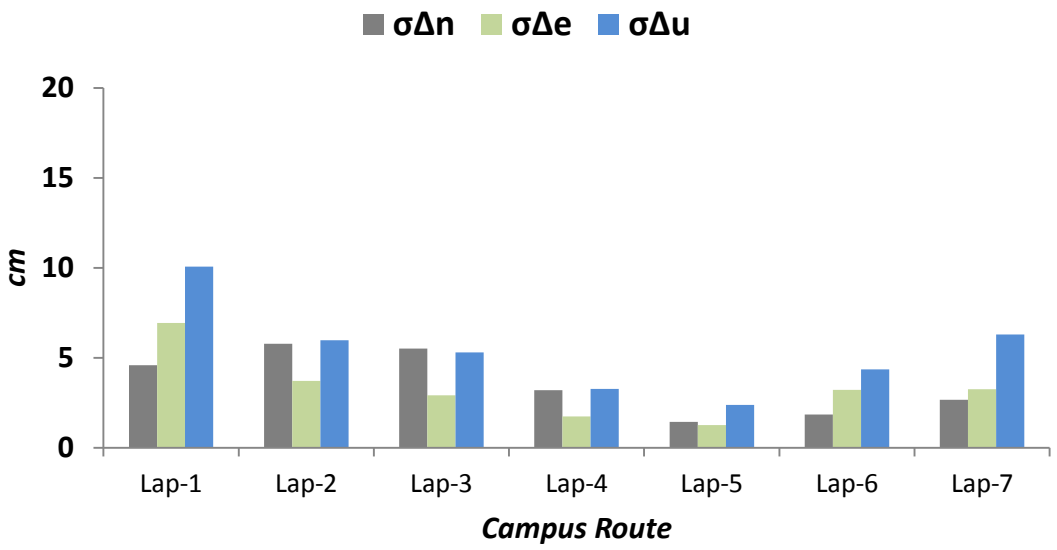

Figure 8 Standart Deviations of Campus Route for 7 Laps

As expected standard deviations corresponding to Campus-Ardicli route, in the rural area, are lower then the other routes, reaching maximum 3 cm level (Figure-9). However standard deviations of the coordinate differences related to the Bosna-Hersek District route are very high, particularly in the up directions (Figure-9).

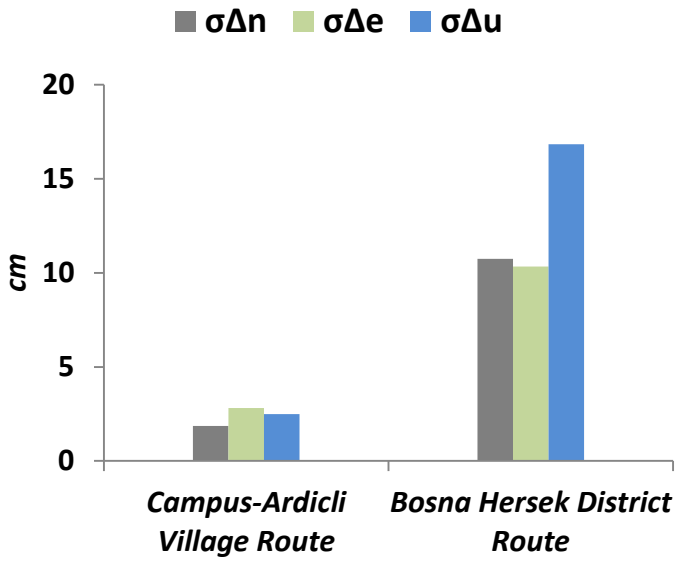

Figure 9 Standart Deviations of Capmus-Ardicli Village and Bosna-Hersek District Routes

3. CONCLUSION

This study examines the performance of differential kinematic and kinematic PPP method for three different routes including rural and urban areas. 7 laps were performed for Campus route and one lap for the others. According to the results, it is observed that kinematic PPP is a valuable method that can obtain precise coordinates for different satellite visibility condition. While using differential kinematic method the precise coordinates were obtained in rural area however some meaningless and less precise coordinates were estimated in urban areas. Coordinate differences are generally larger in the up components for the routes in the urban areas. In addition differences in all directions are clearer in Bosna-Hersek District Route which has many high buildings. Similar to the coordinate differences, standard deviations corresponding to the Bosna-Hersek District Route have higher values.

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