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ANALYSIS OF THE INFLUENCE OF OROGRAPHICAL FACTORS ON THE PLANIMETRIC ACCURACY OF POINTS DETERMINED USING GPS IN FORESTED AREAS

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Abstract

This research aims to identify the manner in which orographically factors influence the horizontal precision of GPS coordinates. The study area is a mountainous region in the Bran locality, mainly covered with spruce forests. Data was collected using the Stop&Go method with post-processing, using two GPS receivers (Trimble Pro XH and Pro XT). Data was stratified considering the following criteria: orography (valley, slope, crest) and aspect (S-N, E-V). Field data was post-processed and the resulting precisions were analysed using the Statistica software. The influencing factors were analysed individually, but also in different combinations. The best accuracy was obtained for points located on crests, followed by points on slopes (which had a good precision) and finally points in valleys (which had acceptable or low precision).

***Key words**: GIS, GPS, mountainous forests, statistical analysis.*

INTRODUCTION

This research paper aims to highlight the factors that influence the horizontal precision of point positioning using GPS equipment in a forest environment. The study area is represented by the mountainous forests of the Bran-Moeciu area (Figure 1). There are numerous studies carried out in this area, which analysed the point coordinates precision depending on category (forest, border, forest road, open wood and alpine barren zone) (Teresneu et al., 2014), the precision of coordinates for points on the edge of forest canopy (Teresneu & Vasilescu, 2015) and the implications on the area of forest parcels (Teresneu et al., 2011). For this study, the methods and means used in similar studies were considered, which highlighted that in a forest environment the number of visible satellites is much lower (Wang et al., 2014), the tree canopy considerably lowers the precision of coordinate calculation (Ordonez Galan et al., 2011; 2013; Weilin et al., 2000; Zhang et al., 2014), the presence of a snow layer further decreases positioning accuracy (Janez et al., 2004), the vegetative season greatly influences this precision (Dogan et al., 2014; Sawaguchi et al., 2003). For this paper the positive aspects offered by remote sensing were not taken into account (Vorovencii, 2014a, 2014b).

Figure 1. Study area

MATERIALS AND METHODS

Materials used for this study are: cadastral maps with forest boundaries, corroborated with parcel descriptions from the forest management plan; two GPS receivers, type *Trimble Pro XT and Trimble Pro XH.*

Direct measurements were made to determine the coordinates of over 2700 points (the specific method used was *Stop&Go* with post-

processing). Data was downloaded from the GPS receivers using the *Trimble GPS Pathfinder Office,* and for post-processing the Top GEOCART Brasov permanent station was used. Data was stratified considering the following criteria: orography, regardless of the presence of forest (valley, slope, crest), aspect (S-N, E-V), spruce forest for the three orographic classes (valley, slope, crest), spruce forest for the two aspect classes (S-N, E-V), beech forest for the three orographic classes (valley, slope, crest), beech forest for the two aspect classes (S-N, E-V).
This data was then processed using the Statistica software, by calculating the common statistical indices (minimum, maximum, mean, standard error of mean, mode, frequency of mode, standard deviation, coefficient of variation).
A GIS project for the study area was created in which the coordinates of points determined with GPS receivers were imported.

RESULTS AND DISCUSSIONS

Experimental data was represented graphically and the relative cumulative frequencies were assigned to the categories of horizontal precision values. In this way, allotments for the orographic factors and aspects can be observed in Figure 2.

As the two graphs show, exponential distributions are obtained, with some tendency of normalization.

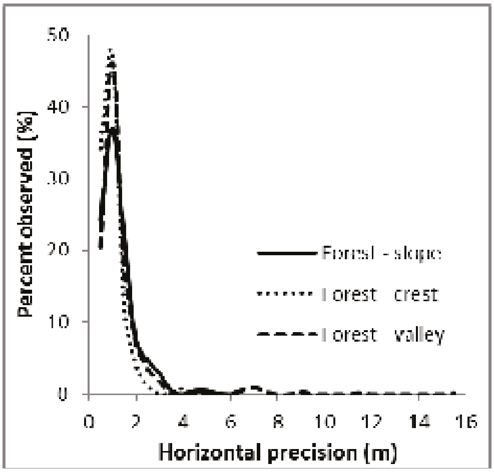

Figure 2. Influence of orography

Next, a series of statistical indices were calculated: minimum, maximum, mean, standard error of mean, mode, standard deviation and coefficient of variation (Table 1).
It can be seen that factor were analysed individually, but also in groups of two and three, respectively.

Table 1. Calculation of statistical indices

Categories	Valid N	Mean	Mode	Minimum	Maximim	Std Dev	Coef Var
Valley	205	0.99	0.4	0.2	7.5	0.84	85.64
Slope	781	1.00	0.5	0.2	8.2	0.74	74.50
Crest	10	0.54	0.5	0.4	0.8	0.11	19.91
S-N	626	0.96	0.5	0.2	8.2	0.81	84.27
E-V	370	1.04	0.4	0.2	5.4	0.68	64.77
Spruce-Valley	144	0.96	0.5	0.2	3.9	0.60	62.13
Spruce-Slope	570	0.94	0.5	0.2	8.2	0.69	73.40
Spruce-Crest	10	0.54	0.5	0.4	0.8	0.11	19.91
Spruce-S-N	437	0.95	0.5	0.2	8.2	0.72	76.22
Spruce-E-V	277	0.95	0.4	0.2	3.3	0.59	62.57
Spruce-Slope-S-N	293	0.94	0.5	0.2	8.2	0.78	82.62
Spruce-Slope-E-V	277	0.95	0.4	0.2	3.3	0.59	62.57
Beech-Slope-S-N	128	0.96	0.6	0.4	6.8	0.82	85.95
Beech-Slope-E-V	93	1.33	Multiple	0.6	5.4	0.82	61.47

Analysis of the obtained results leads to the conclusion that the horizontal accuracy for points located on crests (regardless of the type of analysed forest) have a lower variation, with points on slope having an intermediate value and points in valleys a relatively large one.

If mean is considered, we can state that it is better for points located on crests (regardless of forest type), the other two situations having a lower accuracy. As for aspect, it can be seen that the differences are practically meaningless.

Mode has relatively small amplitude, from 0.4 in various situations to 0.6 for points located on slopes and an S-N aspect. Mode also has a multiple value in the case of beech stands located on slopes with an E-V aspect.

Furthermore, statistical indices such as median, quartiles and percentiles were analysed (Table 2). Graphical representation of orographically and aspect factors are shown in Figure 3.

Analysis of the two representations shows that a better horizontal accuracy is obtained for points located on crests, relative to the other two conditions. Furthermore, a minor influence of the aspect factor is shown.

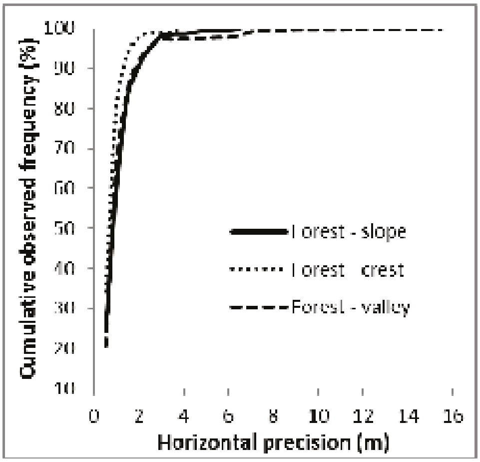

Figure 3. Relative frequencies - orography

Table 2. Calculation of median, quartiles and percentiles

Categories	Median	Lower Quartile	Upper Quartile	Percentile 90	Percentile 95
Valley	0.8	0.5	1.2	1.7	2.1
Slope	0.8	0.5	1.2	1.8	2.3
Crest	0.5	0.5	0.6	0.7	0.8
S-N	0.8	0.5	1.1	1.8	2.1
E-V	0.9	0.6	1.3	1.85	2.4
Spruce-Valley	0.8	0.5	1.2	1.8	2.1
Spruce-Slope	0.7	0.5	1.1	1.8	2.3
Spruce-Crest	0.5	0.5	0.6	0.7	0.8
Spruce-S-N	0.8	0.5	1.2	1.8	2.1
Spruce-E-V	0.7	0.5	1.2	1.8	2.3
Spruce-Slope-S-N	0.7	0.5	1.1	1.8	2.1
Spruce-Slope-E-V	0.7	0.5	1.2	1.8	2.3
Beech-Slope-S-N	0.7	0.6	0.95	1.7	2
Beech-Slope-E-V	1.1	0.9	1.4	2	3.1

CONCLUSIONS

To conclude, it can be said that orography has the greatest influence on point positioning accuracy. Especially high accuracies are obtained on crests, where satellite signals are considerably better. Somewhat lower accuracies are obtained for points located on slopes, and the worst accuracies are obtained in valleys, where satellite signals are weakest.

Furthermore, if the valley has an S-N aspect, then accuracy is even worse.

Regarding the influence of aspect on horizontal precision for GPS positioning of points, it can be said that, in all cases, sunny aspect is the most favourable.

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