TESTING ALS DATA FOR HYDROLOGICAL RISK MAPS USING GNSS MEASUREMENTS

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Abstract*: The study herein is trying to check at what extent the existent spatial low-resolution points ALS data type (1 point / 4 square meters) used to model the hydrologic risk may also be applied in other smaller hydrographic basines or in other zones prone to hydrologic risk compared to those already modelled according to CE 60/2007 directive. This study analyses the differences between the DEM obtained from ALS data and that obtained by GNSS land measurements (survey). For this purpose, data from different parts of the basin: river bed, river meadow and coastal area and also from other positions from the scanning strip was considfered. The data were compared by using the functions provided by ArcGis. The area submitted to this study is Nicolina river hydrologic basin and the ALS data are those used to model the hydrologic risk maps of the Prut-Barlad river basin.*
Keywords: *ALS data, DEM, hydrologic risk map, GNSS measurements, tested data, statistical interpretation*

1. Introduction

It is known that according to the European Directive 60/2007 in our country there were hydrological risk maps for the main courses and for other areas with historically proven hydrological risk; but in the context of climate change and unpredictable anthropogenic interventions (deforestation, land use change, construction in minor settlements, etc.), new areas appear subject to hydrological risk.

In this context, this paper explores the possibility of using existing data for the identification and modeling of new hydrological risk areas.

2. Material and research method

The data used in this study were obtained from the Prut-Barlad River Basin Administration and were purchased by SC TRP SRL in 2012 in order to create the Land`s (terrain`s) Digital Model and the Complete and Uniform Area of the Digital Model, being further used to determine/obtain the Flooding hazard and Flooding risk Maps corresponding to the Prut-Barlad hydrografic river basin (Fig.1).

The scanned data have the following spatial resolution:

- 16 points / squared meter – for a surface of approximatively 500 squared kilometers – for urban areas (crowded inhabited area): Iasi, Botosani, Vaslui, Tecuci, Barlad
- 1 point / squared meter – for a surface of approximatively 3,500 squared kilometers – for Baseu, Jijia, Elan, Chineja, Bârlad and Siret River Basins
- 1 point / 4 squared meter - for a surface of approximatively 16,500 squared kilometers – for the rest of the studied area.

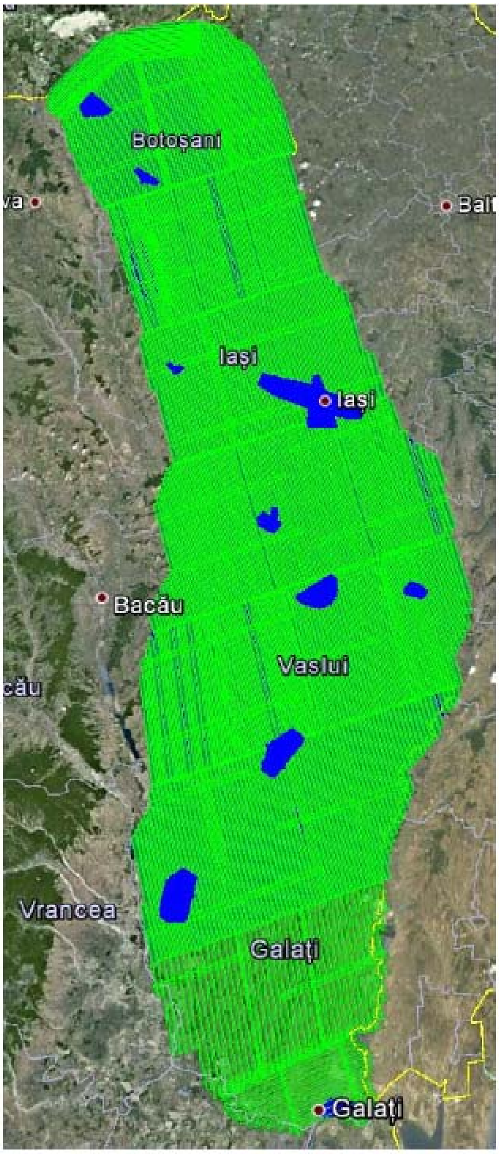

Fig. 1. Tested zones according to landform

The ALS strips have the average length of 45 km and the width of 1.5 to 2.0 km, these dimensions being choosen from precision reasons, considering the inertial IMU systems.

ALS points are of 15 / 10 cm precision in horizontal / vertical plane, according to sensor`s technical specifications. The impulse amplitudes were modulated by aid of an automated control system (Automatic Gain Control – AGC) and the amplitudes` values were assigned to each point (`s atributes). From the data pre-processing performed by SC TRP SRL resulted files of *.las şi *.laz format (*.las format being an archive). The plane rectangular coordinates were computed in the WGS84 Universal Transversal Mercator System, zone 35N and the altitudes were determined in ellipsoidal WGS84 reference system.

Testing zones

For validating the DEM three types of tests were considered (choosen):
- According to landform;
- According to zone`s position inside the ALS scanning strips;
- Singular points identified on DEM in the thalweg of the river.

The tested zones according to the landform were choosen in the following three situations:
- river meadow – plane;
- coastal zone – inclined plane;
- mixed zone.

The tested zones are approximately 250 x 500 m. The measurements of the tested zones/areas were made by using a GNSS receiver (Fig.2). The points density was ensured to be of approximately the same density as LSA points and the measurement points to accurately describe the landform characteristics (e.g. slope changes, settlements etc.).

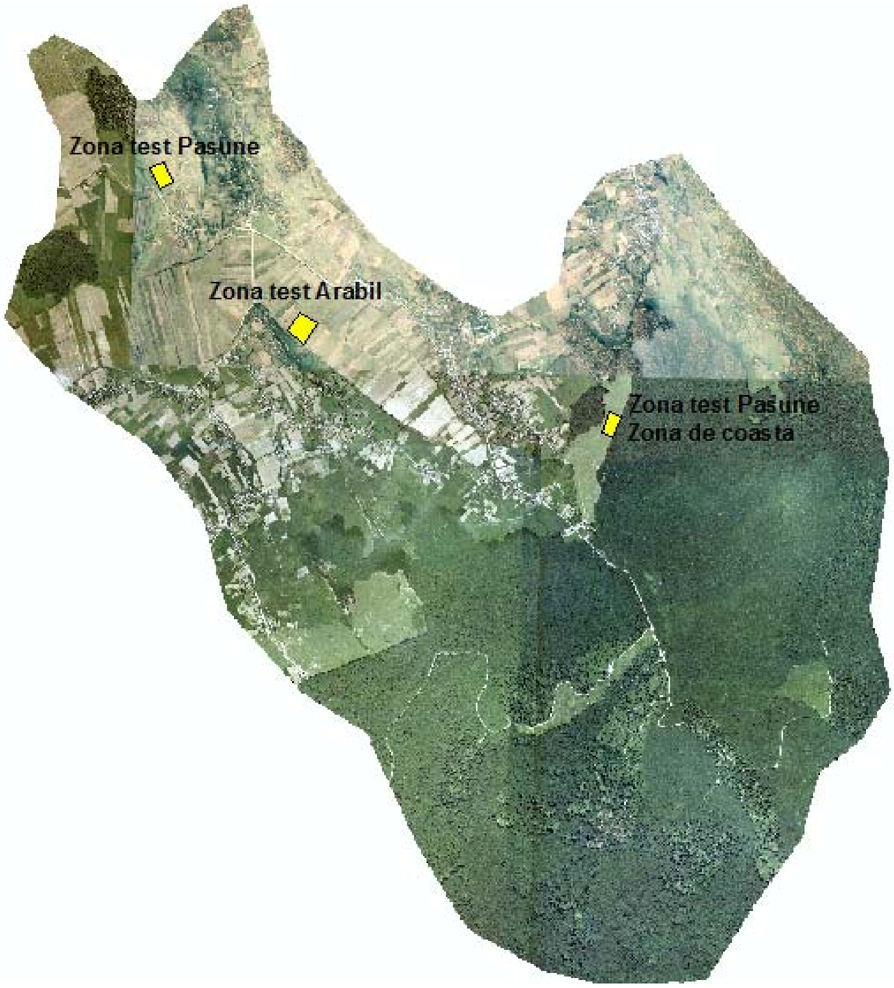

Fig. 2. The tested zones

Flow of tested data processing

For data validation a comparison flow was designed to ensure correct data evaluation. The principle of comparison is to analyze the differences between two DEMs obtained from two ALS and GNSS data sources and processed in a similar way (Fig. 3).

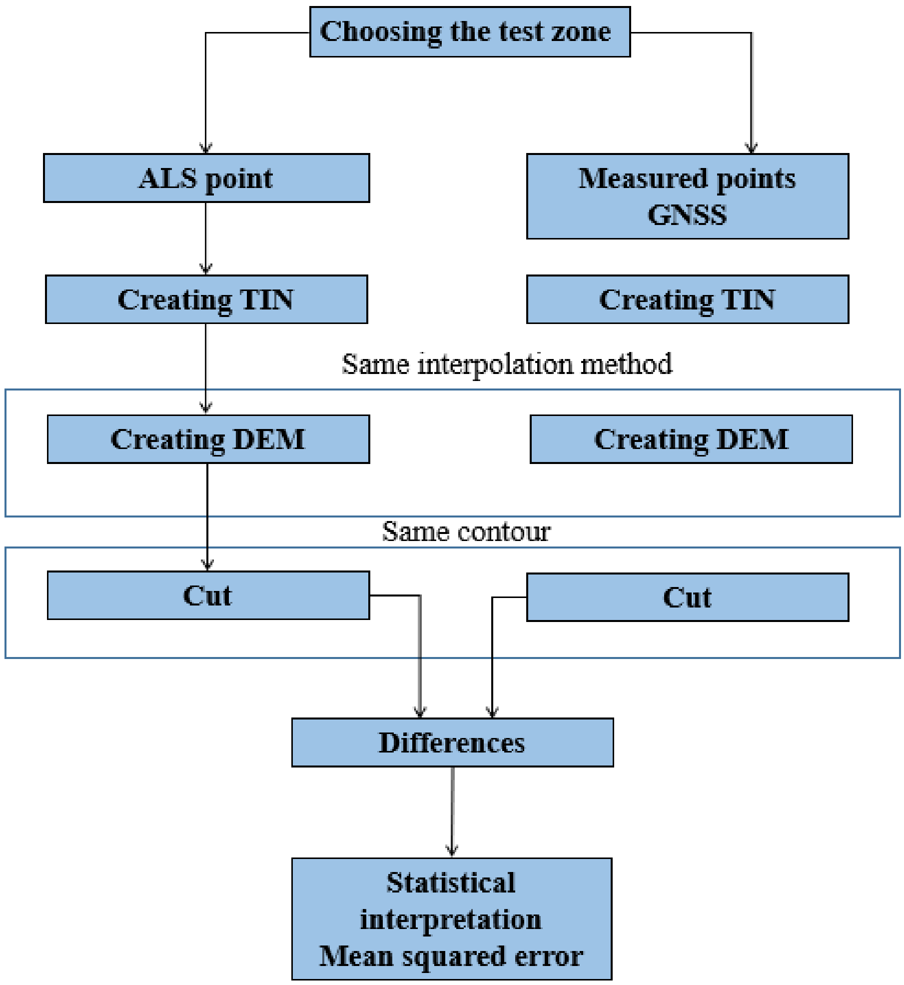

Fig. 3. Comparison flow

The reference data of compared DEMs have to fulfil the following criteria:

- ALS and measured points density should be alike;
- To result from the same interpolation method.
- The contours to be cut must be identical;
- The same grid size.

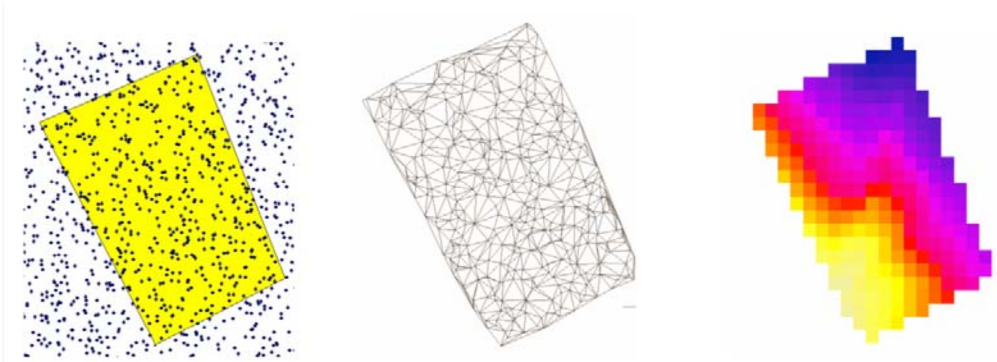

Fig. 4. Representation of the test zones on the comparison flow of ALS data

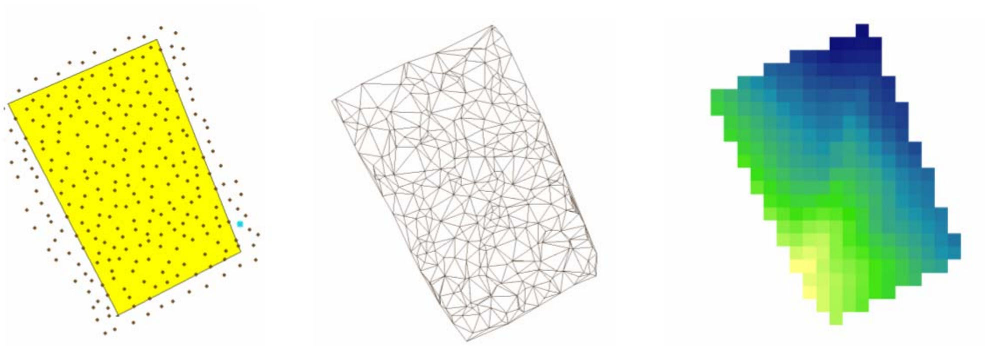

Fig. 5. Representation of test zones of the comparison flow of GNSS measured data

3. Results of the theoretical and experimental study

Comparative data was obtained by processing in ArcGIS using TIN interpolation-specific functions, DEM generation, TXT export and tabular comparison.

Table 1. Benchmarking of DEM ALS points versus measured DEM GNSS points

Lidar point	X	Y	Z	GNSS point	X	Y	Z	Difference
1	5214651.54	545840.60	162.51	1	5214651.54	545840.60	162.74	0.23
2	5214644.54	545826.60	162.39	2	5214644.54	545826.60	162.08	-0.31
3	5214644.54	545833.60	162.07	3	5214644.54	545833.60	161.88	-0.19
4	5214644.54	545840.60	161.84	4	5214644.54	545840.60	161.96	0.12
5	5214644.54	545847.60	161.98	5	5214644.54	545847.60	161.80	-0.18
6	5214637.54	545805.60	159.28	6	5214637.54	545805.60	159.53	0.25
7	5214637.54	545812.60	160.10	7	5214637.54	545812.60	159.84	-0.26
8	5214637.54	545819.60	160.87	8	5214637.54	545819.60	161.20	0.33
9	5214637.54	545826.60	161.53	9	5214637.54	545826.60	161.22	-0.31
….	…	…	…	…	…	…	…	…
239	5214511.54	545840.60	144.01	239	5214511.54	545840.60	144.12	0.11
240	5214511.54	545847.60	145.42	240	5214511.54	545847.60	145.58	0.16
241	5214511.54	545854.60	146.97	241	5214511.54	545854.60	146.69	-0.28
242	5214504.54	545819.60	139.55	242	5214504.54	545819.60	139.62	0.07
243	5214504.54	545826.60	141.26	243	5214504.54	545826.60	141.35	0.09
244	5214504.54	545833.60	142.71	244	5214504.54	545833.60	142.60	-0.11
245	5214504.54	545840.60	144.26	245	5214504.54	545840.60	144.40	0.14
246	5214497.54	545826.60	141.17	246	5214497.54	545826.60	141.20	0.03

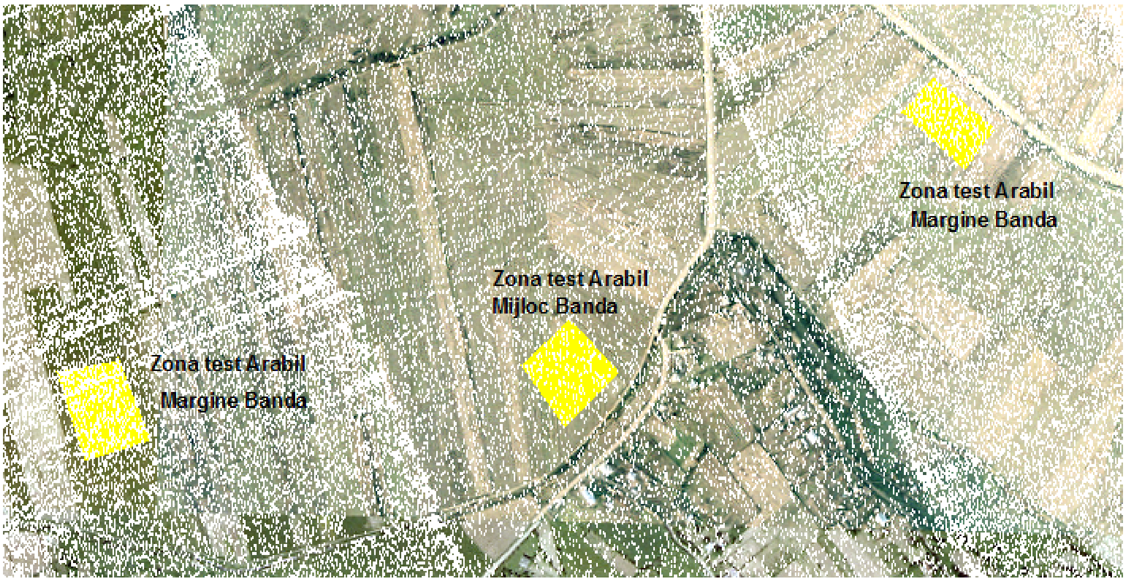

Fig. 6. Test zones with different location in ALS scanning strips

The errors that may occur in the different location inside the ALS scanning strips may be, on one hand determined by the fact that scanner`s emmited ray does not fall perpendicular to the scanned area and the spot will be of ovoid shape instead of a circular one and may negatively affect the measurement and, on the other hand due to the poor calibration of the measuring strips.

The values of the mean squared error of the differences between DEMs resulted from ALS points and GNSS measured points in various test zones are presented in the table below:

Table 2

Test zone type	Squared mean error of level differences [m]
Meadow	0.24
Coastal zone	0.28
Complex	0.35
Left edge of ALS strip	0.21
ALS	0.20
ALS / Right edge of ALS strip	0.23

For determining the accuracy of generated DEM of the bed river zone, 13 GNSS measured points were considered in the river thalweg and their levels were compared to those corresponding to cells from the flow accumulation dirrections obtained from DEM and the ArcGIS implemented algorithm.

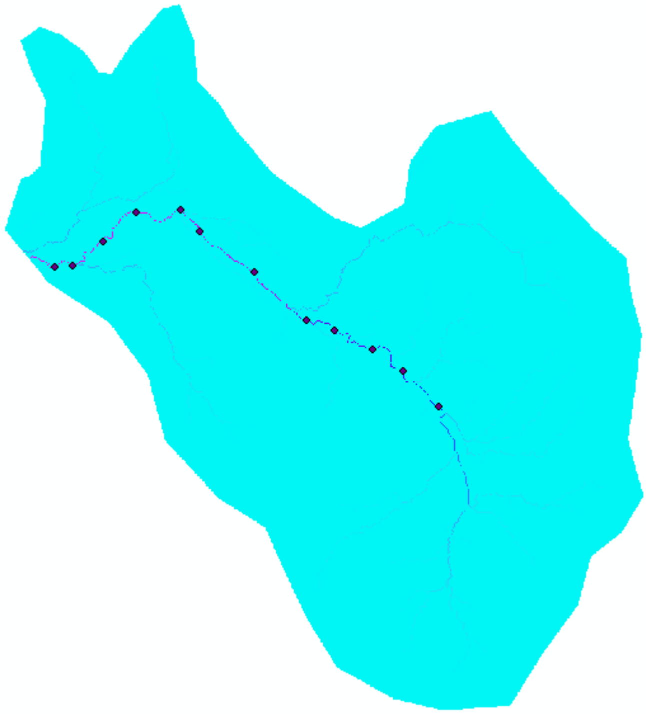

Fig. 7. Test points in river thalweg

The test points were firstly identified on DEM, than traced in the field and finally their levels were measured, the results being shown in Table 3.

The levels were measured twice in each section and the arithmetic mean was recorded. This procedure was adopted because the water absorbs the scanning ALS rays/beam and consequently, on the generated DEM, only the higher levels than water level of the measured section may be registered.

Table 3. Benchmarking of thalweg levels from DEM versus GNSS measured thalweg levels

Point no.	DEM thalweg level[m]	Measured thalweg level[m]	Differences [m]
1	148.04	147.37	-0.67
2	143.75	143.56	-0.19
3	141.65	140.78	-0.87
4	141.23	140.67	-0.56
5	138.76	137.87	-0.89
6	135.49	135.31	-0.18
7	132.55	131.81	-0.74
8	130.84	129.82	-1.02
9	128.91	128.23	-0.68
10	127.57	126.68	-0.89
11	125.50	124.74	-0.76
12	122.83	122.60	-0.23
13	120.62	119.85	-0.77

4. Conclusions

The precision of points measured in meadow area are the closest to the precision indicated in the technical specifications of the used sensor. (0.2 – 0.15);

Coastal zones and mostly the complex ones presented higher differences, that may be related to operating person that effectively performs the measurements and more accurately appreciates the landform than the ALS uniform screening. Concerning the hydrologic model, this aspect is not crucial because the higher differences were not determined in points from the zones prone to flooding risk.

The verifications in thalweg revealed that only 3 of the 13 DEM points are validated by the measured levels. This indicates that the river bed morphology is not correctly evaluated by ALS scanning / screening with the resolution of only 1point/4 m^2. In this case precise topographic measurements are to be recommended for the bed river zones. These topographic measurements have to be performed also for identifying the wet/moist? vital areas in order to correctly obtain the hydrologic model to accurately draw / determine the flooding risk maps.

The tested ALS data may be successfuly used to model the hydrologic risk maps. For the river-bed zones these ALS data have to be accompanied by the topographic measurements to correctly determine the morphology of the landform. As a final conclusion, these ALS data may be used by approximately 90%.

5. References

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