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MONITORING THE CADASTRAL PARAMETERS OF WATER SUPPY PIPE USING GIS MODELS

BY

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Abstract. GIS models are used in various fields of activity. They monitor complex systems of special installations for water supply systems and special constructions for each components. A particular problem in monitoring the water supply system is the main water supply pipe through its importance and complexity. The main water supply pipeline is of a lengthy length, in which case there are issues related to the ownership of the land it crosses. Particular importance in the exploitation process presents access to emergency response pipelines. The elaborated paper deals with various existing situations along the pipeline where positioning on private private properties involves a series of additional data in the GIS monitoring model. In these cases, the GIS model should bring together the real estate cadastre with the cadastre for network utility. The implementation of modules for a monitoring program that includes real estate and network utilty cadastre is done in accordance with the cadastral data of the plots and the enplacement of the water supply pipe. The paper presents studies and researches realized in the purpose of monitoring with GIS models of the main water pipe for the transport and distribution of drinking water. The paper treats the problems that apper on the pipeline route on certain section from the surce to rervoir. By implementing GIS models in the main water supply pipelines, where the urbanistic cadastre correlates with the real estate cadastre, it is intended to identify areas of land with access problems, hard-to-reach areas, private private areas, etc.

Keywords: database; digital plans; legal issues; location; proprietary issues.

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1. Introduction

The water supply system is a complex of buildings, installations and measures that have as their primary purpose to ensure the quality and quantity of water required by consumers. The main components of a water supply system: capture, treatment plants, pumping stations, main water supply, reservoir, distribution network (Mănescu, 1994).

Main water supply pipes are important in creating and operating a water supply system, they connect the distribution system to the water source. The pipeline is made up of pipes with different diameters, fittings, special function constructions (Luca *et al*., 2015).

In the literature, a series of studies on adduction pipelines are presented. Thus, Luca *et al*., (2015), studied the exploitation parameters of the Iasi-Timisesti pipeline, including water losses and concluded that they influence the stability of the pipeline and the way it works. Losses are determined by pipeline location, operating mode and aging process. As mentioned in the EPA, (2002) the water supply system, implicitly the conduction pipelines, which is a interdependent mix of technology, customers, community services, finance, location and regulatory issues. Monitoring and maintenance of main water supply pipes is a challenge because of their length, component materials, but also high repair or rehabilitation costs. Such repairs are often preferred over rehabilitation and replacement.

A water supply system has attached a multitude of spatial attributes data. In order to improve, manage and make work more efficient and to reduce the workload of workers, one of the best methods is to design the GIS water supply network (Wang *et al*., 2008).

In Sacramento, United States of America, the Canal Water Director has developed pipeline rehabilitation plan that pursued the following objectives (SSWD, 2011):

– ensuring a safe water transport system;

– inventory of the existing distribution networks of the county by size, type and age;

– providing a plan for the monitoring of the supply and the assessment of the site conditions;

– providing a plan for the rehabilitation or replacement of pipelines to incorporate new technologies, management practices and the needs of the study area;

– provide a direction and a framework for future revisions.

2. Main Water Supply Timişeşti - Iaşi – Case study

The Timişeşti – Iaşi water main crosses two counties and a number of administrative territorial units. It starts its route in the outskirts of Timişeşti commune and crosses both common in Neamț County and in Iaşi County, rivers, reliefs, roads, railways.

The area of the study considered in the research is the main water supply AdI Timişeşti – Iaşi, as well as the water supply AdII Timişeşti – Iaşi (Fig. 1). The main water supply I was put into operation in 1911 and is also known as the "King Carol I" transmission main, the length of the transmission main pipeline is 104 km. The water supply II was commissioned in 1970 and is 102 km long.

Fig. 1 – General water supply scheme of Iasi county (Luca *et al.*, 2015).

The Timişeşti – Iaşi water main crosses various relief forms, localities, street networks and private properties along the route. Its location involves a number of special problems regarding: maintenance, repairs, rehabilitation/ upgrading works. The completion of these works requires the right of access to the site area.

Adduction pipes encounter natural obstacles (Moldova, Siret, Strunga Hill), but also artificial (roads, railways) which they overload and subtract through special hydro-technical constructions. This raises problems of access to interventions in the special construction of undercrossing and overcrossing.

The case study analyzes the following scenarios:

a) Scenario 1 refers to the problems of intervention in case of undercrossing river;

b) Scenario 2 deals with the problems of intervention in the event of overcrossing rivers;

c) Scenario 3, which represents problems of intervention at repairs/ interventions, rehabilitation/modernization, at the pipeline located on private or public property.

In order to carry out the case study for the Timişeşti – Iaşi pipeline, the following steps were taken:

Stage I: Schematic phase of the analysis model according to the data to be collected and the need for the study.

Stage II: Stage of acquisition of data and identification of the study area. The data necessary for the realization of an analysis model are collected from the cadastral documentation provided by OCPI Iaşi, and S.C. APAVITAL Iaşi provided measurements for the location of the pipeline,

Stage III: Making or improving the model by correlating the real estate cadastre (measurements made, identifying private and public properties, delimiting areas with access problems to interventions). The data collected from the two sources is merged and processed in the Autocad program. Verification of the model of analysis is done by means of cadastral plans, orthophotomaps and field research.

Stage IV: Developing or improving hydro-cadastral elements by improving pipeline location data, pipeline material, its current structural condition, access conditions, time interventions for repairs, etc. The data is processed and entered into the GIS monitoring model.

Stage Five: Signaling problems encountered on sections studied and analysis of different cases encountered in the study area.

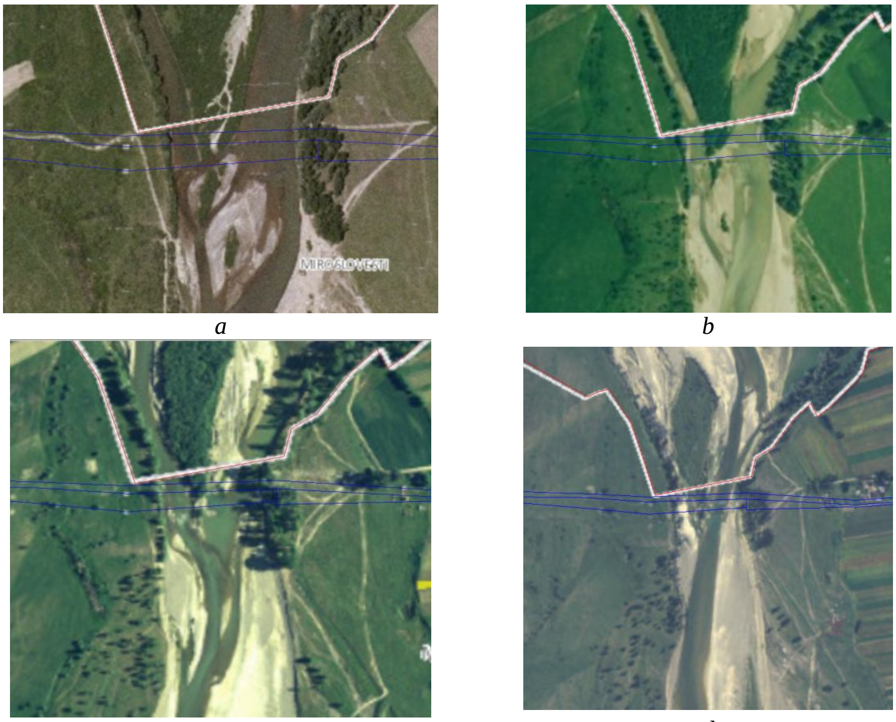
The analysis carried out in "Scenario 1" represents the problems of interventions in damages on the conduit that undercross Moldova river.

a *b*

Fig. 2 – Undercrossing water main in the area of Moldova river: *a* – pipeline route in the underground river; *b* – image with the underground location (Luca *et al*., 2015).

The underrcorssing area is located in the Northwest part of the Mirosloveşti commune, in an area outside the area, the 49 sector, the HC 478 plot, at the Moțca UAT limit near the European road E85. Thus, the water supply undercross the Moldova River, as can be seen in Fig. 3. The riverbed is continuously morphologically modified by annual floods and ballast operations. Intervention in case of damage to the conduit can be made difficult by these changes of the riverbed.

In case of damage, the following parts are involved: the Siret basin water administration of the Moldova River, SC APAVITAL the owner of the water pipe, the commune of Miroslovești on the territory of which the main water supply passes.



a *b*

c *d*

Fig. 3 – Viewing the Moldovan River course in different years:
a – 2005; *b* – 2009; *c* – 2010; *d* – 2016.

The analysis in "Scenario 2", which is the problem of intervention in the event of overcrossing. As a result of the field research, it can be noticed that the water main overpasses the river Moldova in the area of Butea – Răchițeni. In the case of a damage the direct company involve are the water - sewer SC APAVITAL, ABA Siret, UAT Butea and UAT Răchițeni.

The studied section is located at the boundary between the two administrative territorial units Butea and Răchițeni, in the parcel HC 465 and HC 933 according to the cadastral plans of outside the built-up areas drawn at 1: 10,000 scale. It is positioned parallel to the national road DN 28 crossing the Siret River (Fig. 4).

As mentioned in the NE 035-06 norm, when the pipeline site may affect traffic in the area, the police will also be notified.

The analysis in "Scenario 3", dealing with problems of intervention at the adduction pipeline to interventions for private or public property. In order to achieve this scenario, the location of the Timişeşti – Iaşi water supply and the buildings that are registered in the county, in conjunction with the cadastral plans, orthophotomaps, proprietary documents existing in the OCPI database, were taken into consideration. Thus, the overlapping of the built-in buildings over the adduction route was done (Fig. 5), and a follow-up of the analysis was as follows:

– at the level of Iaşi County it can be noticed that the buildings that are not yet listed are predominant;

a

b

Fig. 4 – Overcrossing of the II adduction over the Siret River in the area of Scheia: *a* – lateral view; *b* – general view.

– the route of main water supply passes through several territorial administrative units;

– the main water supply has a route along the communal, county or national roads, but it can be seen that there is the case when they cross the nesting buildings.

In order to carry out rehabilitation or repair works on certain sections of the main water supply or even the whole main water supply, it is necessary to know the route and the buildings that cross it. Thus, in the case of private property, owners are required to be compensated in case of damage, and in case of rehabilitation, an expropriation corridor is to be carried out. This can be done easily by working together with the cadastre of the real estate. There is no legislation in place in Romania to regulate this issue, but in order to create an expropriation or compensation corridor it is necessary to draw up a contract between SC APAVITAL and the owners of the affected buildings.

A similar situation encountered at national level is represented by the rehabilitation project for the water supply pipeline of the localities of Haţeg, Călan, Simeria and Deva, where the process of registration of the main water supply corridor was carried out and the landowners were identified. As mentioned in the Decision no.*168*/2014, the procedure is a tedious process requiring the production of a large number of documents. The corridor has a width of about 5 m and a length of 26.8 km.

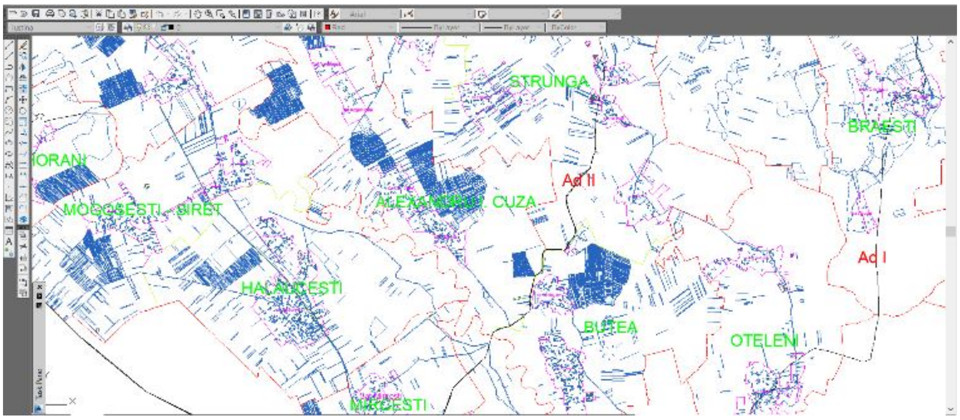


Fig. 5 – Viewing the Timişeşti – Iaşi route in the county of Iaşi.

In the case of the Iaşi county for the realization of an expropriation corridor it is proceeding similarly to the case of the adduction in the Bretea Romana area. After analyzing the constructive structure of the Timişeşti – Iaşi pipeline, we have exemplified the following cases:

a) Public domain, in the case of the immobile with cadastral number 62,857, located in the outside the built-up areas commune of A.I. Cuza, sector 86, plot CC 573/1 with an area of 2,910 m² of land in the property of Butea commune. The main water supply pipeline is located underground in the right of the national road DN 28 at a distance of about 4 m. If we consider that an opening of at least 5 m of the total area of 2,910 m² is required for an expropriation corridor dismantled an area of 800 m², the surface of the building would be reduced to 2,110 m². In this respect, from the cadastral point of view, it is necessary to draw up a documentation of the detachment and compensation of the owner (Fig. 6).

A special situation in this building is that there are graves from the Second World War on the ground, as well as the Cemetery of the Butea heroes, and the route of main water supply passes even under some of the tombs (Fig.7).

However, the expropriation corridor may require a width of more than 5 m because it must be in line with the size of the intervention means. For example, an excavator has a width of more than 8 m, which would require a 10 m corridor.

Fig. 6 – Viewing a corridor for the expropriation of the Bredu Romanian area, Hunedoara county (www.geoportal.ancpi.ro).

a *b*

Fig. 7 – Viewing aduction location area: *a* – orthofotoplan; *b* – general view (www.googlemaps.ro).

b) The private domain, in the case of immobile property with cadastral number 60,353, located on the outside the built-up areas of Oțeleni commune, sector 40/3, plot A 685, with an area of 3379 m² of land. The field is located near the communal road DC 82A which connects the village of Oțeleni and Buhonca village.

If we take into account the fact that an opening of at least 5 m is required in order to achieve an expropriation corridor, two surfaces should be dismantled out of the total area of 3,379 m², because the route of the adduction pipe cuts the building in two. It will result in the area of 220 m² attributed to the corridor, and the resultant plots would have the areas of 910 m² and 2,249 m² respectively. In this respect, from the cadastral point of view, it is necessary to draw up a documentation of the detachment and compensation of the owner.

A disadvantage of this situation is that the property has no continuity. Since land is used for agricultural purposes, landowners in the area would have disrupted land plots (Fig. 8).

Fig. 8 – View the emplacement of the private ownership of Oțeleni commune.

3. Conclusions

Analysis models facilitate the inspection, maintenance and monitoring of water supply systems.

The monitoring of the main water supply pipes is useful for the rehabilitation and refurbishment processes.

The route of adduction is of a lengthy length which makes the problems of positioning it to be topical.

Collaboration of the real estate cadastre with the landlord renders ownership issues in the case of expropriations easy to solve.

Early identification of problems of access to interventions on pipelines shortens the type of intervention crew analysis.

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MONITORIZAREA PARAMETRILOR CADASTRALI AI ADUCŢIUNILOR DE APĂ FOLOSIND MODELE GIS

(Rezumat)

Modelele GIS sunt folosite în diverse domenii de activitate. În România doar o parte din sistemele de alimentare cu apă sunt monitorizate prin modele GIS de către regiile de apă – canal. Conducta de aducţiune are o lungime mare, situaţie în care pe traseul acesteia apar probleme privind dreptul de proprietate asupra terenurilor pe care aceasta le traversează. O importanţă deosebită în procesul de exploatare îl prezintă accesul echipelor de intervenţie la conducta de aducţiune în caz de avarie. Lucrarea elaborată tratează diverse situaţii existente pe traseul conductei, în care poziţionarea pe terenuri proprietate privată implică o serie de date suplimentare în modelul de monitorizare GIS. În aceste cazuri, modelul GIS trebuie să pună în conlucrare cadastrul imobiliar cu cadastrul edilitar. Realizarea modulelor din programul de monitorizare hidroedilitar se face în concordanţă cu datele cadastrale ale parcelelor din terenul de amplasament. Prin implementarea unor modele GIS la conductele de aducţiune, în care se corelează cadastrul hidroedilitar cu cadastrul imobiliar, se urmăreşte identificarea zonelor de teren cu probleme de acces, a zonelor de relief greu accesibile, a zonelor proprietate privată etc.

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PERFORMANCE ANALYSIS OF SUPERVISED IMAGE CLASSIFICATION TECHNIQUES FOR THE CLASSIFICATION OF SENTINEL-2 IMAGERY

BY

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Abstract. One of the most used application in remote sensing is the creation of land use and land cover maps through a process called image classification. There are various papers related to this subject, which also include the accuracy assessment of results.

This paper describes a study that was carried out to perform supervised classification, using different methods and to evaluate the accuracy of results. The study used Sentinel- 2B satellite image, taken in August 26, 2017. In order to classify the image Random Forest and Maximum Likelihood methods were used. Four different scenarios were defined for every method, depending on the bands used in the classification, from visible to infrared. The NDVI was also used in scenario no 4. In order to improve the results, the number of samples increase from 282 to 346, for all scenarios. The land use/cover classes for the study area were classified into 4 themes namely Sparse vegetation, Dense vegetation, Urban area and Bare soil.

Keywords: satellite images; Sentinel-2; land use/cover; supervised classification; maximum likelihood; random forest.

1. Introduction

In remote sensing, the concepts of land use and land cover are used alternatives, but their meaning is completely different. Land cover includes

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everything that lies above the terrestrial crust, *i.e.* vegetation, urban areas, water, bared soil etc., while land use refers to the purpose of each class in part defines equivalent categories of service from cadaster.

Land use term is used in studies of global monitoring and management of soil resources, while land cover is used in various applications such as urban expansion, management activities of extraction of natural resources, the delineation of damage caused by various natural disasters such as tornadoes, earthquakes, floods, fires, etc., protection of wildlife habitats etc.

Sentinel-2 is a multispectral mission, that provide high resolution optical imagery, which has as objectives land observation, including: vegetation, soil and water cover, inland waterways and coastal areas; land use and change detection maps, disaster relief support; climate change monitoring etc. Sentinel-2A has been launched on June 2015, while Sentinel-2B was launched on February 2017. The mission has been designed as a dependable multispectral Earth observation system that will ensure the continuity of Landsat and SPOT observations and improve the availability of data for users.

2. Study Area, Materials and Methods

The study area is located in South- South Est of Galați County (Fig. 1) and comprises the Scânteieşti commune. The study area is 90 km^2 and the elevation is between 20-180m.

In order to analyze the land cover, we used optical satellite images, taken by Sentinel-2A on 26 August 2017. The image used for this study was downloaded from Sentinels Scientific Data Hub [https://scihub.esa.int]. The preprocessing and analyzes of satellite image was made using Sentinel Application Platform (SNAP), Sentinel 2 Toolbox.

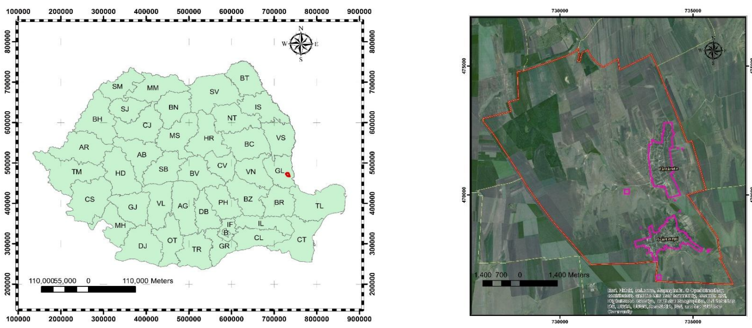


Fig. 1 – The location of study area.

The Multispectral Instrument has 13 spectral bands, from visible and near-infrared to shortwave-infrared, at different spatial resolutions (Fig. 2). The spatial resolution of Sentinel-2A images depends on spectral bands, having values from 10 meters (B2, B3, B4 and B8), 20 meters (B5, B6, B7, B8a, B11 and B12), up to 60 meters (B1, B9 and B10) (Iurist *et al.*, 2015).

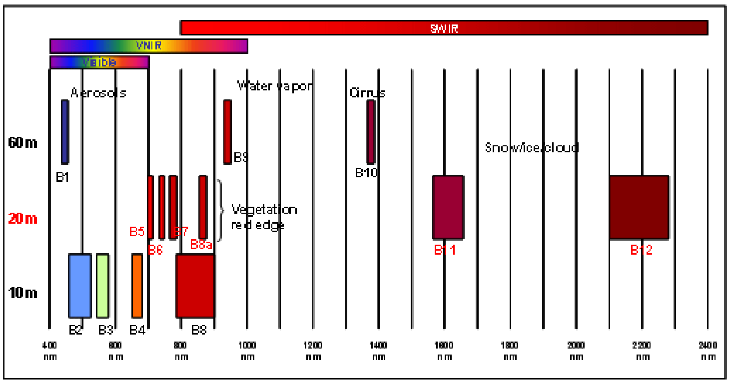


Fig. 2 Sentinel-2A Spectral Bands
Source: [http://www.cesbio.ups-tlse.fr/us/index_sentinel2.html].

The satellite image was classified using supervised classification, Random Forest method and Maximum Likelihood method.

Supervised classification method involves the intervention of the operator in the classification process. Classification is determined by the first class under the supervision of information after which the spectral classes. For each class of information is defined by the operator, representative samples of the collected spectral signatures. These are used in automated classification as reference standards, being compared to each pixel in the image. Supervised classification is a classification method based on pixel.

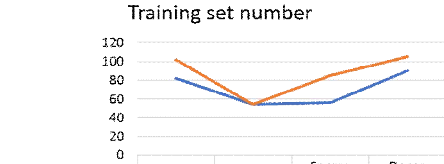
Random Forest (RF) is a classification and regression tree technique invented by Breiman**Error! Reference source not found.**. A RF randomly and iteratively samples the data and variables to generate a large group, or forest, of classification and regression trees. The classification output from RF represents the statistical mode of many decision trees achieving a more robust model than a single classification tree produced by a single model run (Lillesand *et al.*, 2008; Breiman *et al.*, 2001).

The maximum likelihood (ML) classifier is one of the most popular classification methods, in which a pixel with the maximum likelihood is classified into the corresponding class. The likelihood is defined as the posterior probability of a pixel belonging to a given class (SNAP Manual).

We defined 4 classes in order to classified the satellite images: Bare soil, Urban Area, Sparse vegetation and Dense vegetation. The Bare soil class includes bare land and soil without vegetation, Dense Vegetation represents areas covered by forest, Sparse Vegetation represents areas cover by low vegetation, while Urban class defines settlements, artificial and industry areas.

In order to achieve high classification accuracy, different cases were defined, using different bans of Sentinel-2 data. The image was classified using two methods (RF and ML). For every method we used two sets of training. First set contains 282 training, while the second set contains 346 training (Fig. 3).

Also, four scenarios were used in order to classify the images. In first scenarios we used the visible bands Blue, Green and Red (B2, B3 and B4). In second scenarios we used the visible bands and the infrared band also (B8). In third scenario we used all band with 10 and 20 m resolution, while in the las scenario we used all band from third scenario and also, the NDVI (Fig. 4).



	Bare soil	Urban area	Sparse vegetation	Dense vegetation
Training set no. 1	82	54	56	90
Training set no. 2	102	54	85	105

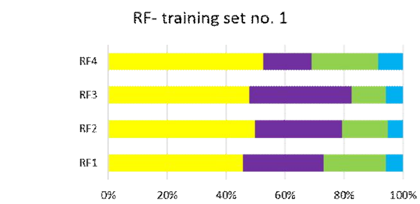
Fig. 3 – Training set number.

Scenario	No of variables	Description of variables
1	3	B2 B3 B4
2	4	B2 B3 B4 B8
3	10	B2 B3 B4 B5 B6 B7 B8 B8A B11 B12
4	11	B2 B3 B4 B5 B6 B7 B8 B8A B11 B12 NDVI

Fig. 4 – Description of scenario.

3. Results and Discussion

Analyzing the classification results we can observe that for Random Forest method, when we used training no. 1, in scenario no. 1, 2 and 3 the results for Bare soil and Dense vegetation are approximately the same (around 47% for Bare soil and 5% for Dense vegetation). The results for urban area are different for all scenario, from 16% to 35%.



	RF1	RF2	RF3	RF4
Bare soil	45.783	49.88	47.857	52.508
Urban area	27.321	29.341	34.648	16.415
Sparse vegetation	20.983	15.603	11.651	22.767
Dense vegetation	5.912	5.177	5.844	8.311

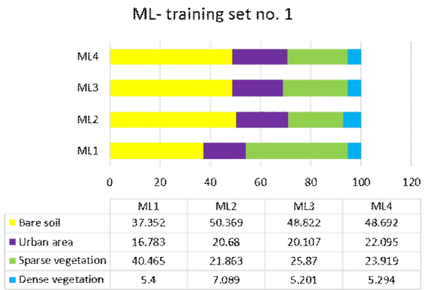
Fig. 5 – Classification results using RF method, set no. 1 of training, for all scenario.

	2RF1	2RF2	2RF3	2RF4
Bare soil	42.174	49.019	49.805	47.244
Urban area	18.633	22.246	28.155	12.958
Sparse vegetation	28.198	18.382	12.162	26.529
Dense vegetation	10.996	10.354	9.878	13.268

Fig. 6 – Classification results using RF method, set no. 2 of training, for all scenario.

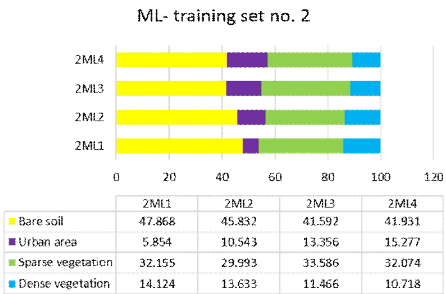
The results of RF methods for second training set are quite different for all scenario. For Bare Soil the percentage varies between 42 and 50 percent. For Urban area the results are different for all scenario and the percentage varies between 12 and 28 percent. The results are different also for sparse vegetation while for dense vegetation the results are close to each other.

The classification results when we used Maximum Likelihood method were different for the first two scenario, while for the last two the results are similar. In the first scenario the Bare Land occupied 37 % from the study area, Urban area 17%. Sparse Vegetation 40% and Dense Vegetation 5%. The resulting percentage is too high for Sparse Vegetation and this is due to the wrong classification of Bare Soil.



	ML1	ML2	ML3	ML4
Bare soil	37.352	50.369	48.822	48.692
Urban area	16.783	20.68	20.107	22.095
Sparse vegetation	40.465	21.863	25.87	23.919
Dense vegetation	5.4	7.089	5.201	5.294

Fig. 7 – Classification results using ML method, set no. 1 of training, for all scenario.

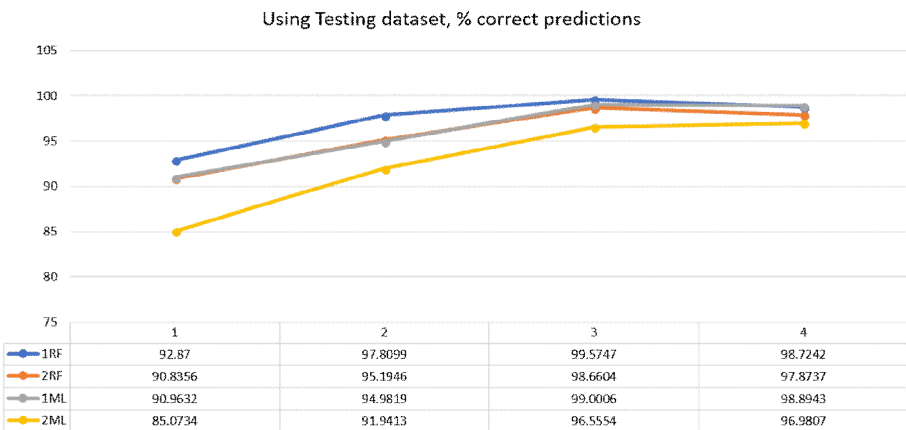


	2ML1	2ML2	2ML3	2ML4
Bare soil	47.868	45.832	41.592	41.931
Urban area	5.854	10.543	13.356	15.277
Sparse vegetation	32.155	29.993	33.586	32.074
Dense vegetation	14.124	13.633	11.466	10.718

Fig. 8 – Classification results using ML method, set no. 2 of training, for all scenario.

For the second training data set, the results of ML classification, for the first scenario are: 47% Bare soil, 5% Urban area, 32% Sparse vegetation and 14% dense vegetation. For the second scenario the result for Urban area are very different (10.5%) compared to first scenario. For the last two scenario the results, for each class, differ by 2 percent from each other.

Analyzing the correct predictions, we can observe that the best results are obtained for third scenario.



	1	2	3	4
1RF	92.87	97.8099	99.5747	98.7242
2RF	90.8356	95.1946	98.6604	97.8737
1ML	90.9632	94.9819	99.0006	98.8943
2ML	85.0734	91.9413	96.5554	96.9807

Fig. 9 – Correct prediction – using testing dataset.

4. Conclusion

The success of an image classification depends on many factors. The availability of high-quality remotely sensed imagery and ancillary data, the design of a proper classification procedure, and the analyst's skills and experiences are the most important ones.

In the present study, the classification accuracy assessment has been performed to evaluate an efficient classification method for deriving the land use land cover map of Scanteiesti commune. As can been seen from the results, the Random Forest classifier gives better results for the scenario no. 3.

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EVALUAREA PRECIZIEI CLASIFICĂRII IMAGINILOR OPTICE SENTINEL-2

(Rezumat)

Crearea hărților tematice ce reprezintă modul de utilizare şi acoperire al terenurilor este una dintre cele mai utilizate aplicații în teledetecție. Există numeroase lucrări de specialitate privind acest subiect, ce includ şi evaluarea preciziei clasificării.

În această lucrare este prezentat un studiu în care s-a efectuat clasificarea supervizată a unei imagini satelitare, folosind metode şi scenarii diferite, şi evaluarea preciziei rezultatelor. În cadrul studiului s-a utilizat o imagine optică Sentinel-2B, preluată în data de 26 August 2017. Ca metode de clasificare am folosit algoritmul Arborilor de decizie și algoritmul probabilității maxime. S-au definit patru scenarii, pentru fiecare metodă folosită, pe baza benzilor spectrale utilizate în cadrul clasificării, de la vizibil la infraroșu. În scenariul numărul 4 s-a utilizat de asemenea și Indicele Normalizat al Vegetației. Pentru a îmbunătăți rezultatele, s-au folosit inițial 282 eşantioane şi mai apoi numărul acestora a crescut la 346. În vederea determinării modului de utilizare/acoperire al terenului s-au definit 4 clase: vegetație rară, vegetație densă, zonă urbană și teren fără vegetație.

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THEORETICAL BASIS AND GIS BLENDING IN FLOOD MODELING

BY

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Abstract. The classical methods which are used for determining the morphometric and morphographic characteristics of an Hydrographic Basin and the characteristics of the flood-generating of the maximum rainfall, are methods that perform the calculation of maximum flows produced by floods.

The slope flood modelling process begins to be automated with the use of GIS.

The manipulation of the database created through geoinformation software and its analysis provides numerical information of the characteristics (layer of curveslevel, hydrographic layer, soils and utilities layer), which are shaped as inputs into formulas (rational, reductive and more chosen in modeling the rain-drain process) to calculate the maximum flows.

The automation process is mainly based on the complexity of data that can be managed and analyzed by GIS.

The modeling through implementing GIS is presented in a case study.

The main purpose of flood modeling by GIS methods is to warn or notify about hydrological issues for better water resource management of hydrotechnical systems, warning humans of the region and take precautionary measures to prevent damage caused by catastrophic floods.

Keywords: floods; average; flows; GIS; surface; hydrographic.

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1. Introduction

Geographic information systems have been designed to create large surface models, states and administrative entities, being used to map and store spatial informations. The easyway of use and manipulating spatial data and the very good results recorded by the modeling, have made a great interest for the introduction of GIS methods into engineering. The main purpose of the implementation of GIS. In these structures, it is to develop environments with GIS in order to be able to provide solutions to determine the frequency of occurrence of an extreme event and appropriate location of hydrotechnical systems.

The modeling of floods implies, besides the theoretical design and structuring of the model, tools and environments suitable for its realization.

Geoinformation programs offer the possibility of manipulating hydrological data and defining own models or choosing existing models through spatial analysis functions and equations. Spatial analysis functions are embodied in routines that, through equations and analysis, highlight the spatial manifestation of a constituent element of the hydrological model.

In the flood modeling process, the functions provided by ArcInfo and ArcGIS, specific functions for simulating flood paths and delineating water droplets(in balanced) are used: Topogrid, Flowdirection, Flowaccumulation, Stream definition, Streamorder, Flow Path Tracing, Watershed delineation .

The modeling of hydrological systems components is of great importance in the study of floods, being a permanent concern of scientific research with a high applicability in integrated water resource management.

Hydrological models are simplified representations of the complexity of the phenomena that occur within the receiving basin, based on the impulse function combined with the principle of linearity of the hydrological systems. In the context of current climate change, the study of floods is one of the most topical issues for which many hydrological models have been developed, Singh (1995), whose main purpose is to prevent the catastrophic effects generated by them. In order to choose the most appropriate flood analysis model, it is necessary to have access to geographic information that can provide a global view of the components of the drainage system.

2. Implementation of GIS for Superior Hydrological Basin Somesul Mic

Someşul Mic runs its hydrographic basin in the north-western part of the country, extending over the territory of Cluj County, most of the basin and Bihor County, in the upper sector. The hydrographical basin is carried out with the whole surface in the administration of the Someş-Tisa basin branch on the territory managed by the water management system of Cluj, being part of the N of the Somes River Basin in the NE and E part of the Somesul Mare

Hydropower Basin, in the S and SV part of the Mureş Hydrographic Basin, and in the NV part of the Crişuri Hydrographic Basin (Fig. 1), Bilaşco (2008).

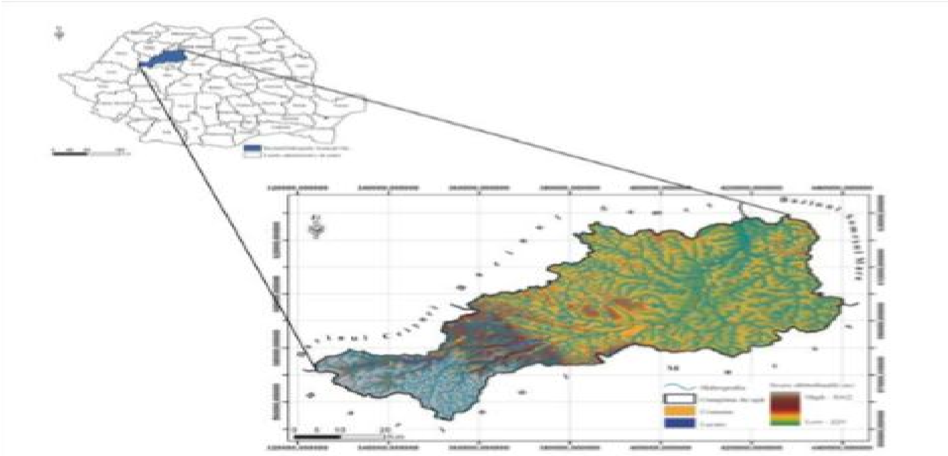

Fig.1 – The location of the Someşul Mic hydrographic basin.

In order to achieve the calculations and to highlight the possibilities offered by the informational geographic systems, only the Lower Hydrological Basin Someşul Mic has been chosen as a study territory (Fig. 2).

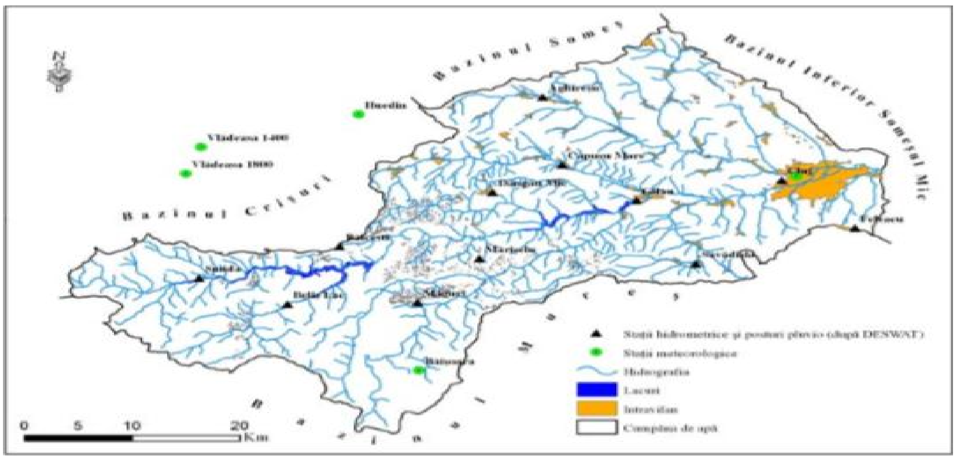

Fig. 2 – Hydrographic Network Someşul Mic.

Making complex, computational, flood identification and forecasting models requires the prioritization of a specific spatial and numeric database.

The data base for GIS hydrological models for maximum flow calculation can be structured into three major parts: the primary database (curveslevel, lakes, hydrographic network, vector information on soils, vegetation, use of (derived from spatial analysis of the primary database, leakage path, accumulation of leakage, hydrographic network extraction) and the modeling database (materialized in sets of vectors and growths resulting from the finalization and realization of the flood identification based on the calculated maximum flow).

2.1. Making the Digital Elevation Model

The most common method to achieve the correct hydrological DEM is the topogrid function and its subordinates. The minimum required data for the topogrid are: the curves level and the hydrographic network that must be in accordance with the topogrid function requirements, downward arcs, springs connected to the nodes to create networks (Fig. 3).

Fig. 3 – DEM Someş.

2.2. Database

Derivative database structures derived from DEM exploitation are raster structures that highlight the main hydraulic and motion characteristics of water on the slopes, but also the geometric and morphometric characteristics of river basins, which are absolutely necessary in the process of identifying, extracting and manipulating spatial data inputs into equation structures and GIS models, designed for the study and calculation of maximum flows from flood recordings.

The methodology of calculating the maximum flow in small river basins implies, in addition to quantifying and analyzing the morphometric characteristics of river basin territories, quantifying and analyzing physico-geographic features as a support for the occurrence and propagation of the maximum leakage. Physical-geographic features that have a high impact on leakage and can not be excluded from the general equation for calculating peak flow rates in small river basins are: vegetation (Fig. 4) as types and extent of expansion in the basin, and soils.

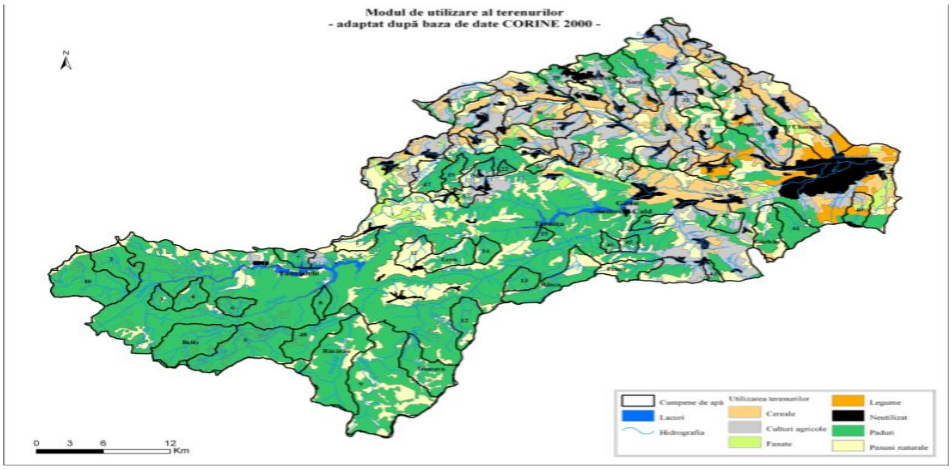

Fig. 4 – Land use.

The geoinformation software provides the user a very simple way to calculate the slope slope (Fig. 5). Through the slope submenu of grid spatial analysis extensions, we calculated the gradient in degrees and percentages using a grid, the digital elevation model, as a computational database.

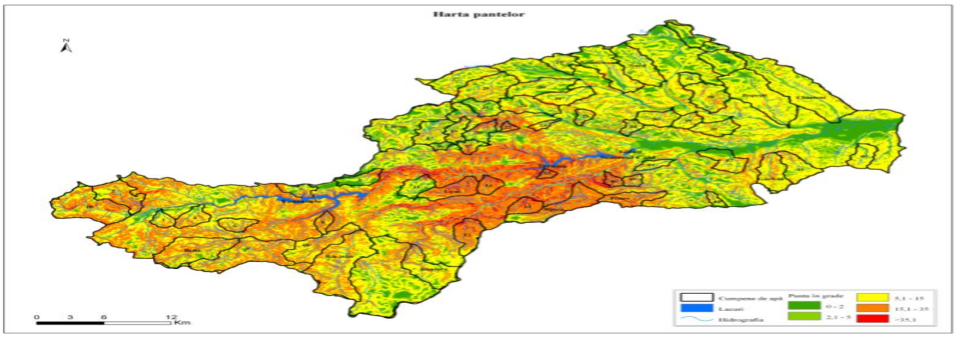

Fig. 5 – Sloping maps.

3. Implementation of Geographic Information Systems in the Calculation of Maximum Flows

Maximum flows are often associated with a series of floods and large water phenomena with catastrophic effects, so it is necessary to highlight the differences between these three categories.

By high water is meant the phases in the life of a river where the leak is high, which usually occurs as a result of slow snow melting or rainfall of low and long duration. Increasing river flows and keeping them at elevated levels for a long time, with no significant increases in peak flow rates, characterizes a high water regime phase.

Floods differ from large waters through a three-dimensional leakage concentration: a rapid increase in water flow, high peak flow rates, and a rapid drop in water flows. The difference between large waters and floods is not made in terms of recording flows, it is done in terms of the growth and decrease time of the hydrograph.

In order to achieve maximum flow calculations, a breakdown should be made according to their origin according to the three major categories: maximum flows from torrential rains, maximum flows from snow melting and maximum flows from combined torrential rains and snow melting.

From studies conducted so far, it has emerged that the most dangerous maximum flows are those resulting from torrential rains, irrespective of the surface of the catchment area covered by that rainfall.

4. Modulation of the Rain-Drain Process

The Mike 11 by DHI, the NAM module (Nedb0r-Afstr0mning Models / Model Rain-Drain) is a conceptual model that reproduces the terrestrial phase of the hydrological cycle. Simulated surface leakage, intermediate runoff and baseline drainage from a hydrographic basin as a function of the amount of water stored in four reservoirs of the river basin between which there is a connection. The four tanks are the snow tank, the surface water storage reservoir, the water storage reservoir in the unsaturated aquifer and the water storage reservoir in the saturated aquifer.

The Mike 11-NAM model (Fig. 6) can also influence the use of water in river basins for uses such as irrigation and water use from the aquifer through pumping to provide utilities such as drinking water or industrial water.

Hydrological circuit parameters such as temporary variation of evaporation, soil moisture, aquifer recharge, and water level evolution in the aquifer can also be used as model input data.

As a result of the simulation, the evolution of hydrological cycle parameters such as slope leakage, intermediate runoff or basic leakage can be obtained.

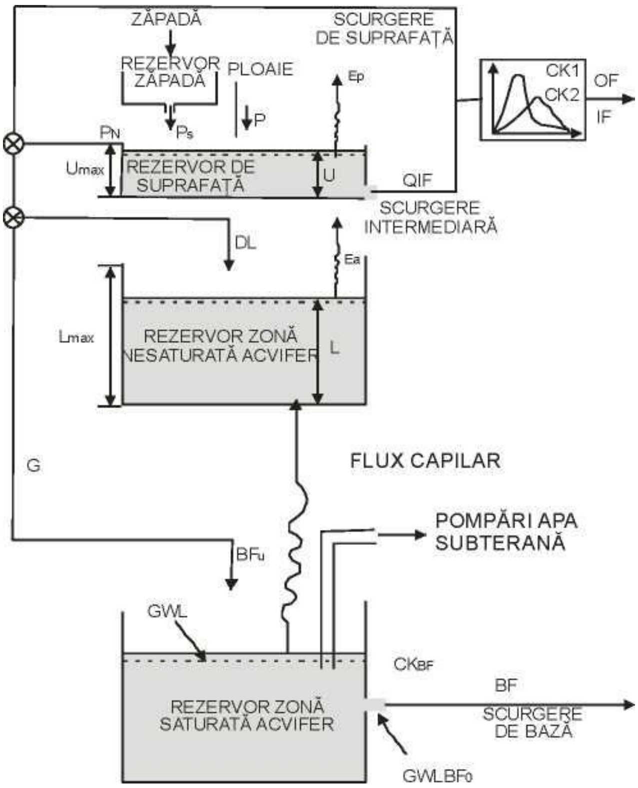

Fig. 6 – Schematic of Mike 11-NAM
(Nedbor-Afstromning Patterns/Rain-Pattern Models).

5. Conclusions

Once the current issue of natural disasters has been defined, it is necessary to identify methods that allow simultaneously:

a) increasing forecasts of the place, timing and characteristics of natural phenomena that can become disaster;

b) realization of scenarios on strategies to be adopted at the time of the disaster ("real-time action");

c) the adoption of strategies applicable after the disaster to reduce damage and return to normal.

All these are achievable with informational geographic systems, G.I.S. and Mike 11.

Hydrological models are the ones that interconnect with the studied area, helping the software programs that serve to understand and solve the existing phenomena such as the flood or the need of designing new hydro technical works, using the simulations made on a basin.

The use of GIS software and software helps you calculate the maximum flow rate faster.

Geographic information systems allow the manipulation and analysis of several components of hydrological models stored in the form of layers with spatially defined spatial attributes, using increasingly diverse time resources and databases.

Today there are many performance GIS platforms that have become dynamic and offer the possibility of modeling hydrological processes much closer to reality.

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BAZĂ TEORETICĂ ŞI GIS ÎN MODELAREA INUNDAȚIILOR

(Rezumat)

Metodele clasice utilizate pentru determinarea caracteristicilor morfometrice şi morfografice ale unui bazin hidrografic şi caracteristicile generatoare de inundații ale precipitațiilor maxime, sunt metode care efectuează calculul debitelor maxime produse de inundații. Procesul de modelare a inundațiilor de pantă începe să fie automatizat cu utilizarea GIS. Manipularea bazei de date creată prin software-ul de geoinformare şi analiza acesteia oferă informații numerice cu privire la caracteristicile (stratul curbe, stratul hidrografic, stratul solurilor şi utilităților), care sunt sub formă de intrări în formule (raționale, reductive şi mai alese în modelarea ploii – procesul de scurgere) pentru calcularea debitelor maxime. Procesul de automatizare se bazează în principal pe complexitatea datelor care pot fi gestionate şi analizate de GIS. Modelarea prin implementarea GIS este prezentată într-un studiu de caz. Principalul scop al modelării inundațiilor prin metode GIS este avertizarea sau notificarea cu privire la problemele hidrologice pentru o mai bună gestionare a resurselor de apă a sistemelor hidrotehnice, avertizarea oamenilor din regiune şi luarea unor măsuri de precauție pentru prevenirea pagubelor cauzate de inundațiile catastrofale.

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HYDRAULIC STUDY ELEMENTS FOR WATER LOSS IN PIPE NETWORKS

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Abstract. The paper approaches analysis elements regarding the hydraulic development of pipes water loss. The magnitude of the “water loss” phenomenon is a present problem in the management of water supply systems, due to its impact on the economic, social and environmental aspects. Water emissions from pipes show through longitudinal or circumferential fissures and cracks. The “water loss” phenomenon is recorded in pipe walls, but it can also be highlighted through emissions around the pipe joints and fittings. The flow parameters considered in the hydraulic analysis of the phenomenon depend on the characteristics of the pipe embedding environment, the fluid, and the leakage area. The paper presents a series of aspects regarding the hydraulic quantification of the physical phenomenon of water losses.

Keywords: damage; equation; hydraulic model; leaks; parameters.

1. Introduction

One of the most complex problems faced by current water supply systems is the "water loss" phenomenon. The issue is encountered both nationally and globally. Economically developed countries (England, Australia,

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USA) and those affected by severe water crises (South Africa, Brazil) are using complex schemes to limit water losses. Among the solutions addressed are the use of modern loss detection technologies, rigorous legislative regulations, strategies to discourage water waste etc. In Romania, the lack of a national strategy for the conservation of water resources has raised the value of water losses to 11.65 m^3/year, (Racovițeanu *et al*., 2015).

The water loss phenomenon can be analysed by assessing the technical component – not all the water supplied by the operator reaches the consumers and the economic one – the water used by consumers is not properly metered or billed 100% (Goodwin, 2013). Given the extensive implications of water loss, it is necessary to study how this complex phenomenon occurs and evolves.

2. Research Material and Methods

The material used in the research aims to highlight and analyse the "water loss" phenomenon in pipe networks. The main components of the research material are:

a) holes, nozzles, flow areas design equation;

b) field studies and research on the "water loss" phenomenon; they are based on the analysis of degradation phenomena identified and repaired on site, accidental damage from operational activity etc.;

c) experimental studies and research in the laboratory; in this case the analysis uses a series of simplifying assumptions, and the results vary depending on the study model, type of research facility, measuring equipment;

d) numerical studies and research, mathematical analysis, specialised computational programs and hydraulic simulation of site phenomena etc.

The research methodology requires the use of existing hydraulic equations and their integration into hydraulic - mathematical models that reflect real situations in the field. These equations are the basis of experimental research, validating the results obtained for different fields of study.

The water loss phenomenon is identified through pores, micro-fissures, fissures, holes, cracks and slits that occur in the pipe wall, fittings or valves. The size of the degradation resulted can range from microscopic sizes to directly visible defects. The water flow in pipe networks is defined by a series of factors dependent on the characteristics of water supply system components where this phenomenon is present (Luca *et al*., 2017):

i) water emission areas are defined by: flow area length, area, equivalent diameter and wall thickness of the pipe;

ii) hydraulically, the losses are characterised by: flow regime, flow rate, flow speed and contraction coefficients, service pressure, longitudinal / transversal velocity etc.;

iii) the emitted fluid is defined by: temperature, viscosity, superficial tension, density, etc.

Physical or numerical models built in the laboratory use parameters adapted to the nature of the problem investigated. The viability of the results obtained is directly dependent on the researchers' ability to replicate the physico-mechanical characteristics encountered on site.

3. Results and Discussions on Hydraulic Computational Elements of Water Losses in Pipes

3.1. Analysis Data

The analysis and interpretation models of the "water loss" phenomenon are based on the equation of flow through the orifices. This describes the water flow delivered from a circular hole (Bartha *et al*., 2004):

$$Q = \mu A\sqrt{2gH}, \tag{1}$$

where: Q is the flow emitted through an orifice with A area, μ – flow coefficient, g – gravitational acceleration, and H – the head available for the orifice.

$$\mu = \varepsilon\varphi, \ (2) \qquad \varepsilon = A_c/A, \ (3) \qquad \varphi = 1\big/\sqrt{1+\zeta}, \tag{4}$$

where: ε – contraction coefficient is the ratio between the contracted section A_c and the orifice section A; φ – velocity coefficient and ζ – resistance coefficient.

The hydraulico-mathematical orifice type model can be assimilated with a nozzle flow model when the condition L_{aj} = (3-5)d is achieved. Considering how the degradations on the steel, galvanised steel and cast iron pipes (small holes in thick walls) are formed, the orifice type model can be applied in the analysis. For other materials such as plastics, concrete or cast iron, the research considers the nozzle flow pattern.

The equations developed from studies and research must be adapted to the flow section, embedding environment, flow characteristics, and boundary conditions.

Models analysing water losses under hydraulic and mathematical aspects are using simplifying assumptions based on principles of assimilation of emission areas to circular orifices, groups of orifices, nozzles and slots (Fig. 1).

Pipe emission areas are assimilated to flow dispensers laid on pressurised pipes, with parameters defined by the function (Luca *et al*., 2017):

$$F\,(d, l, \alpha, \rho, \eta, \sigma, g, H, Q) = 0, \tag{5}$$

where the geometric parameters are: d – equivalent diameter, l – characteristic length, α – angle; the physical parameters of the emitted fluid are: ρ – density, η – dynamic viscosity, σ – surface tension, and flow parameters are: H – flow head, Q – distributor flow rate and g – gravitational acceleration.

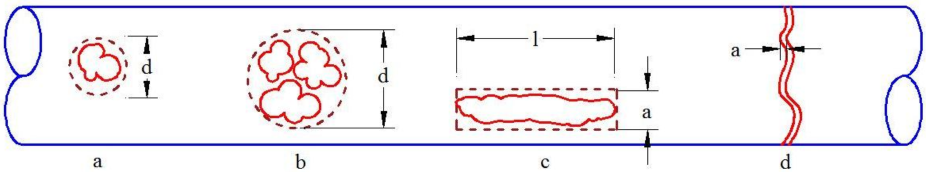

Fig. 1 – Hydraulic flow models through the walls of pipes under pressure;
a – orifice; b – group of orifices; c – slot; d – perimeter slot (Chirica, 2017).

Hydraulic coefficients are dependent on Reynolds number, given the turbulent flow range and high velocity flows. When the water emission occurs only in turbulent regime, the flow and velocity characteristics can be expressed according to the hydraulic and geometric parameters of the distributor (Luca *et al.*, 2017):

$$v = K_v \sqrt{H}, \quad (6) \qquad Q = K_Q \sqrt{H}, \quad (7)$$

where: K_v and K_Q constants depend on the hydraulic and geometric characteristics of the distributor considered in the model. The constants values are determined experimentally, taking into account the characteristics of the surrounding environment and the Reynolds range, for each type of distributor considered.

3.2. Orifice Equation Transformation

The orifice equation has been modified to describe in a simplified manner the hydraulic evolution of water losses in pipes (GIZ, 2011):

$$q = ch^{\alpha}, \quad (8)$$

where q is the water flow emitted, c - the flow coefficient, h - the head at the emission point and α – the leakage exponent.

Field research has shown that the value of the leakage exponent α varies between 0.50 and 2.79 with an average of 1.00 (Farley & Trow, 2003; Thornton & Lambert, 2005). The value of the exponent depends on the size and shape of the emission area (cracks, orifices, slits), the geotechnical conditions on site, the pipe construction material and the flow regime (laminar, laminar-turbulent transition, turbulent). Lambert and Hirner's research have shown that in the case of large water supply systems, between pressure and water loss on pipe a linear relationship can be considered. In this case, the leakage exponent α is considered 1.0 (Lambert & Hirner, 2000).

Extensive studies and researches have been conducted to determine leakage exponent α, under various conditions. Its value may vary between 0.4 and 2.3 depending on the pipe material (Table 1). The data analysis shows that the circumferential cracks introduce a value for α below 1. Its value is the smallest of all analysed forms of failure. The largest difference of variation is recorded for the corrosion of steel pipes, where values are between 0.7 and 2.3.

Table 1
The Leakage Exponent for Different Pipe Failure Modes (Friedl et al., quoted by Fuchs-Hanusch et al., 2014)

Failure / Material	Circumferential fissures	Longitudinal fissures	Corrosion	Degraded joints
Polyethylene	0.5	1.4 – 2.0	–	–
PVC	0.4 – 0.5	1.4 – 2.0	–	–
Asbestos	0.5	0.8 – 1.0	–	0.61 – 1.26
Concrete	–	–	1.5	0.61 – 1.26
Cast iron	0.5 – 0.68	0.5 – 0.85	1.5	0.61 – 1.26
Ductile cast iron	–	–	1.5	0.61 – 1.26
Steel	–	–	0.7 – 2.3	0.61 – 1.26

Starting from the orifice equation, May (1994) establishes the FAVAD concept (model with fixed and variable discharge areas). The formulated equation considers the openings formed by corrosion to be constant surfaces, and the fissures and cracks in the pipe walls are defined as variable surfaces. The classification is based on the impact of the system pressure variation on the size of the defects. For eq. 9, an exponent of 0.5 is considered for fixed flow areas, and 1.5 for the variable ones:

$$Q = k_1 h^{0.5} + k_2 h^{1.5}. \tag{9}$$

In this case, the flow rate is the sum of the flows lost through the fixed and variable flow areas on the degraded surface of the pipe, evaluated by considering the k_1 and k_2 flow coefficients corresponding to the flow characteristics.

4. Conclusions

1. Water losses have a major impact on the management of water supply systems, a situation which requires their study and approach under hydraulic aspects.

2. Pipe degradations can be integrated into hydraulic computational models by assimilating them with well-defined structures in the specialised literature, such as orifices, slots or nozzles.

3. Most hydraulic models developed to study the "water loss" phenomenon are based on the orifice equation, which is processed to reflect specific work scenarios.

4. The hydraulic and mathematical analysis of water losses draws attention to the pressure parameter impact in the assessment and quantification of the phenomena that lead to the occurrence of water emissions in pipes.

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ELEMENTE DE STUDIU HIDRAULIC A PIERDERILOR DE APĂ DIN REŢELELE DE CONDUCTE

(Rezumat)

Lucrarea abordează elemente de analiză privind manifestarea sub aspect hidraulic a pierderilor de apă din conducte. Amplitudinea fenomenului „pierderi de apă" este o problemă de actualitate în managementul sistemelor de alimentare cu apă, prin impactul asupra factorilor economici, sociali şi de mediu. Emisiile de apă din conducte se manifestă prin fisuri longitudinale şi circumferenţiale, prin pori şi orificii. Fenomenul „pierderi de apă" se înregistrează la nivelul pereţilor conductei sau poate fi evidenţiat prin emisii în zona îmbinărilor şi fitingurilor. Parametrii curgerii consideraţi în analiza hidraulică a fenomenului depind de caracteristicile mediului de înglobare, ale fluidului, şi ale zonei de emisie. Lucrarea prezintă o serie de aspecte referitoare la cuantificarea hidraulică a fenomenului fizic al pierderilor de apă.

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A NEW GIS-BASED METHOD FOR INDIVIDUAL TREE ELINEATION FROM A LIDAR DERIVED CANOPY HEIGHT MODEL

BY

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Abstract. In this study, the overall goal was to develop a simplified method for individual tree crown delineation using GIS in a coniferous forest in northeast Romania. The study provides new aspects regarding the choice of method when performing single tree detection in conifer forest type as an alternative to costly field inventories. The study also aims to serve as an acceptable substitute for tree crown delineation that can only be done by algorithms offered by expensive proprietary object-based image processing software. Using the CHM's curvature through its slope, LiDAR makes it possible to delineate individual tree crown. Using the local maxima as input, Thiessen polygons creates a unique and nonoverlapping polygons on the nearest point and serve as buffers for the canopy extent. The proposed algorithm was able to delineate crown polygons by intersecting aggregated points from a negative profile curvature raster with Thiessen polygons.

Keywords: LiDAR; individual treede lineation; canopy height model (CHM); Thiessen polygons; crown delineation.

1. Introduction

LiDAR (Light Detection and Ranging) is a technology that presents the ability to collect hight density 3D point cloud data within densely vegetated

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study areas. LiDAR data can be classified to simplify forest inventory and stand management through the creation of more detailed stand maps or individual tree identification. Canopy Height Model (CHM) or a Normalized Digital Surface Model (nDSM) represents absolute canopy height above the ground and it is calculated by interpolation the first return of the LiDAR points and determining their height above a digital terrain model. To extract the biometric parameters (*e.g.* tree height measurements, crown delineation) and the correct location of single trees in the CHM is fundamental. There were many successful attempts to estimate AGB using LiDAR data but the the main challenges faced in treetop detection and the inability to use points from trees existing under primary canopy.

2. Materials and Methods

Study Area

The study site (47°39'51.5"N 25°38'06.3"E) is located in northeast Romania (Frumosu, Suceava). The size of the study area is about 1 km^2 and mainly covered by coniferous plantation forests and grasslands, all within an elevation range of 800,...,1,130 m above sea level. The forest predominantly consists of Norway spruce (Piceaabies) and European silver fir (Abies alba) plus a few European beech (Fagus Sylvatica). All 23 plots are located in stand 94F, Management Unit III Vama Suceava. The stand it is described by the forest management as a 110 years old with a medium canopy cover.

Field Inventory

The ground truth data was collected in September 2017 in one stand (94F) and three forest vegetation types were covered by the field sampling (Norway spruce, European silver fir and European beech). Twenty-three sampling plots were defined in a systematic way and each plot are used to collect data on trees with a diameter breast height (dbh, diameter measured at 1.37 m above the ground) and tree species determination. The measurement of the tree crown and precise location of each tree was not done to conform with the purpose of the field inventory which is to calibrate LiDAR metrics to estimate the Canopy Cover. Stratified random sampling determined the position of the circular plots (r = 12.6 m) using an aerial ortophotograph. Center of plots were determined using 60-second static measurements with a 12-channel GPS receiver. The coordinates were collected in geographic coordinates (lon/lat) and later transferred in GIS format and reprojected in the WGS84/UTM zone 35N coordinate system.

LiDAR Collection and Processing

The LiDAR data used for this study were collected in the autumn of 2012, using a Riegl LMS-Q560 laser scanner instrument and processed using LP360 and ESRI ArcGis 10.4 software to extract canopy height models. LiDAR data covered the whole area of interest with the point density of 4 points per square meter (pts/m^2), the scanner had a flight altitude of 750.0 m and a scanning angle of 60º. The projection of the LiDAR data acquired during the flight was the WGS84/UTM zone 35N. To calculate the effective height of the trees in the scene, ground and vegetation returns were separated using modules of LA Stools in ArcGIS 10.4.

There is a time difference between the collected data by LiDAR acquisition in September 2012 and the field measurements in September 2017 but our study area consists of mature coniferous forest and is characterized by relatively low temperatures during most of the year, which results in a relatively low tree growth rate.

Preprocessing of Lidar Data

The raw LiDAR data were provided by the Primul Meridian company as a point cloud classified into three classes: ground, water and unclassified but the additional classes were defined by applying automated algorithms in ArcGis 10.4. The range of heights was chosen based on the lowest (5 m) and highest (46 m) trees measured in the field. The points lower than 5 m remained unclassified and potentially represented points reflected from very small vegetation. Many algorithms have been developed for distinguishing between ground reflections and above-ground points, but a number of these algorithms fail in forested areas with steep terrain or require excessive computation time.Table 1 show the the descriptive statistics for tree height.

Table 1

Computed Descriptive Statistics for Tree Height (m) Values

Parameters	Value
Number of trees	408
Hmax	47.64
Hmean	30.93
Hmin	13.99
Hmedian	31.9
Hvar	29.66
Hsd	5.45
Hcv	17.61
Hkurtosis	3.29
Hskewness	–0.7

A digital terrain model (DTM) can be constructed from the ground points, and a digital surface model (DSM) can be derived from the highest points within a defined grid box. The canopy height model (CHM) can be calculated by subtracting the DTM from the DSM. Khosravipouret al. introduced a novel pit-free algorithm that can construct pit-free CHMs directly from lidar data using modules of LAStools and can be adapted to work with different lidar point densities and demonstrates a statistically significant improvement in the accuracy of tree detection (Fig. 1).

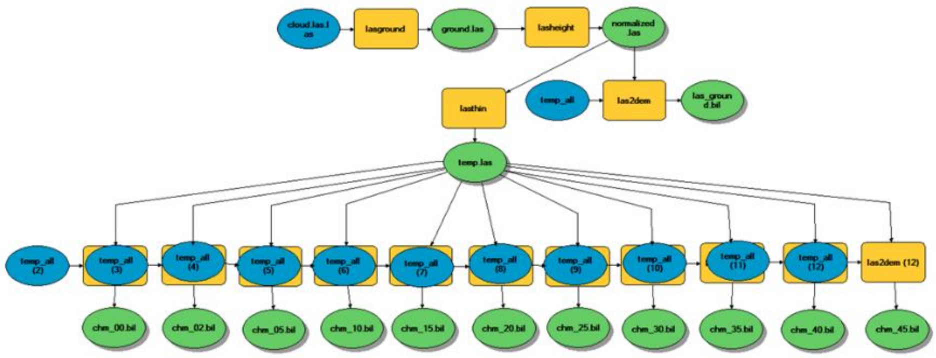

Fig. 1 – Model Builder for CHM.

Individual tree crown delineation based on curvature

R.J.L. Argamosa *et al*. (2016) used a method that implies the extraction of maximum values from the CHM by taking the maximum raster value in a 3 m × 3 m cell (Fig. 2). Thiessen polygons were generated to serve as buffers for the canopy extent and negative profile curvature is measured from the slope of the CHM. The generation of local maxima to determine individual trees is the first step after the second step computes for the curvature points while the last part converts the points to polygons and smooth the edges. Fig. 3 present the workflow of crown delineation algorithm.

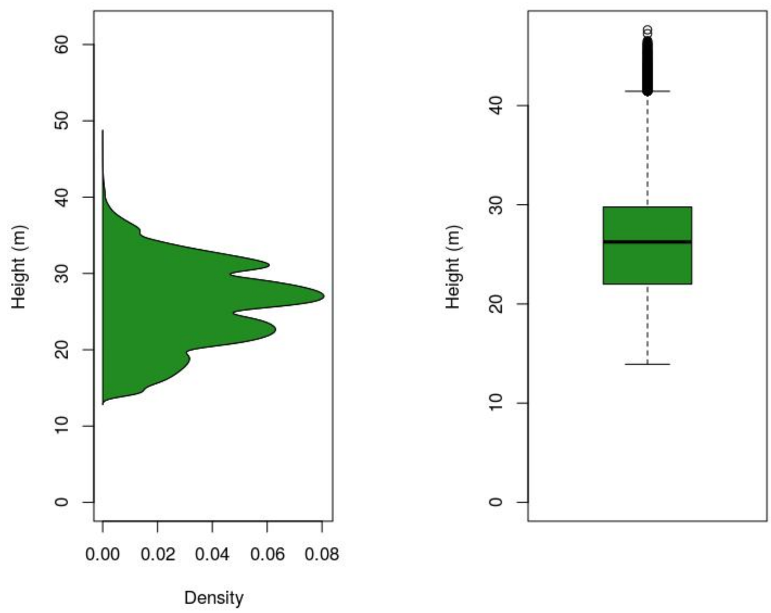

Fig. 2 – CHM profile.

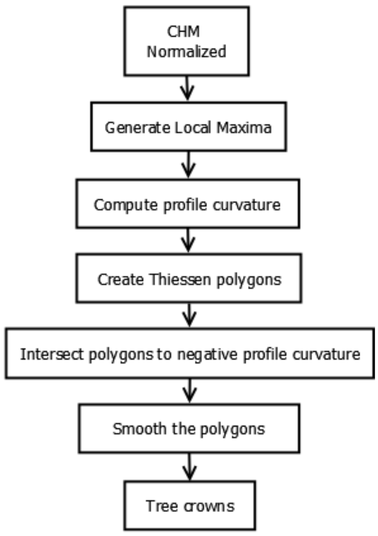

Fig. 3 – Individual tree crown delineation workflow.

The local maxima raster was obtained using the next formula and converted to points.

$$LM = Con\ (CHM = FS, CHM) \tag{1}$$

where: Con – conditional function; CHM – Input CHM; FS – maximum values in a 3 m × 3 m cell; LM – local maxima.

In the second part, the slope was generated (Fig. 4) using an algorithm in ArcGIS 10.4 and converted into degrees by getting the product of the arc tan of the slope and the result of 180 over Pi.

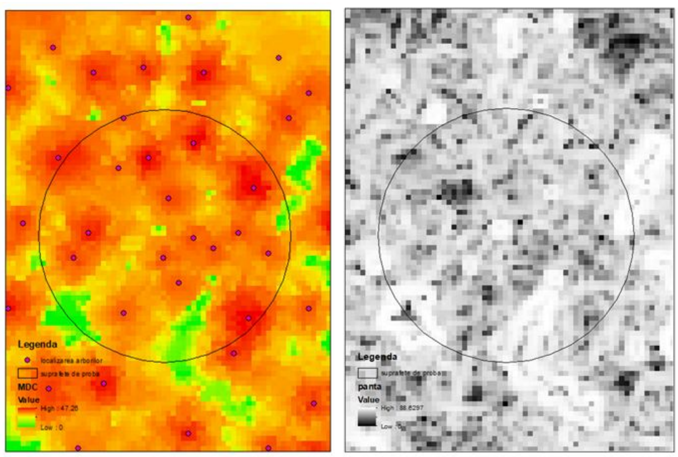

Fig. 4 – CHM overlaid with the local maxima (left) and the local maxima to points overlaid the generated slope raster (right).

The generated slope was used to compute the curvature by getting the curve parallel to the maximum slope. The negative profile was used and converted into points. Thiessen polygon contains only a single point input feature and any location within a Thiessen polygon is closer to its associated point than to any other point input feature.This tool in ArcGIS 10.4 is used to divide the area covered by the input point features into Thiessen or proximal zones. In the last step, the Thiessen polygon was intersected to the negative profile curvature (Fig. 5). The points that intersected a common polygon will be aggregated to create a polygon representing the crown and in the final step create, in ArcGIS 10.4, a new shape file with properly segmented crowns.

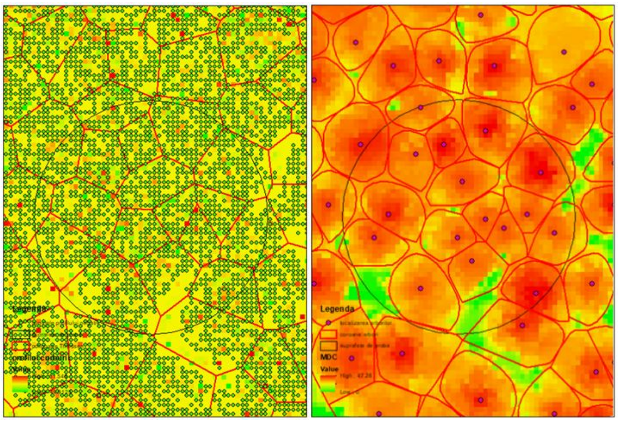

Fig. 5 – Negative profile curvature converted to points and Thiessen polygons (left) and the final output overlaid in the CHM (right).

3. Conclusions

This paper presents an automated processing chain for individual tree segmentation with LiDAR point cloud. Canopy height serves as basic data for the extraction of forest parameters using LiDAR. The delineation was able to represent individual tree crowns accurately. Results show the proposed approach is a promising solution for large-area forest mapping at individual tree level.

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UTILIZAREA TEHNOLOGIEI GIS ÎN DELIMITAREA ARBORILOR INDIVIDUALI UTILIZÂND UN MODEL DIGITAL AL CORONAMENTULUI DERIVAT DIN DATE LiDAR

(Rezumat)

În acest studiu, obiectivul general a fost de a dezvolta o metodă simplificată de delimitare a coroanei individuale folosind GIS într-o pădure de conifere din nord-estul României. Studiul oferă noi aspecte privind alegerea metodei atunci când se efectuează o detecție individuală a arborilor în pădurile de conifere, ca o alternativă la inventarele de teren costisitoare. De asemenea, studiul își propune să servească drept un substitut acceptabil pentru delimitarea coroanei arborilor, care poate fi făcută numai prin algoritmi oferiți de software-ul de procesare a imaginilor, acesta fiind costisitor. Folosind curbura MDC-ului prin panta obținută, LiDAR face posibilă delimitarea coroanei individuale a arborelui. Folosind maximele locale ca date de intrare, poligoanele Thiessen creează un poligon unic și neperfectat la cel mai apropiat punct ce servesc ca limite pentru dimensiunea coroanei. Algoritmul propus a fost capabil să delimiteze poligoanele coroanei prin intersectarea punctelor agregate dintr-un raster negativ al curburii a profilului cu poligoane Thiessen.

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THE AUTOMATIC EXTRACTION OF WATERSHED OF THE HYDROLOGICAL BASINS USING DEM DATA

BY

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Abstract. The evolution and the abundacy of spatial data, of the geographic information systems (GIS) and the models for hydrological aplications offer a lot of opportunities for new aplications, but also present a series of challenges for those who study water resources. This paper allows the extend of knowledge in data space analysis and in the shaping of hydrological basins. This paper offers a integrated overview over the multiple facets of challenges given by the GIS data and a source of basic reference for the selection and the application of GIS in shaping the water runoff of the hydrological basins. A very high importance is given on the spatial data and on the issues there are common for a lot of applications for GIS-Modelling.

This paper presents the application of spatial data in ArcGIS program for the automatic extraction of watersheds of the hydrological basins using the digital elevation model. Using the watershed, the water runoff of the hydrological basins and sub-basins can be easily studied.

Keywords: spatial data; analysis; runoff; GIS; surface; hydrological.

1. Introduction

Geographic Information System (GIS) has become and important tool in the hydrology field and in Earth's water resources managing and studying. Climate change and water resources demands a more knowledgeable disposition of arguably one of our most vital resources.

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GIS has become practical, increasingly dynamic, norrowing the gap between historical data and current hydrologic reality.

A watershed is a upslope area that drains waters to common outlet as concentrated drainage. It also means the line that separates neighbouring drainage basins. On rugged land may be in the form of single range of hills wich is known as a dividing range (Djokic *et al*., 1997).

The watersheds can pe extracted form a DEM by computing the flow direction, flow accumulation and snap pour points and using these in the watershed tool. In the end will result a raster of the watersheds.

These elevation models (DEM) are extracted from the SRTM data and are used in geographic information systems. They can be downloaded freely form the Internet and their file format is widely suported.

2. Data and Methods

2.1. Study Area

The altitudinal numerical model (DEM - SRTM) used in this paper represents a random area (Fig. 1), but this operation can be done using areas all around the Earth.

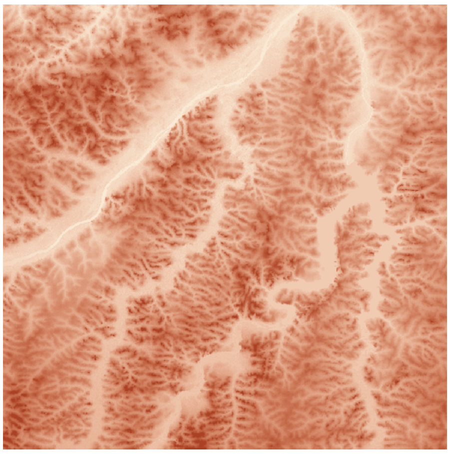

Fig. 1 – Study area.

2.2. Data and Methods

In this paper was used an altitudinal numerical model (DEM - SRTM), that could by downloaded from a platform created by USGS (U.S. Geological Survey). The Shuttle Radar Topography Mission (SRTM) represent an international research that obtain digital elevation models wich generate the most complete high resolution digital topographic database of Earth. The resolution of these images is aprox. 30 m and coverage includes North and South America, Europe, Asia, Australia and Africa.

DEM data (obtained from SRTM project) represents the input data required by the GIS solution (Fig. 2) to fulfill the hydrological analysys for the watershed extraction.

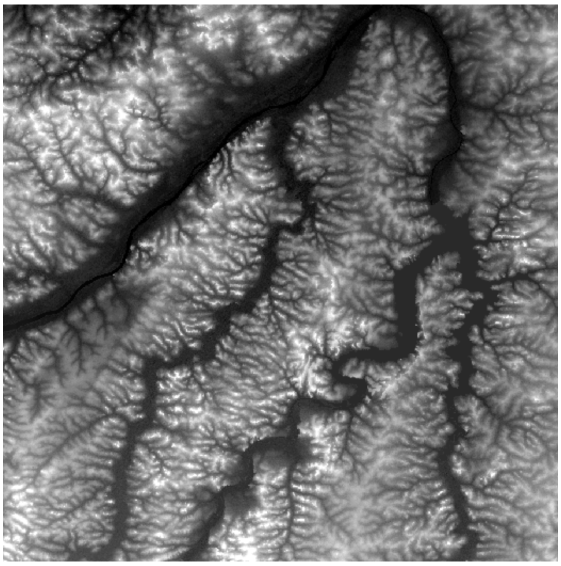

Fig. 2 – DEM data – ArcGIS.

2.3. Data Processing

The methods provided by the ArcGIS 10.3.1 to archieve a better hidological analysis, consist in using ArcToolbox - Spatial Analyst Tools - Hydrology with the folowing tools: Fill, Flow Accumulation, Flow Direction, Snap pour point and finally, the Watershed tool.

The first step is to eliminate the sinks and peaks from the elevation model with Fill tool (Fig. 3). Those are errors due to the resolution of the data rounding of elevation to the nearest integer value. The peaks and the sinks should be eliminate (remove or filled) in order to result a continous derived drainage network. (Planchon & Darboux, 2002; Tarboton *et al.*, 1991).

The second step is to determine the direction of flow from every cell in the raster image. This is possible with the **Flow Direction** tool. In this case an output raster is created showing a ratio of the maximul change in elevation from each cell along the direction of flow to the path length between centers of cell and. The direction of the flow results from the direction of steepest descent (Fig. 4), or maximum drop, from each cell. If all neighbour cells have higher values than the processing cell, this cell will be considered the flow direction. This method of deriving flow direction from a digital elevation model (DEM) is presented in Jenson and Domingue *et al.*, (1988).

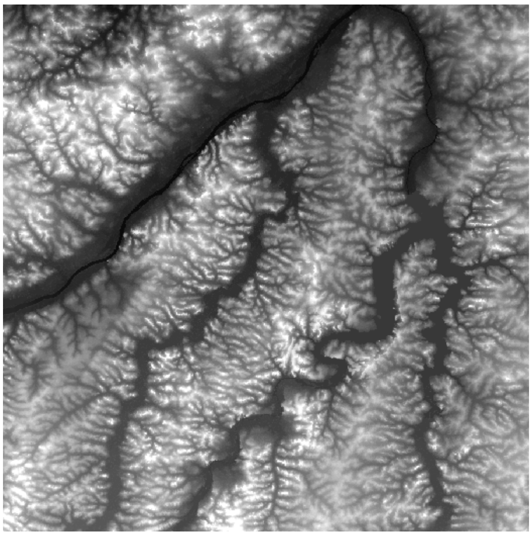

Fig. 3 – Sinks and peaks elimination – ArcGIS.

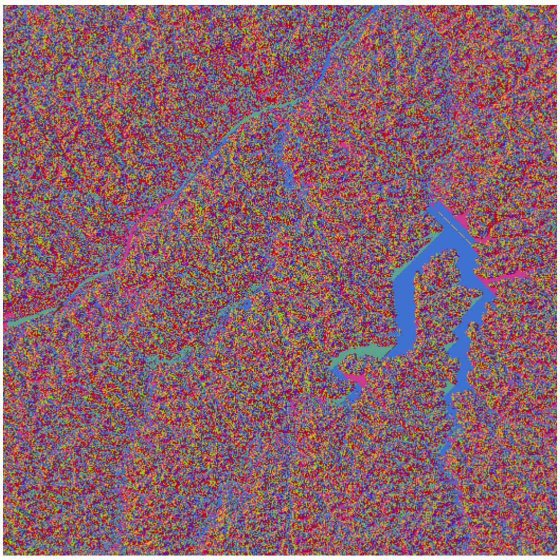

Fig. 4 – Flow Direction – ArcGIS.

After this, we need the Flow Acuumulation tool to calculate to acumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster. This tool is used to identify the stream channels and networks (Fig.5) (Jenson & Domingue, 1988; Tarboton *et al*., 1991).

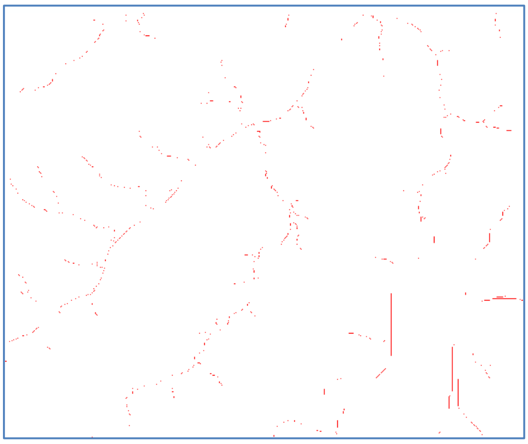

Fig. 5 – Flow accumulation – ArcGIS.

The last step of the the watershed extraction is the selection points of high accumulated flow. This selection represents a manually editing by clicking in highest flow accumulation pixel which represents the input data. The output data of **Snap pour point** tool is an integer raster where the original pour point locations have been snapped to locations of higher accumulater flow (Fig. 6) (http://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst).

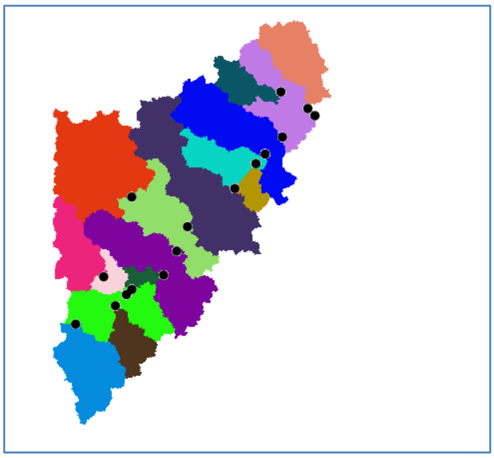

Fig. 6 – Points of high accumualation flow – ArcGIS.

3. Results and Conclusions

Finally it is possible an automatic extraction of watershed that will show us the bounderies between drainage basins or subbasins using Watershed tool. After the automatic delimitation precess of the basins have resulted a map showing the spatial configuration of the watershed (Fig. 7).

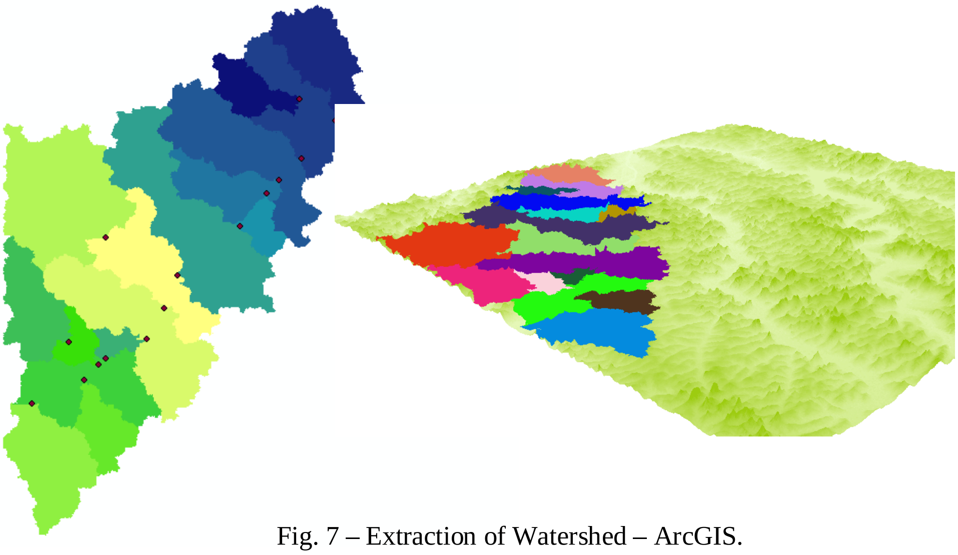

Fig. 7 – Extraction of Watershed – ArcGIS.

In the introductory part of this paper was motivated the usefulness of the automatic extraction process of a watershed based on a DEM data we could say that once the basin is identified can offer us valuable information about how fast the tributaries waters reach to geometric center of the basin.

4. Conclusions

1. DEM (Digital elevation models) data allows us to automatically extract the hydrologic information data with great accuracy.
2. ArcGIS offers a visual representation of the watersheds.
3. Watershed is the upslope area that contributes flow generally water to a common outlet as concentrated drainage. It can be part of a larger watershed and can also contain smaller watersheds, called subbasins.
4. The open source software used in this paper reduce the time needed to perform hydrological data analysis and provide a large amount of information.
5. ArcGIS allows us to identify and fulfill the sinks or remove the peaks areas from a digital elevation model.
6. ArcGIS could generate the flow accumulation and flow direction from DEM data.

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EXTRAGEREA AUTOMATĂ A WATERSHED-ULUI BAZINELOR HIDROGRAFICE FOLOSIND MODELUL DIGITAL DE ELEVAȚIE AL TERENULUI

(Rezumat)

Evoluția şi abundența datelor spațiale, sistemelor informatice geografice (GIS) şi a modelelor pentru aplicații hidrologice oferă multe oportunități pentru noi investigații, dar, de asemenea, prezintă o serie de provocări pentru cei care studiază resursele de apă. Această lucrare permite extinderea cunoştințele în analiza de date spațiale şi modelarea bazinelor hidrografice. Acest articol oferă o privire de ansamblu integrată a multiple fațete ale problemelor de date GIS şi o sursă de informații de bază pentru selectarea şi aplicarea GIS în modelarea scurgerilor hidrologice a bazinelor hidrografice. Accentul se pune pe date şi probleme care sunt comune pentru multe aplicații de date GIS-Modeling.

Lucrarea prezintă punerea în aplicare a datelor spațiale în programul ArcGIS pentru extragerea automată a watershed-ului (cumpăna apelor) bazinelor hidrografice folosind modelul digital de elevație al terenului (DEM). Cu ajutorul watershed-ului se pot studia, cerceta scurgerile de pe suprafața bazinelor şi subbazinelor aferente.

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MAPPING VERTICAL DISPLACEMENT USING SENTINEL DATA: A CASE STUDY OF IASI CITY

BY

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Abstract. The main goal of this paper, using Differential Radar Interferometry (DInSAR) technique - which is a powerful tool to detect and monitor ground deformation, is to detection and mapping ground displacement. Iaşi city is considered as study area in this research. Geographically, study area, is situated on latitude 47°13'N to 47°06'N and longitude 27°31'E to 27°40'E. In this paper was used Sentinel-1A images, kindly provided by The European Space Agency (ESA), with SLC product type, IW sensor mode and vertical polarisation for December 2017. SNAP was used to process the Sentinel – 1 images. The values for displacements, that is refering to LOS, varies between -0.014 m and 0.032 m for descendent pass and between –0.007 and 0.052 m for ascending pass. Vertical ground displacements varies between –0.009 and 0.018 m. It note that in the most of Iasi the vertical displacement is around 0 cm, but in eastern, northern and southern notice a subsidence of ground.

Keywords: Sentinel-1; LOS; vertical displacement.

1. Introduction

Interferometry is a useful technique in circles of science like: remote sensing, oceanography, seismology, engineering metrology, mechanical stress/strain measurement, astronomy, velocimetry and optometry; a comprehensible description of interferometry was done by Hariharan (Hariharan, 2007).

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Satellite-based radar interferometry is a powerful tool to detect and/or monitor ground deformation (movements). A lot of researches have sucsseful resultes and have demonstrated the potential of this technique for a wide field of applications: land subsidence determined by groundwater pumping (Stramondo *et al*., 2007; Tomás *et al*., 2005; Bell *et al*., 2008; Heleno *et al*., 2011), to landslides (Bovenga *et al*., 2012; Hilley *et al*., 2004; Colesanti *et al*., 2003), for mining (Colesanti *et al*., 2005; Jung *et al*., 2007) snd urban planning (Vallone *et al*., 2008; Crosetto *et al*., 2008; Cigna *et al*., 2012).

The scientific community consecrate the role of satellite SAR interferometry to landslide risk and hazard phenomena. Many favorable results have been obtained by the researchers (Catani *et al*., 2005; Herrera *et al*., 2009; Righini *et al*., 2012; Cigna *et al*., 2013; Crosetto *et al*., 2013; Frangioni *et al*., 2014; Rocca *et al*., 2015). Zones characterized by high coherence (over 0.5) of images are required to supply good results (Ferretti *et al*., 2007).

The SAR interferometry differential (DInSAR) technique assume on the processing of minimum 2 SAR images of the same side of the Earth's surface. The detection and/or the mapping of the ground displacement (horizontal/ vertical) that occurred between the 2 acquisitions can be achieved by Differential InSAR (DInSAR) due to the repeat pass interferometry method.

The DInSAR technique provides an "vision", called differential interferogram, that represent the ground displacement occurring between the acquisitions, according to Masson, with a centimetric/millimeter accuracy and a decametric resolution (Massonnet *et al*., 1993). After the removal of the topographic effect, the displacement is determined by differentiating the phase component of the 2 coregistrated SAR images (Gay, 2009).

2. Data and Methods

2.1. Study Area

Iaşi, the largest city in eastern Romania, is the seat of Iaşi County (Fig.1). Capital of the historical region of Moldava, Iaşi has traditionally been

Fig. 1 – Study Area (www.wikipedia.com).

one of the leading centres of Romanian cultural, academic and social. Iaşi, like Rome, is a "legendary city of the seven hills" (Copou, Bucium, Cetăţuia, Breazu, Galata, Şorogari, Repedea-name of hills). The city is positioned on the Bahlui River. This is an affluent of Jijia that flows into the Prut River (www.wikipedia.com).

Study Area is geographically situated on latitude 47°13'N to 47°06'N and longitude 27°31'E to 27°40'E.

2.2. Data and Methods

In April 2014 the Sentinel-1A satellite was launched, and has been operational since October 2014. Sentinel-1A has a potential 12 days revisit cycle.As opposed to missions scientific, Sentinel mission is operational in nature. Finally, and perhaps most importantly, images acquired by the Sentinel system are freely available, offering opportunities that were previously unfeasible due to cost or lack of data (www.esa.int).

One of the reason why S-1 is able to achieve short revisit times is the fact that it uses a wide swath (IW) mode, allowing it to capture SAR images that cover 250 km in width. Though there have been other missions that have used a IW mode, S-1 is the first satellite that uses the Terrain Observation by Progressive Scan (TOPS) mode (Fig. 2) (De Zan & Guarnieri, 2006).

In this paper was used Sentinel-1A images, that could by downloaded from a hub created by The European Space Agency, with SLC product type, IW sensor mode and vertical polarization for December 2017.

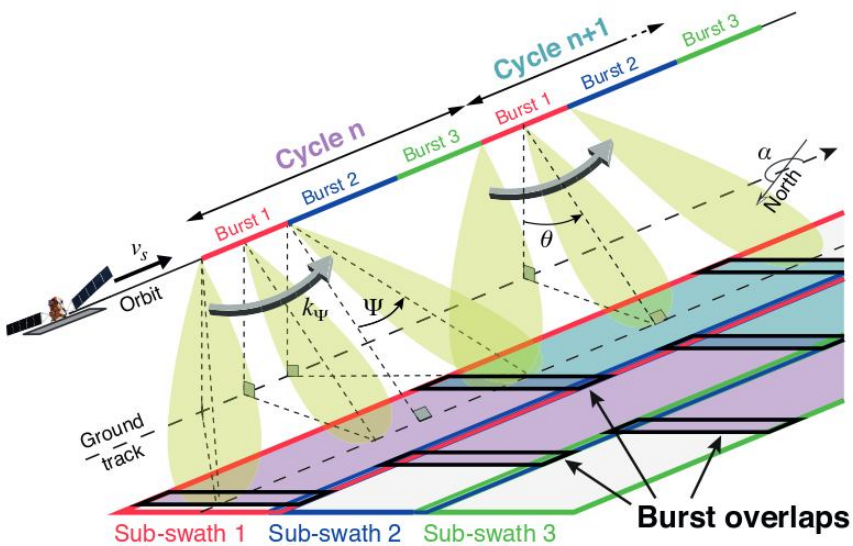

Fig. 2 – Principle of TOPS mode imaging (Grandin *et al.*, 2016).

2.3. Data Processing

DInSAR – a RS technique able to determine surface deformation on the ground using complex SAR images. DInSAR technique uses the interferometric phase obtained by the computation of the phase difference between a pair of SAR images, the interferogram, the main information used. Interferogram offers the phase information are related to the topography of the zone observed and the deformation (movements/displacement) occurred in the time between the 2 images used (Raventós *et al*., 2017).

Sentinel-1 images was processing in SNAP, an open source software, provided by The European Space Agency (ESA). Coherence, according to ESA, must be over 0.5.

3. Results and Discussions

Fig. 3 shows ground displacements in Iasi city for December (8^{th}–20^{th} 2017). Note that figure refer to the SAR Line-of-Sight (LOS). This direction changes with each satellite position along the flight path, so the Doppler frequency varies with azimuth time.

Positive values (red) indicate displacements away from the sensor, while the negative ones (blue) denote displacements toward the SAR sensor. The values for displacements varies between –0.020 and 0.040 m (–20 mm and 40 mm).

Fig. 4 shows vertical ground displacements (uplift/subsidence) in Iasi city for December (8^{th}–20^{th} 2017). Vertical ground displacements varies between –0.014 m and 0.032 m. It note that in the most of Iasi the vertical displacement is around 0 cm, but in eastern, northern and southern notice a subsidence of ground.

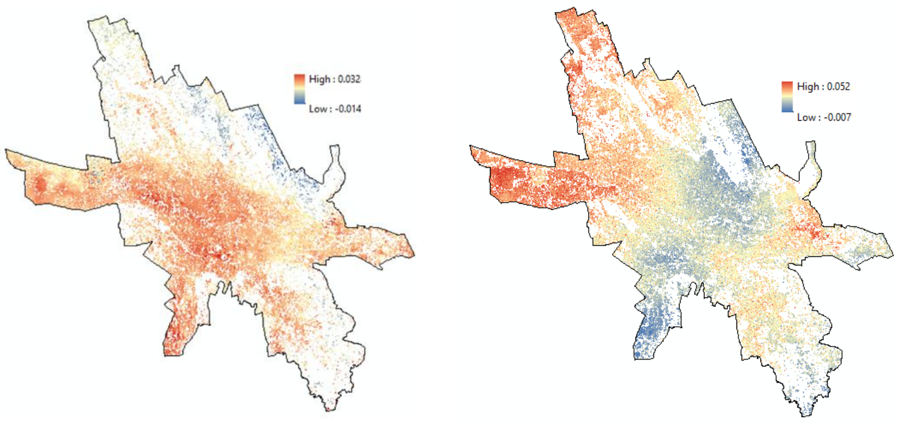

Fig. 3 – Displacements along line of sight (LOS) for images in descending pass (left) and ascending pass (right).

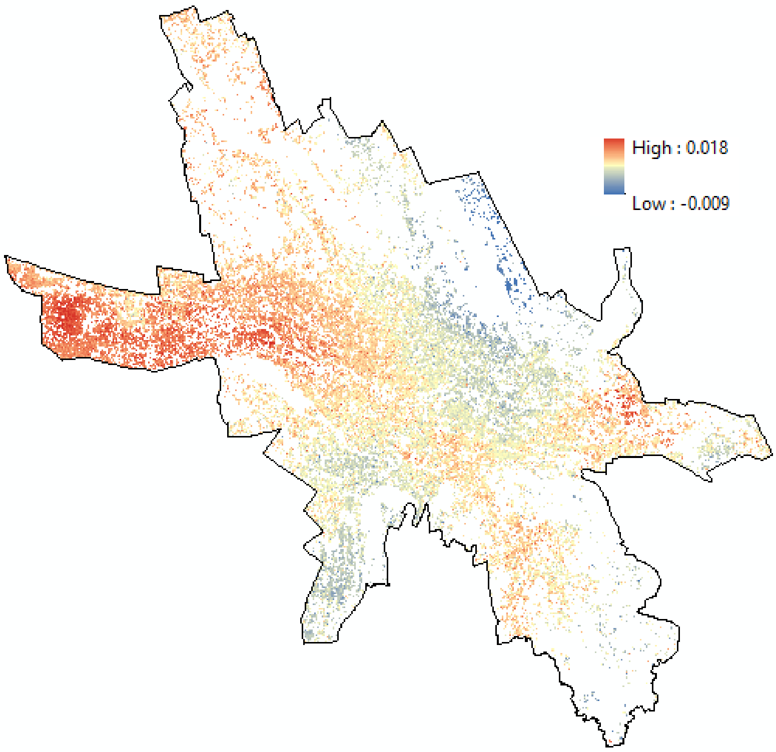

Fig. 4 – Vertical ground displacements (uplift/subsidence).

4. Conclusions

In this paper was used Sentinel-1A images, kindly provided by The European Space Agency (ESA), with SLC product type, IW sensor mode and vertical polarization for December 2017. Sentinel-1 images was processing in SNAP using the DInSAR technique, provided free by The European Space Agency (ESA).

The values for displacements, that is referring to LOS, varies between –0.014 and 0.032 m (–14 and 32 mm) for ascending pass and between –7 and 52 mm for. Vertical ground displacements varies between –0.009 and 0.018 m. It note that in the most of Iasi the vertical displacement is around 0 cm, but in eastern, northern and southern notice a subsidence of ground.

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CARTOGRAFIEREA DEPLASĂRILOR VERTICALE UTILIZÂND DATE: UN STUDIU DE CAZ AL ORAŞULUI IAŞI

(Rezumat)

Scopul principal al acestei lucrări, folosind tehnica Differential Radar Interferometry (DInSAR) – care este o metoda puternică de detectare şi monitorizare a deformării pământului, constă în detectarea şi cartografierea deplasării solului. Oraşul Iaşi este considerat zonă de studiu în această cercetare. Aria de studiu este situată geografic de la 47°13'N la 47°06'N latitudine şi 27°31'E la 27°40'E longitudine. În această lucrare au fost folosite imagini Sentinel-1A furnizate de Agenția Spațială Europeană (ESA), cu tipul de produs SLC, modul senzor IW şi polarizarea verticală pentru decembrie 2017. SNAP a fost utilizat pentru procesarea imaginilor Sentinel-1. Valorile pentru deplasări, care se referă la LOS, variază între –0,014 şi 0,032 m pentru poziția descendentă şi –0,007 m şi 0,052 m pentru poziție ascendentă. Deplasările deplasărilor verticale variază între –0,009 şi 0,018 m. Se remarcă faptul că în cea mai mare parte din Iaşi deplasarea verticală este de aproximativ 0 cm, însă în est, nord şi sud se observă o subzistență a solului.