RUNOFF SIMULATION IN LARGE RURAL AND URBAN AREAS USING MIKE 21 FLEXIBLE MESH MODELING

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Abstract*: The paper presents the way of construction and modeling of the runoff on rural and urban areas. Mike 21 Flexible Mesh software generates results in bidimensional hydrodinamic files that highlight the flow, speed, water level and space expansions of the flooded areas. The bidimensional model is calibrated with reference terms of the measured water level in the modeled area, the maximum limit of the hystorical flood recorded by physical landmarks. It also uses roughness parameters for land use on the analyzed extents.*

Keywords: *runoff simulation, Mike 21 Flexible Mesh, water level, flooded area*

1. Introduction

A mathematical model represents a simplification of reality, so that it is able to reproduce in an acceptable way the observed events, taking into account the main processes observed in reality.

We built a bidimensional model for Negresti town. For the 2D model, a digital terrain model was used that underwent a conversion process, so that the digital terrain model was brought into the *.dfs2 format, used by the Mike by DHI computing program. The same procedure was followed for the processing of land use data, because the program uses the surface roughness coefficients resulting from the land cover method in calculating the surface runoff.

This model requires a digital terrain model, ortho photograms, data on land use and GIS data of streets and buildings in the study area (figure 1).

Fig. 1 – GIS data of streets, buildings and roughness coefficients

The "modeled area" is suggestively named with the name of the locality for which the two-dimensional model was created. The "Data" directory contains the data needed for the layer editor with the morphology of the terrain and the roughness map - * .mdf.

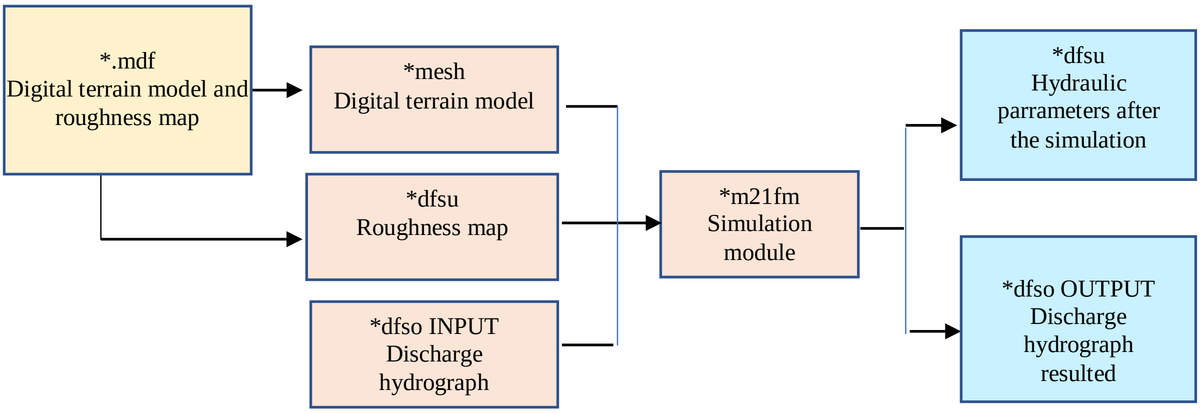

Fig. 2 – Functional scheme for Mike 21 files

2. Research Methodology

After the previous step was finished, the conversion of the digital terrain model into the format supported by the Mike by DHI computations, namely * dfs2, was completed. For this, data was processed in ArcMap, and the final result was a *.xyz file, containing one point for each 1 m x 1 m cell of the digital terrain model. Each point corresponds to a ground quota value and also a pair of coordinates x and y. The Mike Zero program was then used to create the *.dfs2 file (figure 3), through the following steps:

- we established the coordinate of the bottom left corner of the grid to be created and its extension;
- the * xyz file was uploaded and the grid was created specifying its resolution, respectively 1 m, 5 m, 1 5m;
- -the grid values were interpolated and the * dfs2 file was then exported.

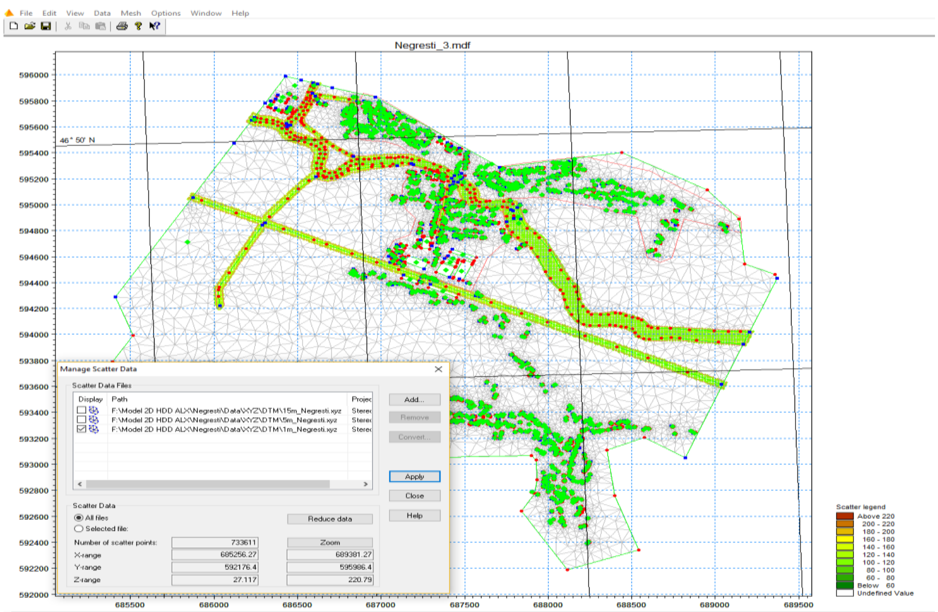

Fig. 3 – *.dfs2 file created in Mike by DHI

After the street printing was completed in the digital terrain model, DTM was processed for existing buildings on interest areas. After the measurements were made, the digital terrain model was processed so that the higher quotas corresponding to the buildings became land quotas, the buildings being virtually eliminated from DTM. Because of this, the land model was corrected by adding buildings. This was done on the basis of a polygon file containing the footprint of the buildings on the land surface. It should be noted that the real height of the buildings has not been respected, this aspect not being important for the final purpose of the study, but it has been chosen a height of the buildings by 5 meters higher than the land quoat at that point.

The final result of the digital terrain model is shown in figure 4:

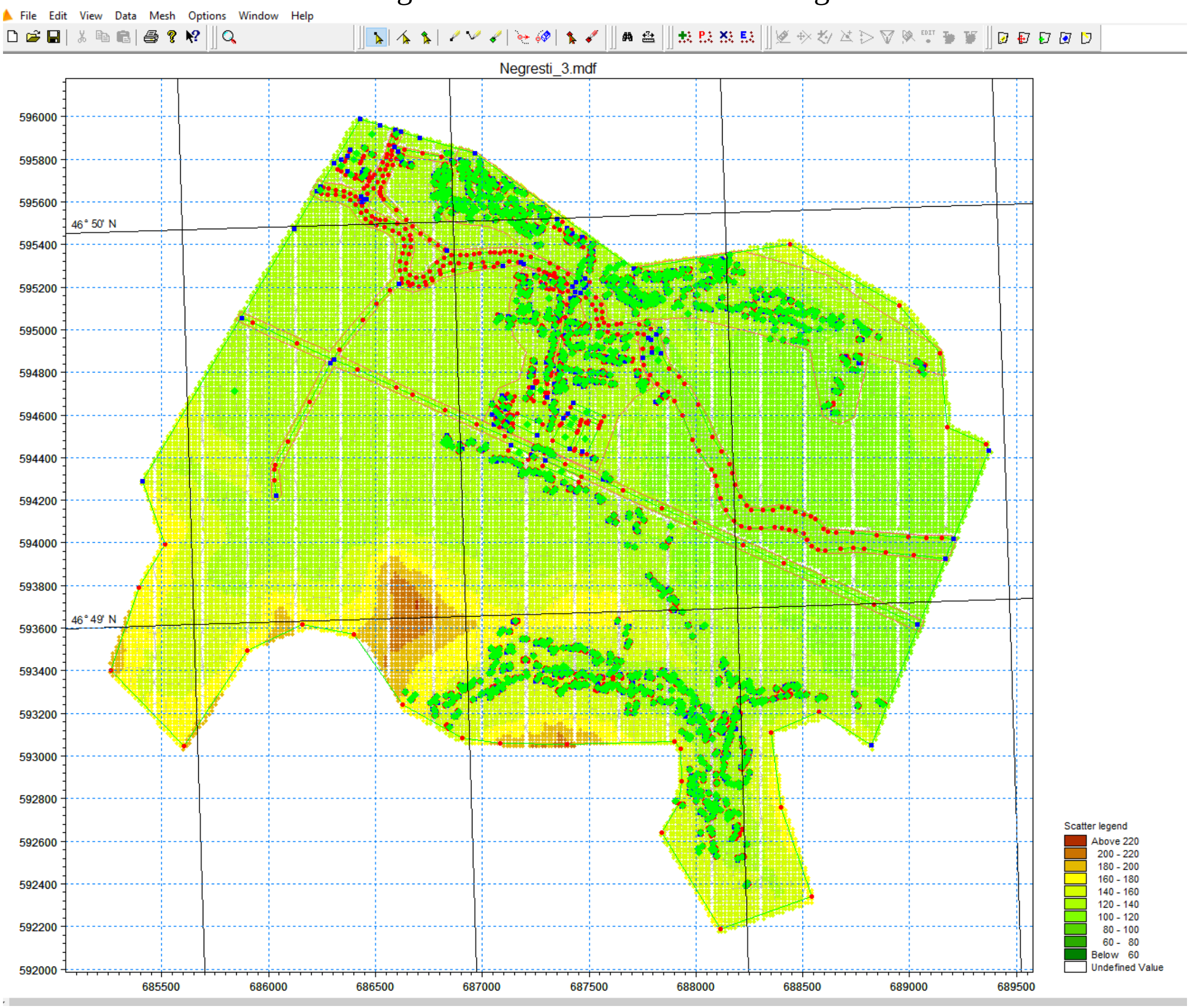

Fig. 4 – *.mdf file created in Mike by DHI

The next step is creating the*.m21fm file, that represents the hydraulic model containing the model area (batimetry / mesh and pattern boundary identification), simulation duration, and hydrodynamic parameters and the time step size (figure 5).

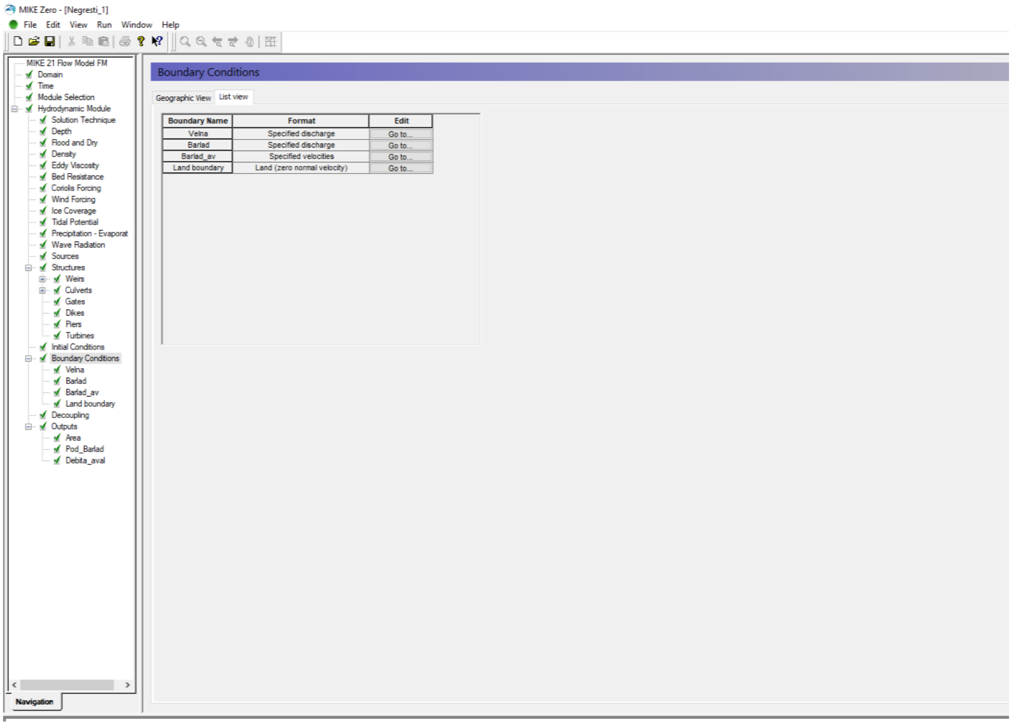

Fig. 5 – *.md21fm file created in Mike by DHI

The maximum discharges with several probabilities of exceedance calculated in natural flow are presented in a time series file with the extension *.dfs0 (figure 6). The bidimensional model is calibrated with reference terms of the measured water level in the modeled area, the maximum limit of the hystorical flood recorded by physical landmarks.

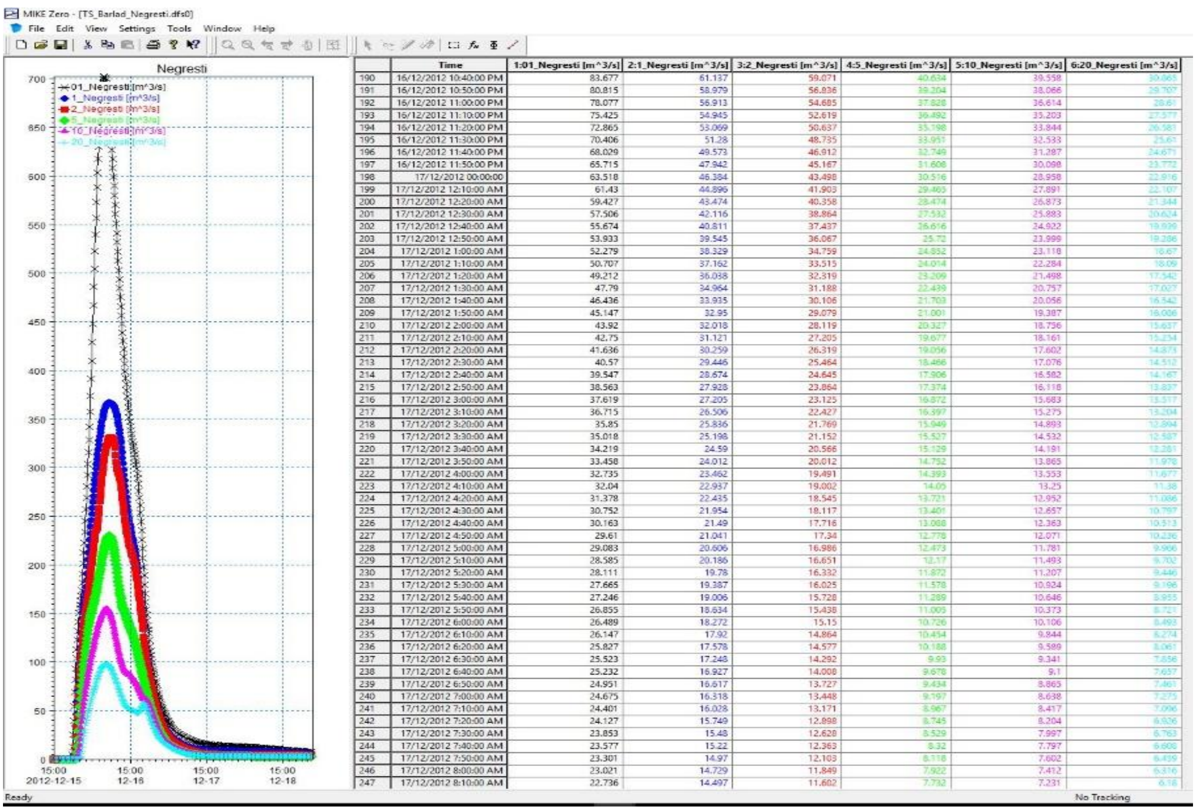

Fig. 6 – *.dfs0 file created in Mike by DHI

Mike 21 Flexible Mesh software generates results in bidimensional hydrodinamic files that highlight the flow, speed, water level and space expansions of the flooded areas. The *.dfsu file contains the result obtained by hydraulic modeling, using the "flexible mesh" support (the time and space version of some parameters selected in the hydraulic model mentioned above). The maximum depths of water are shown in figure 7.

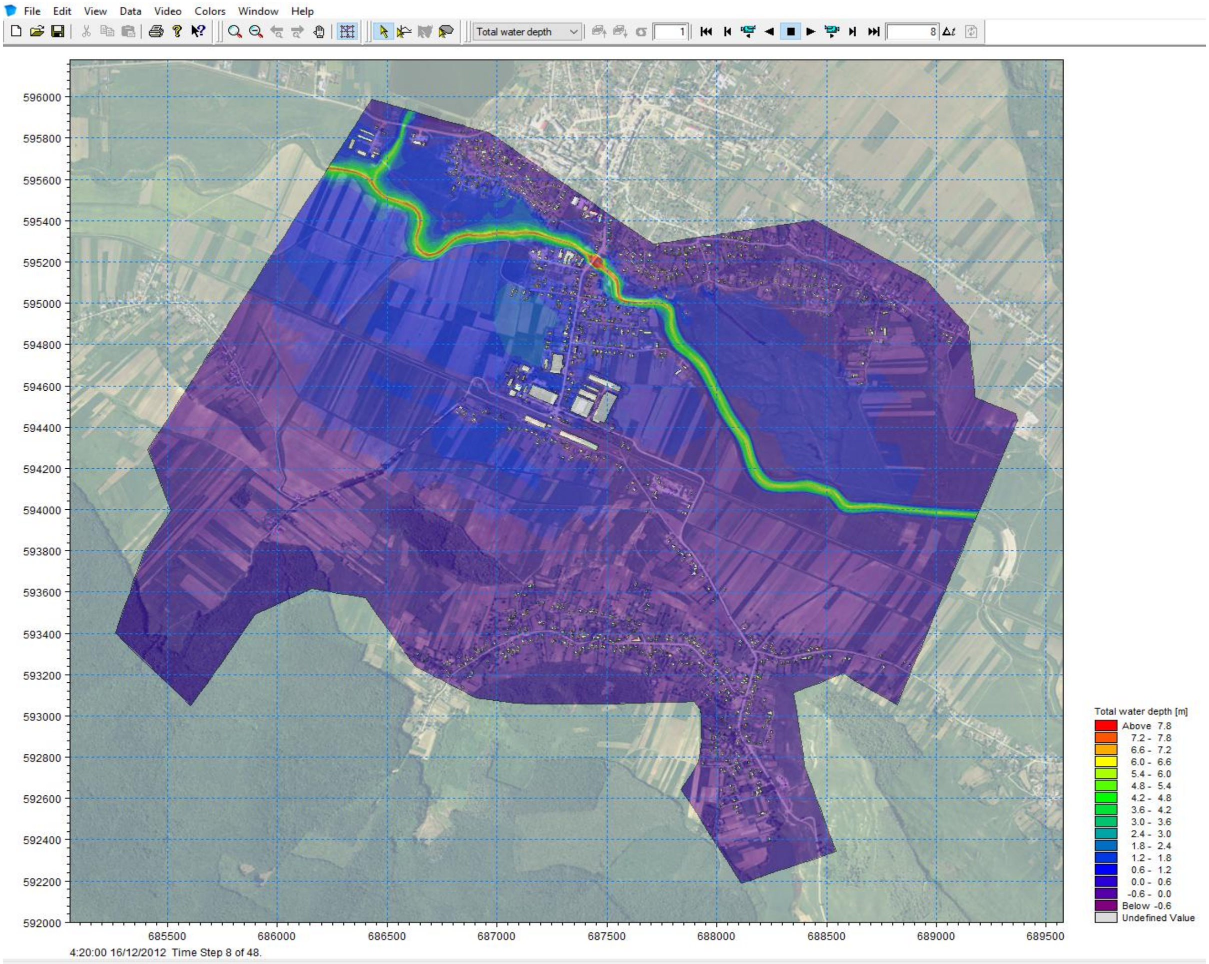

Fig. 7 – Maximum depths of water

The maximum velocities of water in vertical and horizontal dimensions are shown in figure 8 and figure 9.

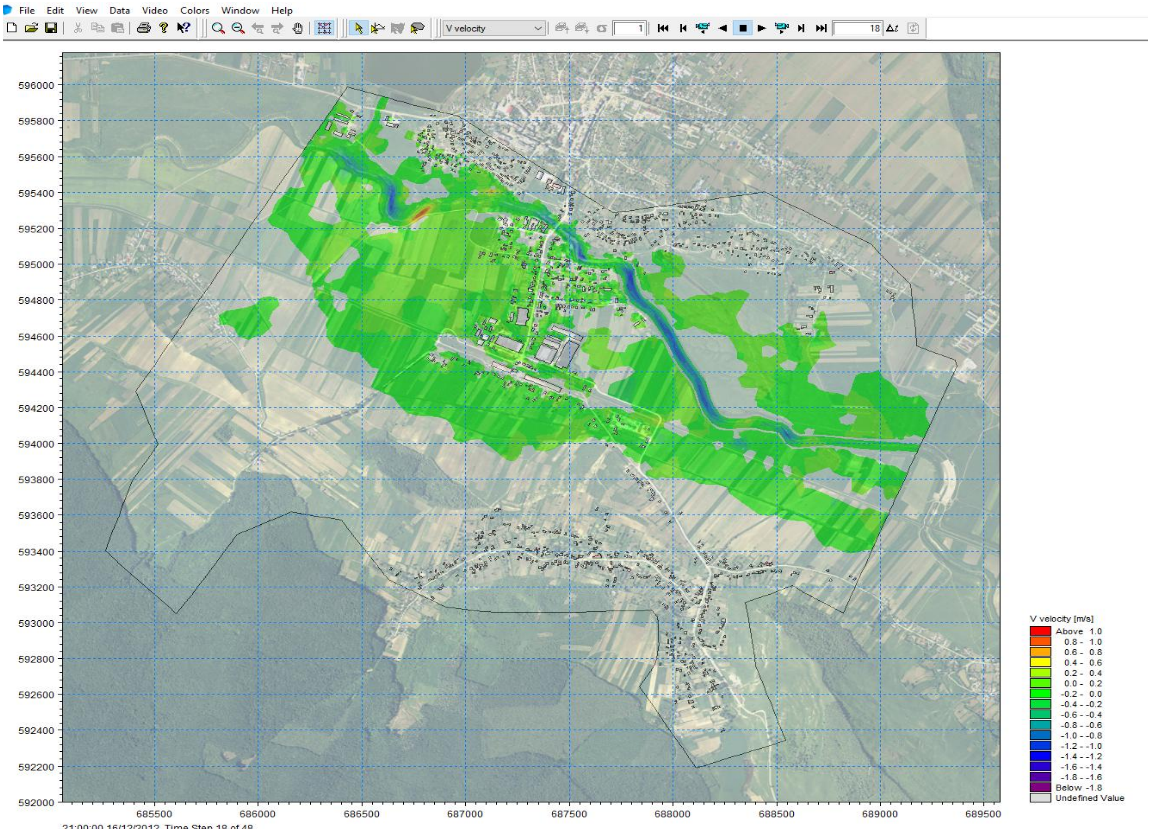

Fig. 8 – Maximum depths of water – vertical dimension

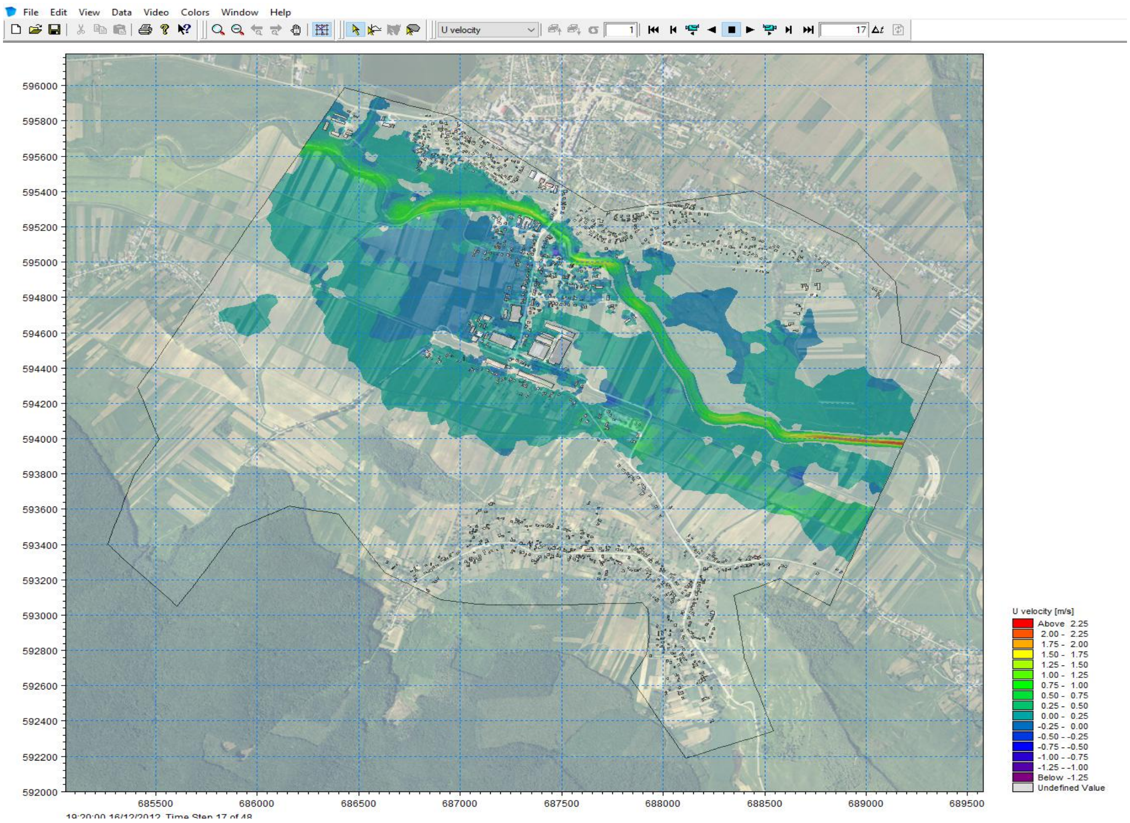

Fig. 9 – Maximum velocity of water – horizontal dimension

Runoff simulation exposed on Google Earth after the maximum discharge with 1% probability of exceedance calculated in natural flow (figure 10).

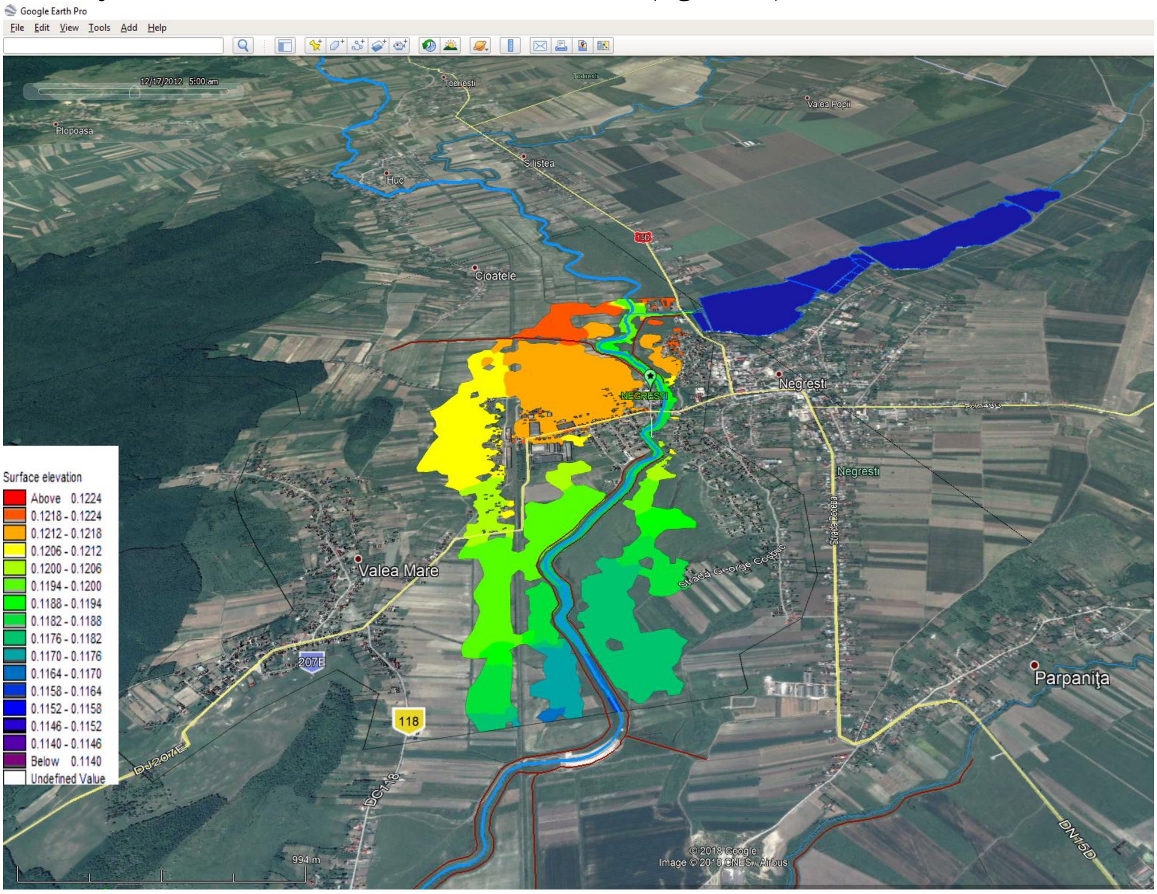

Fig. 10 - Runoff simulation extents on Google Earth

3. Conclusions

The applicability of 2D modeling methods in hydrology is extremely diverse: modeling of event type, evolution of a flood in a certain area studied and it can be used as a tool to limit the negative effects of floods caused by rapid floods in rural and urban areas;

Bidimensional surface runoff is necessary in the management of preliminary flood risk assessment decisions and it opens the perspective of intimate knowledge of the phenomenon of floods, so it represents a fundamental research.

4. References

1. *Corduneanu F., Vintu V., Balan I, Crenganis L., Bucur D., 2016 – Impact of drought on water resources in North – Eastern Romania. Case study – the Prut River, în Environmental Engineering and Management Journal, Vol. 15, No.6,p.1213 – 1223*
2. *Balan, I. Pricop, C., Crenganiș, L., Flood analysis using hydrological modeling. Case study – the flood in the upper catchment of river Geru, Galaţi county, Romania, simpozionul Present Environment and Sustainable Development, Universitatea Alexandru Ioan Cuza - Facultatea de Geografie și Geologie, 2015*

3. Bîrsan, M.V., Teză de doctorat - Modelarea proceselor fizice de tip precipitaţie-scurgere pentru prognoza în timp real a viiturilor, Universitatea din Bucureşti – Facultatea de Fizica – Şcoala Doctorala, 2010

4. Crăciun, I., Giurma, C.-R., Hidrologie specială - Aplicații, Ed. Performantica, Iaşi, 2014

5. Hjelmfelt, A.T. Jr, Kramer K.A., Burwell R.E., Curve number as random variables, Proc. Int. Symp on Rainfall – Runoff Modeling (Ed. V.P. Singh), Water Resources Publication, Littleton, Colo. 365-373, 1982

6. Kirkby, M., Hillslope process – response models based on the continuity equation. In Slopes form and processes Instit. British Geography Specifications Pub. No. 3: 15 – 30, 1971

*7. *** MIKE 11 – A modelling system for rivers and channels – User guide – DHI – Agern Alle 5, DK-2970 Horsholm, Denmark, 2003*

*8. *** MIKE 11 – A modelling system for rivers and channels – Short introduction tutorial - DHI– Agern Alle 5, DK-2970 Horsholm, Denmark, 2003*

*9. ***MIKE 11 Users Manual - DHI water and environment, DK-2970 Horsholm, Denmark DHI, 2006*

*10. ***MIKE 11 Reference Manual - DHI water and environment, DK-2970 Horsholm, Denmark DHI, 2011*

*11. *** United States Department of Agriculture (USDA), National Engineering Handbook, Part 630 Hydrology , chapter 7-12, 1986*

*12. *** United States Department of Agriculture (USDA), Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55), Natural Resources Conservation Service, Conservation Engineering Division, 1985*