

SPATIAL ANALYSIS ON THE 3D MODEL OF THE TERRAIN TO DETERMINE THE HEIGHT OF THE PRECIPITATION LAYER

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Abstract: *In order to anticipate the effects of some extreme phenomenas, such as heavy raining, in hydrographic basins where there are no measuring stations, there were defined automated procedures to determine the height of the precipitation layer. These values of the stratum are necessary to create a rain/drain model of the area, to aknowledge different assurance flows and further to draw the risk maps. The purpose of this written work is to introduce to the public eye a personal approach regarding the above stated demands, by designing an interpolation application applied on the 3D model of a hydrographic basin, which will contain 73 000 points used as a base to determine the height of the precipitation layer after a certain rain phenomenon. The results obtained will constitute the input data for the rain/drain simulation model on this specific basin, allowing the possibility to obtain the flow values in every section of the river.*

Keywords: *3D model, interpolation, precipitation layer, flows*

1. Introduction

Climate changes have determined, during time, the development of extreme phenomenons such as the drop of massive quantities of rainfall in very short periods, which often conduct to flooding and have major social implications, because of the material and sometimes human losses. Therefore, to partially control and limit those effects, an application that runs on GIS platforms was designed, application which simulates possible rain/drain phenomenons and serves to the creation of risk maps for every hydrographic basin. GIS software permits graphic information updates in real time, using as sources photogrammetric and remote sensing technologies, as well as data from meteorological and hydrological stations. There are some hydrographic basins that are not equipped with measuring stations, situation which requires that during the simulation, to obtain data through a process of interpolation from the neighboring stations. Also, not all GIS platforms have specialized functions to support a rain/drain phenomenon modeling, which leads to the development of an application needed to solve this problem. The concerns evaluated for this study were solved by using AUTODESK MAP 3D platform, which is an open GIS, commonly used as a base for creating complex applications in C++, AutoLisp etc.

2. MATERIAL AND METHODS

2.1. MATERIALS USED

The two data sources that were involved in achieving this study are the plan sheet with a scale of 1: 5000 , that generated the 3D elevation model (Figure no.2.1), and all the data obtained from the meteorological stations in the vicinity of the study area (Table 2.1)

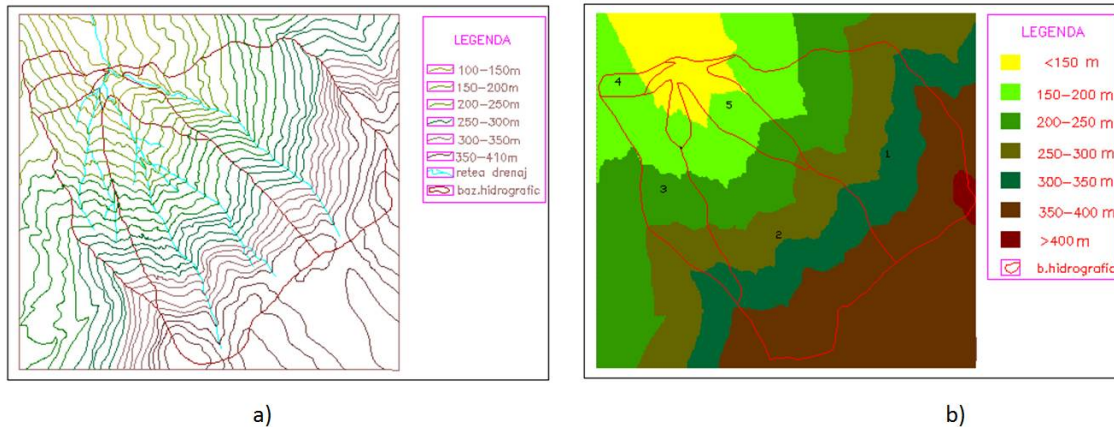


Figure 2.1 Source of graphic data:a) Topographic plan of scale 1:5000; b) Digital model of the elevation[2]

Table 2.1. Alphanumeric data used in the process of interpolation [1]

Name of pluvio station	Precipitation 15.04.1996 (mm)	Precipitation 21.08.1996 (mm)
Ciurbești	38.0	14.8
Mogoșești	33.4	27.1
Tinoasa	27.0	22.2
Bârnova	32.6	46.6
Păun	24.9	31.5
Poieni	45.0	17.2

2.2. WORKING METHOD

Creating the interpolation application

The study area is located between the pluviometric and meteorological stations presented in table 2.1. The precipitation layer height, for each point of the digital model, is determined using the weighted moving average formula [1]. The use of this formula assumes that a station influences more a point value of the grid as it is closest to it and vice versa, a station has less influence as it is further from that point.

The formula used in the process of interpolation is:

$$X_{i,j} = \frac{\sum_{m \in N} p_m^2 * X_m}{\sum_{m \in N} p_m^2} \quad 1)$$

unde: p_m – weight;
 X_{ij} - the precipitation layer height in (i,j) node;
 X_m - the precipitation layer height in station m;
 N - number of stations;

The weight is equal with the inversed square distance: $p_m = \frac{1}{d_m^2}$ 2)

where d_m - the distance from point (i, j) to station m.

The interpolation program was made in C++ and the provided input data was:

- the number of meteorological and pluviographic stations;
- the rectangular coordinates of those stations;
- the precipitation quantity height in the stations zone;
- the data extracted from the contributory area grid of the studied hydrographic basin.[1]

The interpolation results are introduced in a grid which represents the precipitation layer height for the studied area. Furthermore, the program calculates the maximum, minimum and average quantities of precipitations specific to this area.

The following 94 lines of program represent the designed program code entitled "HPRECIPITATII".

```

1.  #include <stdlib.h>
2.  #include <fstream.h>
3.  #include <math.h>
4.  #include <string.h>
5.  #include <iostream.h>
6.  #include <except.h>
7.  #include <iomanip.h>
8.  void citire(long &x, long &y, ifstream &ins)
9.  {
10. const sx=8, sy=9;
11. char bufx[sx], bufy[sy],c
12. ins.get(bufx,sx);
13. x = atoi(bufx);
14. ins.get(bufy,sy);
15. y = atoi(bufy);
16. ins.get(c);
17. }
18. void scrie(long &x, long &y, double &p, ofstream &outs)
19. {
20. const sx=7, sy=8;
21. char bufx[sx], bufy[sy], *bufp;
22. int dec, sign, ndig=1;
23. ltoa(x, bufx, 10);
24. outs.write(bufx,6);
25. outs.write(" ",1);
26. ltoa(y, bufy, 10);
27. outs.write(bufy,7);
28. outs.write(" ",1);
29. bufp=fcvt(p,ndig,&dec,&sign);
30. outs.write(bufp,1+dec);
31. for (int i=0; i<3-dec; i++) { outs.write(" ",1);}
32. outs.write("\n",1);
33. }
34. void main()

```

```
35. {
36. ifstream ins("C:\\bc\\Test\\mnsubbaz.txt");
37. if(!ins)
38. {
39. cerr << "Nu pot deschide fisierul: mnsubbaz.txt";
40. exit(1);
41. }
42. ofstream outs("C:\\bc\\Test\\subbazprecip.txt", ios::app);
43. if(!outs)
44. {
45. cerr << "Nu pot deschide fisierul: subbazprecip.txt";
46. exit(1);
47. }
48. int nr,i,k,ctr;
49. long x,y,x0,y0;
50. double xs[10],ys[10], ps[10],numa,numi,p,precip,p1,p2;
51. cout<<"Coordonatele punctului sectiune: "<<endl;
52. cin>>x0;
53. cin>>y0;
54. citire(x,y,ins);
55. if ((x!=x0)||(y!=y0)) { cerr<<"Continutul fisierului mnsubbaz.txt este
diferit!"<<endl;
56. exit(1); }
57. for (i=0; i<10; i++) { xs[i]=0;
58. ys[i]=0;
59. ps[i]=0; }
60. cout<<"Numarul statiilor: "<<endl;
61. cin>>nr;
62. for (i=0; i<nr; i++)
63. { cout<<"Introduceti coordonatele si precipitatie statiei: "<<(i+1)<<endl;
64. cin>>xs[i];
65. cin>>ys[i];
66. cin>>ps[i];
67. }
68. precip=0;
69. p1=100000;
70. p2=0;
71. ctr=1;
72. x=0;
73. y=0;
74. while ((x!=x0)||(y!=y0))
75. {
76. ins.seekg(-16*ctr,ios::end);
77. citire(x,y,ins);
78. numa=0;
79. numi=0;
80. for (k=0; k<nr; k++)
81. { numa = numa + ps[k]/sqrt((ys[k]-y)*(ys[k]-y)+(xs[k]-x)*(xs[k]-x));
82. numi = numi + 1/sqrt((ys[k]-y)*(ys[k]-y)+(xs[k]-x)*(xs[k]-x)); }
```

```

83. p=numa/numi;
84. precip=precip+p;
85. ctr++;
86. scrie(x,y,p,outs);
87. if (p<p1) { p1=p;}
88. if (p>p2) { p2=p;}
89. }
90. precip=precip/(ctr-1);
91. cout<<"Precipitatie medie pe bazin este: "<<precip<<endl;
92. cout<<"Precipitatie minima este: "<<p1<<endl;
93. cout<<"Precipitatie maxima este: "<<p2<<endl;
94. }

```

The generation of themes containing spatial distribution of the precipitation layer (rain isohyets), as well as the generation of a data table related to each isohyet existent in the model (describing the area, the maximum height, the minimum one and the average height of the precipitation layer), are obtained through an application written in AutoLISP, application dealt with on another occasion.

3. RESULTS

3.1. Thematic distribution for a given precipitation

The application described so far was tested using two rain recorded phenomenons indifferent periods of time, to later compare the results with the information provided by Directia Apelor Prut. The data related to the two rainfalls is presented in tabel 2.1. In the first case it is showed the thematic map with isohyets of a rain taking place in april (Figure 3.1), and the associated alphanumeric information (table 3.1).

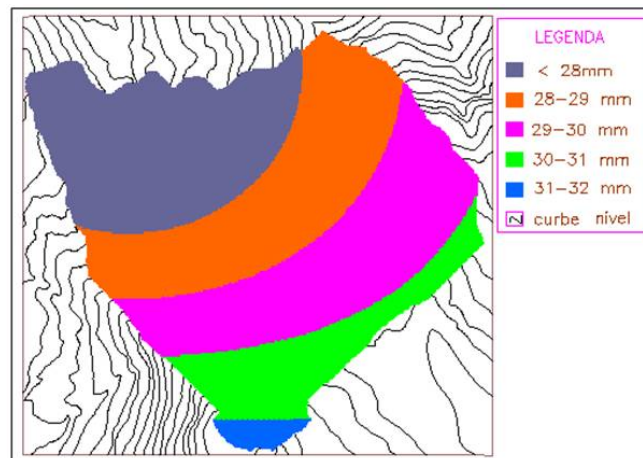


Figure 3.1. Thematic Map with the April rain isohyets

Tabel 3.1 Synoptic table of alphanumeric data associated with Figure 3.1

Isohyet's quantity interval	Isohyet's Area (km ²)	Isohyet's Average quantity of precipitation (mm)	Basin's precipitation (mm)		
			Maximum	Minimum	Average
<=28 mm	1.227	27.490	31.41	27.03	28.82
28-29 mm	1.159	28.566			
29-30 mm	1.158	29.554			
30-31 mm	0.559	30.398			
31-32 mm	0.0783	31.199			

In the second case, similar data is presented in Figure 3.2 and in Table3.2, for a rainfall taking place in august.

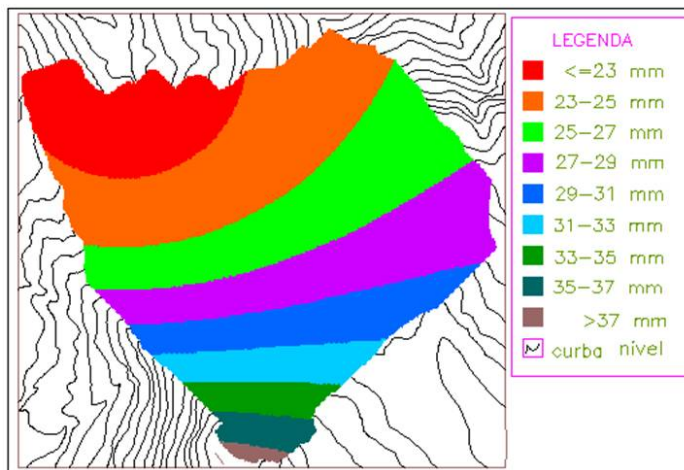


Figure 3.2. Thematic Map with the April rain isohyets

Table 3.1 Synoptic table of alphanumeric data associated with Figure 3.2

Isohyet's quantity interval	Isohyet's Area (km ²)	Isohyet's Average quantity of precipitation (mm)	Basin's precipitation (mm)		
			Maximum	Minimum	Average
<=23 mm	0.595	22.598	38.060	22.200	26.010
23-25 mm	1.027	24.057			
25-27 mm	0.894	26.020			
27-29 mm	0.732	27.997			
29-31 mm	0.428	29.930			
31-33 mm	0.238	31.974			
33-35 mm	0.140	33.976			
35-37 mm	0.100	35.990			
>37 mm	0.0279	37.460			

The comparative analysis was performed to compare the results from maps with isohyets in analogical format with the results obtained in automated systems, using the terrain's numerical model. For the comparison, average precipitation values of the two raifalls were taken into consideration. The results are presented in table 3.3.

Table 3.3. Synoptic table of average quantities of precipitation obtained throughout the two procedures-analogical and digita

X _{mediu} 15.04 1996 (mm)		Col.1/ Col.2	X _{mediu} 21.08 1996 (mm)		Col.4 / Col.5
Interpolat MNT	Map of isohyets		Interpolat MNT	Map of isohyets	
1	2	3	4	5	6
28.82	29,8	0.967	26.01	25.2	1.032

4. Conclusions

- Autodesk MAP is an open platform that enables the development of any GIS application specific to several domains;
- The application can be integrated into a larger one- such as rain/drain- in which the results obtained during the interpolation process become input data for the modeling process;
- The interpolation procedure corresponds to precision requirements, in order to be further used on any study areas of numerical modeling.

5. References

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2. Bofu C., Giurma R.C., 2000, *Numerical Model of Tinoasa Catchement Area*, Bul. Inst. Polit. Iasi, XLVI(L),1-4,s. Hidrot.
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