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Editorial Office: Bd. D. Mangeron 63, 700050, Iași, ROMANIA Tel. 40-232-278683; Fax: 40-232 237666; e-mail: polytech@mail.tuiasi.ro

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#### GIS UTILIZATION IN CLIMATIC RISKS' INVESTIGATION

BY

#### TATIANA CONSTANTINOV, MARIA NEDEALCOV and VALENTIN RĂILEANU

Abstract. Climatic risks' intensity and frequency growth in the past few decades demands using a vast informational database that would allow identifying their regional manifestation particularities adequately In this sense, Geographical Informational Systems ensure simultaneous access to informational database on different level (world, regional, local), obtaining operatively complex analysis of risks under investigation. Keeping in mind that in most cases climatic risks have regional character of manifestation, the actual investigations are of great scientific interest, as they can be useful for comparison with the researches executed abroad.

Key words: GIS, database, virk analysis climatic.

#### **1. Introduction**

Climatic risks evaluation on the actual stage are of great interest, as in last few decades they have a bigger intensity and frequency of manifestation. Experts of United Nations' Development Programme (UNDP), that have elaborated united definition of natural disaster's *risk* (Disaster Risk Index, DRI) state that it's a probability of negative consequences and possible losses, that result from interaction of natural and anthropogenic dangerous phenomena with vulnerability conditions.

Vulnerability - *conditions* determined by natural, social, economical, ecological factors or processes that intensify the receptivity of certain

community to hazards' influence (Reducing Disaster Risk, global report, 2005). These notions will be the basis for identifying climatic risks manifested on Republic of Moldova's territory.

#### 2. Materials and Methods

Thus, natural risks' intensity and frequency growth in last decades demands using unique identification criteria and scientific informational base for local (State Hydrometeorological Service data) as well as world (Centre for Researches of Epidemiological Disasters from Luviana University, Belgium CRED), or regional Drought Management Centre from South-Eastern Europe -DMCSEE) data (Fig.1).





Fig. 1 – Informational database of world (*a*), regional (*b*) and local data (*c*) on climatic risks manifestations on Republic of Moldova's territory.

In this context, Regional Informational Systems became an operative

and trustworthy instrument for storing, processing and graphical presentation of this data.

We also would like to mention, that the most prestigious organization working with natural risks identification is Centre for Researches of Epidemiological Disasters from Luviana University, Belgium (CRED), which stores in world database risks that correspond to the following criteria:

- a) 10 or more people reported;
- b) 100 people reported affected;
- c) a call for international assistance;
- d) declaration of a state of emergency.

Some of natural hazards can be monitorized separately. Thus, Drought Management Centre from South-Eastern Europe (DMCSEE) identifies droughts in the regions on the basis of precipitations standardization. Information taken from world and regional databases were confirmed by local data collected by State Hydrometeorological Service from Republic of Moldova. The latter have contributed to cartographical models development by concretization of the intensity and areas of these risks' manifestations.

#### **3. Obtained Results**

Comparative analysis of natural hazards on Earth manifested in the first semester of year 2008 and average multiannual in last decade (1998-2007) shows us that their consequences have increased essentially in 2008, provoking significant material losses, human victims and affected (Table 1).

Semester of Year 2008 and in the First Semester of Last Decade (1998-2007)							
Natural hazards	2008	1998-2007					
and consequences	1 semester	1 semester					
Number of natural hazards	101	174					
Number of people reported killed	229,043	8,768					
Number of affected people	130,505,312	105,897,081					
Economical losses (mln. \$USA)	34,934	15,076					

 Table 1

 Comparative Analysis of World Natural Hazards Manifested in the First

 Semester of Year 2008 and in the First Semester of Last Decade (1998-2007)

Source: CRED CRUNCH

In regional aspect, for the above mentioned period (1998–2007) floods have provoked highest material losses. Because of extreme temperatures in winter 2006 there were registered victims, and drought in 2007 had caused a large number of affected people (Table 2). According to the number of people affected by drought, by CRED Republic of Moldova occupies second place in Europe after Macedonia [1], the fact that demonstrates that this phenomenon Table 2

has a wide range of manifestation (Fig. 2).

Net Estimation (Period 1998-2007) of Natural Hazards Manifested on								
Republic of Moldova's Territory and their Consequences								
Type of	of Number of Number of Total number Material							
hazard	events	human victims	of affected	losses (000s)				
			people					
Droughta	2000	2	210	-				
Diougins	2007	—	394	—				
Extreme	2006	14						
temperatures	2000	14	-	_				
	1999	—	6,500	—				
Floods	2002	1	1,713	4,000832				
	2005	—	500	7,752				



Fig. 2 – Number of people affected by drought 2007 in Europe (Source: CRED CRUNCH).

Drought manifestation growth in South-Eastern Europe is conditioned by using common indexes for all regions' countries in order to evaluate area and level of intensity. Presently, it is widely used the so-called Standardized Precipitations Index (SPI) formulated by Makee and others [2]. From the conceptual point of view it represents an equivalent to standardized anomaly of random value (in present case that of precipitations) from norm:

(1) SPI =
$$(x_i - x)/\sigma$$

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where  $x_i$  represents concrete precipitations value,  $x - \text{climatic norm and } \sigma - \text{standard deviation}$ .

The values of this index ranging in the limits of 0.99 < SPI < -0.99indicate that humidification conditions are near the norm. Drought as atmospheric phenomenon begins when SPI evaluation reaches value of -1.0. Correspondingly, moderated drought is observed when indexes deviation from norm are within limits of -1.0 < SPI < -1.49, severe one when they are within -1.5 < SPI < -1.99 and when is SPI < -2.0 drought is considered extreme.

As we mentioned before, Drought Management Centre from South-Eastern Europe (DMCSEE) has an informational database [3] with data that characterizes this index in the region during past decades. The analysis of drought manifestation in 2007 by months apart (May, June, July) shows us that more than 50% of republic's territory in June and July where affected by the drought that was considered extreme according to SPI. Moreover, this qualificative in June is attributed to the Northern part of Republic, which is conditioned by the predominance in its South-Eastern part of cyclonic masses penetrated from Black Sea basin (Fig.3).



Fig. 3 – Drought phenomenon's spatial distribution (*a* – May, *b* – June, *c* – July) in year 2007, in South-Eastern Europe (Source: Drought Management Centre from South-Eastern Europe).



Fig. 4 Drought phenomenon's spatial distribution (a - May, b - June, c - July) in year 2007, on Republic of Moldova's territory.

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Cartographical modeling of Republic's data (using software Surfer), specifies SPI's level of intensity (Fig. 4) on Republic's territory. Humidification conditions that are near the norm can be distinguished in June (Fig. 4*b*) in South-Eastern part of Republic, determined mainly by vast amount of precipitations in June, 4th (Fig. 5), the amount that greatly exceeded mean monthly norm (73 mm).



Fig. 5 Cartographical modeling of vast amount of precipitations in June, 4<sup>th</sup>, year 2007 on Republic of Moldova's territory.

Thus, thanks to Regional Geographical Informational Systems new possibilities appear for using and processing of local and regional data from existent informational database. Cartographical modeling of regional data is extremely important, as they can explain climatic risks manifestations in dependence of territorial orographic particularities and specifics of atmospheric circulation. In can be proven by synoptical situation in June 2007, when, on the background of protracted drought period, the cyclonic masses from Black Sea basin have provoked rain showers with a significant amount of precipitations that exceeded essentially monthly climatic norm for the region and have "deregulated" zonality principles in extreme droughts manifestation.

A specific feature of humidification regime for the last years is frequent alternation of "drought-humid" antipodal periods during the year and in their manifestation from year to year.

Thus, if year 2007 was very droughty, year 2008 was characterized by abundant precipitations (Fig.6). The analysis of schematic maps that characterize the aspect of precipitations' spatial distribution in May, June, July 2008 in South-Eastern Europe, not excluding Republic's territory, shows us that rain showers in July in some localities of Northern parts of Republic have amounted more than three climatic norms, which is also confirmed my data modeling for the country (Fig.7).



Fig. 6 Monthly precipitations' spatial distribution (*a* – May, *b* – June, *c* – July) in year 2008, in South-Eastern Europe (Source: Drought Management Centre from South-Eastern Europe).



Fig. 7 Monthly precipitations' spatial distribution (a - May, b - June, c - July) in year 2008, on Republic of Moldova's territory.

### 4. Conclusions

In conclusion we'd like to add, that Geographical Informational Systems, while being a quick instrument that can be used for informational databases with different scale (local, regional or world), and it also reveals frequent manifestations of rain showers and droughts. Frequent alternations of droughts and abundant precipitations that provoke floods shows us that the country's territory in on the edge of substantial climatic changes.

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Institute of Ecology and Geography, Academy of Sciences, Republic of Moldova e-mail: marianedealcov @gmail.com

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#### UTILIZAREA SIG ÎN STUDIUL RISCURILOR CLIMATICE

#### (Rezumat)

Sporirea intensității și frecvenței riscurilor climatice din ultimele decenii necesită utilizarea unei baze informaționale ample de date ce ar putea permite evidențierea adecvată a particularităților regionale de manifestare ale acestora. În acest context, Sistemele Informaționale Geografice, asigură accesarea concomitentă a bazei informaționale de diferit nivel (mondial, regional, local), obținând în mod operativ analiza complexă a riscurilor supuse studiului. Ținând cont de faptul, că riscurile climatice în cele mai dese cazuri pot avea un caracter regional de manifestare, investigațiile propuse prezintă un interes științific deosebit, deoarece acestea pot fi utile în compararea cu studiile efectuate peste hotarele republicii. BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI Publicat de Universitatea Tehnică "Gheorghe Asachi" din Iași Tomul LV (LIX), Fasc. 3, 2009 Secția HIDROTEHNICĂ

## THE IONOSPHERIC IMPACT ON GPS MEASUREMENTS

BY

#### DUMITRU ILIOI, \*GABRIELA BIALI and \*LOREDANA BARGAN

Abstract. This paper analyses the ionospheric effects on GPS signals, how ionospheric refraction varies depending on geographic area and season, and also the influence of the time when observations are made. There will be presented the single layer ionospheric model and the corresponding mapping functions in order to determine the effect of the ionospheric propagation delay on range measurements.

Key words: GPS, ionospheric model, ionospheric propagation.

#### 1. Introduction

The ionosphere represents the part of the atmosphere situated between about 50 km and 1000 km above the Earth's surface. The propagation delay of the GPS signals through the ionosphere depends on the electron content along the signal path and on the frequency used. The influencing parameters for the electron content are mainly the geomagnetic field and the solar activity. Hence, ionospheric refraction varies with geographic location and time. The resulting range error, for GPS signals, can vary from less than 1 m to more than 100 m.

#### 2. The Single Layer Model

The ionosphere can be defined as the part of the high atmosphere where sufficient electrons and ions are present to affect the propagation of radio waves (Davies, 1990; Langley, 1998). The generation of ions and electrons is proportional with the radiation intensity of the sun and to the gas density.

The state of the ionosphere is described by the electron density  $n_e$ , [el/m<sup>3</sup>]. The electron density varies with height as shown in Table 1.

The Electron Density Variation with Height								
Layer	Ι	II	III	IV				
Height domain	[km]	50100	100140	140200	2001000			
Electron density	at day	$10^{8}$	1011	$5 \times 10^{11}$	10 <sup>12</sup>			
$n_e$ , [el/m <sup>3</sup> ]	at night	_	$2 \times 10^{11}$	$5 \times 10^{11}$	$3 \times 10^{11}$			

Table 1The Electron Density Variation with Height

The impact of the state of the ionosphere on the propagation of waves can be characterized by the total number of the electrons ( $\xi$ ), that are included in a column with a cross-sectional area of 1 m<sup>2</sup>, counted along the signal path (*s*), between the satellite (*S*) and the receiver (*P*), and can be written as:

(1) 
$$\xi = \int_{S}^{P} n_{e}(s) \mathrm{d}s \,.$$

In order to simplify the problem, for satellite geodesy one has proposed the single layer model. In this, the total electron content is represented by a spherical layer at the mean ionospheric height, which is at about 400 km, as illustrated in Fig.1.



Fig. 1 – The single layer ionospheric model.

According to (Fig. 1), the zenith angle  $(\check{z})$ , of the ionospheric piercing point (A) by which the signal penetrates the ionosphere layer, is depending on the zenith angle (z) of the point (P) from the Earth's surface and on the height of

the ionosphere layer (*h*) and can be written as follows:

(2) 
$$\sin \check{z} = \frac{r}{r+h} \sin z.$$

The obliquity factor or the mapping function (F), can be defined by the following relation:

(3) 
$$F = \frac{1}{\cos z}.$$

In In (Table 2) there were determined some values for the main geometric elements that characterize the phenomenon of ionospheric refraction and from the analysis of those values one can observe that the effect of ionospheric refraction increases with increasing zenith angle (z).

 
 Table 2

 Obliquity Factor, Zenith Angle and the Distance Between the Observer and the Subionospheric Point

E, [degree]	z, [degree]	ž, [degree]	F	<i>u</i> , [km]
90	0	0	1.00	0
60	30	28	1.13	215
30	60	55	1.73	603
20	70	62	2.14	873
10	80	68	2.66	1,344
5	85	70	2.87	1,712

Table 2 shows that for small elevation angles the total number of the electrons ( $\xi$ ), counted along the signal path, can reach at most three times the value of the total number of the electrons corresponding to the vertical ( $\xi_V$ ), as deducted also from the following relations:

(4) 
$$\xi_V = \xi \cos z \frac{1}{F} \xi.$$

Very important to satellite observations, is the ultraviolet flux emitted by the sun. Regions with highest ionospheric refraction are located up to 15 to 20 degrees on each side of the equator. The electron density is on average 10 to 100 times higher during the day than during the night, as shown in Table 1.

Of particular importance to satellite observations is the change in UV flux emitted by the sun, which occurs after a cycle with a period of approximately 11 years (the last maximum of solar activity occurred in 2000 and the following up will take place in 2011). During maximum solar activity, the signals sent by satellite GPS system can be corrupted very seriously and

accordingly, GPS observations errors will have, in turn, maximum values.

#### 3. The Determination of Ionospheric Refraction Corrections

The propagation of radio waves in a dispersive medium such as the ionosphere, is subject to the laws of physics. Namely, the refractive index  $(n_g)$ , for a group of waves (generated from the overlapping of several different frequency waves), as with the method of measuring the phase codes, can be written, starting from a power series [1], [5] as follows:

(5) 
$$n_g = 1 + Q \frac{n_e}{f^2},$$

while the refractive index  $(n_1)$ , for a single wave (wavelength uniform), such as with the method of measuring the carrier phase is

(6) 
$$n_1 = 1 - Q \frac{n_e}{f^2},$$

where (Q) is a constant that includes the many parameters and has a value of (Q = 40.3) and (f) is the frequency.

Moreover, the total error in determining the pseudorange with the method of measuring the phase codes, due to ionospheric refraction phenomenon has the expression:

(7) 
$$\delta d_{\text{ion, }g} = \int_{S}^{P} (n_g - 1) \mathrm{d}s,$$

and correspondingly, the total error due to the ionospheric refraction in determining the pseudorange with the method of measuring the carrier phase is

(8) 
$$\delta d_{\text{ion},1} = \int_{S}^{P} (n_1 - 1) \, \mathrm{d}s.$$

Substituting (5) and (6) into (7) and (8) respectively, and simplifying, yields

(9) 
$$\delta d_{\text{ion, g}} = \frac{Q}{f^2} \int_{S}^{P} n_e \mathrm{d}s,$$

(10) 
$$\delta d_{\text{ion, 1}} = -\frac{Q}{f^2} \int_{S}^{P} n_e \mathrm{d}s.$$

Hence the range from a code phase observation is measured as too long, and the range from a carrier phase observation is measured as too short.

The unknown integral can be determined by a set of two measurements for the range ( $\rho$ ), namely the ranges ( $\rho_1$ ) and ( $\rho_2$ ), on both frequencies ( $L_1$ ) and ( $L_2$ ), respectively, with:

(11) 
$$\rho = \rho_1 - \delta d_{ion,g}^1; \ \rho = \rho_2 - \delta d_{ion,g}^2$$

By substitution of (9) into (11), it follows that the expression of range correction for code phase measurements on  $(L_1)$ , derived from dual frequency observation is

(12) 
$$\delta d_{ion,g}^{1} = \frac{f_{2}^{2}}{f_{1}^{2} - f_{2}^{2}} (\rho_{2} - \rho_{1})$$

Therefore the ionospheric effect on GPS signals, can be very successfully modeled by dual frequency observations.

#### 4. Conclusions

If only single-frequency receivers are available, the correction due to ionospheric refraction phenomenon is very difficult to determine because it implies an elaborated ionospheric correction model that has to include approximations for the above integral which deals with the total number of the electrons along the path of the GPS signal.

It is hence advisable that for high precision applications to be used only dual frequency equipment. The maximum range errors that can be expected for dual frequency corrected signal is less than 2 cm.

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"Gheorghe Asachi" Technical University of Iaşi, Department of Cadastre email: dilioi@yahoo.com and \* Department of Water improvements and environmental engineering e-mail: gbiali@gmail.com loredana@yahoo.com

#### $R \mathrel{E} \mathrel{F} \mathrel{E} \mathrel{R} \mathrel{E} \mathrel{N} \mathrel{C} \mathrel{E} \mathrel{S}$

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## IMPACTUL IONOSFEREI ASUPRA MĂSURĂTORILOR GPS

#### (Rezumat)

Se analizeaza efectul ionosferei asupra semnalului GPS, modul de variație a refracției ionosferice în funcție de regiunea geografică și de sezon, precum și de ora la care se fac observațiile. Se prezintă modelul stratului unic și parametrii care influențează refracția ionosferică și sunt determinate variațiile refracției ionosferice în funcție de unghiul de oblicitate.

În a doua parte sunt determinate expresiile pentru corecțiile ce trebuie aplicate observațiilor GPS, astfel încât sa fie eliminate erorile datorate fenomenului de refracție ionosferică la măsurarea pseudodistanțelor.

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## MEANS OF SPITAL ANALYSIS APPLIED TO ADMINISTRATIVE UNITS IN THE COUNTY OF CLUJ, WITH THE PURPOSE OF IDENTIFYING COMMUNES WHICH MAY BE PART OF THE METROPOLITAN AREA

#### BY

#### ELENA-MONICA NICOARĂ and IONEL HAIDU

**Abstract.** The study reflects an accessible and objective way of processing and analyzing the contained information in the documentation of urban and regional planning of the County of Cluj in order to obtain a ranking of "capabilities" of the administrative-territorial units, respectively of the central arrangement of the localities. There have been taken into consideration those data which are significant for the studied phenomenon.

As a consequence of the mathematical operations, of the spatial techniques and analysis applied on the database, an appropriate score has been obtained for each administrative-territorial unit. The highest score in an area revealed the existence of a polarizing center – the city of Cluj-Napoca. The scores obtained by the administrative units in the proximity of the poles pointed out the areas of influence.

Key words: GIS, analysis network, administrative-teritorial units.

#### **1. Introduction**

The county of Cluj is part of the North-West Region (Northern Transylvania), which was created based on the law 151/1998 (as amended through the Law 315/2004) through the voluntary association of local public administrations in the counties of Bihor, Bistrita-Năsăud, Cluj, Maramureş, Satu-Mare and Sălaj. It is not an administrative-territorial unit and has no legal personality. The constitution of the region represents the premise of shaping a socio-economic functioning system, as an integrant part of the national macrosystem.

The objective of the study consists in the application of GIS technologies for the investigation and analysis of the network of settlements in the county of Cluj taking into account the identification of the existing polarizing centers in this area.

Polarizing centers are complex systems with areas of influence commensurate with their stage of development. The plans of development drawn up for the micro regions they belong to, must take into consideration the social, cultural, educational, economic progress, the protection and conservation of the values of the archaeological sites and historical monuments, the environmental protection including appropriate plans and measures for the protection of the population and assets against natural risks etc.

In order to identify the polarizing centers in the county we should consider its integration in the system of the North-West Region and to take into account many elements of analysis, such as: the geographical location of settlements, their distribution in the territory according to the main forms of relief, the position towards the main means of communication, the quality of living, the supply facilities, habitable areas, green spaces, housing equipment, the quality of drinking water etc.

To achieve the purposed objective, the following should be established:

a) the election of the entry data and their synthesizing so that they can reflect the analysis of some phenomena, which occur frequently on domains, at county level,

b) the selection of the assessment procedure for domains as well as for the entire process,

c) the application of some operations, methods, techniques and analysis using GIS technology on data, in order to obtain possible polarizing centers and their areas of influence,

d) the establishment of the database and the development of informatics thematic applications.

Outspread on an area of 6674.4 km<sup>2</sup>, Cluj represents 2.8% of the country and occupies the 13th place among the counties in the country, regarding the size. It is situated at the contact of three natural representative units, the Apuseni Mountains, the Someş Plateau and the Plain of Transylvania. One of the important elements in the analysis of the network of settlements is relief. From this point of view, the country of Cluj falls within the administrative units of the country with resources above average.

The systemic function of the North-West Region relies on a network of cities constituted mainly of small and medium-sized cities, which can ensure, through the diversity of their functions, the balance of the territory. Small and medium-sized cities in the region, point out, with insignificant exceptions (Turda – Campia-Turzii, Gherla-Dej) a dissipated currency, which gives them benefits in terms of the outlining of an area of its own polarization. Urban hierarchy has at its top the city of Cluj-Napoca, with economic, cultural and scientific advantages uncontested in the region.

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#### 2. The Single Layer Model

The database was built through vectorising of the topographic maps of the county of Cluj scale 1:100.000, in projection map WGS84 UTM Zone. Layers have been constructed containing overall data corresponding to the studied areas. Alphanumeric data used in this study derive out of the documentations of urban and regional planning existing at the Department of Urban and Territorial Planning (GIS) of Cluj County Council, updated in the light of possibilities, with information from the Regional Department of Statistics Cluj.

From the analysis of the types of data it has been noticed that they generally refer to a territorial limit of a commune or to certain areas with custom extension. Thus, for structuring the database the main goal was the obtaining of two types of layers, one with global values on the administrativeterritorial division of the commune and the other with totalizing values on each custom area representing a given field.

Thematic layers were created in conformity with the pursued phenomenon, for the analysis of the territory of the county: the distribution of population, its density, the migration of labor, the level of education, the endowment with educational establishments and specialized teachers, the endowment with health units and specialized staff , the location of archaeological sites and architectural monuments, the ensuring with utilities of the settlements, the location of natural protected areas, areas of natural risk, the state of viability etc.

The method of summing the scores obtained on the fields was applied for the global assessment. There were three methods for granting scores on the fields. They were chosen so as to distort as little as possible the final result. The first method consisted of granting a score directly proportional to the value obtained. Through the following method, based on the "rule of three" the score has been settled. The third method was applied for example, for the data that relate to the migration of labor. Thus, the value taken into account was positive or negative as the labor force was drawn or not, in the administrative territorial unit.

For example, in a vector type layer under Fig. 1, were concentrated the information on zoning the territory according to the temporary migration of the population, the cultural, educational, architectural and historical value of the area and taking account of the existing facilities. The score given to each area reflects its complexity.

In Fig. 2 is the table with the score for each area of the County of Cluj, according to her profile.

From The Plan for Development of the County of Cluj for the years 2007–2013, drawn up by the "CIVITAS" Foundation Cluj, the Center for Public Policy and a numerous staff of Cluj County Council has taken the index of

development of agriculture and the index for the global development of the economy on the administrative and territorial unit. Separate layers have been constructed, classified according to their degree of development: very small, small, medium, high, very high, maximum. Each class was given a proportionately score.



Fig. 1 – Zoning of the county territory.

	Attrib	utes of prol	Fil			×
	FID	Shape *	Id	profil	punctaj	
	0	Polygon	0	Profil economic periurban intensiv	100	
	1	Polygon	0	Profil economic periurban intensiv	100	
	2	Polygon	0	Profil economic intensiv mixt excedentar	80	1
	3	Polygon	0	Profil economic mixt cu predominarea zootehniei	N 40	
П	4	Polyaon	0	Profil economic local si forestier	hr 20	-
	Re	cord: 🚺 🖣		1 FI Show: All Selected Records (0 out of 14 S	elected)	-

Fig. 2 – The maximum points given to the economic profile within the county.

The functional region (polarized) is defined by the system of relationships established between a center of polarization and the points, the settlements polarized by it. North-West Region is a region with multiple nodes because of the polarization centers with upper rank. These nodal centers are being determined by empirical analysis as well as the development axes connecting the various centers. These centers have polarized functional spaces which are equivalent to the areas of influence. Functional relationships are very fluctuating.

The analysis of the relationships between the regional polarizing center and his sphere of influence allows the establishment of the settlements polarization, the spatial hierarchy which results from different degrees of centralization of the settlements. This analysis must be permanently evaluated due to the changes that occur in space processes.

In The Land Planning Draft of the North-West Region "The network of settlements has been studied in the light of density in the territory, the size and degree of polarization. Contrasting aspects were found between the settlements in the mountain area (with lower density) and those from corridors of the valley or plateau where the index increases. The range of variation of the parameters is extremely large due to implication of other historical, economical or social factors."

This documentation was developed in 2003 by a multidisciplinary team of specialists from the Babes-Bolyai University, the Faculty of Geography. As it results out of this documentation, *11 categories of influence centers* were put in evidence in the North-West region, some of them with urban character and other with rural character. In accordance with this documentation, Cluj-Napoca occupies the second rank in the national hierarchy as a potential of polarization, after the capital city, his influence being manifested over the whole space of Transylvania. It occupies the first place in the region, in the urban hierarchy.

Due to the evolutional transformation and in order to take into consideration the new trends in regional planning which tend to align with those of the European Community, there may be restricted 4 categories of polarizing centers in the North-West:

- 1. Centers of regional importance;
- 2. Balanced role centers in the development of the region;
- 3. Inter-communal centers;
- 4. Communal Centers.

*The centrality* attributed to a polarizing element relates to the property, its quality of possessing an overflow of functions in the area and does not refer to its geographical location. This cannot be measured, but it can be established only on the basis of analysis of indicators made on the basis of rules of calculation.

Based on the analysis of the strategic options for the development of the North-West Region has made an option for a model of *polycentric development* (a development policy sustained by a network of localities with roles of development poles), focused on economical growth through functional specialization of the territory.

In the polycentric development has occurred, thus, the need to strengthen the potential for training of the county's residence, as well as the need to strengthen and/or increase the potential training of a minimum of other cities, which by the end of 2013 can be classified in a rank above the current one. Their development must take into account, especially of the functional and sectional specialization of the territories in the area of influence.

"In the Regional Development of North-West, nine main categories of axes of development are outlined, being grouped into three ranks", according to Land Planning Draft of the North-West Region. In Fig. 3 are presented for the county of Cluj the axes of development.

The axis of development Oradea - Cluj-Napoca (Ib) is the main area for flows of goods, raw materials and passengers and the main vector of crossborder connections. This axis connects the main poles of development, the cities of Cluj-Napoca and Oradea.

The axes of development of second rank develop along Someşul Mic, between Cluj-Napoca and Dej, on Someşul Mare, between Dej and Satu Mare, on Someş, carrying on with Şieu and Bistrița, between the municipalities of Dej and Bistrița. At the same rank, but of a lower class (Ic) falls the axis of development Cluj-Napoca – Zalău – Satu Mare, with the leak to Marghita – Valea lui Mihai.

The axes of development of the third rank penetrate the peripheral sectors at the regional level. They are developing along the railways and the modernized roads, but they have a lower intensity of traffic because of the barriers imposed by the forms of relief.

The class b, from the same rank (3), consists out of the modernized roads in the county, such as the axis of the median section from Plain of Transylvania, Someş Plateau and the eastern sector of the Plopiş Mountains. Axes of rank III, class c, are those of Suplaiului Hills, from the eastern part of the Transylvanian Plain and the Sălaj Hills.



Fig. 3 – The corridors of development in the county of Cluj.

The values are directly proportional with the importance of the rank attributed by experts (Fig. 4).

III Attributes of culoare							
	FID	Shape *	Id	etapa	culoar	punctaj	
Þ	0	Polygon	0	dezvoltare actuala	culoar lb	100	
	1	Polygon	0	dezvoltare actuala	culoar lla	70	
1.5	2	Polygon	0	dezvoltare actuala	culoar llb	60	
	3	Polygon	0	dezvoltare actuala	culoar lla	70	
	4	Polygon	0	dezvoltareactuala	culoar llb	60	
	5	Polygon	0	dezvoltare actuala	culoar lic	50	

Fig. 4 – Scoring for the corridors of development.

The layers resulted from final tests on the domains were managed with the help of two thematic applications. Of those listed above one could see that some partial scores allocated to the studied phenomena refer to an administrative-territorial area and others to areas with different shapes. By applying the mathematical map overlay, a prior step has been made for the final analysis where we obtained a layer with scores that relate to the administrativeterritorial unit and a layer containing the scores given to various areas of different shapes resulting from overlay (Fig. 5).

A layer was created with final scores derived from the algebraic addition of partial scores. It was properly classified and displayed according to the values. A thematic application was created through which totalizing operations had been made. The addition of partial scores for each object (administrative-territorial unit or area) was achieved with the help function "Field Calculator" available in the ArcView 9.1.



Fig. 5 – Scores obtained for each area of interest.

On the above shown map are being particularly highlighted those areas which have been endowed along the analysis with a higher score. Operations, techniques and analysis made on phenomena by using GIS technology, have led to the identification of the four categories of polarizing centers existing in the county of Cluj (Fig. 6).



Fig. 6 – The identification of the polarizing centers in the County of Cluj.

Projects through which the development of the Cluj metropolitan area is being studied, must take into account the current state of area development, all the rules established by documentation of urban and territorial planning developed, including building restrictions on certain areas, protective measures which apply to specific targets or whole places, areas exposed to physical phenomena that generate natural risks.

"The spatial analysis of the influence areas based on gravitational family models, are well-known in quantitative geography, which are inspired by Newton's law of gravity. Gravity models in geography are meant to express the spatial interaction between the same types of attributes located in different places "(I. Haidu, Haidu C., GIS - Spatial Analysis").

In order to study the allocation of localities to the nearest polarizing center, the "Allocation" function available in the package of features for spatial analysis "Spatial Analyst" in the ArcView 9.1., was used.

This operation has been applied on the punctiform layer, specially created for the representation of polarizing centers identified above. "The size of an influence area is defined by the attractivity or the influence that each point detains in the Layer (I. Haidu, Haidu C. "GIS - Spatial Analysis"). The system allocates the cells from raster to the nearest source. Thus, the allocation function identifies with mathematical precision, for each cell which is the nearest polarizing center, in a straight line.

Optionally one can specify a maximum distance to which the search is running. The cells outside the distance will not be taken into account or will receive a No Data value. If this parameter is not specified, then there will be no deadline to which the distance can be measured. In Fig. 7 is presented the outcome.



Fig. 7 – Assigning localities to the identified polarizing.

In order to carry out further tests, such as the temporary migration of labor, are to be applied on the same punctiform layer the functions "Distance" and "Straight Line" from the same menu "Spatial Analyst." The output raster contains distances measured from the center of each cell to the center of the cell, which represents the nearest source.

Thus, according to Fig. 8 through the colored concentric circles, distances are measured in a straight line from each polarizing center to each locality in the county. These results were obtained in an independent thematic application to identify the distances some of the commuters and some students have to cover from the place of residence to the localities where work or study (polarizing centers).

In both cases presented above, Euclidian distances are measured, in units of measure in which the map is being displayed on the screen.



Fig. 8 – Distances from each locality to the nearest polarizing center.

#### **3.** Conclusions

The identification of polarizing centers was done through the use of simple algorithms for granting the score. By the algebraic sum of the partial scores, final score has been obtained.

The scores, obtained by the administrative units out of the vicinity of the poles, highlighted the areas of influence. In the documentation "*The development strategy for the Cluj-Napoca metropolitan area*" elaborated by the company S.C. QUANTUM LEAP S.A. Bucharest, the same administrative-territorial units were bounded to take part in the influence area of the first rank pole – the city of Cluj-Napoca.

The mathematical modeling of the analysis processes helps and supports the classical work of analysis of the experts, but it cannot replace it. The mathematical results carried out on the data are rigorous, without human influence, but we should not forget that the computer modeling process depends on the professional performance of the one who perform it.

The presented study is a modest example of analysis which may be performed with geographical information systems and was conducted in order to find an accessible mathematical support for classical analysis. In particular, the work was carried out so as, to incite and to prove to experts in the field of urban and territorial planning that the thoroughgoing study of the computer science is not necessary so that in the current activity they can be assisted by a geographic information system. This simple procedure of granting scores was designed for the particular case of the county of Cluj. It can be applied to other territories as well, but of course that a complete analysis is required because, certainly there are particular developments of the phenomena in those areas.

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*Cluj County Councili, email:* monica.nicoara@cjcluj.ro

#### $R \mathrel{E} F \mathrel{E} R \mathrel{E} N \mathrel{C} \mathrel{E} S$

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#### PROCEDEE DE ANALIZĂ SPAȚIALĂ APLICATE UNITĂȚILOR ADMINISTRATIV - TERITORIALE DIN JUDEȚUL CLUJ, CU SCOPUL IDENTIFICĂRII COMUNELOR CARE POT FACE PARTE DIN ZONA METROPOLITANĂ

#### (Rezumat)

Se prezintă un mod accesibil și obiectiv de prelucrare și analiză a informațiilor conținute în documentațiile de urbanism și amenajare teritoriului județului Cluj pentru obținerea unei ierarhizări a "capabilităților" unităților administrativ-teritoriale, respectiv a centralității localităților. S-au luat în considerare acele date care sunt semnificative pentru fenomenul studiat.

În urma operațiilor matematice, tehnicilor și analizelor spațiale aplicate asupra bazei de date s-a obținut un punctaj corespunzător fiecărei unități administrativteritoriale. Punctajul cel mai mare dintr-o zonă a evidențiat existența unui centru polarizator – municipiul Cluj-Napoca. Punctajele obținute de către unitățile administrative din vecinătatea polilor au pus în evidență ariile de influență.

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## THE IDENTIFICATION OF PRECIPITATIONS DISTRIBUTION'S REGIONAL PARTICULARITIES USING INFORMATIONAL TECHNOLOGIES

#### BY

#### TATIANA CONSTANTINOV, VALENTIN RĂILEANU and OLGA CRIVOVA

Abstract. Using the database of monthly precipitations registered at 15 meteorological stations in Republic of Moldova in 1961–2005, and these stations characteristics, there were obtained the regression equations of precipitations with relief and geographical location as parameters. On the basis of these equations and Digital Terrain Model we have obtained annual, seasonal and warm period's precipitations' digital maps using GIS technologies.

Key words: .

#### 1. Introduction

The quantity of precipitations conditions cultural plants development. Republic of Moldova, being mostly an agricultural country, needs concrete data on precipitations distribution in multiyear aspect for the whole territory. But data registered at meteorological stations does not reflect real situation on the areas situated between these stations. Traditional methods of spatial interpolation have an insufficient accuracy. Together with appearance of high calculation technologies and Geographical Information Systems (GIS) [1], the possibility for modeling the distribution of various climatic indexes for the vast areas, considering relief's influence on them, geographical position and data registered on meteorological stations, also appeared. One of the well-known methods of spatial interpolation uses regression equations that can be obtained using data registered on meteorological stations, relief's particularities and station's geographical position. The goal was to obtain digital maps showing precipitation's spatial distribution for the whole Republic's territory for various time periods.

#### 2. Materials and Methods

The most progressive methods of study known in the country and abroad were used for investigations, including new technologies of data processing such as STATGRAPHICS software and Geographic Information System ArcView.

The whole database that was meant to be used for creating these maps was actualized by being supplemented with data not only for the basic time period (yeas 1961–1990 according to WMO), but also with information for years 1991–2005, so that climatical indexes' ranges (of precipitations) include an interval of 45 years. From the dataset for 17 meteorological stations situated on Republic of Moldova's territory, we have selected 15 stations, keeping in mind that some them do not have complete data range, or where situated in different places in the period in question. Meteorological stations particularities are shown in Table 1.

Meleorological Stations I articularities								
Meteoro-	Absolute	Relative			X	Y		
logical	altitude	altitude	Slope	Aspect	coordi-	coordi-		
stations					nates	nates		
Bălțata	79.0	37.0	1.5	135	654700	5213401		
Bălți	102.0	12.0	0.5	180	571323	5291731		
Bravicea	78.0	12.0	5.5	225	608561	5247618		
Briceni	242.0	14.8	1.0	135	505111	5356205		
Cahul	196.0	116.0	0.0	0	597743	5078597		
Camenca	154.0	0.0	0.0	0	626697	5322811		
Chişinău	173.0	103.0	0.5	0	641189	5203169		
Comrat	133.0	88.0	0.5	135	625678	5129008		
Cornești	232.0	132.0	5.5	225	575117	5247096		
Dubăsari	41.7	26.9	4.0	225	661081	5238591		
Fălești	161.5	80.0	0.5	180	553239	5270086		
Leova	156.0	136.8	0.5	0	598545	5149071		
Rîbnița	119.0	79.0	1.5	90	653221	5292762		
Soroca	173.0	129.4	1.0	135	597565	5339252		
Tiraspol	20.9	16.0	0.0	225	701873	5189675		

 Table 1

 Meteorological Stations Particularities

Precipitations sums registered at meteorological stations are shown in Table 2.

Mean Values of Precipitations Registered at Meteorological Stations								
Meteorological stations	Annual	Spring	Summer	Autumn	Winter			
Bălțata	519.41	116.95	192.00	115.91	94.54			
Bălți	526.47	119.02	211.23	111.17	85.04			
Bravicea	600.13	138.41	220.21	131.78	109.71			
Briceni	621.97	150.04	238.45	126.52	106.95			
Cahul	543.32	125.80	194.95	120.50	102.06			
Camenca	545.47	121.65	216.26	115.93	91.63			
Chişinău	555.19	126.69	189.69	127.67	111.13			
Comrat	513.37	121.89	176.82	113.15	101.50			
Cornești	651.82	153.95	238.26	143.08	116.52			
Dubăsari	526.32	119.58	186.02	115.82	104.89			
Fălești	577.45	130.91	223.71	127.02	95.80			
Leova	532.06	125.06	186.17	123.97	96.84			
Ribnița	525.43	116.39	201.39	114.97	92.67			
Soroca	574.56	128.91	218.00	123.65	104.00			
Tiraspol	508.39	112.19	182.58	113.04	100.56			

Table 2

General model of multiple regressions can be expressed by formula [2]:

(1) 
$$y = a + \sum_{i=1}^{n} b_i x_i \pm \varepsilon,$$

where y is dependent variable,  $x_i$  – independent variables, n – number of independent variables, a – constant term,  $b_i$  – coefficients of partial regression. Standard error dependent variable estimation  $\varepsilon$  represents residuals' standard deviation and is expressed by formula

(2) 
$$\varepsilon = S_y \sqrt{1 - R^2},$$

where  $S_v$  is standard deviation of the variable y.  $R^2 = r^2 * 100\%$  is coefficient of multiple determination, and r – multiple correlation coefficient. The other parameters that characterize regressional model are P value and mean absolute error MAE. P value is a measure of model's significance. For P < 0.01 the confidence level is d > 99%, for P < 0.05 the confidence level is d > 95%, and for P < 0.1 the confidence level is d > 90%.

#### 3. Obtained Results

The results of regressional analysis are shown in Tables 3 and 4.

	-	of Mean	n Precipitatio	ons	-			
Timo	Coefficients of partial regression for independent variables							
noriod		-	P valu	e				
period	Ah	$A\Delta h$	As	Ay	Constant C			
Winter		0.0689175	2.54403	0.0000176724				
WIIItei	—	0.0808	0.0224	0.0000	_			
Spring	0.138469		<u>3.56955</u>	0.0000196215				
Spring	0.0000	—	0.0002	0.0000	_			
Summor			<u>3.4059</u>	0.000147148	-593.006			
Summer		—	0.0302	0.0010	0.0055			
Autumn	0.0842893		2.84434	0.0000201859				
Autumn	0.0020	_	0.0020	0.0000	_			
Warm	0.389581		<u>9.97834</u>	0.00015146	-408.235			
period	0.0001	—	0.0010	0.0175	0.1760			
Annual	0.450879		13.1234	0.0000903321				
Annual	0.0000	_	0.0001	0.0000	_			

Table 3

Regression Equation Parameters  $P = Ah^*H + A\Delta h^*\Delta H + Au^*S + Ay^*Y + C$ of Mean Precipitations

Note: h – absolute altitude, [m];  $\Delta h$  – relative altitude, [m]; s – slope, [degree]; y – latitude, expressed in meters in Transverse Mercator WGS84 projection with Central Meridian equal to  $27^{0}$  and False Esting equal to 500000m.

Frecipitations Regressional Models									
Time period	Model's P value	R, [%]	R adjusted %	Standard error of estimation, [%]	Mean absolute error, [%]				
Winter	0.0000	99.6	99.6	6.9	5.1				
Spring	0.0000	99.9	99.9	4.9	3.4				
Summer	0.0002	82.2	77.4	9.6	7.1				
Autumn	0.0000	99.9	99.8	5.1	4.1				
Warm period	0.0000	86.2	82.4	15.7	10.8				
Annual	0.0000	99.9	99.9	17.0	12.0				

 Table 4

 Statistical Parameters Showing the Verisimilitude of Mean

 Precipitations' Regressional Models

Precipitations' regressional models for summer and warm period have as independent variables absolute altitude h, slope s, latitude y and constant term; for spring, autumn and annual -h, s, and y; for winter relative altitude  $\Delta h$ , s and y. P values for independent variables vary within the limits of 0.0000 and 0.0302, which corresponds to the confidence level no less than 95% (Table 3). In all time periods P values of all models are no bigger than 0.0002, which corresponds to the confidence level bigger than 99% (Table 3).

Precipitations digital maps for various time periods were elaborated by GIS ArcGIS, using digital terrain model and corresponding regressional models (Figs. 1,...,6).



Fig. 1 – Spring precipitations, [mm].



Fig. 3 - Autummn precipitations, [mm].



Fig 2. – Summer precipitations, [mm].



Fig. 4 – Winter precipitations, [mm].



period,[mm].

Fig. 6 – Annual precipitations, [mm].

#### **3.** Conclusions

1. Regressional models and Informational Geographical Systems usage allowed elaborating digital maps of precipitations distribution for the whole Republic's territory with a high accuracy;

2. Atmospherical precipitations quantity varies in various time periods and in different landscape regions: spring – within the limits of 100 and 200 mm, summer – within the limits of 150 and 290 mm, autumn – within the limits of 100 and 180 mm, winter – within the limits of 85 and 185 mm, warm period – within the limits of 350 and 700 mm, and annual within the limits of 460 and 830 mm;

3. The highest quantity of precipitations falls on Central Moldavian Plateau, Northern Moldavian Plateau, Dniester Plateau and less on Tigheci Hills.

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Institute of Ecology and Geography Academy of Sciences of Moldova email: valentin\_rln@yahoo.com

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#### EVIDENȚIEREA PARTICULARITĂȚILOR REGIONALE DE DISTRIBUȚIE A PRECIPITAȚIILOR ATMOSFERICE PRIN INTERMDIUL TEHNOLOGIILOR INFORMAȚIONALE

#### (Rezumat)

Utilizând baza de date a precipitațiilor atmosferice lunare, înregistrate la 15 stații meteorologice din Republica Moldova în anii 1961–2005, și caracteristicile acestor stații, au fost obținute ecuațiile de regresie a precipitațiilor cu parametrii reliefului și locația geografică. În baza acestor ecuații și a modelului numeric al terenului au fost obținute prin intermediul GIS hărțile digitale ale precipitațiilor atmosferice în aspect anual și sezonier și în perioada caldă a anului.

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## STUDY CONCERNING THE EVOLUTION OF NITRATE CONCENTRATION IN GROUNDWATER BY MEANS OF GIS TECHNIC

#### BY

#### **IRINA MOROZAN and GABRIELA BIALI**

**Abstract.** In the present paper, we try to emphasize the increase of the content of nitrates and nitrites from the underground waters, in direct correlation with the manner of exploitation of agricultural lands and implicitly the levigated quantity of azoth, using the modeling method through the GIS technique.

Both the physical pollution through processes such as: hydric or wind erosion, the destructuring, compacting etc.) and chemical pollution through the alluvial transport with significant pesticide quantities, contribute in this manner even more to sensitizing, favoring and emphasizing the degradation of the quality of underground waters, considered as being "the last hope of drinkable water".

Key words: underground waters, model MNT, software Surfer, GIS.

#### **1. Introduction**

The activity of studying groundwater quality is carried out at the level of large water basins, according to morphological units and within these units according to aquifer structures (underground), by means of hydrogeological stations, including one or more *drillings for observation*.

The most probable causes for which phreatic water does not meet the requirements for drinkable water are:

a) pollution of surface water;

b) hydrogeochemical natural conditions and processes which favor the contamination with various anions and cations;

c) the boom of agriculture during last decades and the excessive use of pesticides, chemical fertilizers with nitrogen and phosphorous as main components determined the accumulation of some of these substances (or their decomposition products) in the soil;

d) the outcomes of the lack of responsibility of former large animal farms with respect to environment preservation measures;

e) climatic, hydrogeological features and the use of irrigation systems which brought about the mineralization of organic matter of soil and the migration of substances resulting from these processes.

A special issue connected to groundwater quality is its nitrate (nitrogen-NO<sub>3</sub>) contents.

The quality of groundwater is considered suitable if its quality indices are comprised within the maximal allowed concentration, enforced under Water Law 410/2002 amended and completed by Law 311/2004.

The main sources of nutrient collection are direct spills from agriculture, leakages and erosion and also the effluents of water treatment plants. It is anticipated that most nutrient uptake is due to agricultural sources (wide sources).

The widespread pollution caused by agricultural land is still the main source of nitrate content in water. Nitrates continue to bring about damages to the environment, determining the eutrophication of coastal and sea waters and the pollution of drinkable water, especially in those areas where groundwater was polluted.

Groundwater is drinkable provided that the value of  $NO_3$  index should be below the maximal allowed concentration enforced through the Water Law ( $NO_3$ -50 mg/l).

#### 2. Case Study

The groundwater of Prut river basin is blocked within porous permeable deposits from the Quaternary and Tertiary period which are on top of even older formations from Cretaceous, Silurian and even Pre-silurian, lying at various depths, but due to climatic conditions and on account of these layers, it has a decreased flow and a high content of salts.

The groundwater from Moldovenesti platform, as far as their natural possibilities of drainage are concerned, in particular their connection to surface waters, are: under pressure (in depth) and phreatic (free).

In the case of Prut river basin, its groundwater is caught in the sandy deposits from the Quaternary period, with clay intertwining of minor hydrogeological significance and gypseous soils. In this context, the water which may be used is found in the river meadow, in poorly permeable and sulphated reserves. Generally speaking, the water is highly sulphated mineralized and hard, and it has a low flow.



Fig. 1 – Locations of hydrogeological stations in Jassy county.

#### 3. Creation of 2D and 3D Information/Thematic Layers About the Distribution of Nitrate Concentrations

As input data we used the nitrate concentrations, determined in the Water Quality Laboratory of Prut Water Department. The tests were conducted on samples of water taken from 23 observation drillings (located through STEREO 70 coordinates) belonging to the National System of Supervision of groundwater quality.

As their assessment is performed by taking water samples from a limited number of drillings which are randomly distributed throughout the territory, only specific data are gathered [1].

Starting from a small number of drillings and respectively, samples, it is only possible to approximate the nitrate concentration throughout the studied territory and it is difficult to develop the most accurate response within due time [2].

This hindrance may be overcome by using a field numerical model based on the spatial design technique.

As drillings are distributed in an ordinate or inordinate area, we can speak about a network pattern or an irregular pattern (triangular). In the network pattern (profile positioning) points coincide with the intersections of a regular grid. Starting from these basic data, nitrate concentration are represented (in my application) in MNT and are usually derived through interpolation. I used the *Surfer* software for this GIS (Figs. 3,...,6).

STEREO 70 Coordinates								
forajul \ anul	IND	Х	Y	2001	2002	2003	2004	
cma				50	50	50	50	
BELCESTI	F1	655584,86	647280,55	1,25	1,05	1,23	1,25	
BELCESTI	F2	655268,52	646983,47	1,16	1,02	0,89	0,34	
BELCESTI	F3	656677,43	646328,63	0,24	0,23	0,20	4,00	
BELCESTI	F4	656776,64	646943,79	1,05	0,85	0,50	0,24	
CIRNICENI	F1	696082,46	653053,35	0,200	1,20	49,70	2,00	
CIRNICENI	F2	693880,40	653097,63	4,000	3,60	25,70	4,70	
CIRNICENI	F3	690868,40	653521,56	0,200	16,00	14,20	4,30	
CIRNICENI	F5	691156,98	650027,41	1,400	23,30	33,92	5,80	
TIBANESTI	F1	679970.07	602429.76	4	14,6	2,77	8	
COSTULENI	F1	720455,61	622856,79	0,42	1,10	0,20	1,10	
COSTULENI	F2	720268,28	622351,86	1,800	23,50	8,10	1,20	
COSTULENI	F3	718504,04	620906,76	1,900	11,40	0,70	4,80	
COTNARI	F2	650091,06	652419,80	23,620	21,25	18,45	16,23	
COTNARI	F1	649598,92	652002,57	34,62	31,45	23,30	20,23	
CRISTESTI	F1	710883,97	637421,06	0,60	137,00	2,00	3,60	
CRISTESTI	F4	707342,91	635030,61	0,140	5,90	3,80	0,00	
CRISTESTI	F5	706655,71	634513,03	1,000	2,10	74,00	1,30	
GLAVANESTI	F2	670076,06	674120,69	192,00	180,00	156,00	142,00	
GLAVANESTI	F1	670598,61	674722,62	184,00	167,00	135,00	121,00	
HIRLAU	F1	646222,34	658591,02	1,400	8,00	4,74	3,10	
IASI	F8	711030,51	631622,38	2,800	6,20	2,09	1,80	
IASI	F9	711466,72	634677,51	17,800	3,30	2,04	11,00	
TG. FRUMOS	F1	668622.48	656541.32	31.76	23.87	18.78	12.00	

 Table 1

 Nitrate Concentration [mg/l] in Observation Drillings Located through

 STEREO 70 Coordinates

From the 12 methods of interpolation provided by the Surfer software I chose to study the evolution of nitrate content of groundwater through Inverse Distance to a Power interpolation method (Fig. 2).

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Fig. 2 – Surfer software detail - the election of the interpolation method and determining the size of the pixel.



Fig. 3 – Thematic layer for the distribution of nitrate concentration in the studied territory in 2001- 2D representation with isolines and 3D representation.



Fig. 4 - Thematic layer for the distribution of nitrate concentration in the studied territory in 2002- 2D representation with isolines and 3D representation.



Fig. 5 - Thematic layer for the distribution of nitrate concentration in the studied territory in 2002 2003- 2D representation with isolines and 3D representation.



Fig. 6 – Thematic layer for the distribution of nitrate concentration in the studied territory in 2002 2004- 2D representation with isolines and 3D representation.

#### 4. Results Obtained

Starting from the values of concentrations determined in the laboratory based on water samples from 23 drillings, after the interpolation, the concentrations are obtained in 7300 points, namely in the centre of each cell; the sizes of a cell are  $750 \times 748 \text{ m}$  (Fig. 7).

Cell configuration file is view in next figure:

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X Direction: 646222.3382	720472.3382	750	100 🗧					
Y Direction: 620906.7589	674762.7589	748	73 🕂					

Fig. 7 – Raster points for nitrate concentration, determined by means of an interpolation method.

This table shows nitrate concentration in all raster points (located through X and Y coordinates) after interpolation, each point lying in the centre of a cell (there are 7300 cells).

		minute Co		<i>ijiei mierpol</i> u	11011	
No.	X	Y	NO <sup>3-</sup> Concentr. (mg/l) in 2001	NO <sup>3-</sup> Concentr. (mg/l) in 2002	NO <sup>3-</sup> Concentr. (mg/l) in 2003	NO <sup>3-</sup> Concentr. (mg/l) in 2004
1	646222,3382	620906,7589	16,17952	19,24192	16,675	11,55797
2	646972,3382	620906,7589	16,08686	19,17712	16,63255	11,49925
3	647722,3382	620906,7589	15,99721	19,11885	16,59633	11,44293
4	648472,3382	620906,7589	15,9108	19,06755	16,56675	11,38918
5	649222,3382	620906,7589	15,82788	19,02363	16,5442	11,33817
6	649972,3382	620906,7589	15,74864	18,9875	16,52902	11,29004
7	650722,3382	620906,7589	15,67325	18,95951	16,52157	11,2449
8	651472,3382	620906,7589	15,60186	18,94001	16,52214	11,20285
9	652222,3382	620906,7589	15,53455	18,92928	16,53101	11,16396
10	652972,3382	620906,7589	15,47135	18,92754	16,5484	11,12825
11	653722,3382	620906,7589	15,41226	18,93498	16,57447	11,09571
12	654472,3382	620906,7589	15,35718	18,95171	16,60934	11,06632
13	655222,3382	620906,7589	15,30598	18,97776	16,65306	11,03997
14	655972,3382	620906,7589	15,25844	19,01309	16,70562	11,01653
15	656722,3382	620906,7589	15,21428	19,05758	16,76692	10,99584
16	657472,3382	620906,7589	15,17317	19,11105	16,83681	10,97767
17	658222,3382	620906,7589	15,13467	19,1732	16,91505	10,96175
18	658972,3382	620906,7589	15,09831	19,24367	17,00133	10,94777
19	659722,3382	620906,7589	15,06356	19,32203	17,09525	10,93539
20	660472,3382	620906,7589	15,0298	19,40774	17,19636	10,92422
21	661222,3382	620906,7589	14,99641	19,50022	17,30413	10,91383
5558	688972,3382	2 662046,7589	15,95078	24,04477	29,7809	13,40612
5559	689722,3382	2 662046,7589	14,86097	23,05962	29,45053	12,69925
5560	690472,3382	2 662046,7589	13,92659	22,18294	29,22894	12,08535
5561	691222,3382	2 662046,7589	13,13598	21,4103	29,10774	11,55761
			•			•
7296	717472,3382	2 674762,7589	19,25596	30,50307	28,28761	14,76395
7297	718222,3382	2 674762,7589	19,10263	30,45878	28,08463	14,64813
7298	718972,3382	2 674762,7589	18,95717	30,41723	27,88771	14,53786
7299	719722,3382	2 674762,7589	18,81914	30,37794	27,69672	14,43284
7300	720472,3382	2 674762,7589	18,68811	30,34048	27,51157	14,33281

 Table 2

 Nitrate Concentration after Interpolation

## 5. Interpretation of Results

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	A	В	С	D	E	F	G	Н	I	J	K	L
1	646222,34	620906,76	19,241923		1997							
2	646972,34	620906,76	19,177124									
3	647722,34	620906,76	19,118854			2						
4	648472,34	620906,76	19,067549									
5	649222,34	620906,76	19,023630									
6	649972,34	620906,76	18,987495									
7	650722,34	620906,76	18,959512									
8	651472,34	620906,76	18,940010									
9	652222,34	620906,76	18,929276				Save As					2 🗙
10	652972,34	620906,76	18,927542									
11	653722,34	620906,76	18,934984				Save in: 🗀	irina doc		-	+ 🗈 🍙	<u>*</u> ⊞ ▼
12	654472,34	620906,76	18,951709			- 2				16		
13	655222,34	620906,76	18,977757				2000					
14	655972,34	620906,76	19,013088				2002					
15	656722,34	620906,76	19,057585									
16	657472,34	620906,76	19,111050									
17	658222,34	620906,76	19,173201									
18	658972,34	620906,76	19,243675									
19	659722,34	620906,76	19,322028			2						
20	660472,34	620906,76	19,407741									
21	661222,34	620906,76	19,500222				File name:	2002				Save
22	661972,34	620906,76	19,598816									
23	662722,34	620906,76	19,702809				Save as type:	Golden Soft	ware Data (*.da	at)	•	Cancel
24	663472,34	620906,76	19,811440				_	Excel Sprea	idsheet (*.xls)			
25	664222,34	620906,76	19,923907					Microsoft Sh	/LK (*.slk)	. ( <sup>8</sup> )		
26	664972,34	620906,76	20,039380					-ASCII Data	iarateo variable: (* txt)	s[.CSV]		
27	665722,34	620906,76	20,157012			2		Golden Soft	ware Data (*.da	t)		
28	666472,34	620906,76	20,275946			-		Atlas Bound	lary (*.bna)	×		
29	667222,34	620906,76	20,395331					Luolden Soft	ware Blanking (	".Dinj		

Fig. 8 - Surfer software detail - save of results obtained.

Results Columna Interpretation Of Results									
Range of values for nitrate concentrations	Year 2001 %	Year 2002 %	Year 2003 %	Year 2004 %					
010	37.12	5.30	9.78	50.36					
1020	38.99	31.85	29.27	33.67					
2030	7.44	38.82	39.66	5.40					
3040	4.79	9.88	10.32	3.01					
4050	2.64	4.07	3.33	1.93					
> 50	9.01	10.07	7.64	5.63					

 Table 3

 Results Obtained And Interpretation Of Results









Fig. 9 – Distribution of concentrations in 2001–2004 years.

#### **3.** Conclusions

Based on the collected and systematized information, Action Programmes are developed and tailored for each location. The Action Programmes comprise the following:

1° compliance with the provisions of the Code of good agricultural practices in the areas vulnerable to nitrate pollution;

2° compliance with the periods of organic fertilizers' ban due to frost;

3° study of the type of houses and farms to be monitored and to which the Nutrient Management Plan will be applied;

4° compliance with distances from water sources for health protection when animal farms, stables and manure storehouses are built;

5° keeping records of the number of animals grazing on local pastures;

6° indicating the area of the lands that provide the best conditions for waste deposit platforms;

7° educational health programmes for the information of the population about the methods of protecting individual and collective water sources.

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"Gheorghe Asachi "Technical University of Iaşi Department of Water Improvements and Environmental Engineering email: irivictor@yahoo.com gbiali@yahoo.com

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#### STUDIUL EVOLUȚIEI CONCENTRAȚIEI DE NITRAȚI ÎN APELE SUBTERANE PE BAZA TEHNICII GIS

#### (Rezumat)

Poluarea solului reprezintă în procesul de evaluare/bonitare a terenurilor agricole, un factor/indicator deosebit de important mai ales atunci când sunt depășite anumite valori ale concentrației ce diminuează semnificativ fertilitatea solului. Principalele metale grele care se găsesc în soluri sunt: Pb, Zn, Cu, Cd, Ni, Cr, As, Bo, Co etc. iar printre sursele de proveniență se enumeră și depozitele de steril și reziduurile de la industria minieră.

În contextul celor de mai sus, în prezenta lucrare se fac referiri la posibilitatea evaluării spațiale și temporale cât mai exacte a acestui tip de poluare, prin crearea unui strat informațional specific poluării cu mai multe metale grele concomitent pe același teritoriu, în vederea integrării lui în pachetul de cca. 18 indicatori luați in considerare în acțiunea complexă de bonitare folosită curent în România.

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