# THE SCS-CN MODEL ASSISTED BY G.I.S. - ALTERNATIVE ESTIMATION OF THE HYDRIC RUNOFF IN REAL TIME

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**ABSTRACT**
In this study is presented and tested a model of hydric runoff estimation (SCS-CN), based on the calculus relation of hydric balance, in which the analysis of parameters that compose the equation of the model is performed using G.I.S. An indirect estimation method of quantity of water subject to surface flow is described, in certain pluviometrical conditions, the main purpose being the realtime forecasting of the possible hydrological hazards.

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## 1. INTRODUCTION

The purpose of this study is to present a method of hydric runoff evaluation which takes into account the antecedent soil moisture.

SCS-CN (Soil Conservation Curve Number) is a model through which we can estimate the runoff water quantity (in mm) in a watershed or on a portion of watershed (side, interbasinal surfaces, river bed or a territory).

This model is based on the calculus relation of hydric balance and it uses, in order to determine the runoff water quantity, the information about: pedogeographical characteristics (texture, structure, permeability, the capacity of water retention, antecedent soil moisture); fitogeographical characteristics (afforestation, arborescent association, capacity of water retention of crowning etc.); hydrological conditions; meteorological conditions (rainfall, snow, the temperature used in the evaporation process etc.)

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## 2. METHODOLOGY

The SCS-CN model is based on the relation:

$$Q = \frac{(P - 0{,}2S)^2}{(P + 0{,}8S)} \quad , \quad \text{if } P \geq 0{,}2S \qquad \textit{(relation no.1)}$$

$$\text{if } P < 0{,}2S, \text{ then } Q = 0$$

-Where: - Q – runoff depth;
- P – precipitations (rainfall and snow);
- S – potential retention;

The estimation of water retention parameters is done applying the next relation:

$$S = \frac{1000}{CN} - 10$$ (having water quantity expressed in inches);

$$S = \frac{25.400}{CN} - 254$$ (having water quantity expressed in mm)

- Where: - CN = f (soil, vegetation, development soil, land use, soil moisture conditions)

Estimation of CN (**C**urve **N**umber) index is realised by:

a) Dividing the soils in four classes or pedological groups depending on the capacity of water infiltration: **A** – high capacity (>7,62 mm), specific to loam-clay texture soils, rate; **B** – medium capacity (3,81-7,62 mm), that characterizes the loamy and loamy-sandy texture soils; **C** – low capacity (1,27-3,81 mm), specific to loam-clay texture soils; **D** – very low capacity (0-1,27 mm), specific to loam-clay and clay-loamy texture);

b) Specific values are assigned to each of those classes, with respect to land use, spatial organizing of each type of land use (row, contour lines and platforms) and hydrological conditions. A conversion of qualitative information to alphanumeric quantitative information (Table 1) was performed.

For soil moisture conditions - a very important factor determining the infiltration speed - we take into estimation AMC indices (**A**ntecedent **M**oisture **C**onditions), depending on the quantity of precipitation fall in the last 5 days: **AMC I** – dry soil conditions, specific to precipitations < 12.7 mm, in the dry season, and < 35.6 mm, in the wet season.

***Determine CN index depending on hydrological conditions of the vegetation and soils*** *(Source: USDA-SCS, 1972)*

**Table 1**

| **Land use** | **Organization land use** | **Hydrological conditions** | **Hydrological Soil Group (HGS)** | | | |
|---|---|---|---|---|---|---|
| | | | **A** | **B** | **C** | **D** |
| Not used | - | - | 77 | 86 | 91 | 94 |
| Croplands | Rows | Poor | 72 | 91 | 88 | 91 |
| | | Good | 67 | 78 | 85 | 89 |
| | Contour lines | Poor | 70 | 79 | 84 | 88 |
| | | Good | 65 | 75 | 82 | 86 |
| | Platforms | Poor | 66 | 74 | 80 | 82 |
| | | Good | 62 | 71 | 78 | 81 |
| Grains | Rows | Poor | 65 | 76 | 84 | 88 |
| | | Good | 63 | 75 | 83 | 87 |
| | Contour lines | Poor | 63 | 74 | 82 | 85 |
| | | Good | 61 | 73 | 81 | 84 |
| | Platforms | Poor | 61 | 72 | 79 | 82 |
| | | Good | 59 | 70 | 78 | 81 |
| Grassland/vegetables | Rows | Poor | 66 | 77 | 85 | 89 |
| | | Good | 58 | 72 | 81 | 85 |
| | Contour lines | Poor | 64 | 75 | 83 | 85 |
| | | Good | 55 | 69 | 78 | 83 |
| | Platforms | Poor | 63 | 73 | 80 | 83 |
| | | Good | 51 | 67 | 76 | 80 |
| Pasture | - | Poor | 68 | 79 | 86 | 89 |
| | - | Fair | 49 | 69 | 79 | 84 |
| | - | Good | 39 | 61 | 74 | 80 |
| | Contour lines | Poor | 47 | 67 | 81 | 88 |
| | - | Fair | 25 | 59 | 75 | 83 |
| | - | Good | 6 | 35 | 70 | 79 |
| Hay field | - | Good | 30 | 58 | 71 | 78 |
| Forest | - | Poor | 45 | 66 | 77 | 83 |
| | - | Fair | 36 | 60 | 73 | 79 |
| | - | Good | 25 | 55 | 70 | 77 |

**AMC II** – normal soil moisture conditions, specific to the precipitations of 12.7 – 28 mm in the dry season, respective 35.6 – 53.4 mm in the wet season; **AMC III** – saturated soil conditions, specific to the precipitations > 28 mm, in dry season, respective > 53.4 mm, in wet season. Usually, there are the AMC II indices (Table 1) to take into calculus, depending on each case, taking place an adjustment of CN with AMC I, and/or AMC III indices (Table 2). These indices were also used for analysis of hydric balance in West Charpatian lakes (Man T., Alexe M. 2006).

***Adjusted CN index***

(Source: USDA, 1972) **Table 2**

| **CN** for **AMC II** | Adjust **CN** | |
|---|---|---|
| | **AMC I** | **AMC III** |
| 100 | 100 | 100 |
| 95 | 87 | 98 |
| 90 | 78 | 96 |
| 85 | 70 | 94 |
| 80 | 63 | 91 |
| 75 | 57 | 88 |
| 70 | 51 | 85 |
| 65 | 45 | 82 |
| 60 | 40 | 78 |
| 55 | 35 | 74 |
| 50 | 31 | 70 |

### 2.1. Methodology using G.I.S. technology

The parameters which are included in the calculus of the hydric volume entered in the basin system can be customized and computed, successfully, by using the G.I.S. techniques. So, some steps had to be followed:

▪ *the creation of a vegetation and land use layer* (by digitizing) from the maps on different scales or from other sources: ex. CORINE Landcover, information obtained by using GPS techniques etc.;

▪ *the creation of a soils layer*;

▪ *intersection of these layers*: the land use and soils distribution layers. In order to perform this operation the XTools extension has to be installed.Finally the result will be a map enclosing either the land use characteristics, or the pedogeographical characteristics of the analyzed territory;

▪ the estimation of the CN index for each type of soil, using the correlation table presented below (Table 1) and the assignment of these values in the attributes table specific to the layer resulted after the intersection;

▪ the estimation of the retention parameters (S) and of the runoff water volume (Q), taking into account the quantitative characteristics of the precipitation, using the **F**ield **C**alculator function.

## 3. APPLICATION

Following the described work methodology, we conucted a test of the model in the Hydrographical Basin of Valea Mare. The layers for the soil hydrological groups and land use (Fig.1), having as primary data base topographic maps 1:100.000 and pedological maps 1: 200.000 were composed.

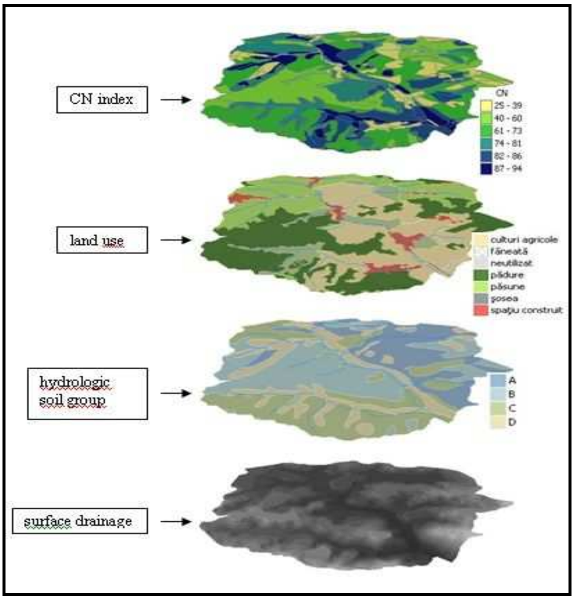



**Fig. 1** ***Necessary layers for the estimation of runoff***

The establishment of the soil hydrological groups is based on the analysis of some parameters as: texture, infiltration and retention capacity of each pedological entity.

The different land use types have consequences in the majority of the surface hydric processes: interception of the precipitated water quantity, infiltration, runoff, its evaporation, erosion of the pedospheric cover etc.

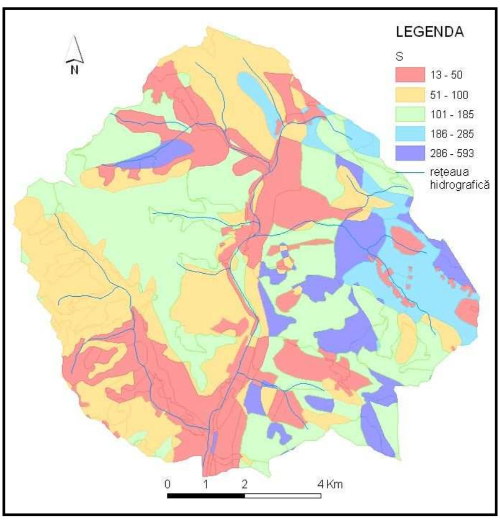
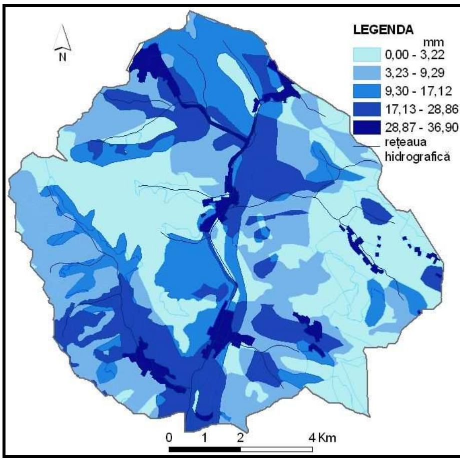



**Fig. 2.** ***Spatial distribution of S index***

In the phitocenotique associations, their type, size, density, crowning level, determine the quantity of water pouring to the soil surface, the shifting speed of the water drops to the soil level, the magnitude of the water-soil impact, the concentration time in the basin, the runoff speed etc.

After elaborating the data necessary to compute the CN indicator for each of polygon resulted from the intersection of the soil hydrological group ∩ land use, the next step is computing and spatializing the S indicator (retention parameters) (Fig. 2).



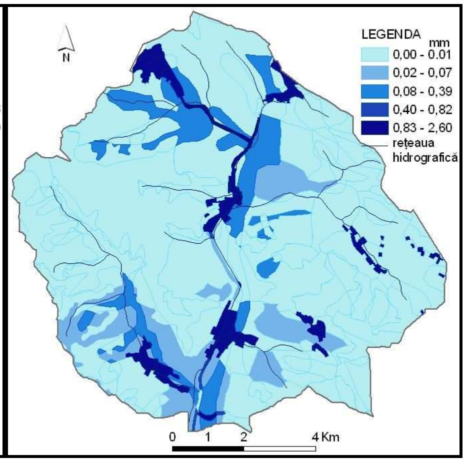




**Fig.3** ***Spatial distribution of runoff values for a rainfall of 10 mm/m²***

**Fig.4** ***Spatial distribution of runoff values for 50mm/m²***

Because of the reduced surface of the reception basin, the quantity of precipitation was considered to be uniform in the whole basin. The behaviour of the basin was simulated in conditions of precipitation of 10mm/m², 50mm/m², 100mm/m².

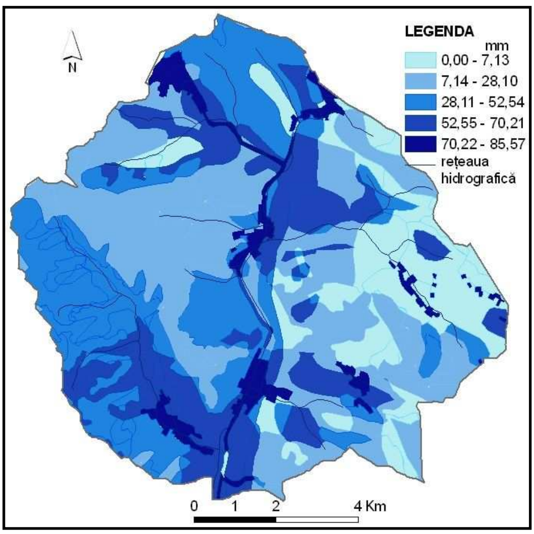



**Fig. 5**: ***Spatial distribution of runoff values for a rainfall of 100 mm/m$^2$***

By applying relation (1), three layers used in the evaluation of the runoff water layer there had been obtained, for each of the three rain categories (**Fig. 3, 4, 5**). In the runnof layer, polygons where P < 0,2S were assigned value 0.

For simulating the hydrologic response of the basin for different land use categories and different pedogeographical characteristics, the surface water layer subject to surface flow was computed for five CN values: 47, 58, 65, 73, 85 (Fig. 6).

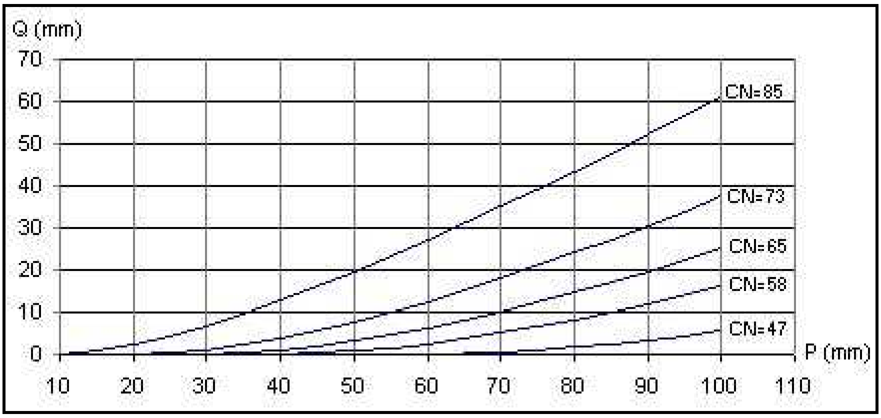



**Fig.6:** ***Relation rainfall-runoff for different values CN***

## 4. CONCLUSIONS

Applying the SCS-CN model, combined with a number of G.I.S. functions, for analysing the runoff on a watershed level, can be an efficient solution in the context of an continuous increase in the need of forecasting the hydric hazards.

The strengths of this model are the rapidity of obtaining the results and the fact that the antecedent soil moisture is taken into account; in the same time the model offers the possibility to simulate the hydric runoff either at a daily, monthly, seasonal or annual scale, or for each rainfall. An identified drawback is that this model ignores some parameters such as evapotranspiration or the water reserve in the soil created by irrigation, in the agricultural areas.

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# HUNGARIAN TOPONYMS IN GAZETTEERS

**A. Guszlev[1], L. Lukács[2]**

**ABSTRACT**
Gazetteers are compiled to support identification of placenames. Gazetteers are sources of name forms in map-making, administration, and other fields. Hungarian toponyms can be found also in official gazetteers of Hungary and in diverse world gazetteers on the Web. This article summarizes development of Hungarian gazetteers and shows the possibilities and problems related to on-line gazetteers.

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## 1. INTRODUCTION

People living in communities name geographical objects in their surroundings. Geographical names are used as identifiers of geographical features in verbal and written communication. Each community and nation has a set of toponyms in their mother tongue. Areas of different name collections overlap each other so geographical objects usually have two or more name variants in the same or also in different languages. Use of several name variants can be ambiguous, that is why international associations make an effort to standardize geographical names, determine only one recommended name for each object. On the other hand, toponyms are parts of national cultural heritage. Every nation tries to protect and use them in education, in literature and in everyday communication.

Compiling gazetteers could be a solution for the contradiction between the name standardization and the living name variants. A gazetteer can help in collecting the geographical names and their attributes, makes name variants identifiable.

Hungarian language is spoken in all countries of the Carpathian Basin (Austria, Slovakia, Ukraine, Romania, Serbia, Croatia and Slovenia), and there are populous Hungarian minorities in these countries. Hungary was extended over the whole Basin for centuries so there are a great number of Hungarian geographical names of medieval origin in this region, mostly used up to presents. The area covered by Hungarian toponyms is 3.5–4 times bigger than the current state area [Faragó, 2005].

Name databases, gazetteers or detailed maps are needed for compiling the name-content of a map. There are registers, official name lists of administrative, settlement and street names and other digital sources and most of them also available on the Web, but a general gazetteer of these names is still missing [Guszlev and Lukács, 2006].

## 2. GAZETTEERS

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Glossary of terms for Standardization of Geographical Names gives the following definition for *gazetteers* [UNGEGN, 2002]:

*List of toponyms arranged in alphabetic or other sequential order, with an indication of their location and preferably including variant names, type of topographic feature and other defining or descriptive information.*

This definition shows that a name of its own is not a unique identifier for a geographic place. The name, the object-type and spatial location are needed for unambiguous identification [ADLG, 2002] *(see Figure 1).*

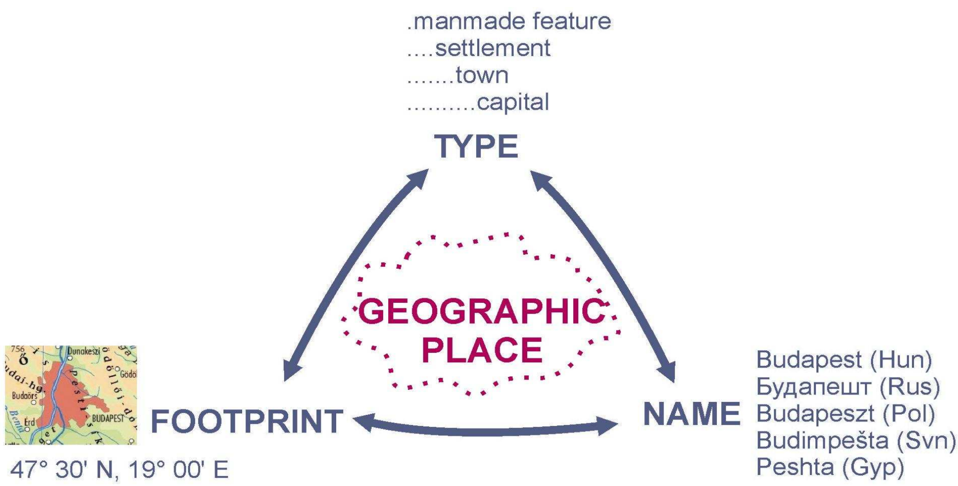


**Fig. 1:** ***The object type, the name and the 'footprint' (location) as identifiers of a geographic place (based on figure of ADL Gazetteer team, 2002)***

The same name can denote diverse geographical objects even at the same place (e.g. Margitsziget is a settlement part of Budapest, while Margit-sziget is an island in the Danube), so you need to know also the object type. The spelling of Hungarian toponyms sometimes gives information about the type of the object.

The same name form can denote objects of similar types at different locations (e.g. Velence is a settlement in Hungary and the name is the Hungarian exonym form of Venice in Italy). These names are called *homonyms* [UNGEGN, 2002].

Essentials of a gazetteer entry for place identification are:

- Toponym (geographical name)
- Object type and
- Spatial location (coordinates*)*

The aim of compiling gazetteers is to register correct forms of official names, alternate names and their location and attribute data (e.g. type, language, origin etc.). Gazetteers can be data sources for correct spelling of the names and for uniform and consistent toponym usage.

In articles and advertisements geographical names occur in various (and sometimes false) forms and there are often faults in spelling. The reason may be the lack of professional and widely available data sources. People reckon maps as authoritative data sources, so they search for spelling of the names on maps primarily. As gazetteers are the main sources of names in mapmaking processes, cartographers have a share in compiling convenient gazetteers.

Gazetteers are used in several fields which deal with toponyms:

- Cartography
- Geoinformatics
- Geography, biology, ecology
- History, ethnography, linguistics, literature
- Education
- Press
- Tourism

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### 2. 1. International organizations, standards and recommendations on gazetteers

Relevance of toponymy and gazetteers is indicated by the fact that many international organizations deal with analysis of toponyms, and the problems of name usage. These organizations harmonize the processes of national toponymic researches, prepare standards and recommendations for compiling gazetteers, provide toponymic guidelines and tutorials for map-making.

Some of the main organizations:

*United Nations Group of Experts on Geographical Names (UNGEGN*) was established in 1967.

*Working Group on Toponymic Data Files and Gazetteers* (as a part of the UNGEGN) was established in 1998.

*ISO Technical Committee Geographic Information/ Geomatics 211 (ISO TC 211)* The standard ISO 19112 – Geographic information – Spatial referencing by geographic identifiers (compared to the ISO 19111 standard of coordinates) This is a conceptual scheme, defining structure and components of XML based name storing.

These organizations collaborate with other associations, e.g. with the *Unicode Consortium* for using uniform characters, standardized diacritical marks in digital character sets.

*Open Geospatial Consortium (OGC)* recommends specifications for protocols of Web Gazetteer Services. Web Gazetteer Service (WGS) is a specialized Web Feature Service that provides additional capabilities specific to a gazetteer-like feature collection. The WGS recommendation is based on OGC directives like Web Feature Service, Filter Encoding and Geographical Markup Language [Guszlev and Lukács, 2006].

## 3. GAZETTEERS IN HUNGARY

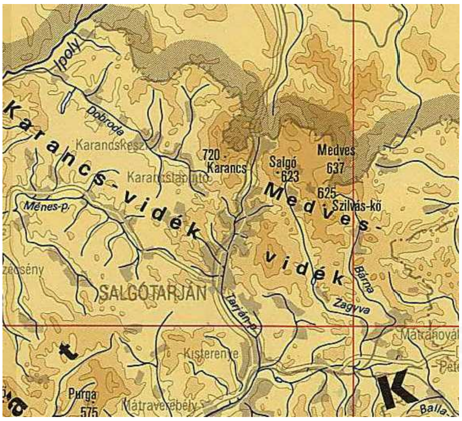
### 3. 1. Traditional gazetteers

Traditional paper gazetteers mark geographical names with a pair of coordinates or other spatial references (e.g. administrative unit) in text or table form. There are some attribute data related to the name entries: name variants, not recommended name forms, origin etc. Paper gazetteers often do not include maps for visualization.

The needs for professional name sources necessitated the collection of Hungarian geographical names, determination of standard forms, elaboration a gazetteer of Hungarian toponyms and development of the grammatical rules. The Hungarian Board on

Geographical Names (Magyar Földrajzinév-bizottság, Fnb) was established for executing these tasks in 1964. As a result of its works, Fnb published the Gazetteer of Hungary I-II. (FNT I-II) in the 1970's. The FNT I. stored 715 of the best-known nationally spread geographical names in the form which is nearest to the local usage in the related region. According to the decree No. 10/1974.(III.31.) MEM by the Minister for Agriculture and Food, *geographical names should be used in official publications in the form given in the Gazetteer* [FNT I, 1982].

FNT has a simple data structure, gazetteer entries are in alphabetical order and, in addition, they are visualized on a map-sheet *(see Figure 2).*




**Karancs;** h; Karancs-vidék (legm. p.); Ng., CSSZ.
Karancslapujtő; 720 m; **C10**

**Karancs-vidék;** hdt; Északi-középhegység; Ng.
V: Karancs, Karancs-hegység, Karancs-Medves, Karancs--Medves-hegység; **C10**

**Karasica;** vf; Baranyai-dombság; Bar., JUG.
*Feked–Illocska → Duna (JUG.)
V: Karasica-vízfolyás, Karassó; Sz: Karasica-csatorna, Karasica-patak; **J–K7**

**Fig. 2.** ***: Cartographical presentation and entries in FNTI***

The gazetteer was created for cartographical use. In the name entries at the first place the geographical name is given, established for official use and the name is followed by additional data:

General information:

- Object type
- The county or the region where the feature lies
- The source or respective countries, in case of water courses

Additional information:

- In case of water courses a town name is given where the source or starting point can be found.
- The name of source and the receptive branch, canal or lake
- For mountains and hills altitudes are also given.

Variant names:

- Name variants which are not suggested for use (they are included only for a more complete information, and for comparison)
- Name variants of sections in case of water courses

Spatial location: reference letter and number showing the position of the feature on the map supplement. [FNT I., 1982]

The gazetteer also has an index which contains only the variant names.

This gazetteer helps the compilation of map labels only by simple searching and gives no possibility for querying by attributes. Traditional gazetteers can be kept up-to-date hardly because of the paper form.

### 3. 2. Digital gazetteers

In the 1990's a digital name database of Hungarian toponyms was developed by the FÖMI (Földmérési és Távérzékelési Intézet, Institute of Geodesy, Cartography and Remote Sensing). This gazetteer database is called FNT like the former paper versions, but has a different content. The digital version has two forms with different scales. FNT 1 corresponds in name quantity to a topographic map in scale 1:40 000. FNT 2 corresponds to a large-scale (1:10 000) topographic map, but FNT 2 database is still not completed (60% is ready).

The digital FNT contains 41 types of geographical objects with alternate names and other attributes. The content includes the names of Hungarian settlements and parts of the settlements (with number of population and other attribute data), beyond the geographical names of the paper FNT. Digital FNT is made not for special cartographic but general use, so it gives no information about cartographical representation. For spatial reference, FNT gives a pair of coordinates for each name records in EOV (Hungarian Uniform Projection, Egységes Országos Vetület) coordinate system. In case of watercourses the reference point is the point of exit from a settlement area. In case of landscape regions or other polygon objects there is no standard point for referencing.

| Azonosító | Név | Típus_ | Megye_ | Település_név | EOVY | EOVX | Magasság | Mag | Lakos | Néps | Vízfo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 71575 | Karancs | 14 | 13 | Karancslapujtő | 704514 | 312905 | 729 | 161 | 0 | 0 | 0 |
| 36717 | Karancs | 16 | 13 | | 696000 | 312000 | 0 | 0 | 0 | 0 | 0 |
| 36149 | Karancsalja | 33 | 13 | | 702856 | 309839 | 0 | 0 | 1601 | 1990 | 0 |
| 71576 | Karancsapátfalva | 2 | 13 | Karancslapujtő | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36152 | Karancsberény | 33 | 13 | | 702094 | 316020 | 0 | 0 | 1041 | 1990 | 0 |
| 71516 | Karancsberényi-patak | 36 | 13 | Karancsberény | 706080 | 316171 | 0 | 0 | 0 | 0 | 0 |
| 71517 | Karancsberényi-patak | 36 | 13 | Karancsberény | 702053 | 315238 | 0 | 0 | 0 | 0 | 5001 |
| 6279 | Karancsdűlő | 20 | 11 | Törökszentmiklć | 751500 | 206500 | 0 | 0 | 61 | 1980 | 0 |

**Fig. 3.** ***Digital FNT***

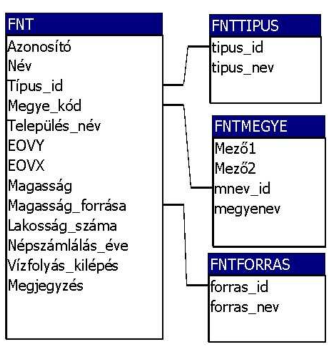



**Fig. 4.** ***Relations in digital FNT***

FNT, like other digital gazetteers, is a simple relational database. Complex queries, special filtering even on parts of names or attribute data is available in this structure. A more elaborated detailed thesaurus and better structured database provides more special and faster queries *(see Figure 3 and 4).*

This structure gives more possibilities to store temporal dimensions and to analyze changes in the name status and usage. The temporal scope of the gazetteer is variable for supporting historical research or editing historical maps.

Developments and trends on the Web have an effect also on the development of digital gazetteers. Growth of web-communication and community collaboration entails compilation of new object lists, thesauri and ontologies. A semi-controlled geographical vocabulary can be base of management of the geographical names. Large on-line gazetteers have thesaurus of the object types, one of the most known example is the Alexandria Digital Library Gazetteer (ADLG) Theaurus, which contains 215 object types in 4 levels. GeoNET Names Server (GNS) includes approx. 650 object types.

Hungarian gazetteers (both paper and digital ones) also have object types (paper FNT has 19, digital FNT has 39 types) but without hierarchy.

There are projects for creating geo-ontologies as more complex conceptual systems for gazetteers. A gazetteer based on a geo-ontology could be the model of the real world by the names of the objects, considering spatial and temporal relations, topology and hierarchy.

The main role of a gazetteer is to show geographical names (and references) with correct spelling. In practice, gazetteers are made to be toponymic segment of other information systems (e.g. statistical, economic, cultural and geographical databases). For this reason, general identifiers (e.g. postal codes, NUTS codes, ISO country codes or KSH codes in Hungary) are stored in gazetteers. It should be included at the data integration. If there are no standard identifiers, names could be keys for joining more databases. In this case spelling and diacritical marks in the name must be checked.

Additionally, different digital datasets can be processed for gathering data. Process of digital datasets can be automatized if they have a formal relationship. Relation could be two harmonious data field or a normal difference (e.g. differences in diacritical marks). Datasets can join by determination of a key field. (Key field contains the same data in different databases*)*. Integration of different sources can cause problems also with the data content, therefore automatization of the whole integration process need manual checking.

Digital gazetteers contain spatial and attribute data so it is worth to implement gazetteers also in GIS environment. Geoinformation systems are digital data-storing, data-processing and analyzing systems, which are able to process and visualize a great number of spatial data. GIS tools support asking queries both by attributes and location which are main functions of a gazetteer. In a GIS-gazetteer the map is not just a graphical method of visualization, but could take a part in analyzing of spatial phenomena of the names usage [Guszlev and Lukács, 2006].

Data contents of GIS gazetteers do not differ from traditional gazetteers. The method of gathering spatial data is the main difference. In a GIS gazetteer a geometrical object (point, polyline or polygon) belongs to each geographical name. Spatial data (usually coordinates of nodes or bounding box of the object) is joined to this reference object. In other words, the object ID of the stored geometrical object is the link between spatial data and attributes of a name entry in a GIS gazetteer *(see Figure 5).*

The large on-line gazetteers too are based on geoinformation system.

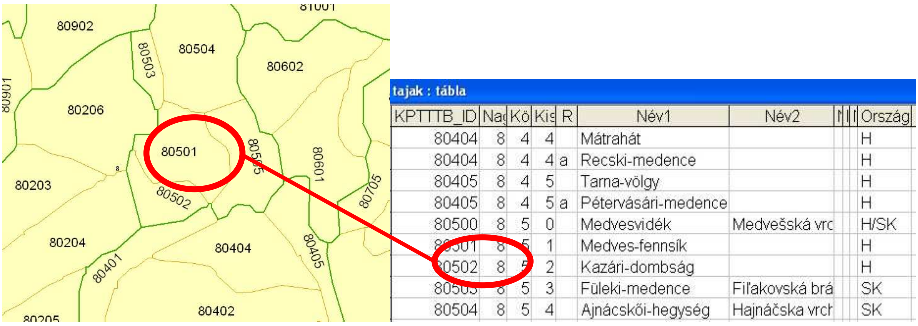


**Fig. 5.** ***Joining of polygons and attribute data by ID in ArcMap***

### 3. 3. On-line world gazetteers and the Hungarian toponyms

There are several name lists and gazetteers available on the Web. Name lists are searchable but usually have no spatial references and map visualization. The multilingual place name lists on *Transindex (www.transindex.ro)* are important sources of Hungarian names and their name variants in other languages. In practice, users should use an atlas or map to help identify the placenames spatially *(see Figure 6).*

**Fig. 6.** ***Place name dictionary on Transidex***

World gazetteers available on the Internet contain numerous Hungarian toponyms. These gazetteers are multilingual, including variant names in Hungarian and in other languages, which facilitate identification procedure of geographical features.

Three world gazetteers were examined in the point of view of Hungarian toponyms [Guszlev and Lukács, 2006]. All of these gazetteers contain millions of names of the world.

GEOnet Names Server (GNS)

Getty Thesaurus of Geographic Names (GTGN)

Alexandria Digital Library Gazetteer (ADLG)

GNS and GTGN are based on military name-collecting. The sources of these are small scale topographical maps, world atlases and gazetteers.

The ADL Gazetteer is developed by the Alexandria Digital Library (University of California, Santa Barbara). The main point of this project is the recognition that search based on spatial reference data could be applied not only to maps but any objects having spatial reference, e.g. georeferenced photo collections, reports of specific areas, or even pieces of music compositions which contain references [Goodchild, 2004] *(see Figure 7).*

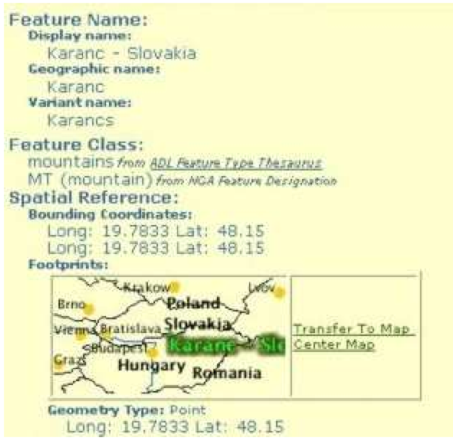



**Fig. 7.** ***User interface of Alexandria Digital Library Gazetteer***

At the same time problems come forward in using these gazetteers for map-designing. Each gazetteer stores toponyms as point elements with coordinate pairs. These coordinates are determined with arc minute precision. This means that precision of data available for Hungary is 1.3–1.8 km, which is not sufficient for cartographical use under a certain scale. GNS contains 29 861 entries about Hungary (there are 105 000 entries in FNT, for comparison), in the following categories:

- Settlement names (19638)
- Relief names (3343)
- Landscape region names (2819)
- Hydrological names (1962)
- Railway station names, names of other pronounced points (1904)
- Administrative names (119)
- Vegetation names (76)
- 20 Hungarian toponyms were examined in these world gazetteers and query results were recorded. Some of them are inside the current state and others are outside Hungary. Names of hills, mountains, plains, historical regions, lakes and rivers were also searched (*see Table 1).*

***Hungarian toponyms in world gazetteers***

**Table 1**

| TOPONYM | GEONAMES | GETTY | ADLG |
|---|---|---|---|
| **Mátra** | Mátra | Mátra | Matra |
| | Mátra Hegység | | Matra Hegyseg |
| **Kárpátok** | Karpátok | Karpátok | Karpatok |
| | Carpates | Carpates | Carpates |
| | Carpathian Mountains | Carpathian | Carpathian |
| | Carpathians | Carpathians | Carpathians |
| | Carpați, Munții | Carpati, Muntii | Carpati, Muntii |
| | Carpații | Karpaten | Carpatii |

| | | | |
|---|---|---|---|
| | Karpaten<br>Karpaty | Karpaty | Karpaten<br>Karpaty |
| **Alföld** | Alföld<br>Nagy Magyar Alföld<br>Al’fël’d<br>Bol’shaya Sredne-Dunayskaya Nizmennost’<br>Great Alfold<br>Great Hungarian Plain<br>Great Plain<br>Hungarian Plain | Alföld | Alfold<br>Nagy Magyar<br>Al'fel'd<br>Bol'shaya Sredne-Dunayskaya Nizmennost'<br>Great Alfold<br>Great Hungarian<br>Great Plain<br>Hungarian Plain |
| **Kisalföld** | Little Hungarian Plain<br>Little Plain<br>Upper Hungarian | —— | Kis Alfold<br>Little Alfold<br>Little Hungarian<br>Little Plain<br>Upper Hungarian |
| **Csallóköz** | Csallóköz<br>Ostrov<br>Great Schütt<br>Veľký Ostrov Žitný<br>Veľký Žitný Ostrov | —— | Csallokoz<br>Ostrov<br>Great Schutt<br>Velky Ostrov Zitny<br>Velky Zitny Ostrov |
| **Erdély** | Erdély<br>Transilvania<br>Ardeal<br>Siebenbürgen<br>Transilvanie<br>Transilvaniei<br>Transylvania | Erdély<br>Transilvania<br>Siebenbürgen<br>Transylvania<br>Transylvanie<br>Transylvanië | Erdely<br>Transilvania<br>Ardeal<br>Siebenburgen<br>Transilvanie<br>Transilvaniei<br>Transylvania |
| **Felvidék** | —— | —— | —— |
| **Jászság** | Jazygia | —— | Jazygia |
| **Fertő** | Fertő<br>Fertő-tó<br>Fertő Tói<br>Fertő Tava<br>Neusiedler See<br>Neusiedler Lake | Ferto<br>Ferto tó<br>Fertoto<br>Neusiedler See<br>Neusiedler | Ferto<br>Ferto-to<br>Ferto Toi<br>Ferto Tava<br>Neusiedler See<br>Neusiedler Lake |
| **Küküllő** | —— | —— | —— |

The table shows some of the results of our investigation. In the first column are the Hungarian toponyms and in the other columns are the name forms in the world gazetteers. The Hungarian form with correct spelling and form was signed with orange color. Names with peach color are Hungarian forms with spelling faults or not used form. White ones are the name forms in foreign languages.

The Hungarian diacritical marks are treated defectively or sometimes they are missing in international digital gazetteers, for example: Karpatok instead of the correct term Kárpátok (Carpathian Mountains), Gocsej instead of Göcsej (hills). In addition, the spelling of the names does not suit Hungarian grammatical rules, Kis Alföld, instead of Kisalföld (Little Alföld).

Beyond spelling errors there are distortions in the form of Hungarian toponyms in world gazetteers (Ferto Tava instead of Fertő). Sources of names are not Hungarian but foreign databases or maps. Density of toponyms is not homogenous within a scale range, likely because of insufficient name sources. For example some of the major regions, like Alföld and Erdély can be found in gazetteers, but other major regions, Kisalföld and Felvidék are not included. Elaboration of Hungarian toponyms for transborder regions is not uniform as well, some of the Hungarian names are stored (Csallóköz, Száva, Kárpátok) in the databases and others (Küküllő, Deliblát) are missing [Guszlev and Lukács, 2006].

## 6. CONCLUSIONS

Gazetteer of Hungary and on-line world gazetteers contain thousands of Hungarian toponyms. In our research these gazetteers were examined as place name sources for compiling toponymic content of maps. For identification of a geographical footprint data of spatial location is needed beyond the place name and feature type. Therefore georeferenced gazetteers or gazetteers with cartographical visualization are more usable than simple name lists without spatial data. The Gazetteer of Hungary contains correct name forms, coordinates and useful attribute data, but does not embrace the whole Hungarian naming area, only the current state. In cartography, it is important to show place names for the whole map area in the language of the map-reader. The largest multilingual world gazetteers store plenty of Hungarian name forms for the Carpathian Basin, but names in them are often not correct in spelling. For these reasons it could be useful to compile an on-line gazetteer with visualization possibilities for the whole Carpathian Region.

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# BUILDING MANAGEMENT IN PUBLIC SECTOR OF HEALTH CARE, WITH AND WITHOUT GIS

**I. Haidu[1], F. Muresan[2], Lucia Daina[3]**

**ABSTRACT**
Gestion d'immeubles dans le secteur public de la santé, avec et sans le G.I.S. Il y a 16 unités de santé avec les lits dans le comté de Bihor qui ont un impact important sur des coûts de santé. Là l'efficacité comporte l'amélioration continue de la gestion, tous les deux unité d'intérieur et tous les deux au niveau du comté. Les données comparatives actuelles de papier concernant la gestion d'immeubles dans la santé dans le secteur public. Nous présentons notre expérience d'employer le G.I.S. dans la gestion de santé au niveau du comté. Nous concluons cela qui fait les cartes topographiques devons être point de départ dans l'investissement d'infrastructure de santé.

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The buildings from the public sector of health care have intrinsic characteristics such as location, size, spatial interrelations which make possible their spatial depiction and representation. Form the point o view of the health care management a building is one of the factors which influence the characteristics of the medical service that can be offered. In order to offer adequate medical services the buildings from the health sector must comply with a set of hygienic and sanitary conditions in order to be authorized.

## 1. TYPES OF PUBLIC CARE BUILDINGS

Law 95/2006 defines the types of sanitary units and the conditions which must be completed in order for them to be classified in a certain typology. Other juridical documents, related to the above mentioned law, offer details and stipulate the types of buildings nominally. Each county has several types of sanitary units intended for different medical needs and services.

Bihor County has a total number of 16 sanitary units classified into five categories according to the hereby table (Table 1).

Types and names of hospitals from Bihor County

**Table 1**

| Hospital type | Hospital's name |
|---|---|
| Clinical hospitals | The County Clinical Hospital Oradea<br>„Dr. Gavril Curteanu” Children's Clinic Oradea<br>The Obstetrics and Gynaecology Clinic Oradea<br>The Psychiatric and Neurology Clinic Oradea<br>The Pneumophtisiology Clinic Oradea<br>The recovery Clinic Felix Spa |
| City and Municipal hospitals | „Ep. N. Popovici” Municipal Hospital Beiuș<br>„Dr. Pop Mircea” Municipal Hospital Marghita<br>Salonta Municipal Hospital<br>Aleșd City Hospital |
| Specialized hospitals | The Psychiatric and the Safety Measures Hospital<br>The Psychiatric Hospital Nucet |
| Health centres | Ștei Health Centre<br>Bratca Health Centre<br>Valea lui Mihai Health Centre |

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The overall capacity for providing medical services by the hospitals is expressed in the total number of beds and in the number of ambulatory units. The total number of beds in the above mentioned hospitals is of 4527. Apart form the compartments and the sections with beds, the hospitals, under the current conditions from Romania, manage other auxiliary services such as: kitchens, laundry, but also installations serving the whole structure of the hospital: the electrical network, the water and sterile water supplies, the sewage.

## 2. MANAGING BUILDINGS WITHOUT GIS

There is an interested on the part of the medical authorities for creating adequate conditions for providing health services in the public sanitary units. The current legislation requires minimal functioning conditions, which must be met by both the sections with beds and the auxiliary services of the hospital.

The paper evaluates the characteristics of the public care units from Bihor County based on a questioner realized in order to evaluate the needs for rehabilitating the infrastructure. The questionnaire focuses on identifying the information which can be used in accomplishing the rehabilitation projects of the hospital infrastructure and for assessing the current situation of the rehabilitation projects.

The characteristics evaluated for each hospital are shown in the above table (Table 2).

The components of questionnaire for evaluating the infrastructure of the public health units

**Table 2**

| | |
|---|---|
| Has the hospital an permanent authorization? If not state **the main reasons**. | |
| Hospital type | Monoblock |
| | Sections (no of sections) |
| Building year | |
| Seismic expertise | |
| Heating unit | Installation year |
| | Used fossils |
| | Efficiency |
| Laundry | Internal / External |
| | Age |
| Eating unit | Internal / External |
| | Age |
| Incinerator | Internal / External |
| | Accreditation according the UE norms |
| Water supply deficiency | |
| Electrical installation deficiency | |
| Sterilization | Internal / External |
| | Age |
| Functional operating rooms | |
| Modernization of the infrastructure projects, stage | Feasibility stage |
| | Ongoing financing |
| **Enumeration** | |
| Investment plan | Main directions |
| **Enumeration** | Estimated sum |

The answer of the medical units was introduce in a tabular computer program (Excel) in a synthetic form and thus provided the synthetic image of the hospital units Based on the excel tables one can have a synthesis of the medical buildings' characteristics at county level. The sanitary authorization for functioning exists in 75% of cases. The monoblock hospitals represent: 31 % from the units, the rest are pavilion units with a number of units comprised between 2 and 9.

The year of the construction varies between: 1806 and 1994.

Without GIS one can have descriptive characteristics of the sanitary units which can be useful to a manager for developing the infrastructure but which do not offer a complete picture. The data gathering in a table form can be the starting point for a geoinformatical database. GIS was already successfully used (Tirt 2006) in the national sanitary domain.

## 3. MANAGING BUILDINGS WITH GIS.

Using GIS in managing building supposes the creation of the graphical and attribute database (Mureşan 2005).

In order to create the graphical database a declassified cartographic support was use which was scanned, georeferenced. The scale used was one 1:100000. The distance between the digitized topographic curves is 40 m. The topographic map was compiled for the whole Bihor County through digitization, including the township centres, the roads, the railways, and the hydrographical network.

The attribute database was compiled through the construction of a complex table comprising several lines and columns. The lines represent the name of the hospital, and the column the parameters considered to be important for the study of which we enumerate: the total number of beds, the existing highly performance medical apparatus, the hospital financing differentiated on types of sources etc

The buildings of the public medical units with topographic coordinates based on the Stereo 1970 georeferential system are represented on the digital map. (Figure 1 ).

Using GIS in building management is based on identifying the hospitals which agree to certain criteria and then on their depiction on an interactive map (Mureşan 2005). For instance if we intend to identify the hospitals corresponding to a certain criteria we choose from the rolling menu the option (apparatus in use or criterion) and then we push the Search Button. All hospitals corresponding to this criterion will be marked (Figure 2). Apart from this other information about hospitals can be visualized too (Table 2) with the help of a secondary window (Figure 3).

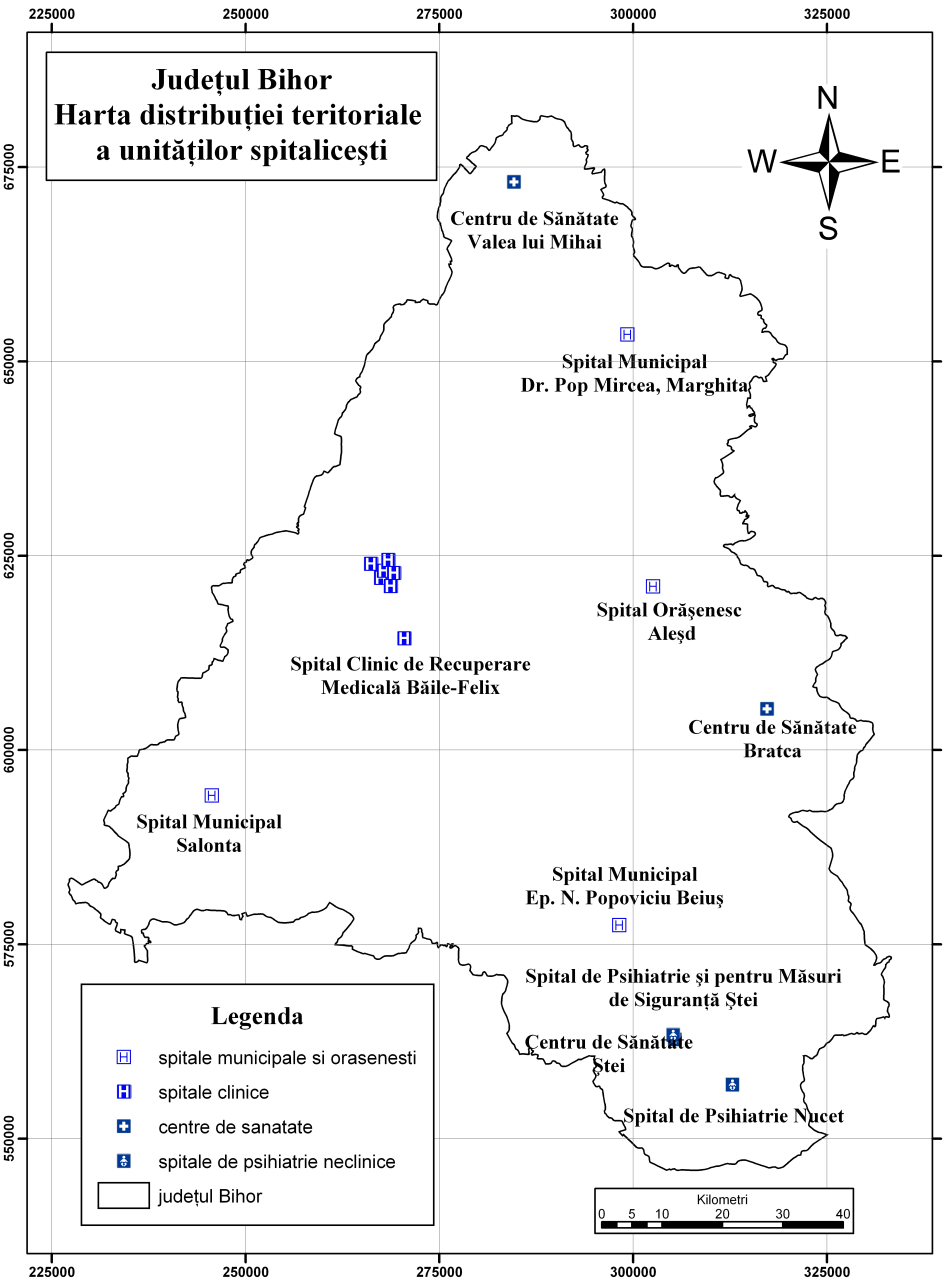


**Fig. 1.** ***The distribution map of the hospital units from Bihor County***

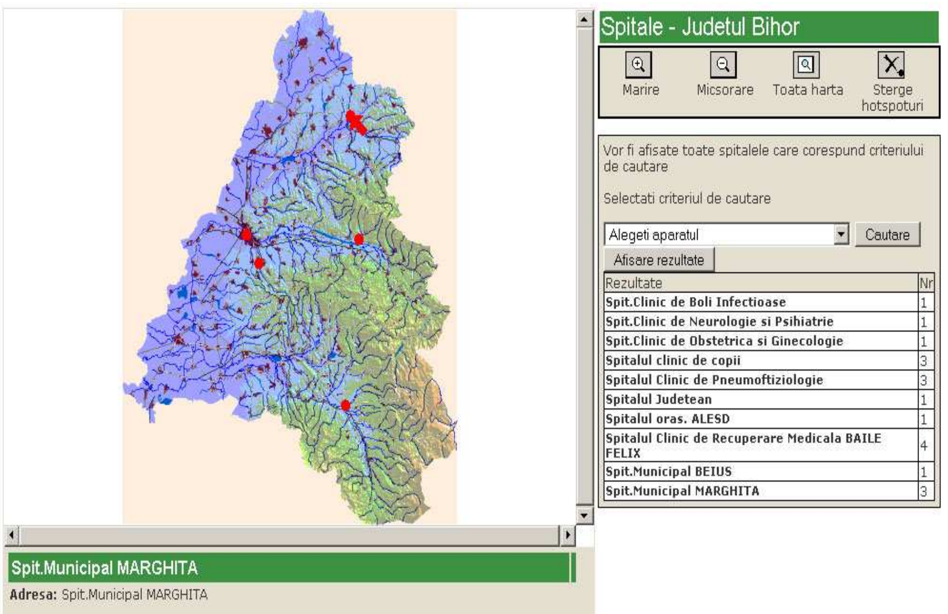


**Fig. 2.** ***Căutarea unui imobil folosind un criteriu ales***

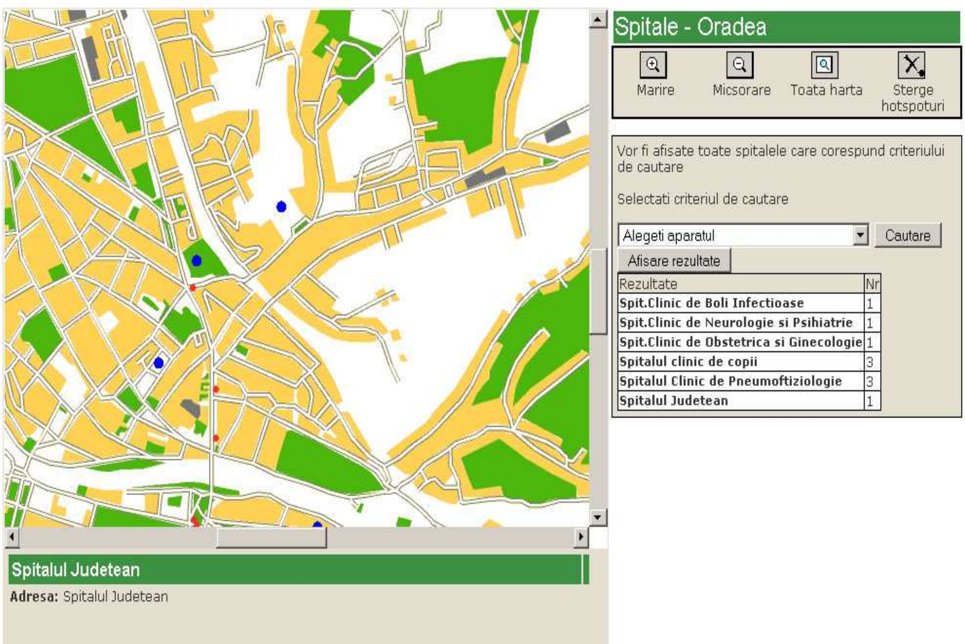


**Fig. 3.** ***The secondary unit for identifying criteria***

## 4. DEBATE

The management of the buildings from the public health system (hospitals) is a topic relevant for both the public debate from Romania and for the specialized world literature. The interest is motivated also by the fact that the hospitals are the largest resource consumers in any sanitary system, situation which requires finding new ways of obtaining better results under limited resources.

The paper presents the evaluation of the sanitary units (hospitals) from Bihor County and a comparison between the data analyzed with GIS and the data analyzed without a GIS system.

GIS offers relevant information for the management of the public sanitary units. If the hereby paper considers the management at county level further projects must consider the GIS implementation in topographic projections on public health units.

The integrated evaluation of the buildings, equipment, hospital efficiency and of the use of financing can lead for the future to finding innovating solutions which in turn may lead to the final increase of performance in providing medical service

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# DATABASE MANAGEMENT SYSTEMS FOR SPATIAL DATA STRUCTURES – AN OVERVIEW

**AL. M. Imbroane[1] , L. Bucur[2]**

**ABSTRACT**
*Database Management Systems for Spatial Data Structures - An Overview*: The database is the foundation of Geographical Information System (GIS). One obvious drawback of the standard Database Management System (DBMS) is that they cannot manipulate efficiently geographical data. Different GIS architectures try to solve these problems in their own manners, each with its own advantages and disadvantages. Some of them, use pure relational database, others object-oriented database (OO-DB). For a better perception of spatial data models in relational DBMS (RDBMS) some authors propose some extensions to the relational model to make it more suitable for geographical operations. The extension is a transition between RDBMS and OO-DB. The OO approach is an alternative to the relational model for information system and especially for GIS software. The main objective of this paper is to identify a number of keys issues that need to be addressed in the near term before we can expect to see support of spatial data management in commercial database systems. Another objective is to clarify the definitions used by GIS designer and users, like entity, attribute and object which is used for different meaning.

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## 1. GENERAL PROBLEMS.

A GIS is more than just a database model in which different types of data structures must be incorporate. There seems to be a consensus in the literature about the architecture of a GIS. Most of the authors describe the following five main components: data input, storage, analysis, output and the user-interface. The ways these five components are implemented dustings a GIS from other information systems. The fact that GIS have to deal with spatial or locational data, in primary and applied geographic research (Kolejka 2006), separates them from other types of information systems. Because spatial data are the main component of a database they are also called spatial information systems. The CAD/CAM systems deal also with spatial data, but there is a big difference between them. In GIS spatial and alphanumeric (aspatial) data are linked so that a processing in one component is reflected in the other. GIS also support digital images, which can be integrated together with other data.

Developing of any spatial information system, begin with *analysis*, when the issue of what the system is required to do is clarified. It follows *design*, when the problem of how the system will satisfy its requirements is tackled. The translation of the design into something that relay works is the *implementation* stage, which may be the customisation of a proprietary system. At the end are usage and *maintenance*. This sequencing of activities in system development is not meant to suggest a strict temporal dependency between stages. The analysis phase can be decomposed into two stages. First, phenomena in the application domain are represent as processes in an appropriate abstract application domain model; then this model is transformed into the conceptual computational model that is computationally tractable but independent of any specific computational paradigm. The design phase moves from the specification provided within the conceptual computational

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model to the design of the logical computational model, embedded in a particular computational paradigm, either relational database, object-oriented, or others. The physical computational model corresponds to implementation and is the representation of the real world phenomena as computational process.

## 2. DATA IN GIS.

Geographic databases contain collections of spatial data representing the variety of views for the real world at a specific time. The term *spatial* refers to the location of objects positioned in geographic space. *Spatial objects* are representations of the elements of the real world such as rivers, countries, railways, and buildings. The diversity of data that are collected over the same area, often from different sources, imposes a question of how to integrate and to keep them consistent in order to provide correct answers for spatial queries.

The geographic entities or objects in GIS are based on two different types of data: *spatial* and *attribute*. Spatial data have two formats: *raster* and *vector*. The vector format can be represented in two components: *geometric* (*graphic*) data and *topological* data. Geometric data have a quantitative nature and are used to represent coordinates, lines, areas etc. The two-dimensional vector format has three subtypes: *point*, *line* and *polygon*, named *features*. These features are called also 'graphics primitives' (definition borough from CAD/CAM software). The geometric or non-topological data model is those in which any positional information is recorded. The recognition of individual spatial units as separate unconnected elements characterised the early data organisation for digital cartography. Topological data describe the relationship between the geometric data. Topological relationship is invariant under topological transformation like translation, scaling and rotation. These are several types of topological relationship: *connectivity*, *adjacency*, and *inclusion*. Examples of queries concerning topological relationship are: which area are neighbor of each other (adjacency), which line are connected and form a network or a road (connectivity), and which lakes laye in certain country (inclusion). Topological data are not always stored explicitly, because in principle they can be derived from geometric data. Note that this definition of topological data is slightly different from the stricter our used in mathematics.

Attributes or descriptive, or aspatial data are alphanumeric data related to the graphic entities. They also called thematic data because they contain themselves a layer of the graphic features. A unique identifier links them. This operation is called *geocoding* or *address matching*. The fact is that attributes data can be linked with other tabular data (external) and so the new data can be processed together with the others. This is one of the powerful specific operations in GIS. Spatial data and attribute data can be stored separately or together depending of the database design performed by the GIS proprietary. A geographical database is a set of geometric entities (spatial features) and attributes. The problem arises: how is better to organise these kinds of data?

The GIS database can be thought of as a representation or model of real-world geographical systems. To this end it is useful to make a distinction between *geographical entities* and *spatial entity*. A geographical entity is a term used with respect to an element of real-world system; that is entities are contained in geographical space. A *spatial entity* is a GIS representation of geographical entity. For example, geographical entities such town, highway and county are represent in GIS database in form of point, line, and area (polygon). Some authors (Malczewski, 1999) use the *object* instead *spatial entity* (*spatial features*). The problem is that the *object* is a consecrate thing used in computer programming (the object-oriented programming) which has different meanings. It is better, to avoid confusions, the word object to be use just when we are talking in programming language terms.

The data stored may be in the form of one or more files, or in the form of database. The difference between a files and a database is semantic and varies somewhat from one discipline to another. For GIS purpose, a file is regarded as a single collection of information that can be stored, whilst a collection of files is regarded as a library. A database comprises one or more files structured in a particular way by a DBMS and accessed through it. Today almost all GIS data is stored in databases. The various methods of data storage differ primarily according to the facilities or operation supported by the DBMS. GIS Databases are currently investigated in Romania by many authors (Haidu,C. 2006).

## 3. **DATABASE CONSTRUCTION.**

Data may be stored in separate unrelated tables, in a single table, in connected tables or as list, sets or collections. A *data set* is a single collection of information, without any particular requirement as to form of organisation. A database is a collection of non-redundant data sharable among different applicants. Within database, data are organised in files, which contain particular records of data, the rows of data, and the record has data for a particular place, event or entity (Laurini and Thomson 1992). The database approach to storing geographical data offers a number of advantages over traditional file-based datasets (Date, 1995): collecting all data at a single location reduces redundancy and duplication; maintenance costs decrease because of better organization and decreased data duplication; applications become data independent so that multiple applications are used the same data and they can evolve separately over the time; user knowledge can be transferred between applications more easy because the database remains constant; data sharing is facilitated and a corporate view of data can be provided to all managers and users; security and standards for data access can be established and enforced.

Large and complex databases require specialised database management systems (DBMS) software to ensure database integrity and longevity. A DBMS is a software application designed to organize the efficient and effective storage and access of data. To carry on these functions DBMS provide a number of important capabilities (Longley et. al., 2001): data model, data load, index, query language, security, controlled update, backup and recovery, database administration, applications and programmable API.

A DBMS must be customised to meet the needs of particular applications. In order to do this we must have a precise idea of the way that information is structured in the system and the kinds of algorithms that will act upon the data. There are three main stages in the process of customising a database system for a particular application.

**1. Construction of the conceptual model (database analysis).**

**2. Translation of the conceptual model into the logical model (database design).**

**3. Translation of the design into a system that works on a particular DBMS and platform or internal model (database implementation).**

The conceptual model corresponds to a synthesis of all external models. It is called this for two reasons (Laurini and Thomson 1992): first because it is made of very sound concepts, secondly because it is the basis for the conception process. Although an abstraction of the real world, the result of the conceptual modelling is supposedly quite concrete in nature, consisting of schematic representations phenomena and how they are related. The organisation scheme created at this stage generally deals with only the information content of the database, not the physical storage, so that the same conceptual model may be appropriate for diverse physical implementations. Many difficulties arise in designing the conceptual model as a synthesis of several external models, especially in dealing with the geometric and topological data.

The next step is called database design, in which the conceptual model is converted in the logical models. In fact it is the first step in computing. The expression logical model has two meanings. First it constitutes a mathematical bases or a set of mathematical concepts. Secondly, it corresponds to the transformation (mapping) of the conceptual model with the tools offered by the logical modelling. In other words, we have a transfer between the conceptual models and a new modelling level, which is more computing, oriented.

The realisation of conceptual model is achieved by mapping the conditions of the semantic data model into the definitions, constraints and procedures for one of these models, most especially today, the relational or other new types, extension of relational or object oriented. In this way the permanent properties of the database are clearly specified, whatever the circumstances pertaining to a particular set of instances of phenomena. This procedure is associated, in practical sense, in the creation of data dictionary, a set of statement about important properties of the data items, such name, type of data, range of values or missing values.

## 4. FIRST GENERATION OF DATABASE SYSTEM: HIERARCHICAL AND NETWORK DATABASE SYSTEM.

A hierarchical database system support a hierarchical structure of record organise in files at various logical levels with connections between the levels. Each record contains a field defined as the key field, which organise the hierarchy. There are no connections between records of the same level. Hierarchical database systems are easily expanded and updated. However, they require large index files, must be frequently maintained and are susceptible to multiple entities. Searches are rapid, but search routines are fixed and constrained by the structures. Thus, records at the same level cannot be searched, nor can new links or new search routines be defined. The elements or the structure are related only through one-to-many connections. This constraint imposes the presupposition that all quarries are known in advance and accounted for structuring and entering data. This constraint is not always natural or suitable for GIS applications. As a result, hierarchical database structures are usually restricted to storing digital map data in GIS (Bernhardsen, 1992).

On the other hand, raster data may be stored in compressed form using run-length encoding. Raster data may be even more efficiently stored in quad tree hierarchical structure. Quad tree is a generic name for several kinds of index that are building by recursive division of space into quadrants. The quad tree paradigm divides the area into square cells of size varying from relatively large down to that of smallest cell of the raster. Usually, the squares are successively quartered into four smaller squares. The quartering may be continued until a square is found to be homogeneous, so that it no longer needs to be divided, and the data on it can be stored as a unit. The quad trees can use also to store lines and polygons. Each object is rasterised and enclosed by a square. The square is then progressively subdivided into blocks of four squares of equal size until the squares are completely inside or outside the object or the maximum depth of the quad tree is reached.

This structure requires two tables: one for attribute data for homogeneous areas and one for pointers that locate attributes.

In a network database each element, or a collection of like records, has connections to several different-level elements. The term essentially describes the logical and physical view of the data as a group of records with links between records. Interconnections are made in hierarchical organisation, and a characteristic may be associated with two main objects. The network structure is more closely represent the complex interrelationship, which often exists between real-world geographical objects. It improves the flexibility and reduces the multiple entities of hierarchical structure. The elements of network may be related through one-to-many, many-to-one, and many-to-many connections (Bernhardsen, 1992). The network structures better suited to geographical data than the hierarchical structure, it is frequently used in GIS applications. It is more suitable for utility projects (AM/FM).

## 5. THE RELATIONAL DATA MODEL

RDBMS is a database system made up of files with data elements in two-dimensional array (rows and columns). This DBMS has the capability to recombine data elements from different relations resulting in a great flexibility of data usage. The relational model contains the following components: collection of objects or relations set of operations to act on the relations and data integrity for accuracy and consistency.

As their name implies, relations play a major impact in relational database. A formal definition of relation is (Codd, 1970): Given a collection of sets $D_1$, $D_2$, … , $D_n$, $R$ is a relation on these sets if it is a set of ordered n-tuples $\{d_1, d_2, \ldots, d_n\}$ with $d_i \in D_i$. The sets $D_i$ $(1<i<n)$ are called domains of $R$ and n is the degree of $R$. The element $d_i$ are the attributes of the relation.

A relation consists of a number of tuples or records that can be described by two-dimensional table. Each row of this table contains a tuple. The columns each describe a certain attribute. Within a relation at least one attribute must have unique value for each tuple. This attribute is called the *primary key*. It identifies the tuple and other attribute that is dependent on it and may not have an empty value. The normal forms of relations are important during the design of relational database applications. They help to remove redundancy, so that it is easier to keep the database consistent if changes are made. For the attribute data relational database is an ideal environment. The problems appear at spatial features and their relationship.

### 5.1. A pure relational solution. Definition of data

We examine the possibilities to storage geographical data in traditional RDBMS. We consider only static geographical data, a simplified version of the data structure described by Smith (1985). This data deals with point, node, chains and polygons. The following relations are defined (bold denote a primary key and *italic* denote foreign key):

- Point (pntid, x, y)
- Node (nodeid, *pntid*)
- Chainpoints (chainid, pntseq, *pntid*)
- Chaintopol (chainid, *strnode, endnode, lftpol, rgtpol*)
- Polygon (polid, chnseq, *chainid*)

An isolate point is determined by an unique, called point identifier, and two numbers, which denote the bidimensional co-ordinate (x,y ). A node also contains a node identifier (primary key) and a co-ordinate pair. For this reason we have two possibilities: to storage the co-ordinate like points or to make a relationship to the point, using foreign key *pntid*. The second one is much better for the integrity of database. *Pntid* is a primary key for point feature and foreign key for node feature. The chain concept in topological data model is captured in two relations: chainpoints and chaintopol. The first of these describes the shape of chain. The second relation captures the topological aspect of a chain. Chainpoints denotes an arc feature, which is a chain of linked segments. It also has a chain identifier (chainid) and a sequence of points, both primary keys. Because point contain an identifier *pntid* must be include as foreign key. The next entry, chaintopol, contain itself the topology. These kinds of chains delineate polygons. Beside its own identifier (chainid), it contains start node, and end node, left polygon and right polygon. All are foreign keys. The polygon feature is defined by it own identifier, a sequence of chains, as primary keys, which enclose polygon and subsequently chain identifiers as foreign keys. We make a notice here. Chainpoints is better to contain start node and arc node for facilities in network operations. Also a polygon is determined by an isolate point, which lies inside, called centroid, as primary key.

### 5.2. The entity-relationship model.

One of most compelling and widely uses approach to forming a conceptual model is known as the entity-relationship (ER) model. An entity type is an abstraction that represents a class of similar objects, about which the system is going to contain information. A relationship type connects one or more entity types.

The entity type can have attributes that serve to describe them. As we mentioned, the spatial database and attribute database can be storage separate or together. The first case is just presented. For the other alternative, the structure can be

- Point (**pntid**, x, y, pattr)
- Node (**nodeid**, *pntid*, nattr)
- Chainpoints (**chainid**, **pntseq**, *pntid*, chainattr)
- Chaintopol (**chainid**, *strnode*, *endnode*, *lftpol*, *rgtpol*, chainattr)
- Polygon (**polid**, **chnseq**, *chainid*, polattr)

Where pattr is a field that contain the description of that point (tower, well and so on). This field can be used for matching large RDB stored separately. Otherwise it must be used the first primary key to that link. Same for the others attributes.

The relationship may have their own attribute, which is independent of any of the attribute of the participant entities. The ER model; allow the expression of a limited range of integrity constraints. Relationship type is subdivided into many-to-many and one-to-many relationship.

The advantage of RDBMS: rigorous design methodology; all other database structures can reduced to a set of relational tables; easy to use compared to other databases systems; modifiable (new tables and rows can be added easily); very flexible and powerful; fast processing.

A reason for adopting RDBMS in geographical data is the simplicity of the structure. Beside it is well known by large group of user. In every geographical database then also has to be a way to store the thematic (alphanumeric) data. This is another reason for designers of commercial GIS. Because of the problems with the spatial data, their database is often split into two parts: a relational part for attributes and a special part for the geometric data. Then two parts are linked by corresponding object-ids of the attribute and geometric parts: the dual architecture.

## 6. EXTENDED RELATIONAL DATABASE.

The extended data model approach is also described as spatial database management system approach, with the GIS serving as the query processor sitting on top of the database itself. Most implementation to date are of the vector-topological kind, with relational tables holding map co-ordinate data for point/nodes and line segments, together with other table containing topological information. Attributes may be stored in the same tables as the map feature database or in separate accessible via relational joins.

### 6.1. The extend entity-relationship model (EER).

The *extended* or *enhanced* entity-relationship (EER) model has features additional to than provided by ER model. These include the construct of subclass, superclass and category, which are closely related to *generalisation* and *specialisation* and the mechanism of *attribute inheritance*. This allows the expression of more meaning in the description of the database and leads toward object-oriented modelling.

En entity type E1 is a subtype of entity type E2 if every occurrence of E1 is also an occurrence of type E2. The operation of forming subtypes from types is called *specialisation*, while the converse operation of forming supertypes from types is called *generalisation*. Specialisation and generalisation are inverse to each other.

Specialisation may summarised as the creation of new types such that: each occurrence of the subtype is an occurrence of supertype; the subtype has the same identifying attributes as the supertype; the subtype has all the attribute of the supertype and possible some more; the subtype enters into all relationship in which the supertype is involved and possible some more.

The entire collection of subtype-supertype relationship in a particular EER model is called its *hierarchy*.

Generalisation is the reverse modelling process to specialisation. A technical problem with generalisation occurs when we wish to generalise from heterogeneous entity type. The difficulty arises in finding a set of identifying attributes for the generalised type; because the subtypes may all have different identifiers. Consideration of this leads to the concept of *categorisation*, where several heterogeneous entities (with their own attributes and relationship) combine into a common category (Elmasri, Narathe, 1994). Categorisation actually adds considerable modelling power, because it provides the ability to represent the inner complexity of entities no longer be treated as indecomposable.

## 7. OBJECT-ORIENTED APPROACH.

The Object-Oriented (OO) approach, have been promoted especially is areas for which the application of pure relational technology has been found problematic. Examples of such area are CAD and GIS. Each area is characterised by one or more non-classical features, such as structurally complex information, specialised graphical requirements and non-standard transactions. OO data models and systems embody reach data structures and semantics in the construction of complex databases, such as complex data objects, class/subclass hierarchies, class composition hierarchies, property inheritance, methods of active data etc. This not only brings the power and flexibility to the system but also adds complexity to implementations, including the development of knowledge discovery mechanism (Mango M., Kodratoff Y., 1991). The main advantage of the OO paradigm is it's easy of understanding; it enables natural representation of real world objects, their mutual relationship and behavior and is therefore close to end-user. An OO application consists of a set of objects with their own private state, interacting between themselves. The OO approach can be useful during several phases of the development of a GIS: information and requirement analysis, system design and implementation. The interest in OO GISs appears growing (Clementini et. al, 1990; Egenhofer, Frank 1989b).

OO design is a method design encompassing the process of OO decomposition and a notation for depicting both logical (class and object structure) and physical (module and process architecture) as well as static and dynamic models of the system under design (Booch, 1994). Object-Oriented database system (OODBS), has developed capabilities such as persistence, long transactions and versioning, unlike most traditional RDBMS. Through combining database functionality with OO programming, OODBS has become an expressive device for multimedia applications, client-server systems as well GIS and CAD (Wachowicz, 1999).

The OO database on the market have in common basic characteristics such as methods associated with objects, inheritance of attributes and procedures from supertype (superclass), and the ability to define the type (class) of objects, their attribute type and relationships. However they differ substantially in query language. The difference result from the fact that OODBS have been elaborated based on programming languages for their data models. The lack of a standard or a format background for OO query has caused differences in query language syntax, completeness, SQL compatibility and treatment of encapsulation (Cattell, 1991).

**7.1 Foundation of OO approach.**

As is state in ANSI Object Oriented Database Task Group Final Technical Report (1991), an object is something ‘which plays role with respect to a request for an operation. The request invokes the operation that defines some service to be performed’. A *request* is a communication from an object to another and, at the system level; it is implemented as a message between objects. Exactly how object will respond to a message in any particular case is dependent on its *state*. Its state is constituted by the totality of attribute values for given object at any time. In ER model the static aspect of an object is expressed by a collection of attributes. For instance a city object might have *name*, *centre*, *population*, *area* among attributes. Objects are similar to the concept of entity.

The totally responses to messages is its *behavior*. In other words behavior consists of a collection of operations that can be performed on objects in the object type. Operations define the behavior of the objects. Objects with similar behaviors are organised into *types*. At the design and implementation stages we often talk about *object classes*, which are groupings of objects with corresponding *data structures* and *methods*. Each operation will be implement as a method, which acts on members of implemented object classes and returns a number of an object class. A class therefore represents a generalization of a set of objects with common properties and behavior. A class can be thought of as a template for objects. When creating an object data model the data model designer specifies classes and the relationship between classes. Objects are *instantiated* (generated) from this description. Thus, an object class is an implementation construct while an object type is a semantic notion.

There are three key facets of object data that make them especially good for modelling geographic systems: *encapsulation*, *inheritance*, *polymorphism* and *behavior*.

### 7.2. OO system modelling

One of the great advantages of object modelling over entity modelling is that the objects in the modelling process can be the natural objects that we observe in the real world. In a geographical object data model, the real world is modelled as a collection of objects and relationships between objects. Each entity in the real world to be included in the GIS is an object.

An object type is declared by given a name and an optional list of parameters. The optionally follows details of inheritance, state, behaviour and integrity constraints. The status of an object type consists of a collection of attributes and describes the static aspects of an entity in ER model. However, each occurrence of an attribute is itself an object. The details of the implementation of each operation are not the concern of conceptual data model. Some general groups of operations are: *constructors-destructors, accesors, transformer, object composition, aggregation and association*.

Topologic relationships are generally built into class definition. For example, modelling real world entities as a network class will cause network topology to be built for the nodes and lines participating in the network. Similarly, real-world entities model, as topologic polygon classes will be structured using the nod-line model.

Arc/Info 8.x provides us an integrated data storage plan. It uses an Object-Oriented data model to store an entity's shape data and attribute data together. All the concerned data of an entity form a record in the geodatabase, while entities that have the same characteristics will form a table in geodatabase, which is called a feature class. Under such a model, the relationship between geometric data and attribute data of an entity has been greatly enhanced; they provide us much more completive information. But unfortunately, this object-oriented data model has not taken temporal information into account. It remains a snap-shot data model and thereafter it lacks the ability to track the evolution of an entity or a phenomenon. It is just an object-oriented spatial data model but not a spatiotemporal one. However, it is still a good example which we can learn form while trying to develop a spatiotemporal data model. At least, it gives us the following principles in developing a spatiotemporal data model: Object-oriented ideas and technologies should be introduced.

## 8. OBJECT-RELATIONAL DBMS.

In spite of technical elegance of OODBMS, they have not proven to be as commercially successful as some predicted. This is because the fact that RDBMS vendors have added many of the OODBMS capabilities to their standard RDBMS software to create hybrid object-relational DBMS (ORDBMS). An ORDBMS can be thought of as an RDBMS engine adapted to handle objects (Longley et. al., 2001). That is both the data describing what an object is and the behavior that determines what an object does are stored together as an integrated whole. Although there are differences in the technology, scope and performance of these systems, they all provide basic capabilities to store manage and query geographical objects. It is important to realise that none of this is a complete GIS software system itself. They have no real capabilities for spatial editing, mapping and analysis. Spatial analysis is in many ways the core of GIS, because it includes al the transformations, manipulations and methods that can be applied to geographical data to add value to them. Effective spatial analysis requires an intelligent user, not just a powerful computer.

An ideal geographic ORDBMS is one that has been extended to support geographic object types and functions in several ways (Longley et. al., 2001): query parser, query optimiser, query language, indexing services, storage management, transaction services and replication.

## 9. DEDUCTIVE DATABASE.

Beside the relational and OO database, there are other paradigms that offer some advantage. One of them is the *deductive database*. A deductive database (DDB) provides persistence for computation using logic-based language such as Prolog. Logic programming systems consists of two parts: a logic program represents declarative knowledge and an inference mechanism, used to answer queries on basis of this knowledge. The relational model can be viewed as allowing the expression of a set of facts. DDB allows the storage of not just facts but more general propositions. Storage of propositions may avoid the storage of much data. DDB also support deduction with their data. The use of logic provides a natural, intuitive method of generating precise definitions of parametric shapes and high-level spatial relations (Worboys, 1995).

The use of logic in design is not new. Some examples include its use in shape grammar and reasoning systems (Chase, 1989; Damski, Gero, 1996; Heisserman, Krishnamurti, 1992a; 1992b; Krishnamurti, Giraud, 1986). The weaknesses of the shape grammar implementations are in their limitations dues to computational problems; those of other logic-based systems are in their representations of design objects, which—with few exceptions—cannot support emergent features. The shape algebra formalism is extended by using logic to make more precise, generalized, parametric definitions of shape and spatial relations than has been previously possible. The value of such a model and the advantages of the representations used over more traditional 'kit-of-parts' models can be demonstrated by the use of these generalized spatial relations for solving typical problems involving spatial reasoning.

DDB can be through of a generalising the concept of a relational database. They comprise an *extension* (similar to a classical relational database) and an *intension*. Intension consists of virtual relations that are defined in term of other relations using logic. The important point is that we have a new relation that is defined, not by specifying tuples, but as a logical combination of other relations: hence the name 'virtual relation'. Thus DDB allow the manipulation of data that are implied by explicitly stored facts, allowing the measuring of the data to be considered in ways that cannot be accommodated by conventional database. This ability is potentially relevant to GIS, in which much information is stored in implicit form. The use of logic provides a natural, intuitive method of generating precise definitions of parametric shapes and high-level spatial relations. Its use as a specification and programming tool has become widespread over the past two decades, providing advantages over traditional procedural programming methods, among those the ability to specify the knowledge to be encapsulated in a model (description) without the need to specify data manipulation procedures (prescription) (Kowalski, 1979). The use of logic can facilitate a top-down method of development, from the abstract to the specific. The symbolic abstractions of logic formulations enable one to denote entire classes of data structures and procedures while ignoring their details. This can be a more natural method of development than having to deal with often no intuitive formulations.

Using deduction carries out computing a query in a DDB. A conventional database consist of a body of data in some highly structured format (tabular in the case of relational database) defined and accessed by means of a database language. Most GIS store their data in this way, either in tabular form in a relational database or in some more specialised database structures. In contrast, a DDB aims to use logic as the basis for database definition, query and manipulation. It handles a body of expressions in a logic-based language that allow the expression of propositions, description of their inter-relationship and management of their storage. It both defines the structure of the data and acts as query language and control mechanism. The database operates by applying deductions to the logical expressions to evaluate their truth or to find values that satisfy them.

In designing the DDB must choose which of the wide variety of logics to implement. The system of logic must be sufficiently expressive, yet not slow the database down with its computational demands, and it should allow a wide variety of possible models. Data should be stored in a format that both flexible and compact. Geographical information has spatial component and so appropriately extended logic may be applied. For GIS it is necessarily not just deductive, rule-based tabular data but rule-based complex object, a system that takes the best of object orientation, databases and deduction adds support for graphical interactive user interface. DDB technology holds out hopes of being able to address and solve these complex problems. Object orientation and logic are not mutually exclusive, and these have been some attempts (Abdelmoty et al., 1993b) to unify them in the context of GIS.

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# QUANTIFICATION DES PRECIPITATIONS : APPLICATION AU NORD OUEST DE L'ALGERIE – LA METHODE PLUVIA

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**RESUME**

Toute modélisation hydrologique est fortement conditionnée par la qualité de l'estimation spatiale de la pluviométrie. Egalement la compréhension des modalités de la reconstitution de la ressource en eau suppose une bonne connaissance de la structuration des champs de précipitations dans l'espace étudié (Humbert J. et al., 1993). Les gradients altimitriques, les effets des crêtes ainsi que l'influence du site constituent des facteurs majeurs pour rendre compte de la non adéquation de l'application des méthodes classiques d'interpolation pour estimer la pluie moyenne au niveau d'un bassin donné. Dans cette optique, nous avons entamé un travail sur la cartographie automatique des précipitations dans le Nord-Ouest de l'Algérie. La région d'étude est connue par une variabilité spatiale des pluies. La zone étudiée s'étend sur 89 420 $km^2$ environ, elle est située entre 2°10'10 ''ouest et 3°10'11'' est de longitude et entre 34°18'54'' et 36°48'12'' de latitude Nord. La région étudiée s'allonge sur 250 km du Sud au Nord et sur environ 500 km de l'Ouest à l'Est.

Cette approche appartient à la famille statistique (combinée à un krigeage des résidus) est exploite, grâce à l'utilisation d'un modèle numérique de terrain (M.N.T.), les relations existant entre les précipitations et certaines caractéristiques topo-morphométriques de la région d'étude. Cette méthode est issue de travaux débuté au CEREG (Université de Strasbourg) à la fin des années 1980, et qui ont aboutit en 1995-1996 à un logiciel opérationnel nommé PLUVIA, testé et validé sur le Nord-Est de la France, en Iran par Dumas D. en 1998.

**Mots Clés :** Variabilité interannuelle des pluies, répartition spatiale des précipitations, variographie, cartographie automatique, Pluvia, Nord—Ouest de l'Algérie

**ABSTRACT**

Any hydrological modelling is strongly conditioned by the quality of the estimation of the spatial rainfall. Also, understanding of the terms of the of water resources reconstitution requires a good knowledge of the precipitation structuring in the studied area (J. Humbert et al. , 1993). Altimitrics Gradients, the effects of the peaks as well as the influence of the site are major factors to show the non-suitability of the application of the conventional interpolation methods for estimating the average rainfall in a given basin. From this perspective, we carried out a work on automatic rainfall mapping in the north-western Algeria. The study area is known by a great spatial variability of rainfall. The study area covers around 89,420 $km^2$, it is located at 2 ° 10'10"west and 3 ° 10'11"is longitude and between 34 ° 18'54"and 36 ° 48'12 "north latitude. The study area has 250 km from the South to the North and about 500 km from the West to the East.

This approach is a member of the Statistics family methods (combined with a kriging residue) is operated, through the use of the digital elevation model (M.N.T.), the relationship between precipitation and some morphometrics factors of the study area. This method is the result of work started in CEREG (University of Strasbourg) in the late 1980s, and which have resulted in 1995-1996 to operational software named PLUVIA, tested and validated in the north-eastern of France and in Iran by Dumas D.(1998).

**Keywords:** Interannual variability of rainfall, spatial distribution of rainfall, variographie, automatic mapping, Pluvia, North-Western, Algeria

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## 1. INTRODUCTION

La robustesse des modèles hydrologiques (relation pluie, débit) et l'estimation du bilan de l'eau sont étroitement liées à une estimation correcte de la pluie qui constitue le paramètre d'entré dans ces modèles. A partir de là, de nombreux auteurs ont estimé intéressant et utile de trouver de relations liant le paramètre pluie aux facteurs relatif au relief et à la situation géographique pour mieux expliquer la répartition spatiale des précipitations. Ces relations permettent d'estimer au mieux en tout point de l'espace, la pluviométrie, en se basant sur les données fournies par les mesures classiques.

Deux approches sont largement utilisées pour l'estimation spatiale de la pluie :
- l'approche géostatistique (krigeage) après avoir identifier la structure spatiale à partir des valeurs mesurés aux postes pluviométriques (Hevesi et al., 1992).

L'approche basée sur les relations statistiques entre les précipitations et les caractéristiques de relief (l'altitude, l'altitude lissée, l'exposition, les effets de site, la distance à la mer), (Spreen 1945), (Laborde 1984), (Bénichou et Le Breton 1987), (Marand et Zumstein 1990), (Daly et al. 1994), (Meddi 1992), (Meddi et al., 1998), (Paul and David 2006).

Cette dernière approche permet d'appréhender le rôle du relief et complète la manque procurer pour l'insuffisance du réseau de mesure.

De nombreux travaux ont été menés pour comparer ces deux approches (Creutin et Obled 1982, Humbert et al. 1997 et Kieffer 1998.

L'approche PLUVIA appartient à la famille statistique (combinée à un krigeage des résidus) est exploite, grâce à l'utilisation d'un modèle numérique de terrain (M.N.T.), les relations existant entre les précipitations et certaines caractéristiques topo-morphométriques de la région d'étude (Humbert J. et al., 1998).

Cette méthode sera appliquée sur le Nord-Ouest de l'Algérie.

## 2. PRESENTATION DE LA REGION D'ETUDE

### 2.1. Situation géographique

La zone étudiée s'étend sur 89 420 km$^2$ environ,. Ile est située entre 2°10'10 ''ouest et 3°10'11'' est de longitude et entre 34°18'54'' et 36°48'12'' de latitude Nord (Fig. 1).

La région étudiée s'allonge sur 250 km du Sud au Nord et sur environ 500 km de l'Ouest à l'Est.

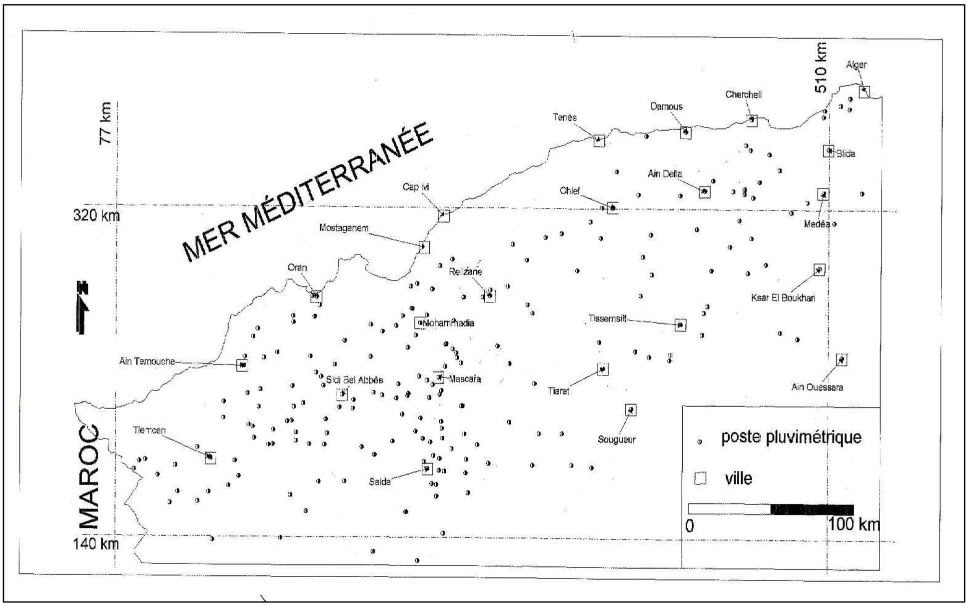



**Fig. 1.** ***Situation géographique des stations pluviométriques***

## 3. LES DONNES ET LES STATIONS PLUVIOMETRIQUES

### 3.1. Choix des stations et de la période d'étude

La représentativité spatiale et temporelle des stations pluviométriques a une influence majeure sur les cartes finales. Nous possédons 218 stations (Fig. 1) réparties aléatoirement dans l'espace étudié. Les données proviennent des deux organismes responsables du réseau pluviométrique à savoir l'Agence Nationale des Ressources Hydraulique (A.N.R.H.) et l'Office Nationale de Météorologique (O.N.M.). Les postes sélectionnés possèdent une séries de mesures suffisantes pour mener à bien cette étude, c'est-à-dire 30 ans tel que préconisé par l'Office Mondiale de Météorologie (O.M.M.). Certaine stations présentent des lacunes qui seront comblées en utilisant la méthode de régression linéaire à l'échelle mensuelle avec des stations de bases (mesure complète et correcte).

Un réseau bien distribué et représentant convenablement la zoné étudié doit traduire, par leur seule altitude, fidèlement la topographie, l'histogramme des fréquences relatives des altitudes de toutes les stations devrait être sensiblement proche de la courbe hypsographique de la région étudiée (Dumas D., 1998).

Deux cent station ont été utilisées pour l'établissement des relations pluie-morphométrie. Afin de tester et valider les cartes obtenues en utilisant la méthodologie PLUVIA, il serait judicieux de garder un certain nombre de stations représentatives de situation topographiques et géographiques variées. Alors, 18 stations vont être utilisées pour la validation des modèles obtenus. La figure n°3 montre la répartition altitudinale des stations étudiées.

## 4. METHEDOLOGIE A UTILISE

De nombreuses méthodologies en été misent au point et ont utilisé dans différentes parties du monde. Une nouvelle approche, semblable dans sa philosophie aux autres, a été mise au point par le Professeur Humbert de l'université de Strasbourg. Celle-ci est appelée **PLUVIA**. Cette dernière a été testée dans le Nord Est de la France et en Iran. Les résultats trouvés sont très encourageants. Pour la première fois elle sera utilisée en Algérie.

### 4.1. Méthodologie PLUVIA

#### 4.1.1. Introduction

La méthode permet de déterminer la quantité de pluies en un point d'une zone étudiée à partir de données de pluies mesurées en un certain nombre de postes climatologiques et en tenant compte du relief (MNT à un pas d'espace de 1 km). Le fondement de cette méthode consiste à associer aux postes de mesures, la pluviométrie à des paramètres statistiques appliqués à l'altitude tels que la moyenne, l'écart type, le coefficient de variation, le premier décile, le premier quartile, la médiane, le dernier quartile et le dernier décile. Ces paramètres, dits morphométriques, sont calculés sur des fenêtres de taille allant de 1 à 30 km avec un pas de 1 km et ayant 9 orientations différentes (centrée, nord, sud, est, ouest, excentrée nord, excentrée sud, excentrée est, excentrée ouest), Fig. 4.

Pluvia caractérise ainsi chaque station de mesure par un ensemble de 2160 paramètres morphométriques calculés une fois pour toutes et stockés dans sa banque de données et par le jeu de données de pluies mensuelles mesurées.

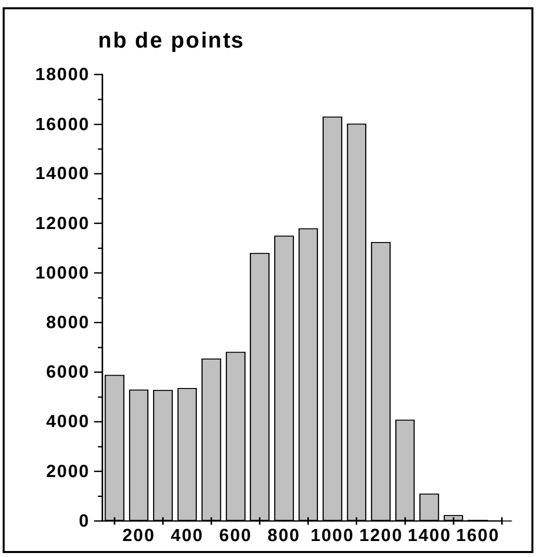



**Fig. 2.** ***Histogramme des altitudes de la région étudiée***

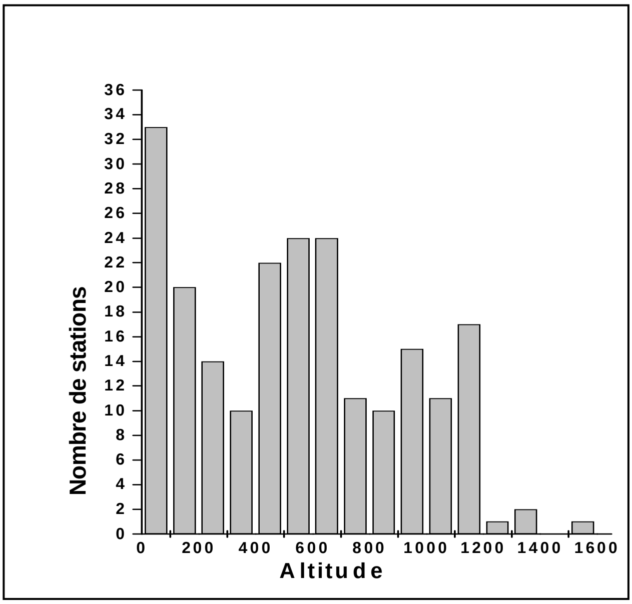



**Fig. 3.** ***Répartition altitudinale des 218 stations retenues***

Le logiciel contenant la technique Pluvia met en forme les paramètres retenus et les valeurs de pluie mesurées aux postes sélectionnés et autorise le traitement statistique par régression linéaire multiple pas à pas. Ce traitement statistique permet d'obtenir des variables explicatives (généralement, 3 à 4 prédicateurs suffisent pour expliquer 88 à plus de 95% de la variance). Pluvia propose la saisie des meilleurs prédicateurs et détermine la valeur de la pluie selon l'équation :

$$\mathbf{Log\ P = a + b.LogX1 + c.LogX2 + .... + k.LogXn}$$

Pour une date donnée et cela en chaque point d'une zone d'étude définie à un pas d'espace variable. Pluvia enregistre les pluies brutes ainsi calculées et calcule les résidus au niveau des stations retenues. Les résidus obtenus entre les valeurs mesurées et calculées sont ensuite analysés par krigeage, une technique d'interpolation qui permet de corriger les précipitations brutes calculées précédemment. Enfin Pluvia assure le lien avec un logiciel de cartographie pour la réalisation des cartes de niveau de pluies.

## 5. LA CONSTRUCTION DU MNT

La taille des mailles de ce MNT est d’environ 925 m. Cette maille est tout à fait suffisante pour l’utilisation que nous faisons. Nous avons ainsi échantillonné 213675 altitudes. La région d’étude est comprise dans rectangle de 555 km de longueur sur 385 km de largeur

## 6. LES PARAMETRES MORPHOMETRIQUES

Les pluies mesurées aux postes sont conjuguées aux différents paramètres morphométriques sur des fenêtres de tailles et d'orientation variables. Pour chaque station, nous avons calculé de nombreuses séries d'altitudes moyennes, d'écarts types et de coefficients de variation, sur 24 fenêtres carrées, mailles de calcul, à progresser régulière de 1 km (de 1 à 30 km), Humbert et al. (1993) :

- des fenêtres appelées centrées : la station est située au centre de la maille de calcul ;
- des fenêtres appelées excentrées ouest : la station est située sur le côté est de la maille de calcul ;
- des fenêtres appelées excentrées est : la station est située sur le côté ouest de la maille de calcul ;
- des fenêtres appelées excentrées nord : la station est située sur le côté sud de la maille de calcul ;
- des fenêtres appelées excentrées nord-ouest : la station est située dans le coin sud-est de la maille de calcul ;
- des fenêtres appelées excentrées nord-est : la station est située dans le coin sud-ouest de la maille de calcul ;

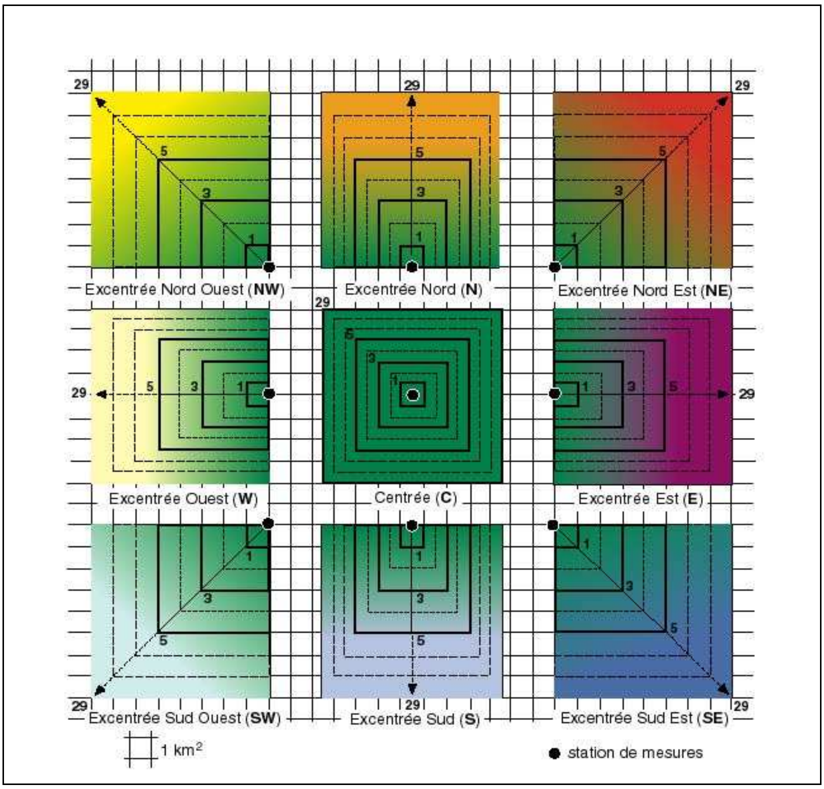



**Fig. 4.** ***Schématisation des neuf (09) fenêtres représentation schématique de la paramétrisation omnidirectionnelle***

L'altitude moyenne des trois derniers types de fenêtres a été calculée pour tenir compte de la morphométrie positionnée face aux vents dominants.

L'utilisation de ces différents types de fenêtres se justifie par l'hétérogénéité du relief de la région étudiée. Cette méthode présente un inconvénient majeur qui réside dans la production un jeu de paramètres dont la plupart sont fortement autocorrélés. Les redondances d'informations chutent rapidement lorsque l'on compare des fenêtres de tailles différentes et a fortiori lorsque les directions sont divergentes (Humbert et al., 1993). On peut voir sur la figure 12 les différences qui peuvent résulter du choix de la taille et de l'orientation des fenêtres sur le calcul de l'altitude moyenne de la station de Ksar El Boukhari (Fig. n°5). L'écart maximal pour la station de Ksar El Boukhari est enregistré entre la fenêtre excentrée nord et celle excentré nord-ouest entre lesquelles on enregistre 130 m de différence d'altitude moyenne. Le relief est caractérisé par 8 indices morphométriques différents auxquels on ajoute l'altitude effective du poste pluviométrique (Z) et les coordonnées géographiques des stations, Partant du principe qu'au niveau de deux sites, dont les caractéristiques morphométriques sont les mêmes et s'ils sont situés suivant une direction d'écoulement, il pleuvra sur le site par où les vents arrivent, les masses nuageuses peuvent ne pas atteindre le second site (Laborde J.P., 1984). Les paramètres explicatifs peuvent être regroupés comme suit:

- Les positions géographiques des stations (X, Y, Z);
- Les indices qui mesurent la rugosité du relief avec l'écart type (E) et le coefficient de variation (CV);
- Les indices morphométriques avec l'altitude moyenne (M), l'altitude médiane (D) et les altitudes à signification fréquentielle représentant 10 % des altitudes proches de la station (PD pour le premier décile), puis 25 % (PQ pour le premier quartile), 75 % (DQ pour le dernier quartile) et 90 % (DD pour le dernier décile).

Donc, chaque poste pluviométrique est caractérisé par un jeu de 1443 paramètres**.**

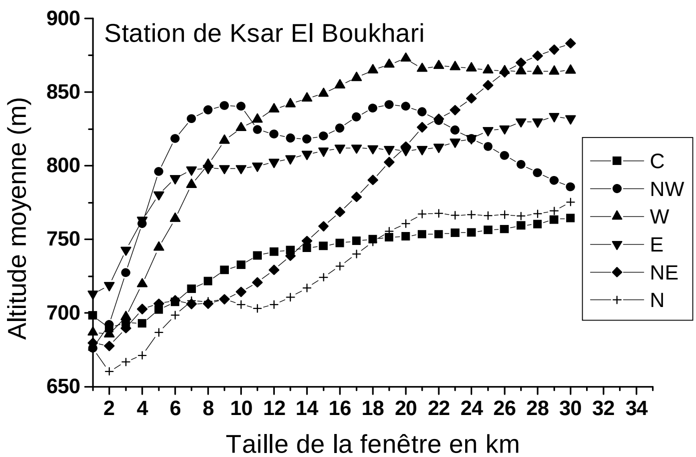



**Fig. 5.** ***Exemple de relation entre la dimension de différentes fenêtres et l'altitude moyenne de la station de Ksar El Boukhari***

## 7. LE CALCUL DES PRECIPITATIONS

L'estimation des pluies au niveau des points du maillage de la région étudiée est faite par la somme de deux termes. Le premier est issu de la combinaison linéaire des paramètres explicatifs de la pluie. Le second terme représente les résidus (la partie non expliquée des pluies par le relief et les coordonnées géographiques) et il permet d'optimiser le résultat final (Dumas D., 1998 et Mahr N. et al., 2000).

### 7.1. Corrélation entre les pluies et les paramètres morphométriques et géographiques

Le nombre important de paramètres rend très délicat. Cela, nous a poussé à procéder d'abord à sélectionner les variables explicatives la plus signifiante du point de vue statistique (coefficient de corrélation directe entre la pluie et chaque paramètre). Cette étape, nous a permis de faire une sélection des paramètres les intéressants. Il est pratiquement impossible de mettre ici la matrice de corrélation globale. La figure n°6 montre l'évolution du coefficient de corrélation avec les différentes altitudes calculées sur des fenêtres croissantes pour les pluies annuelles. Ce corrélogramme nous permet de voire une meilleure corrélation entre la pluie annuel et les altitudes moyennes calculées pour des fenêtres de dimensions de 29 km à 30 km d'orientation Nord, Nord-Est et Nord-Ouest. Cette évolution du coefficient de corrélation montre que les pluies annuelles sont influencées par les volumes montagneux de direction nord (centre, est et ouest) et en liaison étroite avec les flux météorologiques dominants de ces directions.

A l'échelle mensuelle, On constate des relations très spécifique (relative à chaque mois), chacune d'elles traduisant des relations spécifiques avec l'orographie en fonction de la répartition fréquentielle des types de temps enregistrés sur la période. Sur la figue n°7 est représentée la relation entre les pluies de quatre mois (un mois par saison) et l'altitude moyenne de direction Nord-Est. En hiver , le maximum de corrélation appartient à des fenêtres de dimensions élevées (29 et 30 km) montrant l'influence régionale dont les perturbations sont de secteurs nord, nord-est et nord-ouest.

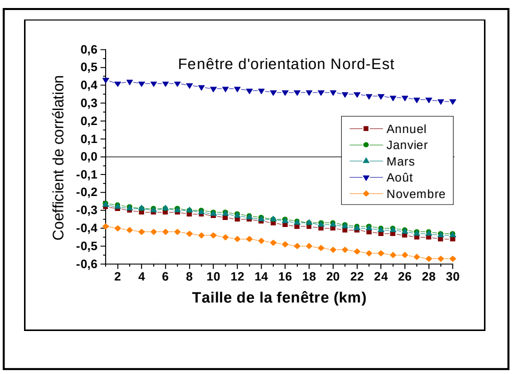



**Fig. 7.** ***Exemples de corrélations entre les précipitations annuelles et l'altitude moyenne calculée sur des fenêtres de taille croissantes et d'orientations variées***

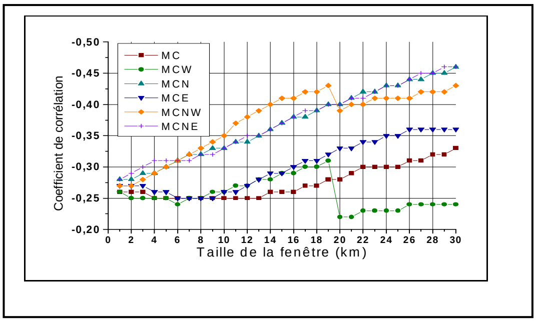



**Fig. 6.** ***Exemples de corrélations entre les précipitations annuelles et mensuelles et l'altitude moyenne calculée sur des fenêtres de taille croissantes et d'orientations Nord-Est***

### 7.2. Les pluies calculées

Les précipitations varient rapidement avec le site, plus amplement avec la situation et enfin lentement avec la région. Elles peuvent donc être considérées comme une fonction de trois composantes (Laborde J.P., 1993) :

$$R(X) = f\,(R_{site}(X),\ R_{situation}(X),\ R_{région}(X))$$

Les paramètres caractéristiques de chaque station ont été calculés par le logiciel PLUVIA. Une sélection des paramètres les plus explicatif du phénomène « pluviométrique » a été faite dans une première étape telle que décrite précédemment. L'ensemble des traitements a été faite en utilisant le logiciel HYDROLAB (Laborde J.P., 1998). Cela donne un ensemble d'équations de la forme :

$$\text{Log } P = a + b \text{ Log } X_1 + c \text{ Log } X_2 + \dots\dots\dots\dots + k \text{ Log } X_n$$

Avec :

P = précipitation calculées (pour une période i en un point j)
X1, …., Xn = variables explicatives
a = constante de régression
b…..k = coefficient de régression.

### 7.3. Interpolation et cartographie automatique

Avant la cartographie automatique des pluies annuelles et mensuelles, il est indispensable d'effectuer un calcul des pluies aux nœuds du maillage de la région étudiée. Ce calcul se fait par l'intermédiaire des relations pluies - morphométries trouvées précédemment. Afin d'obtenir les grilles finales à cartographier, il est nécessaire d'ajouter aux pluies calculées les résidus de régressions. Ces résidus sont stationnaires d'ordre 2, c'est à dire qu'ils sont nuls en moyenne et de variance constante. Ces résidus se prêtent donc plus facilement à une interpolation (Laborde J.P., 1993).

### 7.4. Optimisation des précipitations avec les résidus

Certains auteurs ne s'intéressent qu'aux résidus qui, selon eux, reflètent les véritables rugosités spatiales alors que les modèles ne montrent que les grandes tendances lissées du phénomène (Dumas D., 1998). L'intérêt de la prise en compte des résidus dans sur le résultat final de la spatialisation des pluies a été montré par de nombreux auteurs Laborde J.P., 1988 dans le nord-est de la France, Meddi M., 1994 dans le bassin versant de l'Oued Mina (Algérie), Humbert J., 1993 et 1997 dans le massif vosgien (France) etc.

Le calcul final des pluies se fait par la somme des pluies calculées et des résidus. Ces résidus correspondent à une partie des pluies non expliquée directement par le relief mais dont la signification exacte reste néanmoins complexe (Dumas D., 1998). Pour ajouter ces résidus aux pluies calculées, ils sont régionalisés avec une interpolation utilisant un algorithme de krigeage sans effet de pépite. De cette façon, on obtient pour chaque nœud du MNT une valeur des résidus qui permettent la correction des précipitations calculées et d'optimiser ainsi le résultat final sur l'ensemble de la zone étudiée.

Afin de montrer l'opportunité de la régionalisation des résidus, nous avons entamé une étude variographique des résidus.

### 7.5. Variogrammes des résidus de régressions

Les variogrammes expérimentaux ont été calculés par tranche de 5 km de distance du fait de la densité du réseau qui est jugé suffisante. Le variogramme expérimental $\gamma(h)$ est la variance des écarts entre les résidus de régression entre deux points distants de h (Laborde J.P., 1993). Nous avons calculé les variogrammes expérimentaux dans deux directions privilégiés à savoir nord-sud et est-ouest (Fig. 8 et 9).

L'étude des variogrammes montre bien l'adaptation du modèle exponentiel :

$$\gamma(h) = \sigma^2 (1 - e^{\frac{-h}{p}})$$

Le palier et la porté p ont été ajustés graphiquement de manière est ce que le modèle théorique passe par le nuage de points (au milieu).

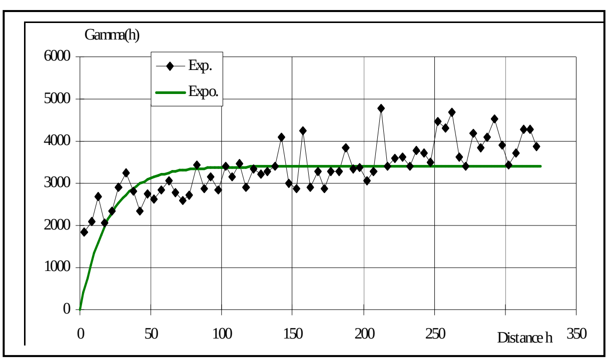



**Fig. 8.** ***Variogramme des résidus de régression (annuelle) dans la direction Nord-Sud***

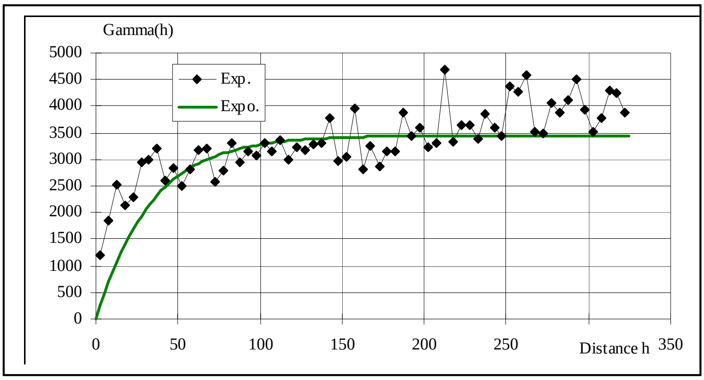



**Fig. 9.** ***Variogramme des résidus de régression (annuelle) dans la direction Est-Ouest***

### 7.6. Cartographie des précipitations

L'ajout des résidus interpoles aux valeurs des pluies calculées permet l'obtention d'une grille, à maille carrée d'un km, contenant les précipitations finales à cartographier.

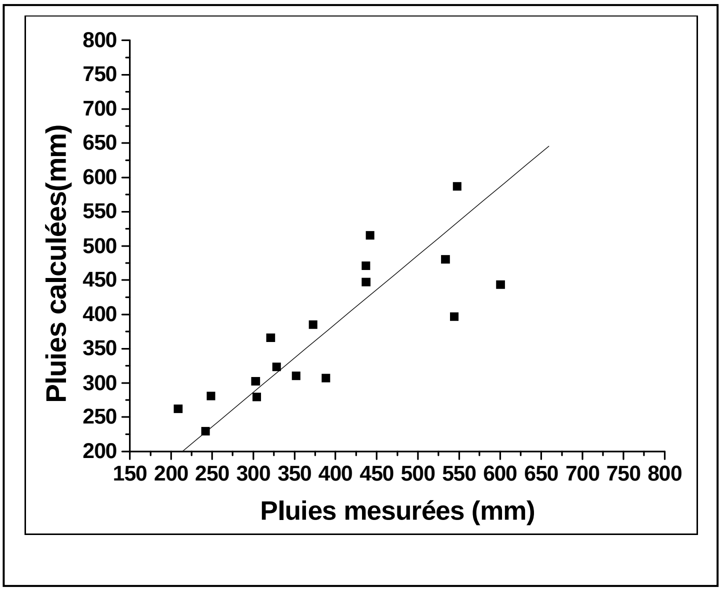
### 7.7. La validation des modèles

Afin de juger de la robustesse des modèles établis et leurs stabilités, de nombreuses validations ont été effectuées sur les 18 stations écartées du lot initial. Les figures suivantes illustres les résultats d'une validation appliquée à 18 postes (Fig. 10, 11, 12 et 13). Pour mieux vérifier les hypothèses statistiques, il est préférable de vérifier la normalité des résidus issus de chaque régression. Plus de 80 % des erreurs moyennes sont compris entre –25% et +25% pour les pluies annuelles et celles des mois de janvier, de mars et de novembre (Tab. 1).

***Fourchettes d'erreurs sur les 18 stations tests***

**Tableau 1**

| **Fourchettes d'erreurs** | **Annuel %** | **Janvier %** | **Mars %** | **Novembre %** |
|---|---|---|---|---|
| -15 % à +15 % | 63 | 55 | 56 | 59 |
| -25 % à +25 % | 85 | 83 | 85 | 87 |



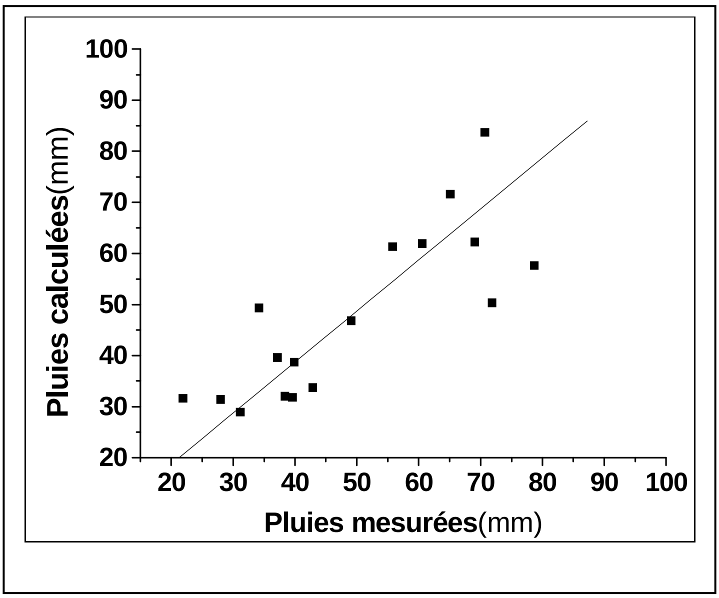




**Fig. 11.** ***Validation des régression mensuelles (Janvier) sur 18 stations***

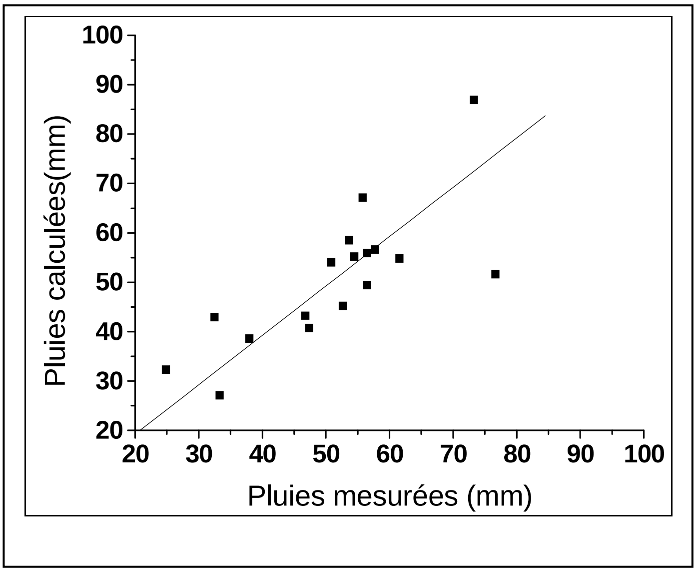



**Fig. 12.** ***Validation des régression mensuelles (Mars) sur 18 stations***

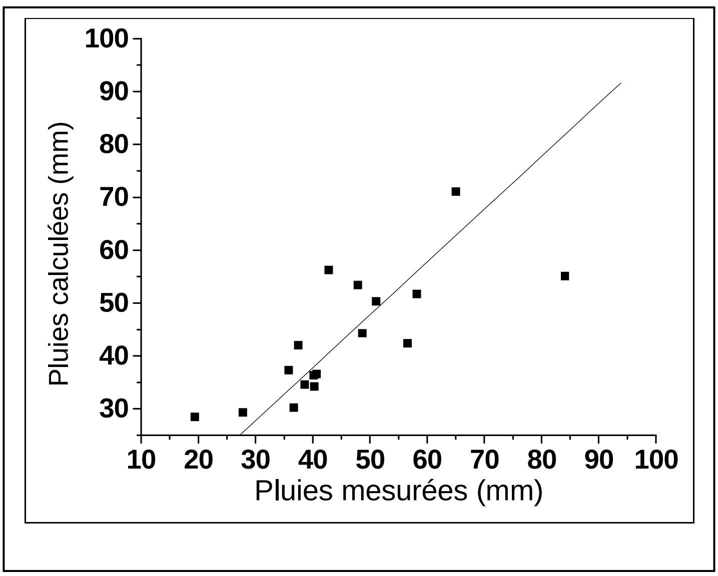



**Fig. 13.** ***Validation des régression mensuelles (Novembre) sur 18 stations***

### 7.8. Interprétation des cartes pluviométriques

Les résultats pour le module interannuel, les pluies du mois de janvier, de mars et de novembre sont regroupés dans le tableau n° 2.

***Résumé des résultats obtenus et les différentes régressions multiples***

**Tableau n.2**

| Paramètre | Annuel | | Janvier | | Mars | | Novembre | |
|---|---|---|---|---|---|---|---|---|
| R (coef.Corré) F (Fisher) Constante | 0,83 50,93 0,236 | | 0,81 51,15 -0,901 | | 0,80 41,95 -0,145 | | 0,83 50,77 -0,636 | |
| | Coef. Corr. Part. | Coef. Régression | Coef. Corr. Part. | Coef. Régression | Coef. Corr. Part. | Coef. Régression | Coef. Corr. Part. | Coef. Régression |
| X Lambert | -0,24 | -0,172 | | | -0,41 | -0,357 | -0,25 | -0,199 |
| Y Lambert | +0,51 | +0,953 | +0,57 | +0,844 | +0,42 | +0,874 | +0,47 | +0,983 |
| Z – altitude | +0,61 | +0,198 | +0,52 | +0,198 | +0,57 | +0 ,214 | +0,53 | 0,186 |
| CV-NE-29 | | | +0,35 | +0,187 | +0,21 | +0,098 | +0,33 | +0,165 |
| CV-NE-30 | +0,22 | +0,095 | | | | | | |
| DD-NW-25 | -0,33 | -0,058 | -0,20 | -0,042 | -0,19 | -0,048 | -0,28 | -0,052 |
| DQ-NE-29 | | | | | +0,15 | +0,038 | | |
| E-C-7 | +0,30 | +0,076 | +0,28 | +0,098 | +0,39 | +0,125 | +0,19 | +0,056 |
| PD-NW-29 | | | | | -0,18 | -0,029 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **PD-NE-29** | | | | | | | **+0,28** | **+0,064** |
| **PQ-NW-29** | **-0,20** | **-0,031** | **-0,28** | **-0,057** | | | **-0,24** | **-0,045** |
| **PQ-NE-29** | **+0,23** | **+0,046** | **+0,32** | **+0,084** | | | | |
| **DQ-E-5** | | | | | | | | |

**7. 8. 1. Echelle annuelle (Fig. 10):**

La carte montre bien les tendances pluviométriques de la région étudiée. Elle illustre bien l'influence de trois facteurs sur la répartition spatiale des précipitations à savoir: l'altitude, la longitude et la latitude. Les pluies croissent du nord au sud et de l'ouest à l'est. L'augmentation des pluies en altitude, proche du littoral, est liée aux masses d'air humide venues du nord (nord-ouest, nord et nord-est). Sur le nord, à l'est de la région étudiée, les pluies dépassent les 850 mm. Ces pluies diminuent fortement vers le sud où on enregistre des pluies de l'ordre de 100 mm dont le rapport est de l'ordre de 8 fois. Le gradient vertical, à l'est de la région, est d'environ 3 mm/km. On constate une certaine augmentation des pluies sur les massifs d'Oursenis, les monts de Tiaret les monts de Tlemcenet l'Atlas Blédien.

**7. 8. 2. Mois de Janvier (Fig. 11):**

Les précipitations du mois de janvier sont plutôt sur la partie nord-est de la région étudiée du fait des flux prédominants du nord-est. Avec une diminution dans la partie ouest de la région étudiée du fait de l'effet d'abri vis à vis des vents humide de direction ouest. Les vents de direction nord ouest vident leur humidité proche du littoral et sur les massifs montagneux et elles se vident en allant vers le sud. Egalement, les pluies croissent sur le massif d' Oursenis, les monts de medéa et l'Atlas Blédien.

**7. 8. 3. Mois de Mars (Fig. 12):**

La situation est sensiblement identique au mois de janvier, néanmoins, les pluies augmentent sensiblement dans les parties intérieurs de la région étudiées. La pluviométrie est toujours en étroite relation avec les flux du nord-est prédominant et également les vents de direction nord-ouest telle que indiquée par les paramètres explicatifs des pluies de mars.

**7. 8. 4. Mois de Novembre (Fig. 13):**

Les pluies du mois de novembre augment du sud au nord et de l'ouest à l'est de la zone étudiée. Les vents responsable de ces pluies sont de direction nord, nord-ouest et est selon les paramètres explicatifs. Les régions qui reçoivent les pluies les plus importantes sont semblables à celles des mois de janvier et du mois de mars.

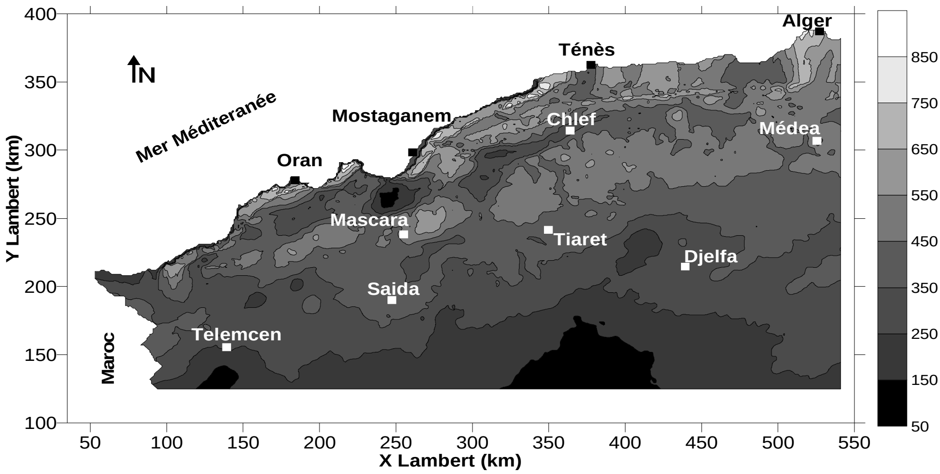



**Fig. 14** *: **Variation Annuelle des précipitations (1968-1998)***

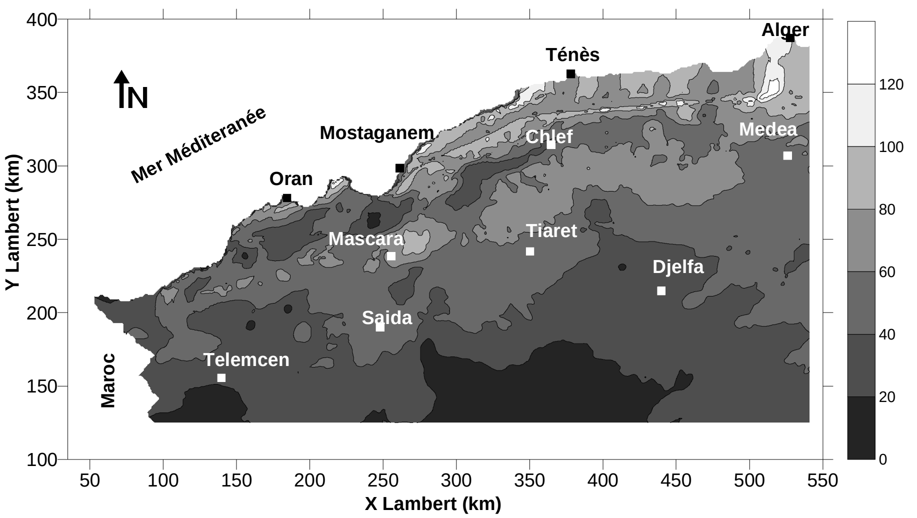



**Fig. 15** *: **Variation des précipitations du mois de Janvier (1968-1998)***

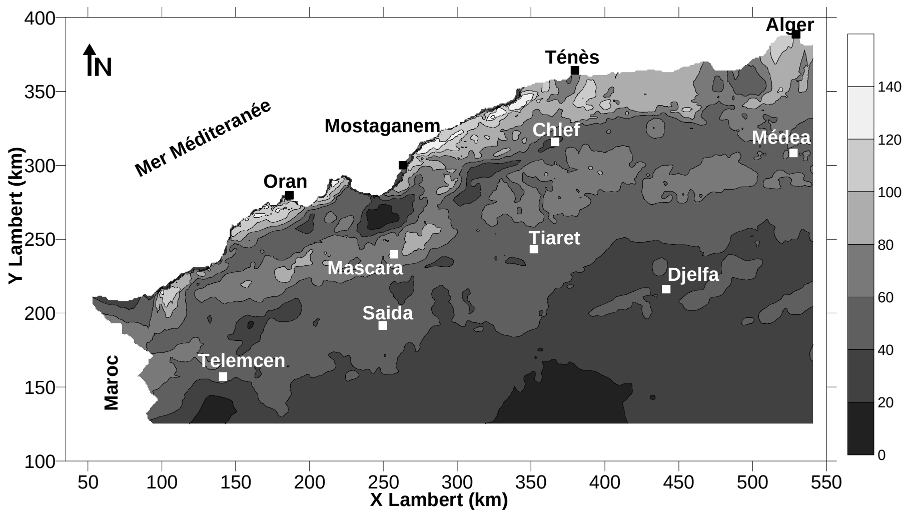



**Fig. 16** ***: Variation des précipitations du mois de Mars (1968-1998)***

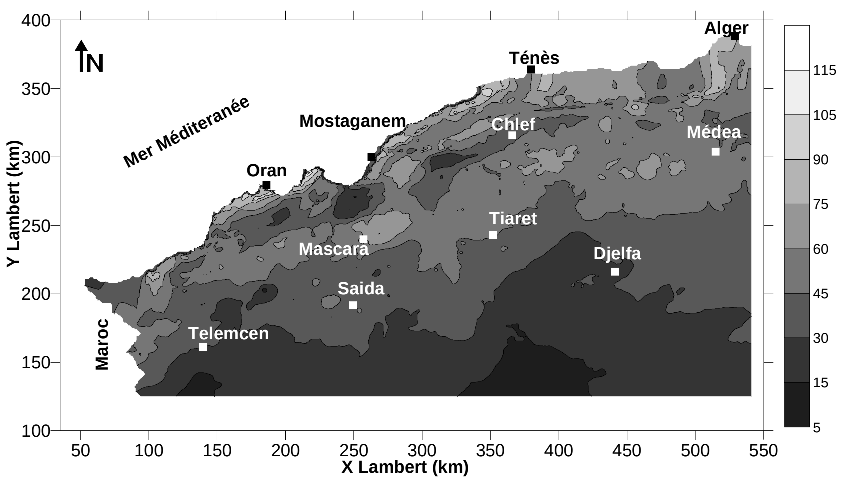



**Fig. 17** ***: Variation Saisonnière des précipitations du mois de Novembre (1968-1998)***

## 8. COMPARAISON AVEC LA CARTE DE L'ANRH (1993)

La carte pluviométrique de l'Algérie du Nord établi par l'Agence Nationale des Ressources Hydrauliques (A.N.R.H.) sous l'autorité scientifique du Professeur Laborde en 1993 s'appuyait sur 470 postes de l'Algérie du Nord (1922-60, 1969-89). ) On remarque une bonne adéquation entre les racines carrées des moyennes pluviométriques selon l'ANRH et celles calculées par Pluvia (Fig. 18) avec un coefficient de corrélation égal à 0.96. La relation est :

$$P_{68-03} = (0.92\sqrt{P_{ANRH-Laborde}} + 0.25)^2$$

Seules 5 stations sur les 116 stations communes sortent de l'intervalle de confiance à 95%. Donc, dans l'ensemble les estimations faites et la carte établit sont tout à fait cohérentes avec celle de l'ANRH. Mais, nous avons trouvé une baisse, en moyenne, de l'ordre de 13 % par rapport aux pluies moyennes issues de la carte de l'ANRH.

## 9. CONCLUSION

La méthode Pluvia a permis de tracer les cartes pluviométriques en fonction de la topographie des pluies annuelles, du mois de janvier, du mois de mars et du mois de novembre.

L'étude de validation des modèles a montré une certaine logique dans le tracé de ces cartes. L'étude statistique, concernant cette validation, a montré que les erreurs sur l'estimation des précipitations restent acceptables.

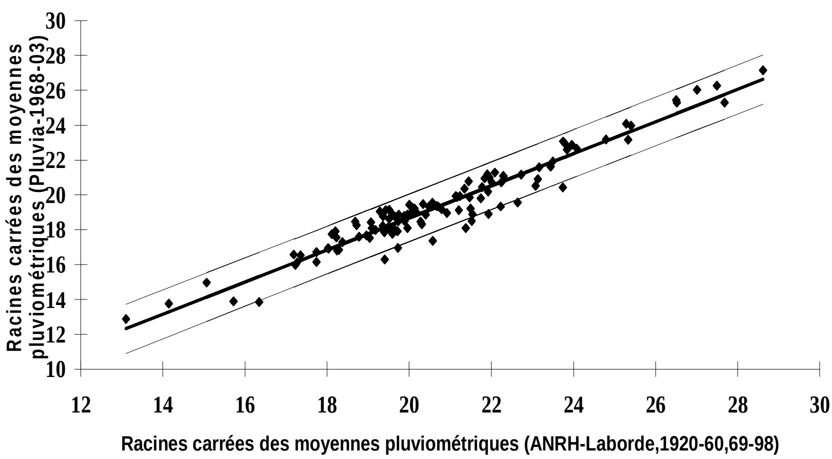



**Fig. 18** ***Relation entre les pluies de la carte ANRH Laborde (1920-60, 69-98)et la carte Pluvia (1968-03)***

Après avoir effectué ce travail, nous pouvons dire que cette méthodologie peut être envisagée pour l'étude de l'évolution pluviométrique dans l'espace, néanmoins, il est indispensable de compléter les fonctionnalités de ce logiciel par l'introduction, par exemple, de la distance à la mer selon les différentes directions.

Les pluies annuelles et celles des mois de janvier, mars et de novembre, augmentent du sud au nord et de l'ouest à l'est. La partie littorale et les sommets qui lui sont proche reçoivent les pluies les plus importantes. Les régions intérieures reçoivent moins de pluies du fait de l'appauvrissement des masses nuageuses de leurs humidités au fur et à mesure qu'elle se dirige vers l'intérieur.

Les facteurs physiographiques et météorologiques interviennent implicitement dans les équations de régressions par (Drogue G. et al., 2002):

- La taille et la morphologie des secteurs montagneux au alentour des stations pluviométriques;
- La distance des postes pluviométriques des crêtes secondaires (influence locale) et principales (influence régionale);
- L'origine et la direction des masses d'air humide;

Nous avons trouvé une cohérence acceptable avec la carte de l'ANRH réalisée en 1993 avec une baisse de 13 % sur les pluies moyennes annuelles.

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# A STUDY ON THE OCCURRENCE OF FOG IN THE UPPER MURES BASIN

**Zs. Magyari-Sáska**[1]

**ABSTRACT**
The proesent study aims do describe the fog phenomena in the Upper Mures Bassin and an analysis of the persistence of fog in the region. The data source is NCDC, comprising data about fog occurence,average daily visibility, as well as daily minimum temperatures. The study includes both a descriptive statistics of the phenomena and a part of frequantial analysis. The descriptive statistics succeeds in identifying the valley fog in the area as being typical to the winter months. The frequential analysis targets both detecting the number of days with fog in the area with a visibility under 1000 m, as well as the number of consecutive days in which the mean daily visibility is under 1000 m. The result of this analysis is the statement that, in the long run, the proportion of consecutive days having a visibility under 1000m with respect to the numer of days with visibility under 1000m is around 40% at Joseni and approximately 80% for Toplița.

*

## 1. THE FOG PHENOMENA

Fog is an agglomeration of water particles being in pending above the ground. The phenomena appear when water vapors from the atmosphere become saturated, mostly due to the cooling of temperature bellow dew point. There are several types of fog, depending on water condensation conditions:
- Radiation fog is formed by the cooling of ground after sunset in calm conditions with clear sky, which produces condensation in the nearby air. This type of fog could have at most 1m height from ground in calm conditions.
- Advection fog occurs when moist air appears over a cool surface and is cooled. It is common as a warm front passes over an area with significant snow.
- Evaporation fog, is the most localized type and is created by cold air passing over much warmer water or moist land
- Valley fog forms in mountain valleys as the result of a temperature inversion, often during winter. It is caused by heavier cold air settling into in a valley, with warmer air passing over the mountains above. It is in fact a radiation fog blocked by local topography.
- Upslope fog forms when winds blow air up a slope, adiabatically cooling (without heat transfer) appear as it rises, and causing the moisture in it to condense.

## 2. DESCRIPTIVE STATISTICAL CHARACTERIZATION

The descriptive statistical characterization is necessary from multiple motifs. First of all it’s based on this characterization makes possible the estimation of spatial and temporal apparition of fog. Regarding the fog phenomena an analysis which takes care of several meteorological factors can identify different types of fog. On the other hand a

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spatial correlation between fog apparition, or a regression between topography and fog apparition could be also useful.

Figure 1 and 2 presents a global aspect of the fog apparition in the study area.

Comparing these figures the following notification can be made:

- The fog apparition and strongly related to it the reduced visibility is characteristic for Calimani station, situated at 2021m altitude;
- Bucin station also situated on a crag at 1279m, has different characteristics, the foggy days and a reduced visibility days with visibility below 1000m is comparable with the stations in the Giurgeu Depression
- Regarding the foggy day number Toplita station has more foggy days than Joseni, even if the mean visibility is much reduced is Joseni that in Toplita

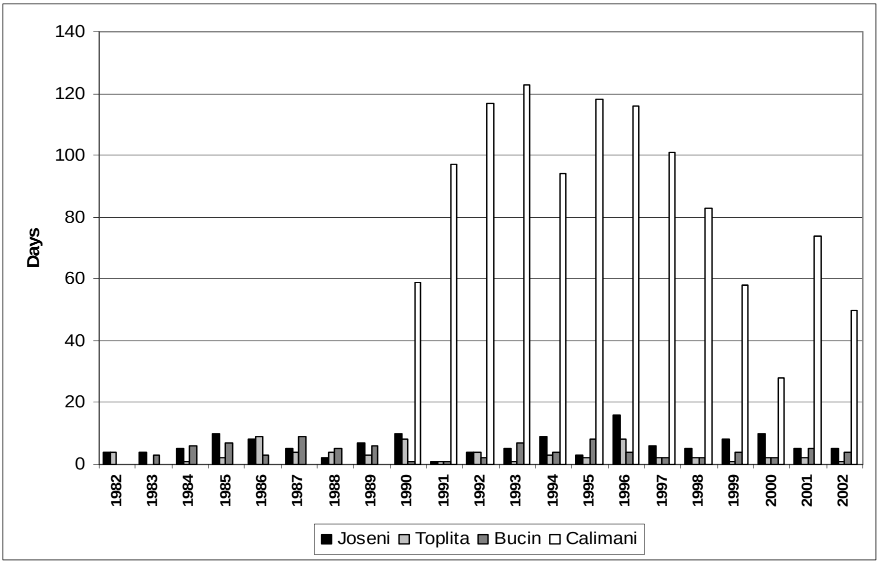


**Fig. 1. –** ***Annual average of foggy days***

A complete characterization of mean foggy days with different visibility limits is presented bellow.

***Annual number of foggy days***

Table 1.

| | JOSENI | TOPLIȚA | BUCIN | CĂLIMANI |
|---|---|---|---|---|
| Annual mean foggy days | 59.95 | 71.09 | 74.05 | 211.61 |
| Annual mean days having mean daily visibility bellow 1000m | 6.28 | 3.04 | 4.25 | 86.00 |
| Annual mean days having mean daily visibility bellow 500m | 4.28 | 1.28 | 2.10 | 82.92 |

The total number of days in which the mean daily visibility is below 5m has the following distribution in the studied period (1982-2002): Joseni 4 days, Toplita 0 days, Bucin 3 days, Calimani 354 days.

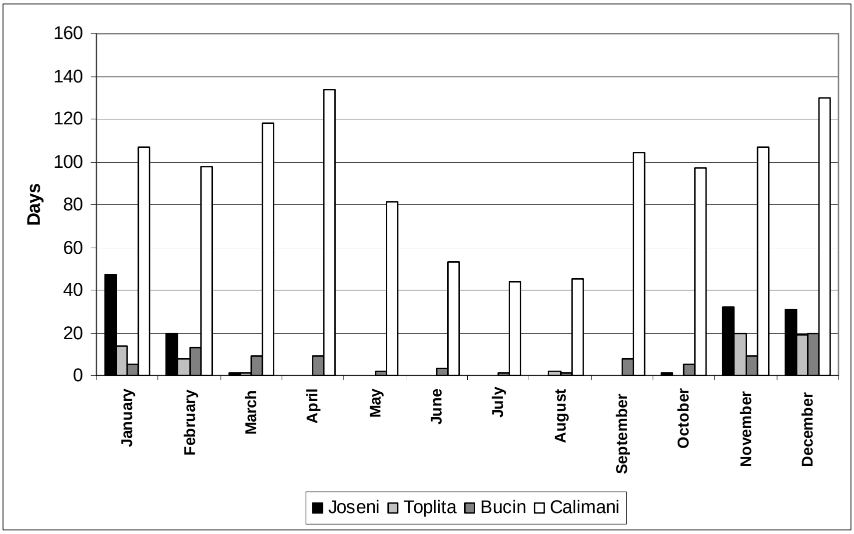


**Fig. 2*: Monthly average number of foggy days having mean daily visibility bellow 1000m***

It's important to notice that the number of foggy days have a rising trend from May to October at Toplita comparing with Joseni. It's also evident that the fog represents risk in Giurgeu Depression mostly in winter period. Based on this observation we start to study the condition of fog apparition in winter month (November, December, January and February). The result was that temperature inversions are an essential factor in fog presence, having a daily mean visibility bellow 1000m.

Studying the station pairs (Joseni-Bucin, Toplita-Calimani) we can conclude that in case of Joseni-Bucin pair the temperature inversions are strongly correlated with daily mean visibility, while for Toplita-Joseni station this is not obvious. This result is not surprising because of Calimani station high altitude, encountering almost all times foggy conditions.

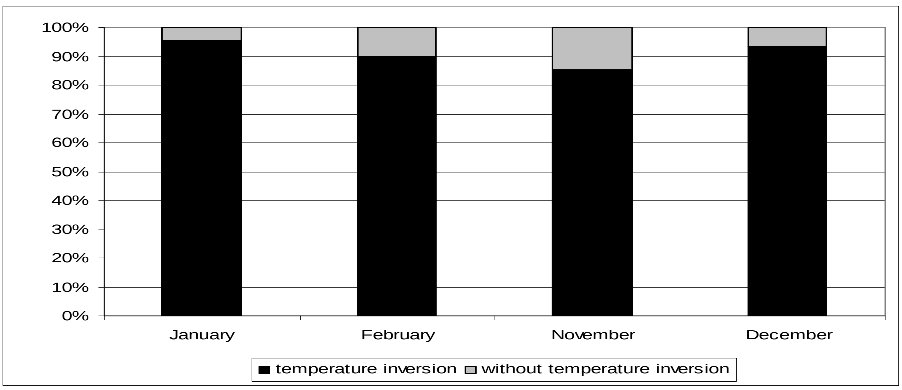


***Fig. 3: Frequency of days with temperature inversion correlated to fog apparition (mean daily visibility bellow 1000m)***

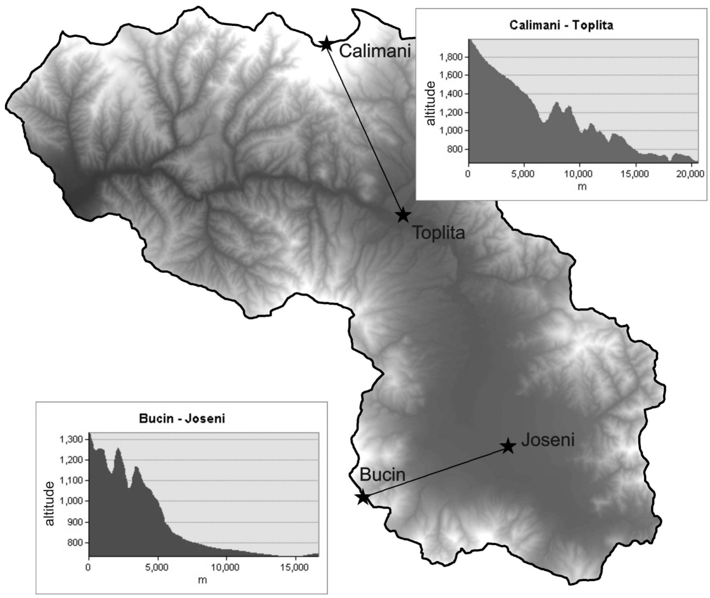


***Fig. 4: Position of meteorological stations in the study area and the longitudinal profiles between them***

An eventual correlation between Joseni and Toplita stations was also studied, both of them situated in the Depression.

***Percentage of common fog apparition at Joseni and Toplița stations***

Table 2.

| MONTH | PERCENTAGE OF COMMON FOG APPARITION |
|---|---|
| January | 74.65% |
| February | 64.65% |
| November | 74.67% |
| December | 65.32% |

Almost in 70% of the cases if the fog presence is observed at Joseni was also observed at Toplita. The Pearson correlation value has interpretable values for January, November and December.

***Correlation values of mean daily visibility between Joseni and Toplița stations***

Table 3.

| MONTH | CORRELATION VALUE |
|---|---|
| January | 0.31 |
| February | – |
| November | 0.86 |
| December | 0.46 |

The only month with significant correlation value is November, in case of the other month the correlation value does not show a true correlation between mean visibility values. As a conclusion a visibility interpolation based on this relation cannot be made.

The persistence of fog was also studied based on consecutive days with fog having visibility bellow 1000m. The study was also made just for the mentioned winter month for Joseni and Toplita stations.

The results show up an important correlation between successive foggy days at Joseni and Toplita. This correlation values was 0.70 for foggy days and a little bit higher (0.73) when the maximum daily mean1000m visibility was imposed.
The mean annual successive day number, when visibility was bellow 1000m is 2.05 for Joseni and 1.25 for Toplita.

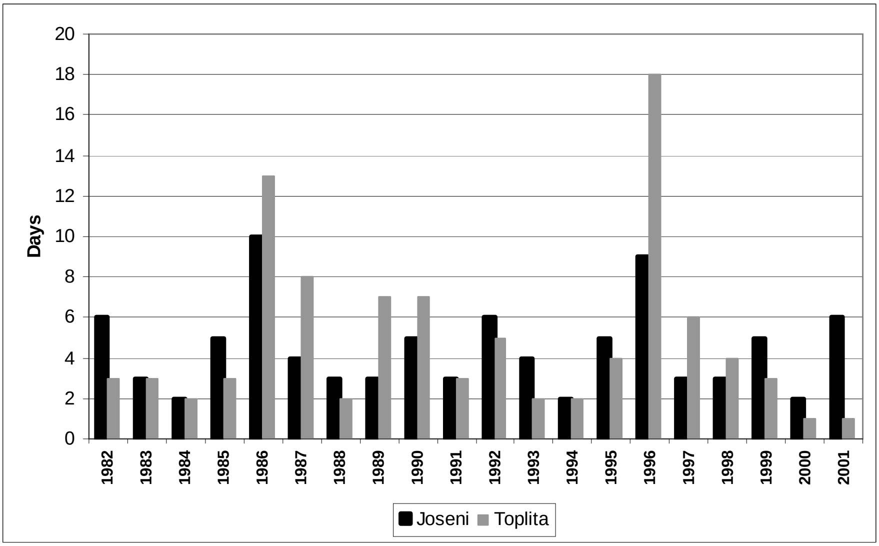


***Fig. 5: Number of consecutive foggy days (without visibility limitations)***

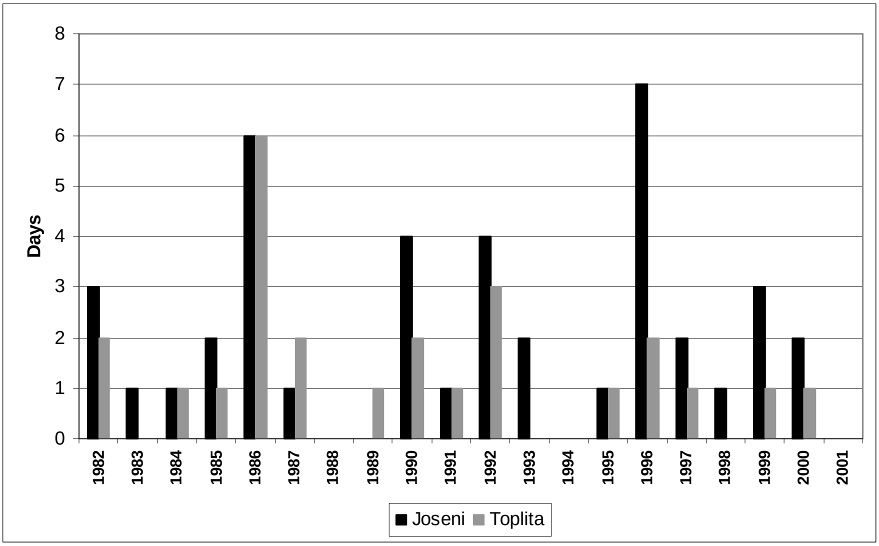


*Fig. 5: Number of consecutive foggy days (mean daily visibility bellow 1000m)*

## 3. FREQUENCY ANALYSIS

This part of the research wants to determine the most suitable distribution laws which can characterize the fog apparition, together with the return periods for different quantiles representing annual days number with visibility bellow 1000m and the longest number of successive days with mean daily visibility bellow 1000m.

Both characteristics are in discrete space, so discrete distribution laws should be studied. The used software were EasyFit and R. Our former research showed up that R offer high precision in distribution fitting and quantile determination for different return periods. It's only lack is that doesn't have a proper method for estimating distribution fitting, even if different statistical test are present (Anderson-Darling, Kolmogorov-Smirnov, Chi-Square). For this phase of the analysis EasyFit was used.

The studied discrete distribution laws were:

- binomial
- negative binomial
- Poisson
- discrete uniform
- geometrical
- hypergeometrical
- logarithmical

The following observation should be made before using these laws:

1. the logaritmical law can be used only if the data series does not contain zero. Because of a zero value present at Toplita, in this study thsi law was omitted
2. the parameter estimation was made by fitdistr function in R, using maximum likelihood method
3. binomial and hypergeometrical laws does not have a parameter estimation method in R, so their values was determined manually

The table bellow holds the estimated parameters for every used discrete distribution law:

***Estimated parameters for different distribution laws for the study of foggy days number***

Table 4.

| DISTRIBUTION | JOSENI | TOPLIȚA | BUCIN | CĂLIMANI |
|---|---|---|---|---|
| Negativ binomială (n,µ) | 9.0797; 6.2857 | 3.7766; 3.0476 | 18.3004; 4.2499 | 7.6998; 86 |
| Discret uniformă (a,b) | 1; 10 | 0; 9 | 1; 9 | 28; 123 |
| Geometrică (p) | 0.13725 | 0.24706 | 0.19048 | 0.01149 |
| Poisson (λ) | 6.2857 | 3.0476 | 4.25 | 86 |
| Binomială (n,p) | 7665; 0.00082 | 7665; 0.000397 | 7300; 0.000582 | 4745; 0.0112 |
| Hipergeometrică (N,m,n) | 7665; 132; 365 | 7665; 64; 365 | 7300; 85; 365 | 4745; 1118; 365 |

For determining the best distribution the Anderson-Darling test was used because this method is more sensible at distribution tails where the extreme values can appear. Based on this method the following result were obtained:

Joseni: negative binomial
Toplita: Poisson
Bucin: Poisson
Calimani: negative binomial

The number of foggy days having visibility bellow 1000m for different return periods is presented bellow:

Estimated number of foggy days with mean daily visibility bellow 1000m for different return periods

Table 5.

| Return period (years) | JOSENI | TOPLIȚA | BUCIN | CĂLIMANI |
|---|---|---|---|---|
| 10 | 11 | 5 | 7 | 129 |
| 20 | 12 | 6 | 8 | 145 |
| 50 | 14 | 7 | 9 | 164 |
| 100 | 16 | 8 | 10 | 178 |
| 150 | 16 | 8 | 10 | 186 |
| 200 | 17 | 8 | 10 | 191 |
| 500 | 18 | 9 | 11 | 207 |

A similar study was made for determining the maximum consecutive foggy days with visibility bellow 1000m. The analysis was made only for Joseni and Toplita and just for winter month. The resulted distribution laws are:

Joseni: Poisson
Toplita: hypergeometric

The quantiles for different return periods are bellow:

***Estimated numbers of consecutive foggy days with mean daily visibility bellow 1000m for different return periods***

Table 6.

| Return period (years) | JOSENI | TOPLIȚA |
|---|---|---|
| 10 | 4 | 4 |
| 20 | 5 | 5 |
| 50 | 5 | 5 |
| 100 | 6 | 6 |
| 150 | 6 | 6 |
| 200 | 7 | 6 |
| 500 | 7 | 7 |

## 4. CONCLUSIONS

Using NCDC database we could identify the valley fog, characteristic for the study region. For this identification we used three meteorological components: the presence of fog, daily mean visibility and daily minimum temperature.

The pronounced correlation between the periods in which mean daily visibility is bellow 1000m at Joseni and Toplita stations related to that fact that does not exists significant correlation between daily mean visibility between stations the interpolation of visibility can be made just for persistent fog.

Comparing the data series presenting foggy days with daily mean visibility below 1000m and the number of successive days with mean visibility bellow 1000m both of them resulted from frequency analysis, we can observe two opposite directions for long term period (over 200 years) at Joseni and Toplita stations. At Joseni we have a slightly ascending trend (from 36% to 38%) in percentage of successive day with mean daily visibility bellow 1000m from all foggy days with mean visibility bellow 1000m, while at Toplita we can observe a slightly descending trend (from 80% to 77%) for the same characteristic.

On the other hand for a short time period (0-20 years) we could observe a significant percentual rise of successive foggy days with mean daily visibility bellow 1000m. Noticing the high value of successive foggy days in 2006, related to the fact that the analyzed data series ends in 2002, we have a validity of our analysis.

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# THE ANALYSIS OF THE DAILY WIND CHILL INDEX OF PEAK OMU STATION, ROMANIA BY MEANS OF POWER SPECTRA AND WAVELET TRANSFORM

**G. Najjar**[1], **B.S. David**[2]

**ABSTRACT**
Le concept de la température ressentie au vent. a été d'abord quantifiée des expériences exécutées sur le mesurage du rate de refroidissement d'eau dans un récipient quitté à l'extérieur. Une fois créée le concept de la température ressentie au vent a apprécié l'utilisation étendue dans la description de la sévérité combinée de vent et de température aérienne basse sur les humains. Le présent article propose une application innovatrice de l'index de la température ressentie au vent en utilisant des méthodes modernes de résolution spectrale et la transformée en ondelettes. Le moment de transition de cirulations plus chaud vers les circulations plus zonales et polaires manifestées à travers le temps sur la Roumanie est identifié par l'utilisation d'un Index WTC historique.
**Key words**: Windchill index (WTC), time series, spectral analysis, wavelet.

## 1. INTRODUCTION

One of the principal modes of heat transfer from an object is convection to the surrounding air. Convective heat transfer increases significantly with increasing air velocity. Thus a person is cooled at a faster rate under windy conditions than under calm conditions, given equal air temperature. Wind chill is a concept that relates the rate of heat loss from humans under windy conditions to an equivalent air temperature for calm conditions. The wind chill temperature (WCT) is an equivalent air temperature equal to the air temperature needed to produce the same cooling effect under calm conditions. Thus, it is not actually a temperature, but rather an index that helps relate the cooling effect of the wind to the air temperature under calm air conditions. It is important to remember that the wind will not cause an exposed object to become colder than the ambient air. Higher wind speeds will only cause the object to cool to the ambient temperature more quickly.

The concept of a wind chill temperature was first quantified from experiments performed in 1941 by U.S. Army Major Paul Siple and geographer Charles Passel while wintering over in Antarctica. They measured the cooling rate of water in a container left hanging outside and developed a temperature index for wind chill based on this data. After the publication of their results (Siple and Passel 1945), the wind chill concept has enjoyed widespread use in describing the combined severity of wind and low air temperature on humans. In 1973, NWS meteorologists began using WCT to describe human comfort level and, more significantly, to warn of the risk to human safety with regard to expected cold weather conditions.

These wind chill forecasts and warnings were expressed in equivalent temperatures (EF). Shortly thereafter, MSC also began using the Siple and Passel Index by including wind chill information in their public weather forecasts as a cooling rate in watts

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per square meter (W m-2). A table of WCT values was created as a public health tool to reduce the number of cases of hypothermia, frostbite, and other cold-related injuries. It warned people who had to be outdoors of the need to dress more warmly than the temperature alone might indicate.

In 2001, NWS implemented an updated Windchill Temperature (WCT) index. The change improves upon the former WCT Index used by the NWS and the Meteorological Services of Canada, which was based on the 1945 Siple and Passel Index.

## 2. METHODS AND DATA

The aim of the present investigation is to analyze the WCT as a tool of revealing information of the more general atmospheric processes which have affected the Romanian climate over the last two decades. For these purposes daily historical data concerning the wind speed and the mean daily temperatures from the highest mountain station in Romania (Vf Omu 2506 m) were used for a time span ranging from 1990 01 01 up to 2007 12 01 in order to construct the index. The data are continuous and homogenous thus providing a basis for in-depth analysis.

The formula for calculating the index is presented bellow:

**- Wind Chill ($^oF$) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T\,(V^{0.16})$**

* The formula is usually computed in Fahrenheit and then a conversion to Celsius is applied

-Where, T = Air Temperature ($^oF$)

-V = Wind Speed (mph)

Notes:

- Uses calculated wind speed at an average height of five feet (typical height of a human face) based on readings from the national standard height of 33 feet (typical height of an anemometer);
- is based on the latest heat transfer theory, i.e., heat loss from the body to its surroundings, during cold and breezy/windy days;
- uses a standard factor for skin tissue and assumes a no sunlight scenario.

After the WTC was constructed for the historical period indicated above methods of multitaper spectral analysis and continuous wavelet transform were applied to the data (after subtracting the fit and the mean and dividing to the standard deviation.).

The *wavelet transform* can be used to analyze time series that contain nonstationary power at many different frequencies (Daubechies 1990). Assume that one has a time series, *xn*, with equal time spacing d*t* and *n* = 0 … *N* - 1. Also assume that one has a *wavelet function,* y0 (h) that depends on a nondimensional "time" parameter h. To be "admissible" as a wavelet, this function must have zero mean and be localized in both time and frequency space (Farge 1992). In this approach the Morlet wavelet, consisting of a:

$$\psi_0(\eta) = \pi^{-1/4} e^{i\omega_0\eta} e^{-\eta^2/2}$$

was used.

Where w0 is the nondimensional frequency, here taken to be 6 to satisfy the admissibility condition (Farge 1992). This wavelet is shown in Fig 1.

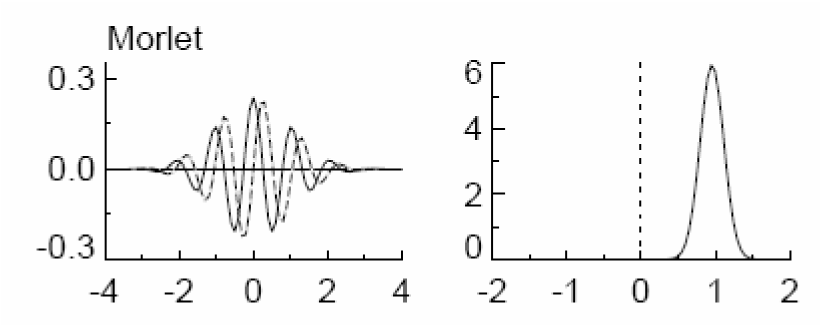


**Fig. 1.** ***The Morlet wavelet.***

A multitaper spectrum is produced by averaging multiple windowed FFTs generated with a set of orthogonal data tapering windows known as discrete prolate spheroidal sequences (DPSS), Slepian functions, or eigentapers. Since each of the windows in a specific sequence is uncorrelated, an unbiased average spectrum can be produced and an F-ratio test is offered for determining the significance of any given peak in the spectrum.

A multitaper spectrum offers no greater frequency resolution than a single tapered spectrum. In fact, the spectral peaks resulting from the algorithm have a flat-topped envelope shape which makes the central frequency determination more difficult. What is gained is a reduced-variance spectral estimator that retains a high dynamic range and which utilizes all of the data in the record.

The Slepian data tapers are sometimes called eigentapers since they are generated using an eigenvector routine. There are two primary parameters, one that controls the frequency width of the window (nPi) and the other controls the number of windows in the sequence (Nwin). There are limits to the number of windows that can be used as spectral leakage increases as the sequence progresses. For a width of 2, up to 3 sequences are permitted. For a width of 3, up to 5 sequences are allowed, and for a width of 4, up to 7 sequences

## 3. **RESULTS AND DISCUSSION**

The multitapers have been used on the normalized index, which means that the mean value for the entire interval has been subtracted from each annual value and then the residual divided by the standard deviation.

Figure 2 shows the spectrum of the Omu WTC Idex series, over 17 years of records, at daily resolution. Three significant peaks can be noticed at a level of 99% significance, although other relevant more numerous peaks appear at lower levels of significance.

For localization in the time domain also, the continuous wavelet transform was applied. Wavelet spectra can be used to obtain fractures in frequency (Mateescu 2006). The most sudden jumps were identified with great accuracy around the following dates: 1996/12/11; 2002/02/26 and 2007/10/08. The fractures in frequency are clearly visible in the time domain and their significance comes evident after analyzing the climatic diagrams for that period (Figure 3). The synoptic situation on two of the dates records weak ridges while the third situation can be described by zonal circulation. In all the three cases there are low altitude anticyclonic areas with a tendency of dissolution.

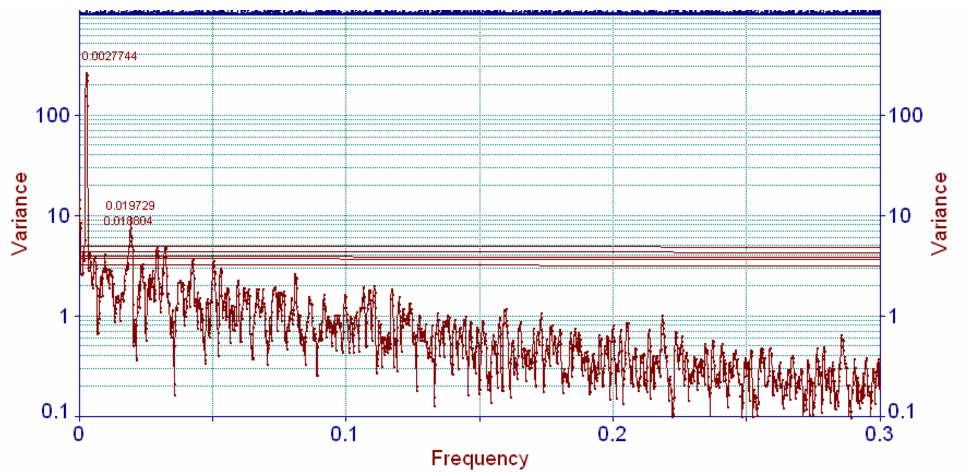


**Fig. 2.** ***The multitaper spectral resolution of the WTC index for the Omu station.***

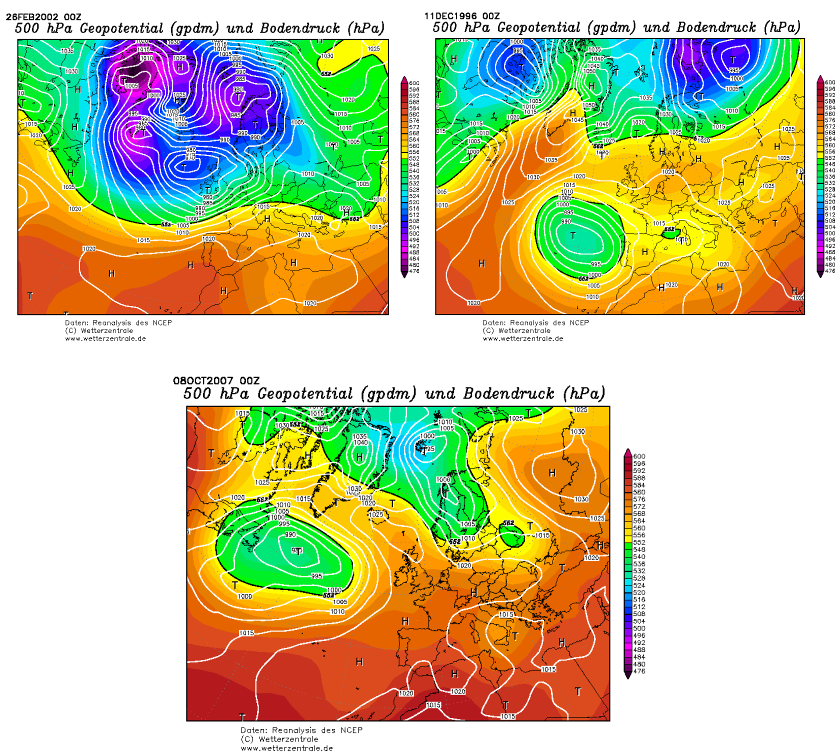


**Fig. 3.** ***The synoptic situation for the time-frequency domain fractures observed by analyzing the WTC index of the Vf. Omu station..***

The date 18.12.2006 marks the transition from a SW circulation to a NW circulation over the general background of an advancing thalweg. In 8.10.2007 the Western or WSW circulation is present with elevated temperatures in altitude. 26.02.2002, the most evident of the discontinuities is rather a more “delicate” situation, namely a slight altitudinal confluence of a post – thalweg nature. However the ridge is still present.

The common element for all these synoptic situations is the warm air infiltration which corresponds to a transition between the predominant types of circulation that affect the Romanian territory. Most precisely the moment of transition from the southern or western circulation towards the colder zonal or polar circulations is recorded.

However in order to confirm the accuracy of analysis we needed confirmation from a less obvious fracture. Such a “lesser” fracture was recorded in 29.11.1999. On this date the synoptic situation recorded a strong high ridge combined with a strong pressure land anticyclone (1035mba) centered over Romania. The date of 29.11.1999 marks the precise day when the circulation gets “disoluted”.

## 4. CONCLUSIONS

The article proposes an innovative use of the WTC Index for identifying the moments of transition from one major type of circulation to another. This is a modern approach of the use of the WTC index, an index which was traditionally used in describing the combined severity of wind and low air temperature on humans.

The use of modern spectral analysis methods and of the wavelet spectrum transform in analyzing the WTC Index proves to be a high resolution method allowing for the identification of the most significant atmospheric changes. Further exploration must be undertaken to fully establish the proposed method by expanding the number of stations taken into account.

*Aknowledgements: The authors wish to thank to the following: CNCSIS grant no 244/2007;*

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# ABOUT THE INFLUENCE OF SPACE SCALE ON THE SPATIALISATION OF METEO-CLIMATIC VARIABLES

**C. V. Patriche**[1]

**ABSTRACT**
The article approaches some problems related to the in influence of the space scale on the quality of statistically based spatial models of meteo-climatic variables. The neighborhood information issue is discussed, meaning the extent to which the information from the area surrounding a point of measurement is more relevant for spatialisation than the strictly local information. Then we approach the problem of spatialisation in heterogeneous regions and the applicability of the models at different scales. Finally, we tackle the problem of the outliers, the presence of which could lead us to incorrect interpretations.

The elaboration of statistically based spatial models for meteo-climatic variables requires insight on some aspects, which could help us improve the models or avoid errors. We discuss in this article some of these aspects, related to the influence of the space scale on the quality of the spatialisations.

## 1. THE NEIGHBORHOOD INFORMATION

Sometimes, the information from the area surrounding a meteorological station / rain gauge is more relevant for the parameter being analyzed than the strictly local information associated to the stations' locations.

The simplest way to account for the neighborhood information is to calculate the mean predictor values for the surrounding area and to test which size of this area is better correlated to the analyzed parameter. In GIS, this is done by filtering the predictors using low-pass filters. Then the predictors mean values can be automatically extracted from these filtered grids.

Previous research has proved the usefulness of this technique mainly for temperature and radiation related variables (*Lhotellier R*, 2005, *Patriche C. V., Lhotellier R*, 2006, *Patriche C. V.*, 2006, *Paul and David 2006*). From figure 1 we may notice that the maximum (best) correlation between different climatic parameters and altitude is, in most cases, associated with a filtered DEM – see (Imecs 2006) - and not with the raw (local) altitudes. These studies have shown that the increase of the explained variance by using low-pass filtered predictors instead of the raw predictors may be as high as 18%, which justifies the use of this technique for the spatialisation of climatic variables.

The optimum moving window size, which is the size associated with the best correlation coefficient, varies greatly from one parameter to another and from one time frame to another (figure 2).

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Example from the French Alps for mean monthly minimum temperature (*Patriche C. V., Lhotellier R.*, 2006)

Example from the Moldavian Plateau (*Patriche C. V.*, 2006)

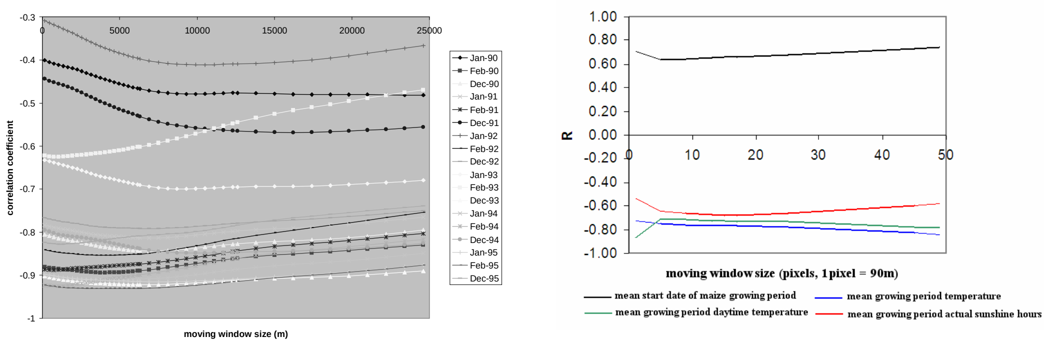


**Fig. 1.** ***Variations of altitude correlations with different climatic parameters according to the moving windows size***

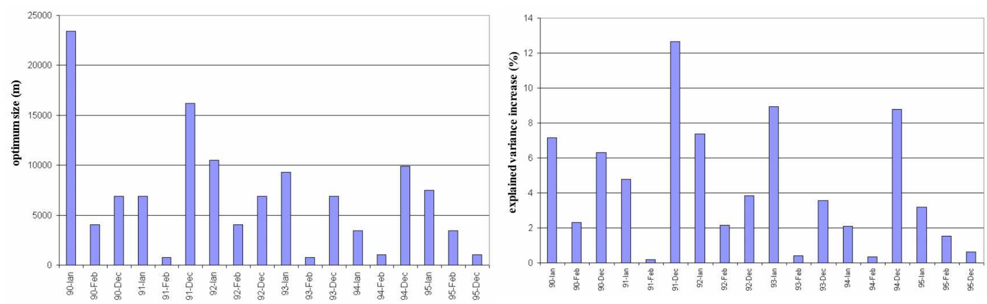


**Fig. 2.** ***The optimum moving window size (left) and the increase in the explained variance (right) caused by using the filtered DEMs instead of the raw altitudes. Example from the French Alps for mean monthly minimum temperature (Patriche C. V., Lhotellier R., 2006)***

The example shown in figure 3 reveals that mean maize growing period temperature in the Moldavian Plateau is correlated the best with the mean altitude values from a surrounding area of 4410 x 4410m, the increase of the explained variance, with respect to the local altitude correlation, being of 13%.

Apart from using the mean predictor values, other moving windows operations may also prove useful for climatic parameters spatialisation, such as the range or standard deviation (e.g. elevation standard deviation). Much more complicated techniques the principal components analysis in order to account for the neighborhood information, such as the Aurelhy method (*Benichou P., Le Breton O.*, 1987) designed for precipitations spatialisation in complex terrain.

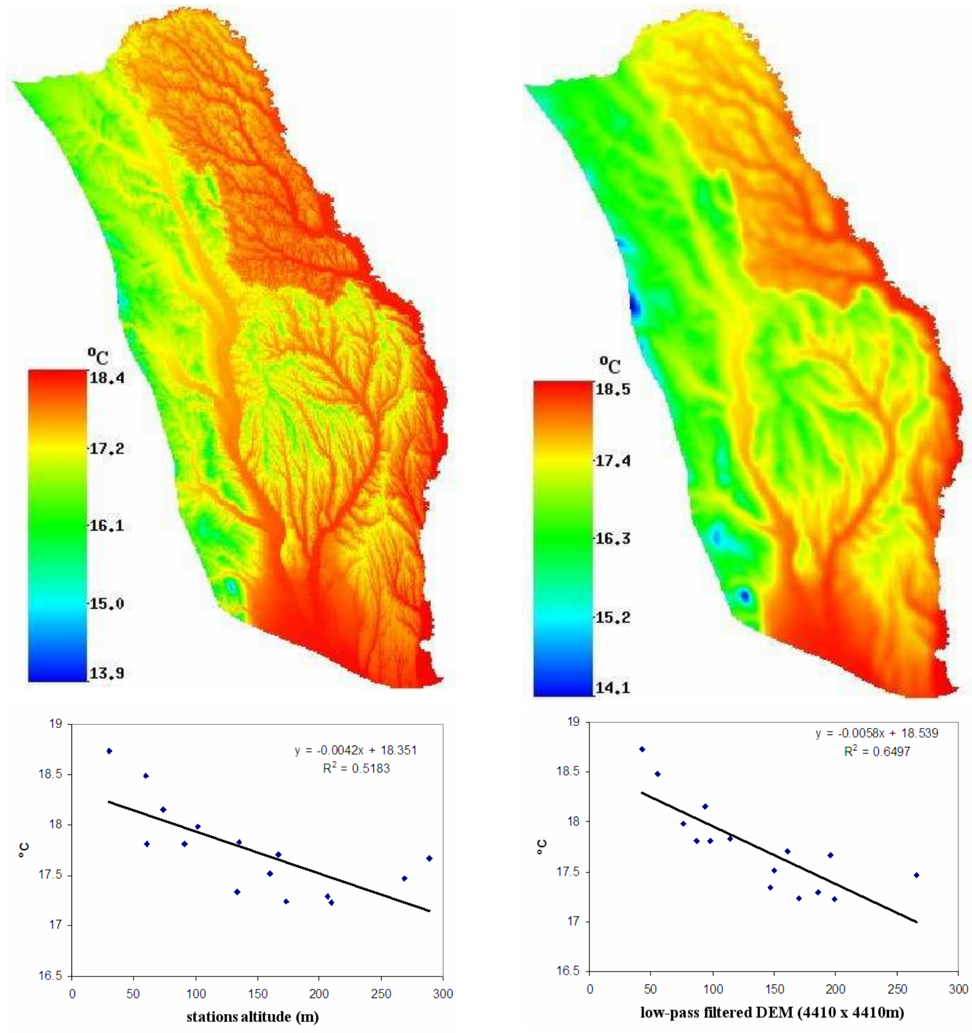


**Fig. 3.** ***Comparison between the spatialisations of the altitude – temperature relationship using the stations altitudes (left) the filtered 4410 x 4410m DEM (right). Example from the Moldavian Plateau for the mean maize growing period temperature***

## 2. **THE PROBLEM OF HETEROGENEOUS REGIONS**

Another issue related to the influence of space scale on climatic space models is that of the heterogeneous regions. Generally, as the scale decreases, the area of investigation becomes larger and therefore more heterogeneous. At local scale, the elaboration of statistically based spatial models is hampered by terrain homogeneity, besides the sparse station network. At first, the decrease of scale is useful for spatialisation because the terrain begins to reveal more and more of its characteristics, becoming therefore able to explain better the spatial distribution of climatic parameters. The problems occur when the decrease of the space scale determines the inclusion within the interest area of a region where the predictor – predictand relationship changes significantly. For such heterogeneous regions, one cannot apply a single regression equation to models the climatic fields. These regions must be first divided into smaller, less heterogeneous, areas, for which the predictor – predictand relationship remains at the same parameters.

An example is shown in figure 4 for the relationship between the mean annual temperature and 3 predictors: altitude, latitude and longitude. At continental scale, the territory of Europe is very heterogeneous. We may notice that the altitude – temperature relationship changes form one region to another to such an extent that a single regression equation for the whole European territory cannot be constructed. A region like the Alps displays a very good altitude – temperature correlation, while the temperature variation within the flat relief of the Russian Plain is statistically independent of the altitude, as temperature inversions are frequent. Here, the latitude comes forward to explain a good part of the temperature spatial distribution.

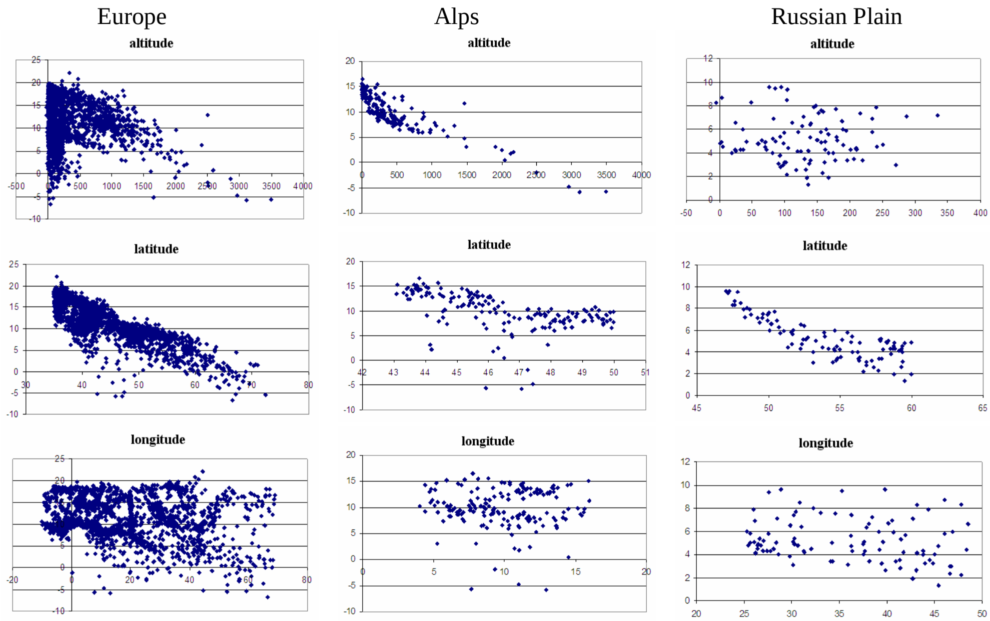


**Fig. 4.** ***Changes of the relationships between the mean annual temperature and the altitude, latitude and longitude for different regions in Europe***

If we deal with a heterogeneous region, then we face the problem of dividing it into sub-regions, which must not be too homogeneous because then we won't the capable of grasping the real predictor – predictand relationship. One way to do that is to examine the change in the regression parameters and stations' residues as we expand (or contract) our study region. Then we can establish the limits of our sub-region, which corresponds to the most stable regression model (maximum correlation, minimum residues). Another way to deal with heterogeneous regions is to apply regression as a local interpolator, but this is frequently hampered by the scarcity of the stations network.

## 3. THE MODELS' APPLICABILITY AT DIFFERENT SPACE SCALES

This issue is tightly related to the previous one. The question we ask here is to what extent a spatial model elaborated for a certain scale is applicable at a different scale. Figure 5 shows an example along this line, where a mean annual stepwise regression model with altitude and latitude as predictors is applied for a much smaller region, respectively the Moldavian Plateau from eastern Romania. We may notice the different temperature gradients revealed by the two regression equations. While the vertical gradient values are very similar, the latitudinal gradients differ considerably. But due to the small latitudinal extent of the Moldavian Plateau (about 2$^{o}$), the errors induced by the different latitudinal gradients are small. Nevertheless, the European model tends to overestimate higher temperature values, the maximum estimated mean annual temperature being 12.8$^{o}$C, which is not found on the Romanian territory. The mean difference between the two spatial models is –1.6°C, which is significant for this parameter. Consequently we may draw the conclusion that, in our example, the continental scale temperature model is not applicable to the regional scale of the Moldavian Plateau.

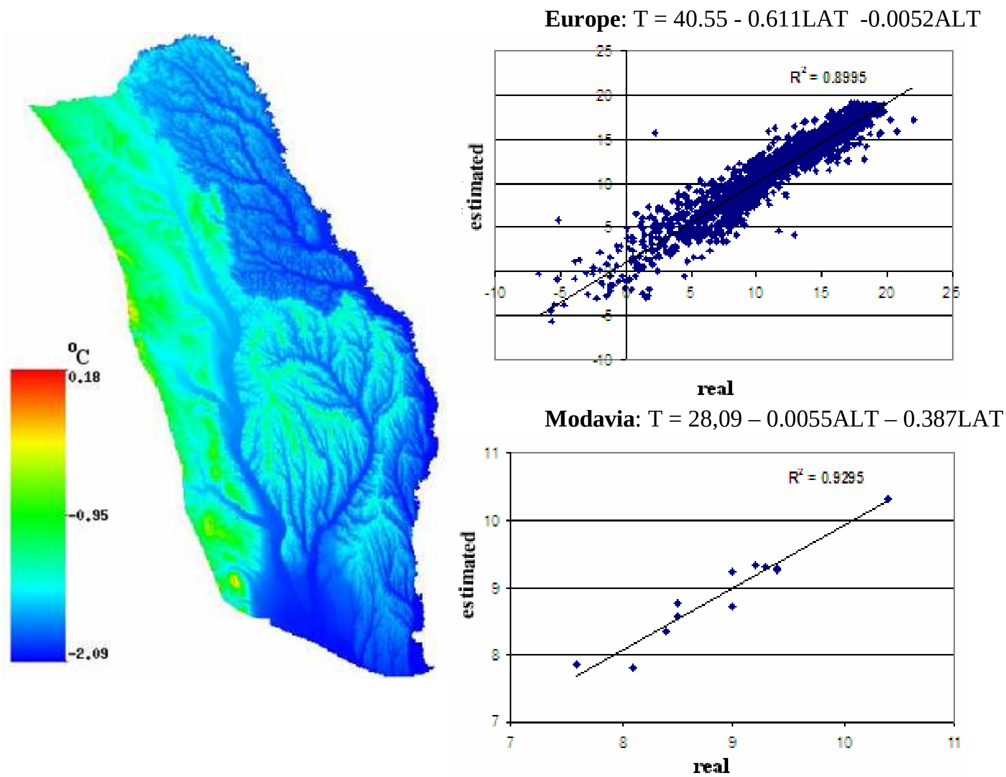


**Fig. 5.** ***The difference between the mean annual temperature spatialisations as functions of altitude and latitude, using the Moldavian Plateau stations and all Europe stations.***

As previously stated, the optimum interpolation region could be identified by noticing the changes of the regression parameters as we expand or contract our region. Figure 6 shows what happens when we expand our plateau region into a mountainous area. The additions to our stations sample of 2 outside higher altitude stations changes significantly the mean annual temperature – altitude regression model. The vertical gradient drops from 0.57°C to 0.47°C and the relation seems to improve itself by the significant increase of the explained variance (from 36.5% to 95.1%). However, the inspection of the residues for the stations situated within the plateau area shows that the temperature values are better estimated using the lower explanative regression model derived form the plateau stations sample only. The apparent improvement of the regression by inserting the 2 outside stations, situated in different climatic conditions, with much lower temperature values, is caused by the effect of "attraction" of the regression line by these points with very different values.

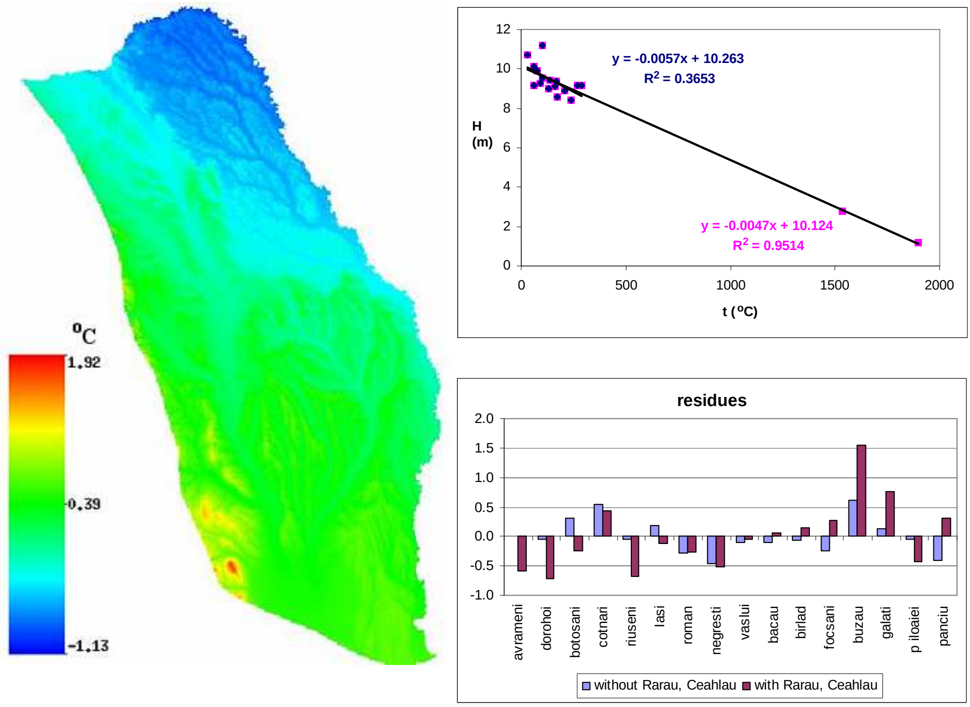


**Fig. 6.** ***The difference between the mean annual temperature spatialisations as functions of altitude with and without 2 outside higher altitude stations***

Therefore we may conclude that the expansion of our plateau region into a mountainous one creates a heterogeneous region for which a single altitude regression model cannot be applied. If the plateau area is our region of interest, we should confine ourselves with the lower predictive regression model derived from inside stations only.

## 1. THE OUTLIERS PROBLEM

The regression models can be negatively influenced by the presence of values evading the spatial variation rules stated by the models (outliers). An example is shown in figure 7 for the mean annual temperature – altitude regression from eastern Romania. The charts display the variation of the correlation coefficients as new stations is progressively included, starting from a sample of 5 stations situated within the Moldavian Plain. We may notice that the inclusion of Cotnari station decreases significantly the correlation, keeping it at lower levels even after the insertions of several other stations. This is due to the fact that Cotnari station is situated in a föehnization area and therefore the temperatures are higher and the precipitations are lower than one would expect for its altitude. If we eliminate this station the regression models improve significantly.

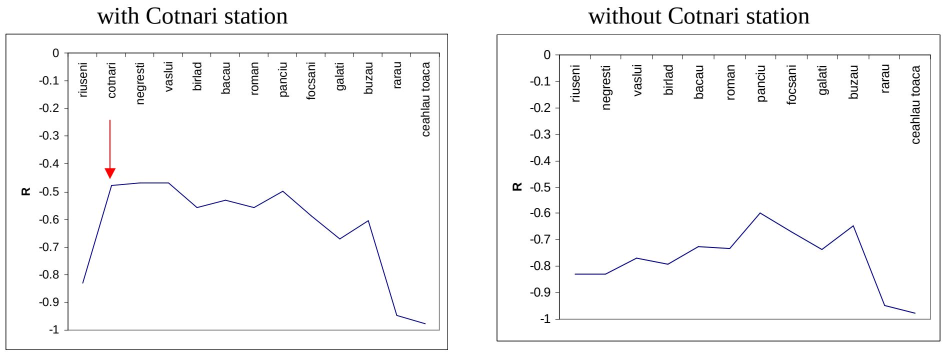


**Fig. 7.** ***Variation of mean annual temperature – altitude correlation coefficients as new stations are progressively included***

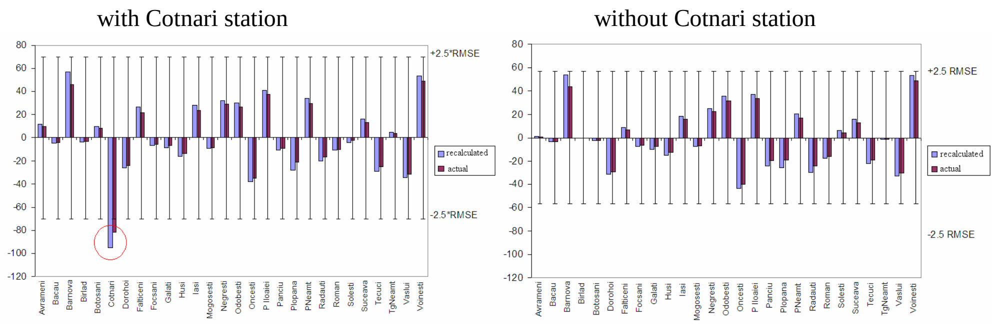


**Fig. 8.** ***Identification of outliers by comparing the residues derived from the regression models with and without Cotnari station (cross-validation). Example for mean annual precipitations within maize growing period in Moldavian Plateau***

But is it correct to eliminate this station? For the regression models, yes, unless we insert another predictor that would be able to account for this spatial anomaly. For the final temperature map, no, because the föehnization area would not be represented. The solution may be a residual kriging spatialisation, which adds the regression residues to the spatial trend. Another approach would be to use the regression as a local interpolator, as mentioned before. This, however, would require a dense stations network, which is not the case for our study region.

How can we identify an outlier? How great should a residue value be in order to regard the corresponding point as an outlier? An example is shown in figure 8 for the same Cotnari station, but for a different climatic parameter (mean annual precipitations). First, we should inspect the magnitude of the residues. If some value goes out the interval limited by ±2.5 RMSE[1] (equivalent in our case with the standard deviation of the residues), then it is possible that this value is an outlier. To establish that, one could compare the residues with those obtained by eliminating the suspect point (cross-validation). If the two regression models are stable, then the magnitude of the residues should be very similar.

[1] Root Mean Square Error

In our example, we notice that the difference between the actual (with Cotnari station) and the recalculated (without Cotnari station) is the greatest in the case of Cotnari station, which means that its exclusion from the model changes significantly the altitude – precipitation relationship.

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# BURNT AREA STATISTICS USING OPEN SOURCE SOFTWARE – THE KASSANDRA 2006 FIRE CASE STUDY

**Anastasia Polychronaki**[1]**, M. Mateescu**[2]

**ABSTRACT**
High licensing costs of proprietary GIS software led to the development of a free, open-source package for Burnt Area Statistics (BAS2), providing not only reporting but also 3D rendering. Operation of the BAS2 tool has been validated by applying the same analysis using ArcGIS, for the Kassandra (2006) forest fire, finding virtually no difference in computed outputs.
**Keywords:** GIS, burnt area statistics, forest fires, post fire assessment, kassandra

## 1. INTRODUCTION

Post-fire assessment is an important issue at Mediterranean and European level (jrc 2008). Existing GIS products can be used for this purpose, but the rationale for developing another GIS tool for Burnt Area Statistics (post-fire assessment) comprises more reasons:

- High costs of proprietary software: one-user license for an industry-standard ArcGIS-based solution, aggregating the necessary packages, would cost from 3000 to 5000 USD (esri 2008). Many countries in the Mediterranean bassin, exposed to forest fires, are still developing countries. Use of free software may lead to significant economies, while the price of proprietary software may be prohibitive to small actors (ex.: educational institutions other than universities and research centers, local governmental structures etc.). For example, an Algerian research assistant has a monthly salary of approximately 615 USD (algerie-dz 2007), an Egyptian assistant professor would be paied 830 USD/month on average (salaryexpert 2008); so averting licensing costs could allow an entity to employ a researcher from 5 to 8 months.
- Features: By design (Dr. I.Gitas) and implementation (eng. M.Mateescu) the product has specific features which are lacking form other software (such as ArcGIS): native 3D rendering, 3D surface computing. (Ilies 2006) also uses 3D GIS rendering.
- Compactness, accessibility: the BAS2 software contains only the relevant functions for performing the specific post-fire analysis; the process is wizard-like and very intuitive, enabling any average user to deal with it (Mateescu 2006).

The BAS2 software being operational and delivered for production, it has been applied to a real-wold case, the forest fire of Kassandra which occured in the year 2000.

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## 2. THE STUDY AREA

The study area is located in North Greece in the southern part of the Kassandra peninsula and belongs to the prefecture of Chalkidiki (Figure 1). The Kassandra peninsula extends approximately from 25°025’ to 25°035’ East (longitude) and 39°090’ to 40°010’ North (latitude). The elevation ranges from sea level to 335 meters and has relatively low slopes and smooth relief. The main type of forest located in the Kassandra peninsula is the pine forest with Pinus halepensis being the dominant species.

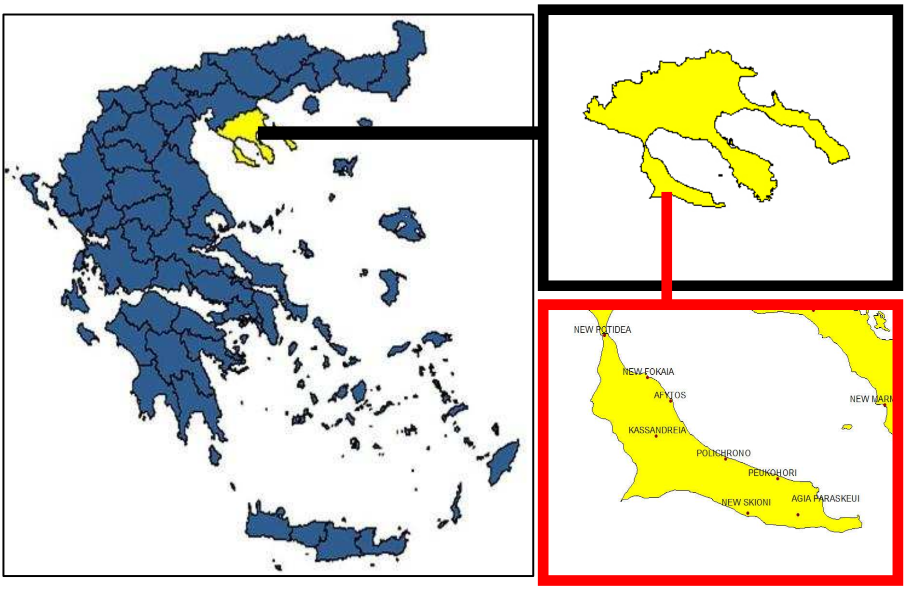


**Fig. 1*: Localization of the Kassandra peninsula in Greece.***

## 3. EVENT DETAILS

On August 21 2006, a major fire ignited, lasting 4 days. The fire had such an intensity and extent that thousand hectares of vegetation (Fig. 2a) and residential areas (Fig. 2b) burned, and even casualities occured.

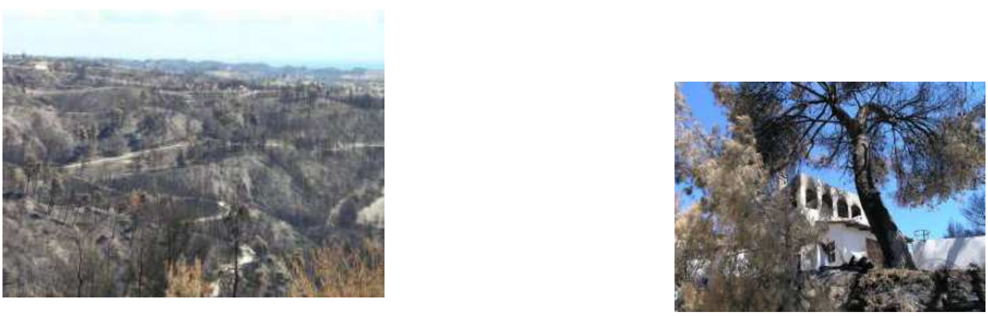

**Fig. 2*: a) burnt vegetation*** ***b) residential areas affected by fire***

## 4. DATASET

A MODIS/Aqua image (250m spatial resolution) taken on 28th August 2006 (Fig.3), three days after the fire, was obtained. Through segmentation and fuzzy logic classification, a layer containing the fire perimeter (Fig. 4) was deducted (Polychronaki 2007). In addition, the DEM (Fig. 5) and the CORINE land cover (Fig. 6) digital map of the area were used.

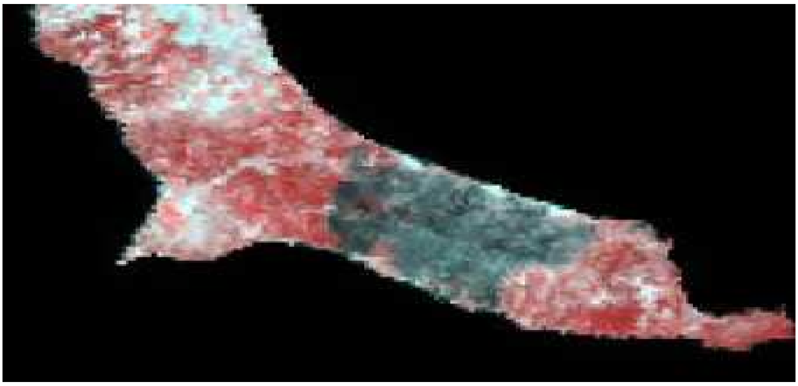

**Fig. 3*: MODIS/Aqua surface reflectance daily L2G global 250m SIN grid V004***

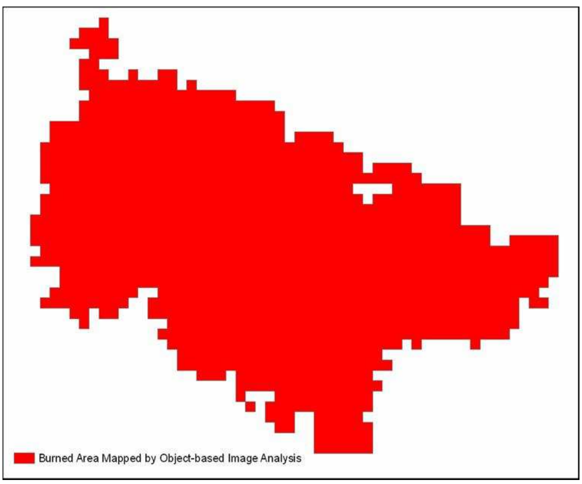


**Fig.4: *Burnt area Mapped by object-based Image Analysis***

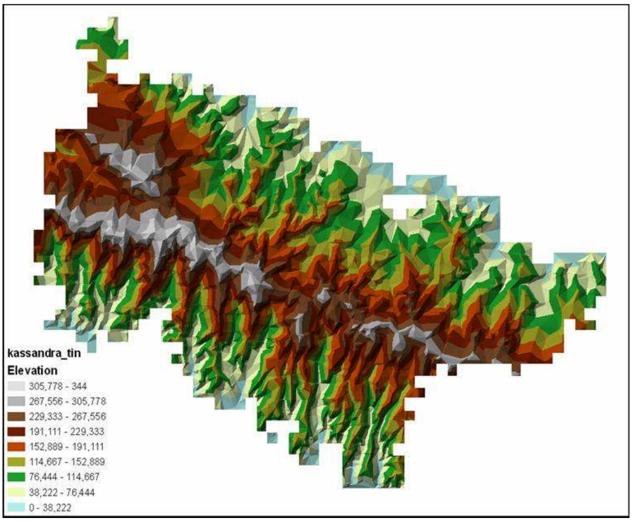


**Fig. 5*: Elevation map of the Kassandra region (TIN layer)***

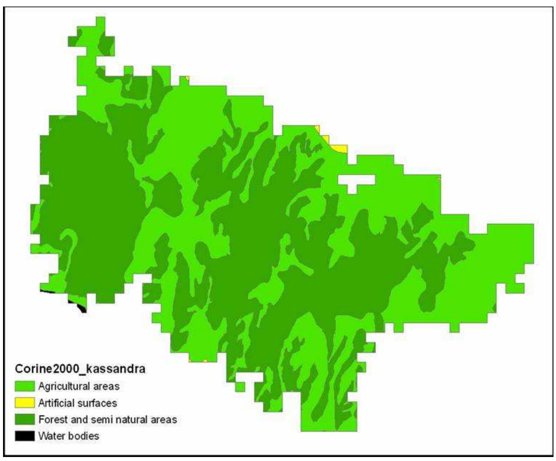


**Fig. 6*: Land use map of the region (from the CORINE dataset)***

## 5. GIS ANALYSIS

The post-fire assessment analysis was run using both the BAS2 (Fig. 7) software and the ArcGIS package.

**Fig. 7*: The BAS2 software tool interface***

Internally the BAS2 uses the General Polygon Clipper (Murta 2007) algorythm; the three-ways intersections (2D) of layers takes somehow longer than in ArcGIS (not more than 5 minutes however).

The results of the analysis are shown below (Table 1)

| KASSANDRA FIRE/ | ARCMAP RESULTS | BAS RESULTS | |
|---|---|---|---|
| | AREA (ha) | AREA (ha) | AREA3D (ha) |
| **Agricultural areas** | 3261.251143 | 3261.251120 | 3366.014652 |
| **Artificial surfaces** | 14.572597 | 14.572596 | 14.625151 |
| **Forest and semi natural areas** | 3697.630452 | 3697.630442 | 3862.858175 |
| **Water bodies** | 6.014652 | 6.014652 | 6.018127 |
| **SUM** | 6979.468845 | 6979.468810 | 7249.516105 |

**Table 1**: ***Kassandra 2007 fire results***

Most of the results are quasiidentical (BAS2 returns the actual 3D butnt area as well, not only planimetric) , the differences in results are of range $10^{-5}$ and may be due to the internal representation of real numbers by 32-bit floating point representations (Goldberg 1991).

Other series of analyses, covering the 2007 Pelloponese fires, resulted in quasiidentical results as well (Table 2):

| PELOPONNESE FIRES SUMMER 2007 | ARCMAP RESULTS | BAS RESULTS | |
|---|---|---|---|
| | AREA (ha) | AREA | AREA3D |
| **Agricultural areas** | 77261.553652 | 77261.531106 | 78266.356792 |
| **Artificial surfaces** | 1491.924104 | 1491.923347 | 1497.420795 |
| **Forest and semi natural areas** | 96745.467884 | 96745.453631 | 100420.353991 |
| **Water bodies** | 172.762091 | 172.761962 | 173.956022 |
| **Wetlands** | 290.518650 | 290.518552 | 291.870869 |
| **SUM** | 175962.226381 | 175962.188598 | 180649.958468 |

The relative difference in case 1 is $5*10^{-7}$% and $2.15*10^{-4}$% in the second case, values so small that can be considered insignificant.

## 6. CONCLUSION

The free BAS2 software tool can be used as an alternative to expensive, proprietary software for the purpose of post fire assessment. Real-world examples were comparatively studied (BAS2 vs. ArcGIS), validating the outputs of BAS2 (minor differences encountered). Development of BAS2 is worth continuing with reporting (detailed output) and rendering (3D rendering in Google Earth by KML output).

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# DATUM AND PROJECTION PARAMETERS FOR THE TRANSYLVANIAN SHEETS OF THE 2ND AND 3RD MILITARY SURVEYS

G. Timár[1], G. Molnár[1], Z. Imecs[2], C. Păunescu[3]

**ABSTRACT**

The Second Military Survey of the Habsburg Empire was carried out in Transylvania around 1860-1872. The survey had no geodetic basis; therefore the maps lacked a projection system. To rectify them with the current maps can be done only by using some landmarks. The study presents a method for rectifying these maps, the precision of the rectification being enough for GIS and cartographic purposes thus providing a useful instrument for the spatial analysis of the natural and anthropic environment of the 19th century Transylvania.

**Keywords:** GIS, Datum rectification, Habsburg Empire, Transilvania

## 1. INTRODUCTION

Prior to WWI, Transylvania was part of the Habsburg Empire, thus the first land surveys were carried out by the Austrian Military Geography Institute. The First Military Survey was carried out at the end of the 18th century, resulting in the production of some 1:28800 plans (Hofstätter, 1989). This survey had no geodetic basis; therefore the maps could not be seen as having a projection system. For this reason, rectify them with the current maps can be done only by using some landmarks (easily identifiable on both sets of maps).

The Second Military Survey of the Habsburg Empire was carried out in Transylvania around 1860, lasting until 1872 (Jankó, 2001). During this period, the Transylvanian administration functioned differently from that in Hungary. It is maybe for this reason that a different geodesic fundament with a different origin was applied in Transylvania than the other parts of the historical Hungary. It is also important to state that the current border between Hungary and Romania does nor correspond to the old one; the following counties: Maramureş, Satu-Mare, Bihor, Arad, Timiş şi Caraş-Severin did not belong to Transylvania, as they were still considered Partium.

The Third Military Survey was carried out on the basis of the International *Gradmessung*, in the 1880s. The coordinate system of these maps was different from the other parts of Hungary and also from the older Transylvanian surveys.

## 2. CARTOGRAPHIC AND GEODETIC BASIS OF THE MAPS

The triangulation network of the Second Military Survey was developed on a hybrid ellipsoid of Zach-Oriani (Bod, 1982). The origin was set to the observatory that functioned in that time North-West of Sibiu, on Hill of Vízakna (Mugnier, 2000; Varga, 2002; Kovács and Bartos-Elekes, 2007). The scale of the survey sheets was 1:28800, with a field extension of 9600 * 6400 Viennese fathoms (18206 * 12137 meters). The scale was a standard for the entire Empire (Jankó, 2001; Timár et al., 2006). The sheets situated west

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from the Sibiu meridian were considered „westliche”, and those situated eastward were „oestliche” ones. The projection system is considered as the Cassini-Soldner projection (Snyder, 1987: Varga, 2000), whose origin was set at the observatory described above, situated in the north-western corner of the plan „Section 19 oestliche Colonne I”. There is no coordinate system marked on the plans; the georeference is given by the sheet numbering and the planar extension, and by the setting of the projection origin. In Partium, both the geodetic base, the projection center and the sheet numbering was different (Timár and Molnár, 2003; Timár, 2004; Timár et al., 2004).

Between 1867 and 1918 Transylvania was part of Hungary, and for this interval a new land survey was carried out starting with 1880. Considering the large extension of Hungary in that time a special system was used for the Transylvania region called „Marosvásárhely (Târgu-Mureş) System”. The geodetic origin of the projection was the Kesztejhegy (Dl. Cîstei) Hill situated 15 km west from Târgu-Mureş. The Bessel 1841 ellipsoid was selected as reference.

In the Second Military Survey the maps were created without a projection system which could be compared with the Cassini projection, but was not identical (Varga, 2002). In case of the Third Survey, this was followed by a stereographic system, but only for those territories part of Northern Transylvania that belonged to Hungary during the Second World War. After 1935 the kilometric grid corresponding to the Târgu-Mureş system was also drawn on the border of the plans which were created without a projection system. The coordinates of the origin point are 600 000 m and 600 000 m, and the new system has a north –eastern orientation. The maps were created at a scale of 1:75 000 and 1:25 000. The plans for the Partium are created in the Budapest system and they have different parameters (Timár et al. 2003a).

In order to establish a correlation between points GPS measurements, the datum and projection parameters were computed for both systems. A check was also carried out on correlating the basic plans of the two land surveys.

## 3. COMPUTATION OF THE GEODETIC DATUM PARAMETERS OF THE SURVEYS

Once the GPS technology available it is possible to determine the position of the points in comparison with the mass center of the Earth (Montag et al., 1996), (Chirila and Dumitrascu 2006), thus to define Earth-centered geodetic datums. WGS84 (*World Geodetic System 1984*; DMA 1986) is such a system. In the GIS practice the local ellipsoids (with a relative position) are defined through their spatial position with respect to the WGS84 ellipsoid.

In the case of the study systems the ellipsoid coordinates of the geodetic centers were known both on the named ellipsoids, as well as on the WGS84 ellipsoid, as they were determined based on simple indirect calculus. For this reason, computing the parameters was done according to the Molodensky-type (3-parameters) transformation method. The Molodensky transform formulas are (Molodensky et al., 1960; DMA, 1990):

$$\Delta\Phi'' = \frac{-dX \sin\Phi \cos\Lambda - dY \sin\Phi \sin\Lambda + dZ \cos\Phi + (a \cdot df + f \cdot da)\sin 2\Phi}{M \sin 1''} \quad (1)$$

$$\Delta\Lambda'' = \frac{-dX \sin\Lambda + dY \cos\Lambda}{N \cos\Phi \sin 1''} \quad (2)$$

$$\Delta h = dX \cos\Phi \cos\Lambda + dY \cos\Phi \sin\Lambda + dZ \sin\Phi + (a \cdot df + f \cdot da)\sin^2\Phi - da \quad (3)$$

where $M(\Phi) = a \dfrac{1-e^2}{(1-e^2\sin^2\Phi)^{3/2}}$ is the curvature in prime meridian;

$N(\Phi) = \dfrac{a}{\sqrt{1-e^2\sin^2\Phi}}$ is the curvature in prime vertical; ΔΦ” and ΔΛ” are the latitude and longitude differences defined between coordinates on the two datums in arc seconds; $\Delta h$ is the difference of the altitudes above the datums; *a* and *f* are the semimajor axis and the flattening of the original ellipsoid; *da* and *df* are their differences between the two datums. Unless the heights on the ellipsoid are known, they can be estimated by using some local or global geoid models, or formula (3) can be skipped during the calculation.

The Molodensky-type *dX*, *dY* and *dZ* parameters, expresses in meters describe the position of the ellipsoid in respect to the center of the Earth. For determining them we have transformed the coordinates of the origin point in rectangular coordinates using the following formulas:

$$X = (N+h)\cos\Phi\cos\Lambda \quad (4)$$

$$Y = (N+h)\cos\Phi\sin\Lambda \quad (5)$$

$$Z = [N(1-e^2)+h]\sin\Phi \quad (6)$$

First on the original datum and then on the WGS84 datum. After that, we calculate the differences:

$$dX = X_{WGS84} - X_{local} \quad (7)$$

$$dY = Y_{WGS84} - Y_{local} \quad (8)$$

$$dZ = Z_{WGS84} - Z_{local} \quad (9)$$

The coordinates of the basepoints on the local datums were given by Varga (2002). We could use the Gauss-Krüger coordinates of the basic points of the Pulkovo datum, of which (with the aid of the parameters published by DMA, 1990) we could determine the WGS84 coordinates. In the case of the local datum we considered the height to the ellipsoid equal with the heights to the geoid. For the WGS84, we increased the heights above the geoid with the values of the geoid undulation given by the global EGM96 geoid model (NIMA, 1997) for the given points. The results are presented in table 1.

Using this method, the small orientation difference between the local and WGS84 datums is not taken into account. Such simplification for a territory of Transylvania results an error of maximum 25 meters in the case of the second and maximum 10 meters in the case of the third survey.

The computed parameters were tested in practice: we correlated the sheets of the surveys with the current maps on global basis. For the Vízakna datum we noticed a constant deviation of 40 m which although it can be corrected manually, by assuming an unsuitable placement of the basic points then and now we could define the parameters which eliminate the error. (Vízakna corrected, cf. Kovács and Bartos-Elekes, 2007).

**Table 1**

| **Datum** | Vízakna | corrected Vízakna | Kesztejhegy | Pulkovo 1942 (Romania) |
|---|---|---|---|---|
| **dX (m)** | 1722 | 1734 | 604 | 27 |
| **dY (m)** | 376 | 399 | -143 | -121 |
| **dZ (m)** | 595 | 595 | 528 | -78 |
| **ellipsoid** | Zach-Oriani | Zach-Oriani | Bessel 1841 | Krasovsky 1940 |
| **a (m)** | 6376130 | 6376130 | 6377397.155 | 6378245 |
| **b (m)** | 6355562.258 | 6355562.258 | 6356078.963 | 6356863.019 |

***The Molodensky-type transformation parameters between the old Transylvanian datums and the WGS 84.***

It is worth mentioning that although defined on the same ellipsoids, the translation parameters for the Kesztejhegy and the Hungarian Gellérthegy (+571 m; -174 m; +572 m; Timár et al. 2003a) systems are slightly different. The cause for this value can be the fact that the triangulation systems used were created and compensated on different territories.

## 4. THE PROJECTION PARAMETERS OF THE MAPS

*The Transylvanian plans of the second land survey:*

The type of projection: Cassini. This is just an aproximative projection, but the recording error of mostly 10 m is enough in the case of GIS applications.

- Reference ellipsoid: Zach-Oriani
- Point of origin in respect to the surface of reference (Marek, 1875):

Φ=45° 50’ 25.13”

Λ=24° 6’ 46.69”

(The above values in the case of longitude were initially give for the meridian of origin Ferro. The Ferro-Greenwich difference was considered of 17° 39’ 46.02”).

Due to the fact that no coordinates are given on the plan, we are free to define the point of origin. A simple solution would be to consider it zero. In practice georeferencing the plans is done in the following stages:

- defining the datum and projection parameters in the GIS software;
- computing the Cassini coordinates for the corners of the studied plan by using its extension in the field and also its system;
- defining the corners point by point using the coordinates calculated in point 2.;
- transforming the first plan in Casini then in any other projection;
- if necessary, for correcting the possible errors, the content of the map can be manually moved without rotation with the aid of a single landmark.

*The Marosvásárhely (Târgu-Mureş) System*

The type of projection: stereographic oblique (*„oblique”* or *„extended” Stereographic*)

- Reference ellipsoid: Bessel 1841
- Point of origin on the reference ellipsoid (Fasching, 1909):

Φ=46° 33’ 8.85”

Λ=24° 23’ 34.935”

The translation values of the origin:

*False Eastings =False Northings*=600000 meters

Conversion factor =1.0

In the case of this system for integration in GIS systems we skipped the double projection (projection from the ellipsoid to the aposphere then to the plane). The resulted error is in the order of centimeters which is negligible in comparison with the error of the datum definition.

## 5. **RESULTS**

The result of the georeference of the maps is illustrated in Figure 1. This figure represents Cluj city in the Second Military Survey (Section 10 westliche Colonne III), a sheet that was converted to UTM, and a three-dimensional image of it was achieved with the use of SRTM (Timár *et al.*, 2003b) elevation dataset. Another example in presented on the color cover: the same territory is presented in a correlated manner – with green the second survey and in black the third survey. It can be noticed on one hand the precision of the correlation inside the city, on the other hand the changes in the meanders of Someşului Mic (Kis Szamos) River in the interval of 30 years between the two surveys. The precision of the rectification is enough for GIS and cartographic purposes thus providing a useful instrument for the spatial analysis of the natural and anthropic environment of the 19$^{th}$ century Transylvania.

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# OPEN GIS INTEGRATED TO GOOGLE MAPS USED IN DESTINATION MARKETING

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**ABSTRACT**
The opportunity of creating a web portal for tourist destination marketing in Cluj Napoca is analyzed, by building an experimental website: http://ro.around-cluj.info. Using an OpenGIS backserver and the Google Maps API web front-end for navigation, the website offers a street map of Cluj Napoca and more than 100 historical features of interest.

**Keywords:** GIS, Open GIS, Google Maps, Destination Marketing, Web GIS

## 1. INTRODUCTION

The purpose of the work is to analyze the opportunity and feasibility of creating a geodatabase accessible through an Internet website using the latest open source GIS software. The site (yet in experimental phase) aims to promote the city and surroundings of Cluj-Napoca as a tourist destination. Promoting is done through web marketing, based on data from multiple market studies and statistics. From the point of view of the hierarchy of the tourist destinations, Cluj-Napoca is the center of Transylvania, being an important cultural and historical city of Romania and Eastern Europe. As an universitary, multicultural and business center with significant potential for the leisure and medical tourism, Cluj-Napoca is the obvious preference of Transylvania's Internet visitors. Considering the existing offers (information platforms) and the visitors' profiles, the need of a web portal with the city map, bus map, tourist objectives and other points of interest such as bars and restaurants (Cosma 2006), was identified. Attempts to create digital, even 3D reality models of tourist destinations (Ilies 2006) exist but none has reached the actual stage of being functional and online.

Creation of such a platform requires a GIS server as the cornerstone of the informational edifice. The quasi prohibitive license costs for traditional GIS systems offering a Web interface (ArcGIS : ArcIMS costs $8000 per server) (ESRI 2008), even if there is large experience with these products locally (Zavate et al. 2006). The choice falls on the very efficient OpenGIS alternatives. Consequently, a multilanguage website (http://around-cluj.info) was developed, built around an interactive map with high-resolution satellite view (*Google Maps* integration), containing to date more than 100 (mainly) historical sites. Each objective in the website may be accessed by clicking it in the map or through a hierarchical categorized directory. The categories and subcategories were structured according to the city's profile and the target markets' needs, the main ones being: *Tourist (Hotels, Restaurants, Art, Tourist Objectives, Tourist Circuits and Routes),*

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*Entertainment (Bar, Cinema, Fun, Museums, Shopping, Sport), Student (Universities, Education, Libraries, Student Organizations),* as well as *Transportation (Bus), Business, Medical, Nature*. In view of the increasing competition between tourist destinations, and of the increasing use of new online promotion techniques, the website promotes the distinctive features of Cluj-Napoca and its surroundings; it underlines the city's image as the historical and cultural capital of Transylvania, with a pronounced academic character, as well as a stimulating business environment. Thus, the website appears as an attractive tool presenting relevant information that should determine some of its online visitors to come in Cluj-Napoca. Afterall, marketing is one of the three pillars that form a tourist destination offer (Goodall 1988).

## 2. THE RATIONALE

"A place becomes a *destination* only when there exists a *tourist* who sees in that place a target of his holiday, hence, there exists a *demand*" (Tamma 1995). The city of Cluj Napoca already is a tourist destination, but its potential is seriously underevaluated and poorly used. As a „melting pot" of students, international businessmen, traffic center, the potential tourists already are *in place*, just the *place* is not well defined.

A study performed in 2006 by Cosma S. and Coros M. on a smaple of 199 interviewed tourists, aimed at identifying the information media preferred by tourists in choosing a destination, generally, and Transylvania, particularly, reveals a 41% preference for the Internet, as shown in the graph below (Fig. 1):

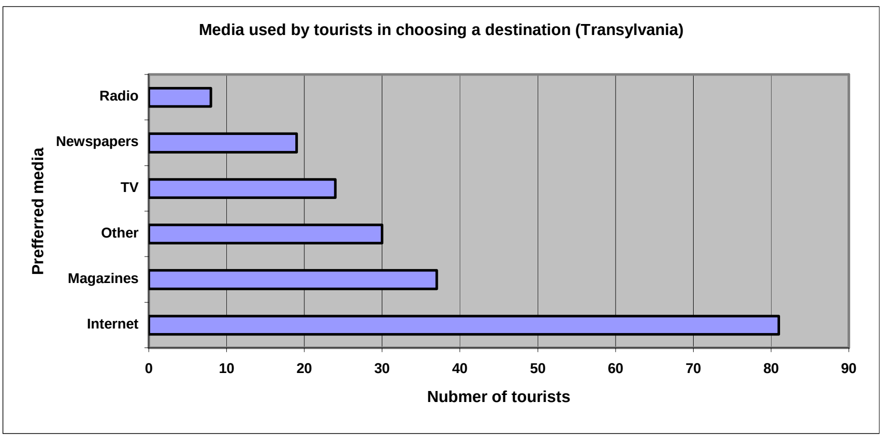


**Fig. 1:** *Media prefferred by tourists in choosing Transilvania as destination (Data source: Cosma, 2006)*

Nowadays tourist likes to *live the experiences as an actor*, like the most recent visions on the evolution of economy and society suggest (Pine, 2003). This tendency determines the tourist to get more and more involved in the process of finding the right holiday and even organizing it.

Knowing these, we deduce that providing all (or almost all) the possible pertinent information to the user (potential tourist) will enable him/her to assemble the most attractive holiday package even from the „research” stage . In this context, the information and communication technologies play a crucial role, a decent website being compulsory nowadays for any decent destination (Martini, 2002). Moreover, the data availability is nonstop, while the staff in a tourist agency cannot effectively know everything about their entire offer, while through Internet this data can be easily found and accessed (Briggs 2001).

The market (Cosma, 2005) also shows that the most required information about Cluj as a tourist destination are: “city map, tourist attractions, bus lines map, cultural objectives, bars and clubs list”.

Thus, choosing the Internet as the media promoting the Cluj-Napoca destination by creating a website with search and navigation capabilities seems fit.

Developing an integrated product and creating a brand is of the competence of an entity with high decision power at city level and this is a long term objective

## 3. THE OPENGIS ENGINE

OpenGIS is an open standard developed by the Open Geospatial Consortium, an „international industry consortium of 345 companies, government agencies and universities participating in a consensus process to develop publicly available interface specifications” (OGC 2008). OpenGIS Specifications support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT (OGC 2008).

Many products follow the OpenGIS specifications, actually, almost every website is GIS-capable, because the worldwide-spread *MySQL* database implements the basic GIS functions and datatypes on the SQL commands layer. Better and more complex products such as *PostGIS* or *GeoServer* exist, the latter was preferred for this purpose for its good compatibility with the Google Maps API.

*GeoServer* supports WFS-T and WMS open protocols from the OGC to produce JPEG, PNG, SVG, KML/KMZ, GML, PDF, Shapefiles and more (GEOSERVER 2008). Adding existing data to a geo-enabled database is trivial as *GeoServer* has native ESRI SHP format support. Most of the data powering the website already existed in legacy SHP files, thus their direct integration in the geodatabase was a must.

*GeoServer* was used to produce the required maps in 256x256 pixels wide *tiles* (transparent PNG images), which compose themselves like a puzzle and are the input of the Google Maps API interface.

## 4. THE USER INTERFACE

Even if *GeoServer* is able to hold geo-enabled data and perform any GIS operation with it, its interface is barren and limited to administrative tasks. The ordinary internet visitor can not „experience” the power of GeoServer without a proper interface. The most widespread, rapid and efficient is the *Google Maps API.*

Google (R) offers the internet-connected world a free cartographic service: the *Google Maps* website and API. There is little difference in using a web-based GoogleMap or a „traditional” desktop product such as ArcView on the level of navigating a map (zoom, drag, drill etc.). Of course, layer overlaying has to be manually programmed in a Google Map enabled website; hence Google has provided the API which is now at the 2.6 version.

Because the Google Maps API is a JavaScript based program (executed locally in an interpreted language), the amount of resources (CPU time and RAM) increases dramatically as the number and complexity of features increases. Considering this, the objectives and features of interest are generated directly as transparent tile layers by GeoServer instead of being fetched vectorially to the GoogleMaps API running in the browser.

Google Maps enables thousands of websites nowadays and, along with the standalone 3D renderer Google Earth, it has developed its API more and more towards the GIS universe (layers of points at version 1.0, lines at 2.0, and polygons from version 2.4 on). GIS-powering the web with Google Maps seems the right choice for the future.

## 5. THE GEOGRAPHIC DATA

The data used is heterogeneous by nature but may be classified in two main categories:

5.1. *Raster satellite imagery* (provided by Google);
5.2. *Vector data* (used internally, presented as raster tiles).

Some of the vector data of interest is the street map of Cluj-Napoca, which comes from a geo-rectified existing *ShapeFile*, and the location data, which was manually digitized directly from the Google satellite imagery, using an internal tool (Fig. 2).


**Figure 2.** *The internal digitization tool used to create maps of tourist objectives in Cluj Napoca*

A number of 121 historical objectives were digitized and photographed, the data describing an objective being its location, imagery and textual description.

## 6. THE BIG PICTURE

In order to show the digitized maps (streets and objectives) the *GeoServer* system accesses the SHP-based geodatabase and generates a huge number of small tiles for all the implemented zoom levels (1 to 16). To ensure the best user experience, hence a maximal speed in navigation, those tiles will be cached as PNG files on the web server, and regenerated by *GeoServer* only when a feature changes in the geodatabase. The whole system is schematically presented in Figure 3:

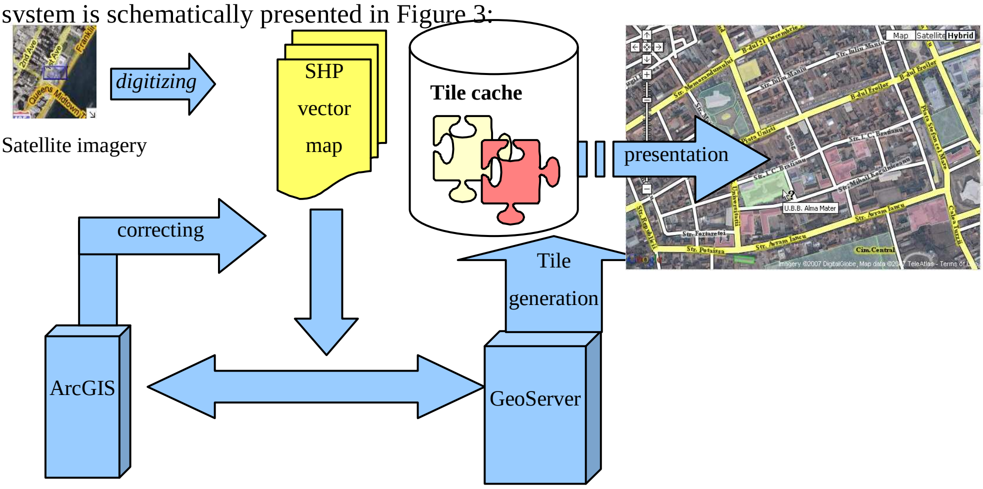


**Figure 3.** *The information flow in the system*

The information should be reachable on the website in three ways: from the map (operational), from a directory (operational), and through the search engine (in development).

## 7. THE WEBSITE STRUCTURE

The goal being to create a web portal with the main tourist attractions from Cluj-Napoca and it's hereabouts, a proximity-to-centre approach was taken in data availability. Information was structured on categories and subcategories, mainly in a structure similar to the well-known files/directory structure of a disc, directories being the categories and files being the webpages. Moreover, in this system, a webpage may belong to multiple categories (such as a file shortcut in the *disc structure* paradigm).

On each page, a map with high-resolution imagery (60cm/pixel), focused on the feature of interest appears, map navigation enabling the user to easily identify interesting objectives in the neighborhood and making the data presentation far more attractive.

### 7.1. THE PAGE STRUCTURE

The „Virtual Cluj" website has a simple and attractive interface (see it at http://ro.around-cluj.info ).

To detail the basic elements, an explanation of items from the main page (Fig. 4) follows:

1. **The page address (separated)**: It is formed by a chain of categories and the name of the feature (if selected), Ex: Cluj > Tourism > Accomodation > Hotel > Hotel „Continental". Each separated element is a link to the corresponding page.

2. **Search field**. It has an internal search engine (in development).
3. **Multilanguage menu.** Any page may be seen in one of the languages implemented (Romanian, English, French, German, Italian).
4. **The directory**. The categories belonging to the page (*all*, for the main page) are shown in this area and are expanded where a better visibility is desired. This area enables the hierarchical navigation in the directory. The main categories are 'Tourism', 'Entertainment', 'Student' and ‘Other', each having its subcategories.
5. **The content area**. For the features of interest, this area contains HTML: text and images about the objective; this area extends unspecifically under the map, fitting to the entire available space in the page. If a category/subcategory is selected, in this area also appears a list with all the subcategories and points of interest subordinated. At a latter date, this area will hold the search results.
6. **The navigation cursor**. Normally the mouse cursor is a crosshair ( **+** ) on the map, but when registered objectives are hovered, it morphs in an interrogation cursor ( **?** ), moreover labeled with the name of the objective under the cursor.
7. **The quick info bubble.** On clicking an objective in the map, a *bubble* window opens, containing brief information: title, a short description, a link to the objective. This enables geo-navigation (by proximity) through the website.

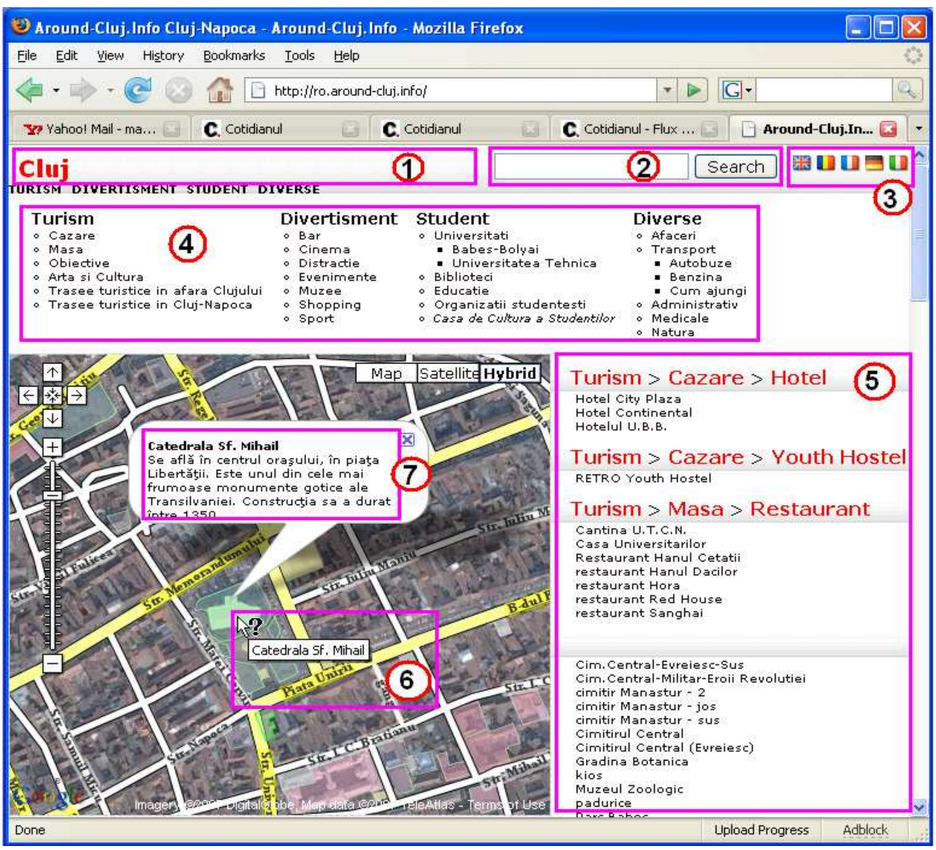


**Figure 4**. *The website’s main page*

## 8. CONCLUSIONS

We assist at an increasing competition between tourist destinations. A tourist destination represents "*an amalgam of products, services, natural and manmade elements able to attire a certain number of visitors in a specific and well defined geographic place*" (Martini, 2002). This amalgam becomes an unitary touristic product through "*the tourist's experience of consuming the product*" (Martini, 2002). Thus, the tourist plays an important role in creating the touristic product, which, for this reason presents a virtual character (Tamma, 2002).

This virtual characteristic of the touristic product has made the investment in searching information about the place where the tourist would spend the holiday become more and more consistent, and in this context appears the importance of the internet as an informational and promotional mean for touristic products and destinations.

Thus, it results opportune creating a website for the promotion of the city of Cluj-Napoca as a tourist destination. By highlighting the objectives that determine its identity and notoriety and by integrating maps with navigation and search options, it seems to be a useful and necessary tool for all the visitors of the city.

Using the most modern available techniques: Google Maps for cartography and satellite images, multilanguage, hierarchical directory structure, internal search engine, tourist objectives profile, the portal has the possibility of reaching a utility, attractiveness and ease in use for its potential virtual and hopefully real visitors of the city.

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