VULNERABILITY TO THE POLLUTION AND URBAN DEVELOPMENT OF THE MASSIVE DUNE OF BOUTELDJA, NORTHEASTERN ALGERIAN

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ABSTRACT
Many cluster of sand extend along the Mediterranean coast from the Maghreb. They occupy the most sprinkled areas and contain important groundwater resources. Their privileged situation near the sea has caused a real invasion by urbanization, generally without network of adequate cleansing. To identify this problem, the massive dune of Bouteldja is taken as example. The study consists in locating the zones vulnerable to the urban development; so a new data interpretation with REHESE method is applied. Thus, unsaturated zones, physical parameters, movement of groundwater and chemical characteristics are taken into account. So, we propose a better urban planning for a durable development.
Keywords: Mediterranean coast of Maghreb, urbanization, vulnerable zones, unsaturated zone

1. INTRODUCTION

Many cluster of sand extend along the Mediterranean coast from the Maghreb, are invaded by a large urbanization without network of adequate purification. The examination of maps (1/200 000, 1/50 000) and many studies (*Gottis, 1953; Drogue, 1966; Suter, 1980; Khérici, 1985, 1992*) showed that the massive dune of the Mediterranean coast of Maghreb covers in a cumulated length more than 350 km of coast and an area about 990 km². The evaluation takes into account the areas of more than 5 Km². These massive are distributed from East to West (**Table 1**).

Geographical distribution of the maghreban massive dune (Khérici 1985)

Table 1

Country	Coast (Km)	Superficie (Km²)	Renewable water resources (millions m^3/year)
Tunisia	93	330	66
Algeria	197	536	128
Morocco	63	116	21

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If the sands dunes cover relatively little surfaces in comparison with the other formations, however, they contain too many groundwater resources in an excellent quality (*Gourmelon, 2006*). It's essentially due to the high rainfall and infiltration. The renewable groundwater resources can be estimated at more than 215 million m^3 /an. This hydrous potential is more exposed to an intense urban occupation (Hubert-moy 2006); the impact would be represented by deterioration of water quality. To identify this problem, the massive dune of Bouteldja is taken as an example. Commonly the groundwater quality is better to those of surface waters, through the protection of natural layers of the soil and a good filtering capacity of the geological formations (*Bousnoubra, 2002, Rouabhia, 2006*); (*Cabrit-Leclerc, 2008*); (*Cariolet and al., 2008*). Soil allows a physicochemical exchange with the environment of tank by causing a delay of the matter of pollution by its destruction or its fixation, consequently the middle aquifer and micro-organisms can react on the polluting products. These phenomena are very complex whose biological reactions are much more effective in unsaturated zone.

In this context, the study consists to locating the vulnerable zones to the urban development and its consequence on the water quality.

The study area included the massive dune of Bouteldja, is located in the extreme Algerian Northeast, between Annaba city and the algerian-tunisian border (**Fig. 1**). It extends along the Mediterranean coast, with a width of approximately 10 km and a surface of 170 Km². The massive dune of Bouteldja has an altitude of 90 m. It has a triangular form and limited from the North by the Mediterranean Sea, from the South by the Bouteldja plain, from the West by the Mafragh river mouth and from the East by the Rosa cape.

The geological formations are dated from the Tertiary age to Quaternary, the firsts are characterized, in the base, by ten meters thickness of Numidian clays (superior Eocene), surmounted by Numidian sandstones (dated from Lottarifien). The Quaternary dune strata, like those of the Maghrebian littoral, have an origin wind, and came essentially from the degradation of the metamorphic strata (*Khérici, 1985*). So, they were transformed gradually to heterogeneous sandy-clayey fallen rocks, then to sands with a uniform size forming the coastal beaches.

By wind action, calcareous cementing and vegetable fixing, these sands form dune sandstones (calcarenites).

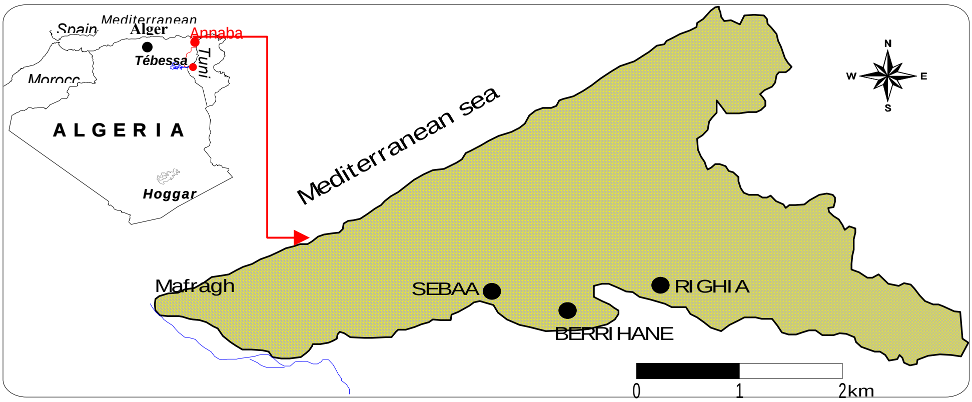

Fig. 1 *Geographical situation of the massive dune of Bouteldja*

Concerning the hydrogeological characteristics of the aquifer, the wind formations of Quaternary age are settled on an impermeable clayey sandy substratum. These sandy formations, locally clayey sandy constituted a free water table on the whole of the massive dune, except in the South, where the aquifer becomes semi confined. The effective thickness of the sandy aquifer varies from 40 m in the East to 180 m in the West. Transmissivity and permeability averages are respectively about 5.10^{-4} to 1, 3.10^{-2} $m^2.s^{-1}$ and 6.10^{-5} to 10^{-4} $m.s^{-1}$ (*Khérici, 1985, 1992*). The storage coefficient exceeds 10%. The productivity of this aquifer is relatively homogeneous and the specific flows are between 60 and100 m^3 h^{-1}. Taking into account the thickness of these sands and their interstitial porosity, the water reserves are appreciable and exceeded 34 $Mm^3.Year^{-1}$.

At present, the exploitation is being low (less than 1/3 of the evaluated resources). The groundwater flow is relatively high in the South to the alluvial plain (confined aquifer) and in the North toward the sea where the hydraulic gradient is 5.10^{-3}. On the other hand, It becomes low in the West where the slope exceeds seldom $1,3.10^{-3}$, which favours the marine intrusion partially (*Bousnoubra and al., 2001*). The aquifer supply is directly done by rainwater and water coming from numidian sandstones in the South-East and the East. Notwithstanding the high nitrates concentrations, the aquifer water quality is good where the dissolved salts tenors exceed seldom 300 mg l^{-1}.

2. EXPERIMENTATION AND METHODOLOGY

In the aquifer, the pollutant migration is ruled by two ways: one is vertical, crossing the surface layers of the water table (unsaturated zone); the other is horizontal following the water table flow direction (saturated zone).

The vulnerability of the water table to various pollutions is conditioned by several factors, among which one quotes:

- The reservoir filtering capacity.
- The thickness of unsaturated zone of the reservoir.
- The flow speed of groundwater.
- The reservoir nature (confined or free).

In general case, the soil transverse section is the follower:

- A first organic layer with a thickness from few centimetres to few meters, It's the place of biological and physicochemical activity. It allows a total purification for a thickness H>1.2 m (*Rehse, 1977; Detay, 1997; Khérici, 1993; Bousnoubra, 2002; Rouabhia and al., 2008*), attributing to it a very high self-purification coefficient (1/H=0.8): it's the soil part witch exploited by plants roots.

- A zone of vertical pollution transfer in porous unsaturated environment, where the self-purification indexes are given according to the thickness of the layers and their lithological nature (*Rehse, 1977*). Thus, the sands characteristic index of Bouteldja water table is equivalent to I = 0.17 in the unsaturated zone.

- A zone of horizontal transfer, where the self purification capacity is done by dilution in the aquifer (saturated zone), according to the flow speed. The index in the saturated zone of Bouteldja water table, with a speed lower than 3 m $.day^{-1}$ is: ia = 0.01 (*Detay, 1997*).

If we define Mx (Mx = Md + Mr) as being the purifying capacity on the totality of the transfer, Md as purifying capacity on the vertical way ($Md = h_1\ i_1 + h_2\ i_2 + h_3\ i_3 +\dots h_n$

i_n ; where h is the dry height of the various ground categories in the water table unsaturated zone and i is the characteristic index associated for each ground type) and Mr as purifying capacity on the horizontal distance, according to Rehse, (1977) and Detay, (1997) the purification is complete for Mx = 1. One can identify two cases:

- Md >1, the purification is total in the cover layers and the delimitation of a perimeter protection isn't necessary.

- Md < 1, the remediation is not complete. It must be continued in the aquifer during the horizontal transfer; in this case the calculation of protection perimeters is needed. Thus, one calculates the purifying capacity in the aquifer Mr (Mr = 1-Md) which takes account of the distance L (L=Mr/ia) (ia is the characteristic index associated for each ground type in saturated zone) to horizontally cover for a total purification.

3. RESULTS AND DISCUSSIONS

To see the impact of the agglomerations on groundwater, it is essential to evaluate the aquifer purifying capacity.

The greatness defining the call zone, for a pumping in a water table with initial and unidirectional flow for a homogeneous aquifer, are essentially characterized by a fine interstitial porosity and a regular permeability.

The space distribution of the water table purifying capacity (**Fig. 2**), calculated according to the method of Rehse, definite previously, allowed the distinction of three various vulnerability zones:

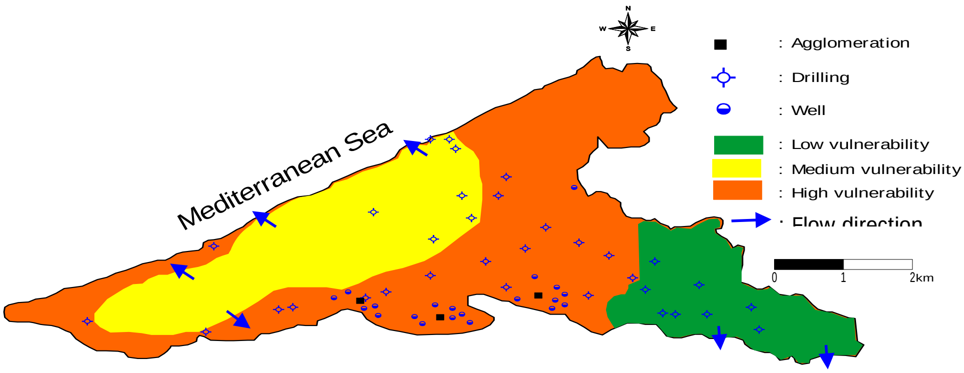

Fig. 2 *Distribution of the vulnerability zones in the massive dune of Bouteldja*

•A high self-purification capacity, in the West which defining the zone A, with higher values than 1 (Md > 1).

• More in the East, the power scrubber of the aquifer is relatively higher, defining the zone B. In this area Md varies between 1.14 and 2.10 identified a permeability coefficient about 3.10^{-4} $m.s^{-1}$ and an unsatured zone included between 7.5 m and 12.5 m. These characteristics express a vertical purification in the first meters by favoring degradation or a trapping of some polluting substances.

• In the centre and near the marsh, one identifies the zone C, where self-purifier capacity is low with values inferior than 1 (0.33 < Md < 0.66) expressed by a thin unsaturated zone (lower than 5.5 m). Consequently the zone C must be equipped with early perimeters protection. According to our estimates like L = Mr/ia, they vary from ten to the hundred meters around the water samples.

Different sectors of vulnerabilities are confirmed by the spatial variation of nitrates concentrations (**Table 2**) revealing an important anthropogenic pollution in the zone C (toward agglomeration) where one registers values largely higher than the potability standards. In the two other sectors (A and B) the nitrate concentrations exceed rarely 10 mg/l. The evolution of nitrates contents in time (October 1985 - November 2005) shows a

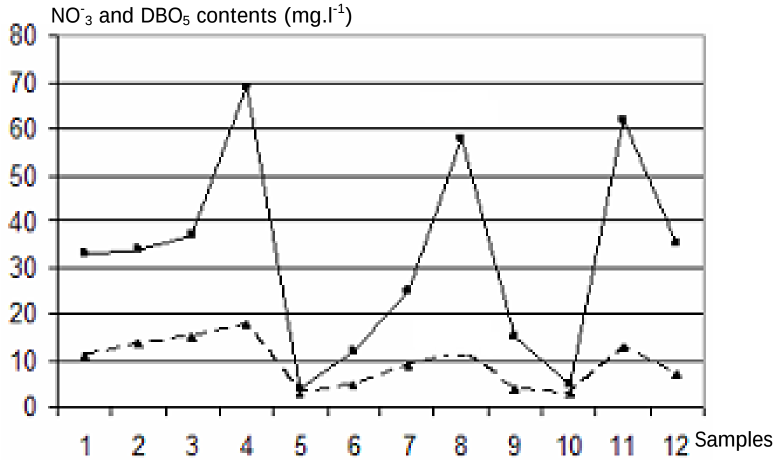

Fig. 3 *NO^-_3 and BDO_5 contents in 12 water samples located in the urban zones (November 2005)*

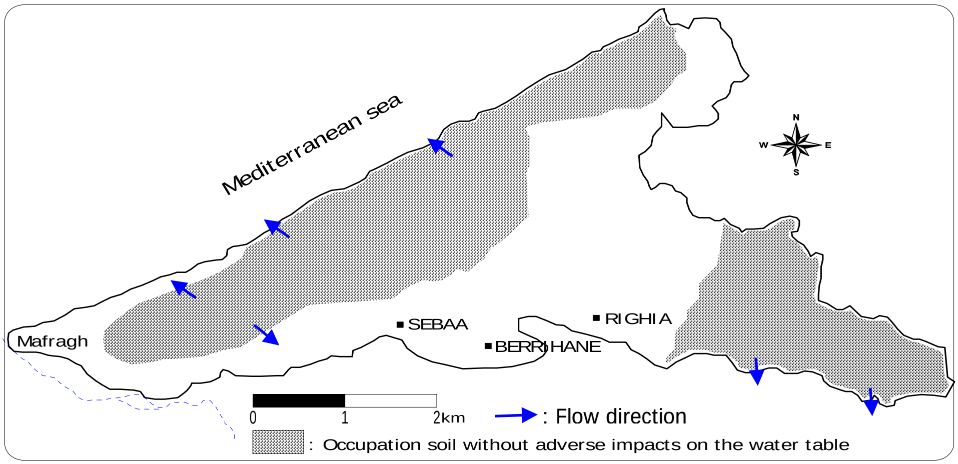

Fig. 4 *Future planning map*

marked increase in nitrates in the localities of Sebaa, Berrihane and Righia (*Khérici, 2006; Ramdani, 1996; Sedrati, 2006*). This contents variation identifies different degrees of pollution which can be explained by the insufficiency or the inexistence of canal evacuation in the majority of towns, or by the low rate of connection to the cleaning up network. Fragmentary analyses of BDO_5 (**Fig. 3**) revealed contents exceeding 5 $mg.l^{-1}$; thus supporting the preceding observation, and rather confirms the urban origin.

Space variation of the nitrate concentrations in the massive dune of Bouteldja (November 2005)

Table 2

Water samplers	Nitrate contents	Vulnerability nature	Water samples		Nitrate content	Vulnerability nature
1	1.0	A	27		2.0	B
2	3.0	A	28		3.0	A
3	10.0	C	29		4.0	B
4	8.0	C	30		4.0	B
5	2.0	A	31		10.0	C
6	2.0	C	32	Wells resulting from the periphery of the agglomeration of Berrihane (6010	32.9	C
7	2.0	C	33		32.4	C
8	3.0	C	34		17.1	C
9	5.0	C	35		84.8	C
10	3.0	B	36		42.7	C
11	5.0	C	37		43.1	C
12	4.0	C	38		4.2	C
13	3.0	A	39		71.1	C
14	2.0	C	40	Wells resulting from the periphery of the gglomeration of Righia (2720 inhabitants)	34.8	C
15	1.0	C	42		57.9	C
16	2.0	A	44		131.7	C
17	10.0	A	45		8.1	C
18	2.0	C	46		78.7	C
19	4.0	C	47	Wells resulting from the periphery of the agglomeration of Sebaa	13.8	C
20	2.0	C	48		25.7	C
21	3.0	C	49		54.7	C
22	3.0	C	50		104.8	C
23	7.0	C	51		14.07	C
24	4.0	B	52		5.5	C
25	2.0	C	53		13.3	C
26	4.0	C	54		72.9	C

4. CONCLUSION

The vulnerability of the dune aquifer towards to possible surface contaminants remains to define and ameliorate by studies in the transfer parameters and organic pollution parameters in the unsaturated zone. According to the self-purification degree, the study enabled to definite three zones of pollution risk. At present, the high vulnerable region reveals highly nitrates contents directly due to the agglomerations activities effect. To this end the occupation of grounds (**Fig. 4**) can be done in extreme cases in zones A and B, but must be regulated so as to preserve the areas at risk of groundwater pollution (*Hubert-moy et al. 2006; Gourmelon et al. 2006*) of the massive dune (zone C).The establishment of perimeter protection is not sufficient to ensure effective security; it must be complemented by the establishment of an overall plan drainage of sewerage systems and by the construction of stations effluent treatment in urban areas

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THE JULY 2007 HEAT WAVE IN OLTENIA (SOUTH-WEST OF ROMANIA) IN THE CONTEXT OF CLIMATE CHANGE

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ABSTRACT
This paper analyzes the July 2007 heat wave when many records have been registered (daily maximum temperature higher than 40°C and consecutive "dog days" in some localities, about ten days). The absolute record for July (43.50C at Giurgiu on 05.07.2000) was exceeded by Calafat (44.3°C), Bechet (44.2°C), Moldova Noua and Bailesti (44°C), which were also very close to the maximum absolute temperature record (44.5°C at Ion-Sion in August 1951). These extreme meteorological phenomena not only through their high intensity, but also their long lasting presence, required the issuance by NAM of several meteorological warnings. On July 24 a red code warning was issued for Oltenia for the first time. The "dog days" produced a lot of damages in our region and also a part of the Romanian territory was affected. This analysis adds more elements of the climatic variability panel in Romania concerning the thermal regime and the extreme associated phenomena. The results and the conclusions of this work will support the forecasters to anticipate the heat waves.
Keywords: heat wave, climate change, synoptic analysis, TUI (Temperature-Humidity Index), Oltenia.

1. INTRODUCTION

The scientific community considers that the increasing intensity, frequency and duration of extreme weather phenomena in the recent decades (heat waves, floods, droughts, violent storms, strong wind gusts, etc.) constitute the evidence of global warming. The heat wave that dominated southern Romania in July 2007, distinguished by a high persistence of dog days and a record-breaking number of days with maximum temperature greater than or equal to 400C, can be an example of this trend.

Recent studies show an increase in the troposphere oscillations frequency, meaning the shortening of synoptic periods (*Chivu, Dima, 2006*). But in the case presented in this work we can not speak of any significant variation, neither of air pressure variations, nor of the thermal regime. Oltenia can record up to 8 periods with dog days, particularly in the warmest years (*Marinica, 2006*). During the period analyzed here, maximum temperatures recorded the highest values for the summer of 2007. Thus, a long period of anticyclonic weather caused by the long presence of ridge relief consistent in all fields (pressure, geopotential and thermal) produced warm weather, even dog days in the plain areas.

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The modification of the temperature regime in Romania is mainly influenced by advectives processes, closely related to the atmospheric circulation on a large scale. Climatologically, the annual temperature variation in Romania systematically records a maximum in July (*Stancescu, 1983*), but we often meet dog days periods even in June or August in the same state of tropical warm advection and heat radiation in the anticyclone regime (*Clima Romaniei, 2008*). In summer, we must add the number of days when maxima temperatures record high values to the characteristics of extreme weather, (*Schuepbach and Michna, 2003*), especially if they have negative consequences on the population and economy (*Balteanu, 1992*).

2. DATA AND METHODS USED

In this paper we have used daily diagnostic data from 17 meteorological stations in the CMR Oltenia network and real maps (surface and altitude) for the Atlantic-European region obtained from the grid messages (00 UTC NCEP analysis).

The method consists in highlighting the values and duration of extreme temperatures, starting from the synoptic context in which they take place and in automatically processing the daily minima and maxima of each meteorological station. The obtained diagrams give the variation of these elements around the multiannual daily means, and calculating the average on territory proves, through a graphic, the spatial significance of deviations from standards.

3. RESULTS (The synoptic analysis)

The July 2007 heat wave which affected the southern half of Europe, and therefore Romania, was caused by a tropical air mass advection of North African origin.

In most of the analyzed period (15-24 July), the high geopotential field persisted and reached values of 592 damgp (in comparison with 575 damgp as it is normal for Romania in July), with a ridge gait. This was "doubled" by a thermal ridge at 850 hPa level with values over 200C, reaching 300 on July 24th. At the surface level, the pressure field, with relatively high values in the first part of the interval, changes easily into a field of relatively low pressure, not necessarily for reasons of dynamic nature, but mostly due to the heat factor involvement (**Fig. 1a, 1b** and **2**).

Figures 1a and 1b show the similarity of geopotential and thermal fields. Basically, the thermal ridge doubled the geopotential ridge.

Maps highlights pressure field at ground level, and the geopotential field at 500 hPa level, also reflecting the thermal structure of the dominant air mass in the lower and middle troposphere. The geopotential field at 500 hPa shows the presence and especially the persistence of a thermal ridge extended from northern Africa to Central and southeast Europe (not shown in this paper).

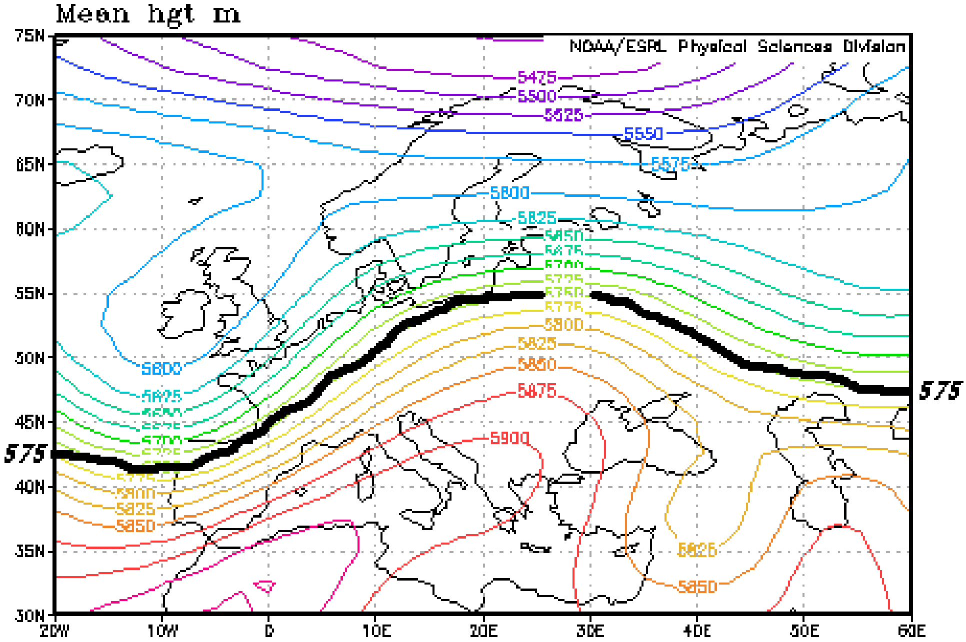

Fig. 1a: *Atlantic-European region: geopotential height at 500 hPa level. Geopotential is mediated for 15-24 July 2007.*

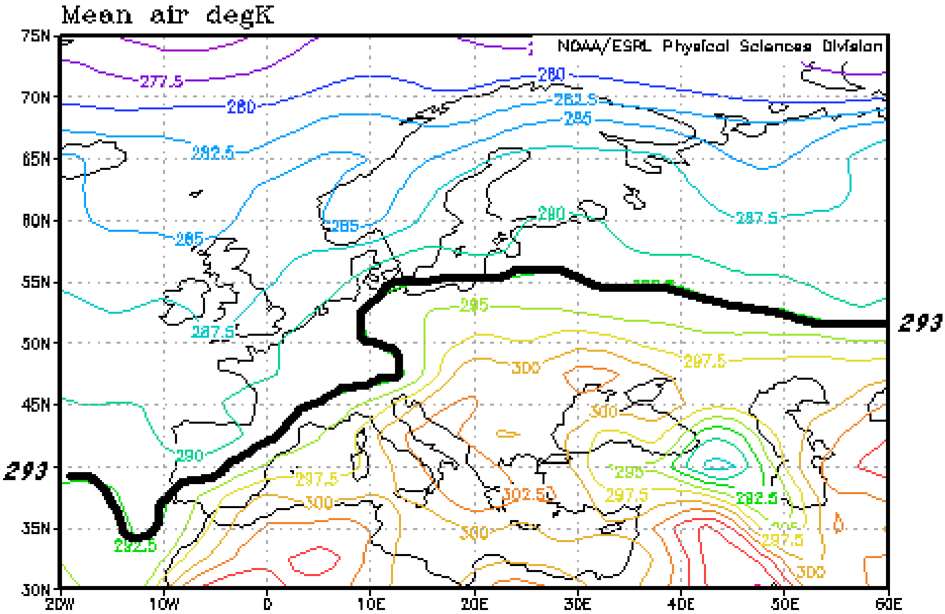

Fig. 1b: ***Atlantic-European region: the temperature (^{0}K) at 850 hPa level. Temperature is mediated for 15-24 July 2007. Note that 27^{0}C isotherm (300^{0}K) is above Ukraine and temperatures between 27-30^{0}C are in the area of Romania.***

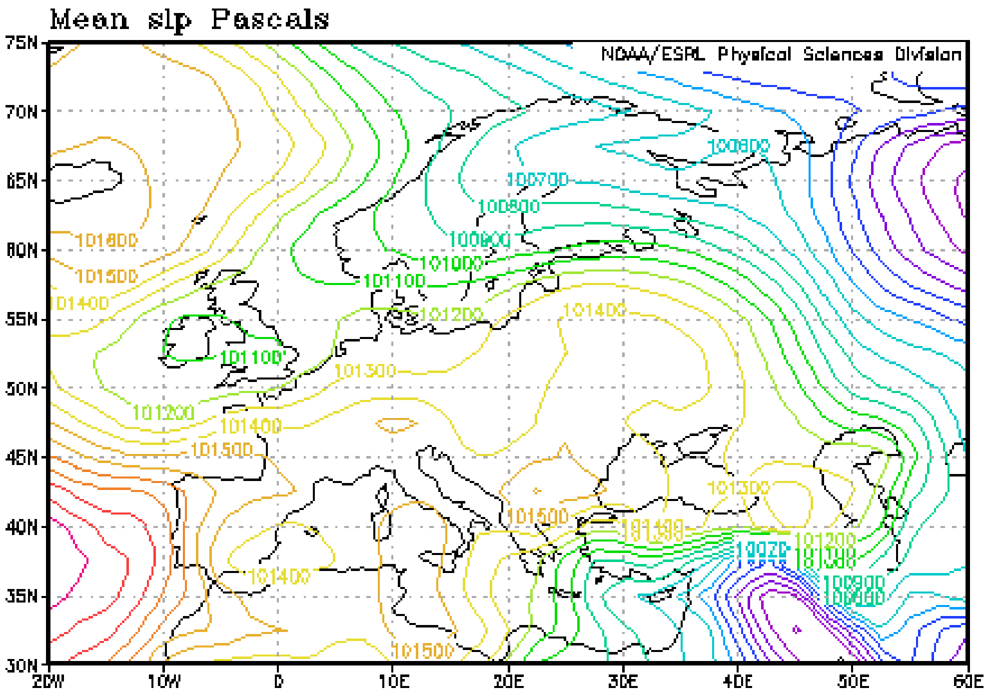

Fig. 2: ***Atlantic-European region: mean sea level pressure. Values of pressure are mediated for 15-24 July 2007***

4. DISCUSSIONS

The warm weather characterization and the thermal discomfort are proved by the following maps (**Fig. 3, 4a, 4b** and **5**) illustrating the evolution of the temperature - humidity index (TUI) for the analyzed period on Oltenia weather stations and also the persistence of tropical air mass at the level of our region.

Such stationary at high levels of the thermal regime fully justify the weather warnings issued by NAM (code yellow, orange and finally red) between 16-23.07 regarding the magnitude and duration of the forecast phenomena (dog days, overcoming TUI values).

July 2007 temperatures have exceeded 44^{0}C, the highest recorded in the region. The combination of extreme temperatures with drought and feathers of current gave severe blows to agriculture in Romania, Ukraine, Moldova and Bulgaria, but also to tourism in Croatia and Greece. Albania, Bosnia, Macedonia, Montenegro and Serbia were also vulnerable to the effects of short-term regional climate crisis. 2007 was the warmest year in the last 109 years in Romania.

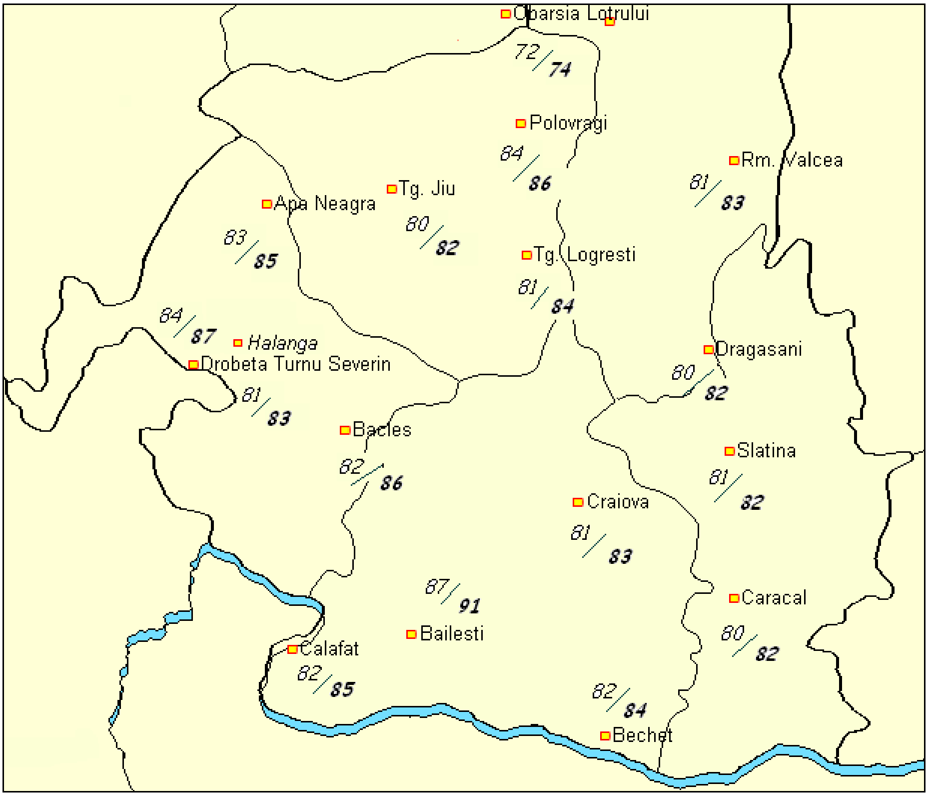

Fig. 3 *Oltenia region: mean maxima values / the highest maximum TUI value during 15-24 July 2007.*

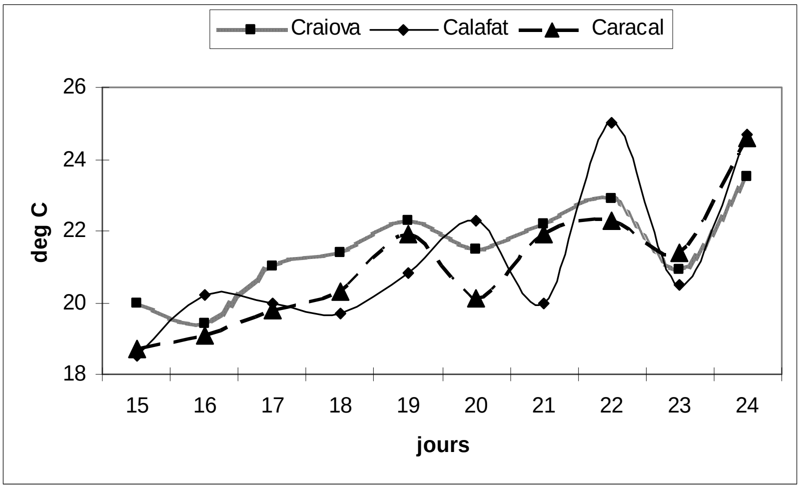

Fig. 4a *Minima temperatures at several meteorological stations in southern Oltenia (region affected by the code red)*

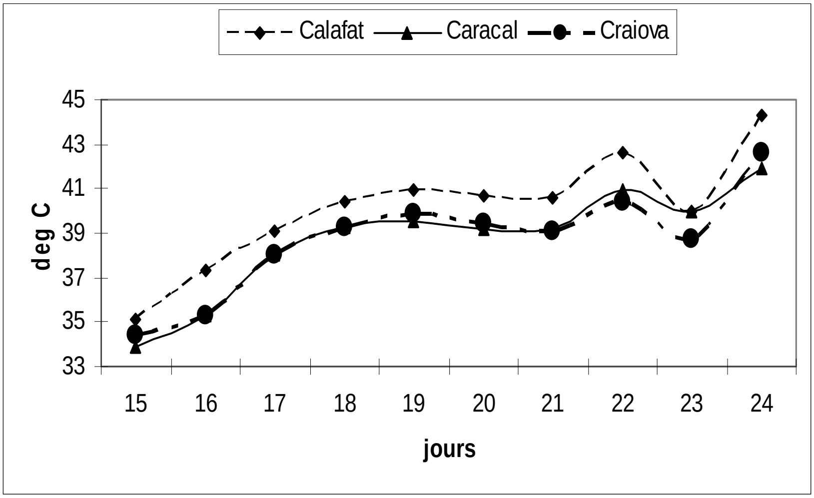

Fig. 4b *Maxima temperatures at several meteorological stations in southern Oltenia (region affected by the code red)*

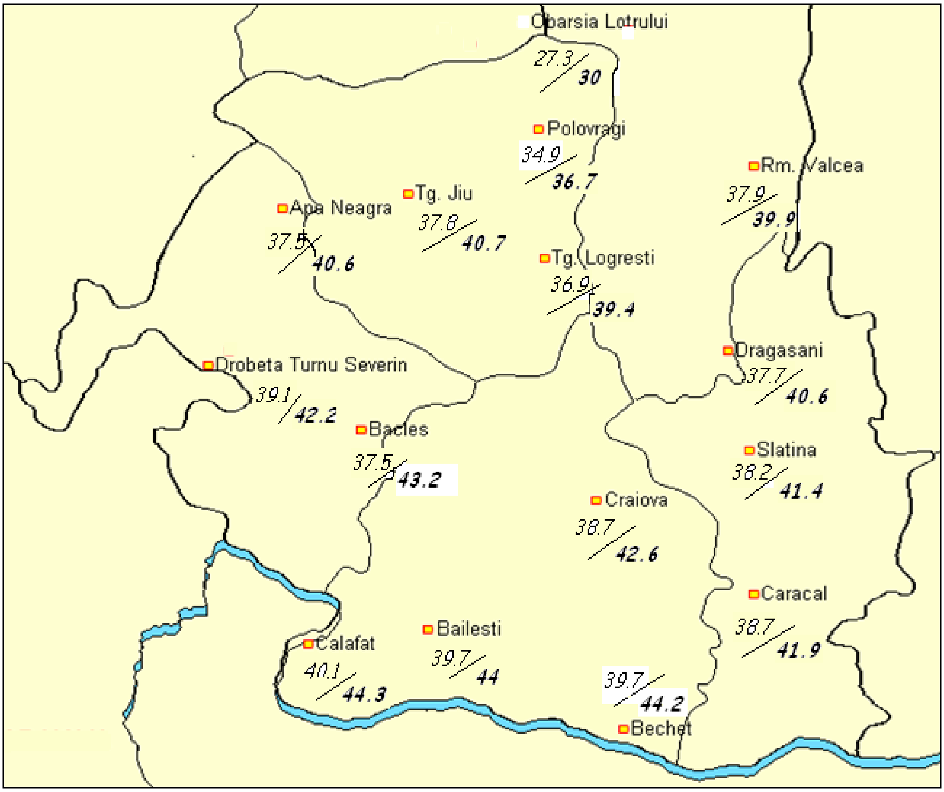

Fig. 5 *Oltenia region: mean maxima temperatures / the highest maximum temperature during 15-24 July 2007*

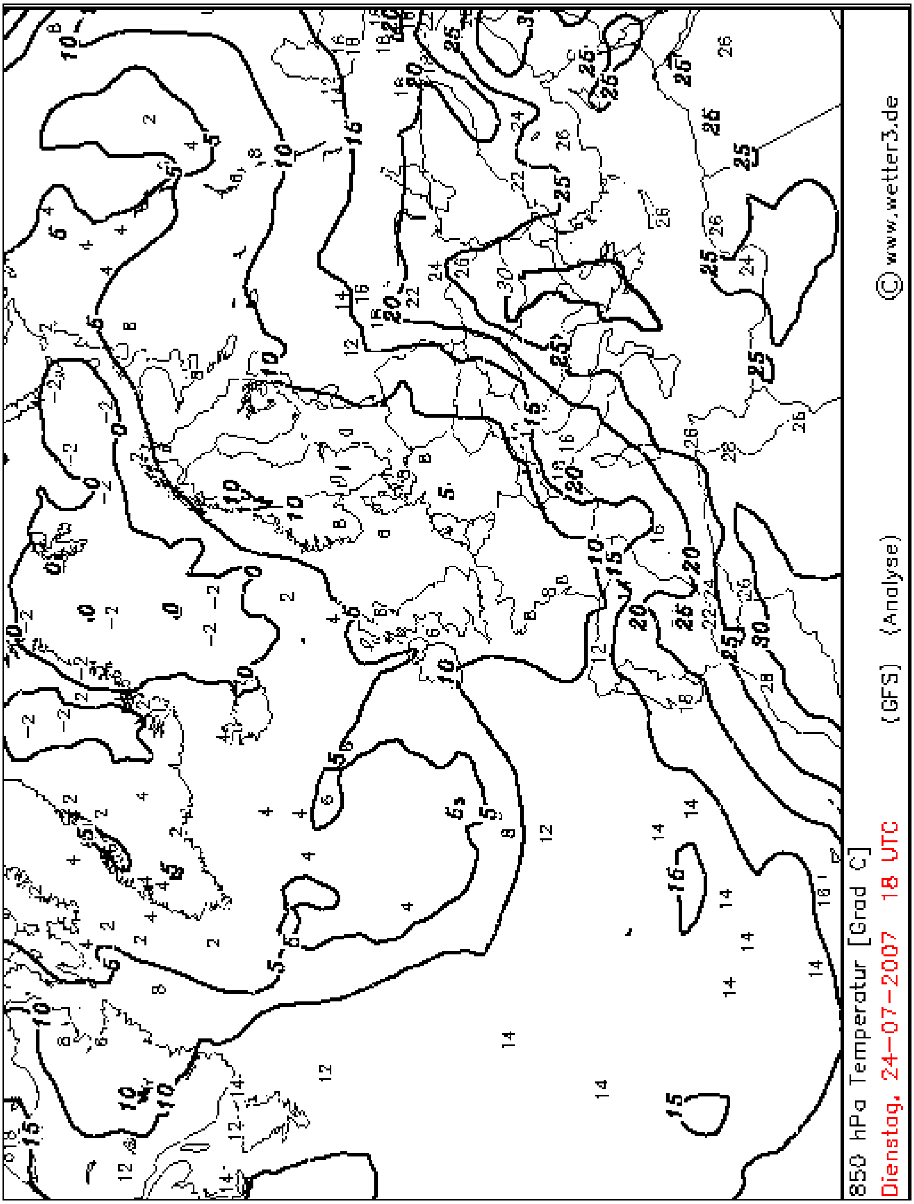

Fig. 6 *Atlantic-European region: temperature (in ^{0}C) at 850 hPa level on 24 July 2007, 18 UTC. Note that 30^{0}C isotherm is above the south of our country*

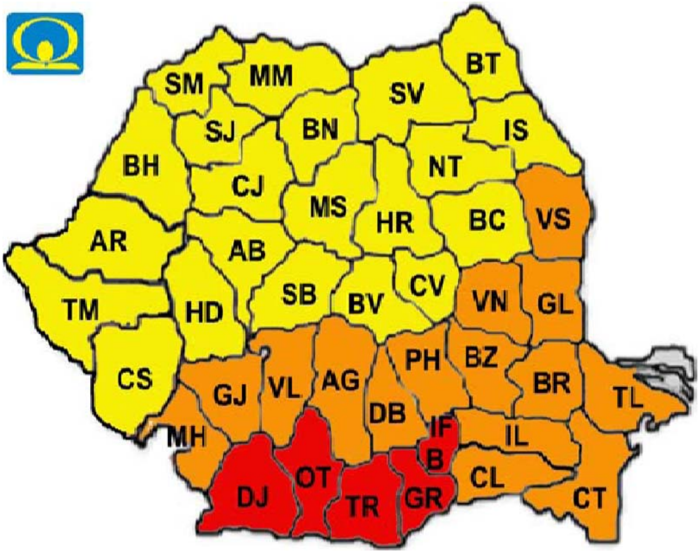

Fig. 7 *Incidence of meteorological codes in Romania on 24 July 2007*

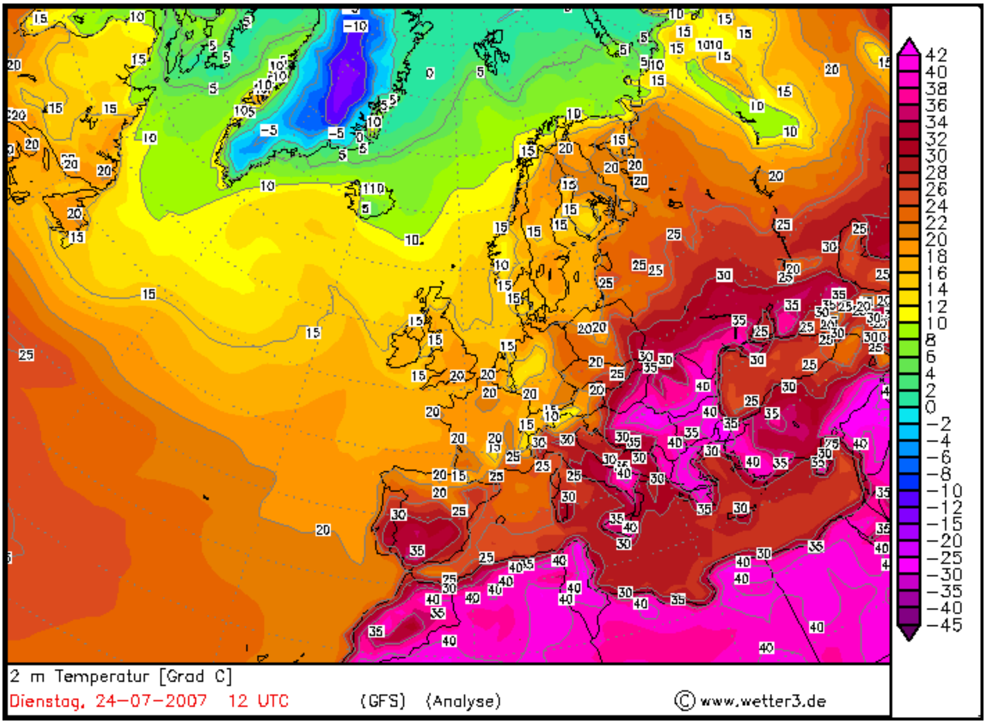

Fig. 8 *Temperature at 2 meters on 24 July 2007 at 12 UTC*

The summer of 2007 was the hottest one for Romania, as it has been presented in this paper, and probably also for southeastern Europe (*Busuioc et al, 2007*) (as well as it is presented in figures 8, 9,10 and 11). Summer 2007 was comparable to that in 1946, but with a greater persistence of the dog days (T_{max}> 35^0C):

♦ an absolute maximum temperature for July was exceeded (44.3^0C on July 24, Calafat);

♦ an absolute monthly maximum temperature was outdated at 3 weather stations (Calafat, Bechet and Bailesti);

♦ record number of daily maxima temperatures > 40^0C (36 cases);

♦ record number of consecutive dog days: 10 days (Bailesti, Calafat, Caracal, Bechet, Dr Tr Severin, Craiova);

♦ record number of consecutive tropical nights (Tmin> 20^0C) = 10 nights (Dragasani, Halanga, Bacles, Craiova);

♦ The highest minima temperature: 25^0C on 23 July 2007 at Calafat, 24.6^0C on 24 July at Caracal, etc.

From the 16th to the 24th of July, 33 people died due to heat, according to the centralized data of the Ministry of Health. This adds many cases of lipothymia, spasmophilia and hypertension and even come.

4. CONCLUSIONS

The last century climate data show a gradual warming of the atmosphere.

The global warming phenomenon led to an increasing frequency of the extreme events, respectively more situations of frequent extreme temperatures - heat waves, worsening droughts in some regions, heavy rain falls in other areas, the melting of glaciers and arctic ice and an increase in the global average level of oceans and seas.

2007 was marked by extreme weather events: floods atypical, prolonged heat waves, storms etc.

This year the extreme variations of the climate have been a rule for the entire globe, Earth's surface temperatures reached the record since 1800, when the first records were made, warns World Meteorological Organization (WMO).

Floods, droughts, heat waves and storms can be part of the natural climate variations and cannot be directly attributed to the climate changes. However, such extreme weather situations are in agreement with the predictions of what might happen if global temperatures increase.

The changes in the climate are included in the global context, but with the customization of the geographical region in which our country is located.

The most pronounced dog days were recorded between the 15^{th} and the 24^{th} of July, when maxima temperatures were frequently over 35^0 ... 40^0C on extensive areas of the southern, southeastern, eastern and western country. On the 24^{th} of July 2007, maxima temperatures reached very high values (40 ... 44°C), locally in Banat, Oltenia, Muntenia, Dobrogea and Moldavia.

Calafat reached 44.3°C, which was above the July absolute maximum temperature (43.5°C) recorded on the 5^{th} of July 2000, at Giurgiu.

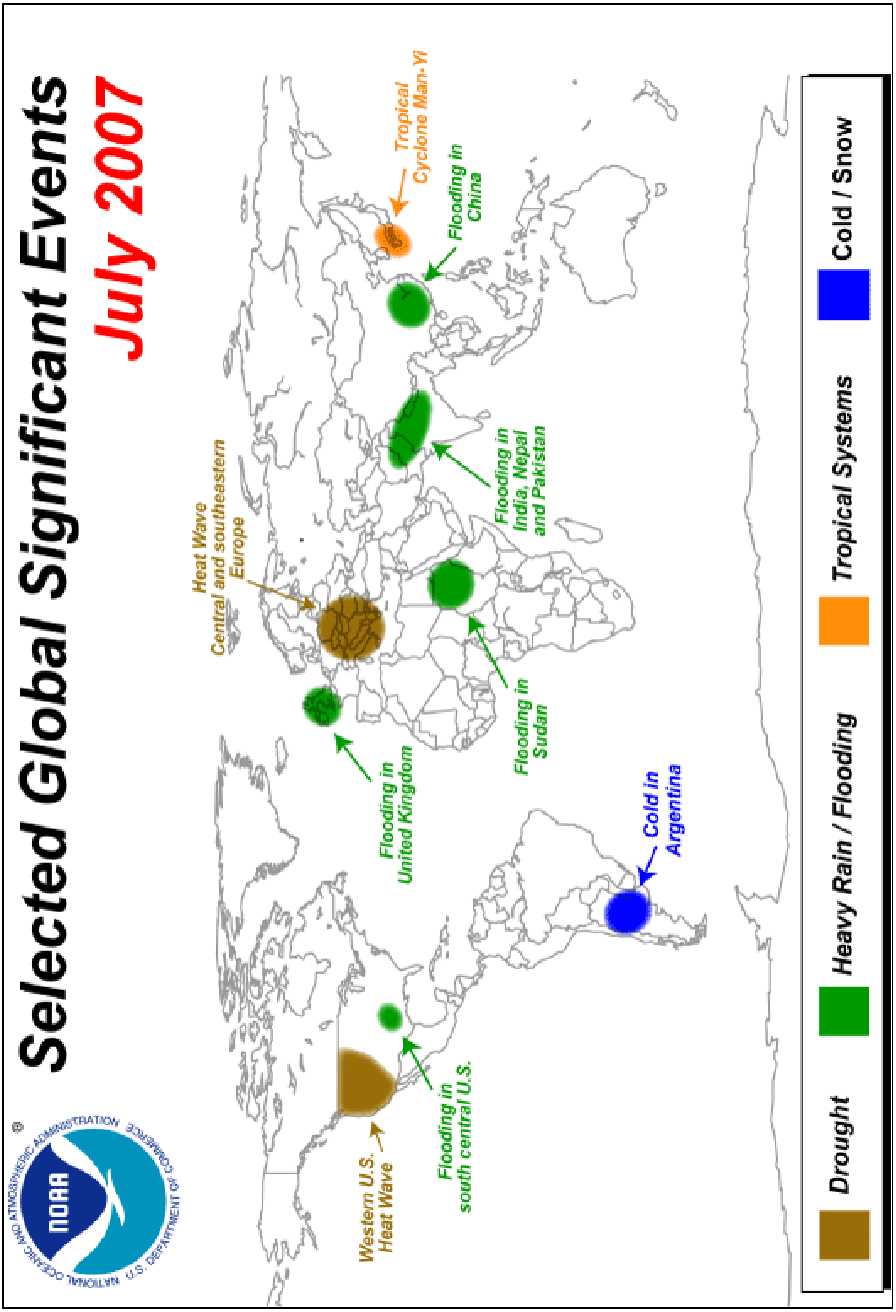

Fig. 9 *Worldwide extreme phenomena in July 2007 (source NOAA)*

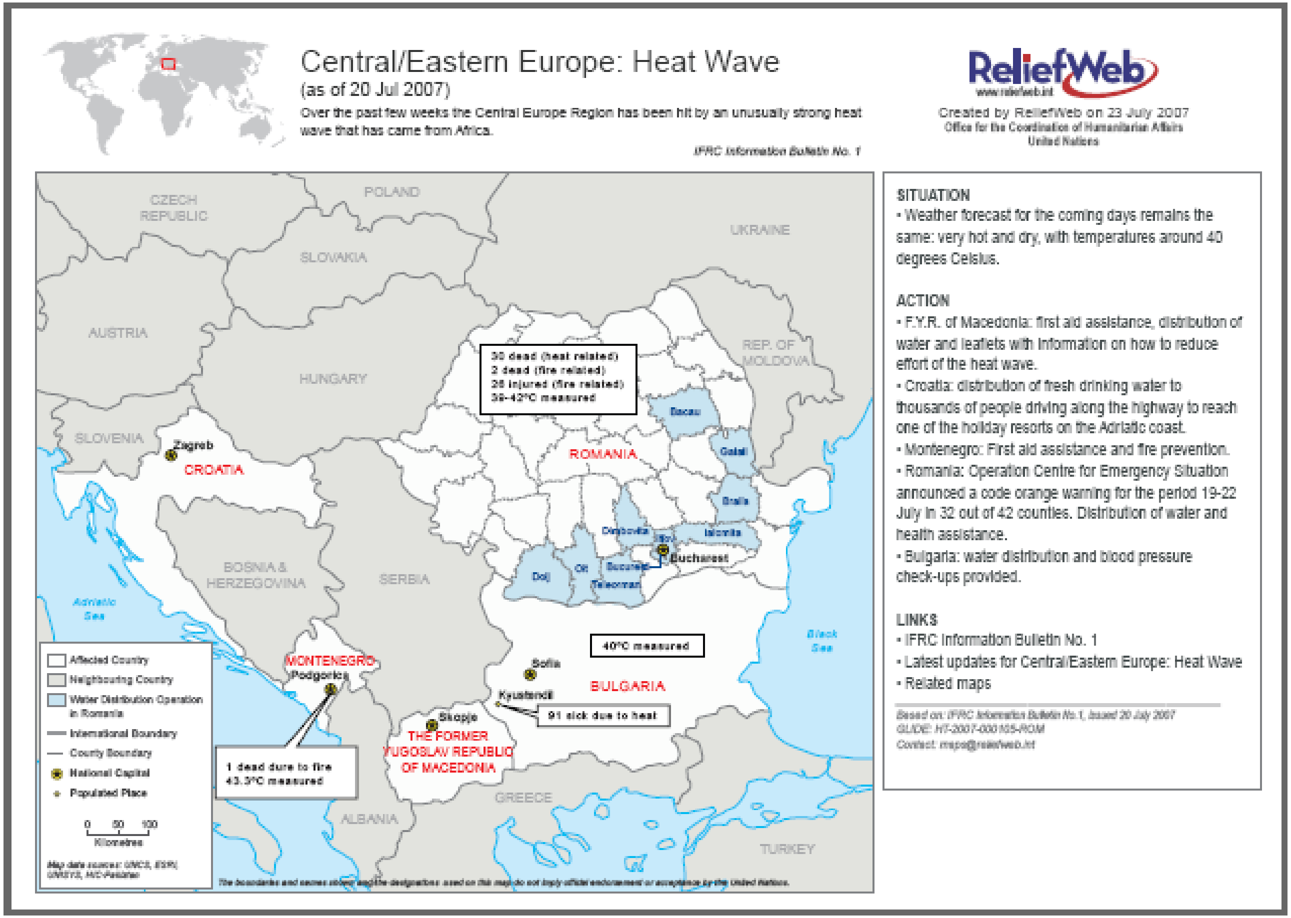

Fig. 10 *Consequences of the heat wave in Central/Eastern Europe* **in**

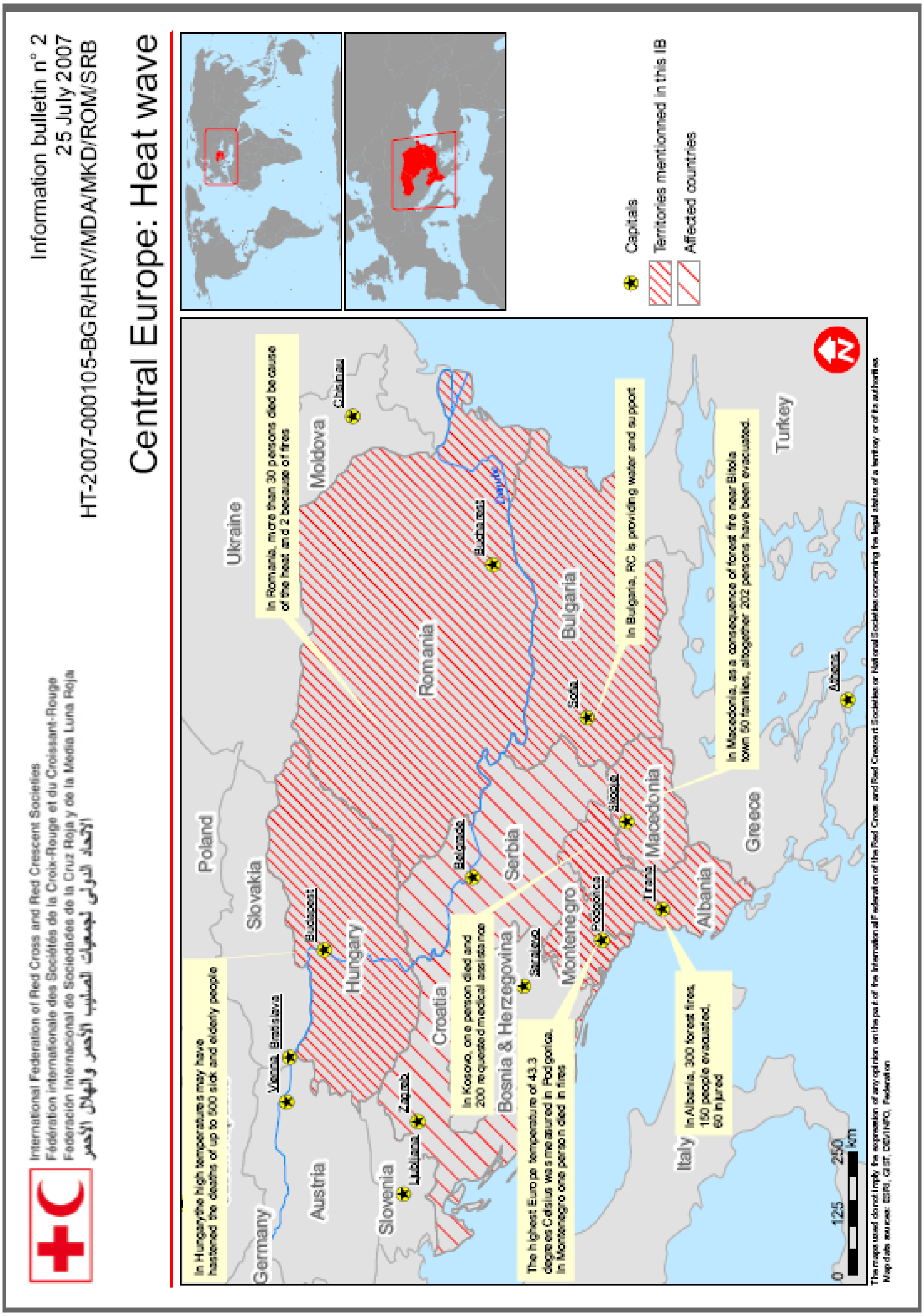

Fig. 11 *Consequences of the heat wave in Central/Eastern Europe in July 2007*

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ON-LINE AIR QUALITY MONITORING AND WARNING SUPPORT SYSTEM FOR BUCHAREST URBAN AREA

V. Crăciunescu[1], Mihaela Caian[1], C. Flueraru[1], Argentina Nertan[1]

ABSTRACT
Air quality is a major issue for all the important cities in the world. Bucharest is no exception. The air pollution in Bucharest, due to traffic and industry, is abundant, especially in areas the human population is concentrated. The fast rate of economic growth is bringing more sources of air pollution. In this context, the AIRAWARE project, funded in the EU LIFE framework, is aiming to build a pilot air quality monitoring and forecasting system to ensure a sustainable development of the rapidly expansive urban areas in Bucharest, minimizing and preventing the air pollution impact on human health.
The AIRAWARE system has a distributed architecture with dedicated sub-systems for: (1) air quality monitoring; (2) numerical modeling and forecast; (3) geospatial portal for data integration, visualization, query and analysis; (4) slow-flow and rapid-flow feedback. The G.I.S sub-system, described in detail in this paper, is build entirely with standard compliant free and open source software applications like GDAL, Geoserver, PostgreSQL + Post G.I.S, OpenLayers, TileCache.
The AIRAWARE system users list include the main local and national authorities in the domain of air quality monitoring, forecasting, air pollution abatement and mitigation of impacts, such as: the National Meteorological Administration, the Regional Environmental Protection Agency of Bucharest, the Direction for Public Health of Bucharest, the Centre for Urban Planning of Bucharest, the Institute of Biology of the Romanian Academy and Meteo-France as strategic European partner.
Keywords: air quality, AIRAWARE, open source, G.I.S, Bucharest

1. INTRODUCTION

Air quality is a major issue for all the important cities in the world. Bucharest is no exception. The air pollution in Bucharest, due to traffic and industry, is abundant, especially in areas the human population is concentrated. The fast rate of economic growth is bringing more sources of air pollution.

In this context, the AIRAWARE project, funded in the EU LIFE framework aims to address multi-targeting awareness of air quality impacts, with a high component of feedback on prevention and mitigation actions by creating an on-line geospatially enabled system. The system aggregate informations related to air quality monitoring and forecast, impact survey, pollution cadaster, pollution indicators (bio-indicators, human health indicators). Responsible authorities, which are part of the system (the National Meteorological Administration - NMA, the Regional Environmental Protection Agency of Bucharest - REPA-B, the Direction for Public Health of Bucharest - DPH-B, the Centre for Urban Planning of Bucharest - UMPC-B, the Institute of Biology of the Romanian Academy - IB-RA), are expected to use the system as a decision support tool for short and long term sustainable urban air quality management.

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[1] *National Meteorological Administration - Bucharest, Romania*

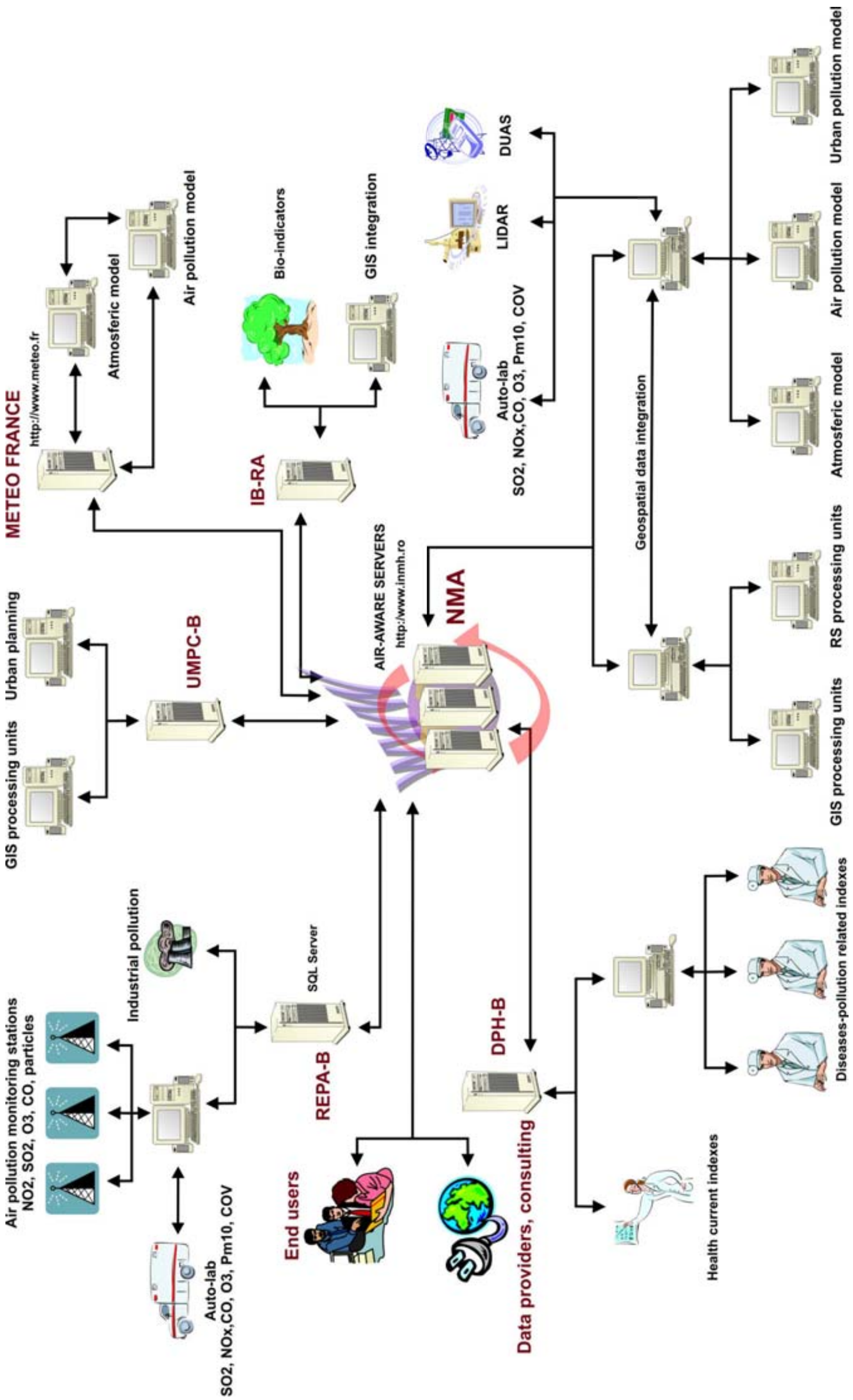

Fig. 1 *AIRAWARE on-line system flowchart*

Technically, the AIRAWARE on-line system was designed following a distributed architecture. All the partners and end-users are able to access the system using a thin web client (via a simple web browser like Internet Explorer or Mozilla Firefox) or a thick desktop client, to store, display, query, analyze and retrieve Bucharest air quality related information's (**Fig. 1**).

The main functions of the system are:

1. acquisition, validation, storage, spatial analysis and data interpretation;
2. management and exchange of raster and vector graphic information, and also of related attribute data for the air quality monitoring activities;
3. handling and preparation for a data rapid access;
4. information updating (temporal modification);
5. data restoring, including the elaboration of thematic documents;
6. generation of value-added information;
7. distribution of the derived products, forecasts and warnings to the interested authorities, media, etc.

2. AIR QUALITY COMPONENT

2.1. Air quality monitoring sub-system

Includes fixed ground monitoring stations measuring the most important pollutants (NO2, SO2, O3, PM10, PM2.5, Pb, benzene, CO), mobile laboratories and a complex LIDAR/DIAL spatial measurement of emission/ambient air contamination data, allowing both 3D modeling of diffusive, non-point source emissions, as well as a complex 3D spatial ambient air contamination information.

2.2. Numerical modeling and forecast subsystem

Involves chemical processes, transport and dispersion of pollutants for a complex, real or forecasted state of the atmospheric boundary layer. The sub-system depicts the 3D air pollutant "hat" evolution for various time ranges anticipation, from few hours to 3 days, while the larger scale forecasted trajectories provide climatological behavior estimates for pollutant transport over the urban and peri-urban areas of Bucharest. Several mathematical models are link together to provide the described functionality: ALLADIN (a limited area version of the ARPEGE spectral global model for numerical weather forecasting), TEB (simulates turbulent surface fluxes for urban areas for a given complex representation of urban surface), MEDIA (a French 3D Eulerian model for short, medium and long range transport of pollutant in the atmosphere), MOCAGE (a French global three dimensional chemistry and transport model), OML (a modern Gaussian plume model, based on boundary layer scaling) and OSPM (a semi-empirical model of street canyon flow and dispersion).

The forecast model outputs two main types of data: regularly distributed grids and pollutant trajectories, both in plain ASCII and binary file formats. In order to make use of this data in the AIRAWARE G.I.S based system, some conversions and data adaptation need to be performed. Detailed procedures were elaborated for each type of output from the model (E.g. wind forecast, temperature forecast, pollutant concentration etc.). Operations like file format conversion, data reprojection and interpolation were chained together using the Python powerful programming environment.

3. GEOSPATIAL COMPONENT: AIRAWARE GEOPORTAL

A geospatial portal is a human interface to a collection of online geospatial information resources, including data sets and services (*OGC, 2004*). The AIRAWARE geoportal represent the public face of the AIRAWARE on-line system, created to facilitate the sharing of air quality geospatial data and knowledge.

3.1. Open source G.I.S

The Free and Open Source G.I.S (FOSS) space includes products to fill every level of the OpenG.I.S spatial data infrastructure stack (*Ramsey, 2007*). The main advantages of FOSS software are (1) the availability of the source code and the right to modify and use the software in any way; (2) not tied to a single vendor; (3) big community to support; (4) good security, reliability & stability; (5) very good standard compliancy; (6) lower implementation cost.

The entire AIRAWARE geoportal and back-end modules are based on the existing FOSS and FOSS4G applications.

3.2. Data fusion and routing

The system needs to handle different types of spatial geo-data (scanned maps, satellite images, vector files, digital elevation models, model outputs) in different file formats and coordinates system (Stereographic 1970 – official Romanian coordinate system, Gauss-Kruger, UTM – Universal Transverse Mercator), processed by the project partners on different computing platforms and software environments. To make all the work easily available to the participants and end-users, a detailed specification package, mostly based on GDAL/OGR libraries, has been developed and implemented into a central application. These ensure the fact that every piece of information is correctly parsed and represented into the portal (**Fig. 2**).

The application is also able to automatically route the data from the project participants to the system (mainly the mathematical models) and to webmapping application. For this purpose, a Task and Stay Resident (TSR) application was constructed.

When project participants send new data to the system, a configuration file is created. The TSR application constantly checks the configuration files. When changes are detected, the applications forward the new file (through FTP connections) to the appropriate processing application or mathematical model. The TSR application wait for the output file to be created and notify the users to check the results. If necessary, more processing steps are initiated.

The TSR has been constructed such that it is able to monitor every 10 seconds for the arrival of a triggering file. Multiple requests can be simultaneous handled. All the performed operations and recorded in a file log. Based on this log, the users and project partners are able to track the system activity and to detect any malfunctions.

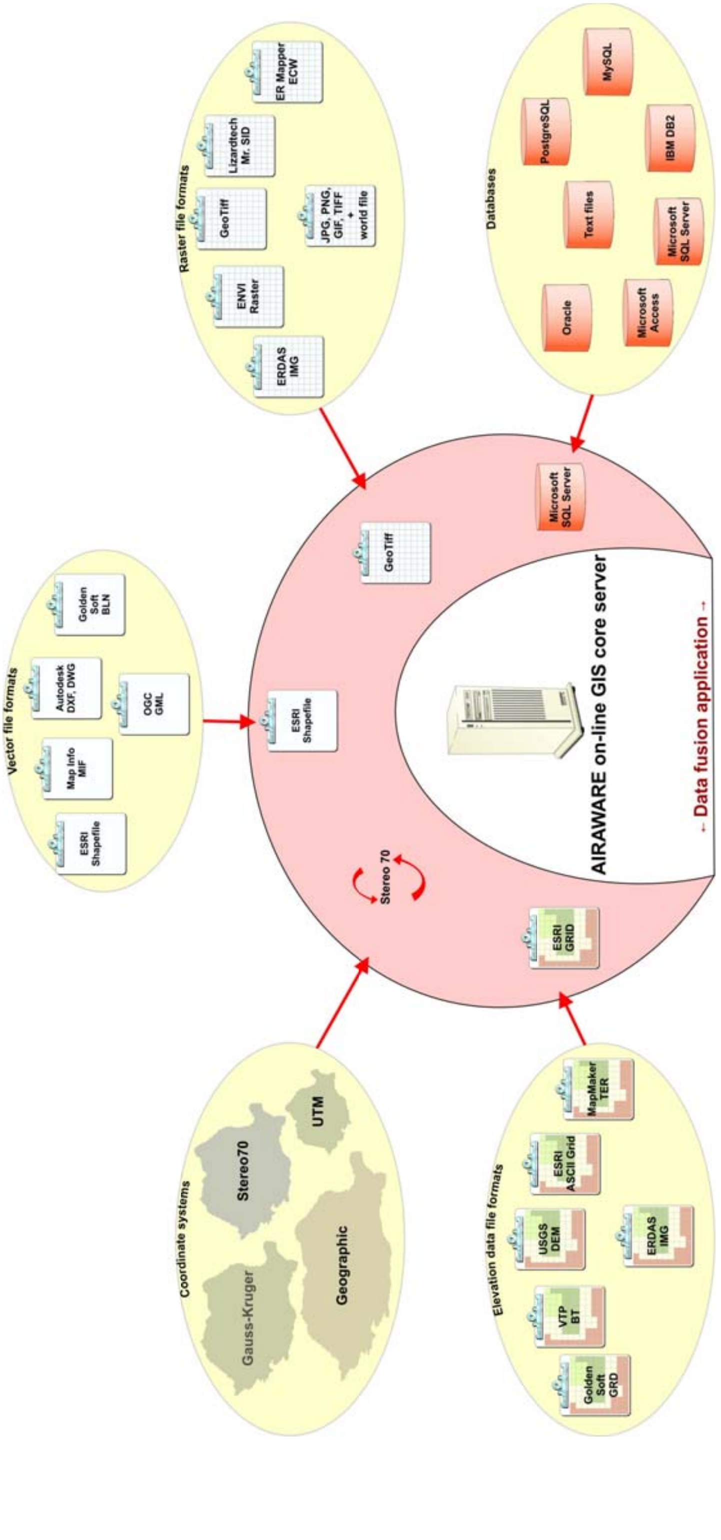

Fig. 2 *Data fusion and routing application*

3.3. Portal structure

The content is managed by Textpattern, a powerful and flexible, open source content management (CMS) application. For supplementary, specific functionality, custom modules were built. Other free applications are providing server-side functionality: MySQL (relational database management system), PHP, Python, Java (server-side scripting languages), Apache (webserver), Tomcat (servlet container), phpMyAdmin, phpPgAdmin (web clients for database management).

For geospatial data management, top open source applications were also integrated in the website: PostGIS (geospatial data storage), GeoNetwork Opensource (geospatial data catalog and metadata editor), Geoserver (standard geospatial server for serving data via WMS and WFS), OpenLayers (client webmapping application), TileCache (Python-based WMS/TMS server, with pluggable caching mechanisms and rendering backends).

The information flow between the various server side applications and the front end graphical interface is determined by the interaction with the portal users and their requests (**Fig. 3**).

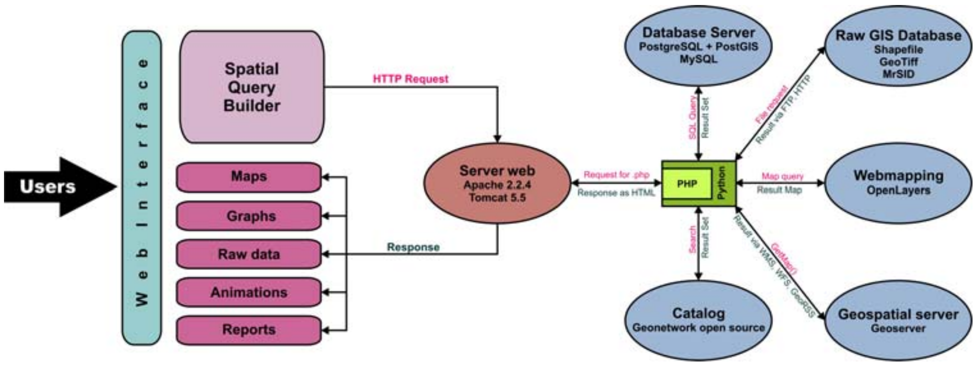

Fig. 3 *Portal information flow*

3.4. Portal interface

The website interface was carefully designed, respecting the existing W3C (World Wide Web Consortium) standards and separating the structure from the presentation by using strict XHTML markup and CSS (Cascade Style Sheets). New web technologies, like AJAX (Asynchronous JavaScript and XML), were also used to increase the interactivity. The goal was to obtain a simple, friendly and accessible environment for air quality data management. From the user’s perspective, when a button is clicked, an operation is performed, and a result appears on the screen. This summarizes a complex process of communication between the viewer and the server.

The portal is divided in several functional sections. Each section contains a predefined type of information. The most important one is the map section. Here the users can view and explore the cartographic representation of the spatial data stored in the G.I.S database. Both Raster and Vector (points, lines or polygons) data can be displayed in this area. The map can also include labels for the represented spatial entities, generated based on the related database attributes. The cartographic symbols and labels are automatically adjusted

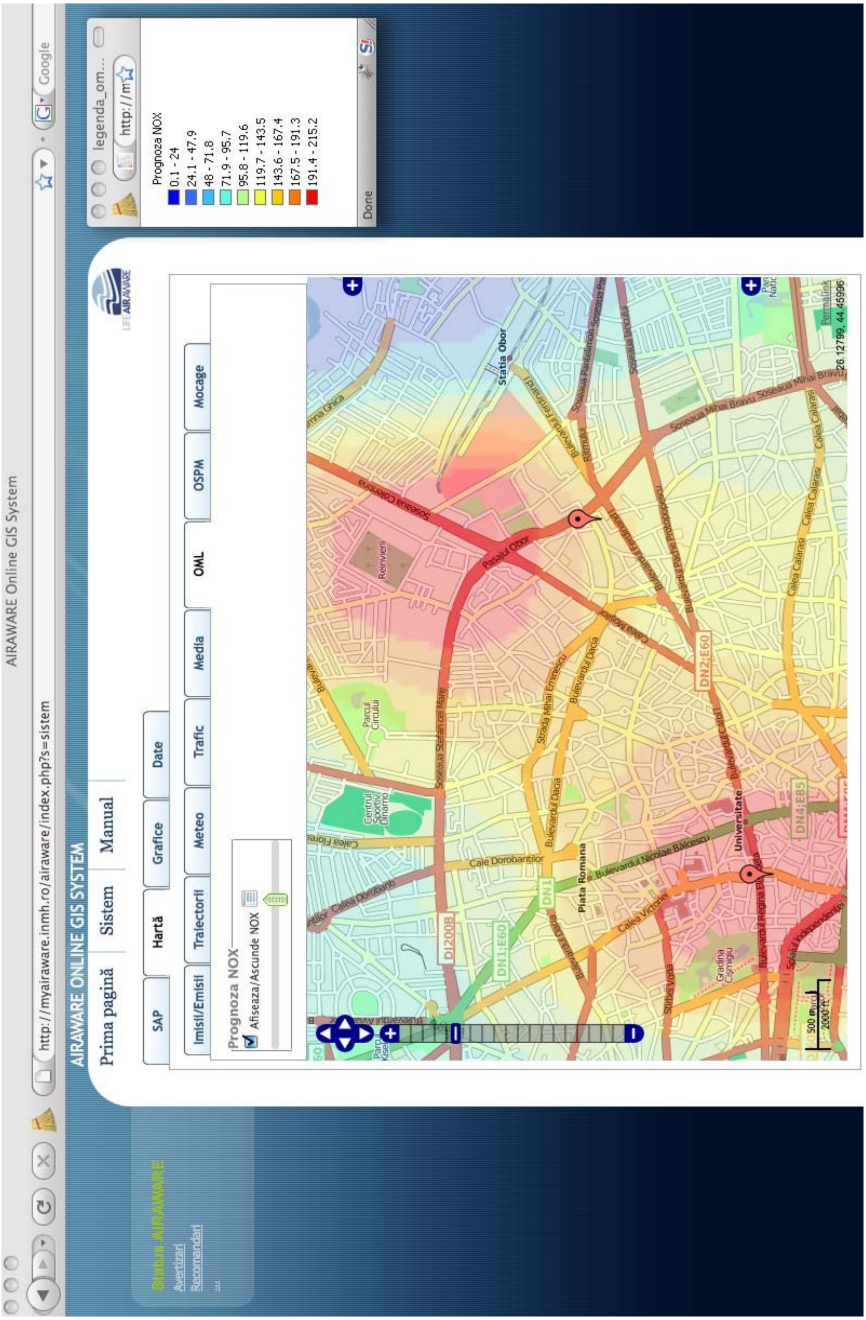

Fig. 4 *NOX concentration forecast displayed using the AIRAWARE system*

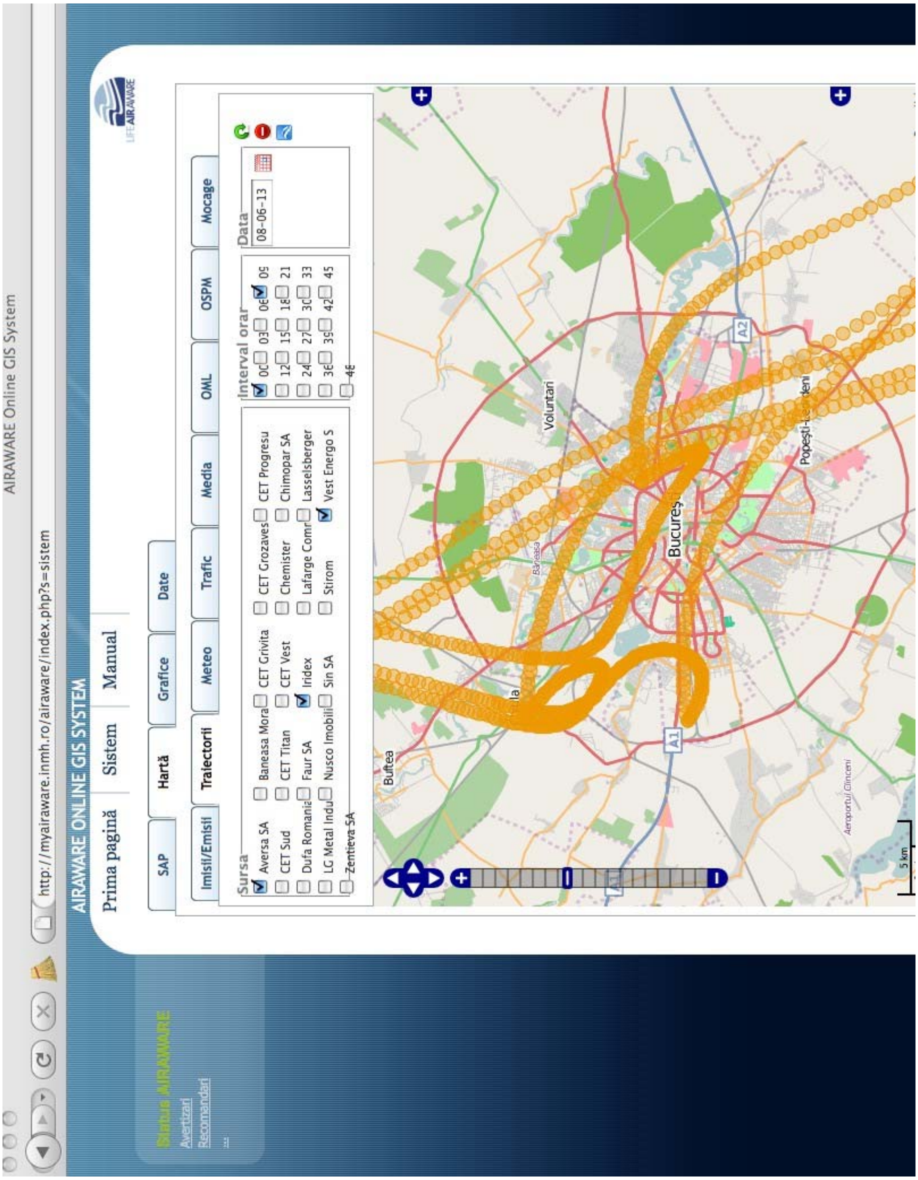

Fig. 5 Pollutant trajectories forecast displayed using the AIRAWARE system

Fig. 6 *April 2008: O3 recorded values at two monitoring stations*

according with the representation scale. The map is refreshed after each action performed by the user. The geospatial information, represented as map layers, can be divided in two categories:

(1) the background database, represented by typical G.I.S data (street network, buildings, river network, landuse, points of interes, DEM, satellite data). Additionally to the G.I.S database developed within the AIRAWARE project, the users can chose to display OpenStreetMap, Google Maps, Yahoo Maps or Microsoft Maps as background data.

(2) air quality related data, like mathematical model outputs (e.g. meteorological forecast: temperature, pressure, wind speed & direction etc.; pollutant forecast concentrations: PM10, CO, NO, NO2, SO2, O3, Benzene), pollution measured status, bio and health indicators.

Examples of the map section graphical interface are presented in **fig. 4** and **5**.

The users with who require more advanced G.I.S functionality or want to use their own data processing algorithms can access the AIRAWARE system content using a desktop (thick) client. This is possible due to the standard data access protocols and methods implemented on the AIR-AWARE server-side. Also, the users with poor or zero G.I.S knowledge are able to access some of the AIRAWARE products within popular, easy to use, applications like Google Earth.

Other sections on AIRAWARE portal allow the user to display the air quality informations as graphs (**Fig. 6**), tables or download the source data in popular file formats as ESRI Shapefile, KML (Keyhole Markup Language), MS Excel, CSV (Coma Separated Values).

4. CONCLUSIONS

The domain of free and open source geospatial applications is growing fast and provides reliable solutions for all the stages of geodata management. The FOSS4G plays an important role in adaptation of G.I.S technology by stimulating new experimental approaches and by providing access to G.I.S for the users who cannot or do not want to use proprietary products. The construction of the AIRAWARE system proved that possibility to build a complex system using only standard compliant, free and open source software, thus lowering the implementation costs and increasing portability and chances for large scale adoption.

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GEOLOGICAL MAPS SHOWING TRANSYLVANIA FROM AROUND 1900

C. Galambos[1], Z. Unger[1]

ABSTRACT
Three interesting geological map items, showing at least a part of Transylvania, are introduced in this work: the Herbich map (1878) of the historical Siculia, the 1896 and 1922 maps of the historical Hungary. The map of Herbich is the first member of the famous map series of the freshly founded Royal Geological Institute of Hungary. The 1896 map is the first one showing also Transylvania according to the Bologna geological color standard. The 1922 map shows also the territories east and south of the Carpathians and was printed in 35 color shades, which is a record of the maps of this region, too. The geological content of the maps is compared in this work as well as the method and results of the georeference of these maps into the modern G.I.S systems.
Keywords: geological maps, Transylvania, map colors, map signs, georeference, map projections, Romania, Hungary

1. INTRODUCTION

The usage of the colors is continuous from the early cradle of the cultures. Looking back to the history, we see that every age had its own color and shape fashion. A continuous development is outlined as every age formed its tradition to the utilization of the colors.

The application of the maps shows a similar movement: a huge development occurred from the wooden and shell maps of the natural tribes via Ptolemy to nowadays. Ore sites, water sources and mines are shown even on the oldest maps. Later the signs of postal directions, agricultural features became also frequently applied. The specialization of the maps, therefore the occurring of the geological maps, began in the late 18th and early 19th centuries. In the 19th century the general development of the sciences brought advances in the geological mapping. Instead of the random usage of colors and signs, a mostly unified system spread worldwide.

2. THE MAP OF FRANZ HERBICH (1878)

In the Habsburg Monarchy, similarly to numerous other European countries, the systematic geological mapping has been started from the mid-19th century. The Hungarian Geological Society was founded in 1848 in Videfalva (now Vidiná in central Slovakia). The Geological Institute of the Monarchy was founded in 1849 in Vienna and the Royal Hungarian Geological Institute became independent (in 1869) after the 1867 compromise between the Austrians and Hungarians. For comparison, the British Geological Survey was opting out from the Ordnance Survey in 1835, and the U. S. Geological Survey was founded in 1879. This is the period of the starting of systematic geological survey of the Pannonian Basin, too (*Stegena, 1998*).

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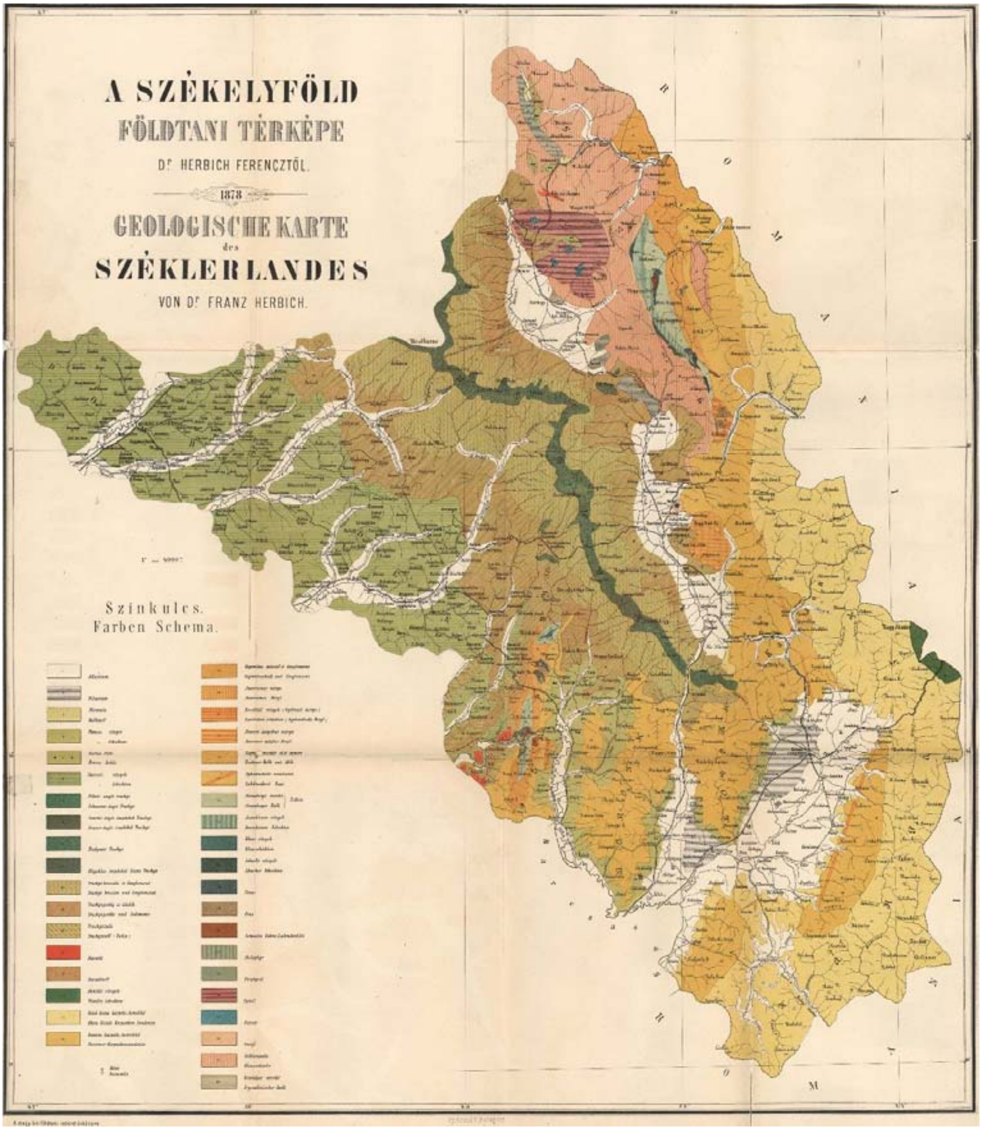

Fig. 1 *Geological map of Szeklerland (Székelyföld, Ținutul Secuiesc) by Herbich (1878)*

One of the first geological cartographic work of the Hungarian Geological Institute was the of Herbich map about Seklerland (Ținutul Secuiesc). It was issued in 1878 as an appendix map of the first monographic work of the Royal Hungarian Geological Institute (*Herbich, 1878*; **Fig. 1**). This map depicts only a part of Transylvania. The usage of the colors does not follow any standard; it only fits to the aesthetical approach of the author.

The scale of the map is very interesting. According to the map description (**Fig. 2**), it is »1" = 4000°«, which means that one Viennese inch in the map equals to 4000 Viennese fathoms in the field. In decimal context, the scale is 1:288,000, which is the figure of a derived map series based on the Second Military Survey of the Habsburg Empire (*Kretschmer et al., 2004; Timár et al., 2006; Jankó, 2007*). It can be supposed that this map (originally its topographic base) has the projection of the Second Military Survey, but slightly rotated to obtain almost vertical meridian lines.

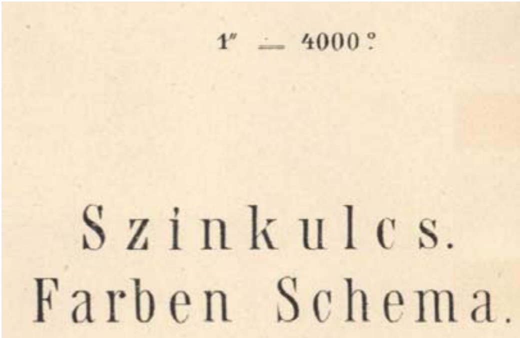

Fig. 2 *Zoom to the scale description and the legend header of Fig. 1*

3. THE BOLOGNA CONVENTION OF THE COLOR IN GEOLOGICAL MAPS

The development of the stratigraphy brought the renewal of the methods of depiction in the geological maps. The First Geological Congress of Paris in 1878 gave a program to unify the stratigraphic classification and nomenclature. This new system was accepted at the Second Geological Congress of Bologna in 1881, as well as the unified color coding and sign system of the geological maps (*Capellini, 1882; Staub and Szontagh, 1886; Fülöp et al., 1975; Galambos, 2004).* This color and sign system was a result of an international application, where the applicants proposed the colors and signns of the geological maps and sections (*Inkey és Schmidt, 1880*). The basic theory of the color usage was that the older the depicted geological unit, the darker the hue indicating it in the map. This theory is used till nowadays.

In the early geological maps, the lithological unit was indicated by figures, in these maps they are depicted by colors. Combined use of figures with colors and surface signs makes easier the identification of the patches and also pasting new objects during the compilation of the map (*Galambos, 2006*).

4. THE MAPS OF BÖCKH AND KOCH (1896) AND LÓCZY (1922)

The summarizing work of the Hungarian Geological Society, the Geological Map of Hungary (*Böckh and Koch, 1896*) was completed according to the new Bologna system. The geological information was hand-painted on a printed topographic base map in 1893. Later, in 1896, it was issued in fully printed version to the millenial celebrations of Hungary. The map was presented in the 1900 World Expo in Paris, where it was awarded a gold medal (*Pálfy, 1901; Böckh, 1903*; **Fig. 3**).

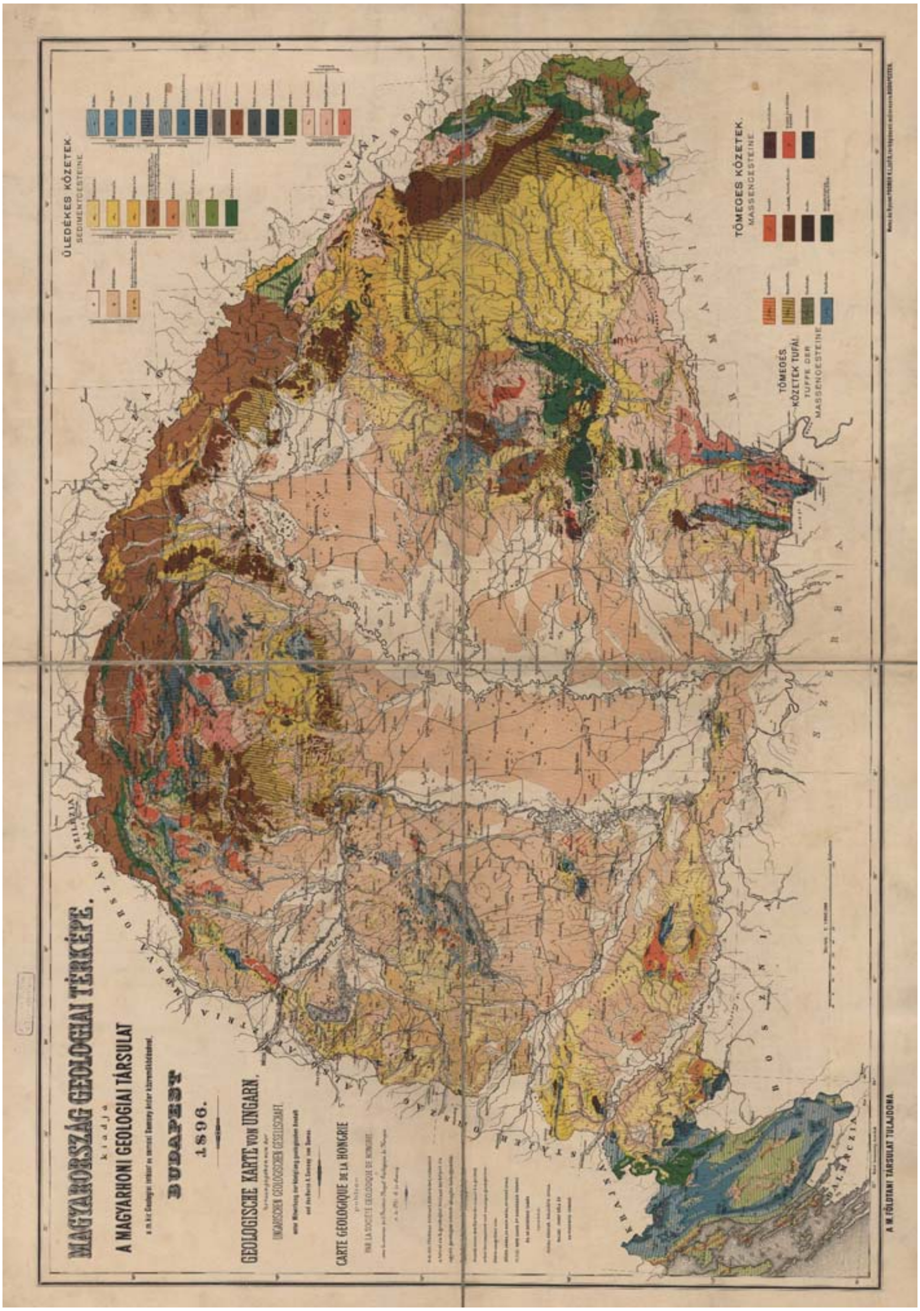

Fig. 3 *Geological map of the Pannonian Basin by Böckh & Koch (1896)*

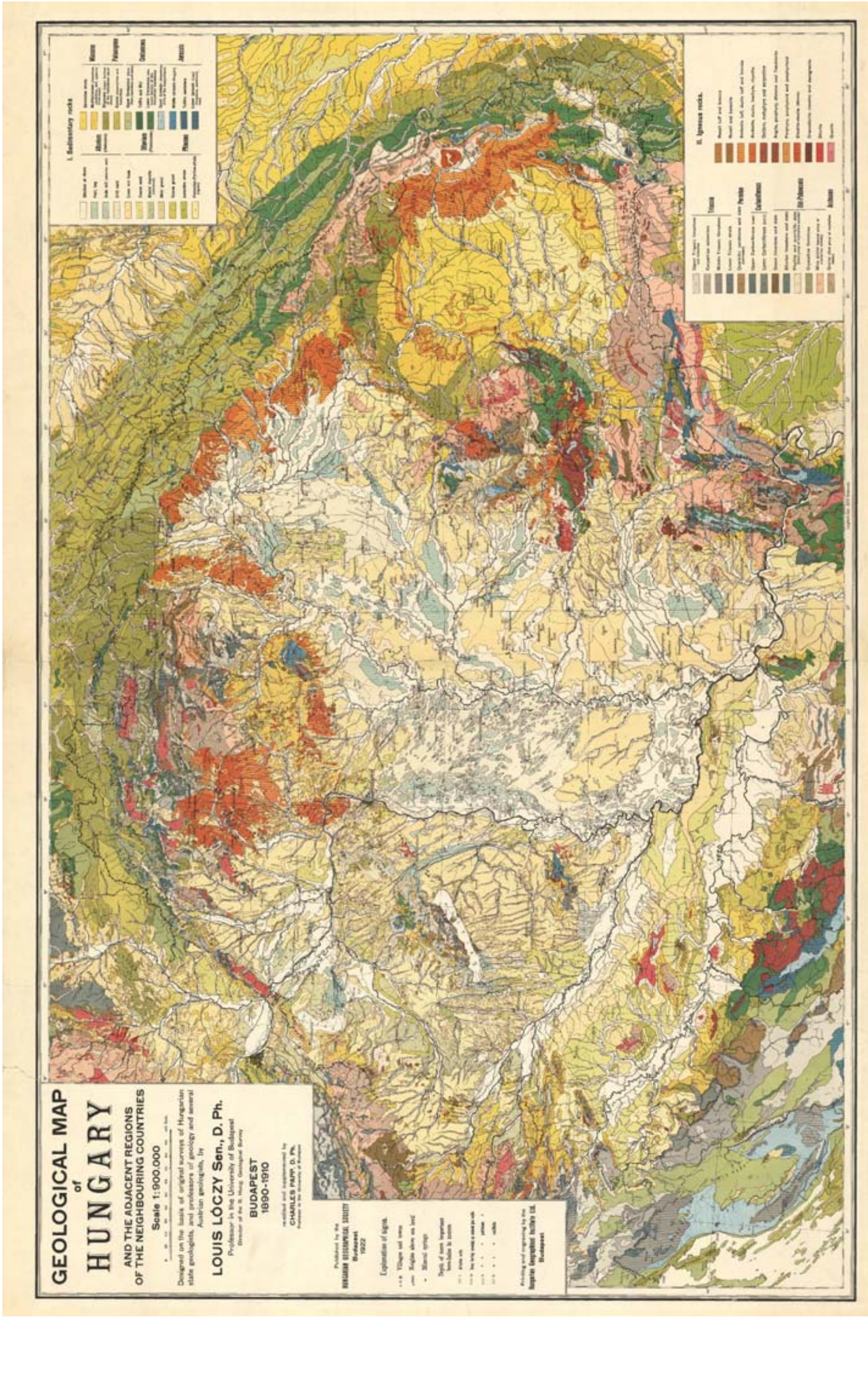

Fig. 4 *Geological map of the Pannonian Basin and the adjacent territories by Lóczy (1922)*

The map of Lajos Lóczy (1922) was compiled between 1890 and 1910. It shows the geological units of the historical Hungary and the adjacent territories with a scale of 1:360,000 in manuscript form. It was printed only after the death of the author, in 1922 by Károly Papp as a publication of the Hungarian Geographical Society (**Fig. 4**), with a scale of 1:900,000, using 35 different printing colors, which is unique in the Hungarian cartography (*Fodor, 1954*). For eg. a Romanian user of this map it is important, that geology of a part of the Old Romanian Kingdom, Moldva and Muntenia, is also depicted (**Fig. 5**).

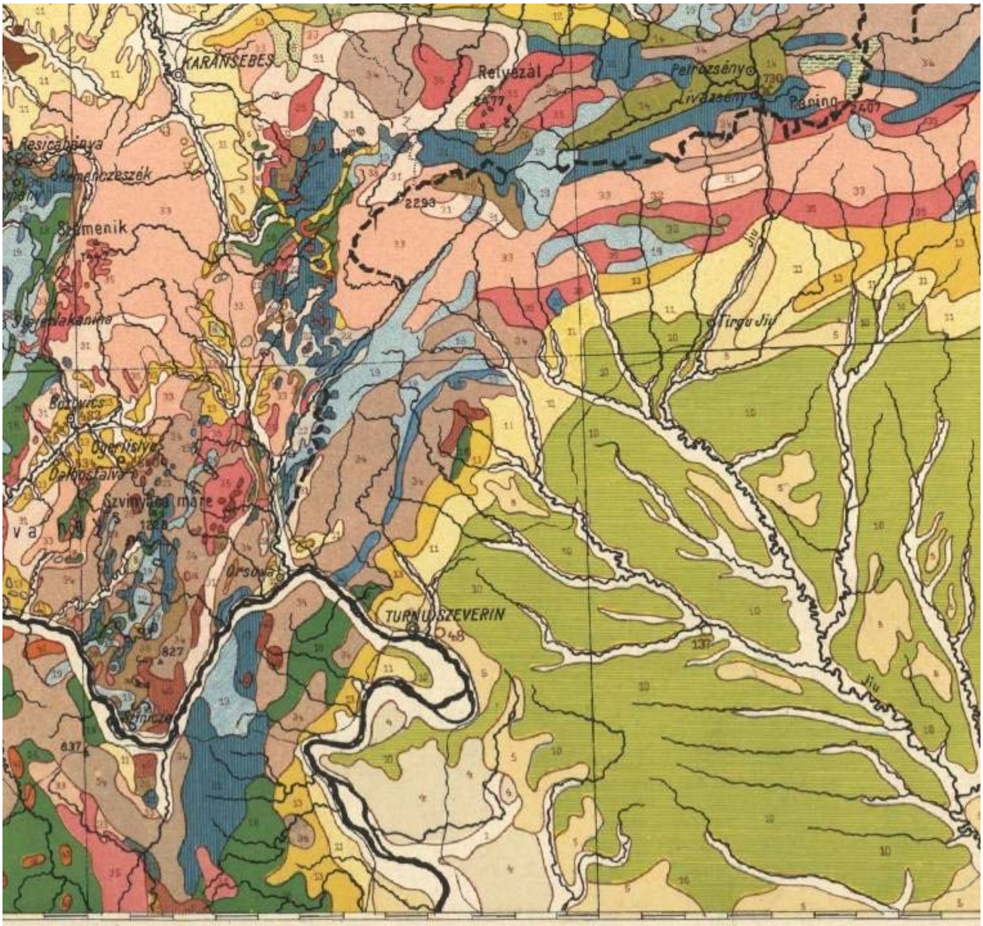

Fig. 5 *The map of Lóczy (1922) gives quite a detailed view of the geology of Oltenia, too (for modern geological context of the area, cf. e.g. Maţenco et al., 1997 or Cloetingh et al., 2005)*

5. PROJECTIONS AND GEOREFERENCE OF THESE MAPS

Georeferencing of the above reviewed maps means its rectification to a map coordinate system that is known in the Geographic Information System (G.I.S) software environment of our data. To make this rectification, a set of ground control points (GCPs) should be defined by their image coordinates in the scanned raster image and also by their map projection coordinates.

As it was mentioned above, the map of Herbich (1878) can be interpreted to be in a Vienna-centered projection system of the Second Military Survey derivatives. In fact, a low scale map such this one, covering only a small part (< 200 km) of the Earth, can be rectified almost any map projection that is valid in the mapped area. For this map, the rectification was done using the Romanian Stereo-70 system as its projection center is near to the central meridian of the map.

Fig. 6 *Three-dimensional image based on the map of Herbich (1878) and the SRTM elevation dataset (Werner, 2001; Timár et al., 2003c)*

The other two cartographic products can be interpreted either in the Budapest-centered Stereographic projection (*Timár et al., 2003a*) or in a real conic projection, whose parameters should be estimated using the analysis of the geographic coordinate grid (*Timár et al., 2003b; Galambos, 2009*).

In all cases, the crossing points of the meridians and paralels can be used as GCPs. Their image coordinates can be obtained by simply clicking on them during the rectification. Their geographic coordinates should be entered manually. In case of the usage of the Ferro prime meridian (as in the map of Herbich, 1878, and Böckh & Koch, 1896), the Ferro-Greenwich longitude shift should be applied as 17° 39' 46" (*Timár, 2007*). After entering the geographical coordinates, they should be promptly converted to the projected coordinates used. Without this step, the rectification has a significant error.

Rectifying the maps, the content of them is integrated to a G.I.S system and can be cross-evaluated by any other georeferenced dataset. The historical content of the maps can be used together with modern informations, eg. by making three-dimensional pictures using the old maps and the modern elevation datasets (**Fig. 6**).

Acknowledgements:

The displayed archive maps are the properties of the Library of the Geological Institute of Hungary, librarians Olga Piros and Márta Csongrádi are thanked for their accessibility.

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USING G.I.S IN ORDER TO DETECT THE OPTIMAL AREAS FOR DEDICATED ADVERTISING
- The Oradea city case -

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ABSTRACT
In the present paper we analyze the posibility of implementing G.I.S. in the publicity domain. Locating the optimum areas to undertake a certain kind of publicity is conditioned by knowing a set of complex factors (geodemographic, socio-economical, educational characteristics, the infrastructure of the targeted space, etc). A first stage is building a complex as possible a database reffering to the publicity campaign. Afterwards, based on some G.I.S functions we can try to develop identifying and grading algorithms for publicity areas.
Keywords: advertising, G.I.S, data base, detection, Oradea

1. INTRODUCTORY ELEMENTS

The shortest and most eficient producer-consumer route is comunication, and the basic instrument of comunication is publicity, an efficient way to provide information to the consumer and at the same time intensify competition.

Usually, publicity groups any type of presentation or promotion of ideas or services. Of the means to promote a product mentioned in a series of studies in the field (*Gutu, 1994; Petrescu, 2002; Farbey, 2005; Marcenac, 2006*) we should mention : newspapers and magazines , television, radio, galleries, dirrect correspondence, tvmarketing, phones, the internet, outdoor publicity etc.

The main objectives of this paper are :

- compiling a G.I.S. database needed to optimaly locate publicity materials.
- the G.I.S. analysis of legislative restrictions regarding the placementof publicity materials.

Using G.I.S. in publicity management is, at least in Romania, a new concept. A recent study has targeted highlighting some characteristics of the G.I.S. database that would be useful to publicity management *(Lupău et al., 2006)*.

In order for the publicity to be efficient, a first step is to locate possible clients and especially certain categories of clients that could be interested in the products/services of a company or organizations. Also, to locate potential clients, a series of factors have to be taken into account : demographical, socio-economical, legislative etc. Just knowing the size of the population of an urban area (the clients) is not enough. You also have to know segmentation of the market, to identify the interests and needs of the potential clients and choosing the best way to transmit the desired message.

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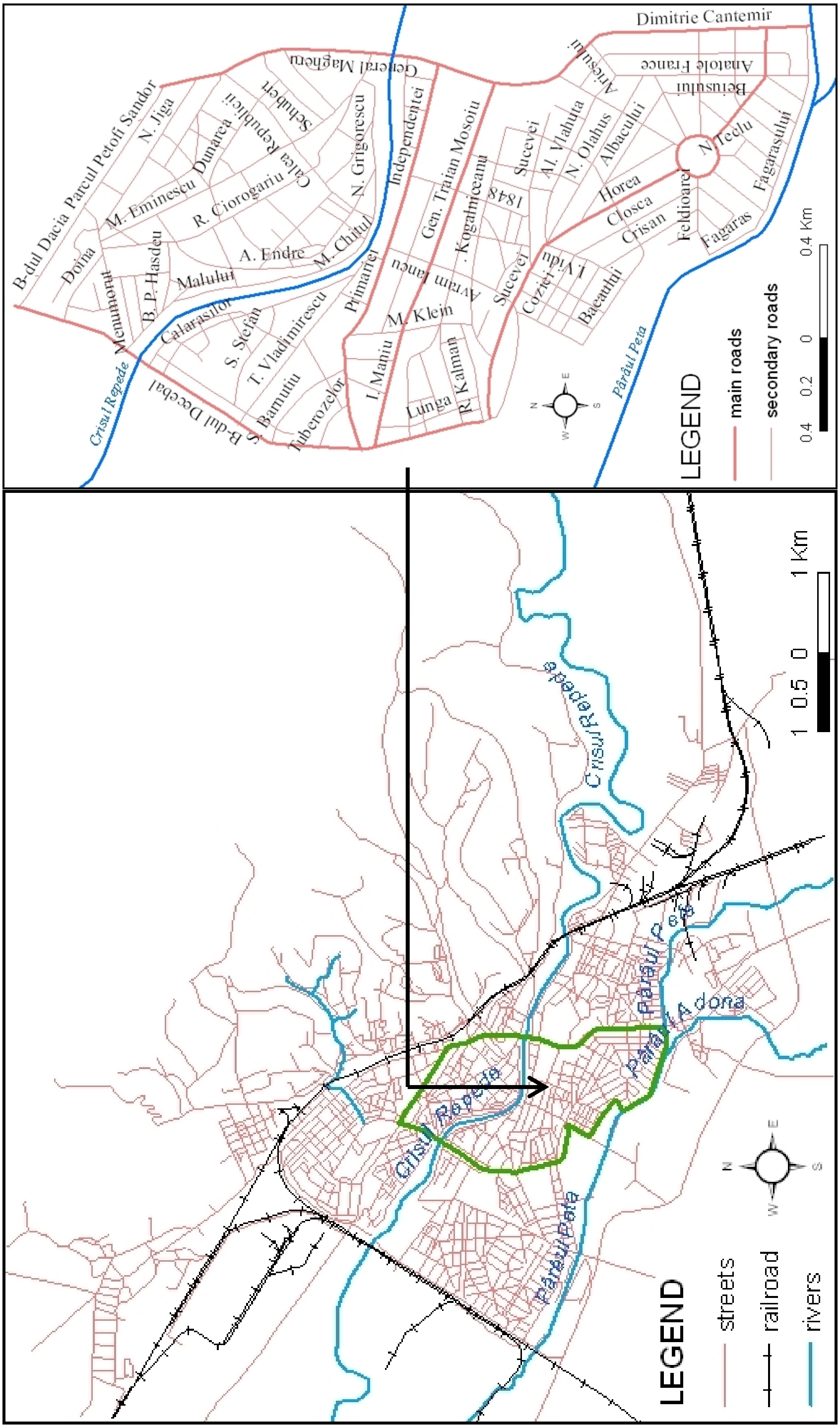

Fig. 1 *The City/Municipality of Oradea. Localising elements of thestudy area*

The segmentation of the market is done to identify the target audience, defining a limited number of potential clients and directing all the marketing efforts towards them, most of the products having a specific profile, a particular type of clients, a special character, its own niche in the market.

The targeted market segment can also be defined by : *the value and intensity of sales* (clients that never buy, clients with low/medium/high potential of purchase), *the target audience of the publicity* (clients, consumers/users, staff, suppliers, local comunity around offices and factories, the financial comunity, bancs, institutions, stockholders, commercial or financial centers, people that can influence the progress of the company – local authorities, commercial associations, the government, those who form the public opinion : journalists, political leaders) and *the sales or th buying capacity* compared to the average (regions with sales below/at/above the average).

The tendency is to divide the market and comercialize specific products for specific segments : „you don't sale to everybody, but to your market" (*Farbey, 2005*). That way, publicity must reflect the way a product is connected to the preocupations of the consumers, to their needs (*Iliescu and Petre, 2006*).

The study surface corresponds with the central area of the municipality of Oradea (**Fig. 1**), as it is marked by : Dacia Blvd to the NE, Calea Republicii, General Magheru Blvd and Dimitrie Cantemir Blvd to the E, Fagaras St and Barcau St to the S and SE, Decebal Blvd and Matei Basarab Blvd to the W.

2. THE ANALYSIS OF OPTIMAL AREAS TO UNDERTAKE PUBLICITARY ACTIVITIES

Out of the multitude of factors that influence publicitary activity, in this study we have directed our attention to these next aspects : the organization of the street net, population, surface dedicated to green spaces, tourist and cultural attractions, learning institutions, sanitary institutions.

This way, with the help of the G.I.S, we have compiled a vector database partaining to a series of factors that would encourage or disscourage different publicitary activities, offering the user the possibility to manipulate, add or update the information.

The street network influences the publicity activity through density, but also by type of street (**Fig. 1**) – main streets like a boulevard with at least 4 lanes, secundary streets with 2 lanes. The role of the transport routes as a medium for transmiting the publicity message becomes primordial, basing itself on the mobility of the population, its concentration along transport routes and the intensity of the traffis respectively.

In this case, the most efficient media environment to undertake publicitary activities becomes the outdoor publicity, and the one based on the means of transport. The importance of this way of comunication comes from several points of view:

- the high number of possible locations (locations for comercial posters, bus stops, interiors and exteriors of common transportation, the exterior of privately owned means of transportation, train stations, etc.);
- the wide geographical coverage (being a means of mass comunication, it reaches large, undifferentiated categories of the audience, mostly supporting new products or services being introduced to the market);

- it has the advantage of repetition, passers-by coming back to the same place frequently – characteristic of common transportation;

- includes using a variety of means of transmition of a publicitary message : posters, banners, meshes, billboards (still or mobile) and other types of luminous advertising.

Although at first sight the instruments of outdoor advertising present numerous advantages, both for clarity of the transmited message (supporting their efficiency in built-up urban areas with intense car and pedestrian traffic, in areas of tourist interest, etc), and for the number of possible locations, still, in their placement there are numerous local legislative restrictions to be taken into consideration regarding : respecting the traffic and pedestrian circulation, placement with respect to different public institutions, places of worship, central/restricted areas, etc.

Technical norms concerning the design and placement of constructions, instalations and billboards stipulate that :

- to place billboards on existent poles it takes the written approval of the owners of the poles that are on public property (for example, the electric company), and also of the highway police. The dimensions in these cases will be no more than 0.80 x 1.20 m and a hight of at least 3.50 m off the ground, and the distance between billboards on the same side of the street must be at least 25m, so that in the visual field of the driver they don't become a continuous front and that they don't prevent them from reading roadsigns and seeing stoplights.

- it is prohibited to install posters and advertisement systems in underground and overhead passages, on poles that support traffic signs and roadsigns, in curves with reduced visibility an conflict areas with extraordinary traffic events, in areas with traffic signals and in intersections. Posters and Advertisements that are supposed to highlight public interest areas are an exception, if they have the approval of the local public administration, by decree of the local council.

- the small sized luminous advertisements ($< 1\ m^2$) placed on the electric poles won't use colours specific to traffic signs and intermittent lights and they will be facing the sidewalks, except for when the alignment of the poles is towards the buildings and not the street;

- in the case of luminous advertisements, the reflectors will be placed so that the lighting is even and that it doesn't bother traffic and pedestrian vision;

- light-up or luminous pannels can't be placed in front of building windows and can't exceed the surface of the walls they are being placed on;

- on the sidewalks, only outside the central areas, mobile pannels, selfcarrying, 0.5 x 0.9m can be placed next to buildings, only if the sidewalks are wider that 3.0m;

- the smallest distances between billboards are 25m for small and medium boards and 50m for big ones; when a succesion of small/medium/large boards is formed, in any combination, the distance betwen them will be 50m. Their dimension can't be bigger than 4x3m.

- no advertisements of any kind can be placed in roundabouts, on the traffic islands or the streets or in curves with low visibility;

- there can't be more than 3 succesive advertisements with the same content;

Fig. 2 *Locating areas with restrictions about placing advertising materials*

- when puting up pannels there will be at least 4m distance between the sides and the edge of the street, and on the bottom, at least 2.5m from the ground. Authorization to break will be solicited where necessary;

- pannels that need a foundationcan't be put up on sidewalks narrower than 5m and in the green zones between th sidewalks and the streets;

Besides the configuration of the street network, all these legal requirements can constitute the object of a G.I.S database that will contribute to the outlining, by means of network analysis, to the indentification of possible surfaces for placing advertisements.

For example, considering the restriction that pannels of any type or dimensions can't be placed less than 50m from intersections of 4 lane streets or 30m from intersections of 2 lane streets, the **C**reate **B**uffers function created a layer that contains the limits of the surfaces where pannels can't be placed. (**Fig. 2a**)

The protected areas of a city have special characteristics about authorizing advertising placements. That way, in the central area of the city it is acceptable to :

- place signs, but only as part of one-of-a-kind projects and adapted to tha available surfaces, without afecting details or competing with the architecture of the building, considering the historical and ambiental value of every building;

- place pannels, banners, etc only for temporary events or in the interest of the comunity (festivals, ellections, holidays, etc).

In these areas, it is prohibited to :

- advertise inside historical reservations;
- place signboards at a 90° angle to the front of the building;
- change the signboards (that announce a commercial activity) into advertisements by displaying products, merchandise and services;
- modify hardware elements to hold up signboards;
- place mixt signboards and advertisements;
- place large advertisemnts (more than 0.5x0.9m);
- place mobile pannels or any other form of advertisements on the pavement;
- mask architectural elements or decorations of any kind (ornaments, framing, ironware);
- write on storefronts (inside or outside), walls or access gates with self-sticking materials or with spraypaint;
- write commercials on the upside of terrase sunshades;
- write on cornices or balconies;
- advertise for cigarettes and alcoholic beverages;
- inscribe " For Sale", "For Rent", etc on fabric.

As a study surface we have located a protected area (**Fig. 2b**) that is mostly formed by cultural points of interest (museums, churches, monuments, learning institutions).

Fig. 3 *The density of the population (a) and the repartition of the green zones (b)*

The population conditiones the development of different types of publicity by density as well as age group, sex, social status, level of education, income, etc. Taking into consideration the demographical characteristics is a strategic measure. For example, knowing that this part of town is mostly populated by the younger group could open it up to promoting products for young people (sporting goods, IT, pizza places, tourist packages, etc). The density of the population compels the advertising activity to be dirrected towards intensly populated areas. A layer concerning the density of the population (**Fig. 3a**) was made using information about the number of inhabitants aged over 18 in order to highlight the areas where the advertising activity can be concentrated.

Although ***parks,*** real areas of population concentration, especially during the weekends, would make an optimum location to promote some products and services, placing advertising materials directly on the ground or in special supports in the parks and green areas of the cities is prohibited. However, in the neighbouring areas, where the law allows for it, the accent could be placed on advertising for tourist offers, aquiring sporting equipment, informing the population about cultural or entertainment manifestations, etc.

For the study surface we have compiled a polygon type vector database (**Fig. 3b**) that encompases the green areas (parks, town squares, etc).

Cultural, tourist and health objectives also represent points of interest for the deployment of specific advertising activities. For this purpose we have made a point vector database containing museums, churches, monuments, learning institutions, health institutions and farmacies, lodgings (**Fig. 4**).

Still it is prohibited to place posters and commercials on real estate that has been declared a historical monument or that is protected by motions from the local council and in the protective areas constituted around them, in areas with a special security and supervision regime or on trees planted on the public grounds. However, the County Board for Culture can authorize the temporary placement of support surfaces that would cover the fronts of the historical monuments during the undertaking of renovation or restauration works or for publicity during the preparations and throughout the course of cultural or socio-humanitarian events, if the organizers are based in a building that is considered a historical monument.

As far as learning and health institutions are concerned (**Fig. 4b and 4c**), the legal provisions do not impose restrictions except for alcohol an tabacco ads, as these products cannot be promoted in the institutions mentioned above or at a distance smaller tha 200m from their entrance, measured from the public roads.

Because they belong to the private sector, hotels and pensions (**Fig. 4d**) present fewer impediments about the placement of ads, authorizations to undertake advertising activities using building fronts, terraces and roofs, but also the interiors of the respective buildings as it only requires th written consent of the owner. Using hotels and pensions to promote products could prove to be an advantage both because of the number of visitors, and also for their categories which are generaly defined by their financial posibilities.

Fig. 4 *Objectives that help locate the optimum areas for advertising activities : museums, churches, monuments (a); learning institution (b); health institutions and farmacies (c); lodgings (d)*

3. CONCLUSIONS

Publicity can be any form of presentation or promotion of ideas, goods or services. However, it must be adapted to the client, product and the environment where the promotion will take place.

A first step in making sure that the campaign is efficient is to locate the potential clients and most of all, a certain categoryof clients (depending on age, sex, income, social status, education level etc.), that might be interested in the products/services offered by the company/organization.

The general tendency is to segment the market and sell specific products for specific segments, with the publicity reflecting the way a product relates to the preocupations, interests and needs of the buyers.

The G.I.S.'s intake is also an advantage because it creates a complex database that is easy to manipulate, that allows for the organization and update of the information, as well as the existence of two posibilities to store and visualize the information, graphicaly and in the form of a table.

G.I.S also offers the posibility to display, add or eliminate the information in themed layers according to the interests of the user (advertising agencies, companies that want to monitor their own advertising as well as the competition's, etc). Ultimately, by using certain G.I.S functions, we can try to develop and apply algorithms to identify and grade advertising areas.

Of course, for a more detailed study, this database can be extended with information gathered during sociological, quality and quantity studies (for example: opinion polls), censuses etc.

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USING LOW-PASS FILTERS TO IMPROVE REGRESSION MODELS FOR CLIMATE VARIABLES. A STUDY CASE OF WINTER MEAN MINIMUM TEMPERATURES IN THE FRENCH ALPS

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ABSTRACT

Our study presents a simple G.I.S-based technique, which can be successfully used to improve the regression spatial models of climate variables, especially in the case of air temperature. This technique is a low-pass filter which calculates the means of the predictors within moving windows of different sizes. In this way, we are able to account for more general terrain characteristics, depicted from a larger area surrounding the meteorological stations. This information is sometimes more relevant for the spatial variation of some climatic elements then the strictly local terrain information. Our study proves this point in the case of mean monthly minimum and maximum winter temperatures in the French Alps.

Keywords: low-pass filter, climate, regression, G.I.S, French Alps

1. INTRODUCTION

The present study addresses the problem of climatic parameters spatialisation, synthesizing a series of results achieved within the framework of COST719 European project: *The Use of Geographic Information System in Climatology and Meteorology*. The main objectives of this action was to broaden and enhance the potential of G.I.S in the fields of climatology and meteorology (*Chapman, Thornes,* 2003), encouraging and fostering European co-operation (*Dyras et al.,* 2005).

For most climatologic applications, the only collected values in the meteorological stations are not sufficient. Spatial interpolation of these data is often essential to obtain estimated values in each point of a studied space. This field is sometimes called gridded climatology (*Tveito and al.,* 2005).

The spatialisation of climatic information (*Willmot, Matsuura*, 1995; *Courault, Monestiez*, 1999; *Joly et al*., 2003; *Stahl et al*., 2006; *Dobesch, Dumolard, Dyras,* 2007) has developed rapidly and significantly as an effect of the development of G.I.S and statistical (geostatistical) methods. At present, there is quite a large range of interpolation methods, some of them integrated in G.I.S software packages, from simple mathematical interpolations, such as the IDW (Inverse Distance Weighting), to complex stochastic methods, such as regression analysis or kriging (*Dobesch, Tveito, Bessemoulin,* 2001). Numerous studies have proved that, among the various spatialisation methods, the regression and kriging and their combination (residual kriging) generate the best spatial

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models for climatic variables (*Tveito, Schöner, 2001; Lhotellier, 2005; Jun et al.*, 2006). However, a series of aspects still require more inS.I.Ght: the interpolation of momentarily values (ex: diurnal values); the interpolation of climatic variables depending mainly on air masses dynamics (ex: precipitation, *Atkinson, Lloyd, 1998*); the interpolation of variables in complex terrain areas (ex: mountainous areas).

Our study is based on data collected from a sample of 66 meteorological stations (source: *MeteoFrance*) representing the mean monthly minimum and maximum winter temperatures for the 1990-1995 time period. The study region, situated in the French Alps, includes the territory of Isère, Hautes-Alpes, Savoie and Haute Savoie departments, covering a surface of about 24000 km^2. For the derivation of new geomorphologic predictors we used the DEM (Digital Elevation Model) elaborated by IGN (Institut Géographique National - France), modified with a spatial resolution of 150 x 150 m.

2. RESULTS

Low-pass filtering of predictors in moving windows of different sizes helps us consider the predictors' influence from a larger area surrounding the stations. This technique was applied on the DEM, using windows sizes ranging from 450 x 450 m to 24600 x 24600 m. The technique proved useful for improving the minimum temperature spatialisation and able to account for some temperature inversions, which is not the case for the maximum temperatures.

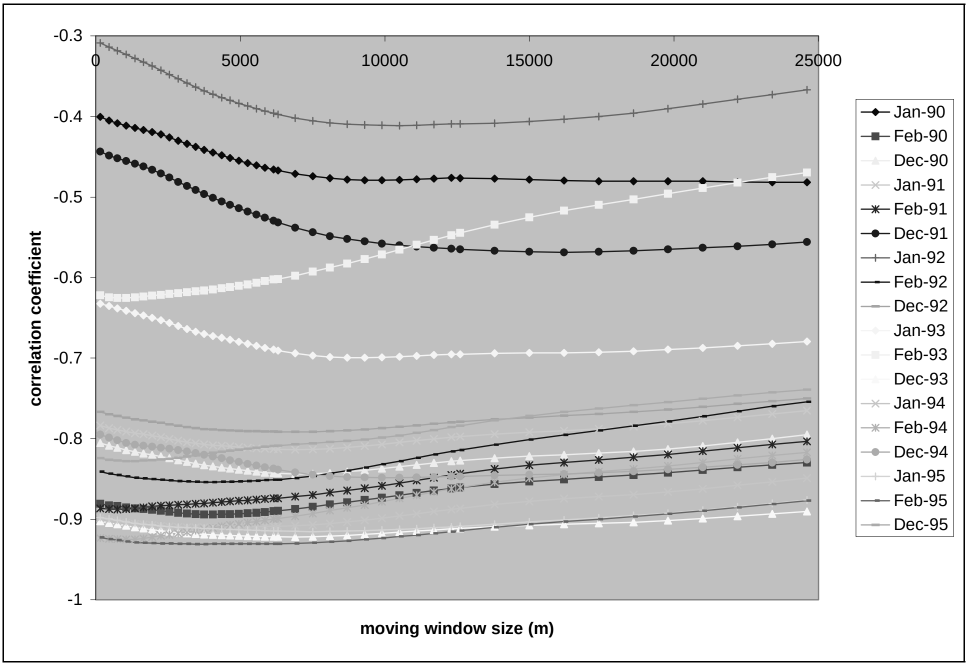

Fig. 1 *Variation of temperature-altitude correlation coefficients with the moving windows size*

Fig. 1 emphasizes that the maximum (best) correlation between minimum temperature and altitude is always associated with a filtered DEM and not with the raw (local) altitudes. This means that, for minimum temperatures spatialisation, the more general altitude information, referring to a more or less extended region around the meteorological station, is more important than the local station altitude. For example, in the case of December 1991, the correlation with the local stations altitude is –0.44, while the maximum correlation with the filtered DEMs is –0.57 and it is associated with a moving window size of 16200 m.

The *optimum moving window size*, that is the size associated with the best correlation coefficient, varies from month to month, from 750m to 23400 m (**Fig. 2**). In most cases, the optimum size is less than 5000 m (44.4% of the total months), while an optimum size of 5000 m to 10000 m is associated with 38.3% of the months.

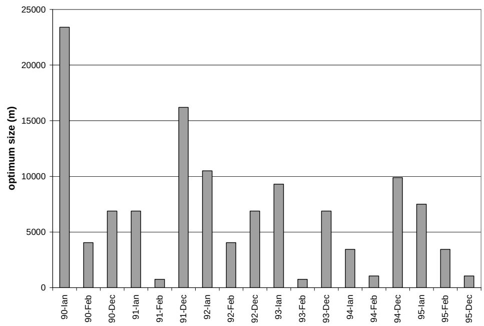

Fig. 2. ***The optimum moving window size***

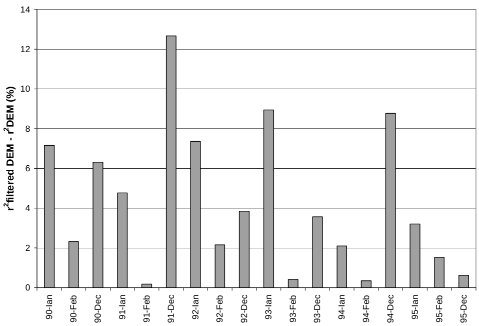

Fig. 3. ***Explained variance increase***

The increase of the explained variance as a consequence of using filtered DEMs instead of the raw DEM varies also significantly from month to month (**Fig. 3**), from less than 2% (27.8%) to more than 12%, as in December 1991 mentioned above. A value of more than 6% of explained variance increase, which justifies the use of the moving windows technique, is associated with 33.3% of the total months.

Fig. 4 compares the results achieved by a classical residual kriging approach, using local predictors values (at stations' locations) with those obtained by using low-pass filtered predictors for the mean minimum temperature of December 1995. A little edge effect is due to low-pass filters but roughness and curvature of the relief are more integrated in the multivariate regression model. Temperature inversions appear on both maps but the relief effects seem to be more accurate reproduced with low-pass filters. The first regression model, using punctual data explains 78% of the variance (RMSE = 0.97^{o}C), while the second model, using filtered data, explains 84% (RMSE = 0.83^{o}C). Both models are built with 5 predictors.

Predictors:

(1): longitude, latitude, elevation, potential radiation, slope, projected aspect NS and WE, tangential curvature, plan curvature, profile curvature at the measure point.

(2): the same as (1) but computed with moving average filters.

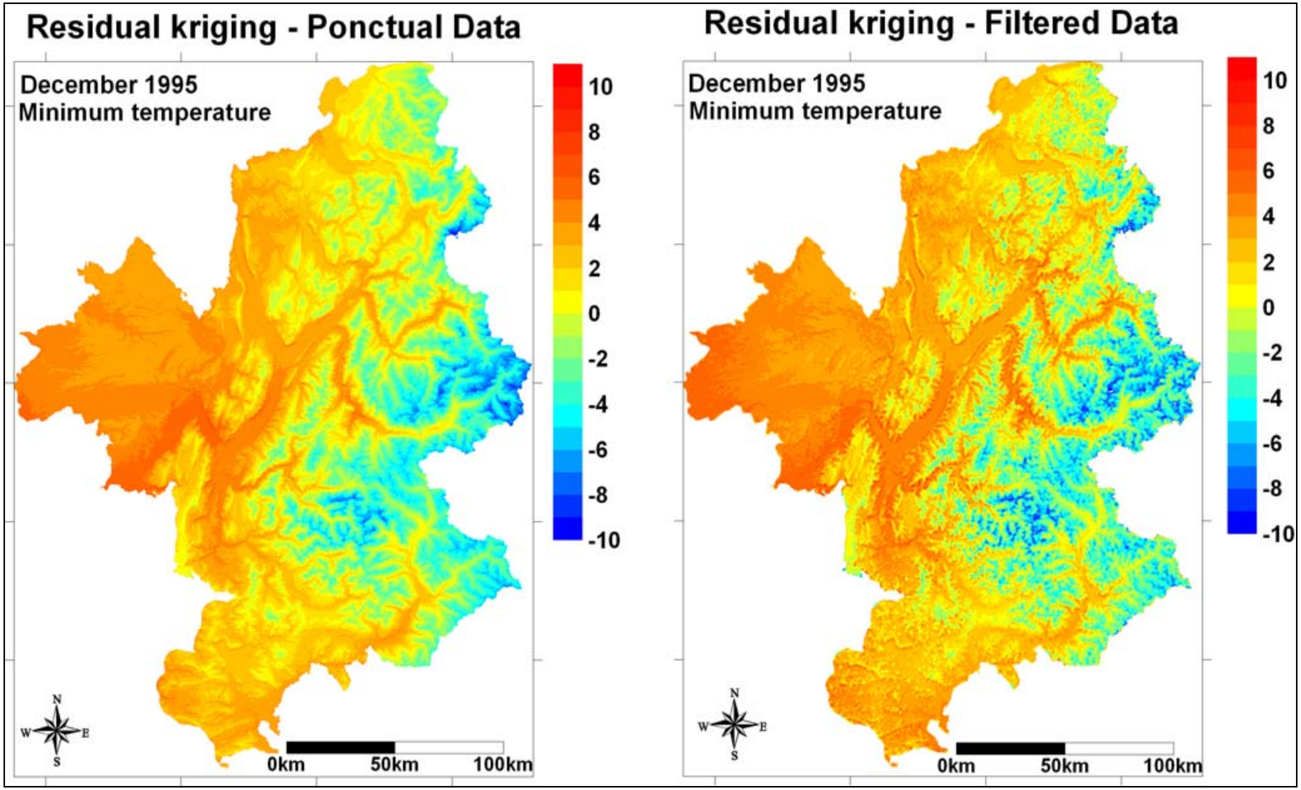

Fig. 4 *Comparing December 1995 minimum temperature maps computed with punctual data and with filtered data*

Comparison of explained variance values achieved by stepwise multiple regressions using punctual data and filtered data for winter mean minimum temperatures

Table 1

MONTHS	R^2 - PUNCTUAL DATA (1)	R^2 - FILTERED DATA (2)
January 1990	0.38	**0.60**
February 1990	0.87	**0.91**
December 1990	0.69	**0.85**
January 1991	0.69	**0.79**
February 1991	0.84	**0.88**
December 1991	0.44	**0.61**
January 1992	0.34	**0.63**
February 1992	0.83	**0.88**
December 1992	0.77	**0.83**
January 1993	0.59	**0.82**
February 1993	0.58	**0.68**
December 1993	0.87	**0.94**
January 1994	0.84	**0.91**
February 1994	0.89	**0.94**
December 1994	0.78	**0.87**
January 1995	0.88	**0.92**
February 1995	**0.91**	0.90
December 1995	0.78	**0.84**

For all winter months form 1990-1995 period, excepting February 1995, we notice that the regression with filtered predictors performs better than the regression based on punctual predictors data (**Table 1**), proving therefore the usefulness of the moving windows technique. The increase of the explained variance has an average of about 10% and can go as high as 29% for our data sample (the case of January 1992). Generally, we may notice that the R^2 difference between the 2 categories of regression models is higher for the months when the spatial distribution of air temperature is less predictable and smaller when the spatial distribution can be well explained by terrain characteristics. This means that the moving windows technique is especially useful for those situations when the classical residual kriging (with punctual data) fails to explain the spatial distribution of air temperature.

These findings are also valid for daily scales, an example being shown in **fig. 5**. For the minimum temperature of December the 1st 1995, the S.I.Gnificant predictors included in the stepwise regression model, using punctual data, were only the longitude and the latitude (R^2 = 0.27). Therefore, the map is similar to an ordinary kriging computation (relief is not taken into account at all). On the contrary, filtered grids permit to include relief curvature and elevation. The resulting map is not only more “credible”, but also more correct (R^2 = 0.58).

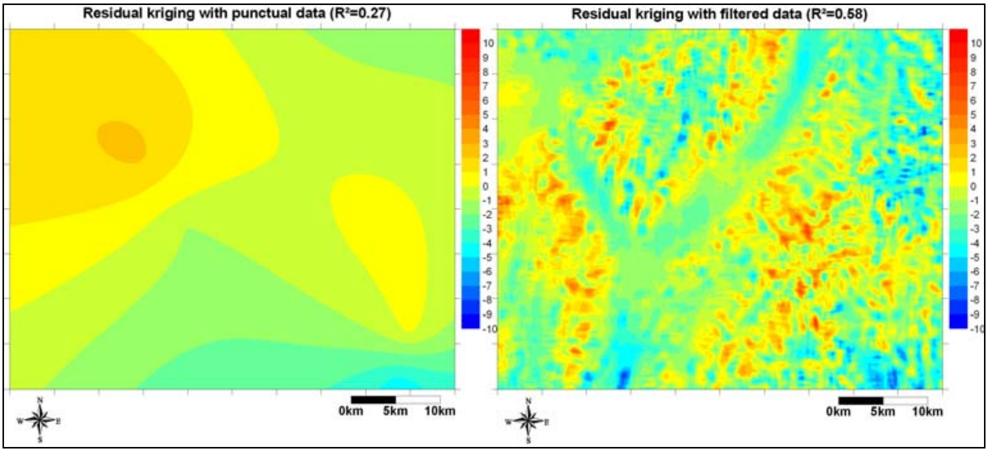

Fig. 5 *Comparing minimum temperature maps for December the 1st 1995 computed with punctual data and with filtered data*

3. CONCLUSIONS

Our study proves the usefulness of applying the moving windows technique for improving the spatial regression models of climate variables, at least in the case of winter minimum temperatures. Even though applying a low-pass filter in a G.I.S environment is a simple task, the identification of the optimum window size is quite laborious because it requires the computation of many successive correlations between the analyzed climatic variable and the mean predictor values taken form greater and greater areas surrounding the meteorological stations. As a consequence we recommend the use of this technique especially when the classical regression (or residual kriging), based on punctual data, fails to explain the spatial distribution of the analyzed climatic element in a satisfactory manner.

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EVOLUTION DU CHIMISME DES EAUX DE L'AQUIFER SUPERFICIEL DE ZAAFRANE (REGION DE LA STEPPE ALGERIENNE)

A. Maoui[1], N. Kherici[1], F. Derradji[1]

RÉSUMÉ
Zaafrane, une zone de transition entre le Sahara et le Nord, est caractérisé par un climat semi-aride. Afin d'étudier l'hydrochimistry des eaux de la nappe superficielle à l'interprétation de deux périodes de données chimiques montre l'évolution de chlorure, sulfate, de sodium et de potassium. Piézométriques carte suggère que l'eau se déplace du Sud-Est towords nord-ouest d'accord avec la diminution de la caractéristique rapport r.SO42-/r.Cl-, prouver que l'origine est évaporites du Sud. La dégradation de la qualité de l'eau peut être attribuée à la pollution organique dans la plupart des cas, directement liée à la pollution anthropique dans cette région rurale, favorisée par l'absence d'un réseau de santé.
Mots clés: hydrochimie, l'aquifère, la pollution, la salinité, Zaafrane.

ABSTRACT. ***CHIMISME EVOLUTION OF WATERS SUPERFICIAL AQUIFER TO ZAAFRANE (ALGERIAN STEPE REGION)***. Zaafrane area, a transition zone between Sahara and North, is characterized by a semi arid climate. In order to study the hydrochimistry of waters of the superficial aquifer the interpretation of two periods of chemical data shows the evolution of chloride, sulfate, sodium and potassium. Piezometric map suggests that water is moving from the South East towords North west agree with the diminution of characteristic rapport r.SO42-/r.Cl-,prove that evaporites originate is from the South .Degradation of water quality can be attribuated to an organic pollution in most cases, linked to direct anthropic pollution in this rural area ,favoured by the absence of a sanitation network.
Keywords: hydrochemistry, aquifer, pollution, salinity, Zaafrane.

1. INTRODUCTION

Le bassin du Zahrez Gharbie représente un bon exemple des dépressions fermées et salées .Il est situé le long de la bordure Nord de l'Atlas Saharien, La région de Zâafrane objet de notre étude est située au Sud de la sebkha du Zahrez Ghabie (**Fig. 1**), elle appartient à une Wilaya (département) de la steppe Sud Algéroises (Djelfa).Les roches des ces régions sont sédimentaires et d'age secondaire, tertiaire et surtout quaternaire. Cette région se caractérise par un réseau hydrographique endoréique où l'écoulement de plusieurs Oueds dépendent des averses saisonnières que connaissent la région. Une végétation très dégradées mise à part quelques parcelles mises en valeurs et les quelques plantes steppiques (aroise,alfa...), le climat de cette région steppique est semi-aride étant donné que la précipitation moyenne annuelle est de l'ordre de 296mm tandis que la température moyenne annuelle enreG.I.Strée sur une période de 20ans, est de l'ordre de 14.91°C.L'objectif du travail c'est le suivie de l'évolution du chimisme des eaux, dans un

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aquifère superficielle sur deux périodes avril 2005 et juillet 2005 d'une part, d'autre part mettre le point sur les risques de pollution.

2. MATERIELS ET METHODES

A fin de réaliser un suivi hydrochimique et piézométrique sur deux périodes (basses et hautes aux) 28chantillons ont été prélevés à partir de puits captant la nappe superficielle (**Fig. 2**). Après mesure in situ de la conductivité par un conductivimètre digital BAMASCO K250 et du pH par un pH-mètre HANAN type 9321, les échantillons sont placés dans des bouteilles en plastique et conservés à une température de 4°C. Les teneurs de calcium, sodium et potassium sont déterminées par spectrophotométrie d'émission de flamme JENWEY-PEP7.

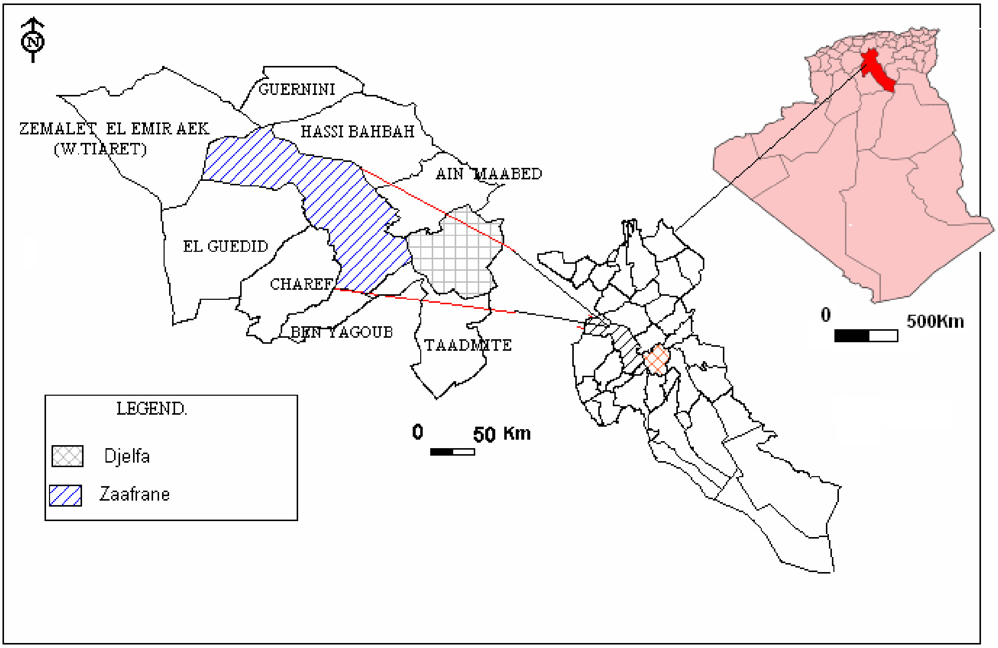

Fig .1 *Situation géographique de la région d'étude*

Les chlorures sont déterminés par volumétrie selon la méthode de Mohr, pour la dureté totale elle est obtenue par Complexométrie. La dureté magnésienne est déterminée par différence de la dureté calcique, cette dernière est obtenue par spectrophotométrie à flamme. Le dosage des bicarbonates est réalisé par titrimétrie, on travaillé sur un volume précis d'échantillons (50ml) sur lequel on a fait agir une solution de concentration connue d'acide sulfurique H_2SO_4 (1/50) N, la réaction qui se produit est due à la neutralisation des ions de bicarbonate par les ions H^+ de l'acide sulfurique. La méthode néphélométrie est utilisée pour la détermination de la teneur des sulfates avec un spectrophotomètre UV-visible de marque BEKMAN DU 520 réglé à une longueur d'onde de 420 nm et étalonné

avant chaque détermination de concentration des sulfates qui est reliée à la turbidité de la suspension ($BaSO_4$).

La spectrophotométrie moléculaire est la méthode la plus utilisée pour le dosage du bore et fait l'objet d'une norme (AFNOR NFT 90-041). Cette méthode est basée sur le principe de l'absorption de la lumière par un composé coloré, le réactif de coloration employé est l'Azométhine H Après une préparation de série d'étalons, l'absorbance est lue sur une longueur d'onde λ = 430 nm . Les nitrates sont dosés par colorimétrie et le KNO_3 est utilisé pour préparer les étalons. La longueur d'onde est fixée λ= 475 nm pour la lecture de l'absorbance. Il est à noter que des dilutions ont été faites sur tous les échantillons prélevés avant chaque mesure et elles sont prises en considération lors des calculs des concentrations des nitrates à partir de la courbe, d'étalonnage. L'ensemble des résultats des analyses hhydrochimiques sont rassemblées dans **le tableau 1.**

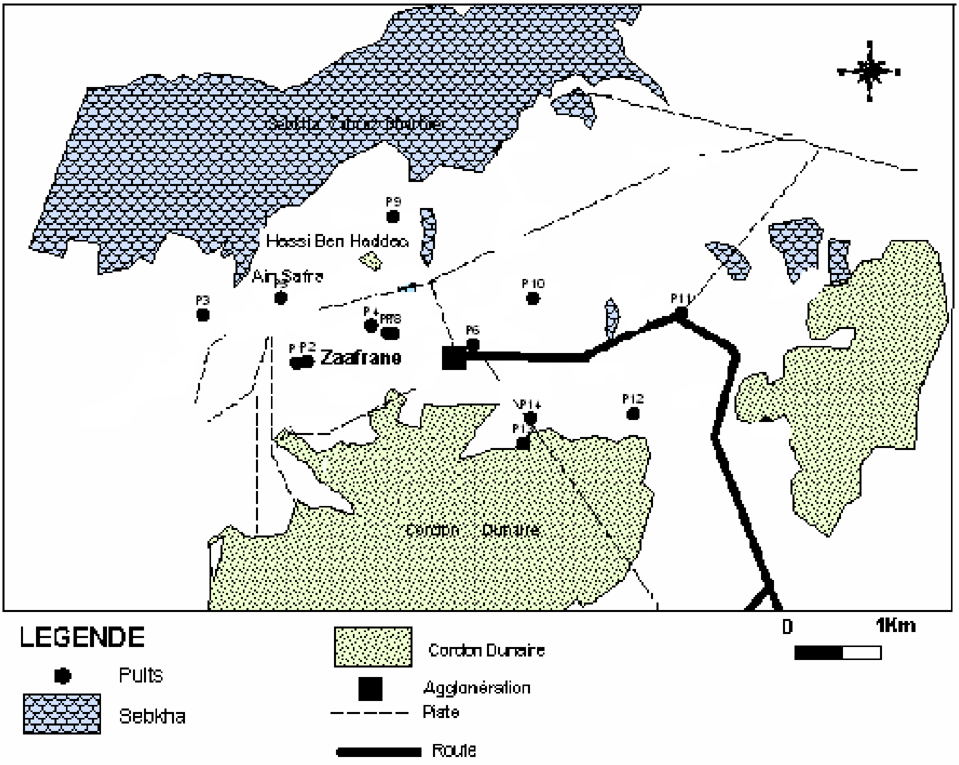

Fig.2 *Répartition des points d'echantillonage*

Résultats des analyses hydrochimiques

Tableau 1

Période Avril 2005											
			CE	Na^+	Ca^{++}	Mg^{++}	K^+	HCO_3^-	Cl^-	SO_4^{--}	B	NO_3^-
puits	pH	tC°	(µs/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
P1	7,4	18,8	3690	202,8	94,26	74,49	3,212	207,1	315,5	312,4	0,598	32,77
P2	4,31	19,2	3040	260,1	74,53	59,78	2,42	177,2	324,1	328	0,619	31,85
P3	7,32	17	8530	394,7	269,2	158	18,04	224,5	1032	458,8	0,413	56,48
P4	7,29	17,6	5820	290,9	132	60,26	10,12	180,2	430,5	359,4	0,433	40,93
P5	7,41	15,1	3790	241,3	87,98	63,67	11,53	101,3	381,5	266,3	0,364	67,04
P6	7	17,8	5430	309,5	86,41	94,28	6,576	124,5	540,5	327	0,419	30,93
P7	8,41	16,5	5390	255,4	163,4	68,04	16,52	137,3	516,2	250,4	0,454	72,96
P8	6,92	16,5	6100	245,7	219,9	86,51	17,34	111,4	765,7	197,6	0,481	21,27
P9	7,58	18,16	2640	169,4	94,26	34,99	7,126	98,75	321,2	134,4	0,289	40,93
P10	7,47	17,1	2950	194,2	113,1	37,42	13,53	93,33	348,1	202,6	0,323	47,59
P11	7,49	16,5	5760	255,4	188,8	70,47	16,55	109,8	635,3	197,9	0,378	75,19
P12	7,39	18,7	4070	249,4	94,53	71,51	8,528	92,24	460,8	205,7	0,344	59,63
P13	7,08	18,6	2030	186,7	85,4	31,1	6,033	83,84	338,2	120,5	0,241	23,14
P14	7,31	20,1	2590	188,9	78,25	31,59	10,52	87,27	341,9	105	0,275	37,11

Période juillet 2005											
			CE	Na^+	Ca^{++}	Mg^{++}	K^+	HCO_3^-	Cl^-	SO_4^{--}	B	NO_3^-
puits	pH	tC°	(µs/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
P1	7,38	18,6	4250	174,8	208,6	88,45	4,029	217,6	443,6	347,6	0,22	51,67
P2	7,29	19,4	4570	161,9	277	68,53	5,23	203,3	474,5	365,8	0,206	60,13
P3	7,03	17,2	10820	397,3	378,5	170,1	13,47	274,5	994,4	573,1	0,639	98,63
P4	7,2	16,5	6270	232,7	214,9	79,01	14,3	210,1	438,9	477,4	0,358	61,67
P5	7,52	17,4	4270	173,8	196	65,12	10,1	215,8	370,2	312,3	0,296	45,33
P6	7,23	17,1	8250	237,2	264,4	97,69	12,62	174,1	674,3	407,5	0,529	72,58
P7	8,58	16,2	5970	223,8	203,4	75,33	12,94	139,4	481	390,9	0,286	42,6
P8	7,1	18,1	6320	218	170,8	79,7	12,67	184,4	465,7	297,6	0,254	86,64
P9	7,43	16,8	3300	194,2	143,3	49,57	13,04	127,8	390,4	302,4	0,241	30,1
P10	7,45	17	3450	120,1	126,4	53,95	12,83	133,3	206,4	324,2	0,261	36,64
P11	7,21	18,1	7370	203	220	74,36	17,46	207,3	500,5	308	0,399	88,17
P12	7,2	18,9	4220	234,6	113,8	72,9	7,363	227,8	339,1	325,5	0,344	56,76
P13	7,19	20	3070	164,7	132,7	44,71	10,52	130	240	309,7	0,206	74,13
P14	7,12	19,7	3120	188,5	189,6	44,8	10,94	136,7	284,2	394,4	0,259	85,83

3. RESULTATS ET DISCUSION

3.1. Analyse en composante principale

Une A.C.P a été pratiquée sur 28 individus (analyses) et 10 paramètres. Le **tableau 2** donne les valeurs propres et l'inertie, les deux premier facteurs fournissent une inertie expliquée de 71.10 % qui semble très bonne compte tenu de l'inertie moyenne .Toutefois le pourcentage cumulé tend lentement vers 10% ce qui traduit la complexité des influences qui s'exerce sur le chimisme des eaux.

Inertie dans les 3 premières composantes principales

Tableau 2

Facteur	Valeurs propres	Percentage totale de la variance	Percentage cumulé
1	5,7421	57,421	57,42
2	1,3682	13,682	71,10
3	1,3158	13,158	84,26

Les coefficients de corrélation (**Tableau 3**) les plus significatifs relient aussi le sodium au chlorure et au calcium et relient les sulfates au calcium, sodium et chlorure. Les diagrammes de rayons X effectués sur des horizons des sols salés de la région de Zahrez par A. Halitim ont montré de plus du gypse ($CaSO_4$, nH_2O), de la calcite ($CaCO_3$), du quartz et d'autres sels solubles qui sont l'halite (NaCl), l'hexahydrite ($MgSO_4,6H_2O$) et la thénardite (Na_2SO_4), en plus des sels hygroscopiques détectés à l'aide de la microsonde dans les croûtes lamellaires riches en halite.

Matrice de coorélation

Tableau 3

Variable	CE	Na^+	Ca^{++}	Mg^{++}	K^+	HCO_3^-	Cl^-	SO_4^{--}	B	NO_3^-
CE	1	0,72	0,808	0,88	0,536	0,601	0,863	0,668	0,514	0,517
Na^+	0,72	1	0,385	0,799	0,293	0,351	0,814	0,466	0,648	0,226
Ca^{++}	0,808	0,385	1	0,726	0,449	0,63	0,732	0,688	0,195	0,54
Mg^{++}	0,88	0,799	0,726	1	0,295	0,664	0,882	0,708	0,531	0,363
K^+	0,536	0,293	0,449	0,295	1	-0,046	0,506	0,125	0,05	0,39
HCO_3^-	0,601	0,351	0,63	0,664	-0,046	1	0,382	0,785	0,346	0,367
Cl^-	0,863	0,814	0,732	0,882	0,506	0,382	1	0,436	0,485	0,292
SO_4^{--}	0,668	0,466	0,688	0,708	0,125	0,785	0,436	1	0,322	0,428
B	0,514	0,648	0,195	0,531	0,05	0,346	0,485	0,322	1	0,054
NO_3^-	0,517	0,226	0,54	0,363	0,39	0,367	0,292	0,428	0,054	1

Il s’agit du $MgCl_2$ et du $CaCl_2$. Ces sels vont influencer le chimisme des eaux de la nappe superficielle après lessivage. Ce qui explique les résultats des corrélations entre les différents éléments majeurs.

La conductivité électrique qui traduit la minéralisation est bien corrélée avec le facteur 1 (**Tableau 4**) à l’exception du potassium, les autres éléments majeurs présentent une bonne corrélation avec le facteur 1. Ce qui nous permet de considérer ce facteur comme facteur de minéralisation. Les variables donnant les meilleurs contributions sur l’axe factoriel 2 sont : le bore et les nitrates, donc le facteur 2 peut être considéré comme facteur caractérisant la pollution de l’aquifère superficielle .

Corrélation entre variable et poids factoriels

Tableau 4

Variable	Fact.1	Fact.2
CE	-0,960	-0,062
Na^+	-0,778	0,417
Ca^{++}	-0,835	-0,365
K^+	-0,451	-0,492
HCO_3^-	-0,697	0,025
Cl^-	-0,876	0,105
Mg^{++}	-0,942	0,166
$SO4^{--}$	-0,766	-0,062
B	-0,553	0,647
NO_3^-	-0,529	-0,594

3.2 Evolution du chimisme des eaux

L’évolution du pôle chloruré sodique au pôle sulfaté calcique magnésien pour la majorité des échantillons, comme le montre le diagramme de Piper (**Fig. 3**). Cette évolution peut être expliquée par une accentuation de la dissolution des evaporites, liée à la diminution de niveau piézométrique de la nappe superficielle, dans la période de basses eaux, qui se caractérisent aussi éventuellement par une forte évaporation favorisant la précipitation des sels, gypse en pariculier. La carte du niveau d’eau dans la nappe superficille (**Fig. 4**) indique un sens d’ecoulement du Sud –Est au Nord –Ouest .

Le rapport caractéristique r SO_4^{2-}/rCl^- diminue dans le sens d’écoulement (**Fig. 5**) d’où la salinité des eaux de l’aquifère superficiel est acquise par le lessivage de formations triasiques situées au sud de la région d’étude.

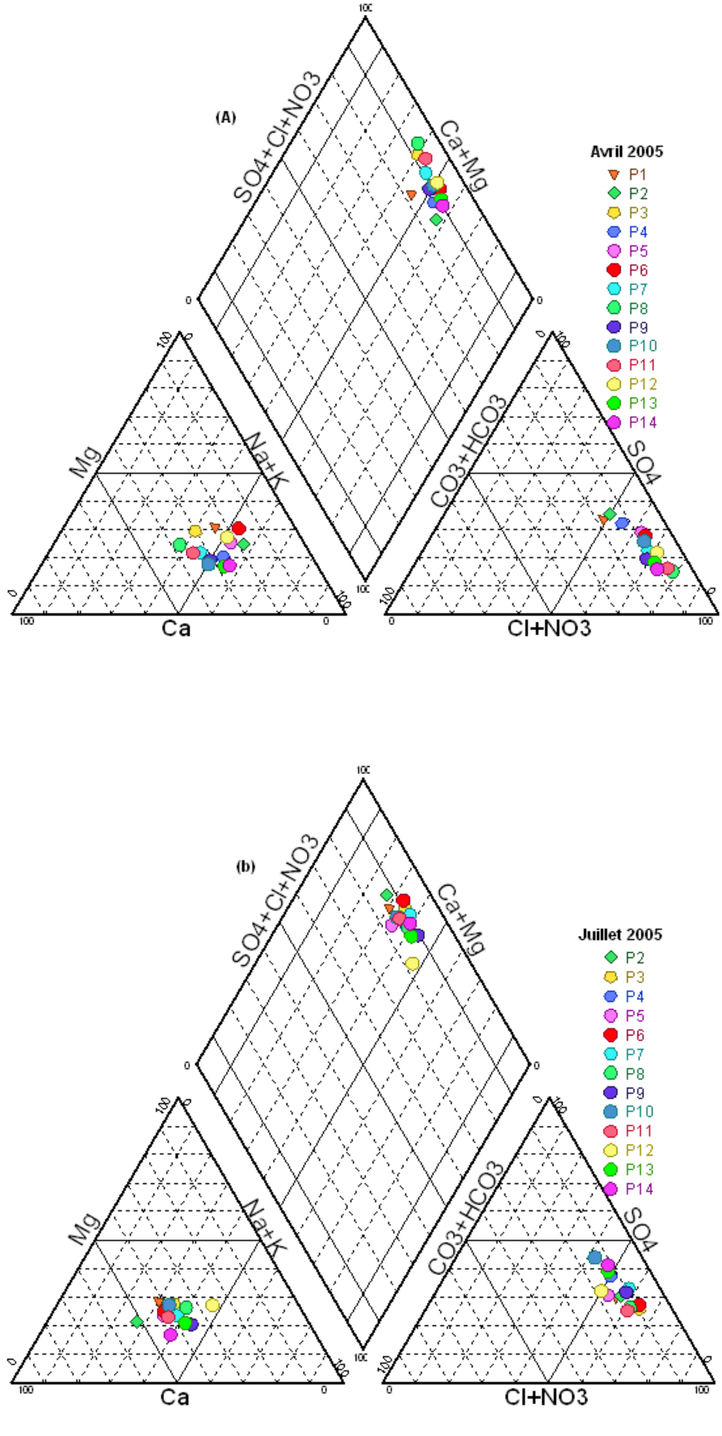

Fig. 3 *Digramme de Piper*

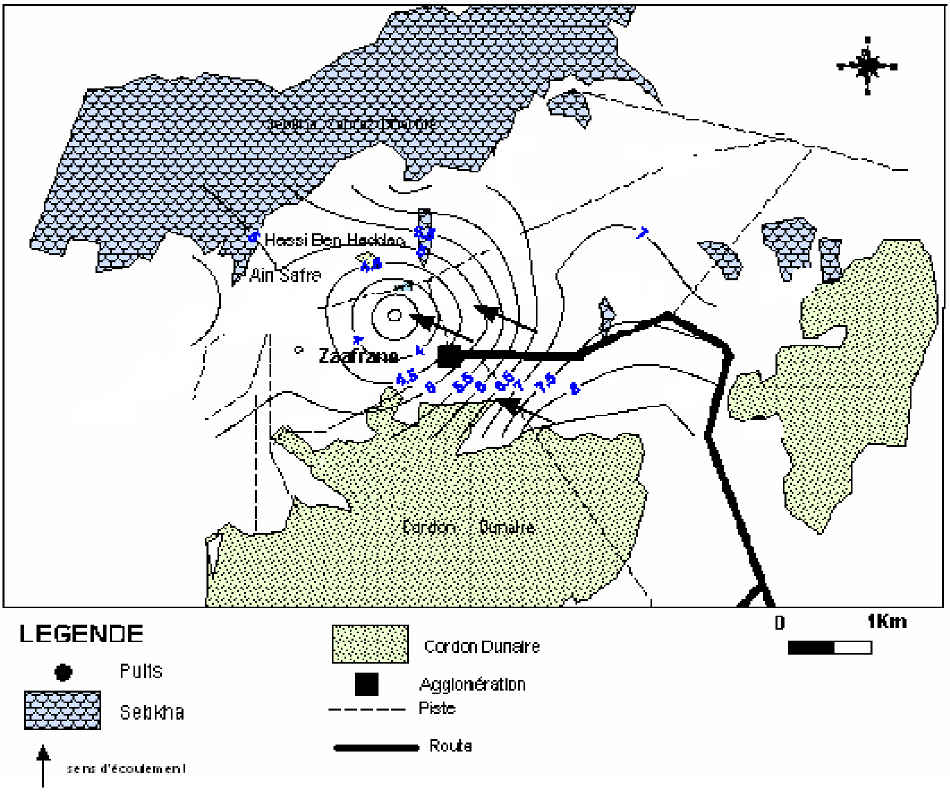

Fig. 4 *Carte du niveau d'eau de la nappe superficielle (Juillet .2005)*

3.3 Pollution des eaux de la nappe superficille

Le bore est présent à l'état de trace dans les eaux souterraines, son origine naturelle est très rare et son existence ne peut être que d'origine anthropique. Il provient essentiellement des rejets industriels, urbains ou domestiques, par sa présence en forte concentration dans les détergents sous forme de perborates (20 % de la composition des lessives en poudre); il est parfois utilisé comme traceur de pollution dans les études d'assainissement.Les concentrations enregistées ne dépassent pas le 1mg/l (**Fig. 6**). L'influence des rejets domestiques n'est pas ecarté , surtout que les puits captants la nappe superficielles sont mal protégés dans une région rurale.

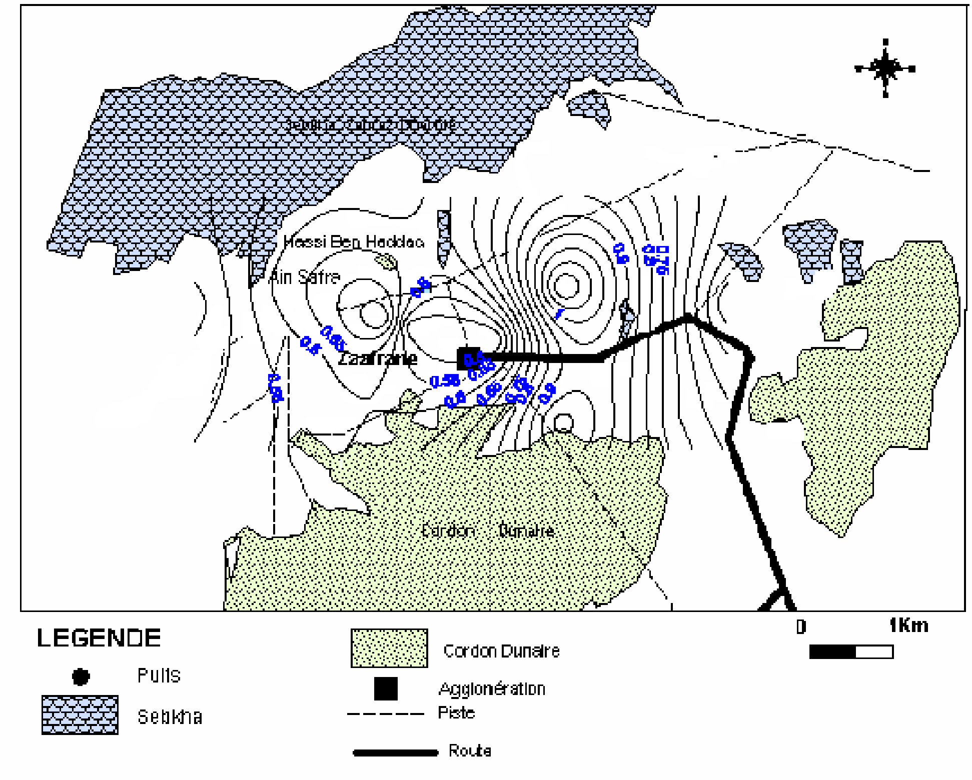

Fig. 5 *Variation spatiale du Raport* $(r.SO_4^{--}/rCl^-)$

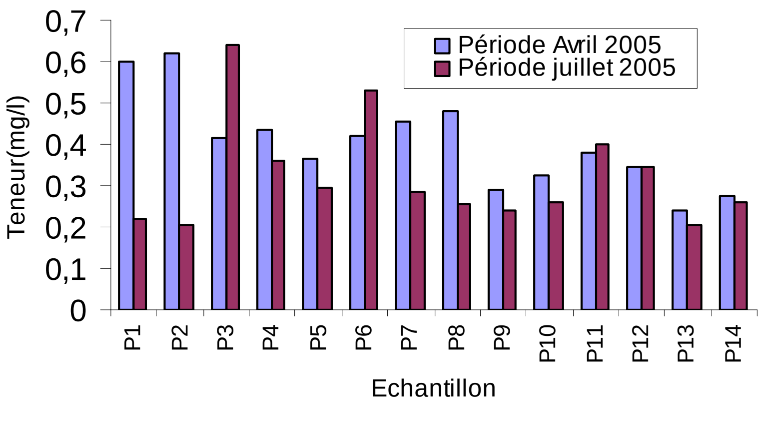

Fig. 6 *Variation des teneurs en bore dans les eaux de la nappe superficielle*

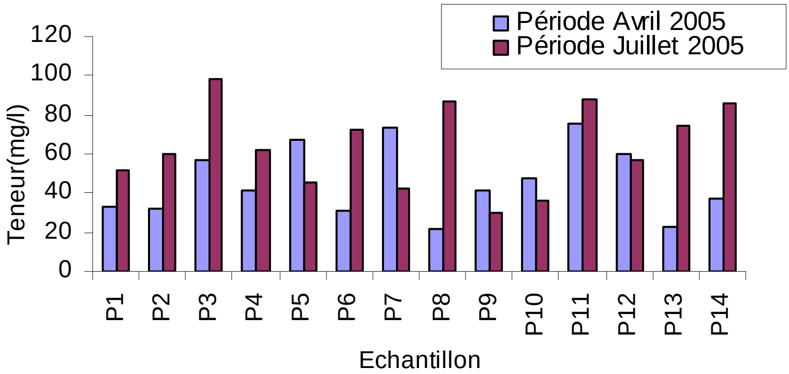

Fig. 7 *Variation des teneurs en nitrate dans les eaux de la nappe superficielle*

Les teneures les plus élevées en nitrates sont enregistrées durant la période de basses eaux (**Fig. 7**) où ils dépassent les 80 mg/l comme c'est le cas du puits P3, une diminution sensible est observée durant la période de hautes eaux (Avril 2005). L'une des sources d'azote dans les eaux souterraines est l'hydrolyse des composés azotés des êtres vivants (urines, rejets…) et des engrais utilisés dans l'agriculture intensive. Les pluies ont pour effet de diluer la concentration des contaminants, elles vont entraîner une modification de la répartition des temps de séjour et inévitablement du rendement épuratoire. L'autoépuration est meilleure en hiver et en printemps par la dillution des polluants.

4. CONCLUSIONS

La dilution des eaux de la nappe superficielle de Zâafrane par les eaux des pluies hivernales, diminue la minéralisation. La salinité des eaux de l'aquifère superficielle est aquise par un lessivage des formations evaporitiques situées dans la partie Sud de la région, le Rocher de Sel en particulier. Les eaux de l'aquifère superficille de Zâafrane sont de qualité médicore, pour l'irrigation vu leurs minéralisation élévées, ce qui constitue un risque pour les projets de mises en valeurs des terres ,dans cette région du vaste domaine steppique Algériens. La pollution des eaux vient s'ajouter aux problème de salinité, elle est surtout liée aux rejets domestiques. Des mesures d'urgences doivent êtres prises pour la protection des puits captant l'aquifère superficiel contre toutes pollution diffuse surtout d'origine organique.

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SOME STATISTICAL CONSIDERATION ON THE CLIMATES OF ROMANIA

J.L Mercier[1], B.S. David[2]

ABSTRACT

In this study, regional climates of Romania were identified based on the properties of 13 monthly rainfall and 22 temperature time series models of Romania. The autocorrelation (ACF) and partial autocorrelation (PACF) of selected series revealed the seasonal behavior of the monthly rainfall and temperatures. After the parameters of the models were estimated and the residuals of the models analyzed to be time independent and the normality was checked, the multiplicative ARIMA model was fitted to monthly rainfall and temeperature time series of the stations. To determine regional climates, a hierarchical cluster analysis was applied on autocorrelation coefficients at different lags and two main climatic groups are proposed based on the time series models, namely, simple and moderate climates. The results of the time series modeling showed a moderate variation of the temporal pattern of the monthly rainfall over Romania while moderate temperature variation is present. No reliable results could be estimated for the Carpathian region. The study fails to show any significant correlation between the seasonal autocorrelation coefficient of the rainfall and temperature time series and the rainfall and temperature coefficient of variation and elevation of the Different models for precipitation also imply the relatively high variation in the spatial rainfall producing mechanism and different stationarity and periodicity characteristics of the rainfall temporal pattern over Romania.

Key words: climate, statistics, time series, ARIMA model, Romania.

1. INTRODUCTION

Hydrologists have always tried to classify atmospheric and hydrologic events in order to simplify the hydrologic convolutions and the observations or to save the time and the budget. Most of these methods are used for the regionalization of hydrologic phenomena like rainfall, streamflow and other components of water cycle. Principal components, factor analysis and different cluster techniques have been used to classify daily rainfall patterns and their relationship to the atmospheric circulation (*Romero et al., 1999; Bojariu et al 2004; Tomozeiu et al 2004*); to classify flood and drought years (*Singh, 1999*) and their connections with the NAO phenomena (*Stefan et al 2004*) to classify streamflow regimes (*Sanz and del Jalon, 2005; Harris et al., 2000*); *Acerman (1985)*; *Acerman, Sinclair (1986)* concluded that the cluster analysis has some intrinsic worth to explain the observed variation in data. *Soltani et al (2007)* applied cluster and principal component analysis (PCA) to the territory of Sweden and concluded that cluster analysis is an appropriate method to use on a national scale with heterogeneous hydrological regimes. Autoregressive integrated moving average (ARIMA) model is the most widely used time series model in hydrologic and climatic time series modeling. *Salas et al. (1980)* reviewed all these models

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and described their characteristics. *Hipel and McLeod (1994), Haidu (1997)* also presented the ARIMA family among the other models such as broken line, fractional ARMA model (FARMA), fractional Gaussian noise (FGN) and others. After choosing the model, the modeler should estimate its parameters and then apply diagnostic checking of the selected model. These three modeling steps were completely described by *Box and Jenkins (1976)* and have been applied, developed and improved by many hydrologists (e.g. *Hipel et al., 1977; McLeod et al., 1977*).

2. METHODOLOGY

Climate data. For this study, 13 monthly rainfall and 22 temperature time series of meteorological stations of Romania were used. The data has been corrected and homogenized according the MASH procedure. Since this is not subject of this article we shall not insist on it.

ARIMA models. In this section, we will explain the general form of ARIMA models. The Box–Jenkins model has two general forms:, ARIMA (p,d,q) and the multiplicative ARIMA (p,d,q) × (P,D,Q) in which p and q are nonseasonal autoregressive and moving average parameters,

P and Q are the seasonal autoregressive and moving average parameters, respectively.

The two other parameters, d and D, are required nonseasonal and seasonal differencing respectively, used to make the series stationary.

The form of ARIMA (p,d,q) is written as:

$$\varphi(B)(1 - B)dZt = \theta(B)\varepsilon t$$

and multiplicative ARIMA(p,d,q) × (P,D,Q) has the following form,

$$\varphi p(B)\_P\ (BS)\square d\square D\ S\ Zt = \theta q(B)\_Q(BS)\varepsilon t$$

Time series modeling. Time series modeling includes three steps of model identification, model estimation and diagnostic checking (goodness of fit test). In the first step, the initial models which seem to represent the behavior of the time series and are worthy for the further investigation and parameter estimation are identified following the guidelines presented by *Box and Jenkins (1976)*, applied by *Hipel et al. (1977)*; *McLeod et al. (1977)*. These guidelines are based on the behavior of the autocorrelation (ACF) and partial autocorrelation functions (PACF).

After model identification, the modeler needs to obtain an efficient estimation of the parameters. The model parameters should satisfy two conditions, namely, stationarity and invertibility for the autoregressive and the moving average parameters, respectively. The parameters should also be tested as to whether they are statistically significant or not. Associated with parameter values are standard error of estimation and related *t*-value which are used to investigate the statistical S.I.Gnificance of the parameters.

Goodness of fit tests verify the validity of the model by some tools. In this step, the residuals of the model are considered to be time-independent and normally distributed over time.

Regionalization: multivariate methods. Multivariate techniques are common methods for classifying meteorological data such as rainfall. Principal components and cluster techniques are used in this study to classify autocorrelation coefficient of rainfall series in different groups. Let the matrix **X** (m × k) consist of autocorrelation coefficients at lags k = 1, . . . , 12 of m stations. k = 12 is chosen as the autocorrelation; coefficients of higher lags are not S.I.Gnificant or have similar seasonal fluctuations as the first k = 12. A commonly used dissimilarity measure is the Euclidean distance (*d*2 *rs*) which is written as follows (*Jobson, 1992*):

$$d_{rs}^2 = \sum_{j=1}^{k} (x_{rj} - x_{sj})^2$$

- where the rth and sth rows of the data matrix X is denoted by (xr1, xr2, . . . , xrk) and (xs1, xs2, . . . , xsk) respectively.

In this study, our matrix consists of 12 lags of ACF of 13 rainfall time series and 22 temperature series. These 12 autocorrelation coefficients are selected because the coefficients in higher lags are similar to them or are not S.I.Gnificant at very higher lags. This means a matrix of 35 columns of stations and 12 rows of autocorrelation coefficients of rainfall and temperature series.

The Euclidean distance of dissimilarity is then used in the cluster techniques. As the variables must not be correlated with each other, PCA is usually prefixed. PCA was first applied to reduce a large data matrix into some important factors (principal components). The first principal component is the linear combination of the original variables that captures as much of the variation in the original data as possible. The second component captures the maximum variation that is uncorrelated with the first component, and so on. After having decided which autocorrelation coefficient at which lags are to be used for classification, cluster analysis based on Ward's method is applied. To choose the proper number of the clusters, one can refer to the total spatial variance for each number of the clusters. The R-Squared, squared multiple correlation or the decrease in the proportion of variance accounted for due to joining two clusters to form the current cluster, is the key to select the number of the proper clusters.

3. RESULTS AND DISCUSSIONS

By using clsuter analysis, we identified 2 possible regional climates modeled on two seasons (**Fig. 1** and **2**). The first step was to apply PCA analysis to the autocorrelation coefficients at lag k = 1 up to lag k = 12 for all the 35 stations used. In order to improve the interpretation of the PCA results VARIMAX method (*Kaiser, 1964*) was used. Such a method is common for cases when it precedes a cluster-like analysis (*Soltani et al, 2007*). **Table 2** presents principal component loading.

Apparently for temperatures PC 1 has the largest loads for lags k = 4–8, explaining 68.51 % of the total variance between stations while PC2 has the largest loads at lags k = 2 and k = 4, explaining 28.88 % of the total variance. The first two factors can be interpreted as '*stationarity*' and '*periodicity*'. We base our statement on the fact that significant autocorrelations at lags superior to lag 3 exist, and that they are a sign of stationarity between the characteristics of temperature and precipitations like mean and variance, while significant correlations at lag 12 are a sign of seasonality and periodicity (the alternating seasons in our case) (after *Salas, 1993 and Soltani et al, 2007*).

ARIMA models for temperature and rainfall series

Table 1

NO	STATION	PRECIP.	GROUP	TEMPERATURE	GROUP
1	Iasi	(1,01) X (4,1,1)	2	(1,0,0) x(4,1,1)	2
2	BAIA MARE			(1,0,0) x(4,1,1)	2
3	BOTOSANI	(1,01) X (3,1,1)	2	(1,0,0) x(4,1,1)	
4	SUCEAVA			(1,0,0) x(3,1,1)	2
5	ORADEA			1,0,0) x (4,0,0)	2
6	CEAHLAU TOACA			(0,0,0) x(3,1,1)	1
7	CLUJ-NAPOCA	(1,01) X (4,1,1)	2	(1,0,0) x(4,1,1)	2
8	TG. MURES			(1,0,0) x(2,1,1)	2
9	BACAU			(1,0,0) x(2,1,1)	2
10	MIERCUREA CIUC	(1,01) X (4,1,1)	2	(1,0,0) x(3,1,1)	2
11	ARAD	(0,0,0)x(2,1,1)	1	(1,0,0) x (4,0,0)	2
12	TIMISOARA	(0,0,0)x(2,1,1)	1	1,0,0) x (4,0,0)	2
13	SIBIU	(1,0,0)x(2,1,1)	2	(1,0,0) x (3,0,0)	2
14	RIMNICU VALCEA	(1,01) X (3,1,1)	2	1,0,0) x (4,0,0)	2
15	BUZAU			1,0,0) x (4,0,0)	2
16	SULINA	(0,0,0)x(3,1,1)	1	1,0,0) x (4,0,0)	2
17	DROBETA TURNU SEVER			1,0,0) x (4,0,0)	2
18	BUCURESTI INMH-BANE	(0,0,0)x(3,1,1)	1	1,0,0) x (3,0,0)	2
19	CRAIOVA	(0,0,0)x(3,1,1)	1	(1,0,0) x(2,1,1)	2
20	OMU			(0,0,0) x(3,1,1)	1
21	RARAU (MONASTERY)			(0,0,0) x(2,1,1)	1
22	CARANSEBES	(0,0,0)x(3,1,1)	1	(1,0,0) x(2,1,1)	2

* * * H I E R A R C H I C A L C L U S T E R   A N A L Y S I S * * *

a) Dendrogram using Average Linkage (Between Groups)

```
                         Rescaled Distance Cluster Combine

   C A S E    0         5        10        15        20        25
  Label  Num  +---------+---------+---------+---------+---------+

          5    ⇩⇘
          6    ⇩▫
          7    ⇩⇳⇩⇘
          8    ⇩⇙ ▫⇩⇩⇩⇩⇩⇘
          4    ⇩⇩⇩⇙
▫⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇘
          3    ⇩⇩⇩×⇩⇩⇩⇩⇩⇙                                    ⇔
          9    ⇩⇩⇩⇙                                            ⇔
          2    ⇩⇩⇩×⇩⇩⇩⇩⇩⇩⇩⇘                                    ⇔
         10    ⇩⇩⇩⇙
▫⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇙
         11    ⇩⇩⇩×⇩⇩⇩⇘   ⇔
         12    ⇩⇩⇩⇙    ▫⇩⇩⇩⇙
          1    ⇩⇩⇩⇩⇩⇩⇩⇙
```

b) **Dendrogram using Ward Method**

```
                         Rescaled Distance Cluster Combine

   C A S E    0         5        10        15        20        25
  Label  Num  +---------+---------+---------+---------+---------+

          1    ⇩⇘
          6    ⇩▫
          5    ⇩⇳⇩⇘
         10    ⇩▫ ⇔
          9    ⇩▫ ⇔
          8    ⇩⇙
▫⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇘
         11    ⇩⇘ ⇔                                              ⇔
         12    ⇩▫ ⇔                                             ⇔
         13    ⇩▫ ⇔                                             ⇔
          3    ⇩⇳⇩⇙                                              ⇔
          7    ⇩▫                                              ⇔
          4    ⇩⇙                                               ⇔
          2
⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇙
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Fig. 1 *Cluster analysis at lag level (a) and at station level (b) for precipitations (temperature is not displayed due to space issues)*

The same inference can be made on rainfall values for PC 1 → 52,37 % and PC 2 → 45,81 %. In other words, stationarity and periodicity are the two main elements by which the temporal characteristics between stations could be explained. The third factor can be called '*T-GCM*' effect. '*T-GCM* ', refers to the 'topographic-general circulation model' effects on the temporal behavior of the rainfall (after *Salas, 1993 and Soltani et al, 2007*).

This means that 2.5 -3 % of temperature and rainfall variation are under the effect of altitude and atmospheric circulation. Future investigation on this issue has to be considered especially if we take into account the fact that out of the 22 temperature and 13 precipitation series only 4 series are from mountain regions, so approximately 18% of the sample population while the mountain surface weights around 35 % from the terrain. Also no mountain station was used for rainfall.

The matrix of the 2 factor components was used then in cluster analysis based on Ward's method. The groups are nominated in **Table 1**. By analysing **Fig. 1** we can conclude that from a thermal point of view there is a clear division between two seasons winter and summer each sub-divided into two subseasons.

At station grouping level, the isolation of Timisoara and Bucuresti (Filaret) stations is an enigma; one hypothesis usually advanced is that they represent heat islands amidst large open spaces.

The same analysis for rainfall indicates two groups aligned around a N-S ax:

- group 1: Bucuresti, Sulina, Sibiu, Drobeta-Turnu Severin, Caransebes, Bacau
- group 2: Arad, Timisoara, Ramnicu Valcea, Miercurea Ciuc, Cluj-Napoca and Iasi

PC loading a) temperatures and b) rainfall

Table 2

	Component	
	1	2
L1	.390	.897
L2	.575	.806
L3	.784	.611
L4	.858	.492
L5	.905	.406
L6	.930	.362
L7	.908	.412
L8	.877	.470
L9	.706	.697
L10	.619	.778
L11	.400	.903
L12	.363	.914

Rotated Component Matrix (a)

	Component	
	1	2
L1	-.767	-.637
L2	-.796	.589
L3	-.487	.846
L4	.791	.588
L5	.991	.121
L6	.999	.020
L7	.999	-.030
L8	.989	-.131
L9	.300	-.860
L10	-.978	-.175
L11	-.997	-.031
L12	-.997	-.004

Rotated Component Matrix (b)

The relations between the time series models and the characteristics of temperature and rainfall have been interpreted in the following manner:

The ACF and PACF functions indicate the presence of a seasonal component which indicates that the same months are correlated between themselves during consecutive years. The existence of a seasonal component is also indicative of the atmospheric conditions of Romania.

Certain stations display a non-seasonal component MA which indicates the existence of some non-seasonal fluctuations at certain stations like: Miercurea Ciuc, Ramnicu Valcea, Botosani etc.

Relatively strong AR parameters for some stations can be interpreted as a persintence of the climatic conditions (*Soltani, 2007*). Egg. the continental character more evident towards North and center is typically displayed by a strong AR parameter (either in the case of temperature or rainfall). Also such a parameter in the case of rainfall suggests a differentiated rainfall production mechanism conditioned by the long duration large scale anticicylonic circulation (from weeks up to months). It can also be explained as an effect of elevation. (*after Burlando and Rosso, 1993*).

However, such an elevation effect can only be suspected as there are no S.I.Gnificant correlations between lags 1 and 2 and the altitude of the stations. Also no S.I.Gnificant correlations exist among lags 4 – 8, which if existent would imply a strong influence of elevation in the genesis of temperature and rainfall.

A low order seasonal MA suggests a rather simply and homogenous mechanism of rain formation (*Burlando and Rosso, 1993; Soltani et al 2007*).

Based on the cluster analysis and the previous remarks we can identify two rainfall climates after *Soltani et al (2007)* who identified three types of climates based on the approximated ARIMA model: simple (1), complex (2) and moderate (3).

The first group includes pure seasonal models ARIMA (p,d,q)12. The second group has a general shape ARIMA (p,d,q) × (P,D,Q)12 with low AR and MA parameters; the complex group has the similar shape but with stronger AR and MA parameters.

In other words such groups can be defined as climates with simple origin conditions and regular fluctuations (group 1), simple origin conditions but more persistent and heterogeneous due to the differentiated formation mechanisms (group 2) and very heterogeneous genesis conditions due to the interactions between the microclimatic conditions and elevation (group 3).

In our analysis we could identify two major rainfall groups: a central – Nordic group with a non-seasonal AR parameter which points out to some more complex origin conditions and a purely seasonal southern group. In the case of temperatures we also can identify two groups which more or less points out to an altitudinal differentiation. Slight North-South delimitation can be traced by the existence of a seasonal MA parameter with value equal to 1.

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MISE EN EVIDENCE DE L'IMPACT DES CHAGEMENTS CLIMATIQUES SUR LES RESSOURCES EN EAUX SOUTERRAINES A L'ECHELLE DU BASSIN VERSANT: CAS DU BASSIN VERSANT N'FIS (Haouz - Marrakech Maroc)

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RESUMÉ
Cet article présente les travaux entrepris pour étudier l'impact des changements climatiques sur la recharge de la nappe phréatique plioquaternaire au niveau du bassin versant N'Fis (Haouz- Marrakech Maroc). Les données utilisées de 13 piézomètres de contrôles et 4 stations météorologiques s'étendant sur 16 et 37 ans et d'autres données spatiales (occupation de sol, MNT…etc.) ont été stockées dans une base de données conviviale grâce à l'outil S.I.G. L'objectif est de faire une évaluation préliminaire des impacts potentiels des changements climatiques sur les ressources en eau souterraines
Le résultat montre que les fluctuations piézométriques sont peu influencées par ces variations et dépendent surtout du retour d'irrigation.
Mots clés: Bassin versant N'FIS, S.I.G, nappe phréatique, changement climatique, Maroc.

ABSTRACT. ***STUDY OF THE IMPACTS OF CLIMATE CHANGES ON GROUNDWATER RESOURCES AT THE SCALE OF WATERSHED: THE CASE OF WATERSHED N'FIS (Haouz - Marrakech Morocco)***. This paper presents the work undertaken to study impacts of climatic changes on the groundwater recharge at the watershed N'Fis (Haouz Marrakech-Maroc). The data from 13 piezometric stations and 4 meteorological stations spanning from 16 to 37 year periods database with other spatial data (soil occupation, DEM etc ....) were integrated in a user-friendly through the tool GIS. The objective is to make a preliminary assessment of potential impacts of climate change on groundwater resources .The result shows that the piezometric fluctuations are not influenced by these variations, but they depend mainly on irrigation return.
Keywords: watershed N'FIS, G.I.S, groundwater, climate change, Morocco.

1. INTRODUCTION

La valorisation des données disponibles, essentiellement spatiales, est en effet indispensable à la compréhension du comportement hydrogéologique des aquifères et au soutien à la gestion de la ressource en eau (*Derouan et al., 2005*). Dans un premier temps, nous présentons la base de données relatives à la connaissance du bassin et de la nappe. Ensuite, nous évoquons le traitement et l'analyse de ces informations pour la détermination des caractéristiques géomorphologiques du bassin versant explicatifs de l'écoulement de surface (pente, reliefs, réseau hydrographique….etc.) et de ces caractéristiques climatiques grâce à la possibilité de croisement des cartes et des méthodes de calcul qu'offrent le

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logiciel S.I.G. Enfin, les couches de données ainsi traitées ont servi à mettre en évidence les fluctuations du niveau piézométrique de la nappe phréatique suite aux variations spatio-temporelles des précipitations (en particulier les pluies exceptionnelles de 1997-1998)

Le bassin versant N'FIS fait partie du Bassin Hydraulique de Tensift ayant une superficie de 24.800 Km² (*ABHT, 2006*). Il occupe 5,2% de cette superficie et il est situé entre 8°37'53'',7°52'53'' à l'Ouest du Maroc et entre 30°52'42'' et 31°37'42'' au Nord (**Fig. 1**). Le principal réservoir est localisé au sein des dépôts alluvionnaires du plioquaternaire, constitués par une alternance de lentilles perméables (composées de galets, graviers et sables) et de formations argilo- marneuses quasi- imperméable. L'ensemble repose sur un substratum imperméable de faciès essentiellement argileux et marneux du Miocène (*Sinan, 2000*). Cette configuration géologique du bassin confère principalement aux lentilles perméables la propriété de conduite de l'eau souterraine dans cette aquifère (*Castany, 1980*).

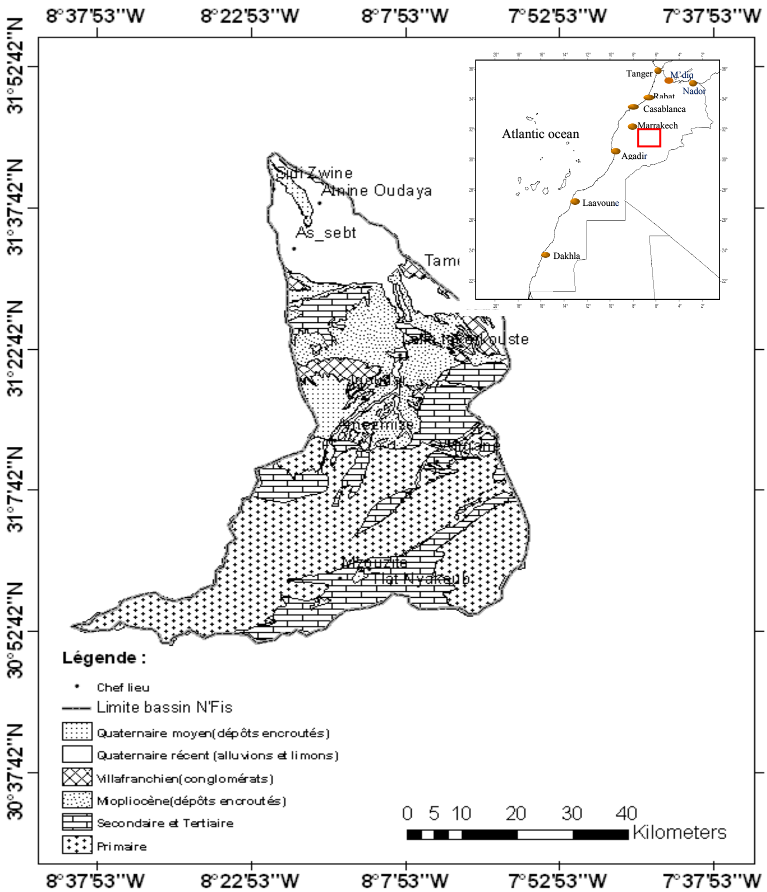

Fig. 1 *Localisation géographique et lithologie du bassin versant N'FIS*

2. DONNEES

Dans le cadre de cette étude, le S.I.G a fourni non seulement un environnement flexible pour la gestion de données localisées (acquisition, structuration, stockage, catalogage, visualisation et diffusion) mais a permis également des fonctions d'analyse spatiale pour une bonne compréhension des différents paramètres étudiés (*Gwenaelle et al., 2007*). Le choix des différentes couches d'informations dépend de l'utilisation envisagée du S.I.G et des données disponibles (*Habert, 2000*). Cela apporte : Stockage claire et définitif des informations, gestion d'une multiplicité d'informations attributaires sur des objets, compréhension des phénomènes, établissement des cartographies rapides, localisation dans l'espace et dans le temps, réaction rapide après des évènements ayant un impact sur le territoire. L'élaboration de cette plate-forme a demandé un travail important de collecte, de validation, et de mise en cohérence et d'archivage des données.

Construction de la base de données :

Le modèle Numérique de Terrain MNT est la donnée source du présent travail. On a été amené à extraire le bassin versant N'FIS et à déduire ses caractéristiques géomorphologiques à partir du MNT disponible sur la zone d'étude. C'est un MNT radar SRTM téléchargeable à partir d'Internet à 90 m de résolution, la précision altimétrique est de 2 à 3 m au niveau de la plaine et de 12 à 15 m dans les zones à forts dénivelés et très accidentées.

Le MNT géoréférencé est intégré dans la base de données cartographique. Les fonctions "identifier les puits" et "combler les puits" ont été utilisées pour faire des corrections sur la grille MNT pour mettre en évidence, numéroter et combler les cellules identifiées comme étant des points bas et pouvant perturber les calculs d'écoulement. La fonction "Directions des écoulements" a permis de calculer les directions des écoulements dans chaque cellule de la grille de MNT corrigée pour délimiter le bassin versant (*Lavenu, 2001*).

Or, l'interpolation engendrée par le calcul des modèles numériques des terrains conduit souvent à des limites du bassin versant différentes de la réalité (problème de géocode ouvert) (*Bergaoui et Camus, 1997*) en particulier lorsqu'il s'agit des bassins versants relativement plats dont il est le cas pour le bassin N'FIS. Pour remédier à ces erreurs, des rectifications ont été faites par numérisation manuelle sur la partie plate du bassin versant N'FIS en se basant sur la carte topographique au 1/250.000 (feuilleNH-29-03 de Marrakech) c'est plus long mais certainement plus juste.

L'utilisation des couches d'informations géographiques en format numérique n'a pas exclu le recours à d'autres sources de données notamment :

- Les cartes géologiques au 1/500.000 ème et les cartes topographiques au 1/250.000 (feuilleNH-29-03 de Marrakech et feuilleNH-29-7 de Taroudant) ont été scannées et géoréférencées pour servir de fond, d'autres thèmes étant dessinés dessus ont permis de générer deux cartes : la carte d'occupation des sols et la carte géologique.
- Des informations brutes (pluviométrie, température; piézométrie; forages; puits….etc.) disponibles à l'Agence du Bassin Hydraulique de Tensift.

Les nombreuses données disponibles ont été valorisées au sein d'une base de données spatiale selon le format (Géodatabase). Ce format offre en effet l'avantage de pouvoir traiter et exploiter les données tant vectorielles que raster, au sein d'un fichier unique, à la fois en tant que base relationnelle et en tant que système d'information géographique (*Derouane, 2005*).

Utilisation de la géostatistique :

Le S.I.G couplé à la géostatistique a permis de fournir les cartes piézométriques de la campagne 1986 et 2002 et la carte de l'écart piézométrique 2002-1986. Le recours aux techniques de krigeage autorise une valorisation de connaissances corrélées du milieu, (*Chiles, 2004*) : Lors de la campagne 2002 les coordonnées des points d'observation ont été relevées par système GPS. Si les lectures pour X et Y sont précises, la mesure du Z est entachée d'une forte imprécision qui en interdit l'utilisation pour toute exploitation orientée vers la définition d'une côte rattachée au NGM. La restitution d'une altitude pour les points de mesure a été faite par report des points sur les cartes topographiques à l'échelle de 1/50.000^{ème} ou 1/100.000^{ème} puis lecture de la cote par interpolation entre les courbes de niveau portées sur les cartes.

3. RESULTATS

Les données utilisées ont pu déterminer deux grands ensembles de facteurs, d'une part la structure physique et d'autre part le climat qui s'exerce sur le bassin, en tant que déterminant de la quantité et de la variabilité des écoulements (*Pella et al., 2003*).

3.1 La structure du bassin versant N'FIS

Carte géologique:

Le bassin versant N'FIS fait partie de la plaine du Haouz dans laquelle se sont accumulés des sédiments néogènes et quaternaires continentaux ; déposés sur un socle primaire arasé pendant le secondaire (*Razoki, 2001*). Tous les étages de la série géologique du Primaire au Quaternaire ont pu être observées soit par des sondages profonds, soit à l'affleurement (Fig. 1) sur la bordure de la plaine (*Mouchkane, 1983)*.Un forage (IRE 53/3141) a été exécuté en 1989, en rive droite du N'FIS a pu montrer les caractéristiques suivantes (*Soulaimani, 1991*):

1. L'affleurement de l'Eocène;
2. En aval pendage immédiat du contact avec les marnes rouges et vertes du Sénonien surmontant la barre turonienne (calcaires dolomitiques karstifiés, 40 m d'épaisseur, pendage de 40° vers le NW).

   Les affleurements se composent de 3 formations :

1. Une formation calcaire perméable du Crétacé, d'Eocène, et du Jurassique.
2. Une formation marno- gréseuse souvent salifère du crétacé, jurassique permo-trias souvent très peu perméable;
3. Une formation métamorphique ou éruptive du primaire précambrien imperméable.

Carte des altitudes et du réseau hydrographique:

La répartition du bassin versant par tranche d'altitude revêt une importance capitale dans les études hydrologiques du fait que la plupart des facteurs météorologique sont fonction de l'altitude (*Aitslimane, 2005*). Les altitudes sont comprises entre 300 m au niveau de l'exutoire et 4100 m dans la partie amont du bassin (**Fig. 2**).

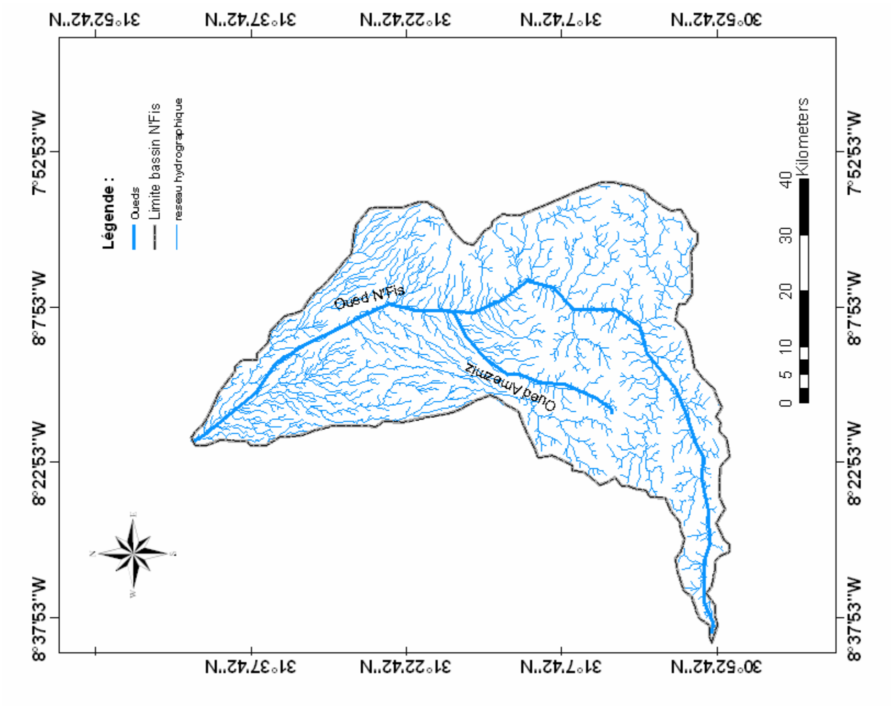

Fig. 3 *Carte du réseau hydrographique du bassin versant*

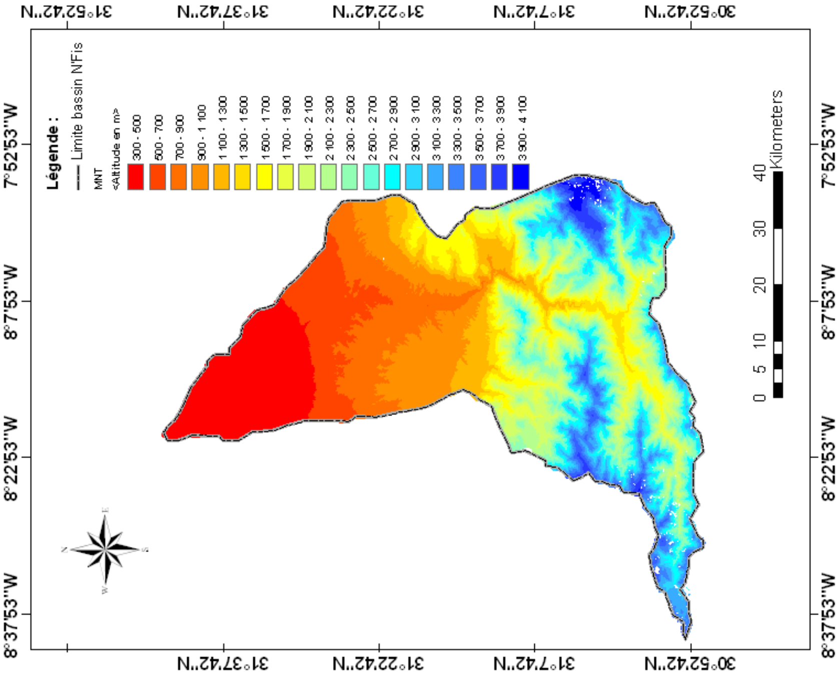

Fig. 2 *Carte des altitudes du bassin versant N'Fis*

A partir du MNT un réseau de drainage théorique a été reconstitué. Le réseau hydrographique du bassin versant N'FIS est très dense. Le cours d'eau principale est oued N'FIS, c'est un affluent principal de l'oued Tensift. Il draine un bassin versant d'une superficie de 1290 km², ce bassin versant coïncide pratiquement avec la limite avale des zones de ruissellement actif (**Fig. 3**). Le bassin versant de N'FIS a son écoulements essentiellement issus des pluies (*Hanich et al. 2006*). Son cours d'eau mesure 152 km jusqu'à la confluence avec l'oued Tensift. Son réseau hydrographique mesure 3322 km environ au barrage, soit une densité de drainage de 1.97 km/km² (*ABHT 2003*).

Carte des pentes:

La réalisation des cartes des pentes pour une étude hydrologique semble être intéressante du fait que toute infiltration, ruissellement et crue dépendent essentiellement des dénivelés du terrain, les pentes des tronçons ont été calculées sur le réseau hydrographique. Le résultat permet de visualiser à l'échelle du bassin les valeurs dominantes de pentes. La figure. 4 montre la prédominance des pentes comprises entre 0 et 20 % au niveau de l'exutoire et entre 20 et 60 % en amont du bassin.

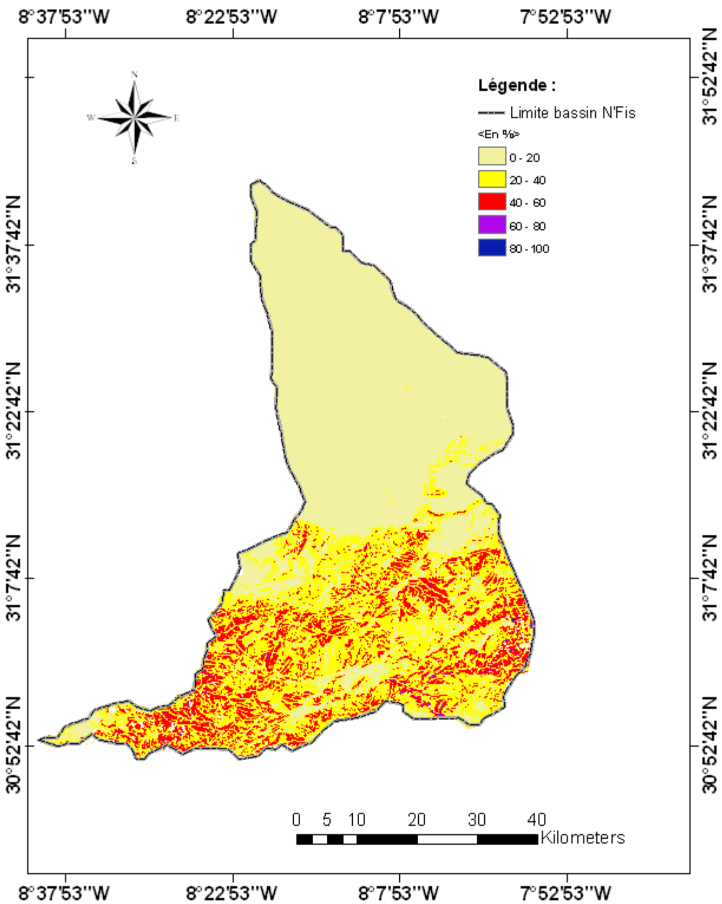

Fig. 4 *Carte des pentes exprimées en pourcentage*

Carte d'occupation du sol (Fig.5):

Au niveau de la plaine l'occupation du sol est classifiée en deux parties (*Abourida A., 2007*) :

- Les sols irrigués : destinés à l'arboriculture, la céréaliculture, la production de fourrage et au maraîchage.
- Partie non irriguée : occupée par du blé pluvial qui ne se développe que lors des années suffisamment pluvieuse.

La zone aménagée de la rive droite du N'FIS (secteurs N1, N2 et N3) s'étend sur une superficie nette de 18 500 ha, le réseau d'irrigation est modernisé au début des années 1990 : l'eau est alors distribuée sous pression au niveau de bornes d'irrigation alors qu'auparavant, elle était distribuée par un réseau gravitaire de canaux à ciel ouvert (*seguia* et *mesref*) dont les prises se situent sur les oueds (*Finet, 2002*) et celle de la rive gauche s'étend sur une superficie de 12.800 ha (*DRPE, 1990*).

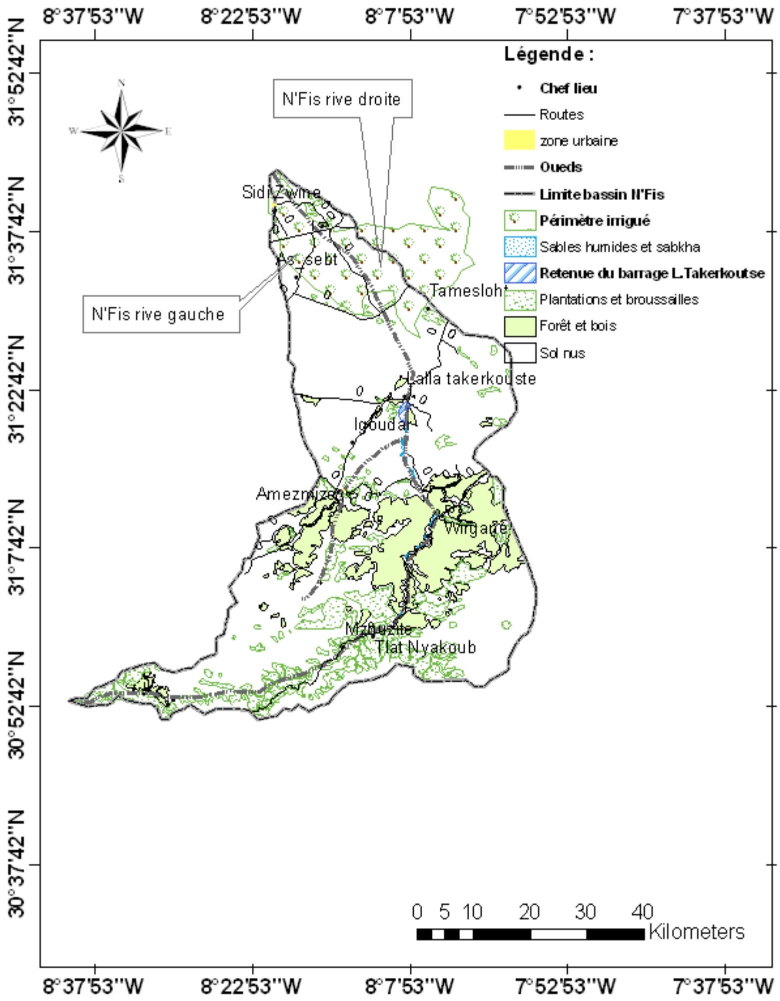

Fig. 5 ***Carte d'occupation du sol***

Etude de la variabilité interannuelle des pluies :

Dans les zones exposées aux différents aléas naturels, des stratégies globales et interdisciplinaires de gestion doivent être basées sur une évaluation spatio-temporelle des niveaux d'aléas et de risques (*Malet et al., 2003*). D'après *Pascin, (1977)* le climat du Haouz comme étant marqué par de forts contrastes dans le temps et dans l'espace. Ainsi, la variation de la pluviométrie inter- annuelle est très grande.

L'analyse temporelle:

Le climat est aride à hiver frais au niveau du bassin suivant la classification de Gaussen-Emberger évaluée pour la station climatique de Lalla Takerkoust. Les tendances dans la distribution des pluies et leur évolution dans le temps pour les 4 stations Lalla Takerkoust, Tahennaout, Imine Elhammam et Marrakech sont illustrées par le graphique de la figure 6.

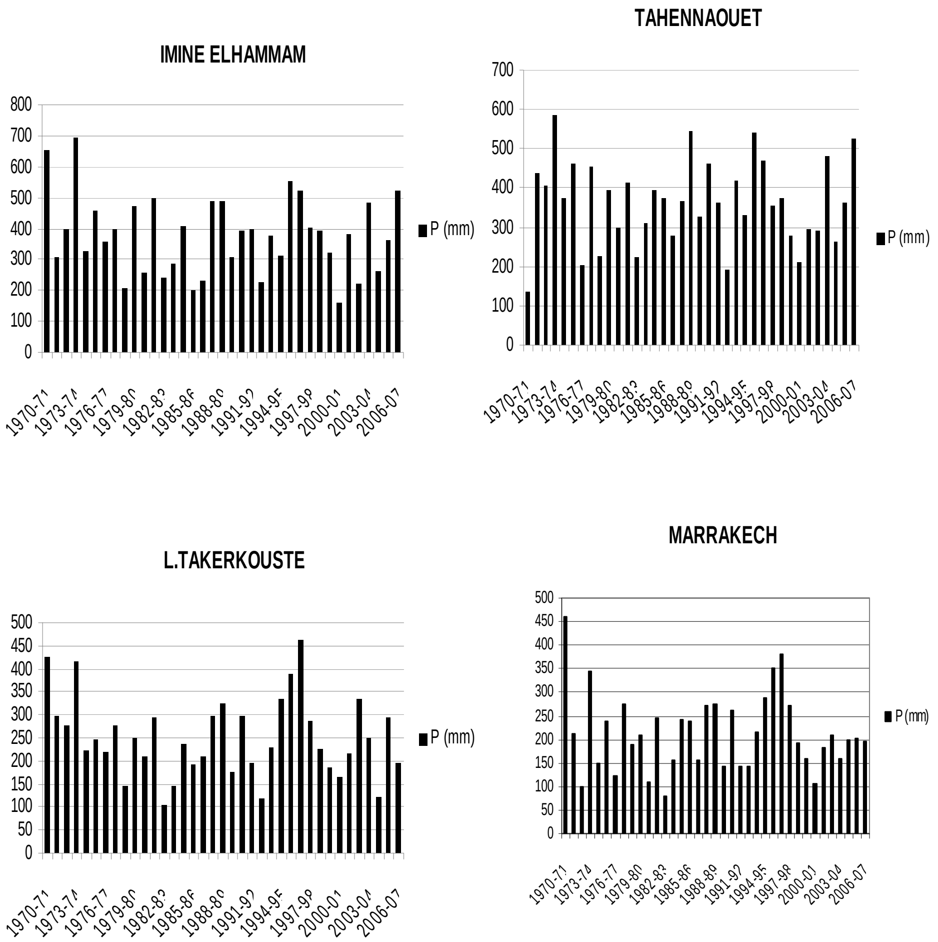

Fig. 6 *Variations des précipitations moyennes annuelles (1970-2007)*

Le bassin montre une pluviosité à caractère synchrone. Ainsi, pour la période allant de 1970-2007, on constate une variabilité des moyennes annuelles de la pluviométrie d'une année à l'autre : les précipitations moyennes annuelles au niveau des stations sont de l'ordre de 361,8mm à Imin Elhammam, 238,1mm à Lalla Takerkoust ,206 ,1 à Marrakech et 358 mm à Tahennaout. Les valeurs extrêmes étant enreG.I.Strées à I min Elhammam avec 694mm pour l'année 1973-74 et 78,7mm pour l'année 1982-83 à la station de Marrakech.

L'analyse spatiale :

La carte des isohyètes moyennes annuelles (**Fig. 8**) a été calculée en utilisant la corrélation altitude- précipitation et les options de calcul sur les couches raster qu'offre le logiciel S.I.G. (Raster Calculator : on appliquant la formule de corrélation : y=0,2715x+113,11 où x est la carte des altitudes) On a décidé d'éliminer 3 autres stations qui ne présentent pas une bonne corrélation avec les altitudes

Les pluies annuelles sont exprimées en moyennes arithmétiques calculées sur les historiques accessibles avec des périodes d'observation homogènes (1970-2007) pour 4 stations (**Tableau 1**): Lalla Takerkoust, Tahennaout, Imine Elhammam et Marrakech. La distribution spatiale des pluies sur le bassin traduit l'augmentation de la pluie avec l'altitude et varie de 200 mm à 1200 mm de la plaine aux reliefs du Haut Atlas et traduit aussi l'influence de la distance à l'atlantique (gradient négatif du sud vers le nord).

Stations météorologiques et leurs caractéristqiues

Tableau 1

Stations	Longitude	Latitude	z (m)	Précipitations moyennes annuelles (mm)	Ecart type (mm)
Imine Elhammam	-8,25177613	31,18025405	770	3618	1258,2
Takerkoust	-8,25794287	31,3738319	630	2388	857
Marrakech	-8,03470517	31,6118458	300	2061	826,9
Tahennaout	-8,08935613	31,3019485	925	3583	107,72

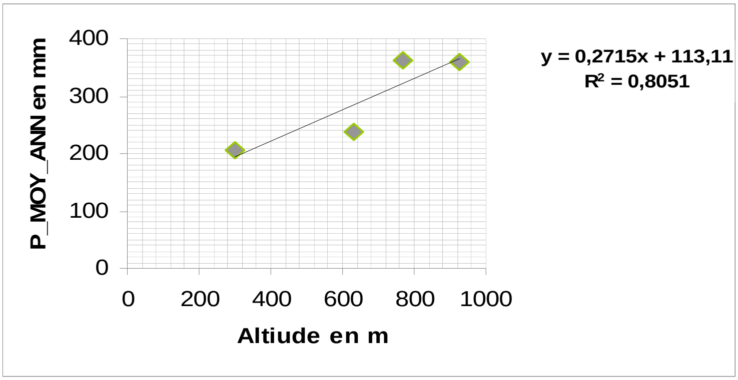

Fig. 7 *Corrélation altitude- précipitations (Moyennes annuelles (1970-2007))*

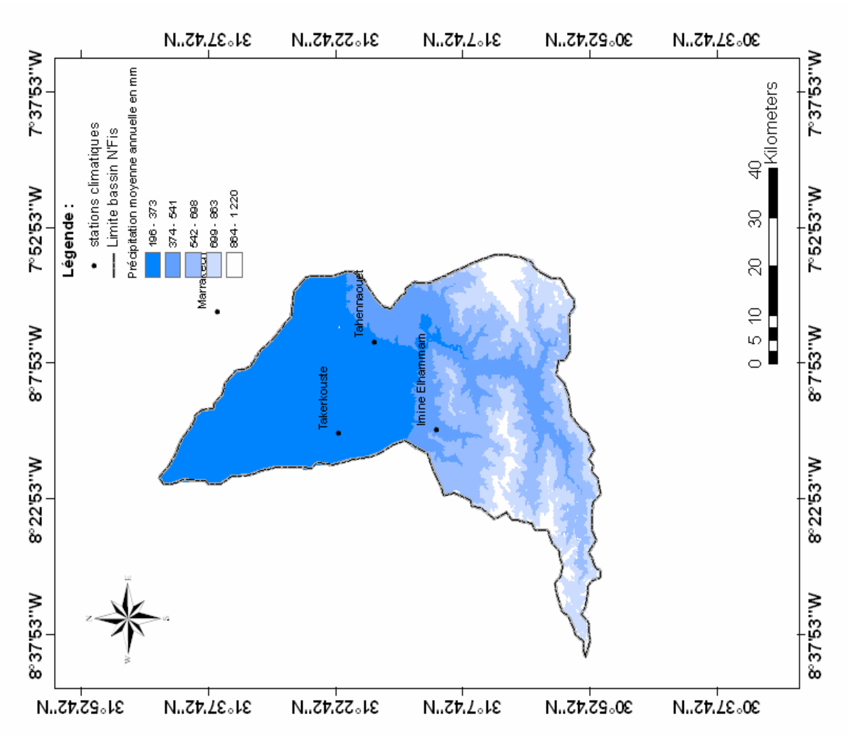

Fig. 8 *Isohyètes moyennes des précipitations moyennes annuelles (1970-2007)*

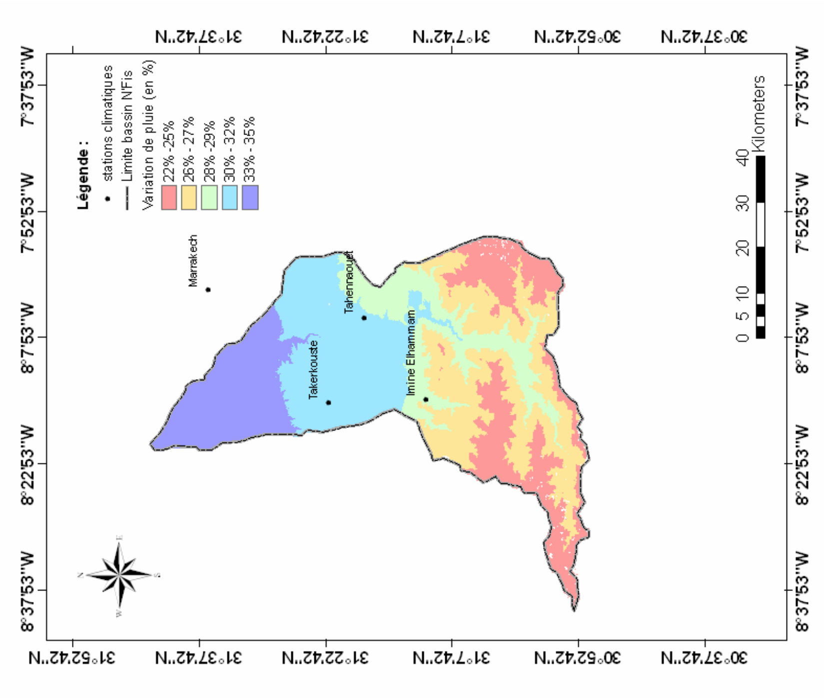

Fig. 9 *Carte du coefficient de variation interannuelle (1970-2007)*

La distribution de la variabilité n'est pas aléatoire. Trois éléments structurent les fluctuations annuelles des pluies : la latitude, la longitude et l'altitude de la zone étudiée (*Meddi et Meddi, 2007*). La variabilité spatiale interannuelle est mieux approchée par la carte du coefficient de variation: pour les 37 ans au niveau du bassin (**Fig. 9**) le coefficient de variation varie entre 22 % et 35 % du Nord vers le sud du bassin ce qui montre une variabilité plus au moins importante. Le bassin est caractérisé dans sa partie sud par un relief très accidenté (comme le montre la carte d'altitude de la **fig. 1**) qui atteint les 4100 m, ces sommets du Haut Atlas qui succèdent la plaine du bassin causent l'appauvrissement progressif de l'atmosphère en vapeur d'eau. Celle-ci a une grande influence sur les variations spatiales de la pluviométrie.

3.3 Etude de l'impact des variations des précipitations sur la piézométrie de la nappe phréatique plioquaternaire:

La nappe est exploitée pour l'alimentation en eau potable de la ville de Marrakech et des autres centres avoisinants, pour l'irrigation traditionnelle et pour l'alimentation en eau de quelques périmètres irrigués. Les prélèvements actuels de la nappe du Haouz (AEP et agriculture) sont estimés à environ 400 millions de m3/an (*Sinan et al., 2003*) dont 124 Mm^3 est prélevé de la nappe N'FIS. Au niveau du secteur N'FIS l'eau est distribuée sous pression au niveau des bornes d'irrigation avec une dotation annuelle de 6800 m3/ha (*Finet, 2002*).

La variation temporelle du niveau piézométrique de la nappe est assurée par un réseau de points d'observation installés par l'Agence du bassin Hydraulique de Tensift (ABHT) depuis les années 70. Pour évaluer l'impact des variations des précipitations sur les fluctuations piézométrique de la nappe au niveau du bassin, on a choisi 3 piézomètres de contrôle (**Fig. 10; 11**): le pièzomètre 385/53 sur la rive droite N'FIS (aménagée par des séguias et cannaux d'irrigation de l'Office Régional de Mise en Valeur Agricole du Haouz ORMVAH), le piézomètre 2576/53 sur la rive gauche N'FIS (aménagée par des séguias) et le pièzomètre 2698/53 (zone non aménagée).La nappe étant libre, les variations de son niveau piézométrique se répercute sur son épaisseur saturée, et donc sur les valeurs de transmissivité (*Sinan, 2005*).

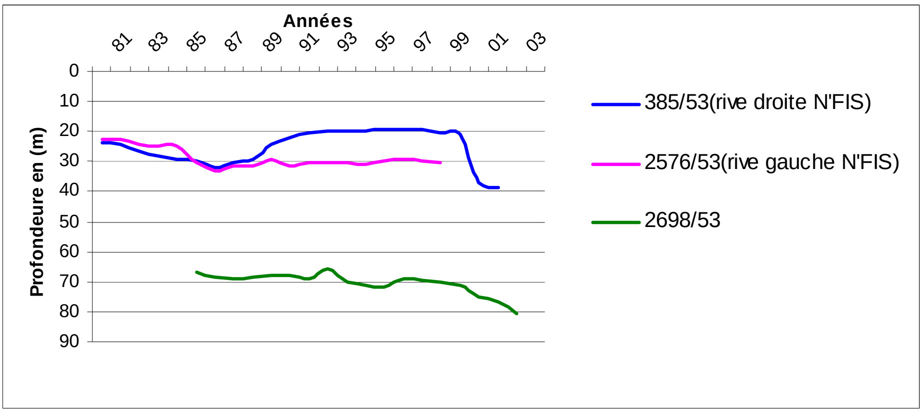

Fig. 10 ***Distribution des points de contrôle piézométrique au niveau de la nappe***

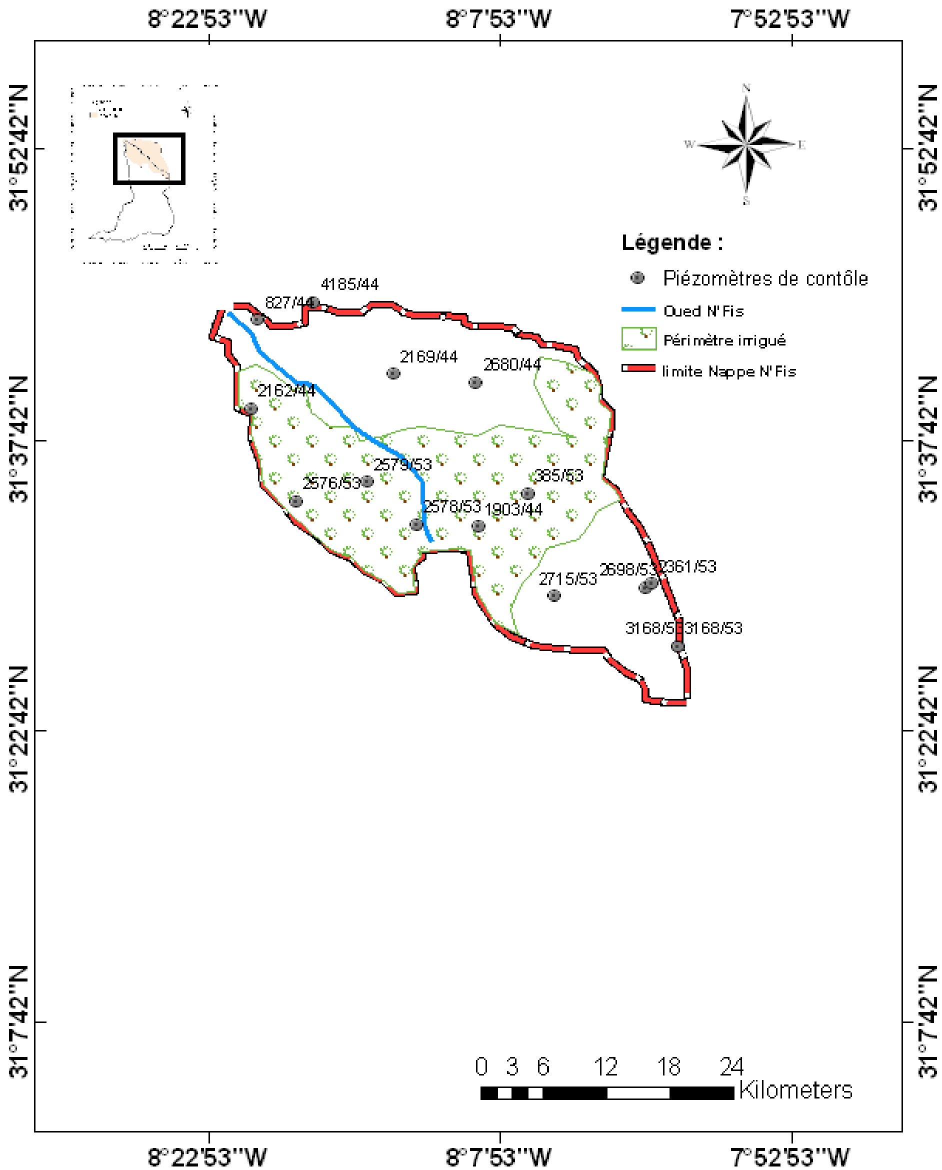

Fig. 11 ***Evolution du niveau de la nappe dans le secteur N'FIS.***

Or les trois points d'eau appartiennent aux zones les plus transmissives (des valeurs qui dépassent 10^{-2} m²/s) qui sont situées dans l'axe central de l'aquifère de direction SW-NE, le long de la faille d'Assoufid qui s'étend entre le nord de l'affleurement primaire de Guemassa et le Haouz oriental (*Sinan, 2005*). Les fluctuations de la piézométrie dans cet aquifère sont donc dues à la recharge par infiltration directe des eaux de pluie et/ou retour d'irrigation.

Les graphes montrent une évolution très variable de la piézométrie : les piézomètres 385/53 et 2576/53 montrent respectivement une baisse continue de 8 m et 10m entre 1981 et 1987 qui correspond à une surexploitation de la nappe, suite à une forte prolifération des stations de pompage pour l'irrigation et l'AEP (**Fig. 12**). Une remontée importante est remarquée entre 1989 et 1992 de l'ordre de 9m pour le piézomètre 385/53 et de l'ordre de 5m pour le piézomètre 2576/53 entre 1986 et 1990 liée à la mise en eau du N'FIS (**Tableau 2**). Le piézomètre 2698 montre une légère variation entre 1986 et 1999 suivie d'une baisse progressive de l'ordre de 10 m entre 1999 et 2003. La période 1990-1997 se caractérise par une variation légère malgré des précipitations relativement élevées en 1995-1996 et 1997-1998 au niveau des 4 stations. Ceci indique que l'infiltration directe des précipitations a un effet moindre sur l'alimentation de la nappe par rapport au retour d'irrigation.

Aménagement hydro- agricole des différents secteurs du N'FIS (Source : DRPE 1990)

Tableau 2

SECTOR	N1	N2	N3	N4	N5
Date de mise en service	1989	1990	1991	1997	1997
Origine de l'eau	Canal rocade et Barrage Lalla - Takerouste	Canal rocade et nappe	Canal rocade et Barrage Lalla-Takerouste et nappe	Barrage Lalla-Takerouste et nappe	Nappe

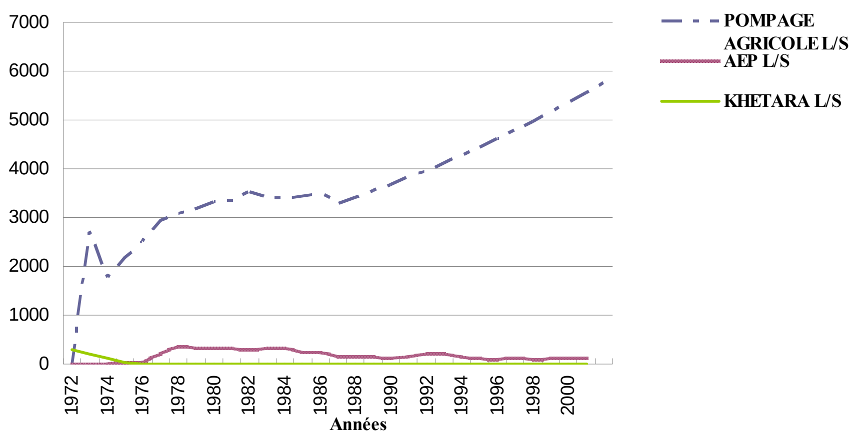

Fig. 12 ***Historique des prélèvements au niveau de la nappe N'FIS***

L’analyse de la carte de l’écart piézométrique entre 1986 et 2002 (**Fig. 13**) illustre bien les effets des cycles climatiques et d’irrigation sur l’évolution piézométrique : les modifications des pratiques d’irrigation en rive droite et gauche du secteur N’FIS se traduisent par une remontée spectaculaire de la piézométrie (de 5 à 20 mètre).En contrepartie, la zone amont de la nappe est plus pessimiste où les prélèvements ont entraîné un abaissement de l’ordre de 20 m et où le coefficient de variation des précipitation est compris entre 30 % et 35 %.

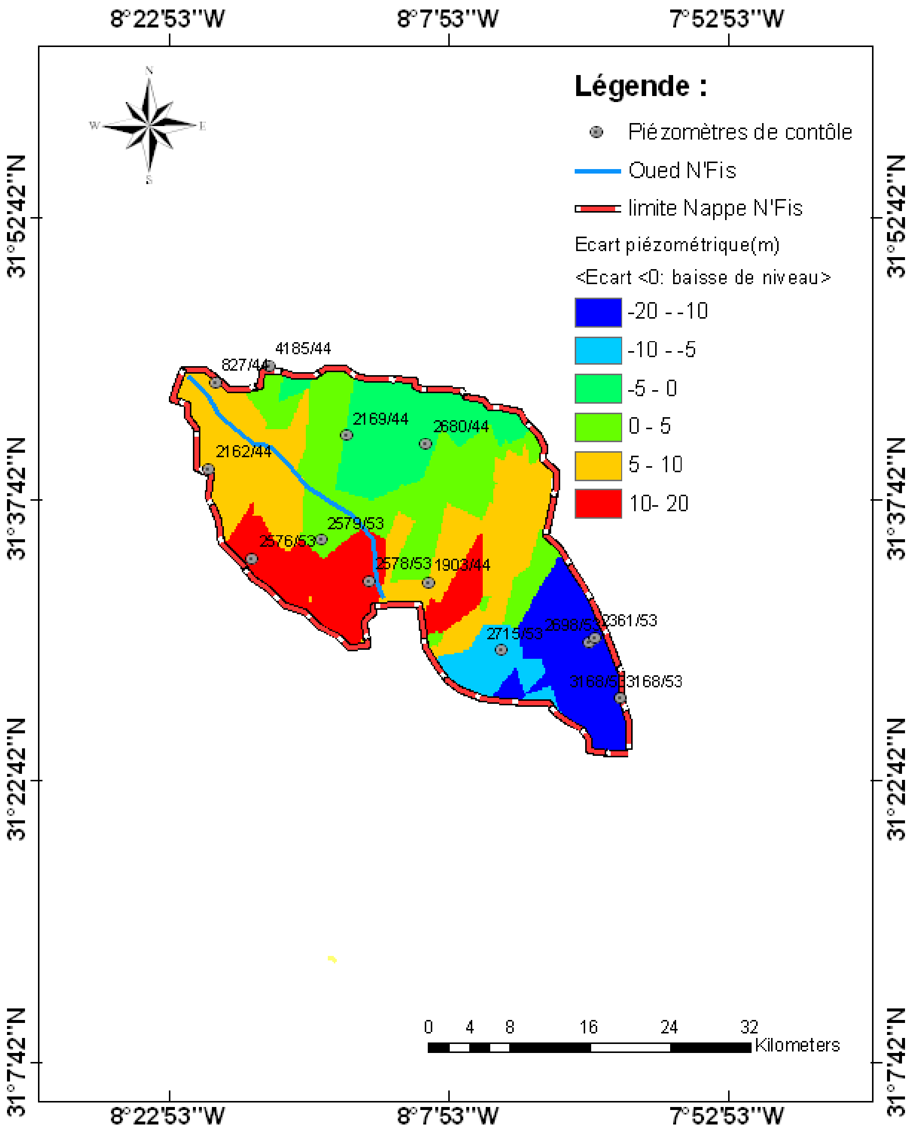

Fig. 13 *Ecart piézométrique 1986-2006*

4. CONCLUSIONS

L'utilisation des multiples fonctions du S.I.G à l'échelle du bassin N'FIS telle qu'elle a été partiellement présentée dans cet article a demandé un long travail de collecte, de saisie, d'analyse et de traitement des données ainsi qu'à la maîtrise de l'outil informatique d'aide à la décision.

L'analyse de la structure physique du bassin montre deux zones bien distinctes: une zone très accidentée (3500-4100) qui succède à une plaine de 300-500 m d'altitude avec un réseau hydrographique dense dont le cours d'eau principal est Oued N'FIS de 152 km de longueur. La distribution spatiale des pluies sur le bassin traduit l'augmentation de la pluie avec l'altitude et varie de 200 mm à 1200 mm de la plaine aux reliefs et suit l'accroissement de la latitude. On note une variation pluviométrique de 34 % au niveau de la plaine du bassin durant les 37 dernières années, cette variation a un effet moindre sur la recharge de la nappe sous forme d'infiltration directe. Toutefois, elle agit en terme de réduction des volumes de l'eau véhiculée par oued N'FIS. La carte de l'écart pluviométrique montre une baisse de la nappe de 20 m durant 16 ans dans sa partie amont et une remontée de 5 à 20 m au niveau du périmètre irrigué.

L'impact des variations spatio-temporelles de la pluviométrie observée durant les 37 ans combinée à l'aménagement hydro- agricole au niveau du bassin N'FIS peut se matérialiser par une modification des processus d'infiltration et de recharge de la nappe par réduction du volume de l'eau véhiculée par oued N'FIS redistribution spatiale de la recharge par infiltration des pertes sur les réseaux d'adduction- distribution.

Une autre partie de traitement des données est entamée pour intégrer d'autres plans d'informations traduisant le comportement hydrodynamique et physique de la nappe (débits, coefficient d'emmagasinement, perméabilité; …etc.) l'objectif est d'identifier les zones convenables pour une recharge artificielle de la nappe pour faire face au rabattement enreG.I.Stré ces dernières années par la conception d'un modèle mathématique.

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