Application of GIS and Remote Sensing Technologies in Disaster Management in Algeria

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SUMMARY

Algeria is affected by fourteen major risks (earthquakes, landslides, floods, forest fires, oil spill, etc) and the means for the management of these disasters are limited and often inadequate. In recent years, Remote Sensing and Geographical Information System (GIS) technologies have been the object of considerable interest to all bodies concerned with space and in particular emergency services and disaster management in Algeria, in collaboration with all other bodies responsible for prevention and management of all major risks in Algeria.

The use of remote sensing and GIS has become an integrated, well developed and successful tool in disaster management. For our part, we are interested in this communication to present our research work concerning the management of risks and we hope to contribute directly or indirectly to putting these new technologies in place in Algeria. This has been done in collaboration with bodies such as the forestry services for the management of the forest fires, the centre for astronomical, astrophysical and geophysical research for the monitoring of earthquakes and so on.

For the first risk of oil pollution, we present, in this communication, a methodology developed for the oil spill identification. The potential for the detection and characterisation of oil spills using ERS-SAR imagery has been studied in this communication. The methodology is easy to apply and is able to determine the identification probability in an automated way. We expect this to be a useful tool for the monitoring services.

For the second risk, a large earthquake (M_s > 6.8) occurred in May 2003 in the Algiers-Boumerdes area (Algeria). Synthetic Aperture Radar Interferometry (InSAR) has been shown to be a valuable tool for monitoring relative surface displacement due to various crustal movements and for creating accurate DEM's using pairs of SAR images. This research is under study in our laboratory and first results as interferograms are obtained and the work is go on.

For the third risk of forests fires, every year, about 30 000 hectares of forests are destroyed by fires in Algeria. Our major preoccupation is to reduce forests fires in the country, thanks to inventory, prevention and management and follow-up. The goal of our work is to set up of a GIS integrating remote sensing data for the prevention and management of the fires.

In this communication, we present through these three examples, our contribution of the Algerian experience in the use of Space technologies for disaster management.

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1. INTRODUCTION

Among risks described above and according to the available statistics a part of the north of Algeria is liable to seismic activity of varying intensities (Boumerdes,2003; Chlef,1980; Tipaza, 1989;etc). Coastal areas of Algeria are exposed to marine pollution and of all the disasters occurring in the country, forest fires (in northern Algeria) are the most frequent and often the most devastating.

Remote Sensing and GIS can be a very useful tool to complement conventional methods involved in Disaster Management Mitigation of natural disaster management can be successful only when detailed knowledge is obtained about the expected frequency, character, and magnitude of hazard events in an area [1] [2]. Although, natural disasters have shown in the last few decades a drastic increase in magnitude and frequency, it can as be observed that there has been a dramatic improvement in technical capabilities to mitigate them [3].

The use of remote sensing data, such as satellite imageries and aerial photos, allows us to map the variabilities of terrain properties, such as vegetation, water, geology, both in space and time. Satellite images give a synoptic overview and provide very useful environmental information, for a wide range of scales, from entire continents to detail of a few meters. Many types of disaster, such as floods, droughts, earthquakes, etc. will have certain precursors that satellite can detect. Remote sensing also allows monitoring the event as it occurs. From the vantage point of satellite we can consider, plan for and operationally monitor the event.

Indeed, a complete strategy for disaster management is required to effectively reduce the impact of natural disaster, which is as referred to as the disaster management cycle [4]. Disaster management consists of two phases taking place before the disaster occurs, which are disaster prevention and disaster preparedness, a three phases taking place after the disaster occurs, which are disaster relief, rehabilitation and reconstruction:

- In the **disaster prevention phase**, GIS is used to manage the large volume of data needed for the hazard and risk assessment.
- In the **disaster preparedness phase**, it is a tool for the planning of evacuation routes, for the design of centres for emergency operations, and for the integration of satellite data with other relevant data in the design of disaster warning systems.
- In the **disaster relief phase**, GIS is extremely useful in combination with Global Positioning System in search and rescue operations in areas that have been devastated and where it is difficult to find ones bearings.
- In the **disaster rehabilitation phase**, GIS is used to organise the damage information and the post-disaster census information, and in the evaluation of sites for reconstruction. Hence, GIS is a useful tool in disaster management if it is used effectively and efficiently.

2. DISASTER MANAGEMENT AND NEW TECHNOLOGIES IN ALGERIA

In recent years, Remote Sensing and Geographical Information System (GIS) technologies have been the object of considerable interest to all bodies concerned with space and in particular emergency services and disaster management in Algeria, in collaboration with all other bodies responsible for prevention and management of all major risks in Algeria.

Among these risks we can mention the most preoccupying as being the forest fires that ravage thousands of hectares every year, earthquakes that have a devastating effect every time, coastal and marine pollution at present little recognised but very real considering the 1200 kilometre Algerian coast line, near which many ships empty their tanks offshore as well as the oil industry activity in many Algerian ports. There are other less frequent hazards but which are always as devastating, the most recent being the sea of mud which engulfed the district of Bab-El-Oued in the city of Algiers following torrential rain with considerable loss of life property.

These risks are often efficiently and carefully managed by administrators of this vital sector feel a growing need for information particularly to be able to count on prevention to avoid disasters or at least to minimise the damage. For the reason, the implication of this new technology is necessary and for the first time the means of communication have been improved sufficiently to make them very efficient.

Much work has already been done collecting data by conventional methods, without any real implication of Geographical Information Systems in every type of risk or in all regional units. This has been done in collaboration with bodies such as the forestry services for the management of the forest fires, the centre for astronomical, astrophysical and geophysical research for the monitoring of earthquakes and so on.

The use of remote sensing and GIS has become an integrated, well developed and successful tool in disaster management. A very powerful tool in combination with these different types of data is GIS. It is defined as a "powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from a real world for a particular set of purposes". GIS allows the combination of different kinds of data using models. GIS allows for the combination of the different kinds of spatial data, with non-spatial data, attribute data and use them as useful information in the various stages of disaster management.

For our part, we will be interested in the presentation of the use of remote sensing and GIS technologies for the management of risks and we hope to contribute directly or indirectly to putting these new technologies in place in Algeria.

2.1. Marine pollution

The problem of the marine pollution is probably one of the most worrying aspects of the deterioration of the environment. This type of pollution is a major risk that would seriously affect the Biosphere-Geosphere balance. Hydrocarbons are the most noted pollutants and the Mediterranean Sea contain 18% of the world's pollution.

Among the remote sensing technologies, SAR (Synthetic Aperture Radar) is very promising because it can provide images both day and night, even when clouds are present. The visual effect of an oil slick on a SAR image is a dark area. The presence of oil reduces the water

surface roughness and consequently also reduces the electromagnetic backscatter. There are a certain number of image features that can be considered as slick signatures [5].
Physical and geometric parameters alone are not always sufficient to provide enough information in order to identify the nature of the oil spill [5]. There are several natural phenomena that can have the same radar signature as an oil spill. To help in the identification of the suspect objects, supplementary data, such as the wind speed that can be calculated from radar images, have proved themselves to be efficient .

It is the fact that when the wind speed is greater than 7-8 m/s and less then 15 m/s, the probability that the slick is an oil spill increases significantly because all other types of spills tend to disappear in the meantime. When the wind speed is less than this value, the slick may also be caused by natural phenomena.

Integrated with the tool for the estimation of the wind vector, represented by the two boxes on the left side of Figure 1, the method for the oil spill identification can be described by the following procedures described in the figure 1 :

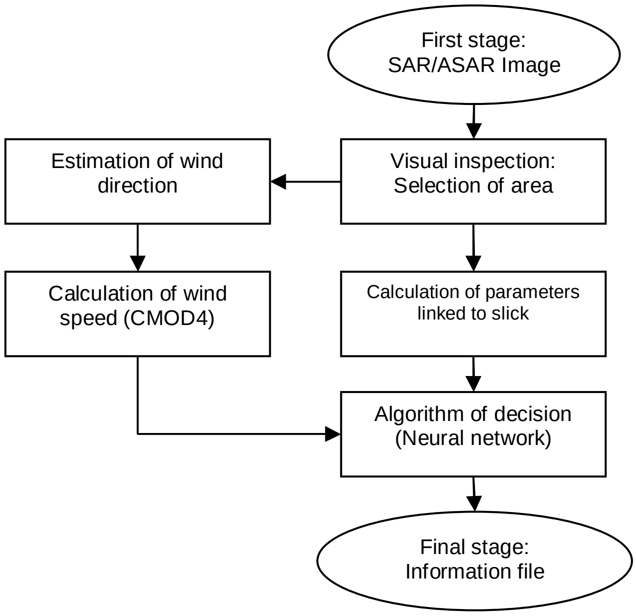


Figure 1 - Synoptic of the method of identification

The inversion of the CMOD4 model allows the calculation of wind speed from an SAR image with an interactive pre-estimate on the image by the operator [7].

The procedure starts with the definition of a region of interest by the user. The tool analyse the overall backscattering of the region and in particular produce a histogram. The histogram generally contains two peaks; the lower is located around the mean backscattering value of the dark object, the taller around the mean value of the background. The local minimum value between the two peaks is stored and is the one used for image fragmentation. To this purpose, the darkest pixel in the region is selected as starting point, then, the region around this pixel grows defining an edge that corresponds to the border of the oil. The region grows until the neighbouring pixels have a value greater of the threshold value given by the local minimum previously calculated. Several routines have been implemented dealing with anomalies from the described general case. Subsequently, the human operator can either accept the result suggested by the automatic procedure or reject it and produce new edge detection by changing the threshold. In this way, the oil spill analysis tool is made flexible and adaptive to a variety of situations. Once the border of the dark object is accepted, a mask is generated and a number of morphological and physical parameters are computed [8].

In conclusion, the potential for the detection and characterisation of oil spills using ERS-SAR imagery has been studied. The methodology is easy to apply and is able to determine the identification probability in an automated way. We expect this to be a useful tool for the monitoring services.

2.2. Seisms and earthquakes

At the CRAAG (Algerian Center of Research in Astronomy, Astrophysical and Geophysical), experience of the GIS is recent. Nevertheless, the CRAAG, conscious of the importance of the use of such a tool, undertook the creation of this system, because we consider that to reduce the seismic risk, we need to have the appropriate tools. In fact, a collation of a certain number of data treated beforehand can shorten the thinking time and speed up intervention in the management of a disaster.

These notable improvements in the managing of a disaster or of its after-effects will certainly contribute to a reduction in the seismic risk in Algeria (figure 2).

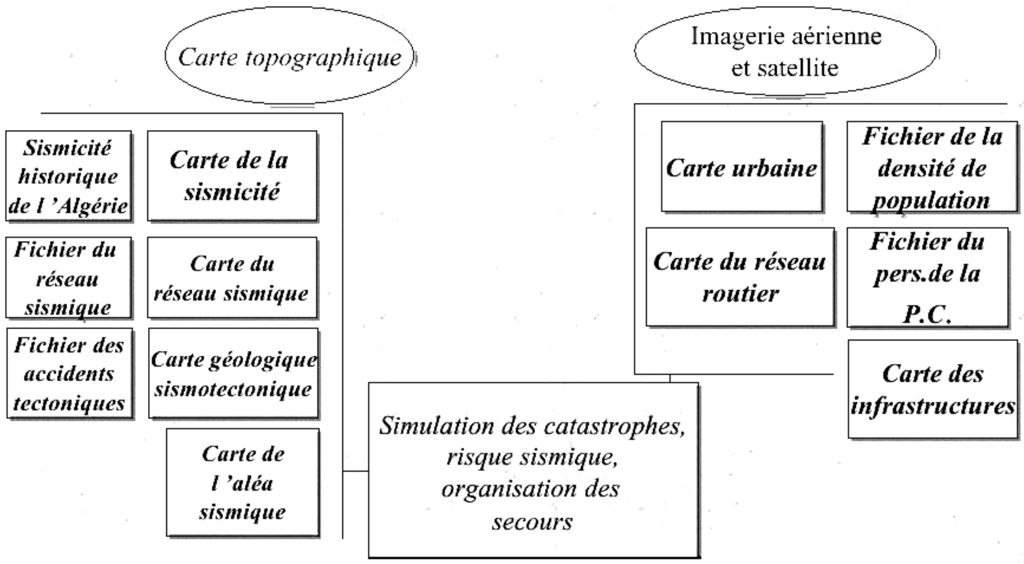


Figure 2: synoptic of seism prevention and management

For our part, the collaboration with the CRAAG is focused on the use satellite data such as interferometric products to detect displacement field resulting from a major earthquake by differential SAR intereferometry and to achieve results comparable in magnitude to those obtained by conventional field survey techniques.

We present in this communication the interferometric procedure we have developed as first step of our strategy to detect terrain displacement. The data used is a couple of SLC (Single

Look Complexes) images acquired in the Tandem mission of the ERS-1(3 January 1996), ERS-2(4 January 1996)) satellites of a part of Algiers area [9].

The complete synoptic of interferometric procedure is given in the figure 3:

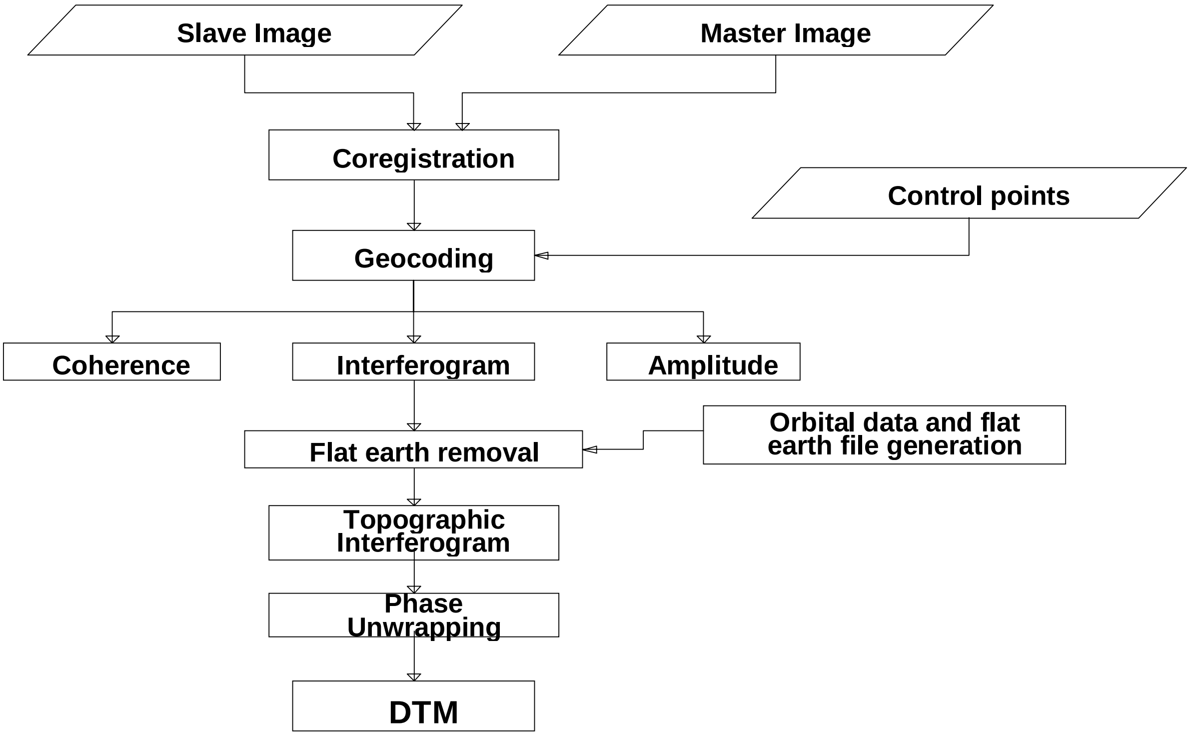
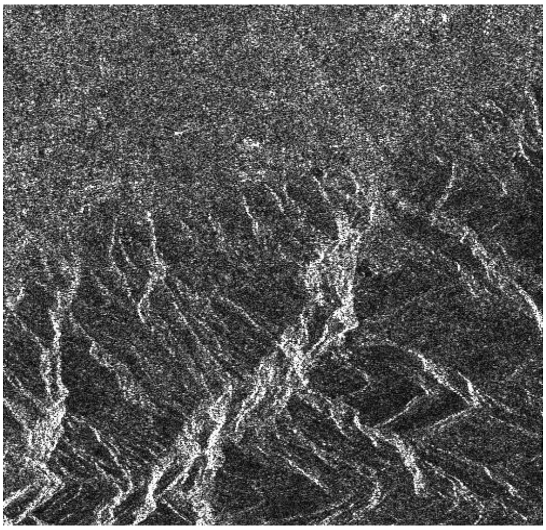


Figure 3: synoptic of interferometric procedure

Three basic steps give the interferometric procedure:
1/ The image processing are the coo-registration: Images are generated giving 20*20m resolution images. The images coo-registration quality for the interferometric process is very important for a good result. (complex interferogram, coherence, interferogram).
2/ In this step we generate the interferometric product and the flat earth file. The complex interferometric is given by

$$\frac{I_{C1}.I_{C2}^{*}}{\sqrt{\sum_{i}\left|I_{C1}\right|^{2}.\sum_{i}\left|I_{C2}\right|^{2}.}}$$

Where I_{C1} , I_{C2} are the master and slave images. In the formula above the window is 3*3.
As a result we give in " figure 4 " the intensity image of the Blidean Atlas (Algiers)extracted from the global scene. The image size is 500x500 pixels. In " figure 5 " we present the correlation of the two images given by the coherence map. This image gives an idea about the interferogram quality and consequently the precision of the digital terrain model.
3/ Phase unwrapping step has been tested using the least squares method where we minimize the quadratic difference between the unwrapped phase and the gradient of the wrapped phase. which is a global one.



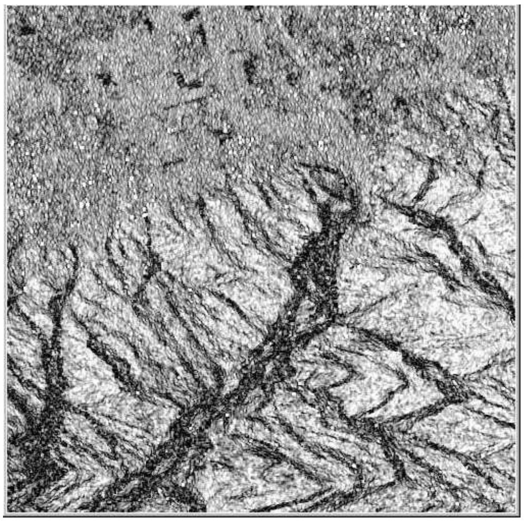


Figure 4: Intensity image (500x500) **Figure 5:**Coherence image (500x500)

The use of differential SAR interferometry allows to capture the extent of the displacement field. In effect, Three interferograms constructed from ESR-1/2 and ENVISAT SAR data can be used to analyse the earthquake mechanism by three-pass method and the digital elevation model elimination. This method can reveal the behaviour of the landslide that could not be observed with discrete GPS measurements.

2.3. Forest fires

Every year about 30 000 hectares of forests are destroyed by fires in Algeria, fires also take a heavy toll in lives and property and our major preoccupation is to reduce forest fires in the country, thanks to inventory, prevention, management and follow-up.

Prevention and early warning systems constitute the only means to limit the cost of damage. In huge fires, options are often limited to the bravery of the firemen attempting to fight the fire.

In the last few years, the data acquired by Earth observation satellites associated with different types of linked information integrated in a Geographical Information System has proved to constitute a viable option for the follow-up of disasters, the identification of areas at risk, and the mapping out of the extent of fire [10].

For the design of the data model and the implementation of methodology, we propose a multilevel step which we schematised by diagram in figure 6.

These levels lead us to distinguish various elements from the risk. Then each one of these elements will be modelled by selecting the components and the parameters necessary as well as a mode of representation. The interpretation and the analysis of the various elements starting from the crossing of the various layers of data of the SIG allow the estimate of the space indice of the risk, the coding of this indice and the realisation of the cartography of the risk fires of Bainem forest. In the global diagram, the definition of scenario and the preparation of plan of forecast and intervention require, in addition to the SIG, the contribution of the institutions concerned with these natural phenomena. This part is not approached in this article [11].

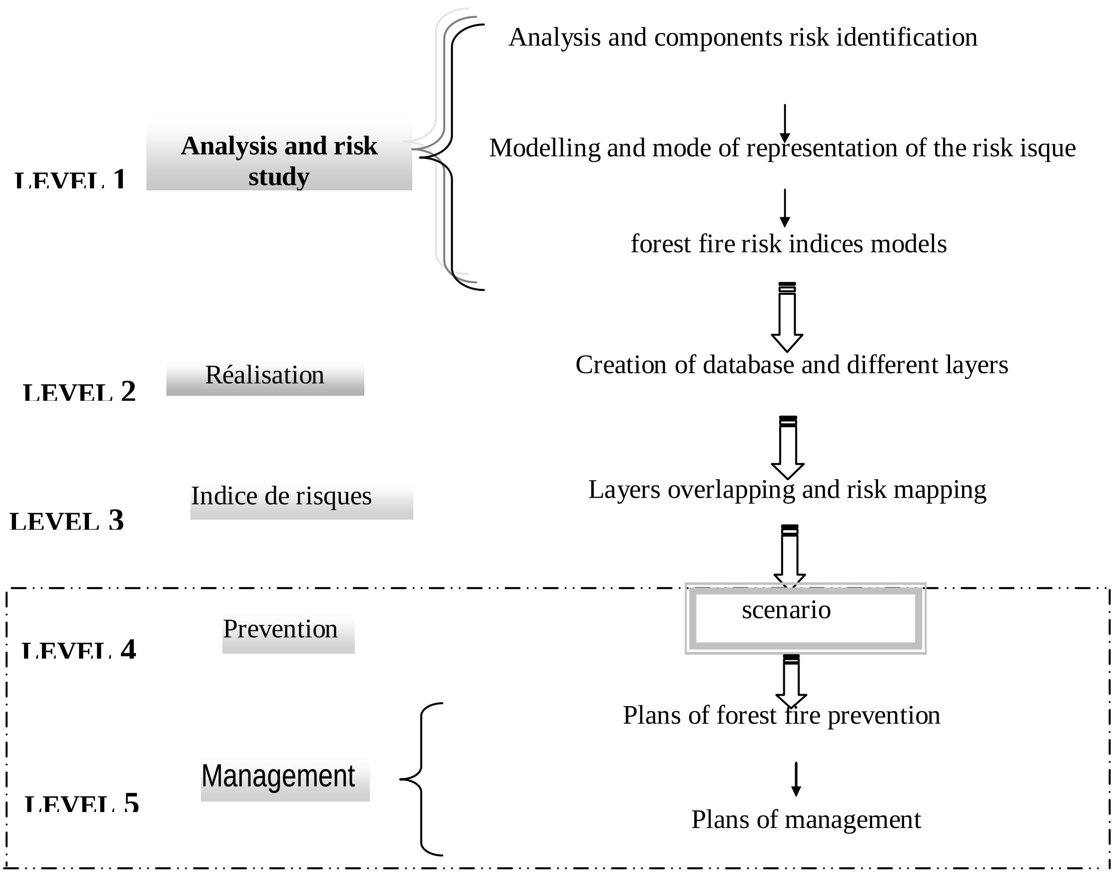


Figure 6 : block diagram for the mapping, the prevention and management of forests

3. CONCLUSION

Analysis of hazard is a complex task, as many factors can play important role in the occurrence of the disastrous event. Therefore, analysis requires a large number of input parameters, and techniques of analysis may be very costly and time consuming. The increased availability of Remote Sensing data and GIS during recent decades has created opportunities for a more detailed and rapid analysis of natural hazards. The proper structure of information system for disaster management should be present to tackle the disaster and to manage it.

In this communication, we present our contribution of the Algerian experience in the use of Space technologies for disaster management. In effect, Remote Sensing and GIS can provide useful information, and create disaster awareness with politicians, concerned decision makers and the public, so that on a national level decisions are taken to set up disaster management organisations. At such a general level, the objective is to give an inventory of disasters and the areas affected or threatened for an entire country. The following types of information should be included:

- Hazard free regions for development.
- Regions with severe hazards where most development should be avoided.
- Regions with hazards where development has already taken place and where measures are needed to reduce the venerability.

The remote sensing and GIS database can be used to create elaborate and effective Disaster Management Information System (DMIS). An integrated approach using scientific and technological advances should be adopted to mitigate and to manage natural hazards. Moreover there should be a national policy for natural disaster management.

REFERENCES

[1] **Cova, T.J.** *GIS in emergency management*. In: Geographical Information Systems, management and applications. Longley, P.A.; Goodchild, M.F.; Maguire, D.J. and Rhind, D.V.

[2] **Pearson, E, Wadge, G, And Wiscoski, A.P.** *An integrated expert system/GIS approach to modeling and mapping hazards.* Proc European conference on GIS, session 26, pp 763-771.

[3] **J. Harms, G. Pierre & J.C. Cazaux, 1997**. *Use of space technologies for majors risks management.* Remote Sensing'96, Spiteri editors, Balkema, Rotterdam,1997.

[4] **Alexander, D., 1993.** *Natural Disasters.* UCl Press ltd. University College London. pp 632.

[5] **Y. Smara.** *Imagerie satellitaire pour la détection de la pollution côtière*. Conférence IMPAC-2000, 23-24 Octobre 2000, Boumerdes, Algérie.

[6] **F. Del Frate, A. Petrocchi, J. Lichtenegger, G. Calabresi.** *Neural networks for oil spill detection using ERS-SAR data.* IEEE Transactions of Geoscience and Remote Sensing, vol. 38, n. 5, pp. 2282-2287,2000.

[7] *CMOD4 Model description*" ESRIN DPE/OM, 8p, February 16, 1993.

[8] **S. Bouchaib**, **Y. Smara, L. Salvatori, F. Del Frate & J. Lichtenneger.** *Oil spill detection and identification using radar sar data in the mediterranean sea.* World Conference on Energy For Sustainable Development, Technology Advances & Environmental Issues, 6-9 December 2004, Cairo, Egypt.

[9] **A. Belhadj-Aissa, F. Hocine, M. Belhadj-Aissa, M.Ouarzeddine & Y. Smara.** *Operational process interferometric for the generation of a digital model of ground Applied to the couple of images ERS-1 ERS-2 to the area of Algiers*. Workshop Fringe2003, 2-5 December 2003, ESA/ESRIN, Frascati, Italie.

[10] **F.G. Alonso & J.L. Casanova Roq**. *Application of NOAA-AVHRR images for the validation and risk assessment of natural disasters in Spain*. Remote Sensing'96, Spiteri editors, Balkema, Rotterdam,1997.

[11] **M. Belhadj Aissa, A. Belhadj Aissa & Y. Smara**. *Geographical information system and simulator of propagation of forest fires applied to the algerian forest.* World

Conference on Energy For Sustainable Development, Technology Advances & Environmental Issues, 6-9 December 2004, Cairo, Egypt.

BIOGRAPHIC NOTES

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