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Participants of the EERWEM workshop organised by ROA in San Fernando (Spain), June 13-16 2006

EDITORIAL

In welcoming you to this edition of the EMSC Newsletter which is focused on our project "Earthquake Monitoring and Earthquake Risk in the Western Mediterranean" (EERWEM), I am also conscious of our many other initiatives and successes in recent times. Collaboration with ORFEUS has gone from strength-to-strength, not only producing our joint leadership of EERWEM, with its important meeting point between North African and European seismological communities, but also the ambitious EC-funded project NERIES (Network of Research Infrastructures for European Seismology). With its many partners, NERIES focuses on developing new tools for improved seismological services through distributed facilities with common protocols and databases to achieve interoperability. The resulting shared infrastructure will form a key segment of the international GMES and GEO programmes in the next 10 years.

Beyond these initiatives, EMSC has continued to improve and develop its Real Time Earthquake Information services with the help of its members and the parametric data provided by the 58 contributing seismological networks. Rapid and reliable information is reported on current seismicity for Euro-Med earthquakes and large global ones through a public web-page. For the potentially damaging ones, an Earthquake Notification Service is also provided by SMS, e-mail or fax, to signed-up recipients. These core services are provided 24/7 thanks to the operational support of LDG (Bruyeres-le-Chatel) and the critically-important back-up of IGN (Madrid). In 2005/06, the location accuracy is confirmed to be better than 12 km, the median dissemination time (after occurrence) for manually reviewed (reliable) earthquake locations, was 33 minutes, a 10% improvement on 2004. This is largely thanks to the increasing efficiency of our data providers and their networks.

New services include, a facility for collecting and disseminating images of earthquake damage from users through a dedicated e-mail address (pictures@emsc-csem.org), and a macroseismic questionnaire available in 18 languages. These latter results are available in the Member section of the EMSC web site. The next step will be to complete intensities with the help and collaboration of ETH Zurich and the British Geological Survey.

Other facilities and services which have been evolving in recent years, and which are now available, include rapid moment tensor solutions from 11 institutes, which are plotted on one map and made available at http://www.emsc-csem.org/index.php?page=current&sub=qmt. They also include special web pages created for high profile events to bring together a wide variety of information, including regional seismicity maps for recent events.

Most of the activity in recent years has been focused on providing ever-more effective and efficient technical tools for our members and their downstream customers. We have reached the position where any inadequacies we face in providing services to researchers, Authorities and the public, lie in the integration of these tools; in particular, to avoid confusion when we use them. For example, the almost instantaneous broadcasting of ten different earthquake solutions or damage assessments by different agencies after a large Euro-Med event, will cause us problems and reduce our collective credibility. To counter this, we now need to spend some time on our policies, protocols and agreements in order to maximise the benefits from the tools and infrastructure we have created together.

However, with a membership of 75 institutions in 49 countries, it is impossible for the EMSC coordination group to discuss all of these issues directly with everyone. As a first step, we propose to issue a questionnaire to gather individual views and ideas about the way forward. We anticipate that this will result in much commonality of opinion from which we can benefit, leaving only a few elements to be debated in more detail. I do hope that all members will take this opportunity to contribute promptly and that your representatives will be able to attend the next EMSC General Assembly in Zurich on 13 June to hear something of the initial outcome and the problems yet to be solved. In this way, we can fully capitalise on all of our collective achievements and investments in recent years.

Chris Browitt
President

Earthquake monitoring and Earthquake Risk for Western Mediterranean (EERWEM): An EC-funded project to coordinate seismological networks in the Western Mediterranean

Bossu R. (1), Davila J. M. (2) and van Eck T. (3)
(1) European Mediterranean Seismological Centre, EMSC, bossu@emsc-csem.org
(2) Real Instituto y Observatorio de la Armada en San Fernando, Spain (ROA)
(3) Observatories and Research Facilities for EUropean Seismology (ORFEUS)

Introduction and Motivation

In 2004, the EERWEM proposal was submitted to the European Commission to improve coordination of existing and developing monitoring infrastructures and associate the Northern African seismological research community to the current and future European integrating initiatives led by the two European organizations in seismology, EMSC and ORFEUS. ROA, already collaborating with Northern Africa Institutes, accepted to join the proposal and the difficult task to organise the EERWEM workshop. It should be noted that at the same time, a counterpart proposal for Eastern Mediterranean named EEREM (*Earthquake monitoring and Earthquake Risk in Eastern Mediterranean*) and sharing the same objectives was also submitted, with the National Research Institute of Astronomy and Geophysics (NRIAG, Egypt) being the organiser for the dedicated workshop. Surprisingly, while EERWEM was well rated, EEREM failed to be funded for reasons that were not made clear by the evaluators.

At the time when the proposal was submitted mid-2004, the motivation for such a project was driven by the devastating Northern African, the Boumerdes (Algeria, M6.8, 21/05/2003) and the Al Hoceima (Morocco, M6.5, 24/02/2004) earthquakes, the then planned large technological investments in the Western Mediterranean area, notably Spain, Morocco and Algeria, and the desire to integrate further the Western Mediterranean within the European initiatives such as the European-Mediterranean Real Time Seismicity (initiated by the EC-project RWS ENV4-CT96-0282) and seismological bulletin (initiated by the EC project EPSI; EVR1-CT-2000-40006) and the European real-time waveform data exchange initiatives (MEREDIAN project EVR1-CT2000-40007).

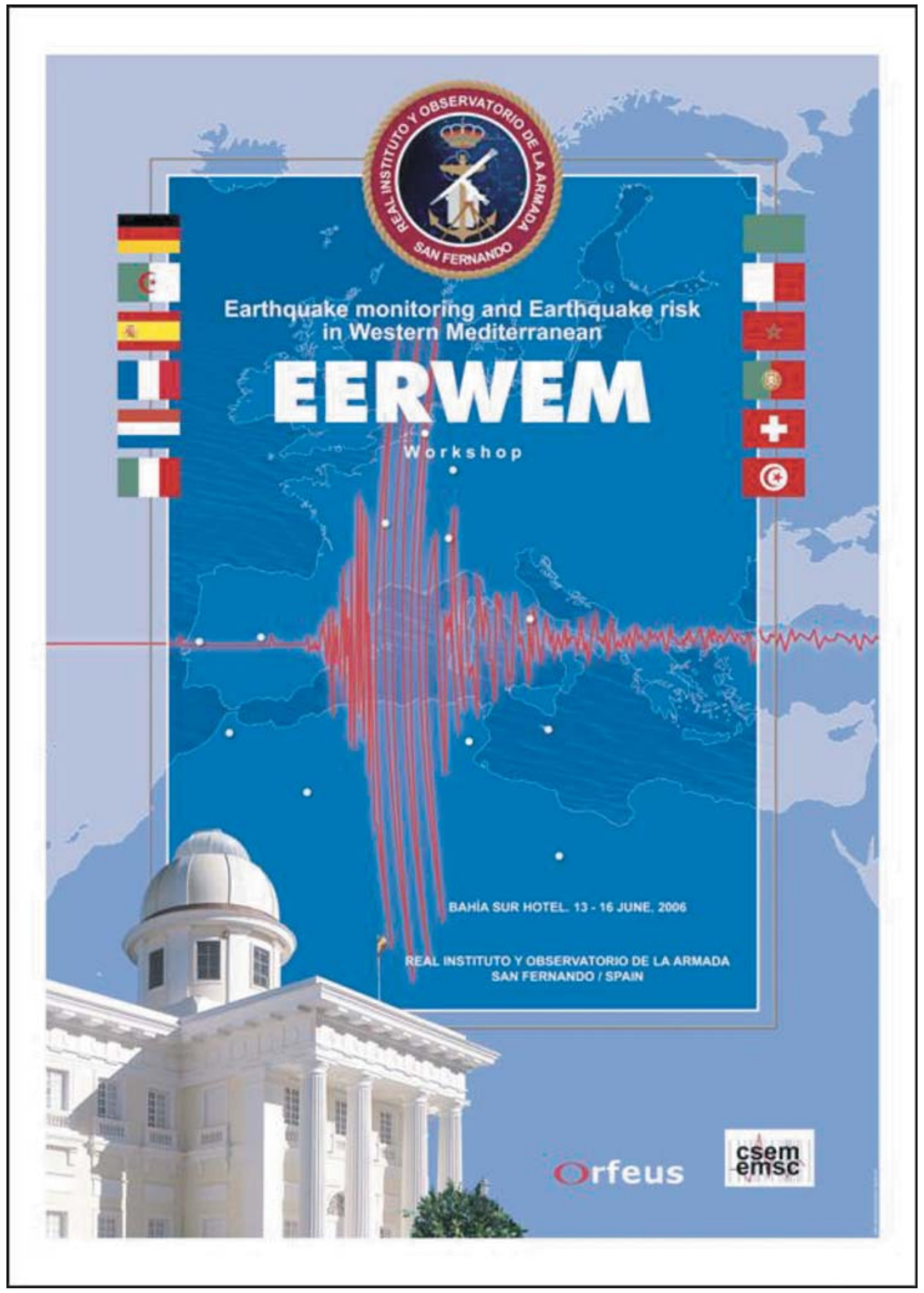
The pertinence of the project has been confirmed at the political level through 3 international initiatives, the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and Connected Seas (ICG/NEAMTWS), the Global Earth Observation System of Systems (GEOSS) and its European counterpart Global Monitoring of Environment and Security (GMES). In all 3 cases, the countries agree that the most appropriate and cost-efficient approach to monitor the environment and improve response to natural disasters is to use the existing infrastructure and ensure real data sharing.

In seismology, the implementation of these ambitious goals is being facilitated by the EC-funded project NERIES (NEtwork of Research Infrastructures for European Seismology: http://neries.knmi.nl), a large project jointly initiated by EMSC and ORFEUS which started on June 1st 2006. It deals with aspects such as interoperability, common protocols and databases, distributed facilities and developing new tools for improved seismological services. The earthquake research infrastructure as aimed at by NERIES will be a key land-based segment of the GMES and the GEO 10-years implementation plan. However, direct participation to the NERIES project is restricted to partners from EU countries and associated states while from a seismological point of view cooperation throughout the European-Mediterranean region is more desirable. EERWEM offers a unique meeting point between the European and Northern African seismological community to help in disseminating the results of NERIES, to help reducing the existing gap between Europe and surrounding countries and to ensure in the long-term a more homogeneous monitoring of the tectonic system of the Eurasia-Africa collision. It also helps facilitate participation of Mediterranean partners in more complex EU-funded projects in the future in an overall framework for a long term cooperation.

A large participation for a well organised workshop

To realize our objectives a workshop was organised in San Fernando (Figure 1), Spain by ROA in which the research organizations and observatories involved in the monitoring of the Western Mediterranean participate together with the EMSC, ORFEUS and researchers from some of the major European earthquake research and observatory facilities. In total 25 institutes or organisations were represented (International: EMSC, FDSN, IOC (UNESCO), ORFEUS; Morocco: CNRST, ISRABAT; Algeria: CRAAG and CGS; Tunisia: INM; Libya: LCRSS; Malta: UM; Italy: INGV; Switzerland: ETHZ; Germany: GFZ; France: GA, LGIT; Monaco: BIC; Spain: ROA, IGN, IGC, CSIC; Portugal: UCM, UE, IMP, IST). It combined the European experience on rapid data exchange and data management with the newly created infrastructure at the Western Mediterranean seismological institutes.

Figure 1: *Poster of the EERWEM workshop*



Tangible results

The workshop summarized the current knowledge, on-going projects and research plans with regard to seismic activity and risk in the region. Participants presented their networks, on-going collaborations and their plans for the future (see the following articles for more details) in relation to the required research and regional monitoring infrastructure taking into account the new context created by the three essential initiatives for our community namely GMES, GEO/GEOSS and NEAMTWS.

Probably the most significant result of the workshop has been the definition of a Memorandum of Understanding (MoU) "*for the establishment of a Cooperation framework on earthquake surveillance in the Western Mediterranean Region*". This MoU was drafted and discussed during the workshop. Its objectives are:

- To improve the cooperation in earthquake monitoring
- To provide input for improved assessment of seismic hazards
- To build a regional network for earthquake surveillance
- To reinforce and ally the local institutions and personnel
- To facilitate access to advanced technologies
- To increase the regional participation in international activities

The MoU includes a first-year of demonstration activities which is the first step towards "*the establishment of a Regional Seismic Network in the Western Mediterranean (RSN-WM), building largely on the existing infrastructures already installed or planned by the national and local agencies […]. The RSN-WM will build the backbone for the participation of the Western Mediterranean countries in the IOC 'North-Eastern Atlantic and Mediterranean Tsunami Warning*

System' (NEAMTWS)". During this demonstration period, the signatories agree to make available in real-time the waveform of at least one station to all the other parties. The final version of the MoU comprises the text in French, Spanish and English and is available on the EERWEM web site (www.roa.es/eerwem).

So far, the MoU has been signed by 19 institutes from 11 different countries, including all the partners from Morocco, Algeria and Tunisia. The national Libyan network may sign the MoU in the future and we are currently exploring the possibility to start exchanging parametric data in the first stage. This MoU constitutes the earthquake (risk) research infrastructure integration plan for the Western Mediterranean region and as such is a significant step towards a better integration of our community on a European-Mediterranean scale.

Its implementation is being facilitated through a system of EERWEM grants (Table 1) although it should be noted that the main part of the budget required to create a regional network (notably hardware) originates from national funding and/or bilateral agreements. Since the workshop a number of bilateral collaborative projects have been initiated

Data supplier (Observatory)	Data receiving observatory	Comments
CNRS, Morocco		One station planning
IGN, Spain		One station testing
I.S. Rabat, Morocco		One station testing (*)
ROA, Spain	I.S. Rabat, Morocco	One station planning (*)
I.S. Rabat, Morocco	IST, Portugal	One station planning (*) project NAVIGATOR
CGS, Algiers	ORFEUS	One station planning (*)
CRAAG, Algiers	IGN, Spain	One station planning (*)
Oran Univ., Algiers	ROA, Spain	One station planning (*)
INM, Tunis	Monaco, France	One station planning

***Table 1:** Current initiatives to initiate and accomplish real-time waveform data exchange. Several of these initiatives benefit so far from EERWEM grants as indicated with (*).*

and signed (ETHZ-CRAAG; Monacco-Tunis, …) and additional initiatives have been pursued. For example, GEOSCOPE has made available in real time its station in Tamanrasset (Algeria) and, by doing so, contributes to the MoU on its own budget. A report will be published on the advancement of the MoU at the end of the first year period, October 2007.

Conclusion

The EERWEM project illustrates the efficiency of a relatively small project to improve collaboration and network coordination on a regional scale. Such coordination is probably one of the main challenges for our community in the next decade. Therefore, we hope this project serves as a demonstration of what can be achieved with existing data exchange tools and we hope to initiate in the near future similar projects in other regions, like, but not exclusively, Eastern Mediterranean.

Acknowledgements

We thank all contributors for their enthusiasm in making the workshop and its successive actions a success. We also thank prof. Domenico Giardini, as coordinator of the NERIES project and president of the board of directors of ORFEUS to initiate the Memorandum of Understanding..

Moroccan Seismic Network and Data Exchange

Jabour N. (1), Timoulali Y. (1), Menzhi M. (1), Hahou Y. (1), Hni L. (1), Badrane S. (1), Kasmi M. (1), Birouk A. (1) and Benchekroun S. (1)
(1) Institut National de Géophysique, CNRST-Rabat; Morocco, jabour@cnrst.ma

The analog seismic network that has been set up by the National Research Center two decades ago for the real seismic monitoring in Morocco and the neighbouring regions has contributed in the identification of new seismogenic zones in spite of many technical difficulties to cover all the national territory. Constituted in the starting years of 30 autonomous short period stations, (Figure 1), the network detectability has gradualy decreased due to the deterioration of the equipments either by climatic or anthropic factors. The seismic network has yielded many data that were in great part sent to international centers, ISC, USGS and later EMSC to complete the bulletins, (Jabour, 2006).

Meanwhile, a VBB seismic station was set up within the framework of the mediteranean network in Midelt Morocco, (Giardini et al., 1980), and later transfered to Rabat, this station is providing near real time seismic data to INGV-Roma.

The need for a real time data exchange has added new constraints in the routine work of the geophysics team. The quick seismic determinations, even from analog data, are sent promptly to the EMSC and IGN in order to be merged with other seismic data. This experience has shown its limits, particularly in the case of large earthquakes when delays in data exchanges do not allow to interpret correctly the parameters of an event, (Jabour et al., 2004).

In cooperation with researchers from IGN-Spain, the implementation of a method for the transfer of seismic signals in real time from the Spanish broad band stations to the CNRST-Morocco (as a first step) was addressed. This step would be followed by the installation of a broad band seismic station that will be provided by IGN-Spain (as a second step) in northern Morocco.

After several tests and with the cooperation of MARWAN service in CNRST- Rabat, we are able to receive seismic signals from five Spanish stations in real time. The method consists of the use of emission and reception techniques developed by the CTBTO using the IP networks. Seismic waveforms are sent from Madrid making use of REDIRIS, GEANT, EUMEDCONNECT and MARWAN networks to be finally recorded in real time in a server within the MARWAN service in the CNRST-Rabat.

Actualy, the National Geophysics Institute is preparing a plan for the upgrading of the existing network. The installation of a new digital network will help tremendously in both rapid seismic determination and data exchange.

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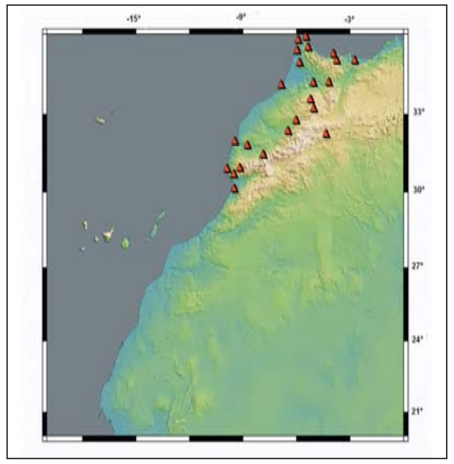
***Figure 1:** Moroccan sesmic network.*



The first steps of a new broad band seismological network (Scientific Institute-Morocco)

A. Rimi (1), M. Harnafi (1) and B. Tadili (1)
(1) Department of Earth's Physics, Scientific Institute, Avenue Ibn Battouta, B.P. 703 Rabat-Agdal, 10106 Morocco, rimi@israbat.ac.ma ; harnafi@israbat.ac.ma ; tadili@israbat.ac.ma

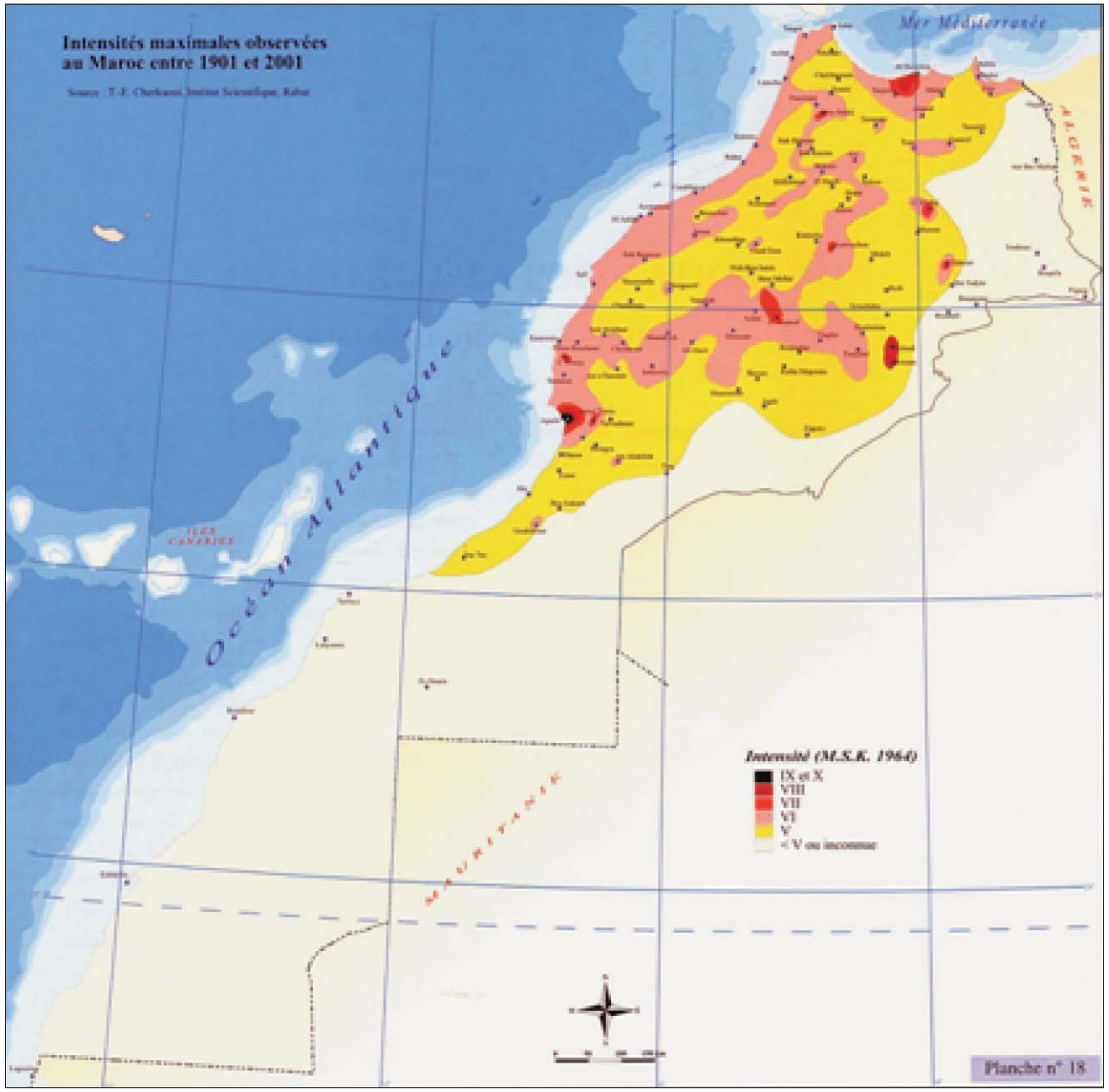
Introduction

Due to outstanding geographical position of Morocco, its tectonic evolution has been the result of continuous interactions between the main lithospheric plates, namely the American, the African and Eurasian plates, on the other hand its seismic activity has been of first-rate importance in the geodynamical studies and the assessment of the seismic risk over the Ibero-Maghrebian region as well.

Historic insight

Since 1933 the attributions as research in seismology of the Section of Earth's Physics and Meteorology (S.P.G.M.) of Scientific Institute (I.S.C.) have been fixed by Viziriel Decree of the 12 Rabia II 1352 (August 5th, 1933) as the research relating to seismology and geophysics and conducting particular studies necessary for various administrations. Only S.P.G.M. has been qualified to make available all information of a geophysical nature for

***Figure 1:** Maximal Intensities felt in Morocco from 1901 to 2001.*



the state departments and the public, under his scientific and technical responsibility.

Role of the Scientific Institute in seismology Observatory work

- a- Design and maintenance of the seismological network for the monitoring of the seismic activity over the territory. In 1937, the first seismological station in Morocco was installed at Ibn Rochd observatory of (Averroès). In the middle of the Seventies, deep seismic soundings and studies of microseismicity began. In 1981, the number of the stations of the national seismological network passed from two in 1964 to fourteen. It was regarded as the 1st in the Arab world and the 2nd in Africa.
- b- Data-gathering provided by the seismological network, their interpretation and diffusion of the results in the form of catalogues, bulletins and seismicity maps. However the diffusion of seismological information in the form of weekly, monthly and annual paper bulletins has been stopped since 1990, but PDF versions of the bulletins were made in the web page of the Institute until 1998. At present data has been sent regularly to the CSEM.
- c- Field intervention, in the event of major earthquake, for the recording of the aftershocks and the macroseismic investigation;
- d- Earthquakes Databases The macroseismic seismological data (since 1913) and instrumental (since 1937) constitute an inheritance of constant increase. These databases are of capital importance for the research tasks in seismology and seismic hazard.

Research Activities

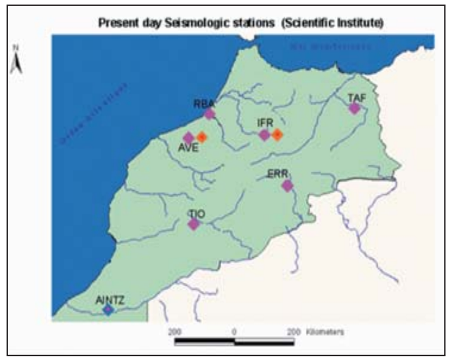
Seismic risk assessment: the research tasks undertaken by the researchers of the DPG relate to seismology, seismic zoning and signal processing. Some lie within the scope of conventions with public, semi-public or private organizations; others are led in collaboration with Moroccan and foreign university institutions.

Present day Situation

A short period network has been operating since 1937 over the Moroccan territory. In 1981, the number of the stations of the national seismological network passed from two in 1964 to fourteen. During the last decade this network has been reduced to four one/three components analogical stations. The data have been transmitted to Rabat by post or by phone. Three stations are being upgraded at present by installing digital equipement.

- Since the EERWEM-ROA workshop held at San Fernando on June 2006, a progress has been recorded in the seismological activities at the Scientific Institute as follows. Several trips of geophysicists between Morocco, ROA and Evora (Portugal) have been done for more than once in both senses thanks to EERWEM and University Complutense of Madrid grants.

Figure 2: *Sismolgical Network, the purple squares indicate short period stations, the orange squares are Broad band stations within cooperation with ROA-UCM; the blue square is a Broad band station which will be installed by Instituto Superior Tecnico, Lisbon.*



- The first Broad Band seismological station in Morocco (After Mednet Station) was carried out on July 2006, within framework of the cooperation agreements between the scientific Institute, the Completense University of Madrid (UCM) and the Royal Observatory of Armada (ROA) of San Fernando, with the support of ROA and UCM via RISTE project.
- The installation still needs some enhancement regarding to the Internet connection, however the Department of Earth's Physics is entirely connected to the Western Mediterranean network in real time which had help to a better determination of the recent earthquakes in Morocco (by using Moroccan stations and some of the Western Mediterranean Network).
- The second Broad Band seismological station in Morocco will be installed at Ifrane observatory (IFR) on April 2007.
- On the other hand a proposal of Joao Fonseca (Instituto Superior Tecnico, Lisbon) to acquire broadband equipment for the Azores Gibraltar region was approved by the Portuguese Government. In this framework it is planed to install one of the new stations at the Aouinet Torkoz observatory (ANTZ), (Figure 2). The first step which is to visit the site and assess its logistic conditions was also approved by EERWEM via ORFEUS to cover the costs of this trip during March 2007.

Outlines

2007-2008

- a- Connecting Averroes observatory and its Broad Band seismological station, to the worldwide seismological network (Internet).
- b- Developing the seismological network by the installation of Broad Band seismological stations at Ifrane thanks to co-operations of ROA-UCM.
- c-Installation of Boroa Band station at the Aouinet Torkoz observatory (ANTZ).
- d-Carrying on a good cooperation with Moroccan institutions to exchange seismological data. The successful recent reoccupation of the HAD station using a digital station of Faculty of Sciences and Techniques of Errachidia is a good example.
- e- Installing two accelerometers for studying ground movements one in AL Hoceima region and the other in Tangiers region.
- f- The file of T. Cherkaoui. (1988), stopped in 1985 is to be brought up to date.
- g- At the time of the fiftieth anniversary of Mohammed 5 Agdal University and the sixty tenth anniversary of Averroes observatory, a scientific meeting will be organized in November 2007 to meet together moroccan seismologists and our partners from Spain, Portugal, Itay and France.

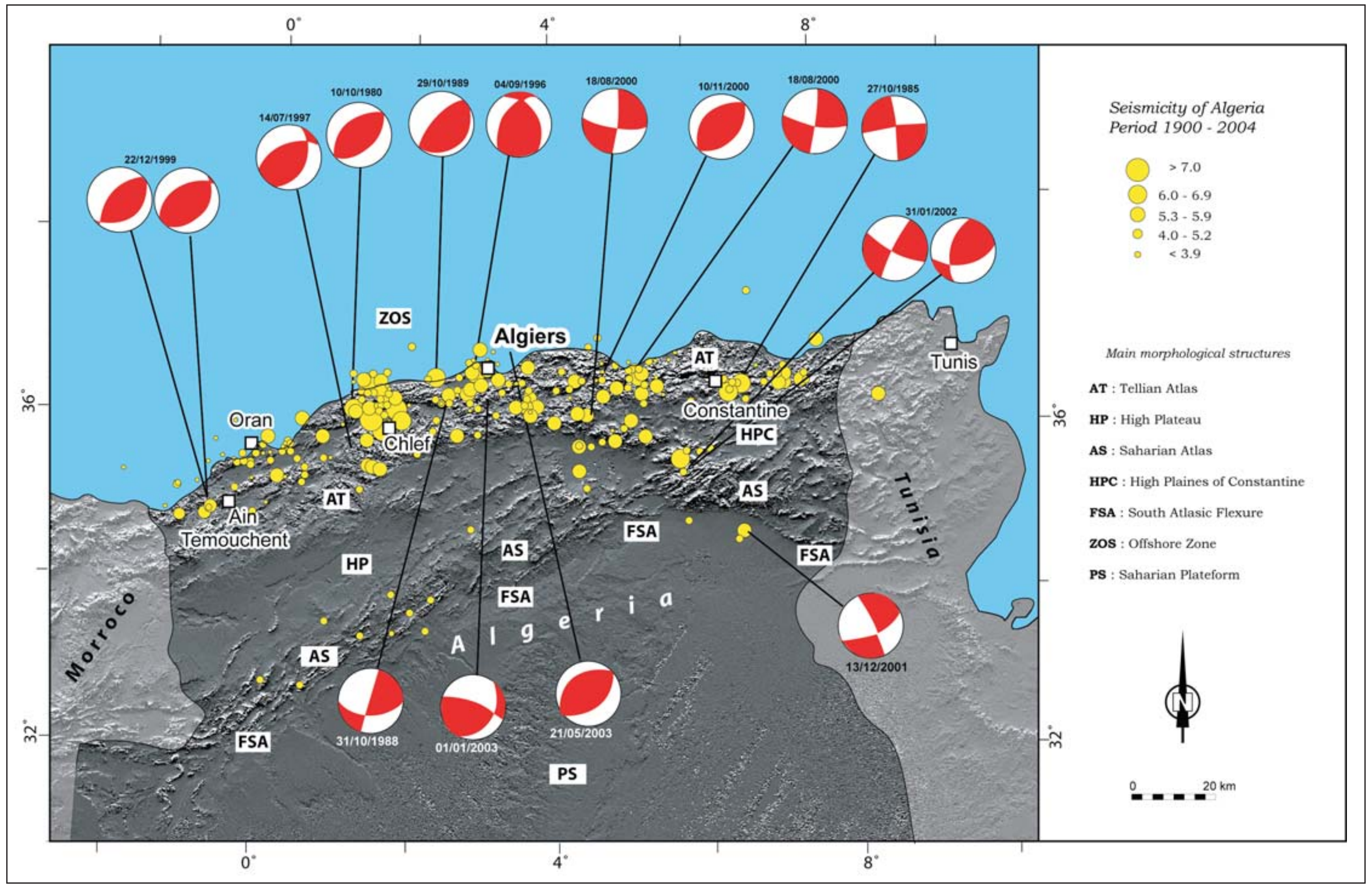
Mid term plan (2010 how should be the network and data policy)

- a- Developing the seismological network: The four geophysical observatories (Averroes, Ifrane, Tiouine and Aouint Torkoz) will be fitted out with Broad Band stations.
- b- Connecting Tiouine and Aouint Torkoz observatories to the electric network.
- c- Connecting the seismological network in real time and data will be available from DPG-IS (Rabat) via Internet,.
- d- Carrying on a good cooperation with Moroccan institutions to exchange seismological data (Universities and CNRST). The successful recent reoccupation of the ERR station (Figure 1) using a short digital station of Faculty of Sciences and Techniques of Errachidia is a good example. We intend starting seismological data exchange with some Broad Band stations installed within the framework of CNRST cooperation with Spanish IGN (Taounate region, Rif).
- e- Studies of microseismic zoning, Application and update of the paraseismic construction code.
- f- With the help of the national institute of geophysics and volcanology of Rome INGV (SISMOS project) we planned to scan and archive especially the old Moroccan data extending from the Thirties through the Sixties, by digitilizing the analytical seismograms.

The Algerian digital network

A.K. Yelles-Chaouche (1), H. Djellit (1), S.Haned (1), A. Deramchi (1), T. Allili (1), A. Kherroubi (1), H. Beldjoudi (1), F. Semmane (1), A. Amrani (1), Z. Haddana (1), F. Chaoui (1), A. Aidi (1) and A. Allili (1)
(1) Centre de Recherche en Astronomie Astrophysique et Géophysique (C.R.A.A.G.) Route de l'Observatoire B.P. 63 Bouzareah Alger,
kyelles@yahoo.fr

Figure 1: Seismicity of northern Algeria



Introduction

Northern Algeria lies along the Eurasian-African tectonic boundary. It is marked, in comparison with other Mediterranean areas (Italia, Greece, Turkey) by a moderate seismic activity (Figure 1). However, some strong events could happen, causing important damage to the urban centers. For examples, we can list the Algiers events of 1365, 1716, the Oran event of 1790, the Blida event of 1825, events of El Asnam of October 10th, 1980 and Boumerdes of May 21st, 2003.

To monitor the seismic activity in Algeria, great efforts were made since 1998 to re-install the telemetry seismological previously deployed in 1990 and which stopped one year and half after. During these last eight years, thirty five stations were installed. This allows to face the major crisis of the Boumerdes earthquake of May 21st, 2003 and to have for the first time a good record of the seismic activity of northern Algeria during a long-time period.

Nevertheless evolution of the technology in terms of captors, digitizers and transmission imposed to adapt our seismic monitoring to these technologies. To update our network, we made recently an acquisition of a new digital network. The main objectives of this network are to improve the data quality and to implement a real time alert system.

The actual REALSAS network (Réseau Algérien de Surveillance et d'Alerte Sismique)

The actual seismic network called "REALSAS" is composed by a central station of Algiers and four subnetworks (Algiers, Oran, Chleff, Constantine) (Figure 2)

Figure 2: The actual seismic network

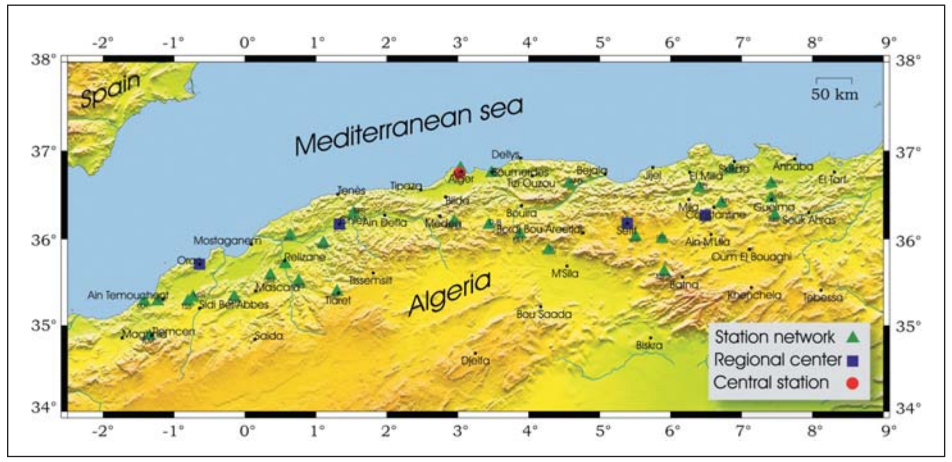
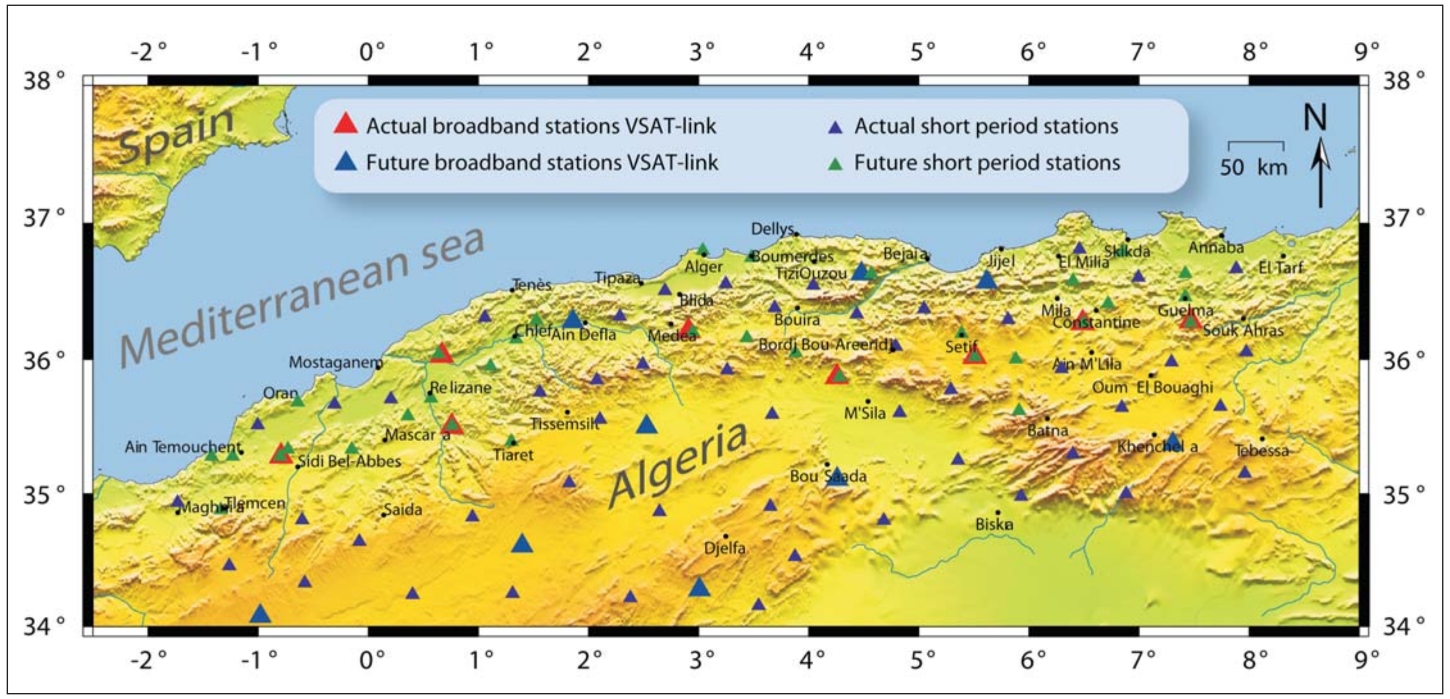


Figure 3: The future Algerian Digital Network



Each subnetwork is composed by a regional station with a three components sensor and some uni-component stations (SS1 short period seismometer), installed in the mountains of the Tellian chain. These later transmit their signal to the regional stations by radio-link mode.

At the central station located at Algiers, all the analogical signals are collected and recorded on drums. The analogical signal is also transformed in digital form for the data processing.

In addition to the telemetry network, some local stations were installed in areas (Guelma, Batna, Médea, Tlemcen, Tipaza) not well covered instrumentally (Figure2). These stations are connected to the central station of Algiers by telephone link.

Although the efforts made these last years, the seismic monitoring still suffers from some technical problems related to the poor quality of the transmission mode due to interferences, the analogical form of the signal delivered by the stations and the lack of a real time detection of the seismic events.

During the Boumerdes earthquake of May 21st, 2003 which lasted 3 years, the seismological service of CRAAG faced the situation with courage and deployed great efforts to face the crisis although the constraints mentioned above. However, this situation indicated the urgent need to accelerate the updating of the network.

This was made in 2006 by the acquisition of a new network formed by 50 new stations of Kinemetrics type.

The new Algerian Digital Network

Deployment

The new digital network which consists of 10 Broad Band stations, 40 short period stations and a Data Center uses the Antelope software for the data processing and data management. The Broad Band sensors and digitizers are respectively STS-2 and Q-330 types. Deployment of the new network started by the implementation of the Data Center on which some available digital stations were connected.

The second phase for the network started recently. It consists to finalize the site selection for the 10 Broad Band stations.

The third phase will be the building of the sites in respect of the several technical recommendations and criteria. This phase will be ended at the end of July 2006.

After installation of these 10 Broad Band stations, installation of the 40 short period stations will start. These stations will be located at places where no seismological stations already exist. This last phase will be ended at the end of 2008.

In parallel, the CRAAG has recently developed cooperation with China and benefits of a new digital network formed by eight Broad Band stations, two VBB seismic stations and a data center. This network using the VSAT transmission system is now in operation and allows a real time detection of the seismic event.

Future developments

Although the installation of this important number of new stations, we have also planning to complete the network by the acquisition of new broad band stations in order to have the more complete coverage of the northern region of Algeria. In addition some other stations will be installed in the Hoggar region where a seismic activity is recorded.

To complete the seismological stations network, some GPS stations will be deployed to analyse the strong motions in this area. Data centers will be developed in the eastern and western part of Algeria to supply the main Data Center of Algiers.

Conclusions

After a period where the Algerian seismic network were reduced to four stations, great efforts have been made these last eight years to redeploy the Algerian seismological network or to update its technology. With the new digital equipment and a total number of about 100 stations, we can assume that Algeria is now well equipped for the seismic monitoring and also to make good research studies in seismology and seismic hazard assessment.

The main challenge now will be to maintain this network in operation and dominate all difficulties which could happen in term of security, data transmission and data processing.

The network will also allow to cooperate with the other foreign seismic centers, to participate with efficiency to the EERWEM project and the next NEAMTWS alert system.

The engineers and researchers team of CRAAG who are in charge this network are ready to face this challenge.

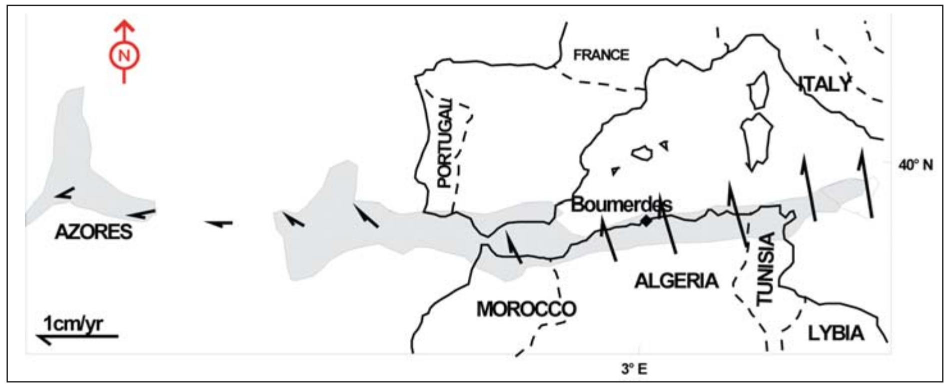
The Algerian accelerograph network

Nasser Laouami (1)
(1) National Earthquake Engineering Research Center, CGS, 1 Rue Kaddour Rahim BP 252 Hussein Dey 16040 Algiers, Algeria.
nlaouami@cgs-dz.org, n_laouami@hotmail.com.

Introduction

Algeria is located on the northern edge of the African plate, which is converging with the European plate since the Mesozoic, with a shortening rate of about 4-8 mm/yr [1, 2, 3] (Figure 1). Northern Algeria is a highly seismic area, as evidenced by the historical (1365 to 1992) seismicity [4, 5, 6] (Figure 2). During the last three decades, northern Algeria experienced several destructive moderate-to-strong earthquakes. Since the 1980 El Asnam earthquake (M_S 7.3), which claimed over 2700 lives and destroyed about 60 000 housings, many moderate, but destructive, earthquakes occurred, such as the Constantine October 27, 1985 (M_S 5.7), Chenoua October 29, 1989 (M_S 6.0), Mascara August 18, 1994 (M_S 5.6), Algiers September 4, 1996 (M_S 5.6), Ain Temouchent December 22, 1999 (M_S 5.6), the Beni Ourtilane November 10, 2000 (M_S 5.5) earthquakes, and the Boumerdes May 21, 2003 (Mw=6.8) earthquake.

Figure 1: Map describing the convergence between the African and Eurasian plates (redrawn from [1]). The arrows indicate the shortening orientation.



The Algerian accelerograph network

Earthquakes representing a major threat to the densely populated and heavily industrialised areas, a better knowledge about the characteristics of earthquake strong ground motion is a useful element in any policy aimed at mitigating the seismic risk in earthquake prone areas.

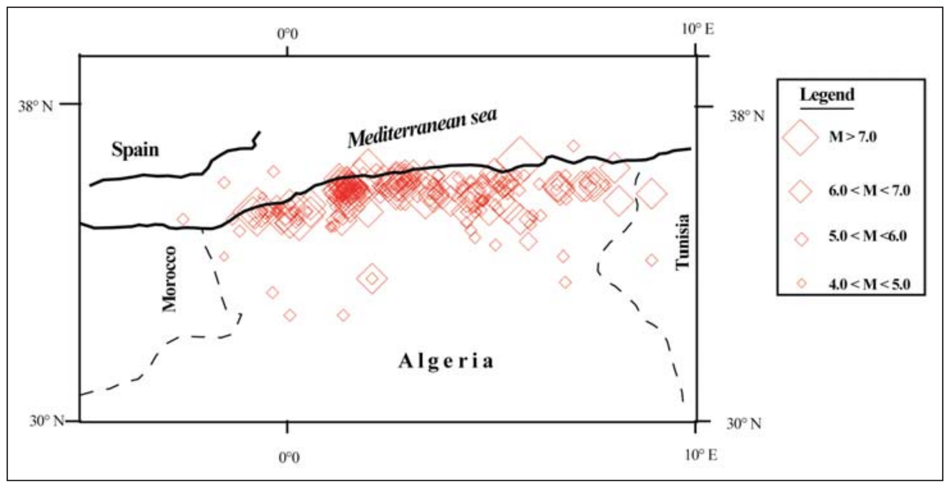
The lack of strong ground motion data was significantly experienced when elaborating the first Algerian aseismic building code in 1976. It was therefore decided to implement a countrywide accelerometer network. The installation of 335 3-component accelerographs started in 1980, 218 of which are already installed in the free field, and 30 in structures (buildings, dams …etc.) (Figure 3). The network was acquired in three stages: (i) following the 1980 El Asnam earthquake, 90 analog SMA-1 accelerographs were installed mainly in the free field, (ii) in 1990, 80 SMA-1 analog and 40 SSA-1 digital accelerographs were acquired in order to densify the existing network, with more emphasis on structures (buildings, dams), and (iii) 125 Etna digital accelerographs, acquired in 2002-2003, are currently being installed.

The objectives for free field installed accelerographs are:

- To monitor active faults to understand the rupture process and be able to interpret the radiation pattern of the motion from the source to the different sites of interest.
- To measure the ground response to earthquakes in different geologic (rock conditions and different types of deposits having different thickness and velocities), and topographic (hills and valleys) conditions.

Data collection on the response of buildings to strong ground motion is the other objective assigned to a limited number of instruments installed in different types of structures. Depending on their height, instrumented buildings are equipped with either two accelerographs for the small ones, and with three accelerographs for the tall ones. An additional instrument dedicated to record the surface free field motion is installed at some distance from the building, to avoid building influence on the recorder ground motion.

Figure 2: Seismicity map of Algeria for the period 1365-1992, after the catalogues of CRAAG [5] and Benouar [6] (Magnitudes Ms).



Data processing

Data processing is carried out with the Kinemetrics SWS [8] and SMA [9] softwares. Analog records are digitized using a 600 dpi scanner [10] and processed with the Kinemetrics scanview software [11]. The sampling frequency for both digital and digitized analog data are set to 200 sps. The Trifunac method [12, 13] used for data processing is based on three steps: (i) instrument correction, (ii) baseline correction of the acceleration data, and (iii) high-pass filtering of velocity and displacement, using an Ormsby filter. For instrument correction the low-pass cut-off frequency of the Ormsby filter is set to 28 Hz for the SMA-1 and SSA-1, and 45 Hz for the ETNA, with a 3 Hz roll-off width. The corner frequency for both long-period baseline correction filtering and high-pass filtering of velocity and displacement, depends mainly on the spectral signal-to-noise ratio of each component, and is estimated in the 0.12-0.2 Hz range with a roll-off width of 0.06 Hz and in the 0.2-0.3 Hz range with a roll-off width of 0.1 Hz for digital and analog data respectively.

Recorded strong motions data base

Since some years, the C.G.S. has developed the earthquake data base. It contains earthquakes recorded by the national accelerograph network which are the El-Asnam October 10, 1980 (M_l = 7.3), the Constantine October 27, 1985 earthquake (M_S=5.7), the Chenoua October 29, 1989 earthquake (M_S=6.0), the Masacra August 18, 1994 earthquake (M_S= 5.6), The Algiers September 4, 1996 earthquake (M_S=5.6), the Ain Temouchent December 22, 1999 earthquake (M_S= 5.6), the Beni Ourtilane earthquake (Ms=), the Boumerdes May 21, 2003 earthquake (Mw=6.8) [14] and the Laalam Marsh 20, 2006 earthquake (Ms=5.2).

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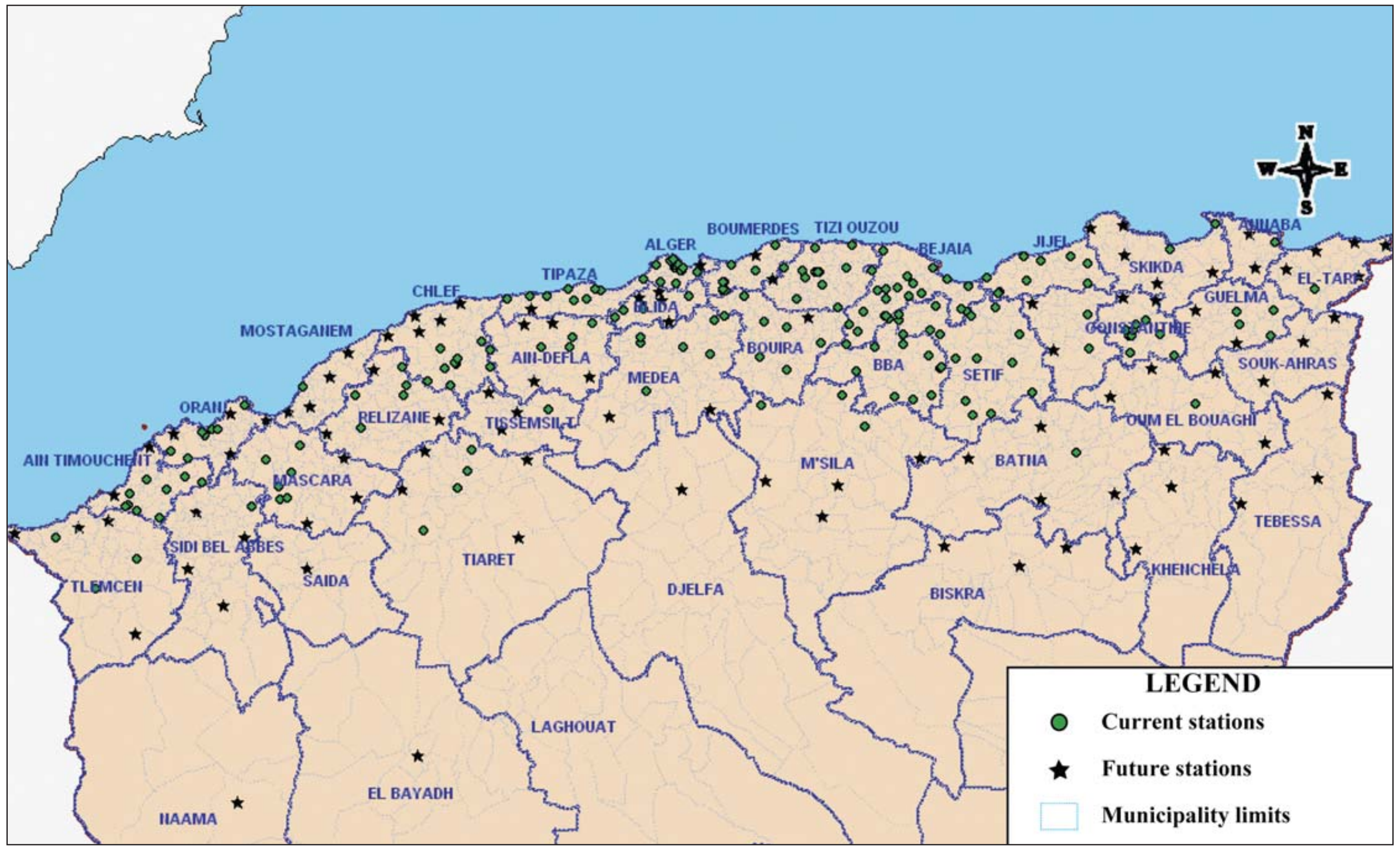
Figure 3: The national accelerograph network, with the regional administrative limits. The numbers in parentheses next to the filled triangles stand for the number of stations installed in the region.



The Tunisian National Meteorological Institute Modernizes the seismological network Project of co-operation Monaco - Tunisia.

Attafi K. (1), Samir B. A. (1), Mondielli P. (2), Deschamps A. (3), Régnier M. (3)
(1) National Institute of Meteorology , INMT, attafi@meteo.tn
(2) Direction environment Town planning and Construction of Monaco
(3) Géosciences Azur, CNRS/IRD/UNSA/UPMC

Throughout its plans of development, Tunisia focused its efforts to ensure its sustainable development and the safeguard of its socio - economic infrastructure and paid a special attention to natural disasters, particularly to earthquake impacts. Within this framework, we plan to upgrade and re design the existing seismological network into the Tunisian Seismic Alert Network (RAST). Moreover, prospecting for partnerships were undertaken, jointly with the CSEM. This interest leads on September 7th, 2006, to a meeting in Tunis between President Ben Ali and SAS the Prince Albert II, who discussed co-operation matters between Tunisia and Monaco. A convention program entitled "Reinforcement of the means and of the capacities in the field of the study of the seismic risk" was signed, on this occasion, by the Tunisian Transport Minister and the Adviser of the Government for the Equipment, the Environment and the Town planning of Monaco.

Figure 1: Seismicity of Tunisia

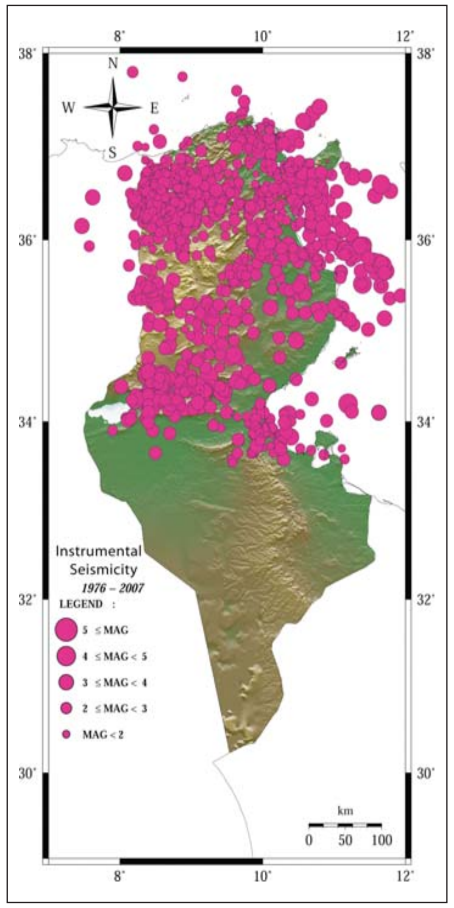
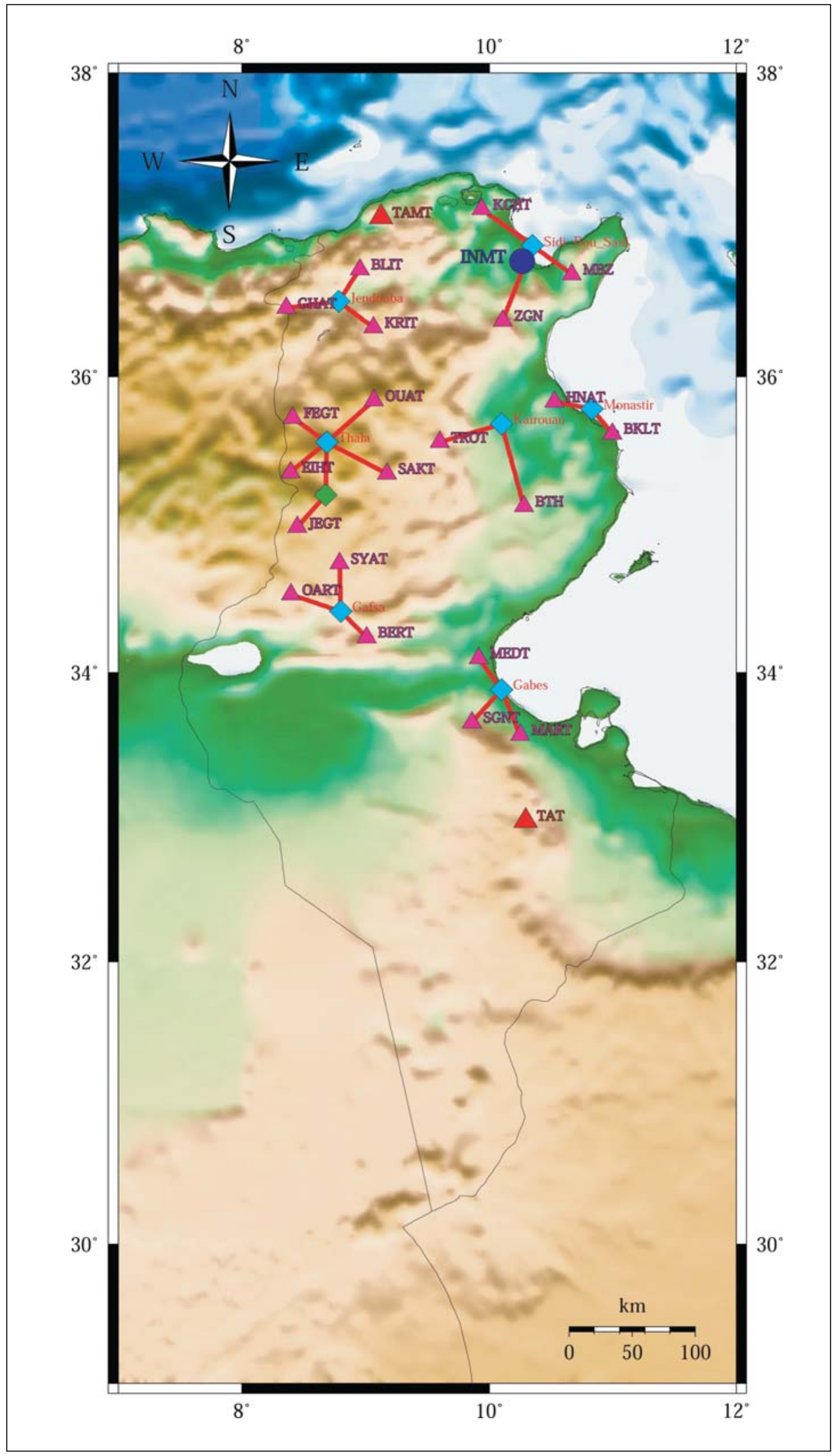


Figure 2: Current seismic network and planned sites for broad band seismic station



The Tunisian State intention is to increase the activity of the National Institute of Meteorology (INMT) in monitoring the seismicity (Figure 1) at the Mediterranean and international scale (reduction of the risks - seismic alert and alert system to the tsunamis). This co-operation project is placed in the perspective of a progressive upgrade of the Tunisian seismic network to digital data transmission which will provide suitable data to the modern scientific needs.

Indeed, the actual seismological network (Figure 2) managed by the INMT has been in operation during these 2 last decades. It comprises 14 seismological mono component stations (analogic transmission UHF) transmitting data to 5 regional receiving sub-centres (Sidi Bou Saïd, Kairouan, Jendouba, Gafsa and Gabès) and 5 digital seismic stations around Thala sub-centre. All the data are then centralized in Tunis for the catalogue establishment and data exchange in real time with the CSEM.

As a modern national network, the proposition for the Tunisian network will include:

A broad band component with rather large space mesh.

A short period component in the active zones with higher station density.

These two components will make it possible to fulfil the missions of detection, alert and analysis of the local and regional seismicity.

Within this co-operation frame, two missions were carried out. The first mission held in Tunisia from 23 to March 25, 2006 during which a contact was made and which was continued during the meeting EERWEM that took place from the 13 to June 16, 2006 in San Fernando in Spain, where the project Tunisia – Monaco was presented.

Figure 3 : Background noise measurement: CMG 40 seismometer– Data logger OSIRIS

Monaco, to reinforce this co-operation project, requested scientific and technical support and assistance from the laboratory Géosciences Azur of Nice - Sophia Antipolis. A second mission was held from 5 to February 9, 2007. The mission objectives were to evaluate a number of sites pre selected by the INMT team. During this on site mission, the two teams Monegasque and Tunisian, carried out background noise measurements (Figure 3) and evaluated the facilities for data transmission.

After processing of the acquired data, the validation of the first three sites will make it possible to choose and order the equipments. Training will be then organized in France at the Laboratory Géosciences Azur for 1 or 2 Tunisian technicians. By the end of the year 2007, three broad band stations should be brought and set up on the Tunisian territory.

The recorded data of these stations will be communicated in real time at the scientific community through a server to be set up the framework of this co-operation. The distribution of these data will improve the visibility of the scientific activity of Tunisia in the Euro - Mediterranean context (Particularly CSEM) and of its effective participation, especially, in the Projects of tsunamis alert (SATANEEM).

The reinforcement of this network, by the means of this co-operation, will be especially useful to improve the capacity of seismic alert with a better earthquake location on the Tunisian territory.

Libyan National Seismological Network (LNSN)

Eshwehdi A.
The National Authority of Scientific research, The Libyan Center for Remote Sensing and Space Science, Seismological Office, P.O.Box 82245
Tripoli, LIBYA, eshwehdi@yahoo.com

Figure 6: Professor. S.Lasocki, Eng. Eshwehdi; head of the seismological office with LNSN staff during training course in September. 2004.

Introduction

The Great Socialist Peoples Libyan Arab Jamahiriya has witnessed vast development and progress in all trends of life. Libya has a coastal line of about 1800km and an area of about 1.8 Mkm², with more than 5 million people. About 70% living in the northern part of the country, where historical and recent instrumental seismic events has been detected due to regional tectonic deformation.

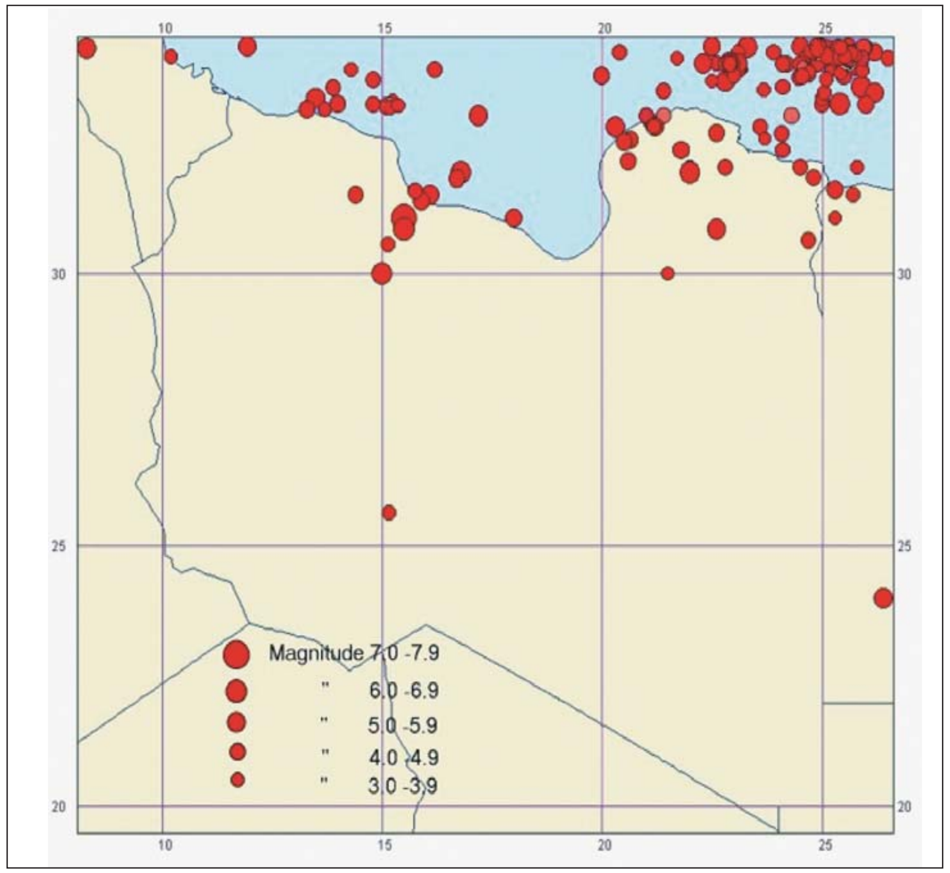
Seismicity

Libya is not commonly a country seismically active. But, several earthquakes of magnitude > 6.0 have occurred within last century, including an earthquake of magnitude 7.1 (1935, April), one of the largest historical events on the African continent.

Most of the seismic activity in Libya lies in the northern part of the country especially in Hun Graben, offshore of Tripoli and Al Jabal Al Akhdar areas (figure 1). Detailed investigations of this seismic activity indicates that there is definitely an amount of seismic risk in some parts of the country specifically in the above mentioned two areas.

According to figure 1, the Libyan Center for Remote Sensing and Space Science (LCRSSS) with supports of university staff and organization of National Authority of Scientific Research decide to implement The Libyan National Seismological Network (LNSN). The objective of this network is to monitor the local and regional seismicity in Libya.

Figure 1: Seismicity of Libya from 1900 to 2000

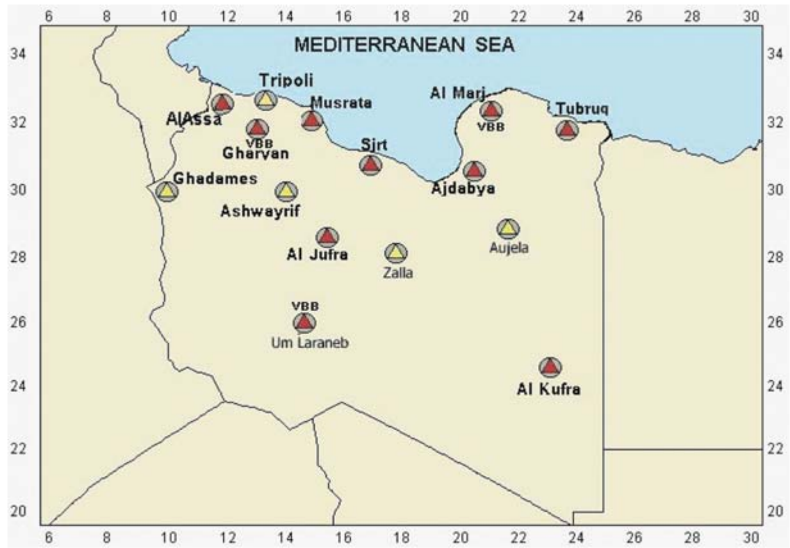


The Objectives of Seismological Office

The principal objectives are, in order of importance:

- Monitoring and recording the seismicity of the region, using two Permanent Seismic networks (*Weak motion network:* Libyan National Seismological Network (LNSN) and *Strong motion network* (SMN)) and a Temporary network (portable seismic stations).
- Determining the level of seismic hazard and risk.
- Studying the physics and structure of the earth's interior.
- Evaluating particular site effects for location of critical constructions such as dams or nuclear power plants, etc...
- Conduct studies to gain a better knowledge regarding the field of earthquake prediction.
- Detect possible nuclear explosions.
- Devise anti-earthquake building design code.
- Give the necessary information to the public.
- Teach and train University students in the field of earthquake seismology and other related fields.

Figure 2: The Libyan National Seismological Network (LNSN)



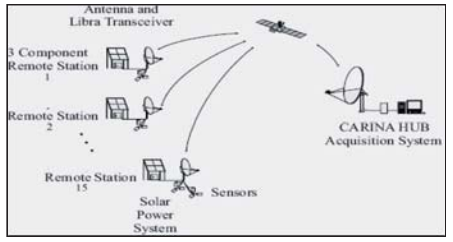
Station name	Latitude	Longitude	Height (m)
ALASSA (ASA)	32.5055	11.3683	73
GHDAMES (GHD)	30.0100	9.2653	600
GHRYAN (GHR)	32.0732	13.0518	709
AJDABYA (JDB)	30.5478	20.1189	49
JUFRA (JFR)	29.0611	15.4877	351
KUFRA (KFR)	24.0968	23.1273	413
MARJ (MRJ)	32.3491	20.5254	408
MISRATH (MSR)	32.1875	15.0050	114
SHWAIRF (SHF)	29.5921	14.1486	429
SIRT (SRT)	31.0487	16.3949	95
TOBRUQ (TBQ)	32.0334	23.5526	139
TRIPOLI (TRP)	32.5068	13.0980	83
UJELA (UJL)	29.0715	21.1816	95
MURZUK (UMB)	26.0829	14.4512	474
ZALLA (ZLA)	28.3322	17.3368	239

The Libyan National Seismological Network

The Network is composed of 15 permanent broad-band Seismic stations, installed with high technical instruments, Broad Band and Very Broad Band sensors (figure 2). The selection of the 15 sites was realized according to the Geophysical and Geological information but with out instrumental investigations and was designed locally referring to the scientific, environmental and safety process (figure 3a). The data are then analyzed and handled using two software (Atlas and Seisan softwares) at the Seismological Data Center (figure 3c).

The Network is controlled from the

Figure 3: a) Remote stations, b) Data acquisition and data analysis at the Seismological Center and c) Software using during the analysis.



Seismological data Center near Gharyan city where the seismic data are received from all remote stations in a real-time. The seismic data which were detected at the remote stations are then transferred to the Central Hub (Seismological Data Center in Gharyan) via satellite (figure 3b and 4).

In addition, thirteen portable seismic stations are used as a temporary network, in a temporary basis for monitoring micro-earthquakes in a limited area with a special seismic activity. The portable station consists of three components broadband seismometer (Trillium) with built-in amplifier (Taurus data logger), GPS clock and a solar panel power supply.

Thanks to these installations, the LNSN has been able to detect 773 events since one year and half (figure 5). This result is very promising and presents a strong interest especially in real time.

Figure 5: Seismicity recorded by the LNSN staff during 1 year and half. 773 events has been recorded and analyzed during this period.

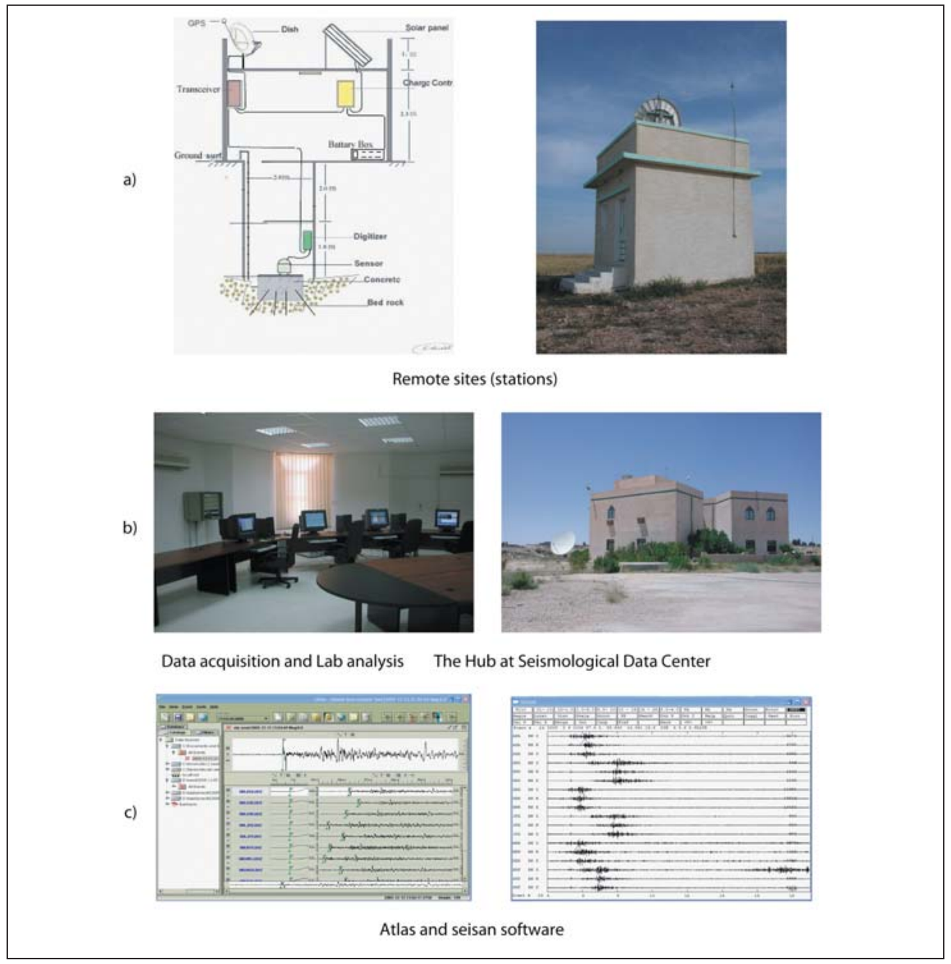
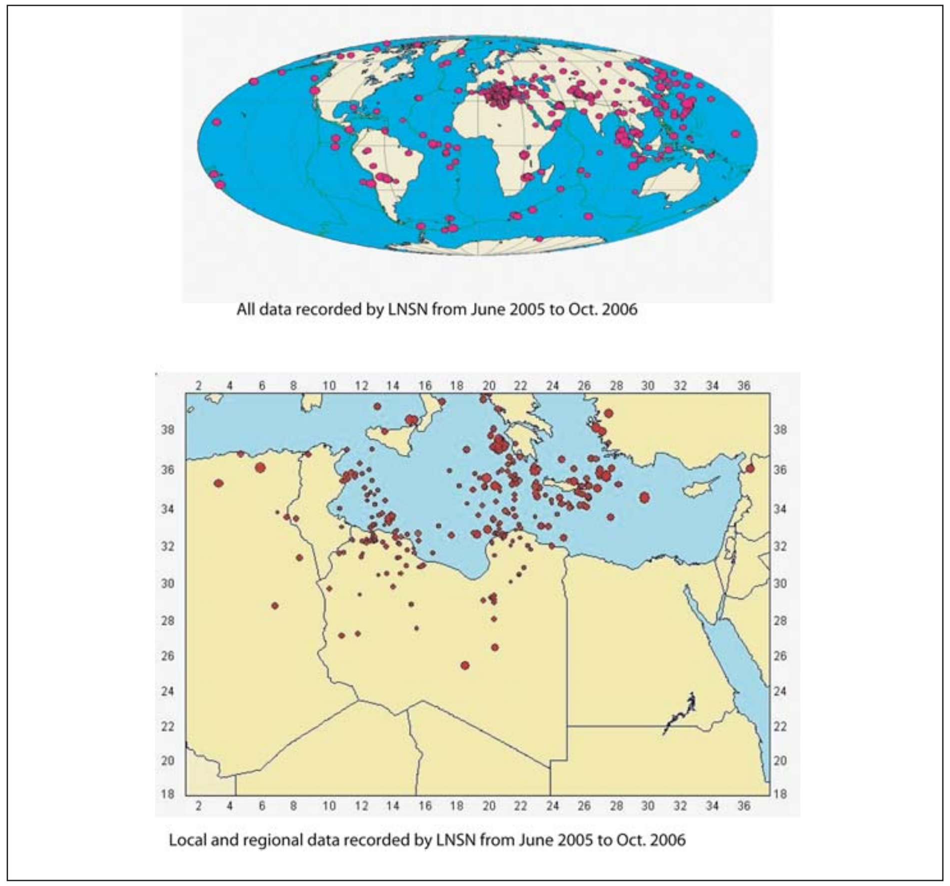


Figure 4: The diagram shows how the seismic data transferred from remote stations to the Hub via satellite, in a real-time mode to be analyzed and archived at the Seismological Center.



In parallel, a proposal of strong motion accelerograph network was considered. Thirty stations will be distributed on major and strategic sites (such as dams, bridges, big factories, high building … etc) and also implemented in free field. This network will be an important contribution in the seismic risk studies.

Conclusion

The Libyan National Seismological Network (LNSN-Weak motion network) was installed and worked successfully.

The data recorded and analyzed by LNSN staff for 1.5 year gives an evidence that Libya seems to be seismically active - moderate seismicity - but if we refer to the instrumental and historical data which collected from international seismological centers (ISC, EMSC, NEIC,…) a big event could happen any time according to the recurrence fact.

The Libyan seismological staff working hard to get an experience from a series of continues training programs that proposed by national and international experts from different seismological centers and universities sponsored by UNESCO.

Regional exchange with northern africa

Antón R. (1)
(1) Instituto Geográfico Nacional (IGN), C/General Ibañez Ibero 3, Madrid, Spain, ranton@fomento.es

Figure 1: Digital IGN stations

Since 2000 February, the IGN has developed its new Seismic Network. Nowadays, 29 stations are placed in the peninsular area and other eight in Canary Islands, one per island except two in Tenerife Island. All of them are digital broad band stations, with three components and VSAT telemetry. IGN is planning to install some additional stations in the future. In the following weeks a new VSAT station will be installed in North Africa (Ceuta).

In the figure 1, the map represents the current and future distribution of the VSAT stations.

Figure 2: VSAT station in Ceuta(ECEU)

We are including acceleration sensors in some of the VSAT stations. An accelerometer was installed in EGRO site and now we are planning to install other sensor in EMIJ station. All six channels are sent via satellite to the seismic reception centre.

IGN is studying the possibility of switching the satellite transmission into another communication system based on telephone dedicated lines, internet or GPRS, just in case of a satellite fail.

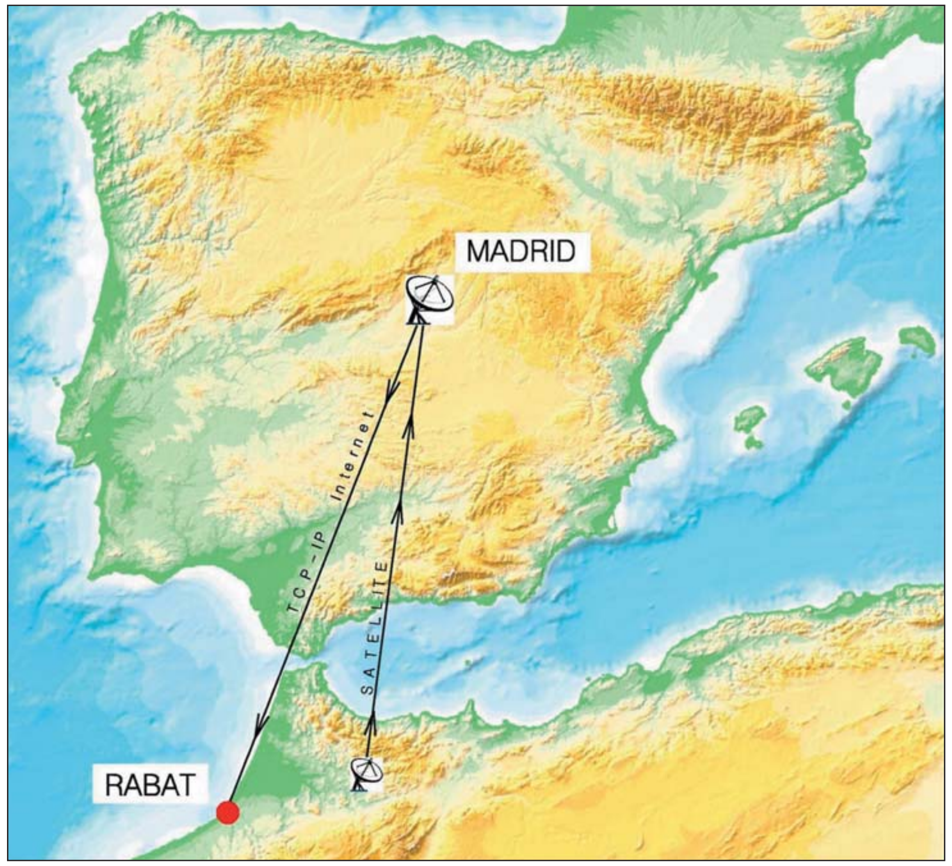
Since the IGN objective is monitoring the entire Ibero-Magrebian region, we are very interested in extending the network to the North of Africa. We have a station in Melilla with a telephone dedicated line. The Ceuta (ECEU) station will be operative in the near future. The main problem with these two stations is to find a location without noise.

Nowadays our collaboration with CNRM (Morocco) and CRAAG (Algeria) is a parametric data interchange (bulletins and alerts). In the last EERWEM meeting in Cadiz (San Fernando), they showed their interest in a waveform data interchange. In order to specify the technical terms of the interchange, Mr. Yelles-Chaouche (CRAAG) is to visit IGN in Madrid next month.

The more advanced item of the project is the data interchange with CNRM. Mr. Nacer and Mr Timoulali began the dialog with us after the EERWEM meeting. They did not have any specific software that was able to receive waveform frames in real time and make seismic locations with them. As CNRM and IGN are members of CTBTO we recommended them that they request the "cdtools" packet software (geotool, cdreceiver, …) available for CTBTO members. They installed this software successfully and, after many problems with the firewalls services, we are sending some VSAT South Spanish stations to Morocco system by TCP-IP internet protocol.

Next step will be the installation of a VSAT station in Morocco country that will be sent to both systems as showed in the next figure.

Figure 3: Telemetry design of future Morocco seismic station

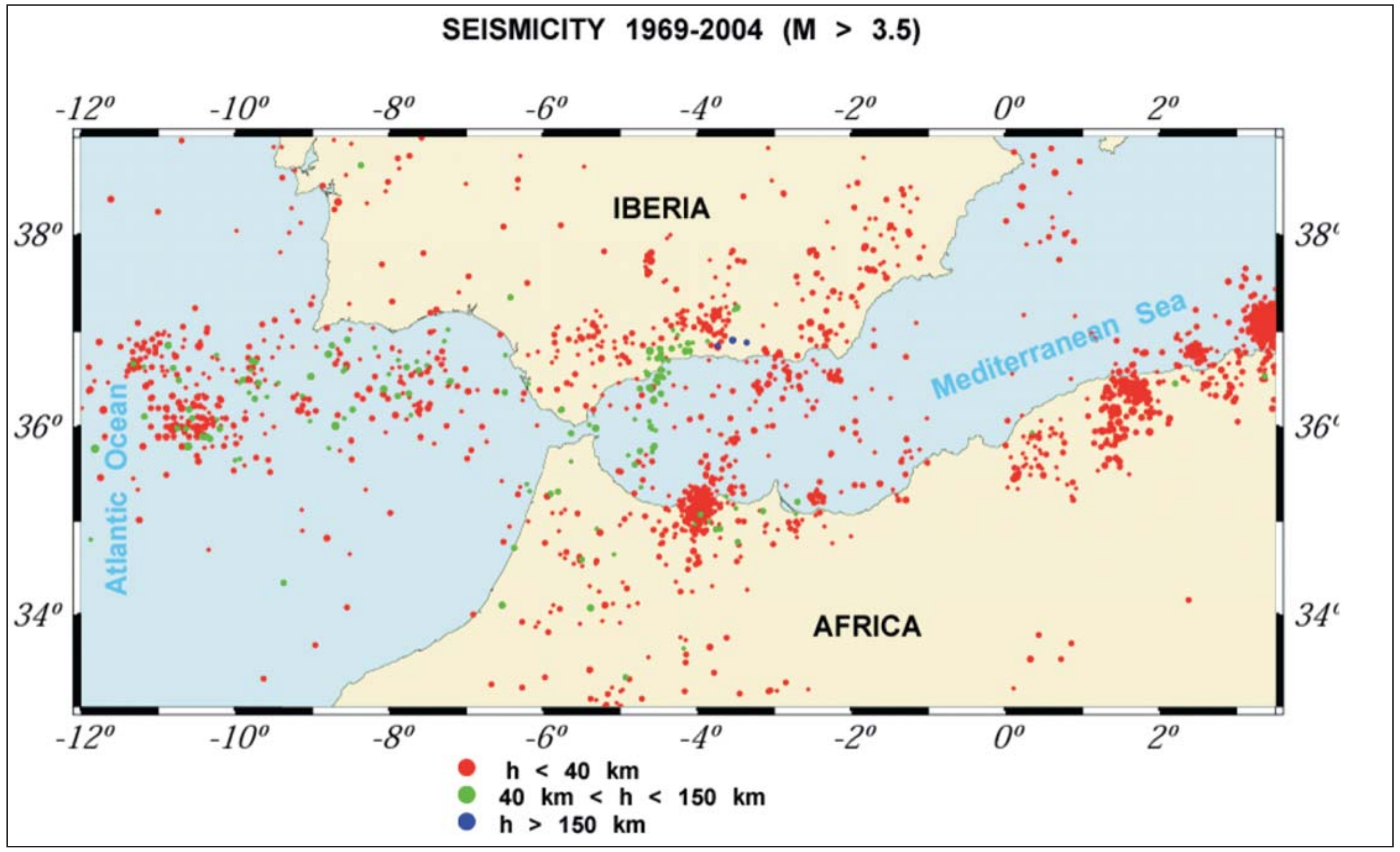


Broad band "western mediterranean" an ocean botton "fomar" seismological networks.

J. Martín Davila (1), A. Pazos (1), E. Buforn (2), A. Udías (2), M. Bezzeghoud (3), B. Caldeira (3), A. Rimi (4), M. Harnafi (4), W. Hanka (5), A. Nadji (6)

(1) Real Instituto y Observatorio de la Armada, San Fernando, Spain. (mdavila@roa.es and pazos@roa.es)
(2) Departamento de Geofísica y Meteorología, Universidad Complutense, Madrid, Spain (ebufornp@fis.ucm.es)
(3) CGE and Physics Department., Universidad de Evora, Evora, Portugal (mourad@uevora.pt)
(4) Institut Scientifique, Université Mohammed V Agdal Rabat, Moroco (harnafi@israbat.ac.ma)
(5) GeoforschungsZentrum, Potsdam, Germany. (hanka@gfz-potsdam.de)
(6) Université d'Oran – Es Sénia, Oran, Algeria (amansour.l@yahoo.fr)

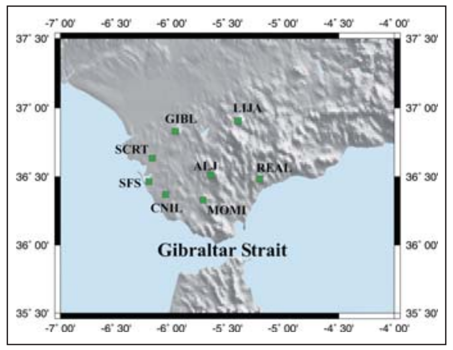
Figure 1: Distribution of epicenters at the Ibero-Maghrebian region (IGN and ROA data files).



Introduction

To study the seismicity associated to the Ibero-Maghrebian region, the Real Instituto y Observatorio de la Armada in San Fernando (ROA) has installed, since 1898, different types of seismological stations. At present two networks are in operation: Long Period station and Short Period net (ROA) and Western Mediterranean Broad Band (WM) net (in collaboration among several institutions). The installation of a network of ocean-bottom seismographs (FOMAR) is underway. The Ibero-Maghrebian region corresponds to the western part of the Eurasia-Africa plate boundary and is of great seismological and tectonic interest. It extends from 12ºW to 3ºE, comprising Southern Iberia and northern Africa, including the Gulf of Cadiz and Alboran Sea (figure 1). Seismicity is characterized by the occurrence of moderate and large magnitude earthquakes at shallow depth, intermediate depth earthquakes ($30<h<150$ km) and some very deep events (650 km). The whole area constitutes a broad deformation zone, without a well defined plate boundary line, with a plate convergence in a NNW-SSE direction at a rate of 1 to 5 mm/year (Buforn et al., 1995).

Figure 2: ROA Short Period seismic network.



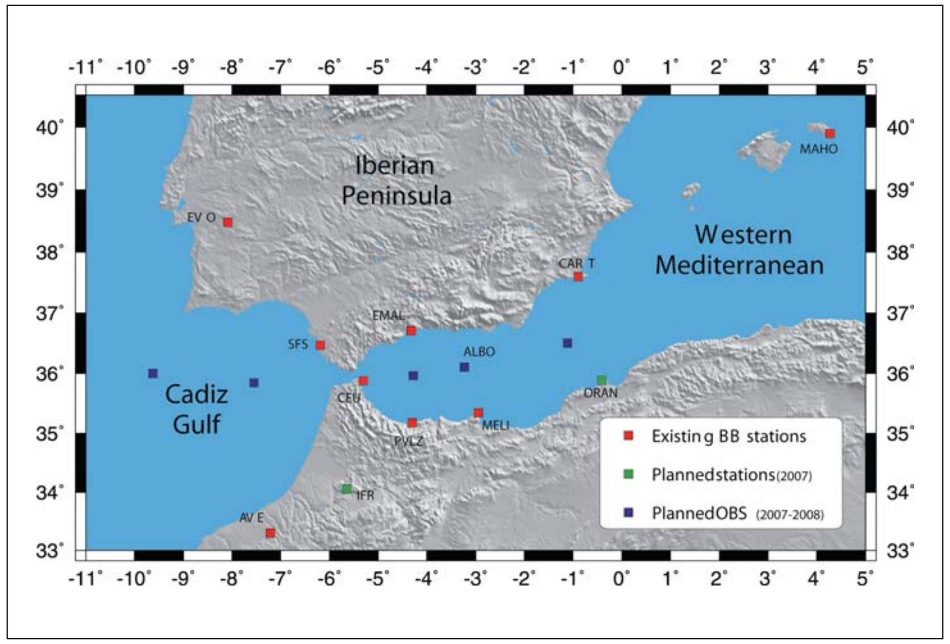
ROA LP seismic station and SP seismic net

A short period network (SFS Network) has been in operation since 1986 in the surrounding area of Gibraltar Strait, in collaboration with Instituto Geográfico Nacional (IGN) and SECEGSA state company (Martin Davila et al, 2001). The network is formed by eight one/three components analogical stations linked to ROA headquarters via radio UHF/VHF (figure 2). These stations are being upgraded at present by extending the sensor bandwidth and converting them to digital transmission (Pazos et al., 2005).

Since 1976 a three components long period station (Spregnether 5100), is operating in a tunnel in San Fernando.

Western mediterranean (WM) broad-band seismological network

Figure 3: Western Mediterranean (WM) BB seismic network and near future OBS FOMAR network.



From 1996, ROA and the Universidad Complutense de Madrid (UCM), with the support of GeoforschungsZentrum of Potsdam (GFZ), have installed a broad band seismological network with stations located in Southern Spain and Spanish sites located in Northern Africa surrounding the Alboran Sea. This network, initially known as ROA/UCM (Buforn et al., 2002), has been renamed as Western Mediterranean network (WM FDSN code) as new stations have been added outside Spanish territory. At present the stations in operation are the following: San Fernando (SFS), Málaga (EMAL), Cartagena (CART) and Evora University (Portugal) (EVO) in the Iberian Peninsula, Mahón (MAHO) at Minorca Island, and three stations at Melilla (MELI), Peñón de Vélez-Gomera (PVLZ), and Ceuta (CEU), in Northern Africa. In most of them permanent geodetic GPS stations are also installed. One more station has been recently installed in Averroes Observatory (Morocco) in collaboration with the Institut Scientifique of Rabat (Université Mohammed V; Morocco). It is planned to install two stations in the near future, in Ifrane (Morocco) and Oran (Algeria), the last one in collaboration with Université d'Oran (figure 3). The headquarters of the network are located in the ROA facilities in San Fernando, Spain.

All WM Network stations have Streckeisen STS-2 sensors, Quanterra or Earth Data digitizers, and a Seiscomp system. Data are available in real time (phone line or Internet) except for PVLZ, CEU and AVE, which will be available in the near future.

"Fomar" ocean botton (OBS) seismic network

Due to the fact that part of the seismic activity is located at marine areas (figure 1), and the poor geographic azimuthal coverage at some zones provided by the land stations, in order to complement the WM broad-band network, ROA and UCM will deploy an OBS network with a permanent OBS near the Alboran island (OBS ALBORAN), linked to land by an underwater cable, and four temporary (three years) OBS in the Gulf of Cadiz and Alboran Sea (FOMAR network) (figure 3). The deployment of the OBS will be carried out within 2007 with the support of the Spanish Navy.

Conclusions

In order to study the seismicity associated to the western part of the Eurasia-Africa plate boundary at the Ibero-Maghrebiam region, ROA in collaboration with UCM and the support of GFZ have deployed, since 1996, a Broad-Band seismic network with stations installed in Southern Spain and Spanish sites in Northern Africa. This network has been expanded with a station in Evora (Universidad de Evora), Portugal, and another in Averroes (Université Mohammed V), Morocco, forming the new Western Mediterranean Network (WM). It's planned to install, in the near future, two stations, in Ifrane (Morocco) and Oran (Algeria), the last one in collaboration with the Université d'Oran.

In order to improve the WM network, five Ocean Bottom Seismographs (OBS) will be deployed in the Gulf of Cadiz and Alboran Sea, including a permanent station (OBS ALBORAN) and three/four (FOMAR net) semi-permanent stations. Deployment of OBS is planned to be carried out on 2007.

Acknowledgements

This work has been partly funded by the Spanish Ministry of Education and Science (MEC) through the projects: RIOA05-23-002 (OBS ALBORAN), CGL2005-24194-E (RED FOMAR) and REN2006-10311-C03-01/02 (RISTE) and UCM projects UCM, AE10/05-13867. The station EVO has been funded by the Portuguese Ministry of Education and Science (MCTES) and by the project POCTI/CTE-GIN/59750/2004.

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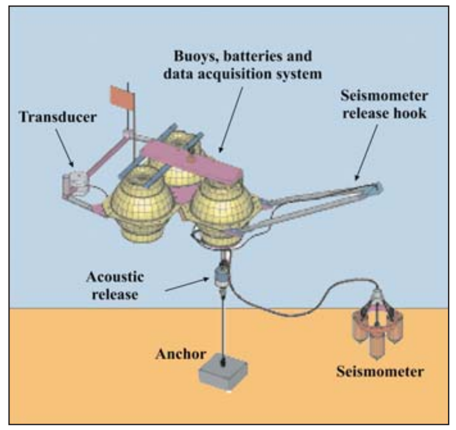
Figure 4: A temporary OBS deployment scheme (courtesy Guralp Systems).



Recent improvements in the Broadband seismic networks in Portugal

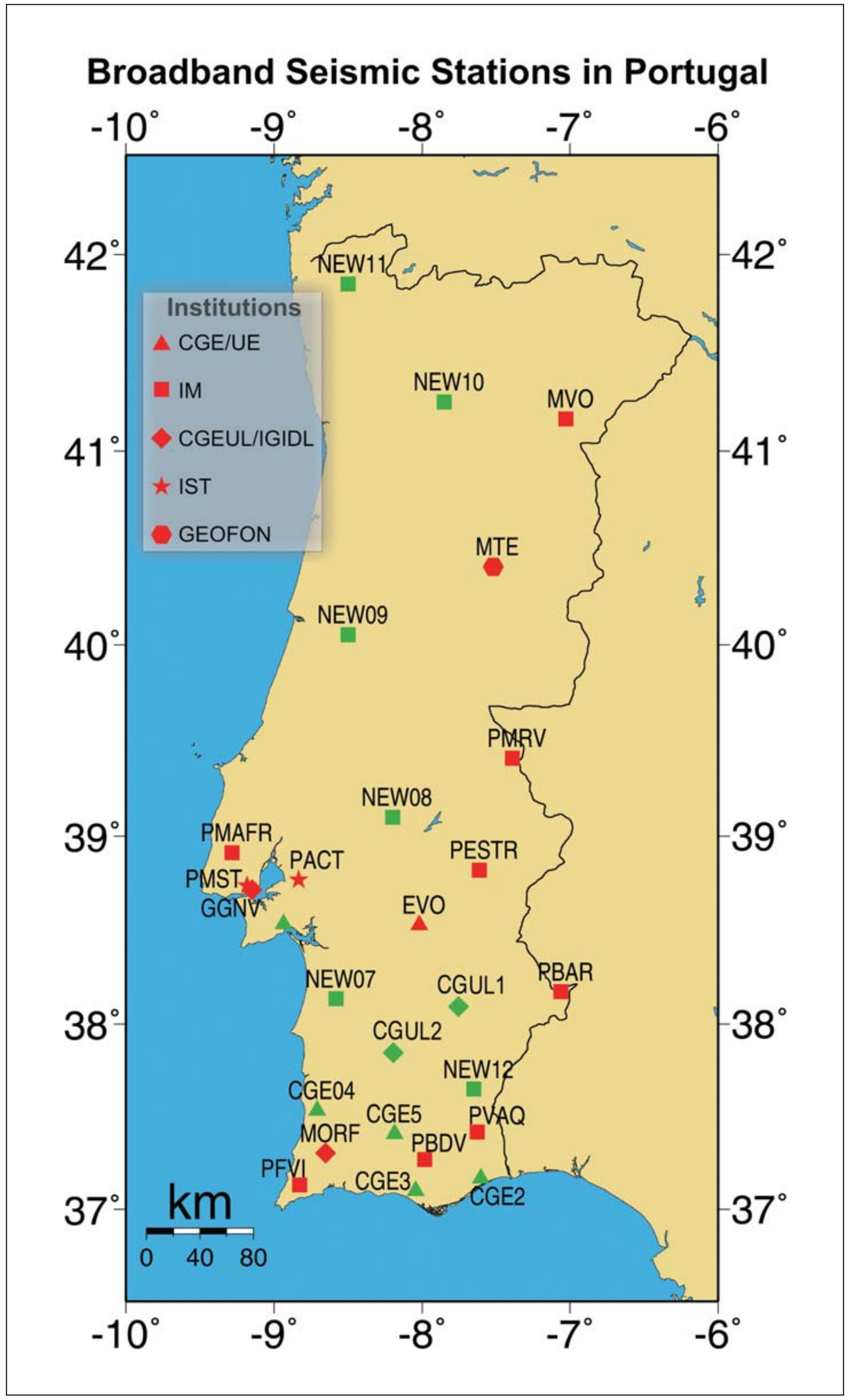
B. Caldeira (1), F. Carrilho (2), M. Miranda (3), M. Bezzeghoud (1), P.M. Alves (2), G. Silveira (4), F. Villalonga (1), J.A. Pena (2), L. Matias (3), J.F. Borges (1), D. Vales (2) C. Corela (3), and G. Madureira (2)
(1) CGE and Physics Dept., Universidade de Évora, Évora, Portugal (bafcc@uevora.pt)
(2) Instituto de Meteorologia, Rua C ao Aeroporto, 1700 Lisboa, Portugal (fernando.carrilho@meteo.pt)
(3) CGUL/IGIDIL and FCUL, Universidade de Lisboa, Lisboa, Portugal (lmatias@fc.ul.pt)
(4) CGUL/IGIDL and ISEL, Lisboa, Portugal (mdsilveira@fc.ul.pt)

Introduction

Portugal, in spite of the significant earthquake region, (e.g.: Borges et al., 2001) has been operating a limited number of broadband digital seismic instruments. The older BB seismic station in a systematic and continuous operation on the country is MTE, belonging to GEOFON and locally supported by IM, which is working since 1997. To efficiently carry out the task of develop the Broadband Portuguese seismic network, there is a collaboration between some national institutions, such as Institute of Meteorology (IM), Geophysics Center of Évora University (CGE/UE), Geophysics Center of University of Lisbon (CGUL/IGIDL) and Instituto Superior Técnico (IST), with governmental support from the National Science and Technology Foundation (Rede Nacional de Geofísica, RNG). From this collaboration we expect shortly to assist the emergence of a high quality infrastructure, significant to real-time monitoring the earthquake activity for use by governmental authorities, and of paramount importance to scientific research. The installation of this network is to be carried out in narrow connection with international institutions as GEOFON, EMSC, ROA, ORFEUS, with who we saw to establish collaborations. Data from some stations are already being exported to international data centers, such as DMC and ORFEUS, and will be used for an upcoming prototype of an Early Warning Tsunami System to be developed for Cadiz Gulf coastal area and southwestern coasts of Portugal mainland, within the framework of the NEAREST project.

While the broadband network is developed they elapse investigation projects that request short period data. Of these projects we highlight the Seismic Tomography of the Continental Lithosphere of Algarve (Portugal) that involve the installation of a Portable seismic network consisting of 30 short-period stations, including a subnet of 7 telemetry stations, in operation since January 2006.

Figure 1: The distribution of the 14 real-time broadband seismic stations in Portugal Continental as of February 2007 (red symbols) and proposed sites (green symbols) to place the now acquired instruments (13 stations).



Broad Band Seismic Network design

The earthquake distribution within Portugal shows that the seismic activity has higher levels in some areas in southern part of Portugal mainland (e.g.: e.g. Carrilho et al., 2004), regions that we plan to use denser seismic station network coverage in order to record lower magnitude earthquakes. This will provide an earthquake database that can be used in more other applications that the seismic observatory and surveillance, such as earthquake source and structure studies which are crucial in understanding of Portugal seismotectonics, and attenuation among others.

The map of Figure 1 shows the actual situation of the seismic real-time broadband coverage in Portugal Continental. 12 VBB (120 sec) and 2 BB stations are now installed, with 2 of them running since mid-2006 and 5 from beginning of 2007; of the VBB, 3 (EVO, MTE and PMAFR) are equipped with STS2 sensors and Quanterra or Earth Data digitizers; the remaining are provided with GURALP sensors (3ESP, 3T and 40T) and CMG DM24 digitizers. 8 of the VBB (PESTR, PMAFR, PFVI, PVAQ, PBDV, PBAR, PMRV [to start on March] and MVO) stations are additionally equipped with strong-motion accelerometers. The BB stations (GGNV, MORF) are equipped with a 30s sensor. Real-time waveforms transfer from stations to the servers is managed by SeisComp/SeedLink, running at each station on Linux. Data communication from the permanent stations to the network server of each institution is performed by several ways. The IM stations (or PM network), the majority, use VSAT; the CGE stations use Internet based communication and the others stations (PMST and PACT) use telemetric transmission of data.

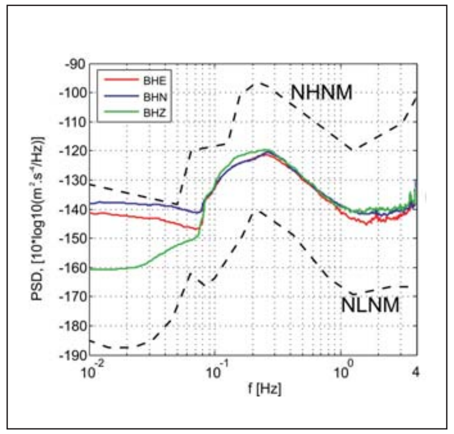
The security of data is guaranteed through an infrastructure with a high level of redundancy. The archiving of raw waveform data (mini-SEED) is made on a mass storage system (each participant institution it is responsible by the safeguard of the data from its stations). These data are real-time exported, by Internet, from the servers of responsible own institutions to the mirrors of the institutions that collaborate. The CGE network server sends the data of EVO to PM and Western Mediterranean (WM) servers and receives CART, MAHO, MALA, MELI and SFS from WM network (see Davila et al., this issue) and PESTR data from PM network. Data from MORF station is transferred directly to PM and then exported, together with PESTR, to CGUL/IGIDL

Quality control

One of the goals of the responsible broadband networks is to ensure that stations produce the maximum possible amount of high-quality, problem-free, data. Our Quality Control practices can be roughly categorized as examining the data for problems in the following tests: sensitivity and orientation; sensitivity and polarity; review of mass position channels.

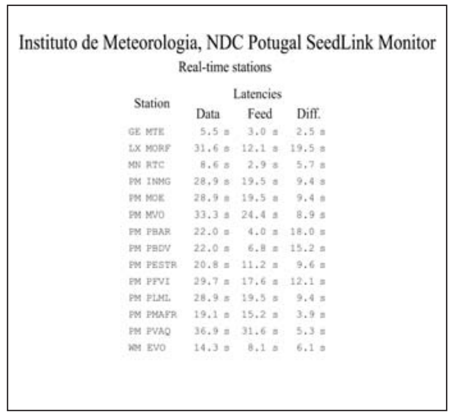
The stations are sited in very different environments ranging from near shore at the Atlantic Sea coast up to distances of about 200 km from the coast, both within cities and industry or traffic roads. New stations are being sited far from those artificial noise sources. To characterize the seismic noise level recorded by each seismometer we are to develop automated power spectral density analyses that will allow continuously check the seismic noise level (Figure 2).

Figure 2: Power spectral density of seismic noise estimated for the station EVO from data acquired during October, 20 and November 21, 2006 for the three components, vertical (Z), north–south (N) and east–west (E). The lower and upper dash curves are the low (NLNM) and high (NHNM) noise models of Peterson (1993).



Another import issue is to monitor the status of real-time data, and for that purpose a latency updated information is produced (using Seiscomp tools) to help the station operators to check for problems (Figure 3).

Figure 3: An example of a real-time data status screen at IM data center.



Instituto de Meteorologia, NDC Potugal SeedLink Monitor

Real-time stations

Station	Latencies		
	Data	Feed	Diff.
GE MTE	5.5 s	3.0 s	2.5 s
LX MORF	31.6 s	12.1 s	19.5 s
MN RTC	8.6 s	2.9 s	5.7 s
PM INMG	28.9 s	19.5 s	9.4 s
PM MOK	28.9 s	19.5 s	9.4 s
PM MVO	33.3 s	24.4 s	8.9 s
PM PBAR	22.0 s	4.0 s	18.0 s
PM PBDV	22.0 s	6.8 s	15.2 s
PM PESTR	20.8 s	11.2 s	9.6 s
PM PFVI	29.7 s	17.6 s	12.1 s
PM PLML	28.9 s	19.5 s	9.4 s
PM PMAFR	19.1 s	15.2 s	3.9 s
PM PVAQ	36.9 s	31.6 s	5.3 s
WM EVO	14.3 s	8.1 s	6.1 s

Conclusions

The currently purpose is to finish the installation of new stations acquired (green symbols on Figure 1). However, we intended to obtain means to enlarge the broadband covering to a wide mesh similar as the proposal for other European countries (about 30km). Other initiative that we intend carry out is to develop one infrastructure of a portable broadband seismic network for experiments involving onshore recording of controlled source and natural seismic events. We expect to obtain these facilities through the "Rede Nacional de Geofísica" project.

The always present objective is the enlargement of International collaborations with other organizations toward common objectives as: disaster reduction, in particular earthquake disaster reduction; education and training; promotion of joint researches.

Acknowledgements

This work has been partially funded by the Portuguese Science and Technology Foundation (FCT) of the Ministry of Science and Superiors Education (MCES) through the projects: MODSISNAC-FCT-2005, SEISMOLITOS-FCT-2004, FCT/POCTI/CTE-GIN/59750/2004, FCT/POCTI/CTE-GIN/55994/2004 and NEAREST-CE-2006.

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The French Accelerometric Network (RAP): current state in 2007.

Philippe GUEGUEN (1) and the RAP Group (2)
(1) Réseau Accélérométrique Permanent, Laboratoire de Géophysique Interne et Tectonophysique, Observatoire de Grenoble, BP 53, 38041 Grenoble Cedex, France, http://www-rap.obs.ujf-grenoble.fr , pguegu@obs.ujf-grenoble.fr
(2) The Rap group is composed of: C. Anténor, P.-Y. Bard, J. Battaglia, S. Bazin, F. Beauducel, S. Benahmed, C. Berge-Thierry, D. Bertil, D. Brunel, M. Cara, E. Chaljub, F. Cotton, F. Courboulex, P. Dervin, A. Deschamps, P. Dominique, J.-M. Douchain, A.-M. Duval, B. Feignier, J.-F. Fels, B. Francois, M. Granet, P. Guéguen, S. Hatton, D. Hatzfeld, M. Langlais, P. Lebellegard, A. Lemarchand, C. Maron, S. Nechtschein, C. Péquegnat, J. Perrot, C. Ponsolles, M. Prot, M. Régnier, A. Roulle, A. Souriau, S. Vidal

France is a country of moderate seismicity but, due to dense urbanized and industrial areas, the seismic risk is significant. Furthermore, recent developments in numerical and semi-empirical methods request a good knowledge of several parameters. The mission of the French accelerometric network program (RAP, Réseau Accelerometrique Permanent) is to expand and modernize significantly the acquisition and application of French accelerometric data (both strong and weak motion) in order to improve earthquake related research and public safety from earthquakes. The RAP is supported by the French Ministry of Ecology and Sustainable Development, the French Ministry of Public Works and by the Institut National des Sciences de l'Univers (INSU-CNRS). This network is the result of co-operative efforts including academic institutions (INSU-CNRS, Universities of Grenoble, Nice, Strasbourg, Toulouse, IPG Paris) and several state agencies (BRGM, CEA, IRSN, LCPC). Since 1995, around 120 stations have been installed all over the French territory including the overseas regions (Figure 1). Since its beginning, the RAP scientific board has proposed technical evolutions in order to maintain the network on its higher level. One Rap strong-motion station is constituted of a strong-motion sensor (Güralp-CMG5 or Kinemetrics-Episensor), and a 24-bits 3-component digitizer (Agecodagis-Titan). The time is calibrated with a radio receiver Telecode or a GPS receiver. The station is telemetrically controlled and data are downloaded by a RTC modem. All regional networks are under the responsibility of regional institutions that have a long tradition in seismic observations.

RAP has initiated instrumental development in coherence with its scientific actions. The main scientific objectives concern the knowledge of source effects and seismic motion, the propagation and attenuation phenomena, the analysis of site effects and the experimental assessment of vulnerability. The network also includes specific research actions (site effects, building monitoring, deep borehole...). Other French accelerometric stations devoted to strong motion recording are also associated to the national network.

Since 1995, 8770 seismic events have been recorded by at least one station of the RAP or associated networks (Figure 2). The deployment of new stations allowed the increase, with a significant degree, of the number of recorded earthquakes. These events correspond to 19159 recordings available through the online access database of the RAP datacenter (Figure 2). Data are available in SAC, ASCII and SEED format. The great sensitivity of the stations allows the detection of low-to-moderate earthquakes (Ml<2) and, simultaneously, their great dynamics allows the recording of the ground motion produced by events of stronger magnitudes (Ml>5) without overflow. The maximal PGA found in the database reaches 0.7g: this value was recorded in the French West Indies and corresponds to the Ml=5.4 (February 14, 2005) aftershock of the Saintes earthquake main shock (21/11/2004, Ml=6.3), at 7 km from the epicenter.

Figure 1: Localization of the RAP stations (left) and the associated networks (right) in France and in the French West Indies islands.

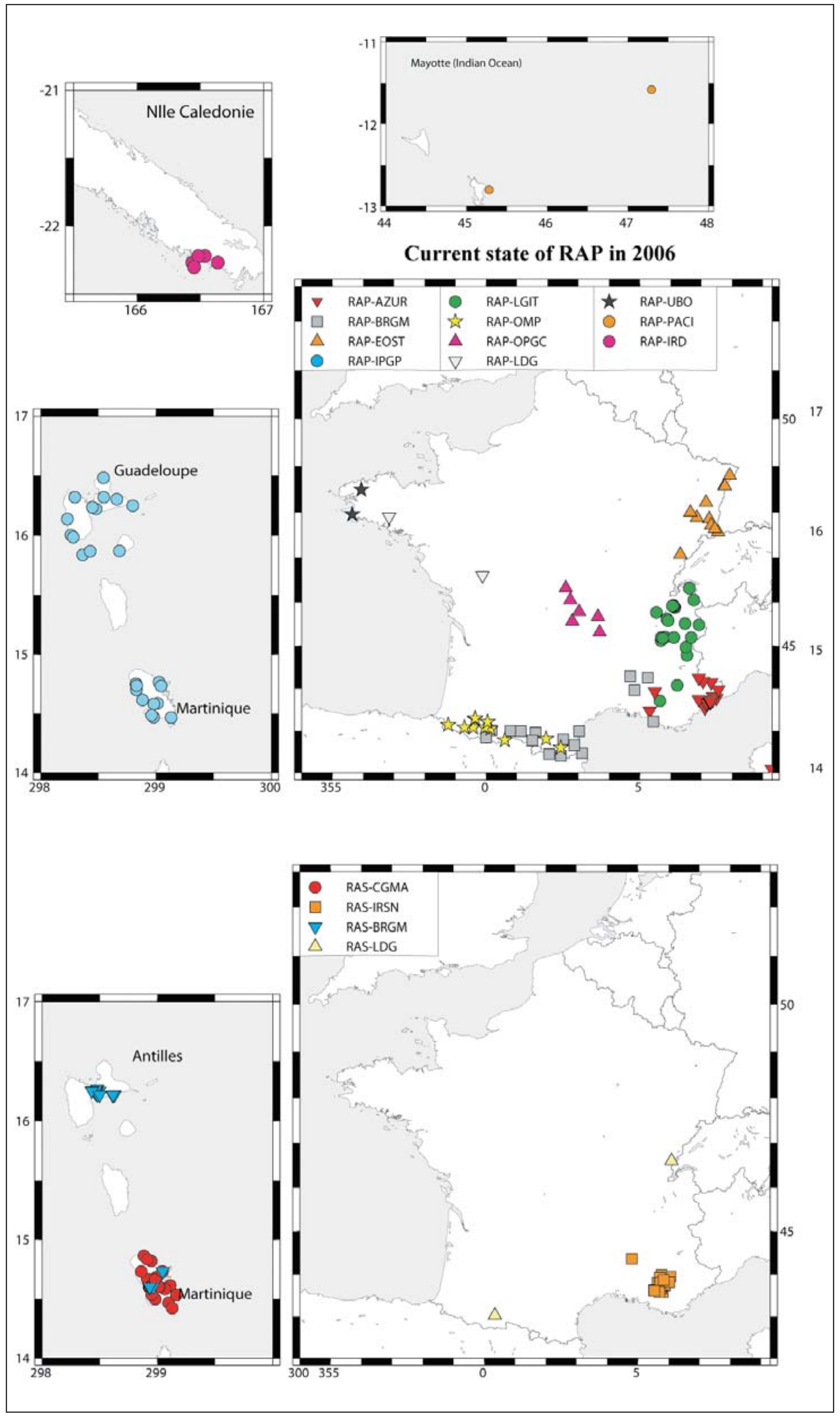
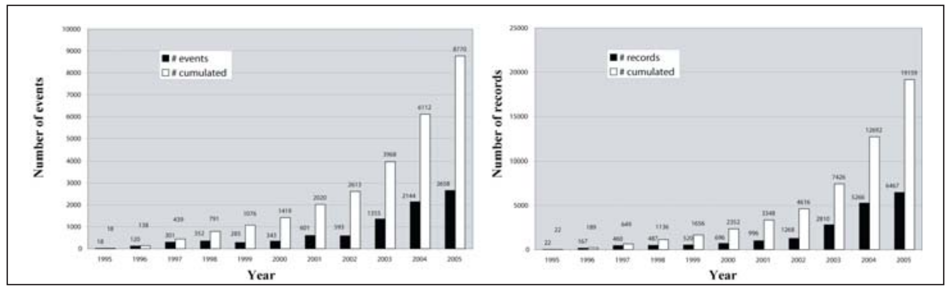


Figure 2: Number of events (left) and recordings (right) per year and cumulated since 1995 available on the online RAP database.



The RAP has now arrived to maturity and its online database brings essential information to the comprehension and the knowledge of the seismic hazard and vulnerability in France. The first studies undertaken on the data show that the use of low-to-moderate seismic motion gives relevant information for the prediction of strong ground motion, which is the base of the seismic hazard assessment. The online access to common waveforms encourages and facilitates the research tasks and increases the quality control of the data by the end-users. Because of the available common and unique database, active synergies between the partners exist illustrated by the technical and scientific workshop of the RAP organized every two years by the scientific board.

Geofon and its role in earthquake monitoring

Hanka W.(1)
(1) Geoforschungszentrum Potsdam. Germany, hanka@gfz-potsdam.de

The original scope of the GEOFON Program of GFZ (Geoforschungszentrum Potsdam, http://geofon.gfz-potsdam.de) is to collect and distribute worldwide high quality seismological data for all kinds of scientific studies (Hanka and Kind, 1994). It consists of three components, the global permanent broadband seismological network, a varying number of mobile network deployments and the GEOFON Data Center (now called GFZ Seismological Data Center). The latter comprises the earthquake information system, a service for real-time data feed distribution and a comprehensive seismological archive. Unlike e.g. IRIS, as an initiative with a similar scope, GEOFON has to operate on a much lower economic level but attempts to achieve its goals using simple, inexpensive but innovative technical solutions and with intensive cooperation on all levels. This concept has been extremely successful over the past decade and many networks and data centers in Europe and worldwide have adopted it. Therefore GEOFON today acts more than a support center and networking, integration and capacity building institution for many networks and data centers rather than a just conventional seismic network and data center on its own.

GEOFON plays also a leading role in near real-time data collection and processing of broadband seismological data both on a European and global scale. Its SeedLink IP data transmission protocol being part of the GEOFON SeisComP data acquisition and processing software package has become a de-facto global

Figure 1: Overview of station distribution of the permanent GEOFON network (triangles, red – online stations, orange - offline stations) and the GEOFON partner networks (yellow circles) in EuroMed area and globally jointly acquired at GFZ via Internet and forming the GEOFON Extended Virtual Network GEVN (as of February 2006).

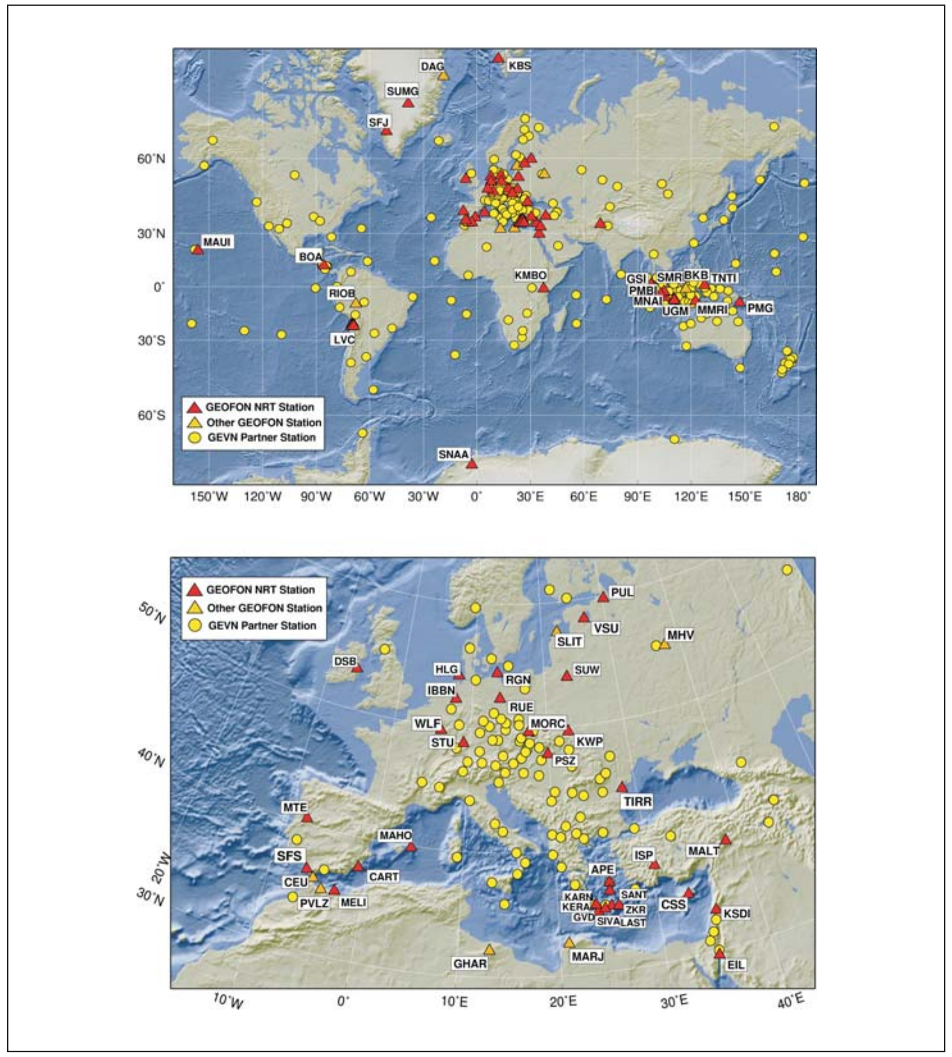


Figure 2: Global alert publication delay times of the GEVN Earthquake Information System in dependence of the geographical region (June-December 2005). Today, the situation has been even substantially improved, namely in SE Asia.

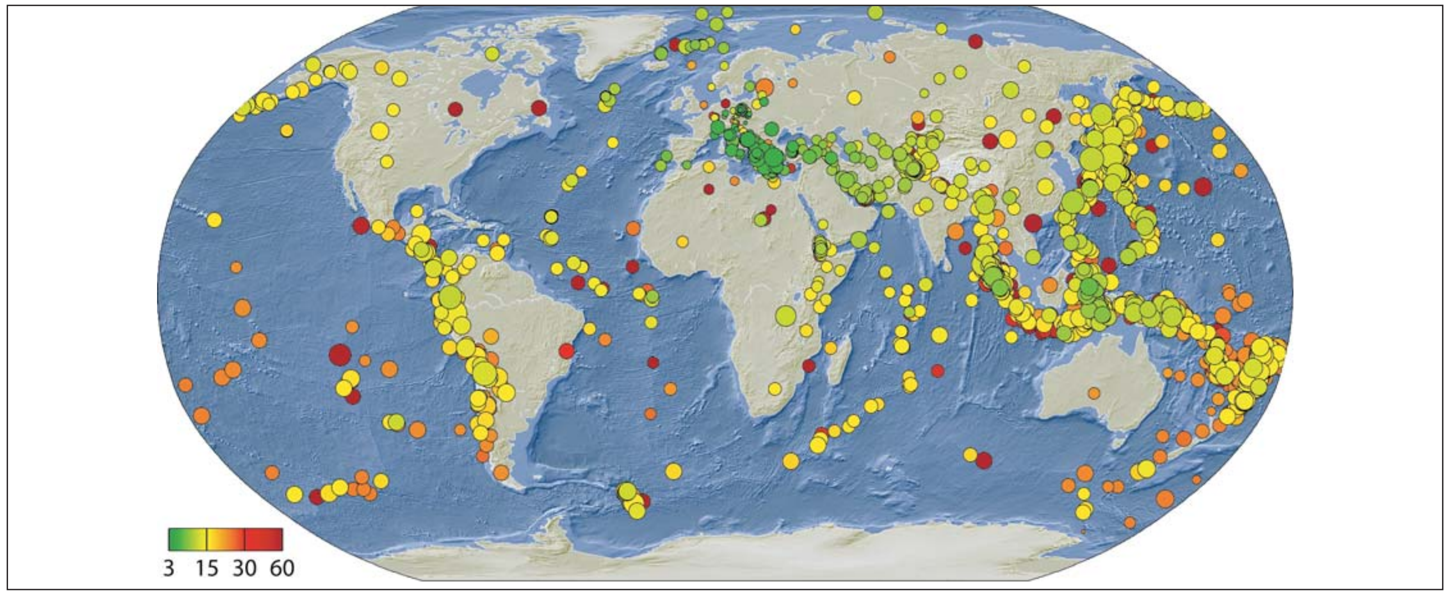
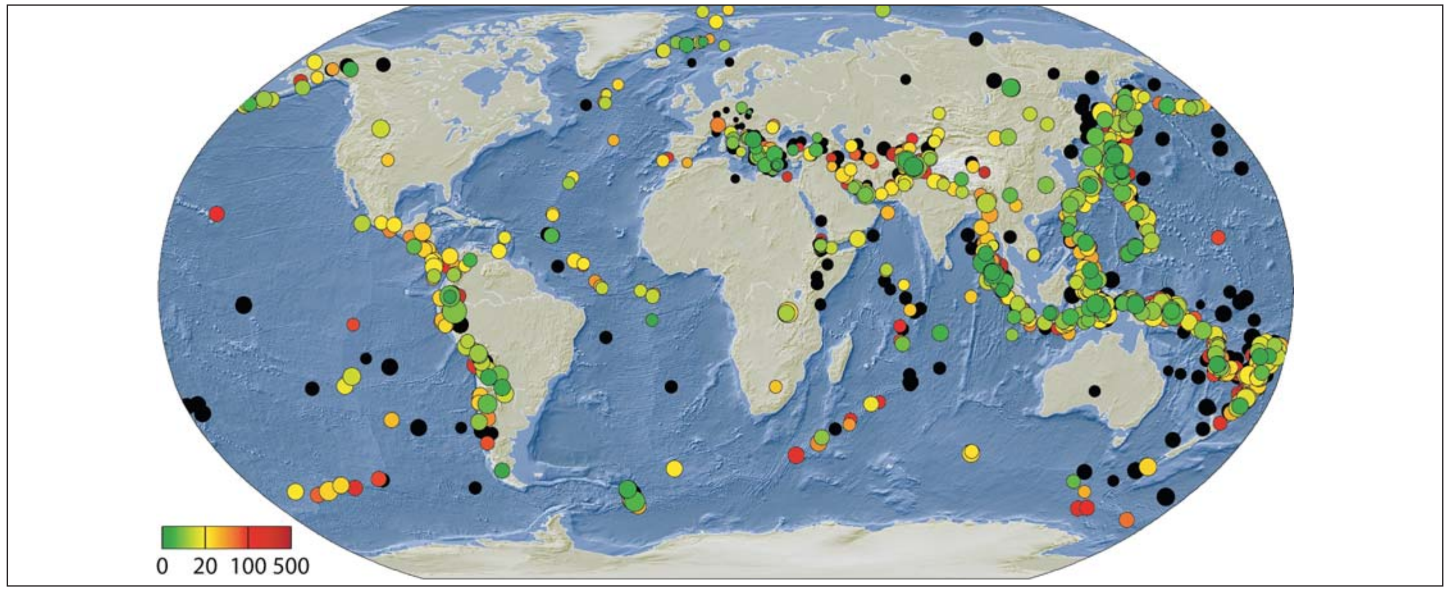


Figure 3: Global location accuracy (in km) for the GEVN Earthquake Information System in dependence of the geographical region and in comparison with NEIC (June-December 2005). Black dots indicate non-associated locations, which might in many cases be "real" events anyway.



standard (Hanka et al., 2003). It is also adopted as a manufacturer independent real-time data exchange protocol by international organizations and major projects, supported by all major commercial suppliers of seismological equipment. The GFZ Seismological Data Center acquires in near real-time data from more than 400 globally distributed stations from GEOFON stations and partner networks (GEOFON Extended Virtual Network – GEVN). Most of them are located in Europe (derived from the Virtual European Broadband Seismic Network – VEBSN, Van Eck et al., 2004) and SE Asia (Figure 1). Most of this data is also archived and re-distributed to the user community. Using these real-time data feeds, automatic processes for data quality checks, event detection, localization and source quantification are performed and the resulting rapid but nevertheless highly reliable earthquake information is automatically published in the Internet (Figure 2 and 3). Likewise, alerts are distributed by email and SMS messages to a wide spread user community.

After the Tsunami tragedy in the Indian Ocean, GEOFON was selected to implement the seismological component of the German contribution to the future Indian Ocean Tsunami Early Warning System (GITEWS, Hanka et al., 2006). This nomination is regarded as recognition of the successful data collection, processing and dissemination strategies implemented over the past decade.

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MedNet status report

Mazza S. (1) and the MedNet Staff (1)
(1) Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy, mazza@ingv.it

MedNet is a network of very broadband seismic stations installed in countries bordering the Mediterranean area. The project started in 1987, with a final goal of 12-15 stations and a spacing of about 1000 km between stations. It was motivated both by research interest and by seismic hazard monitoring.

The network presently comprises 23 operating stations, all of them equipped with state of the art seismographic stations. Their deployment is still governed by the principle of increasing broadband station coverage with due regards to the deployment of similar stations by other operators.

Figure 2: Data Center Products

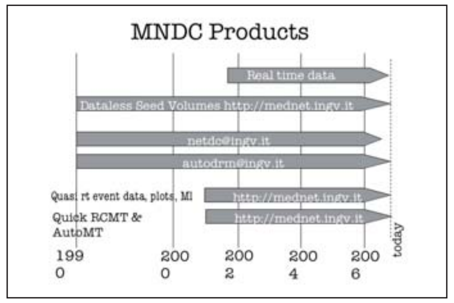
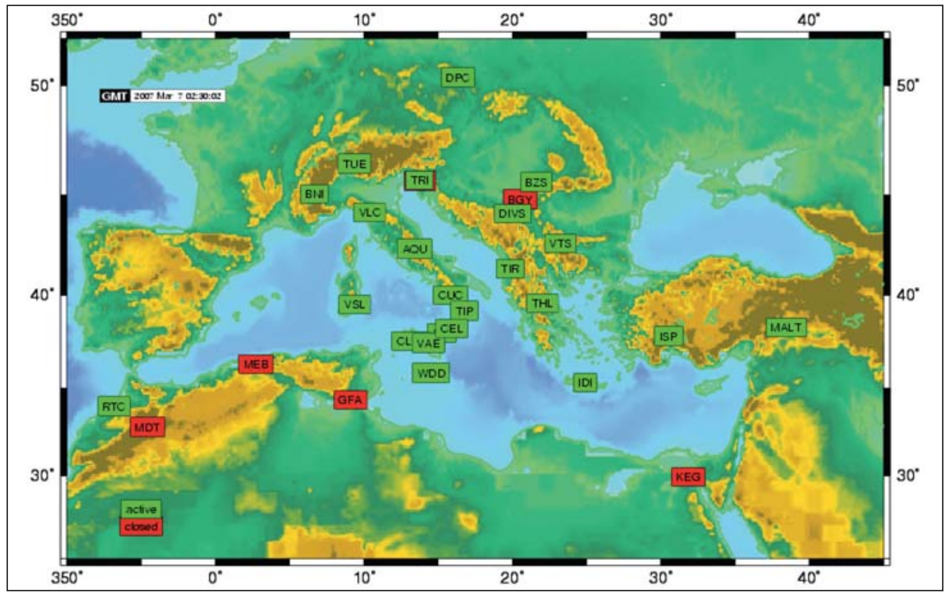


Figure 1: Station Map: closed stations are shown in red, open stations in green.



Seismometers are mostly Streckeisen STS2, with a few STS-1/VBB installed during the early phases of the project. Almost all data-loggers are from Quanterra (Q380-680, Q730, Q4120 and Q330). Data are transmitted in real time from the stations to Rome using TCP protocol and via several different physical links: leased lines, VPN, Internet and satellite link. Real time data acquisition and distribution is accomplished by means of the SeedLink protocol and SeisComP, a software package developed, maintained and freely distributed by GEOFON.

Data are distributed following three main routes: the fast, but restricted one of real time distribution (data are exchanged on a one-to-one basis between Institutions and are usually regulated by bilateral agreements), the intermediate one of distributing data grouped by event (available from the mednet web pages http://mednet.ingv.it), and the last one, slow, but very comprehensive, of sending data at users' request via e-mail or ftp, drawing them from the archive, by standard NetDC and AutoDRM protocols (in SEED and GSE formats respectively). The dissemination of station information is ensured by the so-called dataless SEED volumes, i.e. files in SEED format in which all the information regarding a station is reported, that is its location, channels, response functions, etc.

Presently, fully automatic network functions include:

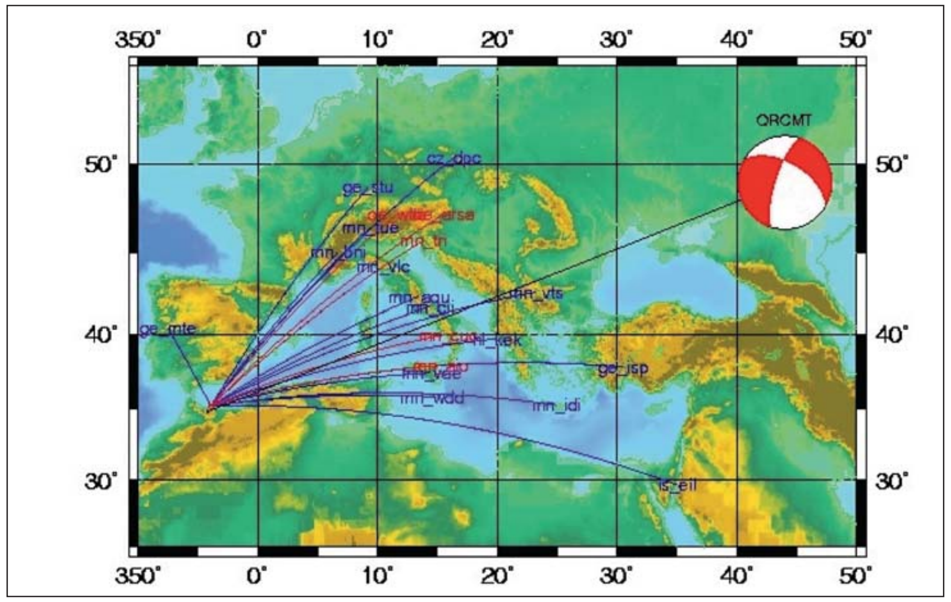
- daily monitoring of state of health;
- data recover after link failures;
- triggered retrieval of event waveforms;
- update of web pages (http://mednet.ingv.it) for events and station information.

Two different techniques for rapid semiautomatic moment tensor solutions are running at MedNet. The first one makes use of the Regional CMT (Arvidsson & Ekström, 1998) routines. The procedure is very stable, but the human intervention is essential. The second procedure is based on Dreger & Romanowicz (1994) TDMT, producing a first unmanned solution, then a successive solution revised by a seismologist. This second approach uses higher frequencies, in order to lower the Mw threshold for which moments are estimated in areas with proper station coverage.

Developments at MedNet are following two main directives:

- within the EC Project NERIES, the MedNet Data Center is contributing to the European Integrated Data Archive, providing support and/or backup to the partner institutions, in cooperation with Orfeus, Geofon and Geoscope Data Centers;
- In the framework of IOC initiative on North East Atlantic Tsunami Warning System (NEAMTWS), INGV is developing a Regional Center for a tsunami watch in the Mediterranean. In this regard, two different algorithms (LocSat and NonLinLoc) and different network configurations are under test at MedNet to check the capability of the extended network for locating potentially tsunamigenic earthquakes.

Figure 3: Example of Moment Tensor Solutions (Mw 6.5 Morocco, February 24th, 2004)



The Unesco Tsunami warning system in the North-East Atlantic and Mediterranean basins.

F. Schindelé (1,2) and H. Hébert (1)
(1) CEA/DASE - BP12 – 91680 Bruyères-Le-Châtel –France, schindel@dase.bruyeres.cea.fr
(2) ICG/PTWS France representative

Considering the 26 December 2004 event in the Indian Ocean that showed the devastating power of the tsunami and that its disastrous consequences could have been reduced if a tsunami early warning system had been in place, the Unesco Intergovernmental Oceanographic Commission established, during its XXIII Assembly, an Intergovernmental Coordination Group for a Tsunami Early Warning System in the North-eastern Atlantic and the Mediterranean and Connected Sea (ICG/NEAMTWS), regions with identified potential for catastrophic tsunamis and with a long known history of tsunami events. The terms of reference of the ICG/NEAMTWS include twelve objectives.

One of the main objective, related to the operational part of the warning system is to organize and facilitate, as appropriate, the exchange of seismic, geodetic, sea-level and other data in or near real-time and information required for interoperability of the ICG/NEAMTWS.

One of the other objectives is to liaise with other relevant organizations, programmes and projects. The IOC's participation during the EERWEM Workshop was the opportunity to provide information on the tsunami warning system in that region to the participants and to the geophysical institutions.

The size of each basin and the distance from the seismic rupture zones to the coastline are small. The tsunami travels very fast in deep sea (800 km/h) and still 160 km/h on the continental platform. For instance, the Figure 1 shows the tsunami travel time from the rupture zone of the Boumerdes 21 May 2003 earthquake, in the West Mediterranean basin (Alasset et al., 2006). The first wave impacts the Balearic coasts less than 30 minutes after the quake and the French coast within less than 80 minutes. Consequently, to provide an early warning, the time delivery of the first seismic warning message must be as short as possible. Sending a message including most of the seismic parameters (origin time, location, depth, magnitude, seismic moment and focal mechanism) less than 10 minutes would be useful for most of the distant coasts. These data will be supplemented by sea-level data that are necessary to check if a tsunami has been generated or not, and how high it is. The amplitude of the tsunami can be computed with numerical modelling codes. For magnitude 6.8 earthquakes, the typical tsunami amplitudes in deep sea vary from 1 to 10 cm (Figure 2). When the tsunami arrives on the Balearic coasts, due to the decrease of the ocean depth, the speed of the tsunami decreases and the amplitude increases simultaneously, reaching 1 to 2 meters in several harbours. In 2003, these waves have destroyed hundred of boats and have induced many wounds and casualties in summer period.

In conclusion, for a rapid, reliable national and regional tsunami warning system, immediate, free and open distribution of raw data from the observing systems in real-time must be acknowledged as a founding principle. We recommend to the EERWEM participants to help IOC to reach that objective.

Figure 1: Tsunami travel time from the 21 May 2003 rupture zone (red ellipse) in the West-Mediterranean basin (30 mn to the Balearic islands and 70-80 mn to the French coasts. Contour lines are the Tsunami travel time every 10 mn.

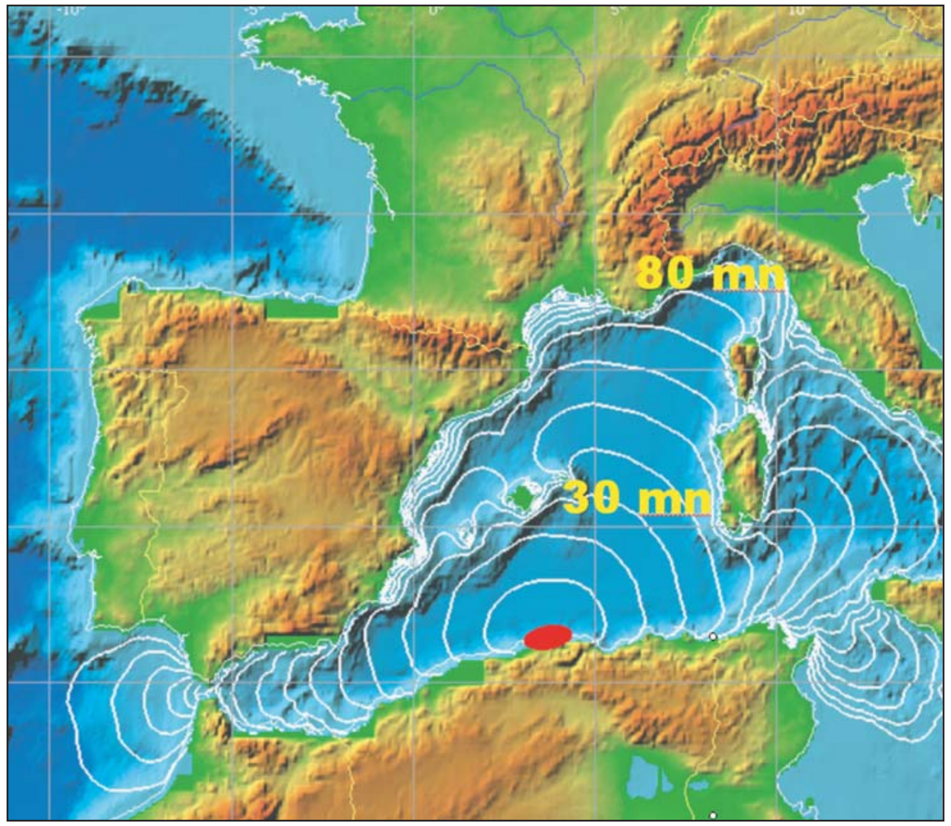


Figure 2: Maximum tsunami height in deep sea (21 May 2003, Magnitude 6.8). This figure shows the directivity of the tsunami phenomena perpendicular to the mean direction of the rupture zone. The Balearic islands are thus located in the most exposed area for this kind of source areas.

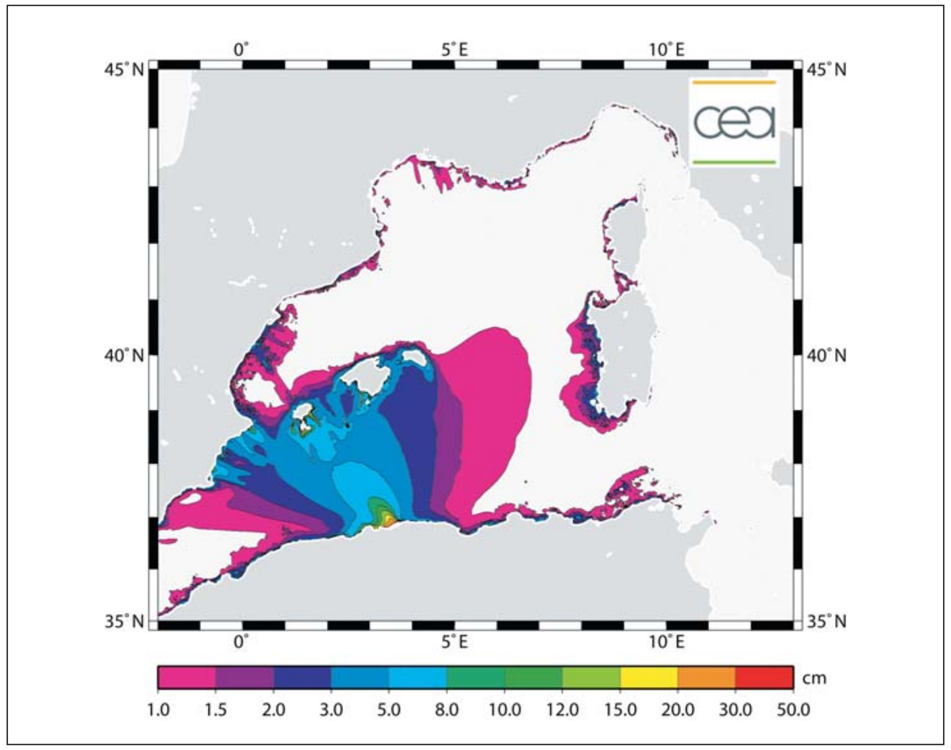
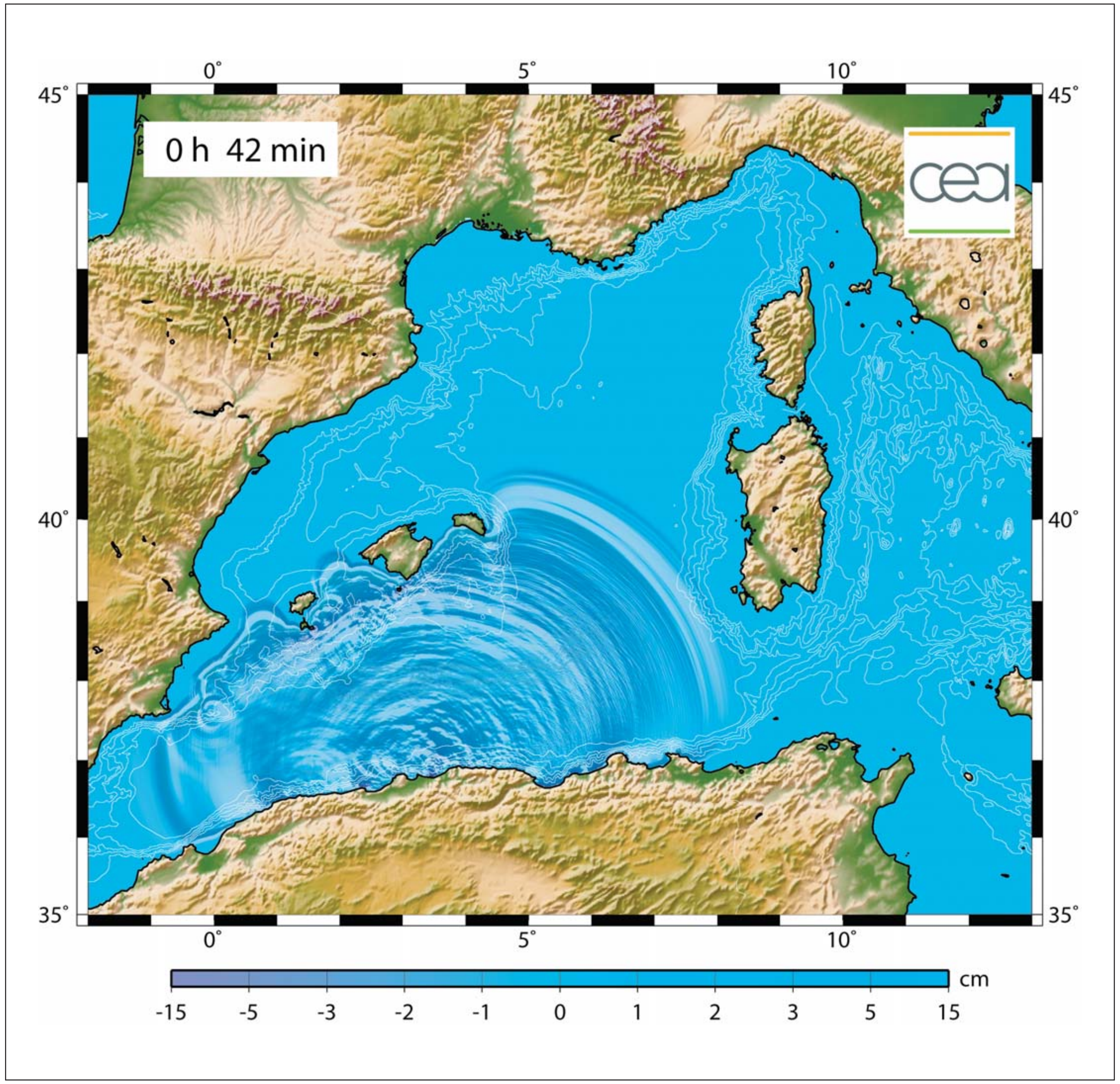


Figure 3: Sea surface after 42 minutes of propagation.



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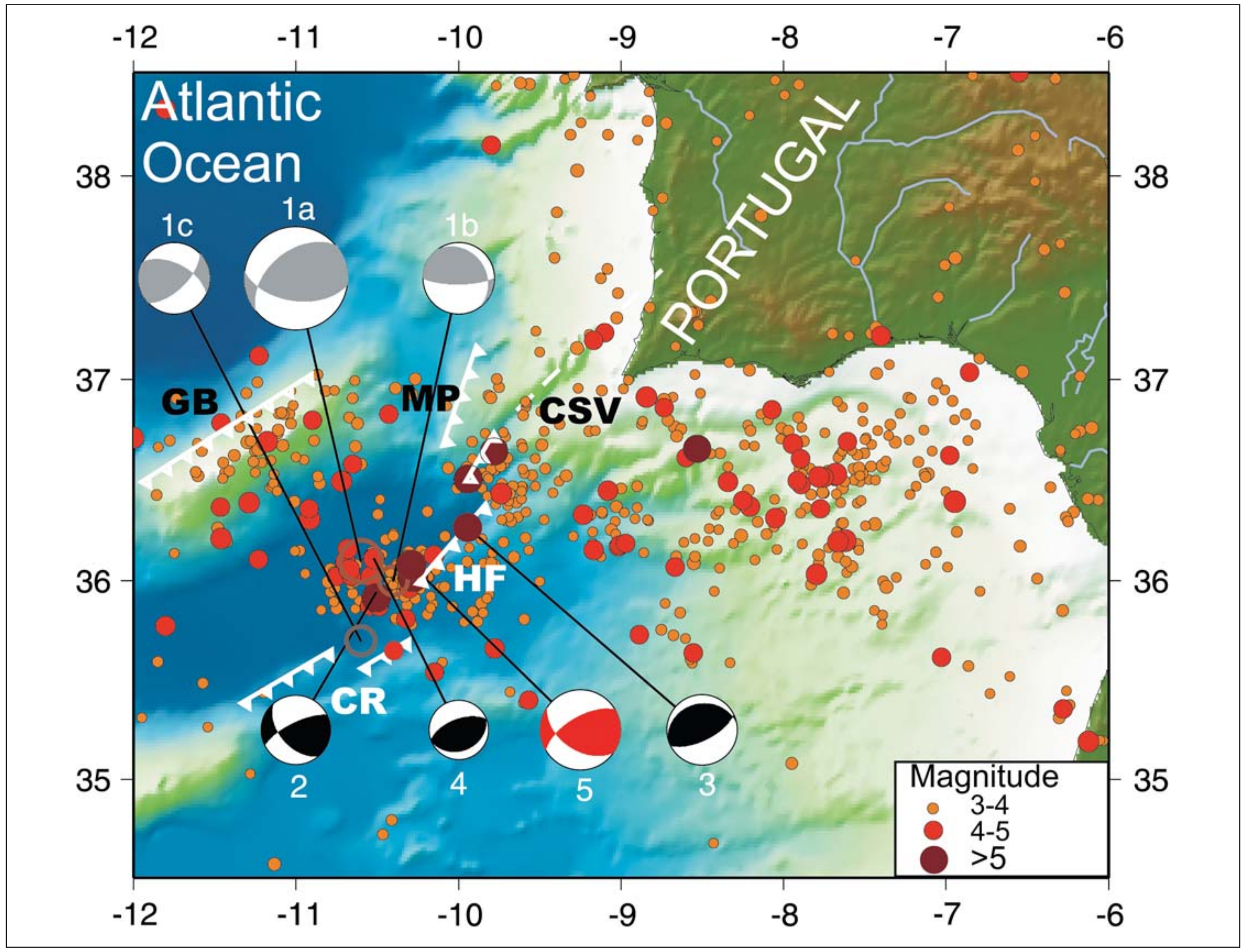
The recent 2007 Portugal earthquake (Mw=6.1) in the seismotectonic context of the SW Atlantic area

J.F. Borges (1), M. Bezzeghoud (1), B. Caldeira (1) and R. Grandin (2)
(1) CGE and Physics Dept., Universidade de Évora, Évora, Portugal (jborges@uevora.pt)
(2) Institut de Physique du Globe de Paris (IPGP), Laboratoire de Tectonique et Mécanique de la Lithosphère, 4 place Jussieu, 75252 Paris, France.

Figure 1: Seismicity provided by the Institute of Meteorology (IM- Portugal), focal mechanisms and major active faults of the region close to the epicentral area of 2007/02/12 earthquake; 1a, 1b and 1c are the 1969 earthquake and two major aftershocks; red mechanism represent the recent 2007 earthquake. CR= Coral Patch Ridge; HF= Horseshoe Fault; MP=Marquês de Pombal Fault; GB= Gorringe Bank; CSV= San Vicente Cape.



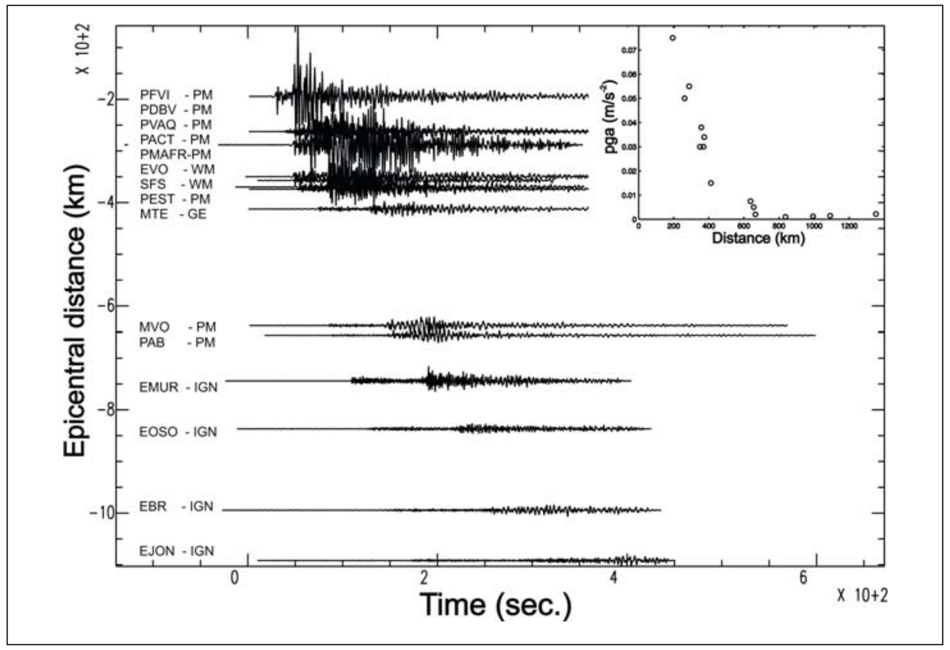
Introduction

An event of magnitude Mw 6.1(EMSC) occurred on 12/02/2007 at 10:35 UTC off coast of South-Western Portugal. The earthquake had its epicentre in the eastern Horseshoe Abyssal Plain, at 175 km South-West of San Vicente Cape (Figure 1). This earthquake is the largest earthquake since the great instrumental earthquake, Ms=8.0 (USGS), occurred on February 28th, 1969 in the same epicentral area. This earthquake was followed by four small aftershocks with magnitude less or equal to 3.5. There has been no reported damage associated to the event since habitated regions are too far away from the epicentre. This event has been widely felt in Portugal, particularly in the Algarve Region (I=IV – IM information), Southern Spain and Western Morocco and up to 700 km away of the epicentre (Salamanca, Madrid) (EMSC report in http://www.emsc-csem.org).

Table 1: Epicentral coordinates and focal mechanisms projected in the Figure 1

Nº	Date	Lat	Lon	Depth	M	Strike	Dip	Rake	REF.
(d/m/yr)(°N)		(°W)	(km)			(⁰)	(⁰)	(⁰)	
1a	28/02/1969	36.1	10.6	22	8.0Ms	324	24	142	Buforn et al. (1988)
1b	28/02/1969	36.2	10.5	37	5.6Ms	46	63	38	Borges (2003)
1c	05/05/1969	36.0	10.4	29	5.5Ms	231	47	54	Buforn et al (1988)
2	29/07/2003	35.90	10.51	30	5.4Ml	245	70	110	Carrilho (2005)
3	13/12/2004	36.29	9.88	29	5.4Ml	260	25	105	Carrilho (2005)
4	21/06/2006	36.10	10.47	30	4.6Mw	249	60	90	Grandin et al. (2007)
5	12/02/2007	36.08	10.29	44	5.9Mw	125	49	144	CMT(Harvard)

Figure 2: Seismic section of the 2007 earthquake recorded by the Instituto de Meteorologia (PM), Western Mediterranean (WM), Geofon (GE) and IGN Networks. In the top right corner, the Peak Ground Acceleration (PGA), in m/s2, as function of the epicentral distance.



Tectonic and seismicity of the area

In the last four years there was an increase in the seismic activity in the area between Gorringe Bank and the Horseshoe Fault (Figure 1 and Table 1).

The region at East of 16°W is dominated by a transpressive tectonic regime, with a very low convergence rate of 4mm/year trending NW to NNW, consistent with the observed maximum horizontal stress direction (Borges et al., 2001). In this region we don't see a clear limit between plates and the deformation is distributed over an increasingly large area that can reach an N-S width of 300 km near the continental margin of Iberia. The seismicity is scattered, but most events are concentrated along a 100 km wide band, trending ESE-WNW from 16°W to 9°W. In the area, a series of topographic structures trending WSW-ENE occur (Figure 1). The Horseshoe scarp and the Marquês de Pombal scarp, parallel to the San Vicente canyon, have experienced deformation since, at least, the Miocene. The latter scenario is supported by the occurrence of unusually large oceanic earthquakes inside the area of scattered seismicity such as the 1969 earthquake (Ms=8.0) and the historical 1755 Lisbon earthquake.

Seismic data and Peak Ground acceleration

Due to the proximity to the epicentre and the magnitude of the event, the Portuguese seismic network (IM), the Western Mediterranean Network (WM) and Spanish network (IGN) (Bento et al., this issue), have recorded a high quality and unsaturated broadband seismic data. The regional broadband records of this event will provide, in the future, an excellent opportunity to an accurate analyses of the source parameters and of the seismic ground motion effects of this earthquake. As example a seismic record section of this earthquake is presented (Figure 2) as well as the peak ground acceleration (PGA) as function of the epicentral distance, for a distance between 200 km and 1200 km. From this plot one can observe that the maximum PGA reached 7.5 cm/s^2 and was measured in the PFVI station.

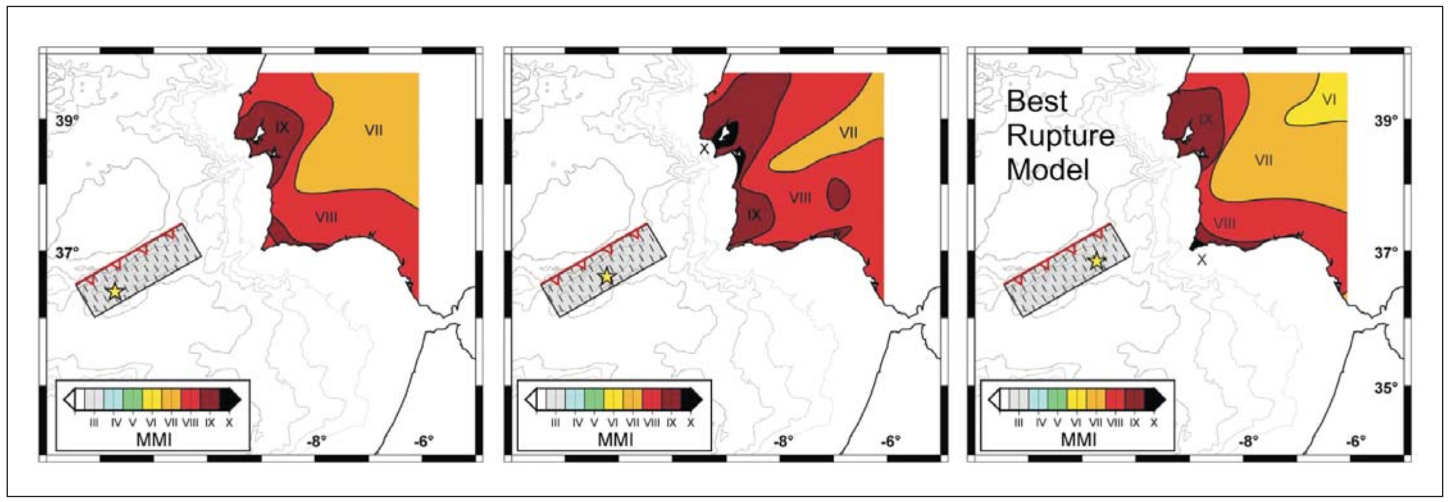
The 2007 earthquake in the context of the SW C.S. Vicente area

The 2007/02/12 earthquake was the strongest event occurring in the area since the 1969 earthquake (M8.0). All the four events (events 2 to 4, Table 1) fall in the same region, and could have been originated on the same fault, although the uncertainties on epicentral locations do not allow this hypothesis to be confirmed (Table 1 and Figure 1 shown thrust mechanisms, with a strike-slip component, consistent with a N-S to NNW-SSE direction of maximum compression (Borges et al., 2001)). All four solutions agree on a NE-SW striking nodal plane which has almost the same configuration as the inferred fault plane of the 1969 earthquake. Both 2004 and 2007 events occurred closer to the coast, at the south-western extremity of the San Vicente Canyon (CSV), and could be attributed to the seismic activity of the Horseshoe Fault (Figure 1), a NE-SW striking thrust fault, with a dip towards SE.

Discussion and implications for the 1755 earthquake Lisbon earthquake

The November 1st, 1755 earthquake was the strongest earthquake ever reported in Europe, and was extremely destructive throughout Portugal, and Morocco; the

Figure 3: Synthetic isoseismic maps for three proposed scenarios of the 1755 Lisbon earthquake. The most realistic hypothesis to fit the observed isoseismic pattern is in the right panel.



shock was even felt in Northern Germany, the Azores and the Cape Verde Islands. The large tsunami-waves generated by the earthquake also provoked extensive damage along the coasts of Portugal, southern Spain and Morocco.

The problem of epicentral location has been addressed by various early studies, and, since the beginning of the instrumental period, a consensus attributed the origin of the earthquake to a structure located between the Gorringe Bank and the Coral Patch Ridge, area where the recent 2007 earthquake occurred. Several scenarios were tested and we concluded that a NE-SW trending fault, possibly outcropping at the base of the NW flank of Gorringe Bank, could be responsible for the 1755 earthquake, as shown in Figure 3.

The epicentral region of the February 12th, 2007 and the events presented in the Figure 1 and listed in Table 1 (events 1 to 5), must be considered as a possibility also for a seismogenic area of 1755 earthquake. This new possibility will be tested using the same methodology already employed for the scenarios built for the Gorringe area (Figure 3).

Acknowledgements

This work has been partially funded by the Portuguese Science and Technology Foundation (FCT) of the Ministry of Science and Superiors Education (MCES) through the projects: MODSISNAC-FCT-2005, SEISMOLITOS-FCT-2004, FCT/POCTI/CTE-GIN/59750/2004, FCT/POCTI/CTE-GIN/55994/2004.

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The Cape St. Vincent Earthquake of February 12, 2007 Macroseismic effects

Jabour N., Hahou Y., Benchekroun S., Timoulali Y., Menzhi M., Hni L., Badrane S., Kasmi M. and Birouk A.
Institut National de Géophysique, CNRST-Rabat; Morocco, jabour@cnrst.ma.

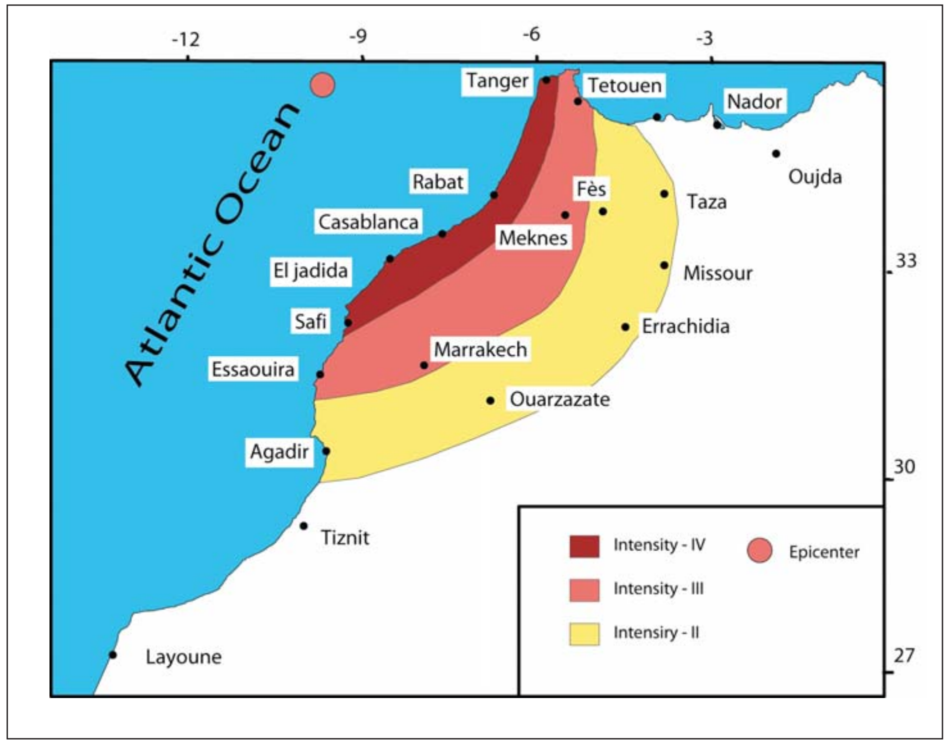
On the 12 February 2007, at 10:35:31 GMT, a strong earthquake of magnitude (M_w=6.1 EMSC; Mb=6.2 USGS) took place off-shore of Portugal, Spain and Morocco. This seismic event caused panic in several moroccan cities. The epicentre was located by the moroccan network in the Atlantic Ocean south of Cape St. Vincent at Latitude 35.45° N and Longitude 9.94° W, M_d=6.0, with an estimated focal depth of 45 km.

The 12 February 2007 earthquake was felt throughout northern cities of Morocco. This earthquake had a maximum macroseismic intensity of IV (all intensities are given in MMS scale) in costal cities of Morocco, Tangier, Rabat, Casablanca, El Jadida and Safi. The event was felt more strongly in Casablanca where the highest buildings in Morocco are grouped.

The occurrence of the 12 February 2007 Cape St. Vincent earthquake that was diffusely felt in the most cities of Morocco, allowed us to arrange the macroseismic survey in the region within the Western Rif and Atlas mountains zone.

The earthquake was slightly felt (intensity II), in Agadir city, Ouarzazet, Errachidia, Taza which are located some 650 km from the epicenter. In this regard, the large extent of the macroseismic area (see figure 1), may be explained by the depth of the hypocenter.

Figure 1: Morocco macroseismicity map of the February 12th 2007, Cape St Vincent earthquake.



The macroseismic map is somewhat similar to those obtained for the 1969 and 1755 earthquakes and shows a general pattern of macroseismic phenomena of Atlantic seismic events, (Levret, 1991).

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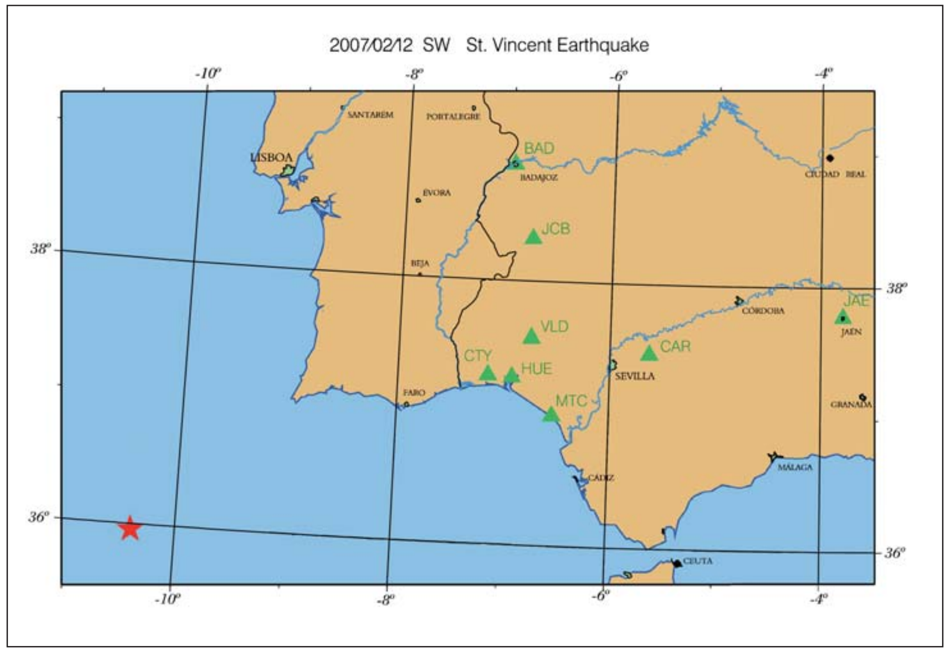
Recorded ground accelerations in the 2007/02/12 SW CAPE ST. Vincent Earthquake

Cabañas L. (1), Martín A.J (1). and Alcalde J.M. (1)
(1) Instituto Geográfico Nacional (IGN). Madrid. Spain, lcabanas@fomento.es

Figure 1: Strong motion stations (green triangles) that were triggered by the earthquake of 12 February 2007



The offshore Mw=6.1, SW Cape St. Vincent earthquake of 12 February 2007 is one of the largest seismic events in the surrounding areas of Spain in last decades. The hypocentral coordinates estimated by the Instituto Geográfico Nacional (IGN) were lat=35.96°N, long=10.41°W, depth=65 km. The earthquake was extensively felt in the SW provinces of Spain, such as Huelva, Sevilla or Córdoba, with EMS intensities III-IV, but also in some distant places (more than 900 km far away from the epicentre) like Madrid, Zaragoza or Santiago de Compostela among others, with EMS intensity II.

The event triggered eight accelerographs of the IGN strong motion network, located at epicentral distances between 326 and 623 km. These sites and the epicentre of the earthquake are represented in the map of the figure 1. The maximum horizontal ground accelerations recorded by these instruments range between 1.65 and 12.95 cm/s^2. Table 1 shows these peak values together with geographical coordinates, epicentral distances and epicentre-station azimuths of the recording stations.

Acceleration response spectra for a 5% critical damping ratio, SA, were calculated from the acceleration records, after being corrected for baseline errors and bandpass filtered between 0.1 and 25 Hz. Horizontal spectra of six of these accelerograms are shown in figure 2.

As a general characteristic, all response spectra show at least two distinct amplification peaks. The first, the predominant period in most of the cases, is located roughly in the range of periods from 0.1 to 0.2 seconds, while the second peak ranges between 0.4 and 0.6 seconds, approximately. Ordinates of both peaks are relatively small, as it is expected as a result of the epicentral distances of the stations and the magnitude of the earthquake.

The largest values of PGA and SA are obtained for the three nearest stations of table 1, all of them on rather soft soils. Specially, this is the case of the stations CTY and MTC that are situated on marine deep deposits of sand and gravel. When most of the spectra of February 12 are compared with those spectra calculated from local earthquakes recorded at the same stations (magnitudes lesser than 4.5), it can be seen (not shown here), that the quoted first peak appears inside the same range from 0.1 to 0.2 seconds, but the second peak disappears. Also interesting is the case of CAR, situated on the top of a hill with steep slopes and in the middle of the Guadalquivir valley, at an epicentral distance of almost 460 km. Its PGA values are greater than other nearer stations for the same event and the response spectra show several peaks, possibly as a contribution of topographical effects

Figure 2: Acceleration response spectra (5% damping) for components EW and NS from six of the recorded motions

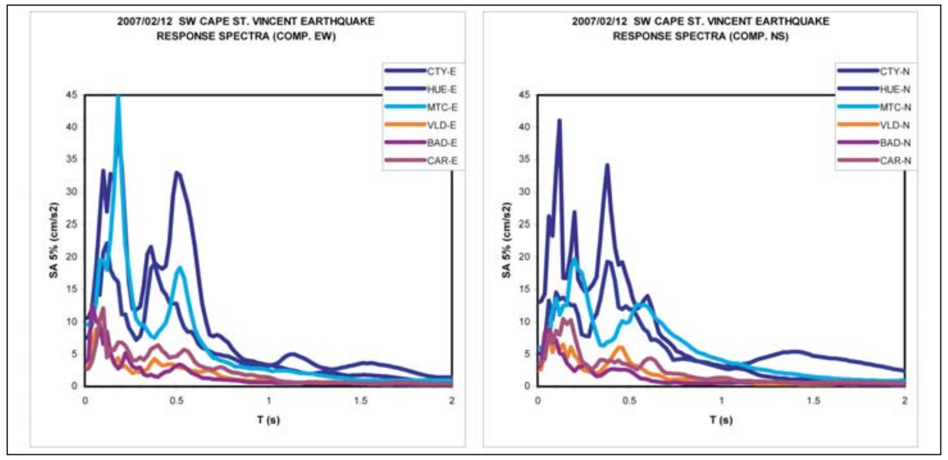


Table 1: Stations of the IGN strong motion network that recorded the earthquake

STATION	PLACE	LON(°)	LAT(°)	Rep (km)	AZIMUTH(°) Epic-Est	PGA (cm/s^2) NS	V	EW
CTY	CARTAYA	-7.153	37.284	326.3	62.3	12.96	6.10	10.53
HUE	HUELVA	-6.925	37.274	344.1	63.9	4.95	3.75	7.41
MTC	MATALASCAÑAS	-6.539	36.992	365.3	70.6	5.90	3.57	9.50
VLD	VALVERDE DEL CAMINO	-6.753	37.572	372.3	60.2	2.45	2.06	2.76
JCB	JEREZ DE LOS CABALLEROS	-6.772	38.322	416.1	49.9	1.77	2.36	1.41
BAD	BADAJOZ	-6.971	38.879	444.5	42.2	2.82	1.62	3.69
CAR	CARMONA	-5.632	37.475	458.7	67.1	3.50	3.25	2.57
JAE	JAEN	-3.789	37.773	623.5	69.2	1.89	0.89	1.65

Macroseismic effects of the 2007 Cape St Vincent earthquake from the EMSC online questionnaire

Musson R.M.W. (1)
(1) BGS, West Mains Road, Edinburgh, UK

Figure 1: Geographical distribution of the macroseismic questionnaires collected by the EMSC

It is a principle of the EMS-98 intensity scale, and the MSK scale before it, that intensity should be assigned to a community rather than an individual observation. Thus, when it comes to the question of automatic intensity assessment from data gathered online, the ideal way to proceed must be based on finding a way to compare a collection of reports from a single place, to the idealised descriptions provided by the scale.

Such a system is currently under development by BGS Edinburgh, initially for use with UK data, and is now being tested in Europe in collaboration with EMSC. The recent earthquake of 12 February 2007 (6.1 Mw) with epicentre off Cape St Vincent, Portugal provided the first real test. This earthquake was widely felt in the Iberian Peninsula (as far as Madrid), and a total of 183 questionnaires were collected from the EMSC web site.

In order to treat the data in a spatially uniform way, the data were sorted into 5km grid squares prior to analysis.

The intensity assignment method now examines the frequency with which different effects were reported within each grid square, in an attempt to mimic the way a human seismologist proceeds to assign intensity to a collection of data.

Figure 2: Distribution of EMS-98 intensities from the 12 February 2007 Cape St Vincent earthquake, from data collected by EMSC.

The algorithm first looks for significant amounts of damage, to see if intensity 7 or 8 is warranted. (Higher intensities would only ever be assigned in the field). Failing that, the algorithm checks the frequency with which "strong" effects (furniture moved, objects fall, etc) are reported, to decide if the intensity is 5 or 6. If there are few strong effects, the algorithm then looks to see whether intensity 4, 3 or 2 provides the better fit.

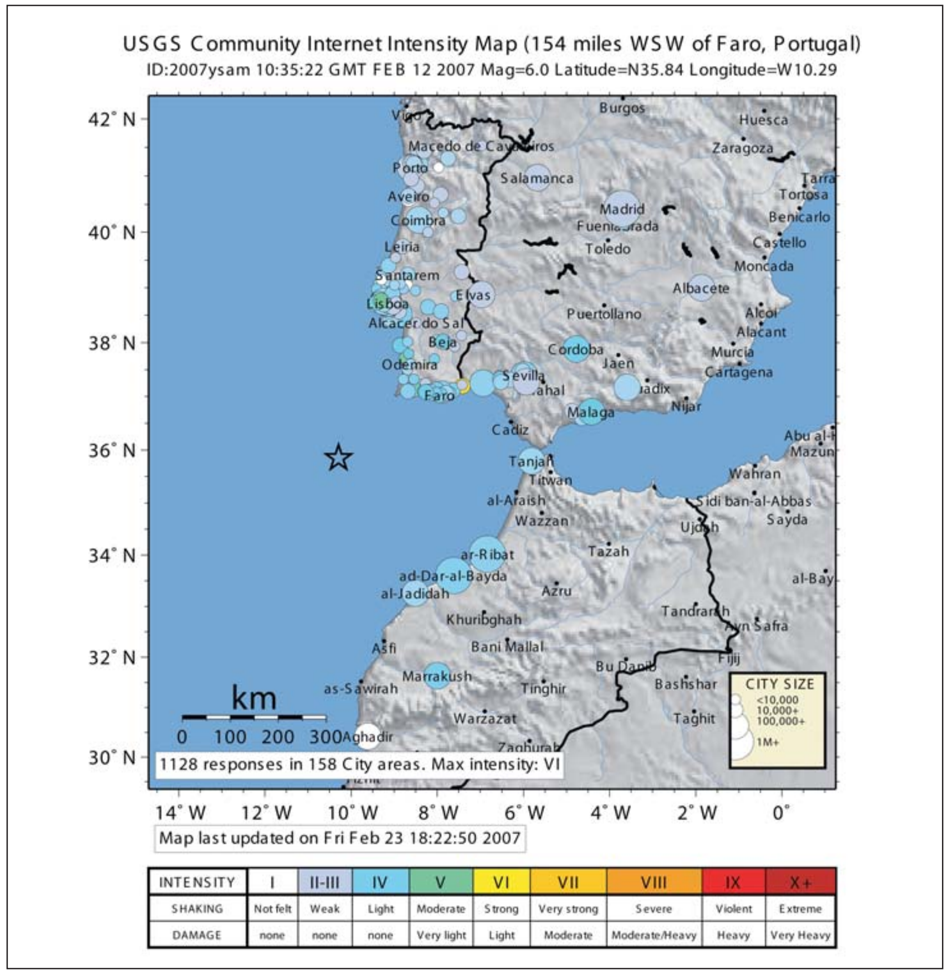
The bigger the sample from each grid square, the more accurate the estimates of frequency are likely to be. It follows that, if the number of reports from one place is too small, one cannot reliably assign intensity. In this study the minimum number of reports was taken to be five, though ideally, a higher number should be used.

The 183 reports reduced to 79 places when sorted by grid square. Of these, only seven squares yielded five or more reports (figure 1). The remainder could only be categorised as "felt" or, in one case, "not felt". The largest number of observations, not surprisingly, came from Lisbon (32 reports, intensity 5). Of the seven locations for which intensity was assigned, five were 5 EMS, with one 4 and one 3 EMS. A location west of Huelva, Andalucía, almost reached intensity 6 on the basis of eleven reports. Of these, two reported minor damage, and all reported large and small objects being thrown down.

It is interesting to compare the EMSC map (Figure 2) with that obtained by the USGS (Figure 3) on the basis of a much larger data set (1128 observations). The highest intensity on the USGS map is 6 (MM), at the southern end of the Portuguese-Spanish border. Generally, though, the USGS map gives the impression of lower intensities (the difference between EMS and MM is considered to be negligible). According to the USGS map, the intensity at Cordoba was 4 MM on six observations, whereas the EMSC data gives 5 EMS on nine observations (two-thirds reported objects falling, or similar effects). However, nine and six are both tiny samples, which limits what one can say reliably about the actual intensity at Cordoba.

Thus, while the system for the automatic assessment of EMS-98 intensities offers an opportunity to process macroseismic data in a human-like way with very little effort, the major restriction at the moment is the online acquisition of large enough data sets to obtain intensity values that are truly representative of what actually happened in any community.

Figure 3: USGS map of MM intensities of the same earthquake, from http://pasadena.wr.usgs.gov/shake/ous/STORE/X2007ysam/ciim_display.html.



On the use of Internet to rapidly collect earthquake impact information

R. Bossu, V. Douet, S. Godey, G. Mazet-Roux and S. Rives
European Mediterranean Seismological Centre, EMSC, bossu@emsc-csem.org

Introduction

In recent years the EMSC services related to rapid earthquake information have evolved rapidly: a new web site has been opened which is much easier to understand for non specialists, and an effort has been made to provide background information for all the reported earthquakes (background seismicity, list of damaging earthquakes, maps of past focal mechanisms etc). In early 2006, a customised Earthquake Notification Service was introduced which allows the users to define areas of interest, the type of information contained in the messages they will receive, and the distribution means (emails, SMS). The number of reported earthquakes has dramatically increased to reach 12 000 in 2006 thanks to increasing data contributions from seismological network operators. We want to stress that all these

Figure 1: Cumulative distribution of the observed time delay to collect macroseismic questionnaires on the EMSC web site. The first questionnaires are collected 20 to 30 minutes after the event's occurrence and a few hours are required to receive the majority of them.

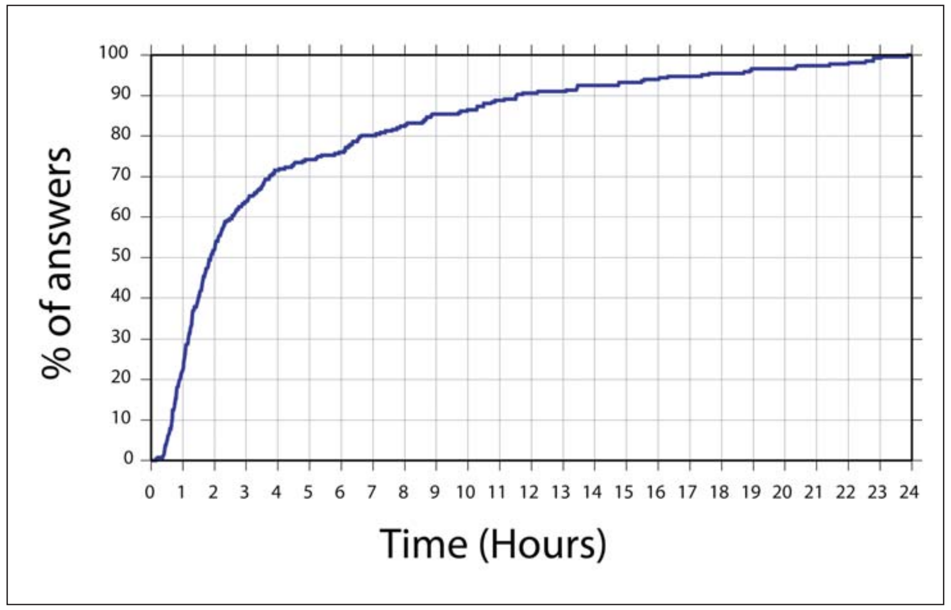
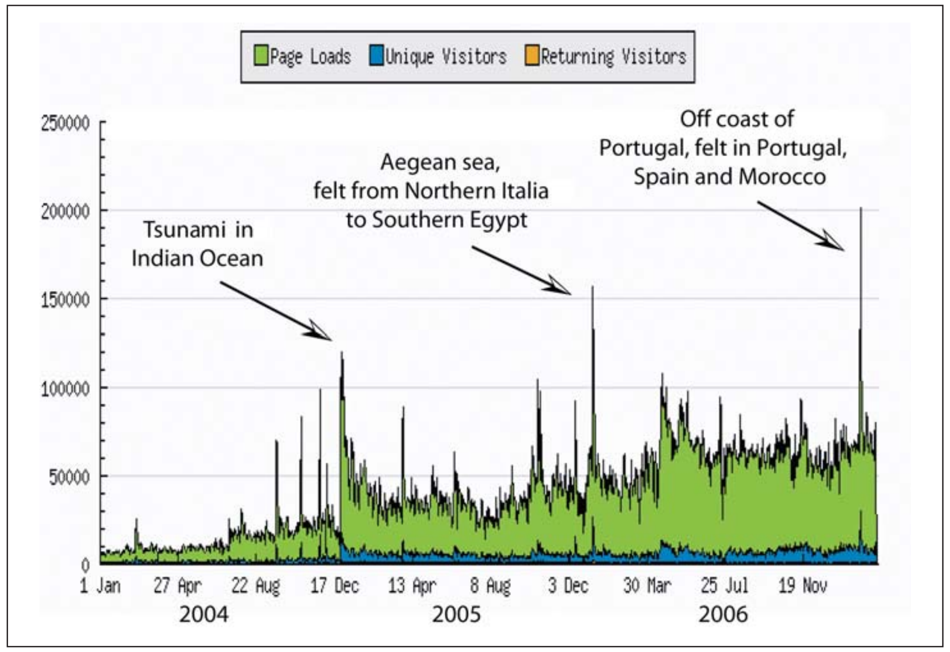


Figure 2: Daily traffic observed on the EMSC web site since January 2004. Each spike can be related to an earthquake in the Euro-Med region or a global earthquake.



services are based on these data contributions kindly provided by 58 different networks whose efforts deserve special praise.

The purpose of this article is not to provide a status on these services which can be found on the yearly report available on the EMSC web site. It is rather to give a rapid overview on services recently developed or still in development at EMSC which aim at rapidly collecting in-situ information on the effects of earthquakes. The three presented services use the Internet to gather pieces of information from the public and witnesses. It includes the now classic online macroseismic questionnaire, and 2 more innovative approaches: a tool to collect images presenting the effect of the earthquakes and an original development named "felt map tool". The latter automatically detects the earthquakes widely felt by the users of the EMSC web site, maps locations where they were felt, and, theoretically, should be able to identify when damage has occurred, all through the inceased wed traffic stimulated by the event.

The macroseismic questionnaire

The macroseismic online questionnaire has been developed thanks to the help of Roger Musson from the British Geological Survey (BGS); it is based on the BGS questionnaire and results are expressed along the European Macroseismic Scale (EMS). Several questions have been added to the BGS questionnaire to be as inclusive as possible and to optimise compatibility with other EMSC questionnaires in use in our community. It is currently available in 18 languages, and any member willing to contribute with a new language version is welcome. After having translated the questionnaire, several institutes have implemented the same version on their own web site. So far, the English version remains used by approximately half of the users. The location of the observations are based on a global database of 150 000 towns and settlements; the postal address is also collected (an option) to allow members to refine geographical sampling if they wish.

All the collected questionnaires are immediately made visible in English for members in the passworded section of the web site (but email addresses remain confidential) which can prove useful for events across a border for example. An exchange tool will be developed to push the collected questionnaires and/or the assigned intensities to the members. The first questionnaires are generally filled within 20-30 minutes of the event's occurrence and the collection rate decreases after a few hours (Figure 1).

As an example, Roger Musson presents in this issue the results of an automatic intensity assignment algorithm applied to the questionnaires collected following the Azores Cape Saint Vincent ridge earthquake. Several others tests will be required before making the system fully operational.

Felt maps

Description of the approach

There is a strong correlation between the daily variations of the traffic on the EMSC web site and earthquake activity, the strong increases being generally associated with earthquakes being widely felt and/or hitting the headlines (Figure 2). This feature is not specific to the EMSC web site but is shared by many, if not all, seismological sites providing rapid earthquake information. The earthquakes causing the surges mirror the typical geographical audience of the site. In the case of the EMSC, they are mainly Euro-Med earthquakes or events having attracted global media attention (Figure 2). A zoom in time shows that the increases can be brutal and occur within minutes of the earthquake's occurrence (Figure 3). The only persons within the public who know so rapidly the existence of an event, and the ones in a position to look for information on the site, are people who actually felt it. In other words, the observed surge of web traffic is initiated by visitors who just felt the earthquake, and their geographical origin will fall within the area where it has been felt (the felt area). This is the basic principle of the felt map tool.

Figure 3: Number of loaded pages per minute. The surge of traffic is detected 3 minutes after the occurrence of the Azores Cape Saint Vincent Ridge earthquake on February 12, 2007

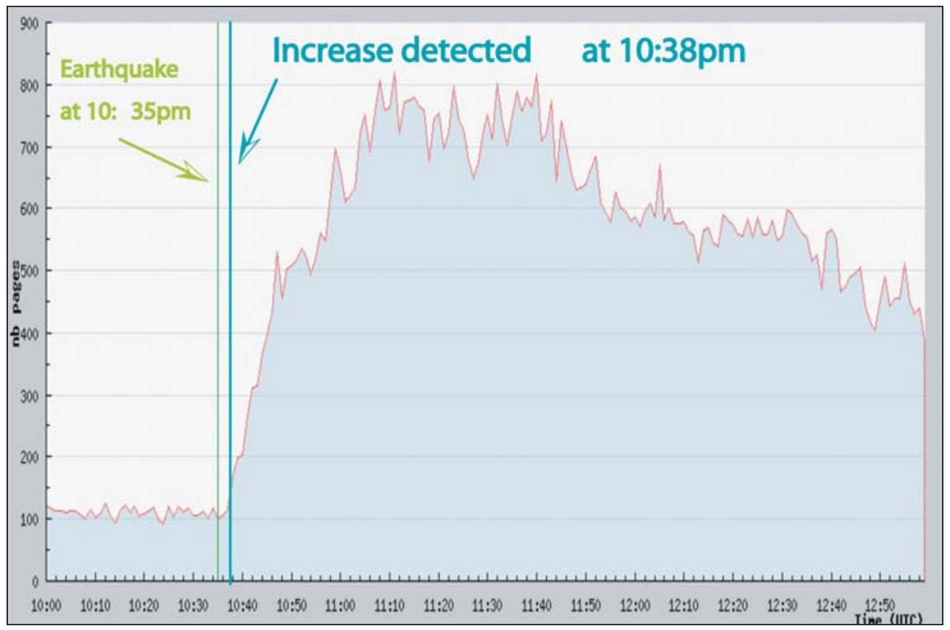
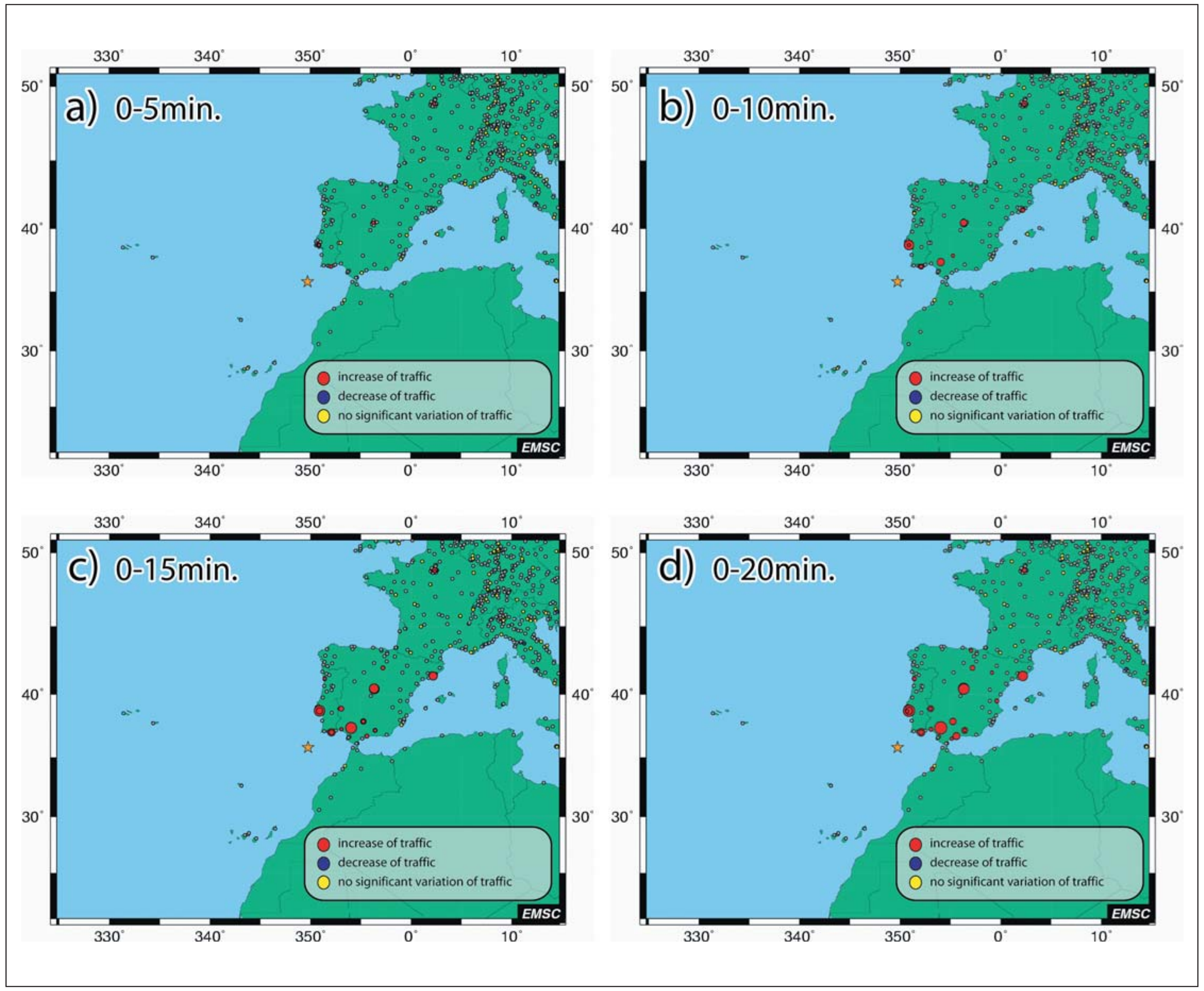


Figure 4: Felt maps obtained for the Feb. 12 2007 M6.1 event in 5 minutes (4a), 10 minutes (4b), 15 minutes (4c) and 20 minutes (4d). The star represents the epicentral location. Red dots represent geographical origin of increased traffic observed during the time window, blue dots represent decreased traffic, and yellow dots represent traffic with no significant variation. Grey dots represent the observed geographic origin of visitors in the last 12 months and characterise the regional audience of the EMSC.



In practice, the web traffic is analysed in time windows starting at the origin time. A geographical location is associated to each recorded IP address using a commercial database. The number of loaded pages from each location is statistically compared with the average observed traffic at the same point. The IP addresses associated with seismological institutes are excluded from the analysis. Significant increases (at 95% confidence level) are mapped in red, significant decreases in blue and non significant variations are mapped in yellow (Figure 4). The size of the dots is a function of the number of IP addresses at a given location, the larger the dots the larger the number of IPs which caused the increase. The grey dots map all the observed geographical origins of visitors during the last 12 months and characterise the geographic audience of the EMSC web site (Figure 4).

Results and limitations

The felt map tool has been in operation for approximately 2 years and has been applied successfully to about thirty events ranging from magnitude 2.7 to 6.1 (the results are fully available to EMSC members). The case presented is the application on the M6.1 Azores Cape Saint Vincent earthquake, 2007/02/12. Within 5 minutes of the earthquake occurrence (Figure 4a), a traffic increase is observed from the Algarve (South coast of Portugal), Lisbon and Madrid. In the following minutes there are confirmed and new increases of traffic observed from Southern Portugal, a wide area of Spain and in Rabat, Morocco (Figures 4b to 4d). This overall picture has been confirmed (see following articles), the event having actually been felt in

Figure 5: Pictures provided by a witness of the explosion of an ammunition storehouse in Novaky (Slovakia) on March 2 2007. The main explosion visible the figure 5a was preceded 1 minute and 10 seconds before by a smaller one which caused the plume of smoke. Windows were broken in a 10 km radius (figure 5b)

Portugal, along the Western coast of Morocco, along the Guadalquivir valley, and as far as Madrid.

The first and main limitation of the approach is its restriction to regions with widespread public access to Internet and where the web site is well identified as a source of rapid earthquake information. These criteria are probably not fully met in Morocco explaining why the observed increases of traffic were limited although the event was widely felt along the Atlantic Coast. On the opposite side, Figure 4 indicates an increase of traffic from Barcelona, although the event was not felt in this town. The likely reason is the intrinsic limitation of the location of IP addresses. The accuracy and reliability of the process depends on several factors including the set-up of the Internet infrastructure. In some countries, or regions, all the traffic is routed from a limited and sometimes a unique router, and only a few, or even a single, location can be determined. The actual geographical origin of visitors can then be much more spatially distributed than the one mapped through the IP addresses. This is what is suspected for Barcelona, the actual traffic originating from a much larger region than the Barcelona area which intersects the felt area.

Discussion

The felt maps identify within 10 or 20 minutes of the occurrence, at least some of the locations where an earthquake has been felt. It is a complementary result to the online macroseismic questionnaire because if it does not provide indications on the level of shaking but it is much faster as it is already available while the first questionnaires are just being filled in (Figure 1). At EMSC, the observed surge of traffic is generally the first indication that a largely felt earthquake has happened (2 to 5 minutes to observe the surge compared to 5 to 10 minutes to get the first location from data contributors). These variations are monitored in real-time to automatically detect small magnitude events felt by a large population when located close to a densely populated area. Such events may remain unreported, at least during the first hours, because of their small magnitudes. That is what happened on November 5, 2006. A surge was observed at 22:55 TU. The felt map indicated Athens as the geographic origin of the surge and the likely location of an event of unknown nature (earthquake, explosion…). The next morning, a magnitude 2.9 event was reported by the Greek networks, centred below the city.

This capacity to automatically identify felt earthquakes among many small events is valuable, especially for institutes which are not permanently staffed, to rapidly inform the seismologist on duty of the existence of a felt event and of requests for information from its own audience. It is complementary to the traditional alert criterion based on the magnitude and ensures information requests from the traditional audience of the site are rapidly answered.

More fundamentally, probably the main advantage of the felt map tool is its capacity to identify locations which have not been affected by damage as people are still able to use the Internet. Except in the few regions of the world monitored by dense real-time accelerometric networks, it is the fastest tool to collect in-situ information on the effect of an earthquake. So far, the tool has not been tested in a case of damage due to the lack of recent damaging earthquake in the Euro-Med region. Theoretically, it should be able to identify them but without discriminating damage on the lifelines and damage on the built environment.

Collection of pictures

There are currently more than one billion owners of mobile phone worldwide. The majority of the new models include a camera. There are then more that 1 billion potential reporters who may be willing to share their pictures on the effects of an earthquake (damage, effects in the landscape). Such information are valuable for the seismological community to document earthquakes and, if received rapidly enough after the event, to provide in-situ constraints on models of damage, or to refined plans of a field survey.

The potential of a collection of pictures was illustrated after the M7.7 earthquake on April 20 2006 in Koryakia region (Russia), a sparsely populated region, when pictures describing the damage in the village of Tilichiki (2,000 inhabitants) were sent spontaneously to the EMSC. They are visible on the EMSC web site. More recently, 18 hours after having reported a magnitude 2.2 event (March 2, 2007) close the city of Novaky (Slovakia), six pictures (Figure 5) were received from a witness which showed that the event was related to the explosion of an ammunition storehouse which broke windows at 10 km distance. They were published on the web site once independently confirmed by our Slovak colleagues.

Conclusion

The presented tools take advantage of the growing Internet traffic on the EMSC web site to collect information on the effects of an earthquake from the public, and, in turn, improve the provided services. The related experience remains limited at this stage, and these services are likely to evolve in the future. For example, some members have expressed interest in receiving SMS notification for felt earthquakes, something which should be feasible in the near future.

Network of Research Infrastructures for European Seismology

http://neries.knmi.nl

Grants for Access to European Seismological Infrastructures

The European Commission, through the EC FP6 project NERIES (Network of Research Infrastructures for European Seismology) will support grants for access to European seismological centres and infrastructures for periods of research and joint technical developments.

The infrastructures selected for access through NERIES are characterized by specific scientific and technical facilities as well as for their capacity to provide adequate scientific, technical and logistic support to external users:

ETHZ/SED (Switzerland) operates the most homogeneous and dense regional broad-band network in the European-Mediterranean region and specializes in the development of tools for data assimilation, data mining and hazard assessment. Contact: Annemarie Christophersen (annemarie@sed.ethz.ch) www.seismo.ethz.ch

CEA/DASE (France), experts in detection and verification seismology provides access to an extensive database of bulletins and waveforms (seismic / infrasound). A large spectrum of software tools is available for specific studies and benchmarks (source inversion, depth estimation, AI classification, etc.) and access to our large parallel computing infrastructure can also be provided. Contact: Jocelyn Guilbert (jocelyn.guilbert@cea.fr) www-dase.cea.fr

INGV (Italy) hosts the SISMOS scanning and digitalization facility, the most advanced facility for the preservation and the analysis of paper recordings of historical earthquakes through digital scanning. Contact: Alberto Michelini (michelini@ingv.it) Web: http://sismos.rm.ingv.it

NORSAR (Norway) is the premier seismological array facility in Europe and a leader in array seismology and automatic on-line data processing. Contact: Johannes Schweitzer (johannes.schweitzer@norsar.no) www.norsar.no/seismology/NERIES.html

ZAMG (Austria) runs the underground Conrad Observatory, a well equipped, ultra-quiet facility for research, testing and calibration of seismic instrumentation and acquisition electronics. Contact: Wolfgang Lenhardt (wolfgang.lenhardt@zamg.ac.at) www.zamg.ac.at/conrad_observatory/

Grants will cover travel and living expenses for periods of 1 week to 2 months, and are primarily open for researchers and network operators from the EU Member States and Associated States. Nevertheless, visitors from other countries can be accepted under specific conditions. Grants will be evaluated four times per year (deadlines: 15 March, 15 June, 15 September, 15 December). Grants will be available until mid 2010.

Applications, including a short scientific proposal and the CV of the investigator(s), should be submitted to the contact for each infrastructure. Additional information and links will become available through the NERIES project pages: http://neries.knmi.nl.

Key NodalMembers	**Contact**
Laboratoire de Détection et de Géophysique (LDG), France	Dr. B. FEIGNIER
GeoForschungsZentrum (GFZ), Germany	Dr. W. HANKA
Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy, Roma	Dr. M. OLIVIERI
Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy, Milano	Dr. P. ALBINI
Instituto Geografico Nacional (IGN), Spain	Dr. E. CARREÑO HERRERO
Active Members	
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Centre de Recherche en Astronomie, Astrophysique et Geophysique (CRAAG), Algeria	Dr. K. YELLES
National Survey for Seismic Protection, Armenia	Dr. A. Sh. ANTONYAN
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Center of Geophysical Monitoring (CGM), Belarus	Dr. A. G. ARONOV
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Federal Meteorological Institute (FMI), Bosnia-Herzegovina	Dr. I. BRLEK
Bulgarian Academy of Sciences , Bulgaria	Dr. E. BOTEV
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Geophysical Institute of the Academy of Sciences (GFU), Czech Republic	Dr. J. ZEDNIK
Geological Survey of Denmark and Greenland, Denmark	Dr. S. GREGERSEN
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Libyan Center for Remote Sensing and Space Science (LCRSSS), Libya	M. H. GASHUT
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