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Centre Sismologique Euro-Méditerranéen
European-Mediterranean Seismological Centre
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EMSC Newsletter

N° 24 / December 2009

The EMSC is undertaking a major challenge this year as it was selected to organize the 32nd General Assembly of the European Seismological Commission. The conference will take place in Montpellier, France, from September 6 to September 10, 2010. It will also feature a Training Course dedicated to Young Seismologists (eligibility conditions and application procedure to come soon).
Organizing such an event is a major occasion for the EMSC to state its role and place in the Euro-Med zone. We will strive to provide all participants with an attractive programme and an enjoyable stay.

The scientific programme will focus on the Euro-Med zone. Our sessions will cover the seismic event from its very source, that is to say from tectonics to its effects on our societies (as described by the sociology of risks). We will also take a look at the newest perspectives offered by information technologies, grid and high performance computing, data assimilation, data mining etc. The programme will also feature: the social impact of seismology (involvement of citizens as key witnesses to seismic events), society acceptance of risk (e.g. acceptance of geothermic projects), sociology of risk, communication in low-risk zones etc.). The social programme is still in preparation, but we can tell you it will feature food and wine, geological trips, excursions in the beautiful French countryside... and of course tours of Montpellier, an exquisite city bathed in sunlight.

REGISTRATION WILL OPEN EARLY 2010

We hope to welcome you in Montpellier in September 2010!

If you are reading the electronic version of our Newsletter, you can click on the ESC2010 banner to access the conference website directly.
If not, please visit us at http://www.esc2010.eu

Also visit the European Seismological Commission website:
http://www.esc-web.org/

The ESC2010 LOC: *Dr. Remy Bossu, EMSC General Secretary, head of the LOC, Marie-Line Nottin, EMSC Communication Officer, Pr. Michel Cara, Institut de Physique du Globe de Strasbourg, Dr. Serge Lallemand, Géosciences Montpellier, Univ. de Montpellier, Marie-Odile Pietrusiak, Observatoire de Recherche Mediterranéen en Environnement, Communication Officer. The ESC2010 is organized with the support of Geosciences Montpellier.*

Table of Contents

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NEWSLETTTER EDITORIAL DECEMBER 2009

Our second Newsletter of 2009 has a strong focus on the educational initiatives of our members in the Euro-Med region, particularly aiming at schools. We have reports from France, Italy, Ireland, Switzerland, and the UK. Of course, EMSC has now published its own map of Euro-Med earthquakes aimed at schoolchildren of around 12 years of age. It spans the period 1998-2008. The first printing, in French (the project received funding from a French Insurance company), has been distributed to schools in France. We hope to have an English version available for ESC2010 in Montpellier.

Also, in this edition, we have an article on the Earth's Seismic Sources and Structures, by Heiner Igel, and a number of reports on recent, significant earthquakes in our region. These include a web-based macroseismic survey of L'Aquila, 2009, which reminds us of the pioneering work of EMSC in developing web-based tools to both enhance the collection of such data and to better engage with our citizens in this two-way process.

Following trials in recent years, these web-based tools are becoming more mature at EMSC, with increasing insight into how they can best serve both the scientific community, individual citizens and agencies concerned with disaster preparation and response. In 2009, the EMSC team, at Bruyêres, has written articles and information sheets to encapsulate our involvement in these "Citizen Seismology" activities. It is now clear that when the citizens in a country become aware that the EMSC is a source of information at the time of a felt earthquake, many of them immediately visit our web-site and, by so doing, provide us with considerable information as well as being recipients themselves. The dramatic surge of visitors in the first two minutes following an event, alerts us to its locality (EMSC's initial solution using our Members' data is achieved in 8-10 minutes, typically). A small percentage of the visitors, who generally increase in numbers over the first hour, provide us with valuable macroseismic questionnaires in that time scale. Some, also provide contemporaneous pictures and videos of damage and transient phenomena, such as rockfalls, to add to a more complete documentation of the event. All of this Internet-based activity adds to our scientific knowledge and provides us with an outreach opportunity to individuals on a considerable scale. The initial felt maps, macroseismic maps and picture library are all put online to provide information to professionals and the public alike. For the latter, this provides an incentive to continue to visit us and achieves a positive feedback loop for seismologist – citizen interaction.

Of increasing importance to the EMSC team, over the past year, has been its preparation in organising the 2010 ESC Assembly in Montpellier. A call for themes has been made and completed across our seismological community, and the call for titles and abstracts is in-hand. We are looking for a strong and high quality response for what will be a most productive meeting in very pleasant surroundings. Our EMSC General Assembly will, as usual, take place during the proceedings providing us with the opportunity to share our ideas and be fully briefed on EMSC activities, including strategy, and key development and EC projects (eg NERIES, NERA, EPOS, etc). The entry for your new diary is "ESC/EMSC 6-10 September, Montpellier, France".

And, finally, the timing of this Newsletter provides me with the opportunity to pass on our greetings for the festive season from the EMSC coordinating centre, together with our best wishes for 2010. We look forward, very much, to catching up with all our members and supporters at the EMSC General Assembly in Montpellier, if not before.

Chris Browitt
President

Try the portal and tell us what you think about it!

NERIES Data Portal Available for Review

The NERIES project data portal is now available for use and review. The data portal provides a single point of access to event parametric information, seismic waveform data, and accelerometric parametric and waveform data. A username and password is required.

Please visit the portal at:
http://www.seismicportal.eu/

A login can be requested from:
neries-dp@knmi.nl

Erratum

A mistake was found in the April 2009 issue of the EMSC Newsletter.

With our sincere apologies, we would like to state that the authors of the **Republican Seismic Survey Center of Azerbaijan National Academy of Sciences** article are G.J. Yetirmishli and V.A. Farajov.

An educational seismicity map was created by the EMSC (in partnership with the Fondation MAIF, a foundation created by a French insurance company) in 2009.

This map, distributed in French junior high schools and created for a national audience, aims to make the young aware of the level of hazard in France. Elaborated from the Euro-Med Bulletin data, this map also gives recent examples of well-known earthquakes people remember (L'Aquila, Izmit, Boumerdes...) . These examples can be compared by the young to help them understand the notion of hazard and the multiple consequences of seismic events, as well as compare the seismic hazard level in France with that of other Euro-Med regions.

You can download this map here: http://www.citizen-seismology.org/

Be aware that it is in French only... at least for now!
A few copies of the A0 paper version of this map remain available.
EMSC members interested by getting a copy can send an email to Marie-Line nottin@emsc-csem.org or Stéphanie godey@emsc-csem.org without forgetting to mention their address!
(Members from French-speaking countries will be favored. We have a limited number of maps to distribute so some requests might remain unanswered.)

NEW

The EMSC has been invited to join the 3rd **Civil Protection Forum** in Brussels, 25-26 Nov 2009, as an exhibitor. The «Civil Protection Forum – Towards a more resilient society» will start a debate on a comprehensive European disaster management strategy to enhance resilience. Participants come to network, learn about new technologies used in civil protection, hear from international partners, discuss the future of European civil protection and much more. The Civil Protection Forum will bring together around 500 delegates, speakers and exhibitors from politics, academia, the civil protection services and international organisations.

Sand volcano produced during the L'Aquila earthquake at Vittorito, 50 km from the epicenter. Photo: Giuseppe Pomposo.

Subsidence on the shore of sink-hole of Sinizzo in San Demetrio dei Vestino, 20 km from the epicenter. Photo: Giuseppe Pomposo.

The above pictures are two examples of the photos recently collected on the EMSC website, concerning the L'Aquila earthquake. All pictures sent by witnesses can be viewed on the EMSC website.

The Euro-Med Bulletin for the year 2008 is now under production. It features two major evolutions in terms of content and computation.
* The ak135 velocity model is now used for all phases and at all distances, according to the IASPEI recommendations.
* In addition, the magnitude threshold, previously set at 3.0, has been completely lifted up. The Euro-Med Bulletin now contains events for the complete magnitude range as provided by the local networks.
This leads to a strong increase of the number of events included in the Bulletin, with an average number of events per day raising from 60 to 210. Furthermore, low magnitude events will also be integrated in the previously computed period of 1998 to 2007. We expect to multiply by three the total number of events which is currently of 106,000.

The new and full release of the Euro-Med Bulletin 1998-2008 with all magnitudes events computed with ak135 model will be available for the ESC 2010.

Towards a better identification of event type

Not all seismic events are earthquakes. Explosions or mine collapses can radiate enough seismic energy to be detected by monitoring networks, which then locate them and assign a magnitude value. These events subsequently end up in earthquake catalogues and affect the picture of the seismicity!

Discrimination of event types is therefore essential for unaltered earthquake catalogues and probabilistic seismic hazard assessments. Local networks may discriminate non-earthquake events thanks to their local knowledge of quarries and mines locations and the way they are operated. Unfortunately, the way the information is (or is not) reported in final bulletins is heterogeneous and can even be inconsistent when the same event is reported by more than one local network.

EMSC initiated a survey of network operators' practices and the conclusion is that there remains a lot of work in this area. The International Seismological Centre (ISC) and the US Geological Survey agreed with this analysis during our last coordination meeting in Golden, last September. This subject is likely to be proposed for an IASPEI working group in the near future.

FEELING THE EARTH SHAKE… AT SCHOOL
EDUSISMO: THE FRENCH EDUCATIONAL SEISMOLOGICAL NETWORK

See authors list at the end of the article

Promotion of responsible behaviour of educated citizens is indispensable in response to the rapid evolution of our society, where scientific information must be correctly understood by the general public. One of the missions of the school, in this case through the teaching of geosciences, is to enable the students to better grasp sciences that were once confined to scientific laboratories. The educational programme "SISMOS à l'École" is a project that focuses on education on seismic risk through a scientific and technological approach. One could hope that this programme will lead the students towards scientific careers.

The programme « SISMOS à l'École » must be considered within the framework of teaching sciences and technologies at school and is a tool to better inform and sensitize the school community to natural risks.

A pilot experiment initiated in the French Riviera region

The innovative idea of the pilot experiment was to study the feasibility and the pedagogical interest of installing a seismometer in a school.

The project was implemented / tried out over a period of ten years (1996-2006) in the south of France. It involved a close partnership between the Conseil Général 06, the rectorat of the Nice district and the GeosciencesAzur research lab. After a two-year period of testing various materials at a pilot site (the Centre International de Valbonne), results from the deployment of five stations showed that it was possible to record high quality signals within a school (Fig. 1).

Figure 1 - Feeling the Earth shake … at school.

The main goal of this pedagogical programme was to make available for the school community an instrument measuring an environmental parameter and the related data.

Teachers took away a number of positive points from this experience : the students were enthusiastic to take measurements, the online database was easy to use, the experience encouraged the development of autonomy, the students took responsibility for the management of the seismic station, and the experience demonstrated the importance of regular contact with a reference scientist.

A seismological network with an educational purpose

The initial experiment has expanded. Since the beginning of the 2006 academic year the programme 'SISMOS à l'École', which is part of the broader project 'Sciences à l'Ecole', has extended the educational seismological network throughout the country.

Following a call to candidature, approximately thirty schools were selected according to the quality of their pedagogical projects in order to build this network (Fig. 2). In each school, a multidisciplinary team of teachers supported by a scientist is carrying out its project centred on a seismic station designed and realized for the school.

Seismological stations directly accessible online by everyone

Current seismicity and the associated signals recorded by the stations are registered online on a website dedicated to this school project. How is this database built?

Each seismological station records in continuous mode the ground motion with a sampling frequency of 50 Hz. Broad band seismometers ensure a high sensitivity and a good reproduction of a large frequency band, which enables to visualize correctly local and teleseismic earthquakes.

A GPS unit allows the data to be synchronized with universal time. As the data are viewable online, students can monitor ground motion in real time.

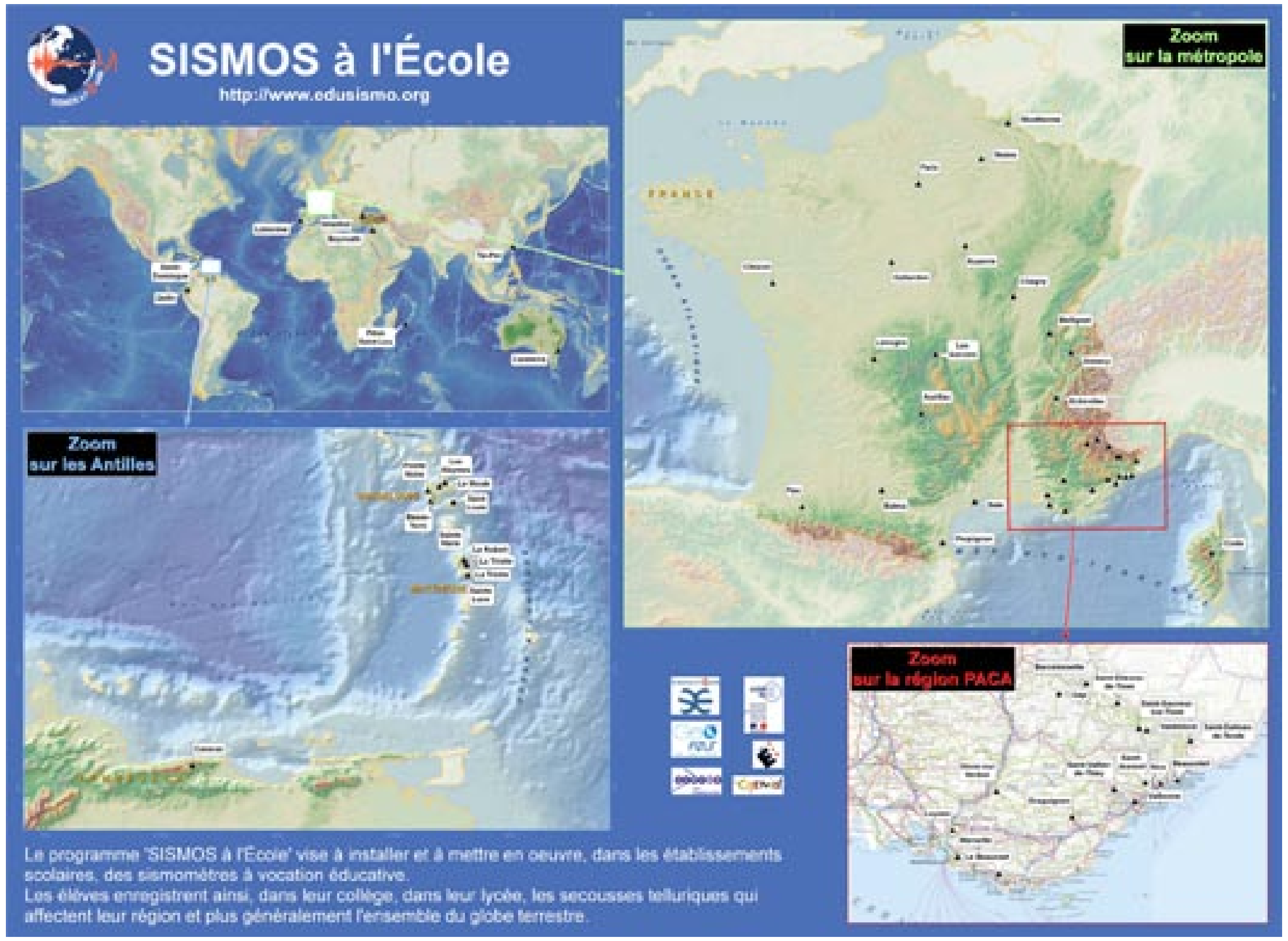

Figure 2 - A map of the "EduSismo" network (seismometers in schools).

They can identify the arrival of earth tremors and other vibrations, natural or generated by human activities (swell, quarry explosions).

Stations are queried daily to extract recordings related to seismic events.
In this way, a national server retrieves and archives seismic events identified by the seismological observatories and corresponding signals received from the stations. Selected events are at times earthquakes close to the station and at other times distant high-magnitude earthquakes. Signals from these events are then fed to an online database constituting a genuine seismic resource and a starting point for educational scientific activities (Fig. 3).

Figure 3 - The stations installed in the schools transmit their data to a central server.

The recorded data can be accessed by the entire educational community on a website.

Using a seismometer in the school

The school curriculum has several important aspects (placing large emphasis on new communication technologies): scientific content (instrumentation, geophysics, Earth sciences), educational dimension (sensitization to seismic risk), regional, national and international dimension (networking several schools). The team of teachers can follow various pedagogical suggestions.

What are the students doing? Observe, measure in order to understand better, compute and discover new parameters... then understand to act more appropriately (Fig. 4).
Within the framework of courses in Earth and Life Sciences, Physics, Technology and Geography, there

Figure 4 - Building scientific know-how, between mining databases and an investigational approach.

are various pedagogical suggestions for the curricula of junior high schools and high schools on the following themes: measurement of a parameter, knowledge of one's geological environment, complex mechanisms of internal geodynamics, and notion of environmental risk.

The network of seismological stations and its database can also be a springboard for multidisciplinary projects bringing together teachers of experimental sciences, technology, mathematicss and geography.

Also, management of a seismological station can be the starting point for a scientific workshop. In such a case, students would have the responsibility of managing a seismological station (concept of educational observation of the environment), work autonomously in teams and develop their skills in the **'Technologies of Information and Communication' (TIC)**.

In all these situations, transversal approaches are encouraged : measurement, observation, building of models, and investigative thinking to grasp scientific concepts related to geosciences and physics. This building of scientific know-how is essential to the education on environmental risk. Best practices all around the network have been shared by teachers of various schools and the following pedagogical suggestions attest to the richness of such sharing.

The «sensors» topic is an essential point. Measurements through a sensor (for example, measurement of ground motion in relation to universal time) could be explored, using sensors from the seismological station or sensors developed by students.
Various aspects of basic science are tackled, including frequency, bandwidth, fidelity, repeatability, and the robustness related to the often linear oscillator behind the sensor.

The «data» topic arises naturally. The analysis of recorded signals leads to various activities, including work on waves, a key notion in our society as radio, TV, and internet use them intensively. Travel times, wave speed, and localization through triangulation are typical concepts a student can easily master without getting into sophisticated mathematical tools.

The «tectonic» topic is also rich in possible activities. Numerous models have been proposed and realized by students. These practical exercises introduce abstract concepts, including seismic cycle, stress build-up, friction phenomena and energy release among others.

The «Earth» topic is obviously central to the teaching of natural sciences. Possible activities include geographical mapping through the presentation of data collected from various schools, the discussion of seismic hazard either on a global scale or a local scale, and the presentation of different seismic signatures such as Benioff planes or Moho discontinuity. These activities demonstrate how we discover the internal structure of the Earth.

The «risk» and «hazard» topics come naturally after these various speculations or analyses. From seismic records, students can illustrate through practical models the notions of intensity, building resonance, paraseismic rules of construction and the induced effects of a tsunami on coastal zones. With many national initiatives, this topic will become increasingly important in educational training.

All these examples of simple activities, which could be carried out by students, have been brought together in a single workbook. This collaborative work which began twelve years ago illustrates the combined efforts of researchers and teachers towards better education and awareness of risk culture, especially in youth.

«O3E»: towards a Euro-Mediterranean project

Students are encouraged to create contacts between schools while teachers share pedagogical ideas. The life of the network is based on exchanges between students, teachers and researchers. These networks now reach beyond France itself. The extension of the project into the Euro-Mediterranean region is underway. The "O3E" project (Observation of the Environment for an Educational purpose at School) unites the various experiments and skills of French, Italian, and Swiss Alps participants. It is a strong sign of the desire to expand this approach of education on natural risk in the European region.

Finally, the goal of projects such as « SISMOS à l'École » is to improve the education of our students in geosciences so that they have a better view of what science is and how it progresses.

They will have learned the importance of precision in the taking of measurements and in reasoning. They will have acquired knowledge about Earth dynamics and how to prepare for risks. We will have educated, and without any doubt, better prepared and more aware citizens.

Other readings...

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J. Virieux (2000) - Educational Seismological project: EDUSEIS, Seismological Research Letters, 71, 530-535

«Sismos à l'Ecole», EduSismo network website: http://www.edusismo.org

«O3E», European Interreg project: O3E.geoazur.eu

"Eduseis", towards an european project: http://www.eduseis.net

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ARE EDUCATIONAL INITIATIVES IN SCHOOLS EFFECTIVELY CONTRIBUTING TO PREVENTION IN ITALY ?

by Stefano Solarino[1]

The social and economic consequences of the recent earthquake in Abruzzo dramatically recalled the fragility of a land where the many ancient monuments and the unscrupulous construction concur to a castastrophe scenario. And of course they recalled the question of what can be done to avoid the losses, making the terms prevention, mitigation, and preparedness prevailing again.
In fact, despite the very poor attention towards safe construction in seismic areas, in Italy several education programs have taken place in the last two decades with the aim to make people conscious of natural hazards and raise their sensibility on the behaviour to adopt during an emergency.

The aim of this article is to discuss the role of education in terms of prevention under the light of the main past experiences in education programs. The first part of the article is thus a short description of the projects held in Italy and of their current heir.

The main initiatives in education, namely the EDURISK (still active) and EDUSEIS projects, had similar targets and goals, but were somewhat different in their means and activities. In fact while they were both aiming at:
1) instructing and informing about what an earthquake is and how one can prepare for it
2) raising awareness of the fact that most of the Italian population lives in seismic areas
3) orienting towards problems related to earthquake preparedness, and the role of prediction and prevention,
they were based on different levels of intervention of the people involved.

The activities included within the EDURISK project are the natural continuation of the early works by *Stucchi et al., 1978* : the primitive education group continued its activity in the context of the **Gruppo Nazionale per la difesa dai Terremoti** (**National Group for Protection Against Earthquakes, GNDT** hereinafter). The EDURISK project continued after GNDT had been subsumed into the **Istituto Nazionale di Geofisica e Vulcanologia** (**INGV** hereinafter).

The activity of EDURISK (www.edurisk.it) is designed for the whole range of schools: students and teachers are offered a wide variety of educational tools and learning courses specifically designed to foster, nurture and enhance knowledge. During its enterprise, EDURISK drafted forth educational tools for the infant, primary and lower secondary school, which are printed in the form of short books and freely distributed to the schools participating in the activities. The teachers undertake to fit the EDURISK prototypes within their curricular activities for at least one academic year, at the end of which they assess their effectiveness, suggest alterations/improvements, and provide additional feedback.

In its subsumption to INGV, EDURISK was associated to an existing group of researchers already devoted to education. The merging of the two research units resulted in a series of initiatives, again mainly devoted to schools but not only. The offer spans from production of printed and multimedia editorial items, to exhibitions, lessons in schools and visits to the seismic centre of the National Earthquake Centre in Rome, with the opportunity to see seismologists attending their everyday work. As INGV is organized into agencies spread all over the Italian territory, these kinds of initiatives regard most of the italian regions and are organized by the Roma, Rocca di Papa, Arezzo, Bologna, Genova, Napoli, Catania, Grottaminarda branches (http://portale.ingv.it/servizi-e-risorse/attivita-scuole, in Italian).

EduSeis (*Educational Seismological Project, Cantore et al., 2003*), was a scientific/educational project which involved high schools, scientific museums and research institutes in different European countries. It covered the fields of environmental and earth sciences using seismology as a tool of scientific learning. The main objective was to create a direct and permanent link between scientists on one hand, teachers and students on the other one. The project was based on the implementation at schools of an earthquake recording station with a network data management. The seismic data recorded by the EduSeis network were analyzed and interpreted in school laboratories by the teachers and their students with the assistance of science museums and the supervision of research institutes. The project in Italy was originally funded by the GNDT.
In the early years of 2000, 10 stations were installed in schools of Southern Italy, but after 2002, due to financial problems, many Italian schools retired from the project. Only a few seismic instruments were kept in operation, under the supervision of the Università della Calabria, Università di Napoli and Città della Scienza.
The latter station was then included in the Sismo a l'Ecole network, contributing to enlarge the area of young seismologists in Europe.

The **O3E** (**European Observatory for Education and Environment**, *Berenguer et al., 2009*) borrows the experiences from 10 years of regional and national educational programs, including the initiatives up to now described. It is an innovative program born from the cooperation between France, Italy and Switzerland to promote responsible behaviour of citizens towards environmental emergencies (earthquakes, storms, floods) by installing sensors of educational vocation in selected schools. Data are recorded in the schools and processed by the students on dedicated servers and then made available through the internet to the entire educational community.
The schools participating in the project are offered a rich series of meetings, classes and technical briefings (http://o3e.geoazur.eu)

Therefore the past and present experiences have schools as main targets. Although based on small amounts of students, an estimate of the impact of this educational initiatives on prevention can be done and turns out to be very positive. In principle the idea of involving schools in education is meaningful. Students are open-minded, do not have pre-concepts; they do like very much being protagonists and having a duty like running a seismic station or processing data helps them to become more responsible. Going into the nature of seismic data helps them to understand the physics behind and, more important, they get the feeling about the limitations that data may introduce when their quality is not high enough or their number and distribution is not sufficient. The availability of data make students more eager to go into the nature of the processes, and learn to estimate what information can be taken out from the single datum. Teachers also benefit from the projects because the availability of instruments and the cooperation with researchers may improve their knowledge on specific topics.

There are of course also advantages for the researchers. The world of scientific research is often considered by the citizens as unreachable, while education projects establish a direct relationship between scientists on one side, teachers and school students on the other one.
This relationship is profitable for each one of the actors, because in the current society scientists must be able to communicate in order to convince people (and financers) of the importance of their work. Nevertheless, even if the involvement of teachers, students and their families is taken into account, the number of persons hit by the initiatives, and possibly educated, is too small. In order to ensure a significant result, education should involve more schools (better all) and last for longer times.
The themes of prevention and mitigation should become topics treated in school books, and not left to the initiatives of a bunch of researchers. By the way, this would cost almost nothing to society.

One can argue: provided that the time devoted to earth sciences in Italian schools is very limited (even in those colleges supposed to specifically form students for further earth science applications at the University), should we insist on the physical aspects of the phenomena, favouring those that will continue in the field of earth sciences, or should we form citizens more conscious about the natural hazards by introducing more information on how to face emergencies? The answer should be easy: although in Europe and, in particular in the Mediterranean area, the risk of strong earthquakes exists, the politics of information and awakening to the seismic prevention are still insufficient in comparison with analogous initiatives undertaken in other seismic regions in the world (such as for example Japan, Western United States).

In this context, the role of media has to be underlined. The educational messages should appear every now and then on newspapers and be the theme of television broadcasts, but most of the time this does not happen until a catastrophe occurs.
Media have an impressive power that they seldom use for scientific divulgation, although a great improvement for the wrapping of the news would result from the cooperation between journalists (bad science, efficient communication) and researchers (good science, inefficient communication).
Unfortunately, media are used to think in terms of economical advantages: from this point of view the impact of prevention is apparently zero. Instead, it has a paramount importance on society because educating people may save human lives and huge amount of money.

Can we assign such a heavy duty only to our students?

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1) Prime Researcher at the Istituto Nazionale di Geofisica e Vulcanologia, Genova, Italy

SEISMOLOGY IN SCHOOLS (SEISMEOLAÍOCHT SA SCOIL) PILOT PROGRAMME, JUNE 2009

by Thomas Blake[1]

Seismology at DIAS

The **Dublin Institute for Advanced Studies (DIAS)** Geophysics Section has been the leading agency in Ireland in the monitoring of earthquakes from all over the world since 1978. Currently, DIAS runs its own seismic network, and collaborates with Met Éireann and with the GeoForschungsZentrum Potsdam in running two broadband stations at Valentia Co Kerry and in the Dublin Mountains.

Outreach at DIAS

Over the last two years the Section has initiated an educational outreach programme, aimed at primary and secondary schools, where DIAS staff members visit schools to talk about earthquakes and other areas of scientific research of the Earth carried out at the Institute. There is also an opportunity for postgraduate students to participate in this programme as part of their postgraduate training to learn how to effectively communicate their scientific research to schools, primarily those in the transition year programme.

Seismology in Schools (Seismeolaíocht sa Scoil) Pilot Project

DIAS has introduced the "Seismology in Schools (Seismeolaíocht sa Scoil) Project" in response to the increasing interest by students in earthquakes, and Earth Science in general. This pilot programme was organised and directed by Mr T. Blake, Experimental Officer in the Section. The possibility of actually recording earthquakes in near real-time in the classroom is a significant development in the classroom study of seismology, and excites the imagination of young minds in exploration of the Earth.
The Seismology in Schools concept started in the United States 15 years ago as the **Princeton Earth Physics Project (PEPP)** at Princeton University. From this the programme was expanded and is a highly successful programme currently run by the **Incorporated Research Institutions for Seismology (IRIS)** organization (see: http://www.iris.edu/edu/AS1.htm) with National Science Foundation funding.
Recently, the U.K. also launched an equivalent initiative, through the **British Geological Survey** (http://www.bgs.ac.uk/schoolseismology/). Due to our collaboration with the **BGS**, DIAS was offered the opportunity to acquire very cost effective seismometers (SEP Seismometer, designed by the BGS (Fig. 1). The software comes free from IRIS.

Our initial concept was to embark on a pilot programme by purchasing seven of these seismometers and loaning out four of them to interested schools on a rotation basis. Depending on how that pilot programme ran, we were planning to enhance the programme with more sensors available on loan.
There was a hugely enthusiastic response by the Education Centre Directors and DIAS was asked to purchase 34 (thirty four) seismometers on their behalf. The Education Centre Directors' nominated a school and teacher to participate in the pilot programme and made a gift to the school of the seismometer.

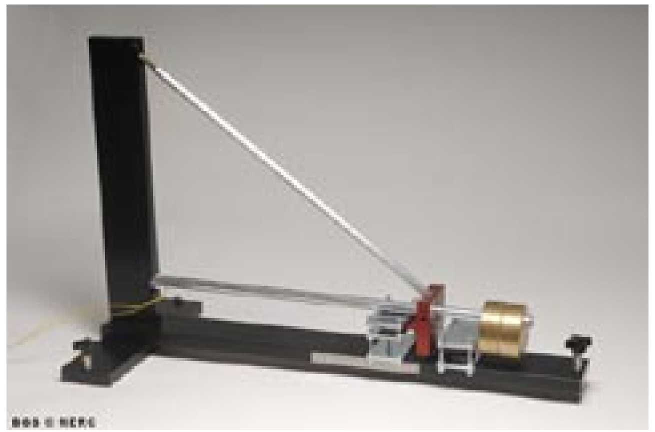


Figure 1 - Science Enhancement Programme SEP Seismometer introduced into 50 schools in Ireland.

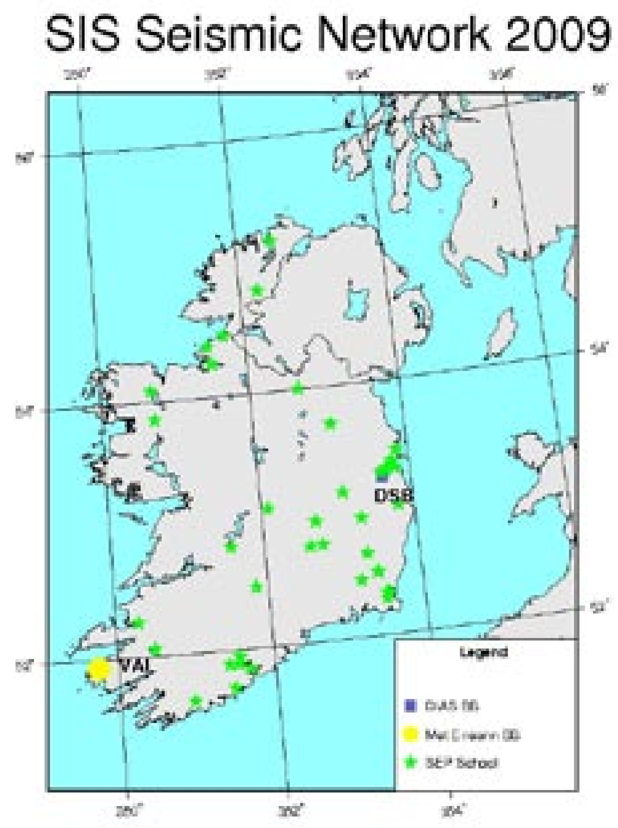


Figure 2 - Distribution of primary and secondary schools in Ireland involved in the Seismology in Schools (Seismeolaíocht sa Scoil) Pilot Project

At the time of writing this report there are a total of 50 schools now actively involved in the project (Fig. 2).

Educational aspects of the Seismology in Schools (Seismeolaíocht sa Scoil) Project

Once trained, educators, at both the primary and secondary levels, will be able to
- Set-up, calibrate, operate and troubleshoot their SEP seismometer
- Use data collected from their SEP seismometer as an integral part of their seismology/plate tectonics instruction
- Participate as part of a larger community of educational seismometer users

There are various learning outcomes depending on the educational sector being trained.
- Students at primary level will be introduced to the working of the seismometer, how to protect it, how to use it, what it measures, how to use the data it produces, and what one can do with the data.

A considerable amount of time will be spent researching and comparing earthquake recordings and data exchange with other students that will require computer broadband facilities. The idea here is to simulate in the classroom for students, as near as possible, the day to day operations of a scientist (in this case a seismologist) and reinforce the role that pure science plays in everyday work.

The secondary programme will introduce students to seismology and will emphasise the fundamental mathematics and physics laws on which seismology is based.
- Wave motion, P-waves, S-waves, Love waves and Raleigh waves, Snell's Law, dispersion, reflection and refraction.
- History of the development of seismology, and what standard seismological observatory procedures are in operation for the evaluation of an earthquake.
- How to locate an earthquake and interpret the data contained in a seismic trace.
- Exchange and compare seismic data of a given earthquake with schools in other countries.

Planning & Funding

Planning and funding estimates are underway for the programme 2009-10. A significant number of schools visits are planned to evaluate and review the consolidation of the programme. The idea of the "buddy" principal where two schools will exchange their experiences of the programme also know as "twinning" of schools will be setup on a trial basis. It is estimated that a budget of €15,000-18,000 will be necessary to support this phase.

Students Success with the programme

Within one week of the seismometer being set up in Scoil Chonglais, in May 2008, one of the strongest earthquakes that year occurred in Sichuan Province in China, on 12th May, measuring 7.8 Magnitude on the Richter Scale and with over 55,000 fatalities.

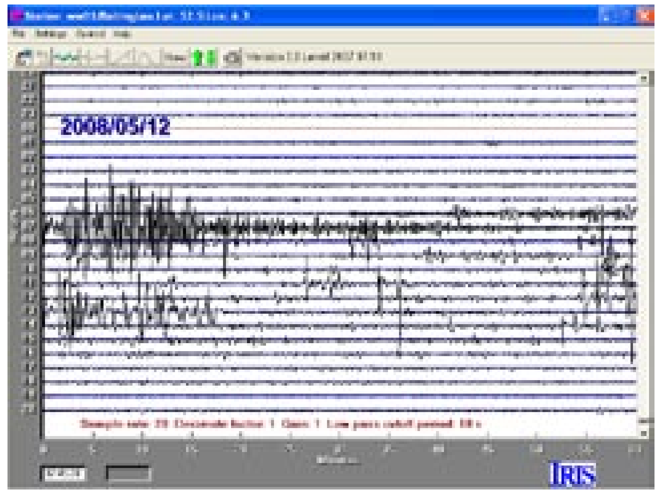


Figure 3 - Sichuan, China, Earthquake Seismogram. The horizontal lines represent 1 hour (60 minutes). The vertical scale represents 24 hours. The first signals from the Sichuan earthquake arrived in Baltinglass on the morning of 2008/05/12 at 0633.

Figure 3 shows the seismic trace of the earthquake which the students saw on their computer screen when they arrived in school that morning.
A major achievement for the Seismology in Schools Programme was a project undertaken by students in Scoil Chonglais in Baltinglass, Co Wicklow. Two Leaving Cert students, Denis Patterson and Shane Curry,

studied the frequency characteristics and differences between the signals recorded by the seismometer of real earthquakes and the signals generated by more culturally controlled sources such as road traffic noise and pneumatic drills.
They received two awards for their efforts in the BT Young Scientist of the Year 2009 Competition: the «International Year of Planet Earth Award» and first prize in the «Category Award: Chemical, Physical and Mathematical Sciences» Senior Section for a project entitled "Seismic Activity in the British Isles and the Wider World" (Fig. 4)

Figure 4 - BTYS 2009 winners. Picture shows from l to r, Mary Carter, IYPE Co-ordinator, Denis Patterson, Shane Curry, Scoil Chonglais, and Tom Blake, DIAS at the BT Young Scientists of the Year 2009 competition

Conclusions

The implementation of the pilot programme has been very a successful joint venture between DIAS, **DSE (Discover Science & Engineering)**, **BGS (British Geological Survey)** and **IRIS (Incorporated Research Institutions for Seismology)**.

Over the last year, upwards of fifty schools have successfully recorded earthquakes from around the globe. Their efforts have been the subject of much attention by the local media, parents and school management boards. Students have had an opportunity to physically interact with and use seismometers to make measurements of earthquakes, and locate the epicentres on world maps. They have been exposed to animated software that helps simplify the physical principals on which earthquakes are based and how the earth as a dynamic planet works. The international makeup of our partners reflects the fact that seismology is an international subject that transcends national boundaries.
Recognising this internationality, the next phase of the programme starts to explore the possibilities of the twining schools of a similar educational level (akin to the 'buddy' principal in the USA) with a view to students exchanging earthquake data, firstly with another Irish school and in subsequent years with schools in the UK, USA and Africa via the internet.
The next phase of the programme for 2009-10, "the consolidation phase", includes further visits to the fifty schools in the academic year 2009-10 to consolidate the programme and ensure that the programme is being implemented correctly. Three Irish universities have bought the seismometer for inclusion in the freshman Physics Laboratory exercises in future semesters.
Similar interest from the Geosciences Faculty of University of Witwatersrand in Johannesburg South Africa resulted in T. Blake being invited to make a keynote address at the 5th Annual Africa Array Meeting in July, 2009. He spoke about how the Seismology in Schools programme helps the promotion of geosciences in Ireland and how this could be applied to the promotion of geosciences in Africa.

The fact that young Irish students in 50 primary and secondary schools now routinely record earthquakes from the other side of the world has made a significant change in how science is introduced in schools and how students perceive the Earth as a dynamic planet. It has stimulated an interdisciplinary/interfaculty collaboration in schools between Mathematics, Geography and Physics not seen here-to-fore in the Irish educational landscape and has added a new dynamic to the teaching and promotion of seismology in schools and universities alike.

1) Geophysics, Section, School of Cosmic Physics, DIAS

SEISMO AT SCHOOL IN SWITZERLAND

by A. Sornette[1], and F. Haslinger[1]

«Seismo at School» is an educational program, which aims to promote public awareness of major environmental hazards, especially the risk of earthquakes. This is accomplished by installing seismic stations in schools in order to record seismic activity in real time. Director Prof. D. Giardini, the Swiss Seismological Service (SED) established this program with the original idea of integrating education and research.

To promote active and meaningful interactions between teachers in schools and researchers in the SED, seismic signals in schools are recorded on strong motion stations meeting the SED standard for the national monitoring networks. Real time databases of earthquakes for schools are generated by combining events recorded using the school stations and events recorded by the broadband seismic stations of the national SED network. All databases for education and outreach initiatives are fed to a web-driven platform.

In addition to a rich collection of earthquake data, this «Seismo at School» platform includes a bibliography, online courses, movies, various educational materials, and software for data analysis. The «Seismo at School» platform is a general but albeit rich resource center for educational activities (http://www.seismoatschool.ethz.ch/)

The installation of seismic stations in school requires that the teachers be trained and are involved even after the training. To accomplish this, the SED offers educational workshops organized at the schools and at focusTerra during the teacher's inservice. SED collaborates with focusTerra's Earth science exhibition (http://www.focus-terra.ethz.ch/).

"Seismo at School" was launched one and half years ago and the school network currently involves eight schools each endowed with its own seismic station. The aim is to install a total of twenty-six stations in twenty-six different schools in the next two years.

Equipment installed in each school:

A) Real time data and events:
(3 schools involved in this program)
Station composed of: Kinemetrics Episensor, Nanometrics Digitizer .

B) Educational activities (8 schools involved in this program)
-One SEP sensor
(http://www.bgs.ac.uk/school-Seismology/seismometer.html)
-One USB sensor
(QuakeCatcher network http://qcn.stanford.edu/index.php)

1) Schweizerischer Erdbebendienst (ETH), Switzerland

UK SCHOOL SEISMOLOGY PROJECT

by Paul Denton[1]

School seismology projects have proven to be a popular and effective outreach activity to promote geoscience in secondary schools (age 11-18). The ability to detect and analyse data from earthquakes which have happened on the other side of the world with your own school seismometer has a powerful motivational effect on students. This article will outline some of the features of the UK school seismology project, hosted at the British Geological Survey which have enabled it to rapidly and effectively establish a presence in over 400 schools in two years.

From the very beginning the **UK school seismology project** (**UKSSP**) set out to change the whole framework of science education in the UK. There was a decline in recruitment of students to geophysics courses at UK universities which was part of a much wider problem of retention for students in all physical sciences once they were free to choose which subjects to study (in the UK students can choose to stop studying all science topics at age 16). The UKSSP was conceived as a tool for reversing these worrying trends in education rather than as a traditional outreach activity, explaining what scientists do to the community.

Project Aims

- Make science more interesting for students aged 11-16, and thereby improve participation rates in science for students aged 16+
- Increase the awareness of geoscience as a potential career and academic discipline amongst students aged 11-18

With these aims in mind it was essential that a school seismology project had the potential to reach out to a significant proportion of the over 4000 secondary schools in the UK with a set of resources that teachers could use themselves and which could be produced and distributed rapidly and cheaply. In 2006 we approached a select focus group of science teachers. The outcome of this period of consultation was the identification of two distinct requirements for the project.

1) A set of classroom activities that teachers could use in traditional 30-40 minute lessons to teach students about some basic physics principles but which all had earthquakes as a unifying theme. These activities needed to be written up in a concise and familiar style so that teachers could easily and rapidly make use of them.

2) A simple and inexpensive seismometer system which can be used to detect earthquake signals and also used to explain some basic physics about how seismometers work.

Teachers in this initial focus group were given the option of either a semi-professional seismometer system with excellent bandwidth, GPS timing, and fully calibrated but in a "blackbox" container which hid the internal mechanics and which used complex force feedback principles to operate, or a simple mechanical seismometer based on a horizontal pendulum with a coil and magnet velocity transducer. The teachers all preferred the simple mechanical design despite all of its technical limitations. At this point as seismologists we had to take a step back and remind ourselves that the aim of the project was not to generate lots of high quality seismic data but to inspire and motivate students.

Development Partners

The project then set up several development partnerships with organisations that have a proven track record and expertise in creating educational resources and science teacher training.

SEP : the **Science Enhancement Programme**, a charitable foundation that develops science resources for its membership (5000+ science teachers) helped us develop the classroom activities and equipment www.sep.org.uk

MUTR : A school science equipment manufacturer and supplier, designed the UK school seismometer system, it is manufactured in the UK and distributed by MUTR through their existing science equipment catalogue www.mutr.co.uk

Science Learning Centre East Midlands, a government funded centre linked to a university education department helped develop the training course for teachers www.slcem.ac.uk

It's all about the data

Of course the success of running seismic monitoring stations in schools depends on providing the teachers with the right tools and training to enable them to analyse the data that they record and so to impress their students. Initially just identifying that the wiggles you are seeing on your display were generated by an earthquake that happened thousands of kilometers away is enough to generate a "wow" moment in schools (as in "wow I didn't know you could do that !"). However we have also produced a set of resources and a training course which enables teachers to take their analysis a step further and to identify P and S phases on their seismograms, calculate how far away the event is, make their own estimate of its magnitude (using a modified Ms formula) and by combining their data with data from schools overseas to make their own estimate of the earthquake location. The UK school seismology project chose the AmaSeis software, which was developed by Alan Jones for the US school seismology project (bingweb.binghamton.edu/~ajones/AmaSeis.html).

The AmaSeis software has three key advantages for use in schools:

1) it is a single program which covers data logging and data analysis

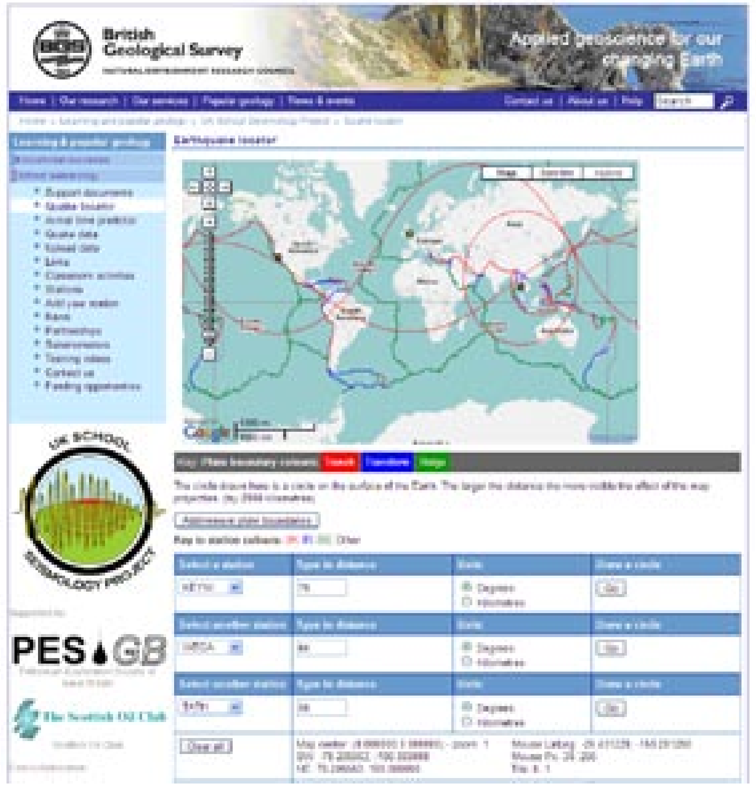
2) it is very simple to use and does not include complex analysis tools which teachers would find confusing

3) it can read and write data in the standard .sac format, simplifying data exchange.

The project resources were launched in May 2007 and it rapidly became clear that in order to provide a suitable framework for recruiting teachers and schools to the program as well as providing training and support to a national project the BGS would need to work closely with lots of partners.

Delivery Partners

The project works with University geoscience departments to deliver the training and seismometer systems to clusters of schools. The Universities use the project as a part of their own outreach activities and can provide ongoing support to local schools. Current partners are; Universities of Leicester, Plymouth, Keele, Leeds, Derby, Edinburgh, Glasgow, Liverpool, Cardiff, Imperial College, Royal Holloway College Open University, and UCL.



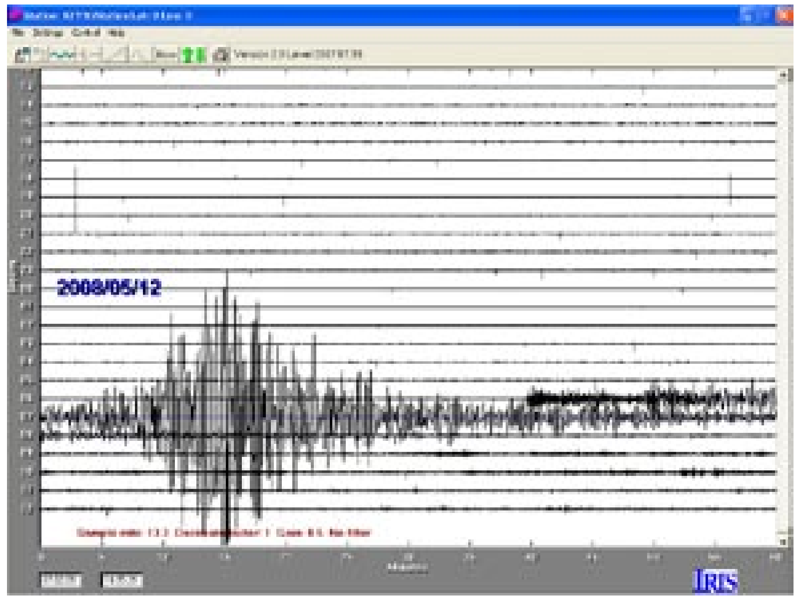
The project website www.bgs.ac.uk/schoolseismology contains a wealth of relevant information and useful tools for teachers and is constantly updated with new events and data files that schools upload.

Ongoing support and sustainability

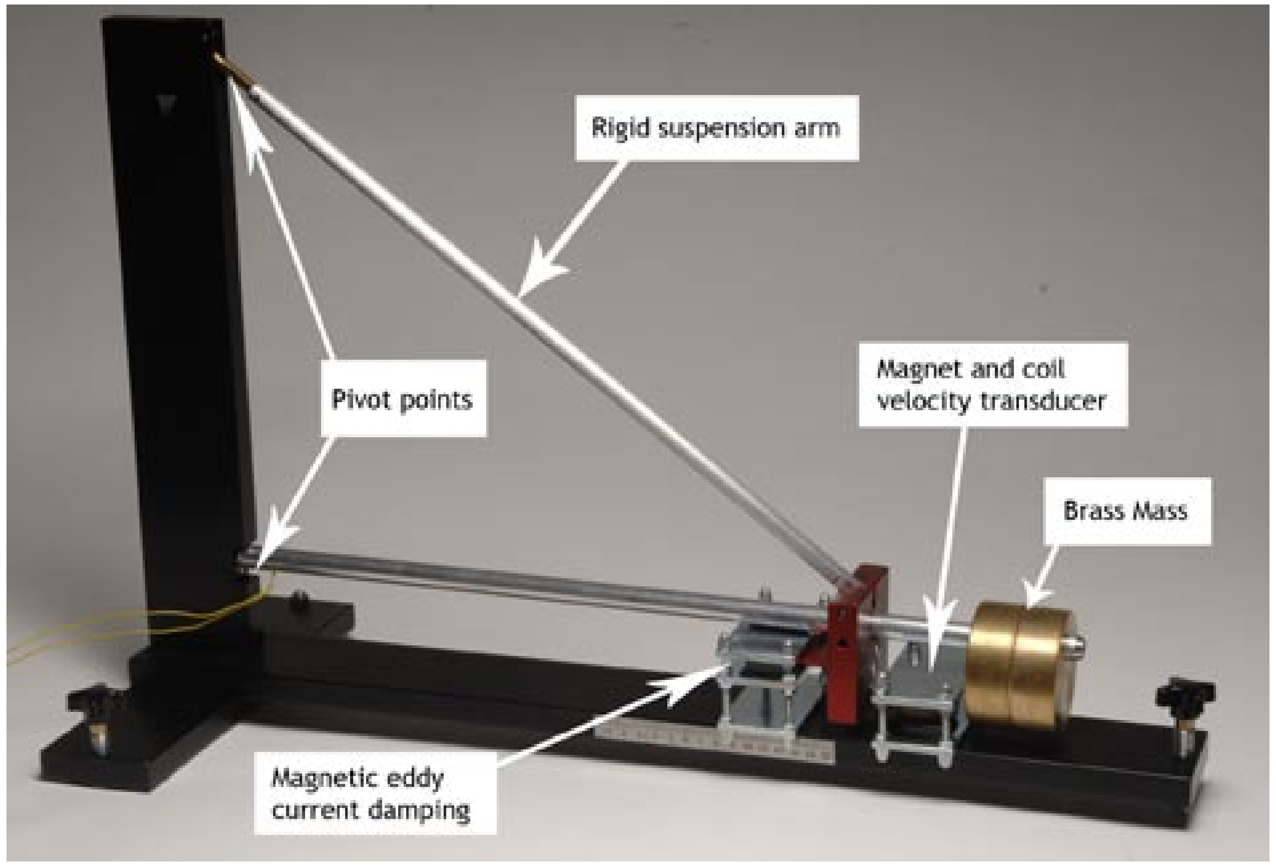
Earthquakes are most interesting just after they have happened, so teachers and schools need access to information and data about the latest events as soon as they occur. The British Geological Survey project website www.bgs.ac.uk/schoolseismology provides timely information about events as soon as they happen. If tells teachers what the predicted arrival times for key phases are at their school (a cheats guide). They can upload their own data files and compare with data recorded by schools in the USA and Ireland (and hopefully soon the rest of the world also). There is extensive use of maps on the website including a graphical tool, the quake locator, for estimating the location of an event based on the range from two or three schools (determined by the P-S delay in the AmaSeis software) and plate tectonics. The site also contains lots of short training videos covering all aspects of the project.

SEP seismometer system for UK schools:

- Manufactured and sold in the UK for £365
- Horizontal pendulum 15-20 seconds natural period (adjustable)
- Eddy current damping (adjustable)



The devastating Sichuan earthquake (M7.9) in May 2008 was detected without clipping by school seismometers in the UK. Even without filtering it is easy to identify P, S and Surface wave phases.



The seismometer is a simple horizontal pendulum with an open and accessible design that enables teachers to explain how it works to students in a classroom.

The project lends itself well to photo and press opportunities and dozens of schools involved in the project have been in featured in local press articles.

- Amplifier x100, filters at 60sec-HP and 5Hz-LP
- 16bit 20sps digitiser
- Over 400 units sold in the UK, Ireland and worldwide (Sept 2009)

Conclusion

Effective school seismology projects will only be constrained by the initial ambitions of the project leaders… think big!

- Ask teachers what they want and can use in their schools
- Work with education experts to produce relevant resources
- Make it cheap and make it work
- Train the teachers with a “bluffers guide to seismology”
- Provide ongoing support through a dynamic website
- Get industry to support the project financially.

Acknowledgments

The project has received financial support from its university partners and also the Petroleum Society of Great Britain, The Scottish Oil club, the Rolls Royce Science prize, Petroleum Geoservices Ltd, the Science Enhancement Programme and the National Endowment for Science Technology and the Arts.

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www.bgs.ac.uk/schoolseismology

DEVELOPING THE UK SCHOOL SEISMOMETER

by Chris Chapman[1]

Since 1994 there have been efforts to promote school seismology in Australia, France, Germany, Italy, New Zealand, Norway, Portugal, the USA, initially with PEPP groups and several other networks, followed by Iris in 2000, each with varying degrees of success.

The aim was to inspire school children to do ‘Real Science with Real Seismic Data’.

Several technologies have been tried. Some systems seem to have experienced poor reliability. Many initiatives seem to have been cost limited. Professor Virieux announced a French / Italian co-operative seismic project in 1998 and Eduseis in 2000. The professional quality French tri-axial seismometers used geophones extended in period to 20 seconds. GPS timing was provided. The network has since expanded to 55 stations http://www.edusismo.org which are mostly located in schools. The Norwegian and New Zealand school projects both used 4.5 Hz geophones, but their response was marginal for recording distant earthquakes. Both projects and the Portuguese schools network have now ceased operating. A few schools in Germany have developed good long period seismic systems http://www.mgm.monschau.de/seismic
What seems to have so far been lacking is co-operation between countries to promote practical seismology for school pupils and to share the data gathered. These are our future scientists and we need more of them!

Discussions for a seismic system for UK schools started in 2005 with a target price of £300 and the merits of systems used in other countries were considered. The broad band PEPP seismometers used in the USA from 1994 were all too expensive.

The response of the widely used American Iris AS1 school seismometer was limited to only 1.5 to 4.5 seconds period. It used a 12 bit ADC and oil damping. There was no possibility in the UK of funding a system similar to the French Eduseis system. Portuguese schools initially used Lehman type seismometers copied from http://psn.quake.net in California.

Unfortunately, these designs had inherent faults which limited their performance and they were very temperature sensitive.

The 'philosophy' behind the UK project seems to have been different to that of the French Eduseis.

The aim has been to inspire a few students in each school each year to take a 'hands-on' practical interest in seismology and to learn to run THEIR OWN seismic station. With the aid of a computer to record seismic events, display the traces on screen and provide help with the analysis of the wave groups, secondary school students were able to become proficient observers. The primary requirement was for a 'good quality' educational seismometer for them to use. While this needed to cover most of the seismic signal range from P to Love waves with reasonable fidelity and sensitivity from 5 Hz to 0.05 Hz, a research grade instrument was not required. It was recognised that school environments were likely to be noisy. The equipment needed to be easy to set up and use, but robust and not easily damaged by an inexperienced operator. A 'teaching' seismometer was required so that students could visually identify the component parts and their relationships:- the frame, the pendulum, the magnetic damper, the magnetic detector, the electronics and the computer logging and display system.
The overall cost needed to be minimised whilst maintaining an adequate performance.

A 'Lehman' type horizontal seismometer was chosen, but a complete redesign was required to suit our educational purposes, conditions and available resources.

The frame was designed as a rigid 'T' with levelling screws and a vertical column. It was made damp and corrosion resistant. A 56 cm arm was chosen with the resonant period extended from 1.5 to 20 seconds. A non-magnetic brass mass of 1 kg was chosen.
The suspension was changed to either a 'rolling plane on a sphere' or to a 'crossed cylinders' low loss type. Both these types were mechanically robust and had been shown to give a lower dynamic loss than a crossed foil suspension. A high field quad NdFeB magnet + copper plate damping system and a quad NdFeB magnet + sensor coil were also developed. The period was set by adjusting the tilt of the frame. The damping was adjusted by sliding the magnet block over a copper damping tongue. The damping force required was a function of the mass and the set period. A rectangular sensor coil was provided to give a constant sensitivity while allowing the mass position to drift up to +/-10mm due to environmental ground tilts. Tilt drift problems had limited the set period of the 1960's WWSSN seismometers to15 seconds. Stewart Bullen had introduced seismology into his secondary school using these techniques and together with the author suggested practical designs for seismic equipment to the Science Enhancement Program http://www.sep.org.uk/

The British Geological Survey promoted a School Seismology initiative in 2006 using developments of this design, which seems to have been very successful.

It has been marketed by MUTR http://www.mutr.co.uk and sales have exceeded 400 systems in the last two years. A significant number of seismometers have been donated by commercial sponsors.

While this seismometer was not technically comparable to the French system, it has been «quite adequate for the purpose» of teaching seismology in schools!

The schools project was launched in the UK in 2007 and Ireland followed in 2008.

The seismometer recorded data continuously at 20 SPS from 5 Hz to a period of over 20 seconds using a low noise 16 bit Delta-Sigma A to D Converter. The output was flat with frequency and individual seismometers could easily be calibrated. They responded to local, regional and teleseismic quakes and the 5 Hz low pass filter rejected local noise quite well. Schools can be quite noisy places! A good performance with regional and teleseismic quakes was important, since few local earthquakes were received in the UK. The amplifier gain could be switched, giving a high enough sensitivity to measure signals <1/10 of the seismic background noise. The free American digital seismic recording and analysis program called AmaSeis was used. It was specially designed for use in schools, was fully maintained by Iris and was 'student friendly'. A 24 hour 'drumplot' display was usually used, but the signal trace could be filtered to remove the ~6 second period microseism background.

See http://www.bgs.ac.uk/schoolseismology/ and links.

The manual is available from http://www.mutr.co.uk/images/Seismometer.pdf

See also http://www.eduseis.net/classroom/cookbook_eng.pdf for details of Eduseis applications.

Very accurate long period timing was required. Teleseismic P waves had a frequency of about 1 Hz. It was usually possible to determine the start of the wave to 0.1 second. However, the apology for a 'clock' supplied in most Personal Computers was seriously inadequate.

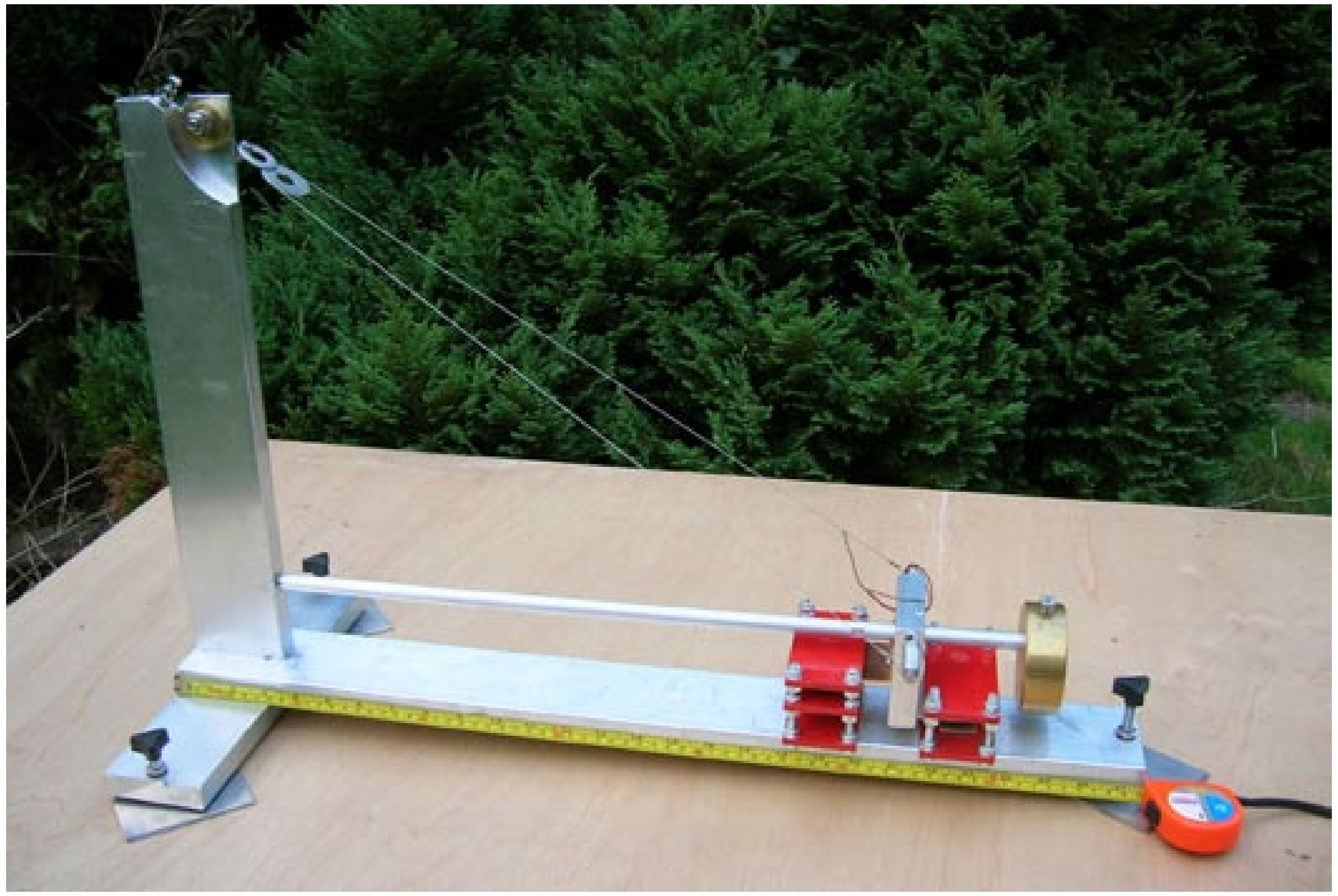

Figure 1 - Lehman Prototype Seismometer

When the computer was permanently connected to the internet, the time set program called 'abouttime' from http://www.arachnoid.com was chosen to update the software clock at five minutes before every hour. This advanced program called up the time server, received the time signal, 'pinged' the server to measure the response delay and then corrected the time signal.
An alternative was to use battery driven DCF77, MSF or WWVB radio corrected clocks and manual correction. They were crystal controlled and updated automatically every hour. The other alternative was to use more costly GPS linked timing.

Large magnitude quakes can result in considerable loss of both human and animal life and cause serious damage to buildings, bridges, roads, railways, dams and canals.
Fires may be generated, land-slips can occur, the course of rivers may change and wells may be damaged. Electricity, gas, water supplies and sewage disposal may be interrupted. Agricultural crops and the ability to harvest them may be effected. Large numbers of people may be destitute and in need of immediate supplies of drinking water, food and shelter.
Using the www, it is possible to monitor the progress of the damage assessment after a quake, the delivery of first aid, later international aid and the eventual recovery phase. Knowledge of a foreign language, particularly Spanish, is helpful.

Seismology does not fit easily into existing school science modules in the UK, so it has usually been organised as an 'after school' or 'science club' activity.
It can be an almost ideal activity to inspire students, since every earthquake is a 'new', random and potentially catastrophic event!

Selected 15 to 18 year old pupils can be trained to do the trace monitoring, logging and analysis to determine the time, range, position and magnitude of a quake. In general, earthquakes greater than about M 6.5 from anywhere on Earth can be recorded. It is unusual in the UK to record less than two earthquakes each week. A world map may be used to plot the quakes detected over a year, with different pin colours for shallow, intermediate and deep quakes. Students should be encouraged to do an 'in depth' study of at least one large quake each year, showing analysis of the seismic trace.

These can form a Seismic Report of two years of practical observations which is viewed as a significant scientific achievement when students apply for University Entrance.

TOWARD A NEW WAY OF THINKING ABOUT EDUCATIONAL SEISMOLOGY

by Antonella Bobbio[1] and Aldo Zollo[2]

Increasing our knowledge about the earthquake phenomena and their effects at the earth surface is an important step toward the education of population in high seismic risk regions and can contribute to raise the awareness on the earthquake risk and possible mitigation actions. In this sense, seismology represents an efficient communication vehicle, allowing to teach and learn about the earthquakes and seismic wave impact through experimental practices and educational activities.

In this regard the viable, experimented paths in seismic risk educational efforts are essentially two.

The first one has an immediate impact, and it is strongly based on traditional communication supports such as booklets, brochures, web sites, videos, large public seminars and conferences. The end-user (student, teacher, large public) generally has a passive role in front of the scientific communication messages, and new knowledge has to be acquired through the individual willing and understanding capacity.

The alternative approach is instead grounded on advanced technologies by the implementation and use of web-oriented and accessible tools, which provide a direct link with the modern laboratory systems, data analysis and modeling. In this case, the end-user has an active role in the knowledge process and is trained to use the scientific laboratory practice by adopting the "learning by doing" modern approach of science communication (ref. Exploratorium of S. Francisco).

The first approach is certainly more manageable, easy-to-use in particular by end-users who are not familiar with the scientific and experimental approaches. It is generally made appealing by the use of an eye-catching look, which is more adapted to a generic public mostly composed by very young pupils, whose attention is captured by nice images and graphic applets, the use of which does not require any further scientific explanation.

The other approach is obviously addressed to a more "specialized" public, e.g. high school students and teachers, and well-trained and guided museum visitors, since it requires a deeper involvement of the end-user in the scientific knowledge process. The game is to make students the main actors of the scientific experience about earthquakes, by leading them along the laboratory research trail, made of seismogram observation, measurement, analysis and interpretation.

These are exactly the principle and basic ideas of the EduSeis project.

Following the successful experience in the USA of the **Princeton Earth Physics Project (PEPP)** in 1995 the first EduSeis station was installed in Europe in Provence-Cote-d'Azur by GeoAzur Institute and the high school "Centre International de Valbonne".

The first EduSeis seismic station in Italy (MSNI) was installed in 1996 in the Science Centre "Città della Scienza" in joint cooperation with the University of Naples "Federico II". In Italy, from 1997 to 2002, more than ten EduSeis stations have been installed in high schools and at research centres in Central and Southern Italy, in particular at the Mt. Vesuvius volcano landscapes.

The basic idea of Eduseis was to use a network of seismic stations installed in high schools and related activities of data analysis as an efficient and pervasive tool for teaching, learning and informing about the earthquake origin, their destructive effects on built environment and the actions needed to mitigate the seismic risk.

About 300 students and 10 teachers (physics, natural sciences, informatics and electronics) from 6 high schools have been fully involved in the yearly-based EduSeis scholar programs. During the EduSeis project, the science museum Città della Scienza built and implemented a school lab (SISMALAB), an interactive exhibit for museum visitors and high school classes.
In this area students and visitors had the possibility to perform seismological data analyses using the EduSeis network data-base and access data from a real-time seismic station (MSNI).
An annual average of 300 000 visitors and school pupils have visited and experienced the EduSeis space-lab installed at the interactive Science museum of Naples, Città della Scienza, where classrooms participated to targeted activities on earthquake seismology and seismic risk monitoring.

We should not neglect the problems and difficulties in the application of structured projects like Eduseis in the Italian school system, in particular the need for a big involvement of teachers and seismo-lab researchers.
The main difficulties in the development of the project were related to the teacher's involvement at zero-cost outside working hours, the small flexibility in school time and space and the insufficient scholastic resources (informatics, tools, lab's instrumentation).

Figure 1 - A group of high-school students visiting and experimenting the seismological data analysis at the SISMALAB space of the Science Museum of Città della Scienza in Naples (Italy)

The new technologies and user-friendly data analysis methods developed in EduSeis have offered students and teachers the opportunity to have access to data and use advanced tools for their analysis. Students, teachers and museum visitors have been guided through educational activities organized at different levels, with the aim to experiment the practicability, the contents and the didactic value.

With the enormous advances in technology and informatics during the last decade, nowadays the experience of multi-media, multi-type data archiving and distribution is largely shared as well as the progresses done in seismic instrument development, installation and management. The products which are now available on the market offer solutions at a relatively high scientific standard with the basic requirement for schools to be "low-cost" and "easy-to-install-and-run".

The experience of the Eduseis project opens new perspectives of educational seismology, with the knowledge and awareness on seismic risk as the final target of the education action.
It may be the time for the educational seismology to move a step forward, from «data sharing» to «sharing methods for data analysis and modeling» providing teachers, students and a large public with new, user-friendly tools for massive seismological data analysis, mapping and interpretation and introduce new approaches in teaching and learning the earthquake risk.

In this regard, we mention the possibility to introduce seismology in schools through the modern technologies for teaching and learning the scientific knowledge based on e-learning platforms.

Figure 2 - The SISMALAB space of the Science Museum of Città della Scienza in Naples (Italy)

We have recently designed, implemented and tested a model of an e-learning environment in the high school ITIS Majorana, located at Somma-Vesuviana, in the surroundings of the Mt. Vesuvius volcano. The proposed e-learning model is built on the EduSeis concepts and educational materials (web-oriented), and is based on computer-supported collaborative learning.
Ten teachers from different disciplines and fifty students at the ITIS «Majorana» technical high school (Naples) have been taking part in a cooperative e-learning experiment in which the students have been working in small groups (communities). The learning process was assisted and supervised by the teachers. The use of network utilities and the «Learning Community» approach promoted the exchange of ideas and expertises between students and teachers and allowed a new approach of the seismology teaching through a multidisciplinary study of the earth dynamics.

Driven by the high-tech development of earthquake observation systems, the educational seismology in schools can represent a suitable, integrated environment which makes students active users of modern technologies rather than passive consumers. The selected vehicle for such training is the seismological observation. Through the user-friendly management of earthquake data collected all around the world, students can experiment the modern systems which are nowadays used to watch and monitor the evolving Earth planet, and actively participate to data acquisition using Internet to share data. Although difficult to implement, this new approach to science education and dissemination will certainly contribute to train tomorrow's environmental citizens, preparing them to cope with natural risks and solutions for mitigating their damaging effects.

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MASTER IN EARTHQUAKE ENGINEERING AND ENGINEERING SEISMOLOGY (www.meees.org)

by M. Calvi, F. Cotton, H. Crowley, S. Garambois, R. Pinho

Abstract

The **MEEES (Masters in Earthquake Engineering and Engineering Seismology)** programme is an Erasmus Mundus Masters Course, that aims to provide higher-level education in the field of Earthquake Engineering and Engineering Seismology. The MEEES is involving 4 participating institutions: the ROSE School of the Institute for Advanced Study Pavia (Italy), the University Joseph Fourier - Grenoble 1 (France), the University of Patras (Greece) and Middle East, Technical University (Turkey), two associated academic partners (University of Potsdam, University of Karlsruhe) and several agencies or companies (CEA, IRD, EDF, Eurocentre, GEM Foundation, EQCO, Studio Calvi, DNECO S.A., DOMI S.A., Willis Group Holdings, Prota Ltd).

The cross-cutting nature of the programme allows students to develop skills which will allow them to communicate across the wide range of fields which comprise the area of seismic risk assessment and mitigation.

Introduction

The process of mitigating seismic risk in earthquake-vulnerable countries must start by the vision of high quality training and education of professionals and researchers in this field.
Despite this demand, however, a needs analysis has shown that advanced training in Earthquake Engineering and Engineering Seismology is rare, particularly in Europe. Indeed, a common problem for most graduate schools is the breadth of expertise of the faculty, since it is difficult to have all the necessary competence within a single institution.

In 2004, the MEEES Consortium set up a top-quality training and research network for researchers at the beginning of their career in a highly sought-after specialist area, by bringing together the expertise from institutions in Italy, France, Greece, and the UK with the aim of bringing a better quality of training and research in earthquake engineering and engineering seismology to Europe.

In 2010, we will continue this Masters programme, and make it stronger through a number of adaptations, earthquake risk assessment and mitigation training and research in Europe will continue to be provided in a united manner, resulting in a European training and research area able to compete, in particular, with US and Japanese centres in all fields related to earthquake risk mitigation. This updated MEEES course has been recently approved by the European Commission and will be funded within the Erasmus Mundus program until 2013.

Programme description

The MEEES course offers a unique integrated programme which brings these components together in a single, joint curriculum. The main objective of the proposed training programme is to ensure that all relevant inter/multidisciplinary, intersectorial and newly emerging disciplinary fields that must be considered when addressing seismic risk mitigation are covered. The skill of communicating between sectors is extremely important in seismic risk assessment and mitigation as the results of seismologists, geotechnical engineers and engineering seismologists are used by structural engineers in vulnerability and damage assessment, and then these results are used by social scientists and economists to define the consequences of earthquakes, which may then be used by government officials who need to make decisions to help reduce seismic risk.

The provision of courses which allow students to build up a level of confidence in communicating between these sectors would not be possible within a single institute because, as mentioned previously, it is rarely the case that the faculty have such a breath of expertise.

The main characteristics of the programme can be summarised as follows:

- All programmes will be 18 months (and thus 90 ECTS* credits); students can choose between a Masters in Earthquake Engineering, a Masters in Engineering Seismology or a Masters in Earthquake Engineering and Engineering Seismology.
- Students must obtain 60 ECTS credits from taught modules and 30 ECTS from a Master's Project.
- The curriculum of the course includes theoretical and engineering seismology, geomechanics, geotechnics and soil dynamics, structural dynamics, seismic design and assessment and seismic risk mitigation.
- All participating institutions will be joint degree-awarding. Students must spend at least one full semester (worth 30 ECTS) in two participating organizations to obtain a joint degree.
- A whole semester is dedicated to the Master's Project which might be period of research (leading to a traditional Masters dissertation) or a placement in industry (such as a design office, or a risk consultancy).
- Associated professional partners are providing placements for the Master's Project. Some also provide scholarships to support the sustainability of the programme.
- An external advisory board, including associated professional partners as well as key academic and professional figures monitor the curriculum of the programme, provide guidelines for complementary skills to aid the employability of graduates, and share best-practice with the consortium.

MEEES application and scholarships

Since 2004, the MEEES programme has had a large increase in the number of applicants, from 302 for the 2005/06 academic year to 637 for the 2008/09 academic year, with a total of over 2000 applications since 2004. The MEEES Masters has accepted 140 students to study, and they have come from over 40 different countries in the world. The selection ratio is 5-10%, thus allowing the best students from all over the world to be selected to come and study in Europe, and raise the standards of the quality of European alumni.
The large number of applicants is also another testament to the need for a Masters course in Earthquake Engineering and Engineering Seismology in Europe.

Admission to the course depends on academic qualifications, past professional experience, reference letters and English proficiency.
In particular, the following selection criteria have been jointly defined by the Consortium to be used to assess the applicants to the MEEES programme:

- The level of previous higher education, considering the duration of the programme, the title obtained, the institution and the professors/lecturers involved in the applicant's curriculum.
- The results obtained in examinations and in the final evaluation of all previous studies
- The content of the letters of reference.
- Professional or other relevant experience.
- Content of curriculum vitae, considering in particular any academic publications.
- Additional information including personal statements, motivation letters etc. supplied

Two types of scholarships are available within the scope of the MEEES programme: third-country Scholarships and standard Scholarships. The third-country scholarship is directly sponsored by the European Commission, under the scope of its Eramus Mundus programme.
The standard scholarship, on the other hand, is financed by the MEEES consortium itself. Within the scope of the MEEES programme there are also opportunities for third-country scholars (academics and/or professionals of outstanding experience) who may wish to carry out teaching or research assignments and scholarly work in any of the MEEES consortium institutions.

The next round of applications is scheduled to open on the 4th of November 2009, with a deadline on December 31st, 2009.

* European Credit Transfert System

Contact

MEEES website: ***http://www.meees.org***

For queries regarding **application procedures and/or administrative matters**, please contact the School Secretariat:
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QUEST: QUANTITATIVE ESTIMATION OF THE EARTH'S SEISMIC SOURCES AND STRUCTURE A MARIE-CURIE INITIAL TRAINING NETWORK

by Heiner Igel[1] and the QUEST team

QUEST (www.quest-itn.org) is an Initial Training Network in the 7th Framework Program of the European Commission.

Its aim is research and training in all aspects of inverse problems in seismology with a strong focus on full waveform inversion.
The 4-year-project starts on December 1, 2009. The 15-partner-network is coordinated by the Geophysics Section of the Department of Earth and Environmental Sciences of the Ludwig-Maximilians-University Munich, Germany.

Rationale: Seismic tomography and supercomputing

Storing CO2 in the subsurface, finding hydrocarbon and other resources and monitoring their extraction, generating energy with Earth's internal heat, and forecasting natural hazards (earthquake-induced ground motion, volcanic eruptions, tsunamis) requires high-resolution tomographic images of the Earth's interior.

The main goal of QUEST is research and training in the development of strategies for seismic imaging using the increasing power of 3-D simulation technology. Existing methodologies are currently subject to a revolutionary change: while so far the observed information was severely reduced and approximate forward solutions were used to determine Earth's structure, the massive increase in available computational resources will allow us soon to make use of the complete information contained in the observations. The actual application to real data and to the Earth in its full three-dimensionality is just at the beginning.

The QUEST objective is to integrate the various elements (wave propagation, high-performance computing, inverse problems) exploiting the synergies of the network expertise and develop the next generation of imaging tools for use on all spatial scales.

With narrowing resources the exploration industry is seeking highly skilled young scientists capable of driving the new computational technologies towards industrial problems. Earth Science graduating students in general are lacking profound theoretical and practical training in numerical methods and **high-performance computing (HPC)** in connection with simulation and inversion software. The training and research on HPC solutions in seismic tomography through QUEST should not only have an impact on industrial applications. We expect progress in understanding the dynamics of our planet, the quantification of natural hazards such as earthquakes, tsunamis, volcanic eruptions and the associated risks. Without (at least partly) automated data analysis schemes on HPC systems, our community will not be able to handle the dramatically increasing data volumes generated by existing and planned observational networks and infrastructure (e.g., NERIES, EPOS).

QUEST will link scientists working on methodologies such as computational wave propagation, the theory of inverse problems, global tomography with two of the best industrial research laboratories world wide (Schlumberger Research Cambridge, IBM Zurich) and two expanding smaller companies (Spectraseis Zurich, MicroseismicInc, USA) both employing some of the most innovative monitoring technologies today. The network is complemented by associating the GOCAD Consortium, involving both industry and academia which has a unique expertise in geometric modelling and gridding of geological structures and representing their heterogeneities. In addition, we associate with the European DEISA project, and a cluster of high-profile **Computational Science institutions in Munich (MCSC)**. These associations will allow the QUEST researchers direct access to training and other facilities in the area of HPC.

Methodologies: Full-wave form tomography and passive imaging

The primary goal is to understand Earth's structure (or processes related to earthquakes) by extracting a maximum amount of information from seismograms.

The basic procedure is to model aspects of the observations (e.g., travel times of seismic body waves, surface wave dispersion curves, wave amplitudes or waveforms), and to minimize the misfit between theoretical predictions and the observations. The state of the art seismic imaging is not yet taking full advantage of the developing multi-core computational power and of the well-advanced simulation technology: a large amount of information on Earth structure or earthquake sources, contained in seismograms, is currently not exploited. One of the main goals of QUEST is to use most or all information in the seismograms. Despite the fact that some of the fundamental concepts concerning modelling and inversion are well understood, the actual application in 3-D is a tremendous challenge particularly in connection with the implementation on HPC systems.

A central tool of seismology is the calculation of synthetic seismograms that can be compared with observations. The only way to generate 'realistic' synthetic seismograms for complex three-dimensional models is by means of numerical methods (e.g., finite differences, spectral elements) implemented on supercomputer hardware. Only now computational power has reached a point where many such 3-D "forward calculations" (i.e., simulations of wave propagation) can be done, making it feasible to perform the imaging by trying to fit complete waveforms (rather than travel times). This methodology - full waveform imaging - represents the primary goal all work packages in QUEST are jointly working towards.

In addition, the recent discovery of the possible structural imaging by correlating ambient background noise (atmosphere-ocean driven micro-seismicity) is revolutionizing tomography. The implications are tremendous: one does not have to wait for earthquakes or active artificial sources radiating seismic waves but one can use seismic waveforms constantly excited by atmosphere and oceans to image internal structures. The two approaches – imaging using actual and virtual sources – complement each other and can partly be used for cross-validation. The applications of this new methodology spans from reservoir scale through imaging of volcanoes to the imaging of sedimentary basins. QUEST will consist of a training network in which the development of both approaches can be pushed in a joint effort, and tested and compared in the same geographical regions.

In summary, the key objectives are:
(1) develop strategies to incorporate complete 3-D modelling into the tomographic imaging of Earth' structure and seismic sources on all scales;
(2) link Earth Science with High-Performance Computing experts and make use of the European supercomputer infrastructure for seismic tomography;
(3) demonstrate the imaging power of full waveform inversion through applications on a reservoir scale, volcanoes, active seismic faults, and planets;
(4) develop and apply novel approaches using passive imaging that make use of virtual sources, investigate and broaden their domains of application on all scales;
(5) disseminate the developed methodologies and standards to the user community through an open-source software repository and web-interfaced benchmark facilities.

Training: The network, workshops, and job opportunities

The QUEST network will offer 18 Ph.D. and 8 post-doc positions in various fields of seismic imaging (structural inversion, source inversion, passive imaging) and their applications in general and applied problems.

The network organizes yearly open research-and-training workshops and special sessions at international meetings.
The first training workshop on fundamentals of seismic imaging will take place at the Hotel Capo Caccia in Alghero (Sardinia) Italy, 19-25 September 2010.

Positions are available in 15 partner institutions within Europe including Germany (Ludwig-Maximilians-University Munich, and University of Potsdam), France (Institut de Physique du Globe, Paris, and Université Joseph Fourier, Grenoble), Italy (INGV Rome, OGS Trieste), Slovakia (Comenius University, Bratislava), Czech Republic (Charles University, Prague), Ireland (University College, Dublin), United Kingdom (Schlumberger Research Cambridge, University of Oxford, and University of East Anglia Norwich), Switzerland (ETH Zurich, and Spectraseis AG Zurich) and the Netherlands (University of Utrecht).

Researchers must be from outside the country of the institution they apply for (with a few exceptions).
Salaries are complemented by substantial support for mobility, career development and travel.

Further information on application procedures is available on the project webpage www.quest-itn.org or by contacting the QUEST project administrator, Greta Kueppers: kueppers@geophysik.uni-muenchen.de.

Applications are accepted until all positions are filled. The status of each position will be reported on the project www pages.

1) Ludwig-Maximilians-University Munich

A GRID BASED VIRTUAL ORGANIZATION FOR SEISMOLOGY IN SOUTH EASTERN EUROPE

See authors list at the end of the article

Introduction

The aim of the European FP7 SEE-GRID-SCI project [1] is to build three grid-based **virtual organizations (VOs)**, namely Seismology, Meteorology and Environment VOs in **South Eastern Europe (SEE)**.

In this article, we focus on the Seismology Virtual Organization [2].

The objectives of the SEEGRID-SCI Seismology Virtual Organization are as follows:
1. Bringing to the EGEE [3] grid platform massive seismology data from the SEE countries,
2. Gridification of seismology applications that are of interest not only to the seismologists but also to the industry such as the insurance companies for seismic risk assessment,
3. Building application services that will provide services to the applications as well as high level interfaces to the seismic data,
4. Promotion of collaborations among researchers in the area of seismology,
5. Training of interested researchers on the use of the Seismology Virtual Organization.

Before the evolution of grid infrastructures, the web was the main medium of delivery for seismic data. Seismic data providers would place their data on web servers from which scientists could either query or download the data that were of interest to them.

This arrangement, however, had several shortcomings.

Firstly, data and computational resources are basically decoupled. It is the duty of each scientist to manually download and manage all the data himself. Automation of this process may require the writing of various scripts which may be quite difficult for a user.

Secondly, retrieving massive data over the web can be too slow and hence not practical. There have been efforts also to make seismic data available by web services which will help in automation, but again this requires users to learn web services programming and to link such services with their applications. Grids solve these problems by offering a platform where computational storage resources and other miscellaneous resources are available all connected by high speed networks. A grid user can write a program and run it on the grid where it can access distributed data just like he would access local data with the help of middleware and other tools.

To realize the aims of the Seismology Virtual Organization, the following services and applications are being developed:

1. Development of Seismic Data Server Application Services providing:
a. Distributed storage and serving of seismic data from different partner countries,
b. Logical organization and indexing of distributed seismic data,
c. Programming tools (called «iterators») that provide easy access to seismic data.

2. Gridification of five seismology applications from different SEE countries, namely, Seismic Risk Assessment, Numerical Modelling of Mantle Convection, Fault Plane Solution , Earthquake Location Finding and Massive Digital Seismological Signal Processing with the Wavelet Analysis.

Seismic Data Server Application Services (SDSAS)

Our Seismology Virtual Organization platform is illustrated in Figure 1.

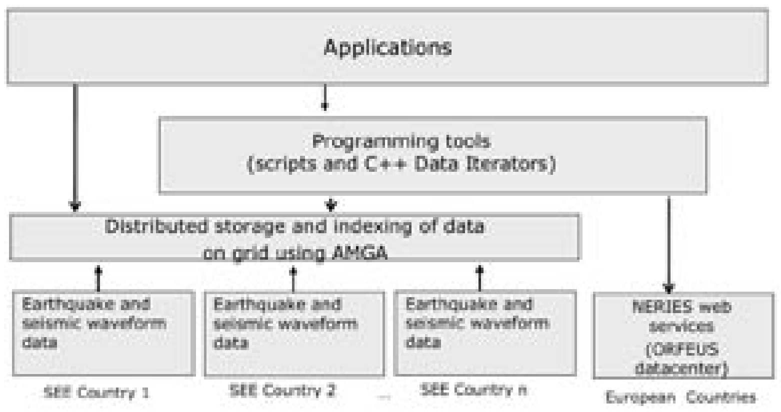

Figure 1 - SEEGRID-SCI Seismology Virtual Organization Platform

Seismology data collected from different countries are stored in distributed storage elements in each country and registered in an LFC [4] file catalog.
The data files are indexed by utilizing an AMGA meta- data catalogue [5]. Seismology VO specific C++ iterator objects [2] are provided to let users iterate through selected parts of seismic data.
Such an approach relieves potential users from the need to learn new tools such as AMGA. It also helps application developers to write file location independent code since all references to the files will be returned by iterators. Iterators are also currently developed for automatically downloading waveform data from the NERIES/ORFEUS datacenter.
These iterators are built on top of the newly released NERIES web services [6].

A web interface application for the SDSAS is also developed at [7].

The contact point for SDSAS is Can Özturan.

Figure 2 - An example of area sources used to generate the risk map of Istanbul by the SRA application

Applications

The details of gridified applications are given below:

1 - Seismic Risk Assessment (SRA)

Seismic Risk Assessment is quite important for public safety and hazards mitigation.

It is also important for the correct determination of earthquake insurance premiums, and for understanding the social and psychological effects of earthquakes. The goal is to develop a grid based application framework [8] to allow embedding alternative (deterministic, probabilistic etc.) assessment models and to produce seismic hazard maps for the SEE region.

The components of the SRA application can be grouped into four:

(i) Methods to access an earthquake database and a catalog of seismicity on grid;

(ii) A master earthquake seismic source model to describe the spatial-temporal distribution of earthquakes, integrating the earthquake history with evidence from seismotectonics, paleoseismology, mapping of active faults, geodesy and geodynamic modeling;

(iii) Alternative seismic hazard models to plug in to the application

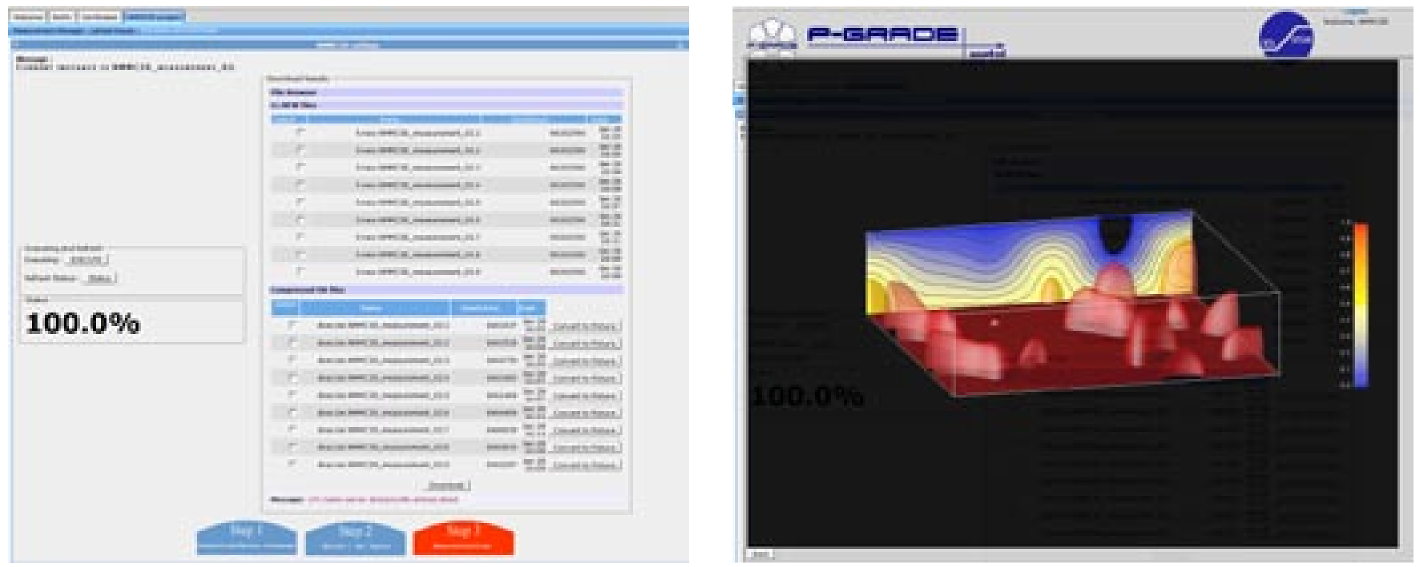

Fig. 3: NMMC3D application executed in P-GRADE Portal

(iv) Seismic hazard maps to be produced with related uncertainties at appropriate scales. Figure 2 shows an example of area sources used to generate the risk map of Istanbul by the SRA application.

The contact person for SRA is Cevat Şener.

2 - Numerical Modelling of Mantle Convection (NMMC3D)

The mantle convection is the driving force of the plate tectonics, which is the principal theory of geosciences. NMMC3D application [9] is focusing on the structure and dynamics of the mantle plumes, including also the topographic and geoid anomalies. In collaboration with the Hungarian MTA SZTAKI Application Porting Centre, the application has been ported to the SEE-GRID-SCI infrastructure.
The work has exploited the parameter study support tools of the P-GRADE grid Portal [10].

The contact person for NMMC3D is Bálint Süle.

3 - Fault Plane Solution (FPS)

FPS application computes faulting mechanism parameters, i.e. dip, strike and rake, that form the source of earthquakes.
In FPS, **Moment Tensor Inversion (MTI)** method is used to compute a regional solution. **Domain Moment Tensor INVerse Code (TDMT_INVC)** program, **Seismic Analysis Code (SAC)** and **Seismic Data Server Application Service (SDSAS)** libraries are used in the development of the application.

The most time-consuming stage of the application is the one that generates the Green functions. The repetition of this step for different crust structures, depths and station locations increases the solution time further. For example, for 5 different crust structures, 10 different depths and 30 stations, the number of repetitions of the process is 5x10x30=1500. To speed up this stage, parallel processing technique has been used. For parallelization, a grid workflow has been developed.

The contact person for FPS is Mehmet Yılmazer.

4 - Earthquake Location Finding (ELF)

ELF application finds the hypocenter of an earthquake by using the seismic waveform data generated by seismic stations.

ELF is based on the widely known HYPO71 application in the seismology area.
ELF is not a computationally intensive application.
However, it is data intensive since it needs to process waveform files from several stations. Hence, there exists opportunities for speeding up ELF by parallelizing file accesses. The application is parallelized by decomposing the problem space spatially and expressing it as a parallel grid workflow. To implement spatial decompositions, stations are divided among multiple processors (worker nodes). A node is assigned a task which is responsible for accessing a specific station's waveform file and computing picks.
The results from all worker nodes are then sent to a collector node which runs the HYPO71 program to locate the hypocenter of the earthquake. The timing results indeed show that parallelization of file accesses improves performance.

The contact person for ELF is Mehmet Yılmazer.

5 - Massive Digital Seismological Signal Processing with Wavelet Analysis (MDSSP-WA)

This application uses continuous wavelet transformation in order to capture the characteristics of the earth crust following the path from the earthquake origin towards the station.
These features are recorded and later classified using pattern matching to identifythe important characteristics of some specific seismic region as seen from that specific station.
A framework for massively parallel wavelet data processing of the seismic waveforms using advanced Grid workflows is developed. Such workflows enable users to use the power of the grid more easily and hence achieve better performance.

The contact person for MDSSP-WA is Ljupco Jordanovski.

Conclusions

Grid e-infrastructures can empower seismologists by offering them a bundle of resources such as massive storage, fast networks, thousands of processors and services that enable them to reach data easily by just calling APIs or creating objects that take care of a lot low level implementation details.

Getting access to all these resources and services involves just getting an account on the grid and becoming a member of the virtual organization.

As a result, seismologist can concentrate on their seismology related work rather than spend months on trying to establish their own computational platforms, download data from web sites, manage their own data and on learning new tools.

We believe that grid e-infrastructures may revolutionize the way seismology research will be carried out in the future.

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[10] P-GRADE Portal, http://portal.p-grade.hu

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CURRENT STATUS OF THE NERIES PROJECT PORTAL AND WEB SERVICE DEVELOPMENTS

by Linus Kamb[1], Alessandro Spinuso[2], Laurent Frobert[1], and Luca Trani[2]

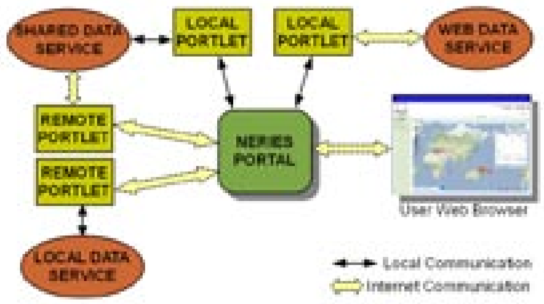
Introduction

The **NERIES project (NEtwork of Research Infrastructures for European Seismology)** is an EC-funded **Integrated Infrastructure Initiative (I3)** designed to integrate data and service resources for the seismological scientific community (See article in CSEM/EMSC Newsletter No. 23: http://www.emsc-csem.org/docs/data/newsletters/newsletter_23_high.pdf). The NERIES project has developed a web-based integrated data access portal. This portal brings together distributed European Data Centers to provide a single web-based access point from which researchers can search for and download selected data and data products from distributed and diverse sources, including seismic event parametric information, seismic and accelerometric waveform data, and historical seismograms. It also provides a framework through which new tools and processing can be included and accessed, allowing linkages to external processing resources and eScience infrastructures.

NERIES portal

Jointly developed at ORFEUS and EMSC, the NERIES portal aggregates individual portlets. Portlets are a special kind of self-contained, targeted web application that conforms to a well-defined standard programming interface (API). This standard API allows portlets to be provided by different, distributed providers and to be aggregated within a portal "container". The NERIES portlets are developed by several of the NERIES partners, and hosted both locally to the portal as well as remotely at participating Data Centers.

The NERIES portlet applications access data resources through local and remote web services. Web services provide machine-accessible data services accessed through standard web communication protocols. In many cases, the web services supporting the portal are also publicly exposed such that researchers may access them directly in order to develop their own applications. These web services provide the integration points for access by other science infrastructures, such as GMES and GEOSS.



Portal architecture: The NERIES portal aggregates access to individual web portlet applications running both locally and at the distributed data centers. These portlets provide an interface to the web data services which provide access to the data resources. The portlets access both local and remote data services.

Event and waveform data portlets

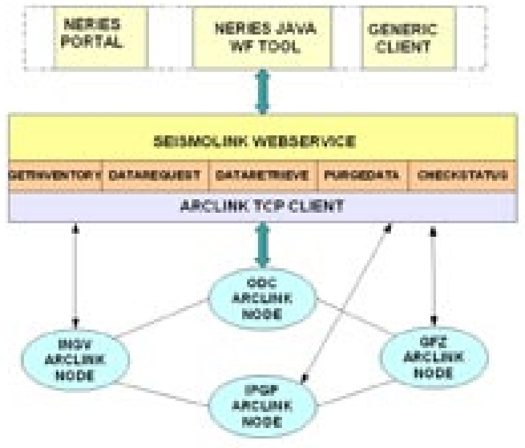
Each data-search portlet provides an interface that is specific to that data type. The Event Explorer tool allows the user to search for events using a map interface with additional event-specific search constraints. Events can then be selected and placed in to the user's "Event Cart" for download or use by other tools. The Waveform Explorer portlet tool running at ORFEUS allows the user to search for and request available seismic waveform data. The waveform tool can operate in event-oriented and time-oriented modes. In the time-oriented mode, the user simply specifies a time window. In the event-oriented mode, the waveform tool queries a remote data service to access the user's Event Cart, allowing the user to select events for which to search for available data. Parametric information for the selected events is retrieved from a web service in QuakeML format (see http://quakeml.ethz.ch). A TauP theoretical travel time computation web service is then called to calculate the data time window based on the event parameters and velocity model. The user has the option to choose which velocity model is invoked by the TauP service. In both time- and event-modes, data is then requested by station-channel and time. Stations and channels are selected using an interactive map-based tool.

Seismolink services

The portal accesses seismic waveform data through the SeismoLink web service. The SeismoLink web service provides an open front end to the ArcLink Data Center-linking middleware. Data requests from the waveform explorer are placed on a queue to be handled by the SeismoLink service. This provides the decoupling necessary between the interactive portal and the asynchronous nature of the waveform request processing. The SeismoLink service can also be accessed directly by external clients. The NERIES Java WaveForm Tool is an example tool allowing users to request waveforms directly, without having to program to the ArcLink API.

User data set management

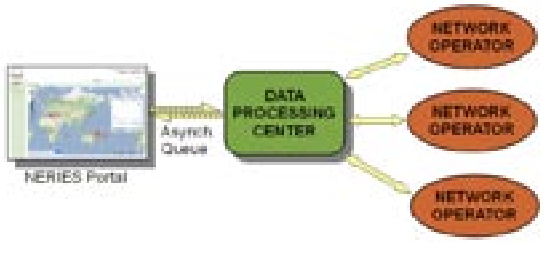
Once a data set has been requested, the request is placed in the user's My NERIES workspace. From here the researcher has access to a number of tools, including data download, providing data quality feedback, publishing the dataset as a shared dataset to be made available to other portal users, and access to various visualization tools. It is through the My NERIES workspace that the researcher will have access to additional external processing tools, such as the RapidSeis link to remote Seismic Analysis software which is currently under development.



Waveform services: Seismic waveform data is accessed through a web data service sitting on top of the ArcLink data center linking middleware. The SeismoLink web service provides access to ArcLink services to the portal and other clients, while hiding the native ArcLink API.

Accelerometric data portlet

The Accelerometric data explorer demonstrates another linkage with external data processing and resources. Using a map-based query interface with additional search filter constraints specific to accelerometric data, the portal user can search for available event-oriented accelerometric data. Once a user has selected the event and station-channels of interest, the data request is sent via a messaging system to an external Data Processing Center. The Data Processing Center then retrieves the requested data from the individual accelerometric network operators, processes the raw data, and returns the requested data in a number of standard formats. This is a potentially long-running external process, and the asynchronous response is handled by the message queue system. Once the data is available for download, the user's request list is updated and the user can download the data.



Accelerometric data: Accelerometric data requests are passed from the portal to a data processing center. The data center gathers the requested data from the appropriate networks and creates the downloadable data package. The data center then notifies the portal when the data package is available.

Meta data management

One of the difficulties faced within the NERIES portal and systems infrastructure is handling the broad range of information beyond just the scientific data and metadata. This information, which we refer to as the **Seismological Meta Information (SMI)**, may include such information as participating organization details, software resource information, models, algorithm descriptions, service and middleware configurations, as well as dataset and data product metadata, etc. In addition to its diversity, this information must also be exchanged between the tools and the services of the NERIES infrastructure, which are often geographically distributed among the partners. Moreover, it has to be accessible to external software agents, such as standalone clients and external eScience applications.

In order to properly handle this variety of information the NERIES project chose to use the **Resource Description Framework (RDF)** as the core metadata format. RDF provides a high degree of flexibility, which allows us to dynamically extend the Information Model both during the iterative development process as well as throughout the lifetime of the NERIES infrastructure. The SMI information is exposed through a W3C-standard SPARQL End Point, which provides a formal and well documented mechanism to query and retrieve the desired information from the RDF data store.

The choice of the flexible RDF format for managing dataset metadata makes possible several other enabling concepts. Datasets can be described in more detail, allowing relationships to other datasets to be inferred. Users may add descriptions and annotations, making the dataset more easily shared and used by others. Once made available, the dataset may be subsequently annotated by others, adding additional descriptions, relations, and perspectives. Detailed provenance can also be maintained, tracking dataset origin and processing steps that have been applied. Maintaining rich metadata about the dataset and data format fosters access by external tools by enabling possible data transformations.

Summary

The NERIES portal and project infrastructure provides an integrated technical solution to the problem of data access to distributed and diverse data sources. The portal provides an extensible framework to aggregate data-specific interactive query applications in to a single access point. These interactive applications are supported by a variety of distributed data web services. These web services are publicly exposed and available for access by individual researchers who wish to write their own scientific applications. They also provide the integration points for external processing applications and existing scientific infrastructures.

1) EMSC, 2) ORFEUS / KNMI

For more information, please visit:
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WEB-BASED MACROSEISMIC SURVEY OF 2009 L'AQUILA EARTHQUAKES SEQUENCE

by P. Sbarra[1], P.Tosi[1], V. De Rubeis [1], C. Ferrari[12]

Introduction

A macroseismic survey system, based on a web questionnaire, at the INGV website, was fully running during L'Aquila 2009 sequence.

Reported effects were statistically analyzed to extrapolate Mercalli-Cancani-Sieberg and European Macroseismic Scale intensities. The final result was the definition of the intensity degrees, with the evaluation of the associated uncertainty. Maps of macroseismic intensity were displayed on-line in almost real time and continuously updated in case of availability of new data. Three major earthquakes are here presented as their macroseismic intensity field, showing the ability of the method for giving fast and reliable results. Quantity and quality of data allow further investigations like definition of attenuation patterns and anomalous intensity areas.

Many seismic institutions collect intensity data through the web. The INGV online questionnaire, based on voluntary collaboration of common people, is reachable at the address www.haisentitoilterremoto.it. It is online since 1997.
During 2007 it was re-designed to report the effects on a single person and location. In this way the judgment of the individual is not erroneously extended to a whole community (as previously done), avoiding data interpretation problems [1]. The use of web-based macroseismic surveys grew up with the wide diffusion of Internet connections. It presents several positive features: almost real time results, low cost survey, fast evaluation of earthquake severity, positive feedback between seismic institutions and people. A large amount of data, even for very small events, allows statistical evaluation of intensities.

The definition of the intensity, following a macroseismic scale, depends on the percentage (few, many or most) of people or buildings reporting a specific effect. When assigning the intensity to one questionnaire, we assume that the compiler belongs to the wider and hence the most probable category of people (many of the EMS scale) [2-3]. This is because we want to display results in real time, as questionnaires are compiled. We cannot follow the standard procedure of first collecting all data and then assigning intensity. The error introduced, at the beginning when few data are received, could vary at the most ±1 degree. It becomes negligible successively when averaging more intensity values from the same place [3].

Intensity maps are produced and displayed when, for a seismic event, more than five questionnaires are compiled. They consist of the geographical distribution of intensities averaged for each town or village. In order to quantify the error associated to the mean intensity, we use the Kalman iterative procedure [4], that appears very suitable when an on-time evaluation and its corresponding reliability are needed. Using our database we estimated the standard deviation of the intensity distribution pertaining to each town. The standard deviations were quite small, lower than 1 degree. Even assuming a standard deviation of 1 degree, the Kalman filtering procedure provides an error associated to the commune intensity of ±0.4 - ±0.3 degrees (respectively with 5 and 15 questionnaires).

Since 2007 more than 106 000 questionnaires were compiled providing more than 1 000 intensity maps, the majority belonging to earthquakes of magnitude in the range 2-4. The most frequent intensity value assigned to a questionnaire was the III-IV degree. We received even questionnaires of felt effects in Italy of some Greek events with high magnitude.

Voluntary compilation of questionnaire has the risk to represent people that felt the quake the most, introducing a sort of positive bias to the data. To overcome this drawback we introduced a group of permanent compilers. When an event occurs, we send an e-mail asking to compile our questionnaire, receiving data even from people who didn't feel the quake.
Up to now we count more than 7200 subscriptions.

Macroseismic intensity analysis

The first analyzed event is the M_l 5,8 occurred on April 6, 2009 (1:32 UTC) near L'Aquila (Fig. 1).
The shock was widely felt throughout Italy and, in the epicentral area, EMS intensity reached X-XI. In just one hour after the event, using our real time mapping with the first 700 questionnaires, we were able to approximate well the current macroseismic field. The sole significant exception was represented by the field close to the epicenter: heavy damages, communication connections failure and people's high fear and suffering, prevented the compilation of questionnaires. This lack of data defined the most severe and highly damaged area, useful for first aid organization. Up to now, for the mainshock, we count more than 11 000 compiled questionnaires averaged over 1 363 towns or villages. For the whole sequence, we have recorded more than 65 000 questionnaires. In the city of L'Aquila and in some villages, many buildings collapsed or were seriously damaged. Figure 1 clearly shows the area of VI EMS with a circular shape of 25 km in radius around the instrumental epicenter (red star); highest intensity degrees, although present into the questionnaire data, were town averaged with lower intensities in the filtered macroseismic field. It is worth to note that the highest intensity zone of L'Aquila, evaluated by macroseismic experts, was referred to the older center town only [5]. Nevertheless, our data allow us to downscale the macroseismic field up to the home addresses.

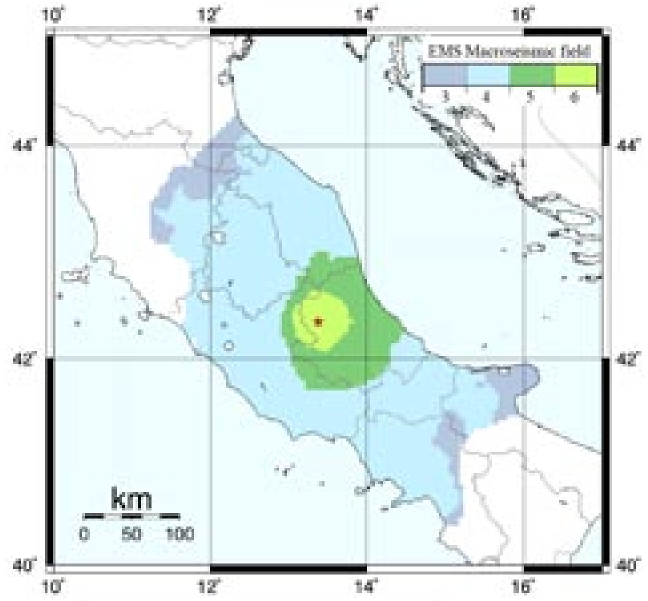

Figure 1 - Filtered macroseismic intensity field of April 6, 1:32 UTC, Ml = 5.8, obtained with 11295 questionnaires.

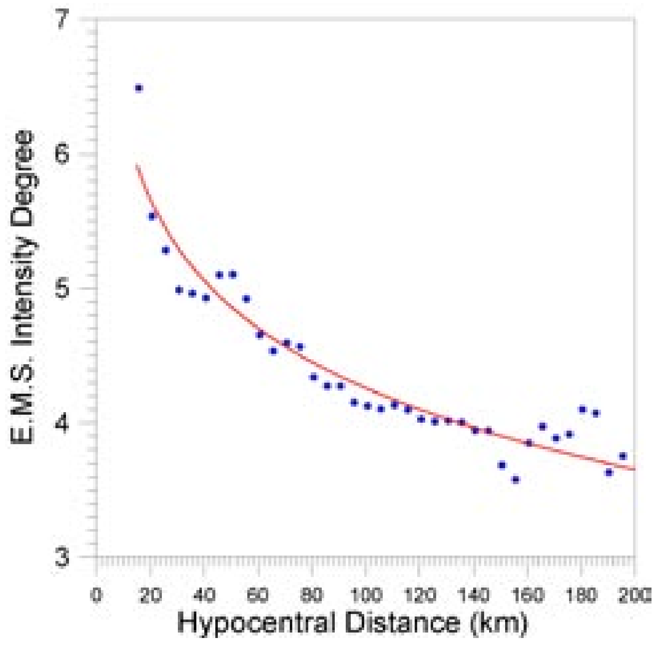

Figure 2 - Earthquake of April 6, 1:32 UTC. Intensity attenuation with hypocentral distance.

Intensity data have been filtered in space using a moving window average of 30 km in radius. The area of the V degree is not symmetrically related to the epicenter, having an elongation toward East: the V lower boundary is distant from the epicenter by about 35 km through West, 85 km through East. This geometry of V degree area closely reflects the spatial distribution of PGA [6]. Low boundaries of the III degree are missing due to the poor data density of the far field data set. We show in Figure 2 the intensity attenuation with hypocentral distance. Dots represent the average intensity calculated within a distance bin of 10 km wide. The red line is the good data fit obtained through the function $I = -0.87Ln(D) + 8.27$

The event of April 7, 2009 (17:43 UTC, M_l 5.3), the strongest aftershock recorded, received more than 3 300 questionnaires. Filtered field is shown on Figure 3. Corresponding intensity areas are reduced in extension compared to the main shock, reflecting the lower magnitude. Highest intensities are markedly anisotropic: VI EMS degree is located toward North – NorthWest in respect to instrumental epicenter, V EMS degree is elongated toward South – East.

The event of April 9, 2009 (00:52 UTC, M_l 5.1) received 2 200 questionnaires (Fig. 4). The VI intensity degree is not represented any more in the filtered field. The V and IV EMS are elongated through North side in respect to instrumental epicenter.

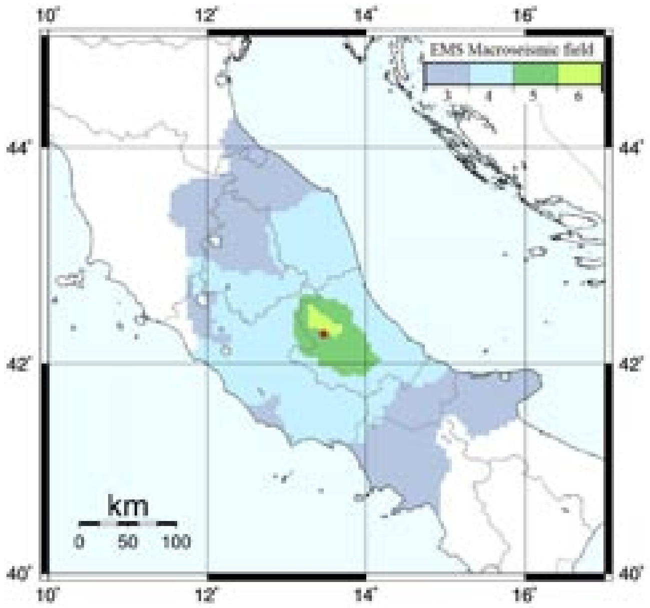

Figure 3 - Filtered macroseismic intensity field of April 7, 17:47 UTC, Ml = 5.3, obtained with 3398 questionnaires.

Conclusions

An advantage of our procedure is the possibility to statistically analyze data in almost real time.
Due to fast data collecting, we were able to signifi-

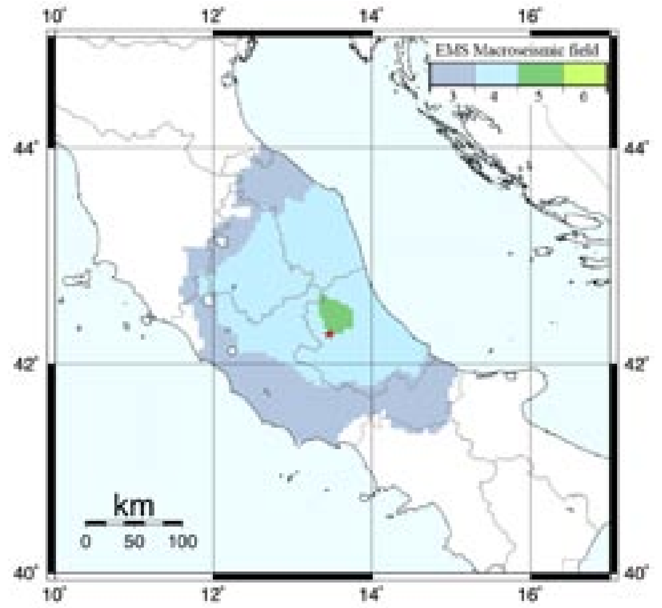

Figure 4 - Filtered macroseismic intensity field of April 9, 00:52 UTC, Ml = 5.1, obtained with 2246 questionnaires.

cantly distinguish aftershocks separately. Reported intensities are compared with those derived from traditional macroseismic survey, showing the reliability of the web-based method [2-3].

Our analysis is not limited to the highest intensities area, but it is easily extended to more peripheral field portions. We quickly obtain good results at a very low cost in terms of funding and time. Medium-high magnitude events receive a bigger surface extension analysis, by the inclusion of areas interested by low intensity effects, usually disregarded by direct inspection for evident cost reasons. Web-based survey is able to investigate intensity attenuation. The shapes of intensity degrees are in agreement with PGA estimation [6].

Acknowledgements

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THE GJORICA EARTHQUAKE OF SEPTEMBER 6, 2009 (M=5.4), ALBANIA

by Rr. Ormeni [1], E. Dushi[1], R. Koçi[1]

Abstract

The Albania earthquake of September 6, 2009 (M_L = 5.4), occurred in Gjorica, about 19 km south of the city of Peshkopia, Albania. Source parameters determination shows these resultats: source time 21:49 41.34s, epicenter coordinates 41.49⁰N and 20.45⁰E and focal depth 7.6 km. The main shock was followed by a great number of aftershocks. From the focal mechanism solution, it results that the earthquake of September 6, 2009 was triggered by a normal active fault with a NW-SE extensional stress direction.
Keywords: Gjorica Earthquake, aftershock activity, focal mechanism, earthquake effects.

Introduction

On September 6, 2009 an earthquake of magnitude (M_L = 5.4), occurred about 19 km south of the city of Peshkopia, Albania. More heavy damage was caused in Gjorica, Qerenec villages and Shupenza municipality in Dibra district. The main shock was followed by a great number of aftershocks, from which the event of September 7, 2009 at 15:20 (UTC) was the biggest one with a local magnitude M_L = 4.2. This earthquake expresses the recently increased seismic activity of the Vlora-Elbasani-Dibra transversal faulting zone. The main event is a shallow one, with a hypocentral depth at 7.6 km. This fact explains the localized destruction in the epicentral zone.
The focal mechanism of main shock has the parameters: strike 219°, dip 40°, rake -90°, shows a normal active fault or fault zone with the extension axes in the NW-SE direction. The source spectral parameters determined on displacement spectra are: f_0 = 0.8 Hz (corner frequency), Δσ = 36 bar (stress drop) and a= 3.6 km (focal radius).

The seismotectonic data of the zone affected by the earthquake

The Albanian orogeny, as the most south-western part of the Euro-Asiatic plate, in convergence with the Adria microplate, is divided into two areas with different tectonic regimes: the external area with a compressive regime, representing its offshore part ; and the internal area with an expanding regime, representing the continental area *(Aliaj.et.al.,1996)*. The movement of the Adria microplate, in our days, is one of the important elements used to understand the geodynamic evolution and the deformations along the western front of the folded Dinarid-Albanid-Hellenid system as well as for all the Mediterranean area *(Altiner,Y., 2006)*.

The territory affected by the earthquake dated September 06, 2009 is located in the northeastern part of Albania. It is also located in the intersection between Diber-Korça and Vlora-Elbasani-Diber tectonic belts with different strike directions. The results of the expanding post Pliocene tectonic regime are the normal tectonic faults which bound to the east, west and north the area of the earthquake dated September 06, 2009 (Fig 1).
There are also visible tectonic faults with east-west direction like the fault located to the north of Peshkopia city and the one to the south of Shupenca village.

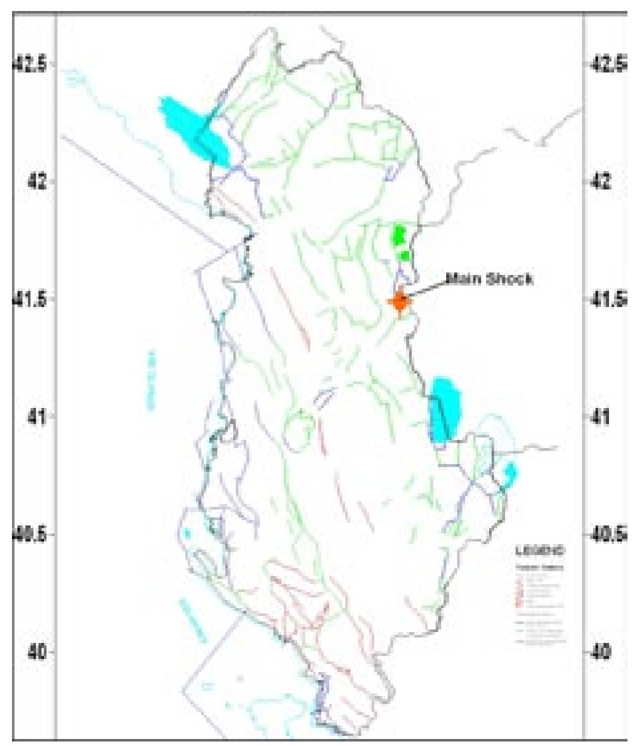

Figure 1 - Seismotectonic map of Albania

Instrumental description of the event

An earthquake of intensity I_0 = VII degree (MSK-64) struck the Northeastern Albania on September 6, 2009, at 21:49 (UTC), causing many damages in Dibra district. The magnitude of this event is determined

M_L = 5.4. More heavy damages were caused in Gjorica, Qerenec villages and Shupenza municipality. This earthquake expresses the increased seismic activity of the Vlora-Elbasani-Dibra transversal faulting zone. This activity began in 2004 and reached its greatest seismic energy release with this event.

Epicenter location for the main shock and subsequent after-shocks is shown in Figure 2. The location procedure was carried out through P and S onsets elaboration based on the local velocity model (*Ormeni, Rr, 2007*) and the time readings from BB Albanian seismological stations as well as other surrounding ones, from MedNet, INGV and AUTH in the distance range of 19-390 km.

Source parameters determination shows the following results: source time 21:49 41.34s, epicenter coordinates 41.49^{0}N and 20.45^{0}E and focal depth 7.6 km. The routine used for this purpose is Hypoinvers program (*Fred W.Klein, 2002*).
The main shock was followed by a great number of aftershocks, of which the event of September 7, 2009 at 15:20 (UTC) was the biggest one with a local magnitude M_L = 4.2
We tried a focal mechanism solution for the main shock, based on the classical method of first onsets polarities, using Focmec routine as it is incorporated in Seisan package, (*Haskov & Ottemoler, 2008*). The solution is respectively: Strike = 219.5°, Dip = 40° and Rake (Slip) = -90^0 (Fig.2). From the focal mechanism solution it results that the earthquake of September 6, 2009 was triggered by a normal active fault with an NW-SE extensional stress direction.

From spectral analyses, using Spec program on corrected waveform data for instrument response and attenuation, main source parameters are determined for the main shock, (*Haskov & Ottemoler, 2008*).
For attenuation correction, are taken into account the quality factor at the general form $Q = Q_0 f^{q\alpha}$, with: Q_0 = 89 and qα = 0.4, in the frequency range f ≥ 1 Hz and κ = 0.03.
These parameters were evaluated using standard coda procedure on the wave form files recorded so far by BB Albanian seismological stations. In this study, BHZ component for PHP station and BHE component for BCI station are taken in consideration.
The source spectral parameters determined on displacement spectra are: f_0 = 0.8 Hz (corner frequency), Δσ = 36 bar (stress drop) and a= 3.6 km (focal radius). These values represent mean values determined from both stations. Based on these spectral values and using the well-known relations, $M_0 = 0.31 \times 10^{18}$ Nm and respective M_W = 5.3, were achieved.

Aftershock study

The aftershock sequence followed the September 6, 2009 event and continued with a relatively high frequency until September 9. These aftershocks continued with a lower frequency as well as with lower magnitude values from September 9, 2009 and on. The overall number of events registered so far is 678 (recorded from the nearest seismological station PHP). From this number, 130 events are localized (Fig.2.). Determined magnitude values were M_L≥2.0. Mostly the foci of these secondary events are located in the SW part of the epicenter zone, with a depth ranging from 1-29 km.

Figure 2 - Map of Areal distribution of seismic activity from September 6, and on; Main shock 2009-09-06-21:49 and subsequent aftershocks; Focal Mechanism solution; Seismological Stations of Albanian Seismological network.

Macroseismic information

The main event is a shallow one, with a hypocentral depth at 7.6 km. This fact explains the localized destruction in the epicentral zone. From the information collected, mainly in the operative way and from the field recognition (*Zaçaj, M., Dogjani, S., Dushi, E., 2009*), it results that Qerenecy village is on the epicentral zone, where heavy damages were observed, (Fig. 3). The Gjorica-Qerenecy area is placed in the epicentral zone, with intensity VII. The shake was felt VI-VII degree at Bulqiza town, V-VI at Peshkopia, Burreli and Librazhdi, IV-V degree at Rresheni, Tirana and Elbasani cities.

Figure 3 - Views of ruined buildings in Qerenecy village and ground cracks (*Zaçaj. M et al. 2009, Field Report*)

Discussion and conclusion

1. The earthquake of September 6, 2009 with an epicenter near the Gjorica village in Dibra district, expresses the increased seismic activity of the Vlora-Elbasani-Dibra transversal faulting zone.

2. The low stress drop value explains the tectonic stress regime in this zone and the long span of aftershocks, which is directly related to the heterogeneity in geological environment.

3. The focal mechanism solution shows a normal active fault or fault zone to be responsible for triggering the September 6, 2009 earthquake.

4. The focal mechanism of the main shock has the following parameters: strike 219°, dip 40°, rake -90°, with the extension axes in the NW-SE direction.

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AFTER SHOCK PROBABILITY ASSESSMENT FOR THE EARTHQUAKE OF SEPTEMBER 6, 2009, ALBANIA, BASED ON THE GUTENBERG-RICHTER AND MODIFIED OMORI FORMULAE

by Serkan Öztürk[1], Rrapo Ormeni[2]

Abstract

In this study, we made a statistical analysis for the aftershock occurrence of the September 6, 2009 earthquake, 21:39 GMT, with a magnitude M_L(5.4) that occurred on the Gjorica village, about 19km south of the city of Peshkopia, Albania. The catalog is homogenous for local magnitude, M_L, and contains about 13 day's time period. The catalog contains 117 aftershocks with a magnitude M_L larger than or equal to 2.0. A model for aftershock occurrence probability based on the combination of Gutenberg-Richter and modified Omori formulae is used in order to predict how many large aftershocks should follow small main shocks and in order to evaluate the aftershock probability that a randomly chosen earthquake is greater than or equal to a certain magnitude of aftershock. For this purpose, we made an application using aftershock sequences of the September 6, 2009 earthquake.

Introduction

The Northeastern part of Albania was struck on September 6, 2009 by an earthquake (M_L=5.4) causing many damages in Dibra district. The Dibra district has been hit by other earthquakes in the last century, resulting in human victims and enormous material loss. The minimization of the human victims, property damage, and social and economical disruption due to earthquakes, essentially depends on reliable estimates of seismic hazard. It is therefore, of a great importance to evaluate the seismic hazard properly. For this purpose, an evaluation of the aftershock probability has been analyzed in this study.
The aftershock probability evaluation method is an effective way to analyze the aftershock activity of the main shock-aftershock pattern and it must be used as a part of earthquake evaluations. The occurrence of aftershocks has been investigated statistically and physically by many seismologists and some principal results are obtained (e.g., *Guo and Ogata, 1997; Öztürk and Bayrak, 2007; Öztürk and Bayrak, 2009)*. An aftershock probability assessment as it is used on the earthquake of September 6, 2009 refers to statistically expressing and evaluating the frequency that an aftershock of a certain magnitude will occur. The modified Omori formula *(Utsu, 1961)* forecasts the number of aftershocks that will occur, but in order to perform a probability evaluation of aftershocks, it is necessary to combine this formula with the Gutenberg-Richter *(Gutenberg-Richter, 1944)* formula. In this study, a model that clarifies the number of events forecasted and the probability of one or more aftershocks by statistically processing the main shock-aftershock pattern has been defined based on the combination of modified Omori and Gutenberg-Richter formulae.

Data used

The data for doing this study were retrieved from Albanian seismological stations, Montenegro seismological stations, also from INGV, MEDNET, and AUTH networks. Complete and homogenous catalogue of aftershock sequences is provided for the main earthquake with M_L=5.4, on September 6, 2009. The number of aftershocks localized was 117 and magnitude values were $M_L \geq 2$.

Method and Analyses of Probability Evaluation

Quantitatively, the larger the magnitude of aftershock, the more their number declines exponentially. The expected number of events $N(T_1,T_2)$ larger than M magnitude of the earthquakes during the time from *Tl to T2* is calculated by:

$$N(T_1,T_2)=\int_{T_1}^{T_2}\lambda(M,s)ds = K\exp\{-\beta(M-M_{th})\}A(T_1,T_2) \quad (1)$$

Here, *K* is a parameter from modified Omori (MO) law; *b* is a parameter of Gutenberg-Richter (GR) formula and M_{th} is magnitude of the smallest earthquake *(Ogata, 1983)*. A(*T1,T2*) is given as:

$$A(T_1,T_2)=\begin{cases}\dfrac{(T_2+c)^{1-p}-(T_1+c)^{1-p}}{1-p} & (p\neq 1)\\ \ln(T_2+c)-\ln(T_1+c) & (p=1)\end{cases} \quad (2)$$

where *c* and *p* are constants from MO formula. The probability *Q* of one or more aftershocks of *M* magnitude or greater occurring since the main shock, from the time T_1 to T_2 is found by Equations 3 and 4 *(e.g., Reasenberg and Jones, 1989)*:

$$Q = 1-\exp\left\{-\int_{T_1}^{T_2}\lambda(M,s)ds\right\} = 1-\exp\{-N(T_1,T_2)\} \quad (3)$$

$$Q=\begin{cases}1-\exp\left[\dfrac{-Ke^{-\beta(M-M_{th})}}{1-p}\left\{\dfrac{1}{(T_2+c)^{p-1}}-\dfrac{1}{(T_1+c)^{p-1}}\right\}\right] & (p\neq 1)\\ 1-\exp\left[-Ke^{-\beta(M-M_{th})}\{\ln(T_2+c)-\ln(T_1+c)\}\right] & (p=1)\end{cases} \quad (4)$$

In these equations, *K* is approximately proportional to the total number of aftershocks; *p* represents the extent of time damping; c compensates for complex aspects immediately after the main shock. *ß* represents the relationship of *b* and ß=*bln10 =2.30b* in the GR formula. *b*-value is related to both the number of small aftershocks and the large aftershocks ratio. Its large value indicates a relatively small number of large earthquakes. M_{th} is the magnitude of the smallest earthquake processed using the MO or the GR formulae. It is premised that all aftershocks larger than M_{th} are observed without omissions. T_1 to T_2, which represent the beginning and the end of the period during the aftershock probability, is evaluated; both represent elapsed time following the main shock. It must be kept in mind that Equation 4 does not represent the probability of an aftershock that matches conditions occurring exactly once; it represents the probability of it occurring more than one time.

The actual application of the probability evaluation methods based on the statistical models involves the problem of determining whether or not it is possible to find the parameters *(K, c, p, b)* for aftershock activity immediately following a main shock.

If the average parameters for the aftershock activity are known, there is a possibility that they can be used effectively as preliminary data until the actual data is available.
For this reason, specific parameters for the aftershock statistical model combining the GR and the MO formulae are compared, and their application range is studied.
Figure 1 shows the number of aftershocks forecasted and Figure 2 shows the aftershock occurrence probability versus the magnitude of aftershocks.

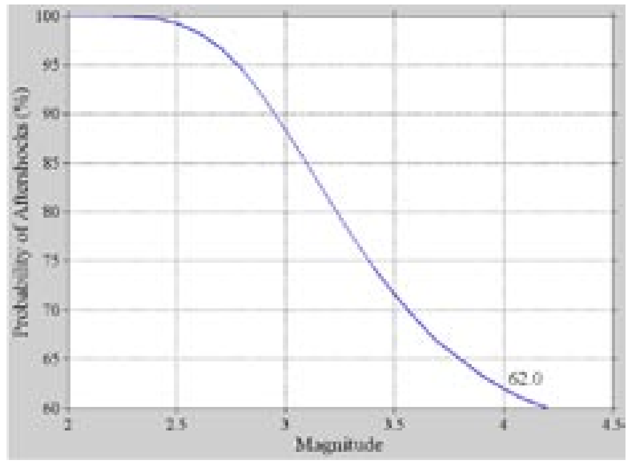

Figure 1 - Aftershock occurrence probability for one or more aftershocks

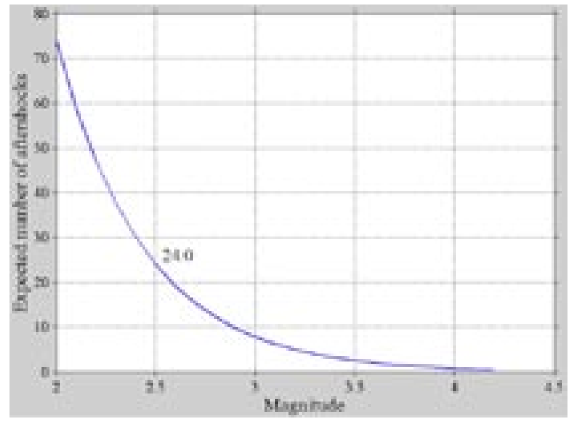

Figure 2 - The number of events forecasted for one or more aftershocks

All calculations are considered for the starting and ending time intervals of the aftershock sequence. For the aftershock sequence, the magnitude of randomly chosen events is taken as M_L=4.0 and the aftershock probability in this magnitude level is shown on each plot. The expected number of aftershocks with magnitude M_L=2.5 is also given on graphs.
The probability of the largest aftershock occurrence for magnitude level of 4.0 is calculated as 62.0 % for Dibra earthquake of 6 September, 2009. The maximum expected numbers of aftershocks for magnitude level of 2.5 was computed 24.

General information for the earthquake occurrence of September 6, 2009 is given in Table 1. Also the maximum *(Ma_{max})* and minimum *(Ma_{min})* magnitudes of aftershock sequence are given. Also, the number of aftershocks *(N)*, completeness magnitude *(M_c)*, starting

Year	Month	Day	Origin Date	Longitude	Latitude	Depth (km)	(M_L)	Ma_{max}	Ma_{min}
2009	08	06	21:49:41	41.49	20.45	7.6	5.4	4.2	2.0

Table 1. Some properties of the earthquake occurred in Gjorica, Diber, Albania

Earthquake	N	T_1 (day)	T_1 (day)	M_c	b-value	K-value	c-value	p-value
September 6, 2009	117	0.008	13	2.8	0.98±0.09	12.59±1.99	0.019±0.031	0.83±0.11

Table 2. Aftershock parameters and statistics used in the probability evaluations

(T_1) and ending (T_2) times for the sequence, b, K, p, and c-values for the aftershock sequence are given in Table 2.

Conclusions

In this study, an example of a statistical application of the aftershock probability evaluation method is carried out for the September 6, 2009 earthquake.

It is an important fact that aftershock probability is one evaluation method and it must be used as a part of earthquake evaluations.
The number of events forecasted and the probability of aftershock activity is evaluated for one or more aftershocks by combining the Gutenberg-Richter and the modified Omori formulae.
As an example, we used M_L=2.5 for the expected number of aftershocks and M_L=4.0 for the probability of the largest aftershock occurrence.
Probability for magnitude level of 4.0 is calculated as 62.0 % and the expected numbers of aftershocks for magnitude level of 2.5 was computed 24.

Thus, such kind of evaluations can make a contribution to the success of disaster protection measures in Dibra region.

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PROBABILISTIC SEISMIC HAZARD ASSESSMENT FOR NORTHERN ALGERIA IN TERMS OF PGA, SA, UHS, AND DEAGGREGATION

by J.A Peláez[1*], M. Hamdache[2], C. López Casado[3], and A. Talbi[2]

In the last few years, a new probabilistic seismic hazard assessment for Northern Algeria has been carried out. The approach used was spatially smoothed seismicity since this methodology combines both the parametric and non-parametric probabilistic methods. Moreover, it is well suited to model the so-called disperse or background seismicity, that is, the seismicity that cannot be assigned to specific geologic structures. Initially, this approach was proposed and developed in works by *Frankel (1995) and Frankel et al. (1996)*.

These new seismic hazard values have been published in terms of mean **peak ground acceleration (PGA)** *(Peláez et al., 2003, 2005)*, **spectral acceleration (SA)**, and **uniform hazard spectra (UHS)** *(Peláez et al., 2006)*. In addition, recently we conducted studies yet unpublished in order to compute seismic hazard deaggregation in terms of magnitude and distance.

Data and methodology

The seismic catalog used for our study mainly consisted of data published by the Spanish IGN, supplemented for the Algerian zone with data published by the CRAAG, and initially updated to 2002. The published data for the study region by the EMSC and by the USGS have also been incorporated into the data file. Afterwards, the catalog was updated to June 2003, including the 21 May 2003, M 6.8, Algiers earthquake *(Hamdache et al., 2004)* and also the reappraisal of significant earthquakes from the 19th century, mainly in northeastern Algeria *(Harbi et al., 2003)*. All the magnitudes and maximum intensities were converted and unified to M_S magnitudes, and all the non-Poissonian earthquakes identified via the methodology proposed by EPRI (1986) were removed. The attenuation relationship developed by *Ambraseys et al. (1996)* was employed in our study as we consider it to be the most reliable one for Algeria, since these authors have considered acceleration data from several earthquakes (e.g., 29 October 1989, M_S 5.7, Tipaza earthquake) recorded in this region.

From our compiled catalog, four complete and Poissonian seismic models were established and used to compute seismic hazard: that with a seismicity of
a) M ≥ M_S 2.5 after 1960;
b) M ≥ M_S 3.5 after 1920;
c) M ≥ M_S 5.5 after 1850; and
d) M ≥ M_S 6.5 after 1700.
The final seismic hazard values are obtained by weighing the partial results derived from each of the models. From the smoothed earthquake number included in each model, the seismic hazard is computed from the well-known total probability theorem in terms of the rate of exceedance of different levels of ground motion.

Results

Among the results obtained, initially we consider mean PGA values with a 10% probability of exceedance in 50 years, that is for a return period of 475 years, for rock conditions (Fig. 1).
The highest values for the seismic hazard appear in the central area of the Tell Atlas. In particular, in the wilaya of Chlef, including the city of El Asnam, and the western part of the wilayas of Tipaza and Ain Defla, the mean PGA is above 0.24 g, and reaches 0.48 g in the epicentral area of the 1954 and 1980 El Asnam earthquakes. The seismic hazard map shows another lobe, with a lower value, around 125 km east of the previous one. It includes the wilayas of Blida and most of Algiers, including the city of Algiers. Values above 0.24 g are also reached in this area.

Afterwards, we derived SA values for rock (v_S > 750 m/s), corresponding to soil types A in the Eurocode 8 (*EC 8, 1998*) and S1 in the Algerian building code (*RPA-99, 2000*), damped at 5%, for different periods.

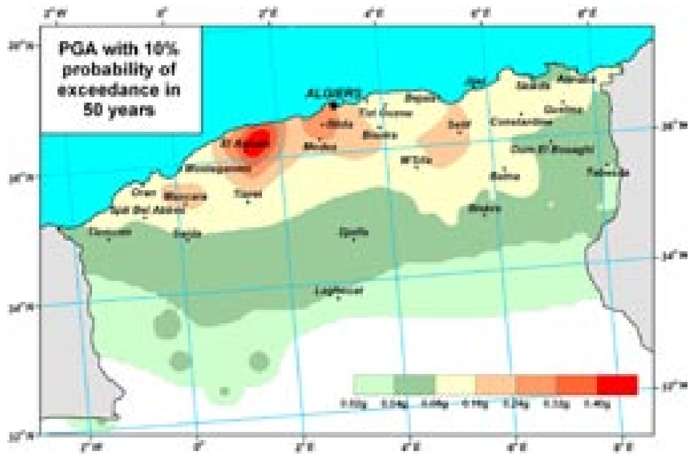

Figure 1 - Probabilistic mean PGA values for rock and a return period of 475 years.

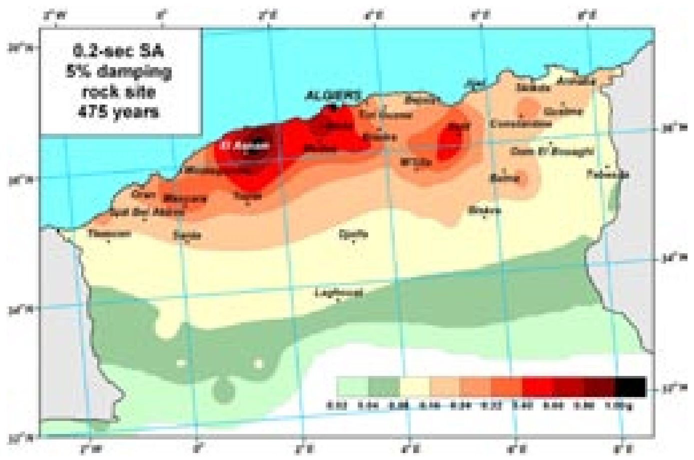

Figure 2 - Probabilistic SA values for rock, 0.2-sec, damped at 5% and a return period of 475 years.

The results were plotted as contour maps as well. These plots commonly show that maximum values occur again in the central part of the Tell Atlas, close to the location of the historical earthquake of January 15, 1891 (macroseismic magnitude M_S 7.0), and close to the more important recent instrumental earthquakes of September 9, 1954 (M_S 6.8), and October 10, 1980 (M_S 7.3). The maximum SA value in this region, for a return period of 475 years, is 0.95 g at 0.2-sec and 0.4-sec, and 1.07 g at 0.3-sec (Fig. 2). This region appears clearly as the seismic focus generating the higher seismic hazard level, independently of the return period being considered.In addition to the seismic hazard assessment at different periods, we have computed the UHS at different locations. The attenuation model used allows high definition in the computation of the spectra.

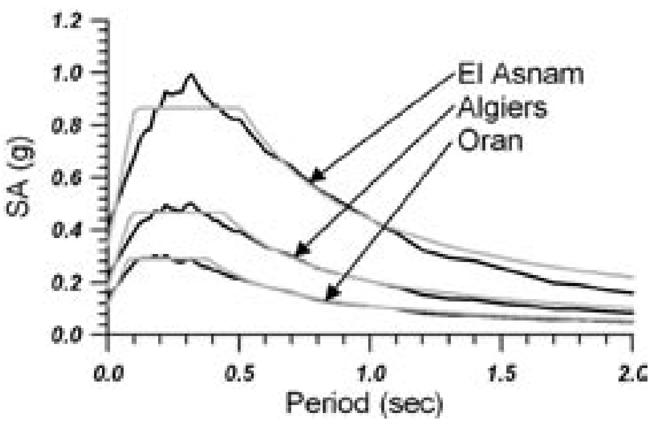

Figure 3 - UHS and design spectra for rock damped at 5%.

The analysis of Figure 3 re-emphasizes the SA values at El Asnam as compared with other ones (Algiers and Oran) for a return period of 475 years.
From the computed uniform hazard spectra for different soil types, and estimated specifically for the most important cities, those obtained from a smoothing approach, for a return period of 475 years and 5% damping, are proposed as design spectra.
To do so, we have used the *Newmark-Hall (1982)* approach with certain modifications. The spectral acceleration for 0.2-sec is used to establish the spectral region for lower periods (region controlled by the acceleration), while a spectral acceleration value for 1.0-sec is used to establish the spectral region for intermediate periods (region controlled by the velocity), as such it is proposed in the recent International Building Codes.

Finally, a deaggregation study of the mean PGA in terms of magnitude and distance was performed. Based on these results, we can compute the so-called control earthquake *(Bernreuter, 1992)*, that is, the earthquake contributing most to the seismic hazard in a certain location from a probabilistic point of view. To define this value, the average values or the modal values of the magnitude and distance can be used; it is the so-called 2D hazard deaggregation technique.
The modal values are more representative when applied to the seismoresistant design or the calculation of the safe shutdown earthquake.

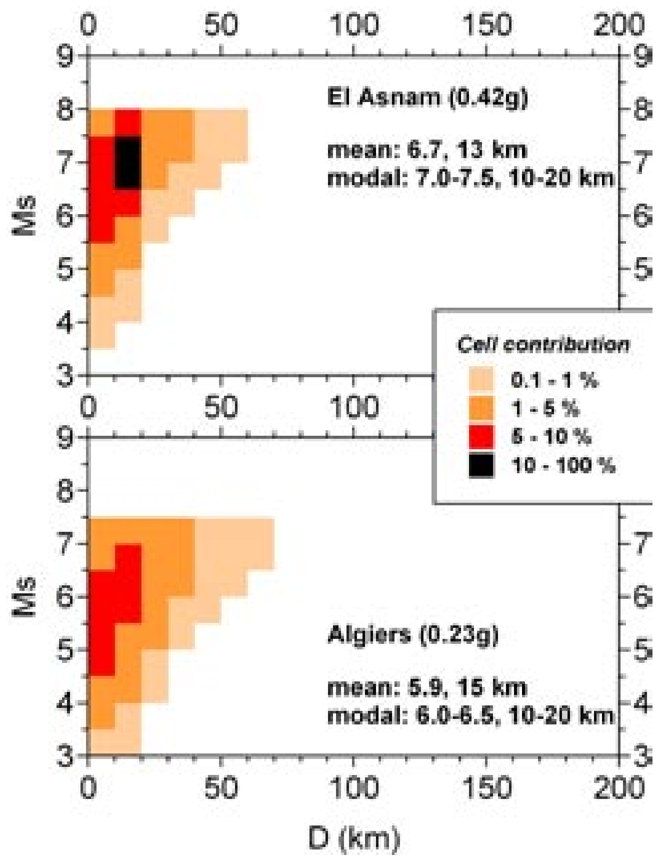

Figure 4 - Probabilistic seismic hazard deaggregation in terms of magnitude and distance for a return period of 475 years.

As an example, some unpublished results are showed in Figure 4. A typical morphology can be observed with a single nearby lobe both in El Asnam and Algiers, where hazard is due exclusively to a single local seismic focus, more or less extensive, surrounding the city.
As can be seen, using the average or modal values to calculate the control earthquake provides values that nearly coincide. The dominant event in these locations is an earthquake hosted less than 20 km away, with a magnitude of M_S 6.0-6.5 in the case of Algiers and of M_S 7.0-7.5 in the case of El Asnam.
As indicated by different authors, and as is already taken into account by different American regulations (e.g., *USNRC, 1997*), this type of study is essential in order to be able to completely analyze the results obtained in any study of seismic hazard.

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RECENT VOLCANIC AND SEISMIC ACTIVITIES 2009 AT HARRAT AL-SHAQAH, WESTERN SAUDI ARABIA

by Hani Zahran[1] , Salah El-Hadidy[2]

Introduction

One of the volcanic provinces in western Saudi Arabia, Harrat Al-Shaqah (also known as Harrat Lunayyir), recently suffered from earthquake swarm with numerous small to moderate-size earthquakes in April-July 2009. The most intensive activity occurred on 17-19th May when six magnitude 4.6-5.7 earthquakes occurred. Following the events the Saudi Civil Defence Authority evacuated the area and relocated over 20000 people to the neighboring cities of Yanbu and Medinah. The activity continued throughout June with several magnitude 4-5 earthquakes but then quieted down in July. Harrat Lunayyir is a lava field, relatively small (1750 km^2) compared to other lava fields in western Saudi Arabia. It lies 50 km east of the Umm Lojj port (Longitudes 37°45'0" and 37°75'0"E and Latitudes 25°10'0"N and 25.17°N). The oldest lavas of Harrat Lunyyir, most probably Pliocene in age (Fig.1), are easily recognizable in the field, as their surfaces are strongly weathered and affected by erosion that is expressed by a well-developed drainage system.

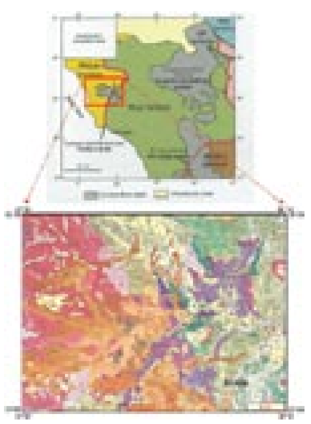

Figure 1 - Location map of Harrat Al-Shaqah, Saudi Arabia

Geological setting of Harrat Al-Shaqah

Geologically Harrat Al-Shaqah is a very young volcanic region composed of late Neogene and Quaternary basaltic lavas and pyroclastics directly overlying deeply eroded Neoproterozoic rocks of the Arabian Shield *(Kemp, 1981; Johnson, 2005)*. The basement rocks surrounding Harrat Lunayyir belong to two different lithostratigraphic units: Midyan terrane located NW and Hijaz terrane in SE *(Johnson, 1998, 2005; Johnson & Woldehaimanot, 2003)*. A complex of fault-bounded belt of ultramafic to mafic ophiolitic rocks known as Jabal Wask ophiolite lay between these two terranes and make the Yanbu suture (the Hudayrah-Jabal Ess fault-zone). Harrat Lunayyir have morphologic characteristics and lava flow stratigraphy indicates its development through the emplacement of numerous flow units over an extended period of time, the last one occurred around 1000 A.D.? It contains more than 50 volcanic cones that were constructed over Precambrian crystalline rocks along N-S to NNW-trending vents. Most of the scoria cones show characteristic tephra sequences of welded and non-welded scoria and agglutinate. Tephra occurs as ash, lapilli, blocks and bombs of various shapes. The fine ashes form a partial or complete cover over many of the surrounding Precambrian rocks. Lava flows are mainly of basaltic composition and form most of the surface of the volcanic field.

Volcanic characteristics of Harrat Al-Shaqah

Harrat Al-Shaqah volcanic field is largely constructed of basaltic lava flows extruded onto the Precambrian basement rocks of the Arabian Shield through N- to NNW-trending vent zones or major eruptive centers. Rocks along the vent zones consist of basaltic rocks as old as 2.5 Ma? The historic eruption of Harrat Lunayyir corresponds to a large monogenetic volcano consisting of high (up to 1370 m above sea level) summit vent constructed from scoria cones and welded spatter surrounded by a field of aa lava flows. In this regard, the volcanic and structural features on Harrat Lunayyir are similar to those of active rift zones on Hawaii, Iceland, and the eastern Snake River Plain, USA *(Greeley, 1982; Hughes et al., 1999; Walker, 2000; Winer et al., 2004)*, where monogenetic basaltic volcanoes are the most common type. The volcanoes range in from small scoria cones to very big scoria cones where much of the material was erupted by explosive mechanisms with variable proportions of lava flows.

The most important faults are located along the extension of a NW-SE trending linear magnetic anomaly that lies to the NW and SE of Harrat Lunayyir *(Kemp, 1981)*. These prominent NW-SE oriented magnetic anomalies in the western part of Saudi Arabia coincide with Tertiary gabbroic dikes formed during an early phase of continental rifting (pre-dating true opening of the Red-Sea) which affected the 30 to 40 km thick Neoproterozoic rocks of the Arabian shield *(Zahran et al., 2003)*

Recent seismicity near Harrat Al-Shaqah (Lunayyir)

An earthquake swarm has been observed in the vicinity of Harrat Al-Shaqah since late 2007, with a noticeable recent increase. About 400 events were recorded in two weeks. On 19th April 2009, another earthquake swarm occurred in Harrat Al-Shaqah, more than 27,000 events were recorded, about 207 of theses events were felt up to 210 km, and the magnitude ranges from 3 to 5.39 on Richter scale. The earthquake activity started with very low magnitude and relatively deep foci (up to 15 km), and continued with an increase in number and magnitude. On 17th May, the seismic activity increased rapidly within a very short period of time, ranging in magnitude from Ml= 4 up to 5.39. The strongest event occurred on 19th May 2009 and was strongly felt around Harrat Al-Shaqah and in surrounding areas. The felt area reached up to 210 km, people were frighten and went out, a few old houses suffered from minor damage. Then the earthquake activity decreased with time and displayed shallower depths (up to 4 km). Analyzes of the waveform data on both time and frequency domains, showed different volcanic earthquake types. We have recorded the high frequency volcanic tectonic earthquake (VT or A-type) at depths up to 10 km, with very clear P and S arrivals, and low frequency volcanic tectonic earthquakes (VL or B-type) with very weak P and S arrivals. It was difficult to distinguish the S-arrivals. In addition we have recorded the multi-phase events, as a combination of both HF and LF events. Up to now, we did not record the volcanic tremors which are considered as a good indication for the time of volcanic eruption. In order to improve the earthquake parameters of these events, including the location of the hypocenters, a small network of portable seismographs consisting of 8 seismic stations has been established in the area, in addition to the permanent seismic stations of **Saudi National Seismic Network (SNSN)**. The data were studied in space-time, depth-time distribution, magnitude frequency diagram, number-time diagram, to understand the characteristics of the earthquake activity, which is more likely to be of earthquake swarm associated with magmatic activity. From the depth distribution of earthquake foci, we determined the location of the magma chamber at about 5 km depth.

1D velocity model

Using the earthquake data of recorded events at Harrat Al-Shaqah, we constructed one dimensional velocity model and used it to improve the determination of earthquake parameters of recorded events, and for the fault plane solutions of the selected events.

Fault plane solutions

Fault plane solutions of the largest events that have been recorded at Harrat Al-Shaqah show pure normal faulting in most cases and normal faulting with a small strike-slip component in some other cases (Fig. 2). The regional stress field deduced from the focal mechanisms of selected events indicates NE–SW tension, which is in a good agreement with the dike modeling and observed geological features associated with the recent earthquake activity.

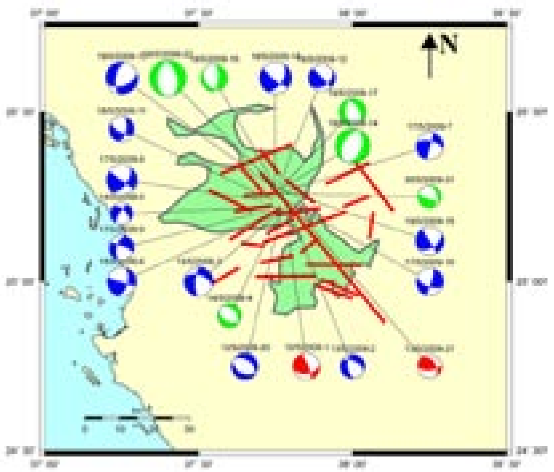

Figure 2 - Fault plane solutions of some selected events recorded by SNSN at Harrat Al-Shaqah

InSAR data

The earthquake swarm observed in Harrat Al-Shaqah is clearly visible in the satellite radar interferograms (**InSAR**). The results are outstanding, owing to the stable surface conditions of this near vegetation-free region. Interferograms spanning the activity in mid-May exhibit a strong deformation that extends across a large 40 km x 40 km area, showing over a meter of extension. In addition, the data show clear signs of surface faulting and graben-like subsidence in the middle of the deformed area with the graben subsidence exceeding 50 cm.

Discussion

The largest recent earthquake in Harrat Lunayyir resulted in a NW-SE oriented surface faulting of approximately 8 km long, with up to 1 m of vertical displacement visible within an area covered by recent sediments, where the down-thrown foot-wall is to the northeast of the fault. An open fissure related to this fault reaches a maximum width of about 5 to 7 m and collapsed rocks within the fissure form micro-graben. The fracture pattern of the fault suggests a largely extensional regime with the principal stretching direction oriented NE-SW. The fracture is located in a major fault zone related to the regional magnetic lineament, close to the youngest cinder scoria cones and the most recently recorded earthquake epicenters. The earlier swarm recorded in 2007 to the southeast, with thousands of earthquakes, was probably due to movement of magma, but it is by no means certain that movement of magma is associated with the latest sequence. Moreover, during the last three months no other visible signs of volcanic activity like gas emanations, fumaroles or scoria extrusions were recorded. The deformation appears to be caused by a near-vertical dike intrusion with a NW- SE orientation, parallel to the Red Sea rift. The dike caused faulting on graben-forming normal faults. Figure 3 shows the distribution of earthquakes, recent fractures and related features as well as the deformation of the area. The shallowest part of the dike appears to have reached within only 5 km of the surface, right below where the graben is the narrowest and under an area with a number of cinder cones from previous volcanic events. The dike appears to have continued to grow after the initial strong phase of activity in mid-May. A deformation interferogram spanning the time period from the end of may until early July shows similar deformation pattern, although with a much smaller amplitude. This continuing activity is also manifested in several magnitude 4+ earthquakes that took place from late May until early July.

From the gathered data it is impossible to state definitely if the seismic activity is due to magma upwelling rather than just release of tectonic stress, although any increase of stress near the present activity was no doubt caused by the earlier magmatic movements.

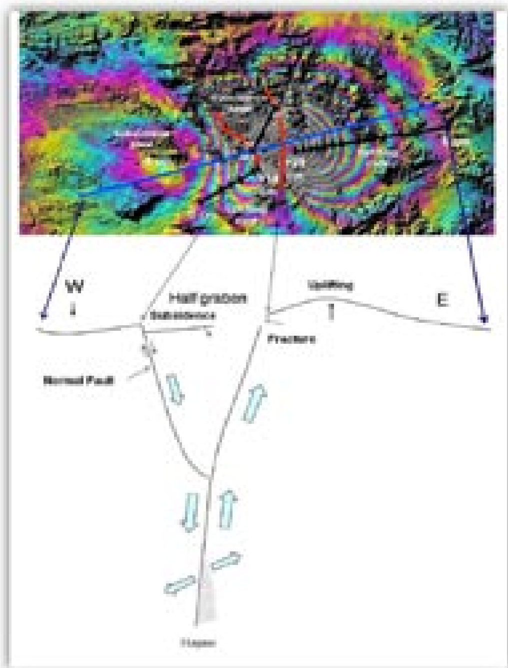

Figure 3 - Interpreted structural model from InSAR data and geologic field observation at Harrat Al-Shaqah

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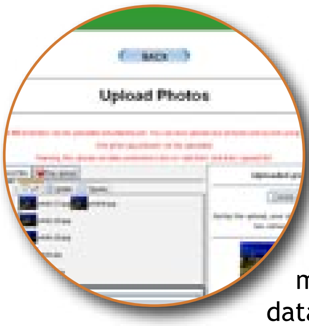

by Yann Théo[1], Marie-Line Nottin[1] and Rémy Bossu[1]

After an earthquake, pictures of the event can be viewed quite easily on the web. But once the event gets old, pictures disappear and can no longer be viewed, a heavy loss for researchers looking for information. **SHERPA**, **Sharing of Earthquake Rupture Pictures Archive**, a web application developed by Yann THEO (theo@emsc-csem.org), aims to fill this void. By making available pictures of past earthquakes and sharing resources, it will act as a reference database for scientists. You can either upload your pictures or browse through the database.

Show what you've got!

Our application is targeted at scientists and scientists only. By uploading your pictures on SHERPA, you will get an audience you could never have gotten before, except if you had the time and means to maintain a personal website (linked to the EMSC website, the application will benefit from its traffic: half a million visits from 150 countries per month). We take care of the support for you, and your pictures - the result of your work and travels - will be on display on the web for your fellow colleagues to see. Sharing your pictures will provide you with an international exposure and a potential wordlwide recognition. Scary? Don't be afraid - while online, your pictures will be perfectly protected.

Remain in Control

To **protect the authors copyright** and avoid an unfair use of the photos, all pictures will be marked by a watermark "NOT FOR PUBLICATION" spread all over, and state the author's name. Authors and authors only have the possibility to remove this mark should they want their work to enter the public domain. If a user sees a picture he/she would like to use (as an illutration for an article for example), he/she can put this picture in his/her cart. After the validation of this cart, a request (stating the name and purposes of the requestor) will be sent to the author(s) to ask to share the picture(s). If an author accepts this request, the requestor will be given the authorization to access a protected folder and download the «unprotected» version of the picture(s) (original size, without watermark). Authors may or may not accept this request, meaning that they will always have a complete control about who will use their picture and for what purposes. Without the author explicit consent, no picture will never be accessible to anyone. We want to state this point very clearly because **ownership and copyright protection are essential to the SHERPA project**.

Pressure ridge along an active fault near the village of Pretagot (West Bengal, India). Picture courtesy of Mr Bollinger.

Browse A Woldwide Picture Library

Uploading pictures is quick and easy: once registered, you can very simply upload pictures that can then be geolocalised using a Google map plugged on the web site. The software is able to read the pictures exif file (a file contained in the picture header) and retrieve location data to auto-localise pictures taken with a gps camera. SHERPA users can then link their pictures with a past earthquake and choose specifications/key words (TAGS) to associate with their pictures. This way, their pictures are identified and searchable in the database. Using these tags, you can alternatively search the database for pictures of a same phenomenon in several events. Comparative data will then be accessible online. The search engine is simple and easy to use: users can search pictures by date, tags, author or location. The pictures selected can be viewed on a map and on a carousel.

We hope you will find SHERPA easy to use and enjoy the possibilities it offers to our scientific community.

Register here:

http://sherpa.emsc-csem.org/

1) EMSC/CSEM