Centre Sismologique Euro-Méditerranéen
European-Mediterranean Seismological Centre

Newsletter

N° 17 SEPTEMBER 2001

EDITORIAL

During the summer, both EMSC and ORFEUS have held meetings to explore how their overlapping seismological communities might be better served in the years to come. Improvements in the speed, accuracy and content of earthquake alerts and the more complete acquisition and safeguarding (for posterity) of the increasing volumes of waveform data, are at the head of the agenda. Outline forward-looking strategy documents will be produced, widely circulated for comment, and then discussed with ESF and EC representatives to engage the broader scientific community. The case for significant infrastructure support for seismology in the EU is growing and the relevance, following recent earthquakes, is clear to all.

For several years, the European-Mediterranean seismological community has been in need of a homogeneous bulletin for the region. After experimenting with different software to produce automatically this bulletin, the LDG and EMSC have developed the Fusion software. The project behind the production of a European-Mediterranean bulletin in now being funded by the European Commission under the programme 'Support to Research Infrastructure'. Bulletins should be made available to the community within a year.

The theme of ensuring rapid, and relevant data capture is picked up in this Newsletter by Musson, Cecič̃ and Mayer-Rosa in their report on developments since the ESC resolved to explore the formation of the European field investigation team (FITESC) to be deployed after large destructive earthquakes. The macroseismic effects are of great importance but the magnitude of such events can often overwhelm the capacity of local and national seismological teams to collect them.

New ideas, developments and data for the forecasting of stress changes in earthquake preparation zones also feature here in an article by Crampin. The costs of sinking 1 to 2km boreholes and of providing shear wave sources may, to some, appear high but in relation to the value of a vulnerable city's infrastructure and economic activity, they are trivial. The prospect of knowing that stress conditions are indicating imminent danger would be of considerable benefit. The scientific challenge is to prove that this can be achieved with confidence, and the socio-politico-economic challenge will be how to react when the stress state is shown to have changed.

Chris Browitt
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Toward a Unified European- Mediterranean Seismological Bulletin

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Historical Background

The European-Mediterranean Seismological Centre has long been involved with the elaboration of a European-Mediterranean seismological bulletin. During the eighties, most seismic bulletins sent to the EMSC by seismological institutes were paper copies received by regular mail. Therefore, significant resources were devoted to retyping these data on the computer and relocating the corresponding seismic events using all available arrival times. This work allowed the monthly publication of a European seismic bulletin, and the development if a database of instrumental seismicity. For example, Figure 1 displays the seismicity for the years 1991-1992 as seen by the EMSC. Unfortunately, the EMSC had to stop this activity in 1993 for budgetary reasons.

Since then, the EMSC members, and the seismological community at large, have regularly emphasised the need for resuming the publication of a high-quality European-Mediterranean bulletin, which could serve as a reference for seismological studies. Thus, several initiatives have been undertaken in the past years toward this goal. Naturally, this new development also has to take into account the spectacular development of data exchange through the Internet.

In 1995,the EMSC organised a workshop to define the exact needs of its members in terms of data and bulletin availability. This led to the conclusion that this bulletin should:

- make optimal use of the seismic bulletins produced on a regular basis by European-Mediterranean seismological observatories ;
- be rapidly available (on a weekly and/or monthly basis) ;
- be complete down to low magnitudes (magnitude 3.5 for the whole region, and even much better for specific regions, such as Fennoscandia) ;
- be of high quality (accurate location and depth estimation) and therefore only use manually reviewed phase picks .

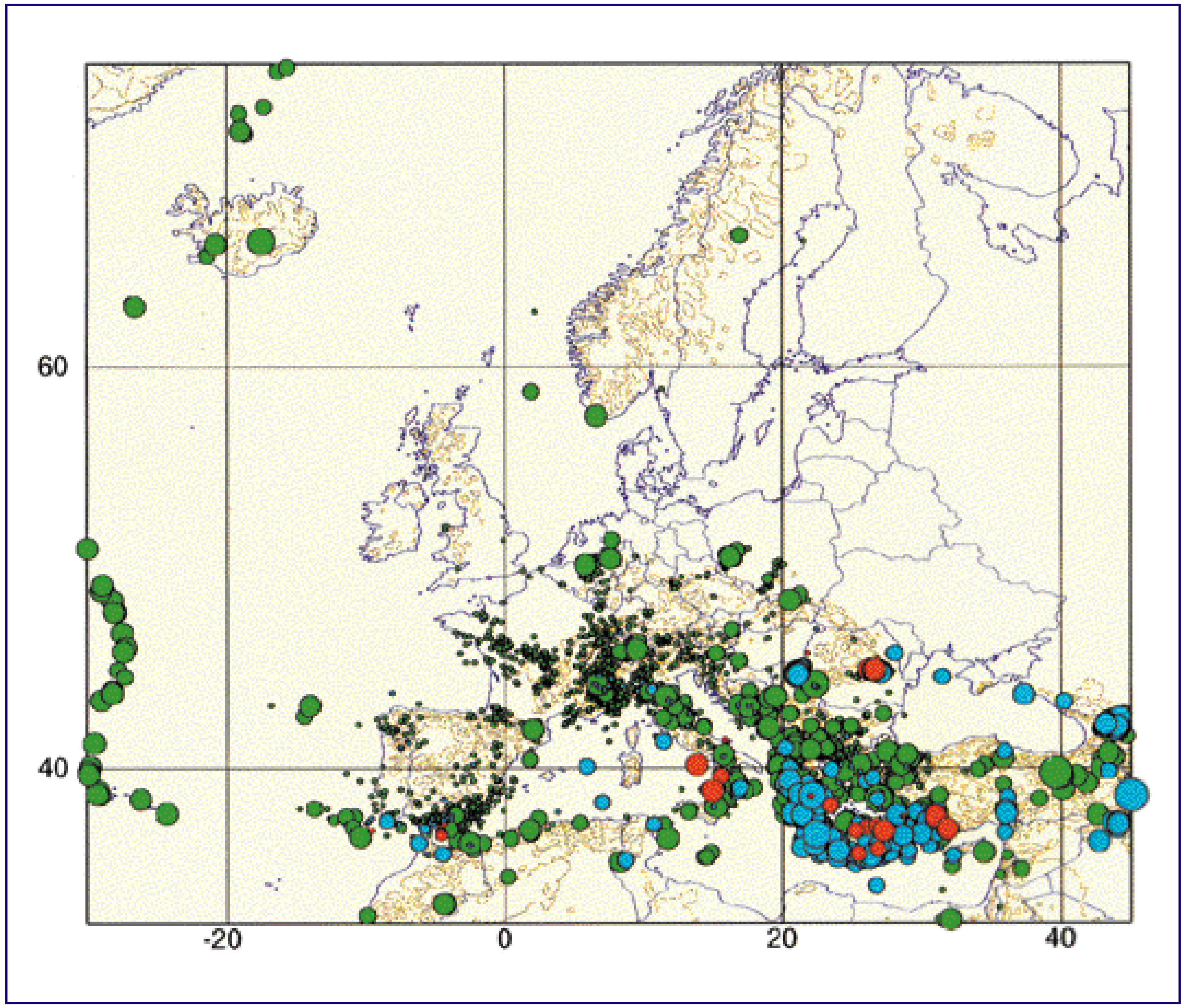

Figure 1

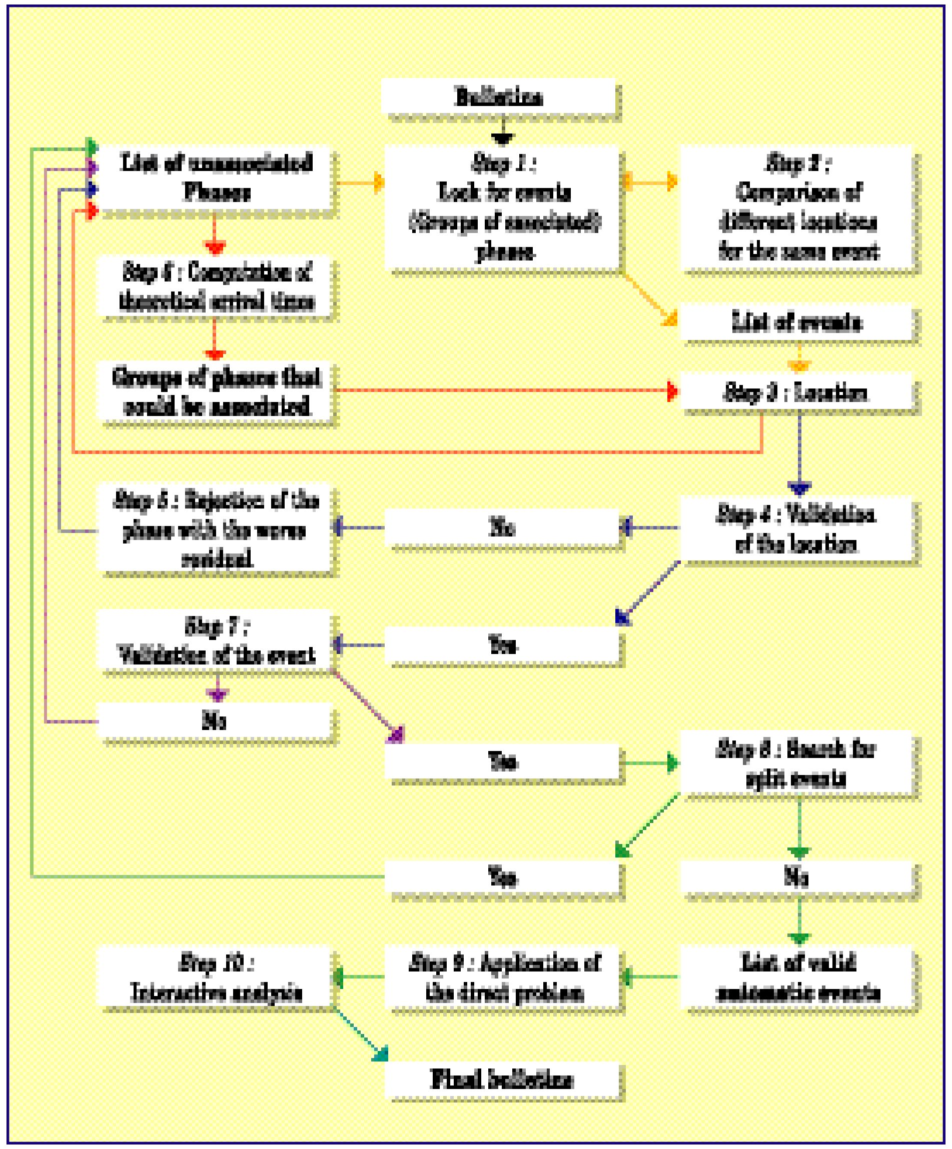

Figure 2

At the same time, in the framework of the GSETT-3 experiment, another group of European seismologists was trying to evaluate the quality of the seismic bulletin issued by the prototype International Data Center (pIDC). Their conclusion was that a European bulletin was needed in order to assess properly the pIDC product. To that end, they initiated an experiment, called EuroBull, in order to demonstrate the feasibility of automatically merging seismological bulletins from several observatories and producing a 'global' bulletin with only minor review by an analyst. The representatives of three countries (Sweden, Italy and France) developed appropriate software for automatic bulletin fusion and succeeded in producing a homogeneous bulletin for the whole year 1995, covering most of Western Europe. These three software were subsequently compared to define an optimal strategy for automatic bulletin fusion.

Recognising the similarities in the two approaches, the EMSC and the participants to the EuroBull experiment held a joint Workshop in 1996.This Workshop led to the definition of an optimal algorithm, which integrated the characteristics of the three pre-existing software. This algorithm was then developed and tested by the LDG and is described subsequently.

Fusion Algorithm

The algorithm (Figure 2) consists of ten different steps of processing which are described hereafter. Input data to the software may take three different forms, all comprised in a bulletin in GSE2.0 format from a given observatory. This bulletin may contain a list of located events with all relevant information, and related phases; several groups of phases that are correlated to the same event, but for which no location is provided; a list of individual phases not linked to any of the events listed in the bulletin. The output of the processing is a bulletin in GSE2.0 format which includes a list of events either resulting from the fusion of the same events found in different bulletins, or events that have just been relocated, and a list of individual phases that could not be associated to any event.

Building a list of initial events
(yellow loop)

- From events in the bulletins:
  In *step 1*, input bulletins are analysed in order to extract groups of phases associated to an event. In *step 2*, these events, coming from different bulletins, are compared one to the others so that multiple location solutions for a given event are recognised. The location comparison is based on the origin time and on the location.
  If several location solutions are found for a given event, the solution kept is that provided by the closest network to the epicentre. This solution is saved in a list used to initialise the process of phase association. The events corresponding to redundant solutions are split and the related phases join the pool of unassociated phases, which already includes all phases that were not associated to an event in the input bulletins.
- From groups of associated phases in the bulletins:
  Bulletins may include groups of phases that, although linked together, are not associated to an event.The Fusion process computes a location for each of these groups when possible (enough phases, convergent solution) which later serves as an event to initialise the process of phase association.
- Remaining possible phase associations:
  P phases with azimuth and slowness: with such information, the hypocentre of an event may be defined;
  Pg phases: the closest station is used as an initial hypocentre for the event;
  (P,S) couples: the distance of the event is obtained from the difference in the arrival times of both phases. A grid search is performed on the circle covering all azimuths ;
  Five P phases in the same time windows may be used to initialise a location computation;

Validating the location
(blue loop)

Using an initial event, the software computes a new location and a new origin time *(step 3)*. The result is validate in *step 4* which includes a number of tests to demonstrate an improvement in the new location with respect to the previous location, if available. The tests cover difference in location, reduced RMS, reduced residuals, and number of defining phases. When the location is not validated, the phase presenting the worse residual is rejected *(step 5)* and the process phase association – location iterates. If the location is validated, and all possible phases have been associated, the event enters the process of event validation *(step 7)*

Associating phases (red loop)

Based on a location, the software scans the list of unassociated phases to retrieve relevant phases in a time window based on theoretical arrival times computed using the newly computed origin time and the IASPEI travel time tables *(step 6)*. The phases are associated one by one to the event. For each association, a new location is computed *(step 3)* and validated *(step 4)*. Constraints are applied when associating phases such as the largest allowed distance between the hypocentre and the station, or the maximum distance between two stations with contributing phases.

Validating the event (magenta loop)

In order to validate an event *(step 7)*, one of the following conditions must be filled: the initial location originated from a input bulletin; the number of defining phases is above a minimum number; the magnitude is above a minimum threshold. If these conditions are not met, additional tests are applied such as a limit on the azimuthal gap, a maximum value for the RMS, a coherency among the magnitudes computed at each station, and for the spatial distribution of the recording stations.

Building the automatic list of events (green loop)

Once an event has been validated, it is compared to the already processed events in order to ensure that it is not part of a split event *(step 8)*. The comparison is performed as in *step 2*. If another event shows the same origin time and location, the best solution is kept, and the phases of the other event are associated to the event showing the best solution which enters the process of phase association – location.

If no split events are found, the next step consists of applying the direct problem *(step 9)*. Remaining phases that could potentially belong to an event based on their theoretical arrival times are associated to that event but they do not contribute to the location process. This could also be applied to arrivals from global bulletins which were not used as input to the process.

Producing a final bulletin (blue loop)

Finally, each event of the automatic list is reviewed manually. During this interactive analysis, the results may be modified, phases may be removed or added, and the event relocated. The results are stored in a database that can be accessed through requests to an autoDRM. Results, which include all contributing events and the Fusion location, are provided in GSE2.0 format.

Applications of the Fusion software

The fusion software may be used for two different goals. The first goal is to relocate, applying a large number of parameters to constrain the programme, event origins from different laboratories. This utilisation is useful for producing an automatic bulletin which should report as objectively as possible the seismic activity around the world. The second goal is research-oriented and derives from the computation of locations for mixed event origins, and allows to analyse the propagation and static residuals at each contributing station, leading to a tomographic survey of the velocity at regional distances.

The automatic bulletin of the French NDC

In the heart of the French NDC resides a database, which collects real-time information from a wide range of sources. The database is connected to a process, which automatically loads, organises and produces a real-time seismic bulletin. The objective is to provide the analysts at the French NDC with the best synopsis of the seismic activity, and this on a daily basis.

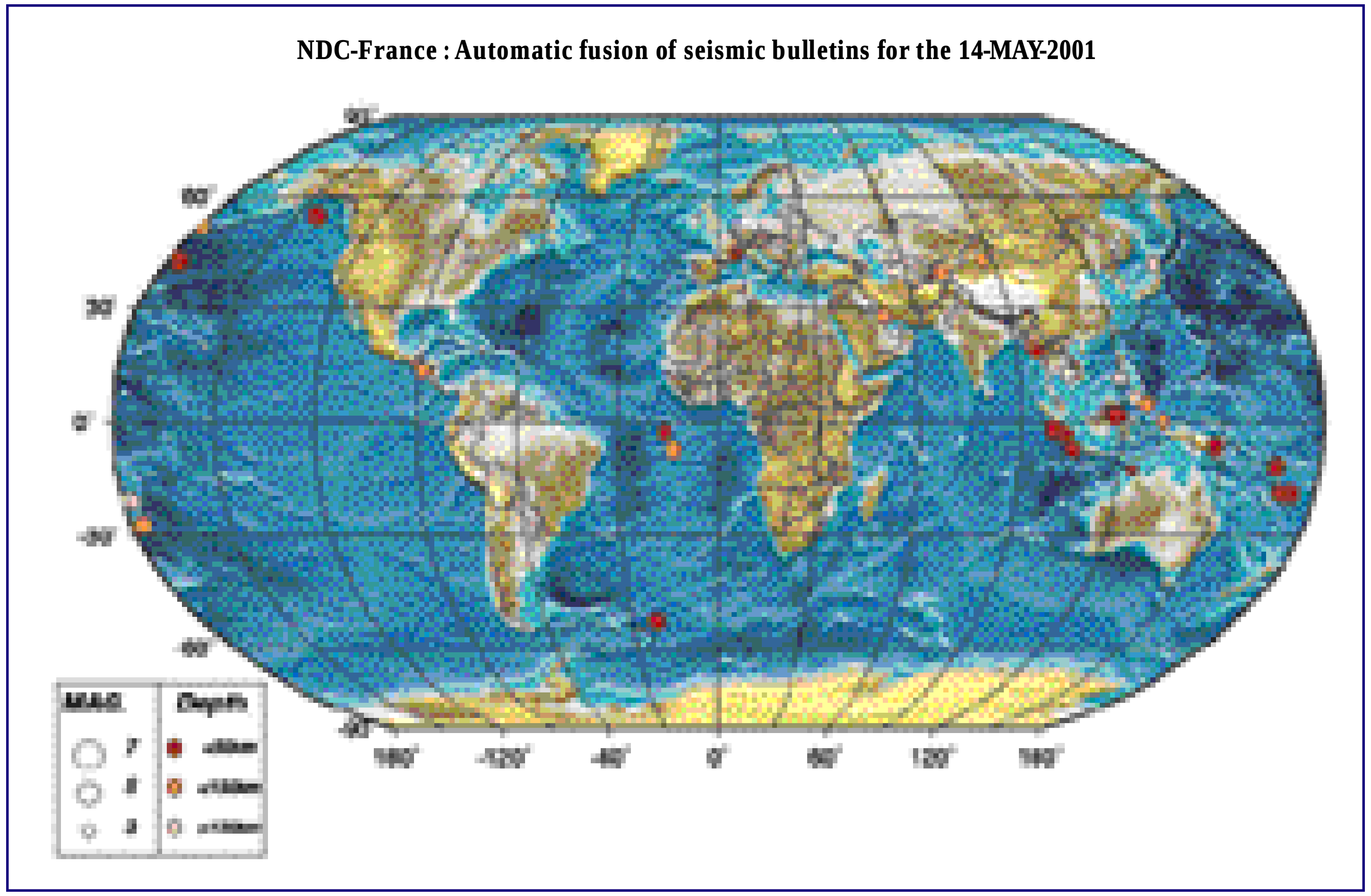

Figure 3

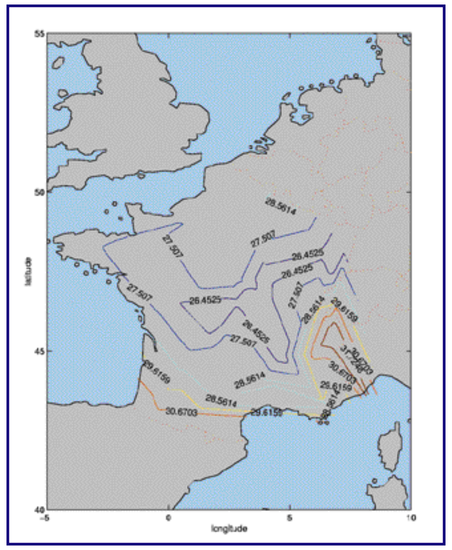

Figure 4

The sources of information consist of automatic locations obtained through requests to the AutoDRMs of several laboratories. The map in Figure 3 is an example of a daily bulletin mixing event origins from several sources. These locations result from the merging of locations from the automatic bulletin SEL1 of the IDC, the EMSC real-time messages, and the LDG automatic location. From 117 origins only 36 met the criteria of a minimum number of four defining phases to be valid. Among these events, 22 were relocated and 8 resulted from the fusion of several origins for the same event.

Determination of station residuals

The results of the Fusion software may also be carefully analysed in order to study time residuals. In July 2000, static residuals of the Pn wave travel-times recorded by the French metropolitan network stations were studied. For this purpose, four months of bulletins stored in the EMSC database were used. The bulletins originally came from the following laboratories: Seismologisches Zentralobservatorium Grafenberg (Germany), British Geological Survey (United Kingdom), University of Bergen (Norway), Laboratoire de Détection et de Géophysique (France), Istituto Nazionale di Geofisica (Italy) and the ReNaSS (France). A bulletin merging all parametric data but the data from the French network was produced by Fusion. It included 54 mixed events defined by more than 16 phases, and showing a RMS residuals smaller than 1.5 s. After correcting all events for the static delays for each event due to the mislocation with depth, the mean value of time residuals between the picked Pn by the LDG, and the estimated arrival time for each station was interpreted as local errors on the model of the Moho depth (set to 25.9 km) produced by the LDG. Figure 4 shows the results of the first step of this analysis, with more than 30 measurements for each station, and an azimuthal coverage greater than 120°.

We know that this interpretation is distorted because we need to compute an inversion of the velocity model in 2D to ensure that the static delay is due to a local variation of the Moho depth. But after this simple calculation we can clearly see the influence of the crustal roots beneath the Alps and the Pyrenees. It seems also that a global Moho depth for France equal to 28,25km could significantly reduce the RMS of the Pn arrivals for the LDG after a fusion with other European networks.

Application of the fusion software to real-time alert data

The fusion software is used on a daily basis for merging real-time messages from networks contributing to the EMSC alert system. For each event reported by more than two networks, a new location is provided within a day. It should be pointed out that most of the real-time messages are produced automatically, and that the new location provided by Fusion is also the result of an automatic process. Therefore, the resulting locations must be used with care for information and not directly for scientific purposes. The results may be found on the following page of the EMSC Web site : http://www.emsc-csem.org ***(select Alert Data / Mixed Data)***

The European-Mediterranean bulletin

On the other hand, the software will be applied to produce a reference bulletin that will gather the manual phase pickings and locations of earthquakes provided by seismological institutes in the European-Mediterranean region. The European Commission, over two years (EPSI project, contract ENVR1-CT2000-40006), is funding a project aiming at producing such a bulletin. By the end of the project, a preliminary version of the bulletin will be edited once a week, and a revised version will be released each month.

In this project, EMSC acts as the co-ordinator, and collaborates with 10 seismological institutes: Laboratoire de Détection et Géophysique, France; Instituto Nazionale de Geofisica, Italy; Institute of Physics of the Earth, Masaryk University, Czech Republic; Federal Institute for Geosciences and Natural Ressources, Germany; Instituto Geografico Nacional, Spain; Geophysical Institute of Israel, Israel; Swiss Seismological Service, Switzerland; National Observatory of Athens, Greece; Institute of Seismology of Helsinki, Finland; International Seismological Center, United Kingdom. More information can be found on the EMSC Web site under 'EPSI project'.

Several topics are addressed under this project. The improvement of the propagation models in poorly covered regions, such as border regions, is one of them. A dataset of calibrated events has been built in order to derive new 1-D velocity models. The first results have been obtained for French-Swiss Alps. The definition of a homogeneous magnitude scale is an important step for a reliable reference seismic bulletin. Experience shows that the differences in the magnitudes reported by several institutes for a given event may vary up to 1.5 magnitude units. Three magnitude computational methods are currently being tested in order to define the most suitable to the need of a large-scale bulletin. Another part of this project consists in developing tools for a complete interactive review of the automatic bulletin, such as the geophysical coherency and the validity of the location results. A final bulletin will be issued after this interactive validation process.

So far, about 10 institutes in Europe provide the EMSC with seismological bulletins including event locations, and about 30 institutes send arrival lists only. Preliminary studies showed that local events could be re-located by using data from one single network without altering the quality of location. However, events located with data from several networks showed a significant decrease in the size of the error ellipses, and the azimutal coverage was improved. Furthermore, a few events could be created and located through the combination of individual phase arrivals from different institutes, especially events in eastern European countries and Turkey. An example of bulletin fusion is provided in Figure 5 showing the merging of bulletins for the first three months of 2000. More than 1000 events resulted from this relocation process.

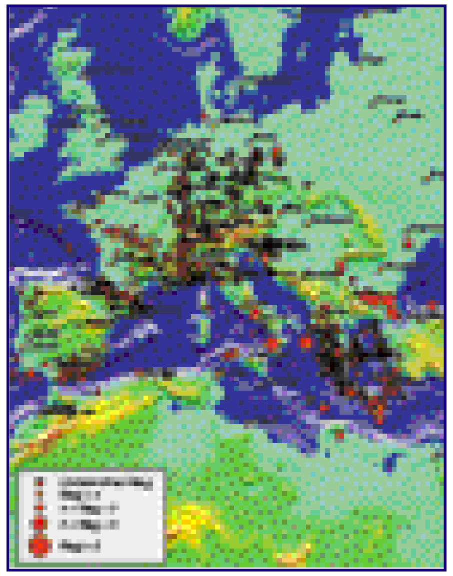

Figure 5

EC Project: EVR1-1999-40002
SMSITES :
Developing Stress-Monitoring Sites and infrastructure for forecasting earthquakes

<http://www.smsites.org>

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Summary

Monitoring the splitting of seismic shear-waves allows the times and magnitudes (and sometimes the locations) of larger earthquakes to be stress-forecast. Such forecasting using small earthquakes as the source of shear-waves requires a nearly continuous swarm of small earthquakes. Such persistent swarms are very uncommon. Consequently, to forecast earthquakes routinely near earthquake-vulnerable cities, for example, requires a controlled-source Stress-Monitoring Site (SMS). The first SMS is being developed near Húsavík in Northern Iceland in the European Commission funded SMSITES Project. This note describes the background, the SMSITES monitoring in Iceland, and the future potential of SMSs.

Background

Shear-wave splitting (seismic birefringence) is seen in almost all rocks in the crust as a result of propagation through the stress-aligned fluid-saturated grain-boundary cracks and pores pervading most rocks (Figure 1). A new understanding of low-level deformation (before fracturing occurs), reviewed by Crampin (1999), shows that the immediate effect of small changes of stress can be *directly* monitored by analysing shear-wave splitting. Both theory and observations suggest that accumulating stress increases the aspect-ratios of stress-aligned microcracks (makes them swell or become fatter) until a level of fracture-criticality is reached. At fracture-criticality, cracking is so extensive that shear-strength is lost and fracturing, faulting, and earthquakes occur. The progress of such stress-induced changes to microcrack geometry and the proximity of fracture-criticality can be monitored by analysing shear-wave splitting.

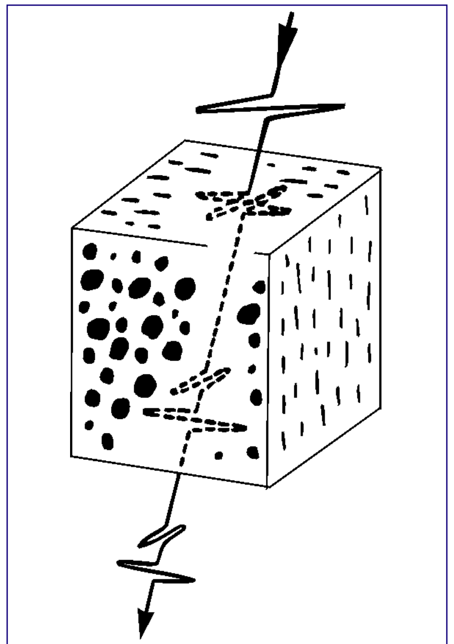

Figure 1. Schematic illustration of shear-wave splitting when shear-waves propagate through stress-aligned fluid-saturated microcracks.

Using swarms of small earthquakes as the source of shear-waves, changes in crack aspect-ratio can be monitored by shear-waves along a specific range of ray path directions within the shear-wave window. Such temporal changes have been seen (with hindsight) before four earthquakes worldwide (reviewed by Crampin, 1999), ranging from the 1986 M_S=6 North Palm Springs earthquake in California to a 1992 M_L=3.7 earthquake in Hainan Island, China. The reason for the small number of observations is the scarcity of persistent swarms of earthquakes and the restrictive source-receiver-stress geometry required to monitor changes in aspect-ratio. The breakthrough came in the European Commission funded PRENLAB projects in Iceland, 1996-2000, where shear-wave splitting was monitored over the highly-seismic transform zone of the Mid-Atlantic Ridge which is onshore in SW Iceland (Volti & Crampin, 2000).

The high seismicity in SW Iceland allowed changes of shear-wave splitting before earthquakes to be monitored routinely in a two-year period (when there was minimal volcanic activity to disturb the stress-field). Before each larger earthquake, the time-delays between the split shear-waves showed crack aspect-ratios increasing until a level of fracture-criticality was reached at a normalised value of 11 - 14 ms/km. At fracture-criticality, the earthquake occurred and aspect-ratios abruptly decreased as the stress was released (Volti & Crampin, 2001). The magnitudes of these earthquakes were proportional to the duration of the stress increases, and the times of the earthquakes were when crack distributions reached fracture-criticality. At the end of the two-year period, an increase in aspect-ratios was recognised before the larger earthquake had occurred and the time and magnitude of a m_b=5 was successfully stress-forecast in a comparatively narrow time-magnitude window (Crampin et al., 1999).

The Stress-Monitoring Site in Iceland

The appropriate range of ray path directions to monitor increasing crack aspect-ratios is the double-leaf solid angle ±(15° - 45°) to the plane of the vertical cracks (Figure 2). These directions need to be monitored subsurface to avoid the severe scattering and attenuation in the uppermost 500m-1000m. The best way to do this is to use a borehole source of shear-waves, the Downhole Orbital Vibrator (DOV), in a 2km well, and record the signals on three-component receivers at the bottom of 1km wells at 300m offsets in appropriate stress-oriented azimuths (Crampin, 2001a, 2001b).

Three wells with suitable geometry, originally drilled for hot water, have been made available for a SMS at Húsavík, Iceland, courtesy of Hreinn Hjartarson of Orkuveita Húsavíkur, the municipal energy company. The wells do not have the optimum source-receiver-stress geometry in Figure 2, but they are a good approximation, and are in a potential seismic gap on the Flatey-Húsavík Fault in the Tjörnes Fracture Zone of the Mid-Atlantic Ridge, where there have been m_b=7 earthquakes in the past. A programme of measurements has begun and three monitoring surveys have been made to date. (It was necessary to suspend measurements during winter months, as Húsavík is only 55km from the Arctic Circle). Shear-waves along the particular source-receiver geometry have not previously been investigated and processing procedures are not yet optimised. At the time of writing (16th July, 2001) three measuring surveys have been recorded (September and November, 2000, and April, 2001), during which the equipment and techniques were set up. Currently, we have observed horizontal shear-wave velocities at 500m-depth to an

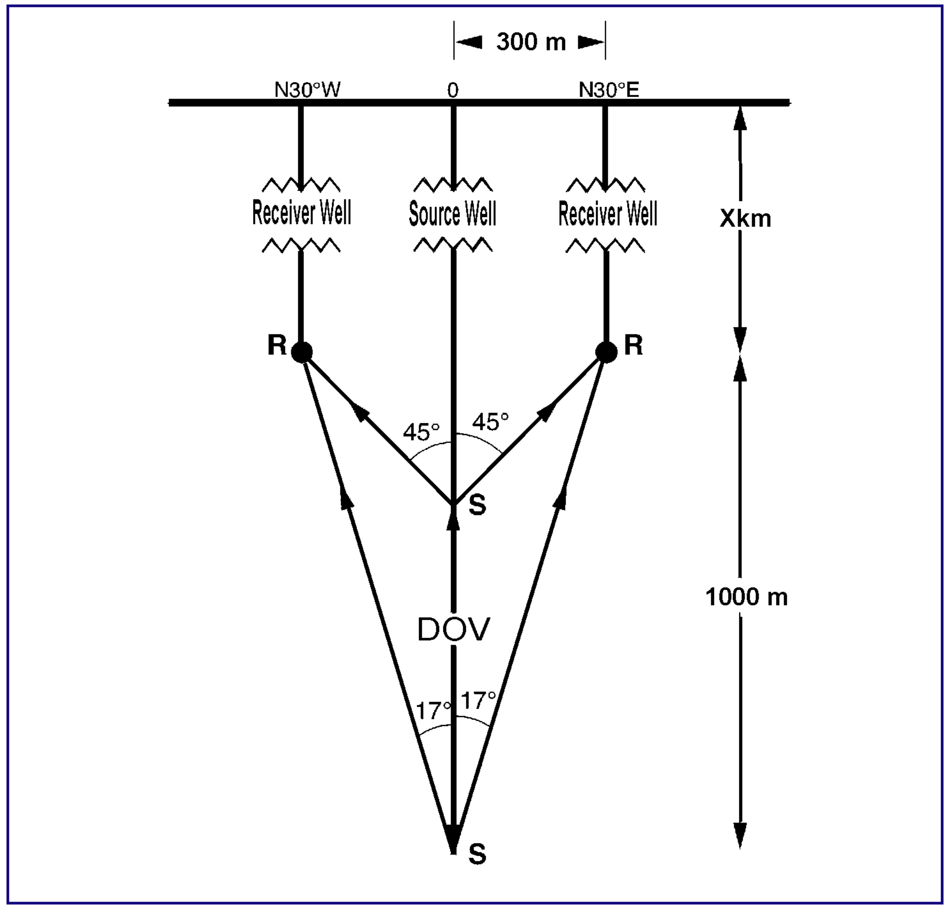

Figure 2. Specifications for a stress-monitoring site (SMS),where Xm is a depth below which the minimum compressional stress is horizontal so that cracks tend to be aligned vertically. The DOV source operates from (X + 300)m- to (X + 1000)m-depth in the deeper well and receivers are at Xm-depth in (at least two) vertical wells at c300m-offset. The azimuths of the offsets should be within ±45° of the azimuthal direction of minimum horizontal stress, which for this example is taken to be North-South.*
**Protected by Patent Application No: PCT/GBOO/01137, filed 24th March,2000.*

accuracy of about 10 microseconds and preliminary observations suggest a 200 microsecond variation which may correlate with Earth Tides. This confirms that the configuration does have sufficient sensitivity to monitor the build up of stress before earthquakes, if a larger earthquake becomes impending. Additionally, observations of shear-wave polarisations immediately above small earthquakes in the fault zone show the 90º-flips in polarisation characteristic of shear-wave splitting in rocks with high pore-fluid pressures (over-pressures). This is thought to indicate the high pore pressures in the fault zone necessary to overcome frictional forces in active fault zones.

The future potential of SMSs

Such Stress-Monitoring Sites, with three 1km- to 2km-deep boreholes using the DOV to monitor shear-wave splitting, could be set up near any earthquake-vulnerable location in Europe or worldwide. The principal costs would be drilling the wells and a smaller annual cost of running the monitoring operations. Although there is not yet enough experience of interpreting SMSs to be able to *guarantee* the accuracy of stress-forecast times and magnitudes of large earthquakes, it is certain that a large earthquake (M_S≥5, say) could not occur within 50km, say, of a SMS without the rock mass showing anomalies in shear-wave splitting time-delays. Thus the development of a SMS near a vulnerable city would, at the very least, remove some of the uncertainty of earthquake hazards, and a large earthquake could not occur without giving due warning.

Since the more SMS there are, the faster this experience will be acquired, further SMS need to be developed. We would like to develop SMSs in different geological and tectonic environments, in order to better understand low-level deformation in different rock types. We invite anyone interested in developing a SMS in their region to contact us at:
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<http://www.smsites.org>.

References

Crampin, S.,1999. Calculable fluid-rock interactions, *J. Geol.Soc.*, **156**, 501-514.

Crampin, S., 2001a. Stress-monitoring sites (SMSs) for stress-forecasting the times and magnitudes of future earthquakes, *Tectonophysics*, in press.

Crampin, S.,2001b. Stress-forecasting earthquakes in a critical crust, Computational *Seismology*, Issue marking V. I. Keilis-Borok's 80th birthday, in press.

Crampin, S., Volti, T. & Stefánsson,R., 1999. A successfully stress-forecast earthquake, Geophys. J. Int., **138**, F1-F5.

Volti, T. & Crampin, S.,2001.A study of shear-wave splitting in Iceland: a summary of four years monitoring stress changes before earthquakes and volcanic eruptions *Bull.Seism. Soc. Am.*, submitted.

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Towards A Macroseismic Survey Team for Severe Earthquakes in Europe and the Mediterranean Basin

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Introduction

Looking back on the development of seismological practice in the last thirty years, it is clear that much attention has been given to the improvement of instrumental recording networks in order to capture the best data on earthquakes when they occur. However, there has not been a corresponding improvement in efforts to collect non-instrumental data. While instrumental data are important in building up an understanding of earthquake source processes, these are not the only subjects of concern to the seismologist. Data on the felt effects of earthquakes (macroseismic data) indicate how damage occurs as a function of magnitude, distance and other factors, and these data are important if one is to be able to estimate the risk from future earthquakes. Increased interest in seismic hazard and risk in recent decades has greatly increased the importance of macroseismic data.

However, strong seismic events in Turkey and Greece in 1999, as well as numerous examples from the past, have shown that the seismological community in Europe lacks any mechanism for the fast organisation of macroseismic data collection in the case of damaging earthquakes in European territory. These data must be collected quickly, in the immediate aftermath of the earthquake, before the cleaning and reconstruction process has started. Otherwise the data get lost and cannot be reconstructed.

There now exists a proposal for the establishment of a framework, under the aegis of the European Community and European Seismological Commission (ESC), for sending survey teams to the area affected by strong earthquakes in Europe and adjacent areas, to ensure that in future these important data are recorded and made available to the wider community. Such a framework would involve the creation of a field team for macroseismic surveys in Europe.

Existing practice, existing problems

At the moment, the procedures for recording and disseminating important data on earthquake intensity distributions from damaging earthquakes in Europe are either incomplete or missing.

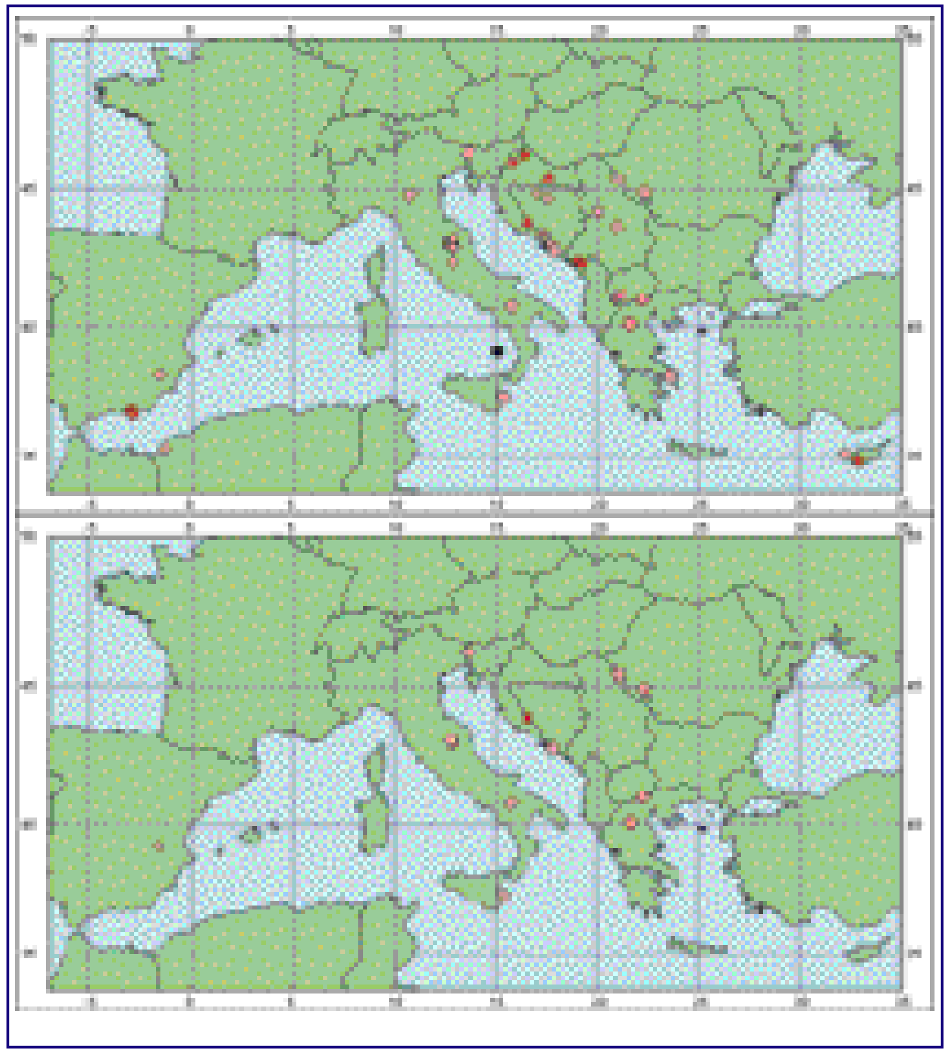

Figure 1
At present, finding information about earthquake intensity in Europe is rather difficult. These two maps purport to show earthquakes in the European Mediterranean area during the 1990s with intensity greater than or equal to 7,according to (above) the USGS PDE database or (below) the NOAA Significant earthquake database. Note the absence of Izmit, Duzce and Aeghio events (among others) from both maps! (Note: symbol size reflects magnitude;darker coloured events are deeper.)

The collection of macroseismic data is routinely the task of the national institute which is charged with seismological monitoring in the country in which the earthquake occurs. Such an institute will usually have procedures in place for making macroseismic surveys of relatively small earthquakes that cause little damage, and which can be surveyed remotely by the use of questionnaires. However, a severe earthquake requires extensive and immediate field investigation to record damage patterns, and experience has shown often that, after such an earthquake, the local seismologists have too many things to do, and are not able to devote resources to activities which require significant amounts of skilled personnel for several days. This is especially true if the event happens in a relatively small country with moderate seismicity and a low number of skilled staff.

Figure 2
A macroseismic field team in action during the Umbria-Marche sequence of 1997. Those shown include Fina Barbano, Gianni Morelli, Ilaria Lesciutta,Raffaele Azzaro, Romano Camassi, Carlo Meletti, Matjaz Godec and Polona Zupancic, at (clockwise from top left) Annifo, Isola, Colli di Verchiano and Aggi. Photos taken between 3 and 8 October 1997 by Ina Ceci?.

Typically, soon or immediately after an earthquake, two types of outside assistance will arrive. The first (in the case of earthquakes with severe loss of life) is the search and rescue teams, whose work is extremely important for humanitarian reasons, but is not concerned with data-gathering. The second consists of engineering missions to examine failed buildings, largely with a view to learning engineering lessons about which buildings failed and why. Such teams are particularly interested in extreme damage and special structures: during the 1997 sequence in Central Italy, the Basilica of Assisi drew far more attention than the damage distribution in numerous small villages in the Apennines, although in terms of estimating seismic risk the latter are actually more important. In other words, engineering-based field survey teams do not necessarily gather the data that are of most use to seismology, and are not a substitute for seismological surveys of the affected area. The seismologist is concerned with the overall damage distribution, including the borderline between slight damage and no damage, and the spatial patterns of variation in intensity caused by local factors (soil, relief, etc). In addition to improving understanding of intensity attenuation, this is also extremely important for calibrating and making useful the large heritage left to us by centuries of historical earthquakes in Europe; both aspects are important in the study of earthquake risk.

A further problem is that even with respect to engineering field teams, these are all at present organised as private or national initiatives, with no responsibility to the international or European community. Typically, independent teams will arrive from Germany, France, Italy, the UK, USA and Japan, each with their own agenda, and at liberty to share or conceal their findings. Since some are organised by private companies it is certainly the case that many data do not reach the public domain at all.

How to improve the present situation

The situation can only be improved by the establishment of a permanent framework for surveying the effects of severe European earthquakes. This would be administered by the ESC, on behalf of the EC, to ensure that the interests of the wider community are served by the preservation and promulgation of the data sets recording the effects of such earthquakes. This framework would incorporate a field investigation team formed of seismologists with experience in collecting and evaluating macroseismic data, who would travel to the affected area as soon as possible after the earthquake and there organise the survey in order to collect high-quality intensity data. The team would be organised within the ESC and report to the EC. The name Field Investigation Team of the European Seismological Commission (FITESC) has been proposed. The formation of such a team was endorsed by a resolution passed at the XXVII General Assembly of the ESC at Lisbon in September 2000, and a provisional committee was appointed to investigate the practical aspects.

The following groups of beneficiaries of the FITESC proposal are envisaged:

Local seismologists: The national institute of the affected country would immediately receive the assistance of trained personnel, which would be highly advantageous in a crisis. There would also be a valuable training aspect involved.

The seismological community in general: The fact that a large quantity of important data would not be lost, but would be collected, interpreted and made available to the scientific community, would be of long-term benefit to many projects, especially those relating to earthquake hazard and risk. One would also see improvements in the calibration of historical earthquakes.

The insurance and reinsurance communities: Improved understanding of the relationships between earthquake size, depth, distance, geology and building type would be of benefit in estimating future earthquake loss levels and setting premiums. The fact that such data would be generally available and not hidden in private archives would particularly benefit smaller companies.

The planning sector: Improved understanding of the relationships between earthquake size, depth, distance, geology and building type would be also be of benefit in the context of preparing civil defence and contingency plans for future earthquakes that might be expected.

All the data gathered would be made available in the shortest possible time; not just the evaluations but all the raw data. They would be placed in the first instance on the Internet, through either or both of the European-Mediterranean Seismological Centre and the Working Group on Macroseismology of the ESC.

Financial considerations

It is considered that the operations envisaged would not be costly, because damaging earthquakes in Europe and its adjacent regions do not happen very often, and the group of the experts sent to any region would not be large. Expenditure would be a function of the occurrence of such earthquakes, and some years no trips would be needed at all. Probably the long-term average would be about one mission per year.

Because such projects are not costly, the matter of financing such a task force ought not to be a serious obstacle. Preliminary financial estimates have been made based on the experience of eight seismologists working in this field. A survey trip consisting of ten people, travelling mostly by air to the "host" country, for ten days, would incur costs for food, accommodation, phones, car hire, petrol, etc, of about 15,400 Euro. The exact cost for any one mission would be variable depending on the circumstances, but this figure gives a rough guide. Because of the long-term strategic nature of this proposal, it is not appropriate to seek financial support through existing short-term project-based initiatives such as the EC DG XII Fifth Framework. The proposed Field Team would operate in a similar way to the EC Committee for the Evaluation of Earthquake Predictions, which has long-term access to modest funds on an «as needed» basis. Appropriate sources of funding are currently under discussion.

Potential Organisation of FITESC

These ground rules for the operation of the team would be established and administered under the framework of the ESC, in particular Subcommission F (Engineering Seismology). This includes the appointment of organising officers, the survey methods, and relations to other groups.

A small group of two to three people would be "on duty" at any time, having the possibility of communicating with each other, and all the experts that are available at the time, by phone or email. The role of these "co-ordinating officers" would be:

a. immediately after a severe earthquake to contact the seismologists of the country where the event happened; in the first contact assessing the situation and making the first decision whether it is necessary to launch a mission or not. A list of responsibles, and their data (phone numbers, portable phones, fax numbers, emails etc.) for each country that would participate in FITESC activity is necessary, and would be established in advance. It goes without saying that no mission would ever be planned without the agreement and co-operation of the host country.
b. to contact the team members in order to see how many of them could go to the area and how quickly.
c. to stay in close contact both with the "host" country experts, as well as with the members of the team.
d. to prepare identification cards and documents for the members of the team.

One of the coordinating officers would always stay at home, operating from base in order to arrange any help the team in the field might need, as well as to monitor the situation and eventually decide on changes and/or additional teams. Details of the survey will depend on the size of the earthquake, length of the aftershock sequence, number of available people, etc. Long earthquake sequences with many aftershocks (e.g. Central Italy, 1997) pose particular problems, as was discovered in what could be considered a prototype field mission organised after the 1997 Umbria-Marche earthquakes (some photographs from this mission accompany this article). The group of experts has to be large and flexible enough in order to be able to cover all eventualities. The teams in different missions would collect data according to a common methodology, and such things as common assessment forms would be prepared in advance for general use.

After strong earthquakes many facilities or logistics are often missing: accommodation, transport and communications for instance; even food and water can be in short supply. For accommodation, it is envisaged that the team would set up a base camp in some locality that is far enough from the epicentral area and thus not damaged or in danger from damaging aftershocks; however, it then includes long trips every day to the area of damage, which can be difficult, especially in winter, due to short days and bad weather. The problem of transport can be solved if the teams come with their own vehicles, otherwise there should be a possibility of renting these conveniently close to the area of work, at airports or large cities. The vehicles owned by the local institution(s) are in most cases already in use for other tasks. When travelling by car, the problem of supplies (food, water, etc.) is lessened. There is also very often a problem of language barriers; ideally the local institution would be able to provide some help; e.g. students of geology or civil engineering could be good local guides and interpreters. These are some of the practical issues that have to be considered in advance.

Ideally the mission teams should include an engineer and geologist as well as seismologists. The participation of young scientists in such teams would also be encouraged, and the missions would contribute towards training goals.

Relations with the host institute are important; missions organised by FITESC would always be co-operative in nature rather than competitive. It is understood that agreements in principle would be established with the different European countries well in advance of an earthquake actually occurring.

The Way Ahead

In conclusion, we consider that the establishment of a European seismological field investigation team, operated by the ESC on behalf of the EC, with the co-operation of EMSC, would have important strategic benefits which would be, in the long term, economic as well as scientific. The operation of the field investigation team would not be expensive, but would need special long-term financial support outside of existing project initiatives. Such sources of funding are being investigated, but equally it is important to consider at the outset the questions about the organisation and personnel, and how the best procedures will be adopted.

The authors are therefore particularly interested to gather opinions from the readers of this newsletter; all ideas and expressions of interest, either from individuals or organisations, would be very welcome.

The ORFEUS page

EUROPEAN SCALE REAL-TIME WAVEFORM DATA EXCHANGE

Torild van Eck,Bernard Dost
and Winfried Hanka

Introduction.

Real-time waveform data exchange has become an economical and realistic option in Europe using Internet and satellite facilities. Some observatories, like NORSAR, have already a long experience, while other observatories are presently implementing this on a national level. Real-time data exchange across borders in Europe and its surroundings, however, has generally been poor in spite of the fact that improving real-time cross border waveform data exchange could boost monitoring performance of European observatories. The economical and technical problems involved are relatively small.As a consequence, this issue is addressed by a. o. the MEREDIAN consortium (EC-project EVR1-CT-2000-40007) co-ordinated within ORFEUS (MEREDIAN, 2000).Below we present a short description of on-going real-time data exchange developments.

Real-time data exchange within MEREDIAN.

Real-time waveform data exchange in Europe has become an important element in the MEREDIAN project with ORFEUS and GEOFON as driving participants. Goals are a) to improve and replace the Spyder® system, which will be phased out in the coming years, b) to provide European observatories and researchers with relevant cross-border data when necessary and c) to enable rapid location and quantification of medium-to-large size earthquakes in Europe and its surroundings. With these goals in mind Orfeus Data Center (ODC) invested in the Antelope® software package that can receive and organise the real-time data stream (Trabant, 2001), while GEOFON develops further the robust real-time data exchange protocol SeedLink and data handling software package SeisComP (Hanka et al., 2000). Details can be found on the MEREDIAN webpages.

Real-time data gathering at the ODC.

Presently real-time data gathering at the ODC concentrates on implementing the Antelope® software package (Trabant,2000).This involves implementing Antelope® ORB-to-ORB connections (with a. o. the Austrian and Slovenian Seismological network) and installing appropriate plug-ins to connect networks and stations offering real-time data (a. o. GEOFON, MEDNET, NORSAR, etc.).The leading principle for the ODC is to be open for all types of data exchange protocols that networks may offer, provided the implementation is efficient. The on-going real-time data exchange developments are actual, not only in Europe, but also in the US. Therefore, our MEREDIAN developments are co-ordinated with IRIS-DMC as well. The minutes of a recent European-US data centre co-ordination meeting can be found on the MEREDIAN web pages.

Data logging software with a real-time waveform data exchange protocol.

GEOFON has assembled a software package called SeisComP, which provides data recording capabilities for arbitrary commercial and non-commercial digitizers and data loggers as well as real-time and dial-up communication for network data collection and data centre services. SeisComP works on Linux PCs and Sun computers. The basic data recording package is presently still based on the ComServ software, originally developed by Quanterra Inc and UC Berkeley for Quanterra data loggers. The communication protocol is SeedLink, a robust protocol that can essentially be used on all kinds of transmission links (Heinloo, 2001). Within MEREDIAN the SeisComP package will be further developed and SeedLink will be stimulated as a data transfer protocol, also among the MEREDIAN data centres. The software, presently already operating in the GEOFON, GRSN and several other networks, is available under the GNU license. More information can be found on the MEREDIAN web pages and under http://www.gfz-potsdam.de/geofon/seiscomp.

Real-time data exchange beyond MEREDIAN.

The developments, described above, are not restricted to MEREDIAN consortium members only. Other interested parties are encouraged to participate as well. Both the SeisComP developments and the SeedLink protocol offer attractive options for networks with limited funds. Therefore, if you are interested in the on-going real-time data exchange developments, please, contact the relevant persons within MEREDIAN.

References.

- Hanka, W.,A.Heinloo and K.-W. Jaeckel,2000. Networked seismographs:GEOFON Real-time Data Distribution.ORFEUS Electronic Newsletter, 2,24.
- MEREDIAN, 2000. Web site: http://orfeus.knmi.nl/meredian
- Heinloo, A.,2001.SeedLink:the Missing Link for Real-Time Earthquake Monitoring. Master thesis, Tartu University, Estonia.
- Trabant, C.,2001. Implementing real-time data exchange at the ORFEUS Data Center. ORFEUS Electronic Newsletter, 3,6.

SHORT ORFEUS ANNOUNCEMENTS

- July 3-5 a meeting on "The future of waveform data exchange and archiving in Europe" has been held in De Bilt. ORFEUS took the initiative for this meeting with European seismologists and representatives from the ESF. A full protocol and other relevant information can be found on the ORFEUS web pages: http://orfeus.knmi.nl/meredian/strategy-meeting/information.html
- July 5-10 the Orfeus Data Center (ODC) and IRIS-DMC had a Data Center co-ordination meeting to discuss and plan recent and future developments. Minutes of this meeting can be found on the MEREDIAN web pages: http://orfeus.knmi.nl/meredian/organisation.html#meetings
- A new ORFEUS Electronic Newsletter has been issued and can be found on: http://orfeus.knmi.nl/newsletter

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Next EMSC Assembly General

The next Assembly will take place in September 2002, in Genoa, during the EGS meeting.

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