Observatories and **R**esearch **F**acilities for **EU**ropean **S**eismology
Volume 1, no 3 October 1999 Orfeus Newsletter

ORFEUS Electronic Newsletter

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Articles and News

Short notes

Announcements

Orfeus at IUGG99 (July)
Board and ExeCom changes.
Meetings.

GSE2SEED version 1.0 available.

ODC-volumes 27-37 are out.

SEED-volumes available on WILBER.

ORFEUS/KNMI in negotiations with EC on MEREDIAN project.

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Observatories and Research Facilities for EUropean Seismology
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Broadband stations in Western Corinth Gulf

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Introduction

Corinth Gulf separates the continental Greece from Peloponnese peninsula. It represents an extensional tectonic structure, belonging to the seismically most active regions of the Mediterranean. The last destructive event of M=6.2 occurred in the Gulf close to the city of Egio in June 1995. The city of Patras, hub of the western Peloponnese, was damaged by the 1993 earthquake. The key role in understanding those earthquakes, and predicting ground motions during similar future events, is played by detailed seismic observations.

Western part of the Corinth Gulf has been monitored since 80's by PATNET, the short-period telemetered seismological network of the Patras University, covering the whole western Greece. Since November 1997, three broadband stations operate in the Gulf as a long-term temporary network, jointly managed by the Charles University and Patras University. Station coordinates and data are available.

On November 18, 1997, one of the seismometers was being deployed just during strong shaking due to M=6.6 earthquake in Zakynthos region, six minutes later followed by an aftershock M=5.9 (epicentral distance of about 100 km). During the following night, hundreds of aftershocks were already recorded at two of these BB stations.

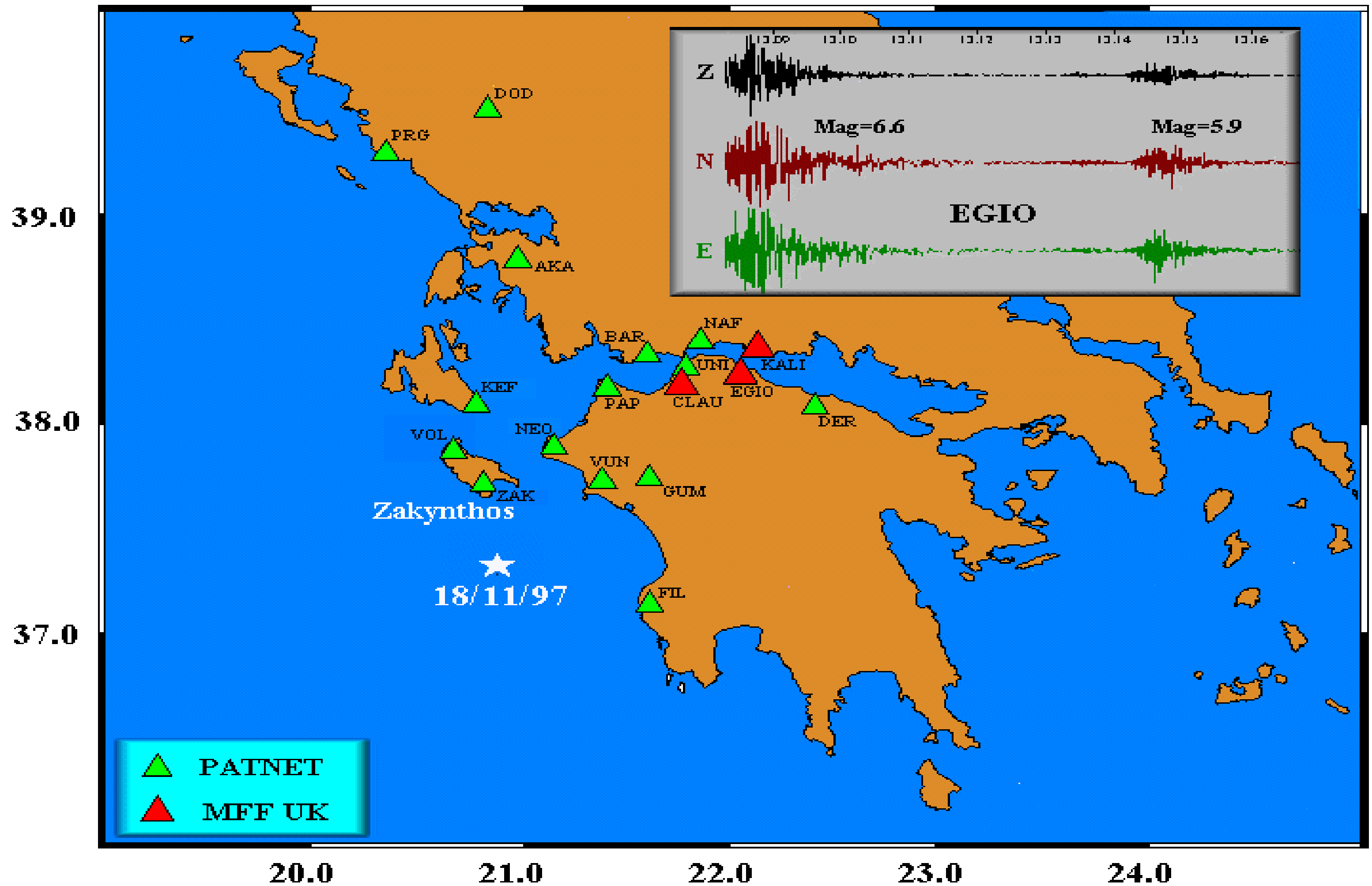

Figure 1. Broadband (red) and PATNET (green) stations, shown together with EGIO record of the Zakynthos earthquake, made during first minutes of the station 'life'.

Recording sites

Since July 1998, the recording sites have remained as follows (Fig. 1): CLAU station at Achaia Clauss, close to the city of Patras, EGIO at Kumari village, close to the city of Egio, and KALI at Sergoula village. The first two are situated on the southern coast of the Gulf. KALI is on the northern coast, accessible from Patras by the Rio-Antirio ferryboat. CLAU seismograph lies on the cemented floor of a small brick house adjacent to a church, close to famous wine yards and wine factory. EGIO seismograph is on a concrete block forming part of the basement and one wall of a masonry uninhabited farmer house. KALI instrument is on a tile-covered ground floor of an unused village school building. All the three are powered from 220V mains, and switch automatically to rechargeable 12V batteries in case of a power brake.

The northern coast exposes bedrock in many places, while the southern cost is mostly covered by sediments. KALI is on limestone, in a steeply sloping coastal mountain range, at the altitude of about 400 m above the sea level, with a magnificent view of the Gulf (thus KALI name, meaning 'good', or 'nice' in Greek). CLAU and EGIO are on the less compact sedimentary rocks, both in a hilly terrain at altitudes of about 200 m. All EGIO records show notable site effects (e.g. in Fig. 2), such as long duration, and frequency-selective amplification.

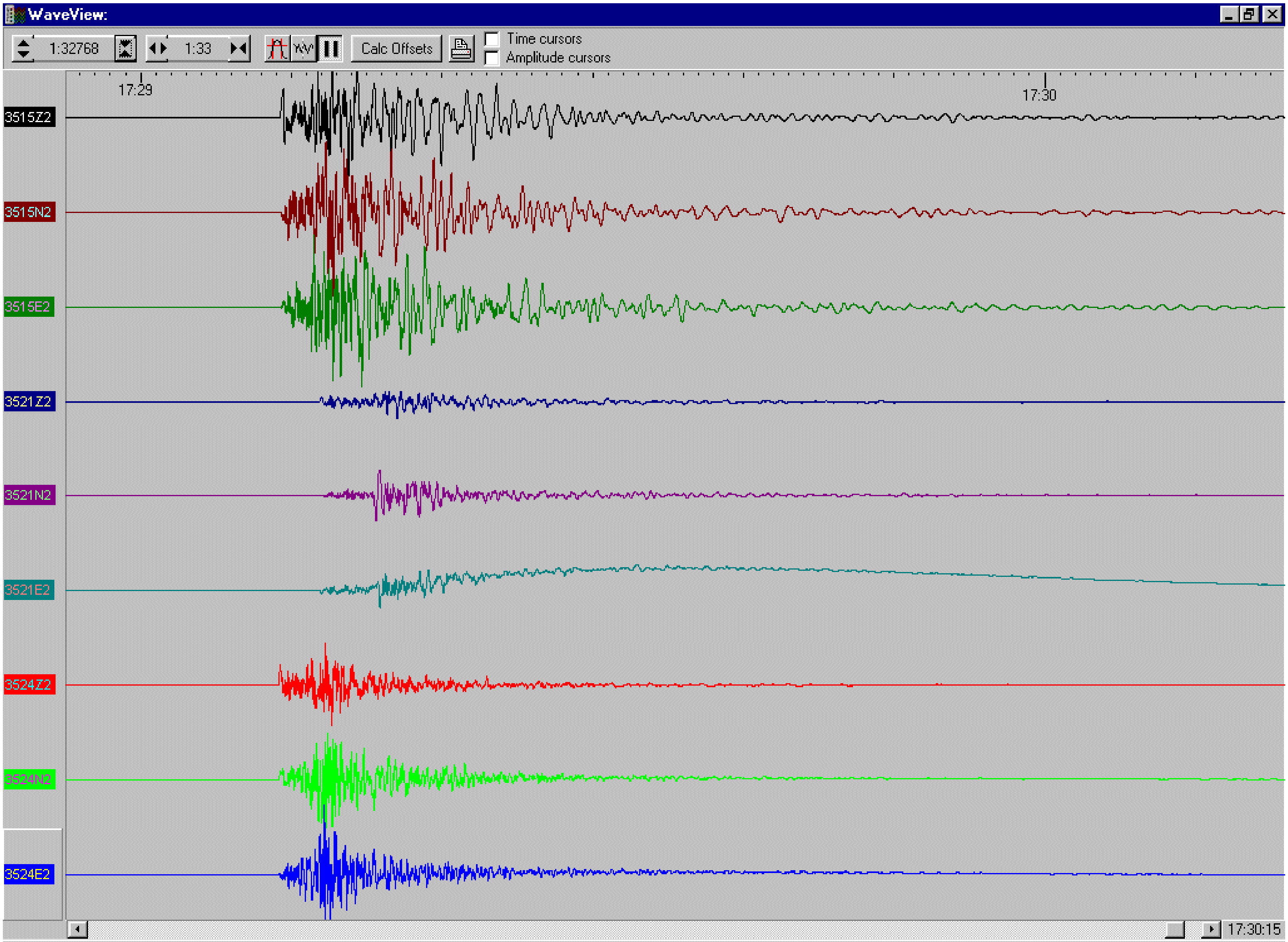

Figure 2. Example of the BB records for a local event belonging to a cluster between the KALI and EGIO station (Fig. 4). EGIO record (top three traces) strongly differs from KALI (bottom), although epicentral distance is the same. CLAU (midlle) has the weakest motion, but EW is disturbed by a 'mouse'.

Instrumentation

All three stations are completely equipped by the Guralp hardware and software. As such, they probably belong to few stations of the world where seismic products of different companies are not mixed with each other. Each station is composed of a CMG-3T three-component seismometer, DM-24 digitizer, GPS antenna, and SAM data logger with a 3.5MB RAM buffer, and 2GB SCSI hard disk. Recording is in a very efficient binary Guralp Compressed Format, GCF, sometimes also called SAM. The records clip (5,500,000 counts) at velocities around 2 millimeters per second. This happens, for example, at magnitudes above 4 from epicentral distances of a few kilometers. That is why CMG5-T strong-motion accelerographs will accompany the BB stations, starting in 1999. The minimum noise level (at KALI and EGIO) is around 500 counts; in CLAU it is usually higher because of proximity of the wine factory. Oceanic microseisms and wind are highly variable, sometimes up to 20,000 counts during stormy days.

Three velocity components (N,E,Z) are recorded, with their mutual orthogonality guaranteed by the fact that all sensors are housed in the same box, while the N-S orientation of the box is only approximately determined by compass. The continuous channels have sampling rate of 20 Hz. The triggered recording is controlled by the Z-component, band-pass filtered for the trigger algorithm between 5 and 45 Hz, and it has sampling rate of 200 Hz. Several combinations of the triggering parameters were tested, which finally settled at STA = 1 s, LTA = 50 s, STA/LTA = 6, pre-trigger time = 40 s, post-trigger time = 70 s. This gives about 100 triggers at each station per month during normal activity in the Gulf, on average. Besides the ground-motion velocity, also the mass position (N,E,Z) is continuously recorded at 4 Hz sampling. Information about the GPS performance, and SCSI disk activity is recorded as text files. As a rule, all streams together represent less than 15 MB per day. Thus a 2GB disk would fill roughly in 4 months. However, because the stations are fully unattended, they require more frequent visits. Most technical problems of the first twelve months were connected with the digitizer. These were solved by Guralp engineers on-site, and by sending one station for repair to England.

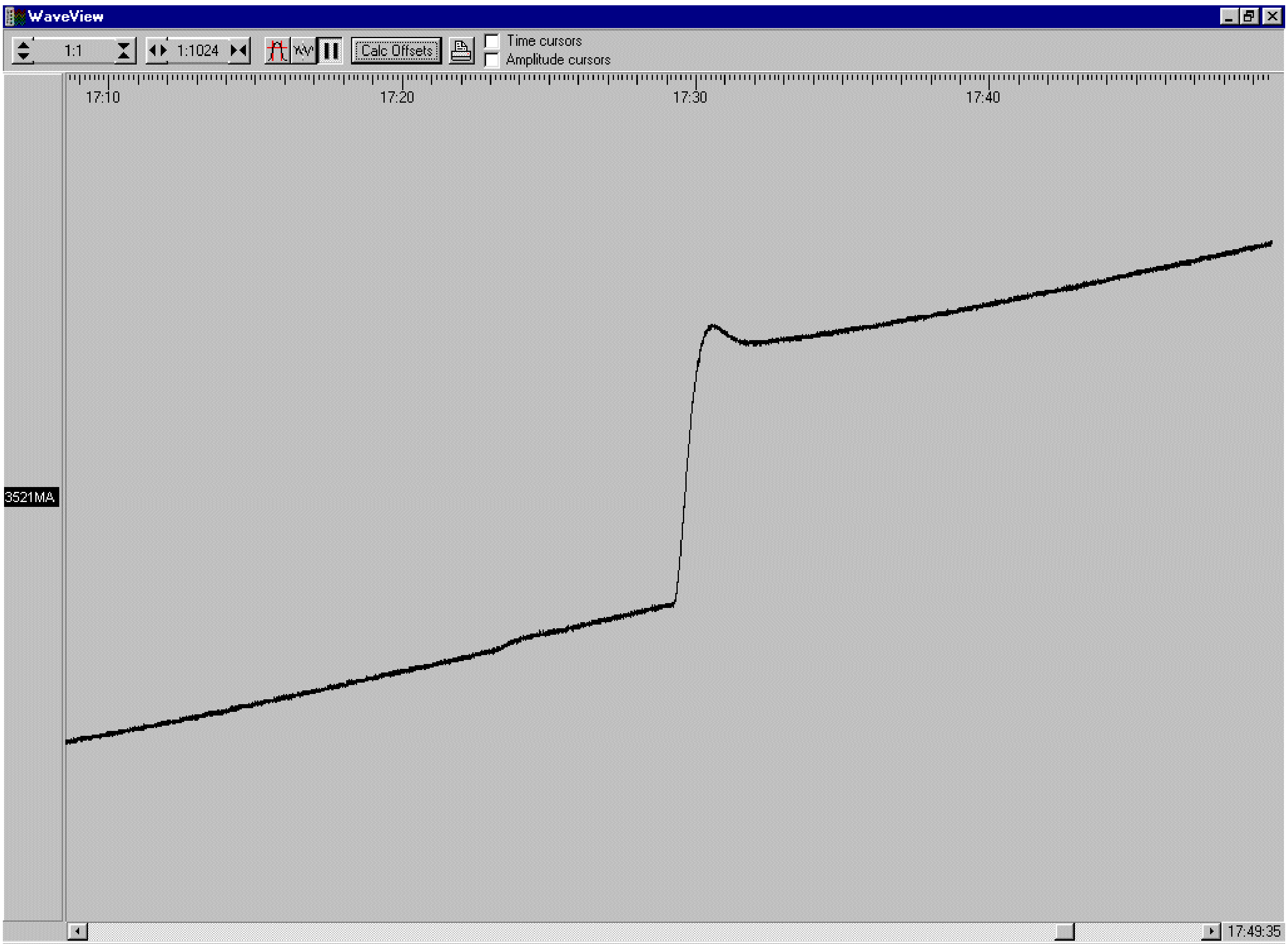

Figure 3. Step in the mass channel at CLAU station, EW component, corresponding to the 'mouse' of Fig. 2.

'Mice'

The most unpleasant remaining problem is 'mice' on the horizontal components. By 'mouse' we mean a spurious velocity wave, about 1 minute long resembling a long-period calibration impulse (Fig. 2). This is accompanied by a step motion on the corresponding mass channel (Fig. 3). The 'mice' occur during onsets of some local seismic events. At a given station 'mice' are more probable for larger ground motions (still below the clipping level). As a rule, one horizontal component at each station suffers more than the other, independently of the event location. For example, EW component at CLAU is always more vulnerable than NS. Moreover, the EW component at CLAU has a 'mouse' already at ground-motion levels at which the other stations remain undisturbed. The 'mice' are not clearly dependent on the centering state. They may occur already at a very well centered state, e.g. at less than one third of the full mass position range. Our primitive interpretation is that the force-balance system does not fully compensate the mass movement, thus it 'jumps', and system responds in a way similar to the step calibration. We think that 'mice' are a challenge for the instrumental specialists.

The 'mice' represent a strong limitation of the source inversions. In particular, the important low-frequency part of spectra ($f < 0.1$ Hz), well above the noise level for nearby local events of magnitudes around 3, are destroyed. It is to mention that, besides the visible 'mice', there is also a less obvious instability of the horizontal components on practically any onset of a local event. As a result, frequencies below 0.1 Hz would need a (non-standard) instrumental correction during data processing, in general.

Data processing

The stations are visited every 3 months. In an ideal case only centering is needed. Every visit includes the SCSI disk exchange, and its replay onto PC hard disk at the Patras University, followed by copying all streams as a whole on CD's. Within 10 days, local events recorded at all three stations with a good S/N ratio are selected in Prague, and extracted from CD's. Binary GCF data, and data converted into PC-SUDS format are exposed on an anonymous ftp server. The Patras group performs the arrival-time reading and HYPO location (including the PATNET data). This, in fact, is already a re-location, since Patras network locates significant earthquakes continuously. Next processing of the BB records of the relocated events is carried out again in Prague. This comprises both analyses of the binary data (user-friendly Guralp software Scream and GCFInfo), as well as conversions into ASCII. Current processing of the ASCII data includes the baseline correction and trend removal, filtration, rotation, spectra, focal mechanisms from spectra and polarities, and modeling waveforms by synthetic seismograms (home made FORTRAN codes).

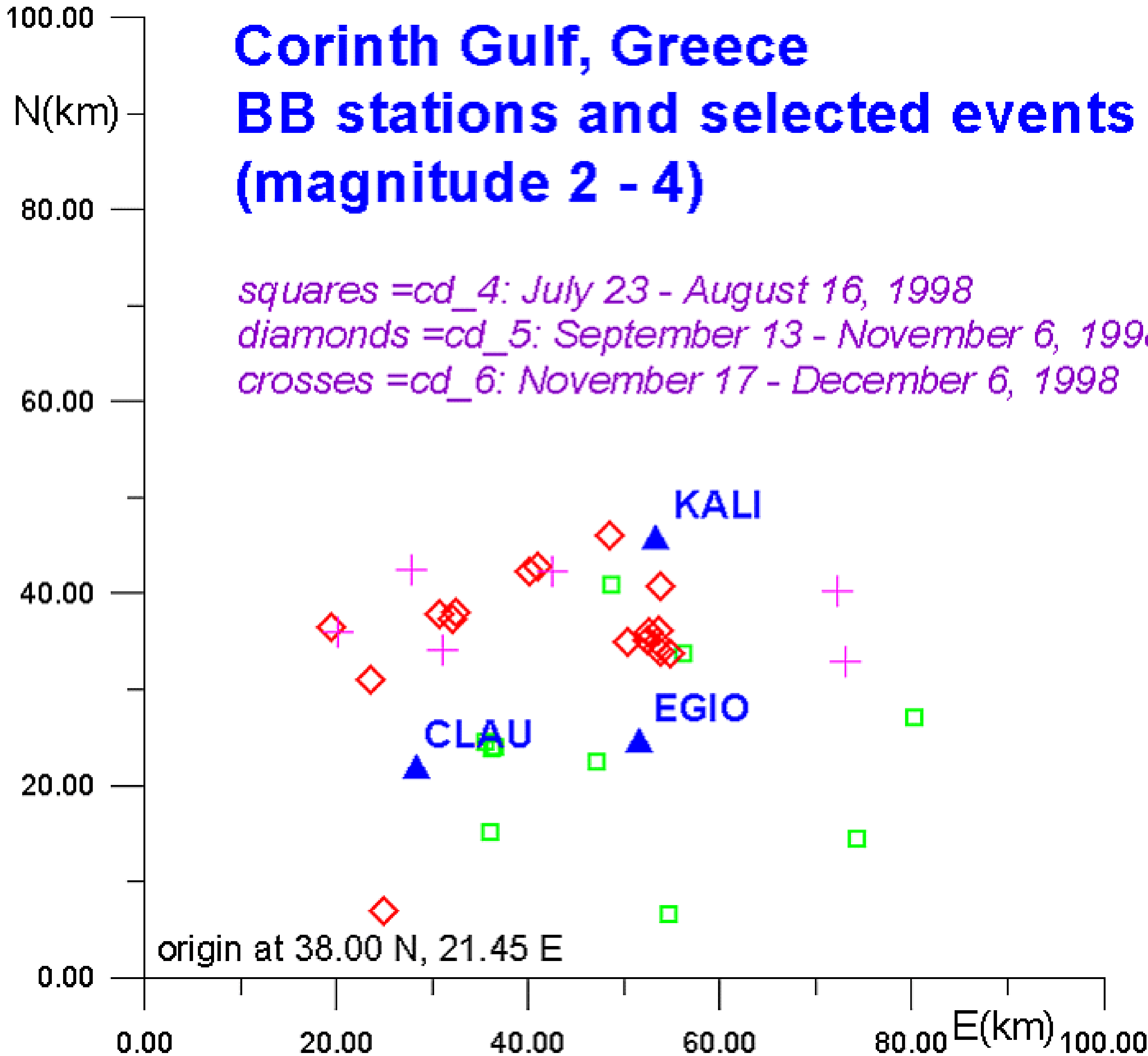

Figure 4. Epicenters of the selected events. Note a cluster between KALI and EGIO stations.

Data. The local broadband waveform data can be downloaded from the server at Prague. The data are organized chronologically, according to the station visits (e.g., cd_4, 5, 6, etc.).

Location. Advanced re-location methods, such as differential evolution and fully non-linear hypocenter determination have been developed and applied to the local events (Kvasnicka and Ruzek, 1999; see web site).

Focal mechanisms. The focal-mechanism inversion, based on the amplitude spectra of the BB records (0.2 to 1 Hz) and PATNET first-motion polarities, has been developed and applied to the clustered events between KALI and EGIO (Zahradnik, 1999; see web site).

Site effects. The site effect at EGIO has been investigated by means of spectral ratios EGIO/KALI from the teleseismic records (Jansky, 1999; see web site 1 and web site 2).

Data archiving. Of course, the main usage of the regional and teleseismic records is expected in a broader international co-operation. Therefore, since 1999, the Charles University has joined Orfeus, and the continuous streams will be copied on CD's and provided every 3 months.

Acknowledgement

N. Melis (EPPO, Athens) provided a very useful advice. E. Sokos and A. Sotiriou (Patras Univ.) assisted in the station deployment. M. McGowan and Ch. Pearcey (Guralp Co.) provided the software and instrumental help. K. Papatsimpa (Patras Univ.) processed the PATNET records. J. Jansky, M. Kvasnicka, V. Plicka and I. Oprsal (Charles Univ.) participated in the fieldwork and data processing. The financial support from two EU Inco-Copernicus projects, COME and ISMOD, and the Charles University grant 5/97/B is appreciated. Two broadband stations were purchased by the Faculty of Mathematics and Physics, Charles University.

Observatories and Research Facilities for EUropean Seismology

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The new Swedish Seismic Network

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Introduction

The history of instrumental seismology in Sweden began 1904 when the 1000 kg Wiechert horizontal pendulum was installed in Uppsala.

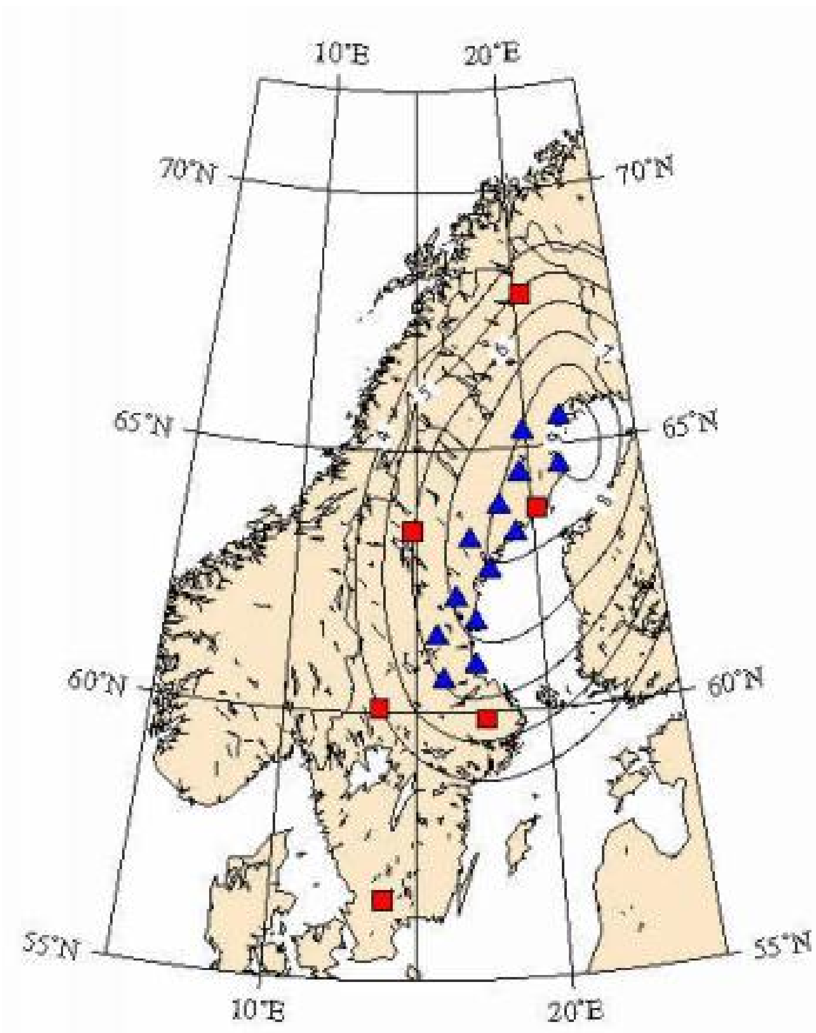

Fig. 1. Station locations in the new Swedish network.

The new Swedish National Seismic Network (SNSN), which is a digital broadband seismic network, is now under construction. The first part of the network was put into operation in 1998. This part of the network consists of six station at approximately the same locations as the stations in the old analog network constructed by Marcus Båth in the 1960s and are shown red squares in figure 1.

Additionally twelve stations are under construction along the coast of the Gulf of Bothnia. This is a separate project financed by the Swedish Natural Science Research Council (NFR), the Knut and Alice Wallenberg Foundation and the Swedish Nuclear Fuel and Waste Management Co (SKB). The main purpose of this network is to study microearthquake activity along the Coast of the Gulf of Bothnia to gain better understanding of the ongoing deformation processes in that area. These stations are shown as blue triangles in figure 1.

All stations are equipped with Güralp CMG-3ESPD broadband seismometers with digital output. These seismometers are flat to velocity in the period range from 0.02 to 30 seconds. The digital data is time stamped within the sensor using the GPS satellite system. The sampling frequency will be 100 sps at all stations.

The data acquisition system used is the so called SIL system which was developed within the SIL project, a joint Nordic project for earthquake prediction research in Iceland, 1988 through 1992 (Stefánsson et al 1993, Böðvarsson et al 1996, 1999). The main achievement of the SIL-project was to establish an automatic earthquake data acquisition and evaluation system, the SIL-system. As detailed plans were made for the SIL project, the importance of microearthquakes for understanding the ongoing deformation processes within the crust were recognized. It was recognized that the recording of earthquakes down to magnitude M_L=0 and retrieval of source information from these events would require a new seismic network design (Stefánsson et al 1986, Böðvarsson 1987). The rapid evolution in computer and communication technology and the introduction of inexpensive but powerful personal computers allowed for such a design of the SIL network (Böðvarsson et al 1996, 1999).

The network operation scheme

Teleseismic events will primary be recorded at the old 6 station locations. During some periods, teleseismic events will probably also be recorded at the remaining stations when research funds are available. Teleseismic events will primary be recorded using information available on Internet. The so called ``E'' type messages from USGS and NEIC, containing a single line of hypocenter and magnitude information on recent earthquakes, are received via electronic mail. Event information from different European networks will also be used for earthquakes occurring at closer distances. A selection programme reads the messages and selects events that fulfill certain criteria of magnitude and epicentral distance. The programme will use the iasp91 traveltime tables (Kennett and Engdahl, 1991) to compute the first arrival time at each station. The teleseismic body wave data are fetched with a sampling rate of 20 samples per seconds and the surface wave data with a sampling rate of 4 samples per second.

Regarding local and regional earthquakes, all 18 stations will be operated as a single seismological network providing automatic location and fault plane solution of all located earthquakes. As in the SIL system in Iceland the automatic analysis performed by the system will be divided into four categories: single- and multi-station analysis, multi-event analysis and the alert analysis. Single-station analysis is performed at each site on data recorded by that station. Multi-station and multi-event analysis is done at the center where data from more than one station are available. The alert monitoring is also done at the center, using parameters derived from the single- and multi-station analysis. A schematic description of the data flow in the system is given in figure 2.

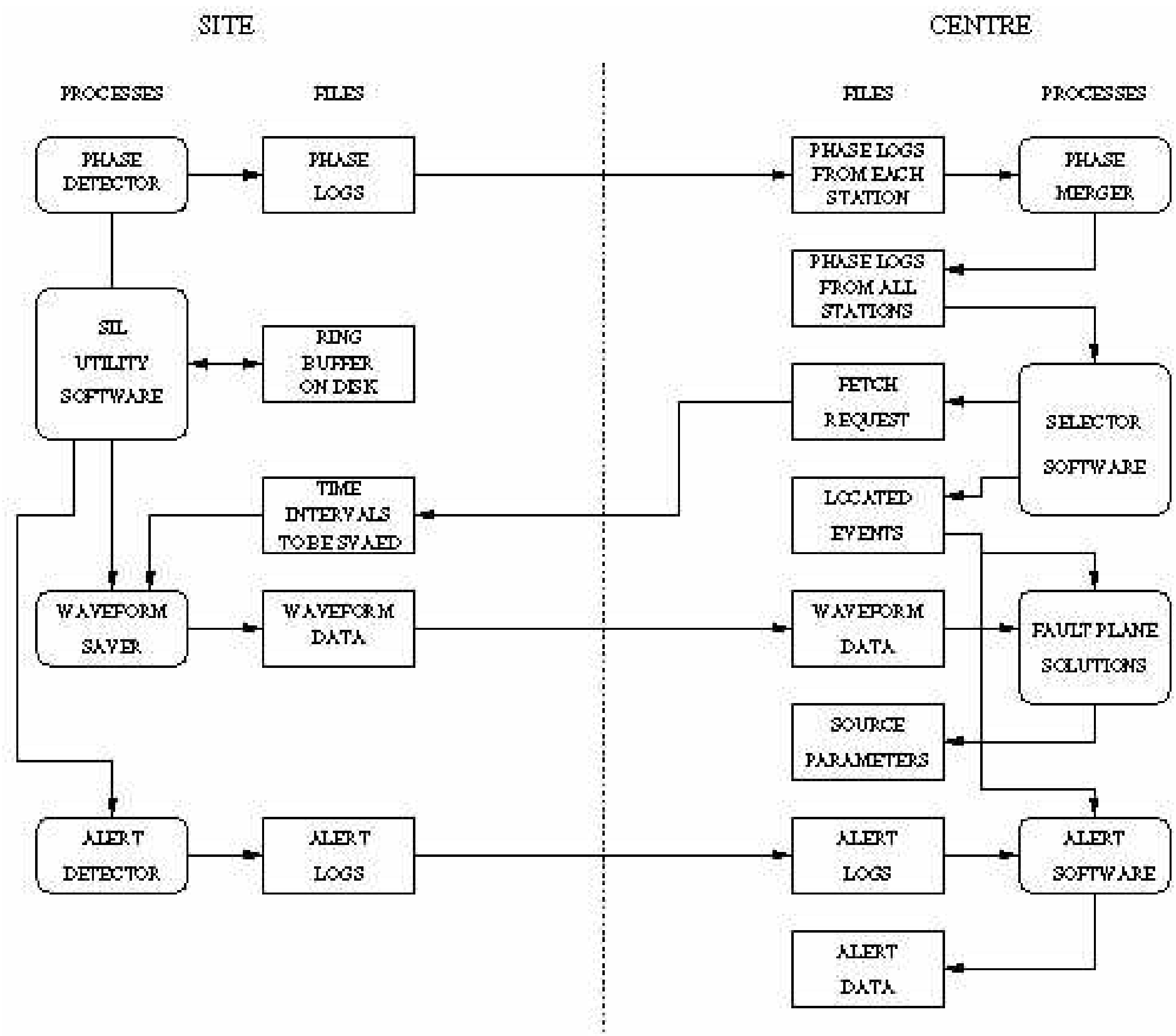

Fig. 2, Processes and data flow in the SIL data acquisition system. From Böðvarsson et al (1999).

Processing at the site stations

The software at the site can be divided into two categories: utility processes and application processes. The utility processes are general data management processes, designed for flexibility and valid for any type of data acquisition. The application processes read a channel of data stream as if it were an endless file. Channels are opened as regular files would be, by a call to the specific function in the utility library. The most recent part of the data are kept in shared memory for fastest possible access.

The communication between the center and the stations is designed to be independent of the physical way it is realized. Unix utilities are used throughout, providing the best possible portability of the software. To minimize data transmission costs the SIL system uses single-station phase detections and multi-station event selection. The basis of this concept is to treat all transients detected at the stations as if they were phases associated with real earthquakes. The detector uses a simple comparison of power in two adjacent windows in six frequency bands of the seismic trace. This is similar to the STA/LTA approach but in our case the time-windows used are short and both of the same length. Selected windows around the detected transients are processed in a manner one would process a true seismic phase and the results stored in a compact structure, called a phase log. Each phase log entry is only 128 bytes long and is therefore inexpensive to transmit to the center. The detection thresholds can therefore be set very low, allowing smaller earthquakes to be detected. The phase logs will be transmitted to the center once every hour. Each phase log includes onset time, duration, reference to previous and following phases, type of phase (P or S), signal and noise averages, maximum amplitude, azimuth and coherency (Roberts et al 1989) and spectral parameters including DC-level and corner frequency.

Processing at the center

Phase association and event location.

Selection of waveform data to be transferred from the stations is carried out automatically by the selector software at the center. At the center, the phase logs from different stations are merged into a single time-ordered list. The first step of the selection process is to search for time intervals which contain two or more phase detections that may originate from the same seismic source. The phase detections in this time interval are then submitted to the iterative location, phase association and phase truncation procedure as explained below. The principles for the step from a list of phase detections to a list of earthquakes or seismic events are described by (Slunga 1980, Böðvarsson et al 1999). In short each combination of three observations (onset times of P or S phases and azimuths of P phases) is taken as defining the initial location of an earthquake and is then followed by iterative location and phase association and truncation. This procedure may lead to a "kinematic event`` (no dynamic constrains) defined by three or more observations. The list of kinematic events contains a large proportion of false events due to random coincidences of observations. Therefore each event is assigned a quality measure. Ideally the quality of an event should measure the probability that the event is a true seismic event. The computation of quality is based on both kinematic considerations and analysis of the amplitudes of the detected phases (dynamic information).

Fault plane solutions.

Apart from locating the earthquake, the routine analysis performed on every recorded event will include estimation of the fault plane solutions for the earthquake. The estimation of focal mechanism and source parameters are based on results of the spectral analysis of short data segments containing the direct P and S wave arrivals. The spectral estimation is done at the site stations, using windows around the automatic time picks, and repeated at the center after manual refinement of arrival time readings. The low frequency amplitude of each phase is determined by fitting a three parameter model to the observed spectra (Boatwright 1978). To estimate the fault plane solution for the earthquake a systematic search over strike, dip and rake is performed. For each combination of the three source angles, the misfit between observed and predicted spectral amplitudes is calculated. In addition to the single best fitting solution, all solutions that fit the observed polarities and have amplitude misfit less than a predefined threshold value are taken as acceptable (Slunga 1981).

The alert system.

The alert system is a collection of routines for monitoring extracted parameters in selected regions and sites. For this purpose, Sweden will be divided into a number of regions and different alert thresholds assigned to each region. The parameters are extracted from the results of the analysis described above and from dedicated alert detectors at the sites. The alert system will be started at regular intervals and for each event defined by the multi-station analysis. Five parameters will be monitored for each region. These are M , the local magnitude of individual earthquakes, N , the number of earthquakes in a time interval, S, a dimensionless measure of moment release during the same time interval and time-weighted measures of the number of events and accumulated moment release (Böðvarsson et al 1999). The purpose of the SNSN alert system is to provide information about the seismic activity in different regions for increased attention of the network operators.

Multi-event absolute and relative locations.

At the SNSN center the algorithm described by Slunga et al (1995) will be used to simultaneously determine absolute and accurate relative locations of clusters of similar earthquakes. An example of the application of the relative location algorithm to a group of earthquakes in the Tjörnes fracture zone in Iceland is shown in Figure 3. After relocation the epicenters of the 18 successfully located events lie on an approximately 1 km long line segment (Figure 3.a). Assuming that all the earthquakes occurred on the same fault, the attitude of the fault can be estimated by fitting a plane through the accurately determined hypocenters. The strike of the best fitting plane through the group is N139ºE, similar to the strike of the main transform faults of the TFZ.

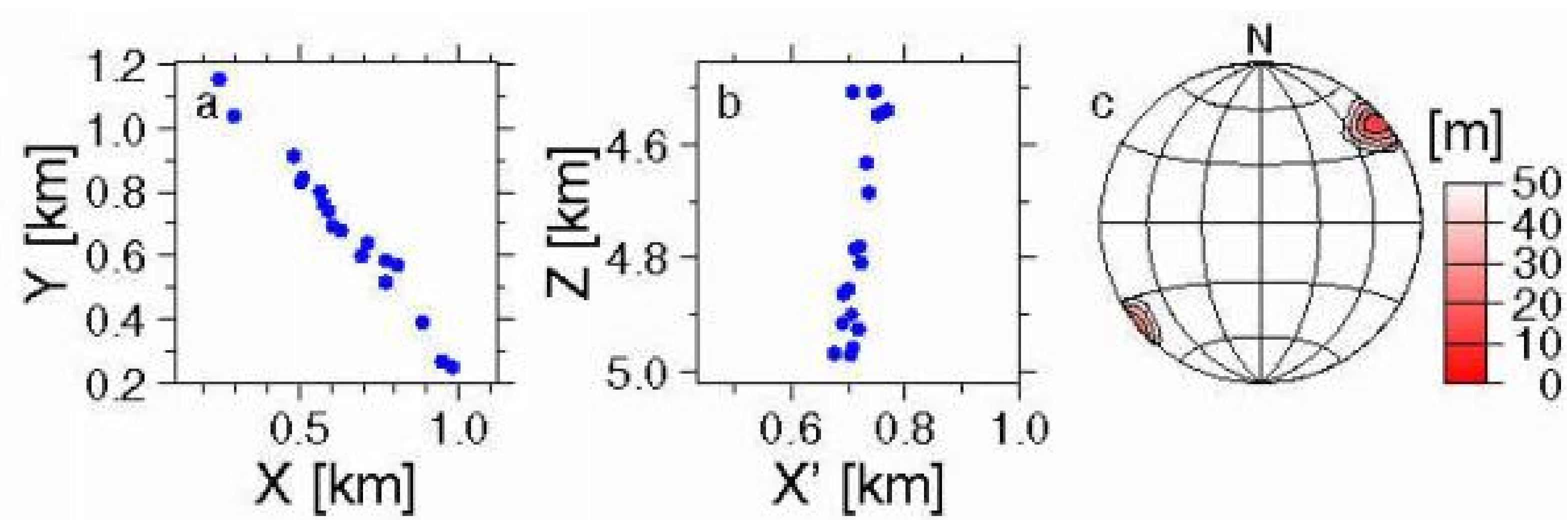

Fig. 3. The relative location of a group of 18 earthquakes in the Tjörnes fracture zone. (a) shows a mapview of the epicenters after relocation, X is east, Y is north. In (b) the hypocenters are viewed along the strike of the best fitting plane through the group. Z is depth and X' is horizontal and orthogonal to the strike. (c) shows the poles to all planes through the hypocenter group, such that the mean distance of the 18 earthquakes from the plane is less than 50~m, plotted on an equal area projection of the lower hemisphere. From Böðvarsson et al (1999).

Acknowledgement

I would like to thank my colleagues Ragnar Slunga, Björn Lund, Conny Holmqvist, Sverker Olsson, Hans Palm and Stefán Böðvarsson who participate actively in the network construction process. Special thanks to the land-owners and others that are housing our stations.

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Observatories and Research Facilities for EUropean Seismology
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A 400 km long Broadband Antenna in the Eifel-Region

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The Eifel

The Eifel with its famous maars and volcanic fields is the youngest volcanic area of Central Europe. The last eruptions occurred approximately 12200 years ago at the Laacher See vulcano and 10900 years ago at the Ulmener Maar - i.e. in geological time just yesterday. Since several years numerous geological, geochemical and geophysical studies have been conducted in this area. Nevertheless little is known about the deep origin and the mechanism responsible for the volcanic activity. In the last 1000 years several destructive earthquakes hit the Lower Rhenish Embayment, which is situated immediately north of the Eifel. The most recent significant event occurred on 13. April 1992 near Roermond/Netherlands ($M_W=5.3$), which caused damage in excess of 50 million Euro. Other significant earthquakes occurred on 8. November 1983 near Liege/Belgium, and 1756 near Dueren/Germany. Another geodynamic feature is the uplift of the Rhenisch Massif up to 250 m in the last 800 ka. All these processes indicate that the Eifel is one of the most geodynamically active areas of Central Europe. The study of the lithospheric-asthenosheric structure of the Eifel and the processes involved is therefore the central aim of this research project.

The Broadband Experiment

A total of 32 mobile broad-band (BB) stations and 126 mobile short-period (SP) stations was operated between November 1997 and June 1998 in the area extending from western Germany to the Benelux and France (Fig. 1a). Recordings of the temporary stations were supplemented by data of permanent BB and SP stations in Germany, the Netherlands, Belgium, Luxembourg and France. The regional and teleseismic events recorded during this time are given in Fig. 1b.

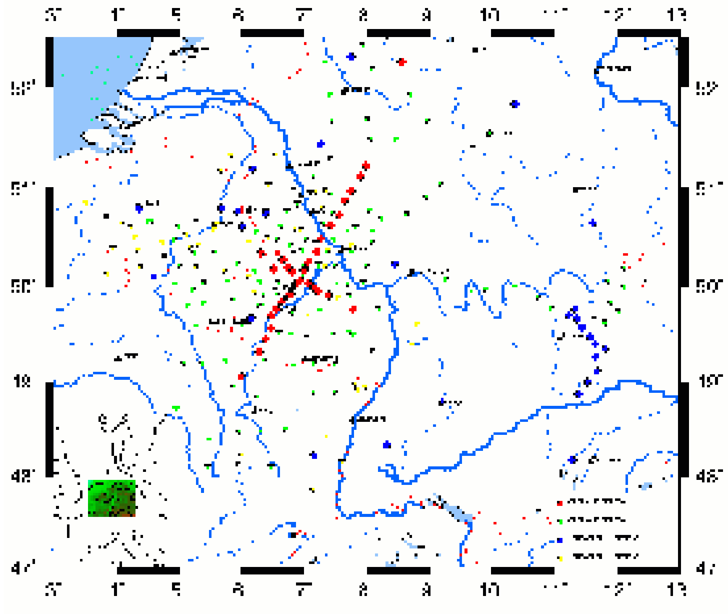

Figure 1a.

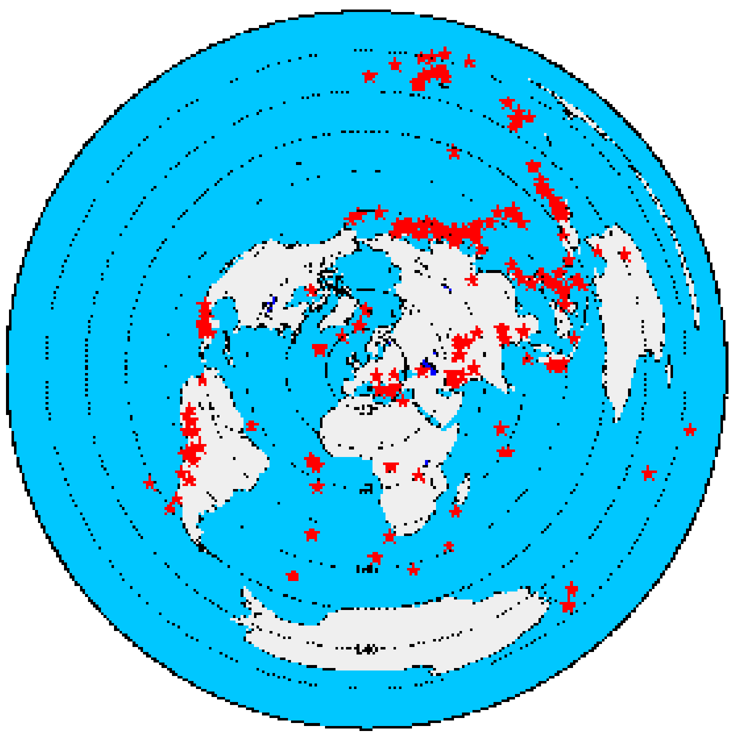

Figure 1b.

Figure 1: The Eifel Plume experiment. (a) Temporary and permanent BB and SP stations of the Eifel Plume experiment. (b) 217 regional and teleseismic events recorded from November 1997 to Summer 1998. Circles are distance in degrees from the Eifel.

Configuration of the BB Array

The deployment of the 32 mobile broadband recorders was carefully planed before the field campaign. As configuration of the BB array we chose a cross with its longer arm striking SW-NE. This nearly 400 km long line with 22 stations is directed towards the active seismic regions in the NW Pacific (e.g. Japan, Kurils) and South America. The shorter, 180 km long line with 14 stations was oriented NW-SE. Together with the short-period stations this allows precise

measurements of slowness and backazimuth.
As sensors 14 Streckeisen STS-2, 12 Guralp 3T, and 6 Guralp T40 were used. During the deployment these instruments were installed on small concrete basements and shielded against temperature variations. Sampling frequency 20 Hz and 50 Hz were used. The preliminary data processing show a good signal-to-noise ratio.

The Aims of the BB experiment

The aims of the seismological BB experiment are

- Investigate upper mantle structure using converted phases and array methods
- Determine the seismic anisotropy using splitting of SKS and other shear waves.

The joint interpretation of these results with teleseismic tomography and geodynamic modelling will help in shedding light on the deep processes responsible for the Eifel volcanism and the ongoing uplift.

Converted Phases

S -> P

Teleseismic S-to-P converted waves underneath a seismic station arrive before the direct S-wave and are best observed on the vertical components (Fig. 3a). The advance relative to S can be used to determine the depth of the discontinuity at which the conversion occurred. Fig. 3b shows a data example recorded at the stations in the Eifel. Fig 3c shows the slowness stack (vespagram) of events with an backazimuth of 286°.

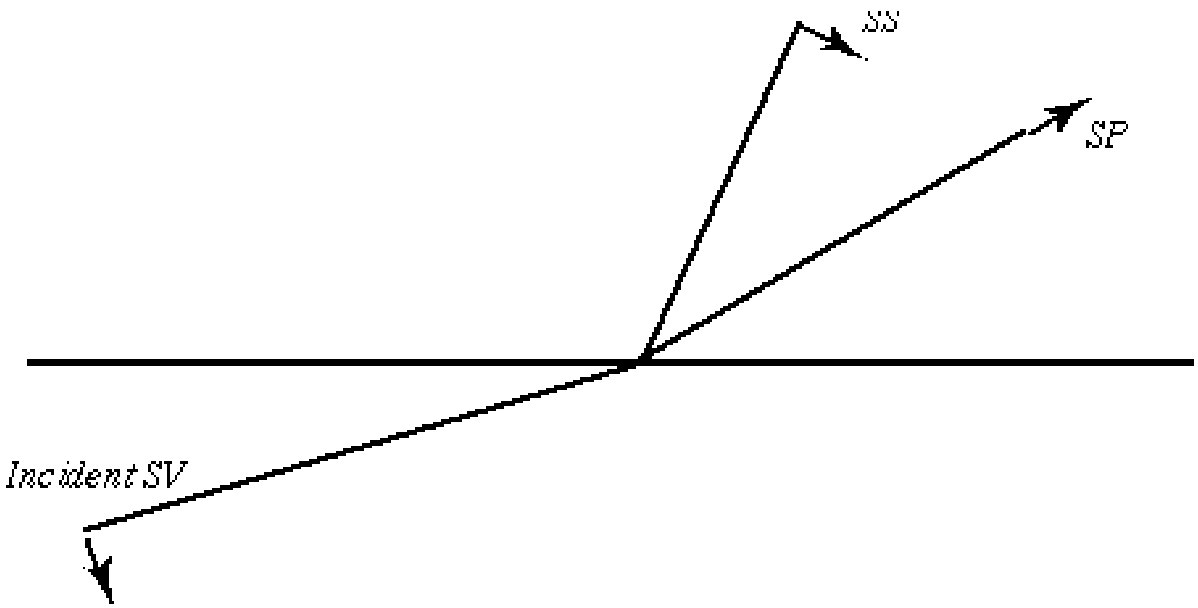

Figure 3a

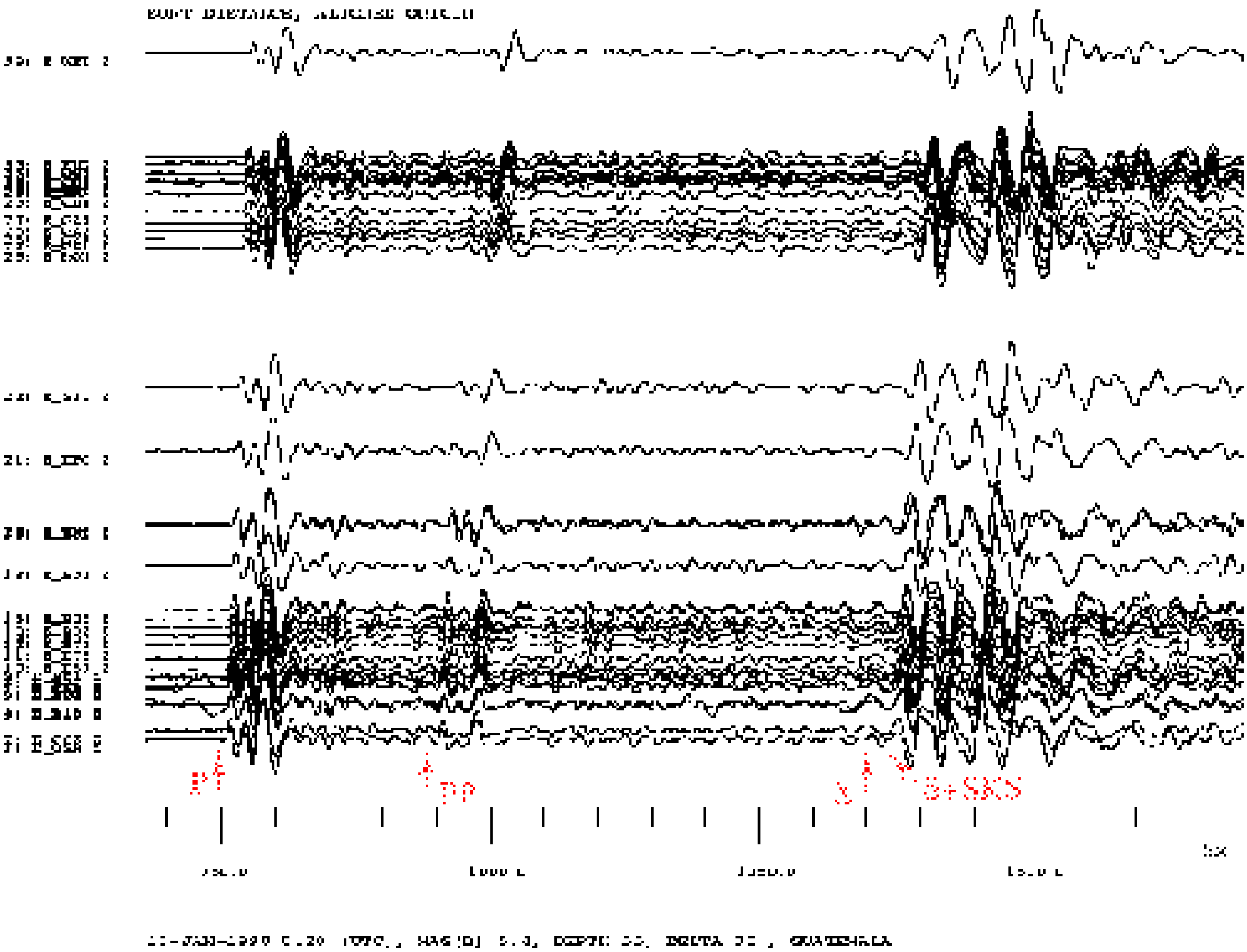

Figure 3b

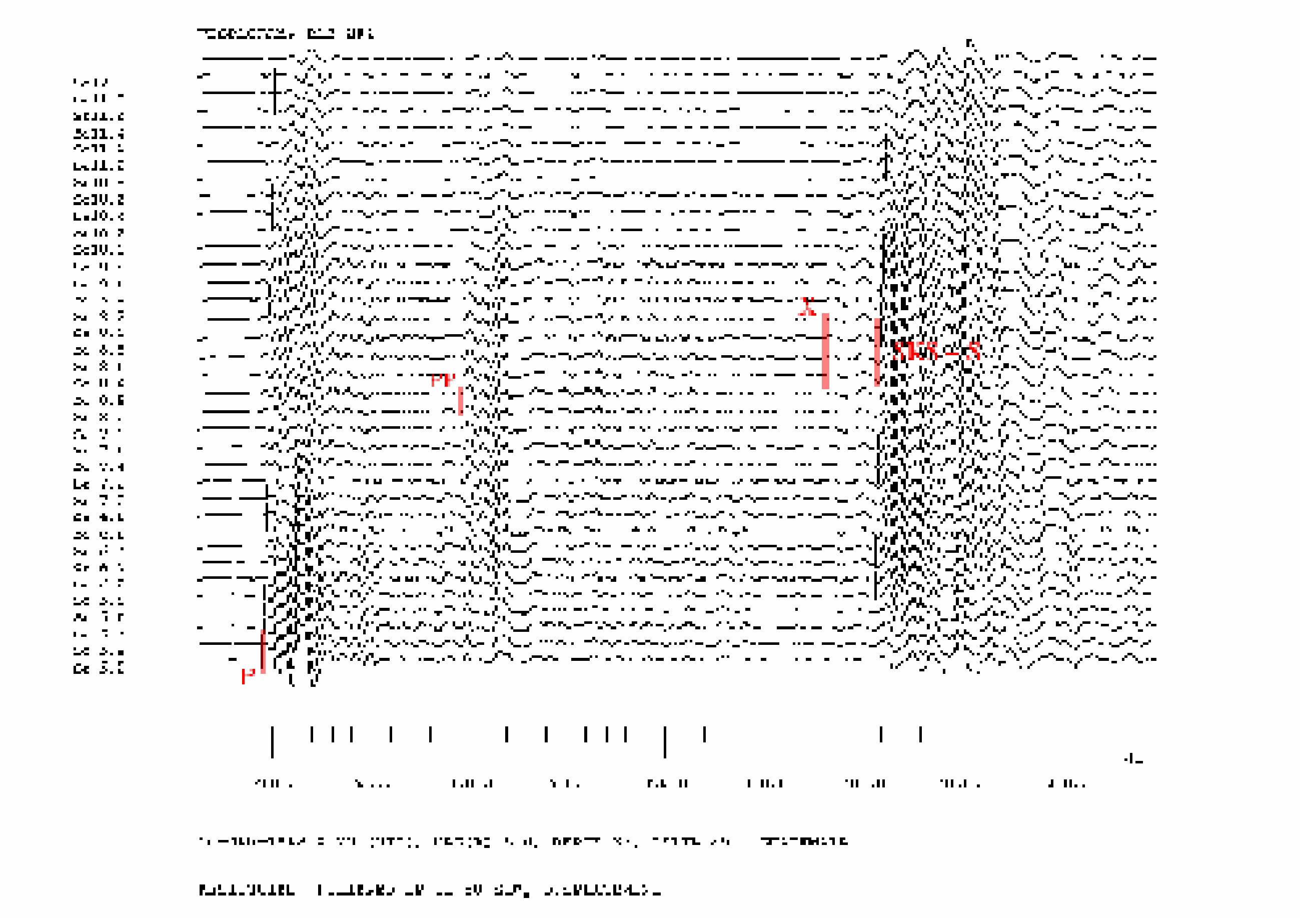

Figure 3c

Figure 3: (a) Sketch of the method and phases used (b) Vertical component recordings of stations of the Eifel experiment. Events are sorted by distance (c) Slowness stack (vespagram) of events with backazimuth 286°. The onset X ahead of S is possibly a S-to-P converted wave at the 410 km discontinuity (thanks to Y.-F. Temme for initial processing).

Seismic Anisotropy

Anisotropy frozen into the lithosphere during the geological past and present-day flow in the asthenosphere are frequently discussed causes to explain splitting of teleseismic shear waves. We will investigate splitting of SKS waves because it can be unambiguously related to anisotropy in the crust and/or mantle beneath the receiver. As a first example we analyzed data from the deep earthquake of November 28, 1997, which occurred in the Peru-Bolivia border region at a depth of 586 km. Good SKS phases were recorded from this event at the Eifel Plume stations. Standard splitting analysis of broad-band and some short-period waveforms (the latter restituted to 20 seconds by deconvolution of the seismometer response) gave the preliminary results shown in Fig. 4. Delay times between the slow and fast split waves are relatively small in this case (less than or equal to 0.5 s), particularly in the area of the Eifel volcanic fields. The fast polarization directions seem to be quite different to those observed elsewhere in central Europe. This suggests that the regional anisotropy pattern is considerably disturbed locally in the immediate area of the Eifel volcanic fields, but more events have to be analyzed before firm conclusions can be drawn.

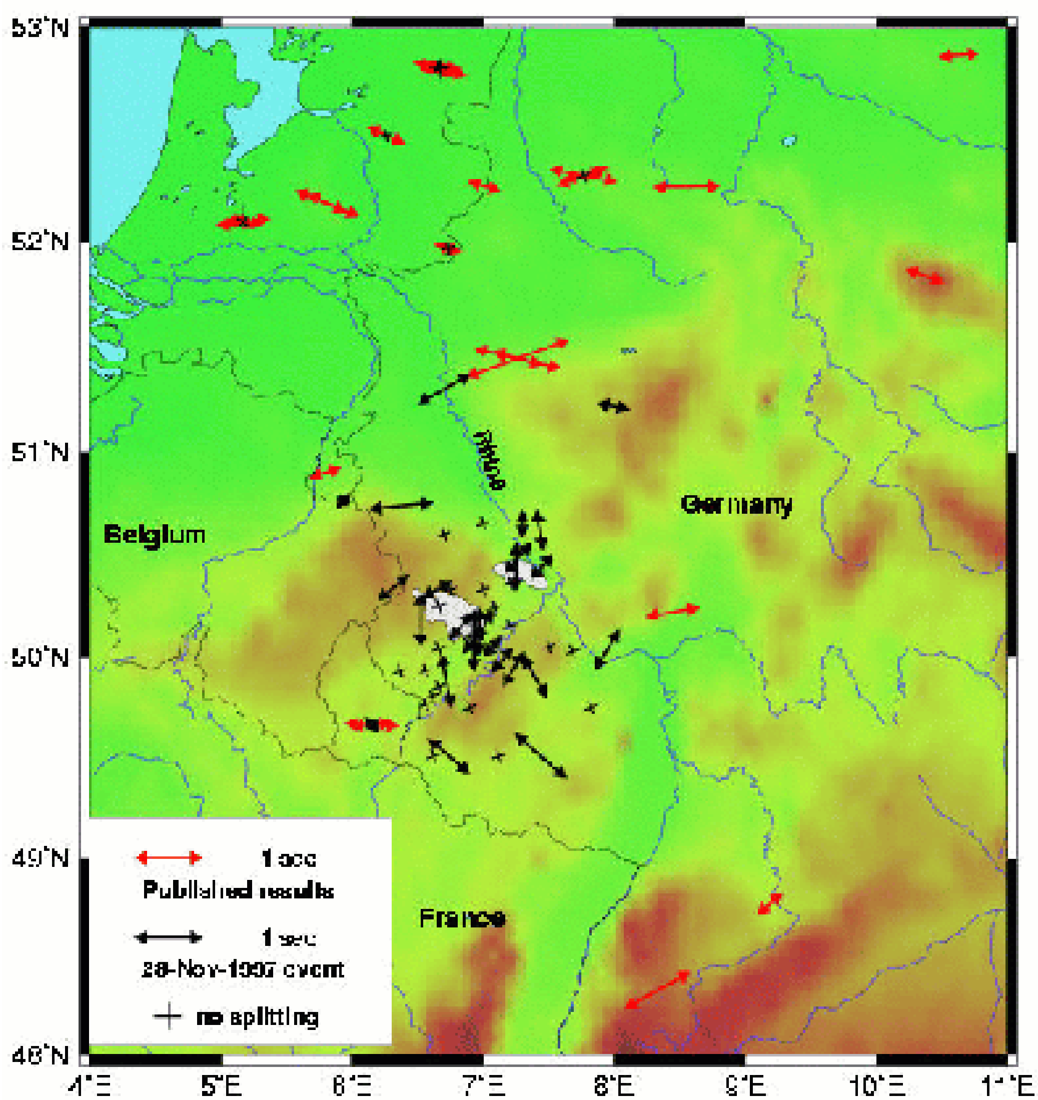

Figure 4: Preliminary plot of the inferred directions of the fast split wave for a deep event in the Peru-Bolivia border region. Crosses indicate "Nulls", i.e. no splitting observed. The crosses are aligned parallel to the back azimuth and perpendicular to it, representing possible directions of the fast and slow split wave. The surface of the Eifel volcanic area is indicated by the grey-filled areas

Acknowledgements

The field equipment were provided by the Geophysical Instrument of the Geo-Forschungs-Zentrum Potsdam, universities of Potsdam, Karlsruhe, and the Free University of Berlin, Germany; the Lithoscope Pool, France; the Royal Observatory of Belgium; and the University of Utrecht; Netherlands. Data from permanent stations were supplied by the Bundesanstalt fuer Geowissenschaften und Rohstoffe, the Erdbebenwarte Bensberg, the GeoForschungsZentrum Potsdam, the Geologisches Landesamt Nordrhein Westfalen, the Landesamt fuer Geologie, Rohstoffe und Bergbau Baden-Wuerttemberg, Germany; the ORFEUS Data Center, the Seismological Division of KNMI, Holland; and the Royal Observatoire of Belgium. Special thanks to Yorck-Fabian Temme for the collection and preparation of the data, the county administration of Daun/Vulkaneifel and the GeoZentrum Vulkaneifel (Dr. Eschghi and Mrs. Rudolf) for providing important logistical help, and numerous offical and private people for providing sites for installationof the instruments. The project is financed by the

Deutsche Forschungsgemeinschaft, the institutions involved, the Royal Observatory of Belgium and the European Center for Geodynamics and Seismology - Musee National d'Histoire Naturelle, Luxembourg.

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For more information visit the Eifel homepage: www.geo.physik.uni-goettingen.de/~eifel

A geoscientific program to study the Earth's mantle under the Eifel and adjoining regions
The broadband seismic experiment

Observatories and Research Facilities for EUropean Seismology
Volume 1, no 3 **October 1999** **Orfeus Newsletter**

Java for the Seismologist

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Introduction - Advantages - Drawbacks - Perspectives - Getting started

Introduction

Java is an object-oriented, platform-independent, internet-ready programming language. What does this provide for a seismologist?

Object-oriented software is strictly modularised, this simplifies and speeds up the development, maintenance, updating and re-use of code. In Java and other object based languages this modularity is implemented through the *class* - a collection of data structures and operations on this data. A class usually represents a real or conceptual entity, such as a seismogram, a time pick or an earthquake location. Within a software package, a realisation of a class is an *object*. The object is accessed through a limited, well defined set of functions and variables, the details of the data storage and inner workings of the object are not visible. An object is thus a sealed "black-box" with only certain "wires", "buttons" and "displays" accessible. This *encapsulation* allows the rapid and easy use or re-use of the object in new code, and allows the inner workings and capabilities of the class to be modified or extended without the need for updating existing code that uses the objet.

For seismology the object-oriented Java language allows the definition, implementation and distribution of, for example, a standard set of "seismological" classes and collections of classes. There is also a multitude of ready to use Java classes freely available on the internet for a wide and rapidly growing number of computational, mathematical and visualisation tasks (see the ORFEUS Java software page for links). A seismologist could use these software modules to rapidly create new programs, and can easily re-use and exchange parts or all of any Java software that incorporates these classes. An effort to define seismological classes is included in the ongoing FISSURES initiative of the IRIS Data Management System, which is described in a companion article.

Java is platform-independent and portable because its class source files are compiled only to unique, machine independent *byte-code*. When run on a specific machine, the byte-code for required classes are further compiled to the corresponding machine code. Because it is platform-independent and portable, Java software can be run on almost any hardware and operating systems - UNIX, Linux, Windows, Sun, PC, Macintosh, ... And this platform independence includes an extensive, easy to use set of graphical user interface and visualisation classes. Thus seismologists can develop and use Java software on their available or preferred systems, and can distribute the compiled Java byte-code for use on any other system. This makes valuable research and teaching software available to the whole seismological community for immediate use, without the complications and time required to obtain, modify and recompile source code for each system. Platform independent Java software currently available includes the TauP Toolkit a seismic travel time calculator from the University of South Carolina, RayGUI Interactive Ray-Tracing from the USGS, and JPitsa from the Synapse Science Center, Moscow. More Java programs can be found on the ORFEUS Java software page.

Java is internet-ready because it incorporates the functionality and security to allow file access, data exchange, distributed computing, and many other operations over the internet. Java also supports the use of "applets" - Java programs which reside on a server but which are transferred over the internet to run through a web browser on a local system. These capabilities will greatly improve the ease, speed and flexibility of distributing and obtaining seismological data, even in near real-time and from remote stations. But the internet features of Java also allow new possibilities for more active and comprehensive use of seismological information in research, teaching and public information. For example, digital seismograms can be interactively selected, viewed and processed with a few clicks of the mouse from a web site, without the need, time or complications of downloading the data, converting data formats and of obtaining, installing and maintaining compatible analysis software. Such Java applet based seismogram analysis is already available through the Seismo Cam of the USGS/CIT Southern California Seismographic Network, the Seismogram Viewer used under the ORFEUS WILBER interface for accessing SPYDER® data, or Seismic View from the Institute of Geophysics, Ukraine. Other seismological applets include a seismic alarm and seismicity display from the USGS. Existing educational applets include those at the Geophysics Department TU Clausthal Learning with JAVA Applets site and the Digital Seismology Tutor from the University of Potsdam, Institute of Earth Sciences. More Java applets can be found on the ORFEUS Java software page.

What are other advantages of Java?

Java is now one of the major computing languages. It is used for an immense range of tasks in the computing, commercial, teaching and research worlds.

The Java language development toolkit (standard classes, documentation, compiler and other utilities) and advanced class packages are avalaible free from Sun. Many other classes, programs and development tools are available free or commerically over the web.

The comprehensive set of classes available with Java and from third parities make it a powerful and easy to use language for many tasks, including visualisation, image processing, educational and interactive projects, data and database manipulation, and general utility programs.

What are the drawbacks of Java for seismologists?

At the moment Java is not as fast as native compiled FORTRAN, C or C++ for repeated, low level operations or for number crunching. Thus it may not be a good choice for high performance visualisation or for mathematically intensive codes. But this may change in the next few years as the Java interpreter-compilers on specific machines become more sophisticated in the use of hardware capabilities and in on-the-fly code optimisation. And already Java can make calls to native functions written in C, though this option looses platform independence. It is possible that Java will soon only be a poor choice for extremely CPU intensive number crunching.

There is also a very large conceptual difference between procedural languages like FORTRAN and C and object-oriented languages like Java and C++. Java is an elegant, relatively simple and well thought out language, and can be learned rapidly. However, designing and producing truly object-oriented software is very difficult from working with "procedural" languages like FORTRAN and C. Learning Java will be relatively easy and enjoyable for those with formal training in object-oriented design and programming techniques. But it is also accessible to those without object-oriented experience because of the widespread use of Java and easy access to documentation.

Where might we go with Java software?

After an earthquake occurs, Java software could actively locate and access trace, event, and macroseismic data over the internet in near real-time from regional and global data centres, seismic networks or individual stations. Filter-interfacing objects would transparently handle the conversion of the data from a heterogeneous set of formats to a set of standard seismological objects. This data could be immediately displayed, processed and analysed, interactively or automatically. Further filter object could present different displays and possible actions on the data to support the needs of different users - station networks (for quality control, event location), seismologists (for preliminary analysis of data from multiple sources and rapid assessment of seismic hazard), and other interested parties with basic or limited seismological knowledge (emergency management specialists, schools, public).

For a researcher, the use of Java, standard seismological classes and the internet opens up completely new ways of working. For example, while reading an article which contains a methodology or algorithm of interest, a researcher could obtain the relevant software over the Internet, and then apply it to their own data set - all within a few minutes, and independently of the type of computing systems and local data formats used by the author of the article or the researcher. Two or more researchers in different laboratories could simultaneously examine, interact with and discuss a sophisticated visualisation of the results of some calculation.

How can a seismologist get started with Java?

Read the What is Java and the Java Tutorial web pages from Sun. Look at the other pages under java.sun.com, or at other Java general information sources on the ORFEUS Java software page.

Try the Java applets and programs listed above or others on the ORFEUS Java software page, and make contact with the authors. (If Java is not already installed on your system, you can download and install the Java SDK from Sun. This is the Java Software Development Ket which allows you run exsiting stand alone Java applications, and to write your own Java applets and applications. If you want to write applets, it may be best to use JDK 1.1 as most browsers do not yet support Java 2 SDK. If you only want to run applets though a browser, you do not need to install Java.)

Choose a basic, seismological processing, visualisation or teaching task that interests you and for which you do not have useful software, and try writing a Java program or have another interested colleague write such a program. For your first Java program, it is a good idea to modify an existing Java program that has similar functionality; for this, the demo programs distributed with the Java SDK are a good choice.

Participate in Java and other sofware discussions at seismological meetings, and participate in the proposed ORFEUS Java workshop in Spring, 2000.

Fissures, Java and Corba

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Introduction - Java - Corba - Fissures

Introduction

Fissures is an effort by IRIS to develop a software framework that address the common, basic functionality needed by seismologists and that will enable the rapid creation of new and interesting scientific and teaching applications. Fissures began as a realization that the inability of current software both to communicate and to handle large volumes of data was hampering the progress of seismologists. It is not uncommon, and might in fact be the norm, for a seismologist wishing to process some data to get the data in one format, read it into a conversion program, output it into another format, read it into a second analysis program do do one step, output the result, translate the results for input into a third program, and so on. If only these specialized applications could communicate directly, much extra effort could be avoided. Secondly, whenever new seismology software packages are developed, they usually start from the ground up, and recreate the same functionality that has been done many times before. If only there was a standard library of seismology objects that took care of the common, boring, low level functionality, then seismologists could concentrate on doing the fun part, which is doing science. To address these issues the FISSURES initiative was begun by IRIS in 1997. FISSURES is based on two complementary technologies, Java and Corba. Java for its object oriented nature and cross-platform abilities, and Corba for its strong, industry standard distributed computing mechanism.

Java

There is a complementary article focusing on Java contained within this edition of the newsletter, and so we leave the details to it. Suffice it to say that Java has received a huge amount of attention in the computer industry lately, and for good reason. It is a clean, well designed object oriented language that has the ability to run on many different platforms without recompiling. It also has a large framework of classes that do many useful, common tasks. These range from advanced GUI elements to database access and from networking to complex data structures. In short, Java makes it easy to do useful things that are very complicated in other languages.

Corba

While Java has received a huge amount of press and hype over the past few years, Corba has only recently been widely noticed in spite of its relative maturity. Thus, most programmers are unfamiliar with what Corba is and what it can do for them. Corba, the Common Object Request Broker Architecture, is a system for doing language and platform neutral distributed computing. It allows applications to access the services of other systems that may be running on different computers, with different CPU types and even different byte ordering, and even written in different languages. Corba allows the access of remote services while giving the appearance that they are local.

At its core, Corba is the combination of first an interface definition language, IDL, along with mappings into various programming languages, and second, an over the wire protocol, IIOP, with Orbs, Object Request Brokers, that listen and translate to and from the protocol.

The object request broker, or Orb, provides for the common needs of distributed systems such as creating the connection from the client to a remote service and exposing a service to the outside world once it is ready to receive requests. The orb is the manager for all Corba interaction within an application. It communicates with other orbs using IIOP, the Internet Inter-Orb Protocol. IIOP defines a mapping from data structures to a byte sequence that can be sent across a communication channel. By using this type of protocol, Corba allows the programmer to operate at a higher level that the more traditional socket level. The programmer need only define what his data objects look like, and the orb handles all of the marshaling and demarshaling to and from IIOP. Lastly, because IIOP is an inter-orb protocol, the only reason anyone would directly interact with it is if they were writing a new orb implementation. Otherwise, it is sufficient to know that IIOP exists and that the orb takes care of the rest.

The interface definition language, or IDL, along with an IDL compiler that maps IDL into the target language, are the real pieces that programmers regularly interact with. IDL allows you to explicitly define the interface to a service independent of its implementation. This strong separation between interface and implementation is a good design principle in general, and by forcing you to do this explicitly, Corba can actually help you to make better design decision early in a project, when they are most helpful. Examples of interfaces in the real world are everywhere. The most common example given is usually a bank. When you go to your bank or any bank, you expect a common interface. In other words you expect to be able to do certain things, like open an account, check your balance, make a deposit, and make a withdrawal. It is really irrelevant to you how the bank accomplishes these things internally, just so long as you get a valid result back. They could have an envelope in the back with your money in it, or they could keep track of how much you have in a sophisticated accounting system, you don't care so long as you can get to your money. This same technique is a good way to design a complex software system. Break it into subsystems and be very explicit about the interfaces between them.

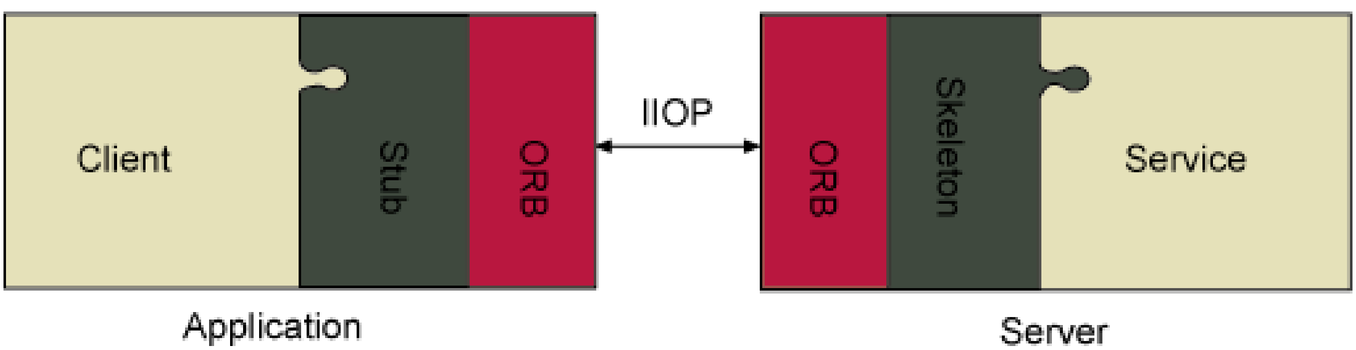
There are two main pieces to actual IDL. The first is naturally interfaces. An interface is a collection of methods (functions) along with their input types and output types. An implementation of this interface must provide each of these functions. This interface definition defines the extent of a subsystem. The second main thing that is possible within IDL is the definition of data structures. These are similar to structs in C and provide for the creation of more complex data types and can be used within their associated interfaces. The IDL for a corba version of "hello world" might look like this.

```
module example {
        struct Name {
                string
firstname;
                string lastname;
        };

        interface
hello_world {
                string say_hello(in Name my_name);
        };
};
```

In this example, say_hello is a method or function within the hello_world interface. It takes a Name structure as an argument and returns a string. It is worth repeating that IDL only defines interfaces, the "what". The "how" of the implementation does not appear.

Once IDL has been created, you must run an IDL compiler on it to produce usable code within the language of you choice. If you want to code in Java, you would use a Java IDL compiler, and similarly for C, C++, Smalltalk, and COBOL. When you run the compiler, the output is source code in the chosen language. So, for instance, in Java each struct is mapped to a class and each interface is mapped to a Java interface. In addition you will get a couple of helper classes and an implementation base. This "ImplBase" class provides the functionality that Corba needs to make use of the interface, it is also knows as a skeleton because it provides the bare bones framework and it is up to you to flesh it out. Lastly, you also get what is known as a stub. This is the functionality that Corba needs on the client side to forward requests and deal with the response. It acts as a local proxy for the remote service.



There are several good sources of information on Corba. The natural first is the OMG, which is the organization that develops and standardizes the specifications for Corba. While there is a lot of information there, the site is a bit confusing and it can be hard to find what you are looking for. Another interesting site is the Free Corba page, which tracks implementations of Corba that are freely available. The TAO orb is a free C++ orb with many features. Also of interest is Orbacus, a Java and C++ orb that is commercial, but is free for non-commercial use. Lastly, there is a built in orb within Java1.2, which can be found at Javasoft.

Fissures

How will Fissures make use of these two technologies. Well, first we are designing interfaces in Corba to several standard services that seismologists use regularly, such as a data repository, travel time calculation service, and filtering service, and building prototypes of each. Also, we are creating a large business model of common seismology objects, along with their basic, commonly needed functionality. For instance, we have defined classes for seismograms, picks, events, origins and predicted arrivals. We have also defined two other objects, DataSet and ChannelGroup that allow for grouping of data. The ChannelGroup holds up to three seismograms and defines them as representing the three components of motion. DataSets in turn hold ChannelGroups and other DataSets, and allow for organization much like folders or directories do on a hard disk. In addition, we are developing a set of display components that will allow new, special purpose GUIs to be quickly developed. For example, a seismogram display widget knows how to display a seismogram. Several seismogram displays can be combined to form an overlay plot or a record section. A particle motion display widget would display the particle motion from two seismograms.

Several things that we think are needed, but not currently widely used will also be included. Such as an auditing system so that the entire processing history of a piece of data can be examined. Units are widely and explicitly used. Thus, if an amplitude is measured in units of meters per second, then that fact will be kept with the measurement. If you later average it with one in centimeters per second, the conversion will automatically happen. And if it is in centimeters, then it will warn you that the units are not compatible. If you don't think units are important, just ask the Mars Climate Orbiter team.

The first use of the fissures framework will be with SCEPP, the South Carolina Earth Physics Project, which will use fissures for both the realtime data recovery as well as for the development of educational software applications. This will provide a good first test as well as becoming a source of additional fissures friendly software.

A great deal of design work has been done, with UML models that you can view if you are interested. Also, slides from my IUGG talk are available as well. We are slowly working on implementing these designs and hope to have a release at the *pre-alpha* level at the beginning of 2000. The system should progress and change frequently over the following year. A beta release will likely be done late in 2000 or early in 2001. The first general release should be relatively soon after that. Any comments on the design are welcome.

Observatories and Research Facilities for EUropean Seismology
Volume 1, no 3 October 1999 Orfeus Newsletter

Minutes ORFEUS workmeeting. Birmingham, IUGG99, July 27, 1999

Attendance: 25 persons (see attached list)

Presentations

- Torild van Eck (secretary general ORFEUS) presents status ORFEUS
- Bernard Dost (director Orfeus Data Center) presents status ODC
- Tim Ahern (Director IRIS Data Management Center) presents specifics on IRIS with relevance to ORFEUS operation.
  - data management and future expectance
  - IRIS DMC is a global data center, Apart from collecting data from IRIS stations, the IRIS DMC is also responsible for archiving continuous data from globally distributed FDSN stations. IRIS DMC has regional ambitioins within the US, but not within the European-Mediterranean area. Regional European data are made available through cooperation with ORFEUS.
  - ORFEUS is the regional archiving center for Europe.
  - some specific cooperation issues with ORFEUS:
    - Global Spyder maintenance
    - homogenization of data access: Wilber
    - NetDC developments

  - conclusion: ORFEUS and its data center (ODC) are important for the IRIS DMC
- Domenico Giardini (new president of board of directors ORFEUS) presents his ideas about ORFEUS/ODC (and EMSC).
  - Europe needs only one seismological center, i.e. EMSC and ORFEUS should join there operations!
  - Orfeus Data Center (ODC) should fit in a long-term strategy for data availability, i.e. we need:
    1. a permanent (seismological) data center in Europe
    2. to archive all data (continuous data preferable!)

  - ORFEUS has a co-ordination task. Optimal effectiveness of the many national networks in Europe requires integration and co-ordination.
  - Real time data access of seismograph stations within Europe should be an overall target. Principly there should be no limitations on data access due to data restriction motives or technical difficulties.
  - Where to go? Proposes to make a new plan to upgrade the ORFEUS operation.
- Winfried Hanka (ex-president ExeCom ORFEUS and responsible for GEOFON) presents the GEOFON operation and its data center.

Discussion

moderator: George Helffrich, new member Scientific Advisory Board ORFEUS/EMSC)

- George presents his view on the situation.
  - He differentiates between two different groups of people interested in international (European) data access:
    - National needs - i.e. hazard/information/CTBTO
      arrival times, waveforms, calibration info, data embargo for crisis management, primarily rapid/short time access
    - Research needs - i.e. basic research
      waveforms, calibration, data stewardship/archiving, temporary deployments rarely short-term data access.

- George questions:
  What is the least common denominator?
  What is the role of ORFEUS? dilemma: The usual request is: We want your data.

Lowest common denominator is the similarity of shared data - it is all broadband. A will to communicate the data must be developed, for two reasons:

1. immediate mutual benefit to locating earthquakes and determining uniform magnitudes
2. to establish the principle of full access to data.

Issues:
Real time data access (for national needs?). Problems:

1. technical. Implementation of procedure like rcp, AutoDRM, telephone, internet.
2. data restriction motivated by funding considerations (MedNet as an example), as well as crisis management.
3. rapid access may not be allowed due to the national needs of homogeneous information, i.e. a few days delay of data.

Data Archiving

1. All data (i.e. continuous and all BB stations in Europe?)
2. Event data
   a. from what magnitude range
   b. which stations (discussions around ORFEUS network)
3. Temporary deployment data

Data access for research (only?).

1. off-line (CDROM/DVD) all stations?
2. on-line (ftp/www)
3. NetDC, i.e. distributed data archiving center.

Discussions

On archiving

- Archiving continuous data at ORFEUS
  This requires a significant upgrading of the ORFEUS operation, i.e. significant additional funding on a regular basis. Hereby should be noted that it is presently difficult to obtain continuous European funding for ORFEUS/EMSC type of operations.
- Gathering all BB data (events with M > 4.9)
  This is presently the goal for ORFEUS.
- larger data centers (such as ORFEUS) should operate as a backup data center.
- practical problems (large costs)
  with large amounts of data on CDROM/DVD and unknown factor about its usefulness. CDROM solves data permanence problem by distributing it to many sites; total loss becomes highly improbable. Different solution may lie in Internet access, since access and selection procedures are rapidly improving.

  Proposed action: ODC-volumes (CDROM with SEED event data) only for selected European-Mediterranean stations (i.e. ORFEUS network definition).

- Data archiving of temporary deployments is presently bad.
  ORFEUS has initiated some activity towards homogeneous archiving. More actions are required.
  ODC should have a prominent role in stewardship/brokerage of BB data from temporary deployments (Soren Gregersen). Presently, data from such deployments disappears far too often in oblivion and is lost. In the USA NFS funded temporary deployments include the obligation to deliver data to IRIS (Tim Ahern). In Europe no similar requirements exist. This is unacceptable.

  Proposed action: ORFEUS board of directors should convince the funding organisations to include data saving requirements within the funding conditions.
  Provide contact info and/or prototypical letters to members of national funding agencies to encourage them to make data archiving a funding requirement.

  Proposed action: Although the ODC develops continuously reformatting tools, this activity should be pursued further with the aim to facilitate formatting to SEED.
  Many data suppliers find the data reformatting (FDSN prefers to SEED for complete relevant information) difficult and costly. Winfried Hanka offered relevant software. ORFEUS Working Group 3 should provide relevant software aids and hardware advice.

On data access for research:

- NetDC provides (in near future) access to data from all major data centers.
  Proposed action: ODC as a data brokerage organisation. The ORFEUS board of directors should put pressure on others to provide their data to the archive. Researchers should request the data from the national networks, who do not have a priority in research needs (Tim Ahern).

On real time data access:
Proposed action: The ODC is developping and implementing procedures to improve near real time data access. This should be and is a key issue for the next year.

Conclusions:

- Questions and suggestions were raised and needs to be worked out.
Up-date. Discussions between Chris, Domenico (and George?) about a joint action to get ORFEUS and EMSC closer (i.e. under one denominator). Bernard and Torild will present a few practical options for ORFEUS (expanding) activities. Chris and Domenico are prepared to approach Brussel for financing.

Proposed strategy:

- The Scientific Advisory Committee for ORFEUS-EMSC works out a scientific plan for the next five years addressing many of the issues, but primarily from the users point of view, i.e. what is necessary. Consultations with the president of the ORFEUS board and the ORFEUS ExeCom are encouraged.

- The ORFEUS staff works out a technical plan with two or three alternatives that consider different sets of requirements. As a basis the discussions at the work, board- and execom-meetings will be used. These alternative should provide a background for funding consultations.

- Domenico Giardini and Chris Browitt will take action in order to find funding on a more permanent basis from European sources for the operations of ORFEUS/EMSC. The SAC report and the ORFEUS staff report should provide the background material for this action.

Up-date. The EC has given a green light for the project proposal "MEREDIAN". Negotiations towards signing the contract are being worked on.

Bernard Dost, Torild van Eck, 7 September, 1999
additions by G. Helffrich, 12 October, 1999

Meeting attendance:

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Observatories and Research Facilities for EUropean Seismology
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Announcements

- **ORFEUS in Birmingham IUGG99**

  ORFEUS workmeeting. Discussions about the ORFEUS operation and summarized in the minutes. ORFEUS participants are invited to vent their opinion either to the ORFEUS ExeCom (President Jan Zednik or the ESC Scientific Advisory Committe (SAC) (among others George Helffrig).
  ORFEUS board meeting. Domenico Giardini (ETH ZÜrich) has replaced Ota Kulhanek (Uppsala University) as president of the board. Ota has been president since the birth of ORFEUS. Winfried Hanka (GFZ, Potsdam) has replaced Michael Weber (GFZ, Potsdam) as German representative in the board. George Stavrakakis (NOA-IG, Athens) has joined the board representing Greece.
  ORFEUS Executive Committee (ExeCom). Jan Zednik (CAS GI, Prague) has replaced Winfried Hanka (GFZ, Potsdam) as president of the ExeCom. Roderick Stewart (IMS/CTBTO, Vienna) has joined the ExeCom as new member.
  ORFEUS Working Groups. The working groups on "station siting", "technical support" and "software" had meetings. Results of these meetings will appear on their respective web sites and the newsletter. Workshops are planned on "Java in seismology" and "Deployment of Mobile networks" for the year 2000.

- **GSE2SEED version 1.0**

  Version 1.0 of GSE2SEED is available. This new version converts GSE2.0 to full SEED provided that all information (including poles and zeros formulation of the response function) is available in the GSE format. Please, report problems, bugs or suggestions for improvement to Reinoud Sleeman.

- **ODC-volumes 27 - 37 are out**

  11 new CDROMs have been printed and are being sent to the participants. They contain the complete SEED volumes for events during 1994. For any comments on these volumes, please, contact Läslo Evers.

- **SEED volumes on WILBER**

  The intention is to replace the SPEED access to the SEED data by ORFEUS Wilber. Consequently, the ODC-volumes for 1992 - 1995 are presently available through WILBER.
  Note: Please note that we plan to replace old Spyder® data as new quality controlled

SEED data becomes available. Old data in Spyder® from stations in the European-Mediterranean area are replaced by quality controlled SEED data. Old Spyder® data from stations not in the region are replaced by quality controlled data available at IRIS.
Any comments or suggestions, please, contact: Bernard Dost or Läslo Evers.

- **EC-project MEREDIAN positively evaluated**

The KNMI co-ordinated an EC proposal 'MEREDIAN' for the benefit of ORFEUS. This proposal submitted June 1999 to the EC program "Energy, Environment and Sustainable Development" under "Support for Research Infrastructure" has received a "favourable evaluation". This means that contract negotiations with the EC have been started.

The project includes as participants: KNMI (De Bilt) IGN (Madrid), ING (Rome), NOA-IG (Athens), GFZ (Potsdam), CNRS (Nice), ZAMG (Vienna), ETH (Zuerich), NORSAR (Kjeller) and GSS (Ljublijana). Co-ordinator is Torild van Eck of the KNMI/ORFEUS.
Details on the project will appear on the web and in the Newsletter when the contract signing has been finalized.