Centre Sismologique Euro-Méditerranéen
European-Mediterranean Seismological Centre

Newsletter

N° 6 DECEMBER 1994

EDITORIAL

The new format adopted for the Newsletter enables a more complete coverage of the subjects presented concerning the activities of the Centre, and prevents it from being restricted to administrative news. This Newsletter is equally open to articles dealing with information exchanged between laboratories, post-earthquake experience, etc...

The preceding issue, the first in this new series, considered the new procedures for rapid epicentre determination, and described the networks and operations of the three key nodal members associated with this task: IGN (Madrid); ING (Rome); and LDG (Paris). It analyzed the results obtained. Since the last issue, the precision of epicentral determination has further improved due to EMSC receiving data from additional networks (see the last page of this issue).

This issue presents two new activities of EMSC, adopted during the Rome assembly, and now in operation: the rapid source parameter determination and the strong motion database. They are operated respectively by the key nodal members GFZ (Potsdam) and CGDS (Moscow). These activities, also related to research laboratories and engineers, should assist in widening the EMSC audience.

The new structure of EMSC, characterized by the distribution of its main activities to key nodal members, and coordinated by the Secretary General is reliable, efficient, and operates at a minimum cost. The structure is unique in Europe, in the Council of Europe sense, and in the Mediterranean basin. As this new structure expands, it will be able to fulfill the needs and hopes of its members.

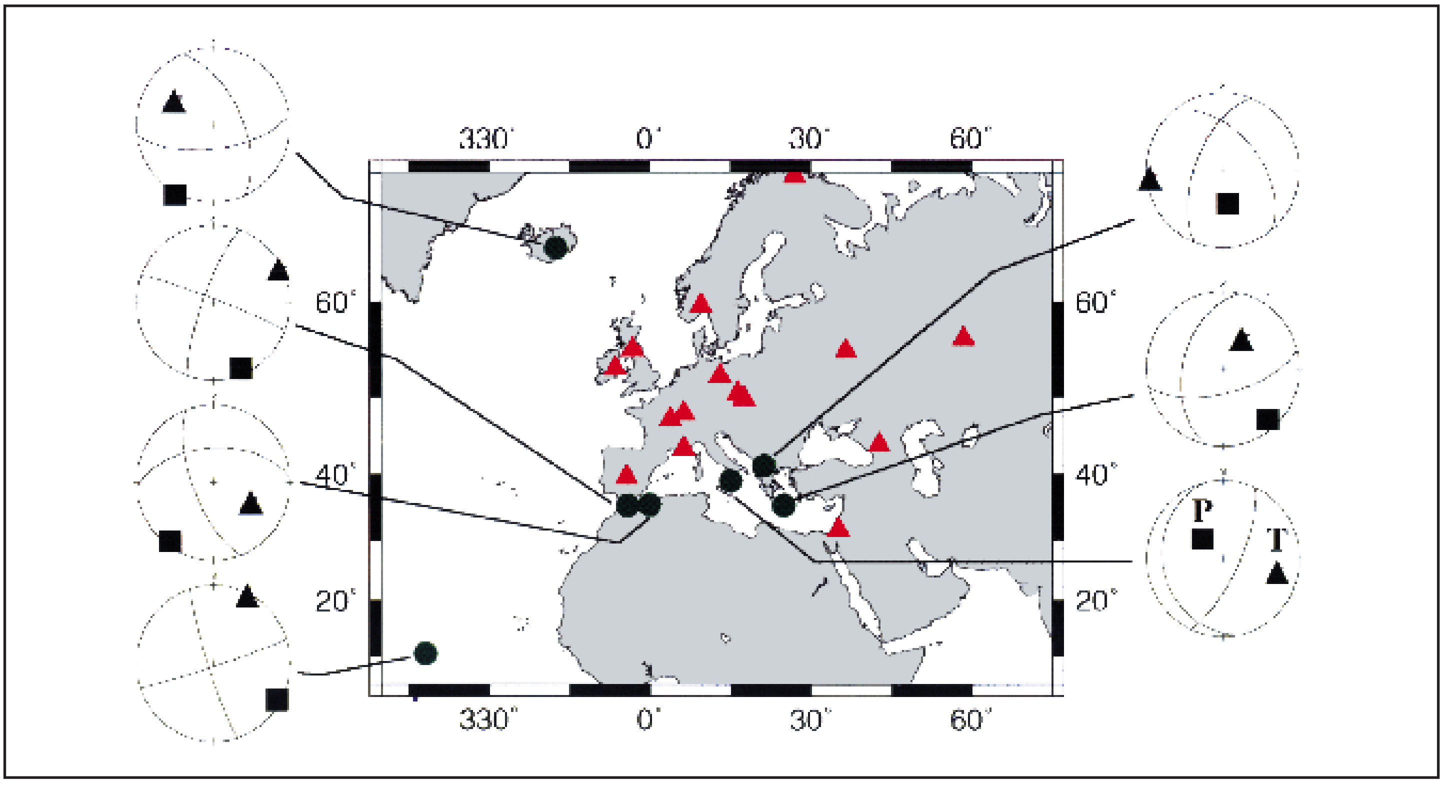
EMSC now represents the preferential base for the exchange of seismological data in the Euro-Mediterranean zone; it represents a potential host for future coordinations between existing initiatives. Links have already been established both on an institutional level with ORFEUS (broadband seismology), and on a personal level with the Transfrontier group for countries with moderate seismicity. Members of EMSC are presently carefully considering the feasibility of a European seismological database with a distributed structure, supported by centres wishing to participate to the network development.

A large step forward has been made with the adoption of the new statutes. Consolidation and development of the new EMSC remains to be accomplished to ensure a better European foothold (I hope the setback in our negociations with ECHO in Brussels is only temporary). This will be the exciting task of the new team elected during the Athens assembly, to take effect on January 1, 1995: President - Chris Browitt (BGS, UK); first Vice-President - Yves Caristan (LDG, F); elected members - C. Papaioannou (AUTH, GR), R. Verbeiren (ORB, B) and C. Weber (BRGM, F). Next year will also see EMSC moving to its new open premises kindly provided by LDG.

Finally, let me just tell you the pleasure I had to act as President of the EMSC for the last few years, and my satisfaction to see now the new EMSC working and developing as we were expecting last year at the same period of time. I would like to thank all of you for the trust you put in the new EMSC. It contributed greatly to make our efforts successful. I look forward to the promising future of our Centre.

Bon vent à tous ! and seasons greetings to all,

Christian Weber
Outgoing President



EMSC Rapid Source Parameter Determination - Source mechanisms of 1994 earthquakes investigated during the test phase.

EMSC RAPID SOURCE PARAMETER DETERMINATION

G. Bock, W. Hanka and R. Kind (GFZ Potsdam)

Introduction

As from the end of 1994, GFZ Potsdam will routinely calculate seismic source parameters of strong (M > 5.5) European earthquakes and disseminate the results rapidly to EMSC users. The main emphasis of this newly established EMSC service will be on an improved focal depth estimate and the determination of the seismic moment tensor for a double couple source using broad-band and long-period waveform data. It is the objective of this article to describe the various steps of the analysis and to present some results that were obtained in 1994 when the new procedure was extensively tested. A quick overview of the procedure is given in the flow chart below.

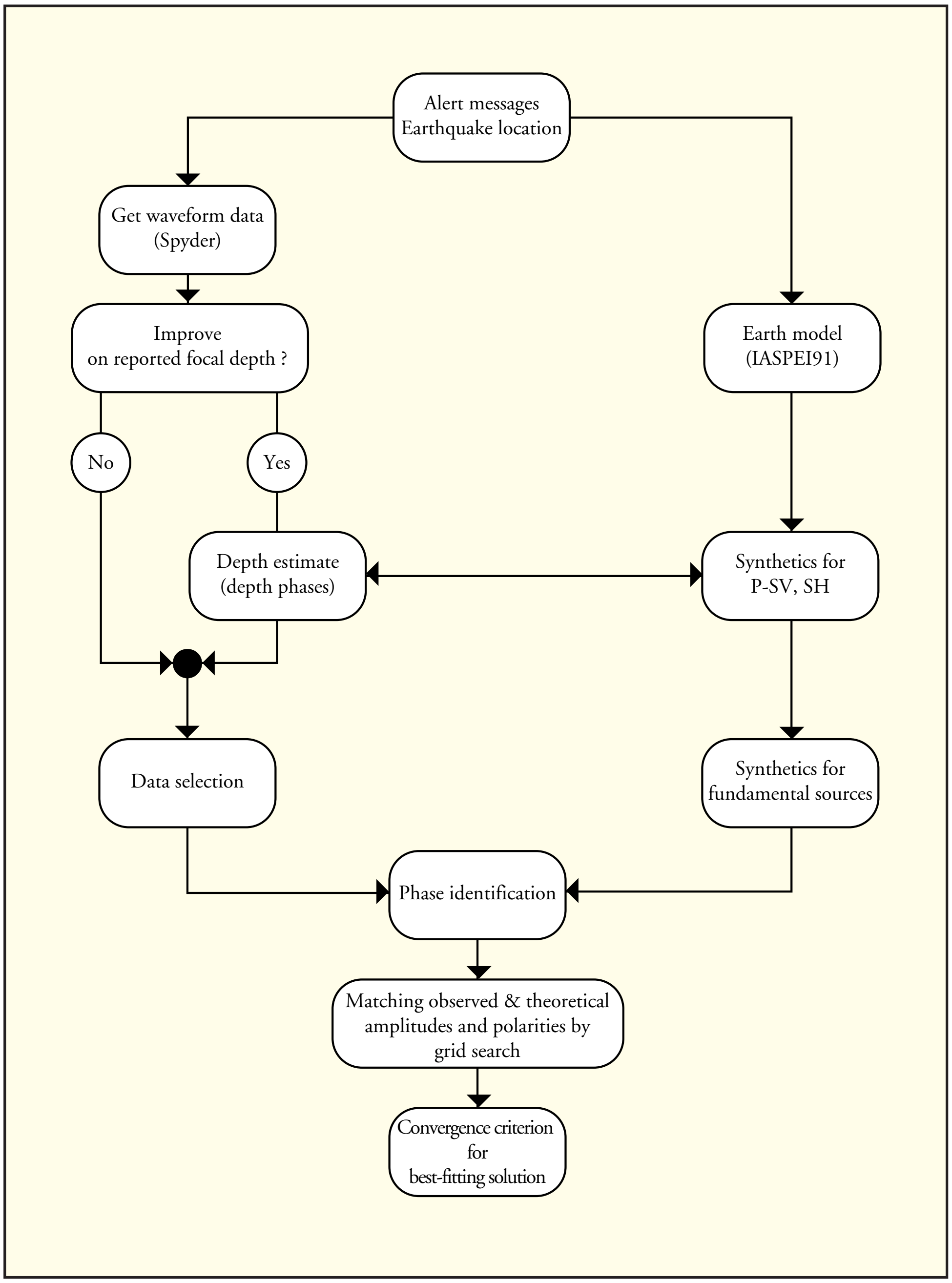
Method of moment tensor determination

The double couple moment tensor is derived from the amplitudes and polarities of body wave phases recorded at regional and teleseismic distances. Generally, amplitudes of seismic phases depend on the radiation pattern of the earthquake source, geometrical spreading, losses through absorption and scattering, and reflection and refraction at seismic boundaries. The general idea is to minimize the differences between observed amplitudes and polarities and their theoretical values as a function of fault strike, fault dip, direction of slip and the scalar seismic moment.

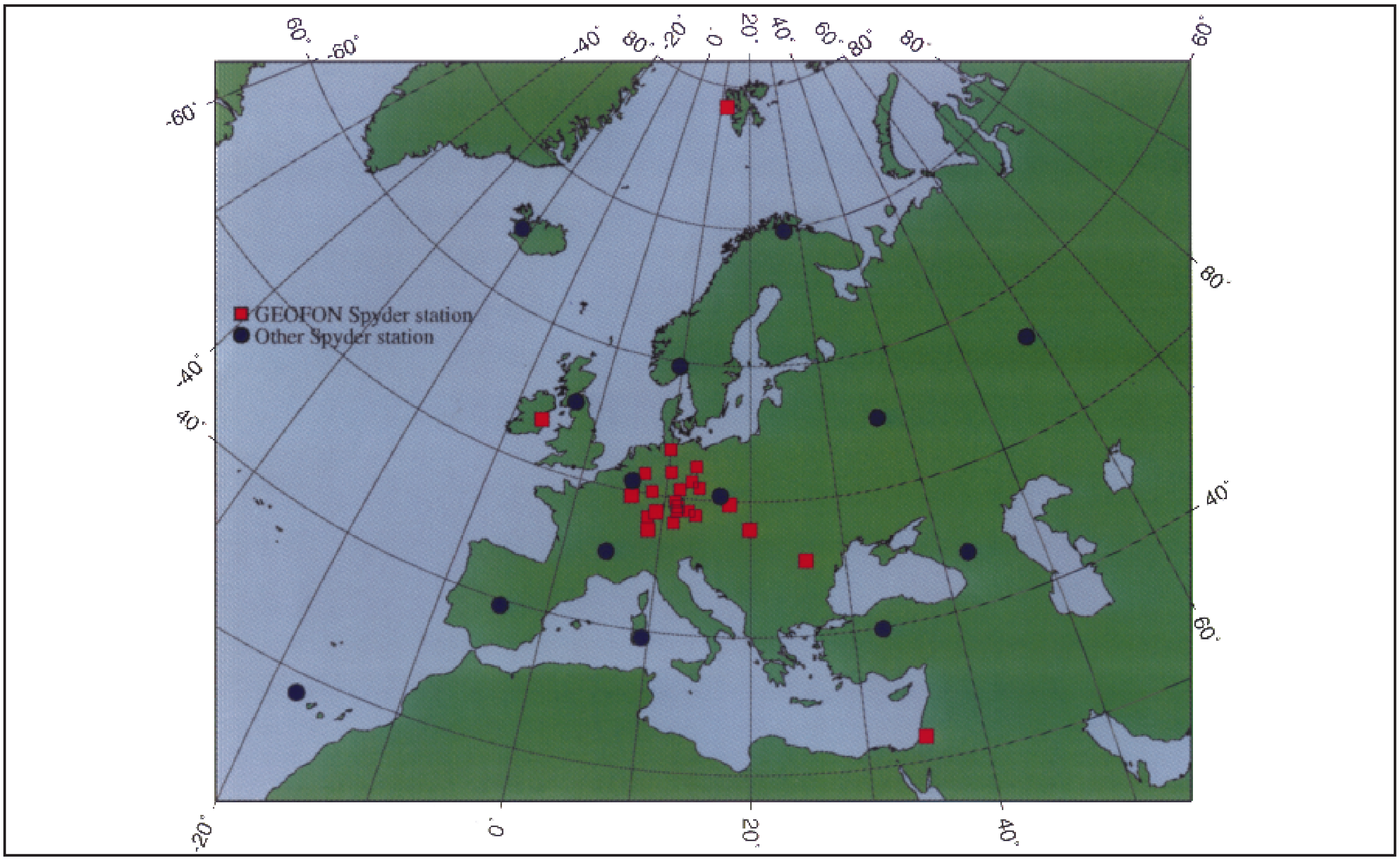
The procedure is outlined in the flow chart of below. First, the available waveforms are inspected for the presence of depth phases and the focal depth estimate reported with the alert message will be modified if necessary. An estimate of the source duration is obtained by measuring the width of the P-wave displacement waveforms derived from broadband records. Then the Earth response (Green's function) is calculated for P-SV and SH with the reflectivity method for the corresponding focal depth. As the reflectivity method is very time consuming, we store the Earth response on file for a range of focal depths. This has the advantage that synthetic seismograms for the fundamental source orientations (i.e., 45 degree

The GEOFON online data pool

The determination of seismic source parameters makes use of broad-band and long-period waveform data that normally become avaible through the GFZ Spyder (former Gopher) system a few hours after significant earthquakes. The online data pool contains near-realtime data that are automatically collected after major events from available global and European stations in a joint effort with IRIS and ORFEUS. The system which has been installed with the help of IRIS DMC forms part of the GEOFON programme at GFZ Potsdam. Spyder is a global seismological communication network which consists of four main nodes at Seattle (IRIS), Tokyo (ERI), Utrecht (ORFEUS) and GFZ Potsdam. After alert messages are issued, for example by NEIS or EMSC, the Spyder main nodes automatically dial up seismograph stations and extract event waveform data. Current practise at GFZ is to extract waveform data from the GEOFON stations, the GRSN (German Regional Seismograph Network) stations and some additional ones (ZUR, PSZ, STU, GERESS, GRFO); these data become available in the online data pool normally a few hours after receipt of the alert message. Waveform data from other SPYDER stations are copied through ORFEUS into the GEOFON online data pool and are also used for the source parameter determination whenever they are available. The locations of the GEOFON, GRSN and the other SPYDER stations in the European area are depicted in the figure next page.



The procedure implemented at GFZ Potsdam.



Distribution of European Spyder stations used for the source parameter determination (red squares : stations accessed by the GEOFON Spyder system, blue circles : stations accessed by ORFEUS or IRIS/IDA).

dip slip, 90 degree dip slip and pure strike slip along a vertical fault) can be calculated very quickly from the stored Green's functions. Theoretical seismograms for any arbitrary shear dislocation can then be quickly derived from the synthetic seismograms for the fundamental source orientations.

At the same time when synthetic seismograms are calculated, data are selected from the online data pool and appropriate filters are chosen that result in good signal-to-noise ratios. In the test phase 1994 we employed bandpass filters with cut-off frequencies between 0.02 and 0.33 Hz. The low-frequency end of the passband is chosen as small as possible in order to obtain a reliable estimate of the scalar seismic moment.

The next step in data analysis is the identification of body wave phases. This is done on the vertical and rotated horizontal (radial and transverse) component seismograms. Identification of P and S phases is straightforward. Their peak-to-peak amplitudes are measured and polarities of P and SH-waves are noted if they are unambiguous. Amplitudes of other phases (e.g., depth phases, PP, ScS) can also be used if they can be reliably identified. Following phase identification, the orientation of the shear dislocation described by strike Q, dip d and rake l angles is varied over the parameter space 0° Q 360°, -90° l 90°, and 0° d 90° in order to minimize the misfit between observed and theoretical amplitudes and polarities. A requirement for a valid solution is that as many as possible polarity readings are fitted by the orientation of the shear dislocation source. For this, we use a simple score count.

In all the cases we have investigated so far, polarity data alone were insufficient to constrain a fault-plane solution. Further constraints come from the amplitude data. A logarithmic l1 norm is employed to judge the goodness of fit between observed and theoretical amplitudes. The quantity

$$\sum_{i=1}^{n} \left| log_{10} a_0 - log_{10} a_c \right|$$

is minimized as function of Q, d, and l. The a_O and a_c denote observed and calculated amplitudes, and n is the number of all phases used in the inversion.

The scalar seismic moment M_{OS} as derived from the s-th station is obtained by minimizing the quantity'

$$\sum_{j=1}^{n} (f_i - M_{os} g_j)^2$$

where f_j is the amplitude of an observed phase, g_j the theoretical amplitude for unit seismic moment, and j the number of amplitude observations per station. The scalar seismic moment M_O is then obtained by averaging over all stations for which values of M_{OS} can be derived. In cases where the instrument response is uncertain, we still can use the amplitude data by minimizing differences in normalized amplitudes rather than in true amplitudes, however, we cannot use these stations for the determination of the seismic moment.

Examples 1994

Till the end of October 1994, the method has been tested with 7 earthquakes. Earthquake locations and the stations used in the inversion are shown on the cover page of this Newsletter. These events are described in the Table next page. A comparison with the Harvard moment tensor solutions shows that reasonable agreement with regard to the type of faulting was obtained for events 1, 2, 4, and 5 although the inferred fault planes of the double couple solutions may somewhat differ between Harvard and our preferred solutions. Major discrepancies are noted for events 3 and 6 while a Harvard solution for event 7 was not available.

Event N°	Origin time Yr/Mo/Dy/Hr/Min	Latitude	Longitude	Depth (Km)	Mw
1	94/01/05/13:24	39.04	15.03	290	6.0
2	94/01/25/07:12	10.50	-42.00	10	5.9
3	94/05/05/05:14	64.60	-42.00	10	5.4
4	94/05/23/06:46	35.50	24.80	80	6.2
5	94/05/26/08:26	35.40	-4.10	10	5.9
6	94/08/18/01:13	35.52	-0.12	10	5.6
7	94/09/01/16:12	41.13	21.20	20	5.3

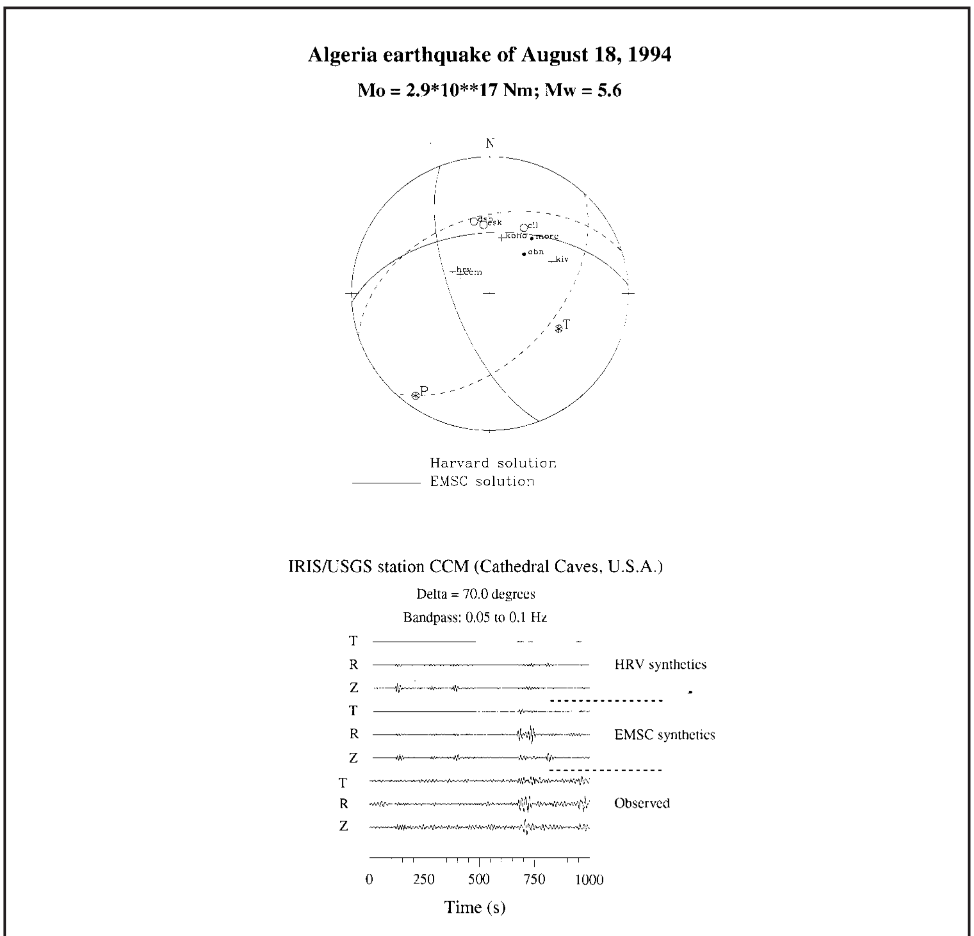
1994 earthquakes investigated during the test phase (The Mw of event 2 is the Ms estimate reported by PDE)

It is interesting to note where the differences between HRV and our solutions arise. In the case of the August 18 Algeria earthquake, the HRV solution is almost pure reverse faulting while our (EMSC) solution is strike slip with a major component of reverse faulting. The synthetic seismograms for station CCM in the figure below nicely illustrate where this discrepancy arises. The observed S wave amplitudes at about 700 s relative time are larger than the P wave amplitudes. This feature is well modelled by the EMSC solution while the P wave amplitudes predicted for the HRV solution are too big relative to S. We also note that the EMSC solution matches the observed P wave polarities. Generally, however, we cannot always expect good agreement between EMSC and HRV solutions because quite different frequency bands and methods are used. The procedure now implemented at GFZ allows us to obtain a mechanism of the initial stages of rupture while HRV gives a centroid solution of the whole rupture history.

In the case of the May 26 Strait of Gibraltar earthquake the type of faulting (predominantly strike slip) is the same, but the strike directions of the inferred fault planes differ by about 20° between our and the HRV solution. Aftershocks following the earthquake of May 26 define an approximately N20°E direction which agrees well with one fault plane of our solution. It suggests that the 200° fault plane was the actual rupture plane in this earthquake.

Concluding remarks

The deviatoric component of the seismic moment tensor of strong European earthquakes will be routinely determined at GFZ as from January 1, 1995, and the results be disseminated to EMSC users as quickly as possible, on behalf of the Coordination Bureau of EMSC. Some delays will inevitably occur. They arise from the time lapse between earthquake occurrence and the receipt of the alert message, and they also depend on the time needed to retrieve the waveform data after the alert message has been received. Based on this year's experience, the delay may accumulate in some cases to more than 12 hours. Delays may also arise from the fact that GFZ has not the capacity to provide a continuous 24 hour service. Nevertheless, we hope that under normal circumstances we can disseminate a moment tensor solution within 48 hours after the event. A test message will be sent out to all EMSC users on January 02, 1995.



Inferred source mechanism of the August 18, 1994, Algeria earthquake.
Observed seismograms at CCM and synthetics for the Harvard CMT solution (top) and the EMSC solution (middle).

EMSC STRONG MOTION DATABASE

Center of Geophysical Data Studies

postal address: CGDS JIPE/ILP P.O.Box 23, Moscow 109651, Russia
electronic mail address : gvi@cgds.msk.su, jjn@wdcb.rssi.ru

The Center of Geophysical Computer Data Studies (CGDS) was founded in January 1991 as a joint effort of the Russian Academy of Sciences and the International Lithosphere Program. CGDS is a key-nodal member of the European-Mediterranean Seismological Centre (EMSC) in Russia. The Centre is affiliated with the Joint Institute of Physics of the Earth (JIPE) of the Russian Academy of Sciences (RAS) and the International Lithosphere Program (ILP) - a joint IUGS/IUGG program devoted to the geodynamical studies based on joint analysis of geophysical and geological data. As a part of the ILP, the centre operates in close coordination with the ILP Coordinating Committee on Data Exchange and Centres.

CGDS consists of two groups. They are: the laboratory of artificial intelligence in geophysics and the laboratory of global seismic hazard information processing. The total number of the CGDS permanent staff is 15 people including 12 scientific researchers and 3 persons of technical staff. Up to 10 students from Moscow Lomonosov University work on their thesis at the CGDS in connection with different projects of the Centre. CGDS is equipped with 3 SUN 3/50 workstations, 7 IBM PC 486 DX and 10 IBM 386 SX/DX. The centre has direct connection with INTERNET and completes the installation of TCP/IP protocol. Direct access to X.25 (TRANSPAC) and electronic mail facility are also available at the CGDS.

CGDS leads and participate in various scientific and technical projects. Syntactic pattern recognition applied to seismic signal analysis is the principal activity of the artificial intelligence group, while development of PC oriented Geographic Information Systems (GIS) as basic instrument for global seismic hazard data processing is the major activity of the other CGDS group.

Beside its activities as a key-nodal member, CGDS is also contributing to the Rapid Determination of Epicentres. The CGDS data server in Moscow is used as a mirror site between the Earthquake Information Center (EIC) in Obninsk where station reports for the whole former Soviet Union are centralized and the EMSC in Bruyeres-le-Châtel.

Strong motion data base: structure and principles of operation.

The Strong Motion Data Base (SMDB) is a relational seismic waveform data base, which allows to store on different platforms (e.g. Sun workstation, IBM PC) and retrieve on the data base server console or through telecommunication channels the waveforms together with a set of essential parameters of the events, stations and instruments. To obtain on-line access to the SMDB, it is required to send a letter of intent to the CGDS to become a registered user. The registered users are able to use telnet to access the menu-driven front-end of the SMDB for data retrieval in text-mode and visualization using X Windows. The needed data will be received by electronic mail.

In the SMDB, data separates into two categories :

I Waveform Data - binary representations of the digital (or digitized analog) strong motion records, and

II Parameter Data - alphanumeric data derived from or pertaining to waveform data.

The waveform data takes the largest space in the SMDB. For the territory of northern Eurasia (former Soviet Union) the amount of data in the binary waveform files is about 15 Mbytes comparing with the 2 Mbytes data sets of the parameters. Nevertheless, the proposed structure of the SMDB allows to maintain a direct access support of the worldwide SMDB (Table 1) at low price IBM PC compatible computers.

As in the Center of Seismic Studies Database, the digital data may be packed into few files usually related to a specific seismic event, e.g. the Spitak 1988 earthquake, and the entire data base may be described within one compact index file.

Table 1. SMDB contents summary.

Data Set	Records	On-line	Events	Stations	M	R, km	Source
United States	2024	1572	89	232	3.0-7.7	2-223	WDCA
Italy	1132	905	68	96	3.0-6.5	1-192	WDCA
Russia	610	610	56	36	3.1-7.2	4-126	CGDS
Mexico	281	85	6	32	? -8.1	21-385	WDCA
China	160	160	31	7	3.2-7.8	7-154	EMSC and CGDS
Japan	177	177	53	39	4.7-7.9	3-319	WDCA
Peru	30	30	7	5	5.3-7.8	73-372	WDCA
Nicaragua	24	24	6	3	4.0-5.6	5-32	WDCA
Total	**4405**	**3563**	**316**	**450**	**3.0-8.1**	**1-385**	**CGDS**

The design of the index file utilizes a relational database management system (DBMS). Digital data is stored in non-DBMS files, which are indexed by a relation describing the data and the physical location of the data in the binary direct access files within the file system. The consequence of this design is the physical separation of the description of waveform data from the waveform data itself, which allows rapid identification and retrieval from the direct access binary waveform data files stored on disk(s), using the conventional queries for the standard DBMS format data sets of the waveform parameters.

Data is received at the SMDB in sets of various (usually ASCII) formats from different sources and are converted to one "station + channel" file in the Contemporary ASCII Format (CAF), so that any waveform channel may be retrieved by the same software and with the same kind of identification. Thus, all waveforms (whether from arrays, three- or single-component stations) are treated on equal footing. The sketch of the data flow in the SMDB is shown in the figure below.

After the necessary preprocessing, including visual control, windowing, scaling to standard units (cm/sec2, cm/sec or cm), component rotation and instrument correction, the waveforms are stored as segments of a compressed binary direct access file. For the next waveform, the data samples may still be placed in the same binary file, and no mark is placed to denote the beginning of a new segment, or a new binary file may be created. This helps keeping the database consistent, easy to update and compact since features of event, instrument responses and location would be the same for many segments.

Strong motion data base contents for the territory of northern Eurasia.

Data consists of 610 "station + channel" components for 56 events (3.1 M 7,2) recorded at 36 stations (4 km R 126 km, Table 2). Up to now all the digital records are stored in the uncorrected form.

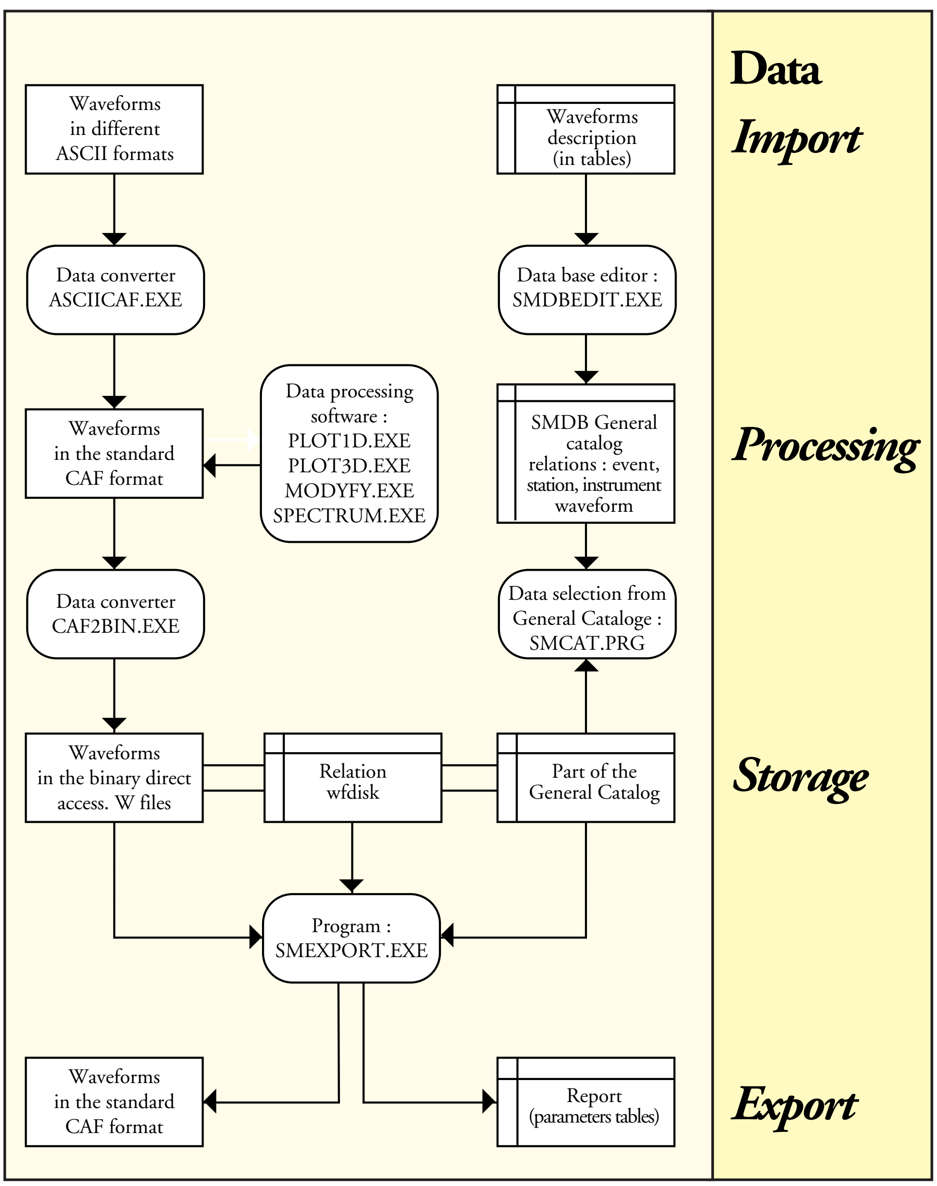
May 17, 1976, Gazli main shock.

The main shock of May 17, 1976, 02h58m40.6sec UTC, 40.38°N, 63.47°E, magnitude 7.2 MS [JIPE], dip-slip, focal depth 10 km, was felt in Gazli, Uzbek SSR, with an intensity of about IX (MSK), six people were killed and 10,000 homeless in Gazli area. The Joint Institute of Physics of the Earth, Moscow, recorded the main shock on a triaxial self-contained optically recording accelerograph located at Karakyr Point, 40.35°N, 63.45°E, hypocentral distance 22 km (S-P readings). The instrument was located at ground level and had the following characteristics: sensitivity, 14.5 mm/g; frequency range, 0 to 20 Hz; film speed, 13 to 15 mm/sec; a triggering system that starts the instrument at MMI intensity level IV (approximately); and a trigger delay of less than 0.2 sec. The subsurface geology at Karakyr Point consists of clay and sandstone, 1420 m thick, underlain by highly resistant metamorphic schist.

The strong motion record from the main shock of May 17 has some defects: the film supply went exhausted while the earthquake was in progress. The record is therefore limited to the first 15 sec of strong motion. The vertical peak ground acceleration during the recorded part of the earthquake exceeded 1 g.

March 19, 1984, Gazli earthquake aftershock sequence.

The main shock of March 19, 1984, 20h28m39sec UTC, 40.38°N, 63.30°E, magnitude 7.2 MS [JIPE], focal depth 16 km, was felt in Gazli, Uzbek SSR, with an intensity of about IX (MSK). The Joint Institute of Physics of the Earth, Moscow, began operating portable seismic stations in the epicentral area March 22, 1984. During the weeks after the main shock, 15 triaxial self-contained optically recording accelerographs were installed in the epicentral area. The network was formed by 7 sensitive instruments ASZ-2 (60 mm/g) and rather rough recorders ASZ-1 (2 sites), SSRZ-M (6 sites) with sensitivity about 20 mm/g. All instru-



Sketch of the data flow in the SMDB

Data set	Records	Events	Stations	M	R (km)	Source
Gazli-76, main shock	3	1	1	7.2	22	IPEM
Gazli-84, aftershocks	148	25	11	3.2-5.2	2-45	IPEM
Spitak-88, main shock	6	2	1	5.8-7.0	37-41	IPEM
Spitak-88, aftershocks	75	6	7	4.1-5.2	7-41	IPEM
Spitak-88, aftershocks	372	21	14	3.1-5.2	4-126	US GS
Dzhava-91,main shock	6	1	2	7.0	100-120	IPEM
Total	**610**	**56**	**36**	**3.1-7.2**	**4-126**	**CGDS**

Table 2. Contents of the SMDB for the territory of northern Eurasia.

ments had free-field locations (without shelter) with different soil conditions.

From March 22 to May 27 more than 800 aftershocks were registered. The strongest one (intensity VI-VII MSK) was recorded on April 11 at the station "31-km", with a peak vertical acceleration 0.3 g. Later in 1984 a set of the strongest 148 components were digitized.

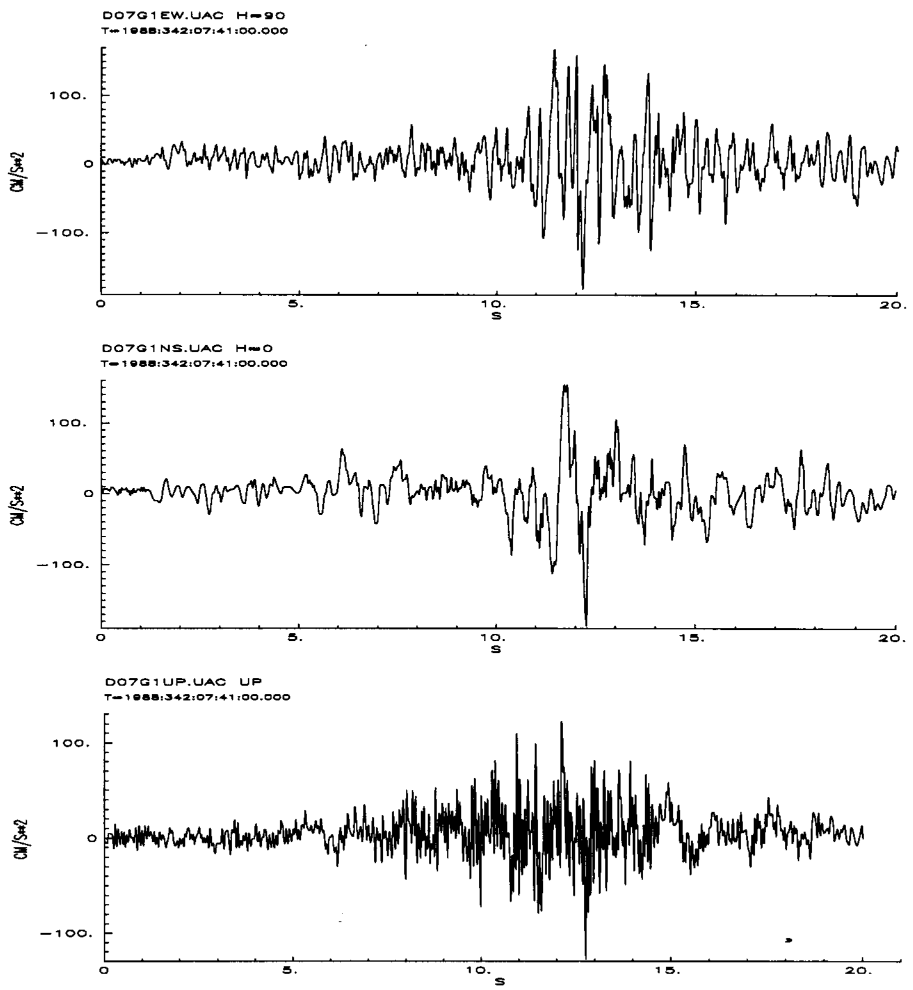
December 7, 1988, Spitak earthquake and aftershock sequence.

The Armenian earthquake of December 7, 1988, 07h41m24sec UTC, 40.99°N, 44.19°E, magnitude 6.9 MS [NEIC], reverse, focal depth 5 km, intensity about X (MSK), produced widespread destruction in the region around the cities of Spitak, Leninakan, Kirovakan with subsequent life loss exceeding 25,000.

The main shock of the earthquake was recorded at the Gukasian seismic station, 35 km North from the epicenter, by the optically recording accelerograph SSRZ-M with the horizontal peak acceleration of 193 cm/s2.

Twelve days after the earthquake, Soviet and French seismic networks were installed in the epicentral area, and 3 days later a field team from the USA installed another network. In the current SMDB version the digital strong motion data obtained by the Soviet and US teams are included.

The Soviet seismic network (7 sites) was equipped by the triaxial self-contained optically recording accelerographs SSRZ-M and ASZ-2. From December 19, 1988, to March 30, 1989, 6 the strongest aftershocks were registered. Later in 1989, a set of the 25 3-component accelerograms were digitized at the Joint Institute of Physics of the Earth, Moscow.



Records of the Spitak main shock.

The US seismic network (14 sites) was equipped by the broad-band high signal resolution digital registers GEOS with the FBA-13 sensors. From December 22, 1988, to January 5, 1989, the network registered 21 aftershock.

FORUM

RAPID DETERMINATION OF EPICENTRES : AN UPDATE

Since the last issue of our Newsletter (July 1994), another four institutes are providing us with data from their seismological networks. The table below lists the new data providers as well as the code which will be used to identify them in the messages released by EMSC.

Code	**Institute**	**Country**
GSSC	Geophysical Survey of the Russian Academy of Sciences, Obninsk	RUSSIA
PPTM,PPTA or TPTM, TPTA	Laboratoire de Détection Géophysique, Tahiti, French Polynesia	FRANCE
ORB	Observatoire Royal de Belgique, Brussels	BELGIUM
LED	Geological Survey of Baden-Wuerttemberg, Freiburg	GERMANY

CALL FOR PAPERS

The EMSC Newsletter, in its new format, will be published 3 times a year. It intends to be an informative tribune open to the whole scientific community. The focus of the Newsletter will be mainly on topics such as data collection and exchange, real-time earthquake analysis, and seismological research related to the Euro-Mediterranean basin. Scientific papers dealing with such topics are welcome. Manuscripts must be in English, no more than 4-typewritten-page long and may include color figures. Publication will be free of charge, provided that the papers are camera-ready copies. Prior to publication, all papers will be reviewed by at least one reviewer.

CENTRE SISMOLOGIQUE EURO-MEDITERRANEEN
EUROPEAN MEDITERRANEAN SEISMOLOGICAL CENTRE
c/o LDG
BP12
91680 Bruyères-le-Châtel, FRANCE
Phone:+33-169264992; +33-169265373
Fax:+33-169264966; +33-164903218
Telex:681862 LABOGEO
E-mail:csem@ldg.bruyeres.cea.fr

Merry Christmas & Happy New Year!

Synop6 Nancy