Observatories and Research Facilities for EUropean Seismology

Volume 5, no 2 **September 2003** **Orfeus Newsletter**

ORFEUS Electronic Newsletter

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Observatories and Research Facilities for EUropean Seismology

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Moment tensor determination for the Ibero-Maghrebian region

Daniel Stich, Jose Morales, Flor de Lis Mancilla and Gerardo Alguacíl

Instituto Andaluz de Geofísica, Universidad de Granada, Campus Universitario de Cartuja s/n, 18071 Granada, Spain

Introduction

The crustal deformation in the Iberian Peninsula, northwestern Africa and the adjacent offshore areas is controlled by the Africa-Eurasia plate collision and extensional processes in the western Mediterranean Basin and Alboran Sea. The regional seismicity is characterized by a diffuse geographical distribution and mainly low to moderate magnitudes. Only in the Atlantic Ocean and northern Algeria, seismicity appears to be focused around a linear plate boundary, and moderate to large earthquakes occur with certain frequency (ISC On-line Bulletin). To date, moment tensor solutions for thirty-four northern Algerian earthquakes are available from routine moment tensor projects on Mediterranean and global scale (like the Harvard CMT project, Dziewonski and Woodhouse, 1983, MedNet regional CMT, Pondrelli et al., 2002, and ETH European Mediterranean moment tensors, Braunmiller et al., 2002). They consistently show reverse to strike-slip faulting style and NW-SE oriented P-axes, and can be related directly to the plate convergence between Africa and Iberia.

Earthquakes are rarely exceeding magnitude 5 on the Iberian Peninsula, northern Morocco, the westernmost Mediterranean Sea and the Atlantic Ocean south of Portugal. Twenty-four events altogether are included in catalogues of European or global routine moment tensor projects. This small set of moment tensor solutions can not be expected to sample adequately the tectonic deformation over this large area with several geotectonic domains and complex neotectonic evolution. For a more detailed seismotectonic picture in and around Iberia, we apply full-waveform analysis to obtain the source parameters of the more frequent small-to-moderate events. Analysis of smaller events requires the use of seismograms from the combined Iberian broadband networks and implies performing key parts of the data processing manually. Moment tensor inversion is then performed in a routine manner for all regional earthquakes with local magnitude >= 3.5 for the Iberian Peninsula, Northern Morocco and adjacent off-shore areas, and local magnitude >= 4.0 for Northwestern Algeria. To date, our catalogue contains eighty-four moment tensor solutions for the Ibero-maghrebian region (Figure 1), ranging in size from moment magnitudes 3.5 to 5.8 (http://www.ugr.es/~iag/tensor/, Stich et al., 2003a).

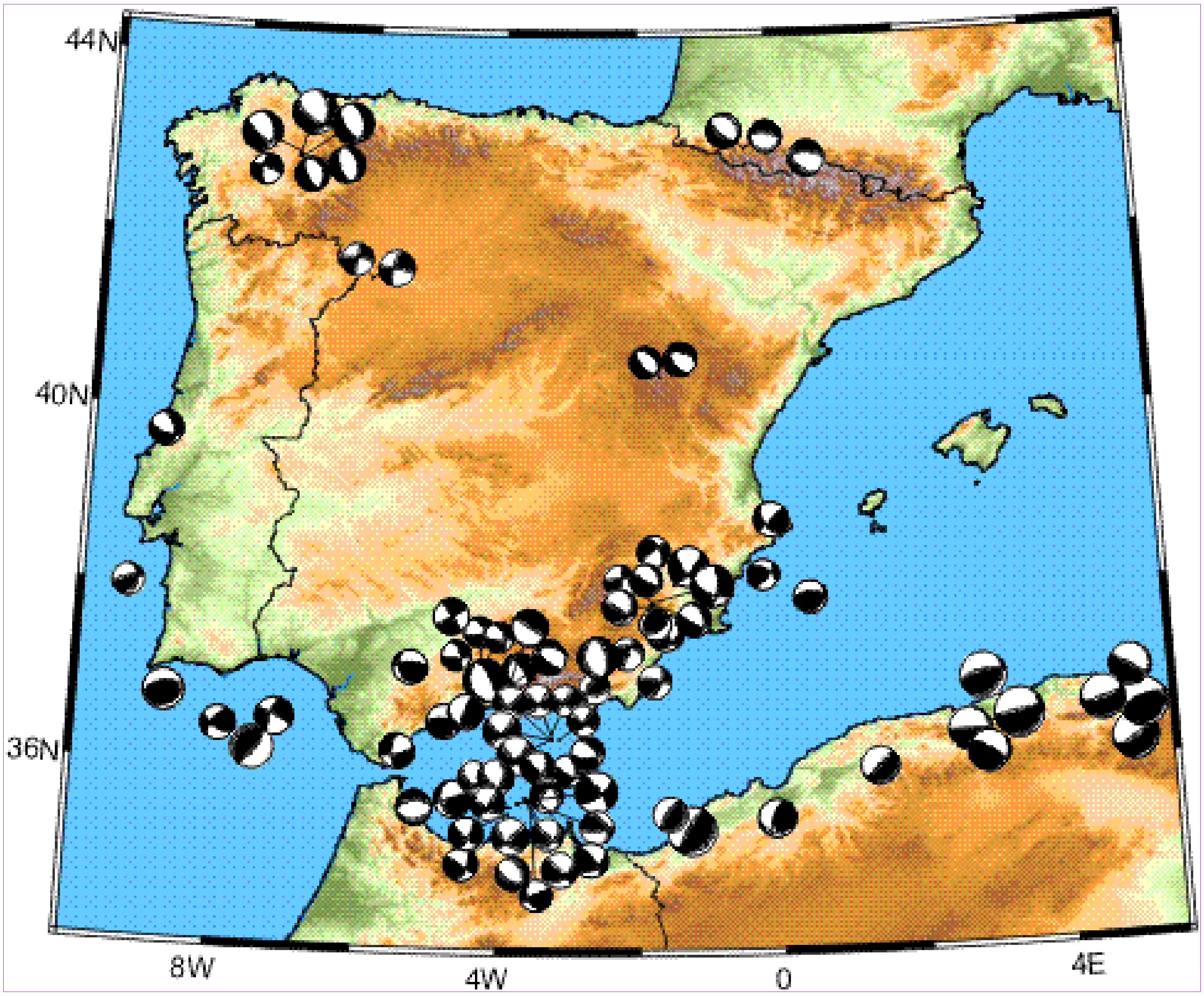

Figure 1. Moment tensor mechanisms available from the IAG moment tensor catalogue. Solutions are dense in the southeastern part of the Iberian Peninsula and in the Alboran Sea, and sample several other seismic zones over the Ibero-Maghrebian region as well.

Moment tensor catalogue

We invert for the deviatoric moment tensor by minimizing the least squares misfit between observed and predicted displacement waveforms at regional distances (Langston et al., 1982). Greens functions to predict displacement are obtained with a reflectivity code (Randall, 1994), parameterizing the lithosphere as a plane layered halfspace with average properties for regional travel-paths in the study area. Three different models are used for wave propagation predominately off-shore, within Alpine domains, or within Hercynian domains (Stich et al., 2003a). Prior to inversion, the observed waveforms and Greens functions are filtered in an intermediate-to-long period pass band, to correct adequately for propagation effects by restricting the inversion to wavelengths that average out small-scale lateral heterogeneities. Typical filter bands are 50 to 20s for events with Mw > 4, and 35 to 15s for events Mw <= 4. Absolute travel times for P-waves are calibrated by aligning seismograms and synthetics at the first arrival. A unit step source time function is assumed when working with the regional long period waveforms of the small and moderate events (Mw < 6).

Moment tensor inversion for small events in a geologically heterogeneous environment is not a trivial problem. The basic requirement for inversion is an appropriate set of broadband waveforms, possibly with good azimuthal coverage, and possibly including stations within near-regional distances and tectonically uniform travel-paths. Also, the inversion procedure cannot be fully automated. A crucial manual task is refining the natural distance-dependent amplitude weighting until obtaining a stable inversion result and adecuate waveform matches. This is generally an iterative procedure. Criteria to down-weight or exclude waveforms are high noise level or propagation along complex paths (where the Greens functions for plane layered media do not provide an appropriate correction). Traces may also be weighted to balance the station coverage over the focal sphere. Moment tensor estimates are usually sensitive to focal depth, and we combine the linear moment tensor inversion with a grid search over a range of depths to evaluate this non-linear effect. Based on the L2-misfit-vs.-depth curve and depth dependence of waveform matches, we select a most appropriate combination of depth and mechanism.

Once a moment tensor solution is obtained, it is double-checked by dislocation grid search modeling. This alternative way to invert magnitude and double-couple focal mechanism serves as a resolution test: We compute waveforms for the full ranges of dislocation source orientations and depths, and then compare them with the observed seismograms to identify the range of valuable mechanisms. The fault angle parameters strike, dip and rake are sampled every 10\272. Those double couple sources that produce significantly larger L2-misfits than the global minimum can be excluded (based on waveform matches, we consider 10% difference a conservative estimate). We usually observe equivalence of both, focal mechanism and quality of fit, for inversion and double couple grid-search, supporting the interpretation in terms of double couple force systems. Nevertheless, the non-double couple component (CLVD) included in the general deviatoric moment tensor may be helpful to absorb effects of uncorrected propagation, noise and finite sources.

With our magnitude criteria, we selected hundred-ninety events since autumn 1995, when the permanent broadband networks probably reached a minimum standard for regional time domain inversion for magnitudes Mw >= 4. For seventy-seven events, we obtained moment tensor solutions that adequately fit the main characteristics of the regional waveforms and passed the grid-search resolution test. With seven solutions for events in the 1980s, using data from the temporary NARS experiment, this amounts to a catalogue of eighty-four moment tensors to date. Recent improvements of broadband network coverage contribute to higher success rates. For the 18 months period November 2001 to April 2003, moment tensor solutions were obtained for twenty-four earthquakes, i.e. ~50% of all events with local magnitude >= 3.5. This is noticeable exceeding the amount of eight solutions that provided routine moment tensor projects on the European scale for the same period. Recent moment tensors include multiple event solutions for the seismic sequences in August 2002 in Bulla, Murcia, SE-Spain (MW<=5.0), January 2003 in Zamora, NW-Spain (MW<=4.2) and February 2003 at the Alboran Ridge (MW<=4.8). Currently, sufficient waveform data for the combined Iberian networks become available within weeks after an earthquake. Our inversion results, waveform fits, and grid-search analysis are posted on-line at http://www.ugr.es/~iag/tensor/.

Examples: Sevilla 2002 and Cordoba 2003

Over most of the Iberian Peninsula, the moment tensor focal mechanism map is dominated by normal or strike slip faulting style, and ~NE-SW orientation of pseudo T-axes. Yet these characteristics do not apply to all mechanisms and several unexpected solutions appear. So far, this is observed mainly in southern Spain, however this may be an effect of better sampling due to higher seismicity. We discuss two selected mechanisms to illustrate heterogeneous faulting and the accuracy of waveform modeling under favorable conditions.

Two small to moderate earthquakes (MW=4.1 and 4.2) occurred within 5 months at a distance of ~75 km from each other in Sevilla (September 15th 2002, 020915) and Cordoba (January 24th 2003, 030124) provinces in western Andalusia. For these epicentral locations we have good azimuthal station coverage, and we used a selection of near-regional broadband waveforms that are available through Geofon (MTE, SFS, CART), IRIS (PAB) and from several IAG stations (SELV, ANER, ARAC, SESP). The inverted moment tensor solutions match the waveforms well in a pass band from ~15 to 35s (Figure 2), except for effects of un-modeled local earth structure at SFS (event 020915) and ANER (event 030124). ANER is a nodal station for the Cordoba focal mechanism, as confirmed by small amplitudes in the vertical component, but waves with transverse polarization are projected onto the radial component because earth structure is not plane layered at this part of the coast. Large amplitudes at the horizontal components of SFS may be attributed to local amplification in the sedimentary environment (this has been observed for several events, Stich et al, 2003a). These traces have been excluded from inversion (weight zero), as well as the radial component of CART (event 030124) with high noise level. For both events, moment tensor solutions are well resolved according to dislocation grid-search modeling.

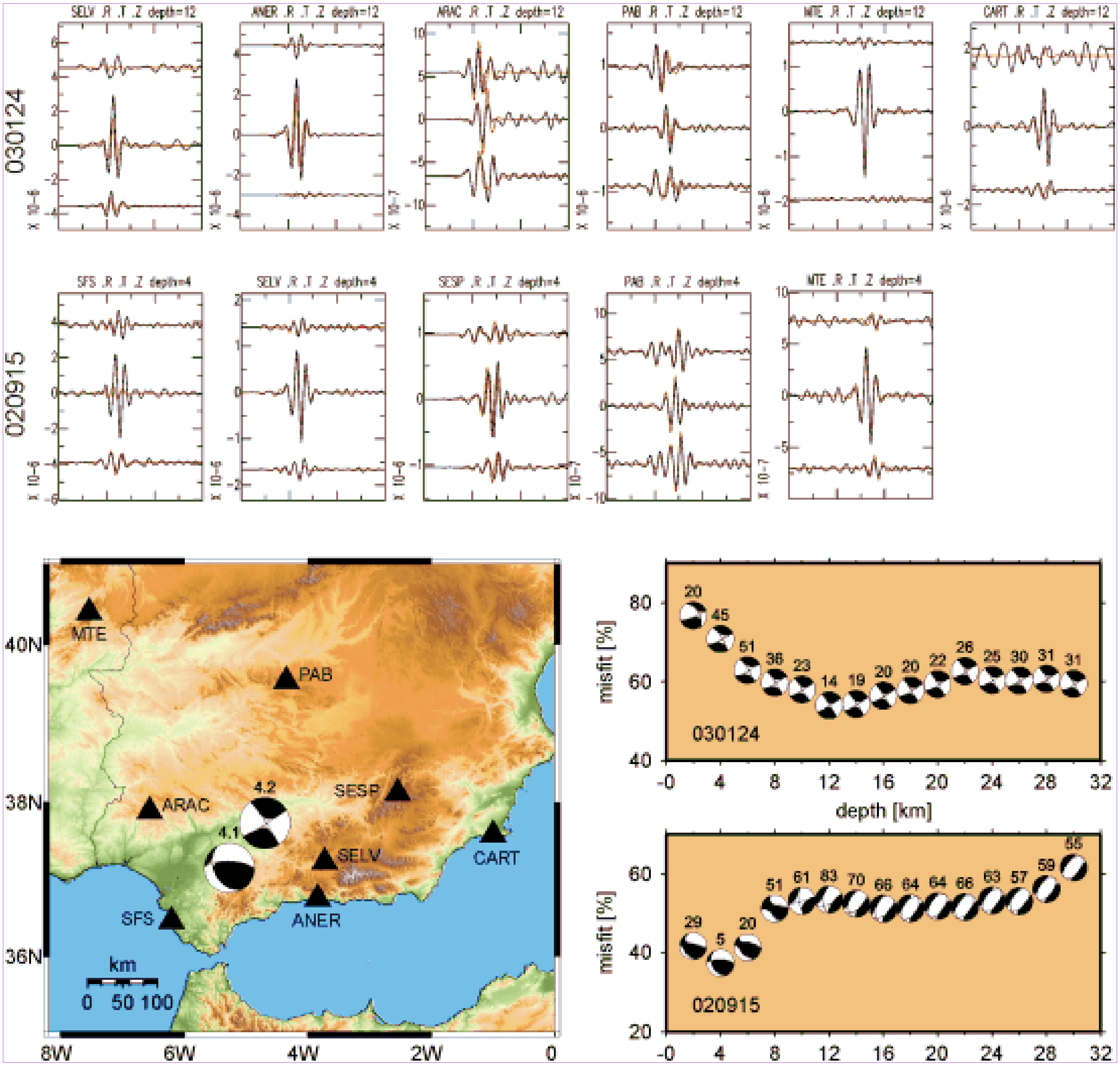

Figure 2. Waveform matches at near-regional distances (100 km to 400 km) and moment tensor solutions for two recent MW~4 events in western Andalusia. Waveforms show from top to bottom radial, transverse and vertical components of displacement, observed seismograms are plotted in black and moment tensor synthetics in red. Waveform boxes show 300s time windows, vertical scale is [m]. The recording geometry (epicenters and selected stations) is given in the map. Two boxes illustrate the evolution of moment tensor solutions with depth, along with the L2-misfits (vertical axes) and CLVD components (numbers above the beach-balls).

The mechanisms are fundamentally different from each other: The Sevilla earthquake shows predominately reverse faulting with P-axis azimuth of N17°E, while the Cordoba earthquake is almost pure strike-slip, with P-axis orientation of N283°E, nearly perpendicular to the Sevilla event. Particularly for the Sevilla quake, results are different from the nearest moment tensor mechanisms at distances of about 100km for the Granada Basin, Gulf of Cadiz and Gibraltar regions, and also from the average trend for the Iberian Peninsula. The occurrence of focal mechanisms that are severely rotated relative to the regional reference orientation suggests heterogeneous tectonic stresses on a local scale, and points to fault interaction.

Summary

We apply time domain moment tensor inversion to full regional long-period waveforms of earthquakes from the Ibero-Maghrebian region and obtained moment tensor solutions for eighty-four events to date. Seventy solutions for the Iberian Peninsula, westernmost Mediterranean Sea and easternmost Atlantic Ocean give a more complete picture of the tectonic deformation of the Iberian microplate, compared to previous moment tensor studies. Moment tensor mechanisms indicate a predominately normal faulting regime over most of the Iberian Peninsula, predominately strike-slip faulting in the Alboran Sea and predominately reverse faulting in northern Algeria. However, several odd solutions point to heterogeneity of faulting and we are still at the beginning of compiling a moment tensor catalogue that represents adequately Ibero-Maghrebian seismotectonics. To collect a larger set of solutions, we have to continuously add moment tensors for future small and moderate events, as well as try to recover and process 20th century, intermediate-period, analogue recordings of moderate earthquakes. An application of time domain moment tensor inversion to the 1910, MW 6.1 earthquake near Adra, southern Spain, was successful (Stich et al, 2003b). Processing of present-day and future seismicity benefits from important recent improvements of several regional broad-band networks. The fairly dense distribution of stations corresponds to the availability of sufficient high quality, near-regional broad-band seismograms even for most of the smaller events.

Acknowledgements

We appreciate the collection and distribution of high quality broad band waveforms by other institutes and data centers, which are at present Geofon, IRIS, ORFEUS, Instituto Geográfico Nacional, Institut d'Estudis Catalans, Institut Cartográfic de Catalunya, Real Observatorio de la Armada, and Universidad Complutense de Madrid. For several past events we used data from the temporal NARS and MIDSEA stations. We are very grateful to Chuck Ammon for his assistance while getting this project started, to him and George Randall for providing program codes, and to the developers of free software SAC and GMT. We receive financial support by the Spanish DGI project REN2002-04198-C02-01, FEDER founds and within the Research Group RNM#104 of Junta de Andalucía.

References

- Braunmiller, J., U. Kradolfer, M. Baer und D. Giardini, 2002. Regional moment tensor determination in the European-Mediterranean area - initial results. *Tectonophysics*, **356**, 5-22.
- Dziewonski, A.M. and J.H. Woodhouse, 1983. An experiment in the systematic study of global seismicity: centroid moment-tensor solutions for 201 moderate and large earthquakes of 1981. *J. Geophys. Res.*, **88**, 3247-3271.
- Langston, C.A., J.S. Barker and G.B. Pavlin, 1982. Point-source inversion techniques. *Phys. Earth Planet. Int.*, **30**, 228-241.
- Pondrelli, S., A. Morelli, G. Ekström, S. Mazza, E. Boschi, and A.M. Dziewonski, 2002. European-Mediterranean regional centroid-moment tensors: 1997-2000. *Phys. Earth Planet. Int.*, **130**, 71-101.
- Randall, G.E., 1994. Efficient calculation of complete differential seismograms for laterally homogeneous

earth models. *Geophys. J. Int.*, **118**, 245-254.

- Stich, D., C.J. Ammon, and J. Morales, 2003a. Moment tensor solutions for small and moderate earthquakes in the Ibero-Maghreb region. *J. Geophys. Res.*, **108**, 2002JB002057.
- Stich, D., J. Battló, J. Morales, R. Macià and S. Dineva, 2003b. Source parameters of the 1910 Mw=6.1 Adra earthquake (southern Spain). *Geophys. J. Int.*, in press.

Observatories and Research Facilities for EUropean Seismology

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Near Real Time Data at NORSAR for CTBT Monitoring

J. Fyen and K. Iranpour

NORSAR, Instituttveien 25, 2007 Kjeller, Norway

Introduction

The Norwegian National Data Center (NDC) is responsible for the design, installation, operation and maintenance of NORSAR's field installations, the data recording and transmission, and the processing and analysis of data. NORSAR's field installations include seismic array stations, three-component seismic stations and radionuclide stations. An infrasound station is planned for installation in 2005. The NDC also maintains databases of seismic data containing digital data of earthquakes, nuclear and non-nuclear explosions since around 1970.
NORSAR performs the technical duties of Norway relating to the Comprehensive Test Ban Treaty (CTBT). The NDC section at NORSAR is tailored to construct, maintain and operate the six Norwegian stations of the International Monitoring System (IMS) established for the verification of compliance with the treaty. Figure 1 shows a map over IMS stations in the Nordic countries including the six Norwegian stations. Under treaty's provisions and described in IMS stations operational manual a set of requirements are to be met. These requirements mostly deal with the issues of data quality and communication between IMS stations and the CTBTO in Vienna, in particular what is defined in the IMS operational manual as data timeliness, data availability and data reliability. The purpose of this report is to describe NORSAR's solution to the issues addressed above.

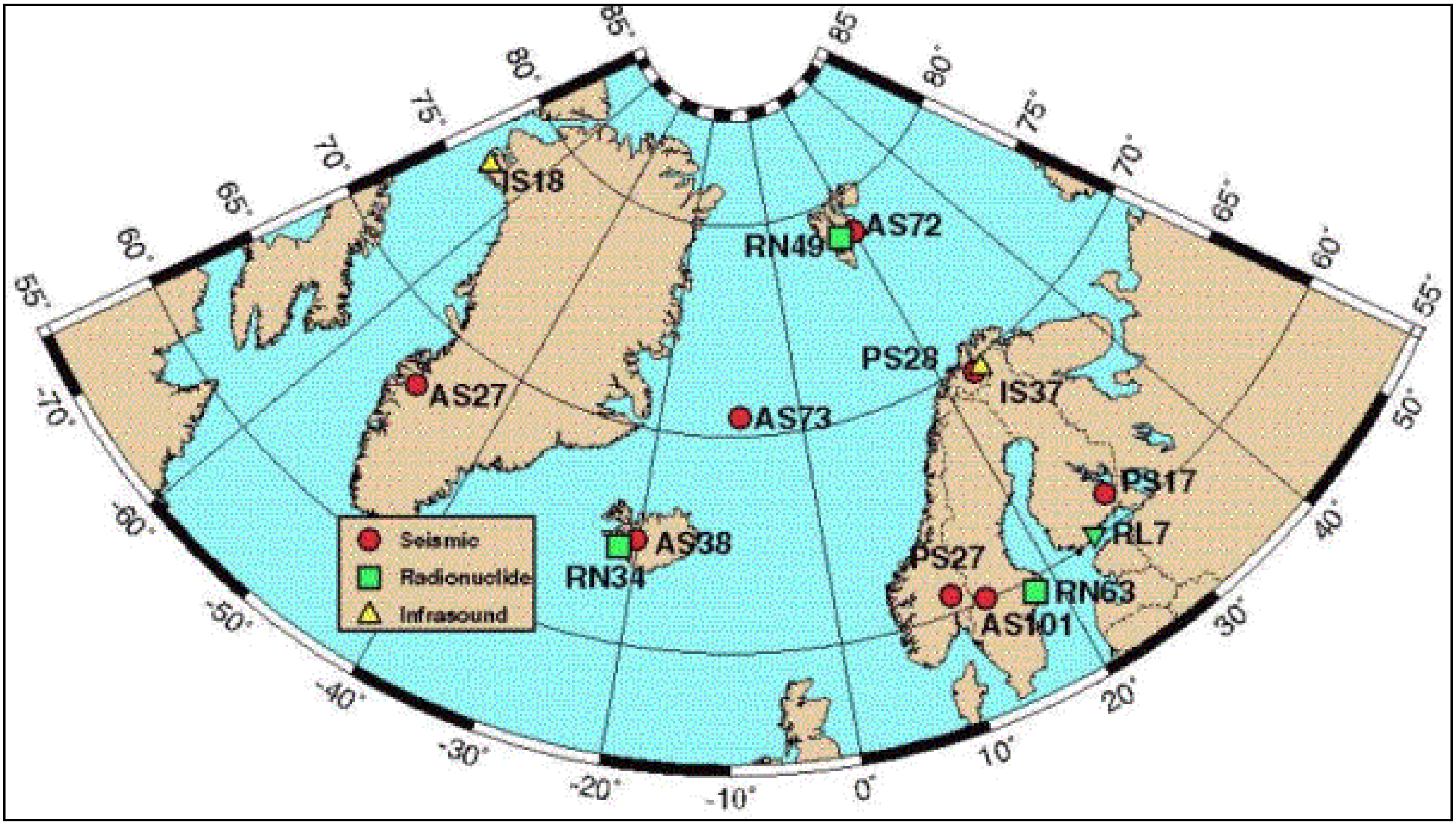

Figure 1. Nordic / Arctic IMS stations. Station codes signify the station type and its number in the IMS network. "PS" and "AS" represent primary and auxiliary seismic stations, "R" represents Radio nuclide stations and "IS" is an InfraSound station.

IMS Stations Operated by NORSAR

Norsar operates three IMS seismic arrays. These are the large teleseismic Norsar array (NOA PS27)* with a diameter of 60km, the regional Arcess array (ARCES PS28) with a diameter of 3km and the small Spitsbergen array (SPITS AS72) with a diameter of 1km. The NOA array consists of 42 different sites with a total of 63 instruments. These are organized in 7 different subarrays. This is the largest array in the IMS network. The ARCES array has 25 sites with 36 instruments and the SPITS array has 9 sites with 12 instruments. SPITS array represents minimum requirements for the size of an IMS array. Figure 2. shows the approximate design of the three arrays and their relative size.

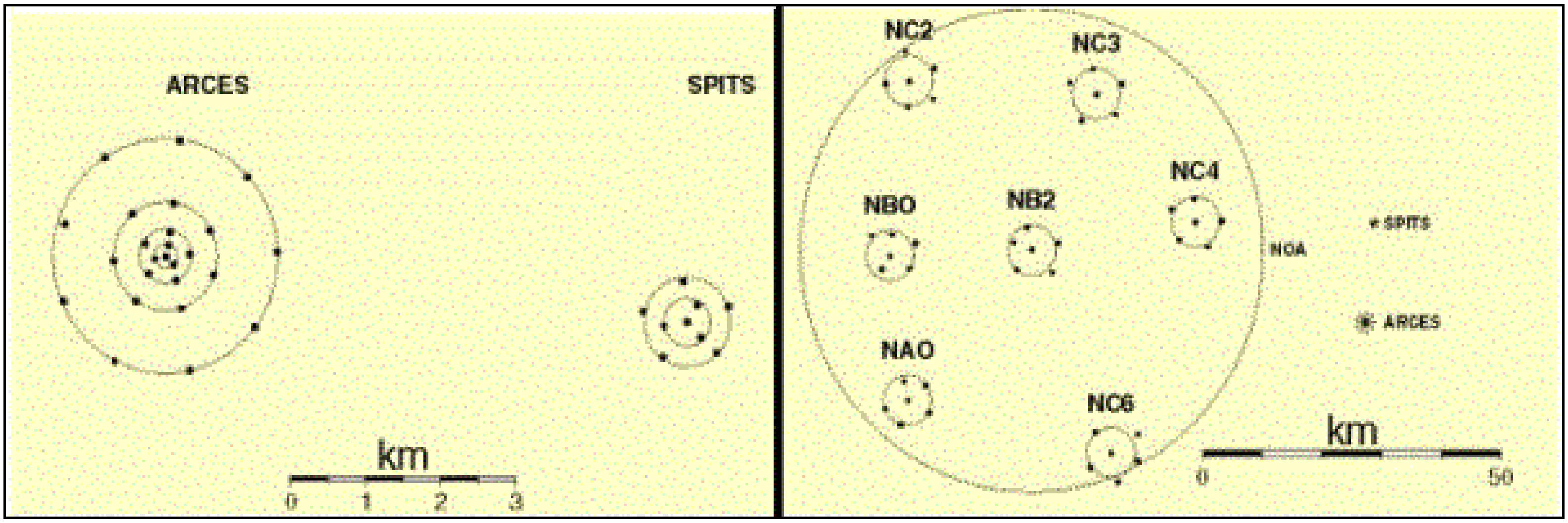

Figure 2. Schematic plot of Norway's IMS seismic arrays. On the left the ARCES array in Karasjok and the SPITS array on the island of Spitsbergen. On the right the NOA array with its group of seven subarrays near the town of Hamar. The ARCES and SPITS arrays are included for comparison.

Data transmission

Near real time data may take several paths from the provider* (station or NDC) to the consumer (IDC). Common to these is the first phase of data transmission and is the transmission of data from individual array element (digitizer) to the Central Recording Facility (CRF). From there on the data is either directly forwarded to the IDC in what is termed basic topology or to the NDC and thereafter to the IDC in what is termed the independent subnetwork. The latter is the choice of implementation for ARCES and SPITS. For NOA, the CRF is at the NDC.

Data from primary stations arriving at IDC must be in the Continuous Data Format, CD1.0 or the more recent version CD1.1. In addition all IMS data destined for the IDC must be authenticated (signed). After January 2000 data must be signed at the digitizer.

Continuous Data Format CD1.0

The Continuous Data Format CD1.0 is a straightforward TCP/IP program-to-program socket communication and is used to send binary formatted data (frames) from the provider to the IDC or conversely from the IDC to the provider. After the initial connection has been established between the sender application and the receiver at IDC, the station sends a Station Identification Frame and receives the designated port for transmission of further data from the other end. Second a Data Format Frame is sent to the IDC identifying the station channels to which the subsequent data belongs. Finally a continuous stream of data frames is sent. The Frames consist of a header containing the nominal time of channel data and a number of subframes each containing data for one channel (normally 10 seconds), time, number of samples in the subframe as well as some state of health data and authentication information (signature). Table 1 shows how a CD1.0 frame is constructed. The status field in each subframe is used for additional state of health data like power on/off, tampering switch, vault open/close etc. Canadian compression is applied on the samples. The "Alpha library" developed by the "Science Applications International Corporations" (SAIC) for the prototype IDC (pIDC) in early nineties is an example of an application used for data exchange between the provider and the IDC. Application of Alpha library is briefly discussed later in this report.

20 bytes Data Frame Header				
4 length	40 signature	8 time stamp	4 # samples	Compressed data samples - 10 seconds
4 length	40 signature	8 time stamp	4 # samples	Compressed data samples - 10 seconds
4 length	40 signature	8 time stamp	4 # samples	Compressed data samples - 10 seconds
4 length	40 signature	8 time stamp	4 # samples	Compressed data samples - 10 seconds
. . N . .				
4 length	40 signature	8 time stamp	4 # samples	Compressed data samples - 10 seconds

Table 1. CD1.0 Data Frame. The number in each cell represents the length of the field in bytes.

Continuous Data Format CD1.`

Continuous Data Format CD1.1 offers some improvements to its predecessor CD1.0. While channel identification is done immediately after the connection is established in CD1.0 through a frame specially designed for that purpose, this happens at the subframe level in CD1.1. Each subframe carries channel information, making it easier to discover errors in the data. Another aspect unique to CD1.1 is the "application acknowledgment" inherent in the design. If the communication protocol does not guarantee error free data transmission, the application acknowledgement level of CD1.1 would compensate for that deficiency. A third addition to the CD1.1 is its ability to issue commands e.g. generating public key, etc.

As to this date the CD1.1 implementation is only available at two IMS stations. The remaining stations still use CD1.0.

SAIC 's "Public Software Bundle" library offers a comprehensive solution to the whole problem of intra station communication, storage and data transmission to the consumer based on the CD1.1 formatted data. The solution is built around the concept of Framestores. A Framestore is basically a set of directories and files for buffering CD1.1 formatted data. Through applications which form part of the public bundle, data can be retrieved and transported to a similar Framestore or larger Framestores formed by multiplexing single ones on the receiving end (CRF/NDC/IDC).

Intra Array Communications

Within an array, each individual site (digitizer) using some error free protocol communicates with the CRF. A frame of information (packet) of some vendor specific format is sent to the CRF by asynchronous, synchronous, UDP or TCP/IP protocol. Data is then converted to CD format and authenticated (signed). The individual site then sends the signature and status information separately from sample data to the CRF. At CRF the CD1 subframes are recreated and along with the corresponding signatures form a 10 seconds CD1 frame which is then sent to the NDC or the IDC. Current systems that use CD1.1 send signed data from digitizer/authenticator in CD1.1 subframes to the CRF.

NORSAR Implementation

The arrays operated by NORSAR was built before 1 January 2000 and thus escaped the requirements later imposed concerning the signing of data at the individual sites rather than centrally. The data arrives at the CRF in some vendor specific format. At PS27 this is Science Horizon's AIM24 single second packets of compressed data. The protocol for transmission is synchronous SDLC (ADCCP). Each frame is synchronized to the start of a second. A communication Interface Module (CIM) connects to the digitizers using an RS422 interface, buffers and delivers one second data frames on the SCSI interface connected to a SUN solaris workstation.

At PS28 Nanometrics HRD24 digitizers pack 17 bytes of compressed data into one frame and transmit this using asynchronous communication to RM4 multiplexers at the center. The RM4 multiplexers are connected with the central SUN solaris workstation in the local ethernet based network. The RM4 acts as a server that can deliver 15 times 17 bytes data frames using UDP protocol.

In both cases the NORSAR applications collect the frames from the AIM24 or the RM4 and store the data into a circular disk buffer. Another application then reads the disk buffer, reformat the data into CD1 subframes and record the data into NORSAR style, time indexed disk loop. Then a third application keeping track of the last transmitted CD1 frame, sends the newly formed frames to the NDC. At the NDC a receiving application takes the CD1 frames and write to a corresponding CD1 indexed diskloop. The concept of NORSAR diskloops is discussed later in this document. Figure 3 and Figure 4 are schematic illustrations of the various steps in NORSAR arrays data communication.

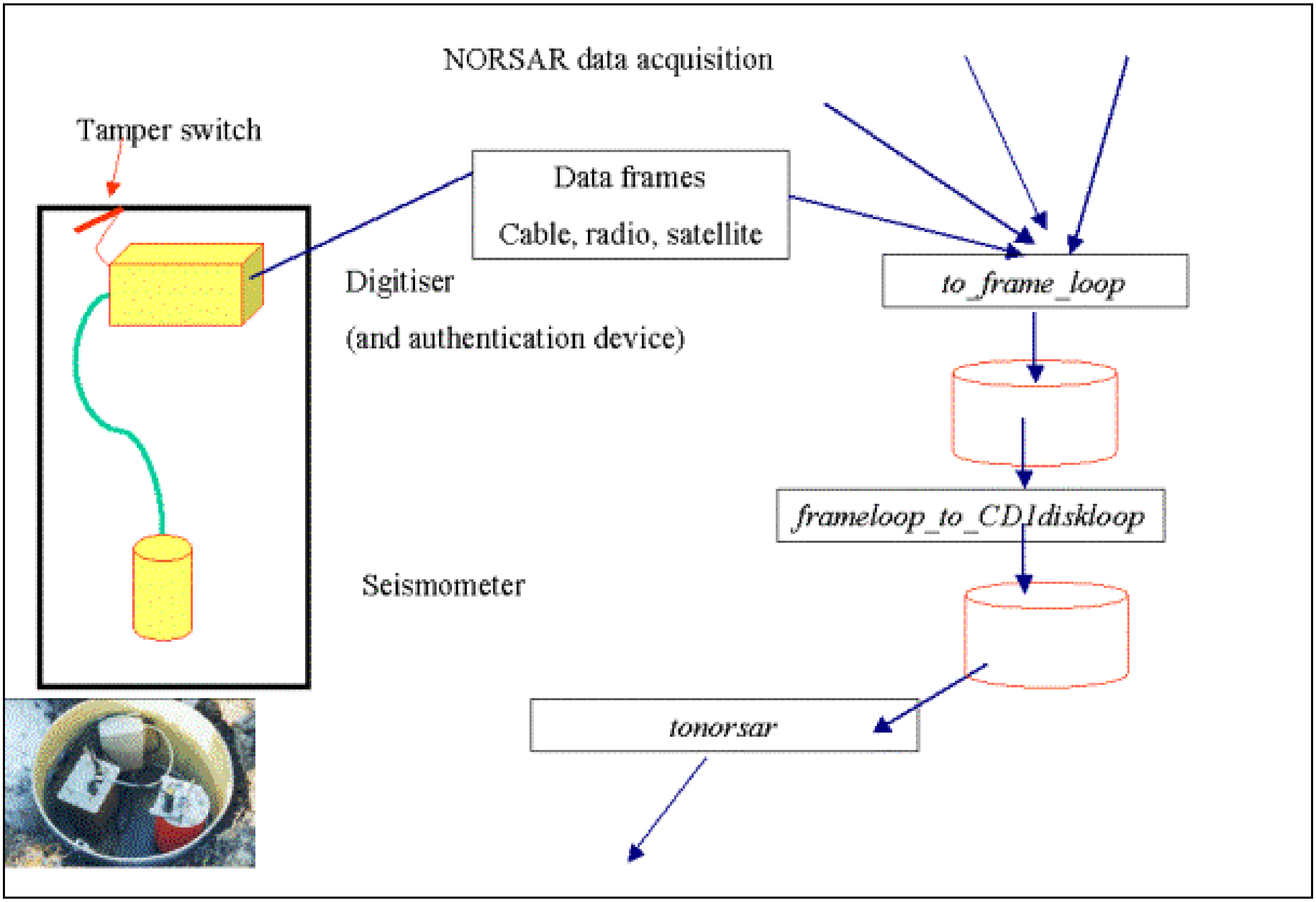

Figure 3. Schematic plot of NORSAR data acquisition from individual sites to the CRF. Data packets are written to a frameloop, converted to CD format before being dispatched to the NDC.

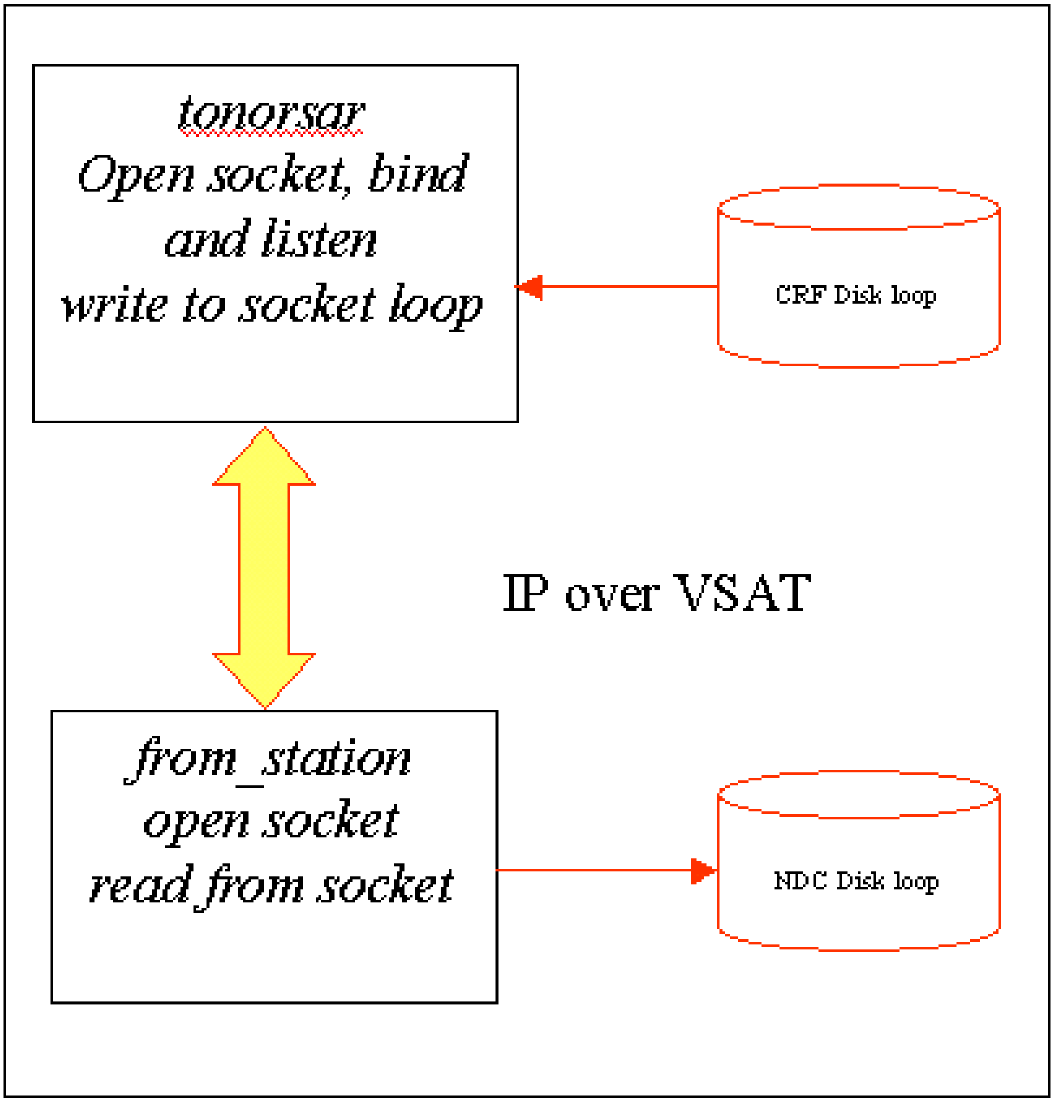

Figure 4. From CRF to NDC. Socket communication used to transmit CD1 frames from one diskloop at CRF to corresponding diskloop at NDC over a VSAT link.

Arriving at the NDC, the CD1 frames are forwarded to the IDC using the Alpha library over the GCI link (at NORSAR this is a frame relay. VSAT is more commonly used). The AlphaRead reads samples from disk loop, and calls a subroutine of alphalib to create CD1 formatted data and write it to the heap file. The AlphaSend empties the heap file by sending CD1 frames to the IDC using LIFO- last in, first out sequence.

NORSAR Continuous Data Disk Loop

The NORSAR diskloop is simply a UNIX file system consisting of as many files as the number of hours of data the disk loop spans. Thus a weeklong diskloop would have 168 files. Each file then contains a number of record slots proportional to the length of each frame. Frames of 10 seconds thus will define files containing 360 slots. Then indexing into the diskloop for reading or writing is a matter of simple arithmetic given the time of the first sample for a record. This structure is independent of the format of data.

At the NDC

When arriving at the NDC, the data now in NORSAR style diskloop is converted to continuous CSS3.0 format. The CSS formatted data is written into a file system organized around the date of data and the station of origin. The file system is input to the automatic array processing tasks. It also serves as the input to the archiving process. A tape robot with a capacity of 30 terabyte reads the data from the CSS file system and writes an indexed copy into a tape where the data can be easily retrieved if needed. NORSAR keeps a comprehensive archive of data dating back to 1971. Segmented data from that time is recorded on \275 inch magnetic tapes. Since September 1982, all continuous data is recorded on tape. This archive is added to by 2.5 Gigabyte of data every day.

In addition to Norwegian stations, NORSAR collects data from the Finnish IMS primary station FINES (PS17) over the internet and the Swedish HAGFORS array (AS101) over a TDMA VSAT link. Data from AS101 is then forwarded to Stockholm over the internet.\240 Figure 5 is an illustration of various paths of data from different sources to the NDC and from there to its final destination at IDC.

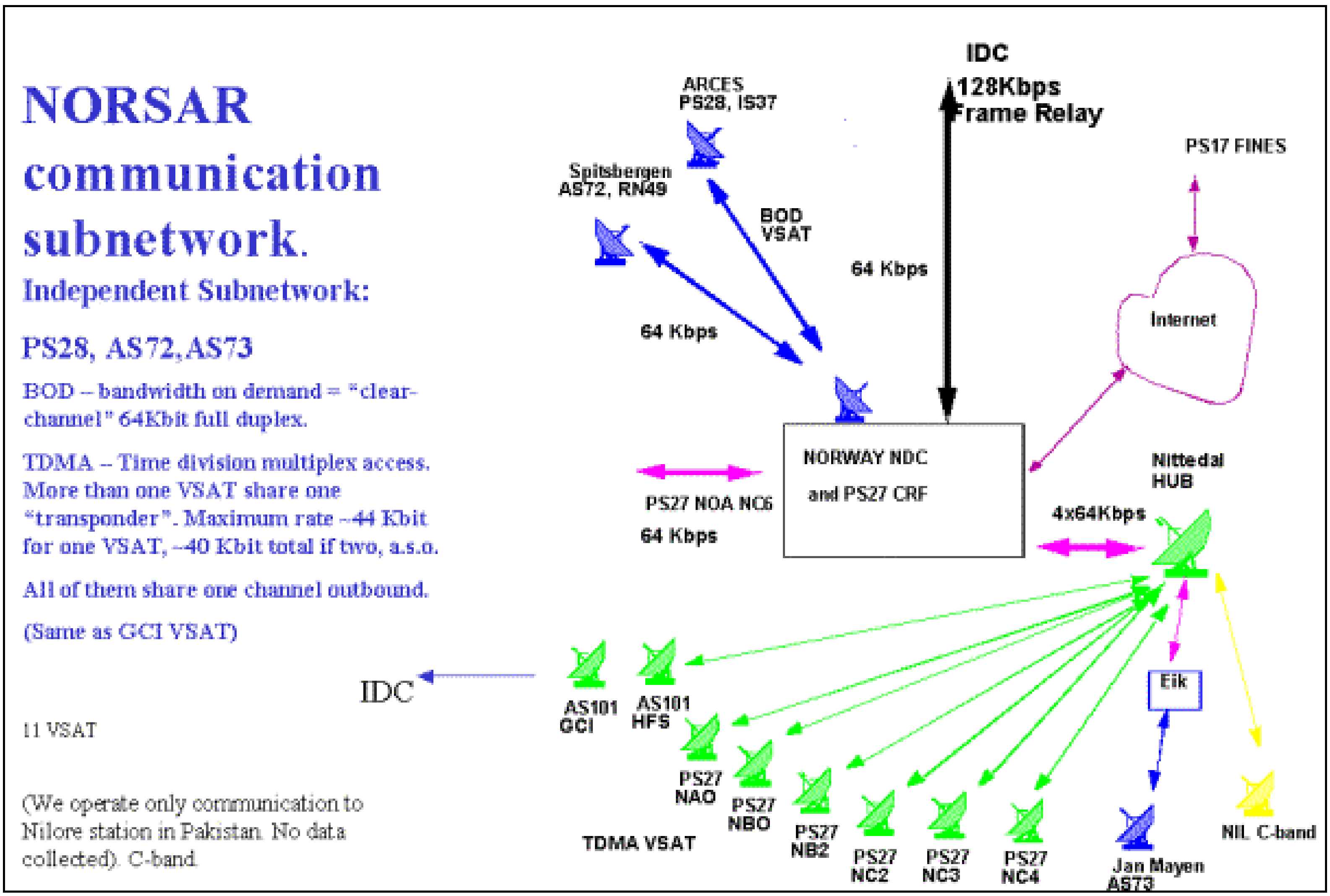

Figure 5. NORSAR independent subnetwork

Summary

Solutions to the challenges of data communication and data processing of seismic arrays have evolved over more than 30 years at NORSAR. The principle idea throughout these years have been to develop simple and at the same time robust solutions. The acquisition and processing tasks have been reduced to smaller and more manageable modules, each concerning itself with only a section of the entire process. The key link between the various modules is the time of latest processed data. All the applications, both those directly communicating with the hardware and those managing the processing, analysis and storage tasks are time sequential.

To ensure recovery of the system in case of a problem leading to stoppage of some of the sub tasks, UNIX crontabs are extensively used. The time sequential concept inherent in all the subtasks allows easy location and recovery of the error by the crontab processes.

* The code represents the designated station code in IMS station network. Seismic stations are assigned either PS (primary station) or AS (Auxiliary station).
* These terms are used in the IDC manual.

Observatories and Research Facilities for EUropean Seismology

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EVO (Evora, Portugal) a broad-band station and GRC (Garchy, France) a broad-band observatory two stations of the GEOSCOPE network

Geneviève Roult and the GEOSCOPE team

Institut de Physique du Globe de Paris, 4 place Jussieu, 75252 PARIS, France

Introduction - EVO - GRC - References

Introduction

The implementation in the nineties of the new generation of digital broadband seismic stations on the global scale (GEOSCOPE in France, GEOFON in Germany and IRIS in USA) and on a regional scale (MedNet in Italy, Pacific21 in Japan, CDSN in China, CNSN in Canada ...) had a fundamental and positive scientific impact. These stations faithfully record the whole spectrum of seismic signals without distortion and the intensive use of these broadband data have provided remarkable images of earth's deep interior by seismic tomography from the surface to the center of the Earth. These tomographic models are now routinely used in various domains as geodynamics and geochemistry. These data are used both for earthquake focal mechanisms studies (Centroid Moment Tensor solutions) and make it possible to obtain the source time function of their rupture or complex time histories of earthquake faulting, related to tectonics. The GEOSCOPE program was launched in 1982 by the National Institute of Sciences of Universe (INSU) at the French National Center of Scientific Research (CNRS), at the instigation of the Institute of Physics of the Earth. The purpose of the GEOSCOPE program was the installation of about 25 stations well distributed worlwide (in particular in the southern hemisphere), in the standard configuration defined by the FDSN (very broad-band 24bit, continuous recording at 20 samples/s). In terms of siting locations, the aim of the GEOSCOPE program is almost fulfilled. We plan to install one new station in Russia, in a northern site at very high latitudes, near Vorkuta, in collaboration with our colleagues of IIEPTM (Moscow), a new station in Patagonia (Cohyaique, Chile), a new joint Concordia (PNRA, Programma Nazionale di Ricerche in Antartide) station in Antarctica (DCC, Dome C) in cooperation with GEOSCOPE, and a joint IRIS/GEOSCOPE station on Tristan Da Cunha Island (Figure 1). In Europe two stations, which have been operating in the past few years, are now being closed for different reasons: EVO in Portugal and GRC in France.

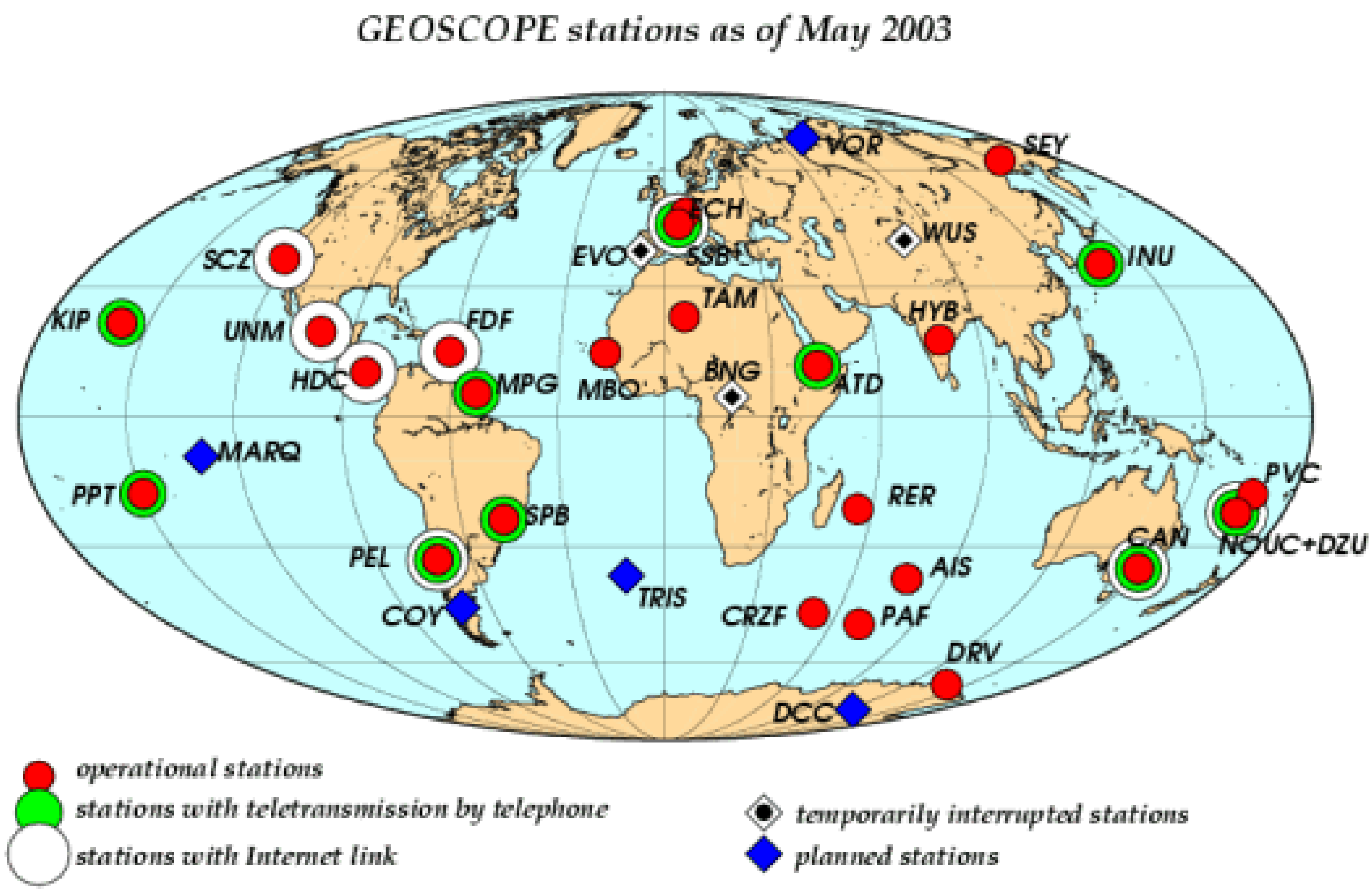


Figure 1. Geographical distribution of the GEOSCOPE network, with information on the stations.

EVO station (Evora, Portugal)

Its geographical coordinates were 38.532 N, 8.013W

This station has been installed by GEOSCOPE and CGUL (Centro de Geofisica de la Universidad de Lisboa). It was equipped in 1992 with three STS1 seismometers, in cooperation with EOST (Ecole et Observatoire des Sciences de la Terre) of Strasbourg in France, and the University of Lisbon in Portugal. Locally, the station was maintained by the Physics Department of the University of Evora. The 3 STS1 sensors were in the old broad-band configuration. The datalogger was a 20bit-digitizer called "Cantin" digitizer, built by Michel Cantin at EOST. The corresponding transfer function corresponded to a flat response in acceleration from 3600s to 600s, and a flat response in velocity from 20s to 1s. The data corresponding to this initial period is not available at the Geoscope Data Center in Paris. February 1996 this station was upgraded and transformed into a Very Broad-Band configuration, corresponding to a 3-components BH channel recorded at 40 samples/s and an LH channel recorded at 1 sample/s. The corresponding transfer functions are plotted on Figure 2.

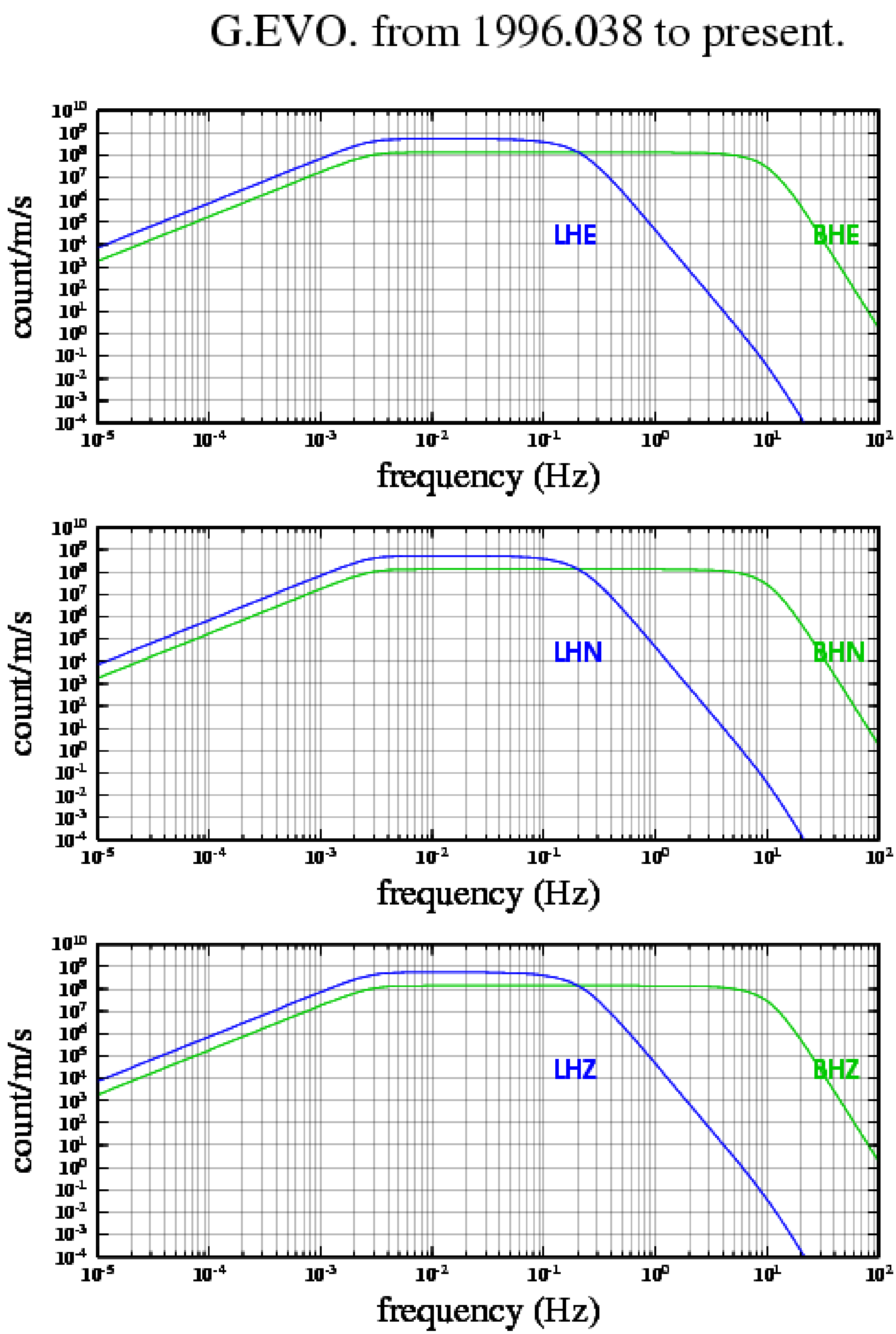


Figure 2. EVO station: transfer function of the different channels (BH, LH) in very broad-band configuration (after February 1996) for the 3 components (vertical, North-South, East-West).

The available data correspond to the period February 1996 to July 1997 and are freely accessible from the GEOSCOPE Data Center in Paris through the common ways (Web, NetDc procedure) described in Roult et al. (2000) or in Roult (2001). The description of the site and the acquisition chain, the plots of the transfer functions are visible on the Geoscope Web site. These data correspond to two different network codes of the FDSN (Federation of Digital Seismographic Networks), GEOSCOPE (G) and the University of Lisboa (LX).

EVO was close to another station, EVOP (latitude = 38,5283N, longitude = 8.1236W, elevation of sensor = 100m) installed by the French military agency CEA/DASE (Departement d'Analyse et de Surveillance de l'Environnement). The sensors are DASE long period seiosmometers. This station located at Santos Brissos, (Valverde, Alentejo) is operated by the Department of Physics of the University of Evora. The data are presently made available through Lisboa.
As EVO and EVOP, 2 "long-period" stations, are so close together, the actual institute decided to move the EVO station to Chaves, a site at the north of Portugal, with the same STS1 seismometers but with now with a Quanterra Q330 datalogger and its baler. This new station will become part of the new broad-band seismic network under the name ULISSEIS (University of LISbon SEISmic network), with network code LX.

GRC (Garchy, France) an experimental site

The GEOSCOPE program claimed for ten years the absolute necessity for installing everywhere various sensors and transforming all the Geoscope seismographic stations in multiparameter observatories. The new generation networks will have to be composed of multiparameter continental or oceanic stations including at least broadband seismometers, environmental sensors (microbarometers, thermometers) and eventually other sensors (electromagnetic sensors, strainmeters, GPS, ...). The design of the complete chain of acquisition, from the sensor to the distribution of data, will imply to integrate all the technical progresses made in micromechanics, electronics, computers, space science, and telecommunication systems. The improvement obtained after correction for the atmospheric pressure is well known now (Figure 3). For scientists who work at long periods and use free oscillations at low frequency (lower than 2mHz), this effect is significant, but can be easily removed if the installation of the station included such a measurement (Beauduin, 1996; Beauduin et al., 1996; Roult & Crawford, 2001). The observation of the interesting phenomenon of free oscillations of the Earth (Nawa et al., 1998; Tanimoto et al., 1999) even in periods seismically quiet can be significantly improved with such recordings.

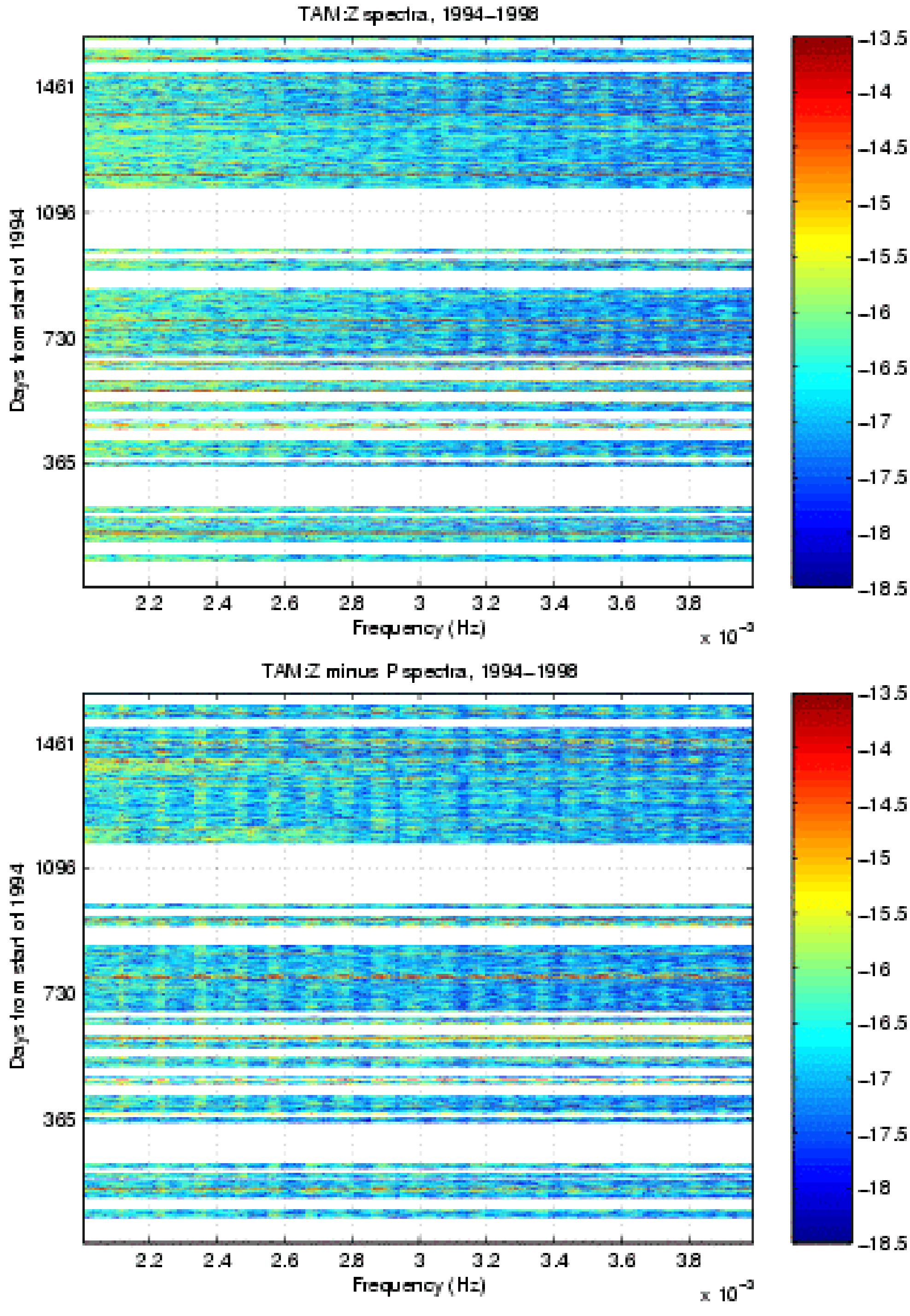


Figure 3. Daily power spectrogram at TAM (Tamanrasset, Algeria) from 1994 to 1998, in the frequency range 2-4mHz. The vertical straight lines correspond to the spheroidal eigenfrequencies of the Earth (Roult and Crawford, 2000).
Top) before atmospheric pressure correction
Bottom) after atmospheric pressure correction

The GEOSCOPE network has two experimental sites in France, one close to Strasbourg (ECH, Echery), used by the Geoscope team of EOST in Strasbourg, and the other one close to Paris (GRC, Garchy) used by the IPGP team. GRC Observatory has been operating from June 21th 2000 to December 19th 2002, in the Massif Central, an ancient geophysical site presently definitively closed by our academic authorities. It is situated in a fractured limestone with hydrological fracturation. A broad-band STS2 seismometer was installed in a seismic vault at the end of a 10m long tunnel, on a concrete floor. The datalogger was a prototype built by a french company (AGECODAGIS in Toulouse) and planned to provide a new generation of digitizers called Geoscope2000, with 6 channels in 24bits and 16 channels in 16 bits. The corresponding transfer functions are plotted in Figure 4. The six 24-bit channels were devoted to the 3 components of the seismometers (sensitivity of 1.74884e+09 counts/m/s) and to the POS channels or boom positions (sensitivity of 4.033994e+09 count/m/s).
The 16 other auxiliary channels were devoted to various environmental parameters (microbarometers inside and outside, thermometer, rain gauge..) or magnetic variometers, tiltmeters. The sampling rate of all these continuously recorded channels is 0.625 sps. The distinction between the different instruments are designed by their location code (00, 10 etc).

- two different thermometers: one PT100 and one PT1000
- five microbarometers: 3 located at quite the same place and 2 others at 10m, in a triangle configuration:
    - one built by Streckeisen , MIBA with a very good resolution
    - one of EFFA-type with a very good resolution
    - three VAISALA-type.

The purpose of the installation of so many different sensors in the vault was to obtain the gradients of temperature and pressure, for a better estimation of their effect on the seismic recordings. The different sensibilities of all these auxiliary sensors are summarized in the following table.

LKI00	3.276800e+01 count/degree C	PT100
LKI10	3.276800e+01 count/degree C	PT1000
LDI00	1.024000e+00 counts/Pascal	Effa
LDI10	3.276800e+00 counts/Pascal	Streckeisen
LDI20	6.291456e-01 counts/Pascal	Vaisala
LDI30	6.291456e-01 counts/Pascal	Vaisala
LDI40	6.291456e-01 counts/Pascal	Vaisala

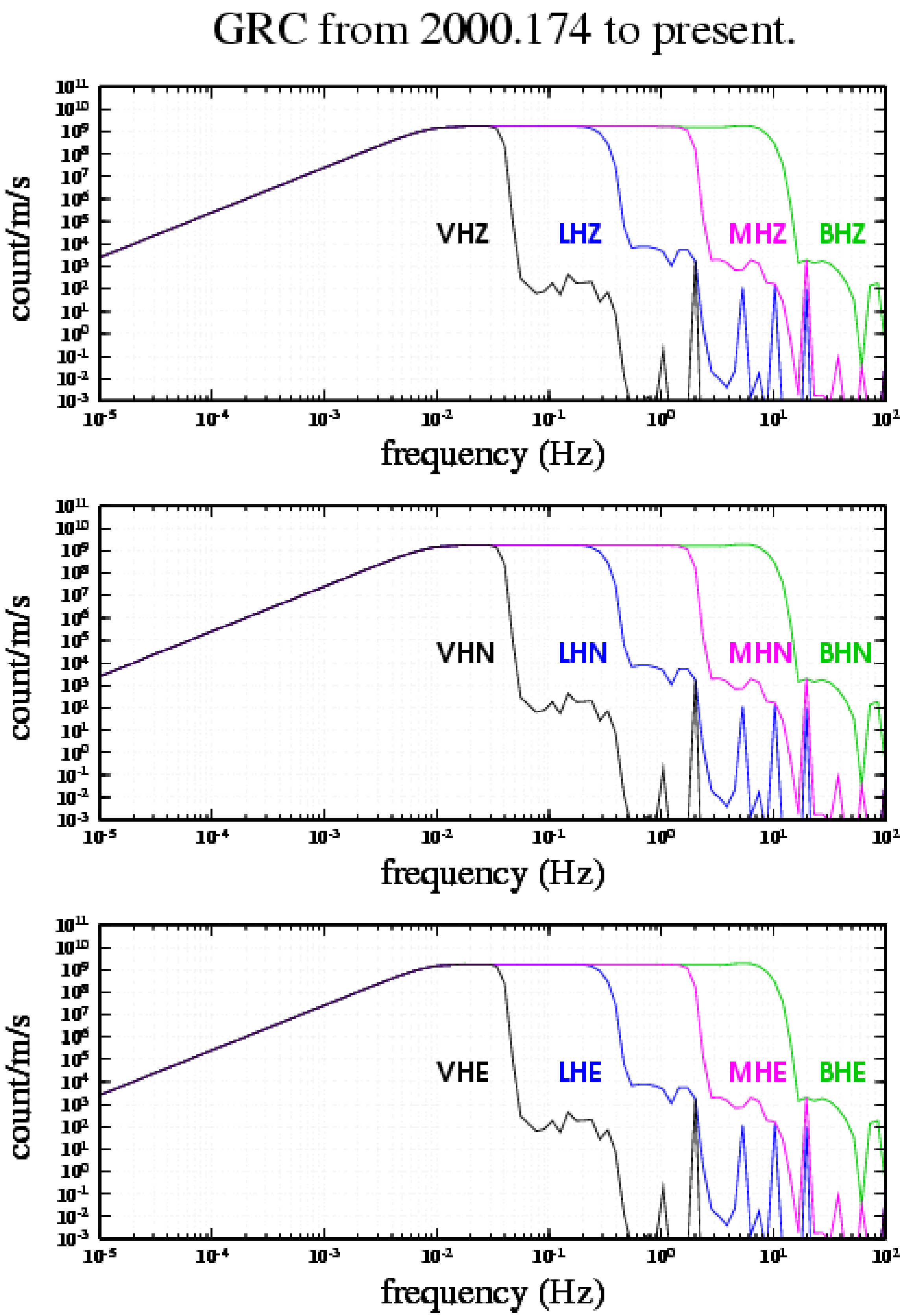


Figure 4. GRC station: transfer functions of the different seismic channels (BH 20sps; MH 5sps; LH 1sps; VH 0.1ps)for the 3 components (vertical, North-South, East-West).

References

- Beauduin, R., 1996. Etude du bruit de fond sismique à l'aide des données GEOSCOPE et des données de l'expérience OFM/SISMOBS, Thesis IPGP, University Paris VII.
- Beauduin, R., P. Lognonné, J.P. Montagner, S. Cacho, J.F. Karczewski, M. Morand, 1996. The effects of the atmospheric pressure changes on seismic signals or how to improve the quality of a station, *Bull. Seismol. Soc. Am.*, **86**, 1760-1769.
- Ekström, G. et al., 2001. Harvard Seismology Research: Seismic noise, Time evolution of long-period noise levels at FDSN stations: IRIS GSN (Global Seismographic Network) and additional stations (http://www.seismology.harvard.edu/~ekstrom/Projects/WQC/temporal.html).
- Montagner, J.P., P. Lognonné, R. Beauduin, G. Roult, J.F. Karczewski and E. Stutzmann, 1998. Towards multiscalar and multiparameter networks for the next century: the French efforts, *Phys. Earth Planet. Int.*, Special Issue I.O.N., **108**, 155-174.
- Nawa, K., N. Suda, Y. Fukao, T. Sato, Y. Aoyama, K. Shibuya, 1998. Incessant excitation of the Earth's free oscillations, *Earths Planets Space*, **50**, 3-8.
- Roult, G., J.P. Montagner, E. Stutzmann, S. Barbier and G. Guiveneux, 1999. The GEOSCOPE Program: its Data Center, *Phys. Earth Planet. Inter.*, **113**, 25-43.
- Roult, G. and W. Crawford,.2000. Analysis of "background" free oscillations and how to improve resolution by subtracting the atmospheric pressure signal, *Phys. Earth Planet. Inter.*, **121**, 325-338.
- Stutzmann, E., G. Roult and L. Astiz, 2000. The seismic noise level at GEOSCOPE stations, *Bull. Seism. Soc. Am.*, **90**, 3, 690-701.
- Tanimoto, T., J. Um, K. Nishida, N. Kobayashi, 1998. Earth's continuous oscillations observed on seismically quiet days, *Geophys. Res. Lett.*, **25 (10)**, 1533-1556.

Observatories and Research Facilities for EUropean Seismology

Volume 5, no 2 September 2003 Orfeus Newsletter

The Republican Center of Seismological Service of the National Academy of Sciences of Azerbeijan

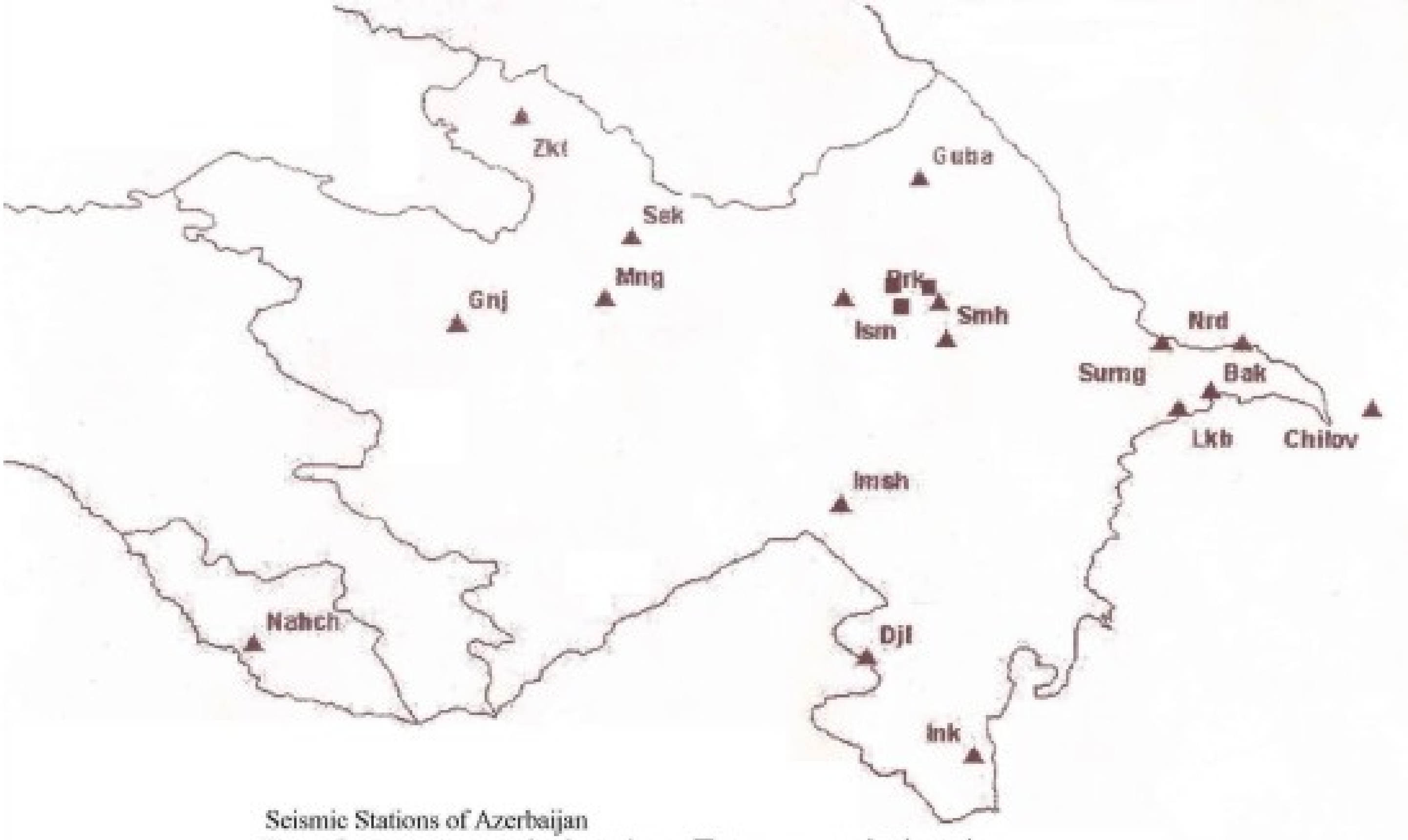
Talat Tagiev and Arif Gasanov

Introduction

The republican Center of Seismological Service of the National Academy of Sciences of Azerbaijan (CSS NASA) is the main seismological body of the republic. CSS NASA was founded under the order of directive bodies of Azerbaijan in 1979.
Research-and-production activity of CSS NASA is directed on the following:

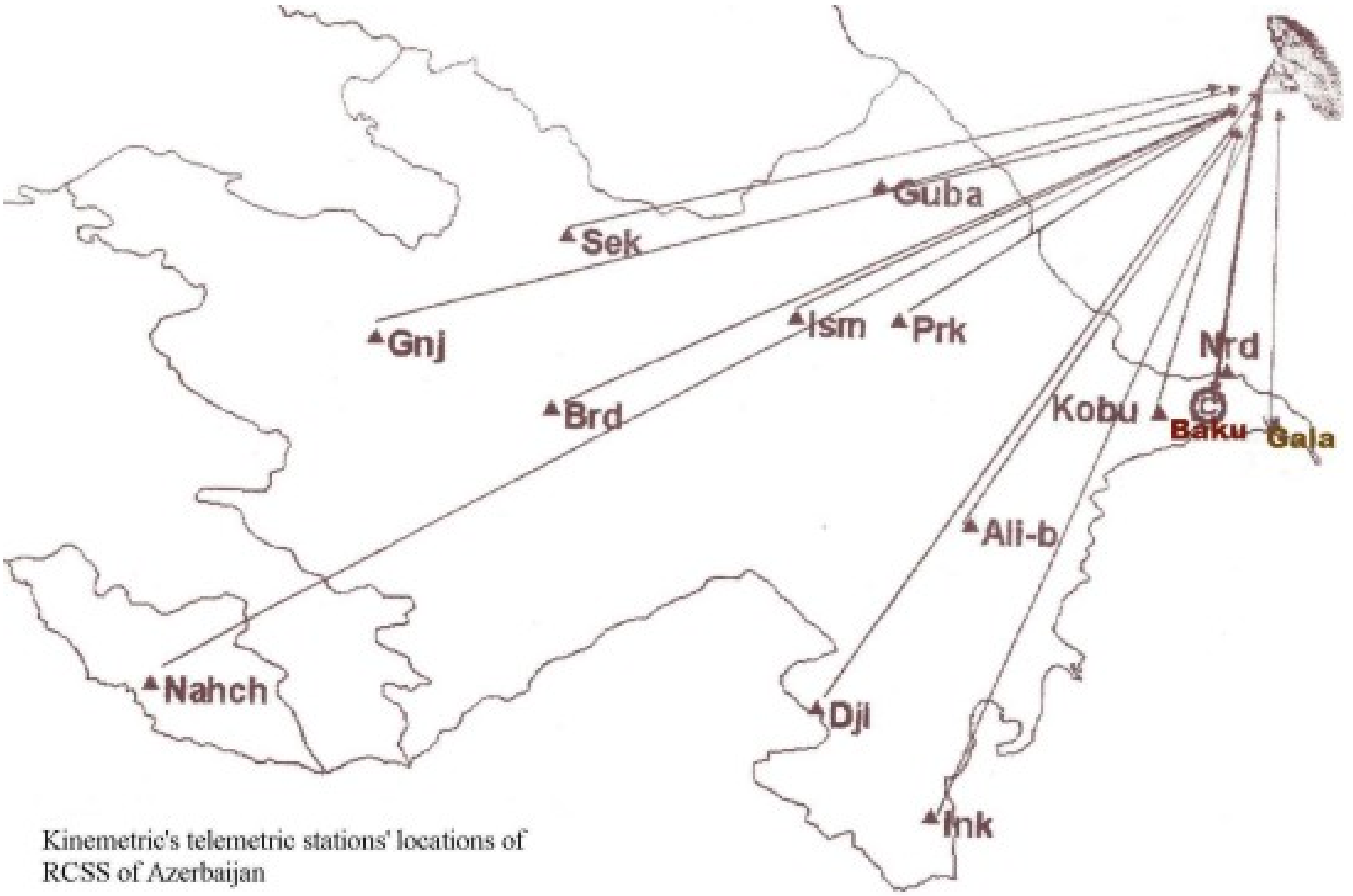
- the study of seismicity on the territory of Azerbaijan
- the study of features of statistical and dynamic parameters of seismic field
- the study of mechanism of seismic center, on specification of seismic tectonics elements and oil and gas prospects of seismic zones based on seismological data

Alongside with seismological research, CSS NASA carries out a big complex of geophysical and geochemical work on revealing the seismically abnormal effects arising before earthquake in the variations of intensity of geomagnetic field, electromagnetic radiations, in the variations of gravitational field and the second derivatives of gravitational potential, in the parameters of hydro geochemical, gas geochemical and radio geochemical fields.
Figure 1 shows the network of CSS NASA. Untill 2000 the network of seismic stations consisted of 19 permanent and 3 temporary stations equipped with short-periodand broadband seismometers, allowing to register earthquakes in a range of frequencies of 0,05-20 Hertz, and also with seismometers for registration of strong movements (threshold of abrasion 3-4 points).



Seismic Stations of Azerbaijan
Legend: ▲-permanent seismic stations; ■ -temporary seismic stations

In the beginning of 2000 six seismic stations (Baku, Pirkuli, Mingechevir, Sheki, Gandzha, Shamkir) were equipped with digital seismographs with telemetric connection channels (manufactured by Italian company ISMES Spa).
In the beginning of 2001 with the purpose of further modernization of the seismological network, on the basis of tender 15 complete sets of telemetric system of seismic monitoring by "Kinemetrics" company (USA) were purchased. Creation of a new network on the base of "Kinemetrics" system has been completed in March, 2003.
Stations of this system are placed on eight working (Baku, Nardaran, Guba, Pirkuli, Ismailli, Sheki, Gandzha, Lenkoran) and seven newly opened seismic stations (Devechi, Gobu, Gala, Ali-Bayramli, Dzhalilabad, Barda, Nakhchivan), see Figure 2.



Kinemetric's telemetric stations' locations of RCSS of Azerbaijan

One of the main advantages of the new system of seismic monitoring is the opportunity of collection and processing of the data in real time. Transfer of the information is made via satellite connection channels.

In the near future will be opened the web-site of our organization and we shall at once let you know the address of the site.

New Publications

The New Manual of Seismological Observatory Practice (NMSOP) has been elaborated by an international IASPEI Working Group. It is now available from the GeoForschungsZentrum Potsdam (ISBN 3-9808780-0-7) for only 30.- EUR, plus shipment and handling cost. The Manual can be ordered on-line from http://www.gfz-potsdam.de/bib/nmsop_formular.html. The NMSOP outlines in a consistent way the social and scientific goals as well as the scope, technology, methodology and basic procedures of observatory seismology. It provides the essential scientific and technical fundamentals, and reveals their inter-relationship. The Manual has been reviewed by 30 external reviewers from 10 countries. It offers plenty of material suitable for introductory university courses into seismology as well as application oriented training in observatory practice. The Manual is also of interest for earthquake engineers and disaster managers who wish to learn more about relevant earthquake parameters.

The Manual appears in two volumes (total of 1250 pages) as a loose-leaf collection in two clamp-folders. This allows easy future up dating and complementing. Volume 1 comprises 13 topically and didactically closely linked chapters:

Chapter 1: Aim and scope of the New Manual of Seismological Observatory Practice
Chapter 2: Seismic Wave Propagation and Earth Models
Chapter 3: Seismic Sources and Source Parameters
Chapter 4: Seismic Signals and Noise
Chapter 5: Seismic Sensors and their Calibration
Chapter 6: Seismic Recording Systems
Chapter 7: Site Selection, Preparation and Installation of Seismic Stations
Chapter 8: Seismic Networks
Chapter 9: Seismic Arrays
Chapter 10: Data Formats, Storage, and Exchange
Chapter 11: Data Analysis and Seismogram Interpretation
Chapter 12: Intensity and Intensity Scales
Chapter 13. Volcano Seismology

The Annex Volume 2 comprises:

- **Datasheets (DS):** Parameter lists of widely used seismic sensors; collection of seismic record examples from all regions, distance and depths ranges; travel-time curves; Earth models; magnitude calibration functions; etc.;
- **Information Sheets (IS):** Detailed treatment of special topics (such as event location, theoretical source presentation, setting of trigger parameters, etc.) as well as condensed summaries of special instructions/recommendations for quick orientation (e.g., new IASPEI proposals for standard nomenclature of seismic phases and magnitude names, examples

of parameter reports according to the new IASPEI Seismic Format, criteria for site selection, etc.);

- **Exercises (EX):** Exercises with solutions on basic observatory tasks such as event location, magnitude estimation, determination of fault-plane solutions and other source parameters, instrument calibration, construction of response curves, etc.;
- **Program Descriptions (DS):** Short descriptions of essential features of freely available software for observatory practice and how to access it;
- **Miscellaneous with References, List of Acronyms, Glossary, Index;**
- **CD-ROM** with the complete Manual as pdf-file and animations of seismic ray propagation and seismogram formation in the distance range 10 km to 167 degrees.

Observatories and Research Facilities for EUropean Seismology

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Announcements

- **Data availability at the ODC**
  The data availability at Orfeus Data Center is being re-structured. The up-to-date status can be found on ODC-online.

- **EC 6th framework proposal NERIES**
  The proposal "Network of Research Infrastructure for European Seismology (NERIES)" for the 6th framework Specific Programme "Structuring the European Research Area" [FP6-2002-Infrastructures-1], specifically "Integrating Activities", has been submitted April 15, 2003.
  At the end of August we have received an evaluation report and a rejection. Unfortunately. However, we are presently considering the options to resubmit parts and/or an improved version in 2004. Domenico Giardini, the proposal coordinator, and several others believe we have a good basis and a constructive evaluation. The proposal is available on CD-ROM on request from ORFEUS. The proposal evaluation is available on our ftp site.
  ORFEUS participants and NERIES participants will be kept informed on the actions planned.

- **EMICES workshop in Athens. September 22-24, 2003**
  ORFEUS WG4 is organising a workshop within the EMICES project:
  "Distributed, Object Oriented Computing for Seismology"
  Place: National and Kapodistrian University of Athens. Department of Geophysics, Athens, Greece.
  Local organiser: Nicholas Voulgaris
  Program coordinator: Anthony Lomax

- **MEREDIAN Annual meeting, September 25-26, 2003**
  Within the MEREDIAN project we will have the first annual meeting gathering all 18 participants. This meeting will take place after the ORFEUS workshop in Athens.
  Place: National and Kapodistrian University of Athens. Department of Geophysics, Athens, Greece.
  Local organiser: Gerry Chouliaras.
  Meeting coordinator: Torild van Eck

- **EMICES meeting in Cyprus. September 10-13, 2003. Nikosia**
  Within the EMICES project the EMSC coordinates together with UNESCO, USGS and the Geological Survey of Cyprus the meeting: "Seismic hazard and data exchange within the Mediterranean"
  The main intention is to provide a venue to discuss and plan mutual cooperation in the fields of data exchange and seismic hazard analysis.

Local organiser: Geological Survey Department Cyprus (George Petrides and Kyriacos Solomi)
European coordinator: Rémy Bossu (EMSC)

- **VEBSN has its own web page**
  Information about its status, planning, data and related developments can presently be found on the VEBSN web pages.
- **Broadband station database at ORFEUS**
  Josep Vila (chairman of WG1) and the ODC staff (notably Lucas Caljé, Chad Trabant and Femke Goutbeek) have mad an MySQL database containing the available information of BB station in and around Europe. The databasequery is accessable on the ORFEUS WG1 web pages. If you have additional information, please, contact Femke Goutbeek at ORFEUS.
- **Unique seismometer overview on the web**
  Josep Vila (chairman of WG1) has made, with the assistance of some colleagues, an excellent and comprehensive overview of BB seismometers and high resolution acquisition systems. The present site is not permanent, but it will always be linked in the ORFEUS WG1 and the ORFEUS WG2 web pages.
  We will appreciate your assistance in improving these pages. Therefore, please, if you have suggestions, corrections or additions contact Josep Vila or the ORFEUS staff.