ORFEUS Electronic Newsletter

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Articles and News

Short notes

Announcements

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The Austrian Seismic Network

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Short-period instrumentation - Broad-band stations -
Strong-motion stations - Analogue stations - General -

The seismic network of Austria is operated by the Department of Geophysics at the Central Institute of Meteorology and Geodynamics (ZAMG) in Vienna.

Short-period instrumentation

At the moment four digital stations in Tyrol operate at 100 Hz sampling rate. This network was established by the end of 1990 allowing a more precise evaluation of the seismic activity in the province of Tyrol of Austria. These stations are equipped with S13-sensors supplied by Teledyne® and the first data IRIS-type acquisition system Quanterra® SPCMU. The four stations are to be upgraded during 2001 with one Q4120 at the station at the Wattenberg (WTTA) and Q730's for the remaining three stations St. Quirin (SQTA), Moosalm (MOTA) and Walderalm (WATA).

Broad-band stations

Five broad-band stations with STS-2 seismometers by Streckeisen and Quanterra®-data loggers have been deployed in Austria so far. All but of two use Q380 data acquisition systems. The two exceptional stations at Hochobir (OBKA) and at the Kölnbreinsperre (KBA) are equipped with Q680-data loggers and strong-motion sensors, whereas 'KBA' is equipped with an FBA23-sensor and 'OBKA' with an 'EpiSensor' manufactured by Kinemetrics®. In addition, two stations of the Institute of Physics of the Earth (IPE) in Brno and one station of the GeoForschungsZentrum Potsdam (GFZ-Potsdam), can be utilized on-line to evaluate tremors in near-realtime. These stations use Q380 data loggers, too. Stations in Austria exhibit a mean delay-time of 10 seconds for data transmission from the seismic station to the data centre in Vienna. Data transmitted telemetrically may take a bit longer due to technical constraints. All data are accessible via 'AutoDRM' via autodrm@zamg.ac.at. All waveform data are processed and analyzed with the 'Environmental Monitoring Software Antelope' by Boulder Real Time Technologies®.

Strong-motion stations

In addition, eighteen strong-motion sensors have been deployed through recent years in Austria. Seven stations operate with SMACH SM-2-sensors from SIGSA, five of which are installed in Vienna and two in the vicinity of Wiener Neustadt - that is 40 km south of Vienna. The other eleven stations are equipped with 'FBA23'-sensors and K2 data acquisition systems manufactured by Kinemetrics®.

Analogue stations

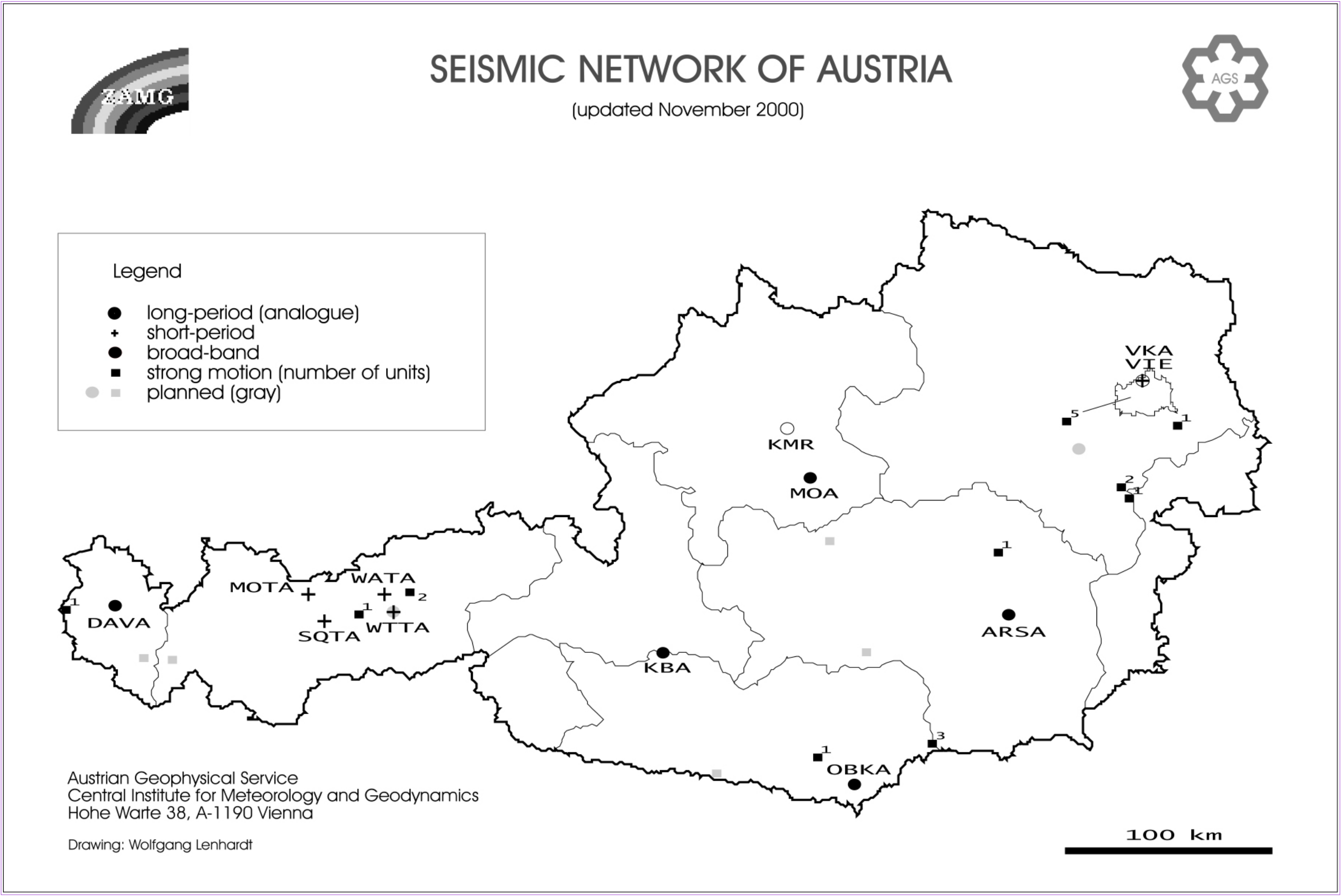
Today, still a few analogue seismometers are in use in Austria, such as in Kremsmünster in the province of Upper Austria and the station Cobenzl in Vienna and one analogue long period instrument at the ZAMG.

General

No mobile stations are available at the ZAMG for deployment for aftershock studies and the like. Nevertheless, significant progress could be made in cooperation with the On-Site Inspection Group of the CTBTO during the aftershock sequence of the Ebreichsdorf earthquake of July 11, 2000 thus establishing the depth horizon at which the recent earthquake seems to have taken place. Although most of these events were to weak to be recorded by remote stations, clear indications regarding the focal mechanisms of the main shock and subsequent largest aftershock could be evaluated by moment tensor inversions (see web-site of the Swiss Seismological Service) and first motion studies which were conducted by the ZAMG.

Seismic stations in Austria

ISC-Code	Location	Latitude	Longitude	Elevation	installed
Short period S13					
MOTA	Moosalm	47.3448	11.1037	1575 m	1990
SQTA	St. Quirin	47.2205	11.2087	1307 m	1989
WATA	Walderalm	47.3357	11.5763	1492 m	1989
WTTA	Wattenberg	47.2638	11.6363	1764 m	1990
broad-band STS2					
ARSA	Arzberg	47.2505	15.5232	577 m	1997
DAVA	Damuels	47.2867	9.8803	1602 m	1999
KBA	Koelnbreinsperre	47.0784	13.3447	1721 m	1997
MOA	Molln	47.8495	14.2659	572 m	1996
OBKA	Hochobir	46.5092	14.5489	1075 m	1998


ZAMG
SEISMIC NETWORK OF AUSTRIA
(updated November 2000)
AGS
Legend
long-period (analogue)
short-period
broad-band
strong motion (number of units)
planned (gray)
VKA
VIE
KMR
MOA
MOTA
WATA
DAVA
SQTA
WTTA
KBA
ARSA
OBKA
Austrian Geophysical Service
Central Institute for Meteorology and Geodynamics
Hohe Warte 38, A-1190 Vienna
Drawing: Wolfgang Lenhardt
100 km

Observatories and Research Facilities for EUropean Seismology
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BFO and Moxa: two observatories for seismological broadband observations

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Introduction

During the last decades a number of seismological stations were established around the world thus improving the data basis for seismological studies. Some of these observatories are equipped with additional instruments besides 3-component broadband seismometers to monitor deformations. Data from these observatories allow integrated studies of the deformation field from seismic frequencies up to tidal bands. When meteorological sensors are installed at these seismological stations, from the monitoring of the environmental conditions conclusions can be drawn whether changes in those affect the noise contents of the seismological observations. Comparisons with i.e. gravity, tilt and strain data then can point to possible physical mechanisms of noise transfer, a first step towards a noise reduction in the seismological wave form data. This belongs to one of the activities of the working group 7 dealing with environmental influences on gravity, tilt, and strain observations, established 1997 by the Earth Tide Commission.

Two observatories operating a 3-component STS2 seismometer and being equipped with further instrumentation for deformation monitoring as well as a set of meteorological sensors are described in the following. Both, the Black Forest Observatory Schiltach and the Geodynamic Observatory Moxa, are located in Germany (Fig. 1) in a distance of about 400 km from each other.

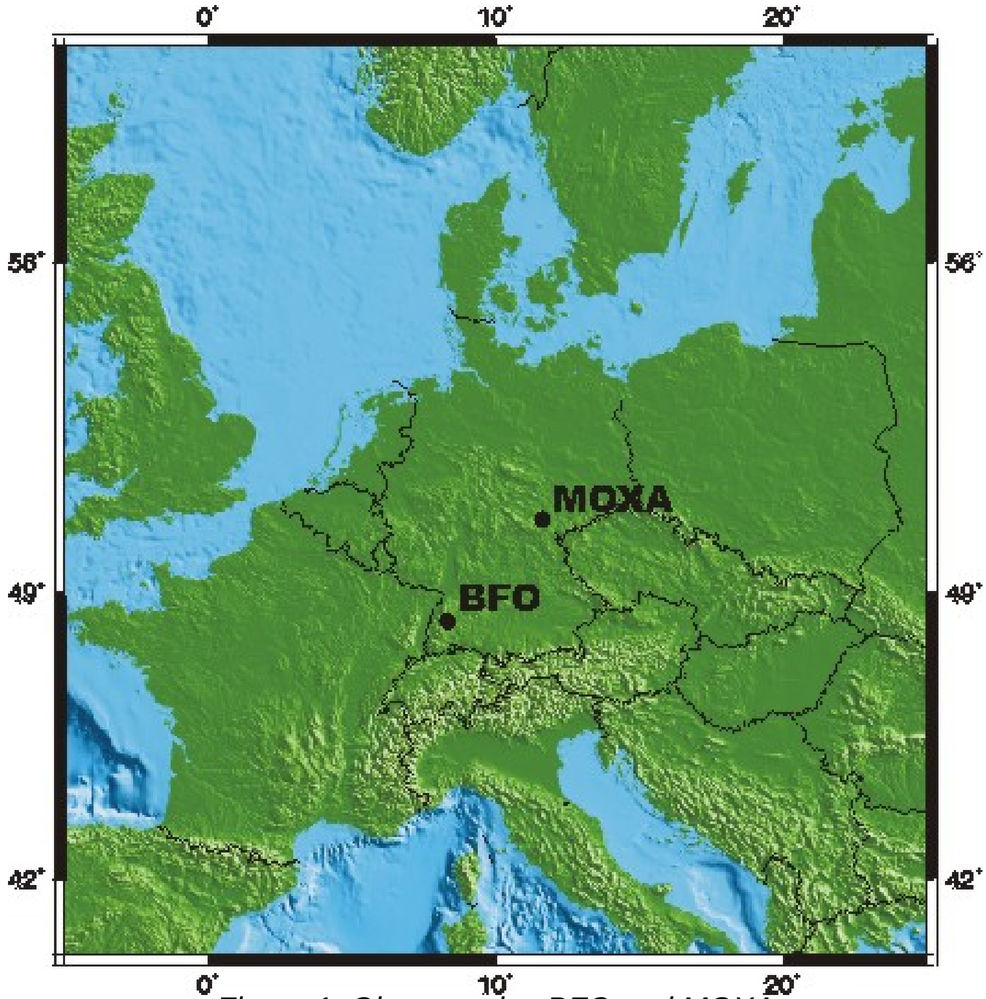

Figure 1. Observaories BFO and MOXA

Black Forest Observatory Schiltach

The Black Forest Observatory (BFO) is also known as Schiltach Observatory and is located in the Central Black Forest in SW-Germany (approximately in the centroid of a triangle with its corners at the cities of Stuttgart, Karlsruhe and Freiburg and about 70 km due east of Strasbourg, France). It is operated jointly by the Institutes of Geophysics and Geodesy at the Universities of Karlsruhe and Stuttgart. The WGS84-coordinates of the STS-2 seismometer are 48.3301 degs N, 8.3296 degs E and 639 m ellipt. elevation (589 m amsl). A brief description of the observatory in English can be found in Emter et al. (1994), more extensive descriptions in German in Emter et al. (1998, 1999). The sensors are located in an old silver and cobalt mine in a hillside, horizontally between 400 to 700 m from the adit and 150 to 170 m below the surface. The rock is granite. An air-lock with a time constant of more than 12 hours stabilizes the environment of the sensors in temperature, air pressure and air convection. Temperature is slightly less than 10 degrees centigrade and is stable to better than 5 mK unless this part is entered. It has not changed by more than 0.05 degrees since 1972. The distance to the nearest small scale industry is a minimum of 4 kilometers. The next railroad with only very little traffic and no freight trains and major road are 5 km to the South. More details on BFO can be found at the following Web-sites:

www-gik.bau-verm.uni-karlsruhe.de/~bfo

www-gpi.physik.uni-karlsruhe.de/pub/widmer/BFO

At present (Dec. 2000) the following instruments are operating at BFO:

Instrument	Sampling Rate (Hz)	Archive
1 STS-2 (ZNE)	80, 20, 1	SZGRF, ORFEUS, IRIS
3 STS-1 (ZNE)	20, 0.2	IRIS, BFO
1 Geotech S-13 (Z)	125 (PCM)	GLA
2 Kinemetrics SH-1 (NE)	125 (PCM)	GLA
1 LCR-ET 19 tidal gravimeter with electrostatic feedback	0.1, 0.2	IRIS, BFO
1 ASKANIA tiltmeter (NE)	0.1, 0.2	IRIS, BFO
1 DPFT (110 m, N 331 E) differential pressure fluid tiltmeter	0.2	BFO
3 Cambridge-strainmeters 10 m Invar wires (N 2, 60, 300 E)	0.1, 0.2	IRIS, BFO
3 magnetic variometers	0.0167	FUR
In addition		
2 Barometers (rel.) inside, outside	0.1, 0.2	IRIS, BFO
2 Thermometers (rel.)	0.0167	BFO
1 rain gauge	0.0167	BFO
1 Anemometer	analog	BFO

(GLA stands for: Geologisches Landesamt Baden-Wuerttemberg, Freiburg; FUR for: Magnetic Observatory Fuerstenfeldbruck)

The mine and some of the instrumentation is also described in Widmer et al. (1992) and Richter et al. (1995). The quality of some of the data from BFO was mentioned in Beauduin et al. (1996), Freybourger et al. (1997), Banka and Crossley (1999) and Masters et al. (2000). Emter et al. (1999) contains a list of relevant publications from the personnel operating BFO. A recent paper showing free-mode spectra is by Zürn et al. (2000). (For more information contact R. Widmer-Schnidrig or W. Zürn at BFO)

Geodynamic Observatory Moxa

Moxa observatory, located in the eastern part of Thuringia (Germany), has a more than 30 year long tradition of seismological observations. It was established in 1964 when the city of Jena became to noisy as a location for a seismological station. The site of Moxa was chosen because it was close enough to Jena (about 30 km south) but at the same time sufficiently far away from industrial plants, major roads, and towns. The given criterium was none of those should exist within a radius of 10 km. Another decisive factor was the existence of the Silberleite valley which allowed to build the observatory partly into a hill. Regarding the geology the observatory is situated in the Ziegenruecker Kulmmulde in the Thuringian-Franconian Slate Mountains that consists of intensively folded and fractured basement rocks. In the surroundings of the station thick series of slates and graywackes of Lower Visean Age are found. During the years 1996 to 1999 the seismological station was modernized and extended into a geodynamic broadband observatory. The general objective of the observatory is to monitor, analyze and interpret geodynamic signals due to mass shifts and deformations at the Earth's surface ranging from seismic frequencies up to long-term variations. Besides studies of global geodynamic signals research interests focus on the influence of environmental variations on the geophysical data monitored and their reduction. Moxa observatory is included in two larger networks: Like the BFO it is a station of the German Regional Seismic Network (GRSN) and with its superconducting gravimeter it belongs to the Global Geodynamics Project (GGP; Crossley et al., 1999), a global network of these instruments (see GGP superconducting gravimeter data base). At the observatory a seismogram archive exists with the first seismogram dating back to 1904. The WGS84-coordinates of the STS-2 seismometer are 50.6447 degs N, 11.6156 degs E and 501 m ellipt. elevation (455 m amsl).

At present (Dec. 2000) the following instruments are operating at the observatory:

Instrument	Sampling Rate (Hz)	Archive
1 STS-2 (ZNE)	80, 20, 1	SZGRF, ORFEUS
1 STS-1 (ZNE, loan BGR)	0.1	MOX
2 quartz tube strainmeters (EW, NS; 25 m long)	0.1	MOX
1 laser strainmeter (diagonal, 38 m long)	0.1	MOX
1 LCR-ET 18 tidal gravimeter with electrostatic feedback	0.1	MOX
1 GWR superconducting gravimeter CD-034 with a double sensor system	1	MOX, GGP (Jan. 2001)
ASKANIA borehole tiltmeters	0.1	MOX

The rock and soil coverage of the observatory chambers ranges from 2 to 3 m in the front area up to 35 m for the observatory parts inside the hill. All strainmeters as well as the STS-1 and STS-2 seismometers are operating in the area with maximum coverage. The gravimeters are installed in the covered front area in a temperature-stabilized room. The tilt measurements are carried out in the boreholes (depth 50 and 100 m) in front of the observatory. For the observation of environmental variations several sensors are available. Most of these sensors are mounted on a pole at a roof corner of the observatory building. The following meteorological parameters are continuously monitored:

- barometric pressure
- air temperature
- air humidity
- wind velocity
- wind direction
- precipitation
- illuminance
- soil temperature/humidity
- groundwater table variations

The sampling rate of these parameters is 0.1 Hz. In addition a temperature and a barometric pressure sensor are installed in the gallery and in the temperature-stabilized gravimeter chamber. The pressure sensor in the gravimeterchamber has a sampling rate of 1 Hz. The monitoring of the water table variations is carried out in a 50 m deep borehole in front of the observatory.

More details on Moxa observatory can be found at www.geo.uni-jena.de/moxa/ or contact Th. Jahr or G. Jentzsch. Some recent publications about the instruments operating at the observatory and results of some noise studies in the long periods are by Jahr et al. (2001) and Kroner et al. (2001).

Note
Station height is here measured according to two definitions:
ellipt: is the distance along the ellipsoidal normal from the reference ellipsoid (representing an idealized earth figure) to the observation point. The ellipsoid used is defined in the World Geodetic System 1984 (WGS84) by the U.S. Department of Defense.
amsl: is short for 'above mean sea level'. The mean sea level is derived from tide-gauge registrations carried out over many years of one or more coastal stations. As mean sea levels of different regions do not coincide, heights are additionally refered to a global height datum as e.g. given by WGS84 at the National Imagery and Mapping Agency (NIMA) in the US.

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Observatories and Research Facilities for EUropean Seismology
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School Yard Seismology

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Background - **Novel Seismograph Design** - **Real Testing of "Geophone" Seismograph** - **School Yard Seismology** - **Conclusions** - **Acknowledgements** - **References** -

Background

Advancements in solid earth physics are driven primarily by access to huge amount of high quality wavefield data as recorded by globally distrubuted seismograph stations. Since these broadband stations are spaced hundreds of kilometers apart the spatial resolution are also of the order of hundreds of kilometers. For localized studies of crust and upper mantle structures significantly smaller station separations are required say as once realized through the large aperture arrays NORSAR and LASA. In this regard, instrumentation and operational costs become critical factors.
Seismologist, in particular in academia, have tried for decades to design a simple, robust and inexpensive seismograph stations which would produce wavefield recordings of adequate quality for research ((Husebye & Thoresen, 1984; Husebye et al., 1984). Again, low operational costs are essential for network operations for more than a few years that is beyond a funding period of typical 3 - 5 years. In this research note, we describe our efforts in designing an inexpensive 3-component short period seismograph station which first deployment is in the school yard of Åsane Gymnas - a high school in Bergen. The motivation for school installation is two-fold; 1) force science interest by students through 'do and learn' experiments tied to an exciting natural phenomenon like earthquakes and 2) to operate a seismic network for research while minimizing running costs. The interest among Norwegian schools in participating is highly satisfactorily so our vague ideas on such an undertaking just a few months ago must now be rated a Project including Web pages and news services. In the last chapter we will outline the structure and future plans of this high school educational project with its routing in observational seismology.

Novel Seismograph Design

Initially, our efforts here were initiated by the need for extensive testing of signal detectors, phase pickers and signal recognition for seismic source identification (Fedorenko et al., 1998, 1999, Fedorenko and Husebye, 1999). In principle it should be simple to retrieve such data from various kind of national and international data centers but in practice not; not at least regarding short period (SP) recordings (monitoring data). Most effective way of handling such tasks are simply to pay research visits to the data center itself. With this motivation but no desire nor resources at hand for reinventing the seismograph, we used standard, inexpensive instrument components for our novel 3-component seismograph design outlined below. It is novel in the sense that station operation constitute an integral part of the school PC-Internet system. Also, students are given access to professional processing software like PITSA so they can undertake signal analysis of their own say investigating crustal structure locally. The choice of instrumentation was motivated by easy commercial access to inexpensive but robust geophones which through proper preamplifier design may mimic SP seismometers as used in say CTBT monitoring. Broadband instruments are more bulky, expensive and more difficult to operate by amateurs; if really needed students can access individual BB stations, or IRIS and ORFEUS data bases.

Geophones Substituting Seismometers

Even in 1960-ties academic institutions experimented with small, inexpensive geophones around $60 each as a substitute for bulky, expensive seismometers (around $2000 each). In the 1990-ties more widespread use of geophones in the role of seismometer become more common in particular where compact size is needed like in ocean-bottom seismometer (OBS) surveys. Our current research interests are for 0.5-40 Hz of the seismic wavefield so we settled for the GS-11D geophones from the Geospace Corp. Huston, TX which has natural undamped frequency at 4.5 Hz. Naturally, a geophone is not a seismometer but may be modified to perform in such a manner. This was achieved in combination with our own elaborated preamplifier with an approximately flat acceleration response in the 0.5 - 40 Hz frequency range (Fig 1).
The motivation for an approximately flat acceleration response is twofold; firstly because this is an advantage/requirement when using the efficient wavelet transform for noise suppression (Husebye & Fedorenko, 1999) and secondly a ground acceleration is a common parameter in seismic loading and risk studies. Most SP seismometers measure ground velocity but since response curves are not always flat the output is in fact a mixture of ground velocities and accelerations.

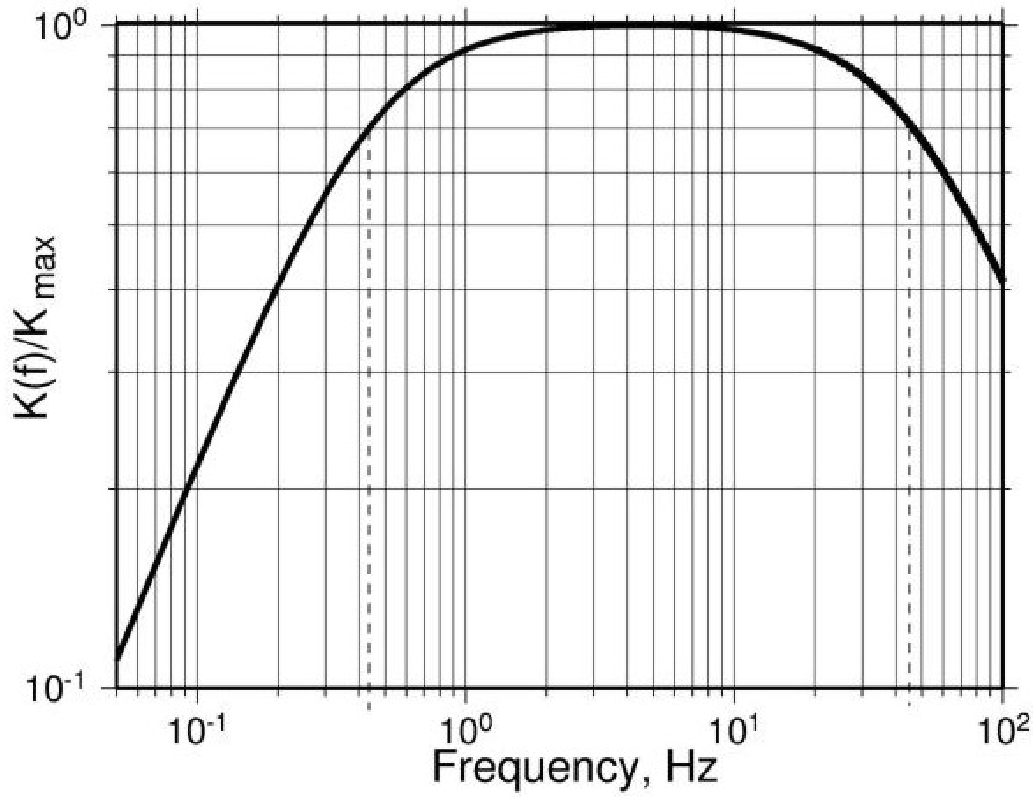

Figure 1. Approximately flat acceleration response for the GS-11D geophone in combination with our own designed preamplifier. In essence, low-cost geophone transformed to high-cost short period seismometer by smart "response" hardware.

Analog to Digital (A/D) Converter

Recently, costly and precise 24-bits A/D have been introduced into seismograph stations which is sort of sampling " overkill" since there is no customary preamplifiers or commutators with dynamic range close to 24-bits. On the other hand, the commonly used 16 bits A/D has a somewhat limited dynamic range at 96 db thus occasionally causing clipping of local EQ recordings. However, it is a well known fact that low-pass filtering of quantization noise by oversampling improves the accuracy of the A/D - converter. We have taken advantage of this thus in effect converting the standard 16 bits A/D converter to one as accurate as 19 - bits with effective dynamic range not worse than 18 bits (Fig. 2) deemed adequate for SP seismic recording systems. Presently the primary sampling rate is 3150 Hz for each channel, while output sampling rate is 50 Hz. In our A/D design we have also built in an effective spike suppressor; in some environments like buildings with much electronic equipment such spikes are a real nuisance.

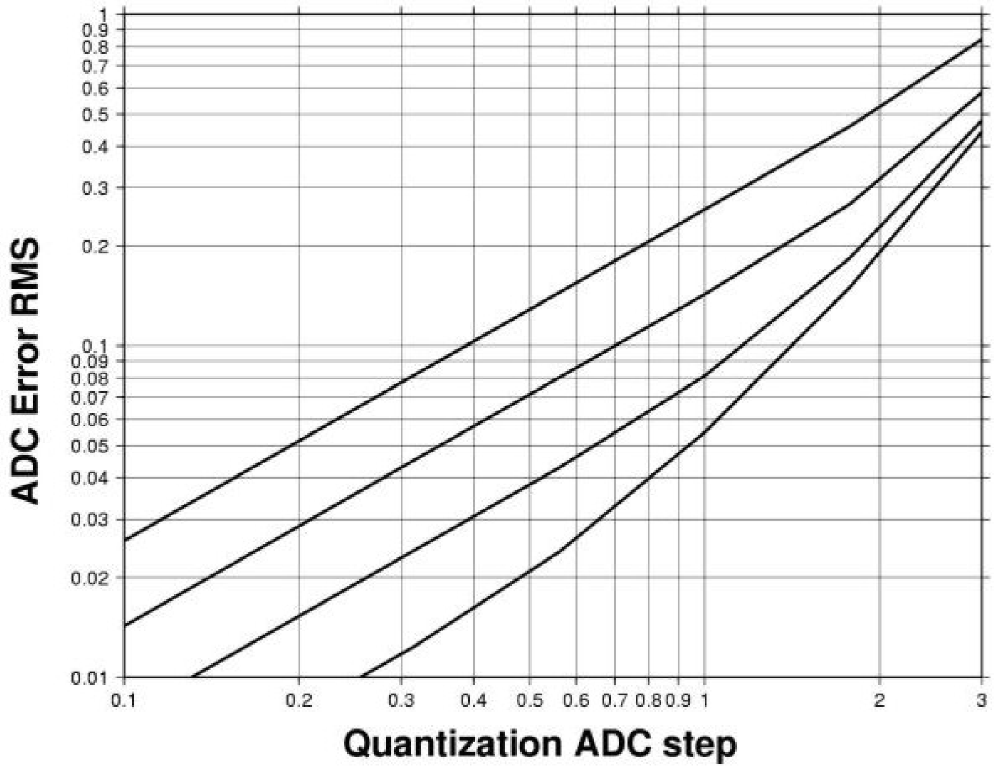

Figure 2. Quantization noise reduction by oversampling. Upper line at both panels represents ADC (A/D converter) output noise without oversampling, f_s/f_{out} = 1. The next lines correspond to oversampling f_s/f_{out} = [4,16,64], respectively. Notice that quantization error with oversampling by 64 is approximately 8 times lower (3 bits gain) than without oversampling. Quantization ADC steps are in units of noise standard deviation, ADC error RMS is $[1/L\text{-}1 \ldots (n_j-n_j^q)^2]^{1/2}$, where n_j is the initial noise, n_j^q is the quantized noise and L is number of samples in the noise realization.

GPS, Radio Clocks and Internet Timing Systems

Effective timing of seismic recordings are important since in very localized surveys, time anomalies of the order of 0.1 sec may be of significance. The most accurate and versatile of these timing systems are the GPS-clock (price around $ 300) which accuracy is at least 0.001 sec or 1 msec. An occasional draw back here is that an external antenna is needed and then expose station to possible unfriendly human interests. Radio clocks (about $40) may also be used but the transmitters in Rugby, UK and DCF-77 near Potsdam, Germany are not always accessible in NW Europe due to wave propagation effects. Disruptions in timing signals are not uncommon. The optimal timing solution would be to use the Internet that is to extract timing information from time servers which in combination with proper managing software can be obtained with the maximal error about 5 msec and mean error of 0.5 msec. Since many schools at least in Norway maintain permanent Internet connection this timing option is very attractive since it is free. We plan to install "our" 3-comp. seismic stations in Central America and here GPS timing will be used.
Non-continuous transmissions may cause problems necessitating so called soft system time adjustment. With this is meant that if external say GPS clock is lost for even a few minutes the time error may exceed the sampling period. In other words, occasionally the 'true' sampling rate may exceed the preset sampling rate unless the soft system time adjusting is part of the total timing system as in case of our design.

CPU and Data Storage

We use an inexpensive CPU unit (Intel 486 or Intel 586 at a cost of $150) which is adequate for signal detection processing in several frequency bands. Via Internet or modem/phone detected signal parameters can be transmitted to the Hub while continuous waveform storage is on a 8 Gigabyte disk (cost about $ 80). Accessing waveform data at the station site via the Internet is very attractive due to cost savings and as such necessary for any "school project". Total cost of our novel seismograph now being operational in the Åsane school yards is less than $ 1000. - work efforts and CPU cost excluded.

Real Testing of "Geophone" Seismograph

The above design features are incorporated in our new seismograph which size is minimalistic as compared to conventional seismometers (Fig. 3). To test relative performance we installed our station on the same site as one of the stations in Norwegian Seismograph Network (NSN). A local EQ recording at both of these stations are shown in Fig. 4. Since ASK (Kinemetrics Ranger) records ground velocity while our ground acceleration the records are not identical - as expected. Ideally, we would like to compare strong local event recordings with those of a nearby BB station but so far this has not been feasible. As regards seismic event detectability a direct comparison between the two station is not feasible since we use a more advanced 2-D signal detector operating in 3 frequency bands producing relatively many signal detections.

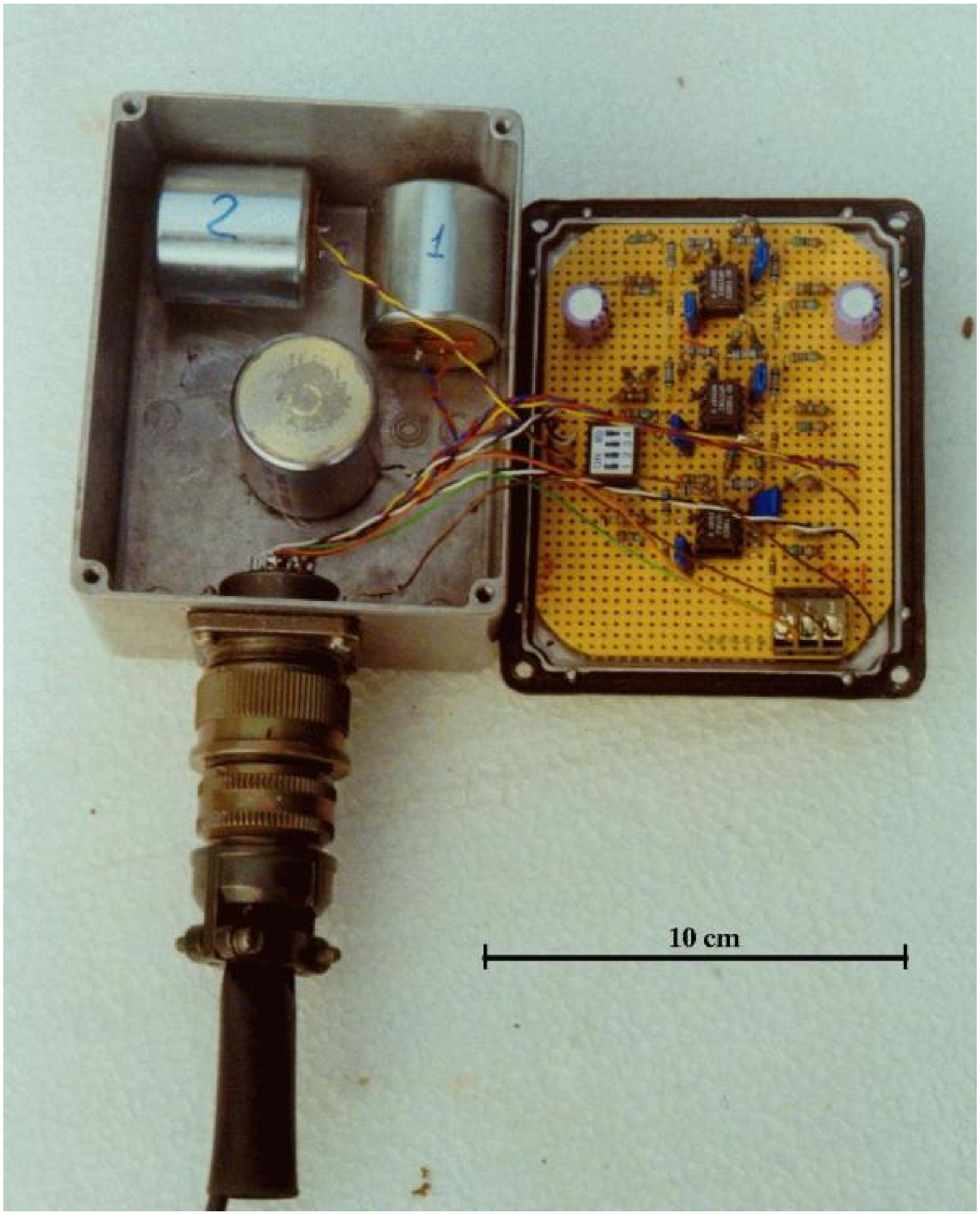

Figure 3. The "School Yard" 3-component seismograph station as installed on solid rock at Åsane Gymnas near Bergen. The three 4.5 Hz geophones are clearly seen while the electronic card is the preamplifier. Instrument box size is 9x11 cm while the field casing box is 20x23 cm. Recordings by this school yard seismograph are shown in Fig. 4.

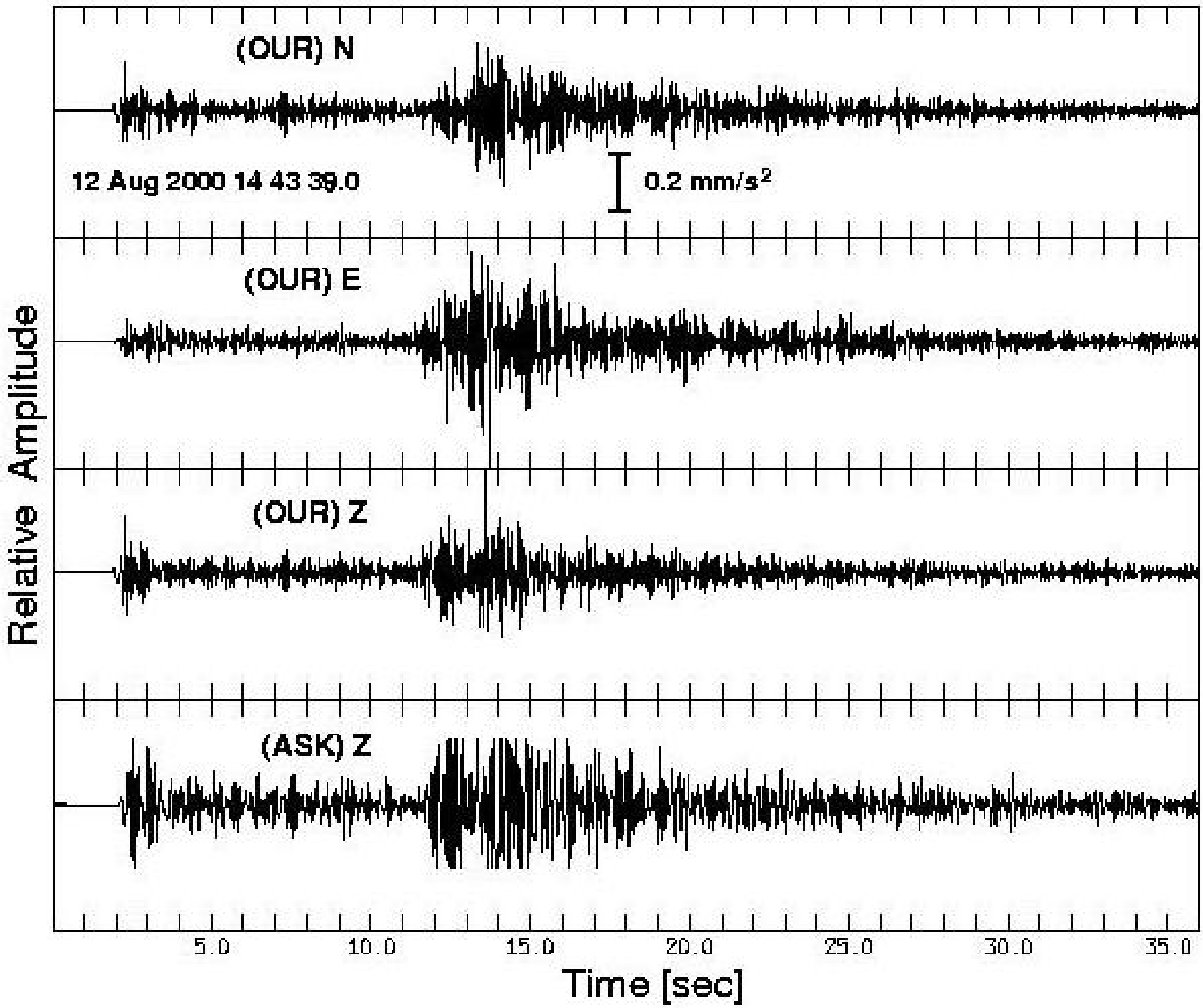

Figure 4. OUR and ASK station recordings of local earthquake; differences in waveforms are attributed to differences in sensor responces.

School Yard Seismology

There is much ongoing efforts aimed at stimulating interest among high school students with a view to also ensure better enrollments in geoscience disciplines at universities (e.g., see the ORFEUS edu-links). From a professional seismological point of view such efforts would be laudable if school yard seismograph deployments will contribute constructively to local seismicity monitoring and crustal tomography studies with high quality wavefield recordings. The crucial element for success is that every participating school have their own seismograph station producing earthquake records of professional quality. Likewise, software for signal analysis must also be available including tasks like signal detection, event location and Richter magnitude estimation - for a start. To test this 'hypothesis' we have as a pilot project installed our novel seismograph station in the school yard of the Åsane Gymnas; we proceeded in the following manner:

- Wooden frame 23x20 cm "fasten" to exposed rock with fast drying cement. The instrument box measures 9x11x5 cm. The site itself is hidden under vegetation to prevent theft and damages.
- Cable with grounding connects the 3-comp. seismometer to the CPU and A/D-converter units in the physics laboratory room inside the school. This CPU has as permanent Internet connection ensuring free data transfer.
- For student signal processing the PITSA software package has been installed.

Our first school installation is undertaken in close cooperation with local teachers. However, the next installation in Sotra High School (West of Bergen) would to the extent possible be done without our presence as this would save us time and lengthy travels - also meant as a challenge to school teachers. Naturally, the installation process step for step would be presented in the form of video instructions. From our point of view, the Åsane school yard seismograph station functions very well providing us easy and free access via Internet to high quality wavefield records. These recordings are naturally compared to ordinary and nearby station records and also checked against the automatic Norsar bulletin and global events listed by ORFEUS and NEIC.
As mentioned school installations also aim at stimulating student interest in geoscience per se but also as a mean to add a new dimension to physics and mathematics teaching. For example, picking P- and S-phase arrivals from local event recordings and then performing epicenter locations are popular exercises. More advanced problems are tied to spectral decompositions, filtering and wavefield polarization analysis. Using data literally from their own backyard are strongly motivating for students interest here which may be helpful in tracking down local quarry blasting sites.
Indeed, to "protect" ourselves from over eager students we try to organize our involvements in a rational way. Firstly, for Åsane the teacher N. A. Eldholm has set up a Tiger Team of students (3x2-persons groups) each of which are given specific working tasks. One team would participate in software development for simplified seismogram analysis of local recordings, another aim at locating local explosions and earthquakes while the third team would present geoscience structural knowledges pertinent to the Bergen area. Each of these teams would be responsible for liaisons with fellow students. A particular popular task is that of making the mandatory high school thesis problems geoscience oriented. We are also asked to create sort of News Letter service for information sharing and inter-school cooperations. Very exciting and encouraging but also demanding - hopefully also rewarding in the future.

Conclusions

We have demonstrated that it is technical feasible to construct, deploy and operate a low cost 3-comp. seismograph (less than $ 1000.) which recording performances match those of a conventional, national network SP seismograph costing at least $ 5000. Through Internet connection the need for radio/GPS clock is eliminated and likewise data transfer costs. Suitable instrumentation sites are often problematic but far less so if installed on exposed rocks in school yards. Such sites may be relatively noise but in practice not much of a problem since station density is most important in local geodynamics and tomography studies.

Network operation and data base organization may be costly undertakings but school yard installations with enthusiastic students in the roles of managers and analysts appear to be a solution to such problems. Perhaps, most important in the context of promoting science in high schools is in fostering science enthusiasm among students actively recording and analyzing earthquakes. Perhaps appropriate to quote one of Åsane "tigers"; "... now I see why maths and physics are important - how can I otherwise understand my school seismograms !"
Further plans: High school curriculas are very tight and modest in geosciences. However, a station at your doorstep create interest in terms of active participation when EQ occur either locally or disasters at far away places. In practical terms this means that math and physics problems are tied to their own EQ recordings. We will help with project work - sort of research on high school level.
Project success depend foremost on local teachers: our contributions here is a Challenging Web page(s) including factual info on geodisiplines and naturally seismology, providing analysis tools like PITSA for signal processing, GMT mapping tool for displays etc. In a longer time perspective, summer schools would be arranged at the Hub (University of Bergen) for teachers to master signal processing, basic seismology and foremost ways of incorporating geosciences in mathematics and physics problem exercises. An other important aspect is to give a hand with selected students Project work say locating local earthquakes, estimating crustal thickness, analysis of macroseismic questionnaires and so forth - goal is to retain science interest through our SEIS-SCHOOL project for many years to come.

Acknowledgements

We want to express our gratitude to Nils A. Eldholm and Sturle Kalstad, Åsane Gymnas and O. Dahle, Sotra VGS for inspiration and enthusiasm in our school yard experiment described here and not at least the learning spirit of the Tiger Team in Seismology at these schools. The research reported here was supported by the Defence Treat Reduction Agency, Department of Defence, USA under Grant DSWA 01-98-C-0159.

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The educational broadband seismic network at Naples (Southern Italy)

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Introduction

Since 1995 the Scientific Museum "Città della Scienza" and our group at the University of Naples started a cooperation aimed at developing modern educational tools in Earth Sciences. With this purpose, a number of educational activities and exhibits have been implemented and are presently operated in the museum and the Department of Physical Sciences. These are mainly addressing to the public visiting the museum, high school teachers and students.

During 1996-1998 two broadband seismic stations were installed in Naples, at the Museum of Science and at the Department of Physical Sciences in the University campus. The museum seismograph is deployed in an exposition room dedicated to the volcanoes and to the themes of seismic monitoring in volcanic and tectonic areas. The seismometer in the Museum responds to different purposes: it records the earthquakes on the whole Planet and functions as an interactive hands-on exhibit through which the visitors (most of all are students) observe live the seismograms produced by their own movement.

The Educational Seismic Network in Southern Italy

Following the successfull experience in USA of the **P**rinceton **E**arth **P**hysics **P**roject (PEPP) (lead by Prof. G.Nolet and Prof. R. Phinney) a similar initiative was launched in Europe since 1997, called the **Edu**cational **Seis**mology project (EduSeis, Virieux et al., 1999; Virieux, 2000), by the Nice (France) and Naples University groups with the creation of an educational broad-band seismic network to be installed in schools and museums.

The fundamental aim of the EduSeis European Network is to confront school students with the current practice of scientific data acquisition and management. Recent networking developments make data and tools, previously only accessible in research laboratories, now also available in the classroom. The basic idea behind the project is that seismological observations can be a vehicle to train the active use of modern technologies, learn about the dynamics and evolution of the Earth and create public awareness about the seismic activity and hazard. These objectives are accomplished by operating and maintaining a high-tech, but low-cost seismic station (sensor, data acquisition board and data acquisition software and processing) to be installed in schools, science centres/museums and other places open to schools and the general public. All components of the seismic station are especially designed for educational purposes and can be operated independently by the students and teachersi themselves.

Presently, in southern Italy four additional EduSeis stations are operated in three high schools ("Copernico" ,downtown Naples; "Ettore Majorana", Isernia, 100 km north of Naples and IPSIA, Pozzuoli, 15 km west of Naples) and in a 100m deep borehole drilled on the slope of Mt. Vesuvius volcano, 25 km east of the town of Naples (Figure 1). In particular the borehole station is part of a cooperative scientific and educational project between Osservatorio Vesuviano, University of L'Aquila and the University of Naples.

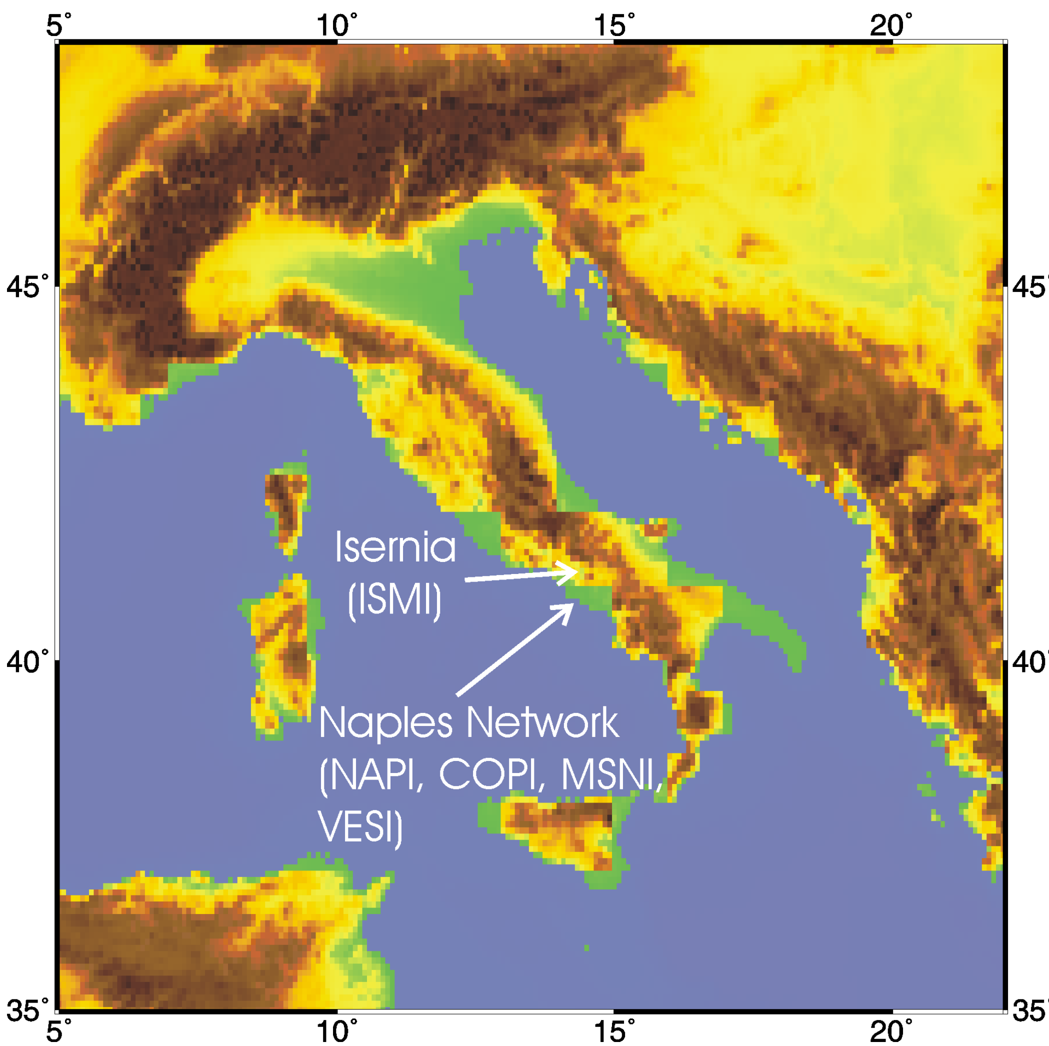

Figure 1. Map of the educational broadband seismic network at Naples and Isernia.

Data Acquisition and Management

The data acquisition system relies on a concept of automatized procedures for station control, mantainance and the availability of user-transparent software protocols for data retrieval and processing. For the southern Italy Eduseis network the data retrieval and management tasks are accomplished by a server (located at the Department of Physical Sciences) connected to the Internet and to the telephone line, running under the LINUX operating system.

The server controls the station and performs the following tasks:

1. Daily authomatic data retrieval
2. Detection of data transmission failures and automatic procedure restart
3. Preliminary data processing and archiving using the WEB facilities and data access.

Software for remote control of the stations and data retrieval have been developed by the group in Nice, with the support of Agecodagis srl, who produced the A/D card.

After retrieving the earthquake location and origin time through the Internet from National and global earthquake agencies, the relevant seismic records are recovered via modem through a daily call to every station of the network. The retrieved seismic waveforms are preliminary processed (filtering, windowing, glitch removal, ..) and transformed to the standard SAC format suitable for educational software applications. A seismic data archive is created and updated on the server and made accessible to schools and the broader public through the WEB using a rather simple data-base architecture (see EduSeis). Software for data formatting and archiving have been developed by the group in Naples.

The seismic waveforms can be either downloaded for local applications or remotely displayed by the Internet browser through a tcl/tk graphic tool developed by André Herrero in Naples. This allows for a seismogram quick view, zooming, arrival time picking and main phase identification based on the IASPEI91 travel time tables (Figure 2).

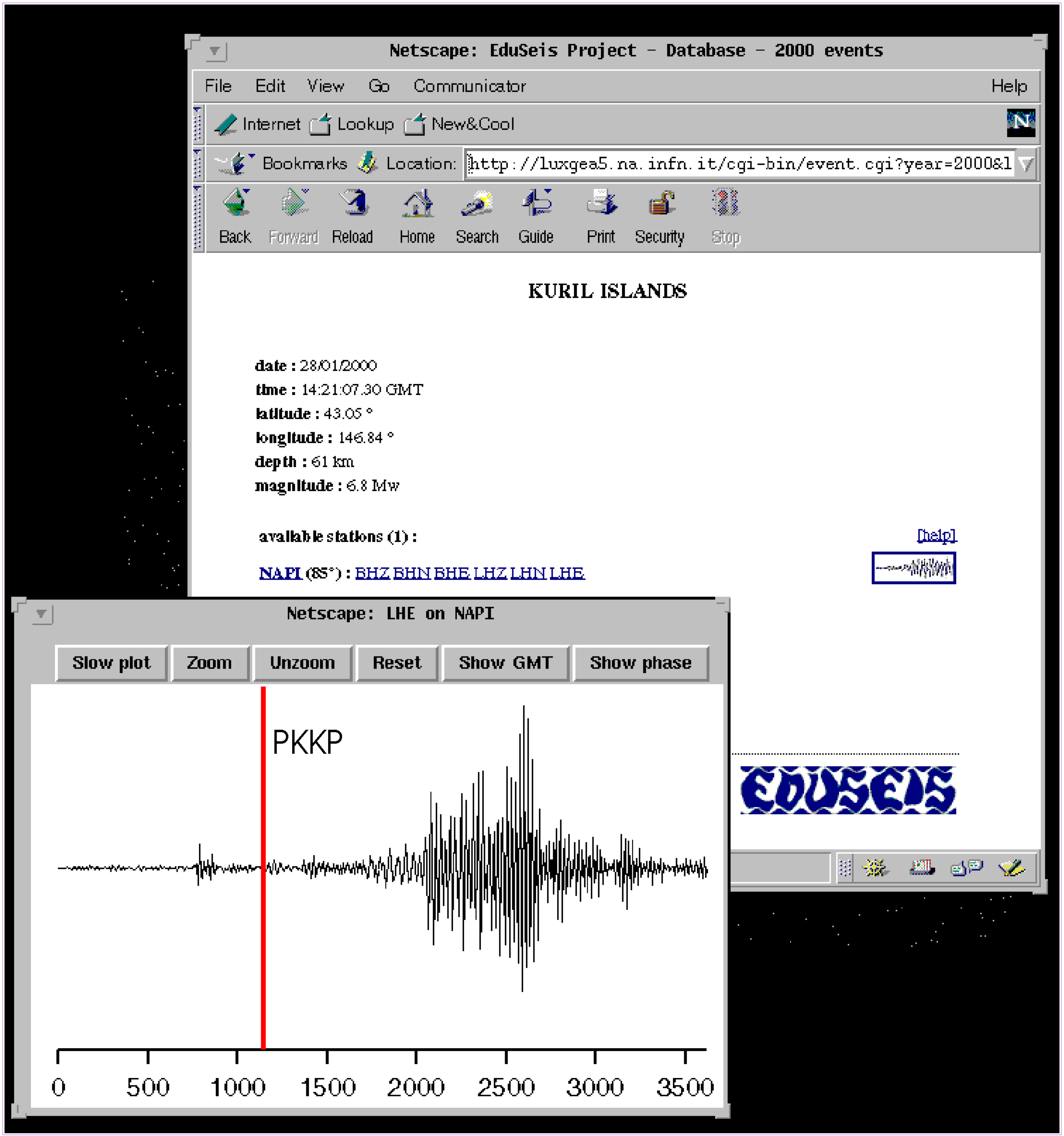

Figure 2. Example of seismogram quick-view and phase detection through the web using the tcl/tk applet.

A nearly real-time display of the ground motion recording at the station NAPI, located in the caves of the Department of Physical Sciences, is also available on the WEB through a Java-based tool developed by Luca D'Auria in Naples (Figure 3). Based on an amplitude threshold criterion, an automatic alert procedure is active, which sends an e-mail to the web manager in case a relevant regional or large global earthquake occurs.

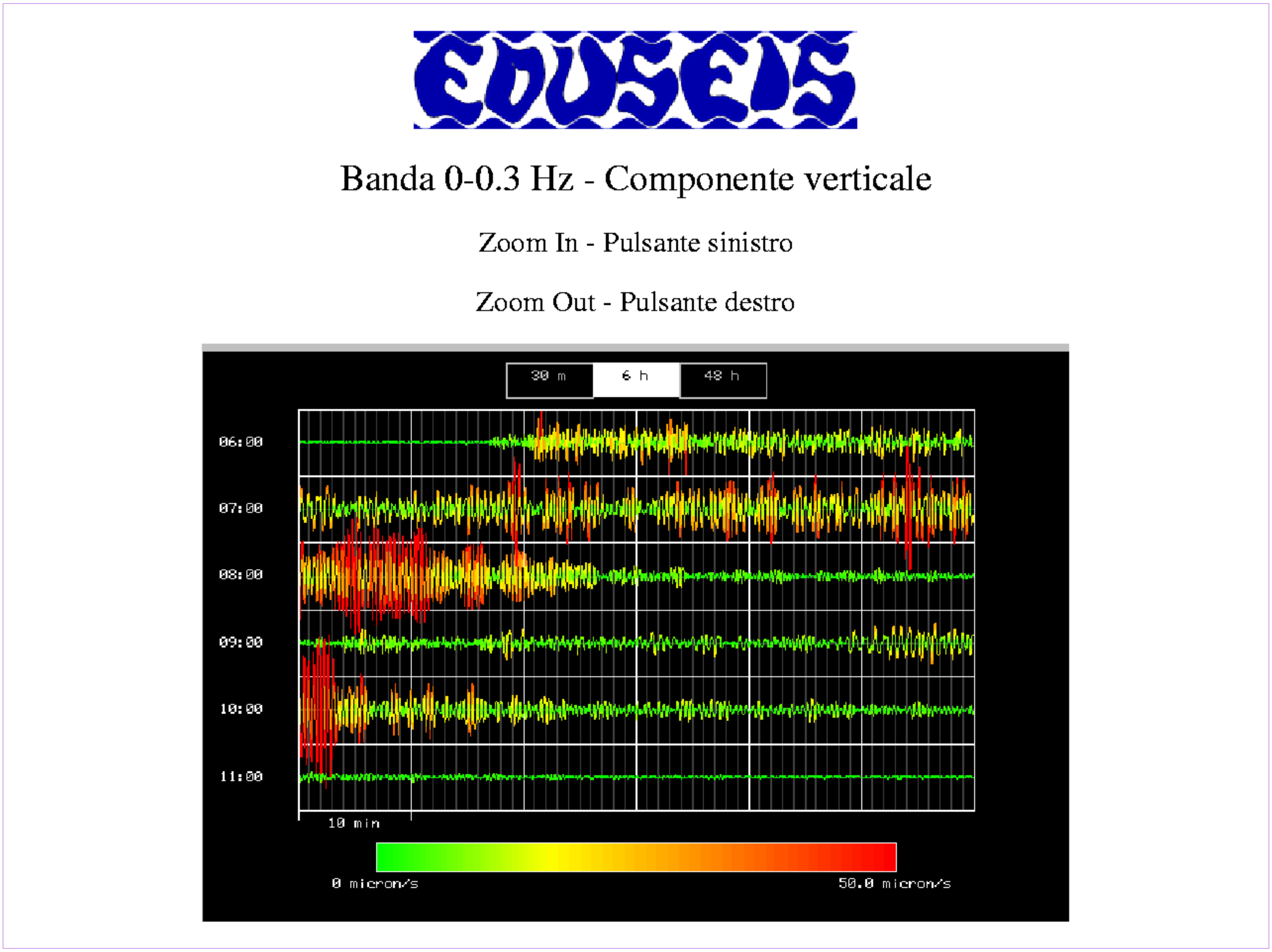

Figure 3. Near real time recording at station NAPI of the event occurred on November 16, 2000, at New Ireland (M=8.0)

Educational Activity and Information on Seismic Risk Through EDUSEIS

The Eduseis project is also an ideal framework for testing and developing seismic station components for educational and research purposes. For instance, the Eduseis stations in Italy and France operate presently a 24-bit A/D card specially designed for the school project by Agecodagis srl in France (J.Virieux, 2000). Since about two years we started to investigate and test tri-axial seismic sensors available on the market, which may be suitable for educational purposes (low-cost, broad-band frequency response and wide dynamic range). The seismic stations operating in southern Italy are equipped with different sensor types. This enable us to make a quantitative comparison of instrument responses and characteristics. Figure 4 displays the horizontal components of ground velocity for an earthquake that occurred on the Sakhalin Islands (Russia) August 4, 2000 as recorded at stations ISMI and NAPI. Both stations are equipped with a broadband sensor (PMD Scientific, 20s-20Hz). VESI is equiped with a short-period sensor (Mark Product, 1-25 Hz) and BENI with an accelerometer (EPISENSOR-Kinemetrics, 10s-100Hz). The traces have been 0.05-0.5Hz band-pass filtered. In France the EduSeis stations are equipped with PMD and Guralp products.

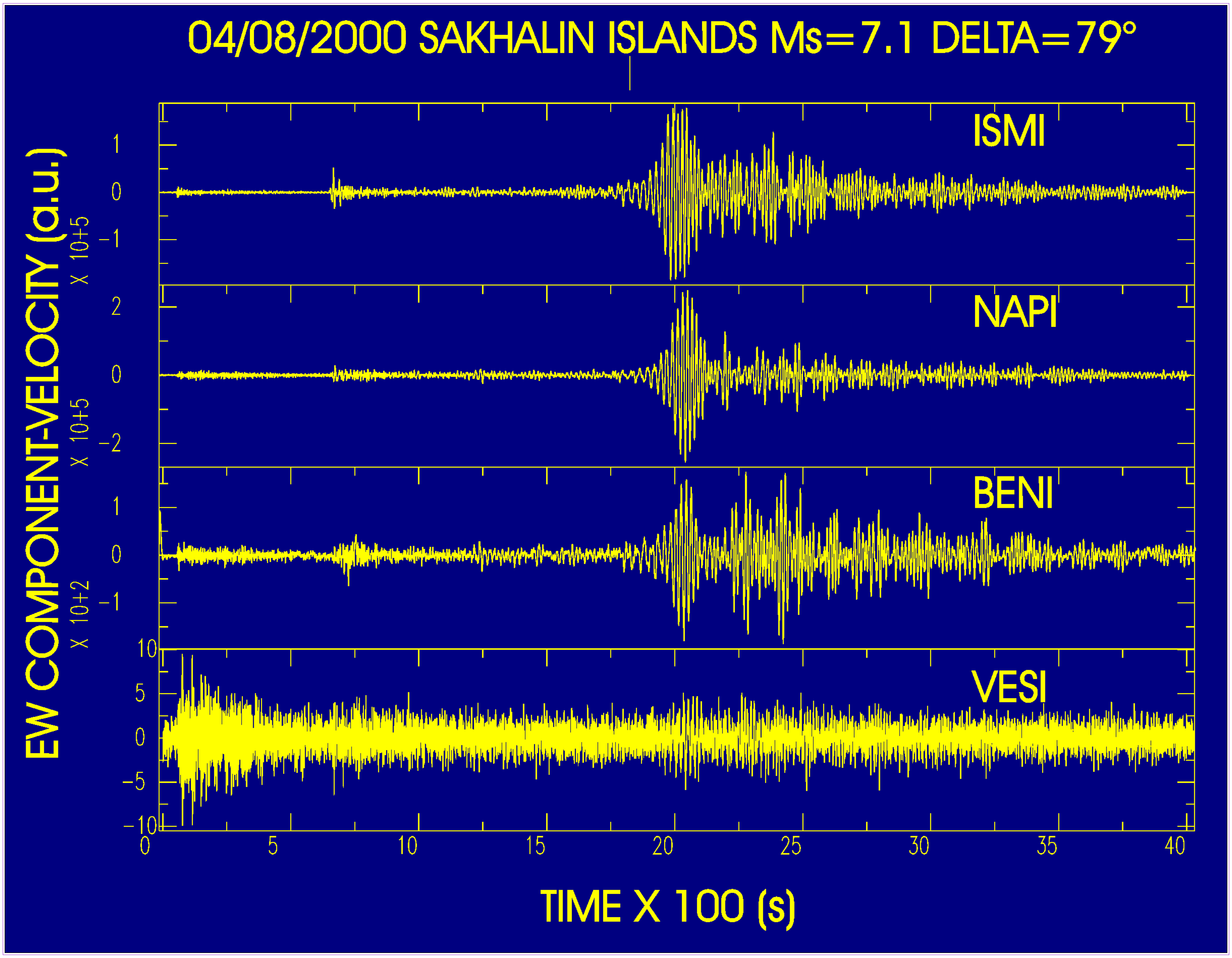

Figure 4. Band-pass filtered recordings at stations of the EduSeis network of the EW component of the ground motion velocity for the Ms=7.1 Sakhalin Island earthquake occurred on August 4, 2000.

The EduSeis project has recently received financial support from the Italian Ministry of Civil Protection (through the National Group for Earthquake Defense) to use the educational seismograph as a tool for training and awareness on the seismic risk. This project is coordinated by the Scientific Museum "Città della Scienza di Napoli" with the participation of the Institute GeoAzur at the University of Nice, the Department of Physical Sciences at the University of Naples and the high school "Liceo Scientifico Copernico" in Naples. The educational activity is organized at different levels for teachers, students and the broader public. A small group of high school teachers participate in practises at university laboratories during which they use the seismic station, analyze and interpret seismic data under the scientific assistance of researchers. For these practises we design and prepare didactic modules dedicated to the seismological practice and to seismic risk evaluation. These modules are used and verified in schools and musea by students and visitors, who provide feedback for adaption and inclusion in the italian scholar curricula.

Acknowledgements

We thank L. D'Auria and A. Herrero for the continuous software and technical support. E. Balzano, L. Cantore, F. Di Martino, C. Paolantonio and M. Simini work at the Eduseis data management and preparation of school activities. We thank J. Virieux, J.L. Berenguer and the Nice group for their participation and support to the EduSeis project. The Eduseis project is supported in Italy by ING-GNDT (2000).

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Networked Seismographs: GEOFON Real-Time Data Distribution

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Introduction

Setting up a modern seismological network providing maximum data quality, highest flexibility, standard data formats, up-to-date storage facilities and effective communication protocols is a difficult and normally a very costly task. Only very few commercially available digitizers are capable to resolve the full seismic spectrum and dynamic range provided by a modern VBB (Very Broad Band) seismometer. Companies offering such digitizers are often not capable to provide a complete real-time network solution fulfilling all wishes seismologists have in their mind or such a commercial solution becomes very expensive. Real-time communication for global networks - like in case of the GTSN (Global Telemetered Seismograph Network) or the IMS (International Monitoring System for CTBT verification) - requires normally very expensive satellite links, which are not suitable for pure research VBB networks. An earlier attempt to use the Internet as communication medium - the LISS (Live Internet Seismic Server) of the Albuquerque Seismic Lab (Slad et al., 1998) - has severe limitations as it supports only one data logger type and requires very reliable permanent Internet connections which are only very rarely available at remote sites. Thus, up to now, real-time data distribution does not play an important role for global or regional multi-national BB networks as replacement for the conventional tape recording.

Therefore the idea to develop an open, flexible, comfortable, and low cost seismological data acquisition, processing, and communication system with real-time networking capability was born. The **Seismological Communication Processor (SeisComP)** project is an initiative of the GEOFON Program of GFZ Potsdam with contributions of several other institutions. It relies on commercial VBB digitizers, cheap, reliable and worldwide available hardware (mainly PCs with Linux operating system), the Internet as major communication channel and - as much as possible - on proven open software. The present version of SeisComP consists of four individual **software packages for data acquisition, recording and monitoring** (station or network processor functionality)**, real-time communication and user access tools** (data center processor functionality).

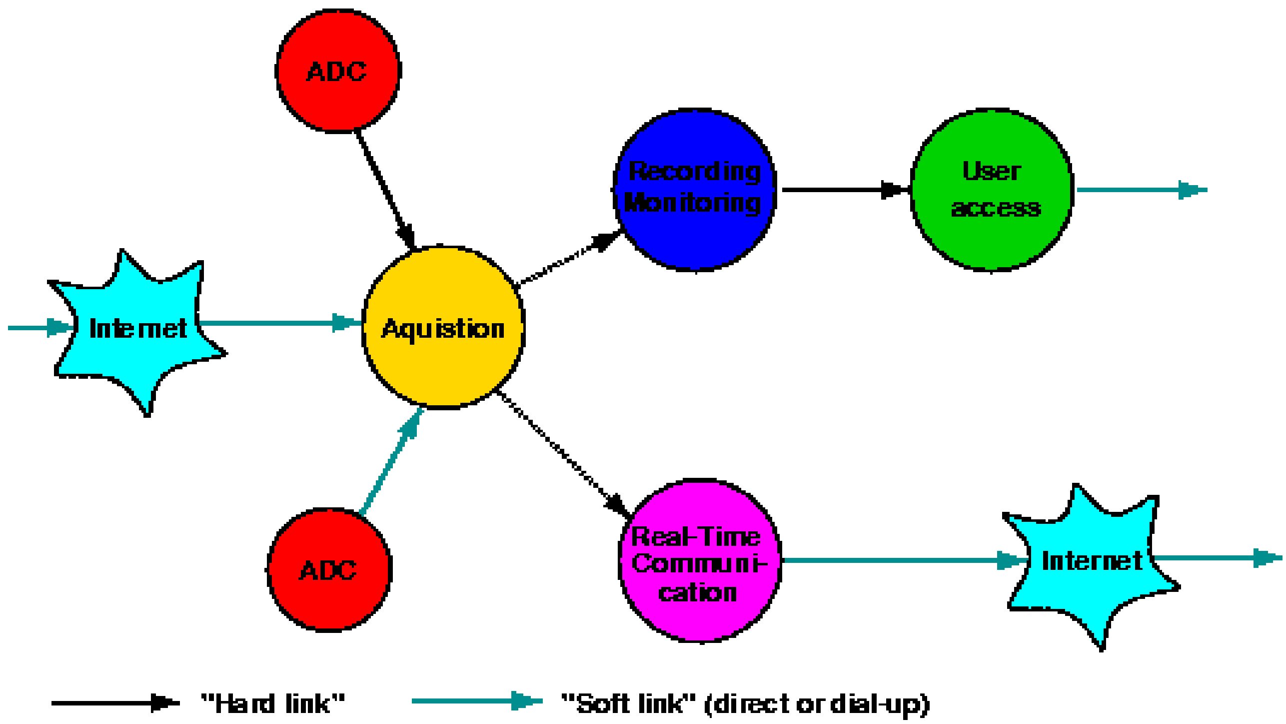

Figure 1. The basic components of a SeisComP system.

Acquisition, recording and user access of the data from one or more digitizers can take place on the same physical computer (stand-alone mode) or on different SeisComP nodes connected by the real-time communication system SeedLink (networked mode). The network communication is based on dedicated or dial-up TCP/IP links or Internet. At each node of the network, locally acquired data and/or data from other nodes can be jointly recorded and accessed. So the configuration of arbitrary "virtual" real-time networks is easy to achieve.

Data acquisition, monitoring and recording

Kernel of the data acquisition and recording part of SeisComP is the **ComServ software package** originally developed by Quanterra Inc and UC Berkeley to provide acquisition functionality for data from Quanterra dataloggers on Sun computers. This package was ported to Linux OS to operate on PC hardware. Therefore, all presently available Quanterra dataloggers are supported (Q680, Q4120, Q730). At GEOFON stations, the data are normally acquired over a RS-232 serial link (hard link, direct cable or arbitrary modem link) using the standard Quanterra comlink protocol. The Quanterra master console is usually connected by a second serial link. The server of the original ComServ package is modified such, that it is possible to acquire data also securely via TCP/IP using the SeedLink protocol (soft link, see below). That allows a combined acquisition of **locally and remotely connected digitizers**, even over large distances using the Internet. It is also possible to connect to the remote station in dial-up mode on arbitrary schedules.

Beside the original Quanterra dataloggers also **other types of digitizers or even arbitrary data sources** can be supported by SeisComP. This is done by implementing plug-ins specially designed for each new digitizer. Presently, in the public SeisComP version, this is the case for the Earth Data PS2400. The actual plug-in talks to the digitizer in its specific transfer protocol and transmits the data and logging information to another program called digiserv, which provides the data in MiniSEED packets to the modified ComServ server. Down-sampling and the generation of multiple data streams for those digitizers which do not support this, can also be performed within digiserv. Normally, it is expected that the digitizers provide correctly time-tagged data already. Lennartz Electronics has just finished a plug-in for their M24 digitizer which does not have GPS timing on board. In this implementation, a GPS corrected real-time clock on the Linux PC is used instead.

Local data recording is essential for stand-alone station processors. The original ComServ datalog client supports only disk storage. A new client, datadump, records on any tape medium and keeps track of disk and tape space. An extended version of the recording and monitoring package, used by SZGRF for the German Regional Seismic Network (GRSN), also supports disk shadowing and automatic CD-R recording.

Data acquisition and recording can be monitored within SeisComP by a number ComServ clients and other tools implemented in the Station Operation Manager (SOM). Among others, the Qplot client provides **online monitor plots** on screen, files (including web browser loadable gif files) or printer. A Java applet for real "live seismograms" is planned in future versions. Also all kinds of logging and state-of-health information can be displayed in special windows.

SeedLink real-time communication

SeisComP nodes can be linked together using the SeedLink server and clients. Server and clients in a SeedLink system are communicating by means of the SeedLink protocol, which is in principle very simple: clients send commands to the server to initiate data transfer, and the server sends back 512-byte Mini-SEED packets with 8-byte SeedLink header. The SeedLink header contains packet sequence number, which is used to resume transmission where it left off: this makes it possible to recover the connection in the case of network errors and also supports **non-permanent connections** (the "dialup mode"). The SeedLink protocol also provides capabilities to request individual SEED channels by channel name and type - this helps to reduce network traffic if the full set of data is not needed. SeedLink server uses only high-level socket interface, so it can run on any physical communication media which is supported by the underlying operating system; this includes dedicated or dial-up links by phone, radio or satellite modems, ISDN, DSL or Ethernet among others. Both **``chain'' or ``star'' type communication models** or a mixture of both are supported.

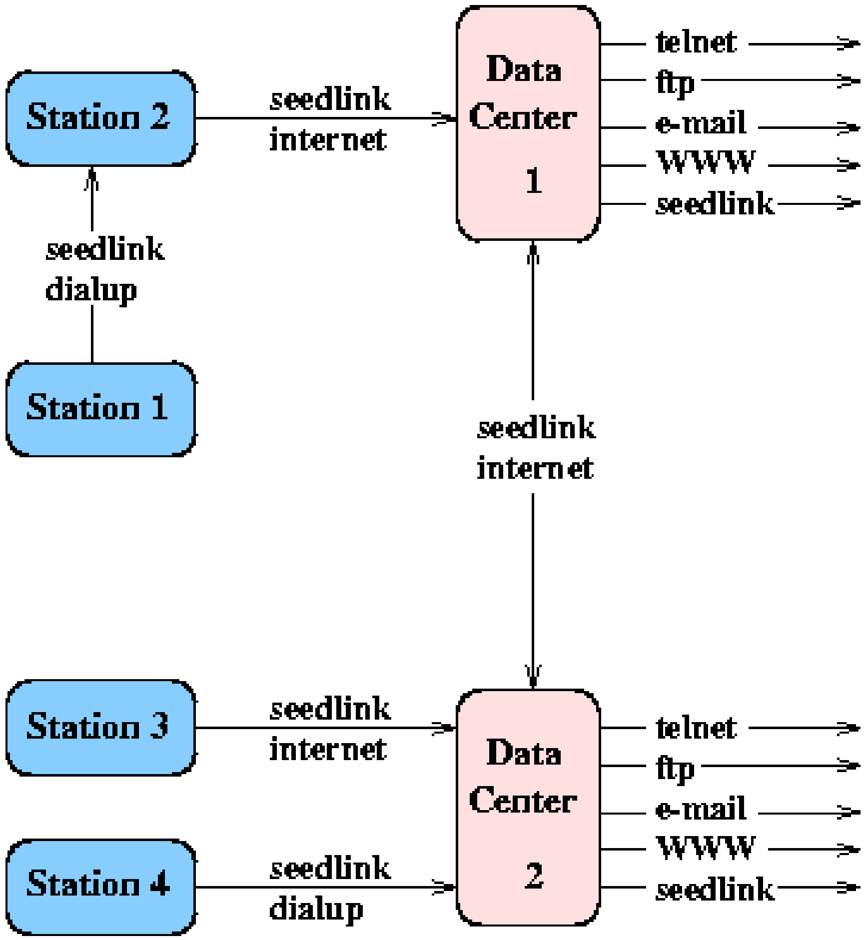

Figure 2. Example data flow in a SeedLink network using direct and dial-up connections and chain and star type communication models.

The SeedLink server is designed to support **unreliable connections**. Some number of recent packets are kept in the main memory for very efficient access, older packets are temporarily stored in the disk buffer. So it is possible to completely recover the connection even if the network is down for a long time. The size of memory and disk buffers can be specified by configuration. No error correction is implemented by SeedLink, however, because the TCP protocol guarantees error-free communication. The SeedLink concept is not only useful for real-time data exchange between stations and data centers - providing SeedLink access to users in addition to traditional data request methods makes it possible to run applications which require real-time datastreams. Each user can in principle create his own **virtual VBB real-time network**.

User access

Several more standard user access tools are also available within SeisComp. A simple telnet (or terminal emulation) based **Data Request Manager** (DRM) provides basic services: check for data availability and logging information, selection of data windows, viewing of selected data (using PASSCAL's pql utility) and downloading by ftp or kermit protocols are supported. Since telnet based access is usually not longer possible in firewall environments, a simple web form interface (**WebDRM**) was developed for data availability check and easy access to the data base. Also two email based data request methods are supported: the Swiss **AutoDRM** (by ETH Zurich and GI Stuttgart) and the IRIS **breq_fast**. The user access package can also be used independent from a SeisComP station or network setup as an **automated data cente**r if the data base is provided in a defined flat-file structure.

SeisComP implementations

Presently 15 stations of the GEOFON network are equipped with SeisComP PCs in connection with Quanterra dataloggers or digitizers (Fig. 3). Ten of those transmit their data already in quasi real-time to the data center in Potsdam. Up to 20 more stations will follow in the next 1-2 years. Also all not-GEOFON supported stations of the German Regional Seismic Network (GRSN) and other similar BB stations in Germany were upgraded to SeisComP systems by SZGRF in 1999. SeedLink real-time data transmission is in test there as well. Two more new local networks in Germany based on SeisComP technology will be installed in 2001: one with 5 stations in the Ruhr mining area (based on Earth Data digitizers) and one with 15 stations in Bavaria (using Lennartz digitizers). The complete 8-station Israeli BB network (including the non-GEOFON stations) runs on SeisComP. Several other implementations are planned in other countries.

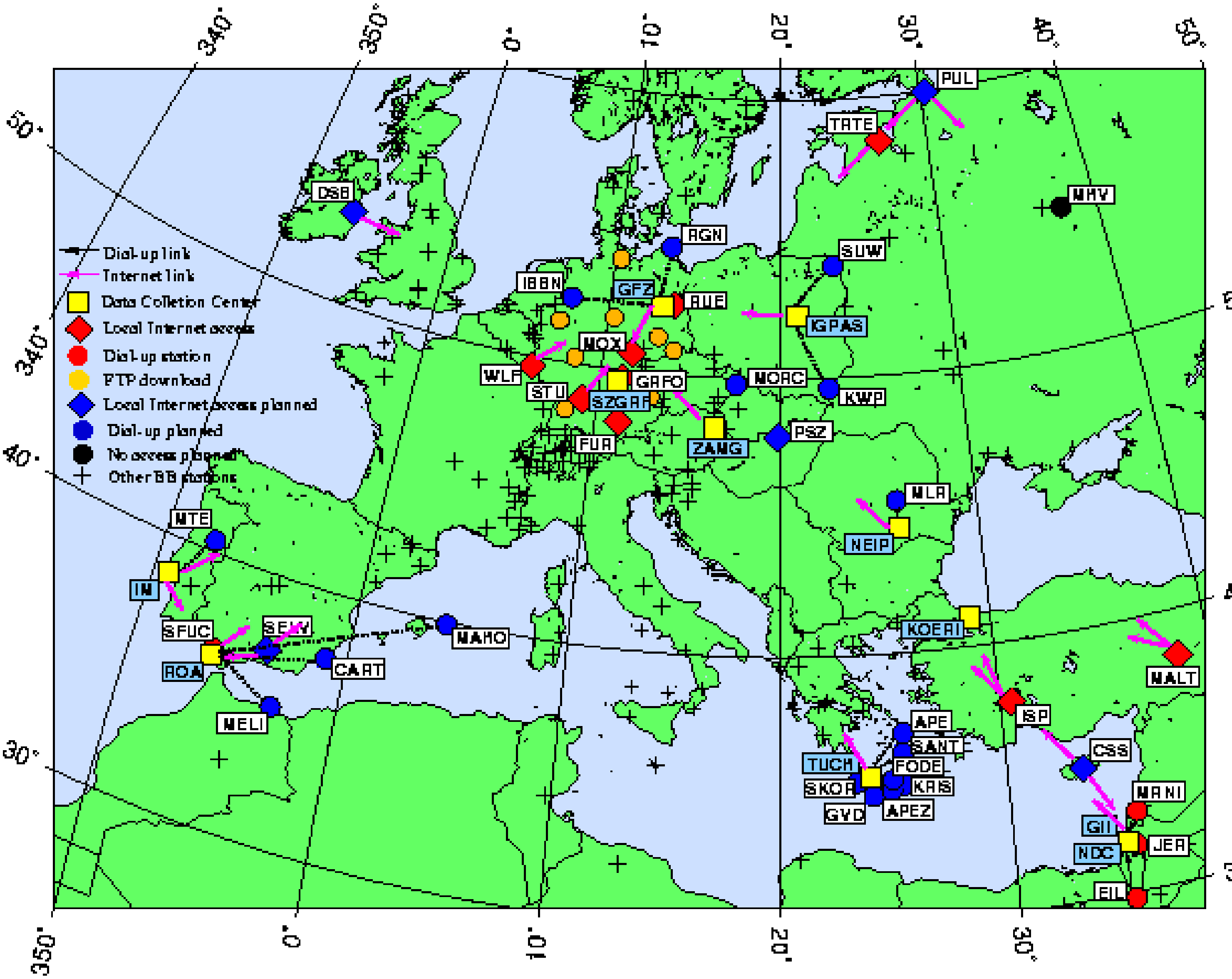

Figure 3. Major SeisComP installations in Euro-Med area, most at GEOFON stations. Dial-up stations are those not directly connected to the Internet but to a data collection center, regardless of the nature of the actual link. Local Internet access can also involve a short-distance dial-up line, but it does not include a DCC. Coordinates of the other BB stations are taken from the ORFEUS BB station inventory.

Outlook

The SeisComP project is far from being completed. Further software developments and SeisComP implementations in a lot more stations and data centers in EuroMed area are part of the EC funded MEREDIAN project under the ORFEUS umbrella. Presently planned developments in this context are the following:

So far only high-power standard office-type or industry PC hardware is used in SeisComP installations. Presently a **low power version based on embedded PC104 boards** is being developed and will become commercially available soon. Together with low-power digitizers (such as the Earth Data PS2400 or the new Q330 by Quanterra) and modern radio communication equipment (wireless LAN, "bluetooth"), this development will allow to use SeisComP in remote field installations where minimizing the power consumption is critical, but where advanced recording or networking capability is still important. Since the new GFZ field datalogger, manufactured by Earth Data, is using a newer version of the PS2400 digitizer unit and also a PC104 based Linux system for recording, it can easily be supported by the SeisComP software as well. That will allow in future temporary experiments with low power equipment following the same networking, monitoring, processing and archiving strategy as used for modern permanent real-time networks (e.g. in connection with a mobile satellite hub for the field data collection center).

A major future SeedLink improvement will be the support of **reverse Internet connections**. That means, the data center will not connect to a station as in standard mode, but the station will connect to the data center via a local Internet provider. Thereafter, the data center will request the next batch of data in the dialup mode as usual. This would allow to perform near-real-time data distribution at lowest possible costs, even take advantage from Internet flat rates. Only this measure will open SeedLink communication forthe majority of GEOFON stations, where direct Internet access is not possible and long-distance dial-up calls are too expensive to be able to download all available data.

A special SeedLink plug-in will be designed to support the **transfer of arbitrary data files**. That will e.g. allow to access non-SeisComP stations with DRM or AutoDRM functionality and feed conventionally retrieved data records into the SeedLink near-real-time distribution scheme. This feature can also be used to replace ftp data transfer of arbitrary files where unreliable Internet connections or security problems will not allow standard ftp usage.

Java based web tools are planned for easy SeisComP installation, configuration and monitoring over the web and across the network.

An **event detection client** will be implemented in the recording and monitoring package to provide event triggering capability for those digitizers, which do not provide this feature onboard.

The IRIS **NetDC** networking protocol for DC-DC data exchange will be integrated in the user access package.

Intensive discussion and several developments regarding real-time data distribution are going on within the IRIS community (Ahern, 2000) as well as in Europe. It is planned to closely coordinate with these efforts and to integrate the SeisComP concept in an even broader context.

Conclusions

The SeisComP concept has been proven to provide an open, flexible and comprehensive solution for a manufacturer independent low-cost networked VBB seismological communication system. It includes software packages for data acquisition, recording, monitoring, real-time networking across all kinds of TCP/IP networks and sophisticated user access. It has been successfully installed in the GEOFON and co-operating networks and provides a number of new features, including real-time data distribution. Besides its advantages in terms of improved network operation - easier maintenance, more complete data basis, faster data quality checks and failure detections - SeisComP offers new possibilities in the usage of regional or even global VBB data for automated near-real-time applications like quick epicenter localization and magnitude determination as well as quick moment tensor computation. This would substantial improve the rapid warning capability of the public after larger earthquakes. Substantial improvements of the package are planned within the MEREDIAN EC project.

Acknowledgements

The SeisComP project is supported by the GeoForschungsZentrum Potsdam and the European Commission within the MEREDIAN project (contract no EVR1-CT-2000-40007). Contributions were made by the Geological Survey of Estonia, the German Central Seismological Observatory Erlangen and Stuttgart University.

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ORFEUS Working Group 2: Instrumentation Workshop in Rome (Italy), November 2000

Damiano Pesaresi
ORFEUS Working Group 2 Chairman

At the end of November 2000 ORFEUS held in cooperation with Istituto Nazionale di Geofisica (ING) a workshop "Installation and operation of seismic broad-band stations". About 40 participants came from all over the world. The program covered various issues related to running a modern broad-band seismic station: we started from the installation of digital feedback seismometers, continued with transfer functions, system responses, calibration. We touched then the issues of various means and formats of data archiving and dissemination. We gave also an overlook of data telemetry.
Teachers were selected from the experts in the relative seismological fields, and they made use of real seismic instrumentation made available by ING and workstations by SUN Italy.
The Workshop was organized in conjunction with the First European Antelope Users Group meeting and the Second European Quanterra Users Group meeting. This stressed once more the close collaboaration between ORFEUS and various entities of the global seismological community, including for example IRIS.
I have to thank, among the others, the ING President Prof. Boschi and Tiziana Lanza and Alessandra Paparelli who helped a lot with local organization.

The ORFEUS Instrumentation Workshop 2000 followed the guidelines seth forth by the experience of the ORFEUS Instrumentation Workshop 1998: it was organized succesfuly in Prague in November 1998. It was then the first time that the annual meeting of the Quanterra Users Group (group of seismic network operators that use high-resolution seismic data acquisition systems produced by Quanterra) was held in Europe.
In the future we are considering having the ORFEUS Instrumentation Workshop every two years, maybe again in conjuction with the Quanterra Users Group meeting. We are also considering to include more exercises, both theoretical and practical, and more data handling lessons. After all, with a good coverage of the European territory with broad band digital seismic stations, the new developments in modern seismology are focused in data telemetry and exchange, which involves data archiving, conversion, propagation and handling.

We would appreciate suggestions from ORFEUS participants on the content of future similar workshops and therefore, please, do not hesitate to contact us.

First MEREDIAN workshop

February 1 and 2, 2001 the MEREDIAN consortium will have its first meeting. MEREDIAN is a new EC-project at ORFEUS. Co-ordinator is the Seismology Division of the Royal Netherlands Meteorological Institute (KNMI) in De Bilt, The Netherlands.

MEREDIAN, is a project (contract EVR1-CT-2000-40007) in the 5th Framework under the *Environment and Sustainable Development* programme and *Support for Research Infrastructure* action and is an acronym for **M**editerranean-**E**uropean **R**apid **E**arthquake **D**ata **I**nformation and **A**rchiving **N**etwork.

Goal of this meeting is to update the working packages and to plan and co-ordinate the work for the next 12 months within the project. Besides a number of presentation also several demonstrations of live data gathering and user software will be given. A preliminary program is available and those interested in the project developments and discussions can contact the project coordinator Torild van Eck for more information.

Specific subjects that will be discussed is real-time (or live) data exchange, through satellite and Internet. Several demonstrations will be given of LISS, SeisComP and Antelope, all actual options for live seismogram data exchnage mechanisms. Further, data archiving issues such as hardware, software, quality control and data access will be compared and discussed. Recent developments of Data user tools, specifically SeisView of Anthony Lomax, will be demonstrated.

Announcements

- **MEREDIAN**
  MEREDIAN has officially started November 1, 2000 and the **first MEREDIAN meeting** will be held February 1-2, 2001 in De Bilt, The Netherlands.
  See also Meredian short note

- **Status report ORFEUS available**
  The ORFEUS staff wrote a status report to the EMSC-ORFEUS Scientific Advisory Board. This report is available on request.

- **Femke Goutbeek has joined the ORFEUS team**
  On December 1, 2000 Femke Goutbeek joined the ORFEUS team. She is for 50% of her time employed by ORFEUS and 50% for the Seismology Department of the KNMI. Femke has received her Masters in Seismology at the Department of Geophysics at the University of Utrecht, The Netherlands. She will start working for both ORFEUS and its Data Center to become familiar with all our activities.