SEISAN WORKSHOP

Bergen, Norway
13-17 October 2008

The main goal of this workshop will be to exchange experience in the use of SEISAN that will allow us to discuss the software in it's present form, but also to look forward toward the future. During the workshop, we plan to highlight particular features in SEISAN and work on data brought by the participants and topics of interest. A basic SEISAN training course will also be provided.

There will be two types of sessions: 1) talks on specific topics and 2) working sessions. The talks should be of interest to all. A large proportion of the time will be spent in the working sessions with a content which to a large extent will be decided by the participants. During the working sessions we will probably form groups that work on specific topics using the participant's data.

Less experienced users will be offered the basic SEISAN training course which can also include users particular requests.

Available at the course will be a new version of SEISAN with a new manual and a much upgraded training course. So no need to bring any of these printed documents.

Venue and Contact phone numbers in Bergen

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Talks program

The time for each talk is about 15 minutes including questions.

Tuesday 14:

Gerardo AlguaciL	The Andalucian Seismic Network (RSA) and its data processing
Klaus Weber	Monitoring of a test disposal facility in Germany
Ian Saunders	The South African National Seismograph Network
Peter Voss	Networks, data storage and quality control: The National Seismological Network of Denmark and Greenland
Terje Utheim	The Norwegian National Seismic Network

Wednesday 15:

Juan Martin Gomez-Gonzales	SEISAN: An important tool for seismic data analysis in Central Mexico
Venus Bass	Seismic data acquisition and processing at the Montserrat Volcano Observatory
Martin Möllhoff	Current and future Seisan usage in the Geophysics Group, University College Dublin
Hans Peter Rasmussen	Daily processing of data from the National Seismological Network of Denmark and Greenland - A neural network event detection
Bladimir Moreno	Seismological network of Cuba

Thursday 16:

Linda Akromah	Mozambique seismicity for the 1st quarter of 2006
Dauda Duncan	New Nigeria network of seismic stations using SEISAN and new instrumentation
Lars Ottemoller	Seismic monitoring at the British Geological Survey
Aysegul Koseoglu Kusmezer	Moment Magnitude Determination for Local and Regional Earthquakes by using SEISAN
Aleksey Konovalov	Source parameters of small earthquakes in South of Sakhalin Island

Friday 17:

Laura Maria Vetri	Activity of the ENI E&P Microseismic group
Oleg Razinkov	Interfacing GEOSIG seismic instruments with SEISAN software
Thanu Harnpattanapanich	Small seismic monitoring nets for irrigation dams in Thailand
Antinio Villasenor	IberArray;A broadband transportable array to investigate the lithospheric structure of the Iberian Peninsula

Preliminary program

Time	**Monday 13**	**Tuesday 14**	**Wednesday 15**	**Thursday 16**	**Friday 17**
09:00-10:30	10:00- Welcome	Talks	Talks	Talks	Talks
Coffee Break					
11:00-12:30	- Introduction to SEISAN (History, basics, formats, capability) - Tour of the institute	Working session	Working session	Working session	Closing Working session
Lunch Break					
13:30-14:00	- Practical arrangements, installation of software etc, start of training - Discuss program and decide on working session content	Continuous data and quality control	- New SEISAN features - SEISAN platforms, which is best ?	Discussion: Future of SEISAN	
14:00-15:00	Working session	Working session	Working session	Working session	
Coffee Break					
15:30-17:00	Working session	Calibration in SEISAN	16:00- City Tour (starting from the Institute)	Working session	
Evening	19:00- IceBreaker at the Institute			19:30 Dinner (hosted by the Institute)	

Abstracts with speaker name (in the order of presentation)

Gerardo Alguacil
The Andalusian Seismic Network (RSA) and its data processing

The Andalusian Seismic Network is composed of two sets of stations: a) a group of seven short-period vertical stations with analogue radio-telemetry to the central recording site at the IAG and b) fifteen broad-band triaxial stations with local data storage running SEISLOG on a low power PC and linked by Ethernet, DSL, GPRS or dial-up modems. They are deployed over Andalusia (Southern Spain). SEISAN is used for the data processing. The volume of routine work overwhelms the analysts. At present we are testing SeisComp as the new data acquisition system for three of the field stations with real time data transmission, and the automatic data processing facilities of this software at the central station as well. The data in miniSeed format are incorporated to SEISAN data base manually with the help of an ad-hoc script, but this process will be soon fully automatic.

Klaus Weber
Monitoring of a test disposal facility in Germany

The former salt mine *Asse II* in Remlingen near Hanover in Western Germany is a test disposal facility for low and medium radioactive waste. After the research and development activities were completed, the mine was partly filled with residue salt coming from another salt mine. Microseismic measurements have been performed since 1980. The network consists of 31 three-component geophone sensors distributed throughout the mine. It is part of the mine’s surveillance system that monitors the geomechanical behaviour of the mine edifice. Spatial arrangements and temporal variations of the microseismic clusters indicate the development of fracture zones and confirm the stabilizing effect of the backfilling of the chambers on the mine edifice.

Ian Saunders, B. Sutherland and L. Brink
The South African National Seismograph Network

The South African National Seismograph Network was established by the Geological Survey of South Africa (now the Council for Geoscience) in 1970. The seismological network continually expanded during the next 36 years to its present status of 8 broadband, 12 extended short-period, 3 short-period stations and 3 strong-motion sensors in South Africa. This is a regional seismological network with real-time data transfer that provides phase information and earthquake locations to a wide national and international audience. It is foreseen that, through ongoing improvements the network will maintain a high standard.

Peter Voss
Networks, data storage and quality control: The National Seismological Network of Denmark and Greenland

The National Seismological Network of Denmark and Greenland includes 8 broad band and 3 short period permanent seismic stations. Additionally to these 6 temporary broad band stations are operated in Greenland.

Data from the seismic stations is collected at the NDC located at the Geological Survey of Denmark and Greenland in Copenhagen, Denmark. Data from the permanent stations is transmitted by Internet. Data from temporary stations is collected when the stations are maintained or send on flash cards or hard disk by mail by a local operator.

Three of our stations in Greenland are operated in collaboration with GEOFON: DAG, SUMG and SFJD. The SFJD station is also joint with USGS and CTBTO. Two stations, SUMG and NEEM, are located on the Greenland Icecap. Several stations are using the SEISCOMP and/or SEISLOG data logger. A SEISCOMP server at the NDC is handling the real time data between the stations and foreign networks. SEISNET is used to store data in a SEISAN database.

Two core areas, one for Denmark and one for Greenland, have been defined to outline where our earthquake catalogue must be complete. To improve global coverage international stations like KBS are included in the processing. To improve the location of the local earthquakes in Denmark and Greenland data from neighbour networks like e.g. the Swedish national seismic network (SNSN) and the Canadian National Seismograph Network (CNSN) are included in the review process of our earthquake bulletin.

Data is quality controlled by daily inspections. Quality control using Power Spectral Density Probability Density Function method is under development and will be presented.

Terje Utheim
The Norwegian National Seismic Network

The Norwegian National Seismic Network (NNSN) consists of around 30 stations, where nearly all have Internet communication to the data center in Bergen. Data, both events and continuous, are downloaded to the data center at regular intervals for further processing, on average up to 12 hours after real time using the UiB SEISNET software. Due to relatively high cost of Internet over telephone lines, continuous data transmission has not been an option.
Access to low cost Internet on most field stations, standardization of data formats and new software now makes near real time data transmission possible and economical.
UiB SEISLOG field stations (Windows or Linux) and SEISLOG embedded systems, now transmit data in a well defined standard format LISS, or SeedLink which can be read by systems like SeisComp/SeedLink and Earthworm.
An NNSN field station typically consists of a PC, a digitizer and sensor where the best are STS2 with EarthData digitizer and the simplest are SARA digitzers with 4.5 Hz geophones.
Testing is now being done at UiB running a real time system in parallel with the SEISNET system. A central SeedLink server reads data in real time from several field stations. The stations are a mix of SEISLOG Windows and SEISLOG Linux and also stations in the GSN network which are transmitted through the LISS server in Albuquerque. Stations from the UK and Finland are also included and a total of 32 stations now enter the real time system.
The SeedLink server serves as storage of continuous data as well as a provider of data for several monitoring clients and for Earthworm.
Earthworm on a Linux system reads data from the SeedLink server and do event detection. Events and continuous data are transmitted to and stored in the standard NNSN SEISAN database for processing.
We have also made some utility clients to monitor the data on the SeedLink server in near real time.
Earthworm triggers have been compared to SEISNET triggers and the conclusion is that Eartworm works well.

Juan Martin Gomez-Gonzales
SEISAN: An important tool for seismic data analysis in Central Mexico

Since seven years ago, the seismology group of Centro de Geociencias (CGEO) of UNAM started to survey several regions at the central and north part of Mexico. The most part of those regions had never been monitored by seismology. We have deployed several temporal seismic networks; composed by digital short period seismographs (GBV316), and we have recorded good quality data, but unfortunately not enough for a good seismic characterization. Thus, we are obligated to analyze those data as much as possible and we need a good knowledge about the available tools like SEISAN. Besides, we also have data recorded by one of the most important temporal seismic networks ever deployed at western Mexico, composed by 50 high resolution very broad band stations (Q330 + STS2). In this case we need as many as possible tools to analyze the data in order of take advantage of such quantity and quality of data. On the other hand, one of our purposes, in the near future, is to deploy the first permanent seismic network in central Mexico, and we will need to have a good handle of the available seismic tools in order improve our seismic knowledge and also become a reference institution in that region. Finally, we have tried to install and/or compile the latest versions of SEISAN in Linux and Mac, even though we are not software developers, we have several questions about SEISAN that we would like to solve. Until this workshop se will present the data we have collected, the challenges we have found and the importance of SEISAN in our projects.

Venus Bass
Seismic data acquisition and processing at the Montserrat Volcano Observatory

Several methods are used to monitor the activity of the Soufrieres Hill Volcano (SHV). The seismic network is, however, the backbone of the monitoring system at the Montserrat Volcano Observatory (MVO).

The MVO seismic network has developed over the 13 years of the SHV eruption (1995-ongoing). An analog seismic network, was installed by the Seismic Research Unit (SRU) before the volcano started to erupt, and was greatly expanded with equipment and help from the United States Geological Survey during the first few weeks of the eruption. A digital network was installed in October 1996. In 2005 it was upgraded to include 10 broadband, high dynamic range instruments with fully digital telemetry.

Seismic data are received at the MVO and recorded onto a computer network. A combination of SCREAM! and EARTHWORM software is currently used to acquire data from the digital network. Continuous and event data are recorded, and converted to SEISAN format. The SEISAN software package is used to analyze the earthquake data for monitoring of activity at SHV.

Martin Möllhoff
Current and future Seisan usage in the Geophysics Group, University College Dublin

Hans Peter Rasmussen
Daily processing of data from the National Seismological Network of Denmark,and Greenland - A neural network event detection

WWSSN seismographs have for decades constituted the backbone of the seismological network of Denmark and Greenland. The seismograms from the WWSSN seismographs were analysed at each station and the phase readings were thereby send to the network centre in Copenhagen by e.g. telex.

As of today the WWSSN seismograph at the DAG station is still active. This and the other WWSSN stations in the network are today upgraded to digital broad band seismographs. In this talk it will be demonstrated how more than 40th years of experience with analysing WWSSN seismograms is incorporated into SEISAN. The demonstration will involve analysis of local and teleseismic earthquake.

Bladimir Moreno

The seismic network of Cuba

Linda Akromah and T. Molea
Mozambique seismicity for the 1st quarter of 2006

This study presents the seismic pattern of southern extension of the East African Rift in Mozambique. It is mostly based on the M = 7.0 earthquake that occurred on the 23rd of February 2006 at 12:19 am. The epicenter was located in Machaze (Manica province). The aftershocks of this event are also examined in this work.

The largest event prior to 2006 was recorded in 1951 at 6.6 magnitude, hence the seismic event that occurred in the Manica province was unexpected. During the Global Seismic Assessment Programme study, a maximum credible earthquake of M = 7.3 was assigned, for a broad zone encompassing the area. Though the earthquake was felt across a large part of Southern Africa, the damage was minimal.

From the above mentioned assessments, preliminary findings indicate that four people were killed and 36 injured in Machaze and Chimoio (Southern Manica province), and Beira (Sofal Province). At least 288 houses were destroyed in Machaze, Espungabera, Mossurizi and Chimoio (Southern Manica province). In addition, six schools, one water tank, three water points, and two small bridges were destroyed in Machaze and Mossurizi. From the questionnaires, the maximum intensity of VI and VII on the Modified Mercalli scale is indicated.

Dauda Duncan
New Nigeria network of seismic stations using SEISAN and the instrumentation

Lars Ottemoller
Seismic monitoring at the British Geological Survey

The British Geological Survey (BGS) monitors the seismicity in and around the British Isles. The seismic network was started in the seventies and built up over the years to 146 short-period stations. An upgrade of this network started a few years ago and will result in a modern network with broadband seismometers, high dynamic range digitizers and real-time communication (Internet, ADSL, satellite). In total the network will comprise about 50 stations, with only few short-period stations remaining. Equipment is used from both Guralp and Nanometrics, and their respective software for data acquisition is used to bring the data to the centre in near real-time. The automated data processing is done through Earthworm. Event data are analysed using SEISAN. Continuous data are kept for all broadband stations and checked for quality and completeness. Real-time data is also exchanged with neighbouring networks. The data is used for routine monitoring, but also research. Our main research objectives are to understand distribution of seismicity and relating earthquakes to tectonics, develop velocity and attenuation models and study the seismic hazard and earthquake effects.

Aleksey Konovalov B.W. Levin and A.S. Sychov
Source parameters of small earthquakes in South of Sakhalin Island

The seismic regime of Okhotsk Sea region is dynamical in time. According to the modern studies (Seno, 1995) high level of seismic activity on Sakhalin Island is caused by tectonic plate boundary located along the island. Analysis of spatial distribution of earthquake hypocenters during last ten years made it possible to find a seismic gap (Tikhonov et al., 2007). Since 2001 the swarm activity has been rapidly increased. Three strong earthquakes which were accompanied by large amount of aftershocks have occurred in the southern part of

Sakhalin Island in the last ten years. The last one – the destructive 2007 Nevelsk earthquake (M_W 6.2) occurred in the seismic gap zone – testify to the manifestation of modern activity of the southern part of the West-Sakhalin fault.

Interest in researches of earthquake physics, of the structure and seismic regime of large earthquake sources in particular, generates a necessity of studying the weak seismicity accompanying strong seismic events. There are essentially new opportunities of quantitative estimations of dynamic source parameters of small earthquakes in regions with dense networks of digital seismic stations.

The aim of this study is the determination of seismic moment tensor of small and moderate earthquakes using records of short-period seismographs (LE-3Dlite). The given problem was solved stage by stage using Fortran subroutines of SEISAN library and the following is executed at present:

1. Frequency-depended attenuation factor of southern part of Sakhalin Island is obtained from seismic coda of local earthquakes assuming a single backscattering wave model: $Q_C(f) \approx 60 \cdot f$. Q_C attenuation is determined from time-domain amplitude measurements in frequency bands centered on the frequencies 1.5, 3, 6, 9, 12 and 18 Hz. Three-component digital waveforms of the local network are used in the calculations. Station corrections caused by local site effect are computed for each registration site.

2. The algorithm of determination and mass estimations of the scalar seismic moments of small earthquakes are realized considering the Gornozavodsk earthquake aftershocks (8.17.2006, M_W 5.6) occurred in Southern Sakhalin. Dynamic source parameters of shocks are determined using *SH*-wave spectra after attenuation, site effect and geometrical spreading corrections. The log-linear relationship $\lg M_0 \pm 0.1 = 0.95 \cdot M_L + 10.2$ between seismic moment M_0 (N·m) and the local magnitude M_L is obtained. Magnitude ranges from 1.3 to 4.0. The obtained results are in good agreement with results obtained in other regions (Roumelioti et al., 2000; Bindi et al. 2001). Average relations of source parameters poorly differ from the world-average data in the examined magnitude range, although differences have taken place and discussed in this study.

The presented methods and results of scalar seismic moment determination using digital waveforms recorded at several seismic stations allow solving, basically, a problem of moment tensor determination. Mechanism solutions of small earthquakes are beginning to be studied (Hardebeck, Shearer, 2003; Vavrycuk, 2005), and first of all applied in regions with high level of seismic activity where additional knowledge of source parameters allow to reveal relation between seismicity and physical processes in the earth's crust.

Aysegul Koseoglu Kusmezer

Moment Magnitude Determination for Local and Regionall Earthquakes by using SEISAN

This study targets to determinate the moment magnitude for local and regional earthquakes using the seismic data from KOERI's Marmara Region Broadband Stations. In long period we will use these solutions, which we are creating via SEISAN Package's AUTOSIG application, with the solutions of the zSacWin Software using the Moment Tensor Inversion algorithm, which is developed in KOERI by our colleague Mehmet Yilmazer. This will enable us to understand and extend our knowledge about the relations between Seismic Moment, Stress Drop, Seismic Energy and release of the fault. On the other hand we are also investigating the correlation values for LogA0 in Marmara Region. To compare the correlations, we are trying to calculate the MI magnitude using Wood Anderson Synthetic Seismogram. SEISAN is used as an analysis tool in my PHD Thesis and the following operations has been done until now and an abstract in brief.

We investigated the moment magnitudes from the displacement spectra of local and regional earthquakes. Whole Bogazici University Kandilli Observatory and Earthquke Reserach Institute Phase Data (KOERI) Earthquake Catalogs, between years 1999 – 2006 has been converted to SEISAN format. SEISAN is configured to use them and KOERI Phase Data between years 1976 – 2006, which has been collected using ISC, has been converted to Seisan

format. The calibration files for whole Broadband stations used in the thesis have been prepared in GSE2 File Format.
The waveform data of the earthquakes between 2006 – 2008 which are occurred in the Marmara Region, has been converted from SAC to Nordic Format and their ML magnitude and epicenters are determinated using SEISAN tools. The time domain signal of waves was especially extracted from the vertical component seismograms.
The displacement spectral amplitude $A(f)$ was found after removal of the instrument response. After the data was transformed into the frequency domain using a standard FFT routine, we are getting the source spectrum to obtain M_0 and f_c parameters.

Laura Maria Vetri
Activity of the ENI E&P Microseismic group

The activity of the group is particularly related to the study of microseismicity (M<3) in ENI production zones for monitoring purposes. The main activities are:

- microseismic networks planning, installation and maintenance.
- keeping & developing know-how about microseismic monitoring systems for environment and reservoir

At the moment in Italy three ENI networks to monitor reservoir production are active: one in the North, one in the Centre and one in the South of Italy.
Data recording and processing are carried out by Lennartz equipment and software.
Data are retrieved every 2 hours, shorter on contingent.
Data transmission to Milan is performed via analogic or GSM modem. No real-time tramission.
At the end of the month a bulletin for each network is emitted.

As regards R&D activity the microseismic group is working on a series of projects and feasibility studies regarding borehole passive seismic acquisition for reservoir characterization and reservoir fracturing follow-up.
One of these projects foresees Seislog to retrieve borehole data.

In routine work Seisan is used
- to perform vibration analysis for monitoring purposes.
- to convert data format
We are checking its potentiality by using it to reprocess data from one of the ENI networks.

As regards our needs we are at the moment looking for software that allows:
- to retrieve data in real time (earthworm + Seisan?)
- to perform data automatic processing
- to perform 3D data location (to be used for borehole acquisition)

Oleg Razinkov
Interfacing GEOSIG seismic instruments with SEISAN software

GeoSIG Ltd. is a Swiss manufacturer of seismic instrumentation. It provides superior instruments as well as complete systems and solutions for earthquake, seismic, structural, dynamic and static monitoring and measuring. Being worked in this industry actively for more than 15 years, GeoSIG gathered significant experience in the development of systems for scientific, industrial and civil engineering applications and established a permanent and strong position in the seismic instrumentation market.

GeoSIG stays in a close cooperation with University of Bergen for years in both hardware and software related matters. In particular, the product line of very compact and low cost seismographs GBV was developed in the frame of this cooperation. Therefore it is obvious that we took care of convenient ways to interface GeoSIG seismic instruments with data processing and analysis systems based on SEISAN. Two ways of such interfacing are possible: through SEISLOG and GeoDAS software packages.

All GeoSIG recorders and digitizers are able to stream data out using GSBU (GeoSIG – Bergen University) data protocol supported by the SEISLOG software. Hence these instruments can easily be integrated into any data acquisition system based on SEISLOG, which creates all necessary data files required by SEISAN.

Another way of interfacing is implemented in GeoDAS – GeoSIG Data Acquisition System software. GeoDAS has been designed to meet all requirements with respect to almost every possible application for seismic data acquisition. The program has an open architecture not only for multiple local seismic recorders connected to the standard serial port, but also for networking of local recorders, supporting modem and network communications, including communication via Internet (TCP/IP protocol). These features provide flexible interfacing between GeoSIG recorders and users irrespective of how far they are located from each other. GeoDAS can be configured to receive data streams from different digitizers and recorders and to detect seismic events. In this case event files can be created in SEISAN format and are stored into the SEISAN database automatically. If GeoDAS downloads event files from instruments working as seismic recorders, these files can also be converted into the SEISAN waveform format.

Thanu Harnpattanapanich
Small seismic monitoring nets for irrigation dams in Thailand

Antinio Villasenor
IberArray;A broadband transportable array to investigate the lithospheric structure of the Iberian Peninsula

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