Online Archives of Historical Earthquake Data: Europe and beyond

Paola Albini[1]

1. Istituto Nazionale di Geofisica e Vulcanologia, Milano, Italy, albini@mi.ingv.it

ABSTRACT

Historical Earthquake Data result from multidisciplinary investigations carried out with the aim of reconstructing the effects and size of the earthquakes of the past centuries. They can be found in published items, in the usual form of a paper or a volume, or remain unpublished, such as is often the case with the internal reports commissioned only to compile regional or national earthquake catalogues. The earthquake data these studies contain may differ importantly, from a mere transcription of the written testimony of an earthquake and its effects to the macroseismic intensity assessed at each of the affected places. These data and the heterogeneous material they come from are considered of a lesser quality, as they derive from descriptive testimonies, are bound to be incomplete and partial, thus not deserving the same archiving processing of instrumentally retrieved earthquake data. The fact remains that historical earthquake data are at the very basis of the knowledge of the seismicity of the past centuries, and their contribution to seismological studies is increasing in many aspects. The collection and preservation of the published and unpublished items supplying historical earthquake data is crucial: a) to preserve material difficult to retrieve and in some cases at risk of loss, b) to have it available for earthquake parameters assessment.

The awareness of the importance of historical earthquake data has given ground to the establishment of a module in the European Union funded project NERIES: the Networking Activity-NA4 "Distributed Archive of Historical Earthquake Data" has among its goals to promote operational links between the infrastructures collecting historical earthquake data, and establish a good practice, common standards and homogeneous procedures across the European datacenters. The key-action of the construction of the Archive has been inventorying the earthquakes and related historical studies starting from the time-window 1000-1600. On the one hand, this inventory gives way to the collection of the publicly available items. On the other hand, it points to a European Intensity Database, compiled according to standard criteria agreed among the partners. An ad hoc software was designed to allow intensity datapoints to be stored, viewed and published.

Beyond Europe, an attempt to merge the efforts of researchers interested in this subject has been made by proposing the IASPEI WG "Historical Seismology". The first aim of the WG was shaping and implementing an online archive of the studies containing historical earthquakes data. In parallel with the European activity, a first trial towards finding a tool suitable to inventory and store the material collected was made by considering the Open-Access facilities already implemented at many academic and scientific institutions. The many difficulties met when dealing with copyrighted material asked to re-define the goals of the WG. The website is currently being designed upon an open-source structure, for an efficient inventorying in the form of a critically annotated bibliographical list of the existing material on the strongest earthquakes worldwide, except Europe.

Key words: historical earthquake data, online archive, Europe, worldwide

Paola Albini

Senior Researcher at the Istituto Nazionale di Geofisica e Vulcanologia, Department of Engineering Seismology, Milano-Pavia, since 2001; previously and since 1988, she was researcher at CNR. Her thematic area is Historical Seismology. Her research and interpretation of the historical documents about the earthquakes of the past in the Euro-Mediterranean area have been published by international scientific journals, and she has been chosen as editor of several collective volumes and special issues on this topic. She actively contributes to international organizations (ESC, AGU, IASPEI, EGU) both as WG responsible and convener, and has been involved in EU research projects since 1988 (RHISE, BEECD, FAUST, NERIES). She has recently published the critical edition of a 16th century manuscript "Treatise on earthquake".

The 1934 South-Western Panama Earthquake sequence

J. Batlló[1], E. Camacho[2,3], R. Macià[4]

1. Institut Geològic de Catalunya, IGC, Balmes 209-211, E-08006 Barcelona, Spain, jbatllo@igc.cat
2. Instituto de Geociencias, Universidad de Panama, Panama, ecamacho@cableonda.net
3. Instituto de Geofísica, UNAM, Circuito de la Inv. Científica s/n Ciudad Universitaria, C.P. 04510 México D. F.
4. Dept. Matemàtica Aplicada II, UPC, Pla de Palau, 18, E-08003 Barcelona, Spain, ramon.macia@upc.edu

ABSTRACT

At the South-Western margin of the Isthmus of Panama, the Cocos, Nazca and the Panama Microplate joint in a triple junction. Here the Panama Fracture Zone which acts as the limit between the Nazca and Cocos plate subducts in an oblique and shallow manner. This is the region with the highest seismic hazard in Central America. On July 18, 1934, the largest earthquake in Panama (Ms 7.7) during the XX Century occurred at the northern end of the Panama Fracture Zone and caused extensive damage in the border region of Panama and Costa Rica. In the two subsequent days six aftershocks with magnitude greater than 6.0, were recorded.

Prior studies of this sequence have focus on the main event. In the present research, we have relocated the six main events using various phases from old seismic bulletins and historical seismograms and re-estimated the focal mechanism of the main event and the two strongest aftershocks. From digitized historical seismograms we have determined the moment magnitude for the main event and aftershocks. Additionally we gather new macro seismic information from Panama and Costa Rica and produce an improved and more complete isoseismal map of the main event.

We conclude that all the events of the sequence were offshore and shallow, at the Panama Fracture Zone, with the three strongest events showing a strike slip type of faulting. The epicentre of the main event is at 7.874N, 82.518W with a recalculated magnitude of Mw7.4. The strongest aftershock, on July 21, was the northernmost, with its epicentre very close to the coast. This may explain, in part, why this event seems to have caused many of the damage produced by this sequence.

Key words: Historical seismograms, Panama earthquakes, Panama Fracture Zone, Earthquake relocation, Focal mechanism.

PRESENTER'S BIOGRAPHY

Josep Batlló: Born in Barcelona, 08.08.1960, Degree in Physics, Universitat de Barcelona; Master of Science, Saint Louis University; Physics Ph. D., Universitat de Barcelona.

He has been teaching at the Universities of Barcelona and Politècnica de Catalunya. He was head of the seismic section at the Observatori de l'Ebre (1991-1997). From 2006 he is working in the seismological unit of the new Institut Geològic de Catalunya.

His research field is geophysics, with special attention to the seismology and the recovery and analysis of old data. These topics put him in a track halfway among seismological research and history of science. The results of his research point specifically to the fields of seismology, meteorology, history of science and of the scientific instruments.

A new automated evaluation of shear-wave splitting to display generally oriented and variable anisotropic structure of the Earth

J. Benjumea[1], J. Plomerová[2], L. Vecsey[3], I. Bondar[4]

1. International Seismological Centre, United Kingdom, juan@isc.ac.uk
2. Geophysical Institute – Czech Acad. Sci., Czech Republic, jpl@ig.cas.cz
3. Geophysical Institute – Czech Acad. Sci., Czech Republic, vecsey@ig.cas.cz
4. International Seismological Centre, United Kingdom, istvan@isc.ac.uk

ABSTRACT

To decipher complexities arising from the Earth structure variations in 3D, namely velocity heterogeneities and anisotropy, we have to leave simple 2D tools and restrictive assumptions which limit drastically modelling of the real inner structure. Any method extended into 3D requires processing of increased amount of data and therefore, this step calls inevitably for an automatization of evaluated parameters. Birefringence of shear waves is considered a proof of presence of seismic-wave velocity anisotropy in the Earth. There are several methods to evaluate an optimal pair of splitting parameters – the split delay time and fast S polarization. We present results of a new automatic method of evaluating the splitting parameters in 3D. The travel-time difference δt between the fast and slow split shear waves and the orientation of the fast S polarization (SKS phases), defined by an angle ψ in the plane normal to the ray path, are calculated from all three components of broad-band digital recordings. Pre-processing of the signals from events with Mw magnitude grater than 5.5 and sufficient S/N ratio includes: filtering (band-pass filter up to 3-30 s), rotation into the LQT co-ordinate system and phase identification and separation (AK135 model). The start- and end-times, and width of moving windows are important and in detail tested parameters as well. We apply a grid search over the ψ and δt parameters and window length. The parameter we minimize in the (ψ ,δ) domain is the minimum square singular value from the SVD (Singular Value Decomposition) signals' matrix factorization, yielding comparable results to the eigen-decomposition from the signal's covariance matrix. The SVD based method is numerically more stable. Errors are estimated using bootstrap, which makes no assumption on the distribution of the error on the splitting parameters. Quality control based on polarization angles, time lag errors and singular values' ratios is applied as well. Though the shear signal dominates on horizontal components, especially back-azimuth variations of the evaluated splitting parameters and different results for waves arriving from opposite directions, document the need for incorporating also the vertical components into analysis and, contrary to the simplified 2D azimuthal anisotropy, to consider full 360° range of both wave propagations and evaluated results. We calculate standard azimuth φ in geographical coordinates from polarization ψ and compare our preliminary results with automatic measurements available in the ISC database (Evans et al., 2006) and in the Shear-wave splitting data base in University Montpellier II (Wüstefeld et al., 2007), as well as with manual evaluations at stations located in different tectonic environments. The popularity of shear-wave splitting analyses has increased with a recent explosion in the use of digital broad-band seismometers also in temporary deployments and with acceptance of seismic velocity anisotropy as a common characteristic of the Earth interior by the geophysical community. We believe the ISC analyses can provide the high-quality world-wide background for other related scientific research, standard measure and a tool for Earth structure studies.

Key words: Shear-wave splitting, birefringence, singular value decomposition, seismic anisotropy

PRESENTER'S BIOGRAPHY

Juan Benjumea was born in Ipiales, Colombia, in 1973. He received the Ingeniero Civil degree in 2003 from Universidad del Valle, Cali, Colombia. He is presently Seismologist and Software developer for International Seismological Centre, Thatcham, UK. From 1995 to 1998 he was a Junior Research Assistant at the Seismological Observatory of SW, Universidad del Valle, Cali, Colombia. From 1998 to 2006 he was Seismologist and Research Assistant at Seismological Observatory of SW. His research interest includes risk analysis, automatic interpretation/procedures for seismological waveforms and anisotropy.

Improved GT5 selection criteria and an updated GT0-5 reference event set

István Bondár[1] and Keith McLaughlin[2]

[1]International Seismological Centre, United Kingdom, istvan@isc.ac.uk
[2]Science Applications International Corp., USA, Keith.L.McLaughlin@saic.com

ABSTRACT

We present improved GT5 selection criteria based on a geometry-based metric that is sensitive to both large azimuthal gaps and potentially correlated travel-time prediction errors, which are the major sources (apart from the velocity model) of location bias. A Monte Carlo study based on GT0 events was used to derive the new selection criteria. Our new GT5 selection criteria offer improvements over those developed by Bondár et al. (2004). The revised criteria apply stricter constraints that avoid the Pg/Pn crossover, and avoid correlated model error biases that may influence unbalanced network geometries. A normalized metric ΔU was derived that measures the deviation of the network from that of a uniform azimuthal distribution; $\Delta U = 0$ corresponds to a uniform distribution, and $\Delta U = 1$ if all stations are at the same azimuth. Crustal events were relocated using local first arriving P arrivals (< 150 km) from the EHB bulletin (Engdahl et al, 1998) using the ak135 (Kennett et al, 1995) travel-time tables. Over 3,700 events satisfied the new GT5 selection criteria that at least one station was within 10 km, the secondary azimuthal gap was less than 160 degrees, and $\Delta U < 0.35$.

We also present an updated GT0-5 reference event set made available at the ISC repository of reference events. Over 2,100 GT5 earthquake locations are based on the hybrid HDC-RCA method of Bondár et al. (2008). The remaining GT0-2 events are either announced nuclear or chemical explosions, explosions associated to explosion features located with overhead imagery, or located by in-mine seismic networks. The data set includes over 7,000 explosion and earthquake locations, accompanied by over 500,000 quality controlled arrivals. The vast majority of arrival data come from the groomed ISC (EHB) bulletin, with some additional data from temporary aftershock deployments not reported to the ISC.

Key words: reference events, ground truth

ISTVÁN BONDÁR

Dr. István Bondár is the senior seismologist at the International Seismological Centre where he is in charge of modernizing the ISC location procedures. Previously he worked for the Science Applications International Corporation as a senior scientist, where he managed various research projects supported by the Air Force Research Lab. He has established ground truth classification criteria and developed selection criteria for identifying GT5 candidate events. He developed the hybrid HDC-RCA multiple event location methodology to produce GT5 event locations, as well as a single-event location method that takes into account the correlation structure of travel-time prediction errors. He was involved in the IMS location calibration work since it inception.

Modernizing ISC location procedures

István Bondár, James Harris, Beatriz Vera, Przemyslaw Kowalski, Li Baokun and Dmitry Storchak

International Seismological Centre, United Kingdom, istvan@isc.ac.uk

ABSTRACT

The International Seismological Centre (ISC), following the recommendations of two previous ISC location workshops held at the IASPEI General Assembly, Santiago, Chile and at the IUGG General Assembly, Perugia, Italy, has adapted the ak135 (Kennett et al., 1995) velocity model in order to improve ISC location accuracy as a first step towards modernizing ISC location procedures. While the ISC reviewed bulletin is produced using ak135 tables for events from January 1, 2006, in parallel with the ak135 locations we still produce automatic locations using the Jeffreys-Bullen travel-time tables. In order to assess the location improvements due to the ak135 model over the Jeffreys-Bullen travel-time tables, we relocated some 7,000 GT0-5 events from the IASPEI Reference Event List hosted by the ISC. The results show that the ak135 locations are marginally better than those using the Jeffreys-Bullen tables, especially for teleseismic events. We also present future directions for modernizing ISC locations.

Key words: ISC location procedures, reference events

ISTVÁN BONDÁR

Dr. István Bondár is the senior seismologist at the International Seismological Centre where he is in charge of modernizing the ISC location procedures. Previously he worked for the Science Applications International Corporation as a senior scientist, where he managed various research projects supported by the Air Force Research Lab. He has established ground truth classification criteria and developed selection criteria for identifying GT5 candidate events. He developed the hybrid HDC-RCA multiple event location methodology to produce GT5 event locations, as well as a single-event location method that takes into account the correlation structure of travel-time prediction errors. He was involved in the IMS location calibration work since it inception.

The new IASPEI standard broadband magnitude mB(BB) – results of first comprehensive testing, automated determination and routine application in tsumani early warning

Peter Bormann[1], Joachim Saul[1], Xu Zhiguo[2], Siegfried Wendt[3]

1. GFZ German Research Center for Geosciences, Germany, pb65@gmx.net
2. China Earthquake Network Center, Beijing, China, xuzhg04@sina.com
3. Geophysical Observatory Collm, University of Leipzig, Germany, wendt@rz-uni-leipzig.de

ABSTRACT

Following the original concept of Beno Gutenberg (1945) for a teleseismic medium- to long-period body-wave magnitude mB, the IASPEI Working Group on Magnitudes recommended in 2005 the reintroduction of mB into global seismological observatory practice and proposed a procedure based on the maximum vertical P-wave amplitude *V*max in the whole P-wave train, measured directly on unfiltered velocity-proportional broadband records at periods between 0.2 and 30 sec. This type of mB is denoted mB(BB).

The recommended standard procedure has been applied in the interactive routine analysis of Chinese and German national broadband seismic network records. Further, an automatic real-time procedure of mB determination has been developed, tested and implemented in the operational German-Indonesian Tsunami Early Warning System. The different data sets revealed that the periods at which mB is measured grow on average exponentially with magnitude, as expected by seismic scaling laws. Since rupture duration T_{rup} also grows on average with M according to $T_{rup} = 0.6M - 2.8$, the time at which *V*max has to be measured may for large and great earthquakes be more than 100 sec after the P onset. This explains why P-wave magnitudes measured within a fixed and too short time window saturate at even lower values than one would expect from the spectral saturation according to the seismic scaling law. In order to objectify the search for *V*max within the whole P-wave train, the length of the measurement time window, that is related to T_{rup}, is estimated in the automatic procedure of mB measurement from the amplitude envelope of high-frequency (1-3 Hz) filtered P-wave signals.

Our mB(BB) data have been compared with short-period (1-Hz) mb, classical mB, Ms, Mwp and Mw. Respective data plots and regression relations show that mB avoids the strong saturation of mb for large and great earthquakes, saturates only at values around 8.3 and scales up to Mw8 rather well with surface-wave magnitudes, Mwp and Mw. However, mB determinations are – with the exception of mb - faster than these other magnitude measurements and compared with Mwp and Mw also much simpler. In order to further speed-up the near real-time availability of mB, a new calibration function has been derived which allows mB determination also in the regional distance range between 5° and 20° (not yet accepted as standard). Thus, in conjunction with the regression relation between mB and Mw, automatically determined on-line mB allows Mw estimates with a standard deviation of 0.3 m.u. within 5 to 15 min. This makes mB a suitable parameter for estimating both seismic moment related earthquake "size" and seismic energy related earthquake "strength", for purposes of either tsunami early warning or rapid assessment of the earthquake shaking potential.

Key words: broadband body-wave magnitude, seismic scaling law, magnitude conversion relations, tsunami early warning

PRESENTER'S BIOGRAPHY

Education: Diploma in in geophysics (1964); PhD (Dr. rer. nat) in seismology 1970, second PhD (Dr. sc. nat) in satellite remote sensing (1980), Professor of geophysics since 1981, Dr. rer. nat. habil in seismology (1992). **Positions held:** Head of Seismology Division of the Central Institute of Physics of the Earth (CIPE), Potsdam, Germany (1972-75); Deputy Director, Central Institute of Physics of the Earth, Potsdam (1978-1985); Head of Department of Seismology and Physics of the Earth´s Interior at CIPE, Potsdam (1981-87); Chairman of the Potsdam International Seismology Training Courses (1981-2004); Editor of the IASPEI New Manual of Seismological Observatory Practice (NMSOP) and Chairman of the related IASPEI and ESC Working Groups (1994-2002); Chairman of the IASPEI Sub-Committee on Training (1997-2003); Secretary of the IASPEI Commission on Practice (now CoSOI) (since 1992); Long-year member of several IASPEI Commissions (on education and for developing countries) and WGs (e.g. on standard phase names and magnitudes).

The new IASPEI standard broadband magnitude Ms(BB) – its peculiarities and relationships to other established magnitude scales

Peter Bormann[1], Xu Zhiguo[2], Siegfried Wendt[3]

1. GFZ German Research Center for Geosciences, Germany, pb65@gmx.net
2. China Earthquake Network Center, Beijing, China, xuzhg04@sina.com
3. Geophysical Observatory Collm, University of Leipzig, Germany, wendt@rz-uni-leipzig.de

ABSTRACT

The IASPEI Working Group on Magnitudes recommended in 2005, as a complement to Ms(20), also standards for a broadband surface-wave magnitude Ms(BB). It is based on direct measurements of the maximum amplitude *V*max of vertical component Rayleigh waves on unfiltered velocity-proportional records in a wider range of periods (3s < T < 60s) and epicentral distances (2° ≤ Δ ≤ 160°) than for Ms(20). These T and Δ ranges agree with the correct application of the Prague-Moscow calibration function for surface waves (Vaněk et al., 1962), which is IASPEI standard since 1967.
We applied the new surface-wave standard to records of shallow earthquakes (focal depth < 60 km) at stations of the Chinese and the German broadband seismic networks. Our data confirm the high stability of Ms(BB) measurements in both the regional and the teleseismic distance range with comparable or even slightly smaller measurement errors than for Ms(20). The residuals Ms(BB)-Ms(20) have only a small distance-dependent trend of < 0.003 units per degree in the whole distance range. This agrees with Bonner et al. (2006) who developed a much more complicated variable-period surface-wave magnitude procedure. We can also show that earlier findings by Herak and Herak (1993) and Rezapour and Pearce (1998) of systematic distance-errors of Ms(20) when calibrated with the IASPEI standard formula is in agreement with the average distance-trend of periods at which the log(A/T)max occurs. The majority of these periods lies both for Chinese and German data outside the range of 18-22s, although the two networks record surface waves with rather different travel paths from different regions and in different distance ranges.
Most important is the result that the regression relation between mB(BB) and Ms(BB) agrees perfectly for German data – and rather good for Chinese data – with the Gutenberg-Richter (1956) relation mB = 0.63 Ms + 2.5, although the latter is based on data in a smaller magnitude range and on Ms values derived from horizontal component ±displacement-proportional amplitude readings around 20 s, using a slightly different calibration function. The Gutenberg-Richter mB-Ms relation was later - in combination with the logEs-mB relation of the same authors – used for deriving the well known relationship log Es = 1.5 Ms + 4.8, on which the derivation of both the seismic moment magnitude scale Mw and – with some change in the constant term – also of the energy magnitude Me is based. Thus, the new broadband body- and surface magnitude scales reproduce perfectly the empirical basis on which these modern magnitude concepts rest. This confirms the compatibility of modern digitally derived magnitude data with classical magnitude definitions and analog measurement practices, assuring catalog stability and continuity. However, the known systematic deviations between Mw and Ms(20) for Mw < 6.8 are reduced to about half by Ms(BB).

Key words: broadband surface-wave magnitude, moment magnitude, magnitude regression relations.

PRESENTER'S BIOGRAPHY

Education: Diploma in in geophysics (1964); PhD (Dr. rer. nat) in seismology 1970, second PhD (Dr. sc. nat) in satellite remote sensing (1980), Professor of geophysics since 1981, Dr. rer. nat. habil in seismology (1992). **Positions held:** Head of Seismology Division of the Central Institute of Physics of the Earth (CIPE), Potsdam, Germany (1972-75); Deputy Director, Central Institute of Physics of the Earth, Potsdam (1978-1985); Head of Department of Seismology and Physics of the Earth´s Interior at CIPE, Potsdam (1981-87); Chairman of the Potsdam International Seismology Training Courses (1981-2004); Editor of the IASPEI New Manual of Seismological Observatory Practice (NMSOP) and Chairman of the related IASPEI and ESC Working Groups (1994-2002); Chairman of the IASPEI Sub-Committee on Training (1997-2003); Secretary of the IASPEI Commission on Practice (now CoSOI) (since 1992); Long-year member of several IASPEI Commissions (on education and for developing countries) and WGs (e.g. on standard phase names and magnitudes).

Proposal for a revised and amended website edition of the IASPEI NMSOP

Peter Bormann

GFZ German Research Center for Geosciences, Germany, pb65@gmx.net

ABSTRACT

The IASPEI New Manual of Seismological Observatory Practice (NMSOP) has been elaborated between 1994 and 2002 by an international Working Group, chaired by the authors. Meanwhile some 1500 hardcopies and CDs in English are used in more than 100 countries by observatory personnel, researchers and lecturers in seismology. Additionally, in 2006 a Chinese translation was published by Seismological Press (2000 copies) and major parts of the NMSOP have also been translated into Russian and made available to observatory personal and researchers at the Russian seismological station and network centers. A revised 1st edition that includes some updates and corrections of typos will soon appear on the library website of the GFZ German Research Center for Geosciences in Potsdam. However, as expressed already in the introduction to the first edition, several important topics have not yet been covered in the Manual, e.g.:

- strong-motion recordings and data analysis for applications in earthquake seismology and engineering;
- deployment, operation and data analysis of ocean-bottom seismographs for better event location, source mechanism, tomography and related studies into the structure, properties and dynamics off-shore seismic areas.
- the use of temporary seismic networks and arrays for noise and earthquake measurements aimed at microzonation and site-amplification studies;

Further, new developments in several areas covered by the first edition require upgrading of the second edition, such as:

- the new IASPEI magnitude measurement standards and results of their application;
- new developments in the field of seismic sensors, data recording systems and data formats;
- new developments in the operation, global data exchange, processing and use of seismic networks and array data;
- new considerations, methodologies and standardization efforts in volcano seismic monitoring and data analysis;
- algorithms for automatic phase interpretation, event localization and macroseismic data processing;
- web-based tutorials, demonstrations and interactive exercises on seismic data analysis.

Several commitments have already been received to take up these issues and to contribute to the second edition of the IASPEI NMSOP. But still engaged collaboration on several issues is urgently required and invited. Interested persons should contact the author (pb65@gmx.net). As a new feature, the second edition is planned to appear only on the internet and be accessible and usable free of charge by everyone interested. All contributions will be peer reviewed and get a doi number so that they can be searched for and downloaded via the internet as individual articles in leading journals. The International Seismological Center (ISC) and the library of the GFZ German Research Center for Geosciences have offered to maintain the NMSOP website and to assure its upgrading in future years in close collaboration with the IASPEI Commission on Seismic Observation and Interpretation. This proposal will be presented as a poster related to S1.

Key words: IASPEI, Manual of Observatory Practice, ocean bottom seismographs, engineering seismology.

PRESENTER'S BIOGRAPHY

Education: Diploma in in geophysics (1964); PhD (Dr. rer. nat) in seismology 1970, second PhD (Dr. sc. nat) in satellite remote sensing (1980), Professor of geophysics since 1981, Dr. rer. nat. habil in seismology (1992). **Positions held:** Head of Seismology Division of the Central Institute of Physics of the Earth (CIPE), Potsdam, Germany (1972-75); Deputy Director, Central Institute of Physics of the Earth, Potsdam (1978-1985); Head of Department of Seismology and Physics of the Earth´s Interior at CIPE, Potsdam (1981-87); Chairman of the Potsdam International Seismology Training Courses (1981-2004); Editor of the IASPEI New Manual of Seismological Observatory Practice (NMSOP) and Chairman of the related IASPEI and ESC Working Groups (1994-2002); Chairman of the IASPEI Sub-Committee on Training (1997-2003); Secretary of the IASPEI Commission on Practice (now CoSOI) (since 1992); Long-year member of several IASPEI Commissions (on education and for developing countries) and WGs (e.g. on standard phase names and magnitudes).

Citizen seismology: An experience feedback

Rémy Bossu,1 Gilles Mazet-Roux,1 and Sébastien Gilles, 1

1. Euro-Mediterranean Seismological Centre (EMSC), Bruyères le Châtel, France, bossu@emsc-csem.org

ABSTRACT

NERIES (www.neries-eu.org) is a research infrastructure project addressing observational seismology in its broadest sense and providing opportunities far beyond the consortium members alone. Many elements within this Integrated Infrastructure Initiative (I3) European Commission project are currently being realized, and a wide-scale collaboration with other projects within Europe and the United States has been established. This presentation will provide an overview of the current status of the project, its ongoing and planned activities in 2009, and the opportunities provided.

NERIES so far has accomplished the following: (1) the Virtual European Broadband Seismic Network (VEBSN) has been extended to more then 250 broadband stations, (2) two deep-sea ocean-bottom seismometer systems have been operating in the Mediterranean for nearly one year, (3) homogeneous earthquake ground shaking maps (shakemaps) can currently be produced at several European observatories, (4) prototypes of portal elements have been launched for broadband-waveform retrieval services, earthquake-parameter services, historical earthquake data, and European tomography model-review and site-response software. In addition to numerous small meetings, NERIES also organized focused workshops and meetings to promote coordination on a European scale; these events addressed such topics as the acceleration of data exchange, European observatory coordination, software developments for Web application, and historical seismology. Grants for European earth scientists have been provided and will continue to be available for research visits at several institutes.

Project collaborations involving NERIES have been set up with the following: (1) the EarthScope program, for Web portal developments; the U.S. Geological Survey , for rapid parameter exchange and shakemap developments; (3) the German-Indonesian Tsunami Early Warning System (GITEWS) program, for waveform and parameter handling, (4) the Seismic Early Warning For Europe (SAFER) program, for rapid warning; (5) the Southern California Earthquake Center (SCEC), for time varying hazard assessment (6) as well as global partnerships for subjects such as XML data format definition and standardization.

One of the goals of NERIES is to design and develop a Web portal, which would be the uppermost layer that provides rendering capabilities for the underlying sets of data. The portal would offer tools and services related to earthquake data to the earth-science community and to the public.

Key words: Cyber infrastructure, International projects

PRESENTER'S BIOGRAPHY

Rémy Bossu has been the Secretary General of the European-Mediterranean Seismological Centre since 2001. EMSC is a non-profit international NGO. Its members are seismological observatories and institutes and there are currently 83 members from 55 countries. It acts as a service provider for rapid earthquake information and it plays a key role in the integration of the Euro-Med seismological community (in close collaboration with ORFEUS (the second European organization in seismology) with the NERIES EC-project being currently the flagship project. Finally, EMSC also aims at improving collaboration and coordination with Northern Africa and the Middle East, EERWEM being its last EC-project on this topic.

The NERIES portal

Rémy Bossu,1 Torild van Eck,2 Sergio Rives, 1 Alessandro Spinuzo, 2 Phetaphone Thomy, 1 and Luca Trani, 2

1. Euro-Mediterranean Seismological Centre (EMSC), Bruyères le Châtel, France, bossu@emsc-csem.org
2. Observatories and Research Facilities for European Seismology (ORFEUS), De Bilt, The Netherlands

ABSTRACT

NERIES (www.neries-eu.org) is a research infrastructure project addressing observational seismology in its broadest sense and providing opportunities far beyond the consortium members alone. Many elements within this Integrated Infrastructure Initiative (I3) European Commission project are currently being realized, and a wide-scale collaboration with other projects within Europe and the United States has been established. The project itself will be presented in a separate presentation.

This presentation will focus on the development of the NERIES portal. The aim is to design and develop a Web portal, which would be the uppermost layer that provides rendering capabilities for the underlying sets of data. The portal would offer tools and services related to earthquake data to the earth-science community and to the public. An alpha version of the portal is currently being tested by an alpha tester group. The next phase of the development is user-driven. Users are invited to define their needs for innovative services through web pages and brainstorming sessions. This will be used to defined the implementation plan.

Key words: Cyber infrastructure, International projects

PRESENTER'S BIOGRAPHY

Rémy Bossu has been the Secretary General of the European-Mediterranean Seismological Centre since 2001. EMSC is a non-profit international NGO. Its members are seismological observatories and institutes and there are currently 83 members from 55 countries. It acts as a service provider for rapid earthquake information and it plays a key role in the integration of the Euro-Med seismological community (in close collaboration with ORFEUS (the second European organization in seismology) with the NERIES EC-project being currently the flagship project. Finally, EMSC also aims at improving collaboration and coordination with Northern Africa and the Middle East, EERWEM being its last EC-project on this topic.

Separation of scattering and intrinsic attenuation in the lithosphere of all Japan estimated from observations of HINET stations

Eduard Carcolé and Haruo Sato

Department of Geophysics, Graduate School of Science,Tohoku University, Aramaki-Aza-Aoba 6-3, Aoba-ku, Sendai-shi, Miyagi-ken, 980-8578, Japan,
eduard@zisin.geophys.tohoku.ac.jp, sato@zisin.geophys.tohoku.ac.jp.

ABSTRACT

Detailed information on the attenuation structure can provide insight into the nature of complexities in the earth structure and composition. In this work, we show estimations of scattering attenuation Q_s^{-1}, intrinsic absorption Q_i^{-1}, and seismic albedo $Q_s^{-1}/\left(Q_s^{-1}+Q_i^{-1}\right)$ by using the Multiple Lapse Time Window Analysis for all Japan. Also coda attenuation has been computed for the same data set. For this study, we have collected data from Hi-net and other networks for events with magnitudes higher than 1.5 and maximum 3.0 within the period June 2002-December 2007. The total number of high sensitivity seismic stations is larger than 1200 stations. For every station, we have collected at least 20 events within a radius of 100km and a maximum depth of 40km. We consider the addition of the square amplitude of the three-components of incoming S-waves as a measure of the energy arriving to the station in order to compute a single envelope. The results from the following frequency bands are considered: 1-2Hz, 2-4Hz, 4-8Hz, 8-16Hz and 16-32Hz. For every attenuation parameter and each frequency band the corresponding contour map is displayed.

In the attenuation contour maps, in the north of Japan, it is possible to identify the main geological regions of Hokkaido and the volcanic front through Hokkaido island and Tohoku region. In northern Hokkaido there is a very strong attenuation region that correlates with a large low velocity region for V_p and V_s and high V_p/V_s ratios. In Tohoku, intrinsic absorption is clearly weaker in the fore-arc than in the back-arc. In central Japan a change of behavior for the attenuation parameters around the Itoigawa-Shizuoka Tectonic Line can be seen and we notice the frequency dependence of the parameters for several geological structures. Some areas showing the maximum stress rates become visible when analyzing the attenuation parameters: Northern Fossa magna basin, the Boso peninsula and the Atotsugawa fault are good examples. Also the presence of volcanoes correlates with some areas showing high absorption and/or scattering values. In south-western Japan, strong attenuation values can be seen in Chugoku and in the Kii peninsula, in correlation again with velocity anomalies. It is noticeable the low scattering values in the Shikoku island. Then a different behavior between the fore-and back-arc appears again clearly. Finally in Kyushu island, it is possible to observe areas of high attenuation due to scattering and related with the volcanic activity.

As a conclusion, we show that the use of an extremely simple scattering model, based on the assumption of isotropic source radiation pattern, isotropic scattering and constant properties of the media makes it possible to obtain meaningful results that can be correlated with the main geotectonical characteristics of Japan and with the results of some other studies, in particular, velocity tomography, seismic profiles and strain analysis. Therefore, the study of scattering in the crust constitutes an important tool in order to describe the properties of the earth media.

Key words: Attenuation, Japan, Scattering.

PRESENTER'S BIOGRAPHY

Eduard Carcolé was born in Barcelona (Spain), where he graduated in Physical Sciences in 1993 in the University of Barcelona (Spain). He first focused his research in the field of Physical Optics, and obtained his M.S. Degree in Optics in 1995 in the Universitat Autònoma de Barcelona. Later on moved to San Diego State University (USA) where he carried out experimental work. He switched his interest into Seismology by showing that it is possible to solve some inverse problems by adapting special numerical algorithms used in Applied Optics in order to compute three-dimensional distributions of scatterers in the crust in his Ph.D (2006), in the Ramon Llull University. Later on he moved to Universitat Politècnica de Catalunya where he got interested in the development of new solutions of the radiative transfer equation. He is now working as a postdoc in Tohoku University (Japan) with Professor Haruo Sato. He is currently working in the analytic research of attenuation and scattering of short-period seismic waves.

A new seismograph network to improve the seismic monitoring in Brazil

Juraci Carvalho, George Sand and Lucas Vieira Barros

Seismological Observatory – University of Brasilia, Brazil, obsis@unb.br

The Brazilian territory, located almost completely inside the stable continental region of the South American plate, has a low to moderate seismicity considering that only 20 events with magnitude ≥ 5 (two of them above 6.0) occurred in the last century. Its large territory makes the low magnitude event detection/location a difficult and costly mission. To face this problem, the main Brazilian seismological institutions, Seismological Observatory of University of Brasilia (SIS-UnB), Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo (IAG/USP), Federal University of Rio Grande do Norte (UFRN) and National Observatory of Rio de Janeiro (ON) decided to collaborate in a joint project, mainly financed by the Brazilian Petroleum company (PETROBRAS), to build a new and modern Seismographic Network to improve the actual monitoring status and lower the magnitude threshold detection/location of events to about 3.5 for the South and Northeast regions and to magnitude of about 4.0 for the Northern region (Brazilian Amazon). The new Seismographic Network foresees the installation of about 60 new modern stations, the construction of suitable infrastructure and a real time data transmission system using satellite data communication. The new network, associated with some existing stations, will increase the number of stations in the present grid and extend the seismic monitoring to the remotest boundaries of the Brazilian territory. The SIS-UnB will be in charge of the sub-network implementation in the Brazilian Amazon region. The objective of this paper is to present technical information on the proposed seismic sub-network for the Amazon area, the site selection location, BB sensor vaults, background noise, equipment installation features, station distribution grid data transmission and central recording facility.

The Brazilian Amazon region embraces seven states with an area of about 5 million square km, and represents around 60% of the Brazilian territory. Any kind of equipment deployment in this area is considered a challenge due to the remoteness and inaccessibility of spots in the Amazon jungle. The seismicity in this area is poorly known and the few seismographic stations installed are unevenly distributed and focused on few specific monitoring clusters, such as, the western belt, with deep events in the end of the submerged Nazca plate under South America plate as well as a few other projects mainly related with monitoring induced seismicity in power plant reservoirs.

The current Seismograph Network operating in this region is considered obsolete, malfunctioning and too scattered to perform a reasonable regional seismic monitoring. Under the above conditions, the event detection/location threshold is not better than a teleseismic global monitoring. The SIS-UnB has some experience in this region, where the first seismic monitoring project was implemented in 1979 and was composed by a few analog seismographic stations to monitor mainly induced seismicity in the power plant reservoir areas. The upcoming Amazon sub-network will be composed by 16 primary BB 3C seismic stations in a grid separation of about 500 km. In addition to this project, the SIS-UnB will implement a few more stations to lower the detection/location threshold to a magnitude of about 3,5.

The goal of the network is to improve the seismic monitoring program in order to produce real time seismic bulletins with fast event source parameters determination. It will also provide immediate answers for information demanded by the National authorities and population in the occasions of important seismic activity occurrences. The project will also set up a high quality seismic data base with high data availability, which will contribute to the research development to better understand the Brazilian intra-plate seismicity, deeper earth structures as well as providing information for future studies in seismic hazards assessment analyses.

Key words: Brazilian seismographic network, seismic monitoring and Brazilian seismicity.

PRESENTER´S BIOGRAPHY

Mr. Carvalho has worked at the Seismological Observatory of the University of Brasilia since 1978. He is an Electronic technician, graduated in Bussiness Studies, and is currently attending a specialization in Environmental Education. He was also trained by JICA, in the Japan in Global Seismological Observation field and has extensive experience in the implementation of seismic instrumentation systems. During 7 years, he worked in Vienna as a team member of the International Monitoring System IMS/CTBTO group for the implementation of the seismographic and infrasound networks.

China Digital Seismic Network and repeating microearthquakes in China

Qi-fu Chen[1], Le Li[1], Fenglin Niu[2, 1]

1. Institute of Earthquake Science, China Earthquake Administration, China, chenqf@seis.ac.cn
2. Department of Earth Science, Rice University, USA, niu@rice.edu

ABSTRACT

The first seismological observatory of China can be traced back to the Jiufeng (Chiufeng) Seismic Station in Beijing which was established in 1930 and managed by Chinese seismologists, and the Xujiahui (Zi-ka-wei) Seismic Station in Shanghai which was established in 1904 by French Catholic missionaries. The first national digital network is the China Digital Seismograph Network which was developed in the 1980s as a Sino-US cooperative effort. With support from the central and local governments, the China Seismological Bureau (CSB) in 1996-2001 established the Digital Seismic Network (CSN) in mainland China with ~300 digital seismic stations.

The upgrading and expansion of the China Digital Seismic Network (CSN) was finished in April 2008 with support of a national project since 2003. The expanded CSN is consist of ~1000 permanent stations with more than 80% broadband sensors, including six volcano seismic networks. The expanded CSN provides excellent opportunities for geodynamicists and seismologists to resolve the fine structures and complexity of the lithosphere and deeper mantle, and to quantify the kinematics and characterize the dynamics of faults in seismogenic systems. These are important research areas that can lead to important breakthroughs in the fundamental understanding of continental dynamics and earthquake mechanics.

The CSN has provided a comprehensive database vital to search repeating microearthquakes occurred in China. Repeating earthquakes are a series of earthquakes regularly occurring on a patch of a fault plane. These earthquakes usually have nearly identical waveforms. We applied the double-difference algorithm and waveform cross-correlation methods to analyze the earthquakes and their waveform data collected by regional CSN stations around metropolitan Beijing from 2001 to 2006 and Yunnan province from 1999 to 2006. We found that approximately 53% of the earthquakes are similar or repeating events along the Tangshan fault, and about 45% of the local seismicity are similar or repeating events along the main faults in Yunnan province. Reoccurrence of earthquake is one of the features of spatial and temporal variations of earthquakes. Most of the similar sequences are aperiodic with recurrence intervals varying from a few minutes to hundreds of days. There are, however, several quasi-periodic sequences which allow us to infer slip rates. The discovery of repeating microearthquakes and its application provide a new means for inferring the slip rate at depth along the active faults.

Key words: China Digital Seismic Network, repeating microearthquake, earthquake relocation, waveform cross correlation

PRESENTER'S BIOGRAPHY

Dr. Qi-fu Chen is a research professor of Institute of Earthquake Science, China Earthquake Administration. He earned his B.Sc. degree in computational mathematics in 1984 from Fudan University and Ph.D. degree in geophysics in 1997 from Institute of Geophysics, China Earthquake Administration. He was awarded the Science and Technology Award for Chinese Young Scientist by China Associate for Science and Technology in 1997. He was awarded the Special Government Allowance issued by the State Council of China in 2006. He worked at the International Seismological Centre (ISC) in 2000 as a Royal Society fellow. From August to November 2006, he was a visiting professor in the Earthquake Research Institute, University of Tokyo. His research interests focus on the structure of fault zones and mechanisms of earthquakes, earthquake prediction research and seismic risk analysis.

The *New Geophysics*: observations of seismic shear-wave splitting lead to a new understanding of low-level fluid-rock deformation

Stuart Crampin[1,2], Yuan Gao[3]

1. School of GeoSciences, University of Edinburgh, Scotland UK, scrampin@geos.ed.ac.uk
2. also at Edinburgh Anisotropy Project, British Geological Survey, Edinburgh, Scotland UK
3. Institute of Earthquake Science, Chinese Earthquake Administration, China, gaoyuan@seis.ac.cn

ABSTRACT

Nearly universal observations of azimuthally-varying shear-wave splitting (seismic birefringence) indicate that there are anisotropic distributions of stress-aligned fluid-saturated microcracks in almost all *in situ* rocks in the crust. These microcracks are typically grain-boundary cracks in crystalline rocks, and elongated pores and pore-throats in porous sedimentary rocks. The degree of shear-wave velocity anisotropy in ostensibly-intact rock (~1.5% to 4.5%) indicates that the microcracks are so closely-spaced they verge on fracturing and hence are critical systems. Because they are critical systems, the evolution of such fluid-saturated rocks under changing conditions can be modelled by *anisotropic poro-elasticity* (*APE*), where the mechanism for low-level pre-fracturing deformation is fluid flow or dispersion along pressure gradients between neighbouring microcracks at different orientations to the stress field. Complex heterogeneous interactive systems are critical-systems and are claimed to be a *New Physics* where the criticality imposes a range of new properties on the initial sub-critical behaviour. Critical systems include: the weather, quantum mechanics, the life cycle of fruit flies, clustering of traffic on roads, the New York Stock Exchange, and a huge range of physical phenomena including fluid-saturated microcracks in the crust.

In the crust, the new critical properties include: monitorability (with shear-wave splitting); calculability (with APE); rock mass controllability (with APE, by feedback); universality (extending to all available space); and extreme (butterfly wings) sensitivity to initial conditions; amongst others. These properties are so different from those of the conventional sub-critical Earth that we claim they are a *New Geophysics.*

This results in a new understanding of low-level fluid-rock deformation that has at least two important implications.

1) Although earthquakes are deterministically unpredictable, due to the linearity/self-similarity of the Gutenberg-Richter relationship, and extreme sensitivity to initial conditions, the extensive stress-accumulation necessary before large earthquakes can be monitored by shear-wave splitting, and the time, magnitude, and in some circumstances location, of impending earthquakes can be stress-forecast.

2) The sensitivity to minor disturbances means that repeat observations between fixed source and recorders may vary with time, with implications, for example, to the disturbance of time-lapse monitoring in hydrocarbon recovery.

Note that this New Geophysics is revealed by interpretation of seismic shear-waves and shear-wave splitting. *P*-waves are sensitive to a large range of phenomena but are rather insensitive to thin fluid-saturated microcracks. In contrast, shear-wave splitting is a function of second-order changes in shear-wave velocities that, by rotation into preferred polarisations, can be measured to first-order precision, and is extremely sensitive to small changes in rock mass conditions. Since shear-wave can be shown to monitor low-level pre-fracturing deformation, this New Geophysics opens a new window into fluid-rock deformation. Papers presenting these ideas are available at <www.geos.ed.ac.uk/homes/scrampin/opinion>.

Key words: Anisotropic Poro-Elasticity (APE), fluid-rock evolution, rock mass calculability, shear-wave splitting, the *New Geophysics*,

PRESENTER'S BIOGRAPHY

Stuart Crampin: PhD, ScD, FRAS, FRSE; Conrad Schlumberger Award (EAGE); Virgil Kauffman Gold Medal (SEG); highly cited <http://www.isihighlycited.com/>; h-index 36.

Crampin pioneered theory, observation, computation, interpretation of seismic anisotropy in 260^{+} papers.

Crampin founded biennial International Workshops on Seismic Anisotropy (14IWSA will be in Perth, Australia).

Crampin founded Edinburgh Anisotropy Project (EAP) at BGS for processing multi-component seismograms. EAP still continues with ~20 oil company sponsors.

Crampin developed anisotropic poro-elasticity (APE) model of fluid-saturated crack deformation. APE led to the successful calculation (prediction) of oil production operations, and successful prediction of time, magnitude, and fault-break of M=5 earthquake.

Crampin developed prototype Stress-Monitoring Site (SMS) between 500m-deep boreholes which recorded spectacular sensitivity to remote minor seismic activity confirming science/technology/sensitivity.

Crampin is currently promoting the concept of crack-critical crust, where *in situ* cracks are so closely-spaced they are critical-systems. Consequently, low-level deformation can be monitored with shear-wave splitting, modelled/predicted with APE, and in appropriate circumstances, future behaviour controlled by feedback.

Automatic computation of IASPEI standard magnitudes at the U.S. Geological Survey/National Earthquake Information Center (USGS/NEIC)

James Dewey[1], Carol Bryan[2], Ray Buland[3], Harley Benz[4]

1. U.S. Geological Survey, MS966, Denver, Colorado, 80225-0046, USA, dewey@usgs.gov
2. Bryan Geophysical LLC, Vancouver, WA 98684, USA, cj_bryan@hotmail.com
3. U.S. Geological Survey, MS966, Denver, Colorado, 80225-0046, USA, buland@usgs.gov
4. U.S. Geological Survey, MS966, Denver, Colorado, 80225-0046, USA, benz@usgs.gov

ABSTRACT

Since 2007, the U.S. Geological Survey/National Earthquake Information Center (USGS/NEIC) has been testing computer algorithms for automatic computation of earthquake magnitudes from digital data, following standard procedures that were adopted by the IASPEI Commission on Seismological Observations and Interpretation at the Santiago, Chile, IASPEI General Assembly, 2005. Inclusion of the IASPEI standard magnitudes in the USGS/NEIC PDE catalog of earthquakes will come with the completion of a new PDE database, planned for 2009. The IASPEI procedure for determining teleseismic magnitude $M_S(20)$, M_S measured from surface waves having periods within a few seconds of 20*s,* is identical with the procedure previously used by the USGS/NEIC. For the short-period body wave magnitude m_b, the WWSSN short-period filter specified in the IASPEI standard procedure has a slightly different response than the short-period filter currently in use at the USGS/NEIC, with the result that the $m_b(IASPEI)$ computed in the USGS/NEIC test for earthquakes of $M_w \geq 6$ are on average larger by about 0.1 magnitude units than the *mb* currently computed at the USGS/NEIC. New for the USGS/NEIC are the broadband body-wave magnitude, $m_B(BB)$, measured from the maximum trace on a broadband velocity-proportional seismogram, and $M_S(BB)$, measured from surface waves having periods in the range $3s \leq T < 60s$. In the immediate aftermath of a strong earthquake, these magnitudes provide early estimates of moment-magnitude (*Mw)* that are independent of the orientation of earthquake focal-mechanism. In the long-term, the $m_B(BB)$ magnitude, and the associated amplitude-measurement times and periods, provides information on the characteristics of the earthquake source that is not available from *Mw* alone. We evaluate the stability of $M_S(BB)$ to changes in the seismotectonic environment of the earthquake source in light of previously published theoretical and observational evidence that $M_S(BB)$ measurements made at periods much less than *20s* are more susceptible than $M_S(20)$ measurements to lateral variations in crustal structure and to changes in source focal-depth.

Key words: earthquake, magnitude, standards, USGS/NEIC

James Dewey (Ph.D., University of California, Berkeley, 1971) is a Research Geophysicist with the U.S. Geological Survey. In addition to earthquake magnitudes, his seismological interests include earthquake location methodologies, regional seismicity and tectonics, macroseismic intensities, and legacy seismographic data.

Implementation of standards for making magnitude measurements from digital data

James Dewey

U.S. Geological Survey, MS966, Denver, Colorado, 80225-0046, USA

ABSTRACT

At the Santiago, Chile, IASPEI General Assembly in 2005, the IASPEI Commission on Seismological Observations and Interpretation provisionally accepted standard procedures for computing the widely used magnitude types M_L, M_S, m_b, m_B, M_W and $m_b(L_g)$ that were proposed by the Working Group On Magnitude Measurements. We now use the notation $m_B(BB)$ in place of m_B, to emphasize that this body-wave magnitude is determined from broadband data. In the case of M_S, standards were accepted for measuring $M_S(20)$ from surface waves having periods within a few seconds of 20*s*, and for measuring $M_S(BB)$ from surface waves having periods in the range $3s < T < 60s$. Implementation of the IASPEI standard procedures has begun at the U.S. Geological Survey/National Earthquake Information Center (USGS/NEIC) and the China Earthquake Network Center (CENC). The International Seismological Centre has requested that contributing agencies submit amplitudes and periods that are measured by the standard procedures. Continued adoption of standard procedures will reduce a serious source of variation in magnitude measurements between agencies and add to the value of these measurements for studies of seismic hazard, earthquake source parameters, and the attenuation structure of the earth. An essential element of the implementation of a standard procedure is comparison of results from different agencies, each of which believes it is computing magnitudes according to the specified procedure. We discuss several cases investigated by members of the Working Group in which such comparisons have revealed slight, statistically significant, differences between the implementation of generalized standard procedures at levels of detail that are greater than covered by the standard procedures. Working Group members are James W. Dewey (chair, dewey@usgs.gov), Peter Bormann (pb65@gmx.net), Irina Gabsatarova (ira@gsras.ru), Søren Gregersen (sg@geus.dk), Alexander A. Gusev (gusev@emsd.iks.ru), Won-Young Kim (wykim@ldeo.columbia.edu), Klaus Klinge (klinge@szgrf.bgr.de), Howard J. Patton (patton@lanl.gov), Bruce W. Presgrave (presgrave@usgs.gov), Liu Ruifeng (liurf@seis.ac.cn), Joachim Saul (saul@gfz-potsdam.de), Dmitry Storchak (dmitry@isc.ac.uk),Robert A. Uhrhammer (bob@seismo.berkeley.edu), Karl Veith (Karl.Veith@itt.com).

Key words: earthquake, magnitude, standards, IASPEI Working Group

James Dewey (Ph.D., University of California, Berkeley, 1971) is a Research Geophysicist with the U.S. Geological Survey. In addition to earthquake magnitudes, his seismological interests include earthquake location methodologies, regional seismicity and tectonics, macroseismic intensities, and legacy seismographic data.

Pilot Earthquake Early Warning for Athens

Diagourtas D[1], Horiuchi S[2], **Makropoulos K[3]**

1. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, diagourtas@geol.uoa.gr
2. National Research Institute for Earth Science and Disaster Prevention, 3-1, Tennodai, Tsukuba, Ibaraki, 305-0006, JAPAN, horiuchi@bosai.go.jp
3. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, kmacrop@geol.uoa.gr

ABSTRACT

Gulf of Corinth is one of the most seismically active areas in Europe and represents one of the most important threats for the metropolitan area of Athens. This area was selected in order to implement a pilot dense seismological network in order to test early warning methodologies and especially the approach developed at NIED in Japan. For this purpose, a dense high dynamic range seismic network is installed in the area of Gulf of Corinth (Central Greece) since August 2007. We present the first results of testing this novel method of determining automatically earthquake focal parameters that was initially deployed at Hinet real-time system since 2002 and is capable of locating earthquakes in a few seconds after the first P-wave arrival.

The earthquake location is calculated by using the arrival times of only a few stations in relationship with the fact that P-waves have not arrived yet at other stations at a given time (Tnow). In addition by using a few ten parameters, a very efficient P-wave picking procedure is implemented that performs automatic event classification and on-the-fly phase picks association. The first tests performed on off line network triggered data by using the same parameters tuned for the Japanese network.

Key words: Earthquake Early Warning, EEW, Real Time Seismology

PRESENTER'S BIOGRAPHY

Professor Kostantinos C. Makropoulos

Born in Greece. Education: BSc in Physics, University of Athens, 1969; PhD in Seismology, University of Edinburgh, 1978. Present position: Professor of Seismology; Director of the Geodynamic Institute of the National Observatory of Athens, President of the Greek Earthquake Planning and Protection Organization. Specialisation: Seismicity, earthquake hazard, risk analysis, earthquake engineering. He has published more than 250 original scientific papers in international journals, proceedings of international conferences and technical reports. He was Chairman of the sub-commission A, Seismicity, of the European Seismological Commission. He is member of many scientific associations. He acts as referee of papers presented to International Conferences or submitted to International Journals. His work is referenced by numerous authors and the Science Citation Index revealed more than 1000 such cases. He participates, as main contractor, in projects financed by Greek institutions and by the European Union.

CRUSTAL SEISMIC ANISOTROPY OBSERVATIONS IN NE BRAZIL: IS THAT EDA?

A F do Nascimento[1], J M Ferreira[1], F H R Bezerra[2], G França[3]

1. Department of Geophysics, Federal University of R.N. State, Brazil, aderson@dfte.ufrn.br, joaquim@dfte.ufrn.br

2. Department of Geology, Federal University of R.N. State, Brazil, bezerrafh@geologia.ufrn.br,

3. Seismological Observatory, Brasília University, Brazil, georgesand@unb.br

ABSTRACT

In NE Brazil, seismic anisotropy has been interpreted as the result of either Precambrian ductile fabric or stress-aligned, fluid-filled grain boundary caused by high pore fluid pressures. The first interpretation is based on the fact that the direction of the fastest S wave splitting agrees with the north-south trending Precambrian fabric. The second interpretation, related to the extensive dilatancy anisotropy (EDA), is based on the stress field orientation and on the assumption that the pore fluid pressure in the region is high enough to modify microcrack distribution and cause S wave polarization to become parallel to the north-south oriented minimum horizontal stress. Here we address this question by investigating this ambiguity. We have analyzed the seismicity in five different locations in NE Brazil (João Câmara, Açu, Senadar Sá, Cascavel and São Caitano). In some areas ductile Precambrian fabric is not parallel or orthogonal to the east-west trending, maximum horizontal stress. We combined the interpretation of fastest S wave polarizations, their time delays, and fabric orientation measured in the field with remote sensing products in these fives areas. Thus we discriminate between (1) stress-aligned fluid-filled cracks, (2) high pore pressure fluids modifying the microcrack distribution and therefore causing 90° flips, and (3) fabric or ‘‘paleostrain’’ as causes for the observed S wave anisotropy. Our main result indicates that the direction of the fastest S wave polarization in the NE Brazil agrees with the northeast-southwest trending fabric. EDA or 90°Flips control of seismic anisotropy, if occurring in NE Brazil, have minor effects.

Key words: Intraplate setting, seismic anisotropy, foliation, EDA, fluids.

PRESENTER'S BIOGRAPHY

Aderson Farias do Nascimento
Aderson Farias do Nascimento received his B.Sc. in Physics in 1995, his M.Sc. In Geophysics in 1996, both degrees from Federal University of Rio Grande do Norte (UFRN), He earned his PhD in Geophysics from University of Edinburgh, UK, in 2002. Since 2004, he has been employed as an adjoint Professor Adjoint of the Physics Department of UFRN. He has a research grant 2 of CNPq. His experience concentrates in Seismology, mainly acting in topics of inverse problems in Geophysics and Seismotectonics. He is a member of the graduate course in Geophysics at UFRN, where he oriented 3 masters' theses. He was the coordinator of the undergraduate course in Physics of UFRN from 2006 to 2008. He is the regional secretary of the Brazilian Society of Geophysics since 2005. He is Associate Editor of “Acta Geophysica” and co-authored 12 articles in international journals, as well as one international book. He has received research grants mainly from the Brazilian Research Council (CNPq) and the Brazilian State Oil Company (Petrobras).

DEVELOPMENT OF REFERENCE EVENT DATA SETS IN THE IRAN REGION USING IN-COUNTRY DATA, ANALYST WAVEFORM REVIEW, AND ADVANCED ALGORITHMS

E. Robert Engdahl (engdahl@colorado.edu) and Eric A. Bergman

University of Colorado, Campus Box 390 UCB, Boulder, CO 80309-0390 USA

This research has the goal of developing reference event data sets that can be used to improve locations in the Iran region, in particular the region bounded by 20-44°N and 41-67°E, by providing information needed to develop and test more accurate travel time models for seismic phases that propagate in the crust and upper mantle. We have also incorporated phase picks from an experienced analyst who reviewed waveforms of particular interest for specific events. These in-country arrival times and analyst-reviewed picks have been associated with known earthquakes reported by international agencies, combined with existing bulletin readings, and relocated using the Engdahl et al. (1998; EHB) methodology. Using in-country data we have formed new events, mostly at lower magnitudes that were not previously included in standard global earthquake catalogs. This has resulted in a catalog of earthquakes in the region for the period 1918-2008 for events larger than about magnitude 2.5. Catalog events larger than about magnitude 4.0 have been highly reviewed. Events at lower magnitudes have been relocated with a standard procedure similar to the EHB procedure, but not all have been systematically reviewed.

The new catalog has been used to conduct detailed analysis of historic and recently occurring event clusters (generally mainshock-aftershock sequences) using a multiple-event relocation technique and data sets of phase arrival times at distances from near-source to teleseismic. Absolute locations of such clusters are constrained using reference event information for one or more of the cluster events provided by local networks, aftershock deployments, or from non-seismic (e.g. InSAR or geological mapping) information. We have also developed a method for direct calibration of a cluster by using arrival time data only from local stations, with an appropriate crustal model, to locate the hypocentroid of the cluster. When both location and origin time can be calibrated for a cluster, we are able to estimate the unbiased travel times to all reporting stations. These estimates are the basis for improved models of the crust and upper mantle, which in the future will permit more accurate routine earthquake locations using regional seismic data.

We have performed multiple-event calibration analyses on 27 earthquake clusters, containing 989 events, in the region. Of these, 3 clusters could not be calibrated at all. 22 clusters contain at least one event with a calibrated location that meets GT5 criteria, a total of 549 GT5 events. We present a summary of the results of these calibration studies in the form of absolute travel time information derived from the calibrated clusters, showing distance-dependence of travel times of different phases from different source regions. We also present summaries of empirical reading error determinations and of travel time variability for different phases. Finally, we present a study of differences between arrival time picks made by an experienced analyst and those obtained from in-country and global bulletins.

Real-time earthquake source parameter determination in the area of the Alps Dinarides junction

A. Gallo, G. Costa**,** P. Suhadolc

Dipartimento di Scienze della Terra, Universita' di Trieste, Italy

A stable and automatic method is implemented to estimate in real time the seismic moment, moment magnitude and corner frequency from broad-band velocimetric and accelerometric data. The procedure gives good results even for medium and small events (M_W<2). The real time data arise from the transfrontier network in the SE Alps.

The S wave-train is identified through the application of an automatic method, which estimates the arrival times based on the hypocenter location, recording site and velocity model. The transversal component of motion is used to minimize conversion effects. The analyzed frequency window is selected on the basis of the comparison between the signal and noise spectrum (SNR). The source spectrum is obtained by correcting the signals for geometrical spreading and intrinsic attenuation. For the latter, different relationships are tested to estimate the dependence of Q on frequency and, thus, to characterize the seismic region. Source spectra for both velocity and displacement are computed following Andrews (1986), and the seismic moment and the first estimate of the corner frequency, f_0 , are then derived. In order to obtain more stable f_0 values, an optimized procedure is proposed, that fits with an w^2 decay (Brune ,1970) the high-frequency part of the spectrum.

The real-time procedure is tested with recordings of the two strongest earthquakes (M_W=5.1 Bovec 2004; M_W=4.9 Carnia 2002) together with some minor events in the SE Alps area, for which independent seismic moment and M_W estimates, obtained by waveform inversion, are available. The M_W values provided by this procedure are in a very good agreement with those obtained from waveform inversion. Finally, the properties of the computed earthquake source parameters in Friuli (NE Italy) and in Slovenia are compared and discussed.

Seismic Hazard Driven Seismological Research in Iran

Mohsen Ghafory-Ashtiany, M. Tatar and M. Mokhtari

International Institute of Earthquake Engineering and seismology (IIEES)
Tehran, Iran; ashtiany@iiees.ac.ir

Iran as one of the very well known continental collision zone located between two Arabian and Eurasian plates which converge at a rate of 24 mm/yr has experienced more than 140 strong earthquakes with magnitude of 7.5 or more in the past centuries. In this century alone, 20 large earthquake, have caused extensive human and economic losses, marking Iran as high earthquake risk region due to incompatible development with the level of exposed hazard in the past. From 1990, specially after Manjil earthquake, to ensure the sustainable development of Iran a multidisciplinary risk reduction strategy with the objective of saving human lives and resources have been initiated. In this respect, seismological research with the objective of more reliable hazard assessment has been the main core of the scientific research needed for risk reduction.

International Institute of Earthquake Engineering and seismology (IIEES) as the main developer of "Iran Earthquake Research Strategy" with the consideration of the insufficient understanding and estimation of seismicity and seismic hazard of Iran have initiated a long term seismological research program with the following objectives:

- Real time Seismic Monitoring: Expansion of Seismic and GPS Networks.
- Understanding and modeling the Kinematic Characteristic of Iran.
- Mapping and Identifying the major active faults of Iran and major cities.
- Investigation of active tectonic of Alborz, Zagros and the transitional zone.
- Paleo-seismological study of main active faults.
- Microseismic and Crustal studies of Iran, specially active regions.
- Geodetic studies of Active area using GPS measurements.
- Revisiting the past major earthquakes.
- Research on mid-term and long-term earthquake prediction.
- Processing and detail analysis of the strong motion data recorded in Iran.
- Development of PGA and spectral value attenuation relationship for Iran.
- Development of detail seismic hazard zoning map of Tehran and major cities

The general outcome and use of the above mentioned projects in the area of seismology are: Better definition of crustal velocity structural beneath the Iranian plateau which resulted in better earthquakes location; Improve quality of the seismic source parameters (magnitude, location, etc.); Understanding the mechanism and rate of deformation; Determination of the seismogenic layer in active regions; Determination of the geometry and mechanism of the active faults; and finally more reliable assessments of active faults and sources and their seismicity and consequently more reliable seismic hazard assessments.

Some of the specific research finding on the main tectonic region of Iran, namely Alborz and Zagros, Makran and

Tabriz are as follows:

- The majority of earthquakes in Zagros are located between 8 to 20 km depth.
- In central Zagros, earthquakes are spread over several parallel faults and are not confined to one possible single blind-fault.
- In the Makran subduction zone (a Tsunamigenic zone), the focal depth of earthquakes is deeper than Zagros and can be reached up to 40 km.
- transition between the Zagros collision zone and the Makran subduction zone is progressive located in the lower crust.
- In Alborz and Tabriz seismic zones, microseismicity essentially is concentrated on major active faults such as Mosha, Khazar, Zardgoli, Manjil and Tabriz.
- Crustal receiver functions from the dense records on a 620-km-long profile across central Zagros provide the direct evidence for crustal thickening in this mountain belt.
- Arabia–Eurasia convergence is accommodated differently in eastern and western Iran. The Central Iranian Block is characterized by coherent plate motion while large right lateral displacement takes place in northwestern Iran (up to 8 ± mm yr−1).

All above outcomes and the development of dense Strong Ground Motion network by BHRC of Iran and processing the rich Acceleration data bank have been used toward improving the quality and reliability of the seismic hazards assessments in Iran. Following points are some of the outcomes:

- Developing reliable SGM Attenuation relation.
- Reliable Assessment of Seismic Hazard of Iran.
- Seismic Hazard micro-zonation of major urban areas.
- Providing reliable design spectra for building codes.
- Expanding the research activities related to SGM.
- Providing inputs for developing of seismically compatible urban area planning
- Pro viding reliable input data for aseismic design of structures.

Selection of interesting signals in seismograms as Inge Lehmann did: this time for attenuation studies

Soren Gregersen

GEUS, Ostervoldgade 10 DK-1350 Copenhagen K, Denmark, sg@geus.dk

Systematics in seismogram data from event to event or from one instrument to another is what we use for extracting interpretations. We select on signal-to-noise characteristics or on frequency content. But we also use another selection criterion, namely making sure that the extracted signals are from the event, we want to investigate or are influenced by the structure, which we want to study. We pick signals that look alike. This is partly subjective, when we do it by eye. Inge Lehmann told in her last paper, what she did when studying travel-time distance curves: "In the beginning observations from the International Seismological Summary were used. Later I preferred to read phases from borrowed records or from copies of records". Modern discussions in Copenhagen have accepted this selection and pinpointed:

1. One can argue for many different technical and computer processing reasons to throw out particular data points, e.g. timing errors.
2. It is not allowed to select some data and leave other data out by subjective, individual choice.
3. It is allowed to take some data points aside and treat them differently, but arguments must be good enough to be written down. This includes selection of data as Inge Lehmann did, where the criterion is that the signals on two stations are from the same event and essentially influenced by the structure under study.

Inge Lehmann made her selection of phase time readings different from another well-known seismologist, Harold Jeffreys. She selected comparative signals, while he instead took into account all supplied time readings, made by various observers from various instruments, and used statistics. In recent attenuation studies of earthquake signals crossing Greenland from station to station, we have chosen the Lehmann approach, but we are still left with too large uncertainties on the amplitudes.

Synthetic rupture models to study the effectiveness of predominant period as an early indicator of earthquake magnitude

Mark W. Hildyard[1], Andreas Rietbrock[2]

1. University of Liverpool, UK, mark.hildyard@liverpool.ac.uk
2. University of Liverpool, UK, a.rietbrock@liverpool.ac.uk

ABSTRACT

T^{p}_{Max} was introduced by Nakamura (1988), and by Allen and Kanamori (2003), as a method for estimating the magnitude of an earthquake from the first few seconds of P-wave arrival. While a number of papers have shown that there is a clear empirical relationship between T^{p}_{Max} and magnitude, the approach still evokes some fundamental questions, such as what is the cause of the considerable scatter and can such scatter be reduced; and can large magnitudes be successfully characterised by this method when magnitudes above M6 and M7, may have rupture durations longer than the first few seconds which are used to determine the earthquake magnitude?

We produced a synthetic dataset from a large number of rupture models to investigate the causes of scatter and its relationship to the rupture process, and also to investigate saturation effects at large magnitudes. We use a simple rupture model where we impose a stress-drop with a prescribed rise-time over a small patch of an explicit fault surface. This stress-drop is propagated to other patches of the fault according to a prescribed rupture rate. The same finite difference model geometry and fault patch size was then used to model events ranging from magnitude 3.7 to 7.2. Moment Magnitude was calculated by integrating the resultant slip on the fault, and T^{p}_{Max} was calculated from seismograms recorded on surface 50 km from the centre of the fault. Initial models used constant distributions for stress drop, rise-time, and rupture rate. Variations in orientation were excluded from the initial investigations as it was assumed that such variations can be resolved with multiple sensors, while rupture effects cannot.

Results show a very smooth increasing trend of T^{p}_{Max} with magnitude, when the geometry and fault rupture properties are kept constant. Geometric effects such as depth and position of the fault introduce a small amount of scatter. Considerable scatter is introduced by variations in the stress drop, rise time, rupture initiation point, and rupture velocity. However, constraining the bounds for these values would constrain the amount of scatter attributable to rupture variations, and lead to clearer bounds on the accuracy of estimated magnitudes. Saturation effects became evident for smaller events than expected, namely for events over magnitude 6. A reduction in T^{p}_{Max} occurred for larger magnitudes, leading to ambiguity. Interestingly however, low frequency filtering was found to reduce the time taken to reach a maximum in the calculation, reaching a maximum in less time than the time to rupture. Filtering low frequencies therefore extended the magnitude range over which the method could be used effectively., and could be an important practical consideration in using the method. The work is being extended to consider heterogeneous distributions in rupture properties, the best manner to combine multiple sensors, and whether a modified function (T^{pd}_{Max}) (Hildyard et al, 2008) improves behaviour in noisy waveforms.

Key words: Magnitude, predominant, period, model, rupture.

PRESENTER'S BIOGRAPHY

Dr Hildyard spent many years in rockburst research in the South African mining industry, where he was involved in developing the finite difference program WAVE. His research interests lie in the fields of modelling, source processes and wave interaction with fracturing. In 2005 he was awarded the Rocha Medal by the International Society for Rock Mechanics (ISRM), for his thesis entitled "Wave interaction with underground openings in fractured rock". He is currently at the University of Liverpool, researching real-time methods for determining magnitude as part of the EC sponsored project, NERIES.

Application of Mwp to locally recorded earthquake seismograms

Barry Hirshorn[1], **Seiji Tsuboi[2]**

1. Pacific Tsunami Warning Center, USA, hirshorn@ptwc.noaa.gov
2. IFREE, JAMSTEC, Japan, tsuboi@jamstec.go.jp

ABSTRACT

To issue accurate and rapid tsunami warnings for potentially tsunamigenic events, it is necessary to estimate the location and size of the earthquake as soon as possible after the event begins. To estimate the earthquake size accurately and promptly from the first-arriving P-waves, Tsuboi et al. (1995) proposed using the P-wave portion of broadband seismograms, and derived the broadband P-wave moment magnitude, Mwp. Mwp has been used to issue early tsunami warnings by both US Tsunami Warning Centers (TWC) since 2000. Both TWCs now issue their initial tsunami warnings, based on an earthquake's hypocentral location, and on Mwp, within 3 to 15 minutes of earthquake origin time, depending on the broadband seismic station density near the epicenter. Mwp uses broadband P waveforms to enable rapid determination of earthquake magnitude. Tsuboi et al. (1995, 1999) showed that Mwp agrees well with Mw calculated from Harvard Centroid Moment Tensor (CMT) solutions for both deep and shallow earthquakes. In order to issue a tsunami warning as soon as possible after the origin time of an earthquake, it is necessary to estimate Mwp from P-waves recorded as closely as possible to the earthquake's epicenter. Although Mwp was first derived to estimate earthquake size for events occurring near the Japanese Islands, the epicentral distances used were mostly greater than 5 degrees to satisfy the far-field approximation used to derive the formula. Thus Tsuboi et al. (1995) questioned whether or not Mwp could be applied to earthquakes recorded at stations located at closer epicentral distances, although Whitmore et al (2002) reported that there is no apparent epicentral distance dependency. In the present study, we use recent results of Mwp determinations archived by the Pacific Tsunami Warning Center, to show that Mwp is applicable to earthquakes recorded at close epicentral distances. We find that it is possible to estimate moment magnitude, sufficient for Tsunami Warning purposes, even for the 2004 Sumatra earthquake (Mw 9.2), using a broadband seismic station located at an epicentral distance of about 3 degrees. Because the fault length of this event, over 1000km, and this epicentral distance of 3 degrees, this seismogram may not be treated as a far-field approximation. Our results demonstrate that Mwp is applicable even for large earthquakes recorded at stations with epicentral distances 5 degrees or less. Thus, Mwp provides quick, accurate estimates of Mw for local earthquakes, enabling the tsunami warning centers to issue early tsunami warnings within three minutes of earthquake origin time.

Key words: Early tsunami warning, moment magnitude, Mwp, broadband seismograms

PRESENTER'S BIOGRAPHY

Seiji Tsuboi

1986, D. Sc., University of Tokyo. 1986, JSPS Fellow. 1987 Research Associate, University of Tokyo, 1996 Associate Professor , National Defense Academy. 1999 Associate Professor, Yokohama City University, 2002 Group Leader, Japan Marine Science and Technology Center. 2004 Program Director, Institute for Research on Earth Evolution, Japan Agency of Marine-Earth Science and Technology.

Seismic velocity and attenuation in the paleo-collision and rifting zone around Korea and Japan

Tae-Kyung Hong[1]

1. Yonsei University, Department of Earth System Sciences,
Seoul 120-749, South Korea, tkhong@yonsei.ac.kr

ABSTRACT

The far-east Asia region around Korea and Japan has experienced complex tectonic evolutions including continental collisions and a rifting. The continental collisions caused unification of massif blocks in the Korean Peninsula into the current shape. Also, the rifting caused opening of the East Sea (Sea of Japan) between Korea and Japan. The far-east Asia region is a good place to study the seismic signature imprinted in the lithosphere and the seismic attenuation in the continental transition zone owing to enormous high dense deployment of permanent seismic stations in Korea and Japan. We investigate the mantle-lid P wave (Pn) velocity and crustally-guided shear-wave (Lg) attenuation. The Pn velocity exhibits high correlation to known tectonic structures. We observe low Pn velocity around backarc basin regions, which implies a recent tectonic activity. We, however, find a strong high velocity anomaly in the continental fragments such as South-Korea Plateau and Oki Bank. Also, high Lg attenuation is observed in the continental-transition zone, which agrees with the seismic tomography. We interpret the seismic velocity and attenuation with respect to tectonic structures.

PRESENTER'S BIOGRAPHY

Dr. Tae-Kyung Hong is an assistant professor at Yonsei University, South Korea. He got his PhD from Australian National University in 2004. He worked as a postdoctoral scientist in University of California, Santa Cruz and Lamont-Doherty Earth Observatory of Columbia University for three years before he joined in Yonsei University as a faculty member. Dr. Hong is interested in various seismic studies including seismic tomography and attenuation, numerical modeling of seismic wave propagation, and source scaling of nuclear explosion.

Study of the February 4th 2008 swarm in NW Peloponnesus (Greece)

Kapetanidis V[1], Kaviris G[2], Papadimitriou P[3], **Makropoulos K[4]**

1. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, vkapetan@geol.uoa.gr
2. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, gkaviris@geol.uoa.gr
3. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, ppapadim@geol.uoa.gr
4. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, kmacrop@geol.uoa.gr

ABSTRACT

The Corinth Rift in Central Greece is one of the most seismically active regions in Europe characterized by normal faulting in an approximate E-W direction. Two moderate earthquakes, with moment magnitudes 4.7 and 4.5 respectively, occurred in NW Peloponnesus (Greece) on February 2008 and triggered a seismic swarm. Focal mechanisms of these events were constrained using local-regional data and a recently developed methodology, based on the generalized inversion and the singular value decomposition technique, revealing strike-slip type faulting. This result, observed for the first time in the study area, is very interesting, since it is not in agreement with the tectonic regime of the southern coast of the western Gulf of Corinth. The epicentral area lies between normal faulting that dominates NW Peloponnesus and strike-slip faulting which characterizes W Peloponnesus. A double-difference method was adopted in order to relocate hypocenters. Catalog as well as Cross-Correlation differential travel-time data were used in order to achieve the best possible results. The relocation process reveals two spatially separated groups, within the swarm, each one of which is distributed around one major event. The analysis of earthquakes of the sequence in NW Peloponnesus that were recorded by the LAKA station, installed in the western part of the southern coast of the Gulf of Corinth, revealed the existence of shear-wave splitting. The direction of polarization of the fast split shear wave, the time delay between the two split shear waves and the polarization direction of the source were estimated using both the polarigram and the hodogram representations. The coherence of the fast shear wave polarizations at LAKA station, irrespective of the azimuth of each event, is consistent with the general NNE-SSW direction of extension of the Gulf of Corinth and, therefore, in agreement with the Extensive Dilatancy Anisotropy (EDA) model. It is important to notice that the time delay values significantly decreased immediately after the occurrence of the first major shock, indicating a change of the medium's properties.

Key words: Relocation, Cross-correlation, Seismic Swarm, Anisotropy Study, Gulf of Corinth.

PRESENTER'S BIOGRAPHY

Professor Kostantinos C. Makropoulos
Born on 8 September 1945 in Greece. Education: BSc in Physics, University of Athens, 1969; PhD in Seismology, University of Edinburgh, 1978. Present position: Professor of Seismology; Director of the Geodynamic Institute of the National Observatory of Athens, President of the Greek Earthquake Planning and Protection Organization. Specialisation: Seismicity, earthquake hazard, risk analysis, earthquake engineering. He has published more than 250 original scientific papers in international journals, proceedings of international conferences and technical reports. He was Chairman of the sub-commission A, Seismicity, of the European Seismological Commission. He is member of many scientific associations. He acts as referee of papers presented to International Conferences or submitted to International Journals. His work is referenced by numerous authors and the Science Citation Index revealed more than 1000 such cases. He participates, as main contractor, in projects financed by Greek institutions and by the European Union.

Green's function retrieval from ambient seismic noise correlations at NORSAR array

Michael Korn[1]

1. Institute of Geophysics and Geology, University Leipzig, Germany, mikorn@uni-leipzig.de

ABSTRACT

It has been established theoretically that the cross correlation of a diffuse wave field between two seismic stations is equivalent to the Green's function, i.e. to the wave field generated by a point source at one of the receivers and recorded at the second one. Ambient seismic noise from distributed sources at the Earth's surface around the receivers may be similar to a diffuse wave field. Therefore the Green's function retrieval technique from ambient noise recordings opens a new way for structural imaging without the need of active sources, and it has a wealth of other possible applications like passive image interferometry to monitor structural variations with time. There are, however, a number of unresolved issues, e.g. to what extent the assumption of ambient noise as a diffuse wave field is valid in different frequency ranges. Another point of interest is, if more information than the fundamental mode surface waves is contained in the reconstructed Green's functions. Short period waves are of special interest in this context as they are effectively scattered within the crust and may be used in the context of passive image interferometry.

In this study ambient noise correlations have been obtained from the short period vertical sensors across the NORSAR array in southern Norway. It is well suited as a test data set with high data quality and long time availability in a region with a well known crustal structure. The main questions to be answered are if body wave phases can be detected and if there is information about scattered waves in the coda of the Green's functions. A 2 months period of continuous data has been used. Inter-receiver distances vary between some km for one subarray, and some tens of km for the whole array. It has been found that even in the short period range the oceanic microseism forms the most significant source of ambient noise, having a strong azimuthal and time dependence and clearly deviating from a diffuse wave field. Nevertheless, by using appropriate averaging procedures Rg waves clearly emerged in the correlations, their velocity being consistent with what is expected from the crustal structure under NORSAR. There is some indication that also body wave phases are contained in the Green's functions at frequencies around 1 Hz, but they are not very clear. It turned out that the useful frequency range is only up to about 3 Hz. At higher frequencies correlation breaks down at distances of only a few km. This may be due to the low noise level in Scandinavia with the lack of strong high frequency noise sources. The Green's functions show some persistent phases at longer lapse time that point to scattering from structural heterogeneity near the array. A comparison with synthetic seismograms employing random crustal heterogeneity will be presented.

Key words: ambient noise, correlation, Green's function, seismic array

PRESENTER'S BIOGRAPHY

Born in 1955.
Diploma degree in Geophysics from Karlsruhe University, 1980.
PhD from Frankfurt University, Germany, 1985.
Postdoc at ANU, Canberra, Australia, 1986-1988.
Assistant professor at University Frankfurt, Germany, 1988-1993.
Professor for Theoretical Geophysics at Leipzig University since 1993.
Among my current research interests are: regional seismology and seismicity, seismic networks, short-period wave propagation, seismic wave scattering, numerical modeling of wave fields

Wavefield of T-phase returned to the source in the northeastern Japan as reflected/scattered waves from the Emperor Seamounts

Masahiro Kosuga

Earthquake and Volcano Observatory, Graduate School of Science and Technology,
Hirosaki University, Japan, mkos@cc.hirosaki-u.ac.jp

ABSTRACT

On 24 July 2008 a large intraplate earthquake (M = 6.8) took place at a depth of 115 km within the subducting Pacific Plate beneath the Iwate Prefecture in northeastern Japan. After about 50 minutes from the earthquake origin, tremor-like signals were observed in a wide area along the Pacific coast of northeastern Japan. Judging from the time difference between the earthquake and the onset of signal, as well as the waveform characteristics, the signal is interpreted as T-phase reflected/scattered back from the Emperor Seamounts in the northern Pacific. There have been many reports about T-phase observed far from their original earthquakes, the T-phase observed in the source region is a rare case. In addition, the wavefield of T-phase has not yet well documented probably because the phase was mainly observed at coastal stations. In this study, I have examined the characteristics of waveform and wavefield of T-phase by using waveform data recorded by a dense seismic network.

The T-phase of the above event has predominant frequency of 1.5 Hz, which is lower compared with the reported dominant frequencies. This difference is attributed to the characteristics of SOFAR channel that trap the acoustic energy. Because the seismograms of T-phase are quite incoherent, I investigated the characteristics of band-pass-filtered (center frequency of 1.5 Hz) RMS envelope. The general shape of envelope is spindle-like, which reflects the contribution of strongly scattered waves. Spatiotemporal variation of RMS amplitude reveals the arrival and movement of T-phase. The phase first arrived at the SE corner of Hokkaido Island, and then at the east coast of northern Tohoku of Honshu Island. The apparent velocity of RMS peaks creeping to the west is roughly 3 km/s, which is close to the average S-wave velocity in the crust. This suggests that T-phase is mainly composed of scattered S-waves. The maximum amplitude and the duration of T-phase are larger in the stations between the eastern coastline and the volcanic front that runs N-S in the backbone range of Tohoku. These phenomena are probably due both to higher Q values in the area and to the repeated arrivals of T-phase. Polarization of T-phase is much linear than that of background noise. This is additional evidence that support the idea of body wave contribution to T-phase. Though the time variation is considerably large, the horizontal direction of polarization of T-phase is nearly N-S. At present I cannot attribute this observation to any structural feature. But this may indicate the dominance of anisotropic scattering, and may lead us to conceive a new structural interpretation. Thus the analysis of T-phase wavefield may help us to understand some unknown character of seismic scattering in the lithosphere.

Key words: T-phase, scattering, wavefield, envelope, polarization.

PRESENTER'S BIOGRAPHY

Masahiro Kosuga is an Associate Professor of Graduate School of Science and Technology, Hirosaki University. He was born in Iwate Prefecture on July 20, 1955, and graduated from the Graduate School of Science, Tohoku University. He belongs to the Earthquake and Volcano Observatory that is an affiliated facility of School. He is a seismologist and his major jobs are the management and administration of Observatory, education to senior and graduate students, and his seismological research. The observatory operates 7 seismic stations and gathers data from about 160 stations covering a region from northern Tohoku to southern Hokkaido in northern Japan. His major research field includes seismicity and seismotectonics in the region, focal mechanisms of earthquakes including non-double-couple or low-frequency events, scattered wavefield by heterogeneities in the lithosphere. During three years until 2007, he served as the editor in chief of Zisin, the Journal of the Seismological Society of Japan.

Stick-and-Slip processes as sources of transoceanic Iceberg Harmonic Tremor

Douglas R. MacAyeal[1] and **Emile A. Okal**[2]

[1]Dept. Geophys. Sci., University of Chicago, Chicago, IL 60637, USA, drm7@midway.uchicago.edu

[2]Dept. Earth & Planet. Sci., Northwestern Univ., Evanston, IL 60208, USA, emile@earth.northwestern.edu

ABSTRACT

During the austral summers of 2003-2006, we operated a temporary seismometer array on an iceberg called C16 that was aground in the Ross Sea, Antarctica, to resolve the mechanism of sources of hydro-acoustic tremor signals which had been observed at near-shore seismic stations on Polynesian islands in the Equatorial Pacific, and identified as emanating from austral icebergs. Numerous tremor episodes were detected by the array on C16, and the results show that the typical iceberg tremor signal consists of extended episodes of stick-slip icequakes (typically thousands per hour) generated when the ice-cliff edges of two tabular icebergs rub against each other during glancing, strike-slip type collisions (e.g., between C16 and a neighboring iceberg, B15A, that was adrift and colliding with C16 as a result of tidal motions). This source mechanism is found to generate strong hydro-acoustic radiation, which explains why Iceberg Harmonic Tremor can be detected in the oceanic SOFAR channel.

Keywords: 2004 tsunami, Tsunami surveys, Tsunami Hazard, Tsunami Simulations, East Africa

PRESENTER's BIOGRAPHY

Emile A. Okal; b. 07 Aug. 1950, Paris, France; M.S., Ecole Normale Supérieure, Paris, 1972; Ph.D., Calif. Inst. Tech., Pasadena, 1978; Asst. to Assoc. Prof., Yale Univ., 1978-1983; Assoc. to Full Prof., Northwestern Univ., 1984− ; Member, Seismol. Soc. Amer., 1975− , Amer. Geophys. Un., 1974− , Fellow 2007.

The Gulf of Corinth (Greece) strong motion network

Makropoulos K[1], Diagourtas D

1. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, kmacrop@geol.uoa.gr
2. University of Athens, Department of Geophysics-Geothermics, Panepistimioupolis-Zographou 157 84, Athens, GREECE, diagourtas@geol.uoa.gr

ABSTRACT

The RASMON strong motion network is in operation around the area of Gulf of Corinth (W. Greece) since 1991, in order to assist the investigation of the complex seismotectonic regime of the area and provide the basis for strong ground motion attenuation and site effect studies. It consists actually of 12 digital (18 or 24 bits) accelerograps and up to now has provided a rich database consisting of 4.212 records of small and medium size earthquake events. Detail site effects investigations and local PGA, PGV, frequency and site depended attenuation laws are presented and discussed.

Key words: Strong Motion, Site Effects, Attenuation Laws, Gulf of Corinth.

PRESENTER'S BIOGRAPHY

Professor Kostantinos C. Makropoulos
Born in Greece. Education: BSc in Physics, University of Athens, 1969; PhD in Seismology, University of Edinburgh, 1978. Present position: Professor of Seismology; Director of the Geodynamic Institute of the National Observatory of Athens, President of the Greek Earthquake Planning and Protection Organization. Specialisation: Seismicity, earthquake hazard, risk analysis, earthquake engineering. He has published more than 250 original scientific papers in international journals, proceedings of international conferences and technical reports. He was Chairman of the sub-commission A, Seismicity, of the European Seismological Commission. He is member of many scientific associations. He acts as referee of papers presented to International Conferences or submitted to International Journals. His work is referenced by numerous authors and the Science Citation Index revealed more than 1000 such cases. He participates, as main contractor, in projects financed by Greek institutions and by the European Union.

Influence of the push force from mid-oceanic ridges on the seismicity of adjacent platform regions

Sh.A. Mukhamediev[1], A.F. Grachev[2], S.L. Yunga[3]

1. Institute of Physics of the Earth, Moscow, Russia, E-mail Address: sh_mukhamediev@inbox.ru
2. Institute of Physics of the Earth, Moscow, Russia, E-mail Address: afgrachev@gmail.com
3. Institute of Physics of the Earth, Moscow, Russia, E-mail Address: syunga@ifz.ru

ABSTRACT

Based on analysis of the intraplate geodynamics and seismicity of platform regions, we assumed that different seismic activity levels of platforms are associated with differences in their position with relation to a Mid-Oceanic ridge (MOR). This hypothesis was reformulated in terms of the intensity of shear stresses τ and was checked numerically in the framework of an exact solution of a 2-D boundary value problem for a model of an elastic or viscoelastic lithospheric plate subjected to a push force from the MOR. It was established that, if all sources of stresses differing from the analyzed push force are taken into account integrally, the value of τ decreases with increasing distance from a ridge. Moreover, it was discovered that the value of τ is smaller on the side of a concave MOR trajectory as compared with its opposite side. The decrease in τ on the concave side of the ridge is due to the fact that the rift, coinciding with the principal stress trajectory, plays the role of a screen preventing the region encompassed by the rift from the penetration of shear stresses. Applying the obtained theoretical results to the study of the East European (EEP) and North American (NAP) platforms, we arrive at the conclusion that a lower seismicity level in the EEP compared to the NAP is most likely related to their asymmetric position relative to the Mid-Atlantic Ridge (MAR): the EEP is farther from the ridge and located on its concave side.

To gain deeper insights into the essence of the push force influence on the seismicity of adjacent platform regions we investigated the nonstationary propagation (diffusion) of stress-strain state disturbances from the MAR to adjacent regions of the NAP and Eurasian plate on basis of the Elsasser model. In doing so we relied on the results obtained by Skordas et al. (1991), who convincingly demonstrated the presence of a close relationship between temporal variations in seismic activity of the MAR and Fennoscandia in the period from 1917 to 1987. We analyzed the NAP seismicity over the same time period and found that a similar relationship exists in this case as well. The characteristic features of the MAR plot of temporal variation in the seismic activity level (due to the nonstationary process of dike intrusion in the axial zone of the ridge) recur approximately every three years for Fennoscandia and every four to eight years for the NAP. These data indicate that the MAR largely controls the seismic activity of the adjacent platforms. The observed time shift can be used for estimating the viscosity of the asthenosphere, amounting to 10^{17} Pa·s with an accuracy of ± 30% in the case considered. The disturbance amplitudes decaying away from the ridge are high enough to change the seismic activity of the adjacent platforms.

Key words: Push force, mid-oceanic ridge, platform seismic activity, stress diffusion.

PRESENTER'S BIOGRAPHY

Shamil Mukhamediev. BORN: July 21, 1947, at Tashkent, Uzbekistan, USSR. Married, a Son (1993). EDUCATION: B.Sc. (1971) and Ph.D. (1974) in Mechanics of Solids, Moscow Institute of Physics and Technology; D.Sc. (1997) in Geophysics, Institute of Physics of the Earth, Moscow. POSITIONS HELD: Junior (1974–1981), Senior (1981–1997) Scientific Researcher, and Principal Investigator (1997–present), Moscow Institute of Physics of the Earth. EXPERIENCE: 35 years research work in the fields of Continuum Mechanics, Rock Mechanics, and Geodynamics. SCIENTIFIC CONTRIBUTIONS: Proposed methods of tectonic stress and paleostress determination from various types of natural indicators; developed a direct approach to the Earth's crust stress fields modeling which takes into complete account the reconstructed principal stress orientations. Seismotectonic study includes investigation of the seismicity dependence on vertical crust movements, revealing the nature of the stress field and seismicity within the stable blocks of the lithosphere, analysis of induced seismicity in oil-production regions.

Semblance for three-component data of small seismic arrays

Hisashi NAKAHARA [1]

1. Tohoku University, Japan, naka@zisin.geophys.tohoku.ac.jp

ABSTRACT

Introduction: Seismic arrays are indispensable to identify wave types through the determination of apparent velocity and directions of incoming phases. Though the number of three-component array data has increased, analysis methods proposed for single-component data are still often used. Semblance (Neidell and Taner, 1971, Geophysics) is one of the popular measures for the analysis of multi-channel, single-component data. Recently, the semblance has been extended to 4-component data by Grandi et al. (2007, Geophysical Prospecting) to perform velocity analysis in geophysical exploration. In this study, we clarify the meaning of the multi-component semblance, and consider its applicability to a small seismic array by using synthetic data.

Meaning: The semblance is a measure to detect coherent phases in array data. Neidell and Taner (1971) interpreted that the semblance is a normalized output/input energy ratio. The textbook of Claerbout (1976) presented another interpretation that the maximization of the semblance corresponds to the minimization of the normalized squared residual between a record at each station in an array and a slant-stacked average over the stations. Based on this argument, it is possible to define the semblance not only for single-component data (scalar waves) but also for three-component data (vector waves). Semblance thus extended to three-component data, three-component semblance, may be applicable to cases when a signal resembles a slant-stacked average wavefield and noises are cancelled by the stacking. This may be the case for the incidence of plane waves on a small array.

Synthetic tests: In order to investigate the applicability of the three-component semblance to a small seismic array, we perform synthetic tests. We set up a seismic array composed of 7 seismometers having a triangular-shape with a linear dimension of about 500m. The geometry is the same as our practical observation in Oshika peninsula, Northeastern Japan (Nakahara et al., 2006, Earth Planet. Space). We assume that three phases with the Ricker wavelet having a central frequency of 2.25Hz are incident on the array from respective directions. One is P-wave, one is SV-wave, and the other is SH-wave. The amplitude of the phases is assumed to be the same. Synthetic seismograms are calculated with adding 1% Gaussian white noises and are band-passed within a band of 1-2.5Hz. Semblance using each of two horizontal components can detect all the three phases successfully. However, semblance using UD component cannot detect the SH phase. On the other hand, the three-component semblance is found to produce similar results to those applied to each of the two horizontal components. The three-component semblance is thought to be more stable than semblance for each component only.

Key words: semblance, three components, seismic array

PRESENTER'S BIOGRAPHY

Hisashi NAKAHARA took a Master of Science at Tohoku University, Japan, in 1996. He took a Doctor of Science at Tohoku University in 2000. Since 1998, he is working for Department of Geophysics, Graduate School of Science, Tohoku University as an assistant professor. His research interests are in generation and propagation of high-frequency seismic waves.

Getting nowadays digital data from old mechanical instruments

Ramon Ortiz[1] and **Josep Vila[2]**

1. Museo Nacional de Ciencias Naturales, CSIC, Madrid, Spain, ramon@mncn.csic.es
2. Institut d'Estudis Catalans and University of Barcelona, Barcelona, Spain, jvila@iec.cat

ABSTRACT

We present a system to acquire digital data from old mechanical instruments. Nowadays modern seismograph systems provide very good and high quality data. However, there are old mechanical seismograph systems in many observatories that, although they are not used, they may work and it is of great interest to get records using these systems. From the scientific point of view digital records from old instruments may allow to complete and improve the accuracy of the response of old systems, thus contributing in the works of seismogram recovery. On the other hand, getting digital data using these instruments highly contribute to education and outreach activities. First, these are the major attraction in observatories (museums) and second, it allows appreciate the physics of the seismogram systems, thus also encouraging and promoting seismology in schools. To carry out this project we implemented a device to monitor the displacements of the mass of the Vicentini and Mainka seismometers in the Observatory Fabra in Barcelona, still in operation since its installation in 1906 and 1914 respectively. We used an industrial induction displacement analogue transducer (IA5-18GM-I3) with a margin of measurement of 2-5 mm to which an electronic adaptor based on an RC filter has been added in order to get symmetric outputs and remove possible mass effects due to centering instabilities. The device installed monitors the mass displacement without perturbing the original mechanical mechanism. This development is a work in progress that is currently running in the Observatory Fabra since April 2008. It collects data at 50 sps by means of an AD7710 ADC converter and it has demonstrated to be an excellent tool in recording all type of events (local/regional and teleseisms). The continuous recording capabilities of nowadays allowed also to perform a differential calibration with respect to modern seismographs in order to obtain an accurate real transfer response. This will open new insights in recovering the old seismographs records of the Observatory.

Key words: Seismic instrumentation, mechanical instruments, old seismogram recovery.

PRESENTER'S BIOGRAPHY

Josep Vila is a Ph.D on Physics (University of Barcelona) and coordinator of the Geophysical laboratory of the Institut d'Estudis Catalans. Josep Vila has been working in seismic instrumentation since 1986 and in applied seismology data analysis in many seismological aspects. This includes volcanic seismology, local/regional and teleseismic events and background noise studies. Nowadays it chairs the WG1 of the Observatories and Research Facilities for European Seismology (ORFEUS) and is the regional coordinator of Europe of the WG1 of the International Federation of Digital Seismograph Networks (FDSN).

Evaluation of earthquake magnitude scales for Greek seismicity

Papadopoulos G.A.[1], Latoussakis I.[2], Daskalaki E.[3], Fokaefs A.[4]

1. Institute of Geodynamics, National Observatory of Athens, Lofos Nymfon, 11810, Athens, Greece, papadop@gein.noa.gr
2. Institute of Geodynamics, National Observatory of Athens, Lofos Nymfon, 11810, Athens, Greece, gialat@gein.noa.gr
3. Institute of Geodynamics, National Observatory of Athens, Lofos Nymfon, 11810, Athens, Greece, edaskal@gein.noa.gr
4. Institute of Geodynamics, National Observatory of Athens, Lofos Nymfon, 11810, Athens, Greece, anna@gein.noa.gr

ABSTRACT

Seismic activity is the highest in the broad European-Mediterranean region and attracts international research interest. The seismicity catalogue is one of the fundamental tools for many purposes related to basic and applied earthquake studies in the Greek area. However, the magnitude determination is a major problem which is due to the historical development of Greek systems for the monitoring of seismic activity. In several earthquake catalogues compiled by different institutes, different earthquake magnitudes are produced which cause confusion and makes a source of errors. We contribute to the direction of minimizing the problems by analyzing and comparing the several catalogues of Greek seismicity and particularly those produced by the National Observatory of Athens (NOA), the University of Thessaloniki as well as by institutes which compile international catalogues like NEIC, ISC and Harvard. We investigated the completeness of the catalogues and found that the catalogue of NOA is the most complete. In addition, we produced linear relations between the several magnitudes produced by the several institutes. Among the most interesting results is that the local magnitude produced by NOA on the basis of the records of the Wood-Anderson instrument installed in the ATH (Athens) station is less by 0.3 units as an average than the Mw magnitude produced by the Harvard CMT solutions for the time period from 1977 to 2006. A proposal is under discussion for the compilation of a homogeneous earthquake catalogue in Greece.

GERASSIMOS A. PAPADOPOULOS' BIOGRAPHY

Dr G.A. Papadopoulos is Research Director with the Institute of Geodynamics, National Observatory of Athens, Greece, and Chairman of the National Committee for the Earthquake Hazard Evaluation. He is holder of PhD degree in Geophysics, University of Thessaloniki (1982). He was visiting researcher at MIT, USA (1984), NIED, Japan (1993) and visiting professor at the Tohoku University (2004). His scientific interests include instrumental and historical seismicity, earthquake prediction and tsunami science. He has published more than 70 reviewed papers in the above topics. He served as President of the International Society for the Prevention and Mitigation of Natural Hazards (2000-2006) and Vice-President of the European Seismological Commission (2006-2008). Since 2005 he is Vice-Chairman of the North-East Atlantic and Mediterranean Sea Tsunami Warning System of the Intergovernemental Oceanographic Commission/UNESCO.

F-K analysis of the long period ambient noise using DESERT2000 experiment data

Vladimir Pinsky, Tatiana Meirov, Abraham Hofstetter

Geophysical Institute of Israel, vlad@seis.mni.gov.il

ABSTRACT

For the last several years seismological community has been attracted to the problem of surface waves tomography based on the BB observations of the propagating ambient noise. The basic theoretical idea exploited was that long-term cross-correlation function made at two locations is proportional to the Green's function between the two points. This statement holds under assumption that sources of the noise are evenly distributed. However, many researchers report about long-term predominant directivity of the noise at different networks, thus, violating the last condition. In this respect, we started investigation of the directivity of the low frequency noise propagating through the Eastern Mediterranean coastal area and tried to detect consistent sources of the seismic noise energy using temporary BB installation of the DESERT2000 experiment. During almost a year in 2000-2001 thirty stations of the BB network of the experiment forming an array with aperture of around 250 km × 100 km were spread over territory of Israel and Jordan, crossing the Dead Sea Fault to the South of the Dead Sea. We have taken 19 stations jointly performing in January 2001 with sampling rate of 50 Hz. The data have been band-pass filtered between 0.01- 2 Hz and resample to a sampling rate of 5 Hz. In this pilot study the broad F-K (BFK) analysis of the data was applied to the consecutive recording samples in the non-intersecting time windows of 240 sec length using frequency band 0.1- 0.2 Hz within apparent velocity range 2.5 – 4.35 km/s (specific for the surface waves). For each time window we extracted azimuth and apparent velocity corresponding maximum of the BFK target function. The azimuth versus time (the number of the time window) distribution obtained demonstrates that azimuth from several certain directions such as 315°± 5°, 260° ± 10°, 60° ± 10° are very consistent, indicating presence of the certain sources at these directions. Apparent velocities versus time concentrate around 3 ± 0.5 km/s for the 315°± 5° and 260° ± 10° azimuths and around 4 ± 0.5 km/s for the 60° ± 10° azimuth. This study can contribute to increasing of the resolution power of the tomography based on ambient noise cross-correlation function and investigation of the sources of the low-frequency propagating noise. This research is supported by the U.S.-Israel Binational Science Foundation.

Key words: Broad FK analysis, ambient noise, surface waves tomography

Vladimir Pinsky

Ph D., Senior Researcher in the Seismological Division of the Geophysical Institute of Israel occupied in the problems of automatic location, signal detection and discrimination for seismic networks and arrays.

The Svalbard, 21st February 2008 earthquake: analysis and interpretation of an intraplate aftershock sequence

Myrto Pirli[1], Johannes Schweitzer[2], Rolf Mjelde[3], Steven Gibbons[4]

1. NORSAR, Norway, myrto.pirli@norsar.no
2. NORSAR, Norway, johannes.schweitzer@norsar.no
3. University of Bergen, Norway, Rolf.Mjelde@geo.uib.no
4. NORSAR, Norway, steven.gibbons@norsar.no

ABSTRACT

On 21st February 2008, a strong earthquake of magnitude 6.0 occurred in the area of the Svalbard Archipelago, Norway. The foci of the mainshock and the vast number of aftershocks that followed are located in the upper crust underneath Storfjorden, off the eastern shores of Spitsbergen. The area is characterized by intraplate seismicity and is situated relatively close to the continental passive margin of the Barents Shelf, as well as the Knipovich Ridge, whose kinematics dominate the regional stress field. The occurrence of the seismic sequence coincided with an ongoing International Polar Year project that aims to study the continental margin in the region between the Knipovich Ridge, Mohns Ridge and Bear Island. Thereby, an extensive interval of the still ongoing sequence was recorded by a significant number of permanent and temporary seismic stations installed in the broader area. This facilitated the detailed investigation of this intraplate activity, both in terms of spatiotemporal evolution and seismotectonic interpretation. The dataset used for this purpose covers a time span of approximately half a year from the occurrence of the mainshock and consists of the listings of the NORSAR regional reviewed bulletin, which includes only those events with an automatic network magnitude larger than 2.0. The accurate relocation of the aftershock sequence is based on the application of waveform cross-correlation techniques on seismic array and single 3-component station data for the P and S wavetrain, and the iterative inversion of the results together with analyst reviewed absolute first onset time readings. On 12th August 2008, two airgun profiles were conducted in Storfjorden, to be employed as calibration data for our analysis. Both lines were drawn to cross the preliminary epicentre of the mainshock and were of NW-SE (~335°) and WNW-ESE (~100°) trend, along the azimuth directions connecting the epicentre to the Spitsbergen array and the seismic stations situated at Hornsund and Hopen Island, respectively. This dataset consists of about 30 shots, which were very well recorded at the nearest seismic stations and arrays. Obtained waveform similarity observations lead to conclusions regarding the clustering patterns within the aftershock sequence, while resulting relative hypocentre locations provide valuable insight into the fault mechanics related with this activity and enhance our understanding of the tectonics in the area of Svalbard. These findings, when compared against focal mechanism solutions and combined with principal component analysis results, suggest the activation of previously unmapped faults underneath the seabed of Storfjorden.

Key words: Svalbard, aftershock sequence, intraplate, waveform cross-correlation, relative location

PRESENTER'S BIOGRAPHY

Myrto Pirli

Dr. Myrto Pirli was born in Athens, Greece, in 1976. She received her Bachelor's degree in Geology from the National and Kapodistrian University of Athens in 1998 and a Master's degree in Geophysics and Seismology in 2001. She received her PhD title in Seismology from the same institution in 2005, the related work constituting the first attempt to introduce array seismology in Greece. She is currently working as a Post-Doc researcher at NORSAR, Norway. Her main research interests involve earthquake monitoring and location, array seismology applications, seismotectonics of seismic sequences and local earthquake seismic tomography studies.

Progress review of the Italo-Argentinean cooperation for the seismological study of the Scotia Sea region, Antarctica

M. Russi[1], J.M. Febrer[2†], M. Guidarelli[3*], M. Plasencia[1,4], G.F. Panza[3,5]

[1] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, Trieste – Italy, mrussi@ogs.trieste.it
[2] Instituto Antartico Argentino – Cerrito 1248, Buenos Aires – Argentina
[3] Dipartimento di Scienze della Terra, Università di Trieste, Trieste – Italy, panza@dst.units.it
[4] Fac. Cs. Astron. y Geof., Univ. Nacional de La Plata, La Plata – Argentina
[5] The Abdus Salam International Centre for Theoretical Physics, Trieste – Italy
[*]Now at School of Earth and Environment, Earth Science Building, University of Leeds, LS2 9JT, UK

ABSTRACT

With the initial objective of defining a site for the possible installation of a permanent seismographic station in the Scotia sea region, oriented to the study of the geodynamics and structural properties of the lithosphere there, the PNRA/OGS and the DNA/IAA installed and operated jointly a temporary station at the Antarctic Argentinean base Esperanza (ESPZ). The temporary seismograph ESPZ operated for three years and it was upgraded to a permanent seismological observatory at the beginning of 1995. Two more stations - USHU in the proximity of Ushuaia (Tierra del Fuego) and ORCD at the Argentinean base Orcadas (South Orkney Is.) - were installed between the end of 1995 and the beginning of 1997. The data collected by the three stations have been used to perform some preliminary investigation on the lithospheric structure of the Scotia Sea region by means of surface wave dispersion analysis. These results represented the guideline for the definition of the most suitable seismological algorithms which, since then, have been developed by the University of Trieste group and extensively applied by the OGS and Trieste University groups to process and interpret the data. Similarly advanced methodologies have been developed and applied to the analysis of regional earthquakes in the area. Four stations of the Antarctic Seismographic Argentinean Italian Network (ASAIN), contributing real time data to the ORFEUS data centre in the framework of the VEBSN (Virtual European Broad-band Seismographic Network) are operated in Antarctica by the OGS-IAA seismological groups while two ASAIN instrumented sites monitor the regional seismicity in Tierra del Fuego. Therefore the ASAIN database represents a fundamental source of open data and its scope will be broadened by the opening of a new ASAIN station at the Antarctic Argentinean base Belgrano II (77° 52’ S, 34° 37’ W) at the beginning of 2009. We give here a short review of the results obtained in the last decade from the study of waveforms recorded in the Scotia Sea region using different seismological methodologies, from surface wave tomography to waveform inversion. The results of the earlier investigations have been maps of the Scotia Sea region, obtained from group velocity tomography dispersion non-linearly inverted into shear wave velocity models. The availability of reliable average structural parameters for the lithosphere of the Scotia Sea region allows the waveform inversion of regional earthquakes to retrieve focal mechanisms and source time functions using the INPAR methodology. As the results of the preliminary studies justify a systematic use of the INPAR methodology in the area, several events have been analysed, recorded in the Scotia Sea region, in Tierra del Fuego and Bransfield Strait. The most recent study made by the OGS and Trieste University seismological groups is the analysis of the aftershock sequence that followed the major event occurred on August 4th 2003, 7.6 Mw close to the Argentinean base Orcadas, known as ”centenary” earthquake.

†Josè Febrer died on May 2nd 2008 after dedicating most of his scientific work to the ASAIN project since its birth in 1992.

Key words: Antarctica, Scotia Sea, ASAIN, INPAR

MARINO RUSSI
Born in Trieste on Feb 27th, 1949. Graduated in Physics at Trieste University on Dec 2nd, 1974. At OGS since 1976. he developed his knowledge in digital seismology in the framework of the activities of the OGS Trieste Seismographic Station. His contribution between 1976 and 1991 has been important in the expansion and conversion to digital acquisition of the North Eastern Italy Seismographic Network. Director of the OGS Seismology Dpt. from 1986 to 1991. As a Programma Nazionale di ricerche in Antartide (PNRA) researcher he participated to six Antarctic campaigns (1991-'92, '93-'94, 2002-‘03, 2003-’04, 2005-’06 and 2006-‘07) dedicating a relevant part of his scientific activity to the development of the ASAIN. Director of the OGS Geophysics of the Lithosphere Dpt. From Sep 1995 to Jun 1996. At present coordinator of the PNRA project “Broad-band seismology, lithospheric structure and geodynamics in the Scotia Sea region” and deputy director of the OGS Seismological Research Centre Dpt.

Radiative transfer approach to the equipartition in scattering media

Haruo Sato[1] and Mare Yamamoto[2],

1. Tohoku University, Sendai, Japan, sato@zisin.geophys.tohoku.ac.jp
2. Tohoku University, Sendai, Japan, mare@zisin.geophys.tohoku.ac.jp

ABSTRACT

In random media, multiple conversion scatterings result in equipartition of elastic waves, which means that the elastic energy is distributed among all the possible states of *P* and *S* waves. The equipartition predicts that the energy density ratio of S- to P-waves is 2 (Vp/Vs)^3 in a three dimensional elastic medium, where Vp and Vs are P- and S-wave velocities, respectively. The equipartition is considered as a necessary condition to retrieve the Green function from correlations of elastic waves in the coda interferometry, but it is not clear how long lapse time is necessary for the energy density ratio to reach the theoretical ratio and the transient process has not been well solved yet. Here, we present a scattering model that shows how the equipartition is established in a 3D scattering medium with lapse time increasing. The scattering power per unit volume is characterized by the scattering coefficient for each scattering mode: gPP, gPS, gSP, and gSS for P-to-P, P-to-S, S-to-P, S-to-S scattering, respectively. Multiple isotropic scattering process for an impulsive spherical radiation from a point source is described by radiative transfer integral equations. P and S wave energy densities can be analytically solved by using the Fourier-Laplace transform in space and time. The energy at a given time is calculated from the space integral of energy density. The whole space energy ratio of S- to P-waves approaches to the expected theoretical ratio, where the characteristic time is (Vp*gPS+Vs*gSP)^(-1), which is mostly controlled by gPS since gPS/gSP=2 (Vp/Vs)^2. Here we numerically simulate how the spatial variation of the local energy density ratio of S- to P-waves varies with lapse time increasing. For numerical simulations we use scattering parameters estimated from the analysis of artificial explosion records around 10 Hz at Asama volcano, Japan, where gSS>gPS>gPP>gSP. For S-wave source radiation, the S wave energy density monotonously decreases near the source location and the energy density ratio approaches the theoretical ratio with the lapse time increasing; however, the necessary lapse time is longer than the characteristic time controlled by gPS. For P-wave source radiation, P waves are rapidly converted to S waves in the vicinity of the source just after the radiation and then the P wave energy density monotonously decreases with lapse time increasing; however, near the source region, strong P-to-S conversion scattering increases the S wave energy density and the energy density ratio of S to P waves once exceeds the theoretical ratio. Then, the energy density ratio slowly decreases and approaches the theoretical ratio with the lapse time increasing, where the slow process is mostly controlled by the diffusion that smoothes out the spatial variation of the S wave energy density. The necessary lapse time is longer than the characteristic time controlled by gPS, too. These simulations show that the whole space energy ratio reaches the theoretical ratio with the characteristic time estimated from gPS; however, the local energy density ratio near the source takes longer time than that to reach the theoretical ratio predicted from the equipartition.

Key words: coda interferometry, scattering media, radiative transfer theory, PS conversion, short period seismogram

PRESENTER'S BIOGRAPHY

Name: Haruo SATO

Born in Tokyo, Japan.

Occupation:

Professor of Solid-Earth Physics, Department of Geophysics, Graduate School of Science, Tohoku University, Sendai, Japan.

Education:

Graduated from the Dept. of Physics, Faculty of Science, Tokyo University of Education (1972),
Received the Doctor of Science degree in geophysics from the University of Tokyo (1984)

Interests:

Seismic wave propagation and scattering in heterogeneous Earth media

IASPEI activity:

Chair of the Task Group on "Seismic Scattering and Heterogeneity" since 2005.

Publication:

"Seismic Wave Propagation and Scattering in the Heterogeneous Earth" by H. Sato and M. Fehler, AIP and Springer-Verlag, New York, 1998.

"Earth Heterogeneity and Scattering Effects on Seismic Waves (Eds. Sato and Fehler)" as the 50th volume of "Advances in Geophysics (Series Ed., R. Dmowska)", Academic Press, 2008.

Real-time detection and location for earthquake early warning at regional scale

Claudio Satriano[1], Anthony Lomax[2], Aldo Zollo[3,1], Alberto Michelini[4], Marco Olivieri[5]

1. AMRA scarl, RISSC-Lab, Italy, satriano@na.infn.it
2. ALomax Scientific, France, anthony@alomax.net
3. Università di Napoli Federico II, Dipartimento di Scienze Fisiche, (RISSC-Lab) Italy, aldo.zollo@unina.it
4. Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, michelini@ingv.it
5. Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, olivieri@ingv.it

ABSTRACT

The ability of detecting and locating a potentially destructive earthquake in a few seconds after its occurrence is a key issue for a regional early warning system.
Here we make use of a new algorithm for earthquake detection and location, which exploits the concept of equal differential time surfaces (EDT) to incorporate, at each second after the first station trigger, the information from both triggered and not yet triggered arrivals. The approach is fully probabilistic and time-evolutionary.
One of the advantages of the present technique above standard methods is its ability to provide useful constraints on the hypocentral position as early as one or two stations have triggered. This can ensure additional leading time for early warning, especially when very dense station coverage of the source area (i.e. mean station spacing of less than 30 km) is not available and, thus, several seconds are required to detect 4 or more arrivals. Furthermore, since the earthquake location is provided as a probability density function, the results can be directly integrated into a fully probabilistic, real-time procedure for hazard evaluation.
In this work we conducted a thorough network performance test using a collection of earthquakes recorded by the Italian National Seismic Network (INSN). INSN is a dense broadband network deployed for monitoring Italian seismicity, managed by the Istituto Nazionale di Geofisica e Vulcanologia (INGV), which consists of 250 stations with a typical spacing of about 40 km.
The analysis shows that, for a variety of events distributed along the Italian Peninsula, standard locations at 4 stations are available within 20 sec for most events and within 10 sec for half of the events, with most of the location errors being smaller than 10 km.
With the present method, we are able to start the location with one or two triggered stations. This reduces the detection time by up to 10 seconds, while the additional information from not-yet-triggered arrivals ensures an error comparable to a standard location using 4 stations.
Such an approach, based on the analysis of the pattern of triggered and not triggered stations, can therefore reduce the time needed to provide a stable hypocentral solution and increase the overall leading time.

Key words: Seismic Early Warning, Earthquake Location, Real-time.

PRESENTER'S BIOGRAPHY

Claudio Satriano was born in Potenza, Italy in 1979. He took his degree in Physics in 2002 at the University of Naples, Italy, discussing a master thesis on automatic signal analysis for seismic exploration based on spatial coherency. His master thesis won the prize "Best new graduate work" at the workshop "Contribute of young researchers to Applied Geophysics", Bari, Italy, in 2003. In 2006, he got a PhD in Geophysics at the University of Bologna, Italy, with a thesis on real-time location for a seismic alert management system. He's currently working at the RISSC-Lab in Naples, on seismic early warning, earthquake location and seismic tomography and contributing to the computing infrastructure of the Irpinia Seismic Network, owned by AMRA center (Analysis and Monitoring of Environmental Risks).

A second study of repeating earthquakes in China

David P. Schaff[1], **Paul G. Richards**[2]

1. Lamont-Doherty Earth Observatory of Columbia University, USA, dschaff@LDEO.columbia.edu
2. Lamont-Doherty Earth Observatory of Columbia University, USA, richards@LDEO.columbia.edu

ABSTRACT

A follow-up to the search for repeating earthquakes in China reported in SCIENCE by Schaff and Richards in 2004 has been carried out for a longer time period, and a greater percentage of events are found to be repeats of each other. The prior study covered the years from 1985 to the beginning of 2000. This second and larger study included the years up through 2005. Our work contributes to the evaluation of a paradigm for seismicity studies in which importance is attached to the build-up and use of an extensive archive of very well located events.

The Annual Bulletin of Chinese Earthquakes contains 22,513 events in and near China for this 21-year time period of which 17,898 events had usable waveforms recorded at 363 stations archived by the IRIS Consortium. The same criteria were used as in Schaff and Richards (2004) to define a repeating event pair. [Windows including the entire seismogram starting 5 s before the P-wave and ending 40 s after the Lg-wave were filtered from 0.5 to 5 Hz. A threshold for the cross-correlation coefficient (CC) of 0.8 or greater was used to identify the repeats. Events meeting this criterion are estimated to be not more than 1 km apart.]

Out of the 17,898 events with waveforms that were searched in the present study, 2379 events were a member of a doublet (6326 pairs), so 13% of the events were classified as repeats. This is over a thousand more events (up from 1301) and 5400 more pairs (up from 950) than we had before, hence an increase of 4% (up from 9%). Close examination of early years revealed that previously unidentified data glitches caused some repeats to mistakenly be identified in the prior study. Even with the removal of these events, the percentage of the total number of repeats is still higher because of the greater rate at which repeats occur in later years, presumably due to the increased station coverage.

We appreciate that several studies of repeating earthquakes in particular regions of China have been conducted, or are underway, based upon use of regional or local stations. The percentage of repeating events appears to be even higher in such studies, than in our own work with stations that typically are at far-regional distances (more than 1000 km). The percentage of repeating events occurring in different magnitude ranges, is a subject of interest from many perspectives.

Doublet events provide a means to evaluate the quality of event location estimates. For the 6326 doublets we have identified in the Annual Bulletin of Chinese Earthquakes from 1985 to 2005, the medium, mean, and maximum separation distances are 16 km, 23 km, and 141 km respectively. Of these doublets in China, 2134 are also reported by the International Seismological Centre, and for them the corresponding separation distances (median, mean, maximum) are 16, 22, and 234 km. The Reviewed Event Bulletin of the Comprehensive Test Ban Treaty Organization includes 912 of these doublets in China, and the corresponding separation distances are 18, 31, and 281 km.

Key words: doublets, repeating earthquakes, precision of earthquake locations

PRESENTER'S BIOGRAPHY

Paul G. Richards was born and educated in England before moving in 1965 to the USA as a graduate student at the California Institute of Technology. Following a postdoc position at the University of California, San Diego, he has worked since 1971 as a professor and seismologist at Columbia University in New York. With Keiiti Aki he co-authored the advanced text "Quantitative Seismology," since translated into Russian, Chinese, and Japanese. With Xiaodong Song in 1996 he discovered seismological evidence for a super-rotation of the Earth's inner core --- since confirmed by several studies using earthquake doublets. He has written more than 130 papers, many of them related to monitoring of underground nuclear explosions. In recent years he has worked with Won-Young Kim, Vitaly Khalturin, David Schaff, and Felix Waldhauser, to achieve significant improvement in methods to characterize both earthquakes and explosions.

More information at http://www.LDEO.columbia.edu/~richards.

Global Study of Polarized Microseismic Noise

Martin Schimmel[1], Eleonore Stutzmann[2], Josep Gallart[1]

1. Institute of Earth Sciences Jaume Almera - CSIC, Spain, schimmel@ija.csic.es
2. Institute Physics of the Earth - IPGP, France, stutz@ipgp.jussieu.fr

ABSTRACT

Seismic background noise is omnipresent through a broad frequency band and hosts different frequency-dependent environmental phenomena mainly due to atmospheric and oceanic processes at different scales. In the present study, we focus on the microseismic noise which are caused by ocean wave energy coupling into seismic energy. We quantify, analyze and characterize the frequency-dependent ground motion recorded by the global seismic network GEOSCOPE.

For our polarization analysis we use continuous waveform data from the global seismic network GEOSCOPE to extract the time-frequency dependent noise polarization from six years of continuous three-component broadband records. The data processing has been done in an automatic way and consisted in the removal of the instrument responses and the time-frequency dependent determination of the degree of polarization and attributes such as the linearity and back azimuths of particle motion. We first analyze how well the noise is polarized and find that the primary and secondary microseisms are clearly more polarized than other noise at surrounding frequency bands. The back azimuths of the particle motion for the secondary microseisms at most stations vary seasonally, year by year, indicating that the noise arrives from the North in Northern hemisphere winter and from the South in Southern hemisphere winter. The measured back azimuths have then be used to determine the generation areas of the secondary microseisms at global scale. We show that there exists a yearly periodicity in the microseismic source locations. We observe that on global scale the secondary microseisms are excited at high latitudes in the Northern and Southern hemisphere during their respective winters. This is seen for all the six years of analyzed data and is explained by the yearly climate change with storms and largest ocean waves in winter.

Our noise polarization study shows that we can localize, characterize and monitor climate induced secondary microseisms. On global scale the sources have a similar seasonal dependence over the year as ocean wave models. The location of seasonal microseismic generation areas can be important for the deployment of temporal seismic experiments and to identify optimal ocean bottom monitoring sites, among others.

Key words: seismic ambient noise, microseisms, polarization

PRESENTER'S BIOGRAPHY

Martin Schimmel received the degree in geophysics, M.Sc., from the University of Karlsruhe, Germany, in 1992, and the Ph.D. Degree from the University Utrecht, Utrecht, the Netherlands in 1997. From 1997 to 2001, he was a Postdoctoral Researcher with the Department of Geophysics, IAG, University of Sao Paulo, Brazil. Since 2001, he has been researcher with the Institute of Earth Sciences "Jaume Almera" of the Spanish Council for Scientific Research (CSIC), Barcelona, Spain. His current research areas and interests include seismic signal detection/identification and understanding of the multitude of seismic signals in seismograms, physical phenomena of seismic wave propagation, and the different strategies to image and constrain the structure of the Earth interior. Presently, he is working on the localization and generation of microseismic noise, regional tomography and the migration of reflected/converted mantle phases.

ORFEUS Data Center – data acquisition, data management and data services

Reinoud Sleeman[1], Gert-Jan van den Hazel[2], Torild van Eck[3]

1. ORFEUS/KNMI, Netherlands, sleeman@knmi.nl
2. ORFEUS/KNMI, Netherlands, hazelvd@knmi.nl
3. ORFEUS/KNMI, Netherlands, vaneck@knmi.nl

ABSTRACT

The mission of the ORFEUS Data Center is to ensure sustainable long-term archiving of high quality seismic broad-band waveform data from seismic stations in and around the European-Mediterranean area, and to provide open and easy access to this data for the scientific community, civil defense agencies and the general public. The growth of the number of seismic stations, the need for automatic quality control and processing procedures as well as the increased use of data in monitoring and scientific purposes demand highly efficient data management and robust procedures to meet the requirements of network operators, scientific users and data center staff. This presentation will show recent developments in data management and services at ORFEUS Data Center, which have been realized for a large part within the framework of the EC FP6 project NERIES (Network of Research Infrastructures for European Seismology)..

Key words: ORFEUS, NERIES, data management, data center

PRESENTER'S BIOGRAPHY

Reinoud Sleeman is seismologist at the Royal Netherlands Meteorological Institute (KNMI) and Director of the ORFEUS Data Center.

Long-term monitoring of the STS-2 self-noise: an experiment in the Conrad Observatory, Austria.

Reinoud Sleeman[1], Peter Melichar[2]

1. KNMI/ORFEUS, Netherlands, sleeman@knmi.nl
2. ZAMG, Austria, melichar@zamg.ac.at

ABSTRACT

At low frequencies (e.g. below 0.1 Hz) in the seismic spectrum the instrumental noise of seismic recording systems increases like in any other active electronic component and may dominate the seismic signal. For any study using low frequency seismic signals it is therefore important to have accurate knowledge about the instrumental noise. Self-noise can be estimated by determining the mutual signal coherency among three similar, collocated instruments. In this presentation we describe an experiment that was conducted for more than 6 months in the Conrad Observatory (Austria) using 4 collocated STS-2 sensors and Q330-HR data-loggers. The Conrad Observatory is a well-equipped, ultra-quiet facility for testing and calibration of seismic instrumentation and acquisition electronics. We investigate the effect of misalignment of sensors and the long-term stability of the sensor self-noise. This research project was grant supported through the EC FP6 project NERIES (Network of Research Infrastructures for European Seismology).
.

Key words: self-noise, STS-2, Conrad Observatory, NERIES.

PRESENTER'S BIOGRAPHY

Reinoud Sleeman is seismologist at the Royal Netherlands Meteorological Institute (KNMI) and Director of the ORFEUS Data Center. His interest for seismic recording systems, seismic data and signal processing has lead to a new technique to measure instrumental self-noise based on 3-channel coherency analysis. Results of this technique, which is applied on 3 STS-2 sensors, are presented during the IASPEI General Assembly 2009, Cape Town.

New seismic array of International monitoring system Kurchatov-Cross and its possibilities

Inna Sokolova, Natalya Mikhailova, Galina Kulikova

1. Institute of Geophysical Research, National Nuclear Center, Kazakhstan, **sokolova@kndc.kz**

ABSTRACT

By the Comprehensive Test-Ban Treaty signed by Kazakhstan in 1996, "Kurchatov-Cross" station (created in 1973 on the territory of former Semipalatinsk Test Site) is included into the seismic monitoring network of the International Monitoring System as auxiliary station (AS058). According to the requirements to the stations of the International Monitoring System, the station was upgraded in 2006 and began its operation in test mode. On December 18, 2006 the station was certified by the international commission as a station of international monitoring. "Cross" seismic array represents two linear profiles (latitudinal and meridional) of instrumental boreholes 22,5 km long each. Each profile has 10 instrumental boreholes (sites) with common central site in the place of profiles intersection. Average distance between the sites is about 2,25 km. Meridional profile (1 – 10 sites) has strike azimuth NE 10°, latitudinal profile (11-20 sites) has strike azimuth NW 280°.
According to data of three component broadband central site KUR21, dynamical characteristics of seismic noise in wide frequency range were studied. Seasonal and daily variations of seismic noise were studied. Seismic noise for KUR21 station was compared with other Kazakhstan seismic stations included into IMS network (PS-26, AS-057, AS-056), and with data of Kurchatov-Cross seismic array obtained in 1994-2000. Noise level close to Peterson Low Noise Model is peculiar for this station, which provides its high efficiency while seismic monitoring.
It was revealed that records of Kurchatov-Cross seismic arrays have many local noise connected with train traffic by rail roads routed near the seismic array. For each class of noise its identity signs such as dominating frequency, duration and record type, time sequence of arrivals at different elements of the array and etc. were studied. Some recommendations were given to analytics concerning utilization of the station data in automatic and interactive processing.
Data about active quarries located at local distances from the array were collected and analyzed. Quarry blasts seismograms were analyzed.
Using records of Kurchatov-Cross seismic array, structure of short-period seismic wave fields from underground nuclear explosions conducted on Asian Test Sites and earthquakes with epicenters adjacent to these Test Sites was studied in details; specific features of waveforms of different nature events were revealed.

Key words: seismic array, nuclear explosions, seismic noise.

PRESENTER'S BIOGRAPHY

Inna Sokolova graduated Kazakh State University on 1992 and have combined B.Sc. and M.Sc. degree in Applied Mathematics, on 1994 she received Ph.D. in Mathematics, Kazakh State University, Kazakh Academy of Sciences, Almaty (1994).
From 1992 till 1999 she worked on O.Yu. Shmidt Institute of Physics of the Earth, Complex Seismological Expedition, Talgar. From 1999 till now she works in the Kazakh National Data Center Institute of Geophysical Research National Nuclear Center, her position is senior scientist.
Present duties are: Discrimination of nuclear explosions, chemical explosions and earthquakes; study of heterogeneities of shear wave attenuation field in the Tien Shan region; study of geodynamics of Central and South Asia and test site area; study of seismicity of Kazakh platform.

SEISMICITY OF WESTERN KAZAKHSTAN ACCORDING TO DATA OF NNC RK NETWORK

Inna Sokolova, Natalya Mikhailova, Alexander Velikanov

1. Institute of Geophysical Research, National Nuclear Center, Kazakhstan, sokolova@kndc.kz

ABSTRACT

During last years mass media has been actively discussing a possibility of large earthquakes in Western Kazakhstan especially due to active extraction of hydrocarbon materials in this region. But the question about both natural and induced seismicity of the region is still open. Until recently there was no reliable information about earthquakes recorded in this region confirmed by instrumental data of the observation stations and reliable catalogues of recorded events were absent too.

New digital network of seismic stations of the National Nuclear Center of RK was created and is operating on the territory of Kazakhstan during last years. Due to careful geological site selection for stations construction and with relation to seismic noise characteristics, good arrays configuration, all stations are high sensitive to both regional and teleseismic events. Two stations included into this network are located in Western Kazakhstan: small aperture Akbulak seismic array and broadband three component Aktyubinsk station. Results of this system operation are used to assess seismic hazard on the territory of the Republis of Kazakhstan and operative control for seismic situation.

These stations commission allowed to increase significantly number of registering events in the region. However, while analyzing the seismicity it is necessary to take into account the fact of large number of active quarries in this region; thus, data about recorded seismic events should be considered with relation to seismic events nature discrimination.

Analysis of huge experimental material allows to assert with high probability that there are some tectonic earthquakes in Western Kazakhstan territory. Collected historical analog seismograms as well as bulletins of global seismic networks also testify existence of natural seismicity. The largest event from instrumentally recorded events happened on April 26, 2008 on the Shalkar lakeside, magnitude M=5.0, intensity 6 in epicentral area by MSK64 scale. The earthquake caused numerous damages in epicentral area and was felt on the large territory of Kazakhstan. Investigated event nature testifies that the earthquake was not man-made, but had karst nature.

All received data on historical and modern seismicity should be taken into account during creation of the new map of seismic zoning of Kazakhstan.

Key words: seismicity.

PRESENTER'S BIOGRAPHY

Inna Sokolova graduated Kazakh State University on 1992 and have combined B.Sc. and M.Sc. degree in Applied Mathematics, on 1994 she received Ph.D. in Mathematics, Kazakh State University, Kazakh Academy of Sciences, Almaty (1994).

From 1992 till 1999 she worked on O.Yu. Shmidt Institute of Physics of the Earth, Complex Seismological Expedition, Talgar. From 1999 till now she works in the Kazakh National Data Center Institute of Geophysical Research National Nuclear Center, her position is senior scientist.

Present duties are: Discrimination of nuclear explosions, chemical explosions and earthquakes; study of heterogeneities of shear wave attenuation field in the Tien Shan region; study of geodynamics of Central and South Asia and test site area; study of seismicity of Kazakh platform.

ISC Bulletin: no longer two years behind

Dmitry Storchak[1], Istvan Bondar[1], James Harris[1], Oriol Gaspa[1]

1. International Seismological Centre, United Kingdom, dmitry@isc.ac.uk

ABSTRACT

Since its establishment in the early 1960s the International Seismological Centre (ISC) has been engaged in collection and revision of final reviewed station and network bulletin data approximately two years behind real time.

The ISC is currently considering a new Development Programme. One of the integral elements of this programme is routine collection of provisional automatic seismic bulletins from various networks and data centres with updates where necessary, loading those into the ISC database, grouping on event basis and making this information available soon after it was reported.

It is our intention to keep the ISC database being constantly updated with this information from the time an event occurs till the time when agencies are able to report results of the final manual review. At this point the provisional information is going to be substituted with the final so that traditional manual analysis of the ISC Bulletin is based on the most accurate information available from networks.

At present we receive provisional bulletins and event notifications from only a dozen of networks, so we invite seismic networks engaged in automatic near real time processing of their data to revise the terms of their data contribution to the ISC.

Key words: ISC, Bulletin

PRESENTER'S BIOGRAPHY

Dmitry Storchak, currently the Director of the ISC, graduated from Moscow Lomonosov State University, worked as a researcher in the Institute of Physics of the Earth Russian Academy of Sciences, since 1995 - at the ISC, responsible for review of the ISC Bulletin – the definitive summary of the world seismicity.

International Seismological Centre (ISC): current status and development plans

Dmitry Storchak[1], Istvan Bondar[1], James Harris[1], Beatriz Vera[1], Oriol Gaspa[1]

1. International Seismological Centre, United Kingdom, dmitry@isc.ac.uk

ABSTRACT

The International Seismological Centre (ISC) is a non-governmental, non-profit making organization supported by 55 research and operational institutions around the world and charged with production of the ISC Bulletin – the definitive summary of world seismicity based on seismic reports from over 120 institutions. Jointly with World Data Center for Seismology (Denver), the ISC runs the International Seismic Station Registry (IR). The ISC provides a number of additional services available from its web-site including the depositary of the IASPEI Reference Event list, EHB & ISS data collections.

The ISC has a substantial development programme that would ensure that the ISC data will remain an important requirement for geophysical research. This programme includes bringing the ISC edited Bulletin schedule to approximately 15-18 months behind real-time as well as starting collection of provisional reports to make the automatic ISC Bulletin as comprehensive as possible before the final data become available to the ISC and the manual review by the ISC analysts begins. There are also plans to introduce a new International Seismic Network and Station Registry in the ISC operations, modernise the way the ISC computes its hypocentres and magnitudes and to attempt taking some useful measurements from waveforms widely available on-line. These measurements are to be used to improve the accuracy of the ISC Bulletin.

Key words: ISC, Bulletin

PRESENTER'S BIOGRAPHY

Dmitry Storchak, currently the Director of the ISC, graduated from Moscow Lomonosov State University, worked as a researcher in the Institute of Physics of the Earth Russian Academy of Sciences, since 1995 - at the ISC, responsible for review of the ISC Bulletin – the definitive summary of the world seismicity.

NEW DEVELOPMENTS OF THE GEOSCOPE PROGRAM

Eléonore Stutzmann[1], Sébastien Bonaimé[2], Constanza Pardo[3], Alessia Maggi[4] and the GEOSCOPE group[1]

1. Institut de Physique du Globe de Paris, France, stutz@ipgp.jussieu.fr
2. Institut de Physique du Globe de Paris, France, bonaime@ipgp.jussieu.fr
3. Institut de Physique du Globe de Paris, France pardo@ipgp.jussieu.fr
4. Ecole et Observatoire des Sciences de la Terre de Strasbourg, France, Alessia.Maggi@eost.u-strasbg.fr

The GEOSCOPE observatory consists of a global seismic network and a data center. The observatory was launched in 1982 by the French National Center of Scientific Research (CNRS/INSU) and progressively 30 stations have been installed across all continents and on islands throughout the oceans. The GEOSCOPE stations are located on 18 countries and equipped with three component very broadband seismometers (STS1 or STS2) and 24 or 26 bit digitizers, as required by the Federation of Seismic Digital Network (FDSN). In most stations, a pressure gauge and a thermometer are also installed. In 2008, 17 stations send data in real or near real time to GEOSCOPE Data Center.

In 2008, two stations have been upgraded and send real time data: UNM in Mexico and HDC in Costa Rica. Two new stations have also been installed: CLF in France and FOMA south of Madagascar. In 2009, we plan to upgrade stations PPT in French Polynesia, COYC in Chile, MPG in Guyana and to install a new station in Rodrigues island. We also plan to progressively replace original STS1 electronics with Metrozet systems. We will also reinstall all STS1 with warpless base plate systems in order to minimize the effects of atmospheric pressure variations thus to improve signal to noise ratio.

Continuous data of all stations are collected in real time or with a delay by the GEOSCOPE Data Center in Paris where they are validated, stored and made accessible to the international scientific community. Users have free and open access to:

- Real time data coming from 17 stations to Geoscope Data Center using the seedlink protocol developed by GEOFON (GFZ, Germany). Seedlink also enables to make these data accessible in real time to Tsunami Warning Centers and to other data centers. These data are also available to users through the GEOSCOPE web interface.
- Validated continuous waveforms and metadata of all stations by using the NetDC system (Networked Data Centers). Data can be requested from GEOSCOPE Data Center and from other networked centers associated to the FDSN.
- A selection of seismograms corresponding to large earthquakes via a web interface
- The power spectrum estimates of the seismic noise averaged over sequences of 24 hours for each station. The noise level of the last 10 years of continuous data has been computed and is accessible via the web. The noise level of real time data is computed at day-8.

GEOSCOPE data center is now networked to the French virtual data center, FOSFORE, in order to give a unique access to French seismological data. In Europe, GEOSCOPE data center participates in NERIES project (NA3 activity) in order to create a distributed archive and database for all continuous digital waveform recordings of the Euro-Med region.

.

Key words: seismic network, data centre, broadband seismic data,

PRESENTER'S BIOGRAPHY

Eléonore Stutzmann

EDUCATION

- Habilitation, University of Paris VII.
- Ph.D. in Earth Science, University of Paris VII.
- Engineer diploma, Ecole et Observatoire de Physique du Globe, Strasbourg.

POSITIONS HELD

- Director of the GEOSCOPE observatory (2007-),http://geoscope.ipgp.jussieu.fr
- Physicist, Institut de Physique du Globe de Paris, France (2007-).
- Adjunct director of the seismological department , Institut de Physique du Globe de Paris, France (2003-2007)
- Associate physicist, Institut de Physique du Globe de Paris, France (1994-2007).
- Member of the GEOSCOPE program executive committee (1994-).
- Post doctorate, University of Utrecht, Netherlands (1993-1994).

RESEARCH INTERESTS

- Mantle geodynamic
- P-wave, S-wave and surface wave tomography to constrain mantle temperature and composition.
- Slab characterization: depth extent, temperature and composition
- Hotspot origin at depth and plume-mantle interaction.
- Seismic networks
- Ocean bottom observatories.
- Seismic noise sources.

SIMULTANEOUS INVERSION OF 3D STRUCTURES AND HYPOCENTERS OF SICHUAN AND SURROUNDING AREAS

Ruomei Sun and Jiwen Teng

1. Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing CHINA, sunrm0@yahoo.com.cn
2. Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing CHINA, jwteng@mail.iggcas.ac.cn

It is a major problem we are facing in earthquake relocation that the inversion of hypocenter is strongly coupled with inversion of velocity structure model. In this work the orthogonal projection operator ($P_{B=}BB^{+}$, where B is the matrix of partial derivatives for hypocenter parameters, B^{+} is the Moore-Penrose generalized inverse matrix of the matrix B) is introduced to separate the two kinds of parameters: velocity structures and earthquake hypocenters. After decoupling by using P_B orthogonal projection operator we got two equation systems.; $(I-P_B)t=(I-P_B)A\delta\upsilon$ and $P_B(t-A\delta\upsilon)=B\delta q$. We assembly a data set We assemble arrival time data of regional and teleseismic events during the period of 1967-2007 recorded by several local seismological bureaus. The results are as follows: The hypocenters of most of the strong shocks are distributed in the transitional zones between high-and low-velocity areas in the crust, especially at edges of high-velocity blocks. Strong shocks predominantly lie above low-velocity blocks or in transitional zones between low-and high- velocity areas in the lower crust. Then we also give relocated hypocenters of this area. The equation system to determine hypocenters is a compatible system. It means if the equation condition is good enough we may get a unique result. We will show the tectonic setting of the Wenchuan shock and the seismicity of the seismic sequence following the M 8.0 main shock.

Key words: 3-D structure, simultaneous inversion, Sichuan, Wenchuan shock

Ms. SUN Ruomei works in the Institute of Geology and Geophysics, Chinese Academy of Sciences. I have been dealing with relocation and tomography for many years.

Variation of seismic coda attenuation characteristics in the Garhwal, northwestern Himalayas

Jayant N. Tripathi[1], Priyamvada Singh[2], Mukut L. Sharma[3]

1. Department of Earth and Planetary Sciences, University of Allahabad, Allahabad - 211002, India; E-mail: jntripathi@gmail.com.
2. Department of Earth and Planetary Sciences, University of Allahabad, Allahabad - 211002, India.
3. Department of Earthquake Engineering, Indian Institute of Technology, Roorkee -247667, India.

ABSTRACT

The S-wave coda is considered to be consisting of back-scattered S-waves from the heterogeneities present in the lithosphere. Single Isotropic Scattering (SIS) model is one of the models developed to explain the above phenomena. In the single-scattering model, the coda is considered as a superposition of back-scattered wavelets from randomly distributed heterogeneities. Seismic coda wave attenuation (Q_c^{-1}) characteristics in the Garhwal, northwestern Himalaya is studied using 113 short-period, vertical component seismic observations from local events of hypocentral distance less than 250 km and magnitude range 1.0 to 4.0 which are mainly from the vicinity of Main Boundary Thrust (MBT) and the Main Central Thrust (MCT), well-defined tectonic discontinuities in the Himalayas. Coda-wave attenuation (Q_c^{-1}) is estimated using single isotropic scattering method at central frequencies 1.5, 3, 5, 7, 9, 12, 16, 20, 24 and 28 Hz at different lapse times (coda window start time from S-wave on set) and coda window lengths, from 10 to 60 seconds at an interval of 10 seconds. The results show that the Q_c^{-1} values are frequency dependent in the considered frequency range, and fit the power law $Q_c^{-1}(f) = Q_0^{-1} f^{-n}$ using least square. The Q_0 (Q_c at 1 Hz) value ranges from about 50 (Q_0^{-1}=20.161×10^{-3}) for lapse time of 10 sec and window length 10 sec combination to about 350 (Q_0^{-1}=2.903×10^{-3}) for lapse time (LT) of 60 sec and window length (WL) 60 sec combination. The exponent of the frequency dependence law, n ranges from 1.195 to 0.691, however, it is greater than 0.8 in general, indicating that the region is seismically and tectonically active with high heterogeneities. The attenuation in this region is less as compared to other tectonic and seismic active regions of the world, however, comparable to other regions of India. The variation of coda attenuation has been estimated for different lapse time and window length combinations to observe the effect with depth and it indicates that the upper lithosphere is more active seismically as compared to the lower lithosphere and the heterogeneity decreases with increasing depth.

Key words: Coda waves, scattering, Q_c, Garhwal Himalaya.

Theory of amplitude correction for true-reflection imaging

Ru-Shan Wu

Modeling and Imaging Laboratory, Earth and Planetary Sciences/IGPP, University of California, Santa Cruz, wrs@pmc.ucsc.edu

ABSTRACT

The goal of true-reflection imaging is to reconstruct the subsurface interfaces or scattering objects with image amplitudes representing the corresponding reflection/scattering strengths using the surface data consisted of backscattered waves,. There are different approaches for the amplitude correction. Here I present a unified theory of amplitude correction based on the theory of resolution operator and imaging principle using backpropagation integral (focusing operator). The amplitude correction matrix derived this way can be related to the deconvolution filter in diffraction tomography and the Hessian matrix in lease-square inversion. However, the matrix structure is different from the Hessian matrix and efficient algorithms can be derived based on our approach.

For strong-contrast heterogeneous media, the structure of the resolving kernel is highly irregular and space domain deconvolution is intractable. We decompose both the wavefield and the kernels into the local angle domain. First local image matrices are obtained by decomposing the wave fields into local plane waves (beamlets) and applying the imaging condition in the local angle domain. Then amplitude correction matrices in the local angle domain are calculated for the specific acquisition geometry and approximate Green's function in the imaging process. The image correction becomes simple normalization in the local angle domain. Some examples of amplitude correction will be shown to demonstrate the theory and method.

Key words: seismic imaging, resolution operator, true-reflection imaging, linear inversion, amplitude compensation

PRESENTER'S BIOGRAPHY

Ru-Shan Wu: Ph.D. in geophysics in 1984 from Massachusetts Institute of Technology, USA. Now he is a research geophysicist and the director of the Modeling and Imaging Laboratory, at the Institute of Geophysics and Planetary Physics, University of California, Santa Cruz. His current research interests include seismic wave propagation, scattering and imaging in heterogeneous media, prestack depth migration, fast methods for elastic wave modeling, scattering and attenuation, diffraction and scattering tomography, and general inversion of wave field. He is a member of AGU, CGA, EAGE, SEG, and SSA. He served as the Chairman of the IASPEI Sub-commission on Heterogeneity and scattering from 1997-2005, and a member of Standing Committee on Seismology and Geodynamics, Board on Earth Sciences and Resources, National Research Council from 2004-2007.