

## **MAPPING FAULTS AND STUDYING VOLCANOES: APPLICATIONS OF DOUBLE-DIFFERENCE RELOCATIONS IN BRITISH COLUMBIA.**

*Natalie Balfour (University of Victoria), John Cassidy (Pacific Geoscience Center), Stan Dosso (University of Victoria)*

This paper applies double-difference earthquake relocation techniques to investigate a number of sources of seismicity in British Columbia, the most seismically active region of Canada. Southwest British Columbia is a complex region of deformation located above a bend in the subducting Juan de Fuca plate. The region experiences all forms of seismicity associated with subduction zones: megathrust earthquakes at the subduction interface (up to  $M \sim 9$ ), large intra-slab earthquakes (up to  $M \sim 7$ ), and events from faults in the overlying crust (up to  $M \sim 7.3$ ). Each of these types of earthquakes poses significant hazard to major population centres but particularly the crustal events due to their frequency and proximity to the surface and urban areas. By investigating seismicity patterns and the state of stress, we seek a better understanding of the forces driving earthquake activity, the locations of active structures, and the resulting seismic hazard. We present evidence for new active structures in the region using double difference earthquake relocation. Preliminary results show lineations in areas of clustered seismicity and have significantly reduced uncertainties over routine catalogue locations. The lineations that we identify appear to be 'hidden' structures that do not extend to the surface. British Columbia also has a number of volcanic belts, including the Anahim hot spot track, where recent swarms of earthquakes have raised questions regarding renewed volcanic activity. Swarm activity was first detected on October 9, 2007, in the vicinity of the Anahim Volcanic Belt, and may represent the reawakening of this seemingly inactive region. Double-difference relocation is applied to microseismic events to investigate how seismicity progresses with time during the swarm. The importance of station geometry in constraining earthquake depths in volcanic regions is also discussed, as this is critical information for monitoring volcanic activity and assessing associated hazards.

**POSTER 97**

## **JANUARY 2008 REVERE-DELLWOOD-WILSON FAULT EARTHQUAKE SEQUENCE OFFSHORE BRITISH COLUMBIA**

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Starting on 5 January 2008, a sequence of strong earthquakes occurred along the seismically active Revere-Dellwood Fault which is located seaward of the continental shelf, between the southern tip of the Queen Charlotte Islands and the northern tip of Vancouver Island. The two largest earthquakes in the sequence, Mw 6.4 and Mw 6.6, occurred at 3:01 and 3:44 a.m. on 5 January and were felt mildly at some communities on the Queen Charlotte Islands, Vancouver Island and the mainland of British Columbia. The Revere-Dellwood is a transform fault about 100 km long in very young lithosphere connecting the Tuzo Wilson spreading centre to the Explorer spreading ridge, and is part of the complicated triple junction region at the northern end of the Cascadia subduction zone. Like the Queen Charlotte Fault and California's San Andreas Fault, it is interpreted that relative Pacific - North America motion takes place along this feature; preferred focal mechanisms indicate mainly right-lateral strike-slip motion. A similar sequence of earthquakes in April 1992 ruptured most of the southern half of the Revere-Dellwood-Wilson Fault. This year's events are distributed mainly along the northern half of the fault and in the region of the Tuzo Wilson spreading centre. Each of these sequences released about 20 years of accumulated strain.

**POSTER 102**

## SEISMIC PRECURSORS TO EXPLOSIVE ERUPTIONS DURING THE 2006 ERUPTION OF AUGUSTINE VOLCANO, ALASKA

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We examine two tools which, in retrospective analysis, were excellent indicators of imminent eruption during the 2006 eruptive activity at Augustine Volcano, south-central Alaska. Augustine Volcano erupted explosively in January 2006 following a 7 month period of precursory activity. High quality broad band seismic data was recorded throughout the different phases of the eruption which included 13 large explosions, continuous low level explosive activity and periods of dome building. The first tool presented here, referred to as the frequency index (FI), is based on a simple ratio of high and low frequency energy in an earthquake seismogram. It is a metric which allows us to quantify the differences between the canonical high-frequency, hybrid and low-frequency volcanic earthquakes. FI values greater than -0.4 indicate earthquakes classically referred to as high frequency or volcano-tectonic events. FI values less than -1.3 correspond to events usually referred to as low frequency earthquakes. Because the FI is based on a ratio and not a spectral peak, hybrid earthquakes are successfully assigned FI values intermediate to these two classes. In this eruption, we find a remarkable correlation between events with FI less than -1.8 and explosive eruptions. We extend the FI analysis to other volcanic areas in Alaska. We apply the technique to a variety of earthquake swarms and compare the differences in FI patterns between earthquake sequences which culminate in volcanic eruptions and those which do not. The second tool we examine is based on repeating seismic waveforms identified through waveform cross-correlation. While the vast majority of earthquakes during this eruption have unique waveforms, subsets of events which do show a high degree of similarity occur and are closely tied to explosive eruption events. 7 of the 13 large explosion events were preceded by clusters of highly similar earthquakes. We apply the FI and correlation tools together to identify changes in high and low frequency earthquake occurrences during periods of explosive volcanic activity. We find that earthquakes that have low FI values and earthquakes exhibiting high degrees of similarity occur almost exclusively immediately prior to or during explosive eruptions, and postulate that they occur as a result of the final ascent of magma in the volcanic edifice.

**POSTER 87**

## **THE QUAKE CATCHER NETWORK: CAPTURING EARTHQUAKES USING DISTRIBUTED COMPUTING**

*Elizabeth Cochran (University of California, Riverside), Jesse Lawrence (Stanford University), Carl Christensen (Stanford University), Ravi Jakka (University of California, Riverside)*

Recent advances in distributed computing provide exciting opportunities for seismic data collection and large computational problems. We are in the early stages of implementing a high density, low cost strong-motion network for rapid response and early warning by placing accelerometers in schools, homes, and offices. The Quake Catcher Network (QCN) employs existing networked laptops and desktops to form a dense, distributed computing seismic network. Costs for this network are minimal because the QCN uses 1) strong motion sensors (accelerometers) already internal to many laptops and 2) low-cost universal serial bus (USB) accelerometers for use with desktops. The Berkeley Open Infrastructure for Network Computing (BOINC!) provides a free, proven paradigm for involving the public in large-scale computational research projects. In the first month of limited release of the QCN software, we successfully received triggers and waveforms from laptops near the M 4.7 April 25, 2008 earthquake in Reno, Nevada.

Engaging the public to participate in seismic data collection is not only an integral part of the project, but an added value to the QCN. The software will provide the client-user with a screen-saver displaying seismic data recorded on their laptop, recently detected earthquakes, and general information about earthquakes and the geosciences. Furthermore, this project will install USB sensors in K-12 classrooms as an educational tool for teaching science. Through a variety of interactive experiments students will learn about earthquakes and the hazards earthquakes pose.

**POSTER 90**

## **NEXT GENERATION PORTABLE DAS WITH WIRELESS CAPABILITY**

*Paul Davis (UCLA)*

In some experiments there is an interest in rapidly installing wirelessly-linked seismic networks to make near-real time unaliased observations in aftershock or volcanic zones in RAMP deployments or for active surveys. In an aftershock zone timely information on events can be useful for array re-design, assessing aftershock damage, or on a volcano predicting when it will erupt. Recent developments in wireless networking using Internet programs make installing of a radio-linked network fairly straightforward. It would allow viewing the data and analyzing it immediately, rather the traditional method of collecting disks and extracting the science at a much later date. The advantages of immediate access to the data and analysis include updating the model, testing the equipment integrity and relocating stations if needed, as well as making decisions on the basis of the seismic activity. Present systems are cumbersome, part of which is due to power requirements. By a combination of duty cycling and multihopping the data using nodes as relays, low power processign and A/D, RF and DAS power can be minimized. We have been developing a DAS radio network (Reftek, CENS collaboration) with the objective of reduction in power and form factor of the nodes, so that the RAMP station can be virtually thrown out of the back of a truck, and the meshed array automatically configures, and starts transmitting data. Construction of the prototypes is under way but final specifications that would satisfy the community needs will be discussed at the SIG meeting Friday.

**POSTER 105**

## **LESSONS FROM THE TRANSPORTABLE ARRAY FOR SEISMIC MONITORING**

*Douglas Dreger (Berkeley Seismological Laboratory), Sean Ford (Berkeley Seismological Laboratory), William Walter (Lawrence Livermore National Laboratory), Summer Ohlendorf (Berkeley Seismological Laboratory)*

Beginning in 2004 the Transportable Array has been deployed in the western US, and as it migrates east it is collecting a wealth of data for crustal, continental and deep Earth structure studies, as well as for the investigation of local seismicity occurring during the deployment. The relatively dense regional coverage enables greatly improved capability for the determination of seismic moment tensors and finite-source models of small to large events. We will present source modeling results for shallow seismic events at the Geysers, California that display unusual non-double-couple seismic moment tensors, an analysis of low-frequency and broadband seismic waves from the August 6, 2007 Mw3.9 Utah coal mine collapse, and the finite-source rupture process of the damaging Mw6.0 Wells, Nevada earthquake. The results for the Geysers earthquakes show relatively large isotropic components suggesting fluid involvement in the source process. The mine collapse event is best characterized as the gravity driven closure of a horizontal crack, yet a secondary source is responsible for large Love waves. Broadband records are used to investigate the kinematics of the collapse. For the Wells earthquake we determine a kinematic rupture model, identify the causative rupture plane, and show how models obtained from such a regional broadband array can be used to characterize the level of strong shaking above the source. The studies of all of these events were facilitated or even made possible by the availability of data from Transportable Array. In each case the resolution of the source models will be discussed in terms of capabilities before, during and after the Transportable Array.

## **NEW RELEASE OF DIMAS-2008: DISPLAY, INTERACTIVE MANIPULATION & ANALYSIS OF SEISMOGRAMS**

*D.V. Droznin (Kamchatka Branch of Geophysical Surveys RAS), S.Y. Droznina (Kamchatka Branch of Geophysical Surveys RAS)*

This Windows-platform program suite was designed to assist seismic network operators in the analysis of seismic waveform data. The suite supports multiple seismologic formats; includes the retrieval and analysis of seismic signals in the time and frequency domain; performs polarization analysis of 3-component records, time and amplitude measurements, filtering, spectrogram calculation, basic strong motion processing, earthquake location, etc.

This software is currently used by the Kamchatka Branch of Geophysical Survey RAS for handling both regional and volcano seismic activity in Kamchatka, Russia.

**POSTER 110**

## **STEALING GOLD FROM THE IVORY TOWER: USGS NATIONAL EARTHQUAKE INFORMATION CENTER'S COLLABORATIONS WITH THE ACADEMIC COMMUNITY**

*Paul Earle (USGS), Harley Benz (USGS), David Wald (USGS), Stuart Sipkin (USGS), Ray Buland (USGS), Jim Dewey (USGS), George Choy (USGS), Dan McNamara (USGS), Gavin Hayes (USGS), Alex Hutko (USGS)*

Collaborations between the academic community and the USGS National Earthquake Information Center (NEIC) have greatly increased in recent years. The results benefit society through faster and more accurate estimates of earthquake effects for emergency response, public and media awareness and basic earth science research and engineering applications. In addition, NEIC provides a highly visible platform for emphasizing the broader impacts of academic research. The collaborations range from investigations involving large projects such as the Global Seismic Network (GSN) and the ANSS backbone to smaller scale efforts including summer sabbaticals and student internships. Cooperative efforts are aided by new tools developed at NEIC to facilitate external algorithm development, increased NEIC research staffing, and improved external and collaborative funding opportunities. The NEIC now maintains methods to access near-realtime data and station metadata externally that use the same protocols used inside the NEIC. This infrastructure allows for easier transition from research ideas to operational systems. Increased collaboration has been aided by funding through external NEHRP/USGS grants, internal USGS funding, and the USGS Mendenhall postdoctoral fellowship program. We will describe recent and ongoing collaborations that illustrate the path from academic inspiration to societal benefit and highlight the types of projects that are conducive to this transition.

## **RAPID SOURCE TYPE AND PARAMETERS OF THE WELLS, NV AND CRANDALL CANYON MINE, UT EVENTS USING THE USARRAY**

*Sean Ford (Berkeley Seismological Laboratory), Doug Dreger (Berkeley Seismological Laboratory), Bill Walter (Lawrence Livermore National Laboratory)*

Seismic data from the USArray provided detailed information on the Wells, Nevada and Crandall Canyon Mine, Utah events in February 2008 and August 2007, respectively. Hours after the Wells event, moment tensor and finite fault solutions were published that helped to define the mechanism and fault-plane. These data could be used to aid in the prediction of areas of strong ground shaking in and around Wells, Nevada. A full moment tensor analysis was performed for the Crandall Canyon Mine event, which when combined with the first-motion analysis, helped to define the M3.9 seismic signal as due to the mine collapse, and not a natural tectonic earthquake. This type of analysis can be used in the future to rapidly determine source-type. We also investigate the collapse kinematics via an empirical Green's function technique.

**POSTER 93**

## **TOWARDS THE DEEP SEISMIC STRUCTURE OF COLIMA VOLCANO, MEXICO**

*Matt Gardine (Geophysical Institute, University of Alaska Fairbanks), Michael West (Geophysical Institute, University of Alaska Fairbanks), Tonatiuh Dominguez (Observatorio Vulcanologico de la Universidad de Colima)*

We present early-stage results of velocity modeling and ray-tracing at Colima Volcano, located in the western section of the Trans-Mexican Volcanic Belt - one of North America's most active volcanic centers. From January 2006 - February 2008, twenty broadband seismometers were deployed in a wide-aperture array around the volcano as part of the IRIS/PASSCAL-supported Colima Volcano Deep Seismic Experiment (CODEX). Data from this deployment, integrated with data from the Mapping of the Rivera Subduction Zone (MARS) project, have been used to characterize both the regional seismicity and the seismicity of the volcano. Colima Volcano has an unusually well-distributed suite of earthquakes on the local, regional, and teleseismic scale. Variations in travel-times of body waves to stations east of the volcano versus those west of the volcano give evidence to lateral heterogeneity in the geology of the deep crust around the volcano. Initial ray-tracing analysis of the regional seismicity, in conjunction with arrival times from local and regional earthquakes, has been used to make an initial estimate of the complicated seismic velocity structure around this prodigious volcanic center.

**POSTER 92**

## APPLYING WAVEFORM RELOCATED BACKGROUND SEISMICITY TO IMAGE LATE QUATERNARY FAULT ZONES IN SOUTHERN CALIFORNIA

*Egill Hauksson (California Institute of Technology)*

Small and major earthquakes mostly rupture different surfaces within fault zones. Major earthquakes that can slip more than several meters rupture along the principal slip zones within fault zones, which are the mapped traces of late Quaternary faults. The background seismicity that does not occur preferentially along the principal slip zones is accommodated on a secondary heterogeneous network of small slip surfaces. The background seismicity forms spatially concentrated distributions extending out to distances of  $\pm 10$  km. We call these distributions of seismicity that are often centered on the principal slip zones, the seismic damage zone. One possible explanation for the presence of the seismic damage zones is that they form as faults accommodate bends and other geometrical irregularities in the principal slip zones. The seismic damage zone forms and matures early in the history of a fault, during the first few kilometers of cumulative offset. As the fault accumulates more offset, the width of the seismic damage zone does not change significantly. However, the rate of background seismicity within the seismic damage zone, or seismic productivity, may decrease with cumulative offset and associated smoothing of the secondary heterogeneous fault networks. For instance, the San Andreas fault zone has a factor of  $\sim 10$  fewer small earthquakes within its seismic damage zone than the San Jacinto fault zone, which has much less cumulative offset. In particular, the seismic damage zone of the Anza San Jacinto segment of the San Jacinto fault accommodates a much higher level of seismicity than any other fault segments and thus appears to be exceptionally weak or under an unusual state of stress. The seismic productivity of the damage zone also depends on the strength of the fault zone, the time since the last major earthquake, as well as the orientation of the fault within the current regional tectonic stress field. The similarity in width of seismic damage zones in southern California suggests that most fault zones are of similar strength. Because small and major earthquakes rupture mostly different surfaces in a fault zone, they may be independent responses to plate tectonic loading, fluid movements, triggering from distant earthquakes, or other processes.

**POSTER 104**

## **DEVELOPING FRAMEWORK TO CONSTRAIN THE GEOMETRY OF THE SEISMIC RUPTURE PLANE IN SUBDUCTION ZONES A PRIORI**

*Gavin Hayes (US Geological Survey National Earthquake Information Center), David Wald (US Geological Survey National Earthquake Information Center)*

Many earthquake source inversions require a priori information about the geometry of the fault on which the earthquake occurred. Our knowledge of this surface is often uncertain, however, and as a result fault geometry misorientation can map into significant error in the final temporal and spatial slip patterns of these inversions. Relying solely on an initial hypocenter and CMT mechanism can be risky when establishing rupture characteristics needed for rapid tsunami and ground shaking estimates.

Here we attempt to improve the quality of fast finite-fault inversion results by combining several independent and complementary datasets to more accurately constrain the geometry of the seismic rupture plane of subducting slabs. Unlike previous analyses aimed at defining the general form of the plate interface, we require mechanisms and locations of the seismicity considered in our inversions to be consistent with their occurrence on the plate interface, by limiting events to those with well-constrained depths and with CMT solutions indicative of shallow-dip thrust faulting. We also require that interface geometries intersect trench axes, known from global fault databases and bathymetry. We construct probability density functions about each earthquake hypocenter based on formal assumptions of their depth uncertainty and use these constraints to solve for the 'most likely' fault plane, exploring fits with both planar, non-planar and polynomial geometries. Where available, data from shallow active seismic experiments across the trench can be used as additional constraint.

Examples are shown for a variety of subduction zone locations worldwide. This method produces a fault plane that is more consistent with all of the data available than is the plane implied by the initial hypocenter and CMT mechanism. Using the aggregated data sets we have developed an algorithm to rapidly determine more accurate initial fault plane geometries for source inversions of future earthquakes.

**POSTER 100**

## EARTHQUAKE SOURCE MODELING USING TIME-REVERSAL OR ADJOINT METHODS

*Vala Hjörleifsdóttir (LDEO, Columbia University), Qinya Liu (Scripps, UCSD), Jeroen Tromp (Caltech)*

In recent years there have been great advances in earthquake source modeling. Despite the effort, many questions about earthquake source physics still remain unanswered. In order to address some of these questions, it is useful to reconstruct what happens on the fault during an event. In this study we focus on determining the slip distribution on the fault plane in time and space. This is a difficult process involving many trade-offs between model parameters. The difficulty lies in the fact that earthquakes are not a controlled experiment, we don't know when and where they will occur, and therefore we have only limited control over what data will be acquired for each event. As a result, much of the advance that can be made, is by extracting more information out of the data that is routinely collected. Here we use a technique that uses 3D wave-forms to invert for the slip on a fault plane during rupture. By including 3D wave-forms we can use parts of the wave-forms that are often discarded as they are altered by structural effects in ways that can not be accurately predicted using 1D Earth models. However, generating 3D synthetic is computationally expensive, and therefore we turn to an 'adjoint' method (Tarantola Geoph. 1984, Tromp et al. GJI 2005), that is computationally less expensive than traditional methods using Green's function libraries. In its simplest form an adjoint method for inverting for source parameters can be viewed as a time-reversal experiment performed with a wave-propagation code (McMechan GJRS 1982). The recorded seismograms are inserted as simultaneous sources at the location of the receiver and the computed wave field (which we call the adjoint wavefield) is recorded on an array around the earthquake location. We show that for source inversions for a moment tensor (distributed) source, the time integral of the adjoint strain is the quantity to monitor. We present time-reversal experiments using synthetic seismograms computed for point sources and finite sources, building intuition for what to expect, and show an example for a real event.

**POSTER 89**

## BACK-PROJECTION OF TELESEISMIC P-WAVES AND POINT-SPREAD FUNCTION DECONVOLUTION FOR IMAGING EARTHQUAKE FINITE-SOURCE RUPTURE PROCESSES

*Alexander Hutko (USGS), Thorne Lay (UCSC)*

Applications of seismic wave back-projection and reverse-time methods to earthquake finite-source rupture imaging have increased with ready availability of large digital data sets and expanded computer processing capabilities. For large earthquakes, these approaches offer potential for explicitly resolving rupture attributes that are treated parametrically in conventional modeling and inversion procedures. Teleseismic P-wave back-projection source imaging using large aperture networks in Japan, Europe and North America is applied to several recent great earthquakes: 26 December 2004 Sumatra-Andaman ( $M_w = 9.15$ ), 15 November 2006 Kuril Islands ( $M_w = 8.3$ ), 13 January 2007 Kuril Islands ( $M_w = 8.1$ ), 1 April 2007 Solomon Islands ( $M_w = 8.1$ ), and 15 August 2007 Peru ( $M_w = 8.0$ ). This computationally fast method uses information contained in the direct teleseismic P-waveform, an important attribute for real time monitoring applications. However, time resolution, network aperture, rate of wave slowness variation across the network, and signal coherence are key issues that limit imaging resolution. Back-projected wavefields have many space-time artifacts due to intrinsically limited resolution associated with the data acquisition geometry and seismic wave periods relative to wavefront curvature. Complexity of the back-projected wavefield for a large event produced by the data acquisition geometry can be reduced by deconvolving empirical or theoretical point-spread functions (the space-time image formed from back-projection of signals from the same network for an effective point-source) from the data images. This facilitates measurement in back-projection images of key rupture attributes such as average rupture velocity and minimum rupture extent. These faulting characteristics can subsequently be used for rapid assessment of near-source ground shaking and tsunami excitation, along with providing a priori constraints on finite-fault slip model inversions.

**POSTER 107**

## **A NOVEL USE OF GLOBAL SEISMIC NETWORK FOR FAST TSUNAMI WARNING**

*Hiroo Kanamori (Seismological Lab., California Inst. of Technology, Pasadena, CA), Luis Rivera (EOST-IPGS; Université Louis Pasteur, Strasbourg, France)*

Traditionally long-period surface waves have been used for retrieval of seismic source parameters. If these waves are to be used for tsunami warning the arrival times are too late to issue rapid warning. Also, for great earthquakes for which reliable tsunami warning is most needed, long-period surface waves often go off scale and are unusable. To overcome these difficulties, we used heretofore unused W phases for retrieval of long-period source parameters. W phase is a long period phase arriving before S wave. It can be interpreted as superposition of the fundamental, 1st, 2nd, and 3rd overtones of spheroidal modes or Rayleigh waves and has a group velocity of 8 km/s at 1000 s and 8.6 km/s at 100 sec. Because of the fast group velocity of W phase, most of W phase energy is contained within a short time window after the arrival of the P wave before clipping occurs. At a distance of 50°, W phase energy is contained within 23 min after the origin time which is the distinct advantage of using W phase for rapid tsunami warning purposes. We use a time-domain deconvolution method to extract W phases from the broad-band records of global seismic networks. The bandwidth of W phase is approximately from 0.001 to 0.01 Hz, and we band-pass filter the data from 0.001 to 0.005 Hz in most cases. Having extracted W phase from the vertical component records, we perform a linear inversion using a point source to determine Mw and the source mechanism of large earthquakes including the 2004 Sumatra-Andaman earthquake, the 2005 Nias earthquake, the 2006 Kuril Is. earthquake, and the 2007 Sumatra earthquake. W phase inversion yields reliable solutions and holds promise of the use of W phase for rapid assessment of tsunami potential.

## **WEIGHING EARTHQUAKES WAVES WITH HIGH-PRECISION SCALES**

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High-precision laboratory scales have detected teleseismic waves by chance from distant earthquakes in the Turkmenistan and Martinique regions. The interpretation yields excellent agreement between recordings of the scales and nearby Wiechert seismographs (Goettingen, Germany). Ground displacement at the locality of the scales were determined in the range of 20-420  $\mu\text{m}$ . The comparison of both data sets showed that the scales respond to local ground accelerations in the same way as a long-period seismometer, if observed displacements are larger than 5  $\mu\text{m}$ . This study implies that high-precision scales can be used as additional devices to monitor earthquake waves as well as similar artificial vibrations. Such measurements are significant to estimate local site effects, and to determine whether observed amplifications of amplitudes mark a potential seismic risk, for instance, at industrial locations. Existing seismic networks could thus be expanded on a large scale at no extra cost, as high-precision scales are available in many laboratories....

**POSTER 113**

## ACCELERATING SCEC SEISMIC HAZARD RESEARCH THROUGH THE USE OF HIGH PERFORMANCE COMPUTING ON THE PETASHA PROJECT

*Phil Maechling (SCEC), Thomas H. Jordan (SCEC and Univ. Southern California), Carl Kesselman (ISI), Reagan Moore (SDSC), J. Bernard Minster (Scripps/UCSD), CME Collaboration*

The SCEC Community Modeling Environment (SCEC/CME) collaboration is conducting a wide-ranging program of seismic hazard research program that uses of high performance computing. Funded through NSF grants, the SCEC PetaShake and PetaSHA projects are scaling up research calculations in order to make use of the petascale computing resources that are under development. SCEC research areas that we believe can make use of petascale computing capabilities including dynamic rupture modeling, wave propagation modeling, probabilistic seismic hazard analysis, and full 3D tomography. The SCEC PetaSHA and PetaShake computational capabilities are organized around the development of robust, re-usable, well-validated simulation systems we call computational platforms. Member of these projects are currently developing the DynaShake Platform (dynamic rupture simulations), the TeraShake Platform (wave propagation simulations), the CyberShake Platform (physics-based probabilistic seismic hazard analysis), the BroadBand Platform (deterministic and stochastic modeling of high frequency synthetic waveforms), the Full 3D Tomography (F3DT) Platform (improvements in structural representations), and utilizing the existing OpenSHA Platform. We describe several current SCEC computational-oriented research projects including the application of the DynaShake Platform to dynamic rupture modeling of the ShakeOut source, the use of the TeraShake Platform, including both the SDSU and CMU AWP codes, to model 1Hz ShakeOut simulations, the use of the CyberShake Platform to investigate physics-based PSHA hazard curves, and the use of the F3DT Platform to produce an improved structural model for a large region in southern California.

**POSTER 103**

## **THE MANY ROLES OF A REGIONAL SEISMIC NETWORK**

*Steve Malone (Univ. of Washington), Paul Bodin (Univ. of Washington), John Vidale (Univ. of Washington)*

The mission of the Pacific Northwest Seismic Network (PNSN) is similar to other university based regional networks in the US. They operate in direct support of education, research and public service. Maintaining an appropriate balance between sometimes competing “clients” requires a broad base of support, a variety of data types and products and a willingness and ability to adapt quickly to changing conditions.

At the PNSN for example, direct financial support comes from five different organizations and indirect support from no less than 40 others; each of who has specific interests in network products. These vary between emergency responders who want accurate earthquake information within minutes (or less) to engineers who want processed waveform data from large earthquakes to school groups who want easy-to-understand, current displays to the IRIS DMC who wants high-quality, calibrated, continuous raw waveforms. Unfortunately compromises must often be made between optimizing operations for one client versus another. An example of such a trade-off is in the siting of stations in which telemetry options may be limited at the quietest sites requiring the use of a noisier site. Another compromise involves sacrificing availability for quality. For example the USNSN and USArray are integrated into the PNSN real-time data stream; however, while their data quality is very high, because of frequent large latencies in delivery they often do not arrive in time to contribute to the routine detection and location of earthquakes. Recent developments include purchasing 21 of the ~85 TA stations in the region from IRIS for permanent inclusion as part of the network and upgrading their telemetry for lower latency, the sensors to include strong-motion and increasing the digitization rate for higher precision timing.

## **CLIMATE MONITORING WITH THE GSN**

*Daniel McNamara (USGS), Richard Aster (New Mexico Institute of Mining and Technology), Peter Bromirski (Scripps Institution of Oceanography), Charles Hutt (USGS), Lind Gee (USGS)*

Seismic background energy “noise” between 5 and 30s period is dominated by a persistent “microseism” arising from energy transferred from ocean gravity waves to elastic Rayleigh waves. In this presentation, we demonstrate the utility of microseisms as a sensitive integrative proxy for assessing long-term global sea swell changes induced by inter-annual through decadal-scale changes in storm intensity.

We apply a microseism-based oceanic extremal storm trigger algorithm to seismic records spanning four decades, taking particular care to ensure that the results are unbiased by data age, quality, and completeness. We evaluate this “microseism index” at long-operating GSN and precursor stations. The oldest station in our study, HG.ALQ, began digitally recording in 1972 and is a precursor to IU.ANMO in Albuquerque, NM. For ALQ analog data prior to 1972, we present methods and results from our digitizing effort.

**POSTER 99**

## **A HIGH VELOCITY LAYER AT DEPTH BENEATH BEZMYANNII VOLCANO, A POSSIBLE SOURCE OF SEISMICITY?**

*Alex Nikulin (Rutgers University), Vadim Levin (Rutgers University), Michael West (University of Alaska, Fairbanks)*

In central Kamchatka, a group of volcanoes (Klyuchevskoi, Bezmyannii, Tolbachik) are offset westward relative to the strike of the remainder of the Kamchatka volcanic arc. On the basis of local seismicity the depth of the subducting Pacific plate beneath these volcanoes is estimated to be around 150 km, while the crustal thickness estimates for Kamchatka fall into the 30-40 km range.

We apply receiver function analysis to data collected by temporary broadband seismic stations BEZB and BEZC installed in the vicinity of Bezmyannii Volcano, (Kamchatka, Russia) by the PIRE group. Our preliminary results indicate a presence of a clearly defined impedance contrast at a depth of 80-90 km below these stations. The signature of this feature corresponds to an abrupt increase of seismic velocity with depth, however its depth range is not consistent with either the crust-mantle transition or the top of the subducting Pacific Plate. A review of data collected in central Kamchatka a decade ago by the Side Edge of Kamchatka Slab project suggests similar features at upper-mantle depths both south and west of the Bezmyannii. We note rare, but consistent local earthquake events associated with the depth range of 75-100 km recorded in both global (IRIS) and local catalogs (KBGS).

We propose a relationship between this seismic activity and the position of a high velocity structure we describe in our observations, and speculate about the plausible nature of this upper-mantle feature in central Kamchatka.

**POSTER 95**

## **PRESUMED MINING BLAST IN WYOMING AS TEST OF TEST BAN TREATY SEISMIC MONITORING SYSTEM**

*Sheila Peacock (AWE Blacknest), David Bowers (AWE Blacknest)*

Identifying small seismic disturbances is important for the monitoring of the Comprehensive Test Ban Treaty (CTBT). Underground test explosions of a kiloton TNT equivalent can produce seismic events of magnitude ~3.5, similar in size to large mining blasts. Determination of reliable locations of such small events by the International Data Centre (IDC), using arrivals at five or fewer International Monitoring System (IMS) stations, depends on correct association with the event, and on azimuth and slowness as well as time measurements. To evaluate the IDC Reviewed Event Bulletin (REB) location procedure, we analyzed a  $M_L=3.5$  event in Wyoming recorded at five US/Canadian IMS stations at regional distance (3-20 deg). The USGS catalog omits this event and others of similar size and location, presumably because they are identified as mining blasts. Our location using REB times, slownesses and azimuths of the Pn and Lg phases was indistinguishable from that in the REB. REB arrivals at four of the IMS stations have poor signal/noise ratio, and at the furthest station, YKA, the arrival coincided with that from a small local event. Removing YKA left only stations in a northeast-southwest line through the epicenter, making the location dependent on azimuth picks; nevertheless our relocation remained within the coverage ellipse of the REB location. We used data from IRIS to independently locate the event with local stations, using time-only picks at one USGS, one Intermountain Network and two USArray stations and one IMS station, all within 3.2 deg. The epicentre falls within the REB coverage ellipse, but closer to (~5 km from) an opencast mine seen in satellite images - the Black Thunder mine used in 1996 CTBT verification experiments. Short-period Rg surface waves, consistent with a shallow source, are recorded at a station 120 km away. Short-period Love waves are also observed, consistent with a blast blowing rock sideways from a vertical face. P and Lg arrivals have scalloped spectra similar to those observed in the 1996 experiment from interference due to the ripple firing of hundreds of explosive shots to cast overburden into a pit. Thus, freely available data from the USArray and local stations have allowed us to verify the REB event location. Further, the published results from the 1996 investigation of mining blasts at Black Thunder helped us interpret the seismic signals recorded by IMS and other stations.

**POSTER 94**

## **PREDICTING EXPLOSIVE ERUPTIONS AT BEZYMIANNY VOLCANO, KAMCHATKA RUSSIA**

*Sergey Senyukov (Kamchatka Branch of Geophysical Surveys, RAS), Michael West (Geophysical Institute, Univ. Alaska Fairbanks), Dimitri Droznin (Kamchatka Branch of Geophysical Surveys, RAS)*

Bezimianny volcano is located in Kamchatka, Russia (55° 58' N, 160° 35' E, 2869 m). The last catastrophic eruption was on March 30, 1956, after 900–1000 years of quiescence. Since 1956 the volcano has had 1–2 eruptions per year with ash plume height up to 15 km above sea level.

Seismic precursors were registered before some eruptions from 1956 to 1994, but no eruptions were predicted officially using seismic data. The Kamchatka Branch of Geophysical Surveys (KBGS) Russian Academy of Science began processing volcanic earthquakes in 1992. During 1996–1999, seismic monitoring was improved significantly: 1) new telemetered stations were installed, 2) seismic data were converted to digital format, 3) custom seismic processing software was written.

KBGS began monitoring the activity of Kamchatkan volcanoes in 2000 (<http://emsd.iks.ru/~ssl/monitoring/main.htm>) using real-time seismic, visual (or video) and satellite (NOAA, AVHRR) data. 7 eruptions of Bezymianny volcano were recorded and investigated from February 2000 to February 2004. As a result of this experience, in May 2004, an algorithm for eruption prediction was established. 6 out of 7 eruptions were successfully predicted within 1–7 days using this algorithm during 2004–2007 in real time. It was also determined that successful prediction at Bezimianny depends on activity at nearby Kluchevskoy volcano.

It is clear that Bezymianny volcano is a good area for testing prediction methods for explosive eruptions due to its activity. 7 new iron bunkers were installed near Bezymianny during 2006–2007 as part of the USA–Russia PIRE project. 8 self-contained seismic stations and one self-contained acoustic station were installed within this project in 2007. The joint processing of data from the KBGS telemetered stations and from the PIRE stations allows us:

- to improve 1-D velocity model of Bezimianny volcano;
- to calculate 3-D velocity model of Bezimianny volcano;
- to relocate the volcanic earthquake centers;
- to create a model of the magma system of Bezimianny volcano and to explain the mechanism of its eruptions;
- to investigate the possibility of detecting ash plumes and the possibility of estimating ash plume heights using seismic, video and acoustic data.

**POSTER 109**

## **ANOMALOUS EARTHQUAKES ASSOCIATED WITH NYIRAGONGO VOLCANO: OBSERVATIONS AND POTENTIAL MECHANISMS**

*Ashley Shuler (Lamont-Doherty Earth Observatory), Goran Ekström (Lamont-Doherty Earth Observatory)*

The Virunga Volcanic Complex, located in the Western Rift Valley of the East African Rift, is the site of a series of unusual earthquakes. Five anomalous events, each of moderate size ( $4.6 \leq M \leq 5.3$ ), were located using long-period surface waves recorded on the Global Seismographic Network. Three of the events occurred within days of the 2002 eruption of Nyiragongo, while the final two events are not linked to a major eruption at Nyiragongo or its neighbor, Nyamuragira. Despite their size, these earthquakes do not appear in global seismicity catalogs. Several common techniques were used to investigate the character of the seismic sources in the context of the volcanic activity of the region, in an attempt to determine their physical mechanisms. The frequency content of these anomalous earthquakes was compared to that from local events found in global catalogs, and the five earthquakes were shown to be slow-slip events, being greatly depleted in frequencies above 0.1 Hz. Each of the newly detected earthquakes was modeled by a series of forces and by a centroid-moment tensor (CMT). A deviatoric moment tensor was shown to provide a better fit to the data. The newly detected earthquakes are highly non-double-couple in nature, each having a large compensated linear vector dipole (CLVD) component of the moment tensor. Focal mechanisms of this geometry are believed to be related to slip on non-planar faults beneath volcanoes. We suggest a mechanism in which these newly detected earthquakes are generated by the collapse of a shallow magma chamber along an inward-dipping cone-shaped ring fault. These earthquakes could be the result of diking events, which lower the pressure in a shallow magma chamber.

**POSTER 91**

## **MICROSEISMICITY AND THE TECTONIC SETTING OF THE SAN JUAN ISLANDS, WASHINGTON**

*Gerry Simila (California State University Northridge), Gary Greene (Moss Landing Marine Lab/Tombolo), Vaughn Barrie (Geological Survey of Canada)*

The offshore areas of the San Juan Islands have been investigated using high-resolution seismic data to map the geology and fault structures as part of a cooperative program between Moss Landing Marine Labs' (MLML) Center for Habitat Studies and the Canadian Geological Survey to map the marine benthic habitats and geology of the greater San Juan Islands – Georgia Basin region. Recently collected high-resolution (300 kHz) Simrad 3003 multibeam bathymetric data and 3.5 kHz seismic reflection profiles collected by the Canadian Hydrographic Service in cooperation with the Geological Survey of Canada and Tombolo of Orcas Island image a set of NW-SE trending faults that cut across the southern end of Lopez Island. These faults trend along, and appear to control, the straight shorelines of the bays of the island and offset or deform recent marine sediments. We interpret these faults to be a splay of the Devil's Mountain Fault that strikes in a nearly E-W direction in the deeper offshore region south of Lopez and San Juan islands.

The historical seismicity for the region includes the 1896 (M=5.0), 1909 (M=6.0), 1920 (M=5.5), 1943 (M=5.0), and 1976 (M=5.1) events. The microseismicity (2000-2007) from the University of Washington Pacific Northwest Seismic Network (PNSN) data files shows scattered events with magnitude range 1.0-3.5 for both shallow (0-30km) and deep (30+km) depths for the San Juan Islands. In August 2007, we installed a high gain vertical seismograph and three-component accelerometer on Orcas Island. The recent seismicity (2007-08) from PNSN shows several small magnitude, scattered events. In light of the potential activity of these faults, and others that we are presently investigating, we are considering additional local seismic monitoring of the region.

**POSTER 96**

## LOCAL EARTHQUAKE VP TOMOGRAPHY OF MOUNT ST. HELENS USING DATA FROM PNSN PERMANENT AND IRIS-PASSCAL TEMPORARY DEPLOYMENTS

*Gregory Waite (Michigan Technological University), Seth Moran (U.S. Geological Survey)*

We developed a new P-wave velocity model for Mount St. Helens using local earthquake data recorded by the Pacific Northwest Seismograph Stations and Cascades Volcano Observatory since the May 18 1980 eruption and data from a dense array of 19 IRIS-PASSCAL stations operated from June 2005 to January 2006. Because the distribution of earthquakes in the study area is nonuniform, we used a graded inversion scheme. The coarse-grid model nodes were spaced 5 km apart horizontally and 2 km apart vertically and the subsequent fine-grid model nodes were spaced 2 km apart horizontally and 1 km apart vertically. We used an offset-and-average routine to smooth the models and reduce bias related to model parameterization, which became obvious as a result of this exercise. Because of the abundance of earthquakes, we were able to compare models computed from independent data sets chosen using the same quality criteria. The location of the grid nodes had a larger influence on the model results than the data, highlighting the importance of the offset-and-average procedure for reducing errors related to arbitrary grid-node locations.

The results are largely consistent with previous geophysical studies of the area: we find high-velocity anomalies NW and NE of the edifice that correspond with igneous intrusions and a prominent low-velocity zone NNW of the edifice that encompasses the linear zone of high seismicity known as the St. Helens Seismic Zone. This low velocity zone may be continuous at depths below 5 km to the south and beneath MSH. The coincidence of the velocity anomalies and the trend of earthquakes is consistent with previous models that have suggested that MSH sits along a significant NNW-trending structure such as a fault. Directly beneath the edifice, we found a low-velocity zone between about 2 and 3.5 km below sea level that may be a shallow magma storage zone. A strong high-velocity anomaly, previously interpreted as a magma plug (Lees, 1992) was found to be east of the vertical zone of earthquakes directly beneath MSH instead of within the earthquake zone. This anomaly may be attributed to crystallized magma, but we do not interpret it as a plug within the conduit. And although the model resolution is poor below about 6 km because of a lack of deep earthquakes, we found low velocities that correspond with the aseismic zone between about 5.5 and 8 km that has previously been modeled as the location of a large magma storage volume.

**POSTER 112**

## **A REAL-TIME PROCEDURE FOR DOUBLE-DIFFERENCE EVENT LOCATION: PERFORMANCE EVALUATION IN NORTHERN CALIFORNIA**

*Felix Waldhauser (Lamont-Doherty Earth Observatory, Columbia University)*

We present a real-time procedure that uses cross-correlation and double-difference methods to rapidly relocate new seismic events with high precision relative to past events with accurately known locations. Waveforms of new events are automatically cross-correlated with those archived for nearby past events to measure accurate differential phase arrival times. These data, together with delay times computed from arrival time picks, are subsequently inverted for the vector connecting the new event to its neighboring events. We test and apply the procedure to earthquakes recorded in Northern California, using real-time data feeds from the Northern California Seismic Network (NCSN) and the Northern California Earthquake Data Center (NCEDC), and a local copy of the seismic archive for earthquakes recorded since 1984. New events are relocated in near real-time relative to a recently developed high-resolution double-difference earthquake catalog for Northern California. Back-testing using past events indicate a median difference between the DD real-time locations and the corresponding locations in the DD catalog of 0.06 km laterally, and 0.17 km vertically. We show that the precision with which we locate new events using these techniques is improving with time, helped by the increasing density of recorded earthquakes along active faults, growth of the digital seismic archives, and continued expansion of seismographic stations. The availability of precise event locations in near real-time has considerable social and economic impact in the evaluation and mitigation of seismic hazards, for example. In addition, the routine production of high-resolution earthquake catalogs will provide, in a timely fashion, the fundamental data required to address questions concerning the physics of earthquakes, the structure and composition of the Earth's interior, and the seismic hazards associated with active faults.

**POSTER 98**

## **REGIONAL WAVE PROPAGATION BENEATH WESTERN US**

*Shengji Wei (Caltech), Ali Konca (Caltech), Yang Luo (Caltech), Sidao Ni (USTC), Yong Chen (USTC), Don V. Helmberger (Caltech)*

The recent Nevada Earthquake (M=6) produced an extraordinary set of crustal wave-guided waves. In this study, we examine the three-component data at all the USArray stations in terms of how well existing models perform in predicting the various phases, Rayleigh waves, Love waves and Pnl waves. To establish the source parameters, we applied the Cut and Paste Code up to distance of 50 for an average local crustal model which produced a normal mechanism (strike=350,dip=410,rake=-850) at a depth of 9 km and Mw=5.9. Assuming this mechanism, we generated synthetics at all distances for a number of 1D and 3D models. The Pnl observations fit the synthetics for the simple models well both in timing( $V_{Pn}=7.9\text{km/s}$ ) and waveform fits out to a distance of about 50 where a great deal of complexity can be seen to the northwest apparently caused by shallow subducted slab material. These paths require considerable crustal thinning and higher P-velocities. Small delays and advances outline the various tectonic province, Colorado Plateau, etc. with velocities compatible with that reported on by Mooney et al.(2005). Five-second Rayleigh waves(Airy Phase) can be observed throughout the whole array and show a great deal of variation( up to 30s). In general, the Love waves are better behaved than the Rayleigh waves. We are presently adding higher frequency to the source description by including source complexity. Preliminary inversions suggest rupture to northeast with a shallow asperity. We are, also, inverting the aftershocks to extend the frequencies to 2 Hz and beyond following the calibration method outlined in Tan and Helmberger(2007). This will allow accurate directivity measurements for events with magnitude larger than 3.5. Thus, we will address the energy decay with distance as a function of frequency band for the various source types.

**POSTER 108**

## **SEISMIC INVESTIGATIONS AT BEZYMIANNY VOLCANO (KAMCHATKA, RUSSIA) THROUGH THE NSF PIRE PROGRAM**

*Michael West (University of Alaska Fairbanks), Sergey Senyukov (Kamchatka Branch of Geophysical Surveys RAS), Victor Chebrov (Kamchatka Branch of Geophysical Surveys, RAS), Weston Thelen (University of Washington), Alex Nikulin (Rutgers University)*

Bezymianny volcano is the target of a major research initiative through the NSF PIRE program (Partnerships for International Research and Education). A major component of this project is enhanced seismic monitoring and research of the volcano and surrounding environs. This endeavor is a cooperation between the University of Alaska Fairbanks and the Russian Academy of Science Far East Division Institute of Volcanology and Seismology and Kamchatka Branch of Geophysical Surveys. With support from the IRIS/PASSCAL instrument facility, the PIRE project is installing a research-grade seismic network on the flanks of Bezymianny volcano over the course of two field seasons in 2007 and 2008. With the assistance of KBGS, broadband campaign seismic stations and infrasound with on-site recording are being supplemented with real-time telemetry. Here we present an overview of preliminary results from this project as well as previous studies which lay the ground work for our current investigations.

The St. Helens-like sector collapse and directed blast eruption of Bezymianny in 1956 (VEI 5) heralded the beginning of what has evolved into one of the most regular, and predictable, sequences of explosive eruptions in the world. The twice annual pattern of recent eruptions strongly suggests that the mechanics of recent Bezymianny eruptions are stable and long-lived. The implication of a robust, largely self-regulating system makes Bezymianny a preeminent target for discerning the mechanics of pre- and post-eruption seismicity and its relationship to lava dome growth and a long-lived magma system.

**POSTER 111**

## **NON-LINEARITY AND TEMPORAL CHANGES OF FAULT ZONE SITE RESPONSE ASSOCIATED WITH STRONG GROUND MOTION**

*Chunquan Wu (Georgia Institute of Technology), Zhigang Peng (Georgia Institute of Technology), Yehuda Ben-Zion (University of Southern California, Los Angeles)*

We systematically analyze temporal changes of fault zone (FZ) site response along the Karadere-Düzce branch of the North Anatolian fault that ruptured during the 1999 İzmit and Düzce earthquake sequences. The study is based primarily on spectral ratios of strong motion seismic data recorded by a FZ station and a station ~400 m away from the fault, and augmented by analysis of weak motion records. The employed data set starts 8 days before and ends 72 days after the Düzce mainshock. The spectral ratios between the stations are computed from the averaged spectra for the two horizontal components of motion. The observations are used to track non-linear behavior and temporal changes of the FZ site response. The peak spectral ratio increases 80-150% and the peak frequency drops 20-40% at the time of the Düzce mainshock. These co-mainshock changes are followed by an apparent recovery with a time scale of ~1 day. However, analysis of temporal changes at each individual station using waveforms generated by repeating earthquakes show lower-amplitude longer-duration variations at both stations that are not detected by the spectral ratio analysis. The results based on the spectral ratios provide lower bounds for the temporal changes of material properties that are consistent with at least 20-40% reduction of seismic velocities during the Düzce mainshock followed by a logarithmic recovery on a time scale of 3 month or more. The observations support previous suggestions that non-linear wave propagation effects and temporal changes of seismic properties are generated by strong ground motion of nearby major earthquakes.

**POSTER 88**

## SYSTEMATIC ANALYSIS TEMPORAL CHANGES OF SITE RESPONSE ASSOCIATED WITH STRONG GROUND MOTION IN JAPAN

*Chunquan Wu (Georgia Institute of Technology), Zhigang Peng (Georgia Institute of Technology), Dominic Assimaki (Georgia Institute of Technology)*

We present a systematic investigation of temporal changes in site response observed prior, during and after large earthquakes, by processing downhole array data from the Japanese Strong Motion Network KIK-Net. We seek to identify the physical mechanisms and governing parameters involved in the observed temporal variations, and accordingly quantify the phenomenon to improve site response predictions for future scenarios. Site response measures the amplitude and frequency modulation of seismic waves as they propagate through the top layers of the earth's crust. Time-varying site response to strong ground motion is associated with the nonlinear behavior of near-surface geomaterials, and prediction of these phenomena is critical for the assessment of site effects in seismology and earthquake engineering. Nonetheless, while there exists observational evidence corroborated by multiple studies on the significance of nonlinear site effects in ground motion predictions, only a few studies have focused on the details of the post-event recovery process of the material. The governing parameters of the rate and time scale of recovery have not been systematically investigated, which prohibits future predictions of site effects to credibly account for temporal changes. We here investigate temporal changes of site response in Japan associated with strong ground motion of the Mw6.7 2000 Western Tottori, the Mw7.0 2003 Miyagi-Oki, and the Mw8.3 2003 Tokachi-Oki earthquakes. We harvest borehole and surface data from the KIK-Net seismogram repository. We focus on stations in the vicinity of the event epicenters starting ~2 months before and ending ~3 months after each mainshock. We then compute spectral ratios from the averaged spectra for the two horizontal components of motion between the surface and borehole stations, and track the co-seismic change and post-seismic recovery of the site response. The peak spectral ratio decreases 20-70% and the peak frequency drops 30-70% immediately after the mainshock. The co-seismic changes are followed by an apparent recovery with time scale ranging from 100s to a few years among all the sites. Results from this work are currently being used to identify the controlling parameters for the percentage of co-seismic change and for the time scale of post-seismic recovery at different sites, and will be presented at the meeting.

**POSTER 106**

## **DETERMINATION OF FAULT PLANE AND RUPTURE DIRECTIVITY OF THE APRIL 2008 M5.2 MOUNT CARMEL EARTHQUAKE, ILLINOIS, USING DOUBLE DIFFERENCE RELOCATION AND SOURCE TIME FUNCTION ESTIMATION TECHNIQUES**

*Hongfeng Yang (Saint Louis University), Risheng Chu (California Institute of Technology), Lupei Zhu (Saint Louis University)*

On April 18, 2008, a moderate earthquake (M5.2) happened in the Wabash Valley seismic zone, southeastern Illinois. A large number of aftershocks including two events with magnitude larger than 4 occurred within one week after the mainshock. We used waveforms recorded by the New Madrid Seismic Network stations to study fault plane and rupture direction of the mainshock. We first applied a sliding-window cross correlation technique to detect small aftershocks. We then relocated all events by the double difference relocation algorithm. Accurate differential P- and S-wave arrival times were obtained by waveform cross correlation. After relocation, all events were located in a SW-NE line which delineates a strike-slip fault.

To determine rupture propagation direction, we used a small magnitude event as the empirical Green's function to estimate source time function of the mainshock. Preliminary result shows that the rupture direction was towards N60°E.

**POSTER 101**