[3]Department of Geophysics, Stanford University, Stanford, CA 94305-2215, United States

Accurate predictions of the intensity and variability of near-source strong ground motions for future large earthquakes depend strongly on our ability to simulate realistic models of earthquake rupture. Commonly used kinematic earthquake source models are characterized by heterogeneity in the slip distribution and a temporal rupture evolution (rise time, rupture velocity, slip-velocity function) that is assumed *a priori*. Such kinematic source models may not be physically realizable as a self-sustaining fault rupture. In order to make near-field ground motion simulations more accurate, we have developed a procedure to generate physically consistent earthquake rupture models. This so-called *pseudo-dynamic* source characterization constitutes inherently kinematic rupture models that are designed to emulate important characteristics of fully dynamic rupture models through a series of empirical relationships derived from the analysis of a set of spontaneous rupture models.
We construct pseudo-dynamic models by first generating a slip distribution using a spatial random-field model that is consistent in its overall scaling and spatial variability with slip distributions observed in past earthquakes [*Mai and Beroza*, 2000; 2002]. We then compute the static stress drop $\Delta\sigma$ associated with this slip distribution [*Andrews*, 1980], which is then used to calculate the local rupture velocity through empirical relations between stress drop $\Delta\sigma$, fracture energy G_c and crack length L_c [*Andrews*, 1976; *Guatteri et al*, 2003]. An equivalent approach is used to simulate the distribution of rise time over the fault and the parameters describing the slip-velocity function. A simple energy-budget calculation is used to discard source models that would not be realizable as spontaneous ruptures.
Our pseudo-dynamic source characterization reproduces the important features of dynamic rupture without full dynamic simulations, and hence circumvents the limits imposed by the computational demand of dynamic rupture modelling for multiple scenario earthquakes. While the relationships between source parameters described in this paper are significant simplifications of the true complexity of the physics of the rupture process, they help identify important relationships between source properties that are relevant for strong ground motion prediction.

S42F-05 1450h INVITED

Strong Motion Network as Infrastructure

Shin Aoi[1] (+81-29-863-7668; aoi@bosai.go.jp)

Takashi Kunugi[1] (kunugi@bosai.go.jp)

Hiroyuki Fujiwara[1] (fujiwara@bosai.go.jp)

[1]National Research Institute for Earth Science and Disaster Prevention, 3-1 Tennodai, Tsukuba, Ibaraki 305-0006, Japan

After the 1995 Hyogoken-Nanbu earthquake, NIED (National Research Institute for Earth Science and Disaster Prevention) installed the K-NET that uniformly covers all Japan with more than one thousand strong-motion accelerometers on the ground surface. In addition to the K-NET, NIED constructed uphole/downhole observation network, KiK-net, with approximately 660 stations. Each KiK-net station has a borehole of 100m or more in depth and strong-motion seismographs have been installed both on the ground surface and at the bottom of the boreholes. The velocity profiles and geological information are widely accessible on the website as well as the observed records. We are coming into an era where we can obtain the data immediately when the earthquakes occur, as we are able to obtain water in every house by just turning on a water faucet. These networks recorded strong-motion waveforms near the source-region. In fact, for most of large inland earthquakes, strong motion records were obtained within 15 km of epicenter and largely contributed to investigating both source processes and ground motion characteristics. For example, approximately 800 stations were triggered by the 2003 Off-Miyagi earthquake (Mw 7.0), an intra-slab earthquake that occurred at 70 km deep. At three stations, PGA (peak ground acceleration) exceeded 1g (980 gal). During the crustal earthquake in July of 2003 at Miyagi prefecture, the other governmental seismograph network for measuring seismic intensity recorded more than 1.5 - 2g at very near-fault stations. The dense network showed that the large accelerations were not accidental phenomena, although they were observed at spatially limited area. When the observation is sparse, it is difficult to judge whether the large ground motions are caused just by locally special situation like the effects of topography and fill-up ground or not. Accumulation of the near-source strong-motion data is very important for evaluating the ground-motion both for the past and future earthquakes.

URL: http://www.k-net.bosai.go.jp/

S42F-06 1510h

Simulation of Broadband Time Histories Combining Deterministic and Stochastic Methodologies

Robert W. Graves[1] (626-449-7650; robert_graves@urscorp.com)

Arben Pitarka[1] (arben_pitarka@urscorp.com)

[1]URS Corporation, 566 El Dorado Street, Pasadena, CA 91101, United States

We present a methodology for generating broadband (0 - 10 Hz) ground motion time histories using a hybrid technique that combines a stochastic approach at high frequencies with a deterministic approach at low frequencies. Currently, the methodology is being developed for moderate and larger crustal earthquakes, although the technique can theoretically be applied to other classes of events as well. The broadband response is obtained by summing the separate responses in the time domain using matched butterworth filters centered at 1 Hz. We use a kinematic description of fault rupture, incorporating spatial heterogeneity in slip, rupture velocity and rise time by discretizing an extended finite-fault into a number of smaller subfaults. The stochastic approach sums the response for each subfault assuming a random phase, an omega-squared source spectrum and simplified Green's functions (Boore, 1983). Gross impedance effects are incorporated using quarter wavelength theory (Boore and Joyner, 1997) to bring the response to a generic baserock level (e.g., V_S = 1000 m/s). The deterministic approach sums the response for many point sources distributed across each subfault. Wave propagation is modeled using a 3D viscoelastic finite difference algorithm with the minimum shear wave velocity set at 620 m/s. Short- and mid-period amplification factors provided by Borcherdt (1994) are used to develop frequency dependent site amplification functions. The amplification functions are applied to the stochastic and determinsitic responses separately since these may have different (computational) reference site velocities. The site velocity is taken as the measured or estimated value of $V_S{}^{30}$. The use of these amplification factors is attractive because they account for non-linear response by considering the input acceleration level. We note that although these design factors are strictly defined for response spectra, we have applied them to the Fourier amplitude spectra of our simulated time histories. This process appears to be justified since the amplification functions vary slowly with frequency and the method produces favorable comparisons with observed broadband motions. We have tested the methodology using ground motion recordings of the Northridge and Loma Prieta earthquakes.

S42F-07 1525h

The Effects of 3D Structure and Finite Sources on Ground Motion in the Yanhuai Basin

Haijiang Wang[1] (+49 (0) 89 2180 4220; haijiang@geophysik.uni-muenchen.de)

Heiner Igel[1] (+49 (0) 89 2180 4204; igel@geophysik.uni-muenchen.de)

Guoquan Wang[1] (+49 (0) 89 2180 4207; wang@geophysik.uni-muenchen.de)

[1]Theresien str 41, Institute for Geophysics. LMU, Munich 80333, Germany

Three dimensional finite difference earthquake scenarios from finite faults are compared with those from a point source for the 1792, Mw 6.75 Shacheng Earthquake, Beijing area, with different velocity models – homogeneous, layered, and heterogeneous. The goal is to separate the effects of fault dimension and heterogeneity on the ground motion and shaking hazard in the study region. The kinematic finite source model is a traditional one (Hartzell, 1978), in which the rupture initiates at the hypocenter of the fault plane and propagates radially. The velocity of this propagation is assumed to be about 80 percent of the shear wave velocity. From the magnitude we can derive the geometrical parameters of the finite fault plane, assumming the shape of the fault is rectangular. Then the fault plane is divided into elements. Each element is treated as a separate point source. The scalar moments of these elements are assigned randomly with the summation equal to the total moment of the point source. We use the same gauss function for these separate elements as for the point case, with the rise time relative to the length and the rupture propagation velocity. Our comparisons are in terms of the velocity and rotation seismograms, the PGV (peak ground velocity), the PGR (peak ground rotation), the shaking duration distribution and response spectrum of velocity. Generally it is observed that the attenuation rate (both of PGV and PGR) at the area of hanging wall is higher than on the opposite side. Further preliminary findings point to (1) enhanced near-fault ground motion in the finite-fault case and (2) complex interaction between the finite fault radiation and the 3D heterogeneity.

URL: http://woerth.geophysik.uni-muenchen.de/~haijiang/abstract.pdf

S42G MCC: 3011 Thursday 1340h

New Views of Seismic Hazard in Cascadia I *(joint with G, T, V)*

Presiding: **G A Ichinose,** URS Corporation**; H Kao,** Geological Survey of Canada

S42G-01 1340h

The north Cascadia Episodic Tremor and Slip (ETS) Event of February and March 2003

Garry Rogers[1] (250 363 6500; rogers@pgc.nrcan.gc.ca)

Herb Dragert[1] (250 363 6500; dragert@pgc.nrcan.gc.ca)

John Cassidy[1] (250 363 6500; cassidy@pgc.nrcan.gc.ca)

Honn Kao[1] (250 363 6500; kao@pgc.nrcan.gc.ca)

[1]Geological Survey of Canada, Pacific Geoscience Centre, P.O. Box 6000, Sidney, BC V8L 4B2, Canada

Repeated slip has been detected on the deep interface of the northern Cascadia subduction zone by observing surface deformation on a network of continuous Global Positioning System sites. These slip events have now been found to have, accompanying tremor-like, non-earthquake, seismic signatures. The tremor is mainly shear wave energy concentrated in a bandwidth of 1-5Hz. We refer to this associated tremor and slip phenomena as Episodic Tremor and Slip (ETS). From the regular 13 to 16 month recurrence times of the previous five ETS events identified beneath southern Vancouver Island since 1996, an ETS event was expected in the region early in 2003. The seismograph and GPS networks operated by the Geological Survey of Canada were supplemented with additional stations to ensure that the seismic and deformation signature of the expected ETS event were well recorded. The first ETS tremors started on February 25 just south of Victoria, British Columbia in the region of the International border. Within a few days, slip was confirmed by southwest displacements at continuous GPS stations in the vicinity of Victoria. The source locations of tremor and slip migrated northwest about 150 km, traversing the southern third of Vancouver Island. The last tremor signal of the sequence was detected on March 26. Tremors emanated from a region on, or very close to, the subduction interface between the two lithospheric plates. They were confined to a band about 50km wide, consistent with the region of the modelled slip, just down dip from the proposed locked zone on the subduction interface.

S42G-02 1355h

Temporal and Spatial Distribution of the Tremors in the Episodic Tremor and Slip (ETS) Event Observed Beneath the Northern Cascadia Subduction Zone in Early 2003

Honn Kao[1] (250-363-6625; hkao@nrcan.gc.ca)

Shao-Ju Shan[1] (sjshan@shaw.ca)

Garry Rogers[1] (grogers@nrcan.gc.ca)

John F. Cassidy[1] (jcassidy@nrcan.gc.ca)

Herb Dragert[1] (hdragert@nrcan.gc.ca)

[1]Geological Survey of Canada, Pacific Geoscience Centre, 9860 West Saanich Road, Sidney, BC V8L4B2, Canada

The tremors associated with the most recent ETS event observed along the northern Cascadia margin were recorded in the greatest detail to date, by a combination of stations from CNSN, POLARIS, and the deployment of a temporal broadband seismic network in the region. Because no clear arrivals of P or S phases can be identified, we develop a method, called "source-scanning", to locate the tremors and to image their source distribution in both time and space. The algorithm systematically examined three-component continuous digital waveforms (from late February to late March, 2003) recorded at 25 broadband seismic stations (spacing at an interval of about 10 km) and identified more than 1600 tremor events with sufficient waveform quality to give coherent patterns of source configuration. The identified events span a width of about 50 km beneath the southern portion of the Vancouver Island and north Washington State. Events to the west generally have source depths shallower than those to the east. When projected onto a cross section perpendicular to the trench axis, the majority of tremors occurred in the vicinity of the inferred plate interface between the subducted Juan de Fuca plate and the overriding North America plate. However, they tend to distribute within a zone of over 10-15 km thick rather than along a plane. The images of many tremor sources show elongated shapes shallowly dipping toward the east, consistent with the geometric configuration of the interplate thrust zone. We hypothesize that the ETS events are the manifestation of the rheological/mechanical behavior along or immediately above the deep portion of the plate interface.

S42G-03 1410h

Duration and Extent of the 2003 Cascadia Slow Earthquake

Timothy Melbourne[1] (5099632799; tim@geophysics.cwu.edu)

Meghan Miller[1] (5099632825; meghan@geology.cwu.edu)

V. Marcelo Santillan[1] (5099631107; marcelo@geology.cwu.edu)

William Sumner[1] (5099632828; sumner@geology.cwu.edu)

Walter Szeliga[1] (5099631071; walter@geology.cwu.edu)

[1]Dept. of Geological Sciences, Central Washington University, Ellensburg, WA 98926, United States

Time-dependent inversion of continuous GPS measurements that capture the 2003 Cascadia slow earthquake, for which the most spatially dense observations to date are available, shows this to be the largest of 9 transients recognized to date in the Pacific Northwest and demonstrates that neither initiation nor propagation are confined specifically to the Juan de Fuca arch. The 2003 slow transient nucleated in early January of 2002 beneath the southern Puget Basin, a region south of all previously recognized transients. By March of 2003, rupture had propagated bi-laterally 250 km to the south and north, reaching as far as the Oregon border to the south and British Columbia, Canada to the north. In total it is recognized on 12 continuous geodetic-grade GPS stations that together form a spatially coherent, N-S propagating pattern of transient reversal from secular fore-arc-normal compression to extension. The total duration and along-strike extent of this event are three months and 500 km, respectively. The great spatial extent of this event, in conjunction with deep tremor correlated with the onset of slow faulting, suggests a high level of fluid permeability over great distances along the critically held deeper Cascadia interface. Moreover, faulting in southernmost Washington state suggests that the dearth of similar transients reported across the remainder of Cascadia reflect more a lack of sufficient instrumentation than a genuine lack of transients. EarthScope will remedy this situation in the near future.

URL: http://www.geodesy.cwu.edu/

S42G-04 1425h

Evidence for Cascadia- Wide Rupture of Episodic Slow Earthquakes

Walter M Szeliga (walter@geology.cwu.edu)

Timothy I Melbourne (tim@geology.cwu.edu)

M Meghan Miller (meghan@geology.cwu.edu)

V. Marcelo Santillan (marcelo@geology.cwu.edu)

W Sumner (sumner@geology.cwu.edu)

Slow faulting events recently recognized along convergent margins globally are now understood to constitute a fundamental mode of significant moment release that can both trigger and be triggered by seismogenic rupture. In the Pacific Northwest, continuous GPS has detected nine slow earthquakes occurring at 14.5±1 month intervals within the northern Cascadia plate interface (Dragert et al, 2001; Miller et al, 2002) accompanied by harmonic tremor notably absent when slow earthquakes are not occurring (Rogers and Dragert, 2003; Obara, 2002). To date no observations of Cascadia slow events have been made outside of the northern Puget basin, suggesting that this region, characterized by a unique bend in the Juan de Fuca plate, is somehow conducive to slow slip. However, spatial and temporal filtering of continuous GPS time series from Northern California and Central Oregon indicates that episodic slow earthquakes do indeed occur here, and by extension, possibly throughout Cascadia. Evidence of six transient slip events are visible on data from permanent GPS stations in Northernmost California during a time period from 1997 to the present. Station YBHB indicates an episodic slow earthquake recurrence interval of 10.8 months, 75% of the 14.5 month interval calculated for stations in the northern Puget Sound. Evidence of episodic slow event is also displayed by the time series of stations in Central Oregon. During one three-month window beginning in November of 2001, transient slip emerged in succession beneath Northern California, southern Oregon, northern Washington and southwestern British Columbia, a total range of over 1000 km. However, a (current) dearth of continuous GPS data for western Oregon preclude the conclusion that this is one event. Together, these transients demonstrate that slow slip events are not confined to the Juan de Fuca arch. Among other issues, this observation has implications with regards to possible along-strike segmentation of seismogenic rupture characteristics for the deeper Cascadia interface.

S42G-05 1440h

Effects of Crustal Densification in Warm Slabs on In-slab Earthquakes and Episodic Tremors and Slips

Kelin Wang[1,2] (250-363-6429; wang@pgc.nrcan.gc.ca)

[1]Geological Survey of Canada, Pacific Geoscience Centre, 9860 W Saanich Rd, Sidney, BC, V8L 4B2, Canada

[2]School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, V8W 3P6, Canada

During subduction, dehydration may facilitate earthquake rupture in both the slab crust and slab mantle. The up to 15% rock densification that accompanies the metabasalt-eclogite transformation is expected to have several mechanical consequences. In warm slabs such as Cascadia and Nankai, this transformation and mantle serpentine breakdown begin at rather shallow depths (30 - 50 km). The pervasively hydrated upper crust transforms to eclogite under equilibrium conditions, but the transformation of the anhydrous parts of the lower crust is kinetically delayed to greater depths. Therefore, densification begins in a thin layer along the top of the slab. Volume reduction gives rise to an equivalent stretching force in the thin layer in all slab-parallel directions, activating existing faults and developing new fractures. Analogous to a weak layer sandwiched between, and bonded to, two strong layers under stretching, fracture spacing in the weak layer scales with the layer thickness. The theory predicts that the densified thin layer must be !0 shattered !1 . The shattered upper crust may have numerous small earthquakes but does not favor large ruptures. In contrast, the much more uniform lower crust and mantle can host larger ruptures, although seismic ruptures occur only in the limited hydrated parts. This explains the observation that relatively few earthquakes deeper inside the slab tend to have larger magnitudes than those just below the slab surface. For example, three recent damaging events (1999 Oaxaca, Mexico; 2001 Geiyo, Nankai; 2001 Nisqually, Cascadia) in warm slabs all occurred in the lower crust or mantle. The densification is generally a steady state process: An increasingly thinner slab moves into an increasingly thinner subduction "slot" continuously, with the downdip width of transition from normal to thinned crust scaling linearly with the subduction rate. However, at the fracture scale, the process is highly nonlinear, and there must be small fluctuations due to mechanical and kinetic irregularities. Readjustments of high-fluid-pressure rocks in and above the shattered subducting crust in responses to such densification fluctuations may be responsible for episodic lower-frequency tremors recorded at the Cascadia and Nankai subduction zones. Transient modifications of slab-surface topography and roughness in the same process may trigger silent slips along the plate interface.

S42G-06 1455h INVITED

Structure of the Northern Cascadia Subduction Zone

Todd A Nicholson[1] (tnicholson@eos.ubc.ca)

Michael G Bostock[1] (bostock@geop.ubc.ca)

John F Cassidy[2]

[1]Department of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver, BC V6T 1Z4, Canada

[2]Pacific Geoscience Centre, Geological Survey of Canada, Box 6000, Sidney, BC V8L 4B2, Canada

As part of the POLARIS (Portable Observatories for Lithospheric Analysis and Research Investigating Seismicity - www.polarisnet.ca) project, we have initiated a broadband seismic experiment across southwestern British Columbia and northwestern Washington. The objective of this work is to better understand the structure of the subducting plate and mantle wedge in northern Cascadia, and its relation to intra-slab (Wadati-Benioff) seismicity. There are currently 30 broadband stations extending across southern Vancouver Island, the Gulf and San Juan Islands, Watcom county and the British Columbia lower mainland in an approximately linear array. We have employed the P-wave coda from 28 teleseismic events recorded on this array in a formal inversion to image fine-scale shear-velocity structure. Preliminary results indicate a structure very similar to that identified across a comparable profile in Oregon. The continental Moho is evident at the eastern end of the profile near 30 km depth but disappears towards the Georgia Strait/Puget sound. Farther west, a horizontal boundary at a similar depth with an "inverted" shear-velocity contrast appears and persists to its projected intersection with the subducting plate. The oceanic crust is clearly evident below southern Vancouver Island as a dipping low-velocity zone but its signature diminishes at depths below 45 km. As for Oregon, we interpret these observations to signal the presence of a serpentinized forearc mantle hydrated, in part, through eclogitization of oceanic crust.

S42G-07 1510h INVITED

Reflections on the Cascadia Slab: Dehydration and Intraslab Earthquakes

Leiph Preston[1] ((206) 543-6626; preston@ess.washington.edu)

Kenneth Creager[1] ((206) 685-2803; kcc@ess.washington.edu)

Robert Crosson[1] ((206) 543-6505; bob@ess.washington.edu)

[1]University of Washington, Dept. of Earth and Space Sciences Box 351310, Seattle, WA 98195, United States

We observe strong wide-angle reflections consistent in time and slowness with reflections off the subducting Juan de Fuca plate from data collected during the 1998 onshore-offshore active-source SHIPS experiment conducted within the inland waterways of NW Washington and SW British Columbia. The times of 1200 reflected waves as well as 120,000 direct waves from both earthquakes and active sources are used in a nonlinear iterative inversion scheme that simultaneously inverts for earthquake locations, smooth 3-D P-wave velocity structure and smooth reflector geometry. The well known trade-off between reflector depth and velocity structure is greatly reduced in our analysis by the combination of simultaneous inversion and high-quality data with adequate crossing paths. We interpret the reflector to be the Moho of the subducting Juan de Fuca plate. The intraslab earthquakes separate into two groups. Those that lie up-dip of the 45km depth contour of the Moho occur below the reflector in material whose velocity exceeds 7.7km/s, placing them within the subducted mantle. Those downdip of this contour occur primarily above the reflector in places where velocities are 6.8-7.5km/s, consistent with them occurring within the subducted crust. We suggest that the intraslab earthquakes result from dehydration embrittlement. The first group is consistent with serpentine dehydration within the subducted mantle, while the second group is consistent with the onset of the basalt to eclogite transformation within the crust which, for Cascadia, is expected to begin at about 40 km depth. If intraslab earthquakes were confined only to the oceanic crust, this would geometrically limit them to about M7. Indeed, the largest intraslab events in Cascadia, such as the 2001 M6.8 Nisqually event, are near this limit. Although no reflections are observed in the vicinity of these large events, wave speeds suggest they nucleate near the subducted Moho. In Cascadia the presence of both subducted mantle and crustal intraslab earthquakes geometrically allows the possibility of significantly larger events. Additionally, the large amplitude of the reflected arrivals relative to direct arrivals suggest that wide-angle slab reflections should be included in strong ground motion calculations from megathrust events. The release of fluids attendant with the basalt to eclogite transformation have observable consequences which may be related to recent discoveries of slow slip events, tremor events, and a serpentinized mantle wedge.

S42G-08 1525h

Rupture process and near-source shaking from the 1965 Seattle-Tacoma and 2001 Nisqually intraslab earthquakes

Gene A Ichinose[1] (626-449-7650; gene_ichinose@urscorp.com)

Paul G Somerville[1] (paul_somerville@urscorp.com)

Hong Kie Thio[1] (hong_kie_thio@urscorp.com)

[1]URS Corporation, 566 El Dorado St. 2nd Floor, Pasadena, CA 91101-2560, United States

The 2001 Nisqually intraslab earthquake produced moderate levels of ground motions below 30% g within the Puget Sound yet caused widespread damage and temporary disruption to buildings and transportation

lifelines. The frequency of intraslab earthquakes (1949 M 7.1, 1965 M_w6.7, and 2001 M_w6.8) makes it important in understanding as much as possible about the source characteristics so that the hazards can be more reliably quantified. We inverted 0.05 to 0.5 Hz strong ground motion, teleseismic, and geodetic data for the 2001 Nisqually earthquake to obtain a variable slip and rake model using the multiple time window method and Green's functions calculated from a regionally calibrated 1-D velocity model. The earthquake has a 12 km^2 sized asperity between 59 and 62 km depth with an average slip of 1.5 m ($M_o = 1.59 \times 10^{26} dyne \times cm$; M_w 6.74). We also inverted teleseismic P- and SH-waves digitized from WWSSN film records for the 1965 Seattle Tacoma earthquake slip and rake model. There are two asperities with areas of 4 and 8 km^2 near the hypocenter. Average slip for these asperities were 2 and 2.8 m ($M_o = 9.43 \times 10^{25} dyne \times cm$; M_w 6.63). Simulating near-source strong ground motions from historical and modern earthquake slip models adds more realism not possible with random or stochastic scenarios. We used a time domain approach to generate PGA and S_a shake-maps for the 1965 and 2001 earthquakes. These shake-maps included the spatial and temporal evolution of slip estimated from the multiple time window inversion of seismic and geodetic data. We added a Kostrov source time function to improve the ground motion spectra at higher frequencies. The shake maps also included site and basin depth corrections based on California geology. The corrections helped reduce the bias in residuals between observed and simulated PGA and Sa but corrections that are more specific to the Puget Sound are needed to reduce the scatter. The patterns of strong ground shaking from the 1965 Seattle-Tacoma earthquake were very different from the 2001 Nisqually earthquake. Strong shaking in urban Seattle by the 1965 earthquake was twice as high (60% g) than by the 2001 earthquake. While retrofitting efforts help limit damages by the 2001 Nisqually earthquake, a future earthquake closer to urban Seattle or larger in magnitude may cause more widespread damage and disruption.

S42H MCC: 3009 Thursday 1600h

Strong Ground Motion Prediction II

Presiding: **H Kawase,** Kyushu University**; B Aagaard,** U.S. Geological Survey

S42H-01 1600h

Effect of Surface Geology on Ground Motions: The Case of Chutzuhu Site (TAP056)

Kuo-Liang Wen[1] (886-3-4227151#5621; wenkl@earth.ncu.edu.tw)

Tao-Ming Chang[2] (886-3-4227151#5652; taoming@s319m.gep.ncu.edu.tw)

Chung-Hsiang Mou[3] (886-3-4227151#5652; serene.mou@yahoo.com.tw)

[1]1. Institute of Geophysics, National Central University, Taiwan, N300, Jung-da Rd, Jung-li, Taoyuan 320, Taiwan

[2]Dept. of Information Management, Hsing Wu College, Taiwan, Linko, Taoyuan 320, Taiwan

[3]3. Institute of Applied Geology, National Central University, Taiwan, N300, Jung-da Rd, Jung-li, Taoyuan 320, Taiwan

Both the two strong motion stations, TAP056 and TAP066, are located in the Yang Ming Shan area. These two stations are not far away, belong to TSMIP strong motion network, and operated by Central Weather Bureau, Taiwan. TAP056 triggered by earthquakes very often, but not for station TAP066. Compared the peak ground accelerations (PGA) recorded at vertical and horizontal components of the station TAP056 are about 3.6 and 9.6 times larger than that of the station TAP066. Most the amplitude spectra recorded at TAP056 have the same response no matter where the earthquakes occurred, but that at TAP066 are different for near-field and far-field events. It shows that local site effects at station TAP056 dominated the spectra shape. From the spectral ratios of TAP056/TAAP066, P-wave potion at vertical component amplified at around 16 Hz and S-wave potion at the horizontal component amplified at 8 10 Hz. After the velocity structure survey and numerical simulation, we can confirm the top soft soil layer dominated the local site response at station TAP056.

S42H-02 1615h

A Quantitative Evaluation of SCEC Community Velocity Model Version 3.0

Po Chen[1] (213-821-2370; pochen@usc.edu)

Li Zhao[1] (zhaol@usc.edu)

Thomas H. Jordan[1] (tjordan@usc.edu)

[1]Department of Earth Sciences, University of Southern California, Los Angeles, CA 90089, United States

We present a systematic methodology for evaluating and improving 3D seismic velocity models using broadband waveform data from regional earthquakes. The operator that maps a synthetic waveform into an observed waveform is expressed in the Rytov form $D(\omega) = \exp[i\omega\delta\tau_p(\omega) - \omega\delta\tau_q(\omega)]$. We measure the phase delay time $\delta\tau_p(\omega)$ and the amplitude reduction time $\delta\tau_q(\omega)$ as a function of frequency ω using Gee & Jordan's [1992] isolation-filter technique, and we correct the data for frequency-dependent interference and frequency-independent source statics. We have applied this procedure to a set of small events in Southern California. Synthetic seismograms were computed using three types of velocity models: the 1D Standard Southern California Crustal Model (SoCaL) [Dreger & Helmberger, 1993], the 3D SCEC Community Velocity Model, Version 3.0 (CVM3.0) [Magistrale et al., 2000], and a set of path-averaged 1D models (A1D) extracted from CVM3.0 by horizontally averaging wave slownesses along source-receiver paths. The 3D synthetics were computed using K. Olsen's finite difference code. More than 1000 measurements were made on both P and S waveforms at frequencies ranging from 0.2 to 1 Hz. Overall, the 3D model provided a substantially better fit to the waveform data than either laterally homogeneous or path-dependent 1D models. Relative to SoCaL, CVM3.0 provided a variance reduction of about 64% in $\delta\tau_p$, and 41% in $\delta\tau_q$. Relative to A1D, the variance reduction is about 46% and 20%, respectively. The same set of measurements can be employed to invert for both seismic source properties and seismic velocity structures. Fully numerical methods are being developed to compute the Fréchet kernels for these measurements [L. Zhao et. al., this meeting]. This methodology thus provides a unified framework for regional studies of seismic sources and Earth structure in Southern California and elsewhere.

S42H-03 1630h

Through Thick and Thin: The Effect of Sediment Deposits on Central US Ground-motion Predictions

Chris H. Cramer (901-678-4992; ccramer@memphis.edu)

U.S. Geological Survey, 3890 Central Ave, Memphis, TN 38152-3050

Local geology and the presence of soils affects the frequency content, amplitude, and duration of ground shaking, and thus also seismic hazard estimates (both scenario and probabilistic). As part of the U.S. Geological Survey's (USGS) efforts to produce state-of-the-art seismic hazard maps in the central US (CUS), techniques have been developed for estimating site amplification distributions from local and regional 3D geological and geophysicsical observations (Gomberg et al., 2003; Cramer, 2003). The estimation of site amplification distributions as a function of input rock ground motion has been completed for the Memphis, TN urban area and is underway for the upper Mississippi embayment. These distributions are used to incorporate the effect of site geology into the USGS national seismic hazard maps for these regions. They also are being incorporated into CUS ShakeMaps and to analyses of seismograms at ANSS sites. Overall uncertainty and sensitivity of site amplification estimates to input data are also being investigated. For the 1 km thick sediments in the Memphis area, the overall standard deviation (sd) varies from 28% to 52%, depending on the input peak ground acceleration (pga) (0.05 - 1.0g). The largest contribution comes from the ground motion variability in the 16 M7-8 seismograms at rock sites that are scaled and used as input ground motions at the base of the soil column (max. sd of 36%). The next largest contributor is the uncertainty in the soil profiles (mostly in shear-wave velocity) derived from a 3D geological model (max. sd of 27%). The third largest contributor is the uncertainty in the dynamic properties of the soils (max. sd of 17%). The effect of equivalent-linear versus non-linear estimates of soil amplification at high frequencies is also being investigated.

S42H-04 1645h

Site Amplification Characteristics and Their Relationship with Averaged S-wave Velocities Derived From K-NET and KiK-Net Strong Motion Records in Japan

Hiroshi Kawase[1] (81-92-642-3331; kawase@arch.kyushu-u.ac.jp)

Hidenori Matsuo[2] (81-3-3763-1111; matsuo@seis.arch.kyushu-u.ac.jp)

[1]Kyushu Univeristy, 6-10-1 Hakozaki, Higashi-ku, Fukuoka 812-8581, Japan

[2]Hitachi Systems and Services, 3-2-16 Ohmori-kita, Ohta-ku, Tokyo 143-8545, Japan

To predict strong ground motions for future scenario earthquake in a broad-band frequency, we need to characterize both source spectra and site amplification. For high frequency we can use statistical method based on the observed records and the summation technique. Thanks to the advent of the K-Net and KiK-net (by NIED) in Japan, we have now plenty of weak motion data, enough to construct statistical Green's functions. In order to represent long- and intermediate period nature of the strong ground motion in the near field region, we want to use theoretical technique such as three-dimensional finite difference method. Any theoretical methods need S-wave velocity structures that should reproduce the observed site amplification quantitatively. In this study we perform first the analysis to separate the so-called source spectra, attenuation coefficient, and the site amplification factors from about 15,000 K-NET, KiK-Net, and JMA records observed at 1,700 stations in Japan. The separation method is the well-established one of Andrews (1980) and the resultant source spectra are modeled as omega-square spectra. As a reference site we use one rock station of KiK-Net in Yamaguchi Prefecture, from which we remove amplification of shallow surface deposits. Once we obtain site amplification factors, we try to reproduce them by using one-dimensional S-wave velocity structures below each site of K-NET and KiK-Net (in total, 1,300). We use Genetic Algorithm to invert the S-wave structures with fixed S-wave velocities in the shallow part. We succeed to reproduce site amplification factors at about one thirds of the sites very well. The majority of not-so-good sites need modification of S-wave velocities in the shallow part based on logging data. We also perform the same kind of separation analysis for PGA, PGV, and JMA Seismic Intensity. We found that PGA site factors correlate best with 5.0 Hz spectral amplification and PGV 2.5 Hz spectral amplification. We also found that the best correlation of site factors can be obtained with the average S wave velocity only for top 5 m for PGA and 10 m to 20 m for PGV. Since we have a space for better representation of velocity structures, the results reported here are not conclusive. Once we get better S-wave velocity structures at as many sites as possible, we expect to extrapolate them and construct an initial model of the three-dimensional basin structure of the whole Japanese islands.

S42H-05 1700h

A Transect of 200 Shallow Shear-Velocity Profiles Across the Los Angeles Basin

Weston A. Thelen[1] (wethelen@seismo.unr.edu); Matthew Clark[1] (mclark@seismo.unr.edu); Christopher Lopez[2] (ctlopez@unr.edu); Chris Loughner[1] (loughner@seismo.unr.edu); Hyunmee Park[2] (hpark@unr.edu); Jim B. Scott[1] (jscott@seismo.unr.edu); Shane B. Smith[2] (sbsmith@unr.edu); Bob Greschke[3] (passcal@passcal.nmt.edu); John N. Louie[1] (775-784-4219; louie@seismo.unr.edu)

[1]Nevada Seismological Lab, Mackay School of Mines, University of Nevada 174, Reno, NV 89557, United States

[2]Dept. of Geological Sciences, Mackay School of Mines, University of Nevada 172, Reno, NV 89557, United States

[3]IRIS-PASSCAL Instrument Center, New Mexico Tech, 100 East Road, Socorro, NM 87801, United States

In July 2003 we evaluated a 60 km transect for shallow shear wave velocities along the San Gabriel River, in the San Gabriel Valley and Los Angeles Basin of southern California. The purpose of the experiment was to evaluate spatial variability of earthquake shaking hazard, and any velocity correlations to mapped geological and soil units. We recorded urban microtremor on 300-m linear arrays, analyzing Rayleigh-wave dispersion curves to forward-model 200 shallow shear-velocity profiles to depths exceeding 100 m. Each 300-m array had 15 seismometers at 20-m intervals. We used IRIS/PASSCAL "Texan" single-channel recorders