Geotechnical Engineering Seminar
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Temporal changes, high-frequency bursts, and strong ground motion

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ABSTRACT:
Active fault zones and the Earth's near-surface layers contain highly damaged materials with intense fractures and micro-cracks. A better quantification of wave propagation and temporal changes in these damaged layers is important for better understanding of various aspects of earthquake physics and predicting strong ground motion caused by large earthquakes. Recent studies based on repeated active sources (e.g., Vidale and Li, 2003) and repeating earthquakes (e.g., Rubinstein and Beroza, 2004, 2005; Peng and Ben-Zion, 2006) have found clear reduction of seismic velocities in the shallow crust associated with large earthquakes (M>=6), followed by logarithmic recovery. However, the resolution of observed temporal changes is limited by the inadequate sampling of the repeated source, especially at times immediately after the mainshock. Here I show some preliminary results from two recent studies on temporal changes of material properties using regular earthquakes, which are briefly summarized as follows: Based on the spectra ratio of strong motions recorded by stations on and off the Karadere segment of the north Anatolian fault, Wu et al. (2008) found 20-40% co-seismic reductions of seismic velocities inside the damaged fault zone, followed by near-complete recovery within ~1 day after the 1999 Mw7.1 Duzce earthquake. The observed temporal changes of FZ site response could be explained by opening of pre-existing cracks inside the FZ due to strong ground motion, followed by a fast logarithmic recovery. Analysis of surface-reflected shear waves from similar earthquakes around the rupture zone of the 1999, M6.4, Chia-Yi, Taiwan, earthquake shows that seismic velocities for both fast and slow shear waves decreases by 3-5% in the top 200 m of the crust at the time of the event, followed by logarithmic recovery with a time scale of 1-2 yrs (Chao and Peng, 2007). However, the P wave velocity and shear wave anisotropy remains essentially unchanged during the entire period. The observations could be explained by opening of fluid-filled microcracks in the shallow crust with no preferred orientation due to the strong shaking of the Chia-Yi mainshock. In the third study (Fischer et al., 2008b), we identify bursts of high-frequency signals recorded by the USGS Parkfield Dense Seismograph Array (UPSAR) that occur only during strong shaking from the 2004 Mw6 Parkfield, California, earthquake and its immediate aftershocks. Because there is no correlation between these high-frequency bursts observed at closely spaced stations, we hypothesize that they are associated with dynamically triggered events occurring within a few tens of meters of the stations in the highly fractured shallow crust. The triggering threshold was found to be ~0.01 MPa, consistent with a previous estimate based on a similar analysis of high-frequency bursts observed in strong motion data from the 1999 Chi-Chi earthquake in Taiwan (Fischer et al., 2008a). The consistent observation of high-frequency bursts at both Parkfield and Taiwan suggest that they may be a common phenomenon associated with strong motion in the very shallow crust.

BIO:
Dr. Zhigang Peng is an Assistant Professor in the School of Earth and Atmospheric Sciences at Georgia Tech. He received his PhD in Geological Sciences from USC, his MS in Electrical Sciences from USC, and his BS in Geophysics and Computer Applications in the University of Science and Technology of China, Hefei, China. His current research interests are high resolution imaging of fault zone structures, earthquake source properties and seismicity parameters, and Earth's deep interior, based on systematic analysis of large seismic data sets.