High-resolution seismic imaging of the very shallow crust

Report for SCEC Award in 2016

Principal Investigator
Yehuda Ben-Zion
Department of Earth Sciences
University of Southern California
Phone: (213) 740-6734, Fax: (213) 740-8801
E-mail: *benzion@usc.edu*

***Proposal Categories*:**
Integration and Theory

SCEC Science Objectives:
4b, 6a, 6c, 4a

Proposal period: February 1, 2016 – January 31, 2017

Summary

We performed detailed imaging of seismic velocities, attenuation and anisotropy in the shallow crust within and around the San Jacinto Fault Zone (SJFZ) using data recorded by dense linear and rectangular fault zone arrays. The studies are associated with a newly developed technique using focal spots of surface waves associated with the zero lag amplitudes of noise cross-correlations computed between different stations. The results reveal very low seismic velocities and attenuation coefficients in the top few hundred m of the crust, along with clear variations of properties across the fault and a shallow trapping structure adjacent to a mapped surface trace of the Clark fault in the trifurcation area. Figure 1 provide example imaging results based on the rectangular fault zone array. In addition, we analyzed random errors in cross-correlations of ambient seismic noise in the frequency domain and estimate confidence interval of stacked cross-spectrum of finite amount of data at different frequencies The technique is applied to constrain values and uncertainties of amplitude and phase velocity of stacked noise cross-spectrum at different frequencies, using data from southern California at both regional scale and dense linear array across the SJFZ. Finally, we developed and implemented a new technique for estimating deviations from a fully diffuse random noise field by analyzing cross-frequency correlations in stations of the regional southern California network.

Intellectual Merit

The obtained very low values of seismic velocities and attenuation coefficients in the top few hundred m of the crust can affect significantly seismic ground motion. The asymmetry of seismic properties across the fault suggests preferred propagation direction of earthquake ruptures in the area to the NW. These results may be used for improved understanding of earthquake physics and seismic shaking hazard. The project led to the development of a new technique for high resolution imaging of seismic properties based on dense array data, an improved method for estimating errors in noise cross correlation imaging, and a new method for estimating deviations from fully diffuse noise field. The techniques allow better characterization of the ambient noise field, and may be used to derive high resolution results in other locations.

Broader impact

The project supported directly one PhD student and contributed to the education of one postdoctoral fellow and one young researcher. The techniques developed in the project may be used to derive high resolution imaging of seismic properties in other locations.

Publications supported by the project

Hillers, G., P. Roux, M. Campillo, Y. Ben-Zion, 2016. Focal spot imaging based on zero lag cross correlation amplitude fields: Application to dense array data at the San Jacinto fault zone, *J. Geophys. Res*., 121, 8048-8067, doi: 10.1002/2016JB013014.

Liu, X. and Y. Ben-Zion, 2016. Estimating correlations of neighboring frequencies in ambient seismic noise, *Geophys. J. Int.*, 206, 1065–1075, doi:10.1093/gji/ggw196.

Liu, X., Y. Ben-Zion and D. Zigone, 2016. Frequency domain analysis of errors in cross-correlations of ambient seismic noise, *Geophys. J. Int*., 207**,** 1630-1652, doi:10.1093/gji/ggw361.

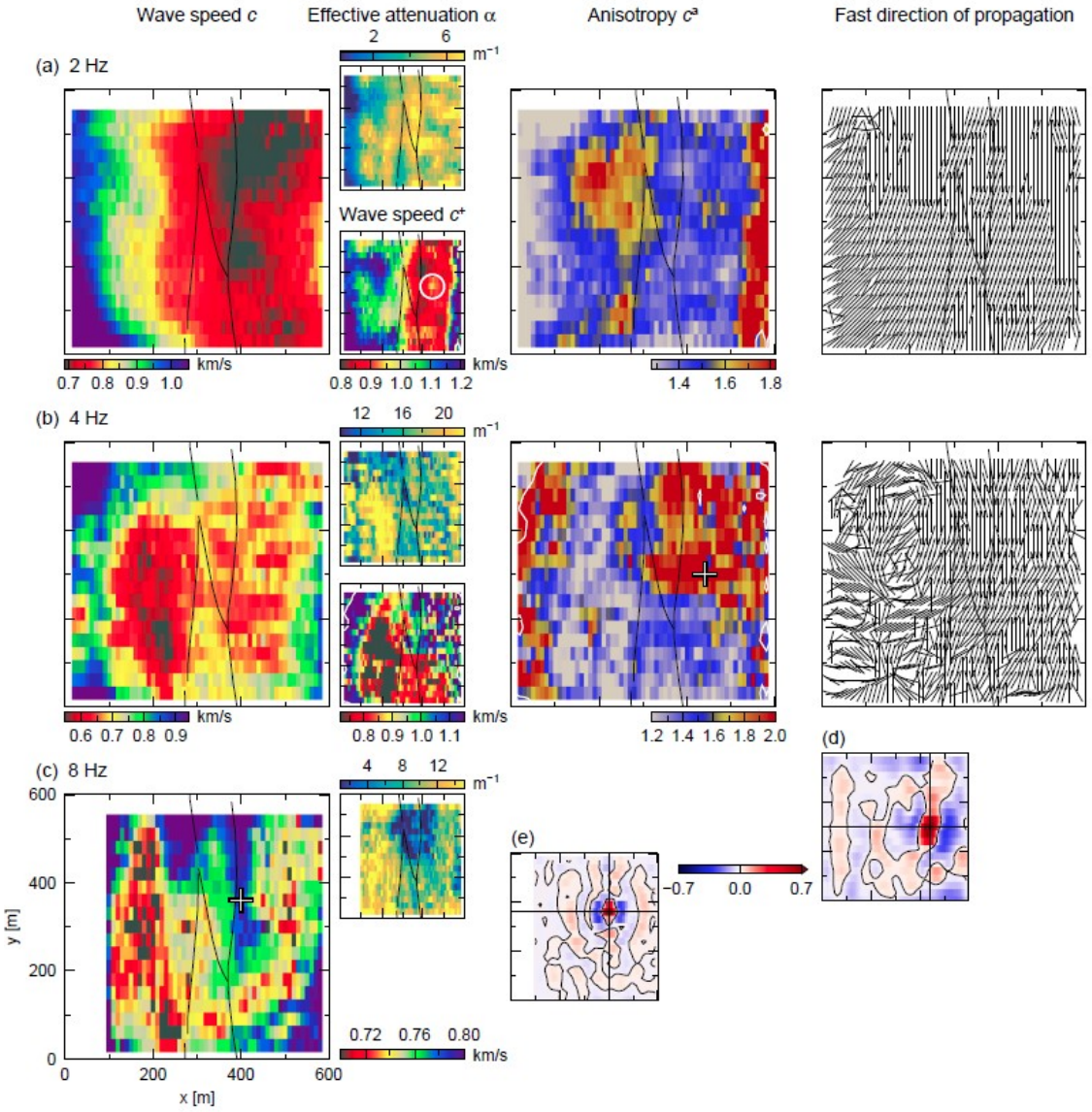

Figure 1. Imaging results on seismic velocities (left column), effective attenuation (second column) and anisotropy (third and right columns) based on focal spot imaging using ambient noise data recorded by a dense seismic array on the San Jacinto fault zone south of Anza. From Hillers *et al.* (2016).