# Annual Report 2007

# 07040: Using seismic noise for the purpose of improving shallow S-wave velocity models

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## Using seismic noise for the purpose of improving shallow S-wave velocity models

Seismic noise is now recognized to be a very useful source for retrieving S-wave velocity structure. We are combining two analysis methods for seismic noise in order to improve shallow S-wave velocity structure in Southern California: the first is the noise correlation method that gives us Rayleigh-wave phase velocity maps for frequencies 0.1-0.2 Hz. The other is the Z/H method (H/V) for 0.1-0.4 Hz which allows us to constrain even shallower depths.

During 2007, we derived the phase velocity maps and the Z/H maps. We intend to invert these data jointly and obtain detailed S-wave velocity structure in the coming year. The results will be provided to update the community velocity model. This modification should improve ground motion prediction as shallow S-wave velocity is a critical parameter for local ground-motion amplification.

I. **Rayleigh-wave phase velocity maps for frequencies 0.1-0.2 Hz:** Using four-year continuous data for broadband stations in Southern California, we generated the Green's functions through the noise correlation approach (e.g., Campillo and Paul, 2003). The number of paths (or the pairs of stations) exceeded 5400. We measured phase velocity for each pair and retrieved phase velocity maps. Figure 1 shows phase velocity maps at four frequencies. Due to low signal-to-noise ratio below 0.1 Hz and above 0.2 Hz, we restricted our analysis to 0.1-0.2 Hz.

II. **Z/H**: Another important property of Rayleigh waves that are sensitive to S-wave velocity at shallow depths is the ellipticity of surface particle motion. We term this Z/H (the inverse of commonly used H/V which can become infinite due to disappearance of vertical motion in deep sedimentary structure) and measured it as a function of frequency. Figure 2 shows the results for each station near the Los Angeles basin region; Z/H values are functions of structure underneath a seismic station. Figure 2 shows clearly, especially in the map for 0.15 Hz, that there is a special feature in the Los Angeles basin, particularly near the Newport-Inglewood fault. Since each measurement is done at a finite frequency, there is an influence zone that is about the order of wavelength. We averaged results in Figure 2 using an averaging length of 18 km, approximately the wavelength for 0.15 Hz. Averaged maps are given in Figure 3. The most important feature in this figure is again the signature for the basin, identified in the map for 0.15 Hz, which then disappears in higher frequency maps. This type of behavior gives us important information as to the variations of S-wave velocity with depth.

III. **Preparation for joint inversion:** We also prepared programs for joint inversion of phase velocity and Z/H. Examples of kernels are shown in Figure 4. Even at a low frequency (0.15 Hz), the Z/H value is sensitive to the upper 5-10 km only. Since we have Z/H up to 0.35 Hz, the data contain information for very shallow S-wave velocity structure in principle. The joint inversion will be carried out in the coming year.

Publications in 2007 that resulted from our activities related to this project are

(1) Tanimoto, Toshiro and L. Rivera, The ZH ratio method for long-period seismic data: Sensitivity kernels and observational techniques, Geophysical Journal International, 172, 187-198, 2008, SCEC #1118.
(2) Tanimoto, Toshiro, Excitation of normal modes by nonlinear interaction of ocean waves, Geophysical Journal International, 168, 571-582, 2007. SCEC #1151.
(3) Tanimoto, Toshiro, Excitation of Microseisms, Geophysical Research letters, 34, L05308, 2007, SCEC #1152.
(4) Gerstft, P. and T. Tanimoto, A year of microseisms in southern California, Geophysical Research Letters, 34, L20304, 2007, SCEC #1153.

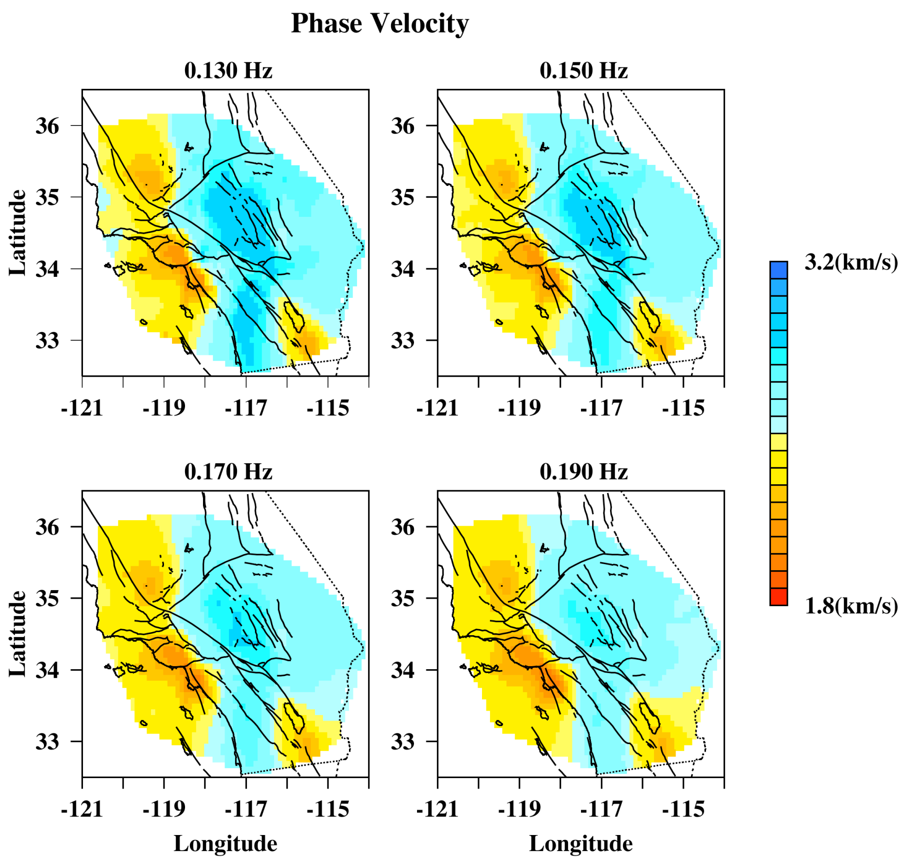


Figure 1: Rayleigh-wave phase velocity maps obtained from the noise-cross correlation method. Significant low velocity regions are found in southern end of the central Valley, the Ventura basin, the Los Angeles basin and the Salton Sea region. These patterns are mostly determined by the (upper) crustal S-wave velocity.

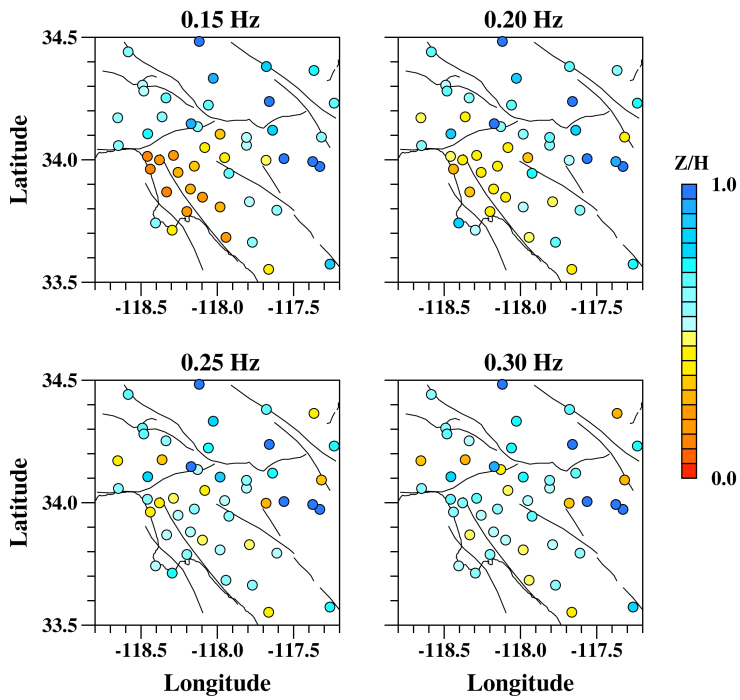


Figure 2: Z/H values for each station. The scale on the right is saturated at 1.0 but stations that exceed 1.0 is few in this map.

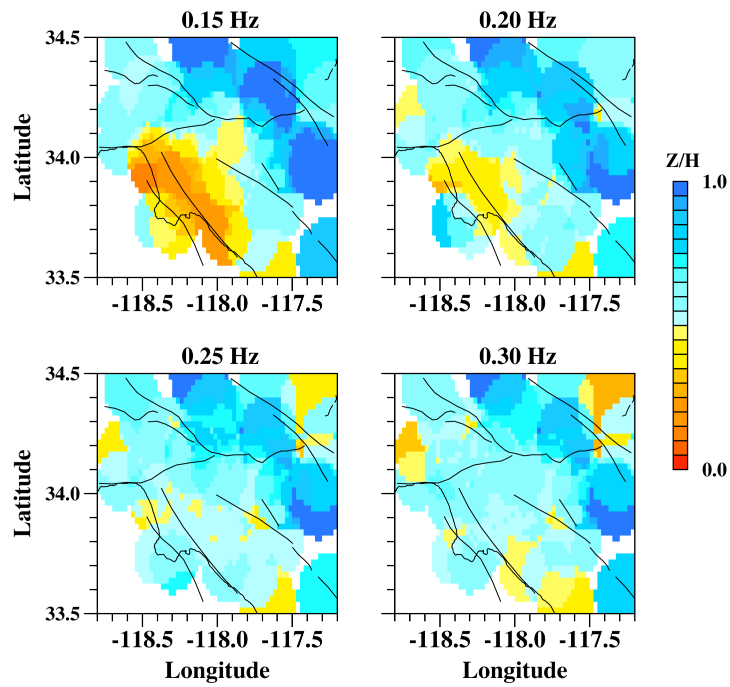


Figure 3: Averaged Z/H map: Averaging was performed for a length of about 18 km, an approximate wavelength for 0.15 Hz. The signature of the basin, very small value near the Newport-Inglewood fault is found for maps below the frequency 0.20 Hz but not above. This feature provides an important piece of information for S-wave velocity structure.

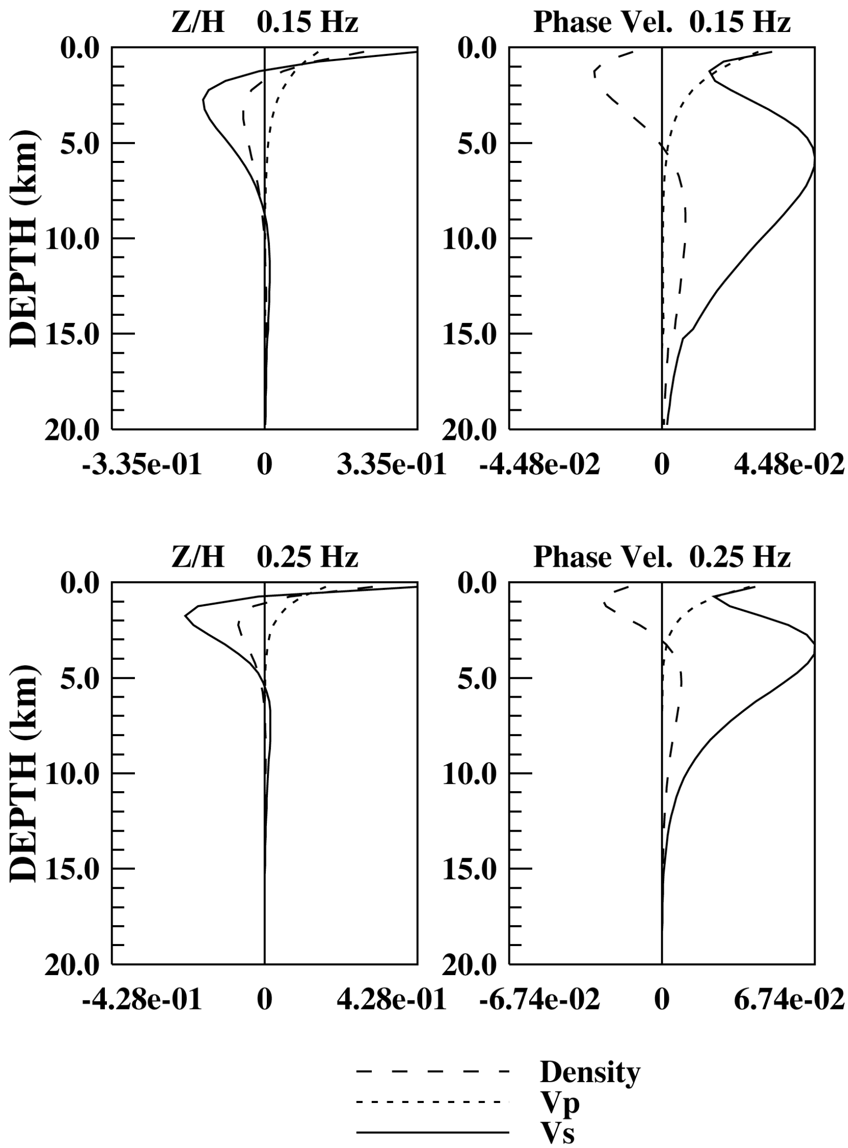


Figure 4: Depth sensitivity kernels of Z/H (left) and Rayleigh-wave phase Velocity (right). The combined data are clearly useful for retrieving the details in S-wave velocity structure in the upper 10 km.