SPECTRAL ANALYSIS OF PORE PRESSURE DATA RECORDED FROM THE 2010 SIERRA EL MAYOR (BAJA CALIFORNIA) EARTHQUAKE AT THE NEES@UCSB WILDLIFE FIELD SITE

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ABSTRACT

On 4 April 2010, the M7.2 Sierra el Mayor event occurred in Baja California, Mexico. The NEES@UCSB Wildlife Liquefaction Array (WLA) in the Imperial Basin is located 110 km NNW of the hypocenter. The event was recorded on all channels at: by three-component strong-motion accelerometers at the surface and in boreholes at various depths and by pore pressure transducers located in a saturated, liquefiable layer.

We have computed the spectra of the pore pressure response in the frequency domain for signals recorded at different depths. At each depth, the spectrum is attenuated as a power law with a sharp discontinuity at an angular frequency close to 1 rps (0.16 Hz). We report the value of the exponents that characterize the power-law behavior of these spectra. We also computed cross-spectral analysis of the pore pressure records from different depths. The functional behaviors of the curves of the cross-spectra are similar to that of the original spectra. For comparison, we present the spectrum of each component of the ground motion recorded at a nearby accelerometer.

Partially due to the late arrival of the surface waves, the frequency content of the recorded pore pressure signal is also a function of time. To gain a better understanding of the time-dependence of the frequency content, we performed a spectral analysis of the signal in a moving window and wavelet transforms of the full signals. The spectral analysis suggests that, except for high frequencies, the curves exhibit a complex behavior as a function of the window position.

1. THE 4 APRIL 2010 M7.2 SIERRA EL MAYOR EVENT RECORDED AT THE NEES@UCSB WILDLIFE STATION

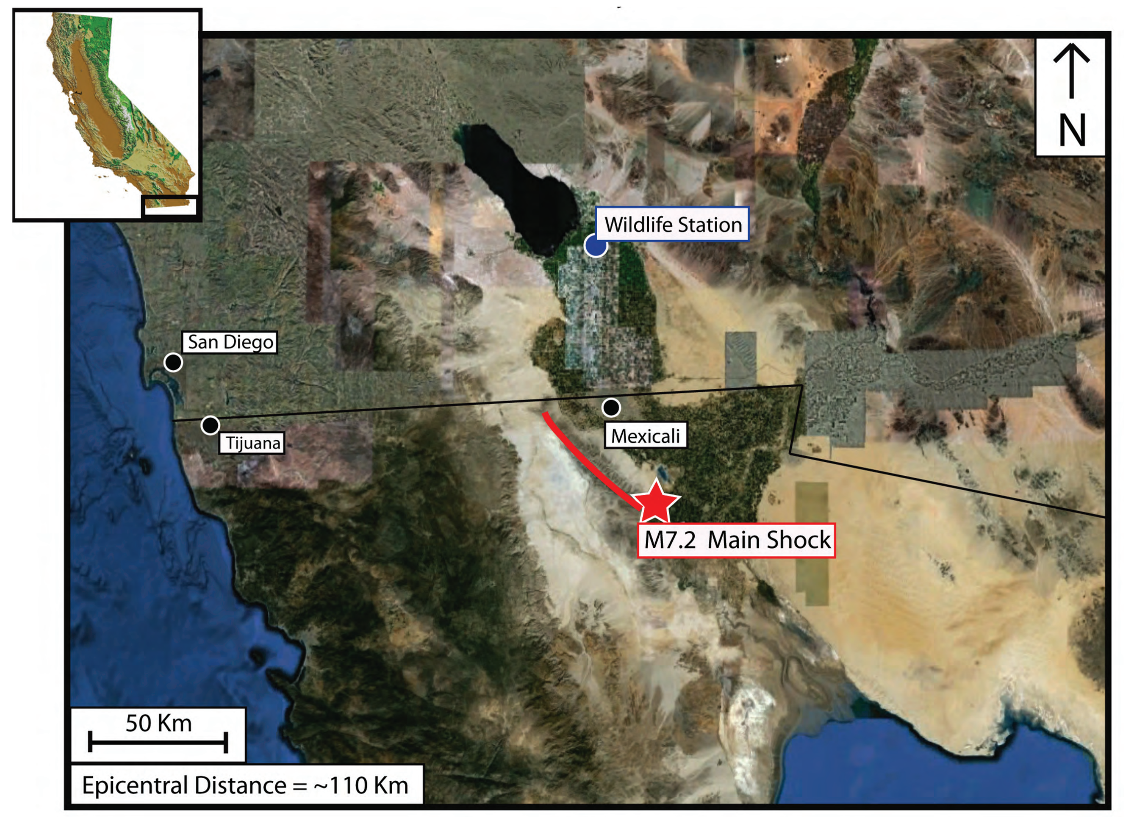


Figure 1: The 4 April 2010 M7.2 Sierra el Mayor event with the NEES@UCSB Wildlife Station 110 km away.

USGS Wildlife Station (5210)

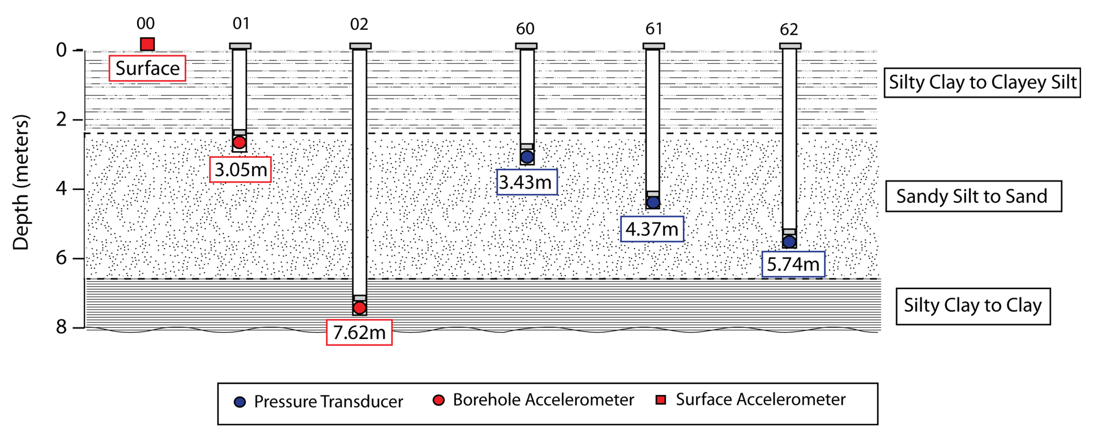


Figure 2: A cross section showing instrumentation at the NEES@UCSB Wildlife Station (Holzer and Youd, 2007, Youd *et al.*, 2007).

2. RECORDED DATA

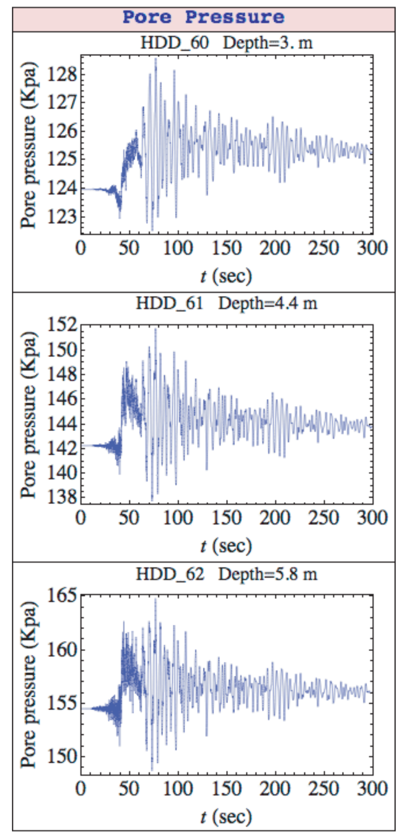


Figure 3: Pore pressure recorded at all depths at Wildlife Station (Figure 1). Pore pressure is recorded at 200 Hz. In the plots above, the data are sampled at 20 Hz.

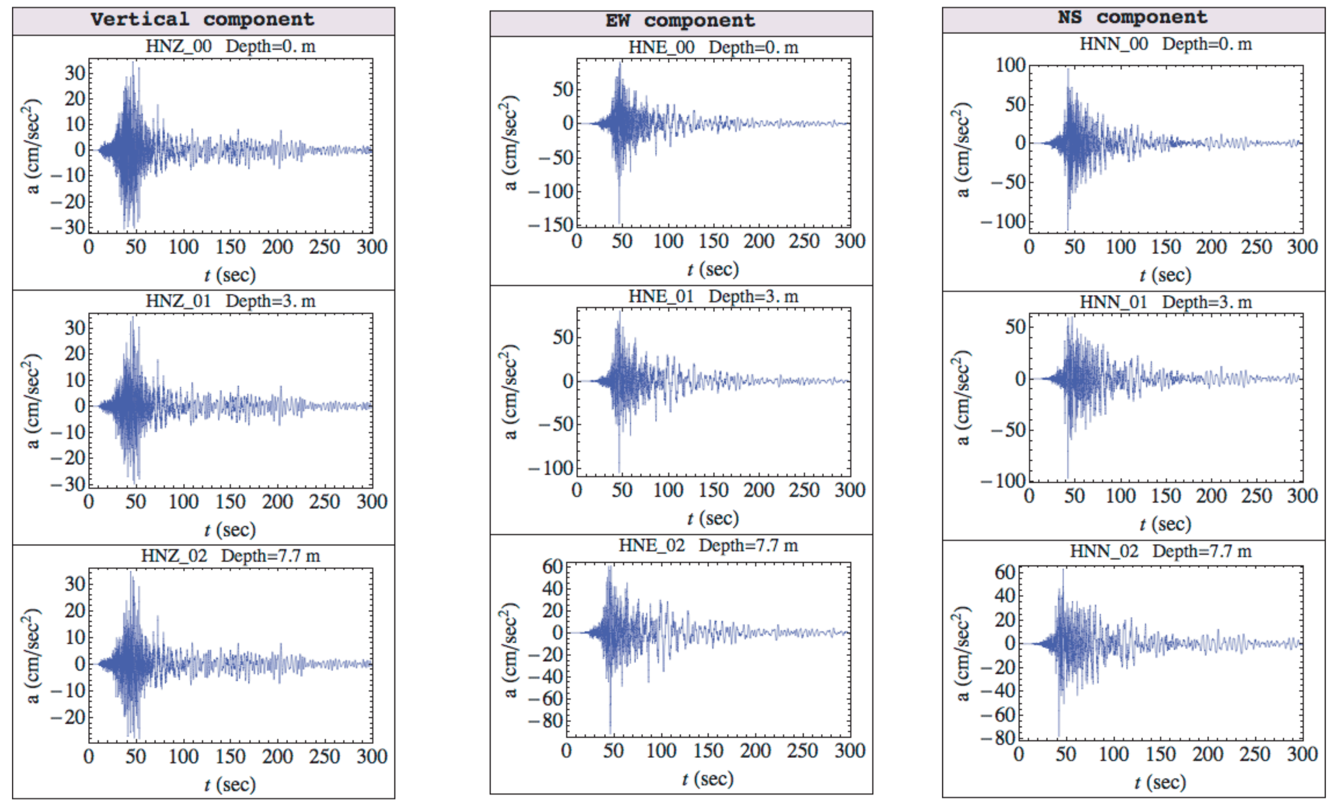


Figure 4: The three components of ground motion recorded at all depths at Wildlife Station. The data are recorded at 200 Hz. In the plots above, the data are sampled at 20 Hz.

3. SPECTRA OF PORE PRESSURE & GROUND MOTION DATA

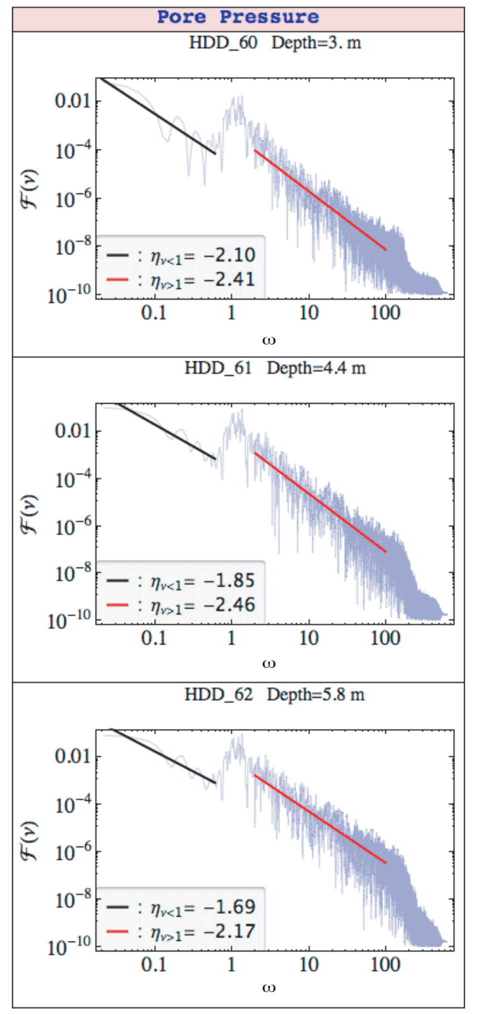


Figure 5: Angular frequency spectra of the recorded pore pressure for a time window of 300 sec (Figure 3). Note the sharp discontinuity at 1 rps that occurs at every depth. For frequencies < 1 rps, the spectra attenuate according to a power law. The same functional dependency is observed for angular frequencies ranging from 2 - 16 rps.

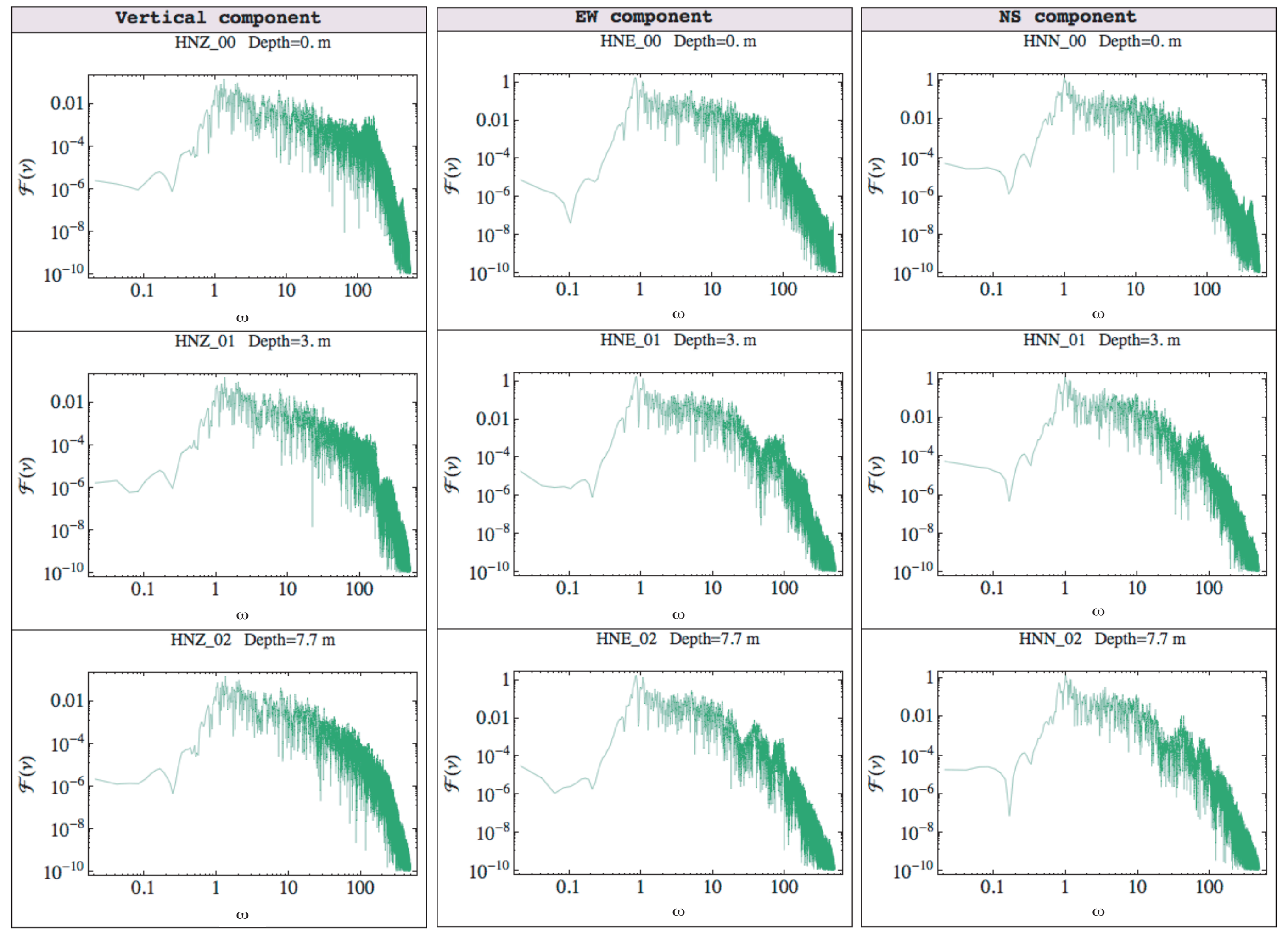
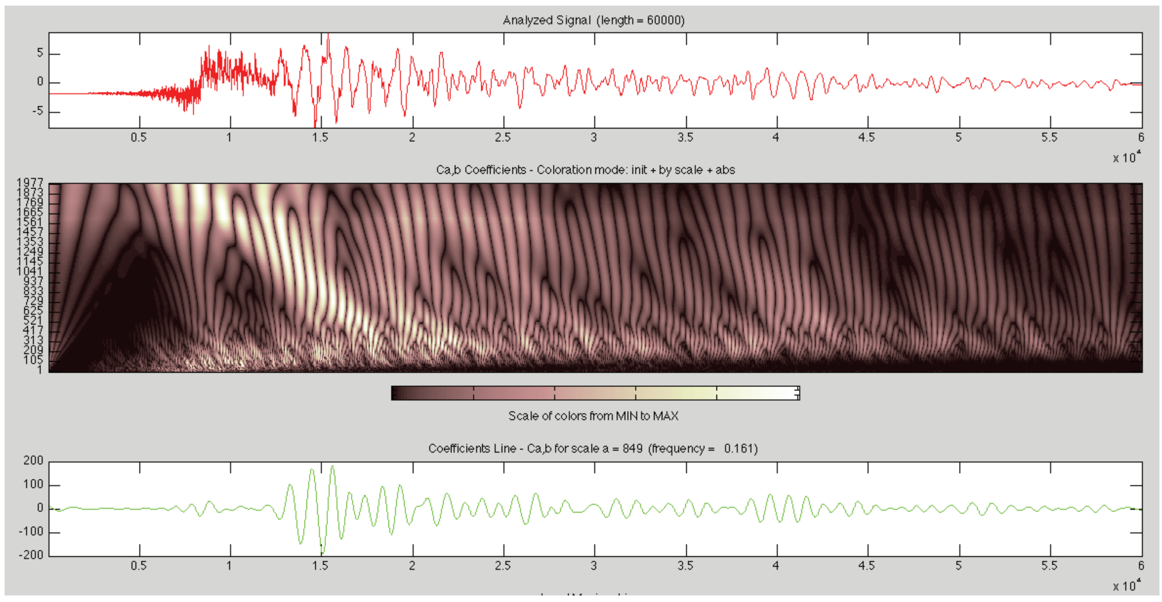


Figure 6: Angular frequency spectra of the three components of ground motion computed for a time window of 300 sec (Figure 4). The shapes of the curves are complicated, especially for the EW and NS components, and there is no simple functional representation. Note that for the EW and NS components at 3 m and 7.7 m depths, there are depletions of the spectral curves at several angular frequencies in the range 10 to 100 rps.

4. WAVELET TRANSFORM

Figure 7: Wavelet transform of 300 seconds of the pore pressure recorded at 5.7m using the Daubechies 10 wavelet. The green line corresponds to the scale equivalent of 0.161 Hz frequency, corresponding to the frequency of the dominant surface wave. The maximum coefficients of the wavelet scales appear in white in the central figure. Note that the maximum coefficient (which corresponds to the maximum energy of the signal) shifts over time from larger scales (low frequencies) to smaller scales (high frequencies).



5. WAVELET ANALYSIS

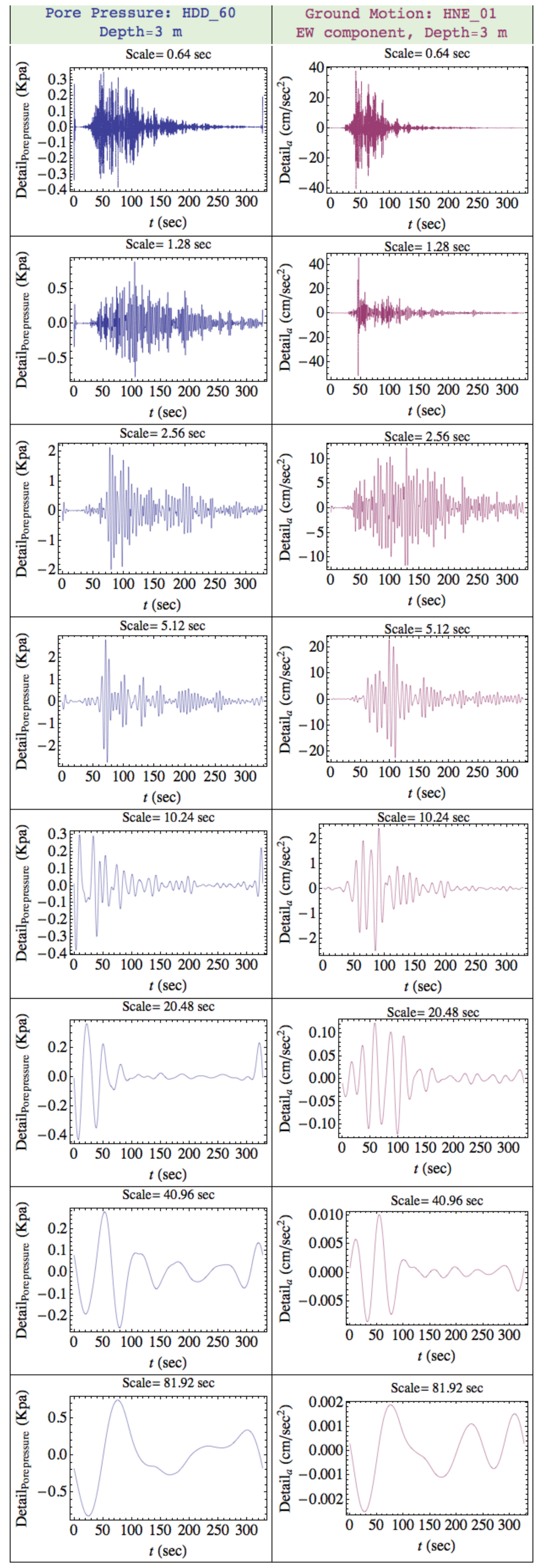


Figure 8: Wavelet decomposition using the Daubechies 10 wavelet is presented for the pore pressure records at 3m and the East component of acceleration at 3m. The signal component for scales from 0.64 sec to 81.92 are graphed for the pore pressure and the acceleration. The negative pore pressure ("sucking") that occurs before the arrival of the S-wave is clearly a long-period phenomenon.

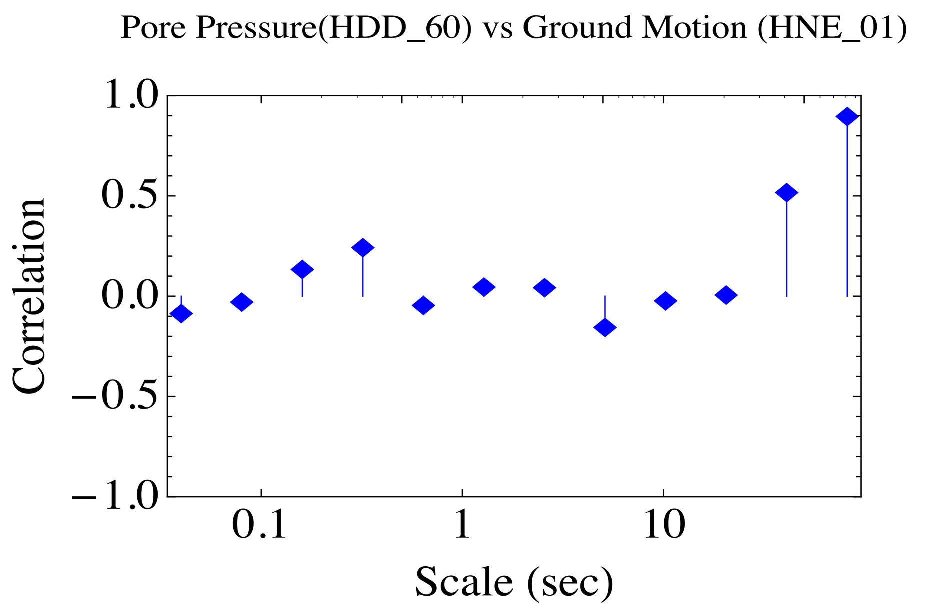


Figure 9: Correlation of the pore pressure signal with the East component of ground acceleration computed for scale values in Figure 8. At long-period scales, the pore pressure signal correlates well with the ground motion.

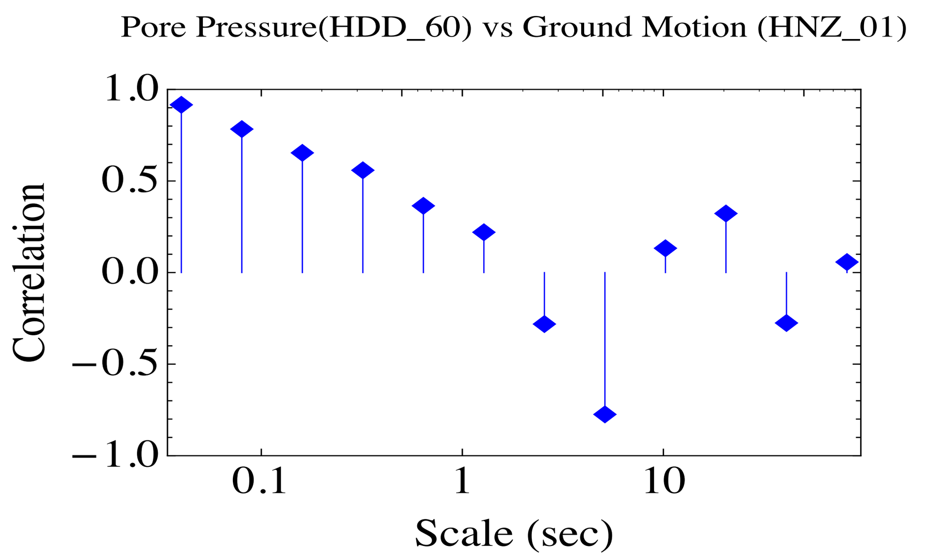


Figure 10: Correlation of the pore pressure signal with the Vertical component of ground acceleration computed for scale values in Figure 8. Note the high correlation with small scales in seconds (relatively higher frequencies).

References

Mallat, S. A Wavelet Tour of Signal Processing. Academic Press, 1999.

Seale, Sandra H., Daniel Lavallee, Jamison H. Steidl, Hank Ratzesberger, and Paul Hegarty. Spectral Analysis of Pore Pressure Data Recorded from the 2010 Sierra el Mayor (Baja California) Earthquake at the NEES@UCSB Wildlife Field Site [abstract]. 2010 AGU Fall Meeting, 13 - 17 December, San Francisco, ID 967823.

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AGU Meeting 2010