THE MAY 16, 2010 Mw. 5.8 PUERTO RICO EARTHQUAKE: SITE CHARACTERIZATION, LOCAL SITES EFFECTS, AND JOINT TIME-FREQUENCY ANALYSIS

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ABSTRACT

On May 16 2010, at 05:16:10 UTC, the northwest area of the Puerto Rico Island was struck by a moderate-sized earthquake (Mw. 5.8). It was felt in the eastern Dominican Republic, the Virgin Islands and all over the Puerto Rico Island. The earthquake was recorded by 63 accelerographic stations of the Puerto Rico Strong Motion Program (PRSMMP) distributed around the island. Only free-field stations seated on soil or rock were used in this study. In the first stage, the accelerograms were analyzed following the well established data processing procedure for acceleration strong motion records through volume I to III, and the Power Spectral Density (PSD) was computed. Secondly, a joint time-frequency analysis was carried out using different time-frequency distributions. The aim of the joint time-frequency spectral decomposition is to assess the strength of the signal energy as a function of the variables frequency “f” and time “t”, in order to generate a distribution which appropriately identifies the energy distribution in the time-frequency plane. The following Cohen class distributions were applied: (i) Short time Fourier Transform (STFT), (ii) Wigner-Ville Distribution (WVD), (iii) Choi-Williams Distribution (CWD), (iv) Reduced Interference Distribution (RID), and (v) Adaptive Optimal Kernel (AOK ). Each of these distributions was applied to the recorded data and a comparison among them was analyzed. Finally, an experimental and numerical modeling of H/V spectral ratio (HVSPR) was performed to characterize the sites in terms of the fundamental vibration frequency, the subsoil geometry and physical properties. The adopted procedure for the site characterization in terms of the subsoil geometry and physical properties was through an iterative forward modeling process until the lowest residual between the experimental and the theoretical HVSPR of the fundamental vibration mode was obtained.

JOINT TIME-FREQUENCY ANALYSIS

The Time-Frequency Representation (TFRs) of signals permits to convert a one-dimensional function of time x(t) into a two-dimensional function of Time and Frequency T(f,t).

Any time-frequency representation that fulfill the equations (1) is considered a Time-Frequency Energy Distribution (TFED) P(t,f).

\[
\begin{align*}
\forall \tau \in \mathbb{R} & \quad \int_{-\infty}^{\infty} |P(t,f)|^2 dt = |x(t)|^2 \\
\forall f \in \mathbb{R} & \quad \int_{-\infty}^{\infty} |P(t,f)|^2 df = |x(t)|^2
\end{align*}
\]

In equation (2), it is important to note that x(t) is the complex associate analytical x(t). The analytical signal is defined as (Quatieri, 1995):

\[
x(t) = x_r(t) + jx_i(t)
\]

Time-Frequency Distributions Kernel

The horizontal to vertical spectral ratio method (HVSPR) was proposed by Nakamura (Nakamura, 1989). It consists in estimating the ratio between the Fourier amplitude spectra of the horizontal and vertical components. The spectral ratio (HVSPR) is defined as:

\[
HVSPR = \frac{|S_h|}{|S_v|}
\]

in which \( V \) is Fourier component of the vertical motion, and \( H \) and \( H \) are those of two orthogonal horizontal motions.

ANALYSIS AND RESULTS

The seismic records used in this analysis were corrected for instrument effects to provide absolute values of acceleration of the ground motions. At first the characteristics of the earthquake signals were analyzed using the FFT and the PSD. The frequency domain representation of the horizontal component (e.g. Station MY09) at least five frequency components, located at 1.5, 1.8, 2.2, 2.5 and 3 Hz are clearly seen. The SP shows a concentration of energy at ~1.4 Hz. From the spectrum, the HVSPR is computed, but first, the average of the two horizontal components was calculated. This process was done for each set of data-station. In modeling the theoretical HVSPR the algorithm developed by Kausel and Roesset (1981), which solve the wave propagation phenomena for SH-, SV- and P-waves was used.

REFERENCE


