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Shear-wave velocity model of the basin of Santiago de Chile derived from ambient noise measurements for the determination of seismic site conditions and amplification

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Extended Abstract / Abstract

Extended mountain valleys with wide plains of fluvial deposits or lakeshores and estuaries with water-saturated sediments are particularly prone to seismic site amplification and non-linear effects. In former times, such seismically unfavourable sites would have been attractive for spacious settlements and industries, and many cities worldwide have grown extensively over such plains and are still expanding. Therefore, the densely populated urban area of Santiago de Chile with more than six million inhabitants, situated in an active tectonic region, suffers significant seismic risk. Due to the dimension of the investigated area, site characterization usually requires substantial investment both in time and money for data aquisition. On the other hand, the necessity of estimating seismic risk for very spacious urban areas wants for at least a first order classification of soil and building vulnerabilty and therefore requires proxies.Measurements of seismic noise at 148 sites have been carried out in the northern part of Santiago de Chile of which 125 allowed further analysis as a confident estimate of the fundamental resonance frequency at these sites was possible. It can be seen that the spatial variation in the thickness of the sedimentary cover, known from previous gravimetric investigations, is roughly retrieved using from the peak in the horizontal-to-vertical (H/V) ratios of ambient noise. We inverted the H/V spectra individually for receiving local S-wave velocity

profiles under the assumption of a horizontally layered one-dimensional structure using geotechnical data and knowledge of the thickness of the sedimentary cover which has been determined previously by gravimetric measurements. The resulting 3D model, derived for a 26 km x 12 km area by a kriging technique to interpolate between the single S-wave velocity profiles, shows good agreement with the few existing data sets but images the entire area as well as deeper parts of the basin in more detail.

Since soil conditions often vary over relatively short distances, what is also verified by large variations in the S-wave velocity-depth gradient, recognition of the importance of ground-motion amplification has led to the development of systematic approaches for mapping seismic site conditions, as well as quantifying both amplitude- and frequency-dependent site amplifications. A now standardized approach for mapping seismic site conditions is measuring and mapping v_s^{30} (average shear-wave velocity in the uppermost 30 m).

Recently, Wald and Allen (2007) suggested a new technique for the estimation of site effects applicable for all spatial resolutions by using the slope of topography as a proxy. Therefore, we checked if any correlation between v_s^{30} and the topographic slope exists on small scale. However, we find that for the investigated area almost no correlation between topographic gradient and calculated S-wave velocity exists. On the contrary, a better but still only approximate correlation between v_s^{30} and local geological conditions is visible. Further proof serves when taking into account the distribution of the observed intensities of the 1985 Valparaiso event, pointing out that high intensities are found in areas where the S-wave velocity is low. This effect is clearly influenced by the v_s^{30} distribution and cannot, even at a rudimentary level, be derived from the topographic gradient.