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Enhancement of long period components of recorded and synthetic ground motions using InSAR

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ABSTRACT

Tall buildings and flexible structures require a better characterization of long period ground motion spectra than the one provided by current seismic building codes. Motivated by that, a methodology is proposed and tested to improve recorded and synthetic ground motions which are consistent with the observed co-seismic displacement field obtained from interferometric synthetic aperture radar (InSAR) analysis of image data for the Tocopilla 2007 earthquake (M_w=7.7) in Northern Chile. A methodology is proposed to correct the observed motions such that, after double integration, they are coherent with the local value of the residual displacement. Synthetic records are generated by using a stochastic finite-fault model coupled with a long period pulse to capture the long period fling effect.

It is observed that the proposed co-seismic correction yields records with more accurate long-period spectral components as compared with regular correction schemes such as acausal filtering. These signals provide an estimate for the velocity and displacement spectra, which are essential for tall-building design. Furthermore, hints are provided as to the shape of long-period spectra for seismic zones prone to large co-seismic displacements such as the Nazca-South American zone.

1. Introduction

Design of flexible structures in seismic regions requires a more consistent characterization of low-frequency ground motion components which are, historically, not well represented by design spectra in building codes. Recorded acceleration data used to derive the response spectra have built-in low-frequency noise that is filtered during baseline correction and signal processing, which in turn annihilates also the true low-frequency contents of the record [1]. Thus, acceleration records usually integrate to near-zero residual ground displacement, or at best yield an inaccurate estimate of the co-seismic displacement, distorting the peak ground displacement (PGD) value and the displacement controlled region of the response spectra. This effect is greatly amplified in places where the crustal deformation may reach from a few centimeters to meters, the seismological near-field. Recent advances in building codes have included to some extent provisions which tend to enhance the long-period portion of the design spectrum by considering different effects. An example of this is the Eurocode 8 [2]. Nevertheless, methods are needed which improve our confidence in the records used to calibrate design spectra for the long period range.

Several methodologies have been proposed for acceleration record processing aiming to recover co-seismic displacement [3]. In a recent publication [4], strong-motion data were corrected by using measurements of continuous GPS stations (1–30 Hz sampling rate). These data showed the low-frequency behavior of the seismic motions and enabled a guided baseline correction of the available acceleration records. These studies show that fling-pulse type recorded motions can be attributed to co-seismic displacement reached gradually from the onset of strong motion. Therefore, knowledge of the static co-seismic displacement field is a tool to improve consistency of ground motion records and spectra at low-frequencies.

A promising alternative to determine the co-seismic displacement field is the use of interferometric SAR synthetic aperture radar (InSAR) [5]. In this technique the complex phase of two interfered satellite radar images of the region affected by an earthquake is the basis to derive the change in surface geometry during the earthquake in the satellite line of sight [6–8] (LOS). The displacements inferred by the procedure have different uses, such as inverse determination of a finite-fault earthquake slip distribution [9–12], the identification of local site effects and activation of secondary faults, and morphology studies (inflation and deflation) at regional level [13–15], to name a few. Moreover, the wide

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