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Azimuthal and thickness variabilities of seismic site effect response of the Utiku landslide (North Island, New-Zealand)

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A monotoring seismic network was installed for 14 months on the re-activated deep-seated landslide of Utiku (North Island, New-Zealand). As this landslide caused subsidence since 1964 to the main Wellington-Auckland highway and more seriously to the railway, it is thoroughly instrumented and monitored nowadays. Boreholes and permanent GPS measurements conducted for surveillance purposes by Geological and Nuclear Sciences Institute (GNS) notably showed that its thickness varies from 70 m to less than 20 m, while its velocity can reach more than 2 m /year in the most active zone. All the studies conducted on this landslide also suggest that its dynamics is mainly controlled by rainfall and is unaffected until now by earthquakes, despite being located in a moderate to active seismic zone. Like other similar landslides, it is however important to assess potential seismic site effects generated by the weathered material. During the seismic monitoring, thousands of earthquakes have been recorded displaying a large variability in magnitude, distance and back-azimuths. It permitted a thorough study on site effect response variability of such 3D objects.

A network of 6 broadband (30s – 40 Hz) seismic stations recorded ambient vibrations as well as thousand of earthquakes over a period of 14 months from November 2008 to January 2010. We present a comparison of spectral amplification analyses derived from the classical ambient seismic noise ratio (H/V), from a near seismic excitation (train) and from a large set of earthquakes measurements (spectral ratio). We study the variability of this amplification along the landslide: 74 measurements were performed disposed along 5 profiles cutting across the landslide. A comparison with boreholes inclinometers measurements first show that small scale variations of landslide thickness control spatial variation of seismic site amplification, both in amplitudes (from 6 to 10) and frequency (1D fundamental frequency from 1.6 to 4.3 Hz). We also measured large azimuthal variations in amplification of horizonthal components, which are not correlated with surface topography. Each station presents a maximum and minimum in horizontal amplification, which could reach a 3 to 10 range in amplitude. We propose that this effect could be controlled by the bottom topography of the landslide body and not by surface topography, as often proposed in other studies. Finally, the large number and variety of recorded earthquakes enables us to study the linearity of site effect amplification as a function of the properties of the seismic excitation (magnitude and distance normalized relationship, back-azimuth of the earthquakes); moderate changes are observed, depending on the studied set of earthquakes.