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Deciphering seismic response of landslide-prone slopes from reconnaissance microtremor measurements with a broad-band velocimeter

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Recent experimental studies have pointed out that susceptibility of slopes to seismically induced failures can be significantly increased by site conditions determining phenomena of directional resonance along potential sliding directions. Evidence of such situations were obtained from long-term accelerometric monitoring conducted in central Italy (Caramanico Terme), and it has been suggested that similar phenomena may have influenced also some of the giant landslides triggered in Taiwan by the 1999 Chi-Chi earthquake. Since factors controlling directional resonance are still unclear, it is of great interest to develop reconnaissance techniques capable to point out the occurrence of conditions of site response directivity. One promising technique is based on the analysis of the azimuthal variations of the spectral ratios between horizontal and vertical component of noise recordings (HVNR), derived from microtremors measured with portable velocimeters. At this regard an extension of observations to low frequency spectral ratios, even below 1 Hz, is desirable, especially in the case of very large landslides whose stability conditions under seismic shaking could be more sensitive to the effect of larger wavelengths. For this reason we tested the employment of a portable broad-band sensor for HVNR measurements on landslide-prone slopes. First, measurements previously carried out at Caramanico with different seismometric sensors were repeated for comparative purposes. Then, data acquisition was extended to other sites in the same area and in two areas of Taiwan, on the giant landslides of Tsaoling and Jiufengershan. It is recognized that the analysis of noise recording on a broader frequency bandwidth poses some supplementary difficulties for the presence of strong low frequency signals that vary with atmospheric and sea conditions. However, the measurements obtained at Caramanico showed that, where clear site response directivity had been revealed by previous observations, the results of HVNR analysis derived from broad-band measurements were consistent with those derived by other type of sensors. At other Caramanico sites, HVNR analysis of the broad-band data provided uncertain results, possibly as effect of variable conditions of data acquisition that might obscure weaker site response effects. In some cases the repeatability of the results was a problem, possibly due to temporary action of a local source of strong polarised noise. The measurements obtained in Taiwan in the two giant landslide areas, both characterised by mass movements occurred along bedding surface, revealed the presence of abnormally high values of HVNR for sites on slip surfaces, with a very strong directional variation through a large frequency band and with pronounced maxima at frequency less than 1-2 Hz, i.e. at frequencies influenced by signals of atmospheric and marine origin. Although the recordings on nearby sites on the flanks or the crowns of the landslides did not reveal similar properties, the representativeness and exact significance of the HVNR data acquired on the slip surfaces need to be more deeply investigated in order to exclude the effects of anomalous acquisition conditions. More in general, contemporaneous measurements of noise with two different types of instruments at different times and varying environmental conditions should help to clarify to what extent the reconnaissance type of noise measurements by broad-band instruments could be useful for detecting directivity in seismic site response.