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Characterization of an unstable mountain slope using 3D active and passive seismic survey, the case of the La Valette landslide.

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As transport routes and population centers in mountainous areas expand, risks associated with rockfalls and rockslides grow at an alarming rate. As a consequence, there is an urgent need to delineate mountain slopes susceptible to catastrophic collapse in a safe and non invasive manner. For this purpose, we have first adapted a 3D tomographic seismic refraction SIRT algorithm (preliminary tests were performed to check the validity of the method) and applied it to 8160 first-arrival traveltimes to obtain the 3D P-wave velocity model of an area in the lower part of the unstable alpine La Valette landslide, a significant segment of which is moving at 0.01–0.02 m/year toward the adjacent valley floor. The La Valette landslide, triggered in 1982, is one of the most important large and complex slope movements in the South French Alps. The landslide associates two styles of activity: a mudslide type of behaviour with the development of a flow tongue in the medium and lower part, and a slump type of behaviour with the development of several rotational slides in the upper part at the main scarp. The landslide extends over a length of 2 km for a variable width of 0.2 km in the lower and medium parts, to 0.45 m in the upper part. Inversion of the first-arrival traveltimes produces a 3D tomogram that reveals the presence of a huge volume of P-wave low-velocities of 800–1300 m/s, mounted on a P-wave high-velocities basement of 1500-2300m/s. The low field velocities result from the presence of dry cracks, fracture zones, and faults. They extend to more than 35 m depth over a 100x150-marea that encompasses the mobile segment of the mountain slope, which is transected by a number of actively opening fracture zones and faults, and a little part of the adjacent stationary slope.
Secondly, the seismic ambient noise cross-correlation technique was used to retrieve a 3D model of the shear wave velocity (Vs) of an area located in the lower part of the landslide, including the area of the above described active survey. Seismic ambient noise was recorded during 8 days at 9 stations located on the landslide. Cross-correlations computed between the vertical components of all station pairs allow the retrieval of the Rayleigh wave Green's functions and the estimation of their group velocity dispersion curves in the 8 to 15 Hz frequency range. These 8 to 15 Hz passive group dispersion curves are complementary to the ones computed from shot signals in the same frequency range. An inversion of the resulting Rayleigh wave group dispersion curves provides local Rayleigh wave group velocities at each cell of the tomographic grid for four fixed different depths. These group velocities are used to retrieve Rayleigh wave propagation time between each stations. These ones are inverted for each depths using a SIRT algorithm to retrieve the 3D model of the landslide. Despite the complex wave propagation in the north-eastern part of the landslide and the sparse ray coverage for the ambient noise survey, estimated velocities (Vp and Vs) and first order features are in good agreement with previous investigations (borehole and 2D seismic tomography sections).