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Seismic characterization of low-magnitude floods and lahars at La Lumbre ravine, Volcán de Colima (Mexico)

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Volcán de Colima currently is the most active volcano in Mexico where a number of rain-induced lahars occur each year. After an explosive phase, lahar frequency increases due to the immediate reworking of pyroclastic material and it progressively decreases in the following years. This behavior was distinctly observed during the two last rainy seasons that followed the intense volcanic activity of July 2015. La Lumbre ravine drains the West-Southwestern slopes of Volcán de Colima and is one of the most active channels of the volcano. Since 2014, monitoring is performed in a heavily instrumented cross-section located at ∼1580 m a.s.l. on the left bank of the channel. At the present day, the monitoring station is equipped with a raingauge, two stage sensors, a videocamera, and different seismic devices. At La Lumbre, lahars initiate as dilute, sediment-laden stream flows and with the entrainment of additional sediment they evolve into hyper-concentrations and debris flows. The hydro-repellency mechanism of the highly vegetated volcanic soils can explain the high frequency of lahars triggered by low-intensity rainfall events: under these hydrophobic conditions, infiltration is inhibited and runoff is facilitated at less highly peaked discharges that are more likely to initiate lahars that can have an impact on the inhabited areas located downstream. This is the reason why the possibility to detect not only large lahars but also low-magnitude flows is particularly important at La Lumbre.

Here we present monitoring data of processes ranging from stream flows to large lahars that occurred during the last rainy seasons along La Lumbre ravine. In particular, we investigate the possibility to estimate the sediment concentration of debris flood and small lahars using a very easy-to-install and low-cost seismic sensor, i.e. a geophone, installed outside the flow path. For instance, we show how a hyper-concentrated flow characterized by a mean velocity of less than 1 meter per second and a flow rate of about 1 cubic meter per second can be satisfactorily detected using a 10-Hz vertical geophone installed at a distance of 15 m from the mid-channel. Geophone data were compared to seismic data gathered with a broadband seismometer and an accelerometer installed at the same cross section. We correlated grain size distribution with the instrumental records of the monitoring station and we found that using both amplitude and spectral information not only the main flow characteristics can be described (number of surges, duration, sediment discharge) but also the main grain-size classes contributing to sediment transport can be adequately estimated. This information can be useful to identify the range of background seismic noise produced by low-magnitude events and to investigate the sediment transport evolution through time.