Seismic tracking of lahars using tremor signals

Hiroyuki Kumagai [a], Pablo Palacios [b], Diego Barba Castillo [b], Masaru Nakano [a]

[a] National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Japan
[b] Instituto Geofísico, Escuela Politécnica Nacional, Quito, Ecuador

Abstract

Debris flows, or lahars, frequently occur in volcanic regions and cause serious disasters to nearby communities. Lahars are commonly observed as long-lasting, high-frequency tremor in seismic records. We propose a seismic technique to locate the source of tremor originating from lahars by using waveform data from a seismic network. In this method, we fit the surface wave amplitudes from point sources positioned over the surface of a volcano to the observed tremor amplitudes, and estimate the spatial distributions of the normalized residuals in successive time windows. The observed tremor amplitudes at individual stations are corrected by site amplification factors independently estimated from coda waves of tectonic earthquakes. The positions of time windows applied to the observed tremor signals are corrected for the travel times of individual source and receiver pairs. We track the source of tremor or lahars as temporal changes of the best-fit locations in the residual distributions. This method is an extension of the existing methods used to locate seismic events and tremor associated with volcanic eruptions. We applied this technique to tremor signals of lahars observed by a seismic network at Cotopaxi volcano, Ecuador. Our analysis showed regions with small residuals on the NE flank of the volcano. This suggests that lahars descended on this flank, which is consistent with the result of a field survey that found fresh lahar deposits on the NE flank. Our method, which can be easily automated, may be useful for the rapid detection and monitoring of lahars.

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