Natural Hazards and Earth System Sciences Discussions

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Reply on RC2

Braden Walsh et al.

Author comment on "Characterizing the evolution of mass flow properties and dynamics through analysis of seismic signals: Insights from the 18 March 2007 Mt. Ruapehu lake-breakout lahar" by Braden Walsh et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-31-AC2, 2022

Addressing Reviewer Comments: Reviewer in **bold** text and response in regular text.

Major comments:

Site amplification:

The time windows prior to the lahar arrival has similar PSF due to the fact that there was already streamflow in the channel and it has been shown in the past that streamflow has higher PSFs. The March lahar was sourced from a lake breakout and hence would show similar PSF to streamflow compared to a more traditional bulky debris flow. To your concern with site amplification, we went ahead and estimated H/V ratios for each station. This analysis of where the H/V frequency peaks are has been included in the revised manuscript.

Frequency analysis:

See response to first major comment from Reviewer 1. We calculated centroidal frequencies and normalized spectrograms to compare to the PSF results. More details on the actual data processing were added as well.

Physical reasons for signal properties

We cite many papers in which data came from natural and laboratory sources that describe the physical reasons why the seismic signals change. On this point, we describe these throughout the manuscript many times and how they relate to our signals. We have gone back through the manuscript and rewrote some areas to better clarify these statements.

Line by line comments:

Line 61-63: a lot of these things are true of seismic instruments as well, and there is more ambiguity in interpretation for quantitative values. I also disagree that they can be used for "accurate" (L66) estimates of flow properties. Only in very limited situations is that true. Changed to "and/or lack the capability to evaluate multiple pulses or flow events"

Line 69-70: Using seismometers for flow monitoring is not young: Changed to "However, in order to fully utilize these instruments, improved interpretation, comprehension, assessment, and universality is needed."

Line 77: previously not recorded by who? People have used three components many times in the past: changed to "yield additional information about the flow that is not utilized if only the vertical component is used"

Line 88-89: Perhaps it would be useful to explain what you mean by terms like plug-like and laminar: These are explained in the references, as well when describing the lahar at COLL

L133: missing "the" and missing comma. Added

L133-134: please explain how velocities are measured. Added how the velocities were estimated. See replies to comment from Reviewer 1.

Line 157: explain what the averaging represents. Added "The flow velocity at RTMT and COLL were estimated from imagery and at TRAN from a flow meter."

Line 166-167: give details as to how the PSF was estimated. Figures 3-5 show the peak spectral amplitude at its represented frequency. Line 166-167 describe how the points were estimated. To add value to this please see the new supplementary figures in which normalized spectrograms for each station and component are displayed.

Line 169: please explain how the arrival time is known. Added "Arrival times are based off of images and eye witnesses at each of the monitoring stations." On line 162.

Line 180-181: how do you know this is the arrival of the head? Why is the word streamflow in parentheses? Line 180 states "prior to the arrival of the head (peak seismic amplitude)." The streamflow was meant to state streamflow is in the channel. We see the confusion. Deleted "(streamflow)"

Figure 4: it's interesting that there is an upward sweep of frequency on the vertical component, any idea why? There is a sweep in all the components, but the vertical shows the most consistent, probably due to the better coupling with the ground compared to the horizontal directions and what controls them.

Line 232: rephrase this sentence: changed to "so that the North component is aligned to be parallel to the flow".

Line 234: site effects cannot be ignored. See comment to major comment.

Line 236: give details on how the energy was computed and directionality. Changed to "The directionality ratio (DR) can be defined as the cross-channel amplitude divided by the flow parallel amplitude."

Line 237-241: add information here about physical reasons why the directionality would contain information about rheology changes. Added information about differences in signal between streamflow and lahar.

Line 265-266: I don't understand what multiple pulses has to do with bulking material that is differing from collecting material from erosion, maybe rephrase sentence. Changed to "or through the coalescing of multiple pulses to shorten the total length of the lahar"

Line 284: this is a vague statement, can you be more specific? The explanation is stated following this statement on lines 285-288.

Line 305: can you explain what is meant by a 4-phase lahar. Added "(see section 1.1)"

Line 364-365: here and elsewhere, are the speculations about flow style corroborated by the camera images or other data types that were collected. See figure 2 and refences to figure 2 throughout the manuscript. Also figure 7 for data relating to COLL. There were also eyewitnesses to confirm the camera images.

Line 405: unclear what is meant by "at different distance away from source". Source is the starting point of the flow event. Changed to "the mass flow source"

Line 435: This statement and the supporting evidence is one worth emphasizing more in the paper. We added some lines throughout to emprise this.

Line 444-446: is the change in directionality unique to when a lahar is passing by? Could it be differentiated from other seismic sources? This is an interesting idea and needs to be looked into in the future, but is outside the realm of this study, but would be a great future study to do. That said, the channel in question in this manuscript always contains streamflow, so the DR is always at "streamflow" levels when only recording "background" noise. Furthermore, DR of background noise in a "dry" channel was recorded at Colima, Mexico and was always high and indistinguishable from lahar DR, see Walsh et al., 2020.

Line 464-466: tilt is usually at much lower frequencies. Since no details were given on how the energy was computed for each component it is hard to assess whether this would have an influence or not. Details are given in the Data and Results sections. Also see the citation given that lead to the statement of tilt. Tilt has also been used as a detection method for mass flows in the past as well.