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Earth Surface Dynamics Discussions

Interactive comment on "Validity, precision and limitations of seismic rockfall monitoring" *by* Michael Dietze et al.

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We would like to thank the referee for the encouraging and helpful comments, all of them obviously devoted to improve the quality and impact of the manuscript.

Reviewer 1.1: *The detection of extremely small events is impressive and exciting. Good work on the locations - this is admitted difficult with a fractured surface and a moving source.*

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Reply: We are glad to see the positive impression our initial version of the manuscript made.

Reviewer 1.2*: P. 3 Line 16: Describe the characteristic frequency content in more detail (there is some discussion later, this may suffice, but I was wondering about it early on)*

Reply: Details given in future revised manuscript version (P.3, Line 16–17), with link to our example in figure 2 b and a reference from another study.

Reviewer 1.3*: P. 6 Line 29: Zimmer and Sitar 2015 may be a better reference for this close-range work (<1km) than Zimmer 2012 (at 6+ km) - V.L. Zimmer, N. Sitar / Engineering Geology 193 (2015) 49–60*

Reply: Indeed, the suggested reference is more appropriate and has been used in the revised version.

Reviewer 1.4*: P. 7 Line 16-17: "signal, i.e., several seconds rise time of the signal from background followed by a long decay into background noise after reaching a maximum amplitude" The 2012 paper dealt with a very large event at distance: smaller events did not always have the same signal (see Zimmer and Sitar 2015)*

Reply: The sentence has been corrected, the suggested reference (Zimmer and Sitar, 2015) is placed after mentioning the other mode of rockfall signals: "more erratic peaks in the seismogram as the result of impulsive impacts".

Reviewer 1.5*: P. 7 Lines 30-35: It's a little unclear how this method works, especially with a moving source - as you note below, the rocks are moving roughly vertically down the slope. It might be interesting in a future work to use this method for segments of the single and create a set of temporal correlations that together show the path? I'm not sure how this would work, but it would be interesting?*

Reply: Indeed, the location must be estimated for each impact individually to minimise smearing effects of a moving source. This is now mentioned in the text. Actually, the first author has submitted a further manuscript that explicitly shows how the method allows locating successive impacts of a complex rockfall sequence: http://www.earth-surf-dynam-discuss.net/esurf-2017-20/ (see figure 3).

Reviewer 1.6*: Table 1 - delta Pmax pre and post optimization: I'm not sure I understand what happens during optimization. Figure 7 looks like you have great location results, but this table seems to show that there was an iterative processing that eliminated some seismic locations and chose others based on additional evidence (e.g. TLS). Can you elaborate or make this a bit clearer? (this is explained later in the text)*

Reply: The description of the table is now improved: deviations with the default location frequency windows are now shown first, the ones with optimised frequency windows in brackets. Also, it is now noted that optimisation is only possible when independent information on rockfall locations is available, as was mentioned in the text further down, already. Additionally, figure 7 was updated. We changed two outdated location deviation values due to older calculations (31 instead of 37 m for event 1, 21 instead of 26 m for event 6). The figure caption does now explicitly mention that the location estimates are shown for optimised location frequency windows for illustrative reasons. In fact the difference would have been obviously visible only for events 1 and 5.

Reviewer 1.7: *P. 11 Lines 9: Is the 5-15 Hz (progressively decreasing signal) correlated with river baseline flow patterns (e.g. fluctuations in river flow due to increased evapotranspiration during the daytime?) Correlations of seismic/acoustic noise with river flow is hard to do, so it would be an interesting result if your instruments were sensitive to this.*

Reply: We have added a reference to the data source (runoff of the main river draining the valley) and an article providing background and agreement of the frequency pattern with our data (Gimbert et al., 2014). Indeed, the seismic signature of this frequency band shows a clear link to the runoff patters of the river, but this topic is a bit out of scope for the manuscript, though still valuable.

Reviewer 1.8: *P. 11 Line 14: I love this "Swiss trains always run on time". However, always is mis-spelled "alyways".*

Reply: We also love the term, and have corrected the typo.

Reviewer 1.9: *P. 11-13 and Figure 4 (environmental noise): I think this is one of the more interesting challenges to discriminating rockfalls from other sources (working toward automatic event detection). Good job identifying other sources and applying rejection criteria (including multi-station detection) to get down to 500 events, and then further confirming the identity of many of those spurious events.*

Reply: Indeed, the period of manual event filtering was an interesting exercise to learn patience. We have added the referees comment (identifying such small events is a challenge on the way to fully automatic detection systems) to the conclusions.

Reviewer 1.10*: Section 5.3 and 5.4: It took a bit of reading to understand the velocity estimate and the location methodology. The assumption is that the waves are arriving on a relatively direct path, but if they are not (if there is weathering, sheeting joints, and variable velocities), it may explain some of the location deviation from seismic-only methods. (Also the valley floor probably has a substantially lower velocity - accounting for that may significantly shrink your location polygons in the cases when Pmax extends to the valley floor- e.g. event 1 and events 6-8). Nevertheless, the fact that you were able to localize such small and mobile seismic sources to the degree that you did is impressive.*

Reply: The referee is correct, there are a series of modifications of the ideal medium under natural conditions. We discuss these potential causes for decreased P_{max} values now chapter 6.2, first paragraph.

Reviewer 1.11*: P. 19 Line 18: could some of the shift to lower frequencies be attributed to overall lower energy release and higher proportional attenuation of higher frequency signals? E.g. with less energy, the high frequency portion of the signal is too low to be detected above ambient noise?*

Reply: Indeed, we have added this alternative explanation to the discussion of this rockfall phase.

Reviewer 1.12: *P. 20 Line 17: sensu stricto, not sensu strictu?*

Reply: We changed the typo.

Reviewer 1.13: *Supplemental material: I tested the supplemental material, and ultimately got it working on my Windows machine (but not my old Mac). Except for the DEM portion (I did not download a DEM), it all worked as promised. Some minor challenges that I noted: Eseis needs: Version 3.3 of R or later (I have an old computer which can't use Version*

Reply: We thank the referee for also checking – and independently confirming the analysis by working with – the supplementary material. Indeed, the R package 'eseis' requires at least R version 3.3. This is due to the dependencies of the package, i.e., other packages that 'eseis' uses, and thus not in our hands. The first author of this manuscript just recently submitted another manuscript to the journal Ancient TL in which exactly this drawback of quickly evolving software is stressed. There are further shortcomings related to working with the package under other than Unix systems, as mentioned below. All these shall however be obsolete once the package is built for CRAN, the comprehensive R Archive Network, a step that is envisioned for the near future, once the pace of added functionality has decreased to a manageable level (cf. http://www.micha-dietze.de/videos/eseis_history.avi).

In summary, the first author is very delighted to see that curious and eager researchers indeed attempt and succeed to reproduce the results of the manuscript with the raw data published along with the manuscript, using free and open software. The first author sees this as a perfect example of open and transparent science, despite the efforts and pitfalls associated with going this way.

***Reviewer 1.14**: 3.3, are there older versions?) Eseis on Windows needs to be installed from your webpage - some of the compiled files aren't readable by Windows, but I did manage to make it all work!*

Reply: Correct, the Github repository of the package and the convenient functionality of the 'devtools' package to install 'eseis' from Github is not available for Windows platforms by default. On my website there is a note and link that help one to install the package 'devtools' on any of the common computer platforms.

***Reviewer 1.15**: Eseis on Windows also needs Rtools On Mac, (Error: Don't know how to decompress files with extension 17.1), might be related to Version 3.2 of R (unresolved)*

Reply: Indeed, running R version 3.3 is essential for installing and using 'eseis', which is in turn required to locate the events depicted by the raw seismic data. As noted above, there are not many alternatives to this (such as sourcing all relevant functions of the package source code by hand). The easiest solution would probably be to install a proper Linux system in a virtual box and therein an up to date version of R.

***Reviewer 1.16**: What data format and resolution does the DEM need to be in? USGS DEM raster*

Reply: The package in its latest version (already 0.3.2 now) has been revised and additional comments about supported file formates as well as projection constraints are added. The supplementary material has also been updated concerning the DEM file

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formats and metric units constraint. In general, any meaningful resolution of the DEM is suitable, depending on the relative size of the area of interest and target resolution.