

Interactive comment on “Analysis of the ground vibration produced by debris flows and other torrential processes at the Rebaixader monitoring site (Central Pyrenees, Spain)” by C. Abancó et al.

C. Abancó et al.

claudia.abanco@upc.edu

Received and published: 25 November 2013

Response to Review of Manuscript from Oldrich Navratil

We wish to thank Oldrich Navratil for his constructive suggestions to improve our paper. In the following, we will answer in detail his remarks and describe how the manuscript improved according to his suggestions and comments.

General comments:

1. Oldrich Navratil (in the following ON): The abstract is not clear for me: too many language approximations. More details and results are needed.

C1868

Authors (A): The abstract has been rewritten. More results and details have been included.

2. ON: P394, L20 to P4395, L8: You mentioned that the factors that influenced the transfer of the ground vibration to the geophones are: (1) the distance to the channel, (2) the material in the channel/banks and (3) the mounting structure of the geophone (in the soil, on the bedrock...). Does the water content in the channel and the banks (and its evolution during the rainfall event) could also influence this transfer function? What are the influences of all these factors on the signal amplitude and frequency? Could you please provide more references and state of the art with the “debris flow” literature but also “seismic” literature?

A: Water content in the channel bed and the channel banks may have some effect in the transfer function of the media. However, we consider that the relevance of the other factors (the ones mentioned in the ms) is much higher in order to consider that the influence of the variation of the water content can be neglected. An extensive review of previous works has been carried out and it does not seem to be a topic treated in other publications. More references on this aspect have been included in the revised ms.

3. ON: P4996, L9: please provide more information about the climate (rainfall mm/yrs, mean max-minT_C), location of rain gauges in the basin and rainfall events (mean, max intensitiesduration...), snow cover...

A: Information on annual precipitation is given: The annual precipitation ranges from 800 to 1200 mm. Further details on triggering rainfalls, location of rain gauges, etc can be found in Hürlimann, M., Abancó, C., Moya, J. and Vilajosana, I. Results and experiences gathered at the Rebaixader debris-flow monitoring site, Central Pyrenees, Spain, Landslides in press, 2013. This paper has been cited in the revised ms.

C1869

4. ON: P4397 L2: you provide no information about the material used except the geophones and the datalogger; what about the video camera, ultrasonic sensor...

5. ON: In the same way no information or methodology is given for the analysis of hydrograph you show us at Table 2

A: Again, we refer to the paper of Hürlimann, et al. in press for publication in Landslides.

6. ON: It would be also useful to show pictures (maybe at Fig 4) of the debris flow events, debris flood and rock fall (if you have) as it is your "reference" method with field observation to discriminate the torrential processes

A: We included some pictures in Figure 4.

7. ON: Construction of the paper: could you compile all your "method" sections (3.2, 4.1 and 5.1) into a single one in 3.2; it would simplify the reading of the paper. In the same way you can compile all your results in a same section (section 4). In a discussion section (sec. 5) you could give your analysis about the debris flow detection and the limits of such system

A: In previous versions of the paper we had structured the paper like ON suggests. However, we selected the present structure, because we thought, it was better to clearly separate the two different techniques. Since the principal purpose of the paper is the comparison of the outcomes that can be achieved from the two different methodologies of signal gathering, it may be clearer to explain the methods separately, and therefore the results also follow this separation of the two techniques.

8. ON: Why don't you present first the "high frequency" signal analysis and next the
C1870

"simplified" signal analysis? I think it would be more logical.

A: We agree with ON that this structure would be more logical in case of equality of data analysed. However, since the higher amount of data analysed in this paper refers to the "simplified" signal analysis, we think it is more logical to present the data from this station first, and then the "high frequency" analysis.

9. ON: P4399 L22 to 4400 L2: This paragraph should be in the section: analysis of "debris flow detection 6.3" rather than here

A: We agree and the paragraph has been moved.

10. ON: 6.2 and 6.3 are methodological issues; could you show them before the signal analysis in a first result's section

A: Since in Section 6.2 and 6.3 we use data from the events described in Section 4 and 5, we think it is more logical to leave these sections at the same position (after presenting the data of the events).

11. ON: P4402 L9: Fig 6 is too small to identify all the phases presented in the following section; please remove this section or provide a new figure; A frequency analysis would also be very interesting ;is there a change in the frequency during all these phases; at phase 2, can you identify different surges ? Is there a specific signature (amplitude/frequency) of the hyper-concentrated flows that generally follows the main debris front?

A: New graphs have been included to Fig.6 in order to incorporate the frequency analysis. Additionally, the corresponding section has been rewritten.

12. ON: P4405L21: you need to conclude; is the amplification of the metal box a problem or not? Is it only an amplification of the signal or can you also find a modification of the structure of the signal and its frequency?

A: The amplification produced by the sheet metal box has been proved for the geophones measuring impulses. In contrast, it has not been possible to quantify the effect of the amplification of the box on the amplitude and the frequency of the signal, because only the geophones measuring with impulses are mounted on boxes. In any case, the amplification is not a problem in the Rebaixader catchment. Without the effect of the boxes, it would have probably been necessary to include an extra amplification in the electronic circuit, due to the attenuation of the signal with the increase of the distance.

13. ON: To discriminate the processes why don't you use a frequency analysis (Fourrier analysis, wavelet...) on the raw output signals of the geophones?

A: As we mentioned in point 11 above, we included a frequency analysis in the revised ms.

14. ON: Fig 6a and c: on the geophone signal we can identify different surges, but on the stage signal (US device), there is only one front and next the signal remains constant: is it a problem of the US device (common with such device when used with debris flow) or can you find a physical explanation? Provide details in the text.

A: We removed the data from the US device in the new version of the ms, because it was not necessary. However, in order to answer the question of ON, the anomalous stage signal was, certainly, a problem of the US device. We agree with ON that this is common in debris flow monitoring with US devices and they would be probably substituted by other types of sensors, such as lasers or radars.

C1872

15. ON: You wrote that Fig6b corresponds to a debris flow but the stage time series would rather correspond to a flood as no front can be identified; please clarify;

A: The stage time series have been removed and the section has been rewritten.

16. ON: Fig 6c shows a problem with the US device; the "y axis" scales are different between the figures;

A: The new Figure 6 doesn't include US data.

17. ON: P4406 L17 to the end of the section: it is very difficult to follow you in this section because there are so many similar abbreviates: EMth IMP, EMthdur, GVth, Dth, maxEMthIMP/s, max over EMthIMP/sec, IMP/s, EMth

A: We simplified the abbreviations in order to help the reader following the section: Eth (Ethd, Ethl) and GVth. Also, we included the cross-reference of Figure 3 in this section, where the parameters are clearly defined in a flow chart.

18. ON: With an alarm system do you need to have so many parameters and thresholds (amplitude and duration)? Is it possible to simplify the system?

A: The "event mode threshold" (Eth) may be avoided for monitoring purposes, by recording the impulses signal continuously, although it allows to filter most of false events (events not caused by debris flows, debris floods or rockfalls). On the contrary the "ground velocity threshold" (GVth) is intrinsic for the signal transformation into impulses/second and can't be removed. To use the geophones as a warning or alarm system the purpose changes, since the detection threshold needs to discriminate between the "event mode" and "no event mode". The experiences gathered by

C1873

the authors show that the simplest way to achieve such a goal is by defining a fixed threshold of the impulses per second value and the duration the signal has to exceed this threshold to consider that an event is taking place. As it was mentioned above, the combination of these two thresholds is very useful to filter false events and also allows avoiding false alarms. On the other hand, thresholds combining process intensity and duration are frequently used for warning of hazardous processes (e.g. intensity – duration thresholds for warning of intense rainfalls and for warning of landsliding).

19. ON: At fig 9, for “y axis”, is it “max EMthIM/sec” or “EMthdur” ?; It is also difficult to understand these figures; please clarify and simplify;

A: The axis titles have been improved to clarify the points mentioned by ON. The y-axis is now called time over Ethi, which means that it indicates the number of seconds that the signal exceeds the threshold Ethi. This value should be used to define an appropriate duration threshold.

20. ON: For this analysis, you have the raw data, so you can lead the following sensitive analysis: how many false alarms would you obtain with different systems and signal thresholds?

A: The reviewer is right about the importance of a sensibility analysis such as the one proposed. However, more data would be necessary for such analysis. Since FLOW-SPI was installed in June 2012, the database of raw data is still short. This may be an interesting analysis to perform in the future.

Minor comments:

21. ON: Title: I would replace “produced” by “generated”

C1874

A: It has been replaced.

22. ON: P4390, L3: not uncertainties. Rather “approximation” or “ambiguity”..

A: It has been changed.

23. ON: L7: replace “time series” by “geophone signal output”

A: It has been replaced.

24. ON: L8: what do you mean by “identify events”?

A: To differentiate the events from other seismic sources (i.e.: to detect events). It has been mentioned in the revised ms.

25. ON: L8: provide examples, too ambiguous: “different types of torrential processes “

A: Examples have been provided. The sentence in the new ms is the following: “(. .) differentiate types of torrential processes, such as rockfalls or debris flood.”

26. ON: L9: How many events did you observed? What is the duration of the monitoring?

A: The monitoring started in 2009 and until summer 2013, 6 debris flows, 11 debris floods and 4 rockfalls have been observed. This information has been included in the revised ms, however, further information can be found at: Hürlimann, M., Abancó, C., Moya, J. and Vilajosana, I. (2013) Results and experiences gathered at the Rebaixader

C1875

debris-flow monitoring site, Central Pyrenees, Spain, Landslides accepted

27. ON: L10: What do you mean by not “registered”? “Recorded” would be better

A: This word has been changed.

28. ON: L10: the signals are not recorded by the geophone but by the datalogger.

A: We changed “recorded at each geophone” by “detected at each geophone” to avoid misunderstandings.

29. ON: L11: what does “the assembly of the geophone” mean?

A: This term is referred to the mounting system.

30. ON: L19: “the data collected by the sensor”: language approximation

A: The words “collected by the sensor” have been removed.

31. ON: L23: Please do not provide the url <http://www.....> in the text but you should add a reference A: A reference has been included and the url removed.

32. ON: L25: Why “Besides debris flow”?

A: We changed this word by “Apart from debris flows”.

C1876

33. ON: P. 4392 L5: Why “historically”?

A: We deleted this word.

34. ON: L22: language approximation: not “seismic data recorded” but “seismic signal recorded”

A: This word has been changed.

35. ON: P. 4393 L23-26: please simplify this sentence; it's not easy to understand

We have rewritten the paragraph. In the new ms, the paragraph is:

“Sediment concentration and boulder content alters the energy transmitted to the ground. Thus, on one hand debris flows can be distinguished from other torrential processes and, on the other hand the different phases of a debris flow can be detected (e.g.: Huang et al., 2007, Navratil 2013).”

36. ON: L26: I invite you to read our paper which deals with this question : High-frequency monitoring of debris-flow propagation along the Réal Torrent, Southern French Prealps, Navratil et al. 2013, DOI:10.1016/j.geomorph.2013.06.017 Geomorphology;

A: We are grateful to ON for the recommendation of their paper. We included the reference in the text.

37. ON: P4394 L2: replace “certain” by “fixed”

A: This word has been replaced.

C1877

38. ON: L6: "record the signal" not the data.

A: This word has been replaced.

39. ON: L8: references are missing;

A: New references have been included: (Arattano, 2000; Abancó et al., 2012; Navratil et al. 2011).

40. ON: L10: problem with the syntax of this sentence A: The sentence has been rewritten. The sentence in the new ms is: "Several features of moving debris flows have been determined due to the analyses of the ground vibrations time series."

41. ON: L11: "hydrograph" or water level time serie?

A: "Hydrograph" has been changed by "flow stage".

42. ON: P4395 L15: please replace "registered" by "recorded";

A: This word has been replaced.

43. ON: L18: replace "extension" by "basin area"; idem at L22

A: These words have been replaced.

C1878

44. ON: L20: define a.s.l.;

A: Above the sea level (a.s.l.).

45.

ON: L19: "located in", not "at";

A: This preposition has been corrected.

46. ON: Fig1: the instrumentation site is not clear: please provide a third and large figure at the local scale with the instrumentation deployed and the geophones' location;

A: Fig1b has been included. Figure caption is now: "Figure 1: a) The Rebaixader torrent, its fan and source area. Seismic stations (FLOW-WR and FLOW-SPI) and the corresponding geophones are indicated and labelled. The ultrasonic device is represented by a black line in the middle of the channel reach. Inset shows the location of the Rebaixader site; b) detailed location of the sensors at the channel section."

47. ON: P4396, L3: The geology of the source "area", not zone;

A: This word has been corrected.

48. - ON: P4396 L16 to 19: the distinction between those two stations is not clear for me

A: We included the reference to the paper Hürlimann et al. (2013) and we rewrote this part in order to avoid misunderstandings.

49. - ON: P4397 L13: you should explain again that FLOW-SPI is a high frequency

C1879

acquisition system; what is the frequency acquisition ? idem for FLOW-WR; acronyms are not very explicit;

A: We mention that FLOW-SPI is a high frequency acquisition system (250 Hz) in the revised manuscript. We did the same for FLOW-WR. SPI comes from SPIDER, which is the recording unit of the high frequency station, and WR stands for WIRING, which is the connecting system between all the sensors and the datalogger in the low frequency station.

50. - ON: P4398 and next: you use the term “Ground velocity signal”; I suggest you to replace it by “Ground Vibration Signal” that may be more explicit?

A: From our point of view it is clearer to use the term Ground Vibration Signal as a generic term of the ground movement recorded by seismic sensors (velocities, accelerations, etc). The output of the geophones in the Rebaixader site is a voltage proportional to a velocity, therefore we use this term to refer to the output signal of the geophones.

51. - ON: L3: I think that this signal preprocessing is not new, so please provide references;

A: ON is right, the technique is not new. In Abancó et al., 2012 the technique is explained with further details; therefore this reference appears in the text.

***** 52. -

ON: P4402 L22-L24: repetition: please remove “....and are about 100 times....debris flood.”

A: Section 5.2 has been rewritten entirely.

C1880

53. - ON: P4403 L17: I don't understand the first sentence, please modify it A: The sentence has been rewritten in order to clarify the meaning. “The ground vibration signal detected by the geophones in both seismic stations of the Rebaixader torrent is conditioned by site-specific conditions of the geophones.”

54. - ON: P4404, L5: Please provide a comparison of your results with the literature

A: A comparison has been included in this section. “The comparison of these results with the similar tests carried out at the Réal Torrent (Navratil et al., 2011) show similarities. Although at the Réal Torrent the higher amplitudes were found when the geophone was fixed on a big boulder embedded in a gravel deposit (situation not present at the Rebaixader), these were followed by the geophones placed inside the soil, which is similar to Geo6.”

55. - ON: L14: the title is not explicit

A: The new title is: “6.2. Assembly of the geophone and distance between flow path and geophone.”

*****56. -

ON: L19: “channel margin” or “banks”

A: This word has been rewritten.

57. - ON: Fig2d : we cannot see the geophone location;

A: Since the geophone is buried, it is not visible. The location is exactly the spot shown in the picture. We included this clarification in the caption of Figure 2.

C1881

58. - ON: Fig 8: please recall the mounting condition of each geophone on each fig: metal box, bed rock, distance...

A: This information has been included in the figure.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 4389, 2013.