

Interactive comment on “Integration of HVSR measures and stratigraphic constraints for seismic microzonation studies: the case of Oliveri (ME)” by P. Di Stefano et al.

Anonymous Referee #2

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Manuscript nhees-2-2597-2014 Integration of HVSR measurements and stratigraphic constraints for seismic microzonation studies: the case of Oliveri (ME)” by Di Stefano P. et al. (2014)

1. Adequacy and relevance of the paper The article focuses on the seismic microzonation of the urban area of Oliveri through a series of HVSR measurements and applying a clustering algorithm to optimize the calculation of the HVSR curves with the purpose of identifying reliable HVSR peaks/reflectors in the 0.6-10 Hz frequency range. A second clustering technique based on the central frequency and amplitude of each peak is applied to identify subsets which can be attributed to continuous spatial phenomena.

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Furthermore, the authors state that the results are constrained by stratigraphic data extracted from a borehole.

The stated objectives are: to identify those places of the explored area which could suffer significant site effects, in addition to define a preliminary V_s -depth subsurface model valid for the investigated zone (page 2). However, the authors say at the beginning of the conclusions (lines that should be part of the introduction): “The main purpose of this work is not, of course, to present the complete results of the first level microzonation study carried out in an urban center of an area of high seismic hazard, but to show how a survey performed by the HVSR method applied to ambient seismic noise, thanks to some significant improvements affecting data processing, can provide results that go far beyond the simple identification of possible site effects at frequencies of interest in earthquake engineering. In this study, the most innovative aspects concerning seismic signal processing are based on the use of clustering techniques which are applied in two stages” (page 22). Thus, I understand that the key geophysical problem consists of checking a clustering procedure with the target of improving substantially the results provided by the standard HVSR method.

That said, I am surprised by the contents of the manuscript. Sincerely, how the clustering technique works is a mystery for me. Not even Figure 5 is well explained, which is supposed to be key in the performance of the proposed working method (it is obvious the lack of explanation in the figure caption and of course in the principal text). It is true that authors make reference to other two manuscripts about the same topic, but still are unpublished. As a general rule, references to unpublished studies are not admissible. In this sense, the manuscript contains some deficiencies in arguments and is not entirely intelligible, at least is not clearly presented (sorry, this is my opinion). Logically, this greatly hampers the study now commented.

Furthermore, the whole article is written in a fuzzy way, unclear, difficult to be understood, not well organized or presented, and on the other hand the implementation of the indicated methodology is far from being clear for a potentially interested reader in

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the subject. The manuscript is clearly unbalanced and is especially cumbersome as it relates to sections 1 (introduction) and 2 (geology) when compared to other subsequent sections related to the physics. Moreover, some title or subtitle of section or subsection should be rewritten/changed for clarity.

In summary, the paper, although in principle is interesting to the extent that proposes a significant improvement ("an innovative procedure") when using HVSR measurements, is however technically deficient because all is not enough contrasted, since some theoretical-practical issues need a thorough revision before admitting the real significance of the working method and to think about future practical applications.

2. Style and presentation issues The manuscript is not properly organized as mentioned above. The text, leaving aside its inherent difficulty and peculiarities, can be substantially improved both formally and technically.

The literature list can be considerably shortened including only the necessary bibliographic references (but not other studies or unpublished works to date). Of course, all references cited in the text must be given in the final list and vice versa, and also they must be all written according to the standards of the journal.

Lastly, most of the figures and their respective captions can be improved.

3. My recommendation My recommendation is that the manuscript must be carefully revised according to the above comments and the more specific ones that are given below.

Major issues First of all, the frequency range of interest is not clear for me. I read 0.6-10 Hz in the abstract (page 2). In section 3, I see 0.1-20 Hz (page 13), after 0.6-20 Hz (page 14), after 0.7-2.6 Hz (page 14). In section 5 a reference to the range 0.7-1.4 (page 18) is made. This should be clarified satisfactorily giving account for any variation.

Leaving aside the great amount of text devoted to geology in previous sections, my

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main criticism concerns sections 3, 4 and 5.

After dealing with a long dissertation in previous pages, we finally arrive to the essential point of the problem here addressed (in page 14 nothing less). This point is the "Agglomerative Hierarchical Clustering (AHC) algorithm, which is selected by testing different hierarchical and non-hierarchical clustering algorithms. We used as proximity measure the Standard Correlation (SCxy) together with the average linkage (AL) criteria (D'Alessandro et al., 2014a). This procedure allowed us to split, almost automatically, peaks probably linked to site effects from other perhaps related to source effects". As I already said, I can hardly understand this part (pages 14-16). How the clustering technique works is a mystery for me. This has to be explained in order and with detail, step by step, with special emphasis on the discrimination between each other peaks, and with particular attention to the stratigraphic peaks characterized by a minimum in the spectral component of the vertical ground motion because of the Rayleigh-wave annihilation at the resonance frequency. The tale of how AHC operates on the HVSR is key to understand the mechanics of the technique applied. Otherwise the work would not meet the announced improvement and would be difficult to understand for a potential reader.

Again we arrive to other essential issue as is a second clustering (pages 14-15) "to group peaks of HVSR average curves related to different sites, so as to identify areas characterized by site effects, which because of the similarity in frequency and amplitude of the corresponding HVSR peaks and the not excessive distance between the measuring points, are probably caused by the same buried structure". The idea is good. I agree with this approach. In other words, it is an attempt of assessing the lateral continuity of possible seismic reflectors. The authors say: "We implemented a clustering procedure to be applied to the parameter vectors that characterize the individual peaks. Each vector contains: period/central frequency, amplitude, coordinates and a parameter indicative of the outcropping lithology. The number of vectors is equal to the number of peaks considered significant". O.K. "The procedure is based on an

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Agglomerative Hierarchical Clustering (AHC) algorithm, using the average linkage (AL) criteria". I agree. The text continues: "To disadvantage (?) the inclusion in the same cluster of more peaks relative to the same measurement point, the relative distance of coincident points was placed equal to 1 (?)". It is only after this point that the text is not clear to me and consequently the way to proceed. Again I find a very confusing text. Furthermore, the attribution of weights to the various parameters involved in the calculation is not justified at all.

Moreover, to what extent it is possible say that the same HVSR peaks at 2 close sites are coming from the same reflector? This should be well clarified.

Figure 5 is key regarding the performance of the proposed working method. What mean the numbers of the horizontal scale? Either in the text, or in the figure caption, the results obtained by clustering, especially the three clusters called R, G and B, have to be presented with more detail.

One can read: "...adopting a cut threshold slightly lower than the optimal one adopted by the calculation code ...". What optimal threshold? What does this mean? Do the authors want to say that the resulting clusters depend on a threshold that nobody knows how it is chosen? This has to be made clear.

One can read: "... in the diagram H/V vs. Fo ...". What is Fo?

Which is finally the adopted model to start the inversion process of the HVSR curves (page 18)? I understand the model is constrained by the information extracted from a borehole, and "From this model estimates of the S wave velocity were obtained, which were subsequently used to define the starting model for the inversion of the other (?) HVSR curves". Well, I would like to see a description or better yet a graphical representation of this starting model. Another possible mistake (page 19): "... evaluation of the thickness of the cover did not take into account the available seismic down-hole data ...". How to reconcile this with the above?

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Lastly, I miss a thorough discussion about the reliability of the solution obtained by inverse modeling (Figure 9). This subject is intrinsic to any inverse problem and both the error of the solution and the resolution achieved in the approach are issues that need an analysis before admitting the velocity-depth and density models. I do not see anywhere the treatment of so important aspects. In addition, due to the non-uniqueness of the solution of any inversion problem, I consider this topic is worthy to be thoroughly studied.

Minor issues (style and presentation issues) First of all, which is the meaning of ME? This acronym (page 1) should be removed if it is not relevant. Where is Oliveri? In Italy, yes, but where? It would be better write Oliveri (north Sicily) as a part of the title.

The authors often use very long phrases and this hinders the understanding of the text. Please, use shorter phrases throughout the text if possible. Also, they abuse of separate paragraphs systematically when should try to give more continuity to their arguments and use point and followed. This is observed along all the text and should be fully corrected.

Pages and pages have been written (often repeating known concepts or else results already obtained in previous work) before entering fully into the treatment and resolution of the problem. The paper is really long (many concepts are repeated several times, up to 3 or 4 times throughout the text) and quite unbalanced in the contents. Sections 1 and 2 have to be shortened but keeping the key items that enable a good and well ordered introduction to the problem, and providing the corresponding references (which not always are given, for example in the second paragraph of section 1, top of page 3, and in other cases). I understand that the problem is essentially of geophysical character, which is solved by applying a typical geophysical analysis method, HVSR, although in this case with the help of a clustering algorithm. If so, I sincerely want to see more physics and less geology.

In any case, my suggestion is to make a right introduction of the HVSR technique in

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section 1 together with a good description of the nature of the ambient seismic noise making a short reference to diffuse wavefields. Other thing: the correct expression is "This paper focuses on ..." (top of page 5).

Another suggestion is a new title for section 2, "The study region", and its division into two subsections 2.1 and 2.2 (from the line "The Oliveri territory is located in the area 932 ...", page 7) with the subtitles "Seismotectonic setting" and "Regional seismicity", respectively, both of them properly organized and shortened.

By the way, magnitude $M_w=6.15$ (page 9) is at least strange (since it has more than two significant digits) and must be probably erroneous for a historical earthquake dated in the 18th century (1786). It could be 6.1 after being estimated from a previously tested intensity-magnitude relationship and applying right conversion formulae.

The completeness threshold "equal to about 2.6" (page 9) requires a convincing explanation and the corresponding reference if appropriate.

Likewise, section 3 can be simply titled "HVSr measurements" for after distinguishing two subsections 3.1 and 3.2 (from the line "To try to identify areas of the town of Oliveri ...", page 13) with the subtitles "Background and points under discussion" and "Implementation", respectively, both of them equally organized and shortened, especially the first of them, that is section 3.1.

Many concepts can be found in SESAME (2004) and therefore section 3 can be properly shortened.

Sorry, I do not understand the sense of the words "capability of the HVSr curve to mimic the HVESr curves" (section 3, page 12). There are other phrases in the text that I neither understand very well. For this reason, let me insist on polishing the language as much as possible.

Another cryptic phrases for me are (section 3, page 12): "In particular, increasing of the processing duration of the (?); producing results whose reliability depends on the

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skill of the operator. The permanence of abnormal (?) windows can cause bias of the estimates of the expected value and the dispersion of the set of selected curves can lead to overestimates of the true uncertainty of the spectral ratios".

Section 4 should be entitled "Clustering technique and frequency maps". But here the key issue is to explain in detail the procedure to be easily understandable (and without making reference to unpublished papers).

Section 5, now titled "Bedrock mapping by inversion of HVSr measurements", is essential and deserves any effort aimed to clarify the inversion process of the H/V curves. By the way, "the available geological information", so mentioned in the text (page 17), is not "reported" in Table 1.

Section 6 (pages 20-21): Is really necessary more geology after everything said in the opening sections? Could not this section be shortened at least a bit?

The conclusions must be written only one time (in section 7, not before) and all together in a summarized way, and in a direct and understandable style. In fact, the first 8 lines in section 7 (page 22) can be removed from the text (it is supposed that are part of the introduction). Only the following paragraphs deserve to be carefully presented.

The bibliographic references (pages 24-29) have to be the fair ones, neither many nor few, only those necessary (of course, those works in preparation or in progress have to be removed from the list).

About the illustrations: Geographical coordinates must be included in the corresponding illustrations (Figures 1, 2, 7 and 10). As a general rule, sizes of letters and numbers on scales should be increased (Figures 3, 4, 5, 6, 7, 9, 10 and 11). In the caption of Figure 6 must be: ..."for the three HVSr clusters...". Additional text should be added in some figure captions in order to allow the easy understanding of the results that are shown in each illustration (without having to back to the main text of the article) (Figures 3, 4, 5, 6, 7, 8, 9 and 10).

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