

Interactive comment on “A hybrid model for mapping simplified seismic response via a GIS-metamodel approach” by G. Grelle et al.

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Referee #2 – AUTHORS: Many thanks to the anonymous referee, of whom we are very curious to know his/her identity, for the excellent review, undertaken with extraordinary detailed and accuracy. The time and the competence given to us has helped to improve the communicative aspect of our article. This anonymous referee reviewed the article with detailed precision and suggestion of possible solutions...therefore many thanks.

–REFEREE: Dear Authors Grelle, Bonito, Revellino, Guerriero and Guadagno, Dear Editorial board of NHESS, Töpfer Hereby My review comments. But first congratulations with the excellent work behind the modelling, python coding and data structuring

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and input. 1. General comments (according to the NHESS criteria) Does the paper address relevant scientific and/or technical questions within the scope of NHESS? Yes about earthquake hazard and local variations due to soil conditions. Does the paper present new data and/or novel concepts, ideas, tools, methods or results? Yes it is a new concept in site characterization. Are these up to international standards? Yes.

– AUTHORS: Many thanks for your appreciation.

–REFEREE: Are the scientific methods and assumptions valid and outlined clearly? Mostly yes, the 'outlined clearly' might be improved, especially for a more general audience.

–AUTHORS: We have tried to improve the language for a more general audience, although the topic needs to use highly technical terminology.

–REFEREE: Are the results sufficient to support the interpretations and the conclusions? Yes, however it remains a model.

–AUTHORS: Yes, it is a computational model trained on physical models that aims to meet the layered lithological setting regarding the distribution of seismic response.

–REFEREE: Does the author reach substantial conclusions? Yes Is the description of the data used, the methods used, the experiments and calculations made, and the results obtained sufficiently complete and accurate to allow their reproduction by fellow scientists (traceability of results)? Mostly yes for the methodology. The input data into the model is not really presented. Does the title clearly and unambiguously reflect the contents of the paper? Yes. The terminology in the title is rather technical but this reflects the rest of the text.

–AUTHORS: Yes, the topic of the paper is mainly focused on the description of methodology.

–REFEREE: Does the abstract provide a concise, complete and unambiguous summary of the work done and the results obtained? Yes, although it might start with the

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interest for the public = reduce risk at local scale by modeling site response. Like in the last sentence of the abstract. Are the title and the abstract pertinent, and easy to understand to a wide and diversified audience? both may be made less technical.

–AUTHORS: The abstract has been modified by also taking into account these suggestions.

–REFEREE: Are mathematical formulae, symbols, abbreviations and units correctly defined and used? If the formulae, symbols or abbreviations are numerous, are there tables or appendixes listing them? OK. Is the size, quality and readability of each figure adequate to the type and quantity of data presented? OK, but almost all captions contain insufficient instructions to understand the figures and tables.

–AUTHORS: We have improved the descriptions in the captions in figures 3, 4, 5 and 6

–REFEREE: Does the author give proper credit to previous and/or related work, and does he/she indicate clearly his/her own contribution? Yes, OK. Are the number and quality of the references appropriate? OK. Are the references accessible by fellow scientists? Yes. Is the overall presentation well structured, clear and easy to understand by a wide and general audience? This might be problematic. But NHESS readers are probably not a general audience. Is the length of the paper adequate, too long or too short? OK.

–AUTHORS: We agree with the referee

–REFEREE: Is there any part of the paper (title, abstract, main text, formulae, symbols, figures and their captions, tables, list of references, appendixes) that needs to be clarified, reduced, added, combined, or eliminated? Main text contains some grammar and spelling mistakes. Figure captions are too concise and abstract may be rewritten for a more general audience. Is the technical language precise and understandable by fellow scientists? Mostly yes, sometimes not due to some broken English. Is the English

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language of good quality, fluent, simple and easy to read and understand by a wide and diversified audience? It is well readable but contains several small grammatical errors and some unclear sentences.

–AUTHORS: We have corrected the grammatical errors and improved the English language used.

–REFEREE: Is the amount and quality of supplementary material (if any) appropriate? No supplementary material available. 2. Specific comments The readability of the manuscript can be greatly improved by a native English speaker/writer review (I am not, but i've done my best in the next section 'Technical corrections'). The way many sentences are constructed adds to the complexity. The topic is difficult but the language should not be.

–AUTHORS: The paper was reviewed by a native English speaker but now an additional review has been performed.

–REFEREE: The abstract could benefit from an introductory sentence that introduces earthquake hazard and its spatial variation due to sediment amplification as a concern for everybody, especially those in high risk area's. This may persuade readers to have a closer look. The relevance to the public is repeated at the end of the abstract where the hybrid model is applied to a real case. At the end of the abstract I would advise to add, in short, the conclusions of the application of the modeling procedure to the real 'test' case. What new results are obtained and how did the model perform Something like 'The result of ... maps with the spatial distribution of acceleration response spectra at 8 different periods of shaking The modeling procedure performed well (robust and accurate) at the control points in the back-validation.' The middle section of the abstract could, in my opinion, be shortened and simplified to highlight not how painfully difficult the work (certainly) is but rather your new approach to model the spatial variability of sediment parameters which are not abundantly available in most settings and of the resulting soil response and the spectral response at surface level. My main advise is to

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check if every difficult word which might 'scare' people is really needed in the abstract. A probably too extreme example: 'This discretizes the seismic underground half-space in a pseudo-tri-dimensional way' contains the same information as 'The area and its subsurface are divided into blocks'. The same language simplification may be applied in the main text, but here it is not that necessary. The specific terminology used in modelling, Hazard and site response should be kept in the main text for clarity.

–AUTHORS: -The abstract was for the most part re-written taking into account the suggestions of the referee:

"In the earthquake prone area the site seismic response due to lithostratigraphic sequence plays a main role in the seismic hazard assessment. A hybrid model, consisting of GIS and metamodel (model of model) procedures, was introduced with the aim to estimate the 1D spatial seismic site response in agreement with spatial variability of sediment parameters. Inputs and outputs are provided and processed by means of an appropriate GIS model, named GIS Cubic Model (GCM). This consists of a block-layered parametric structure aimed to resolve a predicted metamodel by means of pixel to pixel vertical computing. The metamodel, opportunely calibrated, is able to emulate the classic shape of the spectral acceleration response in relation to the main physical parameters that characterize the spectrum itself. Therefore, via the GCM structure and the metamodel, the hybrid model provides maps of normalized acceleration response spectra. The hybrid model is applied and tested on the built-up area of the San Giorio del Sannio village, located in a high-risk seismic zone of Southern Italy. Efficiency tests show good correspondence between the spectral values resulting from proposed approach and the 1D physical computational models. Supported by lithology and geophysical data and corresponding accurate interpretation about modelling, the hybrid model can be an efficient tool in the assessing of the urban planning seismic hazard/risk".

–REFEREE: Throughout the article it is sometimes difficult to know where you are in the modelling process and how much (or few) original measurement data is rep-

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resented. Possibly you could add the geo-data or an impression of it as electronic supplement. The hybrid model validation is performed for four down-hole locations where the sediment parameters are known but this data was probably also used as input in the GCM and the depth dependent litho-dynamic units. In this situation a good fit between model and input is to be expected. Another test would be how well would the model perform at a new site or after removing all the input geodata at one of the four down-hole sites? Maybe I miss the point here as I am not a modelling expert.

–AUTHORS: Regarding this, the text was improved as follows :

"The performance in efficiency of the hybrid model is validated on four down-hole locations where the stratigraphic-logs and the velocity profiles are experimentally known (figure 10). In this regard, we highlight that in the proposed computational model the data of down holes, as well as any data coming from direct or indirect geophysical tests, are used in the build and characterization of the model at the same way. Specifically, the one or more seismic-layers can be associated at one litho-dynamic unit, therefore Vs-h values are part of cloud of values coming from different location and in great part from different geophysical tests such as site-geotechnical correlation tests. In addition the 1D Vs-h models of zones used in the training of hybrid model are obtained using random driven Montecarlo distribution technique; therefore, these training models can be more or less close to the seismic-layer profiles detected by the specific site survey. Therefore, in term of validation, down holes data considered in input does not directly ensure the good fit between model and down-hole input data responses."

–REFEREE: The discussion of the uncertainties or simplifications in the model at Pg 13 lines 9 to 17 seems short.

–AUTHORS: This topic was improved in the discussion:

"The simplification involves many components of the model, each of them influencing different degrees of the estimation/prediction performance of the very same model. These simplifications include: i) the coherent identification in term of Vs-depth values

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distribution of the litho-dynamic units. In fact, in the identification of lithodynamic units, subsequently number of layers and consequently the zones, the modeller should be taken into account of a appropriate distribution of Vs-z values. In some cases, this condition shows as the geophysical e geotechnical proprieties of soils can be decisive in the build of GCM model compared with use exclusive of recognizing of lithologic typology. ii) the efficiency of a prediction model (metamodel) for any given 1D-layered model zone: this aspect is connected to fitting errors which are ordinary in data driven models ; iii) the uncertainties and approximations due to the 1D numerical modelling when it is used in contemporally with a complex-layering or topographic setting; iv) in minor part, the techniques used in the spatial distribution of layer thicknesses"

and in the conclusion: "In conclusion the hybrid model proposed and described in this paper is mainly a spatial computational tool able to deliver data about stratigraphic seismic response on the basis of the trained model built using geological, geotechnical and geophysical dataset. Therefore, the success of the model in the areas seismic characterization is strictly dependent on abundance and quality of the data input and at the same time on the ability in the modelling-design and data interpretation of the geoscientist or technical operator."

–REFEREE: The twofold explanation of the theory of the model first and then the application to the case study is good. This way there is redundancy in the presented methodology and it's application.

–AUTHORS: We are happy that the referee is in agreement with this structure of the paper.

–REFEREE: In the Discussion and the Conclusions section, there is no real reference to the relevance of this study for the general public and more specifically for the people at Giorgio del Sannio. What do the values mean and how can/will/should they be used for new and existing buildings?

–AUTHORS: We are included this part in the discussion: "In the study area the distri-

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bution of NSAT(x,y) shows that for periods between 0.2 and 0.4 seconds the spectral amplification is the greatest reaching values near to 2.0 in a north sector where more recent fluvio-lacustrine deposits and a great thickness of covered layer sequence are present. In addition this spectral range is near to the fundamental vibration frequency of great part of existing buildings." and in the conclusion : "In conclusion, considering the nature of the mapped quantitative information, the hybrid model aspires to perform a third level of reliability (ISSMGE-TC 4, 1999), therefore it is able to deliver quantitative information in the urban planning about the safety measures of the pre-existing build infrastructure and regulate the designing of new."

–REFEREE: The captions of most of the figures should contain more information about what is shown. The graph inset of figure 9 and especially the range of fundamental periods of zones is difficult to understand because the second scale is also the color legend of the period disagregation for the different zones.

–AUTHORS: The graph in figure 9 was modified taking into account the referee suggestions

–REFEREE: 3. Technical corrections These are suggestions by a non-native English speaker who can make mistakes too but who can miss mistakes while reading as well. At several occasions there seem to be double spaces in the printed version. This is maybe just due to the typography but it can easily be checked.

–AUTHORS: We have checked and corrected the double space.

–REFEREE: VS, the expression for shear wave velocity, is written with capital S in subscript (if I am well informed)in this article it is capital V with small s further comments are structured as follows;

–AUTHORS: We have checked and corrected.

–REFEREE: Page nr-line nr: 1-12 'An Hybrid model' = 'A hybrid model'. 1-17 to help the reader, add commas after 'metamodel' and 'function'.

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–AUTHORS: We have corrected it.

–REFEREE: 1-22 'regarding' = 'based on' or 'calculated from' 2-1 consider changing 'Conversely from' to 'In contrast to' for the general audience 2-3 consider deleting 'usually' this is incorporated in 'Many building codes' at start of sentence 2-4 consider deleting 'mainly' this is incorporated in 'Many building codes' at start of sentence 2-4+5 consider changing sentence to '...expressed in terms of spectral acceleration at surface level, derived from spectral acceleration at bedrock level in combination with the amplification due to the sediment column.' or something similar. 2-10 omit the abbreviated first name letter from the 'Kolat et al., 2006' reference. 2-11 'seismo-induced' = 'seismic-induced' seems better to me but not certain 2-12 'To this regard' = 'In this regard' 2-12 to 14 consider changing sentence to '...based on either experimental geophysical methods, such as dynamic low strain (linear) measurements, mainly from ambient noise, or else numerical simulation methods of linear or non-linear stress strain ...' 2-18 to 21 rewrite sentence, message is not clear. The 'However' at the start does not represent a juxtaposition with the previous sentence whereas the 'in addition to' near the end is a change from positive point to criticism of H/V method. 2-23 'characterized' = 'characterize' 3-1 consider 'In the light of ...' = 'Building upon ...' 3-7 to 10 can this be rephrased in a clearer or simpler way to avoid confusion with 'some Hokus Pokus was applied' or refer to the paragraph where it is explained in more detail. 3-30 'regards' = 'regard'. 4-8+9 consider changing to '...corresponds to a "litho-dynamic unit" with specific lithology and dynamic properties. This "litho-dynamic unit" is mainly defined in ...' 4-10 'secondarily' = 'secondly' but can be omitted. 4-13 not sure what is meant by 'fully extended' probably you mean in the matrix of the model as explained in the next sentence. 5-8 to 18 As reader I expect to see the minimum depth and layer thickness value which is used in this study but it is not given.

–AUTHORS: For the case study the thickness distribution has been better illustrated in figure 6.

–REFEREE: 5-15-16 consider changing to '... indicating the absence of the litho-
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dynamic unit.' 5-21 'Shear waves' = 'Shear wave' 5-23 to 26 consider moving ' , the function is a non linear...' together with equation [1] upward after 'To a space-invariant function'. After equation [1] the sentence 'Rigid bedrock assumes...' introduces equation [2]. 6-2 consider changing to '... representative values as they take into account the increase...' 6-6 'regression Vs' = 'regression for Vs' 6-32 consider changing 'admit inversion' = 'allow inverted' 7-6 'waves' = 'wave' 8-1 'layering' = 'layered' 9-21 change to either '

–AUTHORS: We have corrected all the technical notes as suggested

–REFEREE: Bk are the polynomial coefficients' 2* plural or else 2* singular 'Bk is the polynomial coefficient'.

–AUTHORS: We have corrected in " while bk are respectively the four coefficients of polynomial function."

–REFEREE: 10-33 Not clear what 'smaller, thickened' means in this sentence. finer grained, but a thicker package? or coarser grained and thinner package? 11-3 again 'thickened' here i suggest to put 'thick'. 11-21 consider changing 'in relation to' to 'than' 11-33 'simulate' = 'simulated' 12-1 'simulate' = 'simulated' 12-12 reference link missing to (NTC 2008), this reference is also missing in reference list 12-18 'aforementioned' = 'aforementioned' 12-19 consider changing to 'north-south component of the real time history' 12-24 'granular' = 'grain' 13-10+11 consider replacing 'this aspect may be attributed to the following features:' by 'These simplifications include:'. 13-13 what does 'is associated with such a coherence;' mean? do you mean 'depends on this identification;'. 13-22 'spectra' = 'spectral'. 13-26 'spectra' = 'spectral'. 13-28 to 30 consider changing to 'The identification of the average shear wave velocity of the shallow layers, Vsup, must be carried out with accuracy. 13-30 unclear what 'defined taking into account that it is referred to a litho-dynamic unit' maybe add comma after 'defined' or better rephrase. 14-3 'estimate' = 'estimation' and 'amplified' = 'amplification'. 14-4 'errors disaggregated' = 'errors of disaggregated'. 14-5 'that error' = 'that the

error'. 14-6 'subordinate to' = 'less near'. 14-17 two times defined in different context in the sentence. Maybe replace the second by 'spatially predicted' or something similar. 14-21 'consider 'regarding' = 'from' 14-22 consider omitting 'observable' 14-25 'shear waves velocity' = 'shear wave velocities' 15-9 after 'third level' add again the reference to (ISSMGE-T4, 1999) and maybe change to 'third level of reliability' or something similar.

–AUTHORS: We have corrected all the technical notes as suggested

–REFEREE: Figures and captions 19-2 Figure 1 'identification of the litho-dynamic units units' delete the extra 'units' or do you mean the physical units that describe the litho-dynamic units? 22-1 Figure 4 is 'survey' the same as 'borehole'? 24-2 Figure 7 'Simulate' = 'Simulated' and also comma after 'Vs-profiles'. 24-3 'in NERA' = 'in the NERA'. 26-1 Figure 9 'No Smoothed' = 'Unsmoothed'. 26-4 'showed' = 'shown'.

–AUTHORS: We have corrected all the technical notes as suggested

Please also note the supplement to this comment:

<http://www.nat-hazards-earth-syst-sci-discuss.net/2/C432/2014/nhessd-2-C432-2014-supplement.pdf>

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