Reviewer Comments natural hazards and earth system sciences
Manuscript Number: egusphere-2023-1370

Introducing inferred geomorphological sediment thickness as a new site proxy to predict ground-shaking amplification at regional scale. Application to Europe and Eastern Turkey

Karina Loviknes, Fabrice Cotton, Graeme Weatherill

The authors have tested the geomorphological sediment thickness (GST) and classical local soil-conditions proxies such as Vs30 in response to this question: Is GST a relevant global site proxy for PSHA analysis. To do this, they used site-to-site residuals issued from Kotha FAS-Model.

The selected study areas and proposed methodology are of scientific and engineering interest, aligned with the scope of the natural hazards and earth system sciences.

However, the claim that the developed model is based on site-to-site residuals using linear regression is questioned, the organization of the different sections can be improved, and the manuscript lacks adequate explanation in a few areas for a reviewer to fairly assess the technical quality of the study:

1. General remarks

In my opinion, the use of delta_S2S residuals (which is considered here as an epistemic uncertainty) is strongly linked to the Kotha model. To validate the method, several GMMs need to be considered and it needs to be proven that the delta_S2S values do not depend too much on the GMM used.

For me, the simplest way is to deduce the amplification from the FAS ratio and to find a correlation between this ratio and the site proxies. e.g. if this ratio = 2 its interpretation is simple, but with a delta_S2S=-1.5 how can we interpret it especially this study targets ESHM20 by proposing a regional proxy (GST).

With this study we remark that Delta_S2S=f(Proxy) is an heteroscedastic model (Khota model). This Heteroscedasticity lead to biased estimates of the standard errors of the regression coefficients. This can make it difficult to determine the significance of the coefficients and can lead to incorrect conclusions about the relationship between the proxy in the model.

Additionally, heteroscedasticity can also affect the efficiency of the parameter estimates, leading to less precise estimates than would be obtained with a homoscedastic model. I know you are looking for this heteroscedasticity, since the GMM (Kotha) model does not contain any proxy representing site effect. However, I'm wondering if, can you add a site proxy (e.g. GST) to the GMM model to ensure that the delta_S2S follows a homoscedastic model (goal is to validate GMM model).

Why did you use linear regression to have Site amplification factor ?. Site behavior is so complicated that a simple linear model is insufficient to consider the underlying physics. Or use small strain conditions to remove nonlinear effect. In addition, delta_S2S. In this sense, it must be shown that the model developed does not suffer from underfitting.

And I wonder how to obtain the amplification value with delta_S2S. Finally, if this is a sensitivity study, it should be mentioned in the title. Like : **Using site-to-site residuals to testing the Relevance of geomorphological sediment thickness as a regional site proxy. Application to Europe and Eastern Turkey**

2. Specific Remarks

- Eq 1: Why did you not use the site term (e.g. Vs30 inferred) as an explanatory variable for the site effect (fixed effect), this helps reduce random variability; and the delats2 are used to consider uncertainties that are not taken into account by Vs30 (i.e. For example, if *VS* 30 is used for site classification, two sites with the same *VS* 30 can still have significantly different site profiles and therefore have different site amplifications).
- Eq 1 is a non-linear functional form; why did you use linear mixed effect model rather be non-linear model like INLA ?.
- Line 114 : rationalization ? do you mean regionalization.
- The use of a GMM model such as the one used in this study may complicate the interpretation of the results. I suggest you try a site amplification model: Amp(FAS_sur/FAS_Downhole) This way, you would only have delta_S2S and delta_Amp (describes the record-to-record variability of the amplification at site s for earthquake e).
- To make sure there's a correlation between amplification factor (AF) and delta_S2_S, I'd like to have a figure that gives Amp vs exp(delta_S2S). Amp=FAS_soft_soil/FAS_Rock. You can use the EC8 classification.

- In figure 3, I wonder if the (non-Gaussian) distribution of geomorphological sediment thickness (e.g. more than 800 sites have H=0-2 m)... is this non-uniform distribution taken into account when building the model?.
- In eq 6, log is 't log10 or Ln ?. Also does Ys(f,Proxy) represent delta_S2S ?.
- I'm not convinced that delta_S2S can represent amplification itself. But rather the epistemic uncertainty of the site effect part (closely linked to the GMM used). In addition, amplification is normally unitless. However, here, delta_s2s takes unit of the FAS. Thank you for explaining this to me.
- Line 214 : extreme values or outlier value ?.
- Line 217 : What do you mean by "fold cross validation test". Give us some explanations. And why "10" fold ?.
- Figure 5, usually with classical GMMs, we have Vref (e.g Vs30 = 760 m/s), here we don't see this threshold why ?.
- Eq 7 is nothing more and nothing less than the residual equation in equation 6. Why named correction term?. I would like to see a figure that gives the delta_S2Scor vs proxies for some frequencies, it gives us an idea on the presence or not of bias.
- You have chosen 0.46-9.9 Hz frequency range…I want to see the same curves as Figure 7, but for a wide range, e.g. 0.1 to 100 Hz.
- In line 304, you wrote: "The object of this study is to predict regional site amplification over a large area using regionally or globally available site proxies". In my view, this sentence must be in "introduction part".
- The comparison between Figure 8 (training phase) and Figure 3 (testing phase) are not consistent. In fact, you have to validate with a smaller interval (like 350-400 m/s) and add soft sites comparison.

3. review conclusion

This work cannot be published in its current state. I recommend to considering general and specific remarks. After that, the work can be published in the natural hazards and earth system sciences.