COMMENT ON "SHEAR WAVE PROFILES FROM SURFACE WAVE INVERSION: THE IMPACT OF UNCERTAINTY ON SEISMIC SITE RESPONSE ANALYSIS"

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Comment on “Shear wave profiles from surface wave inversion: the impact of uncertainty on seismic site response analysis”

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Short title: Comment on “S wave profiles from SW inversion: impact of uncertainty on SRA”

Comment on “Shear wave profiles from surface wave inversion: the impact of uncertainty on seismic site response analysis”

By Socco et al.

Abstract

We discuss a study on the effect of surface wave solution non-uniqueness on seismic site response. The inversion approach used in the considered paper may lead to a significant overestimation of the uncertainties due to solution non uniqueness. We also address the numerical simulation of seismic site response. We apply a consistent framework to one synthetic dataset to show that, contrary to what is claimed in the considered study, the solution non-uniqueness has negligible effect in the considered case.

Comment

Boaga *et al.* (2011) (in the following called “the Authors”) study the impact of solution non uniqueness of surface wave inversion on seismic site response analysis. The authors refer to a previous study (Foti *et al.* , 2009) in which it was shown that the impact of solution non-uniqueness on seismic response simulations is negligible. Boaga *et al.* claim that, in the case of a gradual velocity increase with depth, solution non uniqueness deeply affects the accuracy of seismic response analyses.

In Foti *et al*. (2009) surface wave dispersion curves were inverted using a Monte Carlo inversion (Socco and Boiero, 2008) that selects a set of equivalent possible solutions through a statistical test. All the equivalent solutions were then used to compute the 1D seismic response of the site.

The approach followed by Authors presents significant differences from the approach followed by Foti *et al.* (2009) and their results cannot be considered an extension of those analyses.

Moreover, we think that some issues in Boaga *et al*. (2011) approach require further clarifications.

The two main concerns are: i) the method used to estimate the solution non uniqueness, and ii) the procedure used to apply the seismic input in the seismic site response simulations.

The selection of “models having equivalent dispersion curves and belonging to the possible solution subset” performed by the Authors does not account for the misfit with the experimental (synthetic) dispersion curve. They randomly select a set of models whose corresponding theoretical dispersion curves fall within arbitrary uncertainty bounds. This approach leads to the selection of models whose dispersion curve points are all well above (or below) the experimental one. These models would not be accepted by any inversion based on the minimisation of misfit between the experimental and the synthetic dispersion curves, as usually adopted. Hence, the Authors’ approach produces the selection of a very wide set of models and overestimate the effect of solution non-uniqueness.

We have inverted the dispersion curve of the synthetic case A of Boaga *et al*. (2011) with the same algorithm of Foti *et al*. (2009). The set of selected equivalent models is completely different and much narrower than the one in Boaga *et al*. (Figure 1).

In our inversion the uncertainties of the dispersion curve and the model space boundaries are the same used by the Authors. For the Monte Carlo inversion 10^5 simulations have been performed and 111 V_S profiles have been selected by the statistical test.

Moreover, the range of models accepted by the Authors is ruled by the uncertainty bounds that they associate to the dispersion curve data points. They claim that the uncertainty bounds are based on the results reported in Lai *et al*. (2005), but the relation adopted by the Authors [$\pm\Delta VR = \pm(0.05VR + 100/f)$] is not reported by Lai *et al*. (2005) and it leads to results which are not consistent with experimental data of Lai *et al*. (2005). It is also to be observed that the expression proposed by the Authors, can lead to uncertainties higher than 100% and negative velocity values for soft soils at low frequencies (e.g. at 1 Hz for VR=100 m/s).

Concerning the numerical simulation of the seismic site response, the Authors use an input motion recorded on stiff outcrop. Its application to soft materials, as those of synthetic case A in Boaga *et al*. (2011), would require a deconvolution procedure (Kramer, 1996), which is not specified in their paper. In any case, for the deconvolution it is necessary to know the depth of the seismic bedrock and this issue is not addressed in Boaga *et al.* (2011). In real cases, if the investigation depth of surface wave does not reach the seismic bedrock, this information should be inferred on the basis of other surveys (e.g. seismic reflection/refraction) as done for instance by Foti *et al*., 2009.

To evaluate the amplification functions for the profiles reported in Figure 1, we assumed a seismic bedrock at a depth of 150 m. This choice is based on the maximum wavelength in the dispersion curve reported in Figure 1b (280 m) and assuming the investigation depth equal to 140m. As the Authors, we performed a set of simulations using the code SHAKE91 (Schnabel *et al*., 1972; Idriss and Sun, 1992) considering the shear wave velocity profiles of Figure 1a. Other input data (Poisson ratio’s, densities, seismic ground motion, stiffness vs. strain and damping vs. strain) were the same used by the Authors. The results are reported in Figure 2, showing that the amplification curves obtained for the set of equivalent shear wave velocity profiles are very similar.

These results confirm the conclusion of the study reported by Foti *et al.*, 2009, showing that the impact of solution non-uniqueness on seismic response simulations is indeed negligible also for this case history.

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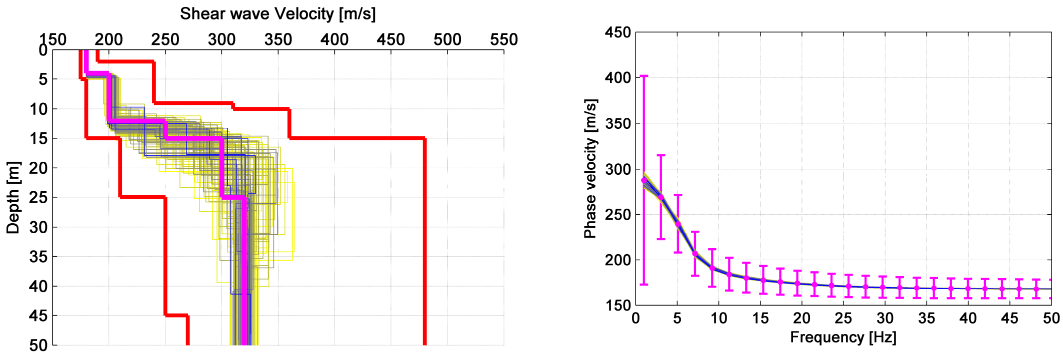
Figure captions

Figure 1 –Synthetic dispersion curve of case A in Boaga *et al*. (2011) is inverted with the approach of Foti *et al.* (2009): a) selected equivalent solutions compared with true model (magenta) and model space boundaries (red); b) experimental (synthetic) dispersion curve (magenta) and synthetic dispersion curves corresponding to selected models. The colours of each numerical dispersion curve is the same of the corresponding model.

Figure 2 – Amplification functions obtained with SHAKE91 for the selected profiles in Figure 1a (Bedrock position: 150m from ground surface). The results are reported with the same color scale of Figure 1.



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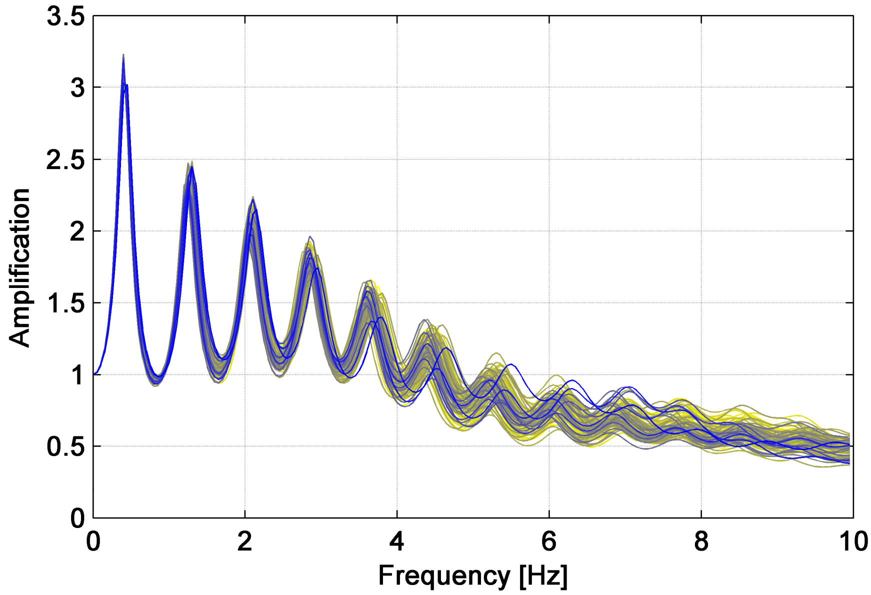

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