



EGUsphere, referee comment RC4
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Comment on egusphere-2022-279

Fabrizio Magrini (Referee)

Referee comment on "Comparison of straight-ray and curved-ray surface wave tomography approaches in near-surface studies" by Mohammadkarim Karimpour et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-279-RC4>, 2022

Dear Editor,

The manuscript "A comparison of straight-ray and curved-ray surface wave tomography approaches at near-surface studies" compares the effectiveness of "straight-ray" and "curved-ray" tomography in seismic imaging tasks. The pros and cons of these two approaches can be considered very well known to the seismological community, but I am not aware of any technical study that discusses them thoroughly and systematically. I suppose that doing so was the purpose of this study.

Unfortunately, I believe that a study of this kind might only be considered useful/appropriate/worth of publication if the technicalities inherent to the methods employed are very clearly explained; this is also very important, of course, to make the work reproducible. The manuscript, however, lacks many details, and does not allow one to fully understand or reproduce the work that was carried out. I suggest that the authors revise their manuscript extensively in this sense. Moreover, the quality of English and of the figures could and should be greatly improved.

The authors will also find my detailed comments/questions below.

Best regards,

Fabrizio Magrini

Abstract: This is too general. It does not display any highlights on the results presented in the paper

Introduction: In general, two different strategies exist to "convert" surface-wave dispersion curves to a 3-D Vs model. As explained in the manuscript, the first (i) involves the calculation of phase-velocity maps, which are then converted to Vs by carrying out many 1-D inversions. The second, instead, (ii) allows one to invert the dispersion curves directly for the 3-D model. In both cases, the data kernels can be calculated (a) by assuming that the waves travel along the great-circle path connecting a given station pair (ray-theory) or (b) by accounting for ray bending (ray-tracing).

In this study, you carry out a comparison between strategies (a) and (b). Is there a reason why you don't contemplate strategies (i) and (ii)? This would hugely benefit both the paper and the seismological community. Moreover, from the introduction, it is not clear which strategy between (i) and (ii) you intend to focus on, and why.

I feel that the motivation for the study should be discussed more in-depth, because the pros and cons of ray-theory vs. ray tracing are well known (for reviews, see Rawlinson & Sambridge 2003, Rawlinson et al. 2010).

General Consideration: This study focuses on very shallow crustal structures; I wonder if the iterative nonlinear-inversion scheme used to convert the dispersion curves to the 3-D Vs model can be considered appropriate in this sense. Wouldn't a globally optimized algorithm be more suited to the solution of a (possibly highly) nonlinear problem such as that of this kind? Adding some consideration on the matter would be useful.

Method: The method, and the related assumptions, should be explained more clearly (see also the points below). In principle, since this is supposed to be a technical work, I believe this part should be highly detailed, so as to make your work reproducible. I suggest that you expand largely this section, and possibly subdivide it into several subsections. It would be good to explain (i) the calculation of dispersion curves, (ii) the ray-theory vs. the ray-tracing algorithm (with the latter one meriting more consideration, especially if you implemented it on your own), (iii) the forward solver that allows you to measure predicted data from a given Vs model, and (iv) the inversion for Vs. In (iv), it would be good to say something about the calculation of sensitivity kernels at different periods. Other points are found below.

- One can only guess that the inversion strategy chosen by the authors involves the direct inversion of surface-wave velocity for the 3-D structure.

- Synthetic tests to verify the accuracy of the ray-tracing algorithm should be presented. What is the relative error as a function of distance from the source based on a *homogenous* medium?

- When you refer to "straight lines", are you referring to great-circle paths? If not, it should be explained that you designed your experiment in a cartesian coordinate system.

- Each vector and matrix in equations (2) and (3) should be thoroughly explained, and their dimensions be explicit. For example, is d_{obs} your slowness, or is it the arrival time obtained from slowness and ray-path distance? How do you calculate the roughness operator R_p ? Generally, the extent of the roughness is determined by a damping scalar coefficient (e.g., Boschi & Dziewonski 1999, Magrini et al. 2022), but you have the matrix $C_{\{R_{\{p\}}\}}$. Can you please be more explicit on its calculation? Can you also provide a reference for your equation (3), or alternatively a derivation for it? As it is, it appears different from, e.g., eqs. (51) and (57) of Rawlinson & Sambridge (2003).

- Is your stopping criterion compatible with previous studies?

Results: An important point that does not seem to be discussed is the choice of damping in the two different inversions. Slightly different values of damping can produce slightly different results. I believe it would be important to discuss in some depth this choice, and to demonstrate, to some degree, that the result of your comparisons is not biased by improper use of regularization. (Note that a given value of roughness damping might be ideal for the ray-theory case but not for the ray-tracing case, and vice versa).

- For example, consider Fig 10: I have the feeling that the large differences between the two inversions might derive from the choice of the roughness damping (the straight-ray tomography seems slightly underdamped). Have the authors experimented with different values?

- Are your synthetic data generated with the mentioned 3-D finite-difference code only in the Case study 1 or also in the Case study 2? Eventually, a brief explanation of this code could go in the Method section.

- I am struggling to understand the meaning of the red arrows/letters in Fig. 8, and the caption is not helping me. Probably I am missing something simple, but this suggests to me that the explanation in the caption should be extended or made clearer.

Discussion: The relative misfit in equation (6) is a function of $\mathbf{fw}(\mathbf{m}_{final})$. May you please be more explicit on the forward calculation of your dispersion curves (predicted

data) based on a given model? Did you use SOFI3D?

Minor

- In the introduction, you refer to Boschi and Dziewonski (1999) while speaking of seismic ambient noise. Clearly, in 1999 ambient-noise tomography did not exist

References

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