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Interactive comment on "Crustal structures beneath the Eastern and Southern Alps from ambient noise tomography" *by* Ehsan Qorbani et al.

Anonymous Referee #1

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This is an interesting study that presents a crustal shear wave velocity model of the eastern and southern Alps by inverting surface wave dispersion data from ambient noise. The final model has clear geological coherence and shows a good correlation between the velocity contrasts and geological structure. But there is still some work to be done. The authors need to perform evaluations of both tomography results and the inversion model to avoid the overinterpretation. I also have concerns about both figures and the manuscript. I hope that the authors will find these suggestions helpful.

Comments:

1) Since the cross-correlation database has been constructed, I am curious why the

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phase velocity information is not included in the tomography.

2) The tomography and final inversion results reflect lots of small-scale anomalies and artifacts, which indicates the tomographic results are not robust. I suggest the authors trying to adjust the smoothing parameter and correlation length, during the phase velocity map construction.

3) The synthetic reconstruction analysis with synthetic models is useful to assess the relative spatial resolution, since the ray path coverage is not uniform, especially after the introduction of AlpArray. Even though the synthetic tests, such as the checkboard test, cannot indicate the range of resolvable scale-lengths, it still could reflect the noise sensitivity and parameterization sensitivity. (Rawlinson and Spakman, 2016)

4) The data coverage is bad for the boundary region and in the long period. It's hard to convince me that the anomalies around the boundary and at deep depths (such as I, II, III, V, and X in Figs 11 and 12; high Vsv anomaly in Figs. 11f and 11g; profiles AA and DD in Fig 14) are realistic. So, I suggest the authors avoiding overinterpreting these features.

5) Several figures are not decent, such as Fig. 3, 5, 6, 7, and 8. In addition, the font-size of the labels and titles is too small in some figures.

Specific comments:

2.3:

Figure 3: I do not think the Figure 3 of the 9 components correlation tensor is necessary. The figure is obscure and hard to distinguish the signal from the background.

3:

Figure 4: Typically, we concern more about the period dependent SNR during FTAN, which more related to the quality of the dispersion measurement, rather than the SNR of CC. The SNR in Figure 4 is meaningless. I suggest adding the figure showing the

period dependent SNR curves for both Rayleigh and Love wave (similar to Fig. 4 in Bensen et al. 2008). The analysis of variation of the SNR with inter-station distance and azimuth could be considered at the fixed period.

Line 161: The figure of the period dependent number of the Rayleigh and Love group velocity measurements is necessary, which could be added in the manuscript or supplement. (Similar to Lin et al. 2008)

Figure 5: The example of FTAN seems not to be very well. The maximum period traced in the FTAN example in Fig. 5a and 5b is 30 s, while the period used in the FTAN is from 1 to 50 s. Is this already belong to the best results of FTAN? In addition, the locations of the station pair used in Fig. 5a and 5b could be marked in Fig. 5c.

4:

Line 175: Why is the grid size set as 8 km? How does the grid size affect the tomography results in different periods?

Line 177: May need to consider to use longer correlation lengths.

4.1:

Figure 6: Path density maps only show the periods of 8 and 16 s. What does the path density map look like for the longer periods, such as 30, 40, and 50 s?

Line 191: The resolution length is only the reflection of the relative path density and choice of parameters in the tomography. It does not indicate the true resolution.

Figure 7: The true resolution actually cannot be reflected by the resolution length map, which is also controlled by the model parameterization. This figure is a little bit redundant. I suggest removing it or put into the supplement.

How about the average misfit of the tomography result for different periods? Could you please provide a figure to show the period dependent misfit variation for both Rayleigh and Love wave group velocity?

4.2:

Figure 8: The number of the path in 20 s should be good, but the tomographic result seems not stable. Why are there so many white blanks in Fig. 8d? Could you please provide the Rayleigh wave group velocity map at 30, 40, and 50 s? Besides, the region of the CZA could be labeled in the figure. The full name of SLA should be indicated in the caption.

5:

Line 231: The final group velocity data used in the inversion is from 4 to 50 s, which should be clarified. Why do you exclude the periods from 1 to 4 s in the step of the inversion rather than in performing FTAN? I suggest to cut off the period range during performing FTAN.

Line 237: How do you determine the thickness of the layer in depth?

The influence of Moho depth is not mentioned in the paper. What is the Moho depth distribution in this region? Will the Moho depth affect the inversion? How are other model parameters assigned in the parameterization?

Figure 10: The figure showing a comparison of depth sensitivity kernel of Rayleigh and Love wave group velocity at different periods to Vp and Vs is helpful. I suggest removing the Fig. 10c and 10d and add another figure of the comparison of the depth sensitivity kernel of Rayleigh and Love wave.

6:

Figures 11 and 12. The tectonic boundaries (dashed lines) in Fig. 11 and 12 are not clear and hard distinguished from faults. It will be helpful to label the abbreviations of the tectonic units mentioned in the paper.

Line 346: Another reason for the discrepancies in the pattern of anomalies between your model and Kastle's is the different station distribution. The introduction of AlpArray

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stations increases the paths in the central region.

Figure 13. Mark anomaly IX in Fig. 13d. Also, it will be helpful to label the tectonic abbreviations mentioned in Fig. 13a.

Additional reference:

Bensen, G.D., Ritzwoller, M.H. and Shapiro, N.M., 2008. Broadband ambient noise surface wave tomography across the United States. Journal of Geophysical Research: Solid Earth, 113(B5).

Lin, Fan-Chi, Morgan P. Moschetti, and Michael H. Ritzwoller. "Surface wave tomography of the western United States from ambient seismic noise: Rayleigh and Love wave phase velocity maps." Geophysical Journal International 173.1 (2008): 281-298

Rawlinson, N. and Spakman, W., 2016. On the use of sensitivity tests in seismic tomography. Geophysical Journal International, 205(2), pp.1221-1243.

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