Answers to reviewer comments #2

https://doi.org/10.5194/se-2021-55-RC2

Title: 3D crustal structure of the Ligurian Sea revealed by ambient noise tomography using ocean bottom seismometer data

Dear Reviewer,

We thank you for the fair and constructive review of our manuscript se-2021-55. Please find below our line-by-line-revision where we carefully respond to all your comments and suggestions and explain how we modified the manuscript.
The comments from the reviews are indicated in **black** and our replies in **red** colour.

ABSTRACT
L26: "no hint OF mantle…"
Changed accordingly.
INTRODUCTION
L37: The term "collision" is improper for describing the emplacement of the Sardinia-Corsica block in its current position. Rather, this block is a crustal remnant left behind during the opening of the Tyrrhenian Sea.
We rephrased the sentence according to the editor's suggestion:
"*the Corsica-Sardinia block was stranded between the Apennines and the European margin in southern France*".

L57: In reality, the paper mainly focuses on the results and does not investigates the geodynamic implication of these (will it be part of a later work?). Thus, I'd rephrase the "To better understand the evolution of the Ligurian Basin and the processes driving its formation".
We rephrased this to: "*To better understand the present-day crustal velocity structure and its implications on the evolution of the Ligurian Basin, [...]*."

FIGURE1: Remove the decimal digits in thick labels. In the map in the bottom-left corner, just show the European continent.
Thank you for these suggestions. We updated Figure 1 accordingly. In the inlay-map, we choose a smaller area centred at the OBS array.
DATA
L76: Can you explain why some of the stations/data were not recovered? What were the issues?
We decided not to mention the stations that we did not use. Instead, we only focus on the 22 stations that did record all components for the complete deployment, in order to increase the focus of the manuscript. The other stations were not used, because they did not record (enough) data.

METHOD
L113: "horizontal signal…" —> horizontal movement We corrected this.

Majority of readers are used to land data. It'd be interesting to show an example of OBS data before and after tilt/compliance correction. Would you please provide that?

A very nice example of OBS data before and after removing tilt and compliance is shown in Figure 9 of Crawford and Webb, 2000.

FIGURE 2: please use a color for the stations that gives more contrast with the background (red/white). Tip: you can use shaded black lines (transparency set to 0.3-0.5) for the line connecting the stations. This will immediately gives an idea of ray density…
We followed the suggestion of reviewer #1 and created hit count maps to show the ray coverage.

FIGURE 4: there is a remnant label "180"…
We could not find the remnant label. Therefore, Figure 4 is unchanged.

L188: In the frequency range that is common to both ambient noise and teleseismic events, what did you do to calculate the group velocity? Average? Weighted-average? According to several papers, when using teleseismic events one systematically overestimate group/phase velocity (several explanation have been hypothesized as a reason for this, fist of all: off-path arrivals). It might be worth having a look to Magrini et al. 2019 (10.1093/gji/ggz560) where they deal with this issue.
Thank you for this comment. To clarify, we did not use overlapping frequency ranges. We decided to evaluate the ambient noise group velocities for periods of 5 – 15 s, and the teleseismic group velocities for periods of 20 – 90 s.
Magrini et al. (2019) is a very interesting study and they do improve the phase velocity results by a significant, though small amount. The change in velocity Magrini et al. observe is in the range of 0.04 km/s. Since we are using group velocities to estimate shear wave velocities, and interpret differences of > 0.1 km/s, we prefer not to apply their method.

FIGURE 5: y-axis label: put a space between "group" and "velocity". Use some transparency for the curve to make them all visible…What is the error on the group velocity estimation? How is it estimated? Can you shrink the x-axis? The curve is not really appreciable and seems really flat.
We corrected the typo and shrank the x-axis, to make it easier to see that the curves are not flat. The error is not estimated based on the dispersion curves but on the picked lagtimes.

L223: Can you provide some more details on the inversion code? Is it stochastic or linearized? Are data uncertainties accounted for and, if yes, how?
Added "iterative, weighted inversion [code]". The uncertainties are accounted for.

RESULTS

FIGURE 6: show colorbar only once and make it bigger We updated Figure 6 accordingly.

FIGURE 7: again, show colorbar only once and make it bigger
We updated Figure 7 accordingly. We also included several more checkerboard setups to allow more conclusions on the resolution. More checkerboard tests are shown in the supplementary material.

FIGURE 8: "depth inversion"?. It's rather an inversion from group-velocities to shear-wave velocities. There's no need to repeat the colorbar 8 times if it is the same.
That is a good point. We invert for shear-wave velocities and keep the depth layers fixed. Therefore, we followed your suggestion and changed the naming. Also, we updated Figure 8.

L313: Why is the RMS here? Please move it to the method or result part. moved to results

DISCUSSION

Here I suggest to comment further on the implication of the results obtained. For example: if there's no serpentined mantle in the basin centre, what causes such high velocities directly underneath the sediments? Can these be caused by thick oceanic crust? What does that mean in the context of the evolution of the Liguro-Provençal basin?

We restructured and re-wrote significant parts of the discussion section. Also, more details are given to the questions raised here. For example, we added a paragraph on the implications on the present day basin structure and its implications for its evolution at the end of Section 5.2: "*Dannowski et al. (2020) suggest that continental crust was (extremely) thinned along their profile, but no spreading occurred. This is in-line with our results. A possible spreading centre has to be located to the southwest. At the Gulf of Lion margin, at the southwestern edge of our research area, Gailler et al. (2009) interpreted their results as oceanic crust, also observing a transition zone made up of "lower crustal material or mixture of serpentinized upper mantle material with lower crustal material" (Gailler et al., 2009). Later, Jolivet et al. (2015) explained the shallow high velocities by exhumed lower crustal material. They also suggest partially serpentinised mantle. Therefore, a possible spreading center might have been located southwest of our research area, possibly as close as the Gulf of Lion margin.*" Another paragraph was added to Section 5.3: "*The apparent thickening of the continental crust towards the northeast is likely related to the position of the rotational pole of the opening of the Ligurian Sea during the Oligocene-Miocene. According to Speranza et al. (2002) and Gattacceca et al. (2007), the rotational pole was located in the northeastern Ligurian Sea at 43.5°N, 9.5°E. Therefore, the southwestern basin was more extensively opened, and the continental crust was thinned further than in the northeast.*"