

General Comments:

In the revised version of their manuscript, Paffrath and co-authors considered all my previously raised concerns. The calculation of crustal corrections and the presentation of the travel-time residuals have been greatly improved. The new Figure A2 suggests that the updated/improved model used for crustal corrections seems much more complete and realistic compared to the one presented in the previous version of the manuscript. I am still in doubts, however, if the current quality of text and English is sufficient for immediate publication in *Solid Earth*. There are still many flaws in style and punctuation, a lot of repetitions and partly superfluous statements and conjunctives. The manuscript would also benefit from improvements in terms of structure. For instance, the discussion (about 3 pages) is mainly an extensive conclusion and, on the other hand, the results presented in section 5 (>9 pages) already include interpretations I would have expected in the discussion (e.g. section 5.4). I have provided a list with selected examples (and suggestions how to improve) as well as additional minor comments below.

We have modified the structure of the manuscript and moved interpretations in section 5.3 and 5.4 to the discussion (section 6). The text in the discussion referring to the interpretation of the traveltimes residuals has been reworked. Other remarks concerning style and phrasing have been taken into account.

One final comment regarding the interpretation of the residuals: In section 5 the authors provide long and detailed descriptions of observations (L, A, W, C, E in Fig. 10), but the interpretation of these observations (especially in section 6) is extremely short and vague. The main conclusion seems that the expected 3-D mantle structure is “complex” (which is not a surprise based on previous studies). Anomalies W and A are associated with known slabs, but the interpretation of C and E is extremely vague and short in section 6 (see previous comment on structure). Also, I have to admit that I do not fully understand how the authors defined the outlines of anomalies W, C, E in Figure 10 and elsewhere. Especially for C and E it is not clear to me at all. On the other hand, the delays (positive residuals) in the western Alps are not discussed/mentioned at all in section 6, although potentially important in terms of the discussion about slab break-off in this part. I completely understand that this will be part of the author’s follow-up tomography study, but I am wondering if all the details in section 5 are really needed for the rather vague interpretation of the residuals.

We note here that the descriptions of the anomalies L, A, W, C, E in the text is just 8 lines long. In addition, definition of these anomalies proved very useful to study the dependency of the location of residual patterns on the azimuth range of the incident waves. The section describing this azimuthal dependence has been shortened and interpretative parts moved to the discussion. The interpretation is as specific as it can be given the fact that only integrative traveltimes residuals are available. It still makes remarkable qualitative statements regarding the location, depth and dip of positive velocity perturbations. The definition of the anomalies is to some extent subjective but not arbitrary as the defined areas group the negative residuals and are separated from their neighbours by (narrow) regions of positive or close-to-zero residuals. This is also the case for anomalies C and E as demonstrated in the inset of Fig. 10. That the definition of C and E makes sense is later confirmed by the fact that they show a very different dependence on wave azimuth. We also have added an interpretative sentence in the discussion regarding the positive residuals in SE France. We do not think that the residuals alone allow statements regarding detachment and slab breakoff because small-scale gaps within regions of positive velocity perturbations will probably not show up as positive traveltimes residuals owing to the integrative behaviour of the residuals.

Detail comments:

- l. 12: "that already indicate" -> "that indicate"

Done

- l. 35: "... below the array." add a reference, e.g. Aki et al 1977

Done

- l. 36: "Imagining ..." -> "Assuming" or "Considering"?

Done

- l. 40: Why not add a reference in this paragraph, others described the trade-off between array aperture and resolved depth range before, e.g. Sandoval et al 2003 & 2004 (GJI), etc.

Done

- l. 61: "forbidding" -> "unfeasible"?

Done

- l. 73: -> Rowe et al doesn't really relate to teleseismic: -> "In case of similar waveforms, e.g. from earthquake clusters or planar waves of teleseismic wave fronts, one can improve traveltimes measurements by ..."

Done

- l. 89: -> "... that already indicate the approximate location of high and low velocity anomalies in the upper mantle prior to any tomographic inversion"

Done

- l. 99: -> ground motions

Done

- l. 115: -> "Because oceanic microseismic noise ... was only possible for strong earthquakes of magnitudes >XX."

Done, quantified minimum magnitudes (which are of course also distance dependent)

- l. 131: "... capability of algorithms applied to different characteristic functions to resolve ... required for high-resolution traveltimes tomography. We will summarize the most..."

Done

- l. 134: "characteristic function picking algorithms" -> Rephrase! See above.

Done

- l. 148: "The crucial question is, how to obtain" -> Rephrase!

Done

- l. 151: "read" -> "determine"

Done

- l. 162: "...propagate into" -> "does not affect"

Done

- l. 172: In this paragraph you should add the reference to Figure 3 to give an overview on the procedure before starting with the detailed description of the individual steps.

Done

- l. 178: -> "... which was originally designed...."

Done

- l. 188: what is the "calculation window"?

We rearranged this part to clarify what we mean with calculation window (cut window in which the characteristic functions are calculated)

- l. 191: We select the moving time window..." Meaning of this sentence is still not clear to me... Try to rephrase?

Removed this part as it is not vital for understanding.

- l. 208: -> "Fig 5a..." The order is wrong! Figure 3 and 4 are not mentioned in the text yet. Therefore Figure 5 should be Figure 3 otherwise mention Figure 3 and 4 before.

Add information that Figure 5 will appear later in the text.

- l. 208: The last sentence of this paragraph doesn't make much sense to me. You mean "To resolve the fine-scale mantle structure below the Alps, it is crucial to reduce the uncertainties of the onsets using additional constraints provided by the high station density of the AlpArray network"?

Improved this sentence

- l. 210: -> "By visual inspection of selected examples, we validated that the large uncertainties..."

Done

- l. 212: "is hidden in the site-specific noise"?

Done

- l. 213: "Another limitation..."

Done

- l. 217: -> "Although too uncertain to be used for tomographic inversion, the AIC onsets turned out to be more precise than onsets predicted with standard 1-D earth models".

Done

- l. 233: Meaning of last sentence of paragraph not clear. "Yield" in terms of what? More picks?

Yes, clarified this.

- l. 244: -> "... Alps, within the shortest possible distance to all other stations to minimize ..."?

Done

- l. 253: -> "... is ≥ 0.8 (Fig. 3)." Delete the following sentence.

Done

- l. 257 -> "... can be determined precisely either automatically or manually. In our case, we applied the automatic picking procedure of section 3.2 to determine the onset on the beam trace."

Done

- l. 264 -> "shown in Figure 8" Wrong order as before... Figures 6 and 7 have not been mentioned yet...

Removed Figure reference.

- l. 271: -> "Figure 5c demonstrates... makes them insufficient"

Done

- l. 318: -> "... only about 10% of the total number..."

Done

- l. 320: It is not explained what you are doing with class-4 picks. Since they don't have an upper error-bound (only a lower bound) these picks should be rejected for tomography. This should be mentioned.

Explained this in the paper

- Figure caption 7: "are identifiable" -> "are characterized by"

Done

- l. 331: "... in one dataset are not present..."

Done

- l. 377: -> "A closer examination of travelttime residuals shown in Figure 9b and 9d reveals that..."

Done

- l. 400: "influence of incident angle is small" -> but doesn't Figure 9b and 9c show otherwise?

We changed this part to explain what we mean here. There is certainly an influence of the distance, but its influence on the residual pattern is less strong.

- Figure caption 10: "small crosses mark station residuals mostly independent of variations in backazimuth"

Done

- Figure caption 10: "Tectonic map" -> "Tectonic units"; provide a proper reference for Handy 20XX if possible, otherwise Handy personal communication?

Added a reference to the MB4D website, where the material can be found.

- l. 421: -> "The resulting vertically stacked travelttime differences (...) between our crustal 3-D model and the crustal 1-D model of Diehl et al. 20XX can be found..." You should add something to this paragraph such as "Crustal contributions to travelttime residuals related to Ivrea body or sedimentary basins (Po etc) are in the order of XX seconds and comparable to the crustal corrections derived by

Waldhauser et al. 2002 and therefore significant when compared to the potential mantel signals and need to be removed..." Otherwise the aim/purpose of Figure A2 is not clear.

Done

- l. 423: -> "The most striking features of the stacked travelttime residuals after crustal correction are the..."

Done

- l. 428: "Defining a separate negative anomaly..." -> this sentence is odd and unclear and needs to be rephrased.

Done

- l. 432: This section and the following ones seem better suited for the discussion (see my general comments)...

Done, see above

- l. 437: "...move around..." -> rephrase! E.g. "location of anomalies varies depending on azimuth" or something?

Done

- l. 440: "... we imagine" -> "we consider"?

Obsolete

- l. 449: "with laterally moving imprint" -> Try to rephrase! "with locations depending on azimuth of incoming wavefield" or something?

Done

- l. 456: "... can not..." -> "cannot"

Done

- l. 463: "The high velocity anomaly building (C)..." -> meaning unclear. You mean the anomaly labeled "C"? rephrase

Done

- l. 466: How are these outlines defined (see my general?)

Done, see above

- l. 472: "Up to now not much was said about..." odd, please rephrase...

Done

- l. 474: "using the techniques described above" -> "using the same procedures as for the high-frequency data (including azimuthal binning, crustal corrections, etc.)" Then you can remove the repetition around line 489 and 490.

Done

- l. 475: "We find that the obtained maps differ systematically..." -> Add a reference to Figure 12 showing the residuals for the low-frequency data. Otherwise it is not clear what you are refereeing to.

Done

- l. 492: "less strong" -> "smaller"? Can you quantify this? E.g. in terms of seconds or in %. Is the difference between the two datasets still significant compared to the mean errors or your picks?

Done

- l. 496 and elsewhere: "disparity" -> Not sure, if this is the right term. I would prefer "difference"

Disparity -> sign/difference

- l. 521: -> "Sophisticated, automatic single-channel picking approaches apparently do not achieve the targeted accuracy for teleseismic traveltimes."

Done

- l. 530: "These are absolutely essential" -> repetition, please delete sentence... "To overcome this problem..."

Done

- l. 531: -> "It proved to be sufficient..."

Done

- l. 539: -> "into the error estimation"

Done

- l. 539: -> "the higher ..., the better"

Done

- l. 540: -> "The definition nicely includes..." -> try to rephrase

Done

- l. 544: -> "... conspicuous bumps should appear..." odd expression, rephrase!

Bumps -> deformations

- l. 553: what is "high-reaching fast upper mantle"? You mean "Upper mantle at shallow depths with fast seismic velocities"?

Obsolete

- l. 554: -> "The strike of the anomaly A correlates with the strike of the Apenninic mountain chain..."

Done

- l. 555: -> what is "slab-like" material? Why not "lithospheric slab"? I think there is evidence for its existence from other studies...

Done

- l. 584: -> "The AlpArray network proved to..."; "high correlation" in terms of what?

Clarified this

- Figure caption A2: Should be improved. If I understand correctly you show the difference between your updated 3-D crustal model (compiled from different crustal models) with the 1-D crustal model of Diehl et al 2009 for a vertical plane wave? It shows the potential crustal contribution to the teleseismic residuals which needs to be corrected for. This is not clear from the current caption.

Done

- l. 632: Somewhere here you might also acknowledge the contributions and comments of editors and reviewers of your manuscript...

That is definitely true!