Responses to the reviewer comments on the resubmitted manuscript "New insights on the fault structure of a geothermal testbed and the associated seismicity based on active seismic tomography" by Schwarz et al.

We appreciate the editor's and reviewers' thoughtful comments on our resubmitted manuscript. Below, we provide a point-by-point response to all comments in the same format as the previous author's response. Reviewer comments appear in blue, and our responses appear in black.

We start with the Editor comments. The Reviewer comments follow below.

Editor comments:

"I agree with Reviewer 1 (response to reviewers, comment 3) regarding the reorganization of section 5. I could suggest the following structure; however, I leave the final decision to the Authors.
4. Travel time tomography
4.1 Method
4.2 Set up the inversion (or Set up the inversion for field data set; or this subsection can be titled as "model parametrization and resolution")
Checkerboard tests to evaluate data coverage, determine appropriate grid/block sizes and smoothing parameters, estimate velocity model and understand the resolvable anomaly size. You can refer to Appendix A for details.
4.3 Comparison of thin and fat ray tomography

5. Results (and Discussions)
5.1 Qualitative description of the velocity model
5.2 Traveltime residuals: the distribution of travel time residuals for the initial and final model as bar graph
5.3 Validation of the velocity model with independent datasets (currently section 5.5)
5.4 Appraisal of rock quality
5.5 Comparison of seismic velocities with induced seismicity

Discussions (a seperate discussion section, if not integrated in the results)
Conclusions"

We changed the structure of the sections as proposed.

"Line 238, you mention that the damping parameter was determined by trial and error. Did you also analyze the trade-off curve such as the L-curve? I noticed that Reviewer1 also raised this point in the revised version.
Appendix A, checkerboard tests: Did you use the same regularization parameters? Have you tested different values and investigated their effects on the results?
The checkerboard tests are shown for fat ray tomography. You may consider including an example for a selected block size (for example 10m) both for thin and fat ray tomography and compare the results."

To address your comment and those of Reviewer 1, we have included a trade-off curve for quantifying our choice. Generally, the results are quite stable for a range of damping factors and damping/smoothing ratios. The regularization parameters that we have identified by trial-and-error,

matched the values obtained with the trade-off analysis very well. We have modified the corresponding section in the manuscript accordingly.

We have performed the checkerboard tests with the thin ray approach as well. The results are comparable. However, it should be noted that the deficiencies of checkerboard tests are more pronounced for thin rays (compared to fat rays), because the thin rays tend to travel along the checkerboard boundaries. We have added a corresponding comment in the revised manuscript.

"Line 310, You can show the distribution of the travel time residuals at the first and last iteration to illustrate the improvement."

We have added the residual distributions of the first and last iterations to the figure.

"Line 374, Please clarify the seismic velocity used in the Fresnel zone calculation."

We have clarified this point (average velocity was used)

"Line 532, Appendix A is split, please check the formatting on page 30."

Done.

"Line 537, What is the amount of the velocity perturbations applied in the checkerboard tests?"

We have chosen a velocity contrast that reflects the velocity changes found in the tomographic model, that is, the velocities were varied by +/- 300 m/s. This was also added to the revised text.

Report 1:

"Lines 212–213: The authors have determined the individual contributions of damping and smoothing through trial-and-error and demonstrated that a damping-to-smoothing ratio of 0.5 is sufficient for the inversion setup. Given the limited spatial extent of the inverted 3D velocity model, it is recommended to provide a trade-off analysis—such as an L-type curve—to optimize the damping/smoothing ratio. This would further ensure the robustness of the results."

See corresponding response to the editor comment.

"Figures 5–7: Regarding ray path density, could the authors provide a quantitative range of values rather than simply indicating "low" or "high" via the color bar? This would help verify whether the number of ray paths used in the inversion is indeed sufficient."

We have changed the colorbar as suggested.

Report 2:

comments

"1. The article still contains a lot of english grammatical mistakes. I have highlighted and commented a significant number of them, see the attached document. Therefore, during the revision I strongly suggest to take help from some professional agency or be reviewed from a native english speaker."

We have incorporated your changes. Furthermore, the manuscript was checked by a professional scientific editor, and we have incorporated his/her changes as well.

"2. A bit of a more effort in needed in the Bibliography section. Many citiations still lacks proper formatting and DOI links. A few comments are made on the figures as well, please check."

We have checked the citations and the Bibliography section. For comments on figures please see the detailed answers below.

Suggestions:

"1. If the word limits allows for the title, I suggest to include the word "Bedretto" and "crosshole" for wider visibilty and scientific completeness. The new title shall be "New insights on the fault structure of Bedretto geothermal testbed and the associated seismicity based on active seismic crosshole tomography"."

We have changed the title as suggested.

"2. The checkerboard test described in Appendix A can be included in the main body of the article. But I leave it to the wisdom of the author(s) whatever they seem appropriate."

We would like to keep the checkerboard tests in the appendix.

Comments provided within the pdf:

"I think adding "Bedretto geothermal tested", and "seismic crosshole tomography" will provide more visibility!"

We have changed the title.

"The title of the article says it is also a decameter-scale study. Please cross-check!"
Done. The paper describes several scale studies.

"Do you mean in terms of "physical properties""

Yes, this was clarified in the text.

Comments on Figure 1:

Small and unnecessary labels in a) are removed. Title in c) is changed.

L102: typo corrected.

"For the manual picking, we employed a Matlab-based in-house software."-> "Can we cite it?"

No, this is an in-house tool that was never published.

L135:"in Figure 2b"

Changed.

"L135: Kindly cross-check this with respect to the figure 2c for receiver and source "

We crosschecked and changed it accordingly.

"L144:P pick??" We've added text for clarification.

"L151: I did not understood this, kindly rephrase." We've rephrased it.

"L164: Citation!": Citation was added

L174, grammar changed.

L176: mxm please cross-verify. Verified – both, the damping and the smoothing matrices are of dimension *m x m*.

"L177: "resp. prevois" ??" We have rephrased the sentence.

"L199-201: This portion reads very ambiguous. Please rephrase it properly."

We have rephrased this paragraph.

Comment on Figure 4: We have changed the table headings accordingly.

"L232: ray-coverage": We use the term coverage instead of ray-coverage on purpose, to highlight the differences to the classical thin ray approach. We have added a sentence on this, for more clarity.

L132: changed as proposed.

"L242: Can we add a line here why we rejected the results of 4.5 and 6 KHz. It is natural to prefer a lower frequency with good SNR, but a sentence here will be useful."

We have added a sentence on this.

L243: We have added “(z-axis)“ for clarity.

L250: changed

L251: changed

L254: We disagree. At 200 m depths, Figure 6 shows a high-velocity zone in the central of the volume.

L268: changed.

Figure 6: “I think it is better to rearrange this figure with all velocity figures on the top panel and ray-coverage in the bottom panel. This will drastically reduce the space.” We disagree. We’ve tried this during the writing process of the paper and it did not significantly improve the figure. We would like to keep it as it is.

“Figure 7: You can reduce the vertical exaggeration to 0.-0.7 of the current scale. The figure looks unnecessarily stretched.” Fine for us. We can check this before the paper gets published.

Figure 7, caption: We have changed as proposed.

L276: changed.

L289: We have added an explanation.

L304: In the rotated coordinate system, the term “depth” is no longer appropriate. Therefore, we prefer our original formulation.

Figure 8: Figure and caption were changed as suggested.

L313: changed.

L335: picking accuracy is misleading, since we have the picking accuracy of the P-wave picks. We mean the accuracy of the borehole traces in general, they typically increase with depth, such that longer boreholes have larger uncertainties towards the end of the borehole.

Figure 9: Since we rotated the coordinate system into the main axes of the boreholes, we would like to stay with the term Z instead of depth. The latter could be misleading, since it is typically “lat, lon, depths” for global coordinates, which is also available for the BedrettoLab. To avoid confusions, we would like to stick with the notation “Z”.

L342: Changed.

L352: References are corrected.

L361/362: We have removed the Menke reference and added instead a short explanation of the D-criterion.

L365: No, $Mw = -3$ is correct.

Figure 10: Title and axis notation was changed as suggested

L380: We prefer our original formulation

L414: Not sure, what the reviewer infers to say. Of course, our statement is based on a literature review!