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Comment on se-2021-40

Nathan Bangs (Referee)

Referee comment on "Reflection tomography by depth warping: a case study across the Java trench" by Yueyang Xia et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-40-RC1, 2021

This paper presents a seismic velocity analysis technique based on a novel non-rigid matching scheme for matching seismic traces in a CIG gather after PSDM. The goal is to derive depth corrections on seismic reflections that can be used for velocity model updating. The paper presents the technique and demonstrates it by applying it to four different settings across the Sunda subduction zone and the Hikurangi margin, each with different challenges for velocity analysis and seismic imaging. The introduction and presentation of the analysis is reasonably well written and easy to follow. However, as discussed below, the writing in later sections, especially the Discussion, needs major revision. Overall, the technique seems very reasonable and effective and is potentially a valuable tool for velocity analysis and prestack depth migration in settings that are not conducive to layer-based models. At its core, the paper is acceptable and should be published. However, I have a number of concerns about the presentation and the basis and validity for many of the claims made here. I suggest major revisions are needed to fix these issues. Below are my biggest issues. There are also many additional comments written on “stickly notes” on the manuscript pages.

Main issues:

- The description of the technique is reasonably well presented and illustrated, but there are two things that are not very clear. First, what is the need for deriving the NRM displacement field and then calculate an NRM residual depth error? It seems like this is simply flattening the arrivals in the gathers. Isn't this effectively the same as picking the arrivals and flattening them to a common depth? Is the NRM technique mostly a convenient way to derive the residual depth errors, or is there an analysis here that makes it superior? More explanation is needed for what the NRM does beyond simply picking the events to derive a depth offset.

Secondly, I did not find an explanation for how the residual depth errors are used to update the model. Table 1 describes the second to last step as "Update the Tomography Model Properties that will Minimize the CIP-gather RMO". I did not find any description of this. How exactly is this done, and is this the only way in which the residuals are used? I thought that this is usually done with some constraint such as a linear or hyperbolic relationship with offset. How is it done here?

- The comparison to the initial model is a problematic basis for making any significant conclusions. I certainly see that there is value in using the initial model to demonstrate the changes over the iterations; however, it is not clear that it represent anything that would make a useful basis for conclusions beyond showing improvement. Were the velocities considered to be the best possible that could be derived from a particular technique, and can that be demonstrated? Are the wide-angle data comparable? The wide-angle data are likely to be affected more by anisotropy than near-zero offset data because their raypaths have a significant horizontal component. It is fine to use an initial model to show how the technique is applied and how it changes from start to finish, but it can't be used to claim that the change in velocity has any geological significance as it is for some of the conclusions. It would be best if it were stated directly that the comparisons between initial and final models are only to demonstrate how the technique improves the results over the iterations and not to show that it is superior to any other technique. You can make it clear that the initial model does not represent a best result from another technique and that you are not claiming this is the degree of improvement that can be expected beyond other techniques.

- There should be some discussion of how anisotropy or effects of streamer feathering may contribute to residual errors or can be accommodated with this technique. There is a brief mention of anisotropy, but no mention of streamer feathering. These are obvious factors that can impact arrival positions within the gathers and skew the velocity models.

- My biggest issue with this paper is with the writing, mostly in sections 4 and 5. There are many vague and unsubstantiated claims made throughout these sections, and some in section 3. For example, in lines 368-372, what determines “large-scale length” what are “significant” velocity corrections? It is not clear why the scale length is appropriate for the first iteration and why there is a corresponding reduction in scale length with subsequent iterations. What makes observed velocity updates more “pronounced”? What defines a “fluctuation of velocity changes” and what determines when they are or are not “related” to “subsurface structures” and what constitutes structures that relate to these changes? This is just three sentences. There are more such issues throughout. There are far too many claims like this that are hard to determine what is meant and what the basis for them is. I have noted many of them on the manuscript, but this section needs to be rewritten.

There are few topic sentences. Without them it is hard to tell what the goal of the paragraph is and where the discussion is leading. The discussion wanders through a number of topics that are not very closely related to each other or seemingly to the rest of the paper. It is not clear why these topics are being discussed and whether they are to help establish the validity of the technique or the results from its application along the Sunda trench or Hikurangi. It is not clear why a new setting (Hikurangi) is added in the discussion rather than as part of the results with the Sunda results.

Overall, this is appears to be a valid technique and the paper does a reasonable job of presenting it, illustrating how it is applied, and showing the expected results. What I don’t understand are the goals of the discussion and how it adds to the paper. The discussion and conclusions need to be significantly revised before this is published.

Please also note the supplement to this comment:
https://se.copernicus.org/preprints/se-2021-40/se-2021-40-RC1-supplement.pdf