Interactive comment on "Relocation of earthquakes in the Southern and Eastern Alps (Austria, Italy) recorded by the dense, temporary SWATH–D network using a Markov chain Monte Carlo inversion" *by* Azam Jozi Najafabadi et al.

Anonymous Referee #3

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The present manuscript by Jozi Najafabadi et al. presents the compilation of a seismicity dataset that will, I presume, eventually be used for a local earthquake tomography study of the Eastern Alps. Using recordings from the dense SWATH-D deployment, they present a careful procedure of obtaining and verifying arrival time picks, derivation of optimal hypocenter locations and a best-fit 1D velocity model. The Bayesian approach for the inversion of hypocenters, velocity model and station corrections is something new, and the present manuscript provides a nice case study for its application. Lastly, the obtained hypocentral locations are compared to mapped faults, from

which the apparent activity or non-activity of a number of structures in the Eastern Alps is inferred. This last part is where I see some potential problems that will make some changes to the manuscript necessary. Overall, the paper is well written and definitely of interest to the readership of Solid Earth and the special volume "New insights on the tectonic evolution of the Alps and the adjacent orogens". I recommend moderate revisions before publication.

General comment:

In section 3.2, it is briefly mentioned that the events for which arrival times on SWATH-D stations were obtained and that were then relocated, used for deriving the 1D velocity model etc. were selected from a synthesized catalog that was based on the bulletins of national agencies. For the tectonic interpretation to be viable, this part needs to be made much more transparent. While it is fine to choose a subset of events based on network criteria when working towards a tomography study, it is a completely different thing when the activity or (more crucial) non-activity of faults is inferred from such a subset. In clearer words: the authors need to convincingly show that their chosen subset of events is representative, and does not systematically miss events from certain regions. I suggest to provide a map with all 2639 events from the different national catalogs, in which the chosen 384 are marked. It would likely be even better if the station distribution from the different national networks could be shown as well. I also suggest to better describe the reasoning behind this approach of choosing a subset of events from national bulletins. Are the national bulletins complete enough that one can exclude that the dense SWATH-D network contains signals from small, previously undetected events? Or was the focus on the larger events that would generate arrival times at a larger number of stations?

I agree with a previous reviewer that fault plane solutions would be nice to have for a more detailed tectonic interpretation. However, I can see that the main aim of the manuscript is the description of the dataset that will be used for tomography, and speculate that the tectonics part was added mainly for the sake of the Special Volume topic.

I believe the careful derivation of the hypocenters and velocity model, using a rather novel approach and performing many quality checks, is in itself enough material, so that a deeper-going tectonic interpretation employing focal mechanisms is not strictly necessary here,

Specific comments:

l.25: Why were only data from 2017/2018 used when the stations ran into 2019? Should be mentioned with a word or two. Also, mentioning the total number of SWATH-D stations here could be useful, especially since the number of AlpArray stations that were also used is brought up in the next paragraph.

l.33/34: "to identify the status of the seismically active volume...". This is a strange formulation, and should be changed.

l.36: remove the

l.55ff: I would recommend to use fewer abbreviations, this is making the manuscript unnecessarily hard to read. Best limit abbreviation to a handful of terms that really show up a lot throughout the manuscript, and write out the rest (this is maybe also my personal taste...).

l.82: this bracket is not closing again

l.91: stuck should be struck; about what time interval are we talking for the ML>6 earthquakes? Last decades, centuries, millennia?

l.96/97: This statement is problematic, because while the present study is using a denser seismic network, the chosen approach of using a subset of events from agency bulletins (see General Comments) makes it impossible that previously missed events (if they exist) will be detected. Thus, the present study can do nothing to address the problem that is hinted at here (inactive region maybe because not well instrumented).

l.105: The "however" doesn't fit here

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l.111: remove "stations"

ll.115-119: For me, this paragraph is the main problem of the manuscript as is. At least for the tectonic interpretation part, the authors need to convince the reader that no selection bias of earthquakes exists, i.e. that regions interpreted as aseismic based on the chosen 344 events are also aseismic if one looks at the entire >2600 events in the original database (see recommendatiosn in General comments). Also, the statement here seems to indicate that the national bulletins were deemed complete, which stands in contrast to l.96/97.

l.135/136: how were outliers defined, and where can I see outliers in Figure 3 (can they be marked?)

l.138: If a part of the goal audience are people mainly interested in the activity of structures in the (south)eastern Alps, the three phases and the triplication distance should be briefly explained, e.g. in a brief sketch that could be added to Figure 4. Also, giving an estimate of the overtaking distance, e.g. with the crustal thickness and velocity given in ll.147/148, would be beneficial.

l.140: be (remove ing)

l.158: is indicated the right word here?

l.160: Well, a Bayesian-type approach has been used for all these geophysical studies. As it is written, it sounds like this was always the exact same approach (which it wasn't)

l.176: structure (-s)

l.212: reformulate that first sentence

Section 5: I am not completely sure I understand the reasoning behind this test. The authors construct a first-order 3D velocity model of the Alps based on published data and perform a retrieval check using the real data (hypocenters, stations) as input. Thus any misfit in the output should stem from 3D structure and/or general uncertainty, but

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only with the assumption of this specific 3D model...since the true 3D structure of the Alps will almost certainly differ from the utilized model (presumably only to second-order differences?), do we have any idea if the retrieved 3D effects are similar for a (subtly, substantially) different reality? I think the paragraph needs a more detailed description about the purpose of the test, what it is supposed to show and what it can not show. Nevertheless, I appreciate the effort that went into performing it!

l.268: Figure (-s)

l.271: reformulate "rather slight", add km after 50

l.275: reformulate "fluctuating"

l.319: "contains an overlay site effect" I'm not sure I understand what exactly is meant here.

l.324: This is not really a sentence

l.332/333: Can hypocenters from the INGV/ZAMG catalogs also be shown in Figure 11, to better illustrate the improvement in hypocenter location?

l.344: it would be interesting to elaborate a bit more on these differences; is there a trend, eg. with bulletins showing systematically larger or smaller depths?

l.345: This is not surprising, since no search for new events beyond those in national catalogs has been performed

l.358: mention the magnitudes of these events

l.398: See General Comment: how well can one argue for the absence of seismicity ("seismic gap") based on a catalog that was only a choice of 384 out of 2639 events? A map showing where the remainder of events (those that were not chosen) were located is essential if such a statement is attempted

l.405ff: spelling: Engadin vs. Engadine Fault

l.427ff: These (at least the first three dotpoints) are not results but the analysis steps that were carried out to retrieve the results. Either only results should be listed, or two separate listings for analysis steps and results are needed.

In the name list of AlpArray people, all those containing special characters have formatting issues (LaTeX syntax?)

Figures:

Figure 1: Typo in Tectonic units legend (forland should be foreland)

Figure 2: The fault lines in this plot are really hard to see. Choosing a larger linewidth would be helpful. A color scale for the topography would also be nice.

Figure 4: Please be more specific about what the "various depths" are that were used to obtain the travel-time corridor. Then, I do not see red dashed lines in the plot (as mentioned in the caption). Lastly, I would prefer if the meaning and implications of this nice plot were elaborated a bit more in the text. Is my interpretation of a change from a Pg-like to a Pn-like trend at around 150-200 km correct? How does this fit to theoretical overtaking distances, does this mean that the first arrival is picked everywhere?

Figure 6: missing values in the histograms (Mu and sigma)

Figure 7: should be 110 m in depth (not km)

Figure 8: What is the reason for the wide spread of models at very shallow depths? Looks like they did not converge there (same in Fig. 10). Thicker lines for the plusses and crosses in subfigure b would be helpful.

Figure 9: Typo in label: pahse should be phase; also, I guess the green line marks the end of the burn-in phase. I don't really see anything in the right subplot (which also has no axis-labels)

Figure 10: Would it be meaningful to compare the station correction pattern to the one from the synthetic test (Fig. 8)? In the caption, abbreviations CA and EA should be

Central and Eastern Alps (not Alpine)

Figure 11: Caption: remove one of the two "and" in fourth line; see level should be sea level

Figure 12: Comparing to Figure 2, it seems that the vast majority of events is at the edge or slightly outside of the SWATH-D network. This should be mentioned, and maybe the rectangle shown in Figure 2 can be added here?

Figure 13: Caption: "for a better clarity the depth and length scales of cross section A are magnified by a factor of 1.5"; does this mean vertical exaggeration of 1.5? Or only that it was upscaled by a factor 1.5 relative to profiles B and C (without any distortion)?