

Interactive comment on “Obtaining reliable localizations with Time Reverse Imaging: limits to array design, velocity models and signal-to-noise ratios” by Claudia Werner and Erik H. Saenger

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Dear Anonymous Referee 2,

thank you for thoroughly studying our manuscript. We would like to especially thank you for the extensive markups done in the supplement to your review. We reviewed all your comments and marked annotations in the pdf and changed the manuscript accordingly. We feel that the overall readability has significantly improved. You suggested to perform an additional simulation with a random network design with random inter-station distances and lots of stations. However, we decided to follow the suggestion of Referee 1 and performed additional simulations with regular inter-station distances

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which produce very accurate source locations. This supports our opinion, that an array with regular inter-station distances is superior to an array with irregular inter-station distances if the same amount of stations is used. Often only a limited number of stations is available when conducting field surveys and therefore we feel that it is crucial to understand the importance of the sensitivity of the station placement on the location accuracy. However, we agree with you that a lot of stations improves the location results and therefore as many stations as possible should be used. All changes to the manuscript as suggested are described below in the order of your comments as well as marked in the attached modified manuscript. Additionally, changes made based on the comments by referee 1 are incorporated.

Please note: In the following text referee's comments are put in bold while the author's response is in normal script. Referee's comments may have been shortened for easier reading. No meaning of content was changed. Numbering of the comments of referees was kept the same.

Major comments:

1) The paper could be shortened and the main findings presented in a more systematic way. At times, I have an impression that the authors describe everything what has been done, rather than summarizing their main findings.

Thank you for your thorough review and honest assessment. We rewrote parts of the manuscript to present our main findings more systematically and more clearly. The changes are mentioned below your corresponding comments. However, we were not able to shorten the manuscript significantly without removing a significant part of the content.

My intuitive conclusion would be that it is best to use a random network distribution, spanning a range of inter-station distances with as many stations as possible. I'm not asking explicitly to test such a case, but if it is not too difficult, it could be a good addition.

We thank you for sharing your ideas on what would be an optimal station distribution. However, we decided to perform additional simulations with 32 stations with homogeneous inter-station distances and obtained very accurate source locations that are superior to the source locations obtained with the real stations in Southern California. We therefore conclude that with a similar amount of stations, regular inter-station distances are better than random inter-station distances. We believe that this is an important conclusion for the application of TRI to field data. Performing a synthetic simulation as you suggested with a random network distribution with a range of inter-station distances would be an interesting addition to this study. Additionally, we agree with you that a lot of stations improves the location results and therefore as many stations as possible should be used. However, we decided to not include it in order to keep the topic of the manuscript a bit more focused on the applicability. Often there are not a lot of stations available and therefore it is crucial to know that placing stations more regularly will increase location accuracy.

2) “Localization” should be replaced throughout the manuscript with “source location”, also “localization quality” is actually the “location accuracy”. It would be good to find a native speaker to read the paper before re-submission if possible.

As suggested, we discussed the manuscript with expert speakers of the English language and changed “to localize” into “to locate” throughout the manuscript. Additionally “localization quality” was changed to “location accuracy”. The word “localization” was either turned into “source location” or kept as “localization” to highlight that we are describing the process of finding a source location in individual phrases. Although not explicitly marked in the supplement, we changed the abstract and the title as well. We thank you for suggesting the term “source location” because now the title incorporates the word “source” and therefore states more directly what the manuscript is dealing with.

3) Defining the criteria to assess the performance of TRI is not clear enough. I

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did not understand what are categories I-IV. Also, some parts are unnecessarily repeated.

We thank you for pointing out that this part is not well explained. We rewrote section “2.3: Evaluation of location success” and concentrated especially on the part where the four categories are explained. Unnecessary repetitions were removed and the explanations were written more precise. Furthermore we updated Figure 2 to help explain this part more directly. Additionally, we highlighted that muting the upper part of the model interferes with locating shallow sources and explained more clearly why we chose a rather large error for the source location.

4) The proposed method is not suitable for shallow sources because the authors mute the upper part of the model. This is an important limitation and should be explicitly stated in the conclusion.

We added the muting of the upper part of the model explicitly in the conclusion and stated it more clearly in the discussion. We are much obliged for helping us sharpen our main message.

5) When the authors are talking about the real data from Southern California, they actually use synthetic data. This is fine but needs to be better explained. Clearly: “To mimic a real case scenario from Southern California, we simulate . . . The advantage of using synthetic data when testing a method is because we know what the true answer is . . .”

This is a good suggestion. The corresponding paragraph was changed according to your suggestion.

6) The discussion part should be more systematic. It is currently divided by recent literature and it is comparing the results from this study with the literature. Instead, it should be divided by the nature of the results, where the literature is cited as needed.

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Thank you for your detailed evaluation of our writing style. We did not realize that we accidentally wrote the discussion this way. We rewrote the discussion to make it more clear and removed unnecessary repetitions. We restructured the section to use references from literature to support our findings instead of the other way around. Additionally, we separated the parts of the discussion more clearly into general discussion about the used method, the station distribution with homogeneous velocity models, complex velocity models and noise and finally, future challenges.

Additional Comments from Referee 2 as found in the supplement to the comment (only major comments are listed, minor comments such as rephrasing of individual sentences or paragraphs for readability are not commented but are marked in the revised manuscript):

Suggestion to change some of the section titles Thank you for suggesting to change some of the section titles. We feel that they more clearly express what the sections are about now. We changed the titles of the following sections according to your suggestions as follows:

section 1.1: We kept the original title (but change the word “localization”) to reflect that this section deals only with the source location of TRI and does not discuss the potential of TRI to characterize sources
section 3.1: changed according to suggestion
section 3.2: changed to be more precise
section 3.3: change according to suggestion

Page 4-5: You suggested to use the deterministic signal case of the signal to produce the illumination map We thank you for suggesting to further improve this method. However, this was tested in previous studies and also as a predecessor to this study. We found that using the not time reversed signal to produce the illumination map achieved the best results in suppressing artefacts. In our opinion, including an additional part in the manuscript discussing a deterministic signal or random noise to produce the illumination map would be too elaborate and elongate the manuscript unnecessary. However, we added a more direct reference to the paper of Witten and

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Artman (2011) where this topic is discussed in more detail.

Page 5: the mention of source coordinates is meaningless without giving the origin We thank you for pointing out this obvious mistake.

We changed how we describe the model dimensions at the beginning of the section to include the origin point and to be able to place the source coordinates in relation to the model.

Page 7, Line 9-10: The referee suggested to use Pythagoras theme to calculate the location error

We agree with you that Pythagoras' theme should be used for calculation location errors. However, in this study the focus was to find station distributions that yield locations roughly in the vicinity of the initial source location. We therefore did not want to restrict the source area too much. When locating real data it is sometimes better to have a location with a rather large error than no source location at all and we wanted to include this in this study to make the study useful for a wider range of applications. For specific applications, the error should be estimated more accurately of course and the setup should be chosen to minimize the error.

Sincerely, Claudia Werner and Erik H. Saenger

Please also note the supplement to this comment:

<https://www.solid-earth-discuss.net/se-2018-76/se-2018-76-AC2-supplement.pdf>

Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2018-76>, 2018.

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