Solid Earth Discussions

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Reply on RC2

Alessio Spurio Mancini et al.

Author comment on "Accelerating Bayesian microseismic event location with deep learning" by Alessio Spurio Mancini et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-24-AC2, 2021

We thank the referee for their positive and constructive comments. Here follow our answers to the four comments raised, in the same order as in the referee's comment:

1. The model in Figure 7 is indeed heterogeneous in 3D, but the variability on the horizontal plane is much smaller than in the vertical direction. This aspect may be hard to see by eye in Figure 7, hence we added a note in the Figure caption to explain this point. We also added some text to the manuscript explaining that although the 3D model used has stronger variability in the vertical direction than in the horizontal plane our method is general and applicable for stronger 3D heterogeneity (see lines 595-609 of the revised manuscript, also in connection with the next point).

2. The deep learning emulators need to be trained on synthetics generated for a given fixed velocity model. Hence, for a different velocity model, the same architecture will perform differently. A new optimisation of the emulator training should be performed for every new model considered, hence it is not a priori easy to predict the performance of the models trained in this work on a more heterogeneous velocity model. For moderately more heterogeneous models, the networks developed in this paper should perform well, albeit not optimally. On the other hand, for models with much stronger heterogeneity, an increased number of training samples will likely be needed to obtain an accurate emulator. Nevertheless, as explained in our reply to referee 1, given the speed-up of our approach, such new optimisations should be computationally feasible. We modified the manuscript to clarify this (see lines 595-609 in the "Discussion and conclusions" section of the revised manuscript).

As for the applicability of our approach to real data, as explained in our reply to referee 1, we note that the framework developed in our paper represents an important starting point towards real data applications. Nevertheless, in order to enhance the performance in real data applications some additional work is needed, notably a more realistic model for the noise characterising the seismic sources. We highlight that even though this represents an additional computational requirement, once such a model has been obtained it is straightforward to insert it in the pipeline developed in the paper. The modular structure of our software allows for seamless integration of any type of noise for the seismic sources. We added a few paragraphs in the "Discussion and conclusions" section to explain these various points (see lines 582-594 of the revised manuscript).

3. We added explanations to the manuscript about some details of the implementation,

avoiding statements unsupported by quantitative estimates. Please see lines 135-137, 180-181, 188-189, 229 of the revised manuscript.

4. We performed several tests with and without using the distance d and found that including it helps the Gaussian processes trained to learn the amplitude and time shift coefficients in each generative model, since those two coefficients depend strongly on the distance of each seismic trace from the receiver. We added a comment on this in sections 3.1 (lines 141-143) and 3.2 (lines 355-357).