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Interactive comment on "An extended trajectory-mechanics approach for calculating the path of a pressure transient: Hydraulic tomographic imaging" *by* Donald W. Vasco et al.

Anonymous Referee #2

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The manuscript introduces a new asymptotic algorithm for the inversion of hydraulic tomography data. The methodology improves the tomographic reconstruction compared to the existing eikonal based inversion and provides more accurate hydraulic conductivity reconstructions. This is demonstrated on both synthetic and field examples. The results are validated with independent data. I find the manuscript very well written and easy to follow. The mathematical foundation is presented thoroughly in a clear way. The topic is relevant, and the proposed methodology provides significant improvements compared to existing interpretation techniques of hydraulic tomography. Hence I only have a few minor recommendations, which I believe can further improve the manuscript.

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General comments

The manuscript provides a very detailed methodology description, which (beyond introducing the proposed method) can be a good reference for asymptotic inversion methods used for hydraulic tomography. I found it very helpful, that the authors provided details on the existing state of the art eikonal inversion, which was later used as reference in the results sections. However, due to the shear amount of information in this section, the reader can find itself easily lost. This is why I recommend including a short overview of the proposed methodology for the end of the section (either in text or in a figure).

Beside the presented comparison with the eikonal solver, how does the proposed methodology compare to the calibration of a non-asymptotic model? Does it have any advantage, or due to the need of the h(x,t) simulation they are similar?

Specific comments

P1L7 I did not find the high permeability feature mentioned in the text, only in the abstract.

P7L30 “we need to conduct a reservoir simulation” – this is a repetition from above, consider rephrasing

P9L9 (Hu et al., 2011) recommended limiting the angles between source-receiver points before the inversion to better reconstruct layered structures with the eikonal inversion. Do you think that implying such limitations would make any difference when using the extended-trajectory-based inversion?

Hu, R., Brauchler, R., Herold, M. and Bayer, P.: Hydraulic tomography analog outcrop study: Combining travel time and steady shape inversion, J. Hydrol., 409(1–2), 350–362, doi:10.1016/j.jhydrol.2011.08.031, 2011.

P10L13 What is the reason behind choosing 10 iterations with one method and 15 with the other. What is the experience at how many iterations can the inversion be

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considered complete? Are any error criteria used to determine when to stop?

P10L23 The misfit reduction associated. . . this sentence is too complicated while it only refers to the introduced methodology, please rephrase

P13L25 The discussion section is very brief and is mainly about the hydraulic tomography and not the presented methodology. It feels a bit odd to me, maybe consider integrating it to another section.

P14L15 What level of improvement would you expect from the proposed methodology in fractured media, where the smoothing behavior of eikonal inversion is more significant?

P14L21 mechanics

Fig. 1 – Are both open circles and filled squares used as hydraulic sources and only the circles as receivers?

Fig. 7 - By the contour lines do you mean the lines close to the top of the figure? – this is misleading in the caption. What is the role of the diagonal line leading southwest from well P3?

Fig. 11 – This reconstruction is also in very good alignment with the following papers from the same site: (Jiménez et al., 2016; Kong et al., 2018; Somogyvári and Bayer, 2017).

Jiménez, S., Mariethoz, G., Brauchler, R. and Bayer, P.: Smart pilot points using reversible-jump Markov-chain Monte Carlo, Water Resour. Res., 52(5), 3966–3983, doi:10.1002/2015WR017922, 2016.

Kong, X.-Z., Deuber, C. A., Kittilä, A., Somogyvári, M., Mikutis, G., Bayer, P., Stark, W. J. and Saar, M. O.: Tomographic Reservoir Imaging with DNA-Labeled Silica Nanotracers: The First Field Validation, Environ. Sci. Technol., acs.est.8b04367, doi:10.1021/acs.est.8b04367, 2018.

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Somogyvári, M. and Bayer, P.: Field validation of thermal tracer tomography for reconstruction of aquifer heterogeneity, Water Resour. Res., 53(6), 5070–5084, doi:10.1002/2017WR020543, 2017.

Fig. 14 – Could you comment on the systematic offset of the 3 latest arrivals?

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