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Comment

Interactive comment on “Study on the limitations of travelttime inversion in the presence of extreme velocity anomalies” by I. Flecha et al.

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Received and published: 24 April 2013

General comments: The manuscript explores the limitations of travelttime inversion in the context of a structure involving a high-velocity layer of variable thickness over a low-velocity layer of variable thickness, using sub-basalt sediments as a specific application. The manuscript is well-organised and well-illustrated but somewhat limited in scope. Therefore it will be of interest to a limited readership. One phase appears to be mis-labelled in some of the figures; if this mis-labelling corresponds to a mis-identification then part of the analysis is flawed. A lot of important technical detail is missing, whilst other aspects are explained and illustrated at great length. There are many minor lapses in English; I only comment on a few of them below. Overall the manuscript reads like a technical report that aims to describe a piece of work that

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has been done, rather than to focus on new insights that will be of broad interest. Substantial revision is required to make this a really high-quality manuscript.

Specific comments: Title: The title is somewhat misleading – the manuscript only addresses a very specific example. A better title would be “A study of the limitations of traveltimes inversion applied to thin basalt layers and sub-basalt sediments” or similar.

P190: The authors might allude to waveform inversion in the introduction – there has been quite a bit of work on the application of waveform inversion to sub-basalt sediments.

P193: Further detail is required on how the synthetics are generated. What geometry is simulated? Shot gathers or receiver gathers? What are the shot and receiver depths? What is the source?

P194: Again, a lot of detail is missing from the description of the TTT inversion. Explain how traveltimes were picked and uncertainties assigned to them. Explain what the starting model was, how the model was parameterized and regularized, what the stopping criterion was, how local minima were avoided, how good a fit was achieved, etc. Line 13 mentions interfaces but presumably there were no interfaces in the first-arrival model? It is claimed that the shallow velocity structure was recovered well but there appear to be large differences in shallow structure between Figures 1 and 3, so what is the basis for this statement?

P195: Figure 4 is a much better match to Figure 1 in the shallow part, so I do not agree that any of the Figure 4 result is similar to the first-arrival inversion. Section 4.1 is somewhat confusing in that the inversion of Fig. 4 is described as using only the traveltimes branches corresponding to the sedimentary cover, but it is not clear then what additional information has been used compared to Fig. 3 to give the improved result – is it just that refracted arrivals that are not first arrivals have been added in?

P196, line 6: The term “theoretical model” is used here and elsewhere; “true model”

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would be a better term.

P196, line 7: How much noise was added and how was the amount of noise required to make the synthetics “more realistic” assessed?

P196, lines 9-24: It is not clear what is meant here: the basalt layer thickness is exactly the same in Figs 5 and 7 and appears to be controlled by the starting model. The thickness of the basalt is not proportional to the offset picked. There is no need to pick a limit between refractions and reflections – at long offsets where one is present both are present. The statement that “there is no benefit by using large apertures to infer basalt seismic properties” is not supported by the analysis and I very much doubt it is true.

P197, lines 16-17: The conclusion that additional information (from boreholes) is required may be true but is not supported by the analysis because no result is shown that makes use of all phases but without the boreholes.

P198, lines 9-21: The information given here is repeated in Fig. 9 and then again in the caption to Fig. 9. We only need to be told it once!

P199, lines 3-6: A short sentence is needed explaining why the authors now switch to 1d models. Some more information is required about the source – what is the significance of the frequencies given? I’m sure the source is not monochromatic.

P199, lines 8-18: To make any sense of this material we need to know some more about the source wavelet and how the picking was done. Is the time difference between the red and cyan lines in Fig. 12 significantly larger than the travelttime error that would arise in noisy real data? It looks rather smaller than the uncertainties quoted in Table 4. If the time difference is less than the other uncertainties, this section adds rather little.

P199, line 19ff: We need to know whether the reflected phase from the base of the basalt was used in the inversion. I infer from Table 4 that it was not but could not find

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this explicitly stated anywhere. The explanation as to why a reduction in the assumed picking error gives a worse model is rather hard to follow and I am not sure what the authors are trying to say here – do they think that noisier data will give a better result?

P201, line 9: “no noise has been considered” – this is not true since noise was introduced in Fig. 6.

P201-202: The Conclusions section is somewhat rambling and disorganized. The authors should pick out key new conclusions from their study. The conclusion that inversion of synthetic data gives better results if the frequencies are higher and the layers are thicker is hardly novel.

Table 3 is unnecessary – these numbers are given in the text.

Fig. 1: Why is the model resampled? There are a couple of typos in the caption.

Figures 2 and 6: The orange picks are not reflections from top basement as stated in the caption – they are refractions from the basement. If they have been mis-interpreted in the inversion, there is potentially a serious problem.

Figures 5 and 7: Subsample the rays so that we can actually see them.

Fig. 12: I’m not sure of the value of this figure but if it is included, it needs a horizontal scale, and the caption should mention that is a blow-up of Fig. 10 not of Fig. 11.

Technical corrections (examples only):

P191, line 4: “times, offset” -> “time-offset” P192, line 1: “geologic” -> “geological”
P192, line 17: “outter” -> “outer” P193, line 8: Delete the first “layer” P193, line 14:
Delete “After intense calculations” P194, line 7: “quite ideal” is an odd description
- rephrase P194, line 23: “layer by layer striping” -> “layer-stripping” P194, line 24:
“developed” -> “developed” P200, line 6: “are better and fit the right model” -> “better
fit the true model”