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# *Interactive comment on* "A new model of the upper mantle structure beneath the western rim of the East European Craton" *by* M. Dec et al.

**M. Dec et al.**

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Dear Reviewer,

Thank you for your valuable suggestions and comments that helped us to improve our manuscript. Below we list detailed answers to your comments.

The authors compare to AK135, but there must be surface wave models of the region that would be more appropriate for comparison. For instance comparison to the Berkeley global model (French et al., Science, 2013) might be useful since it is published online? But other regional models are also likely available.

Reply: In this work we present only P–wave analysis and the majority of the modelling was performed in 1D, therefore comparison with AK135 reference model seems to

be justified. Surface waves derived models are primarily sensitive to S-wave velocity changes, not P–waves. We believe it's more appropriate to compare our results with regional tomographic models based on P-wave travel times like the one of Koulakov et al. (2009). Analysing horizontal sections at 200, 300 and 400 km presented by them we observed similar pattern of the velocity anomalies in the regions analysed in our paper (Fig.1b). Also in vertical section crossing parts presented in Fig.1b we observed similar behaviour of velocity changes. However the comparison is not straightforward as the tomographic models are inherently smooth and continuous whereas our model contain discontinuities modelled using reflected waves.

How have you accounted for anisotropy? Or, how does that affect your result?

Reply: We do not take anisotropy into account. We believe that the different depths of earthquakes and relatively small azimuthal span in the groups of events is prohibitive to perform anisotropic analysis. Also it seems that the azimuthal velocity changes would produce travel time misfit that falls within picking uncertainty range.

What were the criteria used to determine the number of discontinuities you would look for in the data? Some discontinuities are not observed everywhere, even if they exist in global models like PREM – for instance the 220. The process you went through should be described more.

Reply: In this work we analysed earthquakes in the far–regional mode, i.e. with epicentral distances 1500 – 3000 km. Based on the earlier results of e.g. Thybo and Perchuc (1997) Lehman discontinuity at ca. 200 km is clearly distinguishable in the first arrivals and as a reflected wave. With such an offset we can observe seismic discontinuities down to 410–km discontinuity. The discontinuity at ca. 300 km was introduced based on earlier results of Nita et al. (2012) presence of the reflected arrivals above P410P reflected phase.

0.5 – 2 Hz – is that a range frequently used in this type of study? Can you describe the other bands you tested?



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Reply: This type of filter is commonly used in analysing earthquake data recorded in far–regional mode. There are some modifications of it like for example 0.3 – 2.0 Hz or 0.8 – 2.0 Hz used by Chu R. et al. (2012). We tested also 0.1 – 1.0, 0.1 – 2.0, 0.5 – 1.0, 0.5 – 5.0, 0.5 – 8.0 Hz filter bands; but we found 0.5 – 2.0 Hz works the best for our data.

Why use 1997 – 2010? Does the data not exist before/after this?

Reply: The SUW station started to record in 1997, therefore we do not have earlier data. We started our analysis in 2011 working on 14 year period dataset. Nevertheless additional events do not change the final result.

Page 6, line 3: During alignment, is it aligned on absolute amplitude? Or just amplitude?

Reply: We used amplitude normalized to maximum.

A longer description of assumptions and steps taken would be useful in the methods section. What are you aligning on? What are you picking? How do you get to the velocity model? Is there a spherical earth/flat earth conversion?

Reply: We do not change hypocenter locations of events. After calculating differences between models obtained from the analysis of the events from different depths we concluded that within each range of focal depth presented in this work the differences are small enough to carry out seismic modelling simultaneously for all depths. We picked first arrivals (P220 and P440) and reflected waves form discontinuities at the depth of 220, 335 and 440 km (P220P, P335P and P440P respectively). The final model was achieved with forward trial and error method. We use spherical earth conversion in 1D modelling and spherical earth 2D ray–tracing in case of 2D modelling.

I am a bit confused about the 1–D 2–D parts here. Could you describe this better in the methods section (rather than interspersed in results). It looks like you assume a 1D model, except for the case where you have and ocean–continent path, in which



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case you allow for different crusts. But you don't allow for different crusts in the other cases, does this affect your results especially for shallow events? Also, is a 1–D model appropriate for such a large area? Could you separate effects from source–side and receiver side, to get a 1–D model just beneath the station?

Reply: Differences in crustal parts of our model have small influence. We also use average velocities for continental parts of the crust. The depth of the source is much more important in our analysis. In order to reduce this influence we grouped events with respect to focal depths. Our model aims to characterise the border part of the EEC and to point out the main seismic discontinuities. The proposed MP1–SUW model and its interpretations require further studies, preferably using seismic array. Using methods presented in this paper we cannot separate effects from source–side and receiver side.

All the detail on events and also SNR before/after filtering is probably unnecessary.

Reply: We think that showing SNR before and after filtering confirms that using such a filter significantly improves the quality of the modelled data. It also shows the values of this improvement for each section respectively.

Page 1 line 24, add "back–azimuthal" before "seismic section."

Reply: You probably mean page 560 line 16 – we applied this phrase.

More discussion of error bars on the model would help. What is the error in velocity and also depth?

Reply: We are aware of velocity and depth uncertainties. Based on our analysis of the refracted and reflected arrivals, we can conclude our uncertainty of velocity for each layer is $\pm 0.025$ km/s. The uncertainty for the depth of each discontinuity is $\pm 10$ km.

Can you define how kurtosis provides more information in this context (Is there a physical intuition of what that means)?

Reply: If the kurtosis is equal to 3, the error distribution is Gaussian. When the re-



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sults are highly concentrated around the mean value, the kurtosis is larger than 3 and general the errors are smaller. Otherwise, when the kurtosis is smaller, the results are more scattered, which means that the errors are larger.

References:

Chu, R., Schmandt, B. and Helmberger D. V.: Upper mantle P velocity structure beneath the Midwestern United States derived from triplicated waveforms, Geochem. Geophys. Geosyst., 13, 1-21, 2012.

Koulakov, I., Kaban, M. K., Tesauro M. and Cloetingh S.: P- and S-velocity anomalies in the upper mantle beneath Europe from tomographic inversion of ISC data, Geophys. J. Int., 179, 345–366, 2009.

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Interactive comment on Solid Earth Discuss., 6, 559, 2014.