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Interactive comment on "Slab Break-offs in the Alpine Subduction Zone" *by* Emanuel D. Kästle et al.

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Dear Barbara Romanowicz,

Dear Editors,

we appreciate the helpful comments on our manuscript which we have carefully read and taken all into account in the revised version. We re-structured Figures 1 and 2 and created a new Figure (3) to ensure better comparability between the shown models. We show now the surface-wave model in a side-by-side comparison with the body-wave models and also show it on top of the body-wave models, including additional annotations and labels to guide the reader. We have included a point-by-point response that you find below with the original comments in bold letters. We also attached the

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manuscript with the highlighted changes.

Review of Kastle et al.

The idea behind this paper is to combine results from surface wave tomography on the one hand and from body wave tomography of the upper mantle beneath the Alps to choose among possible proposed scenarios of tectonic evolution of the region after continental collision, involving the fate of several subducted slabs.

The authors argue that by combining the two types of results, they take advantage of better resolution of surface waves in the shallow layers (<200 km depth), and additional constraints of body waves in the deeper upper mantle layers.

The main issue I have with the paper in its current form is the presentation: the authors start from the idea of combining the results of surface wave and body wave tomography, trusting the surface wave tomography better at shallow depth, but they don't really allow us to easily judge what happens when you do that: the surface wave and body wave models are presented at different scales (in particular in the depth direction) and there is no effort to adjust the color schemes between the two types of models. In particular, if I understand it correctly, the averages at a given depth taken out before plotting are not the same in the surface wave and body wave models: surface wave images as presented with respect to PREM, whereas the body wave models, by construction, are presented with respect to the regional average. It would therefore make sense to remove the regional average from the surface wave models for a comparison with the other ones. This would actually help visualize small perturbations that are currently hidden because the surface wave images are biased to blue colors in this region of convergence.

All tomographic images in the present manuscript (and supplementary material) are presented without any vertical or horizontal exaggeration, so that there is no distortion

of structures when comparing the surface- to the body-wave models. We consistently use the same color model but we use different scaling in the color bars. This is necessary, because the absolute velocity of the anomalies varies considerably between models and we want to make the models as comparable as possible. In the revised version we subtracted the 1D average from the surface-wave model to show relative velocity deviations from this regional average instead of PREM. This guarantees that all models are shown with respect to their individual regional average. In order to facilitate comparisons, we re-structured the manuscript so that we show the surface-wave model directly next to the body-wave models in the new Figures 1 and 2.

What would be very helpful is to show composite cross-sections with the surface wave model at the top, truncated at some depth (150 or 200 km?) followed by the respective body wave models (see figure 1 below where I have attempted to illustrate this concept for sections B). - You could also show, separately, comparisons of the surface wave and body wave models in the shallow parts to better visualize the compatible elements of the models. With a little more annotations of specific features in those cross-sections, it would be much easier and faster for the reader to follow the text and therefore judge the proposed interpretation, which I find very hard to do as presented. And it would be consistent with the main idea behind the paper, which is to combine the deep structure from body waves with the shallower structure from surface waves.

We re-structured Figures 1 2 to show the different models directly next to each other. We added more annotations to the cross-sections, such as denominations of the mountain ranges at the surface and use consistently the same labels in all cross sections to make it easier for the reader to follow. In the new Figure 3 we plot, as suggested, the surface-wave model on top of the body-wave models. Additionally, we highlight some structural continuities that are discussed in the manuscript. We also added more Figure references and specific references to the labels in the figures in several parts of the text.

details:

page 7 line 24: "eastward increase", do you mean "decrease" ?

Yes, decrease would have been correct. Because the sentence was confusing in the original MS we changed it to “Underneath the eastern Alps all models show a vertical to slightly northward dipping slab (Fig. 2C,D, S10–S12, Lippitsch et al., 2003; Piromallo and Morelli, 2003; Koulakov et al., 2009; Dando et al., 2011; Mitterbauer et al., 2011; Zhao et al., 2016; Hua et al., 2017). This northward dip is most clearly expressed in the model of Lippitsch et al. (2003), who image the slab down to a depth of about 250 km (Fig. 2D).”

page 8 ,lines 19-21: this sentence needs pointing to specific features on one of the figures, otherwise it is hard to evaluate. More generally, better guiding the reader as to which features are discussed on which figures in the Discussion section would be helpful (for example putting more annotations on the cross-sections which would be referred to in the text.

We added more references in the text, also pointing to specific figure labels in the revised version, such as “(Figs. 2A, 3A, label EU/AD)”.

page 8 line 30: "The inferred amount of shortening...". How do you infer that quantitatively (i.e. what rates of slab sinking ?

This sentence was unclear, the inferred amount of shortening is in this case only based on the shortening estimates that are available from surface-geological studies. We changed the sentence to: “The collisional shortening estimates for the western Alps range between 30 – 150 km, when taking the shortening of the European units and 50 km of potential underthrusting of Europe into account (Bellahsen et al., 2014; Schmid et al., 2017; Rosenberg et al., 2019). The inferred amount of shortening from these works is lowest in the south, increases to about 100 km along our cross-section A (Fig. 1) and reaches its maximum in the north at the transition to the Central Alps.”

Please also note the supplement to this comment:
https://www.solid-earth-discuss.net/se-2019-102/se-2019-102-AC1-supplement.pdf

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