Solid Earth Discussions

Solid Earth Discuss., author comment AC1
https://doi.org/10.5194/se-2021-33-AC1, 2021

Reply on RC1

Rainer Kind et al.

Author comment on "Moho and uppermost mantle structure in the Alpine area from S-to-P converted waves" by Rainer Kind et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-33-AC1, 2021

- **RC1**: 'Comment on se-2021-33', Anonymous Referee #1, 07 May 2021 reply This work is based on a large amount of data coming from experiments within the framework of the AlpArray experiment (AlpArray, SWATH-D) and permanent networks, and the application of a novel method using S-to-P conversions ('causal' SRF or C-RF). The objective was to investigate the Moho and lithospheric structure of the greater Alpine region. The size of the analized area allows for an overall view of this region and the general trends along-strike of the Alps, although the paper focuses particularly on the Tauern window, a key area, and the change that occurrs across 13°E all the way to the Pannonian basin. The paper is well written, the comparison with previous studies interesting and the results clearly stated.
  In regard to the observations, it is nice to see the stacked waveforms in the profiles but it is hard to understand how the discontinuities are plotted from the first arrivals. In fact, in general the choice of the line representing the discontinuity often seems arbitrary. Even when the choice of the converted phase "bump " is clear it might be difficult to ascertain where the line representing the discontinuity should be placed, particularly when there is an emergent "bump". This is especially true for the small signals converted below the lithosphere, that are identified as NVG (negative velocity gradient). It seemes that it is possible to identify some clear patterns in the profiles but in many cases it is not so. For example, below-Moho Profile 9B (Figure 11) is convincing, it really shows a jump in the NVG across lat 48.5°, but other profiles are very noisy, for example the discontinuity traced for profile 1B (Figure 3) seems arbitrary. Also, in profile 4B how can you trace such smooth discontinuity when the arrivals are jumping up and down? In profile 5B one cannot really see the arrivals, amplitude is too small, they are flat.....For this reason the suggestion is to have a more cautious approach in identifying the interfaces where S-to-P takes place, and state clearly which are the reliable observation. Some question marks would be appropriate on the figures in dubious cases or when there is more than one choice. This is particulary the case for the B part of the profiles. It seems that the authors are aware of these uncertainty since in the conclusions they only summarize the observations that are more reliable.
- *These comments are fair and understandable. We have tried to make clear that the NVGs are areas of scattered small-scale converters which do not form a single clear "laterally homogeneous discontinuity", which could perhaps be interpreted as LAB. Comparable observations in the mantle lithosphere are rare and therefore any new information is important. The special features of the NVG observations confirm doubts about the existence of a clear seismic LAB, at least in the Alpine area. We will express*

this more clearly and mark it also more clear in the figures. These signals are also very weak with amplitudes only about 2-5% of the incident signals. However we think they are still important indicators of regions where the velocity is decreasing downward. The fact that the NVGs are concentrated in some regions permits their interpretation, together with other data, as possible indicators of significant geodynamic processes We did not yet pick Moho onsets at the stacked traces because of apparent precursors of the Moho onsets. We are working on that problem by comparing waveforms of SV signals with Moho waveforms. This should help to determine Moho onsets more reliably and will allow to produce a map of the Moho depths. The same applies for the NVG signals. The dashed lines near the beginning of the Moho onsets do not mark Moho onset times. They just mark relative changes of the Moho depths along the profiles.

- Finally, filtering and any additional processing of the waveform can cause unwanted effects that might lead to misintepretation. On the other hand, not filtering can also lead to problems due to unsupressed noise which might also lead to misintepretation. The strenghts and weaknesses of both approaches should be pointed out.
- *We used only broadband signals with high signal-to-noise ratio of SV. Frequency filtering can therefore not improve the signal-to-noise ratio in the range of the main periods. The advantage of filtering is the improvement of the signal-to noise ratio for weak signals. One of our goals in an upcoming manuscript is the interpretation of the waveforms of the Moho and possibly the NVG signals, which would be distorted by filtering.*

Specific comments (line numbers on the left)
59-60 "corrected for the sign of the onset", does it mean that negative phases are multiplied by -1 so all SV bumps are positive? *YES*

- 67-68 data selection 50% noise, it is ok for the Moho signal (~10% amplitude) but perhaps not for deeper conversions (~few%). It seems that this is a key aspect determining if sub-Moho signals can be detected. Perhaps in such a heterogeneous area (high signal generated noise) the threshold on the noise on the P component should be lower. It is explained in the text that to have enough waveforms this threshold cannot be too small, but another way to increase the number of wavefomr in each cell is to increase the cell size.To increase the S/N, especially for the sub-Moho part, it might be necessary to loose some (hypothetical) resolution.
- *We agree that permitting a 50% noise limit seems high for the very small NVG signals. This number results from experiments, which we have done. Increasing the cell size would, of course, improve the situation, but the price would be the lateral resolution. We think we found a good compromise.*
- 94 "The signal forms of the Moho (and other) conversions are determined mainly by the signal forms of the incident SV signals." Is this the way the curves are identified in the profiles? If yes, this is also a key aspect, stated this way it is vague. Please explain more clearly, possibly with an example (maybe a figure as Supplementary material).
- *We need to make this clearer. In case of a single discontinuity, the signal form of the converted wave is determined by the signal form of the incident wave. However, if there are several discontinuities close to each other, the resulting signal form will be more complicated. In case of the Moho signal, a comparison of both signals (SV and Moho signals) should be very meaningful. We are now working on that question in a subsequent manuscript also presenting a Moho map. We hope to determine the Moho arrival time more accurately this way. In the present manuscript we did not determine Moho times (with the exception of the depth estimates of the largest Moho depths shown in Fig. 15). In many cases it seems difficult to determine the Moho arrival time because of possible precursors, which could indicate sub-Moho conversions with the same sign. By the way, this is one of the reasons why we avoided deconvolution. Deconvolution changes the waveforms and makes it very likely difficult to identify small precursors. The dashed lines in the Figures A mark only roughly the general trend of the Moho signals along the profile.*
- 97-99 How can we be sure that the negative phases below the Moho that make up the

NVG are real features and not part of the intereference pattern between the "real" phases or an effect of the interference of signal generated noise ? Is there a way to determine the signficance of these scattered negative bumps ?

- *The signals we called NVG are the first arriving signals and we did not see nor do we expect larger signals before the NVG signals which could generate noise. However, theoretically the NVG signals could generate noise, which could disturb the Moho signals. But comparing the amplitudes of both signals, this possibility seems insignificant.*
- 113-116 I agree for profiles 2-4, but for profiles 4-6 the Adriatic Moho between 45 and 46 is completely inferred since there is no data. For profiles 4-6 I think it is not possible (at least with these display) to see the culmination of the Adriatic Moho coming from the observations.
- *You are certainly right. We will change this, also in the figures.*
- 117-119 perhaps from the profiles since the culmination of the Adriatic Moho is seen in profiles 2-4 it would be safer to say change "at least west of 11°" --> "west of 11°" *OK*
Figure 3a. In Profile 1A (figure 3) it is not clear how is the Moho signal onset is identified on the waveforms. The dotted curve does not seem to fall on the first arrival of several traces, it seems it should be more wavy. In particular, the dotted curve does not seem to follow the data (origin time) between 46.5 and 45, in fact it is difficult to identify the arrival time. Similar comments can be applied to other Moho profiles. In general, a clear example on how this interface is identified should be shown.
- *The dotted line does not mark the Moho arrival times. As mentioned above, it marks only the trend of the Moho along the profile. Moho arrival times will be determined in an upcoming manuscript.*
- 120-133 In Figure 9A it appears that the onset of the Moho signal under the black arrow corresponds to about 45-47km depth. Also, the waveforms of the dipping (European) Moho within about 48°-49° seem to interfere and cause the Moho signal to be very broad and extended at depth. It is very difficult to identify the onset on these very emergent arrivals. This is true also for other profiles, for example profile 8 in Figure 10A. Since this are key observations for the interpretation of a change of the subduction style across 13° the authors need to show how this interfaces are constructed from the data in a clearer and more convincing way.
- *This is a very significant point. It is a typical example for positive precursors of the Moho. The determination of the arrival time is therefore difficult. The comparison of the SV and Moho wave-forms could help. We are working on this issue now and give therefore no Moho arrival times in the present paper (except some approximate values in Fig.17). We will improve the explanation of these circumstances in the text.*
- 234-236 Figure 17B is very difficult to read. In particular, one cannot see the values on the lines with constant velocity of Paffrath et al. so the comparison with the present work is also difficult.
- *Thank you for pointing out that Fig. 17B is indeed very difficult to read. We improved this figure for clarity by increasing the size of the numbers denoting p-wave velocities*
- 250-254 From Figure 17B seems that the positive velocity anomaly gradient of Paffrath et al starts at 4° and continues up until about 11° and that the agreement with the present work is between 11° and 14°.
- *It appears that our message presented in the entire paragraph between lines 234-256 was misunderstood. We believe that this is probably due to the poor style of writing on our side. Hence we rewrote the same paragraph to enhance clarity and structure of the arguments. We hope that the point we make now find the acceptance of the reviewers.*
- 259-260 It seems that, given the seemingly arbitrary choice of the Moho interface it is difficult to compare the two results. Perhaps, there seems to be an asymmetry but it should be more precisely shown.
286-287 Can't see a dotted black line in Figure 20B
- *In Fig.18 (as in most other figures) we just displayed our waveforms without picking own Moho onsets. The depth determinations (dotted lines) from the other authors are relatively close to the onsets of our Moho waveforms. The in Fig.20B is cyan, not black.*

- 317-321 It is true that filtering and any additional processing of the waveform can cause unwanted effects that might lead to misintepretation. On the other hand not filtering can also have problems due to unsupressed noise which might also lead to misintepretation. The strenghts and weaknesses of both approaches should be pointed out.
- *this question is repeated from above*