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Moho depth determination in the Eastern Alps-Pannonian basin- Carpathian mountains region based on H-K grid search method and CCP migration of receiver functions

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Study area and seismic stations

Our study area is the Eastern Alps-Carpathian-Pannonian Basin region, where a dense seismological network allows a detailed analysis of the crust mantle boundary. The Pannonian Basin is a geologically complex extensional back-arc basin in Central Europe (Fig. 1.). The Moho discontinuity is generally at shallow depth (20-35 km) in the Pannonian basin as a result of a Miocene extensional event (Horváth et al. 2006). However, the Eastern Alps and Carpathians are characterised by deeper Moho (35-50 km) and a more complex lithospheric structure. In recent years the permanent networks became denser and several temporary deployment campaigns, such as the Carpathian Basin Project (CBP), the South Carpathian Project (SCP) and the AlpArray experiment (Hetényi et al. 2018a) took place. Thus, we used the data of 221 seismological stations for the receiver function analysis.

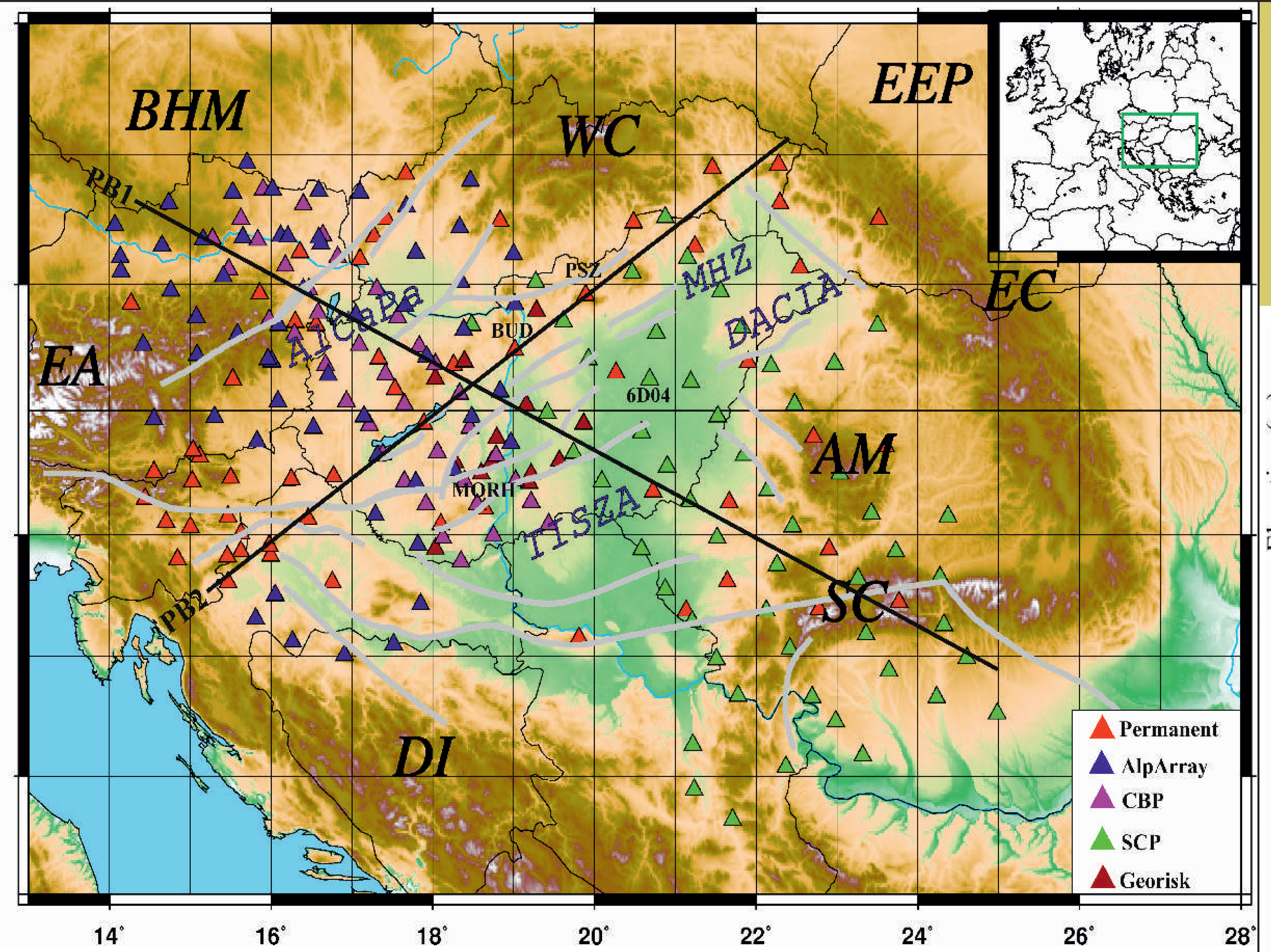

Figure 1. Investigated area, the seismic stations used in this study. Coloured triangles shows different type of seismological stations. PB1 and PB2 mark the locations of migrated cross-sections. Abbreviations: AM: Apuseni Mountains; BHM: Bohemian Massif; DI: Dinarides; EA: Eastern Alps; EC: Eastern Carpathians; EEP: East European Platform; MHZ: Mid-Hungarian Zone; SC: Southern Carpathians; WC: Western Carpathians.

Event selection

- teleseismic earthquakes
- 28°-95° epicentral distances
- magnitudes larger than 5.5
- broadband three-component waveforms filtered them between 0.1 and 1 Hz
- 3 year 3 months of data from the AlpArray temporary network
- 2 years data from CBP and SCP stations
- for the Hungarian and other permanent stations we used all available data since they entered into operations up until March 31 2019

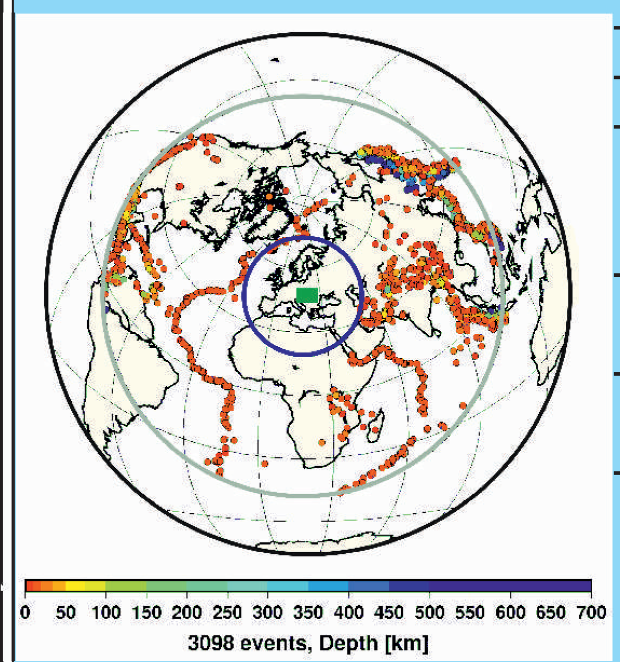

Figure 2. Location of the 3098 earthquakes used in the receiver function analysis. Green square shows location of the Pannonian Basin.

Quality control

We applied three quality control methods. The first (QC1) was an STA /LTA detector with detection threshold 3.5. The second (QC2) was performed in time window 30 s before and 90 s after the first-arriving P-wave. Waveforms with a signal-to-noise ratio above threshold were accepted (Hetényi et al. 2018b).The last quality control method (QC3) was performed on calculated receiver functions. Receiver functions were rejected as poor quality if the P peak below threshold. We tried to keep only the best receiver functions for the further processing methods.

Downloaded waveforms	After QC1	After QC2	After QC3
454.089	240.828	171.255	30.216

Table 1. Number of waveforms after downloading, QC1, QC2 and QC3 at all dataset.

Acknowledgment and References

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Receiver function analysis

For the receiver function analysis we used the iterative time domain deconvolution (Ligorria and Ammon, 1999) with 150 iterations. Fig. 3. shows the stack receiver functions of PB2 section. P, Ps and PpPs multiples are clearly visible in the Dinarides and Western Carpathian, but we can identify only P and Ps peaks in the Pannonian Basin in the most cases. Fig. 4. presents the radial and transversal receiver functions at PSZ and BUD station. Owing to the automatic QC the P and Ps peaks are clearly visible in all azimuthal range.

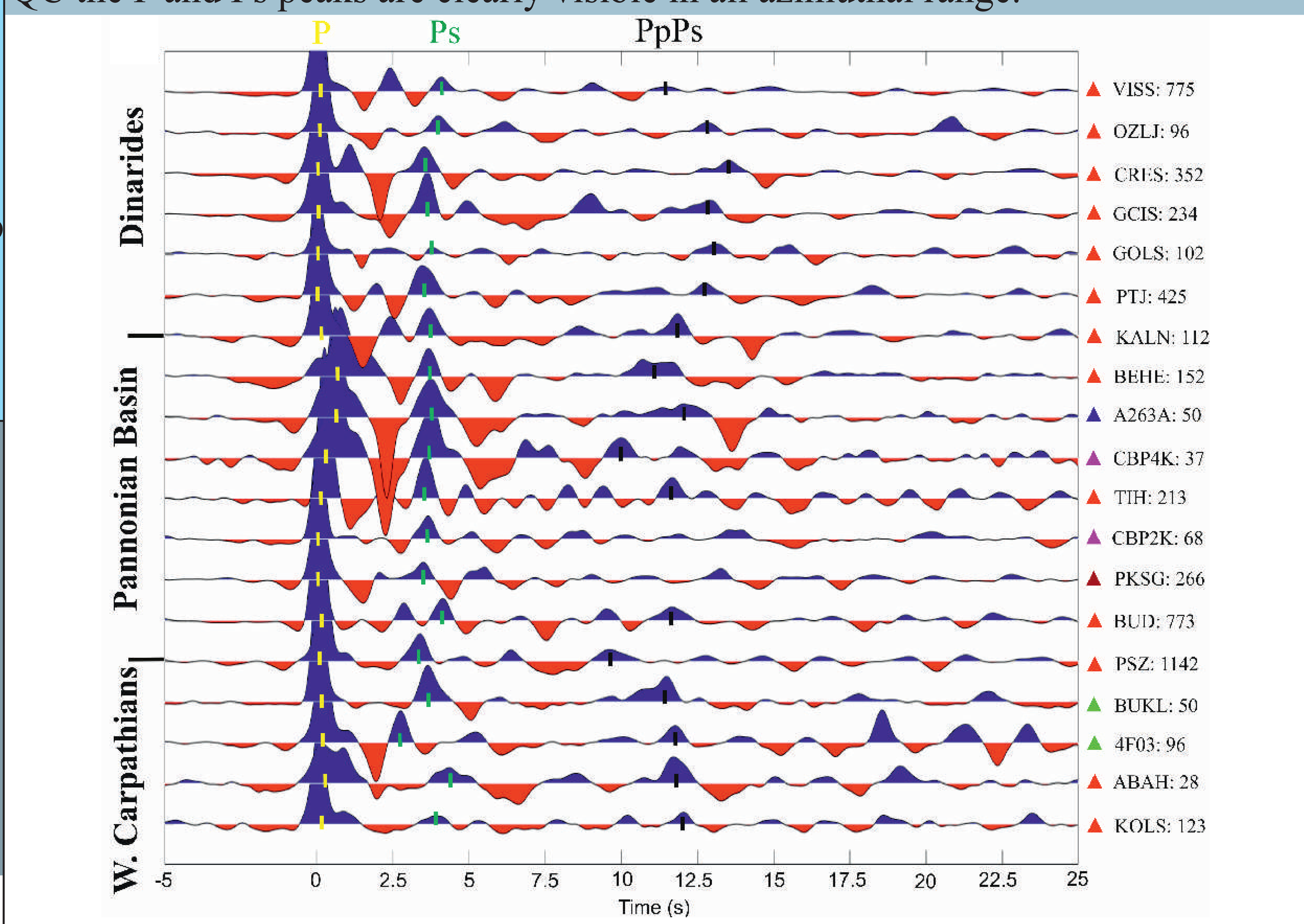

Figure 3. Stacked receiver functions at stations along the PB2 profile.

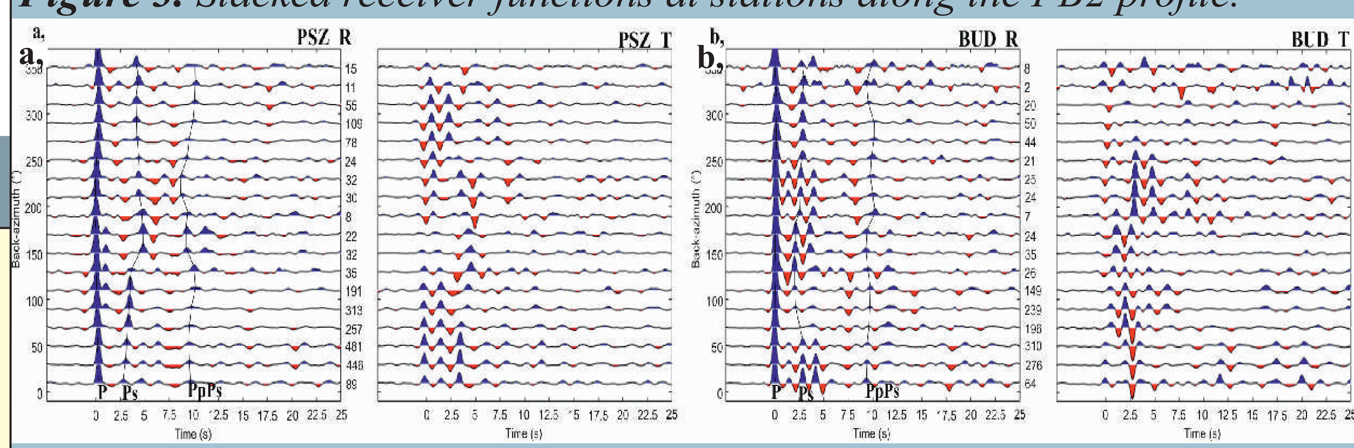

Figure 4. Radial and transversal receiver function at a, PSZ and b, BUD station, sorted by back-azimuth.

Migration

We performed common conversion point (CCP) migration to image the Moho depth beneath the Pannonian Basin independently from the H-K analysis. We defined two profiles, the first from the Eastern Alps to the Southern Carpathians (PB1) and the second section from the Dinarides to the Western Carpathians (PB2). Fig. 1. shows the locations of migrated cross-sections.

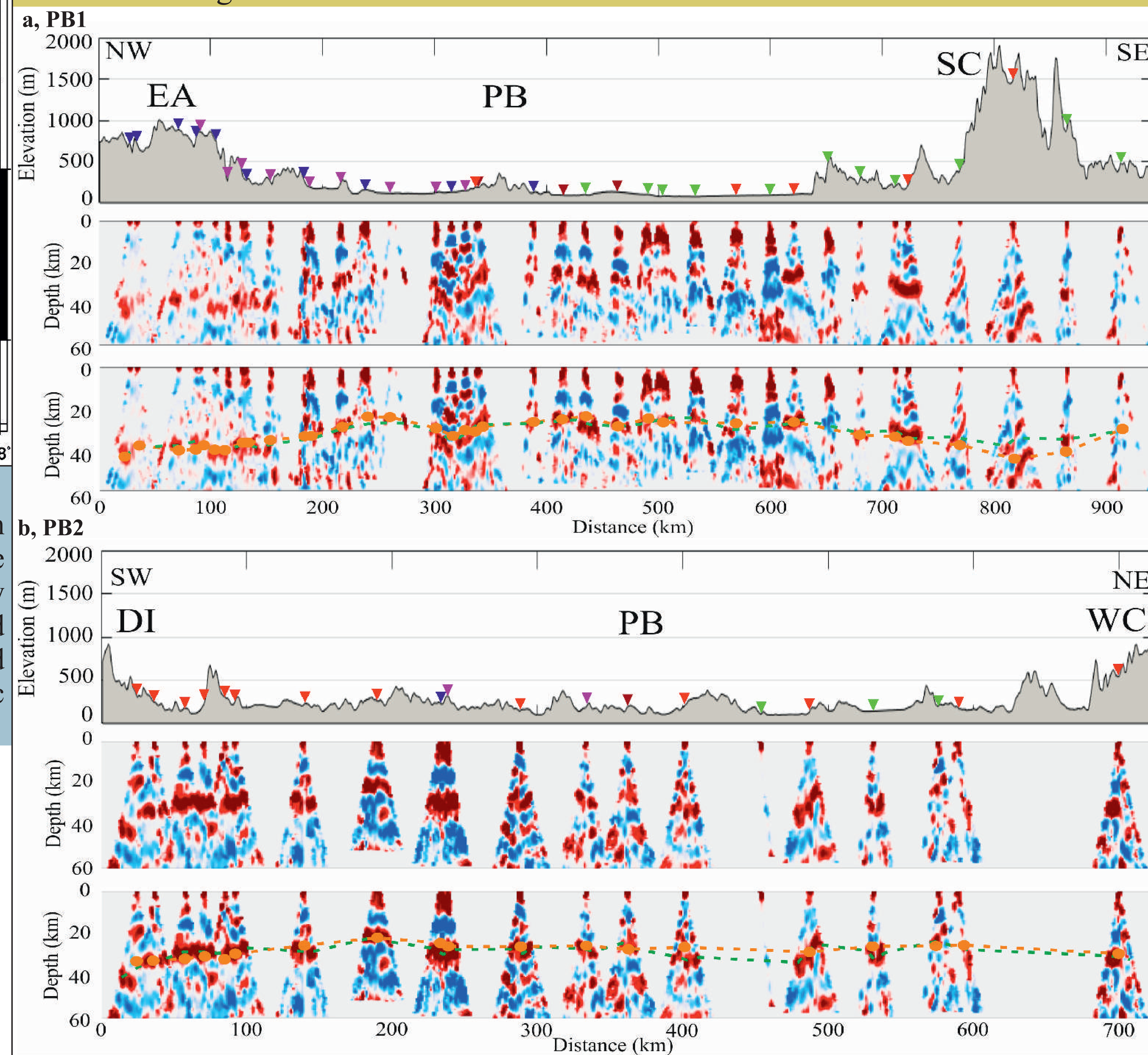

Figure 5. Migrated P-to-S receiver function cross-sections for lines a, PB1 and b, PB2. The dotted green lines present the Moho depth from migration methods. The orange circles show the depth of Moho beneath each station from H-K grid search method. The dotted orange lines show the interpolated depth of Moho from the H-K method.

H-K Grid Search method

We performed the H-K Grid search method Zhu and Kanamori (2000) on the accepted receiver functions.We set different initial Vp velocity for each stations, depending on sedimentary cover. We set the weights of Ps, PpPs and PpSs+PsPs separately for each station (Kalmár et al. 2019). The Moho is between 20 and 50 km in the studied area.The extent of the red area (86% of the peak) around the maximum (star) is a proxy for the uncertainty.

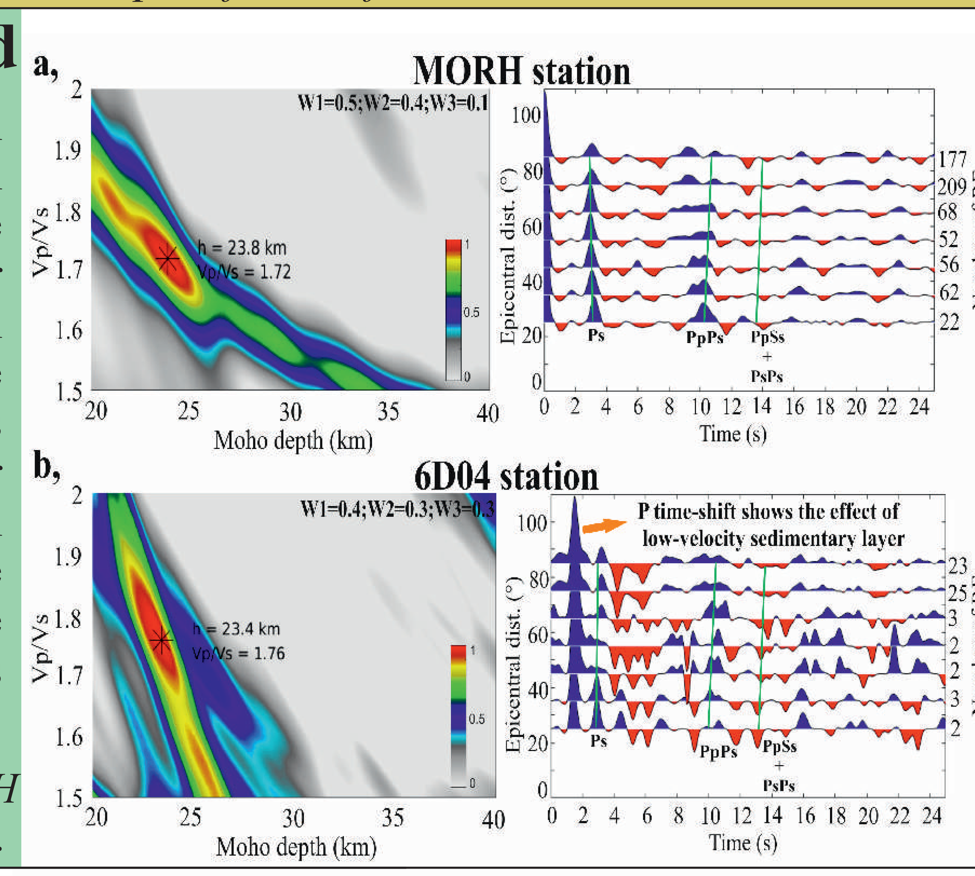

Figure 6. H-K grid search results a, MORH (hard rock); b, 6D04 (sedimentary) station.

Vp/Vs ratio map

We present Vp/Vs ratio map from 1D H-K grid search interpolation. The calculated Vp/Vs values in every case change between 1.5 and 2 in the all investigated area.

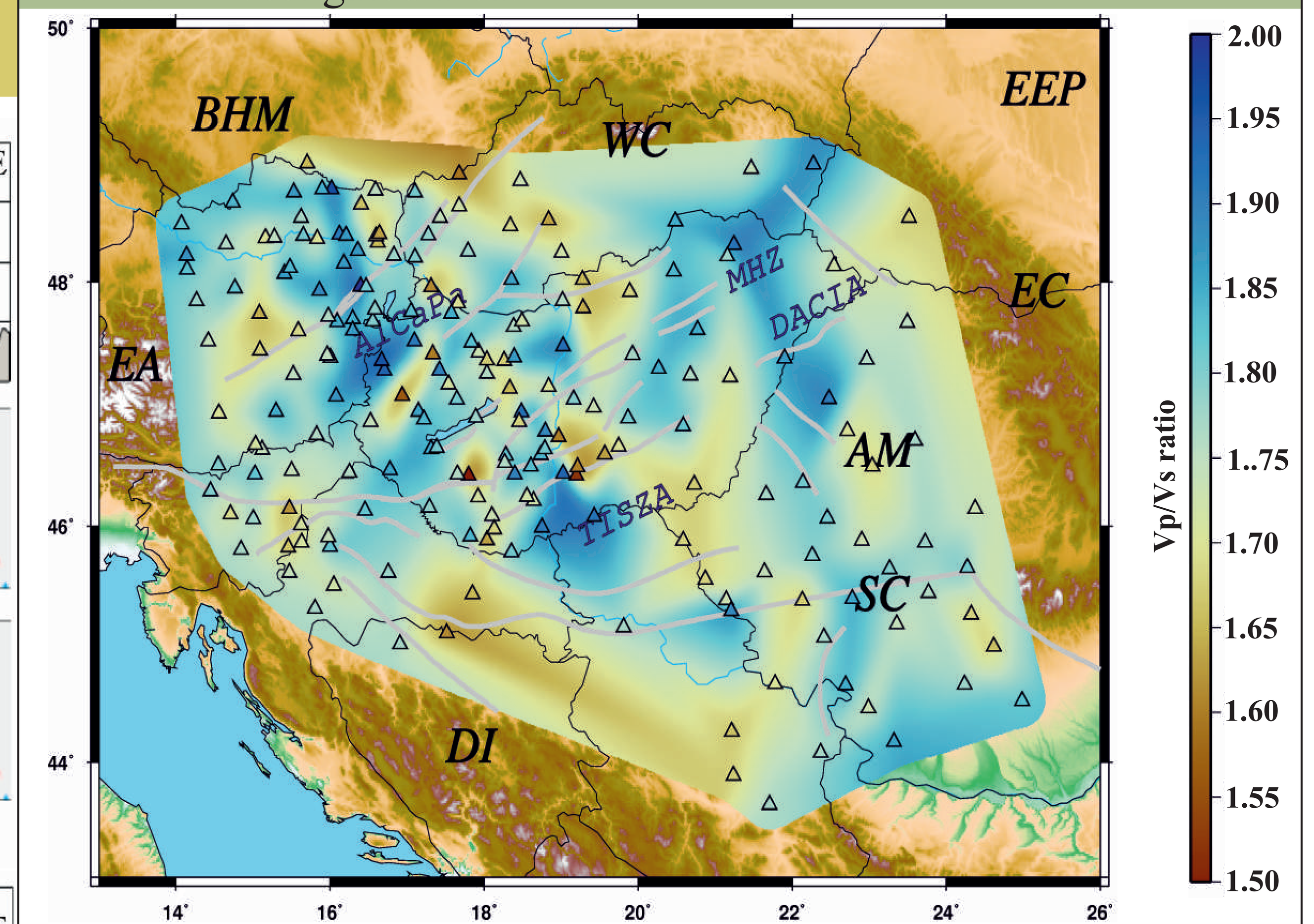

Figure 7. Vp/Vs ratio map from this study.

Moho map

We present a preliminary Moho map from 1D H-K grid search interpolation, and compare it with that of Grad et al. (2009). We expect to produce a more detailed map in the future.

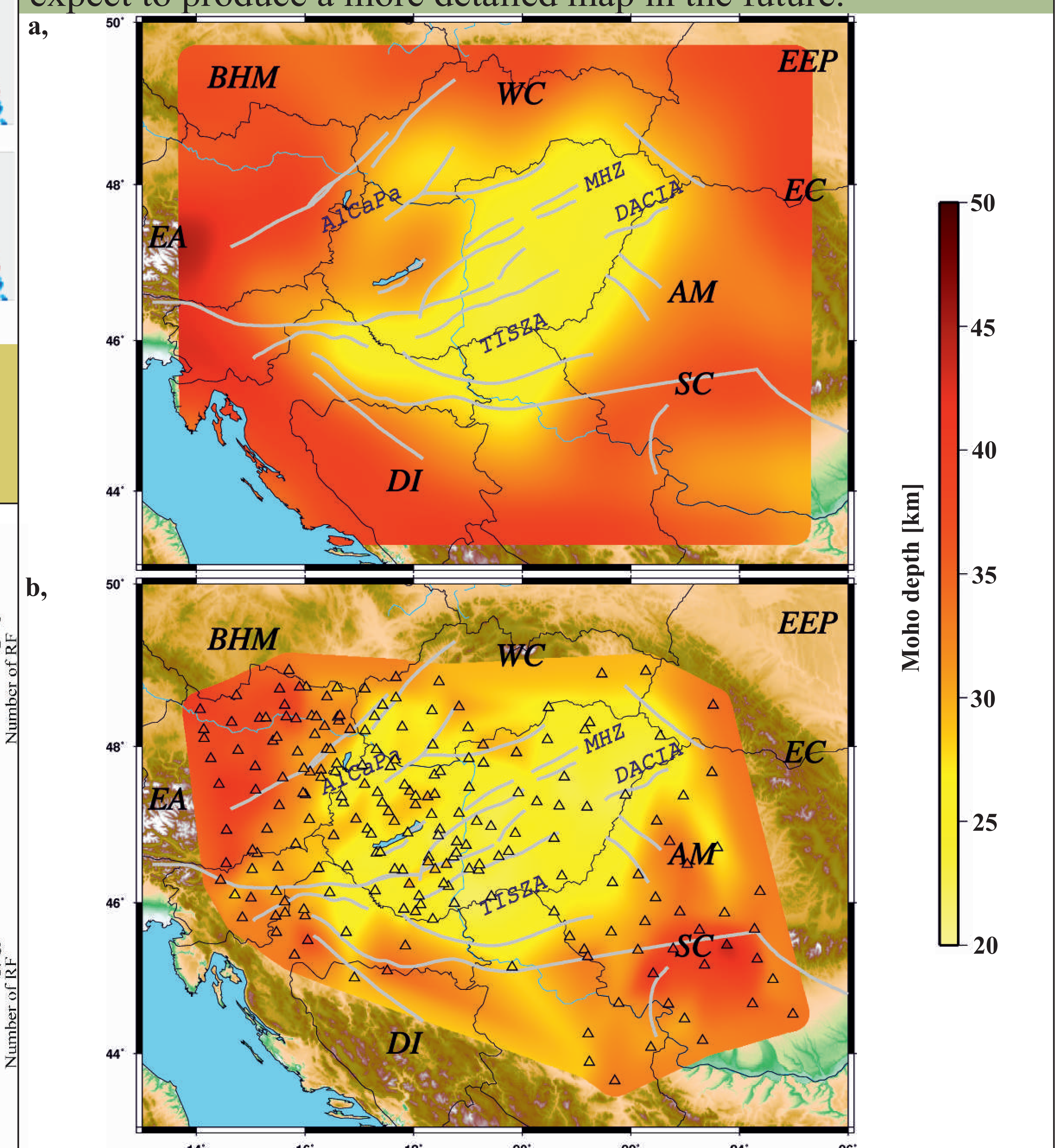

Figure 8. Moho map from a, Grad et al (2009) and b, this study.