The crustal structure of the Pannonian Basin and wider region from P-to-S receiver function analysis

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and the AlpArray Working Group

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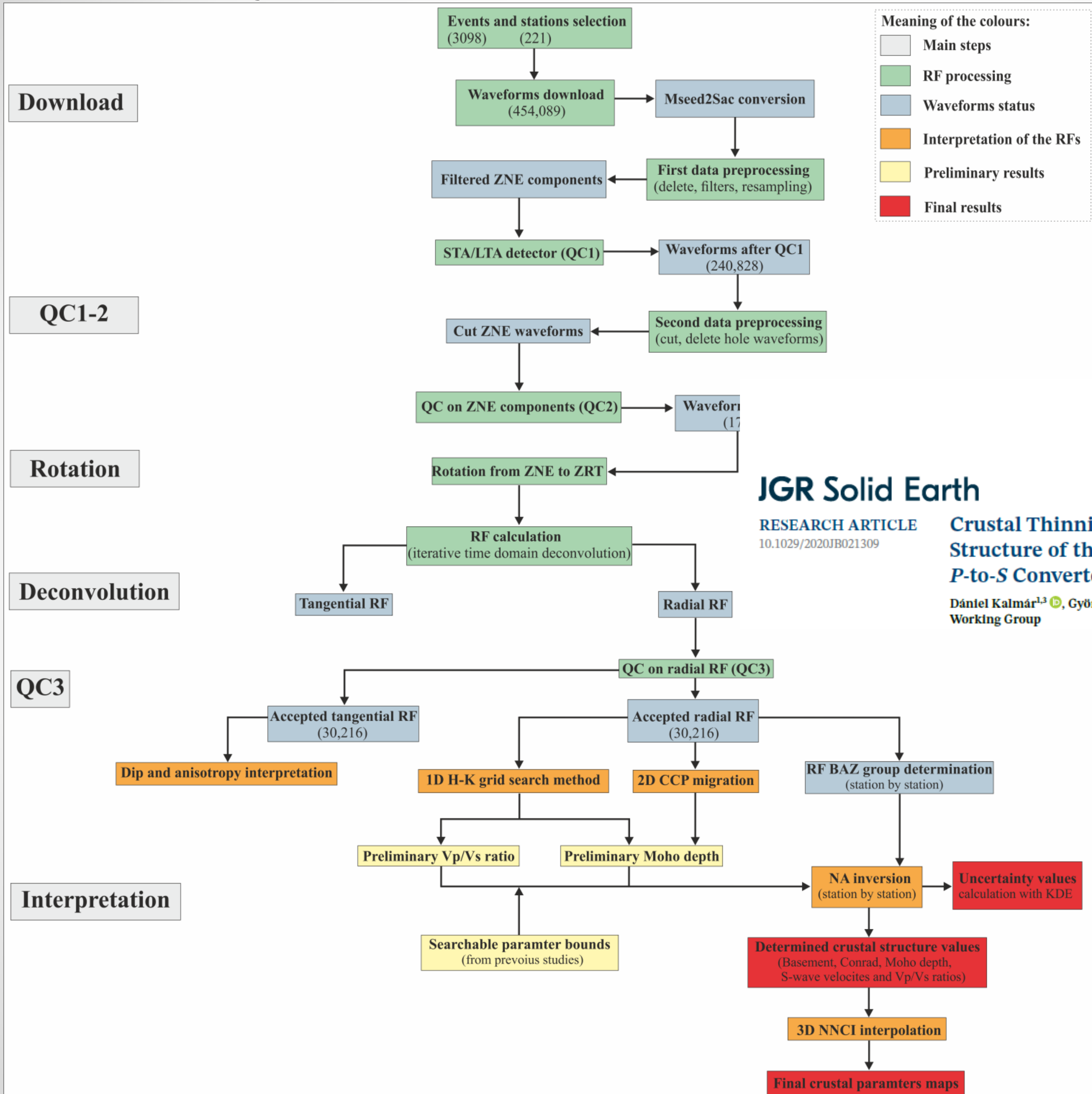
Flowchart of my work



JGR Solid Earth

RESEARCH ARTICLE
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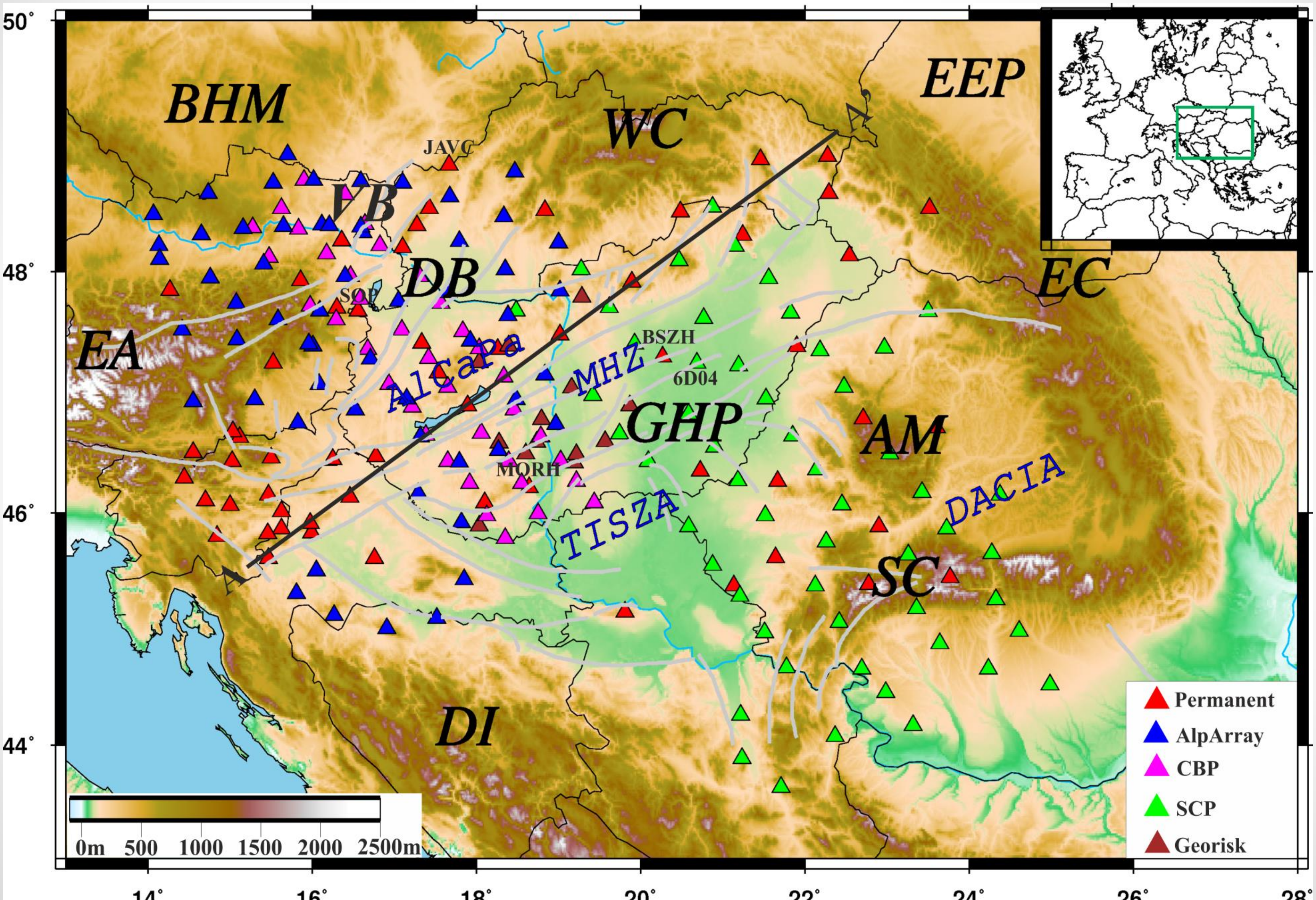
Crustal Thinning From Orogen to Back-Arc Basin: The Structure of the Pannonian Basin Region Revealed by *P*-to-*S* Converted Seismic Waves

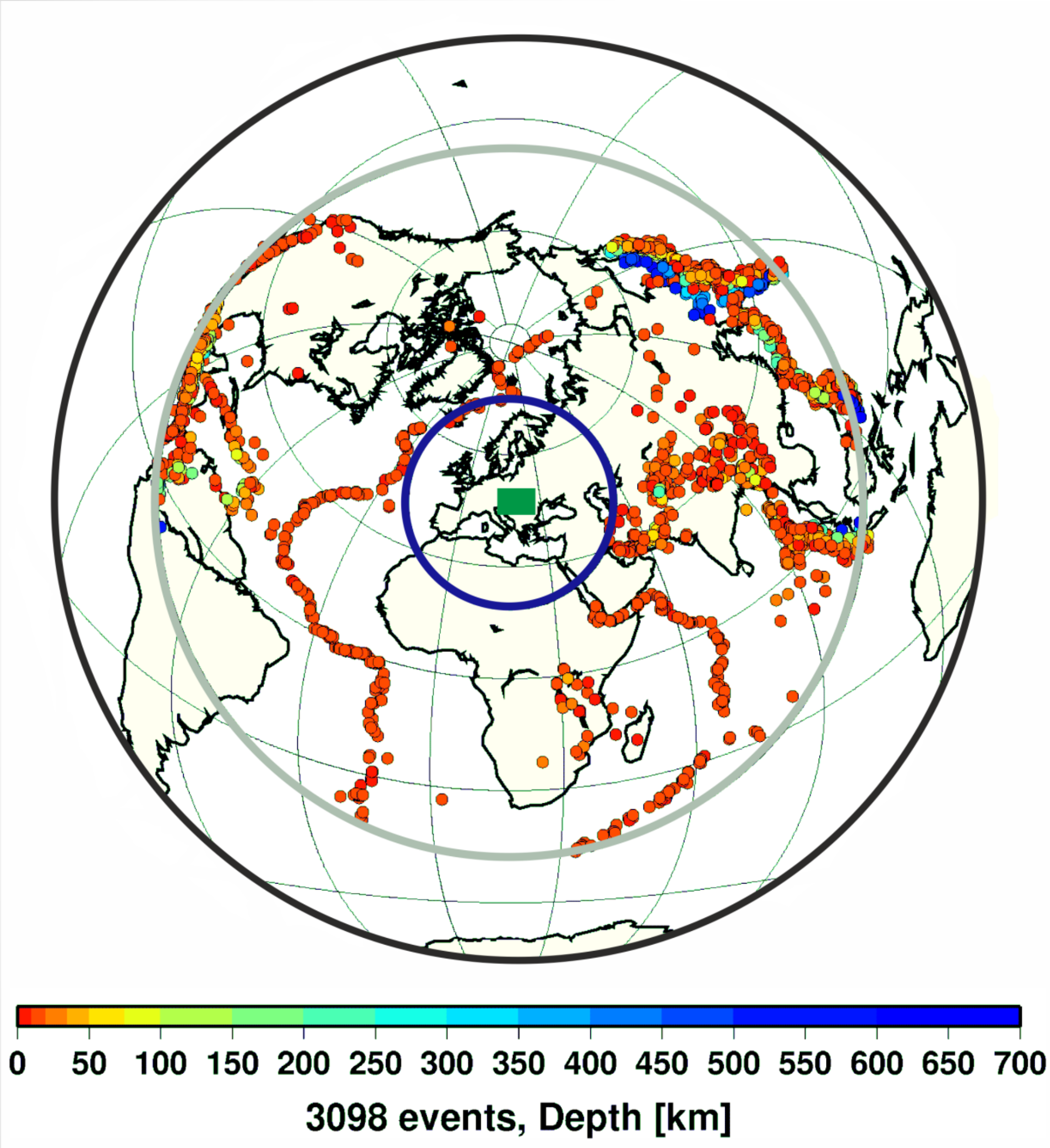
Dániel Kalmár[1,3], György Hetényi[2,3], Attila Balázs[4], István Bondár[5], and AlpArray Working Group

Study area and seismic stations

- We used altogether 221 (71 permanent and 150 temporary) seismological stations



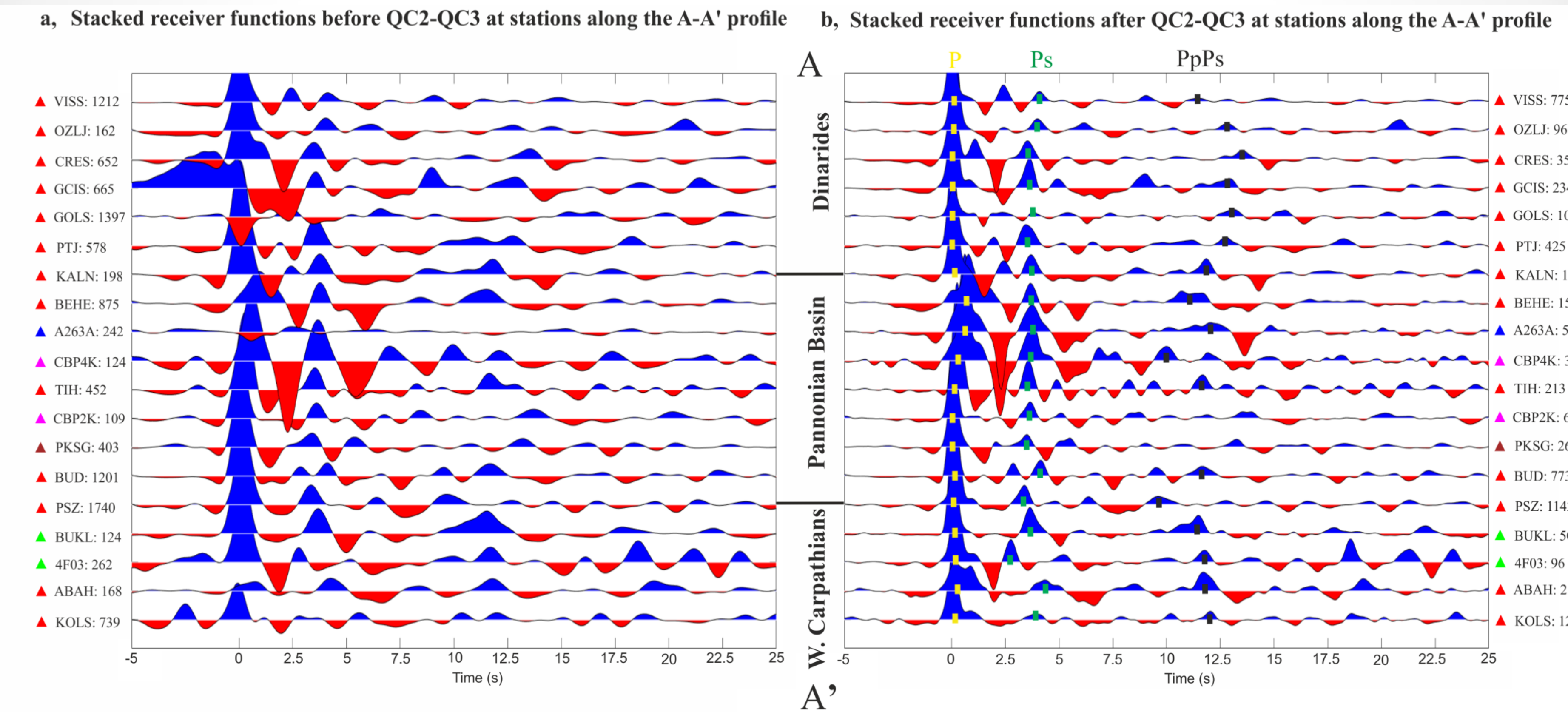
Event selection



- From the USGS catalog
- Epicentral distance 28-95°
- M≥ 5.5
- January 1, 2002- Marc 31 2019
- 17 years data at Permanent stations
- 3 years data at Alparray
- 2 years data at CBP and SCP
- We downloaded the broadband three-component waveforms

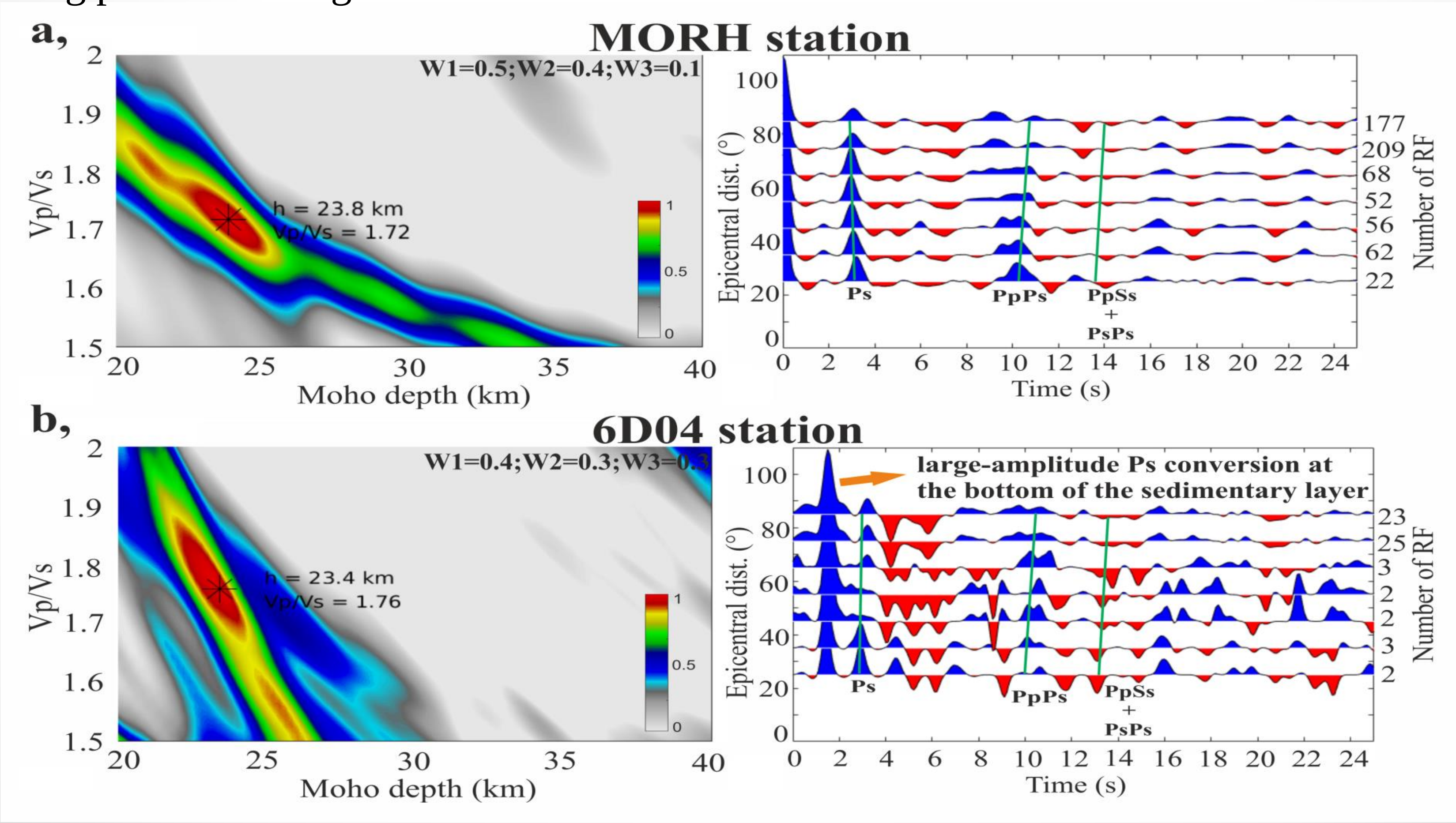
Quality control procedures and receiver function analysis

- We applied a three-fold quality control process: the first two being applied to the observed waveforms (STA/LTA detector and SNR ratio)
- We calculated the receiver functions using the iterative time domain deconvolution (Ligorría & Ammon, 1999) with 150 iterations
- We performed the third quality control step on the radial receiver functions based on the value and time delay of its dominant amplitude (P phase)



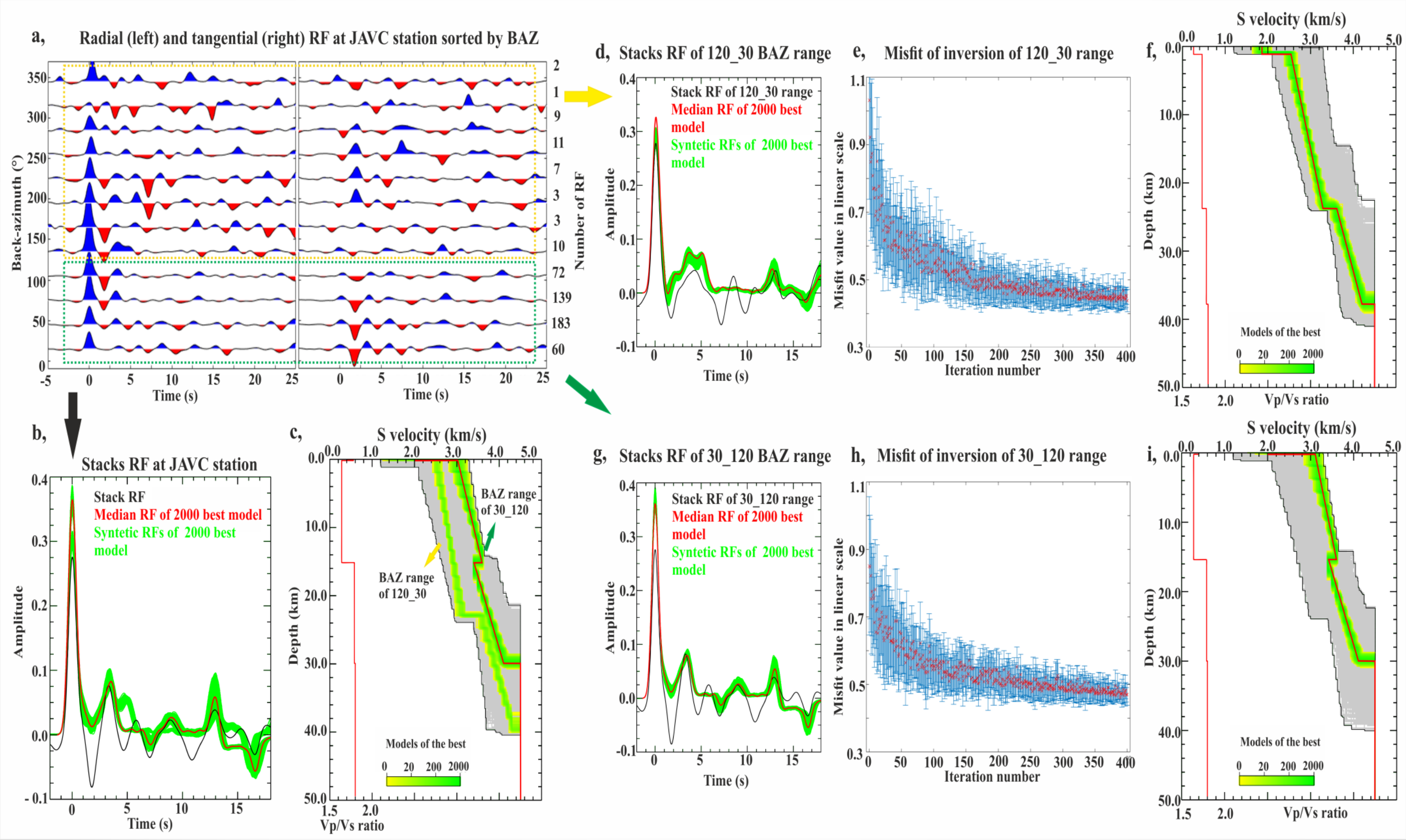
H-Vp/Vs grid search method

- We performed the H-Vp/Vs grid search method (Zhu & Kanamori, 2000)
- The initial Vp velocity for each station separately
- The limits of the Moho depth search range, H between 20 and 40 km in the basin area and between 20 and 50 km in the mountains. The Vp/Vs ratio search range, between 1.5 and 2
- Weights of multiples separately for each station (Kalmár et al., 2019)
- The obtained Moho depth and Vp/Vs ratio from the H-Vp/Vs grid search serve as good starting parameter ranges of the receiver function inversion



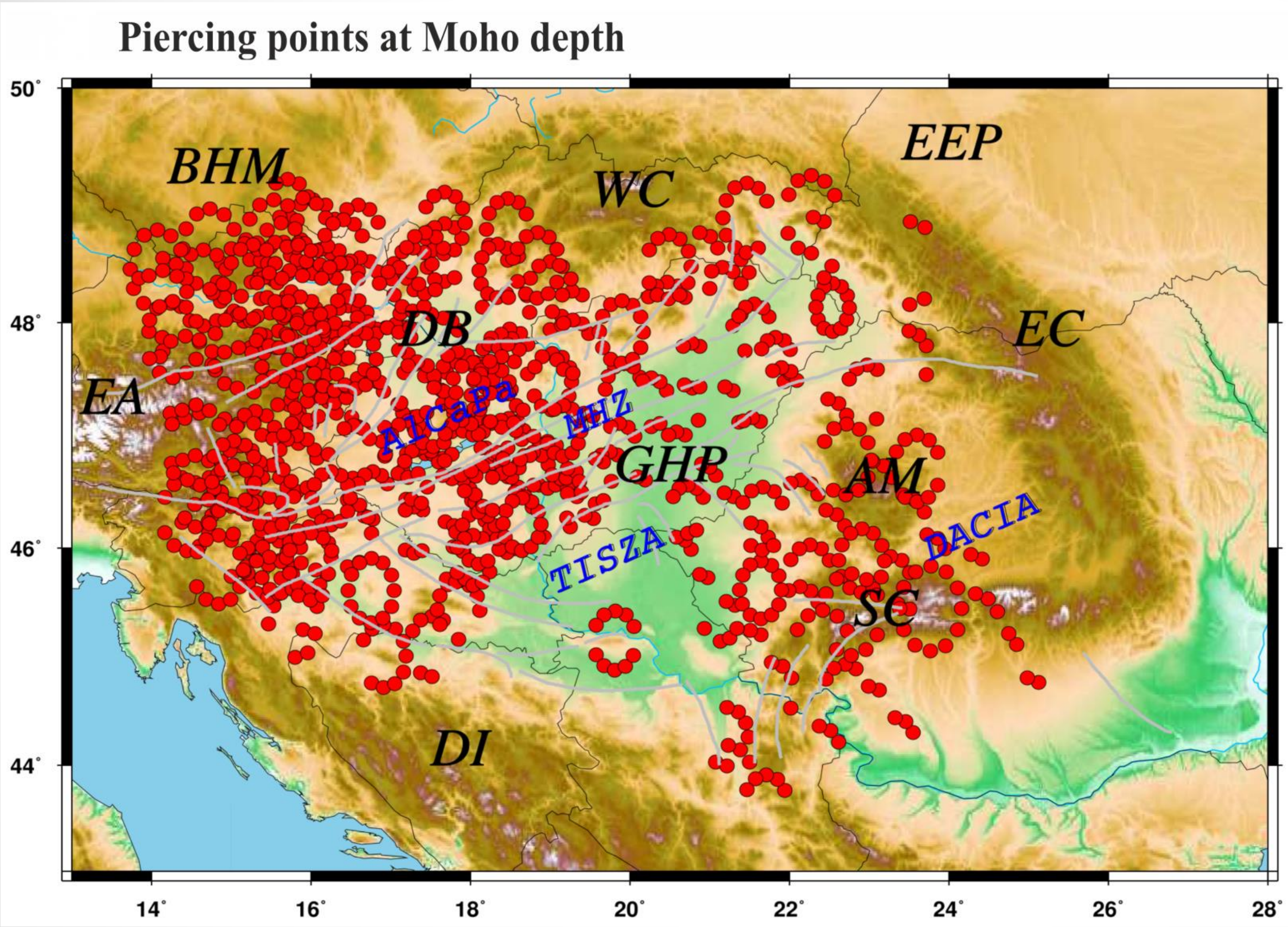
S-wave velocity inversion (grouped by back-azimuth)

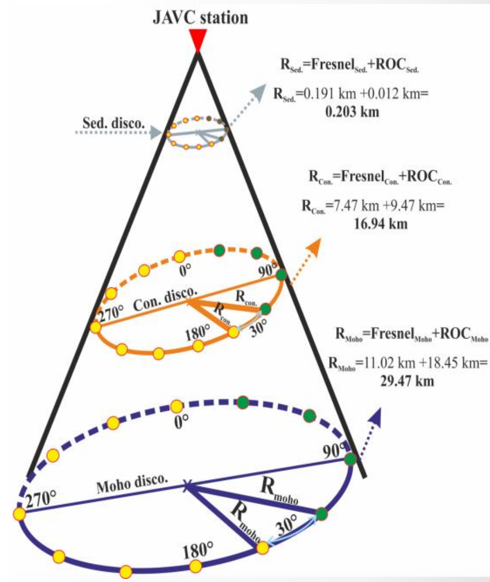
- We applied Neighborhood Algorithm method (Sambridge, 1999) that gives an ensemble of acceptable solutions. This was performed individually for each of the 221 stations
- Inversions have been run for 400 iterations with 50 models tested in each step. In the subsequent iteration step, the best 30 results defined the parameter space to be resampled.



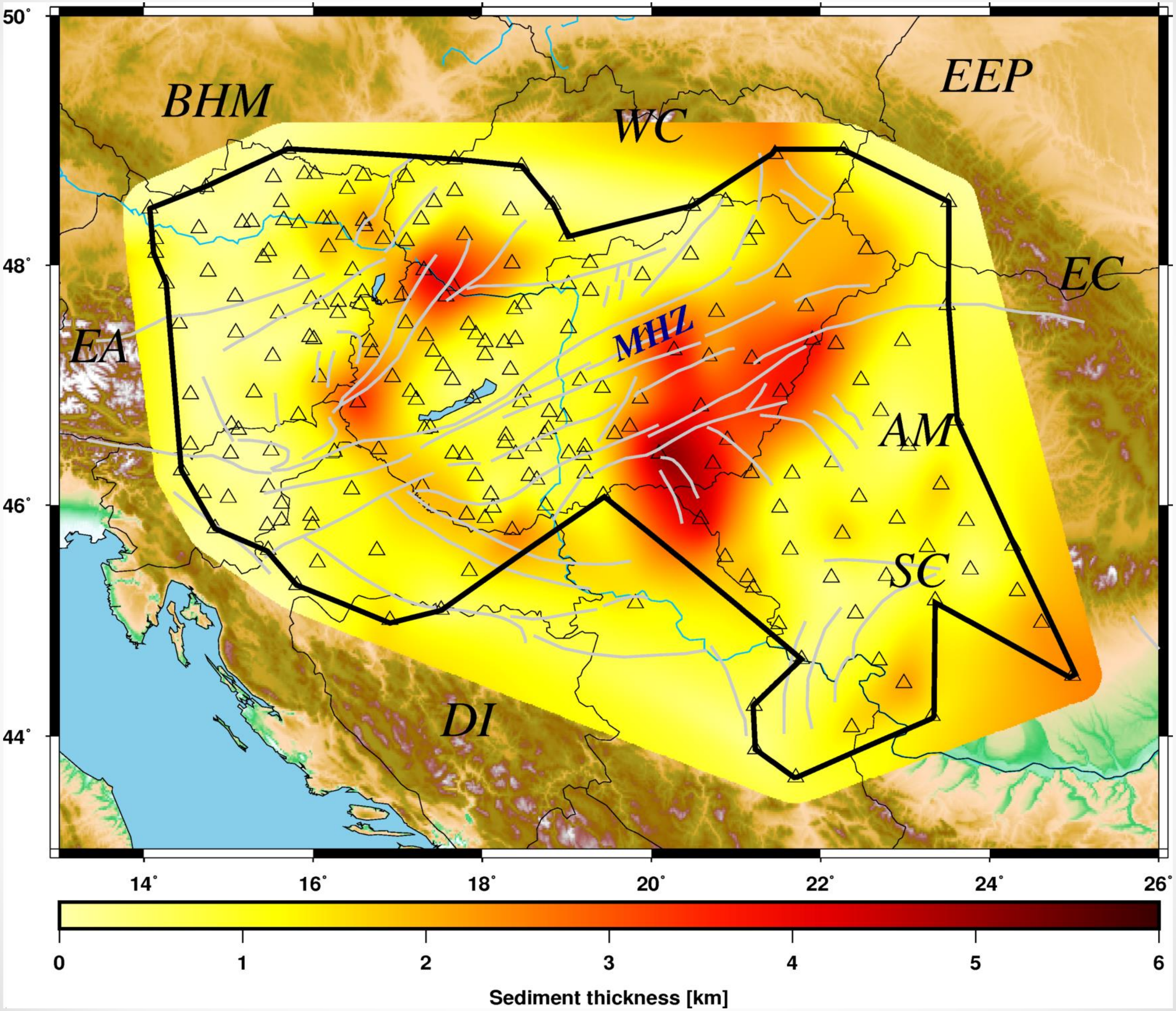
New visualization method (NNCI)

- Natural Neighbor Cone Interpolation (NNCI)
- This model is not directly 3D but is constructed by a much larger number of 1D models than classical interpolation of a single 1D model per station

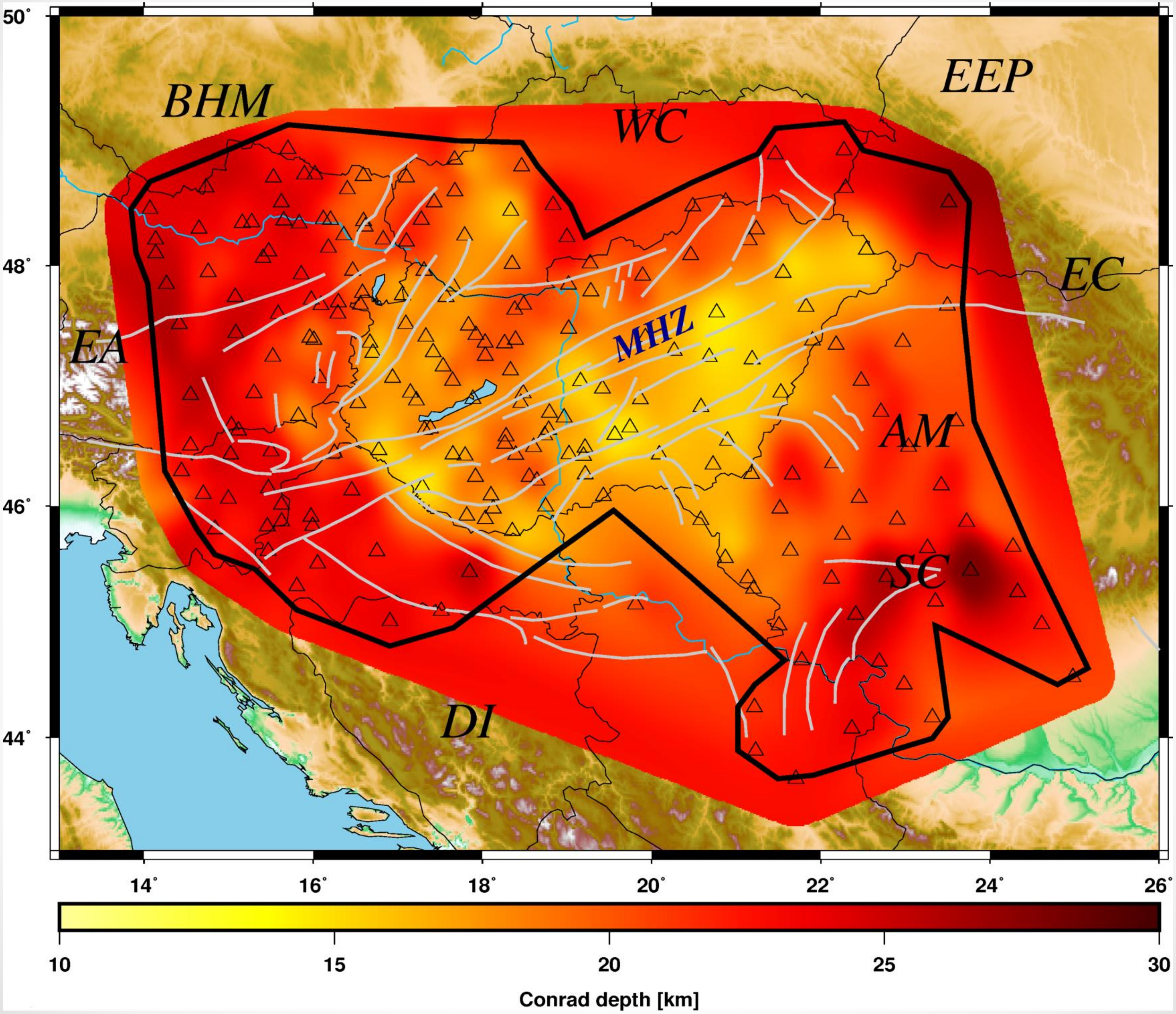




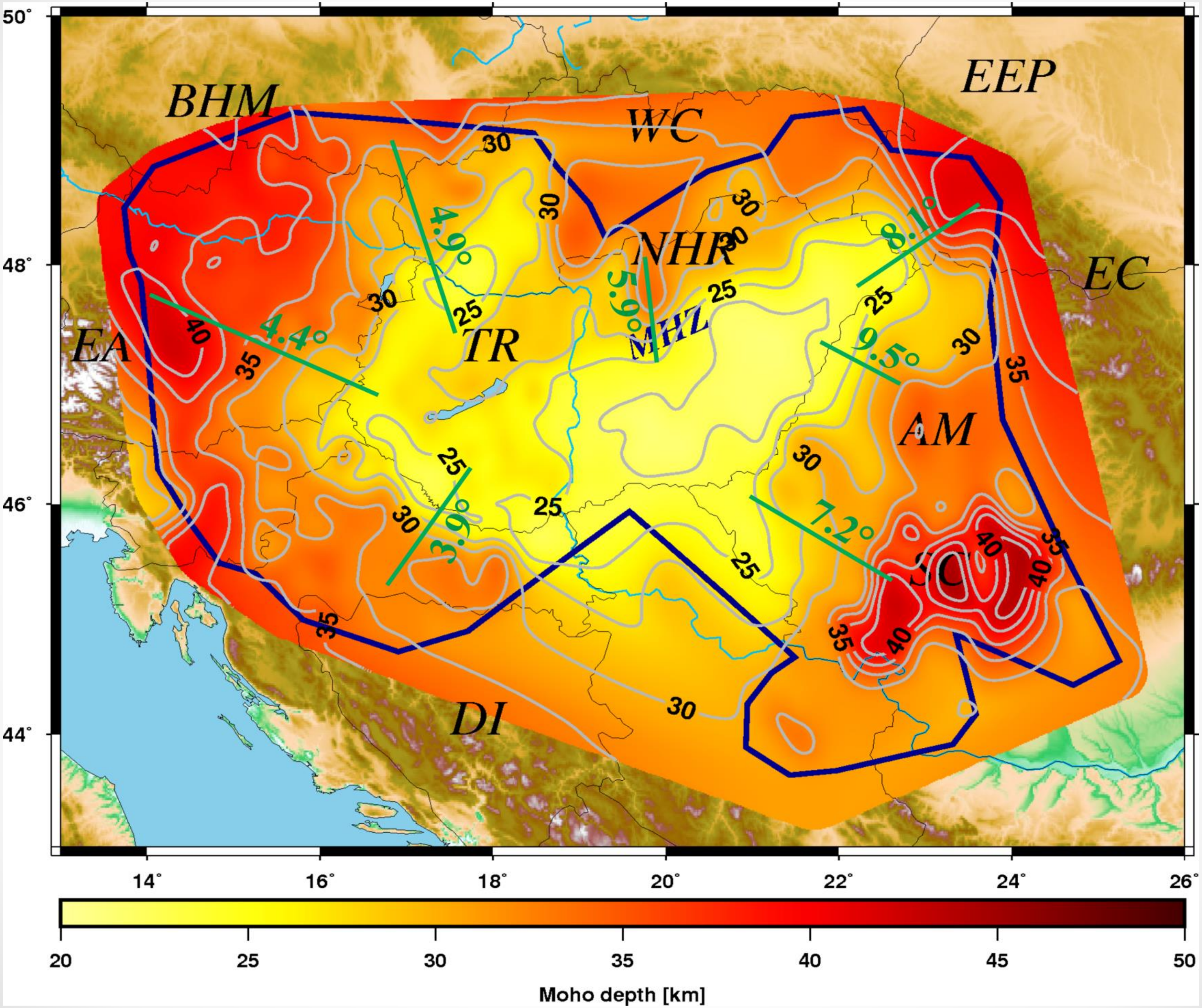
Basement map



Conrad discontinuity



Moho depth



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5.9°
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3.9°
7.2°
50°
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44°
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16°
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25
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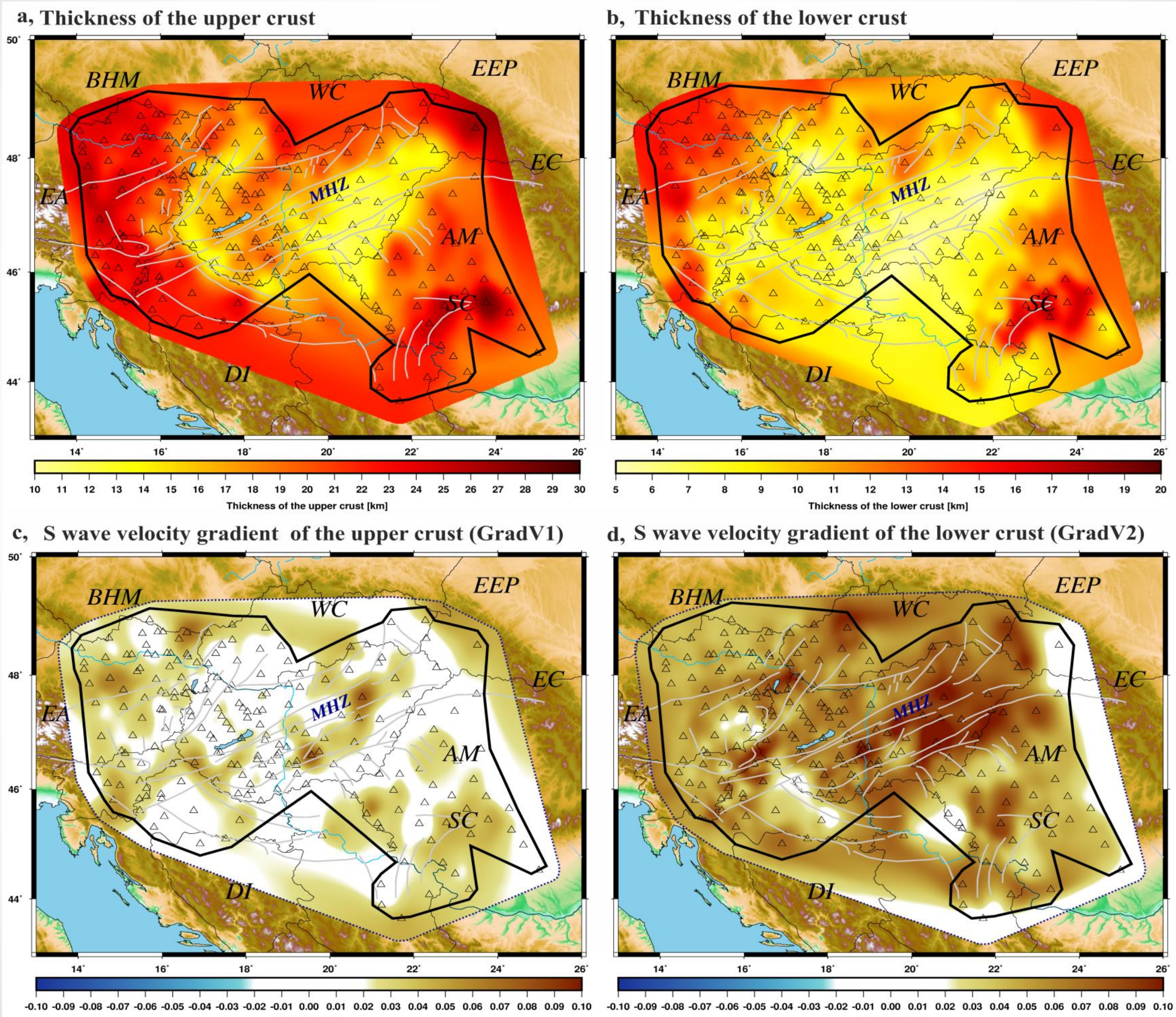
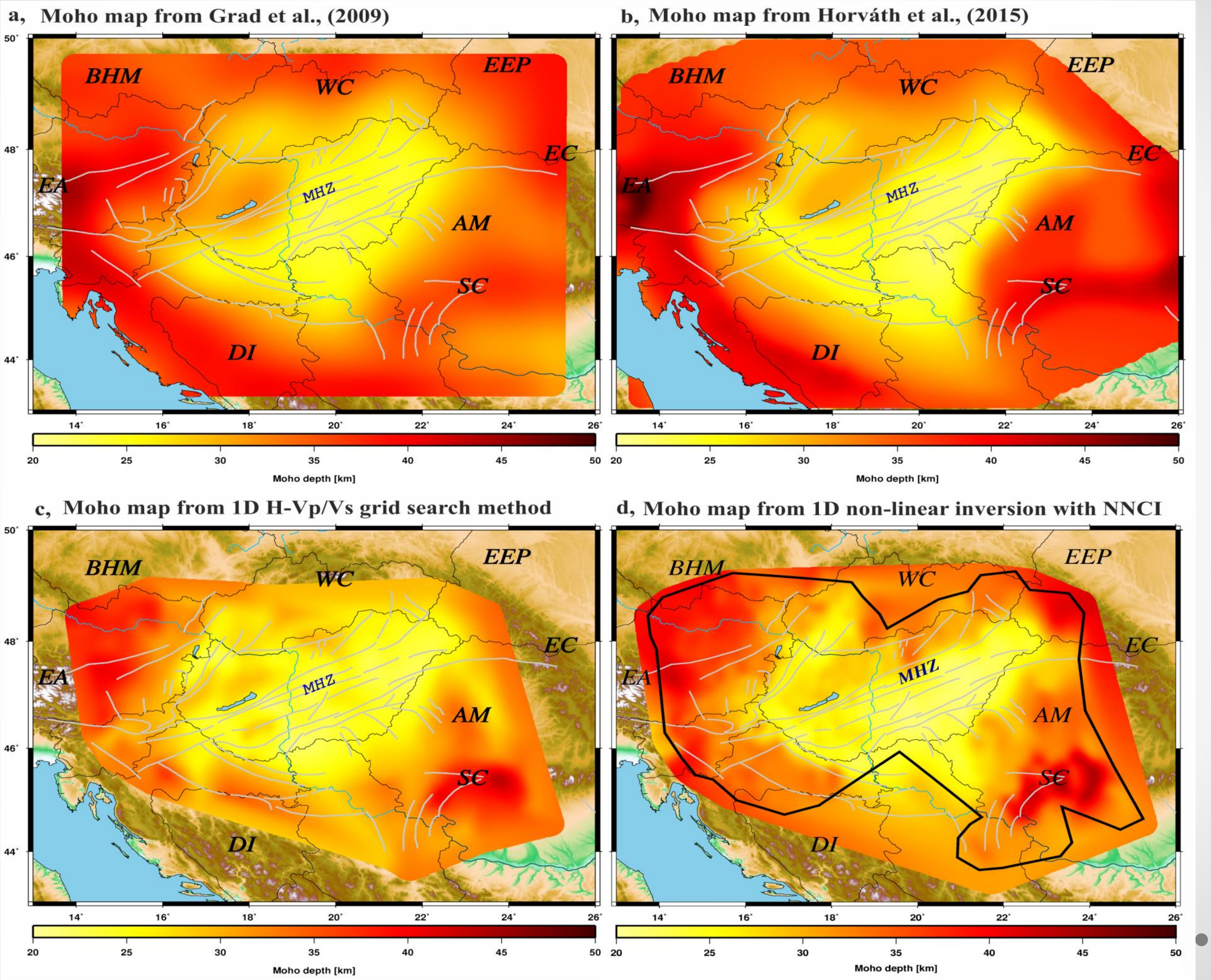
35
40
45
50
Moho depth [km]

First, data-driven upper and lower crust thickness maps



Moho depth comparison with previous studies



Conclusions

- We performed the first comprehensive receiver function analysis in the Pannonian Basin and surrounding regions using the most recent data set (221 stations) available.

- Our study is based on a relatively long time-span (2002–2019) of broadband waveforms with uniform automatic waveform processing and quality control procedures.

- We have developed a new interpolation and visualization algorithm (NNCI), in order to image seismic features (including dip estimates) as accurately as possible.

- We mapped the thickness of major crustal layers and determined their S-wave velocity and Vp/Vs ratios.

- The Conrad depth, upper crust, and lower crust thickness maps are the first for the Pannonian Basin region.

- The Moho depth map presents local variations with more finely and better resolved values than previous investigations.

- The dense seismic network with the large amount of quality-controlled data processed here allowed to infer a 3D structural and shear-wave velocity model of the region.

Acknowledgments

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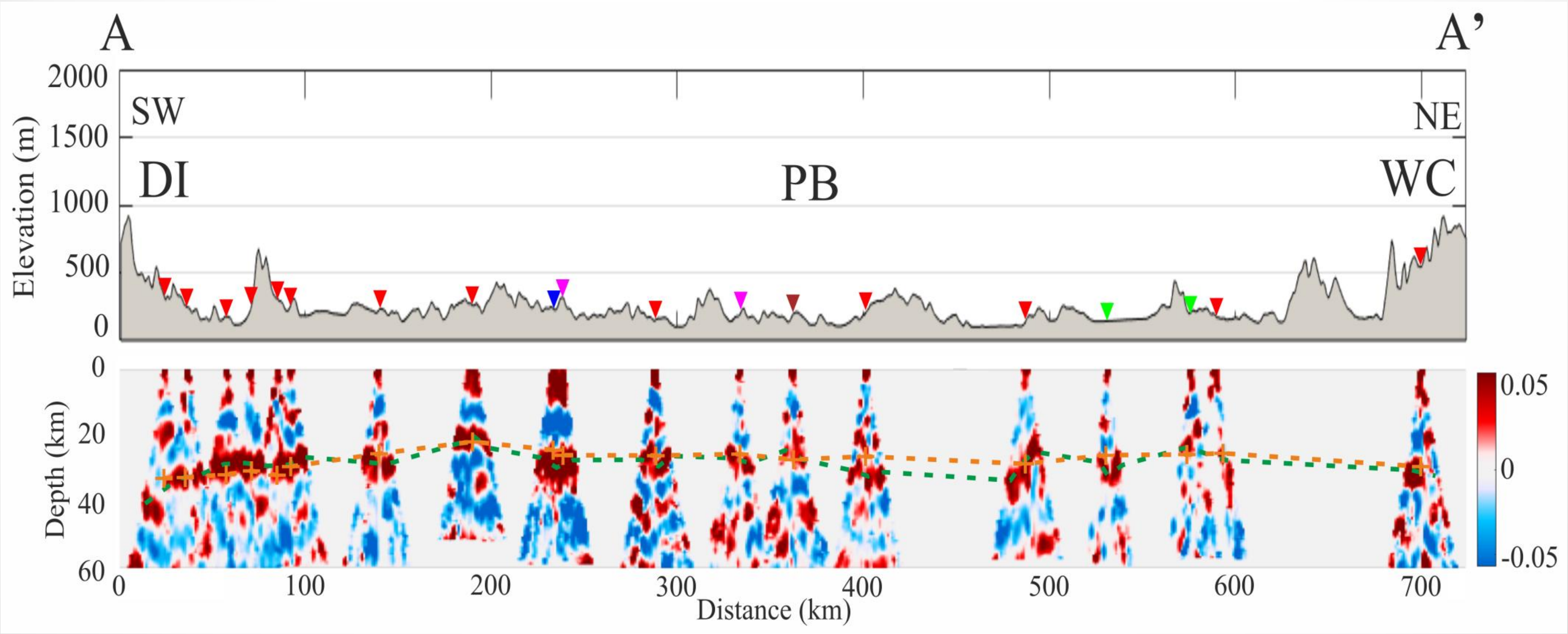
Thank you for your attention!

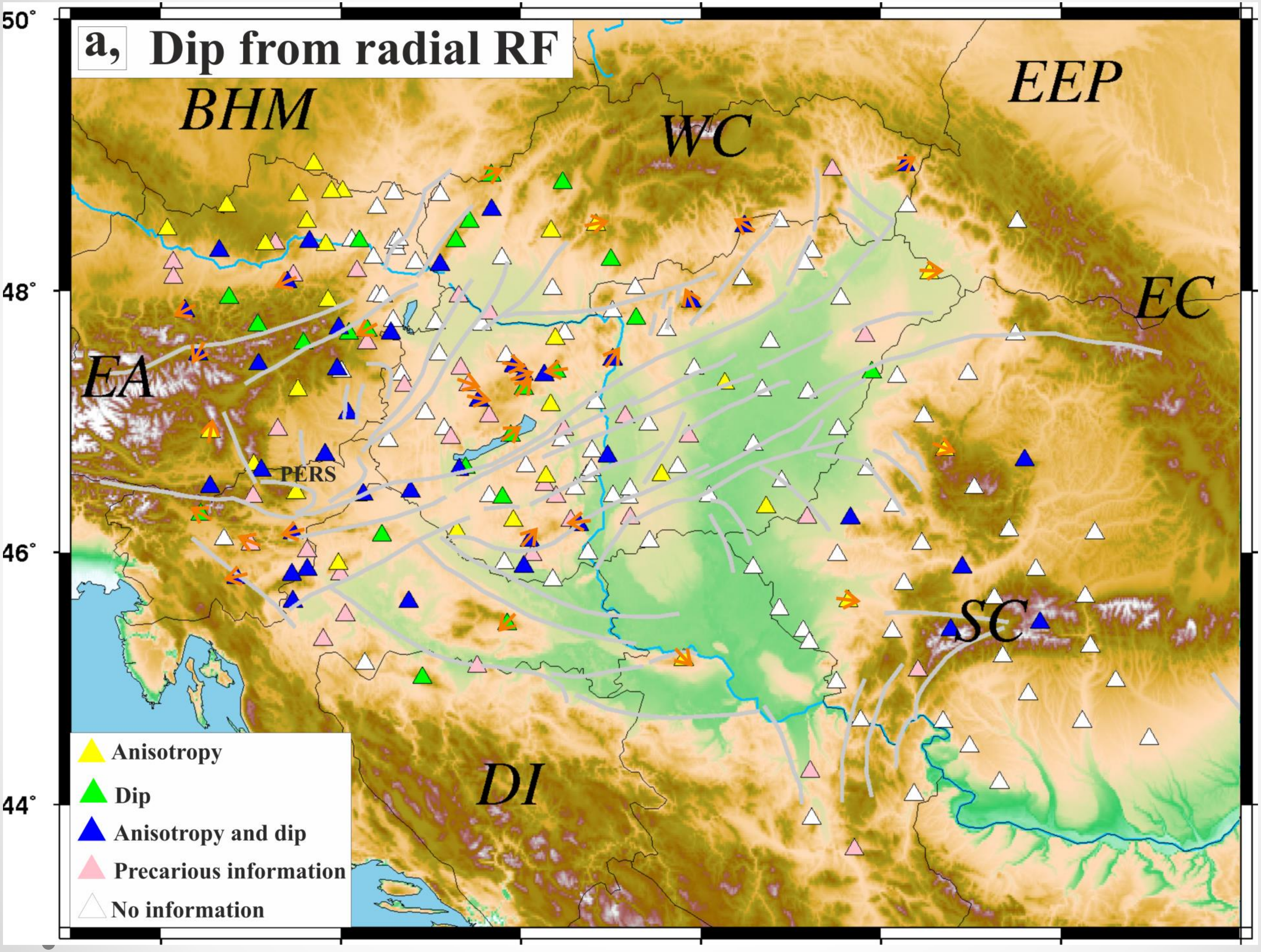
Extra Slides

CCP migration

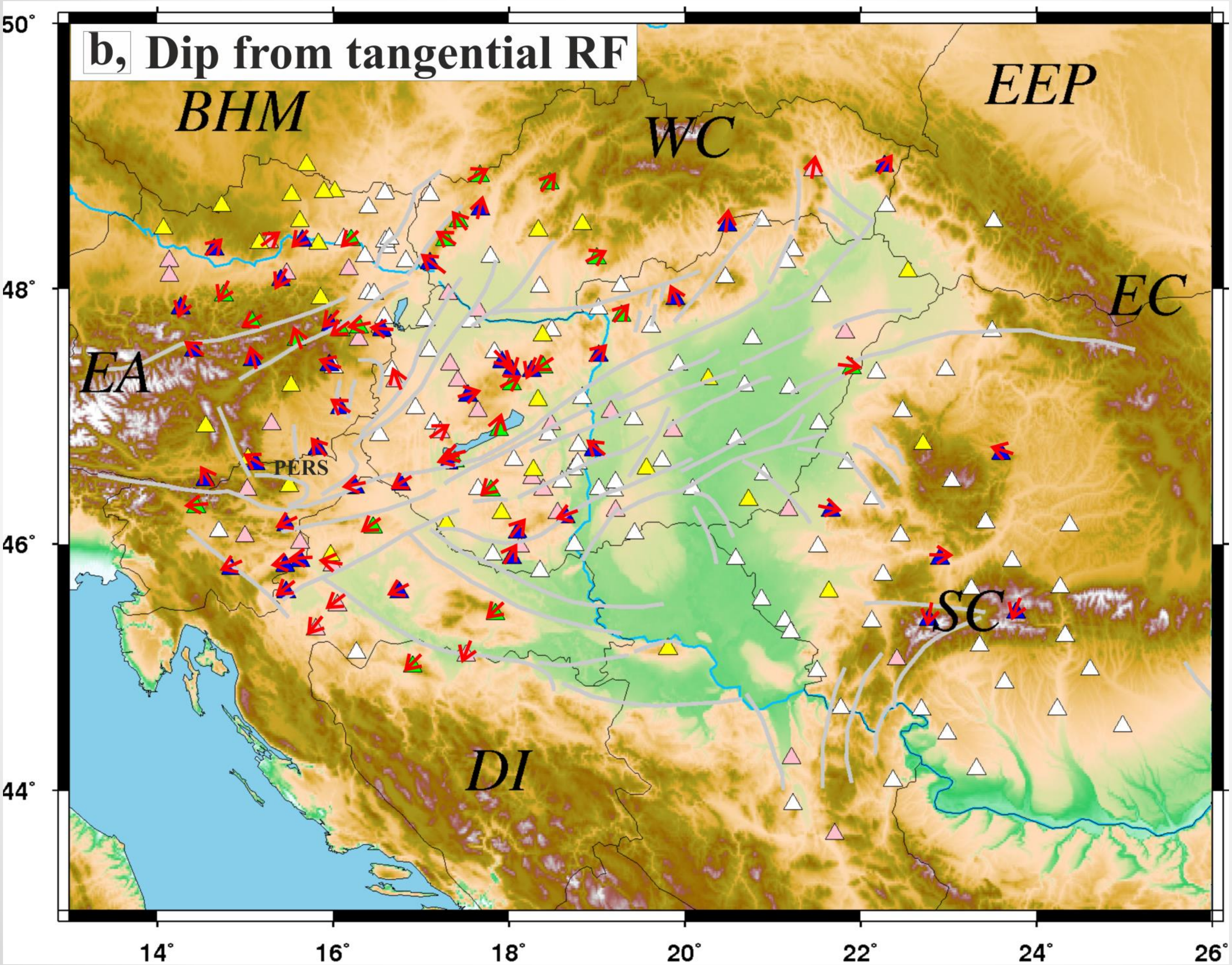
- We imaged the Moho discontinuity with CCP migration method (Zhu, 2000) using a recent 1D local velocity model (Gráczer & Wéber, 2012).
- The sedimentary basin depth correction, we used a Neogene basement depth map compiled recently from reflection seismic profiles and well data (Balázs et al., 2018).
- The pre-stack migration (1 km horizontal and 0.5 km vertical resolution of the bin size)
- The obtained Moho depth and Vp/Vs ratio from the H-Vp/Vs grid search and CCP migration serve as good starting parameter ranges of the receiver function inversion



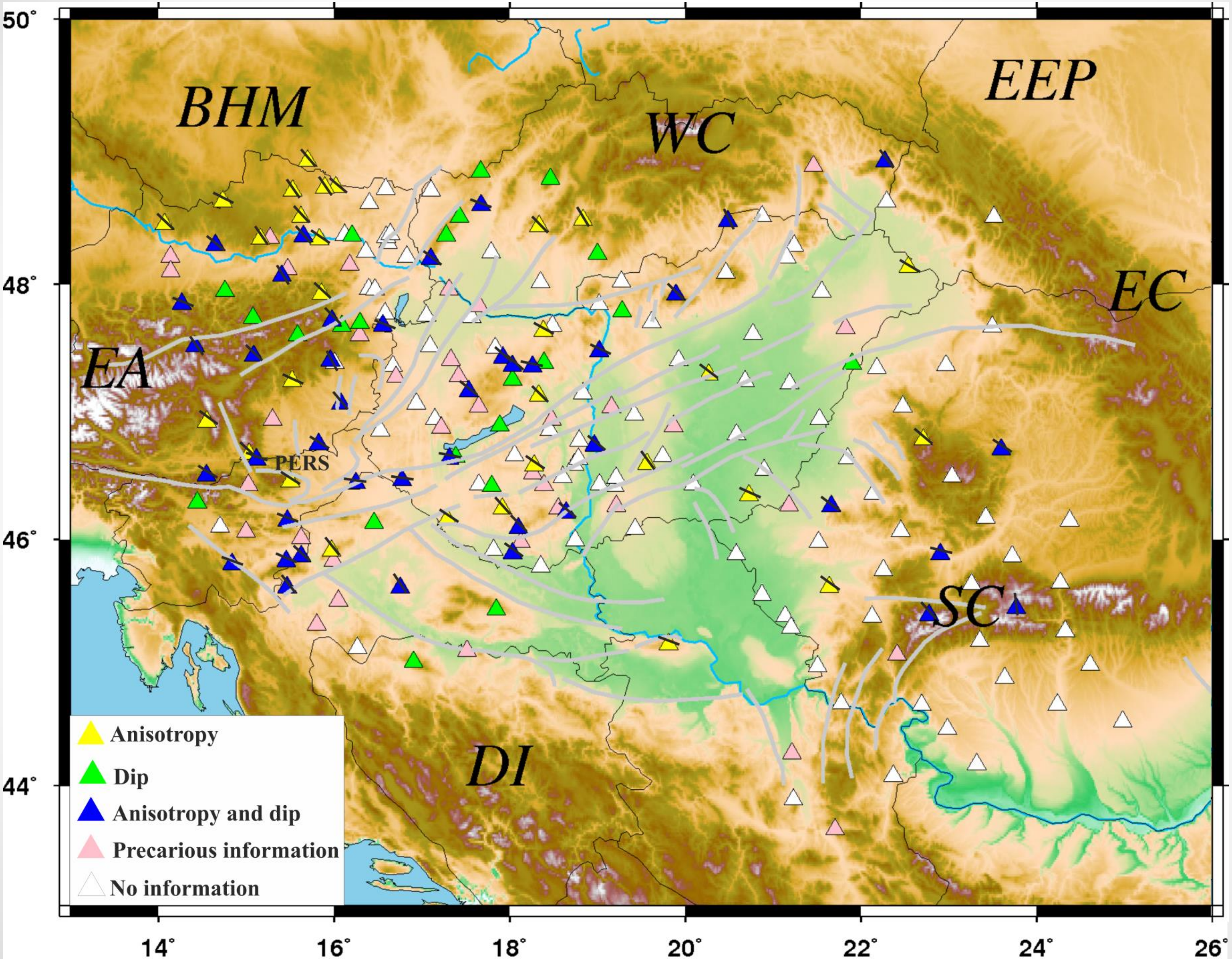
Dip from radial RF



Dip from tangential RF



Anisotropy



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EEP
EC
EA
PERS
SC
DI
Anisotropy
Dip
Anisotropy and dip
Precarious information
No information