Moho depth variation in the continental China from teleseismic receiver function analysis

Shihua Cheng[1], Lianxing Wen[2, 1]

1. Laboratory of Seismology and Physics of Earth's Interior; School of Earth and Space Sciences, University of Science and Technology of China
2. Department of Geosciences, Stony Brook University

Email: cflower@mail.ustc.edu.cn

AGU 2017
S21C-0722

1. Introduction

The continental China has experienced dramatic tectonic activities since Precambian period, and consists of a complex amalgamations of geotectonic units. Mapping the crustal structure of the continental China is thus significant for understanding of its tectonics and geological evolution. In this study, we study the crustal structure in the continental China using teleseismic P-wave receiver functions (PRFs) calculated from the seismic data recorded by 1036 digital broad-band permanent stations and 222 temporary stations, and the database is established. The database serves for H-k stacking analysis, which helps to estimate Moho depths and Vp/Vs ratios underneath all stations. An unified map of Moho depth and Vp/Vs ratio variation in continental China is produced by splines gridding method.

2. Data sources and process

2.1 Data sources

The data sources used in this study mainly contain two parts:

1) Three-component waveform data recorded by 1036 digital broad-band stations from China Earthquake Networks Center (CENC) for earthquakes occurring in the time period from 2012 to 2015, and these stations are denoted by red triangles in Figure 1. Teleseismic events of Mw>6.5 from 30 to 95 degrees are picked;

2) 222 temporary stations deployed by Incorporated Research Institutions for Seismology (IRIS), and these stations are denoted by blue triangles in Figure 1. Teleseismic events of Mw>6.0 from 30 to 95 degrees are picked;

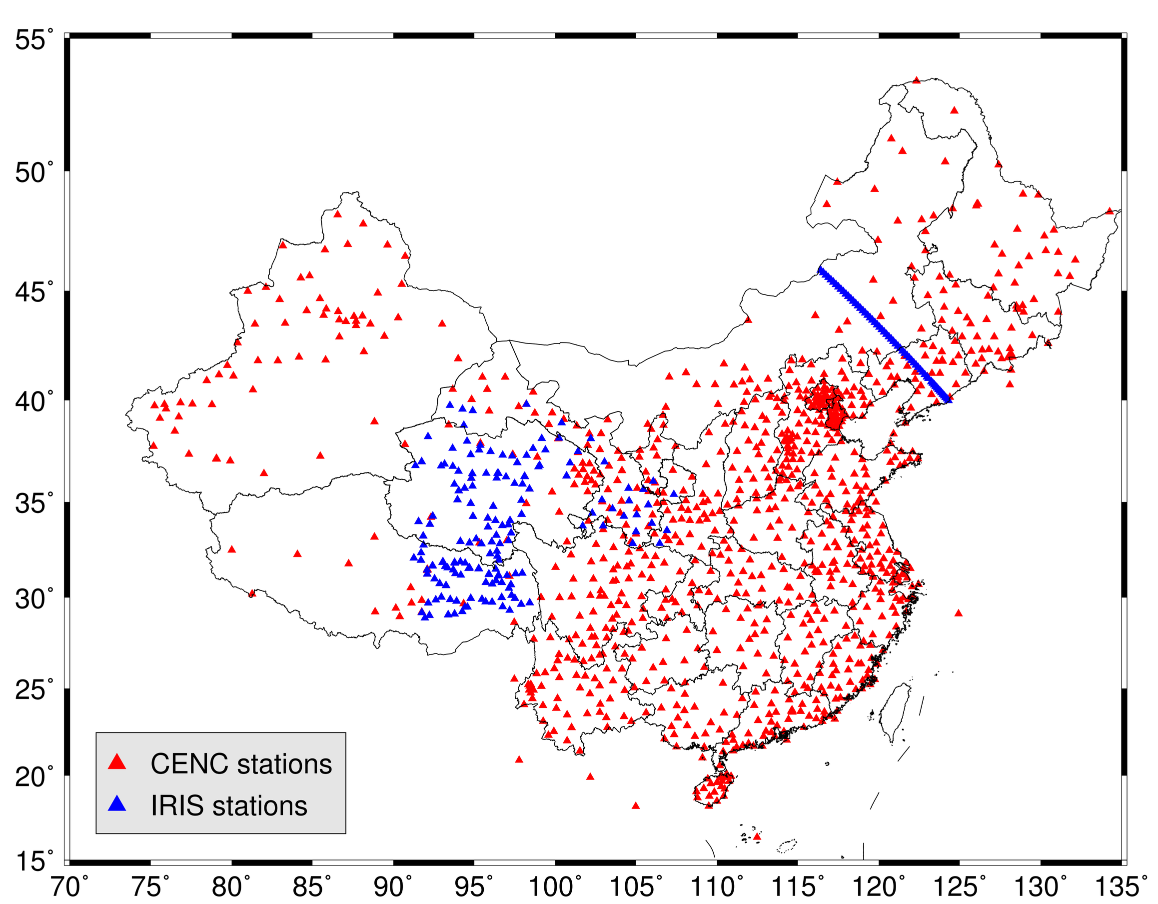
3) Crustal P-wave velocity is derived from Crust 1.0 model, the weighted average of all layers is regarded as average velocity of crust at each point:

$$\widetilde{Vp} = \frac{h_1 v_1 + h_2 v_2 + \cdots + h_8 v_8}{h_{crust}}$$

where $\widetilde{Vp}$ is average velocity of crust, h_n and v_n indicate thickness and P-wave velocity of the n-th layer, and h_{crust} is crustal thickness.

2.2 Data processing

- In order to calculate PRFs, preprocessing steps are applied to raw data firstly. Then the west-east, north-south and vertical (ENZ) components are rotated into the radial, transverse and vertical (RTZ) directions, and we select radial and vertical components to calculate PRFs. A band-pass Butterworth filter, which has the corner frequency of 0.05 and 2.0 Hz, is applied to waveform. Now, we inspect waveform record of each event and discard events of noisy data. Most importantly, vertical component is de-convolved from radial component by using time-domain iterative method, and the iterative number used in this study is 50, which is enough to estimate crustal thickness. Inspection is used again, for the sake of discarding bad receiver functions. After above processes, we establish a PRFs database for those stations used in this study, and this database can serve for H-k stacking analysis.
- In this study, H-k stacking method is used to estimate Moho depth and Vp/Vs ratio. We derive crustal P-wave velocity based on Crust 1.0 model. The weighted factors are 0.7. 0.2 and 0.1 for phase Ps, PpPs and PpSs+PsPs, respectively. Moho depth range of grid search is from 20 to 85 km, in the meantime Vp/Vs ratio is defined from 1.5 to 2.0. The raw seismic waveform record, PRFs record and H-k stacking results are eye-checked for their quality and robustness.
- After H-k stacking analysis, we estimate Moho depth and Vp/Vs ratio underneath each station used in this study (Figure 3 (a), (b)), and an unified map of Moho depth and Vp/Vs ratio variation in continental China is produced by splines gridding method (Figure 3 (c),(d)).



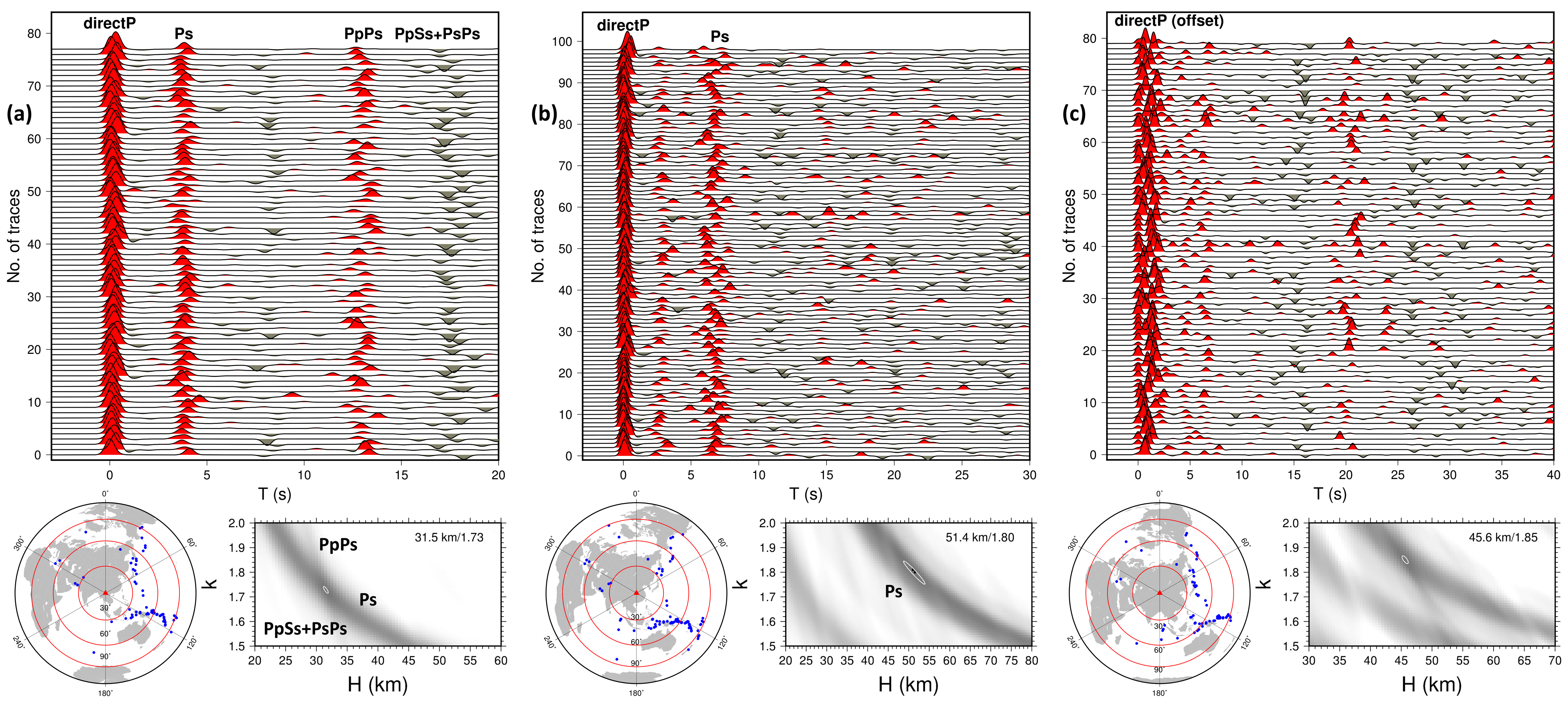
▲ **Figure 1** Map of stations distribution for this study. Red and blue triangles indicate CENC and IRIS stations, respectively.

3. Quality control (qc)

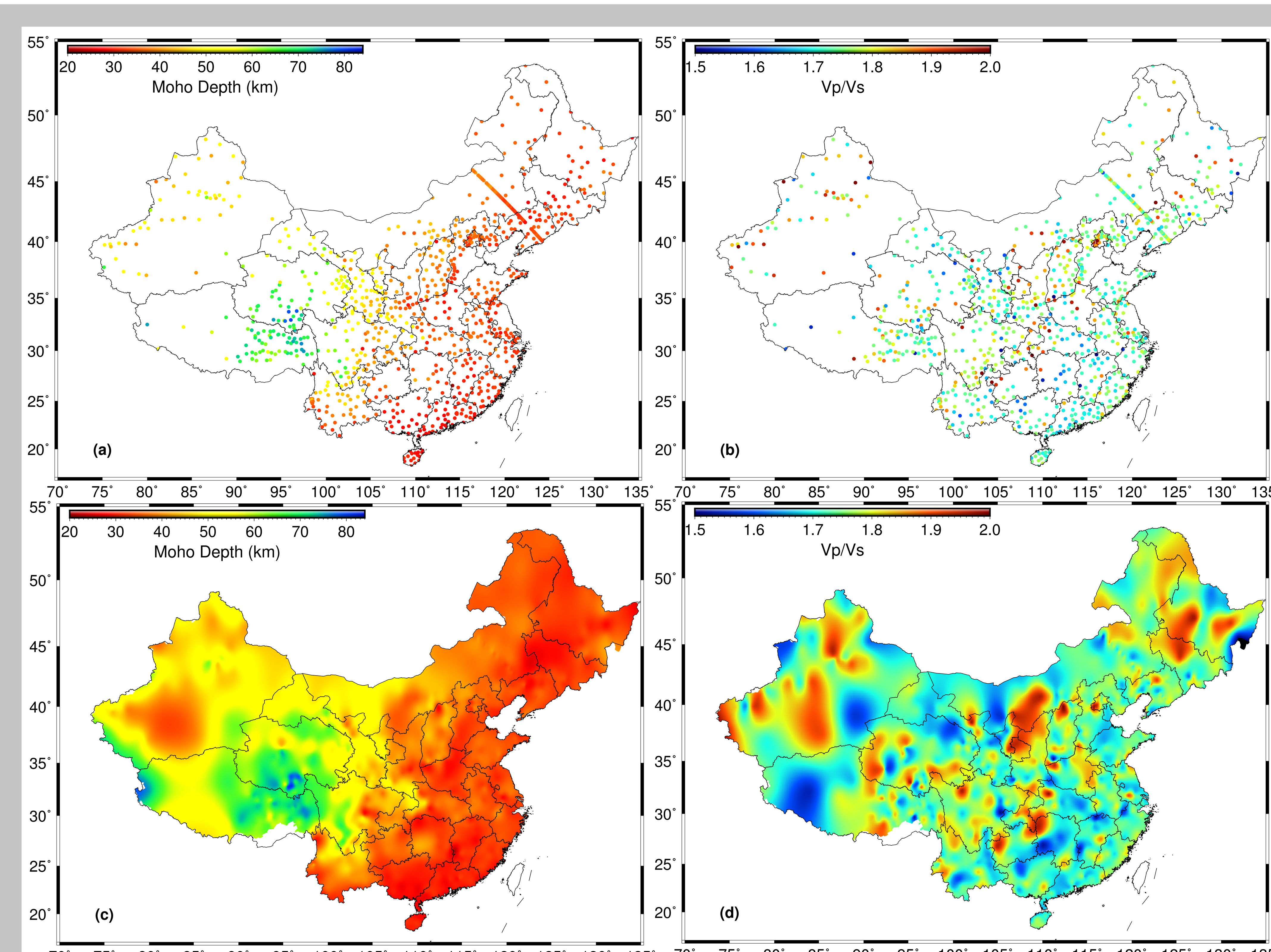
We realize qc process mainly by several eyeable characteristics:

- Whether there are clear phases of direct P, Ps and multiplicity in receiver functions (Figure 2 (b) is a counter-example);
- Whether the offset of direct P phase is too large to derive a reliable result (Figure 2 (c) is a counter-example);
- If the amplitude of direct P phase is not largest in receiver function, then the result will be discarded;
- Whether there are enough seismic events which will be used in H-k stacking analysis;
- Whether the H-k stacking result is extremely abnormal in comparison with nearby stations.

After qc, data of more than 300 stations can not be used at next step. By the data derived from those stations which passes qc, we obtain the Moho depths and Vp/Vs ratios underneath those stations (Figure 3 (a), (b)). Then a unified map of Moho depth and Vp/Vs ratio in continental China can be produced by using splines gridding method (Figure 3 (c), (d)).



▲ **Figure 2** The results of receiver functions for 3 stations, which are located in Sichuan-Yunnan region, Hubei province and Xinjiang region, respectively. Each result contains 3 figures: PRFs array which passes inspection, a distribution map of seismic events corresponding to PRFs array, and H-k stacking result. In the map of seismic events distribution, red triangle and blue dots denote seismic station and earthquakes, respectively. (a) YN.JIH station, which is located in Sichuan-Yunnan region, and the receiver functions are almost perfect. Clear phases direct P, Ps, PpPs, PpSs and PsPs appear, thus the H-k stacking result is very well, which means that at the point (31.5 km, 1.73) three lines cross clearly. (b) HB.ZUX station, which is located in Hubei province. The distribution of receiver functions just shows clear direct P and Ps phases, but not other multiple phases, thus the H-k stacking result just like stick-shape. (c) XJ.HYS station, which is located in Xinjiang region. Thick sedimentary carries huge implications, which result in an obvious offset for direct P phase. The result from HB.ZUX and XJ.HYS should be discarded to ensure the quality and robustness of final result.



▲ **Figure 3** Distribution of (a) Moho depths, (b) Vp/Vs ratios underneath all stations from this study. Unified maps of (c) Moho depths, (b) Vp/Vs ratios in continental China.

4. Conclusions

- We establish a PRFs database for those stations used in this study in continental China region.
- By H-k stacking method, we derive unified maps of Moho depth and Vp/Vs ratio variation in continental China region.
- In continental China region, the obtained Moho depth varies sharply, and a clear downtrend from northeast margin of tibetan plateau (~80 km) to eastern region of continental China (~20 km) can be observed.
- The resolution in part of western continental China region is a bit terrible because of the sparsity of seismic stations.