Upper Mantle Anisotropy in the Continental China from Shear Wave Splitting Analysis

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1. Introduction

The continental China is composed of many tectonic blocks and has undergone complex geological evolutions. Such a complex region provides an ideal environment to study the anisotropy. Information on upper mantle anisotropy would provide important insights into the lithospheric deformation of the region. We investigate the shear wave splitting parameters of more than 1300 seismic stations using SKS phases to show the upper mantle anisotropy pattern of the continental China.

2. Data

Seismic records of 1372 broadband stations installed in China were used in the study, including permanent stations from China National Seismic Networks (CNSN) and temporary stations of the X1, X2, T0, T1 and T2 array (**Figure 1**).

Our SKS data were selected from earthquakes that occurred during 2012-2017 for permanent stations and 2009-2017 for temporary stations with a magnitude above 5.5 and distance range of 85~140° (**Figure 2**). 541 events contributed useful data. All seismograms were band-pass filtered in the 0.04 to 0.15 Hz.

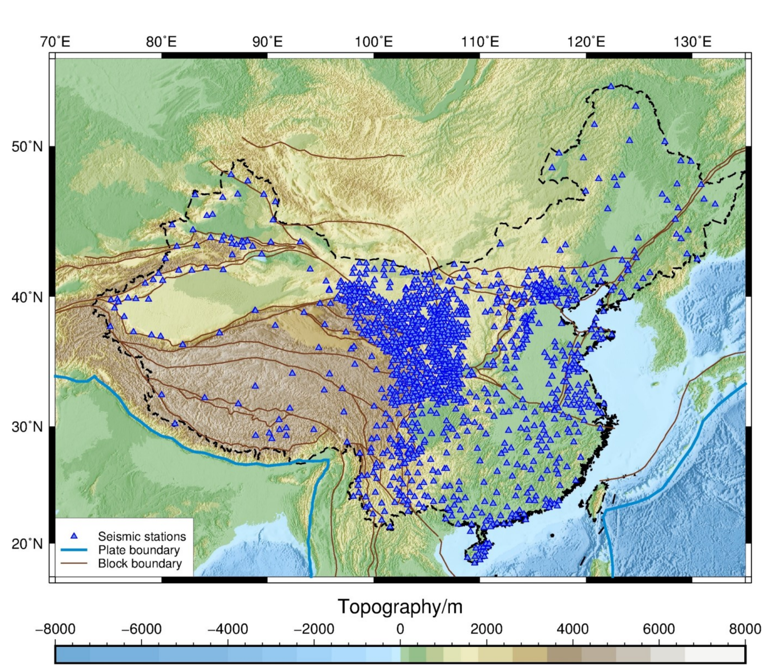

Figure 1. Broadband stations used in this study. Blue triangles: broadband stations; Cyan lines: Plate boundary; Brown lines: block boundary (Zhang et al, 2005).

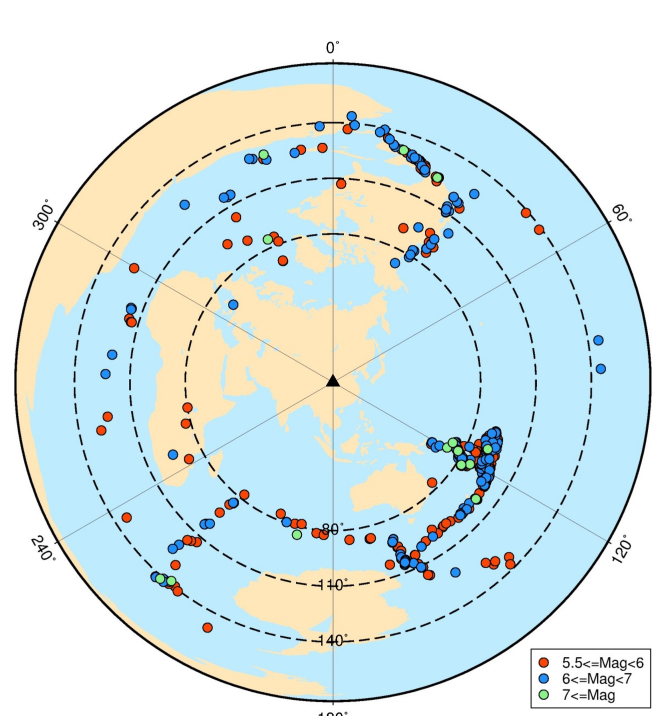

Figure 2. Earthquakes used to provide seismograms with SKS phases. Red circles: earthquakes with magnitude 5.5 ~ 6; Blue circles: earthquakes with magnitude 6 ~ 7; green circles: earthquakes with magnitude larger than 7.

3. Shear-wave splitting measurement

We apply the minimum transverse energy method (Silver and Chan, 1991) to make shear wave splitting measurement. In this method, the minimum of the energy on the transverse component linearizes the particle motion. Through a grid search, the direction of the fast wave ϕ and the delay time δt between the fast and slow waves which best remove the splitting effect can be found. The length of time windows is set to be 20s which include the primary energy of SKS and we use the predicted time of SKS calculated by IASP91 earth model as the beginning of time windows.

The individual measurements are ranked based on the quality categories following Liu et al. 113, B01305, 2008. Only those measurements of quality A (outstanding) and B (good) with small error (error of ϕ is no more than 10° and error of δt is no more than 0.5s) are persevered (**Figure 4**). Besides, results with $\delta t > 2$ (**Figure 5**) are also removed to decrease the cases of highly large δt due to very small energy on the original transverse component.

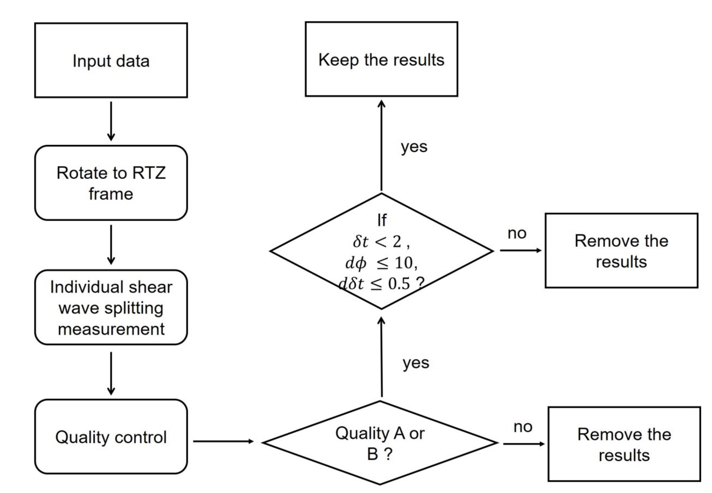

Figure 3. Workflow of shear wave splitting.

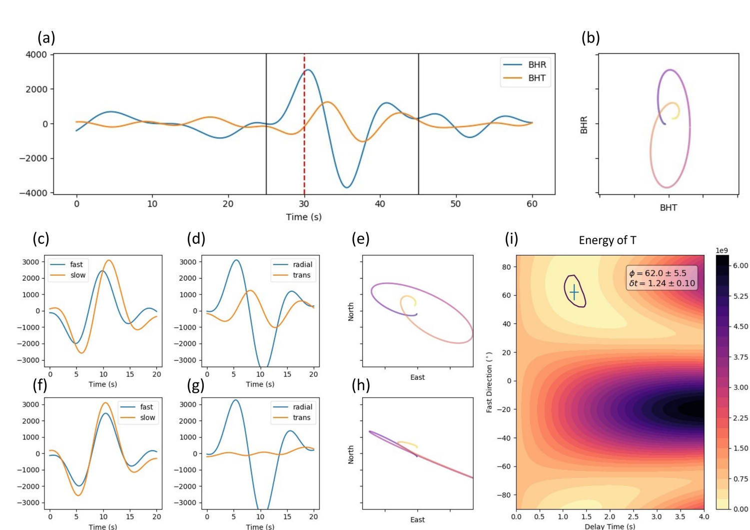

Figure 4. Seismogram and splitting measurement result of Good measurement (rank B). (a): Original R (radial) and T (transverse) components. Black lines: the time window; Red dashed line: the predicted time of SKS from IASP91. (b): Particle motion in the time window. (c): Original fast and slow components. (d): Original R and T components. (e): Original particle motion (in East - North frame). (f) ~ (h) shows corrected waveforms and particle motion. (i) displays the map of minimum energy value on the transverse component.

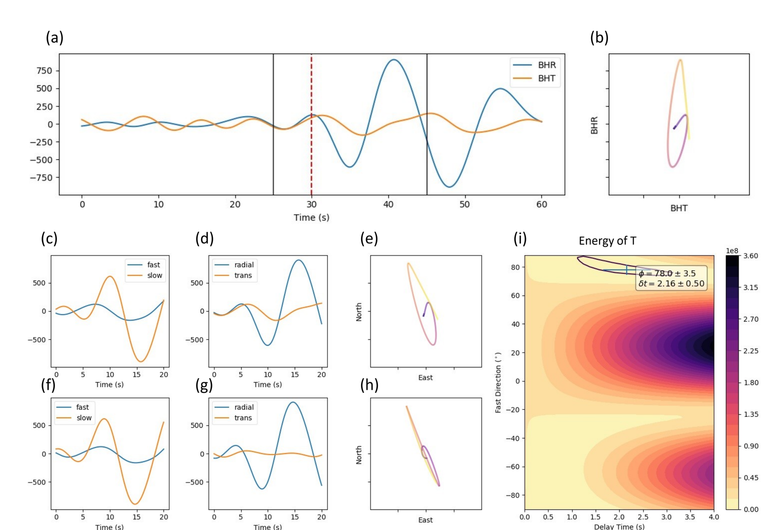

Figure 5. Seismogram of large δt case. The energy on the original transverse component is very small compared with the noise. Also, the original particle motion is not very elliptical but more linear. This case will lead to large δt (often larger than 2s).

4. Results

A total of 6311 pairs of shear wave splitting measurements valid to form the database. We calculate the average result using all valid measurements produced by different earthquakes (**Figure 6**). The range of δt is 0.52 – 2.0s with the average value 1.4s, indicating that the anisotropy of upper mantle widely exists in the continental China. The directions of fast wave polarization ϕ are various in different parts of the continental China.

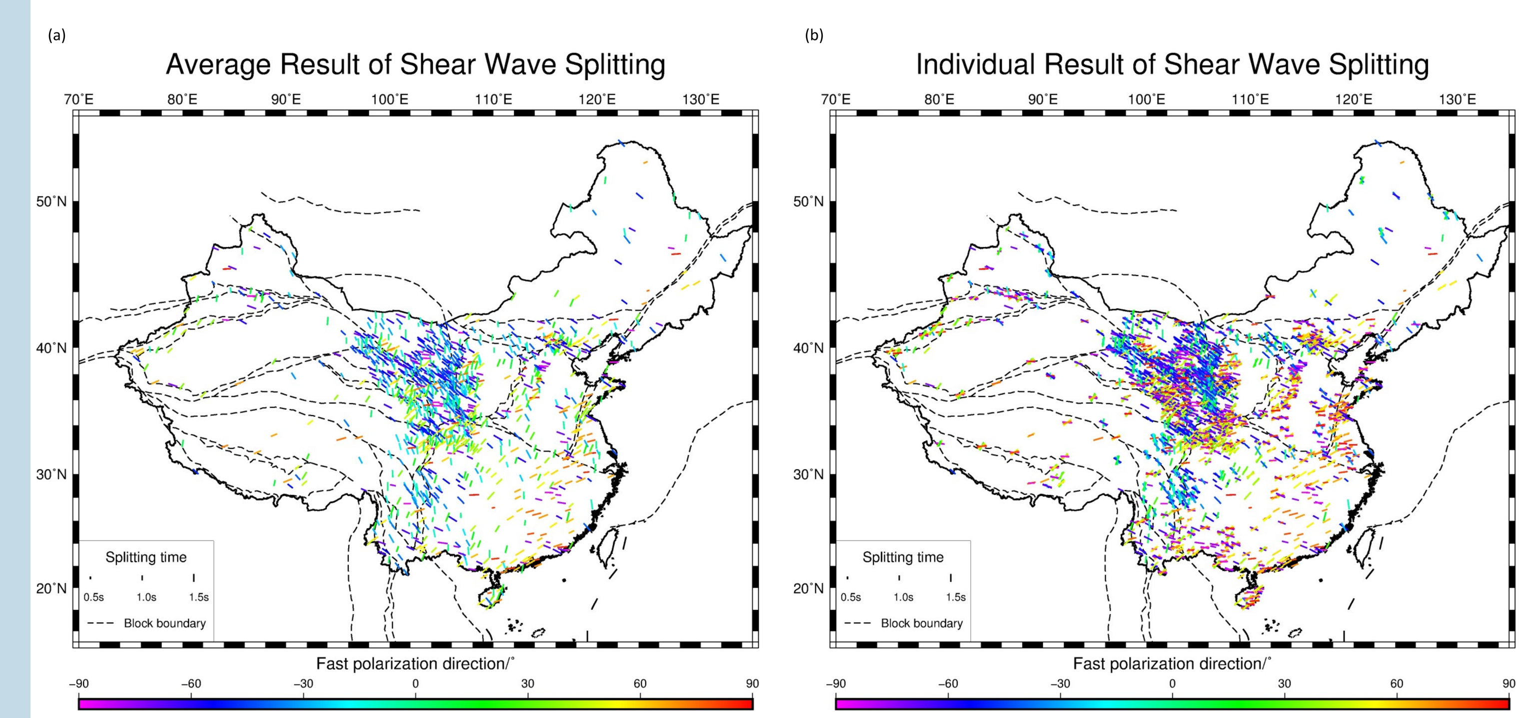

Figure 6. Shear wave splitting results. (a): Average result of each station. The color and direction of the line show the polarization direction of the fast wave. The length of the line is proportional to the delay time. (b): Individual result of each station. Each line represents an individual measurement.

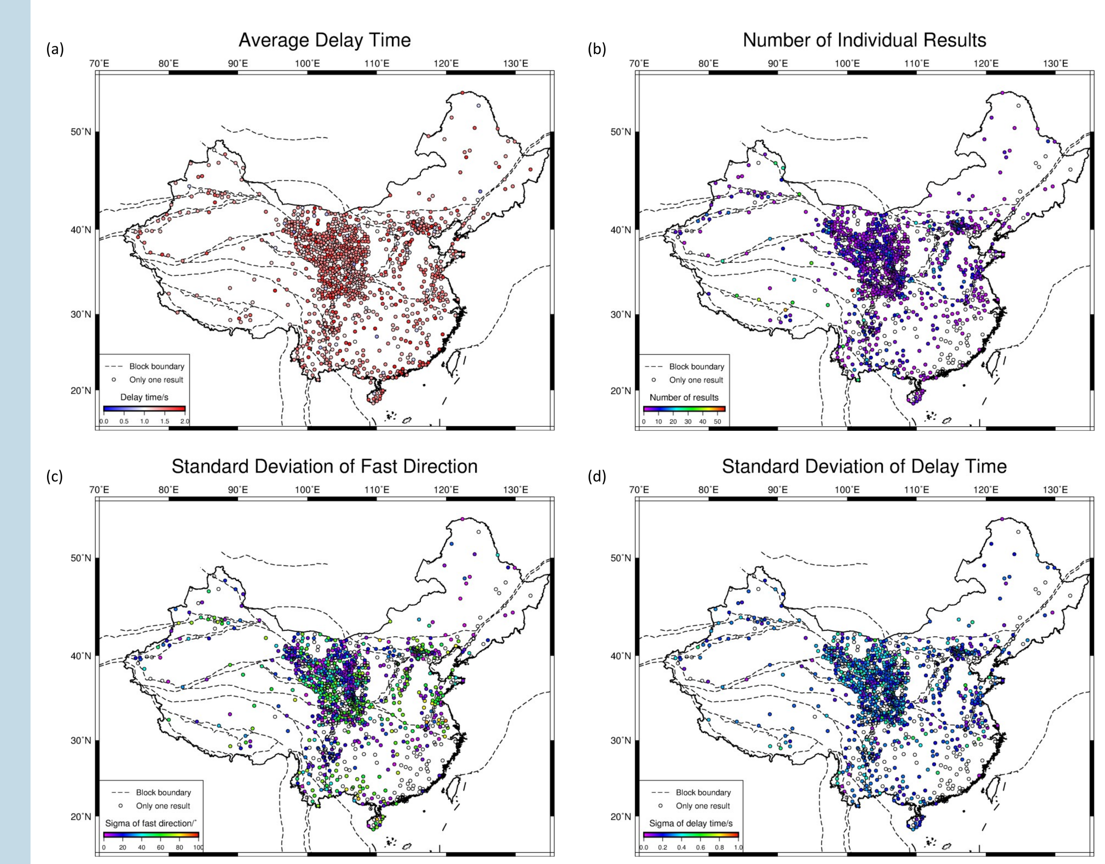

Figure 7. Information of average results. (a): Average delay time. (b): Total number of valid measurements of each station. White circles are stations with only one individual result. (c): Standard deviation of ϕ; (d): Standard deviation of δt.

5. Conclusions

1. We obtain a preliminary database of SKS shear wave splitting parameters in the continental China.
2. Anisotropy exhibits a complex pattern across different tectonic blocks in China, with an average delay time of 1.4s.

6. Acknowledgments

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