Receiver Studies of Crustal Structure of China – A Review and Prospect

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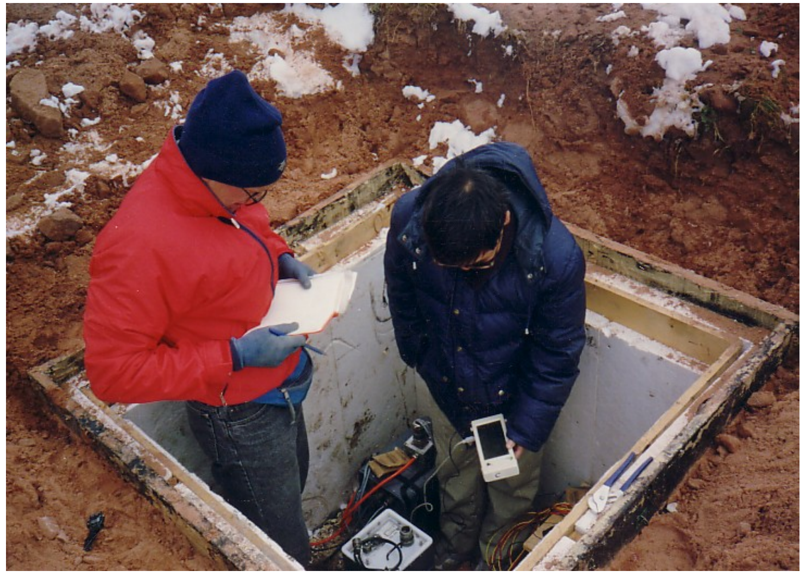
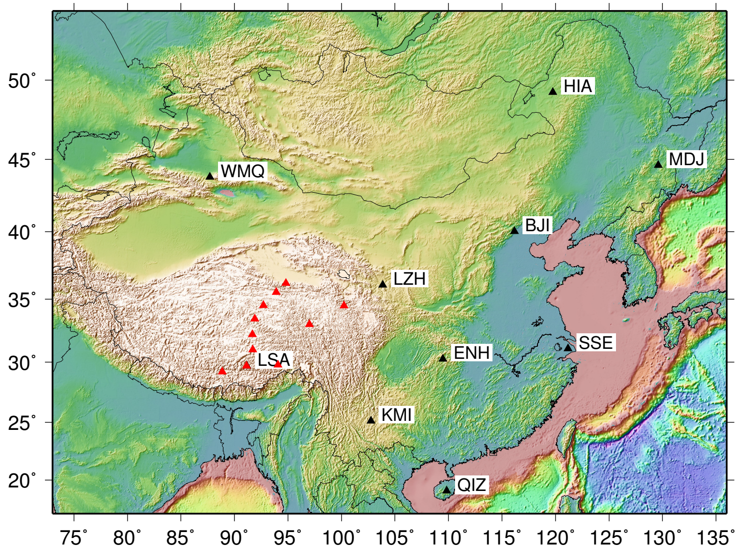
Acknowledgment:

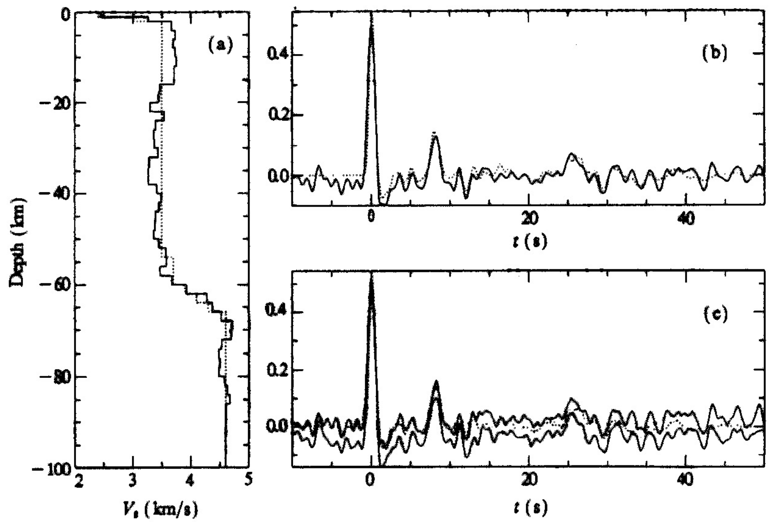
- Li, Yonghua, Mengtan Gao, and Qingju Wu, 2014. Crustal thickness map of the Chinese mainland from teleseismic receiver functions, *Tectonophysics*, 610, 51–60.
- He, Rizheng, Xuefeng Shang, Chunquan Yu, Haijiang Zhang, and Robert D. Van de Hilst, 2014. A unified map of Moho depth and V_p/V_s ratio of continental China by receiver function analysis, *GJI*, 199, 1910-1918.
- Deng, Y., J. Li, X. Song, and L. Zhu, 2016. Evidence for block-wise continuous deformation in the Northeast Tibetan Plateau based on crustal structure from joint inversion, *Science (in review)*.
- NNSFC Grant 42374060.

Outline

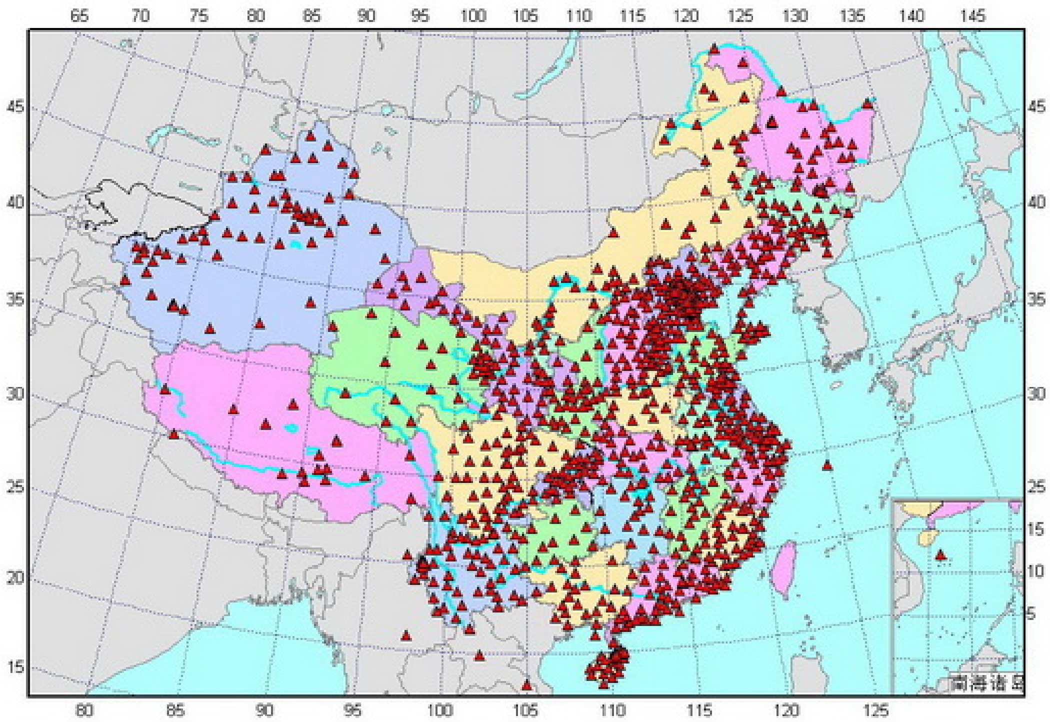
1. A brief review of studies of Chinese crustal structure using receiver function techniques since 1993.
2. Comparison of results of Chinese crustal thicknesses and Poisson's ratios by different research groups so far.
3. Possible causes of discrepancies of results.
4. Suggestions.

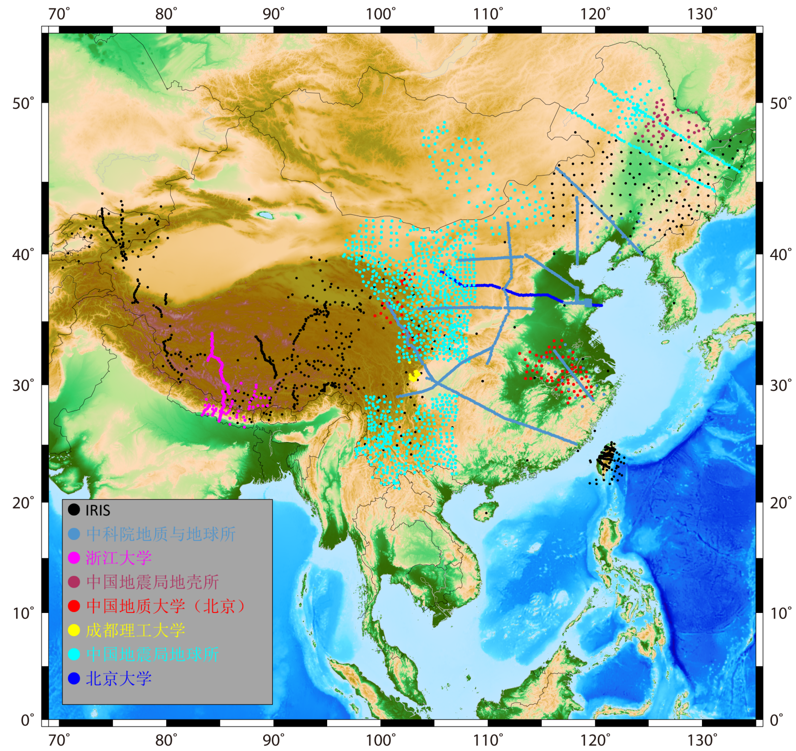






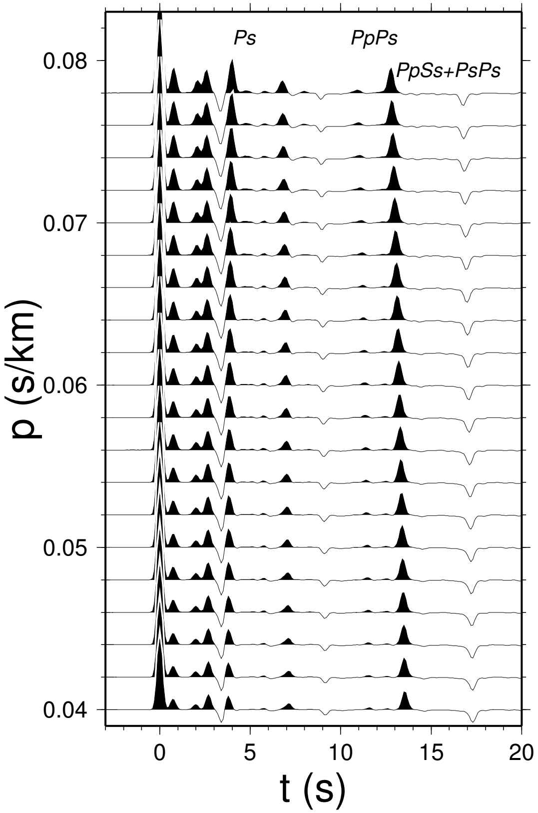
Zhu, L., R. S. Zeng, F. T. Wu, T. J. Owens, and G. E. Randall, Acta Seis. Sinica, 1993

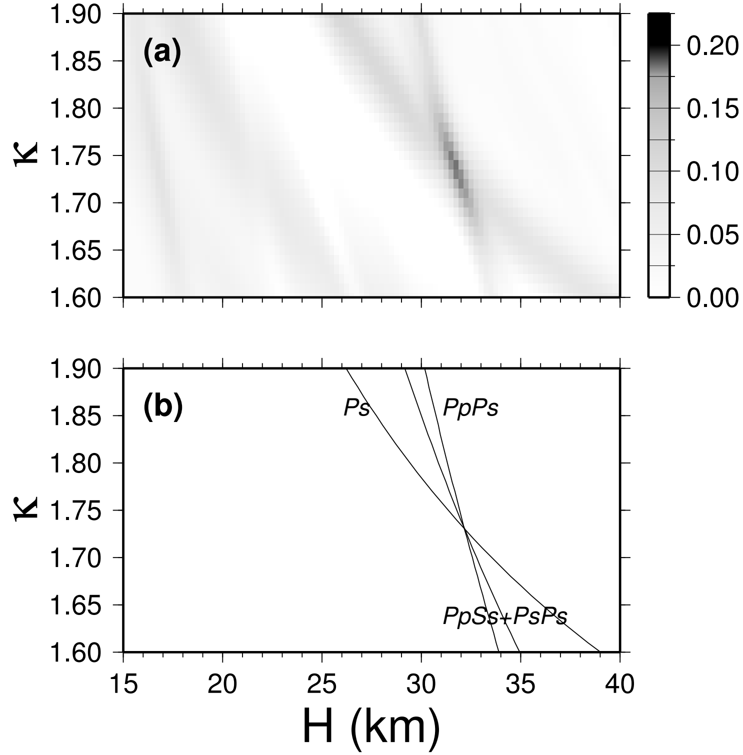




- Today there are 1021 permanent broadband stations and countless portable stations.
- There have been more than 100 publications on using RF to study crustal structure of China.
- Techniques include the H-κ stacking, CCP stacking, and joint inversion.

Estimate crustal thickness H and V_p/V_s ratio κ





$$t_{Ps} = H(\eta_s - \eta_p),$$

$$\frac{\Delta H}{H} = 0.9\frac{\Delta V_p}{V_p},$$

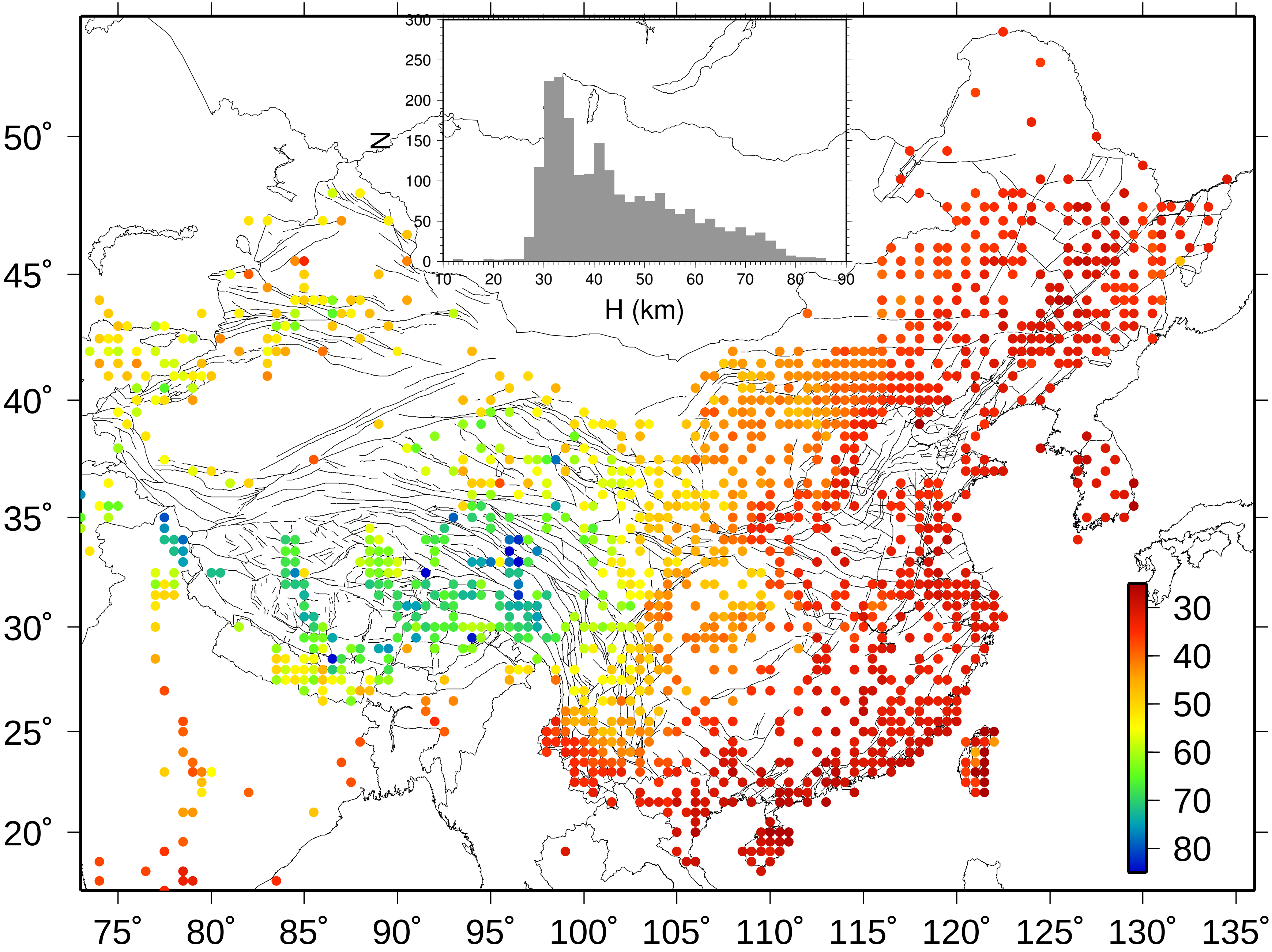
$$\frac{\Delta H}{H} = -2.3\frac{\Delta \kappa}{\kappa}.$$

Adding the multipes

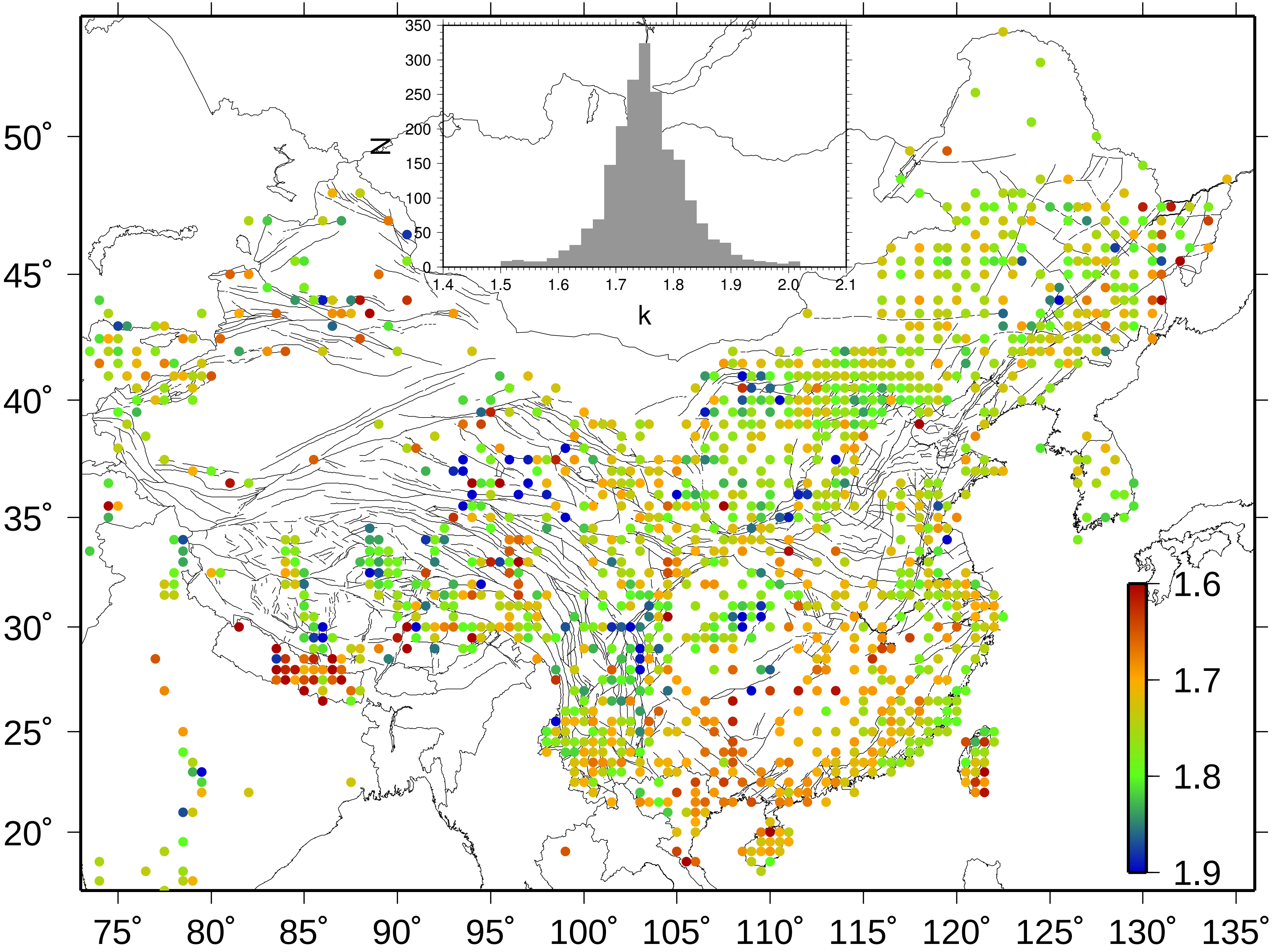
$$t_{PpPs} = H(\eta_s + \eta_p),$$

$$t_{PpSs+PsPs} = 2H\eta_s,$$

does not uniquely determine the three unknowns but can give the “optimal” estimates of H and κ based RFs (Zhu and Kanamori, JGR, 2000).



300
250
200
150
100
50
0
N
10
20
30
40
50
60
70
80
90
H (km)
50°
45°
40°
35°
30°
25°
20°
75°
80°
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
135°
30
40
50
60
70
80



50°
45°
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25°
20°
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85°
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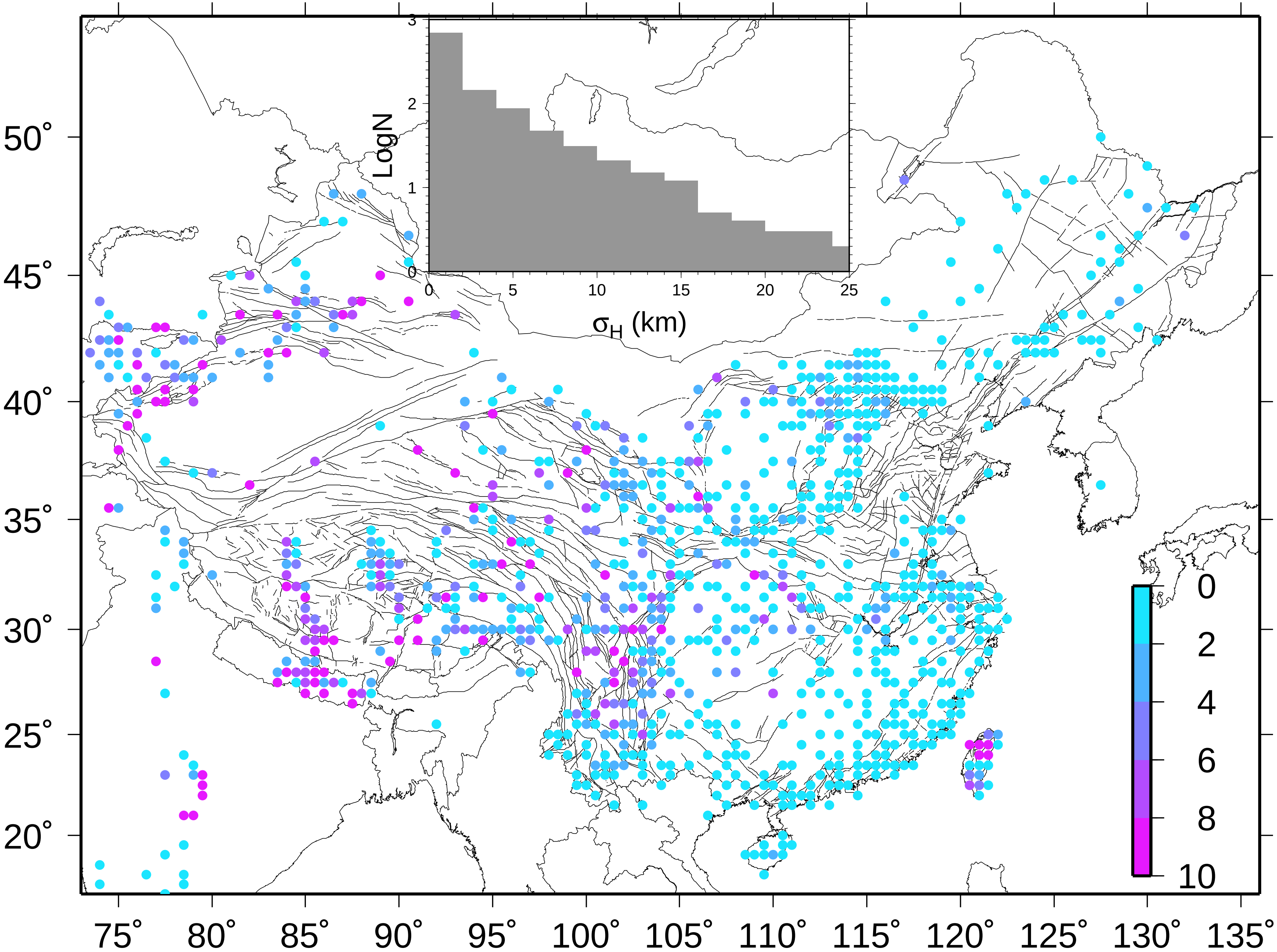
95°
100°
105°
110°
115°
120°
125°
130°
135°
N
k
350
300
250
200
150
100
50
0
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
1.6
1.7
1.8
1.9


3
2
1
0
LogN
0
5
10
15
20
25
σ_H (km)
50°
45°
40°
35°
30°
25°
20°
75°
80°
85°
90°
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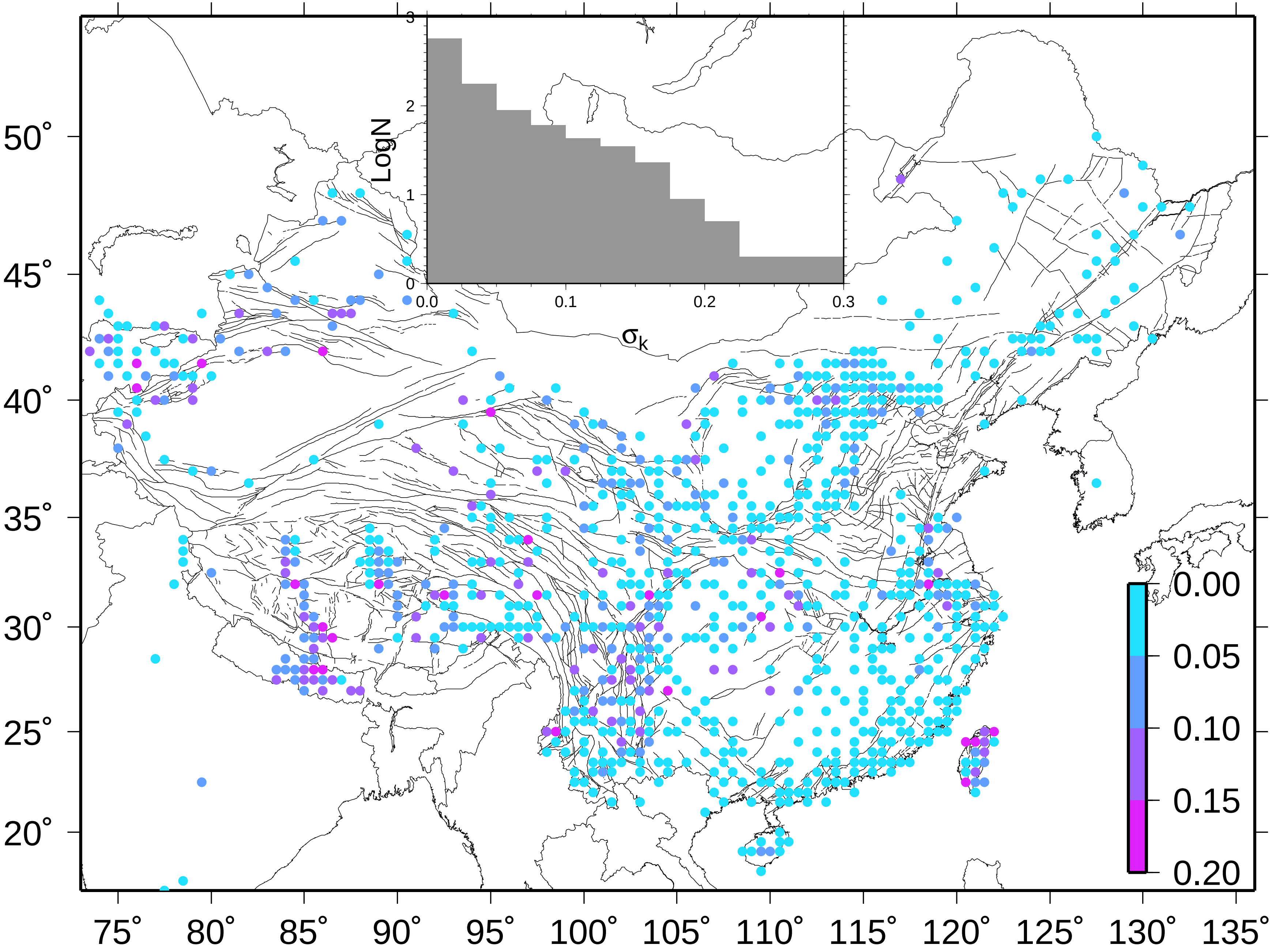
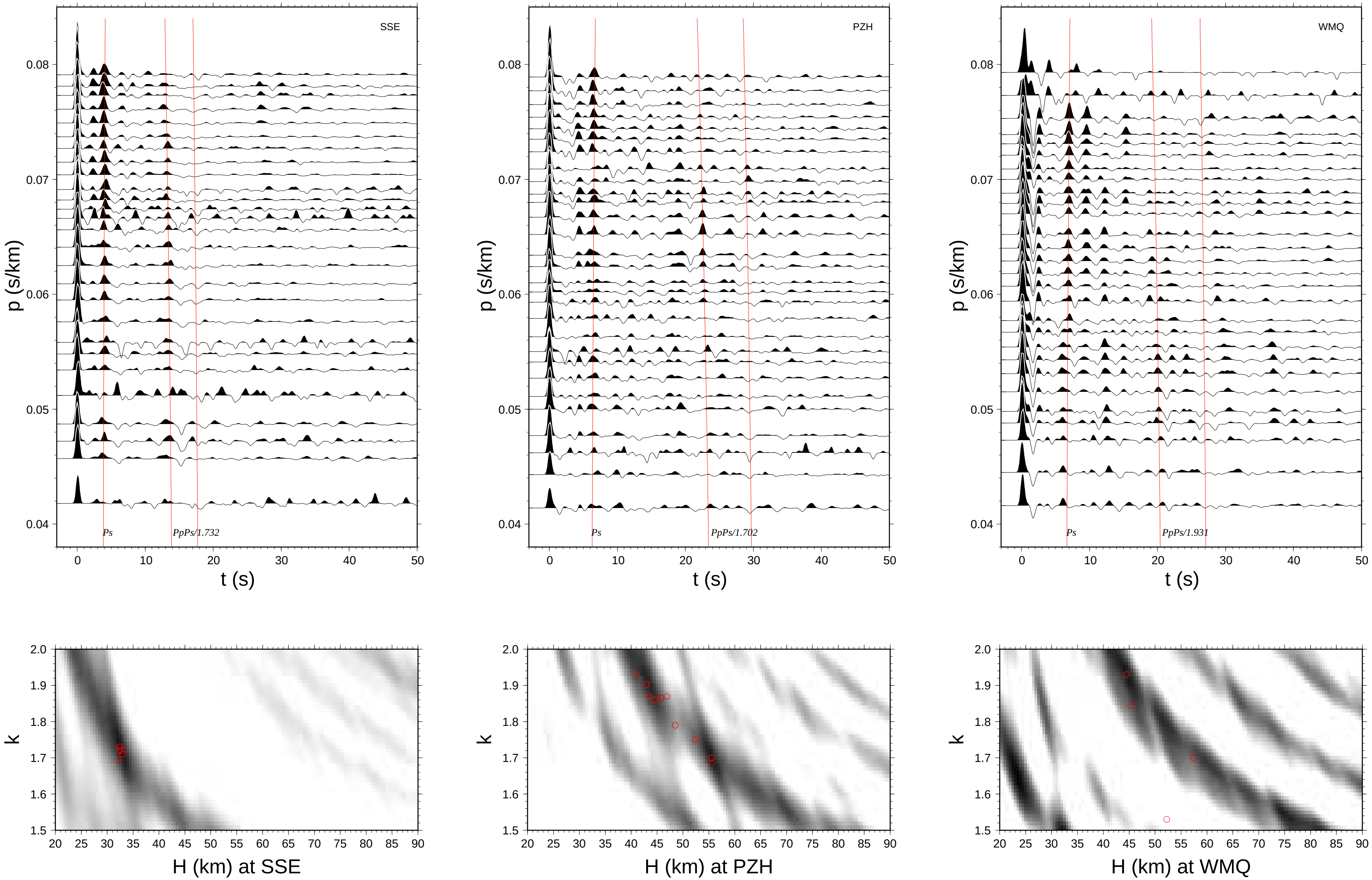
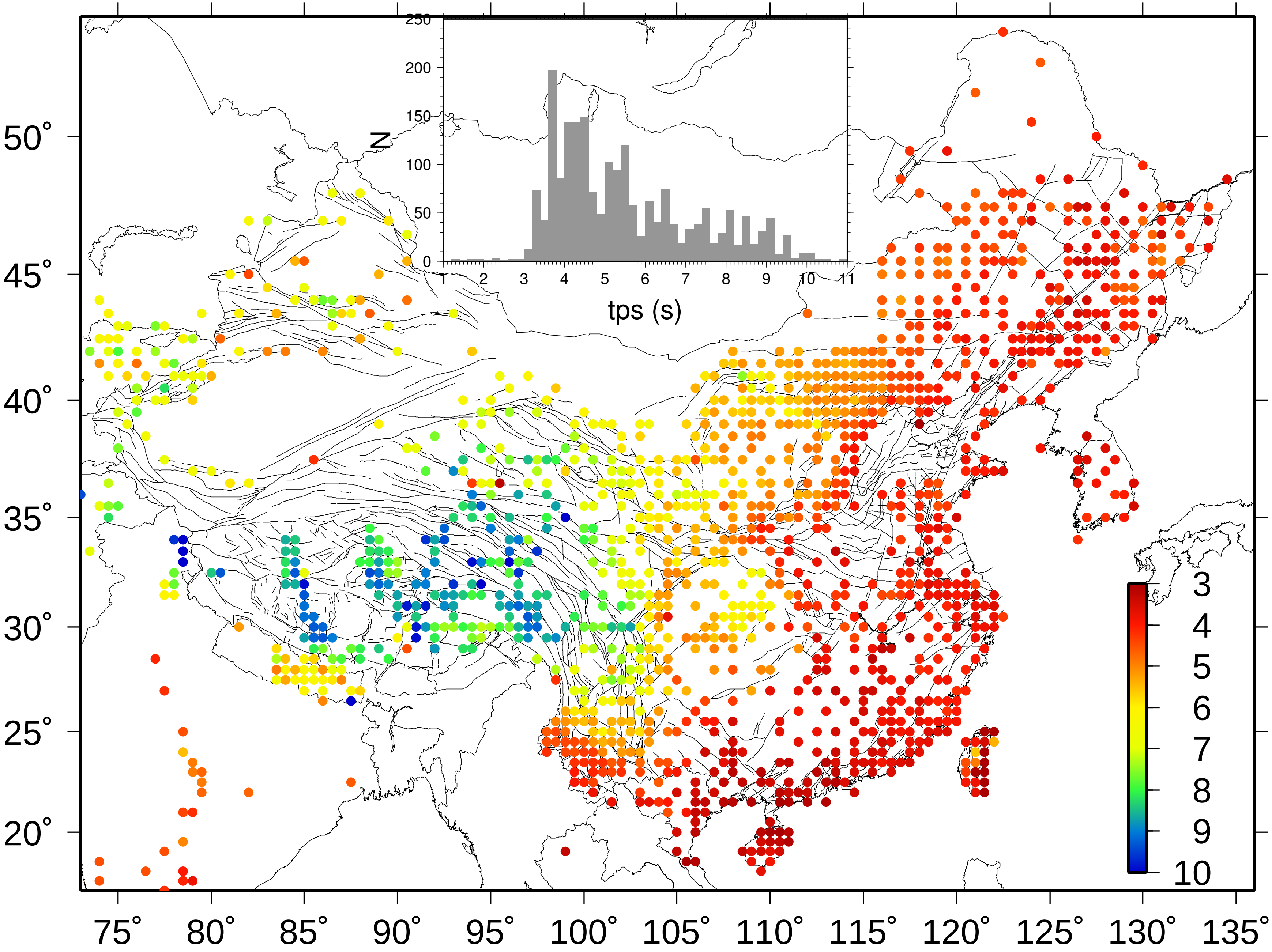
100°
105°
110°
115°
120°
125°
130°
135°
0
2
4
6
8
10



LogN
σk
0.0
0.1
0.2
0.3
0
1
2
3
0.00
0.05
0.10
0.15
0.20
50°
45°
40°
35°
30°
25°
20°
75°
80°
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
135°


SSE
PZH
WMQ
p (s/km)
t (s)
Ps
PpPs/1.732
PpPs/1.702
PpPs/1.931
k
H (km) at SSE
H (km) at PZH
H (km) at WMQ



50°
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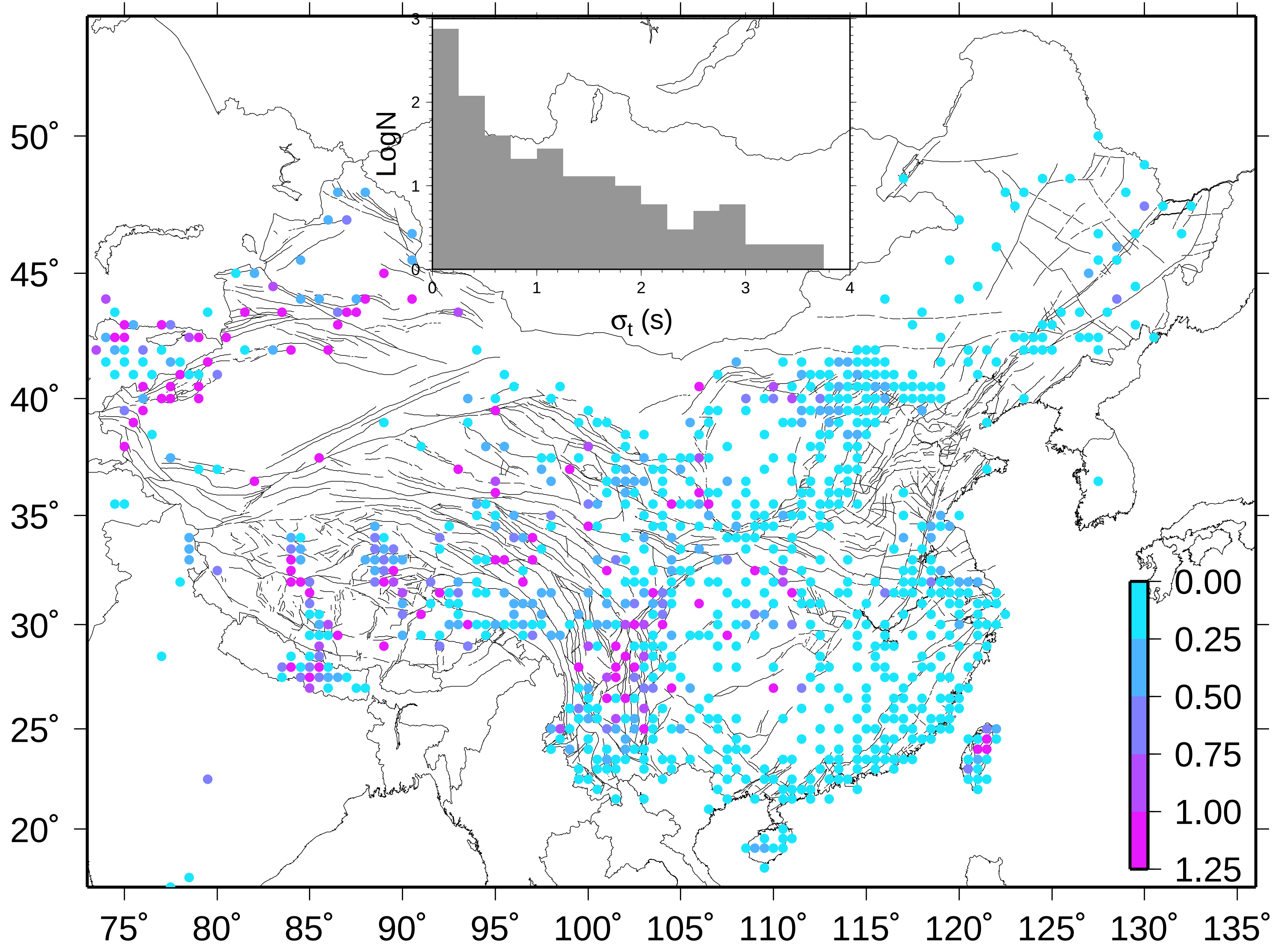
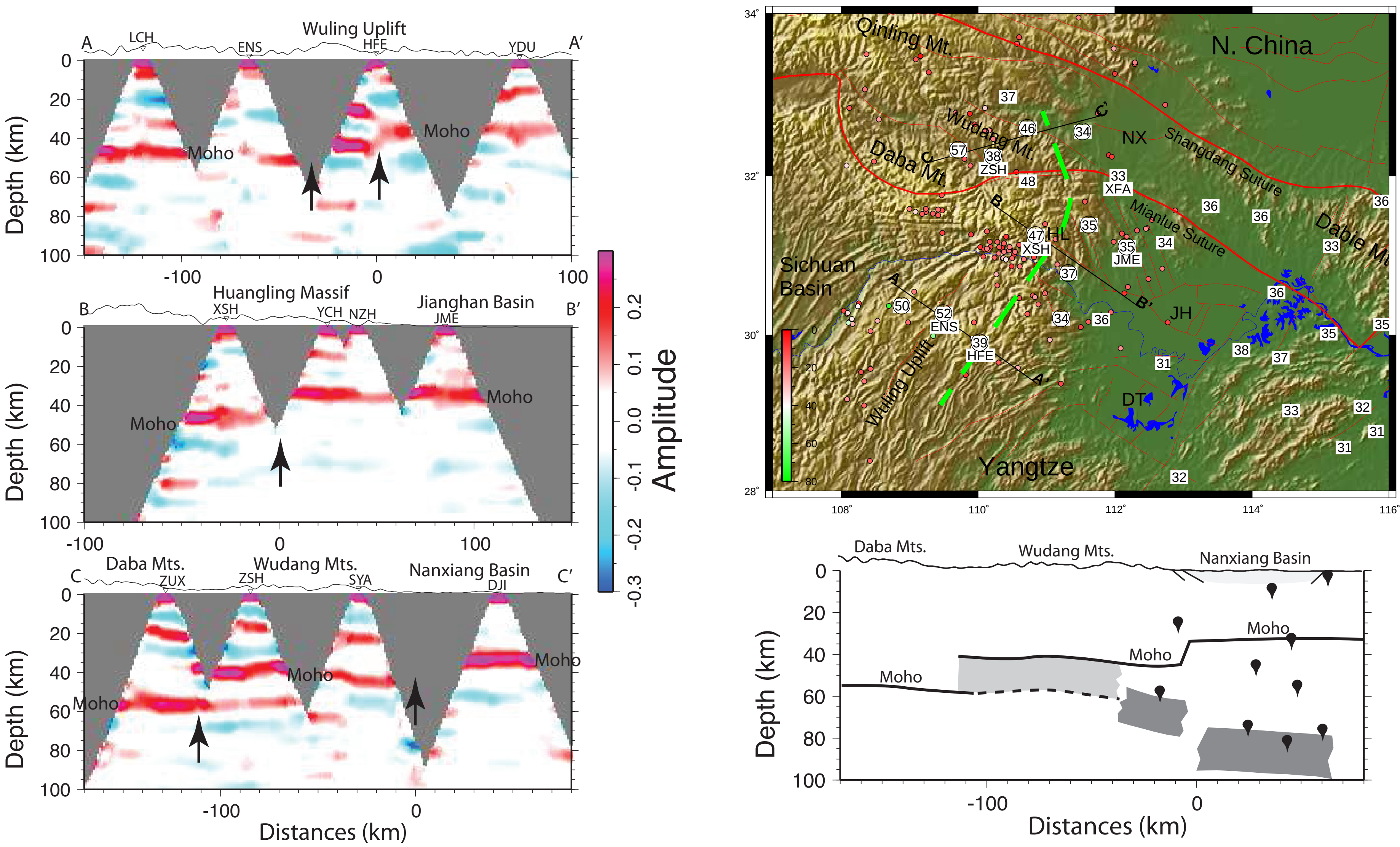
75°
80°
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
135°
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
N
tps (s)
3
4
5
6
7
8
9
10

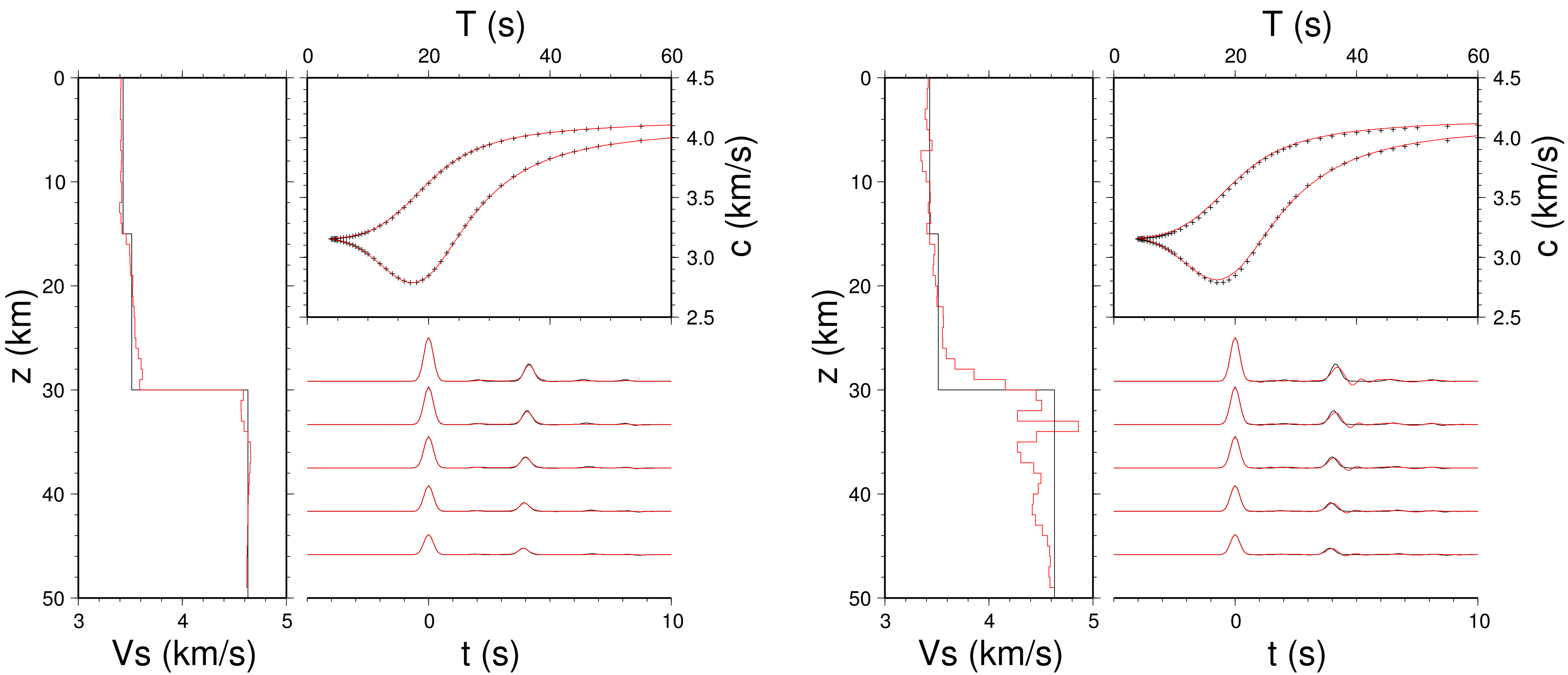


LogN
σt (s)
50°
45°
40°
35°
30°
25°
20°
75°
80°
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
135°
0.00
0.25
0.50
0.75
1.00
1.25



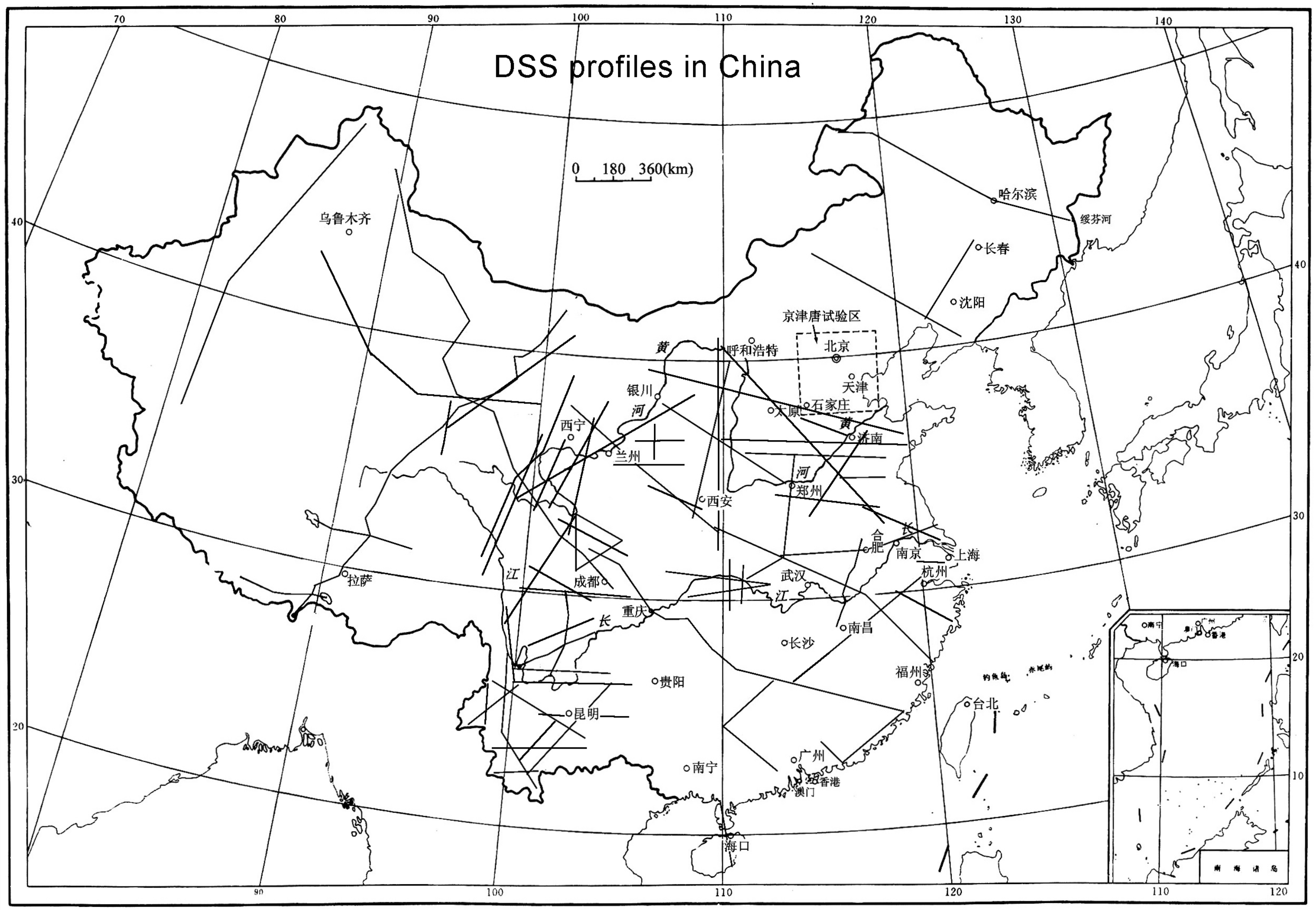
Huang, R., L. Zhu, and Y. Xu, Tectonophysics, 2014.

Joint inversion of RFs and surface wave dispersions

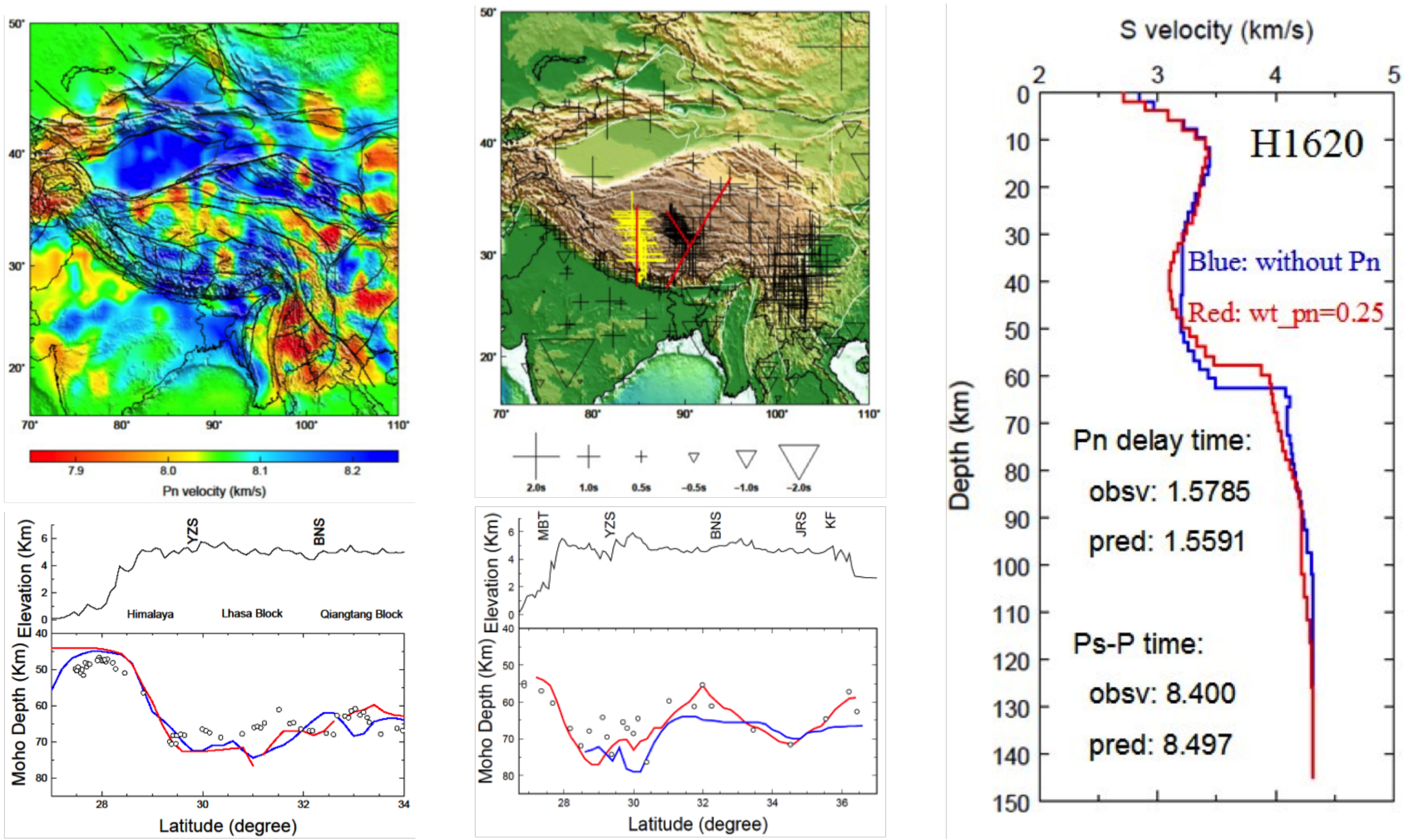


Left) with correct crustal V_p (6.25 km/s) and Right) incorrect V_p (6.50 km/s).

Deep Seismic Sounding (DSS) data

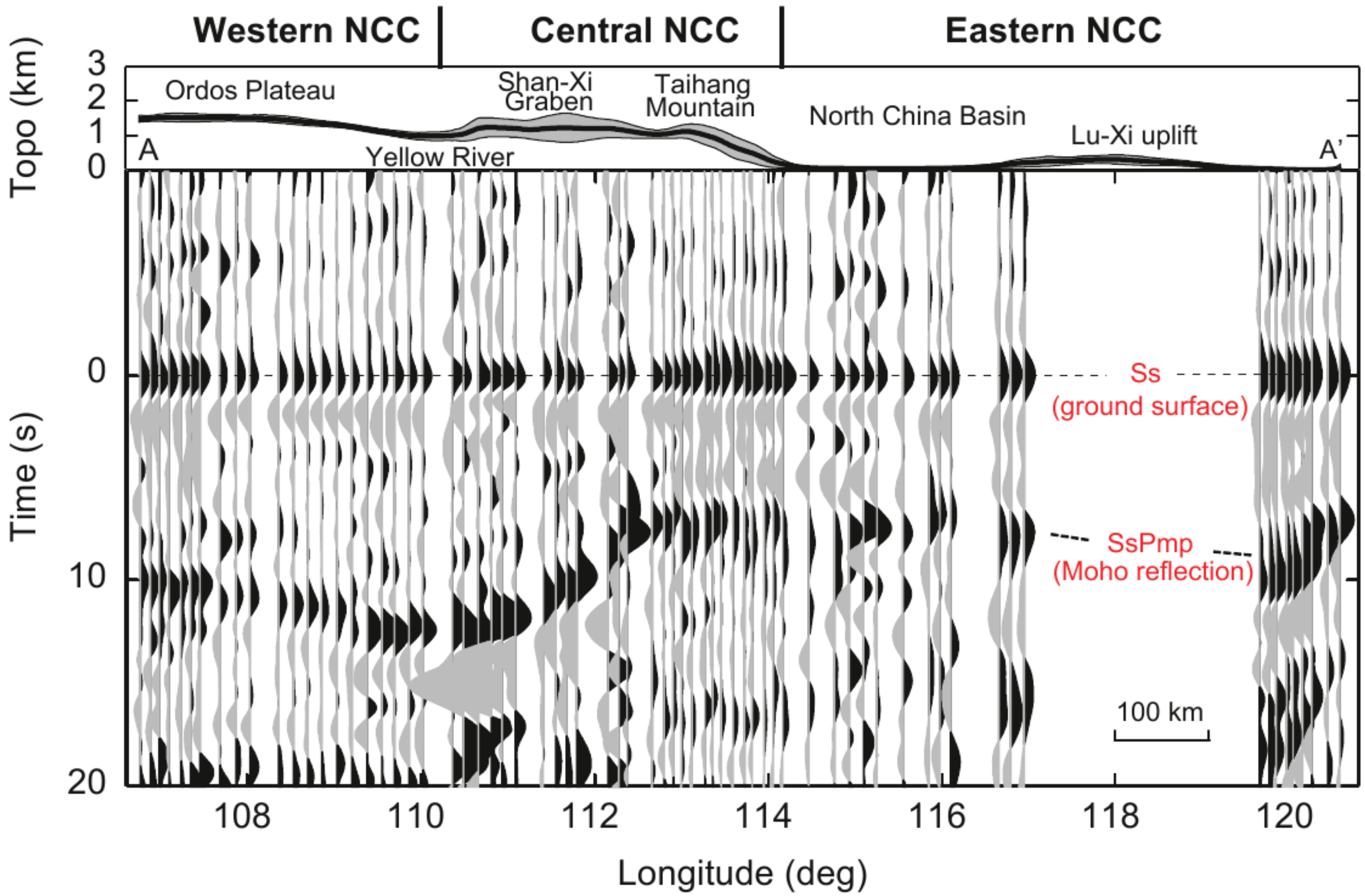


Station delays from P_n tomography of regional earthquakes



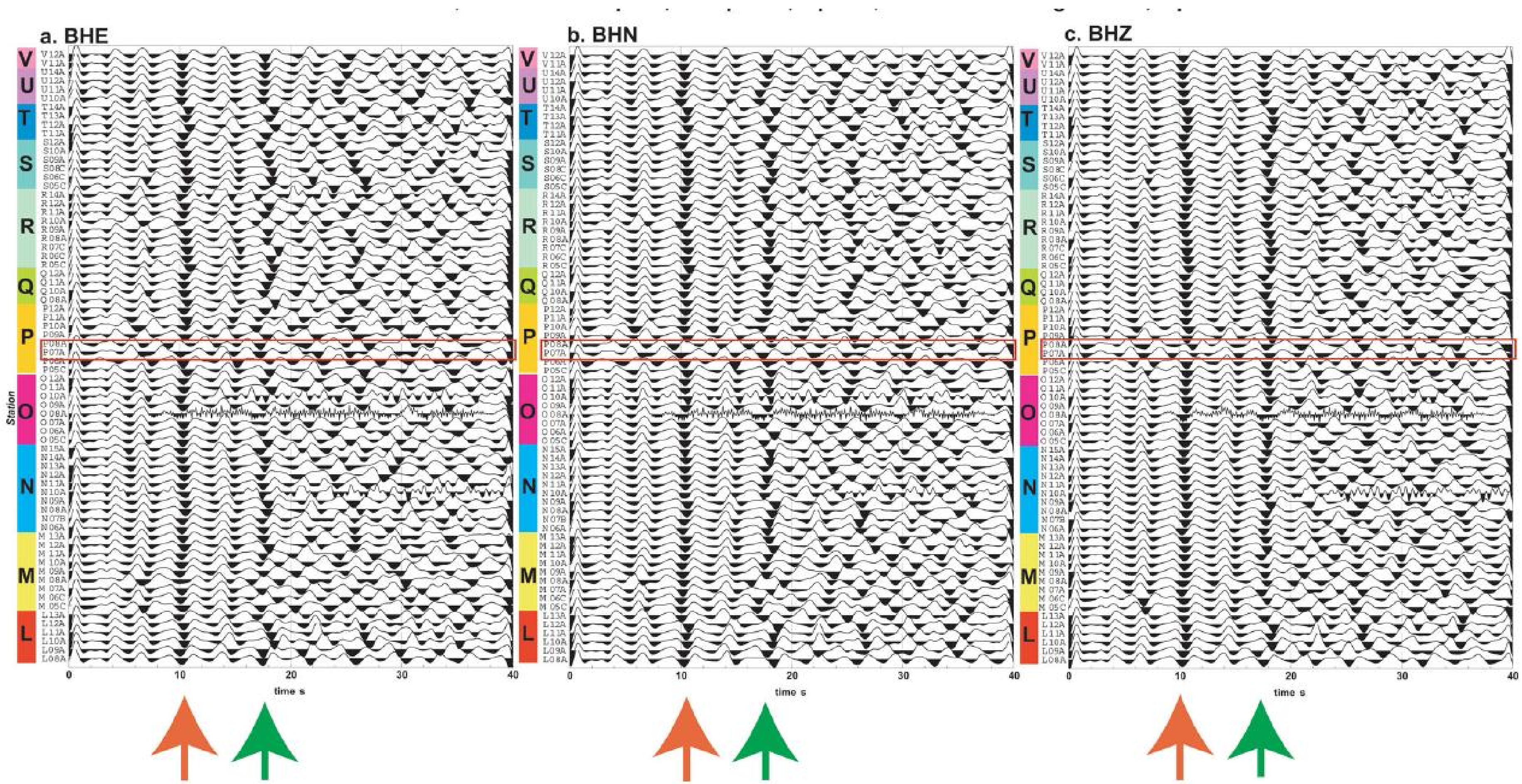
Xu, Z. J., X. Song, and L. Zhu, Tectonophysics, 2013

Virtual DSS using teleseismic events



Yu et al., EPSL, 2012.

Auto-correlation of ambient noise data



Tibuleac and Seggern, GJI, 2012.

Summary

1. The last two decades have witnessed dramatic increase of numbers of seismic stations in China and studies of Chinese crustal structure using the data collected.
2. There are still large station coverage gaps in the western China and offshore.
3. So far, crustal thickness results from different groups are similar in tectonically stable areas (e.g., SCB and Ordos) but differ in tectonically active areas (e.g., TP, Tianshan, and TW) and block boundaries.
4. Some of the differences are due to lack of constraints in the crustal V_p/V_s.
5. Other discrepancies probably reflect complex crustal structure and strong lateral structural variation.
6. Esimating crustal thicknesses beneath thick sedimentary basins is still challenging.

Suggestions

1. Re-exam RF waveforms of those stations with large crustal thickness differences among different groups.
2. Add crustal P-wave travel-time data to RF data and surface wave dispersion data for a joint inversion of crustal structure.
3. Use dense array stations to suppress noise and to improve imaging quality in basins and other complex areas.
4. Continue portable observation projects (e.g. ChinaArray) and use OBSs.
5. Develop smart and automatic data analyzing methods to uniformly process large amount of waveform data.
6. Adopt a user-friendly standard format for seismological models which is able to describe complicated Earth structures.
7. Share both data and models on-line.