Magnetic and thermal constraint on the spatial distribution of continental seismicity

Liguo Jiao[1] and Yu Lei[1]

[1]IGCEA

November 22, 2022

Abstract

Recent fast developments of satellite magnetic observations facilitate global Lithospheric Magnetic Field (LMF) modelling and their applications to subsurface tectonics. Here, the vertical component (Bz) of LMF at an altitude of 200km in Mainland China and surroundings is calculated from two global LMF models NGDC-720 and EMM2017. Next, Bz is used to invert the Curie Point Depth (CPD) by Equivalent Source Dipole (ESD) forward and Nonlinear Conjugate Gradient Method (NCGM) inversion scheme. Then, the surficial Heat Flux (HF) is derived by a simple one-dimensional steady heat conduction equation from the CPD distribution. At last, the continental seismicity is compared statistically to Bz, CPD and HF. Our essential conclusions are as follow: 1) Histograms and boxplots show that most (81.8%) earthquakes (EQs, Ms[?]5.0) occurred in negative Bz areas, and more than a half (53.2%) number of EQs (corresponding to an energy percent of 94.6%) occurred inside areas with Bz between -5 and -3nT, in a period between 2004 and 2007, which is the same with the satellite data collection. When the time span is extended (most to 110 years), these phenomena maintain while weaken; 2) Most (88%) EQs occurred in areas with CPD between 10 and 30km, while only a few (7% and 5%) occurred in shallow (<10km) and deep (>30km) CPD areas, in a period between 2000 and 2010; 3) EQs seldom occurred inside cold areas (HF<50mW/m2), and are prone to occur in warm areas (HF>120mW/m2). EQs are also prone to occur along the boundaries of warm or cold areas. The mechanism of the correlations between EQs and Bz, CPD and HF maybe the lithospheric strength jumps caused by the temperature variations at boundaries between blocks with different CPDs.

Magnetic and thermal constraints on the spatial distribution of continental seismicity

中国地震局地球物理研究所
Institute of Geophysics,China Earthquake Administration

Liguo Jiao, Yu Lei

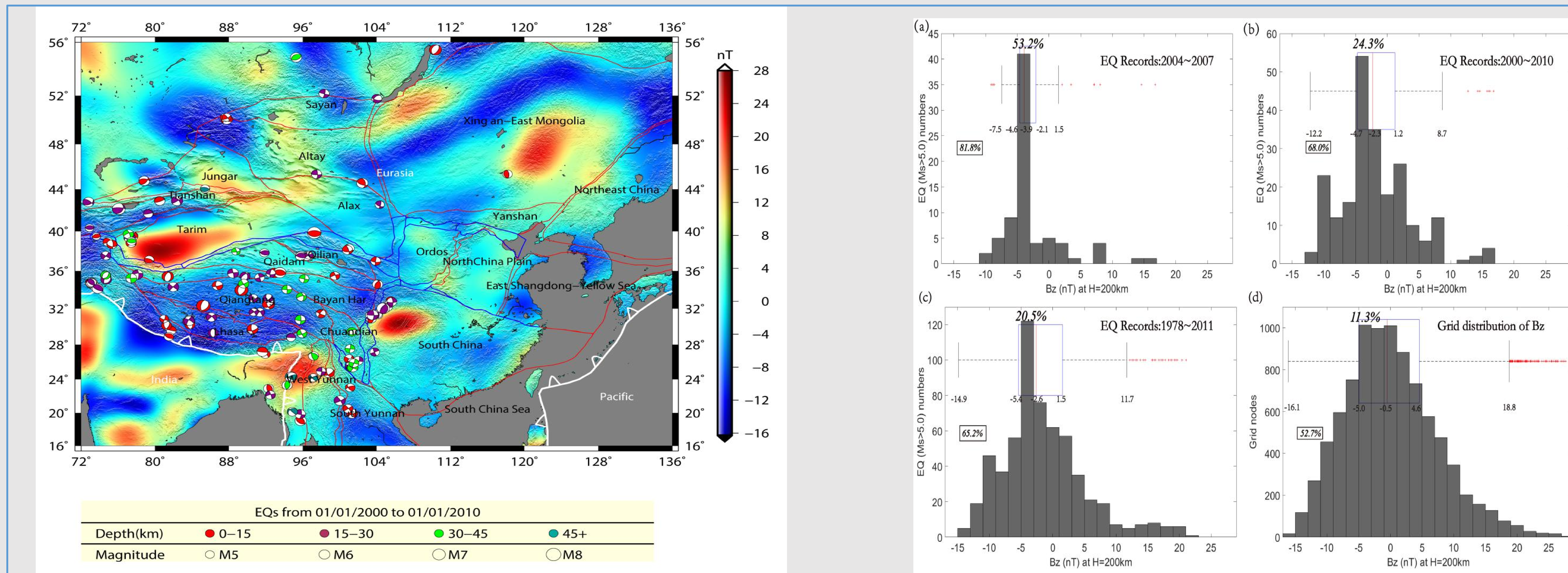
lgjiao@cea-igp.ac.cn

Institute of Geophysics, China Earthquake Administration, Beijing, China

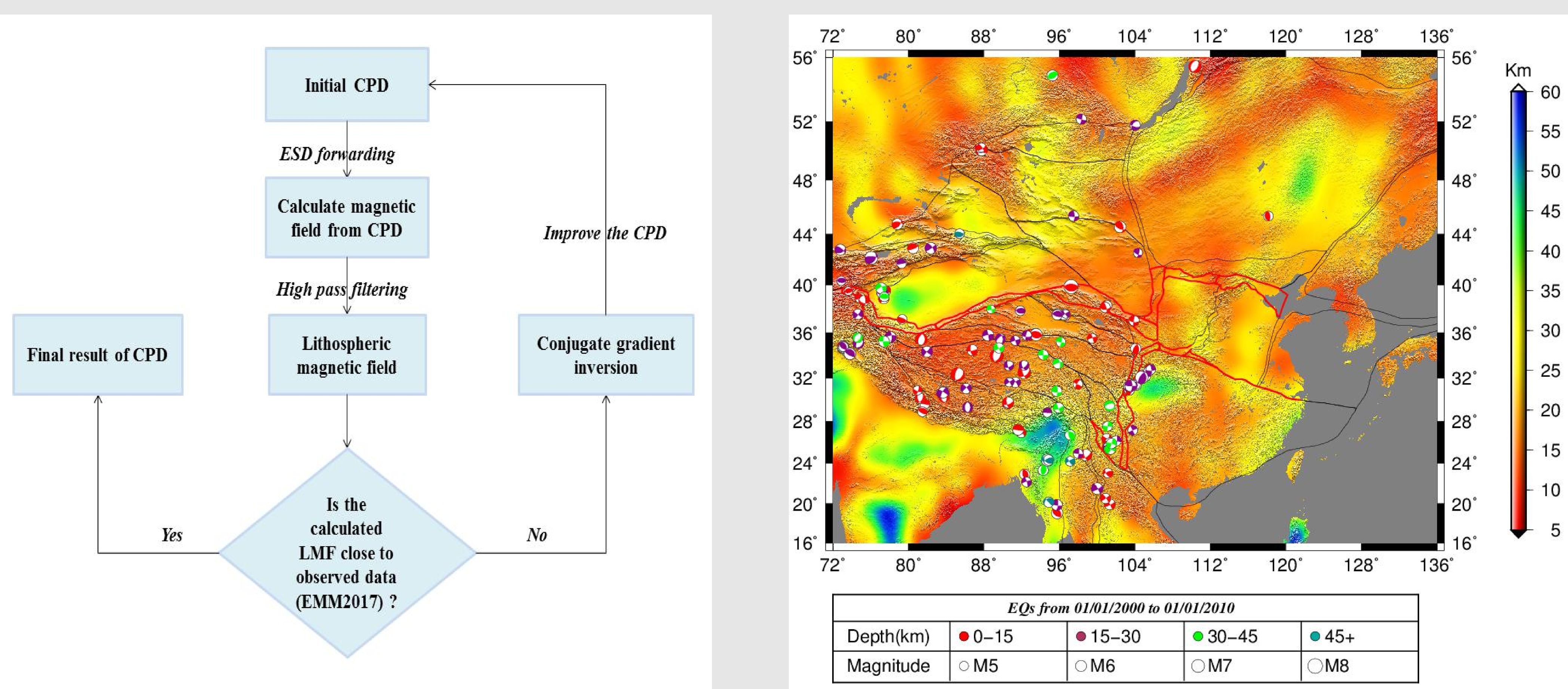
AGU 100 FALL MEETING
San Froncisco, 2019
GP33B-0752

Abstract

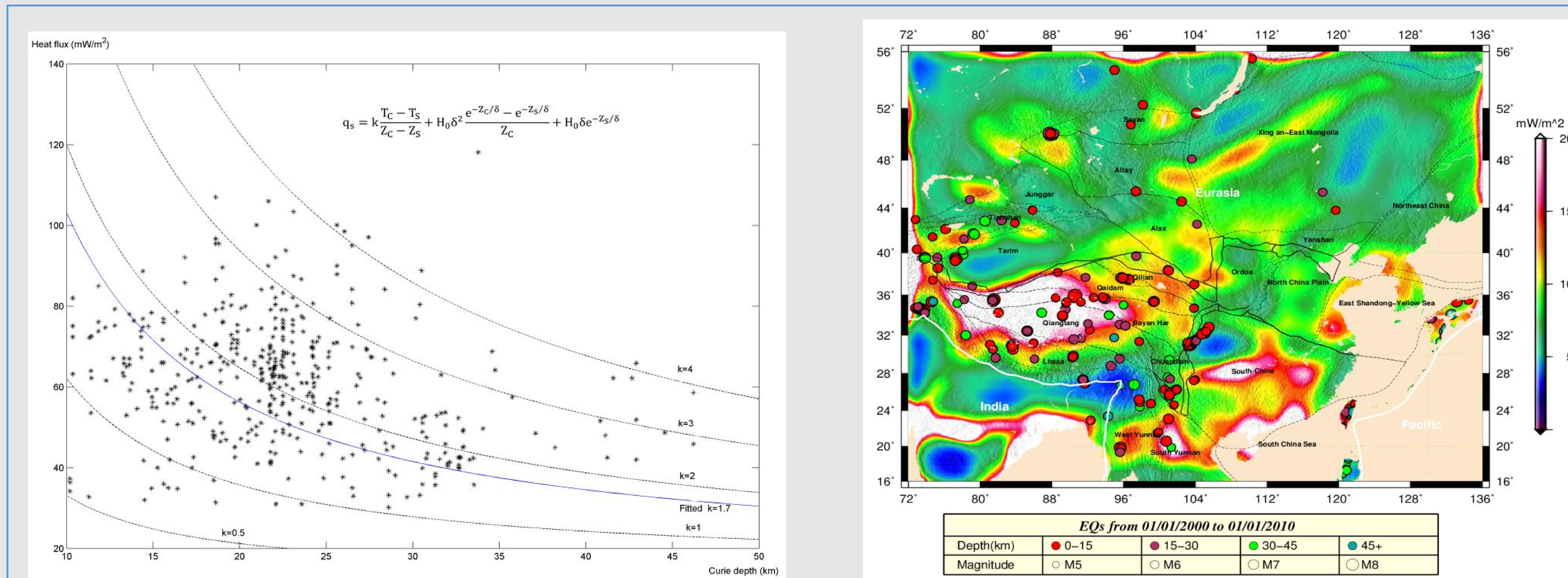
Recent fast developments of satellite magnetic observations facilitate global Lithospheric Magnetic Field (LMF) modelling and their applications to subsurface tectonics. Here, the vertical component (B_z) of LMF at an altitude of 200km in Mainland China and surroundings is calculated from two global LMF models NGDC-720 and EMM2017. Next, B_z is used to invert the Curie Point Depth (CPD) by Equivalent Source Dipole (ESD) forward and Nonlinear Conjugate Gradient Method (NCGM) inversion scheme. Then, the surficial Heat Flux (HF) is derived by a simple one-dimensional steady heat conduction equation from the CPD distribution. At last, the continental seismicity is compared statistically to B_z, CPD and HF. Our essential conclusions are as follow: 1) Histograms and boxplots show that most (81.8%) earthquakes (EQs, $M_s \geq 5.0$) occurred in negative Bz areas, and more than a half (53.2%) number of EQs (corresponding to an energy percent of 94.6%) occurred inside areas with Bz between -5 and -3nT, in a period between 2004 and 2007, which is the same with the satellite data collection. When the time span is extended (most to 110 years), these phenomena maintain while weaken; 2) Most (88%) EQs occurred in areas with CPD between 10 and 30km, while only a few (7% and 5%) occurred in shallow (<10km) and deep (>30km) CPD areas, in a period between 2000 and 2010; 3) EQs seldom occurred inside cold areas (HF<50mW/m²), and are prone to occur in warm areas (HF>120mW/m²). EQs are also prone to occur along the boundaries of warm or cold areas. The mechanism of the correlations between EQs and Bz, CPD and HF maybe the lithospheric strength jumps caused by the temperature variations at boundaries between blocks with different CPDs.



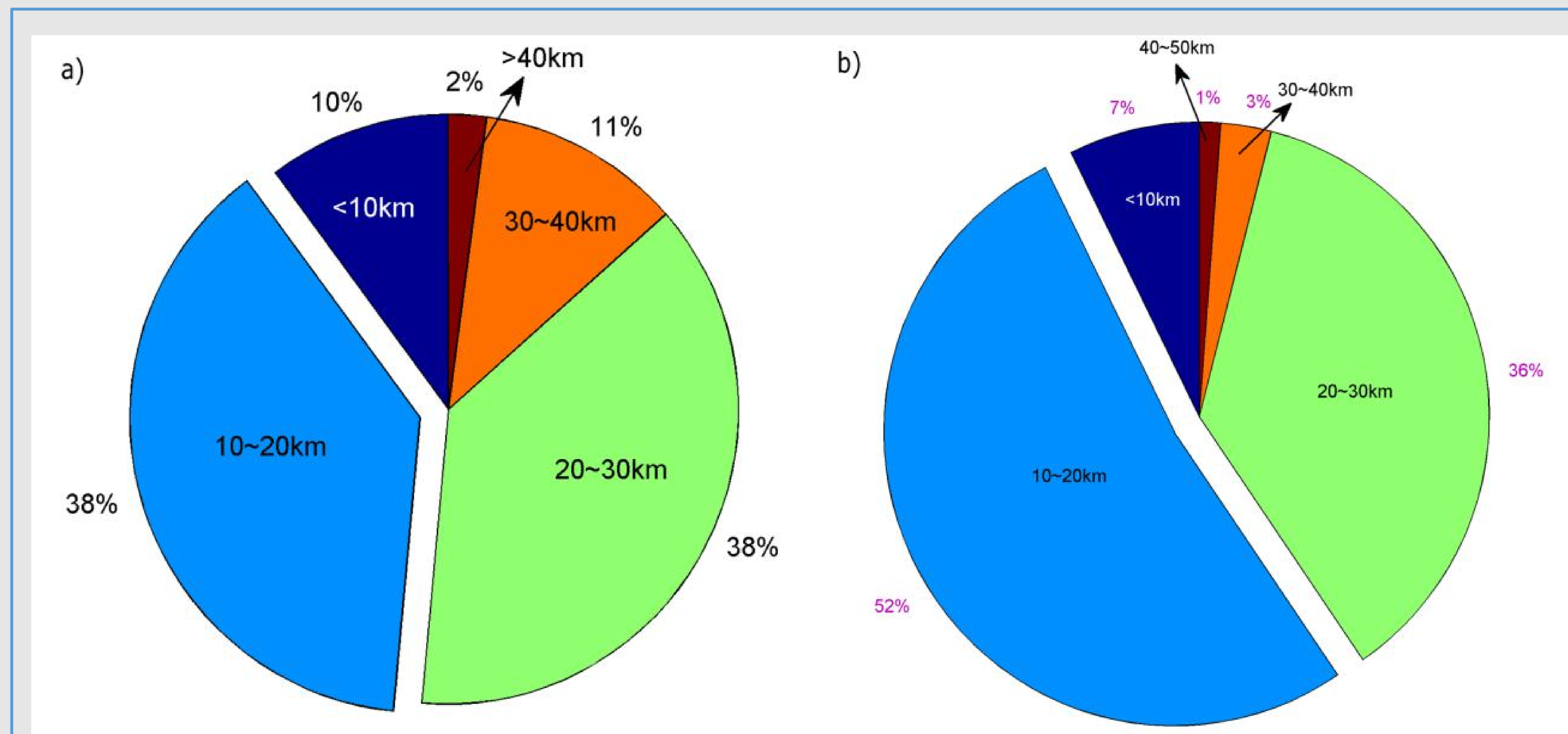
Comparsions between B_z and continental seismicity in Mainlan China. B_z is calculated at an altitude of 200km by NGDC-720. Left: seismicity in ten years; Right: histogram and boxplot of correlations between B_z and seismicity for different periods. See Lei *et al.* (2018) for details.



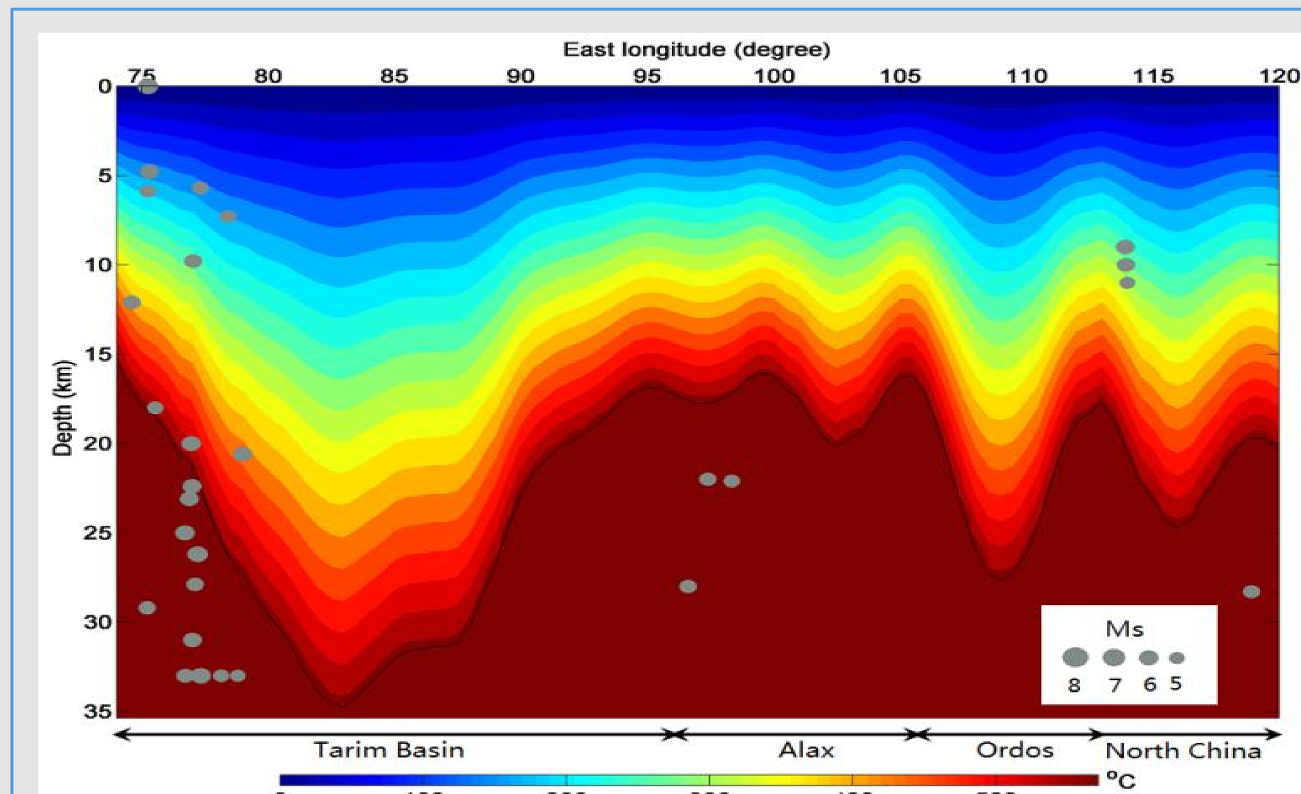
CPD inversion procedure (Left) and result (Right). Initial CPD is interpolated from Li et al. 2017. B_z is calculated from EMM2017.



Surficial heat flux (HF) calculated from CPD distribution by a simplified one-dimensional thermal conduction equation.
Left: theoretical HF for different thermal conduction coefficients and observed HF. Right: Comparison between HF and seismicity.



Distribution of seismicity and CPD. Left: background distribution of different CPDs. Right: seismicity distributions. As can be seen, most (88%) earthquakes occurred in areas with moderate CPD (10~30km), while few (12%) earthquakes occurred in areas with very shallow (<10km) or very deep (>30km) CPD.



Temperature profile (N40º) (above the Curie isotherm) calculated from CPD and seismicity distribution. Similar to the calculation of HF, T is calculated by:

$$T(z)=\frac{H_0\delta^2}{k}(1-e^{-z/\delta})+\frac{z}{Z_C}\left[T_C-\frac{H_0\delta^2}{k}(1-e^{-Z_C/\delta})\right]$$

Though earthquakes are few near the profile, it still indicates that earthquakes tend to occure in areas with high CPD variation gradients.

References:

. Li, C. F., Yu, L., Wang, J., 2017. A global reference model of Curie-point depths based on EMAG2. *Sci. Rep.* 7, 45129; doi: 10.1038/srep45129
. Lei, Y., Jiao, L. & Chen, H., 2018. *Earth Planets Space* 70: 179. https://doi.org/10.1186/s40623-018-0949-7

Acknowledgements

LG is funded by National Key R&D Program of the Ministry of Science and Technology of China with the Project "Integration Platform Construction for Joint Inversion and Interpretation of Integrated Geophysics (Grant No. 2018YFC0603502)" .