

Constructing Long-term Seismic Catalog with AI Phase Picker: Application in the Ridgecrest-Coso Region 2008-2019



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Abstract

The AI-pickers are considered as a substitute of matched filter. We designed a new AI-based detection and location workflow, which consists of Training, event Detection, and phase Picking (TDP). The workflow is applied to the Ridgecrest-Coso region, for both the long-term preseismic period (2008-2019) and the early aftershocks. We show that the TDP workflow realizes comparable detectability with that of matched filter, but is temporally consistent and has well-behaved magnitude distribution. It is also computationally efficient, thus suitable for long-term applications. We make a specific analysis for the Coso geothermal field (CGF). We find that the microseismicity of CGF is shallow and generate high b-value. The temporal variation of b-value is also resolved, which shows high fluctuation that seems to correlate with that of seismicity rate. However, the geothermal production data does not correlate with them.

1. Tectonic Background and AI Workflow

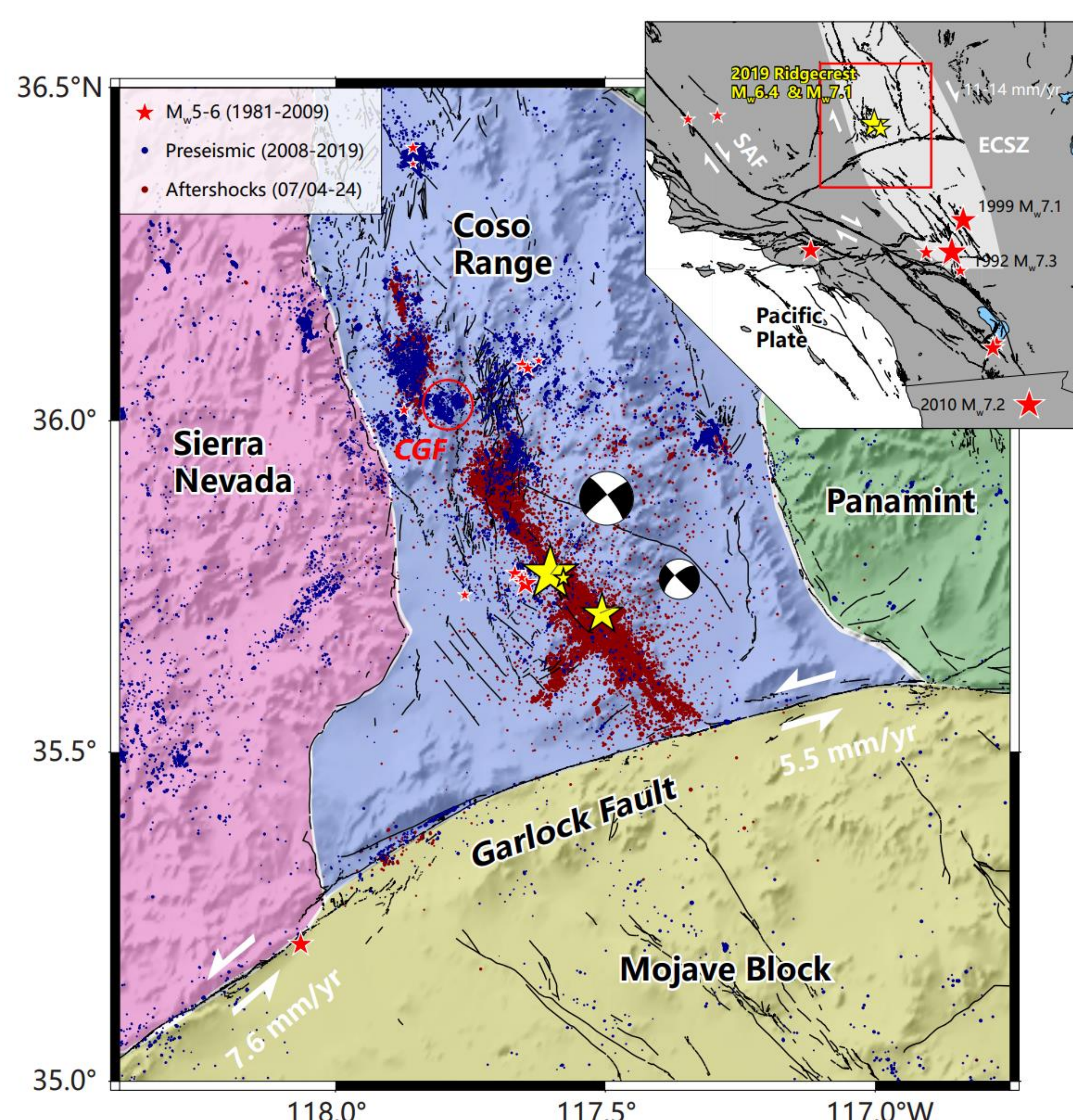


Figure 1: Tectonic background of the Ridgecrest-Coso region. The color patches highlight the litho-tectonic blocks. The dark blue and red dots plot the microseismicity before and after the 2019 Ridgecrest earthquake. The red stars mark the M_w 5-6 earthquakes during 1981-2009, and that in the inset marks the $M_w > 6$ events. The red circle plot the Coso geothermal field (CGF).

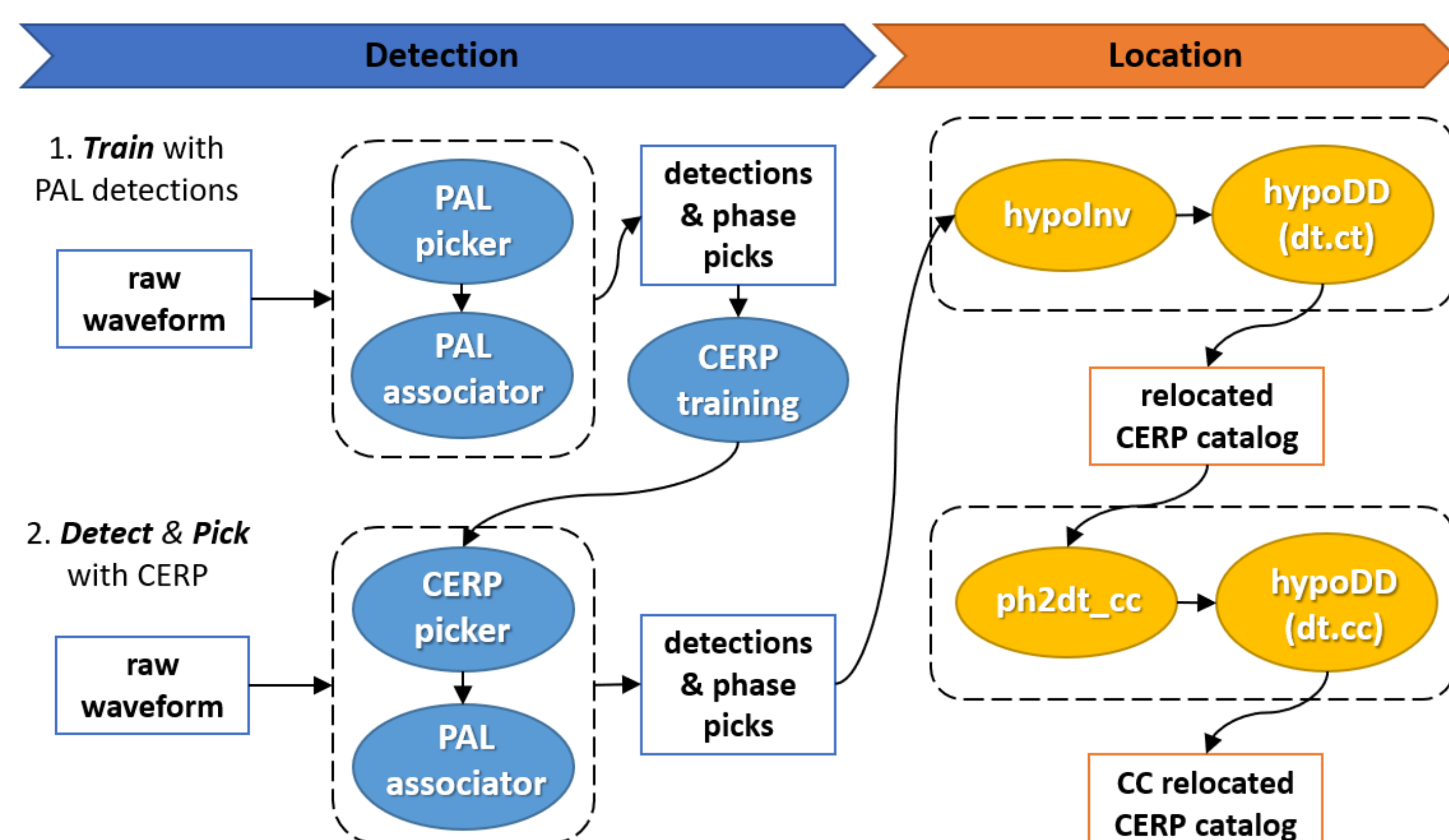


Figure 2: AI detection and location workflow. The blue and orange patches denote the detection and location modules. The rectangles and ellipses plot the i/o data and operations, respectively. PAL is a rule-based workflow (Zhou et al., 2021) and CERP is a hybrid AI model for event detection and phase picking (Zhou et al., 2019).

2. Detection Results: Aftershocks and Preseismic

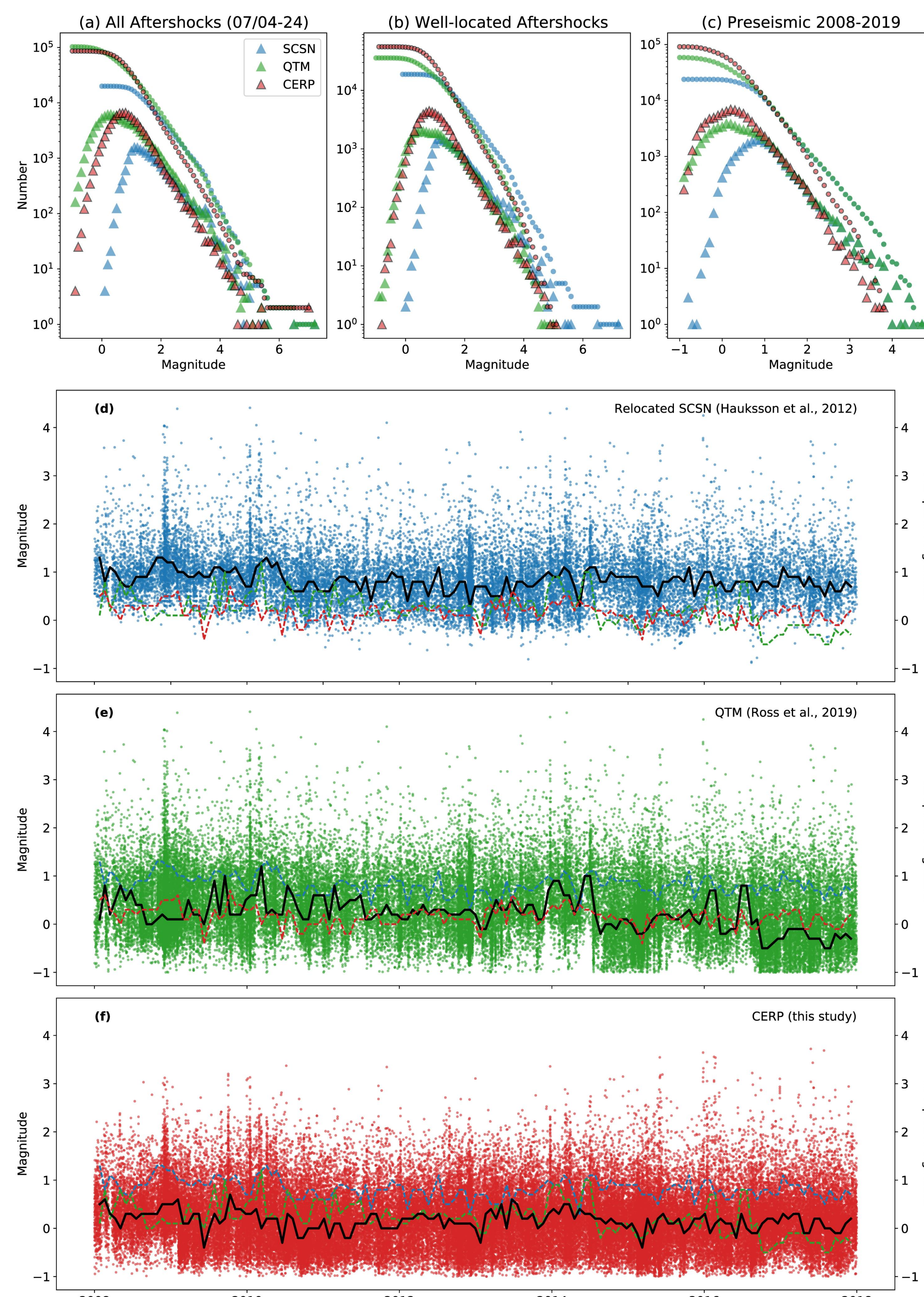


Figure 3: Detection results for aftershocks and preseismic period. (a-c) plot the comparison of frequency-magnitude distribution (FMD) for the early aftershocks, well-located aftershocks, and preseismic, respectively. (d-f) plot the magnitude-time sequence and the complete magnitude (M_c) variation with time. The solid black line denote the M_c for the current subplot, and dashed lines denote that of other catalogs.

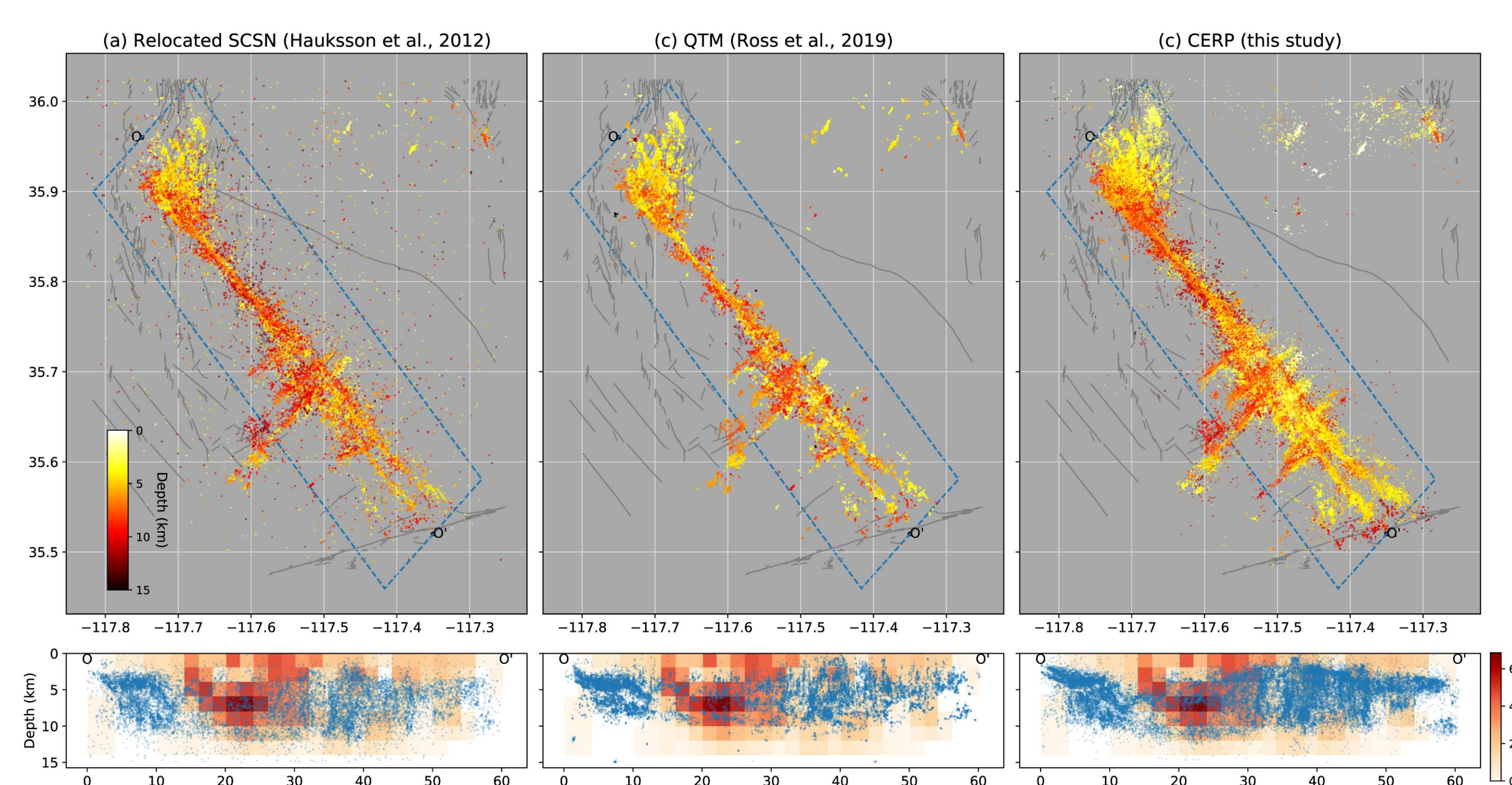


Figure 4: Comparison of aftershock catalogs. The first line plot the map-view distribution, with the focal depth color-coded. The second line plot the along-strike cross-section. The background red shading denote the coseismic rupture from Yue et al. (EPSL, 2021).

3. b-value Analysis in Coso Geothermal Field

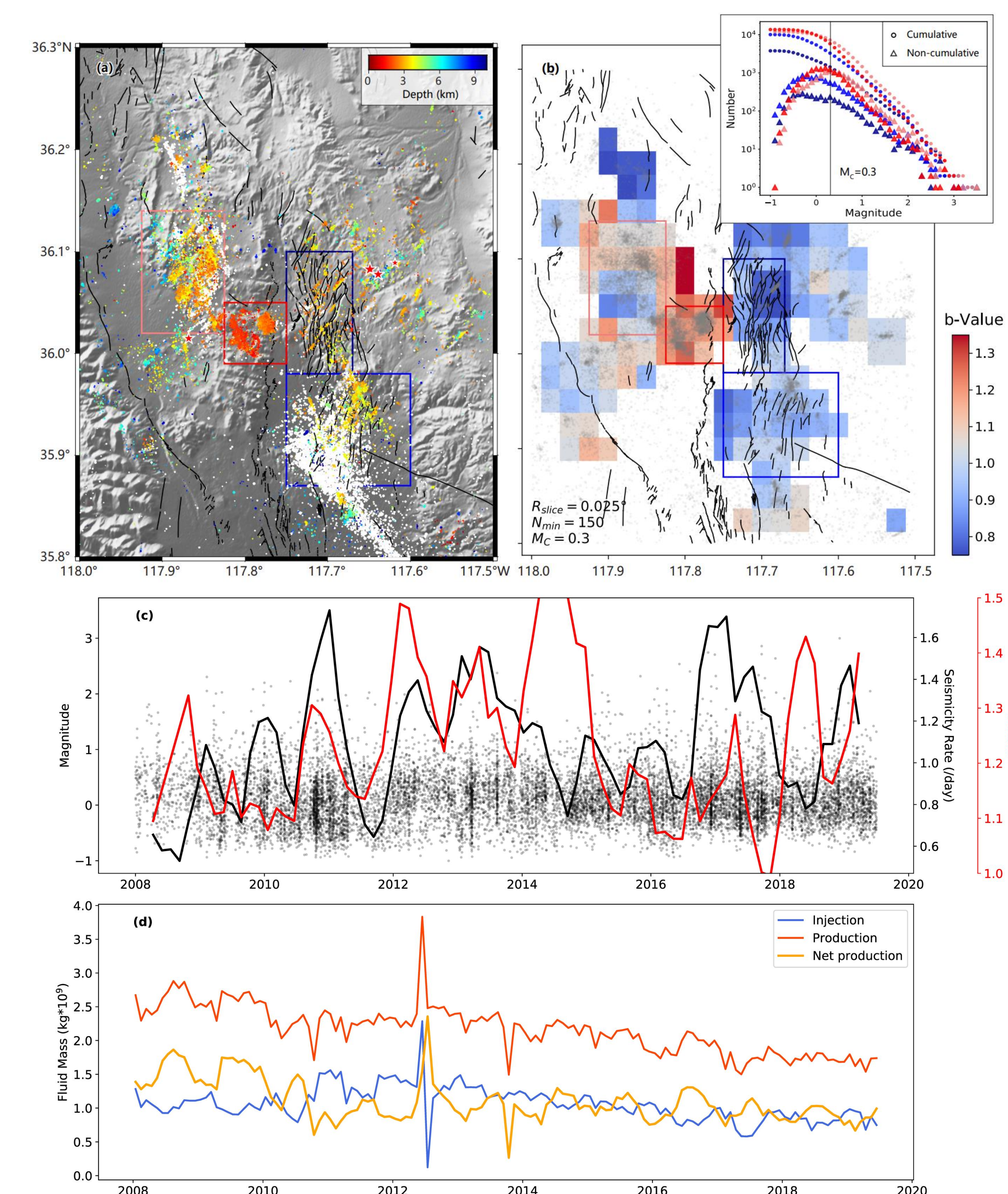


Figure 5: (a) distribution of microseismicity, with the focal depth color-coded. (b) the b-value mapping. The inset shows the FMD of four typical area. (c) Correlation of seismicity rate and b-value for the CGF region (red rectangle in a-b). (d) The geothermal production data.

Summary

The TDP-style AI workflow realizes high and temporally consistent detection performance. As shown in both aftershocks and preseismic period, the detectability is comparable to that of matched filter, but with much higher computational efficiency. The resulting FMD is well-behaved, agreeing with G-R law, thus provide reliable basis for b-value calculation. We show that Coso field generate shallow seismicity of high b-value, which indicate a relatively low stress level. The seismicity rate of Coso is overall constant during 2008-2019, while multiple bursts exist, correlating with the b-value variation.

References

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