

# High-Resolution Seismicity Imaging and Early Aftershock Migration of the 2023 Kahramanmaraş (SE Türkiye) $M_w$ 7.9 & 7.8 Earthquake Doublet



Yijian Zhou<sup>1</sup>, Hongyang Ding<sup>2</sup>, Abhijit Ghosh<sup>1</sup>, Zengxi Ge<sup>2</sup>, and Xiaodong Song<sup>2</sup>

<sup>1</sup>Department of Earth and Planetary Sciences, University of California, Riverside

<sup>2</sup>Institute of Theoretical and Applied Geophysics, Peking University, China

Contact info: [yijian.zhou@email.ucr.edu](mailto:yijian.zhou@email.ucr.edu)

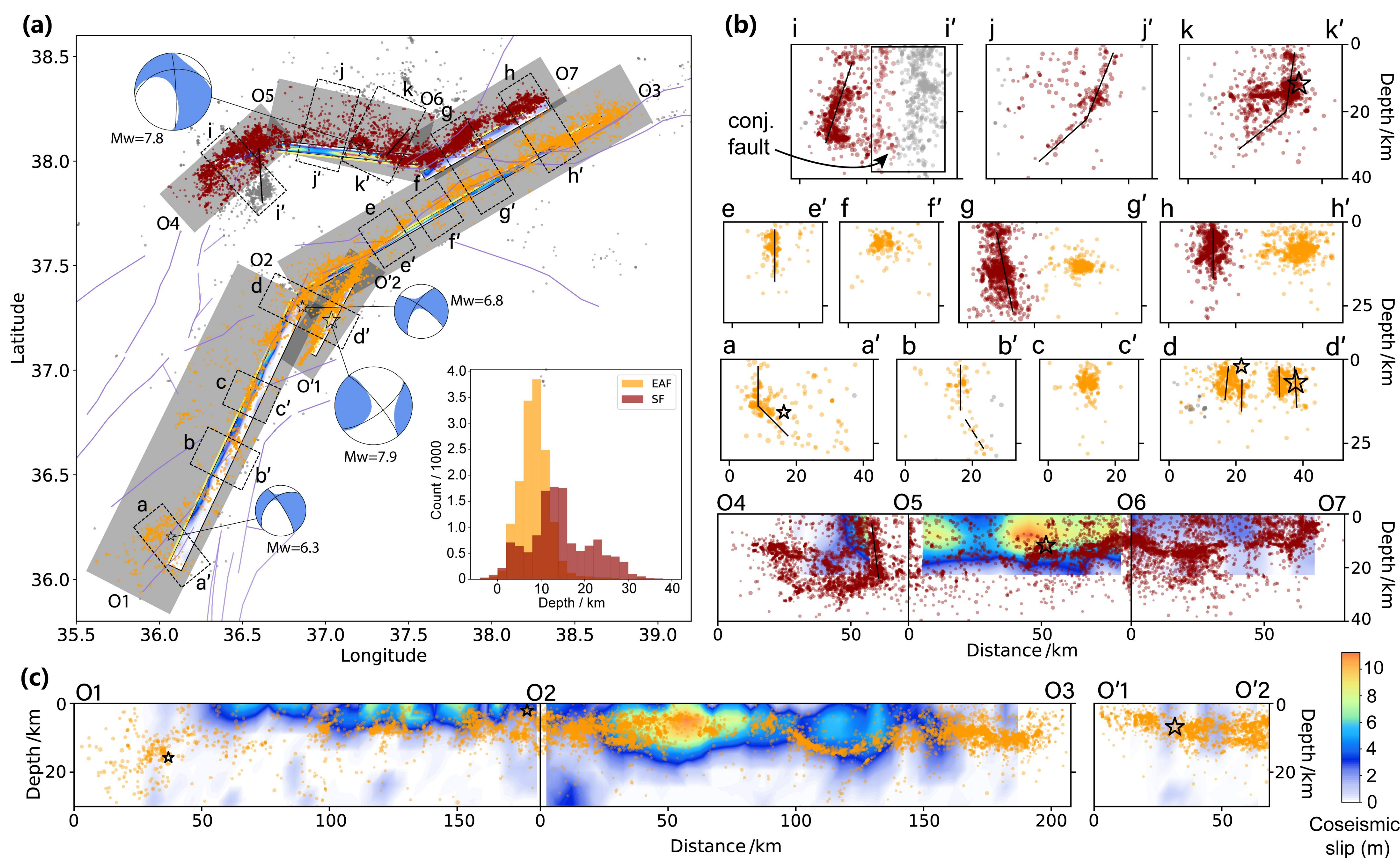


## Abstract

We build a high-resolution early aftershock catalog for the 2023 SE Türkiye seismic sequence with PALM, a seamless workflow that sequentially performs phase Picking, Association, Location, and Matched filter for continuous data. The catalog contains 29,519 well-located events in the two mainshocks rupture region during 2023/02/01-2023/02/28, which significantly improves the detection completeness and relocation precision compared to the public routine catalog. Employing the new PALM catalog, we analyze the structure of the seismogenic fault system. We find that the Eastern Anatolian Fault (EAF) that generated the first  $M_w$  7.9 mainshock is overall near-vertical, whereas complexities are revealed in a small-scale, such as subparallel subfaults, unmapped branches, and stepovers. The seismicity on EAF is shallow (<15 km) and concentrated in depth distribution, indicating a clear lock-creep transition. In contrast, the Sürgü Fault (SF) that is responsible for the second  $M_w$  7.8 mainshock is shovel-shaped for the nucleation segment and has overall low dip angles (~40-80°). Aftershocks on the SF distribute in a broad range of depth, extending down to ~35 km. We also analyze the temporal behavior of seismicity, discovering no immediate foreshocks within ~5 days preceding the first mainshock, and no seismic activity on the SF before the second mainshock.

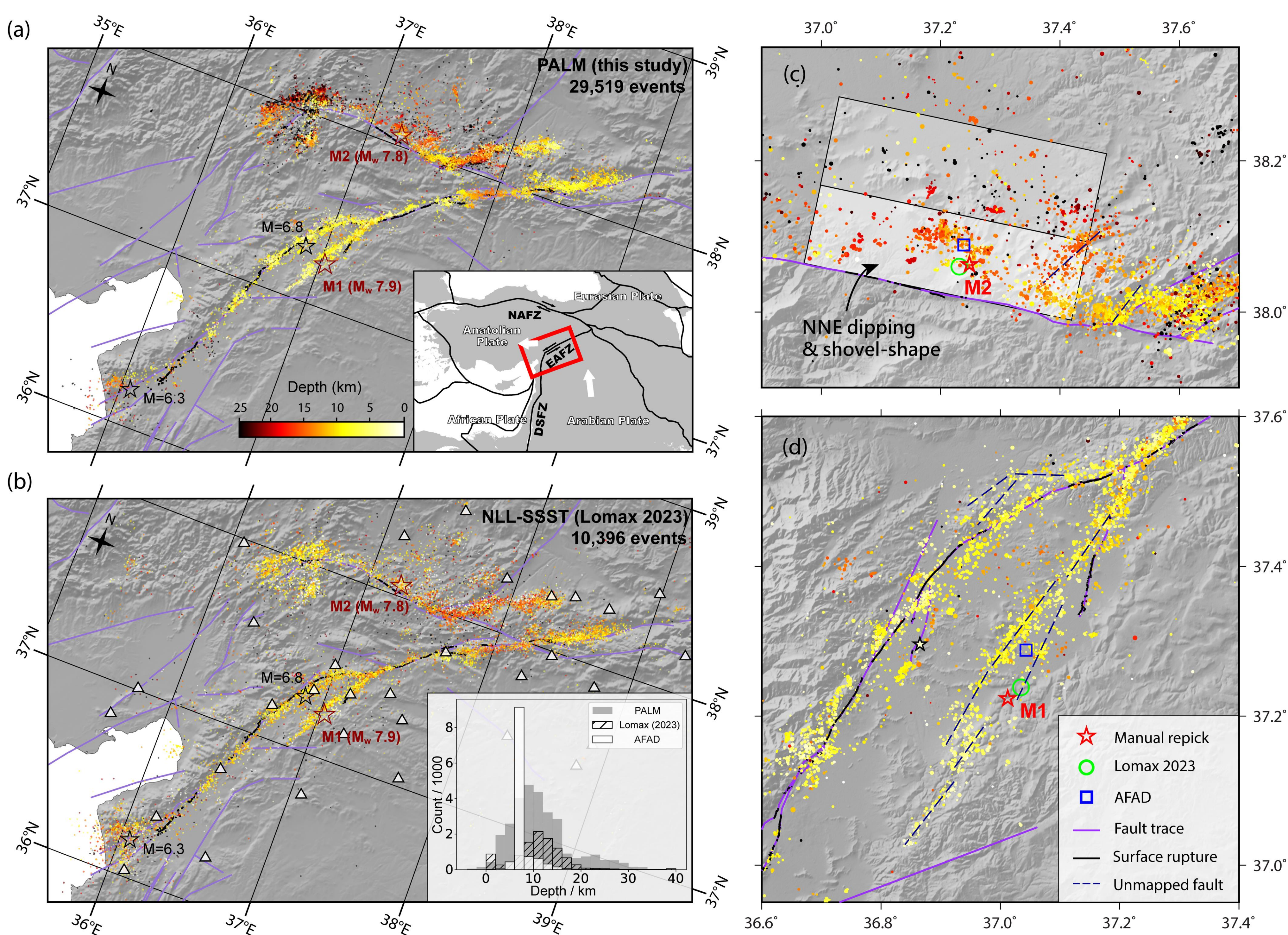
## References

Ding, H., Y. Zhou, Z. Ge, T. Taymaz, A. Ghosh, ... & X. Song (2023). High-Resolution Seismicity Imaging and Early Aftershocks Migration of the 2023 Kahramanmaraş (SE Türkiye)  $M_w$  7.9 & 7.8 Earthquake Doublet. *Earthquake Science*; doi: 10.1016/j.eqs.2023.06.002

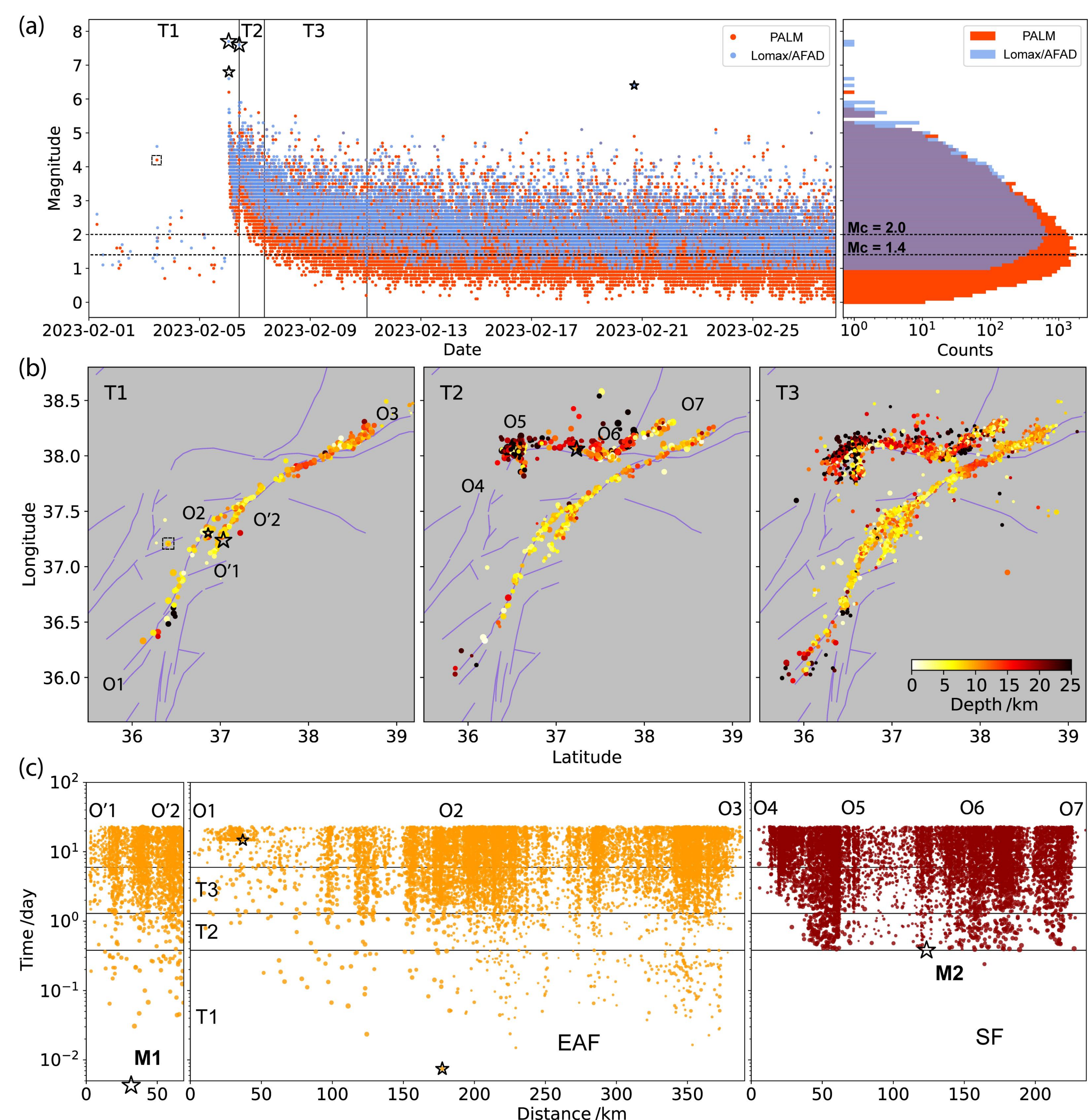


**Figure 2. Aftershock Distribution and Fault Structure Interpretation.**

(a) Map-view of aftershocks using the PALM method with dot size indicating magnitude. Orange and crimson dots from filled regions are projected onto a gray rectangle aligning with the EAF and SF for along-fault profiles. Dots within dashed rectangles are used for normal-fault profiles. Events outside filled rectangles are in gray. Black stars mark  $M > 6$  event epicenters, projected similarly to dots. The colored rectangle is the surface projection of the USGS-NEIC finite fault model, and solid purple lines are consistent with Figure 1. Focal mechanisms for  $M > 6$  events are from GCMT. An inset in (a) displays event depth distribution along SF and EAF. (b) Top panels: normal-fault profiles from (a) with lines denoting inferred fault dip. Lower panel of (b) and (c): along-fault profiles for SF and EAF, including projections of the USGS-NEIC finite fault model for major shocks. Dot colors in (b-c) match those in (a).



**Figure 1. Cataloging Results Comparison.** (a-b) Show aftershock distributions from PALM and Lomax (2023). Dots represent events, with color indicating depth and size reflecting magnitude. Inset in (a) offers a tectonic overview, highlighting the study area in red. Plate-boundary faults are labeled: EAF (Eastern Anatolian Fault), NAF (Northern Anatolian Fault), and DSF (Dead Sea Fault). Inset in (b) depicts depth distribution for PALM, Lomax (2023), and AFAD catalogs. (c-d) Provide a detailed look at the PALM catalog surrounding the mainshocks. Epicenter symbols: this study (red star), Lomax (2023, green circle), and AFAD (blue rectangle). Solid purple lines represent GEM fault traces; black lines show USGS-documented surface ruptures. Dashed lines in (c) hint at interpreted unmapped faults. Transparent boxes in (c) depict varying dip angles of fault planes.



**Figure 3. Temporal Behavior of Aftershocks.**

(a) Left panel displays magnitude-time sequences for PALM (red dots) and AFAD (blue dots) catalogs.  $M > 6$  events are denoted by black stars. Vertical lines indicate time periods: T1 (from 1st February 2023 to M2), T2 (from M2 to ~30 hours post-M1), and T3 (ending 4 days post-M1). An event in the dashed rectangle during T1 is detailed in (b). The right panel illustrates frequency-magnitude distribution for PALM and AFAD. Horizontal histograms show non-cumulative counts for 0.1-binned events. Dashed horizontal lines represent MC for Lomax/AFAD (top) and PALM (bottom). (b) Map-view of PALM catalog events during T1, T2, and T3. Events are depicted as in Figure 1a. Endpoints of along-fault profiles from Figure 2a are highlighted. Solid purple lines remain consistent with Figure 1a. (c) Charts seismicity's temporal evolution along the EAF and SF profiles from Figure 2a. Time, starting from M1's origin, and distance, measured along the filled rectangles' southeast longer side in Figure 2a, are plotted. Time uses a logarithmic scale. Dot color convention follows Figure 2a. Horizontal lines indicate the same time separations as in (a).