A Comprehensive Earthquake Focal Mechanism Catalog for Nevada Obtained Through Deep Learning Algorithms

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Group B
Poster 066

1. Abstract

The state of Nevada ranks among the most seismically active regions in the United States, characterized by numerous active fault systems throughout the Walker Lane and Basin and Range tectonic areas. Despite the high seismic activity rates, Nevada currently lacks a comprehensive catalog of earthquake focal mechanisms that could enhance our understanding of seismotectonic processes.

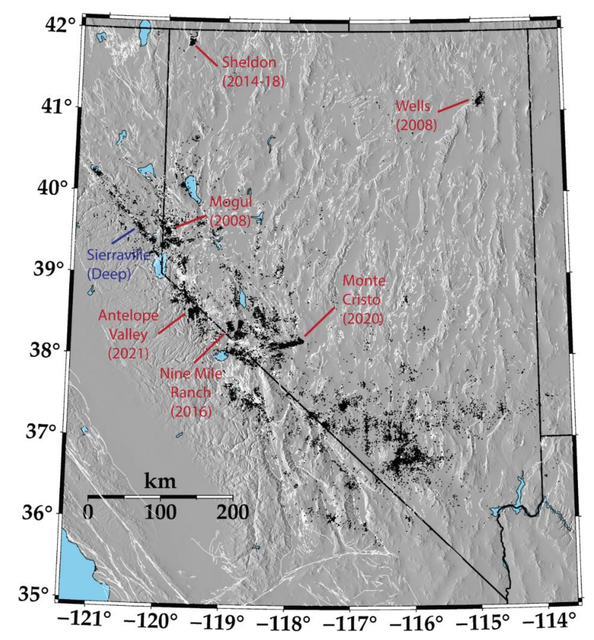

Figure 1: Map of relocated seismicity plotted as black dots with major and more recent earthquake sequences labeled in red. *Trugman (2024)*

2. Introduction

We enhance the NSL's first-motion polarity database with additional measurements using a convolutional neural network. We also incorporate new S/P amplitude ratio measurements to provide further constraints on event mechanisms.

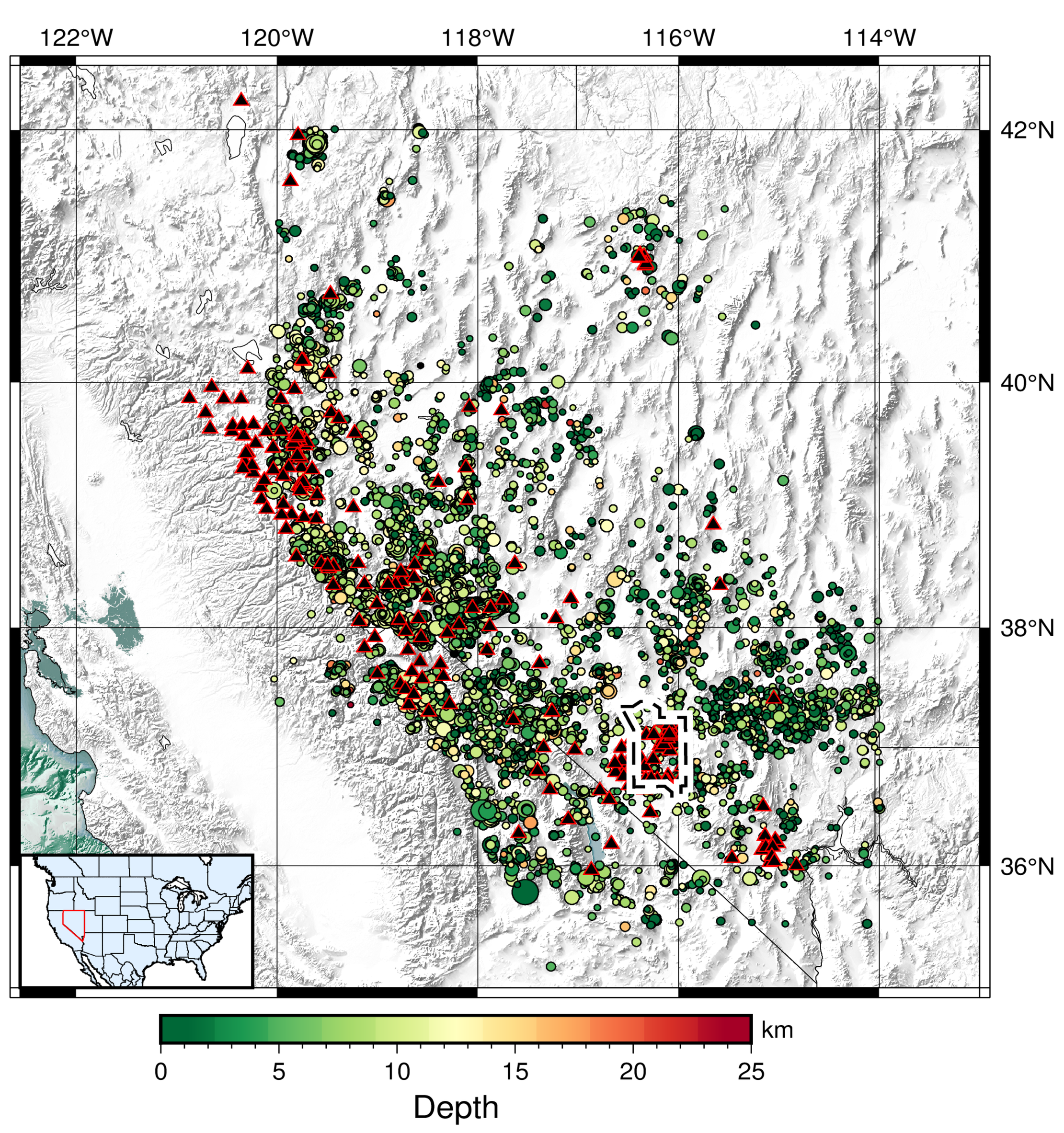

Figure 2: Distribution of 61512 unique earthquakes along with recording stations in the region. Focal mechanisms have been computed for all these events. The outline of the NNSS is represented by a dashed line in the plot.

Data

- 61512 earthquakes with $M_L \geq 1.5$ occurring between *2008* and *2023*.

Methods

- Computing focal mechanisms:
  1. Deep-learning-based method for determination of first-motion polarities.
  2. Measure S/P Amplitude Ratios.
- Determining earthquake focal mechanisms from P-wave first-motion polarities and S/P ratios using SKHASH. (Skoumal et. al, 2024)
- 2 velocity models; Trugman, et.al (2023) for Northern Nevada, Preston, et.al (2018) for Southern Nevada.

3. Deep Learning Model

- Dataset: Trained on Nevada and Southern California data, ~900k recordings with analyst picked polarities.(Up, down and unknown.)
- Trained as a regression model instead of a classification model.
- Output: Probability of Down.

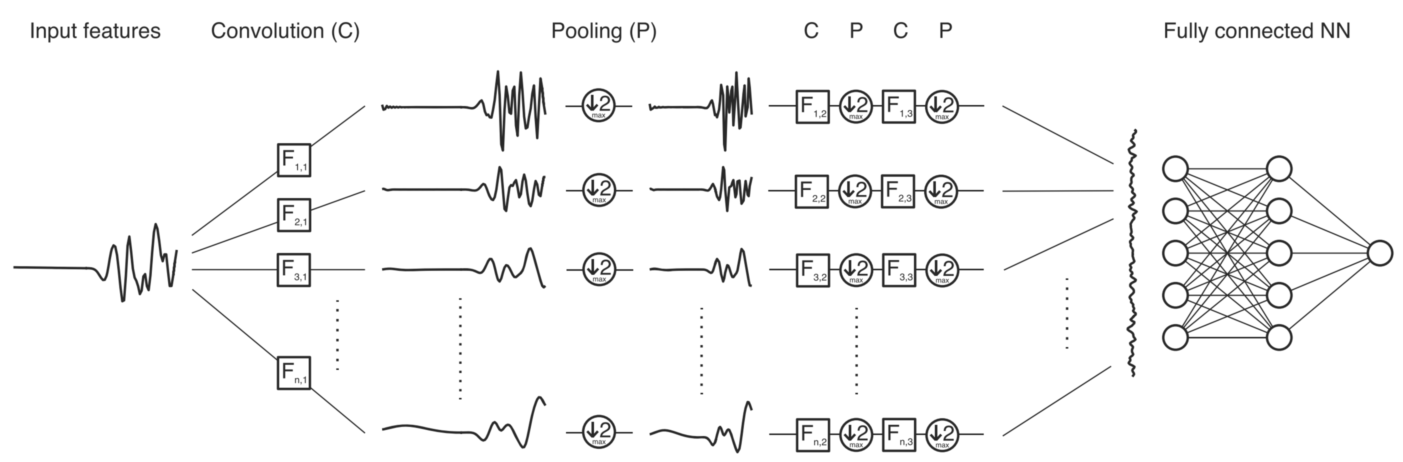

Figure 3: Convolutional Neural Network architecture was adopted from Ross et.al (2018), with some modifications. The modification included using a kernel regularizer in the output layer.

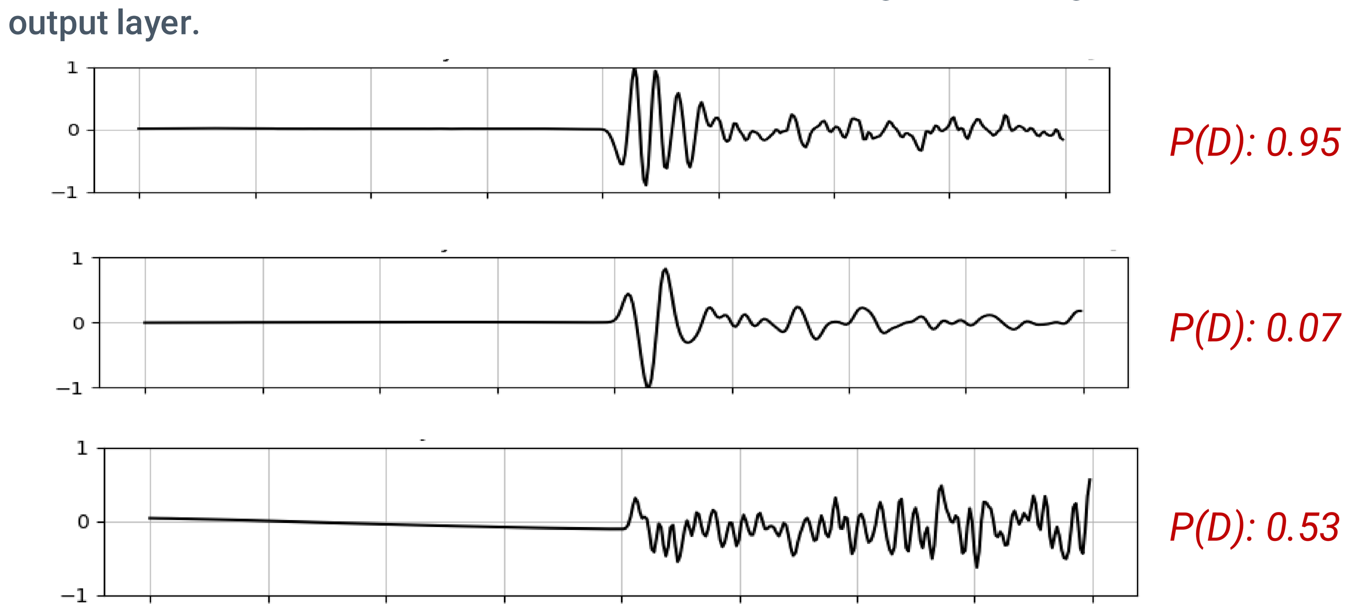

Figure 4: The model computes the probability of the polarity being down. For values where $0 \leq P(D) \leq 0.3$, the polarity is up and polarity is down when $0.7 \leq P(D) \leq 1.0$. All other values are considered as 'Unknowns'.

4. S/P Amplitude Ratios

- Provide important additional information to constrain the focal mechanism besides polarities.
- Using both polarities and S/P ratios provides more accurate earthquake focal mechanisms than only using polarities.

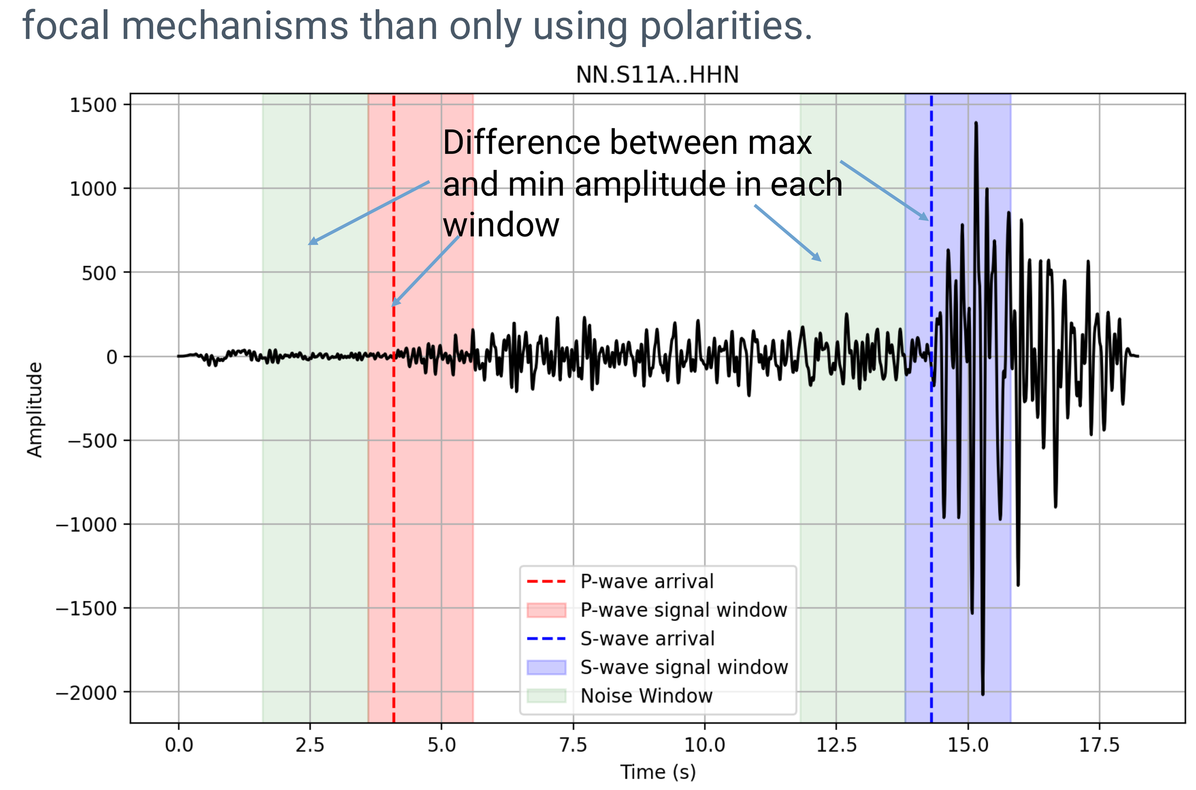

Figure 5: Calculate S/P signal and S/P noise ratio by computing the difference in maximum and minimum amplitude for P and S waves in 2-second noise windows (0.5s before each arrival) and signal windows (starting 0.5s before each arrival, ending 1.5s after).

5. Focal Mechanism: Examples

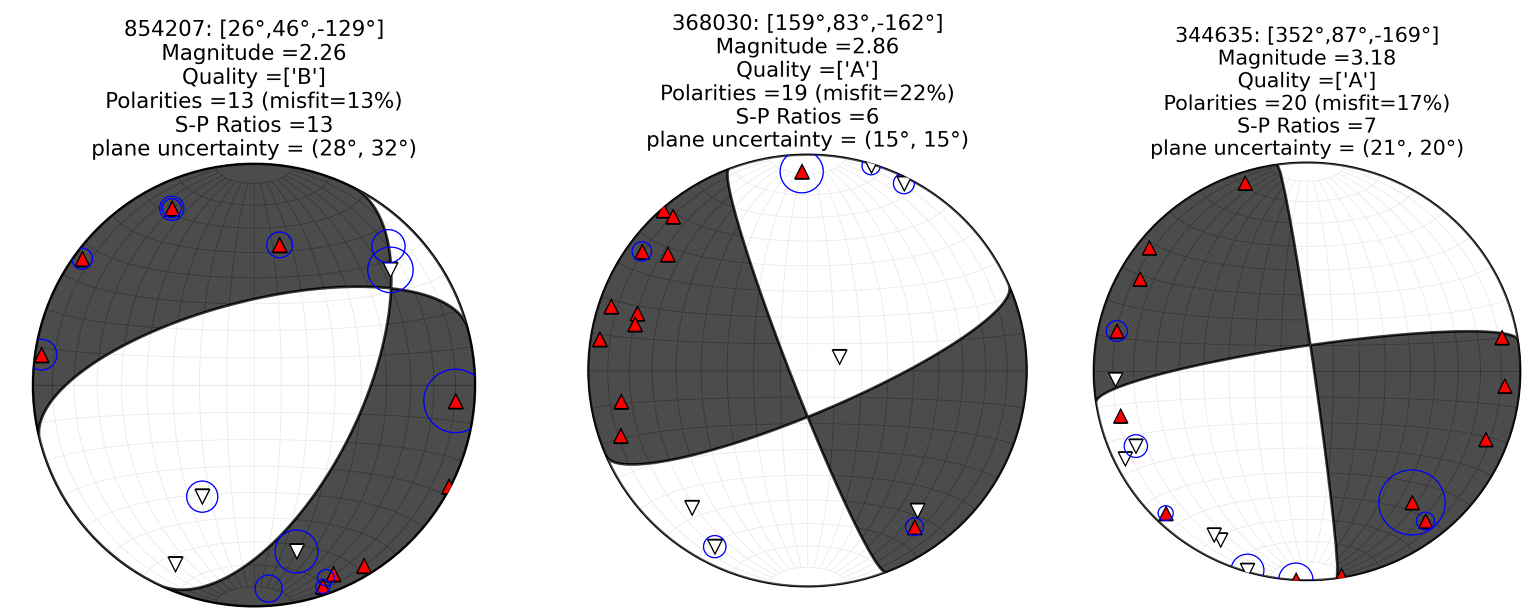

Figure 6: SKHASH evaluates focal mechanism quality based on criteria such as polarity and S/P ratio misfits, RMS fault plane uncertainty, station distribution ratio, and mechanism probabilities. Ratings range from 'A' (highest quality) to 'F' (lowest quality).

6. Discussion

- Large earthquake catalogue with analyst picked polarities, P-wave arrivals and S-wave arrivals from NSL's database.
- High quality focal mechanism solutions for ~10000 events that occurred from 2010 to 2023. A: 1019; B: 2187; C: 6329
- Polarity reversals need a closer look.
- Implementing in real-time.

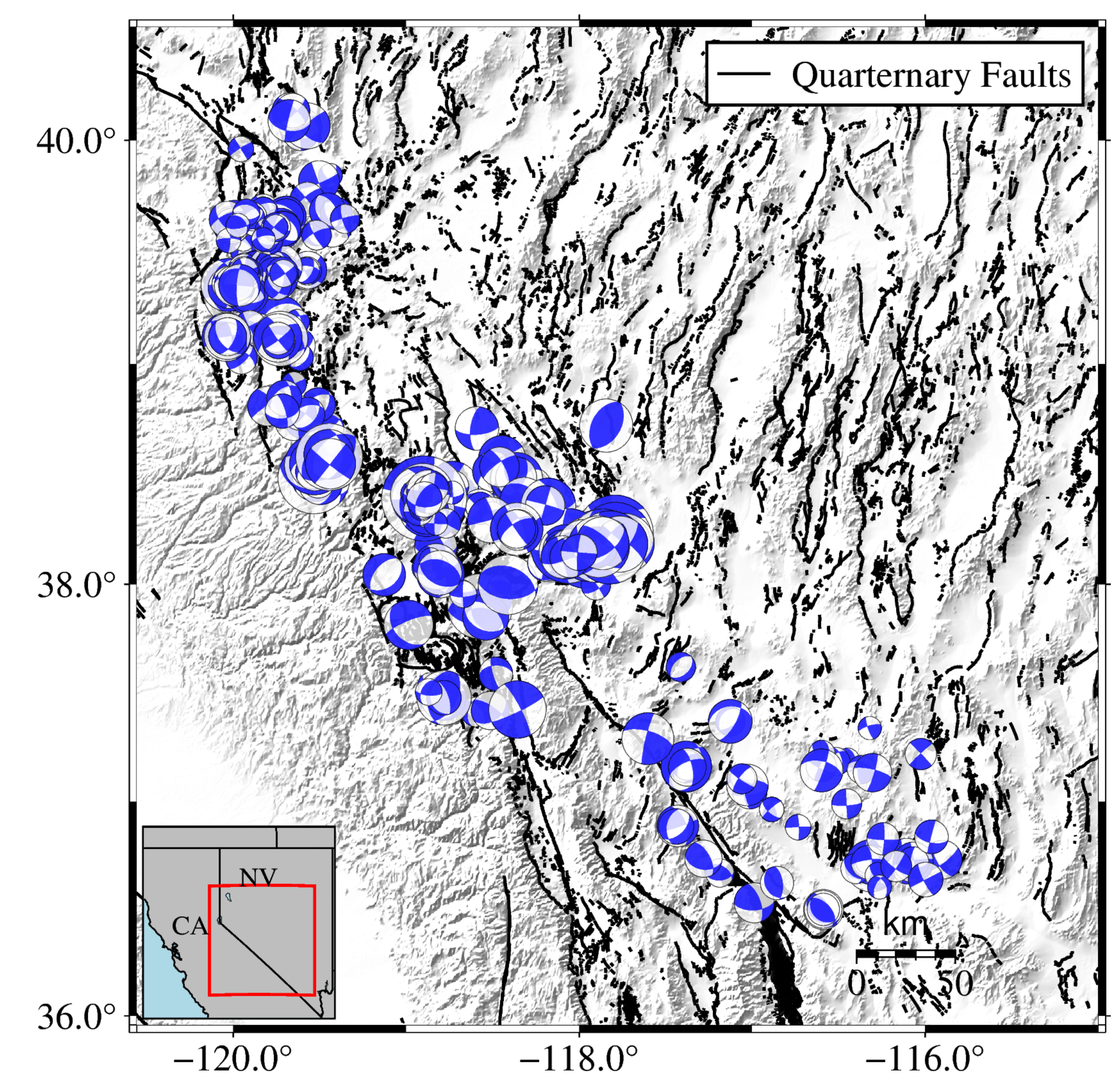

Figure 7: Map here shows the spatial distribution of high-quality focal mechanisms retrieved through our workflow.

7. References

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