A Refined Comprehensive Earthquake Focal Mechanism Catalog for Southern California Derived with Deep Learning Algorithms

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**Abstract**

Earthquake focal mechanisms are primary data for analyzing fault zone geometry, sense of slip, and the crustal stress field. Solving for the focal mechanisms of small earthquakes is challenging because phase arrivals and first-motions are hard to separate from noise. To overcome this challenge, we implement CNN algorithms (Ross et al., 2018a, b) to detect additional phases and polarities for the focal mechanism calculations. Using both existing and these new data we build a high-quality focal mechanism catalog for 696,568 events that occurred from 1981 to 2019 in southern California with the HASH method of Hardebeck and Shearer (2002, 2003). The new focal mechanism catalog is overall consistent with the standard catalog (Yang et al., 2012) but with 42% more solutions and is more consistent with the moment tensor solutions derived using waveform-fitting methods. The new catalog makes it possible to identify a strong stress rotation in the Sierra Cucapah after the 2010 \(M_{w}7.2\) El Mayor Cucapah earthquake, a significant positive correlation between the net production rate and the percentage of reverse faulting events in the Salton Sea Geothermal Field, as well as more near-vertical active faults near the southern San Andreas fault zone. Furthermore, the high-resolution catalog will contribute to future detailed studies of the crustal stress field, earthquake triggering mechanisms, and fault zone geometry and sense of slip in southern California.

**Workflow**

- **Input S/P amplitude ratio**
  - Catalog arrivals (Broad band channels)
  - Catalog arrivals (short-period channels)
  - Additional CNN arrivals (all 3 component channels)
- **Input P-wave polarity**
  - Catalog polarities
  - Additional CNN polarities (\(M < 2.0\) events)
- **Output Focal mechanism**
  - Catalog positive polarity
  - Catalog negative polarity
  - Additional positive polarity
  - Additional negative polarity
  - Catalog S/P ratio
  - Additional S/P ratios
  - Catalog focal mechanism
  - Additional focal mechanisms

**Quality improvements**

- **Common quality A,B,C,D mechanisms**
- **Common quality A&B mechanisms**
- **Common quality A,C,D mechanisms**
- **Common quality B,C,D mechanisms**

**New discoveries**

- **Figure 3. Comparison with the standard catalog (YHS catalog)**
- **Figure 4. Comparisons of the moment tensor catalogs with the YHS catalog and the CNN_SoCal catalog**
- **Figure 5. Comparison of focal mechanisms of similar earthquakes.** The P (red circles), T (green circles) and B axes (black circles) of available focal mechanisms for the 64 events similar to the reference event in the Calabria Valley Pluton (Figure 5e).

**References**


