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Improving Southern California Earthquake Locations and Focal Mechanisms

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Introduction

We have made considerable progress during the last year on this project to develop and implement improved methods for computing earthquake locations and focal mechanisms in southern California. Our goals may be summarized as follows:

- Use source-specific station term (SSST) and waveform cross-correlation techniques to image seismicity using high-precision location techniques.
- Develop more robust methods for computing focal mechanisms for small events and apply them systematically to SCSN/TriNet data.
- Identify seismicity planes in similar event clusters to resolve the fault plane ambiguities in focal mechanism data.

Our SCEC funding was mainly been used for support of postdoc Jeanne Hardebeck (now gone) and graduate student Guoqing Lin. Please note that results from a related project, a joint UCSD/Caltech project to systematically apply waveform cross-correlation to southern California seismograms, are described in a separate report.

Focal Mechanisms

We have released a new method for computing local earthquake focal mechanisms, based on the approach described in *Hardebeck and Shearer* (2002, 2003). Our package is called HASH and is available to the community at:

http://quake.usgs.gov/research/software/index.html#HASH

HASH is a Fortran 77 code that computes double-couple earthquake focal mechanisms from P-wave first motion polarity observations, and optionally S/P amplitude ratios. HASH is designed to produce stable high-quality focal mechanisms, and tests the solution sensitivity to possible errors in the first-motion input and the computed take-off angles. Examples are provided for data in FPFIT input format. The code is designed to be as input-format independent as possible, so only minor editing is needed to use data in other formats. Figure 1 shows an example of the improvement in focal mechanism consistency achieved with our method compared to the classic FPFIT program.

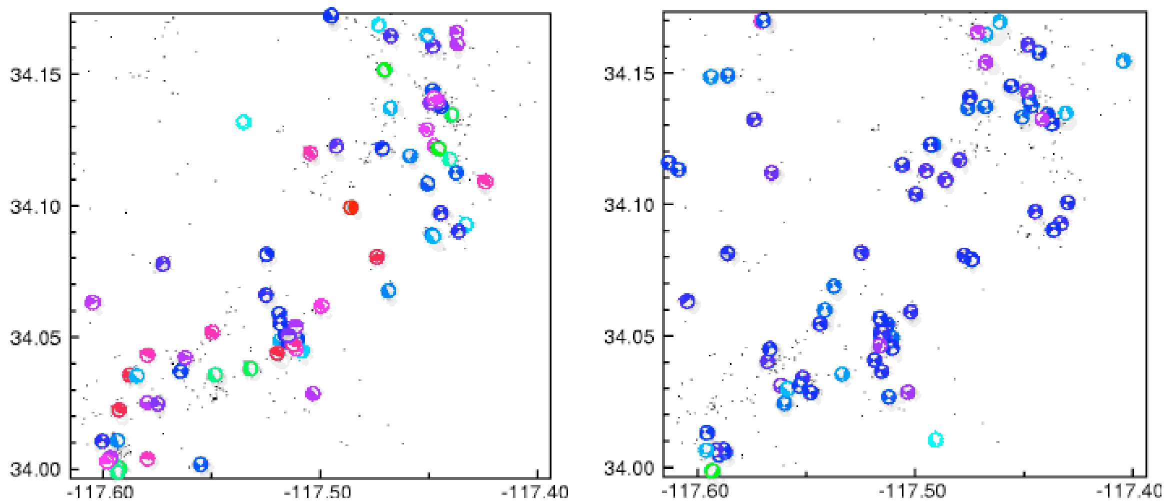

Figure 1. A comparison between focal mechanisms computed, (left), using FPFIT (*Reasenberg and Oppenheimer*, 1985) and, (right), using the method of *Hardebeck and Shearer* (2001). The map view shows focal spheres for events southwest of the junction of the San Jacinto and Cucamonga faults. The methods use the same event locations and polarity data; we plot only those solutions with relatively small estimated errors. Mechanisms are color-coded by faulting style: red for thrust, blue for strike-slip, and green for normal faulting. Note the greater spatial coherence in the Hardebeck and Shearer mechanisms.

Locations

We obtain precise relative locations for over 340,000 southern California earthquakes between 1984 and 2002 by applying the source-specific station term (SSST) method to existing P and S phase picks and a differential location method to over 200,000 events within similar event clusters identified using waveform cross-correlation. (The waveform cross-correlation itself was performed in a joint Caltech/UCSD project that received separate SCEC funding and is described in a different report.) We first relocated the entire catalog using existing phase picks and the SSST method of Richards-*Dinger and Shearer* (2000). Next, we apply cluster analysis to the waveform cross-correlation output in order to identify similar event clusters. Because we do not compute cross-correlation between all possible event pairs, some modifications to standard cluster analysis algorithms were necessary to achieve a suitable method. In particular, the clustering parameters must be carefully chosen to avoid occasional false links between event pairs to cause separate clusters to merge into one large cluster.

We relocate earthquakes within each similar event cluster using the differential times alone, keeping the cluster centroid fixed to its initial SSST location (e.g., *Shearer*, 1998, 2002; *Shearer et al*., 2003). We estimate standard errors for the relative locations from the internal consistency of differential locations between individual event pairs; these errors are often as small as tens of meters. In many cases the relocated events within each similar event cluster align in planar features suggestive of faults.

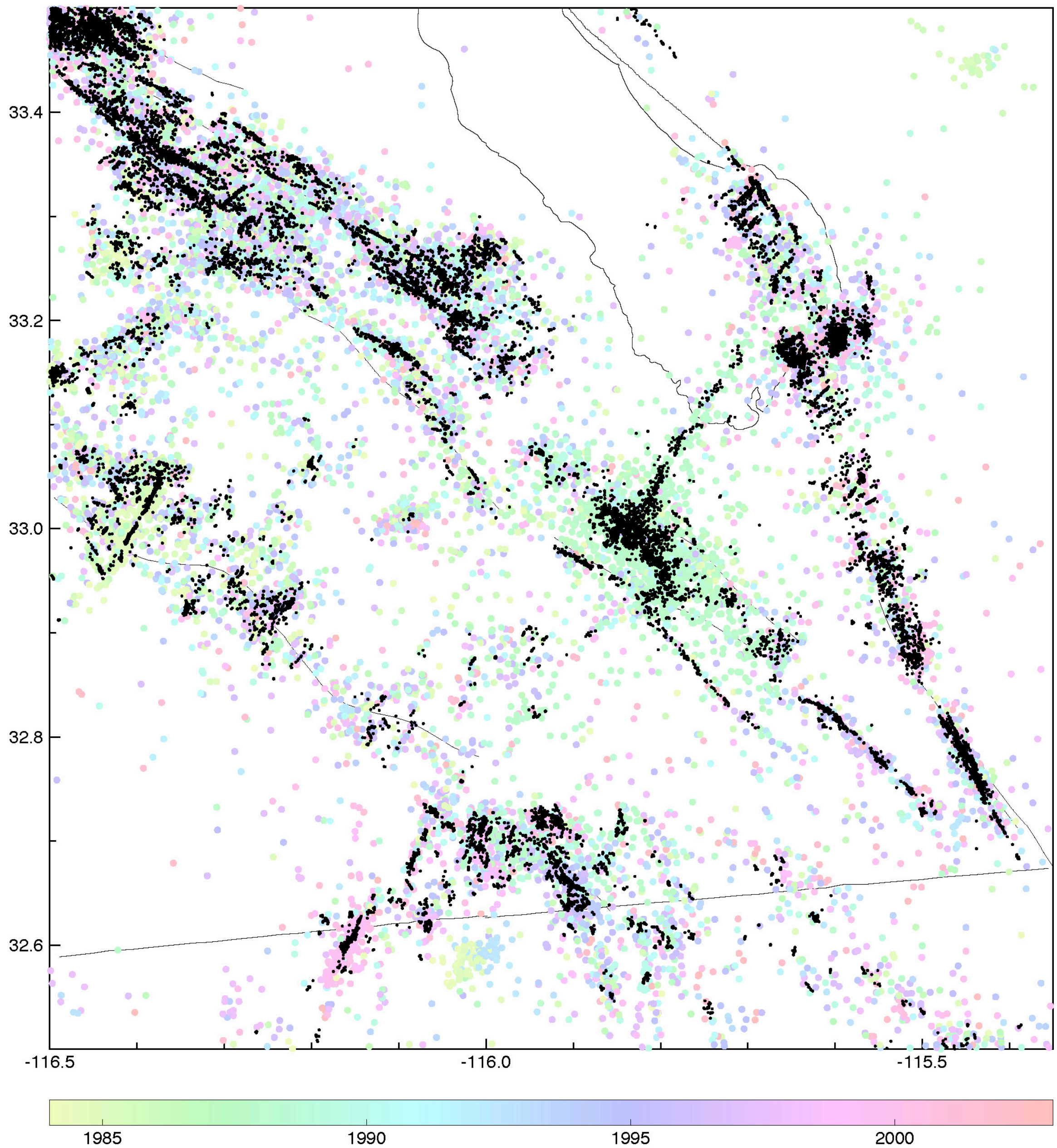

Figure 2. Relocated seismicity in southeastern California, showing numerous northeast striking conjugate faults. These are particularly dramatic in the Brawley seismic zone, which trends south-southeast from the eastern side of the Salton Sea. Also note the enormous complexity of the San Jacinto fault zone to the west of the Salton Sea. Events within similar event clusters were relocated using waveform cross-correlation and are shown in black. Other events, shown colored by year of occurrence, were relocated using the SSST method on phase pick data only.

We observe a surprising number of conjugate faults at small scales that strike nearly perpendicular to the main seismicity trends. In general, the fine-scale details of the seismicity reveal a great deal of structural complexity in southern California fault systems. Some examples of this complexity are shown in Figures 2 and 3, including a striking series of parallel east-northeast trending faults in the Brawley seismic zone. We presented a preliminary version of these locations at the SCEC annual meeting in

September; these locations are currently available in several forms at the SIO Visualization Center (http://www.siovizcenter.ucsd.edu/library/objects/index.html). We will present a more refined version of the locations at the Fall 2003 AGU meeting and we plan to post version 1.0 of our catalog on the SCEC website by the end of the year.

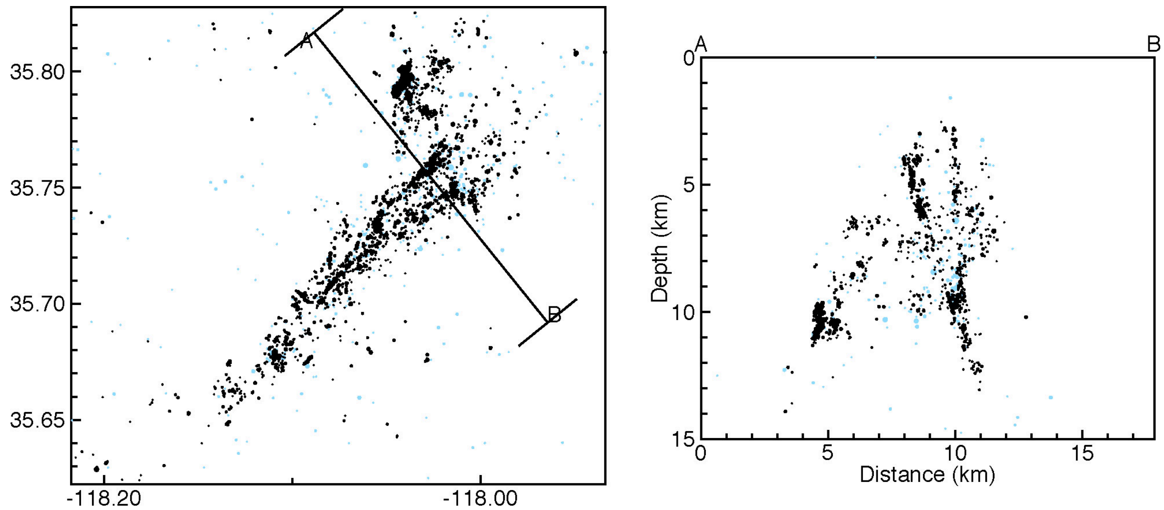

Figure 3. The "Wedge" is a striking seismicity feature in the southernmost Sierra Nevada that contains two faults that form a sharp angle. Most of these events are within similar event clusters and were relocated using waveform cross-correlation; those that are not are shown in light blue and were relocated using phase pick data alone.

References

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