Final Report for SCEC3 projects
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With support from SCEC, a number of important results were developed during SCEC3. These results relate to important SCEC products, such as hazard maps, and to broader scientific investigations of earthquakes relevant to the SCEC mission. Some selected highlights of results include:

- Developed new magnitude-area scaling relation based on constant stress drop scaling *Shaw* [2009]. This scaling law is being used as a branch in the new UCERF3 hazard maps.

- Developed new methodology for using slip-length scaling laws in seismic hazard estimates, and incorporating geologically observable surface slip data into hazard estimates [*Shaw*, 2012]. Previous standard methodologies overlooked this data. This new approach is being used in the new UCERF3 hazard maps.

- Developed new slip-length scaling relation based on constant stress drop scaling. This provides a geometrical explanation for a longstanding puzzle of the large crossover length-scales associated with saturation of slip at large aspect ratio earthquakes [*Shaw*, 2012]. The new scaling law is being used in the new UCERF3 hazard maps.

- Developed new methodology for quantifying natural fault system geometry, based on automated pattern recognition of geometrical test functions. Applying to fault branches, examining the CGS database of fault traces in California, found scale invariant distributions of branch angles, and symmetry in left versus right branches on dextral strike-slip faults in California. This opens up a new avenue for quantifying natural fault system geometry [*Ando et al.*, 2009].

- Showed potential for substantial rapid coseismic slip penetrating deep below the seismogenic layer in dynamic models. Characteristic of slip shown to differ in slip in seismogenic layer versus slip driven into stably sliding layer with mainly long period motion in slip in stably sliding layer compared with long and short period motion in seismogenic layer [*Shaw and Wesnousky*, 2008]. This type of difference in slip appears to have been seen subsequently in the great M9.0 Tohuku earthquake of 2011.

- Surface slip observations quantified with new statistical approaches developed to examine gradients in surface slip under natural noisy observing conditions. Noise amplitude of $1m$ found in surface slip measurements of large earthquakes. Large scale gradients comparable to stress drop measures at event scale show further earthquake invariance of constant stress drop scaling holding down to subevent scales [*Shaw*, 2011].

- Developed new method for exploring jumping probabilities in dynamic models, and showed exponential form fit probabilities [*Shaw and Dieterich*, 2007].

New Magnitude-Area scaling based on constant stress drop

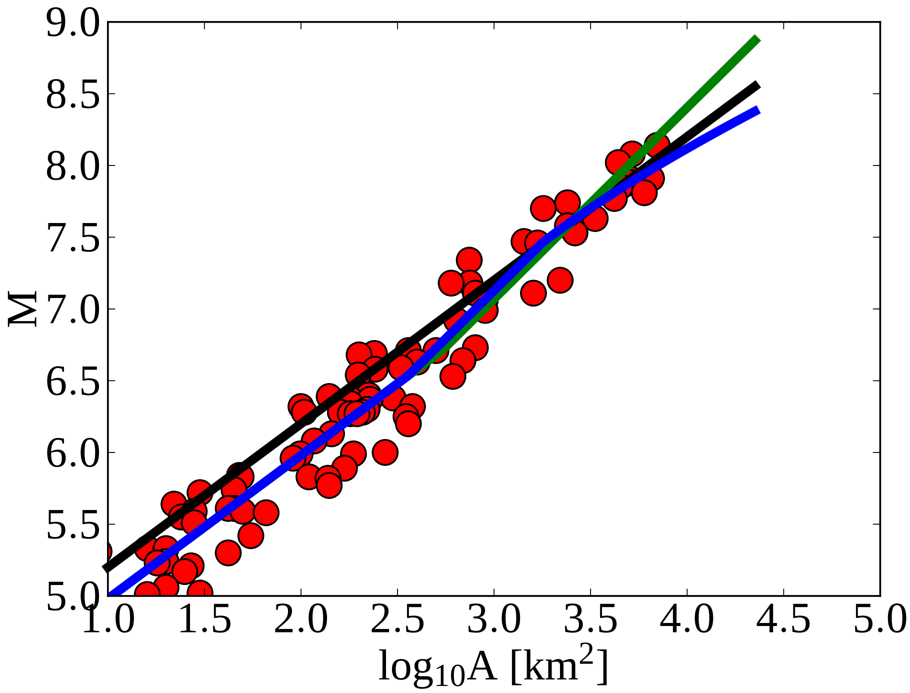


Figure 1: Magnitude area relations for large strike-slip events. Red circles denote magnitude and area of events from [Hanks and Bakun, 2008] database. Black line is linear Ellsworth-B [WGCEP, 2003] magnitude-area relation. Green line is [Hanks and Bakun, 2002] bilinear relation. Blue line is *Shaw* [2009] constant stress drop scaling relation. Blue and green lines overlap at small magnitudes. Unlike the other scaling relations, the constant stress drop scaling relation matches asymptotic scaling both at the small events and at the large events.

New Slip-Length scaling based on constant stress drop

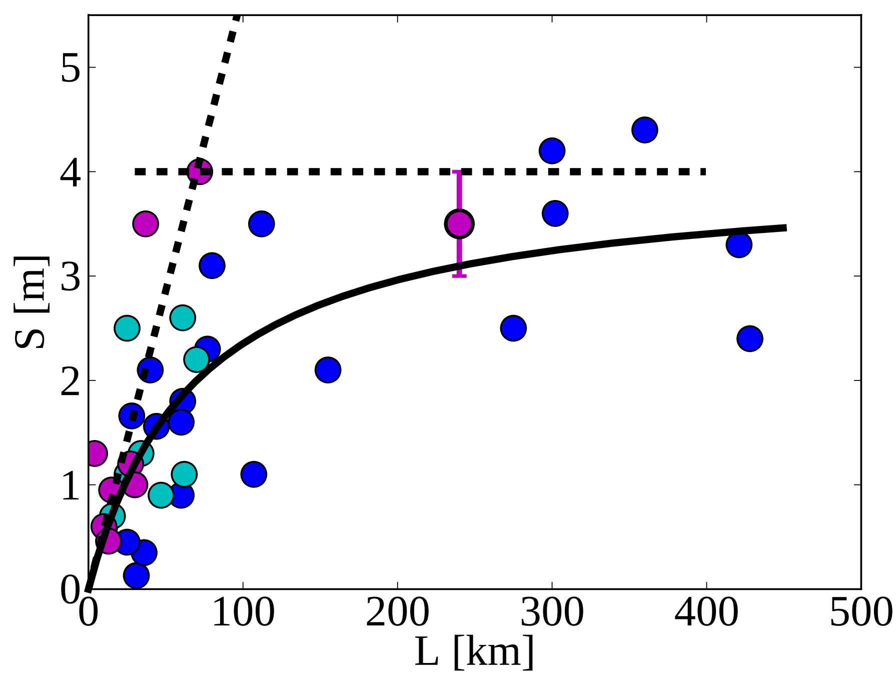
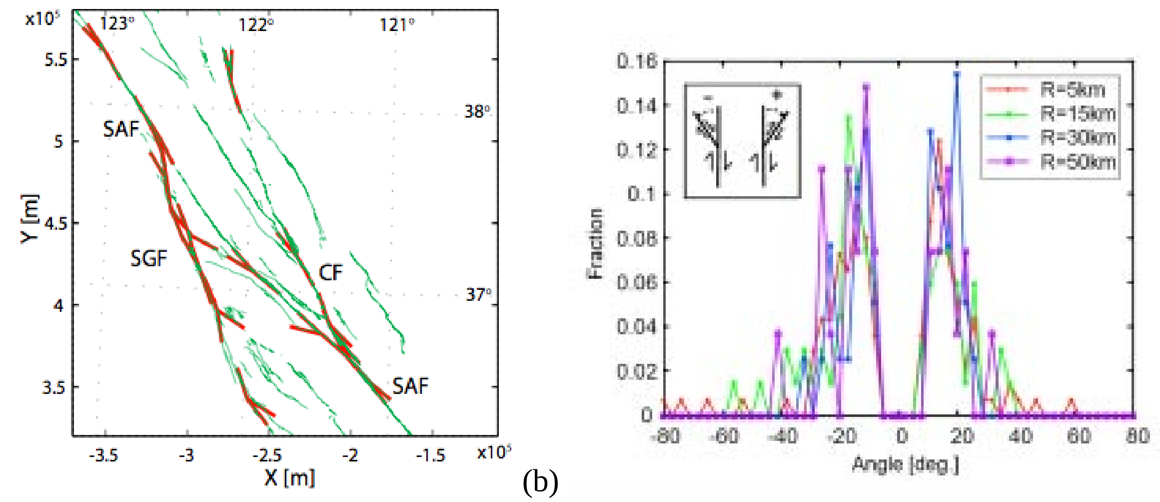


Figure 2: New constant stress drop scaling fit to surface slip-length data. Circles show geological surface slip observations of average slip versus length. Data adapted from [Wesnousky, 2008] compilation; I have supplemented this with the slip from the 2008 M7.9 Wenchuan earthquake, and have also corrected the average slip for the 1857 M7.8 Fort Tejon earthquake to reflect the recent LIDAR results of [Zielke et al, 2010]. Color indicates focal mechanism: strike-slip (blue), normal (cyan), thrust (magenta). Dashed lines show asymptotic scaling limits for circular and long rectangular ruptures. Solid line shows scaling combining these two limits in parallel. Crossover lengthscale occurs at large multiple $L_c = \frac{14}{3}W$ of seismogenic width W. This comes from more careful treatment of how circular ruptures just breaking the surface crossover to long rectangular ruptures. Parameters on lines are: constant stress drop $\Delta\sigma = 4\ MPa$, seismogenic width $W = 15\ km$. From [*Shaw*, 2012].

New method for quantifying natural fault system geometry



(a) (b)

Figure 3: (a) Strike-slip faults in California fit with a Y-shaped object with three equal leg lengths R, with angles between legs to be fit. Plot shown for zoom of Northern California. Green and red lines represent catalogued faults from CGS database, and fitted fault geometry (Y test function), respectively. R=20 km . (b) Statistics of fit splay angles. Probability distribution of angles for different scales. Plot was made at intervals of $3°$. Note invariance of distribution of angles to scale length of test function. Note also left-right symmetry of distribution of splays from the right-lateral strike-slip faults in California. From [*Ando et al.*, 2009].

Outreach activities

- Member WGCEP (Working Group on California Earthquakes Probabilities) developing new UCERF3 hazard models [2010-].
- Member of expert panel for New Zealand updated hazard maps for Cantebury region [2011].
- Member NEPEC (National Earthquake Prediction Evaluation Council) Federal Advisory Committee to the USGS [2006-].

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