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Working Group on Southern California Earthquake Potential

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The Working Group on Southern California Earthquake Potential, now known as the Regional Earthquake Likelihood Models (RELM) project, is putting together several specific, testable models of earthquake occurrence for southern California. These models will be based on past earthquakes, geological fault information, geodetic strain rate, and estimates of incremental stress from past earthquakes. All models will be formulated in terms of a-value, b-value, and corner magnitude values given on a dense grid in longitude and latitude. UCLA's role in this project is to provide an earthquake catalog, to provide a strain rate map based on the SCEC Crustal Motion Model, to provide specific earthquake potential models based on past earthquakes and geodetic deformation, and to provide testing procedures for comparing models with seismicity.

We have held several Working Group meetings and defined the parameters of the earthquake catalog and fault data bases, and we have compiled the historic part of the catalog. The catalog will begin in 1850; report all known earthquakes above magnitude 4.5 in the southern California area covered by the seismic network; include estimates of strike, dip, and rake; have a quantitative description of completeness magnitude thresholds vs. time; and have estimates of magnitude and location uncertainty. Each event will be describable in terms of one or more dislocation patches. Fault surfaces for earthquakes larger than 6.5 will be decomposed into several "subfaults" or dislocation patches, with central location dimensions, strike, rake, dip, and slip for all patches, such that the sum of the patch moments equals to earthquake moment.

We have determined that the maximum horizontal shear strain rate is correlated with earthquake occurrence better than other components. We have provided a gridded map of maximum horizontal shear strain rate for use in constructing earthquake potential models. We are working now to separate total strain rate into secular and episodic components.

We have constructed two earthquake potential models, based on geodetic strain rate and past seismicity, respectively. We have the strain model retrospectively against past earthquake occurrence. If the strain rate were independent of time, this would be a quasi-prospective test, in that the strain rate before the earthquakes would be the same we observe now. In fact, the earthquakes may have affected the strain rate, and a true prospective test against future earthquakes is needed. The past seismicity model has been tested prospectively in subduction zones of the western Pacific, but not for southern California. Figure 1 shows the earthquakes rate estimated from the two models. In spite of the fact that they were derived from completely independent data, the models agree in most respects. They both predict that future earthquakes are more likely in the Brawley seismic zone near the southern end of the San Andreas, and in the region near the Landers and Hector Mine Earthquakes.

We have also examined the relationship between fault length and earthquake magnitude, a necessary ingredient for getting earthquake probabilities from observed fault geometry and slip rate. Based on work by Wells and Coppersmith (1994), most earthquake source

models assume that the moment of the largest earthquake that can occur on a fault depends monotonically on fault dimension (either length or area). This relationship works well when dimension is measured by the estimated rupture area after an earthquake. We tried it out for California earthquakes using fault lengths estimated before the earthquake, and found no significant correlation. Thus the relationship between the fault geometry we can determine now, and the size limits for future earthquakes, is very poorly understood.

Abstracts resulting from this project:

Jackson, D. D., 2000. Forecasting earthquakes on active faults: how large, how often, how regular?, (abstract), NATO Advanced Research Workshop, "State of scientific knowledge regarding earthquake occurrence and implications for public policy", Arbus, Sardinia, October 15-19, 2000. http://ibogeo.df.unibo.it/arw2000/arw-abstracts.htm

Jackson, D. D., 2000. Quantitative measures of forecasting skill applied to earthquake prediction, (abstract), NATO Advanced Research Workshop, "State of scientific knowledge regarding earthquake occurrence and implications for public policy", Arbus, Sardinia, October 15-19, 2000. http://ibogeo.df.unibo.it/arw2000/arw-abstracts.htm

Kagan, Y. Y., 2000. Limits of Earthquake Predictability, (abstract), NATO Advanced Research Workshop, "State of scientific knowledge regarding earthquake occurrence and implications for public policy", Arbus, Sardinia, October 15-19, 2000. http://ibogeo.df.unibo.it/arw2000/arw-abstracts.htm

Jackson, D. D., and Y. Y. Kagan, 2000. Earthquake Potential Estimated from Seismic History, *Eos Trans. AGU*, **81**(48), Fall AGU Meet. Suppl., (abstract), p. F1226.

Bird, P., Kagan, Y. Y., Houston, H. & Jackson, D. D., 2000. Earthquake Potential Estimated from Tectonic Motion, *Eos Trans. AGU*, **81**(48), Fall AGU Meet. Suppl., (abstract), pp. F1226-1227.

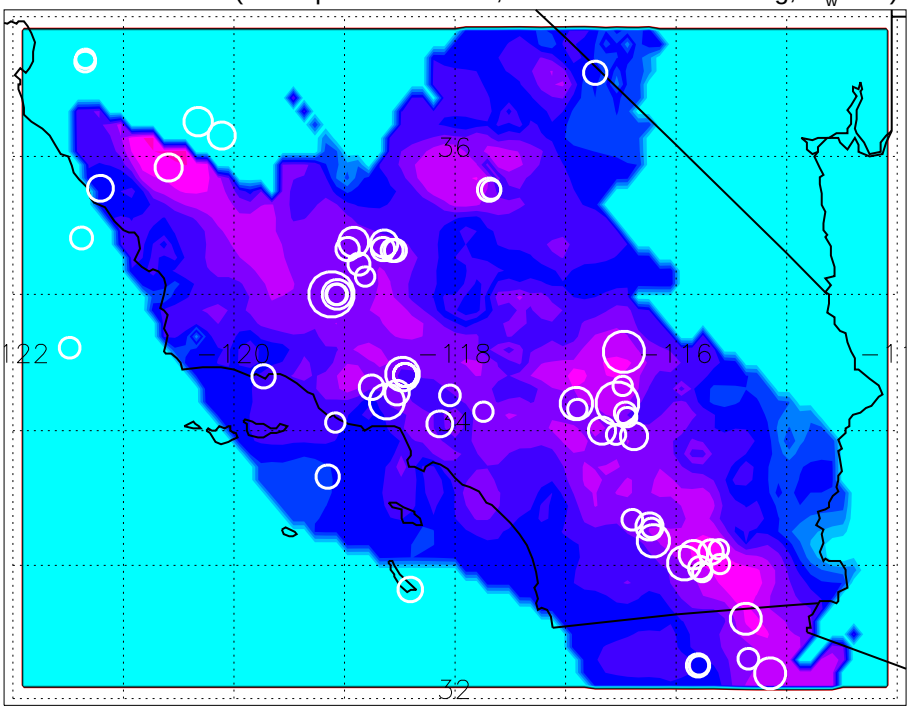
REFERENCE:

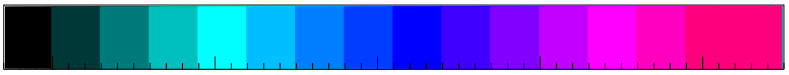
Wells, D. L., and K. J. Coppersmith, 1994. New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement, *Bull. Seismol. Soc. Amer.*, **84**, 974-1002.

Figure caption:

Fig. 1. California earthquake forecasts. Color tones show the probability of earthquake occurrence per unit area. White circles show locations of earthquakes. (a) Forecast based on geodetically observed maximum shear strain rate, and epicenters of earthquakes since 1950. (b) 1989 "Pseudo-forecast" based on previous earthquake catalog and tested on later catalog, and moment centroids of earthquakes from 1989 to 1999 inclusive.

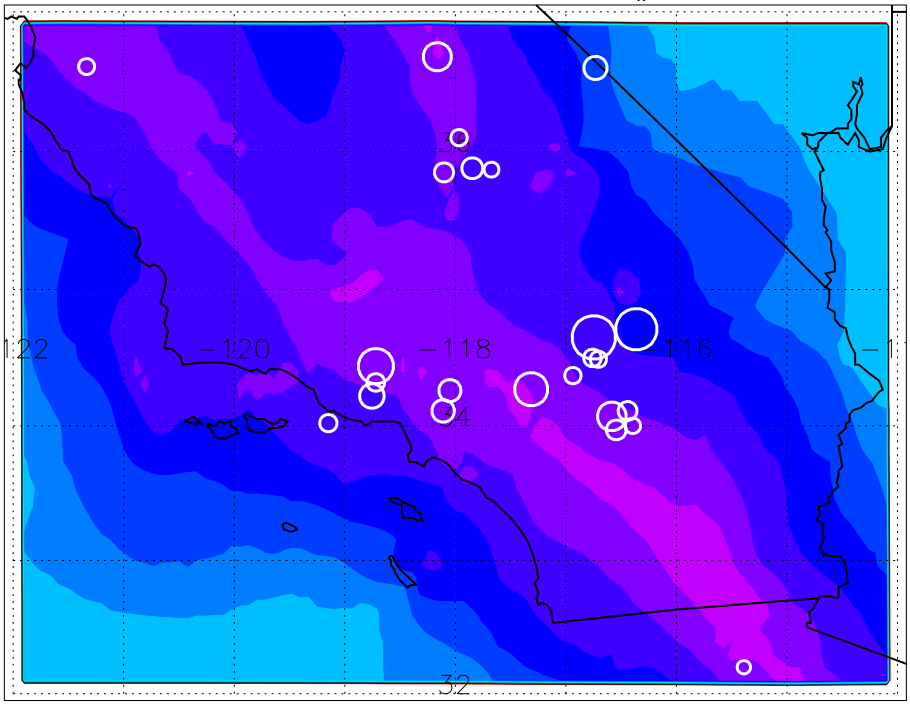
S. California strain (Earthquakes 1950-99, Modif. Ellsworth catalog, M_w>5.5)

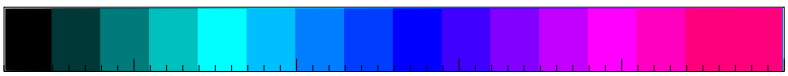




Log_{10} Shear Strain Rate (microstrain/year)

S. California Forecast: 1850-1988, Eqs (Harvard M_w>5.0) in 1989-2000





Log_{10} Earthquake Rate M_w > 5.5, eq/year*$(100km)^2$