Forecasting the evolution of seismicity in southern California: Animations built on earthquake stress transfer

S. Toda[1], *R. S. Stein*[2], *K. Richards-Dinger*[3], and *S. Bozkurt*[2]

[1]*Active Fault Research Center, AIST, Tsukuba 305-8567, Japan*
[2] *U.S. Geological Survey, Menlo Park, CA, USA,* [3] *Geothermal Program Office, Naval Air Weapons Station, China Lake, CA, USA.*

Corresponding Author: S. Toda, s-toda@aist.go.jp

Abstract:

We develop a forecast model to reproduce the distribution of mainshocks, aftershocks and surrounding seismicity observed during 1986-2003 in a 300 x 310 km area centered on the 1992 M=7.3 Landers earthquake. To parse the catalog into frames with equal numbers of aftershocks, we animate seismicity in log-time increments that lengthen after each mainshock; this reveals aftershock zone migration, expansion and densification. We implement a rate/state algorithm that incorporates the static stress transferred by each M≥6 shock, and then evolves. Coulomb stress changes amplify the background seismicity, so small stress changes produce large changes in seismicity rate in areas of high background seismicity. Similarly, seismicity rate declines in the stress shadows are evident only in areas with previously high seismicity rates. Thus a key constituent of the model is the background seismicity rate, which we smooth from 1981-1986 seismicity. The mean spatial correlation coefficient between observed and predicted M≥1.4 shocks (the minimum magnitude of completeness) is 0.52 for 1986-2003, and 0.63 for 1992-2003; a control standard aftershock model yields 0.54 and 0.52 for the same periods. We also evaluate the ability of the model to forecast the total number of aftershocks as a function of time, and as a function of radial distance from each mainshock. Four M≥6.0 shocks struck during the test period; three locate at sites where the expected seismicity rate falls above the 92 percentile, and one above the 75 percentile. The model thus reproduces much—but certainly not all—of the observed spatial and temporal seismicity, from which we infer that the decaying effect of stress transferred by successive mainshocks influences seismicity for decades. Finally, we offer a M≥5 earthquake forecast for 2005-2015, assigning probabilities to 324 10 x 10-km cells.