

## **Annual Report 2004**

### **Collaborative Research – Analysis and Integration of the Earthquake Stress Cycle Evolution and Pattern Informatics Techniques**

**David D. Bowman**

**California State University, Fullerton**

Many large earthquakes are preceded by a regional increase in seismic energy release. This phenomenon, called “accelerating moment release” (AMR), is due primarily to an increase in the number of intermediate-size events in a region surrounding the mainshock. Bowman and King (2001) and King and Bowman (2003) have described a technique for calculating an approximate geologically-constrained loading model that can be used to define regions of AMR before a large earthquake. While this method has been used to search for AMR before large earthquakes in many locations, most of these observations are “postdictions” in the sense that the time, location, and magnitude of the main event were known and used as parameters in determining the region of precursory activity. With sufficient knowledge of the regional tectonics, it should be possible to estimate the likelihood of earthquake rupture scenarios by searching for AMR related to stress accumulation on specific faults. SCEC has previously funded the geophysics group at Cal State Fullerton to conduct a preliminary study using AMR to forecast strike-slip earthquakes on specific faults in southern California. The bulk of this work was done by Julia Clark, a former undergraduate Senior Thesis student of the PI. During 2004, SCEC funded an effort to compare the AMR technique pioneered by the group at CSUF with the Pattern Informatics (PI) index approach being developed by Kristy Tiampo of the University of Western Ontario.

The PI index is a method to quantify correlations in seismic activity over broad space-time windows. Because this technique fundamentally measures short-term variations in the local seismicity rate, earthquake forecasts (both retrospective and prospective) made using both the PI index and AMR should give similar results. The focus of our efforts in the last year has been to begin a comparison of these complementary approaches. The Fullerton group has directed its efforts at two specific topics.

1) The model for AMR proposed by King and Bowman [2003] specifically predicts that the precursory activity will have a strongly heterogeneous distribution in space. The model predicts not only regions of precursory activation of seismicity, but also regions of relative precursory quiescence. We have documented (Mignan et al, JGR, submitted) that the distribution of both accelerated seismicity and quiescence before large earthquakes in California are consistent with the model of King and Bowman [2003]. Because the PI index is capable of detecting positive and negative seismicity rate changes on a very fine spatial grid, we next plan to compare these results to a similar analysis using the PI index.

2) Both the PI index and AMR have been proposed as techniques for prospectively forecasting the occurrence of large events. We have conducted a preliminary comparison of precursory signals found using both techniques. The results are encouraging; there is a broad correlation between “hotspots” found using the PI index and AMR observed using the technique of Bowman and King [2001]. The preliminary results of this comparison are currently in preparation for submittal *Seismological Research Letters*.

SCEC-funded research in 2004 has led to the following manuscripts:

- Mignan, A., D. D. Bowman, and G. C. P. King, Accelerating Moment Release (AMR) before large earthquakes: The stress accumulation model versus stress triggering, submitted to *J. Geophys. Res.*, 2004.
- Tiampo, K., D. Bowman, J. Clark, and J. Rundle, SAM and the PI index: Complementary approaches to earthquake forecasting, *in prep.*, 2004.

In addition, the following papers (funded by earlier SCEC grants) were published this year:

- Bowman, D.D. and C. G. Sammis, Intermittent criticality and the Gutenberg-Richter distribution, *Pure Appl. Geophys.*, *161*, 1945-1956, doi:10.1007/s00024-004-2541-z, 2004.
- Sammis, C. G., D. D. Bowman, and G. C. P. King, Anomalous seismicity and accelerating moment release preceding the 2001 and 2002 earthquakes in northern Baja California, Mexico, *Pure Appl. Geophys.*, *161*, 2369-2378, doi: 10.1007/s00024-004-2569-3, 2004.