**2005 Annual Report**

# Collaborative Research – Integrating the Stress Accumulation Method and Pattern Informatics Technique

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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.

In 2005, 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, in prep) that the distribution of both accelerated seismicity and quiescence before historic

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) We have conducted a preliminary comparison of precursory signals found using both the PI and AMR 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]. However, a direct systematic comparison of predictions made by the two techniques is complicated by the fact that the PI index is calculated on a regional grid, while the AMR approach is scenario-specific. Thus, the central focus of our work in the past year has been to develop an algorithm capable of searching for AMR on a regional grid that can be more directly compared to the PI index. Although this is a straightforward problem in principle, development of a routine that will run in a reasonable amount of time on available hardware requires that the original optimization algorithm be recoded to take advantage of more sophisticated computational techniques (e.g. grid computing). The bulk of our effort this year has been to develop the computational infrastructure necessary to make this direct comparison between techniques. The initial results of this work will be presented at the 2005 Fall AGU Meeting.

This project has led to the following meeting abstracts from the CSUF group:

- Reissman, J., and D. Bowman, Grid-Search for Accelerated Moment Release (AMR) Precursors to California Earthquakes, 2005 SCEC Annual Meeting, Palm Springs, Sept. 11-12, 2005.
- S. Z. Levin, K. F. Tiampo, and D. D. Bowman, Spatial and Temporal Length Scales Characterizing the Evolution of Seismicity Rates, S43D-04, AGU Fall Meeting, 2005.
- Reissman, J., and D. Bowman, Grid-Search for Accelerated Moment Release (AMR) Precursors to California Earthquakes, S53B-1099, AGU Fall Meeting, 2005

The following manuscripts are also in preparation:

- Mignan, A., D. D. Bowman, and G. C. P. King, Accelerating Moment Release (AMR) before large earthquakes: The stress accumulation model versus stress triggering, *in prep.,* 2005.
- Tiampo, K., D. Bowman, and J. Rundle, SAM and the PI index: Complementary approaches to earthquake forecasting, *in prep.*, 2005.