Progress Report for the Funding Period 2003

Proposal: "Implementing and testing seismicity based earthquake probability models in southern California"

Project #03057

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For the 2003 funding period, we received a total of 15k$ in travel support from SCEC for REML related activities. We had in particular requested 3 months support for Matt Gerstenberger to stay in Pasadena; however, because of his employment development (permanent job at GNS, Wellington) he only used half of that. In addition, a RELM meeting was postponed to February 2004, also freeing up funds in 2003. Consequently, we have about $7000 left from our 2003 budget. We have requested in our 2004 proposal to transfer this amount to the 2004 budget.

Below, we summarize the activities supported in parts through the 2003 SCEC funding:

1) ***Development of testing routines for quantitative testing of RELM forecast models.*** Danijel Schorlemmer, in collaboration with David Jackson (who spend 5 months of his 2003 sabbatical in Zurich, supported for by ETH), Matt Gerstenberger and Stefan Wiemer have developed a likelihood based ratio testing for earthquake forecasts in California. The proposed testing builds and expands work by Kagan and Jackson. A draft paper describing the testing is being circulated to all RELM researchers, and we are now awaiting their feedback. This paper is critical for the planned special BSSA volume on RELM. The newly develloped testing procedures were also described during a special session at the 2003 EGS meeting and associated workshop, and presented during the 2003 SCEC meeting. We also successfully applied these likelihood tests to evaluate the performance of a time-dependent model (STEP, see below).

To illustrate the testing somewhat, we show in Figure 1 the likelihood ratio testing of two models. The first, or Null hypothesis is assuming a spatially homogeneous distribution of seismicity, the alternative hypothesis is the 1996 USGS hazard model. To evaluate the performance of the testing, we create a test data set of observed seismicity for a 5 year period which is drawn based on the 1996 forecast model. To evaluate the significance of the likelihood ratios we perform a total of 1000 simulations. The results shown in Figure 1 illustrate that the Null hypothesis (red line) can be reject with high significance,

whereas the alternative hypothesis (green line) cannot be rejected. This result is for us one of the ways to better understand the performance and resolution of the ratio test, which are somewhat abstract and complex to understand. It is encouraging to see that with a 5 year test period these two admitting extreme) models can be separated.

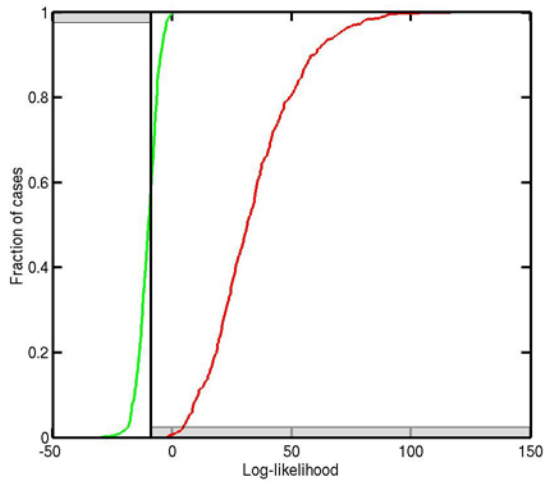

Figure 1. Results of the likelihood ration based test, see the main body of text for details.

2) The STEP model. During the funding period of 2003, much effort was devoted to finalizing the time-dependent model probabilistic earthquake model we have designed for RELM. Matt Gerstenbergers PhD thesis, defended in June 2003, was largely devoted to STEP, and he has completed an extensive USGS open file report describing the model and its testing. The OFR is currently undergoing detailed USGS internal review by D. Jackson (completed) and N. Field, but should be available by the end of 2003. In addition, we have prepared a short publication describing STEP, intended for Science or GRL (authors: Gerstenberger, Wiemer, Jones, and Reasenberg). This publication is also undergoing internal review by a number of reviewers (A. Cornell, B. Ellsworth, N. Field, B. Simpson). To us, the intense scrutiny of our work, especially from the USGS side, is signaling the high relevance and significance of our work. One of the products STEP is delivering is continuously updated maps of tomorrow's probability for an earthquake in California, and our intention to publish maps such as the one shown in Figure 2 need to be well considered before being published. This significance of our work is also highlighted by the fact the Gerstenberger won a Mendenhall fellowship which will partially support the further development of STEP in the future.

SECEC funding supported Matt Gerstenbergers 6 week stay in Pasadena in the summer of 2003, where he presented his thesis work in Caltech and Menlo Park (online video available at the Menlo web site). He also used this time to help implement the STEP approach into the OpenSHA framework. Results of this effort where shown by N. Field during the 2003 SCEC meeting. STEP is thus the first time dependent model to be fully integrated into RELM and OpenSHA.

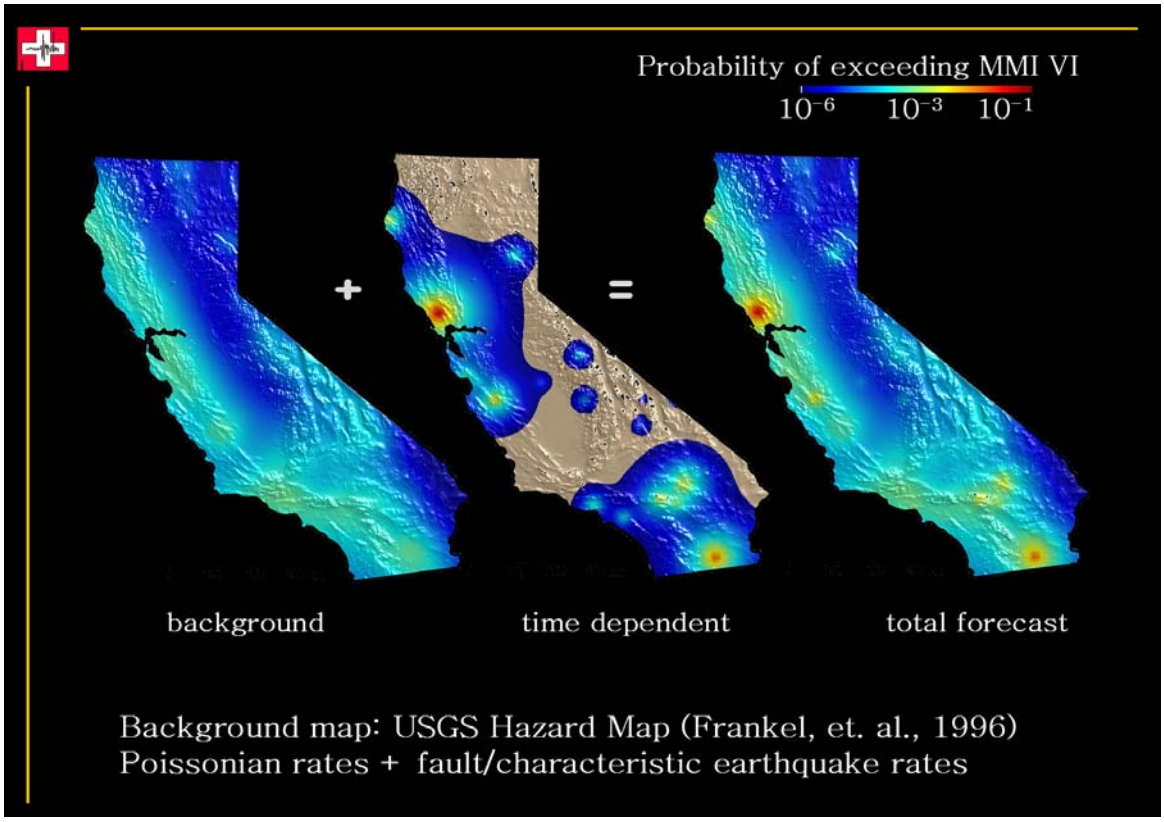

Figure 2. *Maps of California, showing the probability of exceeding MMI VI in the next 24-hr period starting from May 25, 2003, 2:07 a.m., PDT. The left frame depicts the time-independent hazard based on the 1996 USGS hazard maps for California. SF and LA are the locations of San Francisco and Los Angeles, respectively. The center frame represents the time-dependent hazard which exceeds the background including contributions from several events; The right frame is the combination of these two contributions, representing the total forecast of the likelihood of ground shaking in the next 24-hr period.*

3) The ALM model: We have been working for some time on an asperity based likelihood model for California (ALM), which is one of the models under development for RELM. The lead researcher in this effort is PhD student Danijel Schorlemmer (ETH). We are in the final stage of completing two papers that describe ALM based on data for the Parkfield section of the SAF (see Figure 3). An additional paper intended for the RELM special issue, and discussing the implementation of ALM for all of California, has been delayed by the need to first define the testing (see 1). It will be completed in 2004. No funds from SCEC where used in 2003 for ALM development, since a scheduled trip of Schorlemmer to California has been postponed.

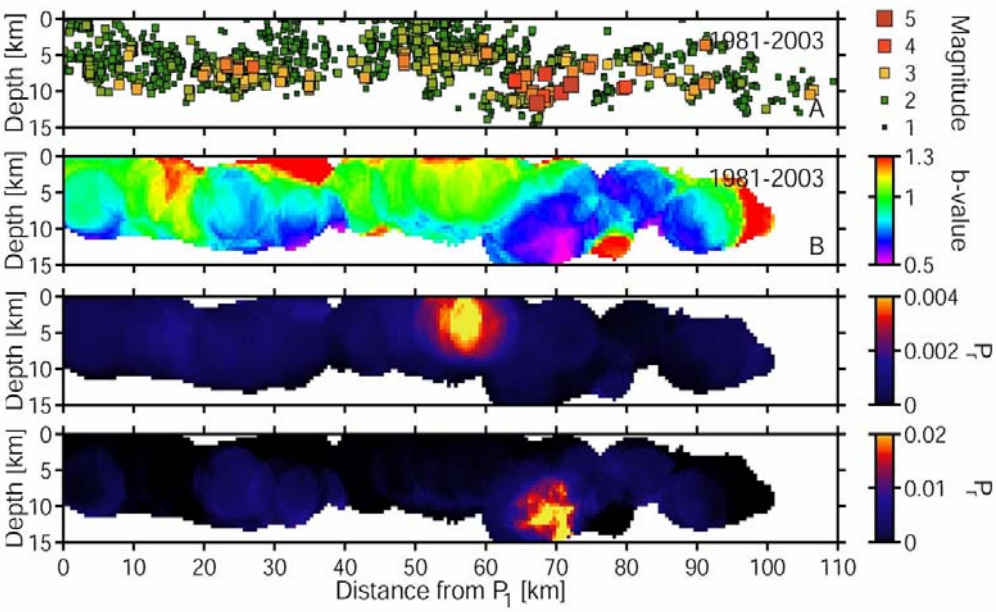

Figure 3. *NW – SE cross-sectional view perpendicular to the San Andreas Fault in the Parkfield region. The top frame shows the seismicity from 1981 – 003, size and color reflects the magnitude. The frame below show the b-value of the Gutenberg-Richter law, mapped our using constant radii of 5 km. Note the low b-values in the locked asperity region. The bottom, two frame shows the annual probability for M6 or larger events, the first frame based on the assumption of an overall constant b of 0.91, the second using the above, spatial varying b-value distribution. In the case of Parkfield, we conclude that only when taking spatial variations in b on the scale of kilometers into account, sensible hazard results are obtained.*