Testing the 1st-Generation RELM Models

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Introduction

The working group for the development of Regional Earthquake Likelihood Models (RELM) began in 2001 as a joint effort of the Southern California Earthquake Center and the U.S. Geological Survey. Given a lack of consensus on how to develop earthquake rupture forecasts (which quantify the probability of all large events throughout a region over a specified time span), the goal was to develop a range of viable models for California. The second step was to evaluate the hazard and loss implications of each model and formally test each against future seismicity. A total of 17 5-year forecasts were submitted on December 31st, 2005, representing the first-generation RELM models. The RELM project will transition into the more ambitious Collaboratory for the Study of Earthquake Predictability (CSEP). In short, CSEP will expand the geographic coverage, introduce other types of formal tests, and accommodate other types of forecasts (e.g., alarm-based predictions).

OpenSHA

OpenSHA, the community modeling environment for seismic hazard analysis (www.OpenSHA.org), is being used to explore the hazard implications of the various RELM models. OpenSHA allows the various models to be distributed over the internet. It also accesses any idle computers via GRID computing to speed up the otherwise lengthy hazard-map computations.

OpenSHA provides a framework where any arbitrarily complex (e.g., physics based) earthquake-rupture forecast, ground-motion, or engineering-response model can "plug in" for analysis without having to change what's being plugged into.

Current Testing Contests

1. Quasi-stationary models provide grid-based 5-year probabilistic forecasts (2006-2010) of main shocks in the magnitude range 5-9. These models can be used for general hazard studies, building codes, etc.

2. Same as 1 but forecasting main shocks and aftershocks

Grid-based Testing (Likelihood Testing)

- Test model's consistency with the observation
- Test model's relative performance compared to other models (R-Test) [Schorlemmer et al., submitted]

Features of the Test

- Includes parameter uncertainties (location, magnitude)
- Includes independence probabilities (Declustering)
- Includes time-magnitude completeness windows
- Resolution independent
- Analysis of spatial and magnitude-range performance

Testing Implementation Issues

- Model definitions (e.g., 5-year models)
- Authorized data sources (e.g., ANSS catalog)
- Definition of testing bins (testing area)
- Declustering (e.g., bootstrapping [Reasenberg, 1985])

Why a Testing Center?

We need a controlled environment for:
- Testing multiple models against each other
- Re-running the tests in case of bugs in the testing procedure
- Documenting each models code and potential changes to it
- Tracking the modeler's additional data and depositing it
- Certifying all steps of testing

Figure 4: Example grid cells (0.1°x0.1°). Each cell is divided into bins (0.1 magnitude unit) spanning the magnitude range for testing. AX-MH: In each bin, the expectation \( \lambda \) is tested against the observation as

Figure 5: Testing and data collection bins. Testing bins are plotted as white patches. The collection area additionally contains the bins plotted as gray patches. Squares indicate events of magnitude \( M \geq 5 \) of the last 5 years.

Summary

- RELM achieved most of its goals:
  - Development of models
  - OpenSHA
- Community-accepted testing is underway
- RELM established a new standard in rigorous testing of probabilistic earthquake forecasts (Testing Center)