T-RELM Testing Center: Rigorous testing of probabilistic earthquake forecast models

D. Schorlemmer1, M. Gerstenberger2, S. Wiemer3, E. Field2, L. Jones2, D. D. Jackson4

1 ETH Zurich, Switzerland. 2 CNS Wellington, New Zealand. 3 USGS Pasadena, USA. 4 UCLA, Los Angeles, USA.

Introduction

Testing probabilistic earthquake models is becoming increasingly important task in seismology.

So far, models have only been tested:
- Pseudo-prospectively
- Using different testing methods (no standards)
- Using non-transparent (non-reproducible) methods
- Not comparatively

With R-RELM we want to achieve:
- Setting a new standard of rigorous forecast tests
- Establish community-accepted testing rules
- Truly prospective 5-years tests
- Comparative tests between each model
- Data-consistency testing
- Set up a central Testing Center

With the Testing Center we can:
- Re-run the codes with alternative options
- Re-run the codes in case of bugs or additional tests
- Document each models code and changes (CVS)
- Track the modeler’s additional data
- ‘Certify’ all steps of testing

Grid-based Testing (Likelihood Testing)

- A bin defines a volume (cell), magnitude range, and range of focal mechanism angles.
- In each bin: Expectation λ

Observation ε
- Proposed default binning: Lon/Lat 0.1° x 0.1°
- Depth 0-50 km
- Magnitude 0.1
- Focal Mech. None (30°)
- Test model consistency with the data (ł-N-Test)
- Test models relative performance compared to other models (ł-Test)

Area of Testing and Data Collection

- Collection area from which data is collected and provided to the models for forecast generation.
- Area for which models are tested

Testing Contests

1. Quasi-stationary models provide 5-years forecasts (M5-M9) for:
   - general hazard studies, building codes, etc.

2. Time-dependent models provide daily forecasts (M4-M9) for:
   - short-term predictability after larger main shocks.
   - emergency services and rescue teams.
   - understanding of time dependence of earthquakes

3. Same as 1 but with yearly updates for:
   - insurance companies
   - understanding intermediate-term time dependence

4. Contests 2 & 3 will be expanded by also testing the models using real-time (not revised) data for forecast generation: Real-time test for:
   - testing practical applicability

Data Sources

- ‘Authorized data’ (independent sources) is provided by the Testing Center
- ‘Non-authorized data’ can be provided by the modelers.
This data needs to be submitted to the Testing Center during the learning period.

Independence Probabilities and Parameter Uncertainties

We account for the following uncertainties:
- Earthquake parameter uncertainties: Longitude, latitude, magnitude, time, focal mechanism angles
- Probability of independence of events

Time-dependent models:
- Test against non-declustered catalogs with bootstrapped uncertainties.
- Quasi-stationary models:
- R-Test uses non-declustered catalogs with bootstrapped uncertainties.
- L-Test and N-Test use bootstrapped independence probabilities by bootstrapping parameters of the declustering algorithm by (Reasenberg, 1985) and bootstrapped uncertainties.

References:

Presentation of Results

All results will presented on a website:
- Simulation results
- Development of significance values over time
- Spatial analysis of model performances.
- Magnitude range performance of models.
- Highscore list

Examples for model expectations:
- The expected number of earthquakes is shown in the USGS 1996 model (Frankel et al., 1996).
- Expected number of earthquakes for the model (Helmstetter et al., submitted)

From T-RELM to CSP (Collaboratory for the Study of Earthquake Predictability)

We are planning to extend the T-RELM capabilities by:
- Introducing testing of alarm-based models
- Introducing testing of fault-based models.
- Expanding the model space
- Integrating more regions and forecast periods
- Integrating new authoritative data sources (e.g., automatic slip distributions)