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Comparative Testing of Clustered Seismicity Models on prominent Aftershock Sequences

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We apply the concept of community-based testing for earthquake forecast models developed in the RELM framework to aftershocks sequences, because the abundant seismicity in aftershocks sequences offers ideal conditions for studying earthquake interaction. The 1992 Landers earthquake earthquake sequence is one of the best recorded and best studied earthquake sequence; however, a comparative experiment to retrospectively forecast earthquakes applying established statistical and physical models has not yet been pursued. We analyze the performance of a total of 9 models from different classes: (1) the Short-Term Earthquake Probability (STEP) model and STEP model elements, (2) a suite of Epidemic Type Aftershock Sequence (ETAS) models with and without parameter dependence on time and space and various spatial triggering kernels, and (3) a suite of models deriving seismicity rates based on the rate and state theory following stress changes due to large and moderate earthquakes in the aftershock sequence. Comparing these models allows addressing the questions: Which models perform well on short time and small spatial scales? Do physical models lead to an information gain over purely statistical models on the scale of an aftershock sequence? Where with respect to the faulting do specific models perform well and where not?

Forecasts are computed for different testing classes, starting just after the Landers

main shock time and forecasting the seismicity on a predefined grid in the magnitude range $3 \leq M \leq 8$ each day for the next 24 hours and for longer time periods. The forecasts are evaluated on a daily basis using the RELM likelihood tests for data consistency and relative performance of the models. Preliminary results show that the statistical models perform well in the long run of the aftershock sequence, but poorly during the initial phase of the sequence due to the lack of sequence specific information. Physical models that resolve stress changes on optimally oriented planes and additionally consider the heterogeneity in the stress computations with a statistical approach lead to similar results. However, models relying on first assumptions perform worse on both, in space and time.

We are currently investigating additional well-recorded aftershocks sequences from a range of tectonic settings, such as the Colfiorito earthquake sequence in Italy or earthquake sequences in Iceland. The ultimate goal of the retrospective experiments in the framework of the EU project Seismic Early Warning For EuRope (SAFER) is to improve the ability of the models to forecast in real-time short-term earthquake probabilities for earthquake sequences.