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Time Dependent Hazard - A Multimodel Approach: Combining STEP with EEPAS

We have split our 2006 funding between development of the combined STEP and EEPAS methodologies and international travel to SCEC related meetings. Additionally, we have retrospectively investigated the information gains of the combined model over each individual model, the National Seismic Hazard Model (NSHM) and a spatially varying Poisson model based only Proximity to Past Earthquakes (PPE) in the catalog.

We have developed two different methodologies for combining the forecasts. The initial attempt was a simple linear combination of the models. We derived a main shock catalog using the independence probabilities calculated by Monte Carlo sampling the input parameter space of the Reasenberg declustering methodology; the EEPAS forecast was then scaled down to match the expected number of main shocks based on the independence probability. However, this methodology ignores the potential contribution to aftershock rates from EEPAS and is not a true optimization of the model combination.

Figure 1 shows the modelled response of both STEP and EEPAS to a synthetic aftershock sequence. It is clear from this figure that the models are responding at a very different time-scale to one another, but that they may contain some overlapping information. We have therefore derived an optimized linear combination factor based on the performance of each model against observed data. Using 126 M > 5.05 events occurring in the RELM testing region between 1984 and 2004 we calculated the likelihood score, for each model, of the forecast in the 24 hour period following each event. Next, assuming that the expected number of earthquakes under the STEP model is close to the actual number over the whole period, we calculated the factor that optimized the total combined-model score using a uniform factor for all magnitudes. After optimizing the STEP/EEPAS combination we did the same for the PPE model. We compared the information rate per earthquake ($\Delta \ln L/N$) of the models, i.e., the increase in log likelihood compared to NSHM divided by the number of earthquakes. The results are shown in Table 1, with the optimized STEP/EEPAS model clearly having the best score.

	NSHM	PPE	EEPAS	STEP	STEP+PPE	STEP+EEPAS
$\Delta \ln L/N$	0.0	1.86	2.45	3.10	3.35	3.63
Optimization Factor	n/a	n/a	n/a	n/a	0.41	0.35

Table 1. Infomation rate per earthquake and optimization factors for each model. A higher information rate indicates a more likely outcome, therefore the STEP+EEPAS model represents the best model. For an optimization factor of r, the combined STEP+EEPAS model is r STEP + (1-r) EEPAS.

Both researchers have travelled overseas to attend SCEC related meetings. The preliminary results of the combined STEP/EEPAS model were presented in a poster at the September 2006 SCEC annual meeting. Additionally, funding from this project was used so that both PI's could attend the CSEP workshop in Zürich, Switzerland where both PI's were invited to give opening presentations. Following the meeting, M. Gerstenberger also attended the CSEP sponsored expert panel meeting with SwissRe.

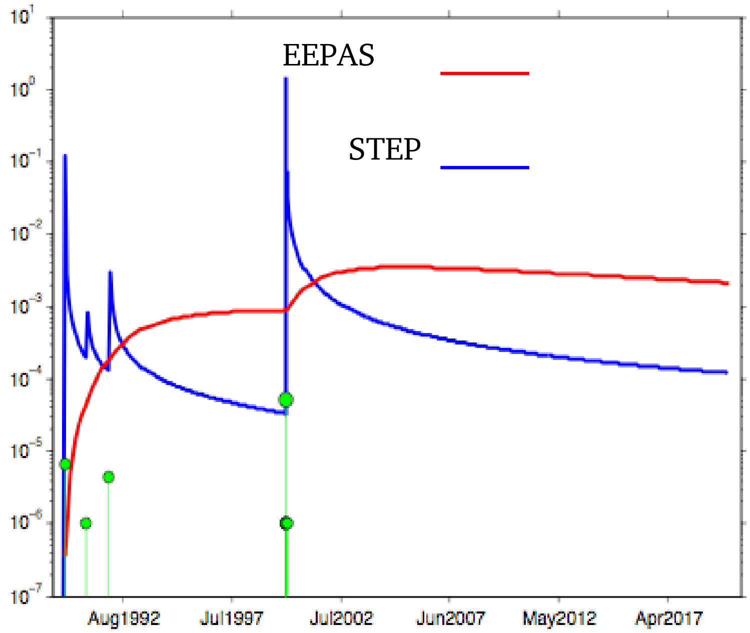

Figure 1. Response of the STEP model (blue) and EEPAS model (red) to a synthethic earthquake catalog. The difference in time-scale of the response of each model is apparent in the figure.