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# ABSTRACT BOOK

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rently evaluating the prospective predictive power of the submitted models. We submitted two self-consistent implementations of the Short-Term Earthquake Probability (STEP) model that produce daily seismicity forecasts; both implementations combine a time-varying and a time-invariant contribution for which we assume that the instrumental Italian earthquake catalog provides the best information. For the time-invariant contribution, we created a smoothed seismicity model from a declustered catalog. The time-varying contribution is the difference between the two implementations: 1) for one implementation (STEP-LG), the original model parameterization and estimation is used; 2) for the other (STEP-NG), we estimate aftershock productivity from the mean abundance model. In the latter implementation, earthquakes with magnitude up to $M_L$=6.2 are expected to trigger fewer events than in the first implementation, whereas larger earthquakes are expected to be more productive. We retrospectively tested the performance of the two implementations for the period January 2007 through July 2009 and applied likelihood tests to evaluate the consistency with observed earthquakes. We find that both implementations are consistent with observed earthquake data in space and that STEP-NG performs better in terms of forecasted rates than STEP-LG. In this presentation, we will evaluate true prospective forecasts from the first months of the CSEP-Italy experiment and report whether the results of the retrospective tests are consistent with the prospective test results for the STEP-models. In addition, we discuss results of all models submitted to the CSEP-EU testing center – including those of other researchers - based on their likelihood scores. In light of these results, we will discuss strategies for communicating these results to the scientific community, decision-makers, and the public.

### *ES8/TU/O3* - ARE SHORT-TERM EVACUATIONS WARRANTED? THE CASE OF THE 2009 L'AQUILA EARTHQUAKE

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The disastrous earthquake in L'Aquila Italy about one year ago ($M_w$6.3, 6 April 2009) highlights again the issue of potentially reducing seismic risk by releasing warnings or initiating mitigation actions. Since earthquakes cluster strongly in space and time, periods of increased seismic hazard are known. During such seismic crises, seismologists typically convey their knowledge of earthquake clustering based on past experience, basic statistics and 'gut feeling'. However, this information is often not quantitative nor reproducible and difficult for decision-makers to digest. We introduce an interdisciplinary approach that combines probabilistic seismic hazard and risk assessment with cost-benefit analysis to allow objective risk-based decision-making. We analyze the effect of uncertainties in different components of this approach. Among various examples, we also consider the 2009 L'Aquila earthquake sequence. The analysis indicates that widespread evacuation was not warranted in the L'Aquila case, supporting the decisions made by authorities in the days and hours leading up to the mainshock. These results demonstrate that the current approach to mitigation actions should be rethought, because it will hardly ever be cost-effective. Instead, future mitigation actions must be based on the weakest buildings and the ones on the poorest soil, just as flooding evacuations are targeted to flood-prone areas only.

### *ES8/TU/O4* - A STRATEGY OF REAL-TIME SEISMICITY EVALUATION FOR OPERATIONAL EARTHQUAKE FORECASTING: RETROSPECTIVE APPLICATION ON THE 6 APRIL 2009 EARTHQUAKE (MW=6.3) IN L'AQUILA, ITALY

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Desicions of civil protection authorities for earthquake countermeasures usually does not match information about non-random variations of seismicity. This often results to an underestimation of the earthquake hazard in short-term sense, that is in time intervals ranging from days to months. Therefore, significant seismicity changes in the time-space-magnitude domains are considered as a powerful tool for the real-time evaluation of the state of seismicity in a target area and at any point of time for operational purposes. Here real-time means that the time distance between the evaluation statement and the end of the seismic period which is under evaluation is about 1 day (=24 hours). To this aim we propose a methodological strategy which may comprise three main stages. In the first, a target area is selected on the basis of seismicity and/or social criteria. Then, significant seismicity changes in space (e.g. epicentral density *q*), time (seismicity rate, *r*) and size (*b*-value) are routinely monitored with appropriate statistical tools applied on daily updated earthquake catalogues, e.g. fractal dimension of *q*, *Z*-statistic for changes in *r*, *p* of Utsu-test for *b*-value changes. Finally, the significance of change of the three parameters is evaluated to characterize the state of ongoing seismicity including the forecasting information for a forthcoming mainshock. Any evaluation output of what has happened until one day ago automatically becomes an input on what one may expect in the days to come. For the strategy implementation an expert system is utilized, the learning phase of which is based on past seismicity experience in several seismogenic zones. The output could be either an alert-based scheme or a probability function for the most probable state of seismicity or both. We have developed the computer algorithm FORMA (foreshock-mainshock-aftershock) which updates automatically the earthquake catalogue, performs calculations of stage two and produces expert system outputs of stage three. Retrospective application of FORMA was performed in the case of the 6 April 2009 earthquake ($M_w$=6.3) in L'Aquila, Italy. A strong foreshock signal was detected 10 days before the mainshock with highly dense concentration of foreshocks in the seismic fault, drastic increase of *r* and drastic drop of the *b*-value. We show the possibilities of the proposed strategy and of the FORMA algorithm for the continuous monitoring of the state of seismicity and consequently for the evaluation of the short-term seismic hazard with promising prospects for operational use by civil protection authorities.

### *ES8/TU/O5* - «NEAREST»: AN EMPIRICAL, NON-PARAMETRIC, FORECASTING MODEL BASED ON NEAREST-NEIGHBOUR DISTANCES BETWEEN EARTHQUAKES

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«Nearest» is the first «alarm-based» earthquake forecasting procedure updated daily in real time. It is being tested at the Southern California Earthquake Center, within CSEP, the Collaboratory for the Study of Earthquake Predictability (www.cseptesting.org). This fully empirical, spatial forecast considers that future earthquakes are most likely to happen at the locations of previous earthquakes, or close to them.

It is based on the empirical distribution function of nearest-neighbour distances between past earthquakes. To obtain a physically meaningful distribution, the earthquakes below the magnitude of completeness of the catalogue are not taken into account. This distribution is not fitted to any model, so no parameter is used.

Following CSEP standards, each testing region is divided into latitude-longitude cells. «Nearest» assigns a probability to each cell, depending on the distance between the cell and past earthquakes, and the above mentioned empirical distribution. Cells which contain past events, or are closer to them, are assigned higher probabilities.

In the four testing regions (California, the whole Earth, Pacific NW and Pacific SW), the results confirm that earthquakes tend to happen in the vicinity of past ones. Thus, most of them occur in a small minority of cells for which the calculated probabilities were higher.

The results are particularly remarkable in California, where the earthquake catalogue is most complete, and the forecasting map is therefore most detailed. The two major earthquakes that have occurred to date during the testing period (the M6.5 Eureka earthquake of January 10, 2010, and the M7.2 Baja California earthquake of April 4, 2010) took place at cells among those with highest probabilities.

There were a few exceptions however, for which the procedure was less efficient. These were the earthquakes that took place in «seismic gaps», relatively distant from any previous, sufficiently large earthquake. An unfortunate example is the Haiti M7.0 shock of January 12, 2010.

The simplicity of the method and the overall results (based on more than 250 earthquakes) suggest that «nearest» might be used as a baseline with which to compare more complex methods. Finally, the tests point out that updating the forecast daily and using catalogues as complete as possible, seemingly contribute to improve the forecasts.