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Probability distribution on faults near the city of Thessaloniki (Northern Greece)

P. Paradisopoulou (1), E. Papadimitriou (1), J. Mirek (2), and V. Karakostas (1)

(1) Aristotle University of Thessaloniki, Geophysics, Thessaloniki, Greece, (2) Faculty of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology, Krakow, Poland

Many studies found that stress triggering and fault interaction theories can be incorporated into quantitative earthquake probability estimates. Using two methods of time dependent probability estimates this work aims at the evaluation of the occurrence probability of anticipated earthquakes in the city of Thessaloniki, an urban center of 1 million people located in northern Greece, conditional to the time elapsed since the last stronger event on each fault of the study area and to the history of the following events on adjacent active faults. The city of Thessaloniki was chosen as a case study because is the second largest city in the territory of Greece surrounded by several small towns. The latest destructive earthquake occurred in 1978 (M=6.5) and caused the collapse of buildings and loss of life in the city and nearby villages. In this study we start from the estimate of the probability of occurrence for the stronger known earthquake on a fault in the period 2011-2041 (30 years) based on a time-dependent renewal model. For this probabilistic earthquake forecast the coseismic stress changes of strong earthquakes (M$\geq$6.5) that occurred since the beginning of 20^{th} century in the study area are calculated. The coseismic stress changes are translated into earthquake probability using an earthquake nucleation constitutive relation. According to this the occurrence rate of the anticipated earthquake is calculated taking into account both permanent (clock advance) and temporary (rate-and-state) perturbations. Earthquake probability on a fault is lowest after the last event but as tectonic stress grows the odds of another earthquake increase. For all needed calculations a probability density function for the time of failure for an earthquake of defined magnitude on the fault of interest must be taken into account along with the calculated stress changes on the fault.

The technique for incorporating stress changes into the estimation of earthquake probability has introduced some uncertainties on the input parameters that affect our results. In order to check if our results are reliable and to confirm the consistency of the model another method is used, giving the option to compare the results of both methods. This new technique can be used with any physical model of earthquake nucleation and can also be used to directly compare the implications of different physical models. This method is modular in that it can be used for any probability density function, any stress change and any quantitative nucleation model.

The estimated probability values that obtained using the above methods concern the probability in each part of a given fault or fault segment, and the probability distribution is illustrated across the specific fault. All calculations were performed at 10km depth but it was necessary to check whether the estimated probability values vary with depth. Therefore, all estimations were performed for each fault or fault segment at the depth of 8, 12 and 15km. The probability calculations were carried out and given for the entire study area during the next 30 years, in the form of tables and maps.