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Numerical simulation method applied for Vrancea (Romania) intermediate-depth earthquakes

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Our main goal is to develop a numerical simulation model for the complete earthquake generation process in the particular case of Vrancea seismic region. Simulation stands on the hypothesis of a discrete hierarchical structure in the Vrancea focal area, as proposed by Trifu and Radulian (1989) and considers the complexity of phenomena and range of scales involved from small-size to major events. The model assumes the existence of typical strength nuclei and weakening areas distributed in the seismic area. Permanent background activity implies a continuously growth of the weakening areas that leads after some time to a critical state of the seismogenic system. From now on, the system is able to generate a major event affecting the entire active segment by a percolation-type process. The numerical algorithm implies parallel computing and interactive visualization techniques, and through a proper tuning with the past seismic activity is able to generate successive seismic cycles characteristic for Vrancea earthquakes.

An essential step in our analysis is to compare theoretical forecasts of numerical simulation model to data observations and use these comparisons as a basis to gain insight into the earthquake cycle and earthquake behaviour and to provide feedback needed for the model refinement process. To this aim the catalog of Vrancea earthquakes is revised and updated. The existing information for Vrancea seismic source offers the possibility to investigate the earthquake phenomenon for two complete cycles, 1940 – 1977 and 1977 – 1986, even though the older data are not accurate and complete for smaller events. The first cycle started after the largest instrumentally recorded event (November 10, 1940, M_w = 7.7) and ended with the shock that caused the strongest damage ever recorded on the Romanian territory and neighbouring countries (March 4, 1977, M_w = 7.5). As concerns the ongoing seismic cycle, the data quality has been

tremendously increased. Relocations for the events occurred after 1995 show a clear alignment of seismicity along a fault-like plane oriented NE-SW. The improvement in the Romanian seismic network allows us to map such features down to a resolution of 1-5 km. At the same time, we can severely reduce the computation time of the simulation algorithm using a 2D geometry instead of a 3D one.

The simulation algorithm successfully reproduces the main characteristics of the Vrancea seismicity: the rate of background seismic activity, the range of the repetition of seismic cycle for largest events, frequency-size distribution, spatial-temporal patterns. We demonstrate the capability and power of the new proposed tool for studying earthquake precursory phenomena and the earthquake cycle. Also the implications and application to time-dependent hazard assessment and earthquake engineering are discussed.