Simulating Earthquakes

The vulnerability of civilisations to natural hazards is growing as a result of the increase of high-risk objects and clustering of populations. Today, an earthquake can trigger a humanitarian or ecological disaster. The 2011 Great East Japan earthquake and the subsequent tsunami, which destructively flooded Japan, illustrate the complexity of the interaction between nature and society and the vulnerability of mankind to seismic extremes. The question ‘could large earthquakes be modelled and predicted in advance?' becomes an urgent topic.

Lithosphere

Driven by thermal convection in the Earth's mantle, the lithosphere is involved in relative movements resulting in stress localisation. The lithosphere presents a hierarchy of blocks: from huge lithospheric plates, smaller shields and mountain chains down to the grains of rock. The blocks and the faults, separating the blocks, interact and move relatively to each other as a result of Earth's dynamics. The movement generates earthquakes when and where the strength of the fault fails to resist a stress load. Studying seismicity by analysis of earthquakes alone has the disadvantage that instrumental observations cover a short time interval compared to the duration of the processes eventually resulting in the seismic activity. The patterns of earthquake occurrence identifiable in earthquake catalogues may be apparent and yet may not be repeated in the future. Moreover, the historical data on seismicity are usually incomplete and this complicates the use of real earthquake data. However, a way out arises: the capacity of today's computers enables simulation of earthquake events.

Synthetic

Modern computer facilities provide useful tools in modelling geodynamical processes leading to large seismic events and in monitoring seismic hazards. Computer modelling of stress localisation and its release/drop as an earthquake occurrence for a region allows generating synthetic earthquake catalogues covering very long time intervals and, thus, providing a basis for reliable estimates of the parameters of the earthquake occurrences. Synthetic earthquakes can assist in interpreting the seismic cycle behaviour and forecasting a future extreme event. These forecasts should be based on but not limited to the physics of earthquake generating processes, geodetic and geophysical data analysis, and paleo-seismological evidences. At present, scientists cannot predict earthquakes with the accuracy with which disaster managers and the general public expect to hear from them. However, geoscientists carry out studies to enhance accurate temporal and spatial prediction of large earthquakes by reducing uncertainties. Scientists were able to launch a satellite some 50 years ago and to send people to the Moon. One day geoscientists will be able to model and to accurately determine time, place and magnitude of large earthquakes in advance.