Geophysical Research Abstracts
Vol. 21, EGU2019-18949, 2019
EGU General Assembly 2019
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Physics-based simulation of spatiotemporal patterns of earthquake preparation in the Nankai mega trust.

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In the latest decade new and more complex physics-based simulators have been developed and have acquired a growing interest as a tool for the comprehension and testing of seismic process models.

Here we introduce a new generation earthquake simulation algorithm and its potentiality for modelling both short- and long-term spatiotemporal process of strong earthquakes preparation. A specific seismogenic structure is modelled by quadrilateral faults constituted by thousands of cells of few kilometres size each. The physical model on which the latest version of our simulation algorithm is based includes, besides tectonic stress loading and static stress transfer as in the previous versions, also the Rate & State constitutive law. The simulator code can be run on a relatively modest computer and is capable of simulating thousands years of seismic activity producing catalogs of tens of thousands events in a wide range of magnitudes. The resulting synthetic catalogs exhibit typical magnitude, space and time features, which are comparable with those of real observations.

In this study we applied the simulator code to a physical model of the Nankai mega trust, a well-known seismic structure 650 km long, aligned with the Pacific Ocean coast of Southern Japan, which generated several earthquakes of magnitude larger than 8.0 in the last few centuries. This structure is typically modelled as subdivided in five main segments characterized by different slip-rates, which can rupture separately from or simultaneously with each other.

The results of this simulation provide interesting inferences on the spatiotemporal properties of seismic activity in the study area. In particular, the recurrence time of large events and their spatial relation, can be studied.

As the simulator algorithm allows displaying the stress pattern on all the cells constituting the seismic structure, in this study we have focused our attention on the time evolution of such stress before, during and after large earthquakes. In particular, we have quantitatively recognized that the ratio between the average stress and its standard deviation on the cells constituting a specific fault segment always increases with accelerating rate before a large rupture on a part or all of such segment, or even several joint segments.