Geophysical Research Abstracts
Vol. 13, EGU2011-3765, 2011
EGU General Assembly 2011

Cycle and triggering of a rate-and-state asperity model.

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Some seismic sources can be seen as locked asperities on a fault surrounded by creeping surfaces. We present here the results obtained by numerical modeling of such a system using rate-and-state framework. In our approach, we consider two elastic semi-infinite half-spaces in contact through an interface with heterogeneous friction properties. The elastic bodies are forced to slip in opposite directions by maintaining a constant velocity at an infinite distance above the fault plane. Asperities are modeled by patches with velocity weakening properties, while creeping areas are modeled by velocity strengthening behaviour.

To begin with, we analyse the response of a single circular asperity. In this case, regular events with rapid unstable slip on the asperity, i.e. earthquakes, occur. These events are separated by slow interseismic loading of the source. During all this sequence, we observe stress interactions between velocity weakening and velocity strengthening parts of the fault.

In addition, each seismic cycle on the asperity can be characterized by its duration, by the stress drop on the source during instability, and the maximum displacement on the fault. Consequently, we study the effect of friction parameters and geometrical parameters (in particular ratio of weakening to strengthening area) on these properties of the seismic cycle on the asperity. This analysis could enable us to interpret seismological observations in terms of friction.

The behaviour of a single asperity is then compared to the case of a fault with uniform weakening properties, which is an equivalent of a Burridge and Knopoff type model, and is in fact the limit case of our model with a creeping area reduced to zero.

In a second time we perturbate the evolution of this system by introducing an instantaneous uniform stress step which could represent the effect of a distant earthquake.

Such a stress change produces on a strengthening fault a slow transient with maximum slipping velocity reached several hours or days after the perturbation, depending on the amplitude of the stress step. The maximum velocity depends on the amplitude of the stress perturbation as well.

In the case of a single asperity, this experiment is a way to study aftershocks that occur on sources after a bigger earthquake or accompanying a large stress transient, each of these sources being represented by an asperity surrounded by creeping areas. We consider a set of identical asperities whose delays to rupture are uniformly distributed between 0 and T (T being the recurrence time of the characteristic earthquake on one source). We are interested in the timing of the events among this population of sources following a stress perturbation, and we analyse the way earthquakes on these asperities are triggered by evaluating the delay between stress perturbation and next rupture for each source. This distribution of delays is interpreted in terms of Omori's law and is compared to the analytic distribution obtained by (Dieterich, 1994) for a set of springs and sliders. The distribution of delays obtained is somewhat different from the one obtained for springs and sliders, owing to complexe interaction between creeping parts and locked parts of the fault. A closer match appears if the simulation is done with a set of uniform weakening faults, as expected.

We used this model in the case of micro-seismicity but it may be applied to any larger size of asperity able to generate big earthquakes.