Understanding the role of fault geometry on earthquake dynamics

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Point

■ Development of a new numerical methods to model earthquake cycle simulations on non-planar faults (spectral boundary element method)

■ Development of new analytical tools using semi-analytical solutions

■ Observation of the combine effect of plate geometry and plate velocity on global subduction zones

研究の領域

予防	応急対応	復旧･復興
	予測･情報力	
	防災基礎力	

Outline

Despite the fact that fault geometry is one of the parameter that can be measured either directly (by mapping fault trace) or indirectly (by analyzing micro-seismicity), its role in the process of earthquake dynamics is still not well understood. Which fault geometrical feature will promote large earthquake generation? Which fault geometrical features will impede large earthquake?
In order to answer these questions, we try to develop new analytical tools, numerical models and performs global scale observations.

(1) Numerical models: We developed new numerical models of earthquake cycles in the context of non-planar fault geometry. One current limitation of such kind of models is the running time consumption. This is why, we developed a fully-dynamic spectral Boundary element method that can handle non-planar fault geometries. Taking advantage of the Fourier transform, it accelerates the calculation.

(2) Simulation are useful if we are available to understand and explain them. One natural way to get some intuition about simulation is to find analytical results. We have developed the small slope assumption and its application to semi analytical methods in 2D. It was used for example to show the existence of a theoretical scaling between slip distribution along a fault and the local fault geometry.

(3) The last step is of course to compare the results of simulation and the analytical results with observations. Guided by the results of simulations and analytical results that indicate that the main effect of fault geometry is to change the normal traction along the fault, we decided to map the normal traction anomaly for the main subduction zones due to elasticity.

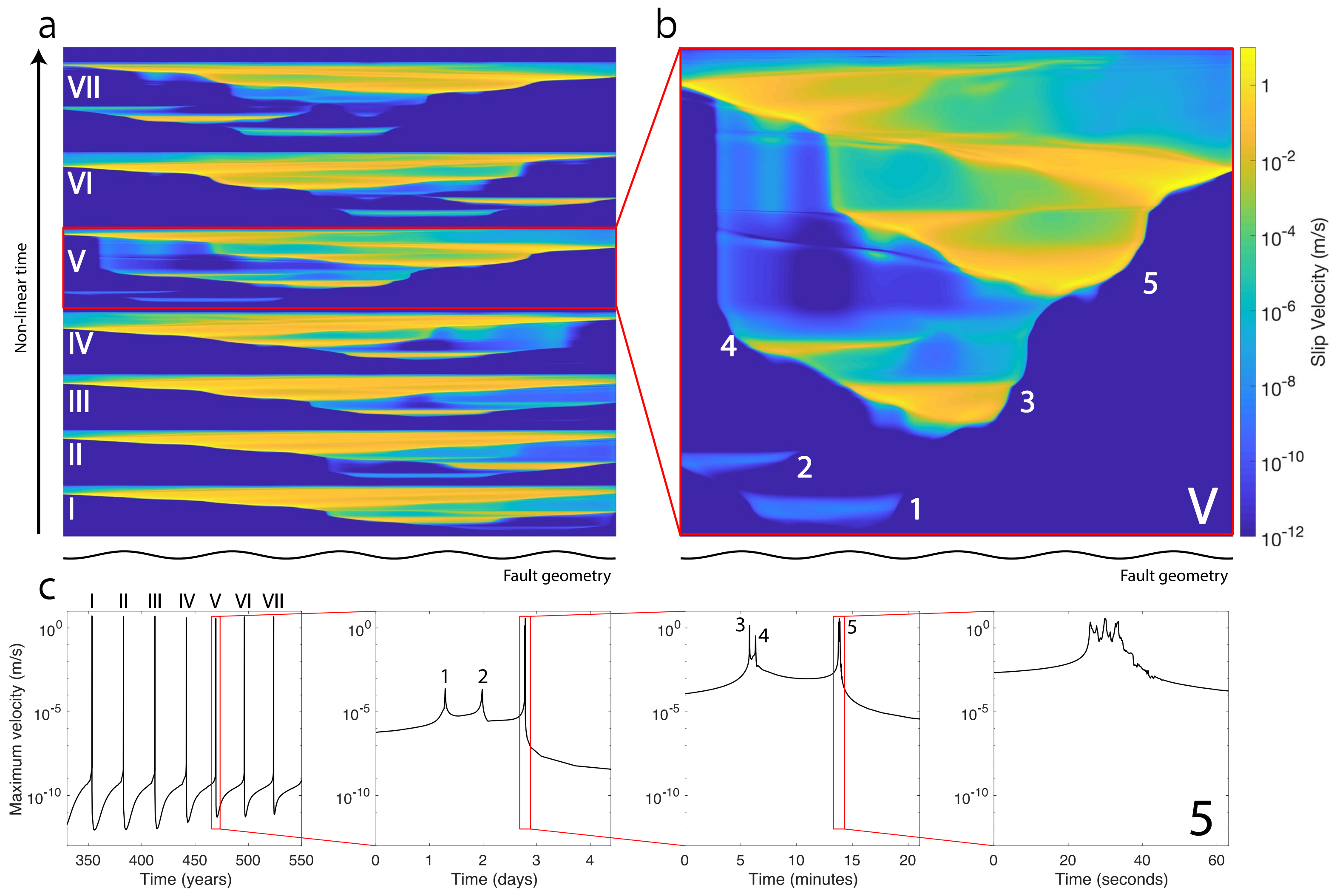

Figure 1: earthquake seismic cycle simulation using a fully dynamic spectral boundary element method (From Romanet and Ozawa, 2021). The fault is sinusoidal and the friction on the fault is modeled by rate and state. (a) Earthquake cycle simulation, (b) zoom on the V-th event. Many foreshocks occur. (c) The maximum velocity on the fault vs time, as time comes close to the main shock, more more foreshocks are occurring.

Future research

So far our work focused on 2D medium, but to be able to understand completely the role of fault geometry in earthquake dynamics, one has to consider 3D medium. This is why we are putting a lot of effort to generalize the tools we have developed in 2D to 3D medium. This is a rather complex task because the slip direction on fault in 3D also comes into play.

- Extend the flat fault approximation to semi-analytical methods in 3D mediums. It may lead to new scaling about geometry on slip direction and/or slip gradient.
- Generalize the spectral boundary element method to 3D. If this is successful, this method will overcome some of the current modeling limitations and expand the kind of problems that we can explore given current computational limitations.