Rapport d'activité

Etude de la génération de séismes et la propagation des ondes sismique
- Study on the earthquake generation and seismic wave propagation processes -

Projet : c2016046700
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Allocation
CINES BULL noeuds fins Occigen : 100 000 heures scalaires

Consommation
CINES BULL noeuds fins Occigen : 75 000 heures scalaires (15/10/2016)

Scientific Results (below is written in English)

The earthquake simulations of the potential Marmara earthquakes (**Aochi and Ulrich, 2015**) were the successful examples to demonstrate how high-performance computations can contribute to practical insight on the forthcoming seismic hazard in the region. The uncertainty in the model parameters was treated probabilistically, so that we were able to discuss the reliability of various scenarios. This year, we have proposed an inverse process to scrutinize a model parameter with respect to the simulated ground motion levels (**Aochi et al., ESC, 2016**; **Aochi et al., in preparation, 2016**). Figure 1 (left) shows this process: Although it lacks the direct observation (as no earthquake happens yet), we know the expected ground motion levels from engineering empirical laws (say, Ground Motion Prediction Equations). Such GMPEs are calibrated for peak values of the ground motions or spectrum amplitudes in function of magnitude, distance, site classification and other simple parameters from past earthquakes. Thus, by carrying out many simulations, we can estimate how the simulated ground motions are close (or far) from the expectation of GMPEs, and thus we can revise the probability of model parameter by this closeness.

On the right panel of Figure 1, we show some examples of the simulated ground motion levels (horizontal Peak Ground Velocities at more than 3000 receivers distributed about every 3 km), and the estimation from a GMPE (an average as solid line, one and two deviations by broken lines). The ground simulations were realized first with Boundary Integral Equation Method (ex. an example of middle panel took 2 hours with 120 cores) to generate the dynamic earthquake scenarios, and then with Finite Difference Method to simulate the seismic wave propagation (1.5 hours with 600 cores). Various initial stress levels and hypocenter locations are studied. When an extremely high stress level is given (below two examples), the simulated ground motions tend to be overestimated comparing to the GMPEs so that such condition would be unlikely. After the statistical calculation of the likelihood of each scenario, we could revise the probability of the model parameter. We believe that this approach is an excellent demonstrator how many simulations are useful not only for generating variety of the results (forward modeling) but also for constraining the model parameters (inverse process).

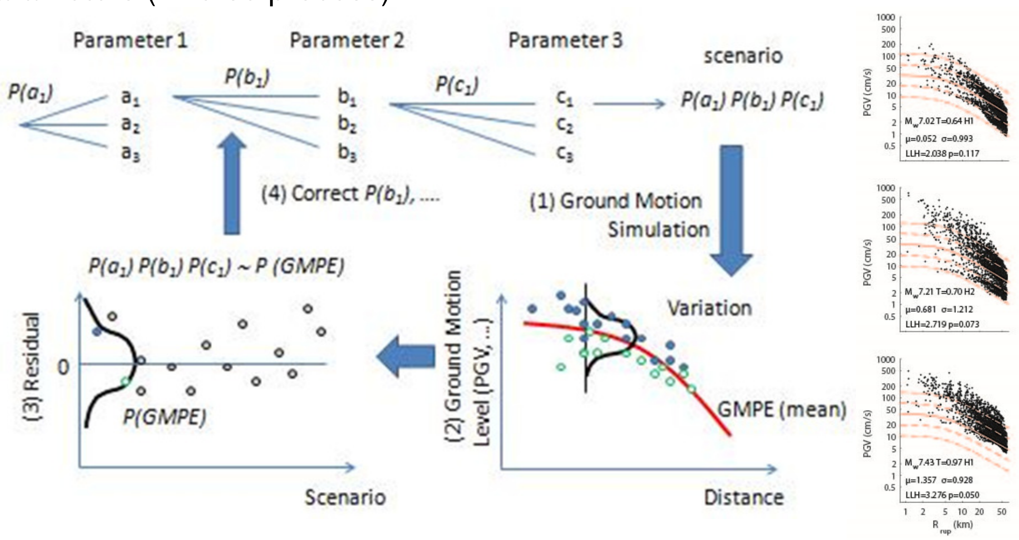

Figure 1 : Left panel shows a strategy of forward modelings of potential earthquake scenarios and ground motions (at top, from left to right), and then an inverse process with respect to the engineering ground motion parameters from Ground Motion Prediction Equations (GMPEs) so as to revise the probability of model parameters (at bottom, from right to left). Right panel shows the three examples of the comparaison in terms of the horizontal Peak Ground Velocity (PGV) between each simulation and the empirical estimation from a GMPE. Figures after ***Aochi et al. (in preparation, 2016)****.*

The second topic we brought this year was to incorporate a nonlinear friction in rupture process. We considered an incoherent slip-strengthening process in advance of slip-weakening process (**Aochi and Ide, submitted to JGR, 2016**). Figure 2 shows a simple case of two superposed asperities of different sizes. The simulation was carried out with a static version of BIEM. We find that slip rate on a small asperity is influenced significantly by the frictional state of the surrounding (a large asperity). This incoherency in friction law would play a significant role of the appearance of different seismicity (slow-to-fast earthquakes).

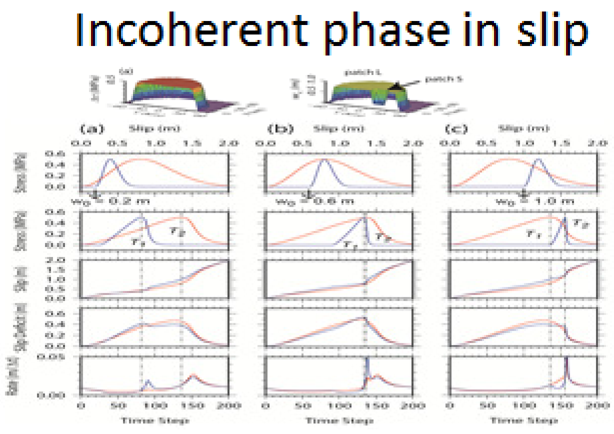

Figure 2: BIEM simulation of two asperities on a plane fault. On top, a spatial distribution of the frictional parameters of slip-dependent law (strength and characteristic slip distance, also seen in the first curve on the below graphs) is shown. The graphs show from top to bottom the given frictional relation on two asperities (Large in red, Small in blue), simulated stress loading with time, slip behavior, slip deficit with respect to the reference and slip rate. (After **Aochi and Ide, 2016**).

Publications in preparation

Aochi, H., T. Ulrich and J. Douglas, Stress accumulation in the Marmara Sea estimated through ground-motion simulations from dynamic rupture scenarios, in preparation for resubmission to J. Geophys. Res., 2016.

Akinci, A., H. Aochi, A. Herrero, M. Pischuitta, and D. Karanikas, 2016. Physics-based broadband ground motin simulations for probable M>7.0 earthquakes in the Marmara Sea region, in preparation, Bull. Seism. Soc. Am.

Publications in 2016

Aochi, H. and S. Ide, Role of multi-scale heterogeneity in slow slips from numerical simulations, submitted to J. Geophys. Res., 2016.

Aochi, H. and M. Yoshimi, Seismological asperities from the point of view of dynamic rupture modeling: the 2007 Mw6.6 Chuetsu-Oki, Japan, earthquake, J. Seismology, doi:10.1007/s10950-016-9569-5, 2016.

Douglas, J. and H. Aochi, Assessing components of ground-motion variability from simulations for the Marmara Sea region (Turkey), Bull. Seism. Soc. Am., 106, 300-306, doi:10.1785/0120150177, 2016.

Conférences et posters

Aochi, H., J. Douglas and T. Ulrich, Using ground-motion simulations to estimate components of aleatory variability and the level of stress accumulation, 35th General Assembly of the European Seismological Commission, Trieste, Italy, 4-10 September 2016.

Aochi, H., T. Ulrich and J. Douglas, Ground motion simulations in Marmara (Turkey) region from 3D finite difference method, EGU General Assembly, Vienna, Austria, 17-22 April 2016.

Références

Aochi, H. and T. Ulrich, A probable earthquake scenario near Istanbul determined from dynamic simulations, Bull. Seism. Soc. Am. , 105(3), 1468-1475, doi:10.1785/0120140283, 2015.