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 : A0010406700
Responsable : AOCHI Hideo

Allocation
CINES BULL noeuds fins Occigen : 90 000 heures scalaires

Consommation
CINES BULL noeuds fins Occigen : 88 472 heures scalaires (21/08/2017)

Scientific Results (below is written in English)

The numerical simulations of dynamic rupture process and seismic wave propagation of the potential Marmara, Turkey, earthquakes were achieved in different publications (**Aochi et al., JGR, 2017**; **Akinci et al., BSSA, 2017**). These are successful contributions to the FP7 MARsite project (ended in 2016) by demonstrating the capacity of numerical simulations on quantitative seismic hazard assessment in the region. We could also propose how to constrain the model parameters with the observations, particularly using the engineering relationship on ground motion parameters.

Another application has been carried out on the ground motion simulations of the 2016 ML4.0 Lacq (SW France). The near-field ground motion pattern is used to constrain the source parameter of this moderate-size earthquake (**Aochi and Burnol, submitted to J. Seismol., 2017**).

On the other hand, between the end of 2016 and the beginning of 2017, we could develop a hybrid BIEM (Boundary Integral Equation Method)-FDM (Finite Difference Method) method, called as 'Boundary Domain Method', in order to treat shallow thrust faulting in the semi-infinite medium, and we are convinced that the method is applicable to the real problem such as the 2016 Central Italy earthquake sequences (**Aochi, EGU 2017; IASPEI 2017**). Figure 1 shows a schematic illustration of the formulation. This keeps the flexibility of the original BIEM but intelligently takes into account of the response of the ground surface to the near-surface faults by FDM. We have repeated numerical tests to check the efficiency and correctness of the solutions by adjusting the interface between BIEM and FDM. Figure 2 demonstrates a snapshot and calculated ground motion in the near field for a given thrust faulting. The numerical code is written principally in C with some Fortran libraries (BIEM), and parallelized with MPI-OpenMP. For a simulation of Magnitude >6 earthquake (2016 Central Italy earthquakes), the capacity of calculation is in the following:

- A dimension of fault plane of 20 km x 20 km (a subfault size of 400 m of BIEM) and a volume of 90 km x 100 km x 50 km (grid spacing of 200 m of FDM).
- Namely, 50 x 50 elements x 300 steps in BIEM, simultaneously 450 x 500 x 150 elements x 4000 steps in FDM.
- It takes about 40 mins on Occigen using 20 nodes, namely 20 x 28 = 560 cores. Note that the duration of calculation strong depends on the dynamic rupture process, which is nonlinear.

We are then interested in the mechanism of the 2016 Central Italy earthquakes from the point of view of source heterogeneity and segmentations. These questions are key to understand the observation and to improve the seismic hazard assessment. We began exploring a better description of source heterogeneity (mechanical parameters) by minimizing the misfit function between the synthetic and the observation. Figure 3 shows the best model currently found among about 60 simulations successfully ran. The calibration of the parametrization is still too difficult to run a global search as an inverse problem. We need to limit the number of parameters and its range. We expect to continue this work in the next proposal.

$$K_{heterogeneous} = K^{BIEM}_{infinite,homogeneous} - K^{FDM}_{infinite,homogeneous} + K^{FDM}_{heterogeneous}$$

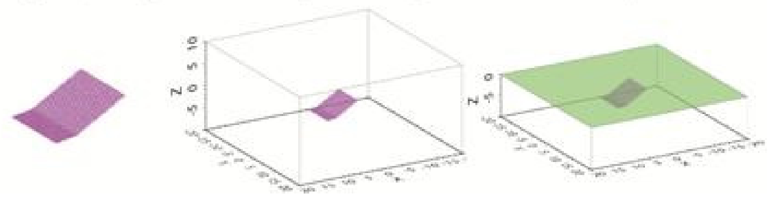

Figure 1 : Schematic formulation of Boundary Domain Method. Numerical kernel in the integral equations for a semi-infinite medium is given by a combination of an analytical kernel of the infinite medium, numerical kernel of infinite medium calculated by FDM and another numerical kernel of semi-infinite medium calculated by FDM.

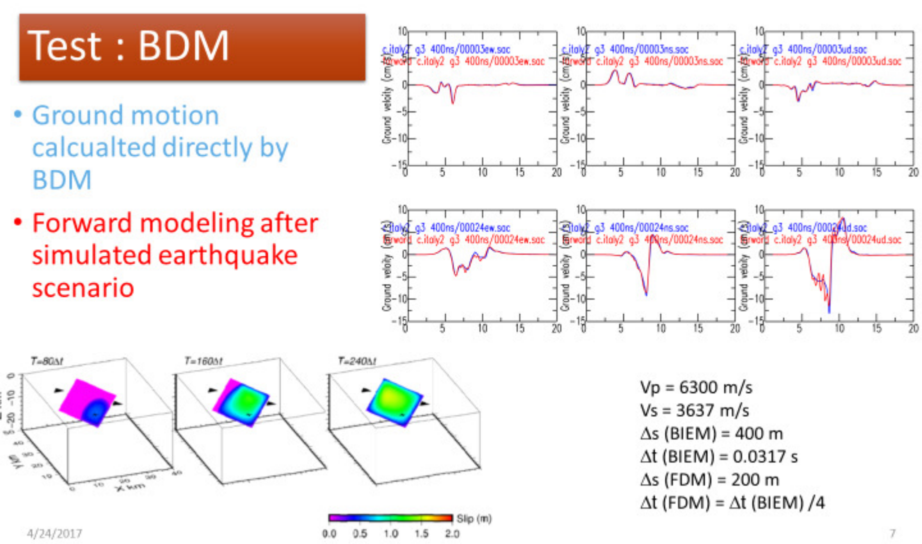

Figure 2: Test of newly developed Boundary Domain Method. The near field ground motions are compared between BDM and the posteriori calculated modeling (Aochi, EGU, 2017).

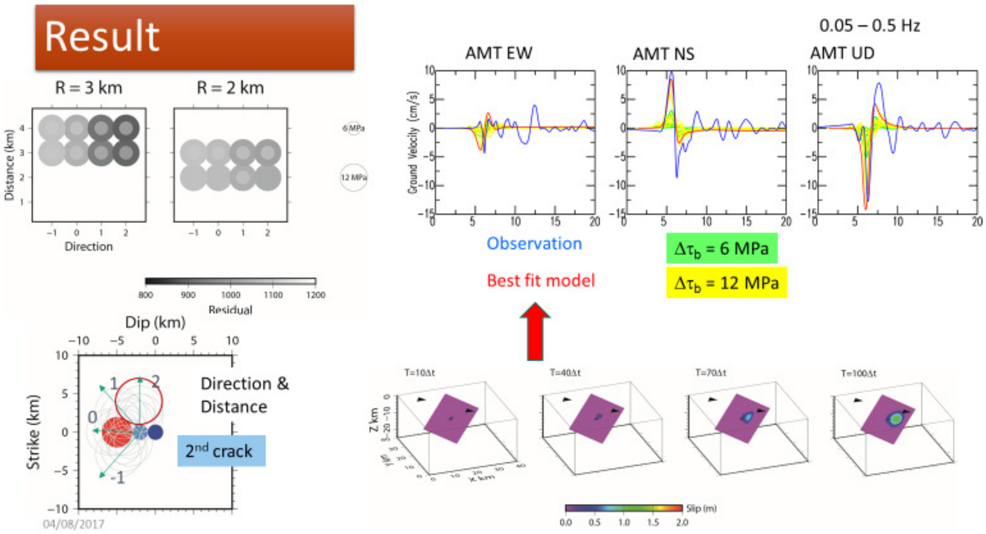

Figure 3: Search of a better model from dynamic rupture simulations for the 24th Auguest ML6.0 Amatrice, Central Italy, earthquake. (Top left): Residual in function of asperity dimension, position and stress drop. (Bottom left): Search of asperity geometry. The best asperity model is illusrtated by red circle. (Top right): Comparison of seismograms at AMT (Amatrice) station near-by. (Bottom right): Snapshot of dynamic rupture propagation for the best model.

Publications submitted or in preparation

Aochi, H., Imaging of strong motion generation area for the 2017 ML6.0 Amatrice, Central Italy, earthquake through dynamic rupture simulations, in preparation for Geophysical Journal International (according to the presentations of IASPEI 2017).

Aochi, H. and A. Burnol, Mechanism of the ML4.0 25th April 2016 earthquake in southwest of France in the vicinity of the Lacq gas field, submitted to J. Seismol., 2017.

Publications in 2017

Akinci, A., H. Aochi, A. Herrero, M. Pischiutta, and D. Karanikas, Phyics-based broadband ground motion simulations for probable M>7.0 earthquakes in the Marmara Sea region, Bull. Seism. Soc. Am., 107, 1307-1323, doi:10.1785/0120160096, 2017.

Aochi, H., T. Ulrich and J. Douglas, Stress accumulation in the Marmara Sea estimated through ground-motion simulations from dynamic rupture scenarios, J. Geophys. Res., 122, 2219-2235, doi: 10.1002/2016JB013790, 2017.

Conferences

Aochi, H., On the nearfield ground motions during the ML6.0 2016 Amatrice, Italy, earthquake, ESG (Earthquake hazard, risk and Strong Ground motion) workshop, Kobe, Japan, 5 August 2017.

Aochi, H., Asperity imaging of the ML6.0 2016 Amatrice, Italy, earthquake from dynamic rupture simulation, IASPEI General Assembly, Kobe, Japan, 30 July-4 August 2017.

Aochi, H., Dynamic rupture simulation of 2016 Central Italy earthquake, EGU General Assembly, Vienna, Austria, 23-28 April, 2017.