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3D Dynamic Earthquake Fracture Simulation (Test Case)

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A 3D dynamic earthquake fracture simulation is being developed for the fault structures which are non-planar to understand heterogeneous stress states in the Marmara Sea. Locating in a seismic gap, a large earthquake is expected in the center of the Sea of Marmara. Concerning the fact that more than 14 million inhabitants of İstanbul, located very closely to the Marmara Sea, the importance of the analysis of the Central Marmara Sea is extremely high. A few 3D dynamic earthquake fracture studies have been already done in the Sea of Marmara for pure right lateral strike-slip stress regimes (Oglesby and Mai, 2012; Aochi and Ulrich, 2015).

In this study, a 3D dynamic earthquake fracture model with heterogeneous stress patches from the TPV5, a SCEC code validation case, is adapted. In this test model, the fault and the ground surfaces are gridded by a scalene triangulation technique using GMSH program. For a grid size changing between 0.616 km and 1.050 km the number of elements for the fault surface is 1984 and for the ground surface is 1216. When these results are compared with Kaneko's results for TPV5 from SPECFEM3D, reliable findings could be observed for the first 6.5 seconds (stations on the fault) although a stability problem is encountered after this time threshold. To solve this problem grid sizes are made smaller, so the number of elements increase 7986 for the fault surface and 4867 for the ground surface. On the other hand, computational problems arise in that case, since the computation time is directly proportional to the number of total elements and the required memory also increases with the square of that. Therefore, it is expected that this method can be adapted for less coarse grid cases, regarding the main difficulty coming from the necessity of an effective supercomputer and run time limitations.

The main objective of this research is to obtain 3D dynamic earthquake rupture scenarios, concerning not only planar and non-planar faults but also heterogeneous stress structures in the Sea of Marmara, using the Boundary Integral Equation Method (BIEM). Adaptation of irregular triangulation for grid meshes with the help of BIEM let us analyze bended faults and obtain non-zero summations of the stress Green's functions (Ando et al, 2007). Hence, stress singularities are accurately evaluated.

As a devastating earthquake is expected in center of the Sea of Marmara, the achievement of this modelling will contribute significantly to a better understanding of the fault movements of the area. In addition, the results will make important contributions to the earthquake and tsunami early warning systems in the Marmara via presented rupture directivities.