Testing the improvement of ShakeMaps using finite-fault models and synthetic seismograms

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ShakeMap package uses empirical ground motion prediction equations (GMPEs) to estimate the ground motion where recorded data are not available. Recorded and estimated values are then interpolated in order to produce a shaking map associated to the considered event. Anyway GMPEs account only for average characteristics of source and wave propagation processes. Within the framework of the DPC-INGV S3 project (2007-09), we evaluate whether the inclusion of directivity effects in GMPEs (companion paper Spagnuolo et al., 2010) or the use of synthetic seismograms from finite-fault rupture models may improve the ShakeMap evaluation. An advantage of using simulated motions from kinematic rupture models is that source effects, as rupture directivity, are directly included in the synthetics. This is particularly interesting in Italy where the regional GMPEs, based on a few number of near-source records for moderate-to-large earthquakes, are not reliable for estimating ground motion in the vicinity of the source.
In this work we investigated how and if the synthetic seismograms generated with finite-fault models can be used in place of (or in addition to) GMPEs within the ShakeMap methodology. We assumed a description of the rupture model with gradually increasing details, from a simple point source to a kinematic rupture history obtained from inversion of strong-motion data. According to the available information synthetic seismograms are calculated with methods that account for the different degree of approximation in source properties.
We chose the M_W 6.9 2008 Iwate-Miyagi (Japan) earthquake as a case study. This earthquake has been recorded by a very large number of stations and the corresponding ShakeMap relies almost totally on the recorded ground motions. Starting from this ideal case, we removed a number of stations in order to evaluate the deviations from the reference map and the sensitivity of the map to the number of stations used.
The removed data are then substituted with synthetic values calculated assuming different source approximations, and the resulting maps are compared to the original ones (containing observed data only). The use of synthetic seismograms computed for finite-fault rupture models produces, in general, an improvement of the calculated ShakeMaps, especially when synthetics are used to integrate real data. When real data are not available and ShakeMap is estimated using GMPEs only, the improvement adding simulated values depends on the considered strong-motion parameters.