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ShakeMap: accounting for finite fault trough synthetic waveforms

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The aim of this work is to evaluate whether synthetic seismograms generated with finite-fault models can be used as an integration to the ground motion prediction equations (GMPEs) within the ShakeMap methodology. Starting from an ideal case, where a very large number of stations is distributed around the epicenter, we remove some stations in order to evaluate the influence on the spatial distribution of ground motion generated with ShakeMap. The removed values are substituted with synthetic values and the obtained maps are compared to the original ones (containing observed data only).

Case study

1. The M_w=6.9 2008 Iwate-Miyagi earthquake

It occurred on June 13 at 23:43:49.7 UTC, on a reverse fault (***Figure 1***). K-Net and KiK-net strong motion networks, operated by the National Research Institute for Earth Science and Disaster Prevention (NIED), obtained a large number of the strong-motion records in the near-source region.

2. Source rupture model

First of all, we used a reduced dataset to reconstruct a finite-fault source model (***Figure 2***). The Piatanesi et al. (2007) code solves the fully non-linear inverse problem and allows for variable slip, rise time, rupture velocity and rake on the fault plane.

3. Synthetic seismograms

We used different simulation techniques (COMPSYN, Spudich and Xu 2003; DSM, Pacor et al. 2005) to compute synthetic seismograms at the same stations that recorded the M_w 6.9 event.

The slip model has been extended to higher frequencies following the k-square model, ***Figure 3*** (Herrero and Bernard, 1994). The velocity model is from Wang et al (2008). Appropriate attenuation parameters as geometrical spreading, quality factor and high-frequency decay (f_{max}) have been considered from literature studies.

4. Ground Motion Prediction Equation

A regional GMPE (Kanno et al., 2006, ***Figure 4***) has been implemented into ShakeMap to better interpolate the ground motion at the phantom points.

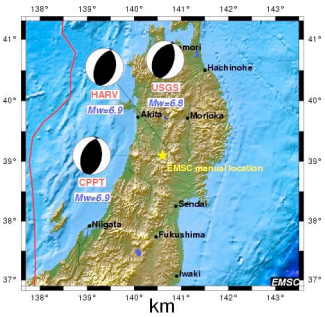


Figure1. Moment tensor solutions for the 2008 Ms=7 Iwate earthquake.

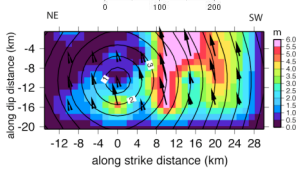


Figure 2. The retrieved slip distribution, the slip direction and the rupture front (0.02Hz<f<0.5Hz).

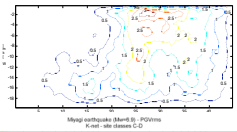


Figure 3. slip distribution to 5Hz (k-square model).

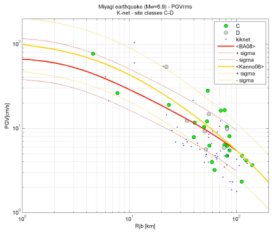
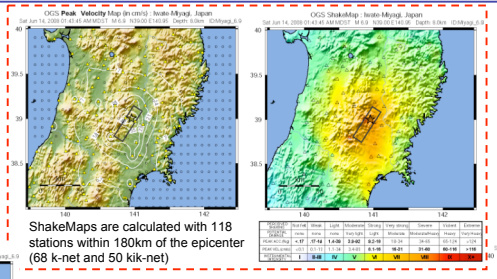


Figure 4. PGV versus distance (Rjb) recorded at K-net stations, classified as C and D sites, and Kik-net stations. Data are compared with Kanno06 (regional) and Boore and Atkinson 2008 (global) GMPEs.

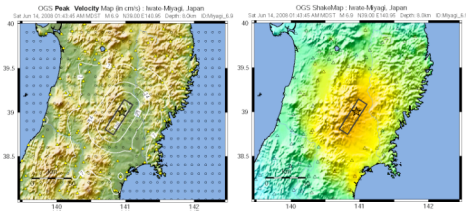
a) PGV and Intensity ShakeMaps calculated with all available records



ShakeMaps are calculated with 118 stations within 180km of the epicenter (68 k-net and 50 kik-net)

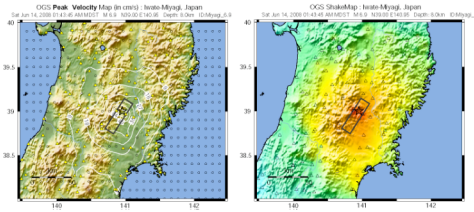
b1) What if there were not stations within 50 km of the epicenter?

From 118 stations to 94 stations



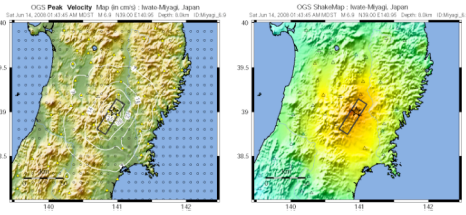
c1) What if we replace values at removed stations with synthetics?

From 94 to 118 stations (94 real + 24 synthetics)



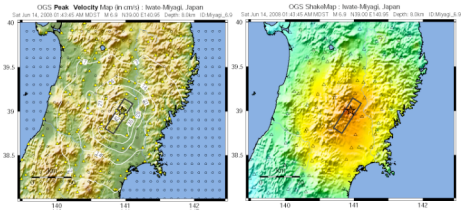
b2) What if we remove some sparse stations?

From 118 stations to 50 stations



c2) What if we replace values at removed stations with synthetics?

From 50 to 118 stations (50 real + 68 synthetics)



To test whether synthetic values can be used to integrate GMPEs in case where recordings are scarce, we propose the following exercise:

a) ShakeMaps are calculated considering all the available stations. For this case study a very dense distribution of stations is available and the produced ShakeMaps rely almost totally on the recorded motion.

b) We remove a subset of stations from the original data set. This can be done with a specific criteria (removing all stations with epicentral distance < 50km, **left panels b1**) or randomly (**right panels b2**).

c) We replace the removed stations with simulated values and compare the obtained "hybrid" ShakeMaps with the original ones (made only with real data).

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Kanno T., A. Narita, N. Morikawa, H. Fujiwara and Y. Fukushima (2006). A New Attenuation Relation for Strong Ground Motion in Japan Based on Recorded Data *Bull. Seism. Soc. Am.*, 96, 879-897; DOI: 10.1785/0120050138.

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