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Comparison between Physics- and Empirical-based Ground Motion Predictions for Hanaore Fault in Kyoto Basin

〇Thinzar Yadanar, Soichiro KUNO, Yuting CHOU, Fumiaki NAGASHIMA, Shinichi MATSUSHIMA

Introduction

In ground motion prediction, physics-based and empirical-based approaches have been widely implemented for different earthquake scenarios. The Physics-based approach involves source rupture process modeling and consideration of seismic wave propagation, so that it requires detailed fault parameters and subsurface structure. On the other hand, the empirical-based approach utilizes ground motion models based on regression of observed data to calculate the expectative ground motion of the earthquakes without taking account of detailed source rupture process and wave propagation.

The aim of our research is to develop a novel approach for probabilistic ground motion prediction by combining physics-based and empirical-based ground motion predictions. By comparing the average and uncertainties of the results from the two different approaches, it can help to highlight the similarity and inconsistency between different approaches which can help us to get the idea of what kind of uncertainty should be considered depending on the site location. In this presentation, we will focus on the comparison of physics-based and empirical-based ground motion predictions results for Hanaore fault, a right lateral strike-slip fault trending NNE-SSW direction, which runs through the north and east part of Kyoto Basin.

Methodology

The purpose of this research is to understand the differences and the similarities of the resulted ground motions on the engineering bedrock from the two different approaches. For the physics-based approach, we use 3D finite difference method for low frequency waveforms (<1.2Hz) and stochastic Green's function method for high frequency waveforms (>1.2Hz). we performed the fourth-order spatial finite different method (Levander, 1988) applying the discontinuous grid (Aoi and Fujiwara, 1999) on the Ground Motion Simulator (GMS) (Aoi et al., 2004). We utilized the stochastic Green's function method (Dan and Sato, 1998; Dan et al., 2000). Both software are provided by the National Research Institute for Earth Science and Disaster Resilience (NIED). The waveforms obtained by the two simulations were combined by applying the matching filter (matching frequency of 0.85Hz, Fig. 1), and then the broadband ground motions on the engineering bedrock were obtained (Fig. 2). For the empirical-based approach, we used the ground motion model (Si and Midorikawa, 1999) to predict the ground motion on the engineering bedrock (NIED, 2011). We utilize the earthquake scenarios for the Hanaore fault provided by Japan Seismic Hazard Information System and follow the recipe for ground motion prediction published by the Headquarters for Earthquake Research Promotion for modeling of fault geometry.

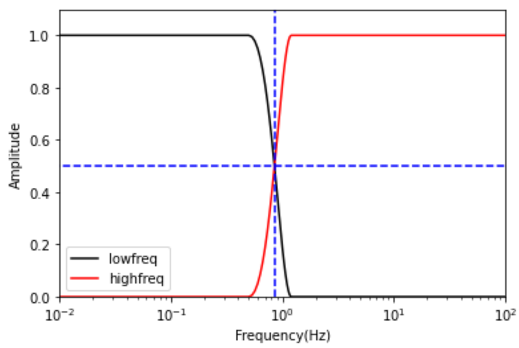

Fig 1. Matching filter applied in the hybrid method

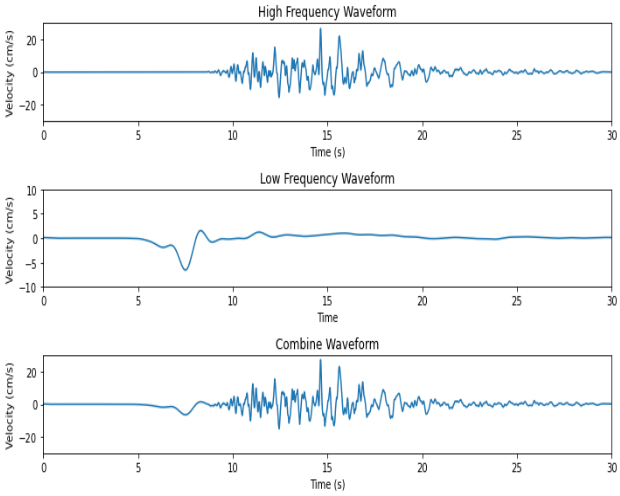

Fig 2. Waveforms simulated by stochastic green's function method (upper panel), 3D finite difference method (middle panel) and Hybrid method (lower panel)

Discussion

Ground motion at one station location depends not only on the mechanism of the fault but also on the subsurface structure around the station. To get a certain ground motion at that station, we should consider the detailed fault rupture process and also detailed subsurface structure of the area of interest. Ground Motion at the sites of interest may vary depending on the source effect (the location of strong motion generation area, directivity, rupture pattern and fault geometry), path effect from source to site and the local site effect of the area. For example, the station at the center of the basin and those at the edge of the basin also have some variations in recorded ground motions because of site characteristics. Ground motion prediction by using ground motion models (empirical-based) which is only consider the magnitude and source to site distance can lead to underestimated or overestimated ground motion results as it does not consider detail source and site conditions.

In our research, we calculate ground motions at 800 stations with 1 km x 1 km grid inside Kyoto basin. By comparing the simulated ground motion results from physics-based and empirical-based approaches, we aim to understand the average and uncertainty of the ground motion from two approaches.

Summary

Our main goal is to integrate physics-based and empirical-based approaches to the probabilistic seismic hazard analyses (PSHA) in consideration of the uncertainty which we can understand from the two different approaches. To achieve this goal, we compare the ground motion results in Kyoto Basin from physics-based and empirical-based approaches to know the variation of the ground motions related to source mechanism and site condition. By understanding of the ground motion variations depending on the source and site, we can perceive the uncertainty that should be considered in PSHA to obtain more reliable ground motion predictions. We will compare the ground motion prediction results at 800 stations in Kyoto Basin by considering three earthquake scenarios of Hanaore Fault.

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