Presentation on

Real-time Integration of Multiple Rupture Models for Earthquake Early Warning (EEW)

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based on

S.E. Minson, S. Wu, J.L. Beck & T.H. Heaton (2017), Combining multiple earthquake models in real time for earthquake early warning, *Bulletin of the Seismological Society of America*, 107(4): 1868-1882.

Introduction

Earthquake early warning (EEW) system provides users tens of seconds to a minute of strong shaking warning before the actual damaging seismic waves arrive at a local site. In the past twenty years, many countries have started operating such a system for two major goals: (1) providing real-time earthquake information to the general public, (2) allowing activation of emergency responses to people/places expected to receive strong shaking. In particular, the second goal defines the practical value of the EEW system. For that reason, it is more important to accurate predict local shaking intensities than the source parameters of an earthquake event. In this presentation, we propose to achieve this goal by exploiting multiple rupture models for EEW.

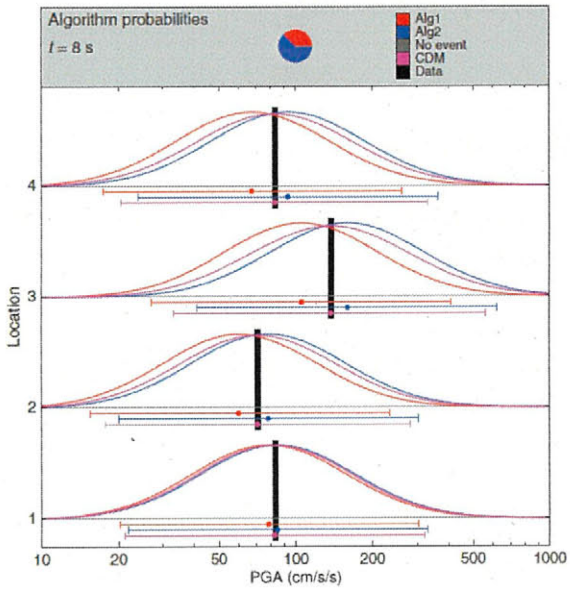
Our examples focus on ShakeAlert, the EEW system for the West Coast of the United States. ShakeAlert is designed to run multiple analyses simultaneously and then to synthesize information from these independent algorithms to issue one unified forecast of local shaking[3]. Currently, ShakeAlert receives warnings from three algorithms: (1) Onsite[6,2], Earthquake Alarm Systems (ElarmS[1,7]), and Virtual Seismologist (VS[4,5]). Each of these algorithms independently uses real-time measurements of seismic data to detect an earthquake and determine its point-source description (magnitude, location, and origin time). Collectively, these three algorithms provide a spectrum of behavior, from faster response (at the potential cost of less accurate source parameters) to more accurate source information (at the potential cost of less timeliness). We demonstrate our algorithm to combine these algorithms' results for a better EEW performance in both simulated and actual earthquake events.

Methodology

An EEW system such as ShakeAlert may operate any number of EEW algorithms, each of which produces an independent prediction of ground motion. Our goal is to combine these ground-motion predictions into a single unified shaking forecast. We accomplish this by estimating the probability that each EEW algorithm is correct, and then use these probabilities to perform model averaging under the Bayesian framework. The real-time observations of ground motions in the whole seismic network are used as a reference to estimate the ground motion prediction accuracy of each algorithm. Using the Bayesian approach, the probabilities that we want to estimate are simply the marginal likelihood in the Bayesian inference using the ground motion data. As there is no analytical solution available, we impose an approximation scheme for fast calculation, so that the algorithm is applicable to EEW in practice.

Results

The figure below shows one of the examples we performed. The x-axis shows the PGA values and the y-axis shows the probability density of PGA at four different locations. One can see that the CDM, indicating our algorithm, is able to improve the predictions given by two existing algorithms (Alg1 and Alg2).



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