Broadband ground motion simulations for the Canterbury earthquakes with nonlinear effective-stress modelling of surficial soils

Annual report, 2015 SCEC Project #15001
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Abstract
This SCEC funding provided travel support for the PI to attend the 2015 SCEC annual meeting to present on-going work related to broadband ground motion simulations of the 2010-2011 Canterbury earthquakes. This project is a multi-institutional effort with researchers from New Zealand and the USA (Rob Graves, USGS, and Brady Cox, UTexas, Austin), and has benefited greatly from interaction with SCEC researchers.

SCEC Annual Science Highlights
Ground Motion Prediction (GMP)
Ground Motion Simulation Validation (GMSV)

Technical Report
To date this project has led to the development of a new 3D seismic velocity model of Canterbury, New Zealand; as well as hybrid broadband simulation of the 10 most significant events in the sequence.

The 3D velocity model explicitly represents the Canterbury sedimentary basin, and other significant geologic horizons, which are expected to have important implications on observed ground motions. The model utilizes numerous sources of data, including 3D regional tomography with a variable-depth inferred Moho, seismic reflection survey lines, geotechnical boreholes and well logs, spectral analysis of surface waves, and CPT logs which provide velocity constraints over their respective ranges of application.

The hybrid broadband simulations utilize the method of Graves and Pitarka (2010,2015). The four largest events are represented via finite fault inversion geometry (while the slip distribution is stochastic), while the remaining utilize point sources. The high frequency stochastic method parameters have been calibrated to New Zealand active shallow crustal conditions, which are very similar to coastal California. The exemplary figure below illustrates the 4 September 2010 event, in which the two images at time increments of 5 seconds clearly illustrate: the significant forward directivity effects that develop at the eastern and western edges of the rupturing faults (t=16s); the modification of the eastward propagating directivity pulse as it encounters the Banks Peninsula volcanic region.

Exemplary Figure

Figure: Simulation of the velocity wavefield at two time instants during the 4 September 2010 Darfield earthquake. Forward directivity effects toward Christchurch and basin-generated surface waves through the city toward Pegasus Bay.
**Science Objectives**

(6e) Collaborate with the engineering community in validation of ground motion simulations.

**Interlectual merits and broader impacts**

The developed 3D velocity model makes use of numerous high quality datasets, and is the first such model developed for the region, and in fact NZ. The hybrid broadband simulations are consistent with those state-of-the-art analyses for other locations, and addresses the GMSV and EERI SCEC objectives.

**Publications**

In addition to a posters at the 2015 SCEC annual meeting, the project results to date have also been published as: