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Simulations of the 1906 San Francisco Earthquake

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Simulations of the 1906 San Francisco Earthquake

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Summary

Simulations of the Great 1906 San Francisco earthquake are being performed as part of the event's centenary. LLNL is participating in a large effort to study this event and possible consequences if the event were to happen today. This document is meant to describe our efforts to others participating in the project.

Regional Simulations of the 1906 San Francisco Earthquake

Arthur Rodgers and Anders Petersson (LLNL)

Bandwidth: 0 – 1.0 Hz

Dimensions: extent of either detailed or regional USGS cencalvm model

Discretization: ~ 25 – 250 m

Features: 3D velocity model(s)

Minimum Vs: 300 m/s

A new elastic finite difference code is being developed at LLNL. We are using this code for two broad thrusts: 1) simulate the 1906 earthquake and 2) to simulate the moderate earthquakes within the regional (“detailed”) model. The code works on a Cartesian geometry and can read in the USGS Bay Area Velocity Model (Release 05.1.0) in parallel using the software developed by Brad Aagaard. This allows a very nice flexibility to build a model on any desired computational domain or grid size.

We have used of the code simulate the 1906 earthquake. The map below shows a snapshot of the ground motion (curl of the velocity at the surface) shortly after initiation.

Simulations of moderate earthquakes will provide some tests of the model and identify elements and/or regions of the model that may be improved. The map below shows three events we have modeled along with broadband stations operated by the University of California, Berkeley. The three-component synthetics are compared to observed waveforms for the Gilroy event to station BRK (University of California, Berkeley) and

station POTR (Potrero Hills, Fairfield). The data and synthetic waveforms are filtered 0.02-0.2 Hz (periods 5-50 seconds).

Gilroy-BKS

Gilroy-POTR

Global Simulations of the 1906 San Francisco Earthquake

Arthur Rodgers and Hrvoje Tkalčić (LLNL)

Bandwidth: 0 – 0.1 Hz

Dimensions: globe or continental-scale section of the globe

Discretization: ~ 5 km

Features: 3D velocity model(s), topography, attenuation, spherical geometry

Minimum Vs: 2.0 km/s

We are using the Spectral Element Method (SEM) to provide a global perspective of the earthquake. We are simulating the available teleseismic waveforms from the event using a three rupture models (uniform; Wald et al., (1992); and Song et al., (2005)). These simulations are performed with the SPECFEM3D code developed by Komatitsch and Tromp (2002) and run on LLNL parallel computers. So far we have run the code on the MCR cluster. The simulations are quite demanding using over 1000 CPU's for up to 30 hours to capture the shear body-waves at distances up to 90°.

The global simulations are valid to 0.1 Hz. This is appropriate to model the limited bandwidth of the 1906 data (0.025 – 0.1 Hz). We will also attempt simulations on a limited solid angle of the earth for a continental-scale perspective. Preliminary analysis shows only slight differences in the teleseismic S-waves between 1D (PREM) and 3D (S20RTS+CRUST2.0) models, while surface waves show dramatic differences. There are surface wave observations at a few stations (ALB, PTR, UPP, KOB, GOT, MUN, ZIK). We are hopeful that modeling the surface waves with an accurate 3D model may be used to provide some insight into the rupture kinematics.

Map of the twelve (12) seismic stations that recorded the 1906 San Francisco earthquake.