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Running SW4 On New Commodity Technology Systems (CTS-1) Platform

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Disclaimer

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We have recently been running earthquake ground motion simulations with SW4 on the new capacity computing systems, called the Commodity Technology Systems - 1 (CTS-1) at Lawrence Livermore National Laboratory (LLNL). SW4 is a fourth order time domain finite difference code developed by LLNL and distributed by the Computational Infrastructure for Geodynamics (CIG). SW4 simulates seismic wave propagation in complex three-dimensional Earth models including anelasticity and surface topography. We are modeling near-fault earthquake strong ground motions for the purposes of evaluating the response of engineered structures, such as nuclear power plants and other critical infrastructure. Engineering analysis of structures requires the inclusion of high frequencies which can cause damage, but are often difficult to include in simulations because of the need for large memory to model fine grid spacing on large domains.

We compiled and ran SW4 on a new system, called Jade. Jade is part of a major investment in capacity computing at the DOE National Labs as part of the Advanced Scientific Computing Program. It is composed of over 2200 compute nodes with 36 cores per node. We performed scaling tests and explored various compiler options to optimize performance.

The image (below) shows a snapshot of the ground motion (magnitude of the ground velocity at the surface) from a magnitude 6.5 earthquake. The domain is 40 x 40 x 25 km with 10 m grid spacing. The material model (inset) cover a sedimentary basin contact with hard rock with the fault situated under the basin edge (white line). The model has stochastic heterogeneity to mimic the variability of wavespeeds due to geologic structure. The earthquake rupture (extending 20 km along strike and 13 km down-dip and shown as thick black line with hypocenter at green star) is based on the Graves and Pitarka (2016) method. This method was validated as part of the Southern California Earthquake Center Broadband Platform project (Dreger et al. 2015). The simulation includes frequencies up to 5 Hz. This simulation required over 40 billion grid points and ran on 2048 nodes (73,728 cores) of Jade. While not the largest simulation we have done, it represents an evolution in our ability simulate realistic earthquake ground motions.

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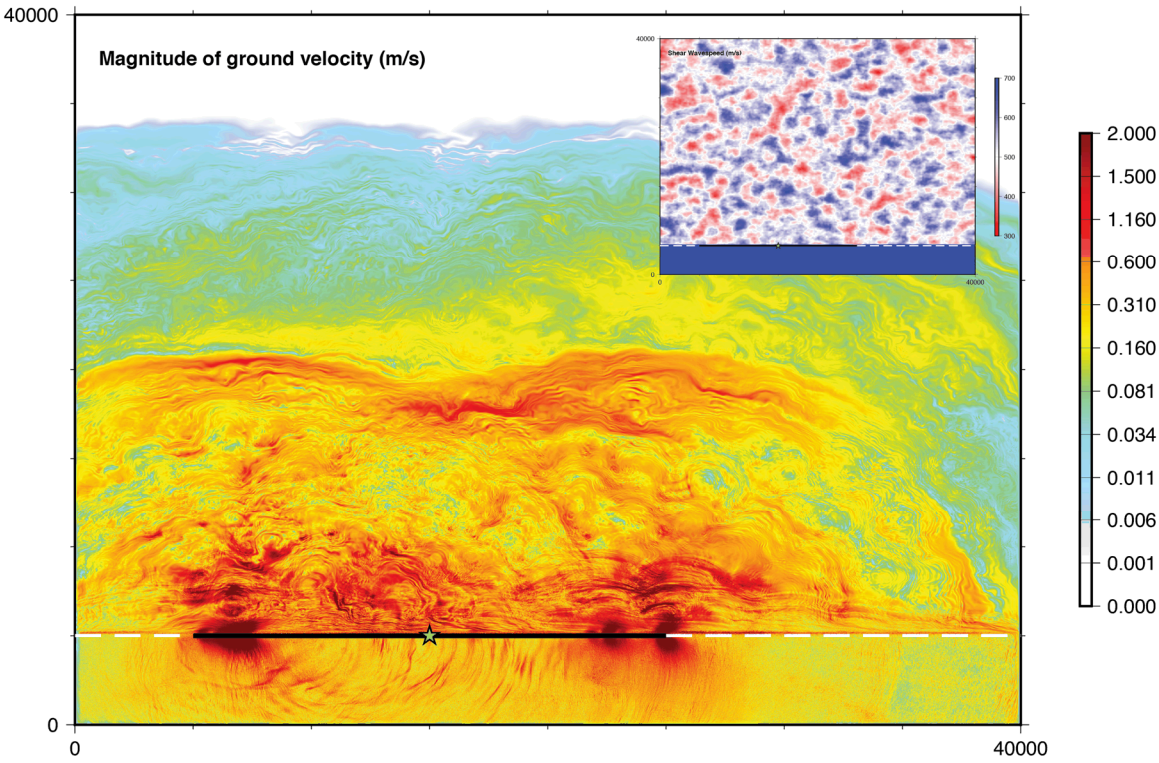
Magnitude of ground velocity (m/s)
Shear Wavespeed (m/s)
2.000
1.500
1.160
0.600
0.310
0.160
0.081
0.034
0.011
0.006
0.001
0.000
40000
0
0
40000