

Toward Petascale Earthquake Simulations

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The Southern California Earthquake Center (SCEC) conducts a collaborative, inter-disciplinary research program in earthquake system science research that makes extensive use of large-scale, physics-based, numerical modeling of earthquake phenomena.

In joint work with K. Olsen, S. Day, P. Maechling and T. Jordan of SCEC, and A. Chourasia of SDSC, we ran a set of very-large scale earthquake simulations on San Andreas Fault that we call the SCEC ShakeOut-D simulations. The ShakeOut-D exercises are coordinated by USGS to strength public awareness and readiness for “the Big One”, the next great earthquake along the southern San Andreas fault. These capability simulations were scientifically and computationally challenging for several reasons including: (1) the simulations were performed for a large (600km x 300km x 80km) geographical volume, (2) the simulations were run at high resolution (100m spacing on a regular grid resulting in 14.4 billion mesh points), and (3) in order to simulate the earthquake rupture more realistically, an earthquake description based on a dynamic rupture simulation was used as a primary input to the simulation.

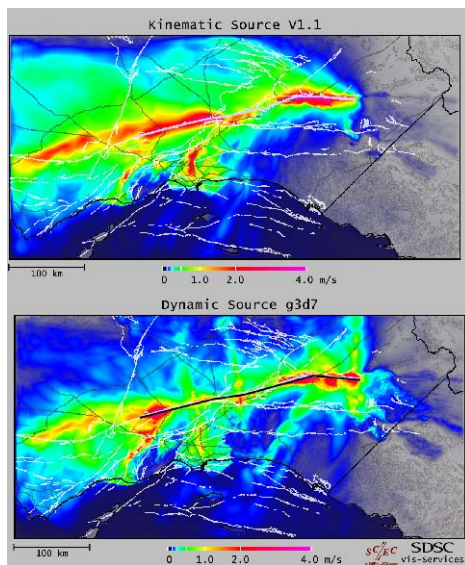


Fig 1: Comparison of PGVs for the ShakeOut-K (top) and ShakeOut-D (bottom) simulations of an Mw 7.8 earthquake on the southern San Andreas Fault. The thick black line is the simplified vertical fault representation used in the ShakeOut-D runs.

The simulations were coordinately executed on multiple TeraGrid systems, including the 504 teraflops Ranger system at Texas Advanced Computing Center. Coordination of high levels of expertise from many disciplines was required to solve the novel challenges that emerged when running the simulations at the large scales. We introduce some details of the optimization techniques that have been implemented to support the ShakeOut-D simulations, the largest and most advanced earthquake wave propagation simulations yet attempted by the SCEC research program. Algorithm adaption is used to manage different computer architectures, and transfer terabytes of simulation outputs cross supercomputer sites. The archival was registered to SCEC digital library at SDSC, managed through the latest SDSC data management tool called iRODS. Thousands of images were created by color mapping the data then overlaying contextual information like freeways, fault lines and topography. The visualization movies are available at <http://visservices.sdsc.edu/projects/scec/shakeout>.

References

- [1] Cui, Y., Moore, R., Olsen, K., Chourasia, A., Maechling, P., Minster, B., Day, S., Hu, Y., Zhu J., Jordan, T. (2008), Toward Petascale Earthquake Simulations, *Acta Geotechnica*, DOI 10.1007/s11440-008-0055-2, Springer.
- [2] Olsen, K., Dalguer, L., Day, S., Cui, S., Zhu, J., Cruz, M., Roten, D., Mayhew, J., Maechling, P., Jordan, T., ShakeOut-D (2008), Ground motion estimates using an ensemble of large earthquakes on the Southern San Andreas Fault with spontaneous rupture Propagation, *submitted to GRL*.