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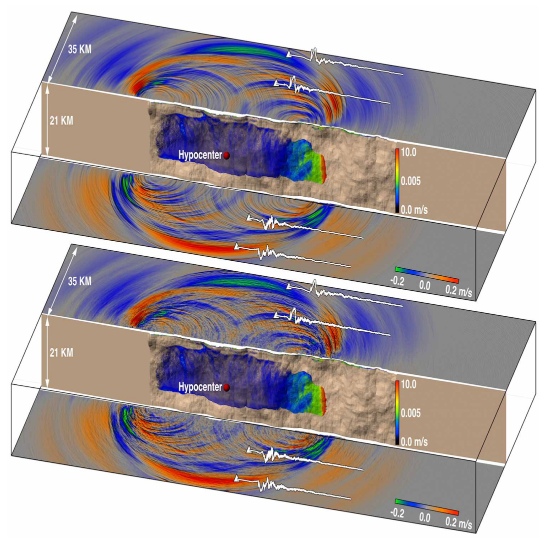
SDSC Researchers Win NVIDIA's 2015 Global Impact Award

Yifeng Cui cited for GPU-Powered earthquake simulations

Researchers at the San Diego Supercomputer Center (SDSC) at the University of California, San Diego, are the recipient of NVIDIA's 2015 Global Impact Award for their collaborative work in developing an accelerated GPU (graphics processing unit) code to simulate earthquake physics necessary for safer building design.



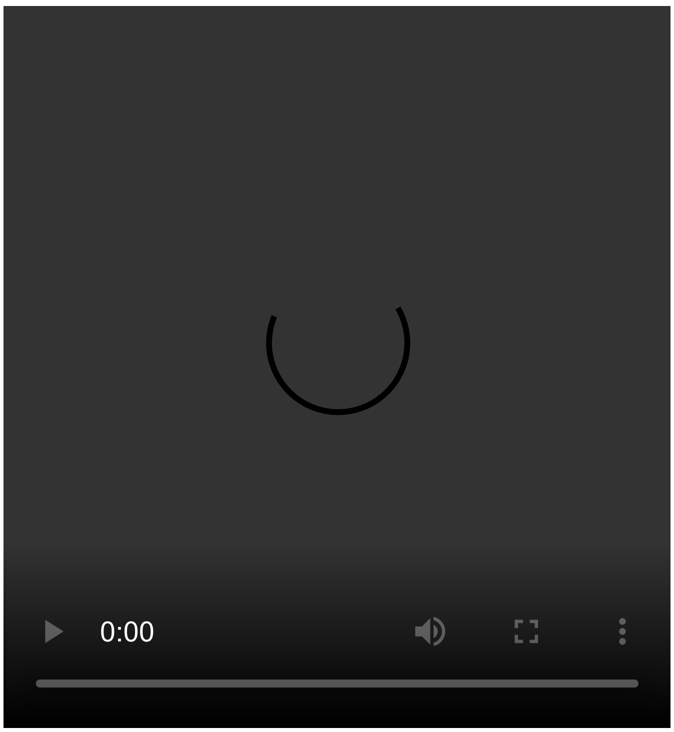
Snapshots of 10-Hz rupture propagation and surface wavefield for a crustal model without (top) and with (bottom) a statistical model of small-scale heterogeneities. Simulations done using NCSA's Blue Waters and ORNL's Titan supercomputers. Image courtesy of Yifeng Cui, Efecan Poyraz (SDSC); Kim Olsen, Steven Day, Kyle Withers, Zheqiang Shi (SDSU); Phillip Maechling, Thomas Jordan (USC). Visualization by Amit Chourasia (SDSC).

Computational Scientist Yifeng Cui and his team, working in collaboration with the Southern California Earthquake Center (SCEC), developed the code to create highly detailed simulations of high-frequency seismic waves in the range of 0-10 Hertz as they propagate through the earth.

"Substantially faster and more energy-efficient earthquake codes are urgently needed for improved seismic hazard analysis," said Cui, who joined SDSC in 2001. Cui is currently director of SDSC's High Performance Geocomputing Laboratory and an adjunct professor with the Department of Geological Sciences at San Diego State University (SDSU).

"We are delighted that NVIDIA has recognized Yifeng and his team for their outstanding development work," said SDSC Director Michael Norman. "SDSC has a long history of supporting advanced earthquake simulations. As part of the large collaboration coordinated by SCEC, Cui and his team created earthquake simulations for multiple San Andreas Fault quake scenarios from 'TeraShake' and 'ShakeOut-D', to a record quake simulation called 'M8' that made headlines for Yifeng and his team in 2010. That milestone calculation was a finalist for the prestigious Gordon Bell prize."

The NVIDIA's Global Impact Award is an annual grant of $150,000 for groundbreaking work using NVIDIA technology that addresses social, humanitarian, and environmental problems. The award comes on the heels of a recent report by the U.S. Geological Survey (USGS) saying that scientists not only believe that California will be rocked by a strong earthquake in the next 30 years, but that the risk of a "mega-quake" such as the one Cui and his team simulated in 2010, is more likely than previously thought.



Animation of the wave propagation during a simulated Magnitude 7.8 earthquake rupturing the San Andreas Fault from southwest to northeast. Red/blue colors reflect the intensity of shaking; green indicates areas of permanent ground deformation. The three colored vertical "signals" show the evolution of seismograms at those locations. Simulation done using NCSA's Blue Waters supercomputer. Image courtesy of Daniel Roten, Yifeng Cui (SDSC); Kim Olsen, Steven Day (SDSU). Visualization by Daniel Roten (SDSC).

Cui was cited by NVIDIA for a more recent collaboration involving SCEC and SDSU in which his team achieved petaflop-level earthquake simulations using GPUs. The highly-scalable code promises to cut both research times and energy costs in simulating seismic events for use in earthquake engineering and disaster management.

This code, known as AWP-ODC and originally developed by Kim Olsen and Steven Day at the Department of Geological Sciences at San Diego State University, is used by SCEC to simulate how earthquakes make the ground move, and is a breakthrough for predicting ground motions that affect small homes and structures, which are vulnerable to high-frequency shaking. Large structures such as skyscrapers and highway overpasses are more vulnerable to long period shaking.

This past year, Cui and his collaborators, using the *Titan* supercomputer at Oak Ridge National Laboratory's Leadership Computing Facility, simulated a 7.2-magnitude quake using a complex geometry representative of the San Andreas Fault. Their code broke scientific and technical barriers, providing scientists for the first time with the ability to simulate ground motions from large fault ruptures with frequencies as high as 10 Hertz in a physically realistic way. The AWP-ODC code ran an estimated 5X faster on NVIDIA GPUs than it would have on traditional architecture.

SCEC researchers are using the GPU-accelerated AWP-ODC code to calculate probabilistic seismic hazard models for California. Calculations for those models require many earthquake simulations, so they are particularly compute-intensive.

“With more people moving to cities in seismically active regions, the economic risks from a devastating earthquake are high and getting higher,” noted Cui. “The GPU capabilities, combined with the high-level GPU programming language CUDA, provide the tremendous horsepower required for acceleration of numerically-intensive 3D simulation of earthquake ground motions. For California, it makes feasible a statewide, high-frequency seismic hazard model that is needed by building engineers, urban planners, and disaster response teams.”

“The full three-dimensional treatment of seismic-wave propagation has the potential to improve seismic hazard analysis models considerably, and that is where the accelerating technology is particularly helpful at this moment,” added Thomas Jordan, director of SCEC. “We may never be able to predict the impending occurrence of extreme earthquakes with any certainty, but we do know that earthquakes cluster in space and time, and that earthquake probabilities can locally increase by a thousand-fold during episodes of seismicity. With GPU computing power we’re gaining insight as to how the ground will move in high-risk areas, and how we can better plan for the aftermath of a major event.”

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