Researches Create Largest-Ever Storm Prediction Model to Simulate Hurricane Sandy Using ‘Blue Waters’ — NCSA’s Cray® XE6™ Supercomputer

Situation
The devastation caused by Hurricane Sandy and other super storms like it signals the need for further advances in the accuracy and reliability of numerical weather prediction. While advance warning allowed millions of people to seek shelter from the hurricane that hit the northeast of the United States in October 2012, significant potential still exists for greater accuracy in predicting landfall time and place, as well as expected wind and water damage.

High-resolution numerical weather simulations carried out on hundreds of thousands of processors on the largest supercomputers can provide these insights, as they allow for a time-to-solution speed previously unimagined. Thus, progressively more accurate parameters can be incorporated into current storm models.

Challenge
For their simulation, the team wanted to use as much of the Blue Waters system as possible while also simulating a meteorologically significant event. With Hurricane Sandy as the focus, they designed the largest storm prediction model yet using real data to simulate the landfall of the super storm.

Previous extreme-scale WRF experiments involved idealized simulations on a dry atmosphere using a 4486 by 4486 by 100 grid size with 2 billion grid cells and a 5 kilometer horizontal resolution. Performance at that time peaked at 50 teraflops per second sustained on 148,000 cores of a Cray® XT5™ system.

For Hurricane Sandy, the team proposed to use 4 billion grid points — two times the previous number — with a horizontal grid resolution of 500 meters. Centered on the location of the storm’s eye on October 29, 2012, the team defined a horizontal grid size of 9120 by 9216 by 48 (1.4 terabytes of input) with 48 vertical levels and a 2-second time step. (The resolution was later increased to 150 vertical levels to produce finer detailed images of the storm for visual analysis.) Every six forecast hours 86 gigabytes of forecast data was written at a rate of up to 2 gigabytes per second and post-processed and displayed using the VAPOR suite of tools, libraries, scripts and sample datasets at NCAR.

About Blue Waters
Housed at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign and supported by the National Science Foundation, the Blue Waters supercomputer is one of the most powerful supercomputers in the world and the fastest system anywhere on a university campus. Scientists and engineers use the computing and data power of Blue Waters to tackle a wide range of challenging problems, from predicting the behavior of complex biological systems to simulating the evolution of the cosmos. The system is based on Cray® XE6™ and XK™ technology and uses hundreds of thousands of computational cores to achieve over 13 petaflops of peak performance.

System Overview
- System: Cray XE/XK hybrid supercomputer
- Cabinets: 288
- Peak Performance: 13 PF
- System Memory: 1.5 PB
- EX Compute Nodes: 22,640 AMD 6276 “Interlagos” processors
- XK Compute Nodes: 4,224 NVIDIA® GK110 “Kepler” GPU accelerators
- Interconnect: Gemini

©2014 Cray Inc. All rights reserved. Cray is a registered trademark of Cray Inc. All other trademarks mentioned herein are the properties of their respective owners. 20140909_V2KJL
**Results**

Through simulation of a compelling real-world problem, the team demonstrated the capability of the Blue Waters supercomputer to conduct a cloud-resolving WRF simulation over a large domain at a very fine spatial resolution. Using 13,680 nodes (437,760 cores) of the Blue Waters system, researchers achieved a sustained rate of 285 teraflops while simulating an 18-hour forecast.

Performance characterizations of the WRF code on the Blue Waters revealed several opportunities for optimization at the source code, run time, and operating system layers. Most of these discoveries only became salient at the scale of the new Blue Waters machine, and thus represent the next generation of benchmarks by which future supercomputer architectures will be judged and procured. These practices were documented for dissemination to the WRF supercomputing community at large.

The model accuracy for predicting such key output fields as rainfall, pressures, wind speeds, and storm track was graphically validated against actual atmospheric measurements from the storm using NCAR’s Vapor software suite. The new scientific discoveries made by the simulations of Hurricane Sandy support the need for increased resolution in these models, along with architectures such as the Cray Blue Waters system, where such codes map exceptionally well.

**About Cray**

Cray is a global supercomputer company that develops highly advanced computing, high-performance storage and data analytics technologies for the world’s most complex challenges. Using Cray solutions, scientists and engineers at labs and enterprises from small research groups to Fortune 100 companies are achieving remarkable breakthroughs in everything from vehicle safety today to energy creation tomorrow.

**Reference**


**Acknowledgment**

This research is part of the Blue Waters sustained petascale computing project, which is supported by the National Science Foundation (award number OCI 07-25070) and the state of Illinois. Blue Waters is a joint effort of the University of Illinois at Urbana-Champaign and its National Center for Supercomputing Applications.