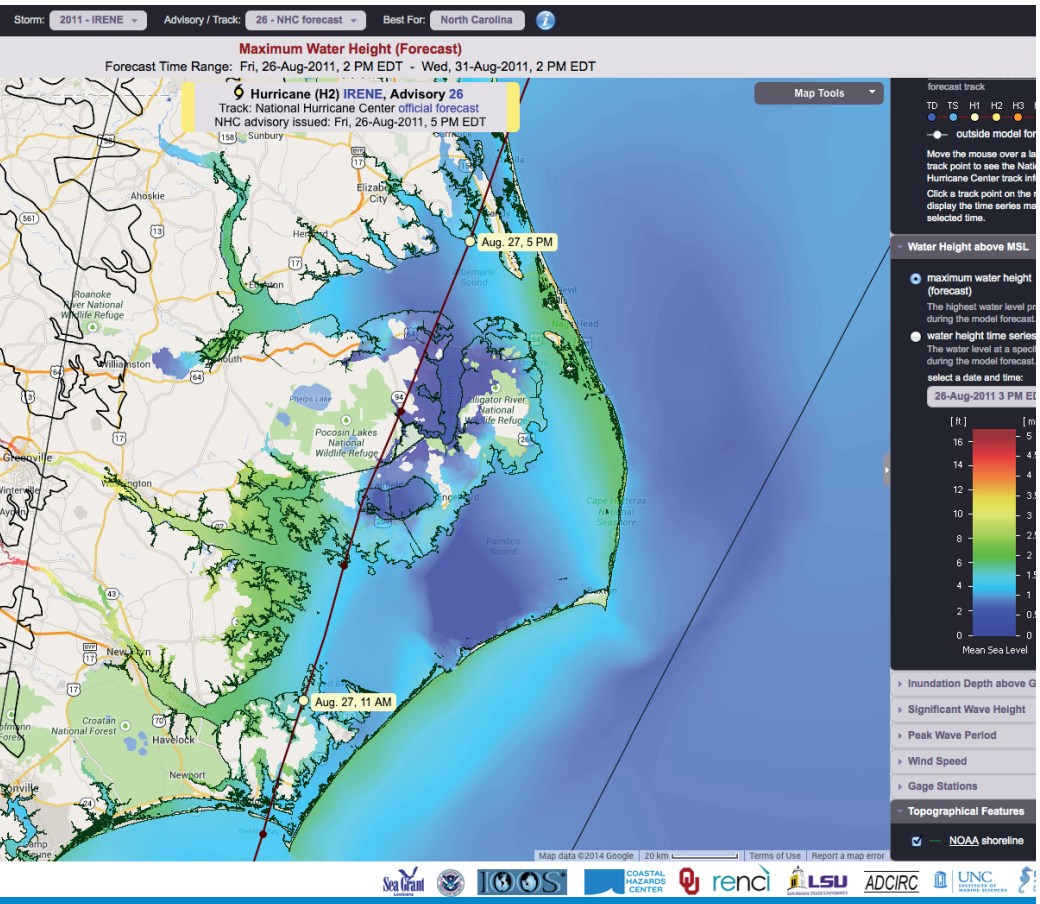
Predicting hurricane storm surge and waves precisely

The Renaissance Computing Institute builds a new high-performance computing (HPC) cluster to quickly generate better intelligence about coastal hazards and risk



"We will be able to provide the additional information that the National Hurricane Center can use in their decision making and forecasting processes with the new Dell-based Hatteras HPC cluster."

Brian Blanton, Senior Research Scientist at RENCI

Customer profile

Company	Renaissance Computing Institute (RENCI)
Industry	Higher Education
Country	United States
Employees	70
Website	www.renci.org

Business need

RENCI wanted to upgrade its HPC cluster to give customers more comprehensive, detailed hurricane-driven storm surge assessments based on multiple computer model simulations.

Solution

The institute deployed a new cluster — based on Dell PowerEdge compute and networking technologies — that runs computations for hurricane wind waves and storm surge.

Benefits

- Computing a larger number of storm surge forecast ensembles
- Providing better intelligence to the National Hurricane Center
- Producing high-resolution models of potential storm surges in less than three hours
- Cutting infrastructure costs
- Adding capacity to HPC cluster quickly and easily

Solutions at a glance

- High-Performance Computing
- Networking
- Server

When hurricanes bear down on the coast of North Carolina, it is essential that storm surge forecasters at the National Hurricane Center in Miami, Florida — and local and regional emergency managers — have as much high-fidelity information as possible. Their forecast guides storm surge predictions and warnings used to inform the public (citizens, emergency managers, and decision makers) about potentially hazardous water levels and wave heights.

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>
> *Brian Blanton, Senior Research Scientist at RENCI*

Getting the most detailed storm surge information and data to forecasters is one of the goals of the Renaissance Computing Institute (RENCI). Part of the University of North Carolina at Chapel Hill, RENCI is a collaborative effort between UNC–Chapel Hill, Duke University and North Carolina State University. The institute, which uses high-performance computing (HPC) to develop and deploy advanced technologies, focuses on providing computations such as storm surge data to customers including the National Hurricane Center and FEMA. "We help customers manage risk, particularly in relation to storm surge and wind waves that cause coastal erosion, property damage and loss of life," says Brian Blanton, a senior research scientist at RENCI. "We provide methods for visualizing storm surge risk analysis, so forecasters can better and more accurately predict the impact of storm surge and waves."

Growing needs for comprehensive, high-resolution data

Perhaps the biggest challenge for RENCI is getting storm surge data to customers as quickly as possible. For example, the typical forecast cycle is six hours long, meaning that federal forecasting operational centers, like the National Centers for Environmental Prediction — a key supplier of meteorological forecast data to the National Hurricane Center — publish their meteorological forecasts every six hours.

To be effective and relevant, RENCI's storm surge prediction system needs to complete its analysis as soon as possible after the official forecast time. Coarse storm surge models run in minutes, but RENCI's modeling system resolves small but important details of the coastal region, and hence takes longer to complete. Due to the high-resolution simulations, RENCI generally completes its analysis in three hours. "If we take any longer than that, whatever information we're computing isn't valuable because it is no longer relevant to decision making," Blanton says.

RENCI also needs to provide uncertainty estimates of the forecast, so "We run a small ensemble of forecast storm tracks that look at the uncertainty in the mean of multiple storm tracks," says

Products & Services

Hardware

- Dell Networking MXL switches
- Dell Networking S4810 switches
- Dell PowerEdge M1000e blade enclosures
- Dell PowerEdge M420 blade servers with Intel® Xeon® processors
- Dell PowerVault MD3660f Series storage arrays

Software

- Simple Linux Utility for Resource Management open-source software (SLURM)

Blanton. "We then derive probabilities of exceedance for coastal storm surge levels and storm surge predictions based on the ensemble results. The more ensemble members we can compute, the more robust storm surge predictions will be."

Additionally, RENCI strives to give its customers statistical hazard assessments at high spatial resolution. "We want to offer very detailed maps of real-time coastal hazards," says Blanton. However, this requires a substantial amount of high-performance computing resources. "Providing very high resolution and precise results comes at an extremely large computation cost," Blanton states.

To meet its customers' requirements for storm surge data, RENCI needed to implement a cost-effective HPC solution.

RENCI builds a high-density, efficient HPC cluster based on integrated and validated Dell technology

For several years, RENCI has used an HPC cluster based on Dell hardware. When it wanted to upgrade that cluster, it looked to Dell once again. "Dell is a very good partner with the University of North Carolina," says John McGee, the director of Cyberinfrastructure at RENCI. "Close to 90 percent of the servers and networking switches we have are Dell. And when you look at the total cost of ownership, the manageability and reliability of the systems, and the support, it's obvious why we stay with Dell."

RENCI created a new HPC cluster called Hatteras that is based on Dell PowerEdge M1000e blade enclosures and PowerEdge M420 blade servers. Each blade server includes two 8-core Intel® Xeon® E5-2400 processors and 96GB of RAM, and the cluster's enclosures each contain 512 cores. The cluster is supported by an InfiniBand FDR/Ethernet 10/40GB interconnect, and includes Dell PowerVault storage arrays and Dell Networking switches.

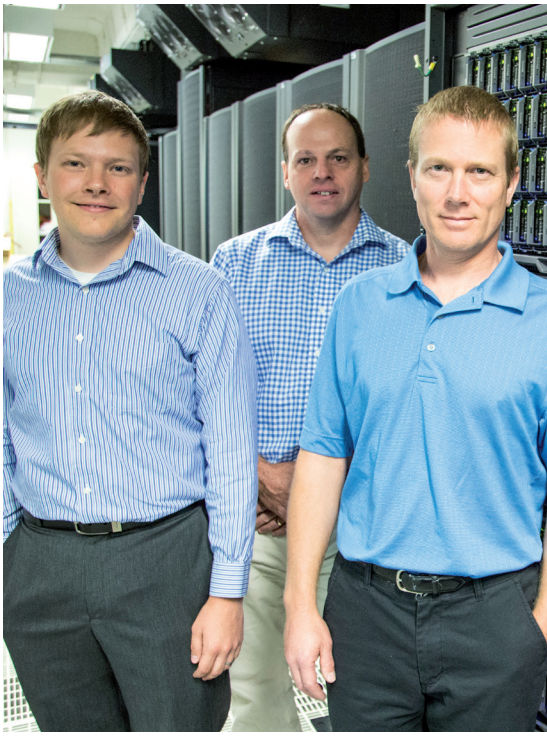
The Hatteras cluster also uses Simple Linux Utility for Resource Management (SLURM) open-source software to manage workload on the cluster. The integrated hardware, networking, and software is tested, validated, and optimized by Dell to ensure the best possible results.

RENCI chose the hardware and architecture for the Hatteras cluster because of their performance, density and efficiency. "The modeling that is being done on the cluster works very well at 512 cores and less," says Casey Averill, Cyberinfrastructure manager and lead administrator at RENCI. "Because of the collaborative work we support, we chose not to build a larger cluster. Instead, we're buying 512-core chunks, and there is plenty of RAM per core." RENCI also chose the solution because of its close strategic relationship with Dell. "Dell has been great about letting us see what's on the horizon," Averill says. "If we didn't know in advance about the quarter-height blades, for example, we might have looked elsewhere. With Dell, we know what's coming six months down the road."

RENCI uses the cluster to run numerical models for rainfall, winds, waves, and storm surge, generating multiple ensembles and delivering them to customers through the Coastal Emergency Risk Assessment website. In addition to the storm surge computations, the Hatteras cluster is also supporting genomics researchers who process large-scale serial jobs.

Delivering more comprehensive storm surge data to national forecasters

RENCI is using its Hatteras HPC cluster to create more complete storm surge modeling. "We can now run a more fully populated statistical representation of a hurricane's track evolution, and that gives us the ability to build more high-resolution ensembles," says Blanton. "With only two or three ensembles, you don't have enough information for stable statistics. What we'd like to do is run 25 or even 50 ensemble



From left to right: Casey Averill, Brian Blanton, and John McGee

assessments, and we can get to that point with this cluster."

With the ability to produce more forecast ensembles, the institute can help its customers better assess storm surge risks. "We're trying to build relationships at the federal level and provide additional guidance during potential hurricane landfall events," says Blanton. "So the more collaborative partnerships we have, the easier it is to talk with the National Hurricane Center about uncertainty within a given forecast, which is one of the things that drives that organization. We will be able to provide the additional information that the National Hurricane Center can use in their decision making and forecasting processes with the new Dell-based Hatteras HPC cluster."

Producing higher-resolution images in less than three hours

The institute can take advantage of the new cluster's capabilities to produce higher-resolution storm surge predictions than before. "The National Hurricane Center runs a well-tested and fast storm surge model, where they can run a storm surge forecast on one processor in a few minutes," says Blanton. "Our model explicitly resolves small-scale features that control the hydraulics of storm surge, but it needs hundreds of processors to run at high resolution as fast as possible."

Additionally, the institute has a better ability to deliver models in a shorter time frame. "With the new HPC cluster, there is a higher throughput and our storm surge models do very well at fewer than 512 cores. We can definitely meet the three-hour window that makes the information useful for decision makers," says Blanton.

Saving money on infrastructure costs

When the institute created the Hatteras cluster, it was able to save significant costs. "Clusters we've purchased in the past have had full InfiniBand fabric connecting all the nodes, because we had some users wanting to run wide simulations," Averill says. "But the storm surge jobs are using fewer than 512 cores, so it was convenient for us to just use one fabric per chassis." The reduction in cabling and switching also means RENCI spends less time on maintenance. "We don't have to worry about managing expensive high-speed connections across the chassis," says McGee. "Personnel costs related to that can get out of control quickly."

RENCI has also reduced costs by using the Dell Networking solution. "We would have had to replace the entire chassis to get to the 10-gigabit level if we didn't use the Dell Networking S4810 switches," says Averill. "No other switches give us 48 10-gig ports for the price."

With its cost savings, the institute was able to increase the size of the cluster without having to increase the overall cluster footprint.

Easier to add capacity to the cluster

RENCI can now easily upgrade the Hatteras cluster when it needs more compute power. "The ease of adding units to this cluster is way beyond what we've had in the past, due to the modular nature of the Dell server and networking technologies," says Averill. "We recently added another four blade chassis, and we had them up and running within a day. Previously, with a fully InfiniBand-connected cluster, we would have had to have an outage on the system and it would have been more challenging to add capacity. And with the density of this solution, we can fit a 640-way InfiniBand-connected supercomputer in a single 10u chassis. In the past, high-performance computing was only possible through the use of multiple racks in a large data center. But now, we can have a very powerful HPC cluster in a single unit with the Dell solution, which is amazing."

The institute will likely use its new capabilities to expand its HPC opportunities. "As systems continue to advance and blade chassis add more cores, the HPC world is really going to grow," says McGee. "We've already gone from 512 to 640 cores in a single bladeenclosure. The opportunities are great in the future in terms of broadening the reach of HPC, especially given the growth in ensemble-based solutions with applications that work very well at hundreds of tightly coupled cores."

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