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Supercomputer will help researchers map climate change down to the local level

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An advance guard of 18-wheelers is scheduled to roll into a business park in Cheyenne, Wyo., this week to unload components of a supercomputer called Yellowstone. This 1.5-quadrillion-calculations-per-second crystal ball will model future climate and forecast extreme weather.

“It’s a big deal,” said climate scientist Linda Mearns of the National Center for Atmospheric Research in Boulder, Colo. Yellowstone will help researchers calculate climate change on a regional, rather than continental, scale. With a better grasp of how warming may affect local water resources, endangered species and extreme winds, local and state governments will be able to plan more effectively.

Marika Holland, chief scientist for NCAR’s Community Earth System Modeling Project, said the new supercomputer is “close to a game-changer. We’ve had incremental improvements in our computational resources over time, but . . . Yellowstone is a whole new scale, and there are things that we will be able to explore that just were not possible before.”

As climate models become more complex and detailed, limited computing power bottlenecks the research. Broad-brush models use less power, but they often cannot consider details that drive local climate, such as complex coastlines or the mountain ranges and valleys that affect rainfall. Researchers refer to this as a problem of “model resolution.”

“If you have an old digital camera that doesn’t have as many megapixels as a new one, you want to get that [new] camera because it takes sharper pictures, and you can store a lot more pictures on it,” said Richard Loft, a director in the computing lab at NCAR.

“It’s the same thing with Yellowstone. We’ve increased our ability to generate more-detailed pictures of the climate system, so we get a sharper, crisper view of things.”

Seven-square-mile ‘pixels’

Yellowstone will be able to generate climate projections for seven-square-mile “pixels,” instead of the 60-square-mile units typically in use now. “We’ve already had the model resolution to confirm the warming of the planet but not to talk about the winners and losers at the regional scale,” Loft said.

The new computer will cost about $30 million; it will be operated by NCAR, which is funded by the National Science Foundation. And just like your own computer, it is likely to be obsolete and ready for replacement by a faster model in about four years.

Yellowstone and its successors will allow modelers to provide a more reliable range of possible answers for local climate questions: How dry will it be by mid-century, say, in the watersheds that feed the Prettyboy and Loch Raven reservoirs, which supply much of Baltimore’s water? How high will summer heat spike in the Shenandoah Valley? Where can Florida panthers and loblolly pine, a major source of timber, survive as the climate shifts?

“Many climate scientists out there are itching to be able to do higher-resolution simulations and more experiments,” Holland said. “One of our working groups has strong links with water resource managers and water utilities. For them, models of sea-level rise, vegetation, snowpack, precipitation and stream-flow changes are all important. Those planners are living with the uncertainty of how climate changes are going to occur.”

Mathew Maltrud of the Los Alamos National Laboratory in New Mexico runs climate models that try to mimic the physics of rivers, vegetation and atmospheric moisture, sea ice and ocean currents.

“We’re moving into a realm where we have models that resemble the ocean, the atmosphere, the ice and the land to a high degree,” he said. Yellowstone will allow those components to interact more realistically.

“For example, what’s going to happen in the southwestern U.S.?” Maltrud asked. “Wetter? Drier? The models out there right now show a lot of agreement on global change, but when it comes to regional scales, there’s lots of variability. We hope to get far better representation of precipitation, which is definitely key for decision-

makers. That could have a very large impact on understanding regional changes all over the world."

The dinosaurs' fate

Several modeling efforts intended to provide data for local and regional planners that are already underway may benefit from additional computing power.

Adam Terando, climate change research coordinator at North Carolina State University, is incorporating climatic factors into regional modeling as part of a federal effort to "make climate-change data more useful and relatable for decision-makers," he said. His research also tries to prophesy a range of future climatic changes that could affect agriculture in the eastern United States: frost days, heat stress and the length of growing seasons.

Those decision-makers "need to know: How is climate change going to affect my wildlife refuge on the coast of North Carolina, or Virginia?" Terando said. The Southeast, for example, has high numbers of amphibian species. The amphibians are reliant on the little puddles that form in the winter and spring called vernal pools, where they hatch their young.

"If the water table changes, how will it affect them?" he asked. "We're talking to these people already. They know they need to be doing planning now, not just for the next 10 years, but for the next 30 or 50 years, and beyond."

Yellowstone will also allow researchers to produce climate snapshots with intervals of hours rather than days; such detail is difficult now because of limited data storage capacity. "That fine step is really what the folks that I work with — the ecologists and biologists and all the resource managers — really need," Terando said, "because that's much more useful for figuring out how climate change could affect different plants and animals."

Loft has been most concerned about projections that raise the possibility of severe drought through the central and southwestern states and in Turkey and Spain — far worse conditions than the drought that has caused water rationing and the liquidation of cattle herds in Texas.

"Would you rather go to a doctor who tells you what you want to hear, or what's really going to happen?" Loft asked. "Not everybody has the same answer to that, I guess. I'd like to know. And this machine's going to help us know more about how bad climate is, as a threat to human civilization, and I think that's a good thing.

“Dinosaurs didn’t have any technology to know something was coming, so they just woke up one day and found out that the planet was destroyed. But if we can know about it 30 years before it happens, and do some things to cope with it, we can still mitigate the impact on human beings,” he said.

Nash reports on climate science and teaches journalism at the University of Richmond.