4. RESEARCH:

Tailored computers could improve climate models, researchers say

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To build better climate models, researchers are designing better computers, ones specifically tailored to the job of tracking how the planet's oceans, clouds and air will change over the coming century.

The goal is to improve forecasts and cut through some of the uncertainty around global climate simulations, particularly since the planet is in flux from rising greenhouse gas emissions. In the most recent assessment report from the Intergovernmental Panel on Climate Change (IPCC), researchers concluded that humanity has a 95 percent likelihood of driving current climate changes (***ClimateWire***, Sept. 27).

But predicting just how this will affect the planet is a much tougher challenge. Most climate simulations break the planet up into 100-by-100-kilometer squares, a scale that's too big to accurately include some important climate forcers, namely clouds, and glosses over important atmospheric activities like storms.

The coarse resolution is a product of not having enough data to look at the atmosphere at finer scales, as well as hardware limitations. Climate models have to run calculations involving rainfall, temperature, human emissions, seasonal air currents and sea levels spread over the entire planet.

This is a daunting task left to some of the most powerful supercomputers in the world, and even then, the calculations take a long time and soak up a lot of energy running on these massive, power-hungry machines that can devour more than a megawatt of electricity running at full tilt.

As a result, scientists are exploring the principle of co-design to improve climate modeling, developing computing hardware and software at the same time with the same goals in mind. With customized machines, researchers expect they can do more with less.

Michael Wehner, a staff scientist at Lawrence Berkeley National Laboratory and a lead author of the climate projections chapter in the latest IPCC assessment report, noted that researchers have recently managed to resolve climate models down to 25 kilometers.

"What we get from that is much better extreme weather. The storms look like real storms, whereas at 100 kilometers, they don't," he said. "What we're getting there is some enhanced realism, but we're not all the way [there]."

Going the way of portable DVD players

The target is to get a simulation that can track the planet in 1-kilometer squares, a scale that can yield meaningful forecasts for policymakers and planners in adapting to climate change and mitigating its effects.

However, the 25-kilometer calculations pushed some of the most advanced supercomputers to the brink, so higher resolution number crunching would be too slow to be useful. "There isn't any machine we can do this on and get a turnaround time where we can actually do meaningful science," Wehner said. "We need to simulate 1,000 times faster than real time."

This problem led Wehner and his colleagues to investigate how they could tune a computer to run these programs more efficiently and quickly. The researchers sketched out Green Flash, a supercomputer design that could reach peak speeds 200 times that of Hopper, the current champion supercomputer at Lawrence Berkeley.

The performance gains come from what the new computer adds on as well as what it subtracts. "The path to efficiency is to reduce waste," Wehner said, observing that most of the features on a standard supercomputer remain unused in these climate simulations, which adds unnecessary upfront purchasing costs, energy expenses and maintenance outlays.

"Not too long ago, to be able to watch an entire movie on your laptop was a pretty incredible thing without running out of battery, but you could buy those little portable DVD players that you could watch a whole movie, no problem," explained

David Donofrio, a computer engineer at Lawrence Berkeley, as an analogy. "It's smaller, lighter than your laptop. But that's all it does, watch movies."

Green Flash, Donofrio added, is moving in a similar direction with high-performance computing, but still retaining enough flexibility to alter climate programs and simulations. The result is a pared-down, specialized machine that yields maximum computing horsepower for understanding changes in temperature, rainfall and seasonality around the world.

But other computer specialists are skeptical.

'More than plugging in numbers'

"Within a narrow definition, the idea has merit," said Dave Turek, vice president of advanced computing at IBM. "Yes, you can optimize some narrow piece [of computation] quite dramatically, but the question is what you've accomplished in the bigger picture."

Turek said running a supercomputer is more than plugging in numbers; the entire workflow for running simulations, from crafting algorithms to harvesting results, can be very time-consuming. Each step in the process can become a bottleneck, so simply speeding up the calculations won't have a big benefit.

Co-designed specialty supercomputers may use less energy and cost less on an individual basis, but national laboratories need to do more than track climate change on their computers. Building specialty computers for each simulation, from astrophysics to nuclear reactors, would in aggregate end up using more energy and become more expensive than a general-purpose machine, according to Turek.

Custom computers are also harder to market and maintain, since there are so few of them, leaving the user on the hook when something goes wrong. "By and large, our customers actually don't want to fool around with computers," Turek said. "They want to do the science and leave the computers to us."

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