To understand climate change, we need to understand weather now

January 23 2019, by Kayla Zacharias

Dan Chavas, an assistant professor of earth, atmospheric and planetary sciences, is working to close the gap between the physics of extreme weather and what we experience in the real world. Credit: Purdue University photo/Rebecca Wilcox

Climate scientists have known for decades that there's more to climate change than higher temperatures. Sea levels are rising, wildfires are blazing and droughts are diminishing water supplies across the globe.

Extreme weather events, such as hurricanes and thunderstorms, are likely to get worse as well. But in order to predict how much these storms will change in a warmer world, we need to understand how they work in the current climate.

Dan Chavas, an assistant professor of atmospheric science at Purdue University, is trying to solve that dilemma.

"When people ask how storms will change in the future, my question is, 'How well do we understand how that phenomenon works in the climate in general?'" he said. "Sometimes that intermediate step gets skipped. If you don't have a basic understanding of the relationship between climate and whatever kind of storm you're looking at, it's hard to say you could answer the climate change question."

Despite causing hundreds of deaths and billions of dollars of damage each year in the U.S., there's a lot about hurricanes we still don't understand. Location, water temperature, pressure and cloud circulation all play a role in the ultimate severity of the storm, but it isn't totally clear how they work together.

Researchers don't yet understand what sets the size of a hurricane, either. Storms can be very large or very small and have the same maximum windspeed. As an expert in the physics of extreme weather, much of Chavas' work to date has focused on what controls the size of a hurricane and how wind speed changes as a function of distance from the center of the storm.

More recently, he's started trying to determine what sets the frequency at which hurricanes form. There are about 90 tropical storms on Earth each year, but no one really knows what governs that number.

"This is a big open question in our field – we don't know why there aren't nine or 900," Chavas said. "I'm researching the formation of hurricanes to figure out why they pop up where they do, what governs the frequency, and how that varies with latitude and in general with space and time."

Chavas uses computer models to simulate storms on Earth. In his research, he often compares two versions of the planet – one that looks a lot like the actual Earth, and a highly simplified version where land doesn't exist, oceans cover the planet entirely and the sun shines the same everywhere.

In this imaginary, uncomplicated world, there are thousands of tropical cyclones.

"They have a lot of interesting properties that are potentially very relevant to the real world," Chavas said. "Like a biologist uses a mouse or a fruit fly as an experimental testing ground, we use a simplified version of the Earth. We can manipulate what happens there – make the world spin twice as fast, or make it bigger or smaller – and test theory."

For a really good estimate of how extreme weather will change in the future, researchers would need a physical understanding of how these phenomena work alongside forecast simulations – to look at both of them simultaneously and see if they match up.

But the tension between physics theory and real-world phenomena in weather and climate science makes this difficult. Many physicists work in settings that are simpler than the actual climate system, sometimes so much so that their results don't apply to the real world.

On the other hand, weather forecasting tends to be practically oriented. Many meteorologists are focused on creating accurate forecasts, and if they can do that, they see less of a need to understand the underlying physics. By bringing his research findings from the simplified world to the real world, Chavas is closing this gap.

"We can always simulate climate into the future, but it helps a lot if we have theories for understanding how weather phenomena work and how they arise in a system that extends to any climate," he said. "If we know how things will change whether the climate is 10 degrees warmer or 10 degrees cooler, or if some other aspect of the climate system is altered, then we can finally say we understand it really well."

Having the computer power to run a global climate model that resolves smaller storms became a reality only in the last decade. Climate models can predict changes in precipitation fairly well, but as they move toward hurricanes and tornadoes, these smaller-scale systems become more difficult to resolve. The models used by the [Intergovernmental Panel on Climate Change](), the United Nations body which produces regular climate change assessment reports, doesn't include tornadoes at all.

Without huge climate models to provide accurate predictions of severe weather, Chavas has turned his focus closer to home, in the Rocky Mountains.

"A hypothesis that's been floating around the scientific community for a long time says that there's a hot spot for severe thunderstorms and tornadoes over North America," he said. "The idea is that having the Rocky Mountains to the west and the Gulf of Mexico to the south creates a conducive environment for [extreme weather events]()."

If the mountains are essential for storm formation, then removing them should eliminate severe weather (so the hypothesis goes). Hypothetically, on a planet completely covered by water, there would be no severe thunderstorms.

Chavas has recently started testing these assumptions in climate models where he manipulates these features on an imaginary Earth. He hopes to publish preliminary results on this within the next several months.

"What features are essential to the formation of severe weather, and how might the magnitude of thunderstorms and tornado activity depend on aspects of the mountains, or the relationship between where the mountain and bodies of water are?" he said. "Most research to date only considers our current configuration of North American topography and land surfaces, from which we can make assumptions about how that gives rise to severe weather on Earth. But until we do experiments where we change those parameters, we won't be sure we understand these systems very well."

Provided by Purdue University