Faster-developing, wetter hurricanes to come

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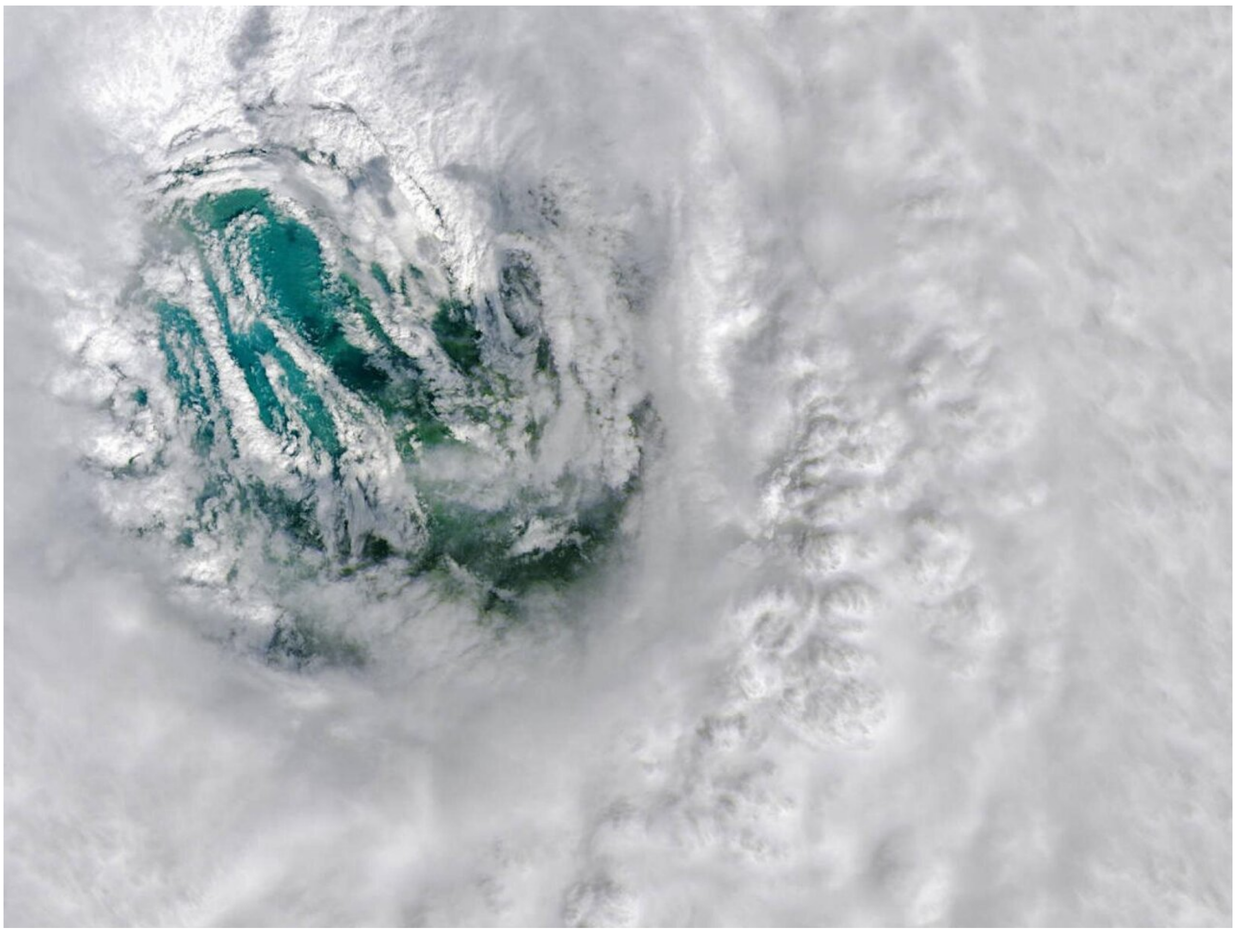

Hurricane Ian, whose wide eye is shown here, is among the strongest storms to strike the U.S. coast. New research finds that rapidly intensifying hurricanes such as Ian will develop faster and grow wetter in a future marked by continued fossil fuel reliance. Credit: NASA

In a new study, researchers at the Department of Energy's Pacific Northwest National Laboratory find that the U.S. Atlantic Coast is becoming a breeding ground for rapidly intensifying hurricanes. Fueled by environmental conditions that beget increasingly severe storms—with climate change as a root contributor—the new research finds that hurricanes are growing wetter and strengthening faster near the already hurricane-battered coastline.

Looking at data that describe the past four decades of hurricane activity and the conditions that shaped them, researchers find the rates at which hurricanes strengthen near the U.S. Atlantic Coast have climbed since 1979. Looking into a future marked by continued fossil fuel reliance, the team finds this trend is likely to continue.

A warmer world, said climate scientist Karthik Balaguru, is poised to bring hurricanes that intensify quicker and, with them, a heightened risk of flooding to the U.S. Atlantic Coast.

"Our findings have profound implications for coastal residents, decision- and policy-makers," said Balaguru. "And this isn't specific only to the Atlantic. It's happening in several prominent coastal regions across the world."

Balaguru's team found that a unique coastal phenomenon lies at the heart of the bustling hurricane activity. A mix of environmental conditions caused by this phenomenon ultimately makes the coastline more conducive to hurricane development.

The same mix of hurricane-favoring conditions doesn't appear in the Gulf of Mexico, which the team explored. But they could form in many other regions, including those near the East Asian coastline and the northwest Arabian Sea.

The new study was published today, October 17, in *Geophysical Research Letters*.

When hurricanes rapidly intensify

Some storms, like Hurricane Ian, which dealt extensive damage and is among the strongest to approach the U.S. coast, can suddenly turn severe. Supercharged by hurricane-friendly conditions like a warmer sea surface or greater atmospheric humidity, they can rapidly intensify, jumping multiple categories sometimes in short order.

Because of the speed at which they build, such hurricanes can elude the predictions of the forecasting community's best tools. That's why members of that community—Balaguru among them—are working to better anticipate and understand the conditions that drive rapid hurricane intensification.

The new study reveals that such hurricane-producing conditions are growing more common along the U.S. Atlantic Coast. The key to this changing environment, said Balaguru, begins with warming.

As global temperatures rise, Earth's surface warms. But that warming doesn't happen uniformly. Earth's surface, after all, isn't made of uniform material. Rocks, dirt, water, trees—it all warms at different rates. And land, for instance, is generally warmer than the sea.

But as greenhouse gases build, said atmospheric scientist and coauthor of the new study Ruby Leung, the temperature difference between warmer land and cooler sea grows more and more divergent.

"Unlike the ocean with unlimited water supply," said Leung, "there's much less water in soil. That means the land can't evaporate as much water, so it can't get rid of the extra heat trapped by greenhouse gases as quickly as the ocean." Indeed, global maps depicting past and future warming show the distinct pattern of land warming more than the sea. This increasingly strong difference can create stronger storms.

What's causing these faster-developing, wetter storms?

The new study describes unique, hurricane-favoring conditions that come about from this difference in warming. Over the warmer land, air pressure is lower. Over the cooler sea, air pressure is relatively higher. The higher-pressure air blows inland toward those warmer, lower-pressure areas.

Earth's rotation guides these winds in a cyclonic, twisting direction. This spinning strengthens something called "vorticity," a spinning motion of air that, in this case, happens in the lowest level of Earth's atmosphere.

This twisting motion pulls humid air near Earth's surface up into the atmosphere. Hurricanes are often described as "heat engines," continually sucking up warm, moist air and converting its energy into damaging winds. That energy comes in part from the condensation of water vapor.

As moist air rises inside the hurricane's core and cools toward the top, water vapor condenses and emits heat. The heat warms nearby air causing it to ascend further. This process invigorates the storm.

Add greenhouse gases that warm the land even more, said Leung, and you strengthen this twisting motion that pulls humid air up. A warmer sea surface—also a product of climate change—adds even more humidity.

Vertical wind shear, however, can throw a wrench into the "heat engine" by injecting dry air into the storm's core, robbing the hurricane of heat and moisture. But Balaguru's team found that this negating force has weakened on the U.S. Atlantic Coast over the past four decades, adding to the problem.

"The nearshore environment has absolutely become more favorable for hurricanes near the Atlantic Coast," said Balaguru, "and that's very consistent with the rising hurricane intensification we've observed in the region."

What role does climate change play?

The team wanted to identify what role climate change plays in shaping these hurricane-favoring conditions. They also wanted to explore how those conditions might change through the rest of the century.

Using models that depict what consequences would follow in a fossil-fuel-based world economy, the team found that the same conditions will increasingly favor storm development, bringing even greater chances of wetter, faster-developing storms through 2100.

Wind shear will weaken on the Atlantic coast. Potential intensity, which denotes the maximum intensity a storm can sustain under the prevailing conditions, will rise. Atmospheric humidity and nearshore vorticity will strengthen as well.

By averaging their results across multiple climate models, the team reduced the "noise" of natural variability within Earth's climate system. After comparing across models, what primarily remained was the clear and distinct signal of climate change.

"The spatial patterns of change we're seeing are consistent across models," said Balaguru, "and that means that what we have seen is likely related to climate change. Natural variability does play a role, but to a lesser degree."

These increasingly stark land-sea temperature differences could arise in other coastal areas. Though this research only focused on the northern hemisphere, one would expect the same thing to happen on coastlines of the southern hemisphere, said Balaguru. Because more storms occur in the northern hemisphere, he added, the effect would likely be more prevalent there.

The land-sea temperature differences hold other implications, too. "For example, they have been associated with increasing aridity over land and changing seasonality of precipitation in some regions," said Leung. "Considering the land-sea warming contrast, this study adds a new and important consequence: changes to hurricane behavior in coastal regions that could affect large populations around the world."

More information: Karthik Balaguru et al, Increasing Hurricane Intensification Rate Near the US Atlantic Coast, *Geophysical Research Letters* (2022). DOI: 10.1029/2022GL099793

Provided by Pacific Northwest National Laboratory

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