Fresh water from rivers and rain makes hurricanes, typhoons, tropical cyclones 50 percent more intense

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An analysis of a decade's worth of tropical cyclones shows that when hurricanes blow over ocean regions swamped by fresh water, the conditions can unexpectedly intensify the storm. Although the probability that hurricanes will hit such conditions is small, ranging from 10 to 23 percent, the effect is potentially large: Hurricanes can become 50 percent more intense, researchers report in a study appearing this week in *Proceedings of the National Academy of Sciences* Early Edition.

These results might help improve predictions of a hurricane's power in certain regions. Such conditions occur where large river systems pour fresh water into the ocean, such as by the Amazon River system, the Ganges River system, or where tropical storms rain considerably, as in the western Pacific Ocean.

"Sixty percent of the world's population lives in areas affected by tropical cyclones," said ocean scientist Karthik Balaguru at the Department of Energy's Pacific Northwest National Laboratory. "Cyclone Nargis killed more than one hundred and thirty eight thousand people in Burma in 2008. We can predict the paths cyclones take, but we need to predict their intensity better to protect people susceptible to their destructive power."

Most hurricanes passing over the ocean lessen in strength as the ocean water cools off due to mixing by the strong winds under the cyclone: this pumps less heat into them. However, Balaguru, his PNNL colleagues and researchers led by Ping Chang at Texas A&M University and Ocean University of China in Qingdao, China found that when enough fresh water pours into the ocean to form what they call a barrier layer, typically about 50 meters below the surface, the ocean water can't cool as much and continues to pump heat into the cyclone. Instead of dying out, the storms grow in intensity by 50 percent on average.

A rough estimate for the destruction wreaked by a hurricane is the cube of its intensity. "A 50 percent increase in intensity can result in a much larger amount of destruction and death," said Balaguru.

Heat of the Ocean

Satellites are very useful for tracking and helping to predict the path of tropical storms as they move across the ocean and develop into cyclones, as well as predicting where the storms will make landfall.

But current technology isn't as good at predicting how intense the storm will be when it does. Satellites can only see the ocean from above, but it's the ocean's heat that feeds the storm. So Balaguru decided to look at the ocean itself.

To do so, Balaguru started with one hurricane: Omar. Omar nearly topped the scales as a Category 4 storm in the eastern Caribbean Sea in October 2008, causing $79 million in damages. Balaguru and colleagues collected data about ocean conditions including water temperature, salt content, and water density, and compared that data to the intensity of the storm.

Feeding Omar

Most of the time, a tropical storm travels across the ocean, where its winds suck up heat from the ocean and builds. But then the heat loss from the water mixes the surface layer -- the warmest, least dense layer of ocean water -- and dredges up colder water from the ocean below it. The colder water cools off the surface temperature, providing less energy and lessening the storm's intensity.

It made sense that conditions that would prevent the top ocean layer from cooling off would increase the intensity of storms, so Balaguru zoomed in on Omar's conditions. As expected, the ocean surface cooled the least along Omar's path as the storm peaked in intensity.

However, when Balaguru looked at the structure of the ocean along Omar's path, he saw another layer, called a barrier layer, between the surface and the colder ocean below. Omar's most intense episodes occurred when it found itself over these thick barrier layers.

But Omar was just one storm. To determine whether the barrier layer connection was real, Balaguru looked at hundreds more tropical storms.

Insulation

Balaguru and colleagues examined 587 tropical storms and cyclones between 1998 and 2007 in the western tropical Atlantic, the western Pacific and the northern Indian Oceans.

They found that the tropical storms over thick barrier layers cooled off 36 percent less than storms over areas lacking barrier layers, and barrier layer storms drew 7 percent more heat from the ocean than other storms. That translated into 50 percent more intense hurricanes on average.

The barrier layer has this effect on storms, Balaguru said, because it insulates the surface layer from the colder water below, preventing the storm's access to cooling water. When fresh water dumps into the salty ocean, it makes the surface layer less salty, creating the barrier layer below it. When a passing storm causes the surface layer to pull up water from below, the water comes from the barrier layer rather than the much colder water beneath.

The team supported their observational analysis with a computer model, comparing tropical cyclones over regions with and without barrier layers. The model found a similar decrease in cooling by the barrier layer storms, more heat transferred from the ocean to the storm, and a similar intensification.

This work addressed what happens to hurricanes now, under current climate conditions. Scientists predict that global warming will have an effect on the ocean water cycle. Future research could explore how the distribution of the barrier layers changes in a warmer world.

More information: K. Balaguru, P. Chang, R. Saravanan, L. R. Leung, Z. Xu, M. Li and J.-S. Hsieh, Effect of Ocean Barrier Layers on Tropical Cyclone Intensification, *Proc Natl Acad Sci* U S A, Early

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