What does climate science tell us about monster storms like Hurricane Michael?

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In the record-hot Florida fall of 2018, Hurricane Michael was rabid with hidden energy absorbed from a Gulf of Mexico 4 to 6 degrees warmer than normal.

Air molecules heavy with moisture and sizzle soared on thunderstorm currents into Michael's eye, releasing latent heat—an invisible smorgasbord of fuel for the burgeoning cyclone.

Twice, the Category 5 hurricane hit warm pools in its trek toward Florida's Panhandle, downing shots of adrenaline that caused bouts of rapid intensification. One of the surges would keep the storm's engines revving right into the vulnerable shoreline, defying climatology that says hurricanes weaken as they approach the Gulf Coast.

Michael's ascent to the top echelon of tropical cyclones was solid physics, but whether the double-barreled rapid intensification events are directly tied to climate change is muddier.

Multiple factors go into creating a potent Category 5 storm like Michael.

More nuanced, and less understood, environmental machinations are needed for rapid intensification. Playing a role are warmer waters, a moist atmosphere, a defined inner core, light wind shear and a clockwise flow of air in the upper levels of the atmosphere that helps the hurricane breathe.

There are signals, however, that more Cat 4s and 5s with dangerous escalations will increase in a warming climate, a terrifying prospect for forecasters who still grapple with predicting rapid intensification.

In the past four years, the Atlantic basin has had six Category 5 storms, including Matthew in 2016, followed by 2017's Irma and Maria, 2018's Michael and this year's Dorian and Lorenzo.

"It's very, very hard to attribute any one event to any kind of external influences," said Kerry Emanuel, an MIT professor of atmospheric science, about attributing Michael's intensification to climate change.

"Most scientists feel that's not the way to go. It's too hard, it's too dicey. But we can put Michael in the context of climate change and what we are beginning to see."

Buoys analyzed by Climate Central have shown a 1 to 2 degree increase in the average water temperature in the Gulf of Mexico from August through October in the past 40 years. High temperatures have peaked near 90 degrees, with the average falling closer to 85 degrees.

In October 2018, Florida had just come off back-to-back record-warm months with September's average temperature reaching 82.3 degrees—3.2 degrees above normal. August's temperature was 82.2, which was 2.2 degrees above normal.

That kind of heat, without a fall cool front to knock temperatures down, helped keep the Gulf of Mexico at between 84 and 86 degrees, and set the stage for Hurricane Michael to prosper.

It became the latest Category 5 hurricane to make landfall in the U.S. when it drove into Mexico Beach near noon on Oct. 10.

Michael Mann, a distinguished professor of atmospheric science and director of Pennsylvania State University's Earth System Science Center, is less hesitant to link climate change to specific storms. He recently co-wrote a column for The Guardian saying that Cat 5 Hurricane Dorian was stronger than it would have been "had we not spent the past 150 years dumping carbon pollution into the atmosphere."

For every 1 degree Celsius of warming (1.8 Fahrenheit), there is a 7% increase in maximum wind speeds and a 23% increase in destructive potential, Mann said.

"So it's fair to say that storms like Dorian have been on average made

roughly 25% more destructive by human-caused warming of the planet," Mann said.

NOAA's Geophysical Fluid Dynamics Laboratory recently issued a 20-page synopsis of current research results about global warming and hurricanes.

In summary, it says sea level rise will cause higher coastal inundation levels for tropical cyclones. That means bigger waves and higher storm surge that reaches farther inland.

Hurricane Michael's surge was estimated between 9 and 14 feet at landfall with the highest inundation happening at Mexico Beach.

The intensity of tropical cyclones likely will increase on average by 1 to 10%, with more Category 4 and 5 storms, but the overall number of hurricanes will stay the same or slightly reduce in number.

Also, Emanuel said he expects the odds of hurricanes rapidly intensifying—defined as an increase in wind speeds of 35 mph or more in a 24-hour period—will increase in a warming world. According to one of his studies, a storm that intensifies by 70 mph in the 24 hours before landfall occurred about once per century in the climate of the late 20th Century.

That may occur every five to 10 years by the end of this century if climate change continues without abatement.

"We are confident we will see more rapidly intensifying storms," Emanuel said.

Hurricane Michael had at least two jolts of rapid intensification, depending on the 24-hour periods examined, said Michael Brennan,

senior hurricane specialist for the NHC.

Two are specifically mentioned in the post-mortem analysis of the storm. The first took it from a tropical depression to a tropical storm in just six hours and to a hurricane the next day. The second took it from a Category 2 hurricane at 7 a.m. on Oct. 9 to a Category 4 and then a 160 mph Category 5 at landfall.

Nick Shay, a professor of Ocean Science, and associate dean of research for the University of Miami's Rosenstiel School of Marine and Atmospheric Science, said the first rapid intensification event happened when the storm ran through a filament of water that had shed off a warm eddy in Gulf of Mexico.

The second warm pool was just off the continental shelf, Shay said.

Both pools were deeply heated, meaning Michael's churning couldn't bring up enough cool water to dull the wind speeds. Typically, storms that run over the continental shelf cause an upwelling that works to weaken the storm.

Shay said a warmer world will strengthen some of the factors that lead to rapid intensification, such as warmer water, but that science doesn't understand yet how all of the processes will work together under climate change.

"Climate change is happening, but how fast and what its relative contributions are during rapid intensity events, I don't think anyone knows that for sure," Shay said. "It's a puzzle. Some pieces fit, some don't."

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