'Brown ocean' can fuel inland tropical cyclones

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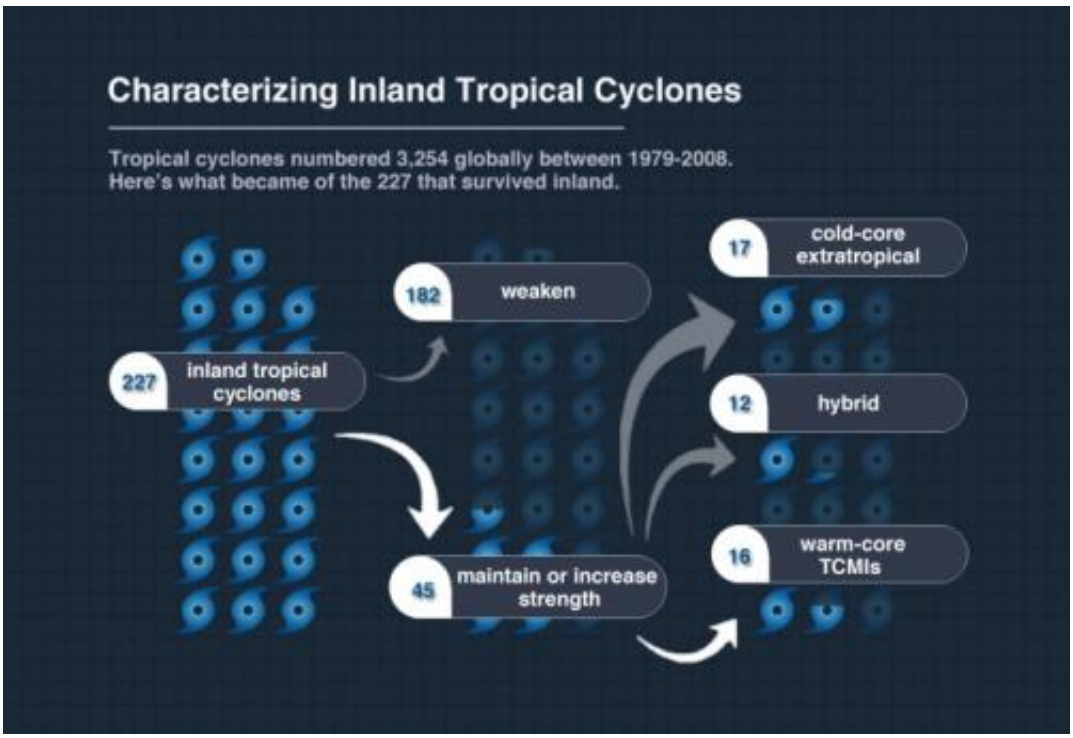


Scientists produced a schematic to categorize inland tropical cyclones, highlighting a newly described sub-category called tropical cyclone maintenance and intensification events, or TCMIs. Credit: NASA/Kathryn Hansen

In the summer of 2007, Tropical Storm Erin stumped meteorologists. Most tropical cyclones dissipate after making landfall, weakened by everything from friction and wind shear to loss of the ocean as a source of heat energy. Not Erin. The storm intensified as it tracked through

Texas. It formed an eye over Oklahoma. As it spun over the southern plains, Erin grew stronger than it ever had been over the ocean.

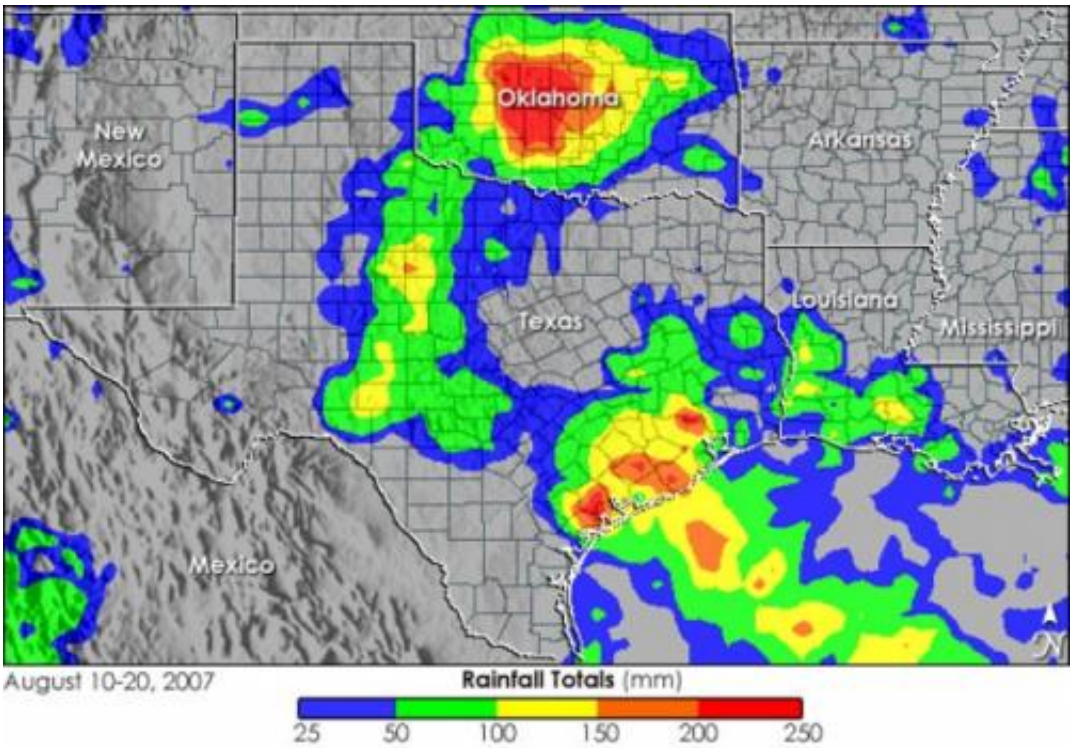
Erin is an example of a newly defined type of inland tropical cyclone that maintains or increases strength after landfall, according to NASA-funded research by Theresa Andersen and J. Marshall Shepherd of the University of Georgia in Athens.

Before making landfall, tropical storms gather power from the warm waters of the ocean. Storms in the newly defined category derive their energy instead from the evaporation of abundant soil moisture—a phenomenon that Andersen and Shepherd call the "brown ocean."

"The land essentially mimics the moisture-rich environment of the ocean, where the storm originated," Andersen said.

The study is the first global assessment of the post-landfall strength and structure of inland tropical cyclones, and the weather and environmental conditions in which they occur.

"A better understanding of inland storm subtypes, and the differences in the physical processes that drive them, could ultimately improve forecasts," Andersen said. "Prediction and earlier warnings can help minimize damage and loss of life from severe flooding, high winds, and other tropical cyclone hazards."



Tropical Storm Erin in 2007 was a warm-core TCMI, which can deliver much more rainfall than their extratropical counterparts. The newly described storm type derives energy over land from the evaporation of abundant soil moisture. Credit: NASA Goddard/Hal Pierce, SSAI

The study was published March 2013 in the International Journal of Climatology.

To better understand tropical cyclones that survive beyond landfall, Andersen and Shepherd accessed data archived by the National Oceanic and Atmospheric Administration's National Climatic Data Center for tropical cyclones from 1979 to 2008. Storms had to meet the criteria of retaining a measureable central pressure by the time they tracked at least 220 miles (350 kilometers) inland, away from the maritime influence of the nearest coast. Next they obtained atmospheric and environmental data for before and after the storms from NASA's Modern Era

Retrospective-Analysis for Research and Applications.

Of the 227 inland tropical cyclones identified, 45 maintained or increased strength, as determined by their wind speed and central pressure. The researchers show, however, that not all such storms are fueled equally.

In October 2012, Hurricane Sandy demonstrated the destructive power of extratropical cyclones—a well-studied storm type that undergoes a known physical and thermal transition. These systems begin as warm-core tropical cyclones that derive energy from the ocean. Over land, the storms transition to cold-core extratropical cyclones that derive energy from clashes between different air masses. Of the study's 45 inland storms that maintained or increased strength, 17 belonged to this category.

Tropical Storm Erin, however, is among the newly described storm category that accounted for 16 of the 45 tropical cyclones. Instead of transitioning from a warm-core to cold-core system, these storms maintain their tropical warm-core characteristics. The storm type, which Andersen and Shepherd call tropical cyclone maintenance and intensification events, or TCMIs, have the potential to deliver much more rainfall than their extratropical counterparts.

"Until events like Erin in 2007, there was not much focus on post-landfall tropical cyclones unless they transitioned," Andersen said. "Erin really brought attention to the inland intensification of tropical cyclones."

"This is particularly critical since a study by former National Hurricane Center Deputy Director Ed Rappaport found that 59 percent of fatalities in landfalling tropical cyclones are from inland freshwater flooding," Shepherd said.

While most inland tropical cyclones occur in the United States and China, the hotspot for TCMIs during the 30-year study period turned out to be Australia. The uneven geographic distribution led Andersen and Shepherd to investigate the environment and conditions surrounding the brown ocean phenomenon that gives rise to the storms.

Andersen and Shepherd show that a brown ocean environment consists of three observable conditions. First, the lower level of the atmosphere mimics a tropical atmosphere with minimal variation in temperature. Second, soils in the vicinity of the storms need to contain ample moisture. Finally, evaporation of the soil moisture releases latent heat, which the team found must measure at least 70 watts averaged per square meter. For comparison, the latent heat flux from the ocean averages about 200 watts per square meter.

Indeed, all three conditions were present when Erin tracked across the U.S. Gulf Coast and Midwest. Still, questions remain about the factors—such as variations in climate, soil and vegetation—that make Australia the region where brown ocean conditions most often turn up.

The research also points to possible implications for storms' response to climate change. "As dry areas get drier and wet areas get wetter, are you priming the soil to get more frequent inland tropical cyclone intensification?" asked Shepherd.

Provided by NASA

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