Drought, Urbanization Were Ingredients for Atlanta's Perfect Storm (Video)

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At 9:38 p.m. on March 14, 2008, a severe thunderstorm that formed just north of Atlanta caused damages across a 6-mile swath of the city as it strengthened into a tornado, barely missing the downtown Georgia Dome arena where thousands were watching a college basketball game that had gone into overtime. Credit: NOAA

On March 14, 2008, a tornado swept through downtown Atlanta, its 130 mile-per-hour winds ripping holes in the roof of the Georgia Dome, blowing out office windows and trashing parts of Centennial Olympic Park. It was an event so rare in an urban landscape that researchers immediately began to examine NASA satellite data and historical archives to see what weather and climatological ingredients may have combined to brew such a storm.

Though hundreds of tornadoes form each year across the United States, records of "downtown tornadic events" are quite rare. The 2008 Atlanta tornado -- the first in the city's recorded history -- was also unique because it developed during extreme drought conditions.

In a NASA-funded study, researchers from Purdue University in West Lafayette, Ind., and the University of Georgia (UGA) in Athens found that intermittent rain in the days before the storms, though providing temporary drought relief, may have moistened some areas enough to create favorable conditions for severe storms to form and intensify. Additionally, the sprawling urban landscape may have given the storms the extra, turbulent energy needed to spin up a tornado. The researchers reported their findings in January at the annual meeting of the American Meteorological Society.

"The Atlanta tornado, though forecasted well, caught us by surprise because it evolved rapidly under very peculiar conditions during a drought and over a downtown area," said Dev Niyogi, an assistant professor of regional climatology at Purdue and lead author of the modeling study. "We wanted to know why it hit Atlanta during one of the longest, harshest droughts the southeast has experienced. Was it a manifestation of the drought? Does urban development have an effect on such a storm?"

Such questions are becoming more relevant as the Intergovernmental Panel on Climate Change, NASA, and other institutions investigate the relationships between extreme water cycle events (such as drought), land cover change, weather, and climate change.

In the southeastern U.S., tornadoes are quite common in the spring when upper level wind patterns, surface moisture, and surface weather features promote severe weather. But moisture was scarce in the weeks leading up to the March 2008 Atlanta tornado, and likely should have suppressed a storm, according to atmospheric scientist Marshall Shepherd of UGA. Shepherd, Niyogi and colleagues recently completed a 50-year climatological assessment that finds tornadic activity is often suppressed during droughts in the Southeast.

To get to the bottom of how such a storm could have developed despite the drought, Purdue researchers Niyogi, Ming Lei, and Anil Kumar, along with Shepherd, investigated reports of isolated rain showers that had swept through parts of Alabama and northwest Georgia in the 48 hours prior to the tornado. They suspected that these "wet pockets" might have triggered, but more likely enhanced, the initial thunderstorms.

The scattered rainfall fell between areas that received no rain, setting up pockets of high humidity between areas of warm, dry air. The wet and dry areas may have acted as weak atmospheric fronts or may have promoted air circulation and evaporation that could have intensified the storms. A similar phenomenon promotes severe thunderstorms in Florida, where moist sea breezes interact with dry interior air masses.

Niyogi and Shepherd also found evidence that storm intensity was amplified by the heat-retaining effects of Atlanta's buildings and streets. The "heat island" effect leads to warmer air temperatures in urban areas because impervious surfaces like glass, metal, concrete and asphalt absorb, reflect, and store heat differently than tree or grass-covered land. Urban environments heat the air and cause moisture to rise quickly, creating a "thunderstorm pump" that can fuel or intensify storms. In March 2008, the differences in soil moisture and Atlanta's sprawling land cover may have provided the perfect blend for storms to intensify.

"A thunderstorm, energized by moist pockets within a drought region, grew into a tornado-causing severe thunderstorm because of weather instabilities it encountered at the rural-urban boundary," Niyogi explained.

"Drought and urbanization do not cause the thunderstorms or tornado, but ultimately they added fuel to the fire of an already energized storm," he added. "The variable rain bands created patches of land that were wet and dry, green and not green. The combination created surface boundaries that can destabilize the weather system and energize an approaching storm, providing the one-two punch."

Niyogi, Shepherd, and colleagues used the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Aqua satellite to assess the state of ground vegetation immediately before and after the storm, as well the long-term differences before and during the drought. The researchers also examined rainfall estimates captured by NASA's Tropical Rainfall Measurement Mission satellite to identify the unusual bands of rainfall two days before the tornado.

Finally, they examined soil moisture data from the Japanese Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) instrument on NASA's Aqua satellite to evaluate the intensity of the drought at the time of the tornado. When these real drought and urban land cover conditions were included in the team's atmosphere-land surface computer models, the simulations produced a more intense storm that mirrored reality.

"Our findings highlight the difficulty in de-tangling the influences of the atmosphere and of Earth's surface within the weather-hydroclimate system," said Shepherd. "Soil moisture and urban land cover are not well-represented in weather models, but a new look at satellite data offers a fresh opportunity to improve forecasts."

"With many studies suggesting more potential for urbanization and droughts in our future," Niyogi added, "it will be important to see if this kind of intense storm development could happen more frequently in future climates."

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