Iowa State researchers find, test winds extending far away from Alabama tornado's path

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Iowa State University's Tornado/Microburst Simulator runs over a 3-D model of a two-mile by three-mile section of rough Alabama countryside. Credit: Photo courtesy of Christopher Karstens/Iowa State University

Christopher Karstens, an Iowa State University doctoral student from Atlantic, was studying a deadly Alabama tornado when he noticed high winds from the storm traveled along valleys and knocked down trees. He built a 3-D model of that Alabama terrain and is using Iowa State's Tornado/Microburst Simulator to confirm rough, complex terrain can channel tornado winds.

Christopher Karstens was on the ground studying the damage caused by

the deadly April 27, 2011, tornado that hit Tuscaloosa and Birmingham, Ala.

It was just a week after the tornado. He was between the two cities, in the rough country of the southern Appalachians about 20 miles northeast of Tuscaloosa. He said it's terrain that's "beyond hilly." It's covered by dense forest and clogged by high brush that's tough to walk through. A hike of about 100 yards sometimes took as long as 45 minutes.

It was a perfect place for Karstens – a doctoral student from Atlantic who's studying under the direction of Bill Gallus, a professor of geological and atmospheric sciences – to study the effects of complex terrain on the structure of a tornado.

The study is part of a larger Iowa State research program led by Partha Sarkar, a professor of aerospace engineering and director of the university's Wind Simulation and Testing Laboratory. The lab includes several conventional wind tunnels and a Tornado/Microburst Simulator that has been fully functional since 2005. The Tornado/Microburst Simulator has helped researchers attract about $2.3 million from the National Oceanic and Atmospheric Administration and $580,000 from the National Science Foundation to study the impacts of tornado and microburst winds near the ground and their effects on buildings and other structures. One goal is to develop innovative ways to make structures, particularly low-rise buildings, stand up to tornadoes, hurricanes, gust fronts and microbursts from thunderstorms.

Iowa State's tornado research teams have included Sarkar; Gallus; Hui Hu and Vinay Dayal, associate professors of aerospace engineering; Fred Haan, an associate professor of mechanical engineering at the Rose-Hulman Institute of Technology in Terre Haute, Ind., and former aerospace engineering faculty member at Iowa State; Sri Sritharan, professor of civil, construction and environmental engineering; and Gene

Takle, professor of agronomy and geological and atmospheric sciences.

"We've learned a lot in terms of the distribution of wind and in terms of the interaction of wind with structures and terrain," said Sarkar.

Sarkar said the researchers have found, for example, that when a tornado blows over rough terrain – forests or densely built cities – the structure of the tornado changes. The swirl and maximum rotational speed of the tornado decrease and the vortex spins tighter with a smaller core.

Karstens took that study further by looking at what happens to a tornado when it hits complex terrain such as cliffs, slopes and valleys. That's why Karstens joined other researchers studying the damage caused by the Tuscaloosa-Birmingham tornado.

The researchers looked at the damage to homes and buildings in the cities – part of their work to develop structures that can withstand high winds. Then Karstens headed for the hills to study the damage there.

He hiked to the storm path and noted damage on the ground and in the trees. He looked for signs that the terrain had disrupted the tornado as it moved up and down the steep slopes. He hiked to the top of valleys so he could take pictures of the damage below.

Back in Ames, he also studied aerial photos of the storm damage. That's when he noticed that trees along valleys far from the tornado path were damaged by high winds.

Karstens returned to the area last January for a second and closer look at specific locations he had identified. He looked at how the damage changed as the storm moved up and over the low mountains. He studied how root and soil conditions could have influenced the storm damage. And he explored side valleys perpendicular and to the left of the

tornado's path to see the storm damage he noticed on the aerial photographs.

"It was very beneficial to go," Karstens said. "By physically observing the damage I could identify the situation, use some intuition and interpret what happened. That can lead to new ideas and thoughts."

One thought he took back to campus is that the perpendicular valleys provided a channel for the high winds and kept them going far from the actual tornado.

To test the theory, Karstens built a 32-foot by 20-foot 3-D foam replica of a 2-mile by 3-mile section of the same Alabama countryside he explored on foot. Then he ran Iowa State's Tornado/Microburst Simulator over the model terrain, taking wind readings inside the various valleys.

Karstens, who has accepted a research job at the Cooperative Institute for Mesoscale Meteorological Studies in Norman, Okla., is still analyzing the data. But he thinks he's onto something new.

"For meteorology, this can add another piece to the puzzle," he said. "It can help us understand the near-surface flow of winds in tornadoes."

Provided by Iowa State University