MYSTERY OF THE TWISTER

CHASING DOWN DEADLY TORNADOES IS MORE THAN JUST A THRILL-SEEKING HOBBY FOR RESEARCHER JOSH WURMAN. HE WANTS TO KNOW WHAT MAKES THEM TICK – AND IS WILLING TO RISK HIS LIFE TO FIND OUT. BY DANIEL WEISS

PHOTO: GETTY IMAGES

Extreme weather researcher Josh Wurman was in his element. On a cornfield-lined road outside Geary, Oklahoma, in the United States in late May 2004, a tornado was advancing from 7 or 8 kilometres off to the east. Wurman monitored data on the twister's wind speeds, captured by a radar dish on the back of his retrofitted Ford F700 flatbed truck, while simultaneously plotting an escape route in case the twister got too close. When the tornado had drawn just a kilometre or two away, he called for retreat to the south, but the truck was soon buffeted by extremely strong winds.

"I yelled at the driver, 'We have to keep moving!' because the tornado was coming towards us," recalls Wurman. "And the driver screamed back at me, 'We're stopped dead in the road even though I'm flooring it.'"

With wind speeds of up to 320 kilometres per hour pummelling the 11.8-tonne truck, there was no way to get traction. The only option was to hunker down and wait. Flying metal debris embedded in the bumper. A door ripped off its hinges. The cabin started to lift off the truck bed. But Wurman was so intent on his work that he barely noticed.

"We were sitting there, making sure our instruments were still recording data," he remembers with a chuckle. "We are kind of military in our discipline. We don't get excited."

Wurman is head of the Center for Severe Weather Research in Boulder, Colorado, in the United States, and over the past 15 years he and his team have collected an unparalleled set of data on tornadoes. Each May and June they traverse Tornado Alley, a vast stretch of the Great Plains in the middle of the United States stretching from Texas to North Dakota, doggedly chasing down supercells, the powerful thunderstorms that can produce violent tornadoes.

A vicious, spinning column of air extends from the base of a thunderstorm cloud in Pampa, Texas, in the United States (opposite page). With speeds of between 120 and 510 kilometres per hour, its power of destruction is intense, tossing cars about like toys and sucking whole fields up into the sky.

PHOTOS: GETTY IMAGES; RYAN MCGUINNESS/ALAMY; SCIENCE PHOTO LIBRARY

TORNADOES IN US HISTORY **1840:** ***Natchez, Mississippi, 317 people killed*** **1896:** ***St. Louis, Missouri, 255 people killed***

Key to their success has been the Doppler on Wheels (DOW), a flatbed truck with a Doppler radar dish mounted on its back that Wurman invented in the 1990s. At that time there was no way to capture high-resolution radar images of the winds that make up tornadoes because no one had dared to set up a large radar dish in close proximity to a storm.

When Wurman proposed putting a 2-metre dish on the back of a truck and driving it to within a few kilometres of tornadoes, many of his colleagues were sceptical. "There was concern that the wind would rip it off," he recalls. "There was concern that the truck would tip over. There was concern that you couldn't operate fancy radar equipment while driving because potholes would break it and computers would crash."

But on June 2, 1995, a few weeks after Wurman put it into action, the DOW proved the naysayers wrong by capturing vivid radar images of a tornado in the Texas Panhandle. By bouncing radar waves off debris caught in the swirl, it revealed winds circulating up to 240 kilometres per hour, as well as a 95-kilometre-per-hour central downdraft. Capturing a full image every two minutes, the DOW revealed that even though the tornado shrank as it died out, it maintained its strength to the end.

"It was one of the best days of my life," says Wurman. "There I was seeing the innards of this tornado and realising, 'That's the first time this has ever been seen!' It's like looking at pond water with a microscope and going, 'Wow, there's amoebas in there!'"

Wurman's willingness to buck conventional wisdom has earned him the respect of many of his colleagues. "If Josh has an exciting idea,

The DOWs of VORTEX2 (above) are fitted with an array of cutting-edge instruments. Inside Tornado researcher Tim Samaras' vehicle (bottom, left) is a portable radar display, designed to view weather information, track storms on radar and receive watches and warnings.

PHOTOS: ALAMY/POLARIS; JIM REED; © COPYRIGHT VORTEX2

1908: *Amite, Louisiana/Purvis, Mississippi, 143 people killed*

1913: *Omaha, Nebraska, 103 people killed*

This rotating supercell thunderstorm was captured by the VORTEX2 team near Dodge City, Kansas, in the United States. Even though tornadoes can cause widespread devastation, they can also be stunningly beautiful.

RECIPE FOR A TORNADO

Violent tornadoes have wreaked havoc on every continent except Antarctica. But they are most common in Tornado Alley, the region in the United States that consistently has the primary ingredients for tornado formation: a source of energy and a source of rotation.

In late spring, low-lying warm, moist air flowing up from the Gulf of Mexico from the southeast provides the energy for thunderstorms. These storms begin to rotate because of the directional differences between the Gulf winds and the jet stream blowing from the west at 9,000 metres. Imagine a giant pinwheel rotating around a horizontal axis, being pushed in one direction at ground level and the opposite direction at high altitude.

A third key ingredient, a cap of warm air at an altitude of 2 to 3 kilometres, spreads out from the high plains near the Rocky Mountains over Tornado Alley. It acts like a lid on a simmering pot of water, preventing the energy low to the ground from leaking away throughout the day, instead causing it to build up until it explodes in a violent, late-afternoon thunderstorm called a supercell. In a supercell, the rotation twists up into a vertical swirling vortex about 2 to 10 kilometres in diameter, which can in turn give birth to a tornado.

Zap! to download a video that shows just how scary a tornado can be – up real close!

Thanks to their state-of-the-art fleet of intercept and support vehicles, Wurman's team have pushed the limits when monitoring tornadoes and supercell thunderstorms. But they are not alone. Meteorology students in the US state of Kansas (below) are also keen to get a piece of the action.

he wants to go ahead and do it and do it all the way," says Howard Bluestein, a meteorology professor at the University of Oklahoma in the United States. "Some of the best visionaries in science are people who do things that people think can't succeed and then turn out to be right."

In the years since, Wurman and his team have captured data on more than 140 tornadoes with the DOW. One in 1999 had the highest tornado wind speeds ever recorded: 486 kilometres per hour. Curtis Alexander, a PhD student working with Wurman, has sifted through the results and made novel discoveries regarding the strength of these twisters.

Conventional strength estimates suggest three-quarters of tornadoes are weak, with peak winds under 177 kilometres per hour; about one quarter are medium strength, and just one percent are violent, with peak winds reaching over 265 kilometres per hour. The DOW observations suggest a tendency towards stronger tornadoes, with between two and three out of ten rated violent, one to two out of ten weak, and the rest in the middle.

DEADLY FORCE

In 2008, tornadoes killed 125 people in the United States, the highest total in a decade. But Wurman warns that a much greater death toll could be in the offing. A few years ago, he and several colleagues published a study examining what would happen if a violent twister tore through a major city. "If one of the worst tornadoes that we have observed going through Kansas or Oklahoma went through suburban Chicago, you could destroy 100,000 homes and wind up with thousands of fatalities," he says.

Wurman and his colleagues hope their data will lead to more accurate forecasts of violent tornadoes. The National Weather Service in the United States currently issues tornado warnings for specific locations with an average of just 15 minutes advance notice. Even then, twisters only form about 30 percent of the time.

Data from the DOW has offered some helpful clues. For example, Wurman says that he can usually tell how much longer a tornado will last from radar imagery, and that the tornadoes produced from the collision of two thunderstorms tend to be short-lived. But the big questions remain unanswered.

"What we don't know are the fine details: why a few of these supercells make violent tornadoes; why a

1925: *Tri-State (Missouri/Illinois/Indiana), United States, 695 people killed* 1936: *Gainesville, Georgia, 203 people killed* 1947: *Woodward, Oklahoma, United States, 181 people killed* 1953: *Waco, Texas, 114 people killed* 2008: *Southern United States, 57 people killed*

The VORTEX2 fleet is fully nomadic with no home base; it needs to be, given that supercell thunderstorms can move rapidly, tracking over a distance of 160 kilometres.

quarter to a third make some kind of tornado; and why 70 percent make no tornado," he says. "We also don't know why, during the two- or three-hour lifespan of a supercell, a certain 10 or 20 minutes is tornadic and the rest is not."

Wurman is optimistic that these questions can be answered, but he believes that rich data on temperature and humidity differences throughout the tornado, in addition to wind-speed data, is key to understanding why tornadoes form when they do. Unfortunately, temperature and humidity must be measured directly rather than at a distance.

To fill in the gaps in their knowledge, over 100 tornado researchers have banded together to participate in VORTEX2, a two-year effort co-led by Wurman, launched in May 2009. Along with DOW-type radar vehicles, the experiment utilises a variety of other instruments. Tornado pods and stick-nets are deployed in the paths of supercells and tornadoes to measure temperature, relative humidity, atmospheric pressure and wind speed close to the ground. Mobile mesonets (networks of automated weather stations) take similar measurements from the tops of cars and weather balloons from above ground.

For almost four weeks during the height of 2009's tornado season, a circus-like caravan of 50 vehicles traversed Tornado Alley in search of twisters, but none materialised. Then, on June 5, deep in the countryside outside Chugwater, Wyoming, they hit the jackpot. A classic supercell thunderstorm spawned a tornado, which Wurman identified on his radar screen before anyone else had with the naked eye.

"We got our radars deployed 10 or 15 minutes before it made a tornado, which is really critical," says Wurman. "It was a pretty tornado, but the unique thing was how many instruments, how many scientists were looking at it and documenting it."

It will take several years to analyse all the data collected on that one tornado, but Wurman foresees it producing tangible benefits. "I do think we will make substantial progress, which will enable people to make better predictions with longer lead times and lower rates of false alarm," he says.

But don't expect Wurman to spend all his time holed up in the office poring over data. Come next May, he'll be the principal investigator for VORTEX2 again, doing what he does best – chasing down storms on the roads of Tornado Alley, trying to get some traction on the big questions of when and why tornadoes form. ■

TORNADO TRACKER

The Doppler on Wheels has come a long way since Wurman cobbled together DOW-1 with a budget of about US$50,000 in the 1990s. The current model, DOW-7, costs around US$500,000 and is outfitted to capture top-notch data while protecting Wurman and his team from the elements.

ANTENNA: 2.44-metres in diameter; focuses the 3.2-centimetre radar waves

PEDESTAL: supports and positions the antenna; WW II surplus; ranges from 0 to 90° in the vertical range and swivels 360°; can move 50° per second

GENERATOR: 12-kilowatt, 3-phase generator; uses the same diesel fuel as the truck and provides power for the radar, air-conditioner and microwave in the cabin

PNEUMATIC MAST: rises 18 metres on compressed air; lifts weather instruments (anemometer to measure wind speed, thermometer to measure temperature and hygristor to measure relative humidity) and communications equipment; with 200-watt radios broadcasting at this height, two DOWs can communicate up to 50 kilometres apart

HYDRAULIC FEET: two 1.2-metre lifts in the front; two 0.9-metre lifts in the rear; keeps the platform completely stable in winds up to 195 kilometres per hour; can compensate for uneven ground within 0.1°

FUEL TANKS: saddle tanks below driver's and passenger's doors each hold 265 litres; reserve tank behind driver's side tank holds 380 litres; in total, 900 litres of diesel fuel is enough to operate the radar for 120 hours consecutively