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poetry

The Sharpest Fall

Amos Magliocco

After a difficult autumn, we needed a steady stretch of road. We were testing a weather instrument, a mobile barometric pressure sensor, which eight months before had measured the sharpest pressure drop ever recorded on Earth, taken from *inside* a tornado. Now we wanted to see if we could make the sensor fail. A mile of flat road would give us a steady pressure and help isolate variables. A level surface promised some control, but even a condition that simple proved difficult to manipulate.

This was a gray January afternoon in Oklahoma, a place where winter begins and ends without distinction as fall's thickening grayness yields to sinewy spring cumulus, their dark underbellies growing into violent storms. My friends, Scott and Bob, and I rode in Bob's silver Pontiac SUV to find a suitable location for our experiment. Both my friends are meteorologists. Scott works with the National Weather Service, and Bob is a graduate student in the University of Oklahoma's prestigious Atmospheric Physics program. All three of us are longtime storm chasers. The pressure sensor we meant to test, mounted atop Bob's SUV, had been installed on another vehicle on April 21, 2007, when it recorded a 194 millibar drop—the equivalent of being thrust three thousand feet in the air—from inside an EF-2 tornado that churned through Tulia, Texas. On the Enhanced Fujita damage scale, an EF-2 rating signals structural damage consistent with 125 to 135 mph winds. And, on that day in Tulia, the tornado destroyed a small industrial park and a new subdivision. Within days of the measurement, Scott started an article presenting the data to the scientific community. The historical importance was obvious: Just nine other readings have been taken inside tornadoes—hardly a significant sample size. In other words, we don't really know yet what's happening in there. Only one other result, from 1906, approached the pressure deficit this sensor had observed; every other reading showed less than half the drop seen in Tulia. If the data were accurate, a new way of thinking about the anatomy and morphology of tornadoes was required.

For my friends and I there was even more at stake. By the time of our test in January 2008, the sensor's original owner and the driver of the vehicle that day in Tulia, our friend Eric Nguyen, was dead. Eric, 29 years old, had committed suicide five months after the tornado during a sudden relapse of a mental illness and a change in medication. He wasn't around to test his pressure sensor or the sonic anemometer (used to measure wind speed), both of which had come under scrutiny from peer reviewers at the *Electronic Journal of Severe Storms Meteorology*. Eric, a meteorologist himself, would have happily engaged in testing his own equipment for the sake of Scott's paper, and none of us doubted he would have done it well, informed by his enthusiasm and expertise for instrumentation and design. But he was gone, and we were left: Scott, whose nine months of dissection and analysis animated the article; Bob, Eric's closest friend in college and who'd inherited his mobile instruments; and me, his storm chasing partner and passenger that day in April when a tornado caught us by surprise in Tulia.

The three of us gathered at Bob's house in Norman, Oklahoma. Like the measurement itself, our tests were unprecedented and offered little basis for expectation. One reviewer asked about the effect of debris striking the mast and sensor housing, so we activated the data-logger and began throwing things. We hurled tennis balls and rocks at the sensor housing, slung baseballs overhand and sidearm style and even clubbed the steel mast with a hockey stick. Most of our pitches sailed into Bob's yard and the street. His neighbors paused at their mailboxes to watch. We delivered everything short of a destructive blow, which hadn't happened in the tornado either. In fact, immediately after the Tulia storm had passed, the pressure returned to the same reading as before, strong evidence for the instrument's integrity. Likewise none of our impacts caused

any error. But we were having fun, straining the boundaries of experimentation to imitate the chaos of a vortex.

Our next test, however, which required a flat strip of highway, would be more organized and controlled. We needed to isolate cause and effect. If we created some kind of instrument error, we had to be able to duplicate the results and demonstrate which variable induced the anomaly. We set out looking for a corner of the world where we could explain one small thing, after so many months of gaping questions over Eric's death: the white-out blizzard of possibilities through which the family and friends of a suicide grope. These new questions seemed easier to grasp, unlike the chemical mechanisms of anti-depressants or the cagey explanations of doctors, and we sought our answers on familiar ground, out here in the Great Plains where the sky regularly descends to Earth for an audience incautious enough to watch.

But it took a while. For starters, we had trouble finding a mile of flat road.

Bob's SUV sported pipes and masts from its roof like the quills of a porcupine. The instruments were mounted on white plastic piping and secured with metal bars: a GPS receiver to stream location data to his computer, the famous pressure sensor in its protective port and a sonic anemometer transmitting bursts of high frequency noise to measure wind speed and direction. Radio antennae and cell phone boosters sat beside a yellow strobe light. Behind the rear seat Bob's red medical bag was tied with bungee cords. As undergrads at Oklahoma, Eric and Bob had been inseparable, even skipping the class photo together. When Eric died, Bob immersed himself in a software design for collecting live weather data from multiple mobile platforms, a project he and Eric had discussed for years. Sleepless from grief, he coded late into the night, while, during the day, he finished a double-Masters in Meteorology and Computer Science and held a part-time job as a programmer. Through Bob's GPS we knew our location exactly. And with 25 years of storm chasing between us, we also knew that east of Norman lay the hilly, forested terrain known as "The Jungle," where tornadoes are difficult to see and harder still to photograph and where flat road is as rare as a Starbucks. But we were distracted by the procedures for our test, speculating about the results and ignoring the increasing slopes and hills of State Road 9.

Even his reviewers had not imagined the test Scott devised. "They would eventually," he said, and he wanted to be ready. More skepticism was on the way. The Tulia data challenged not only existing, published ideas on which professional careers had been built, but also record-holders who advertised their "tornado probes" and historical measurements in applications for grants and federal funding. Scott planned to mount the static pressure head, which housed the sensor, at three different angles: zero degrees (the normal installation), 20 degrees and 40 degrees. For each angle, we would drive one mile at 40 miles per hour, another mile at 60, and a third while going 80. We wanted to see how the sensor reacted to the change in wind direction created by the various angles. Scott's hypothesis was that winds inside a tornado might blow in many directions and not simply from the side.

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A large, striated shelf cloud near Sublette, Kansas, on June 1, 2003.

Any vertical component could induce a dynamic pressure fall and account for some portion of the historic reading. If so, how much? The manufacturer had never attempted a similar test under these conditions. We were looking for an unprecedented error as an explanation for revolutionary data. If a vector change *could* induce errors, the significance of the Tulia data would be lost, another bitter blow. For me, the data and its utility for scientists represented some small benefit from that trauma, something of value to emerge from the pile of debris that surrounded Eric's totaled Nissan Xterra when we climbed out, stunned but uninjured. It was also Eric's final contribution to the science he'd loved since boyhood.

But there's no room for sentiment in science, and if Scott discovered our reading was the result of instrument error, he'd say so. He'd withdraw his paper. We knew Eric would have had it no other way, yet we hoped otherwise. Scott and Eric had known one another since they were teenagers. Frequently, at the end of a long chase season they were the last ones still in the field, hunting storms in the Dakotas in late June. They'd attended weather school at the same time: Scott in Louisiana and Eric in Oklahoma. They'd chased together in caravans or the same car for more than a decade, and Eric was in Scott's wedding party just a month prior to Tulia. A young meteorologist, Scott was already compiling an impressive publication record. When after the tornado Eric discovered the data were intact, he gave the file to Scott, telling him: "It's your data now."

The Oklahoma sky hung high gray above scrub brush and evergreen. The occasional Eucalyptus zipped past the window. Scott rode in the passenger seat and jotted figures in a notebook. Occasionally he looked up from the data-logger in hopes we'd found our flat stretch, but the highway rose and fell, and gradual curves tightened by the mile. "We should have gone west," he said.

"There has to be something," Bob said. We were invested in this direction now, and a little stubborn, sticking to our forecast. Bob proposed a mathematical solution to "back out" any pressure change from elevation, but Scott only tapped his pencil on the dashboard. He was scheduled to work a morning shift back in Topeka, Kansas, a long drive from central Oklahoma, and it was getting late. With the gear and each other's company, it felt like a storm chase. It was also the first time we'd been together since Eric's funeral, and the purpose of our reunion invited long moments of silence. Around a bend, a ribbon of asphalt lay before us like an airport runway. "This might be it," Bob said.

"Better be," Scott replied.

Bob accelerated to shorten our anticipation. Scott's eyes darted from the windshield to the data-logger—if the value held, we'd found our place—and Bob leaned over to check for himself. Then the road dropped just enough to increase the weight of air above us. We groaned and laughed at our unexpected predicament.

"Eric would have loved this," Bob said.

"This is right in his wheelhouse," I said, and we talked about our friend's fascination with weather equipment and instrumentation. Over the years he'd photographed hundreds of mobile radar trucks and rolling meteorology labs. One in particular, a strange vehicle we discovered in 2003 and nicknamed the "Los Alamos Radar Truck," came to mind as the three of us peered over the next rise.

We found it in a Super 8 parking lot in western Oklahoma. Our first reaction was laughter, as if it were an amateur mockup of some unfeasible concept. Rather than the standard dish typical on "Doppler on Wheels" vehicles, this converted Ford pickup featured two white domes next to a large black and silver disc. A steel mast towered over the chassis. Then we stepped close enough to make out the warning bulletins. The disc was labeled "High Energy Pulsed Magnetic Radar." Radiation warning signs were plastered to all four doors—one of them was black and yellow and read: "Neutron X-Ray Emissions Hazard." Beside that: "Electro Magnetic Pulse Emissions Hazard." Numeric keypads controlled the locks, and a logo under the driver's window advertised, "A Siemens International Managed Company." Inside the darkened cab, holsters mounted to the driver's and passenger's doors held 9mm Glock handguns. This was hardly typical research equipment or the kind of gear we associated with the brilliant but squarish grad students who normally operated mobile radars. It was completely over the top: aggressive and vaguely militaristic. We'd seen some unusual contraptions during chase season, but nothing like this. We looked around the parking lot. What *was* this thing? What was it *for*?

Eric jogged from spot to spot, shooting photos as fast as he could, like the vehicle might fall through a trap door or dissolve behind a cloaking device. I couldn't believe the handguns. *Really*, I thought? A High Plains shootout under the shadow of the anvil? Was Al-Qaeda targeting weather-research assets in Scottsbluff, Nebraska? While I considered the melodrama of "coming heavy" to Tornado Alley, my friends contemplated firepower of a different sort. All radars, mobile or stationary, emit electromagnetic radiation; the reflected energy is read and processed as a "return." This "reflectivity" is what TV weather-casters point to on television and what weather service forecasters use to issue warnings. But the radar trucks we recognized were like toasters compared to this, which by its dire warnings and exaggerated security suggested an unprecedented power plant. Why put that kind of juice on four wheels? They must have intended to create some effect, we decided. It looked as if they'd brought the world's biggest rolling microwave oven and needed something to cook.

All night we stole glances to the parking lot from our room and speculated. By 2003, seven years after the movie "Twister," chasing already looked like science fiction. Daredevil-scientists leaped from vans to drop probes in a tornado's path, while armored cars with IMAX cameras for turrets lumbered to interception points. Doppler trucks hoisted themselves on hydraulic legs like mechanized scouts in a Star Wars film. All means to measure, document and record. Then there were the regular chasers like us, geeked-out armadas with antennae and modest instrument suites. But the Los Alamos truck was like nothing we'd ever seen. It was secretive, dangerous and armed to the teeth. Our conjecture kept us awake all night. If they intended to alter some part of a supercell thunderstorm with radiation, what results did they expect? And upon what research was their expectation based? How could you predict the outcome?

In the morning, it was gone. Tucked beneath Eric's windshield wiper was a business card with the same logo as the yellow radiation placard. On the back they'd scribbled a note, "Feel free to ask questions," and an email address.

I found that same card again in the summer of 2007, a few weeks after Eric died. He'd tacked it to a corkboard above his desk beside some of his best tornado photographs and pictures of his young sons. T-shirts with logos from government weather agencies and stormchaser conventions were scattered on the bed. On his desk lay schematics and diagrams of the various weather instruments he'd installed on his own chase vehicle. I gathered the card and blueprints along with other items his parents had insisted that we divide among ourselves and other chasers. The drawings would establish the research-grade quality of Eric's instrumentation, soon to be challenged for the extraordinary observation at Tulia. As I was leaving I stopped in the driveway where Eric's Xterra was parked, a duplicate of the vehicle from that day. GPS data tells the most chilling version, how between the moment we spotted the tornado, signaled by Eric's rapid acceleration, to the instant we came to a stop after the tornado dragged us into an old tire store and collapsed the building on our hood, only eight seconds had passed. Eight seconds during which our car

windows exploded and our ears popped and we huddled in the center of the SUV with our eyes shut tight. Before we left, Eric asked me to turn off the data-logger in his glove box. I flipped the toggle switch, but thought it surely damaged beyond repair—that none of the information could be intact if it had even recorded in the first place. I was wrong. In the morning we returned to salvage more gear and Eric extracted the data-logger. It had recorded the entire event.

The atmosphere is the system that inspired "chaos theory." Even sophisticated computer forecast models eventually lose their way in an increasing swirl of accumulated errors. The effect of these variations starts gradually (the proverbial butterfly in Tokyo who causes a "stovepipe" tornado in Kansas), but the final result is ultimately unpredictable. Eric and I never imagined a tornado coming from behind us in Tulia, just as a year later my friends and I did not foresee two hours looking for flat road. Nor did we anticipate Eric's sudden illness, his catastrophic fall none of us could break. Our compulsion to name and categorize natural phenomena implies a control we don't possess. For chasers this is a necessary illusion, a confidence required to banish the otherwise rational instinct for self-preservation. At the heart of our fascination with the Los Alamos Radar Truck was our hunch that they were in uncharted territory: that, whatever their plans, the consequences were unknown and unknowable.

Bob and Scott and I turned west at last, toward a stretch of prairie where stability seemed more likely. We soon found a suitable road and began the test. We checked our pressure with the instrument mounted correctly, the zero degree offset, then drove one mile at 40, 60 and 80 miles per hour, braking hard at the end near an entrance to a new subdivision. Our error rate increased slightly with speed, an effect of vehicle streamlines. We remounted the pressure port with bungee cords and plastic ties to secure the instrument at a 20-degree tilt. The sensor manufacturer had told Scott that the last time they'd tried anything similar to this was the mid 70s. They faxed a QC test graphed in pencil. "This is what they sent me," he said. "A multimillion dollar instrument company." As far as these tests, we were on our own.

With a 20-degree offset, at all three speeds, the error increased at the same rate it had with zero offset—vehicle streamlines again. Yet the error was a fraction of a millibar, negligible compared to the historic reading. We were enjoying ourselves, checking behind us for traffic that might be alarmed by our erratic driving patterns and giving the all-clear for Bob to floor it. On the fastest runs, Bob's four-banger Pontiac struggled to reach top speed before he had to jam the brakes for a subdivision entrance. Scott scrutinized the data-logger. So much of his work would be lost if these conditions created a malfunction. Finally, we tipped the instrument mast a grotesque 40 degrees, a clownish tilt that reminded us how it had pained Eric to see new chasers mount anemometers inches over their vehicle roofs, subjecting them to massive interference. At this angle we expected a large error rate, but we didn't get it. In fact, the error was marginally smaller than at the standard mount. We were amazed. The vector change hadn't mattered.

Later in 2003 we encountered the Los Alamos truck again. The driver withheld the vehicle's purpose as he had in several email exchanges with Eric. He explained that the large communication console inside the truck exchanged telemetry with aircraft and said the vehicle was only licensed to operate in certain states. He offered specs on the radiation output but omitted their use or the science behind it, if any existed. We studied the truck again. Warning signs surrounded a steel cage in the bed and, inside that cage, a four by four box resembling a reinforced safe sat like some treasure chest. Pipes covered the box and ran toward the large black transmitter atop the instrument bed. It shocked us again to consider the energy implied by such materials and security. How would it withstand softball-sized hail? What if it rolled off a bridge?

The only rational conclusion, we decided, was that they intended to radiate the rear flank downdraft (RFD). The RFD is a "waterfall" of wind that originates on the back side of the storm and cascades down, spreading in all directions when it hits the ground including toward the updraft/downdraft interface where tornadoes form. In the late 90s the RFD and its impact on tornadogenesis was a hot topic among researchers. A working theory suggested that the thermodynamic character (temperature and moisture content) of the RFD has a vital role in creating tornadoes. Simply put, warm and moist RFD, which is buoyant, seems to assist tornado formation, while hot and dry RFD—that is, with a lower relative humidity—short-circuits the process. It was not inconceivable that if one "nuked" the RFD and lowered its relative humidity (by increasing air temperature without a proportionate increase in moisture), you might have some kind of tornado-busting device on your hands. If, that is, you took unproven, almost speculative theories for truth, if you trusted an elephant to follow a thinly painted line through a china shop. If, in other words, you were a madman. There was no way to know you wouldn't create a super-tornado, heating the RFD enough to induce a monster vortex where none might appear otherwise. And how to direct such a powerful beam of energy with any accuracy? Whatever the truth, it seemed that if the Los Alamos operators intended to alter thunderstorms, then they, too, would be as surprised by the results as anybody.

There was something reckless, almost cavalier, about the suppositions required—the confidence—to bring such a device into Tornado Alley and turn its considerable force against an impervious but hardly inanimate prey. What hubris was it necessary to summon? Some ask the same questions of storms chasers, but our relationship to the storm is different than other interactions in the natural world. Humans have a narrative context for mountains; indigenous peoples and even veteran Western climbers honor them and caution those who fail to adopt the same regard. The ocean, too, enjoys long-standing conventions with her devotees, though she regularly consumes any number of them as she has for centuries. But a violent thunderstorm is ephemeral, perhaps its most striking characteristic. While it shares much with the ocean, being made of water, and with mountains, ascending to similar heights, it is indelibly distinguished by its transience. It is *not* an eternal feature of the planet but a fleeting process: a mechanism

An isolated tornado catches sunlight from beneath the shadow of the anvil on May 29, 2004, near Attica, Kansas.

for the atmosphere to redistribute heat and moisture, and within hours of destroying entire communities or hundreds of lives it will always vanish, literally, into thin air. The next storm will differ in behavior and appearance, a cousin of its lethal ancestor to be sure, but not the same. Like a volatile marriage, this relationship of chaser to storm is predictably one-sided. We approach, photograph and run like hell. The storm's combination of mute disregard and sweeping power is practically alien. Humans enjoy few options in this exchange. As the poet Robert Hass wrote:

> We asked the captain what course
> of action he proposed to take toward
> a beast so large, terrifying, and
> unpredictable. He hesitated to
> answer, and then said judiciously:
> "I think I shall praise it."

Praise, essentially, is the chaser's only recourse. We fawn, grope and finally admire the storm through photography and video. The fascination my friends and I developed for the Los Alamos Radar Truck, then, was inhabited mainly by our amazement at such an ornate disrespect for the storm. Later that year, we posted pictures of the vehicle online. Vigorous speculation ensued. One chaser wrote: "That is not a 'RADAR DOME' on the truck... It is a receiver for a Field Radiation detector called VLAND (Very Large Area Neutron Detector)... used to check for Neutron and Gamma particle emissions… BTW... Hi to NSA monitoring via ECHELON!!!!" Others expressed skepticism that such a thing even existed. One chaser who lived many years in New Mexico said *he'd* never seen it. Others argued that it wasn't a weather research tool at all but a security vehicle to escort nuclear materials across state lines. Nobody has seen it again since 2004, and none of our original questions were ever answered.

In a second round of peer review, Scott's editors suggested his theories to explain the Tulia pressure drop had overreached. Concentrate on the data and its relevance, they counseled. Don't venture into vortex dynamics. There existed, they seemed to say, a danger in exploring too deeply the uncharted paths of knowledge. Following their direction, he tapered the scope of the paper to concentrate on wind speeds, direction and pressure. No reviewer raised the vector issues that had inspired our trip in Oklahoma. As with every storm chase, we didn't know ourselves what would happen, much like nobody would have predicted a 194-millibar collapse in a single-cell vortex, or what would happen if you cooked the RFD of a supercell thunderstorm, or that Eric would not live to see Scott's paper accepted for publication in the summer of 2008. One of the thrills prior to any storm season is the knowledge that, by the end of spring, there's no telling what you will have seen. The unprecedented is possible each day. And each day we expect nothing more than another portion of the mystery, which no chaser expects to solve. We can hardly imagine that anyone ever will. ♦