P7.114. EXTREME DAMAGE INCIDENTS IN THE 27 APRIL 2011 TORNADO SUPEROUTBREAK

Eugene W. McCaul, Jr.[1],Kevin R. Knupp[2],
Chris Darden[3], and Kevin Laws[4]
1. Universities Space Research Association, Huntsville, AL
2. University of Alabama Huntsville, Huntsville, AL
3. NOAA National Weather Service, Huntsville, AL
4. NOAA National Weather Service, Birmingham, AL

1. INTRODUCTION

On 27 April 2011, a tornado superoutbreak containing at least 11 EF4 and 4 EF5 tornadoes swept through the Southeastern and Eastern United States, wreaking death and destruction comparable to the worst ever documented in the historical record. The death toll of 319 directly attributable to the tornadoes exceeds even that of the "Jumbo" Outbreak of 3-4 April 1974. Total property losses are believed to have exceeded $10 billion. In Alabama, the epicenter of the outbreak, some 10 million cu. yd. of debris had to be cleared after the storms, and 1.06% of the state's total area was damaged by tornadoes.

With early Spring dynamics superimposed on late Spring thermodynamics, the volatile weather scenario played out in three main waves: (1) an early morning quasi-linear convective system (QLCS) with embedded mesovortices, some containing large, strong tornadoes; (2) a smaller midday QLCS containing damaging winds and weak tornadoes; and (3) a final barrage of powerful discrete supercell storms packing giant, violent long-track tornadoes throughout the afternoon into the night. A more detailed overview of this tornado superoutbreak is provided by Knupp et al. (2013).

While even the early morning QLCS tornadoes caused widespread and locally significant damage, the focus of this paper is on the damages wrought by the violent supercell tornadoes. With a powerful jet aloft in advance of a potent upper tropospheric disturbance, the supercells formed ahead of a dryline and marched swiftly across the Southeast at speeds averaging 50-60 mph, producing tornadoes that in some cases stayed on the ground for more than 2 h, covering distances in excess of 100 mi (185 km). Unsurprisingly, most of these tornadoes inflicted major damage along parts of their tracks. The purpose of this paper is to provide photographic documentation of selected damage events, some of which rival or exceed anything known to us from prior violent tornado outbreaks. Damage descriptions will be listed in chronological order based on the start times of the tornadoes.

2. METHODOLOGY

*Corresponding author address: Eugene W. McCaul, Jr., Universities Space Research Association, 320 Sparkman Drive, Huntsville, AL 35805, e-mail: emccaul@usra.edu

The digital photographic documentation was obtained during ground and aerial surveys conducted as soon as possible after the superoutbreak. Owing to long-lasting power outages, highway obstructions by debris, remote locations of damage, fuel shortages, and the sheer amount and scope of the damage, not all ground surveys could be completed while damage remained undisturbed by power restoration and general recovery operations. Nevertheless, all photos presented herein are believed to be representative of actual damages caused by the tornadoes. Additional information was obtained from interviews with tornado survivors and eyewitnesses, to verify that observed damage was indeed caused by tornadoes, and to clarify the manner in which the damage occurred. Engineering analyses of the damage and assignment of Extended Fujita EF-scale ratings are not the subject of this investigation.

Imagery is provided for selected tornadoes, arranged chronologically by tornado start times. Headers provide the name of the tornado and its EF-scale rating at the time of this writing. Also provided are the tornado start and end times (CST; add 6 h to obtain UTC), total path length and maximum path width (mi), as determined from online search of NOAA's Storm Events Database (http://www.ncdc.noaa.gov/stormevents/).

3. RESULTS AND DISCUSSION

NESHOBA COUNTY, MS, EF5

1330-1400 CST, 28 mi long, 0.5 mi wide

This tornado was the first violent tornado of the outbreak. After touching down near Philadelphia, MS, it raced northeast, increasing in size and violence. In northeastern Neshoba County, the tornado struck a grassy field, stressing the topsoil such that cracks formed, after which it lifted numerous grass clumps out of the ground by the roots, leaving swaths of plowed soil and rubble strewn across the field (Fig. 1). Many of the uprooted grass clumps were two feet deep. Two separate swaths of rubble were found, suggesting the action of suction vortices (Fig. 2). The tornado also snapped and uprooted numerous trees, ripped asphalt off roads, toppled gas station canopies and tossed mobile homes 300 m, killing 3 persons. The parent supercell spawned another tornado (EF1) in Noxubee County, before merging with another supercell and spawning three additional violent tornadoes (see

Rainsville EF5 below). After the merger, the resulting Cordova, AL, supercell persisted for another 13.1 h before dissipating at night near Front Royal, VA.

CULLMAN COUNTY, AL, EF4
1340-1438 CST, 47 mi long, 1.0 mi wide

This tornado formed just southwest of the city of Cullman, then proceeded to strike the historic downtown sector of the city, where it wrecked many long-standing structures (Fig. 3). Already violent, the tornado increased in size as it marched across rural areas northeast of Cullman. It widened to approximately 1 mile after passing through Hulaco in southeast Morgan County, then reached peak intensity as it plowed through the Hog Jaw and Ruth communities northwest of Arab, where it swept recent-vintage homes from their foundations, killing 5 in one house (Fig. 4). Radars detected tornadic debris signatures extending up to 7 km altitude with this storm (Knupp et al. 2013). The tornado ultimately descended into the Tennessee River valley just west of Guntersville Dam, and dissipated in northern Marshall County. The parent supercell went on to produce two other EF4 tornadoes, and persisted for a total of 11.5 hours, finally weakening and merging with smaller storms at night in eastern West Virginia.

HACKLEBURG, AL, EF5
1405-1620 CST, 132 mi long, 1.25 mi wide

This historic tornado, possibly the most violent of the entire outbreak, began in Marion County, AL. Its first significant victim was the town of Hackleburg, whose entire northwest sector was essentially blown away by the then EF5 tornado (Fig. 5). The Wrangler Jeans plant, the town's main economic engine, was flattened, and samples of jeans were found in the town of Courtland, AL, some 46 mi northeast. The tornado wrought severe damage in Phil Campbell, AL, where trees were debarked and large expanses of asphalt were stripped from roads (Fig. 6). Farther downstream, in Oak Grove, AL, the tornado reached 1.25 mi width and major devastation occurred; one car was lofted and carried more than 640 ft. The tornado then ripped through Mt. Hope, AL, and marched towards the Tennessee River, narrowly missing the Browns Ferry Nuclear Power Plant. Many large trunk power lines were destroyed by the tornado, forcing a shutdown of the nuclear plant and plunging Huntsville and all of northeast Alabama into a 5-day power outage. After crossing the river, the tornado tore through Tanner, AL, and blew away the Doppler radar operated by WAFF-TV. In Madison County, the tornado skirted the northwestern suburbs of the cities of Madison and Huntsville, destroying several more subdivisions before weakening briefly. In then reintensified in Lincoln County, TN, and finally dissipated after staying on the ground for 132 mi, and killing at least 72 persons. Papers such as personal photographs from Phil Campbell were carried 353 km and dropped in Lenoir City, TN, by this tornado; this is believed to be a new record for documented long-distance transport of paper debris (Knox et al. 2012).

SMITHVILLE, MS, EF5
1442-1523 CST, 37 mi long, 0.75 mi wide

This violent tornado was the successor to another violent tornado in northeastern Mississippi, from a supercell some distance west of the Hackleburg supercell. The tornado swept away much of the town of Smithville, and lofted a large SUV 0.5 mi before throwing it into the town's water tower, where it left a large dent (Fig. 7); the SUV landed another 0.25 mi downstream in a crumpled ball. In the tornado's path, another pickup truck was lofted and has not yet been found; the owner, who survived by being not at home when the tornado struck, speculates that the truck may have been deposited in Pool B of the Tennessee-Tombigbee Waterway, some 0.3 mi north. Elsewhere in Smithville, a large bag containing an estimated 40 lb of athletic gear was carried 30 mi and dropped onto the town of Hodges, AL. Early reports on the internet that a steel drainage culvert had been ripped out of the ground by the tornado (Fig. 8) proved erroneous; Smithville police officials confirm that the street had been earlier declared unsafe, and that road crews had dug up the culvert to ensure no vehicular traffic could use it.

TUSCALOOSA, AL, EF4
1543-1714 CST, 81 mi long, 1.5 mi wide

This large and iconic tornado was rapidly intensifying as it tore through the city of Tuscaloosa, wreaking historic damage. It reached an apparent maximum in intensity just northeast of town, where it struck a still-used steel train trestle over Hurricane Creek Canyon, ripping three of five tapered steel trusses off their concrete pads and tossing them around; one of the trusses, weighing some 34 tons, was rotated and carried about 100 ft uphill (Fig. 9). Forest in the vicinity of the trestle was almost completely blown down, and littered with fragments of vehicles and appliances. Farther downstream, the tornado roared across a coalyard, derailing 29 or 31 coal hopper cars and displacing one of the 35.8-ton cars 391 ft (Fig. 10). Eyewitnesses affirm that the car was lofted and not rolled. It is not unusual for tornadoes to topple and derail train cars, but to our knowledge, no other tornado in the prior historical record has displaced heavy railcars such distances. The tornado had widened to 1.5 mi diameter by the time it crossed I-65 north of Birmingham, and was the widest tornado reported in the entire outbreak. This tornado killed 64 persons and injured at least 1500 others.

NEWTON, MS, EF3
1608-1622 CST, 11 mi long, 0.25 mi wide

This tornado struck a precast concrete highway bridge over a creek, briefly lifting some of the highway decking slabs off their concrete frame piers, and damaging the concrete guardrails. White concrete patches still bear testment to the parts of the concrete that suffered damage (Fig. 11).

RAINSVILLE, AL, EF5
1719-1759 CST, 37 mi long, 0.75 mi wide

The same supercell that resulted from the merger of a new supercell with the Neshoba County, MS, EF5 storm, spawned a new EF5 tornado in DeKalb County, AL. Just east of Rainsville, AL, the tornado reached peak intensity. It swept away several well-built homes, ripping an 800-lb safe from its concrete slab anchorage and tossing it more than 600 ft into nearby woods. The couple in the home survived by seeking shelter in an underground storm pit, which had part of its soil cover stripped away by the tornado, causing the storm pit to become unstable and heave slightly upwards (Fig. 12). At another residence, destruction of the house was accompanied by collapse of a concrete porch column, which resulted in the leveraging up out of the ground of the supporting concrete porch and foundation (Fig. 13). This tornado also stripped pavement off of several roads. After crossing into Georgia, the tornado dissipated, but was quickly followed by another EF4 violent tornado near Ringgold, GA. The parent supercell storm lasted at least 13.1 h, finally weakening and merging with other convection near Front Royal, VA.

4. ACKNOWLEDGMENTS

This research was supported by the National Science Foundation under grant AGS-1140387. Figs 4, 12 and 13 were captured by NWS Huntsville survey crews, while Fig. 9 was captured by an NWS Birmingham aerial survey crew. Fig. 10 was obtained from Google Maps, using latitude-longitude coordinates 33.512N, -86.947W, and near maximum zoom (Google Maps imagery is subject to change without notice). All other images are copyright Eugene W. McCaul, Jr., and are used with permission. We are grateful to all landowners who allowed us onto their property to obtain photographic documentation of the damage wrought by this violent tornado superoutbreak.

5. REFERENCES

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Fig. 1. In northeast Neshoba County, MS, an EF5 tornado ripped grass out by the roots from a farm field, leaving only swaths of rubble.

Fig. 2. There were two separate swaths of rubble, suggesting the action of suction vortices. Wind stresses evidently caused topsoil to fracture, initiating the damage.

Fig. 3. In the historic district of Cullman, AL, an EF4 tornado caused old masonry structures to collapse.

Fig. 4. Farther northeast, as the Cullman tornado moved into Marshall County at peak size and intensity, modern-vintage brick homes were swept away, resulting in five deaths.

Fig. 5. In Hackleburg, AL, an EF5 tornado obliterated the north side of town.

Fig. 6. In Phil Campbell, AL, the Hackleburg tornado continued at EF5 intensity, stripping pavement of roads. This giant tornado killed 72 in its 132-mi march across north Alabama and southern Tennessee.

Fig. 7. In Smithville, MS, another EF5 tornado destroyed most of the town, hurling a Ford Explorer SUV 0.5 mi into the city's water tank, leaving a permanent dent in its side.

Fig. 8. Contrary to numerous early reports on internet sites, the removal of a steel drainage pipe from a Smithville street was not accomplished by the tornado. The street had been dug up earlier to ensure closure of an unsafe stretch of road to traffic.

Fig. 9. Just northeast of Tuscaloosa, AL, a large and iconic tornado ripped a still-used steel railroad bridge to pieces, throwing and rotating one 34-ton truss tower uphill about 100 ft.

Fig. 10. Near Pleasant Grove, AL, the Tuscaloosa tornado swept across a coalyard rail depot, derailing 29 of 31 empty coal cars, and lofting one of the 35.8-ton cars an astounding 391 ft (center). This tornado reached 1.5 mi width, killed 64 persons, and injured 1500 others.

Fig. 11. Just south of Newton, MS, an EF3 tornado roared across a precast concrete highway bridge with such force that it lifted the highway decking slabs, and damaged the concrete railings (see white patches).

Fig. 12. Near Rainsville, AL, the final EF5 tornado of the outbreak swept homes away, and scoured much of the overlying dirt from the top of a buried storm shelter; the occupants cowered inside, as the shelter shook and almost heaved up out of the soil.

Fig. 13. East of Rainsville, the EF5 tornado demolished old stone and concrete houses, toppling concrete columns, and leveraging one structure's concrete foundation up out of the ground. Some 25 persons were killed by this tornado.