Tornado Debris from the 23 May 2017
“Tybee Tornado”

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On 23 May 2017, an enhanced Fujita scale 2 (EF2) tornado impacted the coastal islands to the east of Savannah, Georgia. This tornado initially touched down on Wilmington Island several miles west of the popular tourist destination of Tybee Island, where it caused EF1 damage to several homes. News reports at the time and afterward often referred to this storm as the “Tybee tornado,” despite the fact that the tornado did not actually traverse Tybee Island, because it was clearly visible from Tybee Island for most of its 11-min, 12-km (7.5-mi) lifetime. The tornado continued to move to the northeast across generally marshy terrain, crossing U.S. Route 80 before impacting the National Park Service (NPS) Fort Pulaski National Monument on Cockspur Island. Here the tornado strengthened to EF2 intensity, snapping trunks of hardwood trees near the ground and causing the concrete walls and roof of the Fort Pulaski National Monument Visitor Center to shift and buckle. The fort was closed for repairs for one month and the damage was estimated at $400,000.

In this short article we focus on the debris lofted by this tornado at Fort Pulaski. The unique nature of the debris, and the careful work of NPS employees in cataloguing the origin and landing points of the debris, allow for an unusually accurate discussion of the trajectories of heavy tornado debris.

METEOROLOGICAL SUMMARY. On the morning of 23 May 2017, a broad mid- to upper-level trough was located across much of the interior United States from the Rockies eastward to the Appalachians. A weak frontal wave was present at the surface across southern Alabama, extending to the northeast on the lee side of the southern Appalachians. The National Oceanic and Atmospheric Administration (NOAA)/NWS Storm Prediction Center (SPC) noted that this frontal zone would likely provide the focus for thunderstorms across the region, and that locally backed surface winds could allow for an isolated tornado threat across portions of Georgia and South Carolina. The Area Forecast Discussion (AFD) issued by Weather Forecast Office (WFO) Charleston, South Carolina (CHS), at around 1100 UTC 23 May 2017 acknowledged that there were signals that “a squall-line type feature” could develop by early afternoon and bring a risk for damaging winds and a few tornadoes, with the...
At 2047 UTC, the first tornado warning was issued for the cell that would go on to produce the Tybee tornado, which had already produced wind damage near Hinesville, Georgia. At 2141 UTC, a tornado warning was issued for areas to the south and east of Savannah, including Wilmington Island and portions of Cockspur Island. A local storm report confirmed a tornado near Fort Pulaski at 2201 UTC (Fig. 1), which was reiterated in a Severe Weather Statement at 2207 UTC. The storm continued to move northeast over water, and the warning was allowed to expire at 2215 UTC.

TORNADO DEBRIS BACKGROUND. While tornadoes have been a topic of research for decades, examination of debris travel and trajectories has received less attention. This type of analysis requires knowledge of the origin of the debris that is rarely available. Most debris for which a starting point can be identified are paper items with addresses or faces on them, such as pictures, checks, and/or mail, or extremely heavy items (vehicles, railcars, etc.) that were so massive that their movement was easily noticed and documented poststorm. However, very little is known about the travel of items that fall between these extremes.

At the base of a tornado, strong radial inflow initially lifts debris and carries it into the core region at the base of the tornado, forming the debris fountain (Snow 1984). In their 2D simulation of motion and concentration of debris and hydrometeors in tornadoes, Dowell et al. (2005) note two flow regimes that influence the travel and deposition of debris. As the tornado lofts debris, some of these objects begin to fall out of the storm. The lightest of these objects (with fall speeds of less than 10 m s$^{-1}$) can once again fall into the inflow layer and be drawn back into...

Fig. 1. Map showing the 2202 UTC 0.5° reflectivity image from the KCLX Weather Surveillance Radar-1988 Doppler (WSR-88D) in Charleston at the approximate time a tornado was impacting Fort Pulaski. The initial tornado warning polygon (red), issued at 2141 UTC, and the tornado damage path (dark gray) as surveyed by WFO CHS are overlaid.
the tornado, concentrating items near the core of the tornado and carrying these objects into the updraft of the storm. In contrast, heavier items are quickly centrifuged away from the core of the tornado.

The debris that is drawn into the updraft can be carried considerable distances, and most previous studies of debris travel focus on these far-flung items. For example, Snow et al. (1995) examined 163 items for the period 1950–90, with travel ranging from as little as 8.05 km (5 mi) to 338 km (210 mi). In their study of a 7 May 1995 tornado, Magsig and Snow (1998) found travel distances for 50 traceable items ranging from 9 to 191 km. Given that both of these studies focused on long-distance transport of items, they examined a total of only 11 heavy (≥0.45 kg (1 lb)) items between both studies. Knox et al. (2013) conducted the most comprehensive study of long-distance debris travel to date, which examined over 900 items that were lifted by the tornadoes across Alabama and neighboring states on 27 April 2011. Data on the starting and ending points for the items were gathered from a Facebook page. Given that the Facebook group that was used for information on debris travel was intended to reunite pictures with their owners, the vast majority of items (over 98.5%) analyzed by Knox et al. were classified as either paper or light (<0.45 kg or 1 lb) items. Travel distances of the items examined by Knox et al. ranged from as little as 0.27–353 km.

However, it is well known from post-tornado damage surveys that extremely heavy items can be transported by tornadoes as they are centrifuged away from the core of the tornado or simply pushed by the winds. As was the case at Fort Pulaski, vehicles are routinely moved by tornadic winds. For example, the Smithville, Mississippi, tornado of 27 April 2011 lofted a vehicle that traveled approximately 800 m (0.5 mi), striking the town’s water tower before continuing an additional 400 m (0.25 mi; McCaul et al. 2012). The Pam-pa, Texas, tornado of 8 June 1995 is well known for lofting a pickup truck approximately 30 m into the air (Davies-Jones et al. 2001). Again on 27 April 2011, the tornado that struck Tuscaloosa, Alabama, moved a 34-t steel truss that was supporting a railroad bridge a distance of 30.48 m (100 ft), and lofted a 32,477-kg (71,600 lb) railcar approximately 118 m (390 ft; McCaul et al. 2012). Fujita’s (1970) examination of the 11 May 1970 Lubbock, Texas, tornado documents the movement of 13 concrete beams that weighed over 49,000 kg (109,000 lb) and a 14,515-kg (32,000 lb) fertilizer tank that was believed to have been airborne for 700 m and then rolled an additional 190 m to its final location.

While the debris lofted by the Tybee tornado is not the heaviest to be transported by a tornado, their travel provides a unique opportunity to examine the movement of items that are neither light nor extremely heavy. In fact, the markers are remarkably similar in weight to common household appliances, such as washing machines or water heaters, that would become part of the debris field when residential structures are impacted by a tornado, and are heavy enough to cause additional damage to anything they might strike. Given this, it is important to understand their travel.

**TRAVEL OF DEBRIS AT FORT PULASKI.**

Four historical markers weighing over 68 kg (150 lb) each were transported by the tornado. Two of these markers were erected in 1958: the John Wesley

![Fig. 2. The endpoint of the Cockspur Island Lighthouse marker, approximately 1.22 m (4 ft) from the pole it was mounted on in the foreground. Photo courtesy of NPS.](image-url)
The History of Emancipation: Gen. David Hunter and General Orders No. 7 (David Hunter) marker was placed in 2008, while the Cockspur Island Lighthouse marker was erected in 2011. Of these markers, the Cockspur Island Lighthouse marker had the shortest travel of around 1.2 m (4 ft; Fig. 2). The remaining markers traveled much farther—at least 67 m (220 ft; Fig. 3). The Wesley marker was broken into at least three sections, and two of these sections were recovered after the tornado (Fig. 4). It is possible that the monument was fractured after impacting one of the vehicles in the parking lot. While anecdotal, a gash in one of the vehicles was approximately the same width as the marker and the vehicles were parked immediately in front of and downwind of the marker (C. Rohe 2017, personal communication). The “top” section of the monument, section 1 (corresponding to the red path in Fig. 3), traveled approximately 160 m (525 ft). The larger of the sections, section 2 (corresponding to the blue path in Fig. 3), traveled approximately 300 m (1,000 ft) and to the right of the tornado track. The David Hunter marker (depicted in orange in Fig. 3) followed a very similar path to the top portion of the Wesley marker, traveling approximately 220 m (730 ft) to the northeast of its start location near the Fort Pulaski National Monument Visitor Center (Fig. 5a). Finally, the Waving Girl marker (depicted in magenta in Fig. 3) took a much different path than the other monuments impacted by the tornado, traveling 67 m (220 ft) in a southerly direction, where it was recovered in an area of vegetation (Fig. 5b). It is apparent that even an EF2 tornado can carry relatively heavy items that could be deadly and extremely damaging to other structures for some distance.
Previous research of long-distance travel of tornado debris by Snow et al. (1995) found that most items come to rest in a concentrated area of debris between 10° and 35° to the left of the tornado path. However, heavy items in that study typically fanned out over a wider area between 10° to the right of the storm path and 75° to the left of the storm path. The data examined by Knox et al. (2013) contain a similar pattern, with heavy items spread between 16° to the right and 51° to the left of the average tornado track. In contrast, the local travel of debris is dominated by the near-tornado wind field and items being centrifuged out of the storm, and this was what occurred at Fort Pulaski. For example, the David Hunter marker and both sections of the Wesley marker appear to be carried with the tornado as it crossed Cockspur Island. However, the Waving Girl marker took a much different path, traveling at an angle greater than 90° to the right of the tornado track, a path that seems much more likely to be related to centrifuging of debris.

CONCLUSIONS. The 23 May 2017 “Tybee tornado” was responsible for $400,000 damage at the Fort Pulaski National Monument in southeast Georgia, closing the site for one month. While no injuries or fatalities were recorded at the fort itself, three fishermen were killed just offshore when their fishing boat was capsized by the tornado. The storm is notable for transporting several heavy historical markers considerable distances. Two intact markers traveled distances of 67 and 220 m (220 and 730 ft, respectively), while portions of the Wesley marker traveled approximately 300 m (about 1,000 ft). These markers demonstrate the varied angles and distances that heavy items can be transported by a tornado of moderate intensity. The study of both the long-distance and local travel of tornado debris is critical to understanding dispersion of hazardous material that may be ingested into a tornado and the potential impacts of these airborne items to people and structures downwind of these storms.

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FOR FURTHER READING

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