Southeastern US Tornado Outbreak 21-22 January 2017

Destruction of Albany Baptist Church in Albany, GA

University of Florida's Wind Hazard Damage Assessment Group
http://windhazard.davidoprevatt.com

David O. Prevatt, Ph.D., PE, dprev@ce.ufl.edu
Frank T. Lombardo, Ph.D., lombaf@illinois.edu
David B. Roueche, Ph.D. david.roueche@ufl.edu

Contributing Authors:

University of Florida

Arpit Bhusar
Siddhesh Rahate
Anant Jain
Alyssa Egnew
Mark Mimms
Allan Gutierrez
Quinten Ozimek

University of Illinois at Urbana-Champaign

Justin Nevill
Daniel Rhee

UF UNIVERSITY of FLORIDA
Herbert Wertheim College of Engineering

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

University of Florida
University of Illinois at Urbana-Champaign
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EXECUTIVE SUMMARY

This is the first preliminary wind damage report to be published in 2017 by the Wind Hazard Damage Assessment Group (WHDAG) of the University of Florida. The report focuses on damage caused by a tornado outbreak affecting large parts of the southeast United States, and it includes information related to two strong tornadoes that affected Adel and Albany in SW Georgia. In the main, we present observations from damage in Albany, GA, caused by an EF-3 rated tornado, with estimated maximum peak wind speeds of 150 mph, a total length of 70 miles and maximum width of 1.25 miles, according to the National Weather Service. Our report is in a hybrid format, to include preliminary damage information culled from online sources, and additionally, a summary of findings of our field investigations by WHDAG members.

We are pleased to welcome participation in this report by the University of Illinois at Urbana-Champaign (UIUC) field survey team, led by Dr. Frank Lombardo. Their objective (of Dr. Lombardo's research group), is to more completely understand the nature of transient wind hazards such as tornadoes and how properties of these hazards are relevant to wind loading of structures. With partial support of NOAA VORTEX-SE project, the UIUC group conducted surveys in collaboration with Dr. Christopher M. Godfrey of the University of North Carolina-Asheville and Dr. Chris J. Peterson from the University of Georgia.

There remains a need to study this tornado outbreak as representative of issues related to tornado occurrences in the Southeastern US. These issues include their fast translation speed, and the wind flow modification and difficulty in observation due to varied terrain and topography. The UF and UIUC survey teams operated independently but were coordinated to cover a wide area with limited resources. The UIUC team introduced the approach to capture directional information from felled trees and road signs which are invaluable to estimating the width of the tornado paths, location of vortex and wind directions. The WHDAG survey team spent one day documenting the performance of structures in a neighborhood of single family homes, a fire station training center (which included a tornado shelter), and a masonry church that was destroyed. The UIUC survey team conducted three case studies on residential structures, as well as collecting the damage to and directions of fallen trees, light posts and signs, using a digital compass.

The damage investigation and this preliminary damage report has been a beneficial exercise for the graduate and undergraduate students involved, for most of whom this was their first post-tornado field investigation. While to a structural engineer much of the observed damage is severe but not unexpected, to a resident of Albany or Adel, the experience must be extremely frightening, devastating and a life-changing event.

The widespread catastrophic failures are not of themselves failures of engineering, but they are the inevitable result of policies that ignore tornado loads from minimum building design standards. It will be up to the populations in our communities (neighborhoods, towns, states) to decide whether to follow the lead of Moore, OK and implement tornado-resilient building codes in the future.

The WHDAG members continue to advocate for policy discussions within communities to determine whether those communities sufficiently understand the added risks of current design approaches or that improving vertical load paths to create tornado-resiliency in new construction will require very moderate increases (less than 3-5%) to the cost of a new home.

This preliminary report presents a summary of the entire tornado outbreak, and preliminary findings from the ground-based surveys. The WHDAG and UIUC teams will provide future updates of their respective field surveys.

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ABOUT THE WIND HAZARD DAMAGE ASSESSMENT GROUP

The Wind Hazard Damage Assessment Group was created through support from the NSF Award #1150975. Its mission is to train university students interested in building construction, engineering and architecture in the forensic engineering and techniques for post-hazard damage surveys and data collection. The team has surveyed damage after several Florida tornadoes and continuously monitors the prevalence of tornadoes worldwide. Ultimately the Damage Assessment Team hopes to inspire upcoming engineers and building professionals in hopes to change the paradigm of widespread catastrophic damage to houses in tornadoes and other extreme wind events.

Please visit our website, http://windhazard.davidoprevatt.com, for additional information, and to download previous damage reports, and filed survey results conducted by our group. Dr. Prevatt and his colleagues have published several papers on recent violent tornadoes that struck Tuscaloosa, AL, Joplin, MO, and Moore, OK. His group has also inspected damaged structures and compiled reports on tornadoes that occur in Florida. Information is also available on the research at www.davidoprevatt.com. Your questions and comments on any aspects of our work are most welcome. Please direct your enquiries to Postdoctoral Researcher, Dr. David B. Roueche.

The portions of this report not covering the Albany, GA tornado were prepared from online sources by University of Florida civil engineering students in Prof. David O. Prevatt's Research Group. The study is done in parallel to our experimental research seeking to understand and quantify the strength of tornadoes and their impact on vulnerable wood-framed residential structures. Compilation of this information is part of student learning objectives in forensic engineering and post-disaster damage investigation.

The students gathered the information from reliable online sources, such as the National Weather Service, Accuweather, the US Census Bureau and the national media. Photographs were also obtained from publicly available Twitter feeds. All sources for photographs not taken by the students are provided in the text.

1 FORECASTS

The potential for a tornado outbreak in the Southeastern United States was recognized several days in advance. By 18 January, the National Weather Service convective outlooks for 21 January and 22 January indicated significant chances for severe weather in the Deep South, as shown in Figure 1. The confidence in a strong severe weather event, including tornadoes, increased further in the subsequent days. The Day 1 outlooks as issued at 8PM on 20 January and 21 January, are shown in Figure 2 and Figure 3.

Figure 1: Day 4 convective outlook from the NWS issued on 18 January and valid for 22 January.

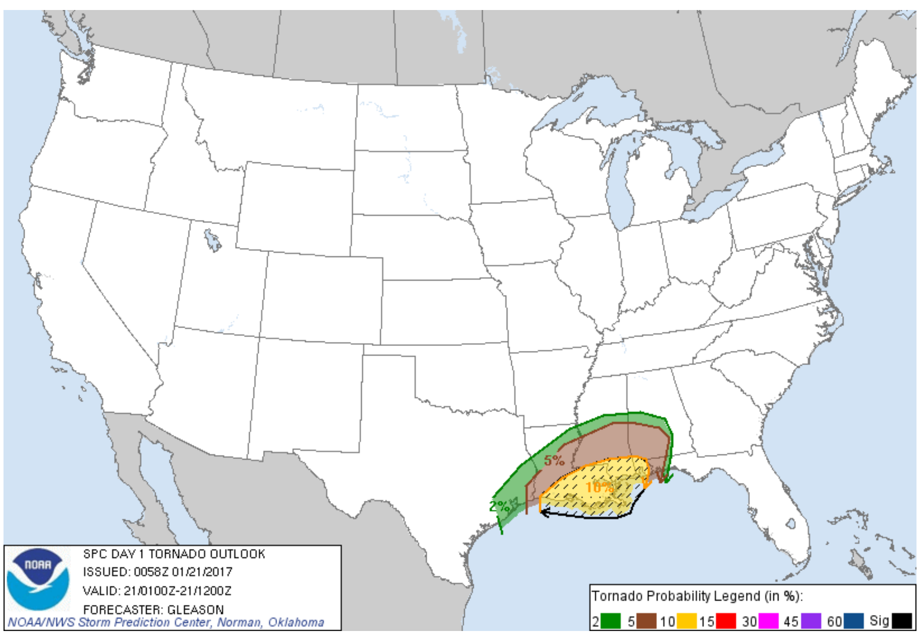

Figure 2: Day 1 tornado probability issued by the NWS at 8PM EST on 20 January for 21 January.

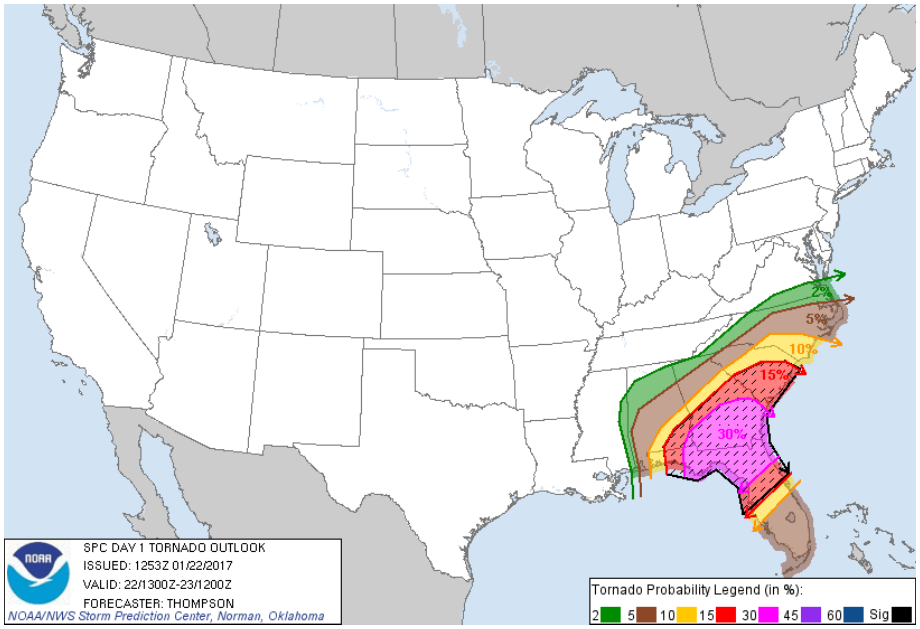

Figure 3: Day 1 tornado probability issued by the NWS at 9 AM on 22 January for 22 January.

The HIGH risk region indicated 30% probability of significant severe weather within 25 miles of a given point in the region. The hatched area represented a 10% probability of EF2 or greater tornadoes within 25 miles of a point.

A Particularly Dangerous Situation tornado watch was issued by the NWS at for a large area in south Georgia and north Florida for 22 January. This was extended to central Florida as the day progressed.

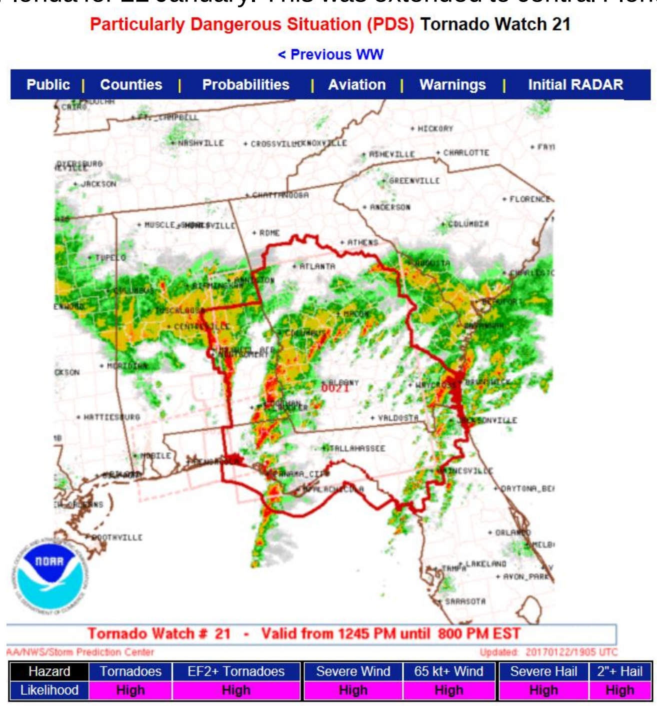

Figure 4: Particularly Dangerous Situation tornado watch issued by NWS at 12:05PM EST.

All told, the severe weather was expected well in advance, tornado watches were in place for affected areas, and overall the impacts could have been much worse than they actually were given the forecasted risks.

2 TIMING OF IMPACTS

The weekend outbreak occurred over two calendar days, the 21st and 22nd of January, but three days in the NWS database, where a day goes from 1200UTC (7 AM EST) on one day to 1200UTC (7 AM EST) on the next. The overall timing within each day is summarized below. Most of the information is taken from the local storm reports, available through the NWS Storm Prediction Center.

Table 1: Summary of the timing of the tornado outbreak

Time (EST)	Event
21 January 2017	
4:50 AM	Tornado reported in Hattiesburg, MS and Petal, MS, damaging hundreds of homes.
6:14 AM	Twenty homes reported damaged in Choctwa County, AL, four injuries.
10:41 AM	Damage to trees and roofing in Catuala, GA in Harris County.
11:20 AM	Damage reported to trees, powerlines and homes in Upson County, GA.
12:28 PM	Damage reported to roof of a Walmart in Warner Robins, GA in Houston County. Three homes with major damage, four with minor damage in same county.
3:52 PM	Injury reported in mobile home destroyed by a tornado in Barnwell County, SC.
6:12 PM	Severe damage reported to two mobile homes in Bossier, LA.
6:56 PM	Five homes with significant damage in Natchitoches County, LA.
2:58 AM	Three injuries in Brooks County, GA with reported tornado.
3:32 AM	Two fatalities when mobile home tossed onto highway in Brooks County, GA.
3:45 AM	Seven fatalities reported in Adel, GA in Cook County. Fatalities occurred in Sunshine Acres mobile home park.
3:50 AM	Two fatalities in Berrien County, likely continuation of Cook County tornado.
22 January 2017	
2:00 PM	Multiples structures damage in Henry County, AL.
3:00 PM	EF1 tornado in Lee County, AL. Path length of 3.08 miles, maximum width of 600 yards.
3:20 PM	Four fatalities and multiple homes damaged in Albany, GA in Dougherty County.
4:15 PM	Houses heavily damaged near Abbeville in Wilcox County, GA.
1:39 AM	EF1 tornado in Palm Beach Gardens in Palm Beach County, FL.
3:45 AM	EF1 tornado in Miami Springs in Miami-Dade County, FL. Multiple apartment buildings with roof damage.

3 SUMMARY OF IMPACTS

At the time of this report, there have been 61 confirmed tornadoes from 21 and 22 January, making these two days one of the largest January tornado outbreaks ever recorded. The areas that sustained the heaviest damage included Hattiesburg and Petal in MS, and Adel and Albany in GA. The locations of these three points are given in Figure 5 along with brief summaries of the impacts. This report primarily focus on the ground surveys of the Albany, GA tornado, but summaries are also provided of the Hattiesburg, MS tornado and the Adel, GA tornado. Damage from an EF1 tornado in Palm Beach Gardens, FL is also summarized since the damaged homes were built to the wind-resistant Florida Building Code. Not every tornado is described in this report, but as they become available, details of each tornado can be accessed through the NWS Damage Assessment Toolkit, or through the individual NWS offices where the tornadoes occurred.

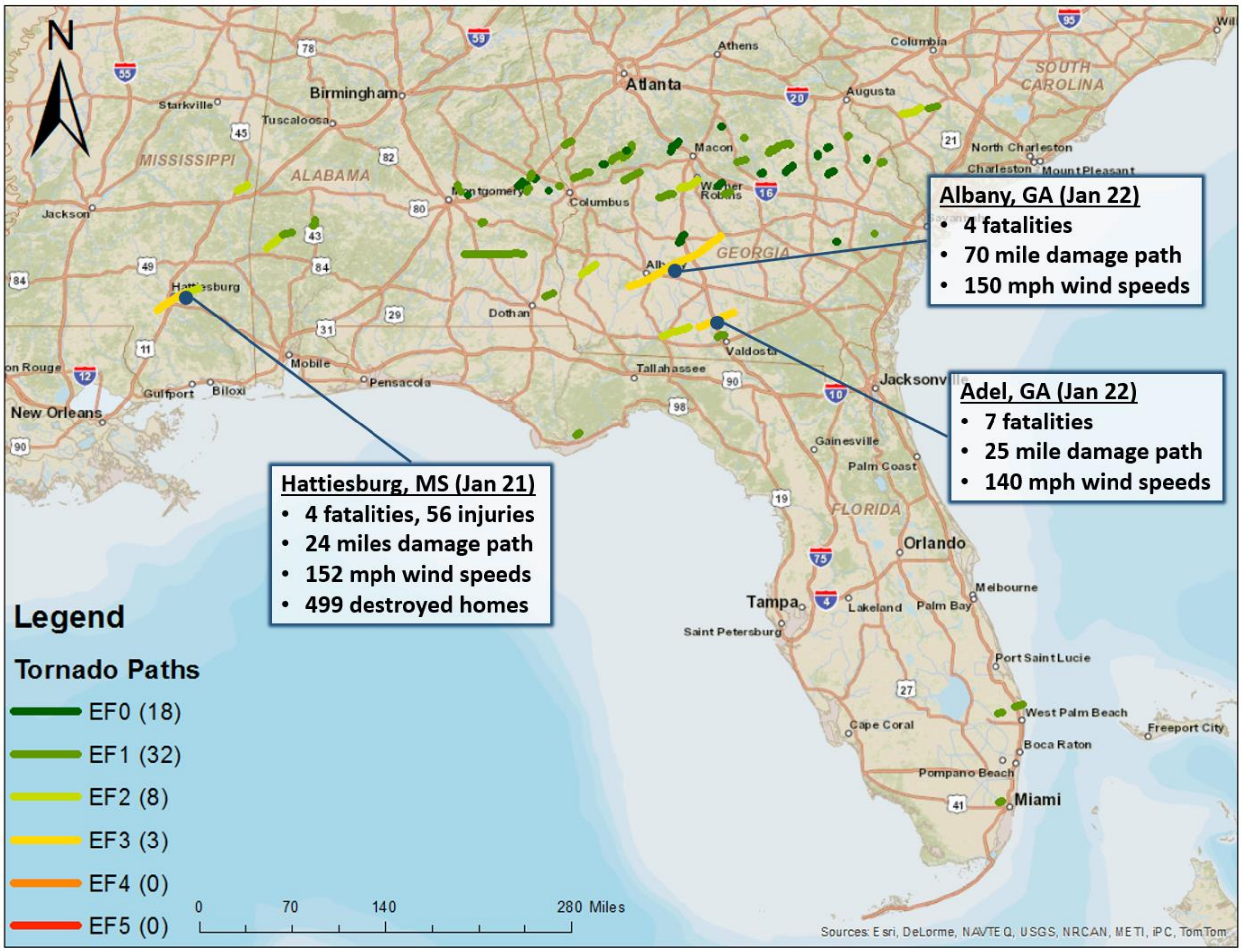

Figure 5: Locations of the 61 confirmed tornado tracks from 21 and 22 January 2017. Tornado paths were extracted from the NWS Damage Assessment Toolkit.

4 GROUND SURVEY OF ALBANY, GA TORNADO BY UF AND UIUC TEAMS

The city of Albany, GA (population 76,000) was struck by a tornado on the afternoon of 22 January 2017. Reports indicated the tornado struck a mobile home park, Big Pine Estates, also known as Paradise Village of Albany, causing three fatalities. A fourth fatality was observed just outside the mobile home park. In addition to the extensive damage at Paradise Village, heavy damage was sustained at the Marine Corps Logistics Base, several industrial sites including a Cooper Tire warehouse, a plywood supplier, and a tractor trailer repair facility, and several churches. The National Weather Service (NWS) rated the tornado EF3, with a path length of approximately 71 miles and a path width of nearly a mile in some areas.

The reports of significant damage from the tornado near Albany, GA led the UF and UIUC teams to deploy for a field assessment of the damage. The University of Florida assessment team, under advisor Dr. David O. Prevatt, consisted of undergraduate students Alyssa Egnew and Mark Mimms, graduate research assistants Arpit Bhusar and Anant Jain, and postdoctoral researcher David Roueche, who are shown in Figure 6. The team left Gainesville at 6:30 AM on Tuesday, 24 January and arrived in Albany, GA at approximately 9:30 AM. The team left Albany, GA around 4:00 PM and briefly drove through tornado-damaged areas near Adel, GA before returning to Gainesville that night. The objective of the team was to collect perishable data concerning the extent and causes of structural failure in relation to the tornado path.

The UIUC team, under advisor Dr. Fank T. Lombardo, consisted of graduate students Justin Nevill and Daniel Rhee. The team arrived in Albany at 11:00 AM on Monday, 23 January and departed on the evening of 24 January. The objective of the UIUC team was to capture perishable data on tree-fall locations and directions and structural damage to residences. This report describes the surveys by the two teams and highlights preliminary findings. A comprehensive report will be issued once analysis of the complete datasets is finished.

Figure 6: UF WHDAG consisting of (left to right): Mark Mimms, Arpit Bhusar, David Roueche, Anant Jain, and Alyssa Egnew.

4.1 Methodology

The teams utilized GPS-capable cameras to capture the damage so that all damage could be geo-located within the tornado path. When individual structures were assessed, the teams were careful to document the damage using multiple photographs from all four sides of the structure. An example is shown in Figure 7. When capturing tree-fall locations, the direction of the felled trees was also recorded using the digital compass of the GPS cameras.

Figure 7: Damage to all four sides of a two story home located at 125 Ramsey Rd, Albany, GA.

4.2 UF WHDAG Survey Sites

The UF team had difficulty accessing some of the sites due to ongoing search and rescue operations. In particular, residential areas around Holly Dr. and along Radiom Springs Rd. were closed off throughout the day the team was on-site. The team was able to conduct ground surveys of a neighborhood off of Sylvester Rd near the edge of the tornado path. The team also surveyed a church and home that sustained heavy damage along Sylvester Rd near the center of the path. Near the Paradise Village, the team also assessed damage to a fire station training center and safe room that was damaged during the tornado. In other portions of the path, the team was only able to take general photographs while driving by. Some of the major sites of interest are shown in Figure 8 in relation to the approximate damage path and the geotagged photographs taken by the team.

4.3 UIUC Survey Sites

The UIUC team's general survey on 23 January 2017 included site-built residences west and east of Radium Springs Road (Figure 9, Damaged Neighborhood 1 and Damaged Neighborhood 2) and a third group of residences north of Moultrie Road and South Mock Road (Damaged Neighborhood 3). These homes are all within Dougherty County, south and southeast of Albany. The UIUC team was able to continue their survey of residences west of Radium Springs Road on 24 January 2017, including detailed surveys of selected residences. The team also had limited pedestrian access to the neighborhood east of Radium Springs Road and South of Holly Drive (Damaged Neighborhood 2) on 24 January 2017, but was unable to access any portion of Holly Drive between Highway 19 and Moultrie Road through the duration of the survey due to ongoing search and rescue operations. The residences in Neighborhood 3 were not included in any detailed survey – overall, these residences were found to have less wind and tree damage than those near Radium Springs.

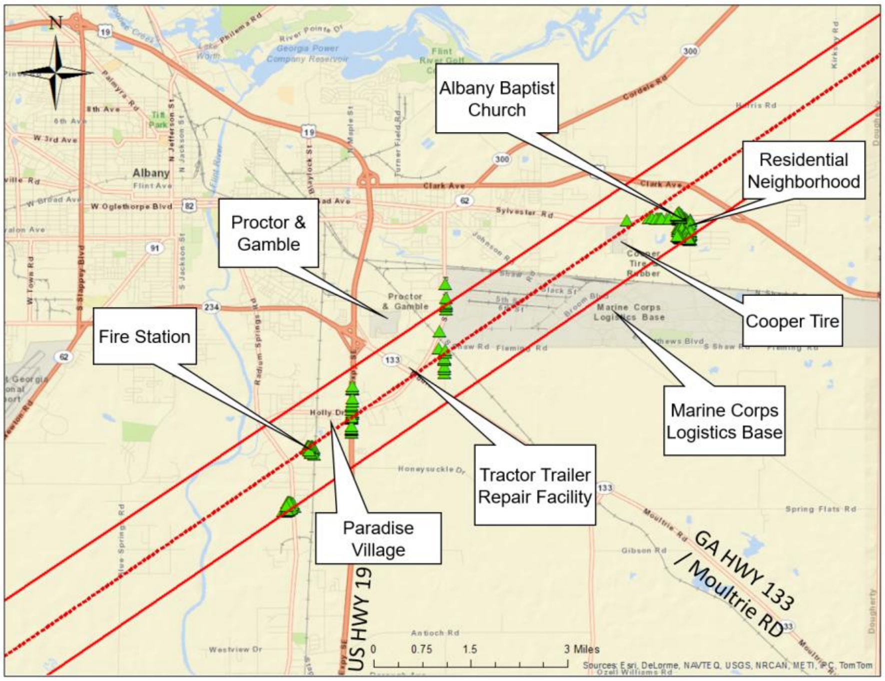

Figure 8: Photographs taken by the UF WHDAG (green triangles) in relation to key sites within the tornado path. The dashed red line indicates the approximate centerline of the tornado, and the solid red lines the extent of the tornado damage.

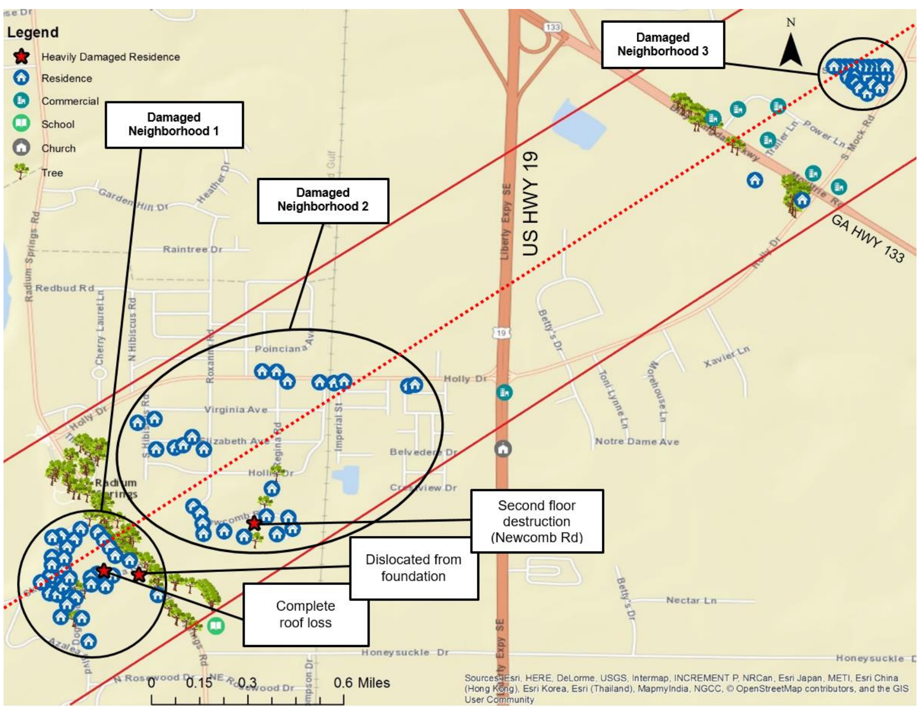

Figure 9: Summary of sites surveyed by the UIUC team in Albany, GA. The dashed red line indicates the approximate centerline of the tornado, and the solid red lines the extent of the tornado damage. Individual trees were selected as representations of damage – the location and density is not representative of the overall tree damage.

4.4 General Observations

Over the majority of the damage path that the teams surveyed, the most common damage was damage to trees and damage caused by trees to structures. In certain portions of the path, notably around Radiom Springs and off Sylvester Rd, heavy structural damage was observed. The photographs below summarize some of the general observations from both the UF WHDAG and UIUC teams.

Figure 10: Uprooted pine tree cuts through a light-framed wood residential structure (Source: UF WHDAG)

Figure 11: Light-framed wood gable roof structure located near north edge of tornado damaged by fallen tree. Only superficial damage elsewhere on structure (Source: UIUC)

Figure 12: Some roofs had asphalt shingle roofing removed (near edge of tornado path (Source: UF WHDAG))

Figure 13: A 2-story structure in "Neighborhood 1" suffered asphalt shingle and siding without any obvious structural damage (Source: UIUC)

Figure 14: Downed electrical poles snapped throughout the tornado path, many observed with windborne debris. The EF Scale (DI24) gives an expected wind speed of 118 mph for this failure. (Source: UF WHDAG)

Figure 15: Several homes were totally destroyed, including this structure, west of Radiom Springs Dr. that lost its entire roof (Source: UIUC).

Figure 16: House located on the Sylvester Rd, adjacent to Albany Baptist Church lost its roof and several exterior walls collapsed (Source: UF WHDAG)

4.5 Newcomb Road residence with majority destruction of second floor

This residence east of Radium Springs Drive Figure 17 was the only residence surveyed by the UIUC team where the majority of the second floor walls had collapsed. Roughly five percent of homes surveyed had an obvious second floor. The walls of the attached garage had also collapsed. The second floor walls appear to have been anchored exclusively with nails, but the relative quality of this construction has not been determined. The residents were unharmed sheltering in the first-floor bathroom.

Figure 17: (Left) Before: Google Streetview; (Right) After: Second floor destroyed, few interior walls remaining (Source: UIUC)

4.6 Fire Station #2 Training Center

Albany Fire Station #2 is located at 115 Honeysuckle Dr., on the right side of the tornado centerline just southeast of the Paradise Village mobile home park where three fatalities occurred. The training center contains a designated ICC500 tornado shelter within the main building. Three fire station personnel sheltered there during the tornado. The shelter itself, a separate room inside a larger building, did not sustain any damage, but the exterior of the building housing the shelter did sustain roof cover loss. In addition, a warehouse on the same site had one of four rolling doors collapse inward, with the resulting pressurization causing the corrugated metal panels on the back side of the building to rip off the supporting metal frame structure. Further analysis is being conducted to estimate failure wind speeds from these observations.

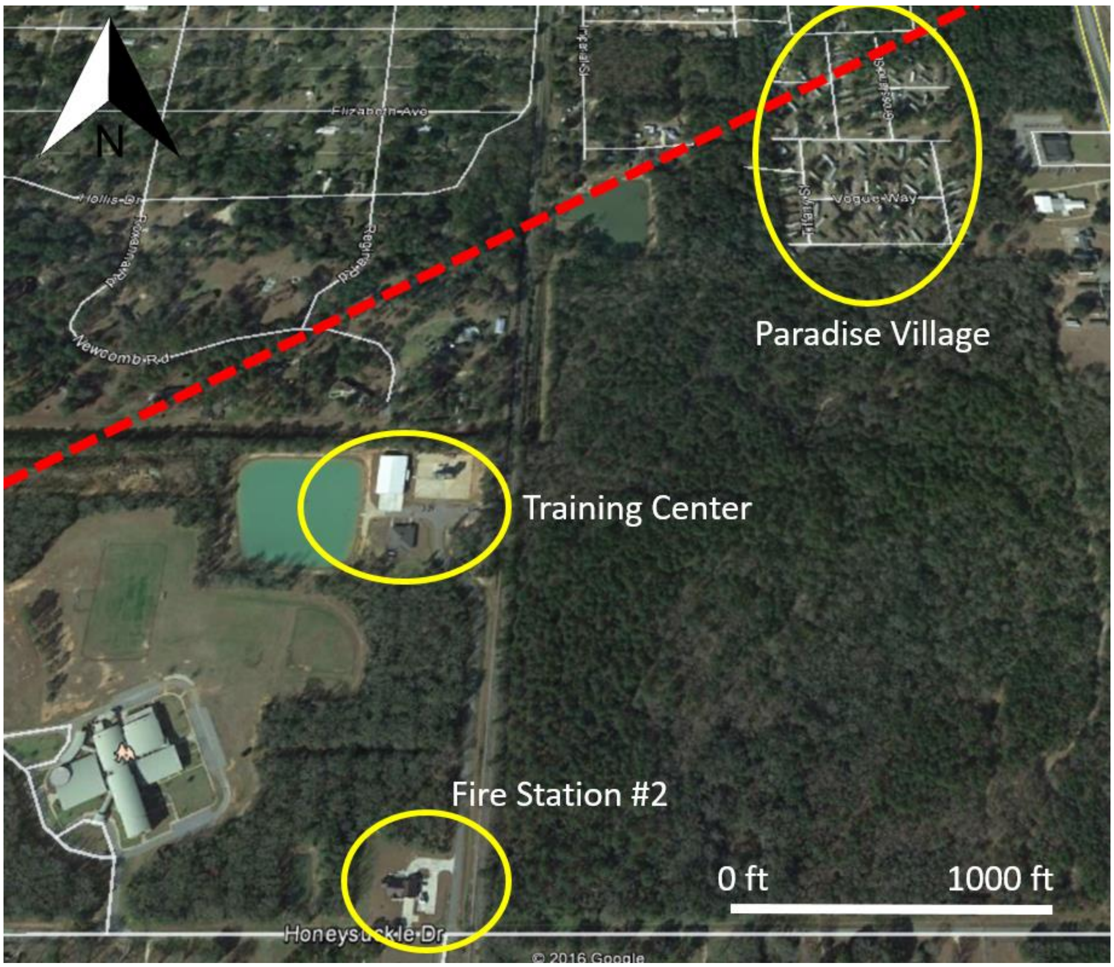

Figure 18: Location of Albany Fire Station #2 and Training Center in relation to the Paradise Village subdivision. An approximation of the tornado centerline is shown by the red dashed line.

Figure 19: Training center (left) and tornado safe room within the building constructed out of reinforced CMU block with ICC approved doors and no windows (right).

4.7 Albany Baptist Church

Albany Baptist Church is located at 3515 Sylvester Rd consisting of two main buildings, a fellowship hall which used to be the sanctuary, and a new sanctuary was built in 2002. Figure 20 and Figure 21 show before and after views of the church. The old sanctuary, is in the foreground and it is light-framed wood structure. The building in the background is the new sanctuary, and it is a reinforced concrete masonry units (CMU) block exterior walls with metal plate wood truss roof structure. The CMU wall had grouted cells, with rebar, at 8 ft on center. A wood top plate was fastened to the tie beam along the top of the wall with ½-inch j-bolts at 4 ft on center. Trusses were spaced at 2 ft on center with a 32 inch overhang, and were fastened to the wood top plate using USP RT12 connectors with (3) 8d nails in each leg of the connector. USP gives an allowable wind uplift capacity of these connectors as 355 lbs. Further analysis is being conducted to estimate the wind speed necessary to cause the observed failures.

While the enhanced construction (at least relative to typical residential structures) might have enabled the church to perform better than it did, several factors may have contributed to its catastrophic failure, including the following:

1) The large open area in front of the church facing the road and the oncoming path of the tornado may have allowed the wind speeds interacting with the church to be higher than they would have been in a densely treed or otherwise sheltered area. Exposure effects on tornadoes are not yet well understood however, so this remains just a hypothesis.
2) The layout of the buildings on the property, with the older, wood-frame structure in front of the newer sanctuary, may have resulted in the older building failing first and the debris impacting the new building, breaching the envelope and increasing the loads.
3) The orientation of the new sanctuary was such that the gable end was in the oncoming path of the tornado. Winds coming from that direction impinging on the gable end of a structure typically produce the worst-case loading condition for the roof.
4) The relatively large overhang of 32 inches allows positive pressures on the underside of the overhang to add to the uplift pressures on the top of the roof surface, significantly increasing the uplift loads on the roof-to-wall connections.

Figure 20: Front view of Albany Baptist Church before the tornado using Bing Streetside.

Figure 21: Front view of Albany Baptist Church after the tornado. Nearly half of the new sanctuary was destroyed by the tornado. The older wood-frame sanctuary was completely destroyed except for one interior room.

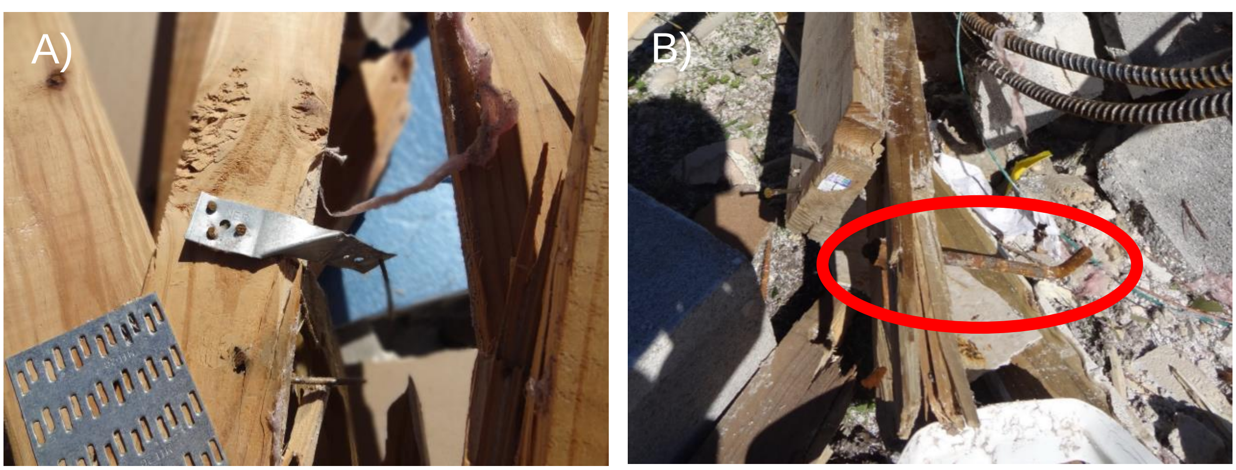

Figure 22: (C) USP RT12 hurricane tie used to attach each truss to the wall plate; (D) j-bolt with nut and washer used to fasten top plate to reinforced tie-beam along top of masonry wall.

5 SUMMARY OF IMPACTS TO OTHER COMMUNITIES

The significant damage to other communities not directly surveyed by the University of Florida Wind Hazard Damage Assessment Team is summarized below.

5.1 Hattiesburg, MS and Petal, MS

The tornado which struck Hattiesburg and Petal, MS has been given a preliminary EF3 rating, with maximum wind speeds estimated at 145 mph. The tornado was on the ground for approximately 31.3 miles and the widest swath of damage was 0.5 miles, according to the NWS Jackson, MS office (http://www.weather.gov/jan/20170121tor). As of 1 PM on 23 January, the Mississippi Emergency Management Agency reported 1,220 homes were damaged in eight counties from the severe weather, with 1,131 of these in Forrest County, where Hattiesburg and Petal are located. Of these 1,131, 499 were deemed destroyed. Four fatalities and 56 injuries were reported in Forrest County. Significant damage was sustained by a variety of structures, including older homes closer to downtown Hattiesburg, institutional buildings at William Carey University, fire stations and churches.

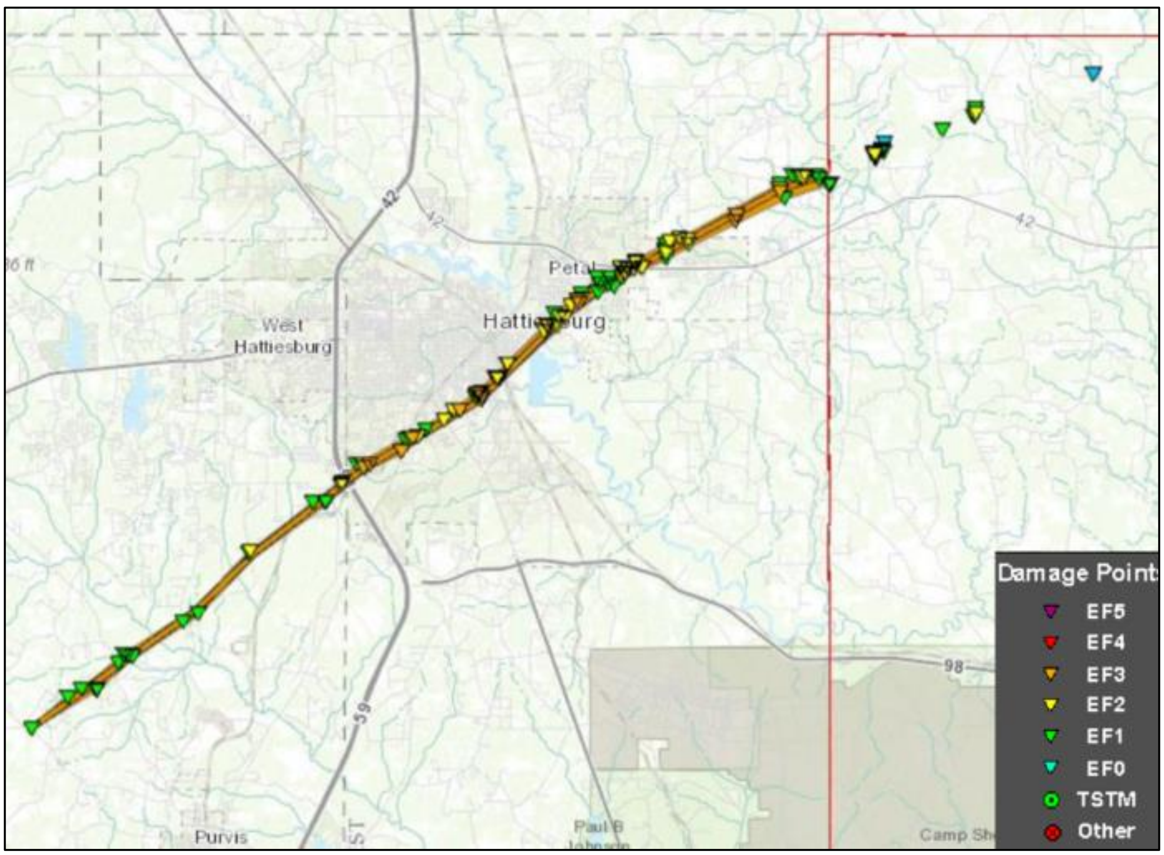

Figure 23: Damage path through Hattiesburg, MS from the NWS Jackson, MS office.

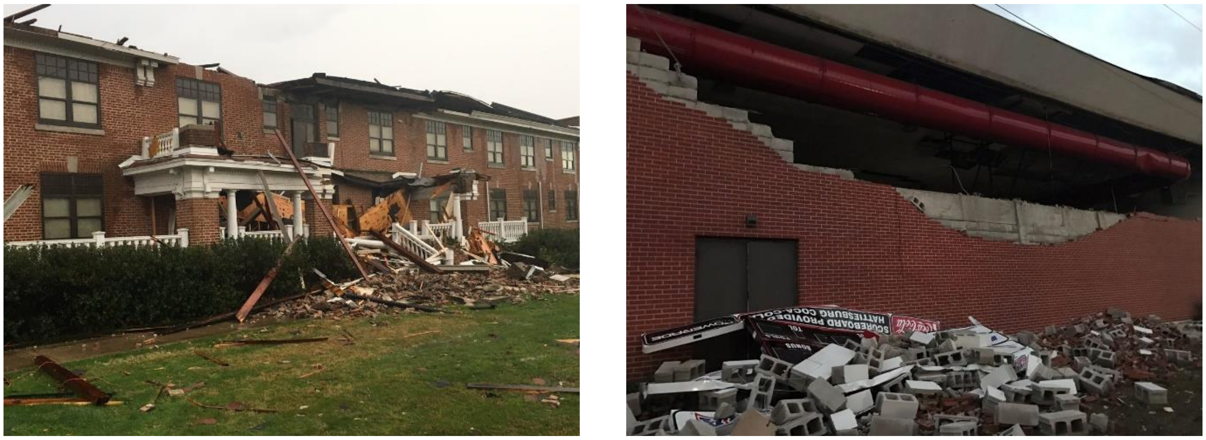

Figure 24: Damage to institutional buildings at William Carey University (Left: @WmCareyU; Right: @RyanMooreMS). Note the lack of grout in-fill in a large section of the CMU wall, which crumbled under the wind loads as a result.

Figure 25: Damage in Hattiesburg to an apartment complex (left, by Ryan Moore) and to Fire Station 2 (right, by Ryan Moore). The large openings shown in the fire station allow wind to pressurize the interior space, enhancing wind loads on the roof system.

5.2 Adel, GA

Adel is a small community of approximately 5,344 people in Cook County, GA. A tornado struck the southern outskirts of the town early in the morning of 22 January. A mobile home park about 3 miles southeast of Adel suffered the most damage, with seven confirmed fatalities and at least 15 homes leveled according to local reports. Much of the area directly in the tornado path was rural, with the exception of Sunshine Acres and a few site-built homes that sustained heavy damage. The damage and fatalities could have been even more extensive if the tornado had traveled a few miles north of its path, as shown in Figure 26.

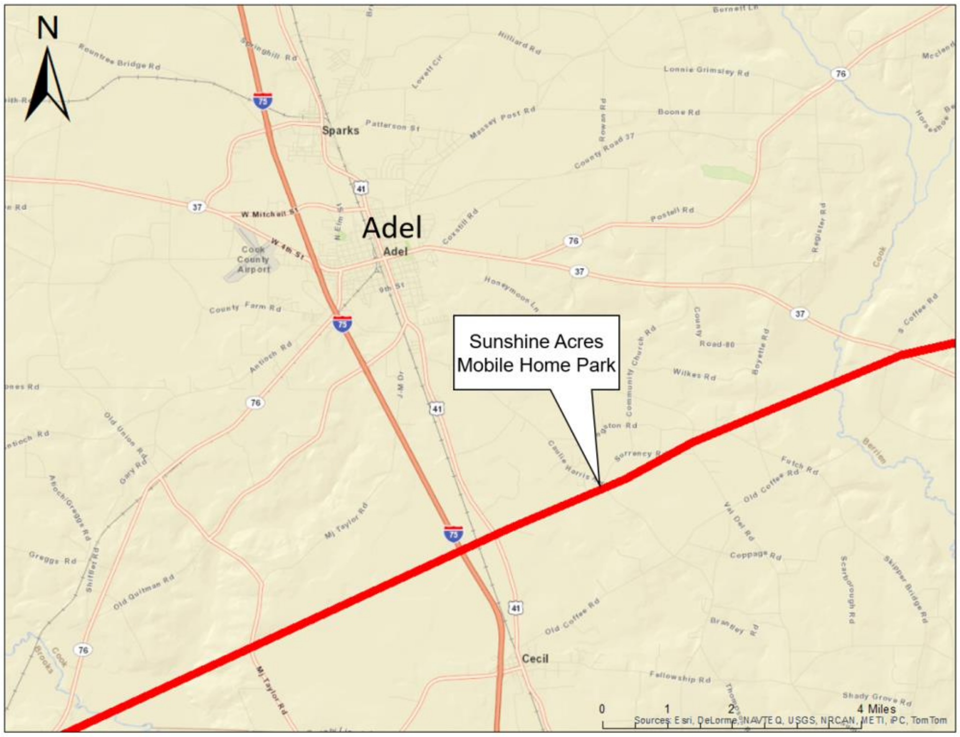

Figure 26: Location of Sunshine Acres, where seven fatalities occurred, relative to Adel, GA.

Figure 27: Damage near Adel, GA to a site built home (left, photo by Andrew Gorton), and Sunshine Acres (right, photo by Nathaniel Maine).

5.3 Florida Tornadoes

Several tornadoes occurred in south Florida in the evening of 22 January as the squall line moved eastward across the Florida peninsula. Figure 28 shows the damage paths as confirmed by the NWS Miami office. Each tornado was rated EF1, with maximum wind speeds estimated at less than 110 mph. Damage mostly consisted of broken tree branches and minor roof covering loss to residential structures. Of interest though was roof cover damage to a set of apartments in Palm Beach Gardens (just north of West Palm Beach). The entire damage path is shown in Figure 29, with the location of the apartments highlighted. A view of the apartments, looking east, is shown in Figure 30.

The apartments were built in 2004, after Florida adopted the statewide wind-resistant building code. In IBC 2003, the design wind speeds for this area of Florida can be interpolated as 145 mph, and further, it is a wind-borne debris region. With an EF1 tornado having maximum wind speeds of 110 mph, the wind speeds encountered by the apartment roofs were well below design, yet a significant number of roofing tiles failed. The failures raise the question as to what performance level the building code actually provides. Was this damage acceptable, since the building did not collapse and there was no loss of life? Should the expectation be that no damage occur in a below-design level wind event? Performance expectations for code-compliant structures are not well defined, and thus the failures observed here are an interesting consideration.

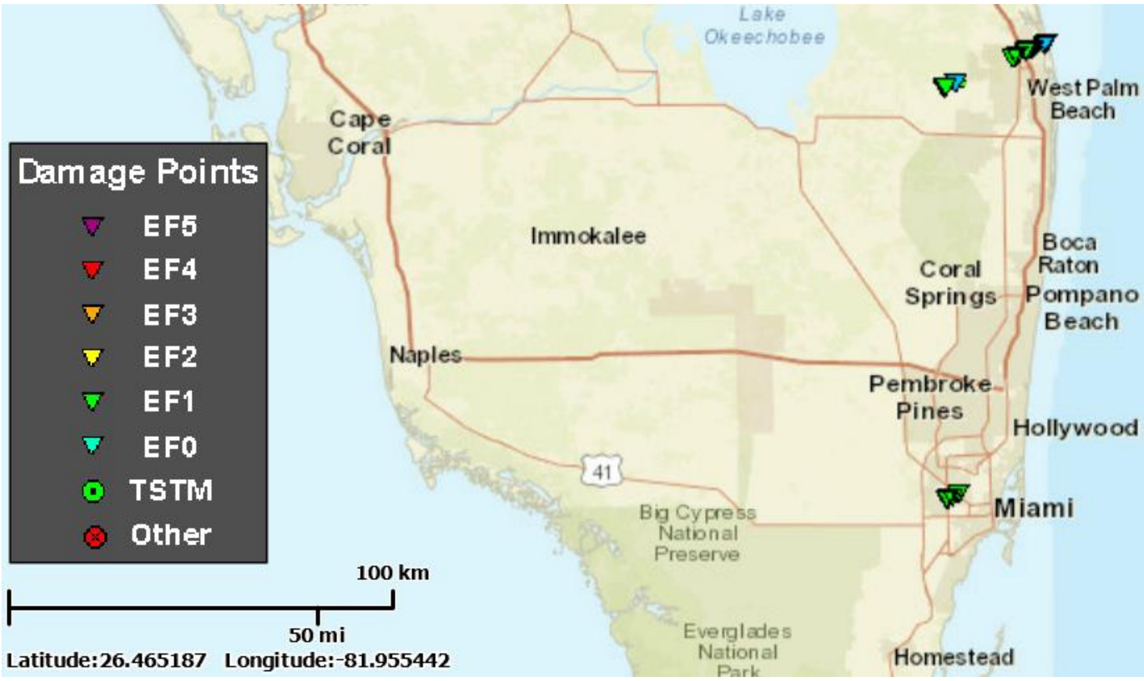

Figure 28: Tornado paths confirmed by the NWS Miami office from the 22 January severe weather. Each of the tornadoes were rated EF1. Map taken from the NWS Damage Assessment Toolkit.

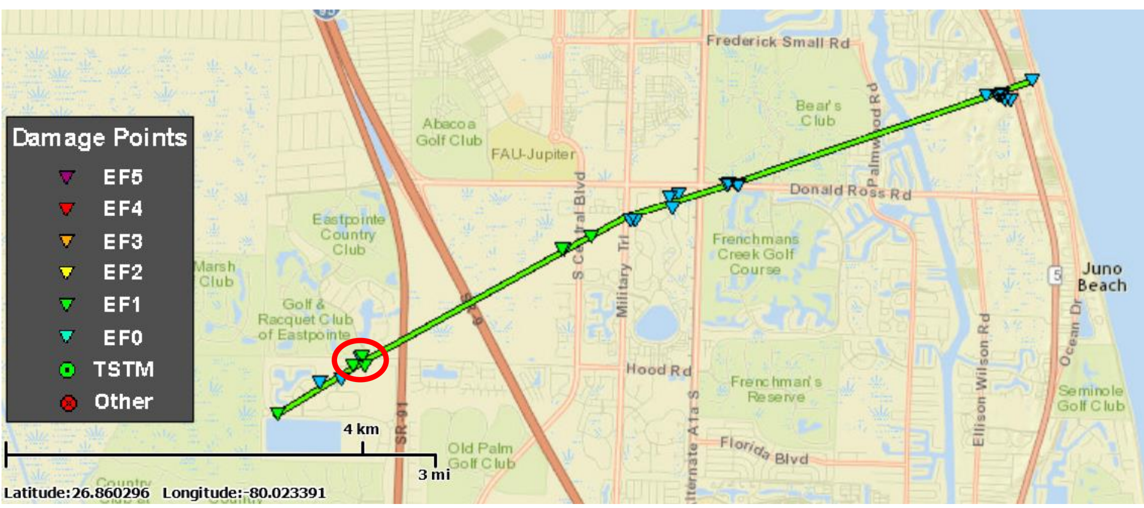

Figure 29: Damage path from EF1 tornado in Palm Beach Gardens, FL. Map taken from the NWS Damage Assessment Toolkit. Location of apartments of interest indicated by red circle.

Figure 30: Clay tile failure on multiple roofs in Palm Beach Gardens from the EF1 tornado. The approximate direction of tornado travel is indicated by the red/white arrow. Photo by [Michael Buczyner.]

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Appendix