Tropical Storm Julia – the Third Named Storm of 2016 in Florida
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Introduction

With its late-evening advisory on 13 September 2016, the National Hurricane Center declared that Tropical Storm Julia had formed from a tropical wave that had formed over Atlantic Ocean waters east of the Lesser Antilles and had more recently meandered near and over land in the eastern and central Florida peninsula. At the time of naming, the center of Julia was located about five miles west of Jacksonville. Julia was unusual in that it strengthened to tropical-storm strength while its center tracked over land and then never over water while the entity was at tropical-storm strength. This way in which Julia strengthened and remained over land is without precedent in the observational record in Florida (Figure 1) and was the first instance in the United States since Tropical Storm Beryl formed over southeastern Louisiana land in August 1988. Of course, it must be noted that, in the case of Julia and other land-forming tropical cyclones, a portion of their circulation is over warm waters. Indeed, because of westerly wind shear, the bulk of Julia's convection resided to the east of its center over Atlantic Ocean waters, even while the center was over land.

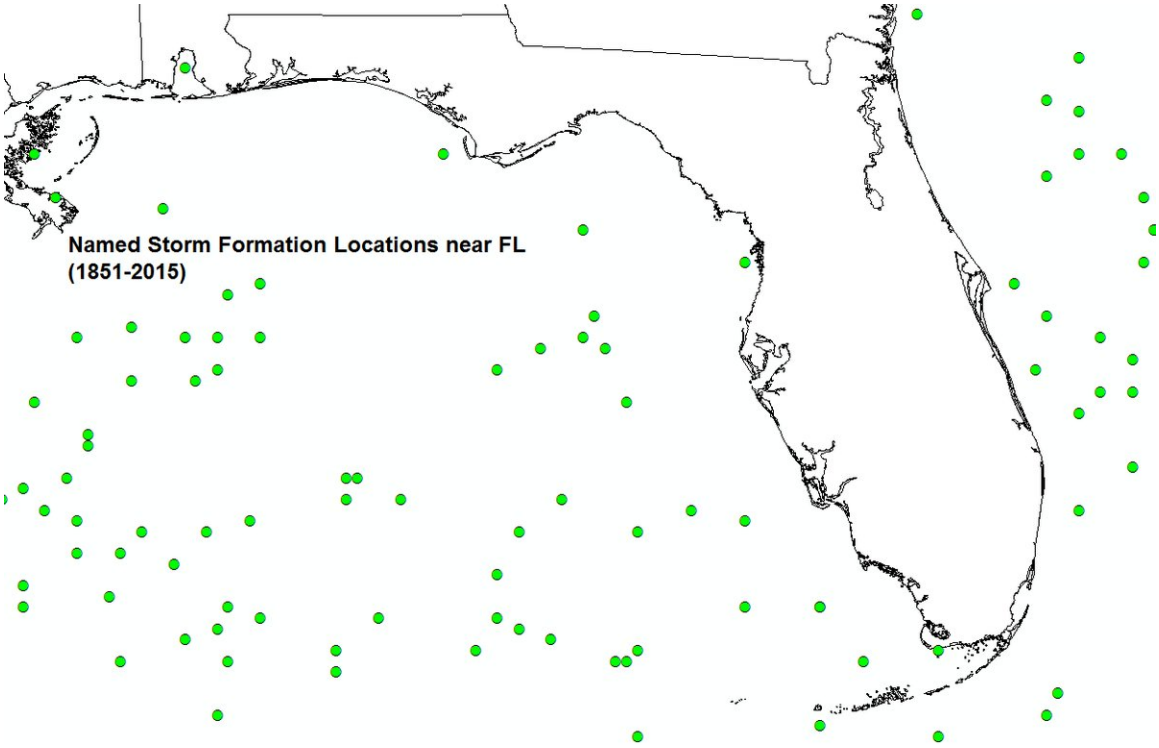

Figure 1: A plot of the locations of formation of tropical storms and hurricanes (i.e., named storms) from 1851 to 2015 in the vicinity of Florida. Courtesy: Philip Klotzbach, Colorado State University.

Julia was the third named storm of 2016 whose center crossed Florida land after Hermine in early September and Colin in early June. The last season in which there were three interactions of tropical-cyclone centers with Florida land was the 2005 season

(Katrina, Tammy, and Wilma), and the last season in which there were more than three interactions was the 2004 season, in which there were four (Bonnie, Charley, Frances, and Jeanne).

Development and Evolution

On 8 September, east of the Lesser Antilles, a tropical wave formed. As this wave progressed northwestward, it encountered unfavorable wind-shear conditions, with its convection remaining east of its center, which lacked a closed circulation. By the morning of the 12th, the wave had crossed the Bahamas and was just off the shore of the central part of the peninsula. It moved slowly on to land, with much of its convection remaining east of the center of the wave, and gathered strength as it encountered more favorable wind-shear conditions. By the evening of the 13th, its winds had reached tropical-storm strength, moving the National Hurricane Center to christen it as Tropical Storm Julia at a position about five miles west of Jacksonville. By the next day, it had moved up the coast into Georgia. Figure 2 shows the track.

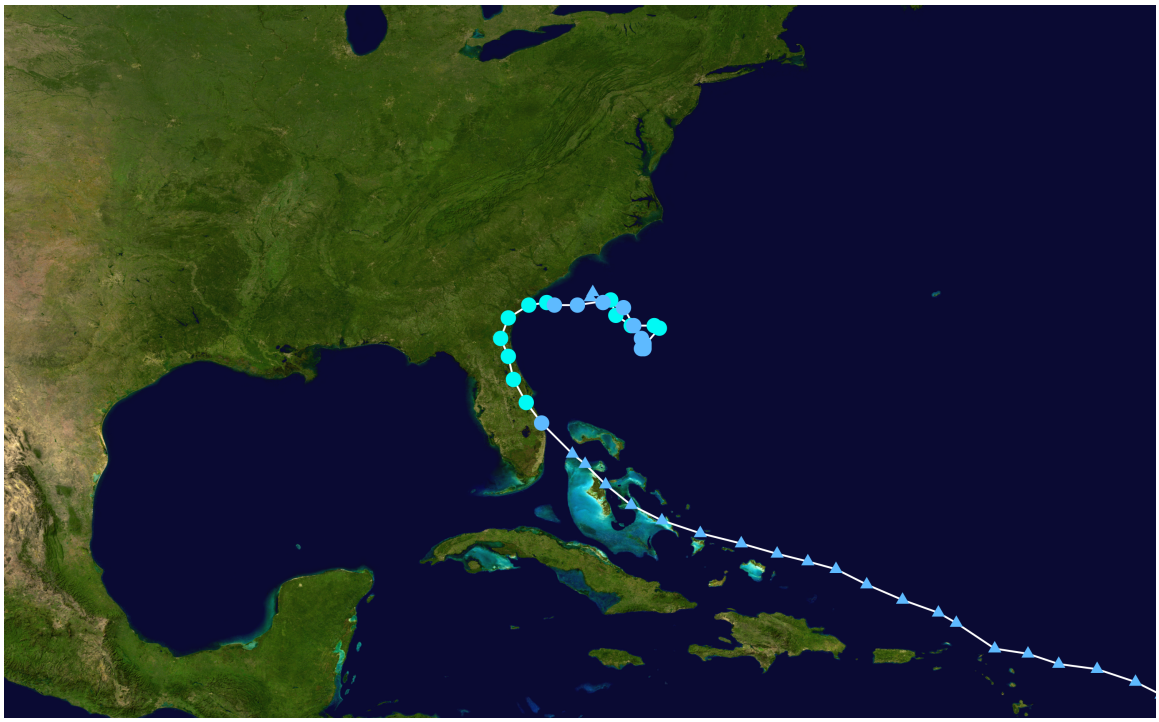

Figure 2: The track of Tropical Storm Julia from its formation as a tropical wave east of the Lesser Antilles to its transition to an extra-tropical storm over Atlantic Ocean waters northeast of Florida.

Impacts

The greatest impact of Julia on Florida land was moderate to heavy rainfall, mainly near the Atlantic coast, in central Florida during the day on the 13th and in north Florida on the night of the 13th into the early morning of the 14th. Owing to near-drought conditions over this region, this rainfall was much needed. The following table shows selected 24-hour rainfall totals greater than 1.00 inch ending the morning of the 14th (which can be taken to be storm totals) for areas of Florida affected by Julia.

LOCATION	COUNTY	AMOUNT (inches)	OBSERVATION NETWORK
Ormond Beach 3.5SE	Volusia	4.27	CoCoRaHS
Melbourne NWS Office	Brevard	4.21	NWS COOP
Jacksonville 14.0NE	Duval	3.57	CoCoRaHS
Edgewater 1.4N	Volusia	3.41	CoCoRaHS
Patrick AFB	Brevard	3.31	ASOS
St. Augustine 3.1SSE	St. Johns	3.31	CoCoRaHS
Melbourne International Airport	Brevard	3.20	ASOS
Cape Canaveral	Brevard	2.95	ASOS
Edgewater 2.4N	Volusia	2.94	CoCoRaHS
St. Augustine South 2.1SSW	St. Johns	2.86	CoCoRaHS
Melbourne 1.1N	Brevard	2.86	CoCoRaHS
Jacksonville 11.4ESE	Duval	2.85	CoCoRaHS
Neptune Beach 0.5NNW	Duval	2.81	CoCoRaHS
Kennedy Space Center	Brevard	2.67	ASOS
Vineland 3SE	Orange	2.64	South Fla. Water Mgmt. Dist.
Titusville 8ENE	Brevard	2.53	USGS
Melbourne 7.5NNW	Brevard	2.52	CoCoRaHS
Palm Shores 4.3NNW	Brevard	2.43	CoCoRaHS
Palm Bay	Brevard	2.40	NWS COOP
Palm Shores 4.0NNW	Brevard	2.20	CoCoRaHS
Jacksonville 7.5E	Duval	2.20	CoCoRaHS
Palm Shores 1.4W	Brevard	2.18	CoCoRaHS
Edgewater 0.1SW	Volusia	2.12	CoCoRaHS
Ponce Inlet 0.5S	Volusia	2.05	CoCoRaHS
Merritt Island 9.1N	Brevard	2.03	CoCoRaHS
New Smyrna Beach 1.5E	Volusia	2.00	CoCoRaHS
Jacksonville 11.9N	Duval	1.99	CoCoRaHS
Micco 1.3NW	Brevard	1.98	CoCoRaHS
Rockledge 1.1WSW	Brevard	1.97	CoCoRaHS
Jacksonville 4.2ESE	Duval	1.94	CoCoRaHS
Jacksonville Craig Municipal Airport	Duval	1.90	ASOS
Buena Ventura Lakes 11.0E	Orange	1.86	CoCoRaHS
Cocoa 2.6WNW	Brevard	1.79	CoCoRaHS

Orlando 12.0S	Orange	1.74	CoCoRaHS
Melbourne Beach 3.9SSE	Brevard	1.73	CoCoRaHS
Indialantic 3.3NNW	Brevard	1.73	CoCoRaHS
Merritt Island 20N	Brevard	1.73	USGS
Jacksonville 3.8ESE	Duval	1.71	CoCoRaHS
Merritt Island 3.6N	Brevard	1.70	CoCoRaHS
Cape Canaveral 0.6 ESE	Brevard	1.68	CoCoRaHS
Rockledge 1.3NE	Brevard	1.59	CoCoRaHS
Jacksonville 4.2NE	Duval	1.59	CoCoRaHS
Jacksonville 12.0SSE	Duval	1.58	CoCoRaHS
Hastings 4NE	St. Johns	1.57	NWS COOP
Jacksonville 13.3NNE	Duval	1.53	CoCoRaHS
Jacksonville International Airport	Duval	1.49	ASOS
Jacksonville 12.0SSE	Duval	1.40	CoCoRaHS
De Land	Volusia	1.39	NWS COOP
Union Park 1.1E	Orange	1.28	CoCoRaHS
Melbourne 4.1S	Brevard	1.26	CoCoRaHS
Orlando International Airport	Orange	1.24	ASOS
Daytona Beach International Airport	Volusia	1.24	ASOS
Merritt Island 3.8N	Brevard	1.23	CoCoRaHS
St. Augustine 12.2WNW	St. Johns	1.21	CoCoRaHS
Palm Coast 5.9S	Flagler	1.19	CoCoRaHS
Fort Pierce 3.4NNE	St. Lucie	1.16	CoCoRaHS
Orlando 4.8NNW	Orange	1.15	CoCoRaHS
New Smyrna Beach 2.3N	Volusia	1.14	CoCoRaHS
Fernandina Beach 6.3SW	Nassau	1.12	CoCoRaHS
Hedges 0.3ESE	Nassau	1.10	CoCoRaHS
Palm Bay 3.1NNW	Brevard	1.06	CoCoRaHS
Titusville	Brevard	1.05	NWS COOP
De Land 1.4WSW	Volusia	1.05	CoCoRaHS
Melbourne Beach	Brevard	1.03	NWS COOP

One tornado occurred in Saint Sebastian River Preserve State Park and the town of Grant-Valkaria, Brevard County, on the afternoon of the 13th. It was rated as weak (EF-0) on the Enhanced Fujita Scale by a damage survey team headed by the National Weather Service Weather Forecast Office in Melbourne. The survey team estimated that its peak wind was 75 to 85 miles per hour, its path length was 3.0 miles, and its

maximum path width was 75 yards. Touching down at around 1:51 PM EDT, the tornado was on the ground for about six minutes. No fatalities or injuries were reported. Damage was described in the survey team's report as follows:
"Most of the touchdown area was remote, but there was damage to a two-block area that included Orchid Tree Drive, Cottonwood Drive, and Crepe Myrtle Drive. Specifically, numerous large tree branches were down, one single-family home had partial roof removal, and the patio enclosure was destroyed. A second home had an RV toppled onto its side".

Many reporting stations within 30 miles of the coast had wind gusts during the storm of between 30 and 50 miles per hour.

Supplementary Links (all working as of 28 September 2016)

A summary of the Grant-Valkaria tornado and Julia's impacts in east-central Florida from the Melbourne National Weather Service Weather Forecast Office: http://www.weather.gov/media/mlb/surveys/GrantValkariaTornado091316.pdf

An archive of products issued by the National Hurricane Center for Julia:
http://www.nhc.noaa.gov/archive/2016/refresh/JULIA+shtml/120922.shtml?

Further discussion on Julia forming and staying over land: https://www.washingtonpost.com/news/capital-weather-gang/wp/2016/09/14/surprise-tropical-storm-julia-to-drench-coastal-south-carolina/