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STATE COLLEGE, PA

AUTUMN 2016

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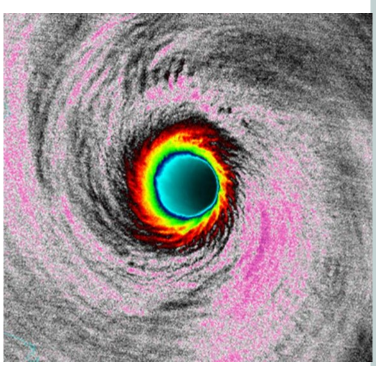


The Long Hot Summer of 2016 in Review

John La Corte—Lead Meteorologist

And a long hot summer it was! In fact the heat lasted well into September before things cooled off toward the end of the month. After an April and May that were cooler than normal in most locations, the oven turned on in June and continued virtually unabated throughout the celestial summer. Figure 1 shows the summertime temperature departures. You have to look close to find the 2 small areas of slightly cooler than normal temperatures anywhere in the eastern United States, otherwise temperatures were well above normal. In fact it wasn't just the eastern US that was warm, Figure 2 shows the vast majority of the contiguous United States had a warmer than normal summer (note the color curve is different). For many locations here in Central Pennsylvania, the summer heat was record setting or at least among the warmest in history. Table 1 (page 2) lists some places where average temperatures made the record books with Williamsport, Bradford and York all experiencing the warmest summers since records began being kept.

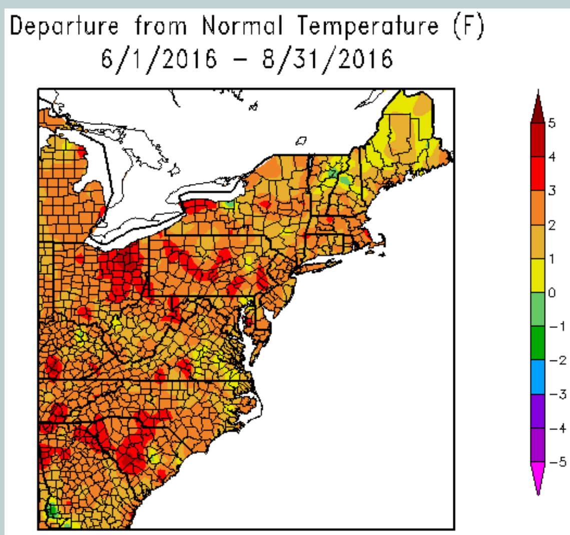


Figure 1. Summer Temperature Departure

Another way we can gauge summer warmth is to count the number of days the high temperature reached or exceeded 90 degrees. Table 2 shows almost all of the listed locations observing many more hot days than are usually seen in a typical summer.

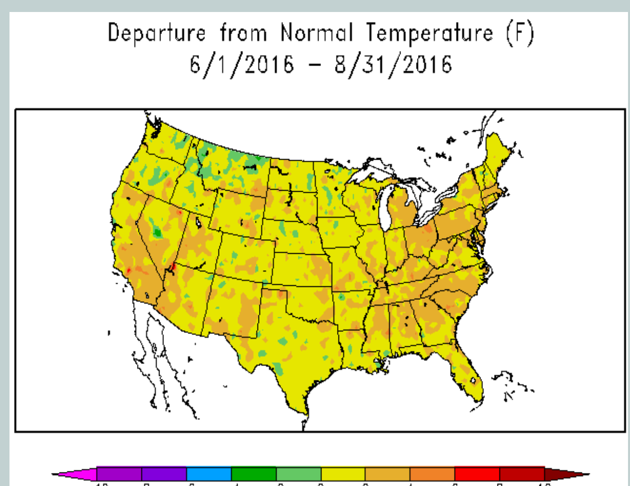


Figure 2. Summer Temperature Departure for the US

According to NOAA (National Oceanic and Atmospheric Administration) July was the hottest month ever recorded. The global average temperature was .87 degrees Celsius (about 1.5 degrees Fahrenheit) above the 20th century average. (cont. page2)

Station	Avg Temp	Rank
Harrisburg	77.3	2nd
Williamsport	74.4	1st
Altoona	71.9	5th
Bradford	66.6	1st
Lewistown	74.9	2nd
State College	72.3	3rd
York	78.0	1st

Table 1. Summer Average Temperature and warmest ranking

In fact, it marked the 15th consecutive warmest month on record for the Earth. It's the longest stretch of consecutive record setting months in the data set. And just to pile on, August also set a record (warmest August ever) making it 16 months in a row of record warm months!

Along with the summer warmth, many areas were (and continue to be) drier than normal. In fact much of the northeast is in a drought (Figure 4) with the areas depicted in red experiencing an extreme drought. Figure 3 shows the percent of normal rainfall for the summer which shows that virtually all central Pennsylvania was drier than normal, with some areas seeing as little as 25-50% of their normal rainfall. Some areas have implemented water restrictions, and if the pattern doesn't change that could become more widespread.

Station	90+	Normal
Harrisburg	34	17
Williamsport	25	13
Altoona	12	6
Bradford	0	0
Lewistown	32	18
State College	6	6
York	47	25

Table 2. Number of 90 Degree Days vs. Normal

As we like to do at this point, we take a look at what the upcoming season may have to offer. The Climate Prediction Center uses a variety of model guidance as well as feeding in indices such as the state of the El Nino/La Nina and the North Atlantic and Pacific Oscillations. These are all explained on their web site (http://www.cpc.ncep.noaa.gov/). Unfortunately this soup of predictors shows that for the local area, there is almost no "signal" pointing to a wet or dry, warm or cold outcome. They call this "equal chances" which just illustrates to low confidence in the forecast we have as we go forward. Figure 5 shows this low confidence outlook for the December through February timeframe.

We had a very warm and snow-less winter last year so for cold and snow haters, it might be hard to do better. Either way we will see you in the Spring to see how we did.

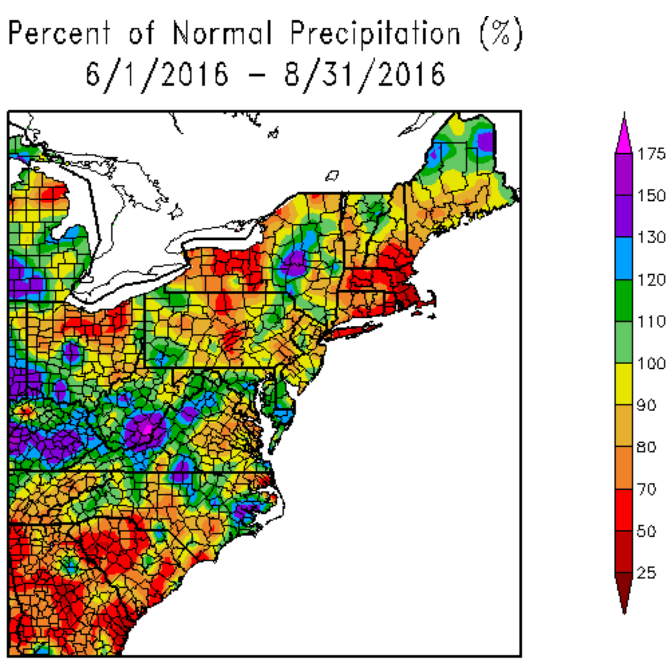


Figure 3. Precipitation Departure

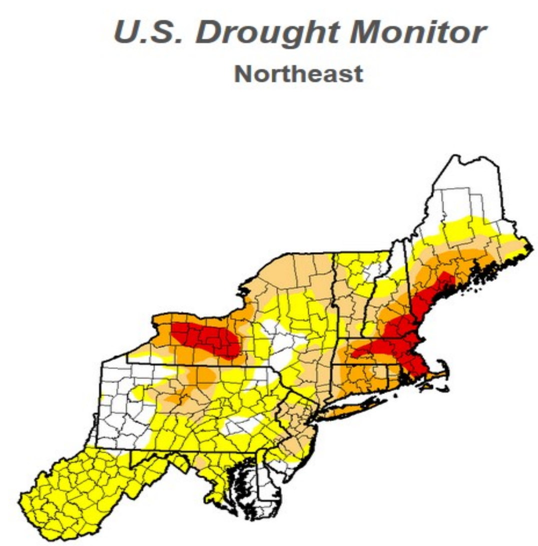


Figure 4. Drought Monitor

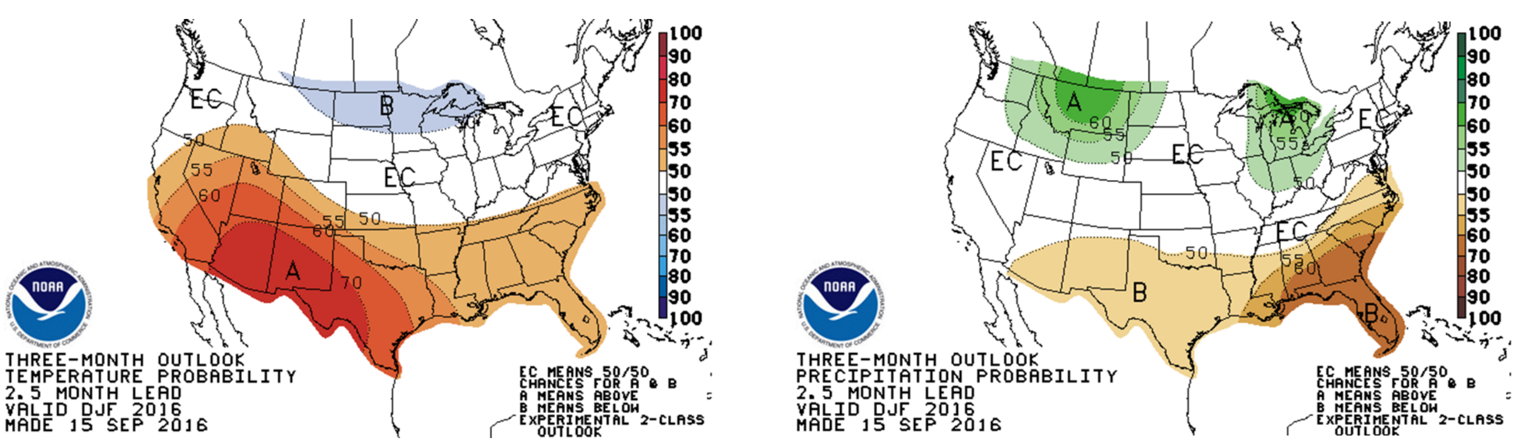


Figure 5. Seasonal Forecast from CPC for the Upcoming Winter. Temperature left/Precipitation right

Hurricane Matthew

John La Corte—Lead Meteorologist

During the third week of September, a disturbance that moved off the African coast several days earlier, began to form into a low pressure area about half way across the tropical Atlantic Ocean. This disturbance continued to slowly evolve and by the time it was entering the Windward Islands of the Caribbean on September 28th, it had strengthened to Tropical Storm Matthew.

Conditions were favorable for continued development as it moved westward over very warm ocean waters, and by the afternoon of September 29th the storm had become a hurricane half way between Puerto Rico and the coast of South America. By the time Matthew moved north of Aruba it had strengthened into a major hurricane (Category 3) with winds of 120 mph.

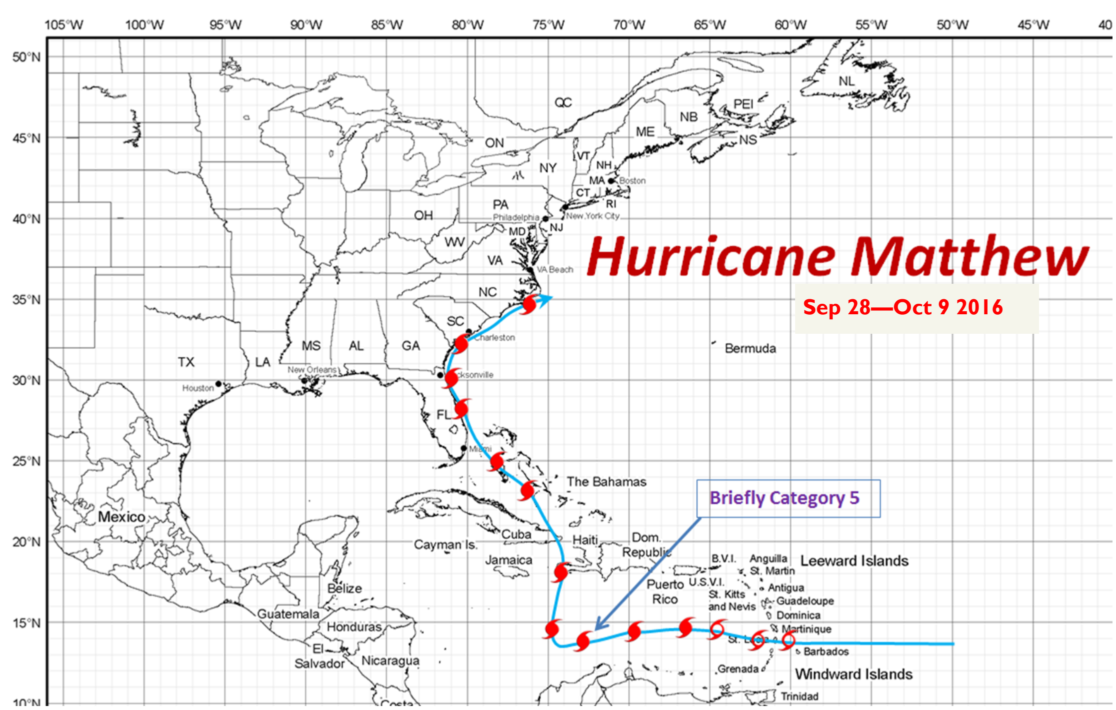
From there Matthew moved slowly west through the southern Caribbean Sea ultimately strengthening into a Category 5 hurricane late on September 30th (see Figure 1). This made Matthew the first category 5 storm in the Atlantic Basin since Felix in 2007. The storm remained a major hurricane for more than 7 days at it moved north, ultimately smashing its way through western Haiti and eastern Cuba with winds reported as high as 155mph, on a track toward the Bahamas and the southeastern United States.

An estimated 1000 people were reported killed as Matthew moved over western Haiti near Les Anglais on October 4th as a category 4 storm. It was the first category 4 hurricane to hit Haiti in more than 50 years (Cleo 1964). The storm then moved slowly north through the Bahamas on October 5th and 6th ripping off roofs and knocking down trees and powerlines with winds observed as high as 120 mph.

The storm continued north paralleling the coasts of Florida, Georgia and the Carolinas. The track of Matthew just off the shoreline allowed the eye of the storm to remain over warm ocean waters, slowing the weakening process. However it did spare the immediate coastal areas a direct hit as the strongest winds associated with the eye wall stayed just offshore. Damage was still widespread however with more than a million people reportedly without power at the height of the storm. Coastal erosion was widespread and severe all the way from Florida up through North Carolina as wind and storm surge battered the region. Inland flooding was also a major problem as heavy rainfall fell over much of the southeastern US even as far north as Virginia and Delaware. Amounts in excess of 10 inches were common from Georgia northward in to Virginia. Savanna Georgia had the dubious honor of reporting the most rain with an amazing storm total of 17.49" being observed at Hunter Army Airfield.

While Matthew was downgraded to an extratropical storm on Sunday October 9th, eventually moving eastward out to sea and getting absorbed in a frontal system, the rain shield progressed north and caused a rare cancelation of the Boston Columbus Day parade bringing an end to the storm's influence on the United States.

Some other storm notables, thanks to the Capital Weather Gang. At least 30 people were killed in the US. Matthew attained category 5 strength at the lowest latitude on record (previous was Ivan in 2004). It caused at least 6 billion dollars in damage in the United States. At least 2000 water rescues were performed in North Carolina alone. The amount of rain that fell during the storm was equivalent to about 13.6 trillion gallons of water, an amount equal to about 75% of the Chesapeake Bay. The highest wind gust in the US was 107 mph at Port Canaveral. It was the only storm to remain a major hurricane as it made landfall in Haiti, Cuba and the Bahamas.



Winter Storm Safety

National Oceanic and Atmospheric Administration

Winter Weather Safety | Winter Warning, Watch | Before a Winter Storm | During a Winter Storm | After a Winter Storm

Winter Resources

- Snow Climatology Map
- Nor'easters
- Ice Storms
- Lake Effect Snow
- Ground Blizzards
- Avalanches
- Extreme Cold/Wind Chill
- Forecasts and Observations
- Education, Outreach, FAQs
- Links and Partners

Winter storms can bring snow, sleet and freezing rain across the entire United States and its territories. Even Hawaii gets snow on its Big Island, and major cities as far south as Atlanta and Dallas have been paralyzed by snow and ice. Blizzards occur when strong wind causes blowing snow and whiteout conditions, making roads impassable. Thousands of people are injured or killed every year in traffic accidents related to slippery roads from winter storms.

This website is designed to teach you how to stay safe before, during and after a winter storm. You will find information on winter alerts, science and hazards, snow coverage maps, and information describing the different types of winter storms. If you or someone you know has been a victim of a winter storm, please share your story so we can prevent others from becoming a victim. When you write, please note that the NWS has permission to use your story and, if possible, let us know the town and state you were in and the year the event took place.

Weather Prediction Center Winter Weather Forecasts—http://www.wpc.ncep.noaa.gov/wwd/winter_wx.shtml

NOAA Weather Radio All Hazards —http://www.nws.noaa.gov/nwr/index.php

National Operational Hydrologic Remote Sensing Center, NOAA Snow Information Source —http://www.nohrsc.noaa.gov/

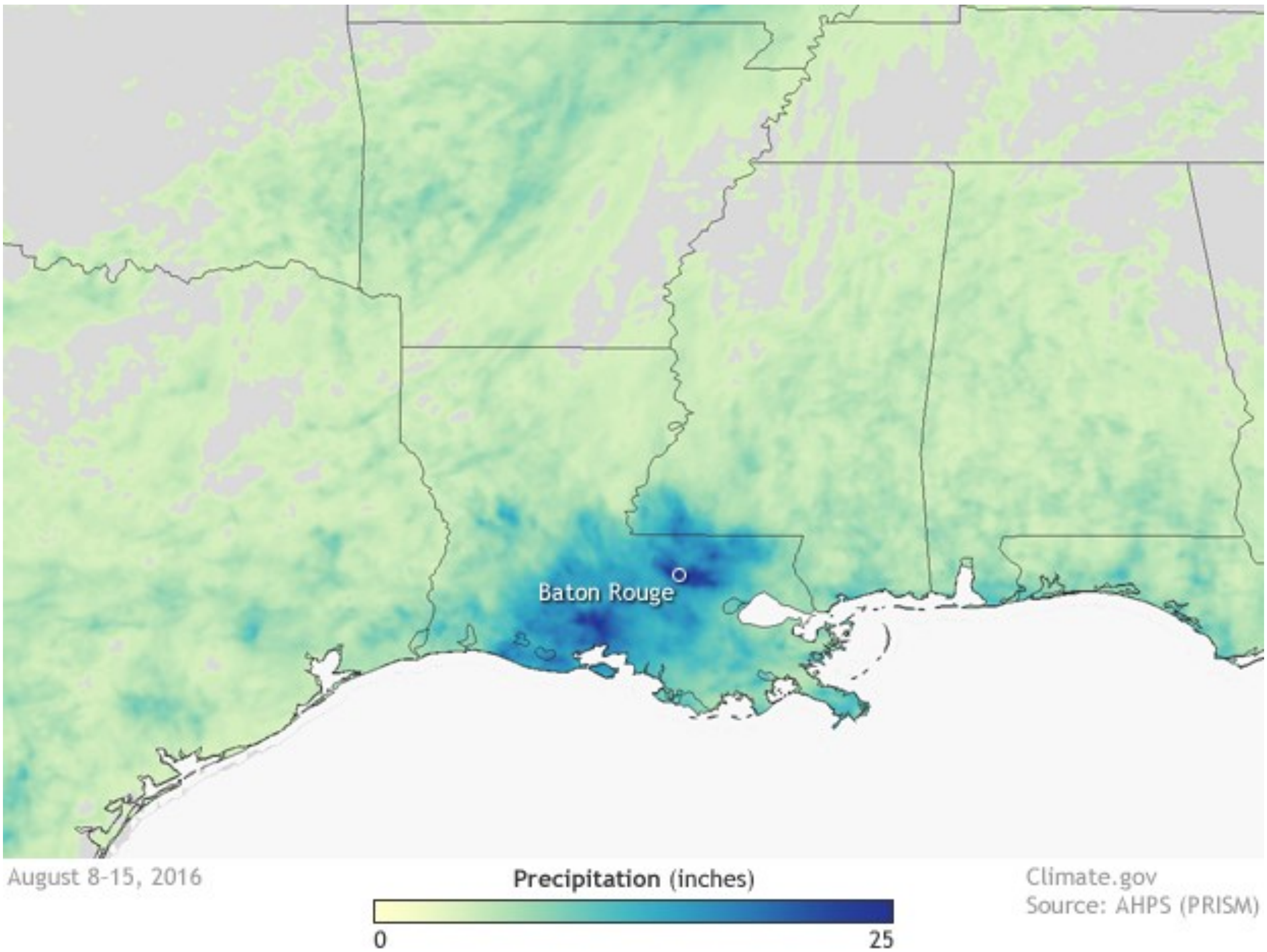
NOAA Snow and Ice Information —http://www.ncdc.noaa.gov/snow-and-ice/index.php

For more information: http://www.nws.noaa.gov/om/winter/index.shtml

August 2016 Extreme Rain and Floods Along the Gulf Coast

Tom DiLiberto—Climate.gov

A combination of an incredibly moist air mass and a slow moving storm system resulted in feet of rain for southern Louisiana. The epic rains caused devastating flooding, which led to the evacuation of tens of thousands, killed at least thirteen people, and paralyzed the region.



Precipitation totals (inches) from August 8-15, 2016. Over two feet of rain was observed in parts of southeastern Louisiana which led to catastrophic flooding, especially in areas around Baton Rouge. NOAA Climate.gov map based on data from AHPS.

Rains started on August 9 as scattered thunderstorms in advance of a slow moving storm system to the east. As that storm moved closer to Louisiana and Mississippi, rainfall totals increased dramatically. On August 11, parts of southern Louisiana and Mississippi observed more than six inches of rain. On August 12, Baton Rouge observed a non-stop battering of thunderstorms resulting in 11.24 inches of rain. On the same day, an observer in Livingston, LA, recorded 17.09 inches of rain between midnight and 3 p.m. The next day brought another round of heavy rain—from three to more than 10 inches in some places—albeit a bit farther west than the day before.

A shocking multi-day deluge led to total rainfall amounts measured in feet. Watson, LA—about 20 miles northeast of Baton Rouge—experienced an astounding 31.39 inches of rain from the storm. White Bayou, LA, saw 26.14 inches. Livingston ended up with 25.52 inches. Baton Rouge “only” received over 19 inches. (cont. page 6)

Extreme Rain cont.

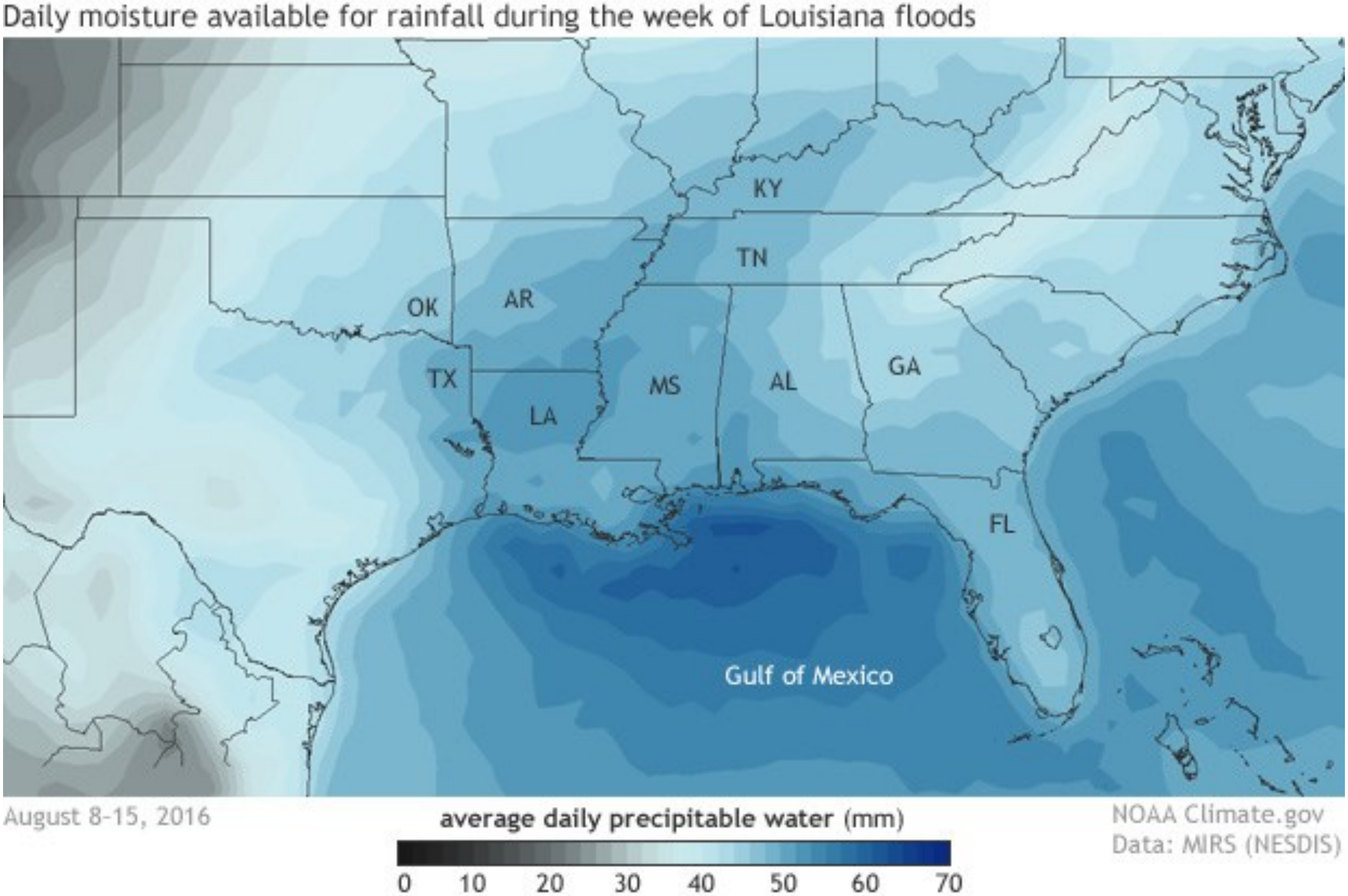
Rains of this magnitude falling in this short amount of time are exceedingly rare. From August 12-13, the two-day rainfall amounts in the hardest hit areas have only around a 0.2% chance of occurring in any given year: a 1 in 500 year event.

A flooded intersection in Baton Rouge, LA, on August 14, 2016. Twitter image by the Louisiana Department of Transportation and Development.

With rains of this magnitude, devastating flooding was sure to follow. And it did. Pictures out of southeastern Louisiana have shown towns and interstates flooded, cars underwater, and lives uprooted. The Amite River at Denham Springs crested at 46.2 feet, breaking the old 1983 record by almost 5 feet! Record river crests also occurred along the Comite River at Olive Branch (29.96 feet) and Joor road (34.22 feet), the Tickfaw River, and the Tangipahoa River.

Twelve parishes in Louisiana—Acadia, Ascension, East Baton Rouge, East Feliciana, Iberia, Lafayette, Livingston, Pointe Coupee, St. Helenca, St. Landry, Tangipahoa, and Vermillion—were declared major federal disaster areas. According to the Associated Press, more than 30,000 people have been rescued, and at least 40,000 homes were damaged. Before and after shots of river flooding can be seen here, put together by NOAA's National Ocean Service.

(Cont page 7)



Average daily precipitable water values from August 8-15, 2016 as determined from satellite. Near record levels of moisture in the air along the Gulf Coast aided in creating the tremendous amount of rainfall which inundated southern Louisiana and Mississippi. Climate.gov image based on data from MIRS-NESDIS.

Where did the rain come from?

The storm system that caused such misery for residents of the Gulf Coast wasn't quite a tropical depression, but it wasn't quite a normal mid-latitude low pressure system, either. One thing is for certain, though: This storm was able to wring out an atmosphere over Louisiana and Mississippi that had near-record amounts of moisture in it. The atmospheric sponge was soaking wet. When scientists look to see how wet an atmosphere is they look at a value called precipitable water. If you magically took all of the water in a column of air and measured it, you would have calculated the precipitable water. Higher values during the summer time usually mean muggy conditions and potentially heavy rains should a storm develop.

The atmosphere over the Gulf Coast was chock full of water during the event. Precipitable water values recorded during a weather balloon launch from Slidell, LA, on August 12 were the second highest on record, ever. A likely contributing factor to the extremely moist atmosphere were well-above-average water temperatures across the Gulf of Mexico with temperatures in the upper 80s to near 90°F (1.5-3.5° F above-average).

Climate change connection

For the southeast United States, extreme daily rainfall events increased 27% between 1958 to 2012 according to the National Climate Assessment. In the future, under high greenhouse gas emissions scenarios, the frequency of extreme daily precipitation events (events that currently occur once every 20 years) is projected to increase everywhere in the United States.

In the southeast, extreme rain events may occur up to two to three times as often by the end of this century than they did between 1981 and 2000, although the projections of precipitation patterns for the southeast are less certain than projections for temperature. Globally, the latest report from the IPCC states that extreme precipitation events over most mid-latitude land masses are very likely to become more intense and more frequent.

Extreme Rain cont.

Back to the event at hand: It is safe to say that the ingredients for a historic event were present in abundance this past week in August. All that was needed was something to come along to take advantage. Unfortunately for the residents of southern Louisiana and Mississippi, a storm system came by at the worst possible time.

A Livingston Parish Deputy Sheriff surveys flood damage from a boat on August 15, 2016. Image courtesy the Rapides County Sheriff's Office.

Significant Tornadoes in Central Pa

Joe Ceru—General Forecaster

This past spring it was shown that there were some discrepancies in the historical tornado database for central Pennsylvania. Starting with data from the Storm Prediction Center (SPC) and National Center for Environmental Information (NCEI), we mapped all the tornados from 1950 until 2015. The records of the tornadoes pre-1950 were done by county and were usually only recorded for storms of EF2 and greater, though there are few exceptions. The data before 1950 will be worked into the tornado climatology, however since we don't have start and end points those will be of limited use in future research.

As we began to quality control the data we could see that many tornadoes, even those mapped as recently as the early 2000's had starting points but no ending points. With the help of a student volunteer, Olivia Angevine, we went through the monthly Storm Data reports and local news to determine the location of the end points. Using this information we were able to correct and improve the tornado climatology for our region.

Another part of this project was to begin to determine the percentage of tornadoes rated Significant (EF2 or greater). Given the information stated above, the numbers are skewed when tornadoes before 1950 are included. So for that reason only tornadoes from 1950 and after were included. The below map is the percentage of tornadoes EF2 or greater along with improved paths. As you can see the area that favors the strongest tornadoes is generally in the Southeast or Lower Susquehanna valley. The other counties have significant topography which will be a focus of the second portion of the project. That portion of the project is to see if there if there is an influence of topography on tornado generation. Using the new information, Olivia and another student volunteer, Zach Chabala, mapped the data on the office relief map. Using this as a template we will then go through digitally to see if terrain had any influence in tornado generation, especially in tornadoes EF2 and lower. We hope to report our findings in the not too distant future,

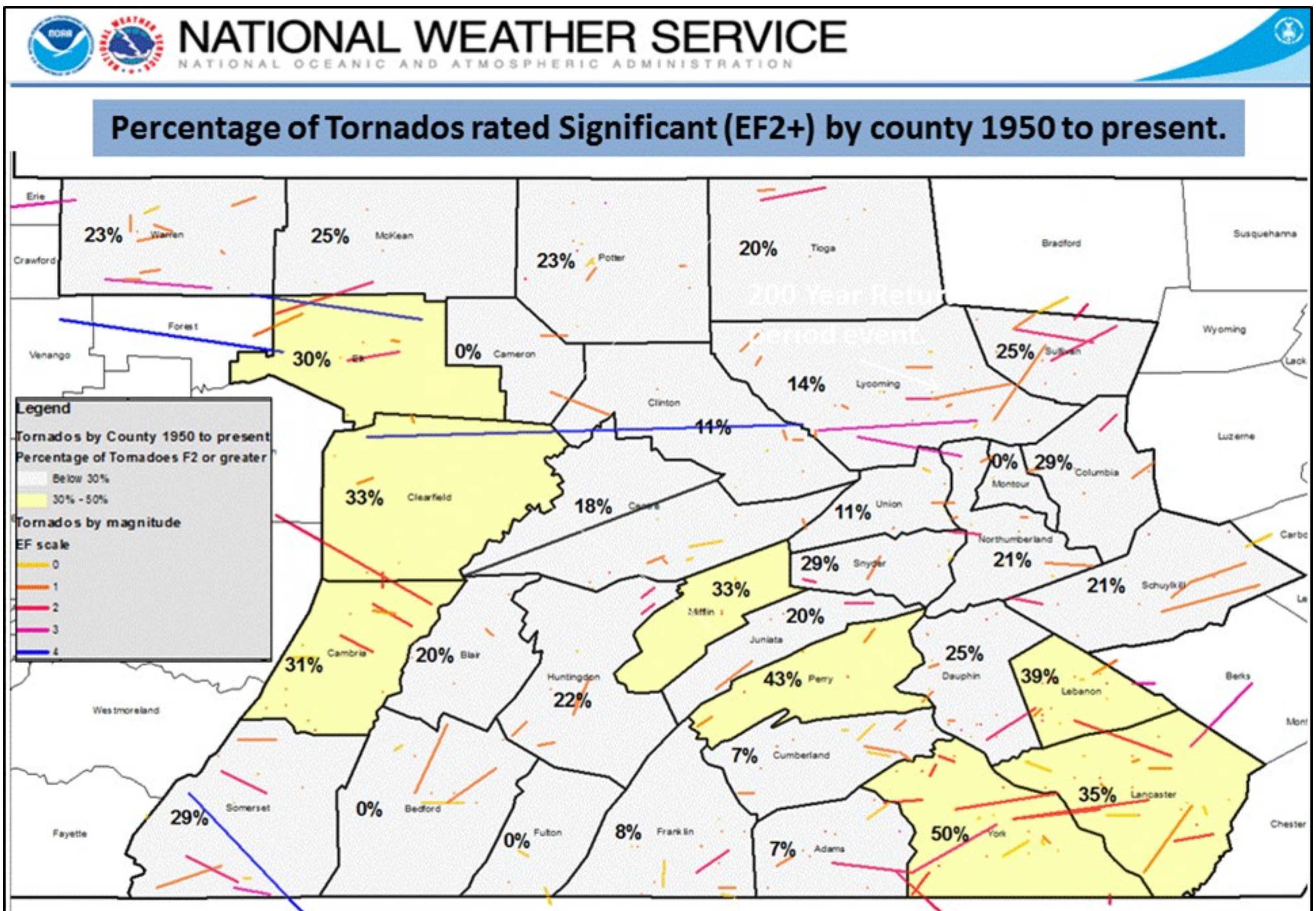


Figure 1. The percentage of tornadoes in each county that are of EF2 strength or greater.

Update Your Spotter Information

John La Corte—Lead Meteorologist

Please help us to keep your contact information up to date. While we hope to get a report from you when severe weather occurs, from time to time we call or email spotters to investigate significant storms. Thus, it is important to keep your contact information current. If any of your contact information (name, phone number/s, addresses, etc) has changed recently, please let us know. Send an email or 'snail mail' note to us at one of the addresses below.

email: *william.gartner@noaa.gov*

U.S. mail:

William Gartner/Skywarn Spotter Update

NWS/WFO State College

328 Innovation Blvd, Rm #330

State College, PA 16803

If you are not sure that we have the most up to date information on file, go ahead and send us an email or note with your current information anyway and we will verify it. Please note that your personal information (address, phone #, email mail address, etc) is NOT shared with or given to anyone else outside of the NWS (unless your permission is gained first) and is used only to contact you in the event of severe weather, send you SkywarnNews email notification, or communicate important program changes.

Please report the following:*

Snow:
- When snow accumulation reaches 3 inches
- When snow accumulation reaches 6 inches
- Storm total after the snow ends (also water equivalent if possible)
- If snow is falling at the rate of 1 inch or more per hour

Ice:
- Any occurrence of or accumulation of freezing rain or freezing drizzle
- Accumulation of ice of ¼ inch or more on trees or wires

Other:
- When forecast winter precipitation differs significantly from observed (i.e. snowing with no snow in forecast, sleet...when only snow is forecast...)
- Any other significant weather occurrence/oddity (i.e. flooding due to snow melt/ice jam, damage from strong winds not associated with a thunderstorm)

And, remember thunderstorms that produce wind damage and flooding rains are still possible even in winter.

*This list of reporting criteria is available on our web page: http://www.weather.gov/ctp/reportSevere

Don't forget: we are on Facebook and Twitter