NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
STORM COURIER
Charleston, SC
Weather Forecast Office
Fall/Winter 2016

Inside this issue:

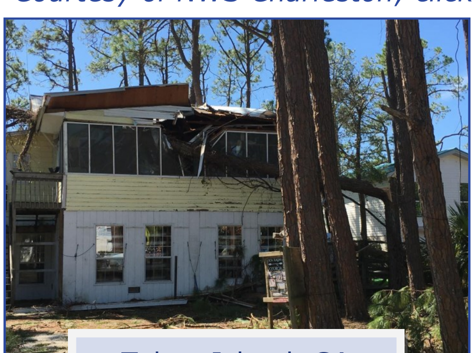
Hurricane Matthew Caps Off an Active Hurricane Season

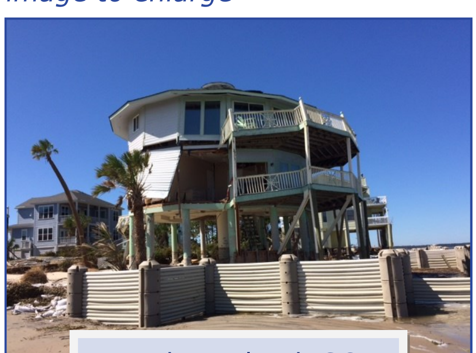
by Robert Bright - Meteorologist

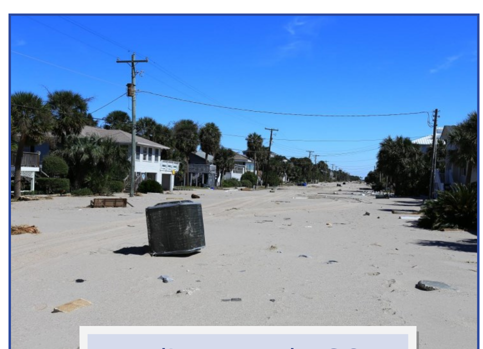
It was quite an active Atlantic basin hurricane season this year with preliminary numbers indicating 15 tropical storms formed, seven of which became hurricanes. Five of these tropical cyclones (Tropical Storms Bonnie, Colin, Hermine and Julia and Hurricane Matthew) affected portions of southeast South Carolina and southeast Georgia, the busiest year since 2004. Although Tropical Storms Bonnie and Colin brought heavy rainfall and flooding, the biggest impacts overall were from Hurricane Matthew, which made landfall near McClellanville, SC as a Category 1 hurricane on October 8th. This was the first hurricane to make landfall in our County Warning Area since Hurricane Gaston in 2004. Hurricane force wind gusts near 100 mph occurred near the coast producing significant damage to trees and power lines. In addition, the storm surge resulted in significant inundation of saltwater in low-lying areas near the coast, reaching at least five feet in some spots. The tide gauge at Fort Pulaski in Chatham County, GA recorded its highest water level ever since 1935, while the water level in Charleston Harbor was the third highest on record. The power of the surge can be seen in the photo below on Edisto Beach where several feet of sand was pushed inland over Palmetto Boulevard. Unfortunately, three people in our County Warning Area lost their lives due to the storm.

Hurricane Matthew Damage Photos

Courtesy of NWS Charleston; click image to enlarge


Tybee Island, GA

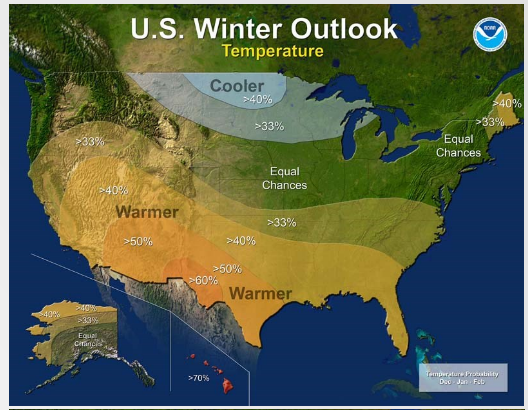

Harbor Island, SC

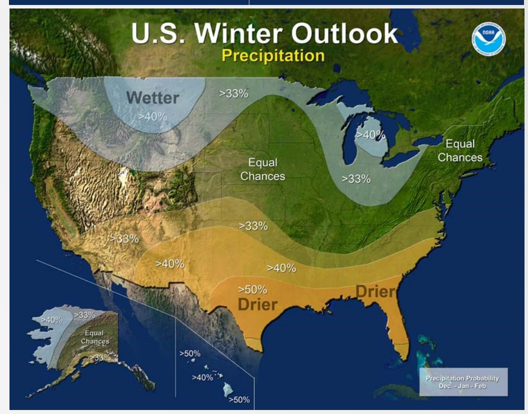

Edisto Beach, SC

U.S. Southeast 2016-17 Winter Outlook

by Emily Timte - Meteorologist

The U.S. Winter Outlook issued by the Climate Prediction Center indicates there are higher probabilities for a warmer than normal and drier than normal winter over southeast South Carolina and southeast Georgia. One of the factors in determining the outlook is the state of the El Nino-Southern Oscillation, or ENSO. The ENSO cycle refers to the variations in several elements that occur across the equatorial Pacific Ocean, such as sea surface temperatures, convective rainfall, surface air pressure, and atmospheric circulation. There are three phases of the ENSO cycle: El Nino (warm phase), La Nina (cold phase), and Neutral (near normal). This year, a weak La Nina is expected to persist through the winter before trending towards ENSO-neutral. During La Nina phases, there tends to be less storminess and precipitation across the southern United States.





Are You Winter Weather Ready?

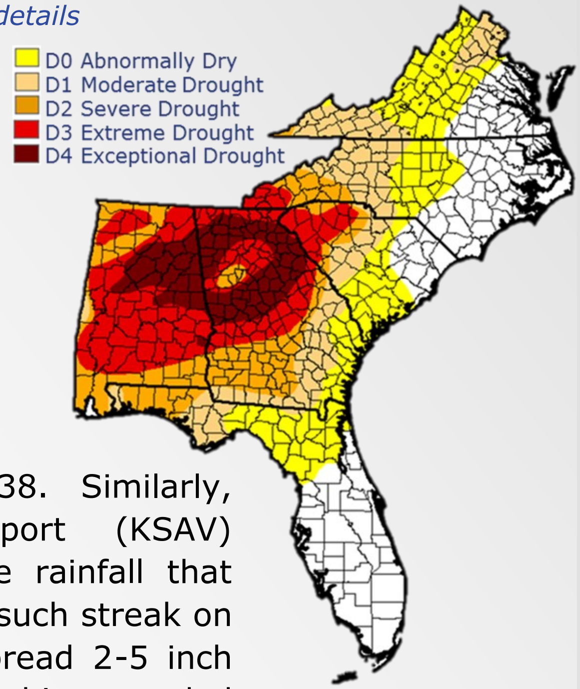
It is important to remember that although odds favor a warmer, drier winter, it does not mean cold outbreaks or winter weather will not occur. It is best to stay prepared for the upcoming winter season by making sure your home, office and vehicles are stocked with the supplies you might need. Learn more about the different winter weather hazards and how you can prepare at the NWS Winter Safety webpage.

Current Drought Status—Extreme to Exceptional Drought Conditions Nearby

by Blair Holloway - Meteorologist

U.S. Drought Monitor

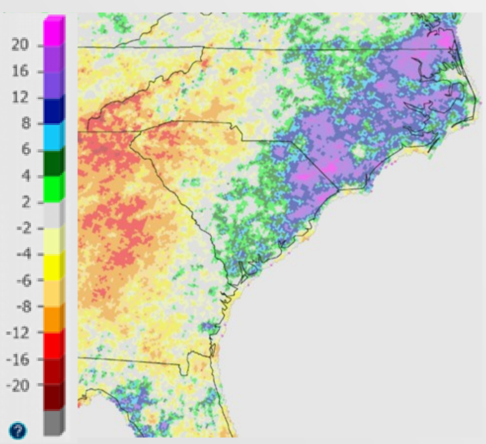
Issued 12/6/16; click image for updated details



The December 6th issuance of the U.S. Drought Monitor shows widespread Abnormally Dry (D0) conditions across southeast South Carolina and southeast Georgia. Also, a small area of Moderate Drought (D1) has crept into inland southeast Georgia including portions of Screven, Jenkins, Candler, Tattnall, and Long counties. This recent increase in dry conditions is primarily due to the lack of rainfall since Hurricane Matthew in early October. In fact, the Charleston International Airport (KCHS) only measured 0.11" of rain in the month of November which ranks as the 2nd driest November and 6th driest month overall dating back to 1938. Similarly, the Savannah-Hilton Head International Airport (KSAV) experienced a 41 day streak with no measurable rainfall that ended on November 25th, which tied for the longest such streak on record dating back to 1871. Fortunately, a widespread 2-5 inch rainfall event occurred December 4th-7th, bringing this extended dry period to an end.

180-Day Departure Precipitation

Created 12/1/16
click image for more details



The worst drought conditions exist just to the west where more than a third of the Southeast U.S. is in Extreme (D3) to Exceptional (D4) Drought. Compared to 6 months ago, the Southeast U.S. drought has worsened significantly and gradually spread across the entire region. The cause of the drought is a long term lack of rainfall, and some locations in the heart of the drought are 16 inches or more below normal for rainfall over the last 180 days. It is interesting to note that the swath of near normal to well above normal rainfall that stretches across southeast Georgia, southeast South Carolina, and eastern North Carolina closely correlates to the eastern bounds of the Moderate (D1) or worse drought. This swath of near normal to well above normal rainfall is almost exclusively due to rainfall from several tropical systems that have impacted the region this hurricane season. Bonnie, Colin, Hermine, Julia, and Matthew all produced significant rains along the southeast coast and helped to prevent or slow the development of drought.

New SOO at NWS Charleston

by Julie Packett - Administrative Support Assistant

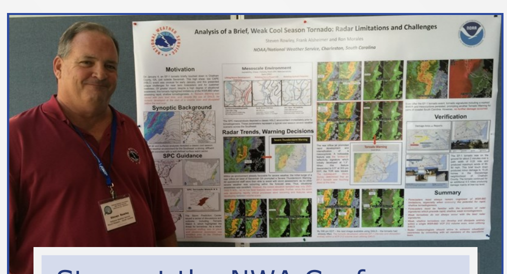
The Science and Operations Officer (SOO) at a NWS office is responsible for implementing new technology and data sets into operations and for organizing training and scientific research conducted in the office. Unbeknownst to him, Steve Rowley has been prepping for the SOO position his entire meteorology career.

Like most meteorologists, Steve's interest in weather started at a young age. Born and raised in Ledyard, CT, Steve recalls when Hurricane Gerda skirted the New England coast, later making landfall in Eastport, Maine, on September 10^{th}, 1969. To him it was much more than just a day home from school as heavy rain and gusty winds impacted the area. After graduating high school, Steve joined the US Air Force as a Weather Specialist. Over time, his interest in weather transitioned into an enthusiasm and excitement for forecasting and research. He followed his USAF career by attending Penn State, where he obtained his BS in Meteorology. After graduation, he spent four years learning about the ins and outs of mesoscale forecasting at Accu-Weather, Inc. More importantly, this is when he met his future wife, Teresa.

Steve made the leap to the National Weather Service in 1993 as a Meteorologist Intern at the Weather Service Office (WSO) in Greensboro, North Carolina. After a brief stint at WFO Greensville-Spartanburg, SC, Steve was promoted to Journey Forecaster at the Wilmington, OH office in 1996. After his promotion in 1999 to Senior Forecaster, Steve and Teresa moved to Gaylord, MI, where they raised their two children. Although the winters in Michigan were reminiscent of those from Steve's childhood, he was ready for a new climate, and in 2006, the Rowley clan moved to Charleston, SC.

As a Senior Forecaster at WFO Charleston, Steve's expertise in winter and severe weather significantly aided the office, especially during the complex winter storms of 2014. In preparation for significant events, Steve enhanced office training by assisting WFO Charleston's former SOO, Frank Alsheimer, in conducting Weather Event Simulator (WES) training with forecasters. This powerful training tool allows forecasters to replay weather events in displaced real-time to allow further interrogation of archived data. Basically, the WES is a weather geek's ideal video game. He has also taken his training expertise outside the office to local high school students by teaching a three day meteorology course, possibly enlightening a whole new generation of weather fanatics.

In addition to enhancing training for others, Steve has completed several research studies on local weather events. Most recently, he presented findings on the January 2015 tornado that touched down in the Savannah area at the National Weather Association Conference in Oklahoma City the following October.



Steve at the NWA Conference

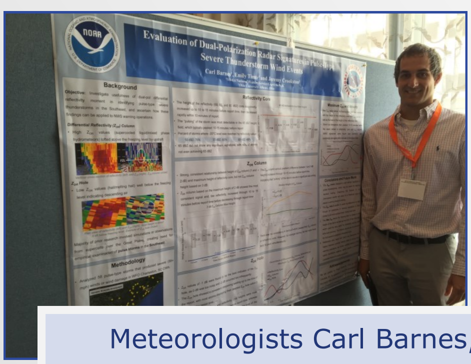
Based on Steve's track record of thorough training and research, his most recent promotion to SOO at NWS Charleston doesn't come as a surprise to his peers. He is now able to fully devote his NWS time to cultivating a learning environment where NWS forecasters can utilize new tools and skills to improve day to day forecasting.

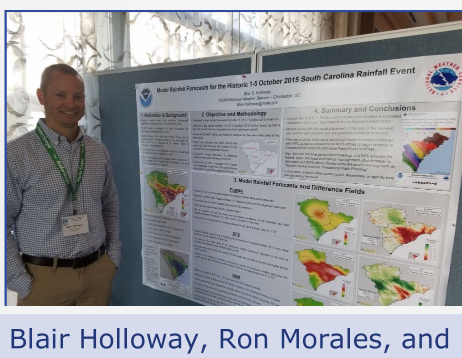
Research Presented at NWA Conference

by Carl Barnes - Meteorologist

The work of NWS Charleston is most readily seen through the forecasts and warnings that we issue, but did you know that we are continuously conducting scientific research to try to develop new, cutting-edge approaches for improving our products? Considering that the other 121 forecast offices around the country are doing the same, the result is a bevy of information and best practices which are most useful if shared across the entire scientific community. One of the most effective outlets for sharing this work is through conferences, many of which feature days full of presentations and scientific poster sessions and evenings of gathering to discuss (and often debate) the ideas which were presented during the day.

In mid-September, members of the NWS Charleston team participated in the National Weather Association (NWA) Conference in Norfolk, VA. Meteorologist Carl Barnes presented research that he, fellow meteorologist Emily Timte, and Student Intern Jeremy Crookston conducted on the value of using new radar capabilities for analyzing the strength of pulse-type (AKA “popcorn/pop-up”) summertime thunderstorms in the Southeast. Meteorologist Blair Holloway presented his diagnosis of how well the major global models predicted the Historic South Carolina Floods of October 2015. Finally, Warning Coordination Meteorologist Ron Morales presented his work, done in conjunction with the Blacksburg, VA NWS office, on the usefulness of Unmanned Aerial Vehicles in assisting with NWS tasks, such as storm surveys. All of these poster presentations were very well received and prompted productive discussion about how this work can be applied to operations and at other offices.





Meteorologists Carl Barnes, Blair Holloway, Ron Morales, and Mike Sporer presenting their research at the NWA Conference in Norfolk, VA. **Click images for research results.**

In addition to the information that our office shared, we were able to bring back information from projects and research that other offices and organizations have conducted to analyze how we can apply them to our operations. This collaboration between the National Weather Service, the Academic Community, and the Private Sector will continue to be instrumental as the volume of tools and resources available within the weather community continues to increase rapidly. Participation in conferences is essential moving forward in order for our office to keep pace with the cutting-edge technology available within the rapidly growing field of meteorology.

Understanding Rogue Waves

by Pete Mohlin - Meteorologist

A rogue wave estimated at 60 feet in the Gulf Stream off of Charleston, SC. Surface winds were lights at 15 knots. The wave was moving away from the ship after crashing into it moments before this photo was taken.

Some say they look like "a wall of water" reaching heights in excess of 70 to 100 feet. Some researchers have surmised that it may have contributed to the sinking of the Edmund Fitzgerald in Lake Superior in 1975. They were once considered mythical and lacking hard evidence for their existence, but now they have been proven to exist and are known to be a natural ocean phenomenon, confirmed by video, photographs, satellite imagery and radar of the ocean surface. They go by several terms; "freak waves", "monster waves" or "killer waves", but more commonly by the term "rogue waves".

In oceanography they are defined as a wave that is greater than twice the size of the surrounding waves. They are generally unpredictable and can come unexpectedly or without warning from any direction, arriving with a tremendous force that can damage or destroy ships, and cause injury or possibly even death to those onboard. The extreme waves can occur singly or in groups of more than one wave. These waves are steep-sided and usually with deep troughs and can occur in any type of weather, even in conditions that might be called "peaceful" or "calm". While we may never know, they might be the cause of many unexplained accidents at sea.

According to NOAA's Ocean Prediction Center there are at least three possible causes of rogue waves:

Constructive interference - Focusing of wave energy

Normal part of the wave spectrum

Some research has indicated that rogue waves in the waters off the southeast coast can form in the southwest quadrant of a departing area of low pressure that is to the northeast. Back swell arriving from the northeast will "collide" with the general north to northeast flow of the Gulf Stream, resulting in focusing of wave energy. One such example may have occurred in September of 2009 when there could have been not one but two possible rogue waves that sank a boat 45 miles east of Charleston.

We find more definitive scientific support of rogue waves having occurred in the so-called "New Year's Wave" or "Draupner Wave" on January 1, 1995, when an 85 foot wave was measured by instrumentation on the Draupner oil rig platform in the North Sea near Norway. This may have been the first rogue wave confirmed by scientific evidence.

Understanding Rogue Waves - Continued

A few other notable rogue waves that have been documented include:

- In 1933 the USS Ramapo encountered a 112 foot wave in the Pacific Ocean. Compare that to the height of the Statue of Liberty which is 111.5 feet tall.
- In 1980 the MV Derbyshire freighter disappeared without a trace during Typhoon Orchid. The wreck was located 14 years later and analysis demonstrated that the vessel almost certainly was hit by waves of at least 92 feet.
- In 1995 the RMS Queen Elizabeth II came across a 95 foot wave "that came out of the darkness" and looked like the "White Cliffs of Dover".
- In 2001 both the MS Bremen and MS Caledonian Star were hit by 98 foot rogue waves in the South Atlantic, which the First Officer of the Caledonian Star indicated that the wave was "just like a mountain, a wall of water coming at us".
- In 2005 the Norwegian Dawn cruise ship was hit by a giant 7 story wave off the coast of Georgia that "appeared out of nowhere", injuring 4 passengers as the "ship was like a cork in a bathtub".

There are numerous research efforts underway regarding rogue waves, some with the hope of predicting them in advance. One such effort is ongoing at the Massachusetts Institute of Technology (MIT), where the early warning system for rogue waves can be detected utilizing radar, LIDAR (a remote sensing method used to measure the ocean's surface) and a laptop computer. If this or other research succeeds, perhaps there could be enough time to "batten down the hatches" and for all onboard to brace before being hit by a rogue wave. Or better yet, perhaps it would enable the vessel to avoid the rogue waves entirely.

Additional sources:

CIO
Freak Waves
TSB of Canada
NWS JetStream
The New York Times
The Post and Courier
Lake Superior Magazine

Teaching Basic Meteorology: A week at Wando High School JROTC

by Steve Rowley - Science and Operations Officer

During early 2013, Major John Farese, a graduate of the US Air Force Academy, former USAF B-52 pilot and current Commander of the Junior Reserve Officer Training Corps (JROTC) program at Wando High School (Mt. Pleasant, SC) asked me if I could present a brief weather talk to 10th and 11th grade Aerospace Science students. I taught this one hour class in September 2013, and the talk was well-received by the JROTC students and instructors. After this initial class, Major Farese and fellow teacher Master Sergeant Mike Gardner asked if I would be interested in greatly expanding the basic weather class to multiple days, potentially condensing and replacing the 5 week curriculum presented by the Aerospace Science textbook. In response to this request, I developed a 3 day class that covered some fundamental concepts of meteorology. During the autumn semesters of 2014, 2015 and 2016, I taught each class to 3 groups

Teaching Basic Meteorology - Continued

of students, for a total of about 5 hours instruction each day. Interestingly, we had to reschedule the 2016 class due to Hurricane Matthew. Also, with help from staff members at our NWS office, I developed an end-of-course test to measure student understanding of these concepts. As a result, we added a fourth day of instruction devoted to a comprehensive class review and testing. At the close of the 2016 session, I had taught some 375 students over a three year period.

During each class, I introduced selected, foundational concepts of meteorology. Since any accurate forecast begins with precise measurement of atmospheric properties, I began with an overview of basic measuring tools such as thermometers, barometers, rain gauges and anemometers, and I briefly described the importance of more complex tools such as satellites and radar. Then, I introduced the concept of global and local heat and pressure imbalances which produce air movement, and I invested considerable time describing the unique properties of water which contribute to our unique Earth environment. We also discussed high and low pressure and fronts and how to depict and identify these features on a weather map. The instruction expanded into more complex topics such as the formation of clouds and precipitation, as well as the wide array of phenomena and hazards produced by thunderstorms, including lightning, hail, downbursts and tornadoes.

The greatest challenges of class preparation included prioritizing concepts, creating non-mathematical narratives for critical principles and laws and fitting topics to limited class time. We explored concepts such as atmospheric stability – the resistance (or lack thereof) to atmospheric motion (especially vertical motion) - and laws such the Bernoulli and Continuity Principles, which describe how planes fly and how the atmosphere compensates for air movement, respectively. Over the entire curriculum, each student received about 6 hours of instruction for a subject that could ultimately entail weeks, months and years. Indeed, the material presented in the Aerospace Science textbook normally encompasses about 5 weeks of instruction.

At the heart of this education initiative, I have always enjoyed teaching; had I not pursued a career as a meteorologist, I believe I would have become a teacher. Further, preparing and conducting these classes forged in me a renewed appreciation for the teaching profession. In short, teaching is demanding, rewarding and essential. Most importantly, I subscribe to the notion that we should strive to develop and improve our "weather literacy" if we are to improve our weather resilience and to effectively evaluate the multiplying streams of information regarding climate change. For these reasons, I look forward to teaching this class again during the coming years.

Weather in the Classroom

Although NWS meteorologist would love to visit every classroom, this just is not feasible. Still, teachers and educators can integrate meteorological elements into their lessons and use our educational webpage as a reference.

Want to Become an Official NWS STORM SPOTTER?

The SKYWARN Storm Spotter Program was created by the National Weather Service to improve warning services due to the need for real-time reports of hail size, wind damage, flash flooding, heavy rain, tornadoes, and waterspouts. These reports aid meteorologist in effectively warning the public of inclement weather. Even as new technology allows the NWS to issue warnings with more lead time, spotters will always be needed as links between radar indications of severe weather and ground truth. Check out our local Storm Spotter webpage for more information on report criteria and methods.

How to Become a NWS Storm Spotter

⇒ **Attend a Local Storm Spotter training class in southeast SC or GA**
Check our latest local Storm Spotter Training Schedule to see if a class is scheduled near you. You may also consider hosting a spotter class; however, we apologize that we will not be able to accommodate all requests.

⇒ **Complete an online Storm Spotter course**
This option is best if you cannot attend one of our in-person training sessions or want to refresh your knowledge. You will need to register on the COMET website to access the training. Be sure to follow the instructions in the Course Description section for how to become an official Storm Spotter for the NWS in Charleston, SC.

⇒ **Attend a Spotter training class outside of the local area**
Most National Weather Services Offices across the country provide training specific to their local areas of responsibility. Click here for training in other areas of the country.

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