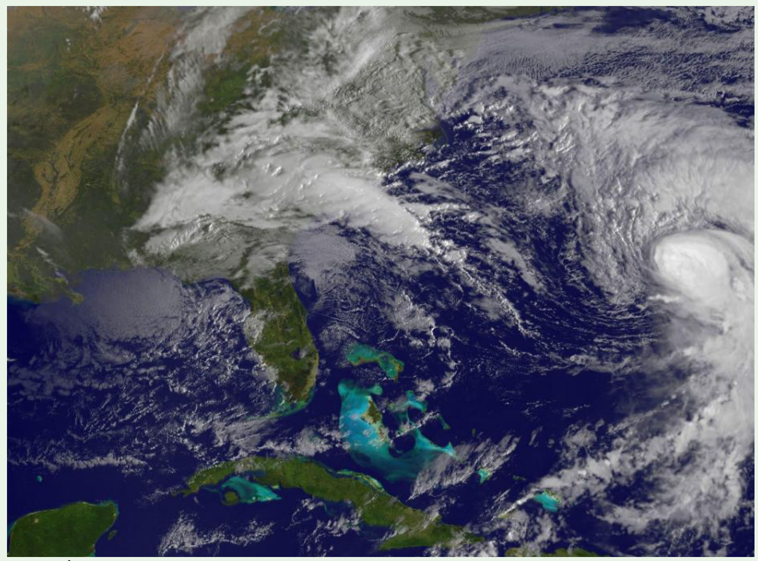
The South Carolina Floods of October 2015

An analysis by the Carolinas Integrated Sciences & Assessments (CISA) at the University of South Carolina of the climatological and hydrological conditions which contributed to this extreme event and how to consider future risks as communities recover and rebuild.

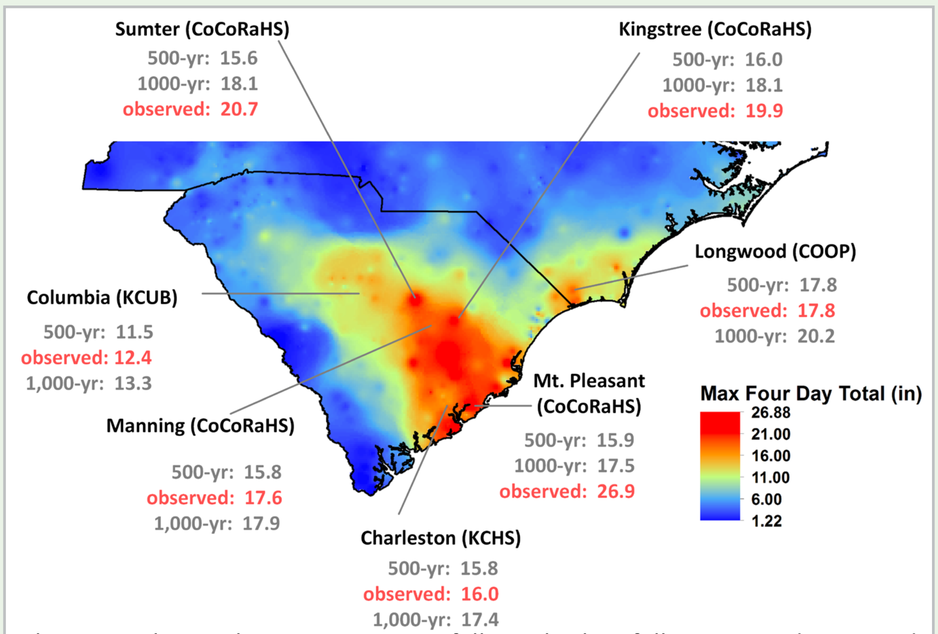
The Weather

A stalled mid-latitude weather system directed a fire hose of deep tropical moisture across South Carolina over a four-day period (October 2-5) leading to record-breaking rainfall totals.

- The extraordinary rainfall was generated by the movement of very moist air over a stalled frontal boundary near the coast.
- The clockwise circulation around a stalled upper level low over southern Georgia directed a narrow plume of tropical moisture northward and then westward across South Carolina over the course of four days.
- The outer circulation of Hurricane Joaquin, situated well off the coast, added additional tropical moisture to the system (see satellite image to the right).
- Mount Pleasant, SC, recorded 26.88 inches of rain over a four-day period. All–time precipitation records were shattered across much of eastern and central South Carolina, with totals ranging from 10 to over 26 inches of rain.
- Columbia and Charleston received 8.19 and 6.40 inches of rainfall, respectively, over a 12-hour period.



NASA/NOAA GOES East satellite image, October 4, 2015



This map shows the maximum rainfall totals that fell over a 4-day period during this event as well as data from weather stations where 500 and 1,000 year recurrence intervals were exceeded. The amount of rain was less than a 1,000 year event in some places and greater than that in others. Mt. Pleasant, SC saw the highest recorded 4-day total (Oct 2-5) at 26.88 inches. Map by Peng Gao.

Columbia, SC Photos Courtesy of George Herron

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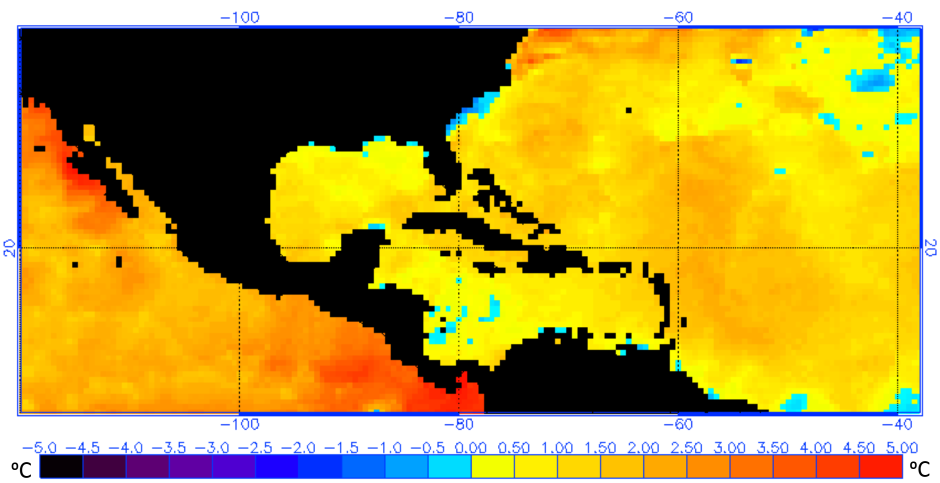
The Climate Context

Understanding current climate conditions and previous events that produced similar rainfall amounts places this event in the context of the multiple factors that contribute to the severity of rainfall and flooding events.

» Soils were already saturated in many areas prior to the heaviest rainfall on Sunday, October 4, which may have affected patterns of flooding. While these rainfall amounts leading up to October 4 were near-normal in many places, they exceeded 7 inches at several coastal stations north of Charleston, from Georgetown to North Myrtle Beach, and at stations in the greater Columbia area.

» Sea surface temperatures (SSTs) in the Atlantic were approximately 1.5-2.5°C (3-4.5°F) warmer than average (see map below). This contributed to higher evaporation rates over the Atlantic and fed more moisture into the weather systems.

NOAA/NESDIS SST Anomaly, October 1, 2015 (°C)



» Tropical storms often interact with mid-latitude weather features like upper level lows, as happened in this event. In 1990, over 8 inches of rain fell between October 10 and 13 in the Savannah, Edisto, Yadkin-Pee Dee, and Catawba River Basins of North and South Carolina and Georgia. In some isolated spots rainfall exceeded 12 inches. In the 1990 case, the remnants of Tropical Storm Klaus brought extensive moisture near the SC coast, while Tropical Storm Marco crossed the region from south to north. The influences of these tropical systems was magnified by a stalled cold front, just as it was in October 2015.

Was this a 1,000 year event?

For precipitation, the standard scientific estimates for the probability of rainfall exceeding certain thresholds (also called recurrence intervals) is documented in NOAA's Atlas 14. The map on page 1 shows observed 4-day total rainfall at selected stations, with reference to recurrence intervals. It is important to remember that the value associated with a 100-year event is the amount of precipitation that, statistically, has a 1% chance of occurring in any given year. A 1,000-year event is the precipitation amount that has a 0.1% chance of occurring in any given year. Within the band of heaviest rainfall, several stations exceeded estimates for a 1,000-year event.

The likelihood (or recurrence interval) for a flood is not the same as that for rainfall because factors including the extent and intensity of rainfall and surface conditions (e.g., saturated soils) will influence runoff to streams and rivers. Based on USGS stream gage data, this was not a 1,000-year flood. Many gage locations did not break records or fall within the top 5 flood events (see page 3 for more information). Another consideration is that record length for stream gages stations range from 5 to 144 years throughout SC. This means that in some places there is not a great deal of information and new information may change the statistics. Click here for a report from USGS about this historical event. See page 19 in the report for a table of other major flooding events in SC dating back to 1893.

Charleston, SC
Photo Source: Tracie Mitchum

Gills Creek in Columbia, SC
Photo Source: Nicole Carey

Charleston, SC
Photo Source: Kyle Buck

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The Hydrologic Response

Heavy rains caused severe to extreme flooding across the state although the peak flows at many USGS gages did not break records as rainfall totals did.

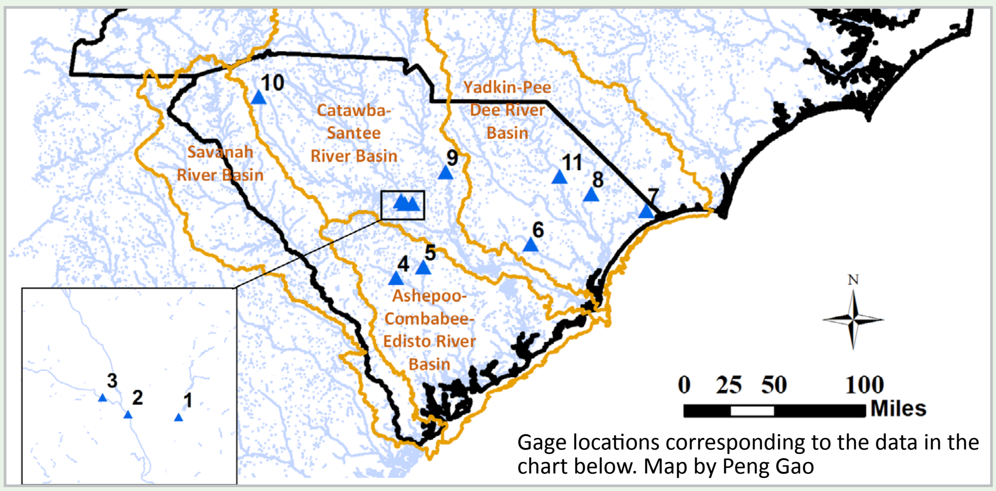
» The hydrologic response was much longer than the four-day rainfall event. For example, flooding in coastal areas occurred as a result of intense and large amounts of precipitation from October 1-5, and then after the rainfall ended as floodwater flowed downstream. Several stream gages show peak flows through October 11 (see table below).

» The Congaree River peaked early on October 4 as a result of the large rainfall amounts received in the Upstate in the days before the major rainfall event, starting October 3.

» Had the upper portion of the Congaree River watershed (e.g., Greenville/Spartanburg area) received precipitation amounts similar to those in the southeastern section of the state (see rainfall map on pg 1), there likely would have been a much larger peak discharge, a few days later.

» Dams change streamflows and alter the frequency of floods. Comparing information about major floods before and after dam construction provides a broader historical context. For example, the Congaree River peaked at 185,000 cubic feet per second (cfs) on October 4. According to the USGS study, this is the 8th highest peak based on the 123-year record at this gage location. The highest recorded peak (364,000 cfs) occurred in 1908, before the Lake Murray dam was constructed.

» Gages where new record peak flows were recorded were mostly in the central to eastern part of SC. This follows from the rainfall amounts which were substantially greater there.



Gage locations corresponding to the data in the chart below. Map by Peng Gao

Gage Number	Gage Location	Oct 2015 Peak (preliminary) cubic feet per second (cfs)	Peak Day (October)	New Record?	Previous or Current Record cfs and year	Comments
1	Gills Creek at Columbia	>3000 (?)	4	Yes (?)	2,880 (1979)	(?) Gage destroyed
2	Congaree River near Columbia	185,000	4	No	231,000 (1936)	Higher peaks occurred before Lake Murray dam
3	Saluda River near Columbia	>50,000 (?)	4 or 5	Yes (?)	53,200 (1965)	(?) Gage destroyed; higher peaks before Lake Murray dam
4	South Fork Edisto River near Denmark	2,100	8	No	13,500 (1936)	Many higher peaks
5	North Fork Edisto near Orangeburg	8,640	5	No	9,500 (1945)	
6	Black River at Kingstree	83,700	6	Yes	58,000 (1973)	
7	Waccamaw River near Longs	16,90	6	No	28,200 (1999)	
8	Little Pee Dee River near Galivants Ferry	8,230	11	No	27,600 (1964)	Many higher peaks
9	Wateree River near Camden	50,900	4	No	168,000 (1936)	Many higher peaks; highest pre-date Wateree dam
10	Saluda River near Greenville	1,660	4	No	11,000 (1949)	Many higher peaks
11	Pee Dee River at Pee Dee	30,100	8	No	220,000 (1945)	Many higher peaks; several dams on this river

Table 1: Representative US Geological Survey stream flow recorded at various locations around the state. This shows that, although the precipitation amounts were significant throughout the state, the new record peak discharges occurred only where the precipitation amounts were largest. Discharge data from http://nwis.waterdata.usgs.gov.

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Flood Impacts, Risks, and Implications for Future Planning

There are many lessons to be learned about community resilience in the wake of such an extreme event. Particularly important are ways communities can consider rebuilding to avoid similar impacts in the future.

Columbia, SC Photo Source: George Herron

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- The amount of flood risk South Carolinians face is based on the nature of this event (extreme rainfall on already saturated soils) in combination with their exposure (e.g., proximity to streams and rivers) and the condition of infrastructure, homes, roads, and businesses in the path of the flooding.
- The situation in the Gills Creek watershed in Columbia is not straightforward. There were three dam breaches in the early morning of October 4 that cumulatively released a large pulse of water. This, perhaps more than the precipitation itself, was a major cause of the spatial extent and depth of the flooding below Lake Katherine in the Crosshill/Garners Ferry Road area.
- As our region has added population and expanded development, the potential for more and greater impacts from an extreme event has grown. However, these impacts can be reduced or avoided through planning for greater resilience during recovery and future growth.
- Flood likelihood estimates are based on statistical averages, not on the number of years between big floods. A so-called "100-year flood" has a 1% chance of occurring in any given year. This means that, over the life of a 30-year mortgage, there is a greater than 25% chance that a house in the 100-year floodplain could flood. These estimates of chance are only as good as the available data. As more data are collected on the changing conditions in a river basin (i.e., increased development to create more impervious surface which influences runoff), the estimates may be revised.
- Important discussions about how to reduce future impacts are beginning. For example, how to rebuild dams, help families and communities that have fewer resources than others to rebuild, and reduce future flood risk.
- This event was an important reminder that even if you do not line in the 100-year floodplain, where insurance is required, your home or business is still at risk to larger floods.

Additional Resources

- SC State Climate Office
- Southeast Regional Climate Center
- USGS South Atlantic Water Science Center
- SC Dept of Health & Environmental Control
- SC Coastal Information Network
- National Weather Service
  - Columbia Office
  - Charleston Office

Future Research

CISA PIs will continue to assess the storm and its hydrologic impacts. Among the relevant questions, scientists at CISA and elsewhere will explore:

- how new information about this event changes probabilities for future similar events
- the accuracy of precipitation predictions for the region
- effective strategies to rebuild more resiliently

About the Carolinas Integrated Sciences & Assessments

Established in 2003, CISA is 1 of 10 NOAA-funded Regional Integrated Sciences & Assessments (RISA) teams. The RISA program supports research teams that help build the nation's capacity to prepare for and adapt to climate variability and change. CISA works at the intersection of climate with water, coasts, and health to connect climate science with decision making in the Carolinas through:

- applied research to produce relevant climate information
- assessments of climate impacts and adaptation strategies
- processes to support and inform community planning
- fostering climate networks and climate communities of practice

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