Historic Rainfall Event

Mesoscale Synoptic Review

October 2015

OPEN-FILE REPORT

South Carolina Department of Natural Resources
Land, Water and Conservation Division
South Carolina State Climatology Office

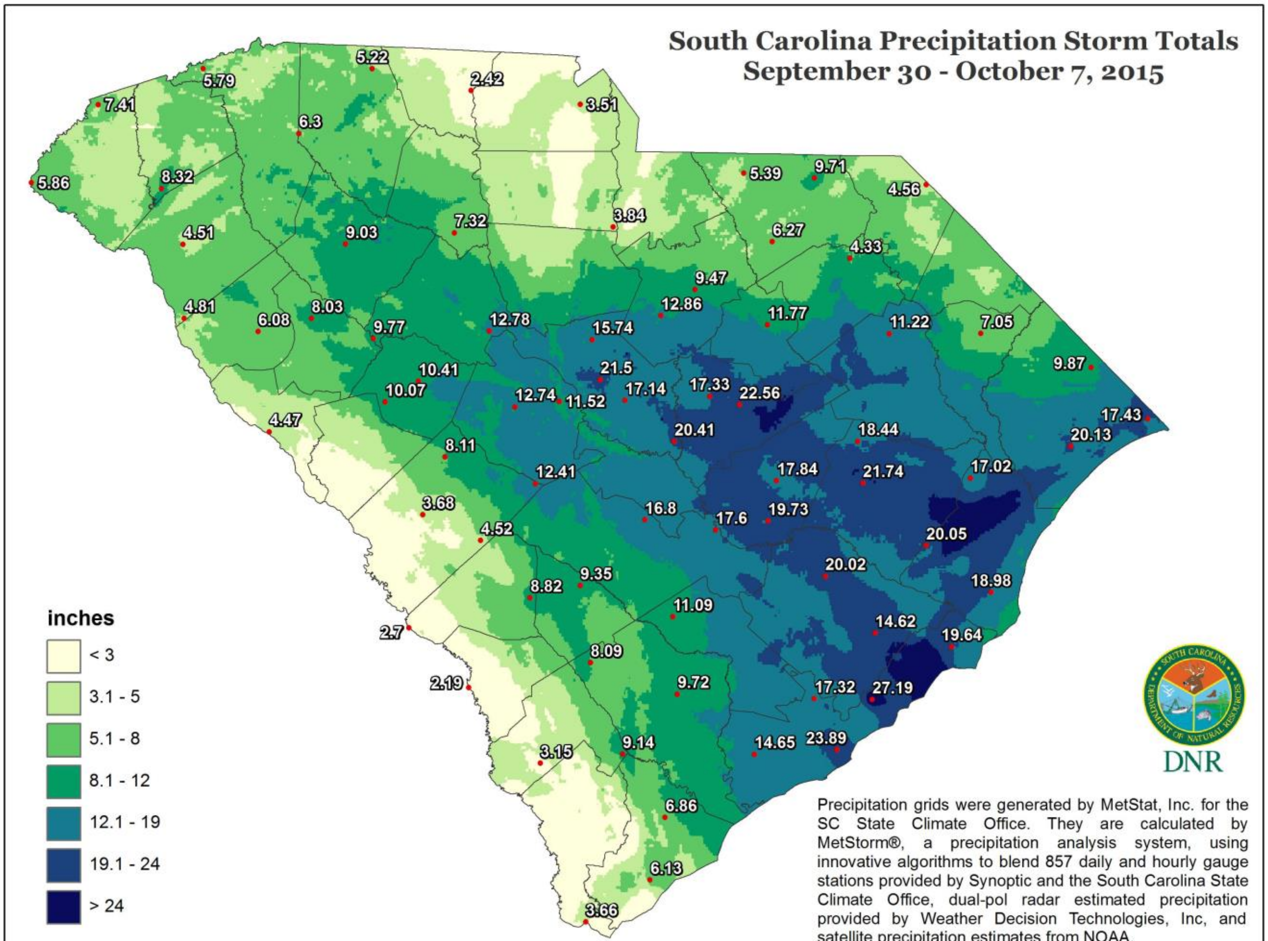

Figure 1. October Historic heavy rainfall event accumulation map.

Event Summary:

The historic heavy rainfall event of October, 2015 produced record rainfall rates and rainfall totals in South Carolina (Figure 1.). The rainfall amounts and distributions across the state were similar in pattern to those normally produced by hurricanes making landfall; however, although the moisture drawn over the State was from deep in the tropics, the synoptic features that produced the heavy rainfall were of a mid-latitude nature rather than that of a tropical cyclone.

The five-day October historic rainfall event and subsequent catastrophic flooding occurred a week after an extended period of state-wide rain. From September 24th until the 29th, rain and heavy rain showers fell across the state triggered by a frontal boundary that stalled along the coast during that period (Figure 2.). Rainfall amounts of one to four inches were recorded by various observing sites. Rainfall amounts of over five inches were observed in Richland and Colleton counties. This September rain event saturated the ground, and increased lake and river levels ahead October's event.

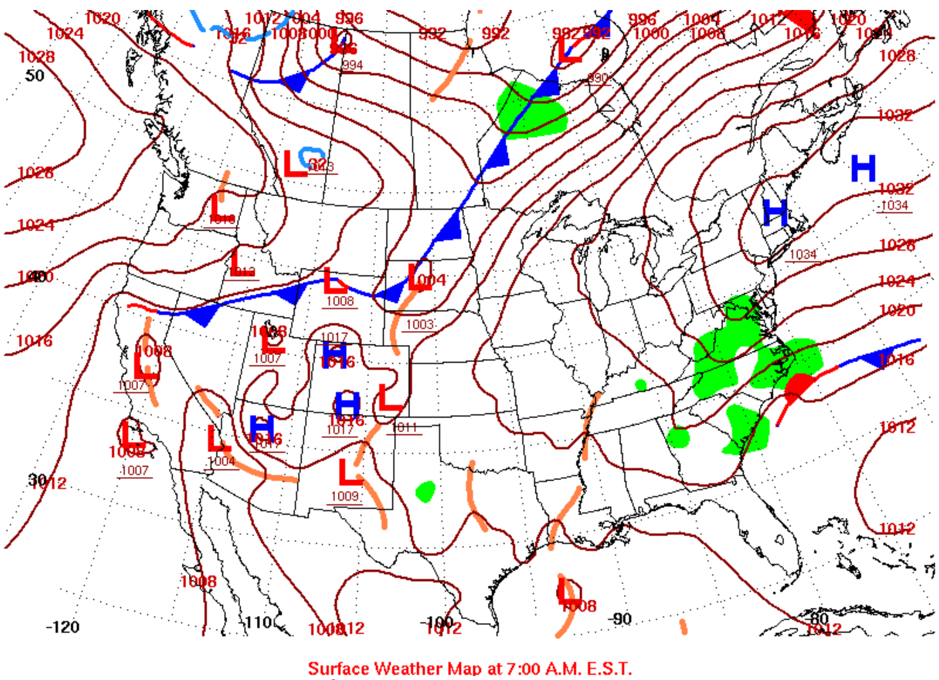

Figure 2. 0700 September 27th, 2015 Surface analysis. (NOAA)

On October 1st, a cold front swept across the state and stalled offshore for the next five days between blocking high pressure centered over Hudson Bay Ontario and a large surface cyclone over the southwest Atlantic (Figure 3.). With the blocking high to the north and cyclonic subtropical flow to the south, a large, synoptic-scale easterly flow of moist air persisted over the Carolinas in September and the first week of October.

The offshore frontal boundary tapped into deep tropical moisture over the Gulf of Mexico and southwest Atlantic as it sat over an anomalously warm pool of water that had been in place since August of 2014 (Figure 4.). This warm water mass maintained a well moistened air-ocean boundary layer off the US Southeast coast that fueled the development of the historically early Tropical Storm Ana in May of 2015, the September rain event described above, and the intensification of Hurricane Joaquin during the first week of October 2015.

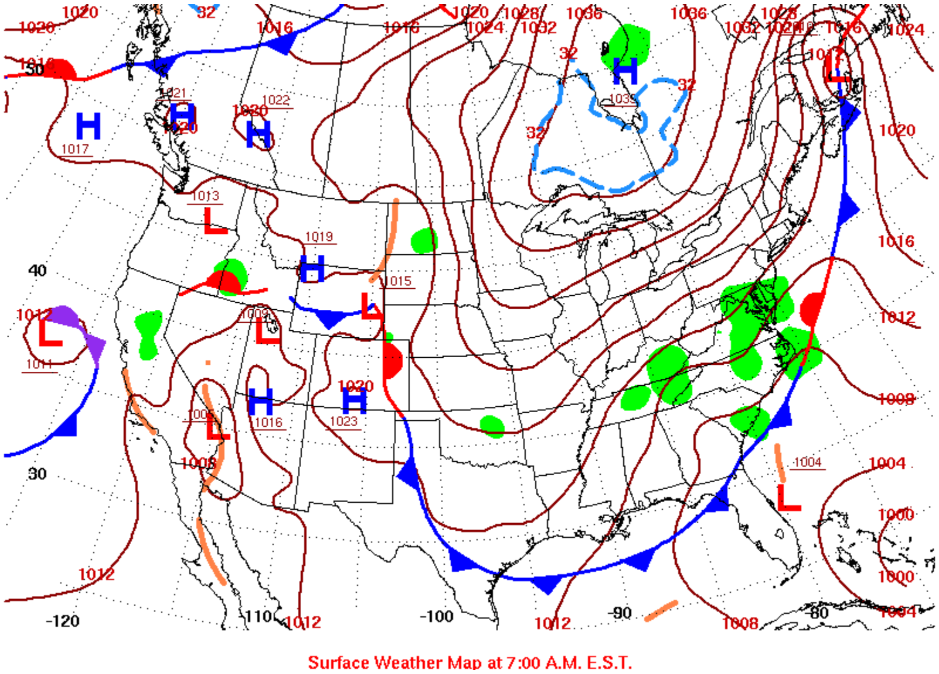

Figure 3. Surface Analysis October 1st, 2015 (NOAA)

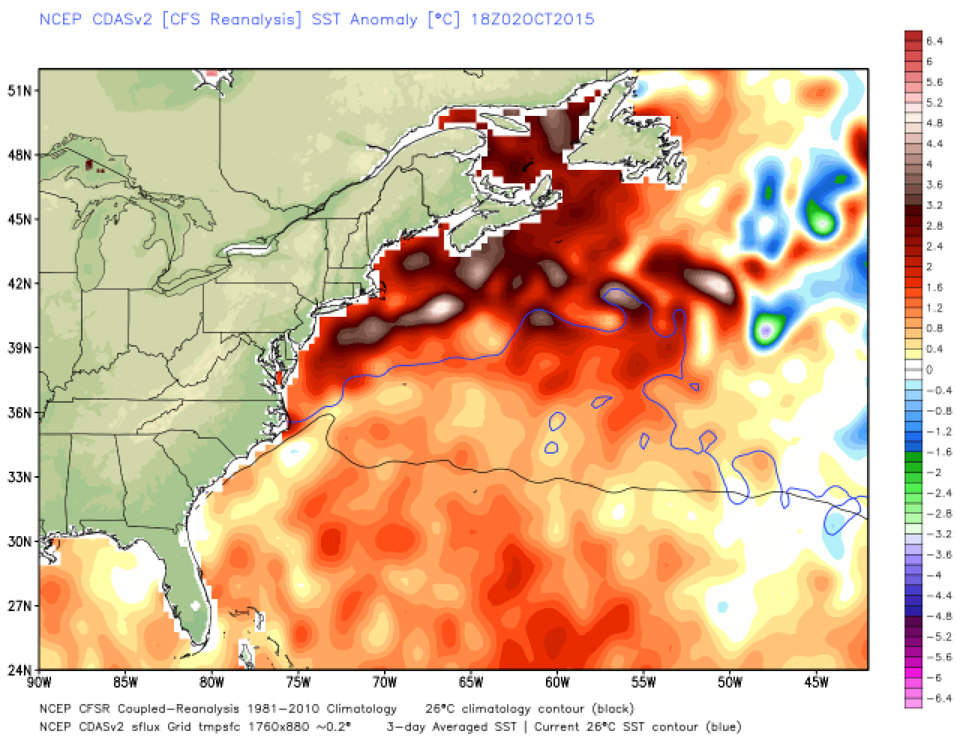

Figure 4. Sea surface temperature analysis 18Z October 2nd, 2015. (WeatherBell Analytics)

As the quasi-stationary front established itself offshore as a conduit for warm moist surface air, an upper level trough of low pressure migrated, deepened and became negatively tilted over the eastern United States. An upper level cut-off low within that negatively tilted trough migrated southeast before stalling over southern Georgia on October 3rd. That cut-off was then blocked in place by an Omega-like trough-ridge-trough mid-level blocking pattern over the US east coast (Figures 5-6.).

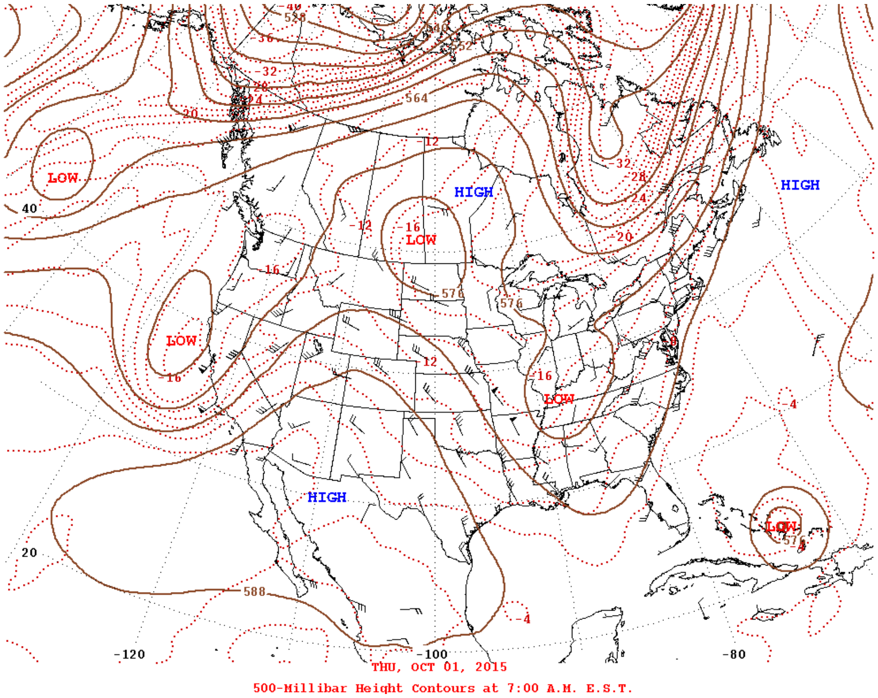

Figure 5. 500 millibar analysis 12Z, October 1st, 2015 (NOAA)

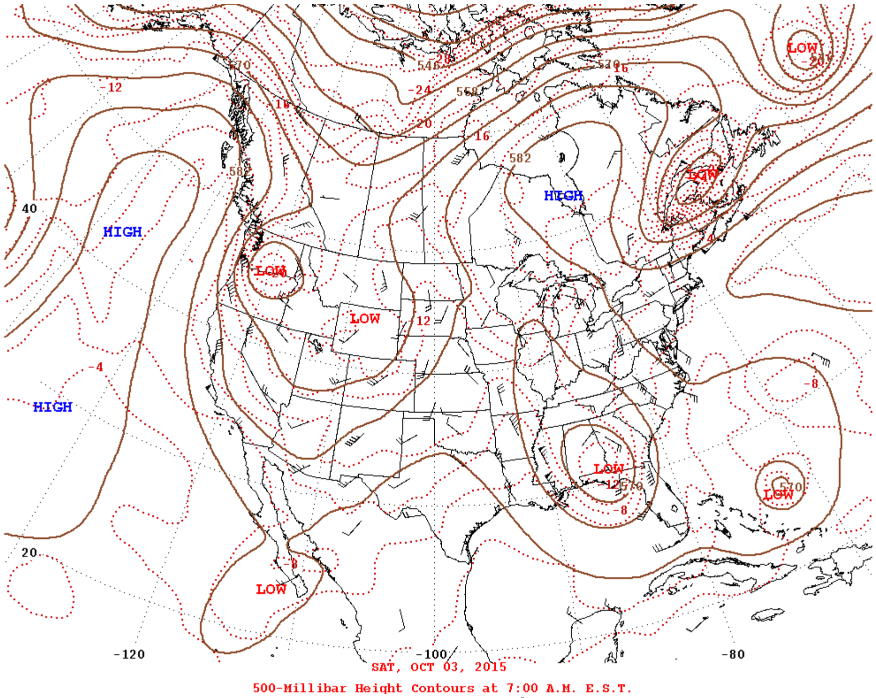

Figure 6. 500 millibar analysis, 12Z, October 3rd, 2015 (NOAA)

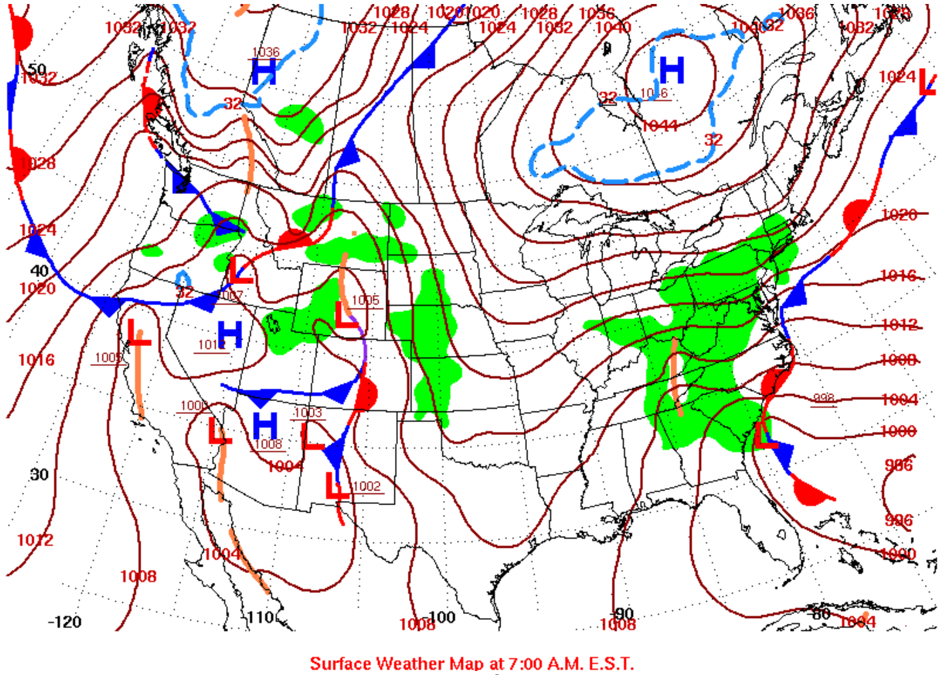

Figure 7. Surface analysis, 0700 October 3rd, 2015 (NOAA)

As the upper closed low tracked southeast in the deepening trough, the stalled frontal boundary offshore produced rain and drizzle October 1st-3rd (Figure 7.). Late Saturday, October 3rd, the blocked cold-core low extended up and northwest from 700 millibars supported by jet couplet at 300 millibars (Figures 8 and 9.). These two jets were closely oriented in a nose-to-tail alignment, with the left exit region of the southern jetlet south-southeast of the right entrance region of the northern 100+ knot jetlet (Figure 10.). This configuration created both a broad area of divergence over the anomalously warm subtropical Atlantic, and strong divergence over South Carolina with a pronounced southeast-northwest alignment from the offshore surface boundary. Lift from the strong divergence over the state, ample moist easterly synoptic flow, surface subtropical thermal forcing and strong upper level baroclinicity combined with impeccable timing late October 3rd to produce the torrential rainfall event for South Carolina.

The upper level jetlet, and associated divergence aloft that forced the training convection from offshore could have been briefly enhanced by the outflow momentum flux from Hurricane Joaquin that had reached maximum intensity midday October 3rd (Table 1.). Figure 10 does not show a conclusive enhancement channel at 200 millibars; however, a more likely enhancement mechanism was that the blocking pattern tightened the gradient aloft creating the 100 knot jet over South Carolina.

Water vapor imagery shows the trough pulling mid-level dry air into the western side of Hurricane Joaquin, suggesting that the upper trough-closed low complex diverted surface moisture away from Joaquin and induced dry air entrainment into the hurricane (Figure 11.). Hurricane Joaquin started to weaken significantly Saturday evening becoming an 85 knot hurricane with a 958 millibar central pressure during the afternoon of October 4th. The east coast trough accelerated the hurricane away from the Bahamas northeast over the open Atlantic.

The blocking pattern rapidly weakened as the stalled coastal front dissipated and the upper level cold core low drifted eastward leaving lingering light rain over the Pee Dee region on Monday October 5th.

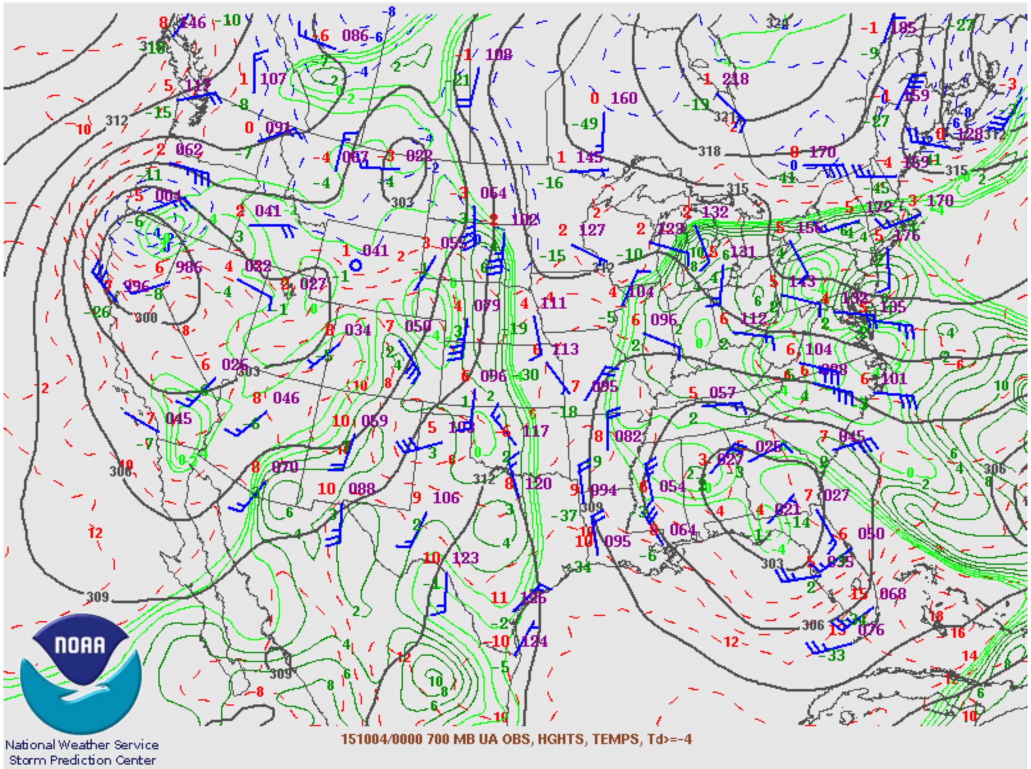

Figure 8. 700 millibar isoheights, dewpoint temperatures 00Z October 4th, 2015. (NOAA)

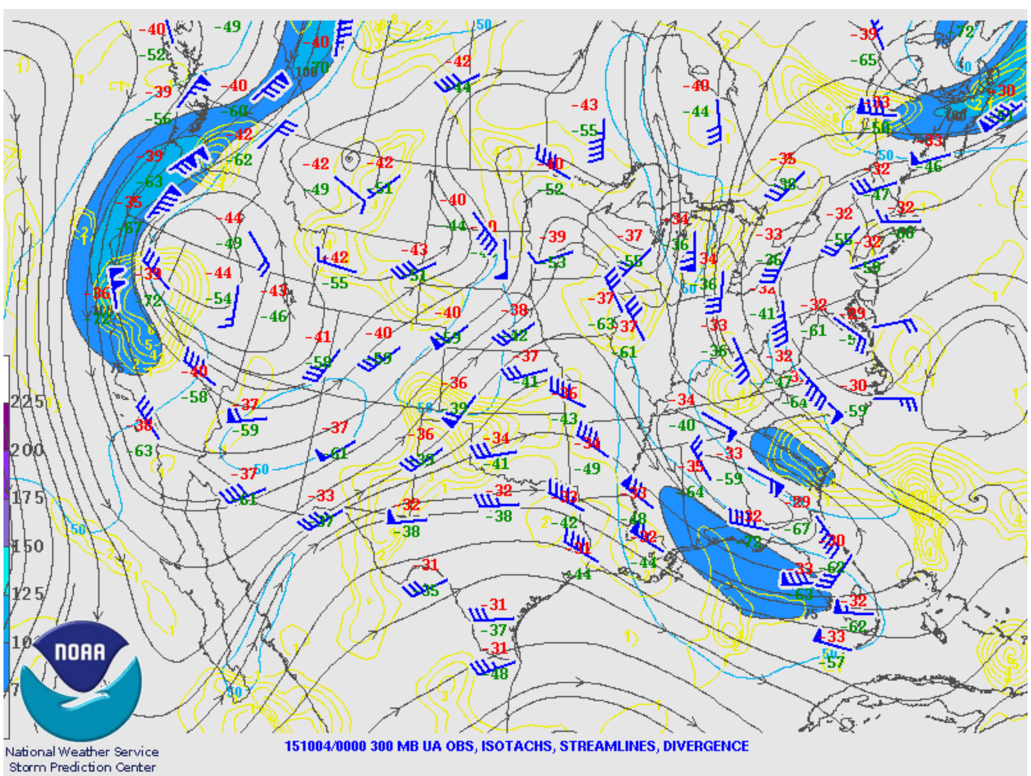

Figure 9. 300 millibar isotachs, streamlines and divergence 00Z October 4th, 2015. (NOAA)

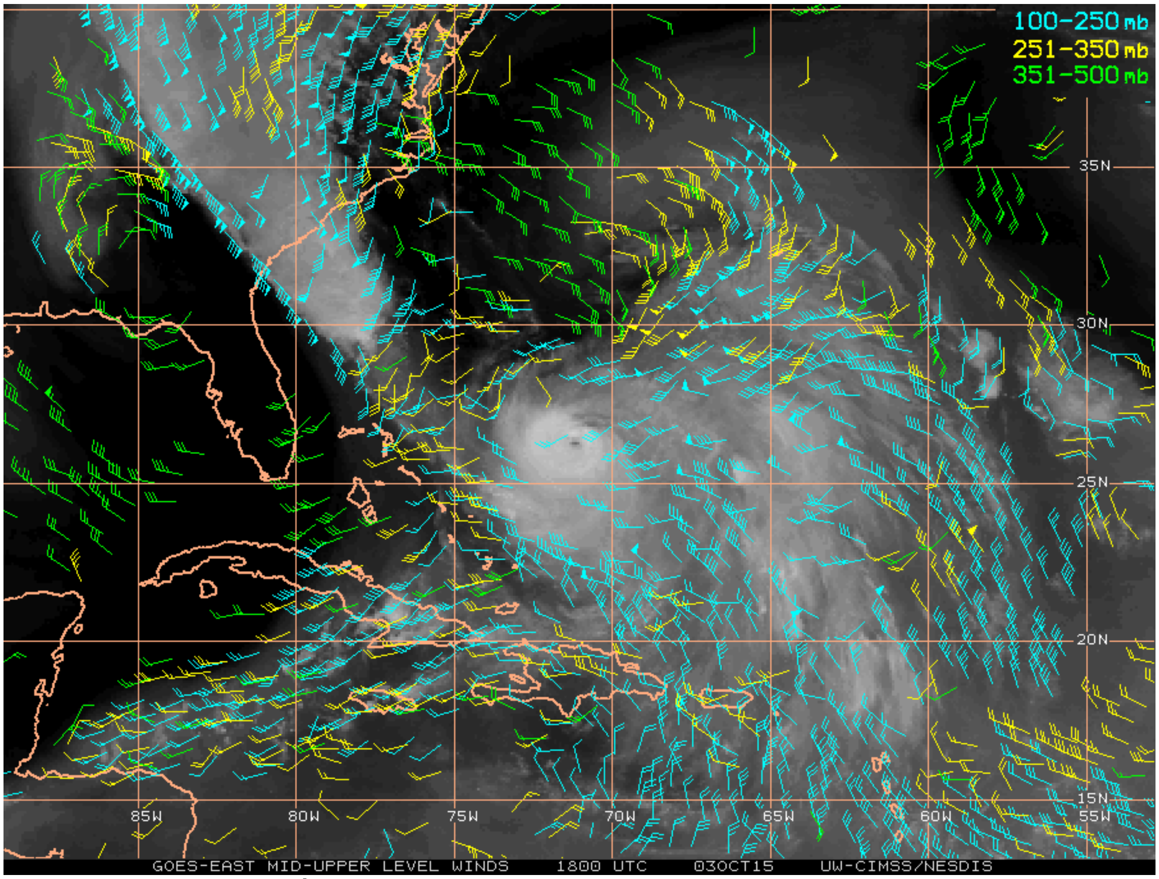

Figure 10. 18Z October 3rd, 2015 Water vapor image with satellite upper level (500-100 millibar) winds (CIMSS U. Wisc.-Mad.)

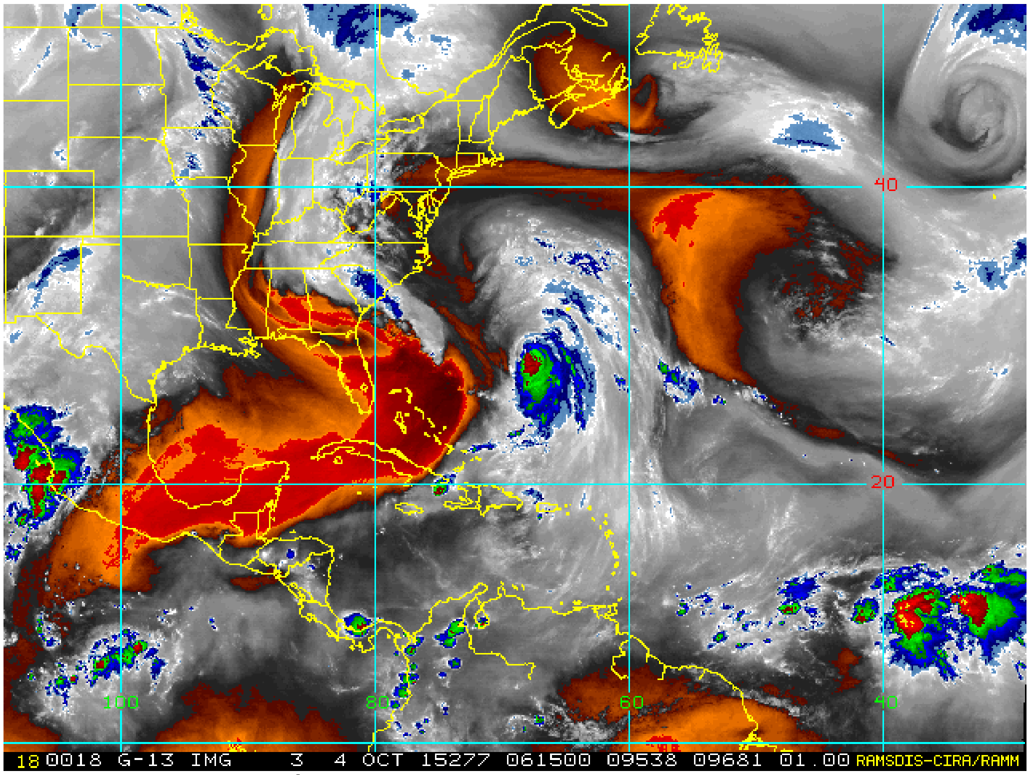

Figure 11. 06Z October 4th, 2015 Water vapor image. (RAMDIS-CIRA/RAMM)

Date/Time (Z)	Pressure (millibars)	Wind/Gust (knots)
03 OCT/0300	944	110/135
03 OCT/0900	945	110/135
03 OCT/1500	936	115/140
03 OCT/1600	933	135/165
03 OCT/2100	934	130/160
04 OCT/0300	944	115/140
04 OCT/0900	952	105/130
04 OCT/1500	957	95/115
04 OCT/2100	958	85/105
05 OCT/0300	961	75/90
05 OCT/0900	964	75/90

Table 1. National Hurricane Center Best Track Intensity (NOAA/NHC)

South Carolina Effects:

As displayed in Figure 1, Georgetown, Charlestown, Berkeley, and Dorchester counties received rainfall amounts above 20 inches. A CoCoRaHS observer in Mount Pleasant recorded a rainfall total of 27.19 inches. In Richland County, where numerous dams failed in the Gills Creek watershed, an unofficial Richland County Winds sensor reported a 21.49 inch rainfall total.

South Carolina suffered catastrophic damage not seen since Hurricane Hugo struck the state in September 1989. Damage estimates to property, transportation infrastructure, and agriculture exceed $1.5 billion.

ACKNOWLEDGEMENTS:

- NOAA Storm Prediction Center
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- The National Hurricane Center
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- Cooperative Institute for Meteorological Satellite Studies/ University of Wisconsin-Madison
- Regional and Mesoscale Meteorology Branch-Cooperative Institute for Research in the Atmosphere-NOAA NESDIS