A Discussion of the 2017 Record Rainfall Year for WFO Mobile

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ABSTRACT

In 2017, The annual rainfall total in Mobile was ranked 8th of 147 recorded years (1871-2018), while Pensacola, Florida was 2nd of 138 years (1880-2018). In addition to a host of non-tropical locally heavy precipitation producing storm systems, three tropical systems directly and indirectly contributed to these totals (i.e., Tropical Storm Cindy, Hurricane Harvey, and Hurricane Nate). A total of ten significant heavy rain events, three tropical and seven non-tropical, over the course of 15 separate days accounted for 42% of the Mobile annual total and 41% of the Pensacola annual rainfall total. This study focuses and discusses both the flash-flooding and heavy rainfall aspects of one such non-tropical heavy rainfall case which occurred over Saraland, Alabama on May 20th, 2017. The goal is to improve our overall forecast understanding of how these events potentially evolve, and how both the established pattern and associated ingredients work in concert to produce intense rainfall.

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1. Introduction

The Gulf Coast region regularly ranks high for annual rainfall, yet 2017 was an abnormal year. The National Weather Service (NWS) Weather Forecast Office (WFO) in Mobile noted that the annual precipitation total for Mobile, Alabama was 83.78 inches recorded at the Mobile Regional Airport. In Pensacola, Florida the rainfall total was 91.91 inches recorded at the Pensacola Regional Airport for 2017. This represents the 8th and 2nd most recorded precipitation in a given year for Mobile and Pensacola respectively. For perspective, the Mobile total was 17.6 inches above the yearly average, while the Pensacola total was 26.6 inches above normal. There were 30 days where flash flood warnings were issued due to intense rainfall totaling 93 individual warnings for the year. In addition, a total of 8 daily rainfall records were broken in both Mobile and Pensacola.

TABLE 1. Top ten rainiest years in the Mobile Area derived from the NOAA Reginal Climate Centers 1871-2018

Rank	Year	Total Precipitation
1	1881	92.32
2	1900	91.18
3	1912	89.86
4	1929	89.34
5	1975	86.58
6	1998	86.52
7	1947	84.20
8	**2017**	**83.78**
9	1983	83.46
10	1961	82.73

Heavy rain is often the precursor to dangerous flash floods. For that reason, understanding the causes of heavy rainfall helps NWS forecasters better predict when and where there is potential for large amounts of rain and subsequent flash flooding.

TABLE 2. Top ten rainiest years in the Pensacola Area derived from the NOAA Reginal Climate Centers 1880-2018

Rank	Year	Total Precipitation
1	1953	93.32
2	**2017**	**91.91**
3	1947	90.32
4	1995	89.45
5	2009	88.30
6	1937	87.58
7	2005	87.32
8	1881	86.02
9	2014	83.17
10	1964	82.96

Studies on the subject of heavy rainfall across the United States often arrive at the same conclusion when it comes to the causes of these events. A study by Maddox et al. (1979) showed that some common features associated with heavy rain and flash floods are: the development of convective storms, abnormally high moisture content, training storms over the same area, and other synoptic and mesoscale factors. Additionally when it comes to the Gulf Coast and the Southeast United States, tropical systems contribute large portions of the overall yearly rainfall total in a relatively short amount of time. In a study by Schumacher (2005) which examined the characteristics of extreme rain events, he notes that generalizations made about rainfall totals and their distributions in the Southeast can vary widely in accordance to tropical activity. With regards to tropical activity, the 2017 Atlantic Hurricane Season is considered a hyperactive season, Goldenberg et al. (2001). Locally, the NWS Forecast Office in Mobile was impacted directly and indirectly by three significant tropical events Tropical Storm Cindy, Hurricane Harvey, and Hurricane Nate. These systems bolstered the precipitation totals for June, August, and October adding to the annual total and underscoring the year to year variability in rainfall along the Gulf Coast region. Finally, a study performed by the National Severe Storms Laboratory looking at the climatology of heavy rain events showed that heavy rainfall and flash flooding is often associated with rain rates greater than 1 inch per hour (in. h^{-1}) which last for an extended period of time (Brooks 1999).

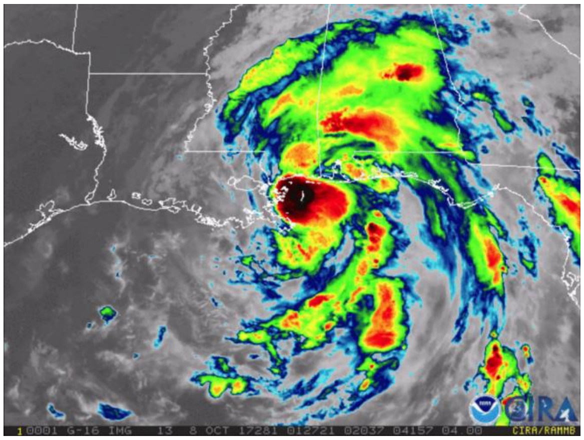

FIG. 1. GOES-16 Infrared Satellite Image of Hurricane Nate on October 7th, 2017 from the Cooperative Institute for Research in the Atmosphere (CIRA).

In 2017, a total of ten significant heavy rain events, three tropical and seven non-tropical, over the course of 15 separate days accounted for 42% of the Mobile annual total and 41% of the Pensacola annual rainfall totals. The following section will focus on one such non-tropical heavy rainfall event in particular where flash flooding occurred within WFO Mobile's County Warning Area (CWA). The purpose being to expand upon how NWS meteorologists assess heavy rainfall potential.

2. May 20th, 2017 Heavy Rainfall Event in Saraland, Alabama

By examining the Saraland, AL flash flood event in May and its local effects, it becomes possible to understand some of the common causes of heavy rainfall. A forecaster will typically implement four steps prior to the onset of a heavy rain event.

- Assess the synoptic & mesoscale moisture content as it compares to climatology
- Determine whether there is the potential for continuous convective storms
- Examine antecedent conditions
- Investigate where the moisture is being transported

Using these steps, forecasters are able to evaluate flash flood likelihood. It is through this lens in which this case will be examined.

Prior to the onset of the heavy rain in Saraland, at 12Z on May 20th a mid-level trough with its axis centered over eastern Colorado sparked a convective line extending from the Southern Plains to central Texas (Fig. 2).

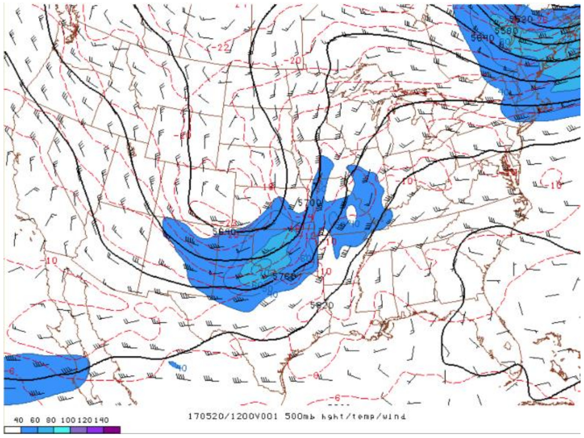

FIG. 2. The 500mb chart for May 20th, 2017 at 12Z. The isohypses are contoured in black, 500mb temperatures are dashed and contoured in red, and wind speeds are shaded in blue. Image taken from the Storm Prediction Center (SPC) Mesoscale Analysis webpage.

As the center of the trough moved slowly to the northeast, the remnants of the convective line travelled eastward into the Lower Mississippi River valley and would act as a focal point for the heavy rain later on in the evening (Fig. 3).

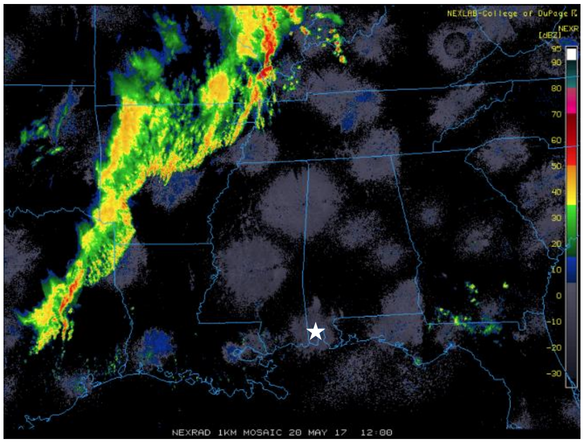

FIG. 3. The Southern Mississippi River Valley radar mosaic for May 20th, 2017 at 12Z. Star denotes the location of Saraland, Alabama Image taken from NEXLAB College of DuPage website.

At the surface, the environment out ahead of the line was primed for convective storms. Along the Gulf Coast, dew points were well into the 70s (Fig. 8). This ample low-level moisture in addition to temperatures reaching the low 80s by midday contributed to mixed-layer convective available potential energy (CAPE) values above 2500 J/kg.

Looking at the 12Z sounding analysis from WFO New Orleans (Fig. 4) acts as an approximation for assessing the localized moisture content. The sounding shows a moist and buoyant overhead air-mass with a precipitable water value of 46.31 mm or 1.82 inches. When compared to the Storm Prediction Center's sounding climatology, the May 20th 12Z profile ranks above the 90th percentile for precipitable water based on a 91-day moving average for the period of record which dates back to 1948. This quantifies the atmosphere overhead as being abnormally saturated; moreover, any storms that form in this environment would have heavy rain potential because of the excess moisture.

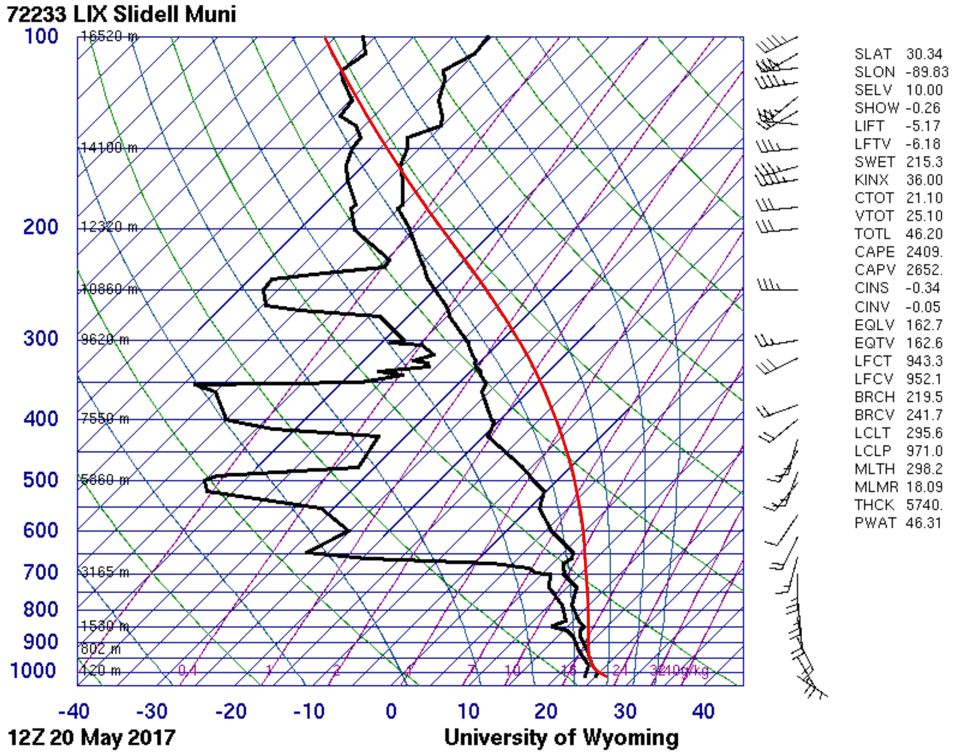

FIG. 4. WFO New Orleans/Baton Rouge Skew-T log-P diagram from the KLIX Slidell radiosonde for May 20th, 2017 at 12Z. Image taken from the University of Wyoming Atmospheric Sounding Archive.

By 18Z, the first storms initiated within the Mobile CWA (Fig. 5) solely due to diurnal heating and buoyancy owing to the lack of any notable inversion layer aloft. These storms were moving north at 20 knots. Meaning that as storms formed along the coast, they moved northward continuously across southern Alabama. This continual training of storms served to moisten the ground ahead of the main convective-line which by 18Z had reached the Louisiana/Mississippi boarder. The 850mb level is often used to access the low-level moisture transport which is calculated by multiplying the 850mb wind in m s^{-1} by the mixing ratio in g g^{-1} then using a scaling factor of 100 (Junker 1999). A relative maximum can be seen when examining the moisture transport vectors over southern and central Gulf Coast in Figure 9. This further justifies the exceptional potential for additional heavy rainfall development in the evening.

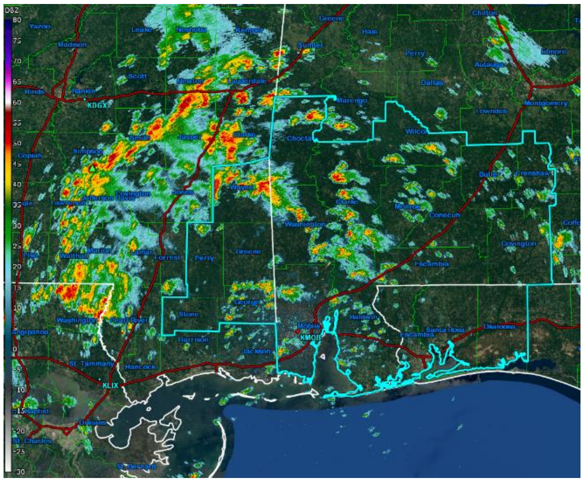

FIG. 5. KMOB Radar image for May 20th, 2017 at 18Z.

Radar estimates show nearly 2.5 inches had fallen by 22Z over areas south of Citronelle and near Mount Vernon. At 23Z the convective line had reached the Mississippi/Alabama border (Fig. 6). Low-level winds along the line were out of the northwest while winds ahead of the line were out of the south allowing for enhanced surface convergence. The surface convergence then redeveloped convection along the line generating storms with torrential rain rates of 2.75 in. h^{-1} over Saraland, Alabama (Fig. 10).

FIG. 6. KMOB Radar image for May 20th, 2017 at 23Z.

These high rain rates prompted WFO Mobile to issue four separate warnings covering most of Mobile and Baldwin Counties while also including parts southern Washington and Clark County. There were several reports of street flooding in the Saraland community (Fig. 7) with many roads blocked off by emergency officials. Even after the line moved eastward into the Florida Panhandle areas over Alabama were still under the trailing stratiform rain until after 06Z. By the end of the heavy rain event, radar estimations show areas near Saraland and Mount Vernon had seen nearly 5 to 7 inches of rainfall over the course of 15 hours (Fig. 11) with 6.44 inches measured at the University of South Alabama mesonet site in Saraland.

3. Conclusion

Intense rainfall events similar to the case in Saraland occurred throughout the year and in addition to the three tropical systems contributed to the 2017 record precipitation. A common predictive parameter used to examine the May 20th 2017 case in Saraland is moisture.

FIG. 7. Car partially submerged in a Hibbett Sport parking lot in Saraland, Alabama. Photo credited to News 5 WKRG.

Forecasters can access heavy rainfall potential by asking question about atmospheric moisture. How much moisture is currently in the atmosphere? How does the amount of moisture compare to climatology? Where is the moisture being transported? How much moisture has already reached the surface? By studying the answers to these questions, it becomes possible to forecast heavy rainfall events and prepare the public for flash flooding. Understanding what contributed to the 2017 record rainfall year and why it was unique is essential to improving forecast techniques and skill. Studies like these act directly towards accomplishing the National Weather Service mission which is "to provide weather… forecast and warnings for the protect protection of life and property and the enhancement of the national economy."

Acknowledgments. Thanks and acknowledgements are extended to the Weather Forecast Office in Mobile for providing the resources to conduct this project and to the NWS volunteers Caitlin Ford and Dillon Blount for inspiring me to compete this research.

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APPENDIX

Additional Figures

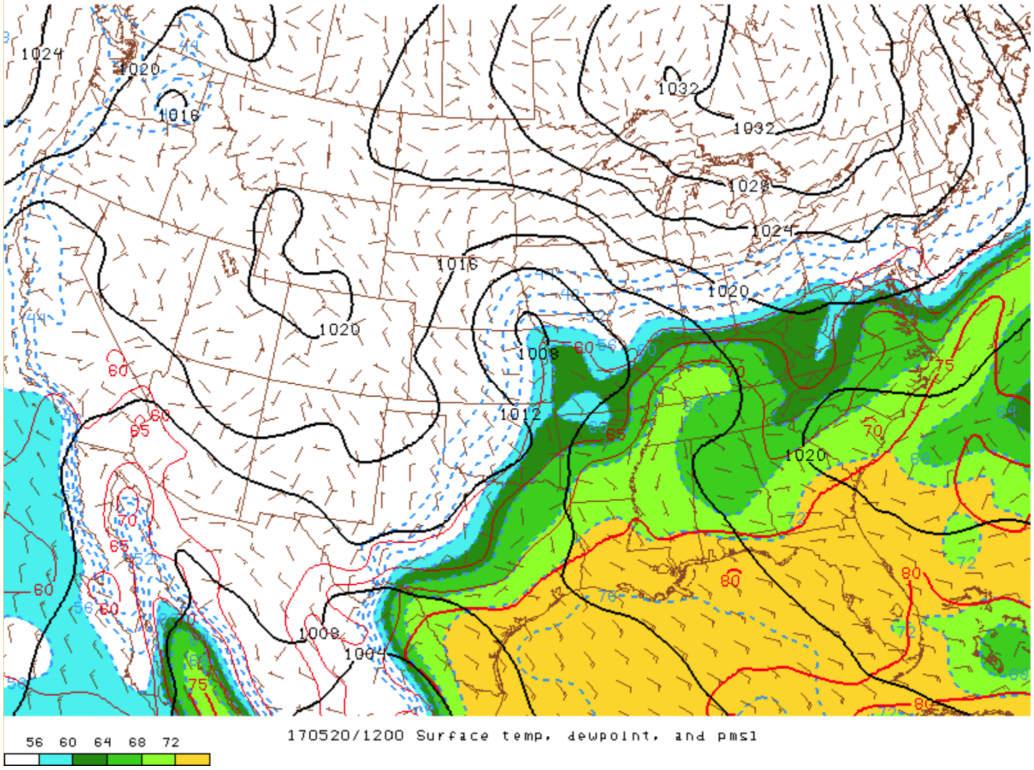

FIG. 8. Surface temperatures and dew points for May 20th, 2017 at 12Z. Image taken from the Storm Prediction Center (SPC) Mesoscale Analysis webpage.

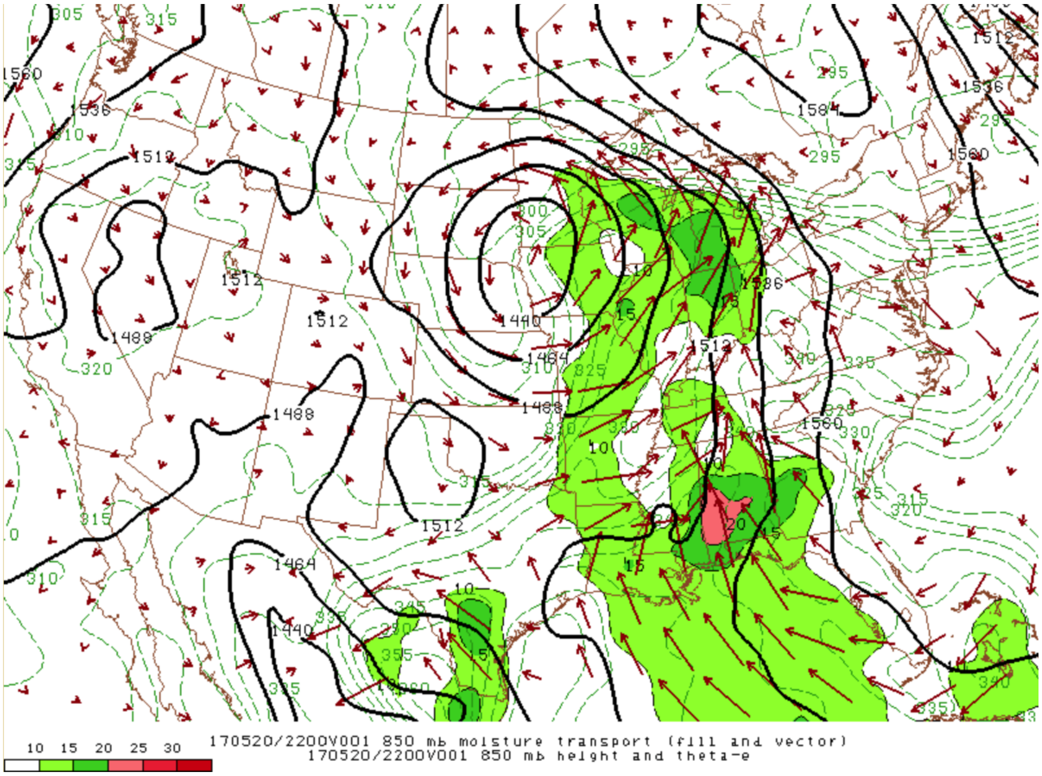

FIG. 9. The 850mb moisture transport chart for May 20th, 2017 at 22Z. The 850mb isohypses are shown in black, 850mb theta-e are contoured and dashed in green and the moisture transport are shaded. Image taken from the Storm Prediction Center (SPC) Mesoscale Analysis webpage.

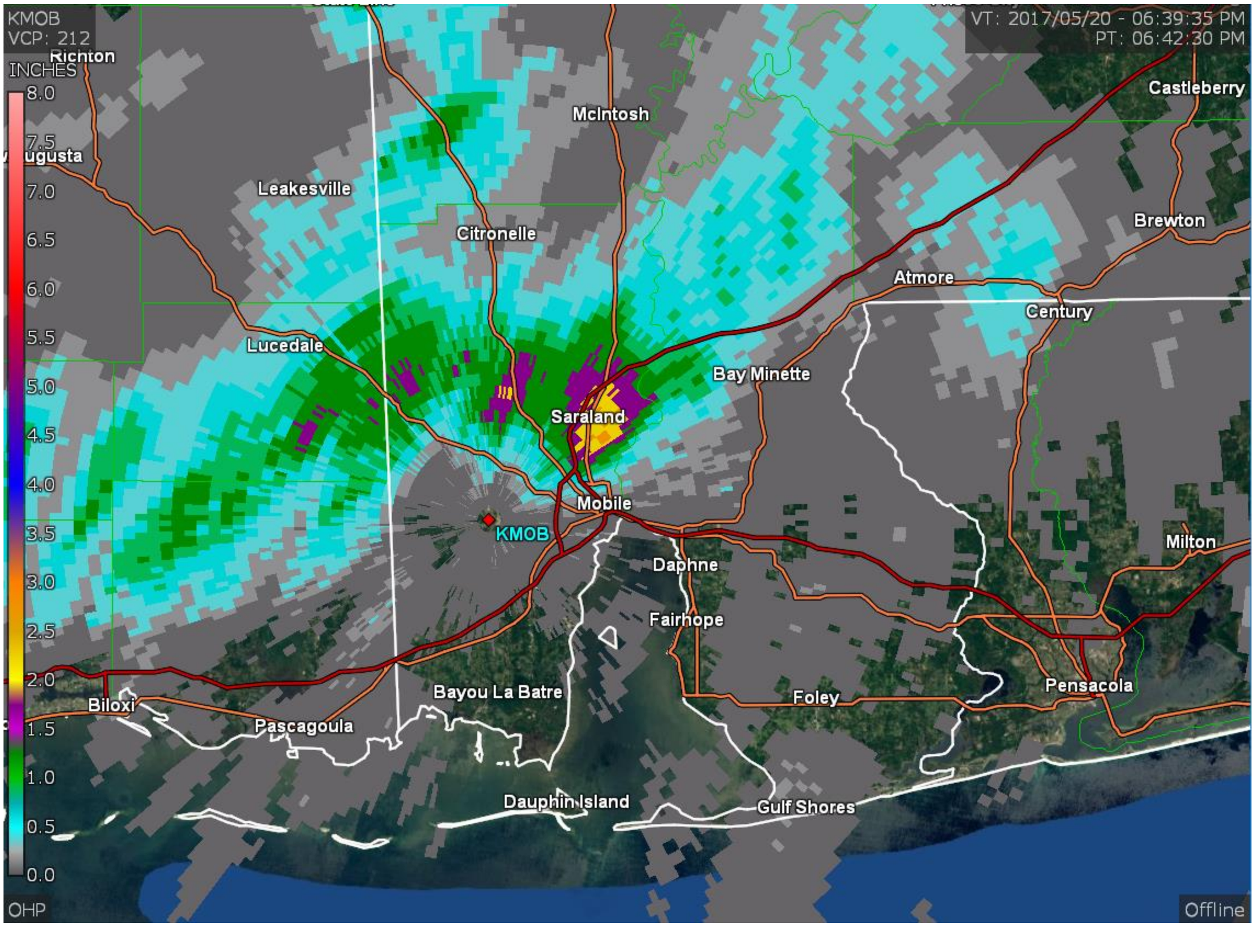

FIG. 10. KMOB One hour precipitation radar estimation for May 20th, 2017 at 0039Z.

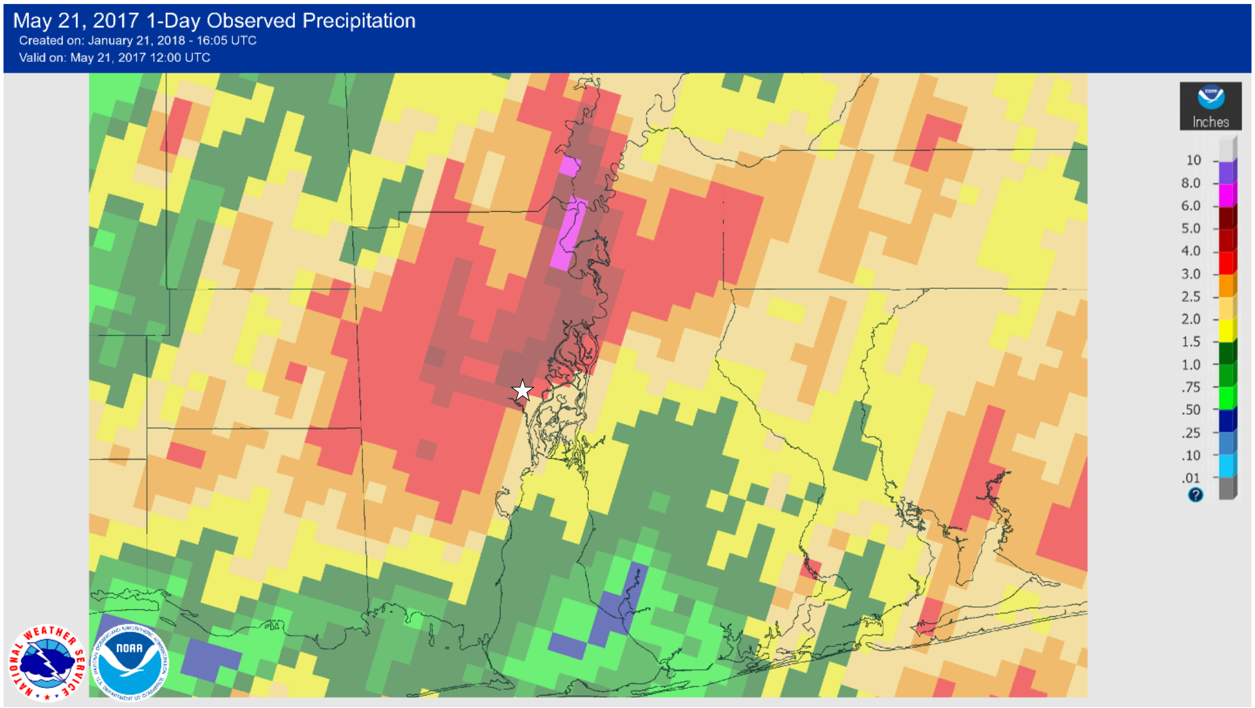

FIG. 11. Radar derived 24-hour rainfall totals for May 20th to May 21st, 2017. Image captured from the Advanced Hydrologic Prediction Service (AHPS) Precipitation Analysis webpage. Star denotes the location of Saraland, Alabama.