iCyclone Chase Report

storm	**Hurricane SALLY**		
location	**Gulf Shores, Alabama, USA**		
date	**15-16 September 2020**		
chasers	**Josh Morgerman**	**author**	**Josh Morgerman**

Overview

Hurricane SALLY struck the Alabama coast, on the E side of Mobile Bay, on the night of 15-16 September 2020.

The author was in **Gulf Shores, Alabama** (30.2492N 87.6841W)—at the landfall point—to document this event. Prior to landfall, the author deployed a data sensor at a fixed, secure location in his hotel (30.2638N 87.6908W), 1 n mi NNW of his chase location. **Highlights:**

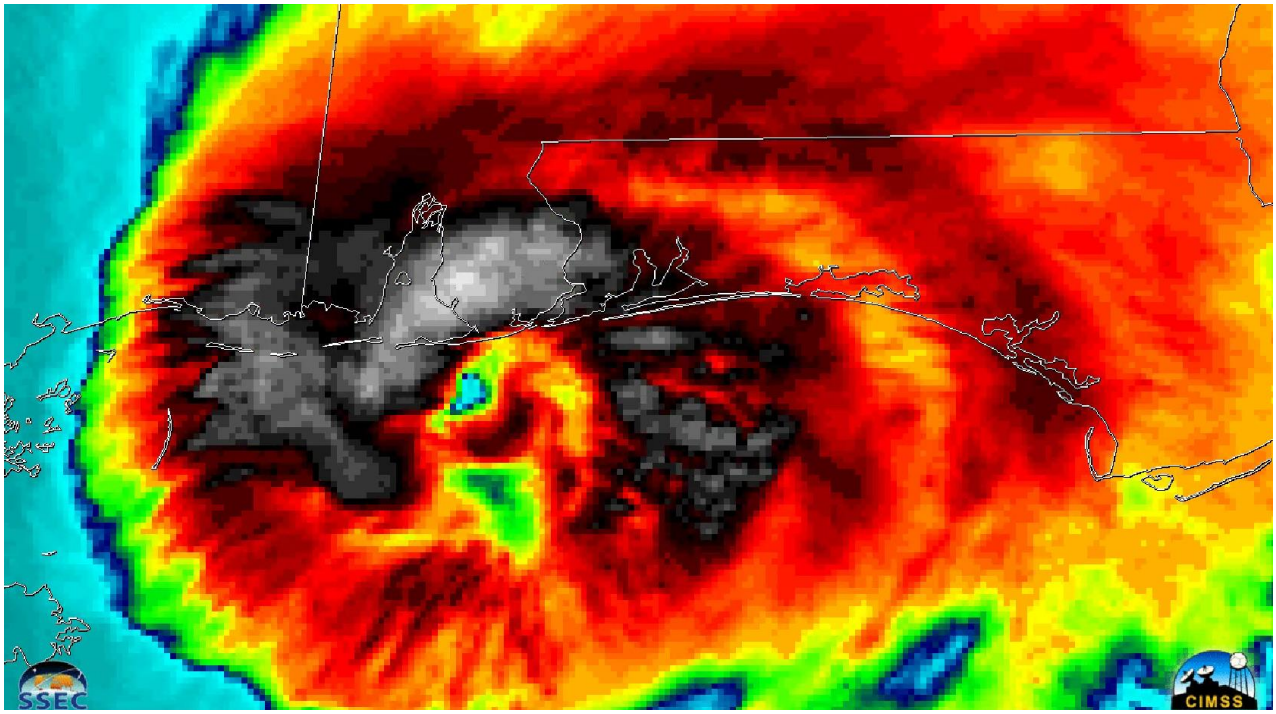
- **Eye Passage.** Almost the exact center of SALLY's slow-moving eye passed over the chase location, bringing a long, **almost 4-hour calm**—from ~3:20 to ~7:15 am CDT 16 September.

- **Minimum Pressure.** The lowest sea-level pressure recorded by the data sensor in Gulf Shores was **968.2 mb at 4:03, 4:22, and 4:34 am CDT (0903Z, 0922Z, and 0934Z) 16 September,** inside the calm eye.

- **Core Gradients.** Data show the cyclone's core had a surprisingly steep air-pressure gradient. Assuming the system's forward speed was 3 kt, pressure changes over time suggest the gradient was as high as **6.4 mb n/mi** in the N (front) eyewall, just outside the eye.

- **Pressure Fluctuations Along Eyewall/Eye Boundary.** Data show wild air-pressure fluctuations, especially during the period of transition from the eyewall into the calm eye.

- **Storm Structure.** The hurricane was **highly asymmetric** as it made landfall, with an intense, sharply-defined, destructive N (front) eyewall but basically no "backside": very little rain followed the eye, and winds after the calm were not destructive.



SALLY at 0621Z, just before landfall in Alabama. (GOES-16 image from CIMSS/SSEC/University of Wisconsin – Madison.)

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Locations

The author documented the passage of Hurricane SALLY's core from two locations in **Gulf Shores, Alabama,** 1 n mi apart.

Chase Location

The author observed the passage of the hurricane at **30.2492N 87.6841W**. This location is the N side of the road on E Beach Boulevard, a couple of blocks E of Gulf Shores Parkway (Highway 59).

High-resolution radar images, as well as the National Hurricane Center's hourly position updates, indicate this location was on the cyclone's track and went through almost **the exact center of the eye.**

Sensor Location

Before positioning at the Chase Location (and before the hurricane struck), the author deployed a data sensor in his hotel, at **30.2638N 87.6908W**. This location is the Quality Inn Ft. Morgan Road – Hwy 59, and it's 1 n mi NNW of the Chase Location.

Like the Chase Location, the Sensor Location went through the center of the hurricane's eye.

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Figure 1 shows the hurricane's track up to and after landfall in Alabama. **Figures 2** and **3** are zoomed-in views. The **Chase Location** (**red star**) and **Sensor Location** (**purple hotel symbol**) are so close to each other—and to the hurricane's track—that they're only clear and distinguishable in the closest view (**Figure 3**).

Figure 1: Chase Map

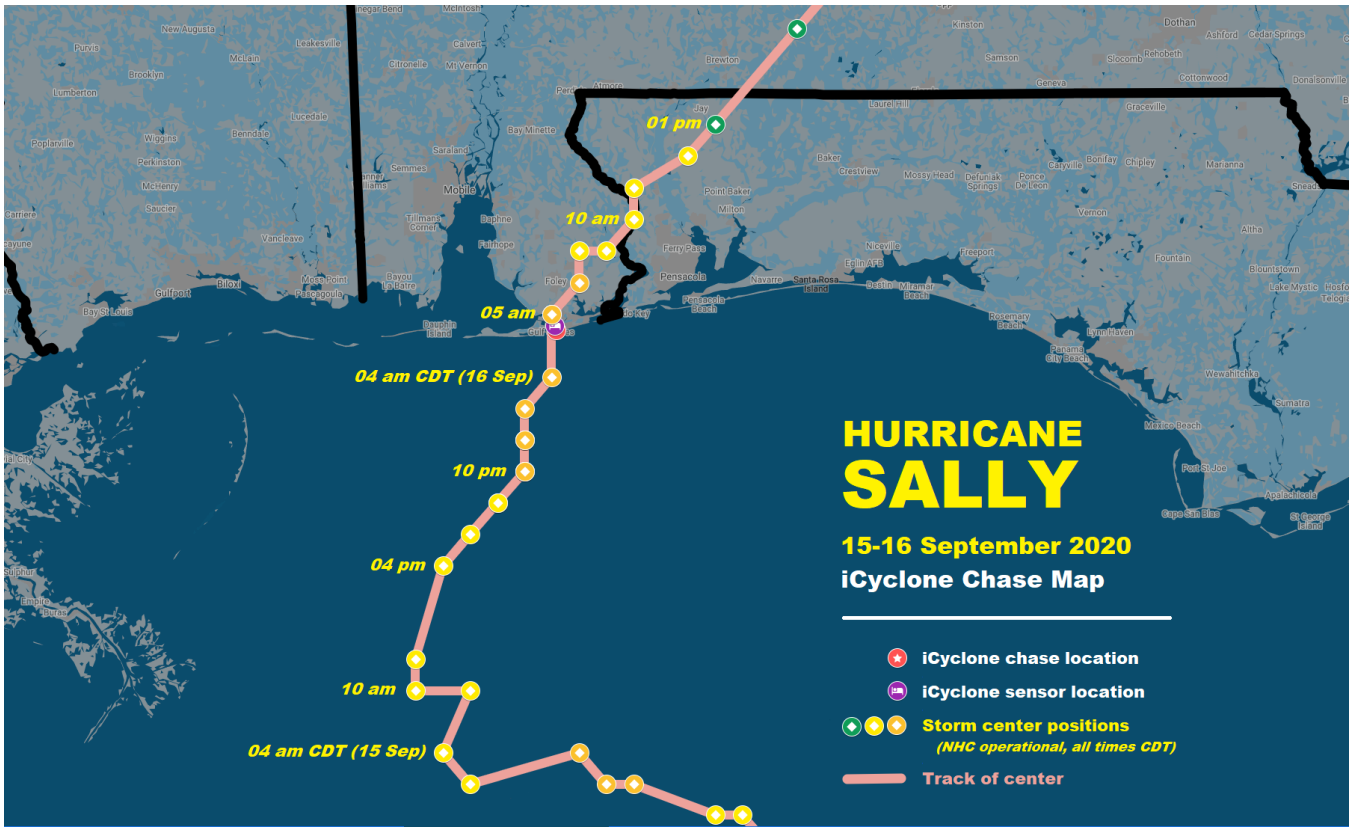

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Figure 2: Chase Map (CLOSE)

Figure 3: Chase Map (CLOSEST)

Observations & Chronology

The center of SALLY's calm eye passed directly over Gulf Shores. As the hurricane approached, the author made observations from various points in and around the center of town (i.e., within a mile of the intersection of Beach Boulevard and Gulf Shores Parkway). Once the core of the hurricane arrived and conditions became dangerous, the author parked his car on the N side of E Beach Boulevard and made the rest of his observations from that point (the **Chase Location**). During this entire time, the sensor was collecting data at the **Sensor Location**.

Following is a detailed chronology that combines A) the author's observations, made mostly from the Chase Location, with B) air-pressure data collected at the Sensor Location. ***Please note: The air-pressure data were collected 1 n mi NNW of where conditions were being observed.***

Color key:

- **Pink = eyewall**
- **Purple = transition from eyewall to eye**
- **Blue = eye**
- **Yellow highlight = minimum air pressure**

Please note that the start and end times of these phases were subjectively determined (without wind data) and should be considered approximate.

TIME (CDT)	MB	CONDITIONS
6:00 pm	**--**	**Windy; moderate rain. Storm-surge flooding in some places.**
6:10 pm	**--**	**Very windy; motion of flags suggests full gale at beachfront.**
6:40 pm	**--**	**Very windy; moderate-to-heavy rain. Power flickering.**
7:35 pm	**996.7**	**Windy; very heavy rain.**
7:40 pm	**996.6**	**Erratic, gusty winds; moderate rain. Power flickering.** (Moat.)
9:25 pm	**997.3**	**Breezy; moderate rain.**
	[Note: At 10 pm, the author made an excursion to Orange Beach. He returned to Gulf Shores and continued logging observations just before 12 midnight.]	
12 midnight	**990.6**	**Very strong winds; moaning sound; heavy rain. Hotel plunges into darkness.**
12:05 am	**989.8**	**Wind and rain increase dramatically.** (Eyewall.)
12:10 am	**989.8**	**Powerful winds; torrential rain. Car shaking.**
1:05 am	**986.7**	**Powerful winds; torrential rain.**
1:15 am	**985.5**	**Powerful winds; extremely heavy rain—near whiteout. Car rocking and jumping.**
2:00 am	**982.9**	**Feels like the strongest winds of the night. (Can't see because power is out.) Big gusts.**
2:15 am	**980.4**	**Powerful winds. Pulled car off road and into driveway for safety.**
2:25 am	**977.4**	**Winds still very gusty and turbulent; rain maybe not as heavy.**

2:40 am	**974.1**	**Wind still ripping; moderate-to-heavy rain.**
2:45 am	**972.0**	**Wind still howling, but not as severe; rain has slacked off to drizzle.** (Transition.)
3:15 am	**972.3**	**Slowly calming down.**
3:20 am	**971.0**	**Relatively calm; rain has stopped.** (Eye.)
3:50 am	**969.1**	**Almost dead calm. Can hear the ocean pounding the beach a block away. Little or no rain.**
4:03 am	**968.2**	**Calm.** ***(This minimum pressure also occurred at 4:22 and 4:34 am.)***
5:00 am	**969.4**	**Calm.**
7:00 am	**975.8**	**Wind rustling; grey sky.**
7:15 am	**977.6**	**Wind picking up again; little or no rain.**
7:25 am	**978.8**	**Windy; little or no rain.**
7:50 am	**981.3**	**Windy; little or no rain.**

Most of the moments described in this chronology are captured in the author's video of the event: https://youtu.be/9tOK3_YEIlg.

Key points:

- **The eye passed over this location.** Because the cyclone moved so slowly—about 3 kt—the eye lasted **almost 4 hours** (~3:20 to 7:15 am CDT).
- **The hurricane was highly asymmetric as it made landfall.**
  - The N (front) eyewall was intense and sharply-defined, with destructive winds.
  - The hurricane had almost no "backside." Very little rain followed the eye, and winds after the calm were not destructive.

  The radar images in **Figures 8** and **9** (below) best capture this asymmetry.

See **Air Pressure Data** (below) Re: instrument calibration and data collection.

See **Figures 10** and **11** (below) for a visualization of this storm chronology, showing air-pressure data and storm phases.

Figure 4: Radar Image—Gulf Shores Just Outside Eyewall

Radar image from Mobile at 11:56 pm CDT, just minutes before the eyewall reached Gulf Shores. The blue marker indicates the author's position. (Image: RadarScope)

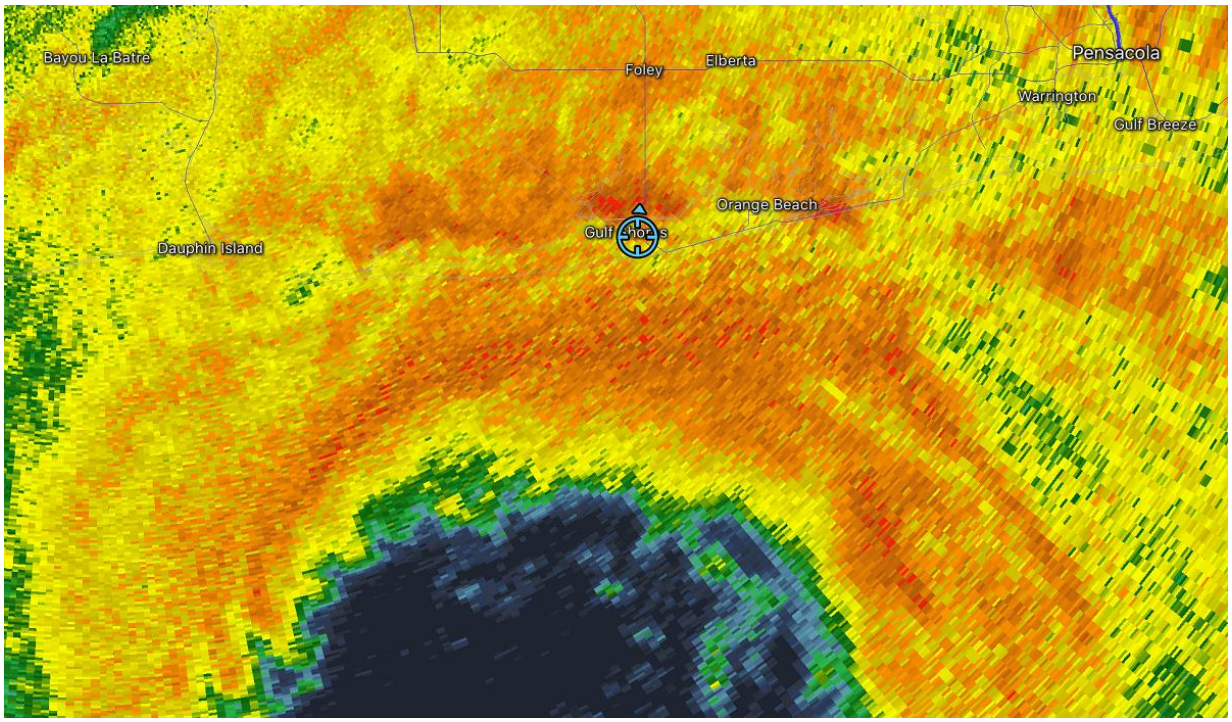


Figure 5: Radar Image—Gulf Shores Just After Entering Eyewall

Radar image from Mobile at 12:14 am CDT, just after the eyewall had reached Gulf Shores with powerful winds. (Image: RadarScope)

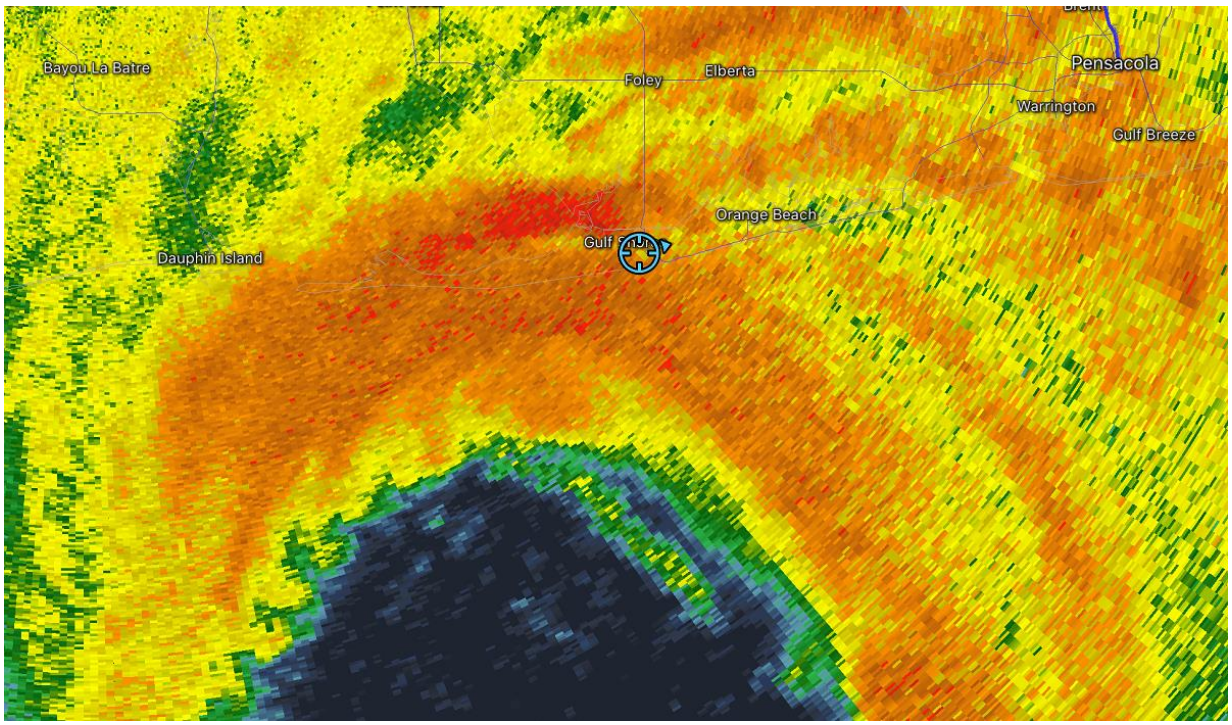


Figure 6: Radar Image—Gulf Shores Just After Entering Eyewall (Far)

A wider view of the Mobile radar image from 12:14 am CDT, just after the eyewall had reached Gulf Shores. (Image: RadarScope)

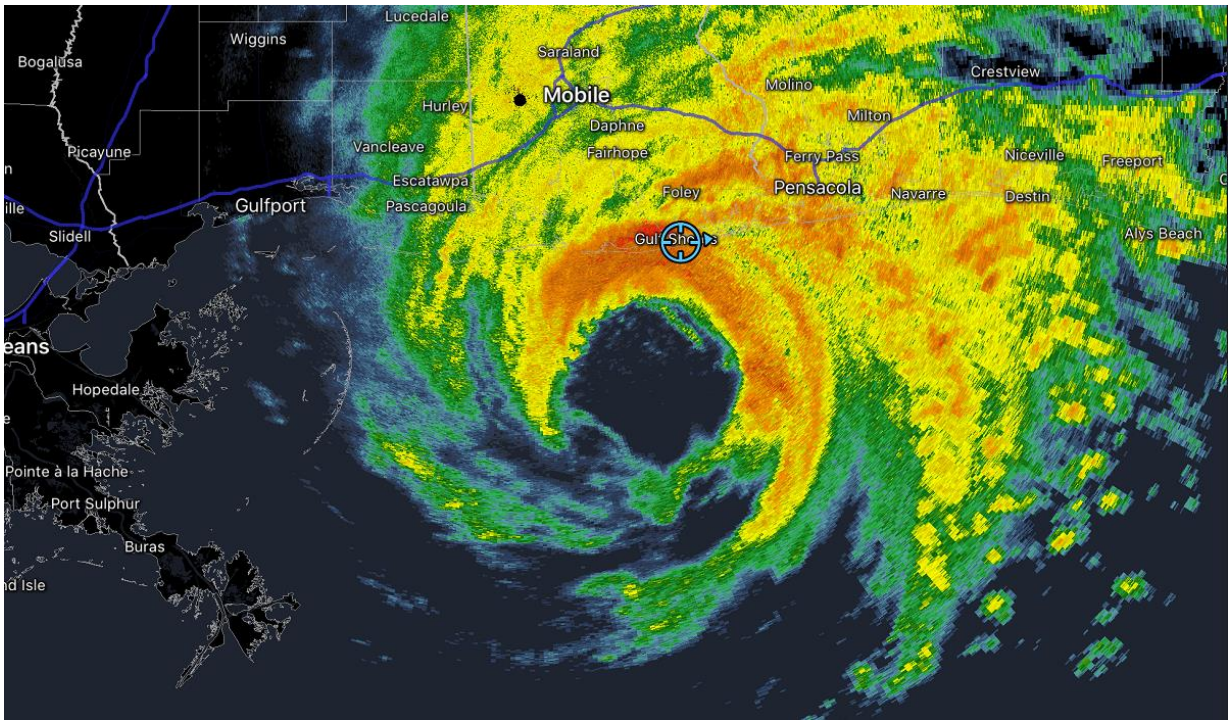


Figure 7: Radar Image—Gulf Shores in Inner Eyewall

Radar image from Mobile at 1:58 am CDT, as the inner eyewall passed over Gulf Shores. The hurricane's fiercest winds were raking the town at this time. (Image: RadarScope)

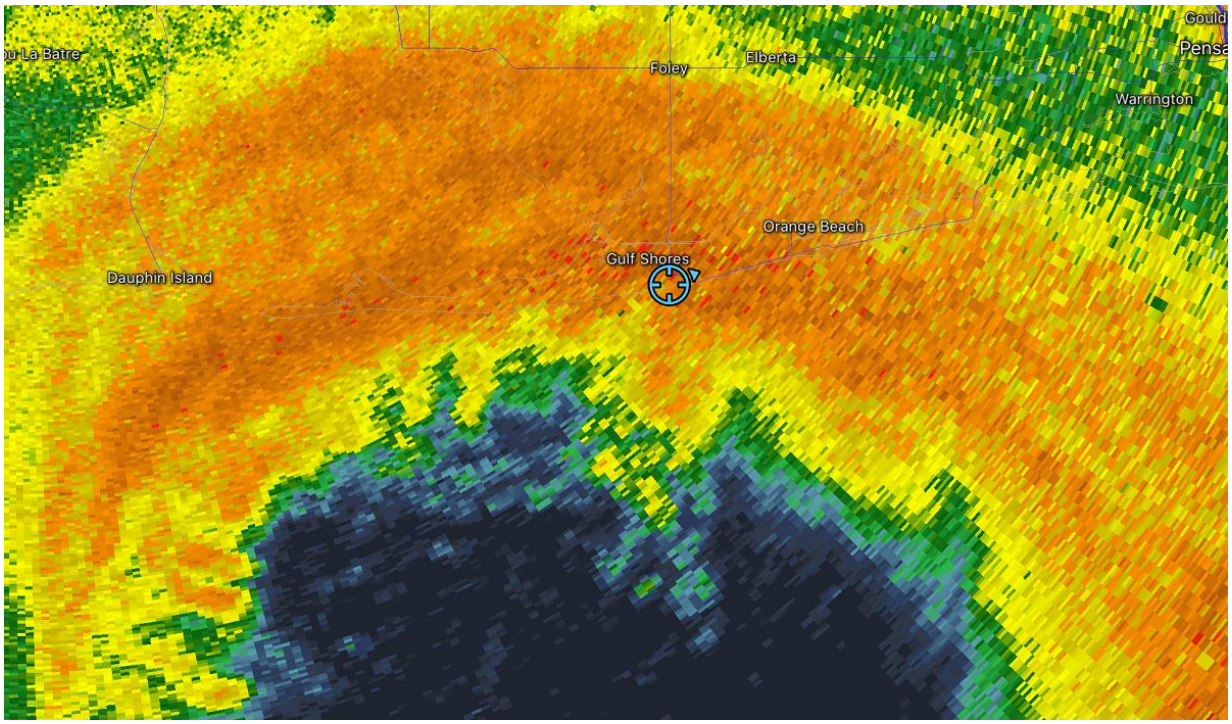


Figure 8: Radar Image—Gulf Shores in Eye

Radar image from Mobile at 4:12 am CDT, as the eye passed over Gulf Shores. At about this time, the author's data sensor was recording its minimum pressure. (Image: RadarScope)

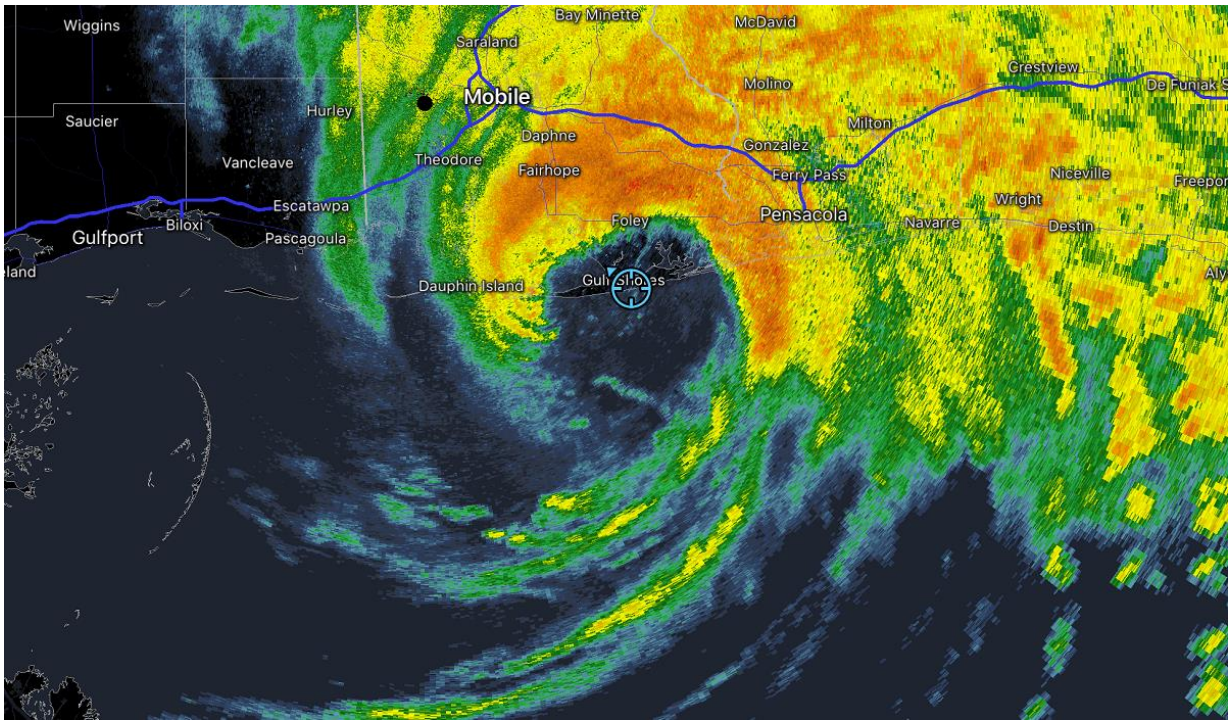
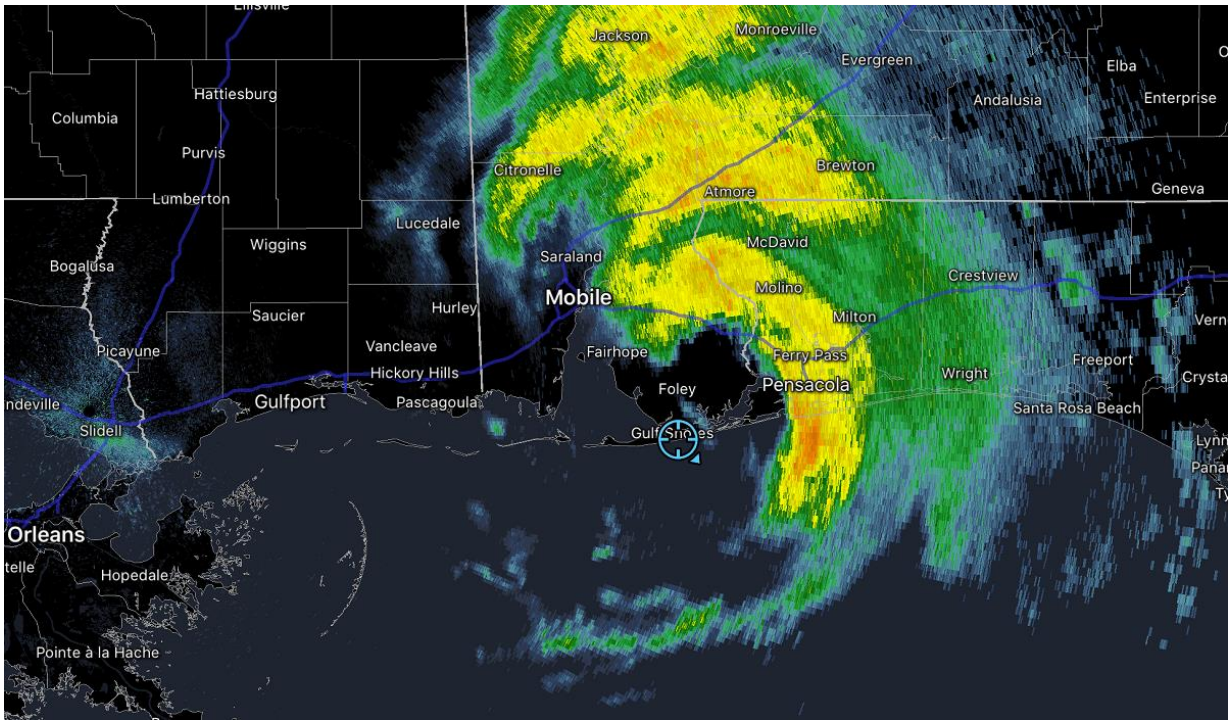


Figure 9: Radar Image—Gulf Shores in Backside

Radar image from New Orleans at 6:59 am CDT, showing the hurricane pulling away from Gulf Shores. Despite the radar site being W of the storm's center, the radar signature shows almost no convection in the SW quadrant. (Image: RadarScope)



Air Pressure Data

The author collected quality-controlled air-pressure data at one location in Gulf Shores—the Sensor Location, at 30.2638N 87.6908W—using a Kestrel 4500.

The device was deployed in a second-story hotel room, on a countertop in a secure place away from the windows. It was left undisturbed during the passage of the hurricane.

The sampling rate for the device was one reading per minute (1/min).

Calibration

To prepare the device to record sea-level pressure, the author estimated the elevation at this location to be 20 ft—therefore, the reference altitude was 35 ft, which is the estimated elevation plus additional height to account for the device being on a countertop on the second floor.

After the hurricane, the author discussed the Sensor Location with geographer James Hyde, who estimated the actual elevation may be closer to 24 ft.

This 4-ft discrepancy would have had a negligible impact on the pressure readings—maybe 0.1 or 0.2 mb, which is well within the accuracy range of the instrument (+/- 1.5 mb). Therefore, the data are considered representative sea-level pressure readings for this event.

Minimum

The lowest recorded pressure at the Sensor Location in Gulf Shores was **968.2 mb.**

This reading occurred three times—at **4:03, 4:22, and 4:34 am CDT,** all near the center of the slow-moving eye.

The complete data are graphed in **Figure 10**, below.

Core Gradient

The data show extremely steep air-pressure gradients in SALLY's inner core—great pressure differences over small distances that are much greater than what the author has observed in past Category-2 hurricanes.

Methodology

The cyclone's forward speed was used to calculate how much time it took for each nautical mile of the cyclone to pass a sensor's fixed location. Gradients were then calculated by noting the change in pressure across these 1-n-mi samples of the cyclone:

1. As per NHC advisories, SALLY was moving at **3 kt** at the time of landfall in Alabama.
2. This forward speed suggests the sensor's fixed location sampled **1 n mi** of the cyclone every **20 minutes.**
3. Pressure changes over 20-minute periods were therefore assumed to **approximately** represent pressure differences across 1-n-mi samples of the cyclone.

Results

Applying this methodology:

Front Side

The data show a very steep pressure gradient in the **inner edge of the N (front) eyewall,** just outside the eye.

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The peak value was **6.4 mb/n mi**. This was derived from a **6.4-mb drop** over 20 minutes, from 981.0 mb at 2:14 am to 974.6 mb 2:34 am CDT.

Figure 12 (below) shows the inner eyewall passing over Gulf Shores at the time this peak gradient was sampled.

Backside

Gradients measured on the **backside** of the hurricane—in the SW quadrant, after the eye passed—were much, much gentler. Not surprisingly, winds in this quad were significantly weaker and nowhere near hurricane force.

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Figure 11 (below) is a zoomed-in view of the pressure data collected in the cyclone's inner core, with the passage of the peak gradient indicated in **dark red**. The contrast between the very sharp gradient on the front side of the hurricane and the soft gradient on the backside is dramatically evident. This was a highly asymmetric cyclone.

Historical Comparison

The gradient measured in SALLY was extremely steep for a hurricane with an estimated intensity of 90 knots—putting it ahead of some very severe landfalling hurricanes.

Following is a list of selected intense cyclones in which the author collected core data, **ranked by calculated peak gradient.** SALLY ranks relatively high on the list, above Category-4 HARVEY and LAURA and Category-3 IRMA and ODILE:

CYCLONE	DATE	LOCATION	WIND	PEAK GRADIENT
DORIAN	01Sep 2019	Marsh Harbour, Bahamas	160 kt	**12.4 mb/n mi**
PATRICIA	23Oct 2015	Emiliano Zapata, JAL, Mexico	130 kt	**10.5 mb/n mi**
MICHAEL	10Oct 2018	Callaway, FL, USA	140 kt	**8.1 mb/n mi**
MARIA	20Sep 2017	Palmas Del Mar, PR, USA	135 kt	**7.1 mb/n mi**
SALLY	15-16Sep 2020	Gulf Shores, AL, USA	90 kt	**6.4 mb/n mi**
HARVEY	25-26Aug 2017	Rockport, TX, USA	115 kt	**6.3 mb/n mi**
IRMA	10Sep 2017	Naples, FL, USA	100 kt	**5.9 mb/n mi**
ODILE	14-15Sep 2014	Cabo San Lucas, BCS, Mexico	110 kt	**4.6 mb/n mi**
LAURA	26-27Aug 2020	Sulphur, LA, USA	130 kt	**4.4 mb/n mi**

This is puzzling, and the author doesn't have an explanation for it. That said, SALLY suddenly strengthened a few hours before landfall, and the author has generally observed that strengthening cyclones have tighter gradients, whereas weakening cyclones have looser, more spread-out gradients.

Limitations

These calculations are coarse, with limitations to their accuracy. For example:

- Small, localized features within a hurricane's core—like mesovortices—can cause **short-term pressure fluctuations** that aren't representative of the system's overall pressure field.

- These calculations do not factor in **changes in the system's intensity.** That said, SALLY's intensity was apparently steady near the time of landfall (when the peak gradient was measured), and the 20-minute sample periods were short enough to limit the impact any intensity changes might have had on pressure trends at the Sensor Location.

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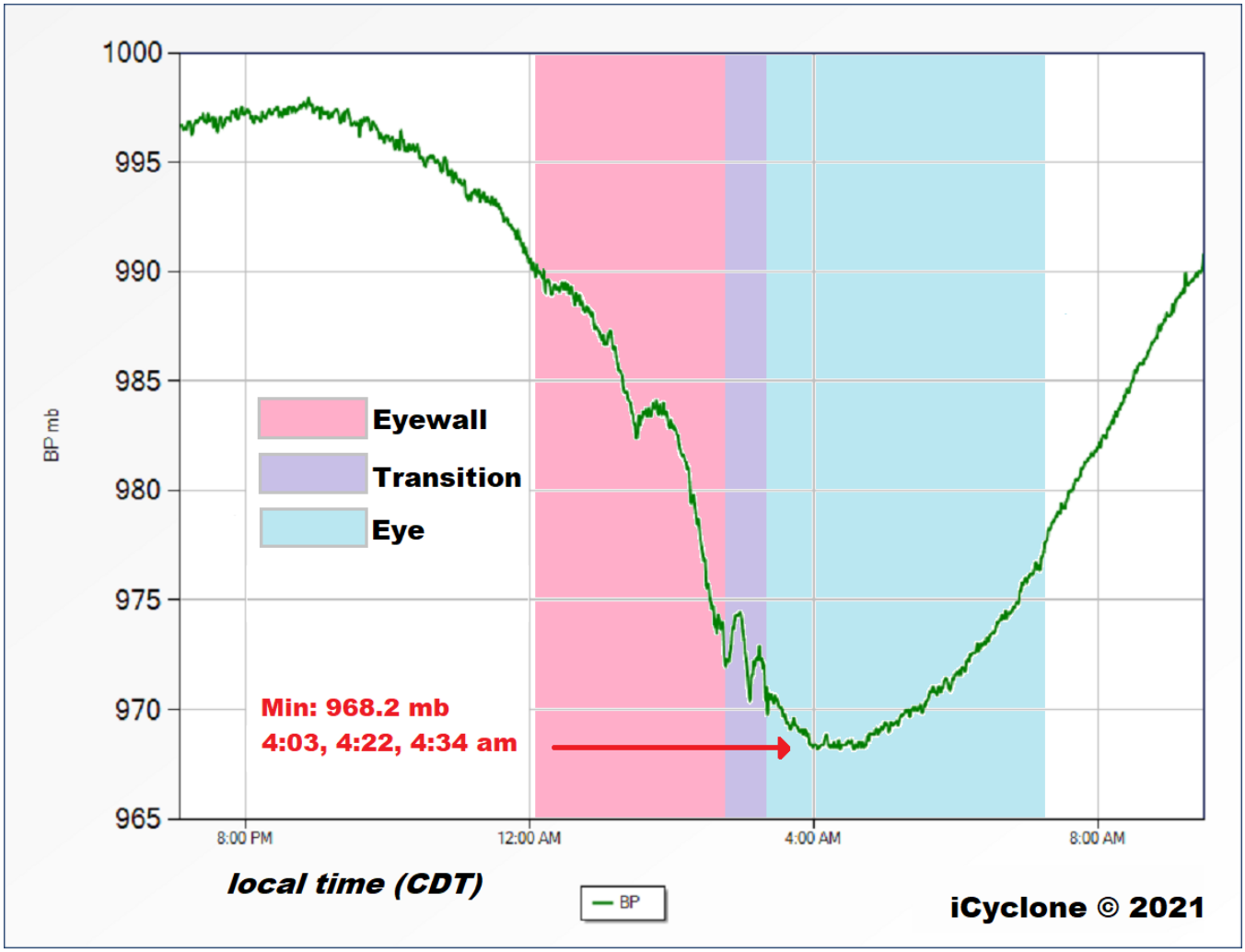
Figure 10: Barogram

Air-pressure data reveal the minimum value of 968.2 mb occurred at 4:03 am, 4:22 am, and 4:34 am CDT, as the eye passed over Gulf Shores. Color key:

- ***The approximate period of eyewall conditions is indicated in pink. (The backside of the hurricane was not well-defined, and there was no eyewall on the S (trailing) side of the eye.)***
- ***The transition period between the eyewall and eye is indicated in purple.***
- ***The calm of the eye is indicated in blue.***



HURRICANE SALLY: 15-16 Sep 2020

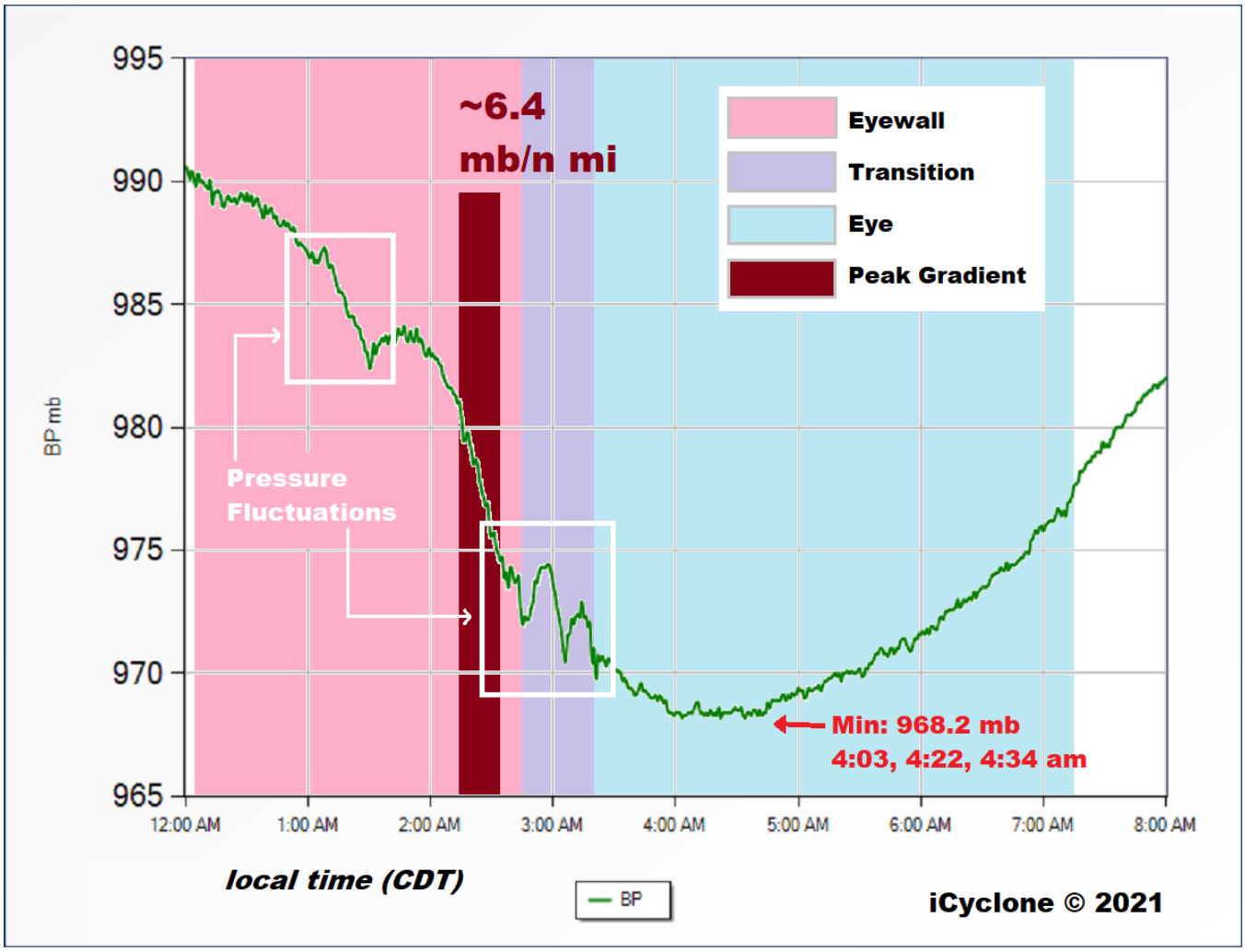
Gulf Shores, Alabama, USA

30.2638N 87.6908W – ref el 20 ft

Figure 11: Barogram (CLOSE VIEW)

A closer view, zooming in on the hours during which the core of the hurricane passed over Gulf Shores. Color key:

- ***The approximate period of eyewall conditions is indicated in pink.***
- ***The transition period between the eyewall and eye is indicated in purple.***
- ***The calm of the eye is indicated in blue.***
- ***The peak gradient is indicated in dark red.***
- ***Phases during which pronounced air-pressure fluctuations occurred are boxed in white.***



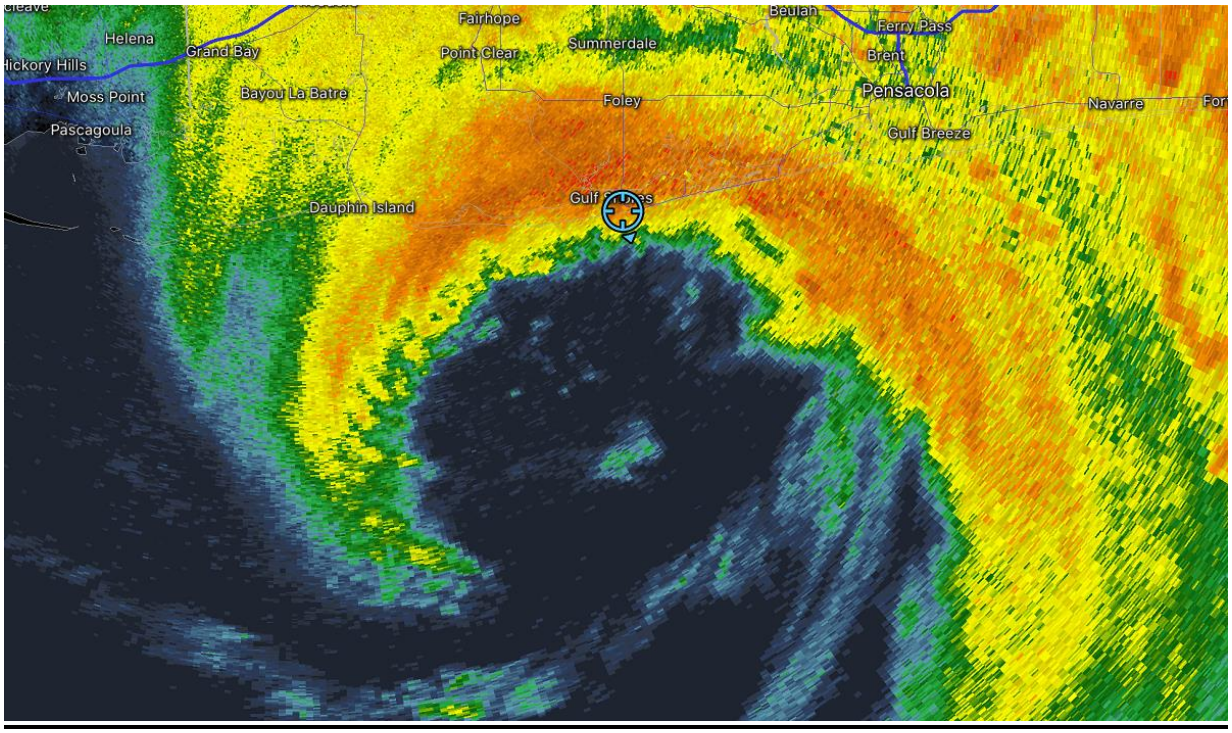
HURRICANE SALLY: 15-16 Sep 2020

Gulf Shores, Alabama, USA

30.2638N 87.6908W – ref el 20 ft ***(CLOSE VIEW)***

Figure 12: Radar Image—Gulf Shores in Peak Gradient

Radar image from Mobile at 2:21 am CDT, as the inner eyewall was passing over Gulf Shores. It was during this time (from 2:14 to 2:34 am) that the peak gradient of 6.4 mb/n mi was sampled—and very high winds were hammering the town.



Pressure Fluctuations

There were some notable pressure fluctuations on the cyclone's front side:

- **N (Front) Eyewall.** Between ~1:00 and 1:45 am CDT, there was small, sharp pressure spike, followed by a rapid dip, and then a partial recovery.
- **Transition from Eyewall to Eye.** Between ~2:35 and 3:20 am CDT, there was a series of 4 distinct, sharp pressure dips.

These pressure fluctuations are especially visible in **Figure 11** (above).

The sharp pressure dips were likely caused by **mesovortices or other localized disturbances** embedded in the deep convection—and along the inner edge—of SALLY's vigorous front eyewall.

Figures 13 and **14** (below) show Gulf Shores in the transition zone between the eyewall and eye, when these fluctuations were occurring. The author has noticed in previous hurricanes that **this eyewall/eye boundary area is often volatile,** with wild pressure fluctuations and sporadic—sometimes violent—gusts.

Figure 13: Radar Image—Gulf Shores in Transition Zone (A)

Radar image from Mobile at 3:07 am CDT, showing Gulf Shores in the volatile transition zone between the eyewall and eye. The air-pressure data show wild fluctuations during this time. (Image: RadarScope)

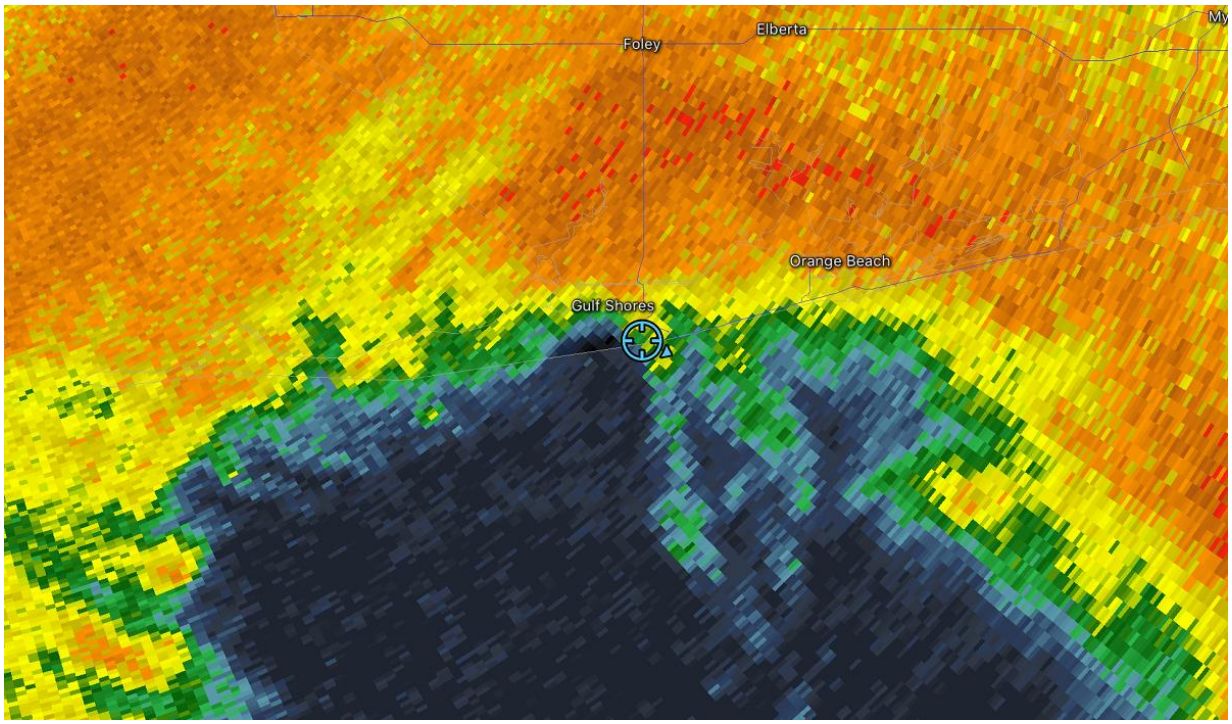
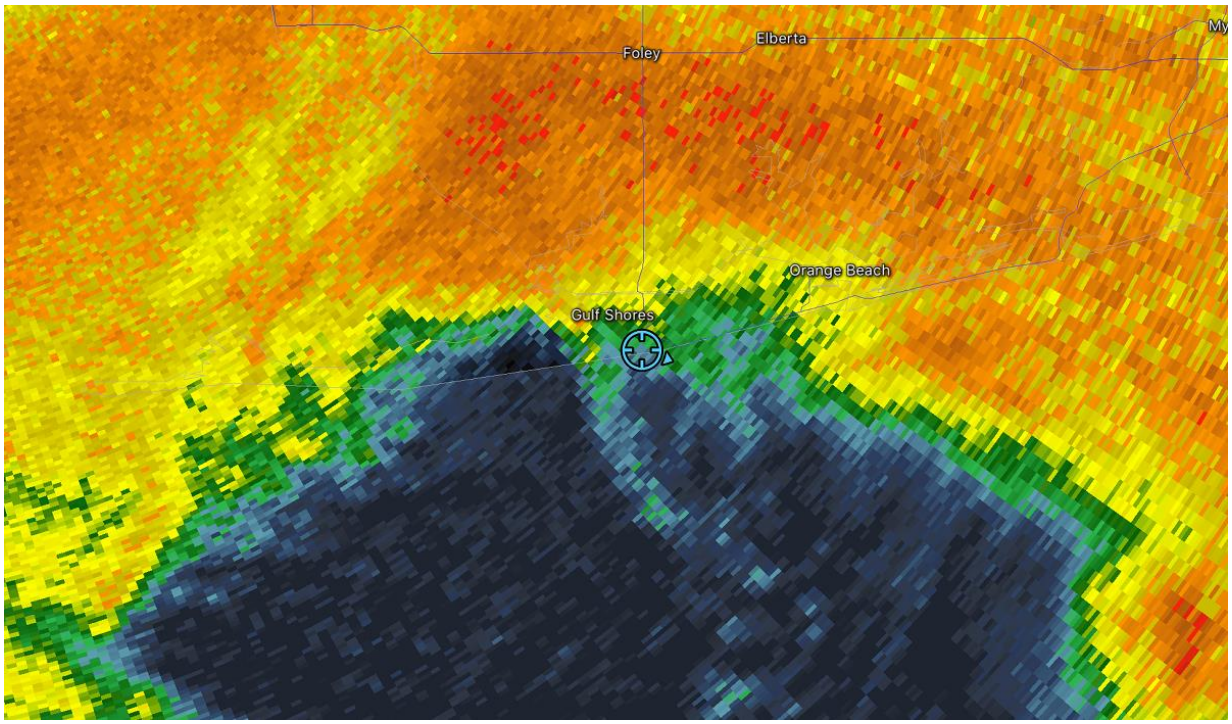


Figure 14: Radar Image—Gulf Shores in Transition Zone (B)

Radar image from Mobile at 3:11 am CDT, also showing Gulf Shores in the volatile transition zone between the eyewall and eye. (Image: RadarScope)



Images

Hurricane SALLY inflicted broad impacts on Gulf Shores and nearby Alabama communities.

Large oceanfront high-rises generally performed well, but smaller, older buildings had roof and façade damage. Serious wind impacts extended well beyond the coast. The town of Foley, 10 n mi inland, saw extensive damage to roofs, signs, trees, and power lines.

Gulf Shores saw widespread, disruptive flooding that seemed to be a combination of rainwater and storm surge. After the hurricane passed, major sections of Beach Boulevard and Gulf Shores Parkway (Highway 59) were underwater, cutting off beachfront neighborhoods from inland ones.

Swaths of Beach Boulevard in Gulf Shores were underwater during Hurricane SALLY.

E Beach Boulevard in Gulf Shores. The author rode out the hurricane's core parked here.

E Beach Boulevard in Gulf Shores. The author pulled his car into the narrow drive between these two buildings for safety at the height of the storm.

Roof damage in Gulf Shores.

Roof damage in Gulf Shores.

Roof and siding damage in Gulf Shores. Some older buildings performed poorly.

Wind damage in Gulf Shores.

Flooding and wind damage in Gulf Shores.

Major flooding in Gulf Shores.

Questions or Feedback?

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