Tropical Storm Chantal

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a. Synoptic History

A strong tropical wave had developed within the Intertropical Convergence Zone (ITCZ) by Sunday, July 7, 2013. As shown in the water vapor image (Fig. 1) the wave, near 9^{o}N and 43^{o}W at this time, was moving quickly towards the west-northwest and was expected to continue this motion for several days.

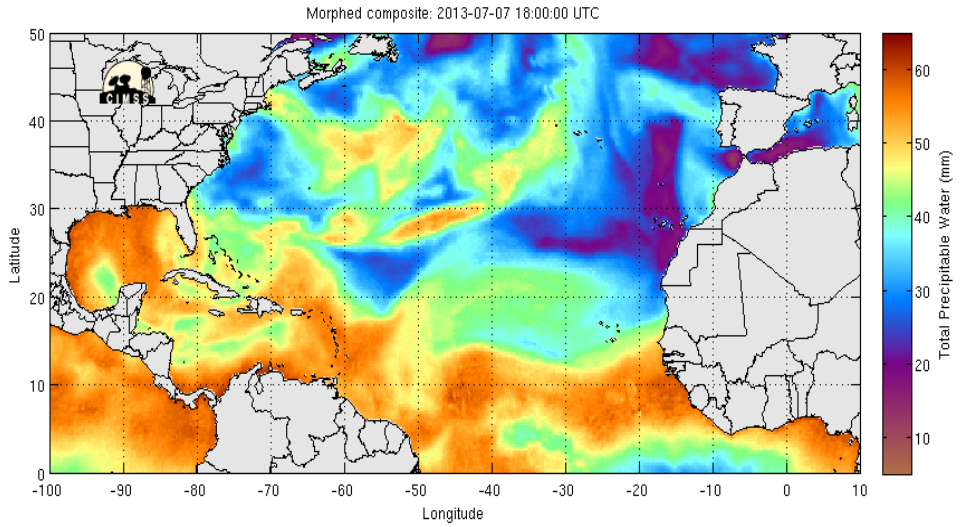

Fig. 1. Total precipitable water as shown on MIMIC/TPW product water vapor image showing a tropical wave for July 7, 2013 at 1800 UTC.

The wave had become stronger through the day with more organized convection. The first advisory for this system from the National Hurricane Center (NHC) in Miami was issued at 1100 pm AST on Sunday night, the 7^{th,} and immediately included tropical storm warnings for parts of the Lesser Antilles. Based largely on the convection and the latest satellite images the storm was upgraded at that time and named Chantal. Positioned at 9.8^{o}N and 47.2^{o}W it had maximum sustained winds of 40 mph and was moving west-northwest at 26 mph.

The advanced scatterometer (ASCAT) showed a small and tight circulation (Fig. 2). This image was very shortly before the first advisory was issued and shows Chantal near 42^{o}W. It was still nestled within the ITCZ in this image as evidenced by the convergent winds extending towards the southwest. Chantal was in an environment conducive to further development except that it was less than 10^{o} of latitude from the equator and that its forward speed was so high.

The initial tropical storm watch for Puerto Rico, including Vieques and Culebra, was issued at 1100 am AST on Monday (Fig. 3). By 500 pm the watch for mainland Puerto Rico was upgraded to a tropical storm warning. The tropical storm watch remained for

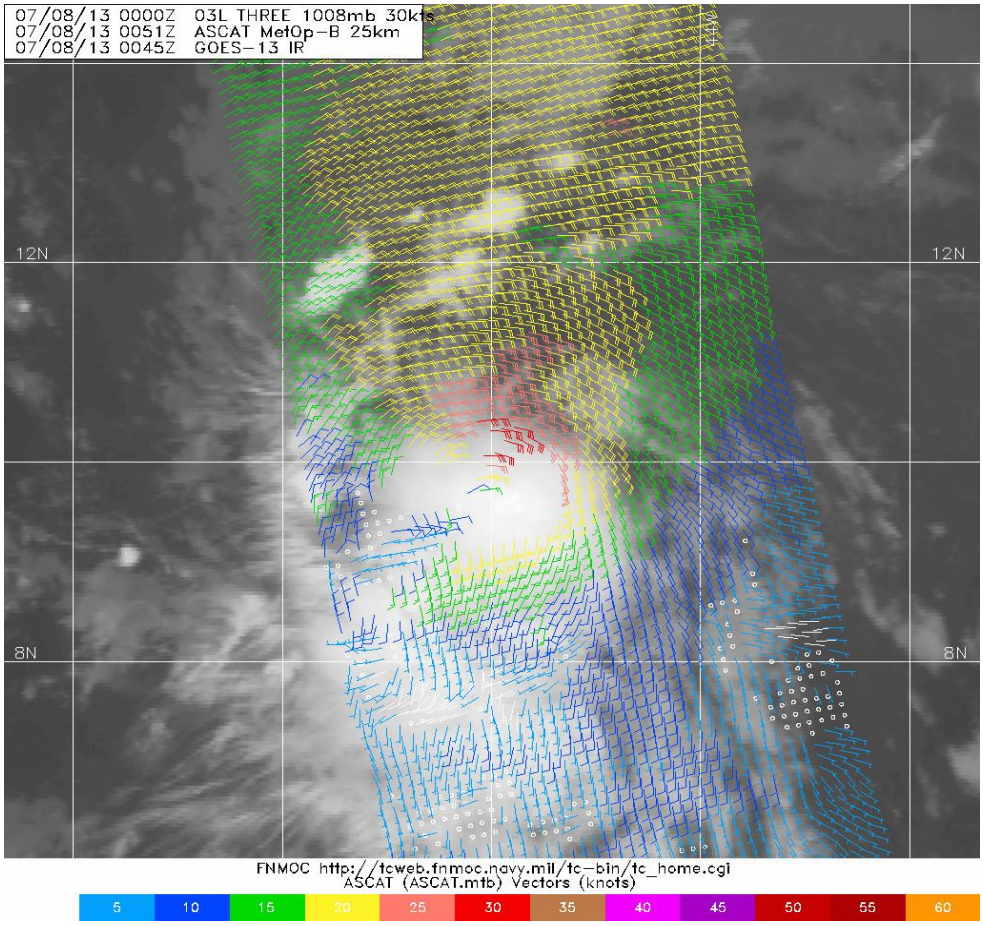

Fig. 2. Advanced scatterometer (ASCAT) descending pass overlaid with an infra-red satellite image, between 0000 and 0100 UTC on July 7, 2013.

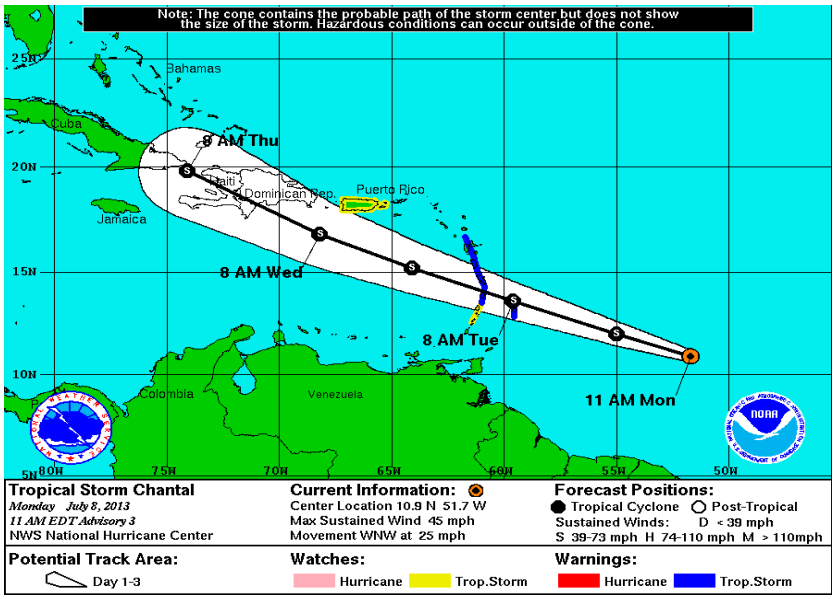

Fig. 3. Forecast track for Tropical Storm Chantal, from NHC, with initial watches and warnings.

Vieques and Culebra but was extended to the U.S. Virgin Islands. It was expected to make its closest pass to the U.S. Virgin Islands and Puerto Rico on Tuesday night.

As Chantal moved towards the Lesser Antilles it was moving towards a less favorable environment than was the ITCZ, including a large Saharan air layer with dust. It would also have to deal with its own 26 mph forward speed, exceptional for a storm to retain a closed circulation. As Chantal moved very quickly towards the west-northwest the steering currents were largely controlled by a strong high pressure ridge over the western Atlantic Ocean (Fig. 4) with a tight pressure gradient between Chantal and the ridge.

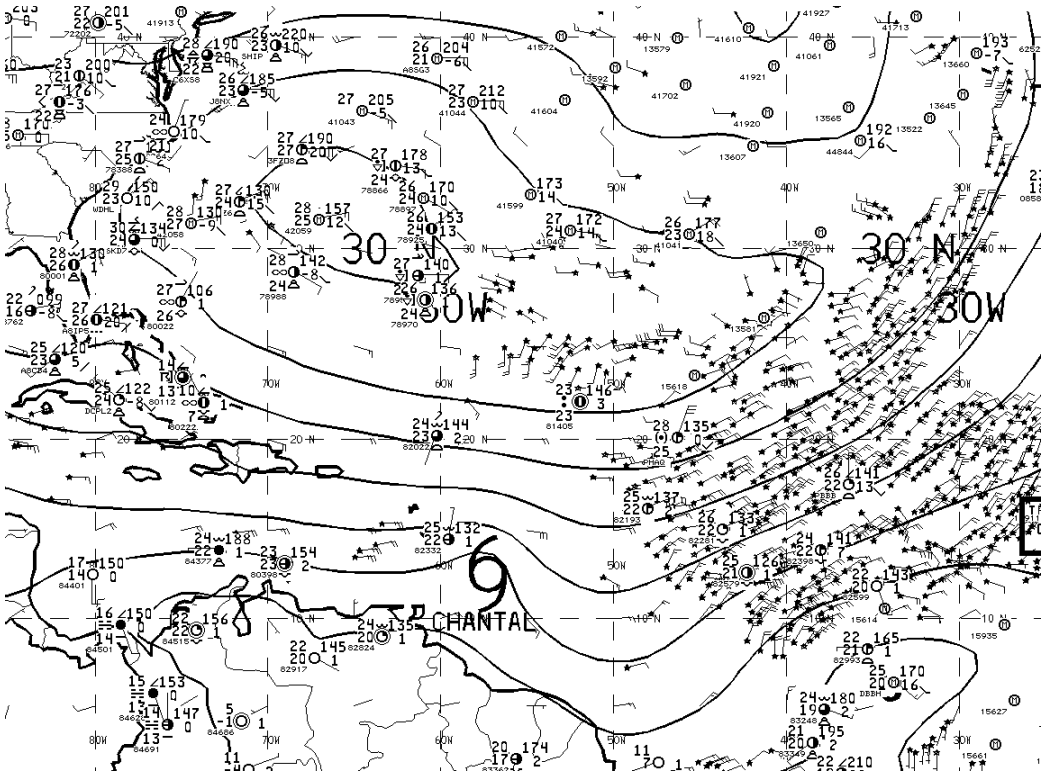

Fig. 4. Surface analysis from NCDC of the western Atlantic on July 9, 2013 at 0600 UTC (200 am AST). Chantal would be forced to continue moving quickly towards the west-northwest.

Little had changed by the time it reached the Lesser Antilles on Tuesday morning except that it became slightly stronger (50 mph). Deep tropical moisture from South America was still feeding into the storm from the south. The upper air sounding from Barbados (Fig. 5) soon after Chantal passed by showed south winds up to 25 knots through the lowest 15,000 ft msl. The precipitable water was measured at a very substantial 64.54 mm (2.54 in.).

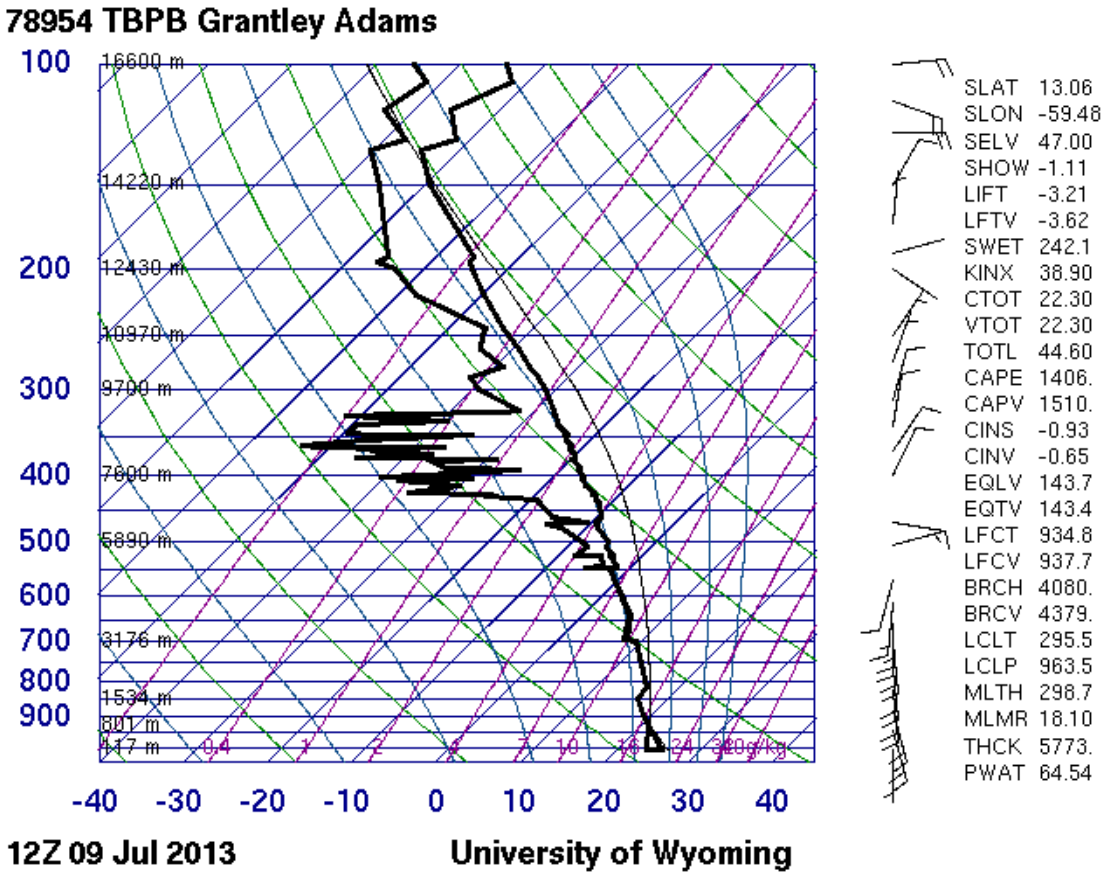

Fig. 5. Upper air sounding from Grantley Adams Airport at Barbados on Tuesday morning at 800 am AST, just after the center of Chantal passed by on its north side.

At nearly the same time the weather radar at Barbados was showing a well-defined circulation towards the northwest (Fig. 6). Meteo-France reported from Lamentin Airport at Martinique a wind gust to 68 knots (78 mph) as Chantal passed just to the south.

Located on the north side of Chantal was Guadeloupe. Their upper air sounding (Fig. 7) showed a maximum wind speed of 53 knots at 736 mb (9153 ft msl). This wind was in the area indicating possible intrusion of the Saharan air causing some drying of the air between 900 mb and 650 mb when the storm center was 305 km (165 nm) south-southeast of Guadeloupe.

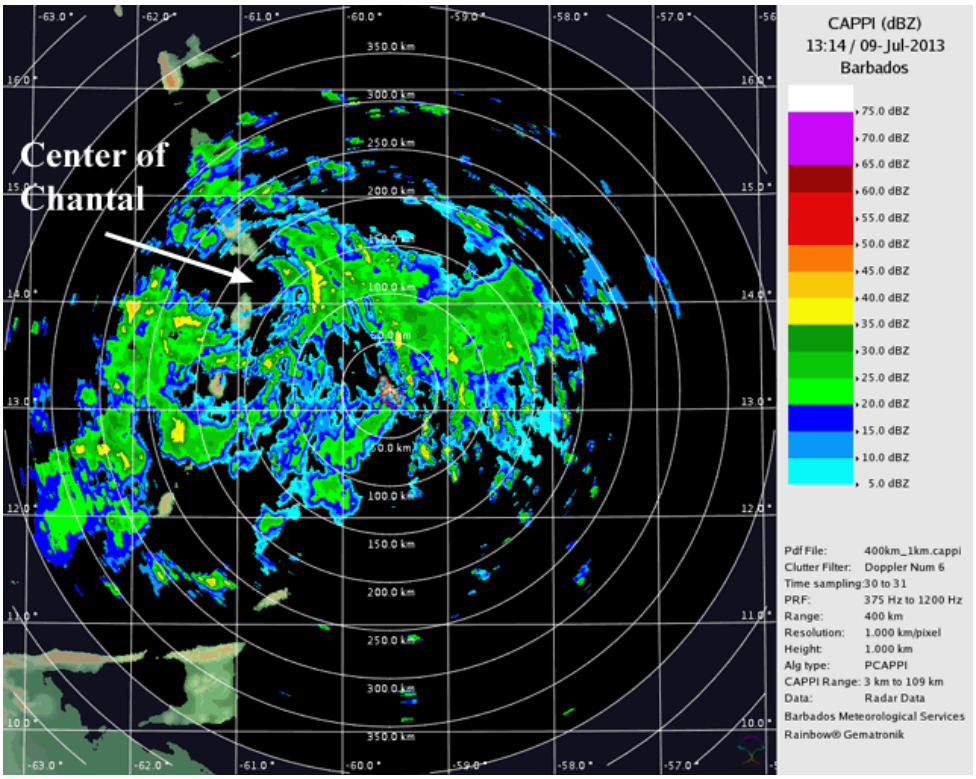

Fig. 6. Weather radar from Barbados for 1314 UTC (914 am AST) on July 9, 2013, shortly after Chantal passed by.

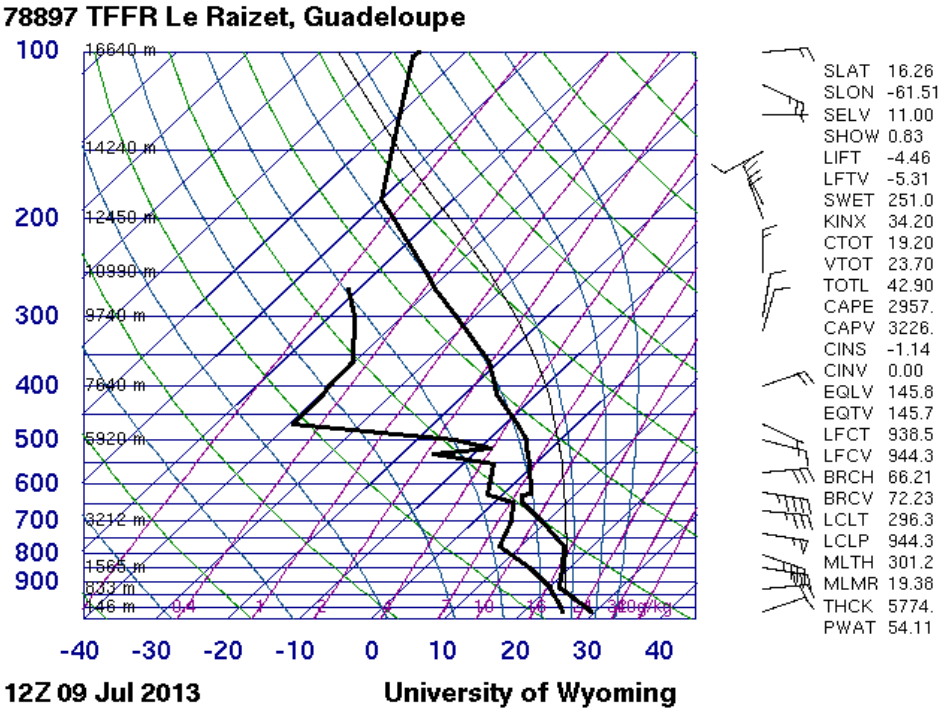

Fig. 7. Upper air sounding for Le Raizet Airport, Guadeloupe on Tuesday morning at 800 am AST, when Chantal was directly south-southeast of this location.

Even after the center passed the Lesser Antilles there was still a large amount of the Saharan air and dust encircling Chantal except probably towards the south where deep moisture was coming directly off the South American continent (Fig. 8).

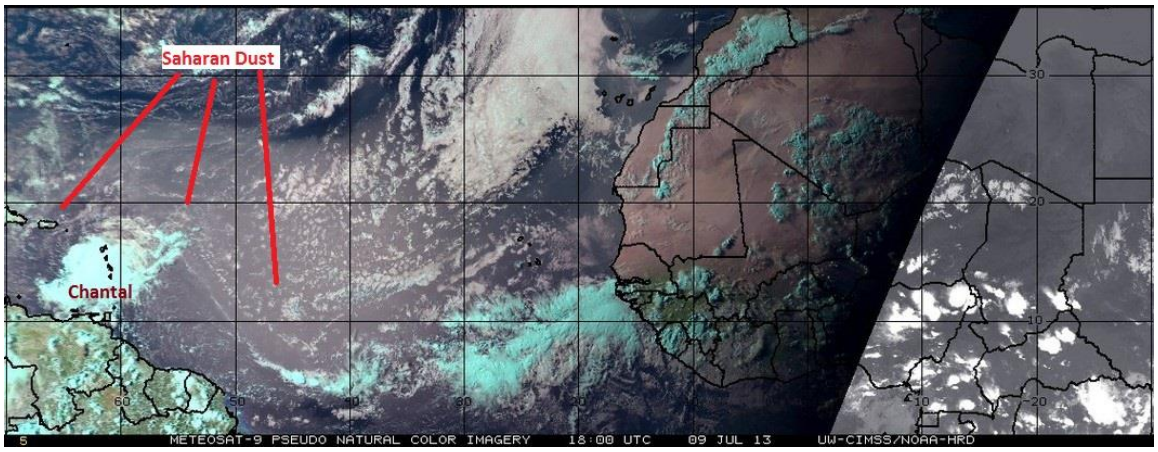

Fig. 8. Visual image showing widespread Saharan layer dust.

Chantal began to look less organized on satellite, especially when reaching the Caribbean Sea (Fig. 9). By the Tuesday evening, the 9th, the Hurricane Hunters crew was having difficulty finding a closed circulation. It was suspected late in the evening and overnight that it was becoming a wave again while the forward speed had increased to 30 mph.

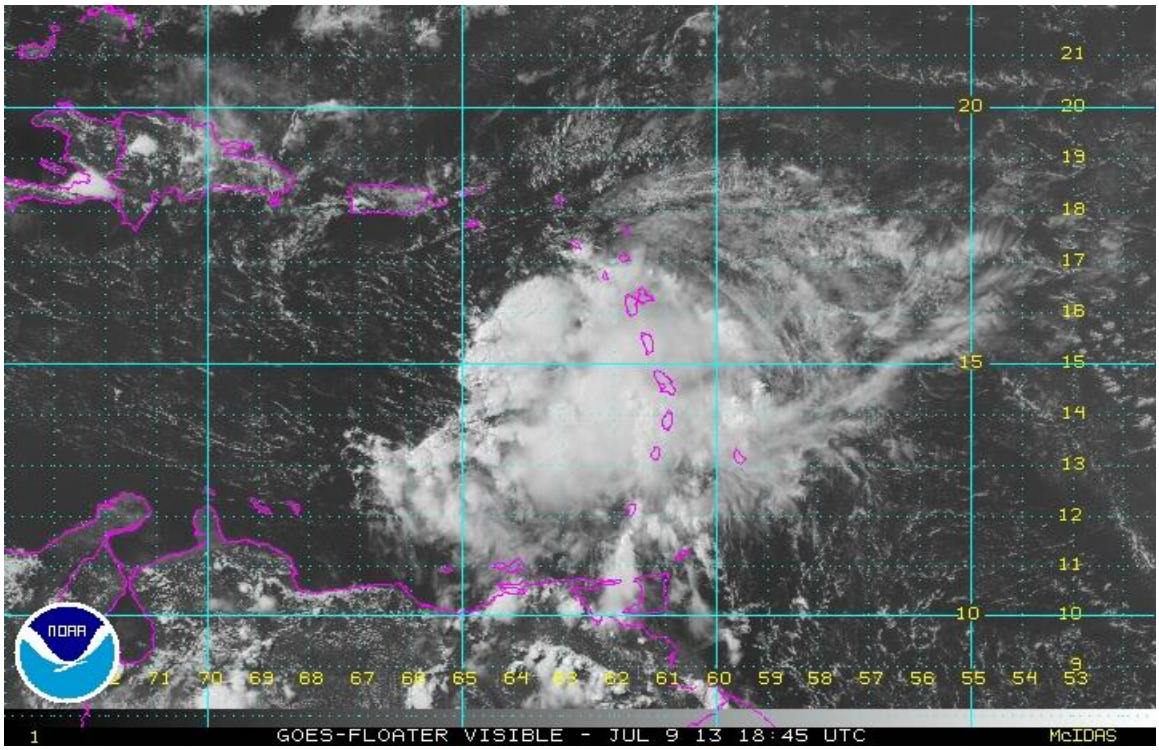

Fig. 9. GOES visible image of Chantal in eastern Caribbean Sea on July 9, 2013 at 1845 UTC (245 pm AST).

Due in part to the strong ridge that lay to the north, the winds were still quite strong on Chantal's north side. Hurricane Hunters found that storm force winds extended about 80 nm northeast of the center. Even around midnight that night the OceanSAT-2 satellite instrument (Fig. 10), continued to show tropical storm force winds but it definitely suggested that Chantal had become an open wave. This trend continued through Wednesday as it approached Hispaniola.

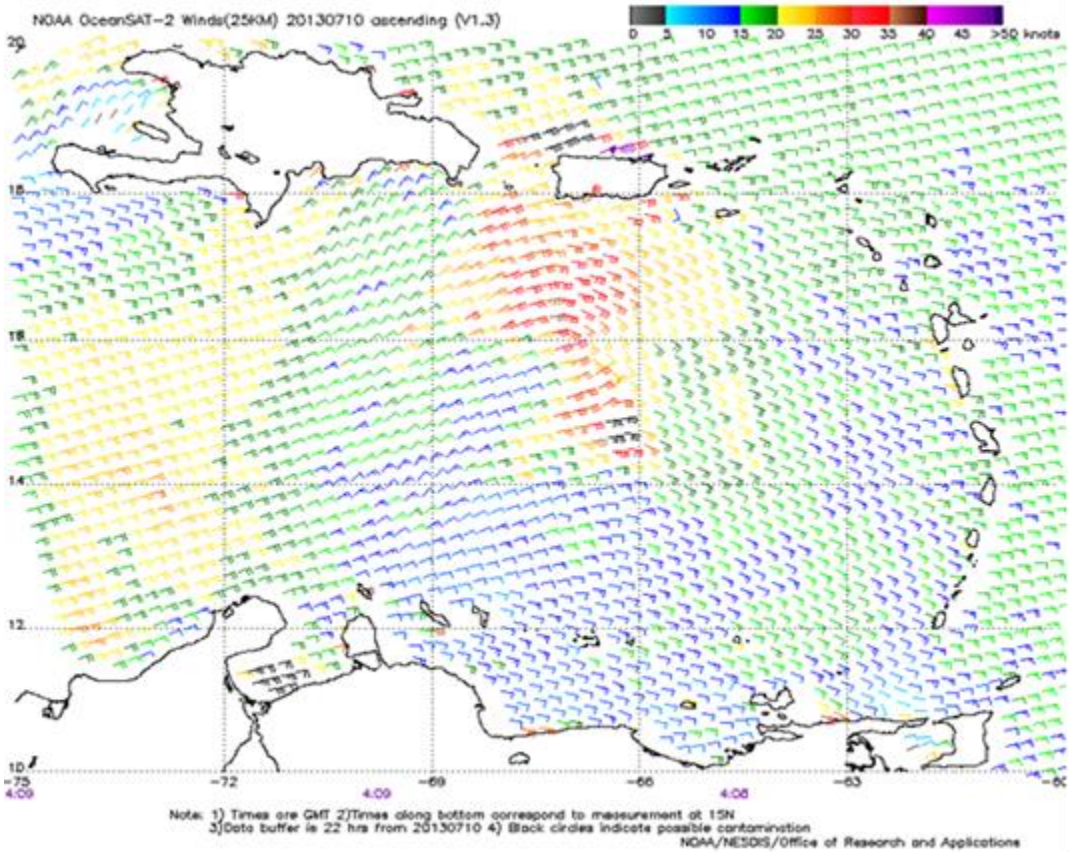

Fig. 10. Ascending pass of OceanSAT-2 satellite instrument, indicating that Chantal was becoming an open wave.

b. Effects on Puerto Rico and the U. S. Virgin Islands

The strongest effects in the forecast area for the San Juan Weather Forecast Office from Chantal occurred when it passed south of Puerto Rico on the night of July 9th as it began to become a tropical wave again. As it entered the Caribbean Sea strong convection arc clouds (squalls) formed on its northwest periphery as depicted in this loop: http://go.wisc.edu/ety2yv. The arc clouds indicated that gust fronts were forming from the thunderstorms. While strong thunderstorms were arriving at St. Kitts in Fig. 9 the winds reported at the airport were not especially strong (maximum sustained winds of 23 mph) but this same thunderstorm complex arrived at Christiansted, Henry E. Rohlsen Airport, St. Croix (140 miles away) only two and a half hours later where the wind gusted to 44 mph at 519 pm AST (Fig. 11)!

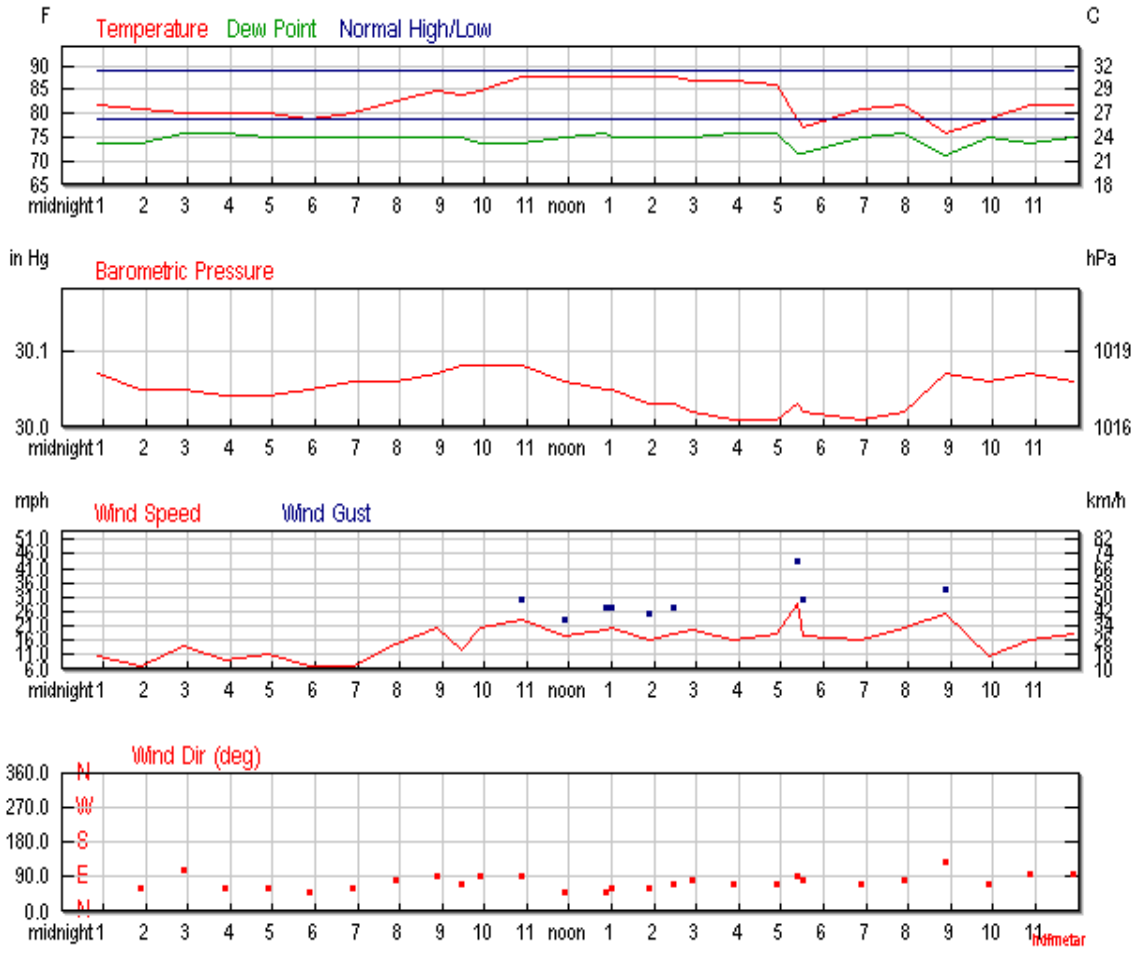

Fig. 11. Plot of meteorological variables for Henry E. Rohlsen Airport on July 9th (http://www.wunderground.com/). Wind gusts are the blue dots.

Most of the winds as they passed over Puerto Rico remained aloft and many people experienced nothing more than a breeze. But the wind was over Puerto Rico as the upper air sounding from San Juan showed (Fig. 12) that evening at 800 pm AST. On the sounding winds were peaking at 43 knots (49 mph) at 2134 m msl (7000 ft) but also showed slightly more unsaturated air that might have been expected, similar to the sounding at Guadeloupe earlier in the day, between 900 mb and 600 mb and hinting at Saharan air influence. Thunderstorm squalls were occasionally pushing these winds to the ground as had occurred at St. Croix slightly earlier.

Several squalls, mainly in eastern Puerto Rico and St. Croix, produced wind gusts in excess of 50 mph. The Las Mareas CARICOOS weather station at Guayama, PR recorded wind gusts to 40 mph and to 51 mph on the evening of the 9th (Fig. 13) and shortly thereafter, from the same squall, a buoy located 9 miles southeast of Ponce recorded a wind gust to 45 mph at about 740 pm AST and another to 49 mph at 1010 pm (Fig. 14).

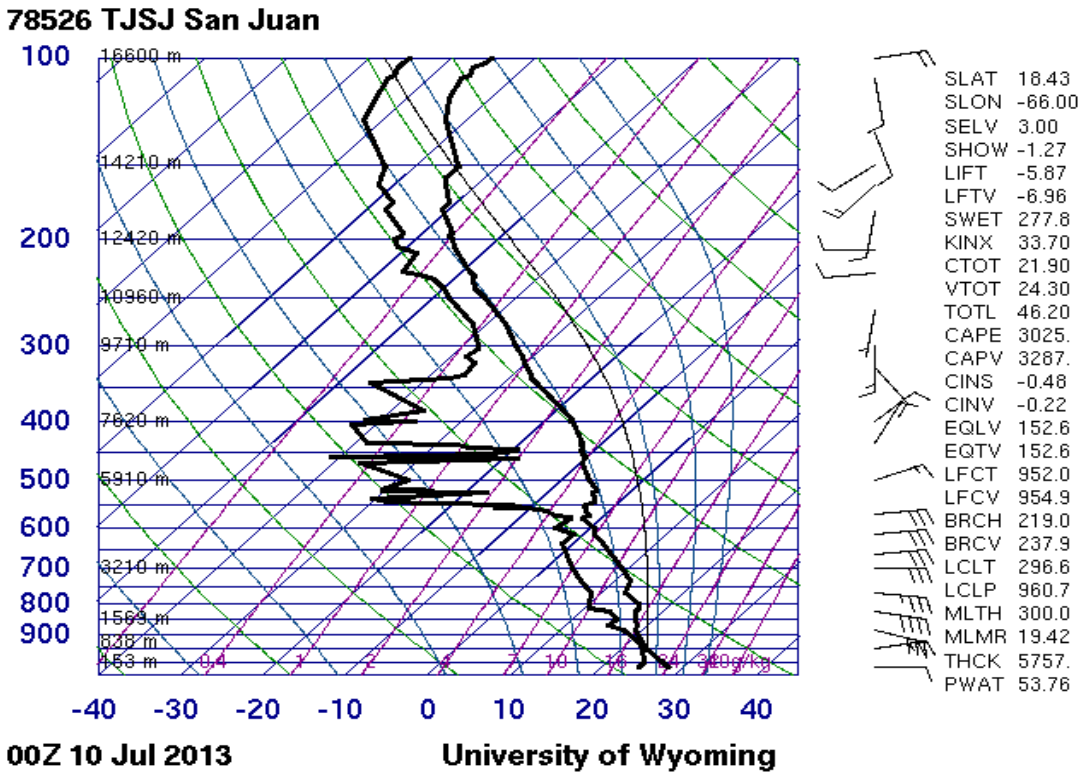

Fig. 12. Upper air sounding from San Juan, PR at 800 pm AST on July 9th.

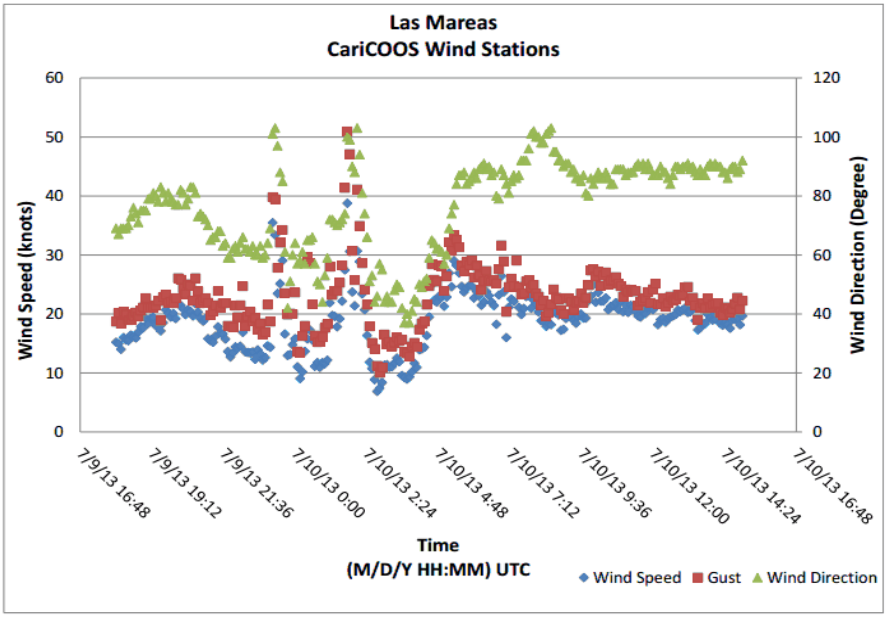

Fig. 13. Wind plot of Las Mareas (Guayama) weather station.

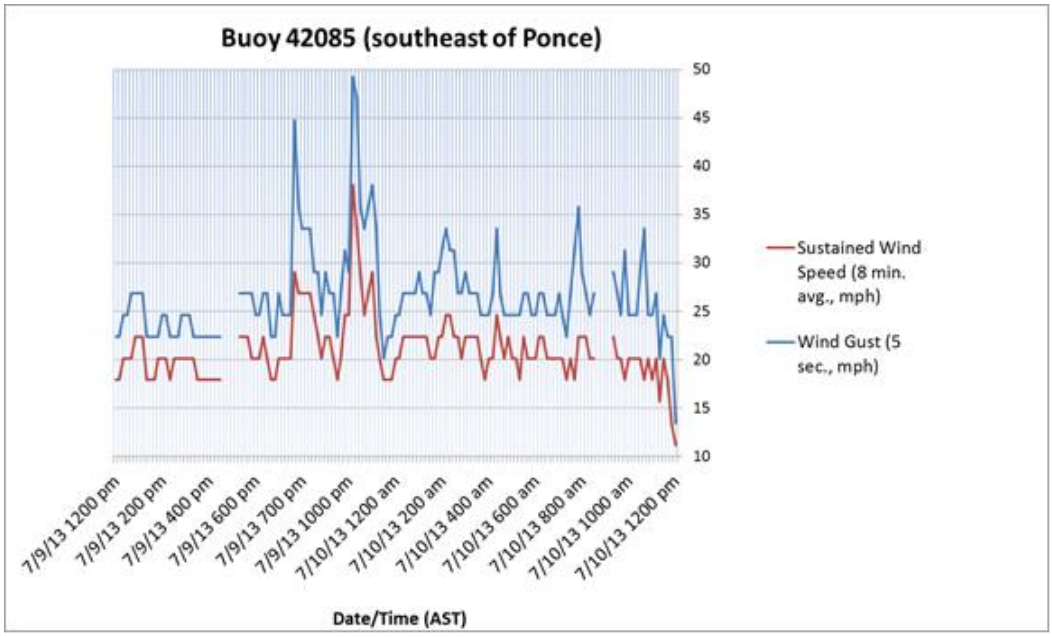

Fig. 14. Historical wind plot of Buoy 42085.

Widespread convection or organized bands were not to arrive over Puerto Rico or the U.S. Virgin Islands but it did develop in cycles across the Caribbean Sea. A satellite view of how precipitation developed on Tuesday and Tuesday night (Fig. 15) shows that most of the thunderstorms narrowly missed Puerto Rico and its coastal waters.

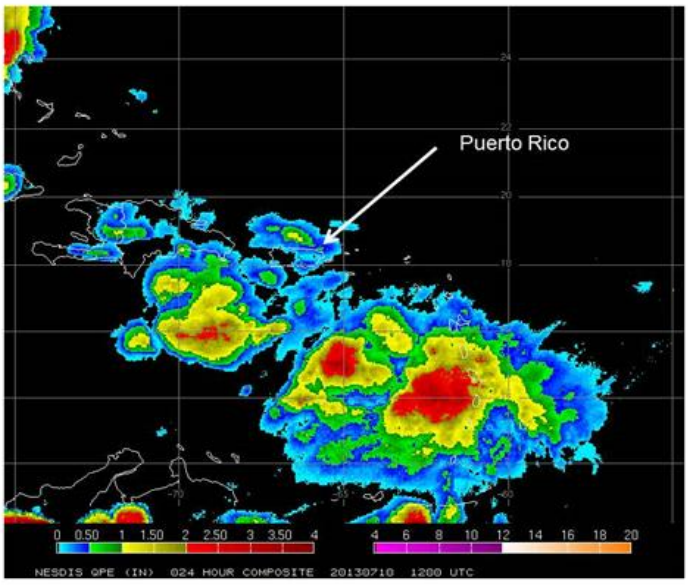

Fig. 15. Satellite image (NESDIS) estimating rainfall across the eastern Caribbean Sea between 1200 UTC (800 am AST) UTC July 9th and 1200 UTC July 10th.

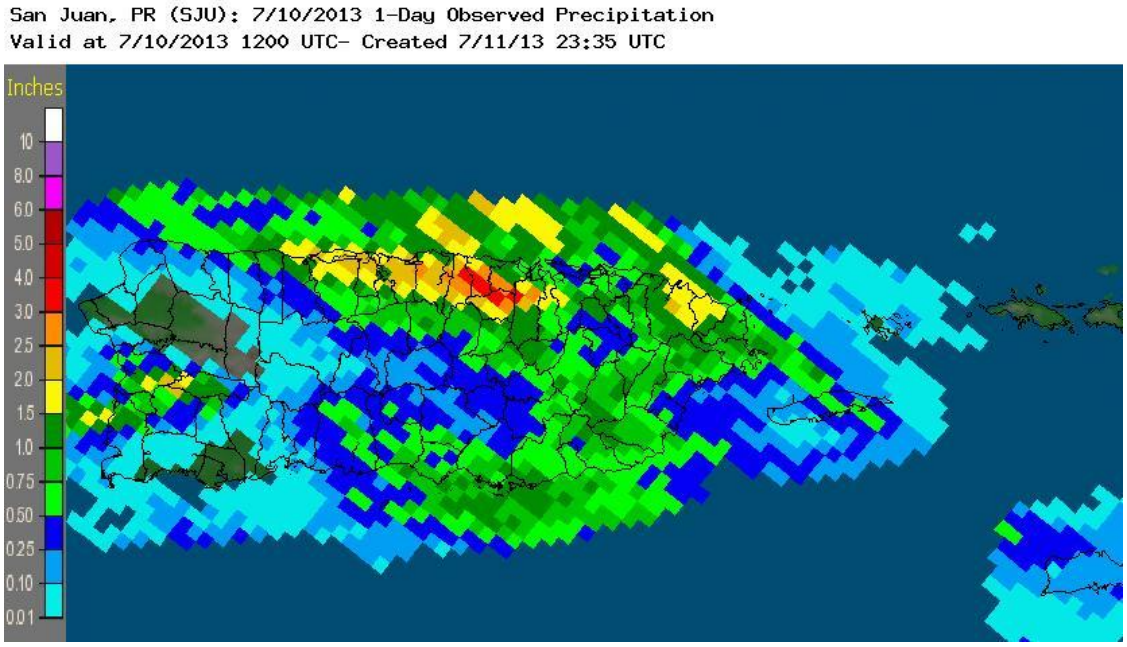

Fig. 15. Observed precipitation for 24 hours ending 1200 UTC (800 am AST), July 10th.

Observed precipitation across Puerto Rico, Vieques, Culebra and the U. S. Virgin Islands (Fig. 15) showed that most rainfall was below an inch however totals were in excess of three inches in parts of Vega Baja, Vega Alta, Dorado and Toa Alta. No flooding was reported across the islands and official river gages did not approach flood stage at any time.

Fig. 16. High surf at Maunabo Beach at southeast Puerto Rico on the morning of July 10th.

As Chantal moved across the Caribbean Sea it generated high waves, mainly in the Caribbean. Buoy 42060 (135 nm southeast of St. Croix) reported seas as high as 3.8 m, or 12.4 ft, at 800 pm AST on July 9th. This was four hours after winds were gusting to 43 mph there. The highest seas reported for buoy 42085 (southeast of Ponce) were 2.5 m, or slightly over 8 ft, which occurred at 300 am AST on July 10 and again at 600 am. Swells crashed waves into south and southeast Puerto Rico and St. Croix on the 10th. Some surfers enjoyed the unusually high surf (Fig. 16).

c. Watches, Warnings and Damage.

Figure 17 shows a history of watches and warnings issued for Chantal while Fig. 18 indicates the expected impacts in graphical form which was issued on the internet and other social media. Most flooding was expected in east and southeast Puerto where it was thought that topographic effects would enhance rainfall. The greatest expected impacts from wind (though a relatively low threat) would be for southwest Puerto Rico while primary marine impacts were expected to be over the Caribbean waters south and southwest from Puerto Rico.

Type of Issuance	Location	Date/Time (AST)
Tropical Storm Watch Issued	Puerto Rico, Vieques, Culebra, Caribbean coastal waters	8th/1100 am
Tropical Storm Watch Issued	U.S. Virgin Islands	8th/500 pm
Tropical Storm Warning Issued	Mainland Puerto Rico, Caribbean coastal waters	8th/500 pm
Flash Flood Watch Issued	U.S. Virgin Islands, Puerto Rico, Vieques, Culebra	9th/452 am
Tropical Storm Warning Ended	Puerto Rico, except for Caribbean coastal waters (zones AMZ741 and AMZ732)	10th/430 am
Tropical Storm Watch Ended	U.S. Virgin Islands, Vieques, Culebra	10th/500 am
Tropical Storm Warning Ended	Caribbean coastal waters (zones AMZ741 and AMZ732)	10th/902 am
Flash Flood Watch Ended	U.S. Virgin Islands, Vieques, Culebra	10th/955 am
Flash Flood Watch Ended	Mainland Puerto Rico	10th/209 pm

Fig. 17. Historical timeline of watches and warnings issued by the National Hurricane Center and San Juan Weather Forecast Office.

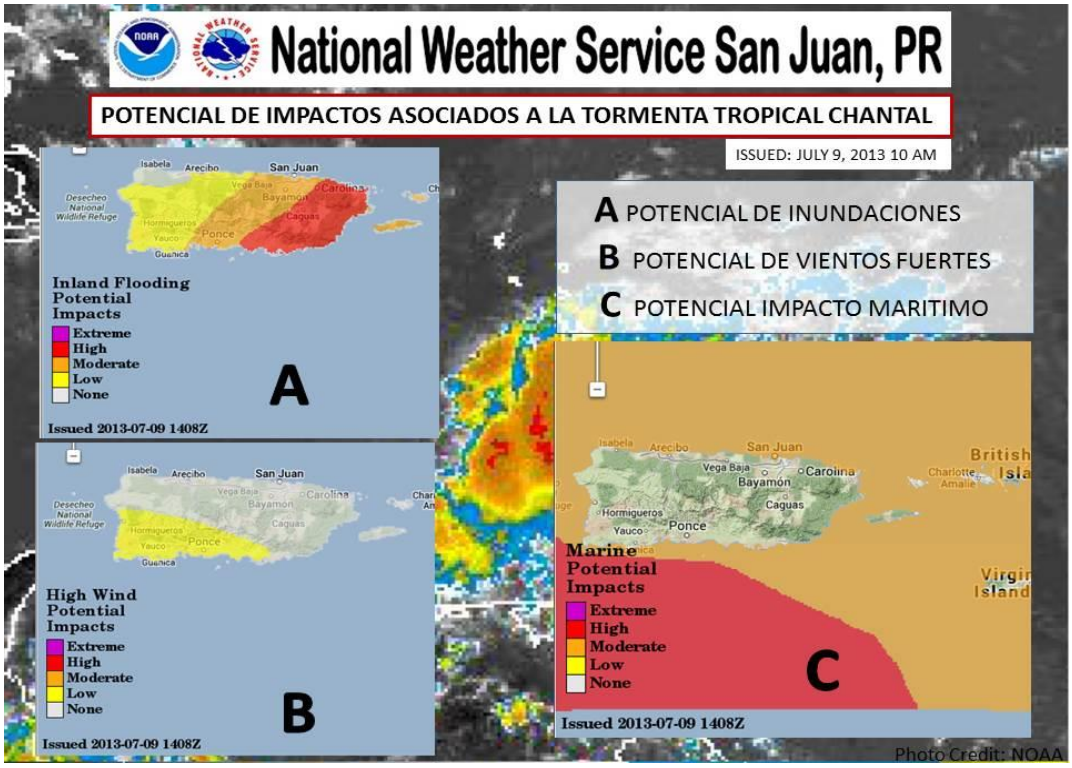

Fig. 18. Graphical impact hurricane local statement from San Juan Weather Forecast Office, issued at 1000 am AST July 9.

Damage from Chantal was rather minor, mostly from wind causing downed power lines or trees falling on power lines or onto roads. The following is a summary of reports received. There were no deaths, injuries or evacuations.

Dorado, PR: Fallen tree over electrical system in the Maisonet-2 community in Barrio Maguayo.
Juncos, PR: A COOP observer reported a 60 mph wind gust.
Aibonito, PR: Power lines down at Road 14 near Las Flores Mall due to gusty winds.
Cayey, PR: Power lines down at Barrio Monte Llano due to gusty winds.
Caguas, PR: Power lines down at Road 765, Barrio Atravezada KM1.1 due to gusty winds.
Caguas, PR: Power lines down at Road 30, Barrio Chayanne due to gusty winds.
Cayey, PR: Power lines down at Barrio Paseo Pluma due to gusty winds.
Aibonito, PR: Power lines down at Road 724 due to gusty winds.
Humacao, PR: Two lanes of Road PR-3 were closed due to fallen tree branches.
Las Piedras, PR: Two lanes of Road PR-948 were closed due to a landslide at Barrio Quebrada Grande.
Saint Croix, VI: Tree down on major highway at mid-island.

d. Conclusion

Chantal developed in the ITCZ within an area ripe for development. Develop it did until reaching the Lesser Antilles but by the time it reached that location Chantal was already

battling dry Saharan air and dust, interaction with the islands, and its own tremendous forward speed as deterrents for continued development. These factors contributed to its demise which happened fairly quickly in the eastern Caribbean Sea and may have become an open tropical wave by the time it was south of Puerto Rico.

Chantal was never forecasted to reach hurricane strength even as it was expected to approach the Dominican Republic. Its forward speed, reaching 30 mph or even slightly higher at times and along with some westerly shear aloft, greatly diminished its organization. This was especially obvious by the time it was south of Hispaniola when advisories were discontinued late on July 10th.