

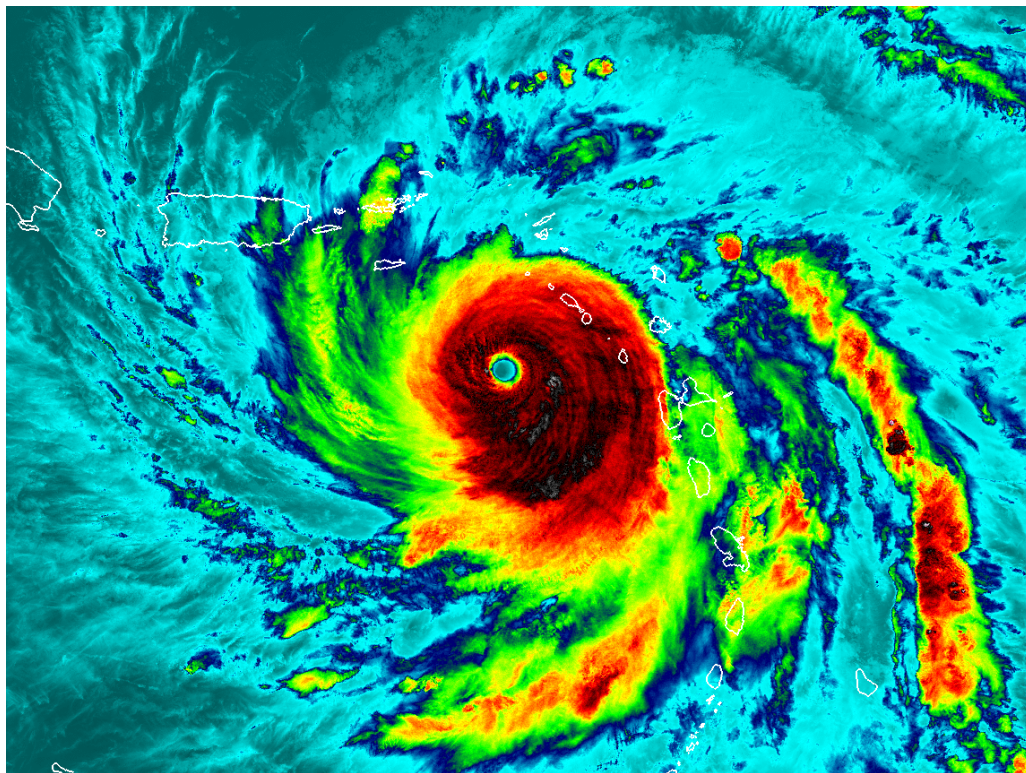


# NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

## HURRICANE MARIA (AL152017)

16–30 September 2017

Richard J. Pasch, Andrew B. Penny, and Robbie Berg  
National Hurricane Center  
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VIIRS SATELLITE IMAGE OF HURRICANE MARIA NEARING PEAK INTENSITY AT 1942 UTC 19 SEPTEMBER 2017. IMAGE COURTESY OF UW-CIMSS.

Maria was a very severe Cape Verde Hurricane that ravaged the island of Dominica at category 5 (on the Saffir-Simpson Hurricane Wind Scale) intensity, and later devastated Puerto Rico as a high-end category 4 hurricane. It also inflicted serious damage on some of the other islands of the northeastern Caribbean Sea. Maria is the third costliest hurricane in United States history.

# Hurricane Maria

16–30 SEPTEMBER 2017

## SYNOPTIC HISTORY

Maria originated from a well-defined tropical wave that departed the west coast of Africa on 12 September. The system moved westward over the tropical Atlantic for the next few days while producing scattered and disorganized deep convection. By 15 September, showers and thunderstorms increased and began to show signs of organization, with some curved cloud bands developing. Deep convection then quickly became more consolidated and better organized, and it is estimated that a tropical depression formed about 580 n mi east of Barbados by 1200 UTC 16 September. The “best track” chart of the tropical cyclone’s path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1<sup>1</sup>.

Moving westward to the south of a mid-level high pressure area, the cyclone strengthened into a tropical storm around 1800 UTC on 16 September. Maria turned toward the west-northwest shortly thereafter, and quickly intensified into a hurricane by 1800 UTC on 17 September. While situated in an environment of warm sea surface temperatures and light vertical shear, the hurricane strengthened extremely rapidly. Maria became a 100-kt major hurricane by 1200 UTC 18 September, and just 12 h later, as it neared Dominica, it became a category 5 hurricane with maximum winds of 145 kt. The hurricane made landfall on the island with that intensity and an estimated minimum central pressure of 922 mb around 0115 UTC 19 September.

After striking Dominica, Maria continued moving west-northwestward and entered the northeastern Caribbean Sea. Slight weakening had occurred due to the system’s interaction with the mountainous island of Dominica, but the hurricane soon regained intensity and strengthened to its peak intensity of 150 kt with a minimum pressure of 908 mb around 0300 UTC 20 September while centered about 25 n mi south of St. Croix. Maria moved west-northwestward to northwestward toward Puerto Rico and, after reaching maximum intensity, underwent an eyewall replacement with an outer eyewall becoming more dominant by the time the center of the system reached Puerto Rico (Figures 4a and 4b). The hurricane weakened somewhat before its landfall on that island due to the eyewall replacement, but also grew in size. Maria’s center crossed the southeast coast of Puerto Rico near Yabucoa around 1015 UTC 20 September, and the hurricane’s maximum winds at that time were near 135 kt, i.e., just below the threshold of category 5 intensity. The hurricane’s center crossed the island, roughly diagonally from southeast to northwest, for several hours and emerged into the Atlantic around 1800 UTC 20 September. By that time, Maria had weakened after interacting with the land mass of Puerto Rico and its maximum winds were estimated to be 95 kt.

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<sup>1</sup> A digital record of the complete best track, including wind radii, can be found on line at <ftp://ftp.nhc.noaa.gov/atcf>. Data for the current year’s storms are located in the *bt* directory, while previous years’ data are located in the *archive* directory.

Over the next couple of days, the hurricane moved northwestward along the southwestern periphery of a mid-level high over the western Atlantic while gradually restrengthening. Although Maria never regained all of its former intensity, its maximum winds increased to near 110 kt by 0000 UTC 22 September while the hurricane was centered about 60 n mi southeast of Grand Turk Island. Maria turned toward the north-northwest, and its center passed 30 to 40 n mi east and northeast of the Turks and Caicos Islands on 22 September. Moderate southwesterly vertical shear prevented any additional strengthening during that period. The system maintained major hurricane status until 0600 UTC 24 September, while turning toward the north. Maria continued to gradually weaken, and it lost its eyewall structure by 25 September while continuing northward at a slow forward speed well offshore of the southeastern U.S. coast. The cyclone then weakened to category 1 status, and by 0600 UTC 27 September the center of the 65-kt hurricane passed about 130 n mi east of Cape Hatteras, North Carolina. On 28 September, Maria turned sharply toward the east and began to accelerate as it weakened to a tropical storm. Moving rapidly eastward to east-northeastward, the system became an extratropical cyclone by 1800 UTC 30 September while centered about 465 n mi southeast of Cape Race, Newfoundland. The cyclone moved east-northeastward until dissipation over the north Atlantic about 400 n mi southwest of Ireland by 1800 UTC 2 October.

## METEOROLOGICAL STATISTICS

Observations in Maria (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from 22 flights of the 53<sup>rd</sup> Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command, and 8 flights of the NOAA Hurricane Hunter P-3 aircraft. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Maria.

Ship reports of winds of tropical storm force associated with Maria are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3.

### ***Winds and Pressure***

Maria's peak intensity of 150 kt is based on a blend of SFMR-observed surface winds of 152 kt and 700-mb flight-level winds of 157 kt. Maria's 65-kt intensity increase over 24 h on 18 September makes it tied for the sixth-fastest intensifying hurricane in the Atlantic basin record.

The intensity of the hurricane when it struck Dominica, 145 kt, is based on an SFMR-observed surface wind of 152 kt which, based on quality control by data processing software, is believed to be somewhat inflated, and a maximum 10-min wind of 130 kt measured at Douglas-

Charles Airport on the island, which conservatively corresponds to a 1-min wind of 143 kt. Maria is the strongest hurricane on record to make landfall on Dominica (or strike within 60 n mi of that island).

Maria's minimum central pressure of 908 mb is based on an eye dropsonde measurement by the Air Force Hurricane Hunters of 910 mb with 23-kt winds at the surface at 0313 UTC 20 September. This is the lowest pressure on record of any hurricane in the Atlantic basin east of 70°W, and breaks the record that had been set just a couple of weeks earlier by Irma of 914 mb.

The landfall intensity of the cyclone in Puerto Rico, 135 kt, is based on an extrapolation of the weakening trend noted in the aircraft data after the eyewall replacement began several hours earlier. There were no believable Doppler-derived winds from the San Juan WSR-88D radar that supported a higher intensity. It should be noted, however, that in Puerto Rico, winds of category 5 intensity were almost certainly felt at some elevated locations on the island.

The landfall pressures of the hurricane in Dominica and Puerto Rico of 922 and 920 mb, respectively, are based on an extrapolation of the system's deepening and filling trends before making landfall in those islands. Several storm chasers observed pressures higher than the estimated minimum value in Puerto Rico, but these observers were not thought to be in the exact center of the hurricane. Maria is the strongest hurricane to make landfall in Puerto Rico since a category 5 hurricane in 1928 (known as Segundo San Felipe).

Maria's eyewall replacement early on 20 September resulted in roughly a tripling of its eye diameter, from 9 n mi to about 28 n mi, prior to landfall in Puerto Rico. This event was likely a major contributor to weakening, but also increased the areal exposure of the island to the hurricane's highest winds.

A peak sustained wind of 93 kt with a gust to 119 kt was reported at St. Croix near the northeast edge of Maria's eyewall. Las Mareas, on the south coast of Puerto Rico, recorded a 1-min sustained wind of 94 kt with a gust to 109 kt in the western eyewall of Maria. Wind gusts to hurricane force were recorded in Guadeloupe and on the northeast coast of the Dominican Republic.

Sustained winds at the low end of tropical storm force occurred over the North Carolina Outer Banks due to Maria.

It should be noted that in Figure 2, beginning around 24 September, Maria's actual maximum winds were as much as 20-30 kt lower than what would be derived from a standard pressure-wind relationship [AC(DVK->W)]. This is mainly due to the expansion of the cyclone's circulation while it moved into higher latitudes.



## Storm Surge<sup>2</sup>

The combined effect of the surge and tide produced maximum inundation levels of 6 to 9 ft above ground level to the north of Maria's landfall along the coasts of Humacao, Naguabo, and Ceiba municipalities in Puerto Rico. Figure 5 provides an analysis of maximum inundation heights along the coasts of Puerto Rico and the U.S. Virgin Islands, and Figure 6 provides peak water levels recorded by tide gauges, relative to Mean Higher High Water (MHHW). The United States Geological Survey (USGS) measured high water marks of 5.1 ft and 4.9 ft above ground level inside structures at Punta Santiago in Humacao. Another high water mark was surveyed at 9.5 ft above the Puerto Rico Vertical Datum of 2002 (PRVD), which converts to about 9 ft MHHW. These data suggest that maximum inundation levels along the immediate shoreline were as high as 9 ft above ground level in these municipalities. Elsewhere along the southeastern coast of Puerto Rico, maximum inundation levels are estimated at 4 to 7 ft above ground level, primarily in the municipalities of Yabucoa, Maunabo, Patillas, and Arroyo. A Puerto Rico Seismic Network tide gauge at Yabucoa Harbor measured a water level of 5.3 ft MHHW, but the sensor went offline for a period and may not have recorded the peak water level.

Maximum inundation levels of 3 to 5 ft above ground level occurred along the coast of northeastern Puerto Rico, especially in the municipalities of Ceiba and Fajardo, and along much of the southern coast from Ponce eastward. A tide gauge in Fajardo measured a water level of 2.2 ft MHHW before it went offline. A USGS storm tide sensor installed on a public dock at Puerto Chico in Fajardo measured a wave-filtered water level of 2.8 ft above the sensor (also about 2.8 ft MHHW), and the waves themselves contributed another 2 ft or so to the total water level, yielding almost 5 ft of inundation in that area. On the southern coast, a high water mark of 5.2 ft PRVD was surveyed at Playa de Salinas, which converts to about 4.8 ft MHHW and supports an estimated maximum inundation of 5 ft above ground level.

Maximum inundation levels of 2 to 4 ft above ground level occurred along much of the northern coast of Puerto Rico. A National Ocean Service (NOS) tide gauge in San Juan Bay measured a peak water level of 2.4 ft MHHW, but the sensor went offline for a period and may not have recorded the highest water level. Farther west, a tide gauge at Arecibo measured a peak water level of 1.9 ft MHHW. Elsewhere, peak water levels along the northwestern, western, and southwestern coasts of Puerto Rico are estimated to have been 1 to 3 ft above ground level.

Post-storm surge simulations suggest that maximum inundation levels of 3 to 5 ft above ground level occurred on Vieques and St. Croix. Tide gauges at Isabel Segunda, Vieques, and Lime Tree Bay, St. Croix, measured peak water levels of 2.0 ft MHHW and 2.8 ft MHHW, respectively, but both of these sensors went offline and may not have recorded the highest water levels. Surge simulations and available tide gauge observations also suggest that maximum inundation levels of 1 to 3 ft above ground level occurred on Culebra, St. Thomas, and St. John.

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<sup>2</sup> Several terms are used to describe water levels due to a storm. **Storm surge** is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tide, and is expressed in terms of height above normal tide levels. Because storm surge represents the deviation from normal water levels, it is not referenced to a vertical datum. **Storm tide** is defined as the water level due to the combination of storm surge and the astronomical tide, and is expressed in terms of height above a vertical datum, i.e. the North American Vertical Datum of 1988 (NAVD88) or Mean Lower Low Water (MLLW). **Inundation** is the total water level that occurs on normally dry ground as a result of the storm tide, and is expressed in terms of height above ground level. At the coast, normally dry land is roughly defined as areas higher than the normal high tide line, or Mean Higher High Water (MHHW).

Maximum inundation levels of 1 to 3 ft above ground level occurred along the coast of North Carolina as Maria moved by offshore. Figure 7 provides maximum water levels from tide gauges along the coast of North Carolina. The NOS tide gauge at the U.S. Coast Guard station at Hatteras, North Carolina, measured a peak water level of 2.7 ft MHHW on the back side of the Outer Banks in Pamlico Sound. Water levels measured by other tide stations in North Carolina and southeastern Virginia were less than 2 ft MHHW.

Although there appears to have been considerable damage due to storm surge and/or wave action in Dominica, no water level measurements are available from that island.

## ***Rainfall and Flooding***

In addition to its furious winds, the hurricane produced enormous amounts of rain on the islands over which it swept. Dominica experienced torrential rains from Maria, with a maximum observed total of 22.8 inches. The rains caused serious flooding and mud slides across that island. Even heavier rainfall occurred in Puerto Rico, where one location had a storm total of nearly 38 inches (Fig. 8). River discharges at many locations in the island were at record or near-record levels. Severe flooding and mud slides affected most of the island, with the most significant flooding associated with the La Plata River. Heavy rains, with totals of at least 10 to 13 inches, also occurred in Guadeloupe and portions of the Dominican Republic, and these rains also likely led to significant flooding and mud slides.

## ***Tornadoes***

Three small tornadoes were observed by a storm chaser near Yabucoa, Puerto Rico, but these have not been confirmed by the National Weather Service.

# **CASUALTY AND DAMAGE STATISTICS**

Maria caused 31 direct deaths in Dominica<sup>3</sup> with 34 missing. In Guadeloupe, two direct fatalities are attributed to Maria: one person died from a falling tree, and another was swept out to sea. In Puerto Rico, the death toll is highly uncertain and the official number stands at 65, which includes an unknown number of indirect deaths. It should be noted that hundreds of additional indirect deaths in Puerto Rico may eventually be attributed to Maria's aftermath pending the results of an official government review. One person died from drowning, and another was killed by a mud slide in St. Thomas. Four persons were swept away by floodwaters, and another individual perished in a mud slide in the Dominican Republic. Three persons died due to

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<sup>3</sup> Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as "direct" deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered indirect" deaths.

floodwaters in Haiti. In the mainland United States, three persons drowned due to rip currents at the Jersey Shore, and there was a fourth drowning death at Fernandina Beach, Florida.

Maria caused catastrophic damage in Dominica, with the majority of structures seriously damaged or destroyed, and most trees and vegetation were downed and/or defoliated. According to media reports, the estimated damage total in Dominica is at least \$1.31 billion. The agricultural sector was essentially eliminated. The once-lush tropical island was effectively reduced to an immense field of debris. In a Facebook post just after the hurricane hit, Dominica's Prime Minister, Roosevelt Skerrit, described the damage as "mind-boggling". The roofs of the majority of buildings and homes were either damaged or blown off. There was extensive damage to roads. Power, phone, and internet service was cut off, leaving the country almost incommunicado with the outside world. Figure 9 shows some examples of the damage in Dominica.

In Guadeloupe, to the north of Dominica, hurricane-force wind gusts and heavy rain caused a great deal of damage, especially along the southern portions of Basse-Terre Island. An estimated 80,000 homes were without electricity, and almost the entire banana crop was destroyed. An estimated \$120 million in damage was reported for Guadeloupe.

To the south of Dominica, the island of Martinique had mostly minor damage.

Among all the U.S. Virgin Islands, St. Croix was the most severely affected by Maria, having experienced the northern portion of the outer eyewall. Wind damage was evident across the entire island with many fallen trees, downed signs, roof damage and complete destruction of many wooden houses. Excessive rainfall generated significant flooding and mud slides across the island. In St. Thomas and St. John, most of the roofs, signs and trees had already been destroyed or damaged earlier by Hurricane Irma, but large rainfall accumulations generated flooding and mud slides across all these islands.

Puerto Rico was devastated by winds and floods. The NOAA estimate of damage in Puerto Rico and the U.S. Virgin Islands due to Maria is 90 billion dollars, with a 90% confidence range of +/- \$25.0 billion, or \$65.0-\$115.0 billion, which makes Maria the third costliest hurricane in U.S. history, behind Katrina (2005) and Harvey (2017). Maria is by far the most destructive hurricane to hit Puerto Rico in modern times, as the previous costliest hurricane on record for the island was Georges in 1998, which in 2017 dollars "only" caused about 5 billion dollars of damage. The combined destructive power of storm surge and wave action from Maria produced extensive damage to buildings, homes and roads along the east and southeast coast of Puerto Rico as well as the south coasts of Vieques and St. Croix. Along these areas, marinas and harbors were severely damaged due to the combination of the waves and currents associated with the surge. A storm surge also caused significant damage over the northwestern coastal area of Puerto Rico. Across the island, many buildings suffered significant damage or were destroyed. Numerous trees were downed, splintered and/or defoliated. River flooding was unprecedented in some areas, especially in the northern portion of the island. The La Plata River flooded the entire alluvial valley including the municipality of Toa Baja, where hundreds of families needed to be rescued from their roof tops. Maria knocked down 80 percent of Puerto Rico's utility poles and all transmission lines, resulting in the loss of power to essentially all of the island's 3.4 million residents. Practically all cell phone service was lost and municipal water supplies were knocked out. At the end of 2017, nearly half of Puerto Rico's residents were still without power, and by the end of January 2018, electricity had been restored to about 65% of the island. Just before

Maria's center made landfall, extreme winds destroyed the WSR-88D radar in Puerto Rico (Figure 10). Other examples of damage in Puerto Rico and St. Croix are shown in Figure 11.

On the island of Vieques, all wooden structures were either damaged or destroyed. The island of Culebra had recently experienced major damage due to Hurricane Irma, rendering the remaining structures on the island extremely vulnerable to Maria's winds. There was total destruction of many wooden houses, along with blown off roofs and sunken boats.

Hundreds of homes were either damaged or destroyed in the northern part of the Dominican Republic, and about 60,000 people lost power in that country. Many communities were cut off as a result of flooding and/or mud slides.

There was no significant damage in North Carolina.

## FORECAST AND WARNING CRITIQUE

The wave from which Maria developed was first mentioned in both the 48- and 120-h Tropical Weather Outlooks with a "low" (<40%) chance of development 60 h prior to Maria's formation. The genesis probabilities within 48 h and 120 h were raised to "medium" (40–60%) 30 h and 54 h prior to formation, respectively, and to "high" (>60%) only 18 h and 42 h before formation, respectively (Table 5). Clearly, the genesis of Maria was not well forecast, and one reason for the poor genesis forecasts was a failure of the global models to definitively predict tropical cyclone formation until very soon before it actually occurred. Figure 12 shows 96- and 120-h GFS and ECMWF forecasts verifying at the time of Maria's genesis; it can be seen that neither global model predicted the development of a closed surface circulation.

A verification of NHC official track forecasts for Maria is given in Table 6a. The mean official track forecast errors increased about 20 n mi per day, ranging from around 20 n mi at 24 h to around 120 n mi at 120 h. These errors were about 50% smaller than the mean official errors for the previous 5-yr period at all forecast intervals (Figure 13). Figure 14 shows that all of the official forecasts issued from the time of Maria's formation up to the night before its second landfall correctly showed that the hurricane would strike Puerto Rico. A homogeneous comparison of the official track errors with selected guidance models is given in Table 6b. Most of the models performed quite well for Maria, including the simple and corrected consensus forecasts. It should be noted that the GFS, which has typically been bested by the ECMWF for track prediction in the Atlantic basin, was superior to the ECMWF at 48 through 120 h.

A verification of NHC official intensity forecasts for Maria is given in Table 7a. The mean official forecast intensity errors were 10 to 15 kt from 24 through 72 h, but were less than 10 kt at days 4 and 5. These errors were 15% to 25% higher than the mean official errors for the previous 5-yr period through 48 h, but 10% lower than the long-term mean at 72 h and 35% to 45% lower at 96 and 120 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 7b. The Florida State University Superensemble (FSSE) had lower mean errors than the official forecasts at all forecast intervals. One issue of note regarding intensity forecasts for Maria was how poorly the rapid intensification episode of 18 September



was anticipated. Figure 15 shows the various intensity guidance models for the forecast beginning at the onset of the episode, and it can be seen the guidance substantially underpredicted Maria's strengthening. It should be noted that the SHIPS model Rapid Intensification Index showed a significant probability, i.e. about a 50% chance, of rapid intensification at this time and the official forecast showed considerable strengthening, but still not nearly enough strengthening. Notwithstanding, beginning with the second official forecast, every NHC forecast indicated that Maria would become a major hurricane by the time it reached Puerto Rico, which was a remarkable 84 h of lead time. In addition, NHC began to forecast Maria making landfall on that island as a category 4 hurricane about 54 h in advance.

NHC's forecast for maximum storm surge inundation heights in Puerto Rico and the U.S. Virgin Islands (first issued at 1500 UTC 18 September) was 6 to 9 ft above ground level. Storm tide sensor data and high water mark observations indicate that maximum inundation of 6 to 9 ft above ground level occurred north of Maria's landfall location on the eastern side of Puerto Rico. The initial forecast for maximum storm surge heights in North Carolina (issued at 2100 UTC 24 September) was 2 to 4 ft above ground level. Water level observations indicate that peak water levels were on the lower end of that forecast range.

The NWS issued storm surge watches and warnings for portions of the North Carolina coast due to the potential for coastal inundation from Maria<sup>4</sup>. NWS first issued a Storm Surge Watch from Cape Lookout to Duck, North Carolina, including some portions of southern Pamlico and southern Albemarle Sounds, at 2100 UTC 24 September. The portion of that area from Ocracoke Inlet to Cape Hatteras was upgraded to a Storm Surge Warning at 1500 UTC 26 September. The water level observation from the U.S. Coast Guard station at Hatteras suggests that up to 3 ft of inundation (which NHC uses as a first-cut threshold for the storm surge watch/warning) may have occurred within the Storm Surge Warning area (Fig. 7).

Watches and warnings associated with Maria are given in Table 8. A Hurricane Warning was issued a little over 34 h before Maria made landfall in Dominica, and a little over 37 h before landfall in Puerto Rico.

In addition to its partners within the NWS, the NHC coordinated watches and warnings with a number of countries for areas around the Caribbean Sea, including Barbados (which has responsibility for Dominica), St. Lucia, France (for Martinique, Guadeloupe, and St. Martin), Antigua (which also has responsibility for Montserrat, St. Kitts, Nevis, Barbuda, Anguilla and the British Virgin Islands), the Netherlands (which has responsibility for Saba and St. Eustatius), St. Maarten, the Dominican Republic, and the Bahamas.

The NHC began providing Impact-Based Decision Support Services (IDSS) to emergency managers on 14 September, when Maria was a tropical wave in the central Atlantic and this IDSS continued through 27 September, when Maria moved away from the North Carolina coast. The IDSS included calls and briefings coordinated through the FEMA Hurricane Liaison Team, which is embedded at the NHC. The briefings included the Territories of Puerto Rico and the U.S. Virgin Islands, FEMA Regions 2 and 3, as well as Federal and state video-teleconferences.

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<sup>4</sup> Currently, storm surge watches and warnings are only issued for the Gulf and Atlantic coasts of the continental United States.

The NHC also collaborated with affected NWS offices (primarily San Juan) to ensure a consistent message, and NWS meteorologists provided IDSS for local and state emergency management offices during Maria.

## ACKNOWLEDGMENTS

The authors thank the San Juan NWS Forecast Office (WFO) for providing information used in this report. Data from the National Data Buoy Center, NOS Center for Operational Oceanographic Products and Services, and United States Geological Survey were also used in this report. David Roth of the NOAA Weather Prediction Center produced the rainfall map.

Table 1. Best track for Hurricane Maria, 16–30 September 2017.

| Date/Time<br>(UTC) | Latitude<br>(°N) | Longitude<br>(°W) | Pressure<br>(mb) | Wind<br>Speed (kt) | Stage               |
|--------------------|------------------|-------------------|------------------|--------------------|---------------------|
| 16 / 1200          | 12.2             | 49.7              | 1006             | 30                 | tropical depression |
| 16 / 1800          | 12.2             | 51.7              | 1004             | 40                 | tropical storm      |
| 17 / 0000          | 12.4             | 53.1              | 1002             | 45                 | "                   |
| 17 / 0600          | 12.8             | 54.4              | 994              | 55                 | "                   |
| 17 / 1200          | 13.3             | 55.7              | 990              | 60                 | "                   |
| 17 / 1800          | 13.6             | 57.0              | 986              | 65                 | hurricane           |
| 18 / 0000          | 14.0             | 58.0              | 979              | 75                 | "                   |
| 18 / 0600          | 14.3             | 59.0              | 977              | 80                 | "                   |
| 18 / 1200          | 14.5             | 59.7              | 967              | 100                | "                   |
| 18 / 1800          | 14.9             | 60.4              | 956              | 110                | "                   |
| 19 / 0000          | 15.3             | 61.1              | 924              | 145                | "                   |
| 19 / 0115          | 15.4             | 61.3              | 922              | 145                | "                   |
| 19 / 0600          | 15.7             | 61.9              | 940              | 135                | "                   |
| 19 / 1200          | 16.1             | 62.7              | 931              | 140                | "                   |
| 19 / 1800          | 16.6             | 63.5              | 920              | 145                | "                   |
| 20 / 0000          | 17.0             | 64.3              | 909              | 150                | "                   |
| 20 / 0300          | 17.3             | 64.7              | 908              | 150                | "                   |
| 20 / 0600          | 17.6             | 65.1              | 913              | 140                | "                   |
| 20 / 1015          | 18.0             | 65.9              | 920              | 135                | "                   |
| 20 / 1200          | 18.2             | 66.2              | 935              | 115                | "                   |
| 20 / 1800          | 18.6             | 67.0              | 959              | 95                 | "                   |
| 21 / 0000          | 18.9             | 67.6              | 958              | 95                 | "                   |
| 21 / 0600          | 19.4             | 68.2              | 959              | 100                | "                   |
| 21 / 1200          | 19.9             | 68.8              | 959              | 100                | "                   |
| 21 / 1800          | 20.5             | 69.5              | 960              | 105                | "                   |
| 22 / 0000          | 20.8             | 70.0              | 953              | 110                | "                   |
| 22 / 0600          | 21.2             | 70.5              | 959              | 110                | "                   |
| 22 / 1200          | 21.9             | 70.9              | 958              | 110                | "                   |
| 22 / 1800          | 22.8             | 71.2              | 959              | 110                | "                   |
| 23 / 0000          | 23.7             | 71.6              | 953              | 105                | "                   |

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage          |
|-----------------|---------------|----------------|---------------|-----------------|----------------|
| 23 / 0600       | 24.4          | 71.9           | 952           | 100             | "              |
| 23 / 1200       | 25.1          | 72.1           | 952           | 100             | "              |
| 23 / 1800       | 25.9          | 72.3           | 952           | 100             | "              |
| 24 / 0000       | 26.6          | 72.4           | 945           | 100             | "              |
| 24 / 0600       | 27.5          | 72.6           | 942           | 95              | "              |
| 24 / 1200       | 28.4          | 72.8           | 947           | 95              | "              |
| 24 / 1800       | 29.1          | 72.9           | 943           | 90              | "              |
| 25 / 0000       | 29.7          | 72.9           | 947           | 85              | "              |
| 25 / 0600       | 30.3          | 72.9           | 954           | 75              | "              |
| 25 / 1200       | 30.8          | 73.0           | 961           | 70              | "              |
| 25 / 1800       | 31.4          | 73.1           | 966           | 70              | "              |
| 26 / 0000       | 32.0          | 73.1           | 966           | 70              | "              |
| 26 / 0600       | 32.6          | 73.1           | 970           | 65              | "              |
| 26 / 1200       | 33.3          | 73.1           | 970           | 65              | "              |
| 26 / 1800       | 33.9          | 73.1           | 975           | 65              | "              |
| 27 / 0000       | 34.4          | 73.0           | 975           | 65              | "              |
| 27 / 0600       | 34.9          | 72.9           | 976           | 65              | "              |
| 27 / 1200       | 35.4          | 72.8           | 977           | 65              | "              |
| 27 / 1800       | 36.0          | 72.6           | 979           | 65              | "              |
| 28 / 0000       | 36.6          | 72.2           | 979           | 65              | "              |
| 28 / 0600       | 36.7          | 71.3           | 982           | 60              | tropical storm |
| 28 / 1200       | 36.8          | 70.0           | 982           | 60              | "              |
| 28 / 1800       | 36.8          | 68.6           | 985           | 55              | "              |
| 29 / 0000       | 36.9          | 66.8           | 985           | 55              | "              |
| 29 / 0600       | 37.0          | 64.7           | 987           | 50              | "              |
| 29 / 1200       | 37.2          | 61.7           | 988           | 50              | "              |
| 29 / 1800       | 37.4          | 59.0           | 988           | 50              | "              |
| 30 / 0000       | 38.1          | 55.6           | 988           | 50              | "              |
| 30 / 0600       | 39.1          | 52.2           | 988           | 50              | "              |
| 30 / 1200       | 40.0          | 48.8           | 988           | 50              | "              |
| 30 / 1800       | 41.2          | 45.6           | 991           | 45              | extratropical  |

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage                              |
|-----------------|---------------|----------------|---------------|-----------------|------------------------------------|
| 01 / 0000       | 42.2          | 42.6           | 994           | 45              | "                                  |
| 01 / 0600       | 43.4          | 39.4           | 996           | 45              | "                                  |
| 01 / 1200       | 44.9          | 35.5           | 999           | 45              | "                                  |
| 01 / 1800       | 46.5          | 31.0           | 1003          | 45              | "                                  |
| 02 / 0000       | 47.5          | 26.5           | 1005          | 40              | "                                  |
| 02 / 0600       | 48.0          | 22.0           | 1012          | 40              | "                                  |
| 02 / 1200       | 48.0          | 17.0           | 1016          | 30              | "                                  |
| 02 / 1800       |               |                |               |                 | dissipated                         |
| 20 / 0300       | 17.3          | 64.7           | 908           | 150             | maximum wind and minimum pressure  |
| 19 / 0115       | 15.4          | 61.3           | 922           | 145             | landfall in Dominica               |
| 20 / 1015       | 18.0          | 65.9           | 920           | 135             | landfall near Yabucoa, Puerto Rico |



Table 3. Selected ship reports with winds of at least 34 kt for Hurricane Maria, 16–30 September 2017.

| Date/Time (UTC) | Ship call sign | Latitude (°N) | Longitude (°W) | Wind dir/speed (kt) | Pressure (mb) |
|-----------------|----------------|---------------|----------------|---------------------|---------------|
| 19 / 0600       | C6FM9          | 12.5          | 62.6           | 290 / 36            | 1015.3        |
| 23 / 1900       | C6VV8          | 23.1          | 74.6           | 270 / 35            | 1007.6        |
| 23 / 2100       | C6VV8          | 23.6          | 74.5           | 270 / 40            | 1007.6        |
| 25 / 0900       | H3VU           | 36.1          | 75.3           | 050 / 36            | 1014.7        |
| 25 / 1400       | C6VV8          | 33.5          | 76.4           | 050 / 45            | 1008.7        |
| 25 / 1600       | C6VV8          | 33.9          | 76.1           | 050 / 40            | 1008.7        |
| 25 / 1800       | 9V9290         | 33.9          | 76.4           | 020 / 35            | 1011          |
| 25 / 1800       | C6VV8          | 34.3          | 75.7           | 020 / 35            | 1010.6        |
| 25 / 2200       | C6VV8          | 35.5          | 74.8           | 050 / 35            | 1011.6        |
| 26 / 1200       | ELQQ4          | 33.9          | 76.6           | 330 / 35            | 1003          |
| 27 / 0600       | WMCS           | 33.7          | 67.8           | 150 / 38            | 1010.2        |
| 27 / 0900       | WMCS           | 33.1          | 68.4           | 160 / 38            | 1009          |
| 27 / 1800       | V7SX3          | 37.4          | 69.8           | 140 / 40            | 1002.9        |
| 29 / 0200       | ZCEK6          | 43.4          | 64.3           | 340 / 35            | 1003.4        |
| 29 / 0600       | PBIG           | 40.9          | 70.9           | 010 / 35            | 1012          |
| 29 / 0600       | ZCDM6          | 43.6          | 64.6           | 330 / 36            | 1005.8        |
| 29 / 0800       | ZCEK6          | 41.9          | 66             | 350 / 40            | 1008          |
| 29 / 1700       | VRGP2          | 35.8          | 60.1           | 210 / 55            | 1014          |



| Location   | Minimum Sea Level Pressure |             | Maximum Surface Wind Speed    |                             |              | Storm surge (ft) <sup>c</sup> | Storm tide (ft) <sup>d</sup> | Estimated Inundation (ft) <sup>e</sup> | Total rain (in) |
|--|----------------------------|-------------|-------------------------------|-----------------------------|--------------|-------------------------------|------------------------------|--|-----------------|
|  | Date/ time (UTC)           | Press. (mb) | Date/ time (UTC) <sup>a</sup> | Sustained (kt) <sup>b</sup> | Gust (kt)    |                               |                              |  |                 |
| Antigua and Barbuda                                    |                            |             |                               |                             |              |                               |                              |  |                 |
| Automated Weather Observation Systems (AWOS) Sites     |                            |             |                               |                             |              |                               |                              |  |                 |
| Antigua<br>(17.14 N 61.79W)                            |                            |             | 19/0900                       | 37                          | 45<br>(10 m) |                               |                              |  |                 |
| National Ocean Service (NOS) Sites                     |                            |             |                               |                             |              |                               |                              |  |                 |
| Barbuda (BARA9)<br>(17.59N 61.82W)                     | 19/1718                    | 1005.8      |                               |                             |              | 0.65                          |                              | 0.7                                    |                 |
| Dominica   |                            |             |                               |                             |              |                               |                              |  |                 |
| International Civil Aviation Organization (ICAO) Sites |                            |             |                               |                             |              |                               |                              |  |                 |
| Canefield Airport (TDCF)<br>(15.34N 61.39W)            | 19/0210                    | 948         | 19/0140                       | 73<br>(10 min)              | 116          |                               |                              |  | 17.8            |
| Douglas–Charles Airport (TDPD)<br>(15.55N 61.30W)      | 19/0240                    | 960         | 19/0240                       | 130<br>(10 min)             |              |                               |                              |  | 2.4             |
| Cophall  |                            |             |                               |                             |              |                               |                              |  | 22.8            |
| Wet Area Belles  | 19/0230                    | 953         | 19/0200                       | 56<br>(10 min)              | 73           |                               |                              |  | 22.0            |
| Salisbury<br>(15.44N 61.44W)                           |                            |             |                               |                             |              |                               |                              |  | 18.5            |
| Pond Casse   |                            |             |                               |                             |              |                               |                              |  | 14.6            |
| Milton Estate  |                            |             |                               |                             |              |                               |                              |  | 3.9             |
| Dominican Republic                                     |                            |             |                               |                             |              |                               |                              |  |                 |
| ICAO Sites   |                            |             |                               |                             |              |                               |                              |  |                 |
| Arroyo Barril (MDAB)<br>(19.20N 69.43W)                | 21/1000                    | 995.8       | 21/1500                       | 40                          | 74<br>(5 m)  |                               |                              |  | 12.2            |
| Samana El Catey (MDCY)<br>(19.27N 69.73W)              | 21/0900                    | 992.8       | 21/1500                       | 34                          | 65<br>(20 m) |                               |                              |  | 5.9             |
| Punta Cana (MDPC)<br>(18.57N 68.36W)                   | 21/0100                    | 993.0       | 21/0900                       | 33                          | 57<br>(19 m) |                               |                              |  | 9.8             |
| Public/Other   |                            |             |                               |                             |              |                               |                              |  |                 |
| Sabana de la Mar<br>(19.05N 69.38W)                    | 21/1200                    | 996.9       | 21/1500                       | 16                          | 59<br>(3 m)  |                               |                              |  | 12.9            |
| Guadeloupe   |                            |             |                               |                             |              |                               |                              |  |                 |
| AWOS Sites   |                            |             |                               |                             |              |                               |                              |  |                 |
| Guadeloupe<br>(16.27N 61.53W)                          |                            |             | 19/0830                       | 40                          | 56<br>(10 m) |                               |                              |  |                 |
| ICAO Sites   |                            |             |                               |                             |              |                               |                              |  |                 |



| Location   | Minimum Sea Level Pressure |             | Maximum Surface Wind Speed    |                             |              | Storm surge (ft) <sup>c</sup> | Storm tide (ft) <sup>d</sup> | Estimated Inundation (ft) <sup>e</sup> | Total rain (in) |
|--|----------------------------|-------------|-------------------------------|-----------------------------|--------------|-------------------------------|------------------------------|--|-----------------|
|  | Date/ time (UTC)           | Press. (mb) | Date/ time (UTC) <sup>a</sup> | Sustained (kt) <sup>b</sup> | Gust (kt)    |                               |                              |  |                 |
| Pointe-a-Pitre Le Raizet Airport (TFFR)<br>(16.26N 61.52W) | 19/0400                    | 997.6       | 19/0500                       | 45                          | 67<br>(11 m) |                               |                              |  | 10.2            |
| Grand Bourg Les Basses Airport (TFFM)<br>(15.87N 61.27W)   | 18/2300                    | 996.6       | 18/2200                       | 41 <sup>f</sup>             | 66<br>(10 m) |                               |                              |  | 2.1             |
| La Desirade Grande Anse Airport (TFFA)<br>(16.34N 61.00W)  | 19/0200                    | 1003.6      | 18/2200                       | 52 <sup>f</sup>             | 67<br>(26 m) |                               |                              |  |                 |
| Baillif Airport (TFFB)<br>(16.01N 61.74W)                  |                            |             | 19/0200                       | 50                          | 80<br>(6 m)  |                               |                              |  | 10.4            |
| Gourbeyre Gros-Morne Dole<br>(16.00N 61.67W)               |                            |             | 19/0106                       |                             | 88           |                               |                              |  |                 |
| Pointe-Noire Bellevue<br>(16.23N 61.78W)                   |                            |             | 19/0236                       |                             | 86           |                               |                              |  |                 |
| North Carolina   |                            |             |                               |                             |              |                               |                              |  |                 |
| Weatherflow Sites  |                            |             |                               |                             |              |                               |                              |  |                 |
| KHK Resort (XRTH)<br>(35.58N 75.47W)                       | 27/1750                    | 998.1       | 27/1655                       | 42                          | 51<br>(16 m) |                               |                              |  |                 |
| Oregon Inlet CG (XORE)<br>(35.77N 75.53W)                  | 27/0640                    | 999.7       | 27/1405                       | 41                          | 48<br>(10 m) |                               |                              |  |                 |
| Jennettes Pier (XJNP)<br>(35.911N 75.59W)                  | 27/1805                    | 1000.8      | 27/1600                       | 41                          | 48<br>(18 m) |                               |                              |  |                 |
| Stumpy Point Tower (XSTP)<br>(35.71N 75.77W)               |                            |             | 27/1805                       | 39                          | 51<br>(98 m) |                               |                              |  |                 |
| Pamlico Sound (XPM2)<br>(35.43N 75.83W)                    | 27/0731                    | 997.7       | 26/1816                       | 36                          | 46<br>(13 m) |                               |                              |  |                 |
| REAL Slick (XSLK)<br>(35.57N 75.49W)                       | 27/0735                    | 999.3       | 27/1555                       | 35                          | 47<br>(6 m)  |                               |                              |  |                 |
| Alligator Bridge (XALI)<br>(35.90N 76.01W)                 | 27/0739                    | 1000.8      | 26/2254                       | 35                          | 46<br>(12 m) |                               |                              |  |                 |
| Frisco Woods (XFRI)<br>(35.25N 75.63W)                     | 27/0745                    | 999.0       | 27/0145                       | 35                          | 45<br>(6 m)  |                               |                              |  |                 |
| Hatteras High (XHAT)<br>(35.26N 75.55W)                    | 27/0521                    | 998.2       | 27/1616                       | 34                          | 44<br>(22 m) |                               |                              |  |                 |
| Avon Ocean (XAVO)<br>(35.35N 75.50W)                       | 27/0719                    | 998.7       | 26/2044                       | 34                          | 44<br>(12 m) |                               |                              |  |                 |
| Ocracoke (XOCR)<br>(35.14N 76.01W)                         | 27/0725                    | 1000.4      | 26/1640                       | 34                          | 42<br>(8 m)  |                               |                              |  |                 |
| National Data Buoy Center (NDBC) Sites                     |                            |             |                               |                             |              |                               |                              |  |                 |
| Diamond Shoals (41025)<br>(35.01N 75.40W)                  | 27/0650                    | 997.1       | 27/0550                       | 36<br>(1 min)               | 47<br>(5 m)  |                               |                              |  |                 |
| NOS Sites  |                            |             |                               |                             |              |                               |                              |  |                 |

| Location  | Minimum Sea Level Pressure |                    | Maximum Surface Wind Speed   |                             |                          | Storm surge (ft) <sup>c</sup> | Storm tide (ft) <sup>d</sup> | Estimated Inundation (ft) <sup>e</sup> | Total rain (in) |
|---|----------------------------|--------------------|------------------------------|-----------------------------|--------------------------|-------------------------------|------------------------------|--|-----------------|
|   | Date/time (UTC)            | Press. (mb)        | Date/time (UTC) <sup>a</sup> | Sustained (kt) <sup>b</sup> | Gust (kt)                |                               |                              |  |                 |
| USCG Station Hatteras (HCGN7)<br>(35.21N 75.70W)          | 27/0700                    | 1000.7             | 26/2000                      | 36                          | 44<br>(10 m)             | 2.85                          | 2.94                         | 2.7                                    |                 |
| Duck (DUKN7)<br>(36.18N 75.75W)                           | 27/1818                    | 1001.7             | 27/1130                      | 38                          | 44<br>(16 m)             | 2.11                          | 3.24                         | 1.7                                    |                 |
| Oregon Inlet Marina (ORIN7)<br>(35.80N 75.55W)            | 27/0654                    | 1001.0             | 27/0724                      | 30                          | 43<br>(8 m)              | 1.75                          | 1.92                         | 1.4                                    |                 |
| Beaufort (BFTN7)<br>(34.72N 76.67W)                       | 27/0700                    | 1003.7             | 26/1830                      | 29                          | 41<br>(9 m)              | 1.54                          | 2.84                         | 1.4                                    |                 |
| Wrightsville Beach (JMPN7)<br>(34.21N 77.79W)             | 26/2130                    | 1006.4             | 29/0912                      | 26                          | 29<br>(15 m)             | 1.59                          | 3.19                         | 1.4                                    |                 |
| Wilmington (WLON7)<br>(34.23N 77.95W)                     | 27/1912                    | 1007.3             |                              |                             |                          | 1.79                          |                              | 0.9                                    |                 |
| <b>Public/Other</b>                                       |                            |                    |                              |                             |                          |                               |                              |  |                 |
| Corbina<br>(35.60N 75.47W)                                |                            |                    | 27/1754                      | 39                          | 51                       |                               |                              |  |                 |
| Kill Devil Hills<br>(36.01N 75.66W)                       | 27/0644                    | 1003               | 27/1629                      | 35                          | 36                       |                               |                              |  |                 |
| <b>Puerto Rico</b>  |                            |                    |                              |                             |                          |                               |                              |  |                 |
| <b>Weatherflow Sites</b>                                  |                            |                    |                              |                             |                          |                               |                              |  |                 |
| Isla Culebrita Light (XCUL)<br>(18.31N 65.23W)            | 20/0839                    | 957.8              | 20/0844                      | 101                         | 120<br>(83 m)            |                               |                              |  |                 |
| San Juan NAVAID (XJUA)<br>(18.46N 66.13W)                 |                            |                    | 20/1130                      | 79 <sup>f</sup>             | 95<br>(14 m)             |                               |                              |  |                 |
| Gurabo (XGUR)<br>(18.26N 65.99W)                          | 20/1130                    | 943.4              | 20/1010                      | 70 <sup>f</sup>             | 104<br>(62 m)            |                               |                              |  |                 |
| Del Rey Marina (XREY)<br>(18.29N 65.63W)                  | 20/0700                    | 995.3              | 20/0840                      | 69 <sup>f</sup>             | 87<br>(10 m)             |                               |                              |  |                 |
| Yabucoa-EI Negro (XYAB)<br>(18.05N 65.83W)                | 20/0931                    | 937.5              | 20/0906                      | 66 <sup>f</sup>             | 102<br>(13 m)            |                               |                              |  |                 |
| Las Mareas (XMRS)<br>(17.93N 66.16W)                      |                            |                    | 20/1214                      | 94                          | 109<br>(11 m)            |                               |                              |  |                 |
| <b>Puerto Rico Seismic Network Sites</b>                  |                            |                    |                              |                             |                          |                               |                              |  |                 |
| Yabucoa Harbor (YABP4)<br>(18.06N 65.83W)                 |                            |                    | 20/1124                      | 71 <sup>f</sup>             | 98 <sup>f</sup><br>(6 m) | 5.44 <sup>f</sup>             |                              | 5.3 <sup>f</sup>                       |                 |
| Fajardo (FRDP4)<br>(18.34N 65.63W)                        | 20/0848                    | 977.4 <sup>f</sup> | 20/0848                      | 63 <sup>f</sup>             | 85 <sup>f</sup><br>(6 m) | 3.17 <sup>f</sup>             |                              | 2.2 <sup>f</sup>                       |                 |
| Isabel Segunda, Vieques Island (VQSP4)<br>(18.15N 65.44W) |                            |                    | 20/0748                      | 44 <sup>f</sup>             | 89 <sup>f</sup><br>(6 m) | 2.86                          |                              | 2.0                                    |                 |

[illegible]





| Location  | Minimum Sea Level Pressure |             | Maximum Surface Wind Speed   |                             |           | Storm surge (ft) <sup>c</sup> | Storm tide (ft) <sup>d</sup> | Estimated Inundation (ft) <sup>e</sup> | Total rain (in) |
|---|----------------------------|-------------|------------------------------|-----------------------------|-----------|-------------------------------|------------------------------|--|-----------------|
|   | Date/time (UTC)            | Press. (mb) | Date/time (UTC) <sup>a</sup> | Sustained (kt) <sup>b</sup> | Gust (kt) |                               |                              |  |                 |
| Lares (LARP4)<br>(18.29N 66.88W)  |                            |             |                              |                             |           |                               |                              |  | 6.91            |
| Naguabo (NGIP4)<br>(18.21N 65.74W)  |                            |             |                              |                             |           |                               |                              |  | 6.31            |
| Caguas 4 NW (BZBP4)<br>(18.27N 66.10W)                                      |                            |             |                              |                             |           |                               |                              |  | 6.14            |
| <b>Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites</b> |                            |             |                              |                             |           |                               |                              |  |                 |
| Juncos 0.3 WSW<br>(PR-JN-1)<br>(18.22N 65.92W)                              |                            |             |                              |                             |           |                               |                              |  | 25.0            |
| Trujillo Alto 0.8 WSW<br>(PR-TR-2)<br>(18.36N 66.03W)                       |                            |             |                              |                             |           |                               |                              |  | 15.43           |
| Rincon 2.8 SE<br>(PR-RN-4)<br>(18.32N 67.22W)                               |                            |             |                              |                             |           |                               |                              |  | 11.78           |
| Juana Diaz 2.9 SW<br>(PR-JD-2)<br>(18.03N 66.54W)                           |                            |             |                              |                             |           |                               |                              |  | 8.78            |
| Lajas 2.2 E (PR-LJ-2)<br>(18.04N 67.03W)                                    |                            |             |                              |                             |           |                               |                              |  | 8.52            |
| Cabo Rojo 0.8 SE<br>(PR-CR-1)<br>(18.08N 67.14W)                            |                            |             |                              |                             |           |                               |                              |  | 7.69            |
| Aguadilla 5.5 NNE<br>(PR-AL-3)<br>(18.51N 67.11W)                           |                            |             |                              |                             |           |                               |                              |  | 6.21            |
| Fajardo 0.4 NE<br>(PR-FJ-2)<br>(18.34N 65.65W)                              |                            |             |                              |                             |           |                               |                              |  | 5.7             |
| <b>USGS High Water Marks</b>  |                            |             |                              |                             |           |                               |                              |  |                 |
| Arrayao, Punta Santiago<br>(PRHUM23681)<br>(18.17N 65.74W)                  |                            |             |                              |                             |           |                               | 9.52                         | 4.9                                    |                 |
| Playa de Naguabo<br>(PRHUM23708)<br>(18.19N 65.73W)                         |                            |             |                              |                             |           |                               | 8.76                         | 1.4                                    |                 |
| Playa de Naguabo<br>(PRHUM23697)<br>(18.18N 65.71W)                         |                            |             |                              |                             |           |                               | 8.75                         | 2.9                                    |                 |
| Playa de Guayanes<br>(PRYAB20635)<br>(18.06N 65.82W)                        |                            |             |                              |                             |           |                               | 8.70                         |  |                 |
| Punta Santiago<br>(PRHUM23667)<br>(18.16N 65.75W)                           |                            |             |                              |                             |           |                               | 8.48                         | 5.1                                    |                 |

| Location   | Minimum Sea Level Pressure |             | Maximum Surface Wind Speed    |                             |           | Storm surge (ft) <sup>c</sup> | Storm tide (ft) <sup>d</sup> | Estimated Inundation (ft) <sup>e</sup> | Total rain (in) |
|--|----------------------------|-------------|-------------------------------|-----------------------------|-----------|-------------------------------|------------------------------|--|-----------------|
|  | Date/ time (UTC)           | Press. (mb) | Date/ time (UTC) <sup>a</sup> | Sustained (kt) <sup>b</sup> | Gust (kt) |                               |                              |  |                 |
| Marina Puerto Chico (PRFAJ20587)<br>(18.35N 65.64W)              |                            |             |                               |                             |           |                               | 5.51                         |  |                 |
| Playa Medio Mundo (PRCEI22309)<br>(18.27N 65.63W)                |                            |             |                               |                             |           |                               | 5.23                         | 2.5                                    |                 |
| USGS Storm Tide Sensors  |                            |             |                               |                             |           |                               |                              |  |                 |
| Ocean Park Beach, San Juan (PRSAN20648)<br>(18.45N 66.04W)       |                            |             |                               |                             |           |                               | 7.95                         |  |                 |
| Villa Pesquera (PRMAU22311)<br>(17.99N 65.89W)                   |                            |             |                               |                             |           |                               | 4.26                         |  |                 |
| Juana Diaz (PRJUA22307)<br>(17.99N 66.48W)                       |                            |             |                               |                             |           |                               | 4.24                         |  |                 |
| Playa Medio Mundo (PRCEI22309)<br>(18.27N 65.63W)                |                            |             |                               |                             |           |                               | 4.21                         |  |                 |
| Villa Pesquera Beach of Patillas (PRPAT22312)<br>(17.98N 65.99W) |                            |             |                               |                             |           |                               | 4.13                         |  |                 |
| Malecon de Arroyo (PRARR22313)<br>(17.96N 66.06W)                |                            |             |                               |                             |           |                               | 3.93                         |  |                 |
| Jobos Bay (PRSAL22314)<br>(17.95N 66.23W)                        |                            |             |                               |                             |           |                               | 3.84                         |  |                 |
| Marina Puerto Chico (PRFAJ20587)<br>(18.35N 65.64W)              |                            |             |                               |                             |           |                               | 3.66                         |  |                 |
| Villa Pesquera Santa Isabel (PRSAN22316)<br>(17.96N 66.41W)      |                            |             |                               |                             |           |                               | 3.62                         |  |                 |
| Dorado Public Beach (PRDOR20633)<br>(18.48N 66.28W)              |                            |             |                               |                             |           |                               | 3.24                         |  |                 |
| Playa de Ponce (PRPON22310)<br>(17.98N 66.62W)                   |                            |             |                               |                             |           |                               | 2.69                         |  |                 |
| Saint Martin   |                            |             |                               |                             |           |                               |                              |  |                 |
| Cul-de-Sac<br>(18.05 N 63.06W)                                   |                            |             | 19/0316                       | 38 <sup>f</sup>             | 48        |                               |                              |  |                 |
| St. Eustatius  |                            |             |                               |                             |           |                               |                              |  |                 |



| Location   | Minimum Sea Level Pressure |                    | Maximum Surface Wind Speed    |                             |                           | Storm surge (ft) <sup>c</sup> | Storm tide (ft) <sup>d</sup> | Estimated Inundation (ft) <sup>e</sup> | Total rain (in) |
|--|----------------------------|--------------------|-------------------------------|-----------------------------|---------------------------|-------------------------------|------------------------------|--|-----------------|
|  | Date/ time (UTC)           | Press. (mb)        | Date/ time (UTC) <sup>a</sup> | Sustained (kt) <sup>b</sup> | Gust (kt)                 |                               |                              |  |                 |
| AWOS Sites   |                            |                    |                               |                             |                           |                               |                              |  |                 |
| St. Eustatius<br>(17.49 N 62.98W)                          |                            |                    | 19/1455                       | 37                          | 52<br>(10 m)              |                               |                              |  |                 |
| Turks and Caicos Islands                                   |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Public/Other   |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Grace Bay<br>(21.80N 72.18W)                               |                            |                    | 22/0930                       | 41                          | 48                        |                               |                              |  |                 |
| U.S. Virgin Islands  |                            |                    |                               |                             |                           |                               |                              |  |                 |
| CarlCOOS Buoys   |                            |                    |                               |                             |                           |                               |                              |  |                 |
| South of St. John<br>(41052)<br>(18.25N 64.76W)            | 20/0700                    | 992.5              | 20/0830                       | 41                          | 56<br>(4 m)               |                               |                              |  |                 |
| NOS Sites  |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Lime Tree Bay, St. Croix<br>(LTBV3)<br>(17.70N 64.75W)     | 20/0342                    | 976.1 <sup>f</sup> | 20/0330                       | 60 <sup>f</sup>             | 89 <sup>f</sup><br>(10 m) | 2.85 <sup>f</sup>             | 3.17 <sup>f</sup>            | 2.8 <sup>f</sup>                       |                 |
| Christiansted Harbor, St. Croix (CHSV3)<br>(17.75N 64.70W) | 20/0518                    | 978.4              | 20/0142                       | 43                          | 65<br>(8 m)               | 2.27                          | 2.36                         | 2.0                                    |                 |
| Lameshur Bay, St. John<br>(LAMV3)<br>(18.32N 64.72W)       | 20/0612                    | 998.2              |                               |                             |                           | 1.48                          | 1.61                         | 1.2                                    |                 |
| Weatherflow Sites  |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Sandy Point NWR, St. Croix (XCRX)<br>(17.68N 64.90W)       | 20/0538                    | 950.1              | 20/0618                       | 93                          | 119<br>(20 m)             |                               |                              |  |                 |
| Rupert Rock, St. Thomas (XRUP)<br>(18.33N 64.93W)          | 20/0701                    | 993.6              | 20/0201                       | 39 <sup>f</sup>             | 56<br>(5 m)               |                               |                              |  |                 |
| Public/Other   |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Christiansted, St. Croix (CVAV3)<br>(17.74N 64.62W)        |                            |                    | 20/0613                       | 86                          | 118                       |                               |                              |  | 5.03            |
| Virginia   |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Weatherflow Sites  |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Chesapeake Light Tower (XCLT)<br>(36.90N 75.71W)           | 27/1951                    | 998.8              | 27/1816                       | 36                          | 42<br>(41 m)              |                               |                              |  |                 |
| NDBC Buoy Sites  |                            |                    |                               |                             |                           |                               |                              |  |                 |
| Virginia Beach (44014)<br>(36.61N 74.84W)                  | 27/1750                    | 998.5              | 27/1559                       | 37<br>(1 min)               | 43<br>(5 m)               |                               |                              |  |                 |
| NOS Sites  |                            |                    |                               |                             |                           |                               |                              |  |                 |

| Location  | Minimum Sea Level Pressure |             | Maximum Surface Wind Speed   |                             |              | Storm surge (ft) <sup>c</sup> | Storm tide (ft) <sup>d</sup> | Estimated Inundation (ft) <sup>e</sup> | Total rain (in) |
|---|----------------------------|-------------|------------------------------|-----------------------------|--------------|-------------------------------|------------------------------|--|-----------------|
|   | Date/time (UTC)            | Press. (mb) | Date/time (UTC) <sup>a</sup> | Sustained (kt) <sup>b</sup> | Gust (kt)    |                               |                              |  |                 |
| Sewells Point (SWPV2)<br>(36.94N 76.33W)                | 27/2030                    | 1005.8      |                              |                             |              | 1.94                          | 2.83                         | 1.7                                    |                 |
| Chesapeake Bay Bridge Tunnel (CHBV2)<br>(37.03N 76.08W) | 27/2018                    | 1005.0      | 26/1900                      | 31                          | 36           | 1.87                          |                              | 1.6                                    |                 |
| Wachapreague (WAHV2)<br>(37.61N 75.69W)                 | 27/2042                    | 1004.9      | 27/1742                      | 28                          | 35<br>(9 m)  | 1.96                          | 3.22                         | 1.4                                    |                 |
| Kiptopeke (KPTV2)<br>(37.17N 75.99W)                    |                            |             | 27/1624                      | 21                          | 27<br>(10 m) | 1.66                          | 2.37                         | 1.3                                    |                 |
| <b>Offshore</b>   |                            |             |                              |                             |              |                               |                              |  |                 |
| <b>NDBC Buoy Sites</b>                                  |                            |             |                              |                             |              |                               |                              |  |                 |
| Caribbean Valley (42060)<br>(16.41N 63.19W)             | 19/1500                    | 955.7       | 19/1442                      | 74<br>(1 min)               | 82<br>(4 m)  |                               |                              |  |                 |
| NE Bahamas (41047)<br>(27.52N 71.53W)                   | 24/0630                    | 987.4       | 24/0154                      | 58<br>(1 min)               | 74<br>(4 m)  |                               |                              |  |                 |
| South Hatteras (41002)<br>(31.76N 74.84W)               | 26/0250                    | 992.4       | 25/2350                      | 41<br>(5 min)               | 52<br>(5 m)  |                               |                              |  |                 |
| East Bahamas (41046)<br>(23.83N 68.42W)                 | 22/2210                    | 1004.9      | 22/2055                      | 37<br>(1 min)               | 45<br>(4 m)  |                               |                              |  |                 |
| West Bermuda (41048)<br>(31.86N 69.59W)                 | 25/2000                    | 1007.0      | 25/0808                      | 35<br>(1 min)               | 39<br>(5 m)  |                               |                              |  |                 |

- <sup>a</sup> Date/time is for sustained wind when both sustained and gust are listed.
- <sup>b</sup> Except as noted, sustained wind averaging periods for C-MAN and land-based reports are 2 min; buoy averaging periods are 8 min.
- <sup>c</sup> Storm surge is water height above normal astronomical tide level.
- <sup>d</sup> Storm tide is water height above the North American Vertical Datum of 1988 (NAVD88) in the continental United States, the Puerto Rico Vertical Datum of 2002 (PRVD02) in Puerto Rico, and the Virgin Islands Vertical Datum of 2009 (VIVD09) in the U.S. Virgin Islands.
- <sup>e</sup> Estimated inundation is the maximum height of water above ground. For tide gauges, the height of the water above Mean Higher High Water (MHHW) is used as a proxy for inundation.
- <sup>f</sup> Incomplete Data



Table 5. Number of hours in advance of the formation of Maria associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the “Low” category do not include forecasts of a 0% chance of genesis.

|                  | Hours Before Genesis |                  |
|------------------|----------------------|------------------|
|                  | 48-Hour Outlook      | 120-Hour Outlook |
| Low (<40%)       | 60                   | 60               |
| Medium (40%-60%) | 30                   | 54               |
| High (>60%)      | 18                   | 42               |

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Maria. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

|                | Forecast Period (h) |             |             |             |             |             |              |
|----------------|---------------------|-------------|-------------|-------------|-------------|-------------|--------------|
|                | 12                  | 24          | 36          | 48          | 72          | 96          | 120          |
| OFCL           | <b>12.9</b>         | <b>20.5</b> | <b>26.8</b> | <b>35.8</b> | <b>58.3</b> | <b>85.0</b> | <b>122.2</b> |
| OCD5           | 29.3                | 69.9        | 112.2       | 149.2       | 191.9       | 214.2       | 225.2        |
| Forecasts      | 55                  | 53          | 51          | 49          | 45          | 41          | 37           |
| OFCL (2012-16) | 24.9                | 39.6        | 54.0        | 71.3        | 105.8       | 155.4       | 208.9        |
| OCD5 (2012-16) | 47.3                | 103.9       | 167.8       | 230.3       | 343.1       | 442.6       | 531.0        |

Table 6b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Maria. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 6a due to the homogeneity requirement.

| Model ID  | Forecast Period (h) |      |       |             |             |             |              |
|-----------|---------------------|------|-------|-------------|-------------|-------------|--------------|
|           | 12                  | 24   | 36    | 48          | 72          | 96          | 120          |
| OFCL      | 12.6                | 19.5 | 24.6  | 33.9        | 54.3        | 85.1        | 126.6        |
| OCD5      | 28.8                | 69.1 | 107.6 | 135.1       | 163.6       | 210.7       | 220.2        |
| GFSI      | 15.2                | 24.2 | 30.8  | 35.4        | <b>47.8</b> | 95.6        | 130.5        |
| HWFI      | 21.0                | 35.2 | 44.9  | 43.7        | 55.9        | 97.5        | 163.4        |
| HMNI      | 18.4                | 30.1 | 37.3  | 44.1        | 61.4        | <b>81.4</b> | <b>107.6</b> |
| EGRI      | 15.4                | 28.9 | 41.7  | 54.8        | 73.7        | 102.1       | 134.8        |
| EMXI      | <b>12.4</b>         | 20.7 | 28.2  | 42.1        | 84.3        | 138.1       | 177.8        |
| CMCI      | 15.3                | 25.7 | 37.2  | 46.9        | 58.9        | 100.4       | 174.6        |
| CTCI      | 15.8                | 27.7 | 39.1  | 49.9        | 81.5        | 119.4       | 157.6        |
| TCON      | 14.9                | 25.0 | 33.0  | 38.3        | <b>49.3</b> | <b>79.0</b> | <b>99.0</b>  |
| TVCA      | 13.5                | 21.9 | 29.0  | 35.8        | 54.3        | <b>81.3</b> | <b>106.2</b> |
| TVCX      | 12.7                | 20.8 | 28.4  | 35.3        | 57.6        | 85.3        | <b>112.6</b> |
| GFEX      | <b>12.5</b>         | 20.1 | 25.7  | <b>33.1</b> | 58.3        | 94.3        | 135.9        |
| HCCA      | <b>12.2</b>         | 20.9 | 28.1  | 35.0        | 58.1        | <b>84.7</b> | <b>107.0</b> |
| FSSE      | 14.5                | 23.0 | 30.8  | 36.7        | 62.6        | <b>84.7</b> | <b>111.9</b> |
| AEMI      | 15.7                | 24.1 | 31.5  | 35.9        | <b>51.9</b> | 108.2       | 152.4        |
| TABS      | 36.0                | 53.5 | 50.6  | 61.5        | 62.5        | 95.6        | 144.0        |
| TABM      | 20.4                | 39.7 | 50.6  | 42.2        | 62.8        | 119.4       | 137.9        |
| TABD      | 20.4                | 39.7 | 50.6  | 42.2        | 62.8        | 119.4       | 137.9        |
| Forecasts | 47                  | 45   | 43    | 41          | 38          | 37          | 33           |

Table 7a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Maria. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

|                | Forecast Period (h) |      |      |      |             |            |            |
|----------------|---------------------|------|------|------|-------------|------------|------------|
|                | 12                  | 24   | 36   | 48   | 72          | 96         | 120        |
| OFCL           | 6.6                 | 10.6 | 13.0 | 14.5 | <b>12.2</b> | <b>8.8</b> | <b>8.1</b> |
| OCD5           | 8.5                 | 13.7 | 17.3 | 18.7 | 15.5        | 12.2       | 14.6       |
| Forecasts      | 55                  | 53   | 51   | 49   | 45          | 41         | 37         |
| OFCL (2012-16) | 5.5                 | 8.2  | 10.5 | 12.0 | 13.4        | 14.0       | 14.5       |
| OCD5 (2012-16) | 7.1                 | 10.5 | 13.0 | 15.1 | 17.4        | 18.2       | 20.6       |

Table 7b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Maria. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 7a due to the homogeneity requirement.

| Model ID  | Forecast Period (h) |             |             |             |             |            |            |
|-----------|---------------------|-------------|-------------|-------------|-------------|------------|------------|
|           | 12                  | 24          | 36          | 48          | 72          | 96         | 120        |
| OFCL      | 6.7                 | 11.0        | 13.8        | 15.2        | 12.0        | 8.4        | 7.7        |
| OCD5      | 8.5                 | 14.0        | 17.6        | 18.5        | 14.1        | 11.2       | 14.2       |
| HWFI      | 7.2                 | <b>10.4</b> | <b>13.1</b> | <b>14.3</b> | <b>11.0</b> | 8.6        | 8.8        |
| HMNI      | 7.6                 | 12.1        | 14.0        | <b>14.7</b> | 14.4        | 12.8       | 14.6       |
| DSHP      | 8.4                 | 14.7        | 19.1        | 20.4        | 16.1        | 14.1       | 15.0       |
| LGEM      | 7.3                 | 12.2        | 15.7        | 16.7        | <b>10.3</b> | <b>7.6</b> | 8.4        |
| ICON      | 7.0                 | 11.6        | 15.1        | 15.8        | <b>10.1</b> | <b>7.1</b> | 9.0        |
| IVCN      | 7.1                 | 11.7        | 15.3        | 15.9        | <b>9.9</b>  | <b>5.4</b> | <b>7.3</b> |
| CTCI      | 8.6                 | 12.6        | 17.2        | 18.1        | 13.6        | <b>7.6</b> | 8.5        |
| GFSI      | 9.9                 | 16.7        | 21.4        | 22.3        | 18.9        | 15.7       | 13.5       |
| EMXI      | 10.6                | 17.5        | 22.8        | 25.5        | 24.9        | 23.1       | 27.5       |
| HCCA      | 7.1                 | 11.5        | 14.8        | <b>15.0</b> | <b>9.9</b>  | <b>3.7</b> | <b>7.3</b> |
| FSSE      | <b>6.2</b>          | <b>9.3</b>  | <b>11.8</b> | <b>12.5</b> | <b>9.4</b>  | <b>6.1</b> | <b>4.5</b> |
| Forecasts | 49                  | 47          | 45          | 43          | 40          | 38         | 35         |

Table 8a. Wind watch and warning summary for Hurricane Maria, 16–30 September 2017.

| Date/Time (UTC) | Action   | Location                                   |
|-----------------|--|--|
| 16 / 1500       | Tropical Storm Watch issued                            | St. Lucia                                  |
| 16 / 1500       | Tropical Storm Watch issued                            | Martinique                                 |
| 16 / 1500       | Tropical Storm Watch issued                            | Guadeloupe                                 |
| 16 / 1500       | Tropical Storm Watch issued                            | Dominica                                   |
| 16 / 1800       | Tropical Storm Watch issued                            | Barbados                                   |
| 16 / 1800       | Tropical Storm Watch issued                            | St. Vincent/Grenadines                     |
| 16 / 2100       | Hurricane Watch issued                                 | Antigua/Barbuda/St. Kitts/Nevis/Montserrat |
| 17 / 0000       | Tropical Storm Watch changed to Hurricane Watch        | Guadeloupe                                 |
| 17 / 0300       | Hurricane Watch issued                                 | Saba/St. Eustatius                         |
| 17 / 0300       | Hurricane Watch issued                                 | St. Maarten                                |
| 17 / 0300       | Hurricane Watch issued                                 | Anguilla                                   |
| 17 / 0900       | Tropical Storm Watch changed to Hurricane Watch        | Dominica                                   |
| 17 / 1200       | Hurricane Watch issued                                 | St. Martin/St. Barthelemy                  |
| 17 / 1500       | Tropical Storm Watch changed to Tropical Storm Warning | St. Lucia                                  |
| 17 / 1500       | Hurricane Watch changed to Hurricane Warning           | Dominica                                   |
| 17 / 1800       | Tropical Storm Watch changed to Tropical Storm Warning | Martinique                                 |
| 17 / 1800       | Hurricane Watch changed to Hurricane Warning           | Guadeloupe                                 |
| 17 / 2100       | Tropical Storm Warning issued                          | Antigua/Barbuda                            |
| 17 / 2100       | Tropical Storm Warning issued                          | Saba/St. Eustatius                         |
| 17 / 2100       | Hurricane Watch discontinued                           | Antigua/Barbuda/St. Kitts/Nevis/Montserrat |
| 17 / 2100       | Hurricane Watch issued                                 | U.S. Virgin Islands                        |
| 17 / 2100       | Hurricane Watch issued                                 | British Virgin Islands                     |
| 17 / 2100       | Hurricane Warning issued                               | St. Kitts/Nevis/Montserrat                 |



| Date/Time (UTC) | Action   | Location   |
|-----------------|--|--|
| 18 / 0000       | Tropical Storm Warning changed to Hurricane Warning    | Martinique   |
| 18 / 0900       | Hurricane Watch issued                                 | Puerto Rico/Vieques/Culebra                                  |
| 18 / 1200       | Tropical Storm Warning changed to Hurricane Warning    | St. Lucia  |
| 18 / 1200       | Tropical Storm Warning issued                          | St. Maarten  |
| 18 / 1500       | Hurricane Watch changed to Hurricane Warning           | U.S. Virgin Islands  |
| 18 / 1500       | Hurricane Watch changed to Hurricane Warning           | British Virgin Islands                                       |
| 18 / 1500       | Tropical Storm Warning issued                          | Anguilla   |
| 18 / 1800       | Tropical Storm Watch discontinued                      | Barbados   |
| 18 / 2100       | Hurricane Watch changed to Hurricane Warning           | Puerto Rico/Vieques/Culebra                                  |
| 18 / 2100       | Hurricane Warning changed to Tropical Storm Warning    | St. Lucia  |
| 18 / 2100       | Tropical Storm Watch issued                            | Puerto Plata to Northern DR/Haiti Border, Dominican Republic |
| 18 / 2100       | Hurricane Watch issued                                 | Isla Saona to Puerto Plata, Dominican Republic               |
| 19 / 0000       | Hurricane Warning changed to Tropical Storm Warning    | Martinique   |
| 19 / 1200       | Tropical Storm Watch discontinued                      | St. Vincent/Grenadines                                       |
| 19 / 1200       | Tropical Storm Warning discontinued                    | St. Lucia  |
| 19 / 1800       | Tropical Storm Watch changed to Tropical Storm Warning | Puerto Plata to Northern DR/Haiti Border, Dominican Republic |
| 19 / 1800       | Hurricane Warning changed to Tropical Storm Warning    | Guadeloupe   |
| 19 / 1800       | Tropical Storm Warning discontinued                    | Martinique   |
| 19 / 1800       | Tropical Storm Warning issued                          | Cabo Engano to Punta Palenque, Dominican Republic            |
| 19 / 1800       | Hurricane Watch modified to                            | Isla Saona to Cabo Engano, Dominican Republic                |

| Date/Time (UTC) | Action  | Location   |
|-----------------|---|--|
| 19 / 1800       | Hurricane Warning issued                          | Cabo Engano to Puerto Plata, Dominican Republic      |
| 19 / 2100       | Tropical Storm Warning discontinued               | Antigua/Barbuda                                      |
| 19 / 2100       | Hurricane Watch issued                            | Turks and Caicos Islands/Southeastern Bahamas        |
| 19 / 2100       | Hurricane Warning discontinued                    | Dominica   |
| 20 / 0000       | Tropical Storm Warning discontinued               | Anguilla   |
| 20 / 0000       | Hurricane Watch discontinued                      | Anguilla   |
| 20 / 0000       | Hurricane Warning discontinued                    | St. Kitts/Nevis/Montserrat                           |
| 20 / 0600       | Tropical Storm Warning changed to Hurricane Watch | Saba/St. Eustatius                                   |
| 20 / 0600       | Tropical Storm Warning issued                     | Saba   |
| 20 / 0900       | Hurricane Watch changed to Hurricane Warning      | Turks and Caicos Islands/Southeastern Bahamas        |
| 20 / 0900       | Tropical Storm Warning discontinued               | Guadeloupe   |
| 20 / 0900       | Hurricane Watch discontinued                      | Saba/St. Eustatius                                   |
| 20 / 1200       | Hurricane Watch changed to Tropical Storm Warning | St. Martin/St. Barthelemy                            |
| 20 / 1500       | Tropical Storm Warning discontinued               | Saba   |
| 20 / 1500       | Tropical Storm Warning discontinued               | St. Maarten  |
| 20 / 1500       | Tropical Storm Warning discontinued               | St. Martin/St. Barthelemy                            |
| 20 / 1500       | Hurricane Watch discontinued                      | St. Maarten  |
| 20 / 2100       | Hurricane Warning discontinued                    | U.S. Virgin Islands                                  |
| 20 / 2100       | Hurricane Warning discontinued                    | British Virgin Islands                               |
| 21 / 0300       | Hurricane Warning discontinued                    | Puerto Rico/Vieques/Culebra                          |
| 21 / 1200       | Tropical Storm Watch issued                       | Central Bahamas                                      |
| 21 / 1500       | Tropical Storm Warning modified to                | Cabo Engano to Andres/Boca Chica, Dominican Republic |
| 21 / 1500       | Hurricane Watch discontinued                      | All  |

| Date/Time (UTC) | Action   | Location   |
|-----------------|--|--|
| 21 / 2100       | Tropical Storm Warning discontinued                    | Cabo Engano to Andres/Boca Chica, Dominican Republic         |
| 22 / 1200       | Tropical Storm Watch changed to Tropical Storm Warning | Central Bahamas  |
| 22 / 1500       | Tropical Storm Warning discontinued                    | Puerto Plata to Northern DR/Haiti Border, Dominican Republic |
| 22 / 1500       | Hurricane Warning discontinued                         | Cabo Engano to Puerto Plata, Dominican Republic              |
| 22 / 2100       | Hurricane Warning changed to Tropical Storm Warning    | Turks and Caicos Islands/Southeastern Bahamas                |
| 23 / 0900       | Tropical Storm Warning discontinued                    | All  |
| 24 / 2100       | Tropical Storm Watch issued                            | Surf City to North Carolina/Virginia Border                  |
| 24 / 2100       | Tropical Storm Watch issued                            | Pamlico Sound  |
| 24 / 2100       | Tropical Storm Watch issued                            | Albemarle Sound  |
| 25 / 0900       | Tropical Storm Watch changed to Tropical Storm Warning | Pamlico Sound  |
| 25 / 0900       | Tropical Storm Watch changed to Tropical Storm Warning | Albemarle Sound  |
| 25 / 0900       | Tropical Storm Watch modified to                       | Duck to North Carolina/Virginia Border                       |
| 25 / 0900       | Tropical Storm Warning issued                          | Cape Lookout to Duck   |
| 25 / 2100       | Tropical Storm Watch discontinued                      | All  |
| 25 / 2100       | Tropical Storm Warning discontinued                    | Cape Lookout to Duck   |
| 25 / 2100       | Tropical Storm Warning issued                          | Bogue Inlet to North Carolina/Virginia Border                |
| 27 / 1500       | Tropical Storm Warning modified to                     | Ocracoke Inlet to North Carolina/Virginia Border             |
| 27 / 2100       | Tropical Storm Warning modified to                     | Cape Hatteras to North Carolina/Virginia Border              |
| 28 / 0000       | Tropical Storm Warning discontinued                    | All  |

Table 8b. Storm surge watch and warning summary for Hurricane Maria, 16–30 September 2017. Note: These are only issued for the Gulf and Atlantic coasts of the continental United States.

| Date/Time (UTC) | Action   | Location                             |
|-----------------|--|--------------------------------------|
| 24 / 2100       | Storm Surge Watch issued                         | Cape Lookout to Duck, North Carolina |
| 26 / 1500       | Storm Surge Watch changed to Storm Surge Warning | Ocracoke Inlet to Cape Hatteras      |
| 27 / 1500       | Storm Surge Watch discontinued                   | west of Ocracoke Inlet               |
| 27 / 2100       | Storm Surge Watch discontinued                   | All                                  |
| 27 / 2100       | Storm Surge Warning discontinued                 | All                                  |

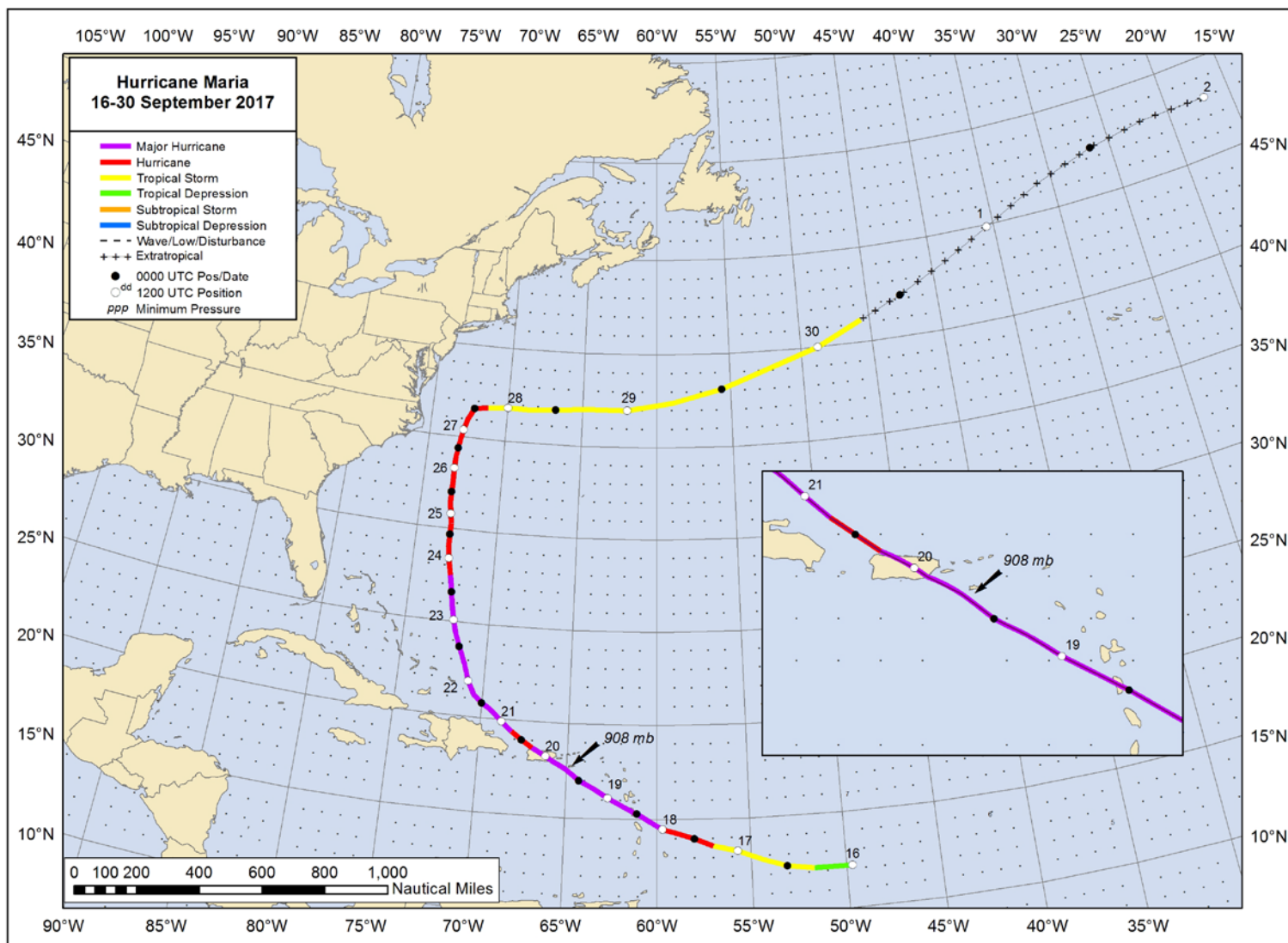


Figure 1. Best track positions for Hurricane Maria, 16–30 September 2017. Track during the extratropical stage is partially based on analyses from the NOAA Ocean Prediction Center.

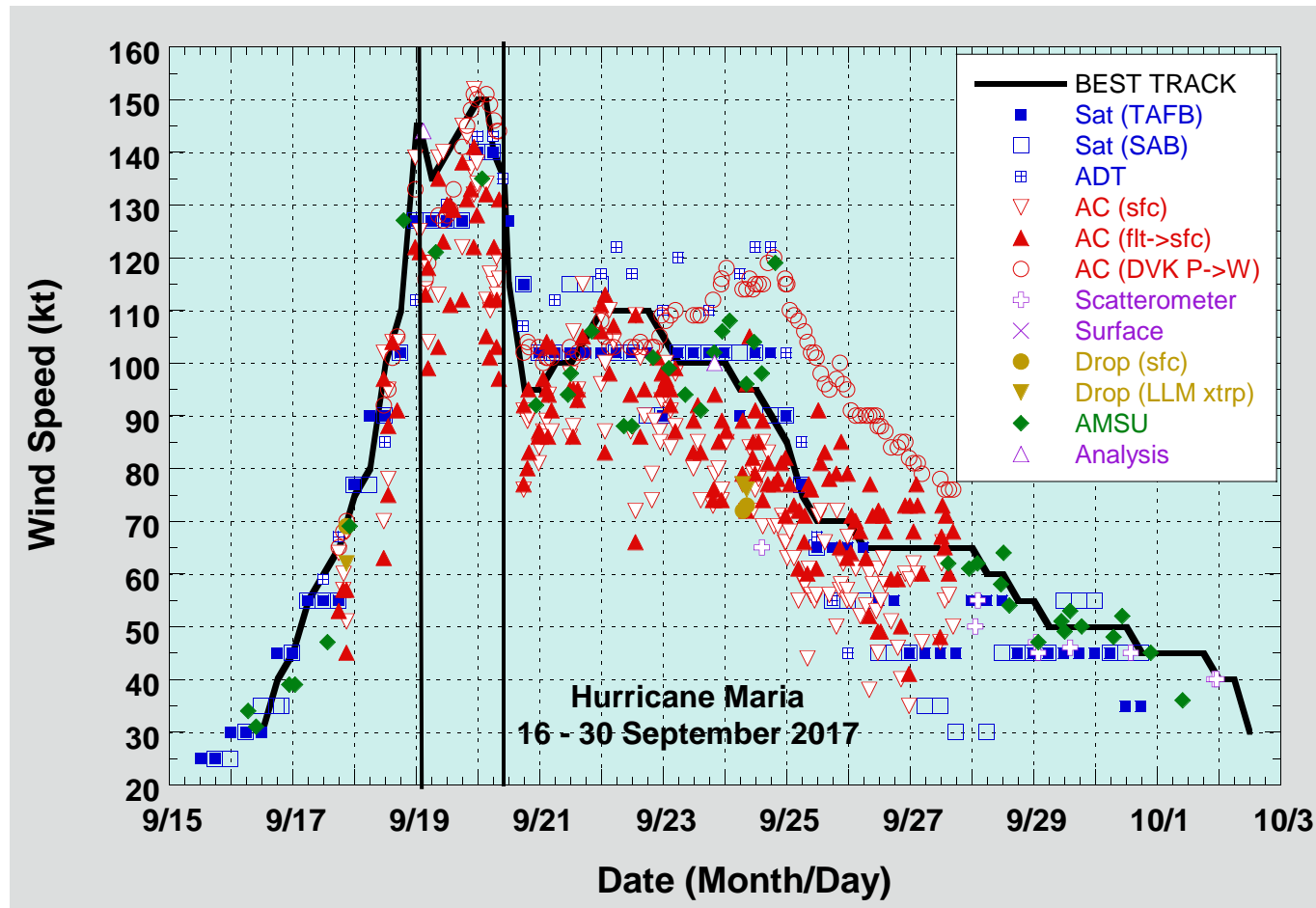


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Maria, 16–30 September 2017. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM). Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfalls.

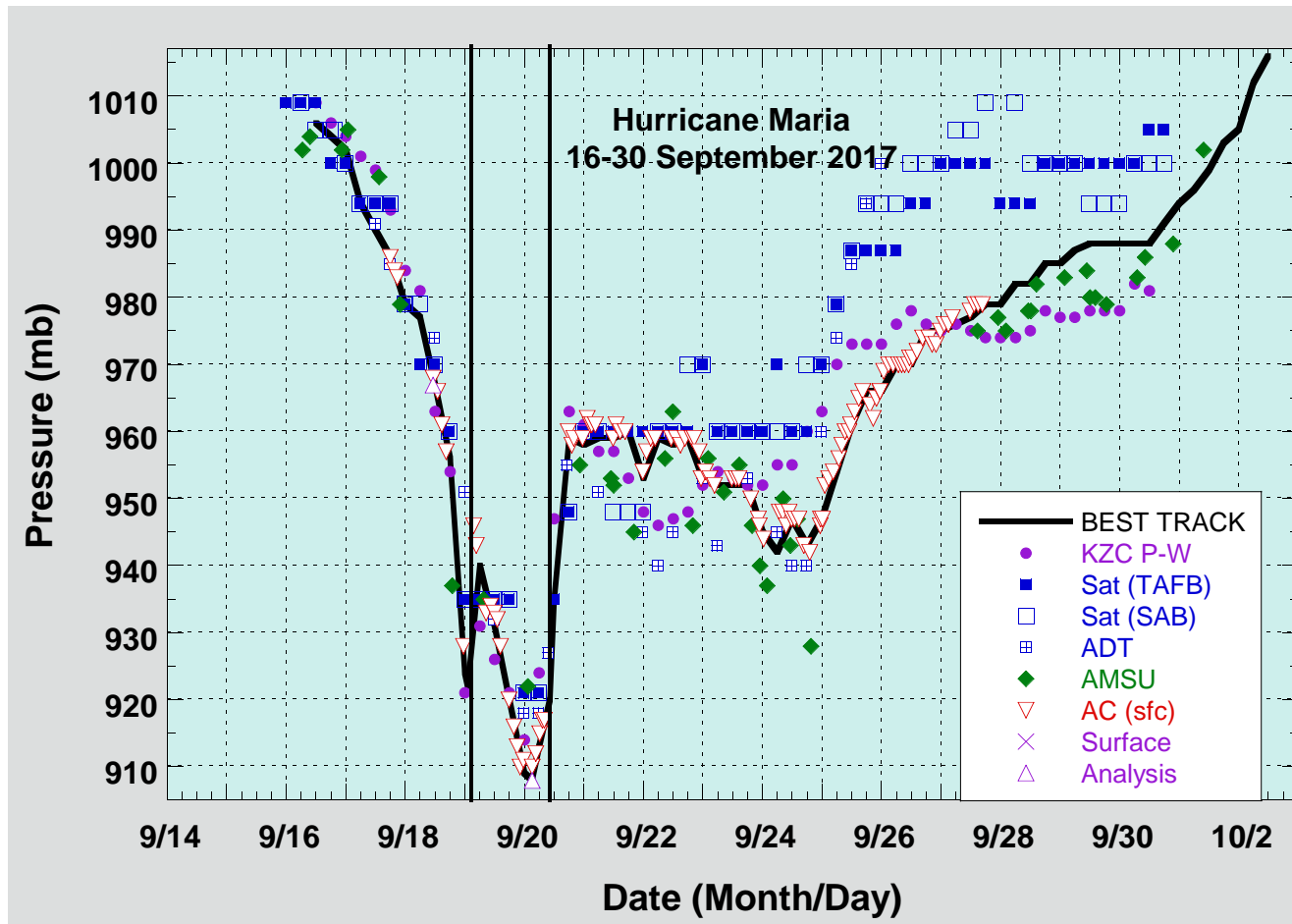


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Maria, 16–30 September 2017. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfalls.



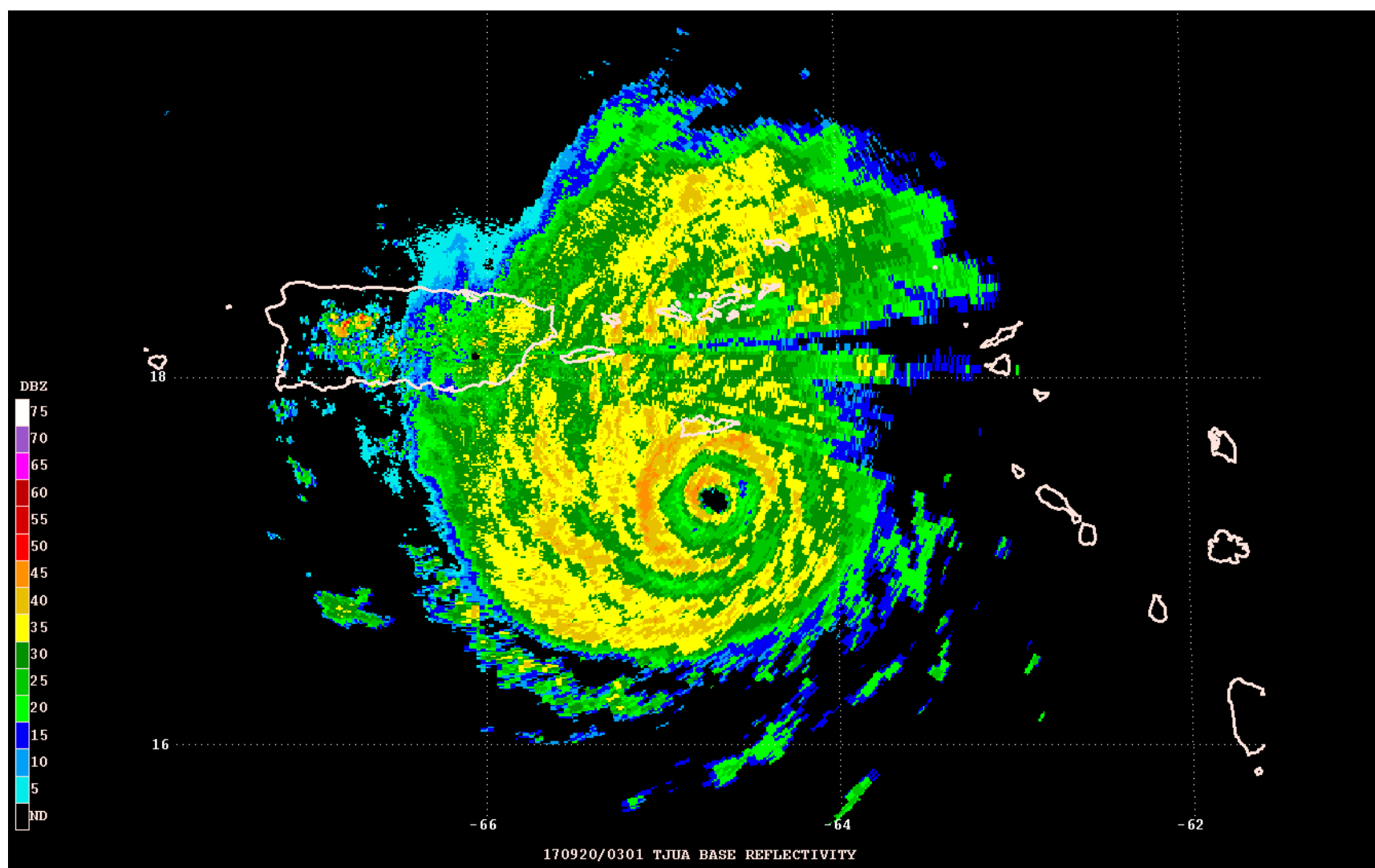


Figure 4a. San Juan WSR-88D radar image of Hurricane Maria near peak intensity at 0301 UTC 20 September, showing the beginning of an eyewall replacement.

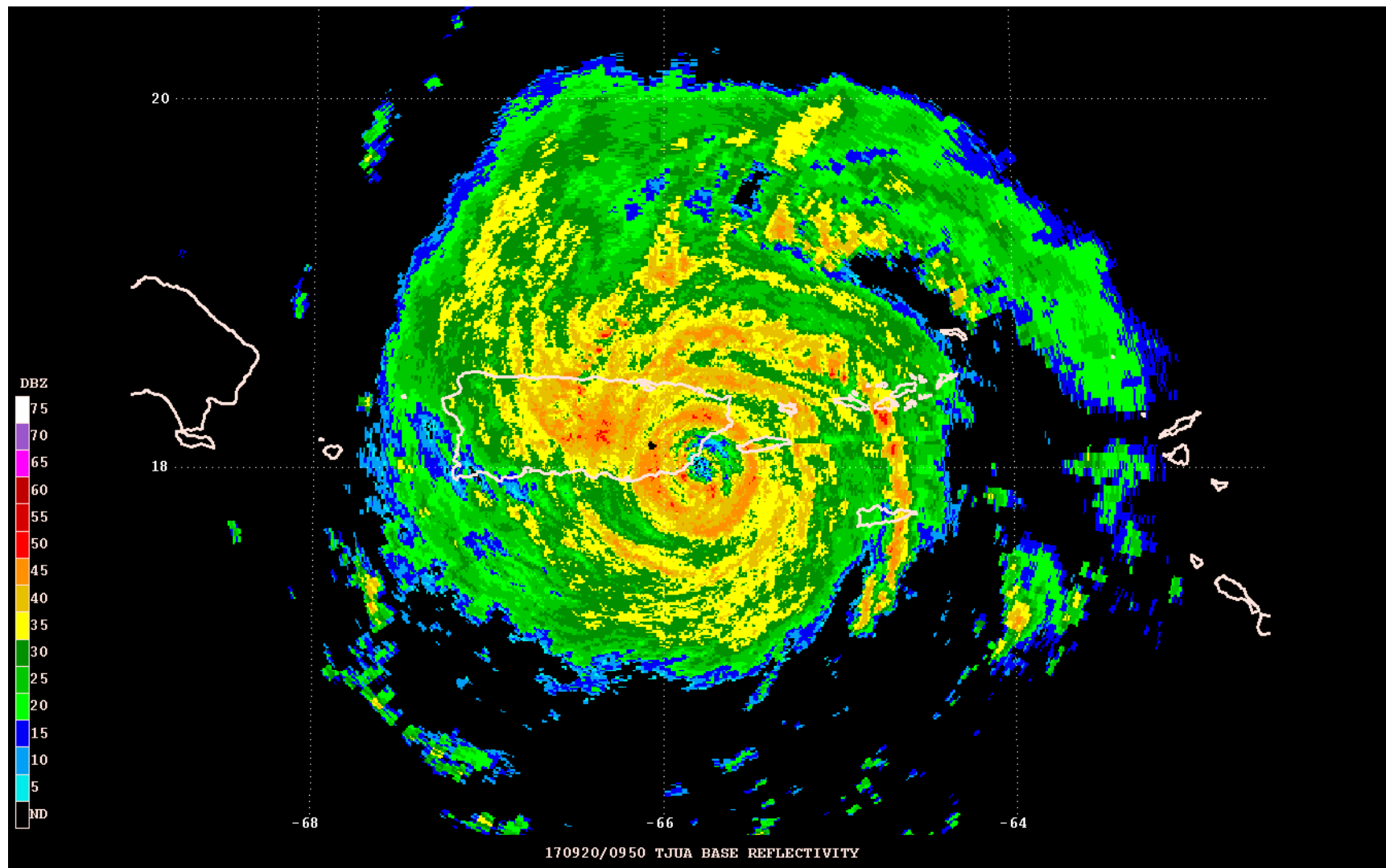


Figure 4b. San Juan WSR-88D radar image of Hurricane Maria at 0950 UTC 20 September, just before landfall in Puerto Rico, showing the more dominant outer eyewall. This was the last image from the radar before it was destroyed.

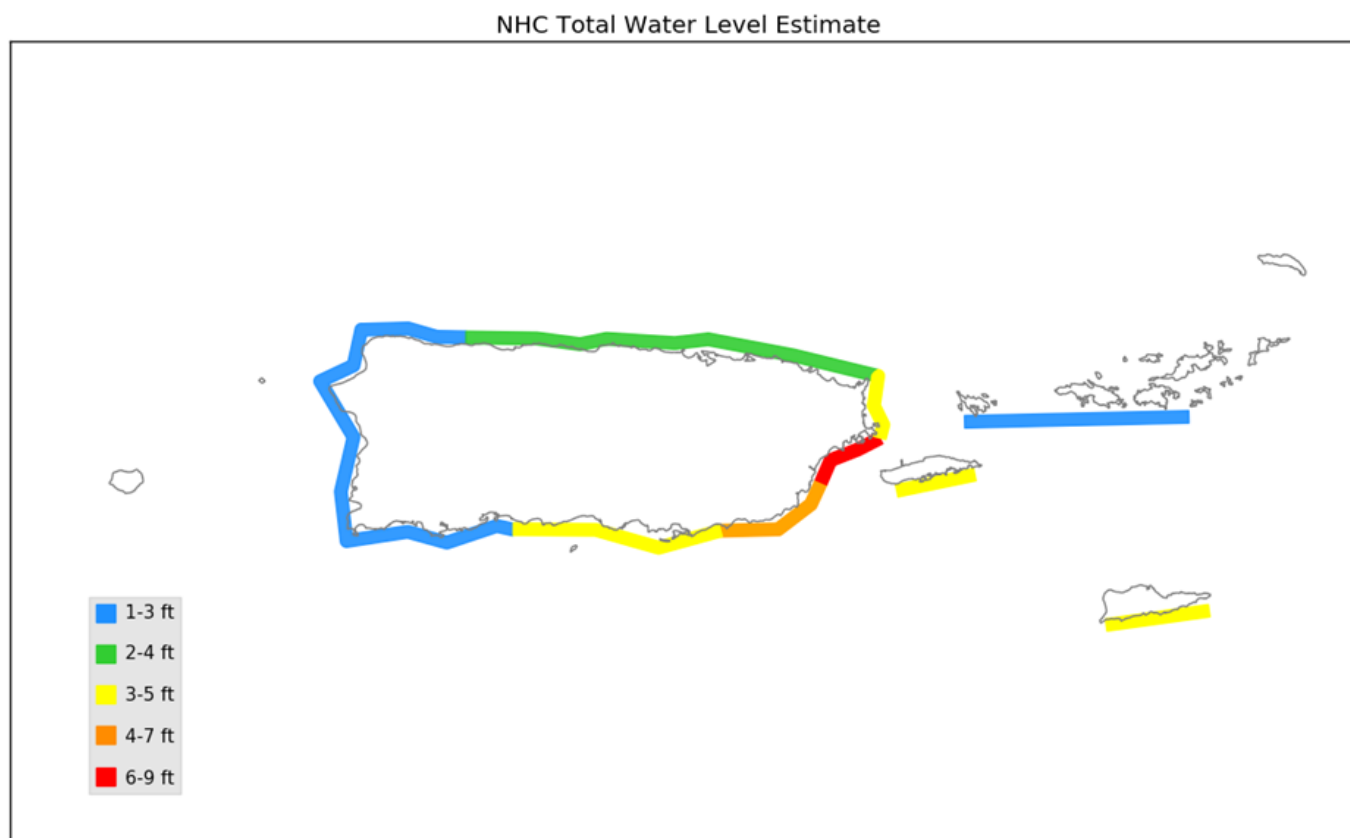


Figure 5. Estimated storm surge inundation (feet above ground level) based on an analysis of water level observations along the coasts of Puerto Rico and the U.S. Virgin Islands from Hurricane Maria. Image courtesy of the NHC Storm Surge Unit.

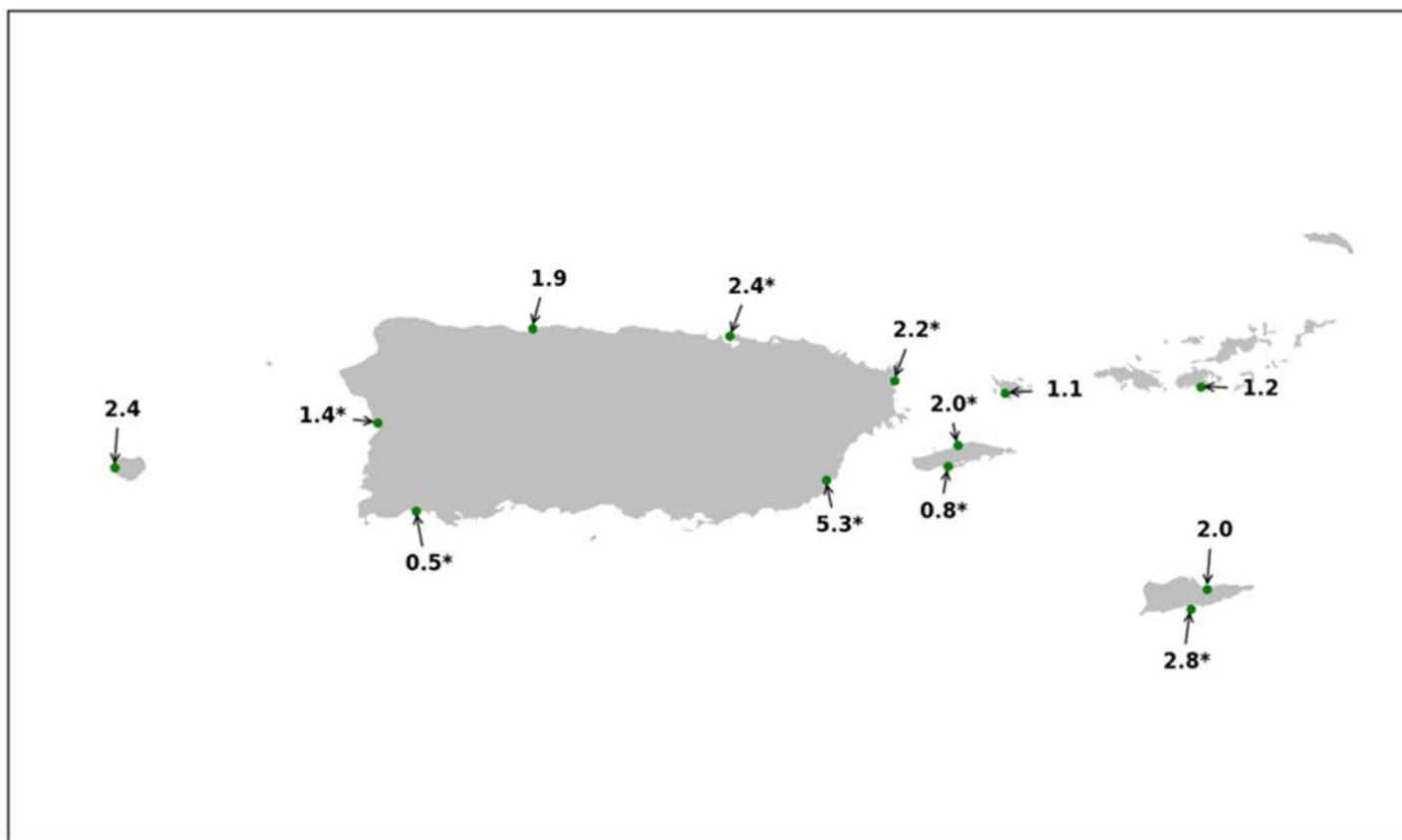


Figure 6. Maximum water levels (feet) measured from tide gauges along the coasts of Puerto Rico and the U.S. Virgin Islands during Hurricane Maria. Water levels are referenced above Mean Higher High Water (MHHW), which is used as a proxy for inundation (above ground level) on normally dry ground along the immediate coastline. Asterisks denote incomplete data. Image courtesy of the NHC Storm Surge Unit.

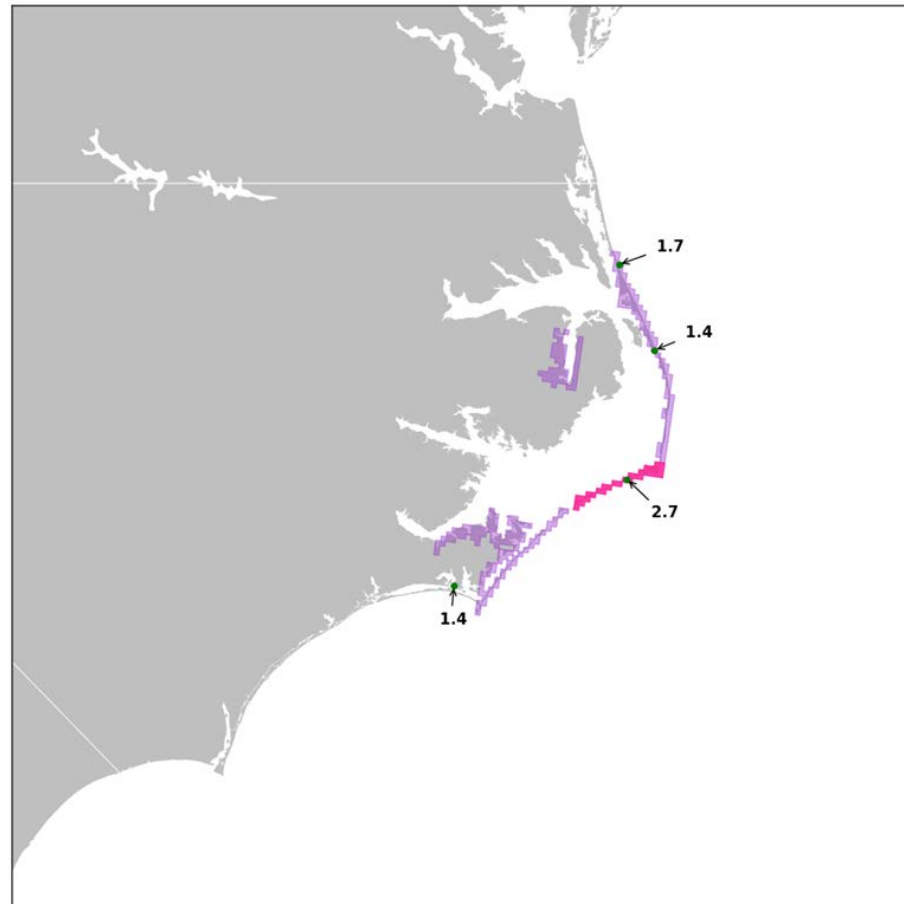


Figure 7. Maximum water levels (feet) measured from tide gauges along the coast of North Carolina during Hurricane Maria and areas covered by storm surge warnings (magenta) and watches (lavender). Water levels are referenced above Mean Higher High Water (MHHW), which is used as a proxy for inundation (above ground level) on normally dry ground along the immediate coastline. Image courtesy of the NHC Storm Surge Unit.

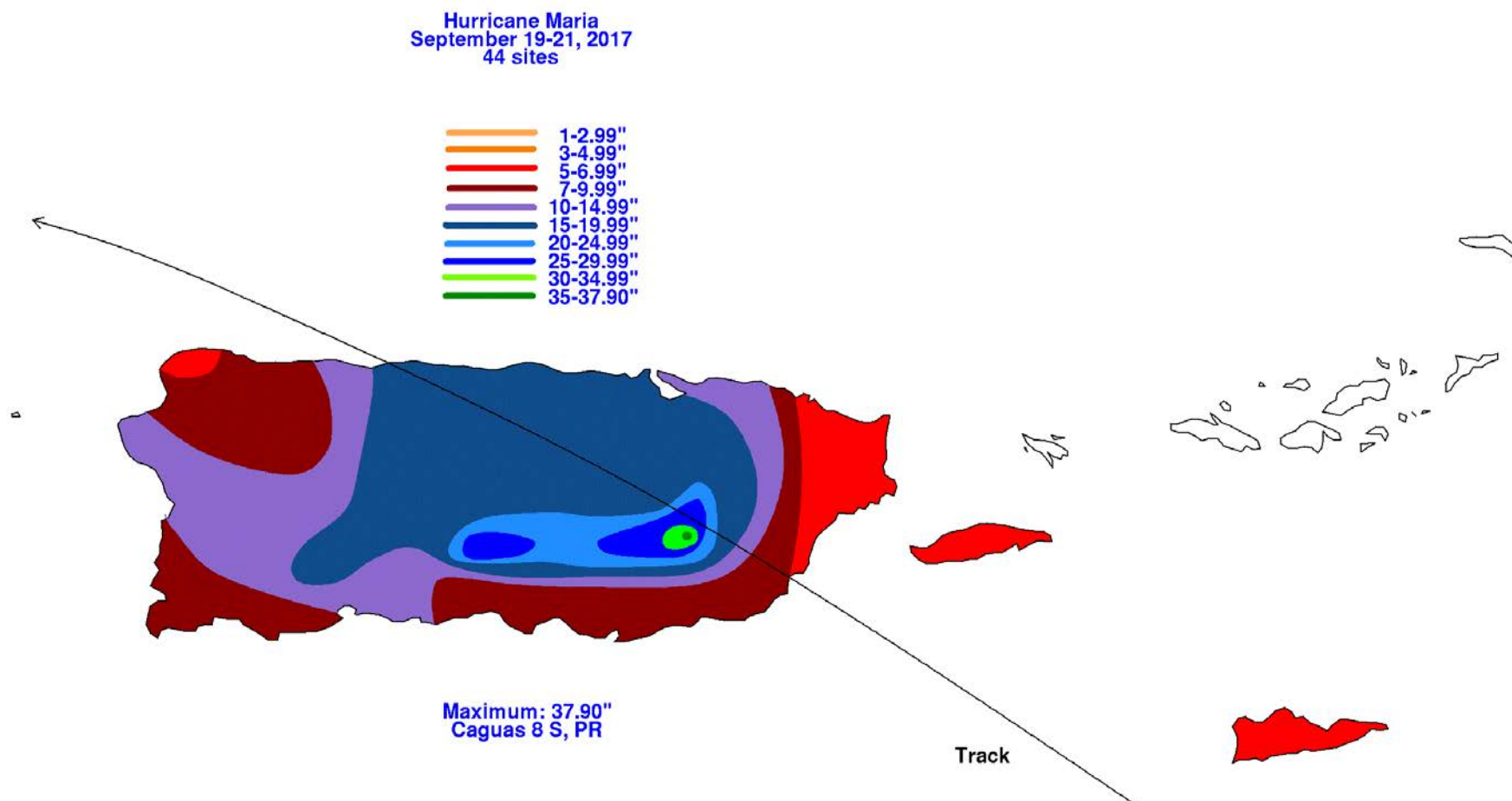


Figure 8. Storm total rainfall (inches) from Hurricane Maria. Figure courtesy of David Roth, NOAA Weather Prediction Center.





Figure 9. Maria's damage in Dominica. Photo credits, clockwise from upper left: National Geographic, responsibletravel.com, AFP/Getty Images, Tomás Ayuso/IRIN.





Figure 10. The remnants of the San Juan WSR-88D radar after its destruction by Hurricane Maria. Photo credit: WFO San Juan.





Figure 11. Maria's damage in Puerto Rico. Damage to St. Croix is shown in the lower right panel. Photo credits, clockwise from upper left: U.S. Air Force, VOA News, Reuters/Jonathan Drake, Hector Retamal/AFP/Getty Images.

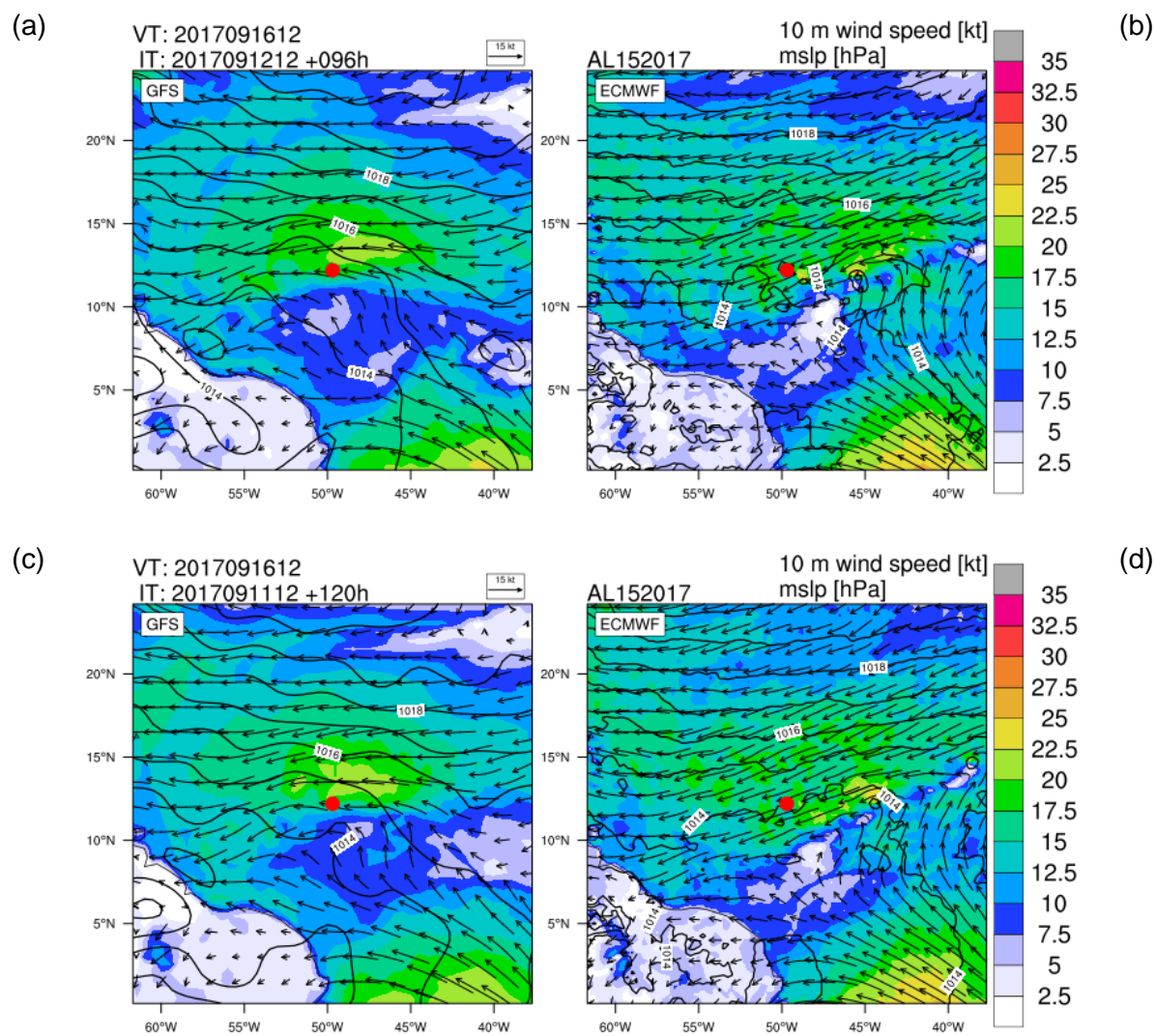


Figure 12. Mean sea-level pressure (black contours, 1-hPa intervals) and 10-m winds (shading and vectors) from (a,c) GFS and (b,d) ECMWF forecasts valid at the time of genesis for Hurricane Maria (1200 UTC September 16). Panels (a) and (b) correspond to 96-h forecasts and (c) and (d) are 120-h forecasts. Red dots indicate the location of Maria's center at the time of genesis.



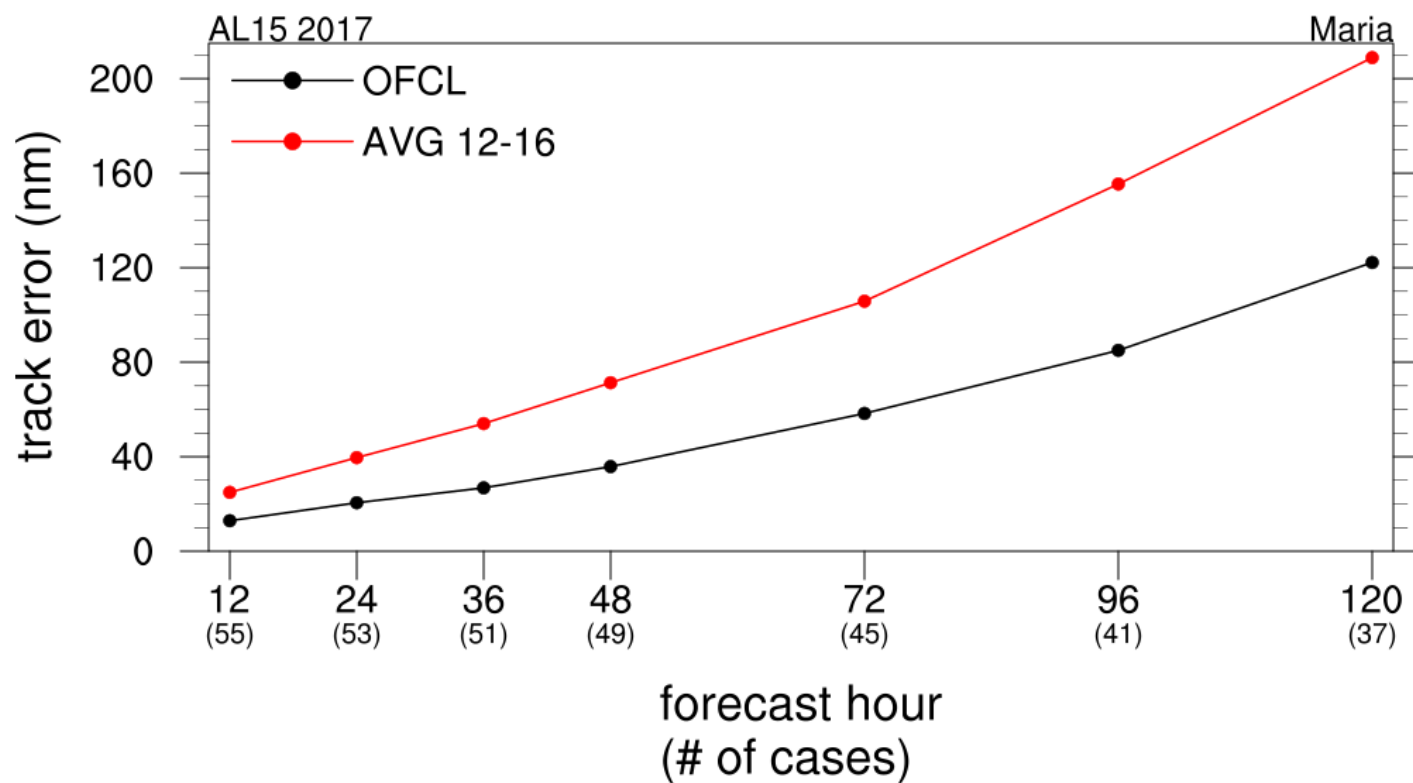


Figure 13. Mean official track forecast errors for Maria (black) and long-term (2012–2016) mean Atlantic basin track errors (red), in n mi.

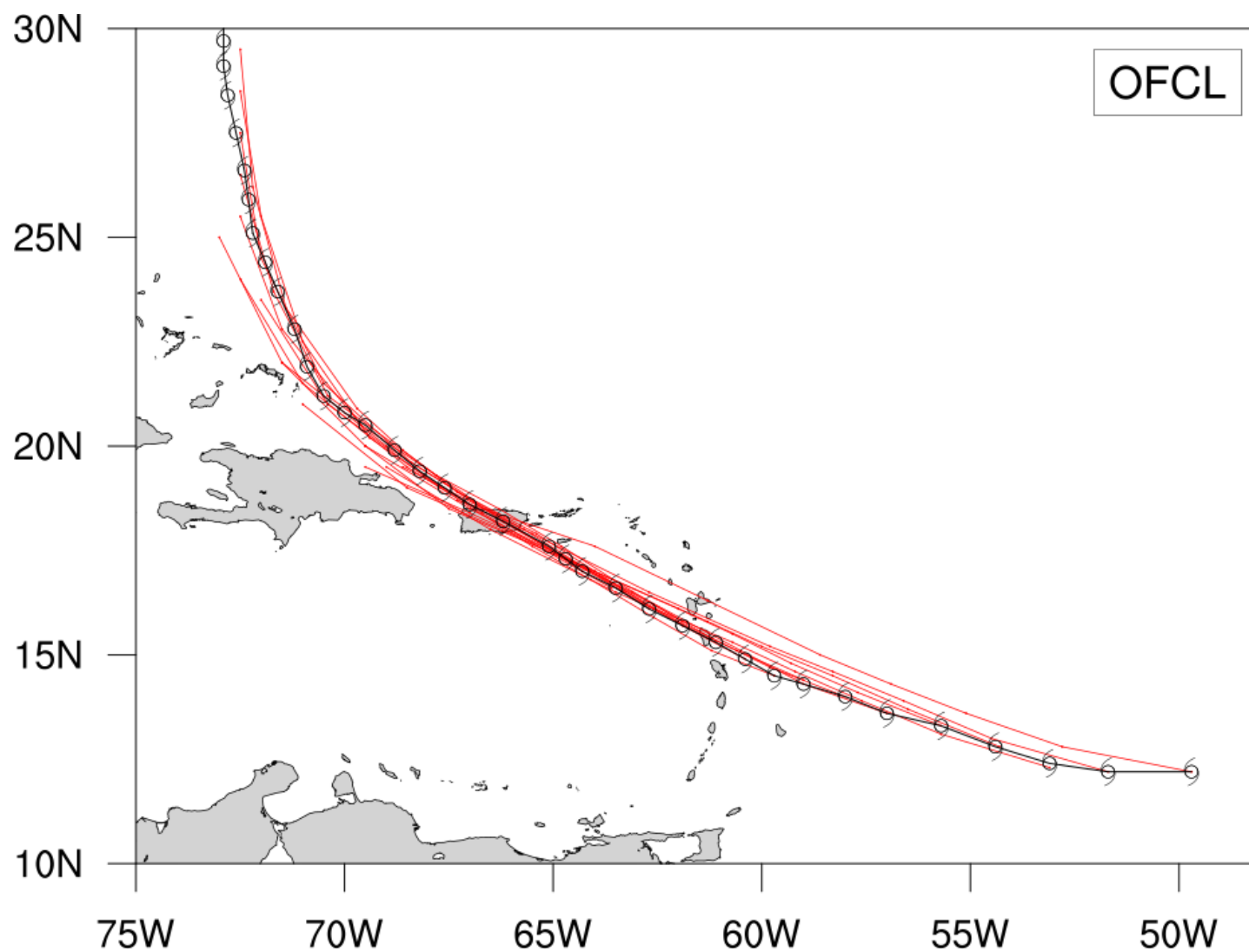


Figure 14. All official track forecasts for Maria from the time of genesis (1200 UTC 16 September) up to shortly before landfall in Puerto Rico (0000 UTC 20 September).

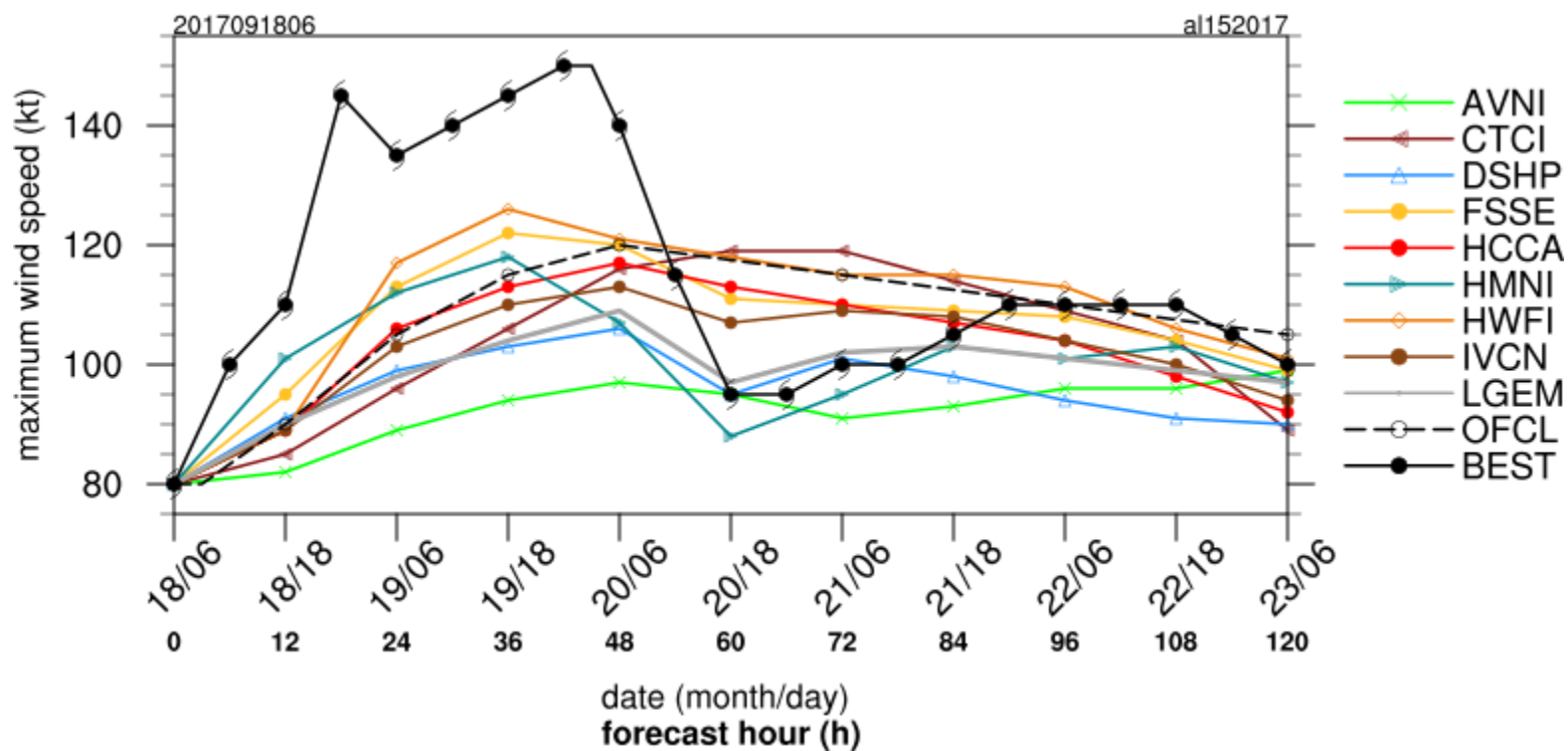


Figure 15. Best track intensity (solid black) and official (dashed black) and model (solid colors) intensity forecasts of intensity for Hurricane Maria from 0600 UTC 18 September 2017.