NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE GONZALO

(AL082014)

12 – 19 October 2014

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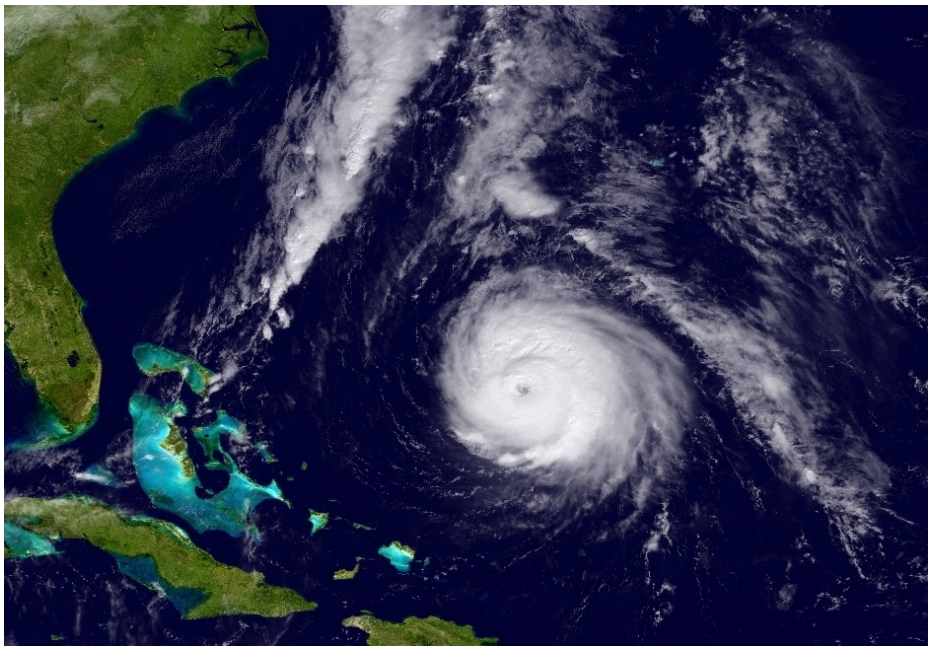

GOES-13 SATELLITE IMAGE OF HURRICANE GONZALO NEAR PEAK INTENSITY ON 16 OCTOBER 2014.

Gonzalo was a tropical cyclone that formed east of the Lesser Antilles and quickly strengthened into a hurricane just before moving through the northern Leeward Islands. A few days later, Gonzalo made landfall in Bermuda as a high-end category 2 hurricane (on the Saffir-Simpson Hurricane Wind Scale), causing extensive damage. Gonzalo's landfall occurred only six days after Hurricane Fay made landfall on the island as a category 1 hurricane.

[1] Original report date 20 January 2015. Updated 4 March 2014 to include additional surface data from St. Barthélemy and St. Martin.

Hurricane Gonzalo

12 – 19 OCTOBER 2014

SYNOPTIC HISTORY

The development of Gonzalo can be traced to a tropical wave that departed the west coast of Africa on 4 October. The wave was accompanied by a large area of cloudiness and thunderstorms while it moved westward across the tropical Atlantic during the next several days. During this time, an upper-level trough over the subtropical eastern and central Atlantic produced strong upper-level westerly winds over the system, which prevented development. Showers and thunderstorms associated with the wave became more concentrated after the passage of an eastward-moving atmospheric Kelvin wave around 10 October. Shortly thereafter, the tropical wave passed west of the upper-level trough axis and into an area of less hostile wind conditions, and a small surface low pressure area formed late on 11 October. Thunderstorm activity associated with system increased in organization, and it is estimated that a tropical depression formed around 0000 UTC 12 October about 340 n mi east of the Leeward Islands. 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[2].

The tropical depression moved westward at about 10 kt to the south of a strong deep-layer ridge. Within an environment of low vertical wind shear and warm waters, the tropical depression strengthened and became a tropical storm by 1200 UTC 12 October when it was located about 220 n mi east of Antigua. Radar data from Guadeloupe and wind observations from an Air Force Reserve Hurricane Hunter aircraft indicated that an inner core with a radius of maximum winds of 10 to 15 n mi had developed, and Gonzalo began to rapidly strengthen late on 12 October. An eye became apparent in radar imagery during the early hours of 13 October, and Gonzalo became a hurricane around 1200 UTC 13 October when it was located just east-southeast of Antigua. Gonzalo turned west-northwestward and passed directly over that island a couple of hours later (Fig. 4).

The hurricane continued to strengthen while it passed through the northern Leeward Islands that afternoon. Gonzalo then turned northwestward before the southwestern portion of the eye moved over St. Barthélemy around 2000 UTC, with the center of the eye passing just north of the island about an hour later. Gonzalo made landfall on the island of St. Martin at about 2245 UTC with an estimated intensity of 75 kt, and passed over Anguilla about 45 minutes later. Shortly thereafter, Gonzalo moved over the Atlantic waters and strengthened to an intensity of 90 kt by 0600 UTC 14 October when it passed about 35 n mi northeast of Anegada, the northeastern-most of the British Virgin Islands.

[2] 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 *btk* directory, while previous years' data are located in the *archive* directory.

The hurricane moved northwestward around the southwestern periphery of a deep-layer ridge over the central Atlantic during the next 24 to 36 h. Gonzalo rapidly intensified and became a major hurricane (category 3 or greater on the Saffir-Simpson Hurricane Wind Scale) at 1800 UTC 14 October when it was located about 145 n mi north of San Juan, Puerto Rico. Gonzalo became a category 4 hurricane 6 h later with an estimated intensity of 115 kt. Over the next 12 to 18 h an eyewall replacement occurred (Fig. 5), and Gonzalo weakened slightly. During this time, the hurricane began moving north-northwestward around the western portion of the ridge that was beginning to shift eastward. The eyewall cycle completed with the radius of maximum winds decreasing to less than 10 n mi by late on 15 October. The hurricane intensified again early the next day while it turned northward, and Gonzalo reached its estimated peak intensity of 125 kt at 1200 UTC 16 October, when it was centered about 460 n mi south-southwest of Bermuda (Fig. 6). After that time, Gonzalo turned north-northeastward between the retreating ridge to its east and a mid- to upper-level trough that was located along the east coast of the United States.

Late on 16 October, the hurricane once again exhibited a double eyewall structure and began to weaken. The inner eyewall gradually eroded and the radius of maximum winds increased from about 10 n mi to 20-25 n mi by early on 17 October. Increasing southwesterly shear and slightly cooler sea surface temperatures caused Gonzalo to weaken to a category 3 hurricane by 1200 UTC 17 October when it was centered about 180 n mi south-southwest of Bermuda. Gonzalo's maximum winds continued to decrease during the afternoon of 17 October while it moved north-northeastward toward Bermuda at about 15 kt. The hurricane made landfall on the southwestern coast of Bermuda (Fig. 7) with an estimated intensity of 95 kt (category 2 intensity) shortly after 0000 UTC 18 October. Several observing sites on the island reported light winds and minimum pressures of around 952 mb between about 0020 and 0040 UTC as the center of the eye passed over the island.

After Gonzalo's passage over Bermuda, the hurricane continued to accelerate north-northeastward, and by 1800 UTC 18 October its forward speed exceeded 30 kt. Increasing southwesterly vertical wind shear and cool waters caused additional weakening as Gonzalo's cloud pattern became less symmetric. The hurricane turned northeastward by early on 19 October and moved over much colder waters north of the Gulf Stream by 0600 UTC 19 October. A few hours later, the center of Gonzalo passed about 45 n mi southeast of the southeastern tip of the Avalon Peninsula of Newfoundland. Gonzalo became a 65-kt extratropical cyclone by 1800 UTC 19 October, while centered about 400 n mi northeast of Cape Race, Newfoundland. The extratropical cyclone turned east-northeastward and weakened before it was absorbed by a cold front several hundred n mi south-southwest of Iceland by 1200 UTC 20 October. The front and remnants of Gonzalo brought strong winds and heavy rains to the United Kingdom and portions of northern Europe the next day.

METEOROLOGICAL STATISTICS

Observations in Gonzalo (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 10 flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. The NOAA Aircraft Operations Center (AOC) flew two operational WP-3D missions and one research flight into Gonzalo. A total of 38 center fixes were provided by reconnaissance aircraft. Radar imagery from Guadeloupe was helpful in tracking Gonzalo during its passage over the Leeward Islands, and data from Bermuda's Doppler radar were also examined. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM), 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 Gonzalo.

Winds and Pressure

The estimated peak intensity of Gonzalo of 125 kt at 1200 and 1800 UTC 16 October is based on blend of SFMR and flight-level winds measured by a NOAA aircraft shortly at 1200 UTC 16 October. The aircraft reported a peak 700 mb flight-level wind of 127 kt and an SFMR wind of 135 kt. The representativeness and/or validity of the peak SFMR wind is somewhat in question since the immediately surrounding observations were much lower (123 and 115 kt).

During the subsequent reconnaissance mission about 12 h later, the U.S. Air Force Hurricane Hunter aircraft measured a peak 700 mb flight-level wind of 136 kt, equivalent to a peak surface wind of 122 kt. The highest SFMR winds on that mission were 107 kt. Objective Dvorak intensity estimates from the UW/CIMSS ADT reached T6.6 (130 kt) between 1200 and 1800 UTC 16 October, although the subjective Dvorak estimates were lower at T5.5 (102 kt) and T6.0 (115 kt) from SAB and TAFB, respectively. Gonzalo's 125-kt peak intensity makes it the strongest October or November hurricane over the Atlantic waters north of 20°N and east of 80°W.

Selected surface observations from land stations and data buoys are given in Table 2. Ship reports of winds of tropical storm force or significantly low pressure associated with Gonzalo are given in Table 3. Gonzalo brought hurricane-force winds to several of the northern Leeward Islands on 13 October and early on 14 October. Operationally Gonzalo was analyzed to be a strong tropical storm until the late afternoon hours of 13 October, when it was upgraded to a hurricane while it approached St. Martin and Anguilla in the northern Leeward Islands. However, wind data from Antigua not available in real time indicate that Gonzalo attained hurricane strength around 1200 UTC that day when it was located just east-southeast of that island. A 1-minute sustained wind of 67 kt with a gust to 78 kt was observed at 1244 UTC on Antigua at V.C. Bird International Airport (Table 2). Sustained hurricane-force winds were also reported on St. Barthélemy. A 1-minute sustained wind of 75 kt at an elevated observing site at Gustavia, and a private weather station reported winds of 66 kt with a gust to 94 kt at 1941 UTC. A minimum pressure of 984.1 mb was observed at the private weather station on Barthélemy at 2111 UTC (Table 2). Sustained hurricane-force winds also likely occurred over portions of St. Martin and Anguilla. The official observing station in St. Martin reported winds of 55 kt with a gust to 69 kt around 0000 UTC 14 October, although higher winds could have

occurred since the record for this station is incomplete. Tropical storm conditions were reported on Barbuda and likely occurred over portions of the northeastern British Virgin Islands.

The final reconnaissance aircraft mission into Gonzalo occurred about four to six hours before the hurricane made landfall on Bermuda, and with limited sampling reported peak 700 mb flight-level winds of 124 kt and SFMR winds of 87 kt. Based on these data, Gonzalo's intensity is analyzed to have been 105 kt at 1800 UTC 17 October. Gonzalo continued to weaken that afternoon and its intensity at landfall on Bermuda is estimated to have been 95 kt, category 2 on the Saffir-Simpson Hurricane Wind Scale. This estimate based on a blend of the earlier aircraft data and subjective and objective Dvorak intensity estimates from around 0000 UTC 18 October. The Dvorak estimates were T5.3 (97 kt) from the ADT and T5.0 (90 kt) from TAFB.

Bermuda experienced an extended period of tropical-storm-force winds or greater beginning around mid-day local time 17 October and ending after daybreak the following morning. Hurricane-force winds occurred over Bermuda for about 6 hours from around 2300 UTC 17 October to 0500 UTC 18 October. The strongest sustained winds experienced on Bermuda were likely of category 2 intensity and occurred on the back side of the hurricane from a northwesterly direction in the southwestern eyewall. The highest (10-minute) mean wind reported on the island was 94 kt with a gust to 113 kt at an elevated site at Commissioner's Point (~46 m) at 0250 UTC. An anemometer on the Bermuda Causeway (elevation ~12 m) measured a 10-minute mean wind of 81 kt with a gust to 98 kt at 0250 UTC. The highest wind gust recorded on Bermuda was 125 kt at St. David's. During the passage of Gonzalo's eye over Bermuda around 0030 UTC 18 October, minimum pressures between 951.9 to 952.9 mb were reported at all of the available official and private weather observing sites (Table 2). The Bermuda Institute of Ocean Sciences research ship, the *Atlantic Explorer*, sent hourly observations while in port at Bermuda. The ship reported peak winds of 56 kt at 2300 UTC 17 October and a minimum pressure of 951.2 mb around 0100 UTC 18 October. Gonzalo was the strongest hurricane to affect Bermuda since Hurricane Fabian in September 2003, and is the strongest October hurricane to make landfall on Bermuda since 1926.

Gonzalo was the second hurricane to pass directly over Bermuda within six days; Fay made landfall on the island as a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) early on 12 October. This is the first time that two hurricanes made landfall on Bermuda in one hurricane season, let alone less than one week apart. Two hurricanes did affect the island within a 10-day period in 1899: during that event, a category 1 hurricane passed just northwest of Bermuda on 4 September and then a category 3 hurricane passed over or just southeast of the Island on 13 September.

Gonzalo also produced tropical-storm-force wind gusts over portions of southeastern Newfoundland, Canada on 19 October. The strongest wind gusts were 54 kt at Cape Race and 40 kt at St. John's International Airport.

Gonzalo was absorbed by a frontal boundary over the North Atlantic about 18 h after it became an extratropical cyclone. The front and a strong low pressure system that formed in association with Gonzalo's remnants produced hurricane-force wind gusts over the United Kingdom and portions of Europe on 21 October. Media reports indicate that the strongest winds in the United Kingdom were experienced over the northern portion of that country. A wind gust

of 76 kt was reported in Oban in western Scotland, and wind gusts of 62 kt were measured at Northumberland and Cumbria.

Rainfall

Rainfall amounts associated with Gonzalo are provided in Table 2. The highest rainfall amount reported in the Leeward Islands was 5.70 inches at St. Martin, and 1.28 inches was received at Antigua. Gonzalo produced 2 to 3 inches of rain in Bermuda and over portions of southeastern Newfoundland, Canada.

Storm Surge

A NOAA National Ocean Service (NOS) tide gauge at Esso Pier in the northern portion of Bermuda measured a storm surge of 2.54 ft. Coastal flooding on Bermuda was minimal since the hurricane made landfall around the time of low tide (Fig. 8). The highest measured storm tide (combination of storm surge and the astronomical tide) was 3.25 ft above mean lower low water at Esso Pier. A storm surge of 1.08 ft was recorded at an NOS tide gauge on Barbuda during Gonzalo's passage on 13 October.

CASUALTY AND DAMAGE STATISTICS

Gonzalo is believed to be responsible for three direct deaths[3], all in the Leeward Islands. An 87-year-old man was killed on a boat that sank in the Simpson Bay Lagoon in St. Maarten. French officials reported two others missing that were believed to be on boats, one on the French side of St. Martin and the other in St. Barthélemy. As of this writing, the whereabouts of these two individuals remain unknown and they are presumed to have been fatalities. No deaths or serious injuries were reported in Bermuda. After Gonzalo was no longer a tropical cyclone, its remnants caused two additional deaths and at least four injuries in Great Britain.

Media reports indicate that strong winds from Gonzalo caused numerous downed trees and utility lines in Anguilla, St. Barthélemy, both the French and Dutch sides of St. Martin, and Anguilla. Some roof and structural damage was also reported on these islands. The downed trees and power lines caused extensive power outages and made many roads impassable after the storm. There have been no monetary damage estimates received for any of the Leeward Islands.

According to media reports, Gonzalo produced $200 to $400 million (USD) in insured losses on Bermuda. Strong winds downed numerous trees and utility poles, and also caused some structural damage including the loss of roofs and collapsed walls. Older structures fared worse than structures constructed under new building codes designed to withstand sustained

[3] 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.

winds up to about 95 kt. Most of the Bermuda was without electricity after the hurricane and it took more than two weeks to fully restore power on the island. A large number of boats were grounded and damage to marine vessels is not included in the aforementioned insured loss estimate. Minor damage to the Bermuda Causeway was also reported.

In the United Kingdom, strong winds caused widespread transportation delays, with trees falling on roadways and rail lines. More than 100 flights were cancelled at London's Heathrow airport and ferry service was also disrupted across the region.

FORECAST AND WARNING CRITIQUE

The development of Gonzalo was not well forecast. Table 4 shows the number of hours in advance of formation that the NHC Tropical Weather Outlook first forecast the indicated likelihood category. The tropical wave from which Gonzalo formed was introduced into the Tropical Weather Outlook at 1200 UTC 10 October, about 36 h before formation. At that time, the system was assessed to have a low chance of formation for both the 48-h and 5-day time periods. The 5-day probability of development was raised to the medium category 6 h later and to the high category at 0000 UTC 11 October, 24 h before development occurred. The timing of genesis was not well predicted, as the 48-h probability of formation was not raised to the medium category until 1800 UTC 11 October, and it remained in that category until formation occurred 6 h later. Formation was not anticipated to occur that soon based on the global model guidance that did not show much development of the system until it was expected to be north of the Leeward Islands a few days later.

A verification of NHC official track forecasts for Gonzalo is given in Table 5a. Official forecast track errors ranged from about 15%-35% lower than the mean official errors for the previous 5-yr period through 48 h. The average NHC track errors at 72 and 96 h were comparable to the long-term average, and above the 5-year average error at 120 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. The best individual track model for Gonzalo was the HWFI, which had lower mean forecast errors than the NHC forecasts at all forecast lead times, except 96 h. The TVCA multi-model consensus and fixed consensus (TCON) also beat the official forecast at all lead times except 96 h. The NHC cross track (left-right) forecast errors for Gonzalo were generally small, however the along-track (fast-slow) errors were quite large. The long-range NHC forecasts exhibited a significant slow bias that resulted in the larger than average 5-day track forecast errors. The NHC forecast track consistently showed the center of Gonzalo passing near or just west of Bermuda beginning with the 1800 UTC 13 October forecast cycle (Fig. 9).

A verification of NHC official intensity forecasts for Gonzalo is given in Table 6a. Official forecast intensity errors were comparable to the mean official errors for the previous 5-yr period, except at 96 and 120 h where it was lower than the long-term average. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. The NHC intensity forecasts exhibited lower than average forecast errors than nearly all of the intensity models at all forecast lead times. Only the DSHP model had lower average forecast errors than the official forecast at 72 h. The NHC forecast and much of the model guidance did

not predict Gonzalo to strengthen as quickly as it did during the first few days of its existence. As a result, the NHC forecasts had a 5 to 15-kt low bias at each of the forecast lead times.

Watches and warnings associated with Gonzalo are given in Table 7. Since Gonzalo formed and strengthened quickly while passing over the Leeward Islands, the lead time for the onset of hurricane-force winds was less than normal. For Bermuda, a Hurricane Watch was issued by the Bermuda Weather Service at 0300 UTC 15 October, about 69 h before Gonzalo made landfall. A hurricane warning was issued at 2100 UTC 15 October, about 51 h before the eye passed over Bermuda.

ACKNOWLEDGEMENTS

The majority of the surface data presented in this report were provided by the meteorological services of the affected countries. Special thanks to Keithley Meade and Dale Destin of the Antigua and Barbuda Meteorological Services for providing one-minute surface wind observations for Antigua. James Dodgson, Kimberly Zuill, and Ian Currie of the Bermuda Weather Service provided surface and radar data, and a detailed report of damages in Bermuda. The National Data Buoy Center and the National Ocean Service supplied surface and storm surge data. Additional surface observation were collected from observing sites available at Weather Underground (www.weatherunderground.com).

Table 1. Best track for Hurricane Gonzalo, 12-19 October 2014.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
11 / 1800	16.4	54.9	1010	25	low
12 / 0000	16.4	55.9	1010	30	tropical depression
12 / 0600	16.4	56.9	1008	30	"
12 / 1200	16.4	57.9	1006	35	tropical storm
12 / 1800	16.4	58.8	1004	40	"
13 / 0000	16.5	59.7	1001	45	"
13 / 0600	16.7	60.6	996	55	"
13 / 1200	17.0	61.5	992	65	hurricane
13 / 1430	17.1	61.8	990	65	landfall at Antigua
13 / 1800	17.6	62.4	988	70	"
13 / 2245	18.1	63.0	984	75	landfall at St. Martin
13 / 2315	18.2	63.1	984	75	landfall at Anguilla
14 / 0000	18.3	63.2	983	80	"
14 / 0600	19.1	64.0	976	90	"
14 / 1200	19.9	64.8	973	95	"
14 / 1800	20.8	65.5	968	100	"
15 / 0000	21.7	66.2	956	115	"
15 / 0600	22.5	67.0	953	115	"
15 / 1200	23.1	67.7	949	115	"
15 / 1800	23.8	68.3	953	110	"
16 / 0000	24.4	68.6	953	110	"
16 / 0600	25.0	68.7	948	115	"
16 / 1200	25.6	68.7	940	125	"
16 / 1800	26.5	68.3	942	125	"
17 / 0000	27.4	67.8	942	120	"

17 / 0600	28.6	67.2	945	115	"
17 / 1200	29.8	66.5	947	110	"
17 / 1800	31.0	65.7	949	105	"
18 / 0000	32.2	64.9	952	95	"
18 / 0030	32.3	64.8	952	95	landfall at Bermuda
18 / 0600	33.7	63.9	955	90	"
18 / 1200	35.6	62.6	960	85	"
18 / 1800	38.2	60.9	964	85	"
19 / 0000	41.2	58.3	965	85	"
19 / 0600	44.5	54.8	968	80	"
19 / 1200	47.8	50.1	970	70	"
19 / 1800	50.6	44.8	976	65	extratropical
20 / 0000	52.6	38.3	982	55	"
20 / 0600	53.9	30.9	988	50	"
20 / 1200					dissipated
16 / 1200	25.6	68.7	940	125	minimum pressure and maximum winds
13 / 1430	17.1	61.8	990	65	landfall at Antigua
13 / 2245	18.1	63.0	984	75	landfall at St. Martin
13 / 2315	18.2	63.1	984	75	landfall at Anguilla
18 / 0030	32.3	64.8	952	95	landfall at Bermuda

Table 2. Selected surface observations in association with Hurricane Gonzalo, 12-19 October 2014.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)	
Antigua V.C. Bird International Airport (TAPA)	13/1244	992.2	13/1244	67[c]	78	1.28
Barbuda Sea port			13/1654	51	61	
Barbuda BARA9 NOAA National Ocean Service (NOS) 17.59°N 61.82°W	13/1654	999.7	13/1730	52	61	
St. Barthélemy St. Jean Airport (TFFJ)	13/2200	986.0	13/1900	58[cd]	85[d]	1.21
St. Barthélemy Gustavia elevation 44 m	13/2100	986.2	13/2300	75[c]	110	1.07
St. Barthélemy ISTBARTH2- Weather Underground 17.90°N 62.81°W elevation 193 m		985.1				
St. Barthélemy ISAINTBA3- Weather Underground 17.90°N 62.82°W elevation 10 m	13/2111	984.1	13/1941	66	94	
St. Martin Princess Juliana International Airport (TNCM)	14/0000	994.1[d]	14/0000	55[d]	69[d]	5.70
St. Martin Grand Case Airport (TFFG)	13/2300	984.5	13/2300	54[cd]	81[d]	3.48[d]
St. Eustatius FD Roosevelt Airport (TNCE)			13/1600		34	
Puerto Rico Fajardo NOAA NOS FRDP4 18.34°N 65.36°W			13/2336	27	34	

Bermuda						
LF Wade International Airport (TXKF)	18/0041	953.0	17/2214	54[de]	73 [d]	2.85
Causeway elevation 12 m			18/0250	81[e]	98	
Commissioner's Point elevation 46 m			18/0250	94[e]	113	
St. David's elevation 15 m			17/2320	78[e]	125	
RCC Bermuda Maritime Operations Centre Elevation 88 m					109 [d]	
Esso Pier BEPB6 NOAA NOS 32.37°N 64.70°W	18/0036	952.3	18/0254	58	78	
Gilbert Hill ISMITHSP3 Weather Underground 32.311°N 64.739°W elevation 59 m	18/0019	951.9				
Chaingate Hill IDEVONSH3 Weather Underground 32.307°N 64.749°W elevation 35 m	18/0030	952.9	18/0250	61	89	
Magnolia Hill ISMITHSP2 Weather Underground 32.319°N 64.743°W elevation 43 m			18/0235	60	92	
Grotto Bay Extremestorms Jim Edds	18/0036	952.8				
Bermuda Weather Service	18/0040	952.3				
Canada						
Cape Race (CWRA)					54	
St. John's International Airport (CYYT)					40	2.03
St. John's West (CXSW)					34	2.20
Mount Pearl						2.72

Ochre Pit Cove						2.38
Port De Grave						2.30
Buoys						
NOAA Buoy 41043 21.061°N 64.9666°W Height 5 m	14/1648	1003.1	14/1714	43 [c]	49	
NOAA Buoy 41046 23.888°N 68.356°W Height 5 m	15/1915	954.9	15/2142	58 [c]	70	
NOAA Buoy 41049 27.537°N 62.945°W Height 5 m			16/1657	29 [c]	33	
Environment Canada Buoy 44141 42.990°N 57.960°W Height 5 m	19/0300	980.9	19/0300	35	47	
Environment Canada Buoy 44139 44.240°N 57.100°W Height 5 m	19/0400	986.6	19/0400	27	33	
Environment Canada Buoy 44251 46.440°N 53.390°W Height 5 m	19/0900	970.5	19/0800	35	43	
Oil Platforms						
Hibernia Rig (VEP717) 46.7°N 48.7°W elevation 130 m	19/1200	996.0	19/1200	85		
GSF Grand Banks (YJUF7) 46.7°N 48.0°W elevation unknown	19/1200	998.6	19/1200	65		
YJQN7 46.4°N 48.4°W	19/1200	999.0	19/1200	78		
VCXF 46.4°N 48.4°W elevation unknown	19/1200	997.1	19/1200	60		

[a] Date/time is for sustained wind when both sustained and gust are listed.

[b] Except as noted, sustained wind averaging periods for C-MAN and land-based reports are 2 min; buoy averaging periods are 8 min.
[c] one-minute wind observation
[d] incomplete record due to instrument or power failure
[e] 10-minute wind observation

Table 3. Selected ship reports with winds of at least 34 kt or significantly low pressure for Hurricane Gonzalo, 12-19 October 2014.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
17 / 1500	A8PQ7	30.0	62.2	150 / 37	1013.0
17 / 1900	A8PQ7	29.6	62.8	170 / 36	1009.0
17 / 2000	WDC941	32.4	64.7	090 / 36	994.9
17 / 2100	WDC941	32.4	64.7	090 / 36	990.8
17 / 2200	WDC941	32.4	64.7	090 / 52	982.5
17 / 2300	WDC941	32.4	64.7	090 / 56	972.8
18 / 0000	WDC941	32.4	64.7	100 / 52	961.4
18 / 0100	WDC941	32.4	64.7	150 / 08	951.2
18 / 0200	WDC941	32.4	64.7	275 / 20	954.4
18 / 0200	A8PQ7	29.0	63.6	220 / 37	1011.0
18 / 0300	WDC941	32.4	64.7	290 / 43	965.9
18 / 0400	WDC941	32.4	64.7	290 / 50	978.9
19 / 0800	WMHA	43.4	47.2	180 / 36	1016.0

Table 4. Number of hours in advance of formation 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 (<30%)	36	36
Medium (30%-50%)	6	30
High (>50%)	-	24

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Gonzalo. 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	**18.3**	**31.6**	**44.5**	**65.0**	117.5	**157.2**	263.6
OCD5	41.3	98.9	148.5	197.9	283.5	391.7	662.3
Forecasts	27	25	23	21	17	13	9
OFCL (2009-13)	28.8	45.5	61.2	77.8	114.5	158.4	208.2
OCD5 (2009-13)	48.2	100.1	160.2	220.8	326.6	410.7	479.4

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Gonzalo. 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 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	15.3	28.1	40.1	58.0	110.5	116.2	214.8
OCD5	38.1	77.2	150.8	182.7	295.5	325.7	763.0
GFSI	18.4	29.1	42.9	66.9	134.8	234.1	**187.9**
GHMI	17.9	**25.6**	41.9	**54.0**	125.0	192.5	305.6
HWFI	**15.1**	**20.4**	**27.7**	**38.3**	**82.4**	124.2	**198.4**
UKMI	18.5	33.5	49.6	69.7	**107.9**	**106.5**	**106.4**
EGRI	18.8	34.3	51.0	71.1	111.0	**108.8**	218.9
EMXI	15.4	28.3	43.3	62.4	144.5	201.0	438.0
CMCI	21.5	40.7	51.7	68.6	124.9	289.5	486.3
NVGI	22.0	42.1	78.3	103.5	212.8	261.0	459.5
GFNI	17.2	30.5	48.4	76.2	206.8	329.9	417.4
AEMI	17.6	30.3	46.3	69.7	145.7	217.2	**132.4**
FSSE	**14.7**	**23.0**	**32.9**	58.2	149.2	180.3	**194.6**
TCON	**12.5**	**18.2**	**25.8**	**42.0**	**88.1**	138.0	**167.3**
TVCA	**12.4**	**18.1**	**27.4**	**42.1**	**90.0**	124.2	**210.8**
LBAR	28.1	49.2	80.3	88.1	143.3	353.9	814.4
BAMD	30.4	50.7	71.4	85.5	125.9	202.3	**134.8**
BAMM	31.5	47.6	73.9	73.5	115.5	145.0	**165.2**
BAMS	43.1	65.8	99.5	93.2	132.7	**102.5**	**186.2**
Forecasts	21	19	19	17	14	8	6

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Gonzalo. 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	8.5	12.0	14.3	**13.8**	15.0	**13.5**	**6.1**
OCD5	9.1	14.1	18.8	22.9	26.6	32.2	23.7
Forecasts	27	25	23	21	17	13	9
OFCL (2009-13)	6.1	10.4	13.4	14.5	15.0	16.4	16.1
OCD5 (2009-13)	7.7	12.7	16.4	18.8	20.5	20.3	20.8

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Gonzalo. 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	8.5	12.0	14.3	13.8	15.0	13.5	6.1
OCD5	9.1	14.1	18.8	22.9	26.6	32.2	23.7
GFSI	10.9	18.4	23.6	28.0	34.2	33.0	17.8
GHMI	12.8	18.1	21.7	23.0	17.6	23.5	20.2
HWFI	10.9	17.1	20.9	22.5	21.9	21.0	18.2
EMXI	10.4	19.6	28.2	37.9	46.3	48.0	37.7
DSHP	9.1	13.0	14.6	15.5	**14.7**	14.1	8.6
LGEM	9.4	13.8	17.8	20.0	21.9	20.8	9.8
ICON	9.6	14.9	18.2	19.1	17.4	18.3	10.0
IVCN	9.6	14.9	18.2	19.1	17.4	18.3	10.0
Forecasts	27	25	23	21	17	13	9

Table 7. Watch and warning summary in association with Hurricane Gonzalo, 12-19 October 2014.

Date/Time (UTC)	Action	Location
12 / 1730	Tropical Storm Watch issued	British Virgin Islands
12 / 1730	Tropical Storm Watch issued	Puerto Rico, U.S. Virgin Islands, Vieques, and Culebra
12 / 1730	Tropical Storm Warning issued	Guadeloupe, Desirade, Les Saintes, Marie Galante, St. Martin, and St. Barthélemy
12 / 1730	Tropical Storm Warning issued	St. Maarten, Saba, and St. Eustatius
12 / 1730	Tropical Storm Warning issued	Barbuda, Antigua, Anguilla, St. Kitts, Nevis, and Montserrat
12 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	British Virgin Islands
12 / 2100	Hurricane Watch issued	British Virgin Islands
12 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	Puerto Rico, U.S. Virgin Islands, Vieques, and Culebra
12 / 2100	Hurricane Watch issued	Puerto Rico, U.S. Virgin Islands, Vieques, and Culebra
13 / 1500	Tropical Storm Warning changed to Hurricane Warning	British Virgin Islands
13 /1500	Hurricane Watch issued	Anguilla
13 / 1500	Hurricane Watch issued	St. Martin/St. Maartin

Date/Time (UTC)	Action	Location
13 / 1500	Tropical Storm Warning discontinued	Guadeloupe, Desirade, Les Saintes, and Marie Galante
13 / 1500	Hurricane Watch discontinued	British Virgin Islands
13 / 1825	Hurricane Watch changed to Hurricane Warning	Anguilla
13 / 1900	Hurricane Watch changed to Hurricane Warning	St. Martin/St. Maartin
13 / 1900	Tropical Storm Warning discontinued	St. Martin/St. Maartin
13 / 1900	Tropical Storm Warning discontinued	Anguilla
14 / 0300	Hurricane Watch discontinued	Puerto Rico, Culebra, Vieques, and St. Croix
14 / 0300	Tropical Storm Warning discontinued	Saba and St. Eustatius
14 / 0300	Tropical Storm Warning discontinued	Antigua, Barbuda, Montserrat, St. Kitts, and Nevis
14 / 0300	Hurricane Warning changed to Tropical Storm Warning	St. Maarten
14 / 0600	Hurricane Warning changed to Tropical Storm Warning	St. Martin
14 / 0600	Hurricane Watch discontinued	Remainder of U.S. Virgin Islands
14 / 0900	Hurricane Warning changed to Tropical Storm Warning	British Virgin Islands

Date/Time (UTC)	Action	Location
14 / 0900	Hurricane Warning changed to Tropical Storm Warning	Anguilla
14 / 0900	Tropical Storm Warning discontinued	St. Maarten
14 / 0900	Tropical Storm Warning discontinued	Puerto Rico, U.S. Virgin Islands, Vieques, and Culebra
14 / 1200	Tropical Storm Warning discontinued	British Virgin Islands
14 / 1200	Tropical Storm Warning discontinued	Anguillla
14 / 1500	Tropical Storm Warning discontinued	St. Martin and St. Barthélemy
15 / 0300	Hurricane Watch issued	Bermuda
15 / 2100	Hurricane Watch changed to Hurricane Warning	Bermuda
17 / 2100	Tropical Storm Watch issued	Southeastern Newfoundland from Arnolds Cove to Chapels Cove
18 / 0900	Hurricane Warning changed to Tropical Storm Warning	Bermuda
18 / 1200	Tropical Storm Warning discontinued	Bermuda
19 / 1500	Tropical Storm Watch discontinued	Southeastern Newfoundland from Arnolds Cove to Chapels Cove

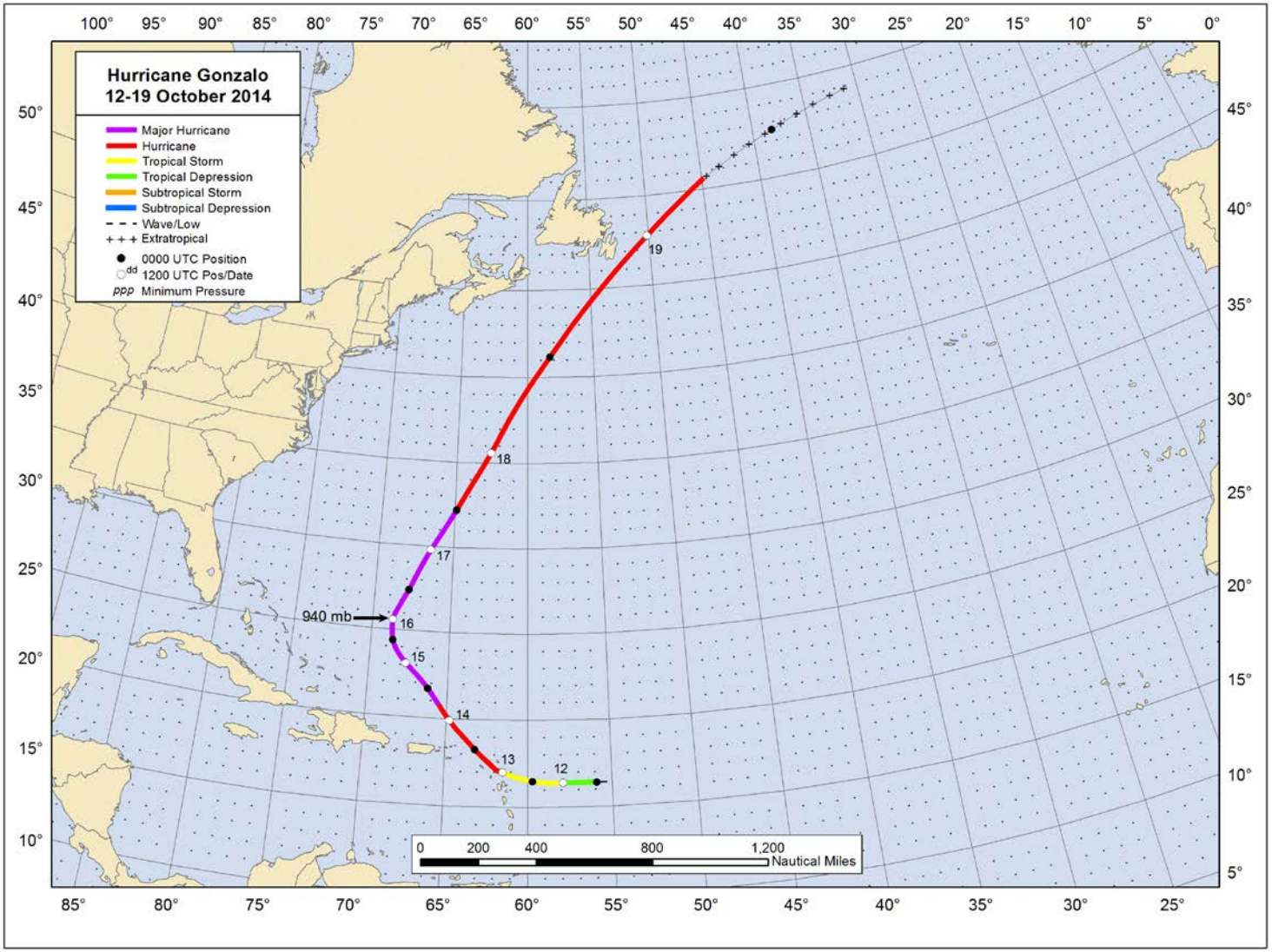

Figure 1. Best track positions for Hurricane Gonzalo, 12-19 October 2014. Track during the extratropical stage is based on analyses from the NOAA Ocean Prediction Center.

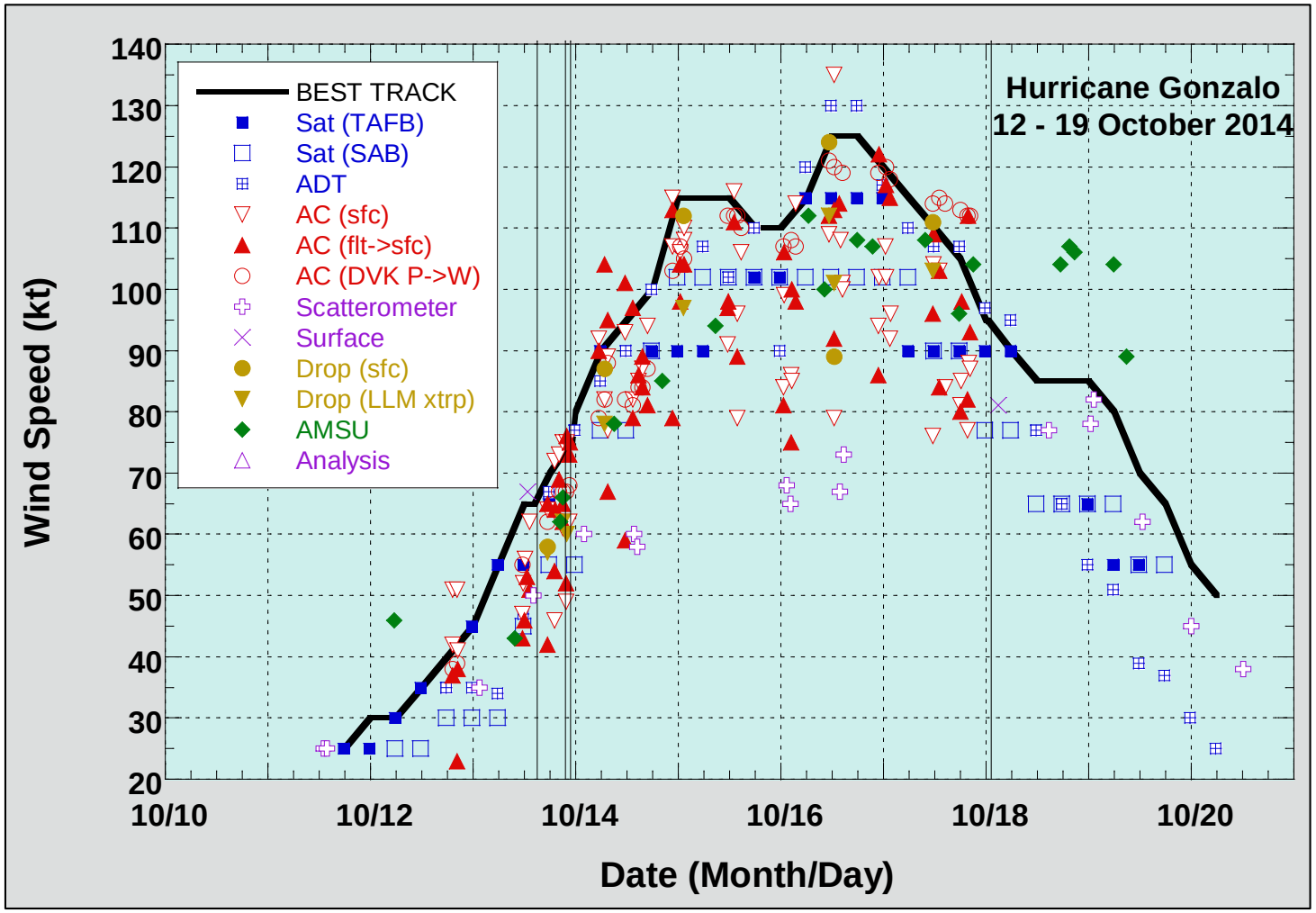

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Gonzalo, 12-19 October 2014. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. 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.

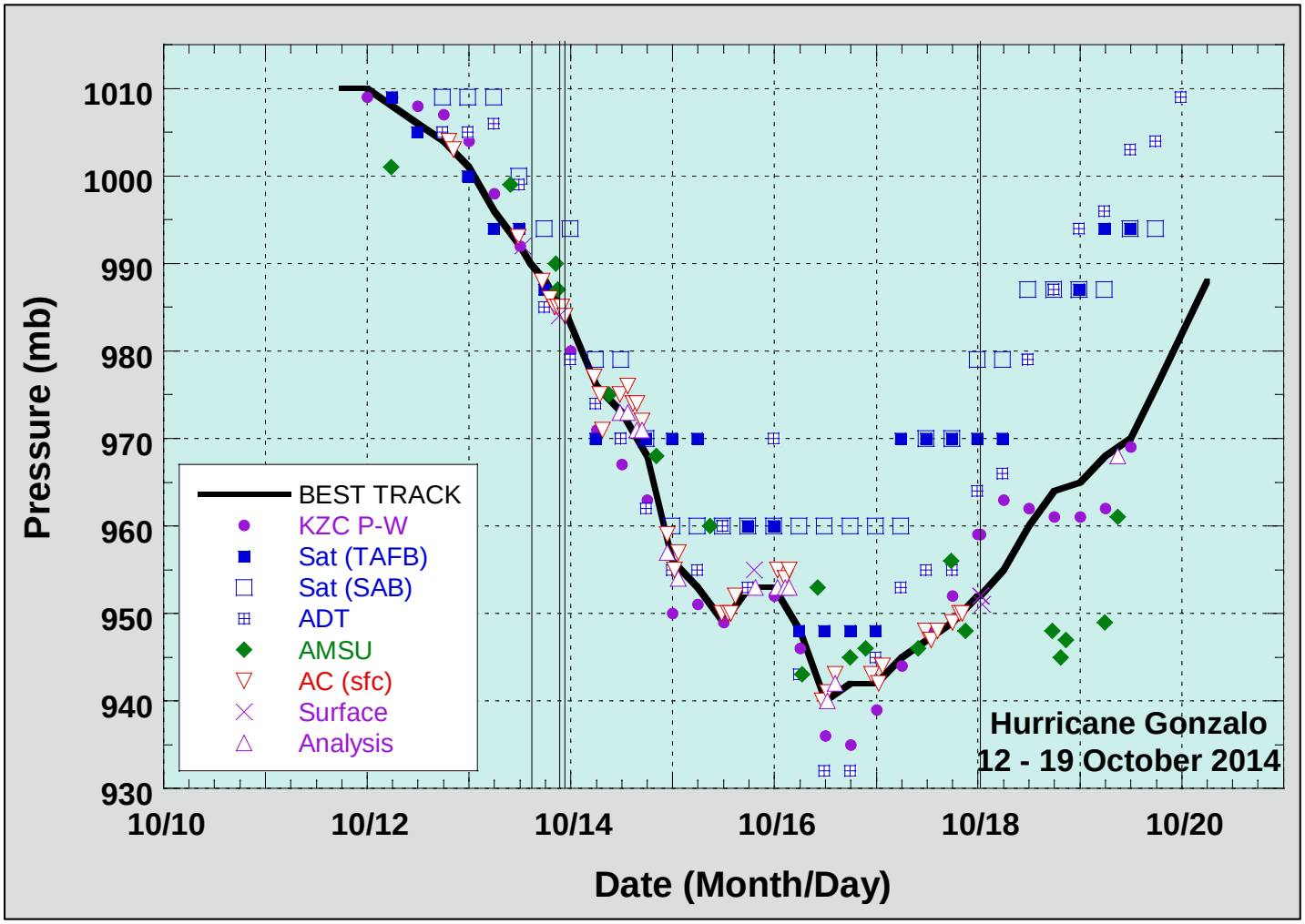

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Gonzalo, 12-19 October 2014. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological 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.

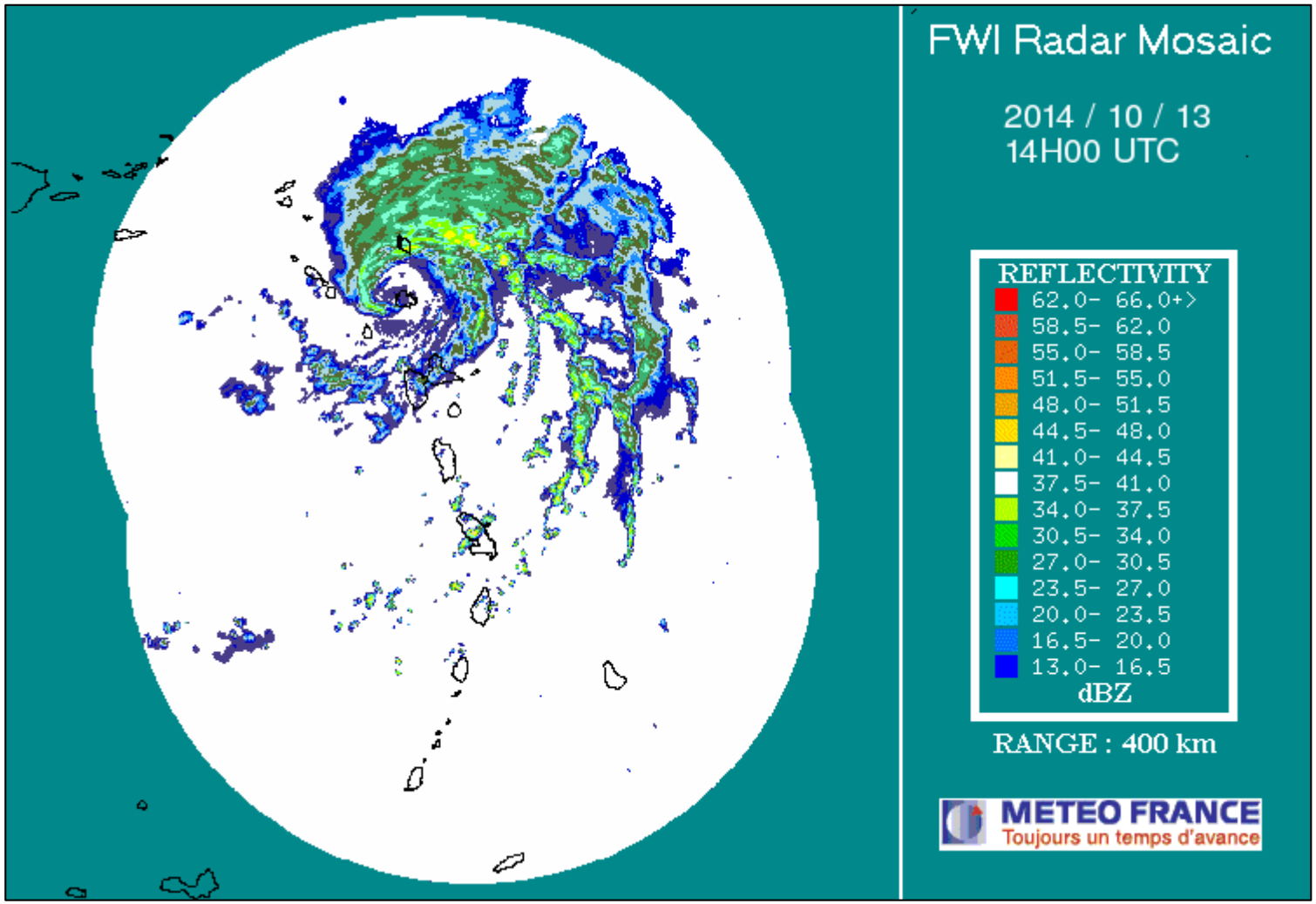

Figure 4. Radar image from Guadeloupe at 1400 UTC 13 October, around the time the center of Gonzalo passed over Antigua. Image courtesy of Meteo France.

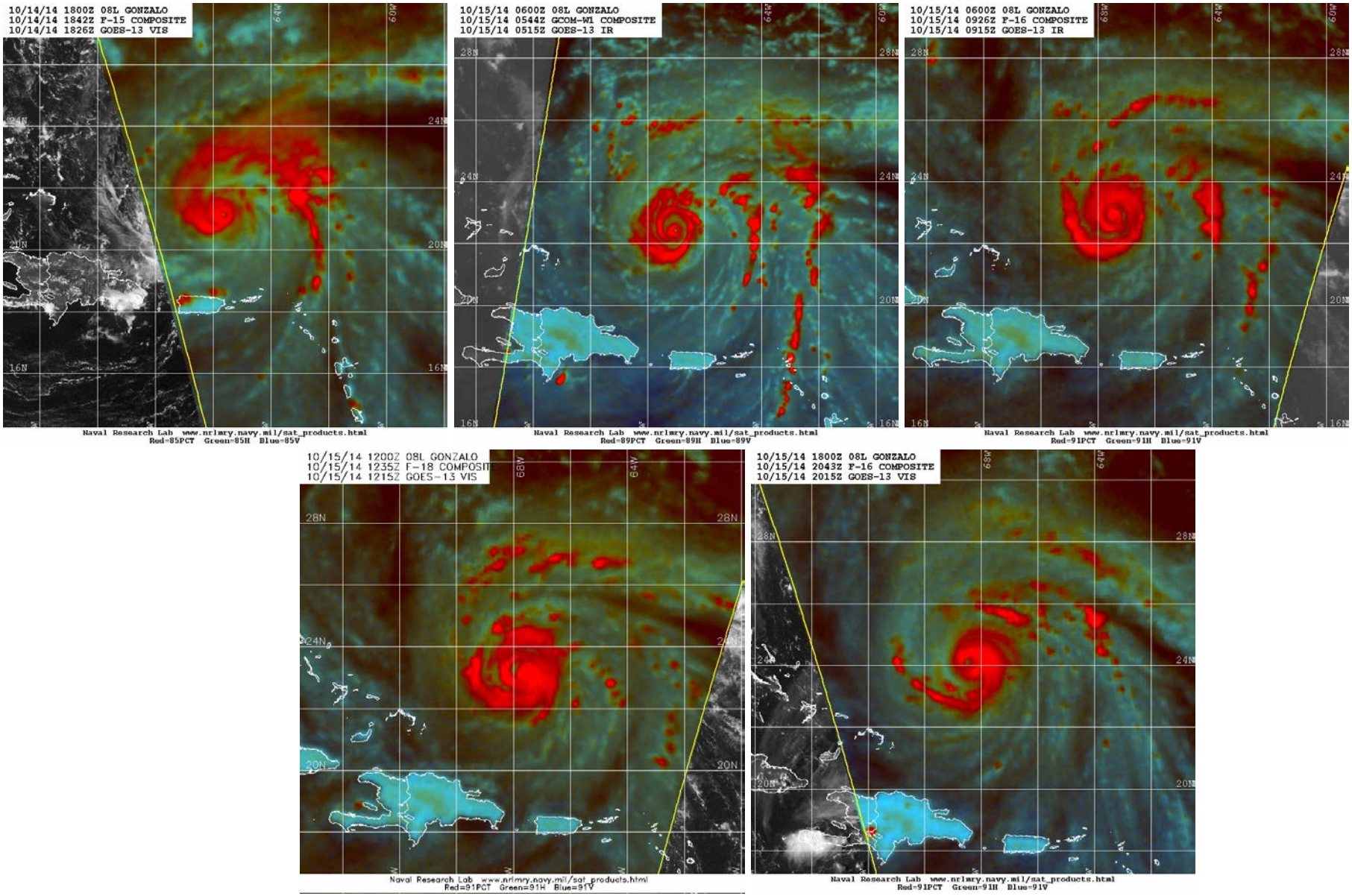

Figure 5. Composite 85 to 91 GHz microwave satellite imagery showing Gonzalo's eyewall replacement between 1842 UTC 14 October and 2043 UTC October 15. Images courtesy of the Naval Research Laboratory.

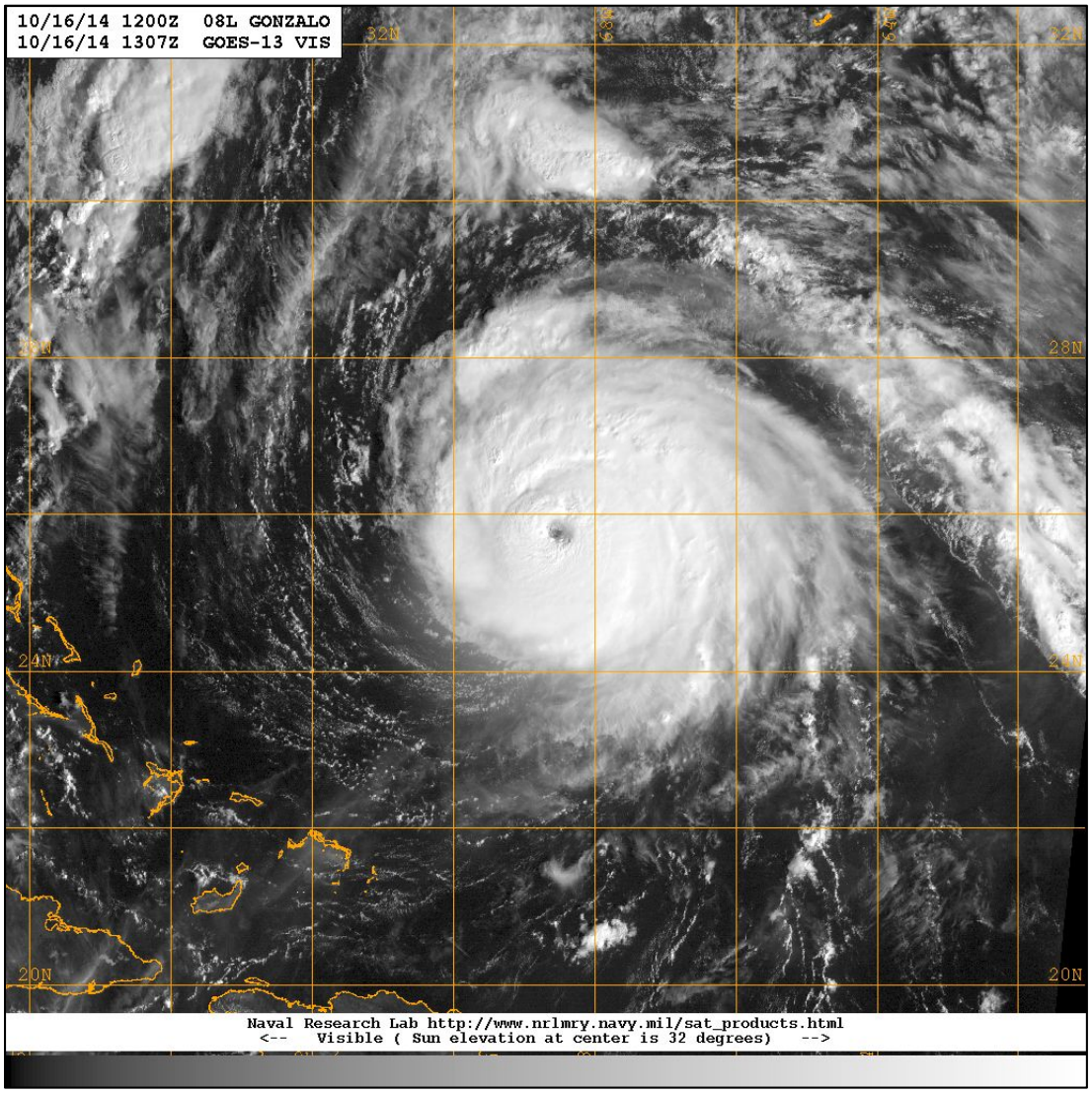

Figure 6. Visible satellite image of Hurricane Gonzalo at its estimated peak intensity of 125 kt (category four on the Saffir-Simpson Hurricane Wind Scale) at 1307 UTC 16 October. Image courtesy of the Naval Research Laboratory.

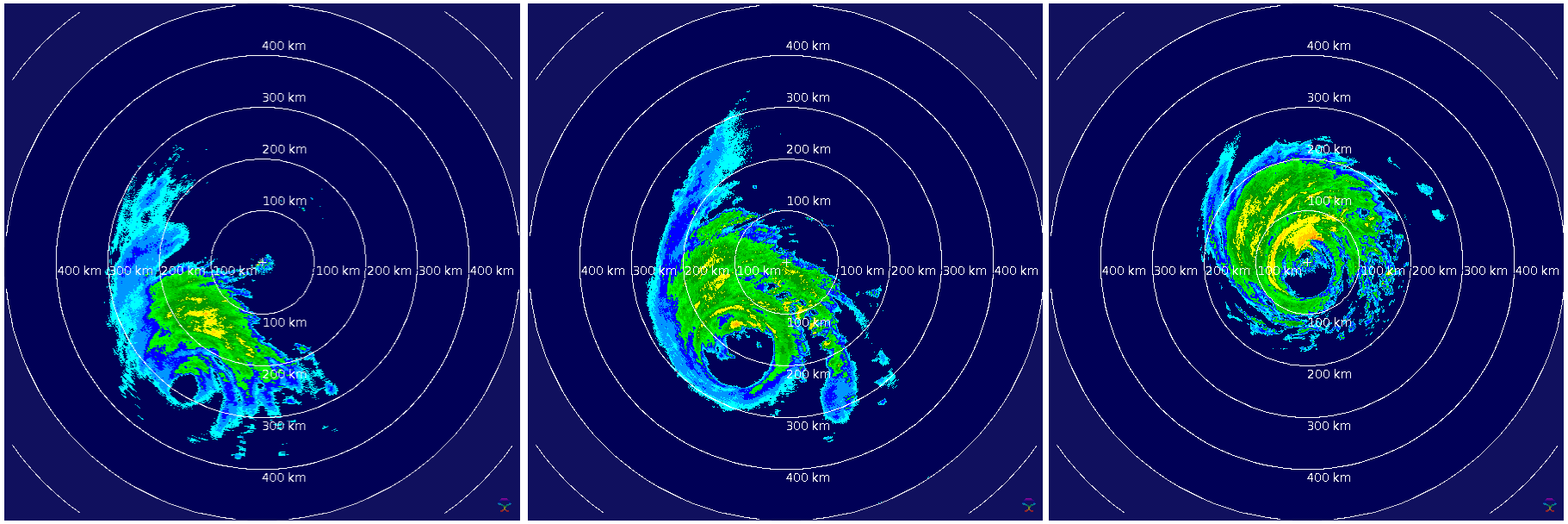

Figure 7. Bermuda radar images of Hurricane Gonzalo at 1423 UTC 17 October (left), 1803 UTC 17 October (middle), and 0043 UTC 18 October (right). The location of the Bermuda radar is denoted by the plus symbol (+) at center of the images. The image on the right is around the time that Gonzalo's eye was over the island. Images courtesy of the Bermuda Weather Service.

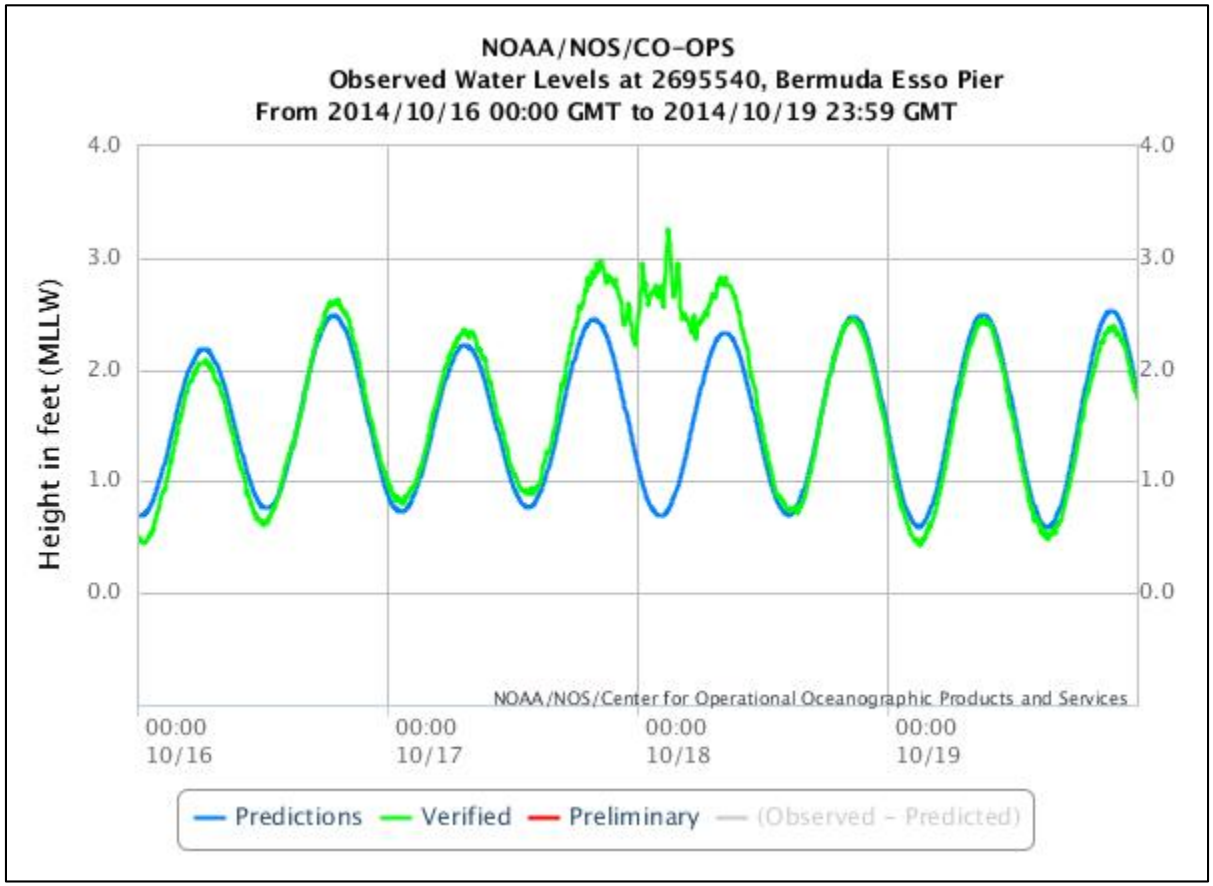

Figure 8. Observed water levels (green) and predicted water levels (blue) during the passage of Gonzalo at Esso Pier, Bermuda during 16 - 19 October 2014. Note that the highest observed water levels occurred during low tide. Image courtesy of the NOAA National Ocean Service.

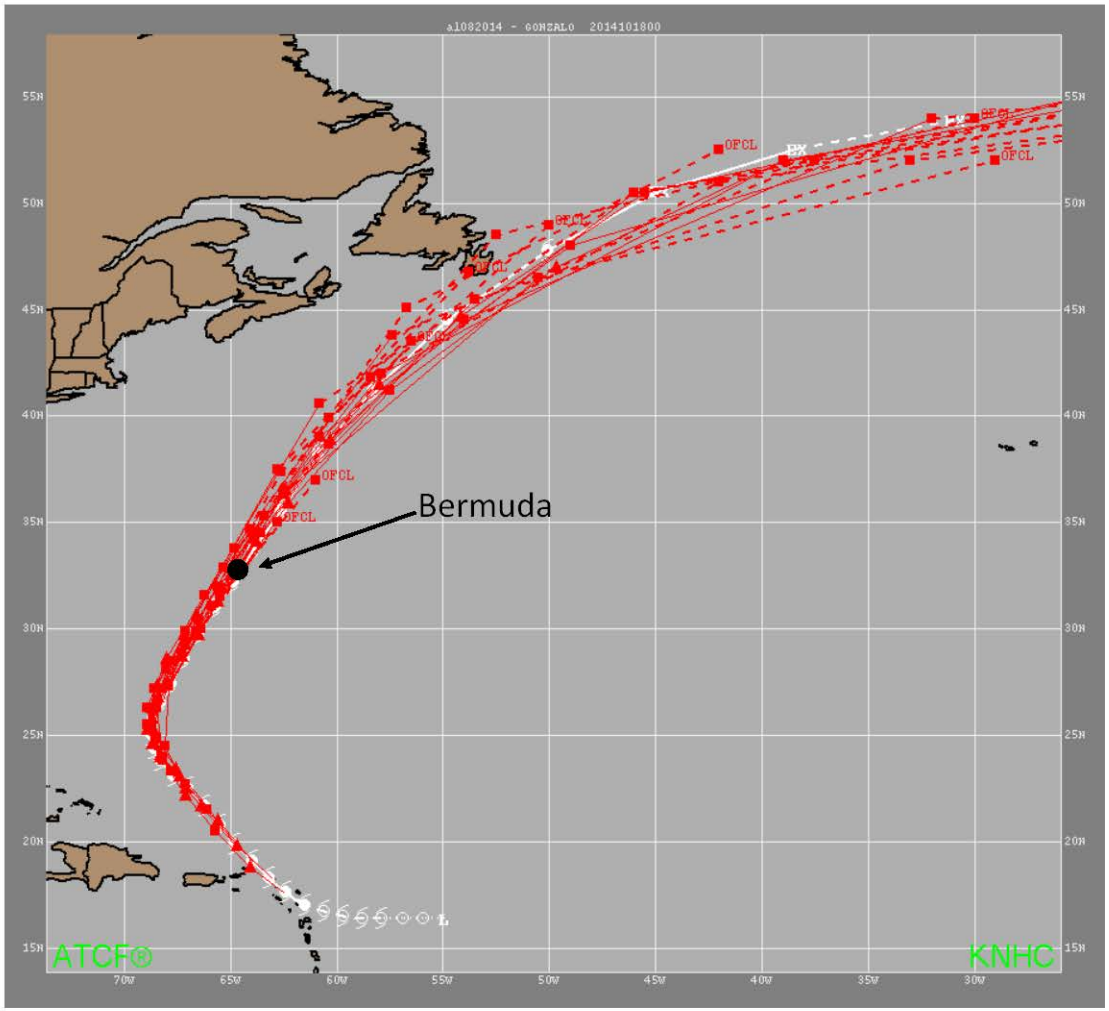

Figure 9. NHC track forecasts for Hurricane Gonzalo (red) from 1800 UTC 13 October through 0000 UTC 18 October. Note the consistency in the forecast tracks near and just west of Bermuda. The best track of Gonzalo is shown in white.