NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE FRANKLIN

(AL082023)

20 August – 1 September 2023

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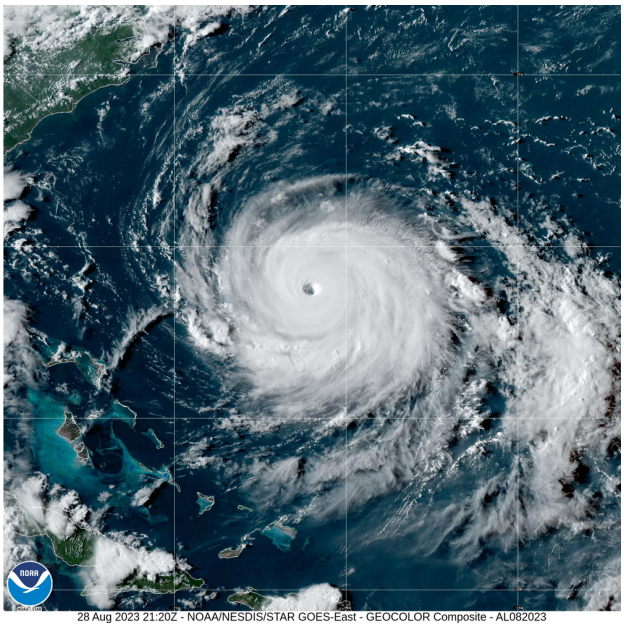
National Hurricane Center
11 June 2024[1]



GOES-16 GEOCOLOR IMAGE OF HURRICANE FRANKLIN NEAR PEAK INTENSITY AT 2120 UTC 28 AUGUST 2023. IMAGE COURTESY OF NOAA/NESDIS/STAR.

Franklin formed over the Caribbean Sea and passed over the Dominican Republic as a poorly organized tropical storm. It subsequently became a Category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) over the southwestern Atlantic that brought tropical-storm conditions to Bermuda.

[1] Original report date 3 April 2024. This version updated the verification section and Figure 9 to include one missing official forecast.

Hurricane Franklin

20 AUGUST – 1 SEPTEMBER 2023

SYNOPTIC HISTORY

Franklin was part of a very busy period of the 2023 Atlantic hurricane season, as during its lifetime it co-existed with Tropical Storms Emily, Gert, Harold, and Jose, as well as Hurricane Idalia. In the middle of August, a very active monsoon trough developed over the tropical Atlantic. By 17 August, three discreet disturbances became apparent in the trough. The eastern system became Tropical Storm Emily, the middle system became Tropical Storm Gert, and the western system – then located east-southeast of the Windward Islands – became Franklin. While the pre-Franklin disturbance formed primarily from the monsoon trough, a weak tropical wave that moved westward from the coast of Africa on 12 August may have also been a factor.

Convection associated with the pre-Franklin disturbance increased on 18 August, and on 19 August surface observations showed that an area of low pressure had formed over the southern Windward Islands. The low moved west-northwestward into the southeastern Caribbean Sea early on 20 August, where the convection became better organized. First-light visible satellite imagery showed a well-defined swirl of low clouds, and based on this and the preceding convective patterns it is estimated that a tropical depression formed near 0600 UTC 20 August about 150 n mi west of St. Vincent. The "best track" chart of the 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 cyclone moved west-northwestward after genesis on the south side of the subtropical ridge, and it became Tropical Storm Franklin 6 h after genesis. This motion, along with intensification, would continue into early 21 August, at which time the maximum winds were 45 kt. At that point Franklin turned westward and southwestward, with the cyclone losing organization due to increasing westerly vertical shear. By early on 22 August, the center of circulation degenerated to the point where it was questionable whether Franklin was still a tropical cyclone, and the system would remain disorganized throughout the day. While that occurred, the system turned northwestward as a mid- to upper-level trough developed over the southeastern United States and created a break in the subtropical ridge. Early on 23 August, the shear decreased as Franklin turned northward, and this allowed the cyclone to become better organized just south of Hispaniola. Continuing northward, the center made landfall on the Barahona Peninsula of the Dominican Republic near 1000 UTC 23 August, with the system taking about 12 h to cross the Dominican Republic to the southwestern Atlantic.

After reaching the southwestern Atlantic, Franklin moved to the north-northeast and strengthened some. However, this intensification paused when the aforementioned trough moved

[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.

east to a position north of the storm, creating westerly shear over the system. The trough to the north also caused the cyclone to move erratically eastward on 25 August. On 26 August, the trough split, with the northern part moving to the east while the southern part became a cut-off low southwest of Franklin. This allowed a ridge to develop northeast of Franklin, which caused the cyclone to turn sharply to the northwest. It also allowed intensification to resume by reducing the shear. Franklin became a hurricane at 1200 UTC that day about 290 n mi north of San Juan, Puerto Rico, and it would steadily strengthen for the next couple of days while continuing northwestward.

On 29 August, Franklin turned northward as it reached the western end of the subtropical ridge, and early that day it rapidly intensified to a peak intensity of 130 kt. After that peak, the cyclone began, but did not complete an eyewall replacement cycle (Fig. 4) that occurred during increasing southwesterly shear. This combination of meteorological elements started a weakening trend. The cyclone recurved to the northeast on 30 August as the shear – aided by the outflow from Hurricane Idalia to its southwest – increased, causing additional weakening. Franklin made its closest approach to Bermuda – about 120-125 n mi to the north-northwest – early on 31 August (Fig. 5), and then it moved east-northeastward into the open Atlantic. The cyclone then underwent extratropical transition and become a hurricane-force extratropical low near 1800 UTC 1 September about 625 n mi northeast of Bermuda.

Post-tropical Franklin continued moving generally east-northeastward over the cold north Atlantic through 3 September while gradually weakening. On 4 September, the cyclone became embedded in a large deep-layer cyclonic gyre over the northeastern Atlantic, and it spent the rest of its life making a large cyclonic loop inside this feature. This interaction initially caused the smaller Franklin to turn southward, which brought it over gradually increasing sea surface temperatures and into an area of lighter shear. This combination allowed for re-development of central convection on 6 September, accompanied by some intensification. However, this attempt to regain tropical cyclone characteristics was short lived, as the convection and the winds diminished on 7 September. After that, the system continued to weaken until it dissipated late on 9 September about 450 n mi northeast of the Azores.

METEOROLOGICAL STATISTICS

Observations in Franklin (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), objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) 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 11 missions of the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command, 7 missions of the NOAA Aircraft Operations Center (AOC) P-3's, and 2 missions of the AOC G-IV jet (Fig. 6). 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 Franklin.

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

Winds and Pressure

Franklin's estimated peak intensity of 130 kt is based on Air Force Reserve Hurricane Hunter aircraft data during a mission on 28–29 August. The plane reported 700-mb flight-level winds of 140 kt in the northeastern eyewall near 2300 UTC 28 August, along with a surface wind estimate of 128 kt from the SFMR at about the same time. The minimum pressure of 926 mb is based on two eye dropsondes near 0000 UTC 29 August reporting pressures of 927 mb and surface winds of about 10 kt.

Franklin's landfall intensity in the Dominican Republic is a little uncertain. After being poorly organized on 22 August, the cyclone was showing increasing organization during the last 10 h before landfall. However, reliable surface observations in the Dominican Republic (Table 3) did not show sustained tropical-storm-force winds, with a peak wind gust of 45 kt at Barahona. In addition, the minimum surface pressures reported across the country were generally 1005–1006 mb. Based on this, the landfall intensity is set to 40 kt with a central pressure of 1003 mb, which are both a little less intense than what was stated operationally. It should be noted that two private weather stations in the Dominican Republic reported gusts higher than 45 kt during Franklin's passage. However, they have been omitted from the table due to uncertainties about their representativeness.

Franklin brought tropical-storm conditions to Bermuda, with Gilbert Hill reporting sustained winds of 40 kt and the L. F. Wade International Airport reporting a gust of 50 kt. Additionally, a gust of 59 kt was reported at an automated station with an elevation of 150 ft.

Shipping generally avoided Franklin, with only a couple of reports of tropical-storm-force winds shown in Table 2. However, several Saildrones encountered the storm over the southwestern Atlantic (Table 3), with Saildrone 1064 reporting sustained winds of 54 kt and a gust to 65 kt on 26 August.

After the initial period of development on 20–21 August, Franklin became very disorganized on 22 August. The low-level circulation became very broad with multiple vorticity centers, and the system may not have met the well-defined center criteria for being a tropical cyclone during this time. Since the system was continually maintaining convection, low pressures, and tropical-storm-force winds, the best track keeps it as a tropical storm on 22 August. However, the best track positions on that day have a much greater-than-normal uncertainty.

After spending several days as an extratropical low, central convection re-formed in association with Franklin on 6 September, accompanied by an increase in winds and a decrease in the radius of maximum winds seen in scatterometer data. These developments indicate the cyclone was trying to regain some subtropical or tropical characteristics. However, the convection dissipated on 7 September, with the system steadily weakening after that occurred. Although the convection did affect the cyclone structure, the post-analysis indicates that the convection did not persist long enough to justify calling the system a subtropical or tropical cyclone during this time.

Storm Surge

Franklin may have caused a limited amount of storm surge along the southern coast of the Dominican Republic. However, there are no quantitative data or information about the impact. Slightly above normal tides affected Bermuda (Table 3). Swells and associated rip currents generated by the cyclone also reached portions of the coast of the northeastern United States, where the impacts were minor.

Rainfall and Flooding

In the Dominican Republic, Franklin caused widespread heavy rains, with many rainfall totals in the 6–10 in range (Fig. 7). The maximum reported rainfall total was 10.06 in (255.6 mm) at Santo Domingo. These rains caused damaging flooding and flash flooding.

Rainfall totals on Bermuda were generally below one inch. No information is available on rainfall from Franklin in Haiti or the Turks and Caicos Islands.

CASUALTY AND DAMAGE STATISTICS

Reports from the Meteorological Service of the Dominican Republic indicate that Franklin directly[3] caused three deaths in the Dominican Republic. Two of these resulted from freshwater flooding, while the cause of the third is unknown. Media reports indicate that Franklin's rains and winds caused about $90 million dollars (USD) of damage in the country, mainly from freshwater flooding damage to homes and infrastructure.

Media reports also indicate that Franklin had minor impacts on Bermuda, with the primary impact being isolated power outages.

FORECAST AND WARNING CRITIQUE

The timing of the genesis of Franklin was poorly forecast (Table 4). The system from which Franklin developed was introduced in the 7-day Tropical Weather Outlook (TWO) only 54 h prior to the best-track genesis time with a low probability (<40%) of development. The 7-day probabilities were raised to the medium category (40-60%) 18 h before genesis and to the high category (>60%) only 6 h before genesis. The system was introduced in the 2-day TWO 54 h before genesis in the low category. However, the probabilities were not raised to the medium

[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.

category until 12 h before genesis and to the high category until after genesis is analyzed to have occurred in the post analysis. A possible reason for the poor timing of the genesis forecasts is that the global models that forecast the system to develop waited to show genesis until it reached the more favorable environment in the central Caribbean Sea. In contrast, the location of Franklin's genesis was well forecast overall (Fig. 8), albeit for a limited number of outlooks.

A verification of NHC official track forecasts for Franklin is given in Table 5a. Official track forecast errors were greater than the mean official errors for the previous 5-yr period at all forecast times. However, the forecasts had considerable skill compared to climatology and persistence, likely due to Franklin's complex track and unusual (for August) partial recurvature out of the central Caribbean. A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. Many of the guidance models had lower mean track forecast errors than the official forecasts at most or all of the forecast times, and overall, the official forecasts had a poor performance compared to the guidance. Examination of the individual forecasts (Fig. 9) shows that while the track forecasts caught the general sense of Franklin's unusual track, there were two significant areas of error. First, the forecasts depicted that Franklin's low-latitude northeasterly motion would be followed by a northwesterly or northerly motion. However, the northwesterly turn that occurred was sharper than the majority of the official forecasts, which had a significant right bias. Second, the early forecasts for Franklin's recurvature into the westerlies called for the storm to move to the north (or left) of the actual track.

A verification of NHC official intensity forecasts for Franklin is given in Table 6a. Official intensity forecast errors were greater than the mean official errors for the previous 5-yr period at 12 and 24 h, comparable to the mean at 36 h, and below the mean from 48-120 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. The official forecasts generally outperformed the model guidance. However, the consensus models IVCN and IVDR, as well as the Florida State Superensemble (FSSE), had lower average errors than the official forecasts at most forecast times. Examination of the individual forecasts (not shown) showed three periods where the official forecasts performed poorly. The first was during 22–23 August, when the official forecasts underestimated the impacts of shear on the cyclone. A similar issue occurred during the period of arrested development on 25 August. The third period of poor performance was during Franklin's rapid intensification to peak intensity, where the peak was stronger than the forecasts.

Watches and warnings associated with Franklin are given in Table 7. A Tropical Storm Watch was issued for the landfall area in the Dominican Republic 61 h before the landfall, with a Tropical Storm Warning issued 55 h before landfall. However, the data are not sufficient to determine how timely the watch and warning was in relation to the onset of tropical-storm conditions. A Tropical Storm Warning was issued for Bermuda about 30 h before the arrival of tropical-storm conditions on the islands. Tropical storm watches and warnings were issued for the Turks and Caicos Islands, but these were later cancelled when the cyclone's wind field did not become as large as forecast.

ACKNOWLEDGEMENTS

Meteorological data for the Dominican Republic, along with the casualties and damage reports, were provided by the Meteorological Service of the Dominican Republic. Official data for Bermuda, including the radar image, was provided by the Bermuda Weather Service and the US National Ocean Service. WeatherFlow provided the WeatherFlow station data for the Dominican Republic and Bermuda. John Cangialosi provided the best track figure, while Dr. Philippe Papin provided the genesis forecast location figure and Dr. Lisa Bucci provided the aircraft missions figure. Saildrone data were provided by Saildrone.

Table 1. Best track for Hurricane Franklin, 20 August – 1 September 2023.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19 / 1800	12.8	60.5	1006	25	low
20 / 0000	13.1	62.1	1006	25	"
20 / 0600	13.5	63.7	1004	30	tropical depression
20 / 1200	14.0	65.2	1002	35	tropical storm
20 / 1800	14.5	66.6	1001	40	"
21 / 0000	14.8	67.9	999	45	"
21 / 0600	14.8	68.8	999	45	"
21 / 1200	14.6	69.5	999	45	"
21 / 1800	14.1	70.0	1002	45	"
22 / 0000	14.0	70.4	1002	45	"
22 / 0600	14.1	70.9	1002	40	"
22 / 1200	14.8	71.1	1003	40	"
22 / 1800	15.6	71.3	1003	35	"
23 / 0000	16.5	71.4	1003	35	"
23 / 0600	17.3	71.4	1003	40	"
23 / 1000	17.9	71.2	1003	40	"
23 / 1200	18.3	71.1	1005	40	"
23 / 1800	19.4	70.8	1004	35	"
24 / 0000	20.6	70.6	1005	40	"
24 / 0600	21.6	70.5	1001	45	"
24 / 1200	22.0	70.0	998	50	"
24 / 1800	22.2	69.3	1000	50	"
25 / 0000	22.4	68.5	1000	50	"
25 / 0600	22.2	68.1	1000	50	"
25 / 1200	21.9	67.9	1003	45	"
25 / 1800	21.8	67.3	1003	45	"
26 / 0000	22.2	66.5	1002	50	"
26 / 0600	22.6	66.0	992	55	"
26 / 1200	23.2	66.5	989	65	hurricane
26 / 1800	23.5	67.3	982	70	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
27 / 0000	23.9	67.9	977	75	"
27 / 0600	24.4	68.5	973	75	"
27 / 1200	24.9	69.1	970	80	"
27 / 1800	25.5	69.7	967	80	"
28 / 0000	26.0	70.3	964	85	"
28 / 0600	26.7	70.6	951	100	"
28 / 1200	27.5	70.9	937	125	"
28 / 1800	28.2	71.1	931	125	"
29 / 0000	28.9	71.1	926	130	"
29 / 0600	29.7	71.0	935	120	"
29 / 1200	30.3	70.7	941	115	"
29 / 1800	31.1	70.2	947	110	"
30 / 0000	31.8	69.5	953	100	"
30 / 0600	32.6	68.7	956	95	"
30 / 1200	33.2	67.8	958	95	"
30 / 1800	33.9	66.7	960	90	"
31 / 0000	34.4	65.2	961	90	"
31 / 0600	34.7	63.9	963	85	"
31 / 1200	35.1	62.6	964	85	"
31 / 1800	35.6	61.1	969	80	"
01 / 0000	36.4	59.7	975	75	"
01 / 0600	37.4	58.2	978	70	"
01 / 1200	38.2	56.6	982	65	"
01 / 1800	38.8	54.6	979	70	extratropical
02 / 0000	39.6	52.0	979	70	"
02 / 0600	41.2	48.8	980	70	"
02 / 1200	43.0	45.9	981	65	"
02 / 1800	44.8	43.4	982	65	"
03 / 0000	45.8	41.0	984	65	"
03 / 0600	46.4	38.7	986	60	"
03 / 1200	47.0	36.2	988	55	"
03 / 1800	47.7	33.4	990	55	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
04 / 0000	47.8	30.8	991	50	"
04 / 0600	47.5	28.6	993	45	"
04 / 1200	47.1	27.3	994	40	"
04 / 1800	46.7	26.8	995	40	"
05 / 0000	46.0	26.6	995	40	"
05 / 0600	44.6	26.3	995	40	"
05 / 1200	42.8	25.4	995	40	"
05 / 1800	41.0	23.8	995	40	"
06 / 0000	40.1	21.6	995	35	"
06 / 0600	40.1	19.4	995	35	"
06 / 1200	41.3	17.7	993	40	"
06 / 1800	43.3	16.5	992	45	"
07 / 0000	45.4	16.0	991	50	"
07 / 0600	46.8	16.1	991	50	"
07 / 1200	47.7	16.3	993	45	"
07 / 1800	48.5	16.5	996	40	"
08 / 0000	48.5	17.2	998	35	"
08 / 0600	48.3	17.8	1001	30	"
08 / 1200	47.9	18.5	1004	30	"
08 / 1800	47.2	18.9	1006	30	"
09 / 0000	46.3	19.1	1007	30	"
09 / 0600	45.3	19.4	1007	30	"
09 / 1200	44.1	19.8	1008	25	"
09 / 1800	43.1	20.3	1008	25	"
10 / 0000					dissipated
23 / 1000	17.9	71.2	1003	40	Landfall on the Barahona Peninsula of the Dominican Republic
29 / 0000	28.9	71.1	926	130	Maximum winds and minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Franklin, 20 August – 1 September 2023.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/ speed (kt)	Pressure (mb)
20/1900	9V6973	15.7	67.9	090/38	1007.0
02/1500	VRLZ4	47.7	42.1	050/35	1005.7

Table 3. Selected surface observations for Hurricane Franklin, 20 August – 1 September 2023.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
NOAA Buoys									
NOAA 41043 (21.03N 64.79W) (4.1m)	26/1010	1004.6	26/0505	35 (1-min)	39				
NOAA 41046 (23.82N 68.39W) (3.8m)	27/0330	988.5	27/0355	47 (1-min)	60				
NOAA 41047 (27.47N 71.45W) (4.1m)	28/1230	988.3	28/1330	49 (1-min)	60				
NOAA 41048 (31.83N 69.57W) (4.1m)	30/0050	954.9	29/2211	72 (1-min)	87				
NOAA 42059 (15.30N 67.48W) (4.1m)	20/2110	1003.2	21/0013	31 (1-min)	35				
Saildrones									
Saildrone 1031 (15.60N 66.70W)	20/1916	1005.4	20/2248	32	38				
Saildrone 1036 (25.26N 66.96W)	27/0728	1003.0	27/0201	37	47				
Saildrone 1064 (23.07N 65.86W)	26/0810	996.5	26/0725	54	65				
Saildrone 1065 (27.94N 65.35W)	27/0900	1010.1	27/1535	30	37				
Dominican Republic									
International Civil Aviation Organization (ICAO) Sites									
Arroyo Barril (MDAB) (19.20N 69.43W)	22/1000	1009.2							3.46
Barahona (MDBH) (18.20N 71.10W)	23/0000	1006.0	21/2100	20	45				5.63
Higuero (MDJB) (18.57N 69.987W)	23/0900	1007.7							9.54
La Romana (MDLR) (18.42N 68.95W)	23/0600	1007.0			25				7.71
Punta Cana (MDPC) (18.57N 68.37W)	23/0700	1007.9			25				4.72
Las America/Santo Domingo (MDSD) (18.43N 69.67W)	23/0700	1007.7	23/1700	18	34				8.75
Santiago (MDST) (19.40N 70.60W)	23/1900	1007.0	21/1800	15	35				0.91

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
WMO Synoptic Sites									
Sabana de la Mar (78467) (19.05N 69.38W)	23/0900	1009.0							3.52
Bayaguana (78473) (18.75N 69.63W)	23/0600	1006.8							7.78
Santo Domingo Central (78486) (18.43N 69.88W)	23/0600	1008.3							10.06
WeatherFlow									
Puntarena (18.25N 70.55W)			23/1535		37				
Santo Domingo (18.48N 69.96W)			23/1815	26	37				
Bermuda									
International Civil Aviation Organization (ICAO) Sites									
L. F. Wade Intl. Aprt. (TXKF) (32.37N 64.68W)	30/2155	1005.0	31/0014	36 (10-min)	50				0.19
National Ocean Service (NOS) Sites									
St. George's Island (BEPB6) (32.37N 64.70W)	30/2300	1005.1				1.12			
Bermuda Ferry Reach Channel (FRCB6) (32.37N 64.70W)	30/2306	1005.4				0.73			
WeatherFlow									
Bluck Point Road (32.30N 64.81W)			30/2315	24	39				
Gilbert Hill (32.31N 64.74W)			31/0115	40	43				
Knapton Hill (32.32N 64.72W)			31/0321	23	38				
Mill Creek (32.30N 64.80W)			30/2200	27	36				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Other Sites									
AWOS site NMB (elevation 150 ft) (32.33N 64.83W)			31/0022		59				

[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] Storm surge is water height above normal astronomical tide level.
[d] For most locations, storm tide is water height above the North American Vertical Datum of 1988 (NAVD88). Storm tide is water height above Mean Lower Low Water (MLLW) for NOS stations in Puerto Rico, the U.S. Virgin Islands, and Barbados.
[e] Estimated inundation is the maximum height of water above ground. For some USGS storm tide pressure sensors, inundation is estimated by subtracting the elevation of the sensor from the recorded storm tide. For other USGS storm tide sensors and USGS high-water marks, inundation is estimated by subtracting the elevation of the land derived from a Digital Elevation Model (DEM) from the recorded and measured storm tide. For NOS tide gauges, the height of the water above Mean Higher High Water (MHHW) is used as a proxy for inundation.

Table 4. Number of hours in advance of formation of Franklin 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	**168-Hour Outlook**
Low (<40%)	54	54
Medium (40%-60%)	12	18
High (>60%)	N/A	6

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Franklin, 20 August – 1 September 2023. 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	60	72	96	120
OFCL	25.8	40.3	51.4	70.8	97.5	133.0	179.9	292.1
OCD5	50.2	106.5	169.8	240.0	307.9	364.5	476.3	512.2
Forecasts	46	44	42	40	38	35	32	27
OFCL (2018-22)	23.8	35.7	47.8	61.4	76.1	90.5	125.7	172.1
OCD5 (2018-22)	46.4	99.2	157.4	215.0	254.9	321.2	405.1	486.6

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Franklin, 20 August – 1 September 2023. 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	60	72	96	120
OFCL	25.2	40.0	51.6	70.8	98.7	136.3	175.9	304.5
OCD5	50.3	105.9	167.1	234.0	300.9	354.5	445.8	474.5
GFSI	**23.7**	**36.4**	52.1	76.4	118.0	190.1	268.5	374.9
HWFI	26.8	45.3	61.5	83.0	104.5	**125.8**	225.9	471.1
HMNI	29.1	45.6	60.9	80.0	110.3	162.1	238.4	351.9
HFAI	26.6	46.3	60.3	71.6	**93.0**	**118.8**	**162.7**	**251.6**
HFBI	27.9	45.6	56.3	**64.9**	**82.5**	**104.0**	**155.7**	**247.3**
EMXI	**24.4**	**38.5**	**47.2**	**60.2**	**67.5**	**73.7**	**115.7**	**199.0**
NVGI	36.5	61.7	83.0	109.2	138.6	157.2	180.5	**251.1**
CMCI	37.0	62.4	67.3	74.3	**93.0**	**131.5**	**167.0**	**270.0**
CTCI	29.2	47.4	65.9	87.1	127.7	185.3	202.6	**299.3**
TVCA	**23.7**	**37.4**	**48.4**	**63.5**	**85.4**	**122.0**	**171.0**	**274.2**
TVCX	**23.2**	**37.0**	**46.4**	**62.2**	**81.3**	**115.2**	**162.4**	**259.1**
GFEX	**22.3**	**34.4**	**40.4**	**56.2**	**77.5**	**113.0**	**170.2**	**250.5**
TVDG	**23.6**	**36.3**	**46.1**	**62.8**	**85.1**	**123.1**	**168.1**	**262.4**
HCCA	**24.3**	**38.6**	**48.5**	**67.1**	**94.7**	**135.7**	186.7	**281.4**
FSSE	**22.6**	**34.4**	**46.0**	**65.6**	**90.3**	**135.6**	199.8	318.4
AEMI	27.9	44.2	59.1	80.1	107.9	148.7	202.4	330.5
UEMI	29.0	43.2	**53.6**	**68.2**	**92.0**	**130.5**	**107.7**	**138.5**
TABS	48.1	92.1	132.9	167.6	198.4	237.0	271.2	350.9
TABM	38.5	69.7	104.3	141.2	178.7	243.2	336.9	514.6
TABD	31.6	52.8	79.6	115.1	174.1	280.4	438.5	680.8
Forecasts	44	42	40	38	36	33	28	25

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Franklin, 20 August – 1 September 2023. 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	60	72	96	120
OFCL	6.5	9.0	9.2	**8.9**	**8.3**	**8.9**	**10.3**	**14.1**
OCD5	6.7	11.5	15.6	16.3	18.4	22.4	30.2	32.1
Forecasts	46	44	41	40	38	36	32	28
OFCL (2018-22)	5.1	7.6	8.9	10.1	10.7	11.5	13.3	15.5
OCD5 (2018-22)	6.8	10.7	13.9	16.5	18.3	20.2	22.9	23.4

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Franklin, 20 August – 1 September 2023. 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	60	72	96	120
OFCL	6.5	9.0	9.2	8.9	8.3	9.1	10.3	14.6
OCD5	6.7	11.5	15.6	16.3	18.4	22.7	32.6	33.2
HWFI	7.8	9.6	13.0	12.1	11.9	14.1	18.4	26.2
HMNI	**6.3**	9.9	11.1	10.6	11.6	11.7	14.9	21.9
HFAI	7.5	9.6	10.5	10.5	12.0	13.0	15.9	**12.8**
HFBI	7.5	**8.7**	10.6	11.1	11.8	12.6	13.7	**13.8**
DSHP	6.5	9.9	11.5	9.7	10.1	12.7	17.1	23.2
LGEM	6.5	9.5	10.5	10.1	11.8	15.0	21.0	26.6
ICON	**6.0**	**8.8**	10.5	9.1	8.4	9.2	13.8	20.7
IVCN	**5.4**	**7.8**	9.3	**7.9**	**8.2**	9.4	11.2	13.8
IVDR	**5.6**	**7.8**	9.3	**8.3**	**8.2**	9.4	11.0	**14.1**
CTCI	**6.1**	10.3	10.5	**8.6**	11.8	14.3	15.8	18.5
GFSI	6.8	9.9	12.8	13.8	14.5	16.7	20.7	22.3
EMXI	7.7	10.9	13.3	15.6	20.3	23.3	29.7	31.0
HCCA	**6.0**	**7.4**	**8.4**	**7.2**	8.7	10.5	11.1	16.1
FSSE	**5.7**	**7.8**	**8.5**	**6.5**	**7.4**	**8.9**	11.4	**13.8**
Forecasts	46	44	42	40	38	35	29	26

Table 7. Watch and warning summary for Hurricane Franklin, 20 August – 1 September 2023.

Date/Time (UTC)	Action	Location
20 / 2100	Tropical Storm Watch issued	South coast of the Dominican Republic from the Dominican Republic-Haiti border eastward to Isla Saona
20 / 2100	Tropical Storm Watch issued	South coast of Haiti from Anse d'Hainault eastward to the Dominican Republic-Haiti border
21 / 0300	Tropical Storm Warning issued	South coast of the Dominican Republic from the Dominican Republic-Haiti border eastward to Isla Saona
21 / 0300	Tropical Storm Warning issued	South coast of Haiti from Anse d'Hainault eastward to the Dominican Republic-Haiti border
21 / 0300	Tropical Storm Watch issued	Eastern and north coasts of the Dominican Republic from Isla Saona to the Dominican Republic-Haiti border
21 / 1200	Tropical Storm Watch issued	Turks and Caicos Islands
22 / 1800	Tropical Storm Warning issued	Eastern and north coasts of the Dominican Republic from Isla Saona to the Dominican Republic-Haiti border
23 / 0900	Tropical Storm Warning issued	Turks and Caicos Islands
23 / 1800	Tropical Storm Warning discontinued	South coast of Haiti from Anse d'Hainault eastward to the Dominican Republic-Haiti border
23 / 2100	Tropical Storm Warning discontinued	South coast of the Dominican Republic from the Dominican Republic-Haiti border to Punta Palenque
24 / 0900	All coastal watches and warning discontinued	Dominican Republic and the Turks and Caicos Islands
29 / 1500	Tropical Storm Warning issued	Bermuda
31 / 0900	All coastal watches and warning discontinued	Bermuda

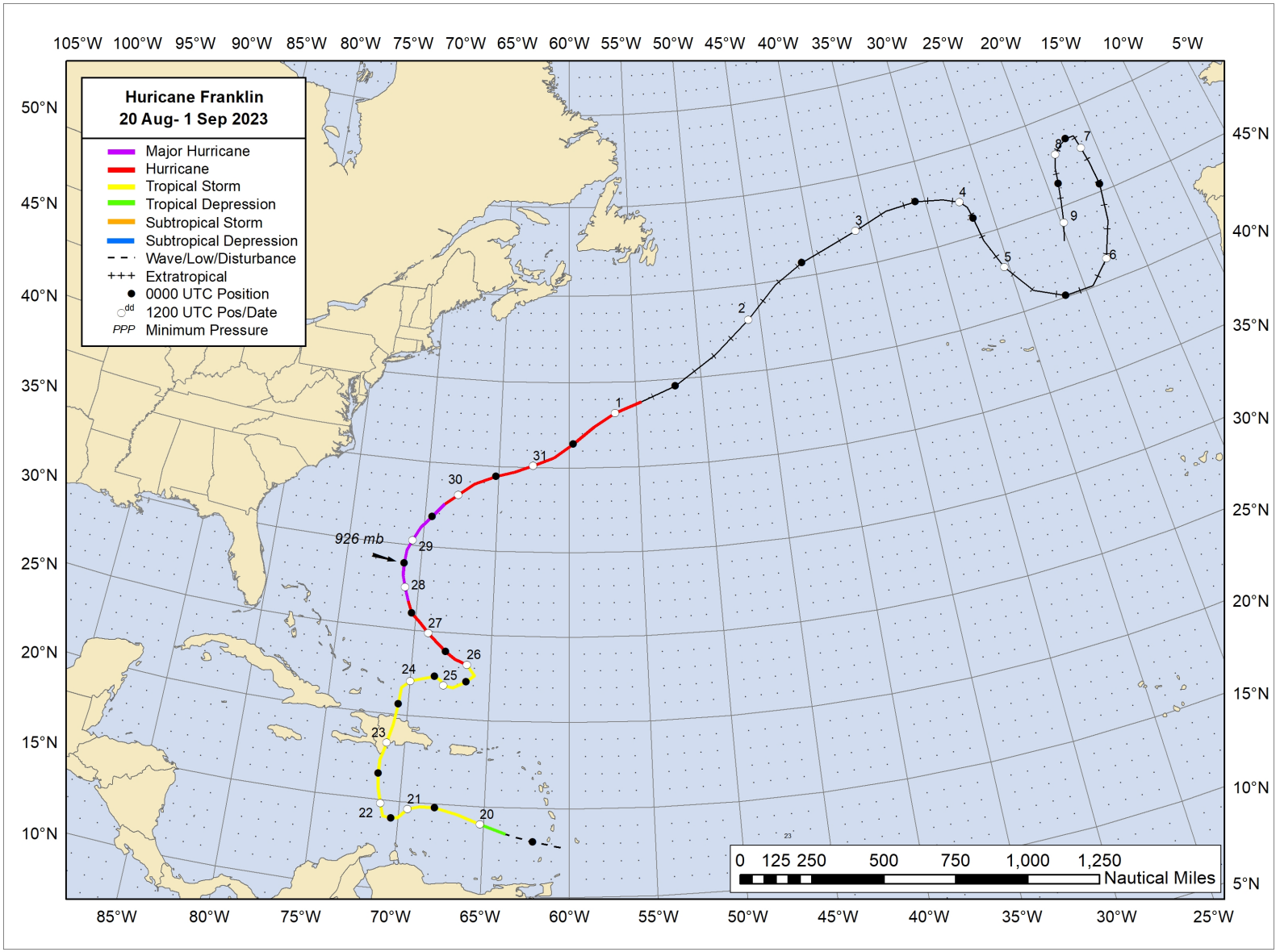


Figure 1. Best track positions for Hurricane Franklin, 20 August – 1 September 2023. Track during the extratropical stage is partially based on analyses from the NOAA Ocean Prediction Center.

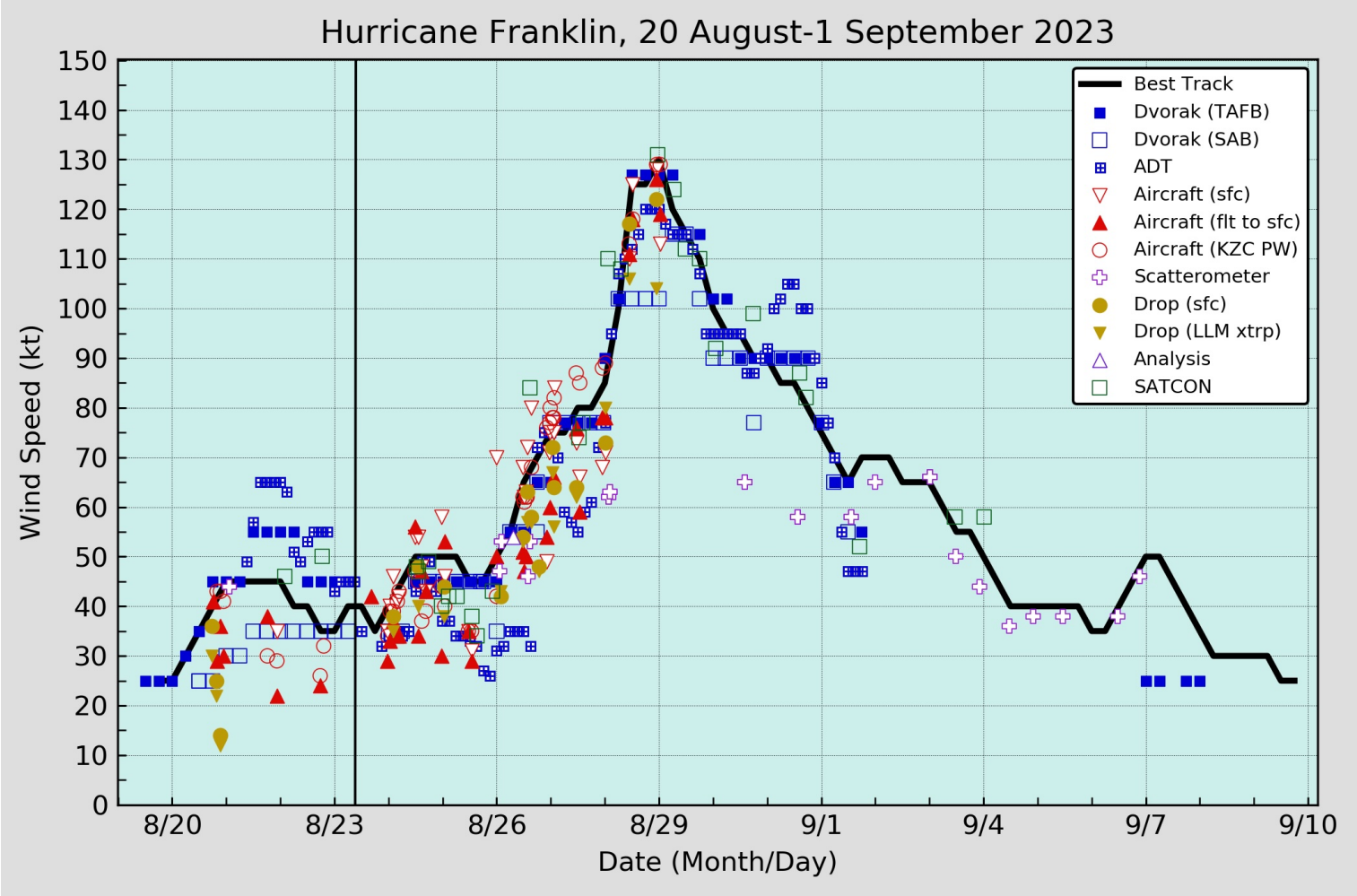


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Franklin, 20 August – 1 September 2023. Aircraft observations have been adjusted for elevation using 90%, 80%, and 75% adjustment factors for observations from 700 mb, 850 mb, and 925 mb, respectively. 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. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfalls.

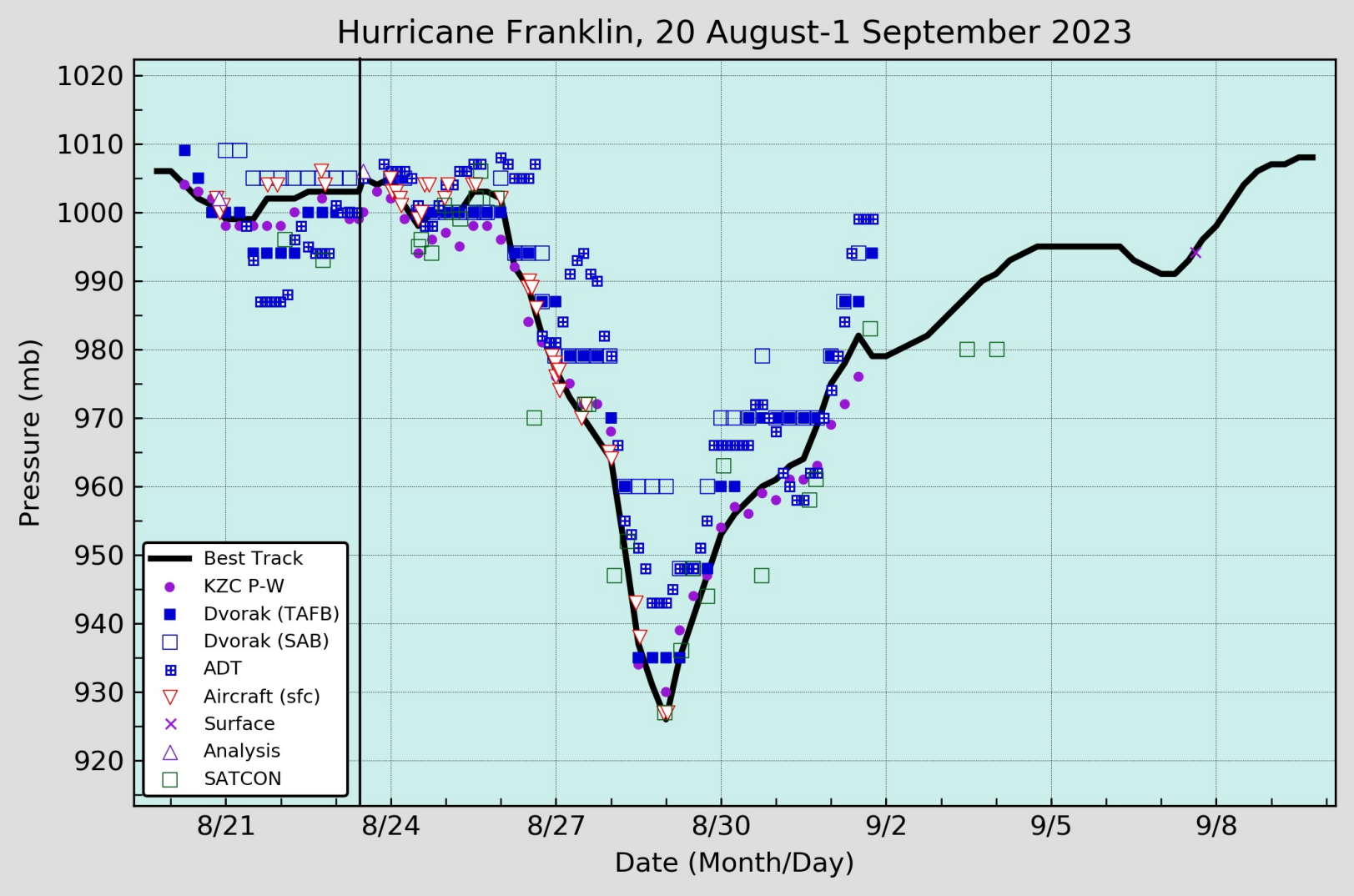


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Franklin, 20 August – 1 September 2023. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. 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.

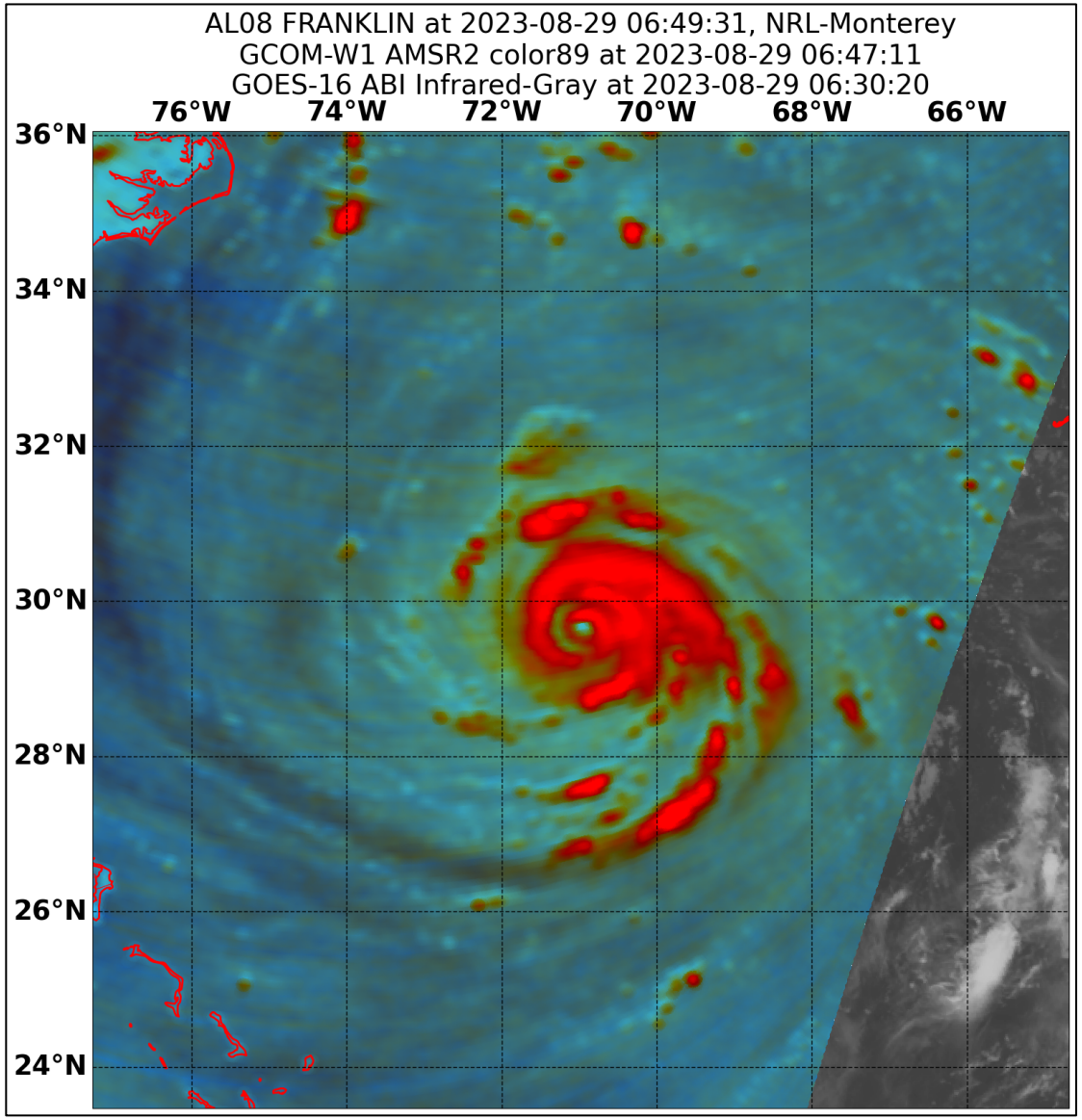


Figure 4. 89-GHz color composite image of Franklin from the AMSR2 instrument on the GCOM-W1satellite taken at 0647 UTC 29 August 2023. Image courtesy of the Naval Research Laboratory, Monterey, CA.

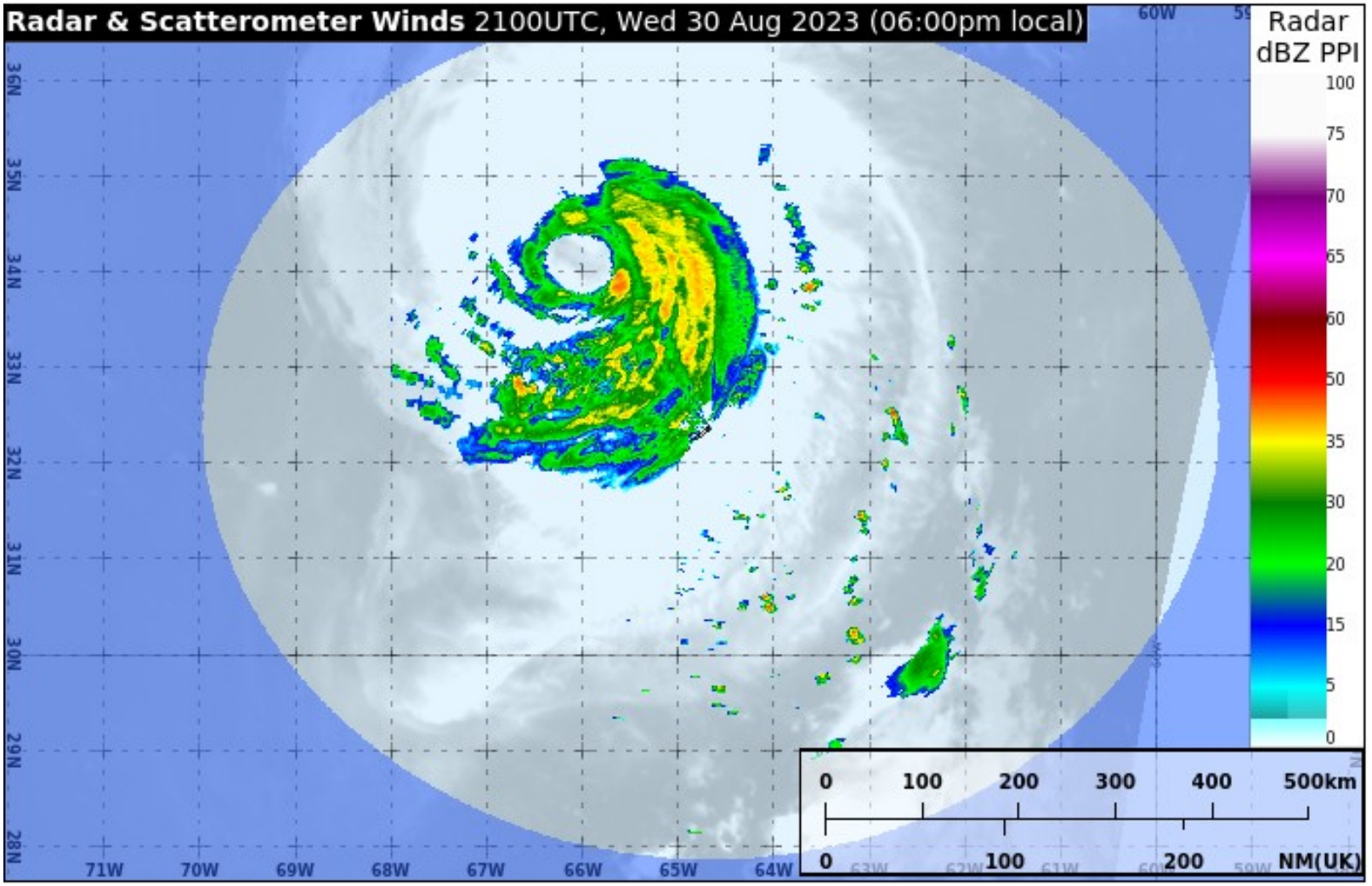


Figure 5. Bermuda radar reflectivity image of Franklin near 2200 UTC 30 August. Image courtesy of the Bermuda Weather Service.

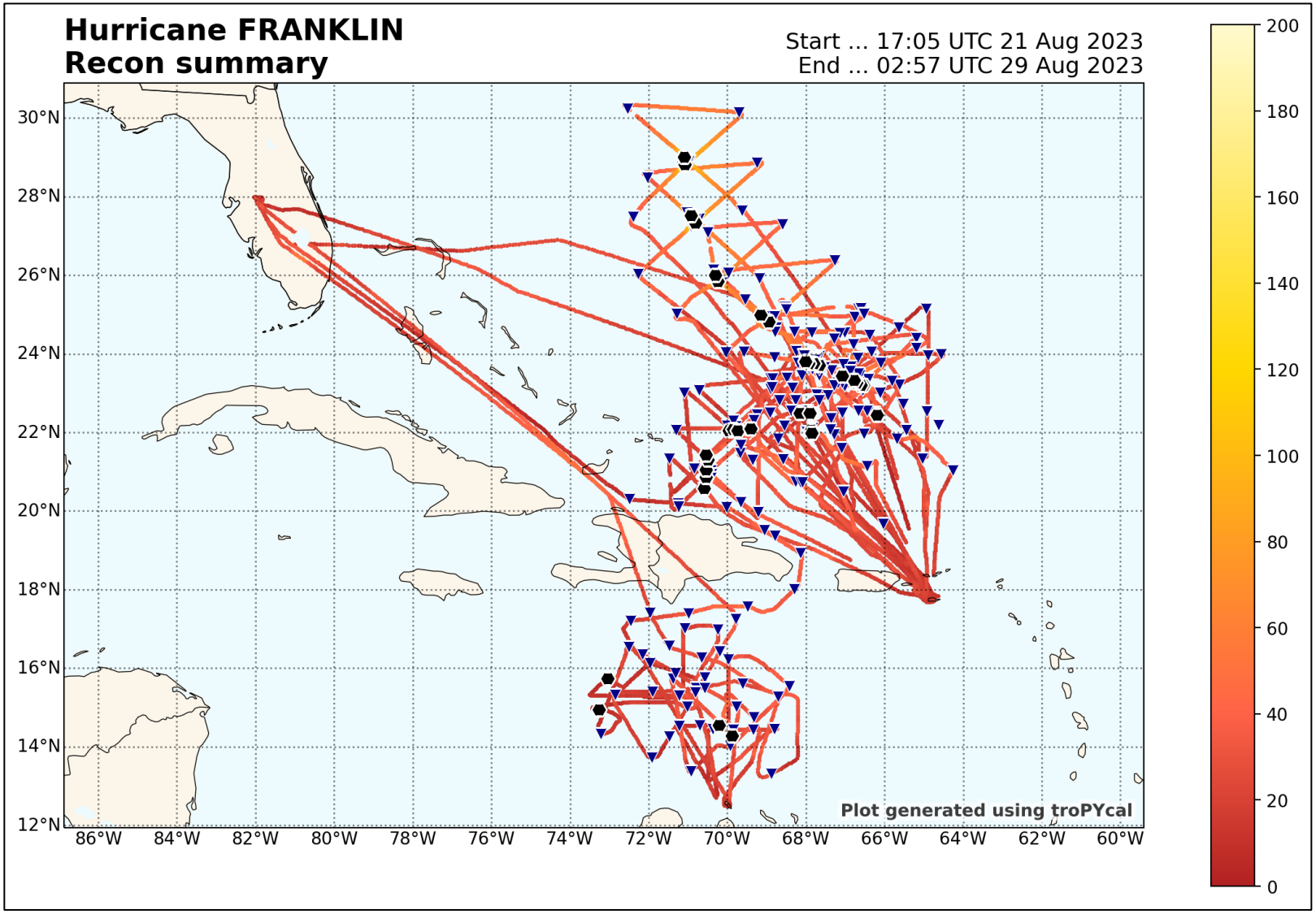


Figure 6. Air Force Reserve and NOAA Hurricane Hunter aircraft flight tracks (red) from reconnaissance missions into Franklin. The black markers denote center fixes, and the blue triangles indicate dropsonde locations. The color coding of the flight tracks is based on the observed flight-level wind speed with the color legend to the right of the map representing the color associated with the various wind speeds in knots.

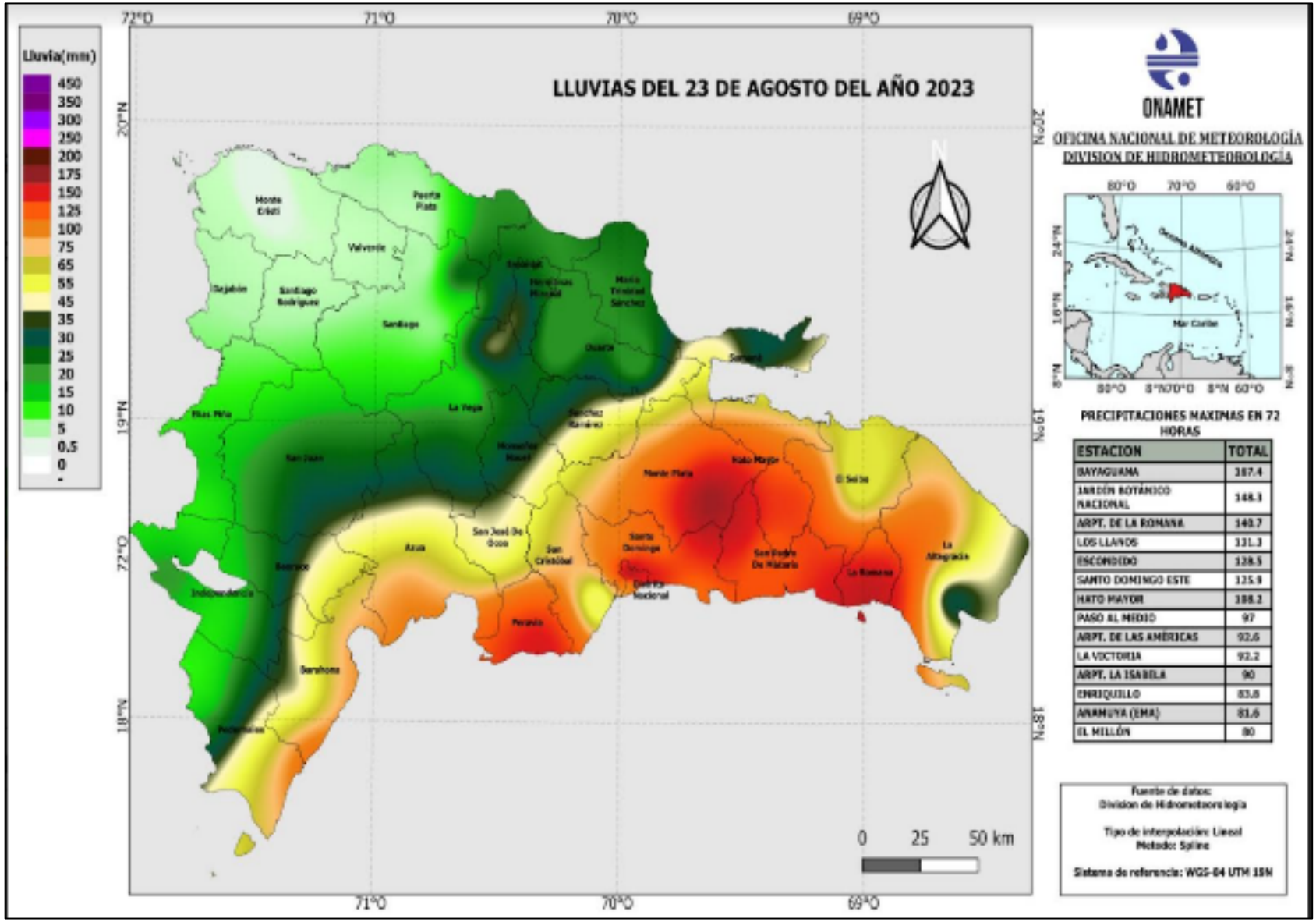


Figure 7. Rainfall totals (mm) in the Dominican Republic during the passage of Franklin. Image courtesy of the Meteorological Service of the Dominican Republic.

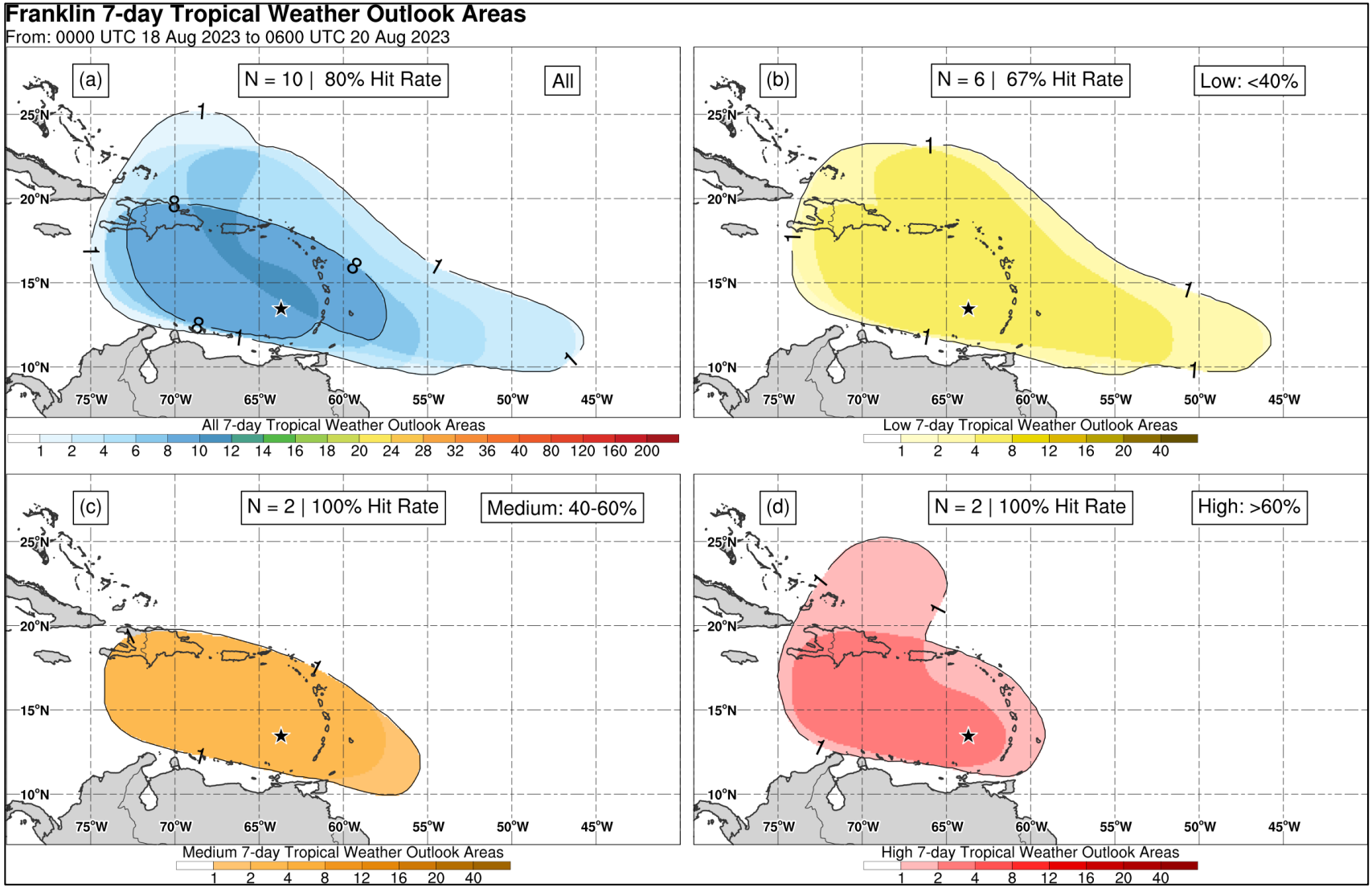


Figure 8. Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks prior to the formation of Hurricane Franklin, 20 August – 1 September 2023 for (a) all probabilistic genesis categories, (b) the low (<40%) category, (c) medium (40–60%) category, and (d) high (>60%) category. The location of genesis is indicated by the black star.

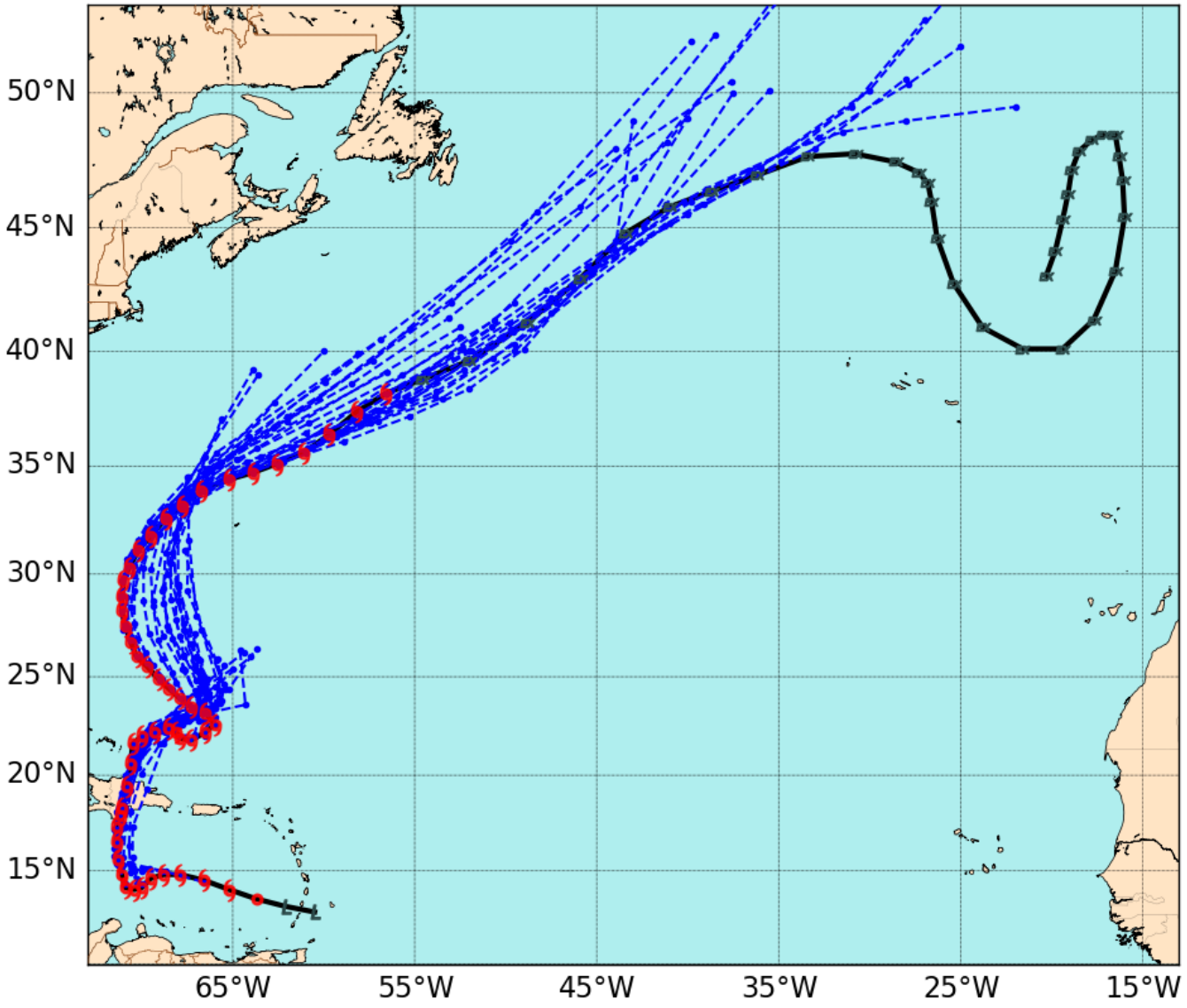


Figure 9. Selected official track forecasts (blue lines, with 0, 12, 24, 36, 48, 60, 72, 96, and 120 h positions indicated) for Hurricane Franklin, 20 August – 1 September 2023. The best track is given by the black line and red symbols with positions given at 6 h intervals.