NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE NORMA

(EP172023)

17–23 October 2023

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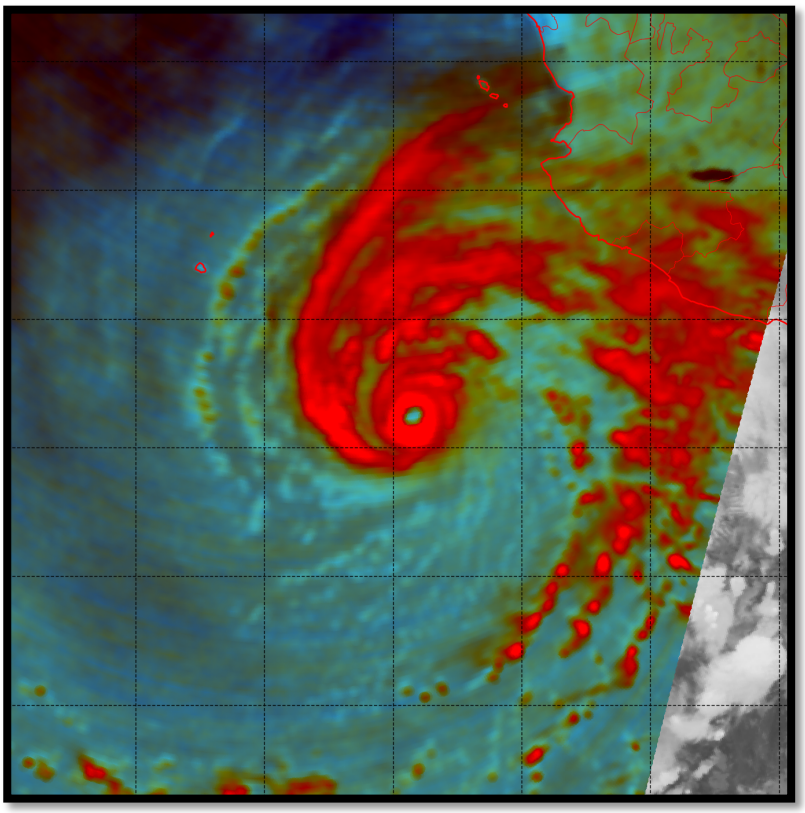

89-GHZ AMSR-2 MICROWAVE SATELLITE IMAGE OF HURRICANE NORMA AT 0900 UTC 19 OCTOBER, JUST BEFORE PEAK INTENSITY. IMAGE COURTESY OF THE NAVAL RESEARCH LABORATORY.

Norma was a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that made landfall as a category 1 hurricane in Baja California Sur and as a tropical depression in Sinaloa, Mexico. Norma caused three indirect fatalities in the state of Sinaloa, Mexico.

Hurricane Norma

17–23 OCTOBER 2023

SYNOPTIC HISTORY

The origins of Norma came from an interaction between the monsoon trough over the eastern Pacific basin and a Gulf of Tehuantepec gap wind event on 15–17 October. On 15 October, a broad area of low pressure developed within the monsoon trough near 98°W with disorganized showers and thunderstorms. Diurnal bursts of convection gradually consolidated within the broad circulation over the next couple of days, and a tropical depression formed by 1200 UTC 17 October about 400 n mi south-southwest of Manzanillo, Mexico. The "best track" chart of Norma'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[1].

The depression became a tropical storm 6 h after formation as it moved quickly west-northwestward out of the monsoon trough. Atmospheric conditions featured ample mid-level moisture, low deep-layer vertical wind shear, and large-scale upper-level diffluence. This environment combined with warm sea surface temperatures were all conducive for strengthening and fueled a nearly 2-day period of rapid intensification. As Norma rapidly intensified, a weakening mid-level ridge over Mexico gradually slowed the storm's forward speed and turned it northward. By 1800 UTC 18 October, Norma became a 65-kt hurricane when it was located about 450 n mi south-southeast of Cabo San Lucas, Mexico.

Rapid strengthening continued and a mere 12 h later, Norma intensified to a 105-kt major hurricane. Satellite data at that time revealed a 20-n mi diameter eye, surrounded by cloud tops between -70 to -75°C. The hurricane continued to travel slowly (about 5 kt) northward on the western periphery of the weak mid-level ridge while still embedded in an environment with light vertical wind shear and over warm ocean waters. At 1200 UTC 19 October, Norma reached an estimated peak intensity of 115 kt (category 4 on the Saffir-Simpson Hurricane Wind Scale) when it was centered about 350 n mi south-southeast of Cabo San Lucas.

Shortly after reaching its peak intensity, the storm encountered increasing vertical wind shear and appeared to entrain some mid-level dry air. Observations from a 53rd Air Force Reserve Hurricane Hunter aircraft showed that the eye was no longer closed and had become asymmetric, and flight-level and SFMR data suggest that Norma had weakened slightly as it began to increase in forward speed and turn north-northwestward. Even though the satellite presentation of the tropical cyclone would indicate that Norma continued to gradually weaken over the next day, a subsequent Air Force reconnaissance mission 24 h later indicated that Norma

[1] 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.

briefly re-strengthened back to 105 kt by 1800 UTC 20 October as its motion turned northwestward about 165 n mi south of the southern tip of the Baja California peninsula.

By 21 October, Norma began to rapidly weaken as it moved toward the Baja California peninsula due to increasing wind shear and cooler ocean waters. The hurricane turned toward the north in the flow between the mid-level ridge over Mexico and an approaching upper-level trough to the northwest. Norma made landfall in the state of Baja California Sur near El Pozo de Cota as a 70-kt hurricane around 2015 UTC 21 October. Over land, Norma weakened to a tropical storm and turned north-northeastward as it crossed the Baja California peninsula. By early 22 October, Norma exited the eastern coast of the peninsula and moved over the Gulf of California. Convection initially pulsed periodically, but was ultimately sheared away by strong upper-level winds associated with the trough, as the tropical storm slowed down further while turning eastward. Norma weakened to a tropical depression and moved into the state of Sinaloa near Eldorado around 1030 UTC 23 October. Shortly thereafter, the system dissipated over the rugged terrain of western Mexico around 1800 UTC that day.

METEOROLOGICAL STATISTICS

Observations in Norma (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 three flights of the 53rd Weather Reconnaissance Squadron (WRS) of the U.S. Air Force Reserve Command (Fig. 4). 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 Norma.

Selected surface observations from land stations are given in Table 2. Ship reports of winds of tropical storm force or greater associated with Norma are given in Table 3.

Winds and Pressure

Norma's estimated peak intensity of 115 kt at 1200 UTC 19 October is based on consensus T6.0/115 kt subjective Dvorak classifications from TAFB and SAB. There were no reconnaissance data available at the estimated time of peak intensity. The satellite presentation of Norma began to degrade shortly after this peak, by which point the reconnaissance aircraft arrived for the first mission. The plane measured a peak 700-mb flight-level wind speed of 111 kt at 1723 UTC 19 October and 102 kt on the SFMR at 1730 UTC. The reconnaissance weather officer also noted that the eyewall was open to the southeast, providing further evidence the aircraft arrived just after the peak intensity.

The estimated minimum central pressure is 939 mb at 1200 UTC 19 October. A dropsonde measurement at 1801 UTC that day (after Norma had begun to weaken) recorded 942 mb with 12-kt of winds at the surface. While 939 mb is several millibars lower than the other estimates available at 1200 UTC, it is assumed that the central pressure at peak intensity was lower than at the time of the dropsonde measurement.

Norma brought hurricane-force winds to the state of Baja California Sur where the center made landfall near El Pozo de Cota, west-northwest of Cabo San Lucas. The third and final Air Force mission investigated Norma shortly before landfall and found hurricane-force SFMR winds in the northwest quadrant, with a maximum wind of 73 kt. A center dropsonde supported a minimum pressure of around 974 mb. Assuming some continued weakening occurred after the plane departed, the landfall intensity is estimated to be 70 kt.

The strongest sustained wind measured by a ground station was 70 kt by a Mexican Navy weather station near Cabo San Lucas at 1430 UTC 21 October, which was several hours before the center of Norma reached the coast. The station also measured a gust of 93 kt. Farther inland, a station up in the mountains measured a sustained wind of 76 kt at 1540 UTC that day, however, at an elevation of approximately 7000 ft, and possibly enhanced by the topography.

Rainfall and Flooding

Norma produced heavy rainfall across the Mexican states of Baja California Sur and Sinaloa. Many areas in these states received 2 or more inches (>50 mm) of rainfall, with locally higher amounts near the landfall locations (Fig. 5). A storm total maximum of 19.21 inches (488.0 mm) of rain was measured in El Quemado, Baja California Sur. Elsewhere in the same state, San Vicente de la Sierra reported 18.89 inches (480.0 mm) and La Palmilla observed 18.62 inches (473.0 mm).

CASUALTY AND DAMAGE STATISTICS

There were three indirect casualties[2] associated with Norma in the Mexican state of Sinaloa. Two deaths occurred as a result of vehicle accidents and one, a child, was due to electrocution[3]. No deaths or injuries were reported in the state of Baja California Sur.

The governor of the state of Baja California Sur estimated the flooding rains, winds, storm surge, and heavy surf produced about $11.1 million USD ($200 million pesos) in infrastructure

[2] 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.

[3] https://www.unotv.com/nacional/huracan-norma-causa-danos-en-bcs-y-sinaloa-muere-un-nino/

damages[4]. Streets and canals flooded in several municipalities and were accompanied by downed trees and utility lines (Fig. 6). An estimated 10,000 homes were without power in Cabo San Lucas[5]. There were many reports of various types of boats washed ashore or damaged at their respective docks. Conditions forced the port in La Paz to close, stranding a ferry carrying over 400 people traveling from the state of Sinaloa in the Gulf of California.[6]

Heavy rainfall and strong winds from Norma also caused flooding that forced road closures, uprooted trees and damaged power lines in the state of Sinaloa. The governor reported infrastructure damages totaling about $12.2 million USD ($220.5 million pesos) and the formation of 18 sinkholes across the state due to the heavy rains[7].

FORECAST AND WARNING CRITIQUE

The genesis of Norma was forecast well in advance (Table 4). The area of low pressure from which Norma developed was introduced in the Tropical Weather Outlook (TWO) 132 h prior to genesis with a low probability (< 40%). The 7-day formation chances were raised to the medium (40-60%) and high (>60%) categories 96 h and 78 h before genesis, respectively. Norma was introduced with a low probability of formation in the 2-day TWO 54 h prior to formation. The 2-day probabilities were raised to the medium and high categories 42 h and 30 h before genesis, respectively. A well-defined area of low pressure formed offshore of southern Mexico by 17 October, just before the system consolidated enough organized convection for genesis to occur. Figure 7 shows composites of 7-day TWO genesis areas for each category prior to the formation of Norma.

A verification of NHC official track forecasts for Norma is given in Table 5a. Official track forecast (OFCL) errors were lower than mean official errors for the previous 5-yr period for the 24–72 h forecast periods. At 12 h and 96 h, the forecast errors were comparable to the long-term mean, but the 120 h forecast errors were notably larger than the 5-yr mean. A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b and Fig. 8. Several of the regional models and consensus aids outperformed OFCL at a variety of the forecast lead times, with the simple consensus aids (TCVE, TVCX, and TVDG) consistently beating OFCL at the 12–96 h forecast lead times.

A verification of NHC official intensity forecasts for Norma is given in Table 6a. At 12 h and 120 h, the official intensity forecast errors were approximately twice as large as the mean official errors for the previous 5-yr period. The large errors could be due to not capturing the rate of rapid intensification and weakening at the short term forecast lead times (Fig. 10). A few early forecasts also predicted significantly stronger-than-observed intensities at the 120-h lead time

[4] https://www.bcsnoticias.mx/huracan-norma-dejo-200-mdp-en-danos-a-infraestructura-no-habra-apoyo-federal-gobernador-de-bcs/

[5] https://www.washingtonpost.com/weather/2023/10/23/hurricane-tammy-pacific-storm-otis-norma/

[6] https://www.pbs.org/newshour/world/norma-downgraded-to-tropical-storm-in-mexico-as-hurricane-tammy-leaves-minor-damage-in-caribbean

[7] https://www.eluniversal.com.mx/estados/tormenta-tropical-norma-causo-danos-en-carreteras-puentes-y-abrio-18-socavones-en-sinaloa/

that likely contributed to the higher-than-average error. However, at 24–48 h and 96 h the official errors were comparable to the mean and at 60–72 h, the errors were lower than the mean. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b and Fig. 9. The official forecast errors were only slightly higher than a few of the regional models and consensus aids between 12–72 h. However, at 96–120 h most model guidance had much lower intensity errors than the official forecast.

Coastal watches and warnings issued by the government of Mexico in association with Norma are given in Table 7. A Hurricane Watch was issued for the Baja California Sur coastline a little over 59 h before landfall. The watch was upgraded to a Hurricane Warning 12 h later, slightly more than 47 h prior to landfall.

ACKNOWLEDGEMENTS

Some data and observations were provided by the National Meteorological Service of Mexico. Dr. Philippe Papin created the Graphical TWO verification figure (Fig. 7).

Table 1. Best track for Hurricane Norma, 17–23 October 2023.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
17 / 0600	12.4	104.4	1005	30	low
17 / 1200	12.7	105.8	1005	30	tropical depression
17 / 1800	12.9	106.9	1004	35	tropical storm
18 / 0000	13.4	107.6	1000	45	"
18 / 0600	13.9	107.8	995	55	"
18 / 1200	14.6	107.8	991	60	"
18 / 1800	15.3	107.9	987	65	hurricane
19 / 0000	16.0	107.9	975	80	"
19 / 0600	16.4	107.8	953	105	"
19 / 1200	16.9	107.7	939	115	"
19 / 1800	17.3	108.0	941	110	"
20 / 0000	17.9	108.2	948	105	"
20 / 0600	18.5	108.5	955	100	"
20 / 1200	19.1	109.0	958	100	"
20 / 1800	19.7	109.5	955	105	"
21 / 0000	20.5	109.9	955	105	"
21 / 0600	21.4	110.1	958	100	"
21 / 1200	22.3	110.2	964	90	"
21 / 1800	22.9	110.3	974	75	"
21 / 2015	23.0	110.1	978	70	"
22 / 0000	23.6	110.1	986	60	tropical storm
22 / 0600	24.3	109.8	990	50	"
22 / 1200	24.6	109.6	987	55	"
22 / 1800	24.7	109.3	987	55	"
23 / 0000	24.7	109.0	991	45	"
23 / 0600	24.5	108.7	993	35	"
23 / 1030	24.7	108.0	999	30	tropical depression
23 / 1200	24.7	107.9	1000	30	low
23 / 1800					dissipated

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19 / 1200	16.9	107.7	939	115	minimum pressure and maximum wind
21 / 2015	23.0	110.1	978	70	Landfall in Baja California Sur, Mexico
23 / 1030	24.7	107.9	999	30	Landfall near Eldorado, Mexico

Table 2. Selected surface observations for Hurricane Norma, 17–23 October 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)				
Mexico									
Baja California Sur									
Cabo San Lucas *elev.735 ft* (22.88N 109.93W)			21/1430	70	93				
Sierra La Laguna *elev. 6395 ft* (23.55N 109.99W)			21/1540	76					
Cabo Pulmo *elev. 85 ft* (23.45N 109.42W)	22/0040	989.2	21/1910	42	55				
Sinaloa									
Culiacán *elev. 13 ft* (24.23N 107.19W)	23/1100	1001.8	23/1020	26	40				

[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 3. Selected ship reports with winds of at least 34 kt for Hurricane Norma, 17–23 October 2023.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/ speed (kt)	Pressure (mb)
20 / 0200	TBWUK7	18.6	105.1	140 / 40	1005.6
20 / 1300	TBWUK7	19.2	105.4	140 / 36	1007.6
21 / 1300	V7A607	24.2	110.3	040 / 37	1006.0
21 / 1400	V7A607	24.2	110.4	020 / 36	1005.0
21 / 1500	V7A607	24.4	110.5	030 / 42	1006.0
21 / 1600	V7A607	24.6	110.5	060 / 42	1007.0
21 / 1700	V7A607	24.7	110.4	040 / 36	1008.0
21 / 1800	V7A607	24.8	110.2	040 / 45	1006.0
21 / 1900	V7A607	24.9	110.1	030 / 46	1006.0
21 / 2200	V7A607	25.3	110.1	030 / 40	1006.0
22 / 1900	V7FK6	25.2	109.2	050 / 40	1003.0

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	**168-Hour Outlook**
Low (<40%)	54	132
Medium (40%-60%)	42	96
High (>60%)	30	78

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Norma. 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	22.6	**33.5**	**37.2**	**41.6**	**49.8**	**61.4**	108.1	134.3
OCD5	41.9	79.3	110.7	136.0	144.8	159.4	278.6	555.0
Forecasts	22	20	18	16	14	12	8	4
OFCL (2018-22)	22.1	34.0	45.4	56.0	70.9	78.7	100.5	117.8
OCD5 (2018-22)	36.7	73.4	114.0	156.9	193.2	244.5	317.0	376.0

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Norma. 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	22.7	30.4	37.2	41.2	49.3	59.4	124.1	144.5
OCD5	40.7	68.7	108.6	136.9	149.1	168.7	321.9	582.6
GFSI	**22.1**	37.1	52.9	62.1	81.0	88.6	**99.9**	182.6
HWFI	25.2	31.0	40.0	50.0	63.5	64.8	**95.9**	174.9
HMNI	25.6	34.8	55.4	66.9	78.5	90.1	**93.6**	**87.1**
HFAI	23.5	**27.5**	**34.0**	44.1	59.2	78.5	**80.1**	156.5
HFBI	**20.7**	**26.9**	**33.8**	51.5	55.1	**53.6**	**86.1**	**108.5**
EGRI	26.4	39.6	58.2	84.0	109.2	145.4	295.3	434.2
EMXI	23.0	30.9	51.4	81.3	113.5	155.5	305.0	419.7
CMCI	30.4	56.9	85.7	111.9	135.6	136.2	125.8	**49.3**
CTCI	25.4	37.9	53.3	64.5	93.7	89.7	173.1	337.2
TVCE	**20.8**	**24.2**	**31.3**	**34.7**	**34.5**	**40.8**	**100.9**	149.2
TVCX	**20.4**	**24.1**	**32.0**	**34.6**	**36.8**	**45.1**	**113.9**	169.9
GFEX	**20.8**	**28.4**	**36.7**	46.8	54.5	68.2	181.3	296.4
TVDG	**20.5**	**25.0**	**31.6**	**35.4**	**36.2**	**44.7**	**121.7**	191.5
HCCA	**19.8**	**27.4**	**35.8**	49.2	64.7	84.9	130.5	206.1
FSSE	**20.8**	**28.9**	37.2	42.5	**48.0**	**51.1**	**113.7**	170.8
AEMI	**20.5**	34.2	46.9	62.8	80.5	103.9	173.2	271.5
TABS	45.4	108.9	165.9	233.1	294.7	351.6	377.5	270.1
TABM	31.0	69.9	116.8	156.5	210.1	271.4	299.9	221.9
TABD	50.7	97.0	180.2	249.6	330.8	422.9	424.2	488.5
Forecasts	20	16	16	14	12	10	5	3

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Norma. 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	9.5	10.2	11.9	12.8	**11.8**	**8.8**	18.1	33.8
OCD5	12.7	17.3	17.0	14.8	20.2	17.4	9.6	9.2
Forecasts	22	20	18	16	14	12	8	4
OFCL (2018-22)	5.4	8.9	11.0	12.8	14.3	15.8	17.0	17.6
OCD5 (2018-22)	6.9	12.1	15.9	18.6	18.7	21.0	22.3	22.1

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Norma. 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	10.2	10.0	12.5	13.9	11.4	8.9	18.3	31.7
OCD5	13.6	17.2	15.9	15.3	22.2	19.1	**8.0**	**8.0**
HWFI	10.6	13.9	15.1	15.9	17.5	15.2	**7.3**	**7.3**
HMNI	**8.6**	10.2	15.9	19.1	21.9	18.9	**8.7**	**6.3**
HFAI	**9.7**	**8.6**	12.8	**12.6**	12.1	**3.1**	**15.0**	36.7
HFBI	11.0	**9.5**	16.6	14.7	18.9	13.6	**18.0**	**28.0**
DSHP	10.5	13.6	18.2	21.6	27.4	29.4	**16.7**	**8.3**
LGEM	10.9	16.1	20.8	24.3	25.6	23.3	**11.0**	**12.7**
ICON	**9.6**	12.4	17.4	20.3	20.7	19.4	**5.7**	**2.7**
IVCN	**9.5**	11.6	16.4	16.9	15.2	12.6	**9.3**	**11.0**
IVDR	**9.6**	11.4	16.1	16.6	14.0	11.0	**10.0**	**12.0**
CTCI	11.4	18.6	21.3	19.6	17.9	14.9	**18.0**	**26.0**
GFSI	10.9	14.7	19.7	22.9	22.4	22.9	**16.3**	**17.0**
EMXI	12.4	20.3	29.0	31.3	30.9	31.1	25.3	**15.3**
HCCA	**8.1**	11.2	15.9	15.3	14.5	8.9	24.7	**28.7**
FSSE	**8.7**	10.1	13.7	**12.7**	**11.0**	**8.7**	**10.0**	**7.3**
Forecasts	20	17	16	14	11	9	3	3

Table 7. Watch and warning summary for Hurricane Norma, 17–23 October 2023.

Date/Time (UTC)	Action	Location
19 / 0900	Hurricane Watch issued	Los Barriles to Todos Santos
19 / 1800	Tropical Storm Watch issued	Las Islas Marias
19 / 2100	Hurricane Watch changed to Hurricane Warning	Los Barriles to Todos Santos
19 / 2100	Tropical Storm Watch issued	La Paz to Los Barriles
19 / 2100	Tropical Storm Watch issued	Todos Santos to Santa Fe
20 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	La Paz to Los Barriles
20 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	Todos Santos to Santa Fe
20 / 1500	Tropical Storm Watch issued	Bahia Tempehuaya to Topolobampo
20 / 1500	Tropical Storm Warning modified to	San Evaristo to Los Barriles
21 / 0300	Tropical Storm Watch modified to	Mazatlan to Topolobampo
21 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	Mazatlan to Topolobampo
21 / 1500	Tropical Storm Watch discontinued	All
22 / 0000	Tropical Storm Warning modified to	San Evaristo to Santa Fe
22 / 0000	Hurricane Warning discontinued	All
22 / 0900	Tropical Storm Warning modified to	Mazatlan to Huatabampito
22 / 2100	Tropical Storm Warning modified to	San Evaristo to Cabo San Lucas
23 / 0300	Tropical Storm Warning discontinued	San Evaristo to Cabo San Lucas
23 / 0900	Tropical Storm Warning discontinued	All

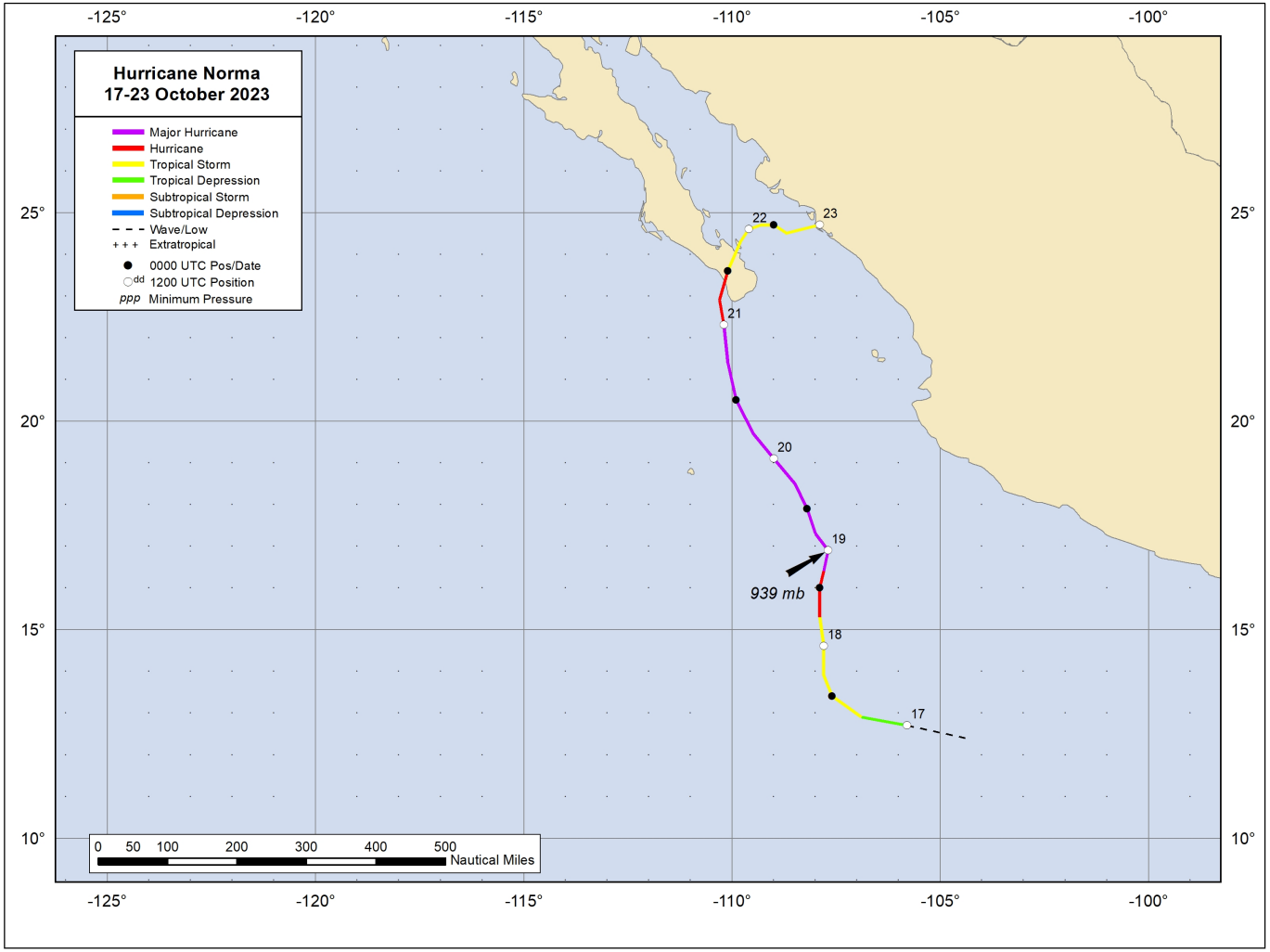

Figure 1. Best track positions for Hurricane Norma, 17–23 October 2023.

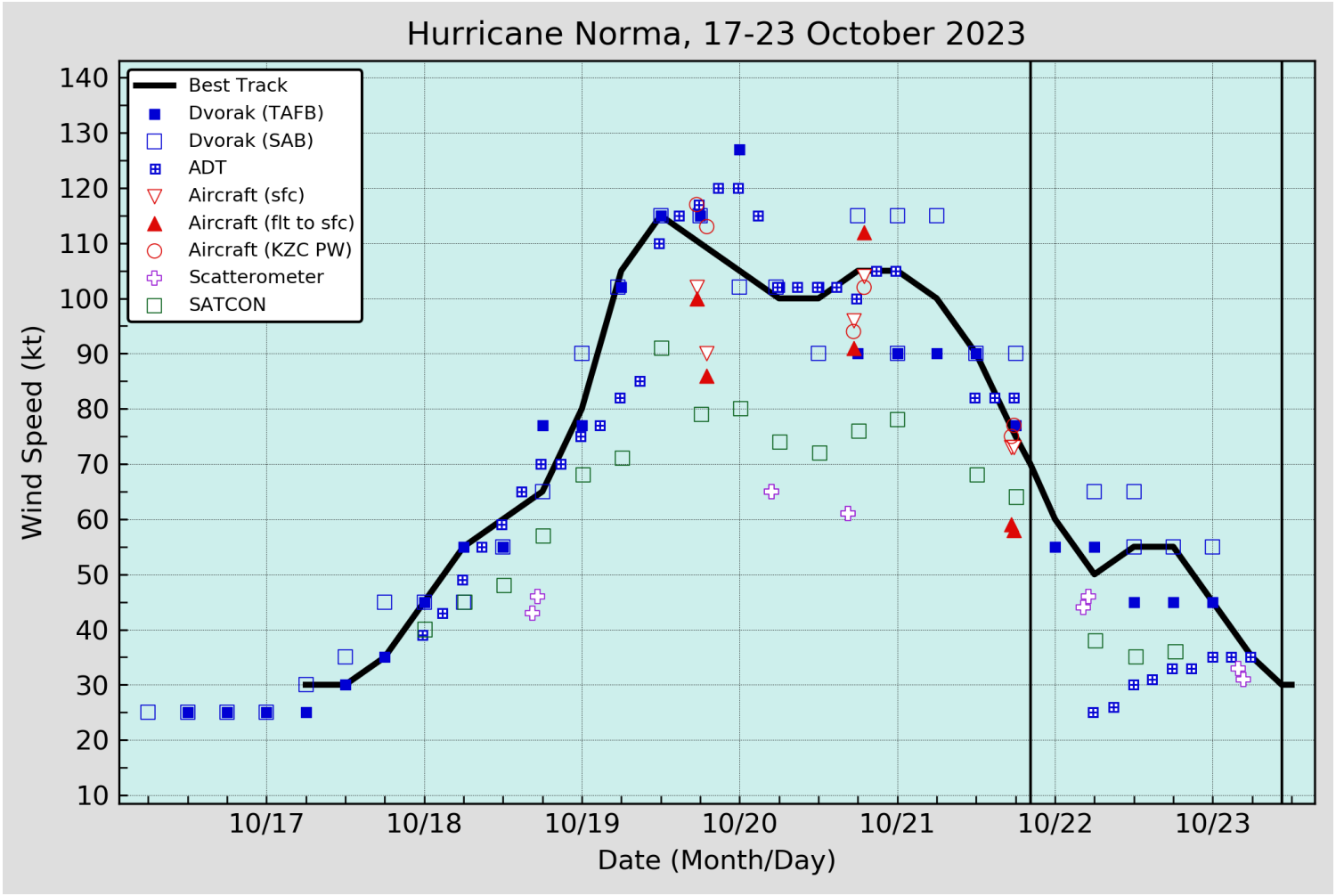

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Norma, 17–23 October 2023. Aircraft observations have been adjusted for elevation using 90%, 80%, and 75% adjustment factors for observations from 700 mb, 850 mb, and 925 mb, respectively. Advanced 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.

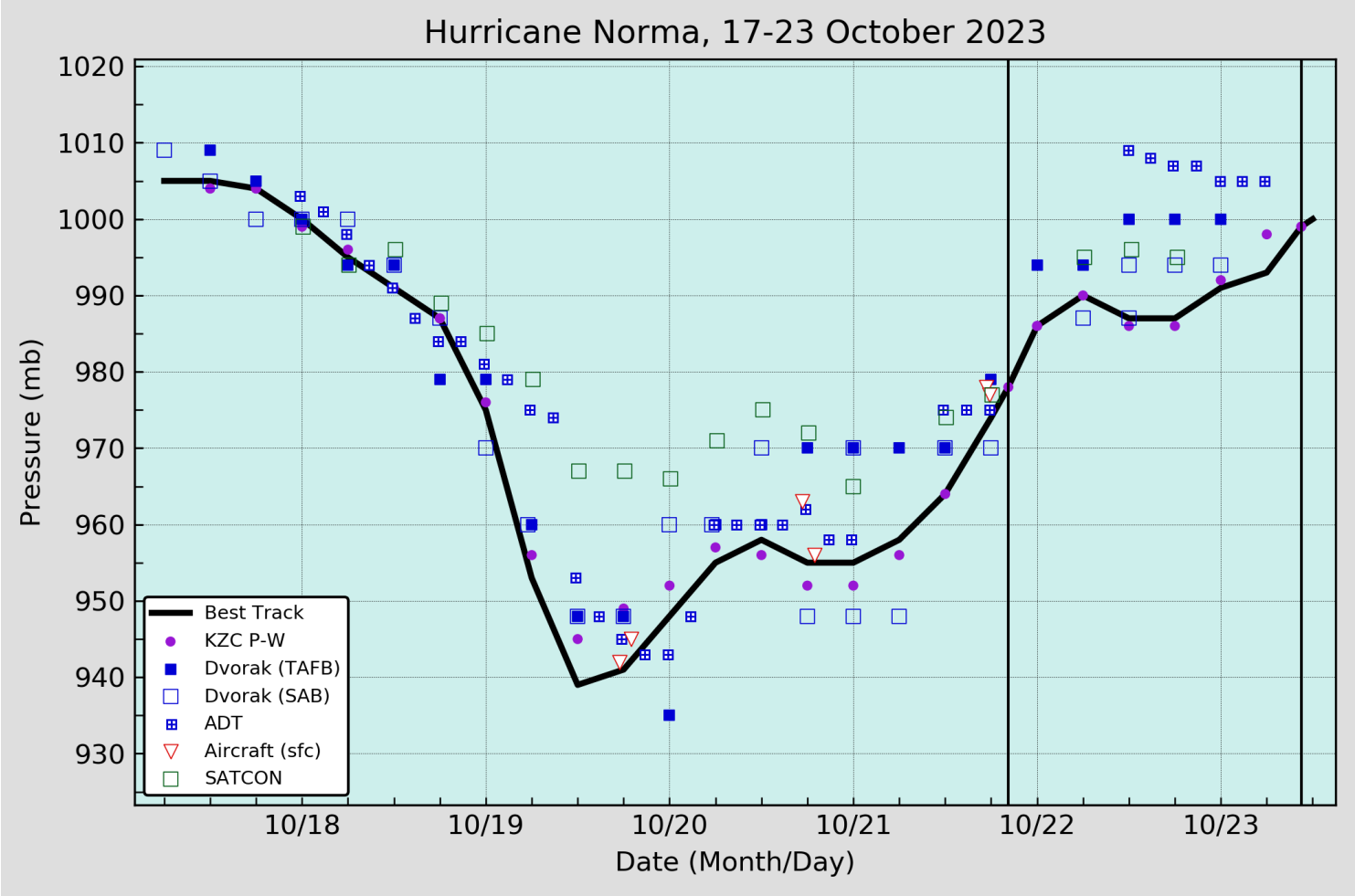

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Norma, 17–23 October 2023. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological 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.

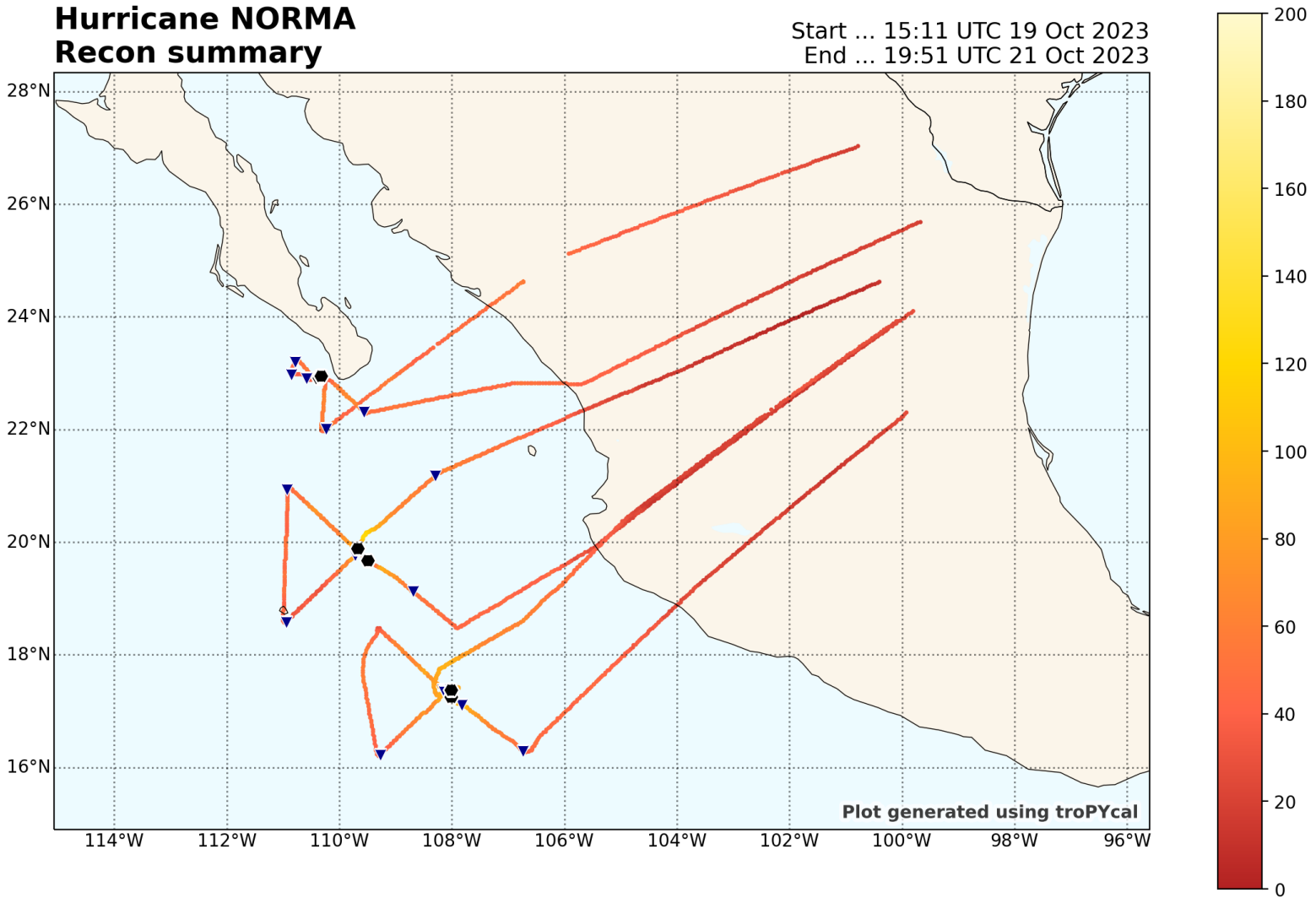

Figure 4. Air Force Reserve Hurricane Hunter aircraft flight tracks (colored lines) from the reconnaissance missions into Hurricane Norma on 19–21 October 2023. The black markers denote center fixes and the blue triangles indicate dropsonde locations. The color of the flight track represents the observed flight-level wind speed in knots at that location (see legend).

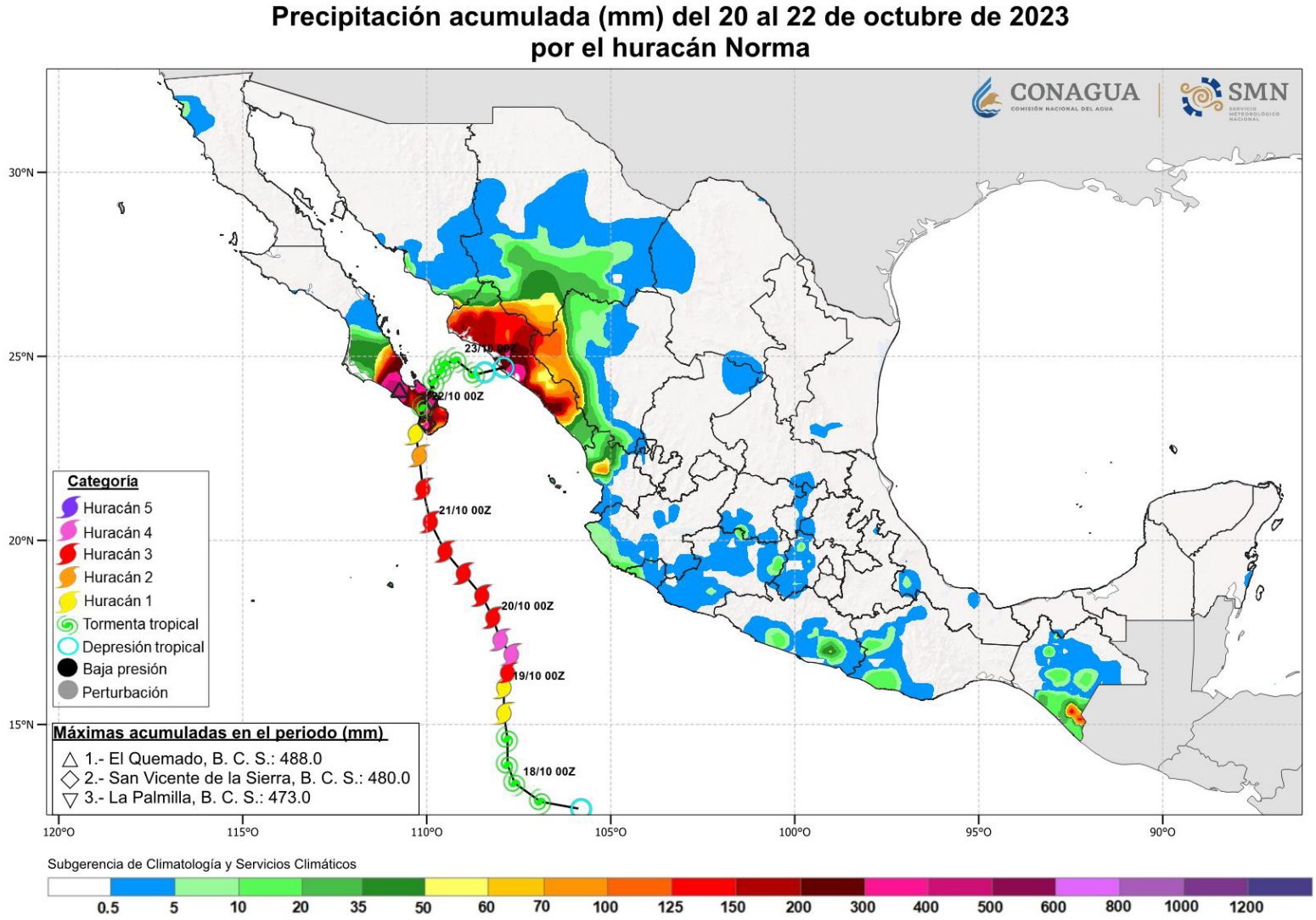

Figure 5. Rainfall accumulations (mm) in Mexico from 20–22 October 2023. Track and intensity are based on the operational NHC assessment. Note, not all of the rainfall depicted here is directly related to Norma. Image courtesy of CONAGUA and the National Meteorological Service of Mexico.

Figure 6. **(Top left)** Fallen utility poles blocking the streets after Hurricane Norma hit the area, in Cabo San Lucas, Mexico. (Credit: Reuters) **(Top right)** A flooded street on 21 October 2023, in La Paz, Mexico. (Credit: Alfredo Martinez/Getty Images) **(Bottom left)** Downed tree lies in the street on 21 October, 2023, in La Paz, Mexico. (Credit: Alfredo Martinez/Getty Images) **(Bottom right)** Damaged restaurant and rough, high surf in Los Cabos, Baja California Sur. (Credit: Joel Cosio/AFP via Getty Images)

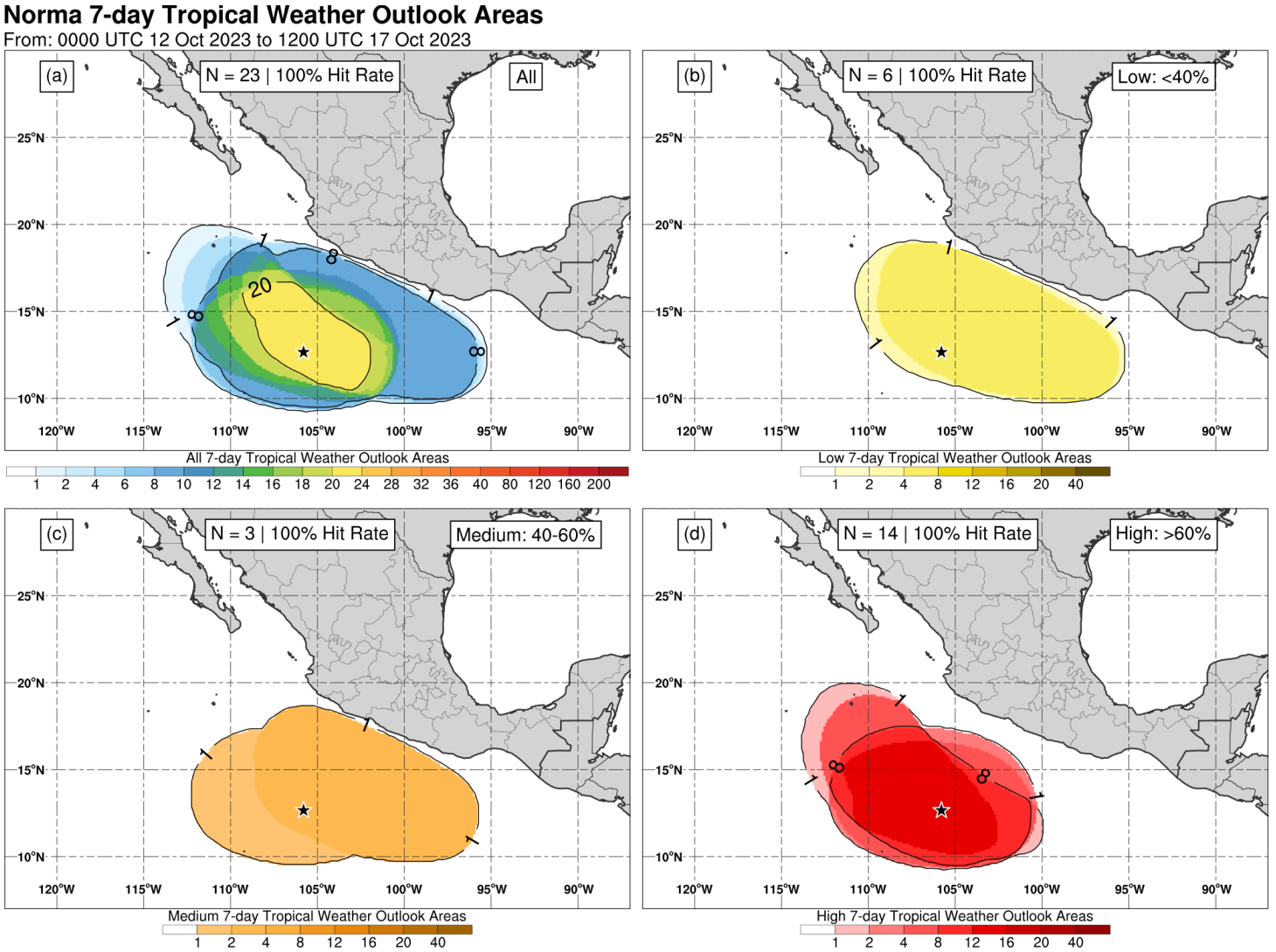

Figure 7. Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks prior to the formation of Norma for (a) all probabilistic genesis categories, (b) the low (<40%) category, (c) medium (40–60%) category, and (d) high (>60%) category. The location of genesis is indicated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

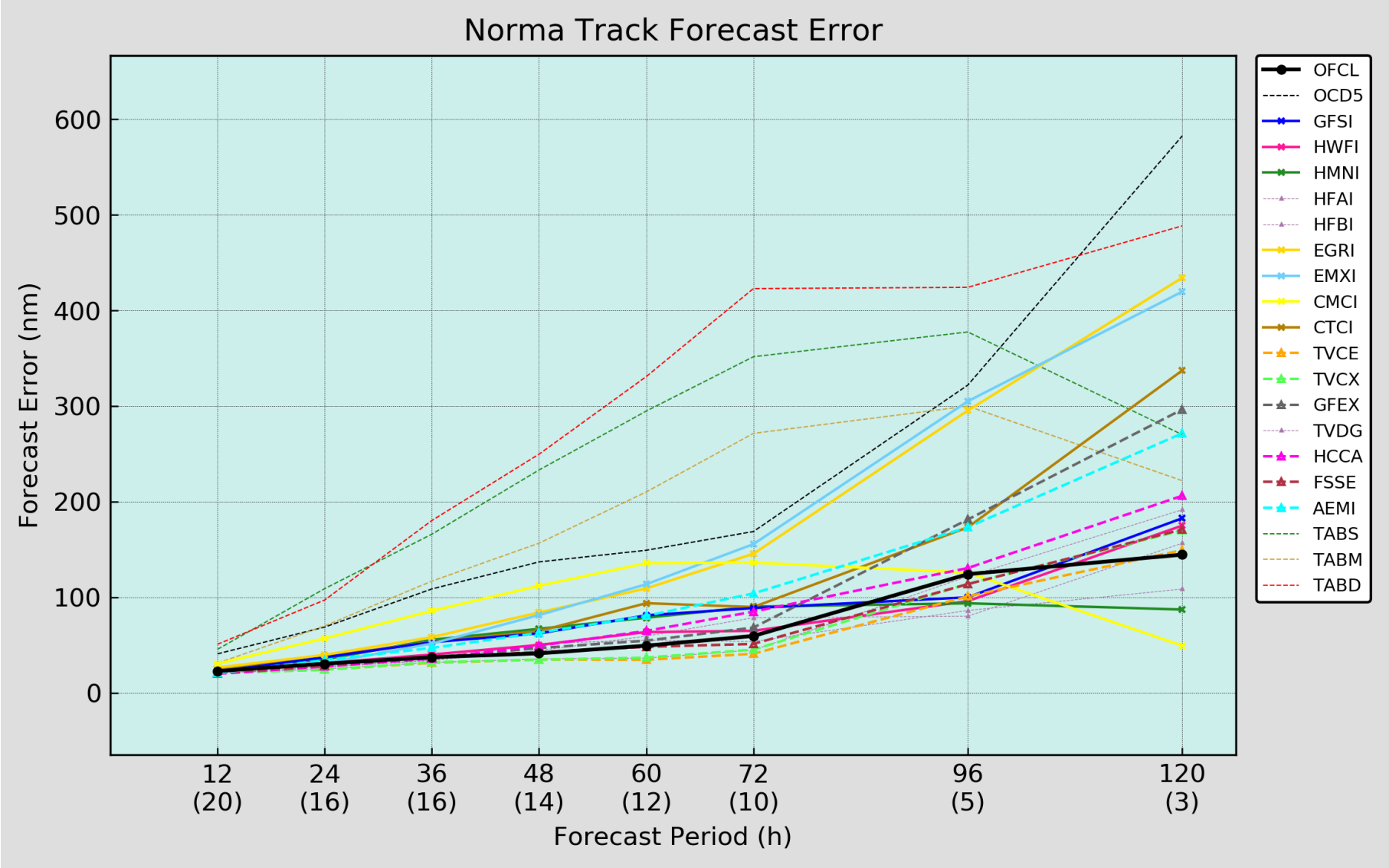

Figure 8. Homogenous comparison of NHC official track forecast errors (OFCL, black line) for Hurricane Norma to select models and consensus aids.

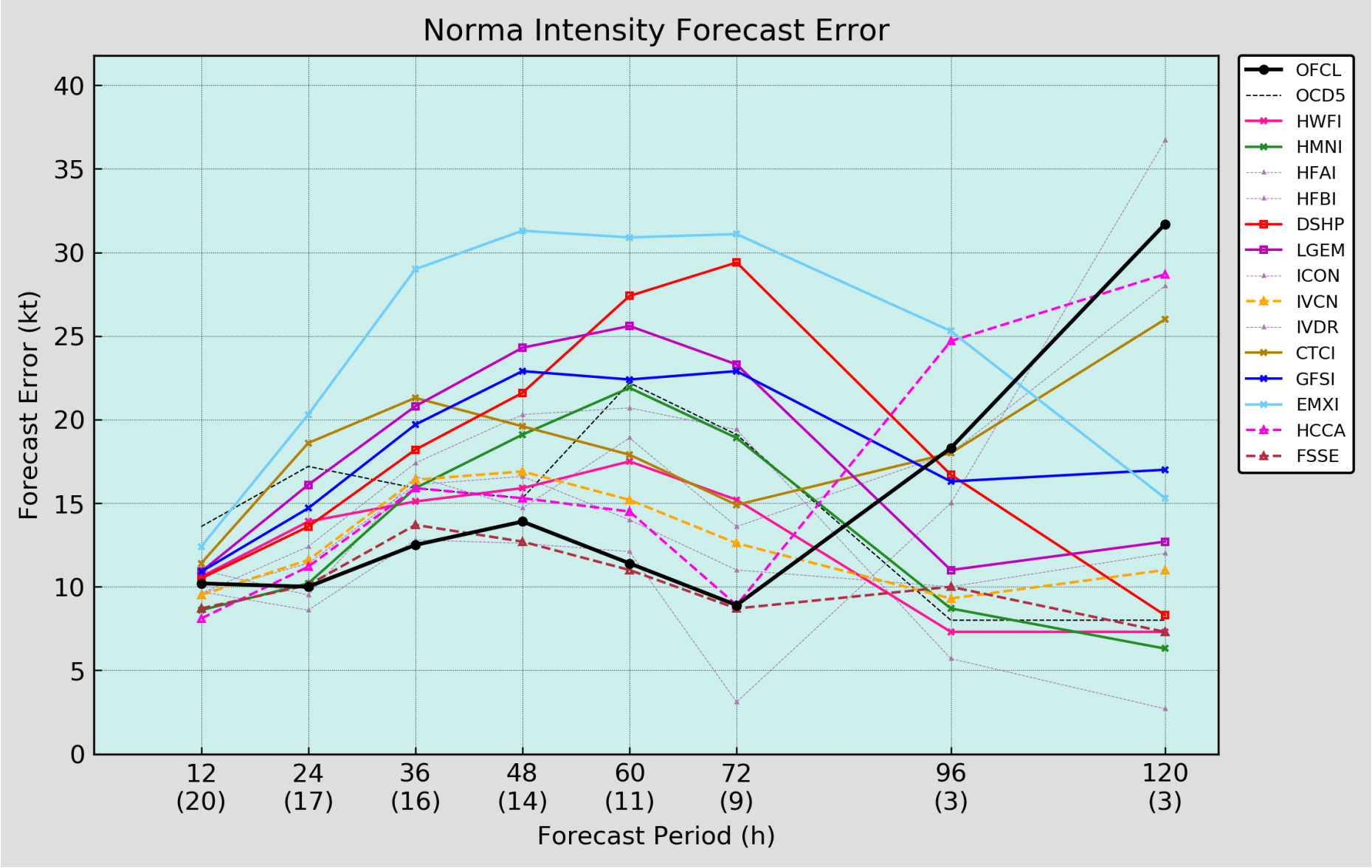

Figure 9. Homogenous comparison of NHC official intensity forecast errors (OFCL, black line) for Hurricane Norma to select models and consensus aids.

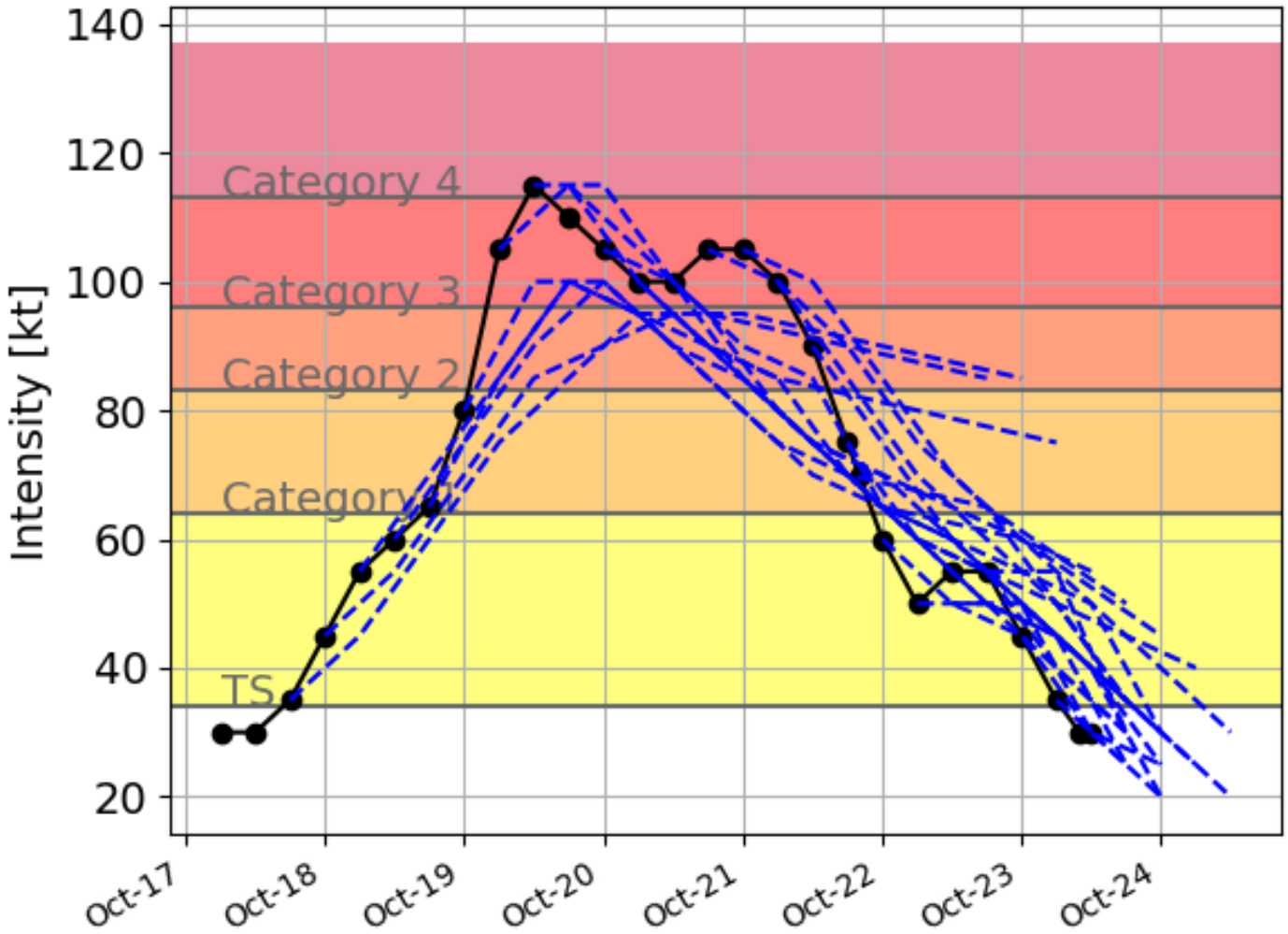

Figure 10. A comparison of NHC official intensity forecasts to the best track intensity of Norma, which is indicated by the solid black line.