# NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT[1]

# HURRICANE DARBY

## (EP052022)

## 9–17 July 2022

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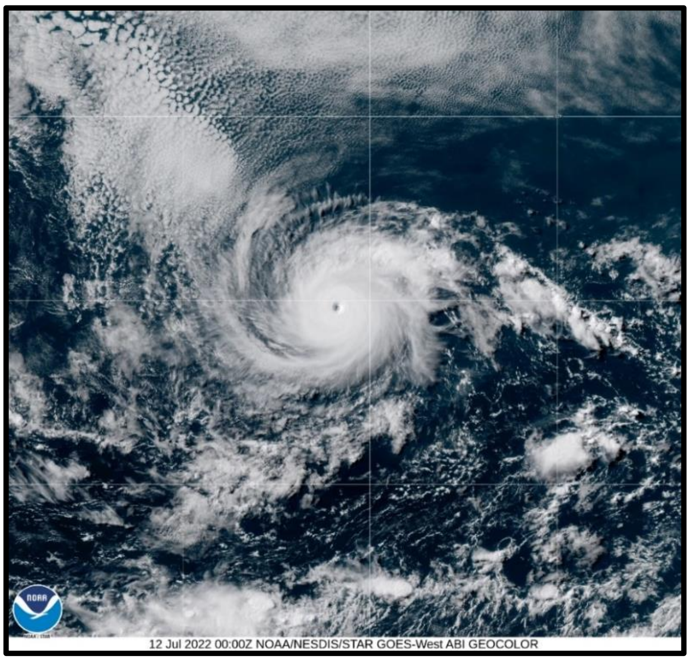


**GOES-17 TRUE COLOR VISIBLE SATELLITE IMAGE OF HURRICANE DARBY AT 0000 UTC 12 JULY, AT ITS PEAK INTENSITY. IMAGE COURTESY OF NOAA/NESDIS/STAR.**

Darby was a powerful and compact category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that originated in the eastern Pacific, crossed into the central Pacific basin, and opened up into a trough south of the island of Hawaii.

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[1] This report is based on Darby's history in the National Hurricane Center's area of responsibility in the eastern Pacific basin (east of 140°W longitude). The report will be updated once the Central Pacific Hurricane Center completes its analysis of Darby in the central North Pacific basin (west of 140°W longitude).

# Hurricane Darby

**9–17 JULY 2022**

## SYNOPTIC HISTORY

The tropical wave that led to the development of Darby emerged off the African coast on 26–27 June, reached the Windward Islands on 1 July, and then crossed Central America on 5–6 July, accompanied by disorganized showers and thunderstorms for this entire period. Convection associated with the wave pulsed in sequence with the diurnal cycle over the next three days or so while the system gradually became more organized and moved westward away from the Mexican coastline. On 9 July, deep convection became persistent around a well-defined surface center, and it is estimated that a tropical depression formed by 1200 UTC 9 July when the system was located about 500 n mi southwest of the southwestern coast of Mexico. The "best track" chart of the tropical cyclone's path is given in Figure 1, with the wind and pressure histories shown in Figures 2 and 3, respectively. The best track positions and intensities are listed in Table 1[2].

Darby steadily intensified after formation, and the system became a tropical storm 6 h after genesis in an environment with low vertical wind shear and over sufficiently warm sea surface temperatures. After a dry air intrusion that briefly caused the intensification to level off, Darby began to rapidly strengthen and became a hurricane by 0000 UTC 11 July while moving westward along the south side of a mid-level ridge. Darby continued to rapidly intensify until reaching a peak intensity of 120 kt at 1800 UTC 11 July when it was located about 985 n mi west-southwest of the southern tip of the Baja California Peninsula. It is estimated that Darby strengthened by an impressive 65 kt over the 24-hour period ending at 0000 UTC 12 July (cover photo). Though the storm reached Category 4 status on the Saffir-Simpson Hurricane Wind Scale, Darby had a very compact wind field. The tropical-storm-force winds are estimated to have only extended outward up to 50 n mi from the center, and the hurricane-force winds only up to 10 n mi (based largely on satellite-derived surface wind data) at the time of peak intensity.

The tiny hurricane maintained its peak intensity for about 12 h before weakening over the next 24 h as satellite imagery showed the eye becoming less distinct and cloud-filled. By 13 July, Darby reached a weakness in the mid-level ridge, turned west-northwestward, and began to re-intensify as a well-defined eye re-emerged. This re-intensification happened despite the hurricane moving over marginal sea surface temperatures (estimated between 25-26°C) while embedded in a dry, stable environment and was likely aided by a weaker-than-predicted vertical wind shear environment. Darby became a major hurricane (100 kt; Category 3) for a second time at 1800 UTC 13 July. The hurricane maintained this intensity for another 6 h before encountering

[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.

an even less favorable environment and oceanic conditions that resulted in gradual weakening as the storm crossed 140°W into the Central Pacific basin.

By 0000 UTC 15 July, Darby turned westward once again and continued weakening while it moved over cooler waters and encountered stronger vertical wind shear produced by an upper-level trough. The storm weakened below hurricane intensity by 1200 UTC 15 July about 530 n mi east-southeast of the Big Island of Hawaii in moderate to strong westerly vertical shear. Darby opened up into a trough shortly before 0000 UTC 17 July just south of the Big Island of Hawaii.

# METEOROLOGICAL STATISTICS

Observations in Darby (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), the Central Pacific Hurricane Center (PHFO), and the Joint Typhoon Warning Center (JTWC) , as well as objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. 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), Defense Meteorological Satellite Program (DMSP) satellites, and the Synthetic Aperture Radar (SAR) were also useful in constructing the best track of Darby.

There were no ship or buoy reports of tropical-storm-force winds associated with Darby.

Darby's peak intensity of 120 kt at 1800 UTC 11 July and 0000 UTC 12 July is primarily based on an ADT Dvorak estimate of T6.1/117 kt and SATCON intensity estimates as high as 120 kt. The estimated minimum pressure of 953 mb is based on a blend of the Knaff-Zehr-Courtney and Dvorak pressure-wind relationships.

# CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Darby.

# FORECAST AND WARNING CRITIQUE

The possibility of Darby's genesis was identified several days in advance but the timing of formation was not well forecast. Table 2 provides the number of hours in advance of formation with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. A low chance (<40%) was introduced in the 5-day forecast period 96 h before Darby formed. The probabilities were raised to the medium (40-60%) and high (>60%) categories 78 h and 66 h before genesis, respectively. Regarding the 2-day forecast period, a low chance of genesis was introduced in the TWO well in advance of formation (78 h), but the probabilities only reached the medium category 18 h prior to formation, and there was no lead time in the high category based on the final best track. NHC forecast the location of formation fairly accurately, with an 82% hit rate, though the genesis location occurred on the east side of the majority of the TWO areas in the high category (Fig. 4) due to Darby forming a little sooner than anticipated.

A preliminary verification of NHC official track forecasts for Darby is given in Table 3a. Official track forecast errors (OFCL) were less than the mean official errors for the previous 5-yr period for the short-term forecast periods (12 and 24 h) and greater than the mean errors for all other forecast times. However, the climatology and persistence (OCD5) error values were lower than their 5-yr averages, indicating Darby's track should have been easier than average to forecast. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b, and forecast skill against OCD5 is illustrated in Figure 5. The NHC OFCL track forecasts were not as skillful as the best performing European (EMXI) or Canadian (CMCI) deterministic models, in addition to most of the consensus aids at all lead times. In comparison, the GFS (GFSI), COAMPS-TC (CTCI), and GFS Ensemble mean (AEMI) were the poorest performing models for the track predictions of Darby.

A preliminary verification of NHC official intensity forecasts for Hurricane Darby is given in Table 4a. Official intensity forecast errors were greater than the mean official errors for the previous 5-yr period, due to Darby's rapid intensification period and the unexpected re-strengthening into a major hurricane. While early official intensity forecasts showed steady strengthening, they did not explicitly show rapid intensification (not shown). A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b with intensity skill provided in Figure 6. Despite the rapid intensification, the official forecast was the most skillful intensity prediction at the 12-, 36-, and 48-h forecast periods, as most of the intensity guidance also failed to indicate Darby would rapidly intensity. The consensus aid HCCA performed best at 24 h, while the statistical model DSHP had the lowest errors at 60 h. HWFI was notably the best-performing model at longer lead times (72 h and beyond).

There were no coastal watches and warnings associated with Hurricane Darby.

Table 1. Best track for Hurricane Darby, 9-17 July 2022. The portion of the track west of 140°W is based on operational data from the Central Pacific Hurricane Center.

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage |
|---|---|---|---|---|---|
| 09 / 1200 | 13.8 | 111.0 | 1008 | 30 | tropical depression |
| 09 / 1800 | 14.2 | 112.8 | 1006 | 35 | tropical storm |
| 10 / 0000 | 14.3 | 114.2 | 1004 | 40 | " |
| 10 / 0600 | 14.3 | 115.5 | 1004 | 40 | " |
| 10 / 1200 | 14.3 | 116.8 | 1002 | 50 | " |
| 10 / 1800 | 14.4 | 118.3 | 999 | 55 | " |
| 11 / 0000 | 14.5 | 119.9 | 991 | 65 | hurricane |
| 11 / 0600 | 14.5 | 121.3 | 979 | 85 | " |
| 11 / 1200 | 14.5 | 122.8 | 966 | 105 | " |
| 11 / 1800 | 14.6 | 124.3 | 953 | 120 | " |
| 12 / 0000 | 14.8 | 125.9 | 953 | 120 | " |
| 12 / 0600 | 14.7 | 127.4 | 957 | 115 | " |
| 12 / 1200 | 14.7 | 129.0 | 957 | 115 | " |
| 12 / 1800 | 14.6 | 130.5 | 966 | 105 | " |
| 13 / 0000 | 14.6 | 132.0 | 972 | 95 | " |
| 13 / 0600 | 14.6 | 133.3 | 978 | 85 | " |
| 13 / 1200 | 14.8 | 134.7 | 977 | 90 | " |
| 13 / 1800 | 15.1 | 136.0 | 968 | 100 | " |

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage |
|---|---|---|---|---|---|
| 14 / 0000 | 15.6 | 137.5 | 968 | 100 | " |
| 14 / 0600 | 16.0 | 138.9 | 971 | 95 | " |
| 14 / 1200 | 16.5 | 140.2 | 977 | 90 | " |
| 14 / 1800 | 16.9 | 141.5 | 980 | 85 | " |
| 15 / 0000 | 17.3 | 142.8 | 985 | 75 | " |
| 15 / 0600 | 17.4 | 144.1 | 990 | 65 | " |
| 15 / 1200 | 17.5 | 145.4 | 993 | 60 | tropical storm |
| 15 / 1800 | 17.6 | 146.8 | 1002 | 50 | " |
| 16 / 0000 | 17.7 | 148.5 | 1006 | 40 | " |
| 16 / 0600 | 17.7 | 150.3 | 1006 | 40 | " |
| 16 / 1200 | 17.7 | 152.3 | 1006 | 40 | " |
| 16 / 1800 | 17.7 | 154.5 | 1007 | 35 | " |
| 17 / 0000 | 17.7 | 156.5 | 1007 | 35 | " |
| 17 / 0600 | | | | | dissipated |
| 11 / 1800 | 14.6 | 124.3 | 953 | 120 | minimum pressure and maximum wind |

Table 2. 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 (<40%) | 78 | 96 |
| Medium (40%-60%) | 18 | 78 |
| High (>60%) | 0 | 66 |

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Darby, 9–17 July 2022. 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. Verification of the track forecasts west of 140°W is based on CPHC's operational assessments.

| | Forecast Period (h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 96 | 120 |
| OFCL | **17.8** | **33.2** | 49.9 | 66.9 | 83.1 | 102.0 | 136.2 | 187.7 |
| OCD5 | 19.7 | 40.7 | 63.3 | 89.6 | 117.7 | 136.2 | 176.4 | 298.6 |
| Forecasts | 19 | 19 | 19 | 19 | 19 | 18 | 14 | 10 |
| OFCL (2017-21) | 21.9 | 33.8 | 45.6 | 56.9 | 74.8 | 79.9 | 99.5 | 121.3 |
| OCD5 (2017-21) | 35.8 | 72.3 | 112.7 | 155.0 | 198.7 | 239.0 | 309.2 | 372.2 |

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Darby, 9–17 July 2022. 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 3a due to the homogeneity requirement. Verification of the track forecasts west of 140°W is based on CPHC's operational assessments.

| Model ID | Forecast Period (h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 96 | 120 |
| OFCL | 18.0 | 33.9 | 52.3 | 69.1 | 83.5 | 100.9 | 139.1 | 190.7 |
| OCD5 | 20.3 | 43.3 | 69.0 | 92.4 | 112.4 | 130.4 | 181.1 | 296.3 |
| GFSI | 22.4 | 43.8 | 67.2 | 93.6 | 122.3 | 149.8 | 221.3 | 286.2 |
| EMXI | **16.2** | **24.8** | **35.7** | **50.7** | **69.0** | **83.3** | **101.7** | **124.0** |
| CMCI | **15.1** | **25.7** | **36.7** | **46.9** | **60.7** | **78.9** | **110.4** | **158.9** |
| HWFI | **15.2** | **32.4** | **51.1** | 72.2 | 92.3 | 109.1 | 158.7 | 227.2 |
| HMNI | 18.4 | 39.8 | 62.9 | 84.9 | 101.1 | 117.3 | 152.5 | **189.6** |
| CTCI | 23.5 | 45.2 | 71.3 | 95.9 | 118.6 | 137.3 | 148.9 | **159.2** |
| AEMI | 21.8 | 40.6 | 59.7 | 77.4 | 94.3 | 110.3 | 147.5 | **181.0** |
| HCCA | **17.4** | **29.0** | **41.2** | **55.1** | **72.9** | **85.4** | **111.2** | **154.1** |
| FSSE | **17.2** | **31.0** | **45.1** | **62.9** | **77.4** | **98.9** | **136.8** | **177.8** |
| GFEX | 18.1 | **32.0** | **48.3** | 70.0 | 91.8 | 111.1 | 158.5 | 205.1 |
| TVCE | **16.6** | **30.5** | **47.5** | **63.3** | **80.6** | **98.8** | **131.7** | **173.7** |
| TVCX | **16.8** | **28.7** | **43.2** | **58.6** | **76.2** | **94.7** | **129.1** | **173.0** |
| TVDG | **17.0** | **28.9** | **43.4** | **58.7** | **73.7** | **93.8** | **134.4** | 191.0 |
| TABD | 18.2 | 43.5 | 82.9 | 137.6 | 202.9 | 283.6 | 402.7 | 573.2 |
| TABM | 20.2 | 44.7 | 69.8 | 98.3 | 132.9 | 172.0 | 242.4 | 348.7 |
| TABS | 22.5 | 49.3 | 78.4 | 103.6 | 123.3 | 130.4 | 154.5 | **179.8** |
| Forecasts | 17 | 17 | 17 | 17 | 17 | 17 | 12 | 8 |

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Darby, 9–17 July 2022. 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. Verification of the track forecasts west of 140°W is based on CPHC's operational assessments.

| | Forecast Period (h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 96 | 120 |
| OFCL | 10.0 | 18.4 | 20.5 | 19.5 | 18.4 | 20.8 | 23.2 | 18.0 |
| OCD5 | 12.4 | 23.1 | 30.2 | 27.7 | 21.8 | 18.2 | 23.1 | 16.3 |
| Forecasts | 19 | 19 | 19 | 19 | 19 | 18 | 14 | 10 |
| OFCL (2017-21) | 5.5 | 9.1 | 11.1 | 12.9 | 15.3 | 15.6 | 16.4 | 17.0 |
| OCD5 (2017-21) | 7.0 | 12.2 | 15.8 | 18.6 | 20.4 | 21.2 | 22.3 | 21.8 |

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Darby, 9–17 July 2022. 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 4a due to the homogeneity requirement. Verification of the track forecasts west of 140°W is based on CPHC's operational assessments.

| Model ID | Forecast Period (h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 60 | 72 | 96 | 120 |
| OFCL | 11.2 | 20.0 | 22.4 | 20.9 | 20.3 | 21.8 | 26.2 | 21.2 |
| OCD5 | 13.2 | 24.0 | 31.4 | 27.9 | 22.3 | **18.4** | **23.7** | **15.6** |
| HWFI | 13.9 | 21.1 | 24.7 | 24.1 | **20.0** | **18.3** | **20.8** | **13.0** |
| HMNI | 13.6 | 23.4 | 25.6 | 23.4 | 21.5 | **19.5** | **24.7** | 21.5 |
| CTCI | 13.1 | 20.9 | 24.8 | 26.5 | 27.9 | 28.6 | 38.0 | 36.8 |
| DSHP | 12.2 | **19.8** | 23.6 | 21.2 | **19.5** | **18.9** | **24.5** | 22.6 |
| LGEM | 11.8 | 21.6 | 28.1 | 29.6 | 28.0 | 26.1 | 34.0 | 31.6 |
| ICON | 12.1 | 20.9 | 24.9 | 24.1 | 21.9 | **20.2** | **25.8** | 22.2 |
| IVCN | 12.1 | 20.8 | 24.8 | 24.4 | 23.0 | **21.7** | 28.1 | 25.1 |
| IVDR | 12.6 | 21.1 | 24.9 | 24.5 | 22.8 | **21.3** | 27.2 | 24.2 |
| HCCA | 11.2 | **18.9** | 24.0 | 23.9 | 21.6 | **20.4** | **25.9** | 23.1 |
| FSSE | 11.9 | 20.5 | 24.6 | 24.2 | 24.9 | 26.5 | 31.2 | 24.9 |
| GFSI | 14.4 | 23.6 | 26.9 | 27.4 | 23.8 | **19.9** | **25.1** | **21.0** |
| EMXI | 13.0 | 20.8 | 23.7 | 22.1 | **20.2** | **18.6** | **23.9** | **20.1** |
| Forecasts | 17 | 17 | 17 | 17 | 17 | 17 | 12 | 8 |

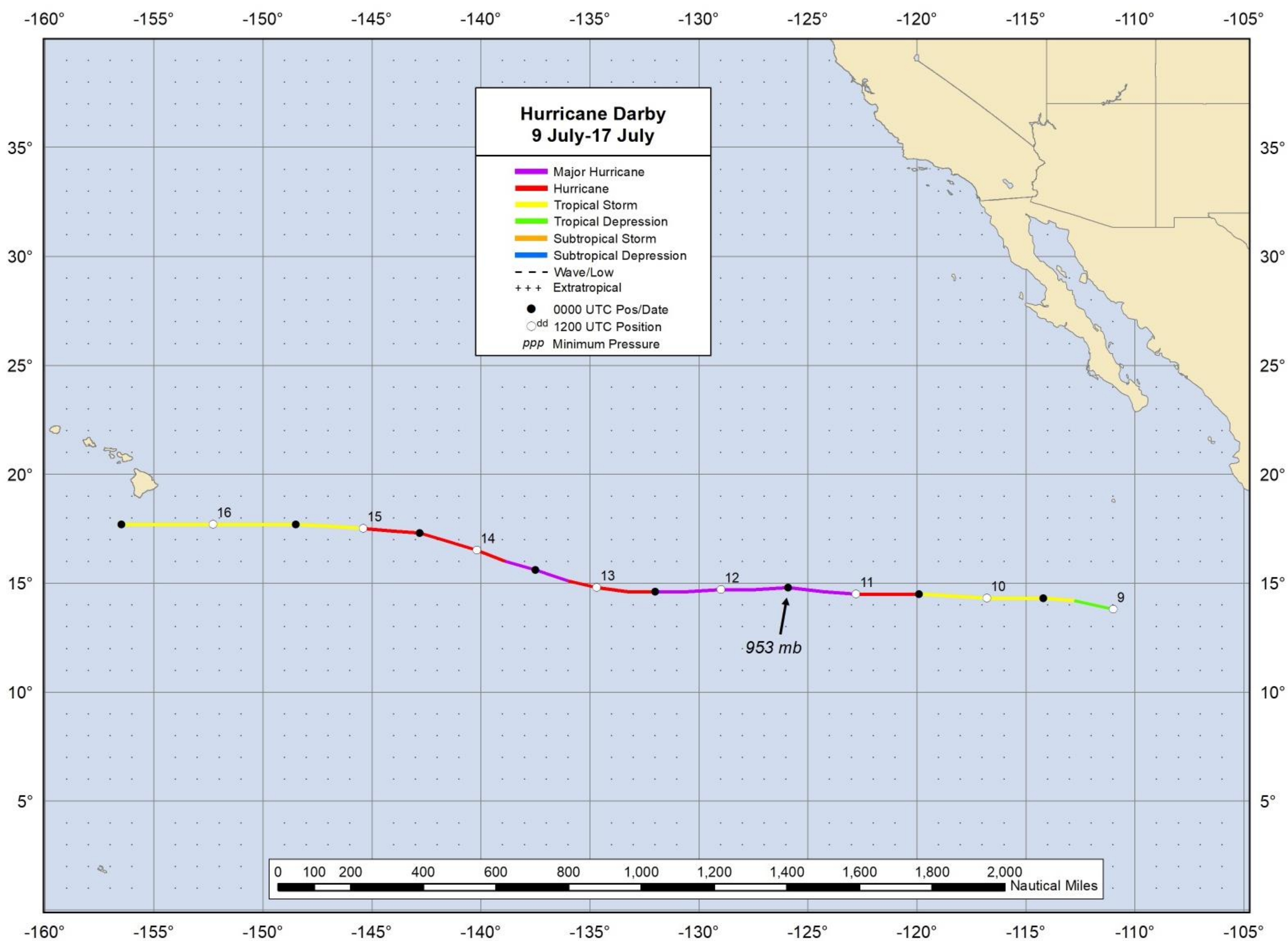


Figure 1. Best track positions for Hurricane Darby, 9–17 July 2022. Note that the best track after 0600 UTC 14 July is based on operational assessments from the Central Pacific Hurricane Center.

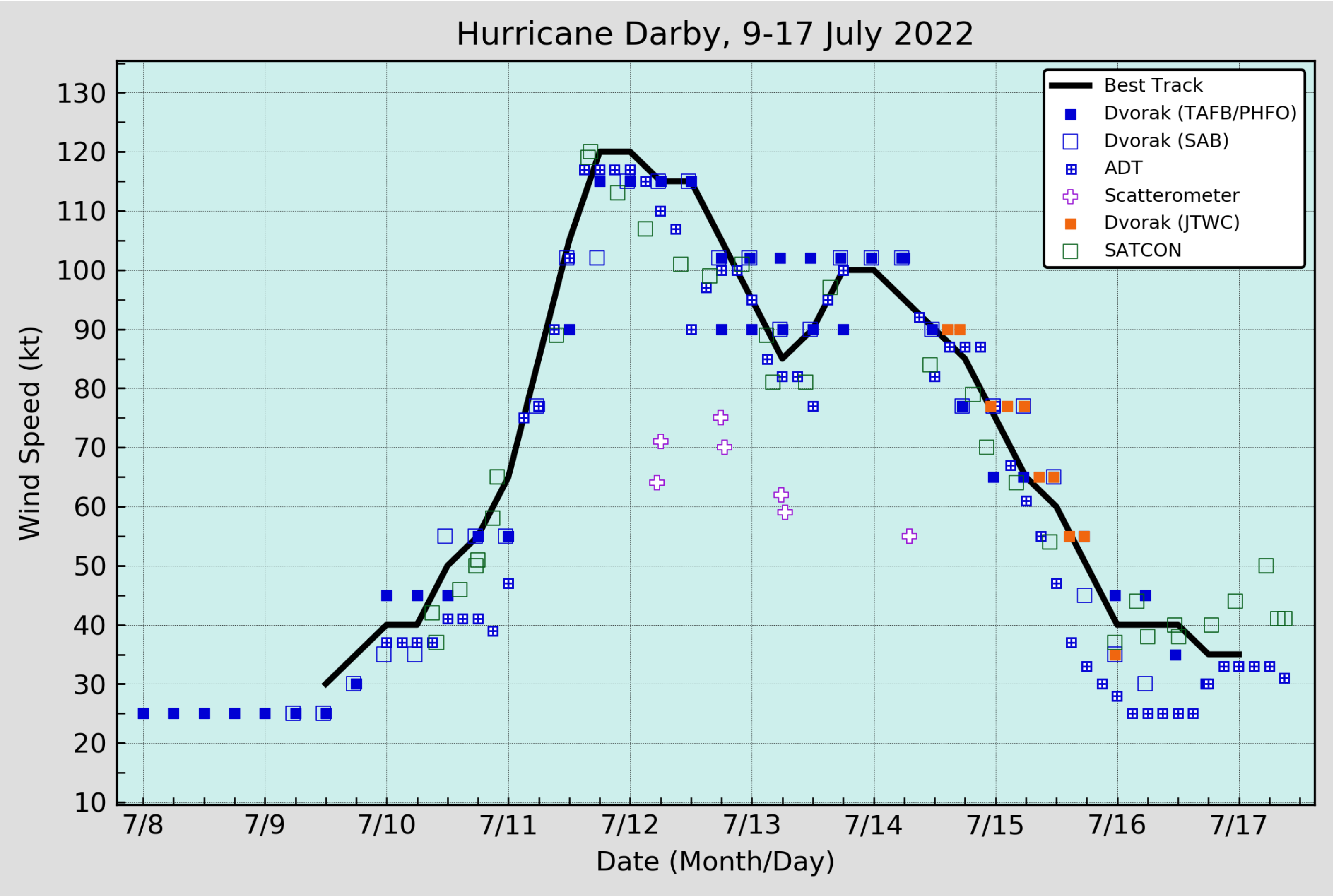


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Darby, 9–17 July 2022. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC. Note that the best track after 0600 UTC 14 July is based on operational assessments from the Central Pacific Hurricane Center.

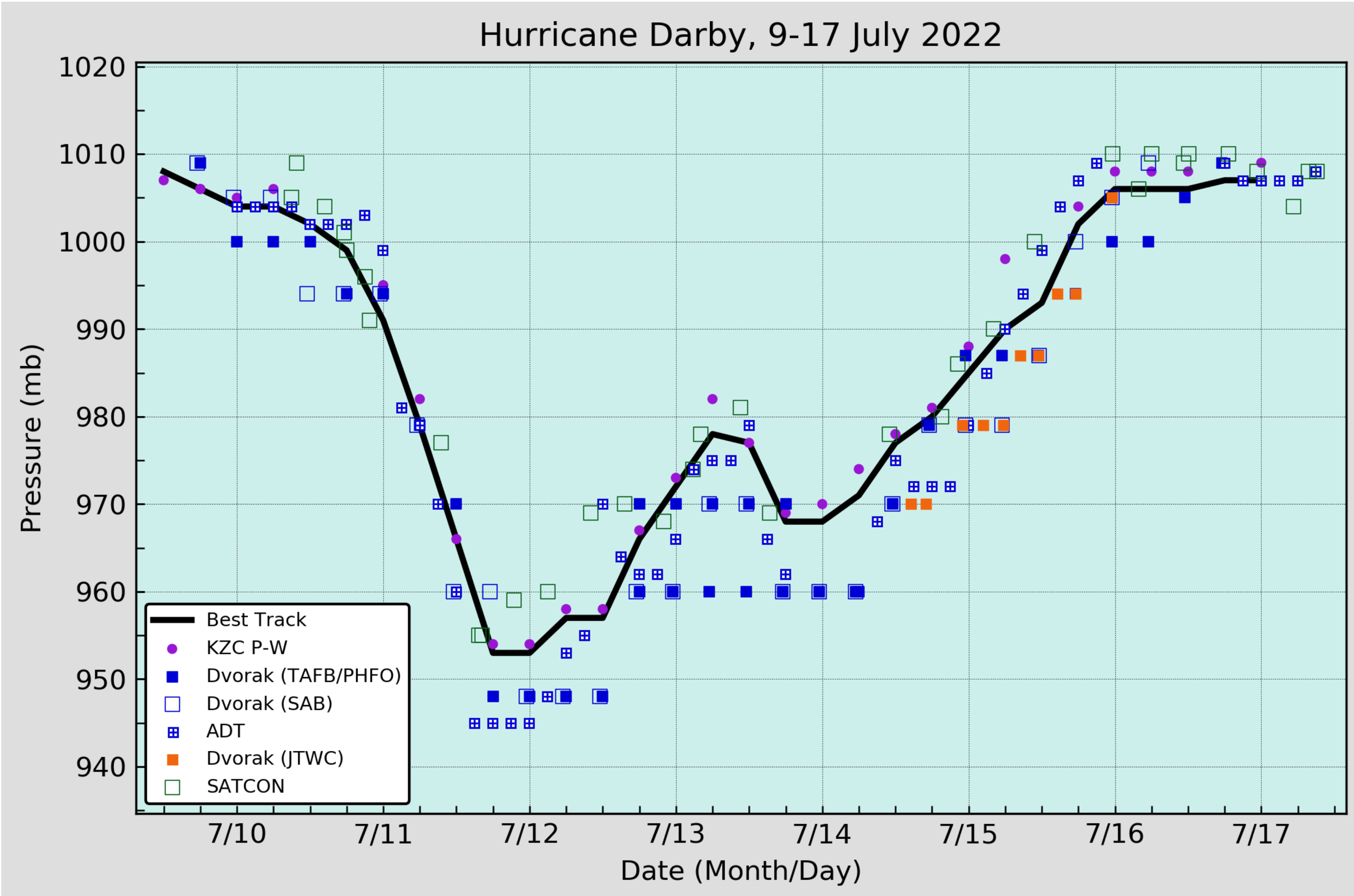


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Darby, 9–17 July 2022. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological 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. Note that the best track after 0600 UTC 14 July is based on operational assessments from the Central Pacific Hurricane Center.

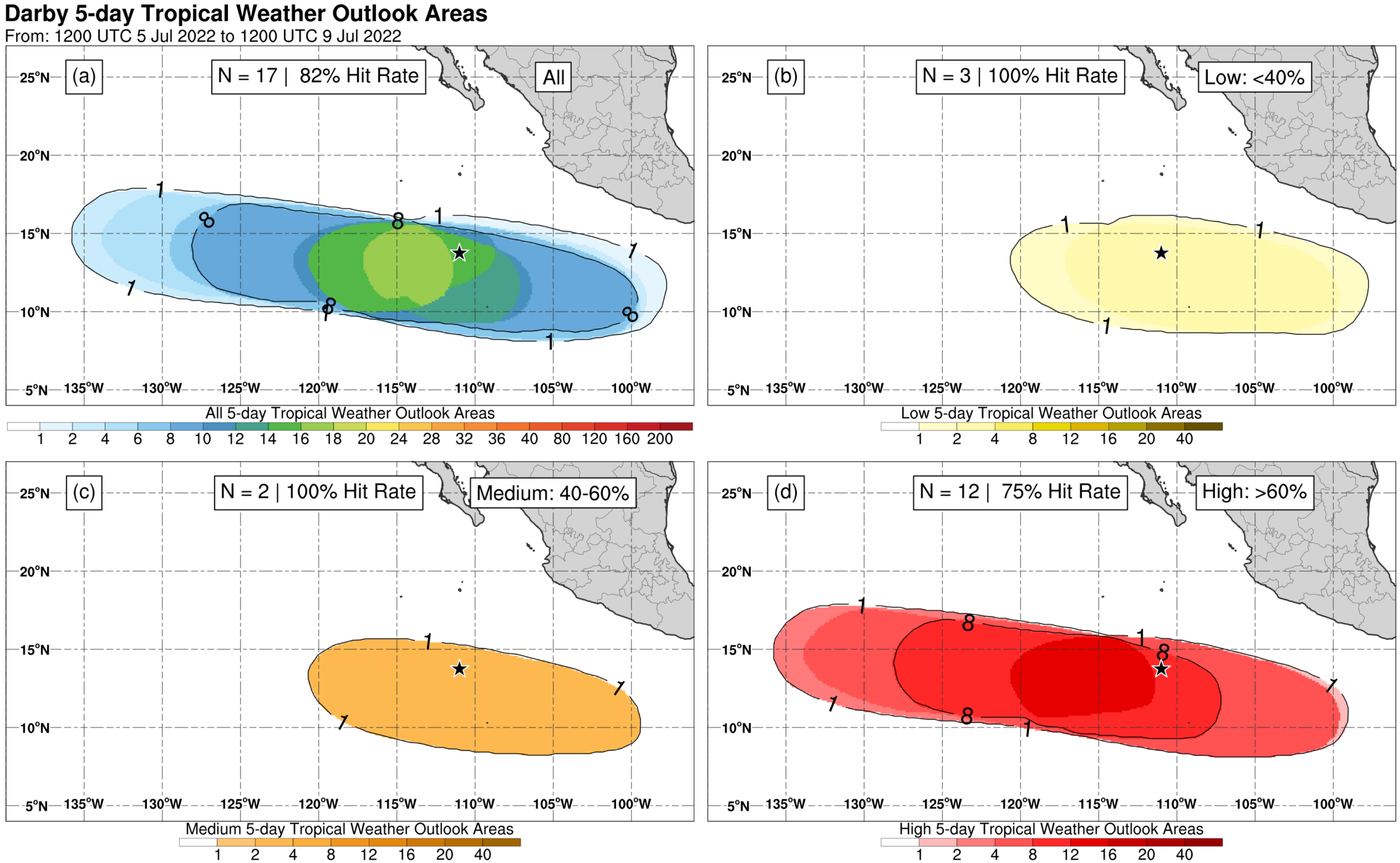


Figure 4. 5-day Tropical Weather Outlook genesis areas associated with the disturbance that developed into Hurricane Darby for (a) all probability areas (10–100%, multi-color shading), (b) low probability areas (< 40%, yellow shading), (c) medium probability areas (40–60%, orange shading), and (d) high probability areas (> 60%, red shading). The black star in each panel indicates the genesis location of Darby. Hit rate indicates the percentage of outlook areas where the genesis location was captured within. Courtesy of Philippe Papin.

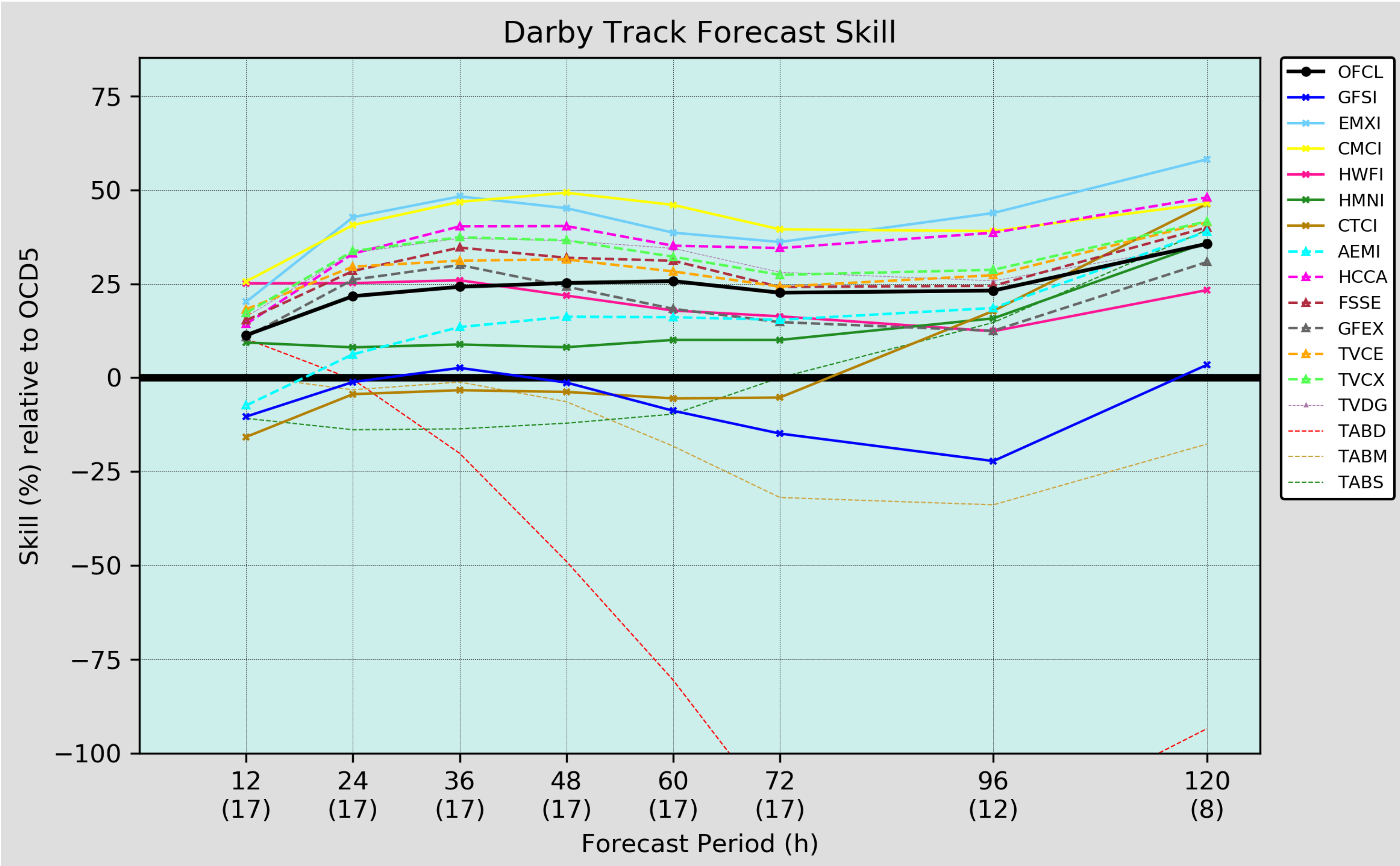


Figure 5. Track forecast skill of the official forecasts and selected models for Hurricane Darby, 9–17 July 2022.

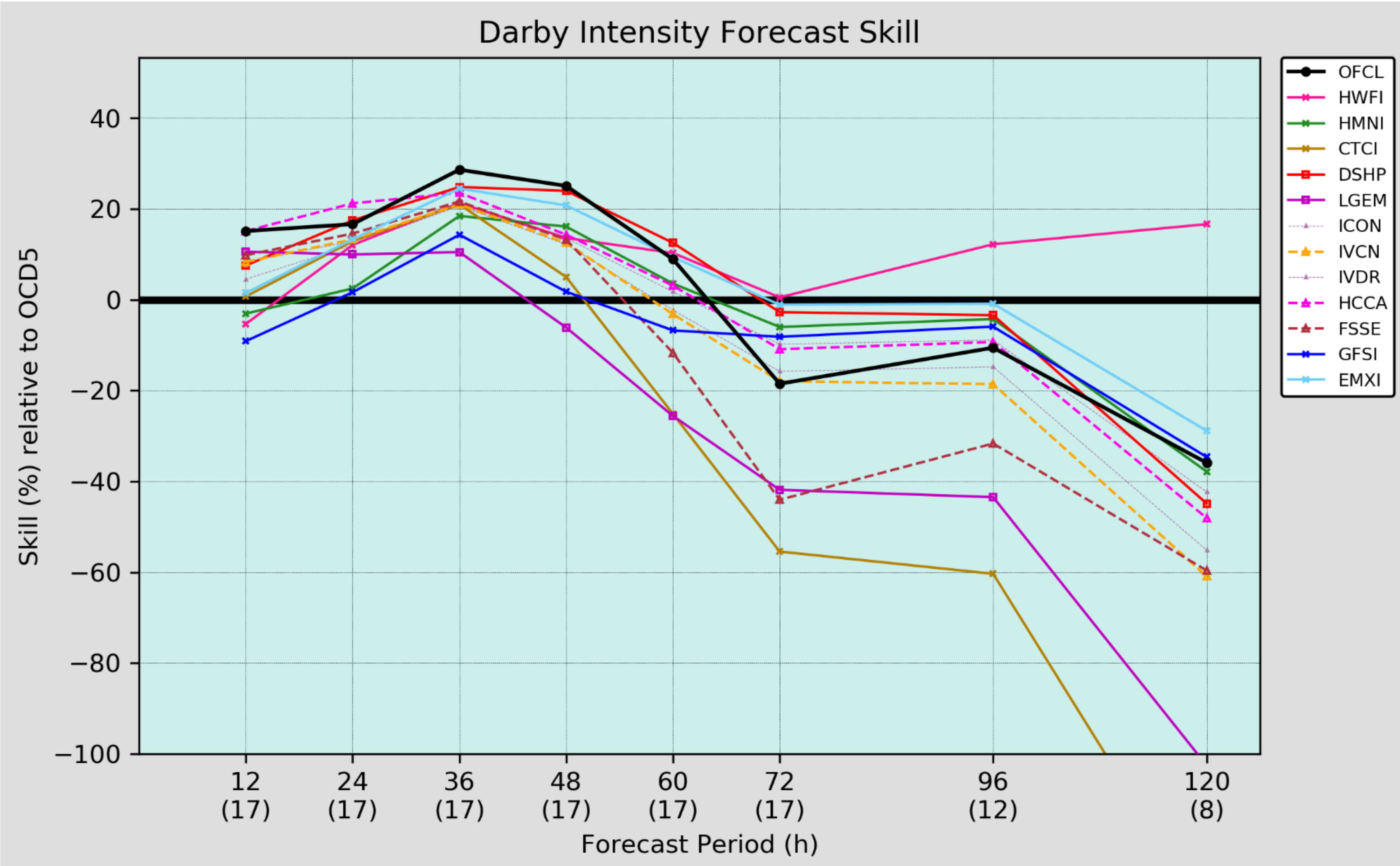


Figure 6. Intensity forecast skill of the official forecasts and selected models for Hurricane Darby, 9–17 July 2022.