NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT[1]

HURRICANE DORA

(EP052023)

31 July–17 August 2023

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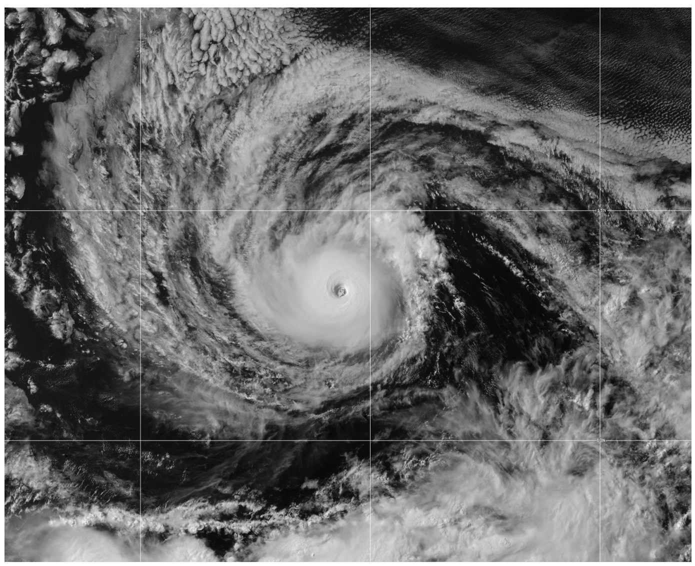
National Hurricane Center
5 March 2024



GOES-18 VISIBLE IMAGE OF HURRICANE DORA AT PEAK INTENSITY AT 0000 UTC 6 AUGUST 2023.
IMAGE COURTESY OF NOAA/NESDIS/STAR.

Dora was a small, long-lived hurricane that reached category 4 intensity (on the Saffir-Simpson Hurricane Wind Scale) while it traversed portions of the eastern and central Pacific basins. Dora crossed the International Dateline, becoming a typhoon, before it weakened and reached the western portion of the Pacific. The hurricane played an indirect meteorological role in the devasting wildfires on Maui, Hawaii.

[1] This report is based on Dora'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 and the Joint Typhoon Warning Center complete their analysis of Dora in the central and western North Pacific basin (west of 140°W and 180°W longitude, respectively).

Hurricane Dora

31 JULY–17 AUGUST 2023

SYNOPTIC HISTORY

Dora originated from a tropical wave that exited the western coast of Africa on 17–18 July. The wave interacted with a low-pressure area embedded in the monsoon trough in the central Atlantic on 21–22 July and crossed the Windward Islands on 25 July. It then moved into the Caribbean Sea with a large area of disorganized showers and thunderstorms. The wave reached Central America and crossed into the eastern portion of the Pacific basin on 28–30 July, still accompanied by disorganized showers and thunderstorms. Genesis occurred about 250 n mi south of Manzanillo, Mexico at 1800 UTC 31 July when satellite-derived surface winds indicated the system had developed a closed circulation and sufficiently deep, organized convection. The "best track" chart of Dora'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].

Dora intensified after formation and became a tropical storm 12 h later at 0600 UTC 1 August. The warm waters, a small but sufficient area of mid-level environmental moisture, and low deep-layer vertical wind shear then allowed the tropical cyclone to rapidly intensify over the next several days. Dora became a hurricane at 0000 UTC 2 August about 445 n mi west-southwest of Manzanillo, Mexico, while it traveled westward along the south side of a deep-level ridge. Dora became a major hurricane by 0000 UTC 3 August, and it completed a 48-h period of rapid intensification at 0600 UTC 3 August as a 115-kt category 4 hurricane, an 80-kt increase in intensity in that time span.

Shortly thereafter, an eyewall replacement cycle (ERC, Fig. 4) briefly halted Dora's intensification. After completing the ERC, the small hurricane strengthened once again, reaching a new peak intensity of 120 kt by 0000 UTC 4 August. Dora then weakened for the subsequent 24-h period when it encountered moderate easterly vertical wind shear on the southern side of the deep-layer ridge that was steering the storm quickly westward. By 0600 UTC 5 August, the vertical wind shear abated, allowing Dora to intensify again. The small hurricane rapidly intensified to its overall estimated peak intensity of 130 kt (cover photo) at 0000 UTC 6 August in the eastern Pacific, when it was located about 1620 n mi west-southwest of the southern tip of the Baja California peninsula.

Later that day around 1500 UTC, Dora crossed 140°W and moved into the Central Pacific basin still being steered westward by a building anticyclone. The southern track over warm waters and a moist atmosphere provided environmental conditions for Dora to remain a strong hurricane while it crossed the Central Pacific basin. The small hurricane passed south of the Hawaiian Islands on 8 August, remaining about 600 n mi away from the island chain. The hurricane turned

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[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.

west-northwestward on the southwestern side of the ridge around 1800 UTC 10 August. Dora reached the International Dateline a little after 0000 UTC 12 August, becoming a rare tropical cyclone to have traveled over all three of the tropical cyclone basins of the Pacific Ocean and only the second to do so as a hurricane (the previous was Hurricane John in 1994). The last system to cross all three tropical cyclone basins of the Pacific Ocean was Hector in 2018.

In the Western Pacific, Dora (now classified as a typhoon) turned northwestward and gradually weakened while it moved over cooler waters and encountered stronger vertical wind shear. The system weakened to a tropical storm by 0000 UTC 13 August and a tropical depression at 1200 UTC that day. Dora gradually turned toward the west within the low-level flow while it weakened. Marginally conducive environmental and oceanic conditions allowed Dora to briefly re-intensify into a tropical storm at 0600 UTC 14 August as it turned northwestward. However, by 0000 UTC 15 August, Dora weakened once again and became a tropical depression as it turned north-northwestward to northward over the following couple of days. Dora briefly became a subtropical depression at 0000 UTC 17 August and finally degenerated into a trough of low pressure 6 h later well to the east of Japan.

METEOROLOGICAL STATISTICS

Observations in Dora (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), Satellite Analysis Branch (SAB), 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), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Dora.

There were no ship or buoy reports of tropical-storm-force winds associated with Dora in the eastern Pacific basin.

Dora's estimated peak intensity of 130 kt in the eastern Pacific basin at 0000 UTC 6 August is based on of a blend of subjective Dvorak intensity estimates from SAB and TAFB of T6.5/127 kt and T7.0/140 kt, respectively, and objective Dvorak estimates from ADT and SATCON of 124 kt and 122 kt, respectively. The estimated minimum pressure of 939 mb is based on the Knaff-Zehr-Courtney pressure-wind relationship. The 130-kt intensity in the eastern Pacific is analyzed to be Dora's overall peak intensity but this is subject to change based on post-storm analysis by the Central Pacific Hurricane Center. Dora's operational peak intensity in the Central Pacific basin is 125 kt.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties[3] directly caused by Dora. The hurricane was indirectly linked to the catastrophic wildfires in Maui, Hawaii. There were some indications that Dora's passage to the south tightened the pressure gradient and enhanced the low-level trade winds across the Hawaiian Islands. Additional information will be provided by the Central Pacific Hurricane Center in an updated version of this report.

FORECAST AND WARNING CRITIQUE

The genesis of Dora was adequately forecast (Table 2). The wave from which Dora developed was introduced in the Tropical Weather Outlook (TWO) with a low probability (<40%) of development in the 7-day forecast period 126 h prior to genesis. The probabilities were raised to the medium (40-60%) and high (>60%) categories 96 h and 72 h before genesis, respectively. Regarding the 2-day probabilities, a low chance of genesis was introduced in the TWO well in advance of formation (78 h), but the probabilities did not reach the medium and high categories until 48 h and 24 h prior to formation, respectively. The location of Dora's genesis was very well forecast with 100% of the Graphical TWO areas (22 in total) enclosing the location of formation (Fig. 5).

A verification of NHC official track forecasts for Dora while it was located in the eastern Pacific basin is given in Table 3a. Official track forecast errors were substantially lower than the mean official errors for the previous 5-yr period between the forecast hours 12–96 h and comparable to the long-term mean at 120 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. While the NHC OFCL track forecast errors were low, several guidance aids were more skillful at various forecast lead times (Fig. 6). Most notably, the regional hurricane model HAFS-A (HFAI) and Florida State Superensemble (FSSE) consensus aid performed better than OFCL at all forecast hours. The Canadian (CMCI) and Navy Global Environment Model (NVGM) were the poorest-performing models for Dora's track.

A verification of NHC official intensity forecasts for Dora in the eastern Pacific is given in Table 4a. Official intensity forecast errors were greater than the mean official errors for the previous 5-yr period, likely due to Dora's the periods of intensity fluctuations and the initial rapid intensification (Fig. 8). This could be attributed to the small size of Dora, as it is well known that smaller tropical cyclones are more susceptible to subtle environmental changes which can lead to these fluctuations, making them more difficult to forecast[4]. A homogeneous comparison of the

[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.
[4] Carrasco, C. A., C. W. Landsea, and Y. Lin, 2014: The Influence of Tropical Cyclone Size on Its Intensification. Wea. Forecasting, 29, 582–590, https://doi.org/10.1175/WAF-D-13-00092.1.

official intensity errors with selected guidance models is given in Table 4b. The official intensity forecast was skillful relative to climatology (OCD5) by about 30-40%, but was out-performed by various consensus aids (FSSE and HCCA) and statistical models (DSHP and LGEM) at different forecast lead times (Fig. 7). The regional model HAFS-A (HFAI) was the only dynamical model to have lower errors than the official forecast at 36-120 h. The GFS (GFSI) and ECMWF (EMXI) global models were the least skillful models for the intensity prediction of Dora.

The verification of Dora's forecasts in the Central Pacific basin will be included in a future version of this report.

There were no coastal watches or warnings associated with Hurricane Dora in the eastern Pacific.

Table 1. Best track for Hurricane Dora, 31 July – 17 August 2023. The portion of the track west of 140°W is based on operational data from the Central Pacific Hurricane Center and the Joint Typhoon Warning Center.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
31 / 1200	14.3	102.6	1008	25	low
31 / 1800	14.8	103.7	1008	30	tropical depression
01 / 0000	15.4	105.0	1008	30	"
01 / 0600	15.8	106.4	1006	35	tropical storm
01 / 1200	16.0	107.9	1002	45	"
01 / 1800	16.1	109.4	998	55	"
02 / 0000	16.1	110.6	994	65	hurricane
02 / 0600	15.9	111.9	985	80	"
02 / 1200	15.7	113.5	976	90	"
02 / 1800	15.5	114.9	976	90	"
03 / 0000	15.3	116.2	956	110	"
03 / 0600	15.1	117.7	952	115	"
03 / 1200	14.9	119.3	955	110	"
03 / 1800	14.5	121.0	958	105	"
04 / 0000	14.2	122.6	950	120	"
04 / 0600	14.1	124.3	952	115	"
04 / 1200	14.0	126.1	957	105	"
04 / 1800	13.8	127.7	957	100	"
05 / 0000	13.7	129.3	972	90	"
05 / 0600	13.5	130.8	972	90	"
05 / 1200	13.4	132.5	967	95	"
05 / 1800	13.3	134.0	950	115	"
06 / 0000	13.2	135.6	939	130	"
06 / 0600	13.1	137.4	939	130	"
06 / 1200	13.0	139.2	943	125	"
06 / 1800	12.9	141.2	948	120	"
07 / 0000	12.7	143.1	948	120	"
07 / 0600	12.6	145.2	948	120	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
07 / 1200	12.4	147.3	953	115	"
07 / 1800	12.3	149.3	953	115	"
08 / 0000	12.1	151.3	953	115	"
08 / 0600	11.8	153.3	953	115	"
08 / 1200	11.5	155.2	953	115	"
08 / 1800	11.5	157.1	953	115	"
09 / 0000	11.4	159.2	953	115	"
09 / 0600	11.4	161.2	953	115	"
09 / 1200	11.4	163.1	953	115	"
09 / 1800	11.5	165.1	950	120	"
10 / 0000	11.6	166.9	946	125	"
10 / 0600	11.9	168.9	950	120	"
10 / 1200	12.1	170.5	961	105	"
10 / 1800	12.5	172.2	961	105	"
11 / 0000	12.9	173.8	961	105	"
11 / 0600	13.5	175.5	961	105	"
11 / 1200	14.2	177.1	965	100	"
11 / 1800	14.8	178.6	968	95	"
12 / 0000	15.6	179.8	960	105	"
12 / 0600	16.5	178.9E	973	90	"
12 / 1200	17.2	177.8E	982	80	"
12 / 1800	17.6	176.6E	987	70	"
13 / 0000	18.0	175.2E	993	60	tropical storm
13 / 0600	18.0	174.0E	996	55	"
13 / 1200	18.0	172.7E	1007	35	"
13 / 1800	18.3	171.5E	1007	30	tropical depression
14 / 0000	18.7	170.2E	1000	30	"
14 / 0600	19.3	169.1E	1007	35	tropical storm
14 / 1200	19.7	168.5E	1008	35	"
14 / 1800	20.1	168.0E	1006	35	"
15 / 0000	20.5	167.7E	1001	25	tropical depression

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
15 / 0600	21.4	167.7E	998	25	"
15 / 1200	22.6	167.9E	999	25	"
15 / 1800	23.7	168.2E	995	30	"
16 / 0000	24.5	168.4E	1010	25	"
16 / 0600	25.3	168.5E	996	25	"
16 / 1200	26.7	168.6E	995	25	"
16 / 1800	27.7	168.3E	994	25	"
17 / 0000	28.7	168.0E	993	25	subtropical depression
17 / 0600					dissipated
06 / 0000	13.2	135.6	939	130	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	**168-Hour Outlook**
Low (<40%)	78	126
Medium (40%-60%)	48	96
High (>60%)	24	72

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Dora. 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	**15.0**	**23.3**	**32.0**	**41.2**	**52.1**	**65.4**	**90.4**	122.2
OCD5	26.2	64.4	121.5	186.1	258.5	343.5	541.6	750.6
Forecasts	24	24	24	24	24	24	24	24
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 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Dora. 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	14.7	24.0	33.1	44.2	52.9	64.3	87.6	118.5
OCD5	22.5	59.4	116.2	178.1	244.4	323.2	520.7	727.5
GFSI	16.2	27.7	37.8	48.3	56.1	**63.7**	**81.7**	**102.8**
HWFI	15.4	28.0	39.5	48.6	53.7	**62.3**	**76.6**	**86.5**
HMNI	**12.9**	25.4	40.0	57.9	73.7	86.5	105.0	137.9
HFAI	14.9	**23.9**	**32.3**	**41.2**	**49.6**	**60.0**	**72.2**	**84.5**
HFBI	16.7	29.5	40.0	50.0	58.3	71.5	107.0	145.2
EGRI	24.3	43.9	60.6	74.7	85.7	98.1	137.2	139.5
EMXI	16.5	32.4	50.9	74.7	94.9	118.2	165.4	204.8
NVGI	25.1	47.5	66.1	86.0	110.7	136.7	191.0	229.1
CMCI	28.8	54.7	84.9	114.6	142.6	174.4	247.6	307.7
CTCI	17.7	26.9	37.3	50.6	66.3	85.4	128.5	157.6
TVCE	**14.5**	25.0	35.3	**43.9**	**52.3**	**62.4**	**81.7**	**103.5**
TVCX	14.8	25.7	34.3	44.6	53.4	**64.0**	**84.3**	**105.7**
GFEX	**14.2**	26.4	38.0	53.6	67.3	82.3	114.9	143.9
TVDG	16.0	25.9	35.4	**43.7**	**51.4**	**60.0**	**78.2**	**94.3**
HCCA	15.7	28.0	39.0	53.2	70.7	91.1	111.5	130.3
FSSE	15.1	**23.2**	**31.1**	**32.6**	**36.9**	**46.4**	**77.5**	**101.3**
AEMI	20.1	32.0	40.7	48.6	**52.2**	**57.3**	**64.2**	**72.4**
TABS	25.6	62.0	96.0	122.5	133.2	130.0	124.4	153.6
TABM	18.3	35.2	56.6	84.2	106.0	124.0	151.7	179.8
TABD	20.4	41.0	62.5	89.3	112.3	134.5	170.6	223.5
Forecasts	19	19	19	19	19	19	19	15

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Dora. 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 intensity forecasts west of 140°W is based on CPHC's operational assessments.

	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	9.0	13.1	16.5	21.2	23.8	25.6	31.7	38.5
OCD5	12.7	20.7	26.9	34.3	38.9	44.4	50.0	55.6
Forecasts	24	24	24	24	24	24	24	24
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 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Dora. 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 intensity 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	8.8	11.4	14.3	19.5	22.9	25.7	34.0	38.6
OCD5	12.4	19.5	25.0	32.1	36.4	42.6	50.8	54.0
HWFI	11.2	14.5	20.1	24.4	30.4	35.4	47.2	49.2
HMNI	10.1	14.5	20.9	26.5	30.8	34.8	43.2	46.9
HFAI	**8.7**	11.7	**12.0**	**17.8**	**21.1**	**24.7**	**32.9**	**35.1**
HFBI	10.8	13.4	14.9	22.3	27.1	31.0	41.4	50.8
DSHP	10.6	15.9	19.6	22.4	23.8	26.3	**32.1**	**33.0**
LGEM	10.9	16.4	20.1	23.6	25.5	27.6	**30.0**	**30.1**
ICON	10.0	14.3	19.4	23.7	27.4	30.8	38.0	39.7
IVCN	9.0	11.7	17.5	22.8	27.0	30.8	38.8	43.0
IVDR	8.9	11.8	17.9	23.7	28.3	32.4	41.0	46.0
CTCI	11.0	18.2	25.2	29.9	34.7	38.6	48.1	56.1
GFSI	13.5	23.3	30.5	36.2	40.0	43.4	52.6	59.7
EMXI	13.5	19.8	25.0	31.2	35.6	39.5	52.6	60.6
HCCA	8.8	12.3	17.9	20.6	**21.4**	**23.2**	37.0	49.5
FSSE	**8.4**	**11.2**	17.7	23.4	27.5	32.4	46.2	58.1
Forecasts	21	21	21	21	21	21	21	21

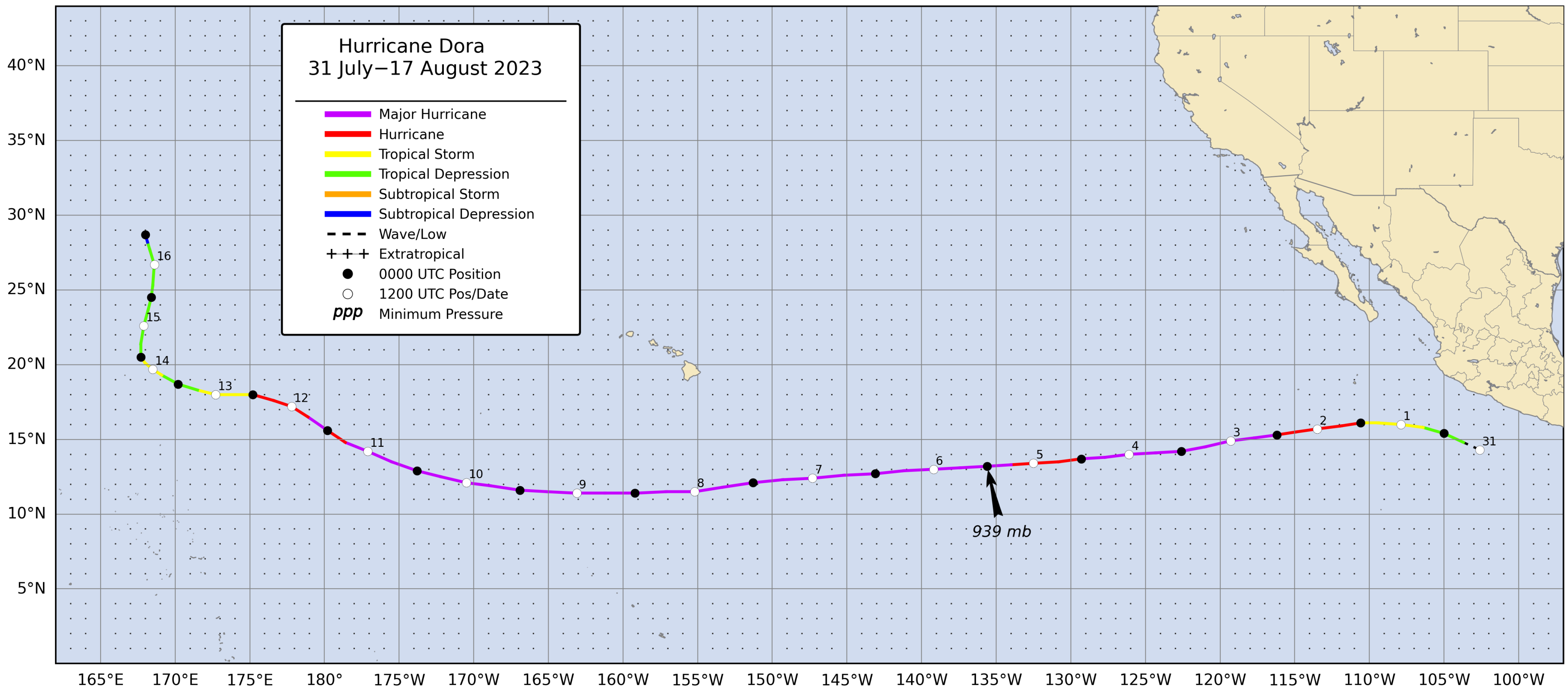

Figure 1. Best track positions for Hurricane Dora, 31 July – 17 August 2023. Note that the best track from 1800 UTC 6 August to 0000 UTC 12 August is based on operational assessments from the Central Pacific Hurricane Center. The best-track after 0000 UTC 12 August is based on operational assessments from the Joint Typhoon Warning Center.

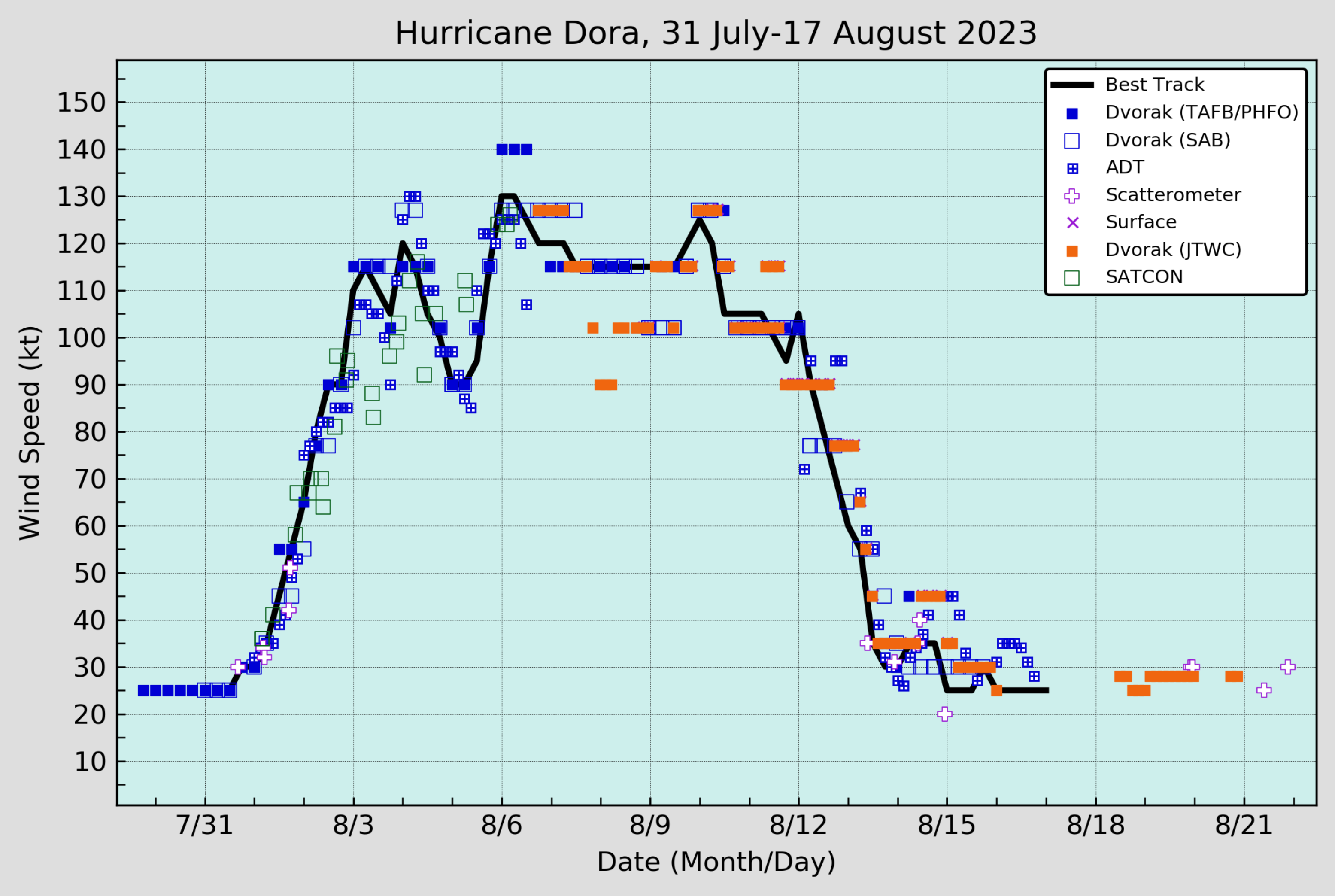

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Dora, 31 July – 17 August 2023. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC. Note that the best track from 1800 UTC 6 August to 0000 UTC 12 August is based on operational assessments from the Central Pacific Hurricane Center. The best-track after 0000 UTC 12 August is based on operational assessments from the Joint Typhoon Warning Center.

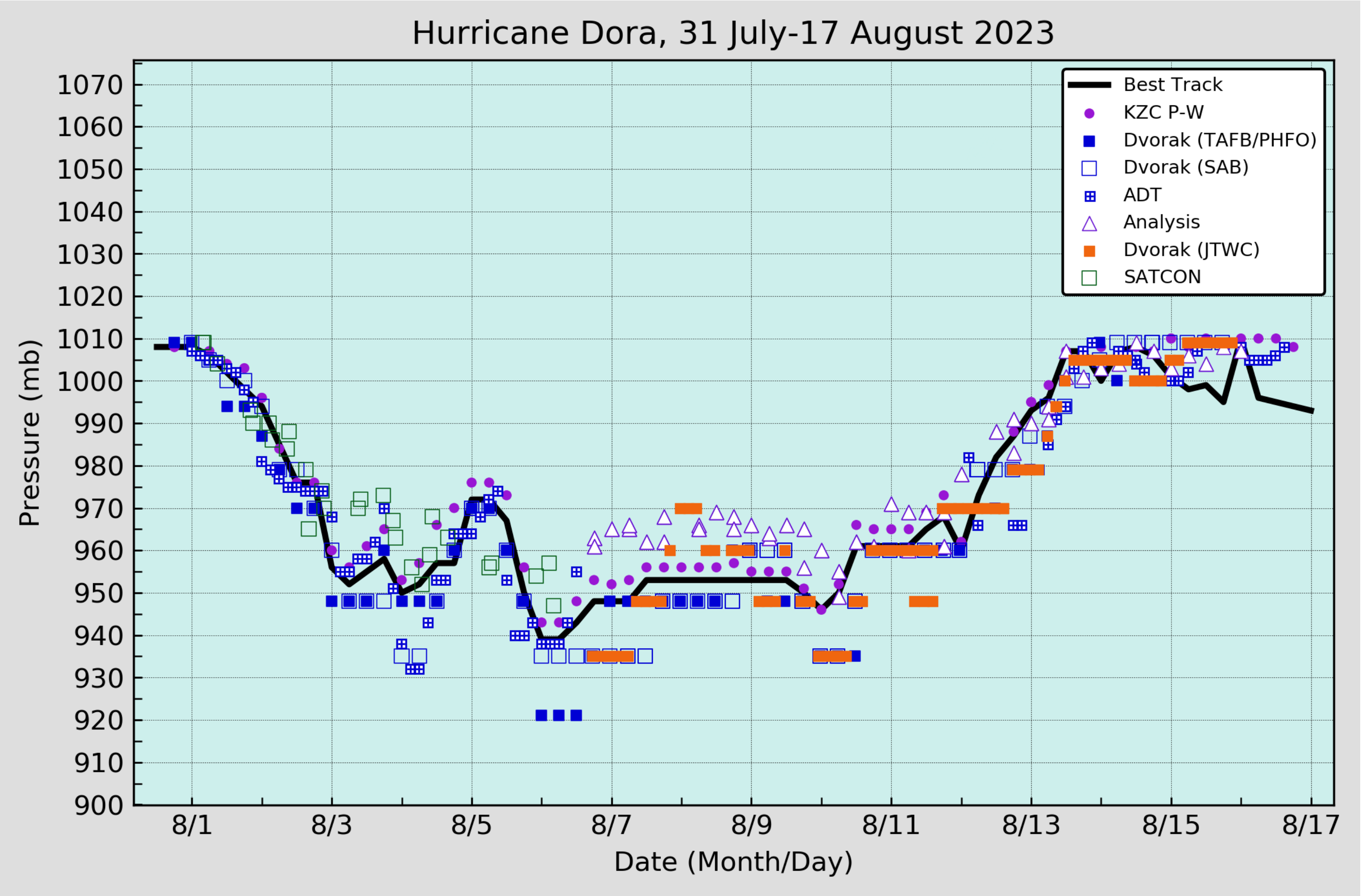

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Dora, 31 July – 17 August 2023. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological 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. Note that the best track from 1800 UTC 6 August to 0000 UTC 12 August is based on operational assessments from the Central Pacific Hurricane Center. The best-track after 0000 UTC 12 August is based on operational assessments from the Joint Typhoon Warning Center.

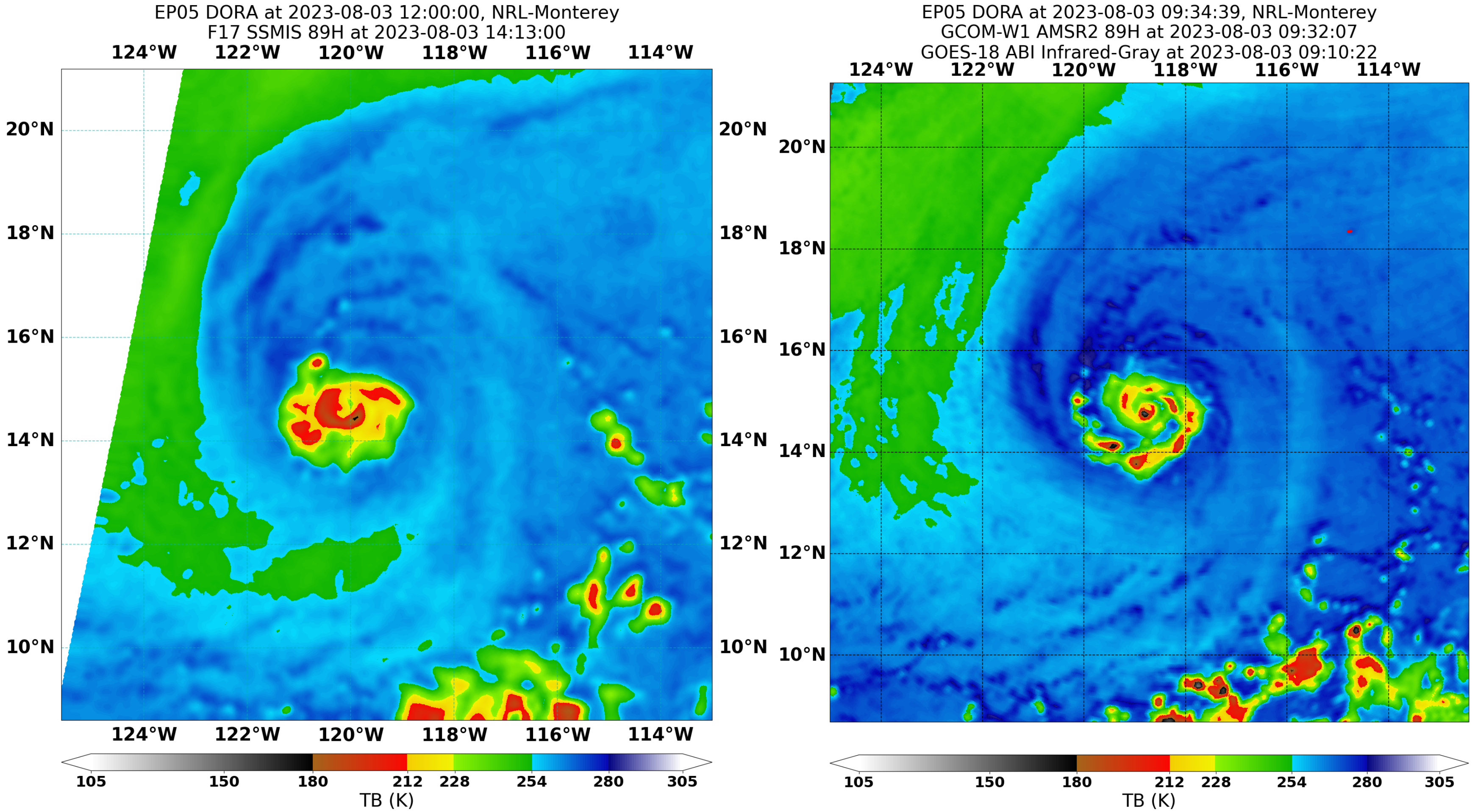

Figure 4. The 89-GHz microwave passes over Hurricane Dora from (left) GCOM-W1 AMSR2 at 0910 UTC 3 August and (right) F-17 SSMI/S at 1413 UTC 3 August.

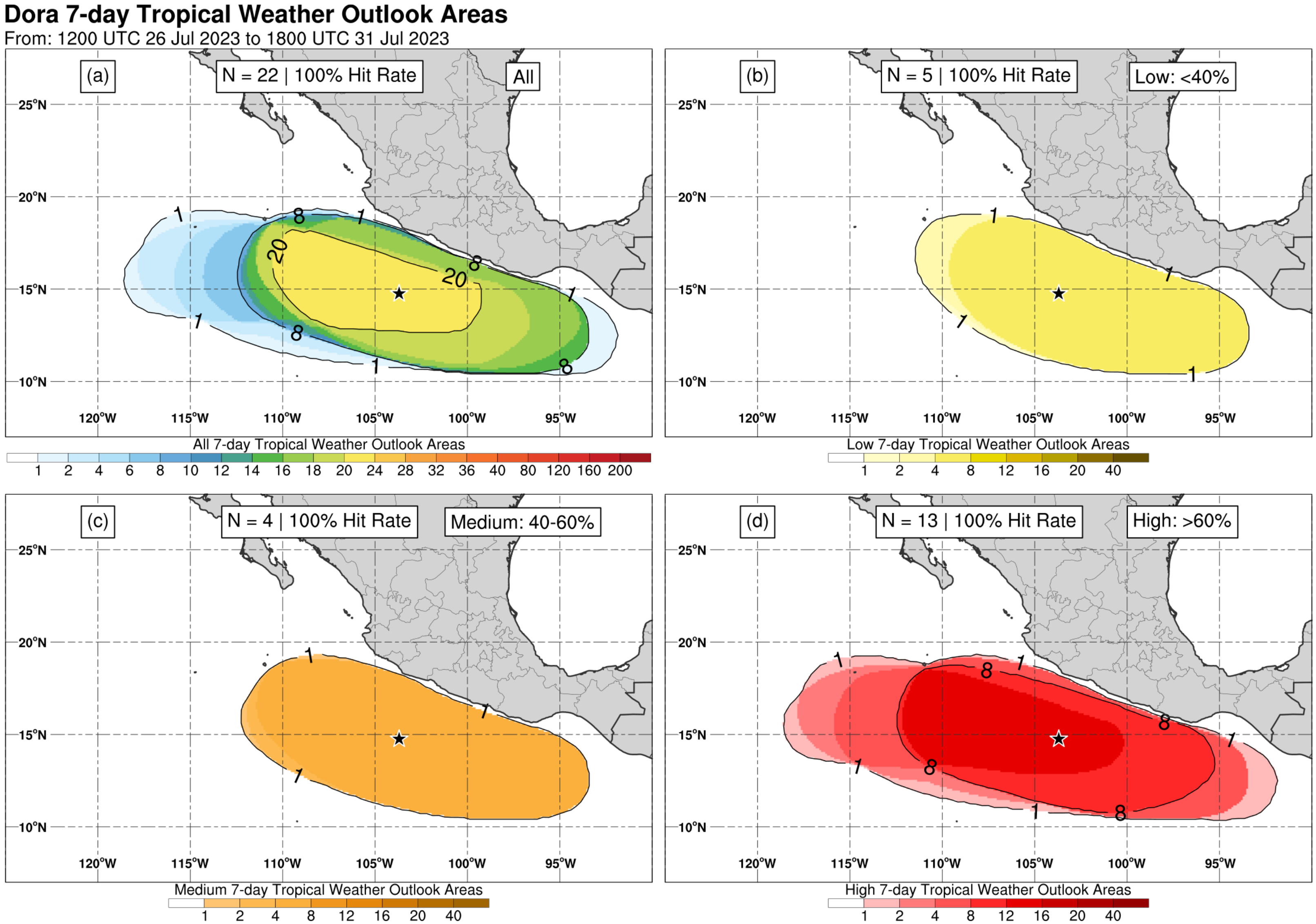

Figure 5. Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks prior to the formation of Dora for (a) all probabilistic genesis categories, (b) the low (<40%) category, (c) medium (40–60%) category, and (d) high (>60%) category. The location of genesis is indicated by the black star.

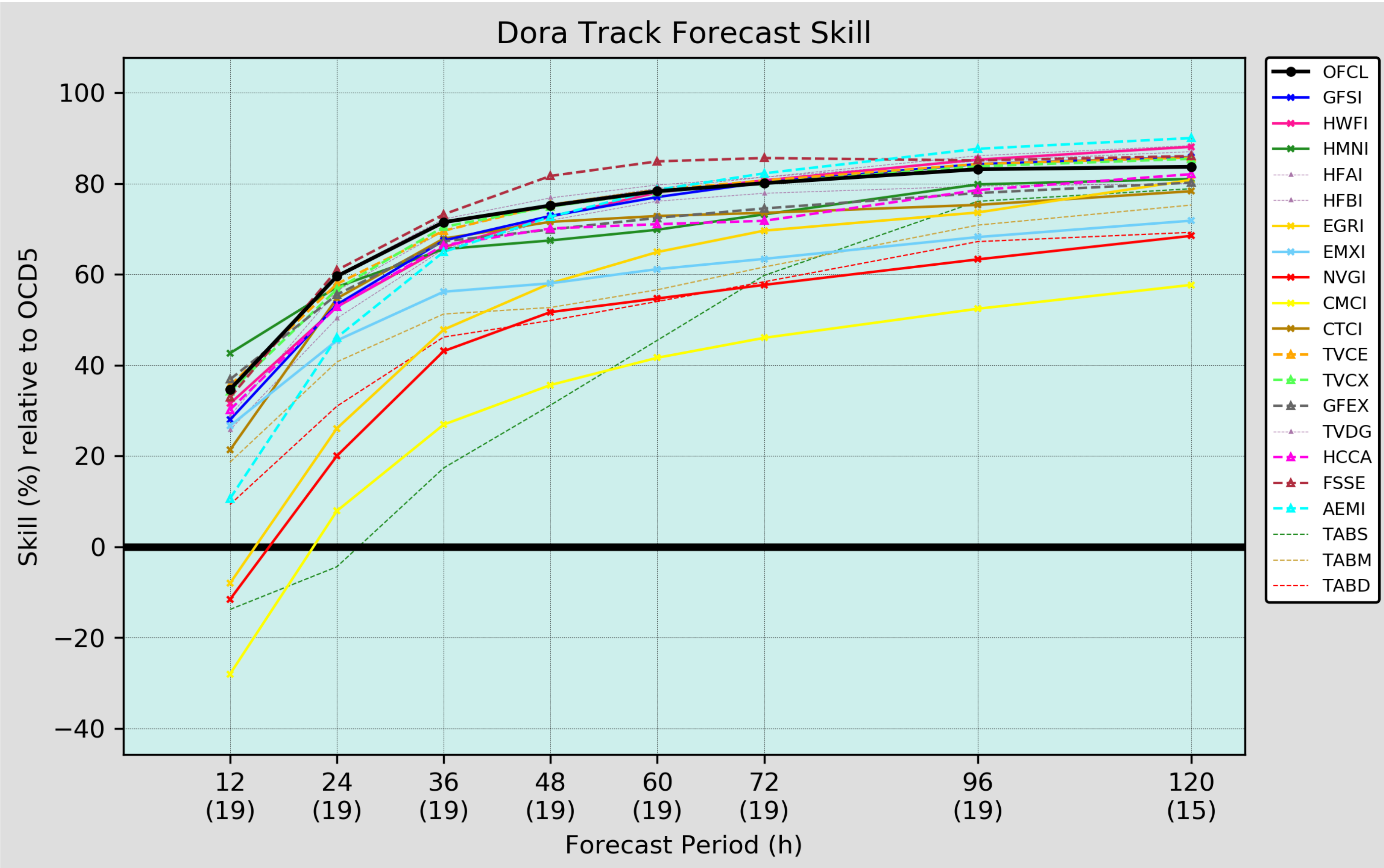

Figure 6. Track forecast skill of NHC official forecasts and selected models for Hurricane Dora in the eastern Pacific basin (1800 UTC 31 July-1200 UTC 6 August)

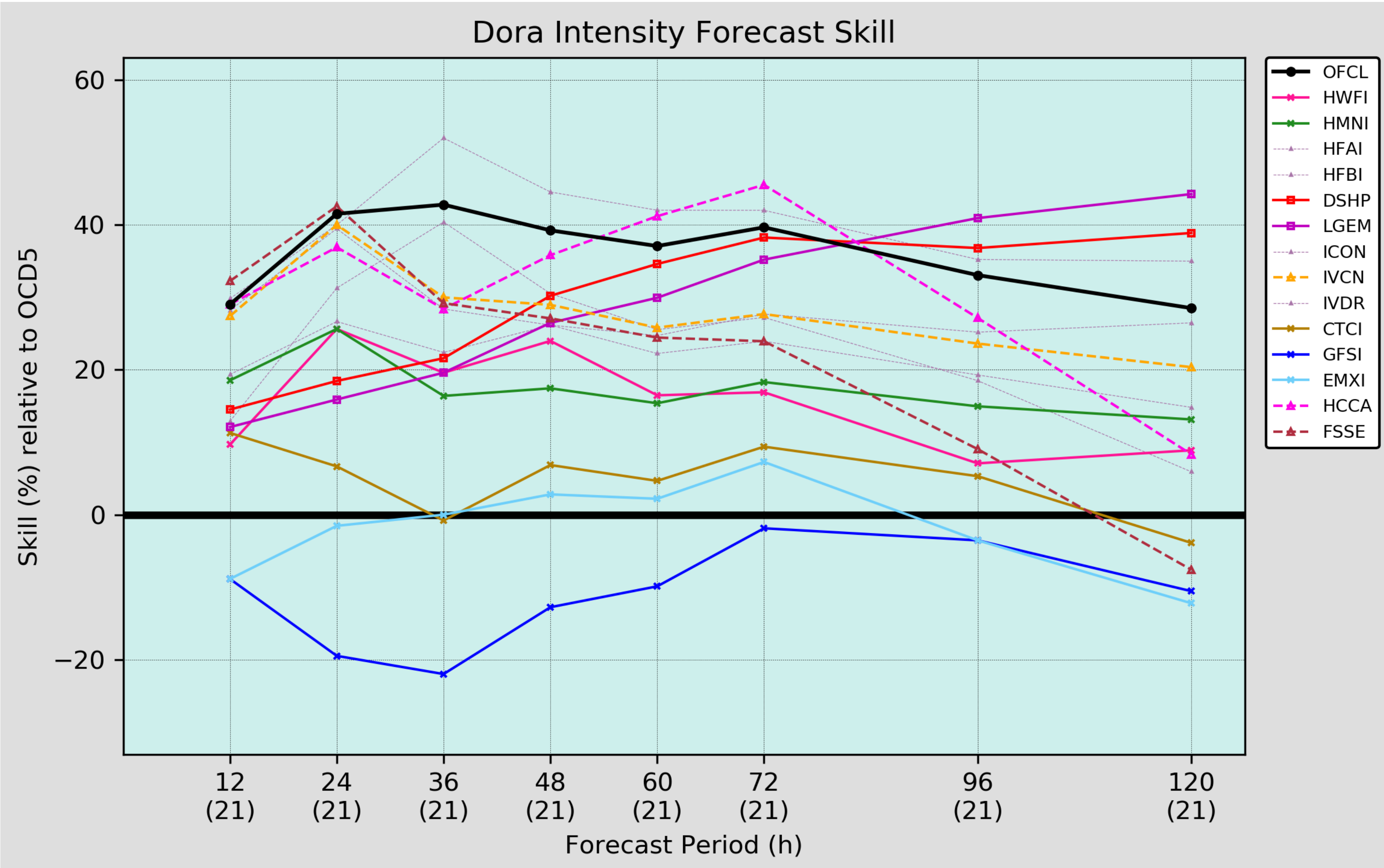

Figure 7. Intensity forecast skill of NHC official forecasts and selected models for Hurricane Dora in the eastern Pacific basin (1800 UTC 31 July-1200 UTC 6 August).

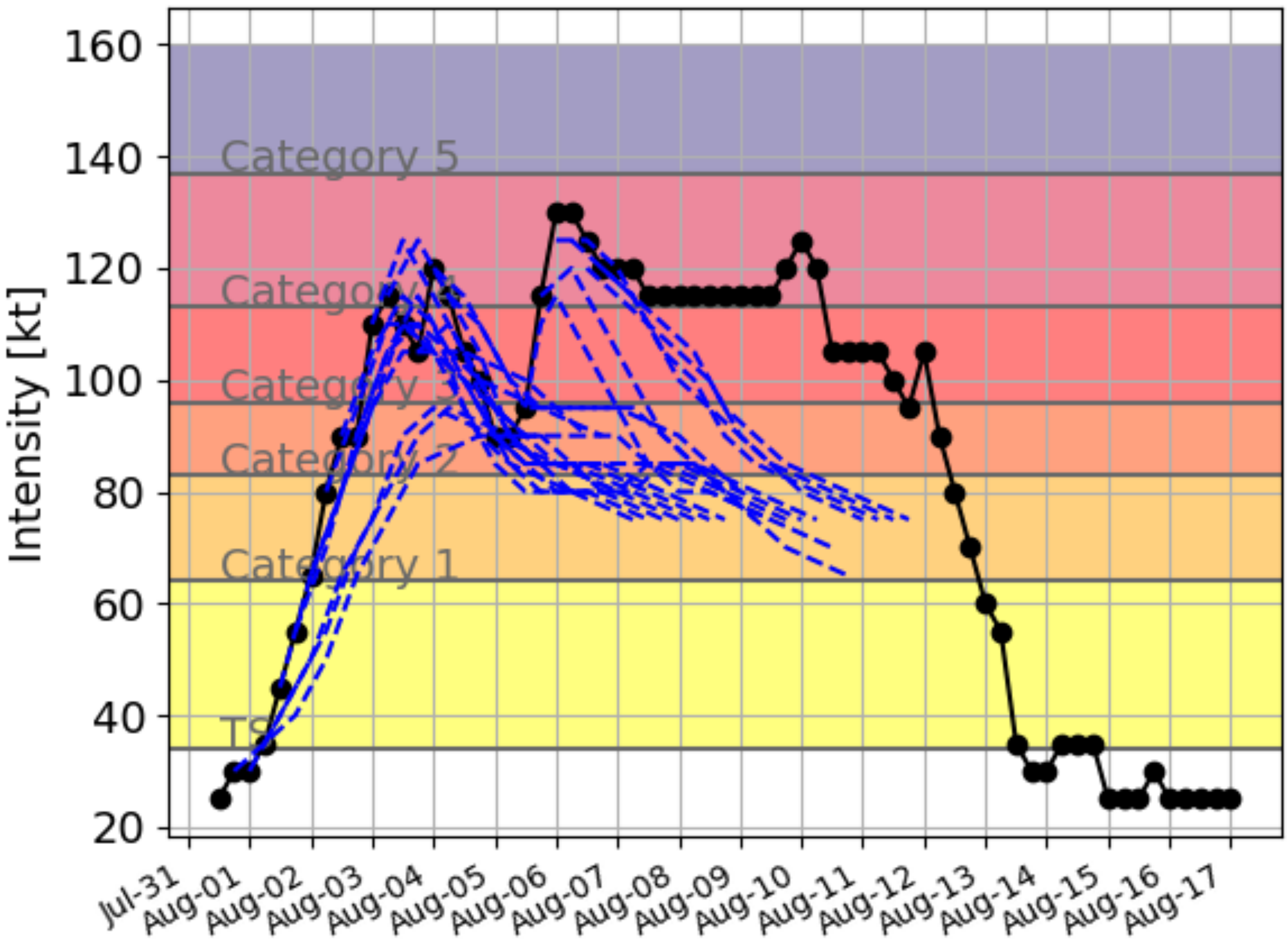

Figure 8. A comparison of NHC official intensity forecasts to the best track intensity of Dora, which is indicated by the solid black line and symbols at 6-h intervals.