

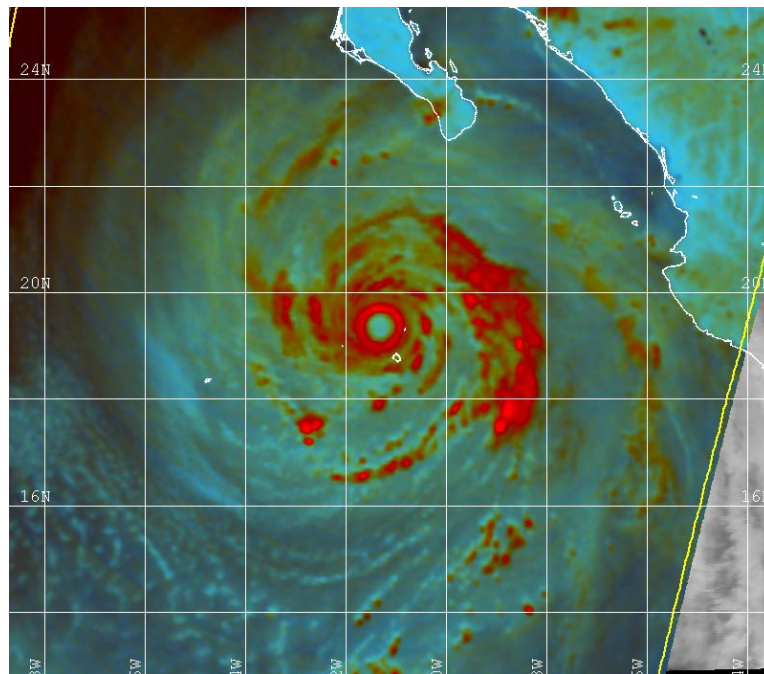


NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE DOLORES (EP052015)

11 – 18 July 2015

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National Hurricane Center
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G-COM-W1 89-GHZ MICROWAVE IMAGE OF HURRICANE DOLORES AFTER THE COMPLETION OF AN EYEWALL REPLACEMENT AT 0849 UTC 16 JULY 2015

Dolores formed south of Mexico and moved west-northwestward to northwestward, becoming a category 3 hurricane (on the Saffir-Simpson Hurricane Wind Scale) as it neared Socorro Island, where it produced hurricane conditions. Moisture associated with Dolores was partially responsible for very rare July heavy rains and flash flooding in southern and central California.

Hurricane Dolores

11 – 18 JULY 2015

SYNOPTIC HISTORY

A tropical wave was first noted in model analyses over the tropical Atlantic on 3 July, moving quickly and uneventfully westward. The wave crossed Central America on 8 July, and entered the far eastern Pacific the next day while an exceptionally strong Madden-Julian Oscillation was enhancing large-scale ascent and moisture throughout the basin. As the wave moved south of southeastern Mexico, it began to interact with a strong upper-level trough that was digging unusually far to the south along 100°W. The interaction of the wave and the trough produced an extensive region of cloudiness, and eventually a concentrated area of deep convection to the east of the trough axis on 10 July. The upper trough cut off and retrograded on the same day, while strong upper-level divergence associated with this feature contributed to additional convective growth and the development of a surface low pressure system about 300 n mi south-southwest of Salina Cruz, Mexico by 0000 UTC 11 July. Although southerly shear associated with the upper-level low was affecting the disturbance, the convective organization of the low gradually increased, and a tropical depression formed around 1200 UTC 11 July about 300 n mi south-southeast of Acapulco, Mexico. The “best track” chart of Dolores’ 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 1¹. The genesis of Dolores represents a relatively rare case of tropical cyclone formation in the eastern Pacific associated with the external forcing provided by an upper-level trough (Montgomery and Farrell 1993).

Dolores moved west-northwestward to northwestward to the south of a mid-level anticyclone over the south-central United States. During its early stages of development late on 11 July and early the following day, satellite data indicate that the center reformed much farther to the north in a new convective burst. After the reformation of the center, a small central dense overcast and a long convective band developed by midday on 12 July. Despite a nearly ideal oceanic and thermodynamic environment of sea surface temperatures around 30° C and high lower to middle-tropospheric moisture, only gradual intensification took place due to moderate northwesterly shear associated with the nearby upper-level trough. The cyclone paralleled the southwestern coast of Mexico about 130 n mi offshore between 12 and 13 July, with scatterometer and ship data indicating winds of tropical storm force near but not quite reaching the coast from Acapulco to Manzanillo, Mexico. Dolores reached hurricane strength at 1200 UTC 13 July while centered about 145 n mi south-southwest of Manzanillo, and then turned westward to west-northwestward away from the coast at a substantially slower forward speed.

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 *bt* directory, while previous years’ data are located in the *archive* directory.

When the influence of the cold low to the northwest of Dolores diminished on 14 July, the cyclone rapidly intensified, and Dolores is estimated to have reached a peak intensity of 115 kt at 0600 UTC 15 July after a 40-kt increase over 24 h. Microwave imagery suggests that an eyewall replacement likely began around this time, and slow weakening occurred while Dolores approached Socorro Island. The eye of the hurricane passed around 15 to 20 n mi to the northeast of Socorro around 0000 UTC 16 July with an intensity of 95 kt. By 16 July and after the eyewall replacement had ended, Dolores appeared poised to re-strengthen, with satellite imagery showing a well-organized cloud pattern and a 35-n mi-wide eye. However, the cyclone was just reaching lower sea surface temperatures, which resulted in a slow but steady rate of weakening.

When Dolores moved over much cooler waters the next day, it rapidly weakened and accelerated north-northwestward between a subtropical ridge to its east and a mid- to upper-level trough offshore of the California coast. The low- to mid-level circulations of Dolores were separating by 0600 UTC 18 July, when the cyclone encountered strong northerly shear, and Dolores weakened to a tropical storm while centered about 325 miles west-southwest of the southern tip of the Baja California peninsula around 1200 UTC that day. Dolores quickly lost all of its deep convection over 23° C water and became a remnant low by 1800 UTC that day. The vigorous circulation continued north-northwestward and gradually spun down further. Now a shallow system, Dolores decelerated on 20 July and turned southward when it encountered the low-level northwesterly flow around the subtropical ridge in the eastern Pacific. The remnant low drifted southward on 21 July, and dissipated early on 22 July a few hundred n mi west-southwest of San Diego, California.

METEOROLOGICAL STATISTICS

Observations in Dolores (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. 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 Dolores.

Dolores' estimated peak intensity of 115 kt is based on satellite classifications of T6.0/115 kt from TAFB and SAB around 0600 UTC 15 July.

Selected ship reports of winds of tropical storm force associated with Dolores are given in Table 3. The Bahamian tanker *Asia Excellence (C6AX5)* reported winds of 55 kt about 75 n mi northeast of Dolores' center at 2300 UTC 12 July, but this observation appears to be too high compared to model initial analyses.

Isolated areas of heavy rains occurred along the coast from near Acapulco to Manzanillo in the outer bands from Dolores from 11 to 13 July. No rainfall totals from this region are available, however.

Dolores passed 15 to 20 n mi northeast of Socorro Island on 16 July around 0000 UTC. An automated station (site elevation of 35 m) on the southern end of the island reported 69 kt (128 km/h) peak 1-minute winds with gusts to 100 kt (185 km/h) between 0030 and 0045 UTC. A minimum pressure of 968.4 mb was recorded about an hour later, but a post-analysis suggests that the pressure may be at least a couple of millibars too low.

As a tropical cyclone, Dolores produced no impacts in the United States. However, a surge of moisture associated with the remnants of the cyclone moved northward ahead of a weak mid-latitude shortwave trough offshore of the California coast on 17 and 18 July. The interaction of the moisture with the trough produced very rare July heavy rains over portions of southern and, to a lesser extent, central California. In general, widespread rainfall accumulations of 2 to 3 inches were observed across southern California (Fig. 4). All-time July monthly rainfall records were set in San Diego (1.03 inches) and Los Angeles (0.28 inches), as well as in almost a dozen other locations. In addition, San Diego and Los Angeles observed their heaviest one-day rainfalls for the month of July. Heavy rains were more significant elsewhere, especially in complex or mountainous terrain (Fig. 4). The city of Ramona received close to 4 inches of rain, which resulted in significant flooding. Similar rainfall totals were estimated by radar over portions of the San Bernardino and Riverside mountains. The flooding in Ramona resulted in debris flows and rock slides that damaged about 90 homes, and many cars in the city were nearly submerged in several feet of water. Heavy rains also caused flooding that washed out a portion of Interstate 10 in California west of the Colorado River, where Doppler radar estimates indicated that as much as 6 to 9 inches of rain occurred. Flash flooding was also reported in low-lying areas of Perris and La Mesa, as well as in the Moreno Valley. The San Diego River crested below flood stage at 8.9 ft and overflowed its banks in a few areas.

High surf related to Dolores also affected the southern California coast for a couple of days, with the highest surf affecting southward-facing beaches.

CASUALTY AND DAMAGE STATISTICS

The widespread heavy rains over southern California on 18 and 19 July occurred far from the tropical cyclone and its remnant circulation. Thus, whatever damage occurred across the region as a result of the excessive rainfall would not be attributed to the cyclone. A person was struck by lightning in California City, California, but it was not clear as to the extent of the person's injuries. This injury is also not considered attributable to Dolores.

FORECAST AND WARNING CRITIQUE

The genesis of Dolores was generally well forecast for the long range, but genesis forecasts were poor for the short range. The precursor disturbance was introduced into the 48-h portion of the Tropical Weather Outlook 36 h prior to genesis. The likelihood of formation was also not increased to the high category (> 60%) of the TWO until 6 h before genesis occurred.

The disturbance from which Dolores developed was introduced in the 5-day portion of the TWO 102 h prior to genesis. The genesis potential was raised to medium (40 - 60%) and then to high 78 h and 60 h, respectively, prior to tropical cyclone formation. Table 2 shows the lead times associated with the genesis forecasts of Dolores.

A verification of NHC official track forecasts for Dolores is given in Table 4a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period at all forecast times, particularly at longer lead times. In fact, the errors were a quarter to a third of the 5-yr means at 96 h and 120 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. Aside from the official forecast that performed extraordinarily well, the ECMWF was quite competitive.

A verification of NHC official intensity forecasts for Dolores is given in Table 5a. Official forecast intensity errors were greater than the mean official errors for the previous 5-yr period at all forecast times. After a period of rapid intensification, the official forecasts predicted additional strengthening in the short term; an eyewall replacement, however, caused weakening to commence earlier than expected (Fig. 5). These forecasts, in addition to those that later did not predict either the rapid decay or its timing, contributed to the greater-than-average errors through 48 h. The significantly greater-than-average errors at longer lead times are associated with forecasts that called for Dolores to remain stronger after crossing 20°N (Fig. 5).

A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. The multi-model consensus (ICON) and the Florida State Superensemble (FSSE), and especially the former, were superior to the official forecast at all forecast times. The HWRF model performed exceptionally well throughout the forecast period, with overall errors at 96 and 120 h considerably lower than those of the official forecast. The GFDL model also had generally small errors relative to the official forecast, most notably at the extended lead times.

Watches associated with Dolores are given in Table 7. A tropical storm watch was issued from Lázaro Cárdenas to Cabo Corrientes on 12 July when the center of Dolores moved farther north than expected and its wind field expanded more than predicted. The watch was discontinued the following day, when Dolores began to move away from the coast.

ACKNOWLEDGEMENTS

Thanks are extended to the Alexander Tardy, the Science and Operations Officer at the Weather Forecast Office in San Diego, who provided information about the impacts in southern California associated with the remnants of Dolores. Thanks are also extended to Michael Brennan, who produced the storm total rainfall plot of southern California (Fig. 4).

Reference

Montgomery, M.T., and B.F. Farrell, 1993: Tropical Cyclone Formation. *J. Atmos. Sci.*, 50, 285 - 310.



Table 1. Best track for Hurricane Dolores, 11-18 July 2015.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
11 / 0000	11.4	96.6	1006	25	low
11 / 0600	11.6	97.5	1006	30	"
11 / 1200	11.9	98.4	1005	30	tropical depression
11 / 1800	12.2	99.4	1004	35	tropical storm
12 / 0000	13.1	100.1	1003	40	"
12 / 0600	14.0	100.7	1001	45	"
12 / 1200	14.9	101.5	1000	45	"
12 / 1800	15.4	102.5	999	50	"
13 / 0000	16.0	103.5	997	55	"
13 / 0600	16.4	104.4	993	60	"
13 / 1200	16.8	105.3	989	65	hurricane
13 / 1800	17.1	106.1	987	70	"
14 / 0000	17.1	106.7	985	70	"
14 / 0600	17.2	107.2	982	75	"
14 / 1200	17.5	107.8	980	75	"
14 / 1800	17.8	108.3	976	80	"
15 / 0000	18.0	108.9	964	95	"
15 / 0600	18.1	109.4	946	115	"
15 / 1200	18.2	109.9	950	110	"
15 / 1800	18.5	110.3	956	105	"
16 / 0000	18.9	110.7	964	95	"
16 / 0600	19.3	111.1	969	90	"
16 / 1200	19.7	111.6	966	90	"
16 / 1800	20.1	112.3	971	85	"
17 / 0000	20.6	112.9	976	80	"
17 / 0600	21.0	113.8	986	65	"



17 / 1200	21.2	114.6	992	55	tropical storm
17 / 1800	21.3	115.5	996	45	"
18 / 0000	21.6	116.3	999	45	"
18 / 0600	22.1	117.0	1001	40	"
18 / 1200	22.8	117.6	1003	35	"
18 / 1800	23.8	118.2	1005	35	low
19 / 0000	24.9	118.8	1006	30	"
19 / 0600	26.1	119.2	1007	30	"
19 / 1200	27.3	119.6	1008	30	"
19 / 1800	28.6	120.0	1009	30	"
20 / 0000	29.8	120.6	1009	30	"
20 / 0600	30.8	121.2	1010	25	"
20 / 1200	31.5	121.7	1010	25	"
20 / 1800	31.7	122.3	1011	20	"
21 / 0000	31.6	122.7	1011	20	"
21 / 0600	31.4	122.6	1012	20	"
21 / 1200	31.1	122.5	1012	20	"
21 / 1800	30.8	122.4	1013	20	"
22 / 0000	30.4	122.3	1014	20	"
15 / 0600	18.1	109.4	946	115	maximum wind and minimum pressure



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%)	36	102
Medium (30%-50%)	12	78
High (>60%)	6	60

Table 3. Selected ship reports with winds of at least 34 kt for Hurricane Dolores, 11-18 July 2015.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
12 / 0300	DHBN	15.9	99.0	100 / 35	1011.4
12 / 1900	C6AX5	17.7	103.4	100 / 38	1008.0
12 / 2300	C6AX5	17.1	102.9	090 / 55	1006.0
13 / 0000	A8LL8	18.0	102.9	120 / 37	1010.0
13 / 0200	C6AX5	16.6	102.4	110 / 45	1003.0



Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Dolores, 11-18 July 2015. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	18.3	23.3	29.8	33.8	41.3	35.7	53.6
OCD5	30.9	48.1	71.3	87.6	98.5	118.8	139.3
Forecasts	27	25	23	21	17	13	9
OFCL (2010-14)	23.4	36.4	47.2	59.4	89.0	123.6	159.5
OCD5 (2010-14)	36.6	74.2	116.5	159.7	245.6	331.1	427.4

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Dolores, 11-18 July 2015. 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.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	15.8	20.9	27.7	32.2	37.3	23.4	53.5
OCD5	29.2	48.5	71.5	89.9	109.2	142.8	167.1
GFSI	20.8	30.9	42.9	53.4	53.4	59.9	111.6
GHMI	21.6	35.9	49.4	63.2	102.9	149.7	249.7
HWFI	19.6	33.5	42.7	57.0	68.4	52.6	77.3
EGRI	18.2	29.4	34.4	41.6	66.0	102.9	162.1
EMXI	13.6	18.1	27.4	31.1	47.3	43.4	56.4
NVGI	17.1	31.0	41.5	59.5	95.2	110.9	157.8
GFNI	22.6	41.2	54.7	70.1	118.1	184.8	333.2
TCON	17.5	25.5	31.6	38.2	50.4	49.4	73.3
TVCE	15.8	23.1	29.1	33.4	43.3	38.5	59.3
FSSE	15.7	22.2	29.6	34.8	52.9	49.7	75.5
AEMI	20.2	30.2	40.5	49.3	55.8	44.2	60.1
BAMS	36.9	57.6	73.2	85.2	88.0	99.8	133.2
BAMM	30.3	48.4	62.7	76.1	102.7	116.2	143.0
BAMD	25.1	40.9	59.7	71.8	91.0	91.5	144.8
Forecasts	25	23	21	19	15	11	7



Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Dolores, 11-18 July 2015. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	9.6	13.8	14.1	16.2	21.2	23.1	26.7
OCD5	11.9	16.7	21.1	24.8	29.1	27.5	15.3
Forecasts	27	25	23	21	17	13	9
OFCL (2010-14)	5.9	9.8	12.5	14.0	15.5	16.3	14.9
OCD5 (2010-14)	7.7	12.8	16.4	18.8	21.1	20.9	19.7

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Dolores, 11-18 July 2015. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	9.8	14.8	15.0	17.8	23.6	22.5	35.8
OCD5	12.5	17.9	23.0	27.1	29.4	21.2	6.5
HWFI	8.8	13.0	15.1	17.8	23.1	17.7	9.2
GHMI	9.5	15.3	19.1	20.5	24.1	18.4	13.2
DSHP	10.9	15.5	16.5	16.9	22.6	25.2	39.0
LGEM	10.4	15.4	16.3	16.7	24.5	24.9	20.3
ICON	9.0	11.4	12.4	14.6	19.3	16.9	14.9
FSSE	9.3	13.0	13.9	13.0	13.6	17.9	33.5
Forecasts	24	22	20	18	14	10	6



Table 7. Watch and warning summary for Hurricane Dolores, 11-18 July 2015.

Date/Time (UTC)	Action	Location
12 / 1500	Tropical Storm Watch issued	Lázaro Cárdenas to Cabo Corrientes
13 / 1500	Tropical Storm Watch modified to	Punta San Telmo to Cabo Corrientes
13 / 2100	Tropical Storm Watch discontinued	All

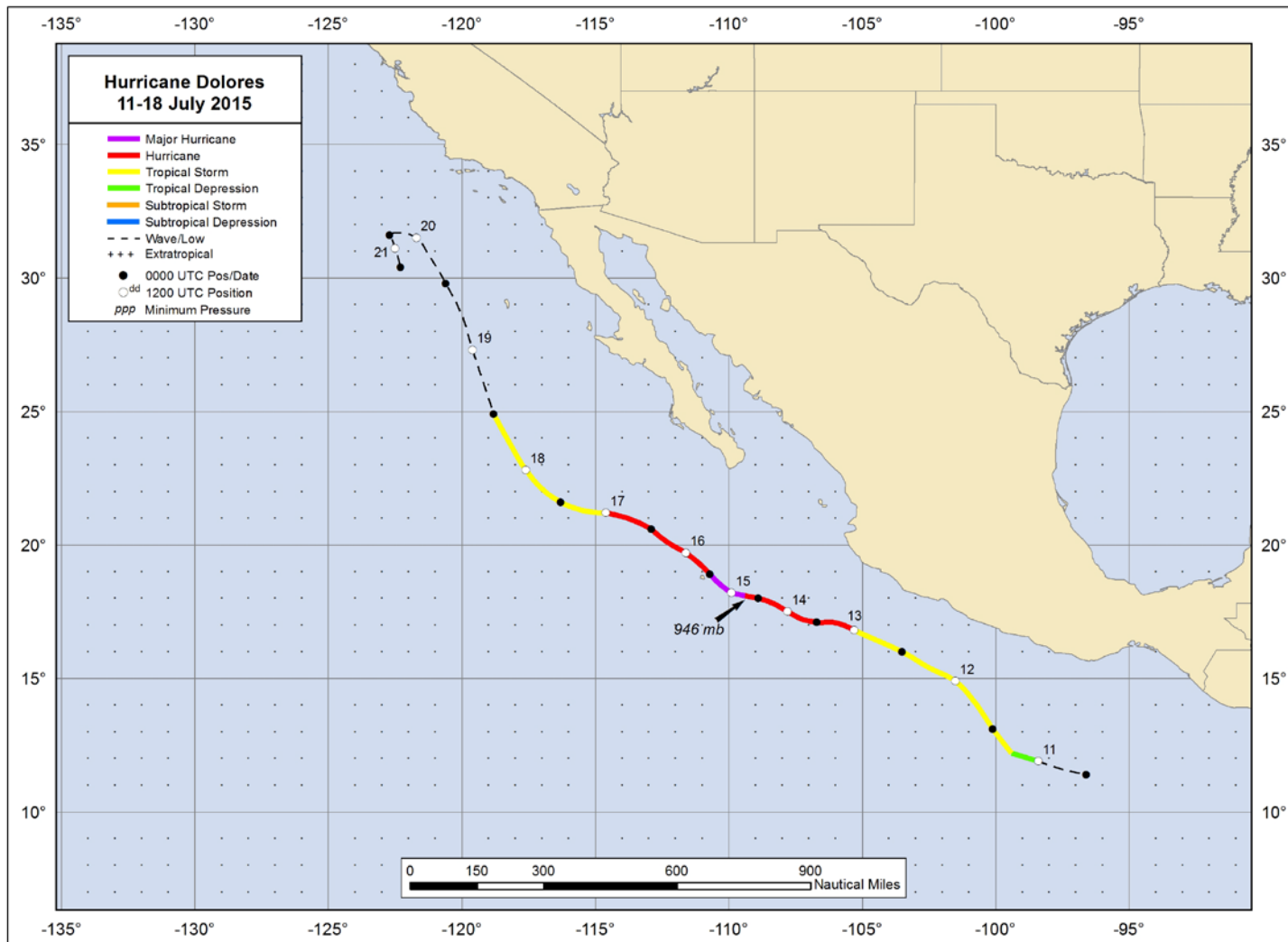


Figure 1. Best track positions for Hurricane Dolores, 11-18 July 2015.

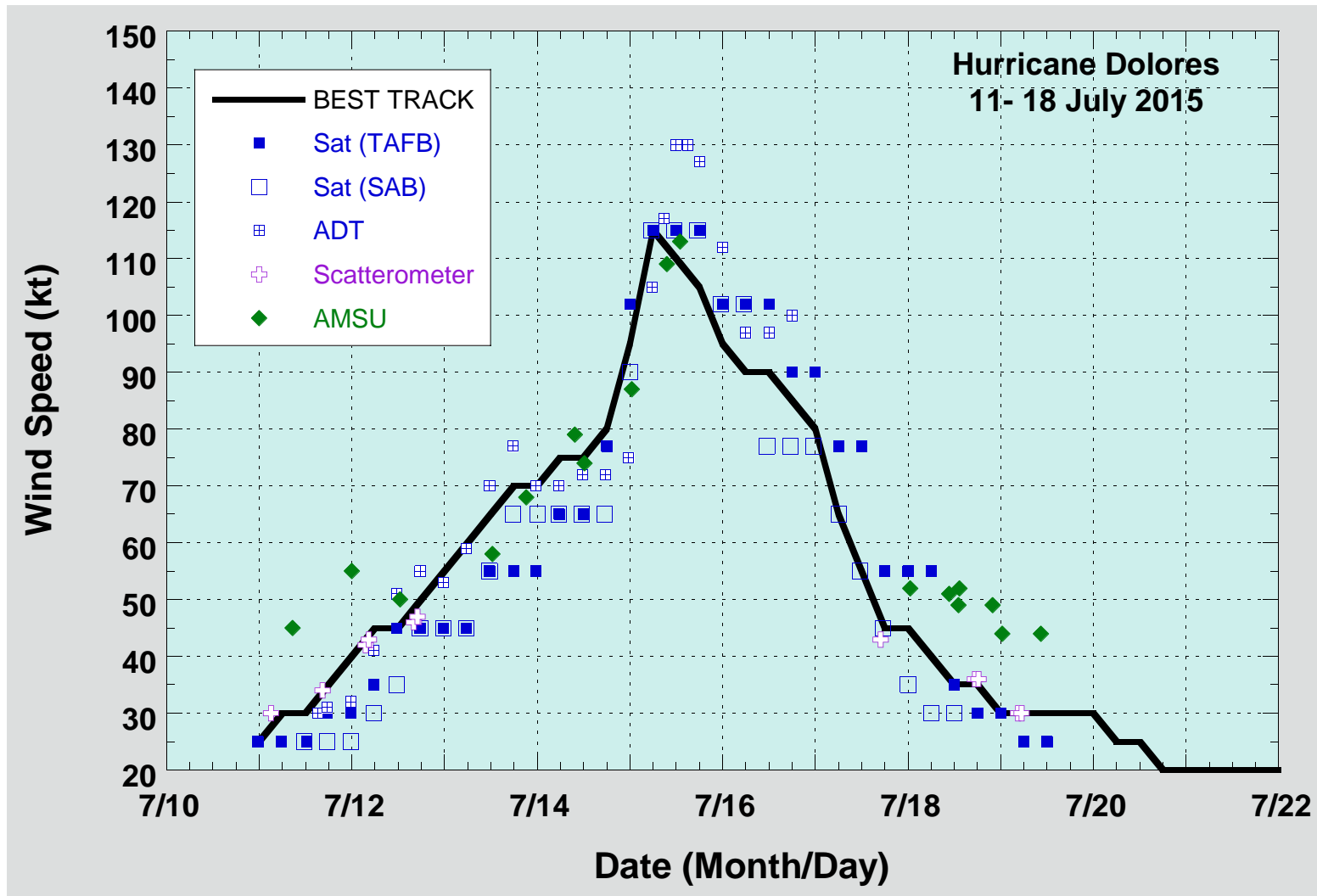


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Dolores, 11-18 July 2015. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

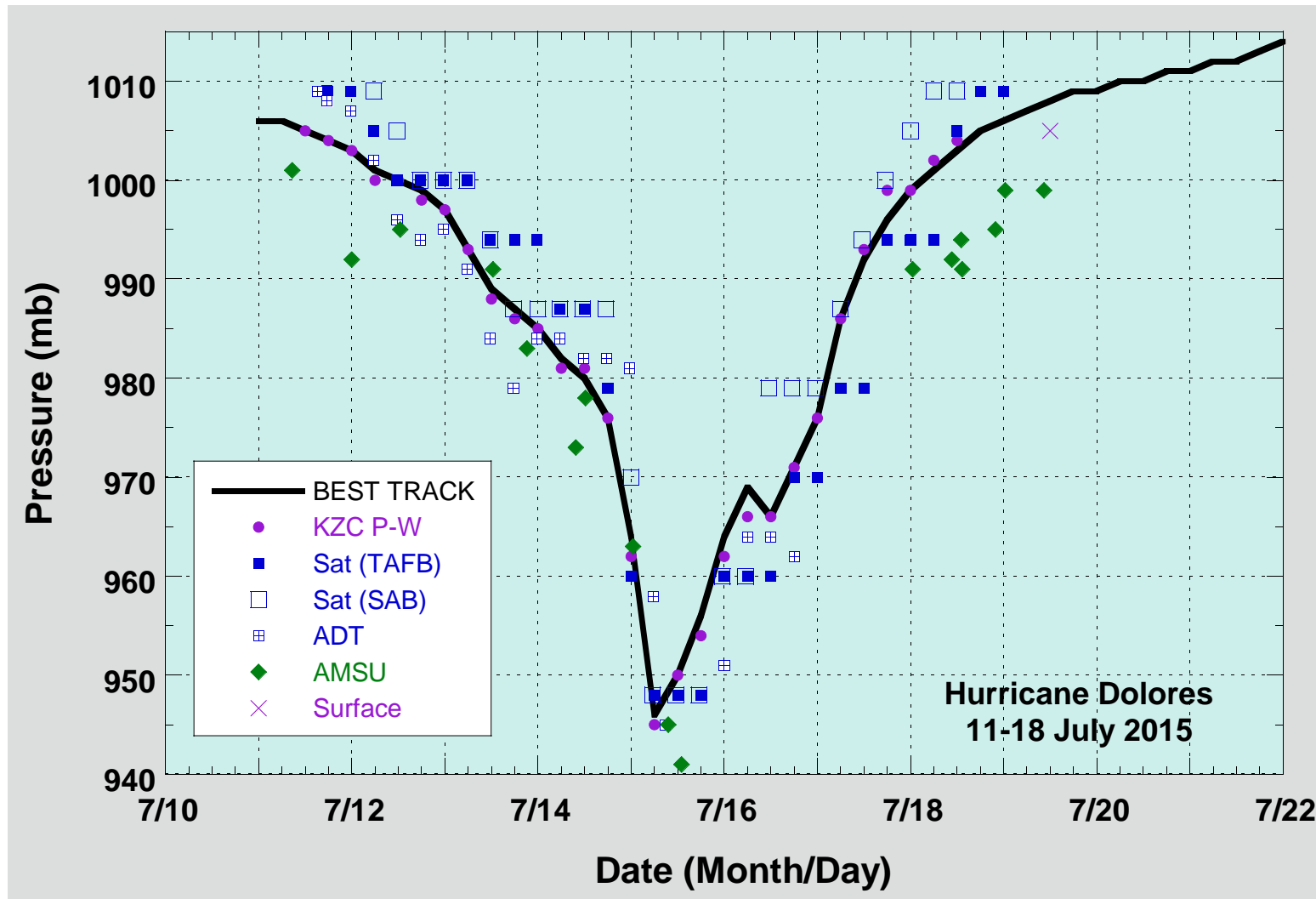


Figure 3. Selected pressure observations and best track minimum central pressure curve Hurricane Dolores, 11-18 July 2015. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

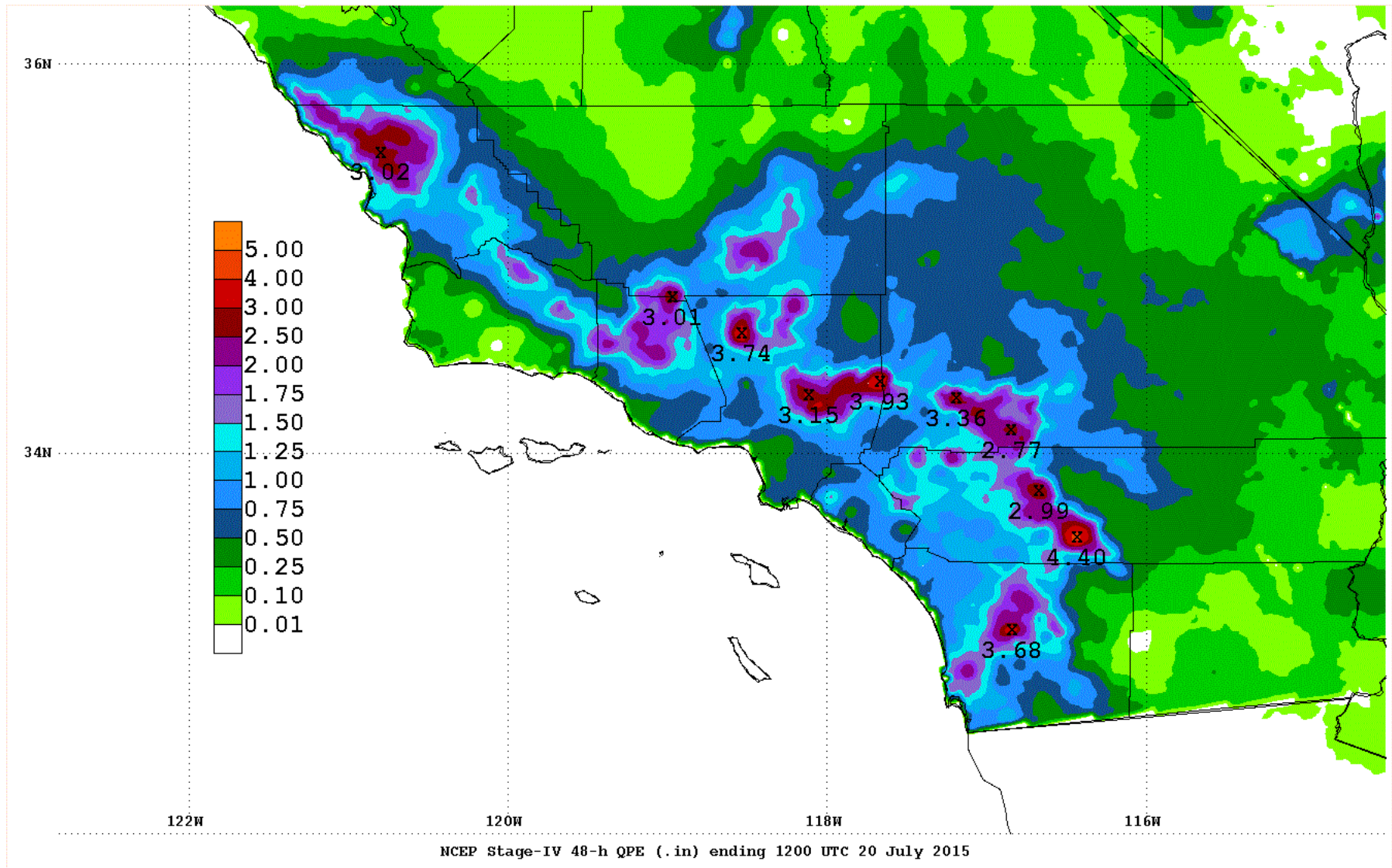


Figure 4. Rainfall totals, partially associated with the moisture from Dolores, over southern and central California from 18 to 19 July. Graphic was produced using NCEP Stage-IV blended radar-gauge composite.

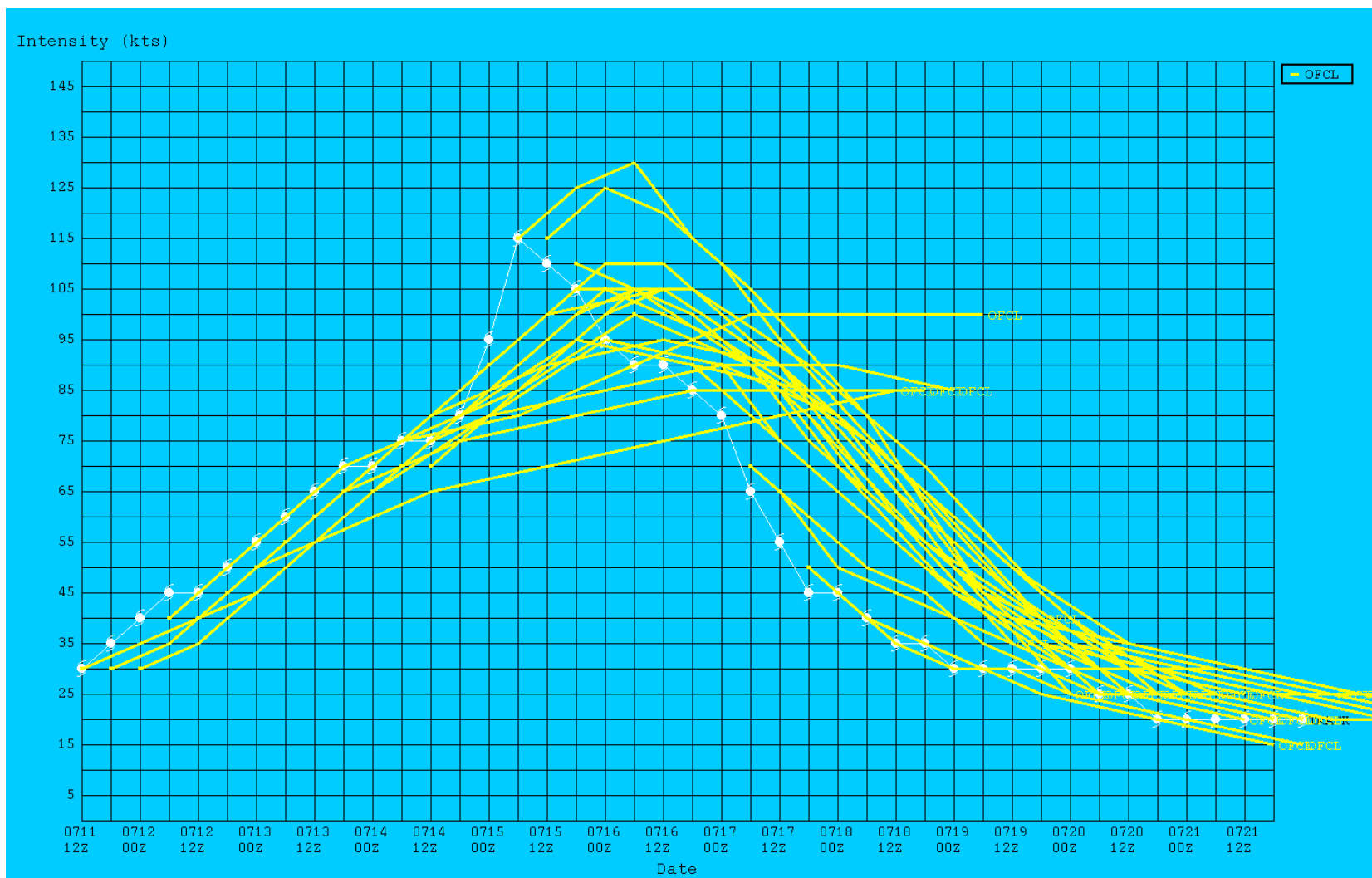


Figure 5. Selected official intensity forecasts (cyan lines) for Hurricane Dolores, 11-18 July, 2015. The best track intensity is given by the thick white line with intensities given at 6 h intervals.