



# NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT<sup>1</sup>

## HURRICANE MADELINE (EP142016)

26 August – 2 September 2016

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MODIS VISIBLE SATELLITE IMAGE OF HURRICANE MADELINE AT 2325 UTC 29 AUGUST 2016.

Madeline formed in the eastern Pacific basin and became a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) in the central Pacific basin. The cyclone weakened while nearing Hawaii, and it passed just south of the Big Island.

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<sup>1</sup> This report focuses on Madeline's history in the National Hurricane Center's area of responsibility (east of 140°W longitude). The report will be updated once the Central Pacific Hurricane Center completes its analysis of the storm for the time the cyclone spent west of 140°W.

# Hurricane Madeline

26 AUGUST – 2 SEPTEMBER 2016

## SYNOPTIC HISTORY

The disturbance that led to the formation of Madeline was first noted in satellite images on 20 August as a broad trough of low pressure located about 500 n mi south of Acapulco, Mexico. This trough moved westward during the next several days with deep convection pulsing near the axis. The thunderstorm activity became more persistent on 25 August, and it consolidated the following day. It is estimated that a tropical depression formed around 1800 UTC 26 August, about 1125 n mi east-southeast of the Big Island of Hawaii. The “best track” chart of the tropical cyclone’s path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1<sup>2</sup>.

A large curved band formed to the west of the center shortly after genesis, and the tropical depression strengthened to a tropical storm 6 h after formation. In an environment of moderate wind shear and over 27°C waters, Madeline continued to slowly strengthen while moving west-northwestward to northwestward on the southwestern periphery of a mid-level high pressure system during the next couple of days. The cyclone moved into the central Pacific basin as a 50-kt tropical storm shortly after 0000 UTC 28 August.

## METEOROLOGICAL STATISTICS

Observations in Madeline (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), Satellite Analysis Branch (SAB), the Central Pacific Hurricane Center (CPHC), and the U.S. Joint Typhoon Warning Center (JTWC), plus objective Advanced Dvorak Technique (ADT) 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 flights of the 53<sup>rd</sup> Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM), 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 Madeline.

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<sup>2</sup> 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.

There were no ship reports of winds of tropical storm force associated with Madeline in the eastern Pacific basin.

The estimated 50-kt peak intensity of Madeline in the eastern Pacific is based on subjective Dvorak classifications from TAFB and SAB and objective Dvorak T-numbers from CIMSS at the University of Wisconsin.

## CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Madeline in the eastern Pacific basin.

## FORECAST AND WARNING CRITIQUE

The genesis of Madeline was well forecast. The system from which it developed was introduced in the 5-day Tropical Weather Outlook 120 h before genesis occurred, and was given a high chance (>60%) of development 96 h in advance. A high chance of genesis was shown in the 48-h outlook 18 h before the tropical cyclone formed.

A verification of NHC official track forecasts for Madeline is given in Table 3a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period from 24 to 96 h, but they were slightly higher than the mean at the other forecast times. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. For the small number of NHC forecasts issued for Madeline, the top-performing track models were EMXI and HWFI, which had lower errors than the official forecasts at all time periods.

A verification of NHC official intensity forecasts for Madeline is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period at 36 h, 96 h, and 120 h, but higher than the mean at the other forecast times. At 72 h the official forecast intensity errors were more than double the average errors due to the failure of predicting the rapid intensification of Madeline on 29 and 30 August. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. HWFI was one of the better-performing models for intensity, which showed Madeline strengthening more than the other guidance and the official forecast.



Table 1. Best track for Hurricane Madeline, 26 August – 2 September 2016. A post-storm analysis has not yet been completed for the portion of the track west of 140°W longitude, and all data for this portion of the storm’s history reflect near-real-time estimates from the Central Pacific Hurricane Center.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
26 / 1800	13.3	136.4	1007	30	tropical depression
27 / 0000	13.9	137.0	1006	35	tropical storm
27 / 0600	14.5	137.6	1002	45	"
27 / 1200	15.1	138.3	1002	45	"
27 / 1800	15.5	139.0	1000	50	"
28 / 0000	15.7	139.7	1000	50	"
28 / 0600	15.9	140.3	998	45	"
28 / 1200	16.2	140.9	1000	45	"
28 / 1800	16.6	141.7	997	55	"
29 / 0000	17.2	142.7	997	55	"
29 / 0600	17.6	143.3	984	75	hurricane
29 / 1200	18.0	144.3	975	85	"
29 / 1800	18.4	145.1	966	100	"
30 / 0000	18.7	145.9	955	110	"
30 / 0600	19.0	146.7	950	115	"
30 / 1200	19.3	147.8	958	105	"
30 / 1800	19.3	148.9	967	100	"
31 / 0000	19.3	149.9	972	95	"
31 / 0600	19.3	151.0	980	80	"
31 / 1200	19.0	152.5	988	70	"
31 / 1800	18.6	153.6	991	65	"
01 / 0000	18.1	154.6	998	55	tropical storm
01 / 0600	17.5	155.6	1003	45	"



01 / 1200	16.9	156.3	1003	45	"
01 / 1800	16.6	157.2	1004	40	"
02 / 0000	16.5	158.4	1006	35	"
02 / 0600	16.5	160.0	1008	30	tropical depression
02 / 1200	16.5	161.5	1009	30	"
02 / 1800	16.5	163.1	1010	25	"
03 / 0000	16.4	165.3	1010	25	disturbance
03 / 0600	16.1	166.9	1010	25	"
03 / 1200	15.9	168.5	1010	25	"
03 / 1800	15.7	169.8	1010	25	"
04 / 0000					dissipated
30 / 0600	19.0	146.7	950	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%)	114	120
Medium (40%-60%)	54	102
High (>60%)	18	96



Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Madeline. 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	25.0	<b>24.6</b>	<b>26.3</b>	<b>34.9</b>	<b>51.5</b>	<b>87.2</b>	164.4
OCD5	43.2	58.5	71.1	82.2	113.5	157.4	219.7
Forecasts	6	6	6	6	6	6	6
OFCL (2011-15)	23.4	36.4	47.2	59.4	89.0	123.6	159.5
OCD5 (2011-15)	36.6	74.2	116.5	159.7	245.6	331.1	427.4



Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Madeline. 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.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	24.9	27.4	35.2	44.3	60.4	110.8	196.9
OCD5	33.4	41.3	45.3	51.2	84.6	158.5	292.1
GFSI	28.6	36.9	50.2	60.1	78.8	113.9	<b>158.3</b>
GHMI	29.7	46.9	72.6	97.5	160.3	242.5	325.4
HWFI	<b>24.2</b>	<b>24.0</b>	<b>29.2</b>	<b>36.5</b>	<b>44.5</b>	<b>80.7</b>	<b>108.3</b>
EGRI	25.6	<b>25.2</b>	<b>31.6</b>	44.3	90.7	155.5	288.8
EMXI	<b>16.4</b>	<b>19.9</b>	<b>31.8</b>	<b>35.9</b>	<b>38.5</b>	<b>55.2</b>	<b>126.5</b>
CMCI	26.7	53.4	67.0	68.4	96.2	131.7	221.7
NVGI	25.4	32.9	36.0	<b>41.4</b>	88.1	180.1	317.8
CTCI	27.8	<b>26.8</b>	<b>28.1</b>	<b>37.0</b>	85.2	160.6	250.7
GFNI	<b>24.8</b>	<b>25.4</b>	37.9	57.6	130.0	256.9	420.0
AEMI	29.4	38.7	54.7	72.9	78.3	<b>102.5</b>	<b>180.4</b>
FSSE	26.2	29.8	39.0	49.9	70.6	118.2	218.5
TVCX	<b>23.4</b>	<b>25.8</b>	<b>31.2</b>	44.5	70.3	<b>101.9</b>	<b>161.6</b>
TVCN	<b>23.4</b>	<b>26.2</b>	35.6	48.2	76.4	113.1	<b>172.3</b>
GFEX	<b>21.6</b>	27.7	35.9	46.3	<b>54.1</b>	<b>70.2</b>	<b>111.5</b>
LBAR	36.1	69.1	129.2	206.6	443.3	745.4	1012.8
BAMS	35.7	60.0	73.0	81.4	108.8	143.4	274.2
BAMM	34.7	58.9	80.0	97.7	119.9	183.7	267.9
BAMD	31.7	51.5	76.5	108.6	175.1	337.0	526.8
Forecasts	4	4	4	4	4	4	4



Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Madeline. 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	6.7	10.0	<b>11.7</b>	16.7	36.7	<b>15.8</b>	<b>8.3</b>
OCD5	7.3	8.7	9.8	25.8	49.3	29.3	6.7
Forecasts	6	6	6	6	6	6	6
OFCL (2011-15)	5.9	9.8	12.5	14.0	15.5	16.3	14.9
OCD5 (2011-15)	7.7	12.8	16.4	18.8	21.1	20.9	19.7



Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Madeline. 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	6.3	12.5	12.5	21.3	36.3	7.5	10.0
OCD5	7.3	<b>8.5</b>	13.0	34.3	48.5	20.8	<b>4.3</b>
GHMI	7.0	<b>7.8</b>	12.5	27.8	36.8	<b>7.3</b>	11.5
HWFI	<b>5.3</b>	<b>7.0</b>	<b>10.8</b>	<b>12.5</b>	<b>27.0</b>	15.3	12.5
GFNI	8.0	<b>6.0</b>	<b>10.3</b>	37.0	47.5	18.3	17.3
CTCI	11.0	14.0	<b>8.8</b>	<b>15.3</b>	<b>22.5</b>	8.5	12.8
FSSE	10.0	17.5	16.0	<b>14.8</b>	<b>29.0</b>	8.3	<b>5.8</b>
DSHP	8.3	13.5	14.5	24.8	40.8	13.5	<b>5.5</b>
LGEM	9.8	13.8	17.3	28.8	46.5	23.8	<b>9.0</b>
IVCN	7.8	<b>11.3</b>	<b>12.3</b>	<b>19.8</b>	<b>34.3</b>	11.8	<b>5.8</b>
GFSI	9.0	13.8	<b>10.0</b>	28.0	44.0	15.0	<b>5.3</b>
EMXI	6.8	<b>2.3</b>	17.3	41.3	51.8	16.8	10.0
Forecasts	4	4	4	4	4	4	4

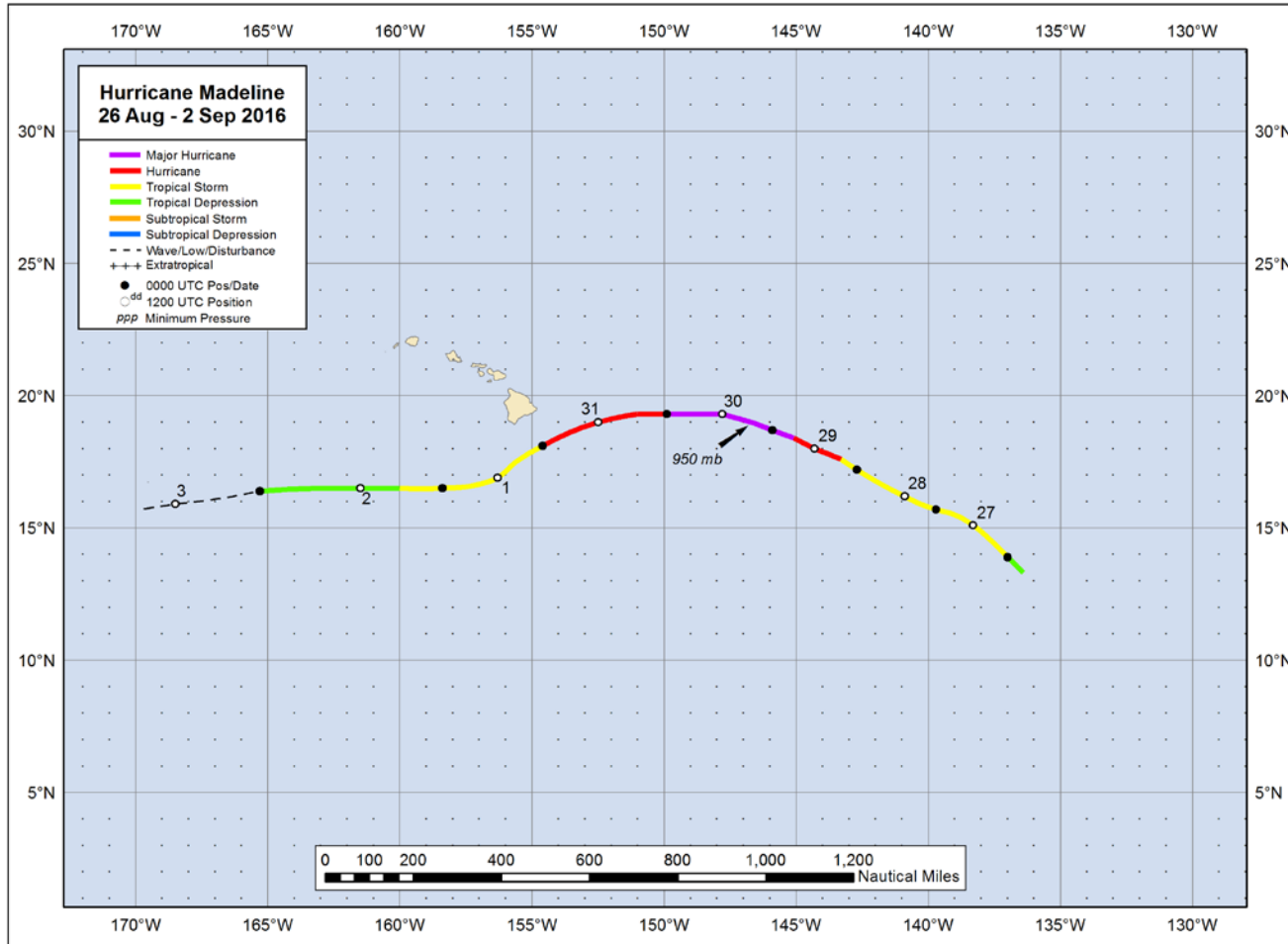


Figure 1. Best track positions for Hurricane Madeline, 26 August - 2 September 2016. A post-storm analysis has not yet been completed for the portion of the track west of 140°W longitude, and all data for this portion of the storm's history reflect near-real-time estimates from the Central Pacific Hurricane Center.



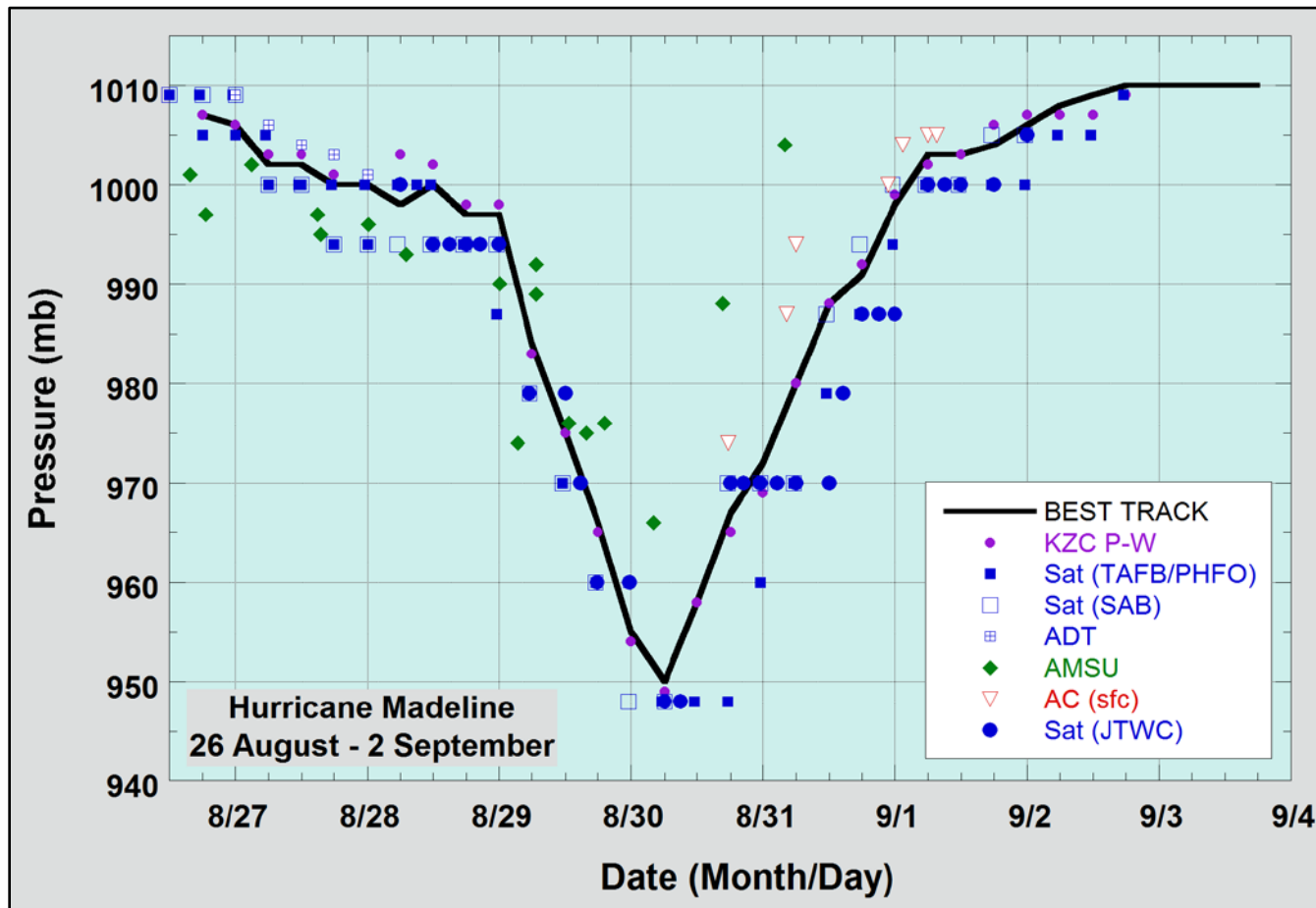


Figure 3 Selected pressure observations and best track minimum central pressure curve for Hurricane Madeline, 26 August-2 September 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for 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. A post-storm analysis has not yet been completed for the portion of the track west of 140°W longitude, and all data for this portion of the storm's history reflect near-real-time estimates from the Central Pacific Hurricane Center.