NATIONAL HURRICANE CENTER
CENTRAL PACIFIC HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE MADELINE

(EP142016)

26 August–2 September 2016

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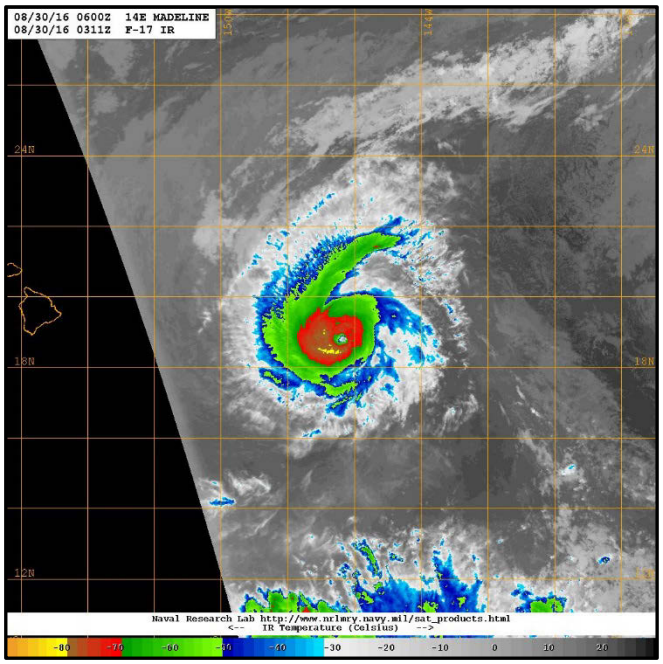

OPERATIONAL LINESCAN SYSTEM (OLS) INFRARED IMAGE OF MADELINE AT 0311 UTC 30 AUGUST 2016. IMAGE COURTESY OF THE NAVAL RESEARCH LABORATORY.

Madeline was a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) which moved into the central Pacific after forming in the northeastern Pacific.

[1] Original report released 5 December 2016. Updated 4 March 2019 to include best track analysis, summary, verification, impacts and damages from CPHC.

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[2].

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 marginally warm waters, Madeline continued to slowly strengthen and moved into the central Pacific basin as a 50-kt tropical storm shortly after 0000 UTC 28 August while being steered northwestward by an upper-level trough northwest of the main Hawaiian Islands and a deep-layer subtropical ridge to the northeast of the system. Vertical wind shear was relatively low, and the tropical cyclone was moving across water temperatures of 27-28° C. About 12 h after crossing into the central Pacific, satellite imagery indicated an improvement in Madeline's organization, with deep convection developing and persisting near the system's core. By 0600 UTC 29 August, Madeline became a hurricane as an eye developed within the central dense overcast. Madeline rapidly intensified to a major hurricane during the next 24 h, and by 0600 UTC 30 August maximum sustained winds were estimated to be near 115 kt, making Madeline a category 4 hurricane on the Saffir-Simpson Hurricane Wind Scale.

Hurricane Hunters from the 53rd Weather Reconnaissance Squadron (53WRS) of the U.S. Air Force Reserve Command conducted the first of four missions into Madeline around 1730 UTC 30 August. These observations indicated that Madeline was weakening, with maximum sustained winds near 100 kt. This weakening trend was likely the result of increasing vertical wind shear from the west-southwest. By 1200 UTC 31 August, the tropical cyclone had weakened to a 70-kt hurricane as it began moving southwestward. Madeline was downgraded to a tropical storm 6 h later when it was centered about 105 n mi southeast of Hilo, Hawaii.

The tropical storm continued to weaken, and began to turn toward the west-southwest by 1200 UTC 1 September after passing about 140 n mi south-southwest of South Point on the Big Island of Hawaii. Then around 0000 UTC 2 September, Madeline's low-level circulation center

[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.

became exposed due to increasing southwesterly vertical wind shear and dry mid-tropospheric air, with maximum sustained winds estimated to be near 35 kt. Madeline was downgraded to a tropical depression 6 h later, and it became a post-tropical low by 1800 UTC 2 September. This remnant low quickly dissipated about 465 n mi southwest of Lihue, Hawaii around 0000 UTC 3 September.

METEOROLOGICAL STATISTICS

Observations in Madeline 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 (CPHC), and the Joint Typhoon Warning Center (JTWC). They also include objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison (CIMSS). Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), 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. Observations also include flight-level, Stepped Frequency Microwave Radiometer (SFMR), and dropwindsonde observations obtained by the 53WRS Hurricane Hunters.

Surface observations during Madeline's passage near the Hawaiian Islands are shown in Table 2.

Madeline's estimated peak intensity of 115 kt in the central Pacific around 0600 UTC 30 August is based on subjective Dvorak satellite intensity estimates of T6.0/115 kt from PHFO, JTWC and SAB. The minimum pressure of 950 mb at the same time as the peak sustained wind speed is based on the Knaff-Zehr-Courtney (KZC) pressure-wind relationship for an intensity of 115 kt.

The 53WRS Hurricane Hunters conducted four reconnaissance missions into Madeline. Three of these missions were at the 700-mb level when the tropical cyclone was located to the east and southeast of the Big Island from 30 August to 1 September. A final mission was conducted at the 850-mb level on 1 September after Madeline had weakened south of the Big Island. These missions resulted in 9 center fixes. Maximum flight-level winds of 100 kt were observed in the initial mission, at 1915 UTC 30 August, while the strongest SFMR-derived surface wind of 115 kt also occurred on this mission.

The lowest surface pressure measured in the eye of Madeline by a dropwindsonde was 974 mb at 1735 UTC 30 August. However, the dropwindsonde also reported a surface wind speed of 14 kt, so the minimum central pressure at that time was estimated to be 973 mb.

CASUALTY AND DAMAGE STATISTICS

There were no reports of casualties associated with Madeline. Swells from Madeline generated surf of up to 25 feet along the east-facing shores of the Big Island of Hawaii, Maui, Molokai, Oahu, and Kauai, with the highest surf over the eastern end of the island chain. The tropical cyclone also produced gusty winds and heavy showers over parts of the Big Island, which resulted in localized power outages and minor flooding. However, no significant property damage or injuries were reported in Hawaii.

FORECAST AND WARNING CRITIQUE

The genesis of Madeline was well forecast (Table 3). 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 4a. 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 4b. 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 5a. 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 5b. HWFI was one of the better-performing models for intensity, which showed Madeline strengthening more than the other guidance and the official forecast.

A verification of CPHC official track forecasts for Madeline is given in Table 6a. Official track forecast errors were lower than the mean official errors for the most recent 5-yr period (note that the 2015 statistics are unavailable at the time of this report, so the 2010-14 means are shown) for all forecast times. This is indicative of the rather well behaved motion that Madeline exhibited as it tracked through the central Pacific. A homogeneous comparison of the official track errors with selected guidance models is given in Table 6b. The official track forecast errors were generally similar to, or in some cases worse, than the model guidance errors. The GFS ensemble mean had lower errors for all forecast periods, while the GFEX had lower errors for all forecast periods, expect at 36 h. The variable consensus models, TVCE and TCON, had lower track errors during the 12 to 36 h and 120 h forecast periods, compared with the TVCX which had lower errors during the 12 to 24 h and 72 to 120 h forecast periods. The FSSE track errors were lower during the 12 to 48 h forecast periods, and the HWRF had lower errors during the 12 to 36 h and 96 h

forecast periods. The GFS had lower errors during the 36 and 48 h forecast periods, while the ECMWF had lower errors during the 72 to 120 h forecast periods.

A verification of CPHC official intensity forecasts for Madeline is shown in Table 7a. Official intensity forecast errors were larger than the mean official errors for the most recent 5-yr period (again, the 2010–14 time period). This likely reflects the difficulty in forecasting the unexpected intensification and weakening phases that occurred as Madeline moved across the central Pacific. A homogeneous comparison of the official intensity errors with selected models is provided in Table 7b. The DSHP, LGEM, FSSE, as well as the variable consensus models, ICON and IVCN, had lower intensity errors for all forecast time periods compared with the official intensity forecasts. The HWRF had lower intensity errors for the 12 to 36 h, and 96 to 120 h forecast periods, and the GHMI had lower errors for the 48 and 72 h forecast periods, while the GFS had lower errors during the 24 h forecast period.

A Hurricane Watch was issued by CPHC for the Big Island of Hawaii at 2100 UTC 29 August (Table 8) when Madeline's center was about 555 n mi (640 mi) east of Hilo. This was followed by the issuance of a Tropical Storm Warning for the Big Island of Hawaii at 1500 UTC 30 August. At the same time, a Tropical Storm Watch was issued for Maui County, which includes Maui, Molokai, Lanai, and Kahoolawe. A Hurricane Warning was issued 6 h later for the Big Island of Hawaii as Madeline, which was a category 3 / 100 kt hurricane was located about 330 n mi (380 mi) east of Hilo, Hawaii. A Tropical Storm Warning was issued for Maui, Molokai, Lanai, and Kahoolawe at 1500 UTC 31 August. As it became clear Madeline was weakening and the center was passing more than 75 n mi (85 mi) southeast of the eastern end of the Hawaiian Island chain, the Hurricane Warning for the Big Island of Hawaii was replaced by a Tropical Storm Warning at 2100 UTC 31 August. The Tropical Storm Warning was discontinued for all Hawaiian Islands in an intermediate advisory issued at 1200 UTC 1 September as Madeline continued to weaken and move west-southwest away from the archipelago.

Table 1. Best track for Hurricane Madeline, 26 August–2 September 2016.

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	1000	50	tropical storm
28 / 1200	16.2	140.9	1000	50	“
28 / 1800	16.6	141.7	997	55	“
29 / 0000	17.2	142.6	994	60	“
29 / 0600	17.6	143.3	982	75	hurricane
29 / 1200	18.0	144.3	975	85	“
29 / 1800	18.4	145.1	962	100	“
30 / 0000	18.7	145.9	955	110	"
30 / 0600	18.9	146.7	950	115	“
30 / 1200	19.2	147.7	962	105	"
30 / 1800	19.2	148.8	972	100	"
31 / 0000	19.2	149.9	978	90	"
31 / 0600	19.2	151.1	985	80	"
31 / 1200	19.0	152.3	990	70	“
31 / 1800	18.6	153.6	994	60	tropical storm
01 / 0000	18.1	154.6	998	55	“
01 / 0600	17.4	155.5	1003	45	“
01 / 1200	16.7	156.3	1003	45	“
01 / 1800	16.5	157.2	1005	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	1008	30	"
02 / 1800	16.5	163.1	1009	25	low

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
03 / 0000					dissipated
30 / 0600	19.0	146.7	950	115	maximum wind and minimum pressure

Table 2. Selected surface observations in the Hawaiian Islands, 31 August–2 September 2016.

Location (State of Hawaii)	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)	Gust (kt)	
International Civil Aviation Organization (ICAO) Sites						
Bradshaw Army Airfield (PHJH)	01/0256	1009.5	01/0015	16	34	
Hilo Intl. Aprt. (PHTO)	01/0253	1012.2	31/2351	17	26	4.94
Kahului Aprt. (PHOG)	01/0320	1012.9	01/0154	19	31	
Kapalua Aprt. (PHJH)			31.1945	19	25	
Keahole Aprt. Kona (PHKO)	01/0145	1008.8	31/2053	15		
Lanai City Aprt. (PHNY)	01.0356	1010.8	01/0456	23	30	
Molokai Aprt. (PHMK)	01/0154	1012.9	31/2254	19	33	
Non-METAR Observations						
Kaneloa (KAOH1)			01/0053	28	45	
Kaupo (KPGH1)			01/2235	25	52	
Kealakomo (KMOH1)			31/2044	28	40	
Kealia Pond NWR (KPDH1)			02/0120	14	29	
Kohala Ranch (KHRH1)			31/2335	28	48	
Lanai 1 (LNIH1)			02/0437	22	35	
Makapulapai (MKPH1)			01/1615	25	36	
Waikoloa (WKVH1)			31/2335	27	46	
National Data Buoy Center (NDBC)						
Buoy 51004	31/1350	1008.6	01/0250	21	27	
Buoy 51003	02/0150	1011.3	01/1850	23	27	
Other						
Glenwood (GLNH1) 19.51°N 155.29°W						9.11
Hakalau (HKUH1) 19.82°N 155.30°W						4.94
Kamuela2 (KMUH1) 20.04°N 155.61°W						1.64

Kamuela Upper (KUUH1) 20.01°N 155.63°W						2.56
Kapapala Ranch (KAYH1) 19.28°N 155.45°W						3.41
Kapapala RAWS (KPRH1) 19.26°N 155.44°W						3.50
Kawainui Stream (KWSH1) 20.10°N 155.70°W						7.78
Kulani NWR (KNWH1) 19.55°N 155.31°W						8.76
Laupahoehoe (LPHH1) 19.98°N 155.23°W						1.82
Pahala (PPLH1) 19.20°N 155.00°W						2.44
Pahoa Beacon (PHAH1) 19.52°N 154.96°W						3.79
Pali2 (PLIH1) 19.33°N 155.29°W						2.95
Papaikou Well (PPWH1) 19.71°N 155.13°W						5.84
Piihonua Kpua (PIIH1) 19.71°N 155.14°W						7.04
Puu Kukui (PKKH1) 20.89°N 156.59°W						4.66
Puu Mali (PMLH1) 19.93°N 155.44°W						1.36
Saddle Road Qry (SDQH1) 19.70°N 155.30°W						10.88
South Point (SOPH1) 18.99°N 155.67°W						1.00
Waiakea Uka (TNLH1) 19.66°N 155.13°W						8.07
Waiakea Exp Sta (WEXH1) 19.65°N 155.08°W						7.27
West Wailuaiki (WWKH1) 20.82°N 156.14°W						3.41

[a] Date/time is for sustained wind when both sustained and gust are listed.

Table 3. 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 4a. 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	**23.8**	**25.5**	**34.2**	**54.2**	**86.9**	168.2
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 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Madeline for forecasts made in the eastern North Pacific basin. 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	24.9	26.3	34.1	44.3	64.5	111.4	202.6
OCD5	33.4	41.3	44.0	51.2	82.1	153.9	297.1
GFSI	28.6	35.6	49.6	60.1	80.8	113.9	**162.6**
GHMI	29.7	45.9	71.6	97.5	163.7	242.6	330.4
HWFI	**24.2**	**23.1**	**27.9**	**36.5**	**44.1**	**80.1**	**109.9**
EGRI	25.6	**23.8**	**30.9**	44.3	96.5	156.5	294.9
EMXI	**16.4**	**18.5**	**30.4**	**35.9**	**40.5**	**56.0**	**131.9**
CMCI	26.7	52.0	65.6	68.4	99.5	132.7	227.7
NVGI	25.4	33.4	37.3	**41.4**	92.1	180.8	324.2
CTCI	27.8	**25.7**	**26.9**	**37.0**	88.5	161.0	255.4
GFNI	**24.8**	**24.2**	36.5	57.6	133.1	257.6	426.2
AEMI	29.8	38.1	54.2	72.9	82.8	**103.7**	**186.2**
FSSE	26.2	28.8	38.0	49.9	74.0	118.5	223.8
TVCX	**23.4**	**24.6**	**30.1**	44.5	73.7	**102.4**	**167.6**
TVCN	**23.4**	**25.1**	34.5	48.2	80.1	113.6	**177.9**
GFEX	**21.6**	26.3	34.7	46.3	**56.3**	**70.6**	**117.0**
LBAR	36.1	68.3	128.5	206.6	447.2	745.9	1017.1
BAMS	35.7	59.8	73.5	81.4	114.7	145.9	279.5
BAMM	34.7	58.2	80.3	97.7	125.2	185.3	272.9
BAMD	31.7	50.6	76.6	108.6	177.2	337.6	530.8
Forecasts	4	4	4	4	4	4	4

Table 5a. 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	**5.0**	**7.5**	**9.2**	15.8	35.8	**14.2**	**7.5**
OCD5	5.7	7.8	11.7	26.7	48.5	27.7	5.5
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 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Madeline for forecasts made in the eastern North Pacific basin. 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	3.8	8.8	11.2	21.3	35.0	6.2	10.0
OCD5	4.8	**7.2**	14.2	34.2	47.2	19.5	**4.2**
GHMI	4.5	**5.0**	11.2	27.8	35.5	**6.0**	11.5
HWFI	4.2	**7.2**	**9.5**	**12.5**	**25.8**	14.0	12.5
GFNI	5.5	**4.8**	11.5	37.0	46.2	19.5	17.2
CTCI	8.5	10.2	**7.5**	**15.2**	**21.5**	7.2	12.8
FSSE	7.5	13.8	14.8	**14.8**	**27.8**	7.0	**5.8**
DSHP	5.8	9.8	13.2	24.8	39.5	12.2	**5.5**
LGEM	7.2	11.0	16.0	28.8	45.2	22.5	**9.0**
IVCN	5.2	**8.5**	**11.0**	**19.8**	**33.0**	10.5	**5.8**
GFSI	6.5	10.0	**8.8**	28.0	42.8	13.8	**5.2**
EMXI	4.2	**4.5**	18.5	41.2	50.5	15.5	10.0
Forecasts	4	4	4	4	4	4	4

Table 6a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Madeline. Mean errors for the previous available 5-yr period are shown for comparison. Official track forecast errors that are smaller than the 5-yr mean intensity errors are shown in bold face type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**24.6**	**39.7**	**55.8**	**66.5**	**93.1**	**111.1**	**151.1**
OCD5	40.1	77.3	121.6	182.1	314.8	382.0	443.1
Forecasts	20	18	16	14	10	6	2
OFCL (2010-14)	27.9	44.1	56.7	73.9	132.3	183.7	258.9

Table 6b. Homogeneous comparison of select track forecast guidance model errors (n mi) for Hurricane Madeline for forecasts made in the central North Pacific basin. Errors smaller than the CPHC official track forecast errors (OFCL) are shown in boldface type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	24.6	39.7	55.8	66.5	93.1	111.1	151.1
OCD5	40.1	77.3	121.6	182.1	314.8	382.0	443.1
GFSI	27.6	41.8	**53.3**	**66.4**	96.3	113.1	169.8
GHMI	37.8	65.8	105.5	141.0	197.8	249.8	229.6
HWFI	**21.1**	**34.1**	**53.1**	67.4	103.8	**88.3**	**53.9**
EGRI	26.7	44.0	58.9	78.5	143.4	163.4	224.5
EMXI	25.5	48.8	76.1	87.2	**77.6**	**74.1**	**103.6**
CMCI	40.6	74.7	98.7	119.5	182.2	**88.8**	**108.0**
AEMI	**22.5**	**37.0**	**43.4**	**45.1**	**52.3**	**87.3**	**112.8**
FSSE	**22.1**	**38.8**	**52.8**	**66.0**	95.0	125.9	177.8
TVCX	**21.7**	**37.5**	57.2	70.3	**92.5**	**104.0**	**104.3**
TCON	**24.3**	**38.3**	**55.5**	75.2	119.9	123.8	**150.5**
GFEX	**21.8**	**38.3**	56.6	**62.8**	**65.4**	**83.0**	**135.9**
TVCE	**21.9**	**38.4**	**55.6**	71.6	101.6	112.6	**108.2**
BAMD	35.4	63.7	95.6	140.7	218.5	290.2	445.3
BAMM	36.0	58.5	66.5	**63.3**	**71.6**	122.7	**103.6**
BAMS	39.5	75.6	111.4	120.4	120.3	146.7	**106.5**
Forecasts	20	18	16	14	10	6	2

Table 7a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Madeline. Mean errors for the previous available 5-yr period are shown for comparison. Official intensity forecast errors that are smaller than the 5-yr mean intensity errors are shown in boldface type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	9.5	18.6	24.7	27.5	24.0	**15.0**	**7.5**
OCD5	9.3	17.8	25.6	29.7	12.2	3.5	15.5
Forecasts	20	18	16	14	10	6	2
OFCL (2010-14)	4.8	8.6	11.6	13.8	18.5	19.3	20.4

Table 7b. Homogeneous comparison of select intensity forecast guidance model errors (kt) for Hurricane Madeline for forecasts made in the central North Pacific basin. Errors smaller than the CPHC official forecast errors (OFCL) are shown in boldface type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	9.5	18.6	24.7	27.5	24.0	15.0	7.5
OCD5	**9.3**	**17.3**	25.6	29.7	**12.2**	**3.5**	15.5
GFSI	9.6	**18.2**	25.9	32.0	32.2	19.5	10.0
GHMI	10.6	21.1	26.5	**25.6**	**22.7**	17.5	15.0
HWFI	**9.1**	**15.7**	**23.4**	32.6	29.7	**10.2**	**4.5**
EMXI	11.8	22.6	33.0	38.2	38.0	37.2	22.5
DSHP	**7.3**	**13.7**	**18.8**	**21.6**	**15.8**	**10.0**	**7.0**
LGEM	**7.2**	**13.8**	**21.1**	**23.8**	**19.8**	**13.8**	**0.5**
ICON	**8.2**	**15.7**	**22.2**	**25.9**	**21.7**	**12.0**	**6.5**
IVCN	**8.3**	**15.8**	**22.3**	**26.1**	**22.3**	**12.0**	**5.5**
FSSE	**8.1**	**14.4**	**20.3**	**23.5**	**20.1**	**12.7**	**3.0**
Forecasts	20	18	16	14	10	6	2

Table 8. Wind watch and warning summary for Hurricane Madeline.

Date/Time (UTC)	Action	Location
29 / 2100	Hurricane Watch issued	Big Island of Hawaii
30 / 1500	Tropical Storm Warning issued	Big Island of Hawaii
30/1500	Tropical Storm Watch issued	Maui, Molokai, Lanai, and Kahoolawe
30/2100	Hurricane Warning issued	Big Island of Hawaii
31/1500	Tropical Storm Warning issued	Maui, Molokai, Lanai, and Kahoolawe
31 / 2100	Hurricane Warning discontinued; Tropical Storm Warning issued	Big Island of Hawaii
01 / 1200	Tropical Storm Warning discontinued	Big Island of Hawaii, Maui, Molokai, Lanai, and Kahoolawe

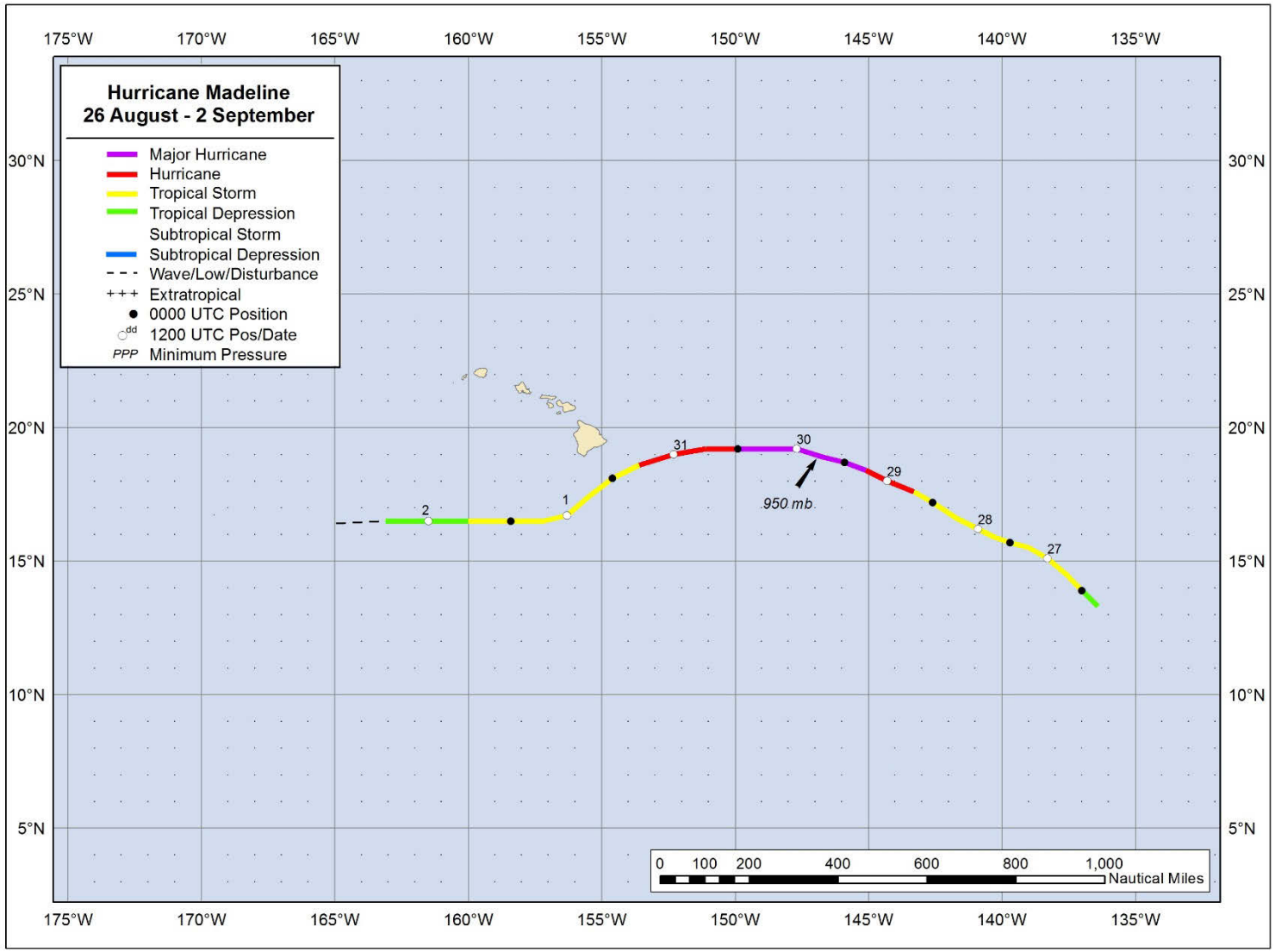

Figure 1. Best track positions for Hurricane Madeline, 26 August–2 September 2016.

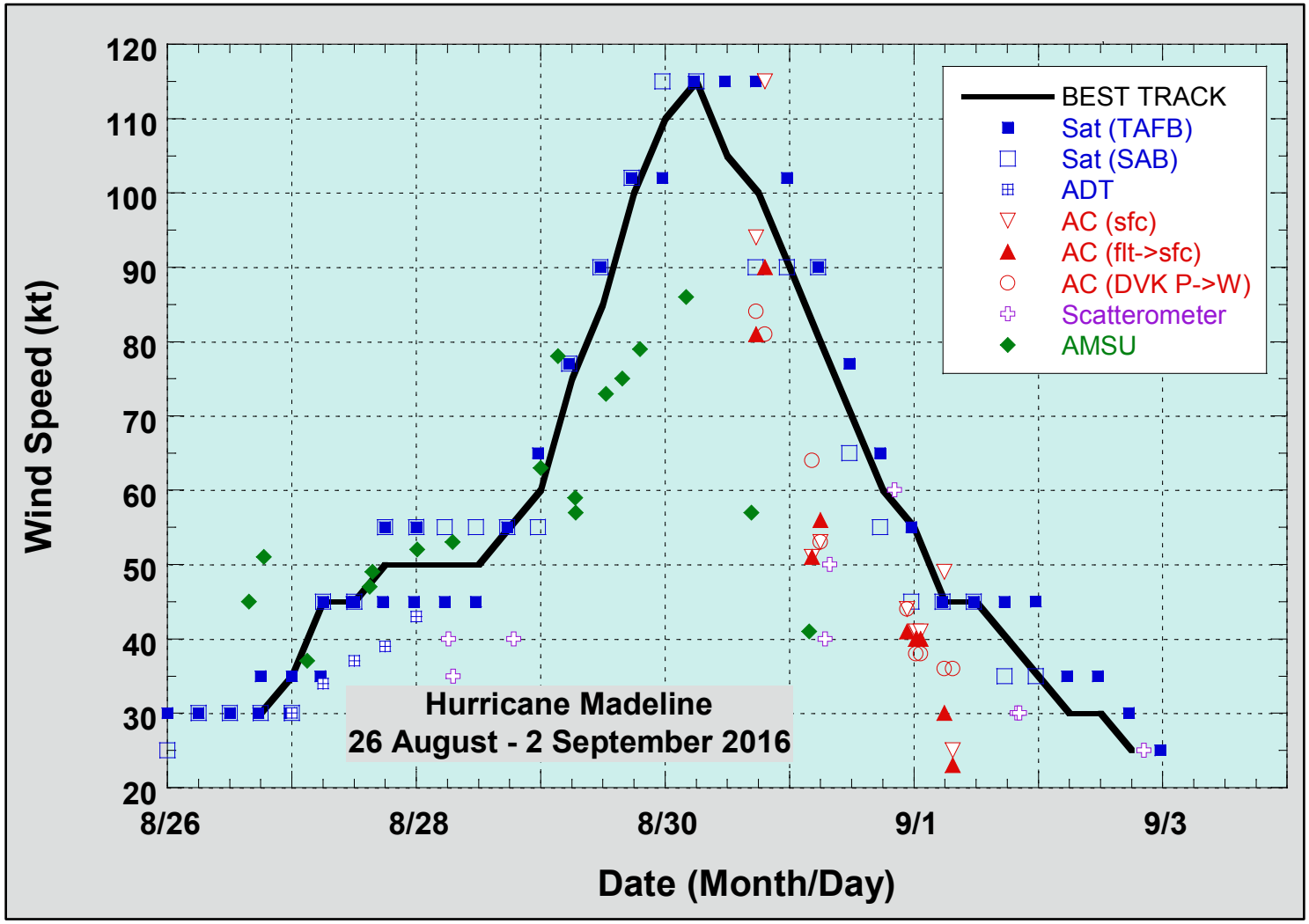

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Madeline, 26 August–2 September 2016. Aircraft observations have been adjusted for elevation using a 90% adjustment factor for observations from 700 mb. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM). 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.

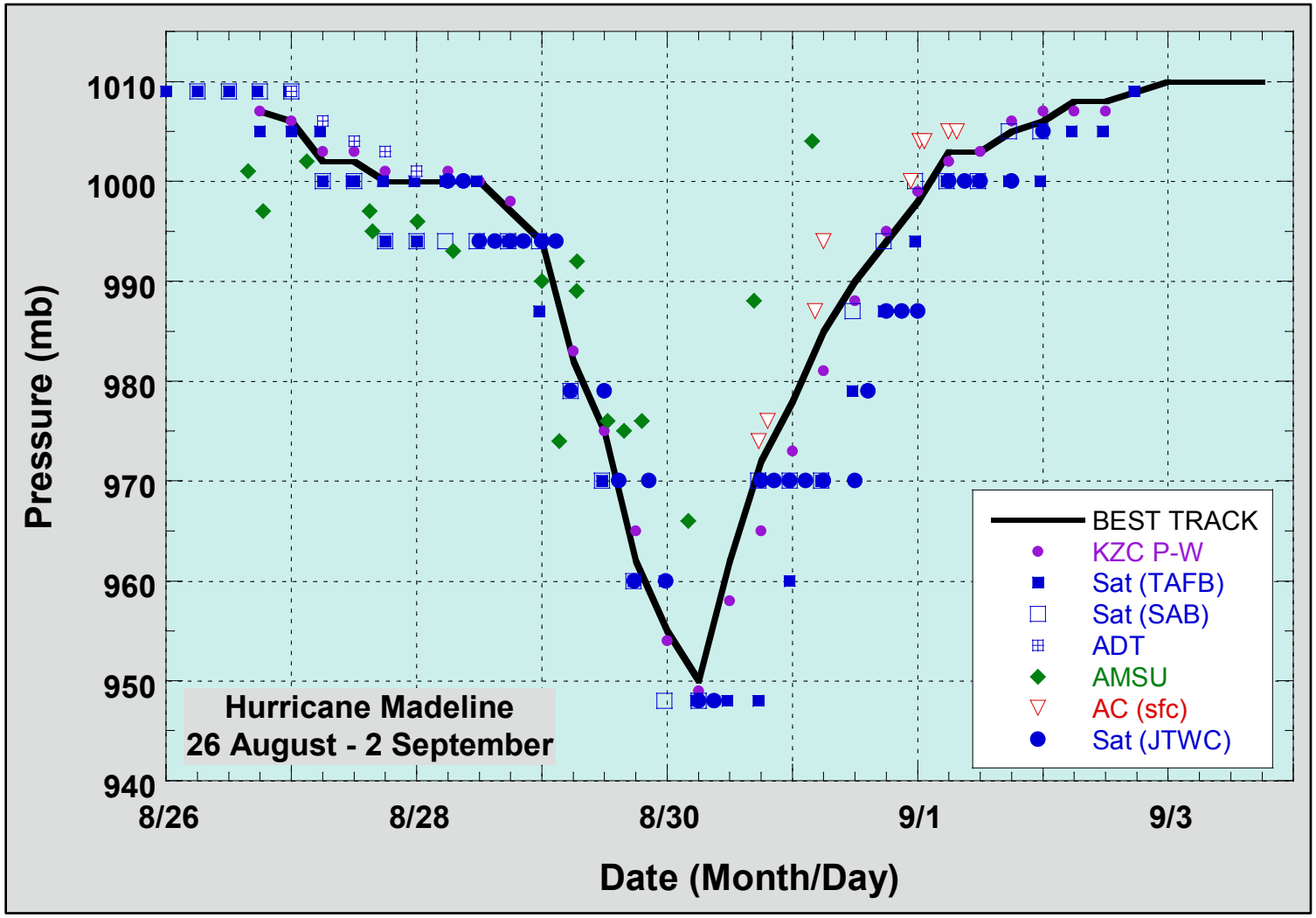

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Madeline, 26 August–2 September 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for 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.