

Tropical Cyclone Report  
Hurricane Hilary  
(EP092011)  
21-30 September 2011

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Hilary twice reached category 4 status (on the Saffir-Simpson Hurricane Wind Scale) off the west coast of Mexico. Although the cyclone passed close to Acapulco, its effects on land were minimal.

a. Synoptic History

Hilary developed from a tropical wave that emerged over the eastern North Atlantic Ocean on 7 September. The well-defined wave moved westward with very limited convection for the next three days. On 10 September, the system briefly exhibited some deep convection, however, no significant development occurred at that time. During 11-16 September, the convection-free wave continued moving westward across the Caribbean. On 17 September, the tropical wave reached the eastern North Pacific and began developing within a pre-existing monsoon trough. A broad low formed on the next day, and deep convection gradually increased allowing Dvorak satellite classifications to commence on 20 September. A tropical depression developed around 0600 UTC 21 September, about 310 n mi southeast of Acapulco, Mexico. 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>1</sup>.

The cyclone initially moved slowly northwestward and then somewhat faster toward the west-northwest over the next couple of days, as its convective structure quickly became organized in an environment of very warm (29-30°C) sea surface temperatures, very low (5-10 kt) tropospheric vertical wind shear, and a moist (~70% relative humidity) mid-troposphere. The system reached tropical storm intensity 6 h after genesis. During the subsequent 54 h, Hilary underwent a prolonged period of rapid intensification, culminating in the cyclone reaching its lifetime peak of 125 kt (category 4 on the Saffir-Simpson Hurricane Wind Scale). Figure 4 is a visible image of Hilary around the time of its peak intensity, while located about 160 n mi west-southwest of Acapulco. At that time, Hilary was a very small cyclone with a maximum extent of tropical-storm-force winds only about 75 n mi from the center.

From 23-27 September, Hilary moved generally westward at 8-10 kt, primarily due to the influence of a zonally oriented deep-layer subtropical ridge to its north. Superimposed upon this general movement was a distinct trochoidal wobble with a period of about 30 h during 22-25 September. After reaching its peak intensity late on 23 September and early on 24 September, Hilary underwent an eyewall replacement cycle, which caused some weakening of the cyclone to

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<sup>1</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.

a category 3 hurricane through early on 26 September. The environment remained conducive for intensification, however, and after the eyewall cycle was complete a secondary maximum in intensity of 115 kt occurred late that day.

By late on 27 September, Hilary began encountering only marginally warm (~27°C) waters and a dry mid-troposphere, and these factors led to a steady weakening of the cyclone. Beginning on 28 September, the hurricane began traversing sub-26°C waters while simultaneously encountering substantially stronger tropospheric vertical shear. Hilary weakened to a tropical storm around 0600 UTC 29 September about 580 nm west-southwest of the southern tip of Baja California, Mexico. Under continued hostile environmental conditions, the cyclone further decayed to a tropical depression around 0600 UTC 30 September, about 620 nm west of the southern tip of Baja California, and finally degenerated to a remnant low about 6 h later. From 28-30 September, Hilary turned toward the northwest as a mid to upper-level low eroded the subtropical ridge north of the cyclone. The remnant low of Hilary meandered generally toward the southwest over the next three days before dissipating about 910 nm west of the southern tip of Baja California after 1200 UTC 3 October.

#### b. Meteorological Statistics

Observations in Hilary (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 (CIMSS)/University of Wisconsin-Madison. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from two flights of the National Oceanic and Atmospheric Agency (NOAA) Aircraft Operations Center WP-3D aircraft. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM) and Aqua, 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 Hilary. Radar reflectivity imagery from Puerto Angel, Mexico, was helpful in determining the position and structure of Hilary on 22 and 23 September, when the cyclone's center was close to the coast of Mexico.

Hilary's estimated peak intensity of 125 kt on 1800 UTC 23 September and 0000 UTC 24 September was based upon a blend of the SAB Dvorak fixes and the ADT. The secondary analyzed maximum of 115 kt at 1800 UTC 26 September and 0000 UTC 27 September was based upon a blend of the SAB/TAFB Dvorak fixes, the ADT, and the CIMSS AMSU intensity estimates.

The NOAA Hurricane Hunter aircraft conducted two research missions into Hilary, late on 28 and 29 September, while the cyclone was weakening. The data obtained were quite valuable in determining best track information for a system that would typically have little or no in-situ observations.

Only one ship (call sign A8EH5, the *Maersk Dallas*) reported tropical-storm-force winds during Hilary's lifetime. The strongest winds reported by the ship were 41 kt at 03 UTC 22 September at 15.1N, 97.0W.

There were no reports of 1-min mean tropical-storm-force winds from any coastal or island stations in Mexico in association with Hilary. However, it is likely that some 1-min mean tropical-storm-force winds did occur along the sparsely monitored coast of Mexico near Acapulco, while Hilary was close to the coast. Peak gusts of 44 kt and 41 kt were observed at 1645 UTC 26 September at Isla Clarion (18.3N, 114.7W) and at 1445 UTC 25 September at Isla Socorro (18.8N, 110.9W), respectively.

#### c. Casualty and Damage Statistics

There were media reports of downed trees in Acapulco after Hilary made its close approach to the Mexican coast on 23 September. No monetary estimate of the damage is available, but it is likely that the total damage was minor. There were three direct fatalities due to Hilary; three fishermen perished when their boat sank off of the town of Marguelia.

#### d. Forecast and Warning Critique

The genesis of Hilary was well forecast. The disturbance that generated Hilary was introduced into the Tropical Weather Outlook with a Low (< 30%) probability about 54 h before genesis occurred. The forecast was boosted to a Medium (30-50%) probability about 36 h before formation and finally raised to a High (>50%) probability about 12 h prior to genesis.

A verification of NHC official track forecasts (OFCL) for Hilary is given in Table 2a. Official forecast track errors were smaller than the mean official errors for the previous 5-yr period through 72 h and were slightly larger at days 4 and 5. Moreover, forecast errors from the climatology-persistence baseline model (OCD5) were also smaller than the previous 5-yr period out through 72 h and about the same at days 4 and 5. This suggests that some of the reduced errors in the official track forecasts might be ascribed to somewhat easier-to-predict tracks out through 72 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 2b. The U.K. Meteorological Office (EGRI) and European Centre for Medium Range Forecasting (EMXI) global models as well as the Florida State University Superensemble (FSSE) outperformed OFCL predictions at nearly all lead times, while the Canadian (CMCI) global model and mean of the Global Forecast System ensembles (AEMI) performed very well at days 4 and 5. However, the regional hurricane models (Geophysical Fluid Dynamics Laboratory [GHMI], Hurricane Weather Research and Forecasting [HWFI], and Geophysical Fluid Dynamics Laboratory-Navy version [GFNI]) verified quite poorly at days 4 and 5 and had no skill relative to climatology-persistence at those times. Figure 5 depicts all of the track forecasts from EMXI, EGRI, AEMI, GHMI, GFSI (the Global Forecast System global model), and OFCL. As can be seen, most of the model guidance and the OFCL predictions, with the exception of the EGRI, had a substantial eastward, or cross-track, bias for the second half of Hilary's lifetime. Most of the model guidance shifted westward each cycle, but not enough to

eliminate the bias. This large cross-track bias may have resulted from too strong of a binary interaction between Hilary and a mid- to upper-level low while the tropical cyclone was steadily weakening on 28 and 29 September.

A verification of NHC official intensity forecasts for Hilary is given in Table 3a. Except for the 12-h forecasts, official forecast intensity errors were substantially smaller than the mean official errors for the previous 5-yr period. However, forecast errors from the climatology-persistence baseline model (OCD5) were substantially larger than that of the previous 5-yr period for the 36-120 h lead times. This implies that improved intensity forecast performance for Hilary is quite noteworthy, as this tropical cyclone's intensity was more difficult to forecast than usual between 1.5 and 5 days. The double peak in intensity led to several very large OCD5 intensity forecast errors. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 3b. Most of the individual and consensus intensity model guidance was bested by OFCL. The most skillful intensity model was the Logistic Growth Equation Model (LGEM), though even this was outperformed by OFCL at 48-96 h.

Watches and warnings associated with Hilary are listed in Table 4.

e. Acknowledgments

Data from Mexico were provided by the Meteorological Service of Mexico. John Cangialosi and William Booth graciously produced software to automatically generate the tropical cyclone track map (Figure 1). Members of the Hurricane Specialist Unit gave numerous helpful suggestions on an earlier version of this report.

Table 1. Best track for Hurricane Hilary, 21-30 September 2011.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
21 / 0600	13.4	96.1	1006	30	tropical depression
21 / 1200	13.7	96.3	1005	35	tropical storm
21 / 1800	14.0	96.4	1003	40	"
22 / 0000	14.3	97.0	1001	45	"
22 / 0600	14.6	97.8	997	55	"
22 / 1200	15.0	98.6	988	70	hurricane
22 / 1800	15.5	99.4	971	90	"
23 / 0000	15.9	100.3	959	105	"
23 / 0600	16.0	101.3	951	115	"
23 / 1200	16.0	102.0	946	120	"
23 / 1800	16.2	102.7	942	125	"
24 / 0000	16.6	103.5	942	125	"
24 / 0600	16.9	104.6	946	120	"
24 / 1200	16.8	105.7	946	120	"
24 / 1800	16.8	106.4	950	115	"
25 / 0000	16.9	107.2	950	115	"
25 / 0600	17.0	108.0	952	110	"
25 / 1200	17.1	108.9	952	110	"
25 / 1800	17.1	109.9	955	105	"
26 / 0000	16.9	110.8	955	105	"
26 / 0600	16.8	111.7	955	105	"
26 / 1200	16.7	112.7	953	110	"
26 / 1800	16.6	113.5	948	115	"
27 / 0000	16.6	114.4	948	115	"
27 / 0600	16.6	115.3	957	105	"
27 / 1200	16.7	116.1	961	100	"
27 / 1800	16.9	116.9	964	95	"
28 / 0000	17.2	117.4	968	90	"
28 / 0600	17.6	117.8	973	80	"
28 / 1200	18.1	118.3	978	75	"
28 / 1800	18.7	118.8	980	70	"
29 / 0000	19.2	119.3	985	65	"
29 / 0600	19.7	119.7	989	60	tropical storm
29 / 1200	20.4	120.1	994	55	"
29 / 1800	21.2	120.5	1000	50	"
30 / 0000	21.7	120.8	1002	40	"
30 / 0600	22.2	121.1	1005	30	tropical depression
30 / 1200	22.9	121.5	1005	30	low
30 / 1800	23.5	121.8	1007	30	"
01 / 0000	23.8	122.4	1007	30	"
01 / 0600	23.8	122.7	1008	25	"

01 / 1200	23.7	123.0	1008	25	"
01 / 1800	23.5	123.3	1009	25	"
02 / 0000	23.2	123.6	1009	25	"
02 / 0600	22.9	124.2	1010	25	"
02 / 1200	22.8	124.8	1010	20	"
02 / 1800	22.8	125.1	1010	20	"
03 / 0000	22.7	125.4	1010	20	"
03 / 0600	22.1	125.8	1010	20	"
03 / 1200	21.8	126.4	1010	20	"
03 / 1800					dissipated
23 / 1800	16.2	102.7	942	125	minimum pressure & maximum intensity

Table 2a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Hilary, 21-30 September 2011. Mean errors for the 5-yr period 2006-10 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 (Hilary)	<b>21.8</b>	<b>34.3</b>	<b>49.0</b>	<b>66.3</b>	<b>110.6</b>	166.9	219.5
OCD5 (Hilary)	29.8	50.8	85.5	127.3	208.1	264.2	315.4
Forecasts	35	33	31	29	25	21	17
OFCL (2006-10)	29.7	49.9	69.0	86.6	119.0	155.8	197.7
OCD5 (2006-10)	38.4	74.8	115.3	155.9	226.3	273.7	310.4

Table 2b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Hilary, 21-30 September 2011. 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 2a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	20.5	34.3	46.0	63.2	113.6	179.3	231.9
OCD5	27.1	48.6	83.6	128.1	210.9	268.5	311.7
GFSI	27.1	49.5	70.8	96.1	153.5	186.3	<b>194.3</b>
GHMI	22.4	41.7	59.9	87.6	169.9	304.7	510.5
HWFI	25.9	47.8	70.8	99.0	178.4	339.2	581.7
GFNI	27.8	48.4	67.0	87.9	161.8	273.8	394.4
NGPI	29.6	45.0	66.5	96.6	180.5	253.7	286.6
EGRI	21.0	<b>29.6</b>	<b>39.8</b>	<b>51.8</b>	<b>77.0</b>	<b>96.0</b>	<b>132.1</b>
EMXI	<b>20.2</b>	<b>32.7</b>	<b>43.1</b>	<b>55.0</b>	<b>90.1</b>	<b>134.0</b>	<b>186.5</b>
CMCI	29.0	39.7	52.2	66.0	<b>91.2</b>	<b>125.8</b>	<b>152.1</b>
AEMI	24.3	42.7	62.4	86.8	118.4	<b>113.1</b>	<b>82.0</b>
BAMS	35.0	64.2	100.1	141.1	209.4	190.7	<b>190.0</b>
BAMM	28.7	51.1	81.8	122.6	214.5	229.1	<b>207.0</b>
BAMD	34.0	67.4	103.8	138.6	225.5	329.0	418.2
TVCE	<b>18.7</b>	<b>28.9</b>	<b>42.1</b>	<b>57.9</b>	<b>113.5</b>	193.7	285.9
TVCC	22.1	<b>33.7</b>	50.2	67.4	145.7	194.0	262.1
FSSE	<b>19.1</b>	<b>27.2</b>	<b>39.5</b>	63.4	<b>104.4</b>	<b>144.6</b>	<b>185.5</b>
Forecasts	29	28	27	25	22	19	15

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Hilary, 21-30 September 2011. Mean errors for the 5-yr period 2006-10 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 (Hilary)	6.3	<b>9.1</b>	<b>12.3</b>	<b>13.3</b>	<b>12.6</b>	<b>12.1</b>	<b>15.6</b>
OCD5 (Hilary)	6.0	12.0	17.7	21.8	28.0	30.4	32.5
Forecasts	35	33	31	29	25	21	17
OFCL (2006-10)	6.3	10.5	13.7	15.1	17.1	18.6	18.0
OCD5 (2006-10)	7.3	11.9	15.3	17.6	19.0	20.3	21.1

Table 3b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Hilary, 21-30 September 2011. 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	6.5	8.7	10.3	10.4	9.8	10.8	14.7
OCD5	<b>6.1</b>	12.0	16.4	19.7	25.7	28.8	30.6
HWFI	9.8	11.8	15.4	18.2	18.5	19.6	31.1
GHMI	8.1	12.1	15.5	16.5	20.8	22.9	31.2
GFNI	8.6	15.1	18.8	15.3	15.3	21.6	25.0
DSHP	6.9	11.9	14.1	14.0	14.6	15.4	19.6
LGEM	<b>5.2</b>	<b>8.0</b>	<b>10.1</b>	12.5	14.9	14.0	<b>11.0</b>
ICON	<b>6.2</b>	9.3	11.9	13.8	15.1	15.2	17.0
IVCN	<b>6.2</b>	9.0	11.3	12.7	14.0	15.6	17.6
FSSE	<b>6.2</b>	<b>8.5</b>	11.4	13.6	19.0	29.4	33.9
Forecasts	33	31	29	27	23	19	15

Table 4. Watch and warning summary for Hurricane Hilary, 21-30 September 2011.

Date/Time (UTC)	Action	Location
21/2100	Tropical Storm Watch issued	Lagunas de Chacahua to Lázaro Cárdenas, Mexico
22/0300	Tropical Storm Watch changed to Tropical Storm Warning	Lagunas de Chacahua to Lázaro Cárdenas, Mexico
22/0300	Tropical Storm Watch issued	Lázaro Cárdenas to Manzanillo, Mexico
22/0900	Tropical Storm Warning modified	Lagunas de Chachua to Punta San Telmo, Mexico
22/0900	Tropical Storm Watch modified	Punta San Telmo to Manzanillo, Mexico
23/0600	Tropical Storm Warning discontinued	Acapulco to Lagnuas de Chacahua, Mexico
23/0600	Tropical Storm Warning modified	Acapulco to Punta San Telmo, Mexico
23/1500	Tropical Storm Warning discontinued	Acapulco to Lagunas de Chacahua, Mexico
23/1500	Tropical Storm Watch discontinued	Punta San Telmo to Manzanillo, Mexico

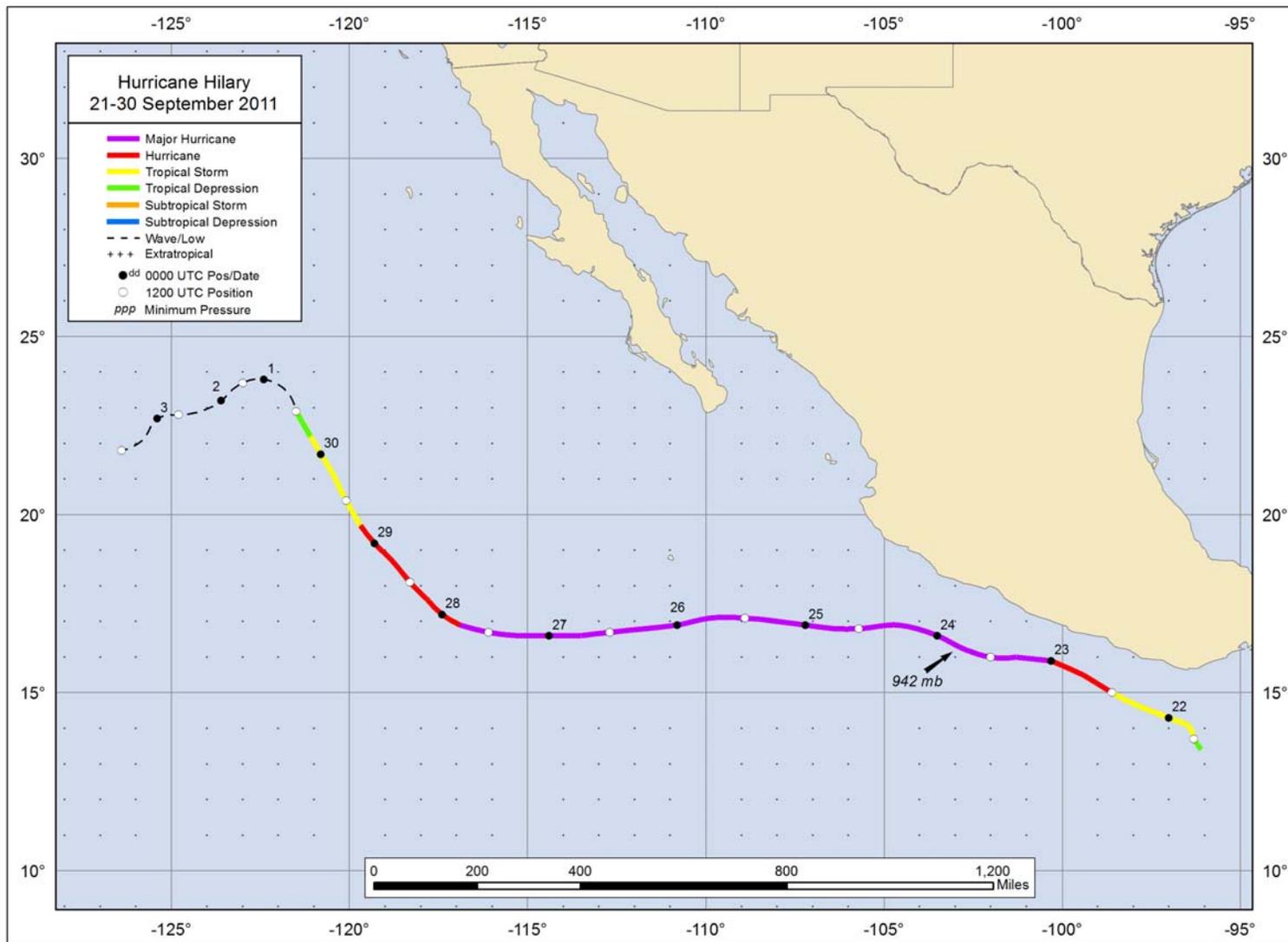


Figure 1. Best track positions for Hurricane Hilary, 21-30 September 2011.

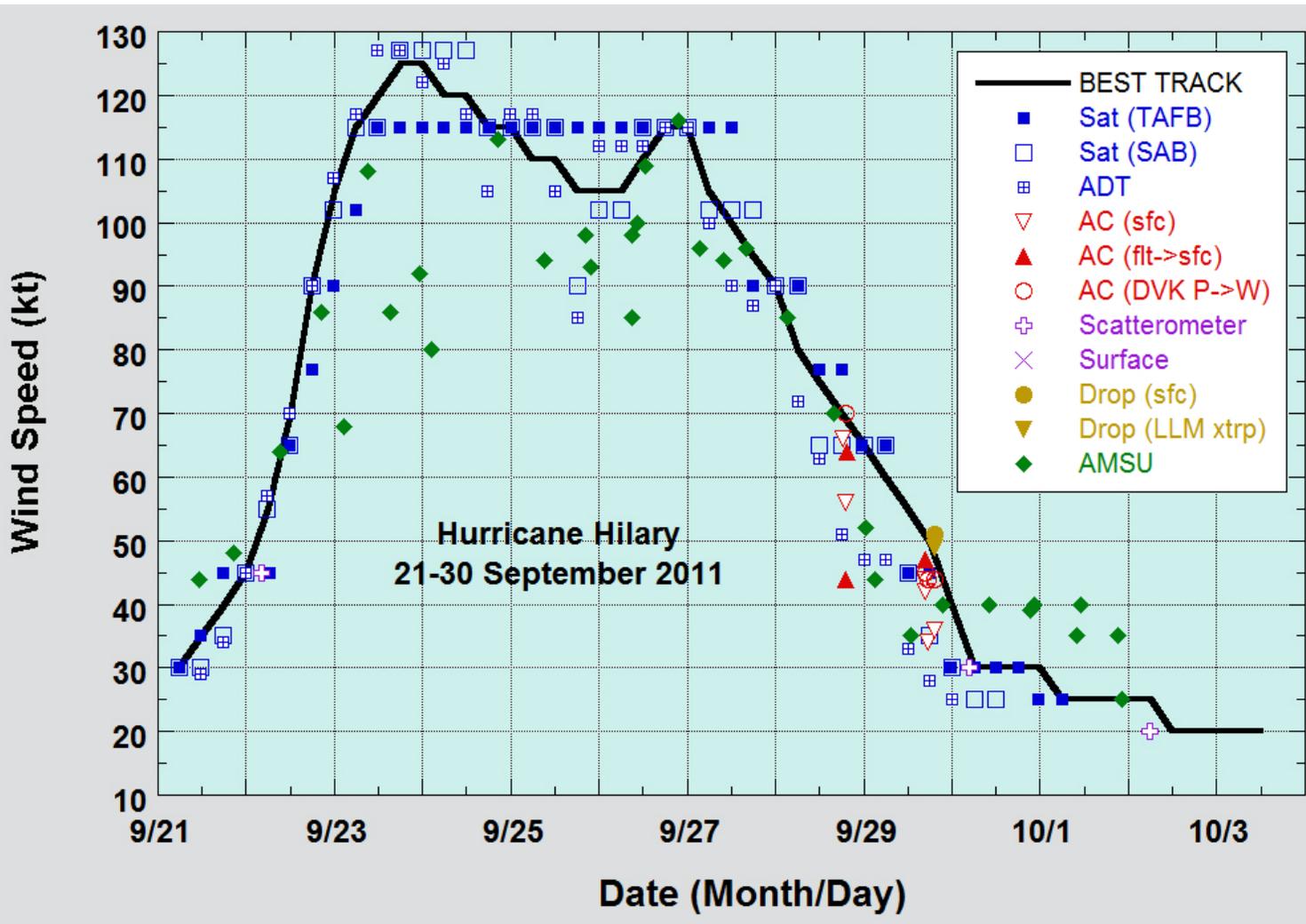


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Hilary, 21-30 September. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde 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 linear averages over a 3-h period centered on the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

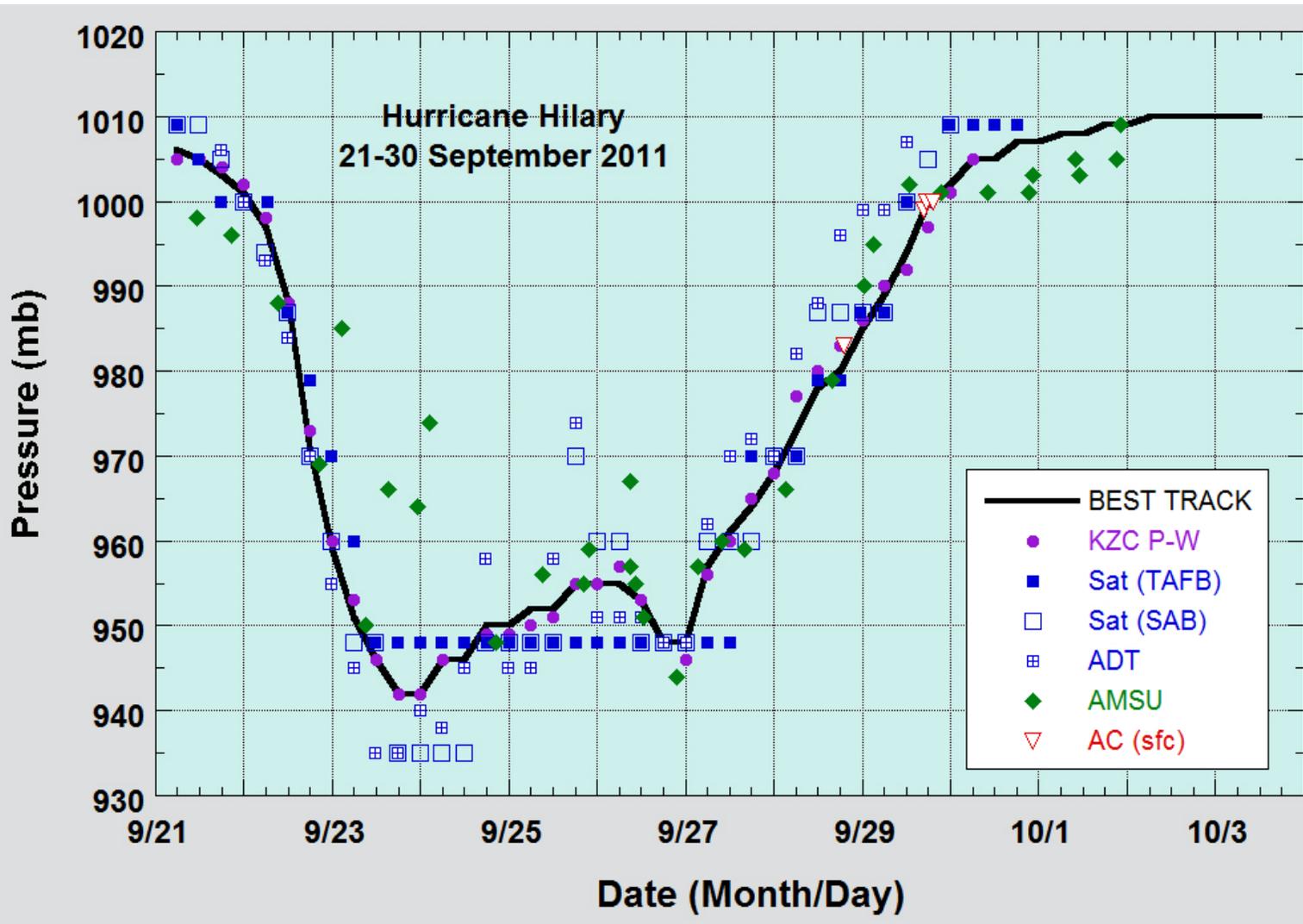


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Hilary, 21-30 September 2011. Advanced Dvorak Technique estimates represent linear averages over a 3-h period centered on the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. The KZC P-W values are obtained by applying the Knaff-Zehr-Courtney pressure-wind relationship to the best track wind data. Dashed vertical lines correspond to 0000 UTC.

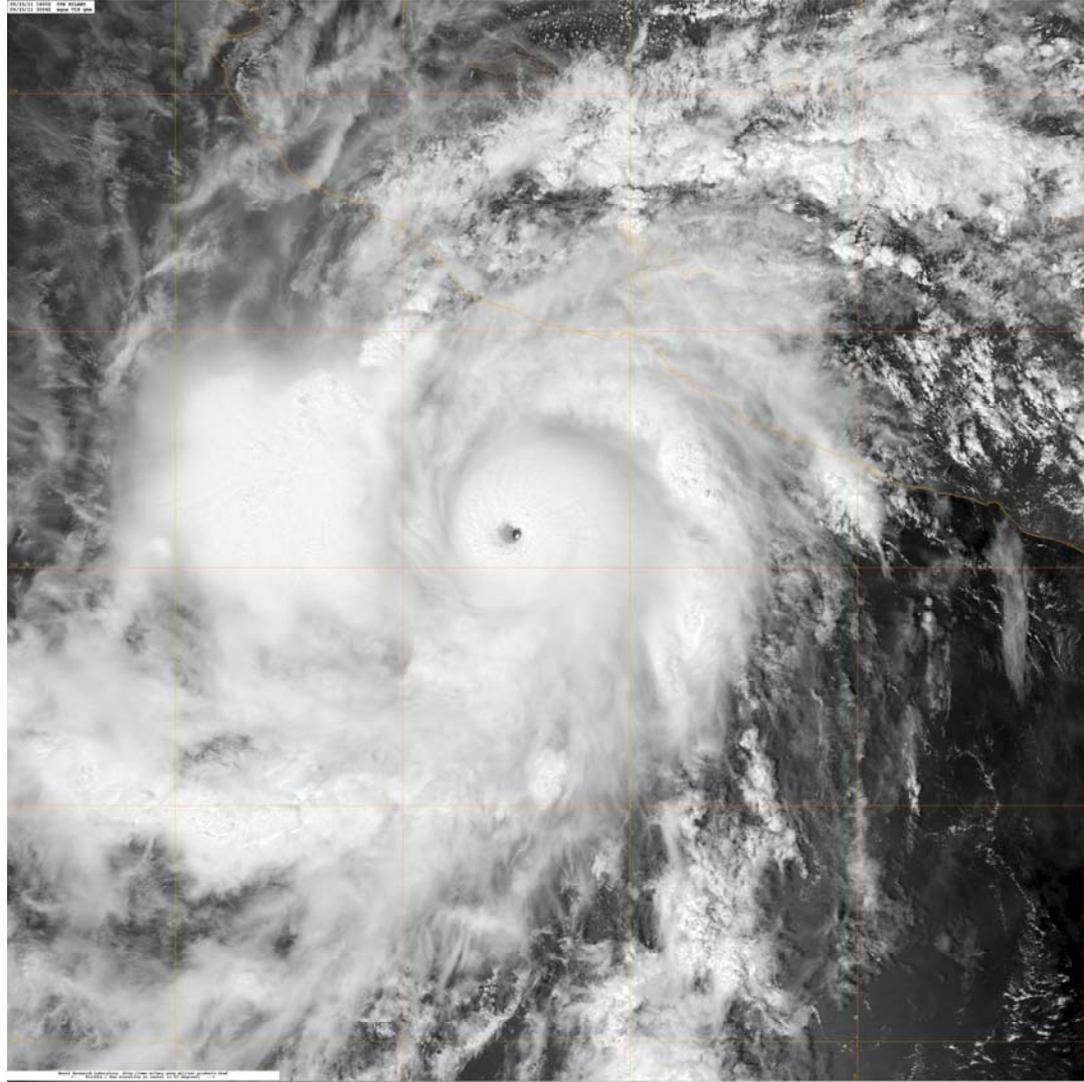


Figure 4. Hurricane Hilary at 2004 UTC 23 September 2011 near the time of maximum intensity (125 kt) from an AQUA visible image. At this time, the maximum extent of 34-kt winds was only about 75 nm, which is consistent with the limited size of the central dense overcast surrounding the well-defined eye. (Image courtesy of the Naval Research Laboratory.)

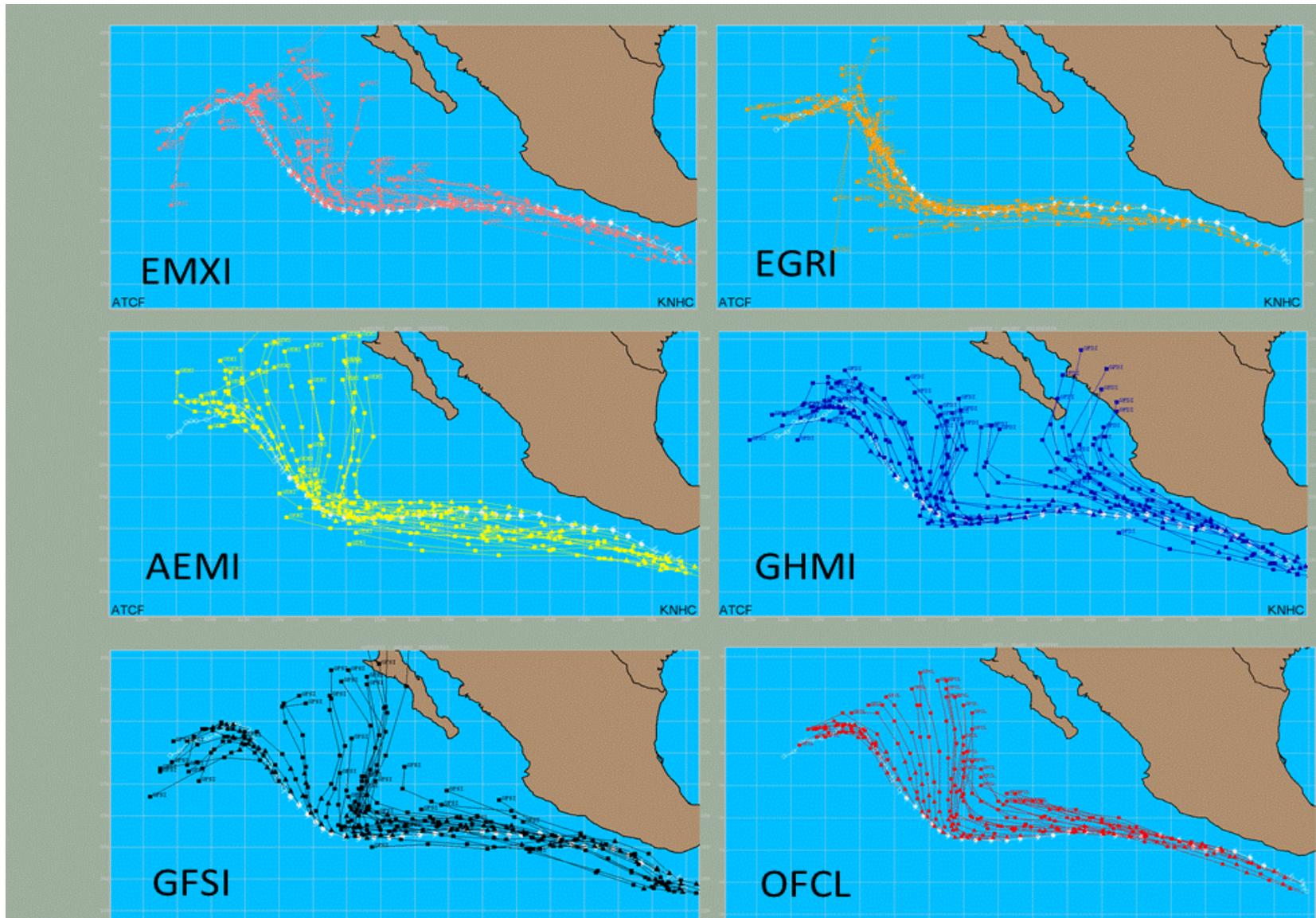


Figure 5. Selected track forecasts with 0, 12, 24, 36, 48, 72, 96, and 120-h positions indicated) for Hurricane Hilary, 21-30 September 2011. The best track is given by the thick white solid line with positions given at 6-h intervals.