Tropical Cyclone Report
Hurricane Adrian
(EP012011)
7 – 12 June 2011

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Adrian paralleled the coast of southwestern Mexico and rapidly intensified to category 4 strength (on the Saffir-Simpson Hurricane Wind Scale) before turning westward and weakening over colder waters.

a. Synoptic History

Several factors appear to have contributed to Adrian's genesis. During the last few days of May, the focus of convective activity along the Intertropical Convergence Zone (ITCZ) shifted eastward over the tropical Pacific Ocean, possibly in response to an atmospheric Kelvin wave[1]. Hovmöller diagrams suggest that the Kelvin wave, which originated over the western Pacific Ocean around 22 May, increased convection south of the Gulf of Tehuantepec around 31 May. A band of strong northeasterly low-level winds, emanating from the mountain gap on the Isthmus of Tehuantepec, induced a perturbation within the ITCZ near 95°W by 2 June. Shower and thunderstorm activity near the perturbation was disorganized and intermittent over the next several days. A second surge of northeasterly winds began early on 6 June and may have contributed additional spin to the disturbance, leading to the development of an area of low pressure by 0000 UTC 7 June about 365 n mi south of Acapulco, Mexico. Deep convection near the low consolidated and become better organized, and a tropical depression formed around 1200 UTC later that day. The depression strengthened to a tropical storm 12 h later while meandering about 300 n mi south of Acapulco. The "best track" of Adrian'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].

As Adrian began to accelerate in a west-northwestward to northwestward direction off the coast of Mexico, it moved through an environment of light vertical wind shear and over water near 30°C. The cyclone went through a 48-h period of rapid intensification, strengthening to hurricane status about 18 to 24 h after becoming a tropical storm and then becoming a major hurricane about 18 h after that. A 50-kt increase in intensity (70 to 120 kt) and an estimated 41-mb drop in central pressure (987 to 946 mb) occurred over the 24-h period from 0000 UTC 9 June to 0000 UTC 10 June. During that time Adrian developed an annular structure with a 20 to

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[1] A Kelvin wave is a type of large-scale, eastward-moving atmospheric wave that can enhance deep convection and contribute to tropical cyclogenesis, especially over the Pacific Ocean. Kelvin waves move eastward about 10° to 20° longitude per day.

[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.

25 n mi-wide eye surrounded by a wide ring of deep convection on enhanced infrared satellite imagery (Fig. 4). However, annular hurricanes normally occur over nearly constant sea surface temperatures, and Adrian soon moved almost directly across the sharp sea surface temperature gradient located to the southwest of Baja California, causing it to weaken rapidly from a category 4 hurricane to a 35-kt post-tropical low in 48 h. The weakening phase over the 24-h period from 1800 UTC 10 June to 1800 UTC 11 June, which included a 55-kt decrease in intensity (110 to 55 kt), may have been accelerated by an increase in southwesterly shear.

As Adrian weakened, it turned toward the west under the influence of the low-level trade wind flow. The system lost nearly all of its deep convection late on 11 June and degenerated into a post-tropical low by 1200 UTC 12 June while centered about 495 n mi southwest of Cabo San Lucas, Mexico. The remnant low lasted for almost another 48 h and opened up into a trough after 0600 UTC 14 June approximately 600 n mi southwest of Cabo San Lucas.

b. Meteorological Statistics

Observations in Adrian (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 Dvorak estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison (UW-CIMSS). Data and imagery from NOAA polar-orbiting satellites (including UW-CIMSS Advanced Microwave Sounding Unit [AMSU] intensity estimates), 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 Adrian.

Adrian's analyzed peak intensity of 120 kt from 0000 to 1200 UTC 10 June is based on peak subjective satellite intensity estimates of 127 kt and 115 kt from TAFB and SAB, respectively, a peak 3-h averaged objective satellite intensity estimate of 117 kt from the UW-CIMSS Advanced Dvorak Technique, and a CIMSS AMSU estimate of 116 kt at 0932 UTC 10 June.

c. Casualty and Damage Statistics

There were no reports of damage or casualties associated with Adrian.

d. Forecast and Warning Critique

The genesis of Adrian was well forecast. The precursor disturbance was first mentioned in the Tropical Weather Outlook at 0000 UTC 4 June and given a "low" (0 to 20%) chance of genesis over the next 48 h, 3.5 days before it became a tropical depression. The disturbance was given a 40% (medium) chance of development exactly 48 h before genesis, and it was raised to 60% (high) 6 h later.

A verification of NHC official track forecasts for Adrian is given in Table 2a. Official forecast track errors were less than impressive, being greater than the mean official errors for the previous 5-yr period and showing no skill relative to CLIPER (OCD5) at all forecast times except 12 h. The official track errors were more than double the previous 5-yr means at 72 and 96 h. Yet, Adrian's track should have been easier to forecast compared to those of an average eastern North Pacific storm over the past five years, according to the OCD5 errors. A homogeneous comparison of the official track errors with selected guidance models is given in Table 2b. In general, the Global Forecast System (GFSI), the European Centre for Medium-Range Weather Forecasts model (EMXI), the United Kingdom Met Office model (EGRI), the GFS ensemble mean (AEMI), and the Beta and Advection Models (BAMD, BAMM, and BAMS) had lower errors than the official forecast at most forecast times. The regional hurricane models, GFDL and HWRF, had greater errors than the official forecast at all forecast times, with each of these models displaying a persistent bias of turning Adrian northward toward Mexico (Fig. 5)[3]. As a result of the poor performance of the GFDL and HWRF, many of the consensus models suffered from larger-than-normal errors, especially from 36 h and beyond. Although the NHC forecasts were predominantly south and west of the consensus models, they still had larger errors than the bulk of the global models.

A verification of NHC official intensity forecasts for Adrian is given in Table 3a. Official forecast intensity errors were also large and greater than the mean official errors for the previous 5-yr period at all forecast times. However, Adrian's periods of rapid intensification and rapid weakening caused the intensity to be unusually difficult to forecast, as shown by the OCD5 errors. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 3b. Overall, the Florida State Superensemble (FSSE) and the Logistic Growth Equation Model (LGEM) had the lowest errors. Despite the difficulty in forecasting the periods of rapid intensity change, the official forecast still outperformed most of the intensity guidance during the short-term (24 to 36 h) part of the forecast period. The GFDL and HWRF had lower errors than the official forecast at 72 and 96 h, but those models indicated lower intensities at those times by having the cyclone farther north and over colder waters or over land (i.e., they were essentially right for the wrong reason).

A tropical storm watch was issued along the coast of southwestern Mexico from Acapulco to Punta San Telmo at 1500 UTC 8 June and discontinued at 0300 UTC 9 June. No tropical-storm-force winds were observed on the coast of Mexico.

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[3] A correction was made to the coding of the HWRF deep convection parameterization scheme on 3 August 2011. Testing and re-evaluation showed that this change led to a large reduction in the northward bias seen in many eastern North Pacific hurricane tracks and a 15 – 60% reduction in eastern North Pacific tropical cyclone track forecast errors for a sample of storms from 2010 and 2011. Testing is ongoing with modifications to the physics of the GFDL Hurricane Model that should also make major improvements to that model's track forecasts.

Table 1. Best track for Hurricane Adrian, 7 – 12 June 2011.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
07 / 0000	10.7	99.7	1007	25	low
07 / 0600	11.2	99.8	1007	25	"
07 / 1200	11.5	99.6	1006	25	tropical depression
07 / 1800	11.7	99.6	1005	30	"
08 / 0000	11.7	99.9	1003	35	tropical storm
08 / 0600	11.9	100.4	1000	45	"
08 / 1200	12.5	100.7	996	55	"
08 / 1800	13.1	101.2	993	60	"
09 / 0000	13.5	102.0	987	70	hurricane
09 / 0600	13.8	102.8	982	75	"
09 / 1200	14.1	103.6	970	90	"
09 / 1800	14.3	104.4	957	105	"
10 / 0000	14.5	105.3	946	120	"
10 / 0600	14.8	106.2	944	120	"
10 / 1200	15.1	107.1	946	120	"
10 / 1800	15.4	108.1	954	110	"
11 / 0000	15.5	109.1	963	100	"
11 / 0600	15.6	110.2	977	80	"
11 / 1200	15.6	111.3	988	65	"
11 / 1800	15.6	112.4	995	55	tropical storm
12 / 0000	15.7	113.5	999	45	"
12 / 0600	16.0	114.5	1003	35	"
12 / 1200	16.3	115.2	1005	35	low
12 / 1800	16.6	115.6	1006	35	"
13 / 0000	16.8	116.0	1007	30	"
13 / 0600	16.9	116.4	1008	25	"
13 / 1200	17.0	116.9	1008	20	"
13 / 1800	17.0	117.5	1008	20	"
14 / 0000	16.9	117.9	1008	20	"
14 / 0600	16.7	118.1	1008	20	"
14 / 1200					dissipated
10 / 0600	14.8	106.2	944	120	minimum pressure and maximum winds

Table 2a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Adrian, 7 – 12 June 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	**25.1**	52.3	83.2	122.8	240.7	357.0	
OCD5	29.8	56.4	75.5	102.3	176.3	237.2	
Forecasts	18	16	14	12	8	4	
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 Adrian, 7 – 12 June 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	18.5	38.1	70.9	116.4	225.9		
OCD5	24.7	45.0	**68.2**	**93.0**	**132.8**		
GFSI	**17.9**	**29.2**	**63.3**	**109.0**	233.7		
GHMI	18.8	38.9	83.8	153.8	369.3		
HWFI	26.8	59.2	115.1	194.9	349.1		
NGPI	24.7	58.7	106.4	172.4	376.8		
EGRI	21.7	**19.0**	**29.9**	**54.1**	**208.6**		
EMXI	**17.6**	**22.0**	**44.2**	**79.4**	**135.7**		
CMCI	33.8	61.3	83.0	**105.0**	**76.3**		
AEMI	23.9	**21.4**	**25.8**	**40.8**	**108.5**		
FSSE	23.2	48.8	101.0	164.5	332.7		
TCON	**17.8**	**37.1**	76.3	134.5	302.6		
TVCE	19.5	**36.1**	76.9	132.8	284.1		
TVCC	21.4	**35.7**	80.0	133.7	265.6		
GUNA	**18.2**	**32.5**	**67.9**	119.7	293.2		
LBAR	29.8	42.5	80.9	123.0	262.2		
BAMD	29.5	**29.2**	**60.0**	**89.6**	**184.1**		
BAMM	26.9	**24.9**	**48.8**	**72.4**	**203.8**		
BAMS	24.0	**25.4**	**43.8**	**71.1**	**206.0**		
Forecasts	7	6	6	5	2		

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Adrian, 7 – 12 June 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	6.7	15.9	22.1	27.1	31.9	30.0	
OCD5	10.6	21.7	31.9	36.8	30.0	14.0	
Forecasts	18	16	14	12	8	4	
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 Adrian, 7 – 12 June 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	6.9	16.1	22.5	25.5	29.2	40.0	
OCD5	11.2	22.6	33.6	36.4	**20.3**	**21.0**	
GHMI	11.6	22.0	23.3	**23.0**	**27.5**	**15.5**	
HWFI	11.4	24.0	32.3	33.3	**21.7**	**11.0**	
FSSE	7.4	**15.6**	**20.7**	**23.6**	**26.7**	**36.0**	
DSHP	9.7	18.8	26.3	29.1	29.2	44.0	
LGEM	7.9	16.4	**22.3**	**24.9**	**27.2**	44.0	
ICON	9.1	19.9	25.3	26.0	**25.3**	**24.5**	
IVCN	9.3	20.0	25.0	**25.2**	**25.0**	**24.5**	
Forecasts	16	14	12	10	6	2	

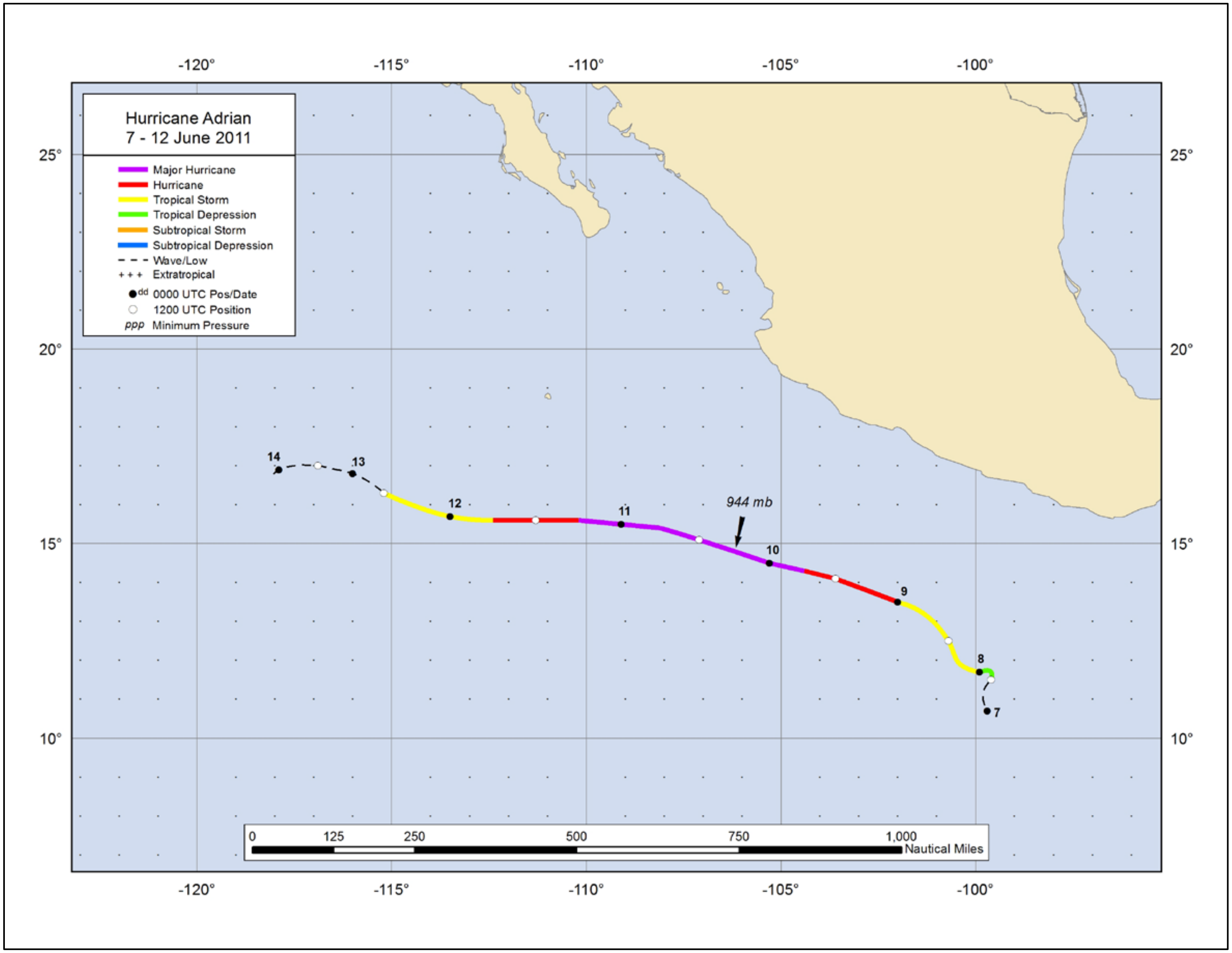

Figure 1. Best track positions for Hurricane Adrian, 7 – 12 June 2011.

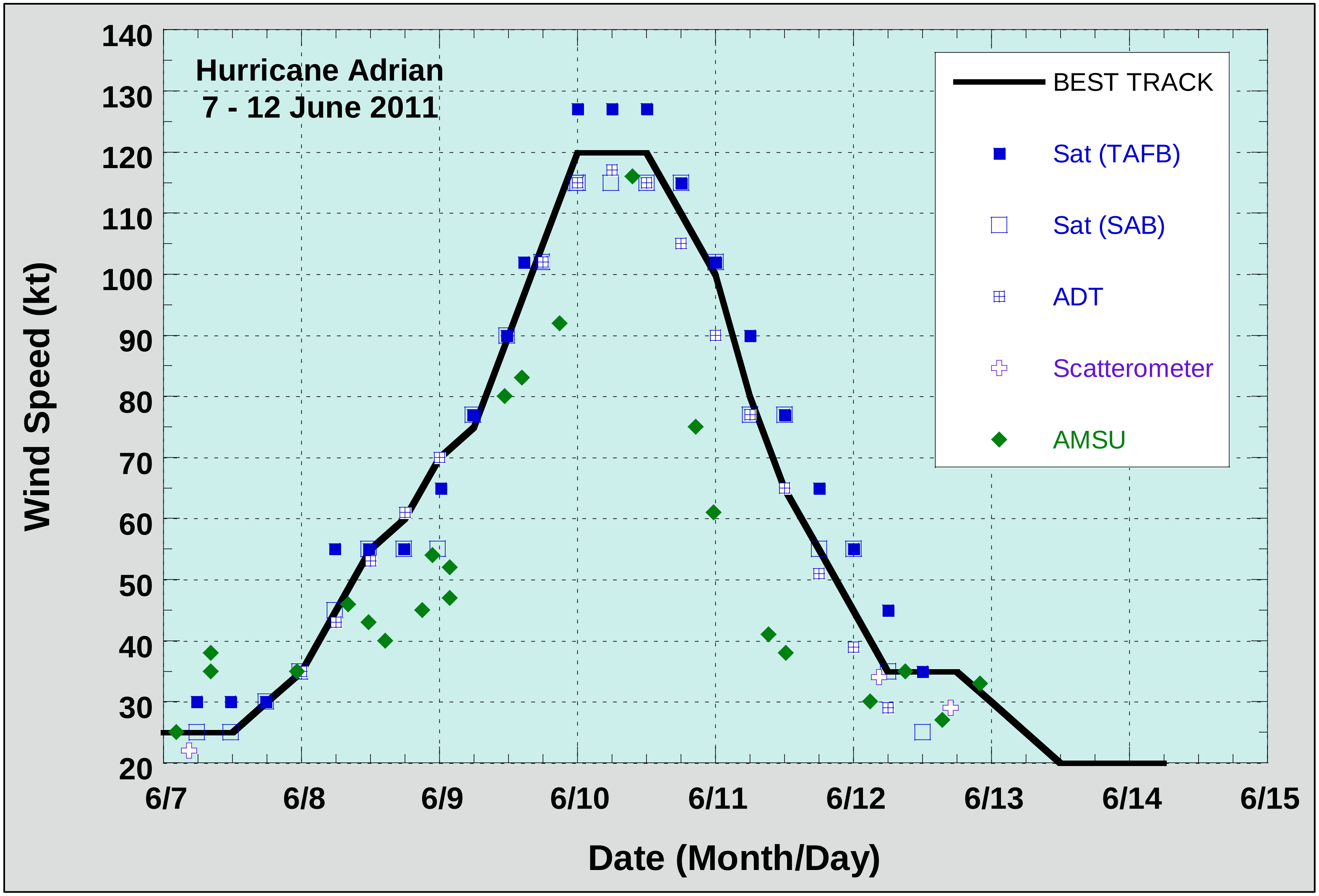

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Adrian, 7 – 12 June 2011. ADT points represent linear averages of UW-CIMSS Advanced Dvorak Technique estimates over a three-hour period centered on the nominal observation time. AMSU intensity estimates are from the UW-CIMSS technique. Dashed vertical lines correspond to 0000 UTC.

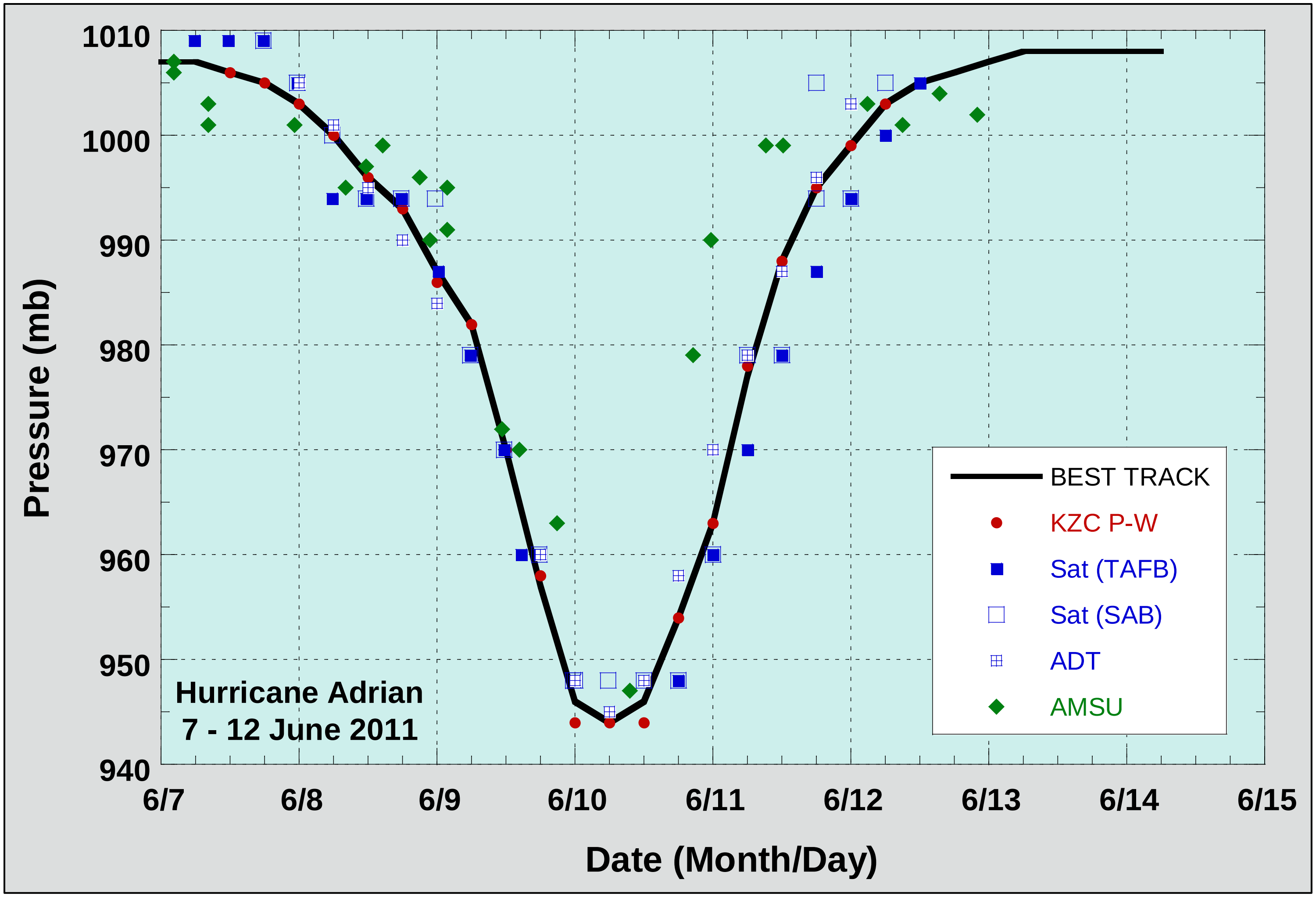

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Adrian, 7 – 12 June 2011. ADT points represent linear averages of UW-CIMSS Advanced Dvorak Technique estimates over a three-hour period centered on the nominal observation time. AMSU intensity estimates are from the UW-CIMSS technique. KZC P-W refers to pressure estimates using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

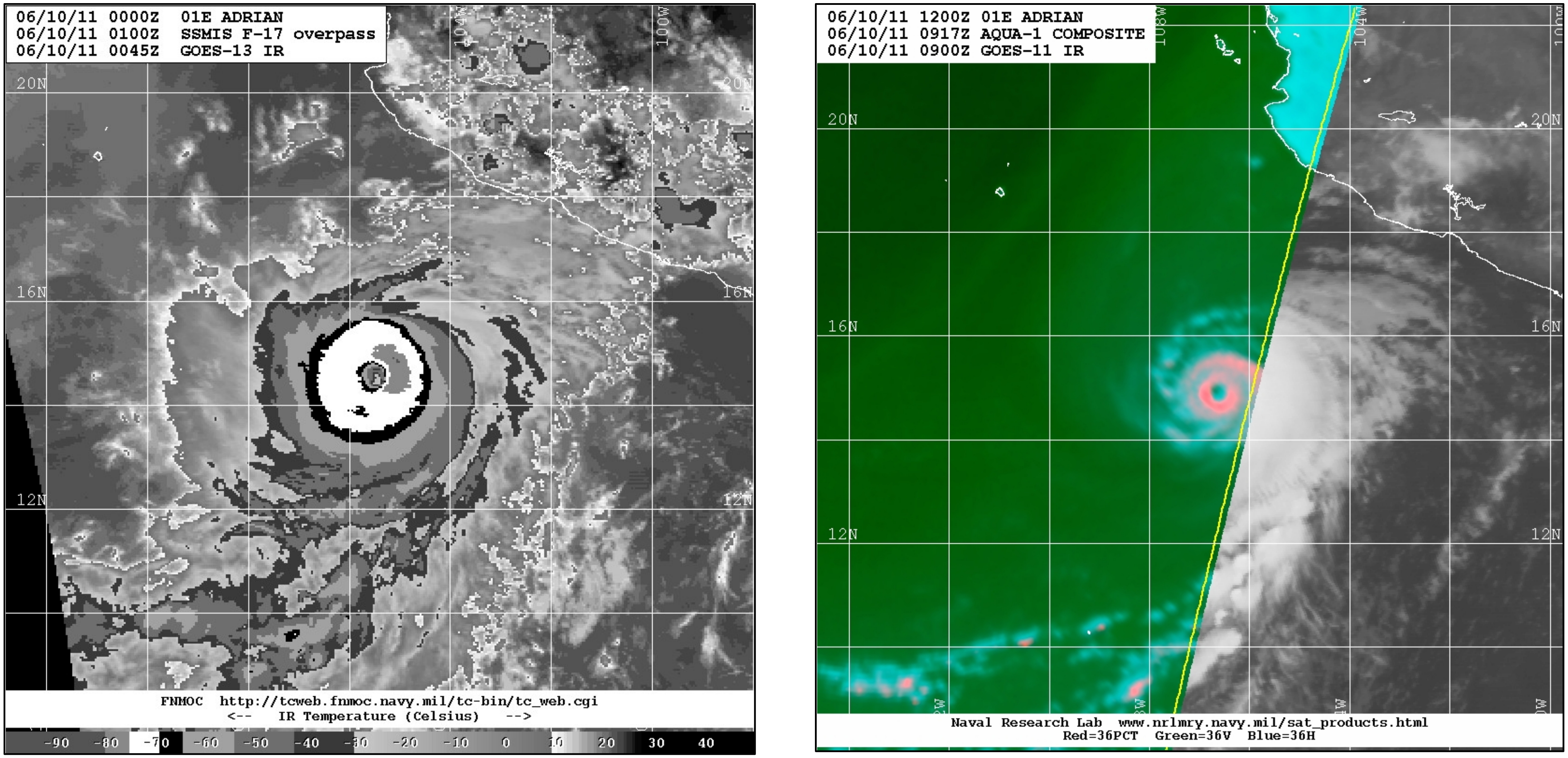

Figure 4. Infrared SSMIS image of Hurricane Adrian at 0100 UTC 10 June (left) and a 36 GHz color composite AMSR-E image at 0917 UTC 10 June (right) during the period of the hurricane's peak intensity of 120 kt.

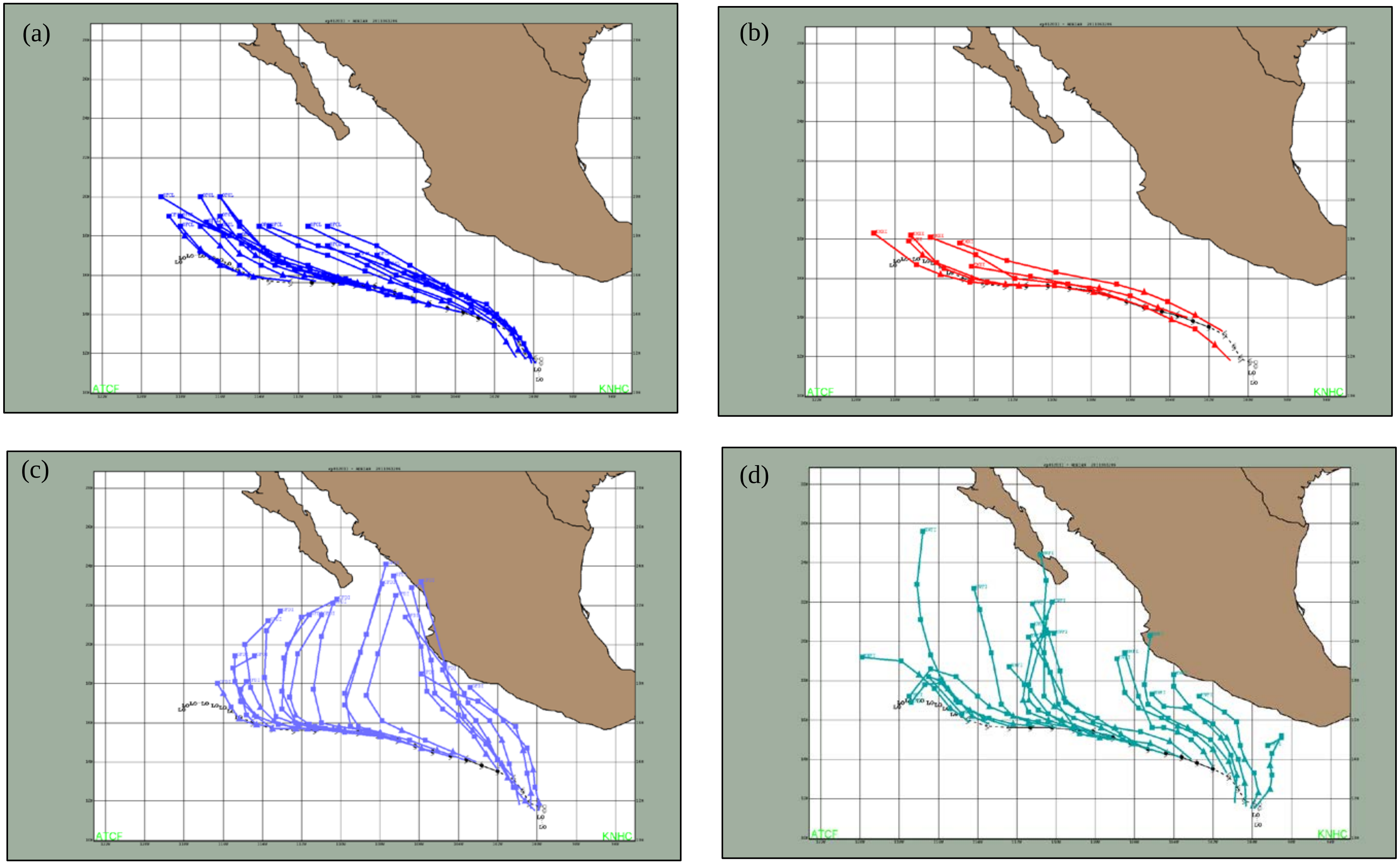

Figure 5. (a) NHC official, (b) EMXI, (c) GHMI, and (d) HWFI track forecasts from 1200 UTC 7 June through 0600 UTC 12 June 2011 for Hurricane Adrian. The best track is given by the black line with positions shown at 6 h intervals.