NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM KAREN

(AL122013)

3 – 6 October 2013

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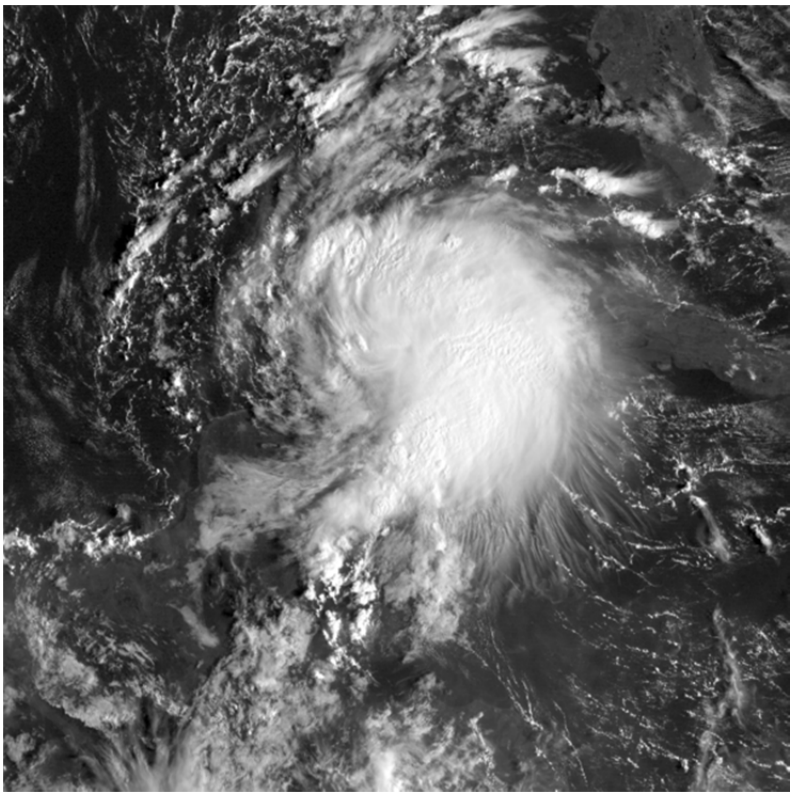

GOES VISIBLE SATELLITE IMAGE OF TROPICAL STORM KAREN IN THE SOUTH-CENTRAL GULF OF MEXICO AROUND AT 1315 UTC 3 OCTOBER. COURTESY OF NAVAL RESEARCH LABORATORY.

Karen was a tropical storm that formed near the Yucatan peninsula and moved northwestward into the north-central Gulf of Mexico, where it dissipated in a high-shear environment. It was one of only a small number of named storms that dissipated in the Gulf of Mexico without making landfall.

Tropical Storm Karen

3 – 6 OCTOBER 2013

SYNOPTIC HISTORY

A tropical wave that emerged off of the west coast of Africa on 16 September traveled across the tropical Atlantic during the next several days and entered the Caribbean Sea on 25 September. The wave encountered a sharp upper-level trough over the western Caribbean Sea on 27 September, causing shower and thunderstorm activity to increase, and the increase in deep convection led to the formation of a broad trough of low pressure to the southeast of Jamaica by 28 September. A well-defined atmospheric Kelvin wave moving out of the eastern Pacific passed the wave that same day and may have contributed to a more favorable large-scale environment for development. The surface trough moved slowly westward during the next couple of days while it approached the Yucatan peninsula with no appreciable change in organization. Even though westerly vertical wind shear was hampering development, a European Space Agency's Advanced Scatterometer (ASCAT) pass from 30 September showed that the surface trough had sharpened and a small area of winds to 30 kt was located east of the trough axis. An Air Force Reserve Hurricane Hunter aircraft investigated the disturbance during the late afternoon of 2 October; the aircraft and buoy data indicated tropical-storm-force winds over a relatively large area of the northwestern Caribbean Sea, but there was no evidence of a well-defined center of circulation. The cloud pattern of the disturbance increased in organization, and surface observations from the Yucatan peninsula suggest that the circulation became better defined by 0600 UTC 3 October, marking the formation of a tropical storm about 30 n mi north of Cancun, Mexico. The "best track" chart of Karen'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[1].

The center of Karen passed near the northeastern tip of the Yucatan peninsula early on 3 October, moving northwestward to north-northwestward into the south-central Gulf of Mexico around the western periphery of a low- to mid-level ridge located near the Florida peninsula. The satellite presentation appeared most organized around 1200 UTC that day and deteriorated after that time, with the center becoming exposed to the west of the deepest convection. Despite the degradation in the cloud pattern, Karen continued to strengthen throughout the day, perhaps in response to the diffluent flow associated with an upper-level shortwave trough moving northeastward from the lower Mississippi Valley and the northwestern Gulf of Mexico. After reaching a peak intensity of 55 kt and a minimum pressure of 998 mb late on 3 October in the south-central Gulf of Mexico, the presumably favorable influence of the shortwave trough diminished. Westerly shear on the north side of a 200-mb anticyclone located over the northwestern Caribbean Sea, as well as dry air in the near-storm environment, contributed to a

[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 *btk* directory, while previous years' data are located in the *archive* directory.

weakening trend beginning early on 4 October. The cloud pattern deteriorated further, with only intermittent bursts of deep convection still occurring near the exposed low-level center during the day.

Karen continued on the same path but at an erratic forward speed from 4 to 5 October around the same low- to mid-level ridge. Westerly shear further increased by 5 October when a large mid- to upper-level trough began to dig over the west-central United States. As a result, the separation between the low-level center and nearest convection significantly increased, and Karen weakened further, becoming a depression around 0000 UTC 6 October while centered about 140 n mi southwest of New Orleans, Louisiana. Karen stalled early on 6 October, when surface observations and cloud-motion vectors indicated that the circulation of the cyclone was becoming elongated. The cyclone degenerated into an open trough by 1200 UTC that day south of the south-central Louisiana coast. The remnants were swept rapidly eastward to east-northeastward across Florida and into the western Atlantic during the next couple of days.

METEOROLOGICAL STATISTICS

Observations in Karen (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. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from seven flights (two invest and five fix missions) of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. There were also four research flights by the NOAA P-3 Orion aircraft. 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 ASCAT, and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Karen.

Ship reports of winds of tropical storm force associated with Karen are given in Table 2. A couple of ships reported sustained winds of around 40 to 45 kt southeast of the center of Karen shortly after genesis over the southeastern Gulf of Mexico. Although the cyclone's precursor low was not yet well defined during the late afternoon of 2 October, a NOAA data buoy in the northwestern Caribbean Sea (42056) reported peak 1-minute winds of 35 kt with gusts to 41 kt and a minimum pressure of 1006.5 mb. Another NOAA data buoy the central Gulf data buoy (42001) observed peak winds of 40 kt with gusts to 49 kt around midday on 4 October and a minimum pressure of 1007.7 mb when the center passed about 30 n mi to the southwest.

The estimated peak intensity of Karen is based on peak bias-corrected SFMR winds of around 50 kt between about 1200 UTC 3 October and 2000 UTC 4 October (SFMR winds in Fig. 2 are not bias-corrected). This coincides with the time when the satellite presentation of the cyclone was most organized. There were a couple of SFMR winds on 4 October (Fig. 2) that appear to be invalid due to rain contamination.

Karen is one of only a small number of named storms (e.g., Alberto 1982) during the reconnaissance era to have dissipated in the Gulf of Mexico without making landfall.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

The genesis of Karen was generally well forecast, especially in the short range. Karen's pre-cursor disturbance was introduced into the 48-h Tropical Weather Outlook at 1800 UTC 28 September, about 84 h prior to genesis, and assessed a low chance (20% or less) of tropical cyclone formation. The probability was increased to medium and high chances 48 h and 12 h prior to tropical cyclone formation, respectively. The system was introduced into the extended-range (5-day) outlook 126 h before genesis occurred, and reached the medium category 18 h later. Five-day formation probabilities never reached the high category because global model guidance was not in good agreement with regard to genesis until it was imminent.

A verification of NHC official track forecasts for Karen is given in Table 3a. Official forecast track errors were greater than the mean official errors for the previous 5-yr period at all forecast times. Large track errors at later times resulted from forecasts calling for Karen to be a deep system and move toward the north and then the northeast into the mid-latitudes (Fig. 4). A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The EMXI and GFS ensemble mean (AEMI) models were the best performers, with track forecast errors significantly below those of the official forecast. Also of note are the FSU Superensemble (FSSE), the multi-model consensus (TVCA), and the BAMS and BAMM models. The last of these bested the rest of the guidance, likely performing well due to the relatively shallow nature of the cyclone.

A verification of NHC official intensity forecasts for Karen is given in Table 4a. Official forecast intensity errors were greater than the mean official errors for the previous 5-yr period at all times. Strong shear caused weakening of the cyclone earlier than expected, leading to the greater-than-average errors through 36 h. Early forecasts that called for Karen to reach hurricane strength prior to reaching the north-central Gulf coast contributed to the very high official intensity errors from 36 h to 72 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. None of the intensity models performed well at later forecast times, although DSHP and LGEM outperformed the rest and the official forecast.

For the first time, data from the NOAA P-3 tail Doppler radar were assimilated into an operational hurricane model in real time. The 1200 UTC 4 October run of the HWRF, which made use of these data, showed considerably less intensification with Karen compared to previous runs.

Watches and warnings associated with Karen are given in Table 5. A tropical storm watch was issued for southeastern Louisiana from Morgan City to Grand Isle at 1300 UTC 3 October, with a hurricane watch issued at the same time from east of Grand Isle, LA, to Indian Pass, FL. The tropical storm watch was upgraded to a tropical storm warning later that afternoon for a smaller portion of the north-central Gulf covering southeastern Louisiana and Mississippi.

Given the weakening trend on 4 October, the hurricane watch was discontinued at 2100 UTC 5 October. All remaining tropical storm warnings were discontinued early on 6 October when Karen was downgraded to a tropical depression. No tropical-storm-force winds occurred along the northern Gulf coast.

Table 1. Best track for Tropical Storm Karen, 3-6 October, 2013.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
03 / 0600	21.5	86.8	1006	45	tropical storm
03 / 1200	22.1	87.4	1004	55	"
03 / 1800	22.8	88.1	1001	55	"
03 / 2100	23.3	88.5	998	55	"
04 / 0000	23.9	89.0	999	50	"
04 / 0600	24.5	89.5	1002	45	"
04 / 1200	25.2	89.9	1002	45	"
04 / 1800	25.8	90.2	1002	45	"
05 / 0000	26.1	90.5	1004	40	"
05 / 0600	26.7	91.0	1007	40	"
05 / 1200	27.6	91.6	1008	40	"
05 / 1800	27.9	91.8	1008	35	"
06 / 0000	28.1	91.9	1008	30	tropical depression
06 / 0600	28.1	91.9	1009	25	"
06 / 1200					dissipated
03 / 1200	22.1	87.4	1004	55	maximum wind
03 / 2100	23.3	88.5	998	55	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Tropical Storm Karen, 3-6 October 2013.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
03 / 1200	C6JT8	21.9	86.4	200 / 44	1007.0
03 / 1500	C6JT8	21.7	86.4	140 / 39	1011.5
03 / 1500	A8GU8	22.7	86.8	120 / 40	1010.0
03 / 1800	A8GU8	22.6	87.3	130 / 47	1007.0

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Karen, 3-6 October 2013. 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	31.2	54.7	89.6	148.4	288.1		
OCD5	34.5	36.1	62.5	107.0	298.4		
Forecasts	11	9	7	5	1		
OFCL (2008-12)	28.6	45.8	62.2	78.6	116.6		
OCD5 (2008-12)	47.5	99.7	161.4	224.0	329.7		

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Karen, 3-6 October 2013. 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	29.9	52.9	87.8	146.6			
OCD5	32.9	**27.6**	**49.5**	**84.0**			
GFSI	**28.7**	**52.1**	93.1	157.6			
GHMI	38.5	73.8	111.0	**143.7**			
HWFI	49.6	89.3	136.1	187.4			
EMXI	**27.2**	**43.4**	**61.0**	**82.0**			
CMCI	44.4	82.8	119.1	147.1			
TVCA	**29.2**	**50.6**	**82.6**	**130.6**			
FSSE	**28.2**	**49.0**	**85.0**	**138.5**			
AEMI	**24.9**	**33.3**	**44.6**	**74.4**			
BAMS	31.5	**44.3**	**60.7**	**48.4**			
BAMM	30.4	**26.9**	**32.9**	**58.3**			
BAMD	52.6	81.4	119.5	159.5			
NAMI	**29.7**	**47.6**	**73.1**	**104.3**			
Forecasts	10	8	6	4			

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Karen, 3-6 October 2013. 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	6.8	11.1	20.7	25.0	6.8		
OCD5	9.5	17.8	26.9	36.6	9.5		
Forecasts	11	9	7	5	1		
OFCL (2008-12)	6.6	10.1	12.2	14.1	15.4		
OCD5 (2008-12)	7.8	11.6	14.0	15.6	17.9		

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Karen, 3-6 October 2013. 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	6.5	11.9	22.5	27.5			
OCD5	9.7	18.9	29.0	40.3			
HWFI	7.4	13.1	24.7	34.8			
GHMI	9.2	14.6	26.2	33.5			
DSHP	**5.6**	**9.8**	**16.3**	**24.3**			
LGEM	6.8	**10.8**	**15.8**	**22.8**			
IVCN	7.2	11.9	**21.0**	29.3			
FSSE	7.4	12.5	**21.8**	30.3			
Forecasts	10	8	6	4			

Table 5. Watch and warning summary for Tropical Storm Karen, 3-6 October 2013.

Date/Time (UTC)	Action	Location
3 / 1300	Tropical Storm Watch issued	Morgan City to Grand Isle
3 / 1300	Tropical Storm Watch issued	Lake Pontchartrain
3 / 1300	Hurricane Watch issued	Grand Isle to Indian Pass
3 / 2100	Tropical Storm Watch issued	Destin to Indian Pass
3 / 2100	Tropical Storm Warning issued	Grand Isle to Pearl River
3 / 2100	Hurricane Watch modified to	Grand Isle to Destin
4 / 1500	Tropical Storm Watch discontinued	Morgan City to Grand Isle
4 / 1500	Tropical Storm Warning modified to	Morgan City to Pearl River
4 / 2100	Tropical Storm Watch modified to	Pearl River to Indian Pass
4 / 2100	Hurricane Watch discontinued	All
5 / 2100	Tropical Storm Watch discontinued	All
5 / 2100	Tropical Storm Warning modified to	Grand Isle to Pearl River
6 / 0300	Tropical Storm Warning discontinued	All

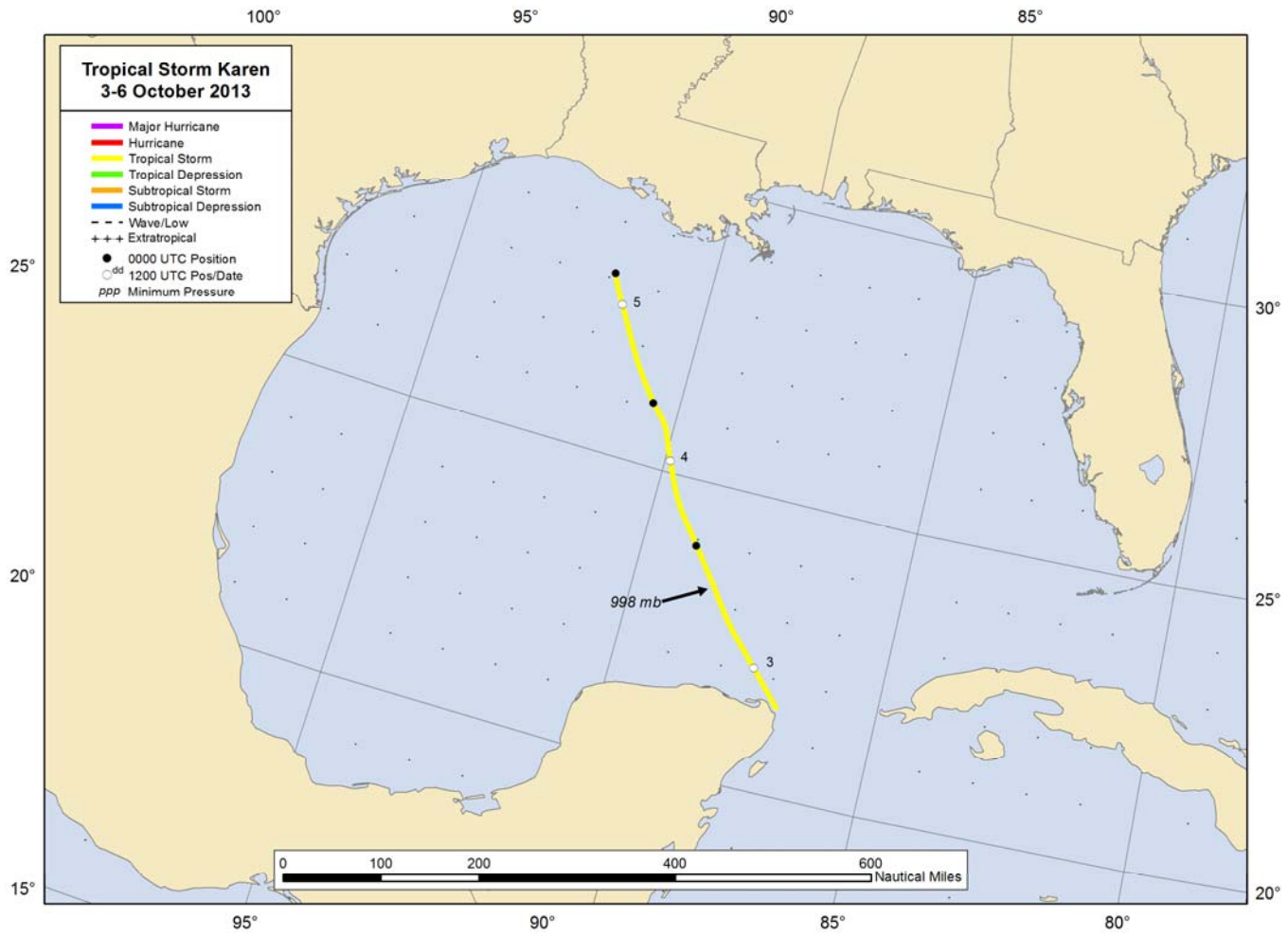

Figure 1. Best track positions for Tropical Storm Karen, 3-6 October 2013.

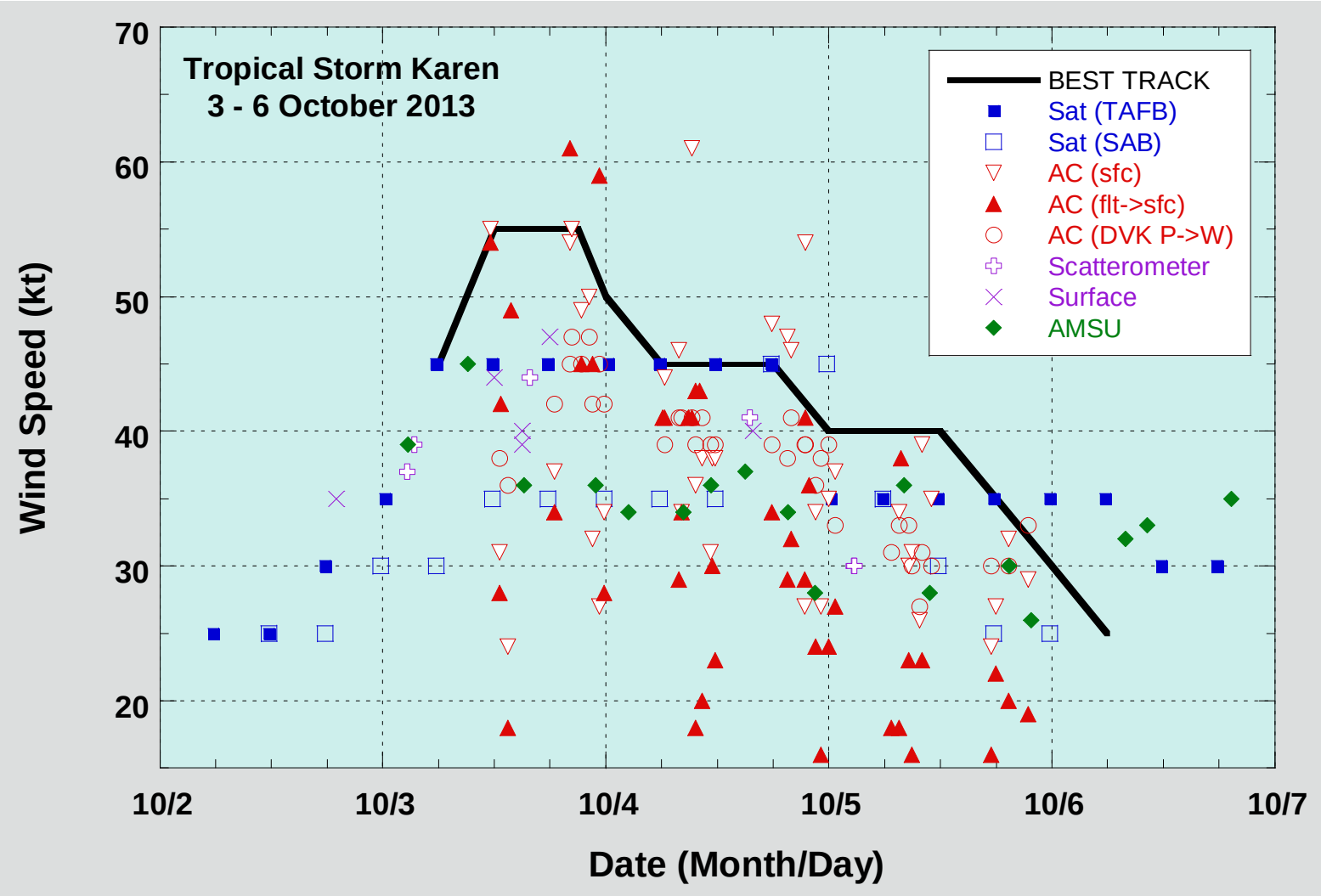

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Karen, 3-6 October 2013. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

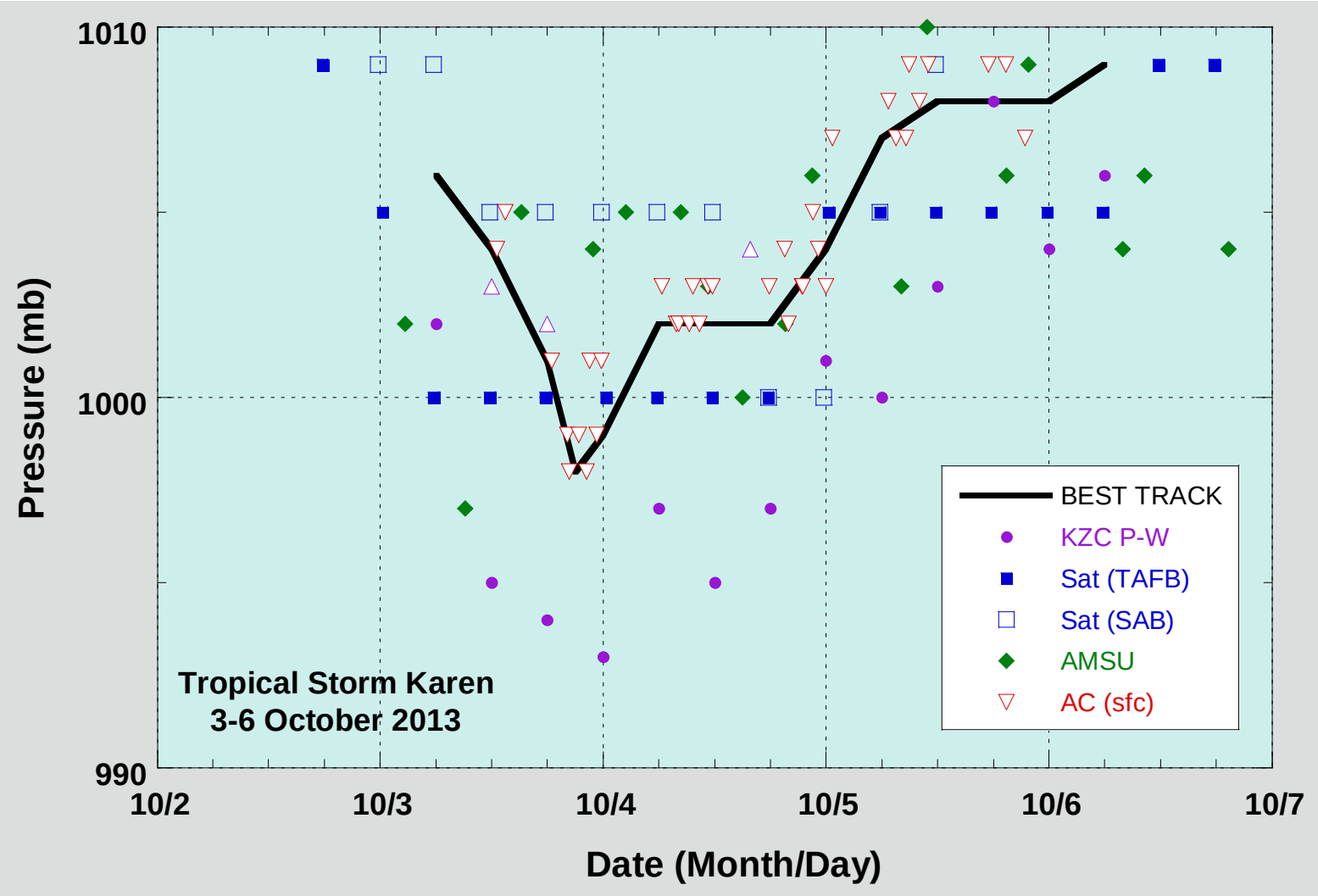

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Karen, 3-6 October 2013. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

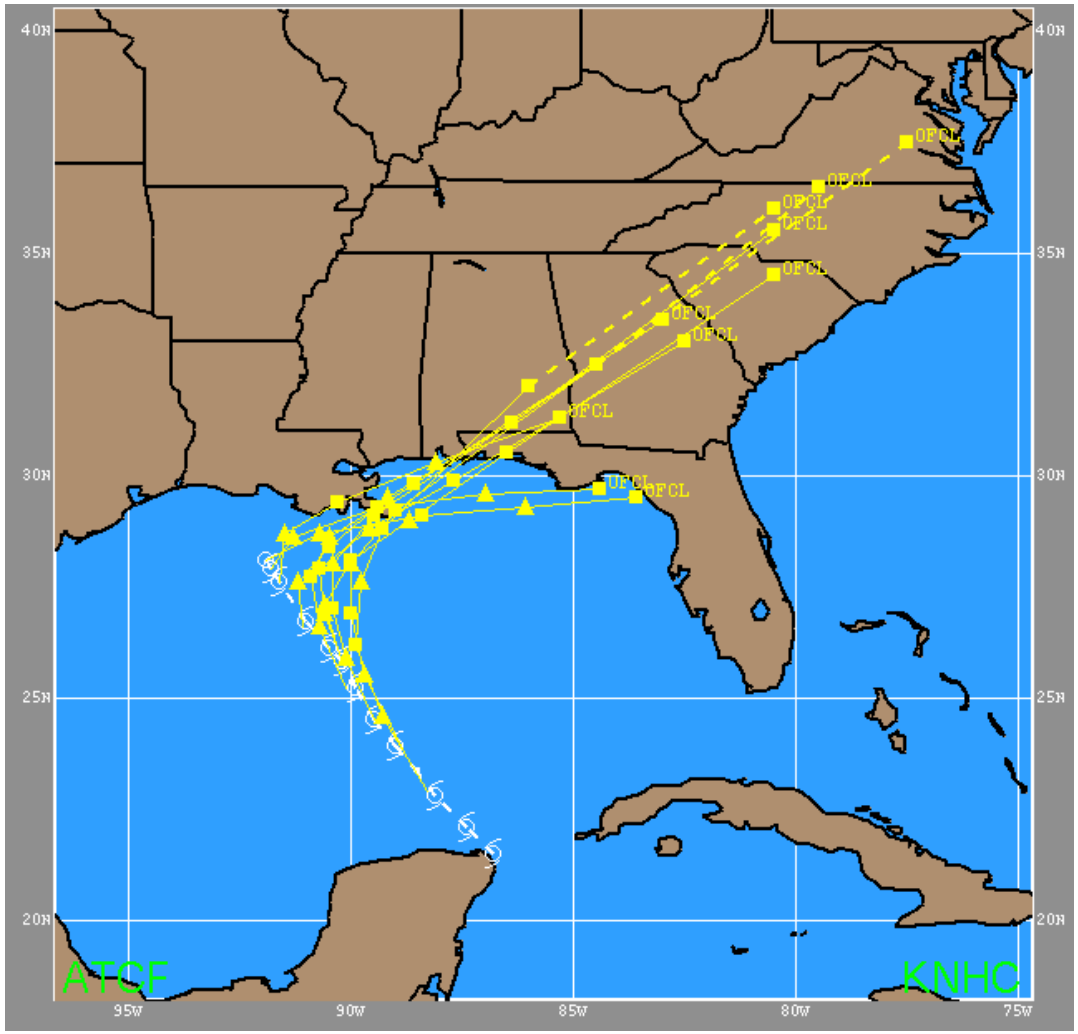

Figure 4. Selected official track forecasts (solid yellow lines, with positions indicated for 0, 12, 24, 36, 48, 72, 96, and 120 h) for Tropical Storm Karen. The best track is given by the dashed white line with positions given at 6-h intervals.