NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM KAY

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18 – 23 August 2016

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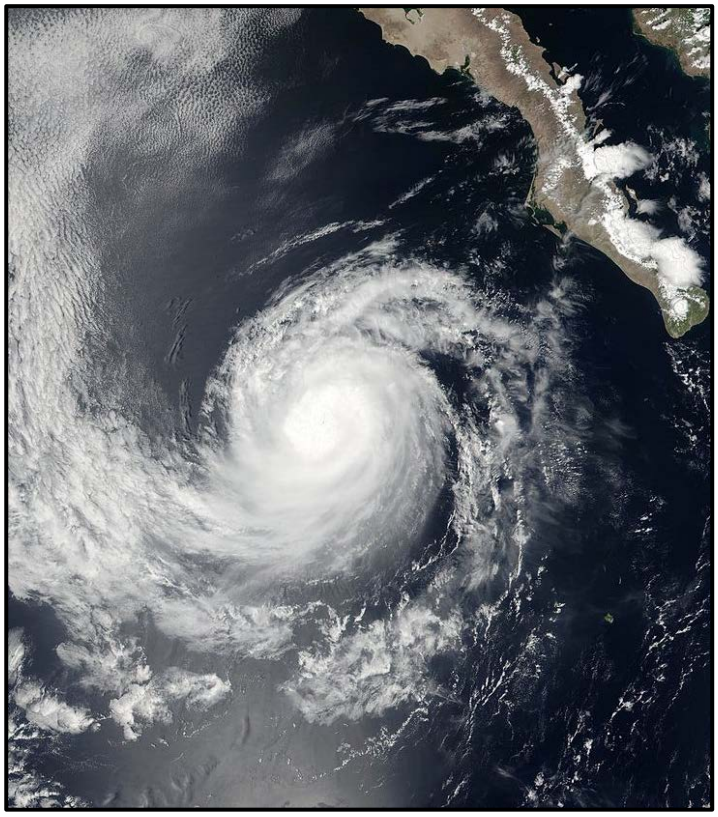

VIIRS IMAGE FROM THE SNPP SATELLITE OF TROPICAL STORM KAY NEAR PEAK INTENSITY AT 2055 UTC 21 AUGUST

Kay was a tropical storm that formed well southwest of southwestern Mexico and passed near Socorro Island. The cyclone dissipated over cool waters well west of the Baja California peninsula.

Tropical Storm Kay

18 – 23 AUGUST 2016

SYNOPTIC HISTORY

A tropical wave moved into the eastern Pacific basin on 11 August, although it was not easily trackable before this time. During the next couple of days, the ill-defined wave was producing disorganized convection as it moved westward to the south of Central America and southeastern Mexico. On 13 August the disturbance began to slow down when it reached 100˚W, and a broad cyclonic gyre formed the next day in association with the wave several hundred n mi south of Acapulco, Mexico, in an environment of moderate easterly shear. The circulation gradually became better defined over the next two days while continuing to generate disorganized convection. By 17 August the gyre finally coalesced into a well-defined low pressure system as it moved north-northwestward around the western periphery of a low-to mid-level ridge extending west-southwestward from the Gulf of Mexico. However, strong 200-850 mb easterly shear of about 25 kt was preventing the persistence of organized deep convection. The deep convection eventually increased in coverage, gaining enough persistence around 1200 UTC 18 August for the system to be classified as a tropical depression while centered about 355 n mi south-southeast of the southern tip of the Baja California peninsula. 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[1].

The depression turned northwestward and moved slowly for the next couple of days, strengthening to a tropical storm around 0600 UTC 19 August while centered about 295 n mi south of the southern tip of the Baja California peninsula. Only slight intensification occurred initially due to the cyclone’s broad wind circulation and a continuation of the easterly shear. Kay passed near Socorro Island later on 19 August, and turned west-northwestward the next day when it crossed 20ºN as the low- to mid-level ridge to the northeast strengthened and expanded westward. Microwave data revealed a mid-level eye about 25 n mi to the west of the low-level center around 1200 UTC 20 August, and Kay is estimated to have reached an intensity of 45 kt at that time. The separation between the low- to mid-level centers soon increased, with the low-level center located near the northeastern edge of a roughly circular mass of deep convection. The cyclone’s deep convection also temporarily diminished, which resulted in some weakening over the next 24 h. On 21 August the easterly shear decreased significantly, and for a short time that day the cyclone’s cloud pattern became more symmetric, with the low-level center embedded in a central mass of deep convection. The cyclone re-strengthened to an intensity of 45 kt around 1800 UTC 21 August while centered about 300 n mi west-southwest of the southern tip of the Baja California peninsula. Kay did not maintain that strength for long, however, since the cyclone reached waters of around 26°C later on 22 August, which caused weakening to commence. The

[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.

cyclone lost all of its deep convection around 1200 UTC the next day after it reached sea surface temperatures near 25°C and was ingesting a much drier and more stable air. Kay became a remnant low at that time, and the remnant low moved west-northwestward for several days before dissipating about 585 n mi west of the southern tip of the Baja California peninsula.

METEOROLOGICAL STATISTICS

Observations in Kay (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. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), 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 Kay.

Kay's estimated peak intensity of 45 kt at 1800 UTC 21 August is based on a Dvorak intensity estimate of T3.0 from TAFB and on a 1658 UTC ASCAT pass that day that indicated peak uncontaminated winds of 43 kt. It is worth noting the large discrepancy between the scatterometer data and UW-CIMSS ADT values throughout most of Kay's life cycle.

There were no ship reports of winds of tropical storm force associated with Kay. Although the center of Kay passed about 25 n mi southwest of Socorro Island on 19 August, an automated Mexican Navy station there measured maximum sustained winds well below tropical storm force, with a peak wind gust of only 29 kt.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

The genesis of Kay was poorly forecast. The wave from which Kay developed was introduced in the 48-h and extended-range portions of the Tropical Weather Outlook 54 h prior to genesis and was assessed a low chance (< 40%) of development. Although the disturbance was placed in the medium category (40% to 60 %) in the extended-range outlook 42 h prior to genesis, it was only assessed a high likelihood (> 60%) of formation 6 h prior to the development of a tropical cyclone. In the 48-h outlook, the system's genesis potential was raised to the medium category just 12 h before tropical cyclogenesis, but it did not reach the high category until the time that genesis occurred. The poor genesis forecasts followed from the mediocre quality of the

dynamical model guidance. Little to no signal for tropical cyclone formation was evident in the dynamical models 4 to 5 days in advance. Only at around 72 h prior to Kay's genesis did a consensus of the global models indicate a consistent potential for tropical cyclone formation. However, the ECMWF model erringly developed the tropical wave to the east of Kay, and as a result, predicted a much later genesis.

A verification of NHC official track forecasts for Kay is given in Table 3a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period through 48 h but greater at 72 h and 96 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The HWRF and NOAA corrected consensus HCCA models were generally superior to the official forecast and all the other guidance in forecasting Kay's track. The bulk of the track guidance outperformed the official forecast at 72 h and 96 h, although the sample size is small at both time periods. The GFS, its ensemble mean (AEMI), and the GFDL fared particularly badly at later times, since their early forecasts showed a weakness in the subtropical ridge that would have caused Kay to move much farther north and east than the best track.

A verification of NHC official intensity forecasts for Kay is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period at all forecast times through 96 h. The official forecasts correctly anticipated that Kay would not intensify much because of the broad nature of its circulation, the marginally conducive upper-level winds, and the cyclone's movement over cooler waters toward the end of the forecast period. Interestingly, early forecasts predicted a quicker demise of the storm than what occurred, which resulted in an almost doubling of the intensity errors by 72 h and 96 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The official forecast excelled above nearly all of the guidance, except for the fixed and variable multi-model consensus (ICON and IVCN). The FSU Superensemble (FSSE) and GFNI models were competitive with the official forecast at most time periods, and the LGEM did notably well beyond 36 h.

There were no coastal tropical cyclone watches or warnings associated with Kay.

Table 1. Best track for Tropical Storm Kay, 18 -23 August 2016.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
17 / 0000	12.4	106.5	1008	25	low
17 / 0600	13.1	106.9	1007	25	"
17 / 1200	13.8	107.3	1007	25	"
17 / 1800	14.6	107.8	1007	25	"
18 / 0000	15.4	108.3	1006	25	"
18 / 0600	16.2	108.8	1006	25	"
18 / 1200	16.9	109.2	1005	30	tropical depression
18 / 1800	17.4	109.7	1005	30	"
19 / 0000	17.7	110.1	1005	30	"
19 / 0600	18.0	110.6	1004	35	tropical storm
19 / 1200	18.3	111.1	1004	35	"
19 / 1800	18.6	111.5	1004	35	"
20 / 0000	19.1	111.8	1003	40	"
20 / 0600	19.5	112.1	1003	40	"
20 / 1200	19.8	112.4	1002	45	"
20 / 1800	20.1	112.7	1003	40	"
21 / 0000	20.4	113.1	1003	40	"
21 / 0600	20.7	113.7	1005	35	"
21 / 1200	21.0	114.4	1002	40	"
21 / 1800	21.3	115.0	1000	45	"
22 / 0000	21.6	115.6	1000	45	"
22 / 0600	21.8	116.2	1001	45	"
22 / 1200	21.9	116.8	1001	45	"
22 / 1800	21.9	117.5	1003	40	"
23 / 0000	21.9	118.2	1004	35	"
23 / 0600	22.1	119.0	1006	30	tropical depression
23 / 1200	22.6	119.8	1008	30	low
23 / 1800	23.2	120.6	1009	30	"
24 / 0000	23.5	121.5	1010	25	"
24 / 0600	23.7	122.5	1010	25	"
24 / 1200	23.8	123.5	1011	25	"

24 / 1800	23.9	124.5	1012	25	"
25 / 0000	23.9	125.5	1012	20	"
25 / 0600	23.8	126.6	1013	20	"
25 / 1200	23.8	127.7	1013	20	"
25 / 1800	23.7	128.7	1014	20	"
26 / 0000	23.6	129.7	1014	20	"
26 / 0600	23.5	130.7	1014	20	"
26 / 1200					dissipated
21 / 1800	21.3	115.0	1000	45	minimum pressure and maximum wind

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%)	42	54
Medium (40%-60%)	12	42
High (>60%)	0	6

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Kay. 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	**21.5**	**28.4**	**28.0**	**41.8**	114.5	273.3	
OCD5	28.6	52.6	68.7	83.2	59.3	81.6	
Forecasts	17	15	13	11	7	3	
OFCL (2011-15)	23.4	36.4	47.2	59.4	89.0	123.6	
OCD5 (2011-15)	36.6	74.2	116.5	159.7	245.6	331.1	

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Kay. 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	21.0	27.1	25.2	35.7	87.7	251.0	
OCD5	29.0	53.7	69.7	82.5	55.2	73.5	
GFSI	24.3	36.7	44.3	47.0	96.9	447.1	
GHMI	30.3	50.9	66.7	91.5	155.5	262.7	
HWFI	**20.0**	**23.9**	**24.1**	**35.0**	105.0	**156.9**	
EGRI	23.0	33.2	35.6	44.4	**68.7**	**114.2**	
EMXI	21.7	33.4	35.6	38.4	**60.9**	**111.2**	
NVGI	25.0	42.8	67.9	93.6	142.7	**177.0**	
GFNI	**20.7**	39.5	57.0	72.0	148.7	**159.8**	
CMCI	25.4	41.1	48.9	49.2	**70.9**	**126.5**	
TCON	23.0	30.1	33.0	37.2	**80.4**	**197.5**	
TVCE	**20.4**	27.6	28.8	36.7	**68.8**	**162.0**	
FSSE	21.3	30.5	33.4	39.8	**80.2**	**241.2**	
HCCA	**18.5**	**23.8**	26.4	**31.5**	**53.6**	**111.4**	
AEMI	23.9	36.6	48.4	67.6	136.8	**222.8**	
BAMS	30.2	47.5	63.8	74.1	**56.5**	**42.3**	
BAMM	32.1	47.8	61.1	69.5	**66.2**	**22.2**	
BAMD	33.2	48.9	60.0	69.1	**70.6**	**84.7**	
Forecasts	15	13	11	9	5	1	

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Kay. 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	**3.2**	**4.3**	**4.6**	**5.5**	**11.4**	**10.0**	
OCD5	4.4	6.1	5.1	3.5	7.9	10.0	
Forecasts	17	15	13	11	7	3	
OFCL (2011-15)	5.9	9.8	12.5	14.0	15.5	16.3	
OCD5 (2011-15)	7.7	12.8	16.4	18.8	21.1	20.9	

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Kay. 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	3.3	5.4	4.5	4.4	8.0	5.0	
OCD5	4.9	6.6	5.5	3.8	9.8	16.0	
HWFI	4.0	6.8	9.3	6.6	9.0	12.0	
GHMI	4.7	5.5	5.5	5.9	10.2	**4.0**	
DSHP	4.7	6.9	6.1	5.6	8.4	5.0	
LGEM	4.7	6.8	5.2	**2.6**	**6.0**	**4.0**	
ICON	3.6	**4.9**	4.8	**2.3**	**6.2**	**3.0**	
IVCN	3.6	**5.3**	5.4	**4.2**	**7.2**	6.0	
GFNI	4.1	**5.2**	**3.9**	5.0	9.2	**0.0**	
GFSI	4.1	6.1	5.5	**4.1**	9.4	6.0	
EMXI	4.3	6.1	7.3	7.9	**6.8**	9.0	
FSSE	4.0	**4.9**	**4.1**	**2.7**	8.0	5.0	
HCCA	4.1	5.9	4.6	**3.1**	**7.0**	10.0	
Forecasts	15	13	11	9	5	1	

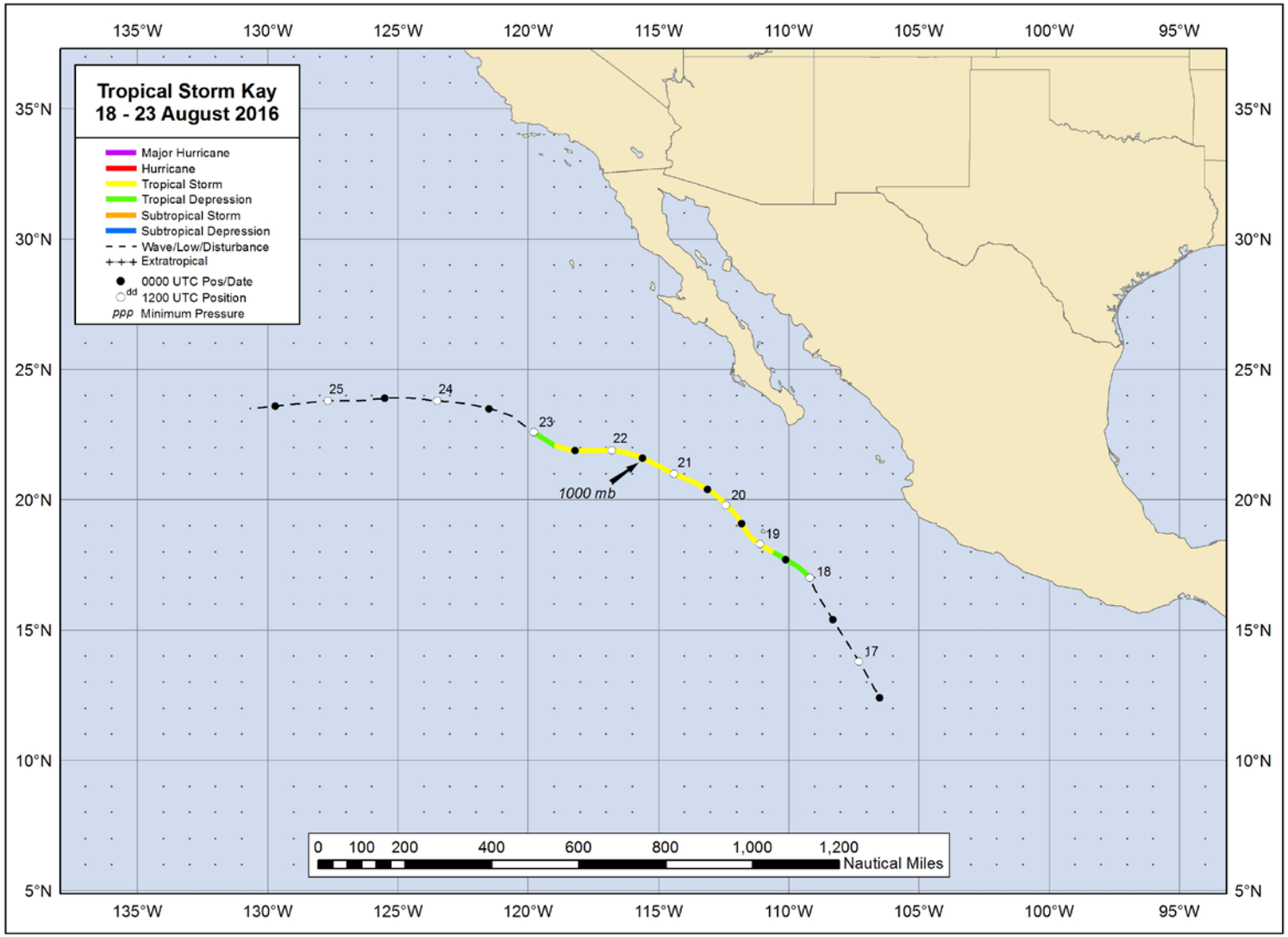

Figure 1. Best track positions for Tropical Storm Kay, 18-23 August 2016.

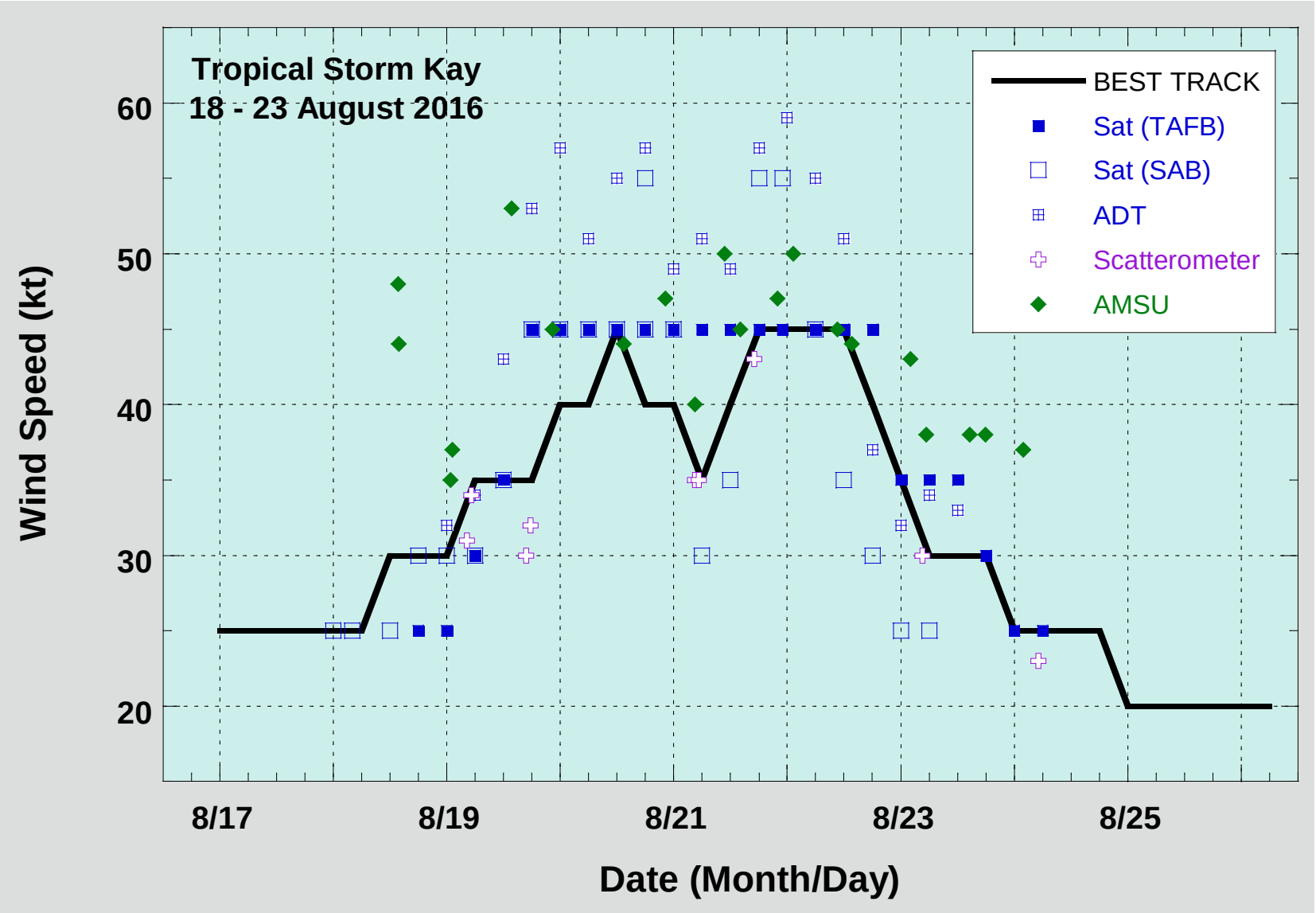

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Kay, 18-23 August 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique.

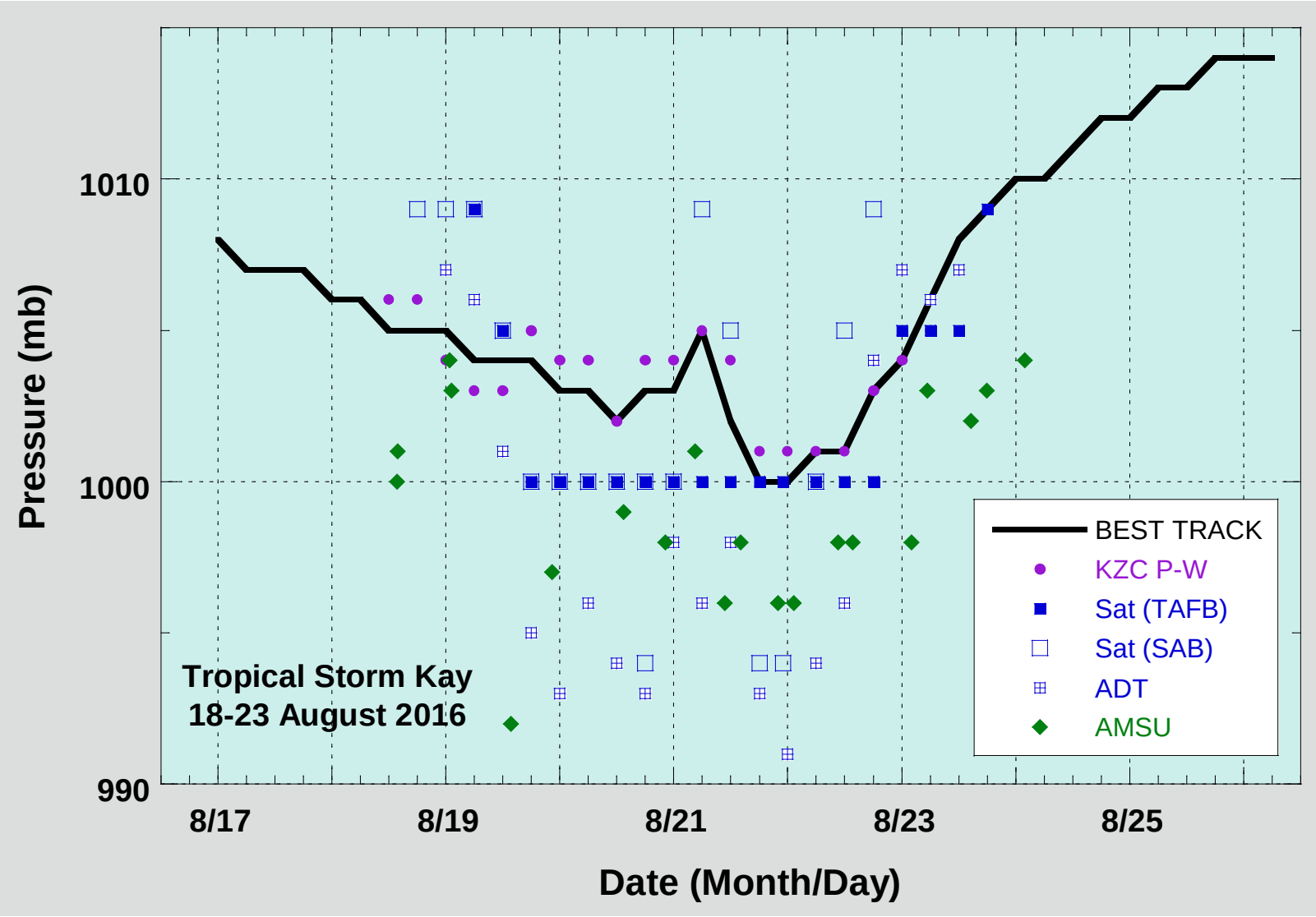

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Kay, 18-23 August 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship.