NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM KATE

(AL102021)

28 August – 1 September 2021

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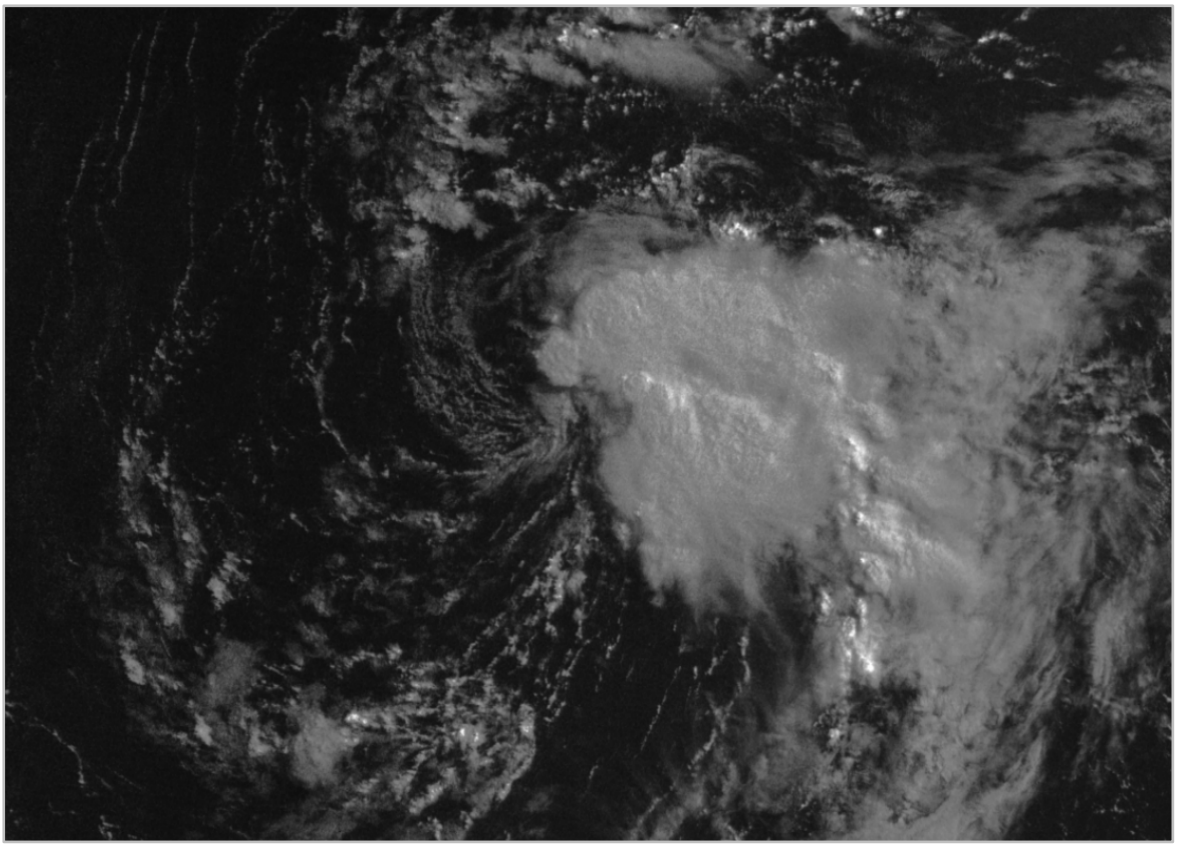
National Hurricane Center
2 December 2021



SUOMI NPP DAY-NIGHT BAND (0.7 μM) VISIBLE SATELLITE IMAGE AT 1200 UTC 30 AUGUST 2021 WHEN KATE HAD REACHED ITS PEAK INTESITY AS A TROPICAL STORM. IMAGE COURTESY OF UW-CIMSS, MADISON, WISCONSIN.

Kate was a relatively short-lived tropical cyclone that briefly became a tropical storm over the central tropical Atlantic Ocean. The storm remained over open waters and did not threaten any land areas.

Tropical Storm Kate

28 AUGUST – 1 SEPTEMBER 2021

SYNOPTIC HISTORY

Kate originated from a tropical wave that emerged off the west coast of Africa on 22 August. The wave was accompanied by a broad low-pressure system, and the large disturbance moved quickly westward along the southern periphery of a strong, deep-layer subtropical ridge over the next couple of days, passing a few hundred n mi south of the Cabo Verde Islands. A turn toward the west-northwest occurred late on 24 August, with the system maintaining a west-northwestward trajectory at 18–20 kt until early on 27 August. The disturbance then abruptly slowed down and turned northwestward as it approached a weakness in the subtropical ridge located over the central tropical Atlantic. The low-pressure system gradually became better defined, and deep convection that had previously been displaced to the east of the low steadily increased and became better organized throughout the day. It is estimated that a tropical depression formed by 0600 UTC 28 August when the system was located about 700 n mi east of the Leeward Islands. 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].

A broad mid-to-upper-level trough that induced the weakness in the subtropical ridge also produced strong vertical wind shear across the cyclone throughout most of its lifetime. The westerly to northwesterly shear hindered the intensification process despite the cyclone's well-defined circulation noted in scatterometer surface wind data and favorable sea-surface temperatures near 29° C beneath the system. Convection occurred primarily in episodic bursts near and east of the center, especially during the nighttime hours, which enabled the small cyclone to finally strengthen into a tropical storm around 0600 UTC 30 August. Kate reached its peak intensity of 40 kt 6 h later (cover photo) when the tropical storm was located about 670 n mi east-northeast of the Leeward Islands. The cyclone maintained a northward motion for the next couple of days and slowly weakened due to a combination of unfavorable shear conditions and the entrainment of very dry mid-level air (700-500-mb humidity values ≤50%). Kate weakened to a tropical depression around 1200 UTC 31 August and degenerated into a north-to-south elongated trough shortly after 1200 UTC 1 September when the system was located about 835 n mi northeast of the northern Leeward Islands. Kate's remnants moved north-northwestward and dissipated a couple of days later over the central subtropical Atlantic Ocean.

[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.

METEOROLOGICAL STATISTICS

Observations in Kate (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), objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) 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 Kate.

There were no ship or buoy reports of tropical-storm-force winds associated with Kate.

Kate's estimated peak intensity of 40 kt at 1200 UTC 30 August is based on a blend of UW-CIMSS ADT and SATCON objective satellite intensity estimates of 39 and 43 kt, respectively. This intensity estimate is supported by 1111 UTC 30 August ASCAT-A scatterometer data that showed peak winds of 36 kt, with the assumption that undersampling had occurred owing to Kate's small size. The estimated minimum pressure of 1004 mb at 1200 UTC 30 August is based on a blend of Dvorak satellite pressure estimates and the Knaff-Zehr-Courtney pressure-wind relationship.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Tropical Storm Kate.

FORECAST AND WARNING CRITIQUE

The genesis of Kate was forecast reasonably well. Table 2 provides the number of hours in advance of formation associated with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. The low-pressure system that developed into Kate was first mentioned in the Atlantic TWO with a medium chance (40-60%) of formation during the next 5 days 108 h prior to genesis (the low category [<40%] was skipped in lieu of introducing the Kate disturbance with a medium chance of development). The 5-day probabilities reached the high category (>60%) 36 h prior to Kate forming. The 2-day genesis probabilities were equally as impressive as the 5-day forecasts, with low, medium, and high chances of formation predicted 108 h, 42 h, and 24 h, respectively, before Kate's genesis occurred.

A verification of NHC official track forecasts (OFCL) for Kate is given in Table 3a. The official forecast mean errors were somewhat higher than the 5-yr means at all forecast times except 96 h. However, the OCD5 errors were considerably lower than their 5-yr means at most

forecast times, indicating that Kate's track was less difficult than average to predict. The larger-than-average track forecast errors through 72 h were due to a distinct right-of-track bias in the first several track forecasts; those forecasts anticipated the tropical cyclone to move in a north-northeasterly direction, vice a northerly to north-northwesterly direction, owing to the westerly shear impinging on the system (Fig. 4). A homogeneous comparison of the official forecast track errors with selected guidance models is given in Table 3b. OFCL track forecasts were bested at all forecast times, except at 96 h, by nearly all of the consensus aids, as well as the ECMWF (EMXI) and Canadian (CMCI) global models. The EMXI model performed the best of all of the available track forecast guidance, beating the OFCL forecasts at all forecast periods.

A verification of NHC official intensity forecasts (OFCL) for Kate is given in Table 4a. Unlike the track forecasts, the official NHC intensity forecast errors were well below the 5-yr means at all forecast times. In fact, OFCL intensity forecast errors were more than 50% better than average in the 24-96-h forecast period, which was due to NHC forecasters realizing early on that Kate would remain in a strongly sheared environment and not strengthen much as a result. OCD5 intensity forecast errors were noticeably lower than the 5-yr means at all forecast times, an indication that Kate's intensity was easier than normal to forecast. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b and forecast skill against OCD5 is illustrated in Fig. 5. None of the intensity guidance outperformed OFCL at all forecast times. The Decay-SHIPS (DSHP) model, the corrected-consensus model HCCA (HFIP Corrected Consensus Approach), and the simple-consensus models ICON, IVCN, and IVDR slightly outperformed the OFCL intensity forecasts through 72 h, while none of the model guidance bested OFCL at 96 h.

No coastal watches and warnings were required for Kate.

ACKNOWLEDGEMENTS

Special thanks to Senior Hurricane Specialist John Cangialosi for producing the track map (Fig. 1).

Table 1. Best track for Tropical Storm Kate, 28 August – 1 September 2021.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
27 / 1200	13.1	47.3	1009	25	low
27 / 1800	13.3	48.4	1009	25	"
28 / 0000	13.5	49.5	1009	25	"
28 / 0600	13.7	49.8	1008	30	tropical depression
28 / 1200	14.5	50.0	1008	30	"
28 / 1800	15.2	50.0	1008	30	"
29 / 0000	16.2	49.9	1008	30	"
29 / 0600	17.3	50.0	1008	30	"
29 / 1200	18.4	50.2	1008	30	"
29 / 1800	19.2	50.3	1008	30	"
30 / 0000	19.8	50.5	1008	30	"
30 / 0600	20.5	50.6	1006	35	tropical storm
30 / 1200	21.3	50.8	1004	40	"
30 / 1800	22.1	50.9	1006	35	"
31 / 0000	22.6	50.9	1006	35	"
31 / 0600	22.8	50.9	1006	35	"
31 / 1200	23.2	50.9	1007	30	tropical depression
31 / 1800	23.9	50.9	1007	30	"
01 / 0000	24.6	51.2	1007	30	"
01 / 0600	25.3	51.5	1008	30	"
01 / 1200	26.6	52.3	1009	30	"
01 / 1800					dissipated
30 / 1200	21.3	50.8	1004	40	maximum wind and minimum pressure

Table 2. Number of hours in advance of formation of Kate 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%)	108	--
Medium (40%-60%)	42	108
High (>60%)	24	36

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Kate, 28 August – 1 September 2021. 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	60	72	96	120
OFCL	27.4	45.5	64.7	88.2	108.1	108.7	**94.6**	
OCD5	47.4	83.2	114.0	144.3	191.8	236.3	542.4	
Forecasts	16	14	12	10	8	6	2	
OFCL (2016-20)	23.9	36.3	49.1	63.9	79.0	94.1	128.1	169.7
OCD5 (2016-20)	45.1	97.2	157.2	216.7	271.1	325.4	414.4	490.0

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Kate, 28 August – 1 September 2021. 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	60	72	96	120
OFCL	27.8	47.3	67.2	89.2	108.1	108.7	94.6	
OCD5	50.0	85.7	119.2	156.5	191.8	236.3	542.4	
GFSI	**26.2**	48.7	76.6	123.1	156.3	165.0	202.8	
EMXI	**27.5**	**40.9**	**56.3**	**71.6**	**81.0**	**73.9**	**26.1**	
CMCI	33.1	**43.6**	**55.6**	**69.4**	**87.6**	**106.0**	126.8	
NVGI	36.0	72.2	108.8	152.2	171.2	141.9	184.1	
AEMI	**24.8**	**40.2**	**59.7**	95.1	125.0	149.1	158.0	
HWFI	**26.5**	51.0	75.2	99.9	114.7	114.8	158.3	
HMNI	**26.5**	**42.5**	**66.2**	104.2	145.2	168.8	167.7	
CTCI	31.6	59.9	93.1	135.0	165.0	195.2	186.5	
HCCA	**25.8**	**46.7**	**67.0**	91.1	108.8	117.0	**92.5**	
TVCX	**25.3**	**40.8**	**58.4**	**80.5**	**95.5**	**97.6**	100.2	
GFEX	**25.6**	**41.9**	**61.4**	89.9	114.5	116.9	111.8	
TVCA	**24.8**	**42.2**	**60.7**	**83.6**	**100.3**	**104.1**	118.8	
TVCE	**25.1**	**42.5**	**60.0**	**84.8**	**105.7**	114.1	123.0	
TVDG	**24.2**	**41.4**	**57.4**	**79.0**	**94.4**	**95.3**	117.2	
TABD	62.3	147.7	223.1	299.4	347.0	387.8	578.6	
TABM	43.4	92.7	136.4	187.1	222.0	260.1	401.6	
TABS	35.4	69.8	101.3	137.1	164.6	201.5	392.0	
Forecasts	15	13	11	9	8	6	2	

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Kate, 28 August – 1 September 2021. 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	60	72	96	120
OFCL	**3.1**	**3.6**	**3.3**	**4.0**	**6.2**	**6.7**	**0.0**	
OCD5	4.3	7.7	10.2	13.1	13.4	16.7	21.5	
Forecasts	16	14	12	10	8	6	2	
OFCL (2016-20)	5.4	8.0	9.6	10.9	11.5	12.1	13.3	14.5
OCD5 (2016-20)	7.0	11.0	14.3	16.8	18.3	19.7	21.7	23.0

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Kate, 28 August – 1 September 2021. 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	60	72	96	120
OFCL	3.3	3.5	3.2	3.3	6.2	6.7	0.0	
OCD5	3.7	6.5	8.5	11.1	13.4	16.7	21.5	
GFSI	4.3	5.8	6.5	6.9	7.1	8.8	12.5	
EMXI	4.1	4.9	6.4	8.3	6.9	**4.3**	3.0	
CMCI	3.4	4.7	4.4	**2.7**	**3.4**	**6.2**	5.0	
NVGI	**3.0**	3.8	3.8	5.3	7.8	11.5	0.0	
HWFI	4.5	4.0	**2.8**	5.1	9.0	16.2	10.5	
HMNI	**2.5**	3.5	6.5	9.2	12.1	16.0	3.0	
CTCI	4.3	5.1	5.7	7.0	13.9	24.5	17.0	
AEMI	4.6	6.5	7.3	7.3	**5.9**	**4.0**	6.0	
HCCA	**2.9**	**2.8**	**2.7**	5.6	8.9	14.2	3.5	
DSHP	**2.7**	**3.2**	**2.8**	3.4	**5.4**	**6.0**	4.5	
LGEM	3.4	4.5	5.0	6.3	**4.4**	**3.2**	1.5	
ICON	**2.8**	**2.0**	**2.1**	3.6	**5.9**	9.7	2.0	
IVCN	**2.9**	**2.6**	**2.7**	3.8	7.1	12.0	3.5	
IVDR	**3.2**	**2.6**	**2.8**	4.1	7.9	13.2	4.0	
Forecasts	15	13	11	9	8	6	2	

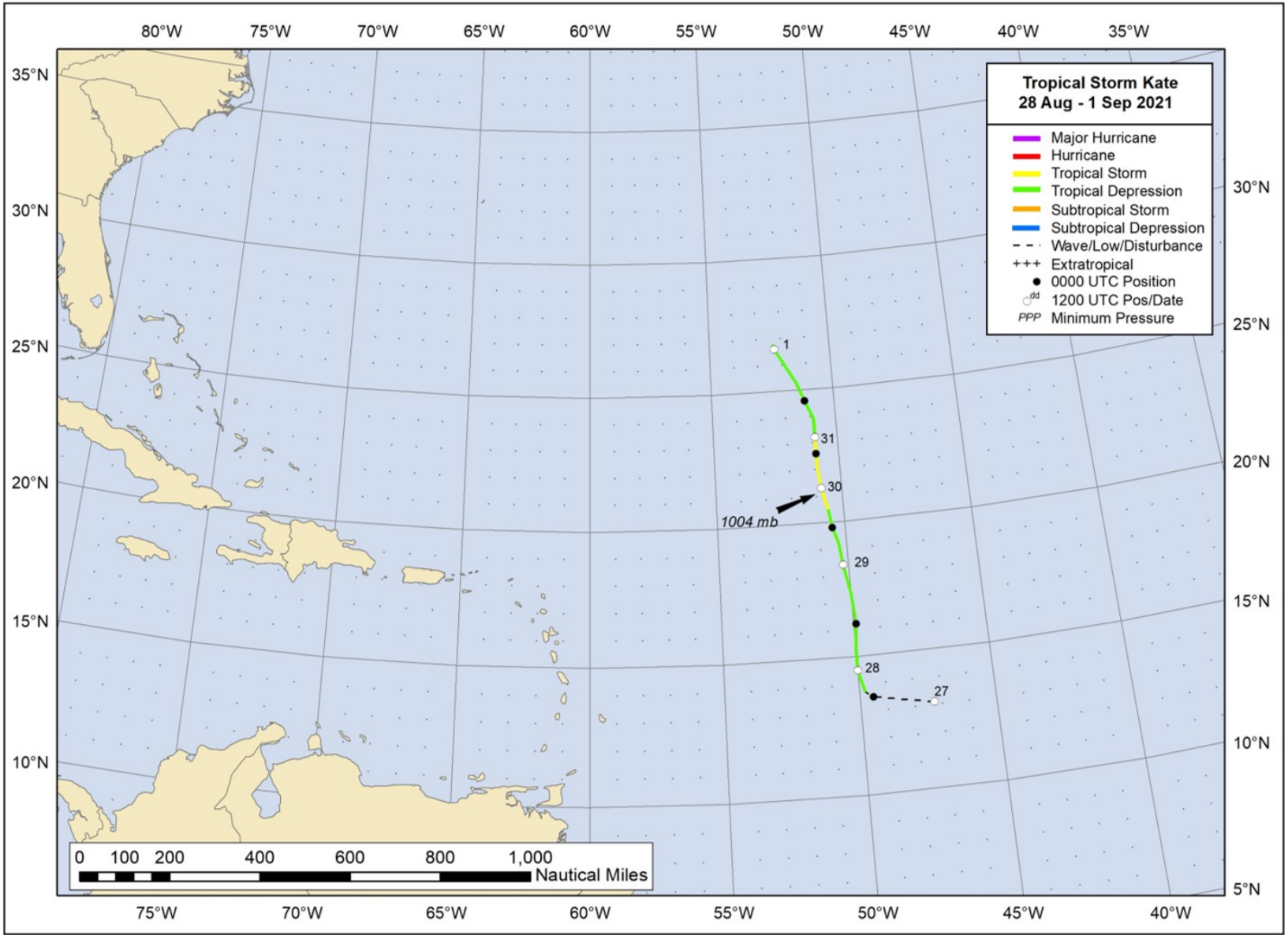


Figure 1. Best track positions for Tropical Storm Kate, 28 August – 1 September 2021.

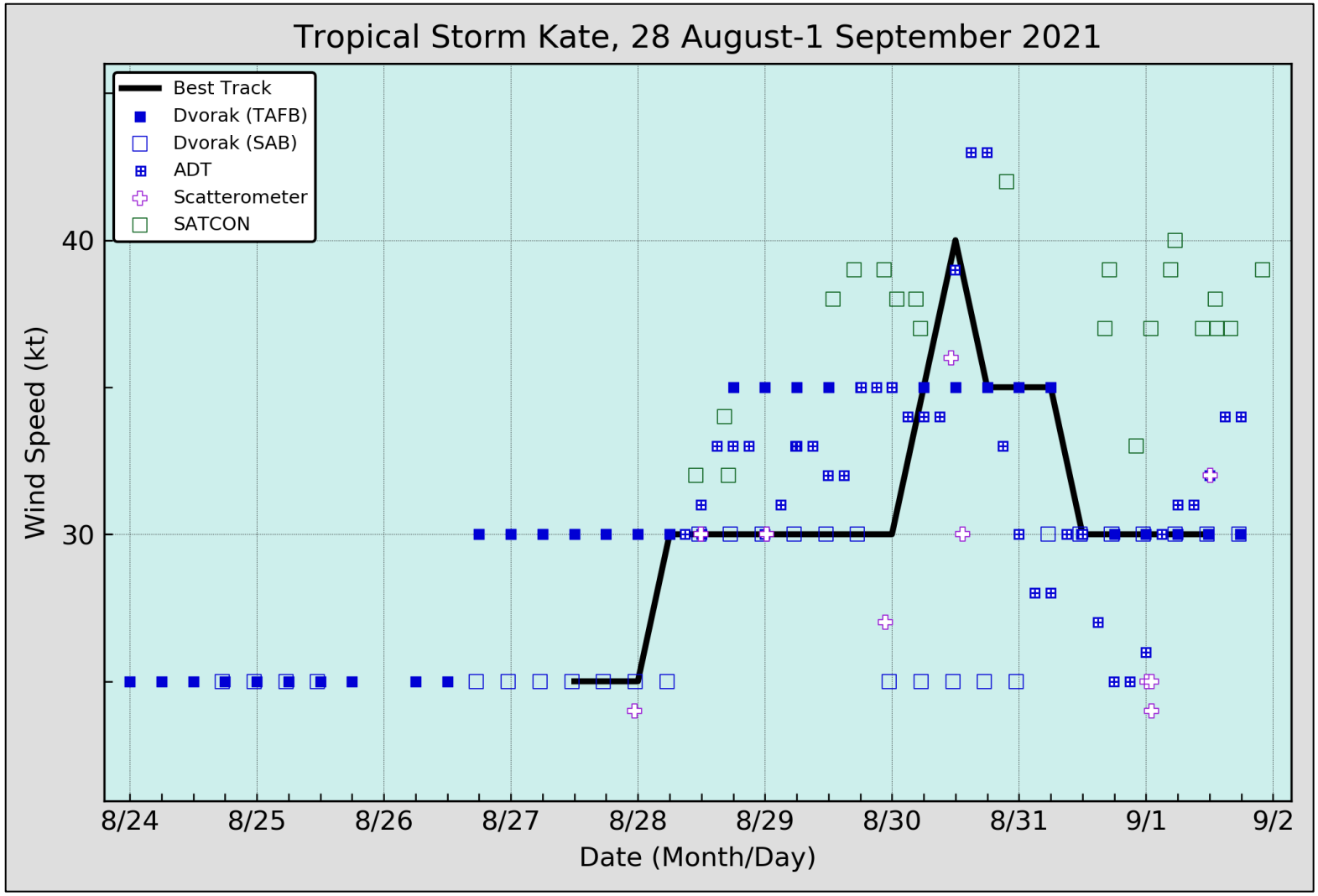


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Kate, 28 August – 1 September 2021. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

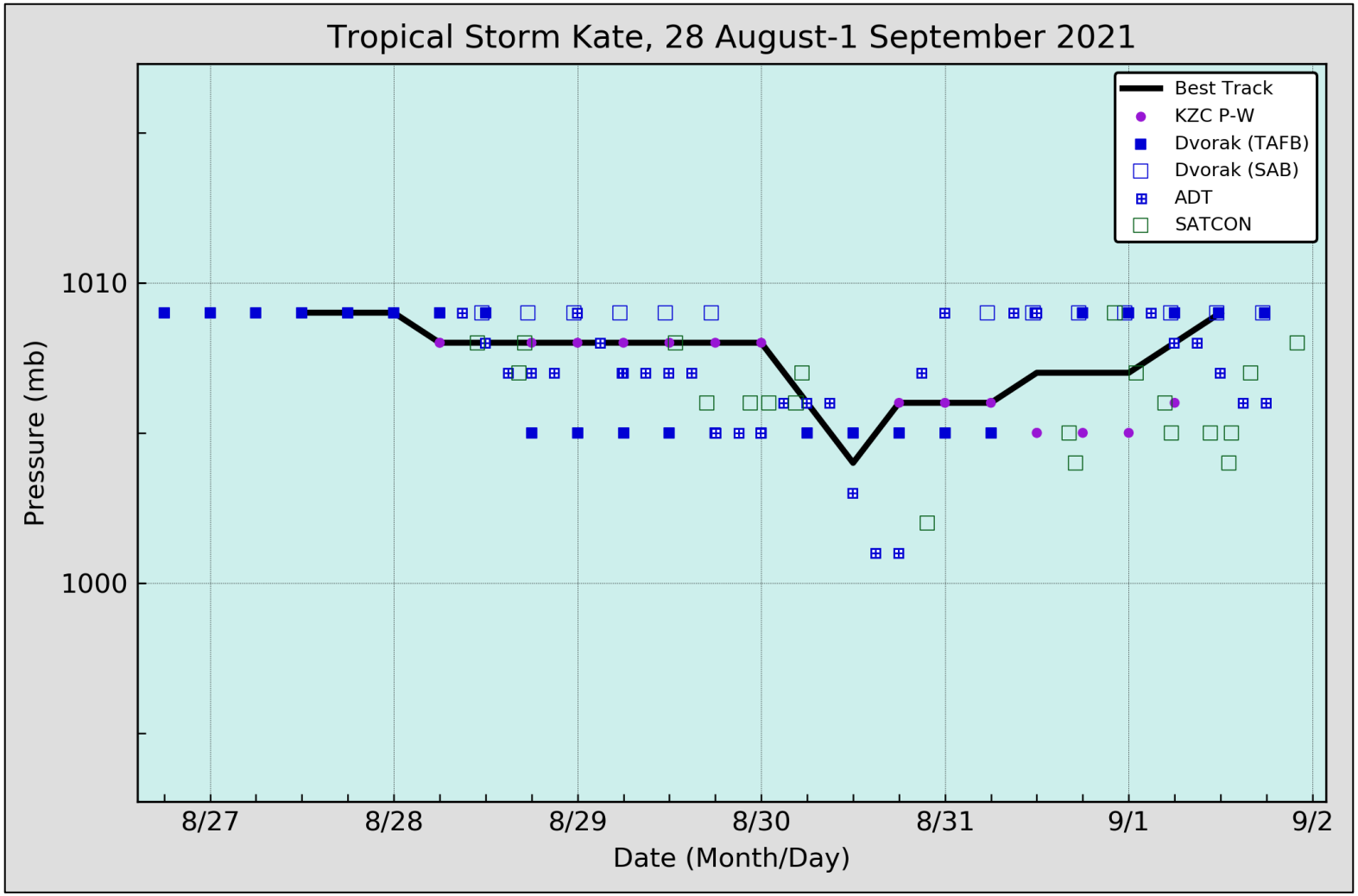


Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Kate, 28 August – 1 September 2021. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

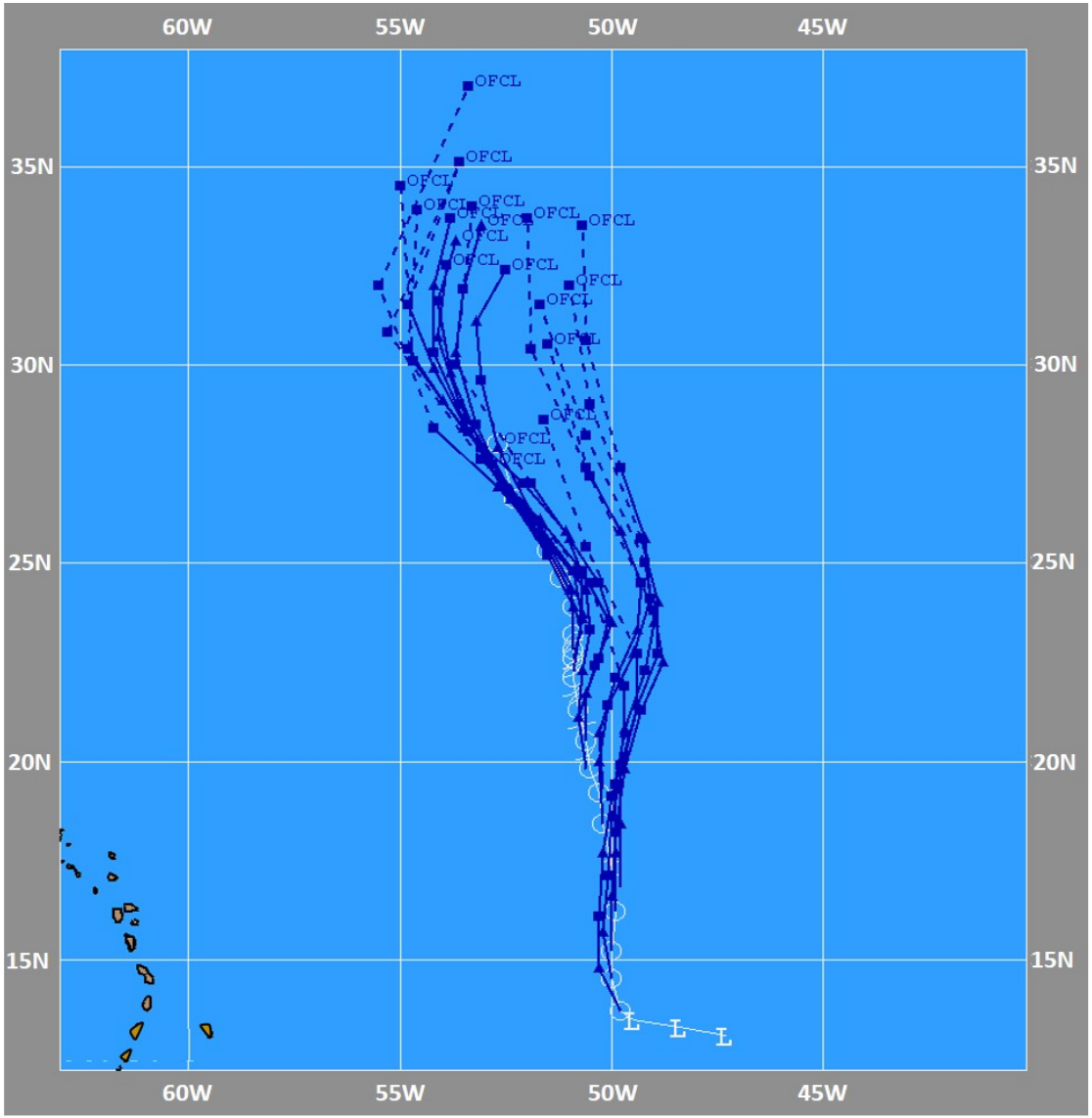


Figure 4. NHC 120-h official track forecasts (OFCL solid and dashed blue lines) for Tropical Storm Kate, 28 August – 1 September 2021. Kate's 'best track' is depicted by the solid white line with status symbols displayed at 6-h intervals.

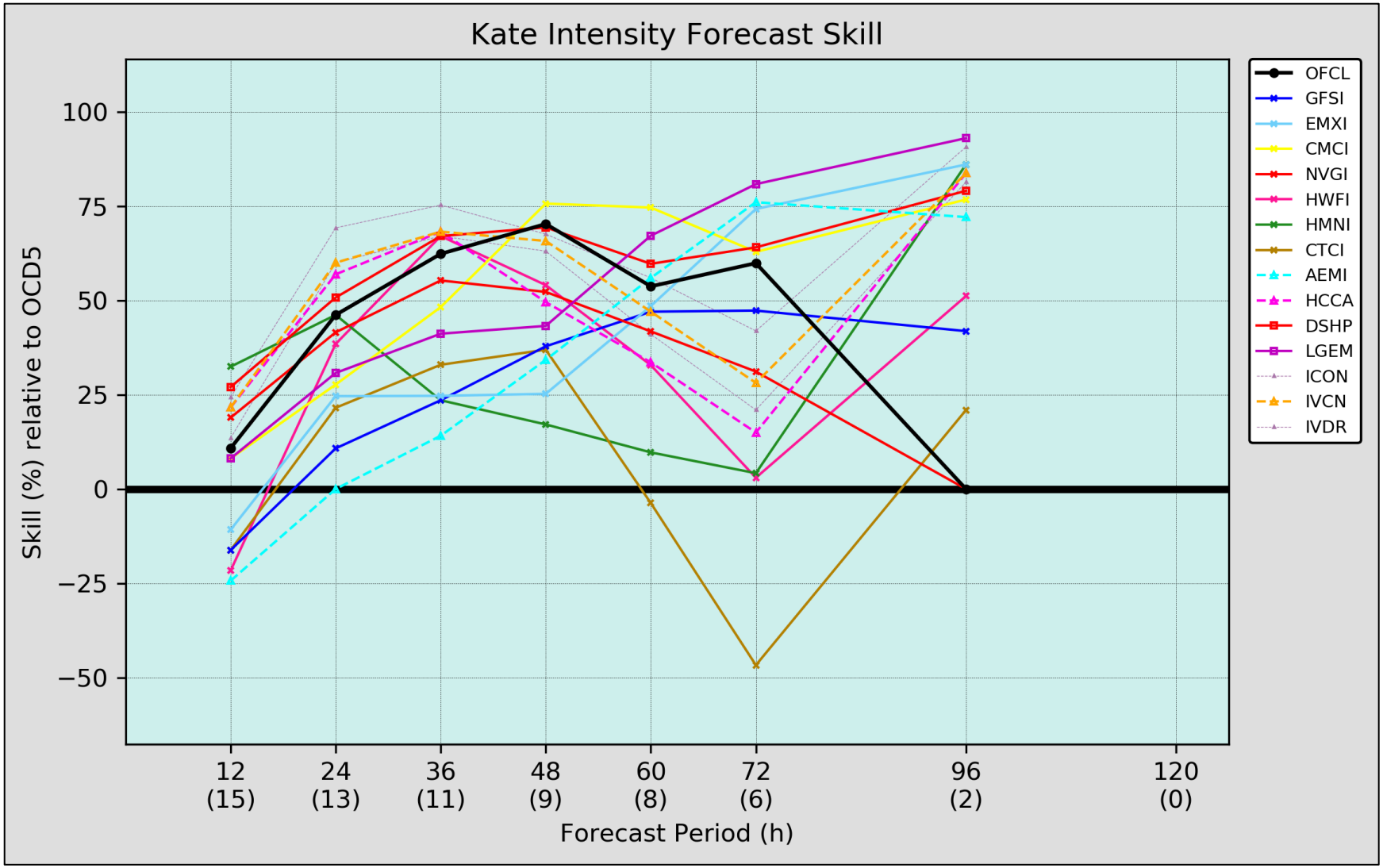


Figure 5. Intensity forecast skill of the official forecasts (OFCL) and selected models for Tropical Storm Kate, 28 August – 1 September 2021.