NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE KIKO

(EP132019)

12–24 September 2019

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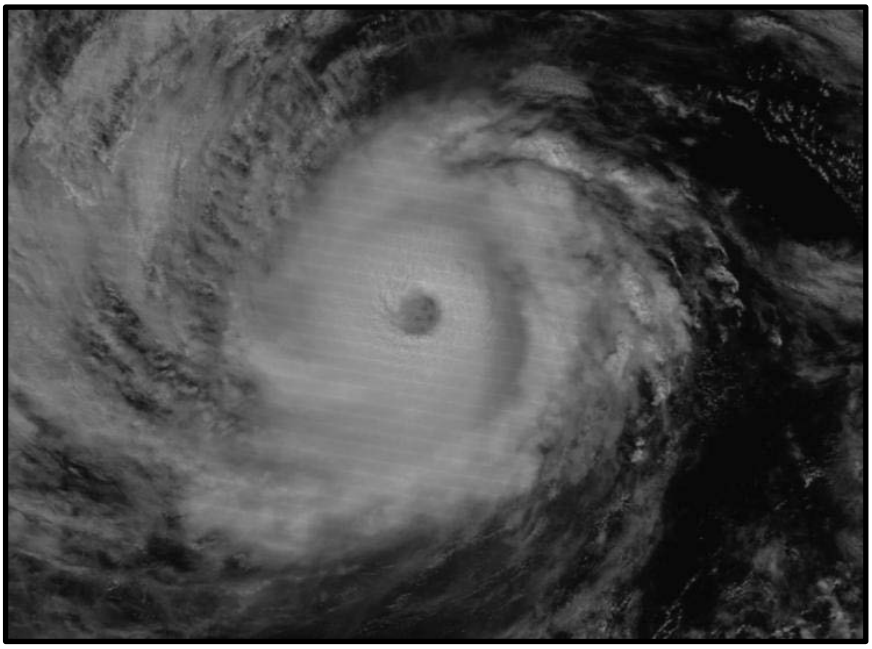
10 January 2020



SUOMI NPP/VIIRS NIGHTTIME IMAGE OF HURRICANE KIKO AT 0942 UTC 15 SEPTEMBER, SHORTLY BEFORE IT REACHED ITS PEAK INTENSITY. IMAGE COURTESY OF NASA WORLDVIEW.

Kiko was a long-lasting eastern North Pacific tropical cyclone that rapidly intensified and became a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale). It then quickly weakened and meandered across the western half of the eastern Pacific basin for another week as a tropical storm. Kiko became a remnant low shortly before it reached the central Pacific and dissipated well east of Hawaii.

Hurricane Kiko

12–24 SEPTEMBER 2019

SYNOPTIC HISTORY

The origins of Kiko can be traced to a tropical wave that moved off the west coast of Africa on 27 August (Fig. 1). The wave produced sporadic convection while it crossed the Atlantic and northern South America at low latitude through 6 September. Convective activity associated with the wave increased but remained disorganized when it emerged over the eastern North Pacific on 7 September, and the forward speed of the wave decreased around that same time. A broad area of low pressure developed by 9 September as the wave continued to move slowly westward across the eastern portion of the basin. The low gradually consolidated over the next few days while its convection became better organized. A well-defined surface circulation with organized deep convection developed by 0600 UTC 12 September, marking the formation of a tropical depression about 375 n mi southwest of Manzanillo, Mexico. The "best track" chart of the tropical cyclone's path is given in Fig. 2, with the wind and pressure histories shown in Figs. 3 and 4, respectively. The best track positions and intensities are listed in Table 1[1].

An extensive mid-level ridge centered over the southeastern United States steered the depression initially west-northwestward after genesis. The system was still fairly disorganized, but it nonetheless strengthened and became a tropical storm by 1800 UTC 12 September. A 24-h period of arrested development followed, during which Kiko's center re-formed at least once. However, the cyclone soon developed a compact inner core, and a period of rapid intensification ensued. Kiko strengthened by an estimated 75 kt during the 36-h period beginning at 0000 UTC 14 September. The hurricane reached its peak intensity of 115 kt (category 4 on the Saffir-Simpson hurricane wind scale) around 1200 UTC 15 September when it was located about 710 n mi west-southwest of the southern tip of the Baja California peninsula (cover image). Kiko turned westward during this time as the aforementioned ridge amplified over Mexico and the eastern Pacific.

After reaching its peak intensity, the hurricane quickly weakened due to a combination of moderate northeasterly wind shear and dry mid-level air that had wrapped into the cyclone's circulation, and by 1200 UTC 17 September Kiko was once again a tropical storm. During the 7 days that followed, oscillations in both the strength of the ridge and the vertical depth of Kiko caused the tropical storm to weave its way slowly across the western half of the eastern North Pacific. Each time Kiko weakened and became vertically shallow, it moved westward to southwestward with the low- to mid-level flow. However, upper-level winds across the tropical storm became southwesterly by 19 September, and this resulted in a deep-layer steering flow with a northward component. Kiko briefly got better organized and turned north-northwestward

[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.

in response to the upper-level winds on 20 September, but a combination of strong wind shear and colder sea surface temperatures (SSTs) caused the tropical storm to quickly weaken and once again turn southwestward about a day later.

Following another northwestward turn on 23 September, Kiko finally weakened for good as it once again encountered colder SSTs and a dry and stable surrounding environment. The cyclone lost all of its deep convection by 1800 UTC 24 September and became a remnant low just 45 n mi east of the eastern boundary of the central North Pacific basin. The remnant low turned westward after it moved over the central Pacific and continued on that general heading until it dissipated well east of Hawaii about two days later.

METEOROLOGICAL STATISTICS

Observations in Kiko (Figs. 3 and 4) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Central Pacific Hurricane Center (PHFO), and the Satellite Analysis Branch (SAB). Objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates were provided by 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 Kiko.

Kiko's peak intensity is based on TAFB and ADT Dvorak intensity estimates of 115 kt at 1200 UTC and 1800 UTC 15 September. The minimum pressure of 950 mb is based on the Knaff-Zehr-Courtney pressure-wind relationship.

There were no ship or buoy observations of tropical-storm-force winds associated with Hurricane Kiko.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Hurricane Kiko.

FORECAST AND WARNING CRITIQUE

The genesis of Kiko was forecast quite well. The wave from which Kiko developed was introduced in the Tropical Weather Outlook with a low (< 40%) chance of development within 5 days 126 h prior to genesis (Table 2). The 5-day forecast reached the high category (> 60%)

84 h before genesis. The 48-h forecasts were also good. The 2-day NHC forecasts reached the low, medium (40–60%), and high categories 84, 66, and 36 h before the formation of the tropical depression, respectively.

A verification of NHC official track forecasts for Hurricane Kiko is given in Table 3a. Official forecast track errors were generally near the mean official errors for the previous 5-yr period. Interestingly, although Kiko's weaving track was fairly unusual for the eastern Pacific, climatology and persistence (OCD5) errors were also near the 5-yr mean. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. All of the multi-model consensus aids performed fairly well and had errors near or slightly lower than the NHC official forecast through 72 h. The consensus aids were generally comparable to or slightly worse than the NHC official forecast at 96 and 120 h. The regional hurricane models (HWFI, HMNI) had fairly low errors through 36 h, while the global UKMET (EGRI) model was the best-performing individual model from 48–96 h. In general, the NHC forecasters noted that the model spread was quite high in many of the forecasts, but no single model was able to consistently outperform the others.

A verification of NHC official intensity forecasts for Hurricane Kiko is given in Table 4a. Official forecast intensity errors were higher than the mean official errors for the previous 5-yr period, except at 120 h. Notably, the NHC official intensity forecasts were not skillful relative to OCD5 at 72 h and beyond. There were two primary periods that caused the high errors of the NHC official intensity forecasts. The first was the rapid intensification and subsequent rapid weakening of Kiko. Although NHC forecasts expected Kiko to strengthen almost immediately from its time of formation, the timing and extent of the rapid intensification and rapid weakening was not well anticipated (Fig. 5a). The second factor was a persistent high bias in the NHC intensity forecasts while Kiko meandered westward as a tropical storm. Every NHC forecast between 1800 UTC 17 September (when Kiko weakened to tropical-storm strength) and 1800 UTC 19 September indicated that Kiko would become a hurricane again, however the cyclone's intensity never exceeded 55 kt. The NHC forecasts from 20 September onward correctly anticipated that Kiko's strength would not change significantly.

A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Similar to the official forecasts, none of the intensity guidance had skill relative to climatology and persistence (OCD5) at 96 or 120 h. Most of the models fared better for the 48 h and shorter forecasts. The GFS in particular was nearly as skillful as the consensus aids TVCE, HCCA and FSSE at 36 h and 48 h. The models did not accurately capture the initial rapid intensification and weakening of Kiko (Fig. 5b–d) and this undoubtedly influenced the NHC forecasts. During Kiko's extended period as a tropical storm between 18–24 September, the regional hurricane models HWFI and HMNI had an extreme high bias and even forecast the cyclone to re-intensify to major hurricane strength (Fig. 5c, d). This contributed greatly to the high bias of the NHC forecasts. The statistical-dynamical guidance was better during that period and had very little bias (Fig. 5b).

There were no coastal watches or warnings associated with Kiko.

Table 1. Best track for Hurricane Kiko, 12–24 September, 2019. Best track points for the remnant low stage west of 140°W in the central Pacific basin were provided by the Central Pacific Hurricane Center.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
12 / 0600	15.2	109.5	1007	25	tropical depression
12 / 1200	15.6	110.6	1006	30	"
12 / 1800	15.9	111.5	1004	35	tropical storm
13 / 0000	16.2	112.3	1004	35	"
13 / 0600	16.4	113.1	1004	35	"
13 / 1200	16.6	114.0	1004	35	"
13 / 1800	16.8	114.9	1004	35	"
14 / 0000	17.0	115.8	1003	40	"
14 / 0600	17.2	116.8	1000	50	"
14 / 1200	17.2	117.8	992	60	"
14 / 1800	17.0	118.8	985	75	hurricane
15 / 0000	16.9	119.6	970	95	"
15 / 0600	16.9	120.3	958	105	"
15 / 1200	17.0	120.9	950	115	"
15 / 1800	17.2	121.6	950	115	"
16 / 0000	17.3	122.3	954	110	"
16 / 0600	17.3	122.9	963	100	"
16 / 1200	17.3	123.4	971	90	"
16 / 1800	17.3	123.8	974	85	"
17 / 0000	17.3	124.1	982	75	"
17 / 0600	17.2	124.4	985	70	"
17 / 1200	17.1	124.6	990	60	tropical storm
17 / 1800	16.9	124.9	995	50	"
18 / 0000	16.6	125.3	1002	45	"
18 / 0600	16.3	125.8	1002	45	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
18 / 1200	16.0	126.4	1001	50	"
18 / 1800	15.8	127.0	998	55	"
19 / 0000	15.8	127.5	998	55	"
19 / 0600	15.8	128.0	998	55	"
19 / 1200	15.9	128.5	1000	50	"
19 / 1800	16.1	129.1	1002	45	"
20 / 0000	16.4	129.6	1002	45	"
20 / 0600	16.9	129.9	1002	45	"
20 / 1200	17.4	130.0	999	50	"
20 / 1800	17.8	130.1	999	50	"
21 / 0000	18.1	130.2	996	55	"
21 / 0600	18.3	130.5	996	55	"
21 / 1200	18.3	130.9	999	50	"
21 / 1800	18.2	131.4	1003	45	"
22 / 0000	17.8	132.0	1005	40	"
22 / 0600	17.3	132.6	1006	35	"
22 / 1200	16.7	133.1	1006	35	"
22 / 1800	16.1	133.6	1006	35	"
23 / 0000	15.6	134.1	1006	35	"
23 / 0600	15.4	134.9	1006	35	"
23 / 1200	15.5	135.7	1002	45	"
23 / 1800	15.8	136.5	1000	50	"
24 / 0000	16.4	137.1	1000	50	"
24 / 0600	17.0	137.7	1002	45	"
24 / 1200	17.4	138.4	1004	40	"
24 / 1800	18.0	139.3	1006	30	low
25 / 0000	18.7	140.1	1007	30	"
25 / 0600	19.3	140.8	1010	25	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
25 / 1200	19.2	141.8	1011	25	"
25 / 1800	19.1	142.6	1012	25	"
26 / 0000	19.1	143.5	1012	25	"
26 / 0600	18.9	144.4	1013	20	"
26 / 1200	18.6	145.2	1013	20	"
26 / 1800	18.7	146.0	1014	20	"
27 / 0000					dissipated
15 / 1200	17.0	120.9	950	115	Maximum winds and minimum pressure

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%)	84	126
Medium (40%-60%)	66	102
High (>60%)	36	84

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Kiko. 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	**19.1**	**28.2**	**39.4**	53.0	80.3	108.8	135.1
OCD5	37.2	76.7	118.6	159.2	231.5	263.2	327.0
Forecasts	47	45	43	41	37	33	29
OFCL (2014-18)	21.1	32.2	41.8	51.8	75.7	101.1	133.7
OCD5 (2014-18)	34.0	69.7	109.0	148.4	223.5	285.5	356.7

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Kiko. 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	18.3	28.0	38.5	53.2	82.5	106.8	133.1
OCD5	38.6	80.8	128.6	168.5	246.8	278.8	342.9
HCCA	**16.0**	**21.7**	**28.5**	**39.0**	**69.2**	109.1	143.8
FSSE	**16.5**	**23.5**	**34.2**	**47.4**	**74.8**	109.9	136.5
TVCE	**16.0**	**21.9**	**33.0**	**46.4**	**80.2**	116.8	142.0
TVCX	**16.7**	**23.9**	**33.7**	**45.3**	**72.5**	**103.6**	134.5
TVDG	**16.4**	**23.3**	**32.9**	**42.9**	**70.7**	107.3	138.8
GFEX	**17.3**	**25.7**	**37.2**	**50.0**	**74.2**	**102.9**	136.5
AEMI	20.3	35.1	50.7	67.4	111.5	156.3	183.4
GFSI	**17.4**	**23.8**	38.8	63.5	124.2	193.6	223.2
EMXI	21.6	34.6	51.6	65.5	96.9	133.8	153.4
EGRI	21.7	29.7	**38.3**	**47.4**	**74.3**	122.3	203.0
NVGI	38.4	64.0	84.1	103.6	141.3	177.1	240.2
HWFI	19.6	**23.9**	**32.4**	58.2	116.5	166.1	181.1
HMNI	**16.5**	**23.1**	**38.4**	65.7	125.4	191.8	216.3
CTCI	**18.0**	**27.2**	45.1	69.1	135.4	197.4	216.8
TABS	36.3	72.5	105.1	130.8	190.3	259.0	293.0
TABM	29.4	45.7	70.0	92.8	140.1	194.7	240.0
TABD	27.5	34.7	54.0	68.0	99.2	171.0	280.7
Forecasts	28	26	26	25	22	20	17

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Kiko. 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	6.4	12.0	14.7	16.5	19.6	17.3	**14.1**
OCD5	8.1	14.5	17.7	18.5	16.9	11.3	7.4
Forecasts	47	45	43	41	37	33	29
OFCL (2014-18)	6.1	10.0	12.2	13.7	15.5	15.4	15.7
OCD5 (2014-18)	7.9	13.1	16.7	19.2	21.8	22.9	22.1

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Kiko. 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	6.0	11.4	13.4	16.3	20.0	16.8	12.4
OCD5	7.7	13.8	17.3	18.6	**17.5**	**10.7**	**6.2**
HCCA	7.1	**11.2**	**11.8**	**13.0**	**19.6**	18.3	15.1
FSSE	7.1	**11.2**	**12.1**	**13.0**	**16.5**	**13.6**	**10.8**
IVCN	7.4	12.2	**12.6**	**13.9**	**18.7**	**16.5**	13.9
ICON	7.7	12.8	13.5	**14.4**	**19.5**	17.1	13.2
IVDR	7.6	12.0	**12.1**	**13.6**	**19.5**	17.6	14.6
HWFI	8.4	12.5	**12.9**	**12.6**	21.8	24.2	19.6
HMNI	9.2	15.0	16.2	18.9	30.2	28.4	20.6
CTCI	7.4	**11.2**	**12.7**	**14.9**	**17.1**	**16.2**	20.1
DSHP	7.7	13.6	15.5	**15.8**	**15.6**	**10.8**	**9.1**
LGEM	7.7	14.0	17.0	18.4	**18.5**	**16.5**	13.3
GFSI	8.2	12.6	**12.5**	**13.4**	**16.7**	**12.7**	**10.6**
EMXI	8.6	13.6	14.6	**15.7**	**16.1**	16.9	16.4
Forecasts	30	28	28	27	24	22	19

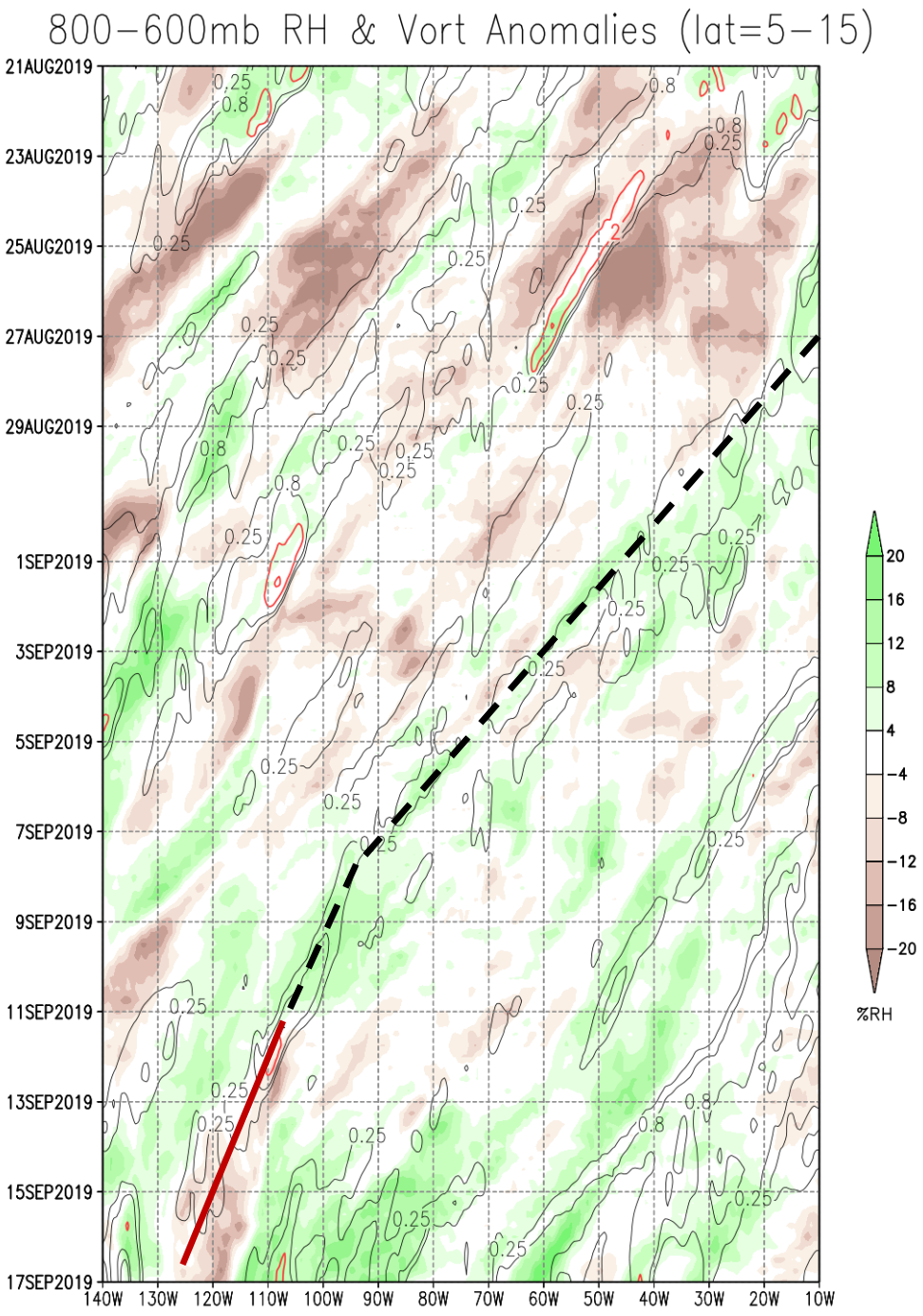


Figure 1. GFS analysis Hovmöller diagram of 800–600-mb relative humidity (shaded, %) and vorticity anomalies (contours, x10^{-5} s^{-1}) from 5°N to 15°N and 140°W to 10°W, 21 August–17 September 2019. The dashed black line approximately traces the axis of the wave from which Kiko developed. The solid dark red line shows the approximate path of the tropical cyclone after genesis. The vorticity anomalies in the diagram are weak after the time of genesis because Kiko moved north of 15°N shortly after it formed. Anomalies were computed relative to the full period shown in the diagram.

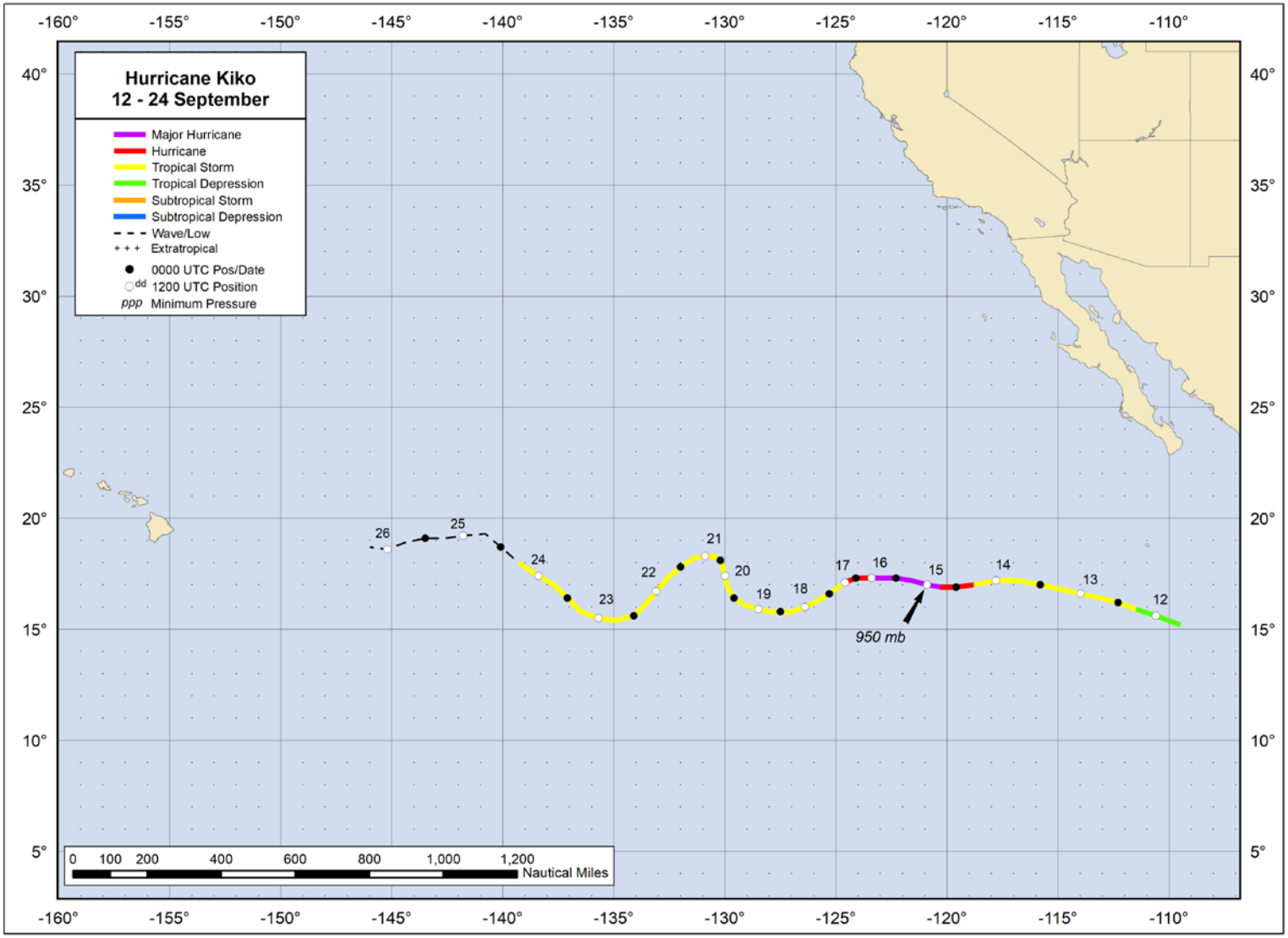


Figure 2. Best track positions for Hurricane Kiko 12–24 September, 2019. Best track points west of 140°W in the central Pacific basin were provided by the Central Pacific Hurricane Center.

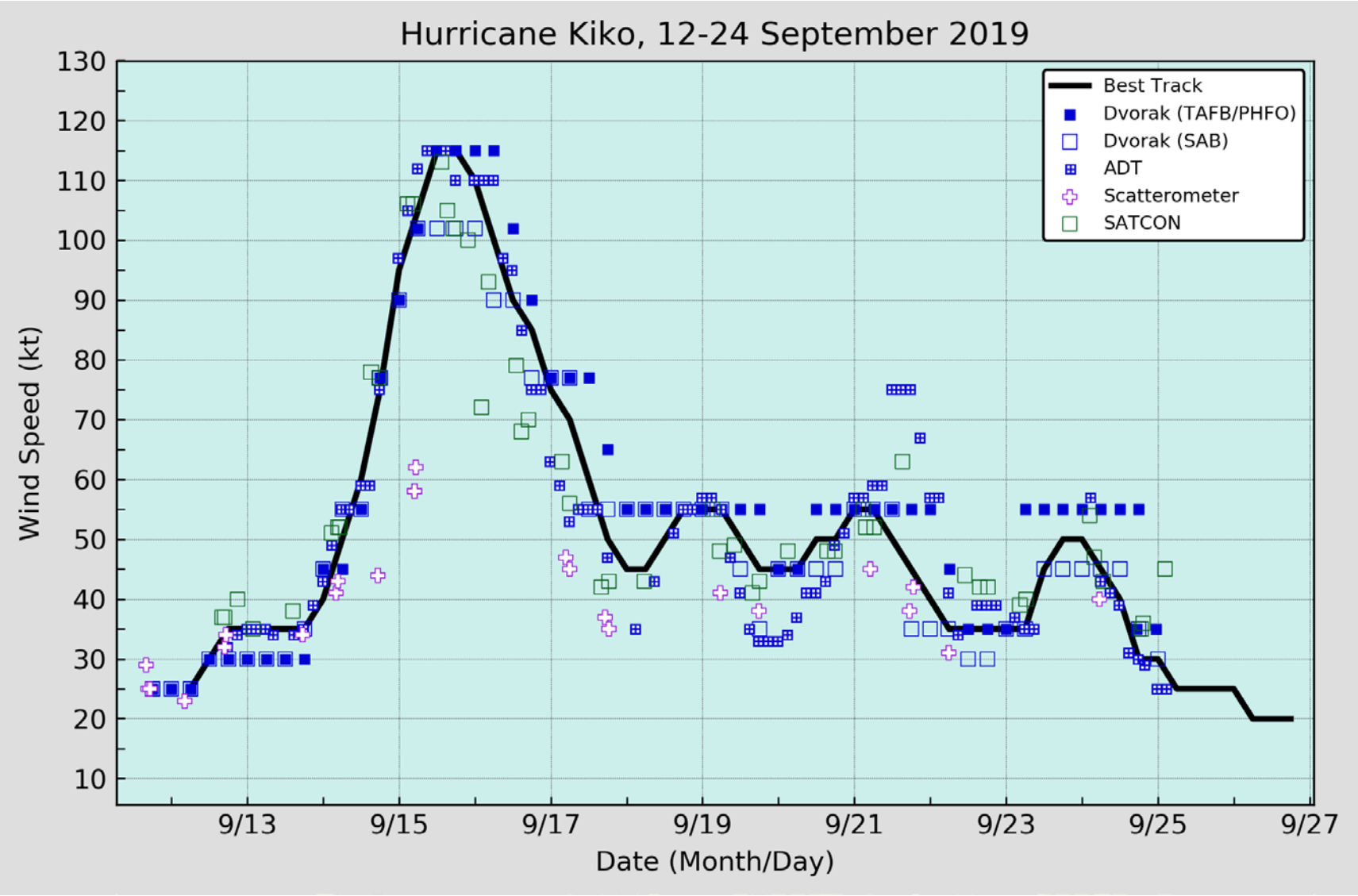


Figure 3. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Kiko. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

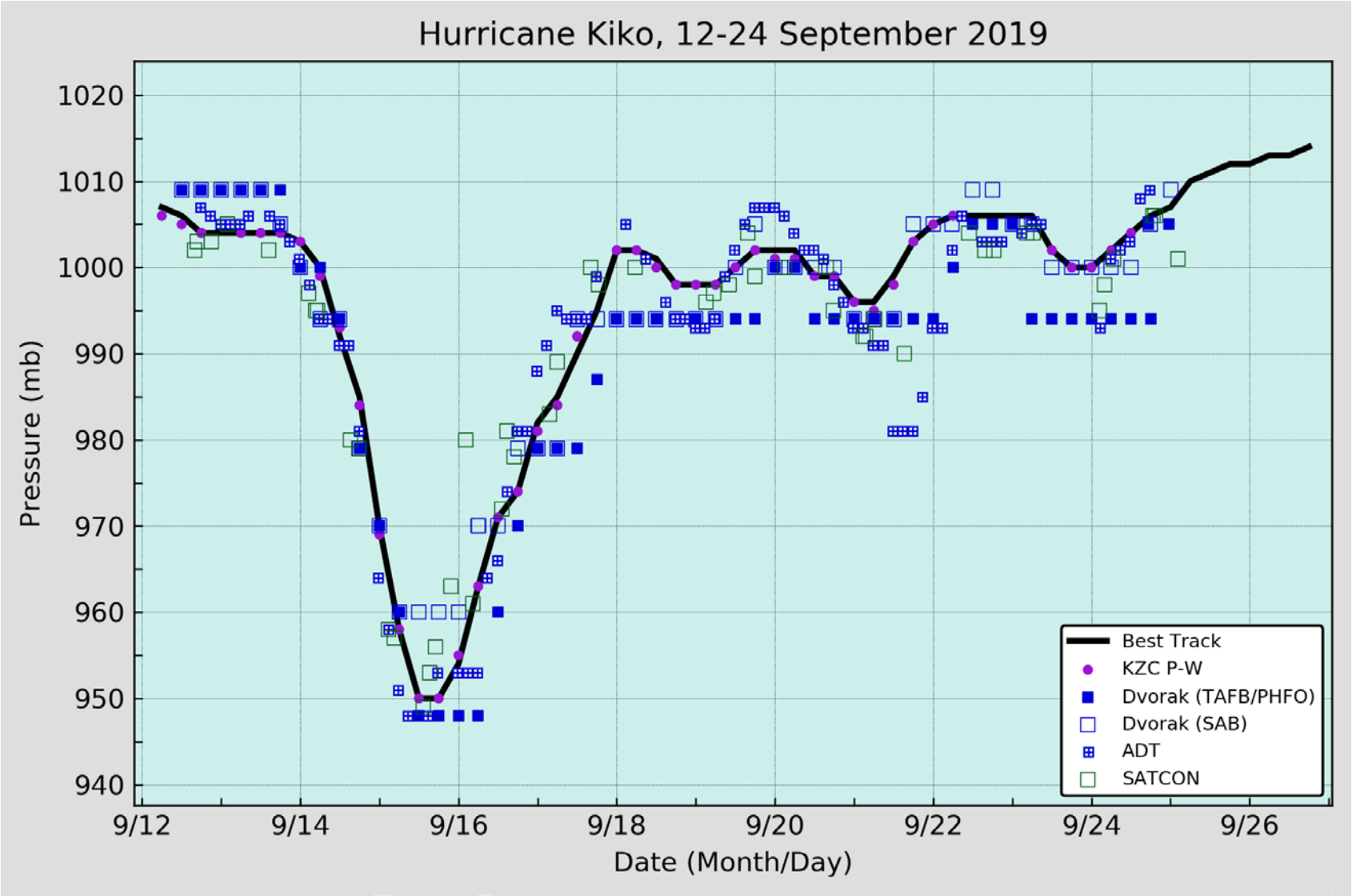


Figure 4. Selected pressure observations and best track minimum central pressure curve for Hurricane Kiko. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

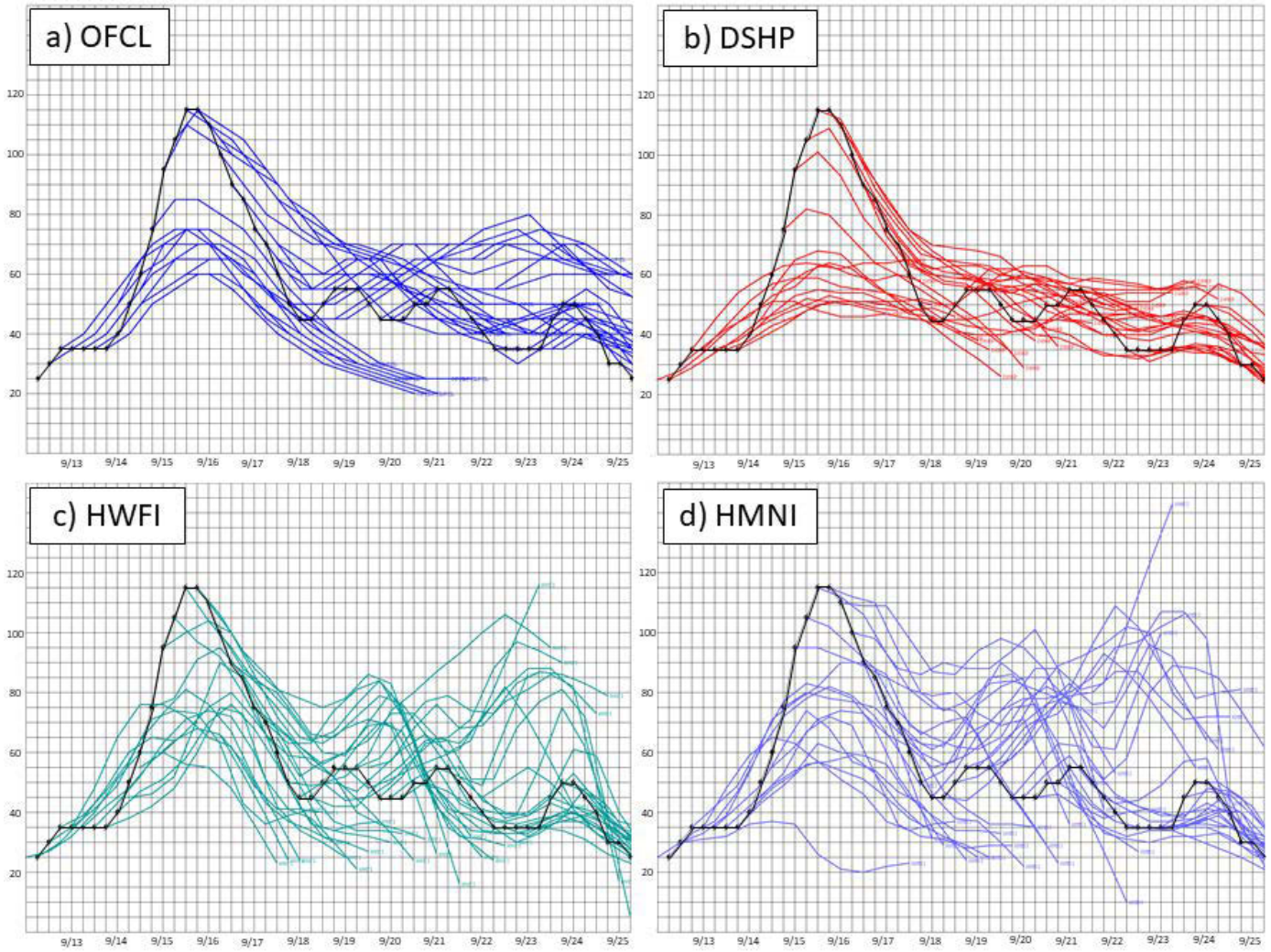


Figure 5. Selected intensity forecasts (kt) for Hurricane Kiko: a) NHC Official Forecast (OFCL) b) Decay-SHIPS (DSHP) c) HWRF (HWFI) d) HMON (HMNI). The best track intensity (kt) is shown in the solid black line. The NHC official forecasts and the guidance all failed to properly forecast the initial rapid intensification and rapid weakening of Kiko. HWFI and HMNI both had significant high biases for later forecasts that negatively influenced the NHC official forecasts.