

Tropical Cyclone Report
Hurricane Kyle
(AL11008)
25-29 September 2008

Lixion A. Avila
National Hurricane Center
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Kyle was a category one hurricane on the Saffir-Simpson Hurricane Scale that made landfall in southwestern Nova Scotia.

a. Synoptic History

The development of Kyle was associated with a tropical wave that moved off the coast of Africa with some convective organization on 12 September. There was a weak low pressure area associated with the wave and the system moved westward and west-southwestward for a few days. As the tropical wave was approaching the Lesser Antilles, it began to interact with a strong upper-level trough over the eastern Caribbean Sea, resulting in an increase in cloudiness and thunderstorms. The surface area of low pressure became better defined as it crossed the Windward Islands and began to develop a larger surface circulation on 19 September. The low pressure area turned toward the northwest and became separated from the wave, which continued its westward track across the Caribbean Sea. The upper-level trough moved westward and weakened, causing small relaxation of westerly shear and allowing the convection associated with the low to become a little more concentrated. The low was near Puerto Rico on 21 September, and continued drifting northwestward. It then spent two days crossing Hispaniola, producing disorganized thunderstorms and a large area of squalls within a convective band over the adjacent Caribbean Sea. During this period, the system lacked a well-defined circulation center as indicated by reconnaissance and local surface data.

The low moved northeastward away from Hispaniola, and finally developed a well-defined surface circulation center. It is estimated that a tropical depression formed at 0000 UTC 25 September about 100 n mi north of the Dominican Republic. Westerly wind shear kept the center to the west of the convection, but as the shear relaxed further, convective bands began to wrap around the center and the system became a tropical storm at 0600 UTC 25 September.

Kyle then moved on a northward track and gradually intensified, becoming a hurricane at 1200 UTC 27 September about 300 n mi west of Bermuda. Kyle continued moving between north and north-northeastward and reached its peak intensity of 75 knots with a central pressure of 989 mb at 1200 UTC 28 September. Thereafter, the cyclone began to lose tropical characteristics as the convection started to become elongated and asymmetric, but it made landfall as a 65-kt hurricane on the western tip of Nova Scotia just north of Yarmouth at 0000 UTC 29 September. Kyle continued rapidly northward and northeastward, developed a frontal structure and became fully extratropical. It was absorbed by a large extratropical low at 1800 UTC 30 September.

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 1¹.

b. Meteorological Statistics

Observations in Kyle (Figs. 2 and 3) include satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), as well as flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command and NOAA P3 reconnaissance missions. Data and imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA QuikSCAT, and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in tracking Kyle. Post-analysis of data from a NOAA P3 genesis research mission indicate that by 0000 UTC 25 September the circulation was well-defined enough to classify the system as a tropical depression as indicated in the final best track. However, operational Dvorak classifications did not support tropical depression status at that time.

Ship reports of winds of tropical storm force associated with Kyle are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3. The ship with call sign *HPYE* located about 100 n mi south of the developing center of Kyle reported winds of 40 knots at 1000 UTC 25 September. This observation was crucial in determining that Kyle had become a tropical storm by that time. The peak intensity of 75 knots was estimated from data from a dropsonde launched from a reconnaissance aircraft. The estimate of 984 mb minimum pressure of Kyle occurred a little bit after the hurricane reached its peak intensity. The minimum pressure was based on the 44011 NOAA buoy, which reported 987.1 mb and winds of 31 knots as the center of Kyle moved nearby. However, although Kyle’s pressure was still falling, the winds were already decreasing. This has been observed in past systems as they transition to an extratropical low.

c. Casualty and Damage Statistics

The low pressure that preceded Kyle produced torrential rains (up to 30 inches) and numerous flash floods and mud slides in Puerto Rico resulting in six deaths. Winds from Kyle caused minor damage over Nova Scotia primarily in the form of some uprooted trees and broken limbs resulting in power outages. Storm surge and waves produced minor street flooding in Shelburne as well.

d. Forecast and Warning Critique

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.

A description of the weather system from which Kyle originated was included in Tropical Weather Outlook (TWO) products beginning at 1200 UTC 18 September. The possibility of tropical cyclone formation was then included in the TWO issued at 1800 UTC 20 September. This was well in advance about five days prior to genesis. The experimental genesis forecast probability reached the high category (> 50%) at 1200 UTC 21 September but the cyclone did not form within the subsequent 48 hours. In fact, the probabilities decreased to the medium category (20 to 50 %) at 1800 UTC 22 September, but then again increased to the high category at 1200 UTC 23 September, about 36 hours before formation. Advisories were initiated 18 hours after the time of formation estimated in the post-analysis.

A verification of official and guidance model track forecasts is given in Table 4. Average official track errors for Kyle were 32, 44, 59, 73, and 68 n mi for the 12, 24, 36, and 72 h forecasts, respectively. The number of forecasts ranged from 12 at 12 h to 2 at 72 h. These errors are lower than the average long-term official track errors (Table 4). Also note in Table 4 that both the European (EMXI) and Geophysical Fluid Dynamic (GFDL) models performed extremely well and their track errors were lower than the average official track errors at most of the time periods.

Average official intensity errors were 4, 4, 3, 3 and 5 kt for the 12, 24, 36, 48 and 72 h forecasts, respectively. For comparison, the average long-term official intensity errors are 7, 10, 12, 14, and 18 kt, respectively. Note that the average official intensity errors are lower than the intensity guidance errors at all forecast times (Table 5).

Watches and warnings associated with Hurricane Kyle are given in Table 5. Given the uncertainty in the forecast track and wind radii, watches and warnings were issued for a portion of the northeast coast of the United States. However, Kyle turned toward the north-northeast with most of the associated weather located north and east of the center. There were no reports of significant weather associated with Kyle along the U.S. northeast coast.

Table 1. Best track for Hurricane Kyle, 25-29 September 2008.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
25 / 0000	21.5	70.0	1005	30	tropical depression
25 / 0600	22.0	69.4	1003	35	tropical storm
25 / 1200	22.4	68.7	1002	40	"
25 / 1800	23.1	68.4	1001	40	"
26 / 0000	24.0	68.0	998	45	"
26 / 0600	25.0	68.2	996	50	"
26 / 1200	26.0	68.6	998	50	"
26 / 1800	26.9	68.6	1000	50	"
27 / 0000	28.7	68.6	998	55	"
27 / 0600	29.9	69.3	996	60	"
27 / 1200	31.2	69.5	996	65	hurricane
27 / 1800	33.3	69.7	995	70	"
28 / 0000	35.3	69.7	995	70	"
28 / 0600	37.4	69.3	992	70	"
28 / 1200	39.4	68.2	989	75	"
28 / 1800	41.6	66.7	984	70	"
29 / 0000	43.8	66.2	985	65	"
29 / 0600	45.6	65.0	990	50	extratropical
29 / 1200	47.7	63.5	994	45	"
29 / 1800	48.2	62.6	999	40	"
30 / 0000	48.4	61.5	1002	35	"
30 / 0600	48.2	61.0	1004	30	"
30 / 1200	48.1	60.8	1005	25	"
30 / 1800					absorbed
28 / 1800	41.6	66.7	984	70	minimum pressure
28 / 1200	39.4	68.2	989	75	maximum intensity
29 / 0000	43.8	66.2	985	65	landfall near Yarmouth, NS

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Kyle, 25-29 September 2008.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
25 / 1000	HPYE	20.3	68.1	190 / 40	1002.0
25 / 1800	KS049	21.9	67.3	240 / 39	
25 / 1900	H3VS	24.9	67.3	180 / 40	1007.0
26 / 0000	P3GY9	25.0	66.6	090 / 35	1011.0
26 / 0500	MKYJ8	25.3	68.5	050 / 45	1006.7
26 / 0600	P3GY9	25.8	65.7	100 / 35	1013.0
26 / 0900	MKYJ8	25.1	67.8	180 / 48	1004.3
26 / 1500	MKYJ8	25.7	66.2	160 / 40	1013.3
26 / 1800	MKYJ8	26.2	65.4	140 / 47	1014.5
26 / 2100	MKYJ8	26.4	64.6	140 / 35	1015.6
28 / 2100	CGUM	42.9	63.5	150 / 37	1008.8
28 / 2100	ZCBU3	43.9	62.1	150 / 40	1017.0
29 / 0000	ZCBU3	43.6	61.3	150 / 37	1017.8
29 / 0600	VAAP	44.9	61.4	160 / 37	1006.9
29 / 1800	VOCZ	47.1	59.5	140 / 35	1010.7

Table 3. Selected surface observations for Hurricane Kyle, 25-29 September 2008.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft) ^c	Storm tide (ft) ^d	Total rain (in)
	Date/time (UTC)	Press. (mb)	Date/time (UTC) ^a	Sustained (kt) ^b	Gust (kt)			
Canada (provided by Environmental Canada)								
Yarmouth, NS	29/0000	988.1	28/2200	26	38	1.7		1.69
Baccaro Point, NS	22/2246	992.1	28/2146	52	67			
Brier Island, NS	29/0100	993.9	29/0400	33	40			
Western Head, NS	29/0200	997.0	29/0300	37	55			
Lunenburg, NS	29/0400	998.1	28/2300	35	44			
McNabs Island, NS	29/0500	1001.5	29/0400	45	55			
Halifax Dockyard, NS			29/0030	34				
Osborne Head, NS			29/0600	35	47			
Grand Etang, NS	29/1100	1005.0	29/0500	36	56			
Halifax, NS						1.3		
Dartmouth, NS						1.5		
North Cape, PE	29/1000	997.3	29/0700	34	45			0.97
Wreckhouse, NF			29/1800	49	50			
Bon Accord, NB								2.82
Havre-Saint-Pierre, QU								2.76
Buoys/C-MAN								
41011 Georges Bank, MA 41.1° N 66.6°W	28/1450	994.6	28/1550	52	72			
44024 42.3 0°N 65.9°W	28/2004	991.2	28/2004	47				
44753 32.0°N 69.7°W	29/0500	1017.9	29/0500	39				
41048 west of Bermuda 32.0°N 69.7°W	27/1321	999.1	27/1217	49	55			
44753 43.60°N 61.3°W	27/0500	1017.9	27/0500	39				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft) ^c	Storm tide (ft) ^d	Total rain (in)
	Date/time (UTC)	Press. (mb)	Date/time (UTC) ^a	Sustained (kt) ^b	Gust (kt)			
41027 Jonesport, Maine 44.3° N 67.3°W	29/0050	999.1	28/2250	33	40			

^a Date/time is for sustained wind when both sustained and gust are listed.

^b Except as noted, sustained wind averaging periods for C-MAN and land-based ASOS reports are 2 min; buoy averaging periods are 8 min; Canada averaging periods are 10 min.

^c Storm surge is water height above normal astronomical tide level.

^d Storm tide is water height above National Geodetic Vertical Datum (1929 mean sea level).

Table 4. Track forecast evaluation (heterogeneous sample) for Hurricane Kyle, 25-29 September 2008. Forecast errors (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in boldface type.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	57 (13)	135 (11)	261 (9)	378 (7)	610 (3)		
GFNI	26 (7)	48 (7)	69 (6)	66 (4)			
GFDI	49 (13)	86 (11)	143 (9)	211 (7)	337 (3)		
HWFI	40 (13)	67 (11)	102 (9)	126 (7)	172 (3)		
GFSI	44 (13)	62 (11)	100 (9)	131 (7)	185 (3)		
AEMI	52 (13)	90 (11)	140 (9)	207 (7)	257 (2)		
NGPI	47 (12)	70 (10)	107 (8)	185 (6)	442 (2)		
UKMI	44 (10)	77 (8)	113 (6)	161 (4)			
EGRI	44 (10)	77 (8)	113 (6)	161 (4)			
EMXI	28 (10)	35 (9)	48 (7)	46 (5)	169 (1)		
BAMD	40 (13)	68 (11)	119 (9)	205 (7)	432 (3)		
BAMM	49 (13)	89 (11)	132 (9)	204 (7)	399 (3)		
BAMS	75 (13)	125 (11)	159 (9)	203 (7)	307 (3)		
LBAR	44 (13)	85 (11)	155 (9)	231 (7)	393 (3)		
TVCN	38 (13)	56 (11)	85 (9)	112 (7)	184 (3)		
GUNA	37 (10)	49 (8)	66 (6)	73 (4)			
FSSE	35 (12)	51 (10)	83 (8)	115 (6)	198 (2)		
OFCL	32 (12)	44 (10)	59 (8)	73 (6)	68 (2)		
NHC Official (2003-2007 mean)	34.0 (1742)	58.2 (1574)	82.2 (1407)	106.2 (1254)	154.2 (996)	207.5 (787)	272.5 (627)

Table 5. Intensity forecast evaluation (heterogeneous sample) for Hurricane Kyle, 25-29 September 2008. Forecast errors (kt) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in boldface type.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
OCD5	6.3 (15)	7.9 (13)	7.3 (11)	9.1 (9)	15.6 (5)		
GHMI	5.3 (15)	5.1 (13)	7.7 (11)	7.2 (9)	25.8 (5)		
HWFI	6.8 (15)	6.3 (13)	3.5 (11)	6.6 (9)	23.2 (5)		
LGEM	7.9 (15)	10.8 (13)	11.2 (11)	14.9 (9)	23.2 (5)		
DSHP	6.7 (15)	7.0 (13)	6.1 (11)	5.7 (9)	9.4 (5)		
FSSE	5.5 (12)	6.2 (10)	5.3 (8)	6.7 (6)	8.0 (2)		
ICON	6.6 (15)	6.3 (13)	3.6 (11)	5.2 (9)	17.2 (5)		
OFCL	4.2 (12)	4.0 (10)	3.1 (8)	3.3 (6)	5.0 (2)		
NHC Official (2003-2007 mean)	6.7 (1742)	10.0 (1574)	12.3 (1407)	14.3 (1254)	18.2 (996)	19.7 (787)	21.8 (627)

Table 6. Watch and warning summary for Hurricane Kyle, 25-29 September 2008.

Date/Time (UTC)	Action	Location
26 / 0900	Tropical Storm Watch issued	Bermuda
26 / 1500	Tropical Storm Watch changed to Tropical Storm Warning	Bermuda
27 / 1500	Tropical Storm Watch issued	Cape Elizabeth to Stonington, Maine
27 / 1500	Tropical Storm Watch issued	Queens NS to Digby NS
27 / 1500	Tropical Storm Watch issued	Charlotte NB to St. John NB
27 / 1500	Hurricane Watch issued	Stonington to Eastport
27 / 1800	Tropical Storm Watch modified to	Lunenburg NS to Queens NS
27 / 1800	Tropical Storm Warning issued	Shelburne NS to Digby NS
27 / 1800	Hurricane Watch issued	Shelburne NS to Digby NS
27 / 2100	Tropical Storm Watch modified to	Cape Elizabeth to Port Clyde
27 / 2100	Tropical Storm Warning discontinued	Bermuda
27 / 2100	Tropical Storm Warning issued	Port Clyde to Eastport, Maine
28 / 0600	Tropical Storm Watch changed to Tropical Storm Warning	Charlotte NB to St. John NB
28 / 0600	Tropical Storm Watch discontinued	Lunenburg NS to Queens NS
28 / 1500	Tropical Storm Watch discontinued	All
28 / 1500	Tropical Storm Warning discontinued	Charlotte NB to St. John NB
28 / 1500	Tropical Storm Warning modified to	Stonington to Eastport
28 / 1800	Tropical Storm Warning changed to Hurricane Warning	Shelburne NS to Digby NS
28 / 1800	Hurricane Watch changed to Tropical Storm Warning	Stonington to Eastport
28 / 1800	Tropical Storm Warning issued	Lunenburg NS to Queens NS
28 / 1800	Tropical Storm Warning issued	Annapolis NS
28 / 1800	Tropical Storm Warning issued	Charlotte NB to Westmorland NB
28 / 1800	Hurricane Watch discontinued	All
29 / 0000	Tropical Storm Warning discontinued	Stonington to Eastport
29 / 0400	Tropical Storm Warning discontinued	All
29 / 0400	Hurricane Warning discontinued	All

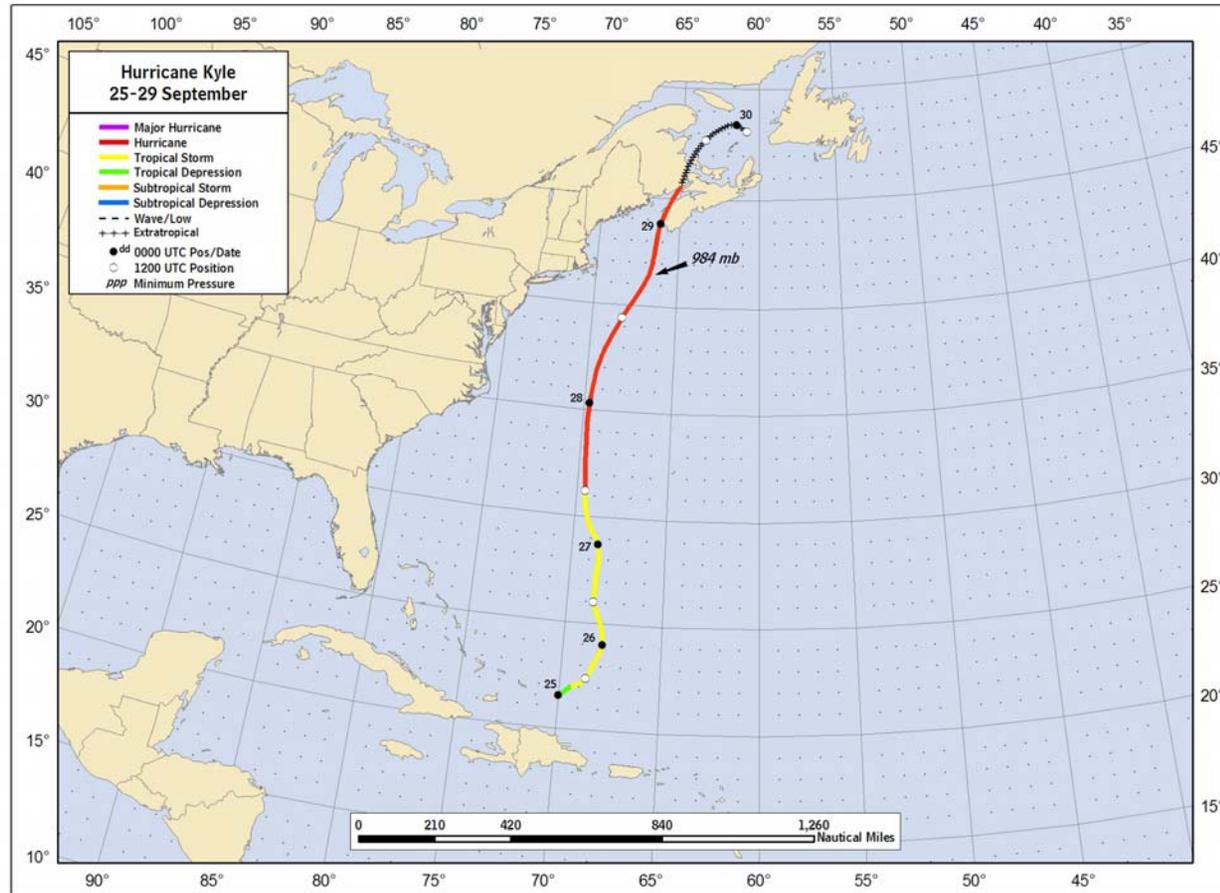


Figure 1. Best track positions for Hurricane Kyle, 25-29 September, 2008. Track during the extratropical stage is based on analyses from the NOAA Ocean Prediction Center.

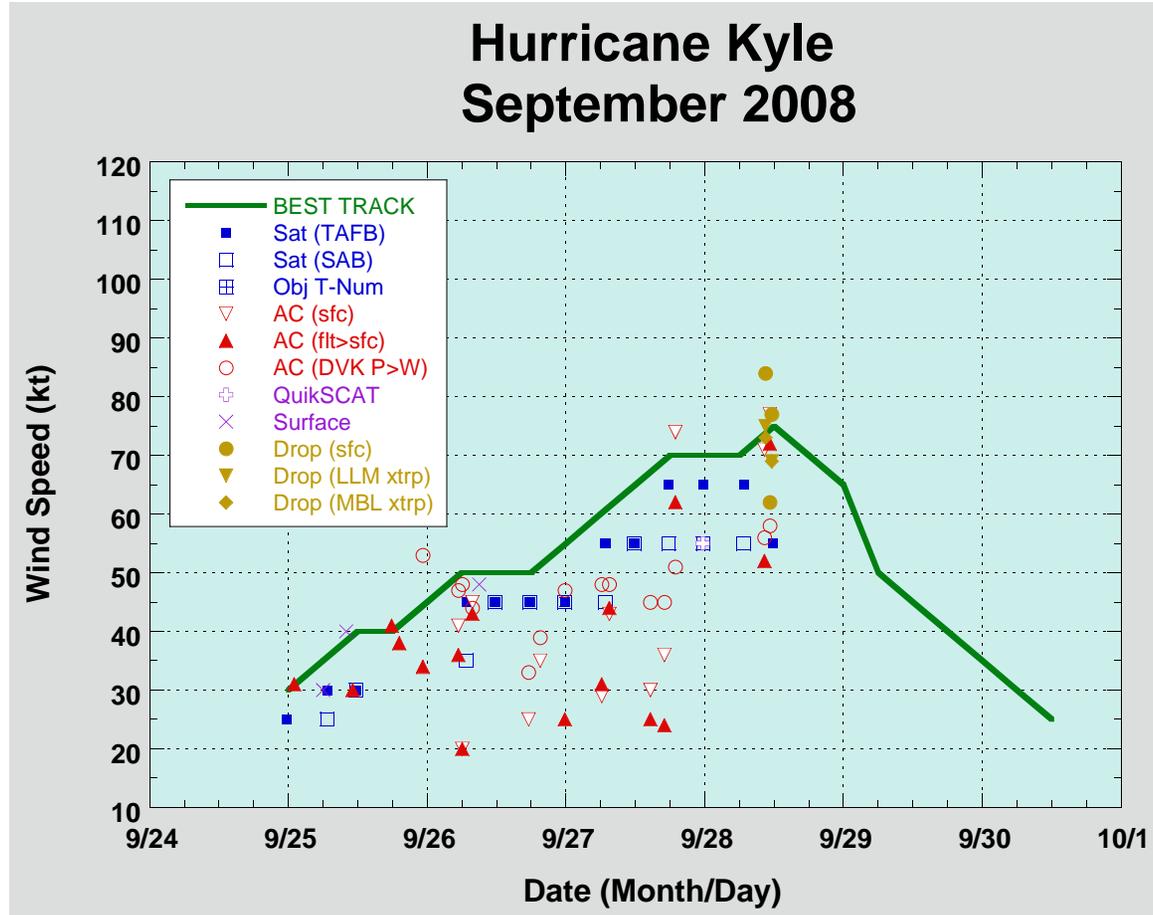


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Kyle, 25-29 September 2008. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM), and from the sounding boundary layer mean (MBL). Estimates during the extratropical stage are based on analyses from the NOAA Ocean Prediction Center. Dashed vertical lines correspond to 0000 UTC.

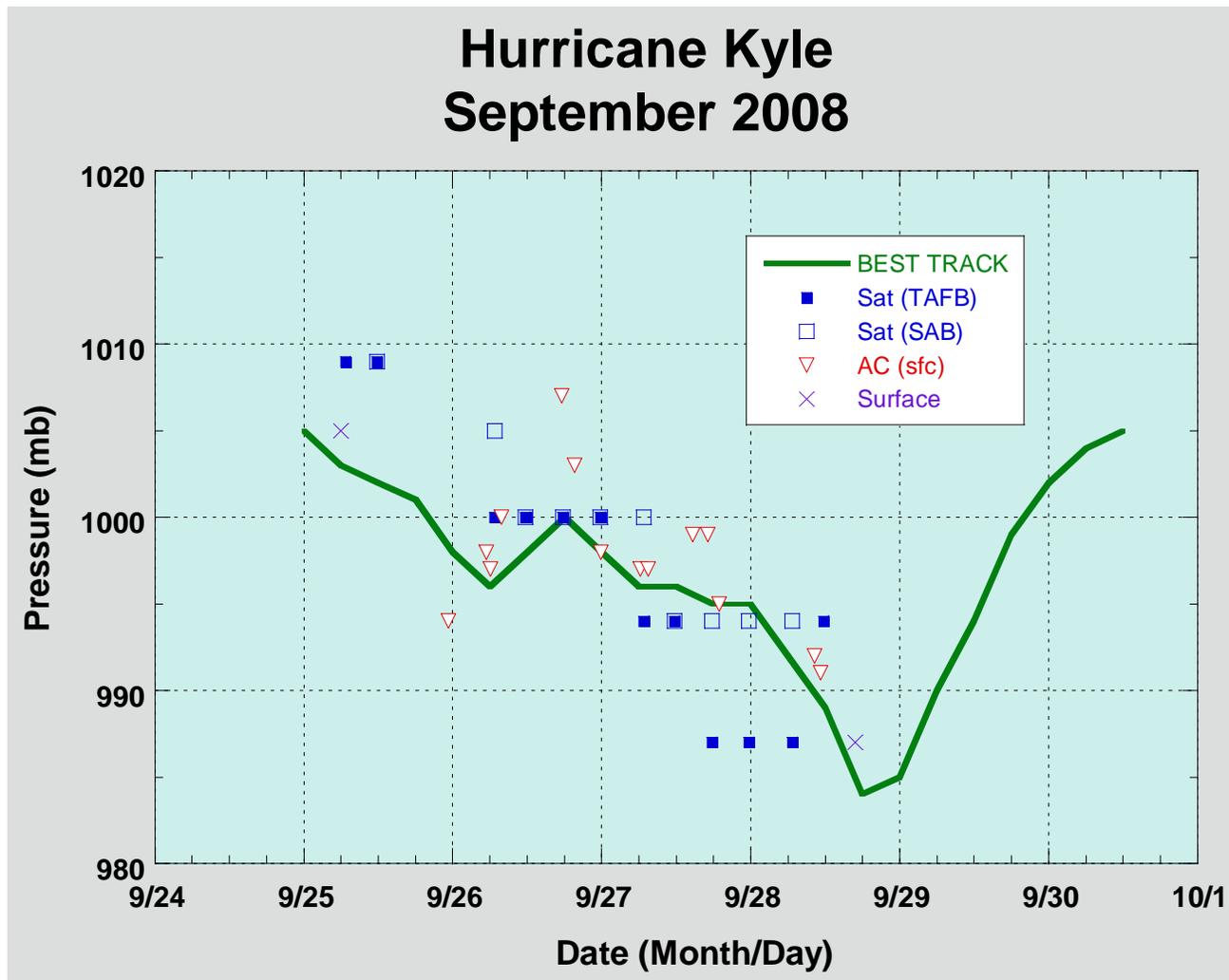


Figure 3. Selected pressure observations and best track minimum central pressure curve for Kyle, 25-29 September 2008. Estimates during the extratropical stage are based on analyses from the NOAA Ocean Prediction Center. Dashed vertical lines correspond to 0000 UTC.