

Tropical Cyclone Report  
Hurricane Kate  
25 September-7 October 2003

Richard J. Pasch and Robert Molleda  
National Hurricane Center  
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Kate had a long, rather unusual track over the east-central Atlantic. It became a powerful hurricane at subtropical latitudes.

a. Synoptic History

A tropical wave crossed the coast of western Africa on 21 September and moved slowly westward, passing near the Cape Verde Islands on 23 September. Although the system was not well organized, meteorologists at the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB) identified a low-level circulation center several hundred miles west-southwest of the Cape Verde Islands on 24 September. Cloudiness and deep convection gradually became better organized into curved bands, and initial Dvorak T-numbers were assigned around 1200 UTC 25 September. It is estimated that a tropical depression formed, roughly 800 n mi west-southwest of the Cape Verde Islands, at 1800 UTC 25 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. Table 1 lists the best track positions and intensities.

The tropical cyclone moved generally northwestward for a couple of days toward a weakness in the subtropical ridge over the central Atlantic. Meanwhile, south-southwesterly upper-level flow caused strong vertical shear over the depression, and the low-cloud center was intermittently exposed to the southwest of the main area of deep convection. Around 1800 UTC 27 September, deep convection increased near the center, and satellite-based estimates indicate that the cyclone became Tropical Storm Kate. Even though the system continued to experience moderate southwesterly shearing, it strengthened further over the next two days while turning northward and northeastward. Kate briefly became a hurricane, from about 1800 UTC 29 September to 0000 UTC 30 September. Then, while weakening, the cyclone took a hairpin turn around the eastern side of a mid-tropospheric cyclonic circulation. By 1 October, Kate was moving west-southwestward on the northern side of the cyclonic circulation. It also regained hurricane strength that day. Kate continued west-southwestward for the next couple of days, guided by the steering flow between an anticyclone to its north and the cyclonic circulation centered to its south. There was a relaxation of vertical shear over the area, and as Kate moved over progressively warmer waters, it strengthened significantly. By 2 October, a well-defined eye was apparent on geostationary satellite images. The hurricane moved westward to west-northwestward over the next couple of days while strengthening to its peak wind intensity of 110 kt at 1800 UTC 4 October. Kate was centered about 565 n mi east-southeast of Bermuda at that time.

Shortly after reaching maximum intensity, the western portion of the hurricane’s central

dense overcast became partially eroded, signifying the beginning of a weakening trend. Also, the forward speed slowed from 10-11 kt to 6-7 kt as Kate neared the western periphery of the deep-layer anticyclone that had been anchored over the north Atlantic for several days. On 5-6 October, the cyclone turned northward, then accelerated north-northeastward ahead of a deep-layer trough. Kate was slow to weaken as an eye was occasionally visible on geostationary satellite imagery. However, the cyclone finally weakened below hurricane strength on 7 October while it continued to accelerate north-northeastward over cooler waters. Kate also began losing tropical characteristics as cold air clouds wrapped around the center over the southern semicircle, and the remaining central convection weakened and became disorganized. The system completed its extratropical transition by 0000 UTC 8 October, but remained a formidable extratropical storm for a couple more days while moving northeastward to eastward across the northern Atlantic. It merged with another extratropical low near Scandinavia on 10 October.

b. Meteorological Statistics

Observations in Hurricane Kate (Figs. 2 and 3) include satellite-based Dvorak technique intensity estimates from TAFB, SAB and the U. S. Air Force Weather Agency (AFWA). QuikSCAT data indicated that Kate had winds of hurricane force from 1800 UTC 29 September to 0000 UTC 30 September. Kate's peak intensity, 110 kt, at 1800 UTC 4 October, is based on a 3-hour average objective Dvorak T-number of 5.8.

Ship reports of winds of tropical storm force associated with Hurricane Kate are given in Table 2.

c. Casualty and Damage Statistics

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

d. Forecast and Warning Critique

Forecasters had a difficult time predicting the path of this tropical cyclone. Average official track errors (with the number of cases in parentheses) for Kate were 48 (47), 91 (45), 133 (43), 179 (41), 288 (37), 363 (33), and 406 (29) n mi for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively<sup>1</sup>. These errors are greater than the average official track errors for the 10-yr period 1993-2002<sup>2</sup> of 45, 81, 116, 150, 225, 282, and 374 n mi, respectively. Table 3 shows a comparison

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<sup>1</sup> All forecast verifications in this report include the depression stage of the cyclone. National Hurricane Center verifications presented in these reports prior to 2003 did not include the depression stage.

<sup>2</sup> Errors given for the 96 and 120 h periods are averages over the two-year period 2001-2.

of the track errors for various models and the official forecast. Several models, notably GFDL, AVNI (GFS), and NGPI had lower errors than the official forecast at practically every forecast period. Interestingly, UKMI, which is normally an excellent performer, had very large average errors for Kate. This was due, in part, to a number of UKMI forecasts that which failed to predict Kate's sharp turn to the west, and took the system erroneously eastward into the eastern Atlantic.

Wind speed forecasts for Kate were mostly better than the long-term means. The average official intensity forecast errors were 4, 7, 9, 10, 12, 17, and 23 kt for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively, compared to the average 1993-2002 errors of 6, 10, 13, 15, 19, 21, and 22 kt, respectively. There was, however, a significant negative bias at 96 and 120 h.

No watches or warnings were required for Kate.

Table 1. Best track for Hurricane Kate, 25 September-7 October 2003.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
25 / 1800	11.8	37.7	1008	30	tropical depression
26 / 0000	12.8	38.5	1008	30	"
26 / 0600	14.0	39.4	1008	30	"
26 / 1200	15.2	40.2	1007	30	"
26 / 1800	16.6	41.0	1007	30	"
27 / 0000	18.0	41.8	1007	30	"
27 / 0600	19.2	43.0	1007	30	"
27 / 1200	20.0	43.8	1007	30	"
27 / 1800	21.0	44.2	1005	35	tropical storm
28 / 0000	22.0	44.5	1000	45	"
28 / 0600	23.0	44.3	997	50	"
28 / 1200	23.9	43.6	997	50	"
28 / 1800	24.8	42.6	997	50	"
29 / 0000	26.1	41.3	997	50	"
29 / 0600	27.2	39.9	994	55	"
29 / 1200	28.3	38.2	991	55	"
29 / 1800	29.2	36.8	987	65	hurricane
30 / 0000	30.0	35.4	987	65	"
30 / 0600	30.8	34.8	992	55	tropical storm
30 / 1200	31.8	35.1	992	55	"
30 / 1800	32.6	36.0	996	50	"
01 / 0000	32.5	37.1	997	50	"
01 / 0600	32.4	38.3	997	50	"
01 / 1200	32.2	39.6	994	55	"
01 / 1800	31.7	40.9	987	65	hurricane

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
02 / 0000	31.1	42.1	987	65	"
02 / 0600	30.3	43.0	979	75	"
02 / 1200	30.1	43.6	979	75	"
02 / 1800	29.9	44.7	976	80	"
03 / 0000	29.6	45.8	976	80	"
03 / 0600	29.4	46.9	970	90	"
03 / 1200	29.4	47.8	970	90	"
03 / 1800	29.6	49.1	962	100	"
04 / 0000	29.9	50.3	962	100	"
04 / 0600	30.1	51.6	962	100	"
04 / 1200	30.1	52.8	956	105	"
04 / 1800	30.2	54.0	952	110	"
05 / 0000	30.3	54.7	962	100	"
05 / 0600	30.4	55.5	968	95	"
05 / 1200	30.7	56.1	973	90	"
05 / 1800	31.4	56.4	975	85	"
06 / 0000	32.3	56.2	977	80	"
06 / 0600	33.5	56.0	977	80	"
06 / 1200	35.2	55.6	979	75	"
06 / 1800	36.9	55.0	983	70	"
07 / 0000	38.6	54.0	987	65	"
07 / 0600	40.5	52.1	987	60	tropical storm
07 / 1200	43.8	49.5	987	60	"
07 / 1800	47.5	47.2	980	60	"
08 / 0000	52.0	44.0	978	60	extratropical

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
08 / 0600	56.5	40.5	974	65	"
08 / 1200	59.5	37.0	974	65	"
08 / 1800	61.1	33.4	970	65	"
09 / 0000	62.1	28.7	970	60	"
09 / 0600	62.5	24.0	972	55	"
09 / 1200	62.6	19.0	973	55	"
09 / 1800	62.5	12.6	976	50	"
10 / 0000	63.0	6.0	980	50	"
10 / 0600					merged with extratropical low
04 / 1800	30.2	54.0	952	110	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Kate, 25 September-7 October 2003.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
28 / 1200	C6QD2	23.0	42.3	180 / 41	1008.2
07 / 0000	JKES	36.9	52.4	180 / 33	1007.5
07 / 0300	JKES	37.2	53.3	220 / 39	1007.0
07 / 0900	HP6038	46.4	48.4	150 / 35	1009.6
07 / 0900	VEP717	46.7	48.7	170 / 39	1009.1
07 / 0900	3FPK7	46.7	48.0	160 / 40	1010.2
07 / 1200	3EXS4	40.2	50.3	250 / 37	1008.0
07 / 1200	CG2959	42.0	46.9	150 / 35	1011.7
07 / 1200	ZCBN5	43.6	44.0	150 / 35	1015.5
07 / 1200	UCTZ	44.5	52.8	320 / 39	1001.5
07 / 1200	HP6038	46.4	48.4	130 / 38	1005.6
07 / 1200	VEP717	46.7	48.7	160 / 45	1004.0
07 / 1200	UIC0	43.4	51.7	300 / 33	993.3
07 / 1200	3FPK7	46.7	48.0	150 / 40	1006.9
07 / 1300	44140	43.8	51.8	300 / 37	998.6
07 / 1400	44140	43.8	51.8	300 / 39	1002.8
07 / 1500	HP6038	46.4	48.4	090 / 50	992.1
07 / 1500	VEP717	46.7	48.7	120 / 38	993.1
07 / 1500	3FPK7	46.7	48.0	120 / 50	996.1
07 / 1600	44140	43.8	51.8	300 / 35	1008.8
07 / 1600	44551	48.4	42.4	160 / 35	1015.3
07 / 1700	44551	48.4	42.4	140 / 35	1013.3
07 / 1800	ZCBN5	43.4	42.1	150 / 40	1016.0
07 / 1800	HP6038	46.4	48.4	280 / 44	991.7
07 / 1800	3FPK7	46.7	48.0	240 / 40	988.9

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
07 / 1800	44551	48.5	42.3	150 / 39	1011.1
07 / 1900	44551	48.5	42.3	130 / 45	1008.0
07 / 2000	44551	48.6	42.3	140 / 49	1004.9
07 / 2100	VEP717	46.7	48.7	320 / 51	1006.0
07 / 2100	3FPK7	46.7	48.0	290 / 48	1007.8
07 / 2100	44551	48.6	42.3	150 / 47	1003.6
07 / 2200	44551	48.6	42.3	190 / 47	1004.7
07 / 2300	44551	48.6	42.3	180 / 45	1005.2

Table 3. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Kate, 25 September-7 October 2003. Forecast errors (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in bold-face type. Verification includes the depression stage, but does not include the extratropical stage, if any.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	71 (47)	156 (45)	264 (43)	383 (41)	586 (37)	801 (33)	1012 (29)
GFNI	<b>46</b> (34)	<b>90</b> (34)	<b>121</b> (32)	<b>138</b> (30)	<b>160</b> (26)		
GFDI	<b>39</b> (39)	<b>62</b> (38)	<b>79</b> (36)	<b>92</b> (33)	<b>193</b> (29)	<b>325</b> (25)	<b>355</b> (21)
GFDL	<b>39</b> (47)	<b>60</b> (40)	<b>70</b> (36)	<b>76</b> (33)	<b>138</b> (29)	<b>264</b> (25)	<b>329</b> (20)
GFDN	52 (21)	<b>79</b> (19)	<b>112</b> (17)	<b>137</b> (16)	<b>145</b> (14)		
LBAR	56 (47)	109 (45)	174 (43)	258 (41)	524 (37)	833 (32)	966 (26)
AVNI	<b>42</b> (46)	<b>75</b> (44)	<b>99</b> (42)	<b>118</b> (40)	<b>167</b> (36)	<b>260</b> (32)	<b>375</b> (28)
AVNO	<b>47</b> (47)	<b>71</b> (45)	<b>92</b> (43)	<b>105</b> (41)	<b>146</b> (37)	<b>228</b> (33)	<b>326</b> (29)
AEMI	<b>46</b> (27)	<b>81</b> (27)	<b>119</b> (27)	<b>167</b> (26)	<b>283</b> (23)	<b>333</b> (19)	534 (14)
BAMD	53 (47)	101 (45)	158 (43)	226 (41)	538 (37)	994 (33)	1615 (28)
BAMM	58 (47)	102 (45)	145 (43)	185 (41)	295 (37)	520 (33)	837 (29)
BAMS	71 (47)	125 (45)	177 (43)	226 (41)	344 (37)	540 (33)	773 (29)
NGPI	50 (43)	<b>87</b> (41)	<b>123</b> (39)	<b>145</b> (37)	<b>161</b> (33)	<b>223</b> (29)	<b>329</b> (24)
NGPS	56 (44)	<b>82</b> (42)	<b>120</b> (40)	<b>148</b> (38)	<b>189</b> (34)	<b>241</b> (30)	<b>321</b> (25)
UKMI	67 (44)	128 (43)	200 (41)	289 (39)	479 (35)	691 (27)	902 (23)
UKM	69 (23)	121 (22)	175 (21)	241 (20)	411 (18)	580 (14)	836 (12)
A98E	59 (47)	116 (45)	164 (43)	249 (41)	510 (37)	873 (33)	1351 (29)
A9UK	50 (22)	120 (22)	171 (21)	263 (20)	475 (18)		
GUNS	<b>43</b> (36)	<b>77</b> (35)	<b>110</b> (33)	<b>148</b> (31)	<b>244</b> (27)	373 (21)	425 (16)
GUNA	<b>41</b> (36)	<b>72</b> (35)	<b>99</b> (33)	<b>132</b> (31)	<b>214</b> (27)	<b>336</b> (21)	415 (16)
OFCL	48 (47)	91 (45)	133 (43)	179 (41)	288 (37)	363 (33)	406 (29)
NHC Official (1993-2002 mean)	45 (2985)	81 (2726)	116 (2481)	150 (2230)	225 (1819)	282 (265)	374 (216)

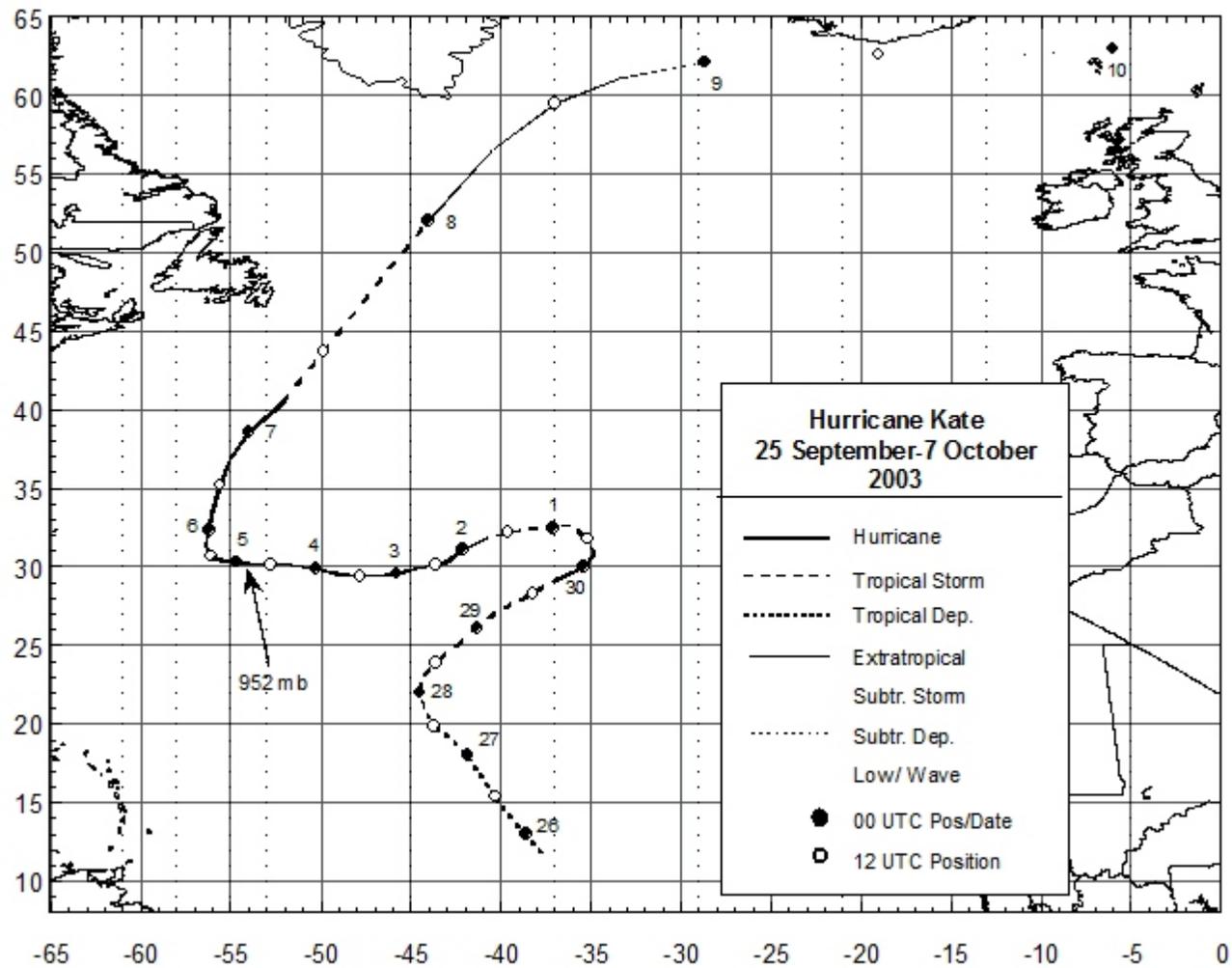


Figure 1. Best track positions for Hurricane Kate, September/October 2003. Track during the extratropical stage is based on analyses from the NOAA Ocean Prediction Center.

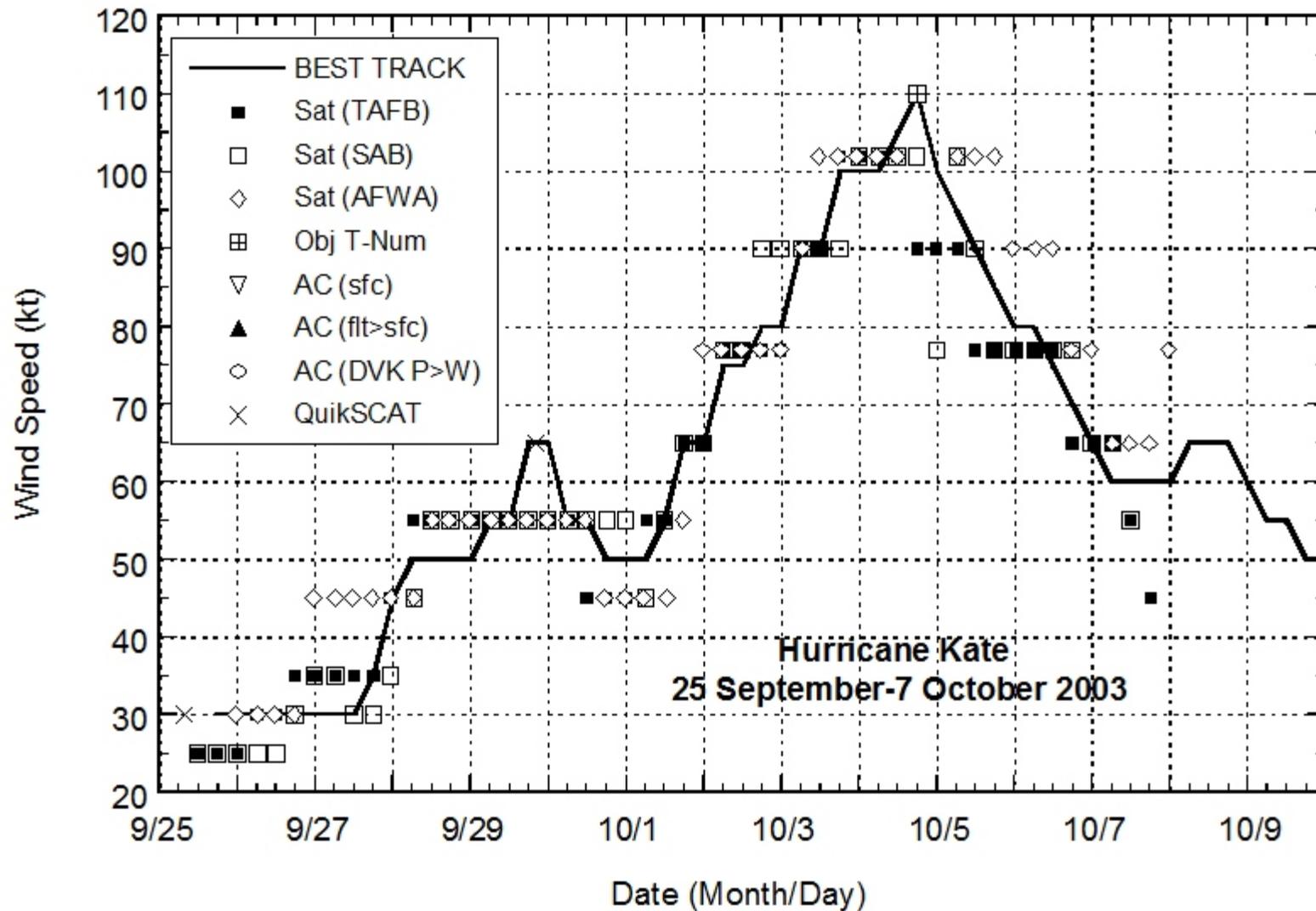


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Kate, 25 September-7 October 2003. Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time. Estimates during the extratropical stage are based on analyses from the NOAA Ocean Prediction Center.

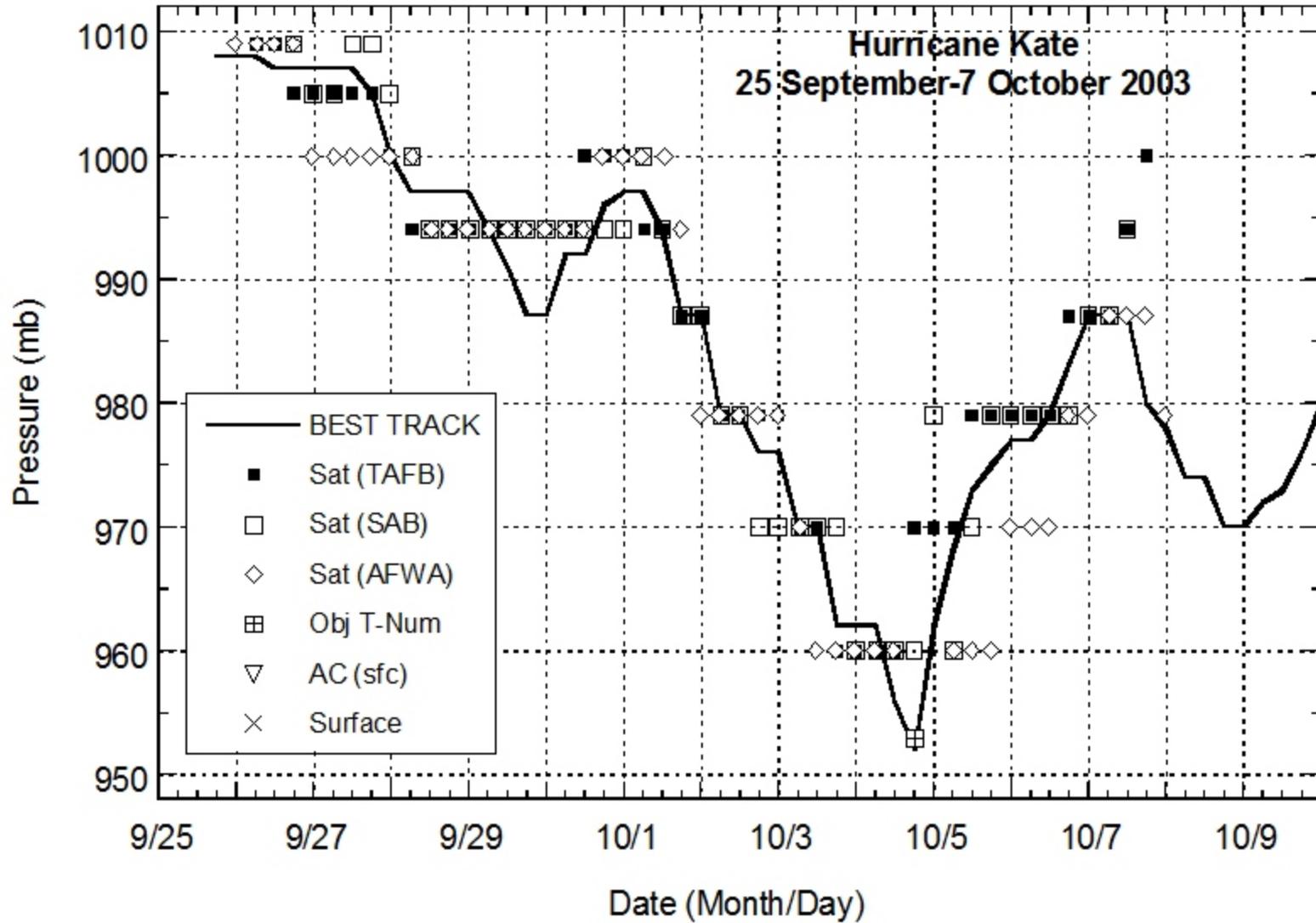


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Kate, 25 September-7 October 2003. Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time. Estimates during the extratropical stage are based on analyses from the NOAA Ocean Prediction Center.