

Tropical Cyclone Report
Hurricane Alex
31 July – 6 August 2004

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Alex brought category 1 hurricane conditions to the North Carolina Outer Banks as its center passed just offshore, and later strengthened to a category 3 hurricane while near 38°N latitude. Only one other hurricane (Ellen of 1973) reached major hurricane status farther north than Alex.

a. Synoptic History

Three distinct weather systems may have played a role in the genesis of Alex. On 26 July, shower activity increased several hundred miles to the east of the northwestern Bahamas. This activity was associated with a weak surface trough, likely of mid-latitude origin. Disorganized showers persisted just to the east of the Bahamas, in the diffluent region to the east of an upper-level low, for the next couple of days. On 28 July, when a tropical wave reached the area, the extent and organization of the convection began to increase. Analyses show that a broad area of surface low pressure formed early on 30 July just northeast of the central Bahamas. The low moved northwestward and over the next 36 hours the circulation slowly became better defined. By 1800 UTC 31 July, when the low center was located about 175 n mi east of Jacksonville, the system had enough convective organization to be classified as a tropical depression.

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. As the depression approached a break in the subtropical ridge early on 1 August, its forward motion slowed, and the cyclone remained nearly stationary for the next day or so about 115 n mi east-southeast of Savannah. The depression remained poorly organized initially, due to northeasterly shear and an environment characterized by subsidence and dry air. However, an upper-level trough was approaching from the west, and in advance of this trough the northeasterly flow over the cyclone began to relax. During this transition the depression was able to strengthen, and it became a tropical storm at 1800 UTC 1 August.

Alex began to move northeastward early on 2 August, taking a track that would slowly approach the coastline of the Carolinas over the next 36 hours. The northeasterly shear continued to diminish during the day as upper-level southwesterlies approached. The deep convection, which had previously been confined to the southwest quadrant of the circulation, was now able to organize in bands to the east of the center. Alex strengthened, becoming a hurricane near 0600 UTC 3 August, when it was centered about 65 n mi south-southeast of Cape Fear.

Aided by warm Gulf Stream waters and light shear, Alex continued to strengthen on 3 August as it neared the North Carolina Outer Banks. The hurricane's maximum sustained winds reached 85 kt (category 2 on the Saffir-Simpson Hurricane Scale) at 1200 UTC, and the minimum pressure fell to 972 mb at 1800 UTC. Alex made its closest approach to land near 1700 UTC, with its center located about 9 n mi southeast of Cape Hatteras, while the western eyewall of the hurricane raked the Outer Banks with sustained category 1 hurricane force winds.

After passing the Outer Banks, Alex turned away from land and accelerated as it became embedded in a deep layer of west-southwesterly flow. Alex strengthened and became a major hurricane (category 3) at 0000 UTC 5 August, with winds of 105 kt and a minimum pressure of 957 mb. At this time Alex was at 38.5E N (385 n mi south-southwest of Halifax, Nova Scotia), moving east-northeastward at 20-25 kt, and over waters just above 26EC – not factors normally associated with major hurricanes. Only Hurricane Ellen of 1973 attained major hurricane status farther north. While the basic environmental current surrounding Alex was low in shear, the cause of this unexpected strengthening remains unknown.

By late on 5 August Alex had moved north of the Gulf Stream over sub-20EC waters and was weakening rapidly. Moving at 40-45 kt, Alex weakened to a tropical storm after 0600 UTC 6 August and became extratropical a few hours later about 830 n mi east of Cape Race Newfoundland. The circulation of Alex was absorbed into a larger extratropical low by 0000 UTC 7 August.

b. Meteorological Statistics

Observations in Alex (Figs. 2 and 3) include satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB) and the U. S. Air Force Weather Agency (AFWA), as well as flight-level and dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Other data sources include microwave satellite imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA QuikSCAT, and Defense Meteorological Satellite Program (DMSP) satellites. Ship reports of winds of tropical storm force associated with Alex are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3.

Alex reached its estimated maximum intensity after all reconnaissance flights had ended; the peak wind estimate of 105 kt is based on a blend of objective and subjective Dvorak numbers. At the time of closest approach to land, Alex's maximum sustained winds are estimated to be 85 kt, based largely on dropsonde surface observations of 77 and 87 kt. The highest observed flight-level wind was 105 kt. This would normally correspond to a surface wind of about 95 kt, but a lower value has been used here because this observation occurred in a non-convective portion of the circulation.

Although the center of Alex remained offshore (and therefore Alex technically did not make landfall), the western portion of the eyewall passed over the North Carolina Outer Banks on 3 August. There was a relatively high density of surface observations in the area for this

event, and these observations generally indicate that category 1 sustained winds were experienced in the Outer Banks. The highest gust accepted as accurate was an unofficial report from a storm chaser of 91 kt in Hatteras Village at 1814 UTC, with a maximum sustained wind report of 67 kt at about the same time. A five-minute mean wind of 65 kt was reported from a 10-m anemometer at Avon Pier. An unofficial gust report of 104 kt at the Ocracoke Ferry office is believed to be in error, based on nearby storm-chaser observations as well as the nature of the damage.

The highest estimated surge values, near 6 ft, occurred on the sound (west) side of the Outer Banks at Buxton and Ocracoke Village. Flooding of this magnitude had not occurred on Ocracoke Island since Hurricane Gloria in 1985. Waters rose to 2-4 ft above normal levels along the lower reaches of the Neuse and Pamlico rivers.

The highest measured rainfall amount associated with Alex, 7.55 in, occurred at Ocracoke, with 5.62 in reported in Beaufort. Doppler radar data indicated a large area of 4-8 in accumulations across extreme southeastern Craven county, eastern Carteret county northeastward across Hyde and Dare counties.

c. Casualty and Damage Statistics

A 26 year-old male was drowned in strong waves and residual rip currents off of Nags Head, North Carolina, two days after the passage of Alex.

Storm surge damage and beach erosion was significant in Dare and Hyde counties on the Outer Banks. Significant wind and water damage occurred from Buxton southward and across Ocracoke Island, where hundreds of vehicles and homes were flooded from sound-side surge. Hurricane force winds produced minor structural damage to homes and businesses and caused extensive damage to trees and power lines.

There was insufficient wind damage associated with Alex to meet the \$25 million reporting level threshold of the American Insurance Services Group. Insured damage from flooding is estimated to be about \$2 million. The total damage from Alex is estimated to be not more than \$5 million.

d. Forecast and Warning Critique

The disturbance that ultimately developed into Alex was first mentioned in the Atlantic Tropical Weather Outlook on 27 July, 4 days prior to genesis. Outlooks began indicating the possibility of tropical cyclogenesis 2 days in advance.

Average official track errors (OFCL) are given in Table 4. OFCL errors for Alex were generally close to the average official track errors for the 10-yr period 1994-2003¹. Through 48

¹ Errors given for the 96 and 120 h periods are averages over the three-year period 2001-3.

h, a number of models had lower errors than the official forecast, including GFSI, BAMD, and the consensus models GUNA and FSSE. Official forecasts were generally better than the objective guidance beyond 48 h.

Average official intensity errors were 10, 14, 20, 28, 40, 43, and 43 kt for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively, considerably above the long-term mean errors of 6, 10, 12, 15, 19, 20, and 21 kt, respectively. The initial strengthening to 85 kt near Cape Hatteras was under-forecast by about 40 kt from 36 h out and beyond, although it was correctly noted in Tropical Cyclone Discussions that there would be an opportunity for strengthening once the northeasterly shear abated. The intensification to major hurricane status at the northern latitudes was not anticipated.

Table 5 lists the watches and warnings associated with Alex. A hurricane warning was issued at 2100 UTC 2 August, roughly 20 hours prior to the onset of hurricane force winds on the Outer Banks – somewhat less lead time than is desirable. The initial warning for the Outer Banks, issued at 1500 UTC 1 August, was a tropical storm warning. At this time all the objective intensity guidance, as well as the official forecast, called for Alex to remain below hurricane strength. Strengthening to a hurricane was first forecast in the advisory issued at 1500 UTC 2 August, but it was felt at that time that hurricane force winds would remain offshore.

Acknowledgments

NWS/WFOs in Newport, Wilmington, Charleston, and Wakefield contributed many of the observations contained in this report. The highest winds observations over land were provided by Mark Sudduth and Weatherflow, Inc.

Table 1. Best track for Hurricane Alex, 31 July - 6 August.

| Date/Time (UTC) | Latitude (EN) | Longitude (EW) | Pressure (mb) | Wind Speed (kt) | Stage |
|-----------------|---------------|----------------|---------------|-----------------|---------------------|
| 31 / 1800 | 30.3 | 78.3 | 1010 | 25 | tropical depression |
| 01 / 0000 | 31.0 | 78.8 | 1009 | 25 | " |
| 01 / 0600 | 31.5 | 79.0 | 1009 | 25 | " |
| 01 / 1200 | 31.6 | 79.1 | 1009 | 30 | " |
| 01 / 1800 | 31.6 | 79.2 | 1009 | 35 | tropical storm |
| 02 / 0000 | 31.5 | 79.3 | 1007 | 35 | " |
| 02 / 0600 | 31.4 | 79.4 | 1005 | 40 | " |
| 02 / 1200 | 31.3 | 79.0 | 992 | 50 | " |
| 02 / 1800 | 31.8 | 78.7 | 993 | 50 | " |
| 03 / 0000 | 32.4 | 78.2 | 987 | 60 | " |
| 03 / 0600 | 33.0 | 77.4 | 983 | 70 | hurricane |
| 03 / 1200 | 34.2 | 76.4 | 974 | 85 | " |
| 03 / 1800 | 35.3 | 75.2 | 972 | 85 | " |
| 04 / 0000 | 36.0 | 73.7 | 974 | 80 | " |
| 04 / 0600 | 36.8 | 72.1 | 973 | 80 | " |
| 04 / 1200 | 37.3 | 70.2 | 973 | 85 | " |
| 04 / 1800 | 37.8 | 68.3 | 965 | 95 | " |
| 05 / 0000 | 38.5 | 66.0 | 957 | 105 | " |
| 05 / 0600 | 39.5 | 63.1 | 957 | 105 | " |
| 05 / 1200 | 40.8 | 59.6 | 962 | 100 | " |
| 05 / 1800 | 42.7 | 55.0 | 970 | 90 | " |
| 06 / 0000 | 44.5 | 49.3 | 978 | 75 | " |
| 06 / 0600 | 46.1 | 44.2 | 984 | 65 | " |
| 06 / 1200 | 47.0 | 37.5 | 987 | 50 | tropical storm |
| 06 / 1800 | 47.4 | 32.7 | 992 | 30 | extratropical |
| 07 / 0000 | | | | | absorbed |
| 05 / 0000 | 38.5 | 66.0 | 957 | 105 | minimum pressure |

Table 2. Selected ship and drifting buoy reports with winds of at least 34 kt for Hurricane Alex, 31 July - 6 August.

| Date/Time (UTC) | Ship call sign | Latitude (EN) | Longitude (EW) | Wind dir/speed (kt) | Pressure (mb) |
|--------------------|----------------|------------------|-------------------|------------------------|------------------|
| 02 / 1200 | 30408 | 32.5 | 78.7 | 010 / 37 | 1003.0 |
| 03 / 0000 | 30408 | 32.5 | 78.7 | 010 / 37 | 1003.0 |
| 04 / 0000 | C6JT | 33.0 | 72.3 | 180 / 50 | 1010.0 |
| 04 / 1500 | WAUY | 35.9 | 67.3 | 260 / 35 | 1006.0 |
| 04 / 1800 | WAUY | 36.0 | 67.9 | 240 / 40 | 1004.1 |
| 04 / 2100 | WAUY | 36.4 | 68.3 | 240 / 40 | 1003.5 |
| 05 / 0000 | WAUY | 36.8 | 68.8 | 280 / 35 | 1005.0 |
| 05 / 1200 | VRWF2 | 35.7 | 59.9 | 220 / 36 | 1012.6 |
| 05 / 1500 | KHRH | 39.3 | 55.9 | 210 / 40 | 1015.8 |
| 05 / 1800 | KHRH | 39.3 | 56.5 | 230 / 35 | 1007.1 |
| 05 / 1800 | 4XFC | 39.7 | 48.3 | 200 / 37 | 1014.0 |
| 05 / 2100 | P3ZY6 | 37.7 | 56.5 | 230 / 35 | 1011.0 |
| 06 / 1200 | ELYD5 | 43.0 | 42.3 | 240 / 40 | 1010.5 |

Table 3. Selected surface observations for Hurricane Alex, 31 July - 6 August.

| 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) | | | |
| North Carolina | | | | | | | | |
| Wilmington (ILM) | 03/0932 | 1003.7 | 03/1001 | 18 | 26 | | | |
| Cape Hatteras (HSE) | 03/1551 | 991.2 ^g | 03/1623 | 38 ^g | 53 | | | |
| Beaufort (MRH) | 03/1356 | 999.2 | 03/1336 | 35 | 46 | | | 5.62 |
| Ocracoke | | | | | | | | 7.55 |
| Newport | | | | | | | | 2.88 |
| Buxton | | | | | | 6 | | |
| Ocracoke Village | | | | | | 6 | | |
| | | | | | | | | |
| N.C. (Unofficial) | | | | | | | | |
| Wrightsville Bch. Pier | | | 03/? | | 34 | | | |
| Hatteras Village | 03/1810 | 981 | 03/1814 | 67 | 91 | | | |
| Avon | | | 03/1715 | | 76 ^g | | | |
| Avon Pier | | | 03/1735 | 65 ^f | 78 | | | |
| Avon (Sound) | | | 03/1900 | 64 ^f | 80 | | | |
| Kure Beach | | | 03/0900 | | 34 | | | |
| Bald Head Island | | | 03/? | | 37 | | | |
| | | | | | | | | |
| Buoys and CMAN sites | | | | | | | | |
| 41025 | 03/1600 | 990.7 ^g | 03/1600 | 47 ^g | 62 | | | |
| 41013 | 03/0750 | 994.9 | 03/0710 | 35 | 45 | | | |
| CLKN7 (Cape Lookout) | 03/1300 | 994.7 | 03/1400 | 51 | 56 | | | |
| FPSN7 (Frying Pan Shls) | 03/1300 | 994.8 | 03/0900 | 33 | 45 | | | |
| DUCN7 (Duck) | 03/2100 | 1002.7 | 03/1900 | 39 | 43 | | 5.12 ^h | |
| 44140 | 05/2200 | 979.3 | | | | | | |

^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.

^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).

^e 2 min average

^f 5 min average

^g Record incomplete due to instrument failure.

^h Water height above mean lower low water.

Table 4. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Alex, 31 July - 6 August. 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.

| Forecast Technique | Forecast Period (h) | | | | | | |
|-------------------------------------|---------------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|
| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
| CLP5 | 60 (22) | 144 (20) | 238 (18) | 305 (16) | 505 (12) | 740 (8) | 817 (4) |
| GFNI | 62 (19) | 101 (17) | 138 (15) | 209 (13) | 338 (6) | 254 (1) | |
| GFDI | 44 (22) | 80 (20) | 127 (18) | 180 (16) | 339 (10) | 215 (1) | |
| LBAR | 45 (22) | 97 (20) | 144 (18) | 163 (16) | 254 (11) | 376 (8) | 178 (3) |
| FSSE | 34 (18) | 45 (16) | 75 (14) | 138 (12) | 331 (7) | 266 (1) | |
| GFSI | 34 (21) | 58 (19) | 88 (17) | 142 (15) | 349 (11) | 286 (7) | 543 (1) |
| AEMI | 37 (22) | 61 (20) | 89 (18) | 143 (16) | 353 (12) | 470 (8) | 586 (3) |
| BAMD | 42 (22) | 68 (20) | 88 (18) | 121 (16) | 246 (12) | 366 (8) | 512 (4) |
| BAMM | 58 (22) | 99 (20) | 143 (18) | 203 (16) | 352 (12) | 293 (8) | 233 (4) |
| BAMS | 87 (22) | 160 (20) | 232 (18) | 306 (16) | 507 (12) | 615 (8) | 1009 (4) |
| NGPI | 57 (22) | 98 (20) | 118 (18) | 155 (16) | 381 (12) | 590 (8) | 715 (4) |
| UKMI | 45 (18) | 69 (18) | 91 (16) | 187 (14) | 390 (10) | 915 (6) | 612 (2) |
| A98E | 45 (22) | 97 (20) | 150 (18) | 173 (16) | 359 (12) | 659 (8) | 537 (4) |
| A9UK | 49 (11) | 95 (10) | 146 (9) | 174 (8) | 343 (6) | | |
| CONU | 46 (22) | 78 (20) | 109 (18) | 159 (16) | 339 (11) | 499 (7) | 645 (3) |
| GUNA | 34 (18) | 64 (18) | 87 (16) | 140 (14) | 353 (9) | 540 (1) | |
| OFCL | 44 (22) | 74 (20) | 104 (18) | 163 (16) | 257 (12) | 260 (8) | 222 (2) |
| NHC Official (1994-2003 mean) | 44 (3172) | 78 (2894) | 112 (2636) | 146 (2368) | 217 (1929) | 248 (421) | 319 (341) |

Table 5. Watch and warning summary for Hurricane Alex, 31 July - 6 August.

| Date/Time (UTC) | Action | Location |
|-----------------|-------------------------------------|-------------------------------------|
| 31 / 2100 | Tropical Storm Watch issued | Edisto Beach to Cape Hatteras |
| 1 / 1500 | Tropical Storm Watch modified to | Edisto Beach to Cape Fear |
| 1 / 1500 | Tropical Storm Warning issued | Cape Fear to Cape Hatteras |
| 1 / 2100 | Tropical Storm Watch modified to | Edisto Beach to South Santee River |
| 1 / 2100 | Tropical Storm Watch issued | Cape Hatteras to Oregon Inlet |
| 1 / 2100 | Tropical Storm Warning modified to | South Santee River to Cape Hatteras |
| 2 / 1500 | Tropical Storm Watch discontinued | All |
| 2 / 1500 | Tropical Storm Warning modified to | South Santee River to Oregon Inlet |
| 2 / 2100 | Tropical Storm Warning modified to | Oregon Inlet to NC/VA border |
| 2 / 2100 | Hurricane Warning issued | Cape Lookout to Oregon Inlet |
| 3 / 0900 | Tropical Storm Warning modified to | Cape Fear to Cape Lookout |
| 3 / 1500 | Tropical Storm Warning modified to | Surf City to Cape Lookout |
| 3 / 2100 | Tropical Storm Warning discontinued | Surf City to Cape Lookout |
| 4 / 0000 | Tropical Storm Warning discontinued | All |
| 4 / 0000 | Hurricane Warning discontinued | All |

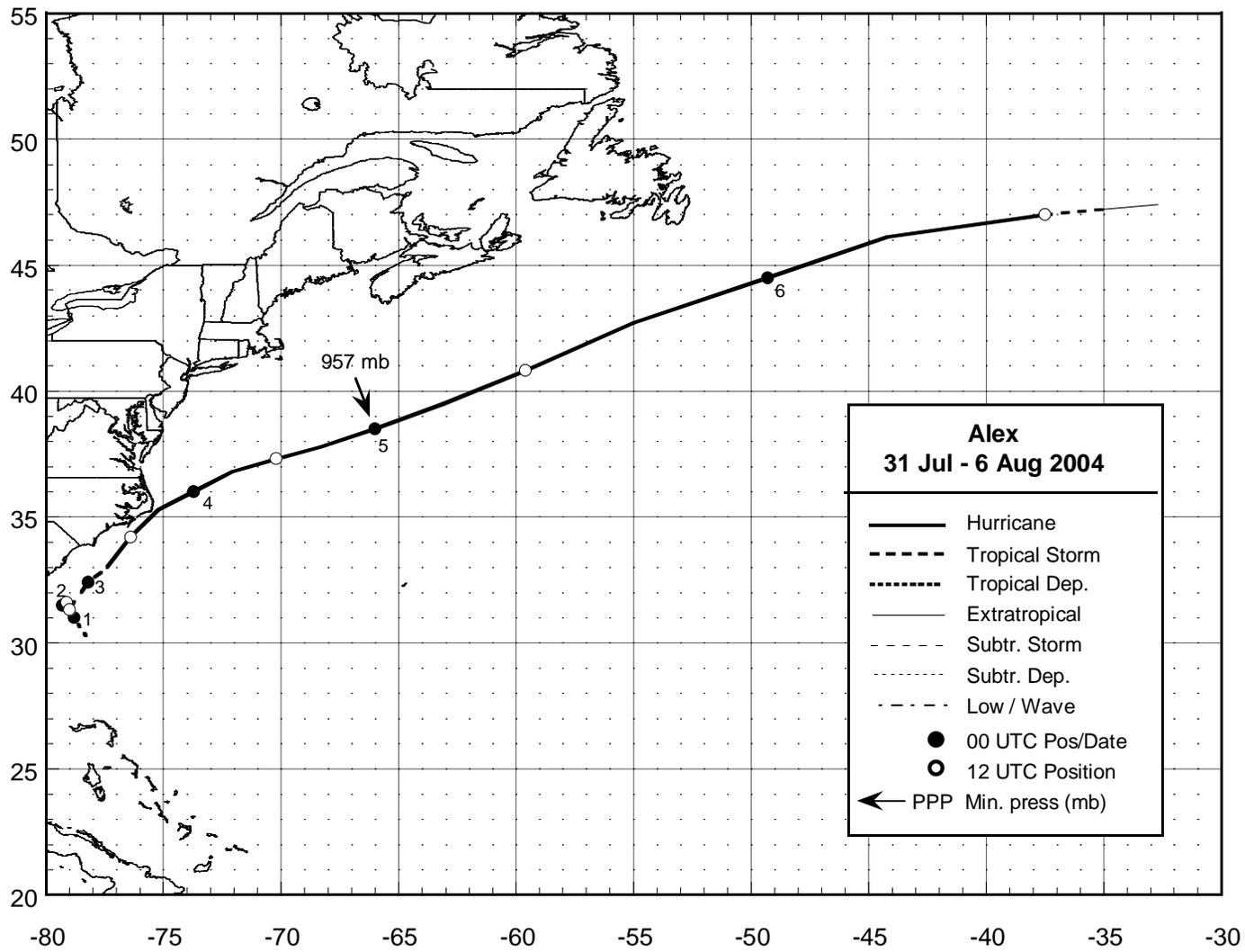


Figure 1. Best track positions for Hurricane Alex, 31 July - 6 August.

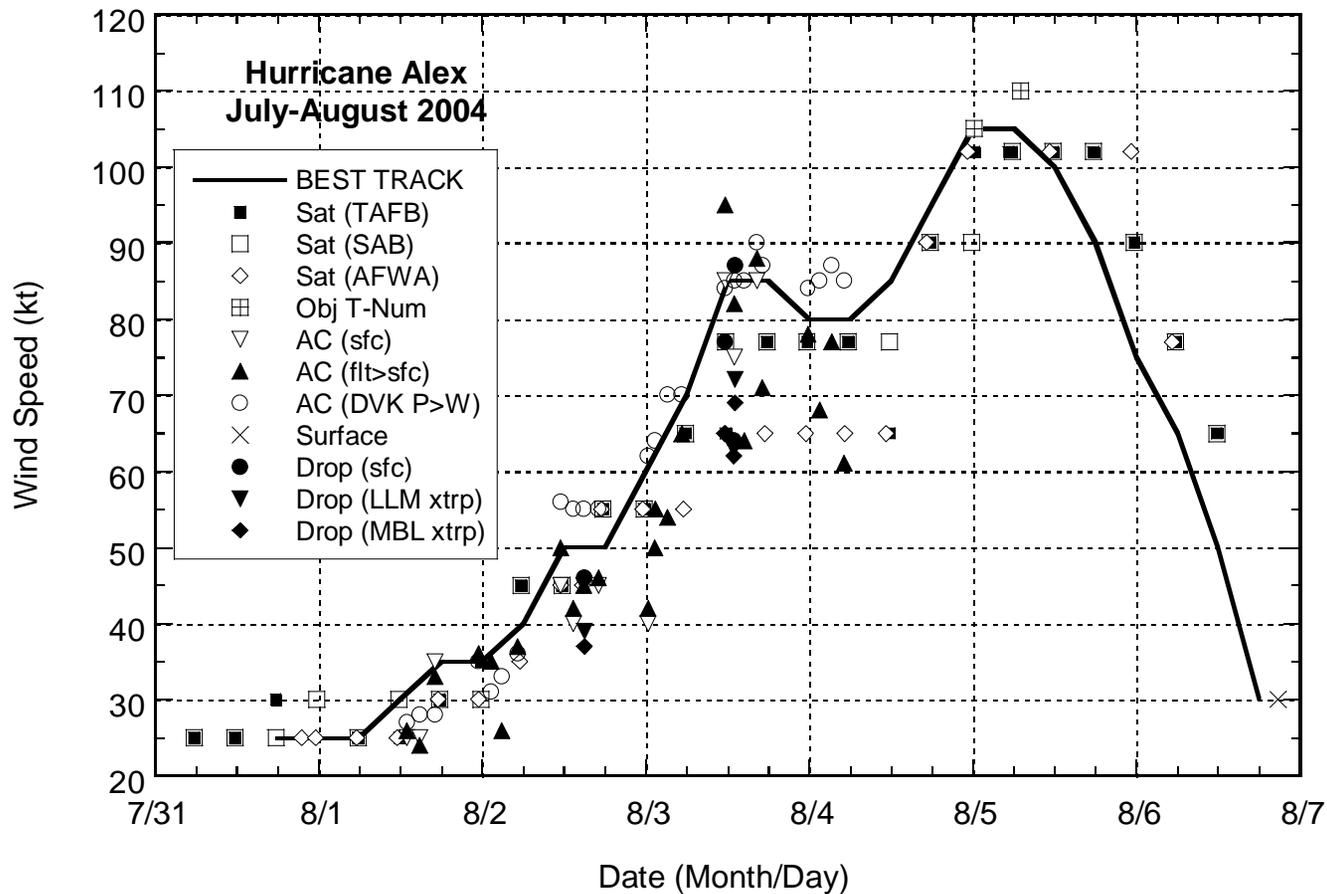


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Alex, 31 July - 6 August. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde 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). Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time.

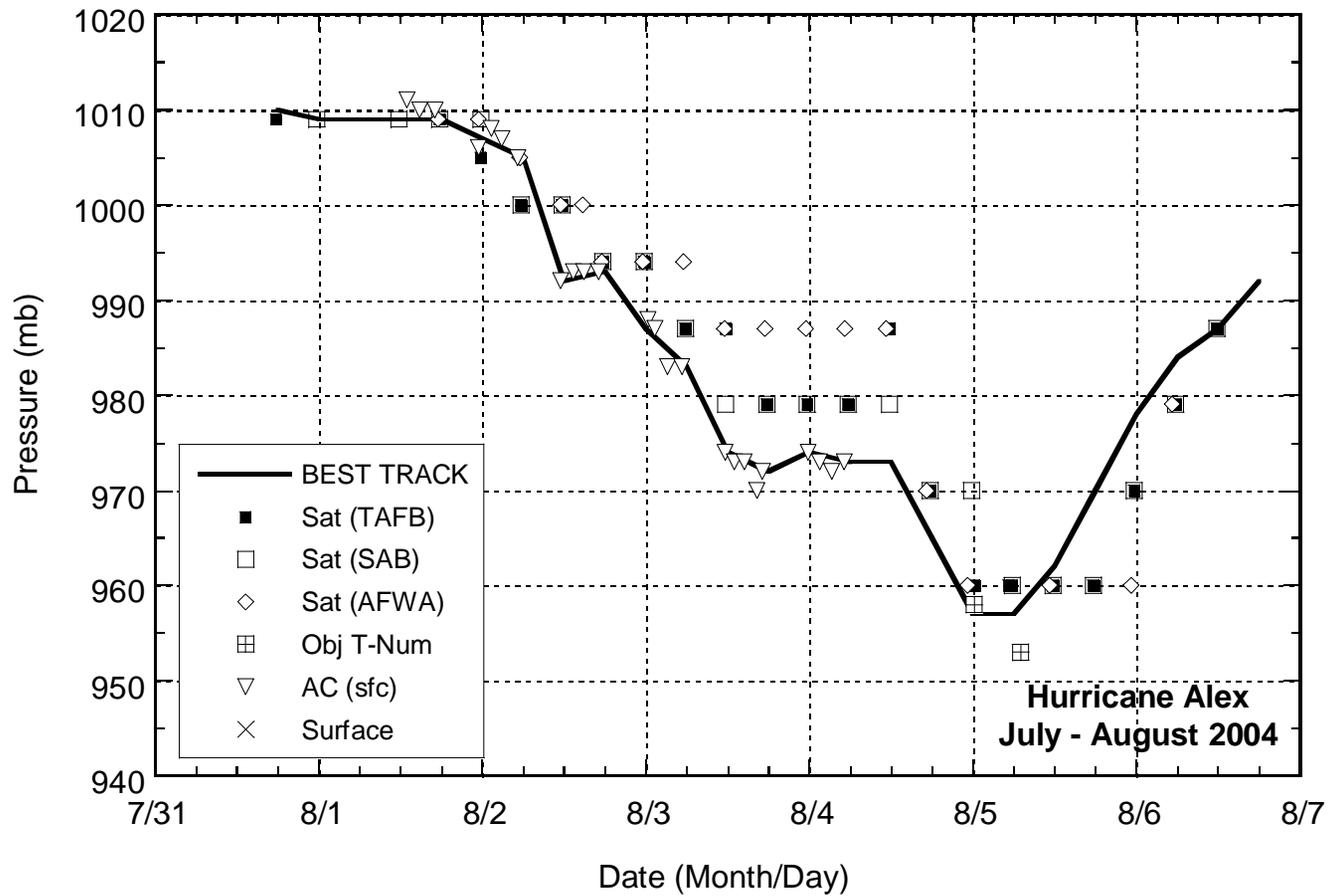


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Alex, 31 July - 6 August. Objective Dvorak estimates represent linear averages over a three-hour period centered on the nominal observation time.