Preliminary Report
Hurricane Danny
16 - 26 July 1997

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Danny was a slow-moving category one hurricane on the Saffir/Simpson Hurricane Scale that made landfall near the mouth of the Mississippi River and in the Mobile Bay area. It produced enormous amounts of rain over extreme southern Alabama.

a. Synoptic History

Like tropical cyclones Ana, Bill, and Claudette, Danny came from a weather system of non-tropical origin. On 13 July, a broad upper-tropospheric trough over the southeastern United States triggered a cluster of thunderstorms over the lower Mississippi River valley. This area of convection drifted southward over the north-central Gulf of Mexico coastal waters, and appears to have contributed to the formation of a small, weak surface low near the coast of Louisiana on the 14th.

Over the next couple of days, the cyclonic circulation expanded somewhat over the northern Gulf. However, surface winds remained quite weak and the associated deep convection was not persistent or well-organized. By 1200 UTC on 16 July, deep convection became a little better organized near the center and the system began to resemble a tropical cyclone. Initial Dvorak satellite classifications were given. Observations from oil rigs and NOAA data buoys at the same time showed that the circulation had become well-defined. These surface and near-surface data indicated that maximum winds were near 25 knots. It is estimated that Tropical Depression Four formed at this time (Table 1), centered about 125 n mi south of the coast of southwestern Louisiana. The track of the tropical cyclone is depicted in Figs. 1a and 1b.

Development of the system was rather slow until around 1200 UTC 17 July. Starting around that time, the amount and organization of deep convection increased dramatically. Data from an Air Force Hurricane Hunter plane "fixing" the center of the cyclone at 1448 UTC on the 17th suggested that the cyclone had reached tropical storm strength. Satellite intensity estimates showed an increase from a T2.0 to T3.0 on the Dvorak scale in the interval from 1200 to 1800 UTC. Danny continued to strengthen, and was a hurricane by 0600 UTC on the 18th. By this time the center was nearing the Mississippi River delta.

While over the northern Gulf coastal area, Danny was generally located on the southeast side of a very weak mid-tropospheric trough that was oriented from east-northeast to west-southwest. In effect, Danny was "sandwiched" between two high pressure areas. Consequently, the cyclone moved quite slowly in a generally east-northeastward direction. It is rather rare for Gulf of Mexico tropical cyclones to move in this direction during the month of July. At times, the forward motion slowed nearly to a halt.

Hurricane Danny made its first landfall, just northwest of the Mississippi River delta near the towns of Empire and Buras, early on 18 July. Danny was a very small hurricane, and significant effects were confined to the area immediately around the eye. Reports from the Hurricane Hunters indicated a radius of maximum winds of eight or nine n mi. Communities from Port Sulphur southeastward to Venice, Louisiana probably experienced hurricane force winds (the Venice ASOS site lost power after reporting wind gusts to 38 knots a couple of hours before the closest approach of the hurricane's center).

After passing over extreme southeastern Louisiana, the center of Danny was back over the Gulf of Mexico, south of the coast of Mississippi, during the day on 18 July. There was a little more strengthening, and Danny reached its peak intensity of 70 knots with a minimum central pressure of 984 mb. The slow-moving hurricane wobbled to the east, then north-northeastward, bringing the eye to the mouth of Mobile Bay, near Fort Morgan, Alabama, just before dawn on the 19th. The eyewall and western edge of the eye passed over Dauphin Island, where sustained hurricane-force winds and torrential rains were experienced. After drifting over extreme southern Mobile Bay, the center plodded eastward, practically stalled, and finally crossed the coast on the southeast shore of the bay near Mullet Point, Alabama around midday on the 19th. Danny continued to move erratically, toward the southeast over extreme southeast Alabama, while weakening to a tropical storm by 0000 UTC on the 20th. The weakening cyclone then turned northward, passing over the extreme northwest Florida panhandle. Danny, weakened to a depression by 1800 UTC on the 20th, moved north to northeastward over Alabama for two days.

Satellite images showed that Danny, although very weak at the surface, still had a well-defined cyclonic cloud signature as it moved eastward over northern Georgia and South Carolina on 22-23 July. The low pressure system moved east-northeastward over North Carolina on the morning of the 24th. Around midday, as the center neared the Atlantic seaboard near the North Carolina/Virginia border, the cyclone began strengthening -- while accelerating in forward speed. The fact that Danny was re-intensifying while still partially over land suggests that it may have been deriving energy from a baroclinic source. A front was situated just to the north of the cyclone around this time. Winds around Danny were already back to tropical storm force as the center moved back over water around 1900 UTC on the 24th.

Just when it looked as if it were racing safely away from the coast, the storm turned north-northeastward, and slowed dramatically, as it appeared to be drawn in toward a middle- to upper-tropospheric cyclone over the northeastern United States. This motion brought Danny to about 25 n mi southeast of Nantucket Island, Massachusetts, around 0000 UTC 26 July. After buffeting southeastern Massachusetts, Danny lost its remaining tropical characteristics, and turned out to sea -- for good. The cyclone was absorbed in a frontal zone over the north Atlantic by 1800 UTC on 27 July.

b. Meteorological Statistics

Figures 2 and 3 depict the curves of minimum central sea-level pressure and maximum one-minute average "surface" (10 meters above ground level) wind speed, respectively, as a function of time. Also plotted are the observations on which the curves are based, consisting of aircraft reconnaissance data from the U.S. Air Force Reserves (the Hurricane Hunters), Dvorak-technique estimates (from the Tropical Analysis and Forecast Branch, TAFB, the Synoptic Analysis Branch, SAB, and the U.S. Air Force Global Weather Center, AFGWC) using satellite imagery, and fixes from synoptic weather map analyses.

The Hurricane Hunters flew a total of 11 missions into Danny, 10 in the Gulf of Mexico (just inland along the Gulf coast) and one in the Atlantic. Just prior to landfall near the mouth of the Mississippi River early on 18 July, the Hurricane Hunters reported maximum flight-level (1500-foot) winds of 80 knots. At about the same time, ten-minute average winds of 55 knots, with gusts to 83 knots, were reported at Grand Isle, Louisiana. Maximum winds reported by the Hurricane Hunters were 82 knots (at 1500 feet) at 1449 UTC 18 July. The minimum central pressure recorded by the aircraft was 984 mb at 2325 UTC on the 18th, and again at 1142, 1259, and 1410 UTC on the 19th.

The Dauphin Island C-MAN site, on the west end of the island, measured 10-minute average winds of 65 knots at 1145 UTC 19 July and gusts to 88 knots 21 minutes earlier. Interestingly, the Mobile WSR-88D radar showed that around these times the strongest eyewall convection was occurring in this vicinity over the southwest quadrant of the hurricane. At 1139 UTC, aircraft reported maximum winds of 64 knots at the 850 mb flight level in the southwest quadrant. Thus, *surface* winds and *flight-level* winds were *about the same* in this highly convective regime of the hurricane.

True to form for a slow-moving hurricane, rainfall totals over extreme southern Alabama were gigantic. Doppler radar estimates suggested maximum storm total precipitation amounts to around 43 inches near Dauphin Island. Recent studies indicate that a new reflectivity vs. rainfall relationship for tropical cyclones, used with the Mobile radar, gives a rather accurate estimate of the actual precipitation. A

rainfall total of 36.71 inches was measured at the Dauphin Island Sea Lab observing site. To the author's knowledge, this is the largest hurricane-related rainfall ever recorded in the state of Alabama, and one of the largest ever measured in the United States. Experience has shown that in the high wind regime of a hurricane, rain gauges do not capture all of the rainfall; so, this amount is probably an underestimate of the total. Fortunately, most of the extreme precipitation amounts occurred in areas near the coast or over water, near southwestern Mobile Bay. This helped to limit the amount of flooding, which would have been disastrous if rains of such magnitude had occurred farther inland. Nonetheless, there was some significant inland flooding along the path of Danny, notably in Charlotte, North Carolina, where rainfall totals of 8 to 12 inches where recorded. The resulting floods caused three deaths (see next section).

Storm tides of generally two to five feet occurred from the Florida/Alabama border to Dauphin Island. A maximum storm tide of 6.54 feet was reported along Highway 182W, about midway between Gulf Shores and Fort Morgan. This exceptionally high water mark may have been the combined result of storm surge and wave action. In the upper part of Mobile Bay, offshore winds blew water out of the bay so that tides were two feet below normal. Observers reported that the bay had never been so low and that, except for the river channels, one could have walked across the bay.

Danny spawned tornadoes in Orange Beach and Alabama Port, Alabama. Farther inland, a severe thunderstorm cell in Danny's circulation produced five tornado touchdowns in Lexington (causing one fatality; see next section), Richland (two touchdowns), Kershaw, and Chesterfield Counties of South Carolina. A small, weak tornado was reported in Abbeville County, South Carolina. A few hours before Danny moved into the Atlantic, tornadoes touched down in the South Norfolk section of Chesapeake, Virginia and also in downtown Norfolk.

In southeastern Massachusetts, the strongest winds were experienced on Nantucket Island. There, sustained tropical storm force winds, with gusts of 50 to 60 knots, were experienced.

Table 2 lists a selection of surface observations taken during Danny.

c. Casualty and Damage Statistics

Danny was directly responsible for four deaths. A man was killed when he was caught at sea on his sailboat, off the Alabama coast near Fort Morgan. A woman was killed by a tornado which tore apart her duplex in Lexington County, South Carolina. In Charlotte, North Carolina (Mecklenberg County), a girl drowned when floodwater swept her into a creek, and a woman was drowned in her car by floodwater. Five additional fatalities are indirectly associated with Danny. A man died of a heart attack while trying to secure a boat during the storm on the Alabama coast, and four people

died in storm-related traffic accidents in Georgia.

According to the American Insurance Services Group, insured losses from Danny were about 60 million dollars. The National Hurricane Center estimates around 100 million dollars in total damage.

d. Forecast and Warning Critique

Excluding the tropical depression stage, the average official track forecast errors for Danny were 45 n mi at 12 hr, 102 n mi at 24 hr, 139 n mi at 36 hr, 150 n mi at 48 hr, and 147 n mi at 72 hr. These are comparable to the long-term averages for 12, 24 and 36 hours, and about 17% and 46% lower than the long-term averages at 48 and 72 hours, respectively. However, the number of cases was rather small, ranging from 18 at 12 hr to only one at 72 hr.

Several of the official track forecasts made when Danny was in the Gulf of Mexico showed a left bias. This was mainly due to a similar left bias in several of the GFDL model predictions, which incorrectly showed landfall on the coast of Mississippi, and very heavy rains spreading over that state. The north-northeastward turn toward Cape Cod was not shown by the objective track prediction models or by the official forecast.

On the 16th, 17th, and early on the 18th of July, there were some fairly large underforecasts of the intensity. Part of this was due to an underprediction of the fast strengthening of Danny to a hurricane while it was near the coast, and part was due to moving the cyclone inland too soon in the forecasts.

Table 3 lists the various watches and warnings that were issued for Danny. A hurricane watch was posted for the Louisiana, Mississippi, and Alabama coasts when the cyclone strengthened into a tropical storm at 1500 UTC 17 July. When Danny had strengthened to a hurricane, this watch was upgraded to a hurricane warning at 0700 UTC 18 July, only a couple of hours before landfall in extreme southeastern Louisiana, and 27 hours before the landfall on the coast of Alabama. The tropical storm warning for southeastern Massachusetts was issued a little less than 12 hours before Danny's closest point of approach to that area, but only a couple of hours prior to the occurrence of sustained tropical storm force winds there.

Acknowledgments

Some of the information in this report came from preliminary storm reports from National Weather Service offices in Lake Charles and Slidell, Louisiana, Mobile, Alabama, Tallahassee, Florida, and Taunton, Massachusetts. Dr. Stephen R. Baig produced the track charts.

Table 1. Best track, Hurricane Danny, 16- 26 July, 1997

Date/Time (UTC)	Position		Pressure (mb)	Wind Speed (kt)	Stage
	Lat. (°N)	Lon. (°W)			
16/1200	27.4	92.6	1013	25	tropical depression
1800	27.5	92.5	1013	30	"
17/0000	27.7	92.3	1011	30	"
0600	27.9	92.0	1007	30	"
1200	28.3	91.4	1003	40	tropical storm
1800	28.6	91.0	1002	50	"
18/0000	28.9	90.2	997	55	"
0600	29.2	89.9	992	65	hurricane
1200	29.5	89.4	990	70	"
1800	29.7	89.0	988	70	"
19/0000	29.8	88.4	984	70	"
0600	30.1	88.1	987	65	"
1200	30.3	88.0	984	70	"
1800	30.4	87.9	986	65	"
20/0000	30.3	87.6	991	60	tropical storm
0600	30.4	87.5	998	45	"
1200	30.6	87.4	1001	35	"
1800	30.8	87.4	1004	30	tropical depression
21/0000	31.0	87.5	1006	25	"
0600	31.3	87.6	1009	20	"
1200	31.7	87.6	1010	20	"
1800	32.1	87.2	1011	20	"
22/0000	32.9	87.1	1011	20	"
0600	33.2	86.8	1012	20	"
1200	33.4	86.6	1013	20	"
1800	33.7	86.3	1013	20	"
23/0000	34.0	86.0	1012	20	"
0600	34.1	85.2	1012	20	"
1200	34.2	84.5	1012	20	"
1800	34.3	83.7	1012	20	"
24/0000	34.4	82.4	1012	20	"
0600	34.6	80.7	1010	20	"
1200	35.2	79.2	1004	30	"
1800	36.4	76.7	1000	40	tropical storm

Table 1 (continued). Best track. Hurricane Danny, 16- 26 July 1997.

25/0000	37.5	73.5	996	50	tropical storm
0600	38.6	71.6	995	50	"
1200	40.0	70.4	995	50	"
1800	40.7	69.9	994	50	"
26/0000	40.7	69.6	995	45	"
0600	40.4	68.0	998	45	extratropical
1200	40.6	65.6	1003	40	"
1800	41.0	63.0	1004	40	"
27/0000	41.7	60.4	1004	40	"
0600	42.8	56.0	1004	40	"
1200	44.0	48.0	1005	30	
1800					merged with a front

19/0000	29.8	88.4	984	70	minimum pressure
19/1200	30.3	88.0	984	70	"
18/0900	29.3	89.7	989	65	landfall near Empire, Louisiana
19/1000	30.2	88.1	984	70	landfall near Fort Morgan, Alabama
19/1800	30.4	87.9	986	65	landfall near Mullet Point, Alabama

Table 2. Hurricane Danny, selected surface observations, July, 1997.

Location	Press. (mb)	Date/ time (UTC)	Sustained wind (kts)[a]	Peak gust (kts)	Date /time (UTC)[b]	Storm surge (ft)[c]	Storm tide (ft)[d]	total rain (in)
Louisiana								
Bayou Bienvenue							5.27	
Buras								9.32
Grand Isle							5.40	
Grand Isle C-MAN			55**	83	18/0900			
New Orleans Intern. Airp.	1008.8	18/1023	24	29	20/0455			0.27
New Orleans Lakefr. Airp.	1008.5	18/1018	33	39	20/0446			1.09
Rigolettes							3.31	
S.W. Pass C-MAN BURL1	1005.6	18/1000	41**	55	18/1130			
Venice ASOS*	1006.4	18/0747	26	38	18/0724			
Mississippi								
Pascagoula Trent Lott Airp.	1005.1	19/1011	22	30	19/0730			
Alabama								
Alabama Port								27.00
Bayou La Batre							2.40	
Bellefontaine								25.00
Chickasaw								17.00
Coden								19.67
Daphne								23.54
Dauphin Island							2.40	
Dauphin Island C-MAN	987.7	19/0900	65**	88	19/1145			
Dauphin Island Sea Lab	985.8	19/1100	60	75	19/0615			36.71
Dog River								16.90
Fairhope Agr. Exp. Stn.				59	20/1353			24.00
Fairhope Treatment Plant								24.00
Gulf Beach (AL/FL state							2.59	
Gulf Shores								30.00
Gulf Shores (5 miles west)								25.00
Gulf Shores ham radio				70	19/1930			
Gulf Shores Fishing Pier			61		19/1500			
Highway 182 W***							6.54	
Little Dauphin Island Bay							5.00	
Malbis								33.00
Mobile (I-65 and Springhill)								16.04
Mobile Bay state docks							-2.00	
Mobile Regional Airport	1004.4	19/1023	31	39	19/1736			13.04
Mobile Brookley Field Airp.	1000.7	19/1104	36	46	20/1011			
Montrose								26.00
Orange Beach ham radio				66	19/0900			
Robertsdale								18.00
Silverhill								22.50
Spanish Fort								20.10
St. Elmo								19.00
Summerdale								21.50
Theodore								21.00
Florida								
Crestview	1009.1	20/0930	20	28	20/2008			1.93

Table 2 (continued). Hurricane Danny, selected surface observations, July, 1997.

Location	Press. (mb)	Date/ time (UTC)	Sustained wind (kts)[a]	Peak gust (kts)	Date /time (UTC)[b]	Storm surge (ft)[c]	Storm tide (ft)[d]	total rain (in)
Florida (cont.)								
Eglin Air Force Base	1009.9	20/0730		32	20/1755			2.22
Hurlburt Air Force Base	1009.1	20/0655	30	38	19/0900			3.76
Milton Whiting Field	1005.8		27	34	20/0239			2.23
Pensacola Naval Air Stn.	1001.1		43	55	20/0216			6.43
Pensacola Regional Airp.	1002.0	20/0552	31	41	20/0208			6.78
North Carolina								
Diamond Shoals Lt. C-MAN	1013.0	24/2200	38	46	24/1900			
Duck pier C-MAN	1009.5	24/1900	42	51	24/2000			
Elizabeth City	1003.7	24/1846	42	55	24/1846			1.20
Rocky Mount				51				
Virginia								
Cape Henry				54				
Chesapeake Bay Br. Tunnel				54				
Chesapeake Light C-MAN	1005.6	24/2000	51**	61	24/2055			
Hampton Roads Br. Tunnel				39				
Langley AFB				54				
Norfolk ASOS	1007.5	24/1752	30	44	24/1817			2.27
Norfolk Naval				51				
Oceana Naval Air (V.Bch.)				43				1.36
Sewells Point							2.0	
Wakefield NWSO								3.01
Massachusetts								
Buzzards Bay C-MAN	1008.5	25/1900	42**	51	25/2240			
Chatham Coast Guard			38		25/1500			
Chatham upper-air site CHH			35	40	25/1645			
Cotuit								2.85
Falmouth								2.63
Martha's Vineyard ASOS	1004.9	25/1935	33	42	25/1945			2.88
Nantucket Island						0.83		
Nantucket Island ASOS	999.5	25/1953	37	45	25/2020			4.14
Nantucket weather spotter			35	61	25/2100			4.52
Otis A.F.B. tower Falmouth	1006.8	25/1955	32	51	25/2155			
Plymouth ASOS			29	37	25/2212			
Vineyard Haven (Martha's)								2.28
Wareham								3.25
NOAA National Data Buoy Center buoys								
42007 (30.1°N 88.8°W)	1001.4	18/2100	35	46	18/2300			
42040 (29.2°N 88.3°W)	1006.2	19/0000	33**	42	18/1520			
44004 (38.5°N 70.7°W)	1004.9	25/0800	32**	42	25/0900			
44008 (40.5°N 69.4°W)	995.4	26/0100	30**	37	25/1800			
44014 (36.6°N 74.8°W)	1003.5	24/2100	42	54	24/2100			

[a]NWS standard averaging period is 1 min; ASOS and C-MAN are 2 min (except where indicated); buoys are 8 min.
[b]Date/time is for sustained wind when both sustained and gust are listed.
[c]Storm surge is water height above normal astronomical tide level.
[d]Storm tide is water height above NGVD.
*Site lost power at 0747 UTC.
**Ten-minute average wind.
***About midway between Gulf Shores and Fort Morgan, AL.

Table 3. Watch and warning summary, Hurricane Danny, July 1997.

Date/time (UTC)	Action	Location
17/1500	hurricane watch and tropical storm warning issued	Cameron, Louisiana to Orange Beach, Alabama
18/0300	hurricane watch and tropical storm warning issued	east of Orange Beach, Alabama to Destin, Florida
18/0300	hurricane watch and tropical storm warning discontinued	west of Morgan City, Louisiana
18/0700	hurricane warning replaces hurricane watch	Morgan City, Louisiana to Destin, Florida (excluding New Orleans, Louisiana)
18/2100	hurricane warning discontinued	west of Grand Isle, Louisiana
19/0300	hurricane warning issued	east of Destin, Florida to Apalachicola, Florida
19/0300	hurricane warning discontinued	west of Gulfport, Mississippi
20/0300	hurricane warning replaced by tropical storm warning	Florida/Alabama border eastward to Panama City, Florida
20/0300	hurricane warning discontinued	east of Panama City, Florida and west of the Florida/Alabama border
20/1500	tropical storm warning discontinued	Florida/Alabama border eastward to Panama City, Florida
25/1230	tropical storm warning issued	Woods Hole to Plymouth, Massachusetts including Cape Cod, Nantucket Island, and Martha's Vineyard
26/0300	tropical storm warning discontinued	north of Chatham, Massachusetts
26/0900	tropical storm warning discontinued	remainder of Massachusetts

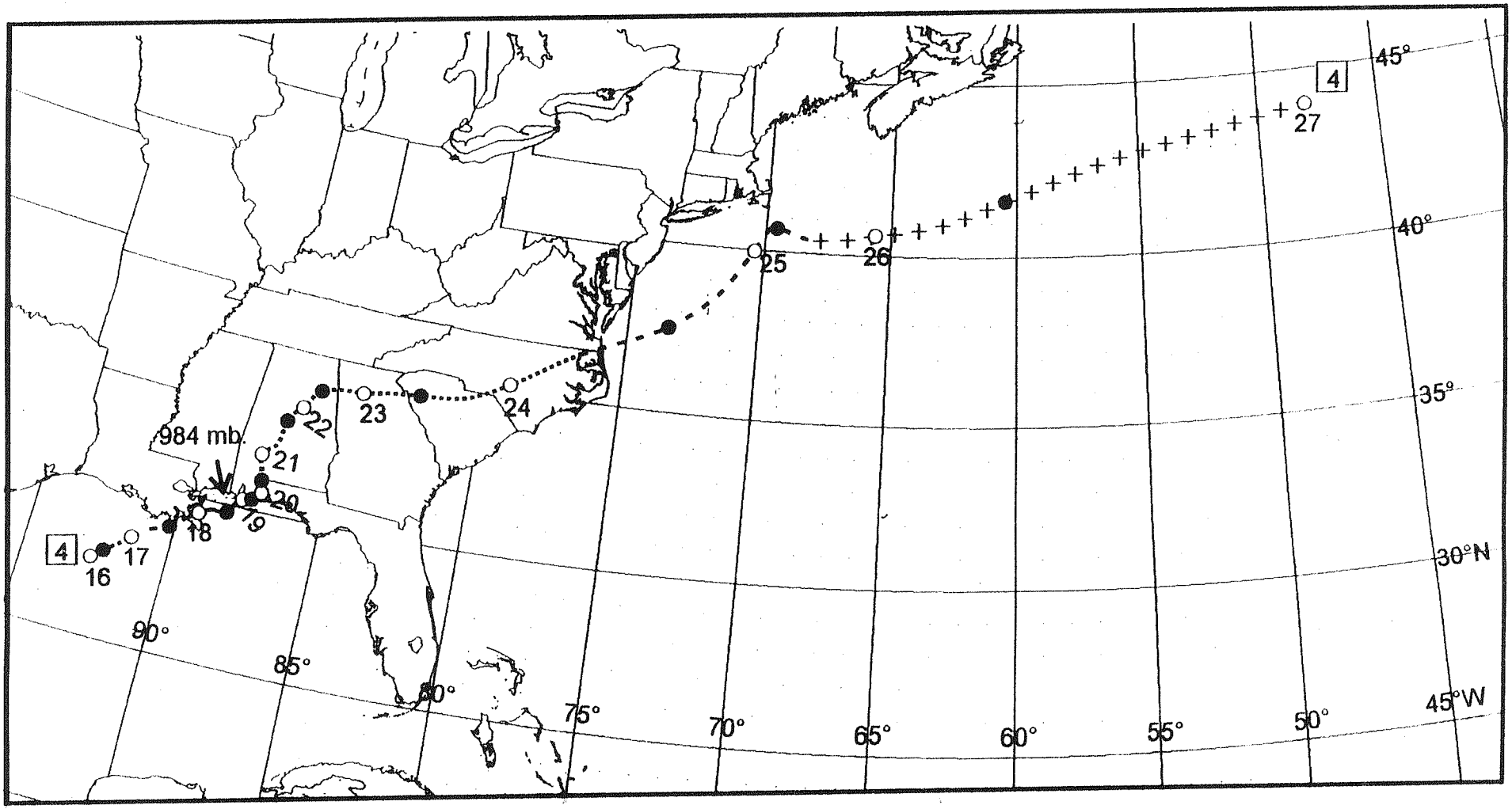

Fig. 1a. Best track positions for Hurricane Danny, 16-26 July, 1997

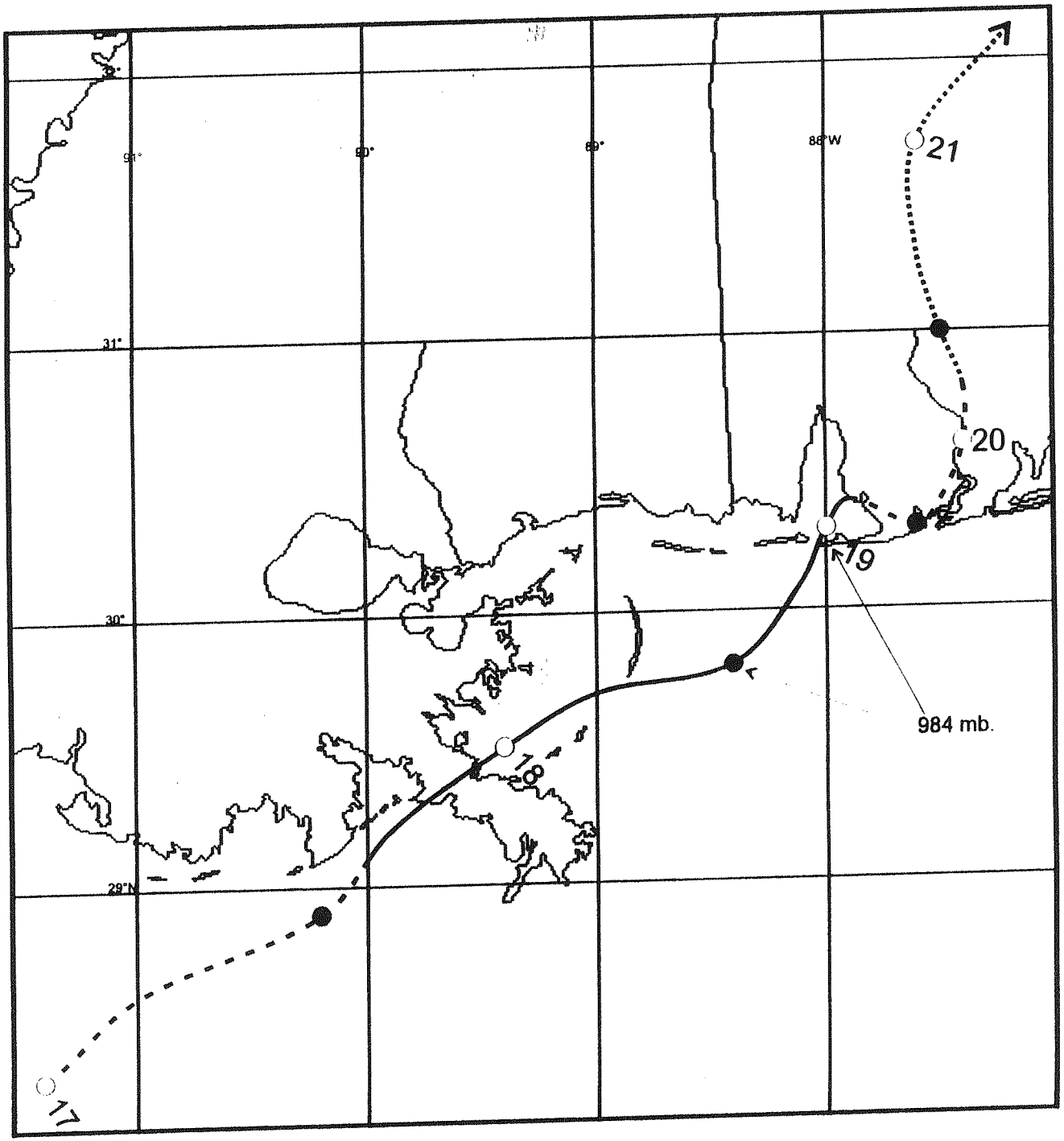

Fig. 1b. Detail of best track positions for Hurricane Danny, 17-21 July 1997

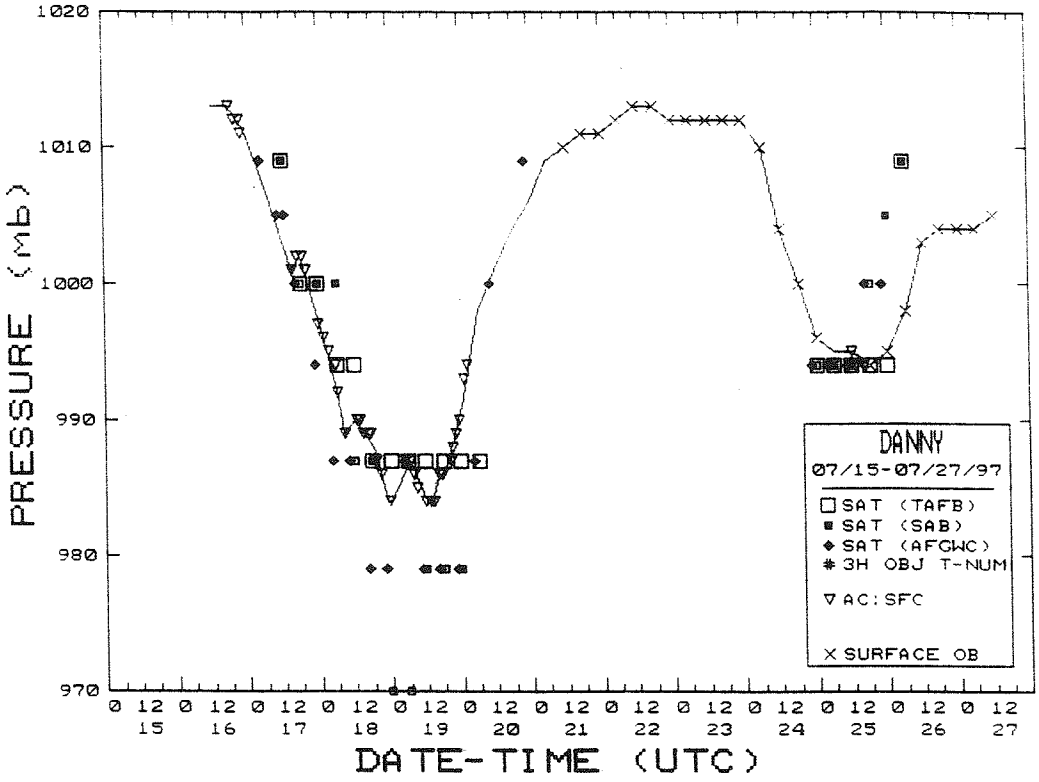

Figure 2. Best track central pressure curve for Hurricane Danny, July, 1997.

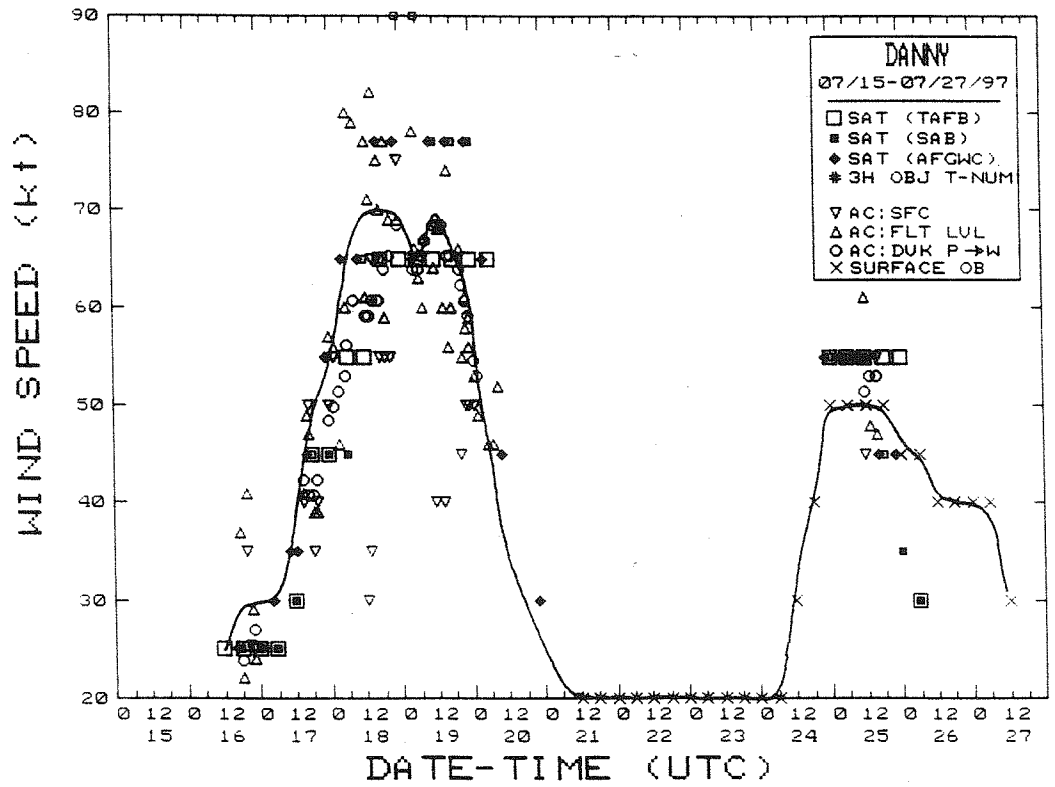

Figure 3. Best track maximum one-minute wind speed curve for Hurricane Danny, July, 1997.