

Reanalysis of Ten U.S. Landfalling Hurricanes

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1. Introduction

The Atlantic hurricane database (HURDAT) contains track and intensity estimates for all tropical storms, subtropical storms, and hurricanes back to 1851 (Jarvinen et al., 1984; Landsea et al. 2004a). Wind (intensity) estimates from Atlantic basin tropical cyclones are recorded in HURDAT in 6-hourly intervals as the maximum 1-min surface (10 m) wind speed (in 5-kt increments in the 20th and 21st centuries) within the circulation of the tropical cyclone. Position estimates (also in 6-hourly intervals) are recorded as the location to the nearest 0.1°. HURDAT was first developed to provide objective track guidance tools during the 1960's and is utilized in a wide variety of ways, including climatic change studies, seasonal forecasting, risk assessment for emergency managers, analysis of potential losses for insurance and business interests, and the development and verification of both official National Hurricane Center (NHC) and computer model predictions of track and intensity (Jarvinen et al., 1984; Landsea et al., 2004a).

Using the original HURDAT file for ten existing U.S. landfalling hurricanes, a wind swath analysis footprint was produced. The storm footprints are produced by the

AEF RealTrack™ system, which guides a numerical weather prediction (NWP) hurricane model along the prescribed track (Dickinson et al., 2004).

Using the storm footprint technology, it can be determined whether the maximum wind each state experienced for the prescribed track and intensity record can be validated. This is done by comparing the resultant maximum state winds from the footprints to the state-based Saffir-Simpson Hurricane Scale (Saffir 1973, Simpson 1974) categories in the best track dataset (Dickinson et al., 2004). Through this analysis and comparison, it was revealed that large discrepancies often exist between the HURDAT record and the Saffir-Simpson state-based categorizations for the affected states.

A complete re-analysis was thus conducted to resolve the discrepancies between the original HURDAT and the state-based Saffir-Simpson categories of impact. The Atlantic basin hurricane database re-analysis project is an on-going effort to extend, revisit and revise the database, including official tracks and intensities of tropical storms (Landsea et al., 2004a, b, 2007). The re-analysis of the Atlantic Hurricane Database is both needed and timely as the records contain random and systematic errors that need to be corrected. In addition, the current knowledge of tropical cyclones has advanced beyond the point of those used in the past. An example arises from surface wind estimation techniques that have evolved over the years (e.g., Franklin et al. 2003), leading to biases in the historical database that have not been addressed. Also efforts made by Fernandez-Partagas and Diaz (1996) to uncover previously undocumented hurricane extended the record from 1851 to 1885 and substantially revised the records from 1886 to 1910. These changes were based on quality controlled assessments and digitization of Fernandez-Partagas' work (Landsea et al., 2004a).

2. Data Sources and Methods:

The majority of the data utilized for the re-analysis efforts of these ten U.S. are ship observations from the *Historical Weather Map* (HWM) series, the Comprehensive Ocean-Atmosphere Data Set (COADS - Woodruff et al., 1987), the *Monthly Weather Review* (MWR) and miscellaneous ship reports obtained from the National Climatic Data Center. The HWM series, a reconstruction of daily surface northern hemisphere synoptic maps begun by the U.S. Navy and U.S. Weather Bureau in the 1920s, was conducted for the years of 1899 through 1969. While COADS is one of the most comprehensive observations ship database available and often contains most ship observations found in HWM, there are some data in HWM not found in COADS. The *Monthly Weather Review* regularly publishes an “Ocean Gales and Storms” section that had significant ship observations, which also were occasionally not found in COADS. For the hurricanes during the reconnaissance era from 1944 onward, aircraft observations archived at the National Hurricane Center provided crucial center position and intensity observations. Finally, for 1985’s Hurricane Gloria satellite-based position and intensity estimates (Dvorak 1975, 1984) were also available.

Once the tropical cyclone impacted land, both station-based meteorological observations and other reports become useful. Station data are available from HWM, the U.S. Weather Bureau Original Monthly Records (OMR) and MWR. The MWR was quite detailed in providing many raw observations as well as providing descriptions of the impacts of the various hurricanes. MWR also provided a graphic called Tracks of the Centers of Cyclones that was the first depiction of positions twice a day for many of the

hurricanes. Finally, for 1960's Hurricane Donna and 1985's Hurricane Gloria, there were also land-based radar observations of the cyclones' position.

Typically, the main new dataset employed was COADS, which contains a huge amount of observations that were not available at the time. The remaining datasets (coastal stations, aircraft, radar, satellite) were usually available at the time that the HURDAT dataset was originally assembled. In addition to the additional ship data, the use of today's physical understanding of the track and structure of TCs and today's analysis methodologies are the main reasons for why substantial changes were introduced into HURDAT. See Landsea et al. (2007) for more details on applications of the most current analysis techniques employed for the reanalysis effort.

The AEF RealTrackTM model (Dickinson et al. 2004) is based on the operational Geophysical Fluid Dynamics Laboratory (GFDL) hurricane forecast model (Kurihara et al., 1998) which uses a multiply nested movable mesh system to depict the interior structure of tropical cyclones. The GFDL model has been extensively modified to permit simulations of the wind field produced by a hurricane with a prescribed track and intensity. RealTrackTM is a dynamical model that utilizes the physical balances in the dynamic equations to determine how a hurricane will respond to local variability in the surface conditions (primarily topography and surface roughness). The RealTrackTM hurricane model incorporates a high-resolution boundary layer (eight vertical levels below 1000 meters) combined with high-resolution information about topography and land use. The model input comes from data describing the tropical cyclone location, maximum wind, and structure (radius of maximum winds and radii of 50 and 34 kt

winds). (1 kt = 0.5144 m/s.) This model is well suited to study recent of historical hurricane events.

3. Position Estimation

All available oceanic and coastal observations were analyzed four times a day (0Z, 6Z, 12Z and 18Z) and the resulting estimated tropical cyclone positions and intensities compared the HWM, MWR and original HURDAT tracks. Changes to the original HURDAT were typically made only if observations supported making substantial (typically at least 0.2° latitude/longitude and 10 kt) alterations to the track and intensity. Possible alterations considered for the storm were for the time and location of genesis, duration of the system, intensity and decay and/or transformation into an extratropical cyclone. All revisions to HURDAT will be examined, commented upon and approved by the National Hurricane Center's Best Track Change Committee before official changes to the database are incorporated.

Tropical cyclone positions were determined primarily through the use of wind direction observations from ships and coastal stations and secondarily through sea level pressure measurements. With these observations and the knowledge that the surface flow in a tropical cyclone is typically symmetric, a relatively reliable estimate of the center of the storm can be obtained from a few peripheral wind direction measurements (see Figure 2 from Landsea et al., 2004). Accuracy of position estimates increased substantially once aircraft observations became available in the 1940s, land-based radars were in place in the 1950s, and satellite analyses were conducted routinely in the 1970s.

4. Intensity Estimation

In comparison with position and track, the intensity analysis is much less straightforward with historical cyclones before the advent of aircraft reconnaissance (in 1944) and geostationary satellite imagery (in 1966). The re-analysis of the 6 hr winds for the cyclones before 1944 was based upon Beaufort ship-based wind estimates, peripheral and central pressure measurements (via pressure-wind relationships), and wind observations from anemometers once the cyclone made landfall.

Sea level central pressure (eye) measurements can provide modestly reliable estimates of the maximum wind speeds in a tropical cyclone in the absence of in situ observations of the peak wind strength (Landsea et al., 2004a). Once a central pressure has been observed or estimated, maximum wind speeds can be obtained from a family of three geographically based pressure-wind relationships (Landsea et al., 2004a). Note that the previous Gulf of Mexico pressure-wind relationship from Landsea et al. (2004a) has been shown to give too high a winds for hurricanes. Thus for this region, the new Brown et al. (2006) pressure-wind relationship for north of 25°N is utilized in the Gulf of Mexico north of that latitude. (The Landsea et al. 2004a pressure-wind relationship for the subtropical latitudes of 25-35°N are quite similar to Brown et al.'s north of 25°N relationship. Likewise, the relationships for the southern latitudes [south of 25°N] also give very close results between Landsea et al. and Brown et al. for all available tropical cyclones. There was a lack of significant numbers observations north of 35°N in the Brown et al. study's database, making comparisons with the high latitude relationship [north of 35°N] of Landsea et al. problematic. Thus except for the Gulf of Mexico, the Landsea et al. pressure-wind relationships are utilized here.) Peripheral pressure

measurements (outside of the eye, but in the eyewall or rainband region) can provide a lower bound for peak wind estimate. Once the landfall intensity for the ten U.S. hurricanes is determined, the spatial variations are analyzed and compared with existing classifications in HURDAT.

After landfall, intensity estimates can be a bit problematic even for data-rich regions as direct observations of the peak wind in a hurricane are rare. The Kaplan and DeMaria (1995, 2001) inland wind decay model provided guidance for determining wind speeds post-landfall. This model takes the maximum wind at landfall and provides decayed maximum wind speed values out to about two days after landfall. The results from the Kaplan and DeMaria inland wind decay model were compared with available observations and only utilized when actual pressure and wind data were too sparse to estimate the maximum wind from direct observations.

Aircraft observations of hurricane began in 1944, which allowed for much more accurate assessment of intensity. Unfortunately, aircraft reconnaissance in the 1940s and 1950s typically only provided intensity information for weak tropical cyclones up to minimal hurricanes. (For major hurricanes of this era, the aircraft was not deemed safe enough to penetrate the center of the storms. Often, they would fly in the periphery of the hurricane, get a center fix from “painting” the eyewall/eye with the radar, and not measure directly the inner core.) Additionally, the flight level winds from the Navy and Air Force reconnaissance aircraft often reported significantly lower winds than expected, due to attenuation of the wind signal by heavy rainfall. This is the case for all of the hurricane examined here, though the NOAA P-3 aircraft observations – only available in 1985’s Hurricane Gloria – are trustworthy. Thus most aircraft observations for intensity

are primarily most useful by converting the central pressure measurement into an approximate maximum sustained wind via the various wind-pressure relationships.

As of the early 1970s, interpretation of satellite imagery from the geostationary satellites allowed for reliable intensity estimates via Dvorak's visible technique (Dvorak 1975) and infrared technique (Dvorak 1984). These analyses were thus available for 1985's Hurricane Gloria.

Once intensity and position estimates were obtained, a revised wind swath footprint was created to confirm or refute the results. Based on the new footprint, the estimates were adjusted to refine the landfall coordinates and track estimates after landfall.

5. Results

The detailed results for the ten hurricanes are included below in an Appendix. Table 1 summarizes all significant changes to the hurricanes.

Table 1: Significant Changes to the Ten U.S. Landfalling Hurricanes

HURRICANE	GENESIS	DECAY	TRACK	INTENSITY	US SAFFIR-SIMPSON	HURDAT INTENSITY BEFORE U.S. LANDFALL
1934 LA	---	Extratropical 12 hr earlier	Minor	MAJOR	LA2 (was LA3)	Boost from 60 to 85 kt
1938 New England	---	Extratropical 6 hr later, Added 6 hr	MAJOR	Minor	NY3, CT3, RI3, MA2 (was NY3, CT3, RI3, MA3)	Boost from 85 to 105 kt
1944 Great Atlantic	---	---	Minor	Minor	NC2, VA2, NY2, CT1, RI2, MA1 (was NC3, VA3, NY3, CT3, RI3, MA2)	Boost from 90 to 110 kt (NC) Boost from 75 to 95 kt (NY)
1945 TX	Added 6 hr	---	Minor	MAJOR	S TX1, C TX2, N TX1 (was C TX 2)	Reduce from 115 to 90 kt
1947 FL/LA	---	Extratropical 24 hr later	Minor	MAJOR	SE FL4, SW FL2, LA2, MS2 (was SE FL4, SW FL2, LA3, MS3)	Reduce from 135 to 115 kt (FL) Boost from 80 to 95 kt (LA)
1954 Carol	Added 6 hr	---	Minor	Minor	NY3, CT2, RI3, MA2, NC1 (was NY3, CT3, RI3, NC2)	Boost from 85 to 95 kt (NC) Boost from 85 to 100 kt (NY)
1954 Edna	Delayed three days	24 hr earlier decay	MAJOR	MAJOR	NC1, MA3, NY1, RI1 (was MA3, ME1)	Boost from 105 to 110 kt (NC) Boost from 80 to 105 kt (MA)
1954 Hazel	---	6 hr earlier decay	Minor	MAJOR	SC3, NC4 (was SC4, NC4, MD2)	Boost from 110 to 115 kt
1960 Donna	Delayed 30 hr	Added 12 hr	MAJOR	MAJOR	SW FL4, SE FL2, NE FL1, NC2, VA1, NY2, CT1, RI1 (was SW FL4, NE FL2, NC3, NY3, CT2, RI1, MA1, NH1, ME1)	No change (FL, NC) Reduce from 90 kt to 85 kt (NY)
1985 Gloria	Added 12 hr	---	MAJOR	Minor	NC2, NY1, CT1, MA1, NH1 (was NC3, NY3, CT2, NH2, ME1)	Boost from 90 to 95 kt (NC) No change (NY)

Most of the track changes introduced for these ten hurricanes are fairly minor (less than a 120 nmi - 2° latitude/longitude - alteration in position at anytime during the TC's lifetime) as easily by seen by inspection of the original and revised track maps. The

most dramatic change in a TC's track was for Edna, in which case the original TC was found to be two separate cyclones and the first three days in Edna's track have been removed. Despite making relatively minor changes overall, all ten hurricanes were adjusted for at least some portion of their track. In general, large changes to intensity (at least a 20 kt alteration at some point in the TC's lifetime) were recorded – both upward and downward – for the majority of individual TCs, typically with more significant changes than those introduced for track.

Of the ten U.S. hurricanes, the analyzed peak U.S. Saffir-Simpson Hurricane Scale category did not go up in any case, stayed the same for seven hurricanes (1938 New England, 1945 TX, 1947 FL/LA, 1954 Carol, 1954 Edna, 1954 Hazel, and 1960 Donna), and revised downward for three hurricanes (1934 LA, 1944 Great Atlantic in both NC and New England, 1985 Gloria in both NC and [two categories in] New England). However, because of the above mentioned common discrepancies in the original HURDAT and the originally analyzed U.S. Saffir-Simpson Hurricane Scale, many of the windspeeds in HURDAT right before and at landfall actually went up significantly. Of the ten U.S. hurricanes, four had a significant (at least 20 kt stronger) boost to the winds at peak landfall (1934 LA, 1938 New England, 1944 Great Atlantic in both NC and New England, and 1954 Edna), four were not significantly changed (1954 Carol, 1954 Hazel, 1960 Donna, and 1985 Gloria), and two were significantly reduced (at least 20 kt weaker - 1945 TX, and 1947 FL/LA).

One result of this study is that the risk of strong TC impacts (defined, for example, by the 100 year return period) will be significantly adjusted in some regions. In

particular, because of the low frequency of strong hurricanes in New England and because three of the six New England hurricanes had significant increases in HURDAT winds (with only minor changes for the other three), we have found that the risk is higher using the revised HURDAT. When catastrophe modelers build their hurricane risk models, they have to either believe the 6-hourly point data or the state-defined Saffir-Simpson categorization. If one measures risk using the point data, the risk for the New York/New England coast is going to be increased when using the revised HURDAT. Such a change, if accepted officially, may have a significant impact on users of HURDAT, such as the insurance industry.

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APPENDIX

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27290 06/04/1934 M=18 2 SNBR= 603 NOT NAMED XING=1 SSS=3
27290 06/04/1934 M=18 2 SNBR= 603 NOT NAMED XING=1 SSS=2
*

27295 06/04* 0 0 0 0* 0 0 0 0*163 877 40 0*167 877 40 0
27295 06/04* 0 0 0 0* 0 0 0 0*170 870 30 0*170 871 35 0
*** *** ** *** *** **

27300 06/05*170 878 40 0*172 881 40 0*173 882 40 0*172 886 40 0
27300 06/05*170 872 40 0*169 874 45 0*168 878 50 0*167 885 45 0
*** *** ** *** *** ** *** *** ** *** *** **

27305 06/06*172 890 40 0*168 896 35 0*163 900 35 0*159 902 40 0
27305 06/06*165 895 40 0*163 905 35 0*160 910 35 0*155 914 30 0
*** *** ** *** *** ** *** *** ** *** *** **

27310 06/07*151 905 40 0*145 905 45 0*143 898 55 0*147 892 60 0
27310 06/07*150 917 30 0*145 917 35 0*140 915 45 0*142 907 50 0
*** *** ** *** ** *** *** ** *** *** **

27315 06/08*157 886 60 0*167 882 60 0*177 878 70 0*186 876 70 0
27315 06/08*152 896 40 0*165 883 45 0*177 875 50 0*186 872 60 0
*** ** *** *** ** *** *** ** *** ** *** **

27320 06/09*194 878 70 0*200 883 60 0*204 890 55 0*207 898 40 0
27320 06/09*194 873 70 0*200 875 70 0*204 880 55 0*208 888 40 0
*** *** ** *** ** *** *** ** *** *** **

27325 06/10*208 905 35 0*210 911 35 0*211 917 35 0*213 922 35 0
27325 06/10*212 898 35 0*216 908 40 0*218 917 45 0*220 925 50 0
*** *** ** *** *** ** *** ** *** *** **

27330 06/11*215 927 35 0*219 933 40 0*220 939 40 0*217 942 40 0
27330 06/11*220 933 50 0*219 939 50 0*217 942 55 0*216 942 60 0
*** *** ** *** ** *** *** ** *** *** **

27335 06/12*213 944 45 0*209 943 45 0*208 938 50 0*208 934 50 0
27335 06/12*215 940 60 0*215 937 65 0*215 934 70 0*215 931 70 0
*** *** ** *** *** ** *** *** ** *** *** **

27340 06/13*211 930 55 0*216 927 55 0*220 925 55 0*223 923 60 0
27340 06/13*215 929 75 0*215 927 75 0*217 925 80 0*220 923 80 0
*** *** ** *** ** *** *** ** *** ** *** **

27345 06/14*225 922 60 0*228 921 65 0*231 920 70 0*237 918 70 0
27345 06/14*223 922 80 0*226 921 80 0*231 920 80 0*237 918 85 0
*** ** *** ** *** ** *** ** *** ** *** **

27350 06/15*243 916 70 0*247 914 70 0*252 913 70 0*259 912 70 0
27350 06/15*243 916 85 0*247 914 85 0*252 913 85 0*257 912 85 0
*** ** *** ** *** ** *** ** *** ** *** **

27355 06/16*268 912 70 0*277 911 70 0*287 910 65 0*298 910 60 0
27355 06/16*263 912 85 0*271 913 85 0*283 915 85 0*297 917 85 966
*** ** *** *** ** *** *** ** *** *** ** *** ***

27360 06/17*309 910 60 0*323 908 55 0*338 902 45 0*349 889 40 0
27360 06/17*311 920 60 0*323 917 45 0*333 910 35 0*342 898 35 0
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27365	06/18*358	873	35	0*365	857	35	0*372	839	35	0*378	818	40	0
27365	06/18*351	882	35	0*360	862	30	0E368	842	30	0E376	822	35	0
	***	***		***	***	**	****	***	**	****	***	**	
27370	06/19E384	797	40	0E391	775	40	0E398	754	40	0E405	739	40	0
27370	06/19E384	802	40	0E391	775	40	0E398	754	40	0E404	739	40	0
	***									***			
27375	06/20E411	724	40	0E420	702	40	0E432	680	40	0E452	660	40	0
27375	06/20E409	724	40	0E415	707	40	0E425	685	45	0E440	665	45	0
	***			***	***		***	***	**	***	***	**	
27380	06/21E472	642	35	0E485	626	35	0E497	610	35	0E510	594	35	0
27380	06/21E457	646	40	0E477	628	40	0E502	610	35	0E530	594	35	0
	***	***	**	***	***	**	***			***			
27385	HR	LA3											
27385	HR	LA2											

Landfall:

6/16/1934 1800Z 29.7N 91.7W 966 mb 85 kt 27 nmi RMW

Minor changes to the track and major changes to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from the Historical Weather Map series, the COADS ship database, Monthly Weather Review, the Original Monthly Records from NCDC, Connor (1956), Dunn and Miller (1960), Schwerdt et al. (1979), Ho et al. (1987), and Jarrell et al. (1992).

June 4:

HWM indicates a low pressure system of more than 1005mb near 16N, 87W. HURDAT lists this storm as a tropical storm at 16.3N, 87.7W at 12UTC. The MWR Tracks of Lows indicates the center at 16N, 87.5W (am) and 17N, 87.5W (pm). No gales or low pressures for any ship or land stations.

June 5:

HWM indicates a tiny closed off system with pressures just below 1005mb near 16N and 87.5W. HURDAT lists this storm as a tropical storm of 45mph winds near 17.3N, 88.2W at 12UTC. The MWR tracks of lows showed a center near 17.5N, 88W (am) and at 17.5N, 89W (pm). Ship highlight: 1004mb with 22kt SW at 16.1N, 87.8W at 12UTC (HWM). Station highlight: 1005mb with 25kt NNW at Belize at 12UTC (HWM).

June 6:

HWM indicates a more broad circulation of just above 1000mb near 15N and 90W. HURDAT lists this storm as a tropical storm with 45mph winds near 16.3N, 90.0W at 12UTC. The MWR tracks of lows showed a center near 16N, 89.5W (am) and 15N, 90W (pm). Ship highlight: 1001mb with 15kt SW at 13.0N, 92.6W at 12UTC (COA). Station highlight: 1002mb with 9kt N at Tapachula at 12UTC (HWM).

June 7:

HWM reveals a low pressure system identical to the prior day. HURDAT lists the storm as a tropical storm with 65mph near 14.3N, 89.8W at 12UTC. MWR tracks of lows shows a storm near 14N, 89.5W (am) and 15N, 88.5W (pm). Ship highlight: 1005mb with 5kt S at 10.6N, 87.9W at 12UTC (COA). Station highlight: 1001mb with 9kt N at Tapachula at 12UTC (HWM).

June 8:

HWM shows a low pressure system of about 1005mb near 16N and 88W. HURDAT lists this storm as a category 1 hurricane with 80mph winds, which is a discrepancy, near 17.7N, 87.8W at 12UTC. MWR tracks of lows indicates the storm to be near 17.5N, 87.5W (am) and 19N, 87.5W (pm). Ship highlight: 1001mb with 22kt SW at 16.8N, 87.2W at 12UTC (HWM). Station highlight: 1004mb with 12kt NNW at Belize at 12UTC (HWM).

June 9:

HWM indicates a low pressure system of just above 1000mb near 18.5N, 89.5W. HURDAT lists the storm as a tropical storm with 65mph winds near 20.4N, 89.0W at 12UTC. MWR tracks of lows shows the storm near 20N, 88W (am) and 20.5N, 90W (pm). Ship highlight: 1004mb with 50kt SSE at 19.4N, 86.5W at 9UTC (MWR); 1002mb with 12kt S at 20.6N, 86.8W at 12UTC (HWM). Station highlight: 1004mb with 26kt W at Campeche at 12UTC (HWM); 1002 mb with 15kt S at Cozumel at 12 UTC (HWM).

June 10:

HWM indicates a low pressure of still above 1000mb near 20.5N and 92.5W. HURDAT lists this storm as a tropical storm with 40mph winds near 21.1N, 91.7W at 12UTC. MWR tracks of lows shows the storm near 21N, 92W (am) and 21.5N, 92.5W (pm). Ship highlight: 1002mb with 30kt N at 23.2N, 94.0W at 17UTC (MWR). Station highlight: 1005mb with 9kt S at Frontera at 12UTC (HWM).

June 11:

HWM indicates a low pressure system of below 1005mb near 20N and 95W. HURDAT lists the storm as a tropical storm with 45mph winds near 22.0N, 93.9W at 12UTC. MWR tracks of lows shows the storm near 22N, 93W (am) and 21.5N, 94W (pm). Ship highlight: 998mb with 35kt SW near 19.5N, 94.2W at 10Z (MWR), 40kt at 19.5N, 94.2W and 20.7N, 95.3W. Station highlight: No gales or low pressures reported.

June 12:

HWM indicates a strengthening system with a pressure below 1000mb near 22N, 94.5W. HURDAT lists the storm as 60mph tropical storm near 20.8N, 93.8W at 12UTC. MWR tracks of lows shows the system at

21N, 93W (am) and 91N, 92.5W (pm). Ship highlight: 989mb with 45kt S near 21.5N, 92.5W at 22UTC (COA). Station highlight: 1004mb with 22kt WSW at Frontera at 12UTC (HWM).

June 13:

HWM indicates a storm of less than 1000mb near 22N, 92.5W. HURDAT lists the system as a tropical storm with 65mph winds near 22.0N, 92.5W at 12UTC. MWR tracks of lows shows the system at 22N, 92.5W (am) and 22.5N, 92W (pm). Ship highlight: 70kt S at 21.2N, 92.8W (MWR); 982mb with 35kt WNW at 21.2N, 92.8W at 9UTC (MWR). Station highlight: 1003mb with 20kt SE at Campeche at 12UTC (HWM).

June 14:

HWM indicates a system of less than 1000mb near 22.5N, 93W. HURDAT lists the system as a Category 1 hurricane with 80mph winds near 23.1N, 92.0W at 12UTC. MWR tracks of lows shows the hurricane at 23N, 92W (am) and at 24N, 91W (pm). Ship highlight: 1000mb with 17kt NNW at 23.2N, 94.0W at 12Z (HWM). Station highlight: 1004mb with 12kt WSW at Campeche at 12UTC (HWM).

June 15:

HWM now shows a strong system of under 995mb near 25.5N, 91.5W. HURDAT lists the storm as a Category 1 hurricane with 80mph winds near 25.2N, 91.3W at 12UTC. MWR tracks of lows shows the hurricane near 25N, 91W (am) and 27N, 91W (pm). Ship highlight: 974mb with 61kt SSE (MWR). Station highlight: 1004mb with 12kt NNW at Galveston at 12UTC (HWM).

June 16:

HWM shows a strong system of near 990mb at 27.5N, 92.5W. HURDAT lists the storm as a Category 1 hurricane with 75mph winds near 28.7N, 91.0W at 12UTC. MWR tracks of lows shows the hurricane near 28N, 91W (am) and overland near 30.5N, 91W (pm). Ship highlight: 997mb with 40kt SSE at 28.3N, 90.0W at 11Z (MWR); 50kt SE at 28.3M, 90.0W (MWR). Station highlight: 968mb with calm eye conditions at Jeanerette at 2030Z (MWR); 979mb with 59kt SE at Morgan City at 20Z (MWR). "Tropical Cyclones in Louisiana, Mississippi, and Alabama - June 16 - Morgan City - Minimal [Category 1 or 2] - 6 killed, \$2,605,000 in damage" (Dunn and Miller). "June 16 - 966 mb central pressure - 27 nmi RMW - 16 kt speed - landfall position 29.2N, 91.0W" (Ho et al.). "1002 mb environmental pressure - 81 kt maximum sustained wind at landfall" (Schwerdt et al.). "LA - Category 3 - 962 mb" (Jarrell et al.). "Analyzed central pressure at landfall - 962 mb" (Connor).

June 17:

HWM shows a system of just below 1005mb near 32N, 90.5W. HURDAT lists the system as a tropical storm with 50mph winds near 33.8N, 90.2W

at 12UTC. MWR tracks of lows shows the storm near 33N, 90W (am) and at 35N, 87.5W (pm). Ship highlight: 997mb with 45kt SE at 28.3N, 90.0W at 0Z (COA). Station highlight: 991mb with 37kt SSE at Jackson at 8Z (AWR).

June 18:

HWM shows a system merging with a cold front with 1005mb near 37N, 82.5W. HURDAT lists the system as a tropical storm with 40mph winds near 37.2N, 83.9W at 12UTC. MWR tracks of lows shows the storm at 36.5N, 93.5W (am) and at 38N, 79W (pm). Ship highlight: no gales or low pressures. Station highlight: 1001mb 26kt E at Nashville at 0020Z (AWR).

June 19:

HWM shows a system merged with a cold front near 39N, 75.5W. HURDAT lists the storm as an extratropical storm with 45mph winds near 39.8N, 75.4W at 12UTC. MWR tracks of lows shows the system at 39.5N, 75.5W (am) and at 41.5N, 72.5W (pm). Ship highlight: 1006mb with 45kt SSE at 39.5N, 69.5W at 21Z (COA); 1001mb with 30kt S at 39.5N, 71.5W at 21Z (COA). Station highlight: 43kt SE at Atlantic City (MWR).

June 20:

HWM shows a strong extratropical low at 42N, 68W. HURDAT lists the storm as an extratropical storm with 45mph near 43.2N, 68W at 12UTC. MWR tracks of lows shows the system at 43N, 68W (am) and at 47N, 64.5W (pm). Ship highlight: 45kt SW at 37N, 69.9W at 0Z (COA); 996mb with 20kt SSW at 40.1N, 72.1W at 0Z (COA). Station highlight: 1003mb with 17kt N at Portland at 12UTC (HWM).

June 21:

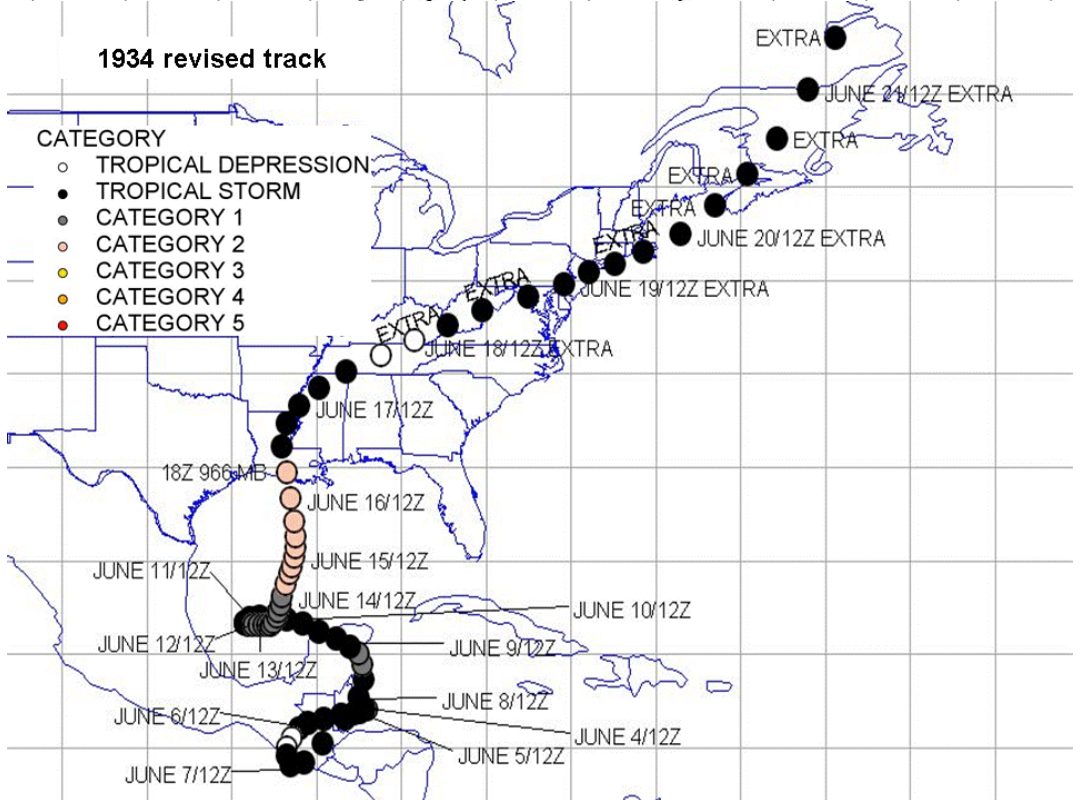
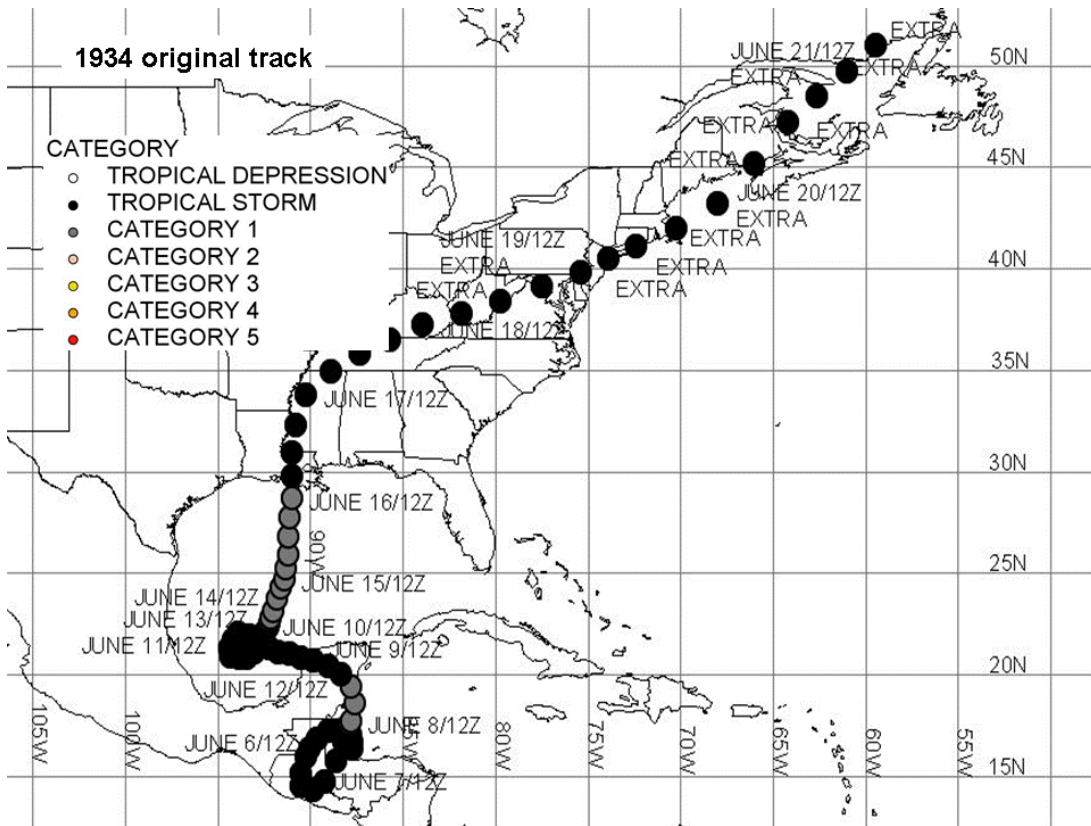
HWM shows a low with a cold front attached to it at around 51.5N, 62W. HURDAT lists the storm as extratropical with 40mph winds near 49.7N, 61.0W at 12UTC. MWR tracks of lows only shows the morning plot at 49.5N, 60.5W. Ship highlight: 1004mb with 26kt NW at 48.0N, 61.5W at 12UTC (HWM). Station highlight: 1001mb with 17kt SE at Harrington at 12UTC (HWM).

No major changes were made to either the genesis or decay of this hurricane. Minor track alterations are made on all days except the 14th, 15th, and 19th. System is started as a tropical depression at 12 UTC on the 4th and upgraded to a tropical storm at 18 UTC six hours later than original. This is based upon the lack of sufficiently low pressures/high winds early on the 4th. 1004 mb peripheral pressure at 13 UTC on the 5th suggests winds of at least 39 kt from the southern pressure-wind relationship - 50 kt chosen for HURDAT, above 40 kt originally. The system likely made landfall in Belize with about 50 kt intensity around 15 UTC on the 5th. Despite moving over Belize and Guatemala during

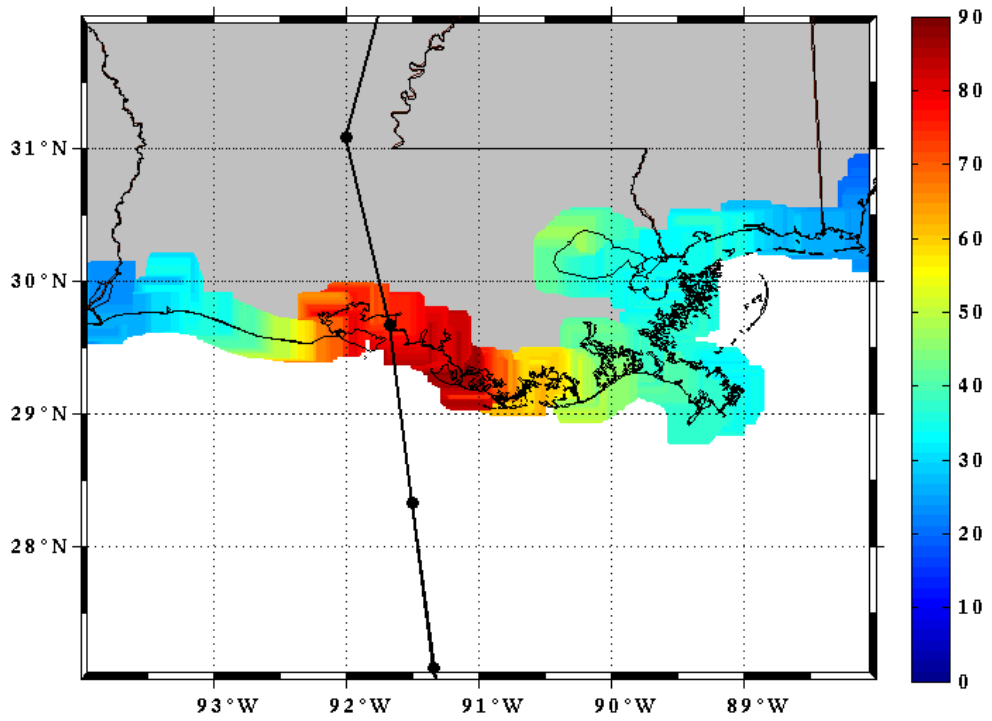
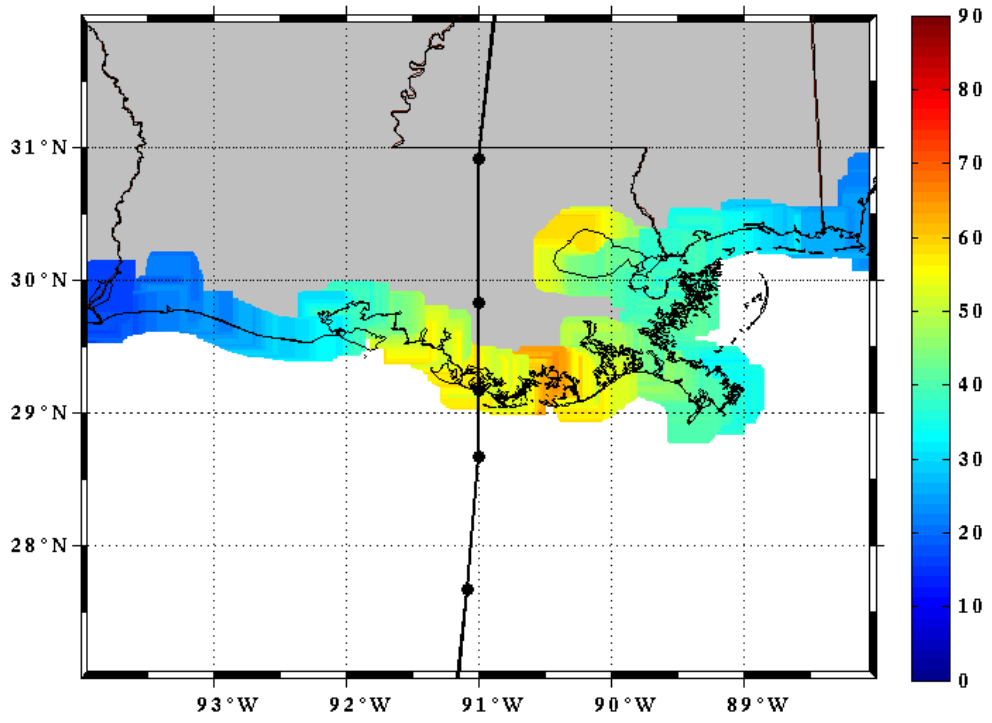
the 6th and early on the 7th, the system quickly reintensified as it reached the Pacific coast around 12 UTC on the 7th as 1001 mb were reported in Tapachula, Mexico at 12 UTC along with the impact described above in San Salvador, El Salvador. 1001 mb peripheral pressure at 12 UTC on the 7th suggests winds of at least 45 kt from the southern pressure-wind relationship - 45 kt chosen for HURDAT as the system was still hugging the coast at that time (reduced from 55 kt originally). The system made a second landfall striking the Pacific coast near the border of Guatemala and El Salvador around 18 UTC on the 7th with winds of about 50 kt. The original HURDAT unrealistically intensified the system from 35 kt on the 6th to 60 kt on the 8th while staying over land the entire time. (It was investigated whether there were actually two tropical systems, instead of one system making a loop over Central America. However, the numerous land and oceanic observations strongly suggest that only one tropical cyclone occurred and that it indeed complete a large loop between the 4th and 8th of June.) The system re-emerged once again over the Caribbean Sea early on the 8th and it likely attained hurricane intensity either late on the 8th or early on the 9th. It is analyzed as making a third landfall, this time over the Yucatan of Mexico around 06 UTC on the 9th as a 70 kt Category 1 hurricane, which is consistent with assessments from the Mexican Meteorological Service at the time. 70 kt is unchanged from that originally in HURDAT. The system once again went back over water, as it went over the Gulf of Mexico around 03 UTC on the 10th. A 998 mb peripheral pressure (with 35 kt SW winds) on 10 UTC on the 11th suggests winds of at least 49 kt from the Gulf of Mexico pressure-wind relationship - 55 kt chosen for HURDAT, up from 50 kt originally. A 989 mb peripheral pressure reading with 45 kt S wind at 22 UTC on the 12th suggests winds of at least 66 kt from the southern pressure-wind relationship - 70 kt chosen for HURDAT at 18 UTC, up from 50 kt originally. This brings the system to a hurricane almost two days earlier than originally indicated in HURDAT. Hurricane intensity was confirmed by wind observations from a ship report on the 13th, as reported in Monthly Weather Review. Another ship report on the 13th reported 982 mb with 35 kt WNW winds at 09 UTC, which suggests winds of at least 75 kt from the southern pressure-wind relationship - 80 kt chosen at 12 UTC, up from 55 kt originally. A ship with 974 mb and about 60 kt of wind on the 15th suggests maximum winds of at least 85 kt from the southern pressure-wind relationship and 80 kt from the new Brown et al. (2006) north of 25°N pressure-wind relationship. 85 kt is chosen for HURDAT, up from 70 kt originally.

The hurricane made landfall around 18 UTC on the 16th near 29.7N, 91.7W along the coast of Louisiana. A central pressure was recorded of 968 mb in Jeanerette, Louisiana a couple hours after landfall at 2030 UTC. Application of the Ho (1989) decay model suggests that the landfall central pressure (using the Florida peninsula decay model - which has the slowest decay function to account for the

rather swampy terrain that the hurricane encountered) was about 966 mb. This agrees with Ho et al.'s assessment, but is a bit weaker than Jarrell et al (who obtained their central pressure value from Connor). Highest observed winds were from Morgan City, Louisiana were 59 kt SE at 20 UTC on the 16th, though it is likely that the peak winds were to the west of Morgan City. 966 mb suggests maximum winds of 89 kt from the Brown et al. north of 25°N pressure-wind relationship. Given the slightly larger RMW (27 nmi) than expected from climatology (22 nmi) for this central pressure/latitude and that the environmental pressures were low (1004 mb), the maximum sustained wind at landfall is estimated to be 85 kt. This makes the hurricane a minimal Category 2 hurricane impact in Louisiana (downgraded from a Category 3 originally), even though the HURDAT winds are Boosted from 65 to 85 kt at landfall. Peak observed winds after landfall were 45 kt within 2 hr of 00 UTC on the 17th, 37 kt at 06 UTC, and less than gale force at 12 UTC. A run of the Kaplan/DeMaria inland decay model suggest winds of 54, 39, and 29 kt, respectively. Keeping in mind the rather typical sparse data coverage of winds, winds chosen for HURDAT are 60 kt at 00 UTC (unchanged), 45 kt at 06 UTC (down from 55 kt), and 35 kt at 12 UTC (down from 45 kt). These values are slightly higher than Kaplan/DeMaria to take into account a possible weaker decay over swampy terrain. The system is brought to tropical depression status at 06 UTC on the 18th, as no further high winds or low pressures were observed by this time. Transition to extratropical is analyzed to have occurred by 12 UTC on the 18th due to an advancing cold front having caught up with the weakening system - this is 12 hours earlier than originally indicated. However, the system did re-intensify slightly on the 19th and 20th, as indicated by a few gale force wind reports and low pressure values on these dates. Winds are boosted slightly on the 20th and 21st accordingly.



Original and revised LA 1934 track maps.



Original and revised LA 1934 hurricane windswaths.

1938 Great New England Hurricane

29185 09/10/1938 M=13 4 SNBR= 647 NOT NAMED XING=1 SSS=3
29185 09/10/1938 M=14 4 SNBR= 647 NOT NAMED XING=1 SSS=3
**

29190 09/10* 0 0 0 0*142 215 35 0*144 238 35 0*146 250 35 0
29190 09/10* 0 0 0 0*134 233 35 0*136 243 40 0*138 253 40 0
*** **

29195 09/11*148 262 35 0*149 274 35 0*150 285 35 0*152 297 35 0
29195 09/11*140 263 45 0*142 274 45 0*145 285 45 0*147 297 45 0
*** **

29200 09/12*153 310 40 0*154 324 40 0*155 337 40 0*156 348 40 0
29200 09/12*149 310 45 0*152 324 45 0*155 337 45 0*158 347 45 0
*** **

29205 09/13*157 358 40 0*158 371 45 0*160 383 45 0*161 394 50 0
29205 09/13*162 357 45 0*166 367 45 0*170 377 45 0*172 388 50 0
*** **

29210 09/14*162 406 50 0*164 419 55 0*167 432 55 0*169 445 60 0
29210 09/14*172 400 50 0*172 412 55 0*172 423 55 0*173 433 60 0
*** **

29215 09/15*172 457 65 0*174 468 70 0*176 478 75 0*179 490 80 0
29215 09/15*175 443 65 0*177 453 70 0*179 463 75 0*181 473 80 0
*** **

29220 09/16*183 502 80 0*186 516 85 0*189 530 85 0*192 540 90 0
29220 09/16*183 483 85 0*186 493 90 0*189 503 95 0*195 513 100 0
*** **

29225 09/17*194 550 95 0*197 563 100 0*200 575 105 0*202 586 115 0
29225 09/17*205 523 105 0*210 534 105 0*212 545 105 0*213 560 115 0
*** **

29230 09/18*204 596 120 0*207 607 125 0*210 620 125 0*213 636 130 0
29230 09/18*213 578 115 0*214 596 115 0*217 615 115 945*222 635 115 0
*** **

29235 09/19*217 656 130 0*223 678 135 0*232 700 135 0*241 716 140 0
29235 09/19*228 655 115 0*235 675 115 0*242 695 115 0*248 711 115 0
*** **

29240 09/20*250 727 140 0*259 736 140 0*267 743 135 0*280 748 130 0
29240 09/20*252 724 115 0*258 734 115 0*267 743 115 943*280 748 120 0
*** **

29245 09/21*298 749 120 0*322 744 110 0*352 731 100 938E390 730 85 940
29245 09/21*298 749 120 0*322 744 120 0*352 731 115 938*394 728 105 941
*** **

29250 09/22E434 731 70 967E453 735 45 988E473 770 35 987E454 791 35 0
29250 09/22E434 731 60 971E465 745 40 0E477 773 35 987E470 778 35 0
** *** **

(The 23rd is new to HURDAT.)
29252 09/23E450 770 30 0* 0 0 0 0* 0 0 0 0* 0 0 0 0

29255 HR NY3 CT3 RI3 MA3
29255 HR NY3 CT3 RI3 MA2

Landfall:

September 21 1945Z: 40.8N, 72.8W, 941 mb, 105 kt, 35-40 nmi RMW

September 21 2040Z: 41.3N, 72.9W, 946 mb, 100 kt, 35-40 nmi RMW

Major changes to the track and minor alterations to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from the Historical Weather Map series, *Monthly Weather Review*, Original Monthly Records from NCDC, the COADS ship database, Tannehill (1938), Pierce (1939), Wexler (1939), Myers and Jordan (1956), Dunn and Miller (1960), Schwerdt et al. (1979), Ho et al. (1987), Jarrell et al. (1992), Boose et al. (2001), Kaplan and DeMaria (2001), and Jarvinen (2006).

September 10: HWM does not analyze a closed low on this day. HURDAT listed this as a 35 kt tropical storm at 14.2N, 21.5W. Available observations suggest that the 40 kt tropical storm was centered at 13.6N, 24.3W. Ship highlights: No gales or low pressures. Land highlights: No gales or low pressures in Cape Verde Islands.

September 11: HWM analyzes an open trough located at 15N, 27W on this day. HURDAT listed this as a 35 kt tropical storm at 15.0N, 28.5W. Available observations suggest that the 45 kt tropical storm was centered at 14.5N, 28.5W. Ship highlights: 40 kt S at 1 UTC at 12.5N, 25.2W (COA); 35 kt SW at 10 UTC at 11.5N, 27.5W. Land highlights: No gales or low pressures in Cape Verde Islands.

September 12: HWM does not analyze a closed low on this day. HURDAT listed this as a 40 kt tropical storm at 15.5N, 33.7W. Available observations suggest that the 45 kt tropical storm was centered at 15.5N, 33.7W. Ship highlights: No gales or low pressures.

September 13: HWM does not analyze a closed low on this day. HURDAT listed this as a 45 kt tropical storm at 16.0N, 38.3W. Available observations suggest that the 45 kt tropical storm was centered at 17.0N, 33.7W. Ship highlights: No gales or low pressures due to lack of ships in the area. "There was some evidence of cyclonic circulation central about 19N, 37W, on the morning of September 13, 1938, but the storm has not been definitely charted prior to the evening of September 16, when it appears to have become a full developed hurricane" (1938 MWR)

September 14: HWM does not analyze a closed low on this day. HURDAT listed this as a 55 kt tropical storm at 16.7N, 43.2W. Available observations suggest that the 55 kt tropical storm was centered at 17.2N, 42.3W. Ship highlights: No gales or low pressures due to

lack of ships in the area.

September 15: HWM does not analyze a closed low on this day. HURDAT listed this as a 75 kt hurricane at 17.6N, 47.8W. Available observations suggest that the 75 kt hurricane was centered at 17.9N, 46.3W. Ship highlights: No gales or low pressures due to lack of ships in the area.

September 16: HWM analyzes a closed low of at most 1010 mb centered near 22.5N, 50.0W. HURDAT listed this as an 85 kt hurricane at 18.9N, 53.0W. Available observations suggest that the 95 kt hurricane was centered at 18.9N, 50.3W. Ship highlights: No gales or low pressures due to lack of ships in the area. Regarding the intensity: "There was some evidence of cyclonic circulation central about 19N, 37W, on the morning of September 13, 1938, but the storm has not been definitely charted prior to the evening of September 16, when it appears to have become a full developed hurricane. At about 9:30 p.m., ships time, on September 16 [September 17 at 0130 UTC], the Brazilian S.S. Alegrete was near the center in approximately 21 12 N., 59 W., barometer 28.31 (uncorrected) [958 mb], wind force 12 [70 kt], shifting from east-northeast to east-southeast. (1938 MWR)

September 17: HWM analyzes a closed low of at most 995 mb centered near 21.5N, 54W. HURDAT listed this as a 105 kt hurricane at 20.0N, 57.5W. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 21N, 55.2W at 12 UTC on this day. Available observations suggest that the 105 kt hurricane was centered at 21.2N, 54.5W. Ship highlights: 45 kt NE and 996 mb at 12 UTC at 22.5N, 54.7W (HWM); 45 kt and 1008 mb at 20 UTC at 22.5N, 58.5W (COA); 35 kt NE and 112 mb at 16 UTC at 23.5N, 57.5W (COA). Regarding the intensity: "Early on the morning of September 17, the Netherlands S.S. Socrates encountered the storm while near 21N, 59W, and had increasing winds, backing from east-northeast to northwest and then to west-southwest, lowest barometer 29.29 inches [992 mb]" (1938 MWR).

September 18: HWM analyzes a closed low of at most 995 mb centered near 21.5N, 61W. HURDAT listed this as a 125 kt hurricane at 21.0N, 62.0W. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 21.2N, 58W at 0 UTC. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 21.5N, 62W at 12 UTC. Available observations suggest that the 125 kt hurricane was centered at 21.7N, 61.5W. Ship highlights: 60 kt ENE and 1003 mb at 0 UTC at 22.5N, 58.5W (COA); 50 kt E and 1011 mb at 8 UTC at 22.5N, 58.5W (COA); 35 kt NW-W and 1004 mb at 20 UTC

at 21.2N, 66.3W (MWR Robin Goodfellow). "The highest wind experienced [by British S.S. Socrates] was W-11 [60 kt] at 9:35 p.m. [September 18 at 0035 UTC], ships time, in latitude 20 38 N, longitude 59 17 W" (1938 MWR). Regarding the intensity: "A vessel reporting by radio gave [a] barometer reading[s] below 28 inches, the British S.S. Corrales, 27.90 inches [945 mb] on the 18th" (1938 MWR).

September 19: HWM analyzes a closed low of at most 990 mb centered near 24.5N, 70W. HURDAT listed this as a 135 kt hurricane at 23.2N, 70.0W. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 21.8N, 65.5W at 0 UTC. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 23.7N, 70.2W at 12 UTC. Available observations suggest that the 135 kt hurricane was centered at 24.2N, 69.5W. Ship highlights: 35 kt NE and 1005 mb at 2 UTC at 28.4N, 69.3W (MWR Pan America); 35 kt W and 1001 mb at 9 UTC at 23.6N, 73.8W (COA); 70 kt E and 982 mb at 10 UTC at 25.5N, 69.9W (MWR Gulfhawk); 50 kt NE and 988 mb at 12 UTC at 25.7N, 70.0W (COA); 45 kt SSW and 1006 mb at 15 UTC at 24.3N, 72.7W (COA); 35 kt SE and 1006 mb at 18 UTC at 23.5N, 69.5W (COA); 45 kt NE and 1007 mb at 21 UTC at 27.4N, 73.4W; 45 kt NE and 1007 mb at 21 UTC at 27.0N, 73.0W (COA); 35 kt S at 21 UTC at 25.6N, 72.8W (COA); 35 kt ENE and 1006 mb at 22 UTC at 27.2N, 74.1W (COA).

September 20: HWM analyzes a closed low of at most 990 mb centered near 27.5N, 75W. HURDAT listed this as a 135 kt hurricane at 26.7N, 74.3W. The MWR Track of the Hurricane of September 16-22, 1938 shows a center near 25.2N, 73W at 0 UTC. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 28.8N, 75.2W at 12 UTC. Available observations suggest that the 135 kt hurricane was centered at 26.7N, 74.3W. Ship Highlights: 65 kt NE at 2 UTC at 26.3N, 74.2W (COA); 50 kt E and 986 at 5 UTC at 33.4N, 74.4W (COA); 50 kt SW at 6 UTC at 26.0N, 74.1W (COA); 70 kt SSE and 992 mb at 8 UTC at 27.8N, 72.6W (MWR Jean Lafitte); 45 kt NE and 956 mb at 9 UTC at 27.1N, 73.9W (MWR Antigua); 70 kt E and 1005 mb at 9 UTC at 27.4N, 72.4W (COA); 70 kt E and 953 mb at 11 UTC at 27.1N, 74.6W (MWR Atlantida); 50 kt SE and 1008 mb at 12 UTC at 27.6N, 72.6W (HWM); 60 kt S at 12 UTC at 25.6N, 73.9W (COA); 70 kt SSE and 986 mb at 12 UTC at 27.6N, 73.8W (COA); 60 kt SE and 980 mb at 12 UTC at 27.8N, 72.5W (COA); 70 kt SSE and 995 mb at 12 UTC at 27.8N, 72.5W (COA); 50 kt SE and 1009 mb at 27.4N, 72.4W (COA); 55 kt SE and 1009 mb at 27.0N, 72.0W (COA); 70 kt S and 976 mb at 14 UTC at 27.6N, 74.0W (MWR Phobos); 70 kt ENE and 950 mb at 22 UTC at 30.0N, 75.4W (MWR India Arrow); Several gales of 35 kt-45 kt observed. Regarding the intensity: "a vessel reporting by radio gave a barometer reading below 28 inches...the British S. S. Carinthia,

27.85 [943 mb] on the 20th" (MWR).

September 21: HWM analyzes an extratropical closed low of at most 990 mb centered near 37.5N, 74.5W attached to a W-E cold front. HURDAT listed this as a 100 kt hurricane at 35.2N, 74.4W. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 30.2N, 76.0 W at 0 UTC. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 35.5N, 75.0W at 12 UTC. Available observations suggest that the 115 kt hurricane was centered at 35.2N, 73.1W. Ship highlights: 60 kt S and 1005 mb at 3 UTC at 30.5N, 72.5W (COA); 70 kt W and 954 mb at 9 UTC at 38.3N, 74.4W (COA); 999 mb at 12 UTC at 40.0N, 70.0W (COA); 992 mb at 12 UTC at 36.8N, 74.8W (COA); 997 mb at 12 UTC at 37.3N, 74.0W (COA); 50 kt SW at 12 UTC at 30.1N, 72.0W (COA); 45 kt N and 998 mb at 13 UTC at 37.5N, 76.5W (COA); 45 kt WSW and 998 mb at 13 UTC at 33.4N, 74.4W (COA); 60 kt N and 969 mb at 36.2N, 74.6W (COA); 70 kt SE and 952 mb at 17 UTC at 38.9N, 72.0W (MWR Birmingham City); 70 kt NW and 970 mb at 39.3N, 73.8W (MWR Stewart); 972 mb at 17 UTC at 38.2N, 74.5W (COA); 993 mb at 37.5N, 76.5W; 997 mb at 17 UTC at 36.9N, 74.8W (COA); 50 kt NNW and 981 mb at 18 UTC at 39.3N, 73.8W (COA); 35 kt SSW and 998 mb at 21 UTC at 40.2N, 70.2W (COA); Several other gales of 35-45 kt observed. Land highlights: 37 kt N at 6 UTC at Hatteras, North Carolina at 35.3N, 75.6W (NCDC); 43 kt N at 7 UTC at Hatteras, North Carolina at 35.3N, 75.6W (NCDC); 49 kt NW at 8 UTC at Hatteras, North Carolina at 35.3N, 75.6W (NCDC); 53 kt at 9 UTC at Hatteras, North Carolina at 35.3N, 75.6W (NCDC); 50 kt NW at 10 UTC at Hatteras, North Carolina at 35.3N, 75.6W (NCDC); 45 kt NW at 11 UTC at Hatteras, North Carolina at 35.3N, 75.6W (NCDC); 43 kt NW at 12 UTC at Hatteras, North Carolina at 35.3N, 75.6W (NCDC); 53 kt W at 17 UTC at Atlantic City, New Jersey at 39.4N, 74.5W (NCDC); 40 kt SE at 17 UTC at Providence, Rhode Island at 41.8N, 71.3W (NCDC); 44 kt N at 17 UTC at New York City, New York at 40.8N, 74.0W (NCDC); 981 mb at 19 UTC at Newark Airport, New Jersey at 40.8N, 74.3W (NCDC); 995 mb at 19 UTC at Nantucket, Massachusetts at 41.3N, 70.1W (NCDC); 946 mb at 20 UTC at Bellport, Long Island, New York at 40.75N, 72.4W (NCDC); 76 kt SW and 979 mb at 20 UTC at Providence, Rhode Island at 41.8N, 71.3W (NCDC); 45 kt SE and 996 mb at 20 UTC at Nantucket, Massachusetts at 41.3N, 70.1W (NCDC); 63 kt S and 985 mb at 21 UTC at Boston at 42.4N, 71.0W (NCDC); 979 mb at 22 UTC at Concord, New Hampshire at 43.2N, 71.5W (NCDC); 975 mb at 22 UTC at Albany, New York at 42.7N, 73.8W (NCDC); 41 kt S and 971 mb at 2330Z at Burlington, Vermont at 44.5N, 73.2W (NCDC); Several other gales and low pressures. "It was not until September 21 that the hurricane approached any coastal or island area close enough to be felt seriously. At about 7:30 a.m. E.S.T. [1130 UTC] of that day, the center was about 75 miles east or slightly north of east from

Cape Hatteras, where the barometer reading at that time was 29.30 and the wind velocity 50 miles an hour from the northwest. With the center approximately the same distance east of Atlantic City, at about 1 p.m. [17 UTC], the hurricane caused a maximum wind velocity of 61 miles an hour from the west at 12:55 p.m. [1655 UTC], simultaneously with the lowest barometer reading, 28.99 inches. At Sandy Hook, the lowest reading was 28.71 inches, shortly after 2 p.m., maximum wind 56 N at 1 p.m. The calm center was felt at Brentwood, Long Island, between 1:50 p.m. and 2:50 p.m. Drizzling rain was reported at intervals, with the sun shining during or three 5-minute periods. The wind movement was so slight during that time that a cigarette could have been lighted in the open without difficulty. Shortly before 4 p.m. the center reached the Connecticut coast passing between New Haven and Bridgeport; lowest pressure at New Haven was 28.11 at 3:50 p.m. At Hartford the minimum pressure, 28.04, was reached at 4:30 p.m. Moving at a very rapid rate, the center crossed Vermont between 6 and 9 p.m., its course having changed from north by east to north by west, while crossing Massachusetts. At Northfield the lowest barometer reading was 28.77 at 7:30 p.m. and at Burlington at 8 p.m." (1938 MWR) "The winds damaged buildings and broke off or uprooted trees in all parts of the area traversed by the storm center and to a distance of about 100 miles to the eastward. Damage to buildings and trees did not extend far to the westward of the path. Destruction of property was especially heavy on the shores of Connecticut, Rhode Island and southern Massachusetts and Long Island. The extreme eastern and extreme western portions of Massachusetts and the western interior of Connecticut suffered relatively little" (1938 MWR). "The exact property damage cannot, of course, be ascertained; but according to the Travelers Insurance Co. of Hartford, Conn., the surveys by the insurance trade and others justify the acceptance of an estimate of at least \$400,000,000. It also claimed the lives of 680 people" (1939 MWR). Boston, MA: "High winds on 21st The maximum wind of 73 miles per hour, for a five-minute period, and of 86 miles [per hour] for a single minute, was the highest velocity ever recorded at this station" (OMR) Burlington, VT: "The highest wind velocity, 47-S, was the highest for any summer or fall month on record. The lowest barometer reading, sea level, 28.68 in., was the lowest for any summer or fall month on record. The greatest 24-hour precipitation, 2.91 in., was the greatest on record for the month. Considerable damage, mostly from falling trees, was caused locally and more extensive damage from wind and floods was caused in other parts of the state". Concord, NH: "Storm of gale proportions during period 3:30 p.m. to 8:30 p.m. Maximum velocity 56 and extreme velocity 61. Lowest barometer 28.91 reduced. Peak of storm at 5:45 p.m. Widespread damage throughout the state. Greatest damage in the

south and central portions. Estimated total loss by flood and wind \$22,000,000. 14 lives lost, 4 by flood and 10 by falling trees."

Hartford, CT: "On September 21st in the afternoon the wind reached a maximum velocity of 46 miles per hour from the NE and an extreme of 59 miles from the east at 3:31 p.m. This caused widespread damage to trees and buildings in Hartford proper amounting close to \$2,000,000. The greatest damage was to the beautiful shade trees in which Hartford has taken pride for a long time. The tidal waves which hit the Connecticut and neighboring shores at the same time was only slightly felt here on account of the flood waters already in the river. The death list in the vicinity was 6." Nantucket, MA: "Abnormally high tides and heavy swell on the ocean side of the island, did considerable damage to shore property, and isolated Madaquet from Smiths Point." Providence, RI: "A severe storm on this date was of hurricane intensity. Rain set in at 1:31 p.m., ending at 6:50 p.m., but the only measurable amounts were .07 inches between 3 and 4 p.m. and .10 inches between 4 and 5 p.m. The wind was from the south from 12 to 1 a.m. and southeast then till 3:50 p.m. when it shifted abruptly to the southwest, continuing southwest during the remainder of the day. The storm was most severe from 4:05 to 4:10 p.m. when the maximum velocity for the period was 87 miles per hour from the southwest with an extreme mile at 4:05 of 95 miles per hour, also from the southwest. The barometer dropped rapidly after 10:00 a.m. till 3:45 p.m. when it read 28.90 inches reduced to sea level after which it rose rapidly or at practically the same rate as the fall. The accompanying tidal wave was 17.60 feet above mean low water in the Providence River at the head of the Narragansett Bay which was 1.48 feet higher than that of the 1815 storm. The number of deaths in Providence was 10, four from drowning and six by crushing from falling or flying debris. In the state of Rhode Island, 258 dead, mostly from drowning. The property damage in Rhode Island is estimated to be \$100,000,000" (OMR)

"NY, CT, RI, MA - All Category 3 - 946 mb central pressure" (Jarrell et al.). "Environmental pressure - 1015 mb, Estimated maximum sustained (equivalent 1 min) surface wind at landfall - 110 kt (Schwerdt et al.). "Sep. 21, 1938, 943 mb central pressure, 946 mb observed in Bellport, NY, RMW of 45 nmi, movement 48 kt, landfall at 40.7N, 72.9W, "storm becoming extratropical" (Ho et al.). "1938 Sep 21, All sections of New England, Extreme Intensity ["Extreme" being 948 mb or less, maximum winds 136 mb and higher]" (Dunn and Miller). "F2/F3 damages observed from wind-caused impacts, Suggests boosting winds at 21st/12Z from 100 to 110 kt, 18Z 85 to 110 kt, landfall at 20Z with 110 kt, 22nd/00Z from 70 to 90 kt, 06Z from 45 to 60 kt" (Boose et al. 2001). "Suggest maximum sustained surface winds of 85 kt" (Kaplan and DeMaria 2001).

September 22: HWM analyzes an extratropical closed low of at most 985 mb centered near 47.5N, 75.5W attached to a stationary front. HURDAT listed this as a 35 kt extratropical low at 47.3N, 77.0W. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 43.5N, 73W at 0 UTC. The MWR Track of the Hurricane of September 16-22, 1938 (Chart IX) shows a center near 46.5N, 77W at 12 UTC. Available observations suggest that the 35 kt extratropical low was centered at 47.7N, 77.3W. Land highlights: 973 mb at 0 UTC at Burlington, Vermont at 44.5N, 73.2W (NCDC); 995 mb at 0 UTC at Portland, Maine at 43.65N, 70.25W (NCDC); 996 mb at 0 UTC at Providence, Rhode Island at 41.8N, 71.3W (NCDC); 993 mb at 0 UTC at Boston, Massachusetts at 42.4N, 71.0W (NCDC); 982 mb at 0 UTC at Albany, New York at 42.7N, 73.8W (NCDC); 993 mb at 6 UTC at Burlington, Vermont at 44.5N, 73.2W (NCDC); Several other gales and low pressures.

September 23: HWM analyzes an extratropical closed low of at most 1005 mb centered near 42.5N, 72.5W attached to a stationary front. HURDAT does not list a position for this day. The MWR Track of the hurricane of September 16-22, 1938 shows a center near 45.0N, 77.0W at 0 UTC. Available observations suggest that the 30 kt extratropical low was centered at 45.0N, 77.0W.

No changes were made to the genesis of this major hurricane. Following a thorough examination of all available data and records for each day of the storm's existence, recommendations were made for moderate to major track modifications to the HURDAT database. These include: 1) removal of unrealistic acceleration at the track beginning, 2) removal of speed problem on the 12th, 3) added a stairstep track on the 17th, 4) only minor changes to timing and position of landfall in New England, 5) added an additional 6 hr position for more realistic end of track.

Recommendations were also made for generally minor intensity alterations to the HURDAT database for the 10th to the 12th, the 16th and 17th, and the 21st and 22nd. Since observations suggest that the cyclone obtained Category 2 status on the 16th at 00Z, rather than at 06Z on the same day as originally documented in HURDAT. Intensities were slightly increased accordingly for the remainder of the 16th and also for the 17th. During this period, one ship, the SS *Alegrete*, recorded a notable (but peripheral) pressure of 958 mb early on the 17th with hurricane force winds also being reported. A 958 mb peripheral pressure reading suggests winds of at least 102 kt from the southern pressure-wind relationships. Winds are boosted from 95 to 105 kt at 00 UTC on the 17th and adjusted upward accordingly on the 16th. Additional ships encountered the storm during the days following this period. These observations include the British

S.S. Corrales (945 mb) on the 18th and the British S.S. Carinthia (943 mb) on the 20th. It is uncertain if these are central pressure measurements, but given the consistency between the two and closeness to observed central pressure values on the 21st, it is suggested that they are likely central pressure measurements. 945 mb central pressure suggests winds of 115 kt from the southern pressure-wind relationship. 115 kt is thus analyzed at 12 UTC on the 18th, down from 125 kt originally. 943 mb central pressure suggests winds of 116 and 108 kt from the southern and subtropical pressure-wind relationship, respectively. 115 kt is thus analyzed at 12 UTC on the 20th, down from 135 kt originally. Winds are adjusted on the 18th to the 20th, accordingly. It was unknown where the 938 mb central pressure value found in HURDAT at 12 UTC on the 21st originated from. However, this value does not appear to be unreasonable, so it is retained.

At landfall (1945Z on the 21st), a pressure of 946 mb measured in Bellport, Long Island, New York was determined to be peripheral, but was used to determine the central pressure of 941 mb. This is close to Ho et al.'s (943 mb) and HURDAT's original (940 mb) values and somewhat deeper than Jarrell et al. (946 mb), who apparently assumed that Bellport observed the central pressure. The position at 1945Z was determined to be 40.8N, 72.8W, just to the east of Bellport, Long Island. As described in Myers and Jordan, the pressure center and the wind center for this hurricane were offset by about 15 nmi due (with the wind center southwest of the pressure center) to its extreme translational speed. As is usually indicated in HURDAT, the best track positions here are based upon the wind (circulation) center. 941 mb suggests winds of 103 kt from the northern-pressure wind relationship. The RMW of the hurricane at landfall is estimated to be 35-40 nmi, somewhat smaller than Ho et al.'s assessment. This is slightly larger than the 30 nmi RMW which would be average given the central pressure and latitude (Vickery et al. 2000). However, the speed of the hurricane was about 40 kt at landfall, which would significantly increase the winds on the right side of the storm. It is estimated that the maximum surface sustained winds at landfall were about 105 kt, which is slightly below the Schwerdt et al.'s and Boose et al.'s value (110 kt) and significantly above that suggested by Kaplan and DeMaria (85 kt) and that shown originally in HURDAT (also 85 kt). (Kaplan and DeMaria's analysis focussed solely upon observed wind values. However, the coastal regions of New York, Connecticut, and Rhode Island where the right side RMW came ashore had no anemometer-based observations available.) This retains the hurricane as a Category 3 at the first (NY) landfall. It is estimated that the central pressure fell slightly - to 946 mb - at the second landfall in Connecticut. The hurricane's second landfall was around 2040 UTC at 41.3N, 72.9W near New Haven and with winds suggested to have dropped slightly to 100 kt. Category 3 winds are likely to have been observed at the eastern tip of Long

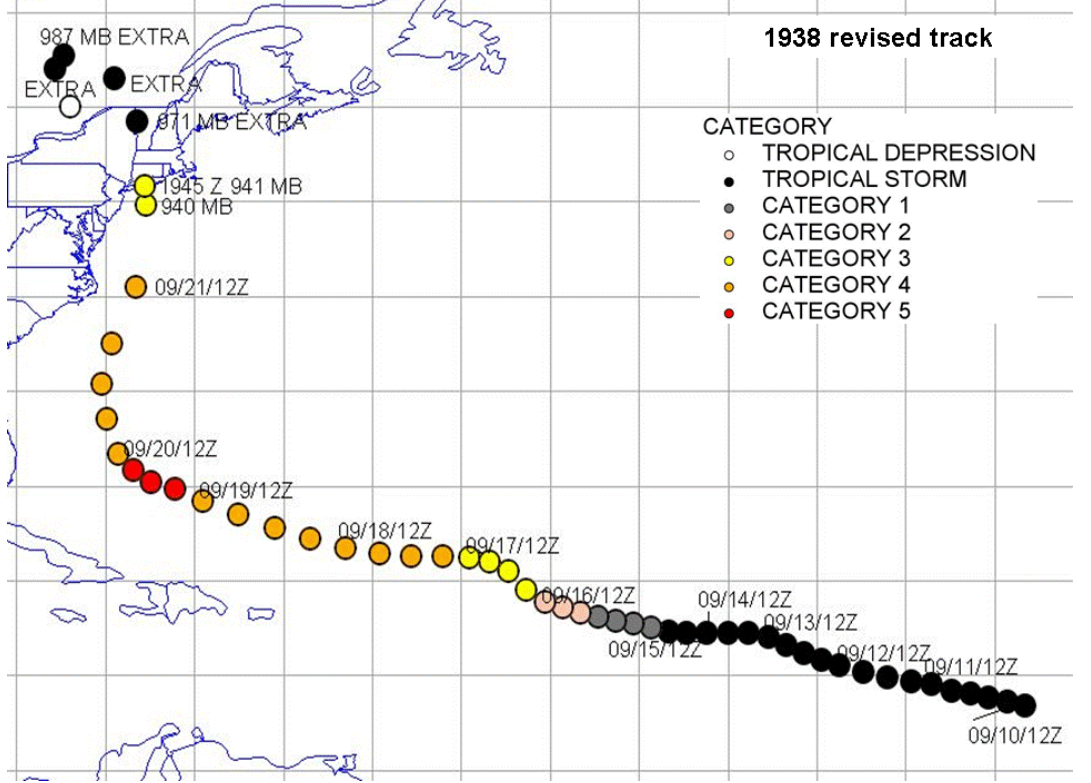
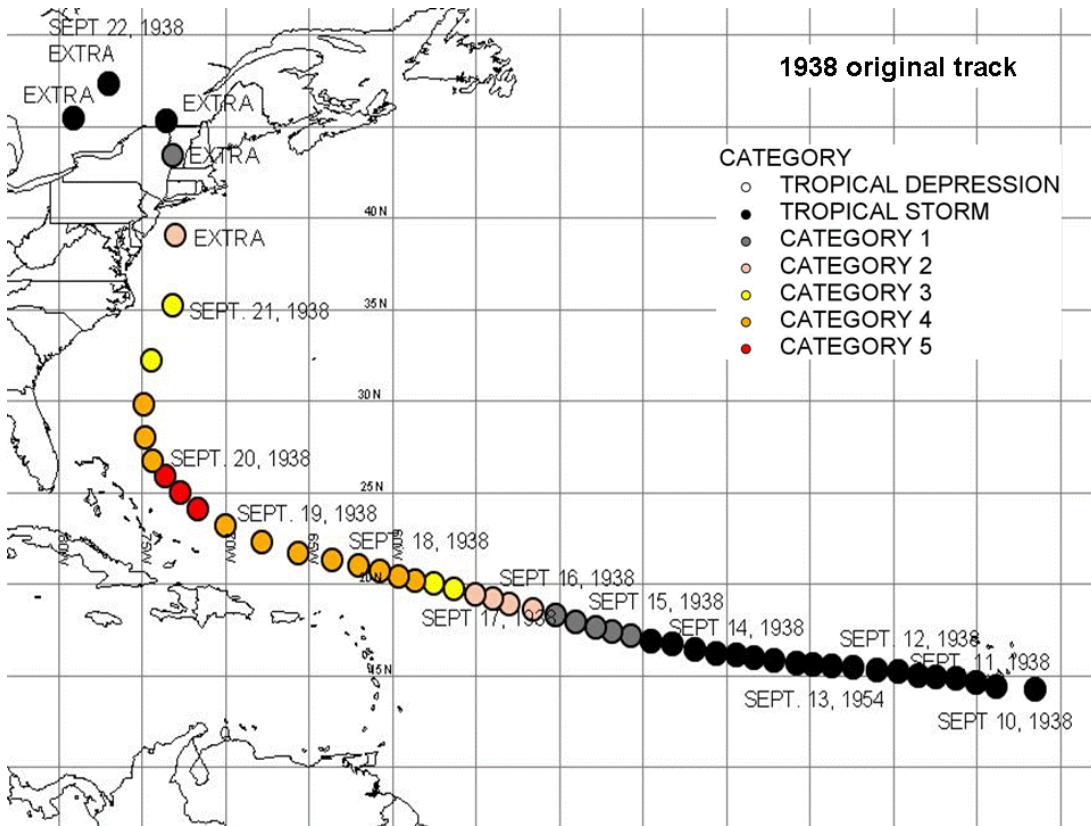
Island, New York, eastern Connecticut, and Rhode Island. The assessment for Massachusetts reflects a downgrade from that originally estimated in HURDAT of a Category 3 strike for this state. An additional post-landfall central pressure were added for the 00Z 22nd HURDAT of 971 mb from Burlington, Vermont. This replaced a value of 967 mb originally in HURDAT. Following landfall, the peak observed winds within two hours of the 00Z and 06Z on the 22nd synoptic times were land-based observations of 60 kt from Boston, Massachusetts and 30 kt from Burlington, Vermont. The Kaplan and DeMaria (2001) inland decay algorithm for New England suggested winds of 57 and 38 kt at 00Z and 06Z, respectively. Consequently, winds in HURDAT were decreased from 70 to 60 kt at 00Z and from 45 to 40 kt at 06Z.

An application of SLOSH for this hurricane was conducted by Jarvinen (2006) For his run, he utilized the pressure center positions, which as mentioned earlier were about 15 nmi southwest of the wind center. Using central pressures of 941 mb at landfall in New York and 946 mb at landfall in Connecticut and an RMW of 26 nmi (from the pressure center), SLOSH's output closely matches the observed storm surges at Providence, Rhode Island and Buzzards Bay, Massachusetts. The SLOSH model gave maximum 1 min surface winds of 115 kt at the southern shoreline on eastern Long Island and 112 kt at the shoreline in Connecticut. However, these values do not take into account any increases in stability due to the cool water near New England. Thus the SLOSH model output is consistent with a Category 3 Impact at landfall in New York and Connecticut.

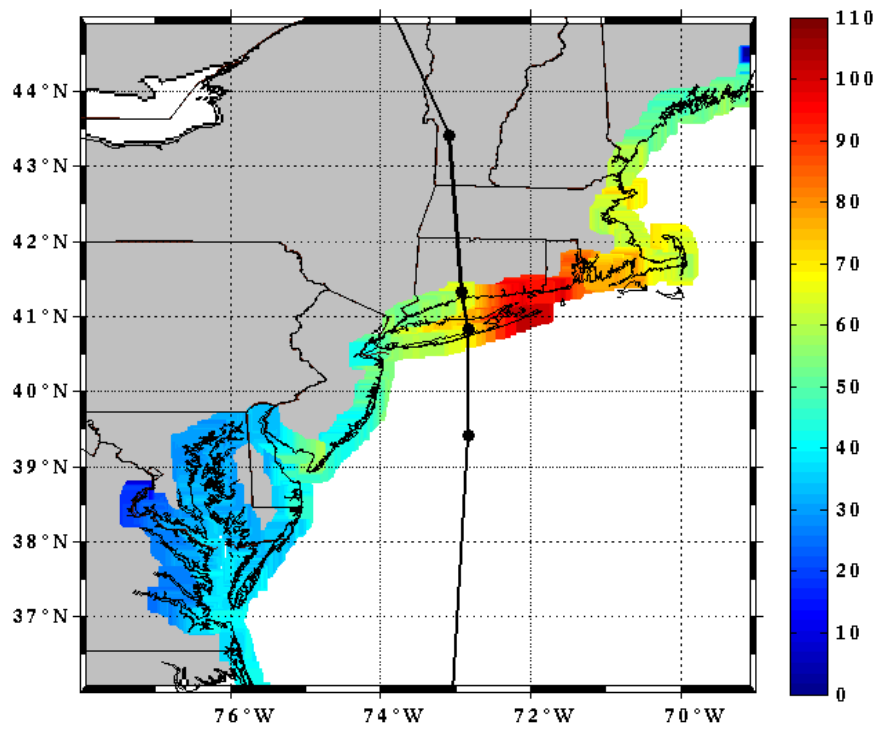
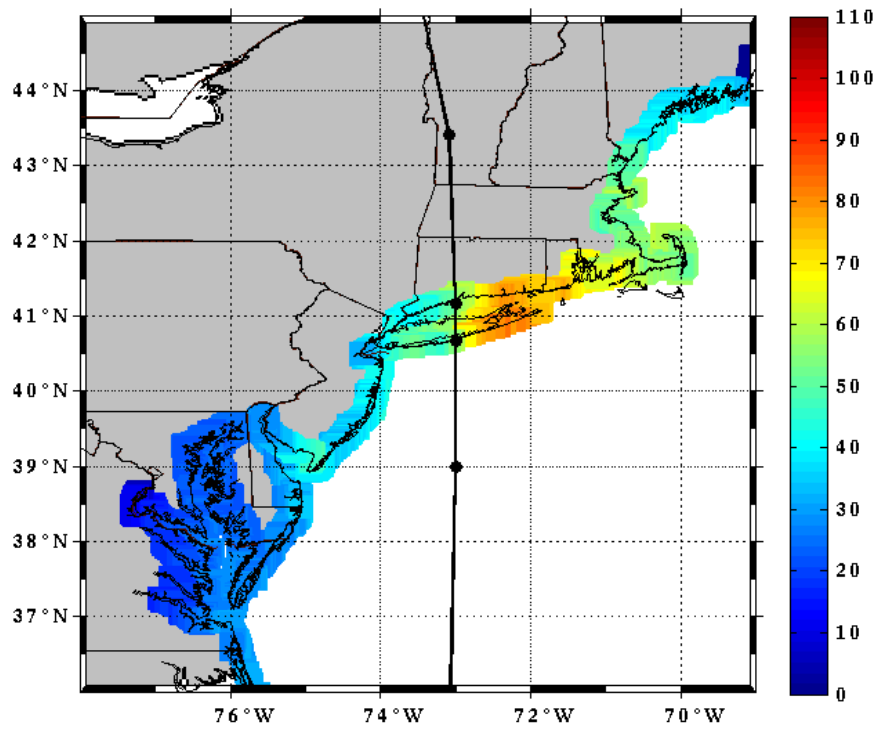
One last consideration was whether the system was extratropical before or after landfall in New England. Oddly, the was listed as extratropical in HURDAT at 18 UTC on the 21st (right before landfall), but the track is shown in Neumann et al. (1999) as still retaining hurricane status until just after landfall. It has been officially considered a hurricane at landfall in Jarrell et al. and in the Saffir-Simpson Hurricane Scale designation in HURDAT. Pierce (1939) considered it extratropical, as he even showed frontal boundaries when the system was as far south as 35N at 12 UTC on the 21st. However, ship observations near the core of the system were lacking on the 21st. While it is clear that the system was extratropical soon after landfall in New England (and was likely completely transitioned by 00 UTC on the 22nd), the lack of observations makes knowing its true character at landfall ambiguous. Perhaps Ho et al.'s assessment of "becoming extratropical" at landfall is most apt. Therefore, the 1938 Great New England hurricane will be retained with hurricane status just up to landfall.

A final note is that the track for the 1938 New England Hurricane was extended an extra six hours on the 23rd to accommodate some Historical Weather Map

data showing that the system was still in existence on this data and also to provide a more realistic velocity at its conclusion.



Original and revised 1938 New England hurricane track maps.



1938 New England hurricane original and revised wind swaths.

1944 Great Atlantic Hurricane

31740 09/09/1944 M= 8 7 SNBR= 703 NOT NAMED XING=1 SSS=3
31740 09/09/1944 M= 8 7 SNBR= 703 NOT NAMED XING=1 SSS=2
*

31745 09/09* 0 0 0 0*208 580 65 0*212 597 70 0*216 610 70 0*
31745 09/09* 0 0 0 0*208 585 45 0*212 597 50 0*216 610 55 0*
*** ** **

31750 09/10*220 623 75 0*225 636 75 0*230 650 75 0*234 663 80 0*
31750 09/10*220 623 60 0*225 636 65 0*230 650 70 0*236 663 75 0*
** ** **

31755 09/11*239 674 85 0*242 681 90 0*245 687 90 0*247 692 95 0*
31755 09/11*243 674 80 0*250 681 85 0*255 687 90 0*257 692 95 0*
*** ** ***

31760 09/12*249 697 105 0*252 703 110 0*256 711 115 943*263 723 120 0*
31760 09/12*258 699 105 0*259 706 110 0*262 715 115 943*266 728 120 0*
*** *** *** **

31765 09/13*271 735 120 0*278 742 115 0*285 748 110 0*297 755 105 0*
31765 09/13*270 740 120 0*276 747 120 0*285 751 120 0*297 755 115 933*
*** *** *** **

31770 09/14*312 760 100 0*327 761 95 0*344 757 90 0*371 747 85 0*
31770 09/14*312 757 115 0*327 756 110 0*344 752 110 942*371 745 105 0*
*** *** *** **

31775 09/15*399 732 75 0*421 715 65 966E442 685 35 0E460 637 35 982*
31775 09/15*399 732 95 953*421 710 70 966E442 685 55 982E460 637 50 *
** *** ** ***

31780 09/16E478 582 30 0E499 526 30 0E520 470 30 0* 0 0 0 0*
31780 09/16E478 582 40 0E499 526 35 0E520 470 30 0* 0 0 0 0*
** ** **

31785 HR NC3 VA3 NY3 CT3 RI3 MA2
31785 HR NC2 VA2 NY2 CT1 RI2 MA1
*** **

Landfall:

7-9/14/1944 1300Z 35.2N 75.0W 90kt 2 17nmi 942mb
7-9/15/1944 0300Z 40.9N 72.3W 95kt 2 29nmi 953mb
7-9/15/1944 0345Z 41.3N 71.5W 95kt 2 29nmi 955mb

Minor changes to the track and to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from the Historical Weather Map series, _Monthly Weather Review_, Original Monthly Records from NCDC, the COADS ship database, Tannehill (1952), Dunn and Miller (1960), Harris (1963), Schwerdt et al. (1979), Ho et al. (1987), Jarrell et al. (1992), Boose et al. (2001), and Cobb (2004).

September 9: HWM analyzes a closed low of at most 1010 mb centered near 20.0N, 610W. HURDAT listed this as a 70 kt category 1 hurricane at 21.2N, 59.7W. The MWR Tracks of Centers of Cyclones for September 1944 (Chart

IX) places the center at 20.5N, 59.5W at 12 UTC on this day. The center of the storm according to a reconnaissance flight reported in the Monthly Weather Review indicated a center located at approximately 21.0N, 60.0W sometime on the 9th. Available observations suggest that the 50 kt tropical storm was centered at 21.2N, 59.7W due to a lack of data in the vicinity of the storm. The intensity of the storm on this day is based on the following quote taken from the 1944 Monthly Weather Review, "strong disturbance existed in the vicinity." Ship highlights: No gales or low pressures present on this day. (An attempt was made to extend the record for this storm before September 9, but due to a lack of data due to World War II, it could not be done.)

September 10: HWM analyzes a closed low of at most 1000 mb centered at 24.0N, 64.8W. HURDAT listed this as a 75 kt category 1 hurricane at 23.0N, 65.0W. The MWR Tracks of Centers of Cyclones for September 1944 (Chart IX) places the center at 21.5N, 61.5W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart IX) places the center at 22.5N, 64.5W at 12 UTC on this day. Available observations suggest that the 70 kt category 1 hurricane was centered at 23.0N, 65.0W due to a lack of data in the vicinity of the storm. Ship highlights: No gales or low pressures on this day.

September 11: HWM analyzes a closed low of at most 995 mb centered at 25.2N, 68.2W. HURDAT listed this as a 95 kt category 2 hurricane at 24.5N, 69.0W. The MWR Tracks of Centers of Cyclones (Chart IX) places the center at 23.5N, 67.5W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart IX) places the center at 25.2N, 68.2W at 12 UTC on this day. Available observations suggest that the 90 kt category 2 hurricane was centered at 25.5N, 68.7W. Ship highlights: 1001 mb and 20kt WNW at 12 UTC at 24.5N, 70.5W (COA); 20 kt WSW and 1002 mb at 17 UTC at 23.5N, 69.5W (COA).

September 12: HWM analyzes a closed low of at most 995 mb centered at 26.0N, 71.5W. HURDAT listed this as a 115 kt category 4 hurricane with 943 mb central pressure at 25.6N, 71.1W. The MWR Tracks of Centers of Cyclones (Chart IX) places the center at 25.0N, 70.3W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart IX) places the center at 25.5N, 71.0W at 12 UTC on this day. Available observations suggest that the 115 kt category 4 hurricane was centered at 26.2N, 71.5W. Ship observations: 1001 mb and 15 kt NW at 13 UTC at 24.5N, 73.5W (COA); 1000 mb and 35 kt W at 13 UTC at 24.5N, 73.5W (COA); 999 mb and 45 kt SW winds at 17 UTC at 25.5N, 73.5W (COA); 1002 mb and 15 kt winds at 17 UTC at 25.5N, 73.5W (COA). Regarding the intensity: unable to track down a source for the 943 mb documented in HURDAT for 12 UTC on this day.

September 13: HWM analyzes a closed low of at most 990 mb centered at 29.5N, 76.0W. HURDAT listed this as a 110 kt category 3 hurricane at 28.5N, 74.8W. The Tracks of Centers of Cyclones (Chart IX) places the

center at 27.5N, 73.5W at 0 UTC on this day. The Tracks of Centers of Cyclones (Chart IX) places the center at 28.0N, 74.5W at 12 UTC on this day. Available observations suggest that the 120 kt category 4 hurricane was centered at 28.5N, 75.1W. Ship observations: 1008 mb and 35 kt NE at 00 UTC at 28.5N, 76.5W (Hugh Cobb); 1000 mb and 35 kt SSW at 01 UTC at 25.5N, 73.5W (COA); 1000 mb at 26.5N, 73.5W (COA); 1005 mb and 17 kt NW at 12 UTC at 25.5N, 77.1W (HWM); 952 mb at 13 UTC at 29.5N, 75.5W (COA); 933 mb at 17 UTC at 29.5N, 75.5W (COA); 1013 mb and 35 kt SE at 17 UTC at 27.5N, 72.5W (COA); 1013 mb and 35 kt SE at 18 UTC at 27.5N, 72.5W (Hugh Cobb). Regarding the intensity: 952 mb central pressure at 12 UTC on this day; 933 mb central pressure at 18 UTC for this day. September 1944 MWR: "At about 9 pm [02 UTC] of the 12th, the storm was centered near the 75th meridian and the expected recurve to the northward became apparent." "It was one of the most violent hurricanes of history; in fact, there is no definite proof of a more violent hurricane in the records. As it approached the northern Bahamas its central pressure was certainly below 27.00 inches [914 mb] (very probably about 26.85 inches [909 mb]) and it was at that time a hurricane of large diameter" (Tannehill).

September 14: HWM analyzes a closed low of at most 985 mb centered at 35.5N, 75.5W. HURDAT listed this as a 90 kt category 2 hurricane at 34.4N, 75.7W. The Tracks of Centers of Cyclones (Chart IX) places the center at 31.0N, 75.5W at 0 UTC on this day. The Tracks of Centers of Cyclones (Chart IX) places the center at 35.0N, 75.5W at 12 UTC on this day. Available observations suggest that the 110 kt category 3 hurricane was centered at 34.4N, 75.2W. Ship observations: 75 kt SW at 00 UTC at 29.5N, 75.5W (Hugh Cobb); 986 mb and 60 kt N at 17 UTC at 37.5N, 76.5W (COA); 997 mb and 40 kt NW at 21 UTC at 37.5N, 76.5W (COA) Land observations: 964 mb at 1230 UTC at 35.2N, 75.7W (OMR Hatteras, NC); 947 mb at 1320 UTC at 35.2N, 75.7W; 35 kt N (OMR Hatteras, NC); 74 kt NW at 1722 UTC at 36.9N, 76.0 W (Cape Henry, VA) (September 1944 MWR); 75 kt NW at 1745 UTC at 36.9N, 76.0W (September 1944 MWR Cape Henry, VA). Edenton, NC: "A hurricane centered 100 miles south of Beaufort, NC at 0400 [0900 UTC], passed along the Eastern coast causing gusts up to 72 knots over this station. Pressure reached a low of 985 mb." Harvey Point, NC: "Light rain began near 0400 [0900 UTC] and increased in intensity during height of storm, and gradually diminished in early afternoon after center passed. Barometer fell sharply as center approached; became unsteady as it passed close to eastward. Lowest pressure recorded at 1130 [1630 UTC] with mercurial barometer of 981.5 mb. Winds increased steadily from NE to become 60-70 knots, gusty, during forenoon. Highest 30 sec. buzzer reading 66 knots, with higher gusts estimated to 80 knots." Wilmington, NC: "A tropical disturbance of great energy moved northward over the Atlantic Ocean some distance east of the North Carolina coast on the 14th. The center of the storm passed about 100 miles east of this station. The lowest barometer reading during the passage of the storm was 29.36 inches

[995 mb] at 4:50 am [0950 UTC], and the highest wind velocity 27 miles per hour [23 kt] at 4:35 am [0935 UTC]." Weeksville, Elizabeth City, NC: "Hurricane passed station before noon [17 UTC]. Rain preceding hurricane. Winds reached highest gust of 79 knots from NNE, and averaged 45 to 50 knots during passage." Richmond, VA: "A tropical hurricane which passed along the coast of Virginia caused heavy rains and fresh winds at Richmond but no damage resulted on this immediate vicinity." Norfolk, VA: "One of the most severe tropical hurricanes in the history of the Norfolk Weather Bureau Office, the records of which go back to 1871, struck this city and the entire coastal area of Virginia, on September 14, 1944. Warnings regarding this storm were issued by the Weather Bureau as much as four days in advance. Its path was carefully charted and its westward and northwestward course plotted and closely followed throughout its journey from the time of its inception in the tropical waters of the Atlantic Ocean until it passed northward along the coast of the United States on September 14th, causing widespread disaster over all areas coming under its influence. Definite effects of the approach of the storm were noticeable in the gentle to moderate easterly winds during the early morning hours. These shifted to northeasterly, with velocity increasing to 20 miles for the hour 6-7 am [11-12 UTC]. The direction continued northeast for four hours, with velocities up to 36 miles an hour. This was followed by a further backing of the wind, which was mostly north until 1 pm, then north west until 4 pm [21 UTC], finally becoming west and southwest. Velocities continued to increase rapidly until a sustained velocity of 56 miles an hour [49 kt] from the NW, for five minutes, occurred from 11:50 am [1650 UTC] to 11:55 am [1655 UTC]. During this interval the fastest single mile passed at the rate of 73 miles an hour [63 kt], from the north, beginning at 11:51 am [1651 UTC]. Velocities of 50 miles an hour [43 kt] continued during the early afternoon but decreased rapidly thereafter to only 11 miles per hour [10 kt] at 6:00 pm [23 UTC]. The barometric pressure fell rapidly during the forenoon, reaching the lowest point at 11:45 am [1645 UTC], when a sea level reading of 29.11 inches [986 mb] was recorded. The center of this storm did not pass directly over Norfolk, but was doubtless a few miles off the coast. Virginia Beach and Cape Henry were doubtless not far from the center as it passed northward. Winds were much stronger at the Cape Henry Weather Bureau Office where a velocity of 85 miles an hour [74 kt] was sustained for a period of five minutes, beginning at 12:22 pm [1722 UTC]. This wind was from the NW. The fastest single mile of wind registered at the Cape Henry Office was at the rate of 134 miles an hour [117 kt], from the NW at 1:13 pm [1813 UTC]. There were gusts for a moments duration, with velocities estimated to be as high as 150 miles an hour. These velocities exceeded all previous records at the Cape Henry Station. The lowest pressure, reduced to sea level, recorded at the Cape Henry Station during the hurricane was 28.86 inches, at 12:10 pm [1710 UTC]. Fortunately for Norfolk and the entire Hampton Roads area, the peak of this hurricane came at low tide. In spite of all the advance notice and warnings given by the Weather Bureau regarding this storm, considerable damage could not be

avoided. Many buildings were unroofed, hundreds of signs were blown down, and thousands of trees were uprooted. Plate glass windows of many stores were blown in or broken by flying debris, and many chimneys were toppled. Crops on thousands of acres of land were seriously injured. Some were washed or blown completely out of the ground. The damage to crops alone, throughout this area was estimated at \$1,000,000. Other property damage was estimated to reach a figure of about equal proportions. There was no loss of life in this immediate vicinity, but two U.S. Coast Guard cutters dispatched from Norfolk in spite of the warnings, to aid another vessel in distress were sunk. Other vessels caught in the storm, including a minesweeper, a destroyer and a lightship, also went to the bottom. A total of 344 men lost their lives. The estimates of the value of property saved as a result of the Bureau's warnings run as high as \$20,000,000, due largely to the removal of many extremely valuable airplanes, as well as other property to points of safety. Doubtless hundreds of lives would have been lost, in addition to those mentioned in the foregoing, had there been no warnings of the approach of this hurricane." Washington, DC: "A tropical hurricane in its northerly course passed near to the Virginia Capes on the 14th and caused great damage along the Atlantic coast and in eastern sections of New England. The barometer at this station fell from 29.83 inches at 10:30 pm [1530 UTC] of the 13th to 29.50 inches at 3:00 pm [18 UTC], 14th. The greatest velocities of the wind during the passage of the hurricane were as follows: 5-minute period: 17 NW at 1:43 pm [1843 UTC]; extreme velocity 18-NW at 1:43 pm [1843 UTC]; Dines anemometer velocity 26-NW at 4:27 pm [2327 UTC]." New York, NY: "The hurricane of September 14, 1944 will long be remembered for its violence, and takes its place among historic storms of the Northeastern States such as the hurricane of September 21, 1938 and the blizzard of March 12, 1888. With an extreme wind velocity of 99 mph [86 kt] and a maximum velocity of 81 mph [70 kt] the all-time wind records of New York City are broken. Damage estimated at \$183,613.00 occurred in New York Harbor and \$830,640.00 on the Long Island and New Jersey Shores. Twenty deaths in New York City and vicinity were attributed to the storm. Trees damaged or lost estimated at 30,000 Due to timely warnings losses were greatly minimized." September 1944 MWR: "Moving almost due north, at a rate of 25-30 miles per hour, the center passed just east of Hatteras at about 9:20 am [1420 UTC] on the 14th." "Tropical Cyclones in the South Atlantic States - Carolinas and Georgia - 1944 Sep 14 - Cape Hatteras - Major [equivalent to Saffir-Simpson Hurricane Scale 2 or 3] - Barometer 27.97 inches at Cape Hatteras" (Dunn and Miller). "108 kt maximum sustained [1 min equivalent] for winds at North Carolina impact. 1009 mb peripheral pressure in North Carolina" (Schwerdt et al.). "944 mb central pressure at time of closest bypass of North Carolina - 17 nmi RMW" (Ho et al.). "1944 - Sep - NC3, VA3 - 947 mb central pressure" (Jarrell et al.).

September 15: HWM analyzes a closed low of at most 985 mb centered at 44.5N, 68.0W. HURDAT listed this as a 35 kt extratropical storm at 44.2N,

68.5W. The Tracks of Centers of Cyclones (Chart IX) places the center at 39.0N, 75.0W at 0 UTC on this day. The Tracks of Centers of Cyclones (Chart IX) places the center at 44.5N, 68.5W at 12 UTC on this day. Available observations suggest the 60 kt extratropical storm with 982 central pressure was centered at 44.2N, 68.5W. Ship observations: 969 mb and 80 kt SE at 39.5N, 72.5W (COA); 990 mb at 12 UTC at 45.5N, 66.0W (HWM). Land observations: 70 kt N at 0030 UTC at 40.7N, 74.0W (September 1944 MWR New York, NY); 960 mb at 35 SW at 0310 UTC at 41.2N, 71.6W (OMR Block Island, RI); 962 mb at 0245 UTC at 41.3N, 72.0W (September 1944 MWR Fishers Island, NY); 71 kt SE at 0230 UTC at 41.2N, 71.6W (September 1944 MWR Block Island, RI); 959 mb at Point Judith, Rhode Island (Ho et al.). September 1944 MWR: "Then turning slightly to the northeastward it moved up the coast, at an accelerated speed of about 40 miles per hour, and crossed over eastern Long Island at about 10 pm [03 UTC on the 15th] of the same date. Moving inland about an hour later near Point Judith, RI, the center crossed the State of Rhode Island and Massachusetts, passing a short distance southeast of Boston, and moved into Massachusetts Bay shortly after 1 am [06 UTC on the 15th]." Hartford, CT: "Weather of September 1944 was outstandingly marked by the passage of a hurricane along the North Atlantic Coast and across Southeastern New England on September 14th and 15th. Nevertheless, considerable damage was reported, due to hurricane winds and heavy rain of Thursday night, September 14, particularly to power lines, telephone lines, trees, fruit, tobacco and corn for Hartford and vicinity and throughout Connecticut. Southeastern coastal areas of Connecticut, Rhode Island and Cape Cod were reported severely damaged by tidal waves and hurricane winds. Eight known deaths due to the hurricane were reported in Connecticut as of September 22, 1944. At 10:07 pm [0307 UTC on 15th] of the 14th gusts were clocked for 4 seconds duration at a rate of 109 mph [95 kt]. The lowest barometer reading had preceded this very shortly, being 28.94 inches [980 mb] (reduced to sea level) at 9:50 pm [0250 UTC]." "Tropical Cyclones in the Middle Atlantic States - 1944 Sep 14-15 - Coast - Major [Saffir-Simpson Hurricane Scale 2-3 equivalent] - 63 killed, damage \$22,500,000. Tropical Cyclones in New England - 1944 Sep 14-15 - Coastal areas - Extreme - [Saffir-Simpson Hurricane Scale 4-5 equivalent] - 390 killed - \$100,000,000" (Tannehill). "95 kt maximum sustained [1 min equivalent] winds at New England landfall. 1011 mb peripheral pressure at New England landfall" (Schwerdt et al.). "F2 structural damage [Saffir-Simpson Hurricane Scale 2 equivalent]" (Boose et al.). "Sep 15 - 955 mb central pressure at landfall - 29 nmi RMW - Landfall point 40.9N, 72.3W - Storm becoming extratropical" (Ho et al.). "The storm surge associated with this hurricane was similar to that of the September 21-22, 1938 storm. The peak surges associated with this storm (1944) coincided very nearly with the normal low tide, and the peak surges of the 1938 storm coincided very nearly with the normal high tide. Thus the observed tides of this storm were lower and produced less damage" (Harris). "1944 - Sep - NY3, CT3,

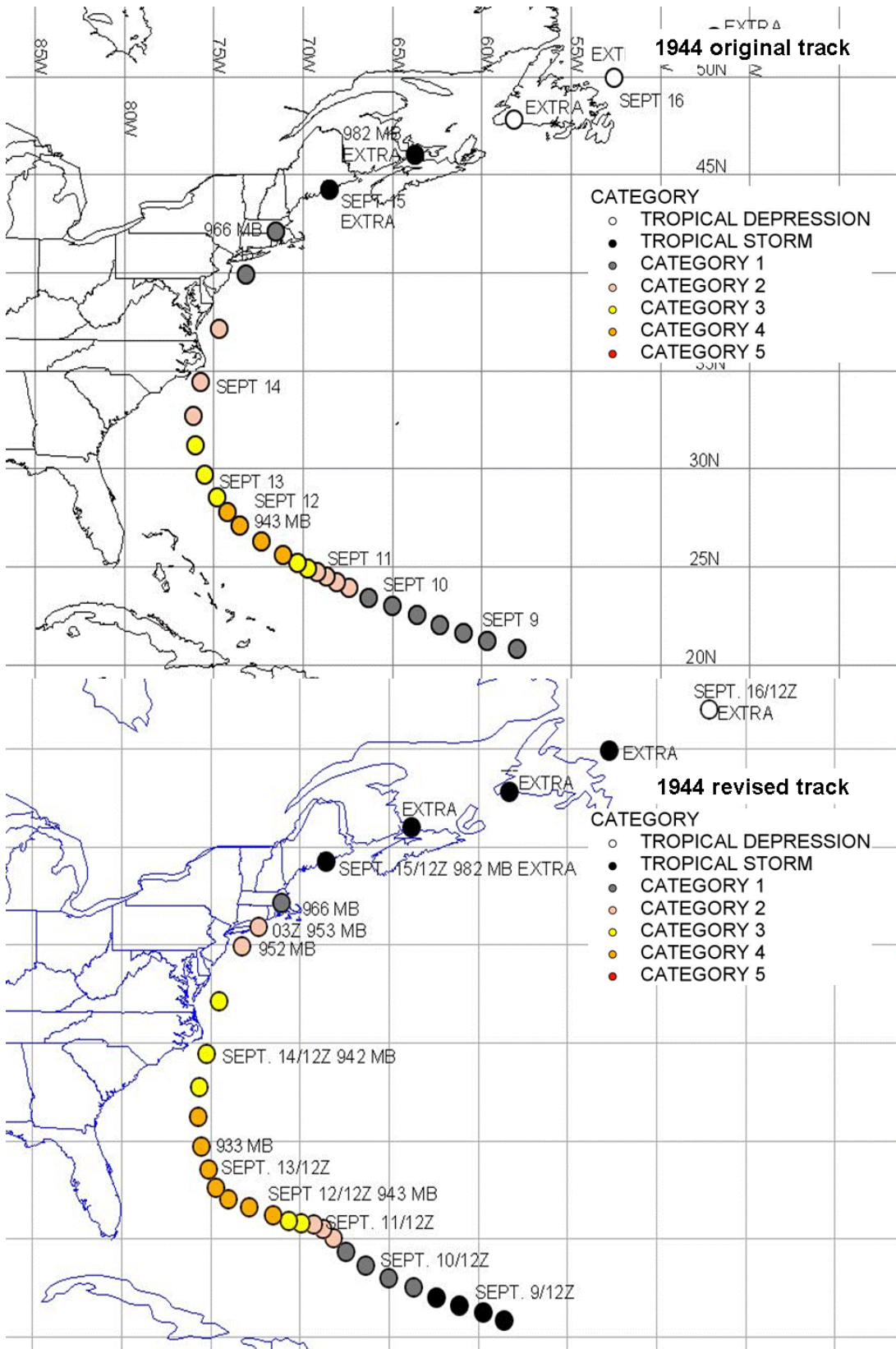
RI3, MA2" (Jarrell et al. 1992).

September 16: HWM analyzes a closed low of at most 985 mb centered at 50.2N, 45.8W. HURDAT listed this as a 30 kt extratropical storm at 52.0N, 47.0W. The Tracks of Centers of Cyclones (Chart IX) places the center at 48.0N, 58.0W at 0 UTC on this day. The Tracks of Centers of Cyclones (Chart IX) does not list a location for 12 UTC on this day. Available observations suggest the 30 kt extratropical storm was centered at 52.0N, 47.0W. Ship observations: 1003 mb at 00 UTC at 50.5N, 54.5W (COA); 1004 mb at 00 UTC at 47.5N, 54.5W (COA); 993 mb at 11 UTC at 53.5N, 44.5W (COA); 998 and 35 kt SSW mb at 14 UTC at 52.5N, 35.5W (COA); 994 mb at 15 UTC at 53.5N, 44.5W (COA); 1000 mb at 22 UTC at 51.5N, 36.5W (COA). Providence, RI: "The Atlantic Hurricane passed over Rhode Island during the evening of September 14, 1944, causing great damage in various parts of the state. Numerous houses were washed away along the beaches, but no loss of life resulted from the storm. Total damage to the entire state was between \$2,000,000 and \$2,500,000. During the height of the storm winds attained a maximum velocity at WBAS of 43 mph [37 kt] for 5 minutes. Extreme velocity of 49 SE for 1 mile, with gusts estimated up to 90 mph [78 kt]. Lowest barometer at WBAS was 28.48 inches [964 mb], while at WBO the lowest reading was 28.56 inches [967 mb] at 11:20 pm [0420 UTC on the 15th]." Nantucket, MA: "The hurricane of September 14-15 was the most severe at Nantucket in recent years. The maximum wind velocity for five minutes was 57-SW at 11:47 pm [0447 UTC on the 15th] on the 14th; extreme velocity was 79-SW at 12:46 am [0546 UTC] of the 15th. Gust velocities were estimated at 90 mph. The hurricane of September 21, 1938 produced a maximum velocity of 52-SE and an extreme velocity of 57-SE. The severity of this storm exceeded that of the hurricane of September 21, 1938 at Nantucket except in relation to high [sic] tides. Damage from this months storm was principally the result of high winds and tusts [sic], while unusually high tides, accompanying the 1938 hurricane, accounted for the greatest damage in that storm. The tide did not rise to unusual heights during this months storm and the resulting water damage was not great." East Boston, MA: "At Boston, lowest pressure occurred at 12:25 am [0525 UTC] on September 15, when the barometer reached a low point of 28.592 inches, station reading, 28.62 [969 mb] inches S.L. Winds reached a maximum (5 min.) velocity of 60 mph [52 kt] at 10:24 pm EST [0324 UTC], direction was NE. Peak gusts of 98 mph [85 kt] were observed (60th mile contact) by buzzer, 10:18 pm [0318 UTC] to 11 pm EST [0400 UTC]. Extreme velocity recorded was 72 mph [63 kt] at 10:28 pm, EST, [0328 UTC] direction was NE." Concord, NH: "The hurricane of September 14-15 caused little damage in the vicinity of the Concord, NH station. A few small trees, and branches of large trees were blown down. The only real property damage of any importance was done to blown down apples, especially the McIntosh variety. Portland, ME: The maximum at the airport was 40 NE with an extreme of 50 NE at 1:08 am [0608 UTC] on the morning of the 15th. Observers noted the

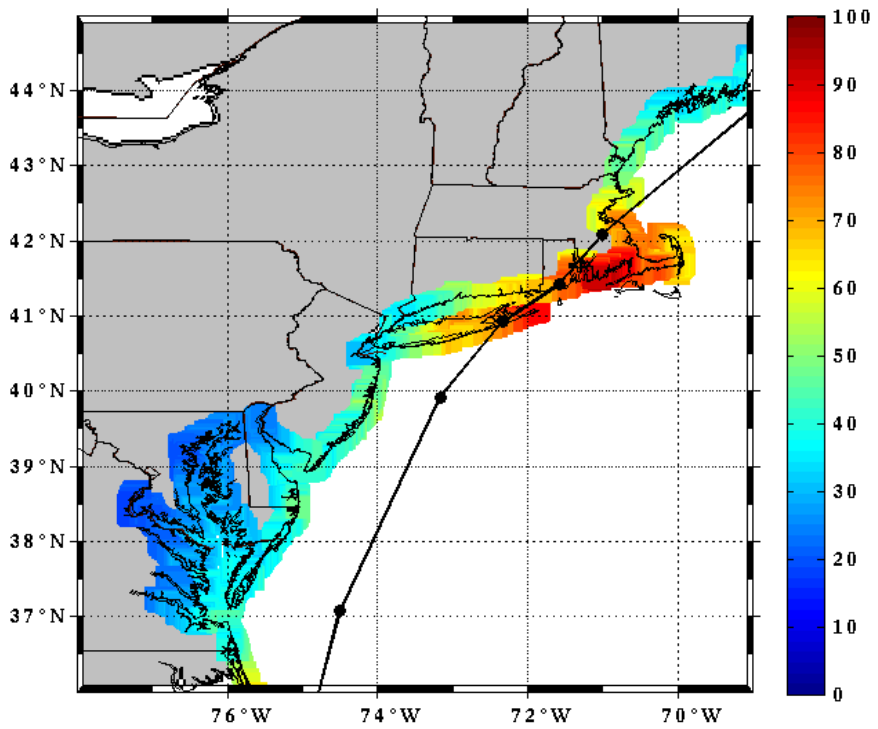
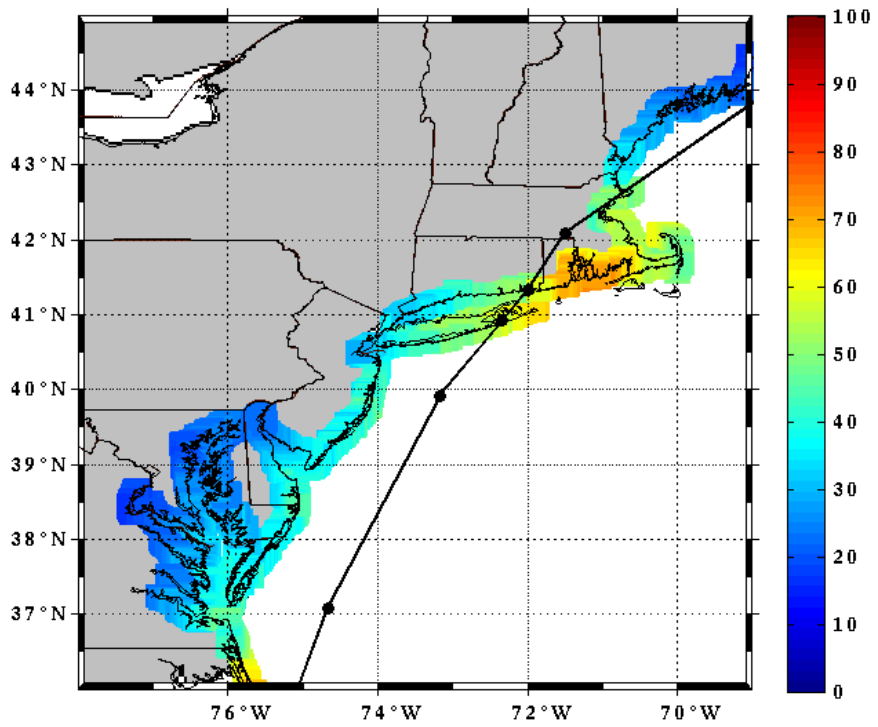
eye of the storm at 4:20 am [0920 UTC] when the wind dropped to moderate and the stars were visible. Then the wind shifted to NW from NE. Some places along the coast, notably Ogunquit the NW wind was an estimated velocity of about 70 and many trees were blown down and minor damage." September 1944 MWR: "A total of 390 lives were lost as a result of the 1944 hurricane, a large proportion of them as a result of marine casualties. The 46 deaths listed as occurring along the coastal areas of the United States is less than 10 percent of the 494 fatalities resulting from the storm of 1938. Heavy marine casualties were directly related to intensified patrol work and other exigencies resulting from war conditions. Property damage has been estimated at approximately \$100,000,000 or about one-third that estimated for the 1938 hurricane."

For genesis of this hurricane, the first position at 06 UTC on the 9th was adjusted to the west for a more realistic initial speed. Originally, HURDAT started this system at genesis as a 65 kt hurricane. Intensity begun as a 45 kt tropical storm and reduced on the 9th and 10th. Evidence for this alteration is based primarily upon the 1944's Monthly Weather Review assessment. The actual genesis point for this hurricane likely occurred farther east before the 9th, but lack of ship observations do not allow for an accurate genesis assessment. Minor track changes were introduced from the 11th through the 14th. No changes made to the intensity from the 11th and 12th, though observations near the center were sparse. There was a 943 mb central pressure listed for 12 UTC on the 12th, which could not be confirmed through available sources. Given observations on the 13th, this central pressure value is likely valid. A 943 mb central pressure suggests winds of 116 kt from the southern pressure-wind relationship and 108 kt from the subtropical pressure-wind relationship - 115 kt retained in HURDAT. At 17 UTC on the 13th, a 933 mb ship observation (possible central pressure) was recorded. 933 mb suggests winds of 115 kt from the subtropical pressure-wind relationship. 115 kt is chosen for HURDAT at 18 UTC on the 13th, up from 105 kt originally. (It is noted that Tannehill suggests a much more intensity hurricane - possibly Category 5 - given the pressure estimated near the Bahamas. However, such an intensity could not be substantiated from available observations.) On the 14th, the hurricane turned to the north and clipped the North Carolina coast. The original HURDAT took the center of the hurricane over the Outer Banks, but observations from Hatteras suggest that instead the hurricane passed just offshore around 13 UTC on the 14th. This agrees with Ho et al.'s assessment that the hurricane did not make a North Carolina landfall. Given the 49 kt wind reported at the time of the 947 mb pressure at Hatteras, it is estimated that the central pressure was around 942 mb. This is just slightly lower than the Ho et al. value of 944 mb. 942 mb suggests winds of 109 kt from the subtropical pressure-wind relationship and 102 kt from the high latitude pressure-wind relationship. Given the small size of the RMW (estimated 17 nmi) given

the climatological average of 25 nmi for that latitude and central pressure, winds are estimated to be 110 kt during its close bypass of North Carolina and Virginia. Peak 5 min observed winds for North Carolina and Virginia were 74 kt (Hatteras) and 75 kt (Cape Henry), which are equivalent to about 80 kt 1 min winds. It is estimated that both North Carolina and Virginia experienced Category 2 sustained winds, which is a downgrade from Category 3 analyzed officially originally. The downgrade from Category 3 to 2 for Virginia matches the assessment of Cobb (2004). The hurricane accelerated to the north-northeast and made landfall at the eastern tip of Long Island, New York around 0300 UTC on the 15th near 40.9N, 72.3W. The hurricane made a second landfall around 0345 UTC on the 15th on the Rhode Island coast near 41.4N, 71.6W. Lowest observed pressures were 959 mb at Point Judith, Rhode Island, 960 mb with 35 kt SW wind at Block Island, Rhode Island, and 962 mb at Fishers Island, New York. Central pressure at landfall in Rhode Island is estimated to be 955 mb (in agreement with Ho et al.). Landfall pressure in New York is estimated to be 953 mb, slightly deeper than at Rhode Island. Highest observed 5 min winds at landfall were 70 kt N in New York City and 71 kt in Block Island. These convert to about 75 kt 1 min peak winds. A 953 mb central pressure suggests wind of 95 kt from the northern pressure-wind relationship. (955 mb gives 93 kt.) Given the near climatological RMW (29 nmi RMW versus 32 nmi climo) and forward speed (30 kt), 95 kt is estimated as the maximum sustained winds at landfall. Thus 95 kt and 953 mb are entered into HURDAT for 00 UTC on the 15th, the last synoptic time before landfall. This is a significant increase compared to 75 kt originally. New York, Connecticut, and Rhode Island are each analyzed as to having been impacted by Category 2 wind conditions, which is a downgrade from Category 3 originally in HURDAT. Massachusetts is analyzed as being impacted by Category 1 winds, which is a downgrade from Category 2 originally. Peak observed winds after landfall (within two hours of the synoptic time) were 61 kt at 06 UTC and 50 kt at 12 UTC. A run of the New England wind-decay model (Kaplan and DeMaria 2001) gives 65 kt and 41 kt at 06 and 12 UTC, respectively. 70 and 55 kt were chosen for HURDAT, because of the latter observation and because the system went back out over the Atlantic after crossing Massachusetts. Thus winds are substantially higher at 12 UTC on the 15th (55 kt) than originally indicated in HURDAT (35 kt). The 982 mb central pressure originally listed as being an 18 UTC reading apparently comes from the 12 UTC Eastport, Maine observation. This is now shifted to correctly being indicated at 12 UTC. No change was made to the assessment that extratropical transition occurred around 12 UTC on the 16th, near the coast of Maine. No change was made in the dissipation of this system.



Original and revised 1944 Great Atlantic hurricane track maps.



Original and revised 1944 Great Atlantic hurricane windswaths.

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32130 08/24/1945 M= 6 5 SNBR= 712 NOT NAMED XING=1 SSS=2
32135 08/24* 0 0 0 0*194 940 60 0*209 947 60 0*216 952 65 0*
32135 08/24*205 944 40 0*213 947 45 0*220 950 50 0*226 953 55 0*
*** ** ** *** ** ** *** ** ** *** ** **
32140 08/25*224 957 70 0*234 961 75 0*243 964 80 0*249 966 85 0*
32140 08/25*233 956 60 0*240 958 70 0*247 960 80 0*253 962 85 0*
*** ** ** *** ** ** *** ** ** *** ** **
32145 08/26*254 967 90 0*260 968 95 0*266 968 100 0*270 968 105 0*
32145 08/26*259 964 90 0*265 966 90 0*270 968 90 0*273 969 90 0*
*** ** ** *** ** ** *** ** ** *** ** **
32150 08/27*273 968 110 0*278 965 115 0*282 962 115 963*286 961 120 966*
32150 08/27*275 969 90 0*278 968 90 0*281 967 90 963*285 964 85 966*
*** ** ** *** ** ** *** ** ** *** ** **
32155 08/28*291 960 120 968*295 960 65 980*299 961 50 987*306 964 40 993*
32155 08/28*290 961 75 0*295 960 65 980*300 961 50 987*305 963 40 993*
*** ** ** *** ** ** *** ** ** *** ** **
32160 08/29*310 966 35 998*315 971 30 1002*318 975 25 1006*321 979 20 1009*
32165 HRBTX2
32165 HRATX1BTX2CTX1
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Landfall: 8/27/1945 ~16 UTC - 28.3N, 96.6W - 18 nmi RMW - 963 mb - 90 kt

Minor changes to the track and major changes to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from the Historical Weather Map series, Monthly Weather Review, daily Surface Weather Observations from NCDC, U.S. Weather Bureau six hourly maps available via microfilm at NHC, the Daily Weather Map series, the COADS ship database, Connor (1956), Dunn and Miller (1960), Schwerdt et al. (1979), Ho et al. (1987), and Jarrell et al. (1992).

August 24: HWM indicates a closed low of at most 1010mb near 25N, 95W. HURDAT lists this as a Tropical Storm at 20.9N, 94.7W at 12 UTC. The MWR Tracks of N. Atlantic Hurricanes and Tropical Disturbances showed a center at 21.8N, 94.9W (a.m.) and at 23.2, 95.5W (p.m.). Ship highlight: No gales or low pressures. Station highlight: No gales or low pressures. Aircraft highlight: 50kt at 21N, 93W at 1530 UTC (USWB). "The storm formed in an area of squalls which had persisted for several days over the Gulf of Campeche, near latitude 21.5N, longitude 95W. It rapidly developed into a hurricane during the morning of August 24 and began a northward movement at a rate of 8 to 10 mph. This rate of forward movement continued during the 24th and the 25th " (MWR).

August 25: HWM indicates a storm with a center at approximately 26N, 96W. HURDAT lists this as a Category 1 hurricane at 24.3N, 96.4W at 12 UTC. The MWR Tracks of N. Atlantic Hurricanes and Tropical Disturbances showed a center at 24.8N, 96W (a.m.) and at 25.9N, 97W (p.m.). Ship highlight: 35 kt E with pressure of 1011mb at 24N, 92W at 0630 UTC (USWB). Station highlight: 39 kt NNE and 1006 mb at Port Isabel at 1830 UTC (USWB). Aircraft highlight: 75-80 kt NW at 25N, 96.3W at 1140 UTC (USWB).

August 26: HWM indicates a storm with a center at approximately 26.5N, 97W. HURDAT lists this as a Category 3 hurricane at 26.6N, 96.8W at 12 UTC. The MWR Tracks of N. Atlantic Hurricanes and Tropical Disturbances showed a center at 27N, 96.5W (a.m.) and at 28.3N, 96W (p.m.) Ship highlight: No gales or low pressures. Station highlight: 72 kt NNE with pressure at 995mb at Corpus Christi at 2200 UTC (SWO). Aircraft highlight: 43 kt SE at 27N, 96.8W at 1745 UTC (USWB). "As the storm neared the coast on the 26th, the speed of translation dropped to about 5 mph, a rate which was maintained until the center moved inland near Port Aransas" (MWR). "Estm. position storm at 25.7 96.4 intensity 105 mph" at 0030 UTC (USWB).

August 27: HWM indicates a closed low of at most 1005mb near 28N, 97W. HURDAT lists this as a Category 4 hurricane at 28.2N, 96.2W at 12 UTC. The MWR Tracks of N. Atlantic Hurricanes and Tropical Disturbances showed a center at 28.9N, 96.5W (a.m.) and at 29.9N, 96.3W (p.m.) Ship highlight: No gales or low pressures. Station highlight: 967 mb (possible central p pressure?) at Palacios at 2000 UTC (SWO); 91 kt E-W at 1930-2130 UTC and 968 mb pressure (peripheral - though no time given) at Port O'Connor (MWR). Aircraft highlight: 48 kt SSE at 27.3N, 95.9W at 1400 UTC (USWB). "Winds accompanying the storm were estimated as high as 135 miles per hour at Seadrift, Port O'Connor, and Port Lavaca... At [Port Aransas] a 20-minute lull in the wind between 1 a.m. and 2 a.m. on the 27th indicated passage of the calm eye of the storm. On the 27th the center also passed a short distance south of Seadrift, Tex., at about 10 a.m., and slightly north of Port O'Connor about 11 a.m. Neither place experienced a calm, although they are only 19 miles apart" (MWR). "Also, the lowest reliable barometer reading was recorded at Camp Hulen, Palacios, Tex., on August 27 about 3 p.m. It was 28.57 inches (967.5 mb), only 0.02 inch higher than the low reported for Galveston in the disastrous hurricane of September 8, 1900" (MWR). "Three deaths were attributed directly to the hurricane: two men were drowned at Port Isabel when their small boat crashed into the jetties, and one person was killed about eight miles north-northeast of Houston in a small tornado that developed in the storm circulation on August 27" (MWR). "Tropical Cyclones in Texas - Aug. 26-27 - Middle Coast - Extreme [Category 4 or 5] - 3 killed - \$20,133,000 in damage" (Dunn and Miller). "Aug. 27 - 968 mb central pressure - 18 nmi RMW - 4 kt forward speed - landfall position 28.5N 96.2W" (Ho et al.). "1005 mb environmental pressure - 80 kt maximum sustained surface wind at landfall"

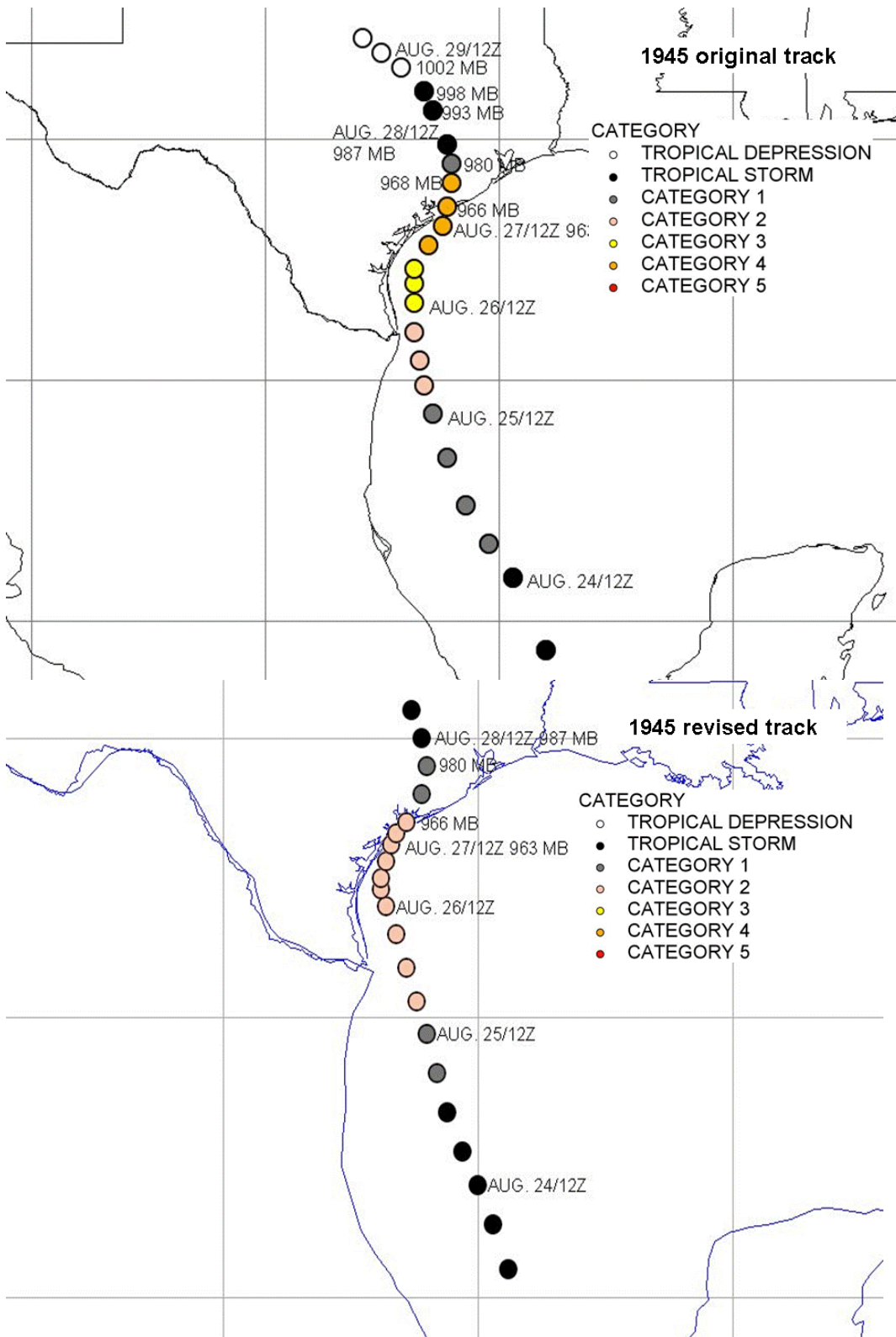
(Schwerdt et al.). "TX - Category 2 - Central coast - 967 mb central pressure at landfall" (Jarrell et al.). "Center crossed coast near Palacios, 967 mb minimum central pressure" (Connor). "Reconnaissance flights by military planes into the vicinity of the hurricane while it was in the Gulf of Mexico greatly aided in determining the position and future movements of the storm. Without the information obtained from these flights, it would have been difficult if not impossible to issue advisories as accurately and so far in advance as was the case with this storm. Reconnaissance pilots located the storm in the Bay of Campeche and determined its dangerous character well before these facts would have been known otherwise" (Daily Weather Map series).

August 28: HWM indicates a small low near 29N, 96W. HURDAT lists this as a Tropical Storm at 29.9N, 96.1W at 12 UTC. The MWR Tracks of N. Atlantic Hurricanes and Tropical Disturbances showed a center at 31N, 97W (a.m.) and at 31.3N, 97.5W (p.m.). Ship highlight: No gales or low pressures. Station highlight: 976mb at Bay City between 3 and 4 UTC (MWR). Aircraft highlight: No gales or low pressures. "Slow progression accounted for excessive precipitation along the coast and for a considerable distance inland. At Houston, for instance, 9.39 inches fell in a 6-hour period ending at 2:30 a.m., August 28. Rainfall along the coast, estimated as high as 30 inches, added to the flooding and damage caused by the wind-impounded waters of the Gulf" (MWR). "The storm decreased slightly in intensity as it moved inland, but winds of hurricane force were still reported over a small area near the center early on the 28th" (Daily Map Series).

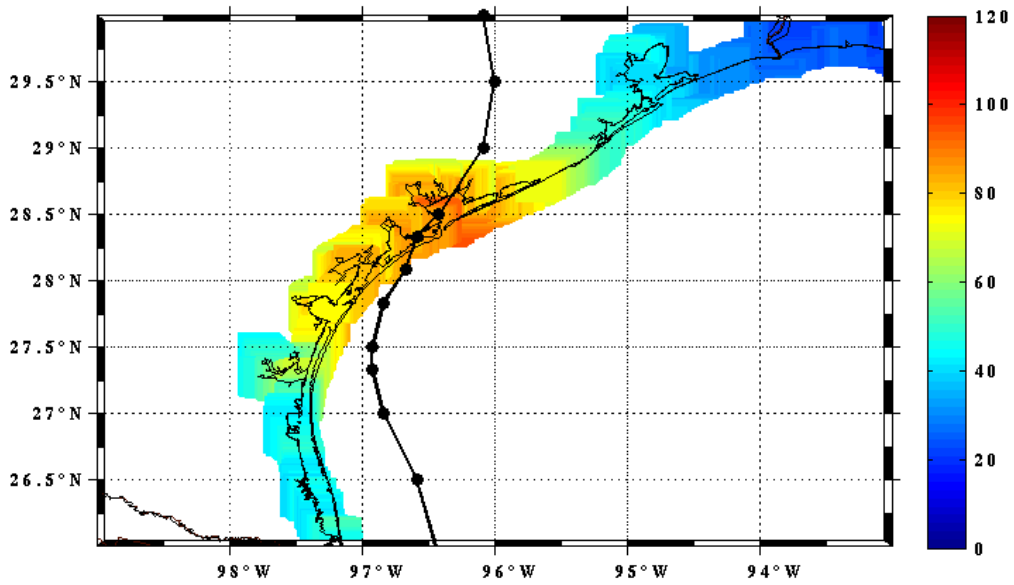
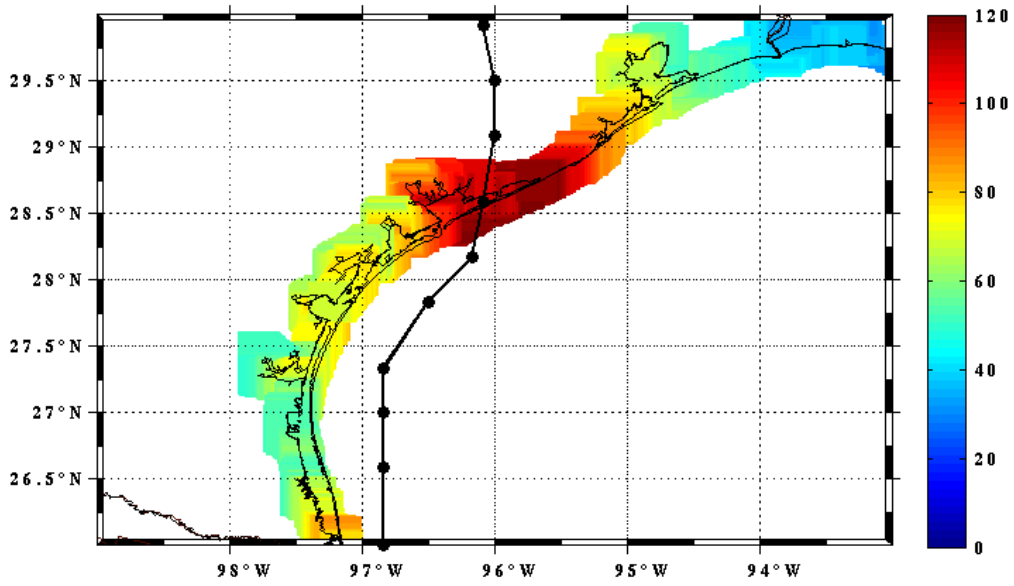
August 29: HWM indicates a closed low at approximately 31N, 98W. HURDAT lists this as a Tropical Depression at 31.8N, 97.5W at 12 UTC. The MWR Tracks of N. Atlantic Hurricanes and Tropical Disturbances showed a center 32N, 98.5W (a.m.) and at 32.5N, 99W (p.m.). Ship highlight: No gales or low pressures. Station highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures. "Continuing a northeastward movement parallel to the coast, the storm began to recurve toward the northwest as it passed west of Matagorda and dissipated in the interior of Texas on the 29th" (MWR).

Genesis begun six hours earlier (at 00 UTC on the 24th) to account for a well developed vortex by the time aircraft reconnaissance reached the system around 14 UTC on the 24th. This change also corrects for an unrealistically abrupt movement in the system's first six hours and for a more gradual spin-up than starting the system at 60 kt. Small track changes are introduced for all but the 29th based upon aircraft reconnaissance and land station data. (Due to World War II, little ship observations were available operationally or from COADS.) Intensity originally was quickly brought up from a tropical storm on the 24th,

to a Category 1 on the 25th, to a Category 3 on the 26th, to a Category 4 on the 27th until landfall. Aircraft observations - which were relying upon estimates of wind from visual assessments of the wind effects on the ocean - did suggest that hurricane force was reached on the 25th. However, the aircraft reconnaissance did not provide any central pressure readings, or any confirmation of Category 3 or 4 winds. The most complete analysis of its intensity was at landfall, which was then used to adjust winds during the preceding two days. The hurricane made landfall 28.3N 96.6W between Seadrift and Port O'Connor, Texas around 16 UTC on the 27th. Despite numerous reports of estimated (visually) wind gusts of up to about 120 kt, the highest observed winds were 91 kt at Port O'Connor. A possible central pressure of 967 mb was recorded at Palacios around 20 UTC, about four hours after landfall. Utilizing the Ho (1987) inland pressure decay model, this suggests a central pressure of 963 mb using the Florida peninsula version (to account for the hurricane primarily passing over Matagorda Bay after making initial landfall on the Texas barrier islands. 963 mb is slightly lower than the Ho et al. and Jarrell et al. estimate of 967 mb, which essentially assumed that the Palacios reading was a landfall value. 963 mb suggests winds of 92 kt from the new Brown et al. (2006) pressure-wind relationship for north of 25°N tropical cyclones. Given the slow speed of motion for this system at landfall (about 5 kt) and its near climatological RMW size (18 nmi versus 20 nmi climatologically from Vickery et al. 2000), 90 kt is chosen for the maximum sustained winds at landfall. This agrees with the Jarrell et al. and HURDAT assessment of Category 2, but requires a reduction in winds on the 26th and 27th. Due to observed hurricane conditions along a large stretch of the coast because of the near-parallel track, Category 1 impacts are also included for south Texas coast (south of Corpus Christi) and the north Texas coast (north of Matagorda Bay). Peak observed winds after landfall were 39 kt at 00 UTC on the 28th, 35 kt at 06 UTC, and below gale force at 12 UTC. Application of the Kaplan and DeMaria (1995) inland decay model suggests winds of 62 kt, 47 kt, and 38 kt, accordingly. Because of the transit of the system over a partial water terrain for the first several hours after landfall, winds are chosen above the model, though at 00 UTC the winds chosen are substantially lower than originally in HURDAT. Additionally, keeping the system hurricane force through 06 UTC on the 28th agrees with the assessment described in the Daily Map Series. No changes were made to the decay phase of the system. Unlike most hurricanes of its era, estimates had already been provided of the central pressure from just before landfall up until final dissipation. All of these values looked reasonable (including the pre-landfall one which agreed exactly with our landfall central pressure), except for 00 UTC on the 28th which appears to be a few millibars too low.



Original and revised TX 1945 hurricane track maps.



Original and revised TX 1945 hurricane windswaths.

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32740 09/04/1947 M=18 4 SNBR= 728 NOT NAMED XING=1 SSS=4
32745 09/04* 0 0 0 0*145 201 45 0*143 215 50 0*142 228 60 0*
32745 09/04* 0 0 0 0*145 201 30 0*143 215 30 0*142 228 30 0*
** ** **

32750 09/05*141 240 65 0*140 250 65 0*140 261 70 0*140 271 70 0*
32750 09/05*141 240 35 0*140 250 35 0*140 261 40 0*140 271 40 0*
** ** **

32755 09/06*141 282 70 0*142 293 70 0*143 304 75 0*143 315 75 0*
32755 09/06*141 282 45 0*142 293 45 0*143 304 50 0*143 315 50 0*
** ** **

32760 09/07*143 326 75 0*142 337 75 0*140 348 75 0*137 360 80 0*
32760 09/07*142 326 50 0*141 337 50 0*140 348 50 0*139 360 50 0*
*** ** *** ** **

32765 09/08*133 372 80 0*128 385 80 0*124 398 80 0*121 410 80 0*
32765 09/08*138 372 50 0*137 385 50 0*136 398 50 0*135 410 50 0*
*** ** *** ** *** **

32770 09/09*119 420 80 0*117 429 80 0*116 438 85 0*116 448 85 0*
32770 09/09*134 420 50 0*133 429 50 0*132 438 50 0*132 448 50 0*
*** ** *** ** *** **

32775 09/10*117 457 85 0*120 467 85 0*123 476 90 0*127 486 90 0*
32775 09/10*133 457 50 0*135 467 50 0*138 476 50 0*141 484 50 0*
*** ** *** ** *** **

32780 09/11*132 497 90 0*137 505 95 0*142 514 95 0*151 529 95 0*
32780 09/11*144 490 50 0*148 498 50 0*152 510 50 999*157 525 55 0*
*** *** ** *** *** ** *** *** **

32785 09/12*161 547 100 0*172 567 100 0*182 586 105 0*189 600 105 0*
32785 09/12*163 545 65 0*169 565 75 0*176 584 85 977*186 603 95 0*
*** *** *** *** *** *** *** *** ***

32790 09/13*195 614 110 0*203 629 110 0*210 643 115 0*215 653 115 0*
32790 09/13*196 622 100 0*206 640 105 0*214 654 110 0*220 664 115 952*
*** *** *** *** *** *** *** *** ***

32795 09/14*220 662 120 0*225 672 120 0*230 682 125 0*236 695 125 0*
32795 09/14*226 674 120 0*232 684 120 0*237 694 125 0*242 704 125 938*
*** *** *** *** *** *** *** *** ***

32800 09/15*243 711 125 0*251 722 130 0*258 733 130 0*262 742 135 0*
32800 09/15*248 716 125 0*254 728 125 0*260 737 120 0*265 745 115 0*
*** *** *** *** *** *** *** *** ***

32805 09/16*264 749 135 0*265 754 140 0*266 760 140 0*267 768 140 0*
32805 09/16*267 752 110 951*267 757 105 0*267 762 105 956*267 769 105 954*
*** *** *** *** *** *** *** *** ***

32810 09/17*267 776 140 0*266 785 140 0*265 795 135 947*263 804 130 0*
32810 09/17*267 778 105 0*265 788 110 0*263 798 115 940*262 806 105 0*
*** *** *** *** *** *** *** *** ***

32815 09/18*261 812 120 0*261 818 85 0*263 825 85 0*269 838 80 0*
32815 09/18*262 813 95 0*263 820 85 0*266 830 85 0*270 843 90 0*
*** *** *** *** *** *** *** *** **

32820 09/19*277 856 80 0*289 877 80 0*300 897 80 966*304 910 75 970*

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32820	09/19*	276	857	95	0*284	873	95	0*294	890	95	966*	303	907	70	970*
		***	***	**	***	***	**	***	***	**	***	***	***	**	
32825	09/20*	308	922	60	984*	316	937	35	987E327	952	30	994E341	959	25	996*
32825	09/20*	311	922	55	984*	319	937	45	987*327	952	35	994*337	959	30	996*
		***		**	***		**	*		**	**	*		**	
32830	09/21E	354	946	25	997E364	933	20	999E374	920	20	1000*	0	0	0	0*
32830	09/21*	350	950	25	997*364	933	20	999E380	915	20	1000*	0	0	0	0*
		****	***		*			***	***						
32835	HRCFL4	LA3	MS3BFL2												
32835	HRCFL4	LA2	MS2BFL2												
		***	***												

Landfall:

9/17 16Z 26.2N, 80.1W, 940 mb, 115kt, RMW 27 nmi

9/19 14Z 29.6N, 89.5W, 966 mb, 95kt, RMW 23 nmi

Minor changes to the track and major changes to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from the Historical Weather Map series, *Monthly Weather Review*, daily Surface Weather Observations from NCDC, U.S. Weather Bureau six hourly maps available via microfilm at NHC, the COADS ship database, Tannehill (1952), Connor (1956), Dunn and Miller (1960), Schwerdt et al. (1979), Ho et al. (1987), Jarrell et al. (1992), and Barnes (1998).

September 3: HWM indicates a closed low of at most 1010 mb near 15N, 17W. HURDAT does not mention a storm on September 3. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

September 4: HWM indicates a closed low of at most 1010 mb near 14N, 21W. HURDAT lists this as a Tropical Storm at 14.3N, 21.5W 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures. "The Pan American Airways station at Dakar, F. W. A., had reported that a low pressure area had developed over French West Africa on September 2 and had moved westward across the coast line. Over the water the depression deepened, and on September 4 gave Dakar 3.36 inches of rain" (MWR).

September 5: HWM indicates a closed low of at most 1010mb near 14N, 26W. HURDAT lists this as a Category 1 hurricane at 14.0N, 26.1W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: 30kt NNW with pressure of 1003mb at 20.2N, 24.2W at 1800 UTC (COA). Aircraft highlight: No gales or low pressures.

September 6: HWM indicates a closed low of at most 1010mb near 14N, 30.5W. HURDAT lists this as a Category 1 hurricane at 14.3N, 30.4W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

September 7: HWM indicates a closed low of at most 1010mb near 14N, 35W. HURDAT lists this as a Category 1 hurricane at 14.0N, 34.8W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

September 8: HWM indicates a closed low of at most 1010mb near 12N, 39.5W. HURDAT lists this as a Category 1 hurricane at 12.4N, 39.8W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

September 9: HWM indicates a closed low of at most 1010mb near 11N, 44W. HURDAT lists this as a Category 2 hurricane at 11.6N, 43.8W at 12 UTC. Ship highlight: No gales or low pressures. Station highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

September 10: HWM indicates a closed low of at most 1005mb near 11N, 48.5W. HURDAT lists this as a Category 2 hurricane at 12.3N, 47.6W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

September 11: HWM indicates a storm of at most 1000mb near 14N, 51.8W. HURDAT lists this as a Category 2 hurricane at 14.2N, 51.4W at 12 UTC. The MWR Tracks of North Atlantic Hurricanes and Tropical Depressions showed a center at 15.5N, 51.5W (a.m.) and at 17.5N, 54.9W (p.m.). Station highlight: No gales or low pressures. Ship highlights: 35kt NE with pressure of 1011mb at 15.1N, 49.1W at 1600 UTC (USWB). Aircraft highlight: 45kt maximum surface wind estimate, central pressure of 999mb at 15.5N, 51.4W at 1500 UTC (USWB). "The first indication that a well developed tropical storm had formed over the Atlantic came in a report from the S.S. Arakaka, radioed during the night of September 10 from a position near latitude 15N, longitude 49W" (MWR).

September 12: HWM indicates a storm of at most 1000mb near 18N, 58.5W. HURDAT lists this as a Category 3 hurricane at 18.2N, 58.6W at 12 UTC. The MWR Tracks of North Atlantic Hurricanes and Tropical Depressions showed a center at 18N, 59W (a.m.) and at 19.5N, 61.5W (p.m.). Station highlight: No gales or low pressures. Ship highlight: 65kt NW at 18.0N, 59.0W at 1200 UTC (HWM); 61kt SE with 1000mb at 18.0N, 58.0W at 1200 UTC (HWM). Aircraft highlight: 125kt surface wind estimate, central pressure of 977mb at 17.8N, 59.3W at 1345 UTC (USWB).

September 13: HWM indicates a storm of at most 1000mb near 21N, 66W. HURDAT lists this as a Category 4 hurricane at 21N, 64.3W at 12 UTC. The MWR Tracks of North Atlantic Hurricanes and Tropical Depressions showed a center at 21N, 64W (a.m.) and at 22N, 67W (p.m.). Station highlight: No gales or low

pressures. Ship highlight: No gales or low pressures. Aircraft highlights: 100kt surface wind estimate, central pressure of 952mb at 22.3N, 66.6W at 1930 UTC (USWB).

September 14: HWM indicates a storm of at most 1000mb near 23.5N, 68.5W. HURDAT lists this as a Category 4 hurricane at 23N, 68.2W at 12 UTC. The MWR Tracks of North Atlantic Hurricanes and Tropical Depressions showed a center at 23.5N, 69W (a.m.) and at 24.5N, 71W (p.m.). Station highlight: No gales or low pressures. Ship highlight: 74kt NW with pressure of 1000mb at 23.5N, 68.5W at 1200 UTC (HWM). Aircraft highlight: 110kt at 24.1N, 69.3W at 1530 UTC (USWB); 95kt SW with pressure of 997mb at 25.0N, 68.2W at 1600 UTC (USWB); 938 mb central pressure at 24.2N, 70.6W at 2027 UTC (USWB).

September 15: HWM indicates a storm of at most 1000mb near 26.5N, 73.5W. HURDAT lists this as a Category 4 hurricane at 25.8N, 73.3W at 12 UTC. The MWR Tracks of North Atlantic Hurricanes and Tropical Depressions showed a center at 26N, 73W (a.m.) and at 26.5N, 75W (p.m.). Station highlight: 35kt N with pressure of 1009mb at Abaco at 2030 UTC (USWB). Ship highlight: 43kt NNW at 26.1N, 76.2W at 2030 UTC (USWB). Aircraft highlight: 80kt NNW at 25.5N, 74.0W at 1240 UTC (USWB); 100kt with pressure of 951mb at 26.6N, 74.8W at 2108 UTC (USWB). "From the time of the storms detection on September 10, reconnaissance planes of the Army and the Navy followed it on a west-northwesterly course until it reached a position east of Abaco Island in the Bahamas on the 15th. Here it came to a virtual standstill for about 24 hours and then moved west-southwestward over that island and on to the Florida east coast at Fort Lauderdale on the 17th." (MWR)

September 16: HWM indicates a storm of at most 1000mb near 27.5N, 77W. HURDAT lists this as a Category 5 hurricane at 26.6N, 76W at 12 UTC. The MWR Tracks of North Atlantic Hurricanes and Tropical Depressions showed a center at 27N, 76.5W (a.m.) and at 27N, 80.5W (p.m.). Station highlight: 83kt NW with pressure of 983mb at Hopetown at 1430 UTC (USWB); 954mb at Hopetown at 1830 UTC (USWB). Ship highlights: 39kt W with pressure of 1002mb at 26.0N, 76.2W at 1230 UTC (HWM); 3kt WSW with pressure of 997mb at 25.4N, 77.8W at 1730 UTC (USWB). Aircraft highlight: 100kt with pressure of 956mb at 26.5N, 77.0W at 2045 UTC (USWB). "Hopetown, on Abaco Island, recorded a highest wind speed of 160mph when the center passed near the observatory" (MWR).

September 17: HWM indicates a strong storm of at most 985mb near 26.7N, 78.8W. HURDAT lists the storm as a category 4 hurricane with winds of 155mph and a central pressure of 947mb. MWR tracks of lows show the hurricane being at 26.5N, 79.5W (am) and at 26.5N, 80.5W (pm). Station highlight: 105kt with pressure of 947mb at Hillsboro Lighthouse, 26.3N, 80.1W, at 1625 UTC for lowest pressure and 1457 for highest wind measurement (MWR). Ship highlights: 43kt SE with pressure of 1006mb at 25.1N, 75.1W at 0030 UTC (USWB); 29kt NW

with pressure of 999mb at 25.3N, 80.3W at 0630 UTC (USWB). Aircraft highlight: No gales or low pressures. "The highest wind recorded by a reliable instrument in Florida was 155mph, at Hillsboro Light near Pompano at 12:56pm on the 17th, at which time the lowest reliable pressure reading of 947.2mb (27.97 inches) was also recorded. Wind of 100mph or over were experienced generally along the Florida east coast from the northern portion of Miami to well north of Palm Beach, a distance of about 70miles, while winds of hurricane force prevailed from approximately Cape Canaveral to Carysfort Reef Light, a distance of about 240 miles. The great expanse of coast subjected to hurricane force winds, from this storm that moved inland at right angles to the coast line, classes it as one of the great storms on record. It was fortunate that in Florida the most destructive portion of the storm passed inland between the large communities of Miami and Palm Beach. As it was, the less heavily populated area between Fort Lauderdale and Lake Worth bore the brunt of its violence. Pompano, Deerfield, Boca Raton, and Delray Beach were in the path of the strongest winds. Moving on a westward course across the State at about 10mph, the storm emerged into the Gulf of Mexico, with the center passing a short distance north of Naples at about 10pm on the 17th. It had passed over swamplands of the Everglades and the Big Cypress, with little damage resulting. The section around Lake Okeechobee was swept by the highest winds, but the dikes held and there was no flooding of rich farm lands and pastures. The loss to crops, especially sugarcane, was estimated at several million dollars, and a considerable number of livestock were lost. Reach Florida's west coast communities, the storm retained much of its intensity. The strongest wind reported was observed at Sanibel Light, where gusts of 120mph were recorded. At Fort Myers the highest wind was estimated at 90mph, with gusts to 110mph. Heave damage occurred along the west coast from Everglades City to Sarasota, with greatest damage in the Ft. Myers-Punta Gorda area. Everglades City was inundated to a depth of 2 feet by tidewater which rose 5.5 feet above normal. At Naples the lull was felt for an hour between 9 and 10pm on the 17th, with the wind dropping to 12mph at 9:45pm. North of Naples strong offshore winds resulted in below-normal tides" (MWR).

September 18:

HWM shows the hurricane as being below 990mb centered around 26.5N, 83.5W. HURDAT lists the system as a category 2 hurricane with winds of 100mph at 12UTC. MWR tracks of lows shows the system at 26.5N, 83W (am) and at 27.5N, 85.5W (pm). Station highlight: 92kt at Naples at 0000Z and 975mb at Naples at 0445Z (MWR). Ship highlight: 35kt SSE with pressure of 1007mb at 24.9N, 80.2W at 0630 UTC (COA). Aircraft highlight: No gales or low pressures.

September 19:

HWM indicates the system making landfall with pressures of at most 990mb near 34.2N and 89.2W. HURDAT lists the storm as a category 1 hurricane with 90mph winds and 966mb central pressure at 12UTC. MWR tracks of lows shows the storm at 34.5N and 89.5W (am). Station highlight: Pressure of 969mb at New Orleans

at 1600 UTC (MWR) and 57kt NW at Burrwood at 1028UTC (MWR). Ship highlight: 35kt WNW with pressure of 1005mb at 25.7N, 87.5W at 0000 UTC (COA). Aircraft highlight: No gales or low pressures. "...[the storm] swept on to the Mississippi and Louisiana coasts during the morning of September 19. By 5 a.m. winds of hurricane force were being felt over the Chandeleur Islands as far northward as Chandeleur Light. The highest tide, 14 feet above normal high tide, was recorded at Chandeleur Light. Along the Mississippi coast, from Pearlinton to Pascagoula, winds reached hurricane force at about 6:30 a.m. of the 19th. Similar winds reached New Orleans at 7:30 a.m. and an hour later extended to the Moisant Airport, just west of the city. These coastal communities experienced the strongest winds of the storm and the greatest duration of hurricane force winds. From Pearlinton, which endured 5.5 hours of these winds, an observer reported that at 3 p.m. he noticed that a south wind was carrying water back into the Pearl River. At 4p.m. the bayous near Pearlinton and the Pearl River at Logtown were overflowing and inundating the land up to the the floor level of the Logtown Post Office, with the river flowing upstream at a rate of about 15m.p.h. Tides along the Mississippi coast rose to 12 feet at Biloxi, Bay St. Louis, and Gulfport, and to about 9 feet at Pascagoula and in the Lake Catherine-Chef Menteur area. The calm center, which passed directly over the business district of New Orleans and the city of Baton Rouge, was estimated to be about 25 miles in diameter as it passed over New Orleans. Moisant Airport was flooded to a depth of 2 feet, and during the height of the storm part of the road of the Administration Building gave way, forcing employees to run to another building in the area. Baton Rouge was not seriously menaced by high winds until about noon, by which time the hurricane was dissipating rapidly. Hurricane force winds did not reach any section west of Melville, LA., where the highest wind was estimated as 75m.p.h., occurring between 3:30 and 4:00p.m. In Mississippi and Louisiana it was estimated the 90 percent of the damage was caused by water. In Mississippi most of the severe water damage was limited to a section within 2 blocks of the water front. Homes there are built practically to the edge of the water, and there is no sea wall for protection. Minor flooding, occurred in one section of New Orleans due to a break in the Industrial Canal levee, and more severe flooding occurred in Jefferson Parish because of breaks in the embankment or overflowing in sections not protected by embankments"(MWR).

September 20:

HWM indicates the system with a closed low of at most 1000mb near 32.9N, 94W. HURDAT lists the storm as an extratropical storm with 994mb and 35mph winds at 12UTC. MWR tracks of lows did not track to storm inland. Station highlights: 43kt NE with a pressure of 1007mb at Pine Bluff, 34.2N, 92.0W at 0630 UTC (USWB); 21kt SW with pressure of 990mb at Lafayette at 0030 UTC (USWB). Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

September 21:

HWM indicates the storm was completely absorbed by the front. HURDAT lists the storm as an extratropical storm of 1000mb and 25mph winds at 37.4N, 92.0W at 12UTC. MWR tracks of lows did not track the storm inland. Station highlight: 13kt E with pressure of 999mb at Fort Smith at 0030 UTC (USWB). Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

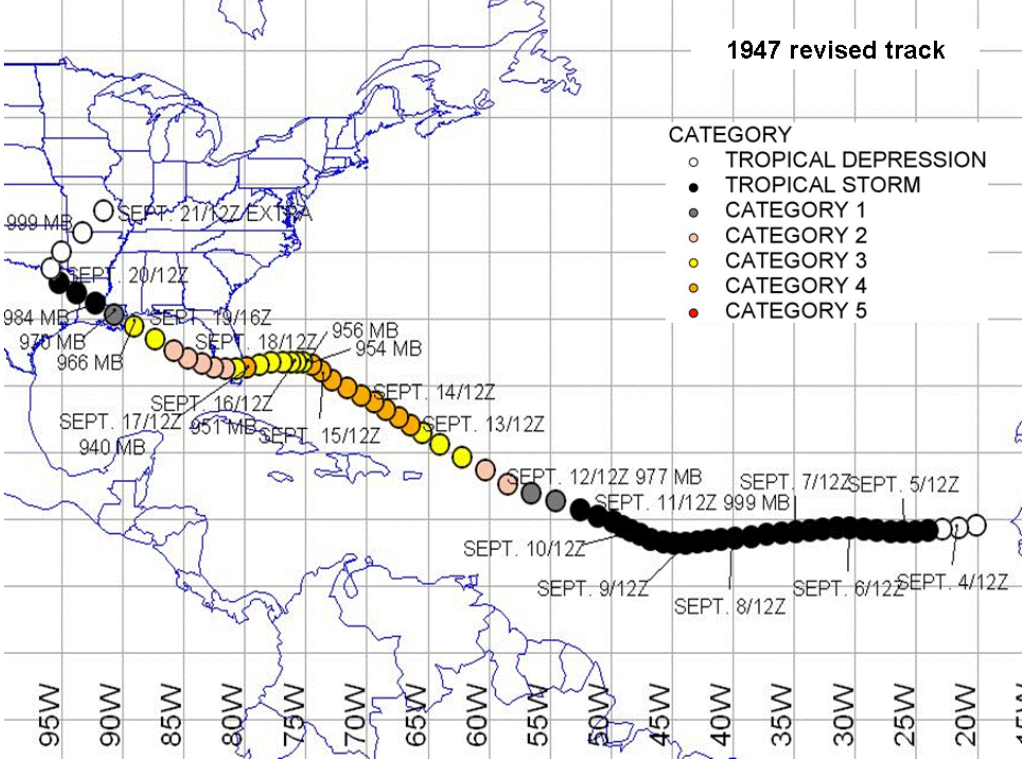
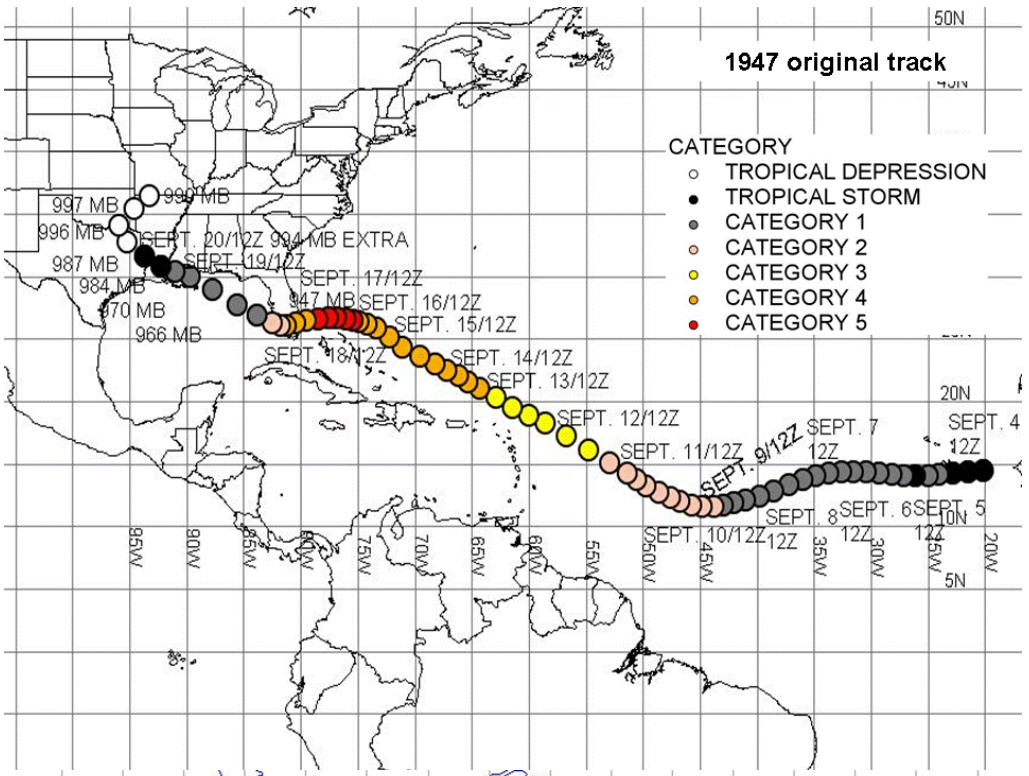
No changes are made to the genesis of this hurricane. Small to moderate track alterations were introduced for all days except for the 4th through the 6th, based upon available ship and land-based observations. In the original HURDAT, the system was quickly brought up to hurricane status on the 5th just south of the Cape Verde Islands. However, the COADS, HWM, and other sources (including Monthly Weather Review in 1947) provided no evidence that hurricane intensity was attained that far east. (Observations, as is usual for the eastern tropical North Atlantic in this era, were quite sparse from the 4th until the 10th.) Indeed, both the 1947 MWR and Tannehill showed this system starting on the 11th near 50W, so it is unclear on what evidence was used to call this a hurricane originally in HURDAT on the 5th near the Cape Verde Islands. Fortunately, aircraft reconnaissance found a central pressure of 999 mb and maximum estimated surface winds of 45 kt around 15Z on the 11th. 999 mb central pressure suggests winds of 49 kt from the southern pressure-wind relationship - 50 kt chosen for HURDAT at 12Z. This is down from 95 kt originally, quite a drastic reduction. Given this rather strong evidence that it was not a hurricane near 50W, the intensity is adjusted downward accordingly on the 4th to the 11th and it is carried across the Atlantic as a 50 kt tropical storm. The system was investigated again by aircraft at 1345Z on the 12th, which found 977 mb central pressure and estimated maximum sustained surface winds of 125 kt. (It is to be noted that aircraft of this era did not have flight-level winds and relied upon visual inspection of the sea state for their surface wind estimates. These, will likely helpful up to Category 1 hurricane conditions, would not be well-calibrated for winds above about 70-80 kt. Thus not much weight is placed upon this 125 kt surface wind value.) 977 mb central pressure suggests winds of 81 kt from the southern pressure-wind relationship. 85 kt is chosen for HURDAT as the system was quickly (20 kt) moving toward the west-northwest, which is down from 105 kt originally. Aircraft monitored the hurricane again on 1930Z on the 13th with a central pressure of 952 mb and estimated maximum surface winds of 100 kt. This pressure suggests winds of 108 kt from the southern pressure-wind relationship. Winds are chosen for HURDAT to be 115 kt due to the tiny (6 nmi diameter) eye reported by reconnaissance, which are the same winds as originally in HURDAT. On the 14th, aircraft reported a central pressure of 938 mb and estimated maximum surface winds of 110 kt. This pressure suggests winds of 120 kt from the southern pressure-wind relationship. 125 kt is chosen for HURDAT at 18Z on the 14th (no change

from previously) as it is assumed that the size of the eye remains small. Aircraft reconnaissance measured 951 mb central pressure at 2108Z on the 15th and estimated surface winds of 100 kt. 951 mb pressure suggests winds of 109 kt and 102 kt from the southern and subtropical pressure-wind relationships, accordingly. 110 kt chosen for HURDAT (down from 135 kt originally) as the eye diameter had expanded to 30 nmi. Around 12 UTC on the 16th, aircraft measured a 956 mb central pressure and estimated surface winds of 100 kt. 956 mb central pressure suggests winds of 104 kt and 98 kt from the southern and subtropical pressure-wind relationships - 105 kt chosen for HURDAT down from 140 kt originally. Hopetown, Bahamas reported a minimum of 954 mb pressure at 1830Z on the 16th, which may have been a central pressure. 954 mb pressure suggests winds of 106 kt and 99 kt from the southern and subtropical pressure-wind relationship. 105 kt chosen for HURDAT at 18Z, down from 140 kt originally.

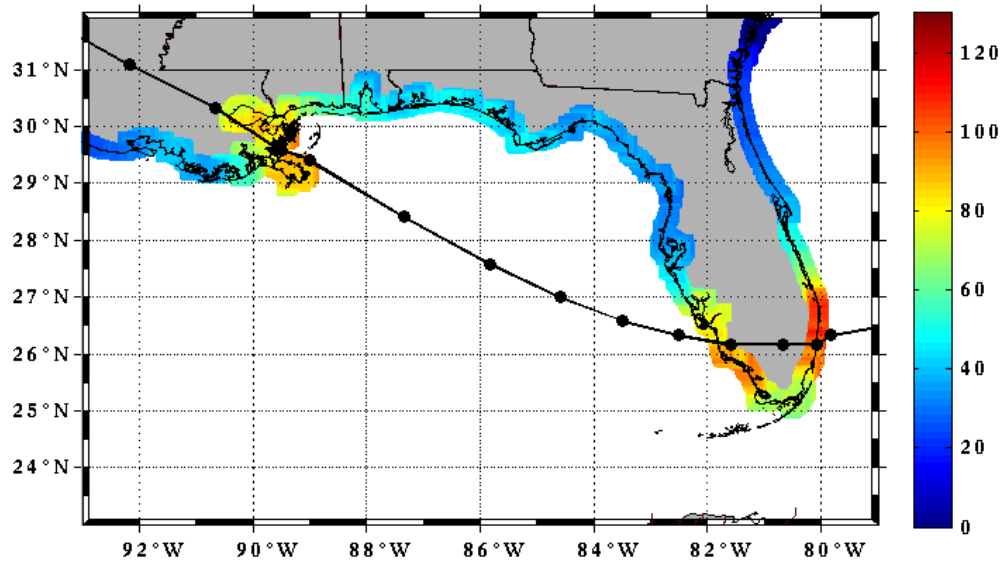
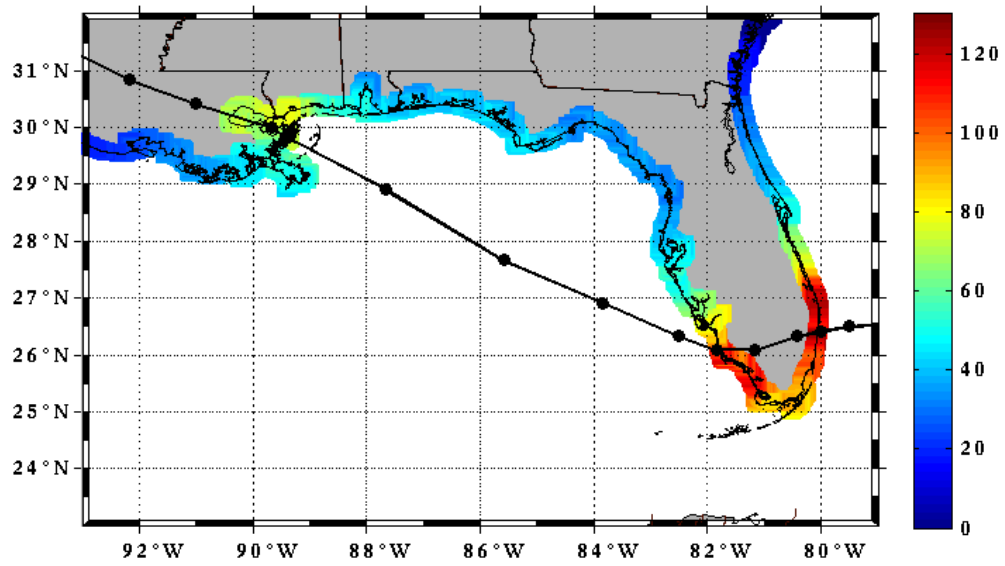
After passing through the northern Bahamas, the hurricane made landfall in southeast Florida just north of Ft. Lauderdale at 26.2N, 80.1W around 16 UTC on the 17th. Lowest pressures recorded were 956 mb in Ft. Lauderdale (which experienced a "1-hr lull") and 947 mb in Hillsboro Light (which experienced "no lull"). These somewhat contradictory datapoints make ascertaining the central pressure problematic. But if one accepts the 947 mb at Hillsboro Light as being outside of the eye, then a 940 mb central pressure at landfall as is currently in Jarrell et al. can be chosen. It is noted that both Ho et al. and the 12Z listing in HURDAT use the 947 mb value as a central pressure, though this does not appear to be the case. A 940 mb central pressure reading suggests winds of 119 kt from the southern pressure-wind relationship and 115 kt from the subtropical pressure-wind relationship. Given that the hurricane's inner core had enlarged to an RMW of 27 nmi (Ho et al.) which is significantly larger than 16 nmi from climatology for this pressure and latitude (Vickery et al.), 115 kt is chosen as the maximum sustained surface winds at landfall. Note that Hillsboro Light observed peak winds of 105 kt 5 min maximum and 135 kt 1 min maximum. The latter value is likely in error because of the noisiness of the instrument utilized in that era for shorter timescale measurements. A conversion of the 5 min wind to 1 min (Powell et al. 1996) gives 111 kt. A run of the Kaplan/DeMaria inland decay model suggests winds of 95 kt at 18Z on the 17th and 67 kt at 00Z on the 18th. Naples observed a peak 5 min wind of 87 kt (converts to 92 kt 1 min) 0005Z. Given the much higher observed winds compared to Kaplan/DeMaria, 105 kt is chosen for 18Z (down from 130 kt) and 95 kt is chosen for 00Z (down from 120 kt). The hurricane made oceanfall back into the Gulf of Mexico around 05Z on the 18th, near Naples. No reconnaissance aircraft was available in the Gulf of

Mexico.

The hurricane accelerated toward the northwest and made a second U.S. landfall around 14Z on the 19th at 29.6N 89.5W southeast of New Orleans. New Orleans observed 969 mb central pressure at 1547Z, which suggests about a 966 mb central pressure at landfall. This is in agreement with the assessment by Ho et al. and what was listed in HURDAT at 12Z. A 966 mb pressure suggests winds of 89 kt from the new Brown et al. (2006) pressure-wind relationship for tropical cyclones north of 25°N. Given the faster than normal forward speed (about 18 kt), maximum sustained winds at landfall are estimated to be 95 kt. Thus winds in HURDAT are boosted accordingly on the 18th and 19th. This makes the impact a Category 2 for Louisiana, which is lower than previously indicated in HURDAT. Based upon an application of the simplified wind model in Schwerdt et al., it is estimated that Mississippi also received Category 2 hurricane conditions, which is a reduction from Category 3 shown originally. After landfall, the maximum observed winds were 48 kt within 2 hr of 18Z, 39 kt near 00Z on the 20th, and 43 kt near 06Z. Application of the Kaplan/DeMaria inland decay model suggests winds of 66 kt, 49 kt, and 40 kt, respectively. Thus winds are reduced to 70 kt at 18Z (down from 75 kt), Reduced to 55 kt at 00Z (down from 60 kt), and bumped up (from 35 kt) to 45 kt at 06Z. While the system was originally analyzed in HURDAT to have become extratropical by 12Z on the 20th over northeastern Texas, observations indicate that a frontal boundary was well to the northwest of the system at that time. Extratropical transition is now indicated to have occurred around 12Z on the 21st.



Original and revised FL/LA 1947 hurricane track maps.



Original and revised 1947 FL/LA hurricane windswaths.

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CAROL - 1954

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36665 08/25/1954 M= 8 3 SNBR= 807 CAROL          XING=1 SSS=3
36670 08/25* 0 0 0 0* 0 0 0 0 0*240 749 30 0*251 755 40 0*
36670 08/25* 0 0 0 0*232 750 25 0*242 751 30 0*251 755 30 0*
          *** **
          *** **

36675 08/26*261 760 45 0*270 763 55 0*277 764 60 0*284 763 60 0*
36675 08/26*261 760 35 0*270 763 40 0*278 764 45 0*285 763 50 1002*
          ** **          *** **          ** ****

36680 08/27*289 762 70 0*293 763 75 0*296 765 80 0*298 766 85 0*
36680 08/27*290 762 55 0*293 763 60 0*296 765 65 995*298 766 80 984*
          *** **          **          ** *** **

36685 08/28*299 767 85 0*301 769 85 0*303 772 85 0*304 774 85 0*
36685 08/28*299 767 85 981*301 769 85 0*303 772 85 0*304 774 85 0*
          ***

36690 08/29*305 776 85 0*307 778 80 0*309 779 80 0*312 780 80 0*
36690 08/29*303 775 85 0*304 776 80 0*306 778 80 0*309 779 80 0*
          *** **          *** **          *** **

36695 08/30*315 781 80 0*319 780 85 0*325 776 85 0*331 770 85 0*
36695 08/30*312 779 80 0*316 777 85 0*321 774 90 0*330 770 95 0*
          *** **          *** **          *** **

36700 08/31*342 761 85 0*373 742 85 0*402 729 85 0E431 718 75 976*
36700 08/31*342 761 95 960*366 739 100 0*393 729 100 955E431 714 75 973*
          ** *** ** ** **          *** **          *** **

36705 09/01E462 711 60 987E489 712 50 992* 0 0 0 0* 0 0 0 0*
36705 09/01E462 711 50 987E489 712 40 992* 0 0 0 0* 0 0 0 0*
          **          **

36710 HR NY3 CT3 RI3 NC2
36710 HR NY3 CT2 RI3 MA2 NC1
          *** ** **

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Landfall:

8/31 0230Z Closest approach to NC (offshore Cape Hatteras)
95 kt/960 mb, RMW 23 nmi, NC1 impact

8/31/1430Z 40.9N 72.2W landfall in NY
100 kt/955 mb, RMW 22 nmi, NY3 impact

8/31/1515Z 41.3N 72.0W landfall in CT
100 kt/957 mb, RMW 22 nmi, CT2, RI3, MA2 impacts

Minor changes both to the track and the intensity shown in
Neumann et al. (1999). Evidence for these alterations comes from

the Historical Weather Map series, *Monthly Weather Review*, daily Surface Weather Observations from NCDC, U.S. Weather Bureau six hourly maps available via microfilm at NHC, aircraft observations available from the Storm Wallets at NHC, the COADS ship database, McGuire (1954), Rhodes (1954), Dunn and Miller (1960), Harris (1963), Schwerdt et al. (1979), Ho et al. (1987), Jarrell et al. (1992), Boose et al. (2001), and Jarvinen (2006).

August 25: HWM does not analyze a closed low on this day. HURDAT listed the storm as a 30 kt tropical depression at 24.0N, 74.9W. Available observations suggest that the 30 kt tropical depression was centered at 24.2N, 75.1W. Ship highlights: No gales or low pressures present on this day.

August 26: HWM analyzes a closed low of at most 1010 mb centered near 28.0N, 76.6W. HURDAT listed the storm as a 60 kt tropical storm at 27.7N, 76.4W. The MWR Tracks of Lows for August 1954 (Chart IX) places the center at 29.9N, 76.8 W with a central pressure of 1011 mb. Available observations suggest that the 45 kt tropical storm was centered at 27.8N, 76.4W. Ship highlights: No gales or low pressures present on this day. The intensity on this day, as recorded by aircraft reconnaissance at 2050 UTC was 1002 mb at 28.8N, 76.2W. At 1:30 AM (630 UTC) on the 26th, it was centered near latitude 27N, longitude 76W, or 300 miles east-northeast of Miami (Climatological Data National Summary August 1954).

August 27: HWM analyzes a closed low of at most 1005 mb centered near 29.9N, 76.4W. HURDAT listed the storm as an 85 kt category 2 hurricane centered at 29.6N, 76.5W. The MWR Tracks of Lows for August 1954 (Chart IX) places the center at 29.9N, 76.8W with a central pressure of 995 mb. Available observations suggest that the 65 kt category 1 hurricane was centered at 29.6N, 76.5W. Ship highlights: 35 kt NNE at 12 UTC at 30.1N, 76.9W (COA ship # 9332). Aircraft reconnaissance recorded center fixes at 1400 UTC at 29.8N, 76.4W with 995 mb, at 2013 UTC at 29.9N, 76.6W with 984 mb, and at 2130 UTC at 29.9N, 76.5W with 981 mb.

August 28: HWM analyzes a closed low of at most 995 mb centered near 30.6N, 77.0W. HURDAT listed the storm as an 85 kt category 2 hurricane centered at 30.3N, 77.2W. The MWR Track of Lows for August 1954 (Chart IX) places the center at 31.0N, 76.9W with a central pressure of 975 mb. Available observations suggest that the 85 kt category 1 hurricane was centered at 30.3N, 77.2W. Ship observations: 35 kt NE at 18 UTC at 32.2N, 791.W (COA ship # 7622).

August 29: HWM analyzes a closed low of at most 995 mb centered near 31.0N, 78.2W. HURDAT listed the storm as an 80 kt category 1 hurricane centered at 30.9N, 77.9W. The MWR Tracks of Lows for August 1954 (Chart IX) places the center at 31.1N, 77.5W with a central pressure of 995 mb.

Available observations suggest the 80 kt category 1 hurricane was centered at 30.6N, 77.8W. Ship observations: 1005 mb and 40 kt NE at 12 UTC at 32.0N, 78.5W (HWM); 1005 mb and 45 NE at 12 UTC at kt 31.8, 78.3W (COA 8152). At 1:30 AM (0630 UTC) of the 29th (the storm) had traveled less than 300 miles to a central location near latitude 30N, longitude 77W, some 200 miles off the extreme northeastern coast of Florida. On the 29th, still moving sluggishly, Carol changed direction to northwestward. This change, at first, posing a threat to the South Carolina shore, developed within twenty-four hours into a return to a northerly heading.

August 30: HWM analyzes a closed low of at most 985 mb centered near 32.0N, 77.1W. HURDAT listed the storm as an 85 kt category 2 hurricane centered at 32.5N, 77.6W. The MWR Tracks of Lows for August 1954 (Chart IX) places the center at 32.4N, 77.3W with a central pressure of 966 mb. Available observations suggest the 90 kt category 2 hurricane was centered at 32.1N, 77.4W. Ship observations: 65 kt NNW at 12 UTC at 32.2N, 72.0W; 986mb and 65 kt N at 18 UTC at 33.5n, 77.3W; 991 mb and 65 kt NNE at 0 UTC at 31.5N, 78.5W. Land observations: 991 mb and 61 kt E at 1130 UTC at 33.8N, 78.0W (SWO Frying Pan Lightship, NC); 983 mb and 70 kt W at 1730 UTC at 33.8N, 78.0W (SWO Frying Pan Lightship, NC); 990 mb at 2330 UTC at 35.2N, 75.0W (SWO Diamond Shoals Lightship, NC). At 5 AM (10 UTC), the hurricane was centered near latitude 32N, longitude 78W, or about 150 miles east-southeast of Charleston, SC; it was moving at about 5 mph toward the north. By noon (17 UTC), heading slightly east of north at the same slow speed, the center had reached latitude 33N, longitude 73W, or about 100 miles south-southeast of Wilmington, NC. Carol now grew into a large storm, was entered upon the second or mature stage of its career. An official bulletin issued at 1 PM (18 UTC) on the 30th stated that it was still moving very slowly north-northwestward but increasing in intensity. Winds near the center were reported to be over 100 mph, while winds of hurricane force extended over 100 miles to the east of the center and 50-60 miles to the west. Gales ranged further outwards, 200 miles to the east and about half that distance to the west. Elizabeth City, NC: lowest pressure reading was 29.25 inches at 2325E (0425 UTC). Norfolk Airport, VA: The tide reached a height of 5.6 feet above mean low water at midnight and began falling. The time of normal high tide would have been at 10:34 PM but due to strong NE winds the tide kept building until midnight. The tower reported observing gusts to 60 mph at 8:55 PM but the highest observed on the W.B. dial was 54 mph about 9:15 PM.

August 31: HWM analyzes a closed low of at most 975 mb centered near 40.0N, 72.5W. HURDAT listed the storm as an 85 kt category 2 hurricane centered at 40.2N, 72.9W. The MWR Tracks of Lows for August 1954 places the center of the storm at 40.2N, 72.8W with a central pressure of 960 mb. Available observations suggest the 100 kt category 3 hurricane was centered at 39.3N, 73.0W. Ship observations: 975mb at 9 UTC at 37.5N, 74.0W; 976 mb

and 65 kt NNE at 12 UTC at 38.4N, 74.2W (COA ship # 77811); 984 mb and 55 kt N at 12 UTC at 39.8N, 73.9W (COA ship # 1791). Land observations: 957 mb and calm at 15 UTC at 41.3N, 72.1W (Jarvinen Croton, CT); 960 mb at 40.8N, 72.6W at 14 UTC at 40.8N, 72.6W (SWO Suffolk County Air Force Base); 87 kt at 1505 UTC at 41.2N, 71.6W (SWO Block Island, RI). 78 kt ESE at 1530 UTC at 41.8N, 71.4W (SWO Providence, RI); 972 mb at 0223 UTC and 68 kt N at 35.3N, 75.6W (SWO Hatteras, NC). The intensity on this day, as recorded by aircraft reconnaissance at 1337 UTC was 964 mb at 40.2N, 72.6W. The western side of Carol lashed the shore from Wilmington northward to Cape Hatteras (NC). Damage amounted to an estimated \$227,500. Strong winds tore down power and telephone lines, and the Trent and Neuse Rivers, their levels raised by the high water accompanying the storm, flooded the waterfront section of New Bern (NC). A peak gust of 78 mph was observed at the Hatteras station of the Weather Bureau. Late on the 30th (31 in UTC time), the hurricane's center passed a few miles east of Cape Hatteras. At 11 PM (4 UTC on 31st) Carol was centered near latitude 36N, longitude 75W, or about 100 miles south-southeast of Norfolk, VA. Its size and the strength of its winds remained about the same, but a rapid and sharp increase occurred in the rate of forward motion as it passed north-northeastward along the Middle Atlantic coast during the early morning of the 31st. The forward speed accelerated to 40 mph, brought the center over extreme eastern Long Island by 9 AM (14 UTC). The effects of the hurricane's passage from the Virginia shore area to Long Island were comparatively slight. The track of the center was 75-100 miles east of the mainland, so that dangerous winds did not reach westward to the coast... The amount of damage in New Jersey was estimated at \$250,000. No monetary estimates of damage in Virginia, Maryland and Delaware were received but it is known to have been minor. The impact of the storm on Long Island and New England was far more serious. The center crossed the south shore of Long Island slightly east of West Hampton about 8:30 AM (1330 UTC). An hour later it passed into Long Island Sound off Cutchogue. By 10:30 AM (1530 UTC) it was over the southeast shore of Connecticut near the mouth of the Connecticut River. Curving slightly on a northward course, the center passed 5-10 miles west of Worcester, MA, about noon (17 UTC) and penetrated into south-central New Hampshire about 1:30 PM (1830 UTC). In mid-afternoon, Carol passed into the third and final stage of its history. The strength of its winds and its speed of forward progress diminished as the center traveled northward over the rugged terrain of New Hampshire. Norfolk Airport, VA: Hurricane Carol passed 110 miles east of Norfolk at 2 AM (7 UTC) at a heading of 35°. Portland, ME: Hurricane Carol caused one death in Portland, one at Port Clyde and at Columbia Falls. Many hundreds of trees fell. Eye of storm passed west of Portland, moving from Concord, NH to near Bethel, Maine. These were highest winds ever recorded in August. East Boston, MA: Hurricane Carol moved north-northeastward from the Cape Hatteras area, entering southern New England on the morning of the 31st and thence sweeping northward into the St. Lawrence Valley early on

Sept 1st. The course of the center of the storm extended across Rhode Island, eastern Massachusetts, and northward along the Maine-New Hampshire border; areas traversed suffered damage comparable to the Sept. 1938 Hurricane, but loss of life was much less. South Weymouth, MA: Lowest pressure observed as Hurricane Carol passed station was 28.677 inches at 1050 AM (1550 UTC), and maximum gust of 81 knots at 1028 AM (1528 UTC). Concord, NH: Winds extremely gusty, resulted in considerable local damage. Some trees and wires, as well as TV antennas blown down. Damage around Concord while important was not near so bad as in some other southern and central NH communities. The local rainfall was one of the heaviest on record. Driving on the roads was very hazardous due to the combined strong winds and reduced visibility from the extremely heavy rainfall.

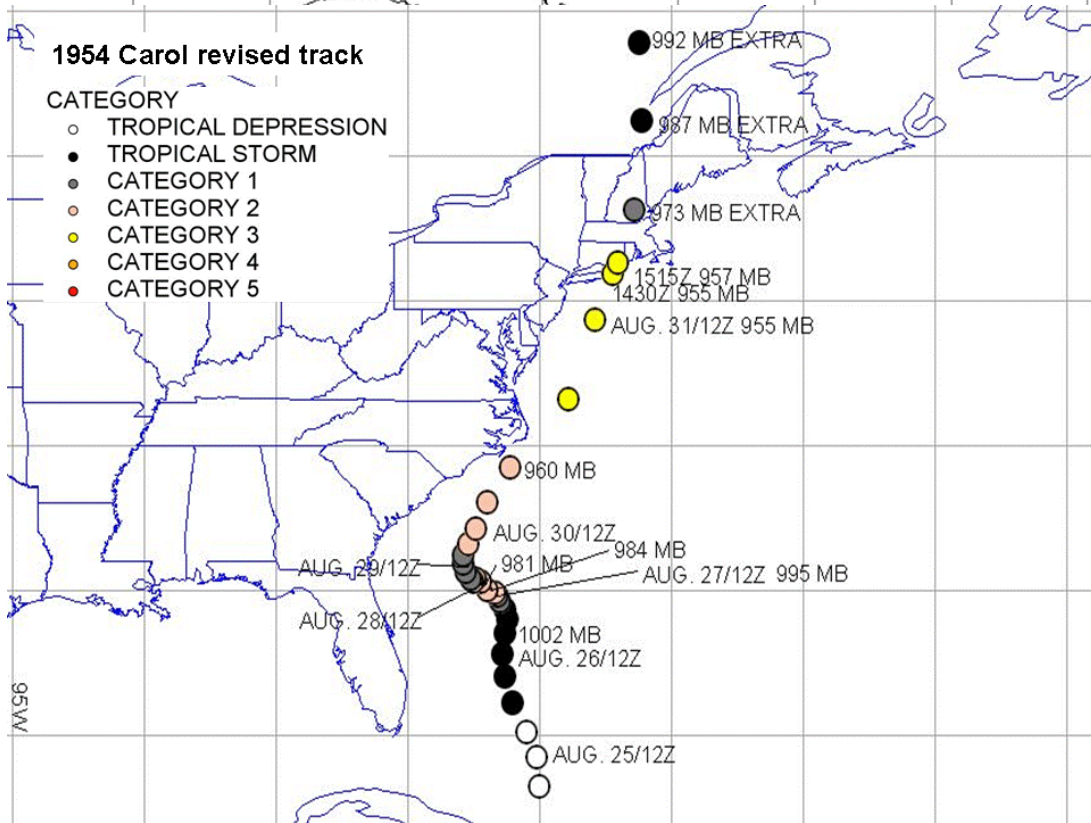
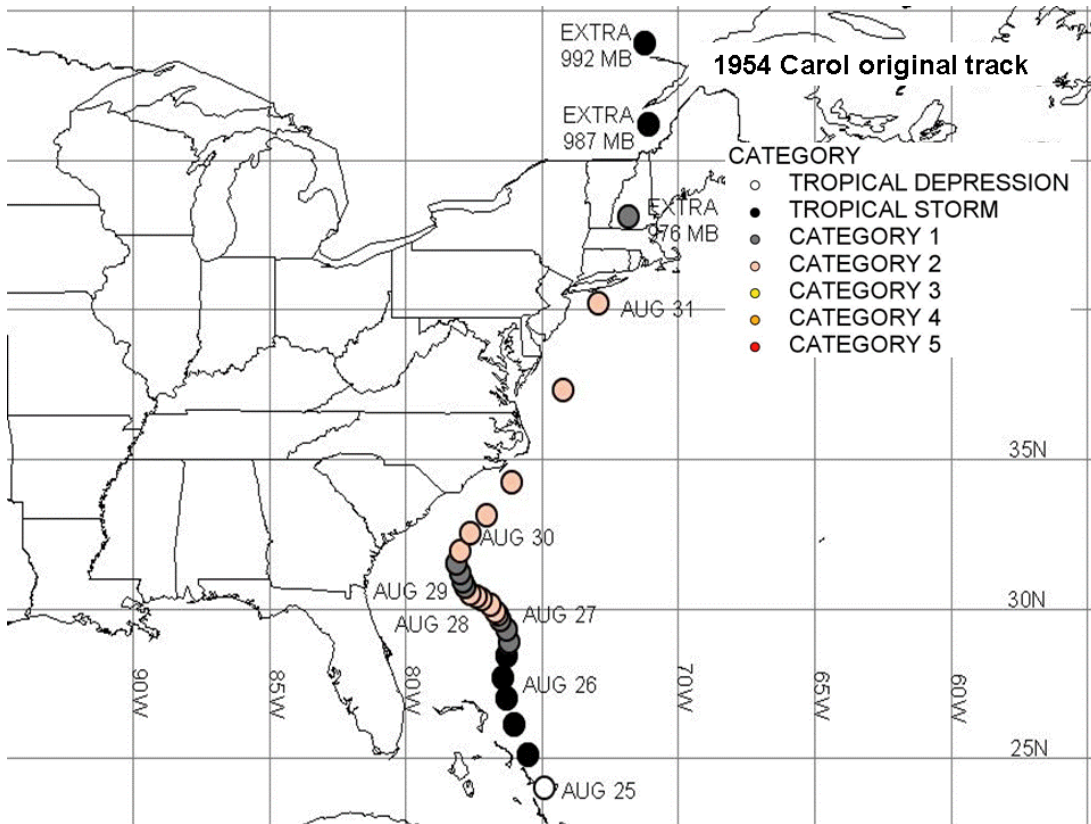
Genesis of Carol is begun six hours earlier than in HURDAT originally from observations of a closed low at 06 UTC on the 25th. Only small alterations were introduced into the track of Carol on all days except for the 28th and 1st when no changes were made. Aircraft reconnaissance center fix observations were available for Carol for much of its lifetime. However, as is typical for hurricanes of the 1950s, most of these were from radar fixes rather than an aircraft penetration of the cyclone. Thus while there are several dozen radar fixes, there only are six central pressure measurements. For the few actual penetrations, winds provided were visually estimated and not reliable (e.g., 125 kt winds for a central pressure of 984 mb). At 2050 UTC on the 26th, aircraft measured a central pressure of 1002 mb and a circular eye of 20 nmi diameter. 1002 mb pressure suggests winds of 45 kt from the subtropical pressure-wind relationship. Given the small size of the reported eye, winds are boosted to 50 kt in HURDAT, which is a reduction from the 60 kt originally at 18 UTC. Three reconnaissance central pressures were reported on the 27th: 995 mb with an 8 nmi eye at 1400 UTC, 984 mb with a 13 nmi eye at 2013 UTC, and 981 mb at 2130 UTC. The last observation suggests winds of 74 kt from the subtropical pressure-wind relationship. Given the small size, 85 kt at 0000 UTC on the 28th was retained in HURDAT. Carol likely became a hurricane around 12 UTC on the 27th, which is about 12 hours later than originally analyzed. No observations were available to determine the inner core intensity of Carol for all of the 28th and 29th and no changes were made to the HURDAT winds. Hurricane force winds and peripheral pressures as low as 983 mb were reported by ships, the Frying Pan Lightship, and Diamond Shoals Lightship on the 30th as Carol approached the Carolinas. An aircraft reconnaissance did measure a 960 mb central pressure late on the 30th southeast of North Carolina. This pressure suggests winds of 94 kt from the subtropical and 90 kt from the high latitude pressure-wind relationships, respectively. Ho et al. estimated a 23 nmi RMW, which is slightly smaller (27 nmi) than climatology for this latitude and central pressure. Thus 95 kt is chosen for HURDAT at 18 UTC on the 30th and 00 UTC on the 31st. This

is an increase from the 85 kt originally indicated in HURDAT. Carol made its closest approach to North Carolina between 02 and 03 UTC on the 31st, as a value of 972 mb was observed in Cape Hatteras with 38 kt NNE winds at 0230 UTC followed by a 978 mb and 58 kt WNW wind at 0326 UTC. (A lower pressure value may have occurred at Cape Hatteras between these observations.) Thus it appears that the center of the eye stayed just offshore of North Carolina, but it is estimated that Category 1 conditions impacted a portion of the extreme eastern North Carolina coast (which is a downgrade from the Category 2 impact originally recorded). Carol accelerated north-northeastward after making a close by-pass of North Carolina and made landfall in New England about 12 hours later. A final aircraft reconnaissance mission reported a central pressure of 964 mb at 1337 UTC on the 31st just south of Long Island, New York.

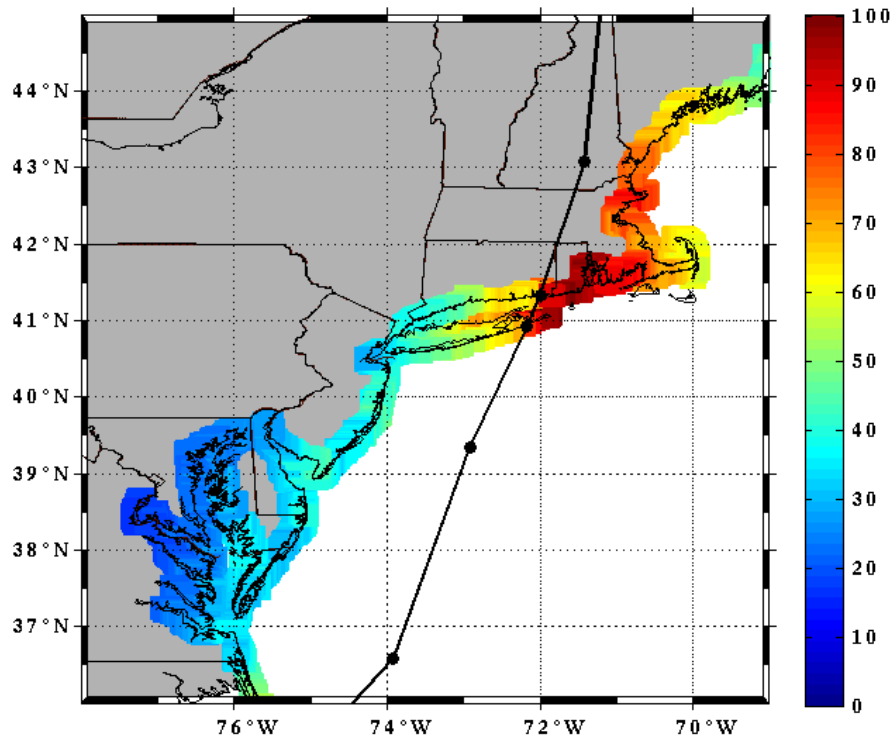
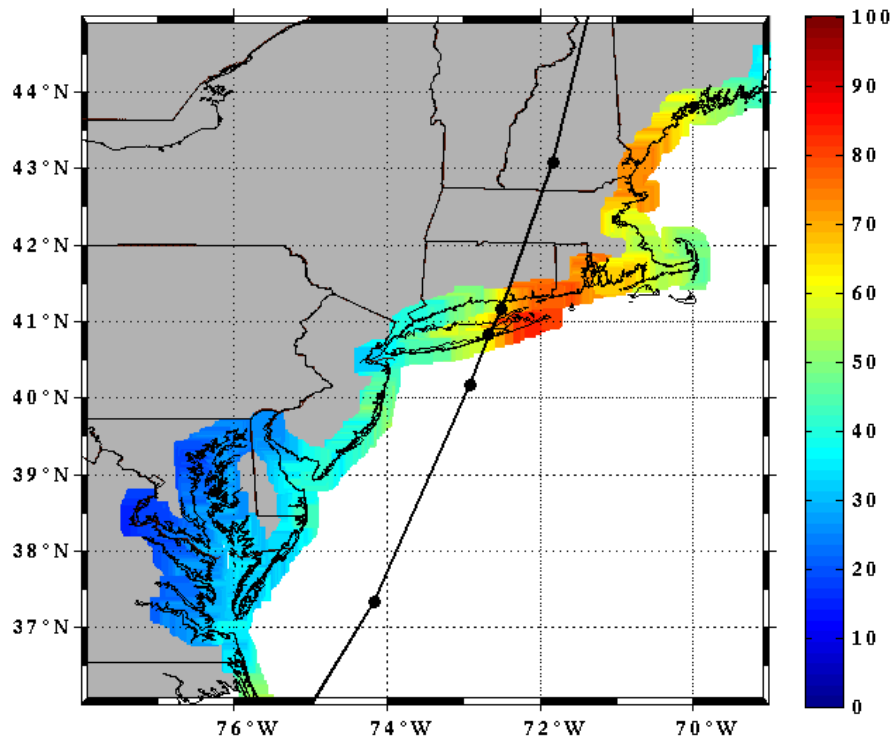
Carol made a first landfall in Long Island around 1430 UTC on the 31st and a second landfall in Connecticut around 1515 UTC on the 31st. Ho et al. estimated a central pressure at landfall in New York of 961 mb. Jarrell et al. indicated a minimum central pressure at landfall in the United States as 960 mb, though it is ambiguous as to whether this was for North Carolina or New York. Jarvinen analyzed Carol as making an initial landfall with 955 mb central pressure in New York and 957 mb central pressure in Connecticut, based upon an eye reading of 957 mb at Groton, Connecticut on the coast. This value is somewhat lower than the aircraft reconnaissance measurement, but given the uncertainties of the aircraft observational technologies at the time, their 964 mb value could have been biased high. Both Ho et al. and Jarvinen agree that Carol had about a 22 nmi RMW at landfall in New England. 955 mb and 957 mb give 93 kt and 92 kt from the northern pressure-wind relationship, respectively. Carol's RMW of 22 nmi is slightly smaller than climatology for this pressure and latitude (26 nmi - Vickery et al. 2000) and the hurricane was moving at about 40 kt at landfall. Both of these factors indicated a stronger wind at landfall than suggested by the pressure-wind relationship. Both at landfall in New York and in Connecticut the maximum sustained surface winds are estimated to be 100 kt. This is in agreement with Schwerdt et al., but is lower than the 113 kt and 110 kt values from the SLOSH runs at the New York and Connecticut coasts, respectively, provided by Jarvinen. (However, it is to be noted that the SLOSH runs do not take into account the cold water and stable conditions that occur around New England, which would reduce the SLOSH winds.) Based upon the landfall location and the RMW, the 100 kt maximum winds likely only occurred along easternmost New York and the Rhode Island coast, retaining New York and Rhode Island as Category 3 impacts. Both Connecticut and Massachusetts likely received a peak of Category 2 sustained winds, which is a downgrade from Category 3 originally for Connecticut but an upgrade (from no hurricane impact) for Massachusetts. Peak observed 1 minute winds were 87 kt at Block Island,

R.I., but as usual the RMW intersected the coast at an area lacking in wind observations.

After landfall, the highest observed winds within two hours of the synoptic times were: at 18 UTC - 78 kt (Block Island at 1600 UTC), at 00 UTC on the 1st - 44 kt (Pollock Rip Lightship at 2345 UTC). Application of the Kaplan and DeMaria (2001) New England inland wind decay model suggests winds of 65 kt at 18 UTC and 43 kt at 00 UTC. Winds in HURDAT are retained at 75 kt at 18 UTC and lowered from 60 down to 50 kt at 00 UTC. Carol's transition to an extratropical storm at 18 UTC on the 31st is unaltered.



Original and revised Hurricane Carol track maps.



Original and revised Hurricane Carol wind swath.

1954 - EDNA

36400 09/02/1954 M=14 5 SNBR= 804 EDNA XING=1 SSS=3
36400 09/05/1954 M=10 5 SNBR= 804 EDNA XING=1 SSS=3
** **

(The 2nd through the 4th are removed from HURDAT.)

36405 09/02* 0 0 0 0*112 564 25 0*121 571 25 0*131 575 25 0*
36410 09/03*142 580 25 0*153 586 25 0*164 592 25 0*171 598 25 0*
36415 09/04*178 606 25 0*186 616 30 0*193 628 35 0*199 641 35 0*

36420 09/05*204 653 35 0*207 662 35 0*209 669 35 0*210 676 35 0*
36420 09/05* 0 0 0 0*207 662 30 0*209 672 35 0*210 682 40 0*
*** ** ** **

36425 09/06*212 682 40 0*214 688 45 0*215 694 50 0*218 701 55 0*
36425 09/06*212 690 45 0*214 698 45 0*215 705 50 0*216 710 50 0*
*** ** ** **

36430 09/07*222 708 65 0*225 715 70 0*230 722 70 0*237 734 70 0*
36430 09/07*218 715 50 0*223 721 50 0*230 728 55 1001*237 734 65 992*
*** ** ** **

36435 09/08*245 744 75 0*252 748 95 0*259 752 100 0*266 756 105 0*
36435 09/08*242 744 70 0*248 748 75 0*255 752 85 979*264 754 95 968*
*** ** ** **

36440 09/09*273 759 105 0*280 761 105 0*287 761 105 0*293 761 105 0*
36440 09/09*270 755 95 0*276 760 95 0*281 765 100 0*286 764 105 0*
*** ** ** **

36445 09/10*298 761 105 0*306 761 105 0*317 761 105 0*330 758 105 0*
36445 09/10*296 762 105 0*304 761 105 0*315 759 105 0*327 756 105 0*
*** ** ** **

36450 09/11*345 753 105 0*360 744 100 0*380 730 90 0*412 708 80 0*
36450 09/11*340 750 110 943*360 738 110 0*383 725 110 0*413 707 105 948*
*** ** ** **

36455 09/12E449 679 65 0E489 638 60 0E524 605 55 0E543 591 50 0*
36455 09/12E447 675 70 0E487 640 60 0E524 605 60 0E545 580 60 0*
*** ** ** **

36460 09/13E555 577 45 0E569 561 40 0E580 545 40 0E584 524 35 0*
36460 09/13E563 565 60 0E579 555 60 0E590 545 60 0E595 530 60 0*
*** ** ** **

36465 09/14E582 504 35 0E578 489 30 0E574 474 30 0E571 459 25 0*
36465 09/14E594 510 60 0E590 489 50 0* 0 0 0 0* 0 0 0 0*
*** ** ** **

(The 15th is removed from HURDAT.)

36470 09/15E567 440 25 0E568 421 25 0* 0 0 0 0* 0 0 0 0*

36475 HR MA3 ME1
36475 HR NC1 MA3 NY1 RI1
*** ** ** **

Landfalls:

11th/03Z - 35.0N 74.5W (closest point of approach) - 943 mb/110 kt -
15 nmi RMW - 65 kt at NC coast
11th/18Z - 41.3N 70.7W - 948 mb/105 kt - 20 nmi RMW
11th/19Z - 41.6N 70.5W - 950 mb/100 kt - 20 nmi RMW
11th/2330Z - 44.6N 67.7W - Already extratropical - Winds at landfall 75 kt

Major changes to both the track and the intensity shown in Neumann et al. (1999). The system previously identified as Edna has been reanalyzed to instead be two separate tropical cyclones: a previously unrecognized tropical depression from September 1st to the 3rd and the main cyclone which instead formed on the 5th and became the hurricane that struck the United States. Evidence for these alterations comes from the Historical Weather Map series, *Monthly Weather Review*, daily Surface Weather Observations from NCDC, U.S. Weather Bureau six hourly maps available via microfilm at NHC, aircraft observations available from the Storm Wallets at NHC, the COADS ship database, Rhodes (1954), Dunn and Miller (1960), Schwerdt et al. (1979), Ho et al. (1987), Jarrell et al. (1992), and Boose et al. (2001).

September 1: HWM does not analyze a closed low in association with the system at 12 UTC on this day. Available observations indicate the formation of a 25 kt tropical depression (not pre-Edna) with a center located at 11.2N, 54.0W at 18 UTC on this day. HURDAT does not list a tropical depression in this area. Ship observations: no gales or low pressures reported on this day.

September 2: HWM does not analyze a closed low on this day. However, it does show a tropical wave along 51W from 15 to 25N. HURDAT listed a tropical depression with 25 kt winds with a center at 12.1N, 57.1W. Available observations suggest the tropical depression maintained its 25 kt wind speed as analyzed at on September 1 and is now located at 11.2N, 56.4W. Ship observations: no gales or low pressures reported on this day.

September 3: HWM analyzes a closed low associated with the new tropical depression with a pressure of at most 1010 mb and a center at 10.0N, 62.5W. HWM also shows a tropical wave along 57W from 17N to 27N. HURDAT listed a 25 kt tropical depression with a center at 16.4N, 59.2W. Available observations indicate a single 25 kt tropical depression (not pre-Edna) with a center at 11.2N, 62.5W. No closed circulation is in the vicinity of the supposed HURDAT pre-Edna depression location. Ship observations: no gales or low pressures reported on this day.

September 4: HWM analyzes a weak low near 13.5N, 68W. HWM also shows a tropical wave along 65W from 17N to 26W. HURDAT listed a 35 kt tropical storm (Edna) with a center at 19.3N, 62.8W. Available

observations suggest the system tracked in HURDAT is not a closed low, but is an open wave. It is also analyzed that the (new) tropical depression dissipated around 06-12 UTC on the 4th in the vicinity of 11N, 65W. Ship observations: no gales or low pressures reported on this day.

September 5: HWM analyzes a closed low of at most 1010 mb at 13.5N, 72W and a tropical wave along 68W from 15N to 26W including a show a tropical storm symbol with a center at 19.2N, 68.5W. HURDAT listed this as a 35 kt tropical storm with a center at 20.9N, 66.9W. Available observations do suggest development of a 35 kt tropical storm with a center at 20.9N, 67.2W at 12 UTC on this day. Ship observations: 45 kt at 2100 UTC at 22.5N, 67.7W (MWR). September 1954 MWR: "The first indication of an apparently closed circulation that subsequently became Edna was noted the night of September 5, in the extreme southwestern Atlantic between Puerto Rico and the Bahama Islands. Some forewarning of the possible formation of a tropical storm was given by a 2100 GMT, September 5 ship report from a position near 22.5N, 67.7W. This report from the Bulk Oil stated that she was encountering very heavy squalls, winds to 50 mph, with gusts to 70 mph, and rapidly falling barometer (MWR)"

September 6: HWM analyzes a closed low and a tropical storm of at most 1000 mb with a center at 21.8N, 69.5W. HURDAT listed this as a 50 kt tropical storm centered at 21.5N, 69.4W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 21.3N, 68.3W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 21.3N, 69.1W with a central pressure of 1006 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review also places the center of the circulation at 22.0N, 69.3W at 12 UTC on this day. Available observations suggest a 50 kt tropical storm is present on this day with a center at 21.5N, 70.5W at 12 UTC on this day. Ship observations: 45 kt S at 18 UTC at 22.0N, 69.3W (COA ship # 77942); a few other gales of 35 and 40 kt reported throughout the day; no low pressures reported on this day. "Hurricane Edna formed in an easterly wave on the afternoon of September 6 near 22N, 70W, and increased to hurricane intensity during the night (MWR)"

September 7: HWM analyzes a closed low of at most 1005 mb centered near 23.3N, 72.3W. HURDAT listed this as a 70 kt category 1 hurricane at 23.0N, 72.2W. The MWR Tracks of Centers of Cyclones places the center at 22.0N, 70.7W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 22.5N, 72.6W with a central pressure of 1002 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review places a center of circulation at 23.5N, 72.8W at 12 UTC on this day. Available observations suggest a 55 kt tropical storm is present on this day with a center located at 23.0N, 70.5W at 12 UTC on this

day. Aircraft Reconnaissance: 23.2N, 73.3W at 1443 UTC with 1001 mb central pressure and 85 kt estimated winds; 23.8N, 73.8W at 2000 UTC with 992 mb central pressure and 100 kt estimate winds; 23.8N, 73.8W at 2030 UTC with 990 mb central pressure and 100 kt estimated winds (NHC). Ship observations: 1002 mb and 65 kt NE at 18 UTC at 24.2N, 74.2W (COA ship # 00473); 45 kt ESE at 0 UTC at 22.9N, 68.9W (COA ship # 03981); 1004 mb at 12 UTC at 20.1N, 75.2W (HWM); a few other gales of 35 and 40 kt reported throughout the day. December 1954 MWR: "During the 7th and 8th it swept the outer Bahama Islands as it moved on a broad curving path northward. The center very close to San Salvador Island, Bahamas, late on the 7th where winds were up to hurricane force in gusts, but no appreciable wind damage resulted."

September 8: HWM analyzes a closed low of at most 1000 mb centered near 25.5N, 75.5W. HURDAT listed this as a 100 kt category 3 hurricane at 25.9N, 75.2W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 24.0N, 74.0W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 25.3N, 75.1W with a central pressure of 991 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review places a center of circulation at 25.7N, 75.3W at 12 UTC on this day. Available observations suggest an 85 kt category 2 hurricane centered at 23.3N, 75.2W at 12 UTC on this day. Aircraft Reconnaissance: Several radar fixes early on the 8th. 25.9N, 75.4W at 1413 UTC with 979 mb central pressure and 70 kt estimated wind; 26.4N, 75.4W at 1934 UTC with 968 mb central pressure and 75 kt estimated wind (NHC). Ship observations: 975 mb and 120 kt at 16 UTC at 26.5N 75.5W (Rhodes); 997 mb and 70 kt NE at 12 UTC at 26.2N, 76.0W; 992 mb and 65 kt at 18 UTC at 25.9N, 75.7W (COADS); a few other gales of 35 and 40 kt reported throughout the day.

September 9: HWM analyzes a closed low of at most 995 mb centered near 28.7N, 76.2W. HURDAT listed this as a 105 kt category 3 hurricane at 28.7N, 76.1W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 26.9N, 75.7W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 28.2N, 76.5W with a central pressure of 978 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review places a center of circulation at 28.8N, 76.9W at 12 UTC on this day. Available observations suggest a 100 kt Category 3 hurricane with a center at 28.5N, 76.8W at 12 UTC on this day. Ship observations: 50 kt N at 18 UTC at 28.3N, 79.8W (COA ship # 57111); a few gales of 35 kt reported throughout the day. Land observations: 999 mb at 2330 UTC at 36.1N, 76.6W (SWO Edenton, NC). December 1954 MWR: "During the 9th and 10th the storm moved northward very near the 76th meridian and gradually turned to the north-northeast closely paralleling Carols path 11 days earlier. It passed just east of Cape Hatteras early in the night of the 10th and winds of about 75 mph were felt on the North Carolina Capes from Cape Lookout to Manteo."

September 10: HWM analyzes a closed low of at most 990 mb centered near 31.1N, 75.8W. HURDAT listed this as a 105 kt category 3 hurricane at 31.7N, 76.1W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 29.5N, 76.1W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 31.2N, 75.9W with a central pressure of 980 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review places a center of circulation at 31.3N, 76.0W at 12 UTC on this day. Available observations suggest a 105 kt Category 3 hurricane with a center at 31.5N, 75.9W at 12 UTC on this day. Ship observations: 60 kt SSE at 6 UTC at 28.2N, 72.7W (COA ship # 63001); 992 mb and 65 kt SE at 18 UTC at 33.0N, 73.5W (COA ship # 62061); a few other gales of 35 and 40 kt reported throughout the day. Land observations: 991 mb at 2224 UTC at 35.3N, 75.6W (SWO Hatteras, NC); 987 mb at 2230 UTC at 34.3N, 77.9W (SWO - Wilmington, NC). September 1954 Climatological Data National Summary (coastal North Carolina area): Storm center offshore; damage minor, but widespread. TV aerials, roofs, and piers damaged along most of coastline. Section of Outer Banks Highway washed out. Corn crop damaged 2 or 3 percent over large area.

September 11: HWM analyzes a closed low of at most 970 mb centered near 38.5N, 72.5W. HURDAT listed this as a 90 kt category 2 hurricane at 38.0N, 73.0W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 34.0N, 75.0W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 38.1N, 72.1W with a central pressure of 978 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review places a center of circulation at 38.5N, 72.3W at 12 UTC on this day. Available observations suggest a 110 kt Category 3 hurricane with a center at 38.3N, 72.5W at 12 UTC on this day. Aircraft reconnaissance: 943 mb at 34.0N, 75.6W around 00 UTC; 947 mb at 39.7N, 71.3W around 15 UTC (Ho). Ship observations: 80 kt NW at 0 UTC at 30.4N, 76.5W (COA ship # 08342); 90 kt NNW at 6 UTC at 36.5N, 75.3W (COA ship # 1775); 982 mb and 70 kt S at 0 UTC at 32.3N, 74.5W (COA ship # 62061); 979 mb and 52 kt SE at 12 UTC at 38.5N, 71.1W (HWM). Land observations: 65 kt at Manteo, NC (Rhodes); 65 kt at Cape Lookout, NC (Rhodes); 983 mb at 0324 UTC and 49 kt NW at 0335 UTC at 35.3N, 75.6W (SWO Hatteras, NC); 83 kt at Brookhaven National Laboratory, Long Island, NY (MWR); 76 kt at 1930 UTC and 969 mb at 18 UTC at Block Island, RI (SWO); 954 mb and 52 kt SSE at 1826 UTC at 41.3N, 70.1W (SWO Nantucket). December 1954 MWR: "It moved rapidly northeastward and passed over Cape Cod on the 11th." September 1954 Climatological Data National Summary (New Jersey shore and adjacent areas): "Some damage extending from Cape May County in South to Raritan Bay in north. Losses mostly minor, but totaling considerable sum. Estimate of damage includes estimated amount of damage by flooding of \$15,000 in Newark and Elizabeth suburbs from heavy rains. Gale winds and heavy rains (some were 5 inches) a hurricane moved northeasterly, approximately 125 miles

off New Jersey shore. Deaths due to traffic accidents, in which storm believed to have been contributing factor." September 1954 Climatological Data National Summary (New England southeaster and coastal sections): "Hurricane struck New England a glancing blow. Its center crossed Martha's Vineyard and Cape Cod shortly after 1 p.m. From then until it passed south and east of Eastport, Me., its course was northeastward, offshore and fairly parallel to New England east coast. Thus nearly all of New England (except Cape Cod and Islands to south). Being on west or north side of center was spared worst of storm with respect to wind force; highest speeds there came with Edna's" backlash, in gusts up to 93 m.p.h. In southern Rhode Island and up to 92 m.p.h. over central Maine coast. Gust speeds above 100 m.p.h. recorded at Martha's Vineyard and over outer Cape Cod. Attendant rainfall was of near-record intensity, measuring 4 to 8 Inches over coastal areas and southeast. Widespread floods and washouts produced by these excessive rains caused more damage then that produced by winds. Radar reports in afternoon of 11th indicated that hurricane had 2 'eyes' about 60 miles apart." September 1954 Climatological Data National Summary (Long Island, New York): "Hurricane winds which attained velocity of 95 m.p.h at Brookhaven National Laboratory swept Long Island where trees were blown down, numerous buildings. Many Small craft sunk, particularly on North Shore Highways and railroads washed out in places by high seas while benches seriously eroded. In Suffolk County, heavy rain washed potato tubers from soil so they were damaged by exposure to sun while other vegetable crops sustained substantial injuries."

September 12: HWM analyzes a closed extratropical low of at most 980 mb centered near 52.0N, 59.9W. HURDAT listed this as a 55 kt extratropical storm at 52.4N, 60.5W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 44.5N, 68.9W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 52.5N, 60.1W with a central pressure of 978 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review places a center of circulation at 52.5N, 60.8W at 12 UTC on this day. Available observations suggest a 60 kt extratropical storm with a center at 52.4N, 60.5W at 12 UTC on this day. Land observations: 987 mb at 0 UTC at 45.5N, 69.6W (SWO Greenville, ME); 975 mb and 50 kt NNW at 0028 UTC at 44.8N, 66.8W (SWO Dow AFB, ME); 976 mb at 0228 UTC at 46.1N, 67.8W (SWO Houlton, ME). Ship observations: 992 mb at 21 UTC at 56.5N, 51.0W (COA ship # 07024); 997 mb and 45 kt at 0 UTC at 40.8N, 68.8W (COA ship # 309 7740).

September 13: HWM analyzes a closed extratropical low of at most 985 mb centered near 59.5N, 53.5W. HURDAT listed this as a 40 kt extratropical storm at 58.0N, 54.5W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 56.2N, 57.0W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 58.1N, 52.8W with a central pressure of 980 mb at 12 UTC on this day. Figure 1 from the September 1954 issue of the Monthly Weather Review places a center of

circulation at 59.1N, 54.1W at 12 UTC on this day. Available observations suggest a 60 kt extratropical storm with a center at 59.0N, 54.5W at 12 UTC on this day. Ship observations: 988 mb at 0 UTC at 56.5N, 51.0W; 990 mb at 12 UTC at 62.0N, 49.0W (COA ship # 07024); 995 mb and 60 kt at 21 UTC at 56.5N, 51.0W (COA ship # 07024).

September 14: HWM analyzes a closed extratropical low of at most 995 mb centered near 57.3N, 47.9W. HURDAT listed this as a 30 kt extratropical storm at 57.4N, 47.4W. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 59.2N, 50.1W at 0 UTC on this day. The MWR Tracks of Centers of Cyclones (Chart X) places the center at 56.8N, 46.5W with a central pressure of 989 mb at 12 UTC on this day. Available observations suggest a 50 kt extratropical storm with a center at 59.0N, 58.9W at 06 UTC on this day. Available observations also suggest that the extratropical storm is no longer closed at 12 UTC on this day. Ship observations: 993 mb and 60 kt WSW at 3 UTC at 57.5N, 51.5W (COA ship # 07024); 995 mb and 50 kt WSW at 0 UTC at 57.5N, 51.5W (COA ship # 07024).

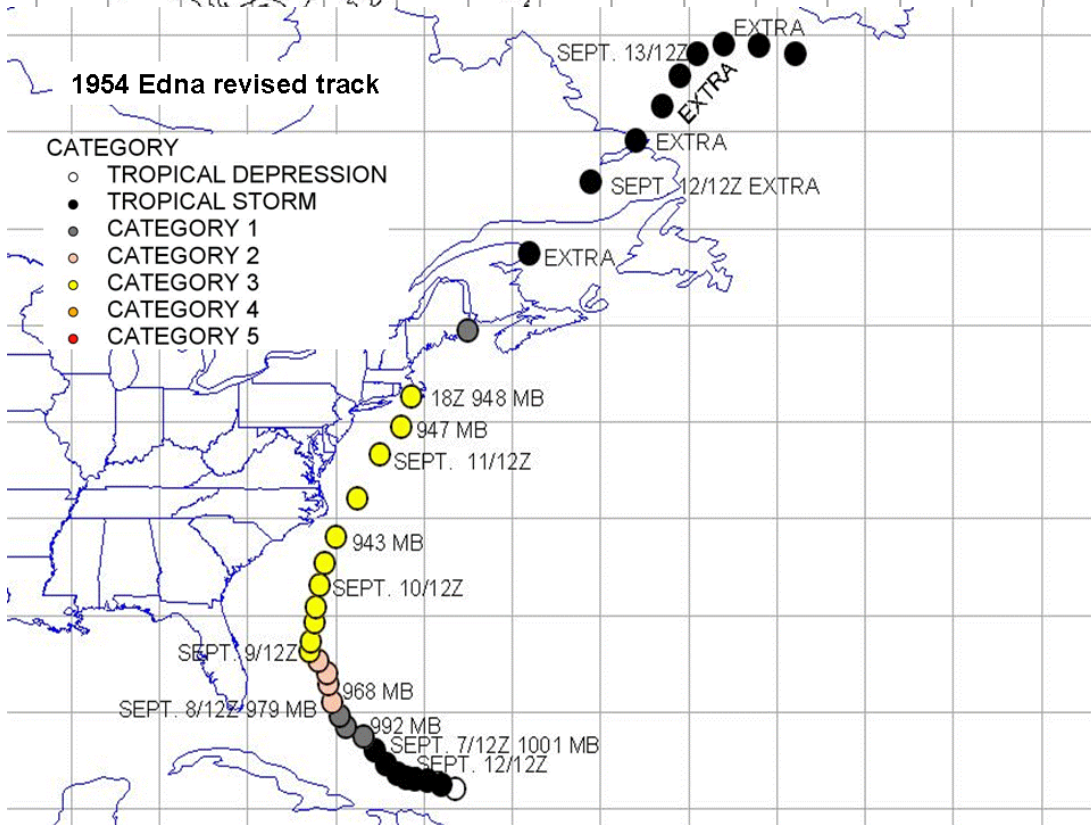
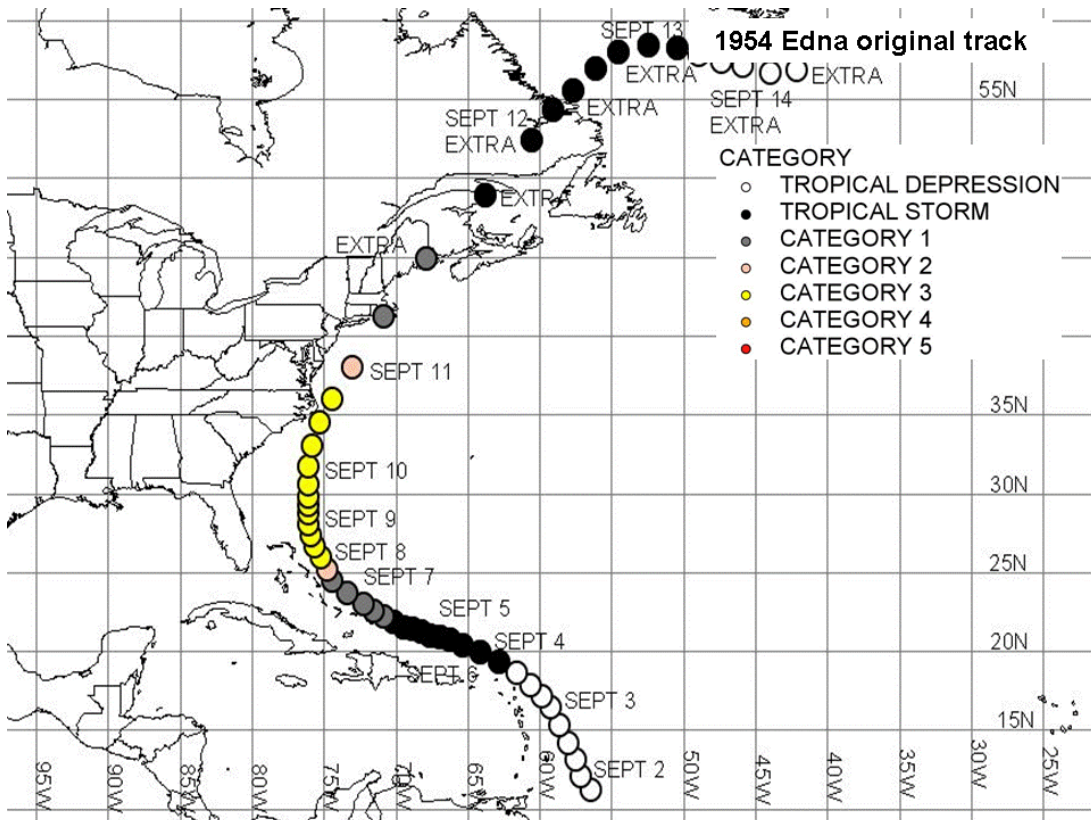
September 15: The MWR Tracks of Centers of Cyclones (Chart X) places the center at 56.7N, 43.2W at 12 UTC on this day. Available observations do not suggest the presence of a closed low in this vicinity on this day. Ship observations: 988 mb at 0 UTC at 62.0N, 33.1W (COA ship # 014); 983 mb at 0 UTC at 55.0N, 30.0W (COA ship # 307 7858); 985 mb at 6 UTC at 59.5N, 33.9W (COA ship # 309 7858).

Observations clearly indicate that the system currently in HURDAT for Edna was instead two separate tropical cyclones. The first system formed around 18 UTC on the 1st, moved westward, passed close to the coasts of Trinidad and Venezuela on the 3rd, and dissipated around 06-12 UTC on the 4th. The system that became Edna is first seen as a tropical wave along 51W on the 2nd. It continued moving westward with little change until the 5th. By late on the 5th, the system became a tropical storm. This major change from HURDAT is supported by rather abundant surface observations, the Historical Weather Map analysis, and the Monthly Weather Review's summary. The remaining track changes for this hurricane are minor. The intensity is slightly increased late on the 5th and early on the 6th to account for observations from the Bulk Oil ship. The first aircraft reconnaissance to investigate the cyclone found 1001 mb central pressure, 28 nmi eye, and 85 kt winds at 1433 UTC on the 7th. However, because of the crude instrumentation of the era for the Navy reconnaissance aircraft, these winds are likely not reliable. At 20 UTC on the 7th the pressure dropped to 992 mb and further down to 990 mb at 2030 UTC. These pressures suggest winds of 45, 61 and 64 kt, respectively, from the southern pressure-wind relationship. Additionally, a ship reported 65 kt winds at 18 UTC on the 7th. Thus winds in HURDAT reduced down from 70 kt to 55 kt at 12 UTC, 70 kt to 65 kt at

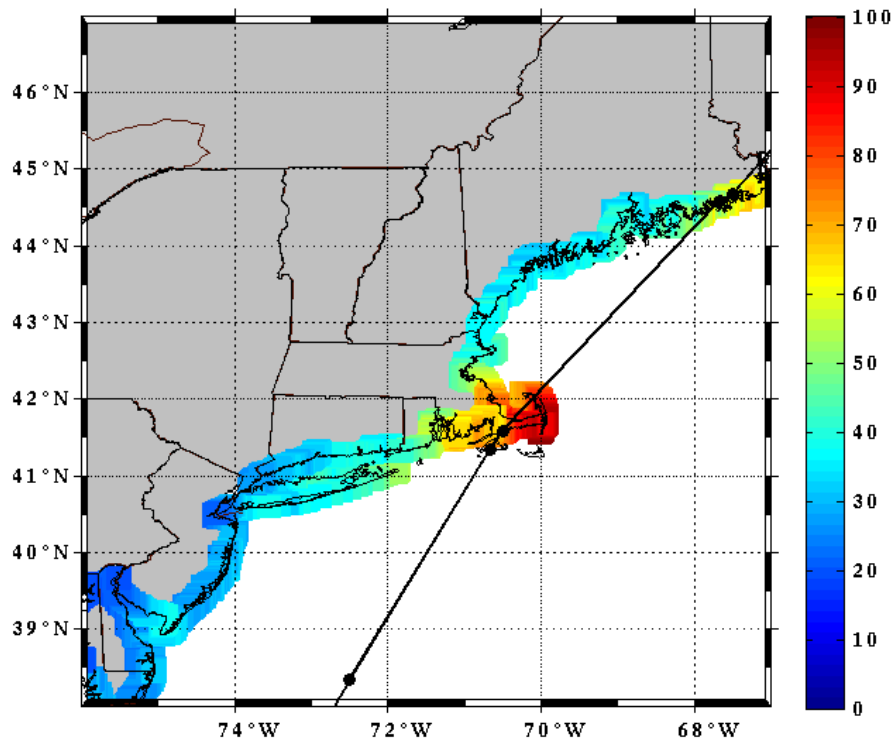
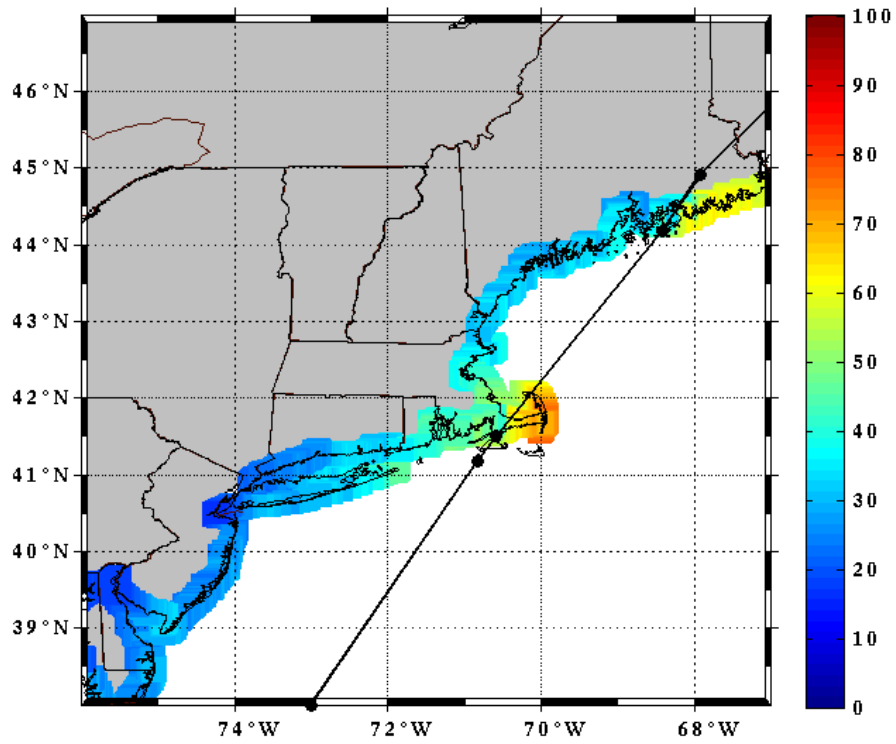
18 UTC, and 75 kt to 70 kt at 00 UTC on the 8th. The next aircraft reconnaissance to provide a central pressure was 979 mb at 1413 UTC on the 8th with a 15 nmi eye. This suggests winds of 79 kt from the southern and 76 kt from the subtropical pressure-wind relationships. 85 kt chosen for HURDAT at 12 UTC (down from 100 kt originally) because of the small eye size. At 1934 UTC on the 8th aircraft reconnaissance measured 968 mb central pressure with a circular 12 nmi eye. 968 mb suggests winds of 87 kt from the subtropical pressure-wind relationship. 95 kt (down from 105 kt originally) chosen for HURDAT at 18 UTC because of the small eye size. These two aircraft-measured central pressures were corroborated by a ship that measured 975 mb at 16 UTC, in between the 979 and 968 mb values. As was typical of the 1950s, there were only two additional hurricane penetrations from aircraft reconnaissance even though it remained off of the U.S. Atlantic coast for three more days. No ship or coastal stations reported hurricane force winds (or equivalent in pressure) from late on the 8th to late on the 10th. Thus it is relatively unknown how intense Edna was on these dates. Aircraft reconnaissance did measure 943 mb central pressure and a 15 nmi eye around 00 UTC on the 11th. This pressure suggests winds of 108 kt from the subtropical and 101 kt from the high latitude pressure-wind relationships. 110 kt chosen at 00 UTC on the 11th (up slightly from 105 kt) because of the small eye size. Winds on the 9th and 10th are interpolated between the 1934 UTC September 8th and 00 UTC September 11th reconnaissance-based estimates, which made for slight reductions on the 9th and no changes on the 10th. Two locations in North Carolina - Mateo and Cape Lookout - observed minimal sustained hurricane force winds. Thus Edna is revised to be considered Category 1 impact in North Carolina, as it bypassed the coast by about 60-75 nmi. After passing North Carolina, the hurricane accelerated while moving north-northeast. A final reconnaissance penetration occurred around 15 UTC on the 11th and gave a 947 mb central pressure.

The hurricane made landfall first on Martha's Vineyard, MA around 18 UTC on the 11th and a second landfall around 19 UTC just west of Hyannis, MA. Lowest observed sea level pressure from a land station was 954 mb at Nantucket at 1826 UTC while the wind was blowing 52 kt SSE. Thus it is estimated that the first landfall was with a central pressure of 948 mb (just slightly higher than measured by reconn three hours earlier) and 950 mb at the second landfall. These pressures suggest winds of 98 and 97 kt from the northern pressure-wind relationship. Given the small RMW of 20 nmi and translational velocity of about 35 kt at landfall, maximum sustained surface winds are estimated at 105 and 100 kt at the first and second landfall. Massachusetts is retained as Category 3 impact and New York and Rhode Island are added as Category 1 impact based upon observed hurricane force sustained winds in both states. After landfall in Massachusetts, Edna moved back over the Atlantic Ocean

for about 5 hours before making a final landfall in Maine at 2330 UTC on the 11th. Based upon available observations, Edna had transformed into a strong extratropical cyclone by 00 UTC on the 12th (as well as at landfall a half an hour earlier). Thus Maine is removed as having a Category 1 hurricane impact, though maximum sustained winds at Maine landfall were about 75 kt. Winds during the 12th to the 14th were increased in its extratropical phase from observed ship observations. Edna's final position is now given as 06 UTC on the 14th, as observations and HWM analyses suggest that it had dissipated by 12 UTC on the 14th. Thus positions through 06 UTC on the 15th are removed.



Original and revised Hurricane Edna track maps.



Original and revised Hurricane Edna wind swath.

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HAZEL - 1954

36605 10/05/1954 M=14 9 SNBR= 808 HAZEL XING=1 SSS=4
36610 10/05* 0 0 0 0*124 592 60 0*127 602 60 0*128 611 70 0*
36610 10/05* 0 0 0 0*120 585 40 0*120 595 50 0*121 605 60 1002*
*** **

36615 10/06*129 621 75 0*131 631 80 0*132 641 85 0*133 651 85 0*
36615 10/06*122 616 70 0*123 629 70 0*125 643 70 998*126 656 70 998*
*** **

36620 10/07*133 661 90 0*133 672 100 0*133 682 105 0*133 691 105 0*
36620 10/07*127 667 70 0*129 677 70 0*132 687 70 997*135 697 70 994*
*** **

36625 10/08*134 699 105 0*135 709 110 0*136 719 110 0*136 725 110 0*
36625 10/08*136 706 75 0*136 713 75 0*136 718 80 986*137 720 80 0*
*** **

36630 10/09*136 731 115 0*136 737 115 0*137 742 115 0*139 748 115 0*
36630 10/09*138 724 85 0*139 732 85 0*140 740 85 0*142 747 90 0*
*** **

36635 10/10*142 753 115 0*146 756 110 0*150 756 105 0*154 756 105 0*
36635 10/10*144 752 95 0*147 755 100 0*150 756 105 0*153 756 105 0*
*** **

36640 10/11*157 755 105 0*161 753 105 0*165 751 105 0*171 748 105 0*
36640 10/11*156 755 105 0*159 753 105 0*164 751 105 0*169 749 105 0*
*** **

36645 10/12*177 744 105 0*182 741 85 0*187 738 85 0*193 735 85 0*
36645 10/12*174 747 105 0*180 743 95 0*186 740 85 0*191 737 85 0*
*** **

36650 10/13*199 733 85 0*205 732 85 0*210 732 85 994*216 733 85 0*
36650 10/13*196 734 85 0*201 731 85 0*208 731 85 0*217 733 85 972*
*** **

36655 10/14*226 735 90 0*240 739 100 0*255 746 105 0*270 757 110 0*
36655 10/14*227 735 85 974*238 738 90 0*252 746 100 0*270 757 110 0*
*** **

36660 10/15*286 768 115 0*302 778 120 0*328 787 110 937E368 782 80 970*
36660 10/15*288 768 115 0*307 780 115 0*327 787 115 938E360 783 80 970*
*** **

36665 10/16E410 774 70 0E452 786 60 0E488 800 50 0E507 800 45 0*
36665 10/16E410 774 70 0E460 793 60 0E488 800 50 982E515 795 45 988*
*** **

36670 10/17E517 799 45 0E528 792 35 0E540 782 35 0E556 762 35 0*
36670 10/17E532 795 45 0E545 795 35 0E555 795 35 0E563 788 35 0*
*** **

36675 10/18E570 730 30 0E581 694 25 0E588 651 25 0* 0 0 0 0*
36675 10/18E570 770 30 0E581 750 25 0* 0 0 0 0* 0 0 0 0*
*** **

36680 HR SC4 NC4 MD2
36680 HR SC3 NC4

*** ***

Landfall:

10/15 1530Z 33.9N 78.5W, 25 nmi RMW, 938 mb central pressure, 26 kt speed, 115 kt maximum sustained surface winds

Minor changes to the track, but major adjustments to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from the Historical Weather Map series, *Monthly Weather Review*, daily Surface Weather Observations from NCDC, U.S. Weather Bureau six hourly maps available via microfilm at NHC, aircraft observations available from the Storm Wallets at NHC, the COADS ship database, Rhodes (1954), Dunn and Miller (1960), Schwerdt et al. (1979), Ho et al. (1987), Jarrell et al. (1992), and Perez et al. (2000).

October 5: HWM indicates a closed low of at most 1010mb near 13N, 61W. HURDAT lists this as a Tropical Storm with 60kt winds at 12.7N, 60.2W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: 85kt with pressure of 1002mb at 12.1N, 61.0W at 2037 UTC (Navy). "This hurricane developed in an easterly wave at latitude 12N, longitude 61.2W, on October 5 at which time highest winds were estimated about 100 mph. The hurricane passed near or slightly north of the island of Grenada in the Windward Islands and into the Caribbean Sea during the evening of the 5th" (MWR). "The center of the storm passed between the islands of Grenada and Carriacou during the evening of the 5th. All of the Grenadine Islands except Carriacou escaped with only minor damage and no loss of life. Total losses on this island were estimated at \$35,000 to property, \$5,000 to crops and \$2,500 to livestock" (Rhodes).

October 6: HWM indicates a storm with a pressure of most 1010mb near 13.5N, 64W. HURDAT lists this as a Category 2 hurricane with 85kt winds at 13.2N, 64.1W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: 35kt NW with pressure of 1002mb at 12.9N, 62.8W at 0625 UTC (USWB). Aircraft highlight: 90kt with pressure of 998mb at 12.5N, 64.3W at 1200 UTC (NAVY).

October 7: HWM indicates a storm with a pressure of at most 1005mb near 13N, 64W. HURDAT lists this as a Category 3 hurricane with 105kt winds at 13.3N, 68.2W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: 35kt ENE with pressure of 1010mb at 15.4N, 68.1W at 1800 UTC (COA). Aircraft highlight: 110kt with pressure of 997mb at 12.9N, 68.7W at 1153 UTC (NAVY). "Highest winds were 115mph on the 7th ... as estimated by reconnaissance aircraft" (MWR).

October 8: HWM indicates a storm with a pressure of at most 1000mb near 13.8N, 72W. HURDAT lists this as a Category 3 hurricane with 110kt winds at

13.6N, 70.9W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: 100kt with pressure of 986mb at 13.5N, 71.9W at 1200 UTC (NAVY). Highest winds estimated by reconnaissance aircraft were "125mph on the 8th" (MWR). Also on the 8th, "the Navy reconnaissance plane encountered severe turbulence and one member of the crew was severely injured, requiring hospitalization, and another sustained minor injuries" (MWR).

October 9: HWM indicates a storm with a pressure of at most 995mb near 14N, 73.9W. HURDAT lists this as a Category 4 hurricane with 115kt winds at 13.6N, 73.7W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: 10kt E with pressure of 999mb at 12.8N, 70.2W at 1200 UTC (COA). Aircraft highlight: No gales or low pressures. The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 14N, 74W with 990mb (12 UTC). "[Hazel] continued on a west to west-northwest course until the night of the 9th-10th when it slowed down in forward speed and curved northward" (MWR).

October 10: HWM indicates a storm with a pressure of at most 990mb near 15.3N, 76W. HURDAT lists this as a Category 3 hurricane with 105kt winds at 15.0N, 75.6W at 12 UTC. Station highlight: No gales or low pressures. Ship highlights: 55kt E with pressure of 1000mb at 15.4N, 75.5W at 1800 UTC (COA); 35kt SW with pressure of 992mb at 14.6N, 75.3W at 1800 UTC (COA). Aircraft highlight: 100kt at 15.2N, 75.6W at 1441 UTC (NAVY). The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 14N, 15W (0 UTC) and at 14.8N, 75.5W with 990mb (12 UTC). "The hurricane moved on a north-northeast course from the night of the 10th-11th until it passed through the Windward Channel and into the southeast Bahamas on the morning of the 13th" (MWR).

October 11: HWM indicates a storm with a pressure of at most 990mb near 16.5N, 75W. HURDAT lists this as a Category 3 hurricane with 105kt winds at 16.5N, 75.1W at 12 UTC. Station highlight: 44kt NNW with pressure of 1001mb at Morant Point (17.9N, 76.2W) at 1800 UTC (USWB). Ship highlights: 52kt NNE with pressure of 1001mb at 16.3N, 75.9W at 0700 UTC (USWB); 30kt ESE with pressure of 995mb at 15.8N, 74.6W at 0000 UTC (COA). Aircraft highlight: 35kt ENE at 18.2N, 75.6W at 1330 UTC (USWB). The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 15.5N, 75.5W (0 UTC) and at 16.3N, 75.2W with 988mb (12 UTC).

October 12: HWM indicates a storm with a pressure of at most 990mb near 19N, 74W. HURDAT lists this as a Category 2 hurricane with 85kt winds at 18.7N, 73.8W at 12 UTC. Station highlight: 30kt NE with pressure of 998 at Baracoa at 2130 UTC (USWB). Ship highlights: 50kt S with pressure of 1005mb at 16.4N, 72.4W at 0000 UTC (COA); 12kt ESE with pressure of 999mb at 19.3N, 73.8W at 0230 UTC (USWB). Aircraft highlight: 61kt E at 20.0N, 74.0W at 1815 UTC (USWB). The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 17.4N, 74.9W (0 UTC) and at 18.9N, 74.2W with 988mb

(12 UTC). "Considerable damage and loss of life resulted in Haiti, especially on the SW peninsula. This area is very mountainous, with peaks of 8,000 ft in the western portion. High winds and seas and torrential rains resulting in floods and landslides accounted for the loss of life, estimated between 400 and 1,000 including 200 or more buried in landslides" (MWR). "The center passed over the western tip of the south peninsula of Haiti during the early morning of October 12, and crossed the northwest peninsula that evening. The western portions of both Haitian peninsula were devastated by the hurricane. Several towns were almost totally demolished, including Dame Marie, Anse d' Hainault, Mole St. Nicolas, and Jean Rabel. The larger cities of Jeremie, Les Cayes, and Port de Paix suffered severe damage from hurricane winds. High tides on the souther coast from Les Cayes westward added to the destruction. Torrential rains fell over most of Haiti, flooding rivers, washing out roads, and destroying property, livestock, and crops. A landslide caused by heavy rains a few days after the hurricane buried the mountain village of Berley...Estimates of total damage in Haiti are not available. The number of deaths were estimated between 400 and 1,000, including 200 or more buried in the landslide. Extreme winds of 125 mph at several places in the western part of the southern peninsula were reported by the Coprs d'Aviation, Bowen Field, Port-au-Prince, Haiti" (Rhodes).

October 13: HWM indicates a storm with a pressure of at most 990mb near 20.6N, 73W. HURDAT lists this as a Category 2 hurricane with 85kt winds at 21.0N, 73.2W at 12 UTC. Station highlight: 22kt ENE with pressure of 994mb at Great Inagua (20.9N, 73.6W) at 1200 UTC (HWM); 52kt SSW at Mayaguana (22.3N, 72.9W) at 21.30 UTC (USWB). Ship highlight: 35kt W with pressure of 1005mb at 17.5N, 73.8W at 0000 UTC (COA); 30kt NNW with pressure of 999mb at 20.2N, 74.3W at 0630 UTC (USWB). Aircraft highlight: 100kt with pressure of 974mb at 22.2N, 73.5W at 2136 UTC (NAVY); 80kt with pressure of 972mb at 21.6N, 73.4W at 1615 UTC (NAVY). The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 20N, 73.5W (0 UTC) and at 21N, 73W with 987mb (12 UTC). "[Hazel] changed course to north then to north-northwest on the 13th, continuing on that course until it passed inland on the North Carolina coast about 0915 EST of the 15th" (MWR). "After passing through the Windward Channel the hurricane moved northward and passed directly over the Island of Great Inagua and between Mayaguana and Acklin Islands, and passed a short distance east of the remainder of the Bahamas. A minimum pressure of 29.34 inches and a maximum wind of only 40 mph were reported at Great Inagua Island. The low wind speed was thought to be due to distortion of the hurricane in its passage through the mountainous terrain bordering the Windward Channel. Damage was minor in the Bahamas. Six lives were lost out of a total of 15 aboard a sailboat that capsized when it was trying to take shelter at Inagua" (Rhodes). "Hazel - October 12-13 - Category 1 impact in Cuba" (Perez).

October 14: HWM indicates a storm with a pressure of at most 990mb near 25.5N, 74.6W. HURDAT lists this as a Category 3 hurricane with 105kt winds at 25.5N, 74.6W at 12 UTC. Station highlight: 52kt SSW at Mayaguana at 0030 UTC (USWB); 30kt ENE with pressure of 992mb at San Salvador at 0930 UTC (USWB). Ship highlight: 52kt NE with pressure of 988mb at 28.2N, 77.5W at 2130 UTC (USWB); 26kt N with pressure of 982mb at 33.2N, 77.8W at 2330 UTC (USWB). Aircraft highlight: 52kt SE at 27.8N, 72.5W at 1354 UTC (USWB); 100kt with pressure of 974mb at 22.5N, 73.4W at 0045 UTC (NAVY). The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 23.1N, 73W (0 UTC) and at 25.5N, 74W with 987mb (12 UTC). "Storm warnings were hoisted at 1100 EST on the 14th from Charleston, S.C., northward on the Virginia Capes, and the remainder of the coast northward to New England was placed on the alert by Washington and Boston Weather Bureau offices" (MWR).

October 15: HWM indicates a closed low of at most 980mb near 33N, 78.5W. HURDAT lists this as a Category 3 hurricane with 110kt winds at 32.8N, 78.7W at 12 UTC. Station highlight: 70kt SW at Kinston at 1845 UTC (SWO); 966mb at Spartanburg (34.9N, 81.9W) at 1750 UTC (SWO). Ship highlight: 35kt N with pressure of 972mb at 31.3N, 78.8W at 0800 UTC (USWB); 70kt ENE with pressure of 1006mb at 32.4N, 77.8W at 0000 UTC (COA). Aircraft highlight: No gales or low pressures. The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 28.9N, 76.8W (0 UTC) and at 33.8N, 78.5W with 976mb (12 UTC). "During the 14th and 15th, and until the hurricane passed inland, the highest winds were estimated in all warning messages in excess of 100mph. Wilmington, N.C., reported a top gust of 98mph and the fastest mile was 82mph. Minimum pressure there was 28.68in. Myrtle Beach, S.C., reported top gusts of 106 mph and lowest pressure reported of 28.47in. (This was the lowest pressure reported on land although 27.70in was reported by a fishing boat at Tilgham Point while in the eye of the storm at 10:30 a.m. EST.) Wind estimates from several points between Myrtle Beach and Cape Fear varied from 130 to 150mph. The devastation along the North and South Carolina beaches was staggering. Every pier in a distance of 170 miles of coastline was demolished and whole lines of beach homes literally disappeared. In some places the tide was over 17ft higher than the mean low water" (MWR). "Total casualties in the Carolinas were 20, most of which were drownings. Damage to the Carolinas is estimated at around \$163 million with \$36 million from the N. Carolina beach area, \$25 million from the S. Carolina beach area, and the remainder from crop and property losses in the interior" (MWR). "More than one half of the total damage in the US occurred in N. Carolina" (Seamon). "Long Beach (NC) was completely destroyed with all of its 300 houses gone, as was Holden Beach with lost all of its 200 houses, and Ocean Isle where no houses remained" (Seamon). "Total losses for South Carolina totaled \$27,000,000 all occurring along the coast except \$2,000,000 in the interior" (Seamon). "Tropical Cyclones in the South Atlantic States - Carolinas and Georgia - 1954 - Oct. 15 (Hazel) - Carolinas - Extreme [Category 4 or 5] - 20 killed, damage \$163,000,000. Tropical Cyclones in the Middle Atlantic States - 1954 - Oct. 15 (Hazel) -

All Sections - Major [Category 2 or 3] - 74 killed, damage \$88,595,000" (Dunn and Miller). "1011 mb environmental pressure, 114 kt maximum sustained winds at the coast" (Schwerdt et al.). "Hazel - Oct. 15 - 938 mb central pressure at landfall - 25 nmi RMW - 26 kt forward speed - 33.9N, 78.5W landfall point" (Ho et al.) "1954 Oct SC, NC 4; MD, 2 - 938 mb central pressure - Hazel" (Jarrell et al.)

October 16: HWM indicates a closed low of at most 985mb near 51N, 79.5W. HURDAT lists this as an Extratropical storm with 50kt winds at 48.8N, 80.0W at 12 UTC. Station highlight: 60kt SE at Binghampton (42.1N, 75.9W) at 0246 UTC (SWO); 975mb at Sampson AFB (42.8N, 76.9W) at 0226 UTC (SWO); 984 mb and 12 kt N at Kirkland Lake, Canada (47.7N, 79.8W) at 1130 UTC (USWB). 990 mb and 12 kt NW at Moosonee, Canada (51.3N, 80.7W) at 1730 UTC (USWB). Ship highlight: 45kt SE with pressure of 998mb at 0000 UTC at 40.1N, 73.4W (COA); 45kt SE with pressure of 998mb at 40.1N, 73.4W at 0000 UTC. Aircraft highlight: No gales or low pressures. The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 42N, 78W (0 UTC) and at 48.8N, 79.5W with 981mb (12 UTC). "Twenty-one deaths were attributed to Hazel in New York and damage ran in the millions. Heavy rains in the extreme west flooded basements and washed out several bridges" (Seamon).

October 17: HWM indicates a closed low of at most 995mb near 56N, 77W. HURDAT lists this as an Extratropical storm with 35kt winds at 54.0N, 78.2W at 12 UTC. Station highlight: 43kt SE 993mb at 55.0N, 78.0W at 1200 UTC. No ship or Aircraft data. The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 52N, 79W (0 UTC) and at 53.4N, 77.5W with 990mb (12 UTC).

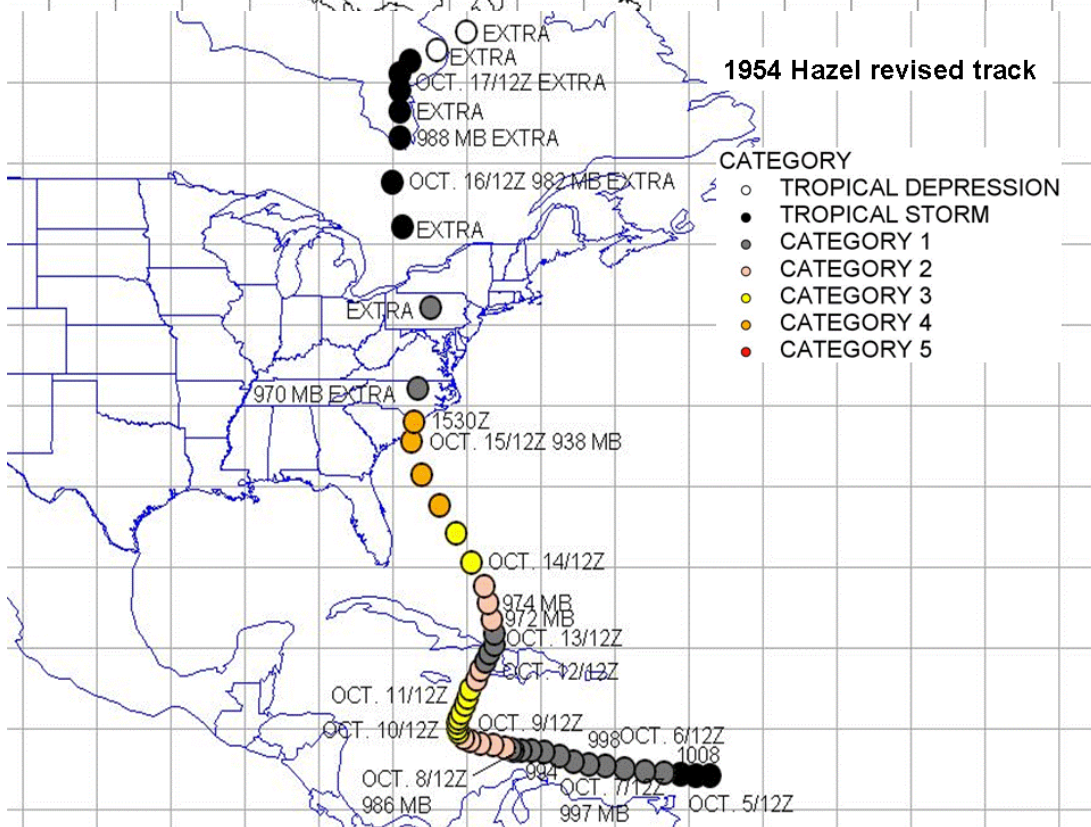
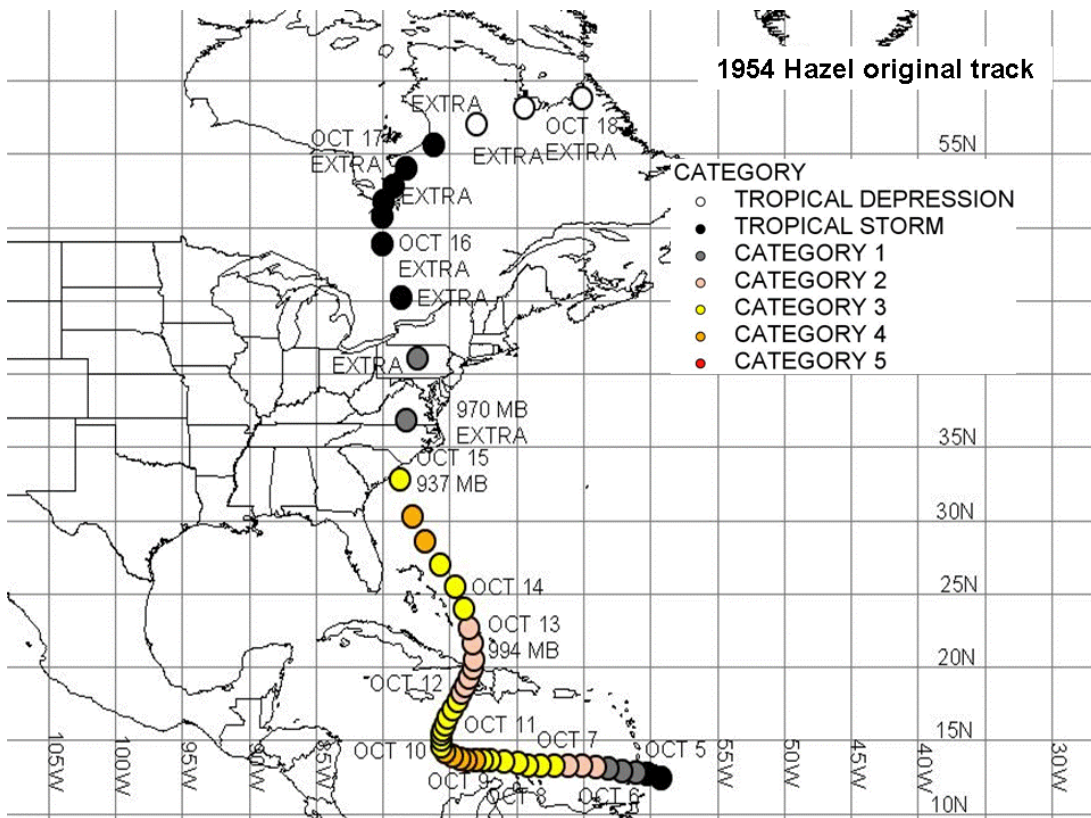
October 18: HWM indicates a closed low of at most 990mb near 61N, 56W. HURDAT lists this as an Extratropical storm with 25kt winds at 58.8N, 65.1W at 12 UTC. The MWR Tracks of Centers of Cyclones at Sea Level showed a center at 57N, 72.5W (0 UTC). Station highlight: 993mb at 63.0N, 49.0W at 1200 UTC. No ship or aircraft data.

No change is made to the genesis of Hazel, though the first report in HURDAT is now begun with a 40 kt intensity rather than 60 kt originally. Track changes are introduced for the entire lifecycle of Hazel, but all are minor adjustments. A central pressure of 1002 mb with a tiny eye diameter of 4 nmi was measured by aircraft reconnaissance at 2037 UTC on the 5th along with estimated winds of 85 kt. (From here on in, the estimated winds will not be mentioned, as they are unreliable.) 1002 mb central pressure suggests winds of 43 kt from the southern pressure-wind relationship. Given the tiny size, winds are chosen at 60 kt at 18 UTC and 70 kt at 00 UTC on the 6th, down from 70 and 75 kt, respectively. Central pressures of 998 mb with an eye diameter of 10 nmi and 5 nmi were observed by aircraft at 12 UTC and 1920 UTC. 998 mb central pressure suggests winds of 51 kt from the southern pressure-wind relationship.

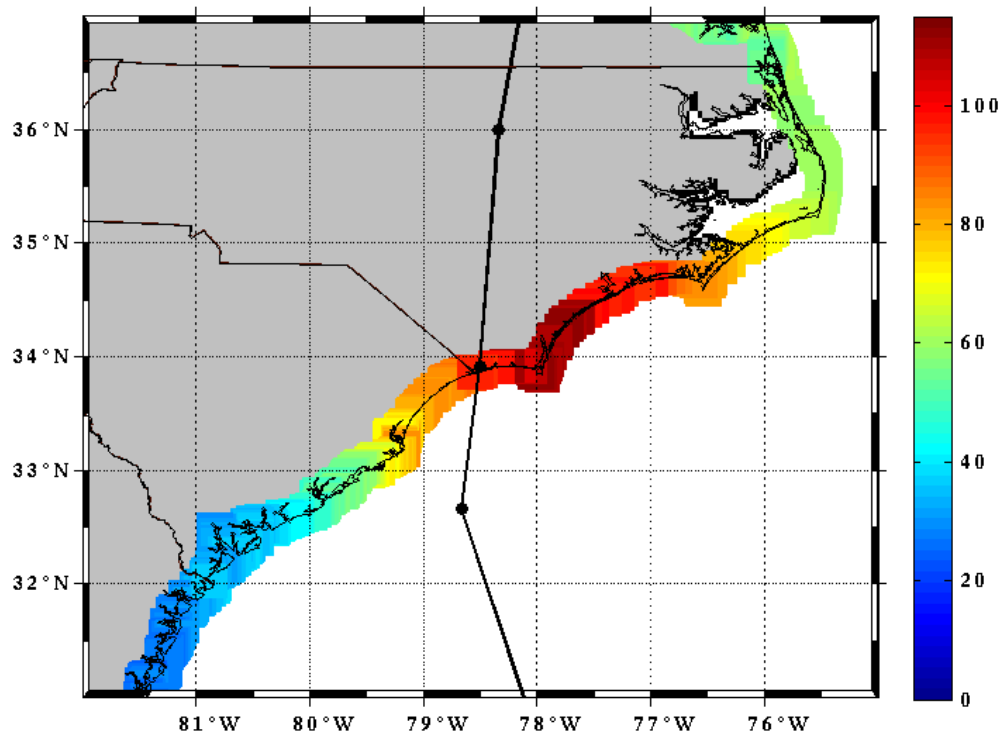
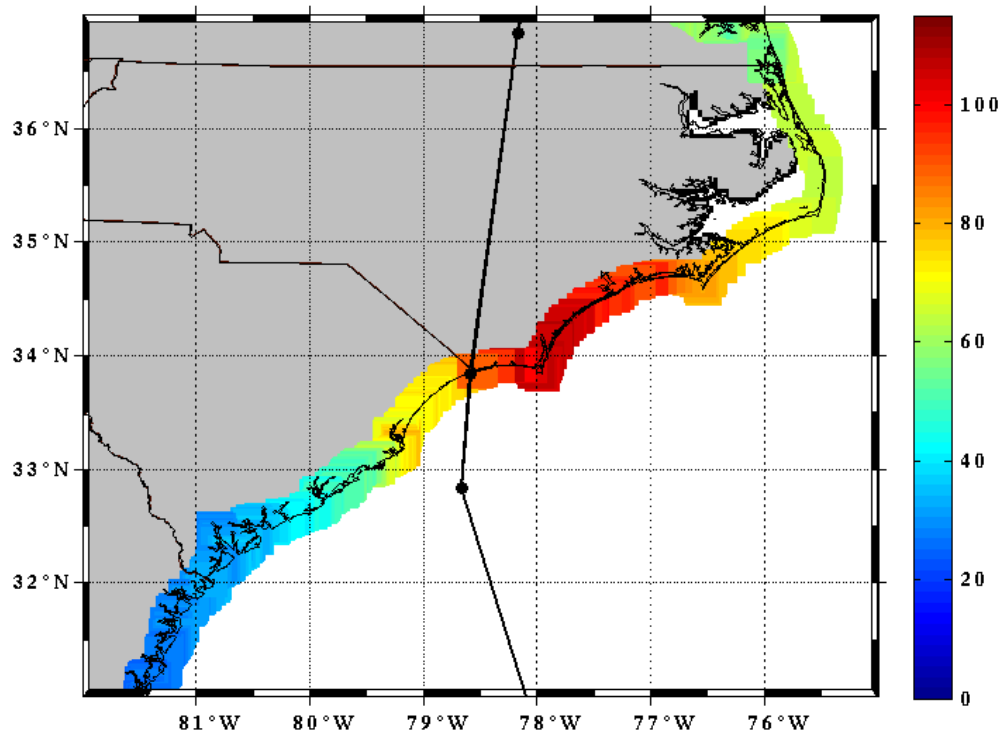
At 12 and 18 UTC, winds are estimated to be 70 kt due to the small size of Hazel - down from 85 kt originally. On the 7th, aircraft measured central pressure of 997 mb with a 7 nmi eye at 1153 UTC and 994 mb with a 10 nmi eye at 1930 UTC. These pressures suggest winds of 55 and 58 kt, respectively, from the southern pressure-wind relationship. Winds are set at 70 kt at 12 and 18 UTC on the 7th (down from 105 kt originally) due to the small size of Hazel. At 12 UTC on the 8th, aircraft reconnaissance measured 986 mb central pressure with an eye diameter of 25 nmi. This suggests winds of 70 kt from the southern wind-pressure relationship. Winds in HURDAT chosen at 80 kt (down from 110 kt originally) because of the deepening found from the 7th. This was the last aircraft penetration for five days until the 13th. From the 9th until the 12th, Hazel moved over the central Caribbean Sea with no ships, aircraft, or land stations within the inner core of strongest winds and lowest pressure. Thus winds are ramped up from 80 kt at the 12 UTC on the 8th to the 105 kt originally shown in HURDAT by 12 UTC on the 10th. The resulting reduction in winds on the 9th (from 115 kt down to 85 kt) is somewhat supported by the ragged and open eye reported from the radar aircraft reports on that date. By the 10th and 11th, the radar observations suggest a smaller and closed eye, suggesting the Category 3 conditions originally shown in HURDAT are reasonable. Hazel's landfall in Haiti was disastrous for that country, and while no measured extreme observations were available, retaining Hazel as a 105 kt hurricane at landfall appears to be prudent. After passing Haiti (with some weakening likely due to interaction with the mountainous island), Hazel moved slowly off to the north over the Atlantic. Aircraft penetrations at 1615 UTC (13th), 2136 UTC (13th), and 0045 UTC (14th) measured 972 mb, 974 mb with an eye diameter of 17 nmi, and 974 mb with an eye diameter of 15 nmi, respectively. These central pressures suggest winds of 87, 85, and 85 kt from the southern pressure-wind relationship. 85 kt at 18 UTC on the 13th and at 00 UTC on the 14th are chosen for HURDAT, the same as original at 18 UTC and down from 90 kt originally at 00 UTC. The 994 mb central pressure in HURDAT originally at 12 UTC on the 13th is erroneous. This value was from Great Inagua, but they were not in the eye at the time, so the value is a peripheral measurement. No further aircraft penetrations were available for the next 36 hours until landfall in the Carolinas.

Hazel made landfall near the South Carolina/North Carolina border at 33.9N 78.5W around 1530 UTC on the 15th of October. A ship at the Carolina's coast reported a central pressure in the eye of Hazel of 938 mb at 1530 UTC on the 15th. Aircraft radar suggested an eye diameter of 18 nmi, which is equivalent to roughly 18 nmi RMW (Kimball and Mulekar 2004). Assuming that the 938 mb is the central pressure at landfall (which agrees with Ho et al. and Jarrell et al.), this value suggests winds of 112 kt from the subtropical pressure-wind relationship. The RMW size being smaller

than climatology for this pressure and latitude (23 nmi) and fast moving (~25 kt at landfall) would argue for a slightly larger wind for this pressure, while the roughly 1008 mb outer closed isobar would suggest slightly less winds. Winds are thus estimated to be 115 kt at landfall, keeping it a Category 4 hurricane. As Hazel made landfall right at the North Carolina/South Carolina border, it is estimated that South Carolina missed experiencing the peak (Category 4) winds and is thus assessed as a Category 3 impact. The winds in HURDAT are adjusted up slightly at 12 UTC on the 15th from 110 kt to 115 kt. After landfall, peak observed winds within 2 hours of the synoptic times were 70 kt at Kinston, NC around 18 UTC on the 15th and 60 kt at Philadelphia, PA around 00 UTC on the 16th. A run of the Kaplan/DeMaria inland decay model suggests winds of 62 kt at 18 UTC on the 15th, though the system was judged to be extratropical at that point (unchanged from originally in HURDAT), so the Kaplan/DeMaria model may not be very applicable by this time. 80 kt are retained in HURDAT at 18 UTC on the 15th. Given the extratropical transition occurring around 18 UTC on the 15th while the system was over North Carolina, impacts farther north would not be considered as a tropical cyclone. It should be noted that observed sustained hurricane force winds were also observed in Virginia and Washington D.C., and likely also occurred in Maryland, Pennsylvania, and New York as well. Thus the "MD2" (Maryland - Saffir-Simpson Hurricane Scale Category 2) originally in HURDAT is removed. A couple of analyzed central pressures of 982 mb and 988 mb were added for 12 and 18 UTC on the 16th based upon land-based observations. Hazel likely was absorbed by a larger extratropical low by 12 UTC on the 18th, thus this position is removed from HURDAT.



Original and revised Hurricane Hazel track maps.



Original and revised Hurricane Hazel windswaths.

39675 08/29/1960 M=17 5 SNBR= 869 DONNA XING=1 SSS=4
39675 08/31/1960 M=15 5 SNBR= 869 DONNA XING=1 SSS=4
** **

39680 08/29* 0 0 0 0* 0 0 0 0* 0 0 0 0*102 215 25 0*
39685 08/30*101 242 25 0*102 255 30 0*103 269 35 0*105 284 35 0*
(The 29th and 30th are removed from HURDAT.)

39690 08/31*108 300 35 0*109 316 35 0*110 331 35 0*114 346 35 0*
39690 08/31*108 300 25 0*109 316 30 0*110 331 35 0*114 346 40 0*
** ** **

39695 09/01*118 362 40 0*120 378 50 0*122 394 65 990*126 411 80 0*
39695 09/01*118 362 45 0*120 378 55 0*122 394 65 990*126 411 70 0*
** ** **

39700 09/02*129 428 95 0*133 443 105 0*136 458 115 980*139 476 120 973*
39700 09/02*129 428 70 0*133 443 70 0*136 458 75 980*139 476 80 973*
** *** **

39705 09/03*143 494 125 0*147 512 130 0*152 529 130 965*156 546 135 947*
39705 09/03*143 494 85 0*147 512 90 0*152 532 95 962*159 550 110 947*
*** **

39710 09/04*160 563 135 0*164 580 140 0*168 595 140 952*172 608 135 0*
39710 09/04*164 566 110 0*165 582 110 0*168 598 105 952*172 609 105 0*
*** **

39715 09/05*177 620 130 0*184 634 120 0*191 647 115 958*197 657 110 0*
39715 09/05*177 620 105 956*184 634 110 952*191 647 105 958*196 657 105 956*
*** **

39720 09/06*203 665 110 0*208 673 110 0*212 681 110 940*215 689 115 0*
39720 09/06*200 665 115 941*206 675 115 0*212 683 120 940*215 689 125 0*
*** **

39725 09/07*218 697 120 0*220 705 120 0*221 713 125 945*221 722 125 0*
39725 09/07*218 697 125 932*220 705 125 0*221 713 120 0*221 723 115 0*
*** **

39730 09/08*222 732 130 0*223 743 130 0*223 753 130 948*224 761 130 944*
39730 09/08*222 734 110 941*223 743 105 0*223 753 105 951*224 761 105 0*
*** **

39735 09/09*224 769 130 948*227 778 130 940*232 787 130 934*237 794 125 939*
39735 09/09*226 769 105 0*229 778 110 943*232 787 115 936*237 794 110 942*
*** **

39740 09/10*242 801 120 932*247 807 115 932*253 813 120 938*262 817 115 950*
39740 09/10*242 801 110 938*247 807 115 930*253 813 110 940*263 818 100 949*
*** **

39745 09/11*273 819 105 960*285 817 100 969*299 808 90 970*314 795 90 966*
39745 09/11*273 819 85 957*285 817 60 967*299 809 65 970*314 798 85 966*
*** **

39750 09/12*331 780 95 958*350 769 90 0*373 748 95 965*400 731 90 0*
39750 09/12*332 781 95 955*351 768 90 958*373 748 90 958*401 733 85 959*
*** **

39755 09/13*431 712 75 0E466 689 60 0E500 660 55 0E531 625 45 0*

39755	09/13*430	712	65	969E470	686	60	975E500	660	60	978E531	625	60	980*
	***		**	***	***	***	***		**	***		**	***
39760	09/14E560	582	35	0*	0	0	0*	0	0	0*	0	0	0*
39760	09/14E560	582	45	985E585	540	40	990E610	500	40	995*	0	0	0*
			**	*****	***	**	*****	***	**	***			
39765	HRBFL4	DFL2	NC3		NY3	CT2	RI1	MA1	NH1	ME1			
39765	HRBFL4	CFL2	DFL1	NC2	VA1	NY2	CT1	RI1					
	*****	***	***	***	***	***	***	***	***	***			

1st Landfall:

10/07Z: 24.8N 80.9W - 930 mb - 115 kt - 18 nmi RMW - BFL4,CFL2

2nd Landfall:

10/19Z: 26.5N 81.9W - 951 mb - 100 kt -(winds low at landfall as right front quadrant overland well before landfall of center) - 11 nmi RMW - DFL1 (as the hurricane moved across the state)

3rd Landfall:

12/05Z: 34.6N 77.2W - 955 mb - 95 kt - 26 nmi RMW - NC2,VA1

4th Landfall:

12/19Z: 40.7N 72.9W - 959 mb - 85 kt - 48 nmi RMW - NY2

5th Landfall:

12/20Z: 41.3N 72.4W - 962 mb - 85 kt - 48 nmi RMW - CT1, RI1 (but due to landfall angle, 85 kt winds were at this time impacting NY, peak winds to impact CT and RI were Cat 1).

Major changes to the track and to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from the Historical Weather Map series, Monthly Weather Review, daily Surface Weather Observations from NCDC, U.S. Weather Bureau six hourly maps available via microfilm at NHC, aircraft observations available from the Storm Wallets at NHC, the COADS ship database, Cry (1960), Harris (1963), Miller (1964), Schwerdt et al. (1979), Ho et al. (1987), Jarrell et al. (1992), Boose et al. (2001), and Dunion et al. (2003).

Aug 29- HWM indicates a low near 10.5N, 19.5W. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures. HURDAT began the system at 18 UTC at 10.2N 21.5W as a 25 kt tropical depressions. However, available observations do not suggest a closed low existed yet on this date. "The passage of an active easterly wave through the area was suggested by unusually heavy rain at Dakar, with which the crash of an airliner there on August 29 was associated and by heavy rain in the Cape Verde Islands on the 30th" (MWR).

Aug 30- HWM indicates a closed low of at most 1010mb near 9.0N, 27.0W.

HURDAT lists this as a Tropical Storm with 35kt winds at 10.3N, 26.9W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures. Observations through 18 UTC on the 30th suggest that no closed circulation existed yet. "...heavy rain in the Cape Verde Islands on the 30th. An aircraft also reported indications of a tropical disturbance near 10.0N, 24.0W" (MWR).

Aug 31- HWM indicates a storm with at most 1010mb near 11.0N, 32.8W. HURDAT lists this as a Tropical Storm with 35kt winds at 11.0N, 33.1W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures. System reanalyzed to have begun as a tropical depression at 00 UTC on the 31st. No changes to the system at 12 UTC.

Sept 1- HWM indicates a storm with at most 1005mb near 11.5N, 39.1W. HURDAT lists this as a Category 1 hurricane with 65kt winds and a pressure of 990mb at 12.2N, 39.4W at 12 UTC. The revised HURDAT retains the same position and intensity. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: No gales or low pressures.

Sept 2- HWM indicates a storm with at most 1000mb near 13.4N, 46.1W. HURDAT lists this as a Category 4 hurricane with 115kt winds and a pressure of 980mb at 13.6N, 45.8W at 12 UTC. The revised HURDAT lists this as a Category 1 hurricane with 75kt winds and a pressure of 980mb at 13.6N, 45.8W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: 45kt with pressure of 1004mb at 14.2N, 48.6W at 1600UTC (COA). Aircraft highlight: Pressure of 973mb at 14.2N, 48.4W at 2001UTC. "Donna, the one major hurricane of the season and the most destructive ever to strike Florida, was detected by aerial reconnaissance on the afternoon of September 2 near 14.0N, 49.0W. Maximum observed surface winds at that time were 120kt and there was a well-developed eye with a central pressure of 973mb. The existence of a tropical storm or hurricane had been indicated earlier in the day by surface ships, apparently on the fringes of the circulation, which reported shifting winds up to 45 kt., and pressures as low as 1004 mb" (MWR).

Sept 3- HWM indicates a storm with at most 1000mb near 14.9N, 53.2W. HURDAT lists this as a Category 4 hurricane with 130kt winds and a pressure of 965mb at 15.2N, 52.9W at 12 UTC. The revised HURDAT lists this as a Category 2 hurricane with 95kt winds and a pressure of 962mb at 15.2N, 53.2W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: Pressure of 962mb at 15.3N, 53.2W at 1255 UTC; 947 mb around 1800 UTC (Cry).

Sept 4- HWM indicates a storm with at most 995mb near 16.4N, 59.6W. HURDAT lists this as a Category 5 hurricane with 140kt winds and a pressure of 952mb

at 16.8N, 59.5W at 12 UTC. The revised HURDAT lists this as a Category 3 hurricane with 105kt winds and a pressure of 952mb at 16.8N, 59.8W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: No gales or low pressures. Aircraft highlight: Pressure of 952mb at 17.0N, 60.0W at 1317 UTC; 35kt winds at 19.5N, 60.7W at 1620 UTC. "Donna continued toward the west-northwest on approximately the climatological track, but at a slightly faster-than-average rate of about 17kt" (MWR).

Sept 5- HWM indicates a storm with at most 995mb near 18.3N, 64.9W. HURDAT lists this as a Category 4 hurricane with 115kt winds and a pressure of 958mb at 19.1N, 64.7W at 12 UTC. The revised HURDAT lists this as a Category 3 hurricane with 105kt winds and a pressure of 958mb at 19.1N, 64.7W at 12 UTC. Station highlight: 110kts with pressure of 952mb at St. Martin (18.0N, 63.0W) (no time given). Ship highlight: 10kts with pressure of 992mb at 20.5N, 72.8W at 2300 UTC. Aircraft highlight: Pressure of 956mb at 18.1N, 62.3W at 0100 UTC; pressure of 956 mb at 1943 UTC. "This [west-northwest] course took the hurricane through the northern Leeward islands during the evening of September 4 with the eye passing over Barbuda, St. Barthelemy, Sint Maarten, Anguila, and about 10 miles to the south of Anegada. The maximum sustained wind observed at Saint Maarten was 110kt and the lowest barometer reading 952mb" (MWR). Wind and tide damage was heavy in the Leeward Islands. A large percentage of the houses on Sint Maarten, Barbuda, and Anguilla were destroyed or severely damaged, with about \$3.25 million in property losses, and five fatalities on Anguilla. Major damage occurred on St. Berthelemy, and on Sombrero and Virgin Gordo damage was characterized as heavy to severe to property, crops, and livestock (Cry). "Only minor damage was reported at St. Thomas, Virgin Islands, with the wind reaching a gust speed of 52kt as the storm center passed about 35 miles to the northeast on September 5. Movement continued toward the west-northwest on the 5th and highest sustained winds were 33kt at San Juan, P.R. as the hurricane passed some 85 miles north" (MWR).

Sept 6- HWM indicates a storm with at most 995mb near 21.0N, 68.2W. HURDAT lists this as a Category 3 hurricane with 110kt winds and a pressure of 940mb at 21.2N, 68.1W at 12 UTC. The revised HURDAT lists this as a Category 4 hurricane with 120kt winds and a pressure of 940mb at 21.2N, 68.3W at 12 UTC. Station highlight: No gales or low pressures. Ship highlight: 35kt SE with pressure of 1016mb at 23.2N, 64.87W at 0600 UTC. Aircraft highlight: Pressure of 932 mb at 1835 UTC at 21.7N, 69.1W at 1835 UTC; 932mb at 21.7N, 69.7W at 2230 UTC. "Serious floods developed over the northern and eastern portions of [Puerto Rico] on the morning of September 6. Despite the warnings, 107 persons were drowned. The greatest loss of life was at Humacao where 84 deaths occurred" (MWR). "A change in the movement of the storm occurred on the 6th with a shift of direction to the west toward the north coast of Cuba. The forward motion also slowed to 12kt and later to 7-9kt with a concurrent drop of central pressure to near 941mb and an increase in maximum

surface winds to around 120kt and later to 130kt" (Cry).

Sept 7- HWM indicates a storm with at most 990mb near 21.3N, 71.4W. HURDAT lists this as a Category 4 hurricane with 125kt winds and a pressure of 945mb at 22.1N, 71.3W at 12 UTC. The revised HURDAT lists this as a Category 4 hurricane with 120kt winds at 22.1N, 71.3W at 12 UTC. Station highlight: 45-50kt at Turks Island (21.5N, 71.2W) no time given. Ship highlight: 43kt W with pressure of 985mb at 21.4N, 71.0W at 0900 UTC; 48kt W at 21.5N, 71.0W at 0600 UTC. Aircraft highlight: Pressure of 941mb at 22.1N, 73.0W at 2150 UTC. "Donna moved into the southeastern Bahamas on the afternoon of the 7th, with the eye passing slightly north of Turks and Grand Caicos Islands" (Cry).

Sept 8- HWM indicates a storm with at most 995mb near 22N, 75.2W. HURDAT lists this as a Category 4 hurricane with 130kt winds and a pressure of 948mb at 22.3N, 75.3W at 12 UTC. The revised HURDAT lists this as Category 3 hurricane with 105kt winds and a pressure of 951mb at 22.3N, 75.3W at 12 UTC. Station highlight: 61kt ENE at The Exumas (23.4N, 75.6W) at 1200 UTC. Ship highlight: 35kt S with pressure of 1007mb at 19.5N, 75.1W at 1200 UTC. Aircraft highlight: Pressure of 951mb at 22.2N, 75.5W at 1300 UTC. "...thence westward to the vicinity of Grand Ragged Island by the morning of the 8th...As Donna approached the southeastern Bahamas, maximum winds were estimated up to 150 m.p.h. Mayaguana was buffeted for 13 hours by winds of hurricane force which reached over 100 m.p.h., at times. Heavy rain continued to accompany the storm in the Bahamas" (Cry) "The eye passed over or very near Mayaguana, Acklins Island, Fortune Island, and Ragged Island. Mayaguana was battered by hurricane force winds for 13 hours" (MWR). "At 0700 EST on September 8, when the hurricane was located only 380 miles southeast of Miami and moving westward at about 10kt the Miami wind at 500mb was still blowing from the west" (MWR). "Damage on Turks and Caicos was estimated at \$288,000. Heavy rains on the southern fringes of the storm lashed at Hispaniola and Jamaica" (Cry).

Sept 9- HWM indicates a storm near 23N, 78.6W. HURDAT lists this as a Category 4 hurricane with 130kt winds and a pressure of 934mb at 23.2N, 78.7W at 12 UTC. The revised HURDAT lists this as a Category 4 hurricane with 115kt winds and a pressure of 936mb at 23.2N, 78.7W at 12 UTC. Station highlight: 65kt S at with pressure of 1004mb at Andros (24.1N, 77.5W) at 1200 UTC. Ship highlight: 87kt NNW at 24.0N, 80.0W at 1800 UTC. Aircraft highlight: 933mb at 23.1N, 78.3W at 0920 UTC (NHRP). "On September 9, Donna skirted the northeastern coast of Cuba, bringing gales and heavy rains to much of the island, then took a west-northwest course, toward the Florida Keys" (MWR). "A progressively increasing turn to the west-northwest began during the afternoon and brought the storm center across Grand Bahama Bank well south of Andros Island to a position near 24.0N, 80.0W by 1900 EST on the 9th, thence over the middle Florida Keys between 0200 and 0300 EST on the 10th...Gales winds and high tides lashed the north coast of Cuba from

Havana eastward. High tides also pounded portions of the south coast, and floods destroyed about 80 houses at Gibard in Oriente Province" (Cry).

Sept 10- HWN indicates a storm with at most 990mb near 25N, 81W. HURDAT lists this as a Category 4 hurricane with 120kt winds and a pressure of 938mb at 25.3N, 81.3W at 12 UTC. The revised HURDAT lists this as a Category 3 hurricane with 110kt winds and a pressure of 940mb at 25.3N, 81.3W at 12 UTC. Station highlight: Pressure of 933mb at Conch Key (24.8N, 80.9W) no time given; 111kt NW at Sombrero Key (24.6N, 81.1W) at 0630 UTC; 949 mb at Naples at 1720 UTC; 80 kt NE at 1831 UTC at Ft. Myers. Ship highlight: No gales or low pressures. Aircraft highlight: Pressure of 937mb at 24.7N, 80.4W at 0400 UTC; 39kt NNW at 25.8N, 83.7W at 1830 UTC. "The center crossed over the middle Keys just northeast of Marathon between 0200 and 0300 EST on September 10. The central pressure had continued to drop as the hurricane moved across the warm waters of the Florida Straits and was approximately 930mb when the center reached the Keys" (MWR). "On the Keys, the central eye extended from just north and east of Marathon shores to Lignumvitae Key" (Cry). "At Sombrero Light, west of the area of strongest winds, the fastest recorded mile was at a rate of 128 m.p.h., at 1:30 am, EST., on the 10th with gusts to 150 mph. At Tavernier, to the east of the area of strongest winds, the fastest measured mile was 120mph, the limit of the anemometer. The indicator needle held solid against this maximum for at least 45 minutes. Anemometers were blown away or stations evacuated at Flamingo, Everglades, and Naples" (Cry). "The lowest atmospheric pressure measured by a calibrated aneroid barometer was 27.55 inches in Conch Key as the eye passed" (Cry). "Tides in the Everglades-Naples-Ft. Myers Beach area were estimated 4 to 7 feet above normal (slightly higher at places) and pushed into the towns, damaging streets, buildings, and docks. Beach erosion and deposition were extensive. North of Bradenton on the west coast and Palm Beach on the east coast maximum tides were mostly 1 to 3 feet above normal and in the Miami area were generally 2 to 4 feet above normal" (Cry). 930 mb central pressure, 18 nmi RMW, landfall at 24.8N 80.9W, speed 9 kt (Ho et al.). 1008 mb peripheral pressure, 114 kt max sustained 1 min wind (Schwerdt et al.). Florida Southwest-Cat, 930 mb central pressure at landfall (Jarrell et al.). 117 kt max sustained surface wind and 16-18 nmi RMW analyzed for 18 UTC 9th, 00 UTC 10th, and 06 UTC 10th (landfall in Keys); 107 kt and 18 nmi RMW at 12 UTC 10th, 98 kt and 18 nmi RMW at 16 UTC 10th (as eye made second landfall at Naples), 94 kt and 10 nmi RMW at 18 UTC 10th (inland) (Dunion et al.).

Sept 11- HWM indicates a storm near 30.0N, 80.2W. HURDAT lists this as a Category 2 hurricane with 90kt winds and a pressure of 970mb at 29.9N, 80.8W at 12 UTC. The revised HURDAT lists this as a Category 1 hurricane with 65kt winds and a pressure of 970mb at 29.9N, 80.8W at 12 UTC. Station highlight: 962 mb at 02 UTC at Wauchula; 59 kt at 0235 UTC at Lakeland. Ship highlight: 25kt S with pressure of 976mb at 27.5N, 77.6W at 0600 UTC; 65kt WNW with

pressure of 985mb at 30.5N, 79.5W at 2100 UTC. Aircraft highlight: 85kt with pressure of 968mb at 30.7N, 80.6W at 1545 UTC. "The eye passed over Naples and Fort Myers as the hurricane turned northward, moved inland, and then continued northeastward to re-enter the Atlantic just north of Daytona Beach about 0400 EST, September 11" (MWR). "Despite the trajectory over land and a filling of central pressure from 950mb at Fort Myers to 970mb on the east coast, the storm was still intense and well organized when it moved into the Atlantic again" (MWR). "Rapid intensification occurred over the ocean and when the center was about 80miles southeast of Charleston, S.C., on the afternoon of September 11, the SS Mae reported winds of 105kt and 20 to 30-foot seas" (MWR). "Damage from wind and tide was extremely heavy on the Keys and the southwest coast, varying from almost complete destruction of all but the most substantial buildings in the area from marathon to Tavernier to battered boats, dock, broken windows and water damage, and lost roofs in all but the western Keys. Extensive destruction of small houses and buildings and roof damage occurred northward to Punta Gorda. Outside these main damage areas, the wind blew over thousands of trees, shattered windows, blew off or damaged roofs and demolished many weak buildings. Wind-driven rain also added to the damage. Power and communications facilities were disrupted throughout central and south Florida" (Cry). "Some tornadoes, embedded in the forward quadrant of the storm, occurred during the afternoon of the 11th. These caused some local damage near Clinton, North Carolina, around 5pm est., and near Elizabethtown, North Carolina, around 2pm. Several persons were injured in the storm near Clinton. Preliminary damage reports indicate property damage in N. Carolina to beaches and cities along the immediate coast and sounds affected by tides and wind near \$20 million; to crops and farm property also near \$20 million; to forests near \$5 million; to inland communities near \$1 million, and to bridges and highways, near \$500,000" (Cry).

Sept 12- HWM indicates a storm of at most 975mb near 37.7N, 74.5W. HURDAT lists this as a Category 2 hurricane with 95kt and a pressure of 965mb at 37.3N, 74.8W at 12 UTC. The revised HURDAT lists this as a Category 2 hurricane with pressure of 958mb at 37.3N, 74.8W at 12 UTC. Station highlight: Pressure of 958mb at Belhaven, NC (35.5N, 76.6W) at 0700-0745 UTC; 70kt NW at Cape Henry, VA at 1208 UTC; 961 mb at Brookhaven, NY at 1950 UTC; 83 kt S at Block Island at 2115 UTC. Ship highlight: 61kt SSE with pressure of 974mb at 39.7N, 72.0W at 1800 UTC; 75kt E with pressure of 991mb at 32.3N, 79.2W at 0000 UTC. "During its passage over North Carolina, Donna's eye was usually large with the area of calm or light variable winds ranging from 50 to 80 miles in diameter. Minimum pressures reported along this section of the track ranged from 958 to 967mb and highest winds were in the 70-90kt bracket" (MWR). "When Donna again reached the ocean, it resumed its rapid movement with a forward speed of 30-35kt, moving northeastward a short distance off the coast and crossing Long Island shortly after noon on September 12. Sustained winds reached about 90kt at several points on Long Island and 50-60kt on western Long Island and in New York City" (MWR). "During

the period the hurricane was moving from North Carolina to southern New England this was as much as 50 to over 100 miles in diameter, an extreme and probably unprecedented size for a hurricane eye" (MWR). "The large eye (possibly the largest of record) was a continuing feature as Donna moved rapidly northeastward, paralleling the Middle Atlantic coast, at some 30-35kt during the morning hours of the 12th" (Cry). "Losses to property were great along the immediate shore, where wind and tide damage to boats, docks, boardwalks, cottages, and buildings were severe in some areas. Hardest hit was Ocean City, Md., where the storm was described by some old residents as the most severe in the City's history. Extensive minor property damage from wind, rain, and small stream overflow throughout inland sections was considerable in the aggregate. Trees falling on lines disrupted power and communications. Additional wind damage was chiefly to small structures, windows and roofs, and signs" (Cry). "Damages in the heavily populated Northeastern States were heavy. Unprecedented flood damage occurred in the Catskill area. The loss at Windham alone was estimated at more than \$1 million. Damage to all types of boats, docks, highways, and bridges on Long Island was very heavy from flooding, high tides, and heavy seas. Many thousands of trees and limbs were blown down by high winds in the Long Island- lower Hudson Valley area, disrupting power, communications, and travel. Tide damage from coastal erosion and flooding was extensive" (Cry). 970 mb central pressure at Florida oceanfall at 29.5N, 81.1W, 24 nmi RMW, speed 16 kt; 958 mb central pressure at North Carolina landfall at 34.4N 77.6W, 26 nmi RMW, speed 26 kt; 959 mb central pressure at New York landfall at 40.6N 73.2W, 48 nmi RMW, speed 32 kt, "storm becoming extratropical" (Ho et al.). 1008 mb peripheral pressure (both NC and NY landfall), maximum sustained 1 min winds of 96 kt in North Carolina and 89 kt in New York (Schwerdt et al.). "The surge pattern along the Atlantic Coast from Cape May northward is similar in many respects to that generated by the storms of September 21-22, 1938, September 13-15 1944, and Carol, August 30-31, 1954...The surge records for the Chesapeake Bay region were very similar for the storms of September 17-19, 1936, September 13-15, 1944, and August 13-15, 1953...The records for the west coast of Florida are very similar to those obtained in the storms of September 17-21, 1926 and September 15-20, 1945" (Harris). Widespread F1 and one case of F2 structural damage in New York/New England. No changes recommended to HURDAT for 6 hourly winds (Boose et al.).

Sept 13- HWM indicates a closed low near 49.5N, 66.5W. HURDAT lists this as an Extratropical storm with 55kt winds at 50.0N, 66.0W at 12 UTC. The revised HURDAT lists this as an Extratropical storm with 60kt winds at 50.0N, 66.0W at 12 UTC. Station highlight: Pressure of 969mb at Haverhill (42.8N, 71.1W) at 0030 UTC; 54kt SE at Portland (43.7N, 70.3W) at 0013 UTC. Ship highlight: 20kt S with pressure of 979mb at 49.6N, 65.2W at 1200 UTC; 60kt W at 47.7N, 59.3W at 1700 UTC. Aircraft highlight: No gales or low pressures. "Gradual filling and weakening occurred farther north as

the center continued rapidly northeastward, moving through Maine just west of Caribou and into Canada late on September 13. Winds of hurricane force still persisted in squalls near the center until about the time it reached the Canadian border" (MWR).

Genesis for Donna is delayed 36 hours due to observations showing that the closed circulation did not exist until around 00 UTC on the 31st. Other than this major change of the track at genesis (and another discussed later for dissipation), only minor alterations of the track were introduced for all days except for the 31st through the 2nd. Unlike most tropical cyclones of the late 1950s and 1960s, central pressure values were provided in HURDAT for the 12 UTC times from the 1st until the 12th. Many of these are not based upon any observation, but were estimated. Those values that were reasonable were retained, but a few were either replaced by actual measurements of the central pressure or removed. As is clear from the Monthly Weather Review writeup, no gale force winds or low pressures were observed until the 2nd. The 990 mb central pressure listed at 12 UTC was likely not actually observed, but does suggest winds of 64 kt from the southern pressure-wind relationship. 65 kt retained, as this is consistent with what was observed on the 2nd. The Navy aircraft reached Donna on the 2nd and found 120 kt estimated surface winds, 973 mb central pressure, and a 22 nmi diameter eye at 2001 UTC. Estimated surface winds, especially in this era, are notoriously unreliable and even Navy/Air Force flight-level winds are suspect. The 973 mb pressure suggests winds of 86 kt from the southern-pressure wind relationship. 80 kt (down from 120 kt) are chosen given the larger than typical (for this central pressure and latitude - Vickery et al. 2000). The 980 mb value in HURDAT for 12 UTC on the 2nd is not based on any observations, but appears to be reasonable and is retained. The next aircraft found that the central pressure dropped to 962 mb with an 18 nmi eye at 1255 UTC on the 3rd. This pressure gives 98 mb from the southern pressure-wind relationship and the eye size is slightly larger than typical - 95 kt chosen for 12 UTC on the 3rd down from 130 kt originally. A central pressure of 947 mb late on the 3rd suggests winds of 114 kt from the southern pressure-wind relationship. 110 kt chosen for 18 UTC on the 3rd, down from 135 kt, due to slightly larger size than climatology.

The hurricane filled some as it reached the Lesser Antilles. A 952 mb central pressure at 1317 UTC on the 4th with an eye diameter of 20 nmi suggests winds of 108 kt from the southern pressure-wind relationship. 105 kt is chosen for 1200 UTC on the 4th due to slightly larger eye than climatology. The pressure oscillated some (956 mb from aircraft at 01 UTC on the 5th, 952 mb from Sint Maarten around 06 UTC, 956 mb from aircraft at 07 UTC, 958 mb from aircraft at 1245 UTC, 960 mb from aircraft at 1345 UTC, 965 mb from aircraft at 1555 UTC, and 956 mb from aircraft at 1943 UTC) during the 5th. Observed sustained winds of 110 kt

from Sint Maarten early on the 5th along with a central pressure of 952 mb from the island justify a 110 kt estimate in HURDAT (down from 120 kt originally). Winds during the remainder of the 5th with pressures slightly higher are analyzed to be 105 kt. The drop in pressure late on the 5th continued into the 6th as 941 mb was observed by aircraft at 0130 UTC, 940 mb at 1306 UTC, and 932 mb at 1835 and 2230 UTC. The 941 mb pressure suggests winds of 118 kt from the southern-pressure wind relationship. As the 21 nmi eye was larger than climatology, the reanalyzed winds were set to 115 kt, up from 110 kt originally at 00 UTC on the 6th. However, the eye contracted down to 10-14 nmi during the remainder of the 6th. The 940 mb pressure suggested winds of 119 kt, 120 kt used in HURDAT at 12 UTC up from 110 kt originally. The 932 mb readings suggest winds of 125 kt, which is used in HURDAT for 18 UTC on the 5th and 00 UTC on the 6th, up from 115 and 120 kt originally. The next available aircraft indicated some weakening with 941 mb central pressure at 2150 UTC on the 7th, which suggested 118 kt from the southern-pressure wind relationship. As the eye had expanded again to 27 nmi, 115 kt is chosen for HURDAT at 18 UTC/7th and 110 kt at 00 UTC/8th (down from 125 and 130 kt, originally). By 13 UTC on the 8th, aircraft reported that the central pressure had risen to 951 mb with an elliptical eye with axes of 30 and 20 nmi. 951 mb suggests winds of 109 kt from the southern-pressure wind relationship. Winds are chosen at 12 UTC on the 8th to be 105 kt due to the larger than climatologically expected eye, down from 130 kt originally. No reliable surface observations of central pressure and/or maximum winds were available from the Bahamas, during Donna's trek across the islands on the 8th and 9th. During the 9th, another intensification of Donna occurred, as 943 mb at 07 UTC, 933 mb at 0920 UTC, 936 mb at 13 UTC, 942 mb at 16 UTC, and 943 mb at 22 UTC were measured by aircraft reconnaissance. The 936 mb suggests winds of 122 kt from the southern pressure-wind relationship and 113 kt from the subtropical pressure-wind relationship. With the eye diameter being larger than climatological, winds are set at 115 kt at 12 UTC on the 9th - which is reduced from 130 kt originally in HURDAT.

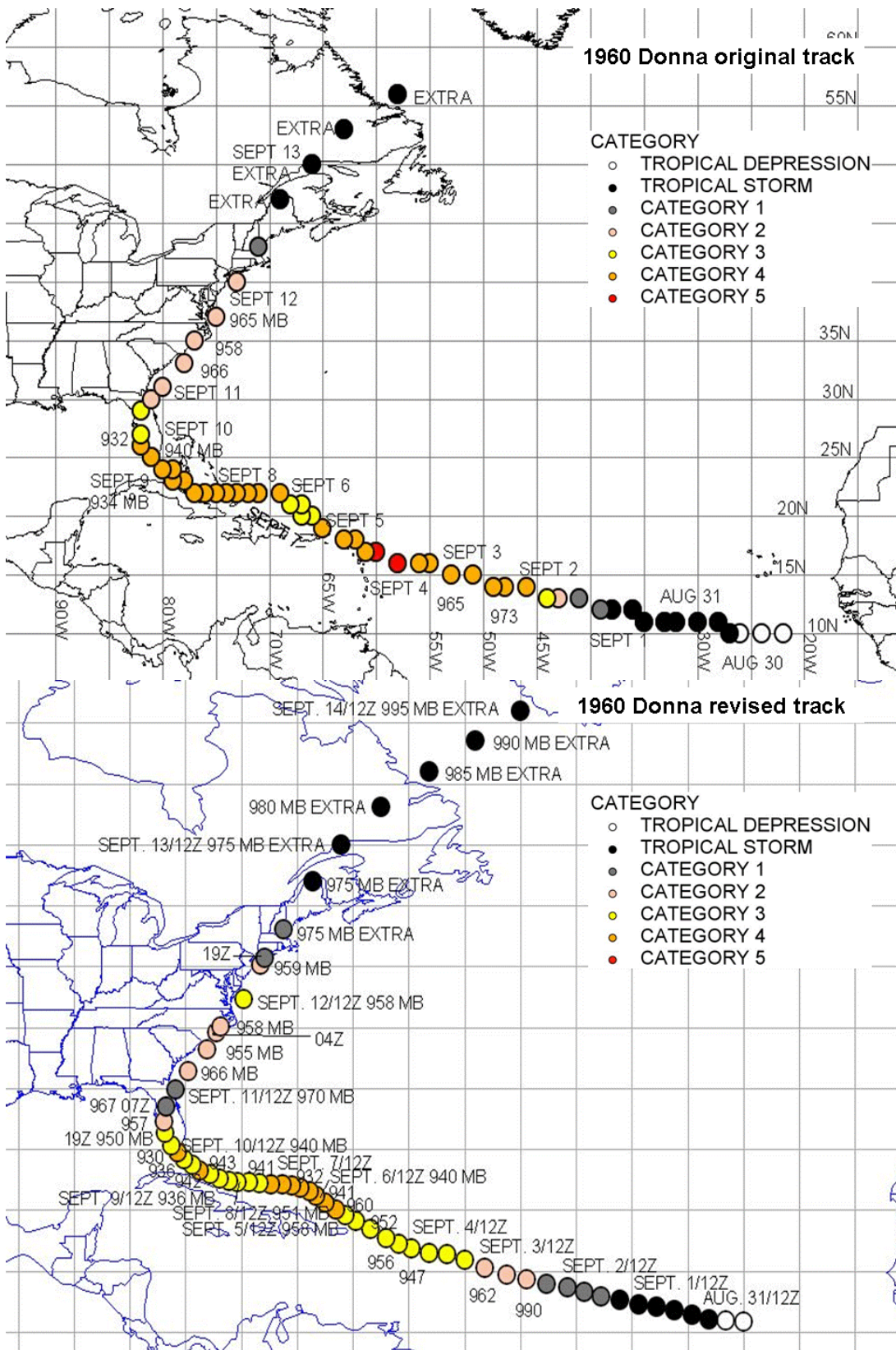
The hurricane intensified again on the 10th as it made landfall in the Florida Keys. Aircraft central pressure was 938 mb at 0050 UTC and 937 mb at 04 UTC. 938 mb pressures suggests winds of 120 kt from the southern and 112 kt from the subtropical pressure-wind relationships. As Donna retained a 20-25 nmi diameter eye, winds were chosen to be 110 kt at 00 UTC, down from 120 kt originally. Donna made landfall over the middle Florida Keys at 24.8N 80.9W around 07 UTC on the 10th wind central pressure of 930 mb, based primarily upon a 933 mb observation from Conch Key. 930 mb suggests winds of 127 kt from the southern and 117 kt from the subtropical pressure-wind relationships. The RMW of 18 nmi is near the average (15 nmi) for this pressure and latitude. Other factors include the slow forward speed of Donna (around 9 kt) and low environmental pressure (1009 mb). These suggest a slightly lower value than the average of the two pressure-

wind relationships, so 115 kt is estimated to be the maximum sustained winds at landfall, retaining Donna as a Category 4 for the Florida Keys (southwest Florida - "BFL"). This is in agreement with the Schwerdt et al. and Dunion et al. estimates. It is noted that the highest sustained wind was 111 kt from Sombrero Key. The close pass of Donna to the boundary between southwest and southeast Florida (at 80.85W) indicates that southeast Florida also received hurricane impacts, which are estimated to be Category 2 based upon the size and landfall location of Donna. After passing the Keys, Donna briefly entered the Gulf of Mexico and then made landfall just north of Naples around 19 UTC on the 10th at 26.5N 81.9W with a central pressure of 949 mb observed at Naples. This pressure would suggest winds of 111 kt from the southern and 103 kt from the subtropical pressure-wind relationship, but the front right quadrant of the hurricane had already been overland for a couple of hours. Thus maximum sustained winds at second landfall are estimated to be 100 kt. The inland decay of Donna over Florida was considered by Dunion et al. with a combination of all available observations along with the Kaplan and DeMaria model. Dunion et al. analyzed 78, 54, and 61 kt for 00, 06, and 12 (just offshore) UTC on the 11th, respectfully. Given that data not observed may cause a small low-bias in the H*Wind analysis scheme, winds in HURDAT are reanalyzed to be 85, 60, and 65 kt, down from 105, 100, and 90 kt originally. This change is consistent with the relative lack of significant structural damage over Lakeland and Orlando, that one would have had if Donna were still a Category 3 hurricane over central Florida. However, it is likely that by the time Donna reached into Northeast Florida (north of 28.2N along its track), it caused sustained Category 1 conditions. Thus it is analyzed as Category 1 for Northeast Florida ("DFL1"), down from Category 2 hurricane status for the region originally. The central pressure for 00 and 06 UTC on the 11th were adjusted downward slightly to 957 and 967 mb (from 960 and 969 mb originally) due to 962 mb measured (at time of peak estimate winds) in Wauchula at 02 UTC. After passing back into the Atlantic, Donna began reintensifying. A Navy reconnaissance measured 968 mb and a 50 nmi diameter eye at 1545 UTC on the 11th, which was the last aircraft to penetrate the hurricane. HURDAT originally had 966 mb at 18 UTC on the 11th and while this was not from an observation, it appears reasonable given the reintensification of the hurricane. 966 mb suggests winds of 85 kt from the subtropical pressure-wind relationship. Winds are chosen to be 85 kt (down from 90 kt) originally due to the large reported eye.

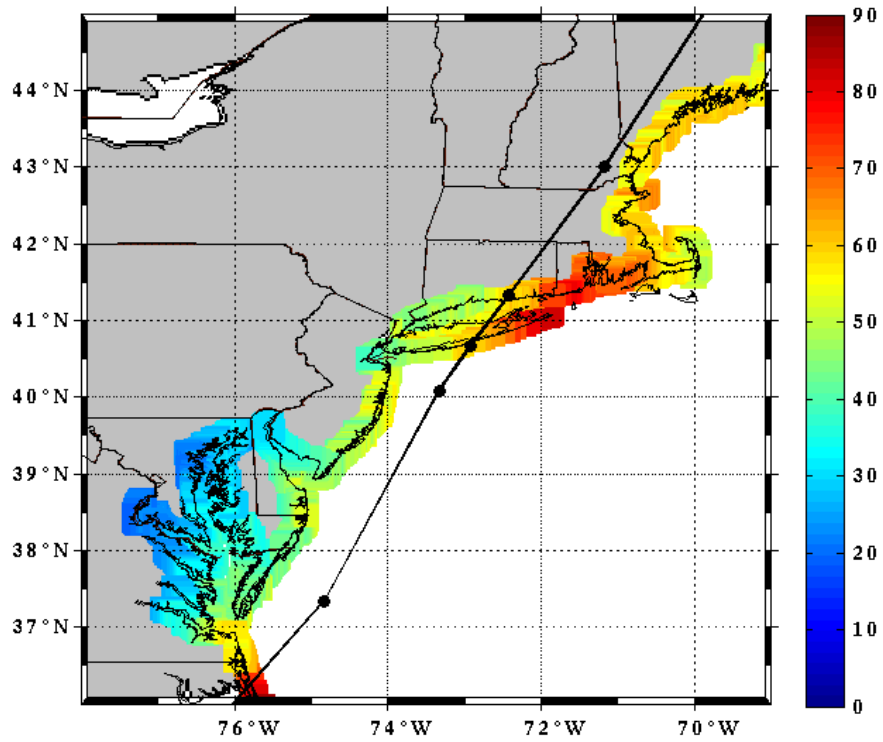
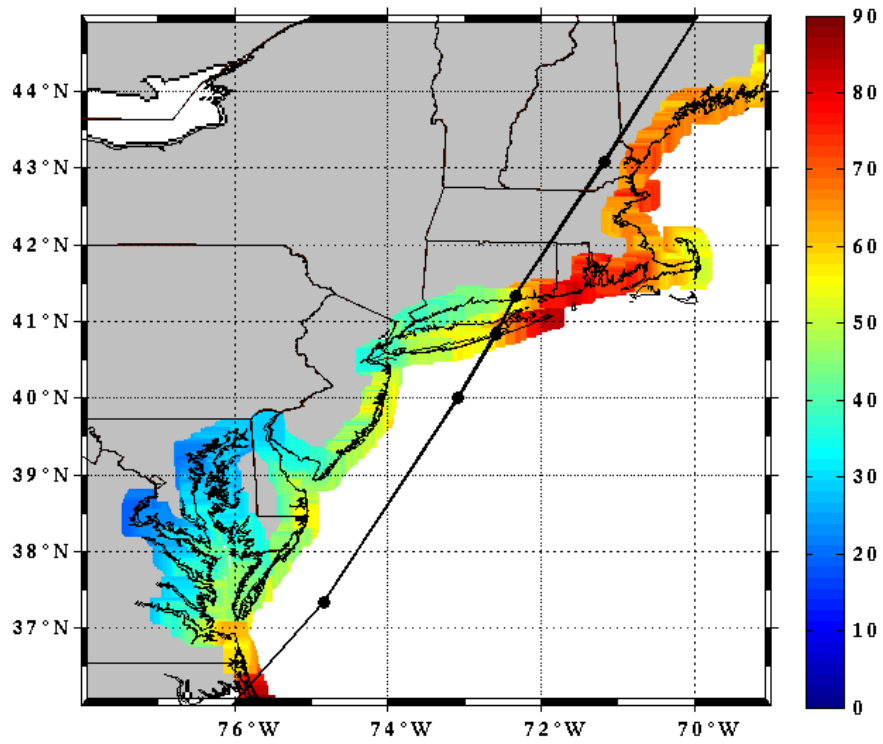
Donna made a third landfall in the United States around 05 UTC on the 12th at 34.6N 77.4W. Lowest observed pressure was 958 mb in the eye at Bellhaven in eastern North Carolina a couple hours after landfall. Thus it is estimated that the central pressure at landfall in North Carolina was about 955 mb. This pressure suggests winds of 99 kt from the subtropical pressure-wind relationship. Because of the large eye size and relatively low (~1009 mb)

environmental pressure, 95 kt is analyzed as the maximum sustained winds at North Carolina landfall. This agrees with the Schwerdt et al. assessment, but is a downgrade from Category 3 originally analyzed in HURDAT to a Category 2 (though the winds in HURDAT at 06 UTC on the 12th remain 95 kt). Highest observed winds in Virginia were 70 kt in Cape Henry, indicating that the state should be listed as having Category 1 hurricane impacts (none were indicated originally).

Donna went back out to sea for about nine more hours before making a fourth U.S. landfall in New York, at 40.7N 72.9W at 19 UTC on the 12th. Observed lowest pressure was at Brookhaven, New York with 961 mb. As the center of Donna appears to have passed just east of Brookhaven, the analyzed central pressure at landfall is 959 mb, in agreement with Ho et al. 959 mb suggests winds of 90 kt from the northern pressure-wind relationship, However, given the large size (48 nmi RMW), maximum sustained surface winds are estimated to be 85 kt at landfall. (Highest observed sustained winds were 83 kt from Block Island, RI.) Around 20 UTC on the 11th, Donna made its fifth (and final) landfall in the United States at 41.3N 72.4W along the Connecticut coastline. Winds are estimated to have dropped to 80 kt by this point. New York is analyzed to have been impacted by Category 2 winds (along the southeastern end of Long Island), which is a downgrade from Category 3 originally. Connecticut, Rhode Island, and Massachusetts are all analyzed to have been impacted by Category 1 winds, which is a downgrade from Category 2 originally for Connecticut and Rhode Island. While winds in Donna are still indicated as 65 kt at 00 UTC on the 13th, these were likely occurring offshore so that New Hampshire and Maine did not receive sustained hurricane force winds. Thus these two states are removed from listing as being impacted by Category 1 conditions. Donna transitioned to extratropical around 06 UTC on the 13th as it approached the Maine-Canada border. Ship observations late on the 13th and on the 14th allowed for analysis of a stronger extratropical storm than originally indicated. An additional 12 hours (06 and 12 UTC on the 14th) were added to HURDAT for Donna as the system was still a distinct entity until that time.



Original and revised Hurricane Donna track maps.



Original and revised Hurricane Donna wind swath

51695 09/16/1985 M=17 7 SNBR=1102 GLORIA XING=1 SSS=3
51695 09/16/1985 M=17 7 SNBR=1102 GLORIA XING=1 SSS=2

*

51700 09/16* 0* 0*1330236 25 1009*1380248 25 1008*
51700 09/16*1200220 25 1009*1250226 25 1009*1300235 25 1009*1350245 25 1008*
*** ** ** **** * ** **

51705 09/17*1410259 30 1008*1430271 30 1008*1460283 35 1007*1470296 35 1007*
51705 09/17*1390259 30 1008*1430275 30 1008*1460290 35 1007*1470302 35 1007*
*** ** ** **** ** ** ** * ** **

51710 09/18*1490317 35 1006*1500338 35 1006*1510359 35 1006*1540381 30 1006*
51710 09/18*1490317 35 1006*1500338 35 1006*1510359 35 1006*1540381 35 1006*
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51715 09/19*1580395 30 1006*1620409 30 1006*1660422 30 1006*1700438 30 1006*
51715 09/19*1580395 35 1006*1620409 35 1006*1660422 35 1006*1700438 35 1006*
** ** ** ** ** ** * ** **

51720 09/20*1720451 35 1005*1740467 40 1004*1750481 45 1003*1760498 45 1002*
51720 09/20*1720451 35 1005*1740467 40 1004*1750481 45 1003*1760500 45 1002*

51725 09/21*1770512 50 1001*1770528 55 1001*1770542 60 1000*1770553 65 1000*
51725 09/21*1770517 45 1001*1770531 45 1001*1770542 50 1000*1770553 50 1000*
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51730 09/22*1780563 65 1000*1780571 70 996*1780582 70 992*1840590 65 990*
51730 09/22*1780563 55 1000*1780571 60 996*1780582 65 991*1840590 65 992*
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51735 09/23*1900602 65 990*1970615 65 989*2040629 65 987*2100642 75 980*
51735 09/23*1900602 65 992*1970615 65 988*2040629 65 988*2100642 80 978*
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51740 09/24*2150655 95 956*2190668 100 952*2250679 100 950*2320690 105 935*
51740 09/24*2150655 105 956*2190668 110 952*2260681 115 950*2320690 120 939*
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51745 09/25*2420700 120 920*2510709 125 920*2610720 115 926*2690730 95 933*
51745 09/25*2420698 135 919*2510709 130 922*2610720 120 929*2690730 110 933*
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51750 09/26*2780740 85 940*2890750 80 944*3000755 80 946*3140762 85 944*
51750 09/26*2780740 100 940*2870750 90 942*3000755 85 946*3140762 85 944*
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51755 09/27*3320760 90 942*3550755 90 942*3840745 85 951*4190728 75 964*
51755 09/27*3320760 90 942*3550755 95 942*3840745 85 951*4190728 70 964*
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51760 09/28E4550700 50 986E4810678 50 987E4950645 50 987E5080612 50 987*
51760 09/28E4550700 50 986E4810678 50 987E4950645 50 987E5080612 45 987*
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51765 09/29E5150575 50 990E5210538 50 990E5240500 50 990E5250475 50 990*
51765 09/29E5150575 40 987E5210550 40 984E5240510 45 980E5250475 55 977*
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51770 09/30E5250450 50 990E5250425 50 990E5250400 50 990E5290379 50 990*
51770 09/30E5250450 60 970E5250425 60 970E5250400 60 970E5350370 60 970*

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51775	10/01E5330359	50	990E5380340	50	990E5450320	50	990E5550300	50	990*				
51775	10/01E5500355	70	970E5550340	70	970E5550320	70	970E5550300	70	965*				
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51780	10/02E5660290	50	960*		0*		0*						0*
51780	10/02E5660290	60	960*		0*		0*						0*
		**											
51785	HR NC3 NY3 CT2		NH2 ME1										
51785	HR NC2 NY1 CT1 MA1 NH1												
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U.S. Landfalls:

9/27 0530UTC 35.2N 75.6W - 942 mb - RMW 15 nmi - max winds at time of landfall 95 kt - max winds at coast (due to RMW being offshore) 85 kt - NC Category 2 impact

9/27 1600UTC 40.6N 73.3W - 961 mb - RMW 30 nmi - max winds at landfall 75 kt - NY Category 1 impact

9/27 1700UTC 41.2N 73.1W - 962 mb - RMW 30 nmi - max winds at landfall 75 kt - CT, RI, MA, NH Category 1 impact

Major changes to the track and minor alterations to the intensity shown in Neumann et al. (1999). Evidence for these alterations comes from Monthly Weather Review, daily Surface Weather Observations from NCDC, NOAA six hourly maps available via microfilm at NHC, aircraft observations available from the Storm Wallets at NHC, the COADS ship database, the NHC Preliminary Report (Lawrence), Franklin et al. (1988), Jarrell et al. (1992), and Boose et al. (2001).

Sept 16: NOAA indicates a tropical wave extended from 19.5N to 7N along 24E, with the axis center at 14N, 24E. HURDAT lists this system as a tropical depression with 25kt winds at 13.3N, 23.6W at 12Z. Ship highlights: no gales or low pressures. Station highlights: no gales or low pressures. Aircraft Highlights: no gales reported. Satellite Estimate: Meteo found the center at 14N, 24E with Dvorak #1.0 at 12Z. "Based upon the European METEOSAT satellite, the system became a tropical depression near the Cape Verde Islands on 16 September and remained near minimal storm strength for several days while travelling toward the WNW at 8 to 10 ms-1 across the tropical Atlantic Ocean" (MWR).

Sept 17: NOAA indicates a closed low of 1005mb centered at 14.5N, 29.5W at 12Z. HURDAT lists the system as a tropical storm with 35kt winds and 1007mb at 14.6N, 28.3W at 12Z. Ship highlights: no gales or low pressures. Station highlights: no gales or low pressures. Aircraft Highlights: no gales reported. Satellite Estimate: METEO found the center at 14.4N, 28.9W with Dvorak #2.5

at 12Z.

Sept 18: NOAA shows the system as Tropical Storm Gloria centered near 15.3N, 37.5W with a pressure of at most 1008mb at 12Z. HURDAT lists the system as a tropical storm with 35kt winds and 1006mb pressure at 15.1N, 35.9W at 12Z. Ship highlights: no gales or low pressures. Station highlights: no gales or low pressures. Aircraft Highlights: no gales reported. Satellite Estimate: GOES6 found the center at 15.4N, 37.5W with Dvorak #2.5 at 12Z.

Sept 19: NOAA shows the system as Tropical Storm Gloria centered near 15.4N, 42.5W with at most 1012mb at 12Z. HURDAT lists the system as a tropical depression with 30kt winds and 1006mb pressure at 16.6N, 42.2W at 12Z. Ship highlights: 35kt E with 1016mb at 18.9N, 39.5W at 12Z. Station highlights: no gales or low pressures. Aircraft Highlights: no gales or low pressures. Satellite Estimate: GOES6 found the center at 15.2N, 42.3W with Dvorak #2.0 at 1130Z.

Sept 20: NOAA shows the system as Tropical Storm Gloria centered near 17.8N, 47.3W with at most 1008mb at 12Z. HURDAT lists the system as a tropical storm with 45kt winds and 1003mb pressure at 17.5N, 48.1W at 12Z. Ship highlights: no gales or low pressures. Station highlights: no gales or low pressures. Aircraft highlights: no gales. Satellite Estimate: GOES6 found the center at 17.9N, 47.1W with Dvorak #3.0 at 12Z.

Sept 21: NOAA shows the system as Tropical Storm Gloria centered near 17.6N, 54.2W with at most 1010mb at 12Z. HURDAT lists the system as a tropical storm with 60kt winds and 1000mb pressure at 17.7N, 54.2W at 12Z. Ship highlights: 55kt SE with 1013mb at 19.3N, 52.5W at 15Z. Station highlights: no gales or low pressures. Aircraft highlights: 57kt 1500' flight level winds, 1000 mb central pressure at 17.7N, 55.2W with a 15 mile eye diameter at 1703Z. Satellite Estimate: GOES6 found the center at 17.8N, 54.5W with Dvorak #3.0 at 12Z. "Aircraft reconnaissance began on the 21st, when the storm was centered about 750km east of the Lesser Antilles" (MWR).

Sept 22: NOAA shows the system as Tropical Storm Gloria with a pressure of 991mb centered near 17.8N, 58.2W at 12Z. HURDAT lists the system as a hurricane with 70kt winds and 992mb at 17.8N, 58.2W at 12Z. Ship highlights: 45kt SE with 1007mb at 18N, 56W at 03Z; 25kt W with 1005mb at 17.4n, 56.5W at 00Z. Station highlights: no gales or low pressures. Aircraft highlights: 68kt flight level winds from 1500', 991mb central pressure at 17.9N, 58.4W with eye diameter of 25 miles at 1341z; 66kt at 850 mb flight level, 989mb at 18.5N, 59.2W with an eye diameter 30 miles. Satellite Estimate: GOES6 found the center at 17.8N, 58.7W with Dvorak #4.0 at 15Z. "On the next day, a reconnaissance aircraft measured winds of 35m/s at an altitude of 500m, and Gloria was upgraded to a hurricane. The two previous storms (Fabian and Henri) had created a weakness over the western portion of

the strong Atlantic surface ridge of high pressure. The ridge had forced Gloria to maintain its westerly course across the Tropical Atlantic. However, by the 22nd, the hurricane began to respond to this weakness and changed its direction of motion from due west to northwest, placing it on a track to the north of the Leeward Islands."

Sept 23: NOAA shows the system as Hurricane Gloria with at most 1004mb centered near 20.5N, 63W at 12Z. HURDAT lists the system as a hurricane with 65kt winds and 987mb pressure at 20.4N, 62.9W at 12Z. Ship highlights: 40kt SE with 1007mb at 21.4N, 62.7W at 18Z. Station Highlights: no gales or low pressures. Aircraft Highlights: 42kt flight level winds at 700mb, 988mb central pressure at 20.4N, 63W at 1228Z; 45kt flight level winds at 700mb, 978mb central pressure at 20.9N, 64.2W at 1723Z. Satellite Estimate: GOES6 found the center at 20.4N, 63W with Dvorak #4.5 at 12Z.

Sept 24: NOAA shows the system as Hurricane Gloria with 950mb pressure centered near 22.8N, 68.1W at 12Z. HURDAT lists the system as a hurricane with 1000kt winds and 950mb pressure at 22.5N, 67.9W at 12Z. Ship highlights: 45kt SSE with 1013mb at 22N, 62W at 00Z; 45kt ESE with 1010mb at 25.9N, 67.2W at 21Z. Station highlights: no gales or low pressures. Aircraft highlights: 82kt flight level winds at 700 mb, 939mb central pressure at 23.2N, 68.9W observing an eye with 10 mile diameter at 17Z; 84 kt flight level winds at 700 mb, 923mb central pressure at 24.1N, 69.8W at 2330Z, observing an eye with 13 mile diameter.

Sept 25: NOAA shows the system as an intense Hurricane Gloria with 929mb pressure centered near 26.1N, 72.2W at 12Z. HURDAT lists the system as a hurricane with 115kt winds and 926mb pressure at 26.1N, 72.0W at 12Z. Ship highlights: 55kt SE with 1010mb at 27N, 68W at 9Z. Station highlights: no gales or low pressures. Aircraft Highlights: 106 kt flight level winds at 700 mb, 919mb central pressure, 24.3N 70.1W, eye with 8 mile diameter at 0120Z; 86kt flight level winds at 700 mb, 929mb central pressure at 26.4N, 72.5W, with an eye of 15 mile diameter at 1223Z. Satellite Estimate: GOES6 found the center at 26.1N, 71.9W with Dvorak #6.5 at 12Z. "Gloria reached a minimum pressure of 919mb at 0120GTM [today] while located approximately 500km north of Hisapanola, 1500km southeast of Cape Hatteras, or 52 hours prior to landfall."

Sept 26: NOAA shows the system as Hurricane Gloria with 947mb pressure centered near 30N, 75.5W at 12Z, moving towards a very weak stationary front. HURDAT lists the system as a hurricane with 80kt winds and 946mb pressure at 30.0N, 75.5W at 12Z. Ship highlights: 35kt SW with 971mb at 27.3N, 74.2W at 12Z; 55kt NNW with 993mb at 33.5N, 77.6W at 22Z. Station highlights: 73kt N with 995mb at Cherry Point, NC at 2335Z; 77kt NNE with 1000mb at Cape Hatteras, NC at 2250Z. Aircraft highlights: 95 kt flight level winds at 700 mb (NOAA), 945 mb central pressure at 29.1N, 75.1W at 0849 UTC.

Satellite Estimate: GOES6 found the center at 30.1N, 75.1W with Dvorak #5.0 at 12Z. "At 2000GMT [today], buoy 41002, located at 32.4N, 75.3W (about 100km ENE of the center of Gloria) measured a sea height of 14.3m. This was the highest sea ever recorded by a NOAA data buoy in a tropical cyclone" (MWR).

Sept 27: NOAA shows the system as Hurricane Gloria centered 38.3N, 74.8W near the South New Jersey Shore at 12Z, with a cold front extending to its south and a warm front to its southeast but still maintaining tropical characteristics in the center of the cyclone. HURDAT lists the system as a hurricane with 85kt winds and 951mb pressure at 38.4N, 74.5W at 12Z. Ship highlights: 85kt SE with 959mb at 35.2N, 75.3W at 5Z; 95kt S with 997mb at 40.0N, 70.8W at 18Z. Station highlights: 948mb at Cape Hatteras, NC at 536Z; 79kt with 985mb at Cape Hatteras, NC at 0250Z; 965 mb at Bridgeport, CT. Aircraft highlights: 103 kt flight level winds at 700 mb (NOAA), central pressure of 942 mb at 35.4N, 75.6W at 0540 UTC with a 15 nmi eye diameter; 100 kt flight level winds at 850 mb (NOAA), central pressure of 955 mb at 39.6N, 73.9W at 1414 UTC. Satellite Estimate: GOES6 found the center at 38.8N, 74.1W with Dvorak #5.5 at 12Z. "The center of Gloria crossed over the Outer Banks of North Carolina with a central pressure of 942mb early on the 27th and weakened while accelerating NNE. Its center passed just offshore of the mid-Atlantic states, so that the strongest winds remained over water and these states experienced the weaker side of the hurricane. The center moved ashore over western Long Island, about ten hours after the North Carolina landfall, and Gloria became extratropical over Maine [by the end of the day]" (MWR). "NC3, NY3, CT2, NH2, ME1, 942 mb central pressure at landfall" (Jarrell et al.). "Landfall: southern Hatteras Island - 27/0530 35.2N, 75.6W, 942 mb, 90 kt. Landfall: western Long Island - 27/1600 40.6N 73.3W, 961 mb, 75 kt" (Prelim Report). "Gloria - 27 Sep - F2 structural damage peak in nine communities - no change suggested for HURDAT" (Boose et al.).

Sept 28: NOAA shows the Gloria as extratropical without a clear center but near the mouth of the St. Lawrence River in eastern Quebec with at most 992mb at 12Z. HURDAT lists Gloria as an extratropical storm with 50kt winds and 987mb pressure at 49.5N, 64.5W at 12Z. Ship highlights: 50kt S with 995mb at 43.8N, 68.9W at 00Z; 25kt ENE with 970mb at 53.4N, 59.2W at 18Z. Station highlights: 72kt SW with 994mb at Portland, Maine at 0052Z; 65kt S with 989mb at Augusta, Maine at 2355Z.

Sept 29: NOAA does not show the system any longer as it tracked north of 50N and out of the jurisdiction of their agency. HURDAT lists the system as an extratropical storm with 50kt winds and 990mb pressure at 52.4N, 50.0W at 12Z. Ship highlights: 50kt WSW with 975mb at 51.5N, 50.1W at 18Z; 60kt WNW with 989mb at 50.3N, 51.1W at 21Z. Station highlights: no gales or low pressures anymore since it does not affect land for the remainder of its lifetime.

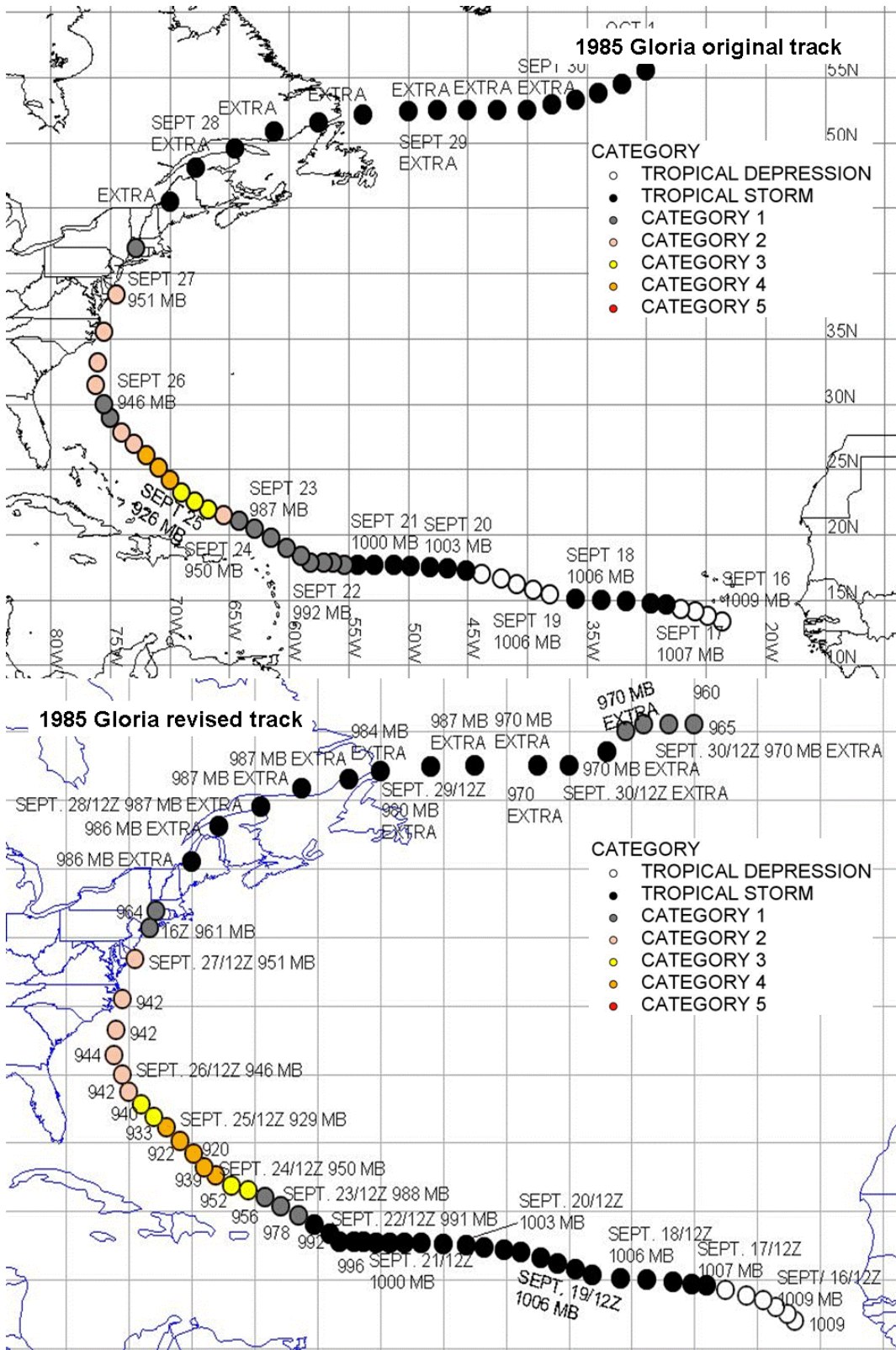
Sept 30: HURDAT lists the system as an extratropical storm with 50kt winds and 990mb pressure at 12z. Ship highlights: 60kt NW with 1006mb at 46.8N, 48.1W at 9Z; 972mb at 53.6N, 36.3W at 18Z.

Oct 1: HURDAT lists the system as an extratropical storm with 50kt winds and 990mb pressure at 12Z. Ship highlights: 5kt E with 969mb at 55.7N, 30.6W at 18Z; 70kt NE with 980mb at 59.1N, 37.3W at 12Z.

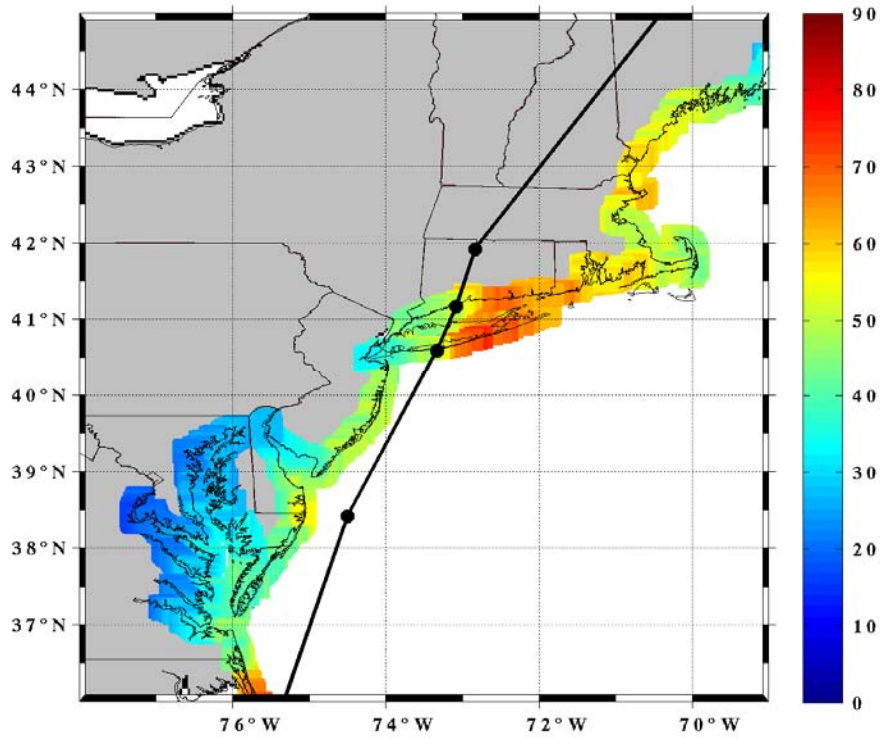
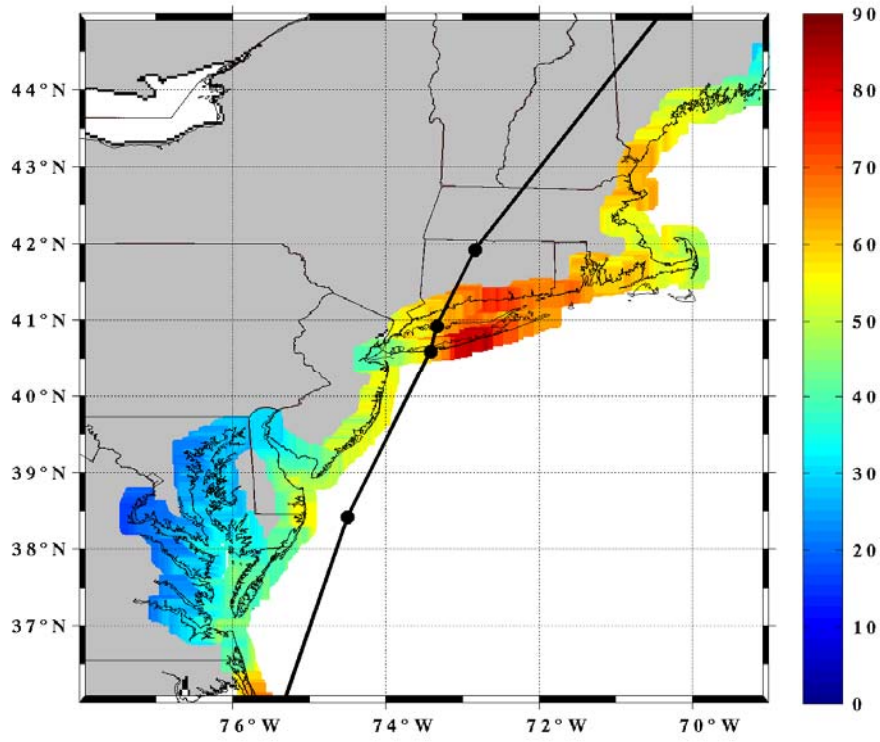
Gloria's genesis is begun twelve hours earlier on the 16th, as surface observations indicate a closed circulation was present by that time. Otherwise, minor track changes were introduced on the 19th, 21st through 26th, and 29th to the 1st. Alterations to the intensity, introduced for all days except the 16th, 17th, and 20th, are relatively minor. A gale force ship from COADS 12 UTC on the 19th is the reason for maintaining minimal tropical storm force throughout the 18th and 19th, despite slightly lower value suggested by Dvorak. First aircraft reconnaissance (Air Force) to investigate Gloria on the 21st found a developing tropical storm. (In general, the Air Force based winds are not reliable due to instrumentation available at the time. The winds are biased low compared with simultaneous NOAA aircraft observations because of the cruder instrumentation available at the time on the Air Force planes. NOAA aircraft winds, however, are trustworthy and used explicitly.) 1000 mb observed at 1703 UTC/21st suggest winds of 47 kt from the southern wind-pressure relationship - 50 kt for 12 and 18 UTC are utilized in HURDAT (down from 60 and 65 kt originally) partly accounting for the small (15 nmi diameter) eye. As directly quoted in MWR: "a reconnaissance aircraft measured winds of 35 m/s [68 kt] at an altitude of 500m, and Gloria was upgraded to a hurricane." This highlights how methodology has changed in the intervening time since Gloria, as flight level winds are now adjusted to the surface rather than used directly into HURDAT. The 991 mb central pressure at 1341 UTC/22nd suggests winds of 63 kt from the southern pressure-wind relationship - 65 kt used in HURDAT down slightly from 70 kt originally. Thus the transition to a hurricane was delayed 18 hours from that shown in HURDAT. Deepening continued on the 23rd and aircraft central pressure was down to 978 mb at 1723 UTC. This suggests 80 kt from the southern pressure-wind relationship - 80 kt chosen for HURDAT, up from 75 kt originally. On the 24th, as Gloria was passing north of Puerto Rico, the hurricane rapidly intensified as pressure reached 939 mb at 1700 UTC. This value suggests winds of 120 kt and 111 kt from the southern and subtropical pressure-wind relationships, respectively. Given the eye diameter of 10 nmi, 120 kt is chosen for HURDAT, up from 105 kt originally at 18 UTC/24th. The hurricane bottomed out at 919 mb at 0120 UTC/25th with an 8 nmi eye diameter. This pressure suggests winds of 136 kt and 124 kt from the southern and subtropical pressure-wind relationships, respectively. Given the tiny eye, winds are chosen at 135 kt at 00 UTC/25th, up from 120 kt originally. On the 26th, Gloria began filling and was

investigated by a NOAA P3. The center fix at 0849 UTC found central pressure had risen to 945 mb and peak flight level winds were 95 kt at 700 mb. Using the Franklin et al. (2003) flight level to surface wind adjustment, this suggests surface winds of 86 kt. Winds are increased from 80 to 90 kt at 06 UTC and 80 to 85 kt at 12 UTC. After the pressure fell to 946 mb, Gloria intensified slightly on the 27th, as it approached North Carolina.

At landfall in North Carolina, the NOAA aircraft found 103 kt at 700 mb and 942 mb central pressure. This flight level wind suggests surface winds of 93 kt. Winds boosted slightly at 06 UTC/27th from 90 to 95 kt. However, given that the right side of Gloria and its radius of maximum winds were just offshore of Cape Hatteras, it is estimated that peak winds in North Carolina were around 85 kt - Category 2. This is a downgrade from Category 3 indicated for this state originally. About ten hours after impacting North Carolina, Gloria hit New York and New England. One final NOAA reconnaissance occurred at 1412 UTC/27th and found flight level winds of 100 kt at 850 mb and 955 mb central pressure. These flight level winds suggest surface winds of about 80 kt. Winds of 85 kt at 12 UTC in HURDAT are retained. Gloria continued to weaken after this aircraft fix and landfall in western Long Island at 40.6N, 73.3W at 1600 UTC/27th with a 961 mb central pressure and 75 kt maximum sustained winds. Gloria made a third landfall in Connecticut around 41.2N, 73.1W at 1700 UTC/27th with 962 mb central pressure and 75 kt maximum wind. Thus New York, Connecticut, Massachusetts, and New Hampshire are analyzed to have been impacted by Category 1 sustained winds. This is a downgrade for New York (Category 3 originally), Connecticut (2), New Hampshire (2), and Maine (1), but an upgrade for Massachusetts (which was not listed originally). A slight reduction in winds at 18 UTC/27th from 75 kt to 70 kt was needed. Extratropical transition at 00 UTC/28th is retained, based upon examinations of Gloria's structure and baroclinicity. The central pressures from 00 UTC/29th until 18 UTC/1st were erroneously set to a constant 990 mb. These were amended (downward primarily) based upon numerous ship observations. Winds are reduced downward late on the 28th through 12 UTC on the 29th, as observations showed that the extratropical stage of Gloria weakened considerably at first. But by late on the 29th, ET-Gloria reintensified and reached hurricane force on the 1st based upon two ship observations.



Original and revised Hurricane Gloria track maps.



Original and revised Hurricane Gloria windswaths.