NOTES AND CORRESPONDENCE

Comments on "Structure and Evolution of a Possible U.S. Landfalling Tropical Storm in 2006"

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ABSTRACT

The Best Track Change Committee of the National Hurricane Center evaluates proposed changes to the Hurricane Database (HURDAT) in the Atlantic and eastern North Pacific basins. In the companion paper, Gruskin documents a possible tropical cyclone that affected portions of the eastern United States on 27–28 June 2006 and proposes that it be added to HURDAT. The committee reviewed the aircraft, radar, rawinsonde, satellite, and surface data available on this system and found it to be a challenging and complex system. A reconnaissance aircraft flying in the system in real time failed to find a closed circulation before landfall, and kinematic parameters suggest the system was more likely to have the structure of an open wave, with any surface circulation at best being poorly defined. Because of the lack of conclusive evidence regarding the existence of a closed surface circulation before landfall, the committee has decided not to add this system to HURDAT as a tropical cyclone.

1. Background

The authors of this note are the current members of the Best Track Change Committee at the National Hurricane Center. To quote from the committee's charter: "The final 'best-tracks' are prepared by the National Hurricane Center (NHC) hurricane specialists at the conclusion of every Atlantic and eastern north Pacific tropical cyclone. These tracks represent the best estimate of tropical cyclone position, intensity and status every six hours during its life cycle. They are based on a comprehensive analysis of all available observational data. Once completed, these tracks are added to the historical tropical cyclone database for each basin. These files (1851 to the present for the Atlantic, 1949 to the present for the eastern north Pacific) are used at NHC for verification of forecasts and other internal applications. They are also used extensively by the research, academic and insurance communities, as well as the media and the public. The best-track files are not static, but rather represent the best current estimates for tropical cyclone track and intensity, given the observations and science available at the time. Newly acquired observations, reinterpretation, or reanalysis may indicate changes to these tracks. Such changes must be dealt with in an organized and well-documented manner." It is the committee's job to evaluate proposed changes to the Hurricane Database (HURDAT) for the Atlantic and eastern North Pacific basins "in an organized and well-documented manner," both for known tropical cyclones (TCs) and for potential new TCs to be added (e.g., Gruskin 2010).

Most of the proposed changes the committee has dealt with since its inception have been provided by the Atlantic Hurricane reanalysis project (Landsea et al. 2004a; Landsea et al. 2008), with the occasional inclusion of special cases such as the reanalysis of Hurricane Andrew (Landsea et al. 2004b). While it is unusual for a proposed change to come through a peer-reviewed journal article, Fay (1962) documented a previously unaccounted-for TC in September 1961, similar to the Gruskin (2010) system. This system was subsequently added to the tracks of the 1961 hurricane season (Dunn 1962).

The NHC uses the following definition of TCs: A warm-core nonfrontal synoptic-scale cyclone, originating

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over tropical or subtropical waters, with organized deep convection and a closed surface wind circulation about a well-defined center (Office of the Federal Coordinator for Meteorology 2009). Any possible TC proposed for addition to HURDAT should meet this definition.

2. Discussion of the June 2006 case

Gruskin (2010) describes the history, structure, and impacts of a possible TC that crossed the North Carolina coast on 27 June 2006 and subsequently moved through the mid-Atlantic states. In its analysis, the committee examined aircraft, radar, rawinsonde, satellite, and surface data available for the case.

One characteristic of the system was its small size, both in the overall diameter and the inner core. Surface observations suggest the system's pressure field was less than 185 km across for most of its life. Radar and aircraft data showed that the inner wind core had a radius of maximum winds (RMW) of ~7 km. TCs can have RMWs this small, as seen in Hurricanes Charley (2004; Franklin et al. 2006) and Wilma (2005; Beven et al. 2008). However, it is also close to the scale of non-TC mesocyclones associated with supercellular convection (Davies-Jones et al. 2001). Satellite and radar data suggest that supercells did not play a significant role in the development and maintenance of the core. Instead, the convection was in spiral bands typically seen in TCs.

Temporally, the inner core was present in Doppler radar velocity data for about 7 h prior to landfall, and it persisted for more than 15 h after landfall. How long the inner core was present before coming onto the range of the land-based radars is unknown.

Gruskin (2010) shows that the inner core was associated with a 4–5-hPa pressure fall at the surface stations that sampled the system center. This is consistent with the pressures observed by the aircraft that traversed the core near 1732 UTC 27 June and other observations. The central pressure measurements were in the 1008–1011-hPa range. Nearby observations indicate pressures of 1014 hPa or higher around the system on all sides, so it had a well-defined, but small, surface low pressure area.

Figure 11 in Gruskin (2010) is a Doppler velocity cross section showing that the strength of the vorticity center decreased with increasing height, indicating that it had a warm core similar to TCs. The cross section and other radar velocity data suggests that the vortex extended upward only to a level of 4 km. However, a vorticity maximum was apparent in the radar data above that up to a 6–7-km level. What this means in terms of TC characteristics is unclear, as systematic data on the vertical extent of TCs are scarce. However, mature TCs can reach heights of 12 km or more (Elsberry et al. 1987). Surface and upper-air data showed little or no temperature gradient near the system on 27 June, suggesting that the cyclone was not extratropical or some type of hybrid system.

TABLE 1. Aircraft flight-level wind data at 300 m for the period 1724–1739 UTC 27 Jun 2006. Data are at 30-s intervals. Latitudes and longitudes are in degrees and minutes. The boldface entry is the time of the lowest pressure.

Time (UTC)	Lat	Lon	Wind direction (°)	10-s avg wind speed (m s^{-1})
1724	34°13′	76°33′	159	21.6
	34°13′	76°35′	157	20.6
1725	34°12′	76°36′	154	20.1
	34°11′	76°38′	150	20.1
1726	34°10′	76°39′	148	19.1
	34°09′	76°40′	147	19.1
1727	34°08′	76°42′	146	19.1
	34°07′	76°43′	143	21.1
1728	34°06′	76°44′	154	19.6
	34°05′	76°45′	151	18.0
1729	34°04′	76°47′	149	20.1
	34°03′	76°48′	149	20.1
1730	34°02′	76°50′	145	22.2
	34°02′	76°51′	151	23.7
1731	34°01′	76°52′	154	25.3
	34°00′	76°54′	154	25.3
1732	**33°59′**	**76°55′**	**156**	**16.5**
	33°58′	76°57′	227	5.2
1733	33°58′	76°58′	252	7.7
	33°57′	77°00′	254	5.2
1734	33°57′	77°02′	258	9.8
	33°56′	77°03′	245	9.8
1735	33°55′	77°05′	241	8.8
	33°55′	77°06′	237	8.8
1736	33°54′	77°07′	232	8.8
	33°53′	77°08′	237	10.3
1737	33°52′	77°10′	234	8.8
	33°51′	77°11′	239	8.8
1738	33°50′	77°12′	236	8.8
	33°49′	77°13′	224	8.2
1739	33°47′	77°14′	217	9.8
	33°46′	77°15′	218	9.8

This system was not called a TC in real time because the reconnaissance aircraft did not find a closed wind circulation. This is a complex issue because of the following factors:

1) Fig. 6 in Gruskin (2010) shows the aircraft (flying at 300 m) sampled the western edge of a small area of outbound (northerly) winds seen in Doppler radar data just west of the center near 1800 UTC. It is possible an existing circulation was not properly sampled.
2) The 1732 UTC aircraft traverse found southwesterly winds to the southwest of the center (again at 300 m, Table 1), where northwesterly winds should have been found if a closed circulation existed.

3) The northerly winds in the Doppler velocities did not appear until about 1800 UTC, suggesting the circulation could have formed after the 1732 UTC traverse.

There are two other factors to be considered concerning the presence or lack thereof of a closed circulation before landfall:

1) The proposed best track in Gruskin (2010) indicates the strongest winds were near 20 m s^{-1} while the system was moving at least 11 m s^{-1}. Kinematically, this implies that the rotational velocity of the vortex was about 9 m s^{-1}, and on the west side the translational southerly flow would be stronger than the rotational northerly flow. Thus, a wavenumber 1 asymmetry based on system motion and these numbers suggests any circulation would be at best poorly defined, with the total wind field more likely to resemble an open wave. The aircraft flight-level data support this, being more representative of an open wave than a closed circulation.
2) Gruskin (2010) notes the northerly winds at station C2542 at landfall. However, the measured velocities were less than 3 m s^{-1}. This is also consistent with the poorly defined circulation implied by the system's kinematics. Reconnaissance aircraft normally do not accurately detect surface wind direction at speeds that light, either with data from the Stepped Frequency Microwave Radiometer or visual examination of the sea surface. Thus, the aircraft usually would not report a closed circulation even if it sampled the area in question. Based on this, the NHC would normally not call such a system a TC because of a lack of evidence of a closed circulation.

3. The committee's decision

After reviewing the available data, the Best Track Change Committee has decided that this system will not added to HURDAT as a new tropical storm. The members' greatest concern was the lack of conclusive evidence of a closed wind circulation prior to landfall as seen in the factors listed above.

The committee acknowledges that the system most resembles a TC in terms of structure and likely energetics. There is little evidence of baroclinic influence on the development, and the small RMW and spiral convective bands likely did not result from supercelluar convective processes. The committee also acknowledges that in contrast to the issues with the wind circulation, the system had a well-defined area of low pressure. Thus, the system could count as a TC under a definition that uses pressure criteria instead of the wind circulation criteria in the NHC definition.

The committee wishes to thank the author for his work on this challenging weather system. The committee invites the author and others to continue research on this and other similar systems to aid our understanding of them and to help improve the associated forecast and warning processes.

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