5D6. A Record Wind Measurement in Hurricane Isabel: Direct Evidence of an Eyewall Mesocyclone?

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I. Introduction

On 13 September, 2003, a dropwindsonde released along the inner edge of the eastern eyewall of Hurricane Isabel measured horizontal and vertical winds of 107 ms^{-1} and 25 ms^{-1}, respectively, at about 1400 m above sea level. This is likely the strongest horizontal wind ever directly measured in a tropical cyclone, and is in the upper 1% of measurements for the vertical wind. The behavior of the instrument suggests the possibility of an eyewall mesocyclone in a strong convective burst, and the measurement has implications for theories on tropical cyclone intensity change and potential intensity.

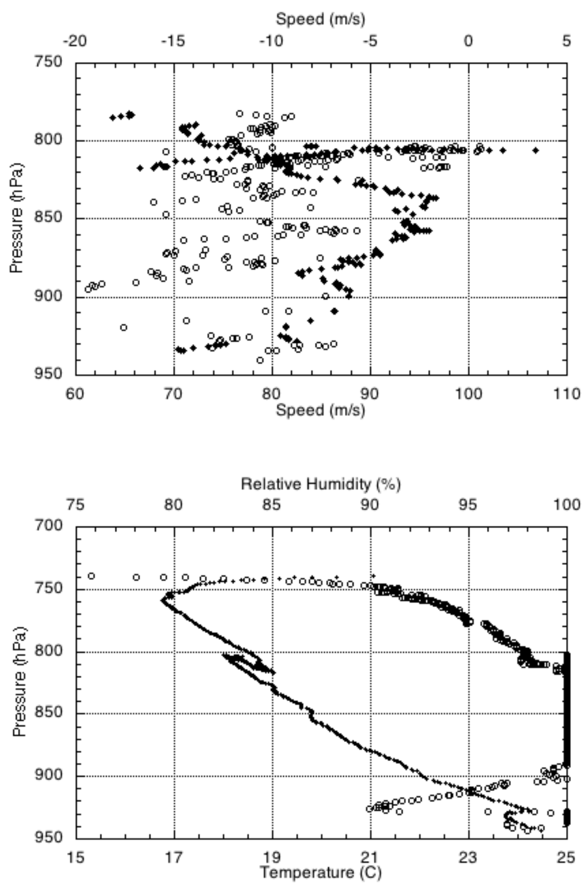

Figure 1. Raw 1 Hz data from dropwindsonde released in Hurricane Isabel at 1752 UTC 13 September, 2003. Horizontal and vertical motion of the dropwindsonde (top), and temperature and humidity during descent.

II. Data

Figure 1 shows the raw data from the dropwindsonde released just inside the eastern eyewall at 1752 UTC 13 September just below 800 hPa, or about 1400 m above sea level, the dropwindsonde encountered a region of very strong updrafts at the top of a saturated air layer. Horizontal winds reached 107 ms^{-1}, and an updraft of nearly 25 ms^{-1} caused the instrument to rise nearly 200 m and remain suspended for nearly 90 s before resuming its regular descent at about 11 ms^{-1}. When the descent resumed, the air temperature was about 1K cooler than the air temperature at the same level in the strong updraft. During the instrument descent, the wind oscillated from less than 70 ms^{-1} to nearly 100 ms^{-1} at least three times, suggesting the possibility of a rotation within the mean circulation of the tropical cyclone.

Aircraft flight-level (~2750 m) wind measurements at the time of the observation (Fig. 2) shows a directional wind shear of 20 degrees, suggesting some rotation reaching the altitude of the aircraft. Figure 3 shows a number of strong

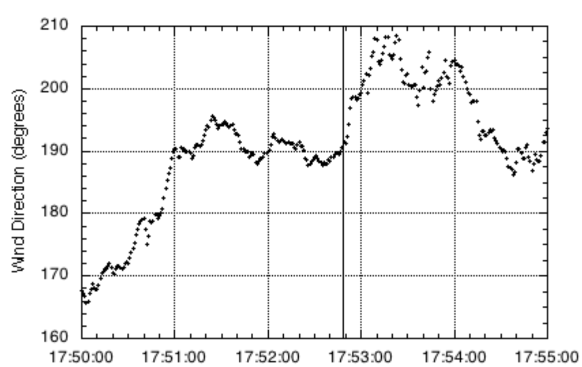

Figure 2. Flight-level wind direction around the time of the dropwindsonde release, shown by the vertical line.

Reflectivity features jutting into the eye at about the time of the dropwindsonde release. These features can be tracked in subsequent radar sweeps during the descent of the dropwindsonde. They are calculated to be rotating in the inner eyewall at roughly 70-80 ms^{-1}, coinciding approximately with the mean observed wind speed during the time it was suspended by the updraft. The dropwindsonde therefore seems to have been suspended in one of these features during the time of the extreme wind measurement. Also note in Fig. 3 that the inner edge of the eyewall has features resembling Kelvin-Helmholtz waves which have been shown in experimental tank tests and numerical simulations to form eyewall mesovortex-like features (Kossin and Schubert 2001, Montgomery et al. 2002).

III.Implications

The dropwindsonde data shown above offers intriguing evidence of the possibility of a very strong eyewall mesovortex. Montgomery et al. (2002) suggest that the strongest winds in tropical cyclones may occur in such eyewall mesovortices, and that wind speeds similar to those measured here may be features of these mesovortices. However, theories on the maximum potential intensity (MPI) of tropical cyclones do not allow for winds as strong as those measured in Hurricane Isabel. It should be noted, though, that MPI theory estimates sustained winds at the top of the boundary layer, not at the height of these observations (Persing and Montgomery 2003). The relatively quiescent environment in which Hurricane Isabel persisted for three days (low environmental shear, no interactions with midlatitude or tropical upper-tropospheric troughs, relatively uniform warm waters below) allowed the tropical cyclone to remain at or near category 5 status. This environment, and the observations taken during this time, provide a unique opportunity to test hypotheses concerning eyewall mesovortices and maximum potential intensity.

Additionally, this observation may be the first direct observation of a feature similar to that encountered by the NOAA aircraft during penetration of the eyewall of Hurricane Hugo on 15 September, 1989 (Marks and Black 1990 , Black and Marks 1991). During that penetration, the aircraft encountered very large up- and down-drafts leading to severe turbulence and damage to the aircraft. This observation may also provide insight into the small-scale features that led to the extreme damage caused by Hurricane Andrew as it made landfall in South Florida on 23 August, 1992 (Wakimoto and Black 1994).

IV. References

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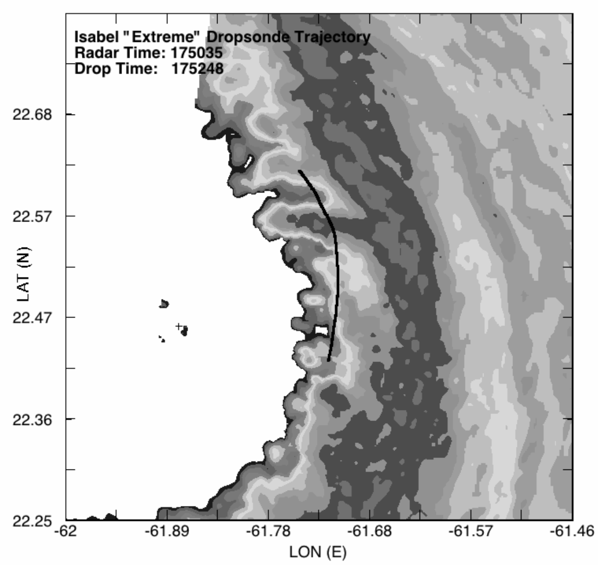

Figure 3. A single reflectivity sweep from the aircraft belly radar at 1750 UTC 13 September 2003. The black line shows the trajectory of the dropwindsonde during descent.