11D.4 OBSERVED EVOLUTION OF EYEWALL CONVECTION AND LOW-WAVENUMBER FLOW IN HURRICANE GUILLERMO (1997)

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1. INTRODUCTION

Animations of radar reflectivity in the hurricane inner core often depict an azimuthal distribution of deep eyewall convection comprised of multiple transient convective cells superimposed upon a quasi-persistent low-wavenumber structure. Recent observations and numerical simulations suggest that environmental vertical wind shear and internal dynamical processes significantly influence such azimuthal distribution (Reasor et al. 2000; Braun 2002). The vertical shear will induce a wavenumber-one asymmetry with enhanced convergence and ascent downshear. The more-transient higher-wavenumber "mesovortices", which rotate cyclonically around the eye and eyewall, will further enhance the ascent in those regions where mesovortical induced outflow converges with the low-level inflow associated with the environmental shear. Recently, Eastin (2003) demonstrated that a considerable fraction of the eyewall vertical mass transport was associated with transient, buoyant, convective-scale updrafts. In some cases, the high equivalent potential temperatures (θ_e) observed in the buoyant updrafts at midlevels were only observed elsewhere in the low-level eye, suggesting an origin in the low-level eye and an association with mesovortical outflow. The objective of this study is to further elucidate the organization and evolution of asymmetric eyewall convection within the context of environmental vertical wind shear, low-wavenumber flow, and thermodynamics through the aid of a unique dual-Doppler dataset.

2. OBSERVATIONS AND DISCUSSION

Two NOAA P-3 aircraft observed the inner core of Hurricane Guillermo between 1800 and 2400 UTC on 2 August 1997. During this period, the hurricane was moving westward over $> 29°$C waters through moderate north-northwesterly vertical shear and was intensifying at an average rate of 2.4 mb hr^{-1} from an initial central pressure of 959 mb. The aircraft flew six coordinated orthogonal passes through the inner core at 3.0 and 5.5 km altitude. Dual-Doppler wind fields were constructed for each coordinated pass following Gamache (1997) and then decomposed into azimuthal mean and perturbation com-

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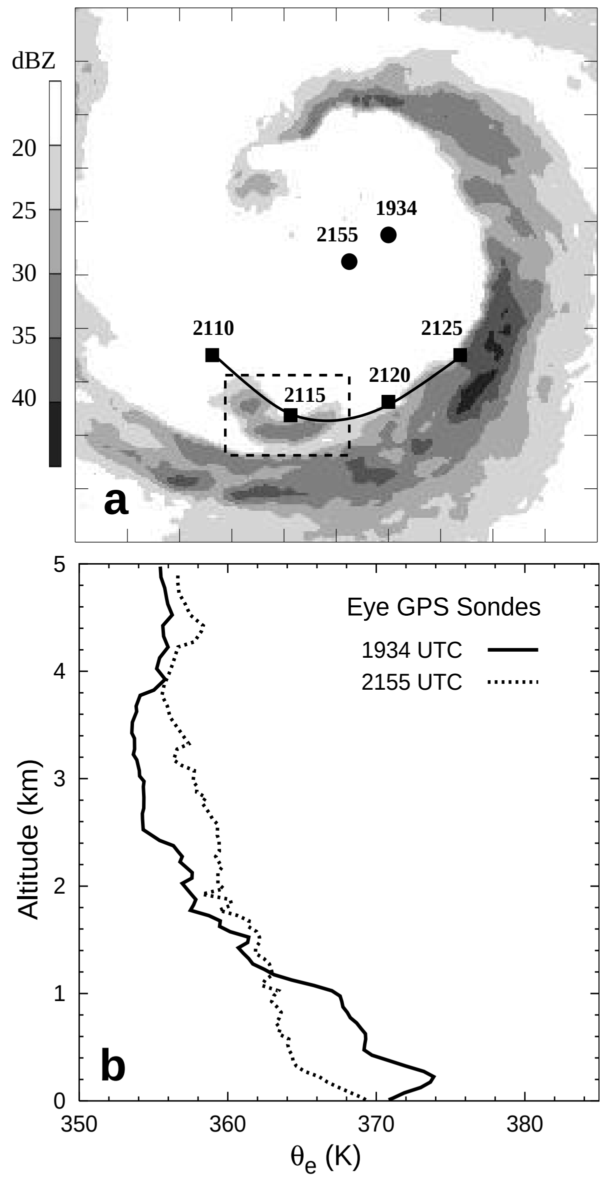

Figure 1: (a) Radar reflectivity at 5.5 km altitude at 2115 UTC on 2 August. The domain is 80×80 km and tic marks are shown every 8 km. GPS dropsonde (filled circles) and convective cell (filled squares) locations and times are also shown. (b) Profiles of θ_e obtained by the GPS sondes.

ponents following methods similar to Reasor et al. (2000). In contrast to previous Doppler radar studies of intense hurricanes, the cloud-filled eye on this day (and on 3 August) has permitted unprecedented wind field documentation throughout a large fraction of the eye.

The observations discussed here focus on the third pass between 2100 and 2130 UTC. Radar animations from both aircraft depict a persistent wavenumber-one reflectivity pattern in the southern and eastern quadrants. At 2110 UTC a prominent convective cell developed along the inner edge of the southwest eyewall (see Fig. 1a). By 2125 UTC the cell had tracked cyclonically around to the southeast and was merging with the wavenumber-one reflectivity pattern. After 2125 UTC the cell was untrackable as a unique feature.

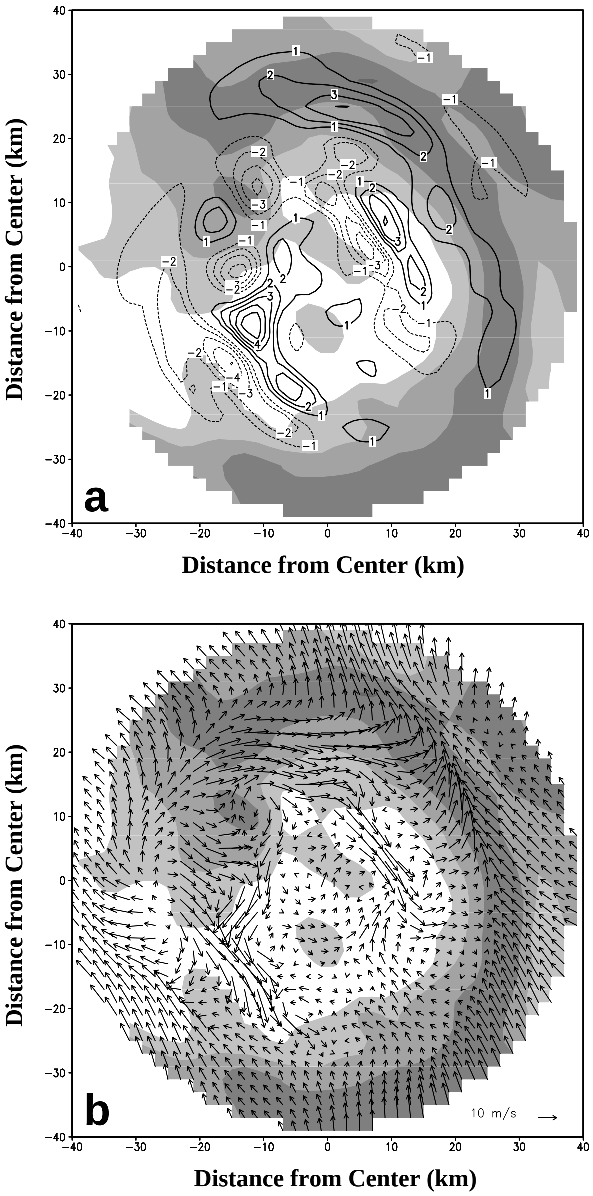

Figure 2: (a) Perturbation vorticity ($\times 10^{-3}$ s^{-1}) and (b) perturbation winds at 2 km altitude from 2106 to 2129 UTC on 2 August. Shaded contours show the 10, 20, and 30 dBZ levels of radar reflectivity.

The total perturbation vorticity (Fig. 2a) and wind (Fig. 2b) fields at 2 km altitude exhibit a rich asymmetric structure. Similar perturbation fields were also observed at 1 km and 3 km. Of interest here, are the mesovortices along the eye/eyewall interface in the southwest quadrant and their associated enhanced outflow from the eye. This outflow is converging with the southerly inflow associated with the environmental shear at roughly the same location where the convective cell developed (Fig 1a).

It is interesting to also note that $\theta_e > 365$ K was predominant in the eye below 1 km during the second pass (at 1934 UTC in Fig. 1b) but not during the fourth pass (at 2155 UTC). Furthermore, as the upper aircraft passed through the east eyewall on the third pass, a convective updraft exhibiting positive local buoyancy and $\theta_e > 368$ K was encountered. Of 14 eyewall updrafts encountered after the third pass, several were positively buoyant but none exhibited $\theta_e > 366$ K. While the convective updraft and convective cell of the third pass cannot be uniquely associated, these observations further imply a link between mesovortical flow across the eye/eyewall interface, the generation of buoyant eyewall convection, and the depletion of a high-θ_e reservoir in the low-level eye.

We have presented compelling observational evidence that mesovortical outflow from the low-level eye can help generate deep eyewall convection. Results concerning the *evolution* of the environmental shear, perturbation flow, and eyewall convection will be presented at the conference.

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