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OBSERVATIONS OF THE EVOLUTION OF PRECIPITATION AND KINEMATIC STRUCTURE IN A HURRICANE AS IT ENCOUNTERED STRONG WESTERLY SHEAR

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1. INTRODUCTION

Recent analytic and numerical modeling of hurricanes suggests the presence of vortex Rossby waves in the core of hurricanes. Such studies include those of Montgomery and Kallenbach (1997) and Wang (2001). Obtaining conclusive evidence of such structures in observations is difficult; however, features that strongly suggest the role of Rossby waves (particularly wave number two) have been seen in Typhoon Herb by Kuo *et al.* (1999), and in Hurricane Olivia by Reasor *et al.* (2000). The difficulty in the case of Typhoon Herb is the lack of dual-Doppler analysis of the feature, although sufficient temporal resolution may have existed. In Hurricane Olivia, sufficient airborne dual-Doppler coverage existed, but the temporal resolution was only approximately 30 minutes.

In this study we revisit the data analyzed by Reasor et al. (2000), and consider in particular the possible interaction of the wave number two Rossby wave with the strong wave number one asymmetry in convergence/divergence. The wavenumber one pattern resulted from Hurricane Oliviia's interaction with the rapid onset of vertical shear in the core, and was probably aided by the ingestion of dry air as the hurricane approached a strong sea-surface temperature front.

2. OBSERVATIONS

The observations discussed here were obtained between 2020 UTC on 25 September and 0015 UTC on 26 September 1994 in Hurricane Olivia, an eastern Pacific Hurricane. At the beginning of the period, the hurricane was highly symmetric with a central pressure of 925 mb with very little vertical shear in the core, while 4 hours later the storm was very asymmetric with intense precipitation with a maximum of 55 dBZ observed to the north by the vertically scanning radar, and very little precipitation to the south. The westerly shear had reached over 15 m s^{-1} in the core, and the central surface pressure had risen to 937 hPa, therefore at an average rate of 3 hPa h^{-1}.

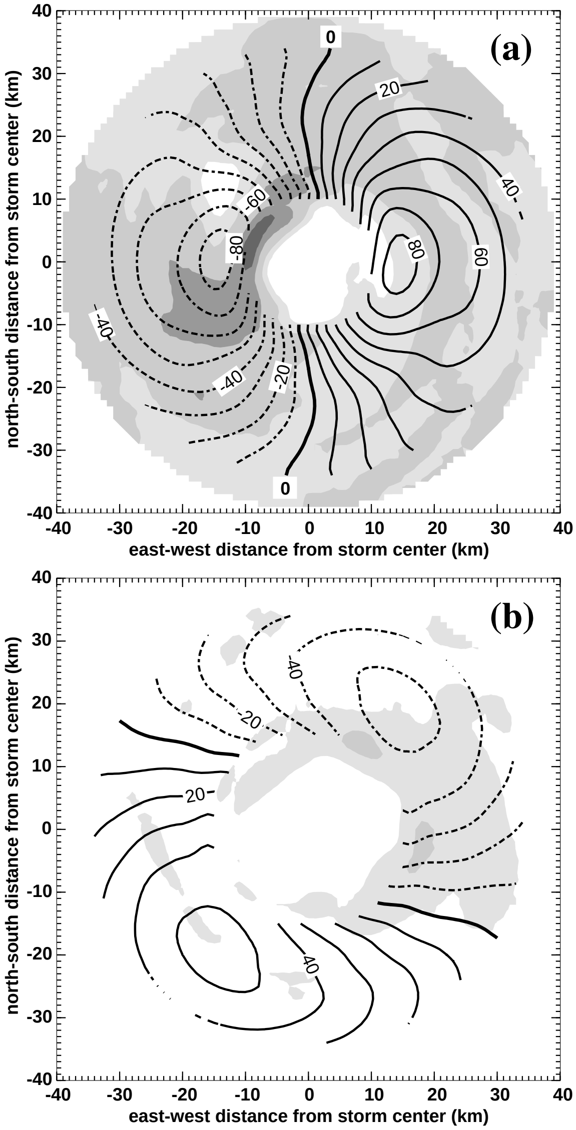

Figure 1. Wavenumber-1 velocity potential (x 1000 m^2 s^{-1}) at 1-km (a) and 9-km (b) levels. Irrotational wind points toward positive gradient. Shaded contours show 20, 30, 40, and 45 dBZ levels of radar reflectivity.

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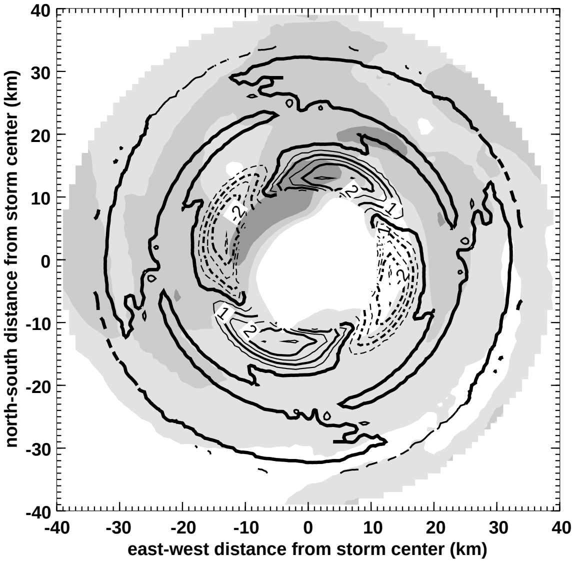

Figure 2. Wavenumber-2 vorticity (x .001 s^{-1}) at 3-km level. Radar reflectivity as in Fig. 1.

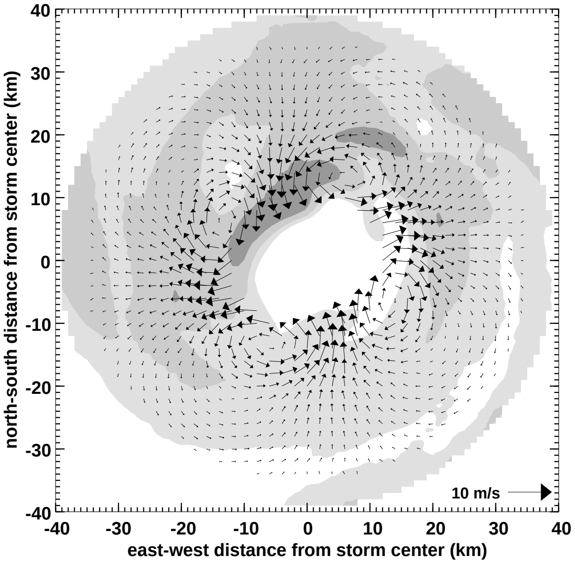

Figure 3. Wavenumber-2 non-divergent wind at 3-km level. Reflectivity as in Fig 1

One response of the core circulation was to set up a strong wavenumber-one divergent irrotational wind field that opposed the shear inside the radius of maximum wind, thus reducing the shear in the eye. This circulation may be seen in the wavenumber-one velocity potential shown in Figs. 1a and b for 1 and 9 km heights. This flow is westerly at low levels and north-easterly at high levels across the eye, while the environmental relative flow is easterly at low levels and westerly at high levels.

At the time shown in Fig. 1, the Doppler analysis also showed a strong wavenumber–2 circulation. In fact, the wavenumber-2 vorticity actually had a stronger amplitude than wavenumber-1 (Reasor et al. 2000). The wavenumber-2 vorticity at the 3-km level is shown in Fig. 2, and the wavenumber-2 non-divergent circulation is shown in Fig. 3. These show a very good correlation between wavenumber 2 and the low-echo vault region with high vertical wind (not shown). It appears that the wavenumber-2 pattern rotated cyclonically through the wavenumber-1 convergence maximum, resulting in a wavenumber-1 stretching of the wavenumber-2 vorticity. The result should be an increase in the wavenumber 1 and 3 vorticity amplitudes, and thus an increase in the asymmetric distribution of vorticity.

Unfortunately, attenuation of the PPI radar reflectivity made it difficult to track radar features consistently and correlate them with Doppler vorticity analyses that come only every 1/2 h. It is thus quite difficult to verify that the rotation rate of the vorticity pattern matches the theoretical 1/2 V_{tmax}. It appears from analysis of Olivia the day before, however, that it may be possible to make this correlation in a hurricane less disrupted by strong shear. Such a case may be discussed at the conference.

3. REFERENCES

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