P5A.1 **MANTLE ECHOES ASSOCIATED WITH DEEP CONVECTION DURING IHOP: OBSERVATIONS AND NUMERICAL SIMULATIONS**

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1. INTRODUCTION

There have been numerous laboratory and numerical simulations of thermal or buoyant plumes. Detailed observations in the atmosphere, however, have been limited to shallow thermals and cumulus clouds. Indeed, to the authors' knowledge, there have been no radar observations of the vertical structure of deep convection during the early stages of development shown in the literature. This lack of data is surprising in light of the numerous years that radars have been used to probe convection.

A large, multiagency and international program called IHOP (International H_2O Project) was held during the spring and summer of 2002 in Texas, Oklahoma, and Kansas. One of the primary objectives of the program was to better understand the processes leading to initiation of convection along convergence boundaries within the convective boundary layer. On two days during the experiment, unique vertical cross sections of the early stages of deep convection were collected by ELDORA onboard a Navy P-3.

2. JUNE 12, 2002

A triple point, east of the surface low pressure center, evident at the intersection of two boundaries seen in the WSR-88D scans recorded from Dodge City, is shown in Fig. 1. The P-3 flew approximate east-west legs along one of the boundaries and through the triple point.

The wind synthesis for the pass from 2102:02 – 2113:01 UTC is shown in Fig. 2. The two boundaries and the triple point are clearly visible. Bands approximately oriented in a northwest to southeast direction can be seen along the east-west boundary (also evident in Fig. 1). First echoes began to form east of the triple point. The P-3 flew underneath one of the developing echoes while an ELDORA scan provided a view of the vertical structure of the storm (Fig. 3). Striking in the image is the 'mushroom cloud' appearance (or mantle echo) with maximum reflectivities in excess of 32 dBZ. Spectral widths (not shown) revealed maximum values aloft within the mantle with relatively low values in the 'trunk' of the echo. The latter observations would suggest laminar flow if the spectral widths can be considered a proxy for turnbulence.

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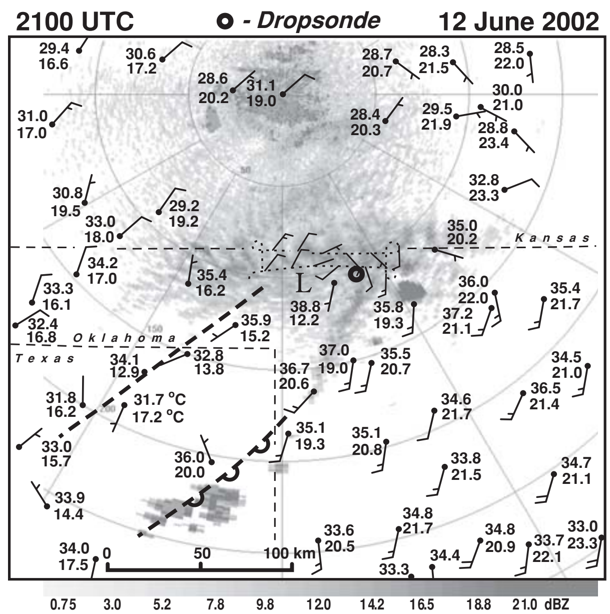


Fig. 1 Surface analysis at 2100 UTC 12 June superimposed onto a WSR-88D radar reflectivity image from Dodge City, Kansas. The black circle represents the location of a dropsonde. The dotted line represents the flight track of the P-3.

3. JUNE 19, 2002

A dryline was positioned in northwest Kansas on June 19 and was apparent as a windshift and radar fine line (Fig. 4). The wind synthesis at a time when first echoes were developing (2137:00- 2149:22 UTC) is shown in Fig. 5. A distinct speed shear is noted across the cold front. Similar to the case on June 12, the aircraft flew directly underneath a developing echo while ELDORA recorded another dramatic image of a mantle cloud (Fig. 6). Maximum radar reflectivities were only ~13 dBZ at a height of 10 km AGL. Maximum updrafts based on the single Doppler velocities measured by the vertically pointing radar exceeded 30 ms^{-1} (not shown). A pronounced weak-echo vault can be seen in the image.

4. NUMERICAL SIMULATIONS

The radar observations on June 12 and 19 provided the verification for a series of numerical simulations using the ARPS model. Preliminary results for both cases showed that the bulk cloud microphysical parameterization as typically config-

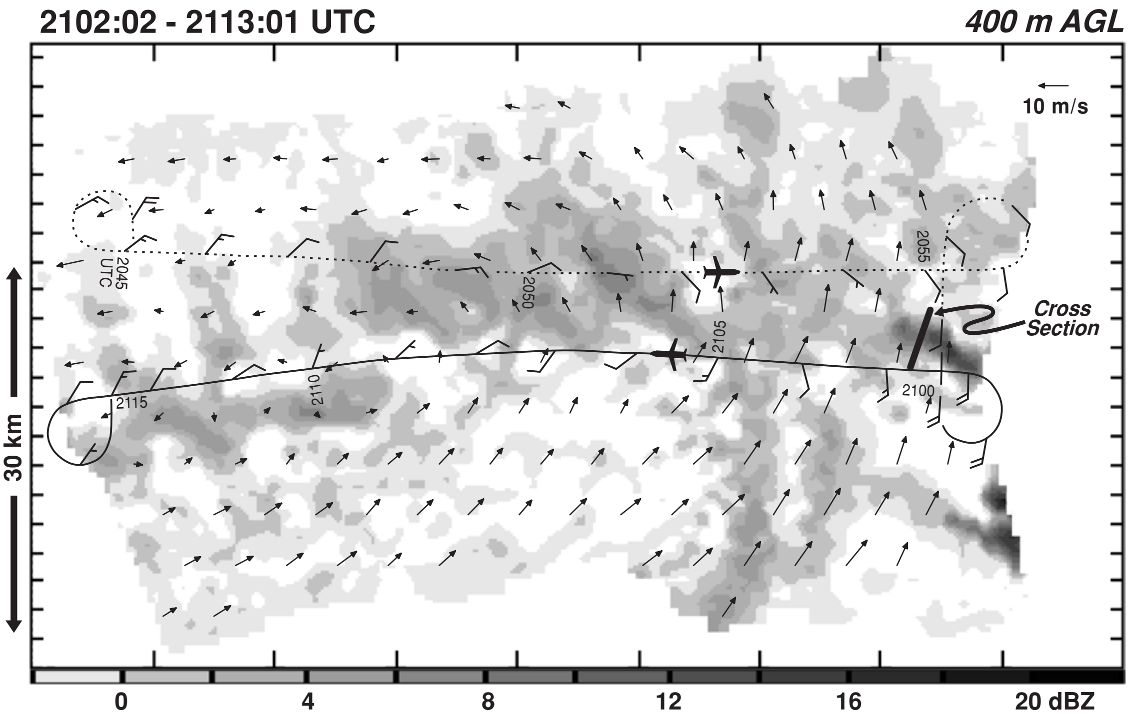


Fig. 2. Radar reflectivity and Doppler wind syntheses at 400 m AGL from 2102:02 – 2113:01 UTC 12 June. The flight-level track and winds are plotted on the figure. The wind synthesis presented in the figure is based on the portion of the flight track drawn as a black line. The thick, black line represents the location of the ELDORA tail radar scan presented in Fig. 3.

ured converts cloud water into precipitation too quickly. Conversion rates and fallspeeds were reduced based on microphysical arguments proposed by other investigators and were found to produce more realistic results. Examples of the simulations are presented in Fig. 7 and are close to matching the observations shown in Figs. 3 and 6.

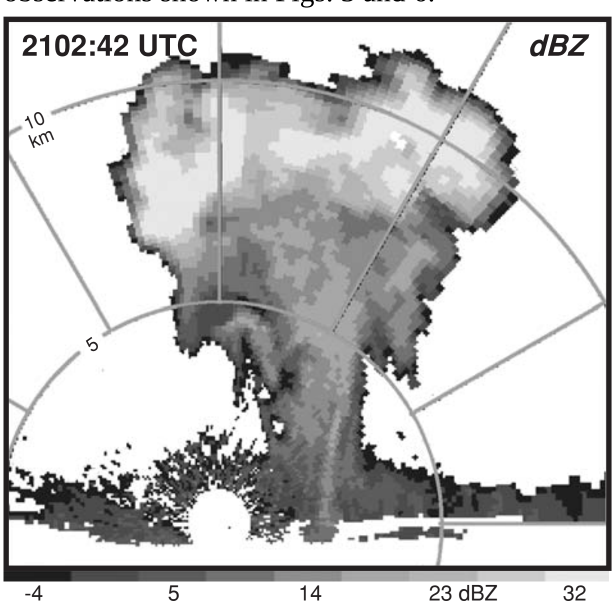


Fig. 3. ELDORA tail radar scan of radar reflectivity through a developing storm on 12 June at 2102:42 UTC. The location of scan is shown in Fig. 2.

Preliminary conclusions suggest that the shape of the mantle echo is a sensitive function of the thermal ascent rate and whether gravity waves are produced during (or as a consequence of) the thermal ascent. There was a slower ascent of the June 12

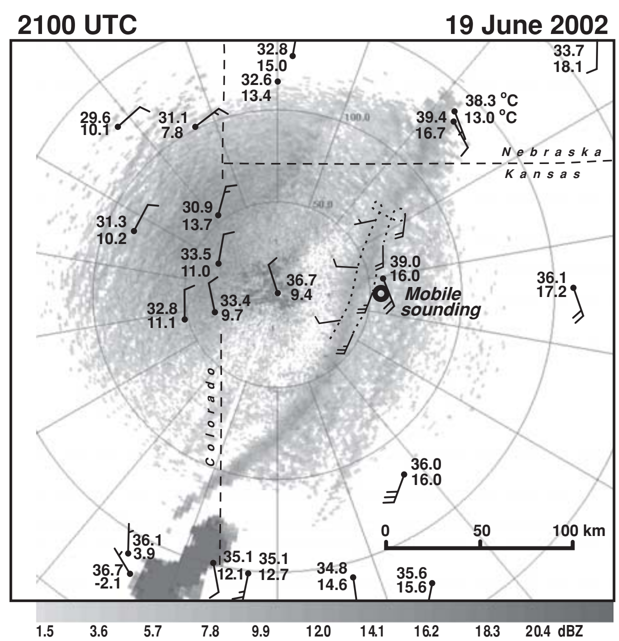
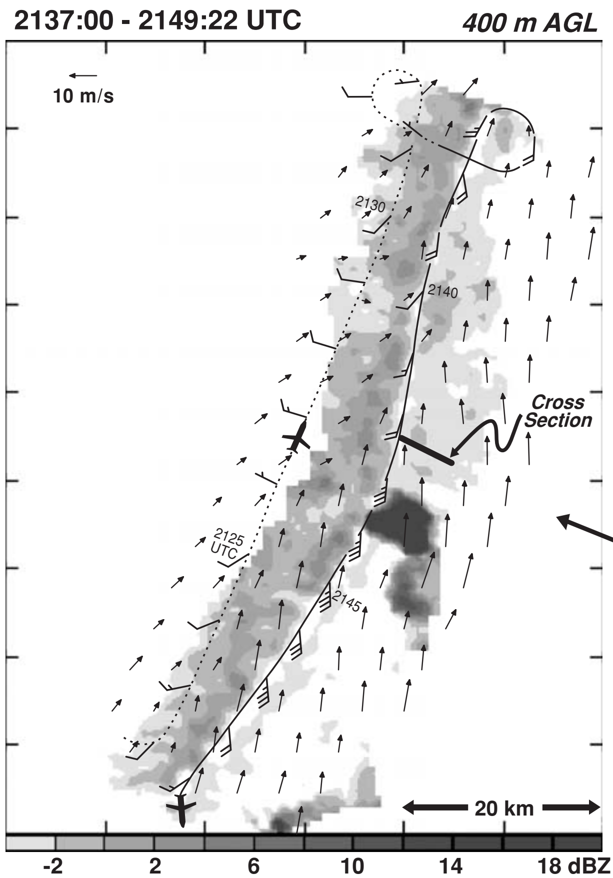


Fig. 4 Surface analysis at 2100 UTC 19 June superimposed onto a WSR-88D radar reflectivity image from Goodland, Kansas. The black circle represents the location of a mobile sounding. The dotted line represents the flight track of the P-3.



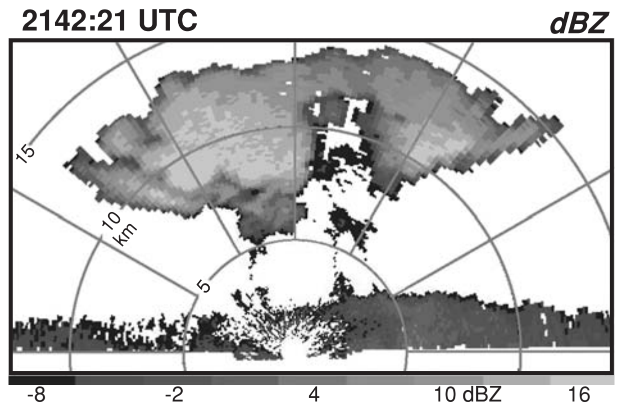


Fig. 6. ELDORA tail radar scan of radar reflectivity through a developing storm on 19 June at 2142:21 UTC. The location of scan is shown in Fig. 5.

Fig. 5. Radar reflectivity and Doppler wind syntheses at 400 m AGL from 2137:00Ä– 2149:22 UTC 19 June. The flight-level track and winds are plotted on the figure. The thick, black line represents the location of the ELDORA tail radar scan presented in Fig. 6.

thermal leading to larger conversion rates and stronger echoes. Rapid ascent on June 19 produce weaker echoes and a weak-echo vault. The effect of these microphysical alterations on longer time scales should be investigated.

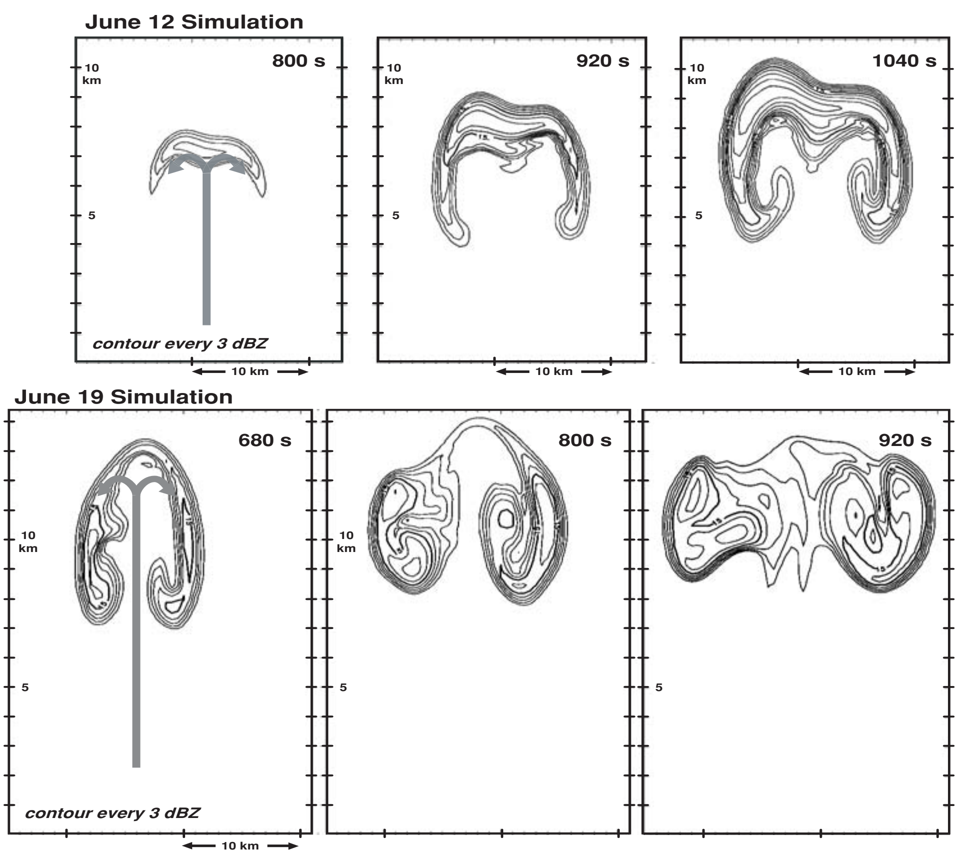


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Fig. 7. Numerical simulations of the June 12 (top row) and 19 (bottom row) storms during the early stages of echo formation. Contours are radar reflectivity drawn every 3 dBZ. Arrows represent general flow pattern based on the wind field (not shown).