11A.6 MULTI-DOPPLER ANALYSIS OF CONVECTIVE INITIATION ON 19 JUNE 2002 DURING IHOP

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1. INTRODUCTION

The International H2O Project (IHOP_2002) field experiment was designed to study the complex 4-D structure of water vapor and its relation to the wind field. One component of this project was the study of the initiation of deep moist convection. Data collection for this component was accomplished predominantly by an armada of ground and airborne vehicles, including mobile Doppler radars, with the goal of establishing a region of high-resolution observations and capturing convective initiation within that region.

On 19 June 2002, two Doppler on Wheels (DOW) radars and the XPOL radar, along with the rest of the mobile armada (field coordinator, mobile soundings, mobile mesonets, mobile radiometer, and MIPS), collected high-resolution data on a boundary near Colby, KS. Convection initiated along this boundary and subsequently moved ahead of it. The boundary was characterized by rather intense misocyclones associated with dust devils and enhanced reflectivity. Dual-Doppler analyses using the two DOW radars reveal the relation between the vorticity and vertical velocity fields along the boundary. In our continuing research, we seek to use these analyses, along with thermodynamic data and satellite data, to relate the initiation of convection to these boundary features.

2. RADAR SPECIFICATIONS

The Doppler On Wheels (DOW) mobile radars (Wurman et al. 1997, 2001) were developed expressly for obtaining high-resolution data in small-scale and short-lived phenomena. The current DOWs can scan rapidly, up to 60°s^{-1}, produce pulses of < 150 ns and sample signals every 83 ns to obtain oversampled range resolution of 12.5 m and non-oversampled resolution of 25 m. The DOWs operate at approximately 9.375 GHz, with peak transmitted power of 250 kW, and beam widths of 0.93°. XPOL has similar specifications except the peak transmitted power is 50 kW and the outgoing radiation has dual-polarization capabilities. In IHOP_2002, baselines were chosen such that the azimuthal resolution at the center of the Intensive Observation Region (IOR) was approximately 200 m.

3. DUAL-DOPPLER WIND SYNTHESIS

After the radar data have been properly edited to de-alias velocities and remove ground clutter and range-folded gates using the NCAR SOLO program, they are objectively analyzed onto a common Cartesian grid, with 100 m grid spacing, using a Barnes scheme in the REORDER analysis program. The locations of the radars are known from GPS measurements recorded during the deployments. Truck orientations are determined using a fast solar alignment technique for DOW3 and for DOW2's first deployment (Arnott et al., 2003). An alternative method determines most likely heading angles as those giving the greatest correlation coefficient between the reflectivity fields from the two radars (Zhang et al., 2001). For the cases considered here, the two methods gave nearly identical results (within 0.2 degrees). Since a solar alignment scan was not available for the second DOW2 deployment, the correlation method is used.

The Barnes smoothing parameters are chosen to eliminate scales near that of the data spacing. The cutoff radius is set to 750 m, or approximately 2.5 times the data spacing at a range of 18 km. The resulting smoothing is greater than would be required simply for eliminating noise close to the radar.

During the experiment, scans from the two DOWs were carefully synchronized every three minutes. Each volume takes approximately 1.5 minutes with 16 elevation angles ranging from 0 to 14.5.

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After all data have been interpolated onto the Cartesian grid, a dual-Doppler analysis is performed using an upward integration scheme in the CEDRIC analysis program with inclusion of data only in regions where the between-beam angle is greater than 30° and less than 150°.

5. RESULTS

On 19 June 2002, convection was expected to initiate along a quasi-stationary cold front near Colby KS. The mobile armada began surveying this region around 1745 UTC and were joined later by several aircraft including the P-3 and Wyoming King Air. The armada intercepted a boundary near Goodland, KS and followed it east toward Colby where the first IOR was executed (Fig. 1) from 1921 to 20:59 UTC at which time DOW2 was re-deployed further east following the boundary. Dual-Doppler coverage was maintained during this transition time by DOW3 and XPOL. After DOW2 was in position (21:21), DOW3 began scanning toward the new IOR while XPOL moved east. Thus, dual-Doppler coverage was maintained throughout the change in IOR. During the initial deployment, storms initiated to the far southwest, in southeast Colorado (Fig. 2), with further initiation progressing NNE along the boundary and eventually occurring in the mobile armada near the time of transition form the first IOR to the second. Aircraft data collection continued until approximately 2205 UTC and the majority of the ground-based armada sampled until 2300 UTC. Mobile ground-based radar data collection was terminated at 2346 UTC.

A dual-Doppler synthesis at 2130 UTC shows the surface vorticity maxima associated with the misocyclones along the boundary (Fig. 3). Several of these misocyclones were associated with dust devils and enhanced reflectivity (not shown). It is estimated that the vorticity maxima associated with this shear zone were separated by approximately 5 km and had peak amplitudes on the order of 10^{-2} s^{-1}. These results are at least qualitatively similar to those predicted by linear theory for horizontal shearing instability (Miles and Howard 1964), which suggests that the wavelengths of the vorticity maxima should be six times the width of the shear zone (roughly 1 km in this case). The vertical motion and vertical velocity maxima are roughly one quarter wavelength out of phase (Fig. 4), consistent with the discussion of Kingsmill (1995). The vortices remain fairly strong through the lowest 1.5 km and then weaken aloft (Fig. 5). The convective cells that initiated along the boundary are now ahead of the boundary and near the baseline of the two DOWS. At least two of the thunderstorms that developed shortly thereafter developed landspout tornadoes that were observed by one of the DOWs.

6. FUTURE WORK

The boundary observed on this day exhibited many interesting features, with misocyclones the most striking. While they were rather intense and consistent with theory, their role in convective initiation on this day is unclear. We seek to combine the wind syntheses with thermodynamic measurements and satellite data to elucidate the mechanisms leading to initiation. In order to tie the boundary processes to the convection that initiated on this day, we will likely require additional measurements from aircraft radar that sampled outside the IOR.

ACKNOWLEDGEMENTS

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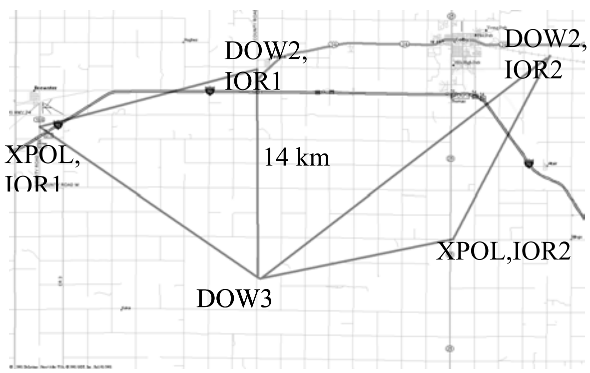

Fig. 1: Ground-based mobile radar deployments near Colby, KS on 19 June 2002.

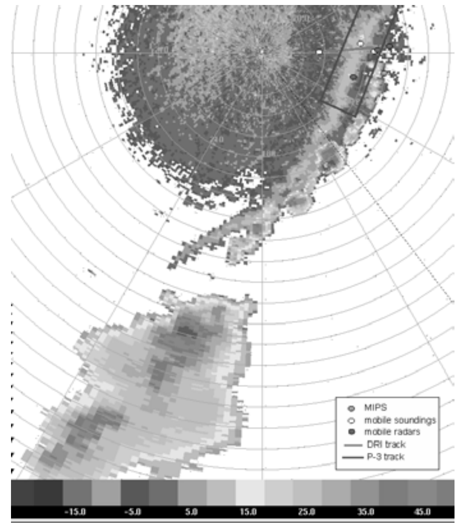

Fig. 2: Reflectivity from Goodland WSR-88D at 2133 UTC with the IHOP armada positions and aircraft tracks (courtesy Crystal Pettet). Range rings are 10 km.

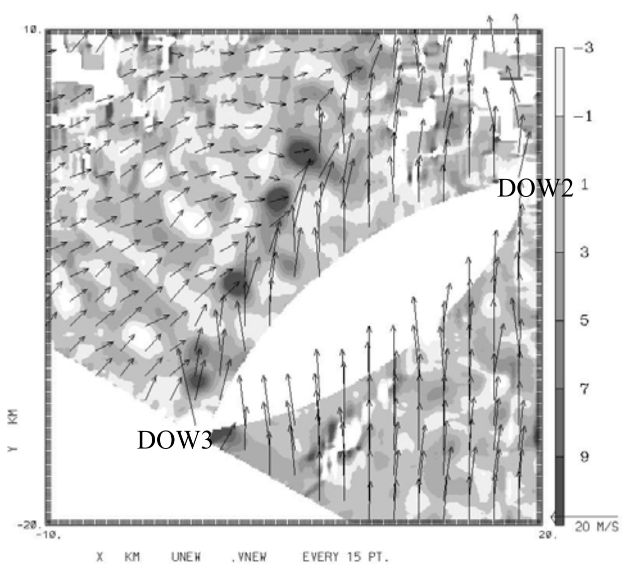

Fig. 3. Dual-Doppler analysis of vertical vorticity (shaded, $x10^{-3}$ s^{-1}) and horizontal wind at the surface at 2130 UTC. Every fifteenth vector is shown.

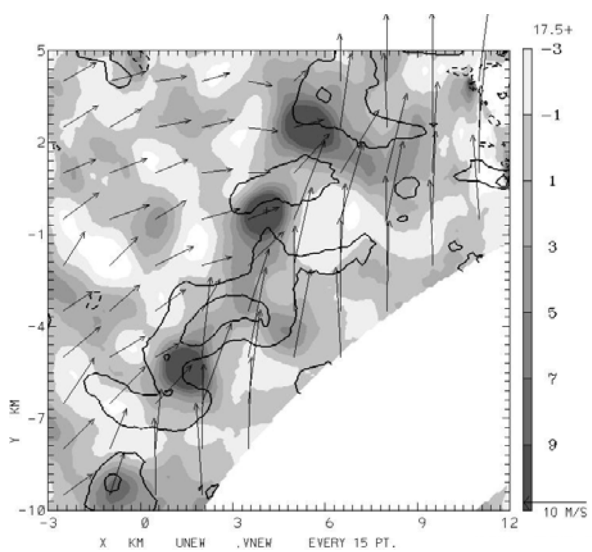

Fig. 4: Dual-Doppler analysis of vertical vorticity (shaded, $x10^{-3}$ s^{-1}), vertical velocity (contours are –2, -1, 1, and 2 m s^{-1}) and horizontal wind at 400 m at 2130 UTC. Every fifteenth vector is shown.

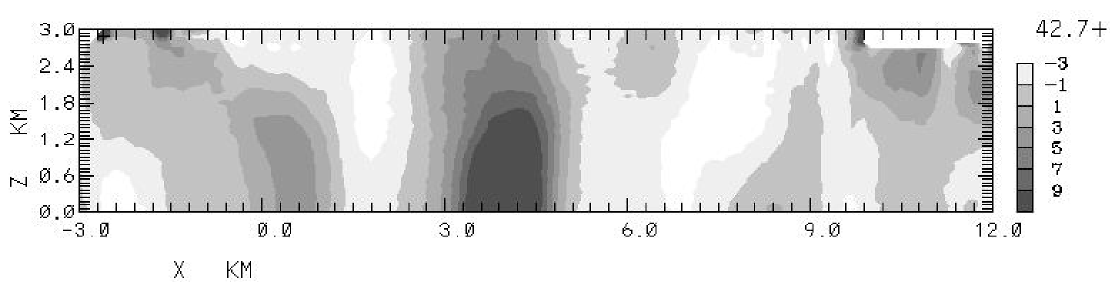

Fig. 5: Vertical vorticity ($x10^{-3}$ s^{-1}) along y=-500m.