OBSERVED TRANSITION FROM AN ELEVATED MESOSCALE CONVECTIVE SYSTEM TO A SURFACE BASED SQUALL LINE: 13TH JUNE, IHOP_2002

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I. INTRODUCTION

Nocturnal deep convection is often associated with severe weather but its prediction remains a difficult forecasting problem. Such convection often has its source air elevated above the planetary boundary layer. Elevated convection forms an important part of the diurnal cycle in the mid-west of the USA, where a nocturnal maximum in convection is observed. For the 2002 International H_20 Project (IHOP_2002) the nocturnal maximum was shown to result from locally initiated storms, which generally formed from elevated initiation episodes, rather than just storms that were initiated elsewhere during the day propagating into the IHOP area at night (Wilson and Roberts, 2006). Systems that formed from elevated initiation episodes were shown to be less likely to produce a significant gust front than systems formed from surface-based initiation episodes, but tended to be longer lived if they produced such a gust front (Wilson and Roberts, 2006). An IHOP_2002 case study of an elevated initiation episode that led to a surface-based MCS with a substantial gust front is discussed below.

II. OUTLINE OF THE SYSTEM EVOLUTION

The system formed from four initiation episodes that occurred between 0500 and 1000 UTC (2300 to 0400 LT), close to the Oklahoma panhandle, ahead of a southwest-northeast oriented cold front. By 1125 UTC these had led to the northwest-southeast oriented lines of deep convection shown in Figure 1(a). These lines gradually developed to give a southwest-northeast oriented squall-line structure (Figure 1b). This occurred by approximately 1300 UTC in western Oklahoma and 1600 UTC in eastern Oklahoma.

III. RESULTS AND CONCLUSIONS

Radiosondes close to the initiation episodes (for example Figure 2) showed elevated layers of air with high theta-e, located above a stable nocturnal boundary layer. The storms initiated from these layers. The best observed initiation episode occurred close to the SPol radar that was deployed for IHOP_2002. This showed that the initiation was a result of the intersection of a northwest-southeast oriented convergence line with a wave propagating through the low-level stable air (Figure 3). The stable air with near neutrally stratified air above (Figure 2), together with a southerly low-level jet favours the trapping of wave energy at low-levels in this case (Crook, 1988).

Using a combination of surface observations and radar data the evolution of the properties of the cold pool as the system propagated across Oklahoma

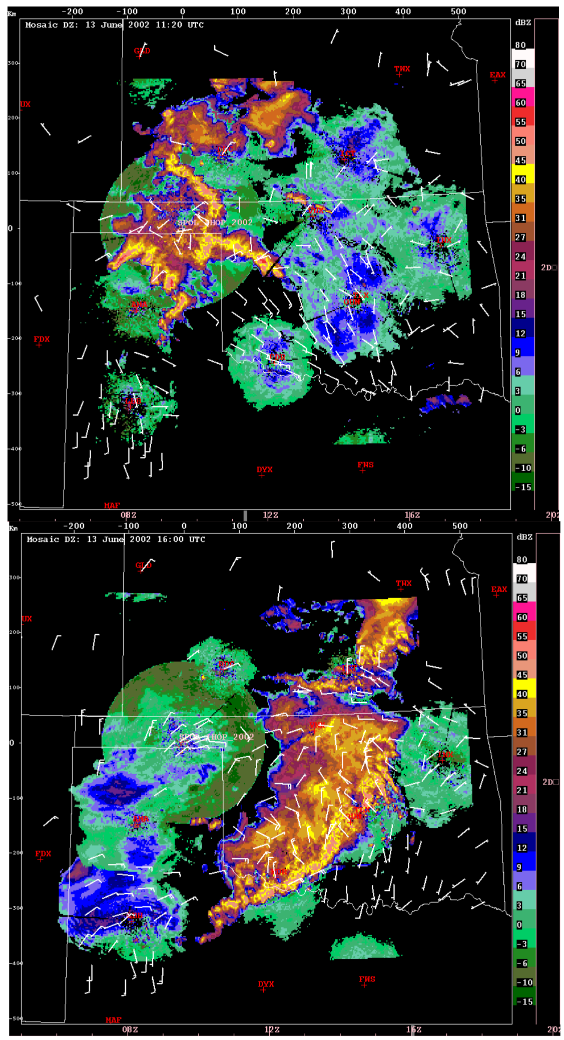

FIG. 1: Radar composite of reflectivity from low-level PPI (plan position indicator) scans at (a) 1125 and (b) 1605UTC. Low-level winds from surface observations are shown in white. White lines show state boundaries, with Oklahoma in the centre.

have been studied (not shown). During the day, once the boundary layer had warmed, the effect of the cold pool was fairly uniform, showing the pressure increase, rapid cooling, wind-speed increase and water vapour mixing ration (WVMR) decrease expected from the observed squall-line MCS. During the night, the cold pool effects were more spatially variable, showing a pressure increase, a rapid cooling, a wind-speed increase and a decrease in WVMR in the west and a much smaller cooling and wind-speed increase in the east, together with an increase in WVMR. In particular, at night some mesonet stations experienced precipitation and a pressure rise for at least an hour before any cold downdraught air could penetrate the stable nocturnal boundary layer. Early on in the systems evolution, when downdraughts from the convection interacted with the stable nocturnal boundary layer, bores and waves were observed propagating ahead of the cold pool and initiating further deep convection.

The reorientation of the northwest-southeast oriented lines of convection (Figure 1a) to the southwest-northeast squall line (Figure 1b) happened before any significant surface heating in western Oklahoma (1300 UTC), and later after some surface warming in the east (1600 UTC). A combination of surface mesonet and radar data suggests that in both the west and the east the time of the reorientation of the convection was similar to the time when the surface cold pool generated by the system could first lift surface air to its level of free convection (essentially the reverse of the surface-based to elevated transition modelled by Parker, 2008). Particularly in the east, across-squall-line banding was observed at the time of the transition (e.g. Figure 1b) similar to that described by Bryan et al (2007).

The case-study raises a number of interesting questions concerning the sensitivity of the cold-pool outflow to microphysical processes and the stable nocturnal boundary layer, and the sensitivity of the transition from elevated to surface-based to the cold-pool outflow. These are being investigated using the Weather Research and Forecasting (WRF) model.

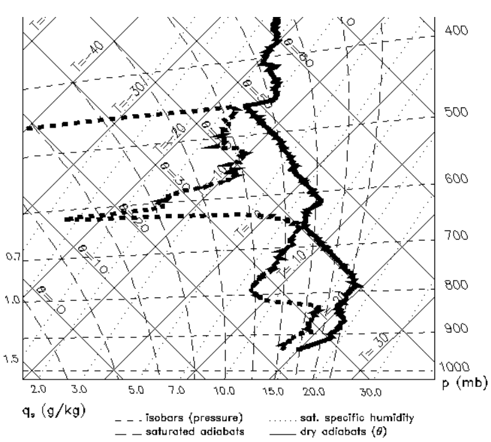

FIG. 2: ARM radiosonde profile from Vici at 0829 UTC, close to the initiation episode observed using the SPol radar (Figure 3).

IV. AKNOWLEDGMENTS

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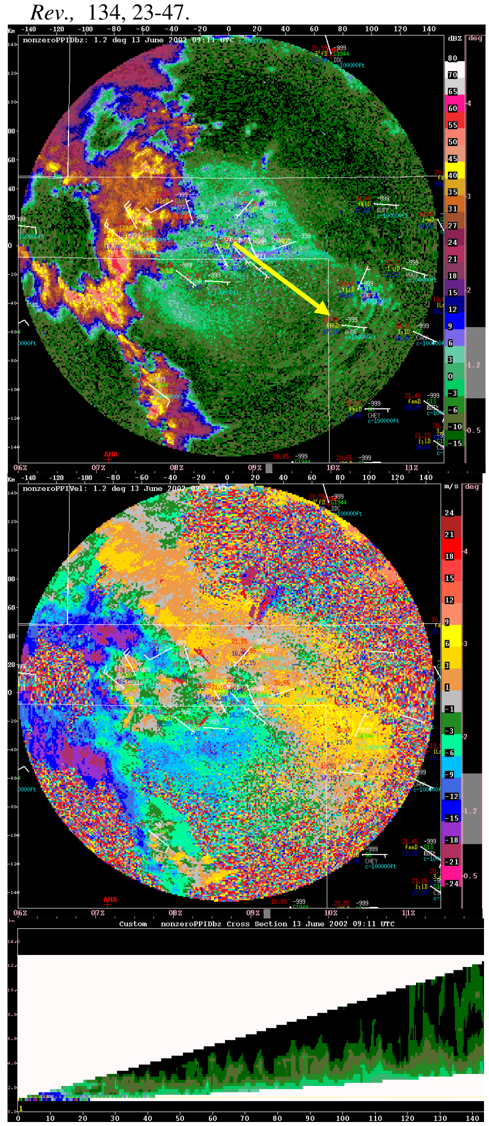

FIG. 3: (a) SPol 1.2 degree scan reflectivity and (b) Doppler winds, both at 0911 UTC. The wave is seen most clearly in (a) approximately 100 km southeast of SPol (see arrow). The convergence line is seen most clearly in (b), running nothwest to southeast. (c) A virtual reflectivity cross-section (built up from multiple PPIs) from SPol southeastwards through the wave at 0911 UTC (approximately along the yellow arrow).