Impact of dryline misocyclones on convection initiation on 19 June 2002 during IHOP

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I. INTRODUCTION

The International H_2O Project (IHOP_2002) was held from 13 May to 25 June of 2002 in the Southern Great Plains region of the United States, with a goal of improving our understanding of the 4-D water vapor field and its interaction with the wind field. In particular, it was hoped that analyses of the high-resolution wind and thermodynamic data collected would better our understanding of water vapor heterogeneity as well as the processes involved in convection initiation. A vast array of instrumentation was deployed, including mobile Doppler radars, mobile mesonet vehicles (i.e., cars with roof-mounted instrumentation), mobile sounding units, aircraft in-situ probes, airborne Doppler radars, airborne lidar, and numerous fixed instruments in the Oklahoma panhandle.

In this study, we focus on the convection initiation thrust of the IHOP_2002 campaign. In particular, we examine the role of small-scale vortices (misocyclones) in the initiation of convection on 19 June 2002 along a dryline in northern Kansas.

II. BACKGROUND

Knowing when and where convection will initiate remains one of the more difficult problems facing forecasters. It has long been recognized that atmospheric boundaries (e.g., cold fronts, drylines, etc.), with their associated upwelling of water vapor, often are preferred initiation locations, but it is less clear why certain portions of a boundary develop convection before others, although many studies (e.g., Wilson et al. 1992) suggested that small-scale circulations associated with the wind-shift along a boundary may organize the vertical velocity field in such a way that certain areas become preferred locations for sustained parcel lifting. A detailed analysis of high-resolution multi-Doppler radar data obtained in several boundaries containing misocyclones during IHOP_2002 revealed such an organizing effect (Marquis et al. 2007, Fig. 1), and the merger of neighboring misocyclones as their population evolves was found to severely distort the boundary in some cases, with trajectory analyses suggesting the merger process may act as an effective mechanism for mixing air mass properties across the boundary.

In this study, we combine multi-Doppler wind analyses with mobile mesonet, mobile sounding, airborne lidar, and photogrammetric cloud observations to examine in greater detail the link between misocyclones and cloud formation, as well as the influence of misocyclones in organizing the water vapor field along the boundary. In order to expand the thermodynamic data coverage from the thin strips generally collected along roads or airplane transects, we use a Lagrangian technique (Ziegler et al. 2007) in which the multi-Doppler derived wind field is used to advect thermodynamic information from its original observation location along backward and forward trajectories.

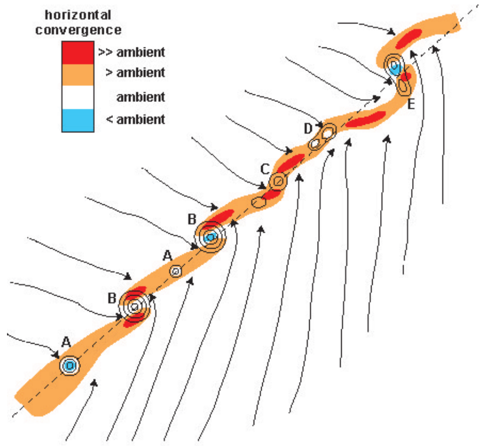

FIG. 1: Conceptual model of convergence along an atmospheric boundary containing misocyclones. The influence of the misocyclones on the vertical velocity depends on their size compared to the width of the boundary, and the merger of neighboring misocyclones often is found to significantly distort the boundary. (adapted from Marquis et al. 2007)

III. 19 JUNE 2002 ANALYSES

The IHOP mobile armada intercepted a dryline near Colby, Kansas on 19 June 2002. This particular dryline was a prolific producer of misocyclones and dust devils, and storms initiated along portions of it. Mobile mesonet water vapor mixing ratio data obtained as probe 1 traversed a misocyclone just prior to vortex merger (Fig. 2) indicate a transition of about 3 g kg^{-1} over less than 5 km with a strong wind shift. A vertical cross-section (Fig. 3) captures the interaction between the misocyclone and the dryline circulation. A Lagrangian analysis at this time (Figs. 4 and 5), illustrates the distortion of the water vapor field in the vicinity of misocyclones that are in the process of rotating about one another and merging. Similar analyses will be carried out for other time periods and combined with cloud analyses derived from photogrammetry as well as water vapor fields from airborne lidar to produce a

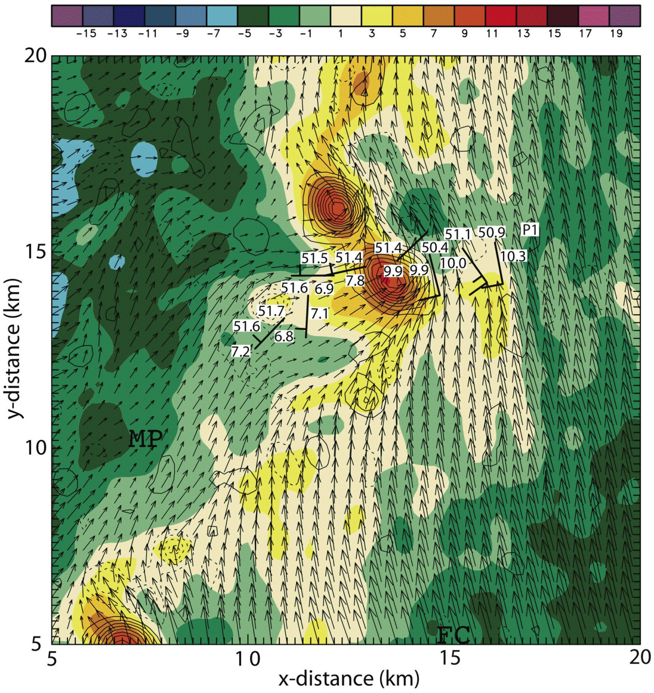

FIG. 2: Ground-relative horizontal wind, vertical vorticity (contoured every 5x10^{-3} s^{-1} with zero excluded), and reflectivity (shaded) at the surface at 2215 UTC on 19 June 2002. The station models show mobile mesonet probe 1 data collected from four minutes before until five minutes after the analysis time. In the station model, the upper number is the virtual potential temperature in °C, the lower number is mixing ratio in g kg^{-1}, and a full wind barb is 10 m s^{-1}.

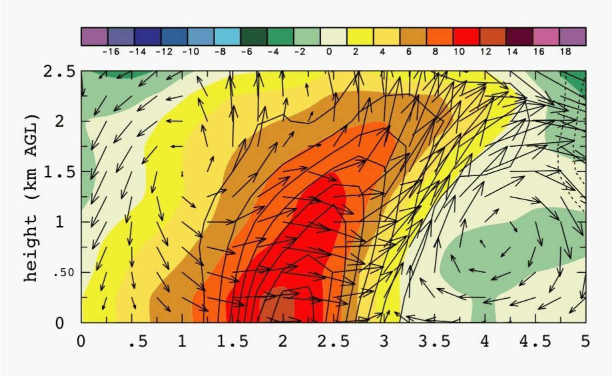

FIG. 3: As in Fig. 2, but for a vertical (SW-NE) cross-section through (14, 14.5) in Fig. 2 intersecting the southernmost vortex in the pair of vortices. Winds are relative to the moving misovortex.

complete picture of convection initiation on this day and the role of misocyclones in that process.

IV. ACKNOWLEDGMENTS

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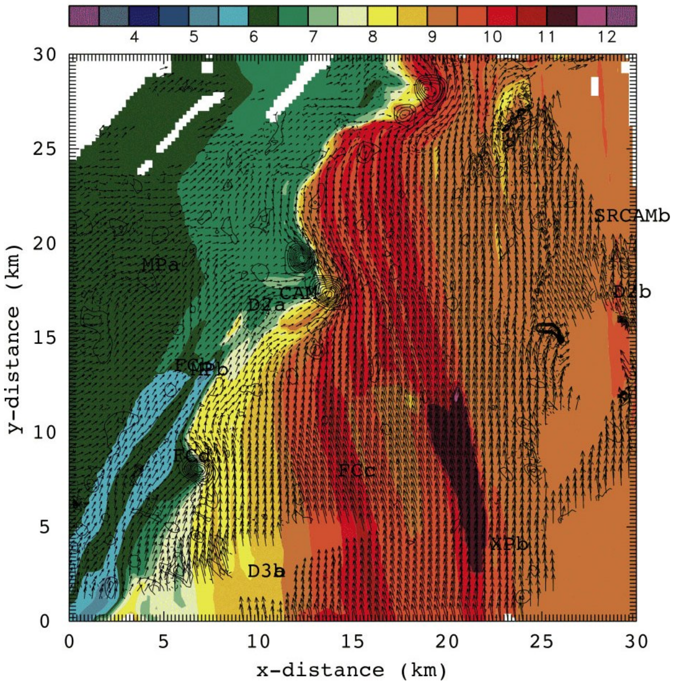

FIG. 4: As in Fig. 2 but shading is water vapor mixing ratio in g kg^{-1} from a Lagrangian analysis of in-situ observations.

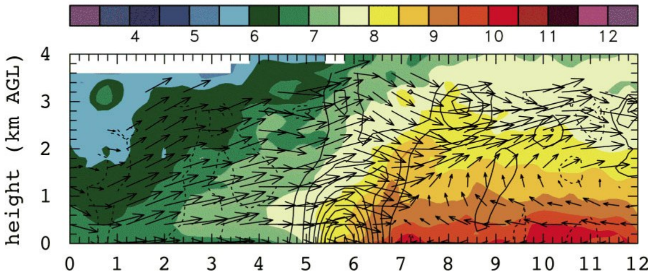

FIG. 5: As in Fig. 4 but for a vertical (E-W) cross-section through (14, 17.2) in Fig. 4.

V. REFERENCES

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