11A.7 RELATION OF RADAR-DERIVED KINEMATIC FEATURES AND IN-SITU MOISTURE TO CUMULUS DEVELOPMENT ON 24 MAY 2002 DURING IHOP

Conrad L. Ziegler*, Erik N. Rasmussen#, Yvette P. Richardson&, Robert M. Rabin@, and Michael S. Buban%

1. INTRODUCTION

One focus of the recent International Water Vapor (H2O) Project (IHOP-2002) was to learn how water vapor, temperature, and airflow in the boundary layer control the initiation or suppression of deep, moist convection. Using IHOP observations, the goal of the present study is to test hypotheses relating cumulus and storm development to updrafts and mesoscale vortices and the levels of moist convective instability and wind shear in the boundary layer. In this paper, we describe our data sources and analysis methods. Preliminary multiple mobile ground-based radar analyses and in-situ atmospheric state observations from mobile mesonets and a mobile sounding system are also presented.

2. OBSERVATIONS AND ANALYSIS

Deploying from bases in Norman, OK, and Liberal, KS, the combined IHOP ground-based mobile facilities joined with aircraft to investigate a dryline and cold frontal triple point near Shamrock in the eastern Texas Panhandle. Deep cumuli developed within the Intensive Observing Region (IOR), and deep severe convection with hail developed east of the IOR near Erick, OK. Thus, this case provided threshold conditions for convection initiation (CI).

NSSL operated a field coordination (FC) vehicle, a mobile CLASS sounding system, a Shared Mobile Atmospheric Research and Teaching (SMART)-radar (SR-1), and 7 mobile mesonets (MM). Also participating were the DOWs 2-3, X-Pol, two NCAR mobile GLASS sounding vehicles, the DRI Mobile Radiometer, and the UAH Mobile Integrated Profiling System (MIPS). Aircraft included the NRL P-3, Wyoming King Air, DLR Falcon, NASA DC-8, and a Learjet deploying dropsondes. Ground-based radar data were collected from up to four radars at 3-min intervals in the period 1815-2045 UTC (all times are Universal Time). In concert with ground-based radar, MM, DRI, and aircraft traverses (including airborne lidar) were obtained along with dropsonde, sounding, and MIPS profiling.

In post-analysis, the ground-based mobile radar data were extensively edited to rotate sweeps relative to true North, remove ground and range-folded targets and regions of weak atmospheric reflectivity, defreckle and despeckle scattered localized targets, and dealias radial velocities using the NCAR Solo software. Two internally consistent methods were used to determine radar sweep orientation: (1) sun scans (DOW-2); (2) correlation of ground targets with towers and roads (SR-1, DOW-3, X-Pol).

In the next analysis step, radar data were spatially interpolated via the Barnes technique using a slightly modified form of the NCAR Reorder software. Radial velocities and reflectivities were interpolated to a 101 x 101 x 11 regular cartesian grid with dimension of 50 x 50 x 2.5 km (i.e. 0.5 km horizontal and 0.25 km vertical grid spacing). The isotropic Barnes weighting function used took the form $w = \exp(-r^2/\kappa)$, where r is the distance from a gridpoint to a datum and κ is a smoothing parameter. For our chosen input parameters, the theoretical response of the Barnes filter is ~ 50% at wavelength λ = 0.83 km and 0.05% at 0.4 km.

In the final analysis step using the NCAR Cedric software, an overdetermined scheme was employed to synthesize radial velocities followed by vertical integration of the mass continuity equation from w = 0 at ground level.

3. RESULTS

A strong cold front moved rapidly southeastward through the IOR during the period of radar observations, passing DOW-3 before 1930 (Fig. 1a) and passing the FC at 2000 (Fig. 1b). A dryline intersected the front near a sub-synoptic low pressure center (SSL) at the classical "triple point" intersection location (Fig. 1). At 1930 the dryline is revealed as a zone of enhanced vertical motion west of a band of enhanced vertical shear (Fig. 2a). At 2000 the shallow cold front has a strong vertical circulation at its leading edge (Fig. 2b). Vertical mesoscale vortices of

*Corresponding author address: Dr. Conrad L. Ziegler, National Severe Storms Laboratory, 1313 Halley Circle, Norman, OK 73069
Cooperative Inst. for Meso. Meteor. Studies (CIMMS), University of Oklahoma, Norman, OK
& Pennsylvania State University, University Park, PA
@NOAA/NSSL, Norman, OK
%University of Oklahoma, Norman, OK

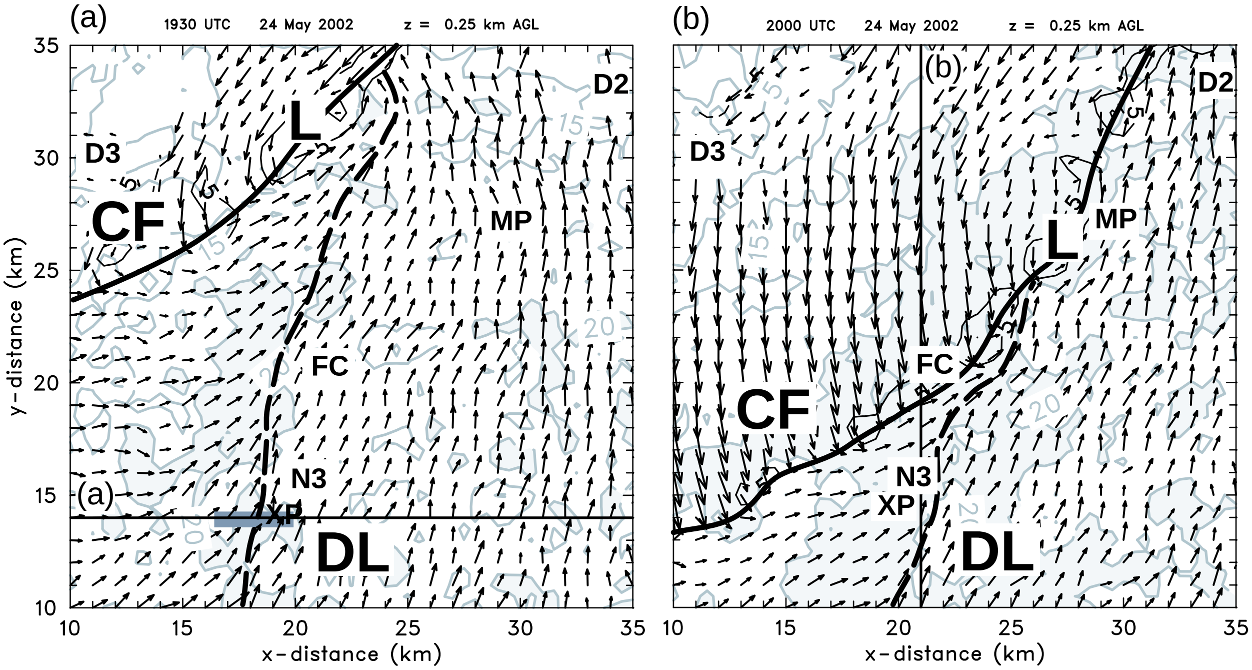

Fig. 1 Horizontal airflow vectors, reflectivity (gray contour at 5 dBZ interval starting at 5 dBZ), and vertical relative vorticity (black contour at 5 x 10^{-3} s^{-1} interval starting at 5 x 10^{-3} s^{-1}) from quadruple-Doppler analyses on 24 May 2002: a) 1930; b) 2000. Reflectivity greater than 20 dBZ has gray fill. Every other vector is plotted, and a vector length of 1 km equals 7.5 m s^{-1}. Thin black lines locate vertical cross-sections in Fig. 2a and Fig. 2b. Heavy solid curve in panels (a) and (b) denotes the cold front, while the heavy dashed curve denotes the dryline. "DL", "CF", and "L" denote the dryline, cold front, and subsynoptic low respectively. Locations of DOW-2, DOW-3, X-Pol, NS-3, FC, and MIPS are denoted by their abbreviations. SR-1 is located at (44,14). The thick gray segment in panel (a) locates the probe-5 transects in Fig. 3b.

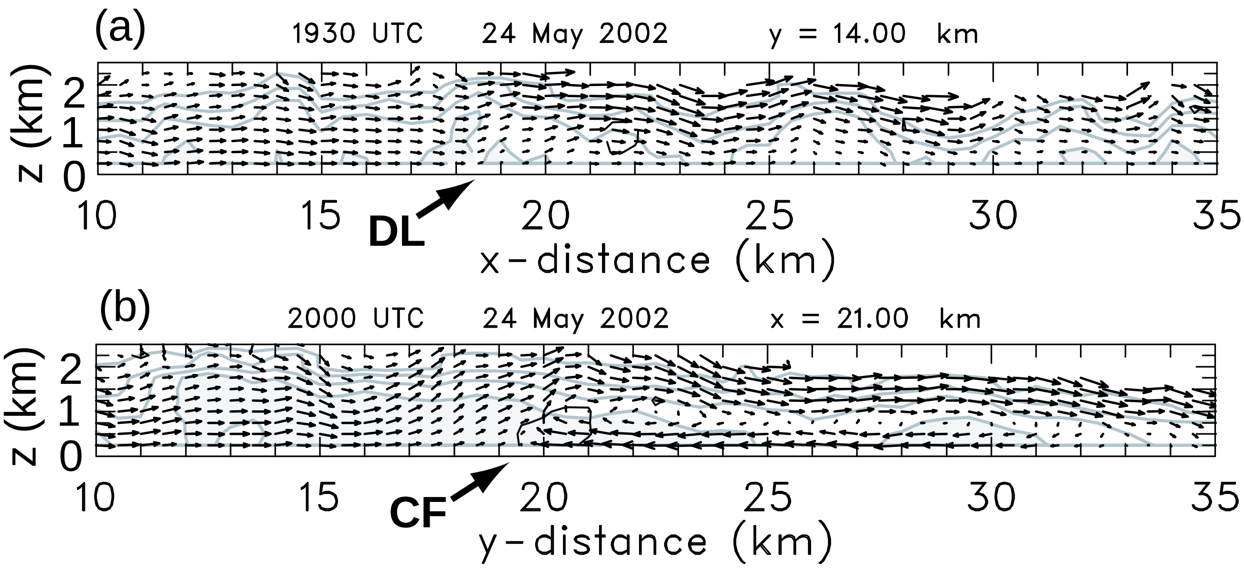

Fig. 2 Analyses of winds, reflectivity, and vertical vorticity at (a) 1930 and (b) 2000 on 24 May 2002 (as in Figure 1), but for vertical cross-sections located as in Fig. 1. A vector length of 1 km equals 15 m s^{-1}.

up to 5-10 x 10^{-3} s^{-1} are present along the cold front and dryline. The cold front is shallower to the northeast of the SSL than to the southwest, associating with a deep front-to-rear flow above the cold air northeast of the SSL (not shown).

Within the context provided by these highly time- and space-resolved ground-based mobile radar analyses, in-situ data were provided by mobile mesonet (MM) traverses (Fig. 3) and mobile soundings

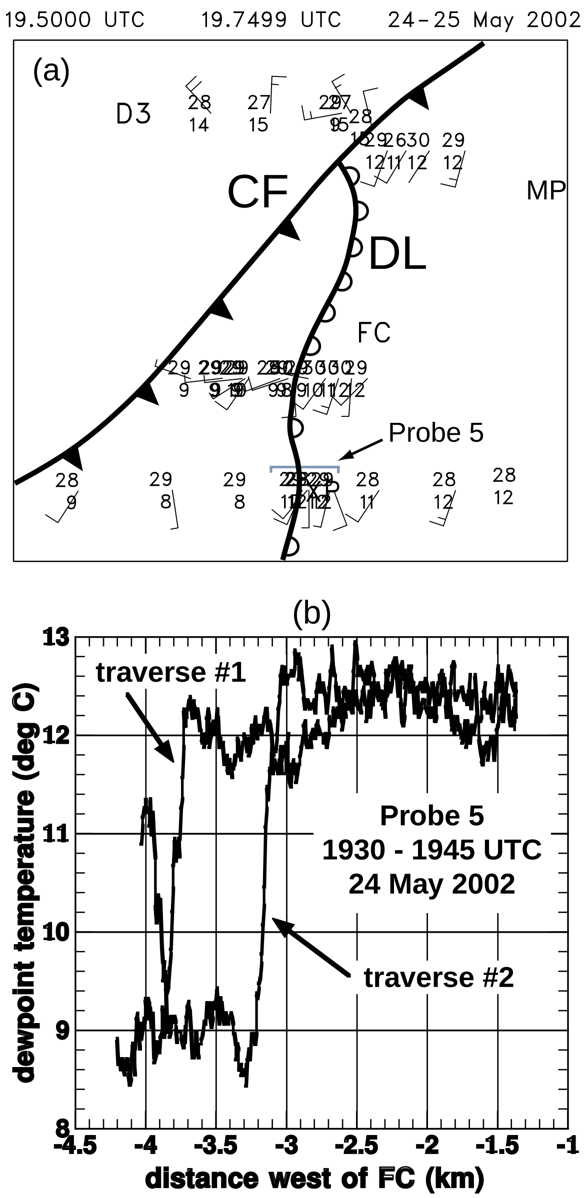

Fig. 3 Mobile mesonet (MM) observations across the dryline and cold front in the interval 1930-1945 on 24 May 2002. (a) plan view of Intensive Observing Region showing all MM observations at 3 min intervals; (b) west-east dewpoint temperature profile of two successive traverses of the dryline by probe 5 relative to the FC position. Note DL movement between #1 and #2.

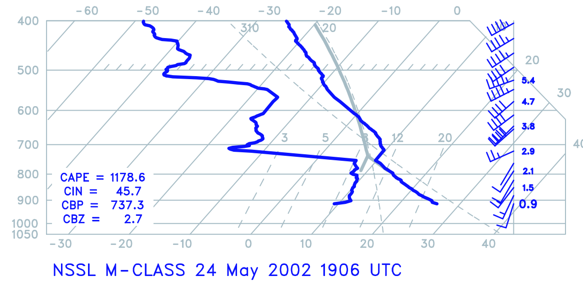

Fig. 4 Skew-T log-p plot of 1908 UTC NSSL mobile-CLASS sounding on 24 May 2002. Lifted parcel lapse rate is denoted by gray curves, while associated CAPE, CIN, and cloud base pressure (CBP) and height (CBZ) are indicated at lower left.

(Fig. 4). Pre-dryline, post-dryline, and post-cold frontal airmasses and the moisture stratification east of the dryline are clearly evident. Small-scale variability along the dryline is also noted (Fig. 3b).

4. DISCUSSION

We are in the process of completing 3-min interval 2-, 3-, and/or 4-radar analyses in the period 1815-2045. We are beginning a Lagrangian (wind analysis)-based objective analysis of all available in-situ data to the radar analysis grid. GOES-8 visible satellite imagery during the afternoon of 24 May has been carefully renavigated and mapped to the radar analysis grid, permitting a point-by-point evaluation of conditions associated with presence or absence of cumulus clouds. Using our gridded analyses, we will evaluate our testable hypotheses via 2 x 2 contingency tables (i.e. predicted vs. observed) convective cloud. We will report our convection initiation hypothesis tests and additional data analyses at the conference.

5. ACKNOWLEDGMENTS

We thank Dave Parsons and Tammy Weckwerth for their dedicated leadership of the IHOP experiment. We also thank the numerous participants whose collective efforts made IHOP a success, especially those individuals who fabricated and maintained the NSSL mobile ground-based facilities and staffed these vehicles during field data collections. Partial funding for this research was provided by National Science Foundation (NSF) grant ATM-0130316, and grants from the NOAA/HPCC, NOAA/USWRP, and NSSL Directors Discretionary fund. We gratefully acknowledge the assistance of Dick Oye and Jay Miller with the NCAR Reorder and Cedric software packages. NCAR is sponsored by the National Science Foundation.