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FINE-SCALE RADAR OBSERVATIONS OF A DRYLINE DURING THE INTERNATIONAL H_2O PROJECT

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1. INTRODUCTION

The Southern Plains dryline has long been identified as a location favorable for the development of deep moist convection. Thunderstorms initiated at the dryline often are in an environment conducive for supercells, with the attendant threat of large hail, damaging winds and tornadoes. Although progress has been made in our understanding of the dryline, the kinematic structure of the boundary is still unclear. Any consistent success in the prediction of convective initiation on the dryline relies on the precise determination of all scales of motion, particularly in the dryline convergence zone (DCZ) where parcels must ascend to the level of free convection (LFC) for initiation to occur.

During the spring of 2002, the International H2O Project (IHOP) sought to resolve the kinematics of the dryline interface, particularly in the context of convective initiation. Ground-based (e.g., S-Pol, SMART-Radar (SR1), DOWs) and airborne-based (e.g., ELDORA) radar platforms were used to collect data. On May 22, 2002, in conjunction with these platforms, the 3-mm wavelength mobile Doppler radar from the University of Massachusetts at Amherst (UMass) obtained very-high resolution RHI data across a dryline in the eastern Oklahoma panhandle. The very narrow beamwidth (0.18 deg) of the antenna permitted ultra-fine scale measurements of the dryline boundary, with height and range resolutions of 5 m and 30 m, respectively, at a distance 1 km from the radar.

2. TESTS ON NUMERICALLY SIMULATED DATA

An observation system simulation experiment (OSSE, e.g., Kuo and Guo 1989) was designed to test various multiple-Doppler data processing techniques. OSSEs (also referred to as *twin experiments*) allow the synthesis of simulated observational fields through the sampling of numerically simulated data. Different processing techniques produce a spectrum of analysis values (e.g., for the wind field) which can be verified against the model solution (the "truth"). The best techniques from the OSSE can then be applied to the observational data with confidence that these methods provide the best estimate for the truth (which is unknown).

An idealized dryline simulation was developed with the Advanced Regional Prediction System (ARPS) from the Center for the Analysis and Prediction of Storms (CAPS) at the University of Oklahoma. The terrain profile followed a tanh profile similar to that of Peckham and Wicker (2000), and was chosen to mimic the average east-west surface elevation change of the Texas and Oklahoma panhandles (where drylines climatologically form most frequently). Vegetation and soil moisture were allowed to increase eastward across the domain, typical of the surface characteristics in the region. Further details of the numerical simulation can be found in Weiss and Bluestein (2002).

Three grids were used for the simulations: an outer coarse domain with a horizontal resolution of 6 km x 6 km, and two nested inner domains with spatial resolution of 1 km x 1 km and 300 m x 300 m, respectively (Fig. 1).

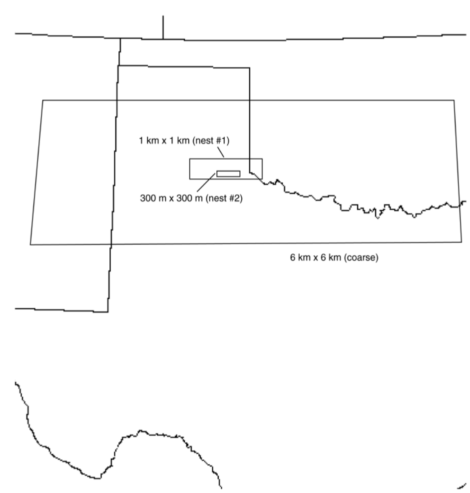

Fig. 1 – The three grids used for the ARPS simulation

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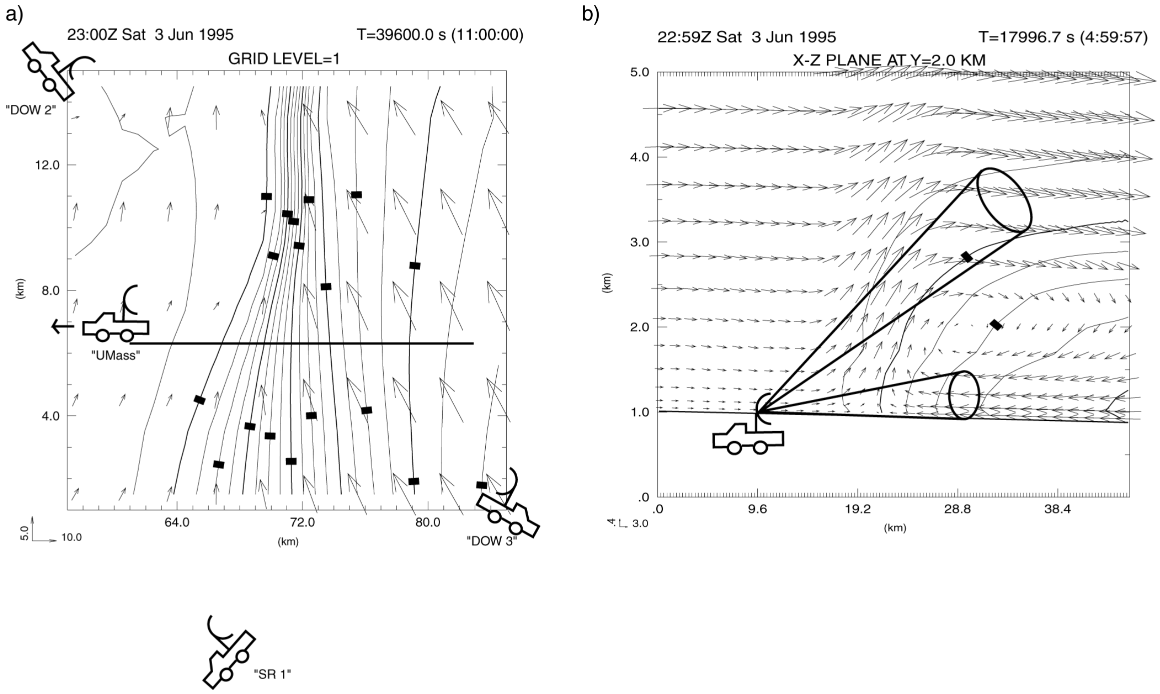

Fig. 2 – a) Configuration (plan view) of the pseudo-radars for the OSSE experiment. The simulation pictured is a plan of the 1 km x 1 km run (nest #1) at 2300 UTC. Contours denote mixing ratio (g kg-1), vectors denote u/v winds (m s-1, scale at bottom left); b) Beam trace of the minimum (0.5 degree) and maximum (11.5 degree) elevation angles for the SR1 volume coverage pattern (VCP) on 22 May 2002. Range to the dryline (~ 10 km) is typical of that during the operations. Note that there are twelve intermediate elevation angles in this VCP (not shown). The simulation pictured is an x-z cross section of the 300 m x 300 m run (nest #2) at 2300 UTC.

The simulations were carried out for 15 hours beginning at 1200 UTC. By 2300 UTC, a moisture gradient had developed and was collocated with a pronounced surface wind shift (Fig. 2a). Upward vertical motion was prominent in the DCZ (w_{max} ~ 1 – 1.5 ms^{-1}) (Fig. 2b), as well as an upward bulge in moisture (not shown). A rotor on the head of the secondary circulation perpendicular to the dryline was also evident, similar in dimension to that observed in previous studies.

Currently, the high resolution output of the finest grid is being used as the basis for the OSSE mentioned above. Three to four pseudo-radars have been positioned about the domain in a configuration similar to that of the 5/22/02 IHOP data set (Fig. 2a). The wind vectors will be converted to radial velocities and interpolated to the coverage pattern of each radar (e.g., Fig. 2b). The results from the OSSE will be presented at the conference.

3. TESTS ON THE 22 MAY 2002 DRYLINE

As mentioned earlier, the UMass radar coordinated with other IHOP mobile radars to gather data on a dryline during the afternoon and evening of 22 May (Table 1). The best variational analysis method determined from the OSSE will be applied to the radial velocity data collected on 22 May from all of the available radar platforms.

A number of different deployment strategies were utilized in the data collection, and were as follows:

1) Velocity Azimuth Display (VAD) – stationary collection of data taken at ~45 degrees elevation. Antenna was rotated horizontally through ~ 220 degree portion of a cone (limited by the hardware of the positioner).

2) Vertical antenna – antenna pointed at ~ 90 degrees and driven across the boundary.

3) Stationary RHI – stationary data collection in which antenna rotated from ~0-90 degrees (Fig. 3). An example is given in Fig. 4.

Time (UTC)	Scan strategy	Other operational radar platforms
2012-2050	Rolling RHI (westward truck motion)	DOW2 (-2035), DOW3 (-2017), SR1 (-2024)
2109-2151	Rolling RHI (eastward truck motion)	DOW2 (2127-), DOW3 (2129-), SR1 (2136-)
2222-2233	Vertical antenna (westward truck motion)	DOW2, DOW3
2242-2325	Stationary RHI	DOW2, DOW3, SR1 (2254-)
2345-0001	Rolling RHI (eastward)	DOW2, DOW3, SR1
0007-0036	Rolling RHI (westward)	DOW2, DOW3, SR1
0036-0045	Stationary RHI	DOW2, DOW3, SR1

Table 1 – Data collection periods and scan strategy for the UMass W-band radar on 22 May 2002

Fig. 3 – Schematic of Stationary RHI (left) and Rolling RHI (right) scanning strategy

4) Rolling RHI – 0-90 degree RHIs collected with the truck in motion (Fig. 3). Radar velocity must be adjusted for truck motion.

The cost function minimized for this variational analysis will be similar in form to the following (e.g., simultaneous velocity component solution with weak constraint on observations and continuity) (cf. Gao et. al. 1999):

$$J = J_O + J_D \qquad (1)$$

where J_o denotes the deviation of the analysis from all of the available Doppler radial velocity data, and J_D is the deviation of the analysis wind fields from that which would satisfy mass continuity exactly. Smoothness constraints may also be necessary.

The preliminary analyses of these data will be presented at the conference.

4. COMMENTS

The motive for this analysis is to *resolve the fine-scale vertical structure of the dryline boundary.* Previous investigators have documented vertical variability to the DCZ. This variability undeniably determines the success or failure of convective initiation. It is logical to conclude, therefore, that finer resolution of the DCZ will yield more clues to this perplexing scientific problem.

Undoubtedly, inclusion of the UMass data will result in the synthesis of finer-scale features. However, it is uncertain how to account for the difference in the spatial resolution of the different radar platforms. Likely some optimal combination of the interpolation of coarse data and the averaging/spreading of fine-resolution data will be necessary.

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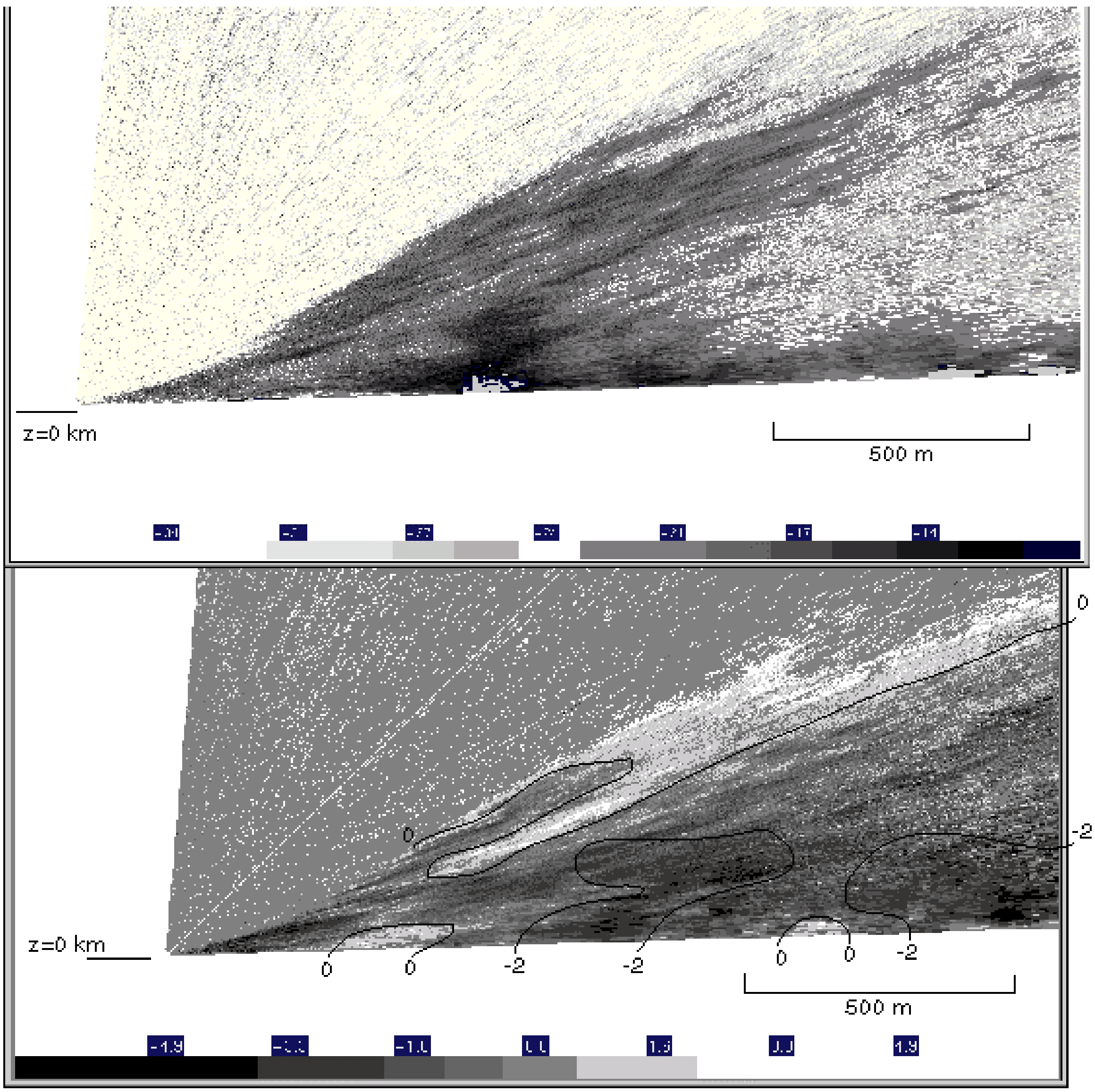

Fig. 4 – (top) UMass W-band reflectivity (dBZ$_e$, shaded) of the retrograding dryline at 0037 UTC from a stationary RHI deployment; (bottom) UMass W-band velocity (m s^{-1}, shaded and contoured). The radar is located in the lower left hand corner of the display. The domain is 1.6 km to the east (right) by 0.6 km in the vertical (upward).