Interaction of a Jetstream with a Squall Line Originating Along an Upper Level Cold Frontal Boundary as Determined from a Comparison of Model and Quad-Doppler Analyses

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BAMEX Bow Echo and MCV Experiment

Objectives

- Analyze the interaction between a convective line and jetstream as observed by airborne Doppler radar measurements from 8 June 2003, during the Bow Echo and Mesoscale Convective Vortex Experiment (BAMEX)
- Use a Weather Research and Forecasting (WRF) simulation of the event to understand the manner in which vertical momentum advection alters upper-level jet structure

Data

The Electra Doppler Radar (ELDORA), aboard the Naval Research Lab (NRL) P-3, used simultaneous fore and aft scanning X-band radars to sample the leading edge of the convective line. The Tail Doppler Radar (TDR), aboard the National Oceanic and Atmospheric Administration (NOAA) P-3, used an alternating fore and aft scanning X-band radar to sample the trailing edge of the line.

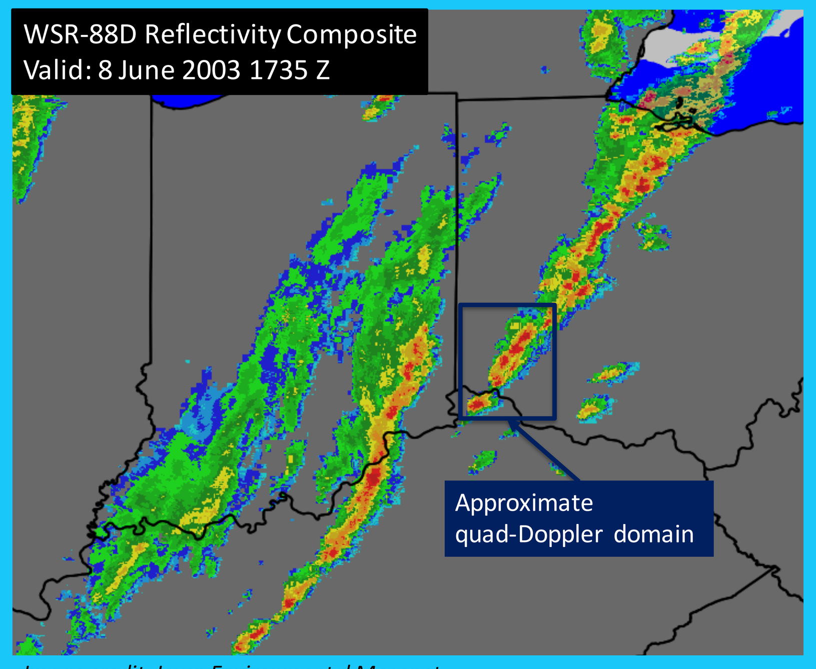


Image credit: Iowa Environmental Mesonet

32 km North American Regional Reanalysis (NARR) data were used in the WRF model (setup summarized below).

Resolution	Vert. Lev	Cumulus	Microphysics	Radiation	PBL
9 km	75	Kain-Fritsch	Morrison	RRTMG	YSU
3 km	75	None	Morrison	RRTMG	YSU

Methodology

The Fore/Aft Scanning Technique (FAST) (Jorgensen et al., 1996) employed by ELDORA and TDR, allows pseudo dual-Doppler wind retrievals from each plane, and pseudo quad-Doppler wind retrievals from combined data.

The radial velocities from each radar are first interpolated to a Cartesian grid, after which horizontal winds are calculated. The vertical component of the wind is then determined through a downward integration of the continuity equation.

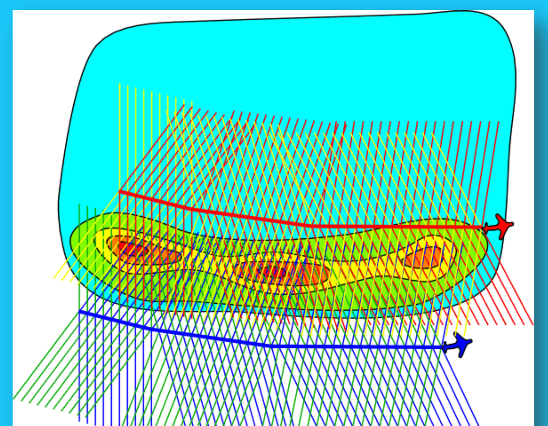
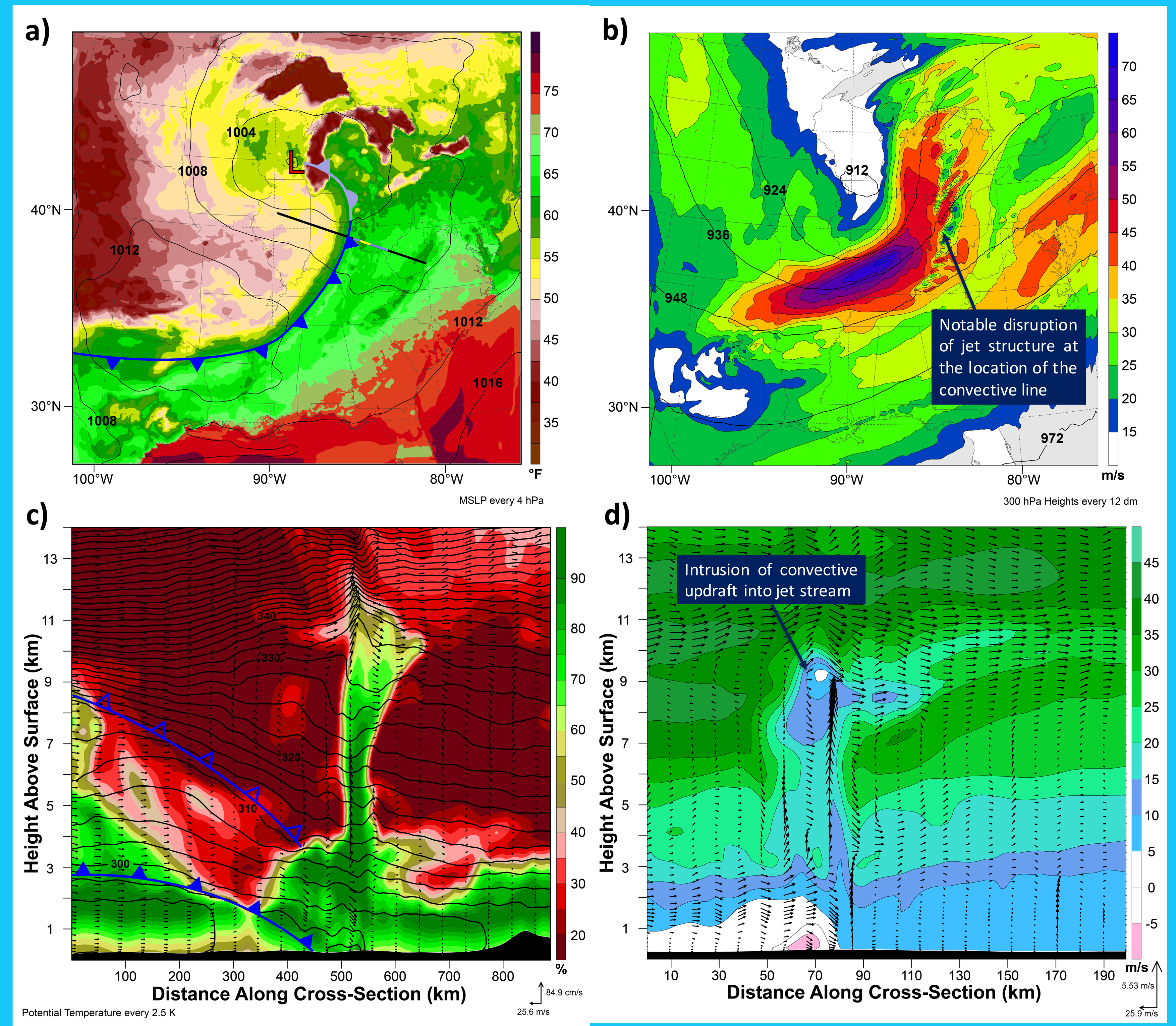
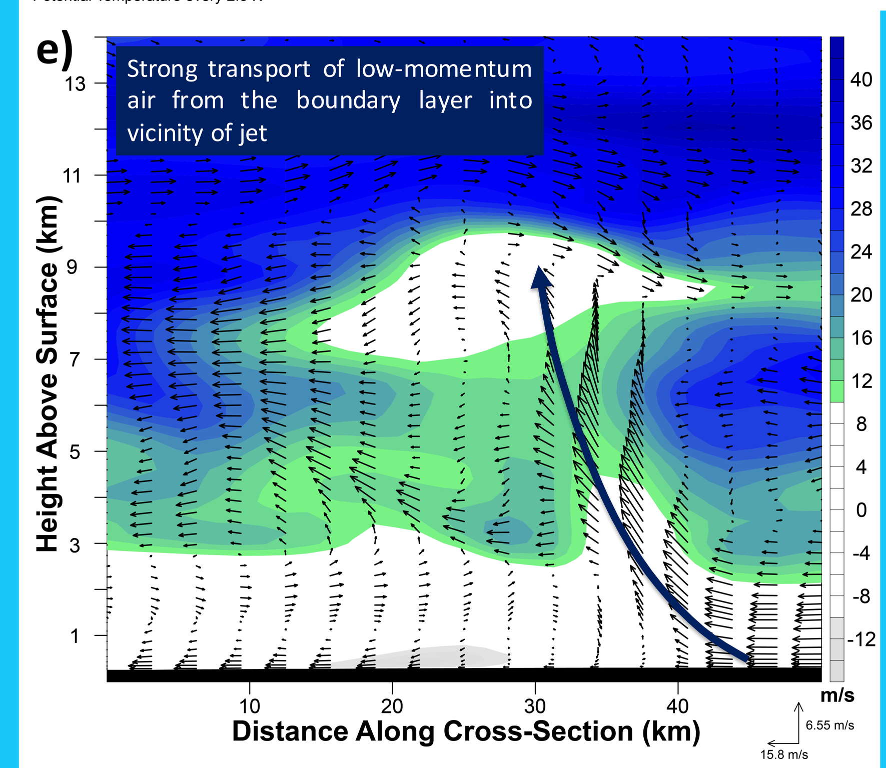


Image credit: Joseph Grim

Figure 1: Illustration of the FAST quad-Doppler scanning method. Blue/red lines and (yellow/green) lines indicate the fore and (aft) scans for each aircraft. The target system is effectively measured by four separate radars, from four different locations.

WRF Simulation Valid 1730 Z





a) Surface dew point temperature and sea-level pressure. 900 km, 200 km, and 50 km cross sections indicated by black, blue, and yellow lines, respectively. Surface fronts and cyclone center at 1730 Z are overlaid.

b) 300 hPa heights and wind speeds.

c) Potential temperature, relative humidity w.r.t. liquid water, and wind vectors in the plane of the cross-section. Approximate location of surface and upper-level cold fronts at 1730 Z are overlaid.

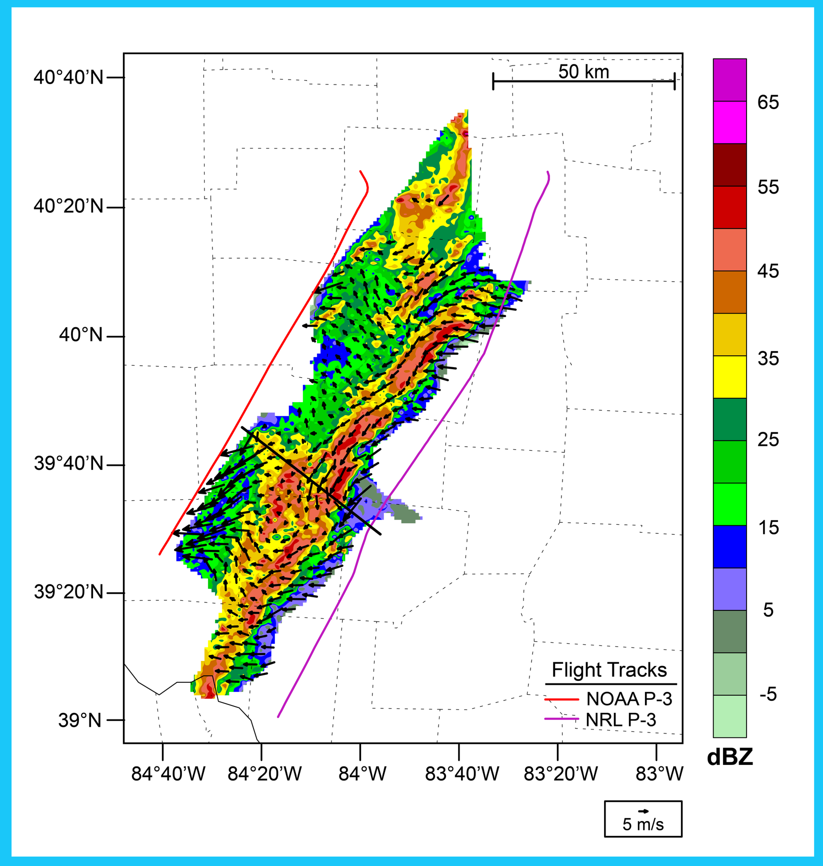
d) Winds normal to the cross-section, and parallel to the convective line (positive is into the plane). Wind vectors are in the plane of the cross-section.

e) Storm-relative absolute momentum (positive is into the plane) and wind vectors in the plane of the cross-section.

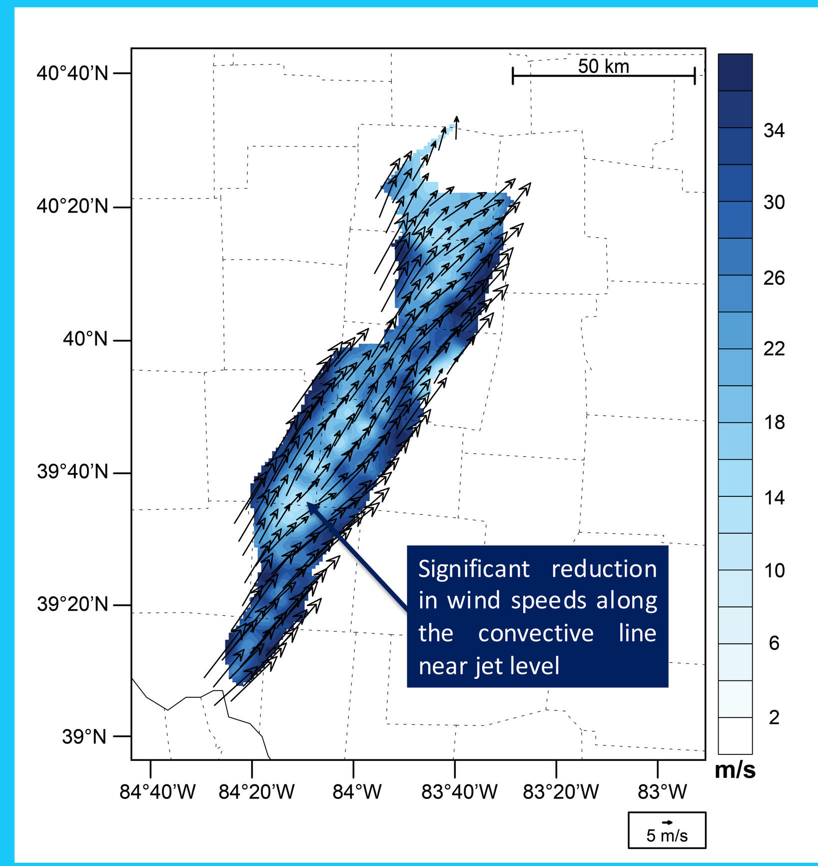
Conclusions and Future Work

- The convective line was likely influenced by both a surface and upper-level cold front
- Low-momentum air from near the surface was transported upward by the convective updraft
  - Significant disruption of the jet is evident in both the horizontal and vertical planes
- Reasonable agreement exists between the model and quad-Doppler analysis
- Further analysis is planned to further elucidate the exact nature of the jet-convection interaction observed
  - 1 km nested domain will be added to simulation
  - Jet-level divergence magnitudes will be compared between the model and Doppler analysis

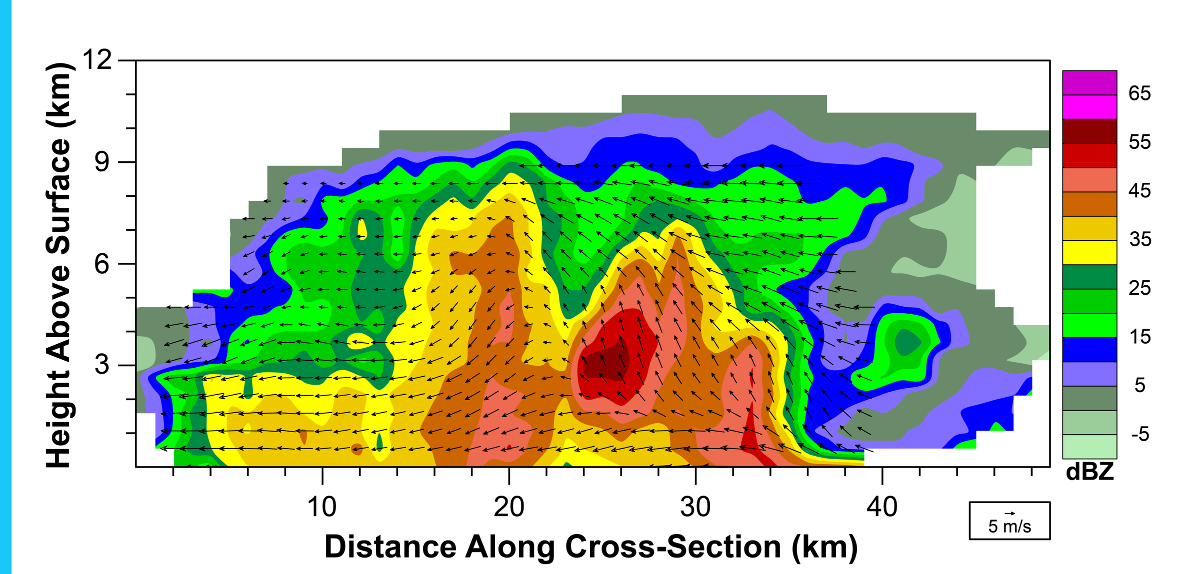
Quad-Doppler Analysis Valid 1733 Z



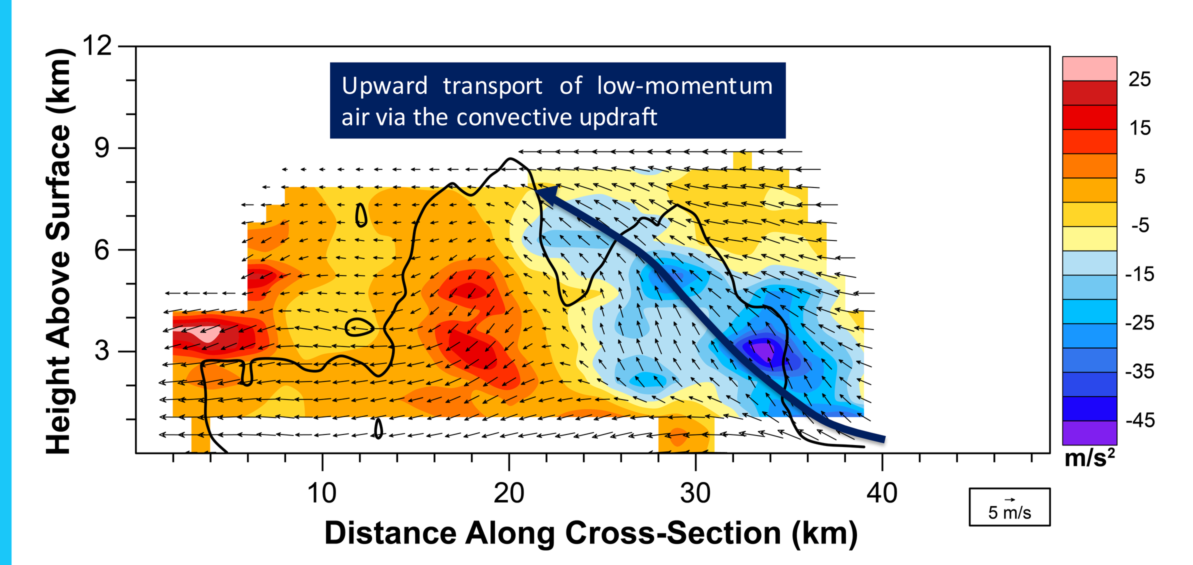
Reflectivity and storm-relative winds at 1 km AGL. Black line indicates location of cross-sections.



Horizontal wind speed and wind vectors at 7.5 km AGL



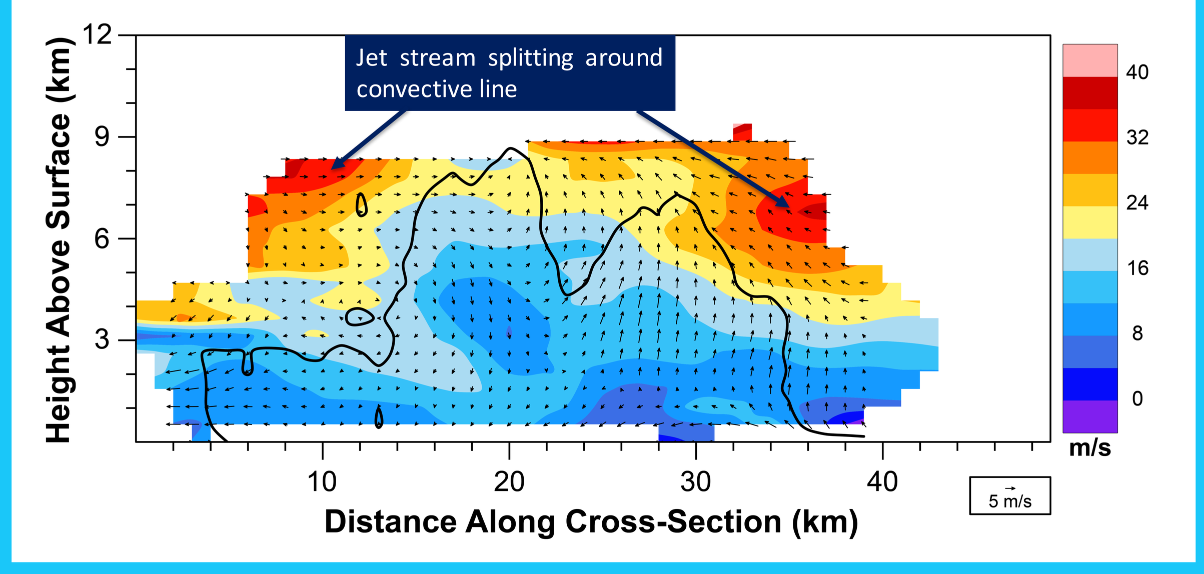
Reflectivity with storm-relative winds in the plane of the cross-section.



Vertical advection of momentum as given by,

$$\frac{dM}{dz} = -w\sqrt{\left(\frac{du}{dz}\right)^2 + \left(\frac{dv}{dz}\right)^2}$$

where u and v are storm-relative and rotated such that the u-axis is parallel to the convective line and normal to the plane of the cross section. Wind vectors are also storm-relative, and in the plane of the cross-section. Negative values correlate with the transport of low momentum air upwards. Positive values indicate transport of high momentum air downward. Black line indicates location of 30 dBZ contour.



Contours of winds normal to the cross-section, and parallel to the convective line (positive is into the plane). Wind vectors are in the plane of the cross-section. Black line indicates location of 30 dBZ contour.

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