Numerical Simulations of a Cold-Season Turbulence Outbreak

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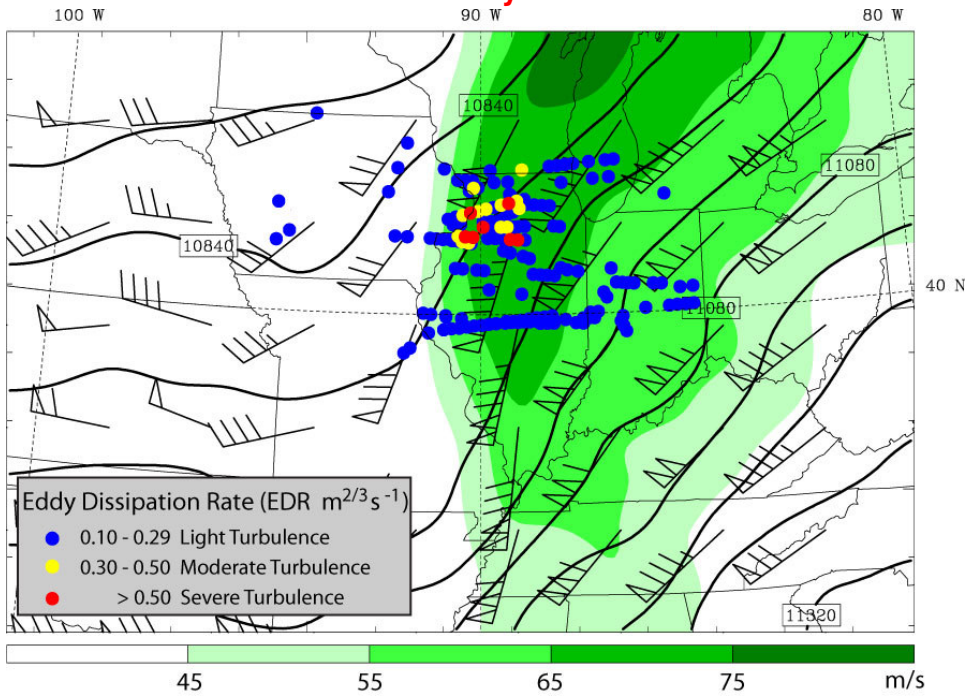
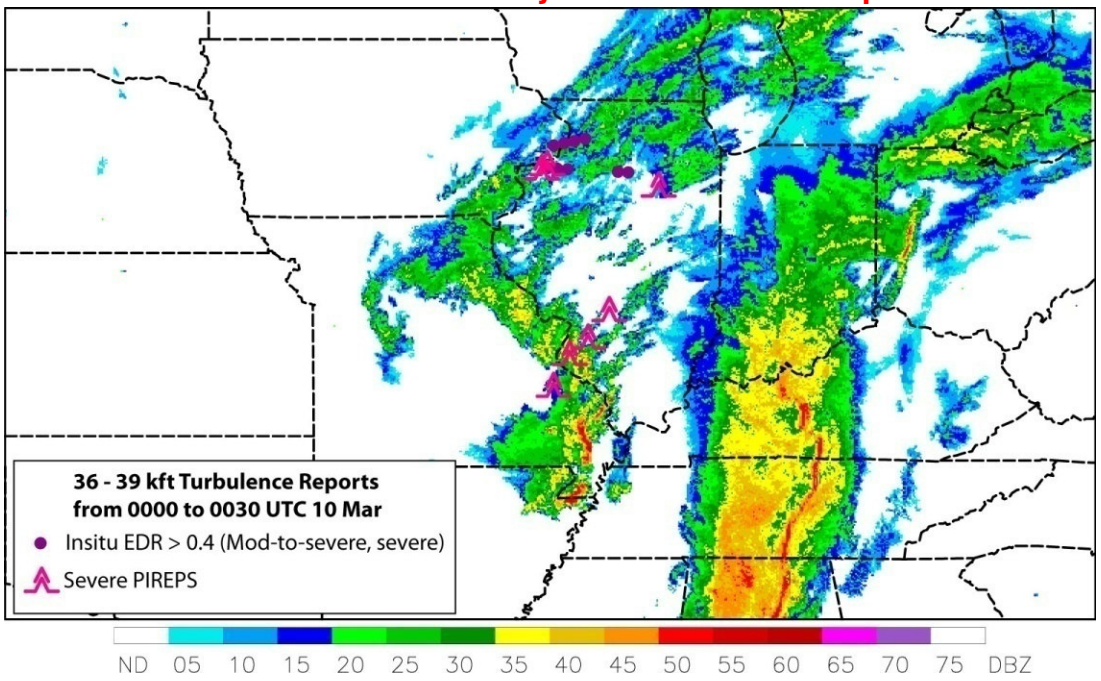
00 UTC 10 Mar 225–hPa RUC Analysis and 21-01 UTC Insitu EDR



00 UTC 10 March Reflectivity and Turbulence Reports



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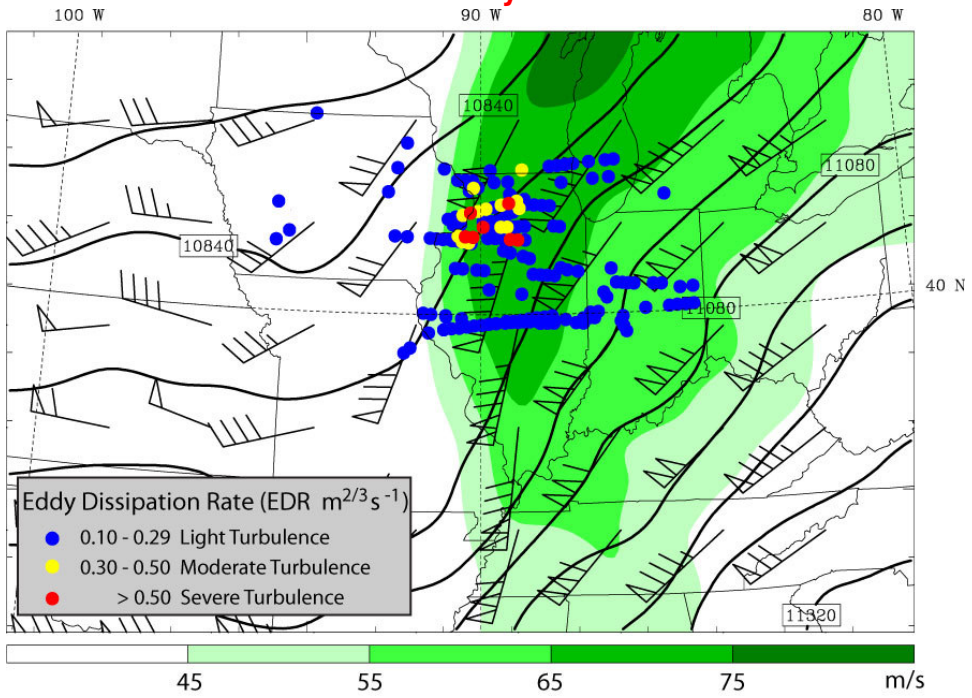

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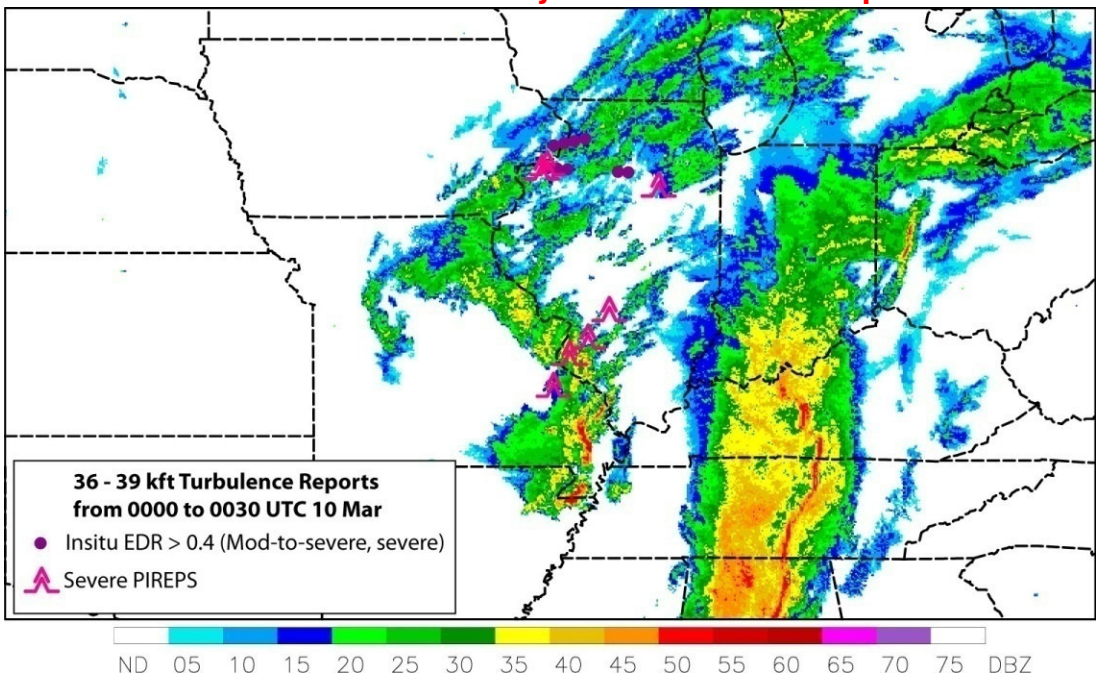
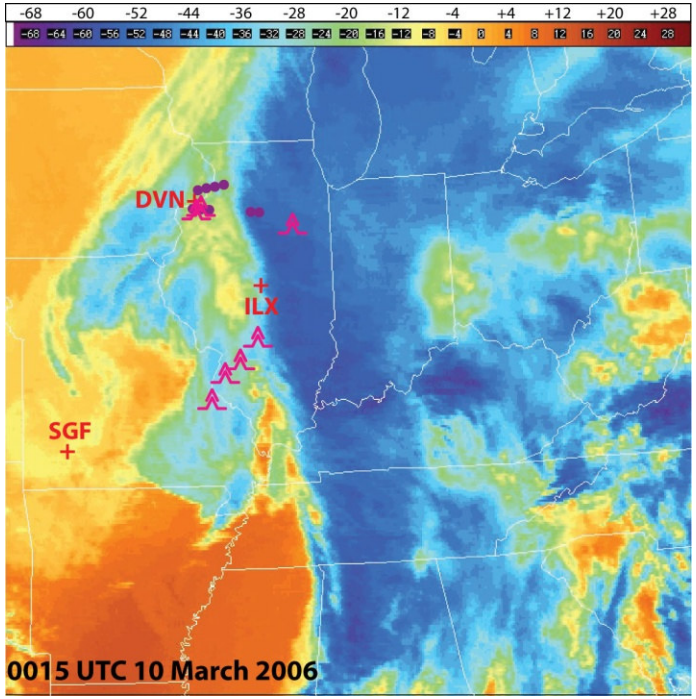
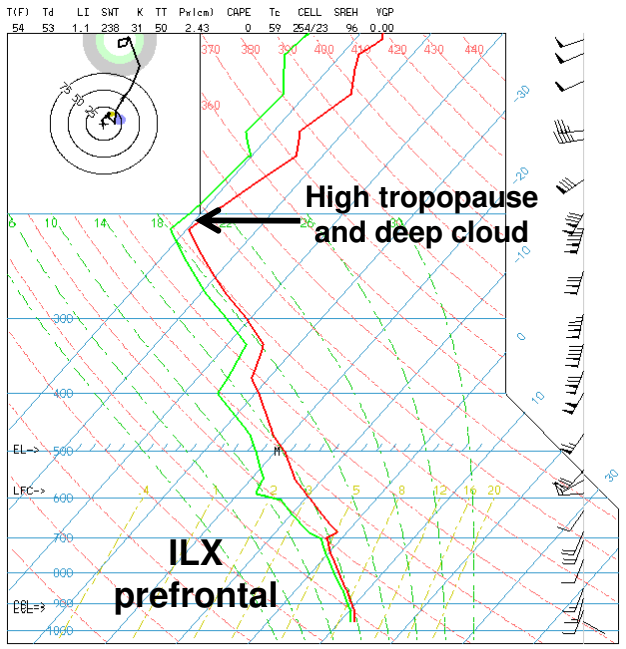


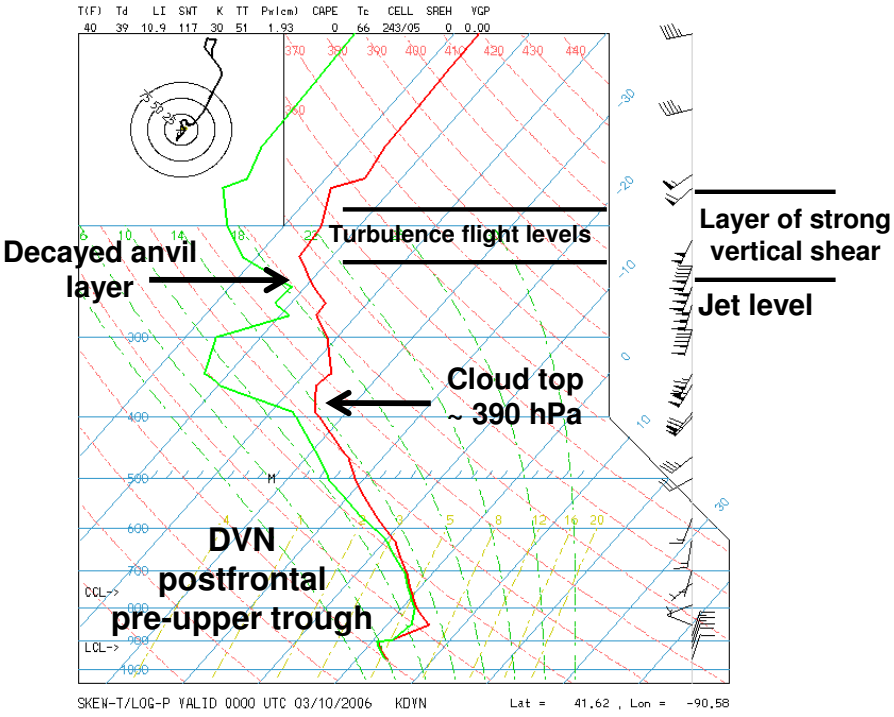
Key Questions :

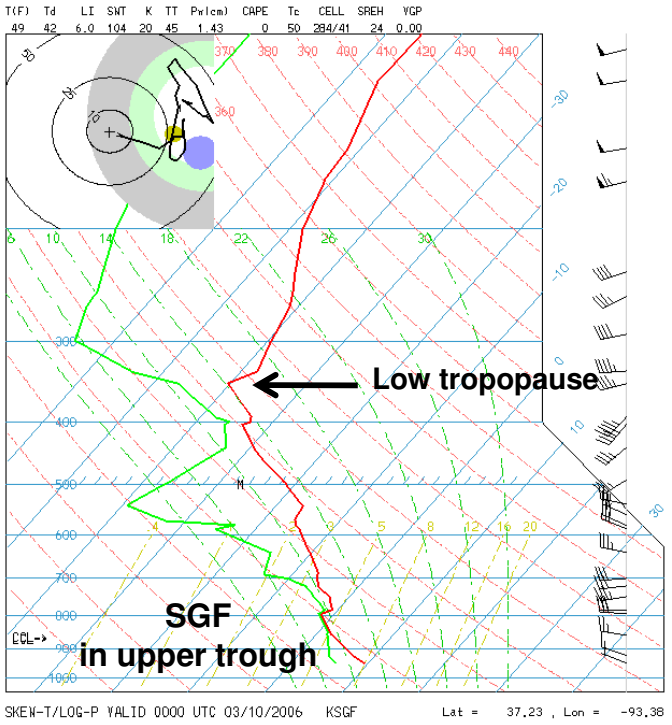
- What is the effect of the precip system on the upper-level flow?
- Does the convection contribute to CAT in this case? If so, what are the mechanisms?

IR Satellite and 190-225-hPa Svr Turbulence



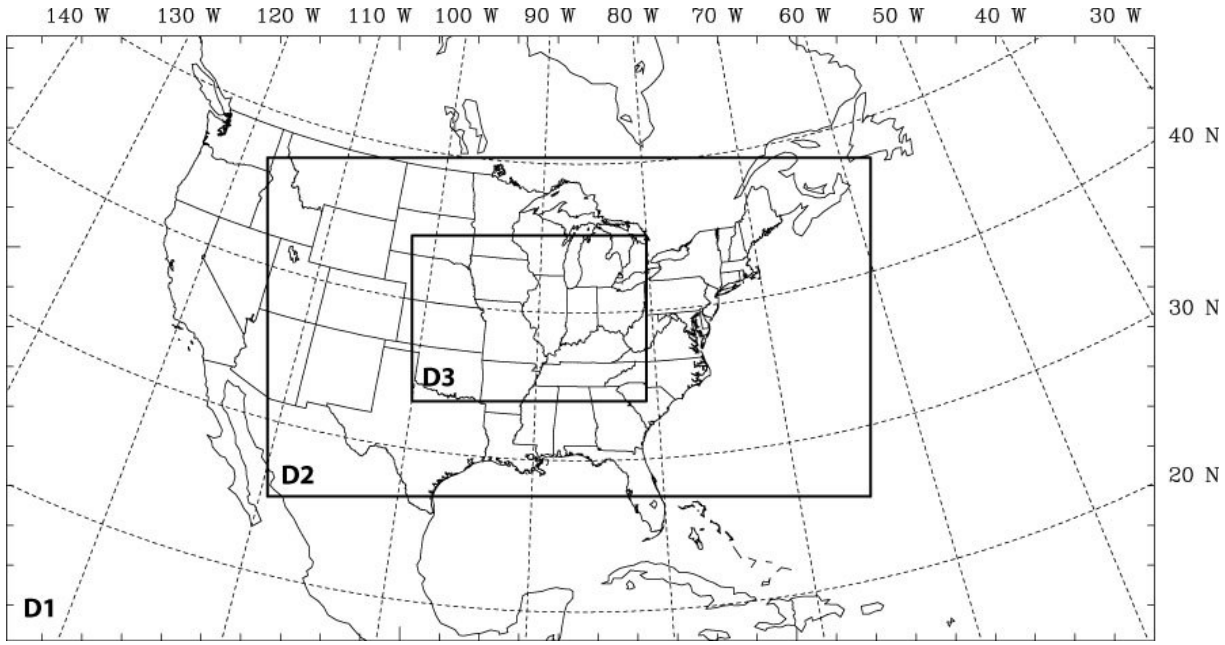






Simulation of the 9-10 March 2006 Turbulence Outbreak

Nested Simulation Domains (Δ = 30 km, 10 km, and 3.3 km)



- Nested simulations with ARW-WRF version 3.1.1
- 80 vertical layers with 20-hPa model top, 3 fixed horizontal domains
- Kain-Fritsch Cumulus Scheme on D1 and D2 with fully explicit convection on D3 (Δx = 3.3 km)
- Initial and boundary conditions from 6-hourly GFS analyses

Model parameterizations

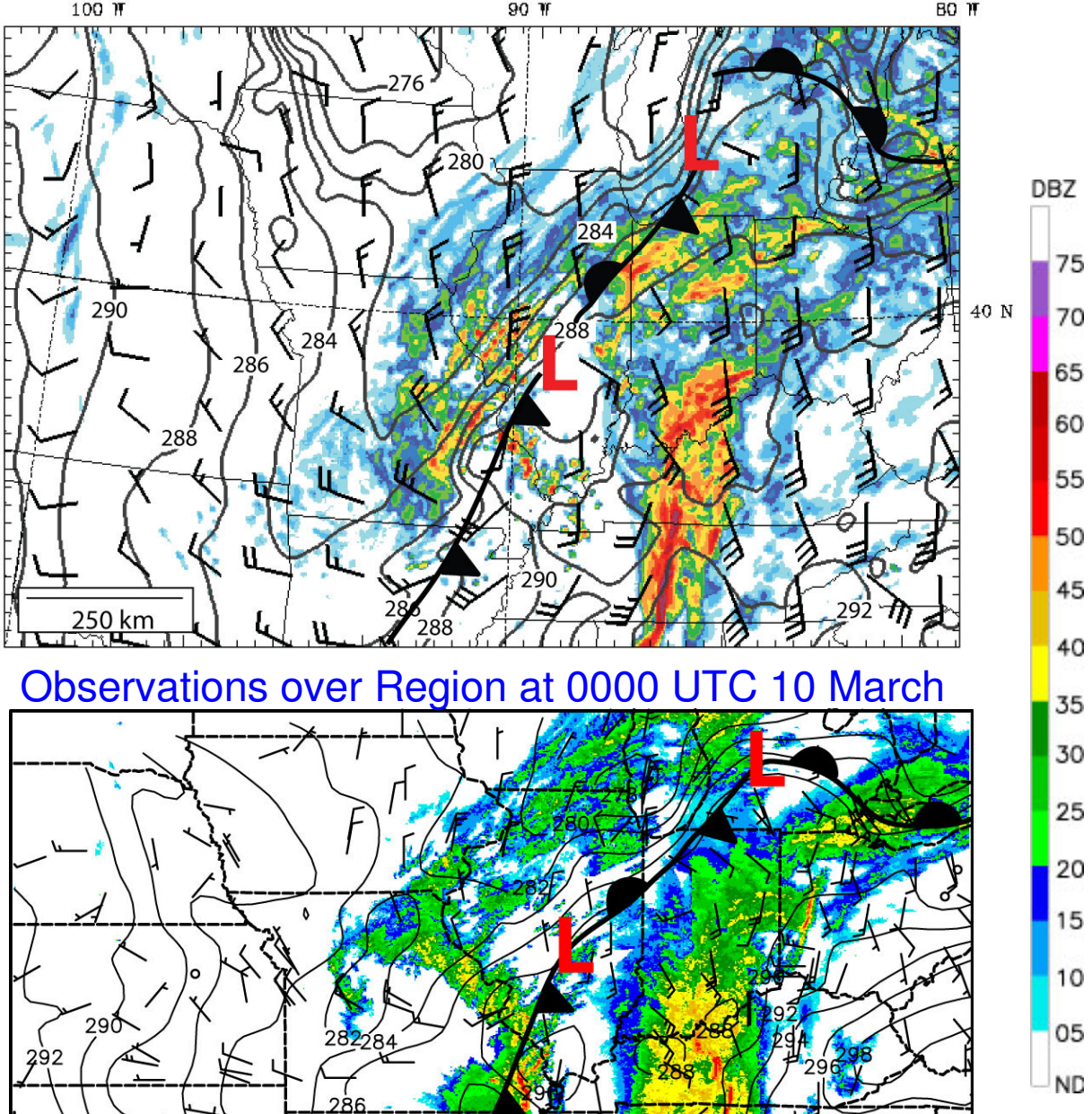
- Lin et al. microphysics
- MYJ PBL scheme
- Dudhia SW radiation
- RRTM LW radiation

Simulations:

- Control (started 24-h prior to reported turbulence)
- Dry simulation (microphysics scheme disabled in D3)
  - eliminates effects of convection within 6-h prior to reported turbulence

24-h Forecast (CTRL) over Domain 3 at 0000 UTC 10 March

- model derived reflectivity
- surface winds
- surface θ (2-K contour intervals)

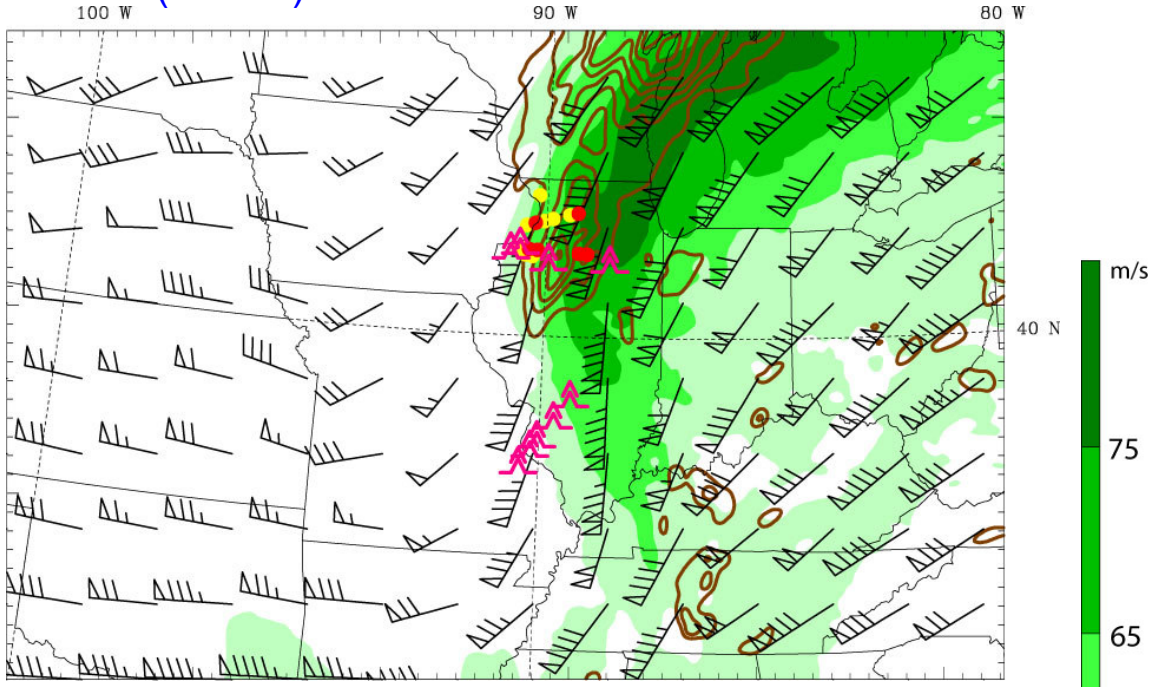


Observations over Region at 0000 UTC 10 March

- NOWRAD reflectivity
- surface winds
- surface θ (2-K contour intervals)

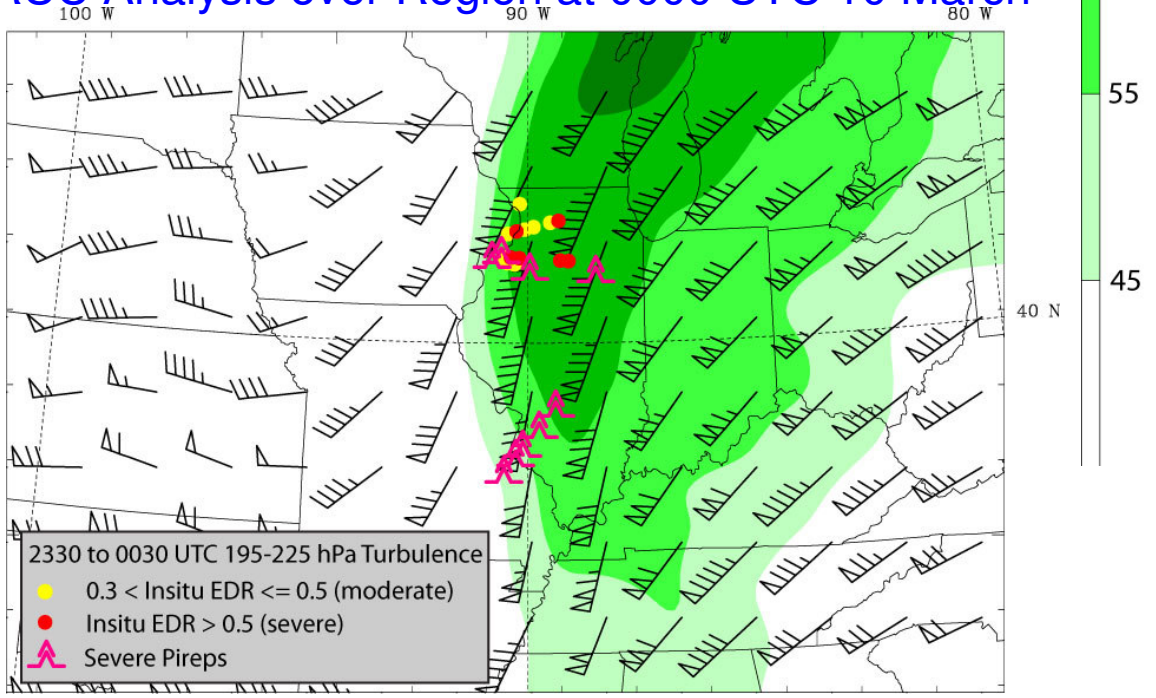
24-h Forecast (CTRL) over Domain 3 at 0000 UTC 10 March

- 225-hPa isotachs
- 225-hPa winds
- 210-hPa TKE (brown contours)



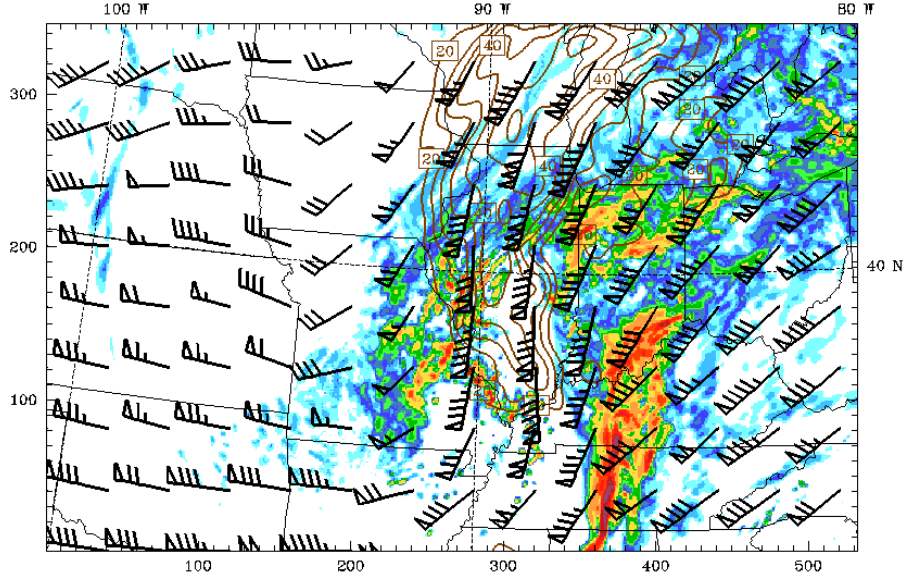
RUC Analysis over Region at 0000 UTC 10 March

- 225-hPa isotachs
- 225-hPa winds
- 195-225-hPa turbulence reports

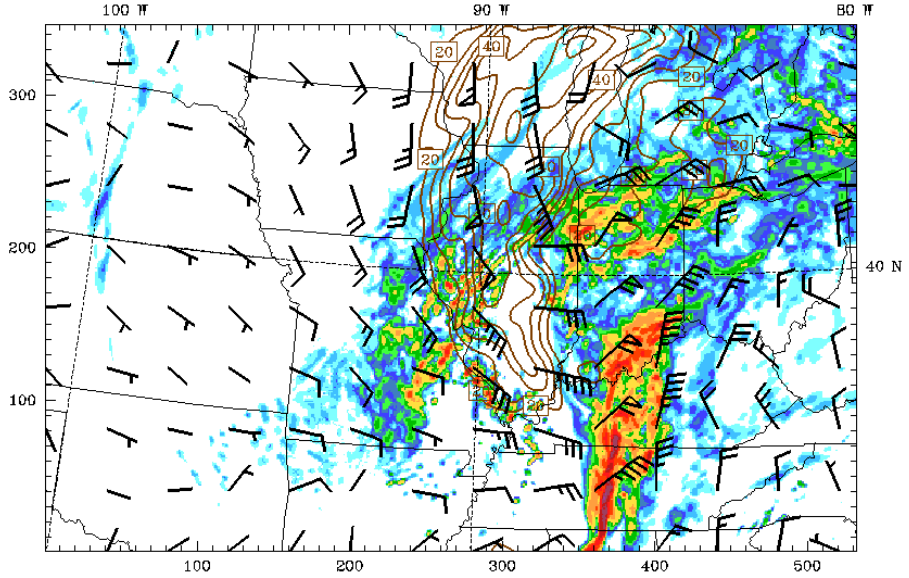


Reflectivity/ Outflow Vertical Shear Magnitude in Current (top) and MCS (bottom) cases

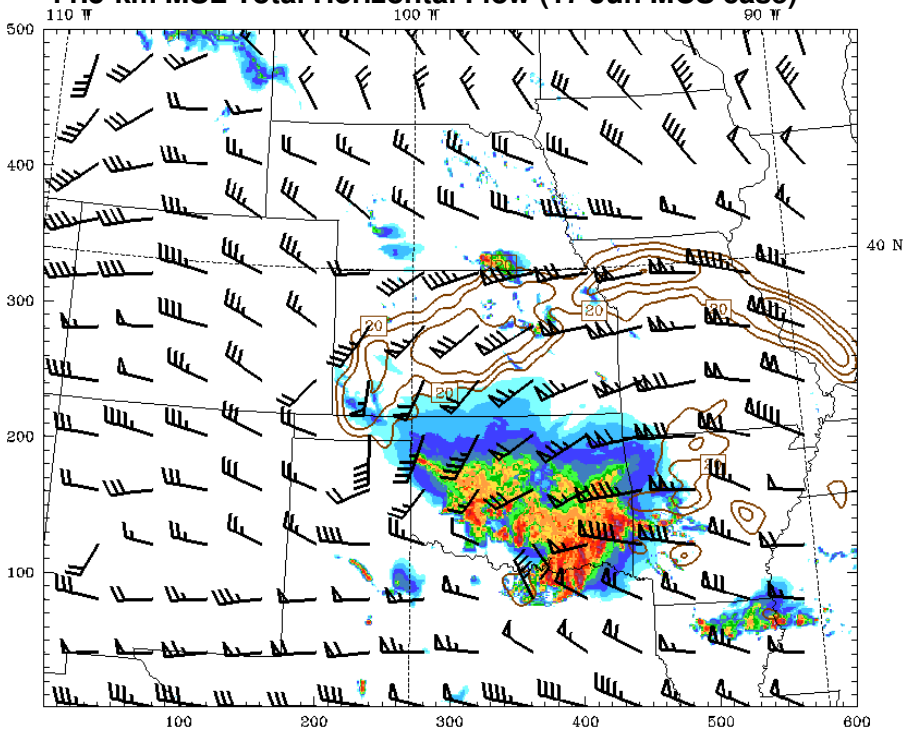
10.5-km MSL Total Horizontal Flow (10 Mar case)



10.5-km MSL Perturbed Horizontal Flow (10 Mar case)



11.5-km MSL Total Horizontal Flow (17 Jun MCS case)



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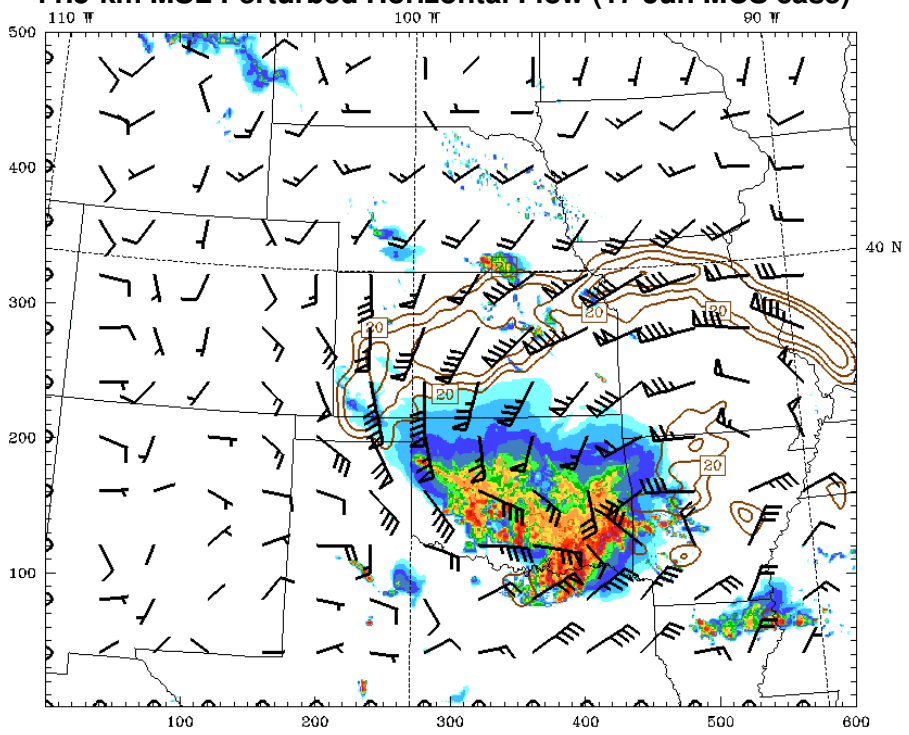
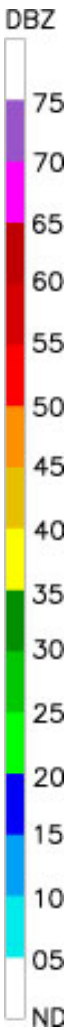
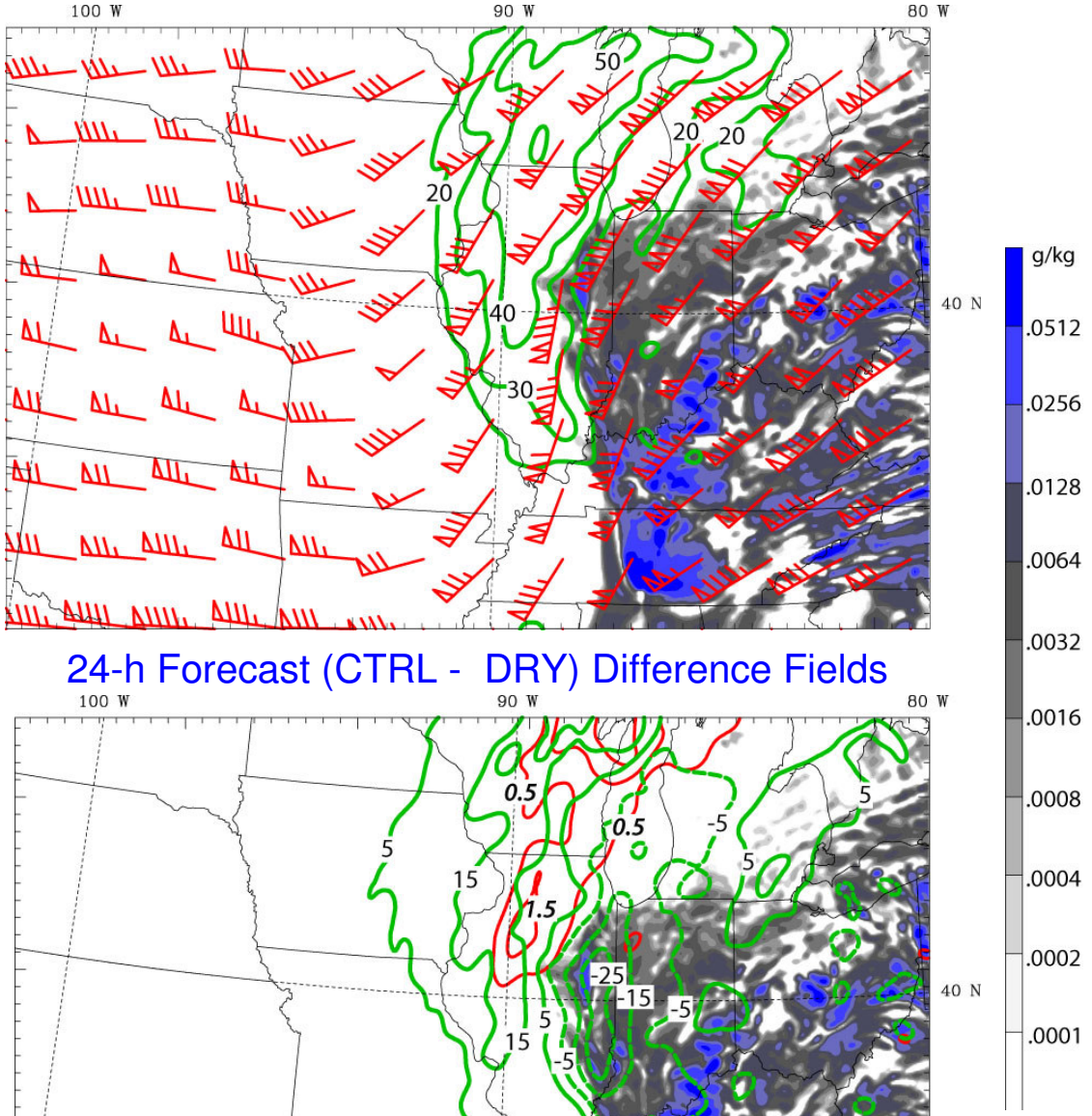




24-h Forecast (CTRL) over Domain 3 at 0000 UTC 10 March

- **CTRL 11.5-km total cloud condensate**
- **CTRL11.5-km winds (red barbs)**
- **CTRL 12 -10.75 vertical shear (green contours)**



24-h Forecast (CTRL - DRY) Difference Fields

- **CTRL 11.5-km total cloud condensate**
- **(CTRL- DRY) 11.5-km TKE (red)**
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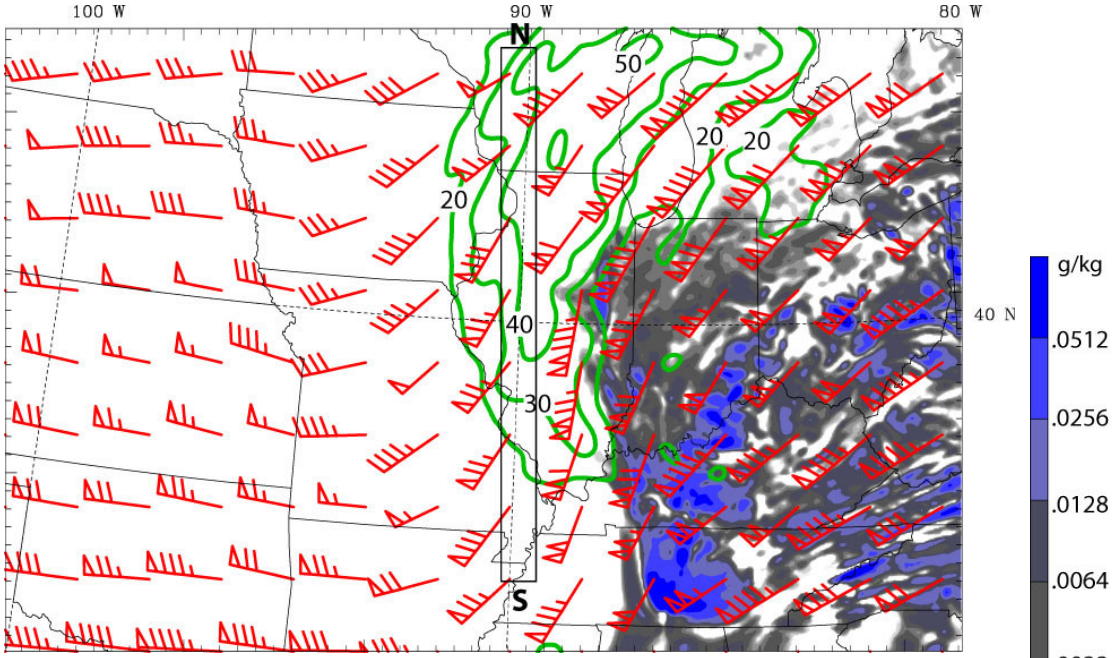

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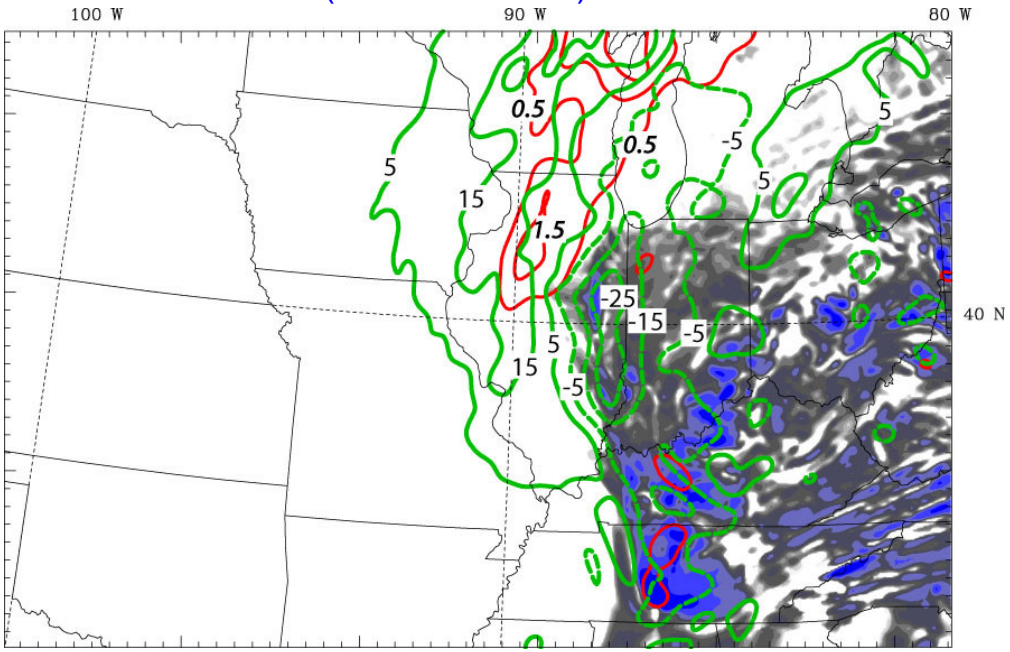
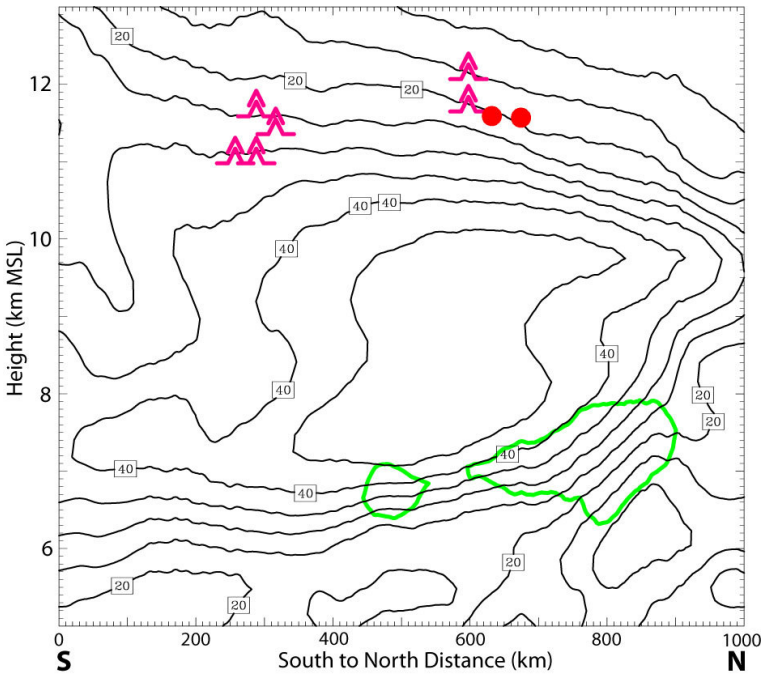
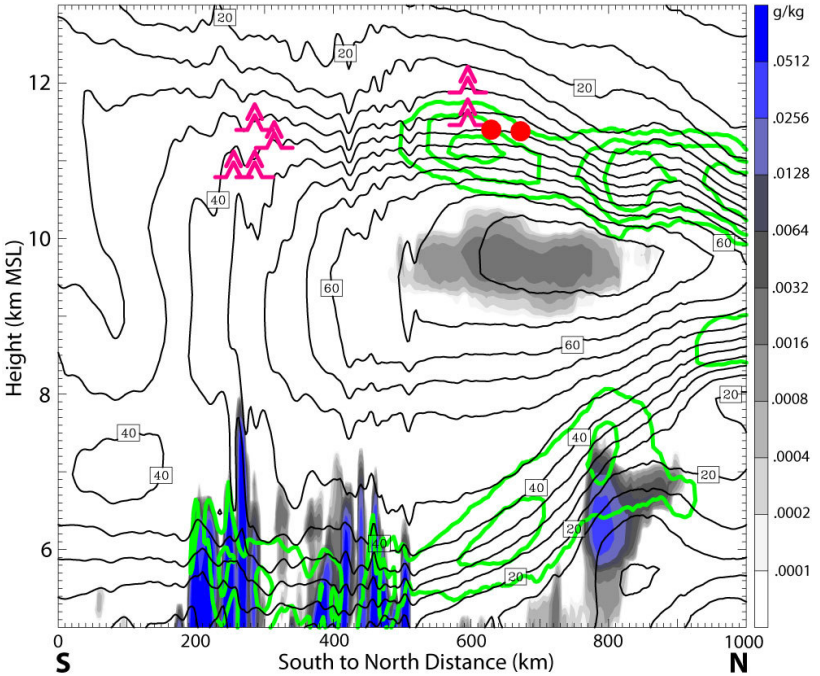


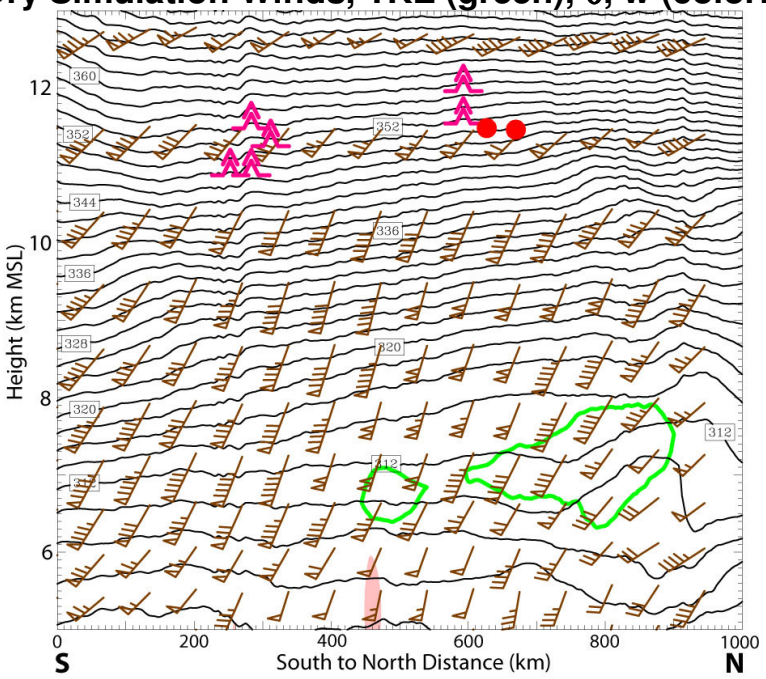
Dry Simulation V-wind, TKE (green)



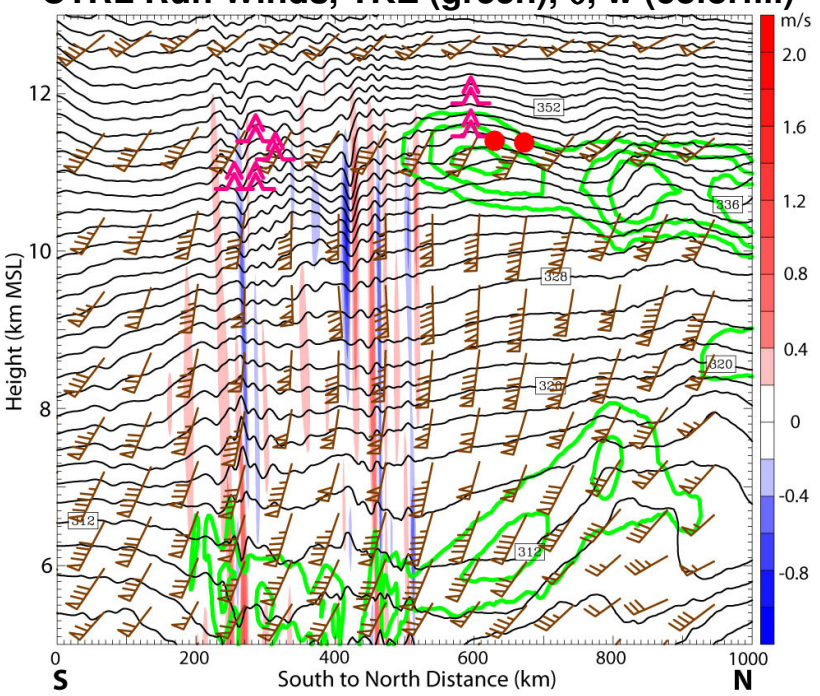
CTRL Run V-wind, TKE (green), Condensate (colorfill)



Dry Simulation Winds, TKE (green), θ, w (colorfill)



CTRL Run Winds, TKE (green), θ, w (colorfill)



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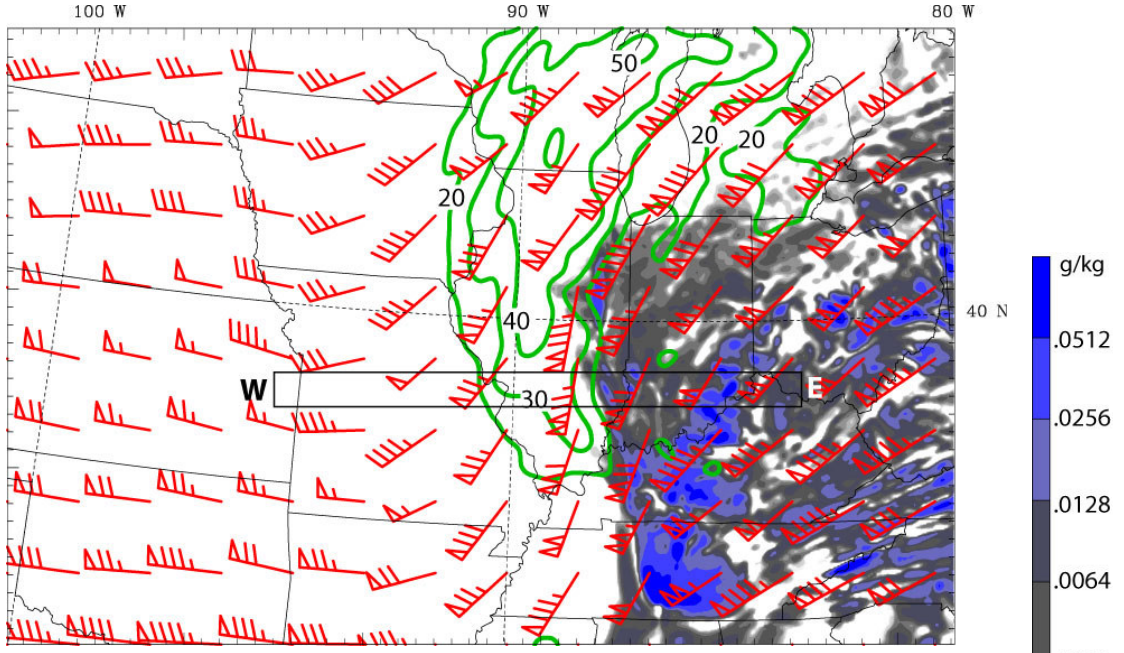

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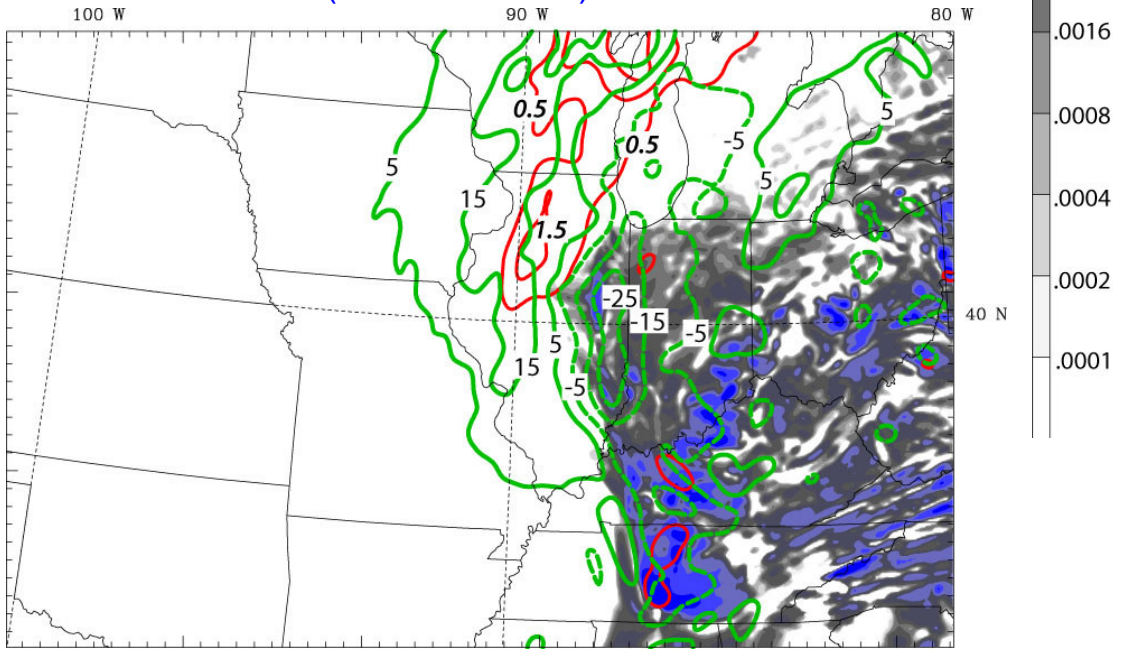
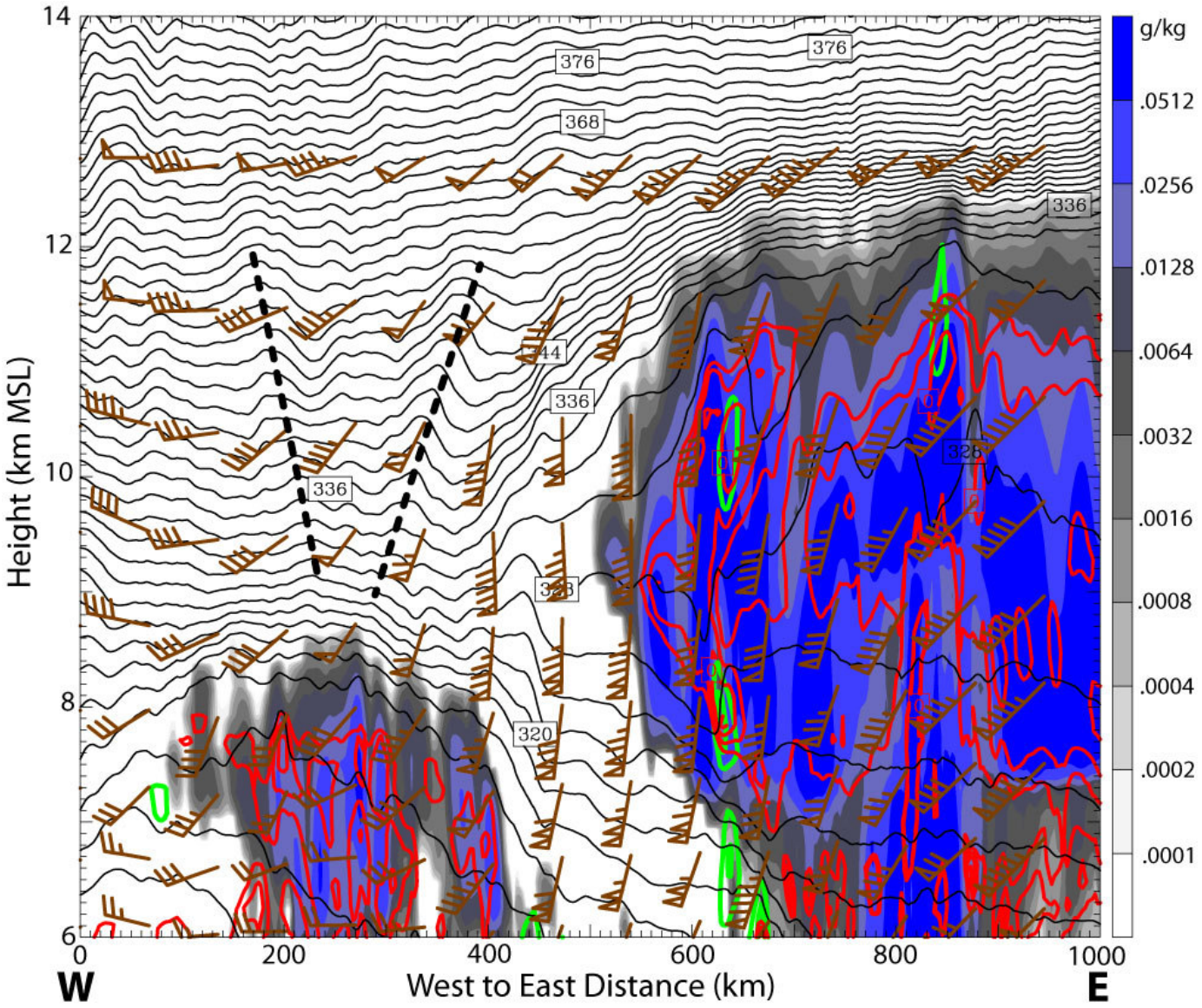


Line-Averaged Cross Section of Cloud (colorfill), θ, Winds, TKE (green), Nm (red)



CTRL 24-h Forecast (0000 UTC 10 March 2006)

Summary

- A nested version of ARW-WRF used to simulate a midlatitude cyclone case (9-10 March 2006) associated with severe aviation turbulence

  - Both organized convection and upper-level flow structure well simulated

- Comparison of full physics CTRL run with dry simulation reveal convection significantly impacts upper-level jet and its associated vertical shear

- Possible turbulence mechanisms are being examined using the simulations

  - CIT related to the convectively-enhanced vertical shear (e.g., K-H instability)

  - Mechanical forcing of gravity waves from convection below (Lane et al. 2003, Lane and Sharman 2008)

  - Gravity-wave emission from unbalanced jets (Knox et al. 2008)