Cold-Season Coupled Upper-Level Jet Streaks in the Northeastern United States
Part 1: Weak Dynamic Cases

Scott M. Rochette[1], Chad M. Gravelle[2], and Thomas A. Niziol[3]

[1]Department of the Earth Sciences, SUNY College at Brockport
[2]Cooperative Institute for Precipitation Systems, Department of Earth and Atmospheric Sciences, Saint Louis University
[3]NOAA/NWSFO Buffalo, NY

SAINT LOUIS UNIVERSITY

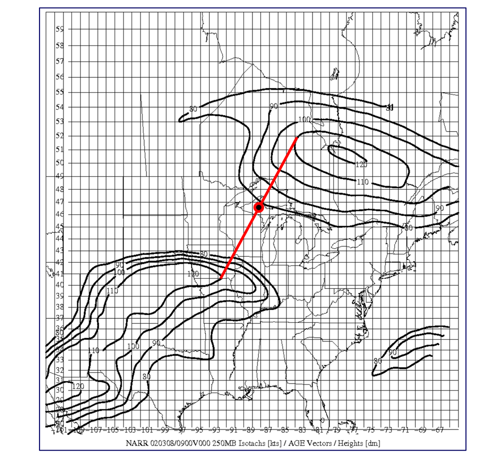
Introduction

- The interaction of transverse circulations associated with two separate upper-level (UL) jet streaks, along with its effects on sensible weather, have been documented in several studies:
  - East Coast cyclogenesis (e.g., Uccellini and Kocin 1987)
  - Heavy/banded precipitation (e.g., Belville and Stewart 1983; Junker et al. 1990; Hakim and Uccellini 1992; Funk and Moore 1995; Melde 1996)
  - Organized severe thunderstorm complexes (e.g., Hamilton et al. 1998; Ashley et al. 2000; Jamski et al. 2000)
- The term 'coupled jet streaks' refers to the presence of two separate jet streaks juxtaposed in such fashion that the ascending branches of the transverse circulations are collocated with one another, resulting in an enhanced area of upward vertical motion (e.g., Uccellini and Kocin 1987).
- This study will investigate coupled UL jet streak occurrences during the cool season (1 October to 31 March) in the northeastern U.S. over 10 seasons (1993 – 2003).

Uccellini and Kocin 1987

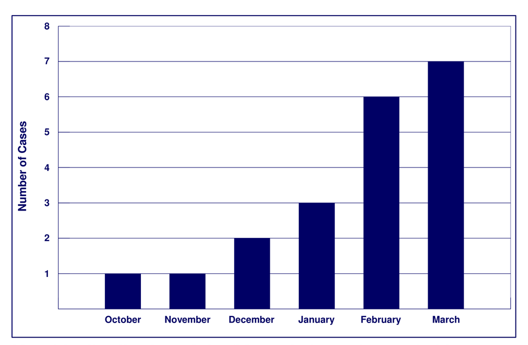
Methodology

- Preliminary examination of the UL flow regime using the North American Regional Reanalysis (NARR) dataset revealed 79 possible coupled jet streak occurrences during the period.
- Using the General Meteorological Package (GEMPAK) with the NARR dataset, plan-view and cross-sectional analyses of the possible occurrences were analyzed to ensure the interaction of the jet streak circulations.
- This revealed 39 coupled jet streak cases, which were then subdivided into weak dynamic (n=20) and strong dynamic (n=19) scenarios.
- The weak dynamic cases (covered in this presentation) were characterized by modest surface circulations (MSLP > 1000 hPa) and open mid-tropospheric waves.



- Center points between the jet streaks were then qualitatively determined by finding the midpoint on a line between the strongest common isotach for the initial coupling time, along with the prior 6- and 12-h time periods (see left).
- The NARR data was objectively analyzed to a 31 x 23 grid with 128 km between gridpoints using the Barnes (1973) objective analysis scheme.
- A 27 x 19 grid was then extracted using the center point between the jet streaks.
- Finally, the data was then averaged over the 20 weak cases using the SLUBREW compositing software developed by Moore et al. (1996).

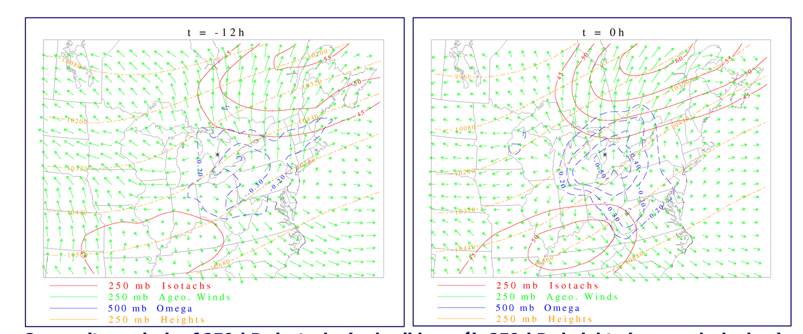
Composites



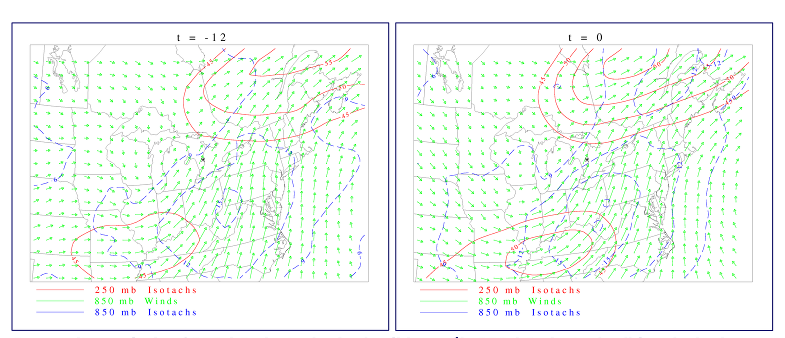
Monthly distribution of the 20 weak dynamic coupled jet streak events.

Date/Time (HHHH/MMDDYYYY)	Location of Jet Streak Interaction	Center Lat/Lon	Distance Exit/Entrance Regions (km)	Distance Jet Cores (km)
1200/11241993	Great Lakes	41.0°N/86.0°W	1520	2718
1200/01121994	Central Appalachians	40.0°N/78.0°W	1386	1781
0000/01171994	Ohio Valley	36.5°N/91.0°W	1873	2547
0000/12051994	Upper Mississippi Valley	44.0°N/96.0°W	1280	3101
0600/02151995	Ohio Valley	39.0°N/86.0°W	1015	2304
1200/02281995	Mid-Atlantic	42.0°N/78.0°W	1525	2324
0000/03291996	Mid-Atlantic	41.0°N/77.0°W	1567	1951
0000/03061997	Ohio Valley	41.0°N/79.0°W	747	1864
0600/12191998	Middle Mississippi Valley	40.0°N/88.0°W	1392	2056
1200/02102000	Middle Mississippi Valley	41.5°N/93.0°W	1225	2560
1800/02122000	Mid-Atlantic	36.0°N/75.0°W	719	1578
0600/02182000	Middle Mississippi Valley	40.0°N/95.0°W	718	3264
0600/03092000	Great Lakes	45.5°N/85.0°W	1563	2261
0600/03152001	Tenessee Valley	35.0°N/91.0°W	908	2135
1800/01062002	Mid-Atlantic	40.0°N/77.5°W	1114	2072
0000/03032002	Ohio Valley	43.0°N/84.0°W	1399	2628
1200/03082002	Upper Mississippi Valley	46.0°N/86.0°W	1176	2445
0600/03262002	Ohio Valley	35.0°N/83.0°W	1428	1992
0600/10262002	Northeast	41.0°N/70.0°W	1031	1942
0000/02252003	Southern Plains	35.0°N/94.0°W	960	3499

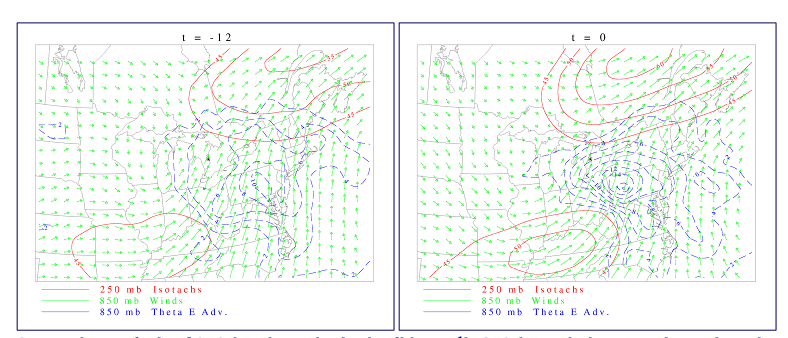
List of weak coupled jet streak cases, including time/date of coupling, area affected, distance between the exit/entrance regions, and distance between jet cores (weak case study in red).



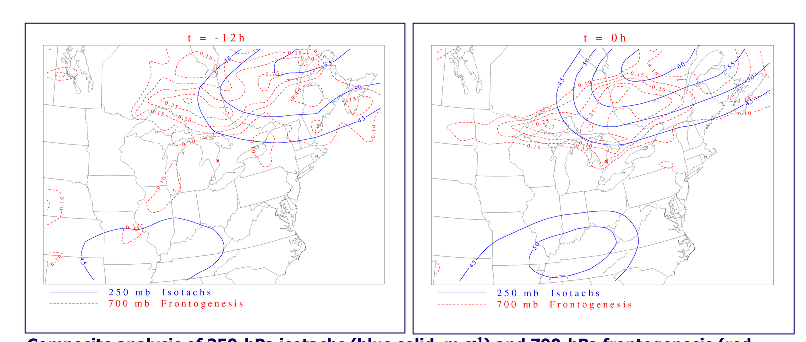
Composite analysis of 250-hPa isotachs (red solid, m s^{-1}), 250-hPa heights (orange dashed, m), 250-hPa ageostrophic wind vectors (green, m s^{-1}), and 500-hPa omega (blue dashed, 10 μbar s^{-1}) at t = -12 h (left) and t = 0 h (right).



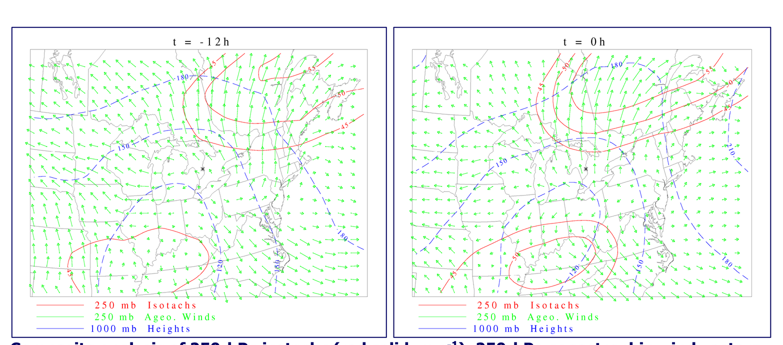
Composite analysis of 250-hPa isotachs (red solid, m s^{-1}), 850-hPa isotachs (blue dashed, m s^{-1}), and 850-hPa wind vectors (green) at t = -12 h (left) and t = 0 h (right).



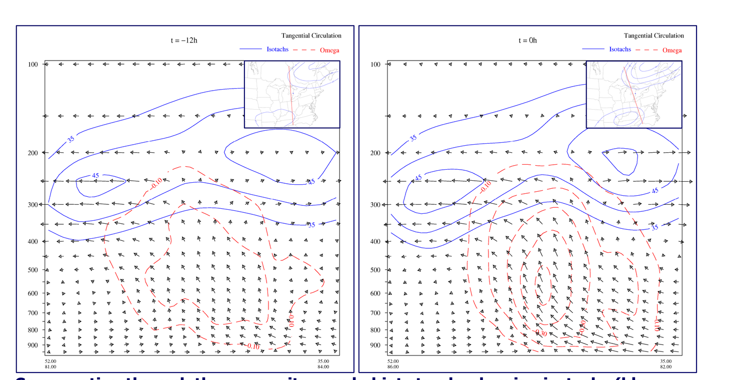
Composite analysis of 250-hPa isotachs (red solid, m s^{-1}), 850-hPa wind vectors (green), and θ_e advection (blue dashed, K hr^{-1}) at t = -12 h (left) and t = 0 h (right).



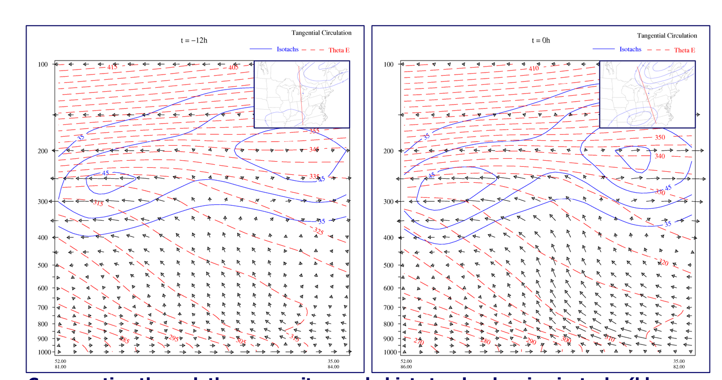
Composite analysis of 250-hPa isotachs (blue solid, m s^{-1}) and 700-hPa frontogenesis (red dashed, 10 K [100 km]$^{-1}$ [3 h]$^{-1}$) at t = -12 h (left) and t = 0 h (right).



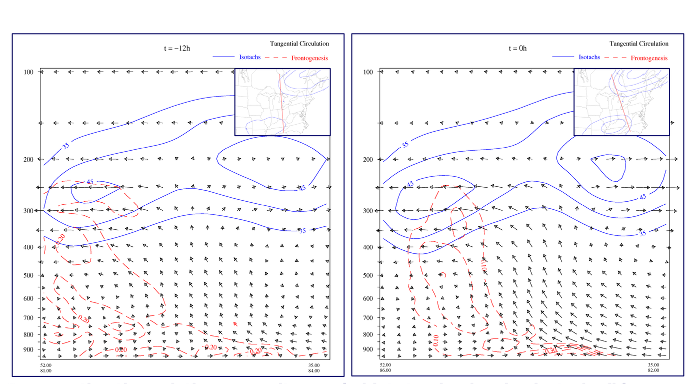
Composite analysis of 250-hPa isotachs (red solid, m s^{-1}), 250-hPa ageostrophic wind vectors (green), and 1000-hPa heights (blue dashed, m) at t = -12 h (left) and t = 0 h (right).



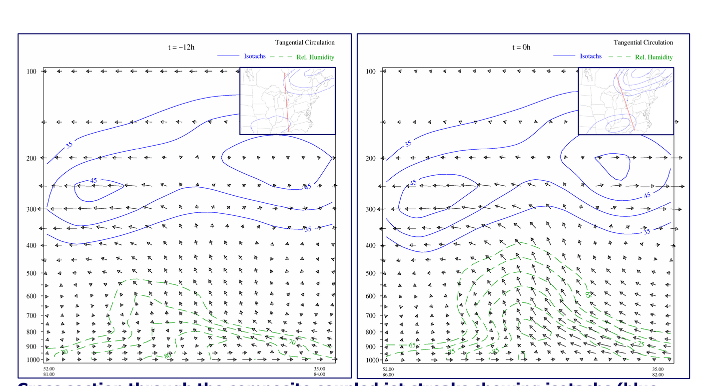
Cross section through the composite coupled jet streaks showing isotachs (blue solid, m s^{-1}), ageostrophic circulation (black arrows), and omega (red dashed, 10 μbar s^{-1}) at t = -12 h (left) and t = 0 h (right). Inset figures provide the orientation of the cross-section with respect to the isotach field.



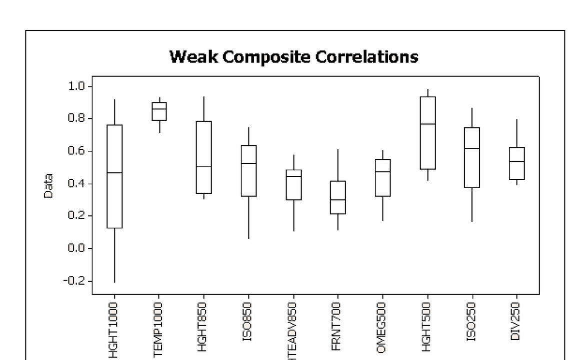
Cross section through the composite coupled jet streaks showing isotachs (blue solid, m s^{-1}), ageostrophic circulation (black arrows), and θ_e (red dashed, K) at t = -12 h (left) and t = 0 h (right). Inset figures provide the orientation of the cross-section with respect to the isotach field.



Cross section through the composite coupled jet streaks showing isotachs (blue solid, m s^{-1}), ageostrophic circulation (black arrows), and frontogenesis (red dashed, 10 K [100 km]$^{-1}$ [3 h]$^{-1}$) at t = -12 h (left) and t = 0 h (right). Inset figures provide the orientation of the cross-section with respect to the isotach field.



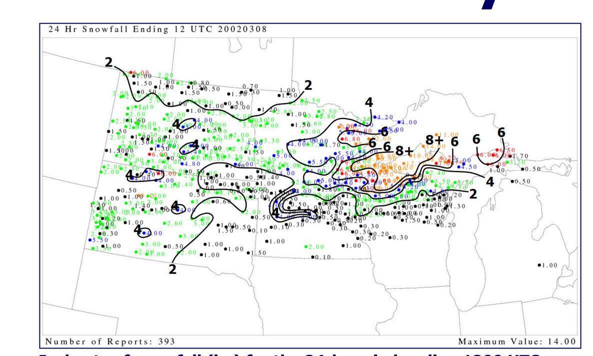
Cross section through the composite coupled jet streaks showing isotachs (blue solid, m s^{-1}), ageostrophic circulation (black arrows), and relative humidity ≥ 60% (green dashed, %) at t = -12 h (left) and t = 0 h (right). Inset figures provide the orientation of the cross-section with respect to the isotach field.



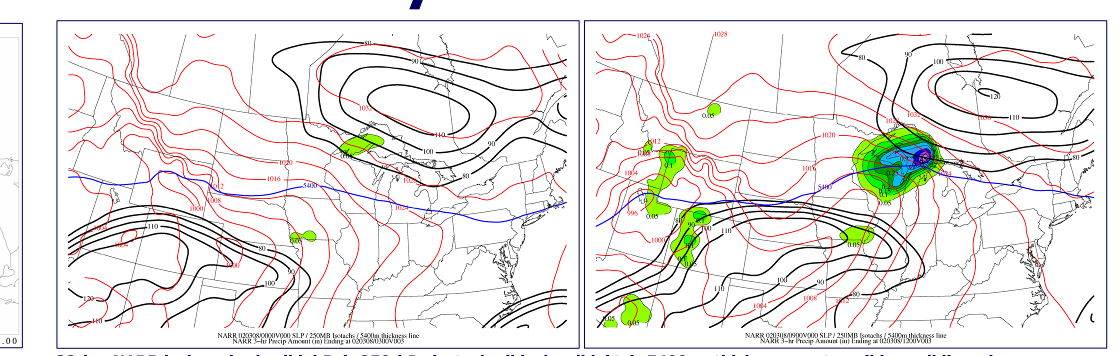
Box-and-whisker plots displaying the range of correlations between the composite fields and the individual weak cases. In each case the horizontal line within each box represents the 50th percentile, the top (bottom) line of the box is the 75th (25th) percentile, and the top (bottom) line outside the box represents the 90th (10th) percentile.

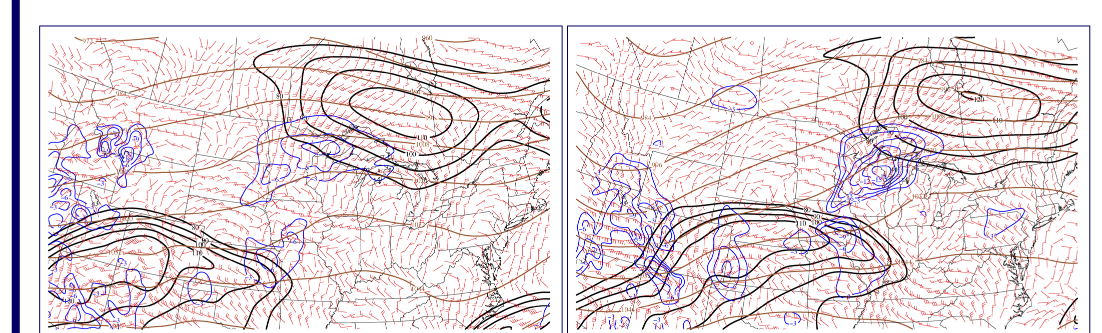
Weak Dynamic Case Study

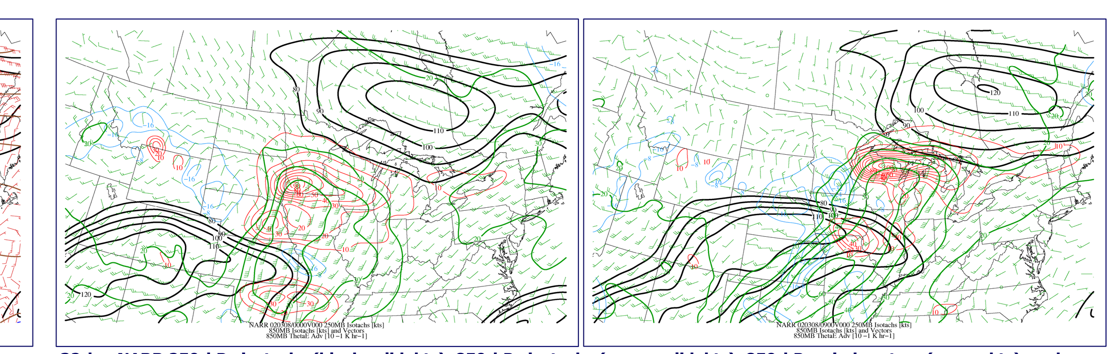
- 8 March 2002
- Regions of 8+ inches of snow
- 80+ reports of thundersnow
- Significant inverted trough development at surface (w/o significant cyclone in vicinity)
- Lake influence unlikely

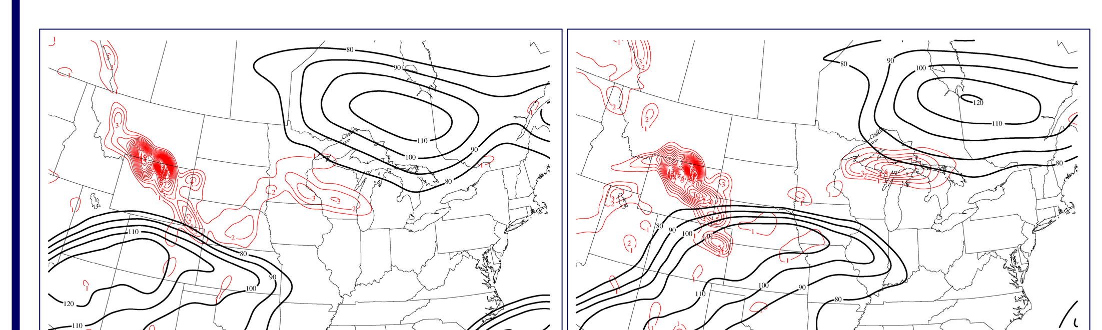


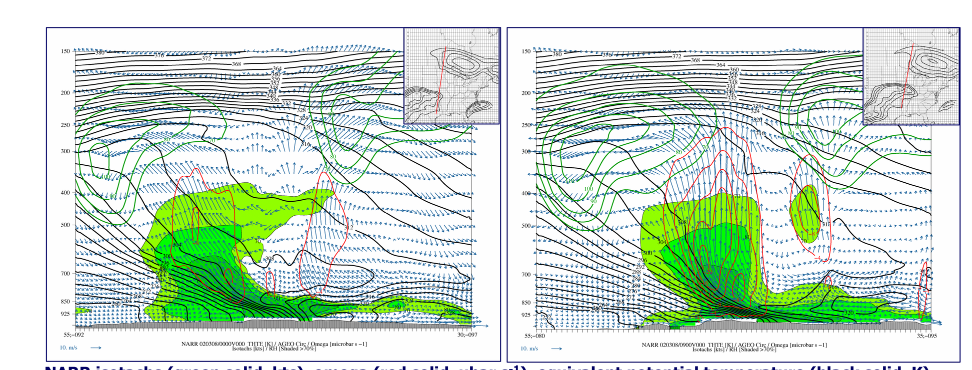
Isohyets of snowfall (in.) for the 24-h period ending 1200 UTC 8 Mar 2002, based upon cooperative station data from NCDC.


32-km NARR isobars (red solid, hPa), 250-hPa isotachs (black solid, kts), 5400-m thickness contour (blue solid), and 3-h accumulated precipitation (shaded > 0.05 in) at 0000 UTC 8 Mar 2002 (left) and 0900 UTC 8 Mar 2002 (right).


32-km NARR 250-hPa heights (brown solid, dkm), 250-hPa isotachs (black solid, kts), 250-hPa ageostrophic wind barbs (red), and 500-hPa omega (blue solid, μbar s^{-1}) at 0000 UTC 8 Mar 2002 (left) and 0900 UTC 8 Mar 2002 (right).


32-km NARR 250-hPa isotachs (black solid, kts), 850-hPa isotachs (green solid, kts), 850-hPa wind vectors (green, kts), and 850-hPa θ_e advection (red solid [+10^{-1} K hr^{-1}], blue solid [-10^{-1} K hr^{-1}]) at 0000 UTC 8 Mar 2002 (left) and 0900 UTC 8 Mar 2002 (right).


32-km NARR 250-hPa isotachs (black solid, kts), and 850-hPa frontogenesis (red solid, K [100 km]$^{-1}$ [3 h]$^{-1}$) at 0000 UTC 8 Mar 2002 (left) and 0900 UTC 8 Mar 2002 (right).


NARR isotachs (green solid, kts), omega (red solid, μbar s^{-1}), equivalent potential temperature (black solid, K), ageostrophic vertical circulation (blue arrows), and RH ≥ 70% (green shading) at 0000 UTC 8 Mar 2002 (left) and 0900 UTC 8 Mar 2002 (right). Inset figures provide the orientation of the cross-section with respect to the isotach field.

Conclusions

- Number of weak dynamic scenarios increases steadily from winter to spring
- 1227 (2351) km average distance between jets' entrance and exit regions (jet cores) at time of coupling
- Southern jet 'parallel' to northern jet
- Northern jet retrogrades slightly and strengthens during coupling period, while southern jet progresses slowly eastward and strengthens
- 250-hPa heights fall significantly upwind of jet streaks, but trough remains weakly defined
- 250-hPa ageostrophic cross-contour flow strengthens during coupling period, resulting in increased/focused upper-level divergence and mid-tropospheric UVM in coupling region
- 850-hPa low-level jet and θ_e advection become stronger and better organized in coupling region over coupling period
- 700-hPa frontogenesis region elongates and strengthens underneath entrance region of northern jet during coupling period
- 'Surface' low remains weakly defined during coupling period, while 1000-hPa inverted trough intensifies in vicinity of northern jet's entrance region
- Poleward/upward transport of warm/moist (high θ_e) air (i.e. ageostrophic circulation) becomes better defined over coupling period
- UVM region narrows/strengthens in between jets over coupling period
- Low-level front strengthens over coupling period
- Mid/upper-tropospheric frontogenetical circulation works in concert with coupled jet circulation as frontogenesis extends upward over coupling period
- Moist layer between jets deepens and narrows over coupling period
- Correlations of basic parameters generally better than those of derived parameters, but minimal differences between weak and strong episodes indicate similar properties for both types of interaction

- This project would not have been possible without COMET Partners Project Award S05-52248 and the help of Charles E. Graves (Saint Louis University) who aided the authors in using the SLUBREW compositing software.