JP2.6 ANALYSIS OF MESOSCALE BANDED FEATURES IN THE 5–6 FEBRUARY 2001 NEW ENGLAND SNOWSTORM

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1. INTRODUCTION

On 5–6 February 2001 a major winter storm produced widespread snow accumulations greater than 30 cm through most of New England, with over 75 cm locally in New Hampshire. The storm featured an intense snowband associated with snowfall rates of 8–13 cm h^{-1}, with a number of finescale bands and convective elements merging into the primary band through the storm's evolution. Several of these finescale bands were associated with thundersnow, which yielded intense snowfall maxima in the lower Connecticut Valley - an orographically unfavored area. The synoptic and mesoscale environment supporting these mesoscale banded features is analyzed.

2. DATA

Mosaic WSR–88D composite radar data with 2 km spatial resolution and 5 min temporal resolution were used to document the evolution of the banded features. Surface and upper-air data were obtained from the national observation network. The National Centers for Environmental Prediction (NCEP) 22 km Eta model analysis, 3-h, and 6-h forecast fields were used to create synoptic summary maps and cross sections. This data was interpolated to a 80 km grid for the synoptic summary maps to facilitate smooth analysis, and interpolated to a 40 km grid for cross-section analysis. GEMPAK software was used to calculate derived dynamic and thermodynamic fields from the model data.

3. ANALYSIS

Composite radar imagery at 2120 UTC 5 February 2001 (Fig. 1) captures the banded features. At this time the primary band (associated with 30-35 dBZ reflectivity) arcs through central New England into eastern New York with several intense (35-40 dBZ) finescale bands noted just off the southern New England coast. Radar animations (http://www.atmos.albany.edu/student/dnovak/radaranimation/radar.html) show these finescale bands rapidly moving northwest and merging with the primary band. By 0000 UTC 6 February 2001 (Fig. 2) the primary band is well established through the heart of New England, with a few finescale bands evident near Cape Cod.

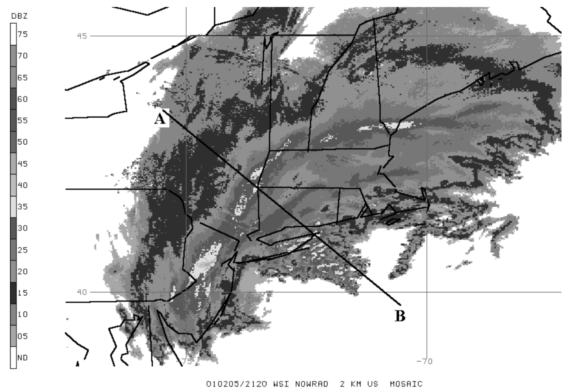

Fig. 1. Composite radar image at 2120 UTC 5 February 2001, with cross section orientation (A-B).

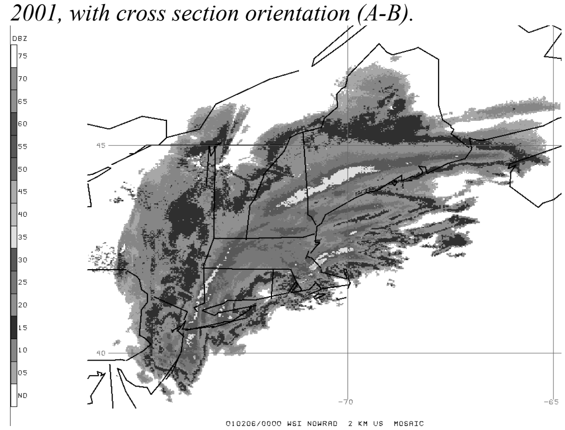

Fig. 2. Composite radar image at 0000 UTC 6 February 2001.

A synoptic summary (Fig. 3) shows the developing storm at 1800 UTC 5 February 2001, just before band development. Surface development was occurring off the mid-Atlantic coast (Fig. 3a) in response to a strong shortwave disturbance rounding the base of the 500 hPa trough (Fig. 3c). At this time a frontogenesis maximum was noted northwest of the cyclone center as the closed midlevel circulation began to form (Fig. 3b). Although heavy precipitation was occurring at this time, it was not especially banded.

The synoptic summary at 0000 UTC 6 February 2001 (Fig. 4) shows the deepening storm just off the New England coast (Fig. 4a). Rapid cyclogenesis was occurring as the 500 hPa trough became negatively tilted (Fig. 4c) and a favorable jet structure was established (Kocin and Uccelini 1990, 58–62). The 700 hPa level (Fig. 4b) exhibited a closed circulation, which maximized deformation northwest of the surface cyclone. This midlevel deformation acting on the

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ambient temperature gradient contributed to intense midlevel frontogenesis, which served as forcing for the primary banded feature. The frontogenesis maximum was also closely correlated to the primary band location. Similar cyclone evolutions have been noted by Nicosia and Grumm (1999) and Novak et al. (2002).

A cross section taken perpendicular to the banded features at 2100 UTC 5 February 2001 provides an assessment of the atmospheric stability and forcing (Fig. 5). The sloping frontal structure is evident in the saturated equivalent potential temperature (θ_{es}) field (Fig. 5a), with a deep layer of negative saturated geostrophic equivalent potential vorticity (EPV) apparent near the middle of the cross section. Note that this position closely coincides with the observed primary band location (Fig. 1). However, it should also be noted that the use of geostrophic EPV in this situation may not be valid, since the flow is highly curved, suggesting that the geostrophic wind may be a poor representation of the actual flow.

An assessment of symmetric stability via θ_{es} is possible since the environment is nearly saturated below 500 hPa (Fig. 5d) (Schultz and Schumacher 1999). The θ_{es} field shows a transition from elevated Conditional Instability (CI) in the far southeast where the finescale bands were initiating, to possible Conditional Symmetric Instability (CSI) near the middle of the cross section where the primary band was located. This is similar to the characteristic stability structure often observed near fronts as shown in Schultz and Schumacher (1999, Fig. 4).

An assessment of the frontogenetical forcing is shown in Fig. 5b. Intense frontogenesis is found along the frontal zone. The full wind and omega tangent to the cross section (black arrows) shows the sloping vertical motion forced by the frontogenesis. This vertical motion was likely enhanced by the weak symmetric stability in the manner shown by Emanuel (1985). It is interesting to note that the omega maximum (Fig. 5c) was located within the maximum dendritic growth temperatures. As shown by Waldstreicher (2002), this factor can contribute to optimal snowfall efficiency, and subsequent enhanced snowfall accumulation.

4. SUMMARY

Investigation shows that the synoptic flow configuration became favorable for mesoscale banding during cyclogenesis as the formation of a closed midlevel circulation maximized deformation northwest of the surface cyclone. This midlevel deformation acting on the ambient temperature gradients contributed to intense midlevel frontogenesis, which served as forcing for the banded features.

A cross section through the banded features shows the environment of the finescale bands was characterized by elevated CI. Further northwest, the primary band was found in an environment characterized by weak symmetric stability. The vertical motion forced by the frontogenesis was likely enhanced by the presence of weak symmetric stability, contributing to the intensity of the primary band. Since the finescale bands noted in southern New England were due to the release of elevated CI, typical orographic effects played a secondary role in snowfall accumulation.

5. ACKNOWLEDGEMENTS

The authors wish to thank Lance Bosart, Daniel Keyser, and Jeff Waldstreicher for providing valuable discussions related to this research. Elizabeth Page and Dolores Kiessling from COMET were instramental in providing the necessary data to undertake this study. Rich Grumm also provided a portion of the 40 km dataset. This work was supported by NOAA Grant 1007941-1-012365, awarded to the University at Albany/SUNY as part of the CSTAR program. Additional information concerning the University at Albany CSTAR project may be found at http://cstar.cestm.albany.edu.

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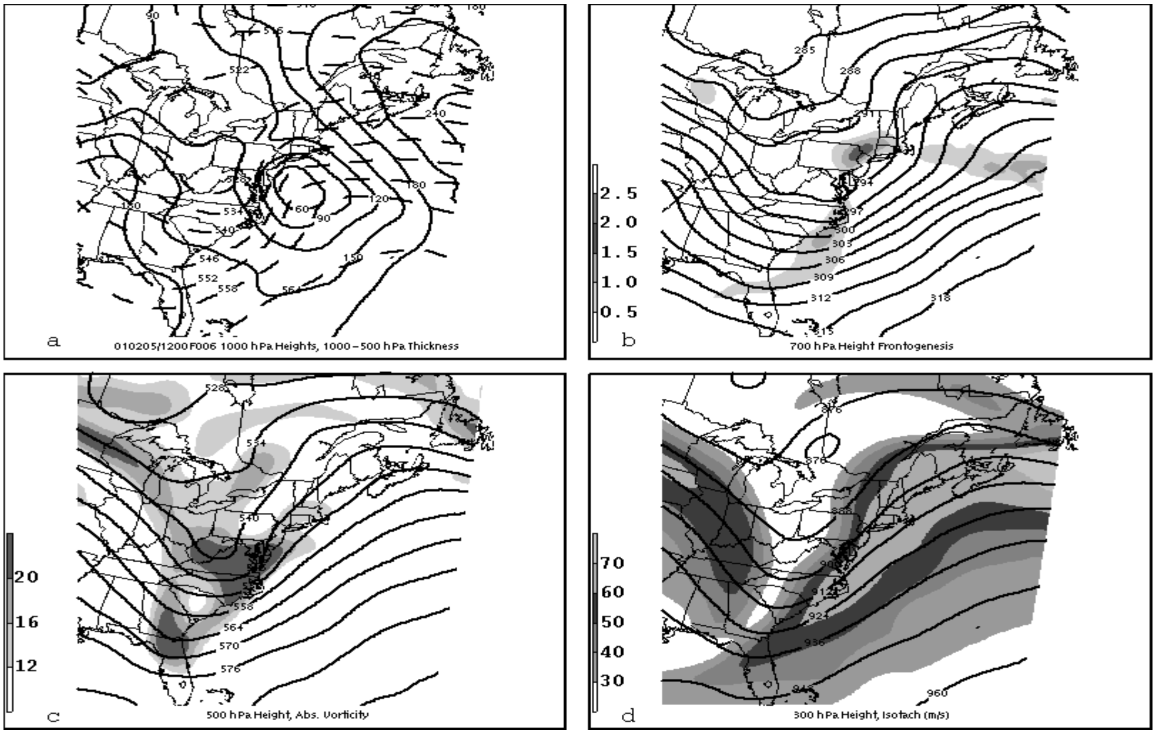

Fig. 3. Synoptic summary from the Eta model 6-h forecast, valid at 1800 UTC 5 February. (a) 1000 hPa heights (solid) every 30 m and 1000–500 hPa thickness (dashed) every 60 m, (b) 700 hPa heights (solid) every 30 m and 2-D Miller frontogenesis [shaded according to scale in ˚C (100 km)$^{-1}$ (3 h)$^{-1}$], (c) 500 hPa heights (solid) every 60 m and absolute vorticity (shaded according to scale in 10^{-5} s^{-1}), and (d) 300 hPa heights (solid) every 120 m and wind speed (shaded according to scale in m s^{-1}).

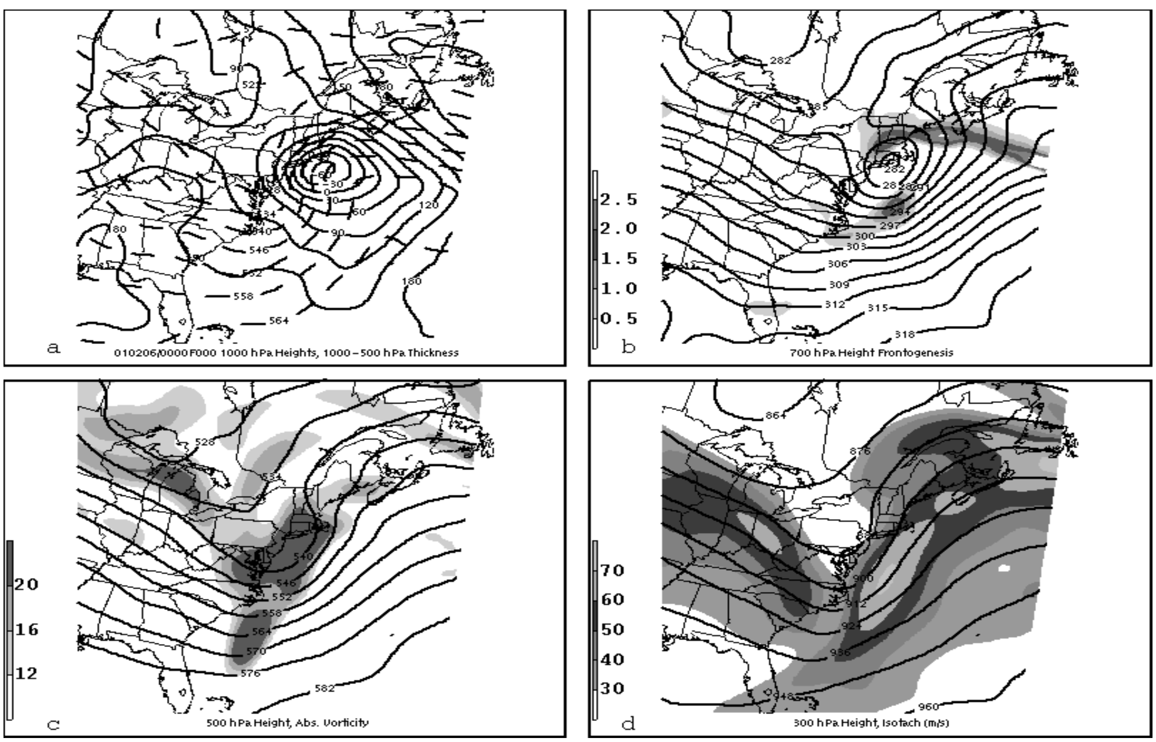

Fig. 4. As in Fig. 2, except model analysis valid at 0000 UTC 6 February 2001.

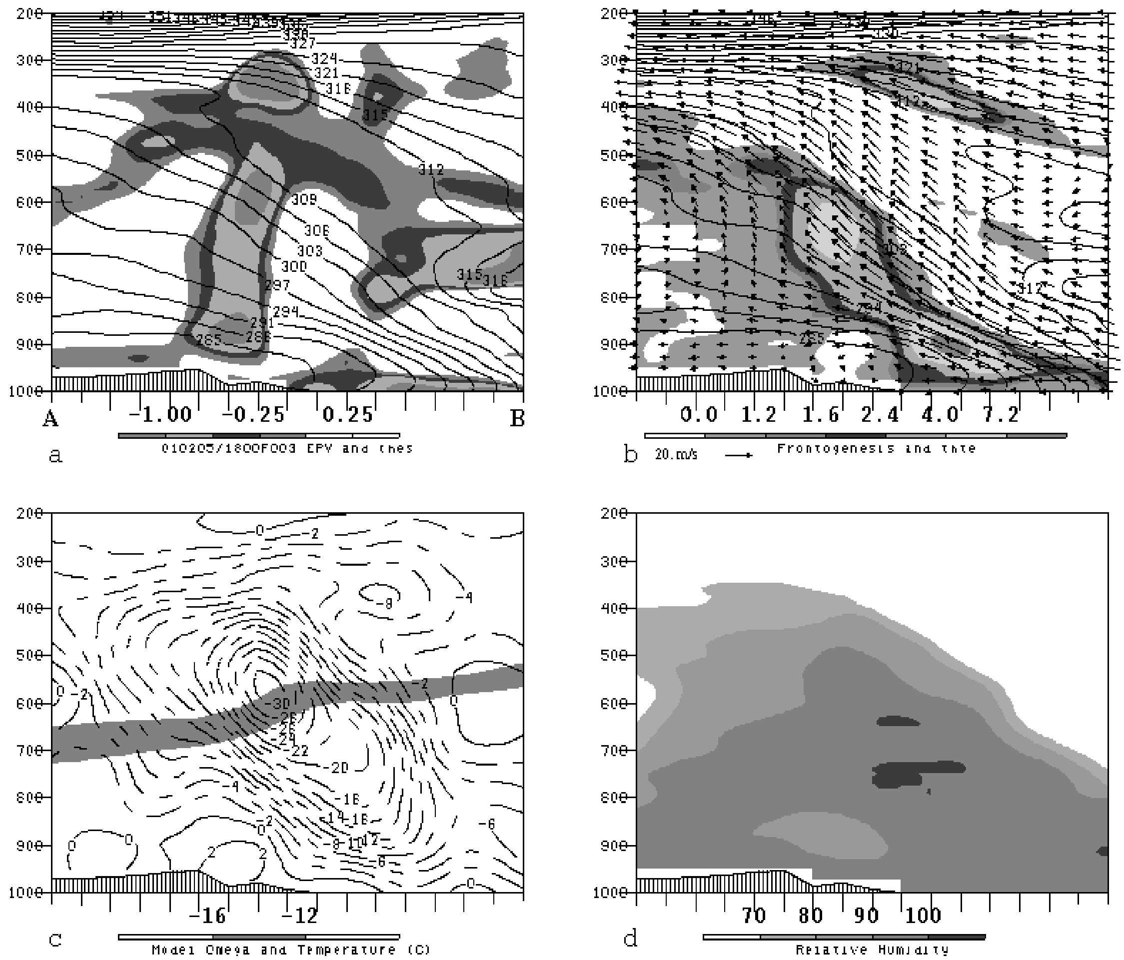

Fig. 5. Cross section through finescale and primary banded features along A-B (orientation shown in Fig. 1) from the Eta model 3-h forecast, valid at 2100 UTC 5 February 2001. (a) Geostrophic EPV (negative regions shaded according to scale), and θ_{es} contoured every 3 K. (b) 2-D Miller frontogenesis [shaded according to scale °C (100 km)$^{-1}$ (3 h)$^{-1}$], θ_e (contoured every 3 K), and full wind and omega tangent to the cross section (black arrows, reference vector shown near scale). (d) Model vertical velocity contoured every 2 x 10^{-3} hPa s^{-1} (dashed where negative), and the -12 to –16 °C layer (shaded). (b) Relative humidity greater than 70% shaded every 10%.