

The Central Indiana Winter Storm of 12-14 February 2007

Chad E. Swain
National Weather Service Indianapolis, Indiana

1. Introduction

A dynamic storm system brought blizzard conditions to parts of central Indiana from 12 February through 14 February 2007. Snowfall amounts over a foot were recorded across the northern sections of central Indiana, accompanied by winds gusting over 35 mph. Figure 1 shows storm total snow amounts. South of the heavy snow band, a mix of sleet, snow, and freezing rain fell, with ice accumulations around a half inch occurring in some areas south of Indianapolis. Accurately forecasting such high amounts of snow requires examining more than basic forcing fields. This paper will look at the various forcing and stability elements that led to the production of the heavy snow.

2. Synoptic Factors

The snowfall was produced by a system with a positive tilt through 300 mb, and was accompanied by a deep-layer baroclinic zone. The frontal zone sloped from south to north across central Indiana from the surface through 500 mb. Figure 2 shows frontogenesis from 925 mb through 500 mb, and Figure 3 shows temperature advection for the same levels.

At 300 mb, a greater than 150kt upper jet extended from northern New England westward to the northern Great Lakes region. The upper-right corner of Figure 4 shows the 300-mb data from the 1200 UTC 13 February upper-air observations (white). The

color image is the wind speed greater than 50kt from the 1200 UTC 13 February initialization of the RUC model.

The system remained an open wave at 500 mb, but a closed low existed at 700 mb and below (Figure 4). An 850-mb low moved from Oklahoma to northern Kentucky from 0000 UTC 13 February to 0000 UTC 14 February. Surface low pressure moved from north-central Texas to central Kentucky during the same time period.

All surface frontal boundaries remained south of Indiana throughout the event. Surface temperatures across central Indiana ranged from the low to mid 30s (F) at 0600 UTC 13 February. With a northeast flow at the surface continuing throughout the day, colder air was advected southwestward into Indiana. By 1800 UTC 13 February, temperatures ranged from the upper teens (F) across the northern sections of central Indiana, to the lower 30s (F) across the southern sections of the state. Figure 5 is a plot of surface conditions at 1200 UTC 13 February and temperature advection (units are in degrees C per 12 hour).

3. Forcing

Q-vector convergence for this case showed forcing for upward motion continuing throughout 13 February as the trough axis approached Indiana. Figure 6 is a time section of Q-vector convergence at Lafayette, Indiana. The data are from the 0 hour of the RUC model from 1200 UTC 13 February to 0100 UTC 14 February. Q-vector convergence extends through much of the atmosphere and lasts through much of the day. In addition,

central Indiana was in the right entrance region of an upper jet (Figure 4). Ucellini and Kocin (1987) have shown that this is a favored region for divergence aloft and enhanced vertical motion. Figure 7 is a cross section of divergence (units are 10^{-5} s^{-1}) and ageostrophic vertical circulation for 1200 UTC 13 February. The right side of the image corresponds to Indiana. Note that upward motion and divergence are maximized in this area.

Frontogenesis can produce enhance larger scale forcing and produce mesoscale bands of heavier precipitation (Moore 1988). For this case, frontogenesis played a role in the heavier precipitation across northern sections of central Indiana. Figure 2 shows frontogenesis for this case at 925 mb, 850 mb, 700 mb, and 500 mb at 1200 UTC 13 February. This 4-panel display clearly shows the axis of strongest frontogenesis sloping northward from southern Indiana at 925 mb to lower Michigan at 500 mb.

Figure 8 shows a 0.5 degree radar image from the Indianapolis WSR-88D (KIND) taken from 1500 UTC 13 February. A band of higher reflectivities exists across the northern section of central Indiana, which is coincident with a location of strong frontogenesis.

4. Stability

The atmosphere was stable to upright convection across the forecast area. The traditional method of diagnosing conditional symmetric instability (CSI) (Moore 1993) revealed stable to neutral conditions (not shown). Moore (1993) has shown that equivalent potential vorticity (EPV) can be used to diagnose the presence of CSI. EPV can also be

calculated with saturated equivalent potential temperature (EPV*). As this case deals with a generally saturated atmosphere, EPV* is used. A cross section of EPV* reveals a period during the afternoon where there was some instability in the mid levels across the northern section of central Indiana (Figure 9). The strong frontogenesis located below the area of instability created upward motion, which was enhanced when ascending parcels interacted with the area of instability.

5. Precipitation Discussion

Temperature profiles led to the variety of precipitation types from north to south. Soundings at 1200 UTC 13 February indicated a nearly saturated column over all sites in the Indianapolis county warning area. A layer of warm air aloft was advected northward into central Indiana in the hours preceding 1200 UTC. The model sounding for Lafayette, Indiana (not shown) indicates that the entire column would remain at or below freezing. At Indianapolis (Figure 10), the warm air allowed a shallow layer between 800 mb and 860 mb to warm near, or just above freezing. This resulted in precipitation type changing to sleet and brief freezing rain at that location. Farther to the southwest, at Bloomington, Indiana (Figure 11), the depth and magnitude of the warm layer aloft allowed the precipitation to fall as liquid for much of the day, which later changed to freezing rain as shallow cold air was advected southward into the Bloomington area during the afternoon.

Upward motion in an area of favored snow growth can lead to more intense snowfall (Auer and White 1982). The level where the air temperature is approximately -15°C is where dendritic snow growth is maximized (Rogers and Yau 1989). Strong upward

motion persisted in the snow growth layer throughout the day across northern sections of the central Indiana (Figure 12), which likely was a key supporting mechanism for continuous moderate to heavy snowfall.

6. Summary

Large-scale forcing combined with mesoscale features to produce strong synoptic and mesoscale ascent across central Indiana for much of the day on 13 February 2007. These forcing mechanisms acted on a nearly saturated atmosphere with a temperature profile favorable for snow. This produced heavy snow across much of central Indiana. From an operational forecasting perspective, looking only at basic forcing fields would miss out many mesoscale details that would lead to forecasting heavy snow. A review of frontogenesis and Q vectors will give additional insight into forcing, while examining stability via EPV* will give clues as to whether bands of heavy snow may be enhanced.

Acknowledgements

The author would like to thank John Kwiatkowski, Science and Operations Officer at Indianapolis, IN, Chad Omitt, Lead Forecaster at Indianapolis, IN, and Dan Miller, Science and Operations Officer at Duluth, MN for their help in the preparation of this paper.

References

- Auer, A.H. Hr., and J.M. White, 1982: The combined role of kinematics, Thermodynamics and cloud physics associated with heavy snowfall episodes. *J. Meteor. Soc. Japan*, **60**, 500-507.
- Bluestein, H.B., 1993: *Synoptic-Dynamic Meteorology in Mid-Latitudes*. Oxford University Press, New York, NY, 431 pp.
- Moore, J.T., and P.D. Blakely, 1988: The role of frontogenetical forcing and conditional symmetric instability in the midwest snowstorm of 30-31 January 1982. *Mon. Wea. Rev.*, **116**, 2155-2171.
- _____, and T. Lambert, 1993: The Use of Equivalent Potential Vorticity to diagnose regions of conditional symmetric instability. *Wea. Forecasting*, **8**, 301-308.
- Rogers, R.R., and M.K. Yau, 1989: *A Short Course in Cloud Physics*. Pergammon Press, 293 pp.
- Ucellini, L.W. and P.J. Kocin, 1987: The interaction of jet streak circulations during heavy snow events along the east coast of the United States. *Wea. Forecasting*, **2**, 289-308.

February 12-14 Snowstorm

Reports from COOP and CoCoRaHS

Prepared Feb 14 2007

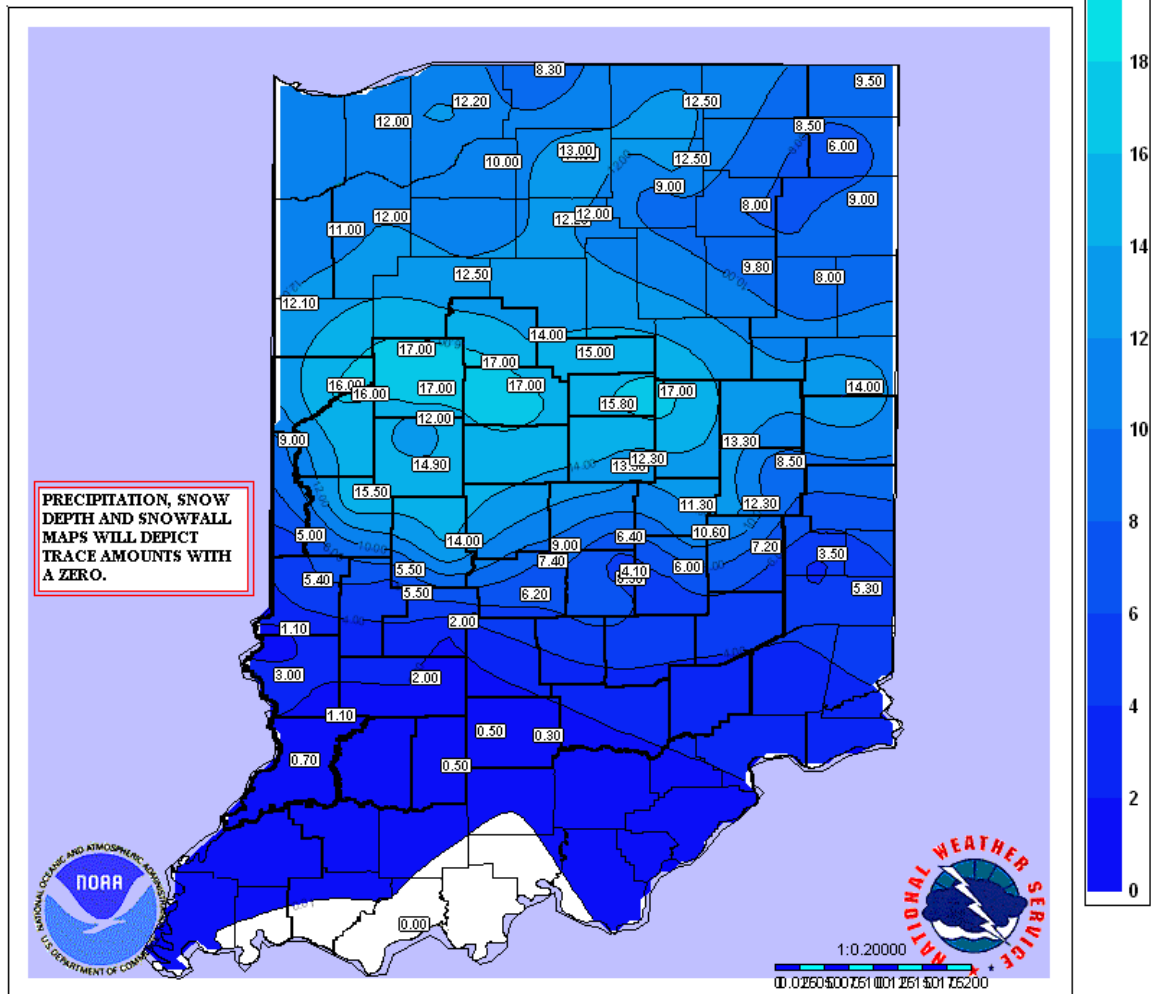
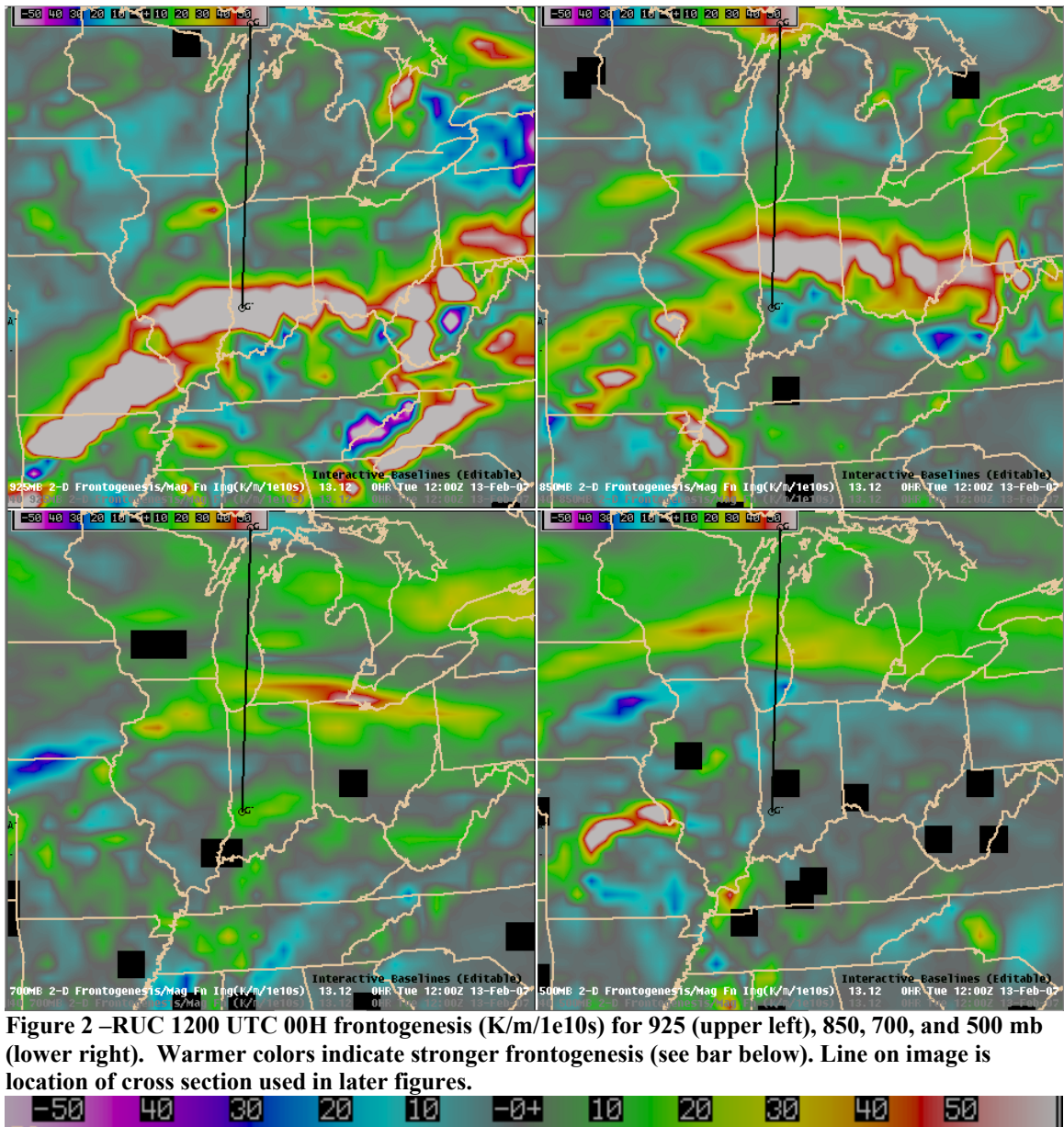


Figure 1 - Storm total snow amounts (inches) for February 12 to February 14



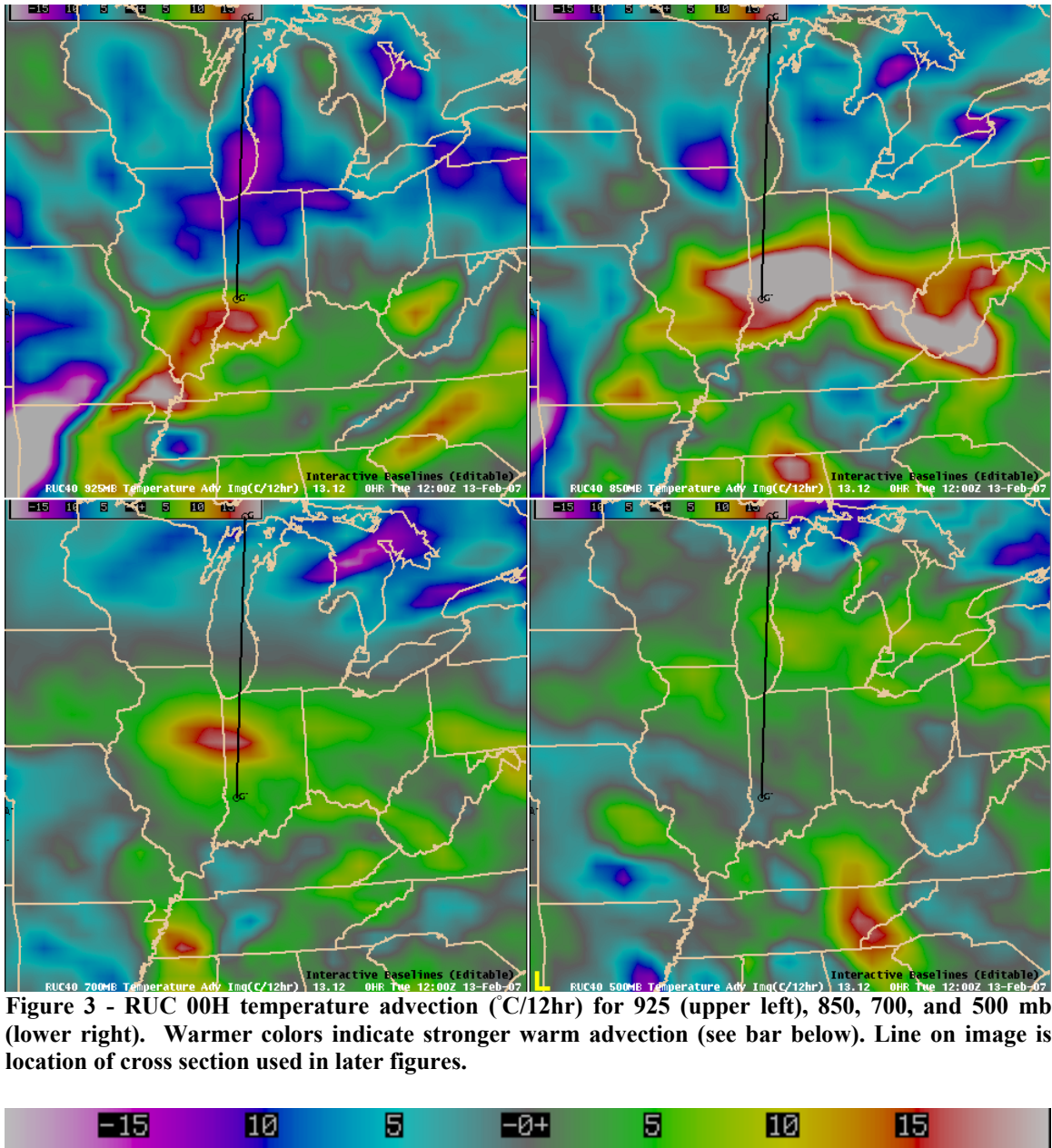


Figure 3 - RUC 00H temperature advection (°C/12hr) for 925 (upper left), 850, 700, and 500 mb (lower right). Warmer colors indicate stronger warm advection (see bar below). Line on image is location of cross section used in later figures.

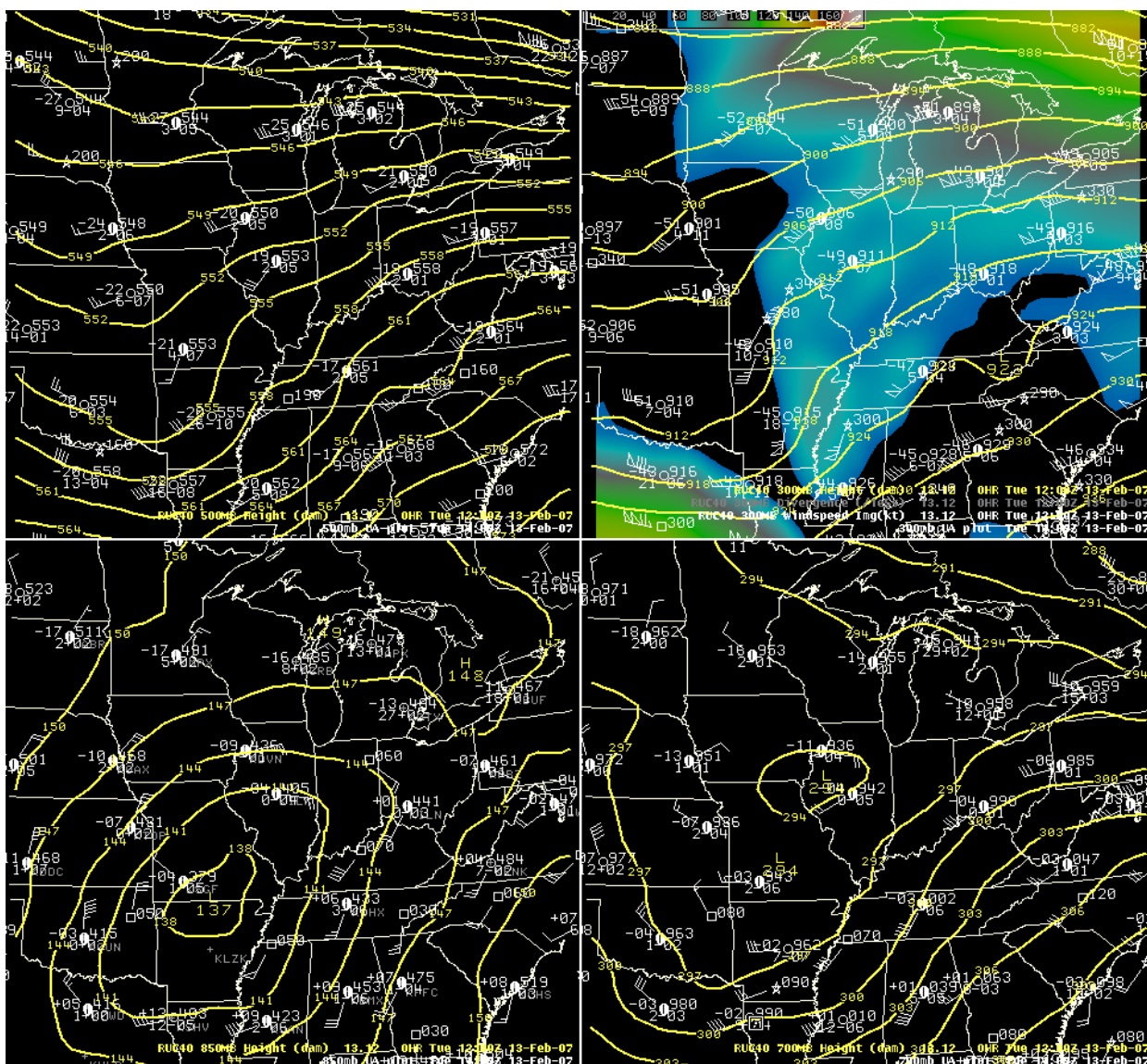


Figure 4 – Plot of upper-air observations (white), height (yellow), and wind speed (image, kt) for 850, 700, 500, and 300 mb. Color bar below correlates to wind speed at 300 mb in the upper right.



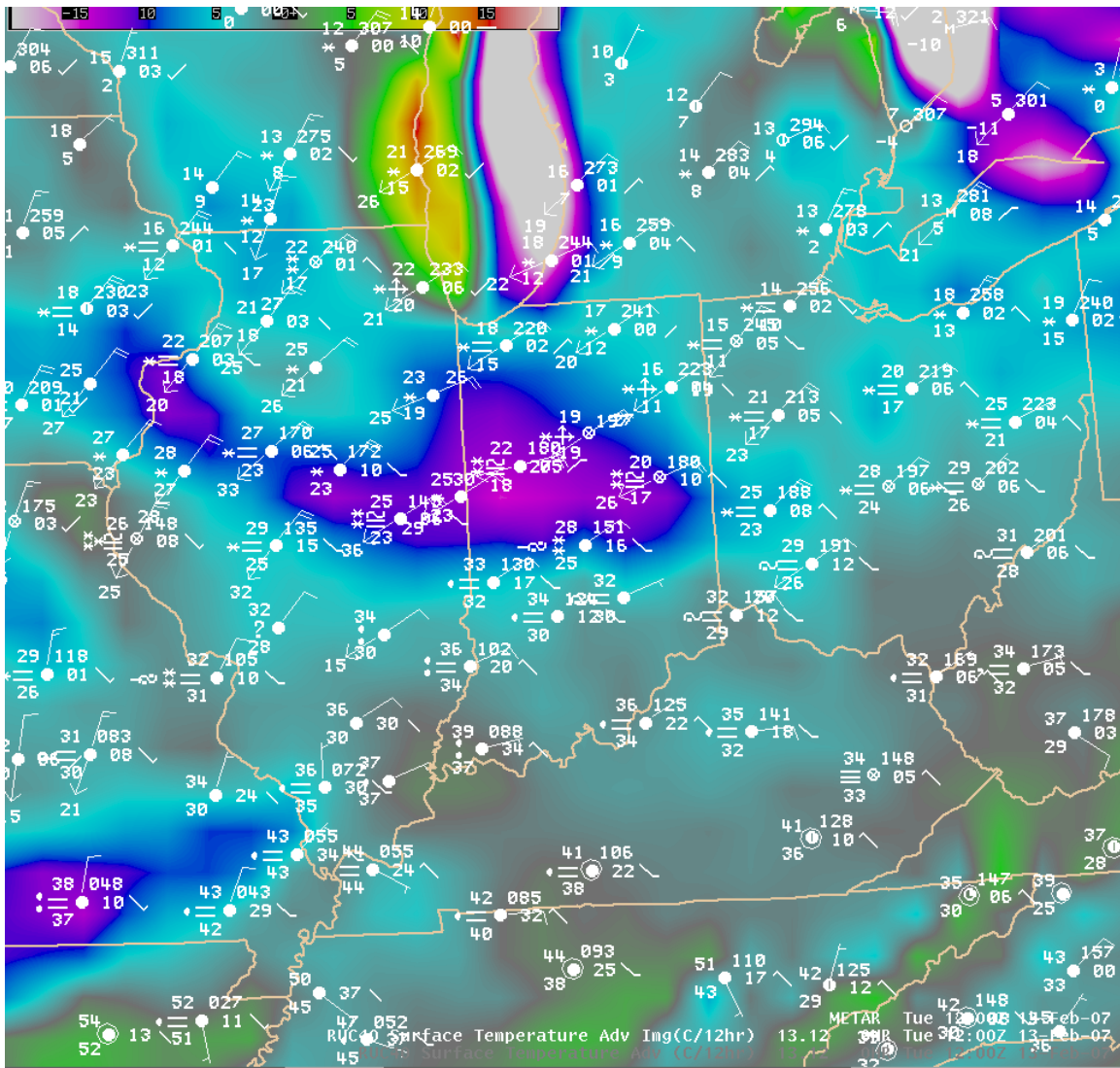


Figure 5 - Surface data plot (white) and RUC 00H temperature advection (image, C per 12 hour) valid 1200 UTC 13 February 2007

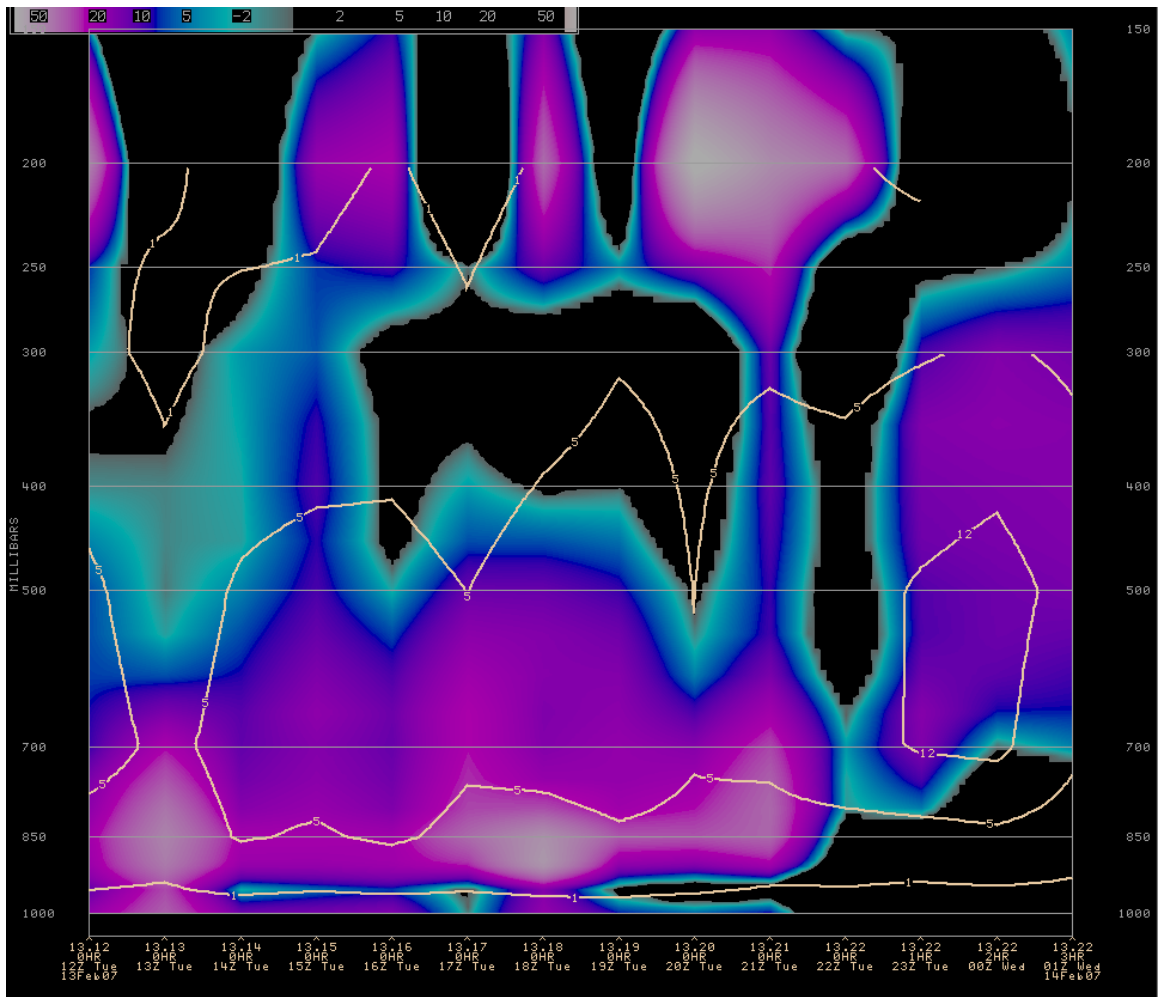


Figure 6 - Time height of RUC Q-vector convergence (image, $\text{K/m}^2/1\text{e16s}$) and omega ($-\mu\text{bar/s}$) for Lafayette, IN from 1200 UTC 13 February to 0100 UTC 14 February. Cooler colors indicate stronger Q-vector convergence (see bar below).



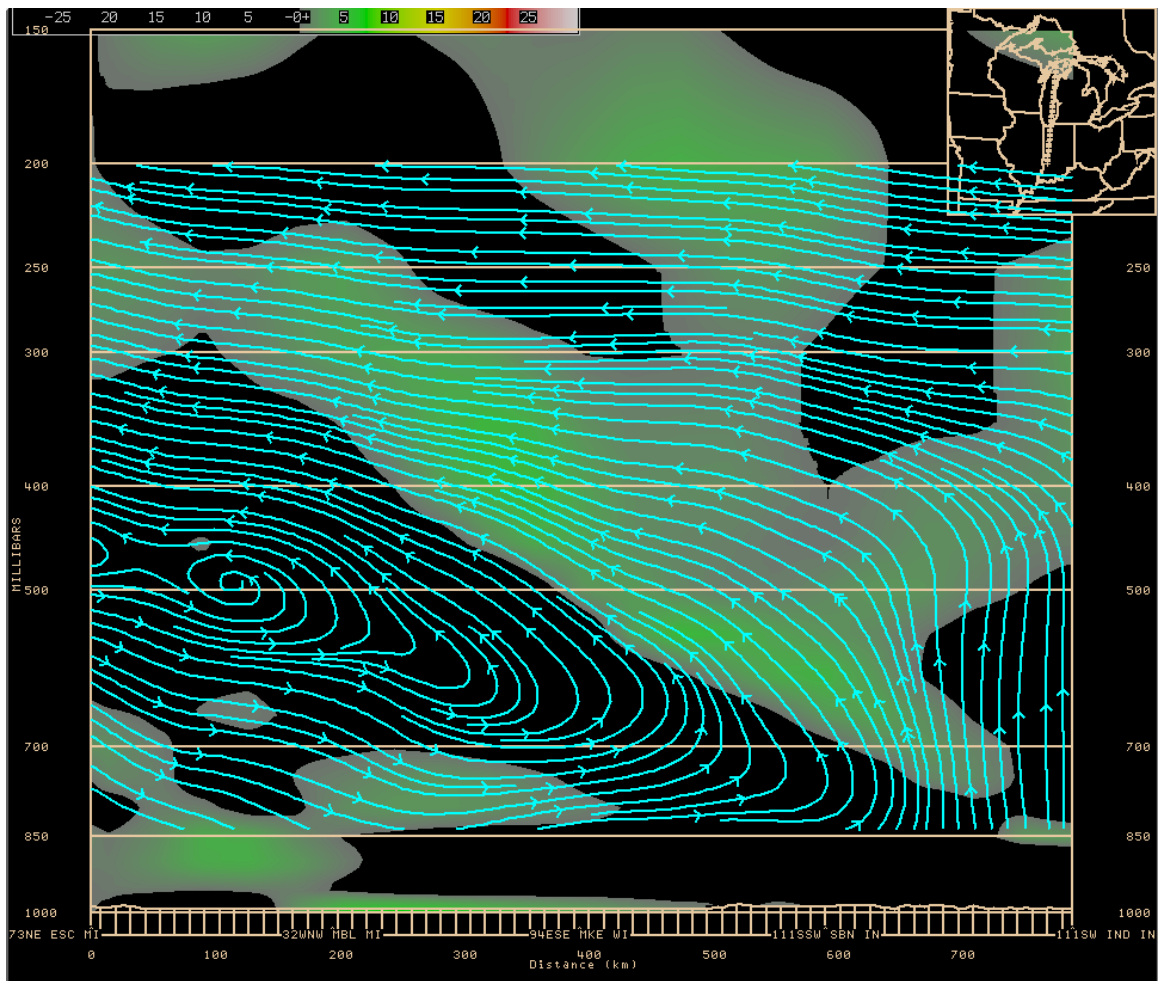
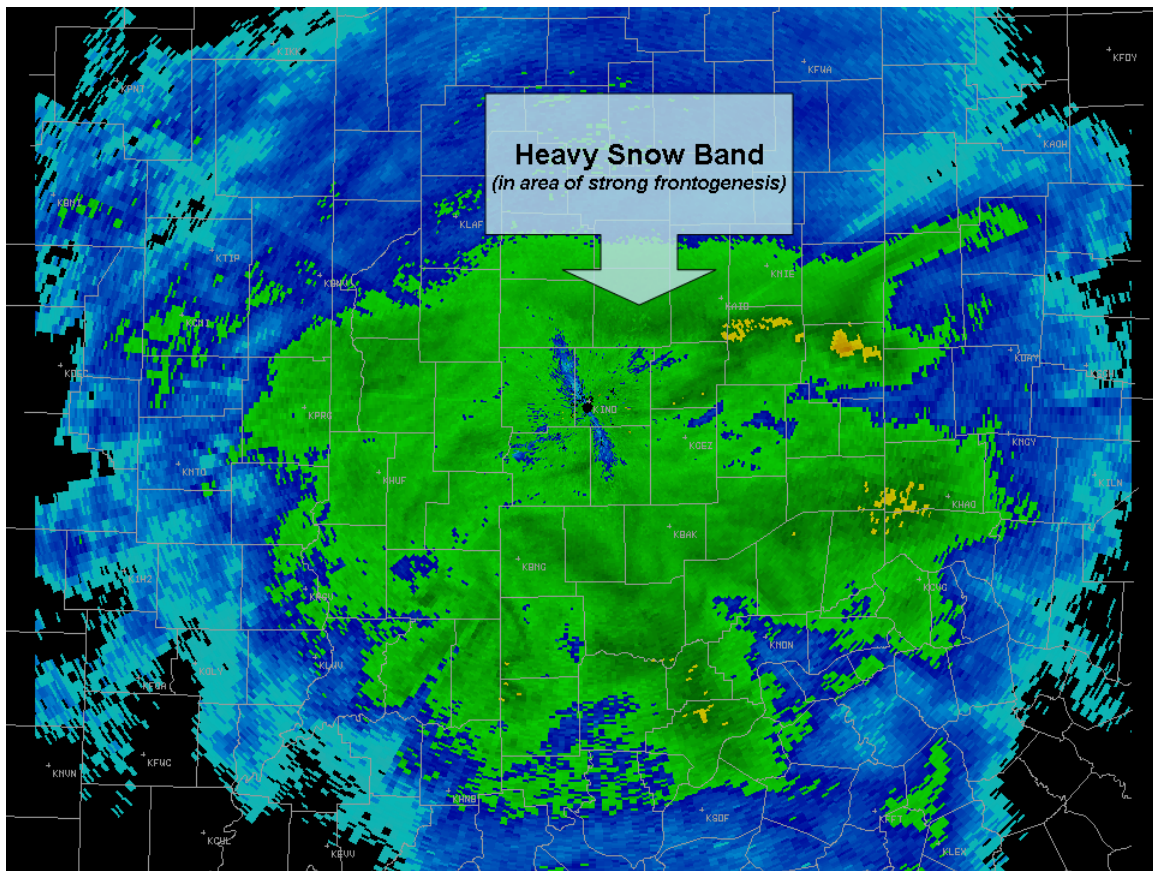


Figure 7 – RUC 00H cross section of ageostrophic vertical circulation (blue) and divergence (image) (1e5s) for 1200 UTC 13 February. See bar below for scale. Indiana is located on the right side of the figure.





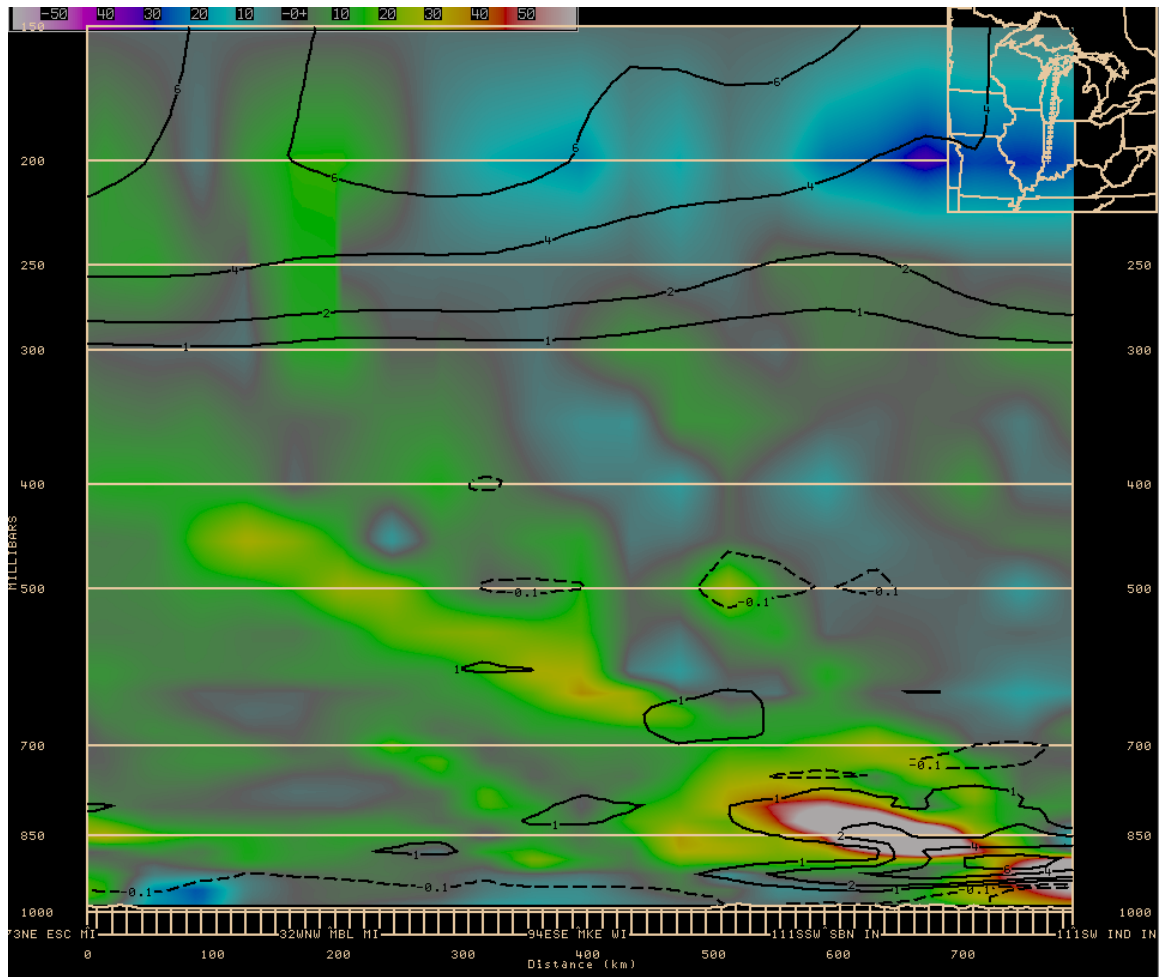


Figure 9 – NAM-WRF cross section of frontogenesis (image, K/m/1e10s) and EPV* (black, PVU) valid at 1800 UTC 13 Feb. Warmer colors indicate stronger frontogenesis (see bar below). Dashed blue lines indicate negative EPV*.



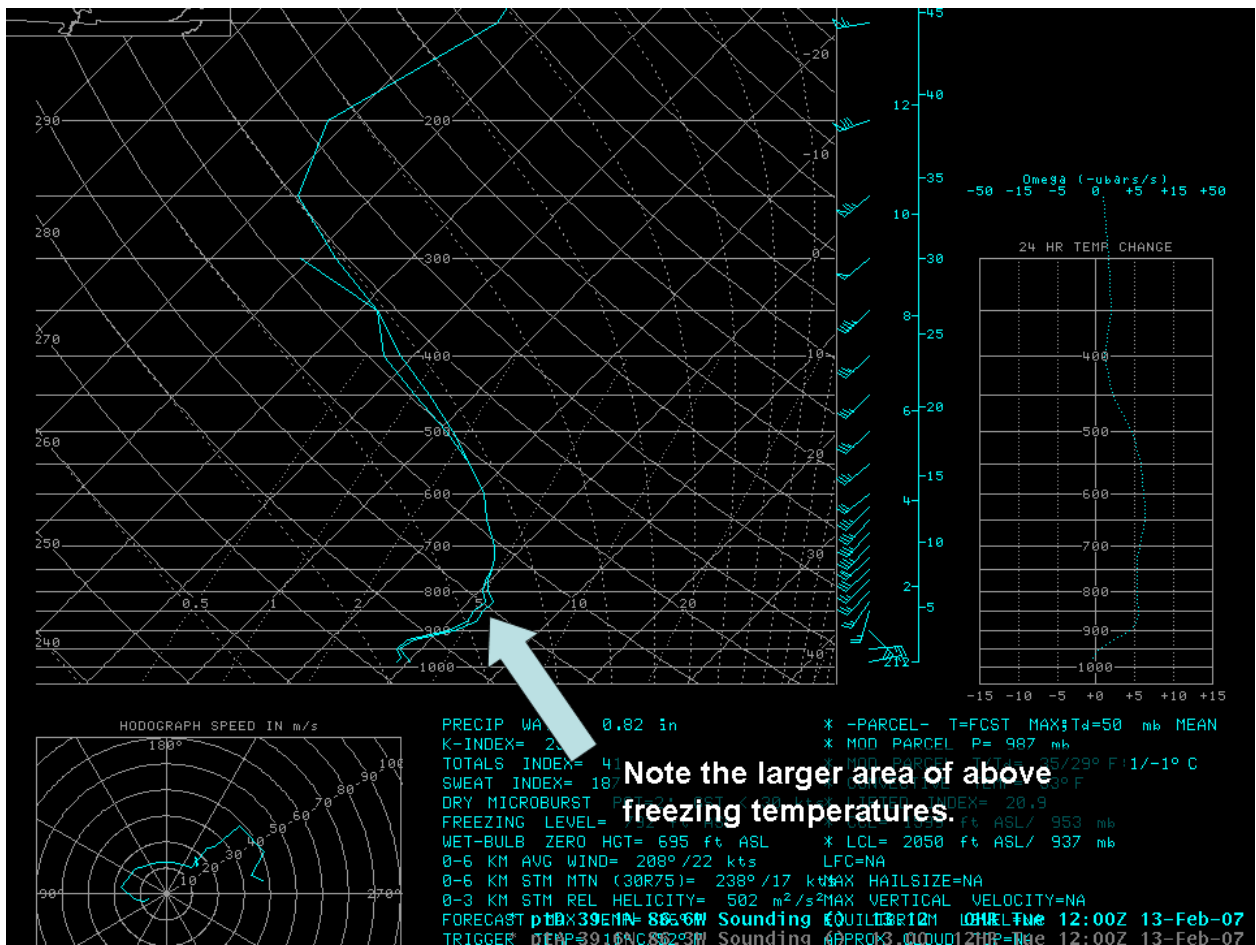


Figure 11 – NAM-WRF 00h sounding for Bloomington (KBMG) valid 1200 UTC 13 February 2007

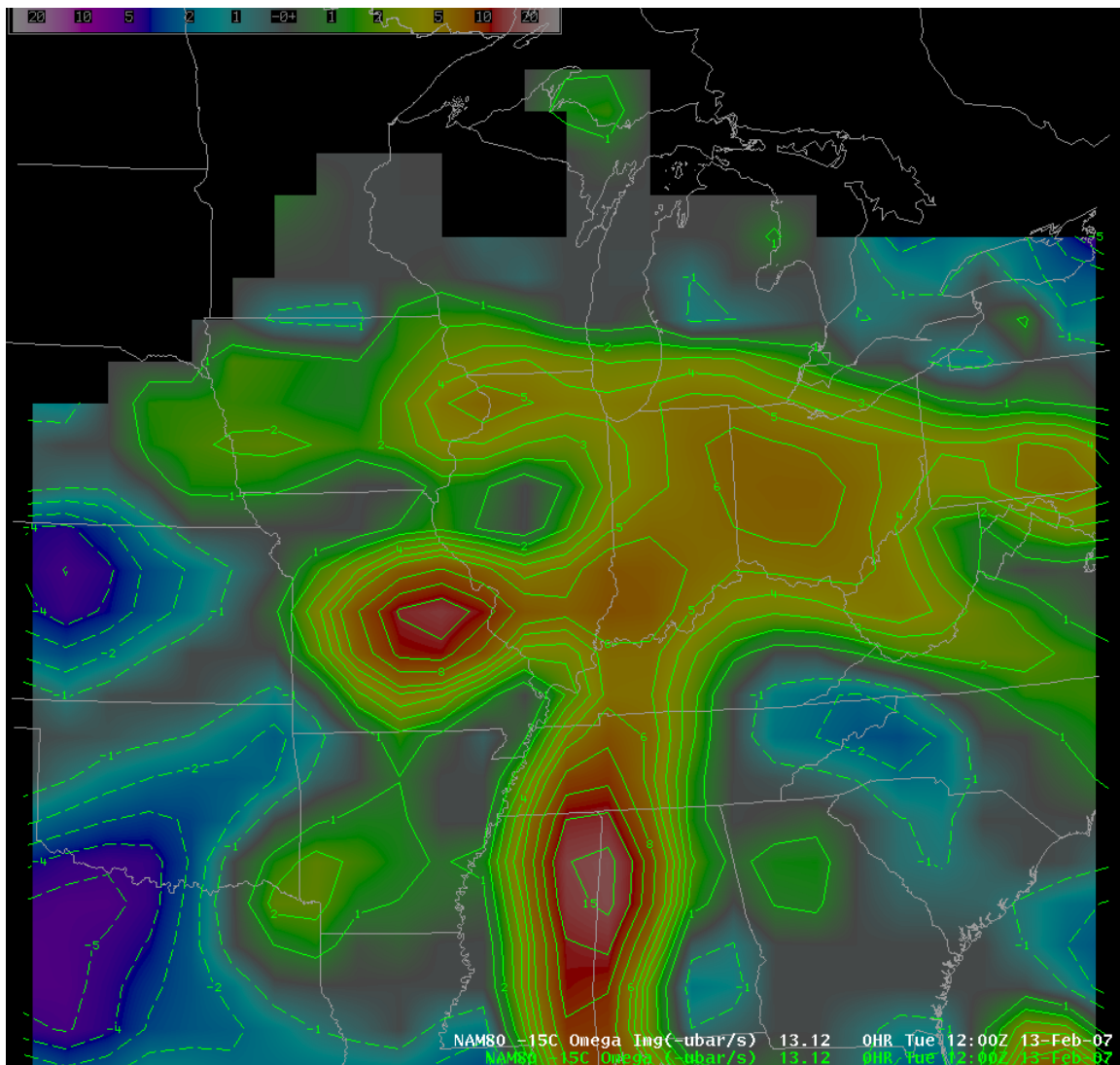
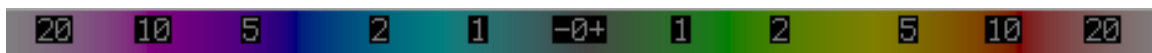


Figure 12 - NAM-WRF 00h omega ($-\mu\text{bar/s}$) on the -15°C level valid at 1200 UTC 13 February 2007. Warm colors indicate upward motion (see bar below).



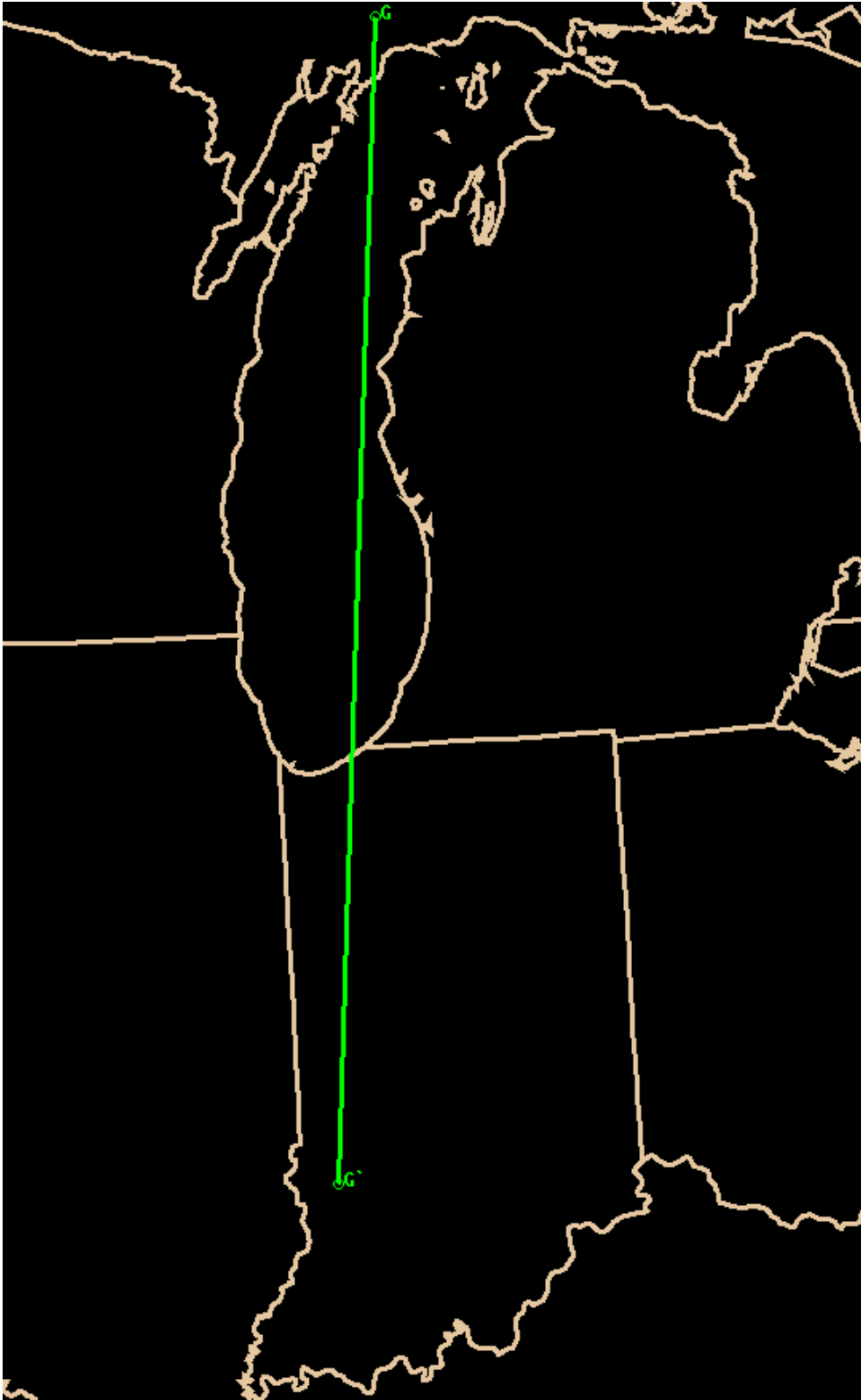


Figure 13 – Location of cross section used in previous figures.