A WES CASE ANALYSIS OF A HEAVY SNOW EVENT OVER NORTHEAST NEVADA ON MARCH 23, 2005

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Introduction

On March 23, 2005 heavy snow fell across the mountains of northeast Nevada during the hours of 0600 UTC – 1800 UTC. In Elko County, total snowfall amounts of 10 to 20 inches were common in the Ruby Mountains and north into the Independence Range and Jarbidge Mountains. This was the third heavy snow event of the month, and contributed to the Spring Flood of 2005 across northeast Nevada. From April 25 to June 27, WFO Elko issued a total of 260 flood products.

The Weather Event Simulator (WES) was used to enhance Situation Awareness (SA) of the forecast staff during rapid snowfall intensification events. The goal of this WES scenario was to review model diagnostic tools which would help identify the best focusing mechanisms for a heavy mountain snow event.

Synoptic and Mesoscale Overview

At 0000 UTC, March 23, 2005, a strong 500mb shortwave trough was ejecting east around an upper level low anchored across the Pacific Northwest. As the shortwave sheared inland toward central and southern California, a 125 kt jet max was present with deep layered moisture across the Great Basin. (Fig. 1).

The NAM 12 km surface analysis for 0000 UTC indicated a developing surface low northwest of Tonopah, NV with strong moist southerly flow ahead of the low and a developing baroclinic boundary (Fig. 2). KLRX radar reflectivity signatures showed two rotating 20-40 dbz precipitation bands moving rapidly north of the surface low in Elko County. Surface temperatures were 40-50 F with 700 mb temperatures -1 to -2 C for a snow level above 8000 ft msl, so mainly rain was falling at most locations.

With the rotation of the heavy precipitation bands north of the surface low, the water vapor satellite showed no signature with only a weakly analyzed vorticity max at 500 mb by the NAM. However, a stronger vorticity max at 700 mb was analyzed between KB23 and KEKO with a much stronger vorticity max southwest of Tonopah (Fig. 3).

700 mb Moisture Diagnostics and Convection

With a strong moist surface inflow along the developing baroclinic boundary, the 0000 UTC NAM analysis indicated deeper layered moisture at 700 mb. A ridge of saturated Theta-E (Theta-Es) was analyzed along the baroclinic boundary from west of Tonopah to Elko with a very strong Theta-E convergence maximum of 95 C/hr (Fig. 4). The rapid increase in moisture convergence along the boundary was supported by a 700 mb inflow of 30-40 kts and 700 mb temperatures remaining at -1 to -2 C. The pooling of high Theta-E air indicated a potential for rapid moist convective development, what has been suggested as a convective “burst point” in the Theta-E convergence maximum.

From 0000 UTC to 0600 UTC, the snow level continued to remain above 8000 ft msl. Convection rapidly developed along the baroclinic boundary in the Theta-Es ridge near the greatest Theta-E convergence and moved north. The KLRX (Elko NV) radar indicated maximum reflectivity echoes of 45 dbz with lightning strikes along the eastern edge of the convection at 0400 UTC (Fig. 5).

Fn Vector Divergence

By 0600 UTC, March 23, 2005, the surface low had moved north to a position just southwest of KEKO. The KLRX radar also indicated a rapid increase in precipitation echoes along the baroclinic boundary south of the low (Fig. 6). Although the surface wind and temperature gradients had decreased, the 700 mb temperature gradient had rapidly increased. The change in magnitude of the thermal gradient at 700 mb was readily apparent in the 0600 UTC NAM Fn Vector Divergence field analysis (Fig. 7). Fn vectors are the normal component of frontogenesis, so large negative values of Fn vector divergence indicated strong convergence and enhanced vertical motion.

From 0600 to 1200 UTC, March 23, 2005, the 700 mb thermal gradient had shifted slowly east along the Ruby Mountains as a 700 mb low continued to develop along the Nevada and Idaho border. The NAM 1200 UTC analysis of 700 mb Fn Vector Divergence maintained a strong thermal gradient and convergence had increased as the 700 mb low intensified (Fig. 8). The precipitation echoes actually decreased around 1200 UTC, but again rapidly increased at 1300 UTC. Three persistent precipitation bands were observed on the KLRX radar to from 1300 UTC through 1800 UTC (Fig. 9). After 1800 UTC, the 700 mb low shifted to the Utah border as the main convergence axis and thermal gradient shifted east. Orographic upslope flow continued to remain northwest and enhance the snow in the Ruby Mountains through 2300 UTC.

Snowfall and Precipitation Totals

Location	Elev.	24hr Snowfall	24hr Liquid
Green Mtn (Ruby Mtns), Elko County	7999 ft.	16 in	1.4 in
Dosey Basin (Ruby Mtns), Elko County	8100 ft.	19 in	2.5 in
Lamoille #3 (Ruby Mtns), Elko County	7700 ft.	12 in	1.1 in
Hole-in-the-Mountain (E. Humboldt) Eko	7900 ft.	11 in	0.9 in
Jacks Peak (Independence), Nrn. Elko	8419 ft.	18 in	1.4 in
Pole Creek (Jarbidge), Nrn Elko County	8330 ft.	10 in	1.3 in
Diamond Peak, Eureka County	7999 ft.	9 in	1.4 in
Lewis Peak, Lander County	7402 ft.	10 in	1.6 in

Discussion and Conclusion

While this event was a typical heavy snow scenario for high elevation terrain, it proved to be valuable in increasing the Situation Awareness of forecasters for future events. One of the key ingredients to forecasting heavy snow across northern Nevada is to be aware of rapidly increasing frontogenesis and Theta-E convergence as the 700 mb thermal gradient strengthens across the Great Basin. The surface analysis was important in determining where the baroclinic boundary was initially forming, but looking at the 700 mb features allowed forecasters to focus on areas of potential enhanced lift and convection. The 700 mb vorticity field was a key indicator in showing a developing 700 mb low as the thermal gradient strengthened.

It is important to look at all aspects of forcing and moisture convergence when looking at heavy snow events. This particular event did have an initial 2-D 700 milibar frontogenesis increase at 0000 UTC, but began to decrease rapidly, washing out after 0600 UTC. A look at the Fn vector divergence proved that the normal (perpendicular) component of the 700 mb thermal gradient was still strong 12 hours into the event. Of course, orographic lift also played a role with north-south mountain ranges in the Great Basin, but this event proved that forecasters should be aware of all the forecasting tools, such as Theta-E convergence, formation and location of baroclinic boundaries, dynamic lift, and lightning observations, available to them.

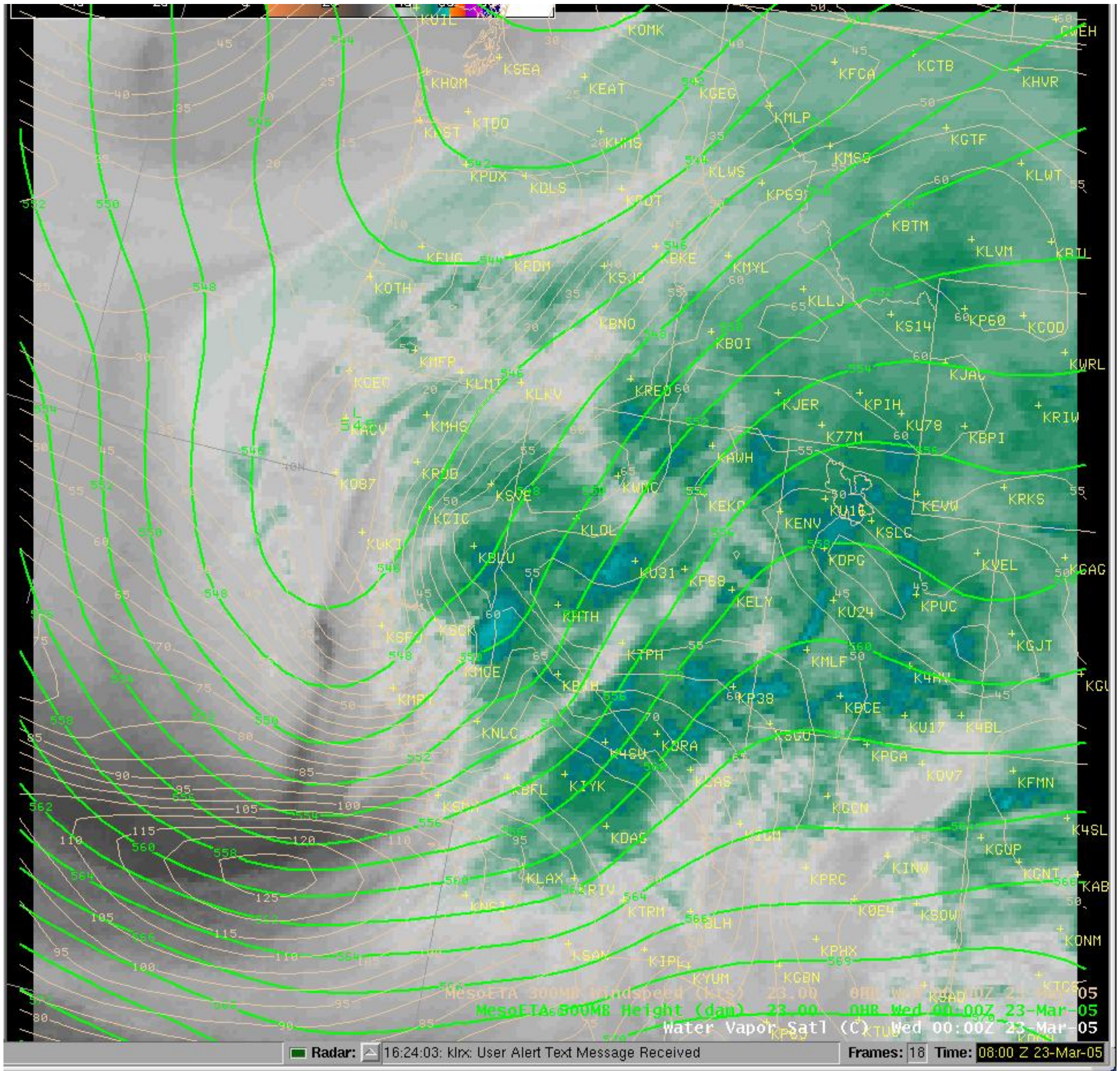

Fig. 1. Water Vapor satellite imagery showing strong shortwave trough and moisture across Great Basin. Contours are NAM 40 km 500 mb heights and 300 mb windspeed, 0000 UTC, March 23, 2005.

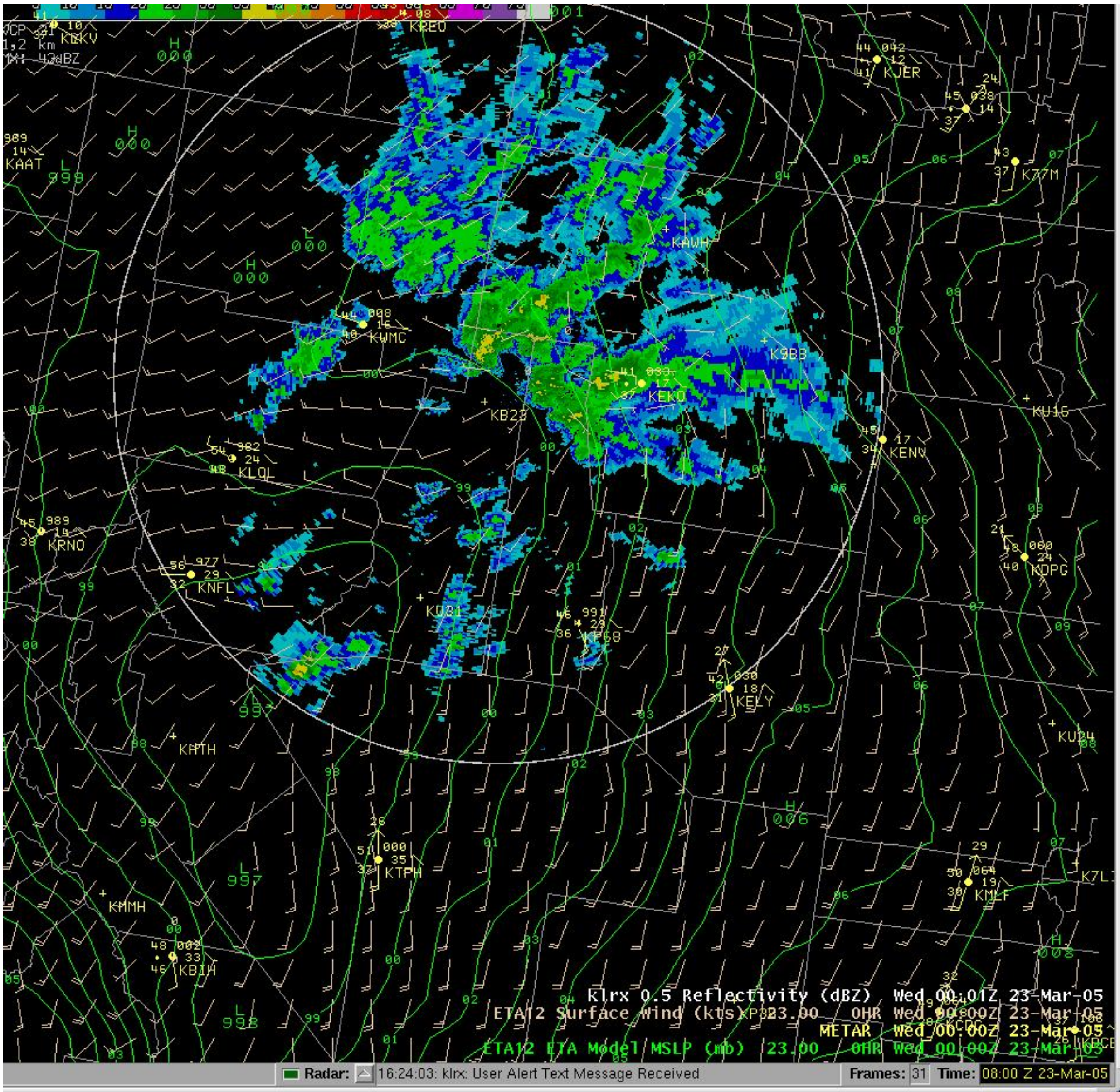

Fig. 2. NAM (Eta12) surface analysis of MSLP, wind, observations and KLRX 0.5 deg reflectivity, 0000 UTC, March 23, 2005. Two heavy precipi bands 20-40 dbz were seen rotating rapidly north into Elko County.

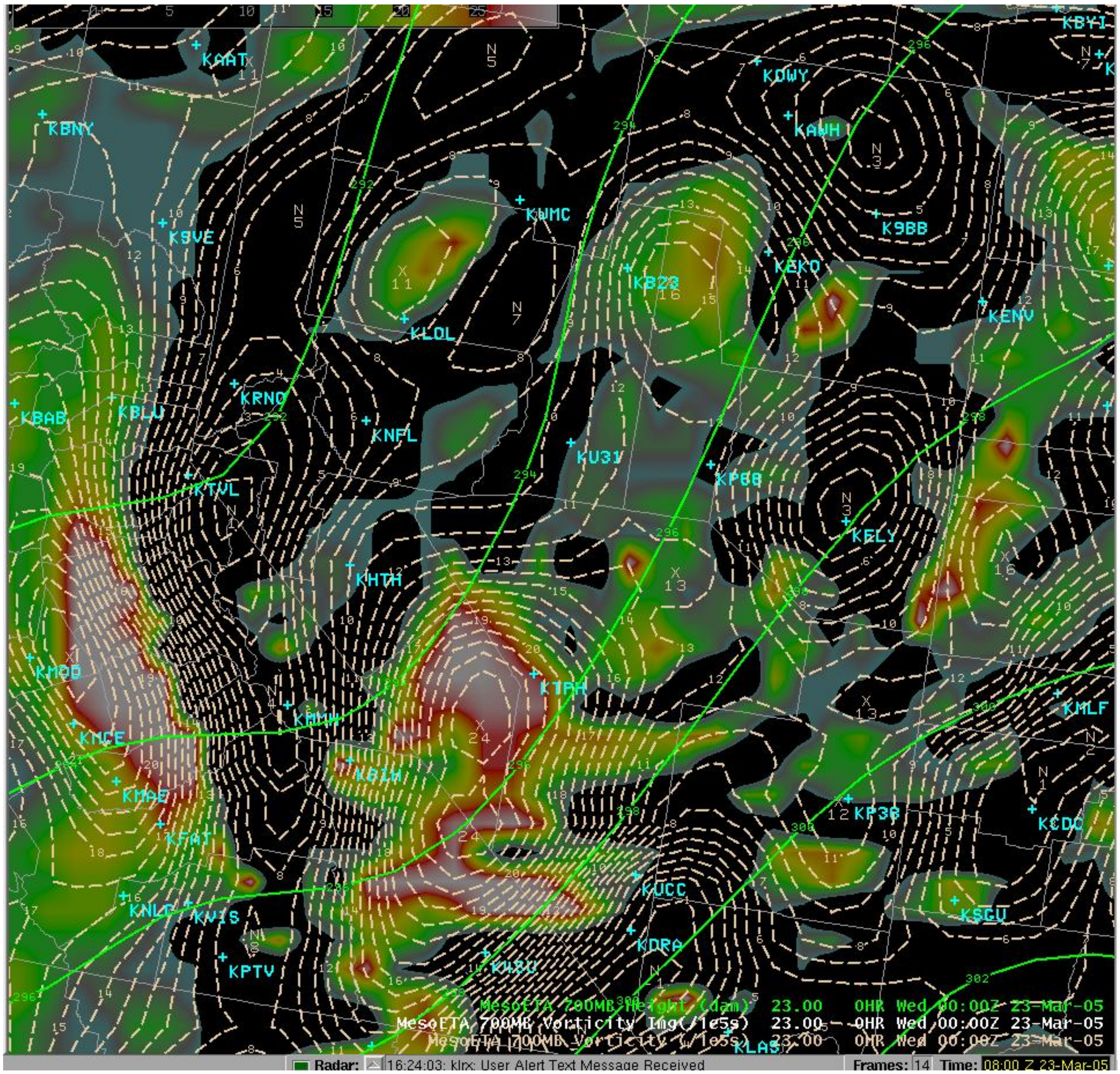

Fig. 3. NAM (MesoEta) analysis of 700 mb heights and vorticity, 0000 UTC, March 23, 2005. Two vorticity maxes were analyzed; one between KB23 and KEKO, the other southwest of KTPH.

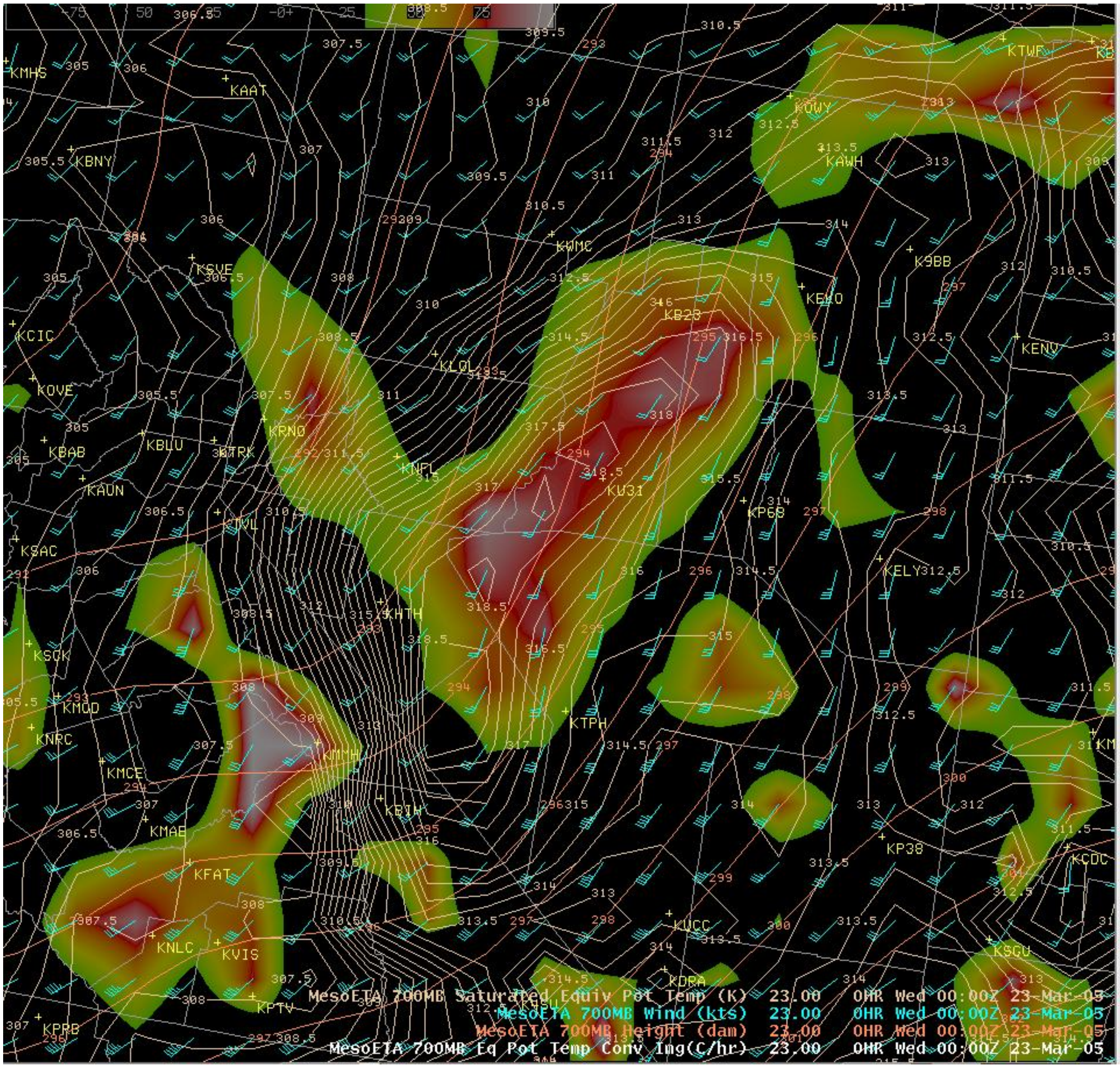

Fig. 4. NAM (MesoEta) analysis of 700 mb Saturated Theta-E (Theta-Es) contours and Theta-E convergence (image) with wind and height fields, 0000UTC, March 23, 2005. Theta-Es values were near 318 K with a Theta-E convergence maximum of 95 C/hr.

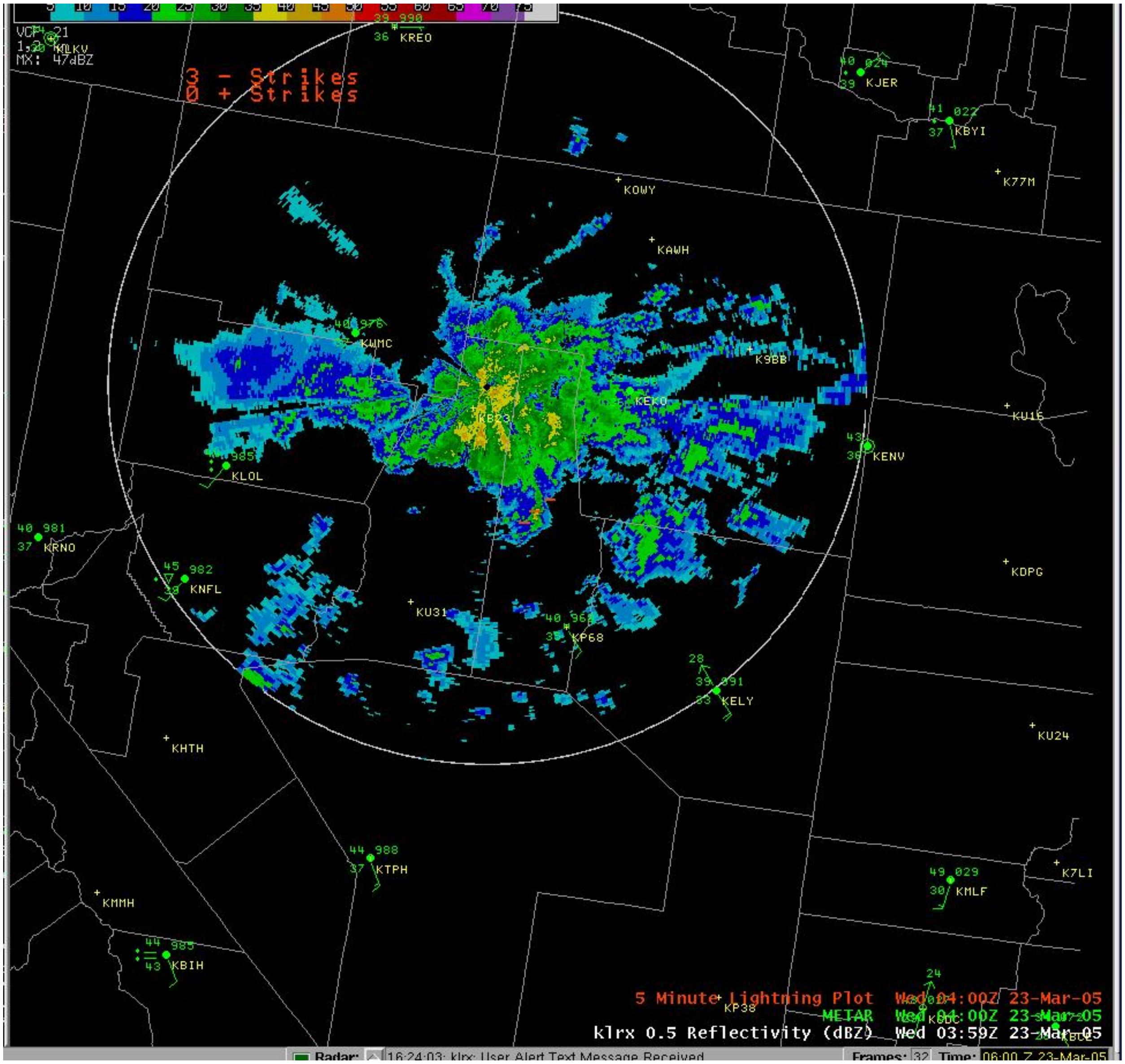

Fig. 5. KLRX 0.5 degree reflectivity image with surface observations and 5 minute lightning plot, 0400 UTC, March 23, 2005. Note the three lightning strikes along eastern edge of the convection.

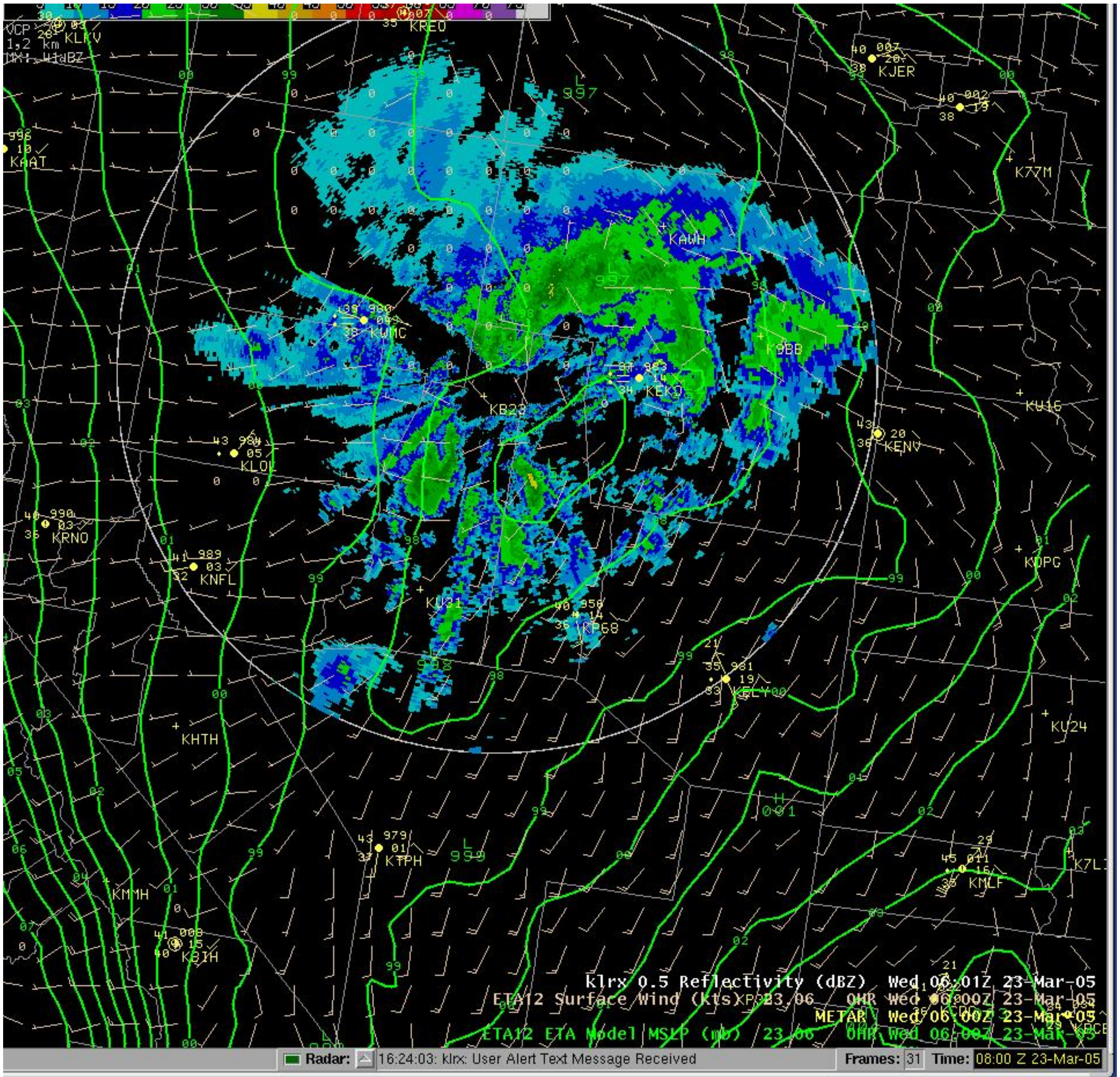

Fig. 6. KLRX 0.5 degree reflectivity image with NAM analysis of MSLP, wind and surface observations, 0600 UTC, March 23, 2005. Precipitation echoes began to develop rapidly south of the surface low along the baroclinic boundary.

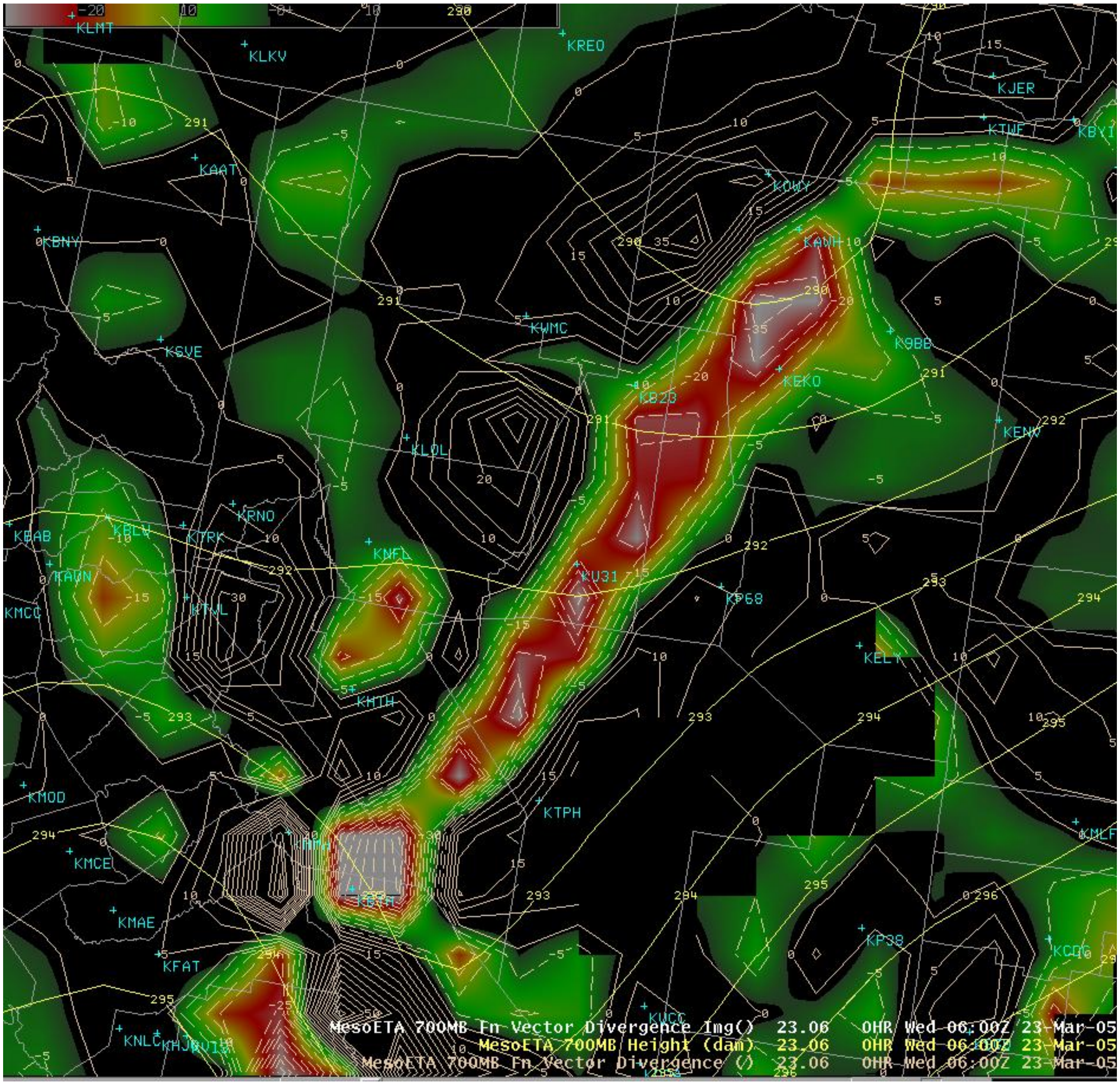

Fig. 7. NAM 700 mb Fn Vector Divergence and 700 mb Height analysis, 0600 UTC, March 23, 2005. Large negative values > -20 units correspond to area of strongest thermal gradient and vertical forcing.

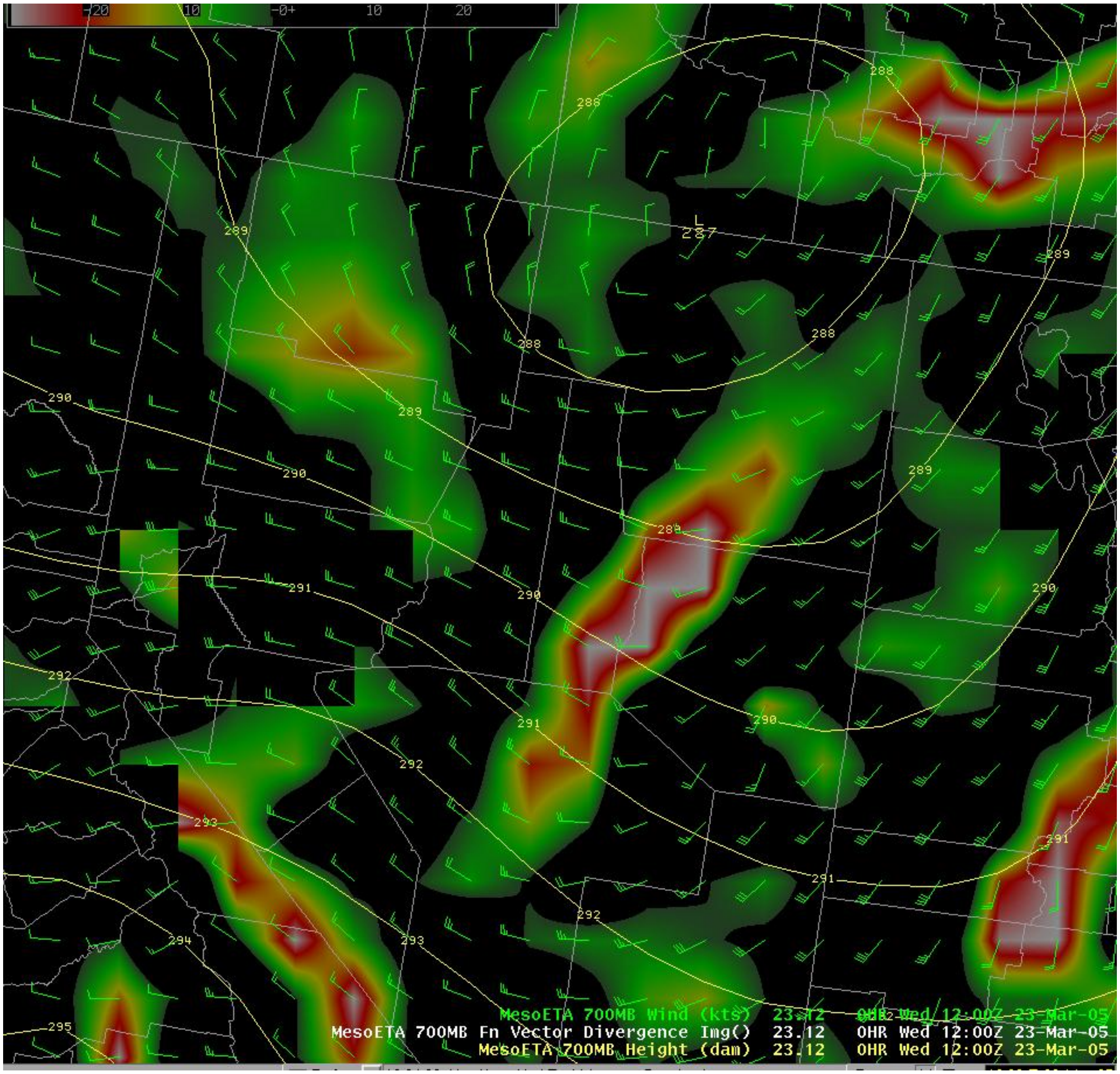

Fig. 8. NAM 700 mb Fn Vector Divergence, heights and wind analysis, 1200 UTC, March 23, 2005. The strongest forcing and thermal gradient had shifted east along and south of the Ruby Mountains.

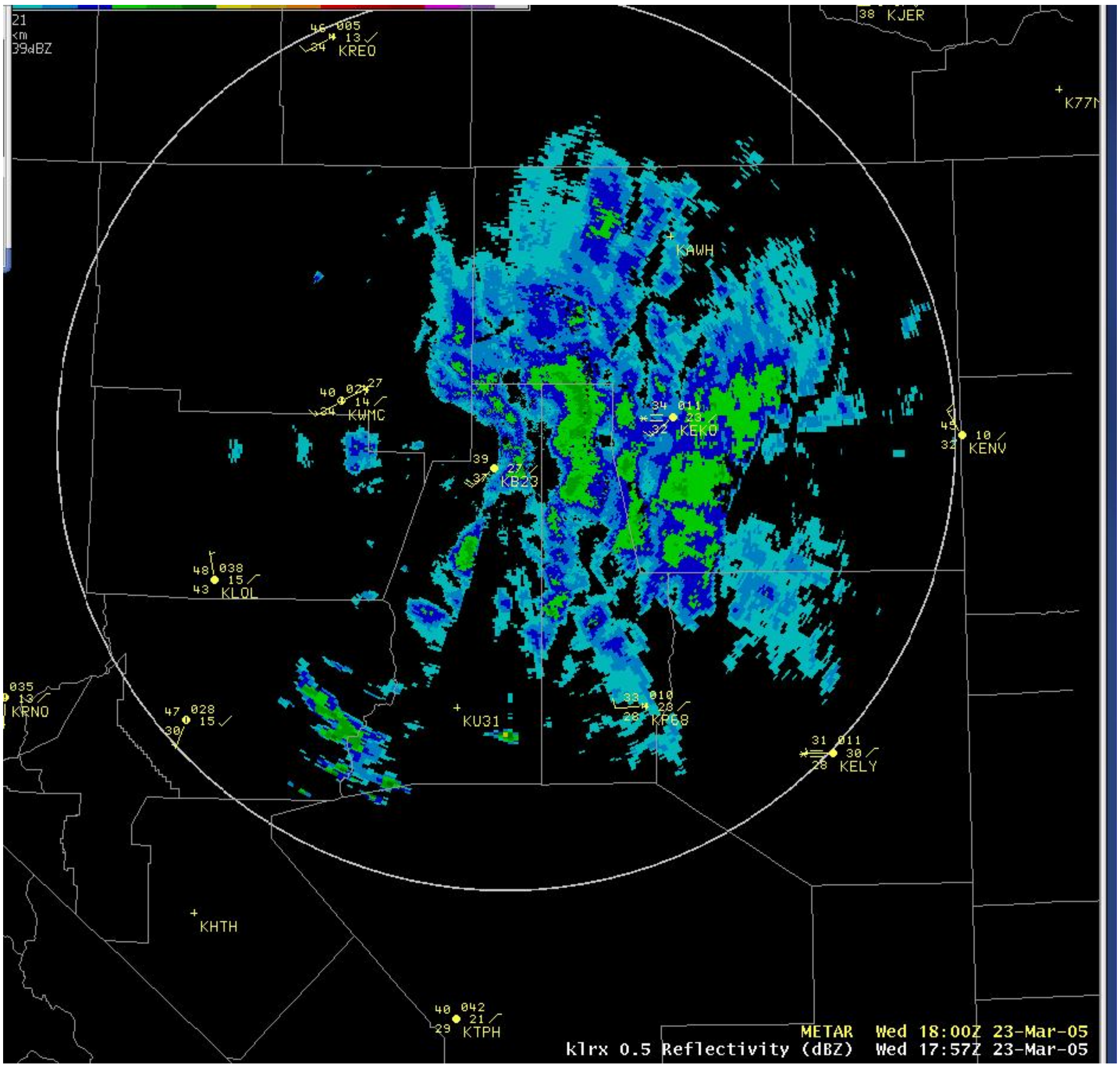

Fig. 9. KLRX 0.5 degree reflectivity image with surface observations, 1800 UTC, March 23, 2005. Three enhanced precipitation bands were seen to persist in Elko and Eureka Counties from 1300 UTC – 1800 UTC before the 700 mb convergence axis and thermal gradient shifted to the east.