The Northeastern Nevada Freezing Rain Event of January 22nd, 2009

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1. Overview

Northeast Nevada received a rare freezing rain event during the morning of January 22nd, 2009, which resulted in very slick roadways and caused several vehicle accidents. Synoptic and mesoscale analyses showed persistent warm air advection aloft ahead of a weak upper level trough off the coast of California, while cold air remained trapped in the valleys. As this upper level trough pushed eastward and weakened, a band of light to moderate rain spread across northern Nevada, producing pockets of freezing rain across the valleys of Elko County. Freezing rain was reported for 4 hours at Elko Regional Airport with unofficial reports of freezing rain at Wells, Nevada, and further north near the Idaho border.

Impacts were generally localized and confined to elevations below 6000 feet where cold air was trapped in the valleys; however, the event still impacted an area where the majority of the population of Elko County resides, resulting in numerous accidents (Figure 1). A total of 18 weather-related accidents were reported by the Nevada Highway Patrol during the morning of January 22nd, with one of them resulting in two fatalities (courtesy: Elko Daily Free Press). These accidents were mainly in the Elko, Spring Creek, and Wells areas along Interstate 80.

2. Synoptic Pattern

A ridge of high pressure dominated the weather pattern across the southwestern United States through the middle of January as a long wave trough anchored itself across the central Pacific Ocean. Eventually, the long wave trough allowed a series of short waves to slowly push east into the eastern Pacific Ocean by the third week of January, which gradually weakened the ridge across the western United States. On January 21st, an upper level trough located off the coast of northern California (Figure 2) slowly pushed east towards Nevada with light rain spreading across portions of northern and central California late in the day. This upper level trough extended further south off the coast of Baja California earlier in the period, but eventually the southern portion of the trough cut off from the main flow aloft forming a closed low well south of the region. The trough off the coast of California remained an open wave as it slowly moved towards the California coastline.

The GFS did a better job handling the short wave feature and associated dynamics compared to the NAM; therefore, the GFS initialized analysis will be used for the discussion. By the early morning of January 22nd, the upper level trough pushed into California with an area of overrunning precipitation.

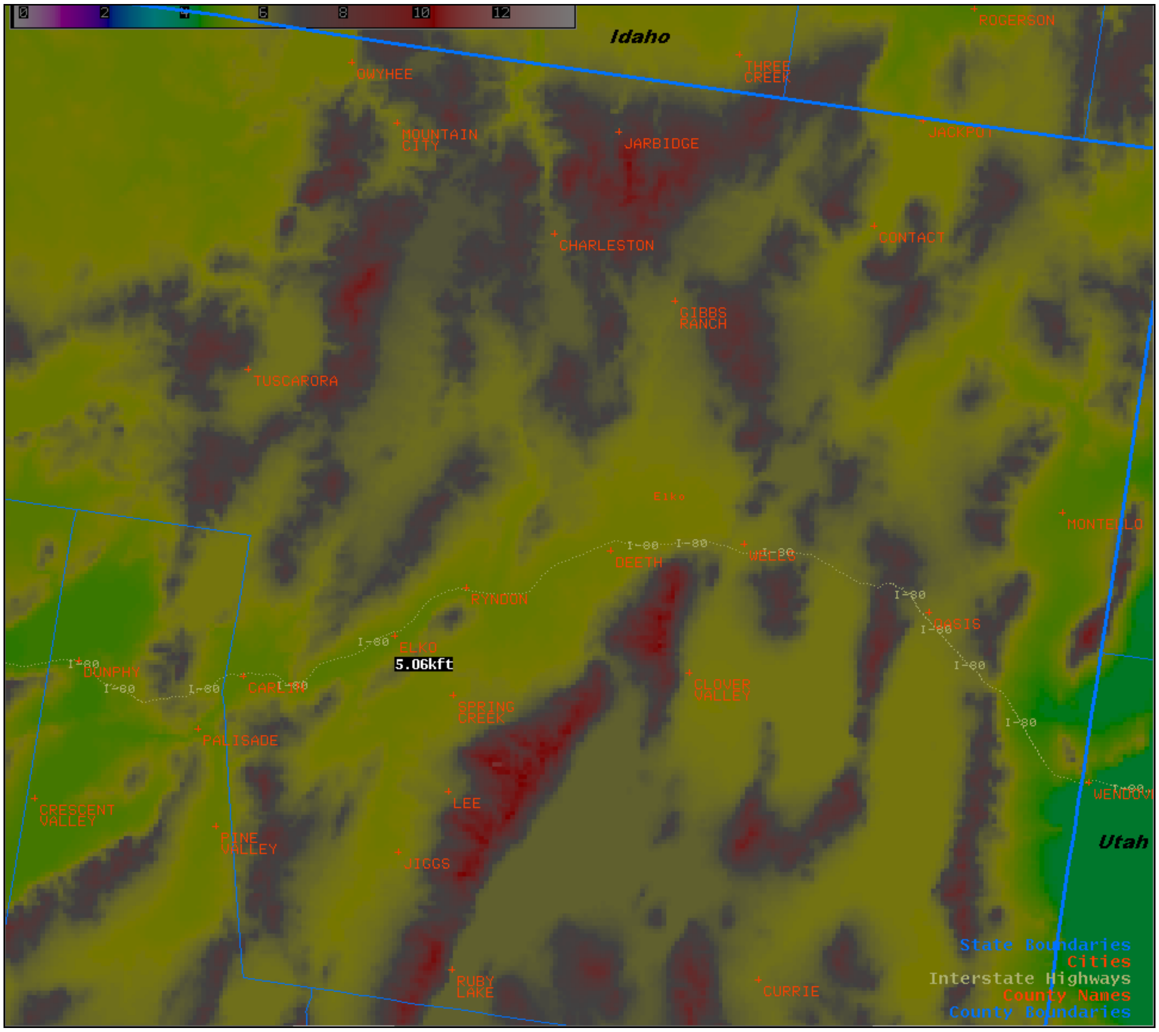


Figure 1. Topographic map of Elko County, Nevada centered on the area affected by freezing rain. Elevation is in thousands of feet and Interstate 80 and towns are shown for reference points.

The precipitation extended into northwestern Nevada by 1200 UTC, with rain reported at the Winnemucca, Nevada ASOS (Figure 3). Figure 4 shows southwest winds in excess of 20 knots at 700 mb with 700 mb temperatures of 1° to 2°C across central and southern Nevada, resulting in an area of moderate warm air advection aloft across northern Nevada, well ahead of the upper trough. The GFS temperature advection forecast in figure 4 supports this claim, showing warm air advection of 5° to 10°C per 12 hours across northern Nevada during the morning of January 22nd.

Surface analyses, during the early morning hours of January 22nd, show a weak north to south pressure gradient across Nevada with weak high pressure to the north (Figure 5). Temperatures across Elko County were mainly below freezing with the Elko ASOS reporting a surface temperature of 30 ˚ F for several hours before the onset of precipitation. In contrast, temperatures to the west and south of Elko County were above

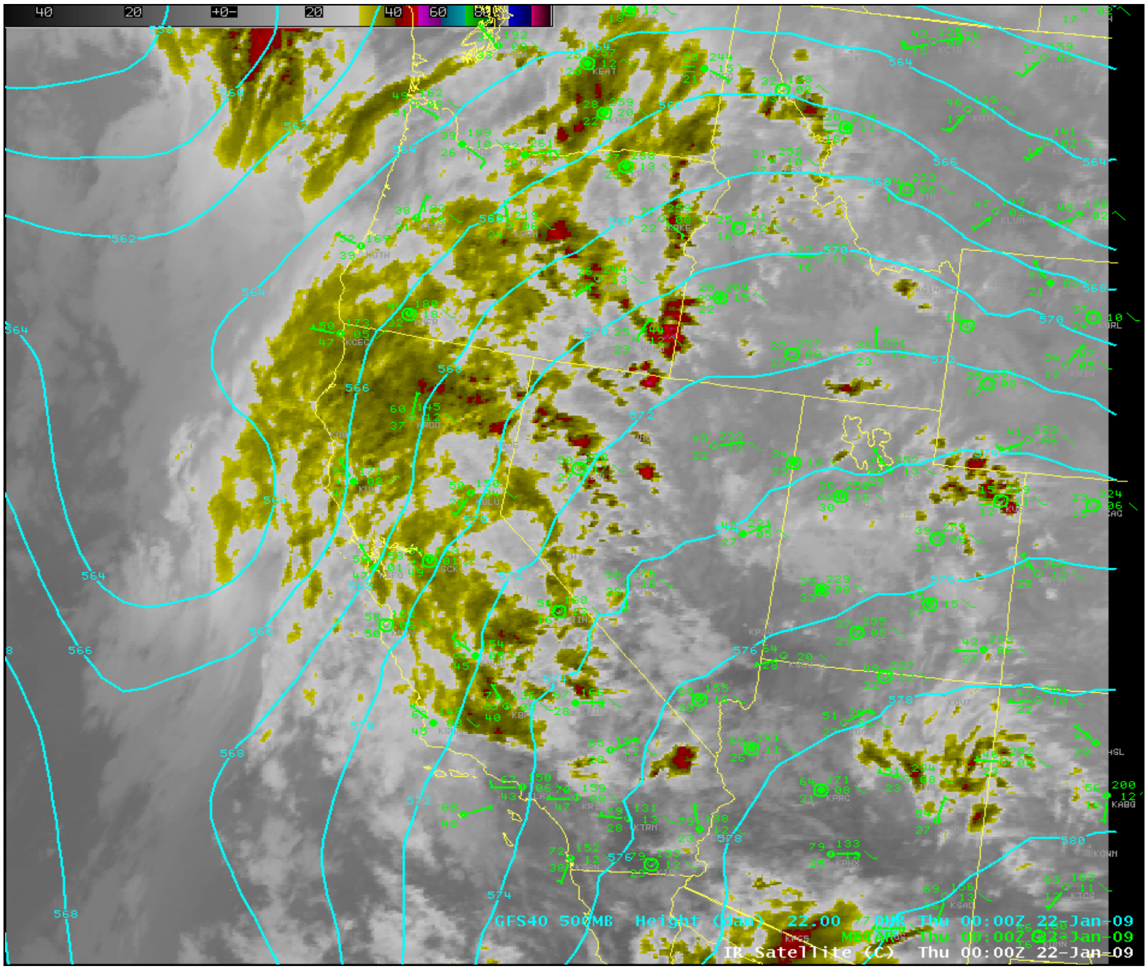


Figure 2. GOES Infrared Satellite imagery 22nd January 2009 at 0000 UTC with GFS 500 mb Heights (cyan) and METAR observations (green).

freezing before 1200 UTC, with even a 42 ˚ F temperature reported at Ely, Nevada at 1100 UTC, south of Elko County. Winnemucca, which is located west of Elko County, reported rain at 1100 UTC with a temperature of 35 ˚ F as the precipitation moved into northwest Nevada. Warm air advection at the surface was observed south of Elko County at Ely, Eureka, and Tonopah with rising temperatures and southeasterly winds prior to dawn; which suggests a poorly defined warm frontal boundary was pushing across central Nevada during the early morning hours of January 22nd. Surface winds were light across Elko County with wind speeds below 10 mph through the early morning hours. Elko ASOS reported easterly winds through 1100 UTC, which is the direction of the diurnal down-valley wind at that location typically seen late at night. No notable areas of cold air advection were detected at the lower levels as temperatures hovered near or just below freezing across the county with light winds.

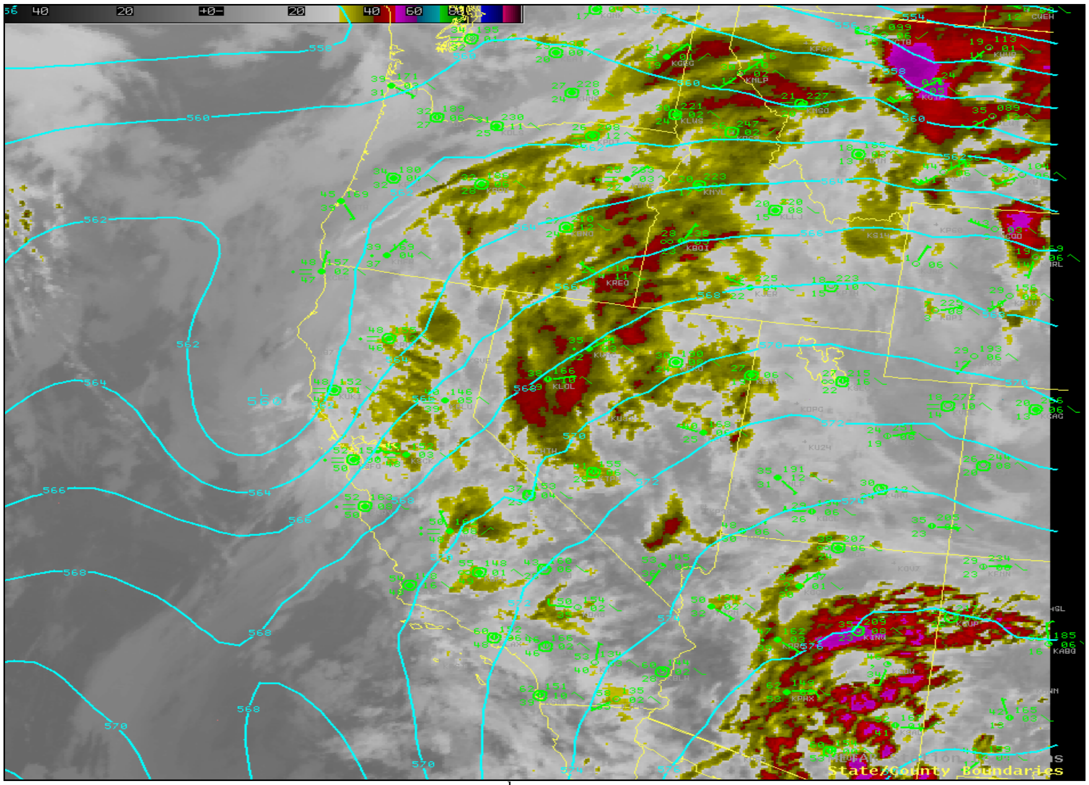


Figure 3. GOES Infrared Satellite imagery 22nd January 2009 at 1200 UTC with GFS 500 mb heights at 1200 UTC (cyan) and METAR observations (green).

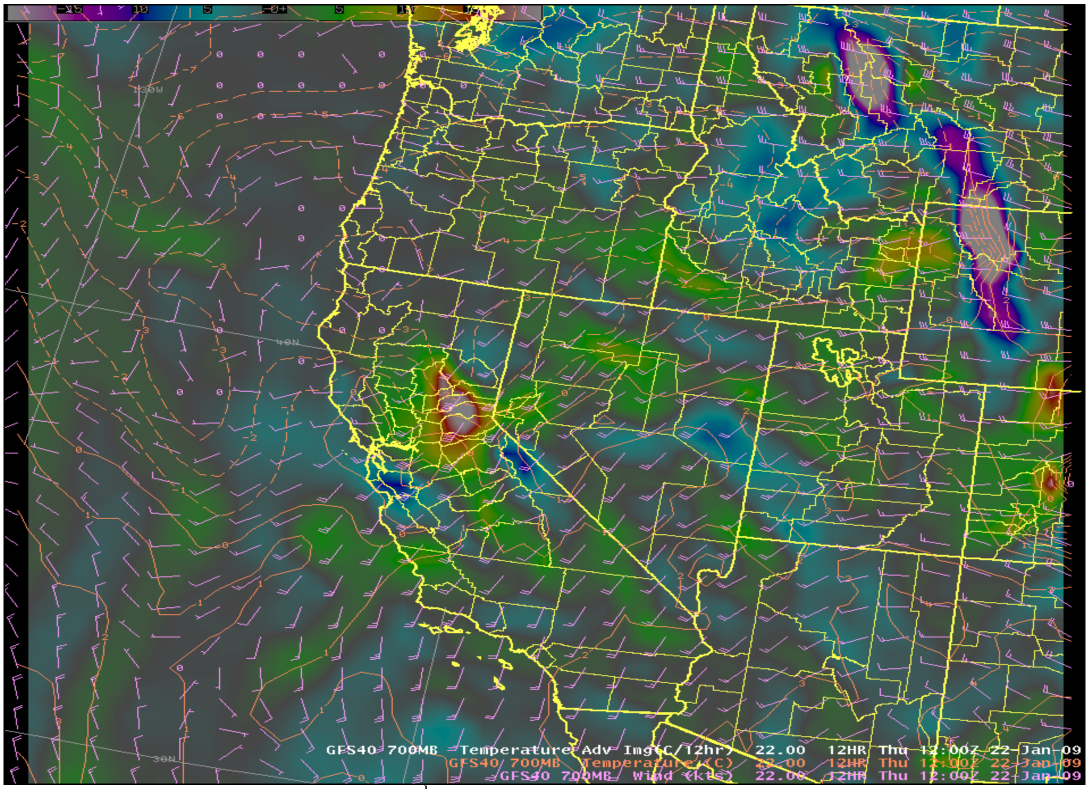


Figure 4. GFS 12 hour forecast for 22nd January 2009 at 1200 UTC with 700 mb temperatures advection (image), 700 mb wind barbs (lavender), and 700 mb temperatures (red).

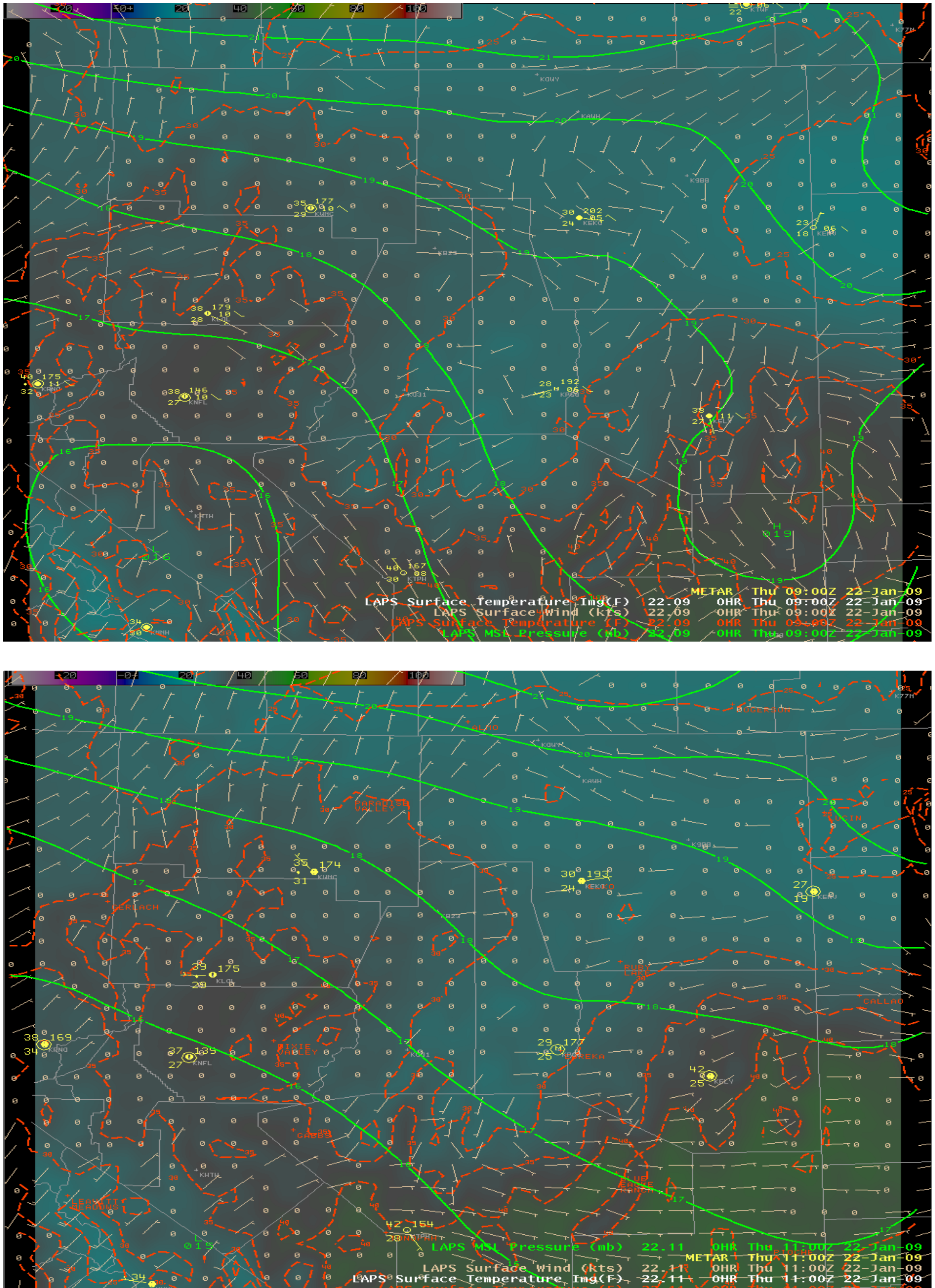


Figure 5. LAPS surface analysis 22nd January 2009 (a) at 0900 UTC (top) (b) at 1100 UTC (bottom) with mean seal level pressure (green solid), surface temperature (image with red dashed lines every 5 F), surface winds (barbs), and METAR observations.

3. Mesoscale Analysis and Discussion

Warm air overrunning aloft, combined with some upper level jet dynamics, produced an area of stratiform precipitation that moved into northwest Nevada just after midnight on January 22nd. This was well ahead of the upper level trough moving into the California coastline with no cold frontal boundary present across Nevada. By 1000 UTC (2:00 AM PST), the band of stratiform precipitation moved into Humboldt County, Nevada, producing rain at Winnemucca 2 hours later (Figure 6). The band moved rather quickly across northern Nevada, with precipitation moving into Elko County by 1200 UTC and freezing rain reported at Elko Airport by 1300 UTC. KLRX radar also showed signs of the precipitation intensifying as base reflectivity increased to between 35 to 45 DBZ by 1300 and 1400 UTC (Figure 7) as the band moved into Elko County; however, with snow levels around 9500 feet above sea level (shown later), believe some of this reflectivity enhancement was due to bright banding immediately around the radar site in Battle Mountain, Nevada[1] as seen in figure 7a. Regardless, the band of light to moderate rain pushed into southern Elko County by 1400 UTC affecting the towns of Elko, Spring Creek, and Wells along Interstate 80 just before the morning commute.

High resolution surface air temperature analysis shows temperatures at or below freezing along interstate 80 as this band of steady light rain moved over the area (Figure 8). Note the contrast in temperatures between the lower valleys where Elko and Wells are located, compared to the surrounding mid-slopes and mountainous terrain. Temperatures well above freezing were reported at elevations above 6000 feet, with the 1200 UTC KLKN RAOB sounding showing above freezing temperatures extending as high as 700 mb (~10,000 feet above sea level). Figure 9 shows a strong temperature inversion with temperatures above 40 degrees Fahrenheit above 775 mb, which supports the GFE surface temperature observation analysis in Figure 8. A deep melting layer is clearly shown in the RAOB sounding which supports a rain event in the mid-slopes, and a freezing rain event in the lowest valleys.

Another key element yet to be discussed was the presence of a snow pack in the valleys before and during the event. Elko reported a snow depth of one inch during the morning of January 22nd, 2009 with possibly higher snow depths further up-valley. Across the Great Basin, a valley snowpack tends to amplify low level temperature inversions as it insulates the surface of the snow and the air immediately above it from the heat stored in the ground (Whiteman, 2000). Also, the rugged terrain helps to trap the cold air in the valleys. Figure 10 shows the diurnal variation of air temperatures before and during the event at various locations in central Elko County. Note the Elko ASOS (magenta) and Halleck Junction (green) temperature plots between 0000 UTC and 0600 UTC before the bulk of the clouds moved into the area; a sharp fall in temperature below freezing is clearly observed with temperatures remaining below freezing through the morning of January 22nd, 2009. In contrast, Lamoille Summit experienced a slower rate of cooling and remained mainly above freezing through most of the morning. The sharp drop in temperature just after 1200 UTC is mostly likely the result of evaporational cooling at the onset of precipitation due to relatively drier air above the valley floor, which was observed in the RAOB sounding (Figure 9). After the start of the precipitation

[1] KLRX radar is located in a mountain range north of Battle Mountain, Nevada at around 7200 feet MSL

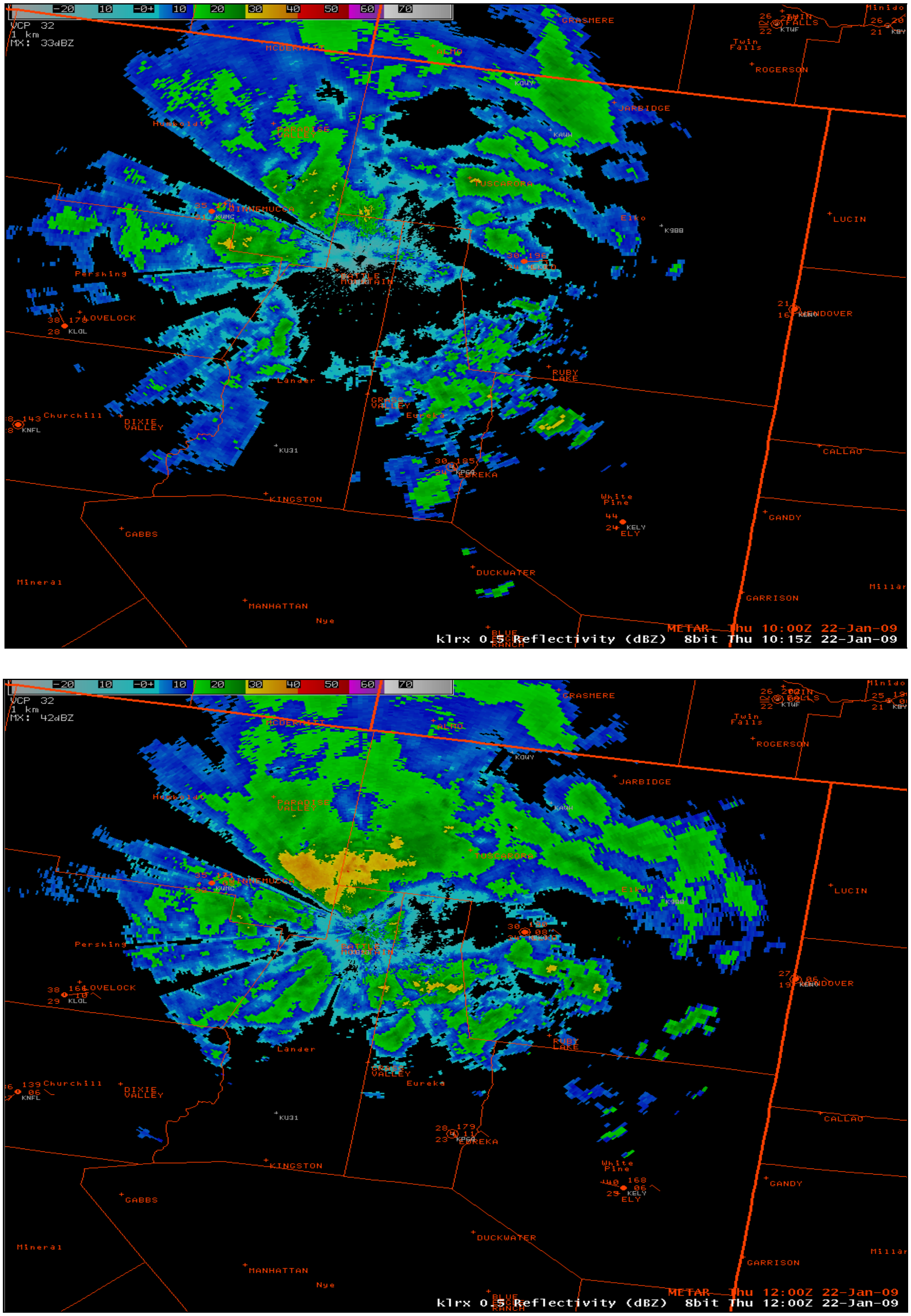


Figure 6. KLRX 0.5° base reflectivity 22nd January 2009 at (a) 1015 UTC (top), and (b) 1200 UTC (bottom) with ASOS observations.

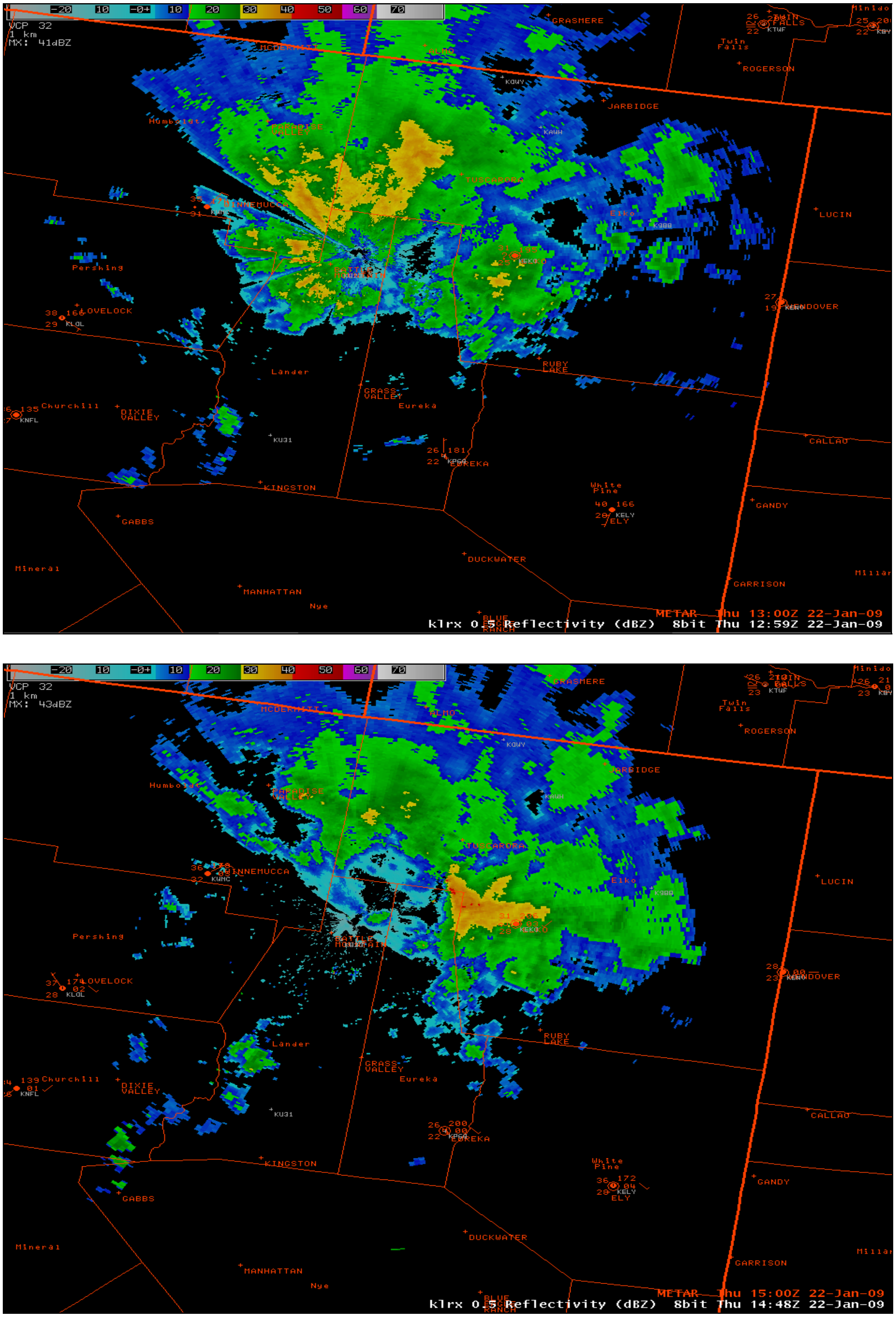


Figure 7. KLRX 0.5° base reflectivity 22nd January 2009 at (a) 1300 UTC (top), and (b) 1445 UTC (bottom) with ASOS observations.

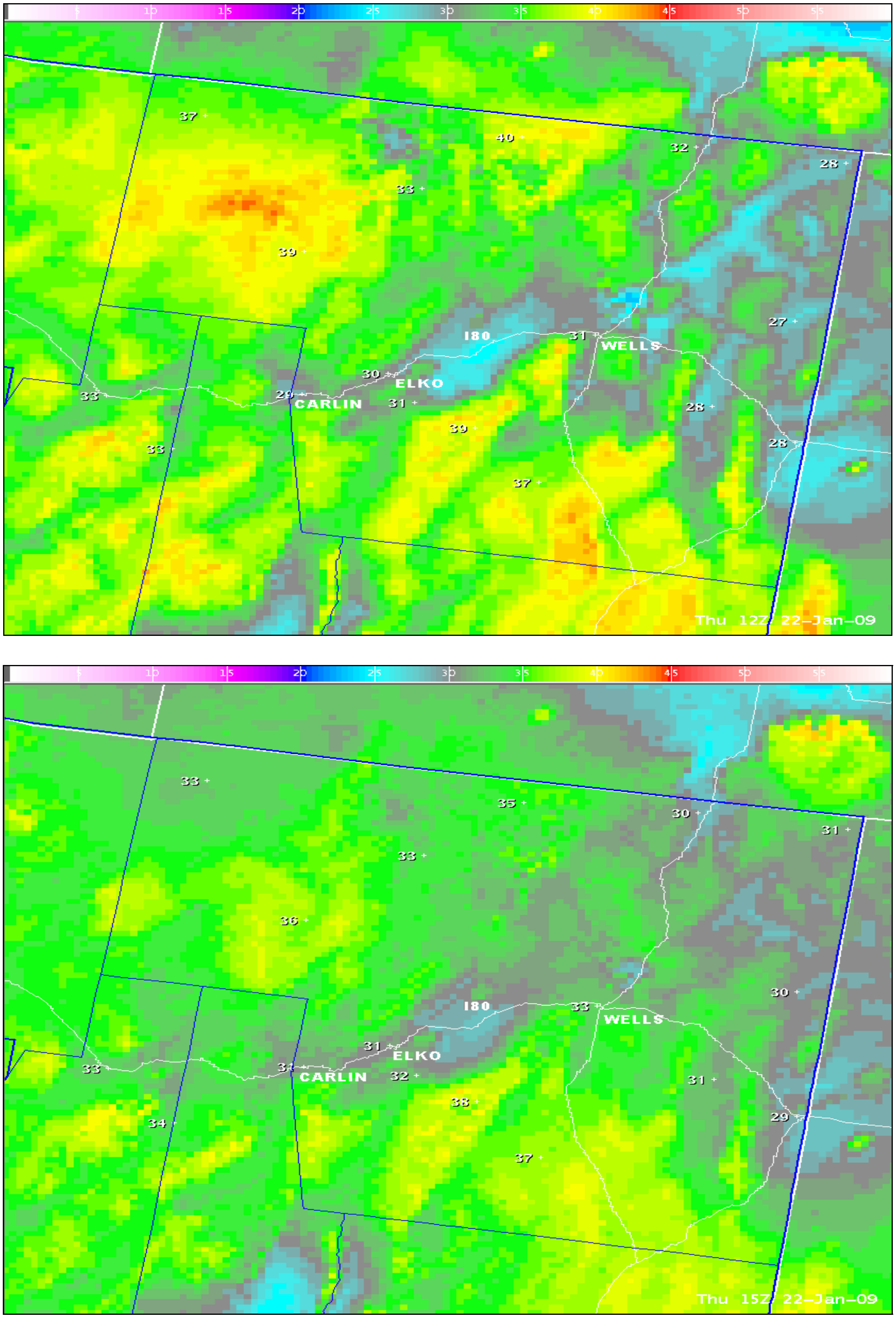


Figure 8. High resolution surface air temperature ($^{\circ}$ F) analysis grid from the GFE hourly observation (Obs) database at (a) 1200 UTC (top) and (b) 1500 UTC (bottom) on 22nd January 2009.

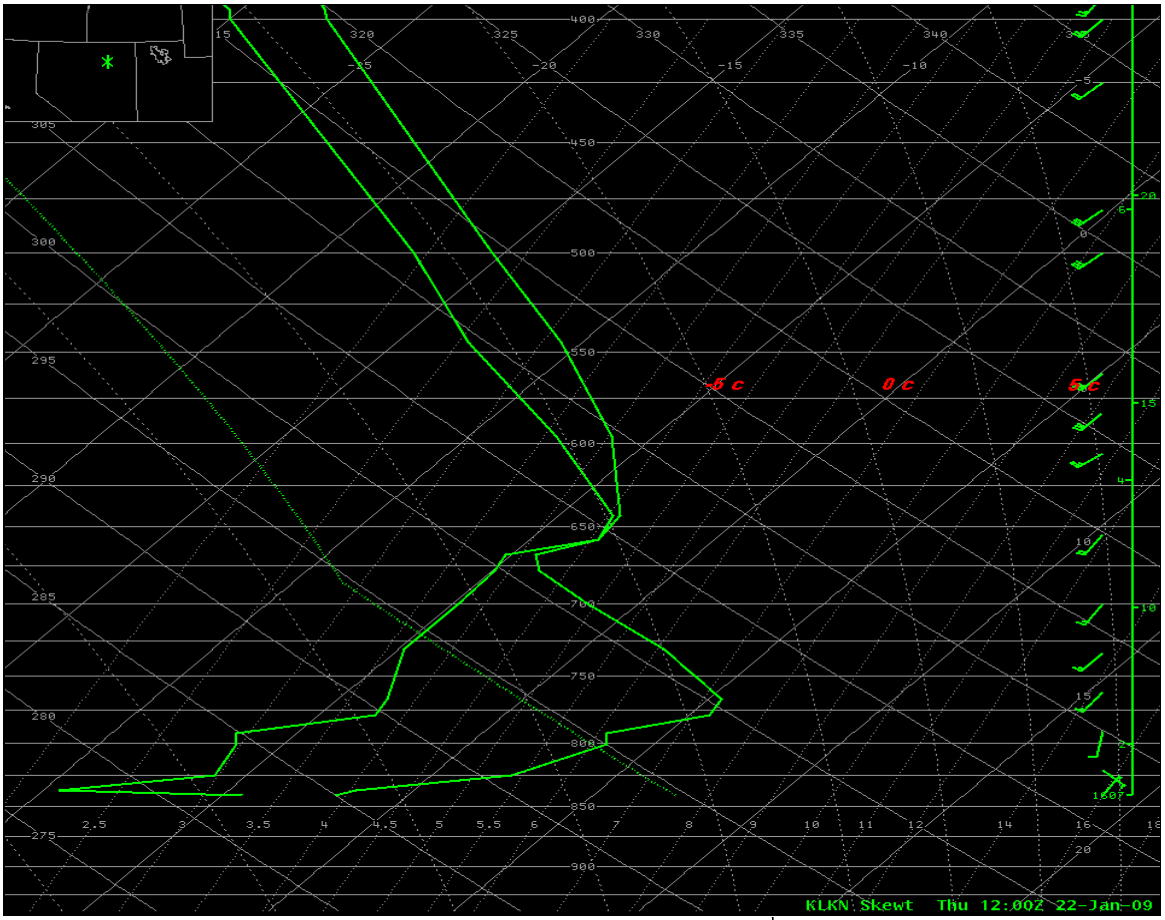


Figure 9. RAOB 1200 UTC sounding released from WFO LKN on 22nd January 2009.

at 1300 UTC, both Lamoille Summit and Elko Airport remained below freezing through the duration of the event with some slight temperature fluctuations; in contrast, the Wells/Moor DOT site (yellow) shows warming temperatures both prior to and after the start of precipitation, suggesting locations close to and above 6000 feet had sufficient warm air advection to warm the air temperatures above freezing. Below 6000 feet, observations showed air temperatures remained below freezing through the duration of the event. The lower levels of the atmosphere did not become well-mixed until the event was over, where Elko Airport observed a steep rise in temperature and became warmer than Lamoille Summit after 1600 UTC.

The suitable conditions for freezing rain across the Intermountain West differ compared to the more common events in the central and eastern United States. In the Intermountain West, typically cold air is trapped in the valleys with warm air advection aloft. Also, mountain ranges can act to limit warm air advection at the surface. Various elements can act to reinforce the cool air at the surface and result in freezing rain across the West. For this event, it is believed that the relatively brief duration of the event, combined with low-level evaporational cooling and a valley snowpack deterred sufficient valley warming to produce an all-rain event**.** The question is: can models accurately show these elements so the forecaster can predict a freezing rain event with

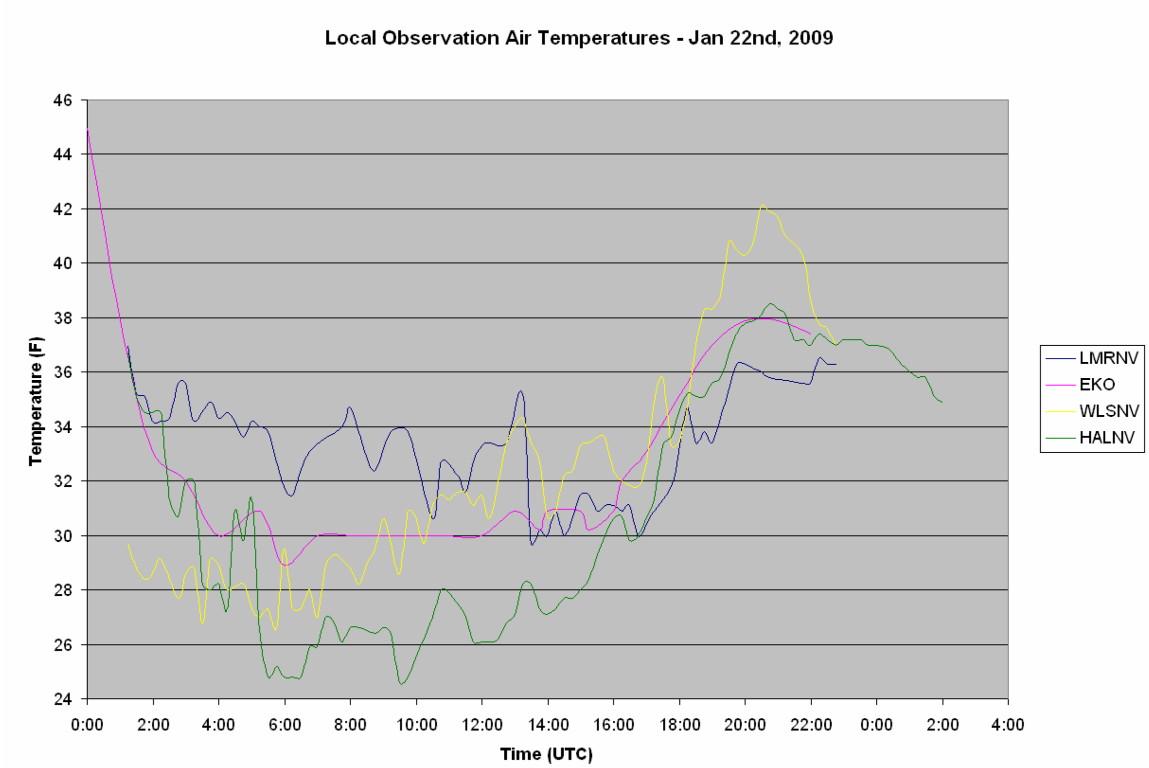


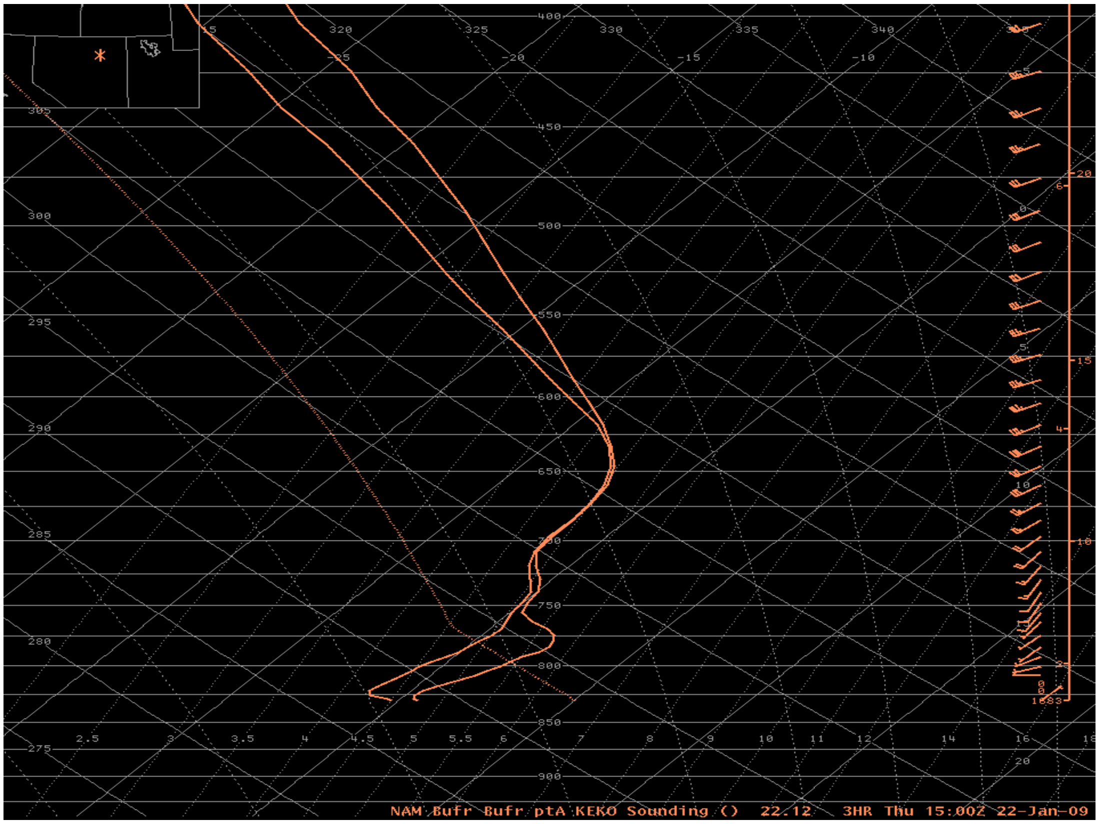
Figure 10. Temperature data from the various observation sites on 22nd January, 2009: Lamoille Summit DOT (LMRNV) at 5786 ft ASL, Elko Regional Airport ASOS (EKO) at 5144 ft ASL, Wells/Moor Grade DOT (WLSNV) at 5875 ft ASL, and Halleck Junction DOT (HALNV) at 5354 ft ASL.

enough lead time across the Intermountain West? Overall model performance and office verification is discussed in the next section.

4. Forecasts and Verification

The model soundings from the 1200 UTC GFS and NAM indicated a warm layer aloft, but failed to indicate temperatures below freezing at the surface (Figure 11). The NAM had light northeast winds at the surface, which was verified by surface ASOS observations through the duration of the event. The GFS, however, showed warm air advection extending all the way to the surface with south winds at five to ten knots around the time of the event. Model soundings generally did a poor job and underestimated the amount of low level valley cold air near the surface.

The model Quantitative Precipitation Forecast (QPF) forecasts for this event included generally limited precipitation amounts, which is what was observed (Figure 12). The River Forecast Center Quantitative Precipitation Estimate (RFCQPE) indicates that the majority of the precipitation received in the CWA between 1200 UTC and 1800 UTC fell across Humboldt and western Elko Counties. Given that this was a limited precipitation event, official forecasts were lower in regards to QPF and Probability of Precipitation (PoP). The Official (NWS) QPF forecasts close to the event had precipitation amounts of around 0.05” forecast for the valleys and as much as 0.10” forecast for the mountains. The Official PoP forecasts in the valleys were increased from 50% to around 60% the



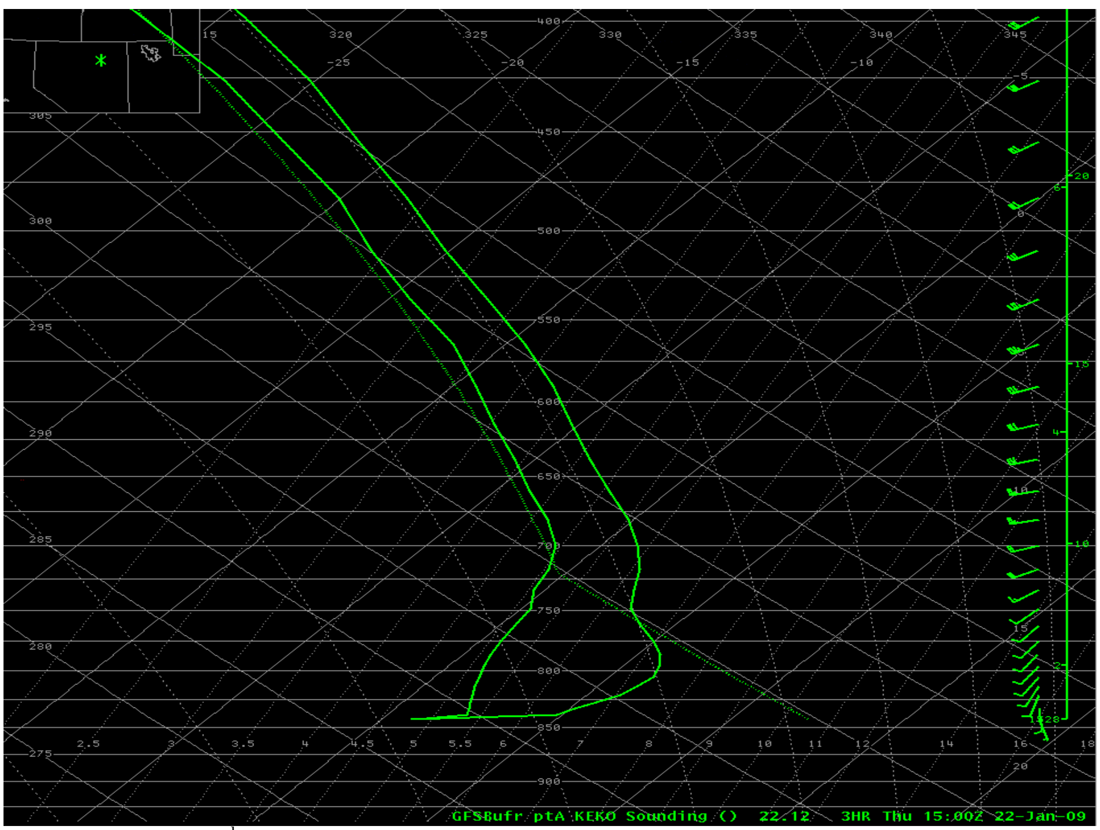


Figure 11. The 22nd January 2009 1500 UTC KEKO forecast Bufr sounding from (**a**) 1200 UTC NAM run (top), and (b) 1200 UTC GFS run (bottom).

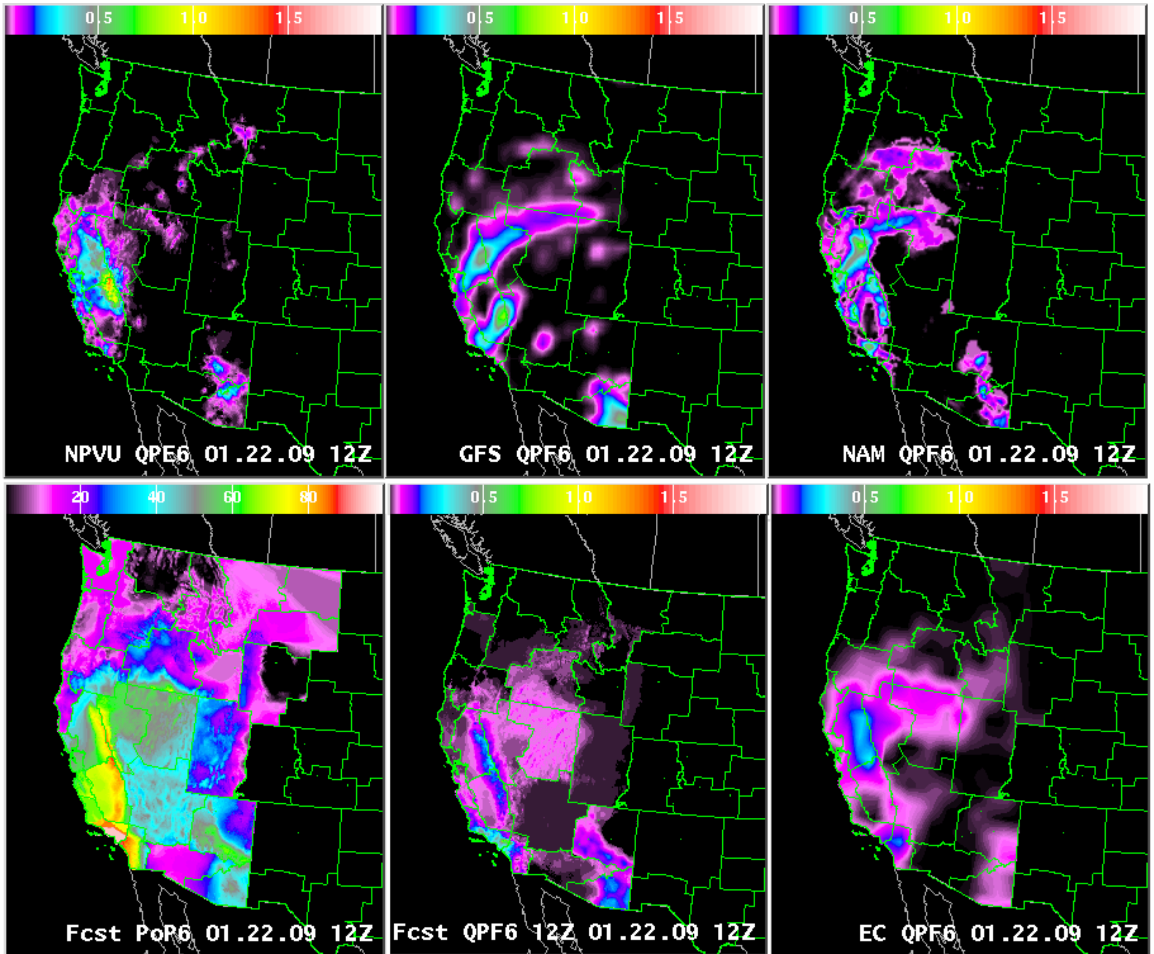


Figure 12. Individual images are valid from 1200 UTC to 1800 UTC on 22nd Jan 2009 and are as follows (clockwise starting in upper left): RFCQPE, GFS QPF, NAM QPF, ECMWF QPF, Official QPF, and Official PoP. The forecasts are from 0000 UTC on 22nd Jan 2009.

morning of the event. At 6:42 AM PST on January 22nd, a Freezing Rain Advisory was issued until 10:00 AM PST for all of Elko County; however, the possibility of freezing rain was mentioned in the Area Forecast Discussion (AFD) prior to the event as well. Road temperature observations from the various DOT sites across the area (Figure 13) indicate that the road temperatures were indeed near zero or below. Lamoille Summit (LMRNV) had the warmest road temperatures of the three observation sites with road temperatures around 32 degrees at the onset of precipitation (Figure 14). LMRNV is a high observation site in regards to elevation compared to the nearby topography, with valleys to the southeast and northwest (Figure 13). Observations from Wells/Moor Grade (WLSNV) and Halleck Junction (HALNV) stayed below freezing until after 1600 UTC (Figures 15 and 16). Forecasts for road temperatures are not available with the current suite of forecast products at WFO LKN. It is anticipated that the new version of the WRF-EMS will provide forecast road temperatures and perhaps help forecast this type of event.

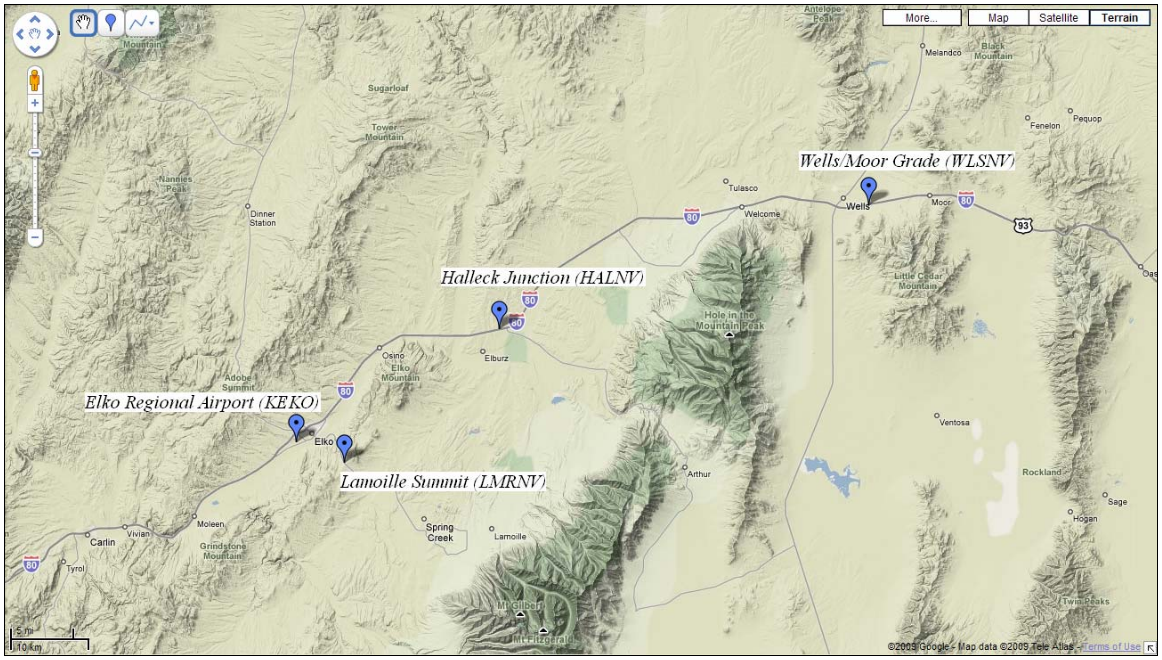


Figure 13. NV DOT RWIS sensor locations across Central Elko County.

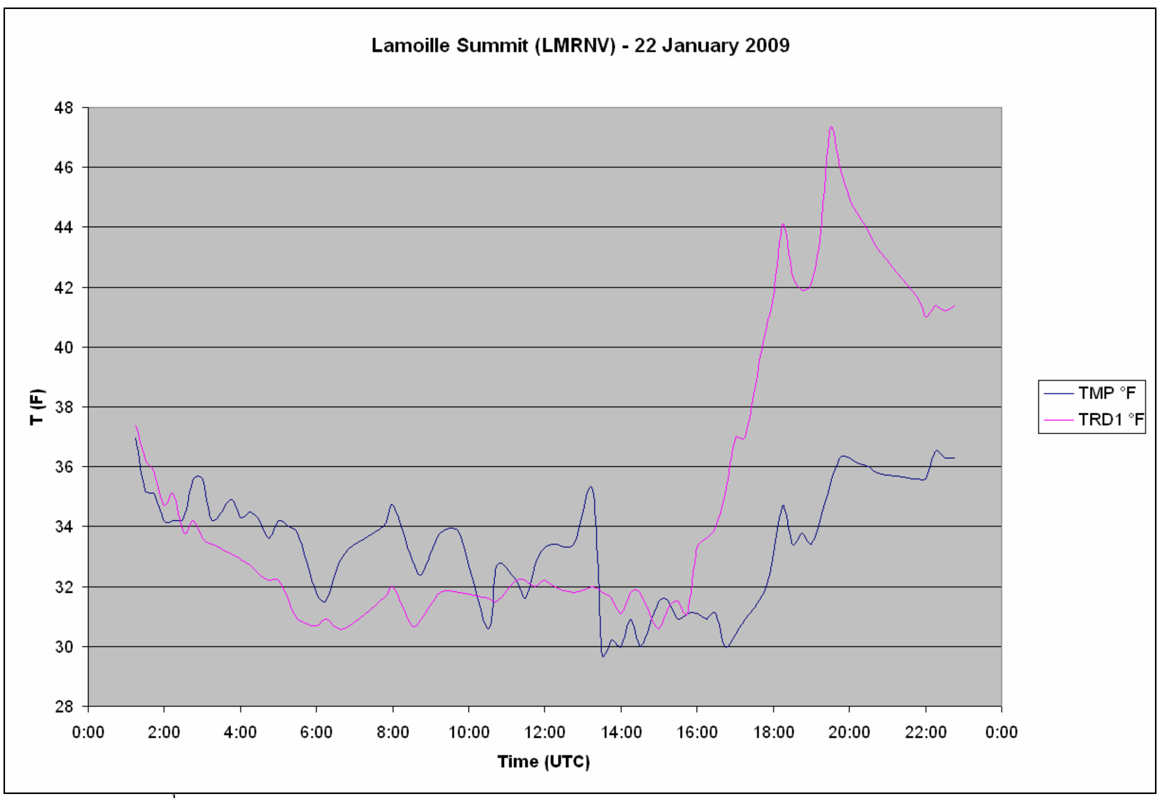


Figure 14. 22nd January 2009 air temperature (TMP ˚F) and pavement temperature (TRD1) observations from the Lamoille Summit (LMRNV) NV DOT RWIS site (5786 ft ASL).

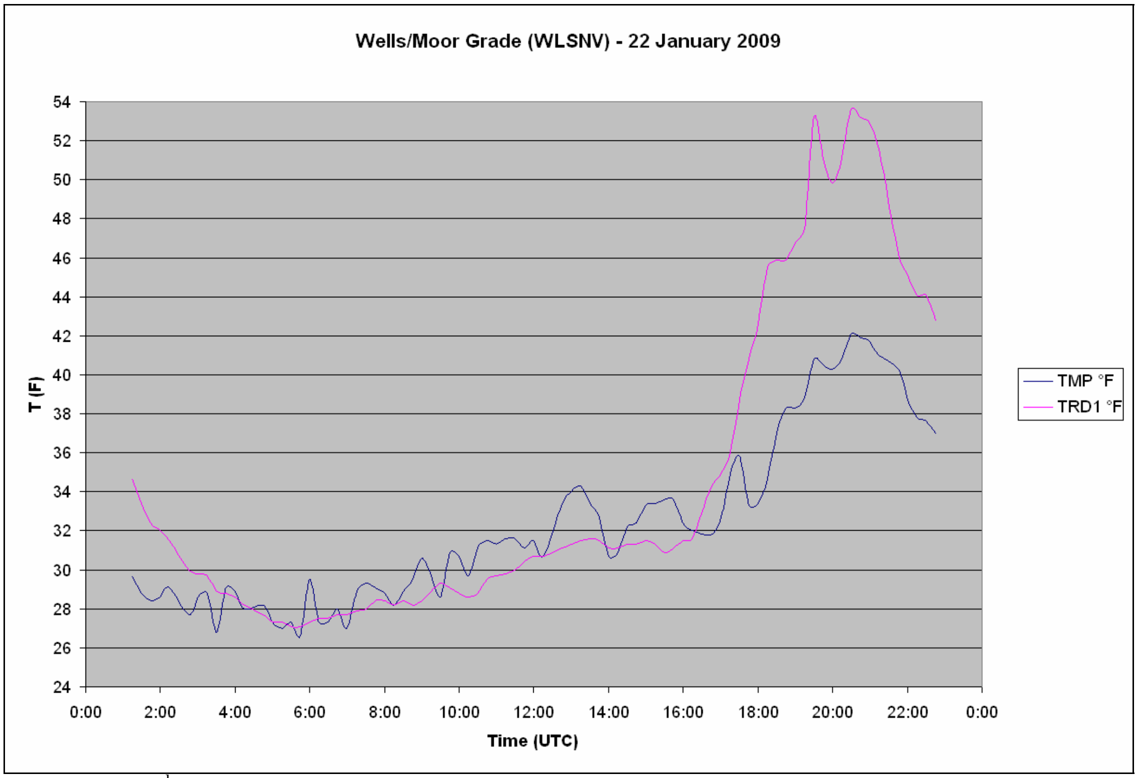


Figure 15. 22nd January 2009 air temperature (TMP ˚F) and pavement temperature observations (TRD1 ˚F) from the Wells/Moor Grade (WLSNV) NV DOT RWIS site (5875 ft ASL).

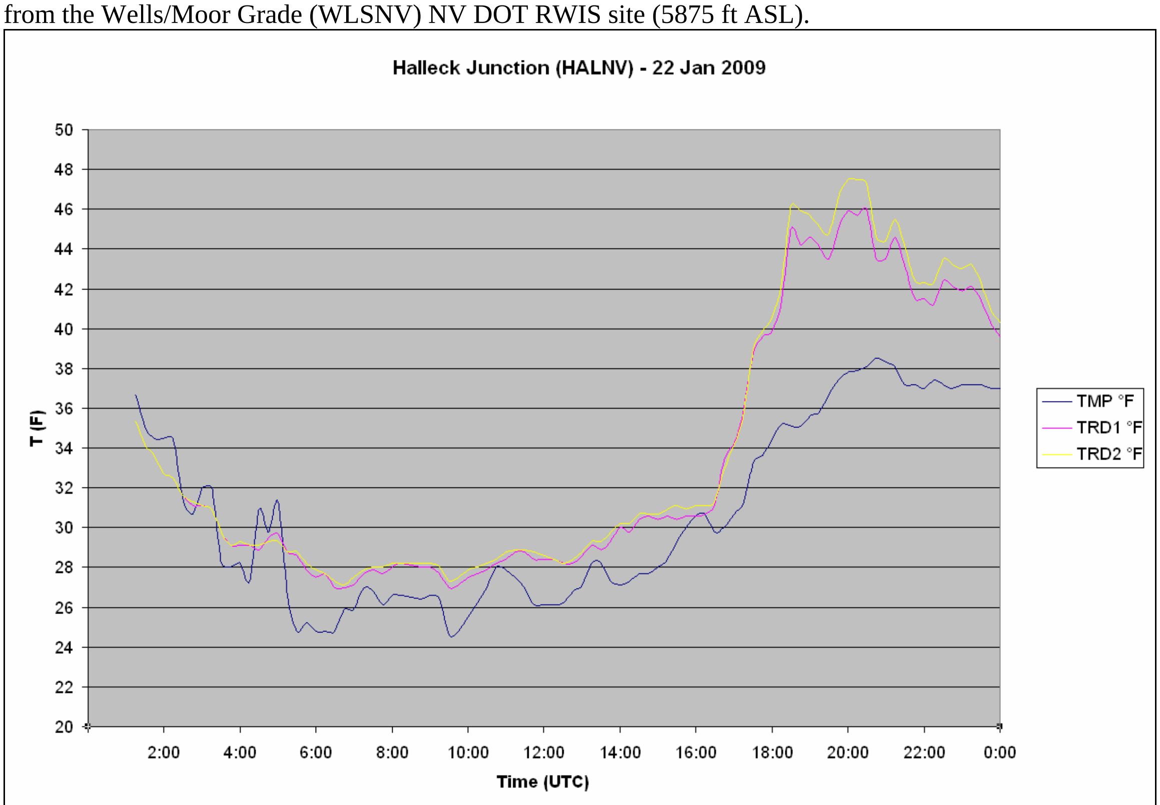


Figure 16. 22nd January 2009 air temperature (TMP ˚F) and pavement temperature observations (TRD1 ˚F) from the Halleck Junction (HALNV) NV DOT RWIS site (5354 ft ASL).

5. Summary

The freezing rain event during the morning of January 22nd, 2009 was localized to the lowest valleys across Elko County. Although the event was brief and precipitation was generally light, very icy conditions were reported in Elko and Wells, Nevada resulting in numerous vehicle accidents and two fatalities. The freezing rain was primarily the result of warm air advection aloft overrunning the cold air trapped in the snow covered valleys. No significant cold air advection near the surface was observed through the duration of the event. The relatively brief duration of the precipitation event likely did not allow sufficient time for the warmer air aloft to mix down to the surface. Poor low level mixing was observed along with evaporational cooling just off the surface; a combination of these factors likely prolonged the subfreezing temperatures across the valleys of Elko County, which allowed freezing rain to accumulate on exposed surfaces.

The precipitation forecast, both QPF and PoP, was a good forecast. Light QPF amounts were forecast and observed and 50 to 60% PoPs were forecast as well, which was justified. However, a rare precipitation type occurred across Northeast Nevada. Freezing rain does not occur in Nevada very often, which made it difficult for forecasters to include it in the Official Forecast. One of the goals of this paper is to raise awareness locally about these rare events and help prepare forecasters for future events. Accurate model forecasts or observations of two main features can help identify potential freezing rain events across Northern Nevada:

1. Warm layer
    a. Warm air advection aloft (800-700 mb) with a significant warm layer sufficient for complete melting.
2. Surface (air and ground) temperatures
    a. A mostly clear sky and light winds after sunset will provide good radiational cooling conditions and allow pavement and air temperatures to fall rather quickly. Also, it is important to understand that the pavement temperatures may be cooler than the air temperature and that these temperatures can be monitored through DOT RWIS observations.
    b. The existence of a valley snowpack adds to the ability for the surface air temperature to cool quickly.

6. References

DuBach, Jared. "Two killed near Wells as ice coats highways**."** Elko Daily Free Press [Elko, Nevada] 22nd January 2009. **[**Available online**:** **http://www.elkodaily.com/articles/2009/01/22/news/breaking_news/doc4978d5bcab04b852745939.txt]**

DuBach, Jared. "Crash victims identified." Elko Daily Free Press [Elko, Nevada] 23rd January 2009. **[**Available online**:** **http://www.elkodaily.com/articles/2009/01/23/news/local_news/doc497a5ad378d85475042147.txt]**

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