January 2005 Banded Snow Event Using the Weather Event Simulator

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Introduction

A banded-snow event occurred on the 12th and 13th of January 2005 over portions of Western Montana and North Central Idaho. In addition, during this same period, an arctic front pushed west of the continental divide through the Glacier Park region and eventually moved into the Flathead valley and south of Kalispell. This complex weather system produced localized snow amounts up to 21 inches over a three day period and ended up as one of the most significant snow events of the year (see Table 1). While the arctic boundary did produce heavy snow and near blizzard conditions close to the continental divide, most of the snowfall and public impact from this event was produced by banded snow structures which occurred west and south of the arctic boundary.

It can be argued that episodes of banded snow have one of the largest winter impacts to the public in the Missoula forecast area. These events can lead to significant valley snowfall over populated areas. In this case, which was typical to similar banded events, many areas received almost no snowfall, whereas others had significant impacts due to persistent moderate to heavy snow. In particular, one of the snow bands became aligned parallel to the west-to-east oriented and heavily traveled I-90 corridor. This stationary band produced localized hourly snowfall rates in excess of 3 inches per hour and led to road closures from Bonner to 15 miles west of Drummond (areas east of Missoula). In addition, this same band produced record snowfall at St Regis (west of Missoula) and caused school closures at both St Regis and Arlee. Figure 1 shows a picture of post-event snow accumulations taken near Rock Creek, which is about 30 miles east of Missoula.

Finally, while banded snow is a common occurrence in the Missoula forecast area, additional dynamical features; such as the arctic intrusion which occurred during this episode; can complicate the forecast analysis. Therefore, a weather event simulation was produced in order to challenge forecasters to sort out important features during a complicated banded snow event.

Synoptic and Mesoscale Discussion

Tuesday, 11 January 2005: On Tuesday morning, the overall synoptic conditions over the area included a 500mb trough located over North Central California and a strong >120kt jet-streak moving southeast over the northwestern British Columbia coast. In addition, remnants of an earlier arctic system left many Western Montana valleys with snow-cover and under a modified arctic air-mass. Surface observations indicated a new arctic system pushing its way south through the Alberta and Saskatchewan plains. The GFS and NAM models both initialized well and had similar placement for major synoptic features. Panel (a) in Figure 2 shows water vapor satellite imagery at 12Z on the 11th with 500mb GFS heights and 300mb wind speeds overlain. Panel (b) on this image shows same fields taken at 18z on the 12th. The GFS and NAM both handled this upper-level forecast well and continued handling the upper level synoptic forecast well throughout the event.

The 11 January forecast for arctic progression for the morning of the 12th was also similar between the NAM and the GFS (see Figure 3). Note that the 700mb trough shown in both models remains stationary with time. Therefore, this feature is an indication of a lee-side stationary trough produced by strong zonal flow over the Washington Cascade mountain range and not an indication of a transient short wave. The forecasted thermodynamic environment at Missoula (MSO) for 12 January showed a saturated atmosphere below 550mb, with strong vertical shear between 700mb and 850mb, and unidirectional wind up to 60kts at 700mb (see Figure 4). In addition, forecast lapse rates over Missoula below 600mb increase from 2 to 10 degrees/km from 12 January-12z to 13 January-00z. By the afternoon of 11th, snow showers had begun over Western Idaho and Northwest Montana. In general, these showers were low-topped with some banded appearance. However, these bands were transient in nature and there were few observations of showers training over a particular location (see Table 1).

Wednesday, 12 January 2005: On Wednesday morning, arctic air had pushed well south of where previous days forecast had indicated it would be. In fact, the arctic front had already moved south of Cut Bank, Montana (KCTB) which is east of the continental divide (see Figure 5). The 12 January-12z NAM forecast valid 13 January-12z indicated the arctic front would dam up at along the continental divide whereas the GFS forecast for the same period showed an arctic intrusion as far west and south as Kalispell, Montana. In addition, radar observations now showed widespread showers over north central Idaho and western Montana with some orographic enhancement over the Idaho panhandle, though still little in the way of organized snow bands. The infrared satellite image beginning at 13z showed two potential snow bands setting up over extreme northeastern Washington through extreme northwestern Montana (see Figure 6). However, these early infrared indications of banding did not persist. In fact, there was little indication via infrared- or visible-satellite-imagery or from radar-imagery whether or not banded precipitation was occurring during the day on the 12th.

By the evening of the 12th of January, the KMSX radar began to pick up banded snow structures in the Missoula area (see Figure 7). Spotter and public phone calls started coming in during the late afternoon of 12 January reporting heavy snow and strong easterly winds in the Glacier Park region which was creating “near blizzard conditions” on US Highway 2 near the continental divide (in the Glacier Park region). In addition, surface observations from Kalispell showed a clear indication of an arctic frontal passage at around 5PM MDT on the 12th.

Thursday, 13 January 2005: Radar-indicated snow bands persisted through the early morning hours of 13 January and satellite infrared imagery showed intermittent evidence of some of the stronger bands. By Thursday morning, models indicated that banding conditions would diminish through the day. Figure 8 shows a NAM-derived time-height diagram for Missoula, which forecasts subsidence inversion lowering with time as well as low-level stabilization. Finally, Figure 9 shows radar trends through mid-morning Thursday showing decreasing banded snow activity through mid-morning Thursday.

Forecast Discussion

Forecasters on the morning of 11 January were faced with a complex weather pattern which included both an arctic front diving south through Saskatchewan and Alberta and an approaching jet streak moving through British Columbia. Based on previous experience, model guidance for these two features led forecasters to have a high confidence in the jet streak dynamics and overall thermodynamic features that could lead to a possible snow banding event[1]; but low confidence on the timing and western extent of a possible arctic intrusion into Western Montana[2]. In addition, forecasters were faced with a possibility that if arctic air moved into Western Montana fast enough, and with enough of a southward extent, that additional snowfall enhancement could be produced as bands formed over the arctic air-mass. Assessments as to model guidance weakness in predicting arctic timing and extent turned out to be true. The NAM model incorrectly blocked the arctic intrusion along the continental divide due to damning problems associated with the model stepped topography and insufficient topographic resolution. On the other hand, the GFS80 accurately produced an arctic intrusion into western Montana, but with incorrect timing and southern extent. In fact, the more accurate prediction by the GFS was probably more of an accident produced by a very poor topographic resolution over Western Montana.

Accurate observations of banding were difficult to obtain or were simply not available as the banding event unfolded overnight on 11 January, and then through the day on 12 January. For instance, the KMSX radar which is located on a mountain at 8000 feet MSL, overshot the initial banded cloud tops which were forming over 100 miles from the radar near the Canadian border. At the same time, poor thermal contrast between the surface and low-topped banded structures made use of infrared satellite imagery problematic. In addition, visible satellite imagery provided little insight to initial banded clouds forming during daylight hours on 12 January due to surface snow cover and lack of shadows that provided almost no visible contrast, and to an intermittent mask of overrunning stratus. Also, preliminary surface observations missed the onset of the event due to the localized hit-or-miss nature of banded snow as well as the remote location of the initial snow bands. Assessments of arctic intrusion were difficult but not quite as

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[1] Banded snow events are common enough in the Missoula forecast area, that most of the seasoned forecasters are well aware of what mesoscale characteristics are favorable to the production of heavy snow bands. These characteristics include (a) existence of a stable capping layer; (b) unidirectional wind speeds of 30 to 50 kts between 850 and 700mb, (c) unstable lapse rates below the stable layer and (d), existence of topographic anchor points which tend to initiate and sustain stationary bands under other favorable conditions (see Petrescu, TA-Lite #03-55). For this case, a northwest flow under strong jet dynamics is a typical (though not unique) pattern for production of convective snow bands.

[2] Numerical models have a poor track record of predicting the timing and strength of arctic intrusions into western Montana. This problem is due in part to poor resolution of topographic features in the area (see Petrescu, TA-Lite #03-11).

frustrating, especially after the 13 January-00Z GTFX sounding data became available and an accurate assessment as to the depth of the arctic air became clearer (see Figure 10). By the evening of 12 January, the significance and extent of convective banding became more obvious and better predictions of the timing and extent of an arctic intrusion into western Montana became possible. In addition, it became clear that significant banding was occurring well south of the arctic boundary and that the forecast needed to differentiate between the two different forcing mechanisms.

Summary and Conclusions

This WES case is an excellent forecaster primer for winter weather preparation over the Missoula forecast area. Specifically, the case not only highlights key forecast elements and model limitations found with two of our most significant winter weather producers[3], but it also highlights observational pitfalls associated with detecting banded snow events. These observational pitfalls include: (a) limitations of surface observations during a localized snow event, especially when that event occurs over a rural area; (b) limitations of radar observations in detecting low-topped clouds distant from the KMSO radar; (c) infrared and visible satellite limitations in detecting low clouds in the presence of an existing snowpack and obscurations produced by higher clouds.

References

Petrescu, Gene, "Using the WES to Mitigate Model Difficulties in forecasting the Movement of an Arctic Front through Western Montana", Western Region TA-Lite #03-11, February 2003.

Petrescu, Gene, "Analysis of the November 11th, 2003 Convective Snow Banding Event in Western Montana Using the Weather Event Simulator", Western Region TA-Lite #03-55, December 2003.

[3] Namely arctic fronts and convectively banded snow events. The third, and more common type of winter weather event is orographically-driven snow. However, this type of event does not typically impact our major population centers, which are for the most part located in precipitation-shadowed valleys.

Station Name	Snowfall ($11^{th}/12^{th}/13^{th}$)	Event Total	2004-2005 3-Day Ranking
Missoula MT	**0.4 / 3.2 / 0.3**	**3.9**	**1**
Missoula 5 S MT	**-**	**14.0**	**-**
Clinton 6 SE MT	**0.5 / 0.6 / 10.2**	**11.3**	**1**
Dixie ID	**0.0 / 3.0 / 8.0**	**11.0**	**4**
Haugan 1W MT	**T / 1.0 / 7.0**	**8.0**	**4**
Heron 2NW MT	**0.1 / 4.7 / 0.2**	**5.5**	**2**
Libby 32SSE MT	**0.2 / 3.7 / 0.8**	**4.7**	**9**
Lindberg Lake MT	**0.5 / 2.4 / 2.8**	**5.7**	**8**
Olney MT	**T / 1.0 / 4.0**	**5.0**	**10**
Ovando 9SSE MT	**0.0 / 4.0 / 0.0**	**4.0**	**1**
Pierce ID	**T / 1.0 / 6.0**	**7.0**	**3**
St Regis 1NE MT	**1.5 / 7.5 / 13.0**	**22.0**	**1**
Seeley Lake RS	**0.1 / 2.0 / 4.5**	**7.5**	**2**
Sula 14 NE MT	**0.0 / 1.3 / 6.1**	**7.4**	**3**
Superior MT	**T / 2.0 / 2.0**	**4.0**	**3**
Swan Lake MT	**1.0 / 0.1 / 3.5**	**4.6**	**15**
Thompson Falls PH MT	**0.2 / 4.0 / 0.0**	**4.2**	**2**
Trout Creek RS MT	**0.0 / 5.5 / 0.5**	**6.0**	**1**
West Glacier MT	**0.4 / 7.1 / T**	**7.5**	**3**
Whitefish MT	**0.0 / T / 4.0**	**4.0**	**8**
Yaak 9NNE MT	**T / 4.0 / 0.0**	**4.0**	**4**
Rogers Pass 9NNE MT	**0.0 / 6.0 / 0.0**	**6.0**	**4**

Table 1. Selected Snowfall Observations 11-13 January 2005. Storm accumulations over seven inches are highlighted in red.

Figure 1. Post-event snow-cover near Rock Creek which is along the I-90 corridor approximately 30 miles east of Missoula (courtesy Gene Petrescu, WFO Missoula SOO).

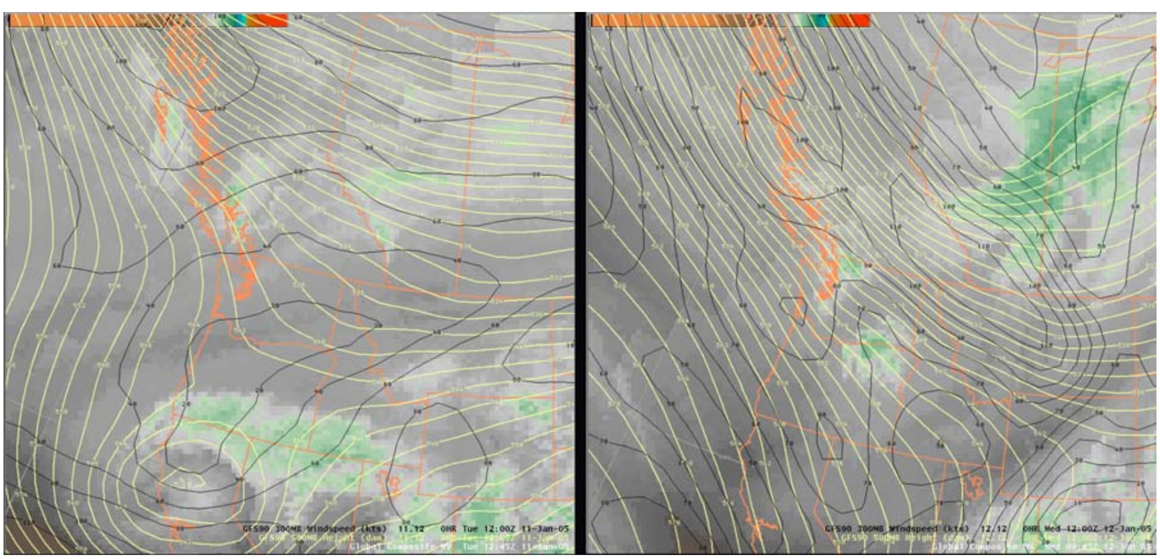

Figure 2. GOES water vapor imagery, GFS 500mb heights, and 300mb wind speeds for 11Jan 05/12z and 12 Jan05/18z.

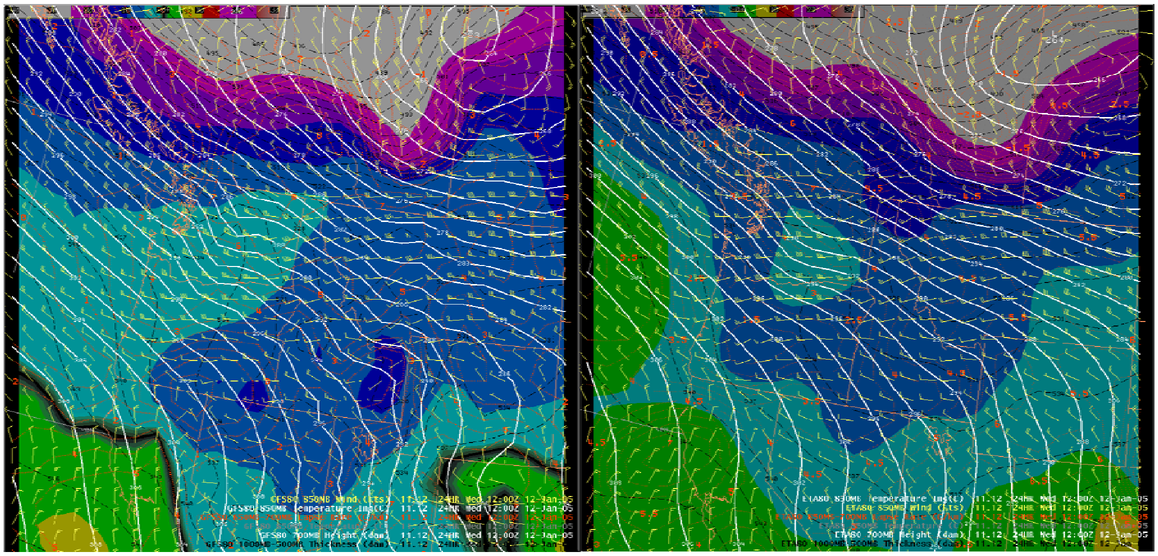

Figure 3. GFS versus NAM arctic 24 hour forecast valid 12 Jan 05/12z. 850mb temperatures are shown as image background, 700mb heights as white contours, 1000-500mb thickness values as black dashed contours, and 850mb winds as yellow wind barbs.

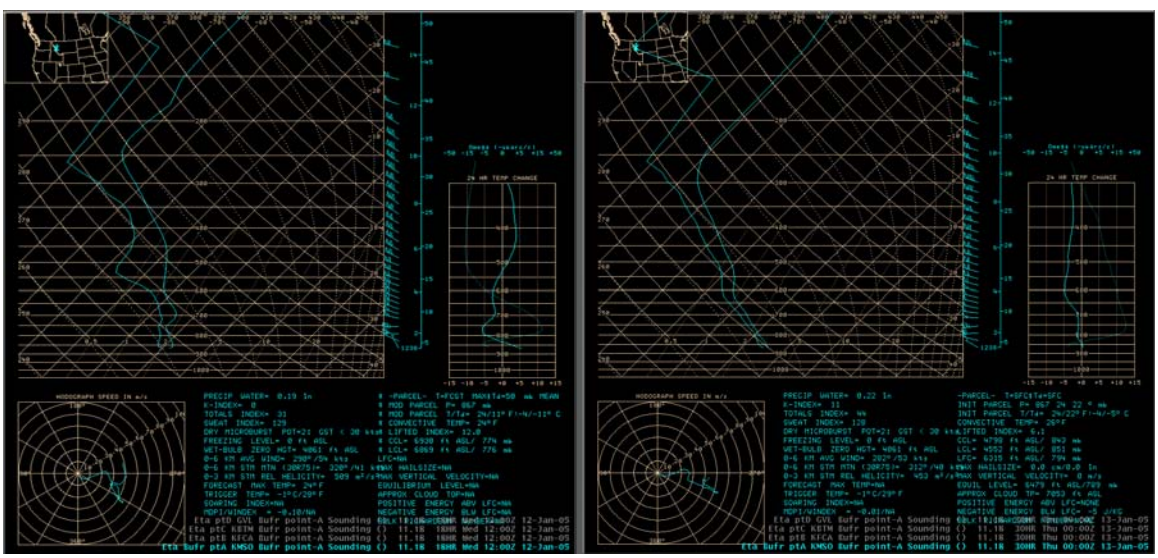

Figure 4. 11 January ETA-buffer forecast sounding for Missoula for (a) 12 Jan/12z and (b) 13 Jan/00Z.

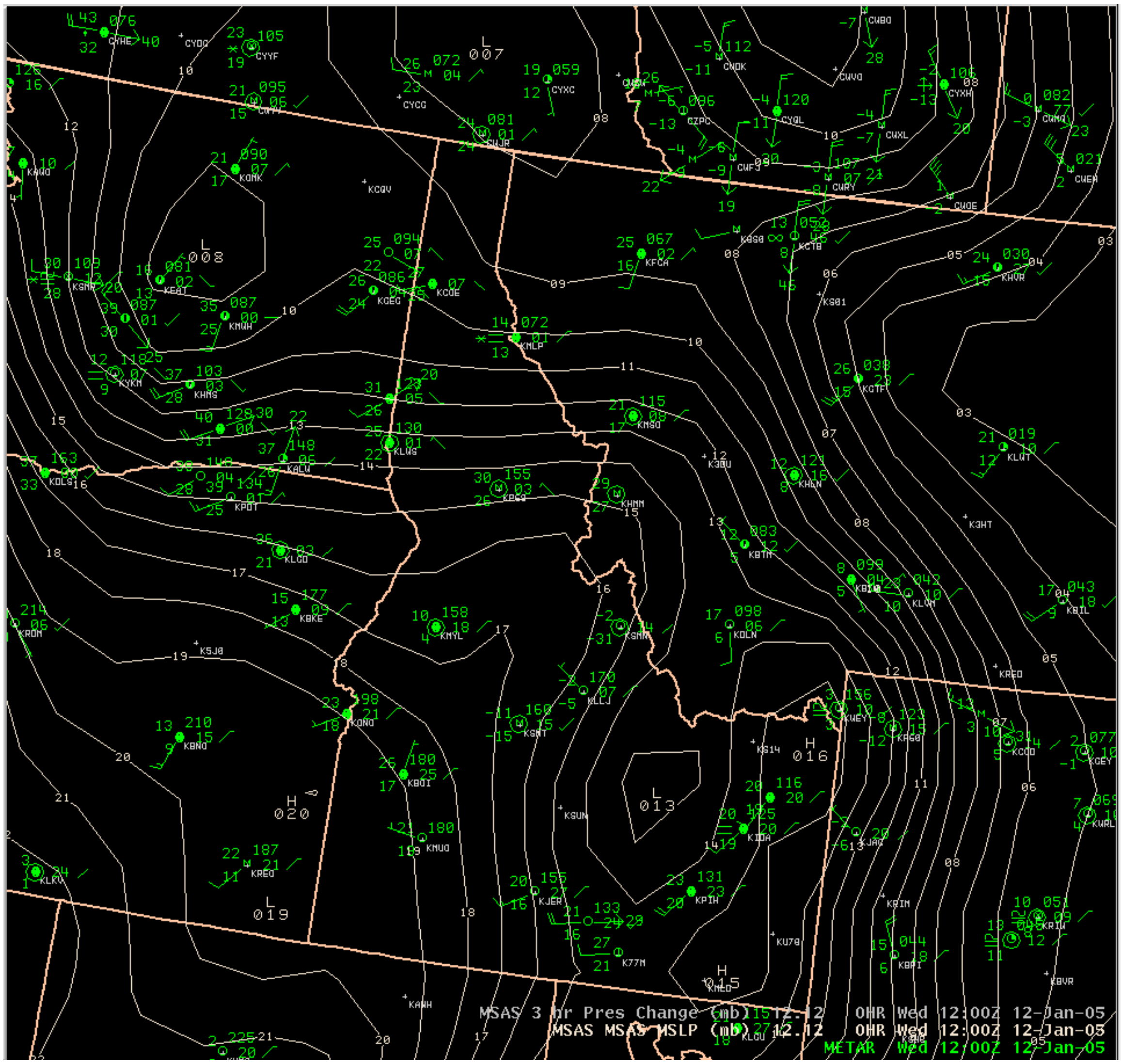

Figure 5. 12 January-12z surface METAR observations and MSAS-derived surface pressure analysis. Note the arctic front has just pushed through Cut Bank, Montana (KCTB).

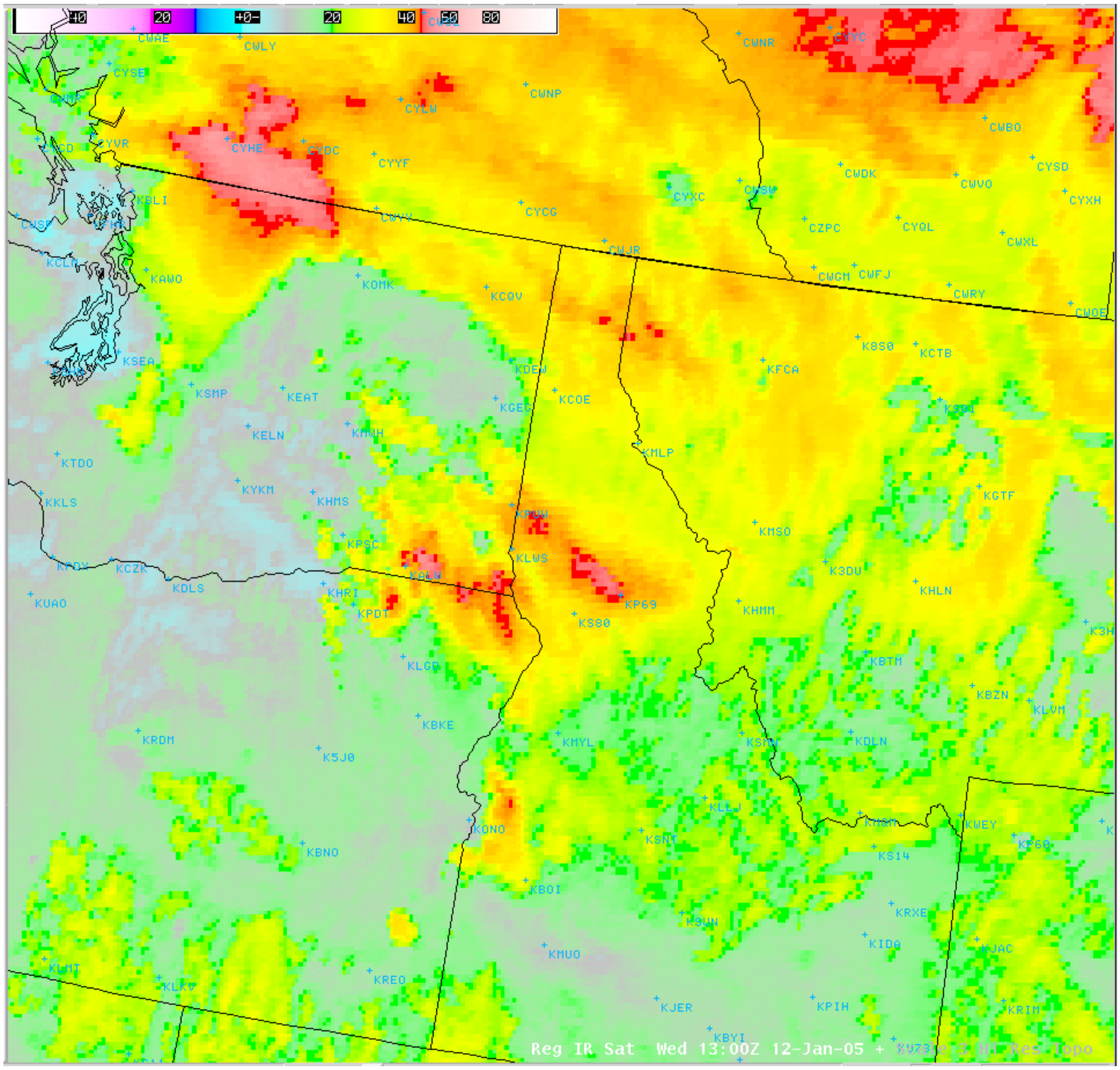

Figure 6. Infrared satellite imagery taken 12 January at 1300z. Features near the Idaho Panhandle and Canadian border are stationary, and are probably banded snow structures. Features in southeast Washington, northeast Oregon, and north Central Idaho are transient showers moving with the mean wind.

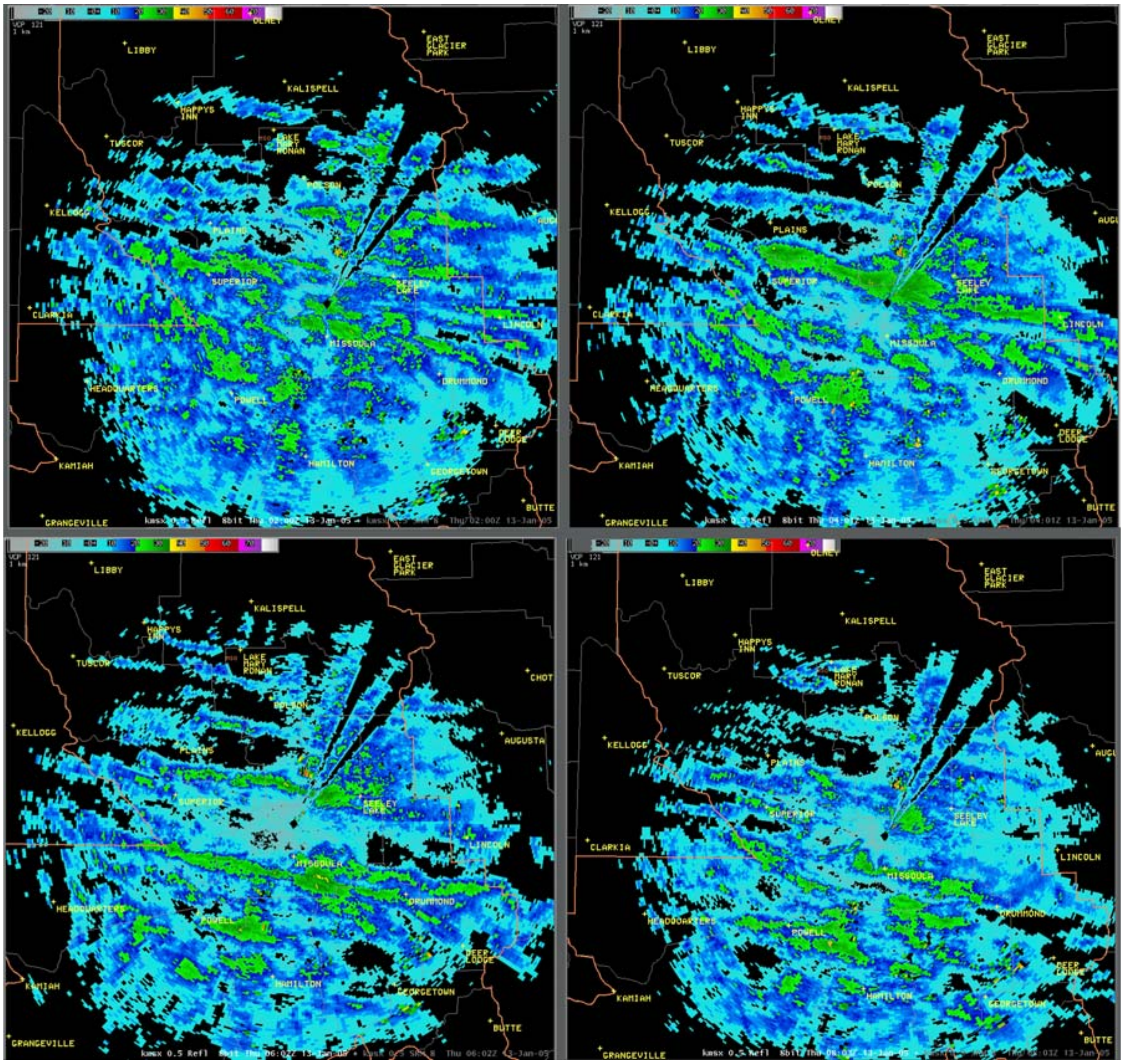

Figure 7. KMSX 0.5-degree, 8-bit radar reflectivity observations for (a) 13/0200z (upper left), (b) 13/0401z (upper right), (c) 13/0602z (lower left), and (d) 13/0803z (lower right).

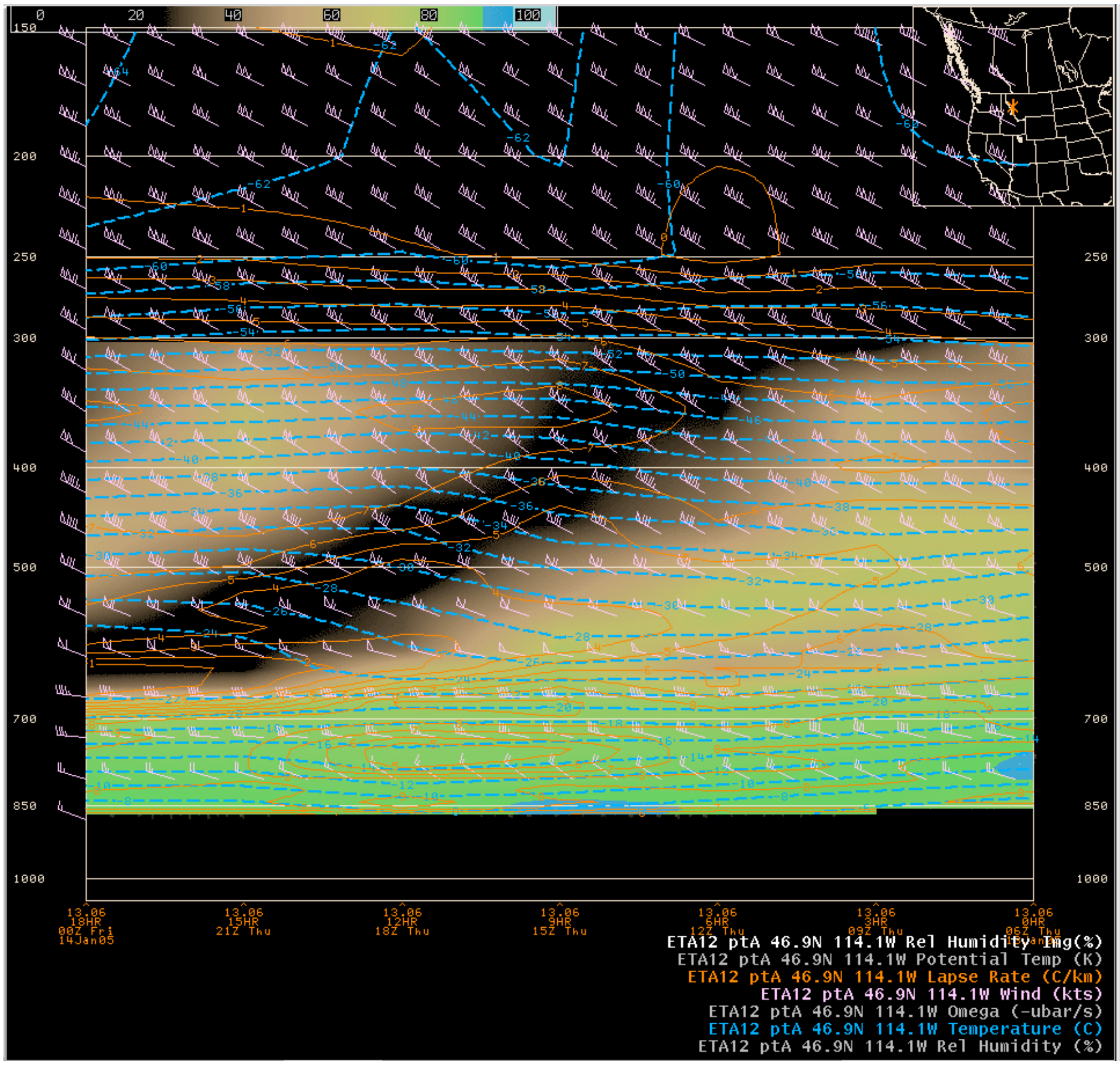

Figure 8. 13 January-12z NAM Time-Height forecast for Missoula, Montana. Note the lowering subsidence inversion predicted through the day Thursday.

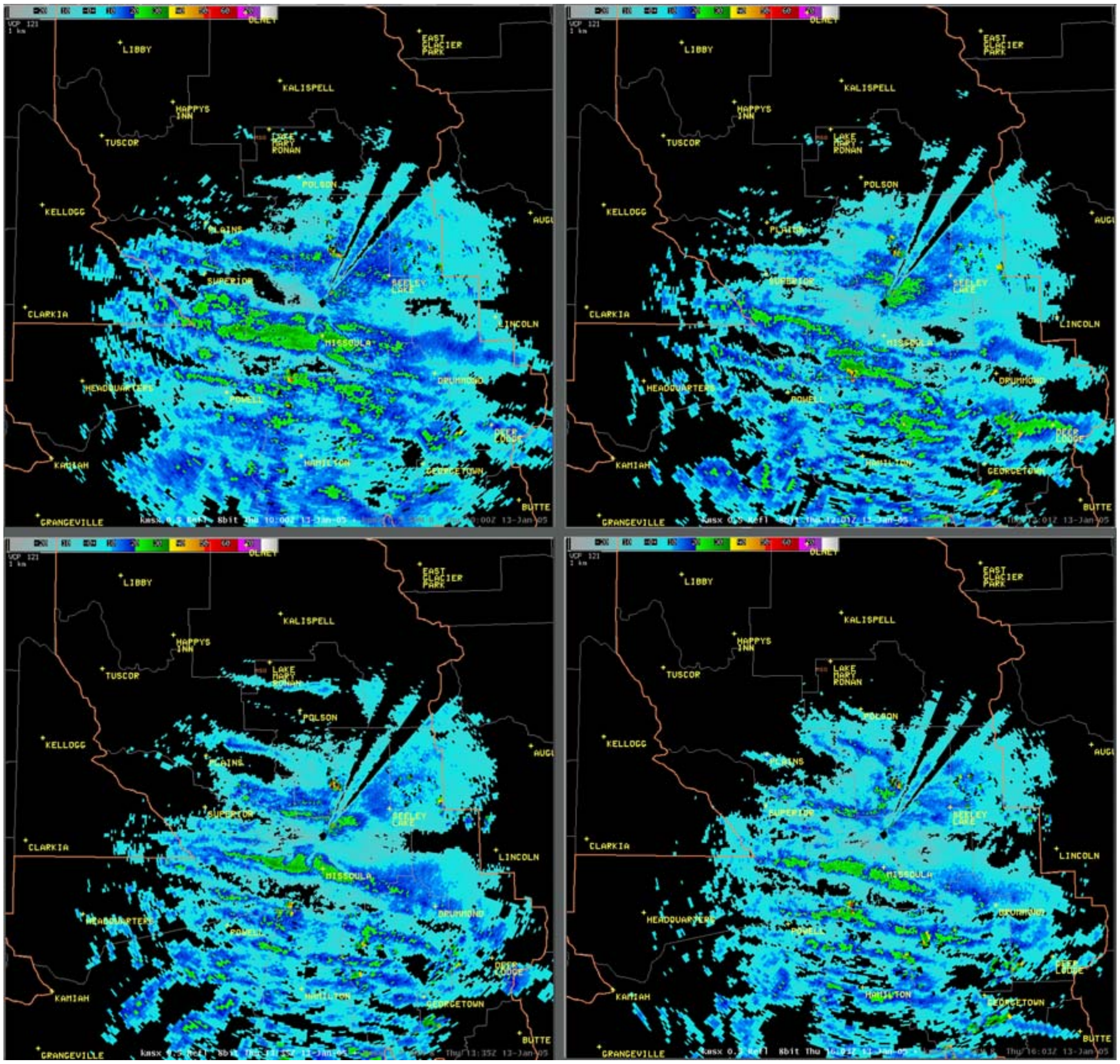

Figure 9. KMSX 0.5-degree, 8-bit radar reflectivity observations for (a) 13/1000z (upper left), (b) 13/1201z (upper right), (c) 13/1335z (lower left), and (d) 13/1603z (lower right).

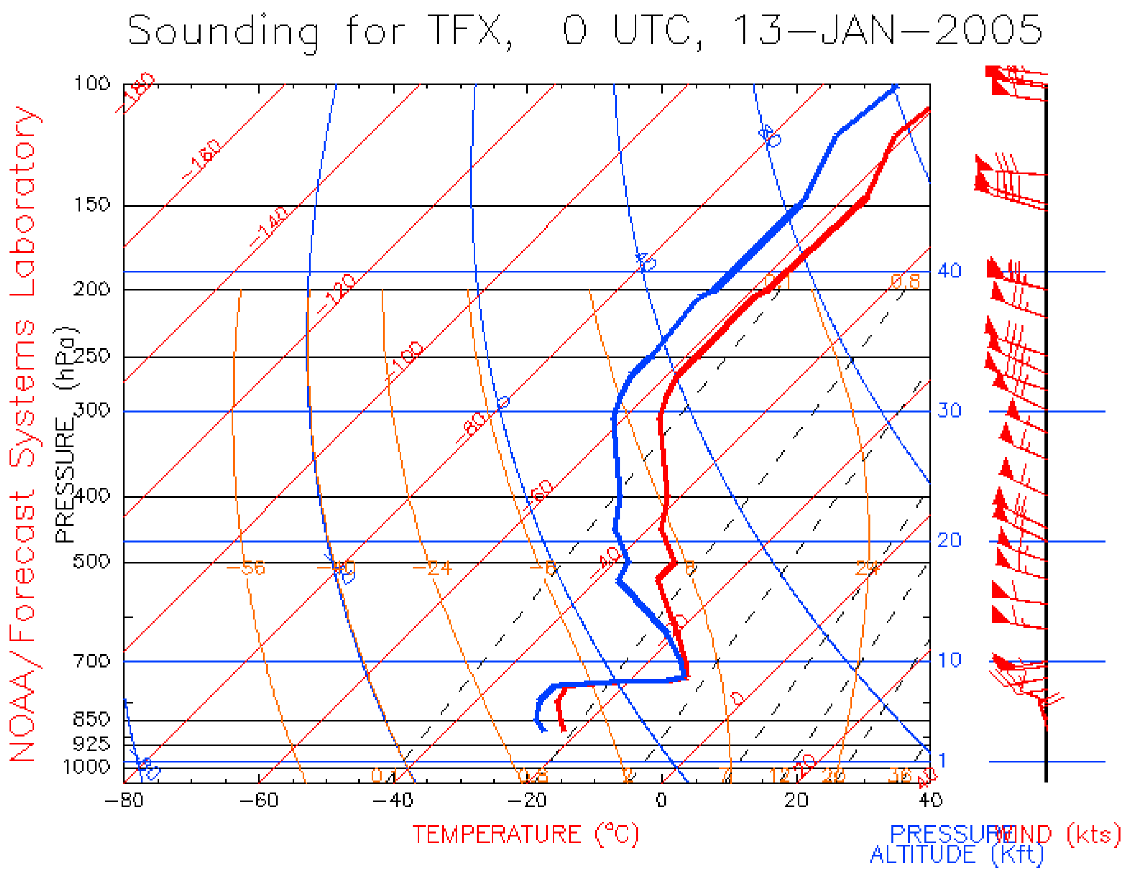

Figure 10. Great Falls sounding from 13 January 2005.