A CENTRAL MONTANA MESOSCALE SNOW EVENT FOR THE WEATHER EVENT SIMULATOR (WES)

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Introduction

This winter case used for the WES simulation was a mesoscale snow event that occurred during the early morning of 21 December 2001. This was not a major snow event, as there were no snowfall reports of 6 inches or greater. However, there were several reports of 3 to 5 inches, which fell in a short (3-5 hour) time period. Of particular interest was a narrow, but heavy band of snow that produced snowfall rates of 1-2 inches per hour in some areas, including the city of Great Falls. This was a very interesting case in that lower elevation locations along the plains of Central Montana received the greatest snowfall amounts, instead of the usual mountainous areas. The nature of this snow event was not typical for central Montana, and proved to be very useful from a training perspective.

Synoptic and Mesoscale Features

A broad upper level trough was positioned over the northwest United States, with a short wave trough moving east through Alberta and Saskatchewan. At the surface, a weak low pressure system was moving east through Southeast Montana and Northeast Wyoming. Weak surface high pressure resided over western Oregon and Washington, resulting in a fairly weak surface pressure gradient over central Montana.

A deformation zone can clearly be seen on the infrared satellite imagery (IR) at 0730Z (Fig. 1). There was also a fairly strong vorticity maximum over central Montana at 0900Z. However, it was elongated, and more importantly parallel to mid-level winds. Therefore the vorticity advection was minimal, and not likely favorable for producing ascent associated with the snowfall.

Discussion

This snow event was mesoscale in terms of both spatial coverage and duration. The narrow band of snow that produced a maximum of 4.6 inches at the Great Falls (GTF) Forecast Office is shown in Fig. 2. Widespread snowfall amounts of generally 3-5 inches fell in parts of 5 counties, all in Central Montana. Not much snow fell over southwest Montana, as the forcing and associated deformation zone weakened considerably as it moved south. The IR imagery from 1100Z shows the warming of cloud tops (Fig 3).

The primary forcing mechanisms for the brief, but heavy snowfall were the previously mentioned mid-level deformation zone and also warm air advection in the low-mid levels. This deformation zone was depicted well by the MesoEta model, and can be seen in the 500millibar (mb) streamline forecast from 0900Z (Fig. 4). The warm air advection, which can be implied from winds veering with height in the Great Falls VAD Wind Profile (VWP) between about 0700Z and 1000Z (Fig. 5), was not forecasted well by the Aviation (AVN) or the MesoEta models. This may explain why the quantitative precipitation forecast (QPF) amounts were less than the observed amounts (0.24 from MesoEta, 0.12 from AVN forecasted at GTF, compared to 0.35 observed at GTF).

Fig. 6 shows a MesoEta forecast time-height plot for GTF. Between about 0600Z and 1000Z, the model showed significant upward omega (-8 mb/s) through a moist layer (85-95% relative humidity). This also coincided with the layer of efficient snow growth (-12 to -18 oC). The data in the time-height plots justified the QPF forecast from the MesoEta, which did remarkably well, especially in terms of positioning (Fig. 7).

Low-level upslope flow, which is a common cause of snowfall across the plains of Central Montana, was not a major factor in this case. The low-level winds were westerly (downslope) when the heaviest snow was actually falling, then shifted to northwest (upslope) after the snow had ceased. Also, winds were generally light throughout the troposphere. This was a great simulation for the forecasters at Great Falls to go through, since the general causes of the snow were atypical for Central Montana.

Figure 1

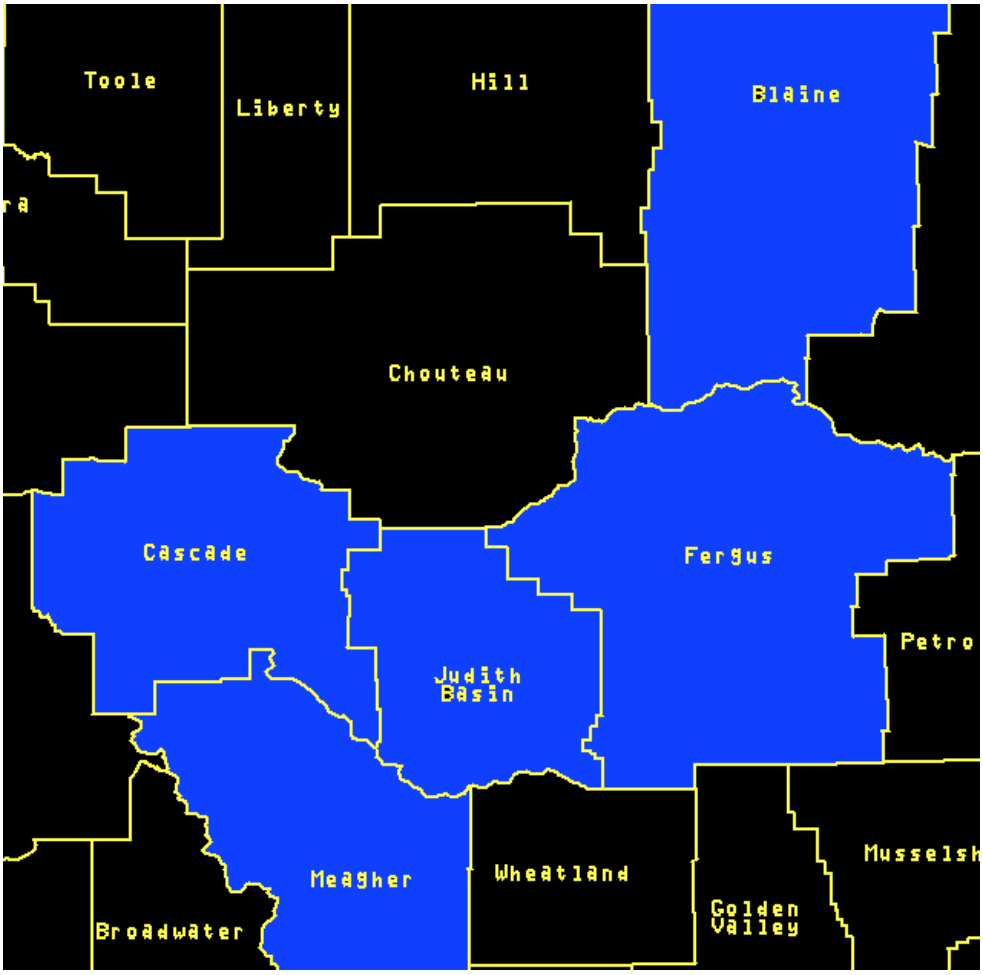

Toole
Liberty
Hill
Blaine
Chouteau
Cascade
Fergus
Judith Basin
Petro
Meagher
Wheatland
Golden Valley
Musselsh
Broadwater

Figure 2

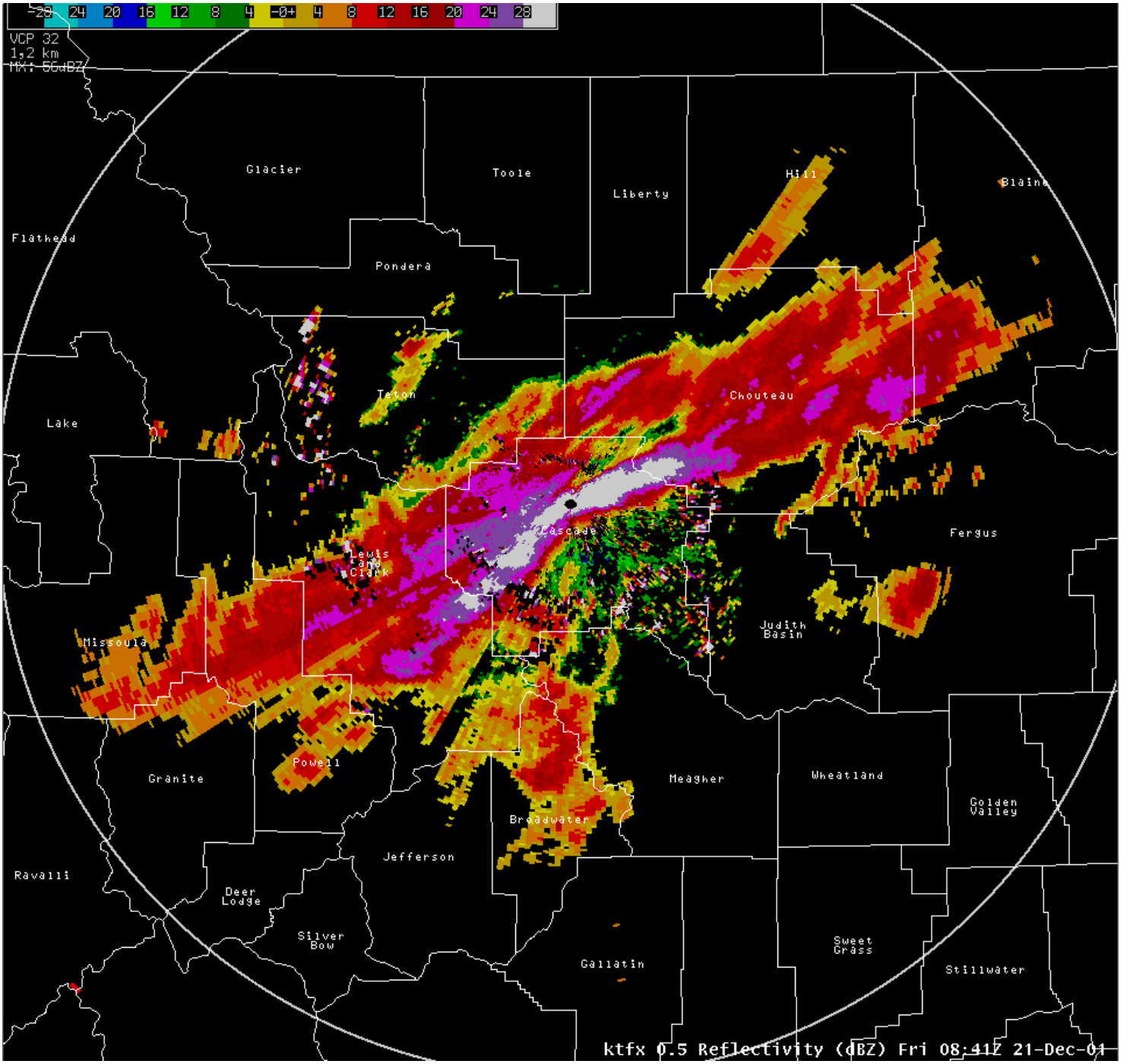

-28 24 20 16 12 8 4 -0+ 4 8 12 16 20 24 28
VCP 32
1.2 km
MAX: 56dBZ
Glacier
Toole
Liberty
Hill
Blaine
Flathead
Pondera
Teton
Chouteau
Lake
Cascade
Fergus
Lewis and Clark
Judith Basin
Missoula
Powell
Granite
Meagher
Wheatland
Golden Valley
Broadwater
Jefferson
Ravalli
Deer Lodge
Silver Bow
Gallatin
Sweet Grass
Stillwater
ktfx 0.5 Reflectivity (dBZ) Fri 08:41Z 21-Dec-01

Figure 3

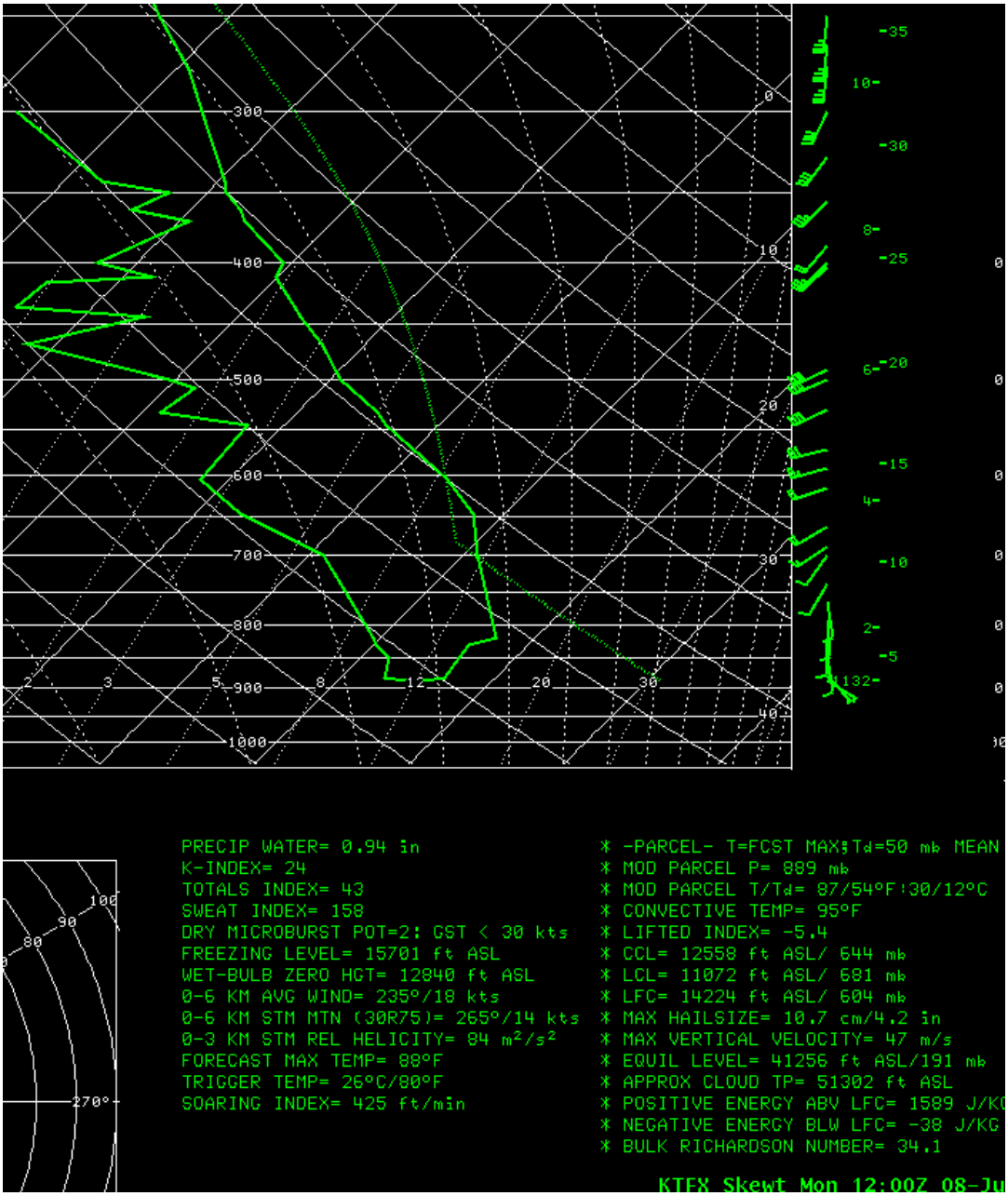

PRECIP WATER= 0.94 in
K-INDEX= 24
TOTALS INDEX= 43
SWEAT INDEX= 158
DRY MICROBURST POT=2: GST < 30 kts
FREEZING LEVEL= 15701 ft ASL
WET-BULB ZERO HGT= 12840 ft ASL
0-6 KM AVG WIND= 235°/18 kts
0-6 KM STM MTN (30R75)= 265°/14 kts
0-3 KM STM REL HELICITY= 84 m²/s²
FORECAST MAX TEMP= 88°F
TRIGGER TEMP= 26°C/80°F
SOARING INDEX= 425 ft/min
* -PARCEL- T=FCST MAX Td=50 mb MEAN
* MOD PARCEL P= 889 mb
* MOD PARCEL T/Td= 87/54°F 30/12°C
* CONVECTIVE TEMP= 95°F
* LIFTED INDEX= -5.4
* CCL= 12558 ft ASL/ 644 mb
* LCL= 11072 ft ASL/ 681 mb
* LFC= 14224 ft ASL/ 604 mb
* MAX HAILSIZE= 10.7 cm/4.2 in
* MAX VERTICAL VELOCITY= 47 m/s
* EQUIL LEVEL= 41256 ft ASL/191 mb
* APPROX CLOUD TP= 51302 ft ASL
* POSITIVE ENERGY ABV LFC= 1589 J/K
* NEGATIVE ENERGY BLW LFC= -38 J/KG
* BULK RICHARDSON NUMBER= 34.1
KTFX Skewt Mon 12:00Z 08-Ju

Figure 4

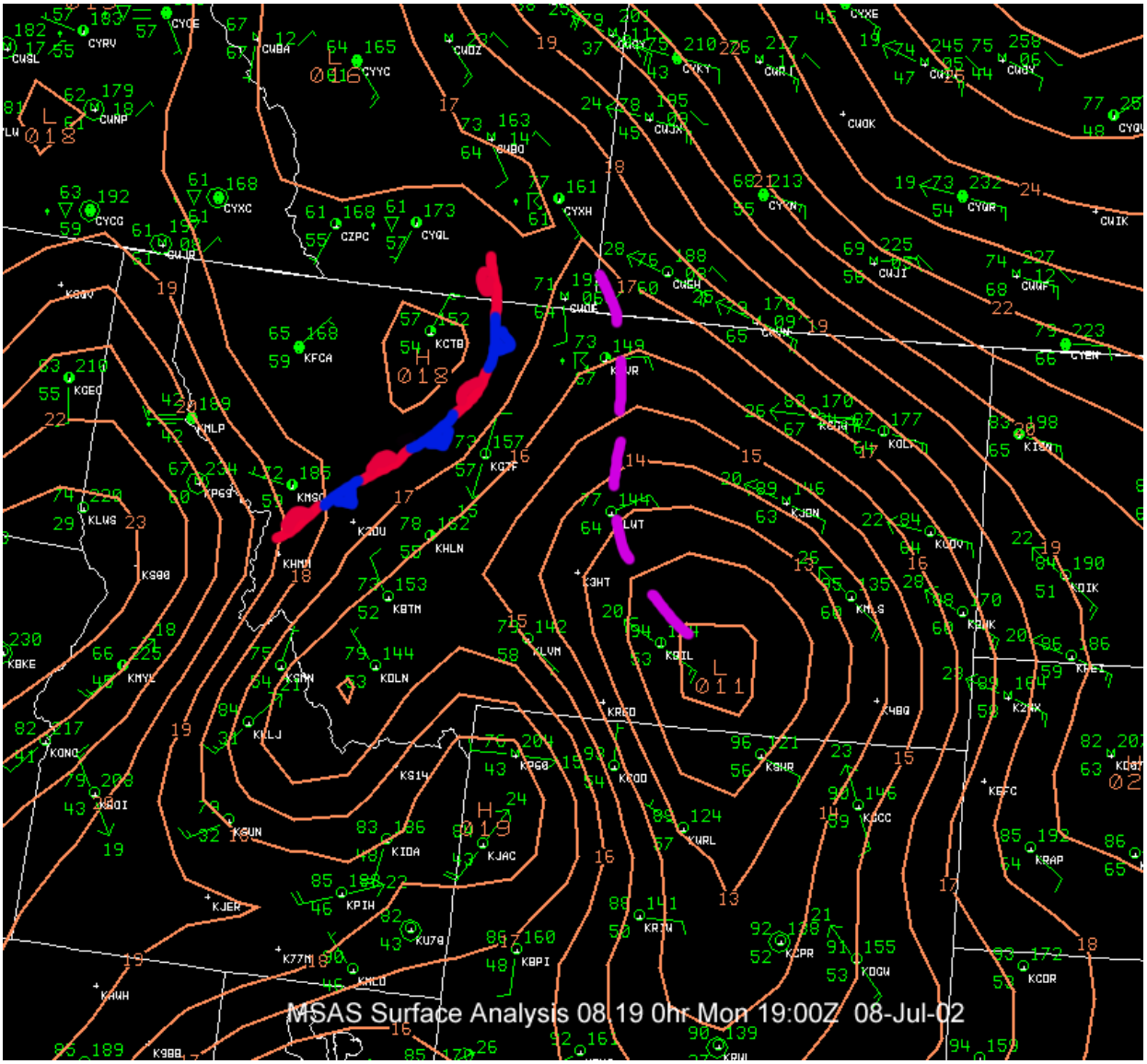


Figure 5

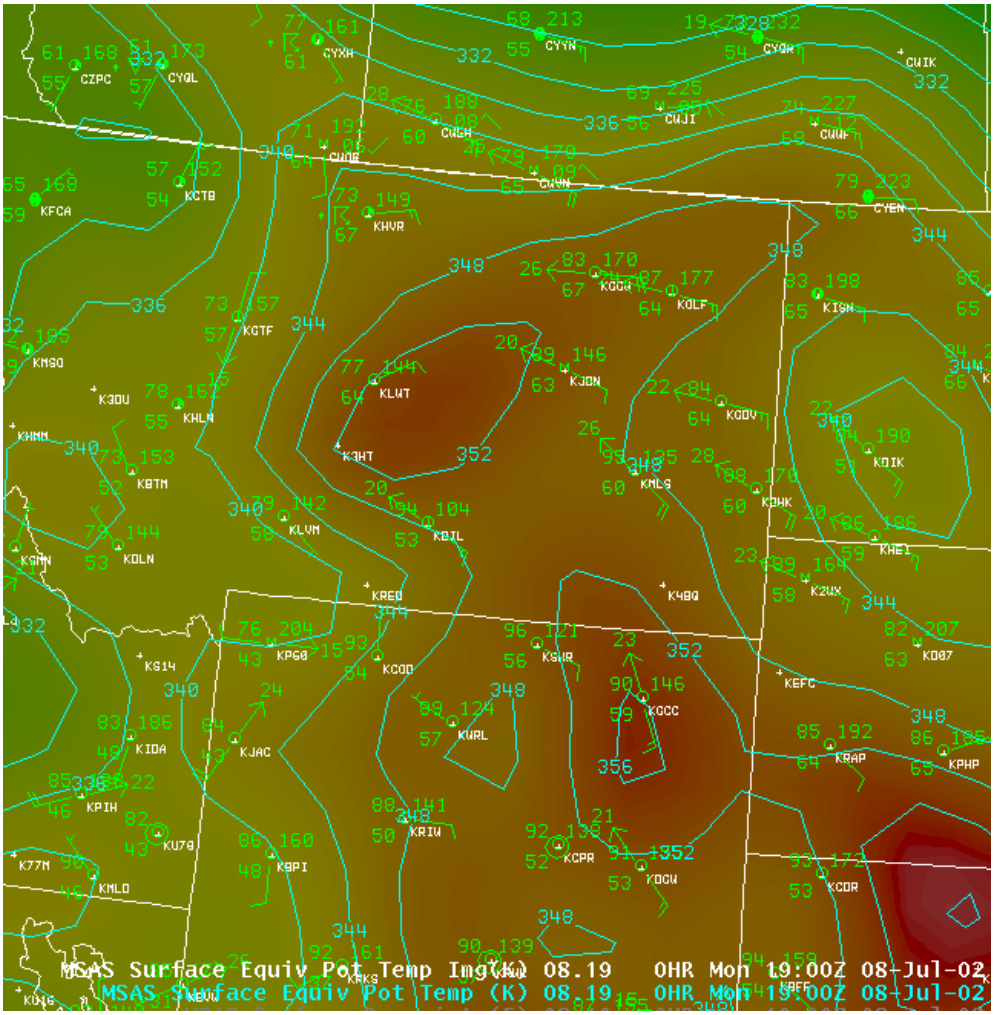
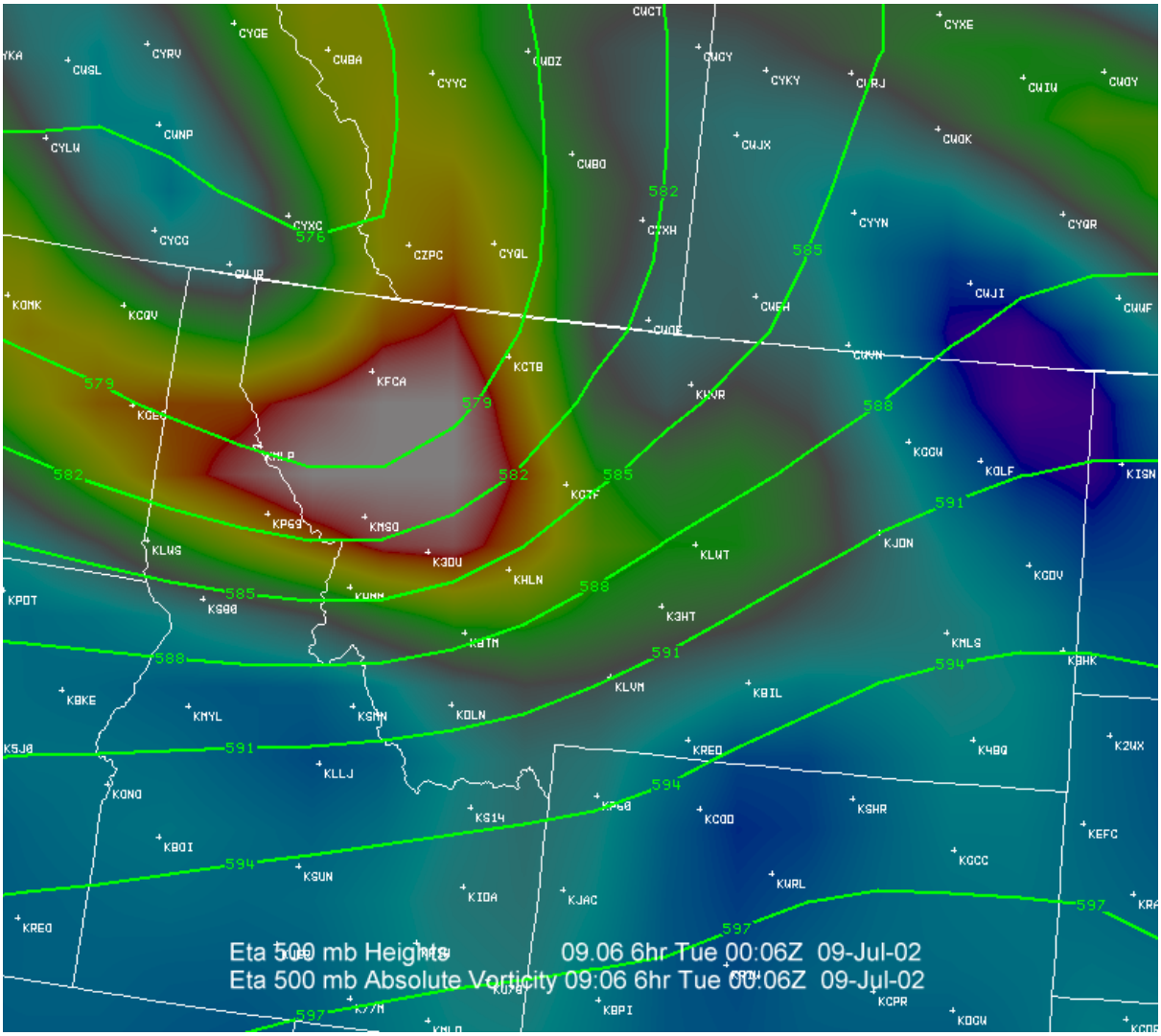


Figure 6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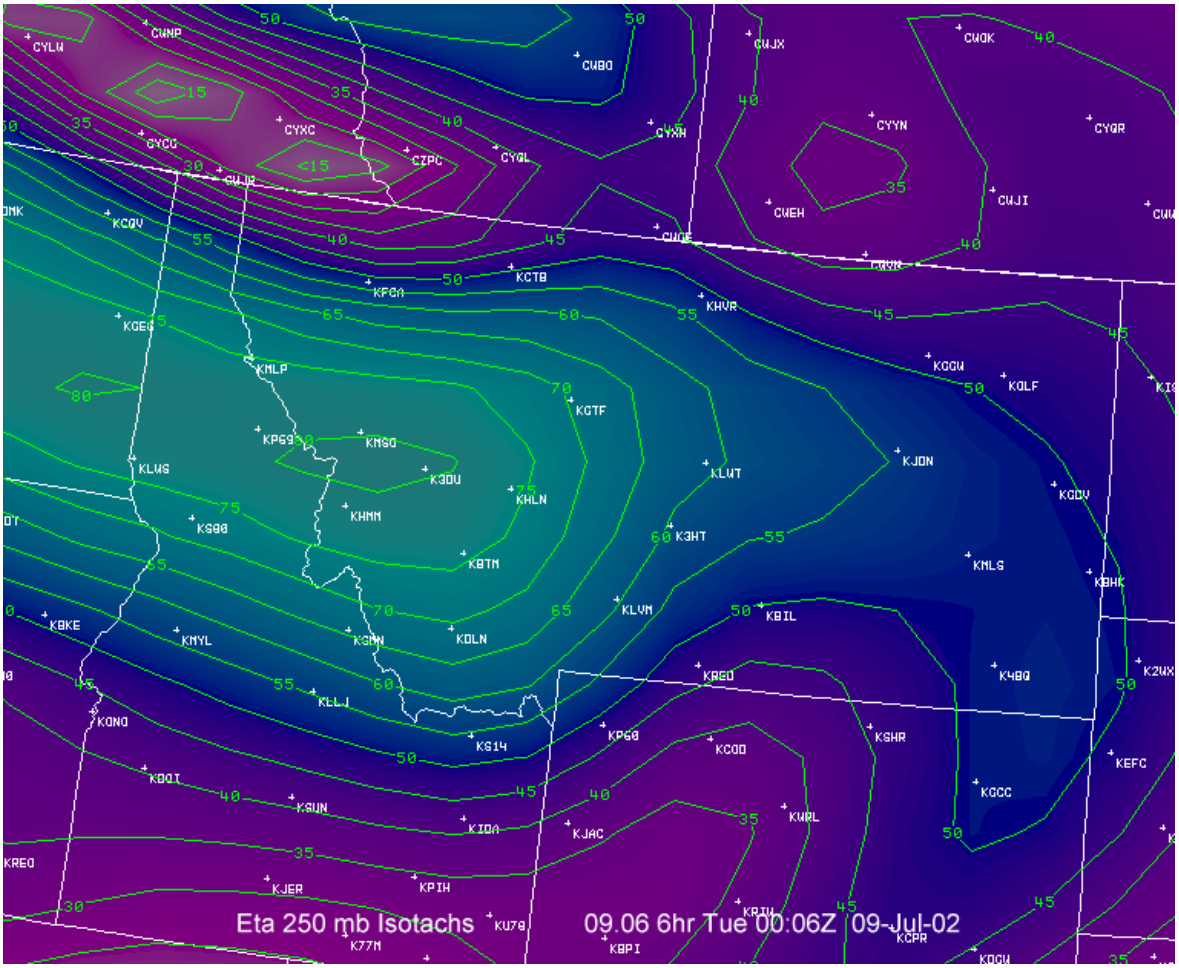
Eta 500 mb Absolute Vorticity 09:06 6hr Tue 00:06Z 09-Jul-02

Figure 7


Eta 250 mb Isotachs
09.06 6hr Tue 00:06Z 09-Jul-02