WES Case for 8 June 2002 with Elevated Severe Thunderstorms

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I. Introduction

This WES case demonstrates that severe convection can form in the presence of a stable boundary layer given strong synoptic-scale forcing and elevated instability. Early on 8 June 2002, both the forecasters in Glasgow and at the Storm Prediction Center (SPC) were expecting some severe weather to occur south of the Missouri River in eastern Montana. By the late afternoon and evening of 8 June, strong to severe elevated thunderstorms moved through northeastern Montana, producing large hail up to 2.75 inches in diameter, wind gusts in excess of 70 mph, and localized rainfall rates of 2 inches per hour. Most of the severe weather was indeed south of the Missouri River.

II. Synoptic Overview

On the morning of 8 June 2002, an upper-level low was centered over eastern Washington (Fig. 1, the initialization from the Eta model) with a 300 mb jet of 80 to 100 kt to the south of the low and diffluence over eastern Montana. The mid-level low was also over eastern Washington at 1200 UTC, 8 June (not shown). Meanwhile, a surface low centered over central Wyoming had a cold front/dryline extending south of the surface low and surface trough stretching north into eastern Montana (Fig. 2). The surface winds at 1200 UTC in eastern Montana were from the east between 10 to 20 kt. Surface dewpoints were in the 30s and 40s over both eastern Montana and upstream in western North Dakota.

The 1200 UTC sounding from Glasgow (Fig. 3) depicted a stable boundary layer, with directional and speed shear through the troposphere. The sounding had easterly flow at the surface through about 700 mb, and winds above 700 mb were generally from the south associated with the mid and upper-level low in eastern Washington (Fig. 1). The sounding also portrayed a stable boundary layer, with a surface-based lifted index (LI) of 7 C .

As the day progressed, the upper low moved eastward keeping eastern Montana in a diffluent pattern aloft, which gave the area a prolonged period of upper level diffluence. The 1200 UTC model run of the Eta forecasted the 300 mb jet to be located over south-central Montana at 00Z UTC 9 June with a maximum wind speed of over 120 kt (Fig. 4). The surface forecast included the low deepening and moving into eastern Wyoming with an trough extending north along the Wyoming border and then northwest into north-central Montana. The Eta model forecasted a large area of precipitation over most of northern Montana (not shown). The precipitation was mostly from overrunning moisture. The forecasters expected the northern areas of Montana would see mostly rain, with isolated thunderstorms. Meanwhile, the areas south of the Missouri River had a potential for severe weather.

III. Mesoscale Analysis

The convective outlook for 8 June from SPC (at 0600 UTC) had areas south of the Missouri River in a slight risk for severe thunderstorms. SPC was expecting greater surface-based instability in that region. At 1300 UTC, SPC decreased the western extent of the slight risk area and expanded the area to north of the Missouri River. Subsequent outlooks were virtually unchanged, with eastern Montana in a slight risk. The Glasgow forecasters were also expecting severe weather on 8 June, mainly south of the Missouri River due to the presence of greater instability over southeast Montana. Most of the precipitation north of the Missouri River was expected to be more stratiform with isolated thunderstorms, due to more stable surface conditions. The mid-day stability from the Eta model (not shown) depicts stable air north of the Missouri River with lifted indices above 2 C . The surface dewpoints did increase into the upper 40s and 50s east of the trough over central and eastern Montana, via the east flow in the low levels (Fig. 5).

SPC issued a mesoscale discussion at 1706 UTC assessing the possibility of severe convection over northeastern Wyoming and southeastern Montana for wind, hail, and isolated tornadoes. At 1847 UTC, SPC issued a tornado watch, the northern most extent covering Wibaux and Prairie counties (the extreme southeast counties in the Glasgow warning area).

Another mesoscale discussion was issued at 2153 UTC, this time for northeast Montana, stating the possibility of mainly elevated, marginally severe convection. SPC issued a severe thunderstorm watch at 2246 UTC for northeast Montana and northwest North Dakota, in response to intensifying storms over eastern montana ahead of the cold front/trough. Hail and isolated wind gusts were expected due to the elevated nature of the storms.

Convection developed ahead of the mid-level dry slot/cold pool, along the surface trough by late morning over central Montana (not shown), and moved NNE at 30 mph well into the Glasgow warning area by 2100 UTC. Convection continued to increase in areal coverage and intensity through 2300 UTC (Fig. 6), even though it was moving into an increasingly stable low level air mass. However, the area had synoptic scale forcing and elevated layers of instability.

IV. Discussion

How did the convection develop in the presence of such a stable low-level environment? Modifying the 1200 UTC sounding for 0000 UTC 9 June conditions (the actual sounding is not avialable) revealed 500-600 J/Kg of convective available potential energy, a most-unstable LI of -2 to -3 C , and no convective inhibition for a parcel lifted from 660 mb (Fig. 7). In contrast, there was no surface based instability, with quite a bit of surface-based CIN and a surface-based LI of 2 to 3 C . Also, the upper level synoptic scale pattern provided additional forcing for the thunderstorms.

A peculiar severe weather report was a 68 kt east wind recorded by the Wolf Point Airport at 2340 UTC 8 June. Typically, severe winds associated with a squall line are in the same direction as the line movement. In this case, 30 to 40 knot outflow winds occurred along and just behind the associated gust front moving to the northeast. But the strongest surface wind was recorded out of the east, behind the highest reflectivity core, and well behind the northeasterly moving gust front. A possible explanation for this is that the downdraft behind the storm from the elevated thunderstorm was able to penetrate the stable boundary layer, which also had east flow and these combined to produced a severe east wind at the Wolf Point Airport.

Knowing the nature of the instability can help the forecaster determine whether convection will be elevated or surface based, and in turn determine the associated severe weather. Surface based convection is more apt for producing tornadoes, hail, and high winds. The greatest threat from elevated convection is usually large hail, because the negative buoyancy of descending air parcels is usually not strong enough to penetrate the low-level stable layer.

Figure Captions

Figure 1. Heights (green contours every 30 m) and wind speeds (shaded) at 300 mb from the initialization of the Eta Model on 1200 UTC 8 June 2002. The wind speeds are shaded in for speeds greater than 80 kt.

Figure 2. Observations (green) and the analysis of mean sea-level pressure (brown contours every 4 mb) from 1200 UTC 8 June 2002.

Figure 3. Upper air sounding for Glasgow on a Skew-T Log P diagram. The sounding is from 1200 UTC 8 June 2002.

Figure 4. Same as Figure 1, except 12 hour forecast valid at 0000 UTC 9 June 2002.

Figure 5. Same as Figure 2, except from 2300 UTC 8 June 2002.

Figure 6. Surface observations (white) and radar reflectivity data from Glasgow and Billings radars (shaded) from 2300 UTC 8 June 2002. The highest reflectivities are in purple and the lightest reflectivities are light blue.

Figure 7. Modified upper air sounding for Glasgow on a Skew-T Log P diagram (brown) for data from 0000 UTC 9 June 2002. The sounding was modified using the 0000 UTC model data, surface data, and information about the weather in Glasgow--it had been raining most of the day.

Figure 1

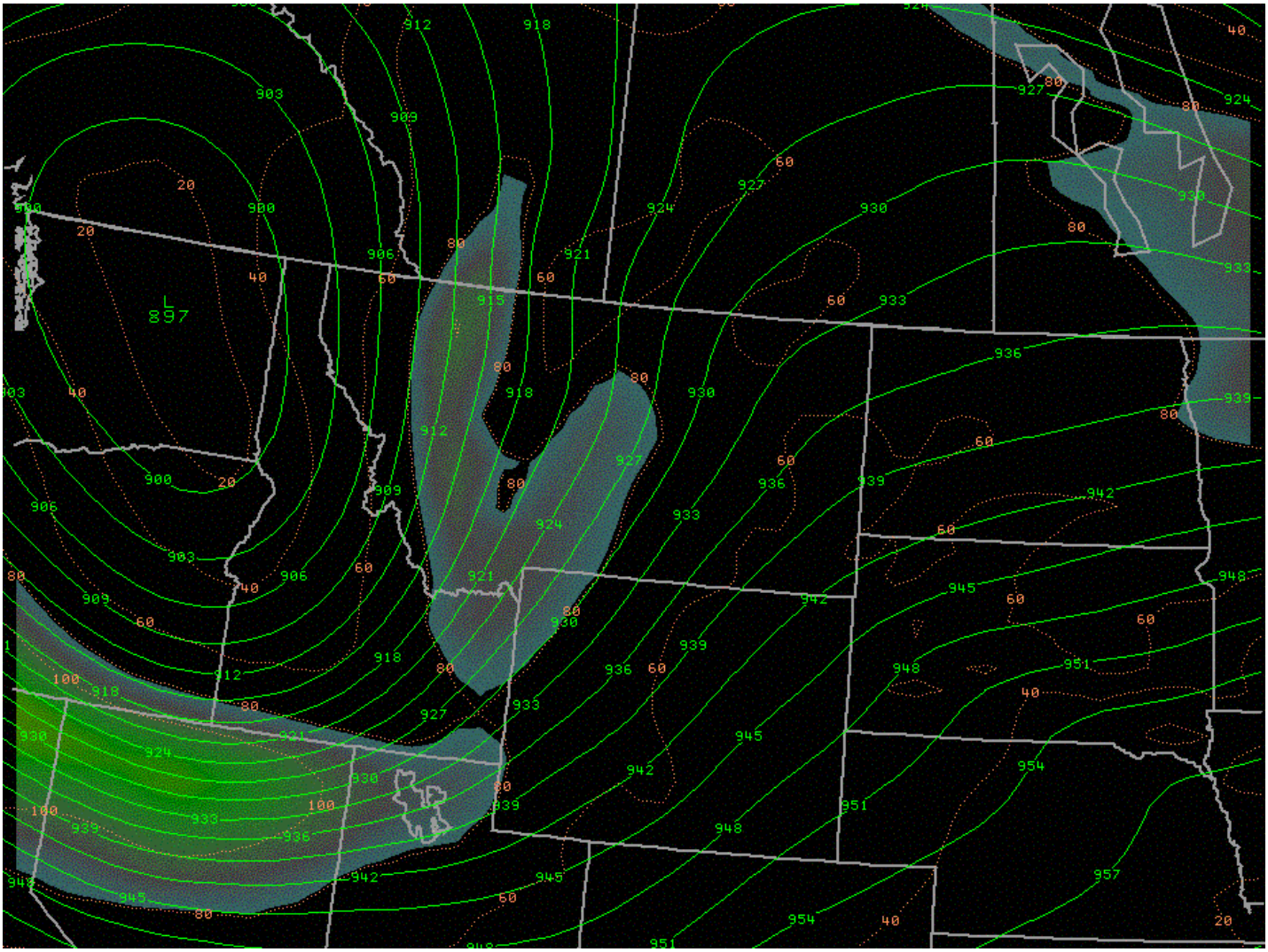


Figure 2

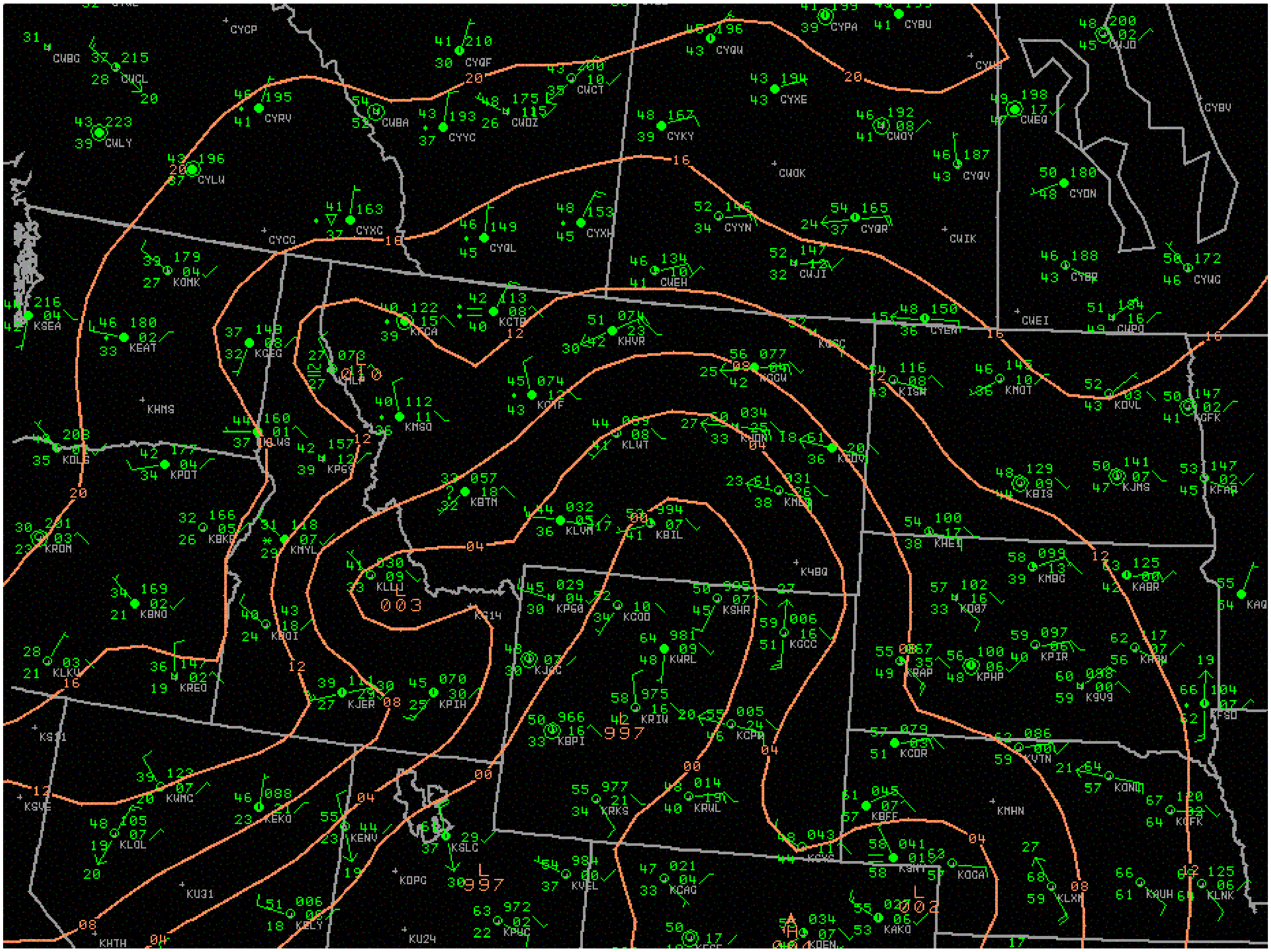


Figure 3

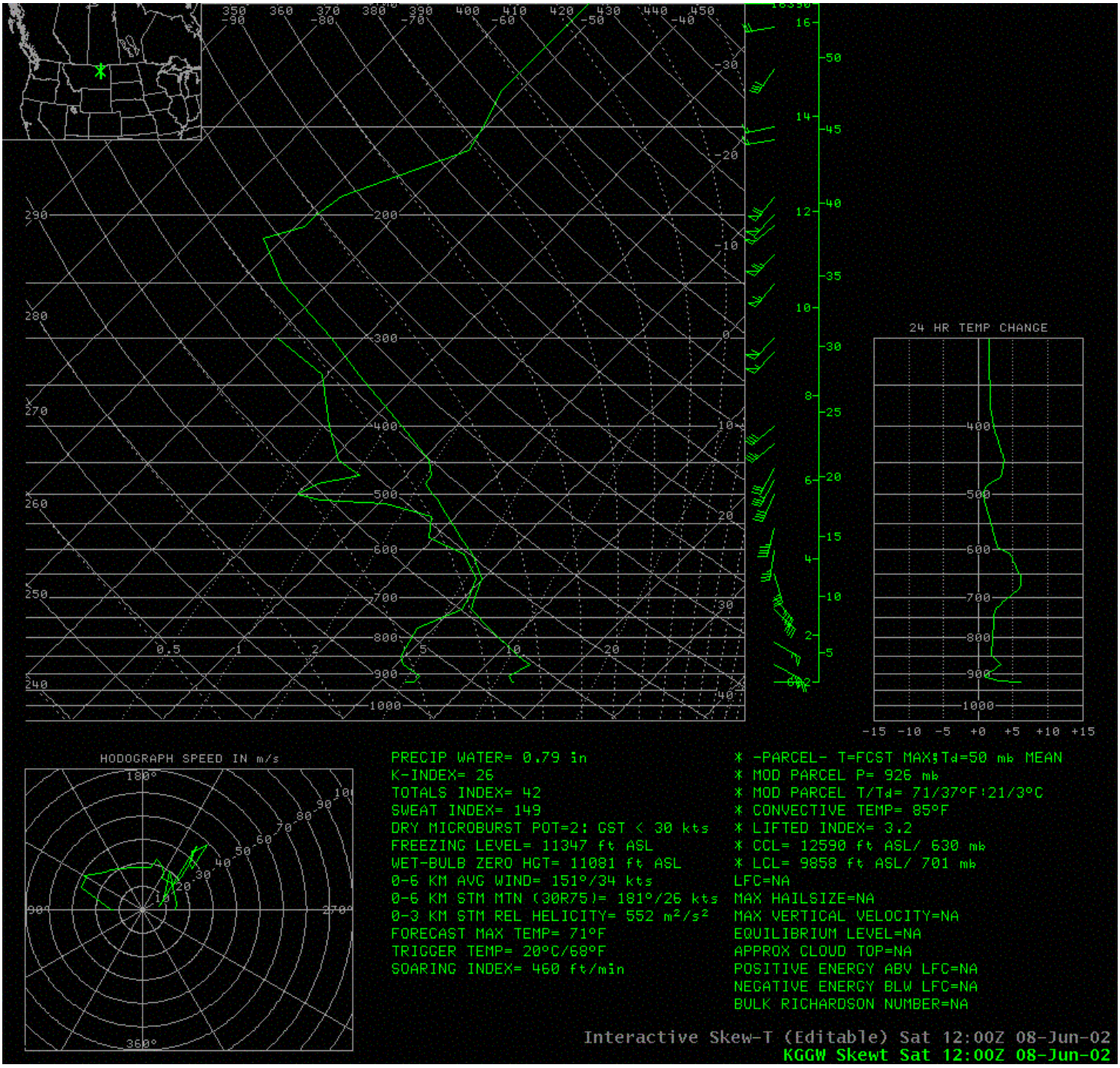

24 HR TEMP CHANGE
HODOGRAPH SPEED IN m/s
PRECIP WATER= 0.79 in
K-INDEX= 26
TOTALS INDEX= 42
SWEAT INDEX= 149
DRY MICROBURST POT=2; CST < 30 kts
FREEZING LEVEL= 11347 ft ASL
WET-BULB ZERO HGT= 11081 ft ASL
0-6 KM AVG WIND= 151°/34 kts
0-6 KM STM MTN (30R75)= 181°/26 kts
0-3 KM STM REL HELICITY= 552 m²/s²
FORECAST MAX TEMP= 71°F
TRIGGER TEMP= 20°C/68°F
SOARING INDEX= 460 ft/min
* -PARCEL- T=FCST MAX;Td=50 mb MEAN
* MOD PARCEL P= 926 mb
* MOD PARCEL T/Td= 71/37°F;21/3°C
* CONVECTIVE TEMP= 85°F
* LIFTED INDEX= 3.2
* CCL= 12590 ft ASL/ 630 mb
* LCL= 9858 ft ASL/ 701 mb
LFC=NA
MAX HAILSIZE=NA
MAX VERTICAL VELOCITY=NA
EQUILIBRIUM LEVEL=NA
APPROX CLOUD TOP=NA
POSITIVE ENERGY ABV LFC=NA
NEGATIVE ENERGY BLW LFC=NA
BULK RICHARDSON NUMBER=NA
Interactive Skew-T (Editable) Sat 12:00Z 08-Jun-02
KGGW Skewt Sat 12:00Z 08-Jun-02

Figure 4

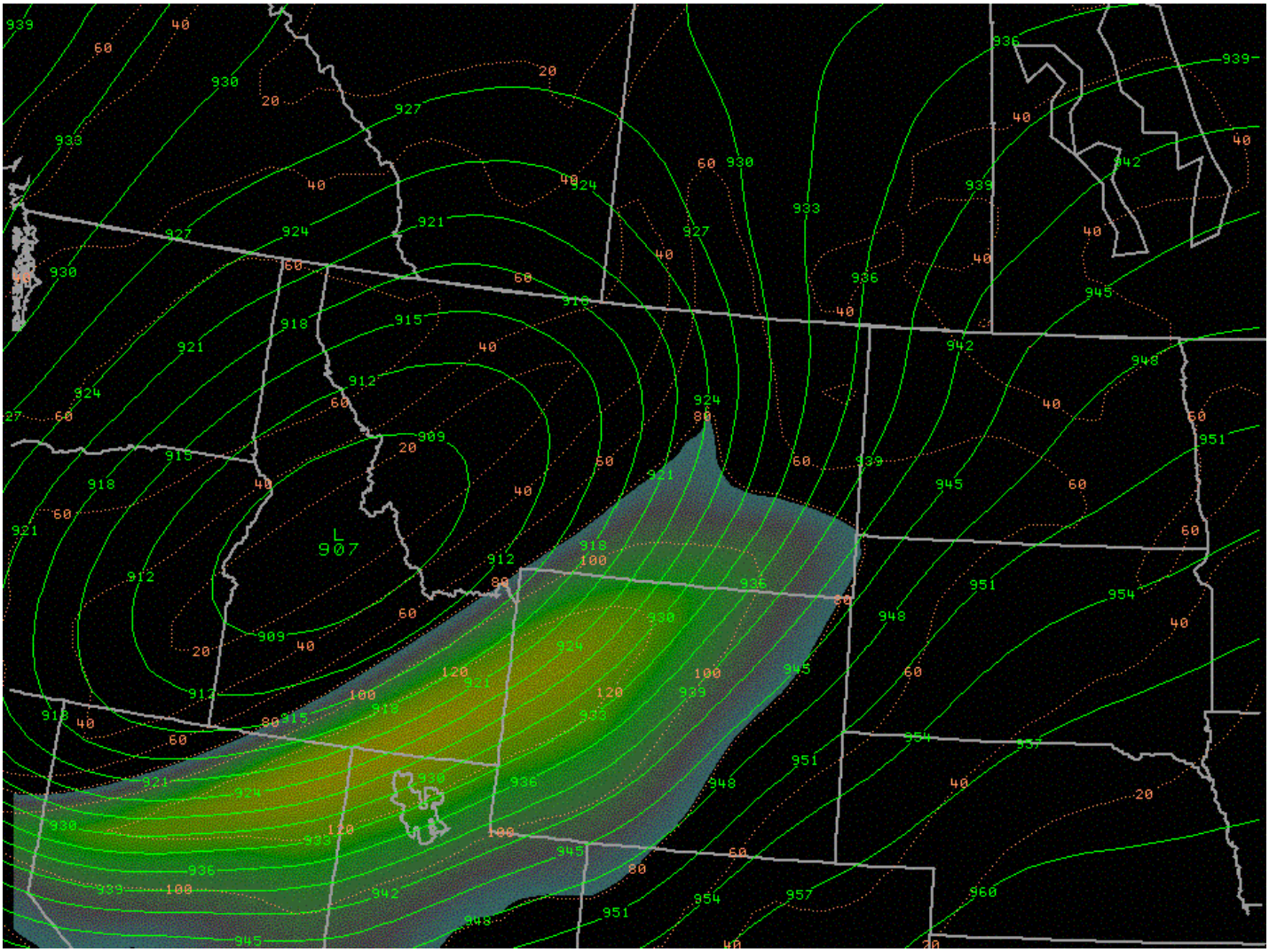


Figure 5

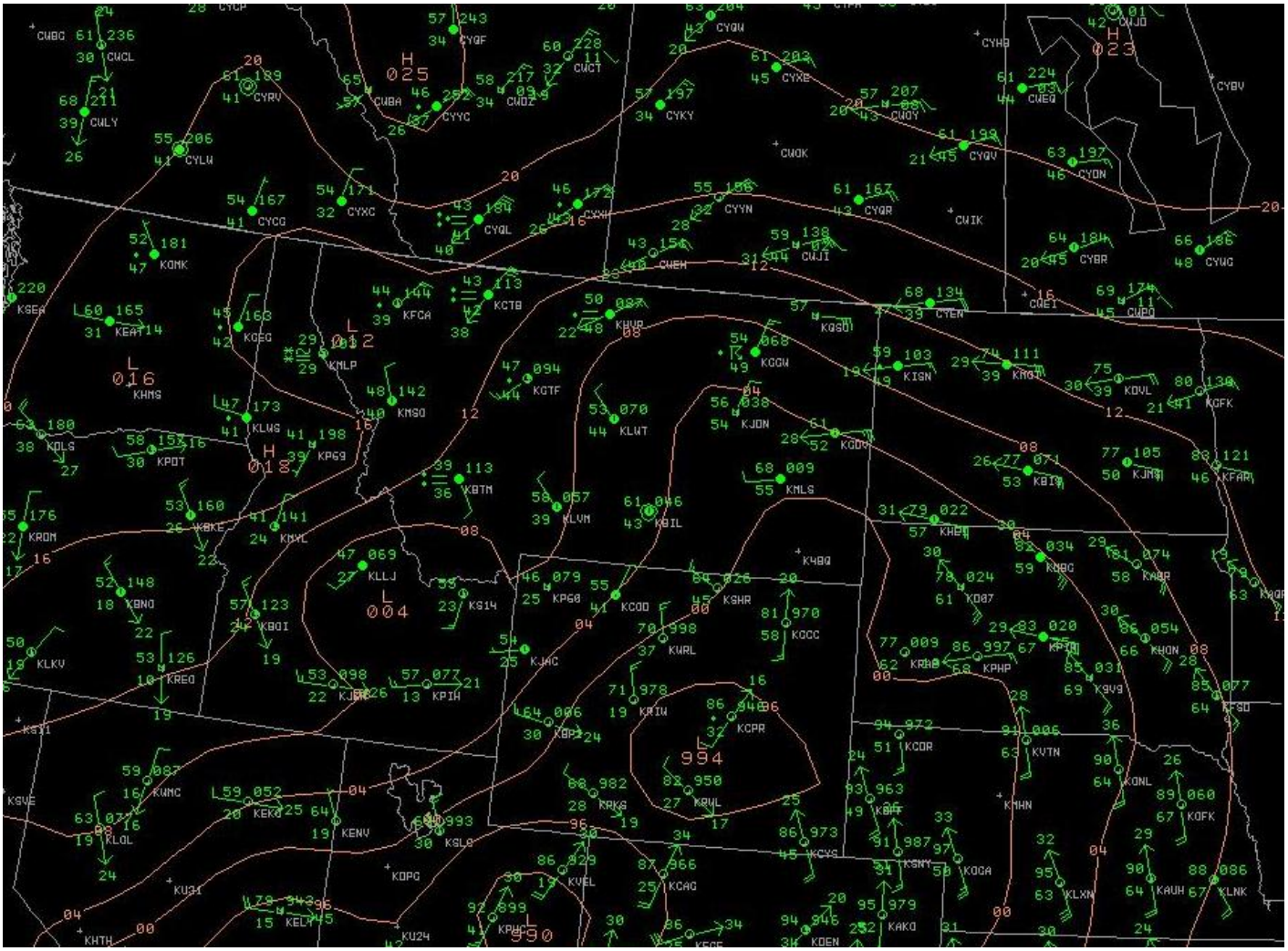


Figure 6

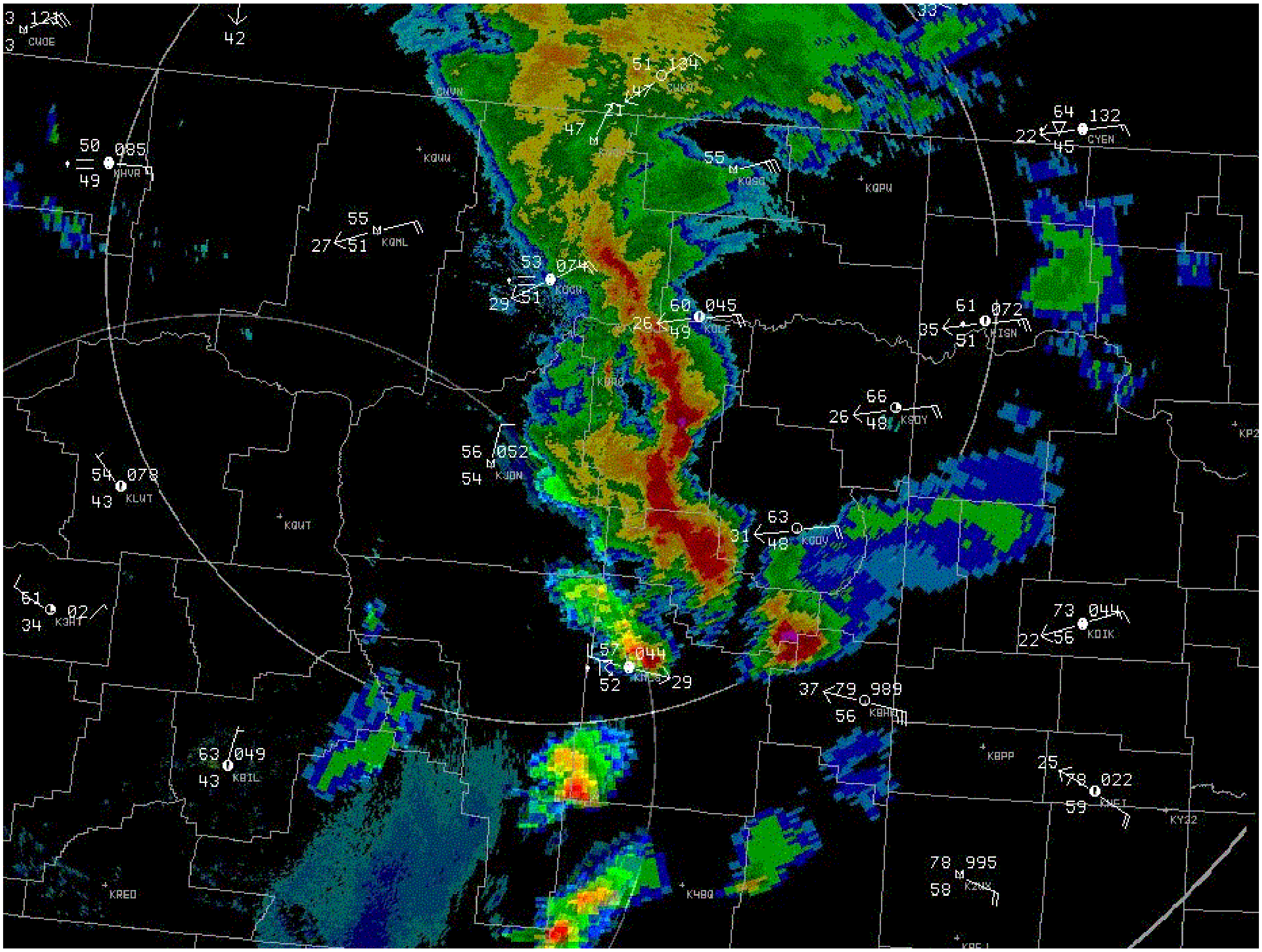
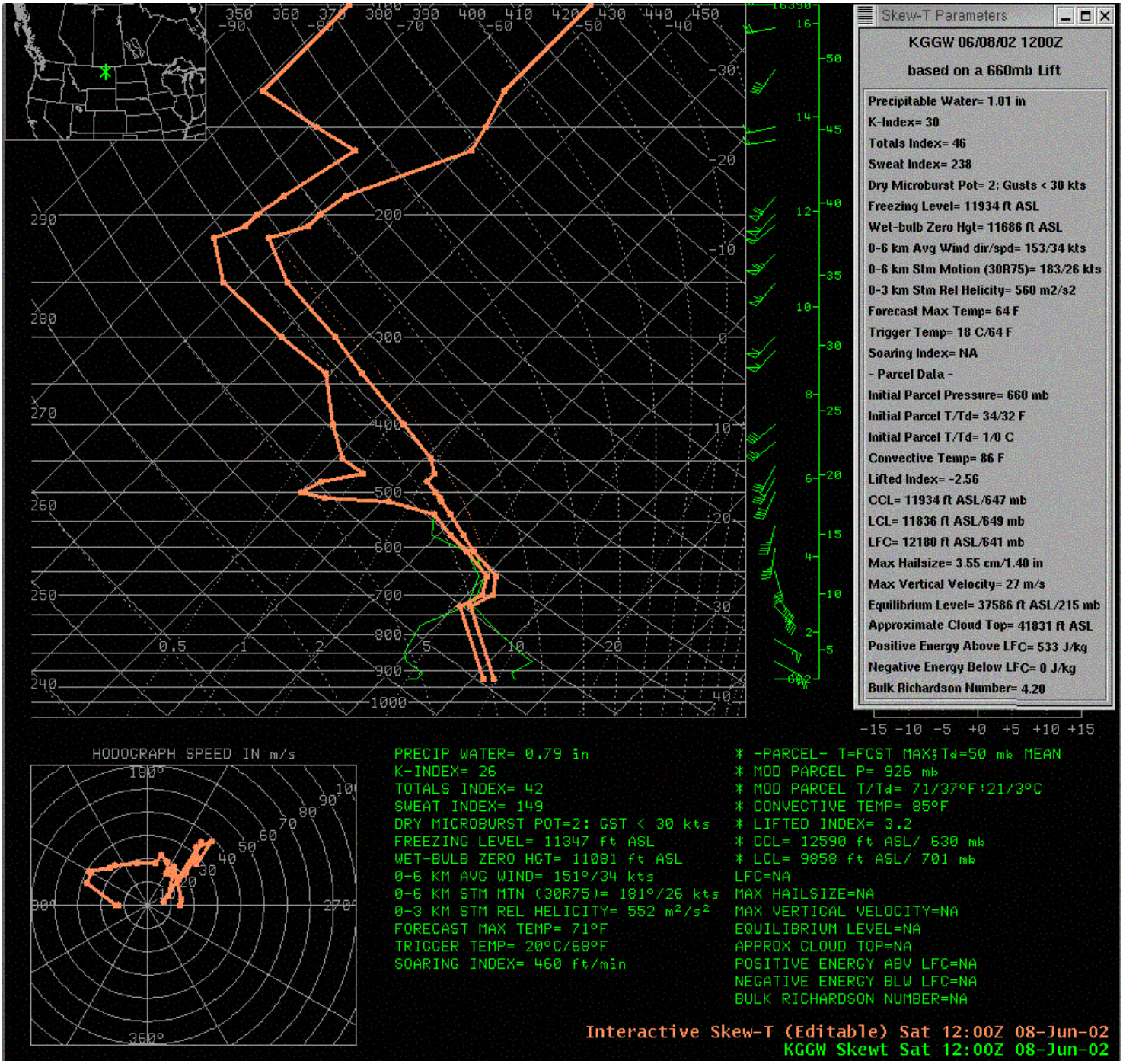


Figure 7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Precipitable Water= 1.01 in
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Totals Index= 46
Sweat Index= 238
Dry Microburst Pot= 2: Gusts < 30 kts
Freezing Level= 11934 ft ASL
Wet-bulb Zero Hgt= 11686 ft ASL
0-6 km Avg Wind dir/spd= 153/34 kts
0-6 km Stm Motion (30R75)= 183/26 kts
0-3 km Stm Rel Helicity= 560 m2/s2
Forecast Max Temp= 64 F
Trigger Temp= 18 C/64 F
Soaring Index= NA
- Parcel Data -
Initial Parcel Pressure= 660 mb
Initial Parcel T/Td= 34/32 F
Initial Parcel T/Td= 1/0 C
Convective Temp= 86 F
Lifted Index= -2.56
CCL= 11934 ft ASL/647 mb
LCL= 11836 ft ASL/649 mb
LFC= 12180 ft ASL/641 mb
Max Hailsize= 3.55 cm/1.40 in
Max Vertical Velocity= 27 m/s
Equilibrium Level= 37586 ft ASL/215 mb
Approximate Cloud Top= 41831 ft ASL
Positive Energy Above LFC= 533 J/kg
Negative Energy Below LFC= 0 J/kg
Bulk Richardson Number= 4.20
HODOGRAPH SPEED IN m/s
PRECIP WATER= 0.79 in
K-INDEX= 26
TOTALS INDEX= 42
SWEAT INDEX= 149
DRY MICROBURST POT=2: GST < 30 kts
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