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DRY MICROBURST GUST POTENTIAL PROGRAM FOR AWIPS

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[Note: Figures 1 and 2 appear only on the Web version of the Technical Attachment.]

Introduction

Dry or low-reflectivity microburst winds are a common forecast problem across the western United States. Low-reflectivity storms typically have reflectivity < 45 dBZ and produce little or no rain at the surface (Wakimoto 1985). Surface microburst winds are the result of a downdraft created by melting/evaporating precipitation. A modeling study by Srivastava (1985) explored the sensitivity of maximum downdraft speeds to subcloud lapse rates and differing amounts of water falling from the cloud. Steeper lapse rates and larger precipitation amounts resulted in stronger downdrafts. Roberts and Wilson (1989) developed a method to forecast microburst gust speed based partly on Srivastava's results. They found that descending reflectivity cores along with increasing radial velocity convergence within cloud or near cloud base were good indicators of downdraft and microburst potential, especially when coupled with low theta-e air above cloud base and a dry-adiabatic sub-cloud lapse rate. However, they also found that lead time for these predictions is on the order of only 0-10 min. Finally, Vasiloff et al. (1998) applied those forecast ideas to storms in the Great Basin region with similar conclusions. Vasiloff also showed examples of typical "inverted-v" dry microburst soundings in the West.

This Technical Attachment (TA) describes an AWIPS application that allows the user to access a table of generalized gust potentials from Srivastava's study. The table is available from the Local Tools pull-down menu on D2D. In addition, important considerations for forecasting microburst winds are summarized from previous works.

Considerations

It is important to qualify Srivastava (1985) results by discussing the framework of his study. First, downdraft speeds are assumed to produce equal surface winds. Thus, small-scale pressure accelerations that might be produced by high pressure at the core of the downdraft are unaccounted for.

Next, the 1-dimensional cloud model neglected ice. Since more latent cooling can be realized from melting plus evaporation, as opposed to only evaporation, frozen precipitation will cause stronger downdrafts than liquid precipitation. Thus, forecasters should note the temperature at cloud base, which can be approximated by the lifting condensation level (LCL). If cloud base temperatures are 0 deg C or colder, ice is expected. Since snow flakes are much easier to melt and evaporate, and may even sublimate (solid directly to vapor phase), those clouds with low CAPE (~200-500 J kg^{-1}) and cold bases are expected to be the most efficient dry microburst producers. These "snow clouds" produce the wispy virga often associated with dry microbursts.

Related to cloud base temperature is the cloud base height above ground (AGL). Srivastava's study used a fixed sub-cloud layer (SCL) depth of 3.7 km AGL. All else equal, if the depth of the SCL is expected to be much less than 3.7 km, the expected surface winds should be reduced. A first guess is to use a linear decrease based on the ratio of actual SCL depth to a 3.7 km depth.

Radar reflectivity factor is an estimate of the cloud water content. Differences in drop size distributions and particle type (e.g., snow) can cause two similar-appearing echoes to have different rainfall rates. Vasiloff (1997) described a case where a dry microburst was produced by a 30 dBZ echo that was not even identified as a storm cell by the WSR-88D storm cell identification and tracking algorithm. Thus, forecasters must be cautious in interpreting radar data.

The forecaster can only estimate what the SCL lapse rate may be as most storms occur away from the sounding site and at different times, i.e., the SCL may become modified in various ways. Model forecast lapse rates will usually be underestimates. The key is to try and determine, based on surface observations and analyses, whether convection will be rooted in the boundary layer or if there will be cooler air at the lowest levels. If the convection is rooted in the boundary layer, then the SCL lapse rate will be dry adiabatic and virtually any precipitation core will produce a strong downdraft, the strength of which will largely depend on particle type and SCL depth. If there are multiple mixed layers below the cloud base, the downdraft will be weakened. Phenomena that cause cooler air at the surface include fronts, lake breeze boundaries, and thunderstorm outflow boundaries.

In summary, because of the many assumptions, the microburst wind speeds provided in the gust table are only estimates to be used as guidance.

Installation of Software on AWIPS

This application requires Perl/tk. Perl/tk can easily be downloaded onto AWIPS using ATN 4.2-66 at www.wrh.noaa.gov. To install the microburst gust potential software, go to the Local Applications Database isl715.nws.noaa.gov/LAD. Use the instructions under Install Doc to install the software onto AWIPS.

Use on AWIPS

This program is best used in conjunction with the interactive SKEW-T option on either observed or forecast soundings. After downloading, the software is available by clicking on the Local Tools menu and selecting Gust Potential. A window will appear, prompting the user for the LCL temperature in deg C, the LCL height in feet (above sea level), and the surface pressure in mb. The LCL height and surface pressure are available either from the output data on the bottom of the observed and forecast soundings, or from the SKEW-T parameters window when using the editable interactive SKEW-T (Fig. 1). In order to find the LCL temp, find the pressure of the LCL from the output data, then left-click on that point of the sounding to get the temperature. If the heights on the graphical SKEW-T are used to find the LCL temperature, you will get a false temperature as those heights differ from those shown in the output data. The output data has the correct heights.

After entering the parameters, the user should click on "accept." The program then calculates the sub-cloud depth based on the entered LCL height and the surface pressure, and pops up a 'Dry Microburst Gust Potential' window which displays the following:

1) The temperature at cloud base (LCL Temp)
2) The depth of the sub-cloud layer
3) A column of lapse rates
4) Several columns of gust speeds, given different expected radar reflectivities
5) Additional comments at the bottom of the screen regarding assumptions about the environment and conditions that may cause the gust potential to be weaker than indicated (highlighted in orange), as well as comments about the reasoning behind the table (in white).

If the SCL depth is less than 3.7 km AGL (approximately 12,000 feet), then a qualifier will appear at the bottom of the table indicating the gust potential may be weaker than indicated. It is up to the forecaster to subjectively modify predicted gusts accordingly. Also, if the LCL temp is greater than 0 deg C, a qualifier will appear alerting the forecaster that the gust potential may be weaker than indicated. The gust potentials displayed are the high speeds for each range of lapse rates and reflectivities, so they are displayed with a less-than sign. This indicates that gusts up to this speed are possible.

In order to determine the gust potential associated with dry microbursts, the forecaster needs to determine what the sub-cloud lapse rate will be at the time of expected convection. However, if convection is rooted in the boundary layer, the sub-cloud lapse rate will be dry-adiabatic. A couple of methods for doing this are to compare the last couple of afternoon soundings to morning soundings, in order to see if the atmosphere has been completely mixing out or not. The forecaster might also use the interactive SKEW-T to determine how much warming is expected to take place, allowing for super-adiabatic lapse rates at the surface. Another method is to use model forecast lapse rates (850-700 mb or 850-500 mb), as seen in Fig. 2. Once the sub-cloud lapse rate has been determined, the forecaster can find the estimated gust potential for the environment from the table.

Acknowledgments

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References

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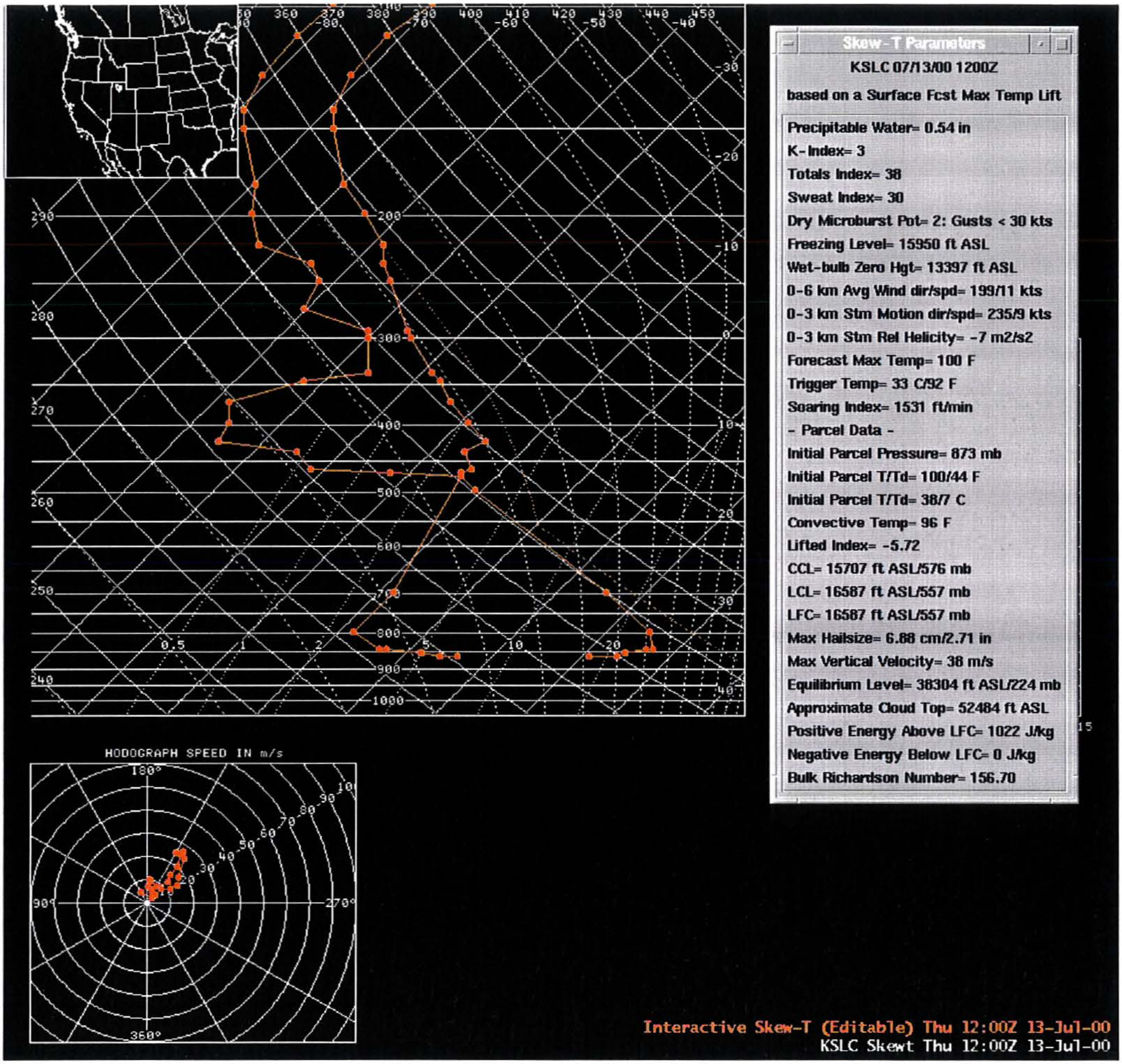
List of figures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KSLC 07/13/00 1200Z
based on a Surface Fcst Max Temp Lift
Precipitable Water= 0.54 in
K-Index= 3
Totals Index= 38
Sweat Index= 30
Dry Microburst Pot= 2: Gusts < 30 kts
Freezing Level= 15950 ft ASL
Wet-bulb Zero Hgt= 13397 ft ASL
0-6 km Avg Wind dir/spd= 199/11 kts
0-3 km Stm Motion dir/spd= 235/9 kts
0-3 km Stm Rel Helicity= -7 m2/s2
Forecast Max Temp= 100 F
Trigger Temp= 33 C/92 F
Soaring Index= 1531 ft/min
- Parcel Data -
Initial Parcel Pressure= 873 mb
Initial Parcel T/Td= 100/44 F
Initial Parcel T/Td= 38/7 C
Convective Temp= 96 F
Lifted Index= -5.72
CCL= 15707 ft ASL/576 mb
LCL= 16587 ft ASL/557 mb
LFC= 16587 ft ASL/557 mb
Max Hailsize= 6.88 cm/2.71 in
Max Vertical Velocity= 38 m/s
Equilibrium Level= 38304 ft ASL/224 mb
Approximate Cloud Top= 52484 ft ASL
Positive Energy Above LFC= 1022 J/kg
Negative Energy Below LFC= 0 J/kg
Bulk Richardson Number= 156.70
HODOGRAPH SPEED IN m/s
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KSLC Skewt Thu 12:00Z 13-Jul-00

Fig 1

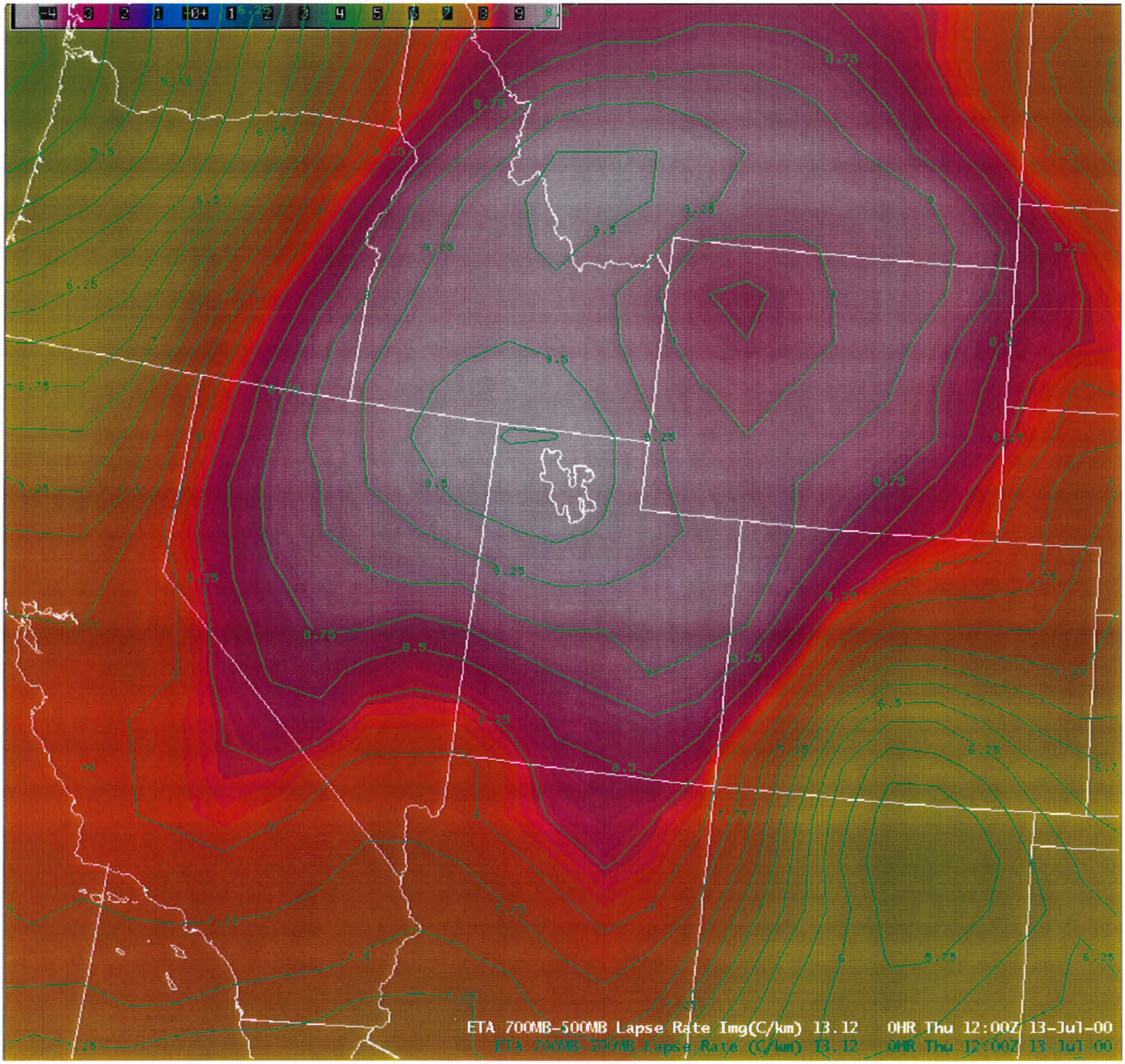
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Fig 2