Strongly Superadiabatic Lapse Rates Aloft
at Six Upper-Air Sounding Sites

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BACKGROUND

One aspect of soundings from the new National Weather Service (NWS) Radiosonde Replacement System (RRS – details may be found at www.ua.nws.noaa.gov/RRS.htm and also on posts here during summer 2007**)** is that, since the thermistor is easily wetted in moist environments, strongly superadiabatic layers aloft (hereafter SSLAs) now appear frequently in the data. This is usually, but not always, due to "wetbulbing" – i.e., the rapid cooling that occurs when water/ice evaporate/sublimate from the thermistor. Examples of soundings each having several SSLAs are shown in Figs. 1 to 3.

OUR STUDY

Slonaker et al. (1996) investigated the occurrence of superadiabatic lapse rates that were found in soundings from the Forecast Systems Laboratory (FSL) data archives several years ago, well prior to the RRS era that we're now in. They found that the most dramatic SSLAs were due to the wetbulbing problem after the thermistor was wetted, usually in an environment with precipitation or convective storms. We have been working together to examine quantitatively the occurrence of SSLAs aloft in the archived data from RRS sites and to compare the frequencies with those identified prior to RSS, when other sondes were used by the NWS.

We began this small project in May of 2008 and identified six upper-air sites that had been flying the Lockheed Martin Sippican GPS Mark IIA Microsonde (the sonde chosen for the RRS program) for two years or more. The sites we examined were:

72214 - Tallahassee, FL
72251 - Corpus Christi, TX
72265 - Midland, TX
72403 - Sterling, VA
72572 - Salt Lake City, UT
72649 - Chanhasen, MN

We processed the archived upper-air data, **point-to-point in the WMO text message data**, searching for SSLAs (we were not interested in surface-based superadiabatic layers since these occur often and are usually physically realistic for afternoon soundings). We searched for lapse rates of 15C/km or greater.

The reason for this criterion is tied to NWS operational procedures for the RRS program (**Radiosonde Replacement System (RRS) Workstation User Guide**, October 2005 – link to this document is below). The RRS data processing software checks, as the WMO message data are determined, for superadiabatic lapse rates meeting these criteria and when such a super is found, a "Check Message" is produced for the operator - see 9.5.3 of the RRS User's Guide at:

www.ua.nws.noaa.gov/Documents/Guide1105.pdf

The operator is instructed (see section 13.11 of the User Guide) to "…take corrective action…" and to "mark the data" and to "…apply user edits…" for layers exhibiting a wetbulb effect. The user is instructed to "…verify super-adiabatic lapse rates for this condition and mark through the data over a long enough period of time to smooth or interpolate the temperature readings." It is not obvious that such procedures can yield accurate data. The procedures can make obviously bad data periods "less bad" and also less obvious to those who might work with the soundings.

Physically unrealistic layers that are not corrected by the operator are transmitted and archived as if they were valid data. However, the User Guide notes that sometimes 10 or more check messages may be generated. We feel that most NWS operators don't perform the suggested, subjective quality control procedures and that RRS has resulted in increased numbers of soundings containing physically unrealistic data. These bad data are going into the long-term upper-air archives. Such problems are not new and research users of the upper-air data have often pointed out the problems with data in the archives (e.g, Pratt 1985; Wade and Barnes, 1988; Bosart, 1990; Elliott and Gaffen, 1991; Schwartz and Doswell, 1991; Wade, 1994).

We examined all soundings in the archives from the identified sites for the period May 1st 2006 through May 31st 2008, a period during which all six sites used the RRS Lockheed Martin Sippican GPS Mark IIA Microsonde instrument. This is a period of slightly more than 2 years, and there are on the order of 1500 individual soundings in the archives at FSL for each station. We then identified one or more prior periods when each site used a different manufacturer's sonde and examined data taken during those periods for comparison. Information on the new sonde used by the NWS can be found at:

http://www.sippican.com/stuff/contentmgr/files/6f597c276e01b5e1f76a5fed153a0117/sheet/gpsmark2.pdf

The goal of this effort was to quantify one aspect of both the quality of the data from the RRS Sippican sondes that most NWS upper-air stations are now using and the effectiveness of the NWS quality control procedures. We do this by comparing the number of SSLAs for the RRS data period with results of similar analyses for periods when other type sondes were used at the sites examined. The results of these analyses provide quantitative indications of the increased rate at which erroneous data are currently going into the upper-air archives.

FINDINGS

Our findings are shown below. We show the number of occurrences for at least one SSLA meeting the lapse rate criteria and we also show counts for three or more such SSLAs occurring during a single flight.

72251 – Corpus Christi TX

Two years of RRS Microsonde MKIIA – GPS soundings (5/01/2006 – 5/31/2008)   1528 flights

At least 1 strongly superadiabatic layer aloft	754 flights (49.3%)
At least 3 strongly superadiabatic layers aloft	154 flights (10.1%)

Two years of VIZ B2 MicroART soundings (5/01/2001 – 5/31/2003)   1546 flights

At least 1 strongly superadiabatic layer aloft	73 flights (4.7%)
At least 3 strongly superadiabatic layers aloft	5 flights (0.3%)

Two years of VIZ B MicroART soundings (05/01/1995 – 05/31/1997)   1530 flights

At least 1 strongly superadiabatic layer aloft	221 flights (14.4%)
At least 3 strongly superadiabatic layers aloft	21 flights (1.4%)

The results for Corpus Christi data are quite astounding and extremely disturbing, showing an increase of more than 10 times as many SSLAs than the prior period when the VIZ B2 instrument was used at that station.. There were about 30 times more flights with three or more SSLAs detected after the switch to the RRS system. It is interesting that the earlier switch to VIZ B2 sondes had led to a significant improvement over the performance of the VIZ B sonde.

The data from Corpus Christi show the worst degradation of data quality (at least for the superadiabatic criteria we examined) of the six stations. We assume that, since the SSLAs we are identifying are mostly due to wetbulbing on the thermistor, the results reflect the frequent presence at Corpus Christi of heavy clouds and saturated environments during flights. Note that we have not attempted to evaluate the impacts of each year's weather on the data from the stations examined. We realize that there are some impacts upon the data depending upon how wet or dry a given year was at a specific location, but we have taken a broad approach here and not tried to assess local weather conditions.

72214 – Tallahassee FL

Two years of RRS Microsonde MKIIA – GPS soundings (5/01/2006 – 5/31/2008)   1555 flights

At least 1 strongly superadiabatic layer aloft	700 flights (45.0%)
At least 3 strongly superadiabatic layers aloft	166 flights (10.7%)

Two years of Vaisala RS80 MicroART soundings (5/01/2003 – 5/31/2005)   1558 flights

At least 1 strongly superadiabatic layer aloft	114 flights (7.3%)
At least 3 strongly superadiabatic layers aloft	17 flights (1.1%)

The degradation of the data quality, as indicated by the increase in the number of SSLAs, has been serious at Tallahassee but not to the degree as that at Corpus Christi. The occurrence of SSLAs increased by more than five times after the change to the RRS and the occurrences of three or more SSLAs increased by about 10 times. Results for the other sites we examined follow:

72265 – Midland TX

Two years of RRS Microsonde MKIIA – GPS soundings (5/01/2006 – 5/31/2008) 1554 flights

At least 1 strongly superadiabatic layer aloft 401 flights (25.8%)
At least 3 strongly superadiabatic layers aloft 63 flights (4.1%)

Two years of Vaisala RS80 MicroART soundings (5/01/2003 – 5/31/2005) 1561 flights

At least 1 strongly superadiabatic layer aloft 58 flights (3.7%)
At least 3 strongly superadiabatic layers aloft 8 flights (0.5%)

72572 – Salt Lake City UT

Two years of RRS Microsonde MKIIA – GPS soundings (5/01/2006 – 5/31/2008) 1523 flights

At least 1 strongly superadiabatic layer aloft 394 flights (25.9%)
At least 3 strongly superadiabatic layers aloft 29 flights (1.9%)

Two years of Vaisala RS80 MicroART soundings (5/01/2003 – 5/31/2005) 1459 flights

At least 1 strongly superadiabatic layer aloft 220 flights (15.1%)
At least 3 strongly superadiabatic layers aloft 105 flights (7.2%)

Two years of SDD MicroART soundings (5/01/1992 – 5/31/1994) 1545 flights

At least 1 strongly superadiabatic layer aloft 284 flights (18.7%)
At least 3 strongly superadiabatic layers aloft 9 flights (0.6%)

The Salt Lake City data seem similar to the results from the other stations, except that the Vaisala RS80 MicroART sonde performed nearly as poorly as the new RRS sonde. The reasons for this are unknown.

72403 – Sterling VA

Two years of RRS Microsonde MKIIA – GPS soundings (5/01/2006 – 5/31/2008) 1580 flights

At least 1 strongly superadiabatic layer aloft	383 flights (24.2%)
At least 3 strongly superadiabatic layers aloft	68 flights (4.3%)

Two years of Vaisala RS80 MicroART soundings (5/01/2003 – 5/31/2005) 1548 flights

At least 1 strongly superadiabatic layer aloft	54 flights (3.5%)
At least 3 strongly superadiabatic layers aloft	25 flights (1.6%)

Two years of VIZ B MicroART soundings (5/01/1993 – 5/31/1995) 1511 flights

At least 1 strongly superadiabatic layer aloft	188 flights (12.4%)
At least 3 strongly superadiabatic layers aloft	14 flights (0.9%)

72649 – Chanhassen MN

Two years of RRS Microsonde MKIIA – GPS soundings (5/01/2006 – 5/31/2008) 1534 flights

At least 1 superadiabatic layer aloft	331 flights (21.6%)
At least 3 superadiabatic layers aloft	69 flights (4.5%)

Two years of Vaisala RS80 MicroART soundings (5/01/2003 – 5/31/2005) 1505 flights

At least 1 superadiabatic layer aloft	59 flights (3.9%)
At least 3 superadiabatic layers aloft	11 flights (0.7%)

The degradation of data quality is similar at all the sites (except Salt Lake City as noted above) and quite significant. The problem with the easily wetted thermistor (note that there are a number of other significant problems with the data from the RRS sondes – (see **"Overview of Problems with Data from the RRS Sippican Sondes"** at www.madweather.com) is seriously compromising the quality of the long term upper-air data base.

There are several aspects of the RRS and the new sonde that probably result in more SSLAs and other problems. The RRS software uses smoothed 1 sec data to determine significant levels. In contrast, the

MicroART software worked with 6-sec smoothed data. The Sippican microsonde is smaller than previous sondes, and thus its sensors are probably smaller with faster response times. The thermistor also apparently does not have a water repellant coating.

SUMMARY AND WARNING

There are large numbers of soundings with physically unrealistic data being added to the upper-air archives each month. The NWS quality control procedures are obviously not working. Anyone using these data for research, computations, or statistical analyses needs to understand that there are new and significant problems with the reliability of the data owing to the NWS transition to the Microsonde MKII – GPS sondes.

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Figures 1, 2 and 3 are shown below
(from the Univ. of Wyoming upper air page - http://weather.uwyo.edu/upperair/)
Red arrows indicate the SSLAs that are present in these three examples.

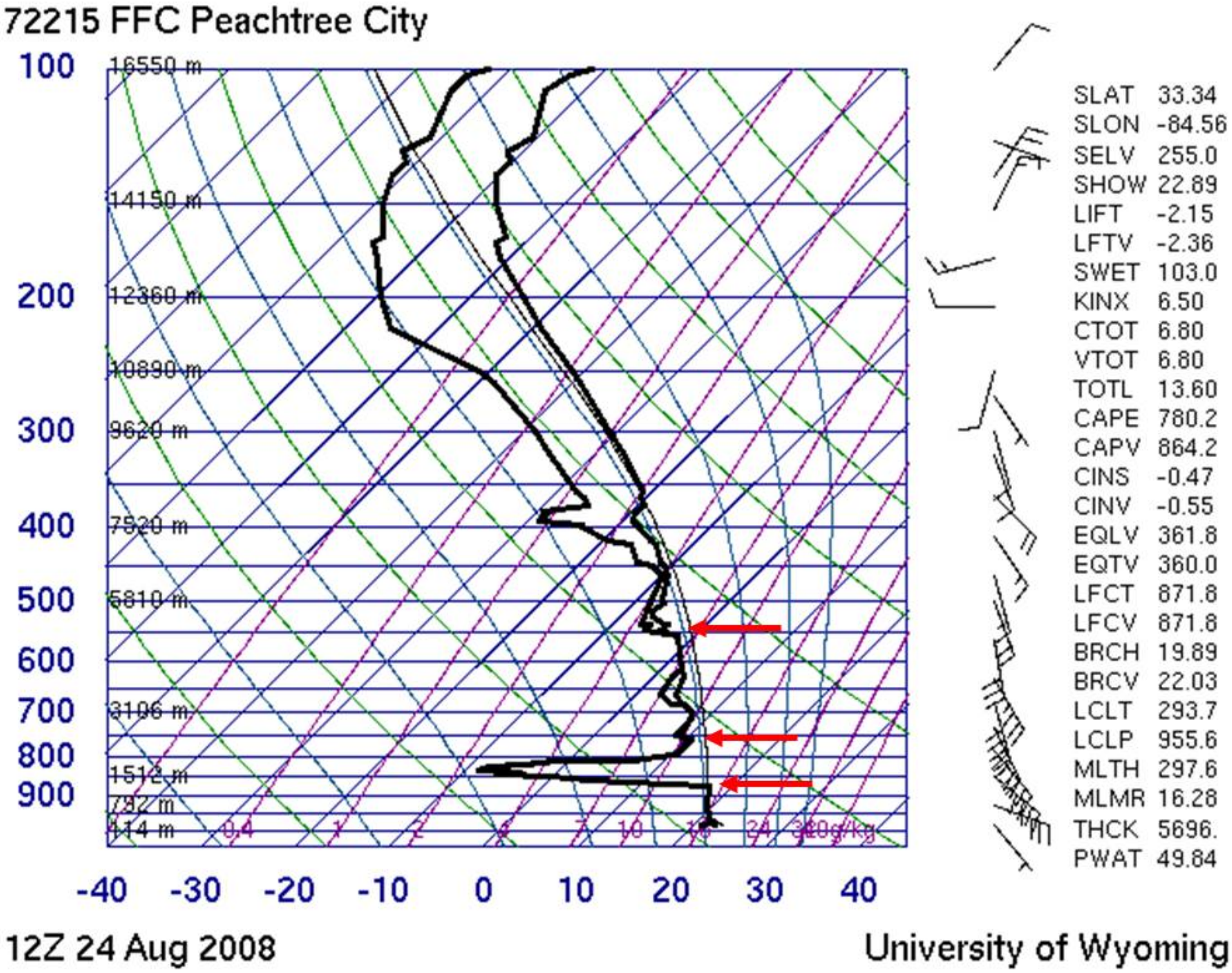
72215 FFC Peachtree City
100
200
300
400
500
600
700
800
900
16550 m
14150 m
12360 m
10890 m
9620 m
7520 m
5810 m
3106 m
1512 m
792 m
114 m
-40 -30 -20 -10 0 10 20 30 40
SLAT 33.34
SLON -84.56
SELV 255.0
SHOW 22.89
LIFT -2.15
LFTV -2.36
SWET 103.0
KINX 6.50
CTOT 6.80
VTOT 6.80
TOTL 13.60
CAPE 780.2
CAPV 864.2
CINS -0.47
CINV -0.55
EQLV 361.8
EQTV 360.0
LFCT 871.8
LFCV 871.8
BRCH 19.89
BRCV 22.03
LCLT 293.7
LCLP 955.6
MLTH 297.6
MLMR 16.28
THCK 5696.
PWAT 49.84
12Z 24 Aug 2008
University of Wyoming

FIGURE 1

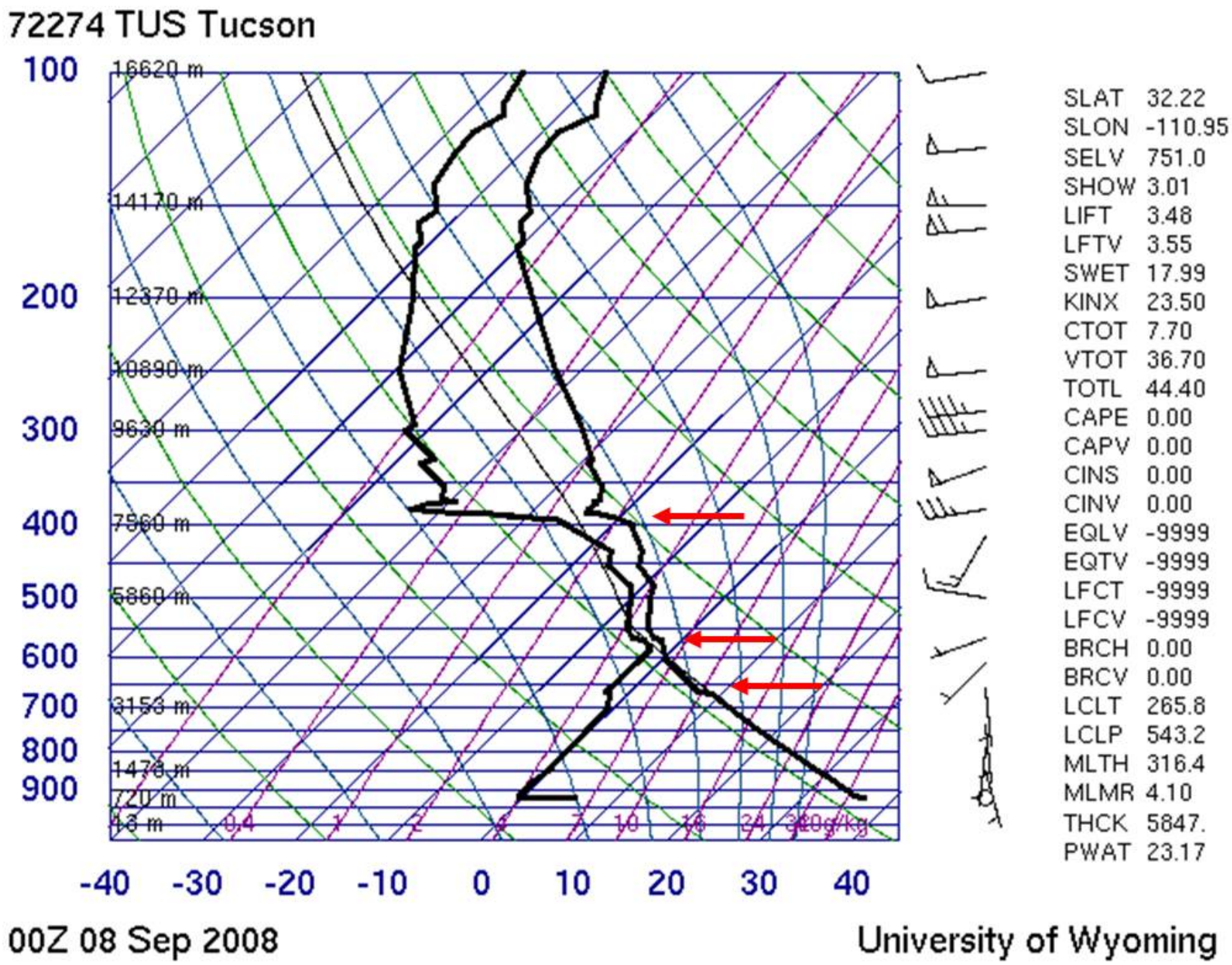
72274 TUS Tucson
100
200
300
400
500
600
700
800
900
16620 m
14170 m
12370 m
10890 m
9630 m
7560 m
5860 m
3153 m
1476 m
720 m
13 m
0.4
1
2
4
7
10
16
24
32
40g/kg
-40
-30
-20
-10
0
10
20
30
40
SLAT 32.22
SLON -110.95
SELV 751.0
SHOW 3.01
LIFT 3.48
LFTV 3.55
SWET 17.99
KINX 23.50
CTOT 7.70
VTOT 36.70
TOTL 44.40
CAPE 0.00
CAPV 0.00
CINS 0.00
CINV 0.00
EQLV -9999
EQTV -9999
LFCT -9999
LFCV -9999
BRCH 0.00
BRCV 0.00
LCLT 265.8
LCLP 543.2
MLTH 316.4
MLMR 4.10
THCK 5847.
PWAT 23.17
00Z 08 Sep 2008
University of Wyoming

FIGURE 2

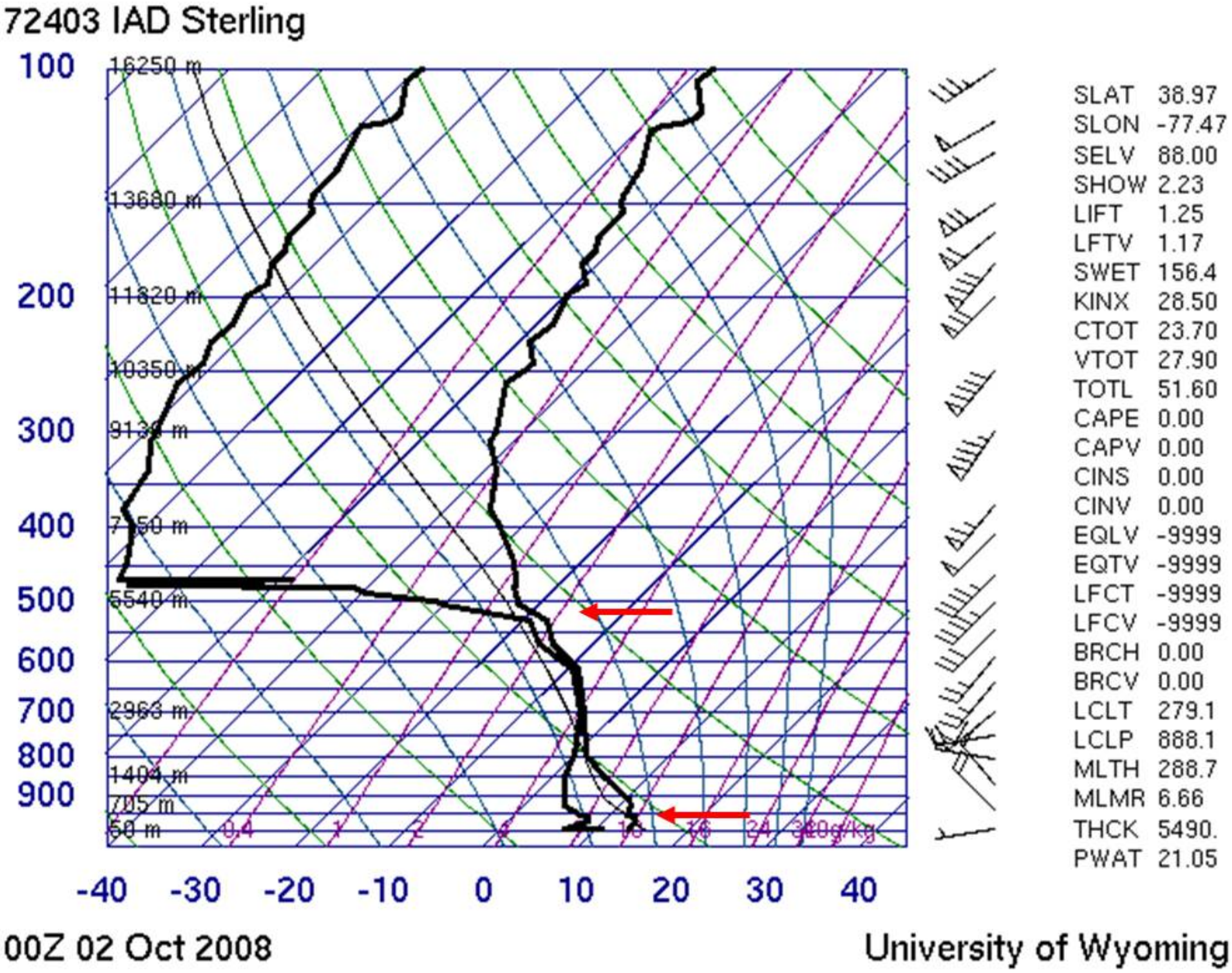
72403 IAD Sterling
100
200
300
400
500
600
700
800
900
16250 m
13680 m
11820 m
10350 m
5540 m
2963 m
1404 m
705 m
50 m
-40 -30 -20 -10 0 10 20 30 40
SLAT 38.97
SLON -77.47
SELV 88.00
SHOW 2.23
LIFT 1.25
LFTV 1.17
SWET 156.4
KINX 28.50
CTOT 23.70
VTOT 27.90
TOTL 51.60
CAPE 0.00
CAPV 0.00
CINS 0.00
CINV 0.00
EQLV -9999
EQTV -9999
LFCT -9999
LFCV -9999
BRCH 0.00
BRCV 0.00
LCLT 279.1
LCLP 888.1
MLTH 288.7
MLMR 6.66
THCK 5490.
PWAT 21.05
00Z 02 Oct 2008
University of Wyoming

FIGURE 3