ATSC 3032 Homework 3

due date: Tuesday 5 March
worth: 4% of the course grade

Skew T exercise (20%) Assuming the following values T=20°C and T_d=5°C at the surface in Denver (p=850 mb). Determine the following:

a. The height of this station above sea level, assuming that the same T applies down to sea level (calculation)
b. LCL (pressure units) (graphical), H_{LCL} (km) (calculation and graphical) and $T_{cloudbase}$ (°C) (calculation and graphical)
c. T_W (°C) and θ_W (K) (graphical only)
d. mixing ratio r (g/kg), r_s (g/kg) (both graphical), and RH (calculation)
e. θ (K), θ_e^*(K), and θ_e (K) (all graphical only)

Please hand in your Skew T diagram with the lines necessary to infer these quantities. Some quantities need to be computed. Hand in a separate sheet with all the answers.

Skew T exercise (80%)
As part of this assignment you will need to hand in the skew T chart. Feel free to make notes on the chart so I understand what you did. Hand in a separate sheet with all the answers.

The sounding data given below are for Dodge City, KS (DDC) at 12 UTC, just before sunrise, for some day in late spring. The exact date is not given, because otherwise you could plot the sounding and obtain various variables from http://weather.uwyo.edu . The data given are PRES (pressure, in mb or hPa), HGHT (height, in m), VTMP (virtual temperature, in °C), and DWPT (dewpoint temperature, in °C).

Plot the virtual temperature and dewpoint profiles at all the levels listed on a blank skew T chart. Then connect the dots, separately for virtual temperature (red line) and for dewpoint (blue line). I should see two solid lines. (20% of the homework)

Then determine the following (5% each, except if noted):

a) At the surface (930 hPa): mixing ratio (r), saturation mixing ratio (r_{sat}), vapor pressure (e), and saturation vapor pressure (e_{sat}). Please demonstrate how to obtain this graphically. You may want to check accuracy by comparing relative humidity calculated as r/r_{sat}, and e/e_{sat}.

b) The LCL, CCL, and convection temperature for surface air (930 hPa).

c) Determine the static stability (unstable, conditionally unstable, absolutely stable, dry or moist neutral) for these layers:
   1. 930-910 mb
   2. 880-850 mb
   3. 500-400 mb

d) At all your levels: derive the wet-bulb temperature graphically, and plot the wet-bulb temperature profile (WLR) as a purple line. (10% of the homework)

e) On the skew T chart, highlight the vertical layer(s) that are potentially unstable, and on your answer sheet, write the (Hint: again look at the WLR)

f) Draw the "critical SALR" line, using a dashed pencil line. (Hint: see Fig. 18 in the Notes on Skew T and Stability)

g) Is there 'latent' instability in this sounding? If so, highlight the vertical layer(s) with latent instability on the skew T chart. (hint: look at the WLR, and the critical SALR)

h) With a pencil line, trace the path of a parcel of air lifted from the surface up to about 250 mb. Does the surface air yield any CAPE?

i) Using the parcel profile you just plotted, determine the lifted index (LI).

j) [if latent instability is present:] At what level is the latent instability maximum, in other words what source level provides the richest air for deep convection?

k) With a green line, trace the path of a parcel of air lifted from the level of maximum latent instability up to about 250 hPa. Does this parcel become positively buoyant? If so, hatch in the area of convective inhibition CIN (parcel colder than the environment) with horizontal lines and the area of convective available potential energy CAPE (parcel warmer than the environment) with vertical lines.

l) [if CAPE is present] Determine the level of free convection (LFC) and the level of neutral buoyancy (LNB) for that parcel. (Note: LNB is also known as the equilibrium level; it is the thunderstorm top)

m) [if CAPE is present] Estimate both the CAPE (J/kg) and the CIN (J/kg) using the area method, for the same parcel. (Hint: a 1x1 square inch box on the skew T you use corresponds with ~250 J/kg)

n) Are thunderstorms possible, according to your CAPE value? Do you expect them to be severe?

o) Compare the CAPE for a parcel lifted from the surface to the CAPE for a parcel lifted from the level of maximum latent instability. Which one is greater? What does that say about the source level of air feeding thunderstorms?

p) (5% extra credit) venture to use this finding to explain the frequent occurrence of thunderstorms at night over the Great Plains. Why does this happen over the Great Plains, and rarely elsewhere? What is special about the Great Plains?

DDC 12 UTC sounding data:

variable	PRES	HGHT	VTMP	DWPT
unit	hPa	m	C	C
	930	790	15	10
	910	910	19	10
	880	1219	20	10
	850	1511	19	10
	820	1755	17	9
	790	2134	14	9
	760	2438	12	7
	740	2646	11	8
	730	2781	10	5
	700	3140	8	0
	670	3449	4	-2
	610	4267	-2	-12
	530	5426	-10	-20
	500	5800	-13	-26
	400	7460	-27	-39
	350	8328	-34	-42
	300	9480	-40	-55
	250	10700	-49	-62
	200	12140	-56	-67
	150	13940	-64	-74
	100	16420	-66	-76