Meteorology 3510
Exercise 10: Due April 17, 2008

This exercise deals with the saturation adiabatic lapse rate, stability, buoyancy oscillations, CAPE, and maximum updraft speeds.

1. Write (and hand in a listing of) a program to calculate the saturation-adiabatic lapse rate Γ_s (in K km^{-1}) for the following pressures and temperatures: 1000, 850, 700, 500, 300, 100 mb; +40, +30, +20, +10, 0, -10, -20, -30, -40 ° C. Present your results in a table similar to the one in the text, or as a contour plot, *clearly labeled*.

2. In a stable unsaturated atmospheric layer, a parcel displaced vertically from its equilibrium level will oscillate with a frequency

$$N = [\frac{g}{T}(\Gamma_d - \gamma)]^{1/2}$$

called the *Brunt-Väisälä frequency.* The corresponding period of oscillation is $\tau = 2\pi/N$. Calculate N and τ for the following values of γ using $T = 288$ K:
(a) $\gamma = 6.5$ K/km (standard atmosphere value),
(b) $\gamma = 3$ K/km (stable layer),
(c) $\gamma = 0$ K/km (isothermal, very stable layer),
(d) $\gamma = 9$ K/km (weakly stable layer).

3. Plot the Tropical Atmosphere sounding (temperature and from the accompanying table) on your skew T-log p diagram and determine the LCL, LFC, and LNB for a parcel that is displaced upwards from the surface. You may plot values at 1-km intervals, except plot at 0.25-km intervals when necessary in order to determine the LCL, LFC, and LNB to the nearest 10 mb. Copy or scan or photograph the chart with the sounding and the parcel properties plotted on it, and the LCL, LFC, and LNB indicated.

4. Calculate the maximum parcel vertical velocity for the following values of PA: 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000 J/kg.

5. Calculate the initial parcel updraft speed required for a parcel to just reach its LFC if the NA is: 50, 100, 150, 200, 300, 400, 500 J/kg.

6. In a well-mixed (that is, constant potential temperature) boundary layer 2 km deep, a parcel rises from near the surface with a potential temperature 1 K greater than that of the mixed layer. The mixed layer is capped by a thick isothermal (constant *temperature*) layer that is 1 K warmer than the mixed layer at 2 km.

   (a) What is the upward speed of the parcel due to its CAPE at the top of the mixed layer?
   (b) How far does the parcel penetrate (overshoot) into the overlaying isothermal layer?

   Hint: The parcel buoyancy can be expressed using potential temperature as

$$g\frac{\theta - \bar{\theta}}{\theta_0},$$

   where no subscript indicates parcel properties, an overbar indicates environment properties, and subscript 0 indicates the reference profile, equal to a constant (288 K) in this case.

Tropical Atmosphere

z(km)	P(mb)	T(K)	w(g/kg)	O3(kg/kg)
16.500	102.00	196.00	0.0032500	3.2500e-07
16.250	106.40	196.50	0.0032250	2.8250e-07
16.000	111.00	197.00	0.0032000	2.4000e-07
15.750	115.90	198.80	0.0032490	2.3250e-07
15.500	121.00	200.50	0.0032980	2.2500e-07
15.250	126.40	202.30	0.0033490	2.1750e-07
15.000	132.00	204.00	0.0034000	2.1000e-07
14.750	137.60	205.50	0.0035180	2.0000e-07
14.500	143.50	207.00	0.0036410	1.9000e-07
14.250	149.60	208.50	0.0037680	1.8000e-07
14.000	156.00	210.00	0.0039000	1.7000e-07
13.750	162.10	211.80	0.0043610	1.6500e-07
13.500	168.50	213.50	0.0048770	1.6000e-07
13.250	175.10	215.30	0.0054540	1.5500e-07
13.000	182.00	217.00	0.0061000	1.5000e-07
12.750	189.30	218.80	0.0079960	1.4500e-07
12.500	196.90	220.50	0.010480	1.4000e-07
12.250	204.80	222.30	0.013730	1.3500e-07
12.000	213.00	224.00	0.018000	1.3000e-07
11.750	221.00	225.50	0.022630	1.2500e-07
11.500	229.40	227.00	0.028460	1.2000e-07
11.250	238.00	228.50	0.035790	1.1500e-07
11.000	247.00	230.00	0.045000	1.1000e-07
10.750	256.20	231.80	0.057500	1.0580e-07
10.500	265.80	233.50	0.073480	1.0150e-07
10.250	275.70	235.30	0.093900	9.7250e-08
10.000	286.00	237.00	0.12000	9.3000e-08
9.7500	296.20	238.80	0.14420	9.0500e-08
9.5000	306.70	240.50	0.17320	8.8000e-08
9.2500	317.70	242.30	0.20810	8.5500e-08
9.0000	329.00	244.00	0.25000	8.3000e-08
8.7500	339.50	245.50	0.29430	8.0750e-08
8.5000	350.30	247.00	0.34640	7.8500e-08
8.2500	361.50	248.50	0.40780	7.6250e-08
8.0000	373.00	250.00	0.48000	7.4000e-08
7.7500	386.90	251.80	0.54540	7.3000e-08
7.5000	401.40	253.50	0.61970	7.2000e-08
7.2500	416.40	255.30	0.70410	7.1000e-08
7.0000	432.00	257.00	0.80000	7.0000e-08
6.7500	446.30	258.80	0.90330	6.9000e-08
6.5000	461.00	260.50	1.0200	6.8000e-08
6.2500	476.20	262.30	1.1520	6.7000e-08
6.0000	492.00	264.00	1.3000	6.6000e-08
5.7500	507.90	265.50	1.4650	6.5250e-08
5.5000	524.40	267.00	1.6520	6.4500e-08
5.2500	541.40	268.50	1.8630	6.3750e-08
5.0000	559.00	270.00	2.1000	6.3000e-08
4.7500	576.70	271.80	2.2570	6.2000e-08
4.5000	594.90	273.50	2.4250	6.1000e-08

4.2500	613.70	275.30	2.6060	6.0000e-08
4.0000	633.00	277.00	2.8000	5.9000e-08
3.7500	652.60	278.80	3.2990	5.8750e-08
3.5000	672.80	280.50	3.8880	5.8500e-08
3.2500	693.60	282.30	4.5820	5.8250e-08
3.0000	715.00	284.00	5.4000	5.8000e-08
2.7500	736.50	285.00	6.2350	5.7500e-08
2.5000	758.70	286.00	7.2000	5.7000e-08
2.2500	781.50	287.00	8.3140	5.6500e-08
2.0000	805.00	288.00	9.6000	5.6000e-08
1.7500	828.70	289.50	10.150	5.5250e-08
1.5000	853.10	291.00	10.730	5.4500e-08
1.2500	878.20	292.50	11.350	5.3750e-08
1.0000	904.00	294.00	12.000	5.3000e-08
0.75000	930.10	295.50	12.900	5.1750e-08
0.50000	956.90	297.00	13.860	5.0500e-08
0.25000	984.60	298.50	14.890	4.9250e-08
0.0000	1013.0	300.00	16.000	4.8000e-08