Liang's print copy

Question:

A moist air parcel at a temperature of 20°C and specific humidity of 10 g kg^{-1} is lifted adiabatically from the upwind base of a mountain, where the pressure is 1000 mbar, to the top, at 3000 m above the base, and is then brought down to the base on the other side of the mountain. Using appropriate equations given in class, calculate the following parameters:

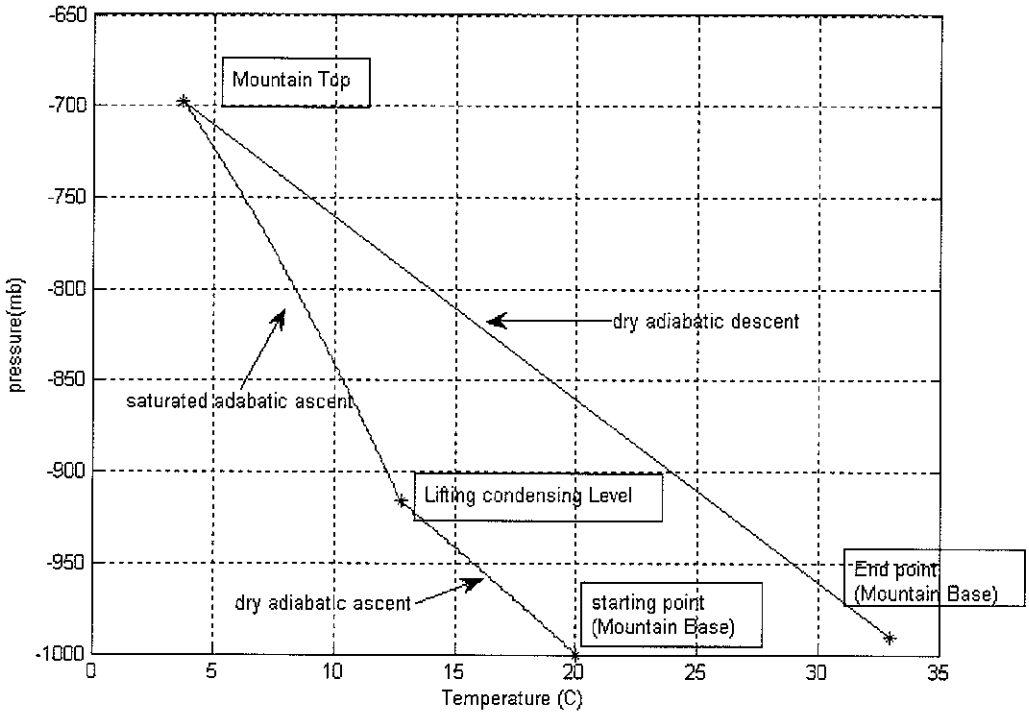
Answer(Note: The f95 files should be opened using Wordpad rather than Notepad as default, since Wordpad could have standard format, the program code is ex2.f95):

(a) At the original base (refer to AnswerA.pdf)

(b) The air parcel would become saturated at some level above the base.(refer to AnswerB.pdf)

(c) The temperature of the parcel at the top of the mountain.(to see the profile, refer to AnswerC.pdf and the following figure generated by matlab)

The temperature of the parcel at the top of the mountain is 12.75° C



(d) The temperature, pressure, vapor pressure, relative humidity, specific humidity, and dew point temperature, of the parcel at the downwind base, assuming that the parcel remained unsaturated during its entire descent.

Exercise 2

Z	P	T	Td	q	e	RH	Tv	Thet	Thetv
m	mb	deg C	deg C	g/kg	mb	%	deg C	deg C	deg C
0	990.	32.96	9.02	7.13	11.29	23.32	34.29	33.84	35.17

(e) Use the pseudoadiabatic chart (i.e. the Stüve diagram discussed in class) to solve the above problem by locating the starting point, the lifting condensation level, the mountain top, and the ending point. For each location, you should be able to determine temperature, pressure, height, mixing ratio, saturated mixing ratio, dew point temperature, relative humidity (approximately mixing ratio divided by saturated mixing ratio), and the rainout amount. Compare these values with those from what is calculated from your code and discuss. (see the hardcopy)

Answer:

The comparison result

	starting point		**LCL**		**mountain top**		**ending point**	
	Stüve	Code	Stüve	Code	Stüve	Code	Stüve	Code
T (°C)	20.0	20.0	12.45	12.75	2.1	3.68	32.0	32.96
P (mb)	1000.0	1000.0	910.0	916.0	700.0	697.0	1000.0	990.0
Z (m)	100.0	0.0	815.0	742.0	3000.0	3000.0	0.0	0.0
w (g/kg)	10.10	10.10	10.10	10.10	6.04	7.13	6.04	7.13
w^* (g/kg)	16.23	14.68	10.10	10.10	6.04	7.13	29.9	30.9
T_d (°C)	13.90	14.19	12.45	12.75	2.1	3.68	7.2	9.0
RH (%)	69.28	69.28	100.0	100.0	100.0	100.0	20.2	23.3
Δq(g/kg)	0.0	0.0	0.0	0.0	4.1	2.87	4.1	2.87

(1) For example, if the numbers are different, why? What are the potential sources?

There are several reasons make the results derived from Stuve Chart and Program different. First, systematic errors exist, for example, when we read values from the figure, the errors from reading can't be neglected. Secondly, the saturated adiabatic process should be described as a curve rather than a straight line which is shown in stuve chart. Since the saturated adiabatic lapse rate is changing with the air parcel ascending and the water vapor condensed. Thirdly, the height used in the program is the relative one to the base of the mountain, while in the stuve chart, all the elevation, and pressures are absolute value and hence the two situations are not in the same scale. For example, the starting point in stuve chart is 100m, while in the programming code, it is regarded as 0m.

(2) Do you expect this to be the real precipitation that would occur in nature? Why?

I don't think this is the real precipitation that would occur in nature, because the formation of precipitation needs some conditions. Precipitation is produced when air parcels become supersaturated with water vapor, condensation and droplet formation occur, and the droplets or particles reach the surface without reevaporation. During ascent, the air parcel become saturated with water vapor, but only combined with particles can precipitation occurs; another factor is

reevaporation, when reevaporation does exist during the process from atmosphere to earth, the real precipitation would be less than the water vapor that condensed.

At the original base
(1)
1000mb = 29.52874 in.Hg
1000mb = 75.00616 cm.Hg
(2)
1000mb = 100.0000 kPa
(3)
q = 9.9999998E-03 kg/kg
(4)
w = 10.10101 g/kg
(5)
q - w = -0.1010103 g/kg
(6)
T = 52.00000 F
(7)
T = 293.1500 K
(8)
Tv = 21.78235 C
(9)
Rd = 287.0000 K/kg/K
(10)
air density = 1.290000 kg/m3
(11)
e = 15.98006 mb
(12)
Pd = 984.0200 mb
(13)
e* = 23.06733 mb
(14)
e* - e = 17.49625 mb
(15)
RH = 69.27572
(16)
Exact Value: q* = 14.47408 mb
Approximate Value: q* = 14.34788 mb
(17)
Td = 14.18677 C
(18)
L = 2452000 J/kg
(19)
dq*/dT = 6.1892747E-04 K-1
(20)

dry adiabatic lapse rate = 9.7609563E-03 C/m
moist adiabatic lapse rate = 3.8864056E-03 C/m
(21)
potential temperature = 20.00000 C
virtual potential temperature = 21.78235 C

At the lifting condensing level(LCL)
(22)
The height at this level is LCL = 743 m
(23)
The pressure at this level is p = 916.4333 mb
(24)
The temperature at this level is T= 12.74762 C
The dew temperature at this level is Td= 12.74384 C
The virtual temperature at this level is Tv= 14.48588 C
(25)
The potential temperature at this level is 19.97287 C
The virtual potential temperature at this level is 21.75507 C
(26)
The specific humidity at this level is q = 10.00000 g/kg
(27)
The rate of changes of saturated specific humidity with temperature is dq*/dT = 6.5534574E-04 K-1
(28)
The relative humidity at this level is RH = 100.0000
(29)
The vapor pressure at this level is e = 14.64830 mb
(30)
The saturated adiabatic lapse rate at this level is 3.7371565E-03 C/m

ENTER Tbase = 20.00000 in degree Celcius at the base
ENTER Pbase = 1000.000 in mbar at the base
ENTER Qbase = 10.00000 in g/kg at the base
ENTER Ztop = 3000.000 in m for the mountain top height
ENTER dz = 3000.000 in m for the height increment

Z	P	T	Td	q	e	RH	Tv	Thet	Thetv
m	mb	deg C	deg C	g/kg	mb	%	deg C	deg C	deg C
0	1000.	20.00	14.19	10.00	15.98	69.28	21.78	20.00	21.78
50	994.	19.51	14.09	10.00	15.89	70.94	21.29	20.00	21.78
100	988.	19.02	13.99	10.00	15.79	72.66	20.80	20.00	21.78
150	983.	18.54	13.89	10.00	15.70	74.43	20.31	20.00	21.78
200	977.	18.05	13.80	10.00	15.61	76.25	19.82	20.00	21.78
250	971.	17.56	13.70	10.00	15.52	78.13	19.33	20.00	21.78
300	966.	17.07	13.60	10.00	15.43	80.06	18.84	20.00	21.78
350	960.	16.58	13.51	10.00	15.34	82.05	18.35	19.99	21.78
400	954.	16.10	13.41	10.00	15.25	84.11	17.85	19.99	21.78
450	949.	15.61	13.31	10.00	15.16	86.22	17.36	19.99	21.77
500	943.	15.12	13.21	10.00	15.07	88.40	16.87	19.99	21.77
550	938.	14.63	13.12	10.00	14.98	90.64	16.38	19.99	21.77
600	932.	14.14	13.02	10.00	14.89	92.95	15.89	19.98	21.77
650	927.	13.66	12.92	10.00	14.81	95.34	15.40	19.98	21.76
700	921.	13.17	12.83	10.00	14.72	97.80	14.91	19.98	21.76
742	917.	12.76	12.75	10.00	14.65	99.92	14.50	19.97	21.76
743	916.	12.75	12.74	10.00	14.64	99.98	14.49	19.97	21.76
744	916.	12.74	12.74	10.00	14.64	100.03	14.48	19.97	21.75
750	916.	12.72	12.72	9.99	14.62	100.00	14.45	20.01	21.79
800	910.	12.53	12.53	9.93	14.44	100.00	14.25	20.31	22.09
850	905.	12.34	12.34	9.87	14.27	100.00	14.05	20.62	22.38
900	900.	12.15	12.15	9.80	14.09	100.00	13.85	20.92	22.68
950	894.	11.96	11.96	9.74	13.92	100.00	13.65	21.23	22.97
1000	889.	11.77	11.77	9.68	13.75	100.00	13.45	21.54	23.27
1050	884.	11.58	11.58	9.62	13.58	100.00	13.25	21.84	23.57
1100	878.	11.39	11.39	9.55	13.41	100.00	13.05	22.15	23.86
1150	873.	11.20	11.20	9.49	13.25	100.00	12.84	22.45	24.16
1200	868.	11.01	11.01	9.43	13.08	100.00	12.64	22.76	24.46
1250	863.	10.82	10.82	9.36	12.92	100.00	12.44	23.07	24.75
1300	858.	10.63	10.63	9.30	12.75	100.00	12.23	23.37	25.05
1350	852.	10.43	10.43	9.24	12.59	100.00	12.03	23.68	25.35
1400	847.	10.24	10.24	9.18	12.43	100.00	11.82	23.99	25.65
1450	842.	10.04	10.04	9.11	12.27	100.00	11.61	24.30	25.94
1500	837.	9.85	9.85	9.05	12.11	100.00	11.41	24.60	26.24
1550	832.	9.65	9.65	8.99	11.96	100.00	11.20	24.91	26.54

1600	827.	9.46	9.46	8.92	11.80	100.00	10.99	25.22	26.84
1650	822.	9.26	9.26	8.86	11.65	100.00	10.78	25.53	27.13
1700	817.	9.06	9.06	8.80	11.49	100.00	10.57	25.83	27.43
1750	812.	8.86	8.86	8.73	11.34	100.00	10.36	26.14	27.73
1800	807.	8.67	8.67	8.67	11.19	100.00	10.15	26.45	28.03
1850	802.	8.47	8.47	8.60	11.04	100.00	9.94	26.76	28.33
1900	798.	8.27	8.27	8.54	10.90	100.00	9.73	27.07	28.62
1950	793.	8.06	8.06	8.48	10.75	100.00	9.51	27.37	28.92
2000	788.	7.86	7.86	8.41	10.60	100.00	9.30	27.68	29.22
2050	783.	7.66	7.66	8.35	10.46	100.00	9.09	27.99	29.52
2100	778.	7.46	7.46	8.29	10.32	100.00	8.87	28.30	29.82
2150	774.	7.25	7.25	8.22	10.18	100.00	8.66	28.61	30.11
2200	769.	7.05	7.05	8.16	10.03	100.00	8.44	28.91	30.41
2250	764.	6.84	6.84	8.09	9.90	100.00	8.22	29.22	30.71
2300	760.	6.64	6.64	8.03	9.76	100.00	8.00	29.53	31.01
2350	755.	6.43	6.43	7.96	9.62	100.00	7.79	29.84	31.31
2400	750.	6.22	6.22	7.90	9.48	100.00	7.57	30.15	31.60
2450	746.	6.02	6.02	7.84	9.35	100.00	7.35	30.46	31.90
2500	741.	5.81	5.81	7.77	9.22	100.00	7.13	30.76	32.20
2550	737.	5.60	5.60	7.71	9.08	100.00	6.91	31.07	32.50
2600	732.	5.39	5.39	7.64	8.95	100.00	6.68	31.38	32.79
2650	728.	5.18	5.18	7.58	8.82	100.00	6.46	31.69	33.09
2700	723.	4.97	4.97	7.51	8.69	100.00	6.24	32.00	33.39
2750	719.	4.75	4.75	7.45	8.57	100.00	6.01	32.30	33.69
2800	714.	4.54	4.54	7.38	8.44	100.00	5.79	32.61	33.98
2850	710.	4.33	4.33	7.32	8.32	100.00	5.56	32.92	34.28
2900	705.	4.11	4.11	7.26	8.19	100.00	5.33	33.23	34.58
2950	701.	3.89	3.89	7.19	8.07	100.00	5.11	33.53	34.87
3000	697.	3.68	3.68	7.13	7.95	100.00	4.88	33.84	35.17
0.	990.	32.96	9.02	7.13	11.29	23.32	34.29	33.84	35.17
Z	P	T	Td	q	e	RH	Tv	Thet	Thetv
m	mb	deg C	deg C	g/kg	mb	%	deg C	deg C	deg C

Z_LCL = 743 m

Rainout = 2.873306 g/kg