

Thermodynamics (wet)

Adiabatic process

- Potential temperature, θ , conserved (from definition)

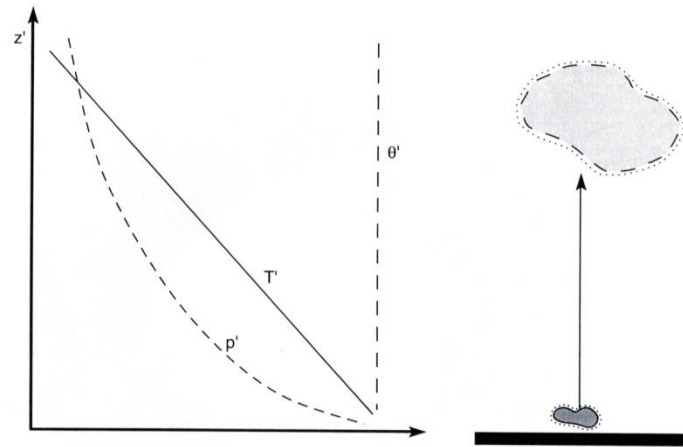


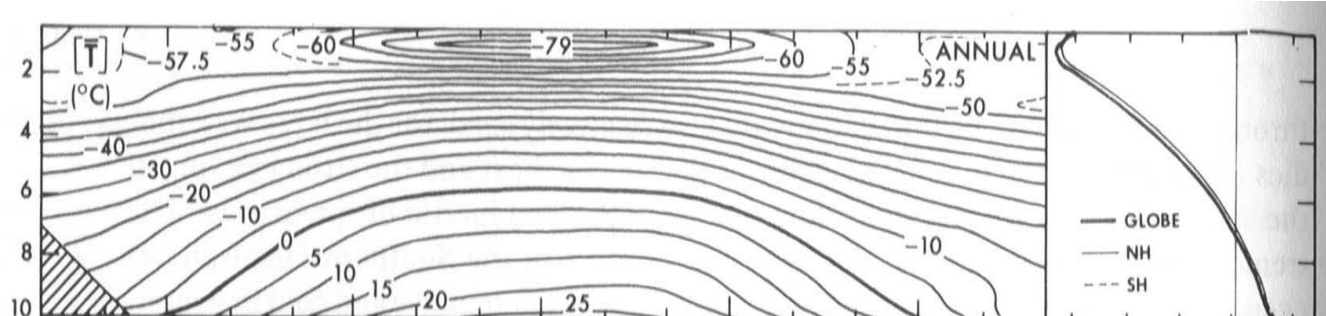
Figure 2.11 Profiles of pressure, temperature, and potential temperature for an individual air parcel ascending adiabatically.

Since we know from hydrostatic that volume is related to altitude, what is the change in temperature with height?

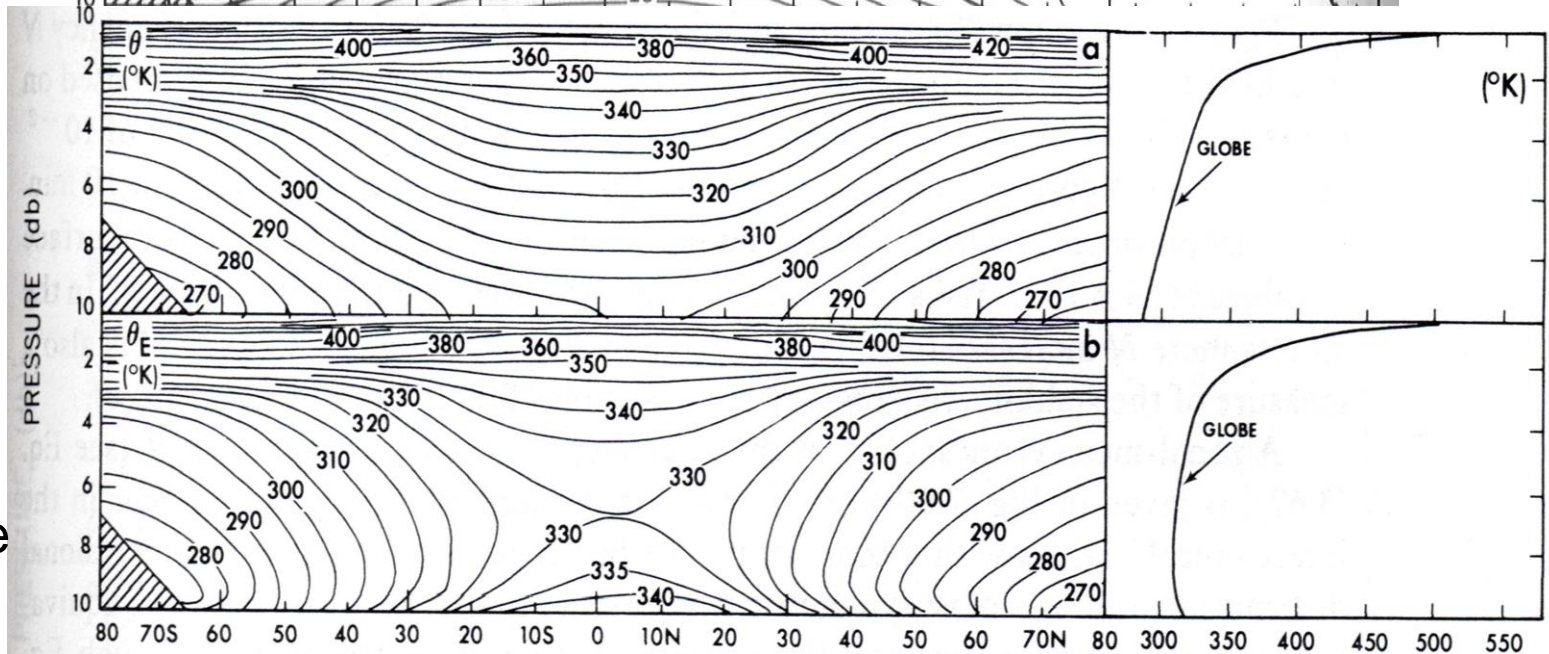
Zonal mean potential temperature

Annual average

Temperature



Potential temperature



Equivalent potential temperature

Diabatic motion: Example

Q: How long does it take for parcels to ascend from the surface to the tropopause in the tropics?
What is the vertical speed?

Potential temperature increases from about 300K to 340K. So requires heating of 40K.

Diabatic heating rates in the tropical troposphere are about 0.8K/day,
Thus about 50 days!

Tropopause is at about 15 km.

So $w = 15\text{km}/50\text{days} = 300\text{m/day} = 3 \text{ mm/s!}$

Example part 2

Q: What about stratosphere?

Potential temperature increased from about 400K to 800K. Do requires heating of 400K.

Diabatic heating rates in the tropical troposphere are about 0.2K/day.

Thus about 2000 days or 5.5 years!

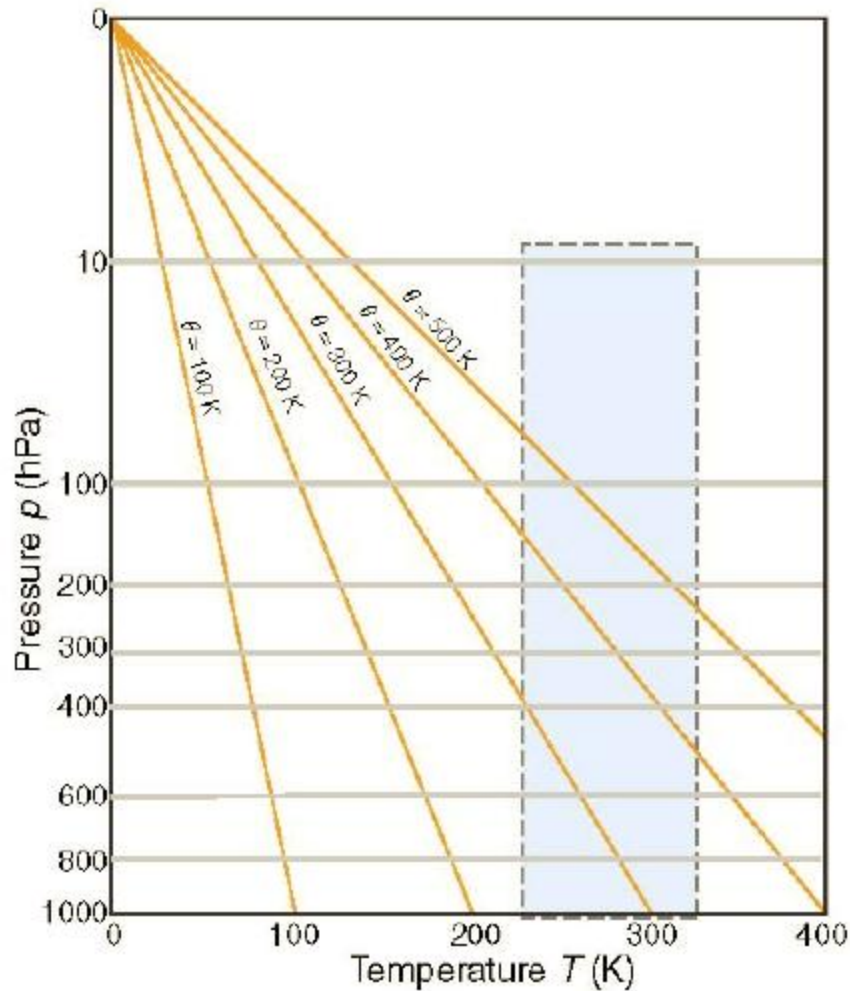
Stratosphere is about 20 km thick.

So $w = 20\text{km}/5.4 \text{ years} = 1.4 \times 10^{-4} \text{ m/s}$

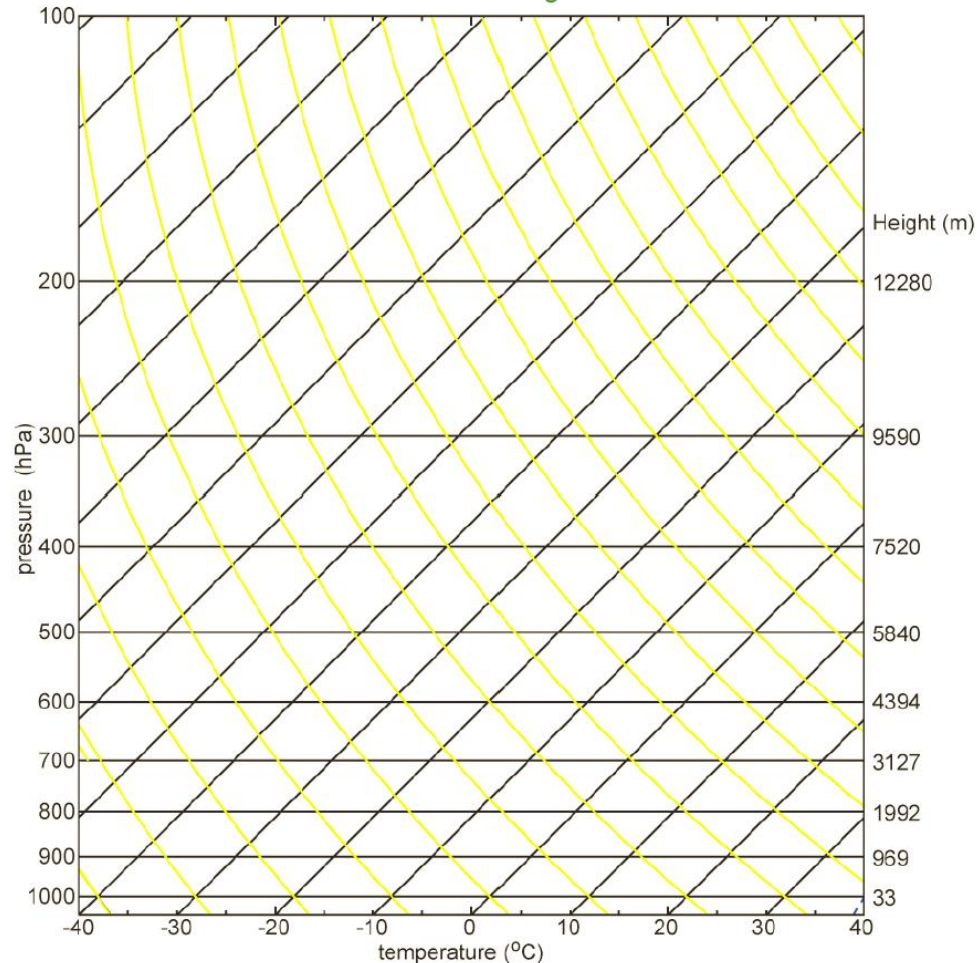
Thermodynamic diagrams

- A diagram whose axes are thermodynamic state variables (T , p , s , ρ , θ , ...)
- Any two! [For a dry atmosphere]
- These diagrams provide a graphic representation of atmospheric thermodynamic properties and can be used to diagnose cloud formation and determine how air parcels will respond to vertical motion.

Pseudoadiabatic chart

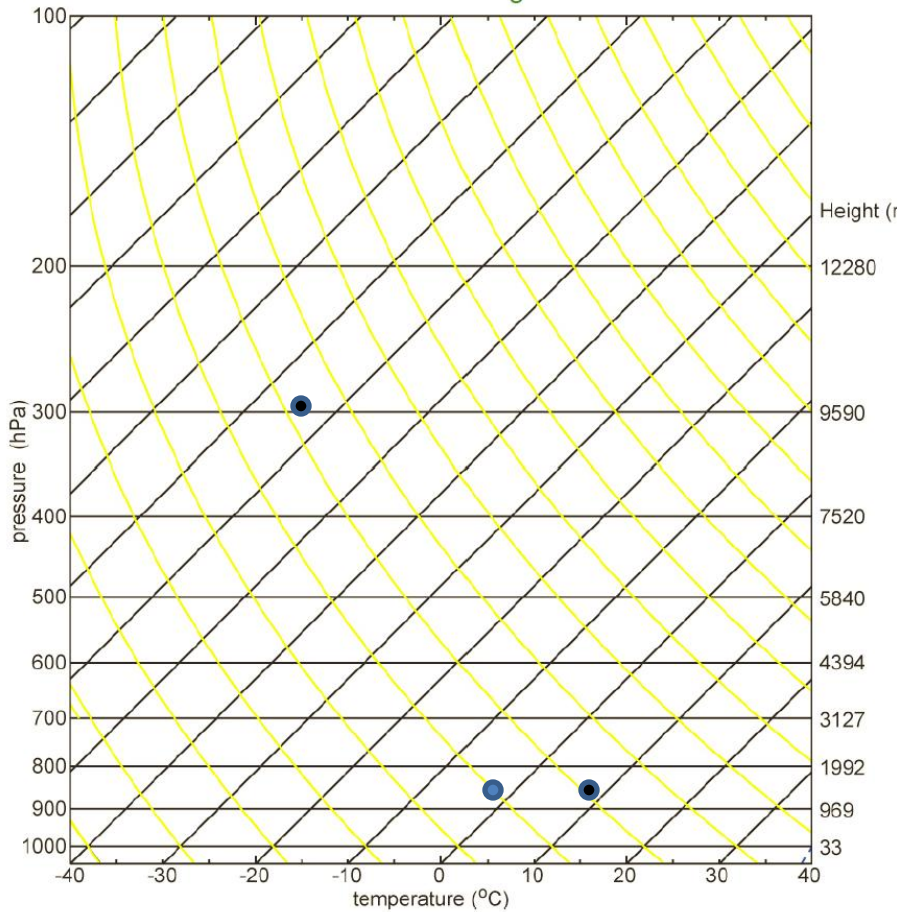


Skew T-log P



1. Pressure: black horizontal lines (Units: hPa or mb)
(logarithm of pressure is used as the vertical axis on this diagram)
2. Temperature: Black lines that slope up and to the right (units: °C)
3. Dry adiabat: Lines of constant potential temperature – curved yellow lines that slope up and to the left.

ATOC weather station

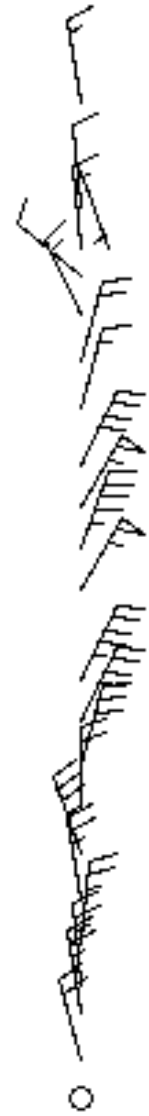
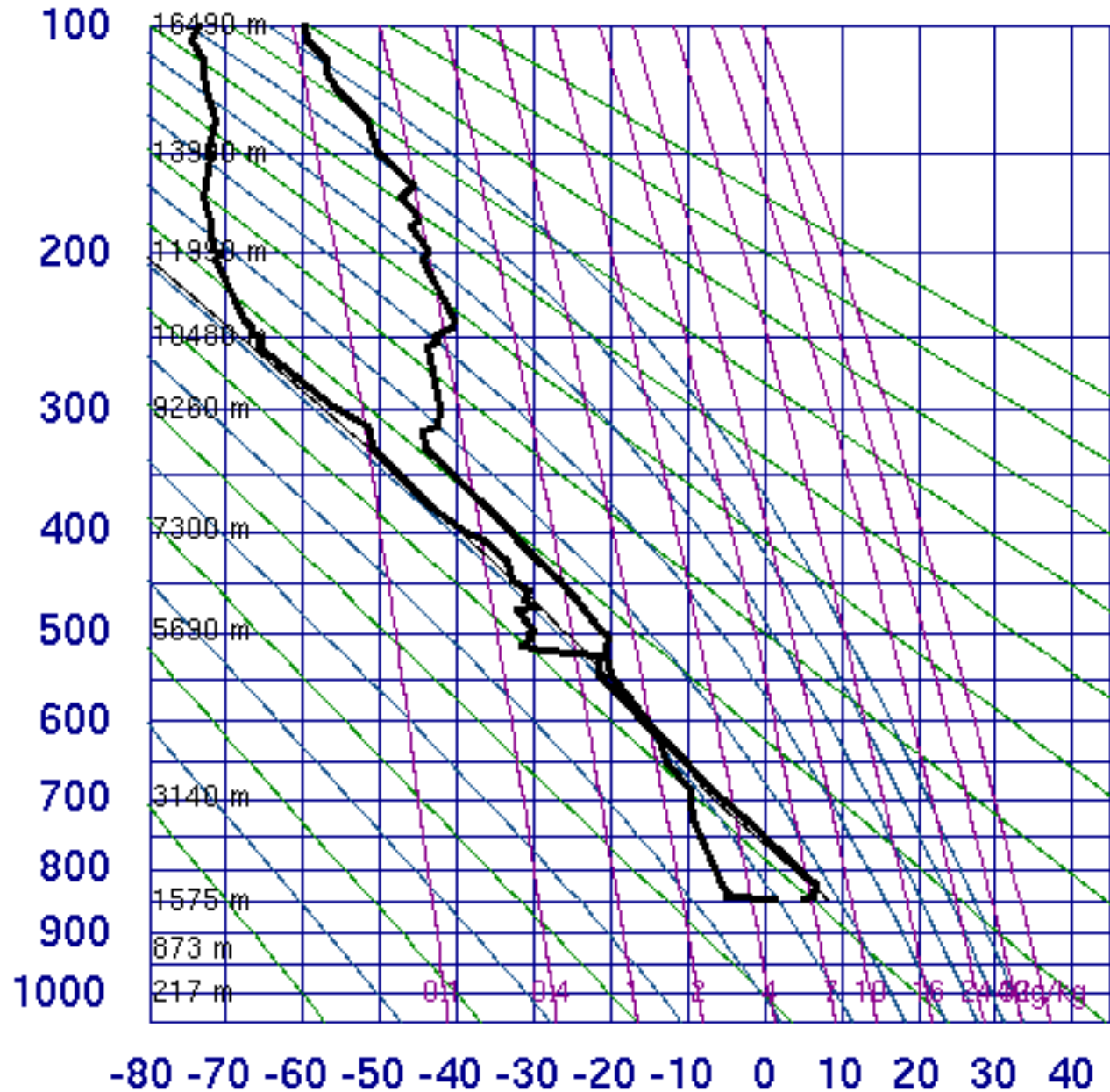


9/22/09 9:10a	Last 24 hours			
	Current	Minimum	Maximum	Average
Temperature (F)	47.5	41.1 @ 09:25	51.9 @ 17:25	45.8
Dewpoint (F)	28.8	26.0 @ 05:05	41.2 @ 12:30	32.7
Humidity (%)	48	40 @ 17:30	91 @ 09:20	61
Solar Flux (W/m ²)	128	0 @ 19:10	851 @ 12:20	67
Pressure (mb)	841.6	840.6 @ 09:15	842.4 @ 21:00	841.5
Wind Speed (mph)	5.0	0.0 @ 10:15	10.0 @ 03:00	3.3
Peak Gust Speed (mph)	8.0	0.0 @ 18:40	17.0 @ 16:00	6.8
Wind Direction (deg)	315			
Rainfall today (inch)	0.00			

P = 841 hPa T = 8.3C Td = -1.7C

Air mass lifted adiabatically to 300 hPa? T = -65C!

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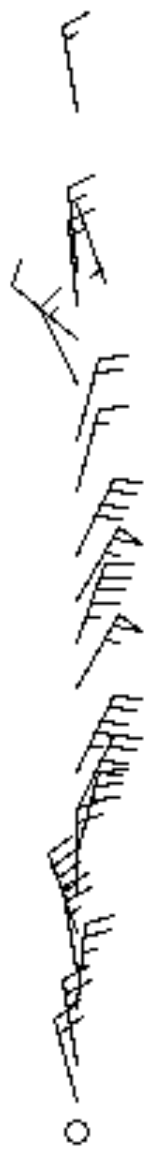
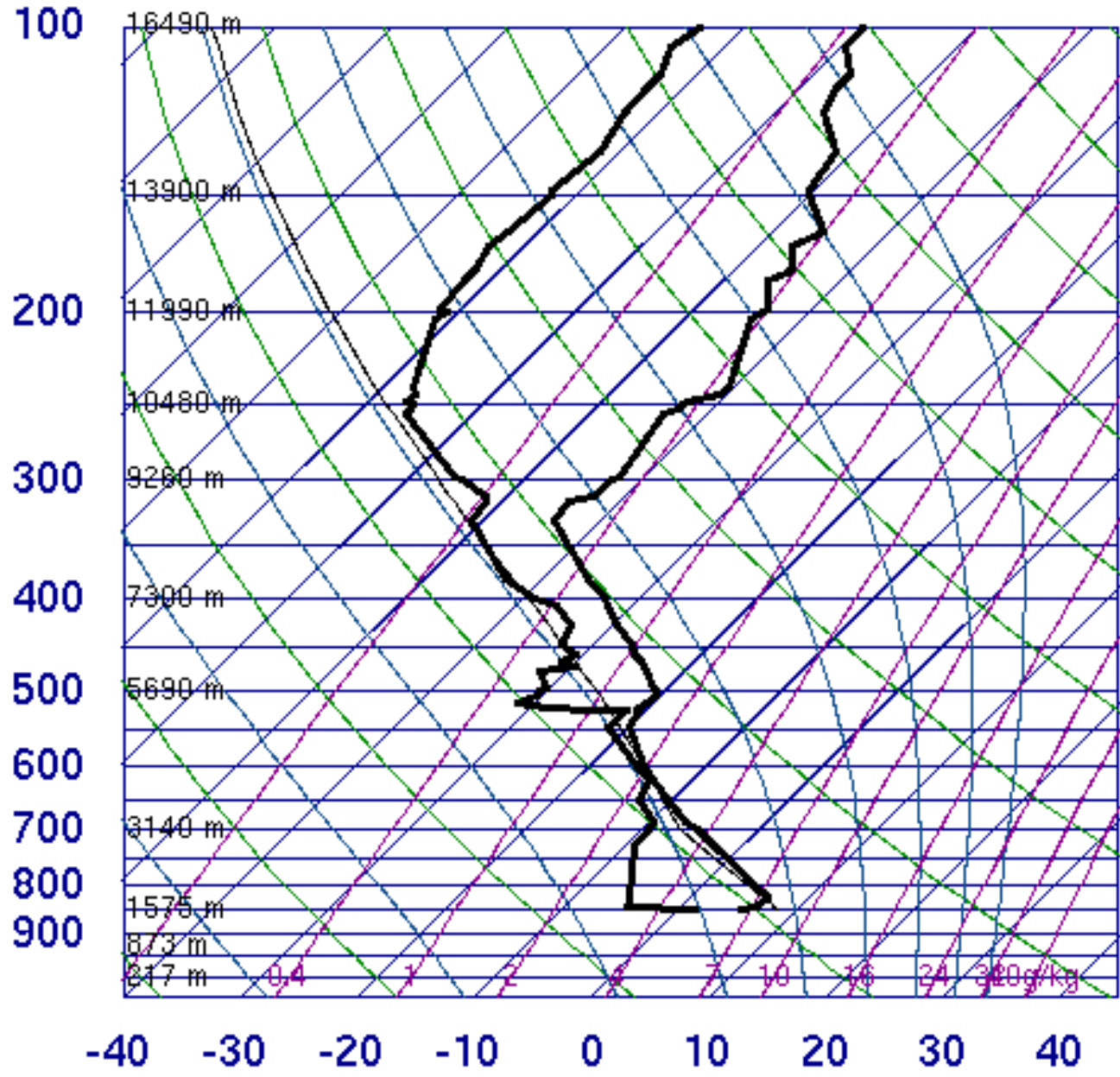


SLAT	39.75
SLON	-104.87
SELV	1625.
SHOW	-9999
LIFT	5.03
LFTV	4.98
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.04
CAPV	0.11
CINS	-59.9
CINV	-55.2
EQLV	596.6
EQTV	595.7
LFCT	605.1
LFCV	608.0
BRCH	0.00
BRCV	0.00
LCLT	265.7
LCLP	692.6
MLTH	295.1
MLMR	3.19
THCK	5473.
PWAT	8.77

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Problems

- Holton: 2.8
- Holton: 2.11

- RY: 2.1
- RY: 2.2
- (copy of Ch 1-3 on web site)