The weak vertical development of these fairweather cumulus clouds implies the rising thermals are rapidly running out of buoyancy; and this in turn tells us something (qualitative) about the "static stability" of the layer in question

Figure 8.4

- We (earlier) derived the unsaturated adiabatic lapse rate ("**DALR**") by combining the 1st law & hydrostatic eqn (Sec 8.1.1):

$$\frac{\Delta T}{\Delta z} = \Gamma_d = -\frac{g}{c_p} = -0.0098\ \mathrm{K\,m^{-1}}$$

- "static stability") of an atmospheric layer is assessed by comparing it's ***actual*** temperature lapse rate (**ELR**, Environmental Lapse Rate) against two *benchmarks*:

DALR

SALR (or MALR)

- As shown here, the ELR is initially steeper than the DALR
- Mixing will return the ELR to the DALR (provided saturation does not occur)
- *Visualize* the "mixing" process as adiabatic vertical motion causing exchange of parcels, followed by non-adiabatic mixing of the displaced parcels with their environment
- The DALR characterizes a “well mixed” (and unsaturated) atmospheric layer

$$\Gamma_d = -\frac{g}{c_p} \approx -0.01 \ \mathrm{K\,m^{-1}}$$

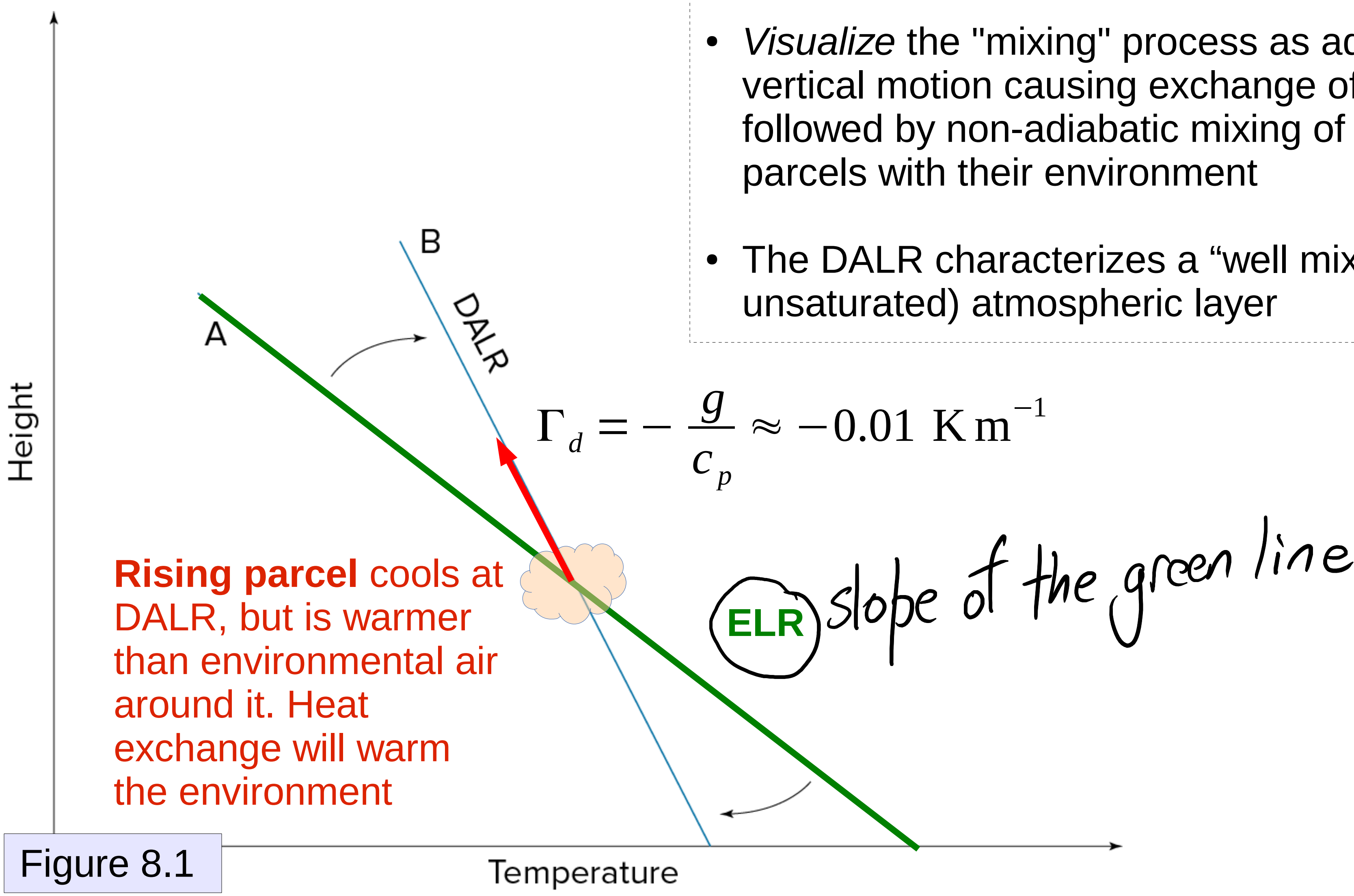

Figure 8.1

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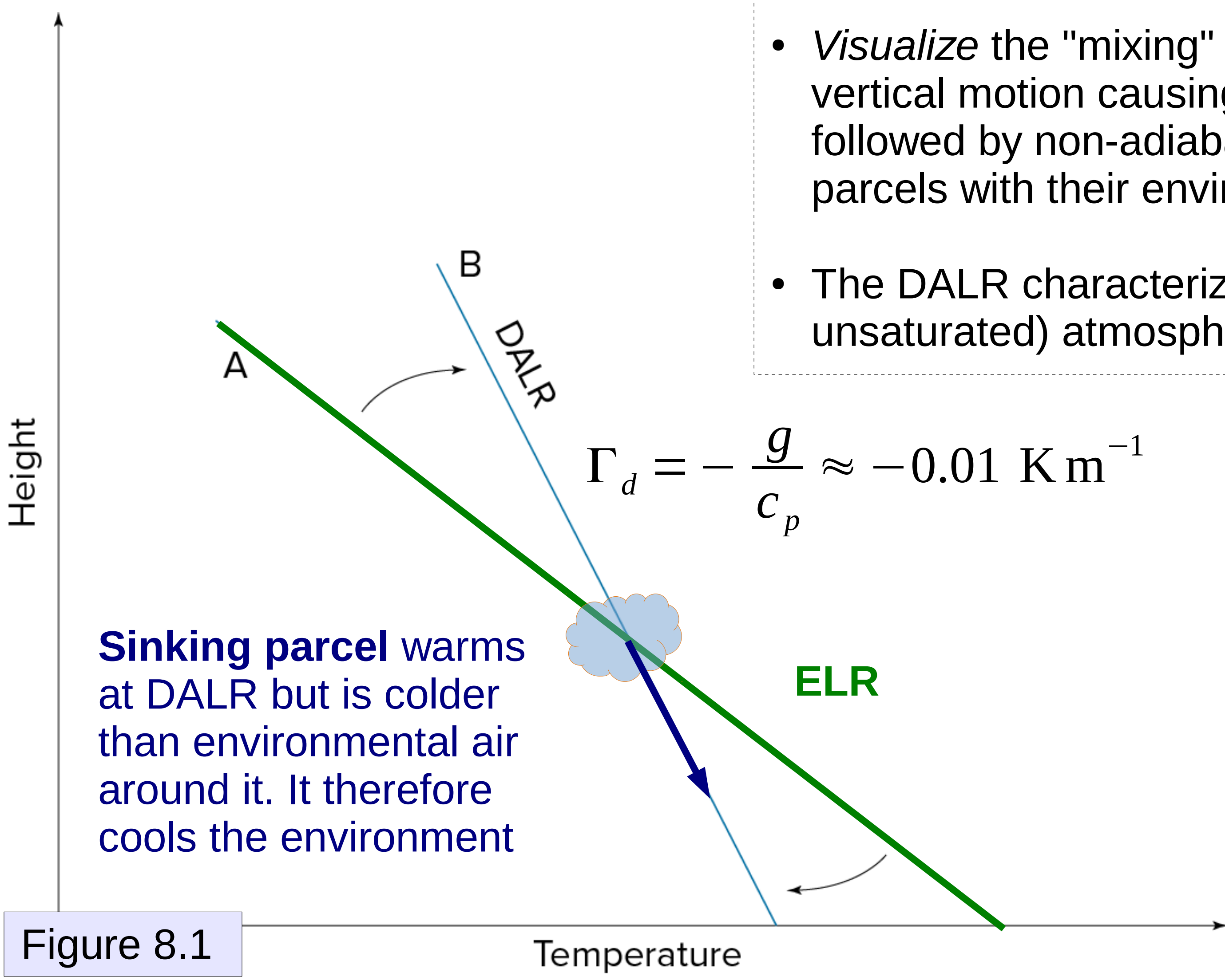


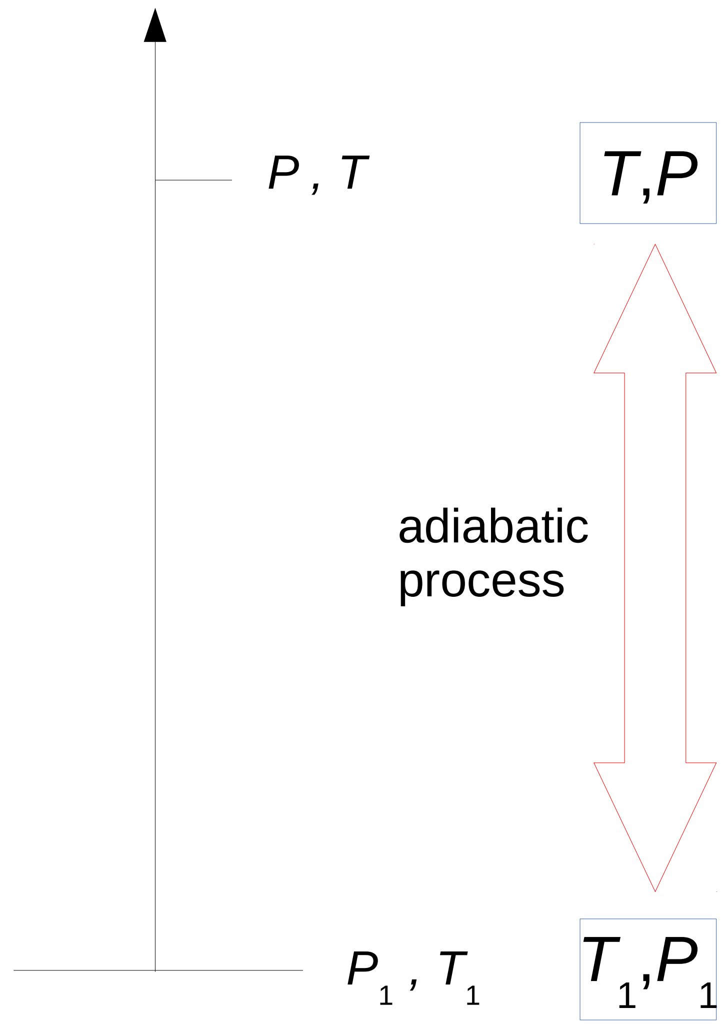
$$\Gamma_d = -\frac{g}{c_p} \approx -0.01\ \mathrm{K\,m^{-1}}$$

Figure 8.1

$$\frac{T}{T_1} = \left[\frac{P}{P_1}\right]^{\frac{R_d}{c_p}} \qquad \left(\text{where } R_d/c_p = 0.286\right)$$

Let P_1 be a reference level; our textbook chooses 100 kPa (i.e. 1000 hPa). Poisson's law tells us that if the parcel (P ,T) is lowered adiabatically to the 1000 hPa level, it's temperature would be

$$T_1 = T\left[\frac{P_1}{P}\right]^{0.286}$$



Therefore we say that the parcel (P , T) has this value as its **potential** temperature, and we use the symbol “theta”:

$$\theta = T\left[\frac{1000}{P}\right]^{0.286}$$

"As long as no heat is transferred between an (unsaturated) air parcel and its surroundings, the potential temperature of the parcel will not change as the parcel rises or sinks"

If we lower the parcel (P , T) dry adiabatically, its temperature will increase at the (magnitude of) DALR... but its potential temperature does not change.

Question: does θ vary with height in a well-mixed, unsaturated layer? NO

$$\Gamma_d = -\frac{g}{c_p} \approx -0.01 \text{ K m}^{-1}$$

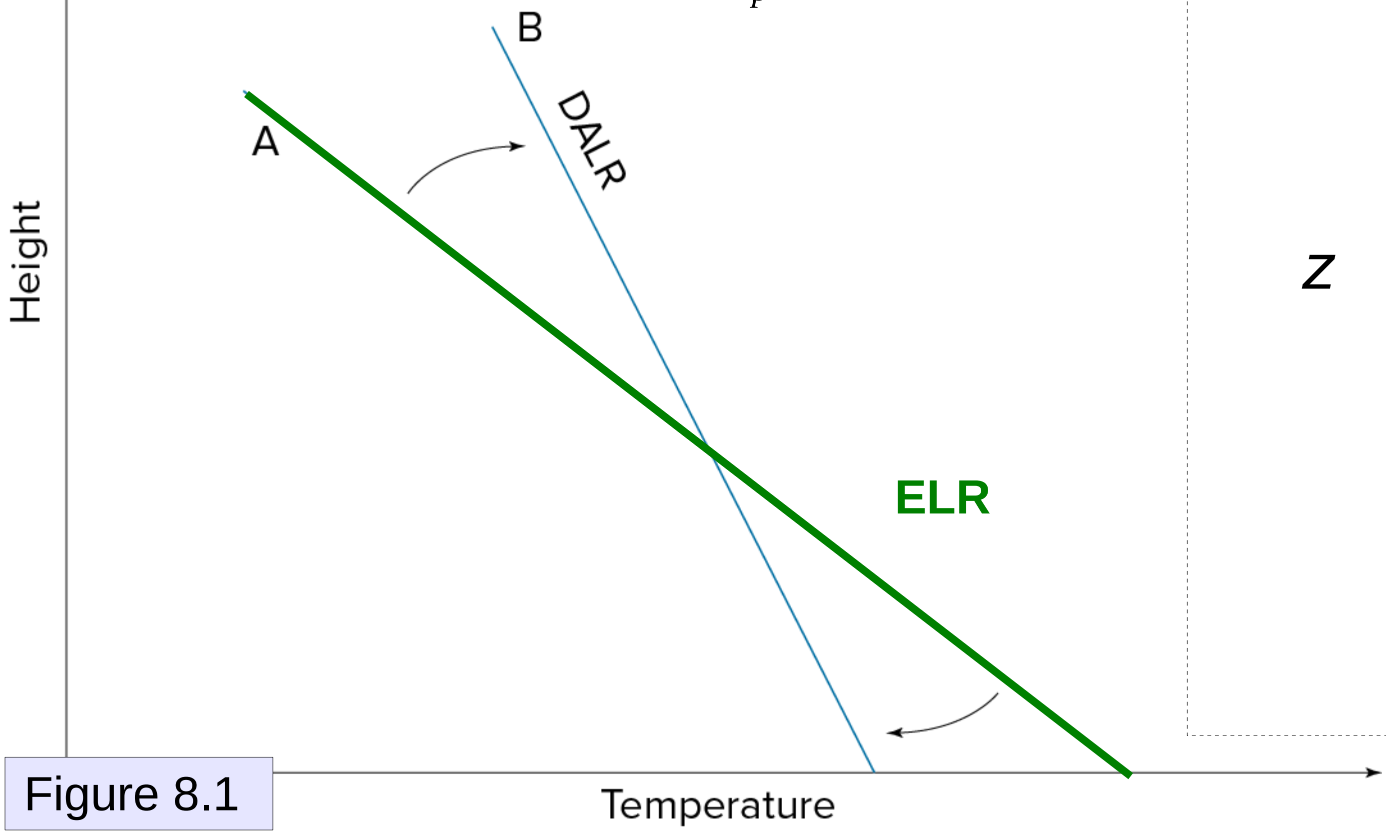
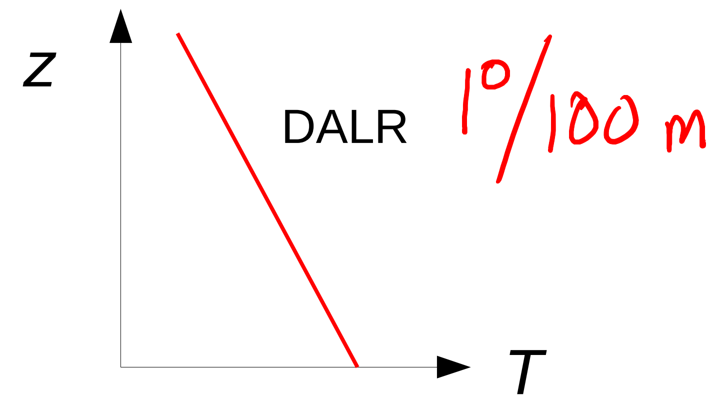
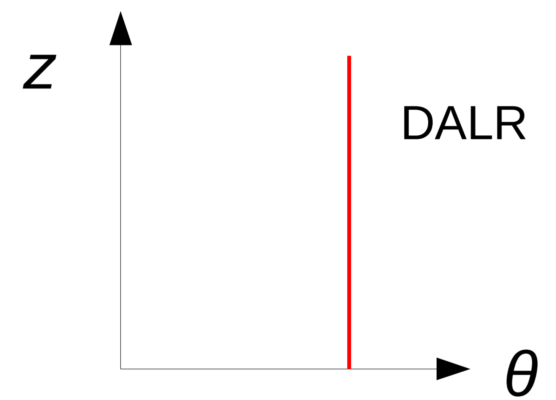


Figure 8.1

A “dry adiabat” is a line of constant potential temperature





Dewpoint depression $T_{dd} = T - T_d$

$$\frac{\Delta T_d}{\Delta z} = -0.002 \ \mathrm{K\,m^{-1}}$$

$$\therefore \frac{\Delta}{\Delta z}\left(T - T_d\right) = -0.8 \ \mathrm{K/100m}$$

When T_{dd} =0, the parcel is at the "Lifting Condensation Level" (LCL)

If ascent continues above the LCL, condensing water vapour releases latent heat, and this reduces the lapse rate. Thus the Saturated Adiabatic Lapse Rate (SALR) is

$$|\Gamma_s| \leqslant |\Gamma_d|$$

The SALR is height-dependent. Near ground, $\Gamma_s \approx -0.4\,\mathrm{K}/(100\,\mathrm{m})$

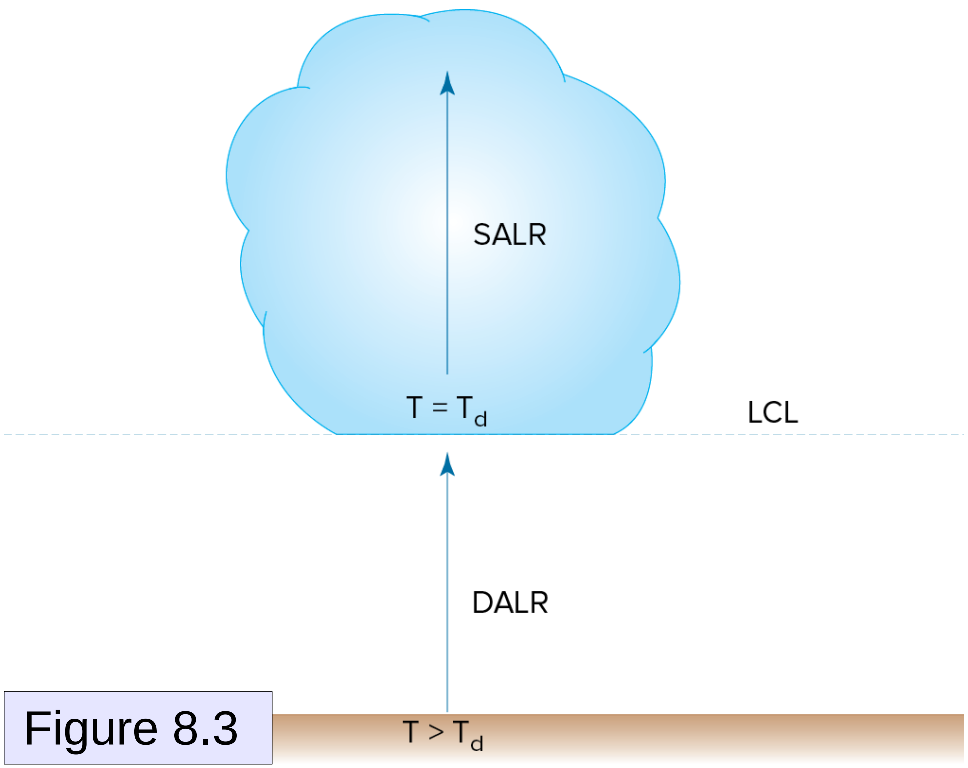


Figure 8.3

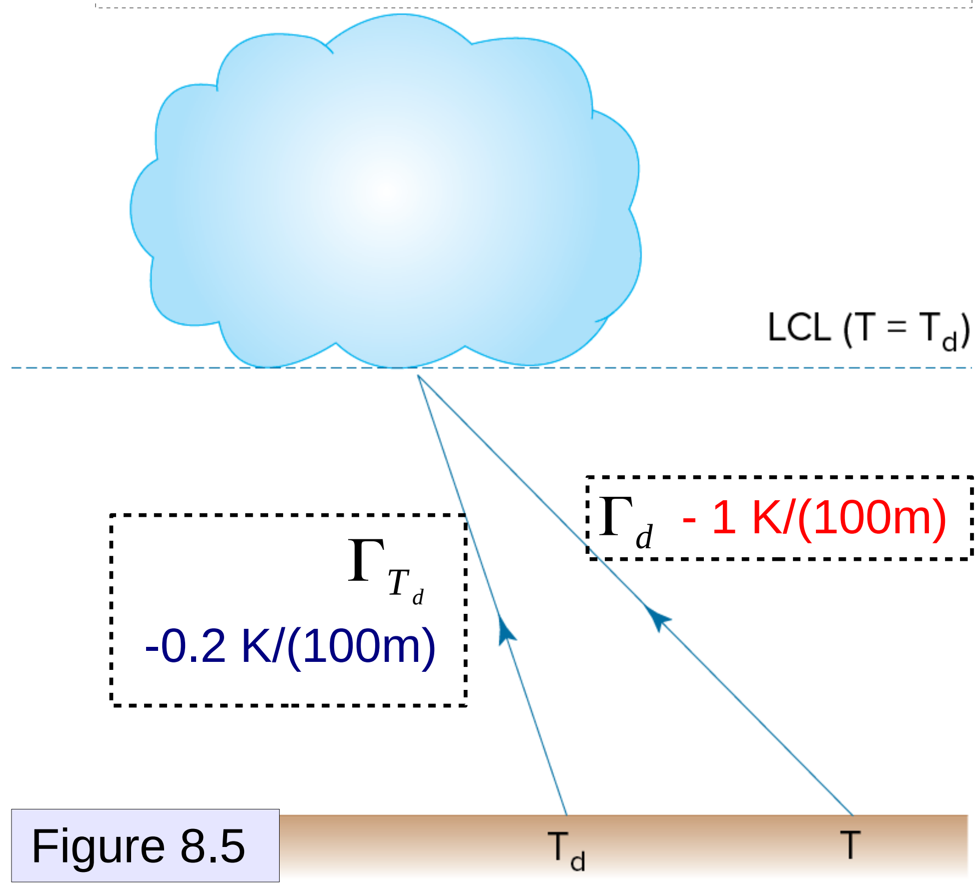
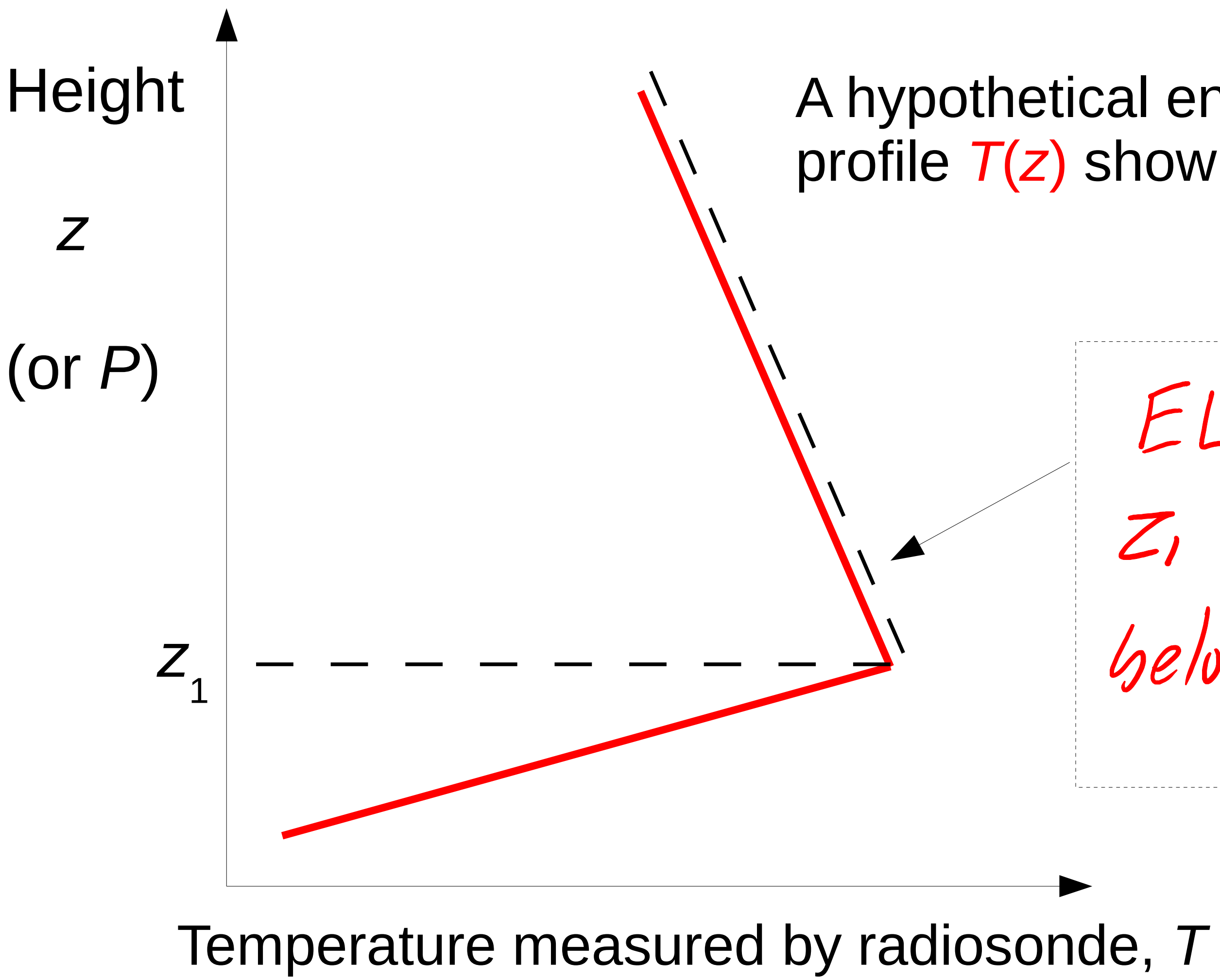


Figure 8.5

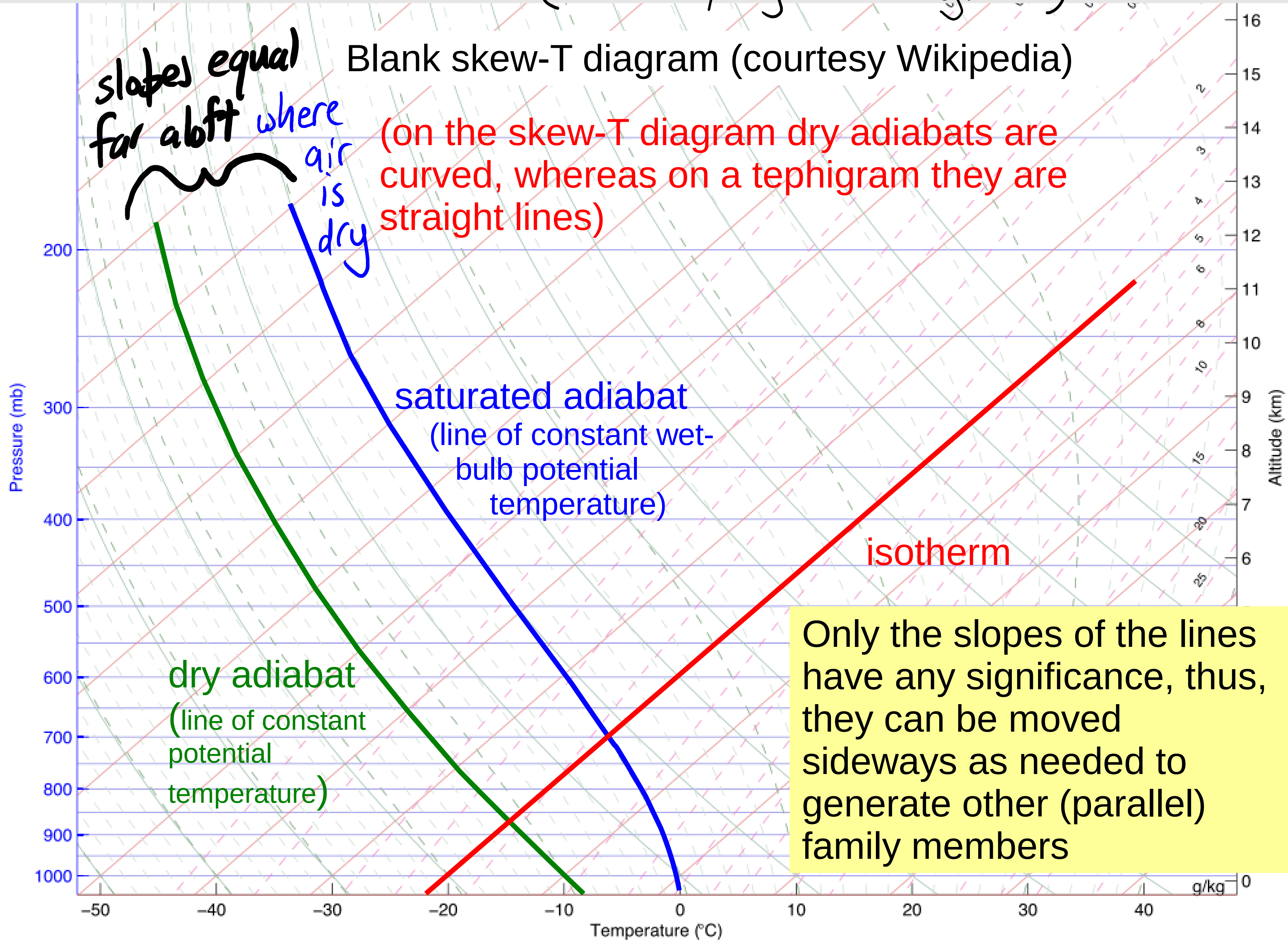


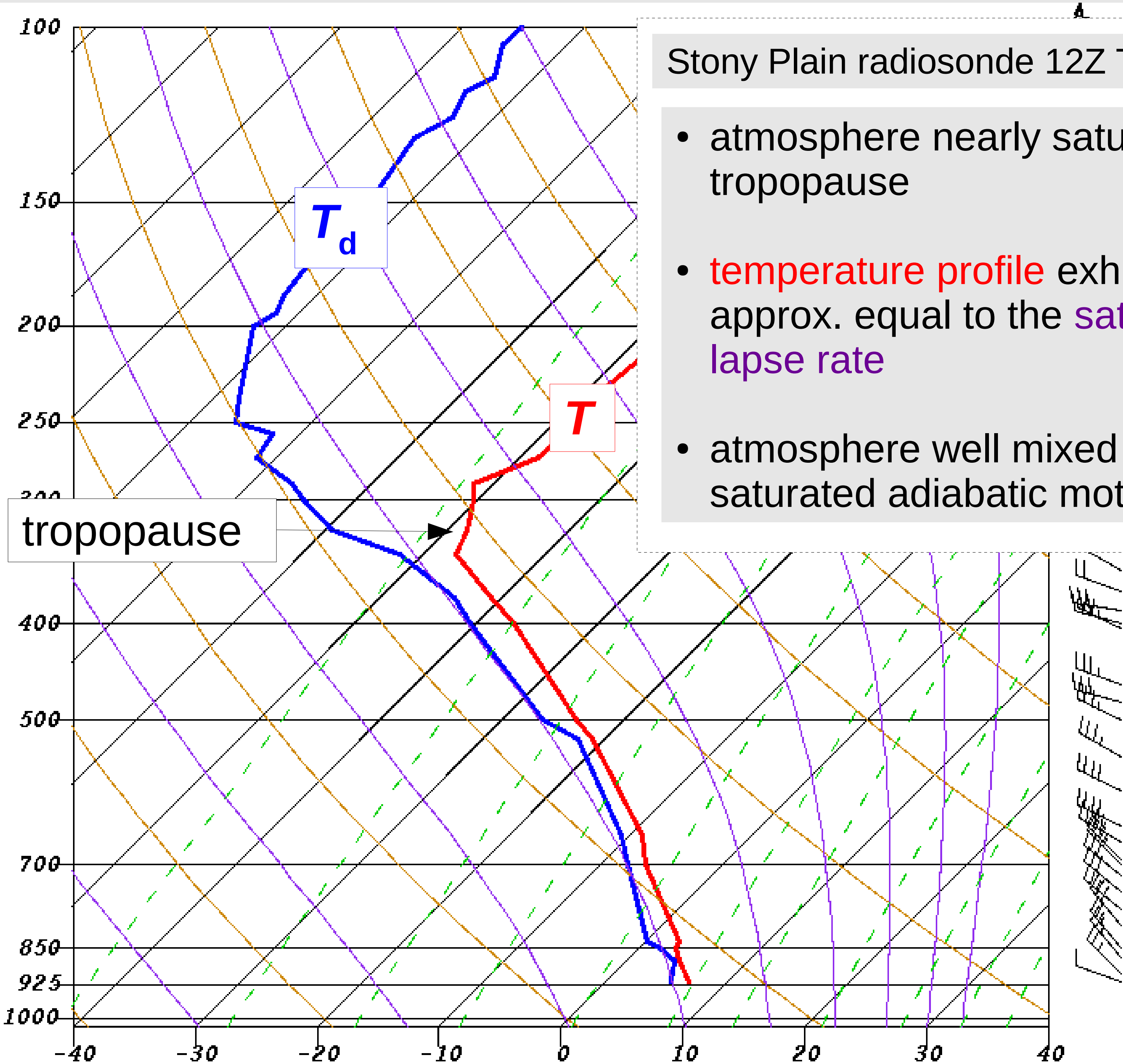
A hypothetical environmental temperature profile $T(z)$ showing an inversion below z_1

ELR is const above z_1 and const. below z_1

This graph is a simple “*x*-*y* plot” of *T* versus height. Atmospheric scientists use several more complicated (but more useful) graphs to display soundings, including the skew-*T* diagram and the tephigram (which are similar). As the skew-*T* diagram is more readily available, this is what I'll use. We'll start with a *blank* skew-*T* chart

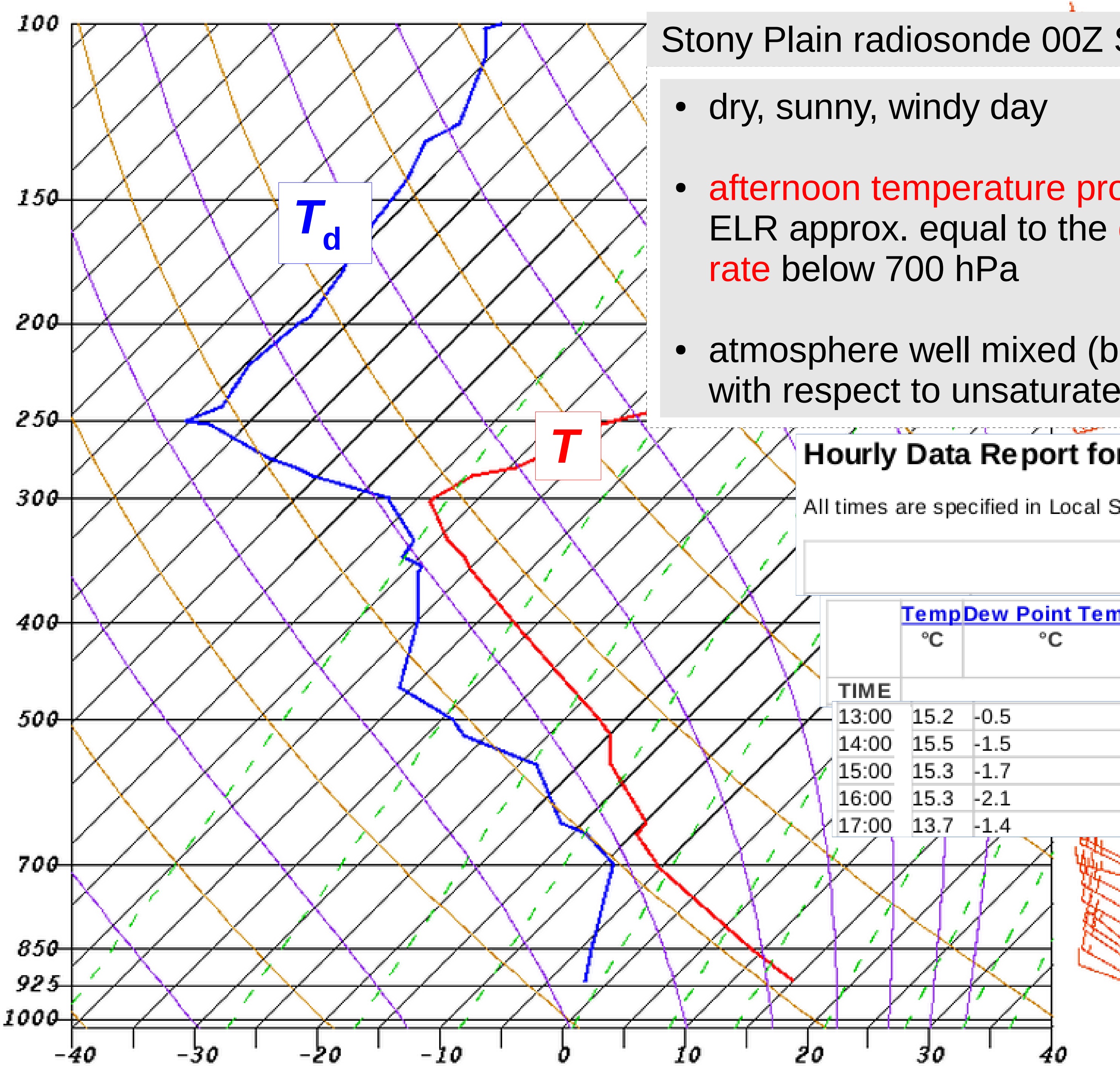
Blank skew-T diagram (courtesy Wikipedia)





Stony Plain radiosonde 12Z Tues 2 Oct. 2012

- atmosphere nearly saturated up to the tropopause
- temperature profile exhibits an ELR approx. equal to the saturated adiabtic lapse rate
- atmosphere well mixed with respect to saturated adiabatic motion



Stony Plain radiosonde 00Z Sun 12 Oct. 2014

- dry, sunny, windy day
- afternoon temperature profile exhibits an ELR approx. equal to the dry adiabtic lapse rate below 700 hPa
- atmosphere well mixed (below 700 hPa) with respect to unsaturated adiabatic motion

Hourly Data Report for October 12, 2014

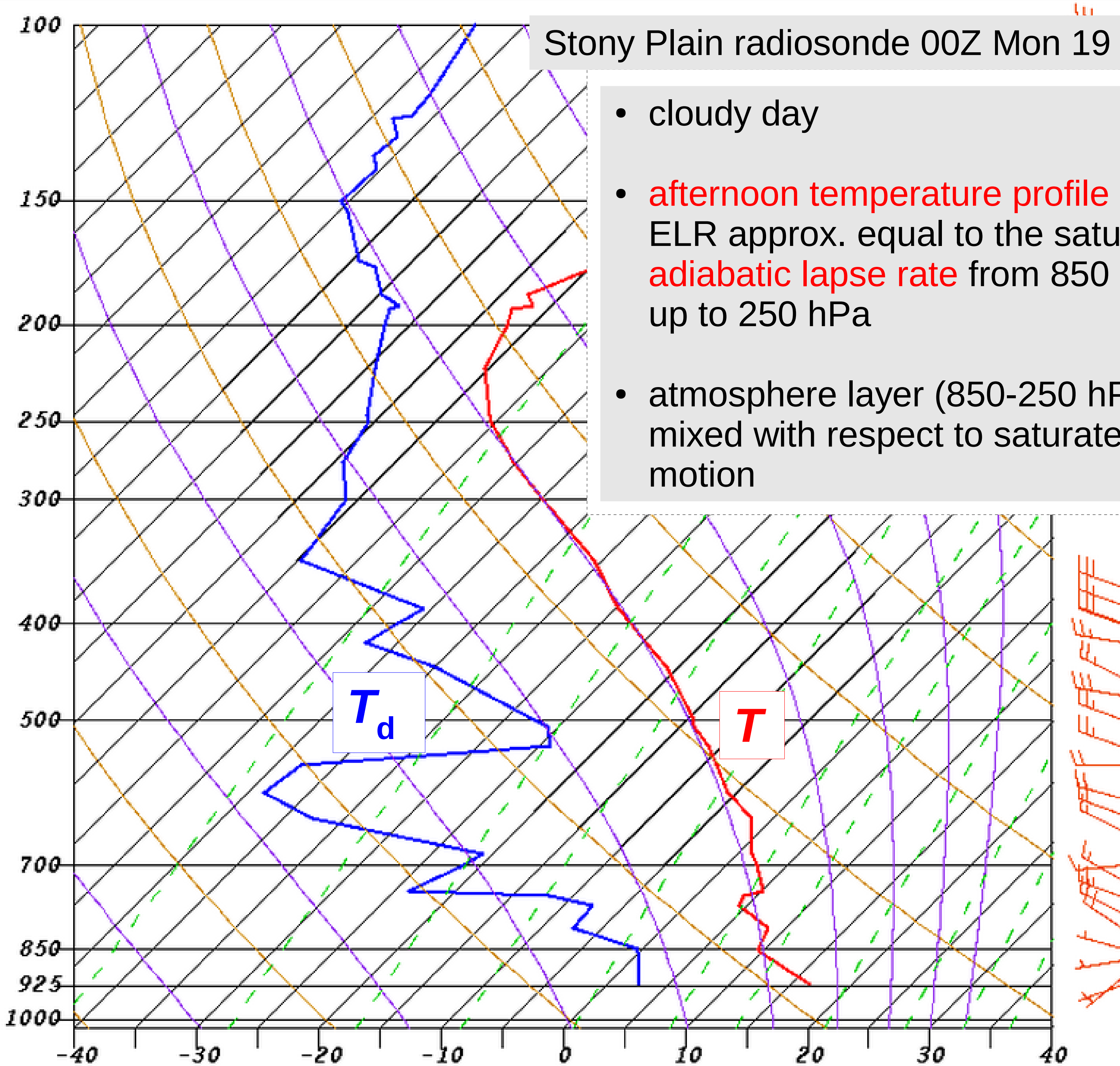
All times are specified in Local Standard Time (LST). Add 1 hour t

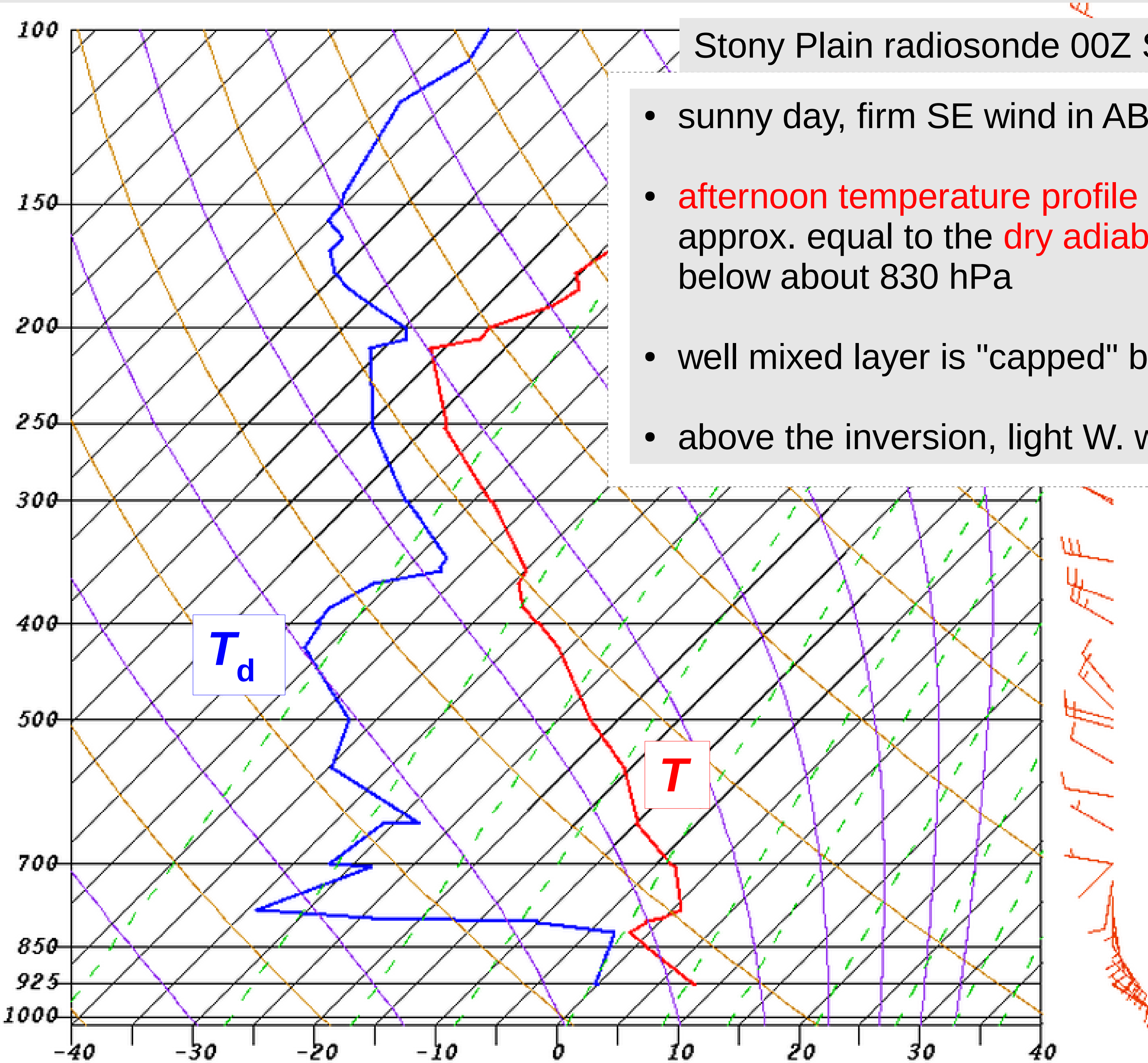
EDMONTON INTL A
ALBERTA

TIME	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h
13:00	15.2	-0.5	34	30	27
14:00	15.5	-1.5	31	30	30
15:00	15.3	-1.7	31	30	27
16:00	15.3	-2.1	30	31	26
17:00	13.7	-1.4	35	35	16

Stony Plain radiosonde 00Z Mon 19 Oct. 2015

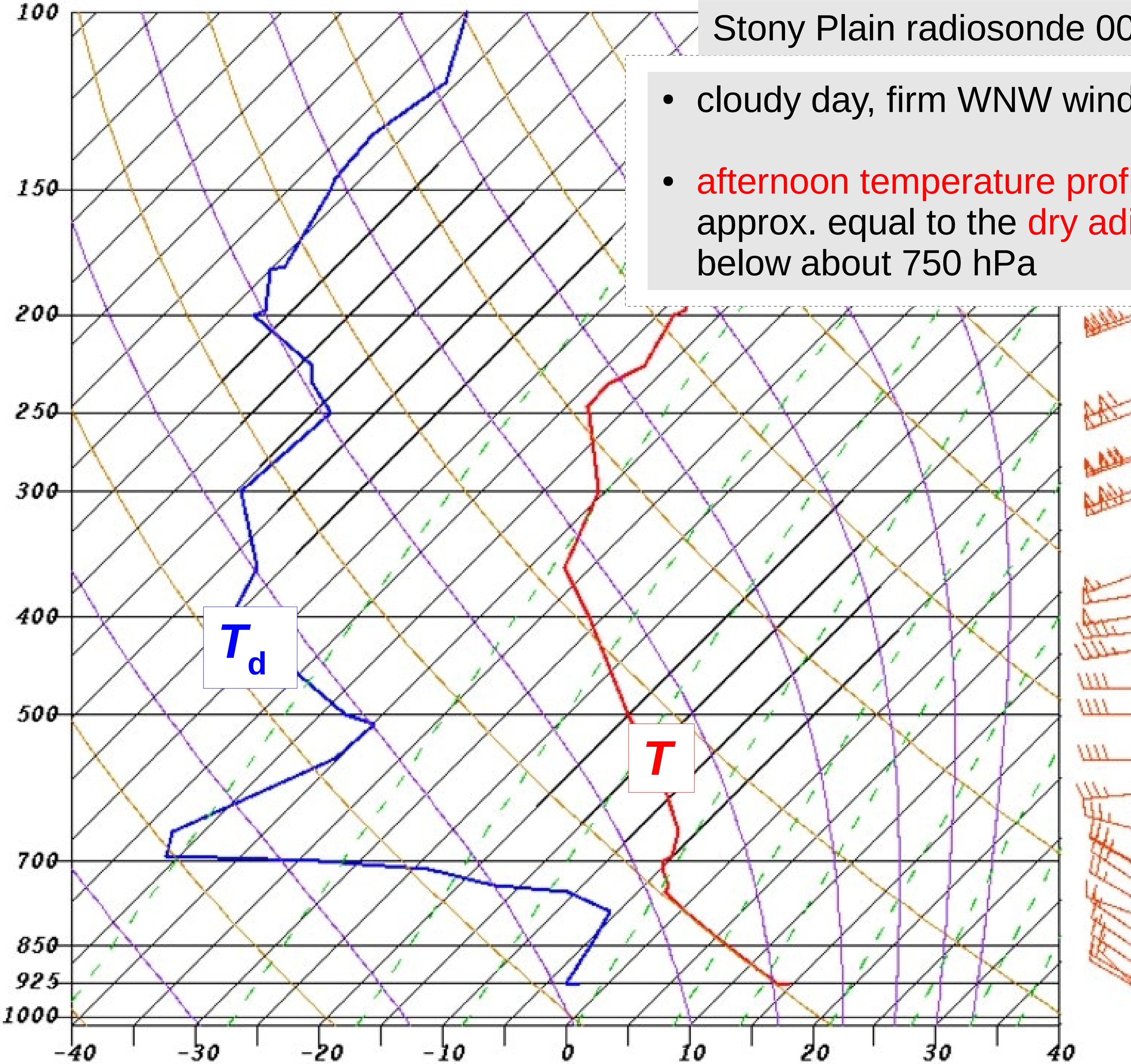
- cloudy day
- afternoon temperature profile exhibits an ELR approx. equal to the saturated adiabatic lapse rate from 850 hPa level up to 250 hPa
- atmosphere layer (850-250 hPa) well mixed with respect to saturated adiabatic motion





Stony Plain radiosonde 00Z Sun 25 Oct. 2015

- sunny day, firm SE wind in ABL
- afternoon temperature profile exhibits an ELR approx. equal to the dry adiabatic lapse rate below about 830 hPa
- well mixed layer is "capped" by an inversion
- above the inversion, light W. wind & very dry



Stony Plain radiosonde 00Z 28 Sep. 2016

- cloudy day, firm WNW wind in ABL
- afternoon temperature profile exhibits an ELR approx. equal to the dry adiabatic lapse rate below about 750 hPa

"Neutral (static) stability" of an unsaturated layer

- ELR is equal to the dry adiabatic lapse rate (10K per kilometer)
- such a layer is termed "neutral with respect to dry adiabatic motion"

"Neutral stability" of a saturated layer

- ELR is equal to the saturated adiabatic lapse rate
- such a layer is "neutral with respect to saturated adiabatic motion"

- a well-mixed layer of air tends to have "neutral stability" (tends to be be "neutrally stratified")
- thus the ELR allows us to diagnose whether air has been subjected to a lot of mixing
- windy summer afternoons typically result in the layer from about 50-1000 m AGL being neutrally stratified (well mixed)

Topics/concepts covered

- effect of mixing on the ELR
- benchmarks for the ELR (the DALR and SALR)
- definition and utility of the potential temperature
- constancy of potential temperature during unsaturated adiabatic motion
- families of curves on the skew-*T* diagram
- (non-) variation with height of potential temperature in a layer whose ELR equals the DALR
- dry adiabat is a line of constant potential temperature