

Moist convection

Announcements

1. Mid term: **13 October** (Tuesday after next)
 - *Intended to be non-traumatic based on class material (lectures, reading, exercises) homework).*
 - *In class, about an hour*
 - *End of chapter 3*
 - *Watch for HW 2 next week.... might be good practice.*

1. Field trip: **5 November** (Thursday, about 4 weeks time)
 - To.... The exotic East Boulder Rec. Center (probably...to be confirmed)
 - Bus RTD 203 directly back to campus (Broadway)
 - Start of/intro to chapter 5

Lifting condensation level

- Height at which a parcel initially at the surface becomes saturated when lifted (dry) adiabatically
- Intersection of dry adiabat and mixing ratio
- Often sets the cloud base height

Level of free convection

- The height at which the temperature of a rising air parcel (T_{parcel}) first exceeds the temperature of the environment (T_{env}).
- *Follow the moist adiabat above the LCL*
- *Often near base of convective cloud.*

Level of neutral buoyancy

- Height at which a parcel rising (moist) adiabatically, reaches the same temperature as the environment.
- *Often at top of convective storms near the tropopause, and forms the anvil as clouds detrain*

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100

200

300

400

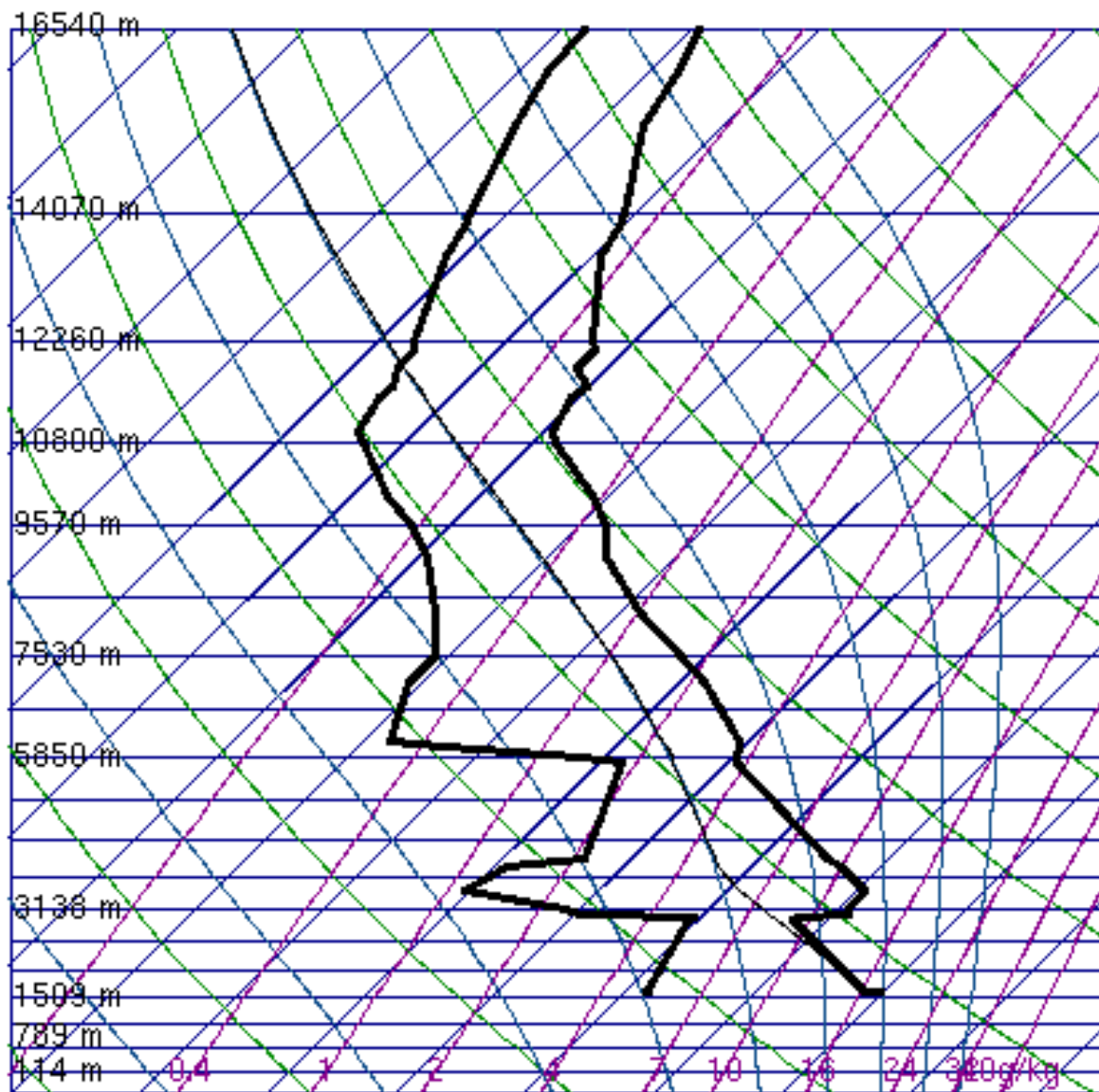
500

600

700

800

900

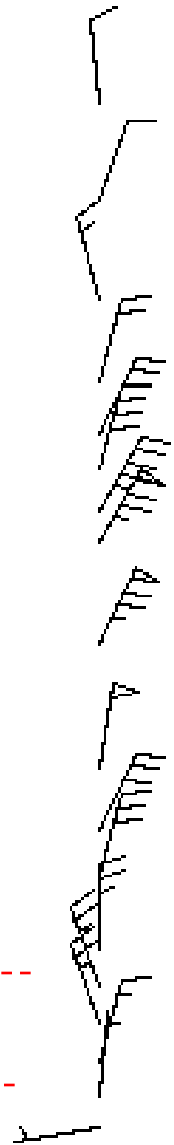
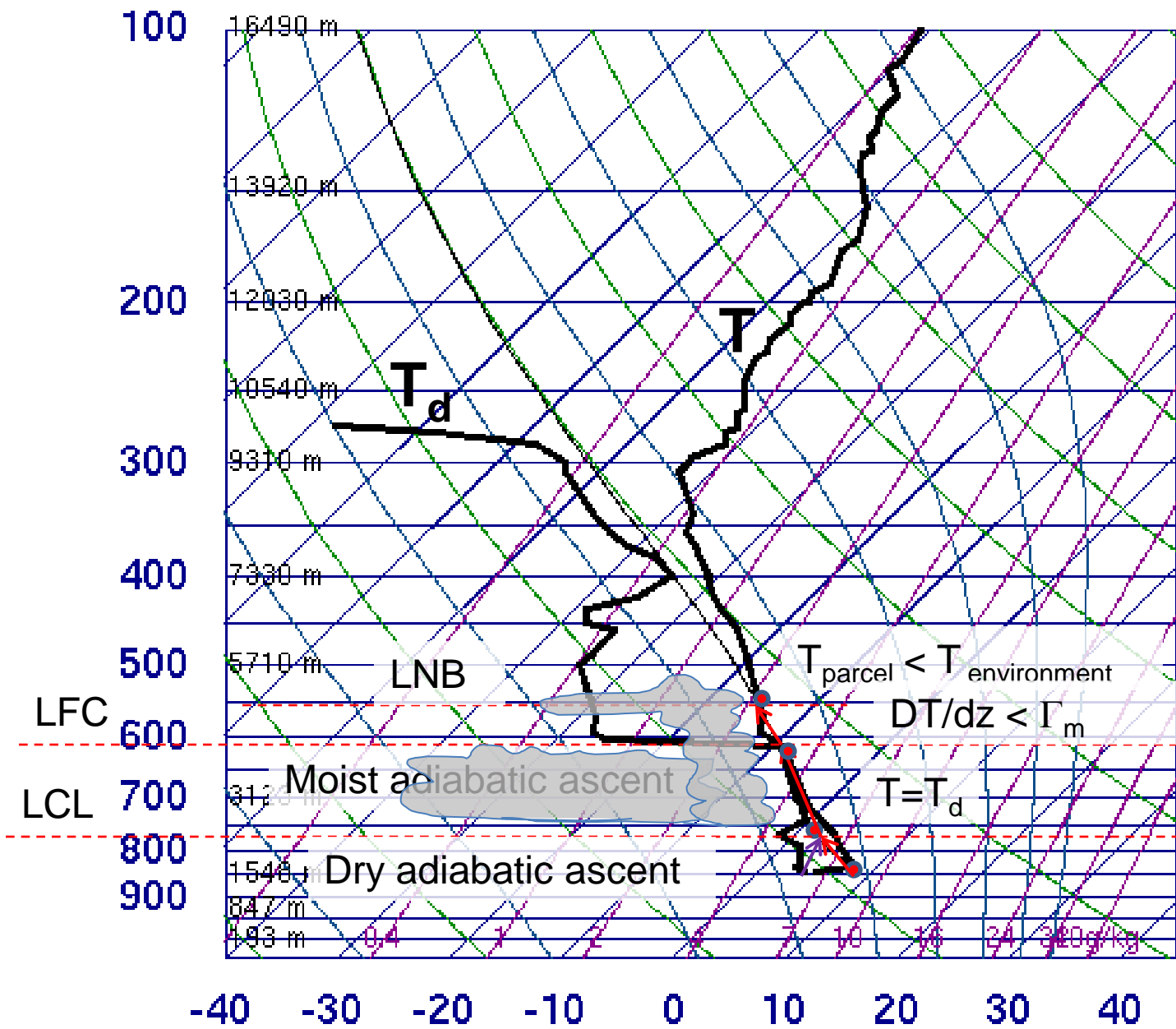


SLAT	39.75
SLON	-104.87
SELV	1625.
SHOW	-9999
LIFT	4.97
LFTV	4.80
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	271.1
LCLP	645.9
MLTH	307.2
MLMR	5.15
THCK	5736.
PWAT	11.40

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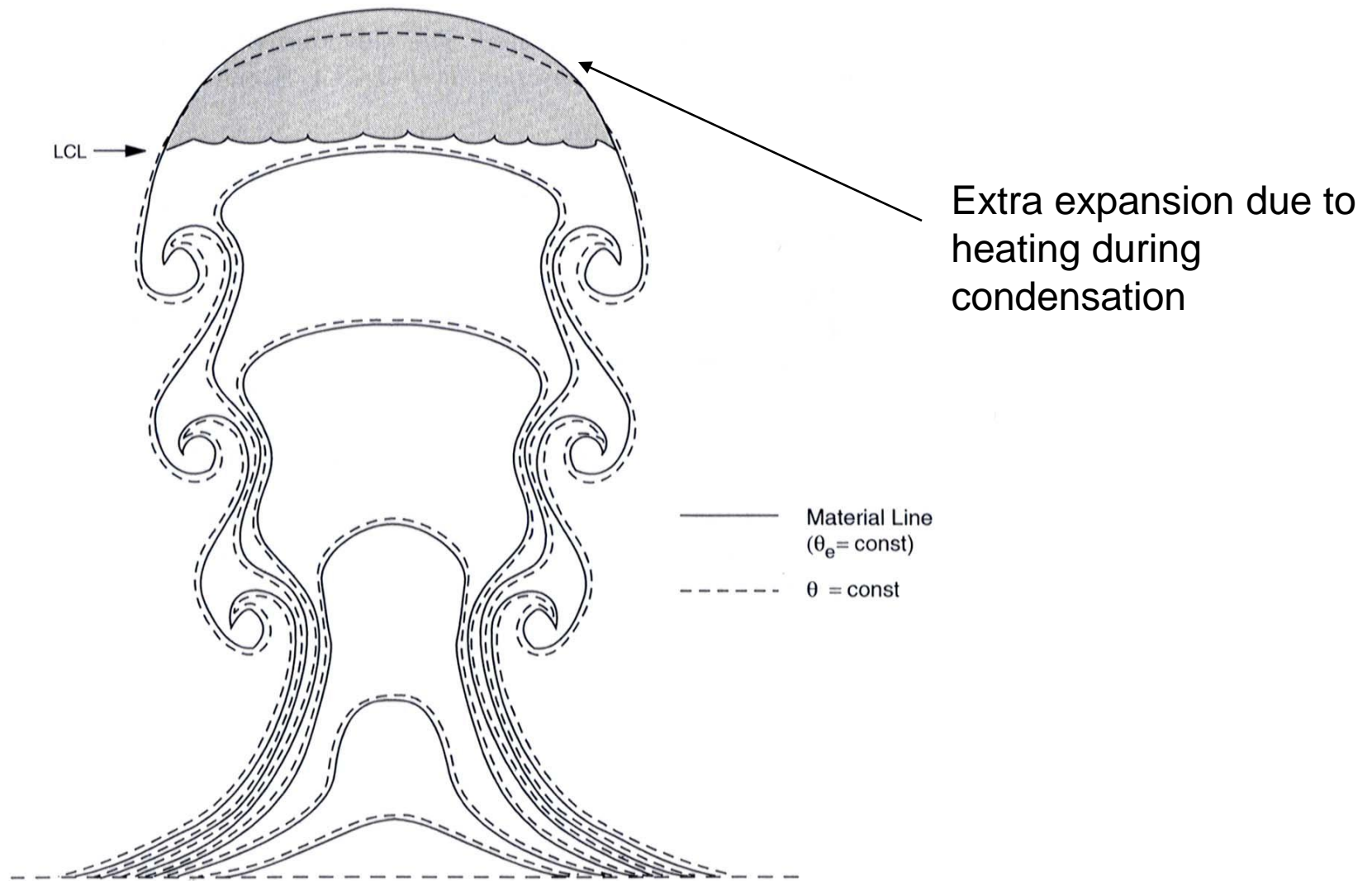


- SLAT 3
- SLON -3
- SELV 1
- SHOW -9
- LIFT 1
- LFTV 0
- SWET -9
- KINX -9
- CTOT -9
- VTOT -9
- TOTL -9
- CAPE 1
- CAPV 1
- CINS -9
- CINV -9
- EQLV 5
- EQTV 5
- LFCT 6
- LFCV 6
- BRCH 0
- BRCV 0
- LCLT 2
- LCLP 7
- MLTH 2
- MLMR 5
- THCK 5
- PWAT 1

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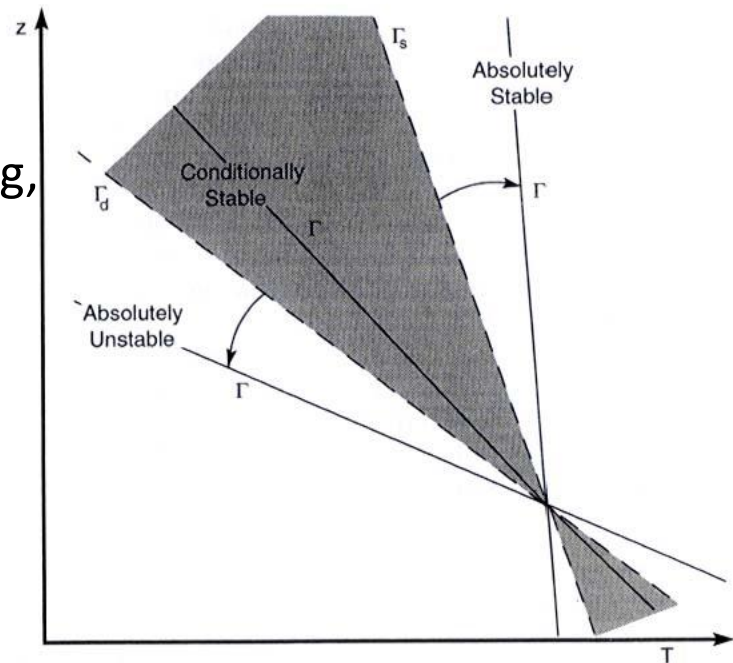
Enhanced buoyancy with condensation



Moisture and buoyancy

- As a moisture condenses it changes the parcel heat from latent to a sensible form which can effect volume and density.
(i.e., we can replace θ with θ_e)
- As such, the lapse rate a parcel follows changes from dry to moist adiabatic.
- As the moist adiabatic lapse rate is a weaker constraint, the buoyancy may increase
- So we have additional conditions for determining the stability of the environmental profile:

- 1) $\Gamma < \Gamma_s$ absolutely stable
(positive restoring, condensation of not)
- 2) $\Gamma > \Gamma_d$ absolutely unstable (negative restoring, condensation or not)
- 3) $\Gamma_s < \Gamma < \Gamma_d$ conditionally stable (positive restoring while unsaturated, but negative restoring if condensation occurs)



Convective instability

- Conditional stability refers to the parcel somewhere in the environment
- Define convective instability (or potential instability) that is unstable only if the parcel is sufficiently modified by displacement.
- Should a displacement allow condensation, the parcel can extract additional energy from the profile
- Energy is released - can do (expansion) work, or be converted to kinetic energy (this is the convective available potential energy, CAPE)
- Rather than considering the lifting condensation level (LCL), we also have a level of free convection (LFC) on a thermodynamic chart
- Very energetic system, e.g. where there is substantial amounts of CAPE or as the profile is very unstable, the buoyancy is greatly enhanced and deep convective plumes. E.g. tropical storms, Supercells of Oklahoma, afternoon storms over Boulder
- However, this requires some kind of trigger to allow the release of CAPE

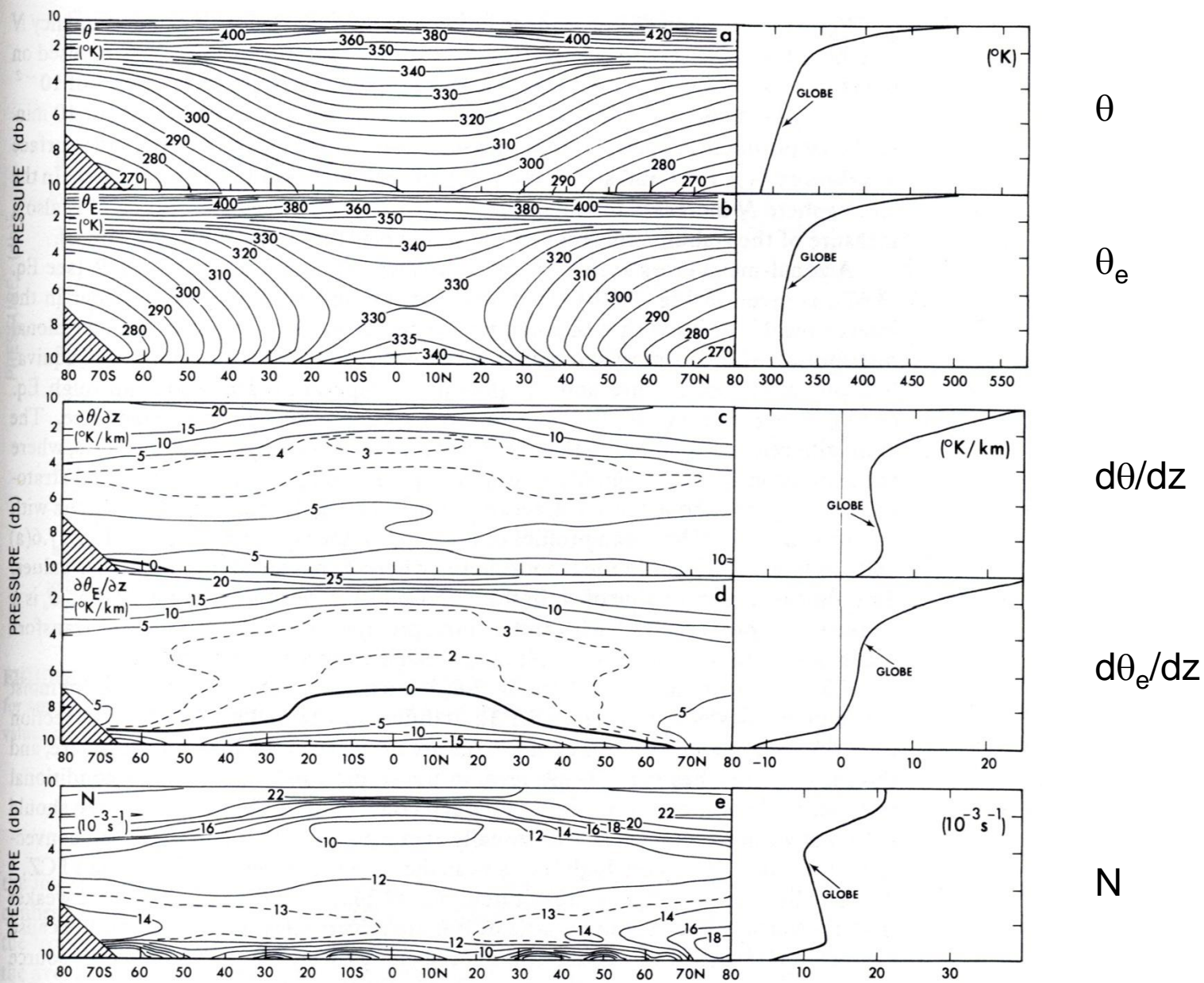


FIGURE 7.6. Zonal-mean cross sections of the potential temperature (a) in K, equivalent potential temperature (b) in K, vertical gradient of potential temperature (c) in K/km, vertical gradient of equivalent potential temperature (d) in K/km, and Brunt-Väisälä frequency in $10^{-3} \text{ rad s}^{-1}$ for annual-mean conditions. Vertical profiles of the global mean values are shown on the right.

Consequences

- If the atmosphere is unstable with respect to the dry adiabat (absolutely unstable), it will over turn.

This *guarantees* high potential temperature is on top

- If the atmosphere is unstable with respect to the moist adiabat, it *may* over turn, but requires a “trigger”
- In either case, convection ensures that the atmosphere is thermally stratified, and is at least neutrally stable on the large scale.
- As such, most large-scale and mostly adiabatic motion is horizontal