SESSION 5: BOUNDARY LAYER INTRODUCTION

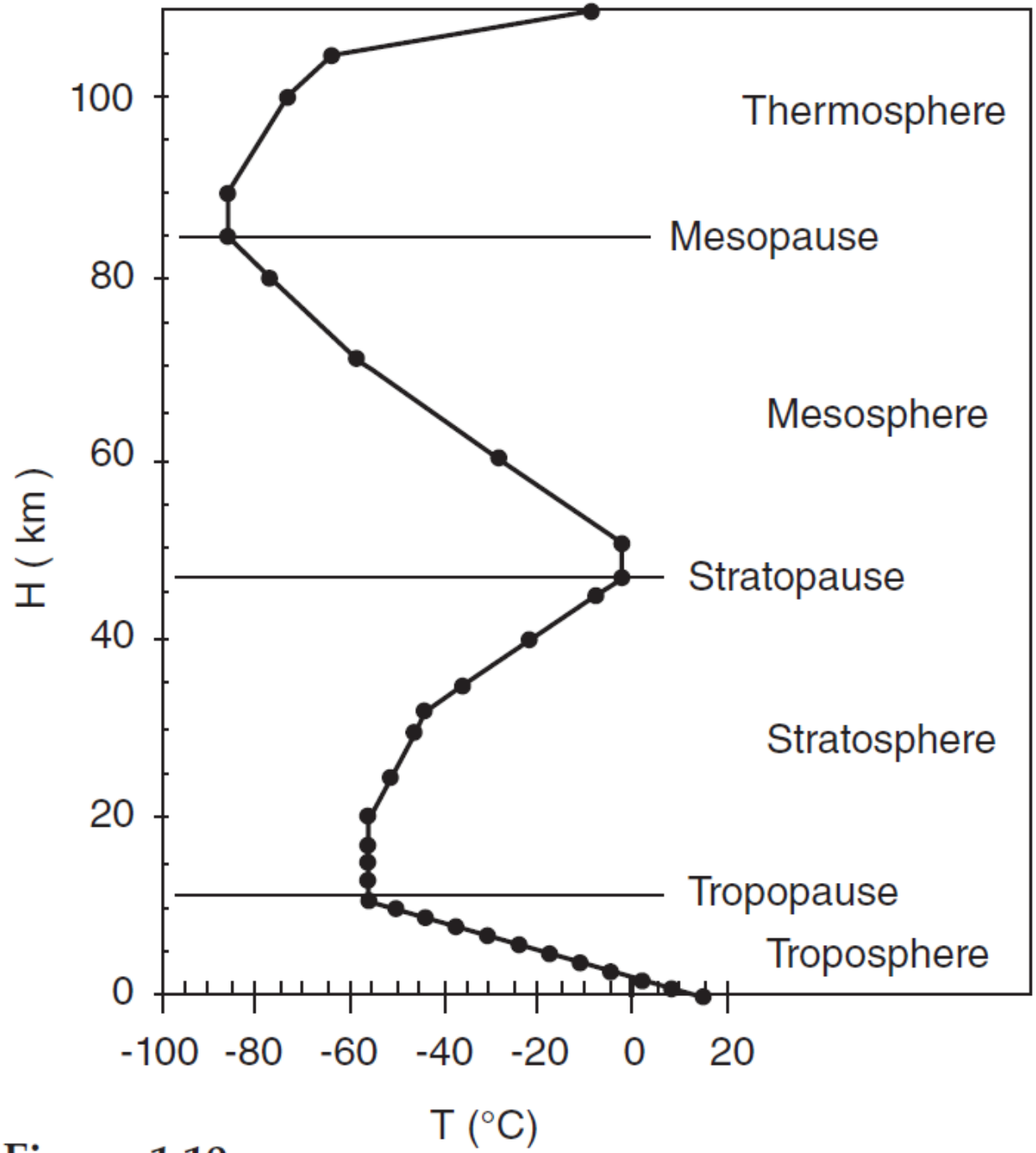
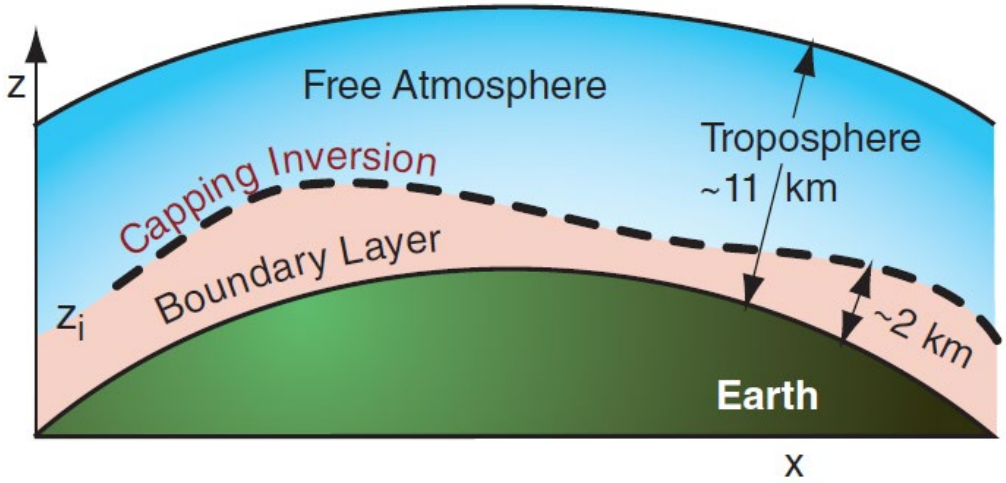

Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
H (km)
100
80
60
40
20
0
-100
-80
-60
-40
-20
0
20
T (°C)

Figure 1.10

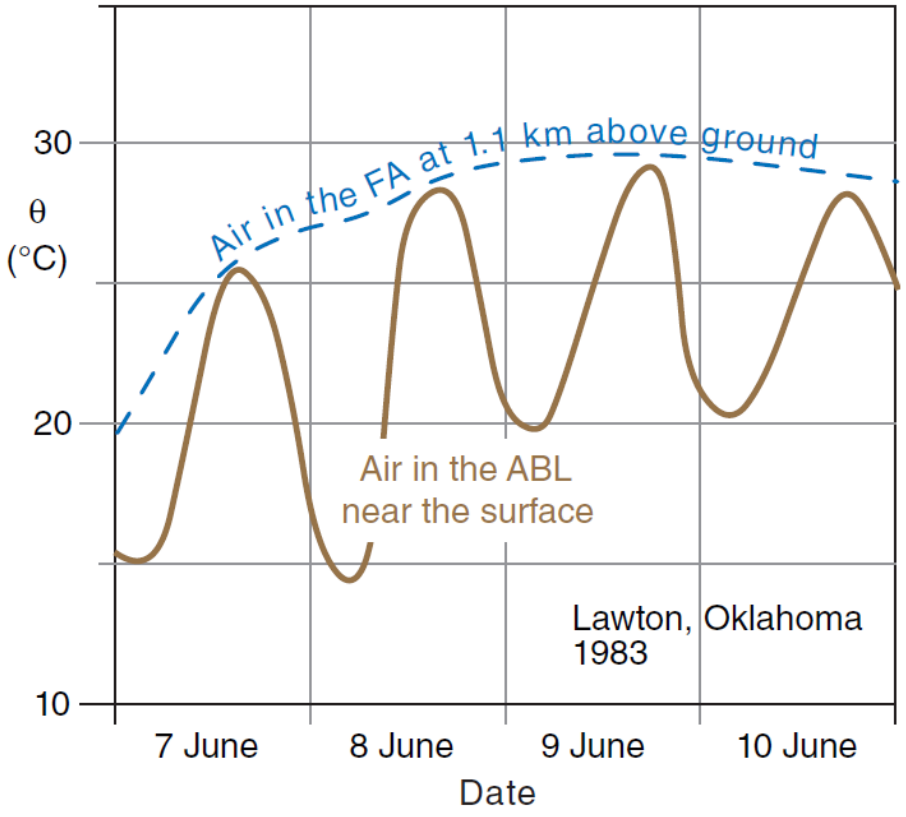
THE ATMOSPHERIC BOUNDARY LAYER

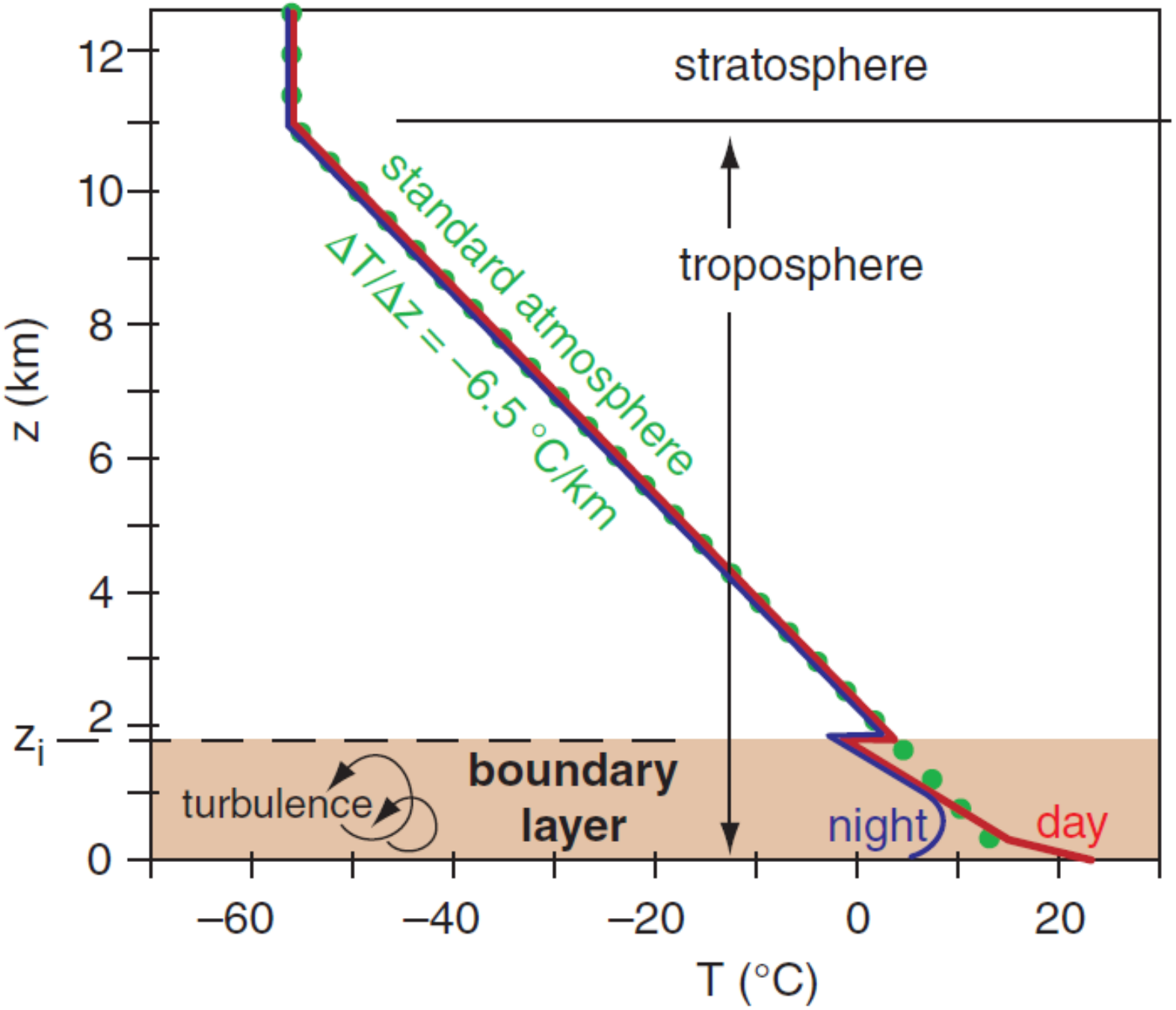
- The ABL (or PBL or BL) is:
  - The portion of the atmosphere that "feels" the effects of Earth's surface → the lower *boundary* of the atmosphere.
  - Typically between 300 and 3000 m thick →
    - Thickness varies in space and time.
  - Is often turbulent in contrast to the free atmosphere (FA).



THE ATMOSPHERIC BOUNDARY LAYER

- The ABL (or PBL or BL):
  - Experiences a daily (*diurnal)* cycle of temperature, humidity, wind, and pollution variation not present in the free atmosphere




stratosphere
troposphere
standard atmosphere
ΔT/ΔZ = –6.5 °C/km
boundary layer
turbulence
night
day
z (km)
z_i
12
10
8
6
4
2
0
–60
–40
–20
0
20
T (°C)

THE ATMOSPHERIC BOUNDARY LAYER

- Boundary layer formation and characteristics are driven by static stability and the resulting atmospheric fluxes.

- Static stability: the tendency of a parcel (bubble) of air to rise or sink based on buoyancy.
  - Adiabatic expansion / compression
  - Lapse rates

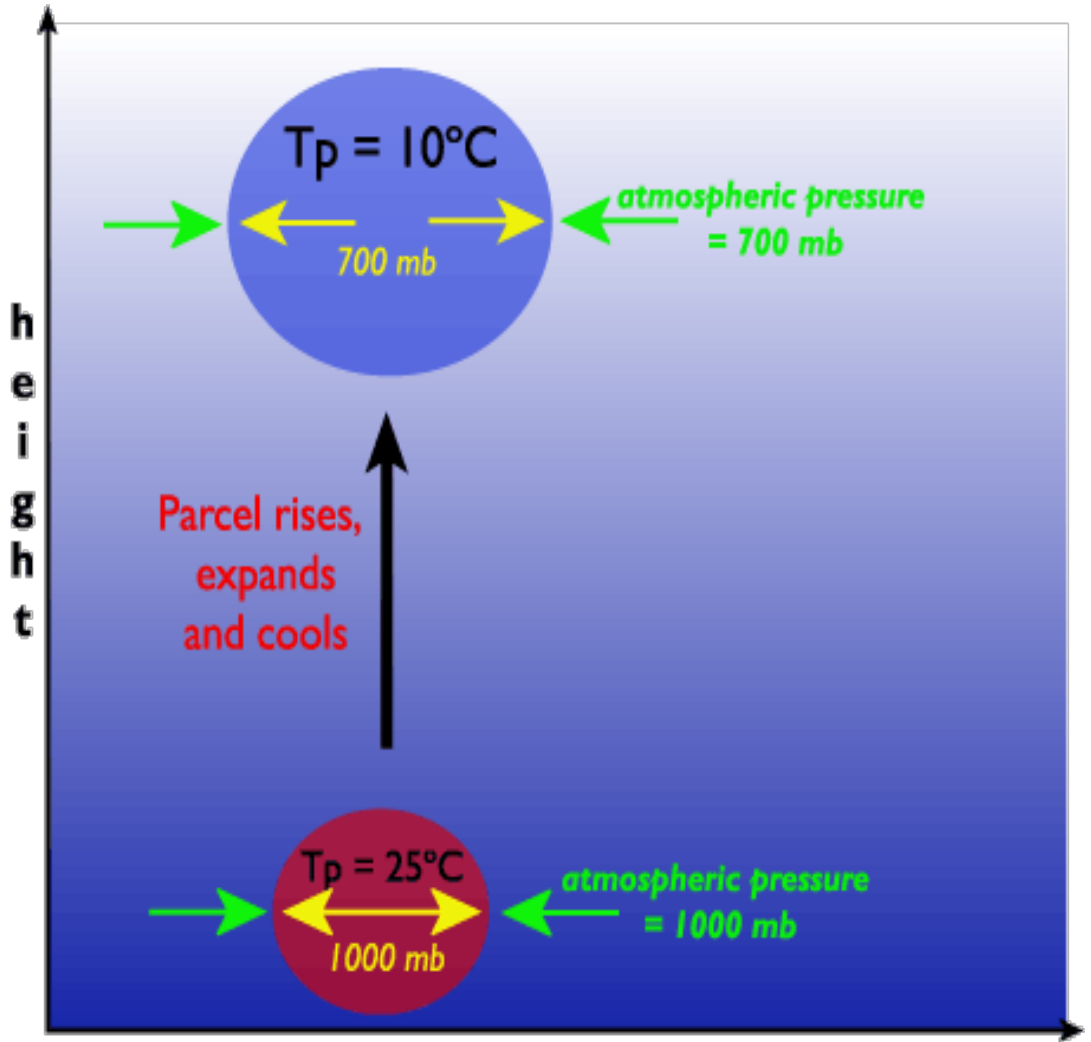
- Flux: the transfer of a quantity per unit area per unit time.
  - Mass flux (kg
  - Heat flux
    - Sensible
    - Latent

BL STABILITY

- If a parcel of air is warmer than its environment, it is positively buoyant and rises.
- If a parcel of air is cooler than its environment, it is negatively buoyant and sinks.
- There is zero buoyant force is the parcel and the environment are the same temperature.
- The environmental temperature is measured (or the standard atmosphere is used). What about the air parcel?

AIR PARCEL TEMPERATURE

- Based on theory and some initial state. Then…



$$\frac{dT}{dz} = 10\ ^{\circ}\mathrm{C}\ /\ \mathrm{km}$$

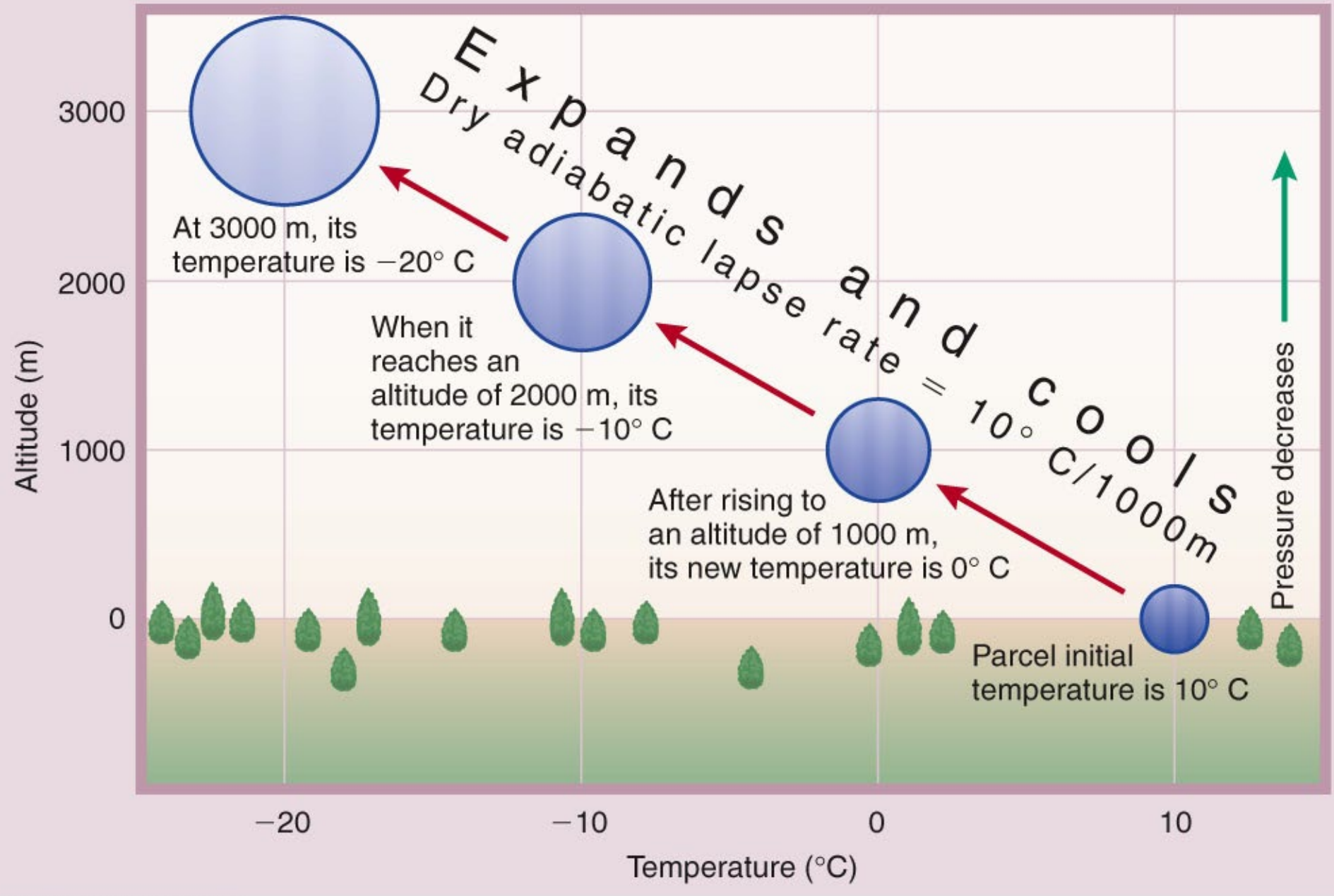
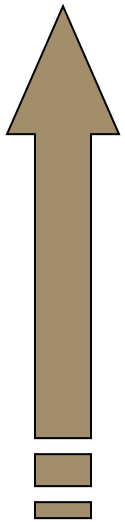


Fig. 3-17, p. 72

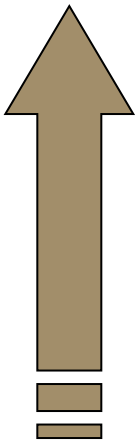
Determining Stability

- Compare environmental & parcel temp



HEIGHT	ENVIRON TEMP	PARCEL TEMP
3 km AGL	-2 °C	?
2 km AGL	6 °C	?
1 km AGL	19 °C	?
SFC	28 °C	30

TEMPERATURE INVERSION LAYER



HEIGHT	ENVIRON TEMP	PARCEL TEMP	
3 km AGL	36 °C	?	0
2 km AGL	34 °C	?	10
1 km AGL	32 °C	?	20
SFC	30 °C	30	

STABILITY SUMMARY

- Stable Boundary Layers are characterized by a lack of vertical motion, calm winds, and reduced turbulence. An inversion is usually present and skies are frequently clear. The boundary layer is shallow.

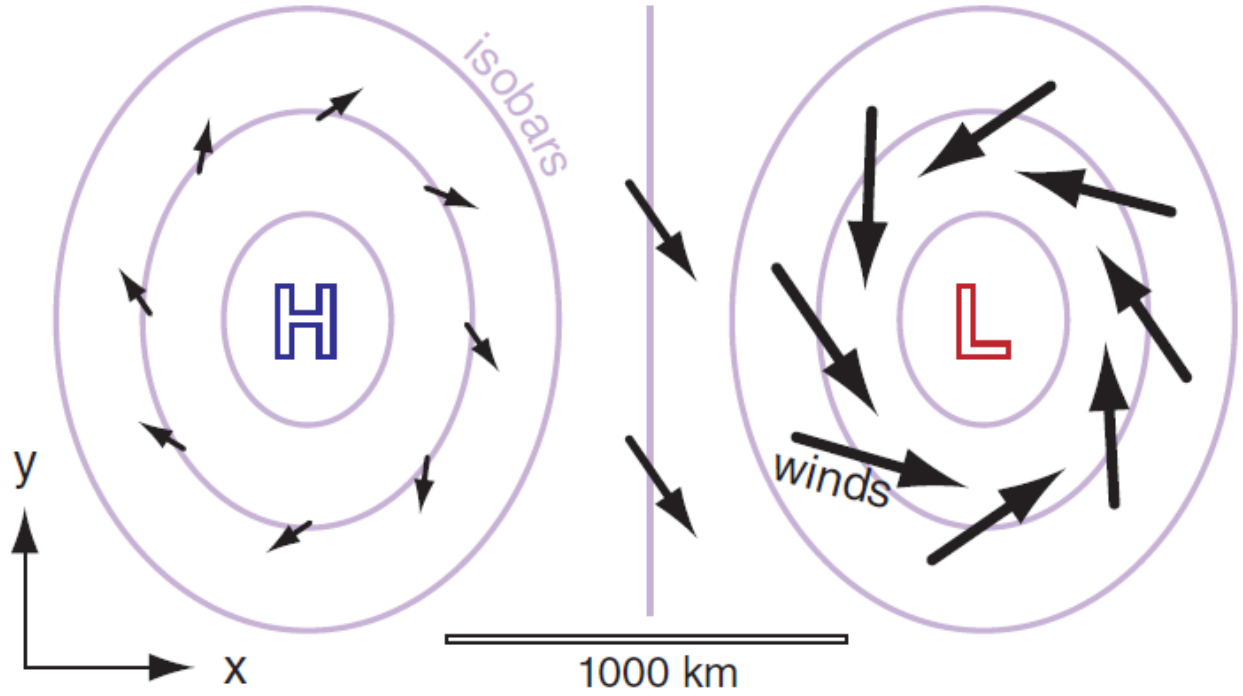
- Unstable boundary layers are characterized by vertical motion, tall cumulus clouds, and turbulence. These boundary layers can be several kilometers deep.

STABLE BL

UNSTABLE BL

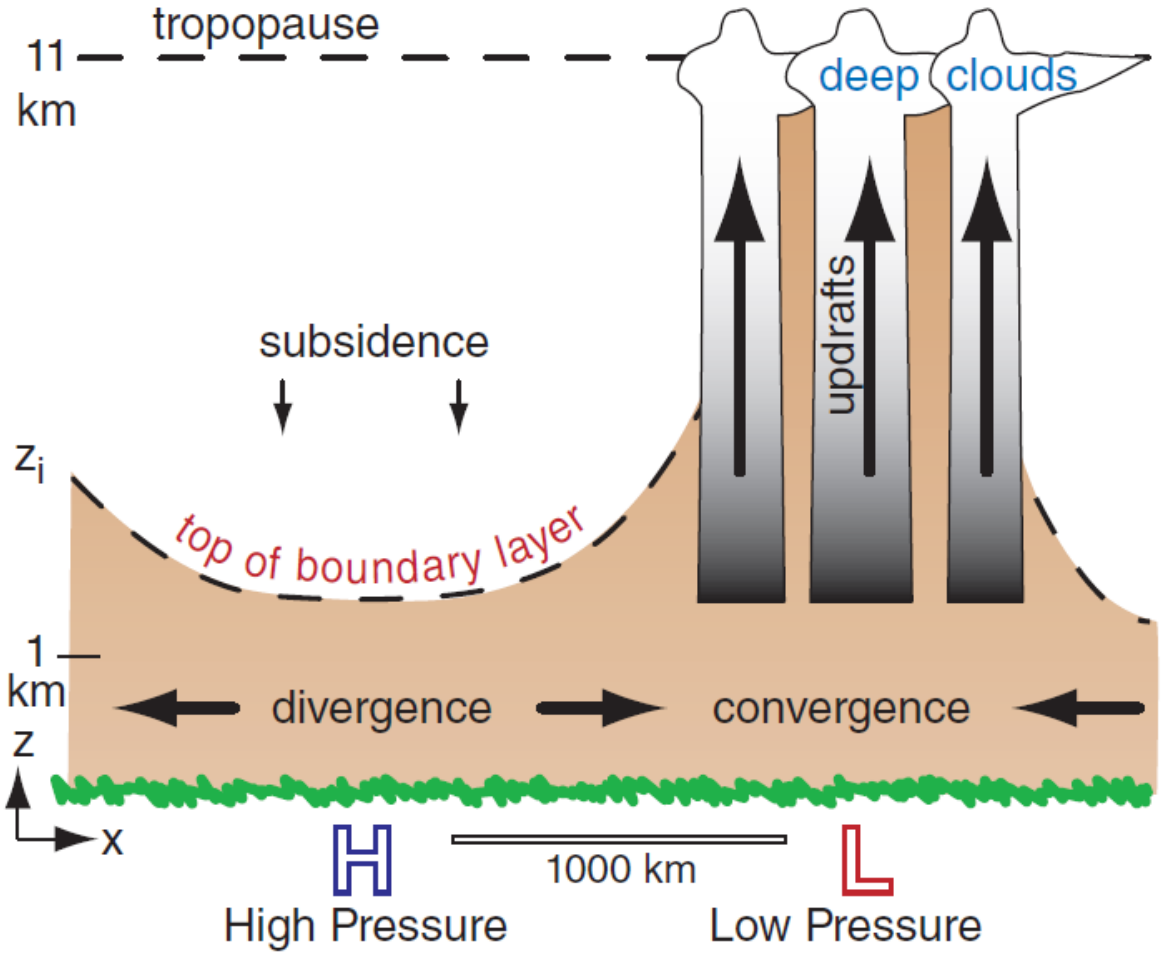
SYNOPTIC CONSIDERATIONS

- Synoptic weather patterns modulate the ABL. Recall the surface (ABL) winds in relation to High and Low pressure



SYNOPTIC CONSIDERATIONS

- Patterns of subsidence and updrafts are associated with Highs and Lows



SYNOPTIC CONSIDERATIONS

- ABL air that stagnates can acquire the characteristics of the region it stagnates over. Thus, and air mass is a body of air that has similar:
  - Temperature
  - Moisture
  - Pollutants

- The boundary between two different air masses is called a front. There are 4 – 5 types of fronts:
  - **Cold**
  - **Warm**
  - Stationary
  - Occluded
  - Dryline

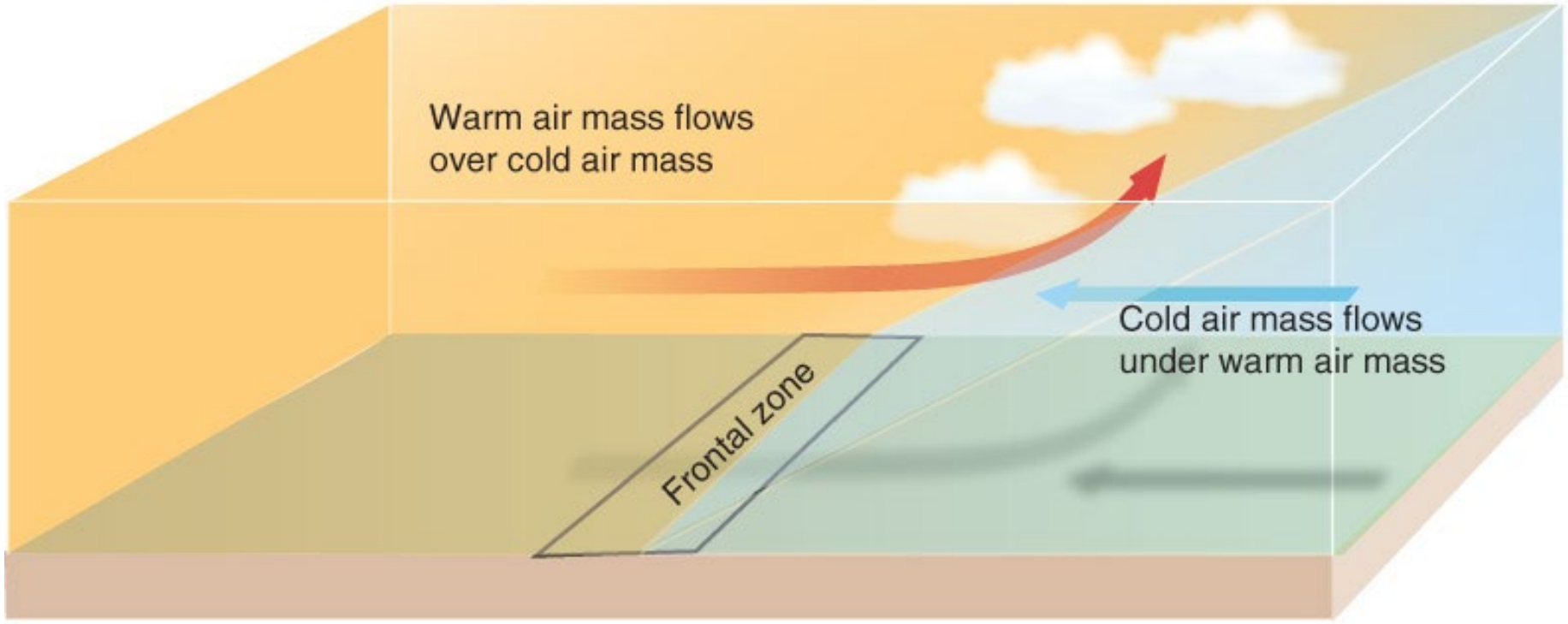
FRONTS

- Air masses are regions of air that have similar temperature moisture characteristics.
  - Advance and retreat
  - Do not readily mix together

- **Front** – A boundary between two different air masses.
  - Can be hundreds of miles long

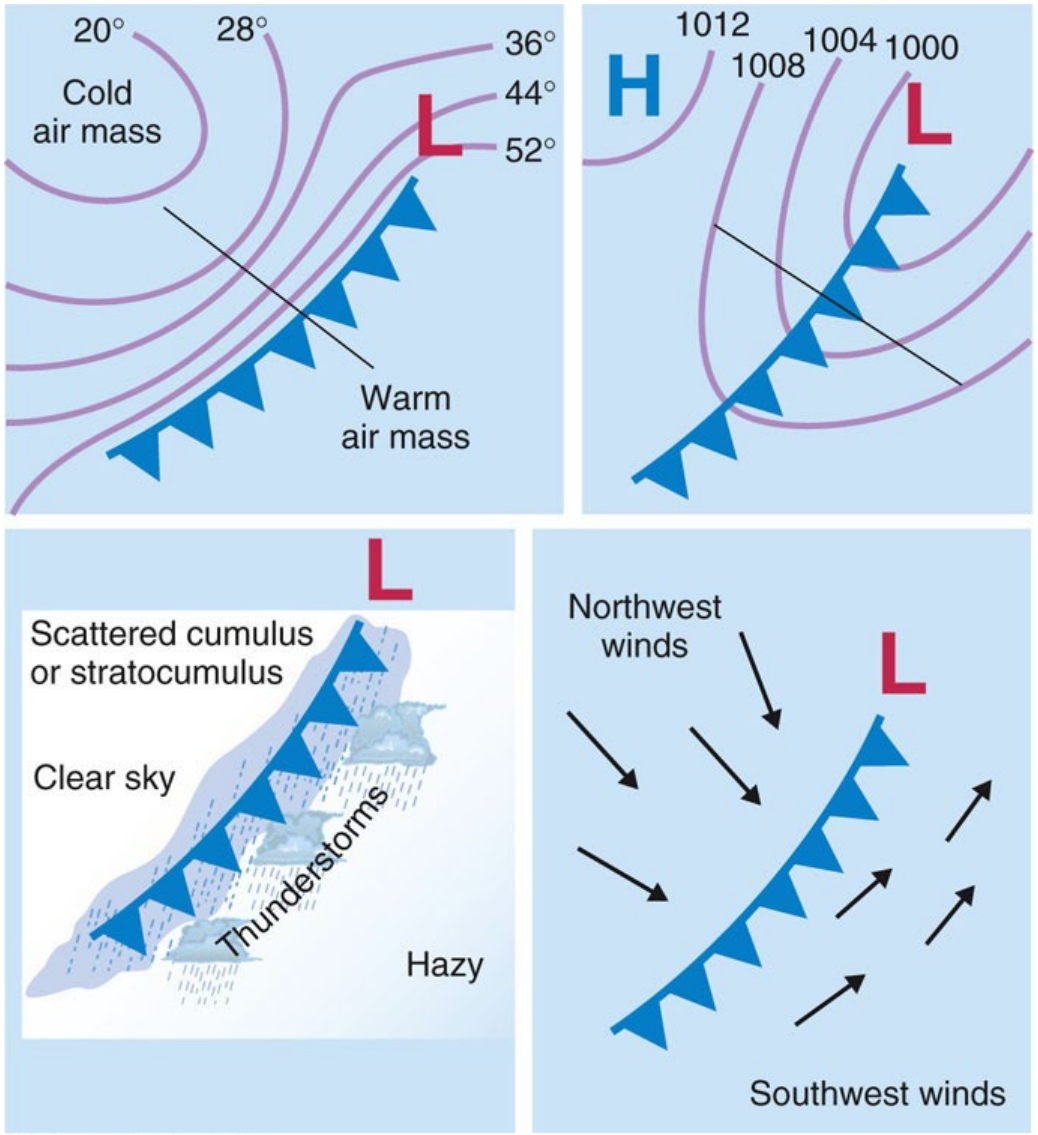
FRONTS

- A generic conceptual model:



- Four types: cold, warm, stationary, and occluded

COLD FRONTS



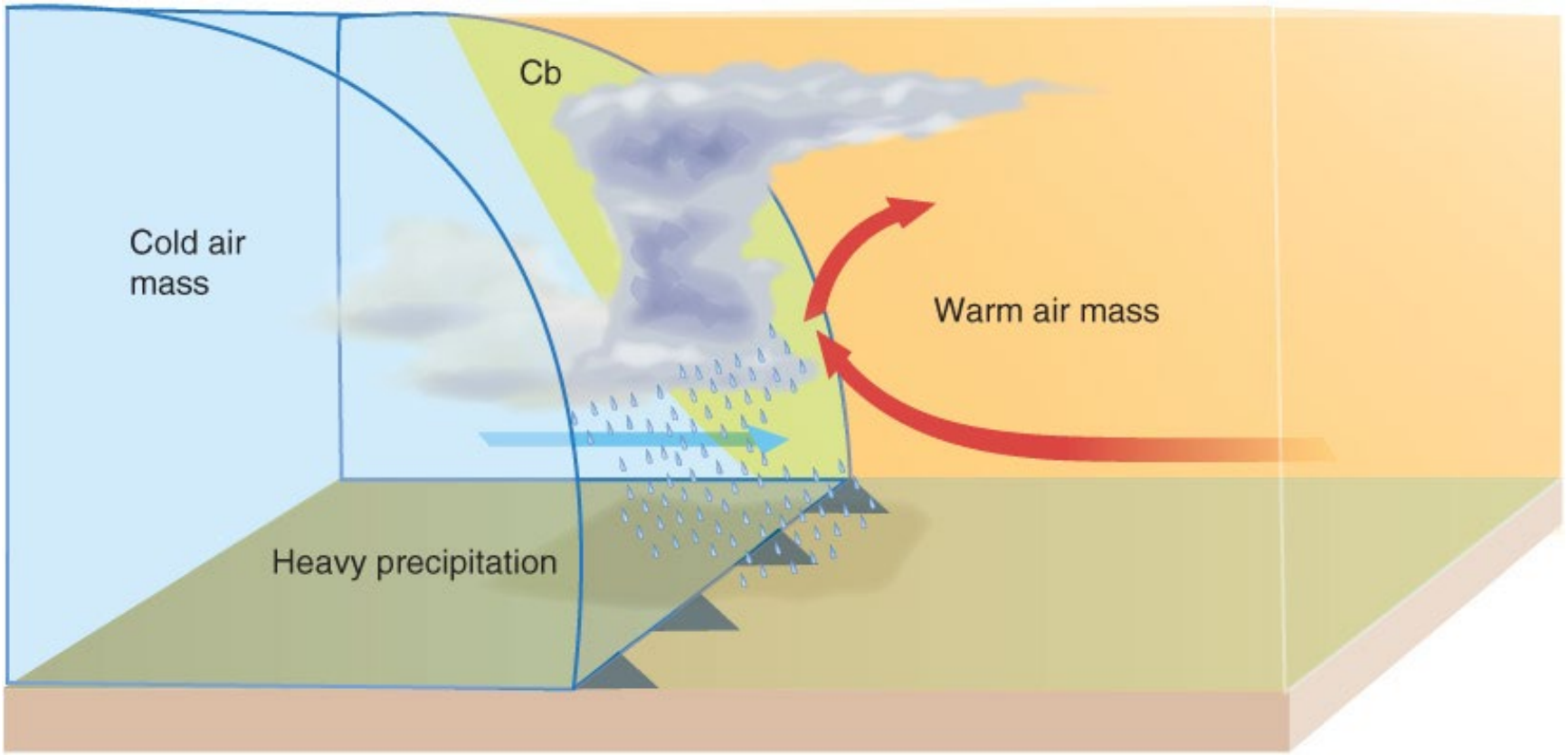
- Cold air advances, replaces warm air at the surface

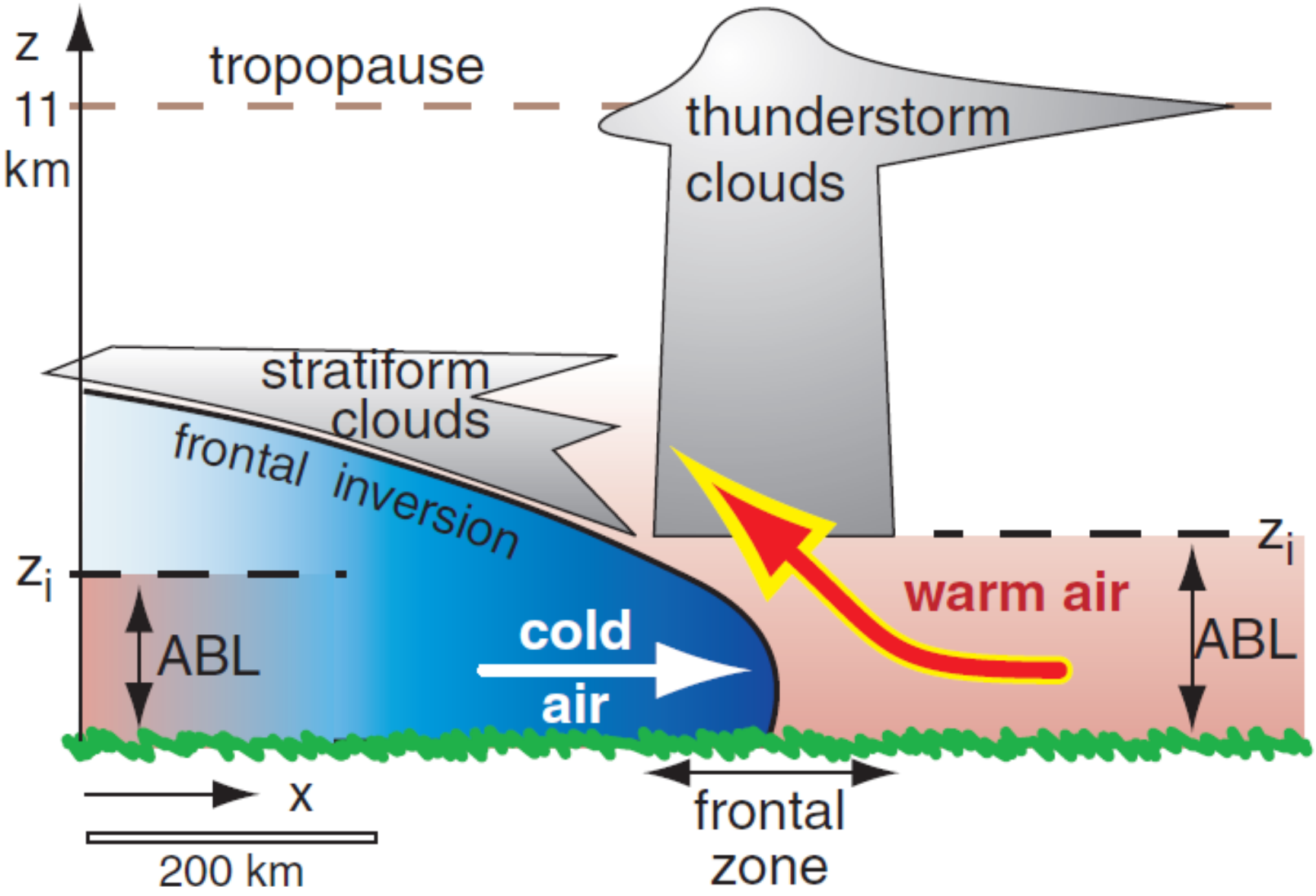
- Change in wind direction/speed

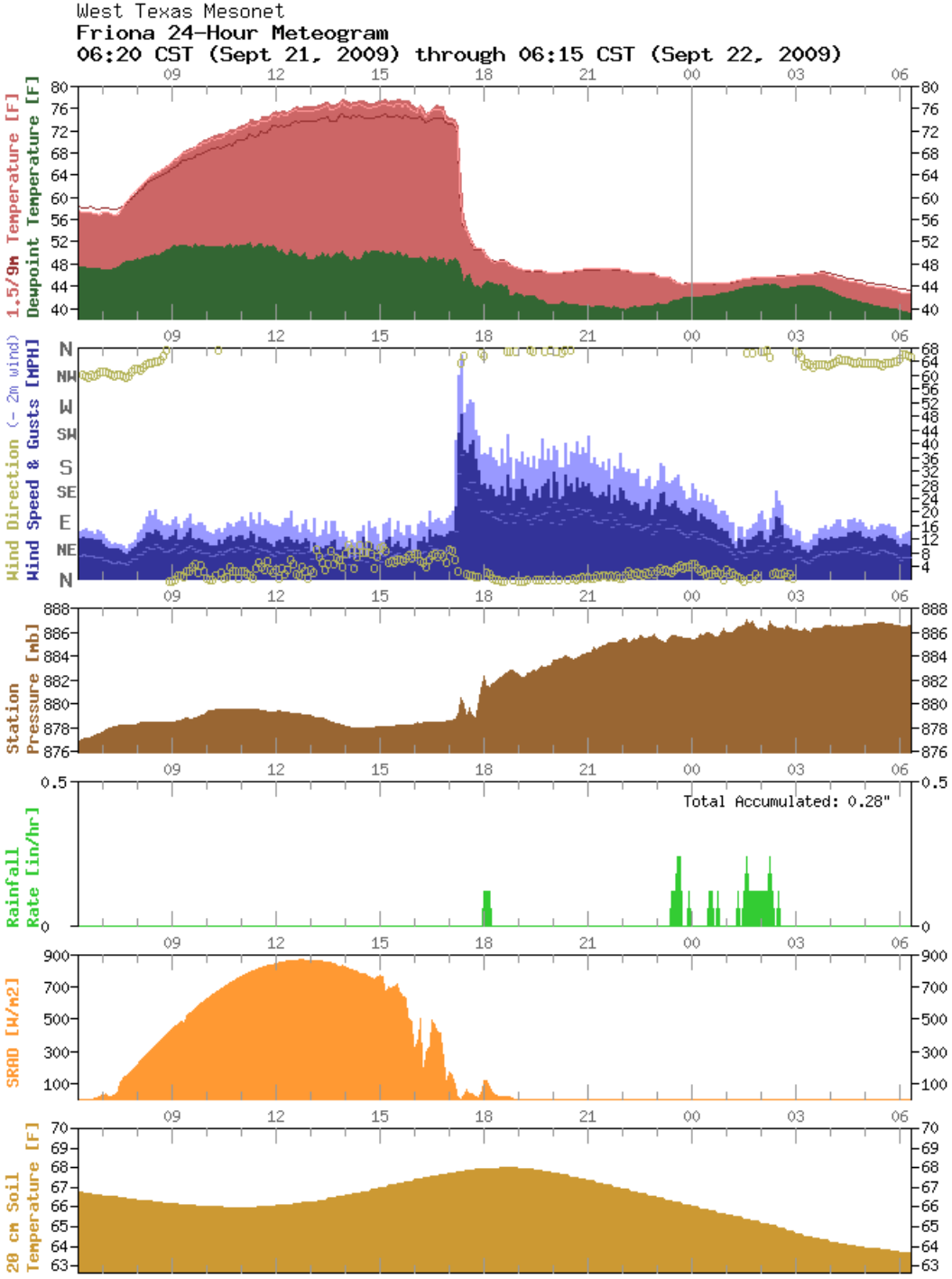
- Minimum in atmospheric pressure

- Blue triangles point in the direction of motion.

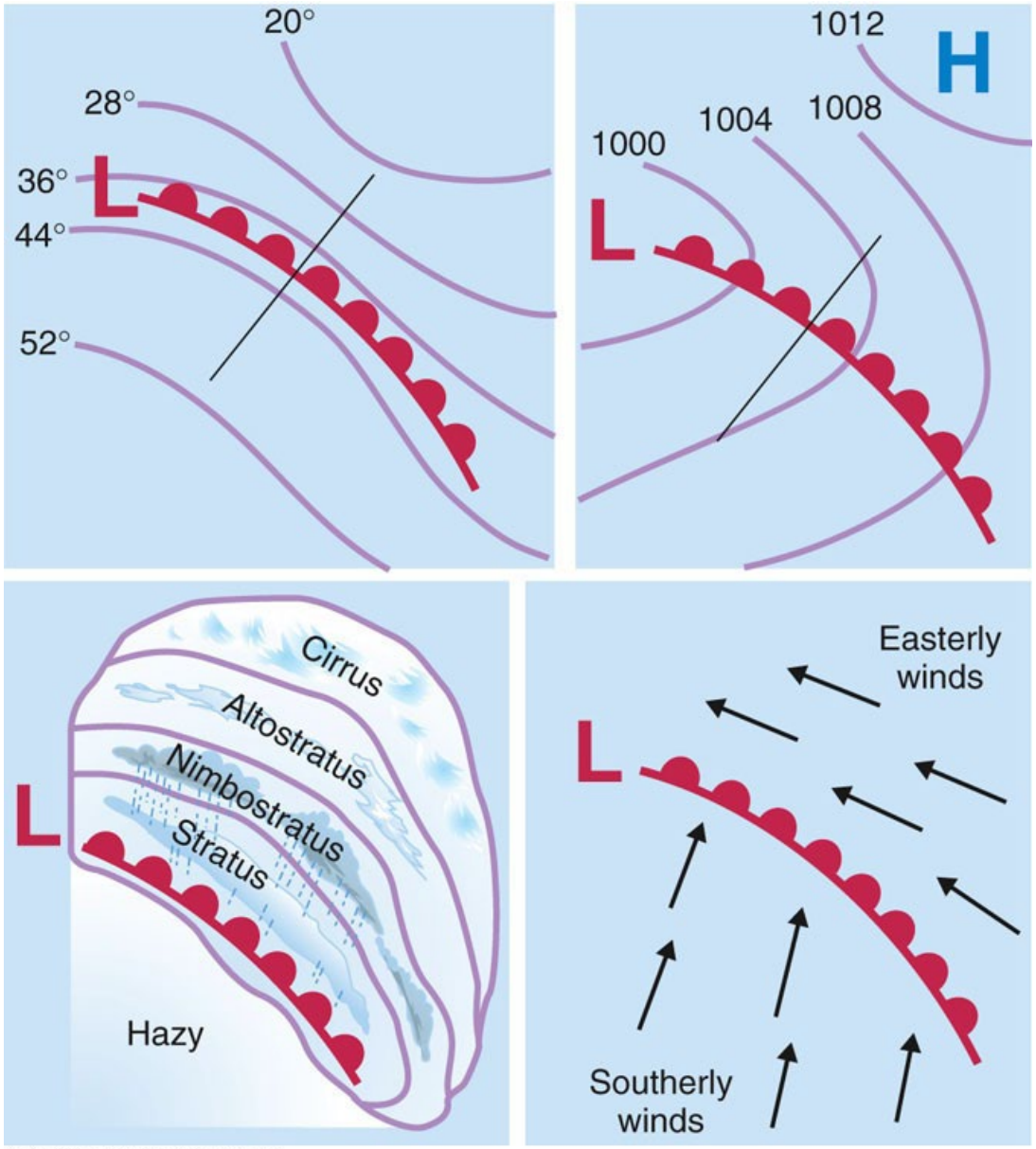
COLD FRONT: VERTICAL STRUCTURE




z
11
km
tropopause
thunderstorm
clouds
stratiform
clouds
frontal inversion
z_i
ABL
cold
air
warm air
z_i
ABL
x
200 km
frontal
zone

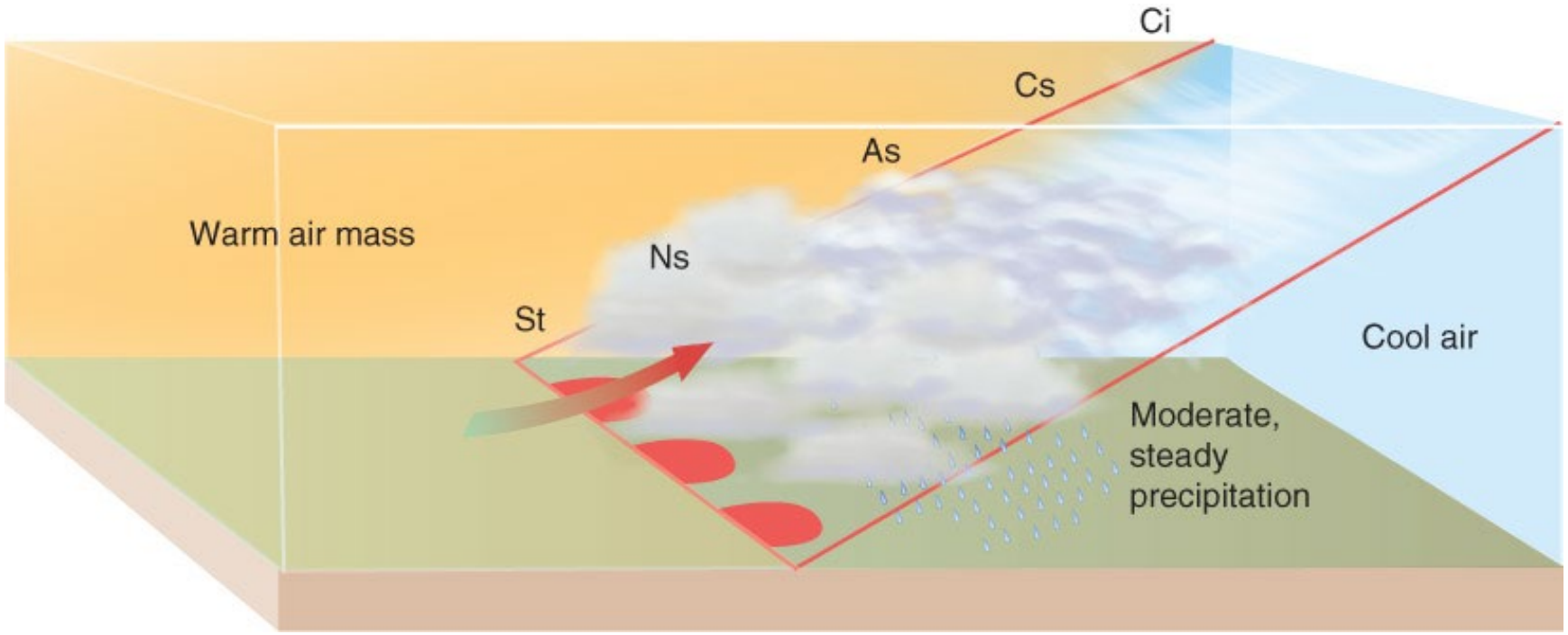

West Texas Mesonet
Friona 24-Hour Meteogram
06:20 CST (Sept 21, 2009) through 06:15 CST (Sept 22, 2009)
1.5/9m Temperature [F]
Dewpoint Temperature [F]
Wind Direction (- 2m wind)
Wind Speed & Gusts [MPH]
Station Pressure [mb]
Rainfall Rate [in/hr]
Total Accumulated: 0.28"
SRAD [W/m2]
20 cm Soil Temperature [F]
09
12
15
18
21
00
03
06

WARM FRONTS



- Warm air advances and replaces the cold air at the surface
- Change in wind direction/speed, temperature, and dewpoint
- Typically move slower than cold fronts.
- Red semicircles point in the direction of motion

WARM FRONT: VERTICAL STRUCTURE



SYNOPTIC CONSIDERATIONS

- Fronts and associated thunderstorms help to pull ABL air away from the surface.
- The air at and behind a cold front is typically statically stable.
- The after the passage of a warm front is typically statically unstable