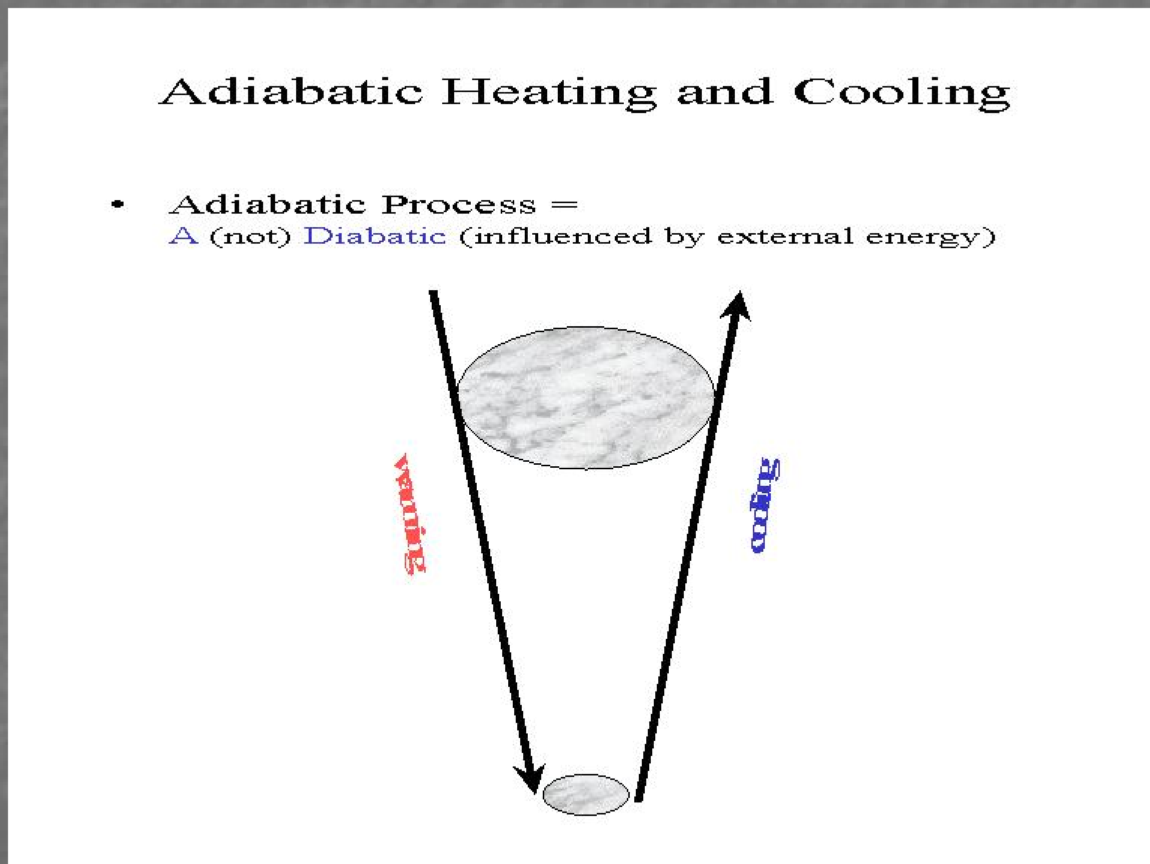
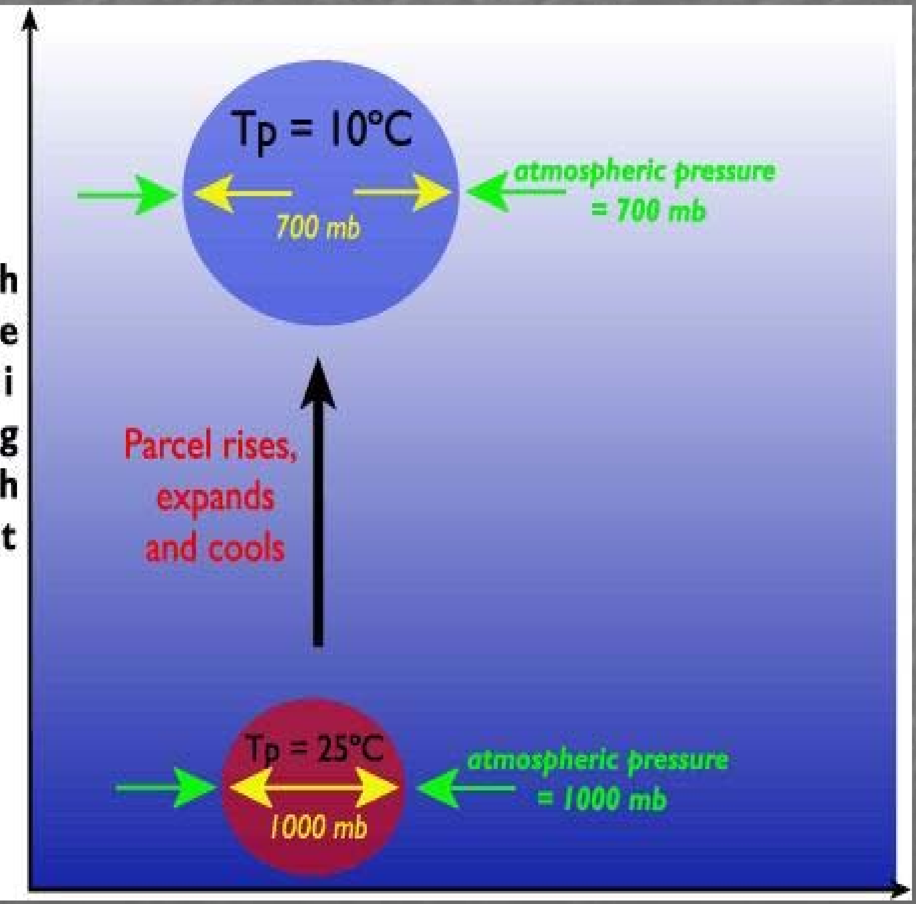
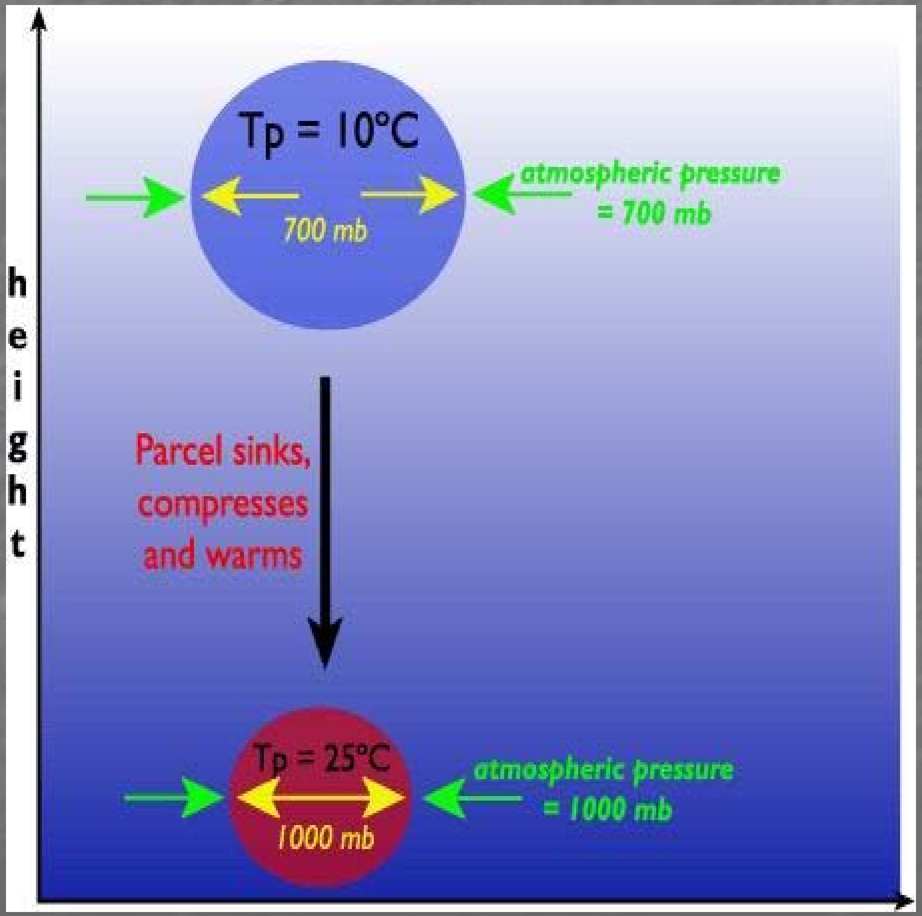
Adyabatik sıcaklık değişimi (adiabatic lapse rate)




Tp = 10°C
atmospheric pressure
= 700 mb
700 mb
height
Parcel rises,
expands
and cools
Tp = 25°C
atmospheric pressure
= 1000 mb
1000 mb


Tp = 10°C
atmospheric pressure
= 700 mb
700 mb
height
Parcel sinks,
compresses
and warms
Tp = 25°C
atmospheric pressure
= 1000 mb
1000 mb

Adiabatic Lapse Rates

- Dry Adiabatic Lapse Rate
  - Rate at which rising air cools due to natural expansion
  - 10º C per 1000 meters
- Wet Adiabatic Lapse Rate
  - Rate at which saturated rising air cools due to natural expansion
  - about 5º C per 1000 meters
  - less than the dry adiabatic lapse rate since energy is being released by the condensing water
- Lifting Condensation Level
  - Altitude at which a rising parcel of air reaches 100% humidity and begins condensation

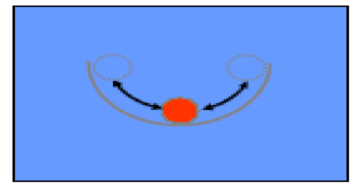
Kararlılık (stability) – Kararsızlık (instability

Stability

- Can be classified into 3 categories
  - Stable
  - Neutral
  - Unstable

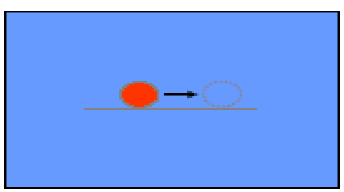
Stable

- Returns to original position after displacement



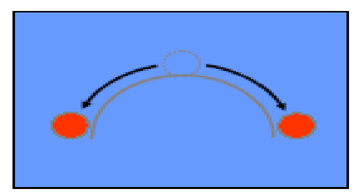
Neutral

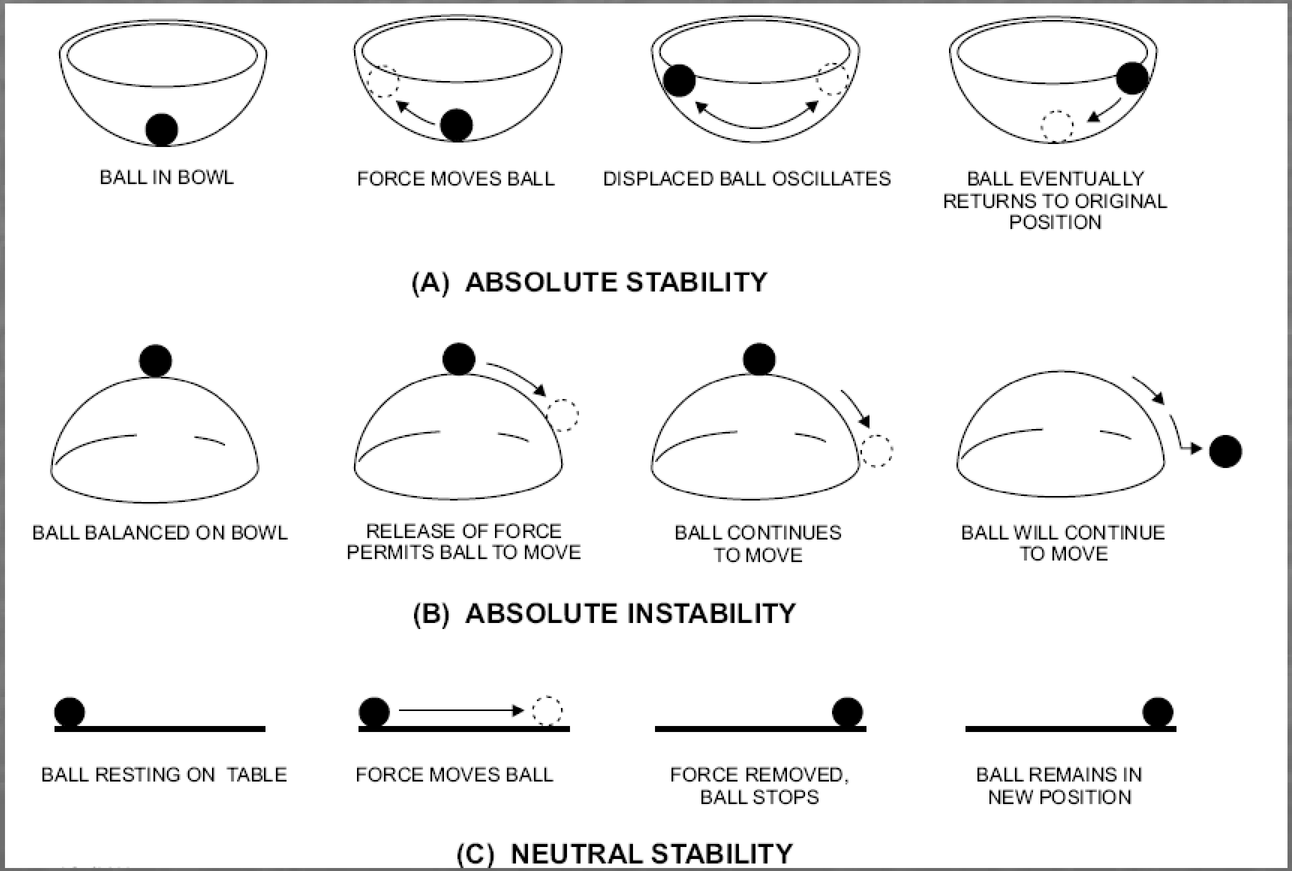
- Remains in new position after being displaced



Unstable

- Moves farther away from its original position




BALL IN BOWL
FORCE MOVES BALL
DISPLACED BALL OSCILLATES
BALL EVENTUALLY RETURNS TO ORIGINAL POSITION
(A) ABSOLUTE STABILITY
BALL BALANCED ON BOWL
RELEASE OF FORCE PERMITS BALL TO MOVE
BALL CONTINUES TO MOVE
BALL WILL CONTINUE TO MOVE
(B) ABSOLUTE INSTABILITY
BALL RESTING ON TABLE
FORCE MOVES BALL
FORCE REMOVED, BALL STOPS
BALL REMAINS IN NEW POSITION
(C) NEUTRAL STABILITY

KARARSIZLIK

- Bir hava kütlesi içindeki sıcaklık değişme oranı, kuru adyabatik sıcaklık değişme oranından (1 ºC/100 m) büyükse veya çevredeki hava kütlelerinin sıcaklık değişme oranından küçükse bu tür hava kütleleri *KARARSIZ* hava kütlesi olarak tanımlanır. Eğer bir hava kütlesi içindeki soğuma oranı 2,4 ºC/100 m olursa hiçbir dış etmen olmadan da hava harekete geçer ve yükselmeye başlar buna *MEKANİK KARARSIZLIK* denir.

KARARLILIK

- Bir yerde alt ve üst katmanları arasında sıcaklık farkı azsa veya çevredeki hava kütlelerinin sıcaklık değişme oranından büyükse bu hava kütleleri *KARALIDIR*. Eğer bir hava kütlesinin içinde sıcaklık terselmesi varsa bu hava tam anlamıyla dengede demektir. Böyle hava kütleleri *MUTLAK KARARLILIK* olarak adlandırılır.

Stability Rules #1,#2, & #3

1. Absolutely Unstable Air
   Whenever the ELR Exceeds the DALR or SALR
   (Positive Buoyancy)

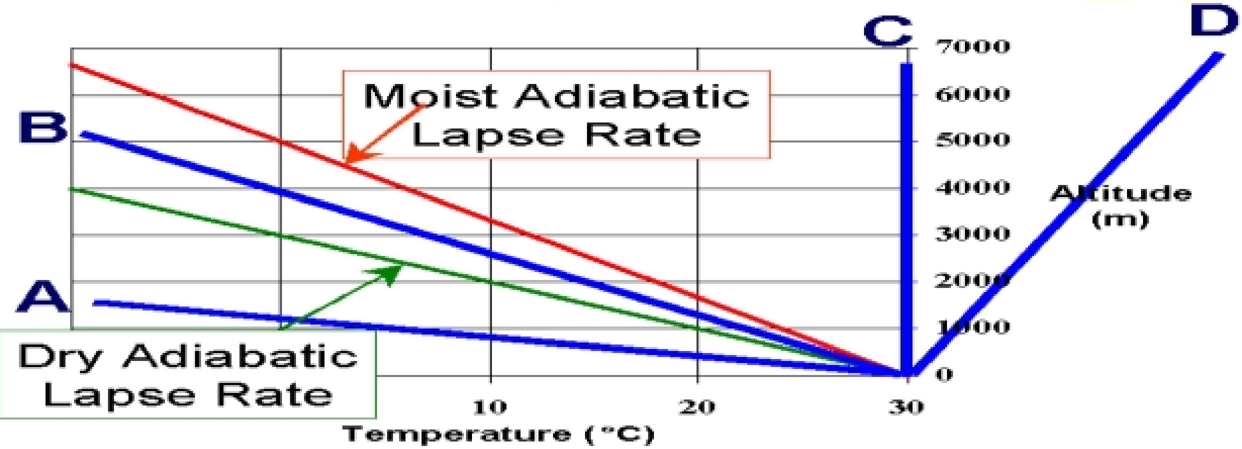
2. Absolutely Stable Air
   Whenever the ELR Is Less Than the DALR or SALR
   (Negative Buoyancy)

3. Conditionally Unstable Air
   Whenever the ELR Is Between the DALR and SALR

Limitations on Lifting

- What causes air to quit rising?
  - Stable air
    - Inversions
  - Entrainment (mixing)

STABILITY



Sounding	Unsaturated	Saturated	Category
A	Unstable	Unstable	Absolute Instability
B	Stable	Unstable	Conditional Instability
C	Stable	Stable	Absolutely Stable -- Isothermal
D	Stable	Stable	Absolutely Stable -- Inversion

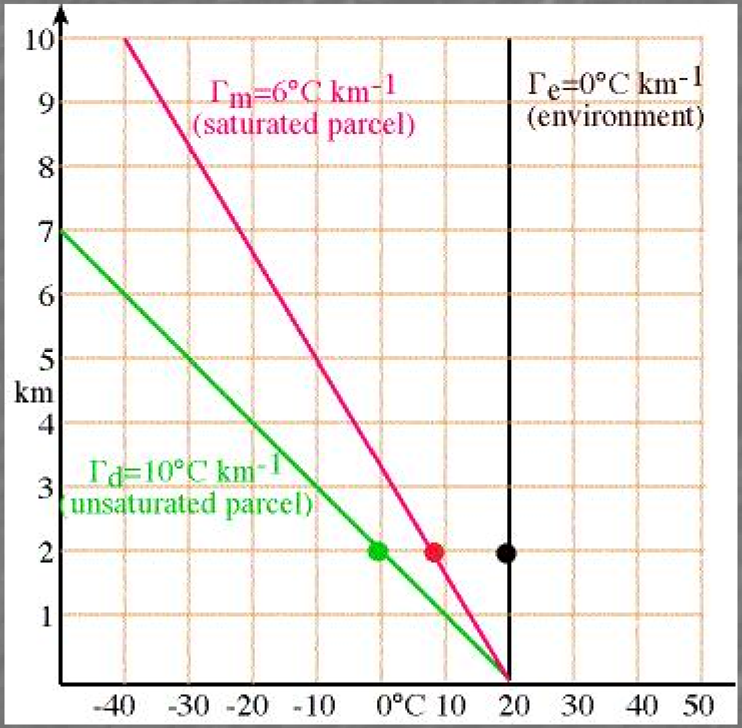
Table 2-1.—Lapse Rates of Temperature

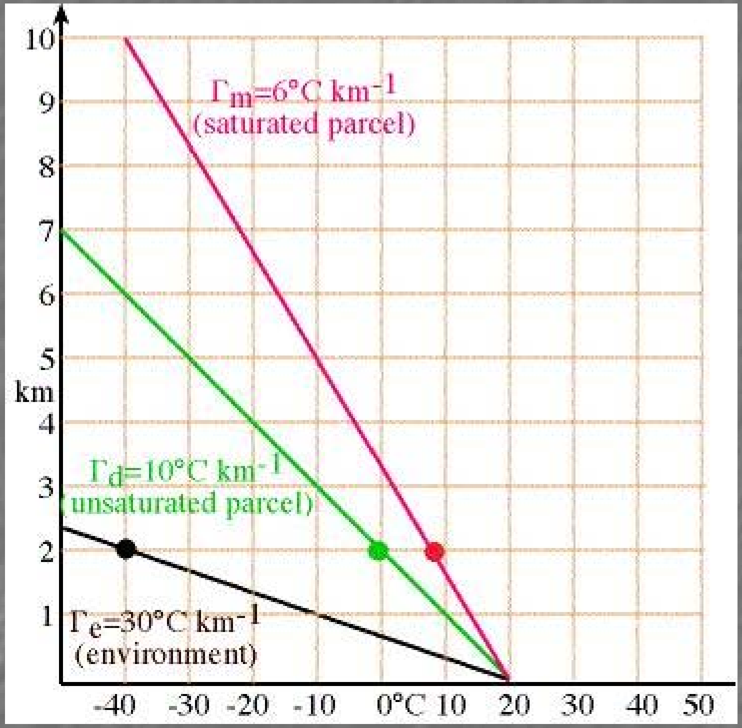
Lapse rate	Per 1,000 feet	Per 100 meters
Dry adiabatic	5 1/2°F	1° C
Saturation (moist) adiabatic	2-3°F	.55° C
Average	3.3°F	.65° C
Superadiabatic	5 1/2-15°F	1-3.42° C
Autoconvective	More than 15° F	More than 3.42° C

Kararlılık-kararsızlık

- Doymamış hava
- $\Gamma e < \Gamma d$ Kararlı
- $\Gamma e = \Gamma d$ Nötr
- $\Gamma e > \Gamma d$ Mutlak kararsız
- Doymuş hava
- $\Gamma e < \Gamma s$ Mutlak kararlı
- $\Gamma e = \Gamma s$ Nötr
- $\Gamma e > \Gamma s$ Kararsız
- $\Gamma d > \Gamma e > \Gamma s$ Koşullu kararsız

Kararlı Kararsız





Buoyancy

- An air parcel rises in the atmosphere when it's density is less than its surroundings
- Let ρ_{env} be the density of the environment. From the Equation of State/Ideal Gas Law

  $\rho_{env} = P/RT_{env}$
- Let ρ_{parcel} be the density of an air parcel. Then

  $\rho_{parcel} = P/RT_{parcel}$
- Since both the parcel and the environment at the same height are at the same pressure
  - when $T_{parcel} > T_{env}$ $\rho_{parcel} < \rho_{env}$ (positive buoyancy)
  - when $T_{parcel} < T_{env}$ $\rho_{parcel} > \rho_{env}$ (negative buoyancy)

Buoyancy

Static Stability is Related to Buoyancy

Parcel of Air

Less dense Than Surrounding Air: Positive Buoyancy

Tends to Rise (Warmer)

More dense Than Surrounding Air: Negative Buoyancy

Tends to Sink if Not Lifted(Colder)

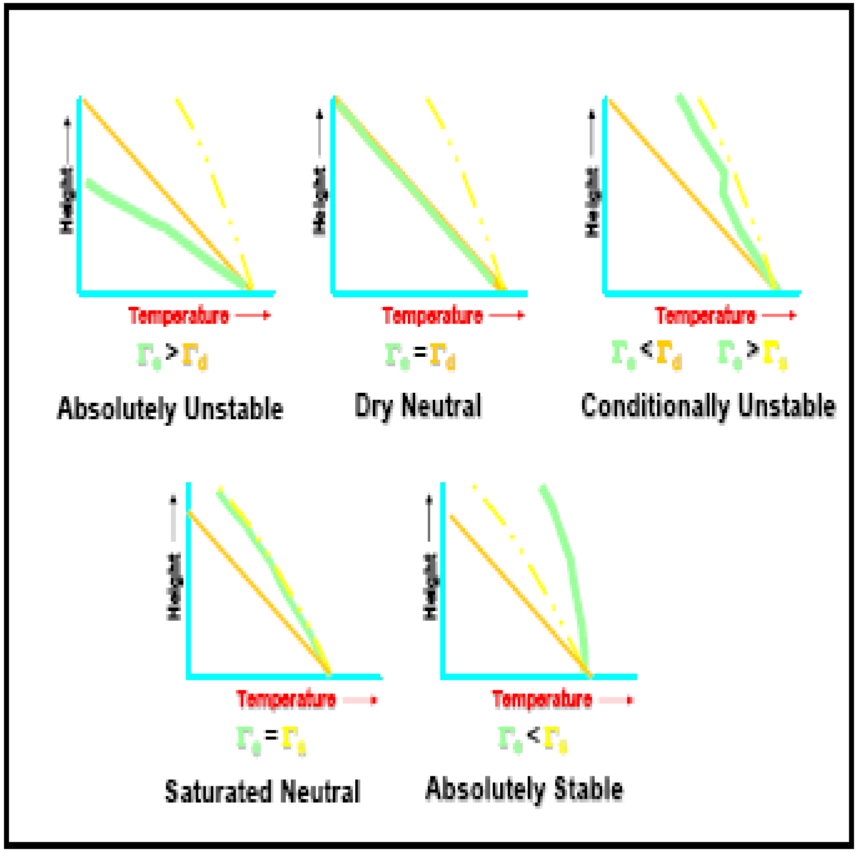
A Rising Parcel of Air

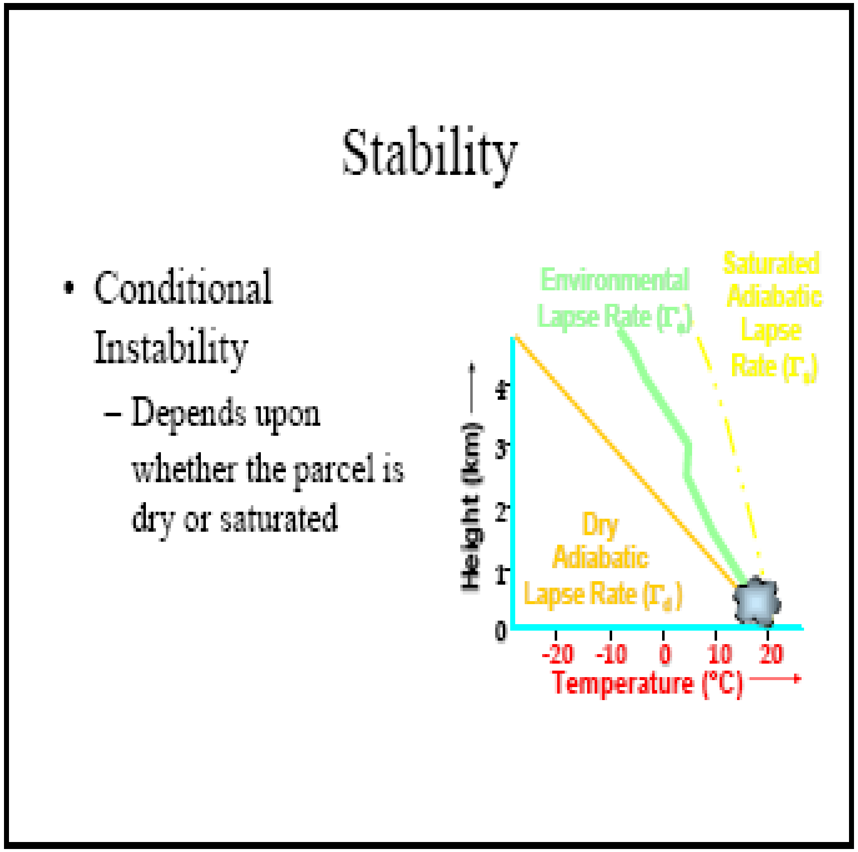
Stops Rising When It Cools to Surrounding Air

Sinks When It Becomes Colder Than Surrounding Air

This Suppresses Uplift

Kararlılık-karasızlık





Absolutely Unstable Air

- Dry Adiabatic Lapse Rate - DALR
- DALR = 10° C/1000 m
- ELR > DALR
- $T_{environment} < T_{parcel}$
- Parcel will rise away from original position

Absolute instability

- The atmosphere is absolutely unstable if the environmental lapse rate exceeds the moist and dry adiabatic lapse rates
- This situation is not long-lived
  - Usually results from surface heating and is confined to a shallow layer near the surface
  - Vertical mixing can eliminate it
- Mixing results in a dry adiabatic lapse rate in the mixed layer, unless condensation (cloud formation) occurs (in which case it is moist adiabatic)

Kararlılık

Static Stability and Environmental Lapse Rate (ELR)

- **Static Stability**
- **Absolutely Unstable Air**
- **Absolutely Stable Air**
- **Conditionally Unstable Air**

Why is stability important?

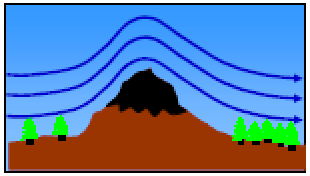
- Vertical motions in the atmosphere are a critical part of energy transport and strongly influence the hydrologic cycle
- Without vertical motion, there would be no precipitation, no mixing of pollutants away from ground level - weather as we know it would simply not exist.
- There are two types of vertical motion:
  - **forced motion** such as forcing air up over a hill, over colder air, or from horizontal convergence
  - **buoyant motion** in which the air rises because it is less dense than its surroundings - stability is especially important here

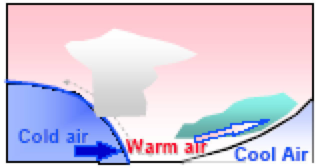
Stability

- How is air displaced?
  - Two methods
    - 1.) Forced Ascent
    - 2.) Auto-Convective Ascent

Forced Ascent

- Some mechanism forces air aloft
  - Usually synoptic scale feature





Forced Ascent

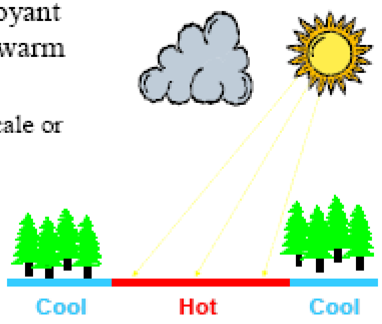
- Type of clouds
  - Depends on stability

Stable - Stratus

Unstable - Cumulus

Auto-Convective Ascent

- Air becomes buoyant by contact with warm ground
  - Usually microscale or mesoscale

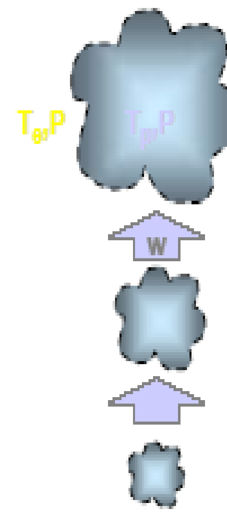


Auto-Convective Ascent

- Type of Clouds
  - Cumulus

Parcel Theory

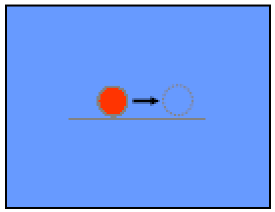
- Assumptions
  - Thermally insulated from its environment
  - Temperature changes adiabatically
  - Always at the same pressure as the environment at that level



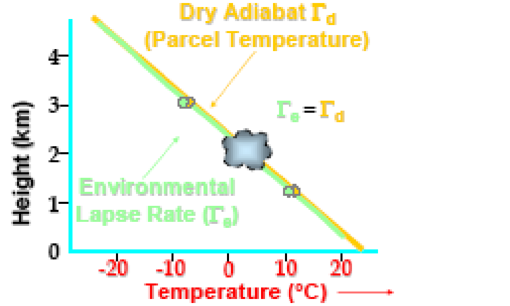
Doymamış havanın kararlı olması

Unsaturated

- Neutral
  - Once displaced, stays

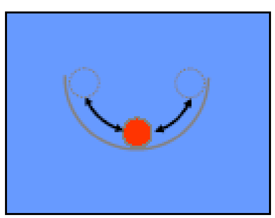


Unsaturated-Neutral

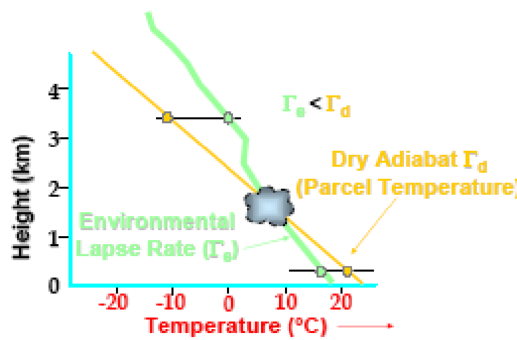


Unsaturated

- Stable
  - Once displaced, returns



Unsaturated-Stable



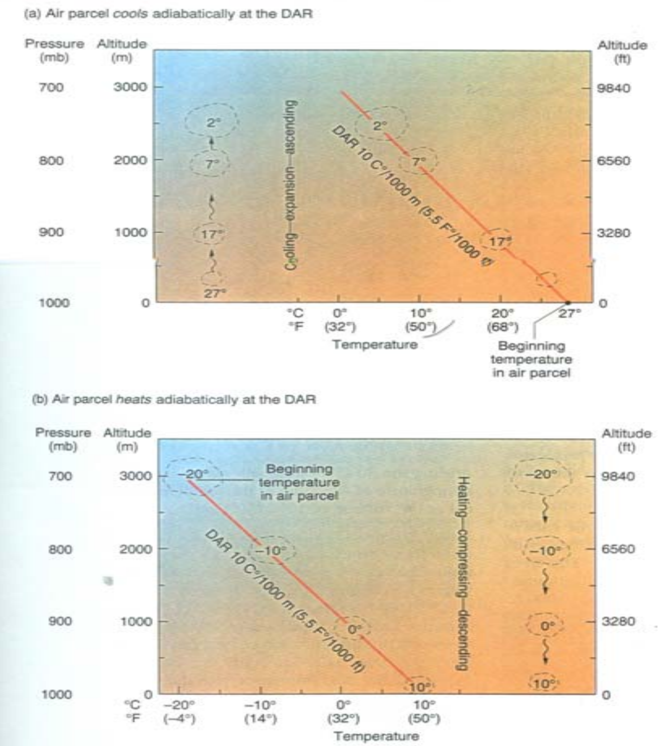
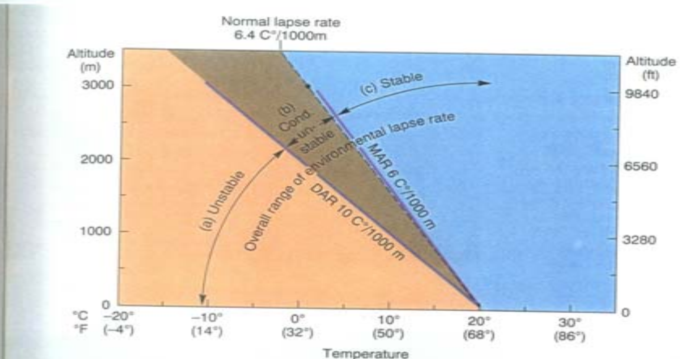
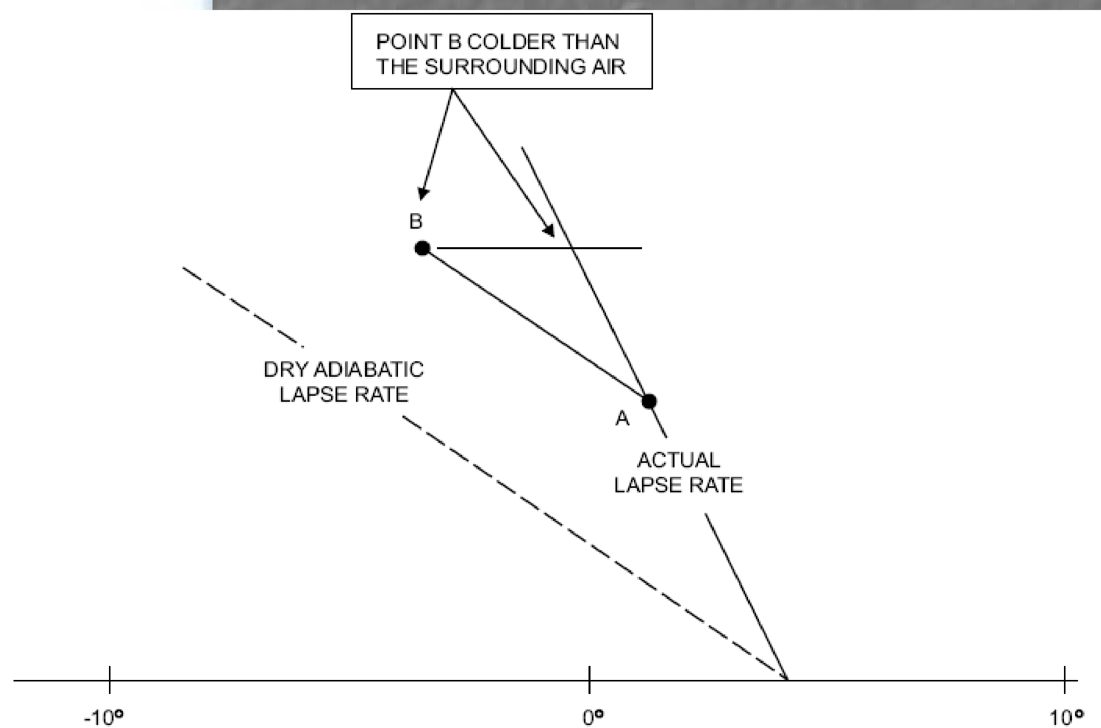


FIGURE 7-19
Adiabatic cooling and heating.
Vertically moving air parcels expand when they rise (because air pressure is less with increasing altitude) and are compressed when they descend.
(a) An air parcel that is less than saturated cools adiabatically at the dry adiabatic rate (DAR). (b) A descending air parcel that is less than saturated heats adiabatically by compression at the DAR.





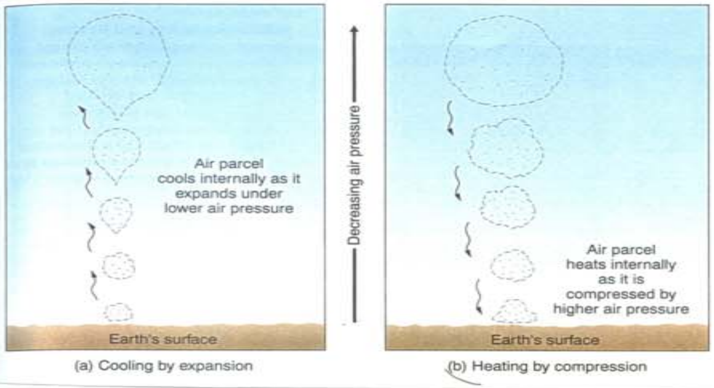


FIGURE 7-18

Vertically moving air experiences temperature changes.

(a) A rising air parcel cools by expansion. (b) A falling air parcel heats by compression.

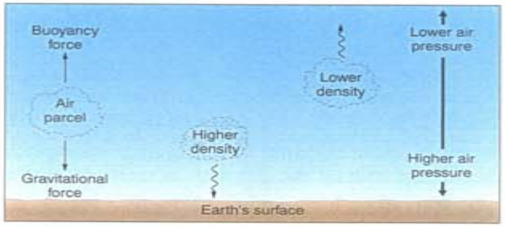


FIGURE 7-16

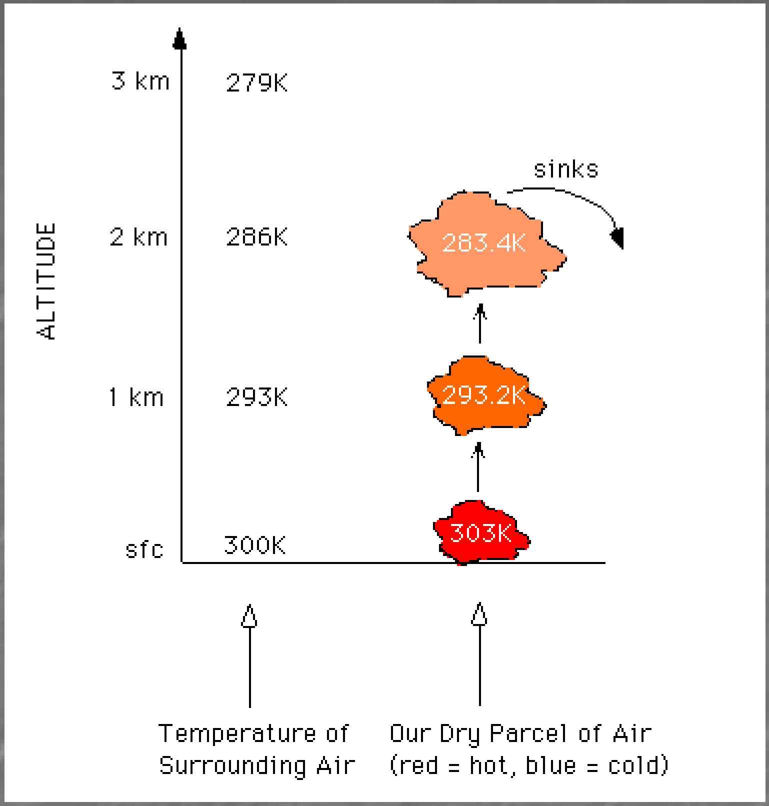
The forces acting on an air parcel.

Buoyancy and gravitational forces work on an air parcel. Different densities produce rising or falling parcels in response to imbalance in these forces.

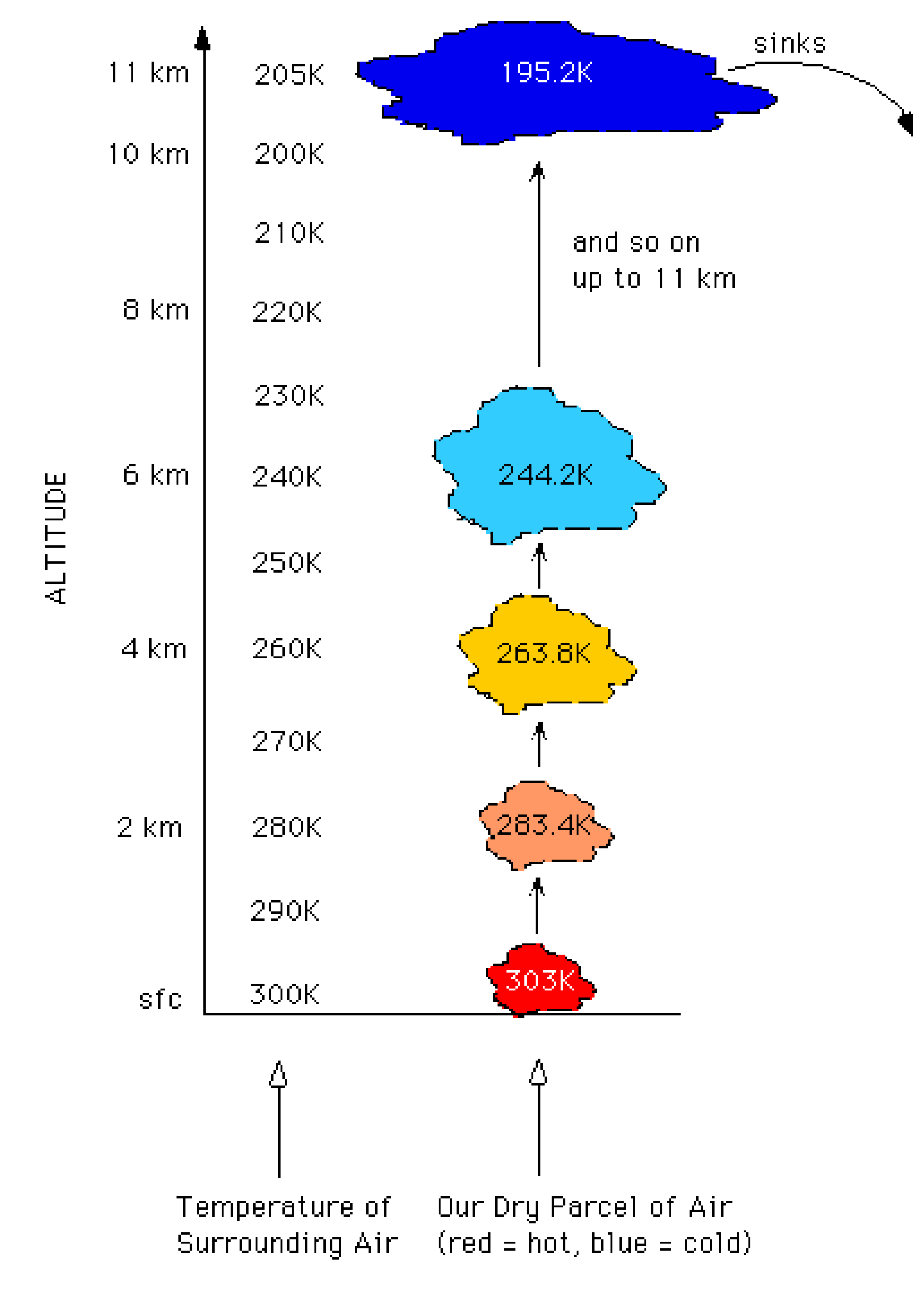
FIGURE 7-17

Principles of air stability and balloon launches.

Principles of stability are illustrated by hot-air balloons being launched in the Swiss Alps. As the temperature inside a balloon increases, the air in the balloon becomes less dense than the surrounding air and the buoyancy force causes the balloon to rise, like a warm air parcel. [Photo by Bap Vandystadt/Photo Researchers, Inc.]



ALTITUDE
3 km
279K
2 km
286K
1 km
293K
sfc
300K
sinks
283.4K
293.2K
303K
Temperature of Surrounding Air
Our Dry Parcel of Air (red = hot, blue = cold)

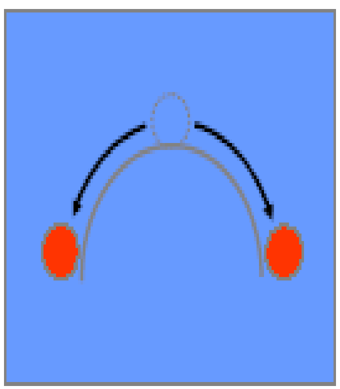


ALTITUDE
11 km
205K
10 km
200K
210K
8 km
220K
230K
6 km
240K
250K
4 km
260K
270K
2 km
280K
290K
sfc
300K
sinks
195.2K
and so on up to 11 km
244.2K
263.8K
283.4K
303K
Temperature of Surrounding Air
Our Dry Parcel of Air (red = hot, blue = cold)

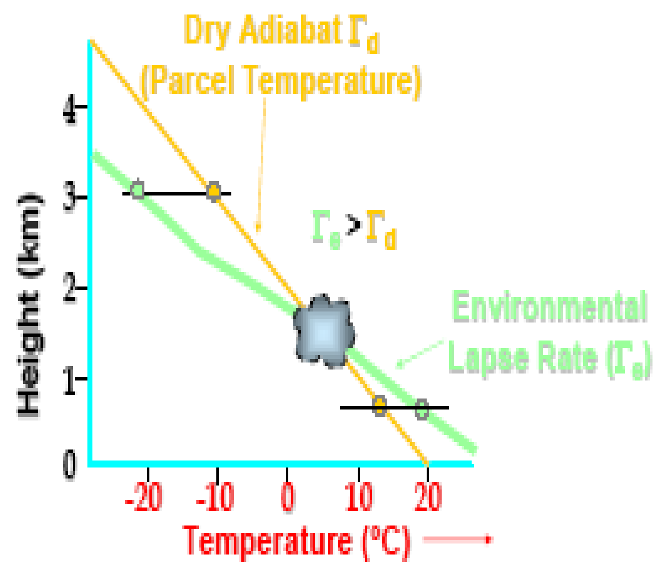
Doymamış havanın kararsız olması

Unsaturated

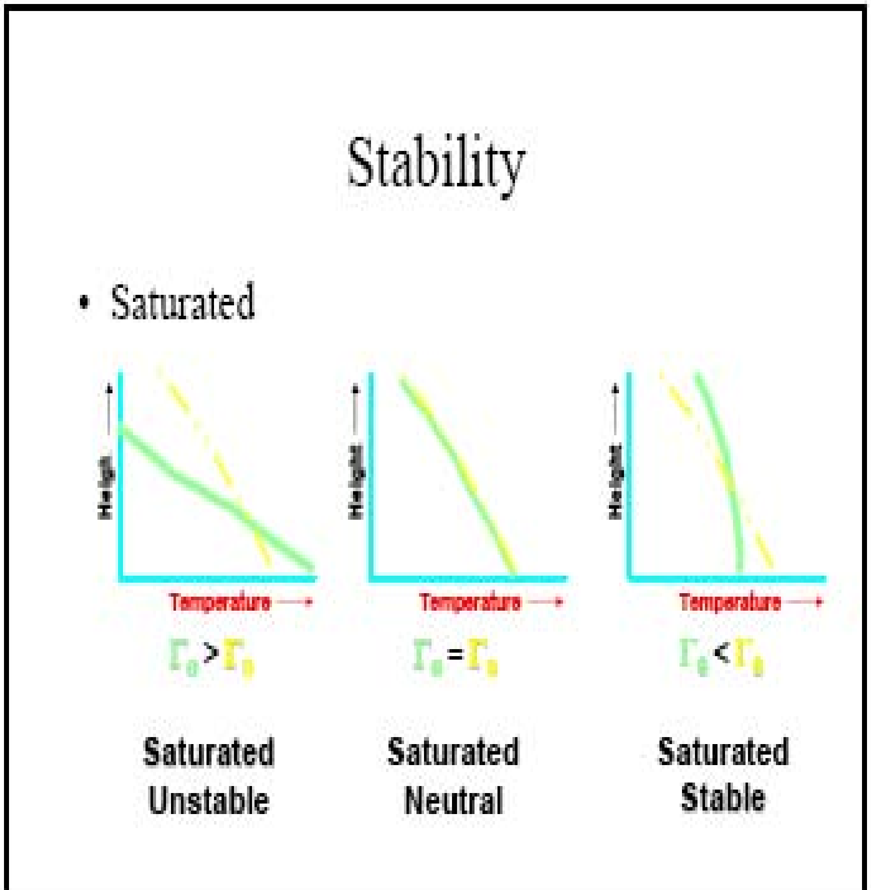
- Unstable
  - Once displaced, continues



Unsaturated-Unstable

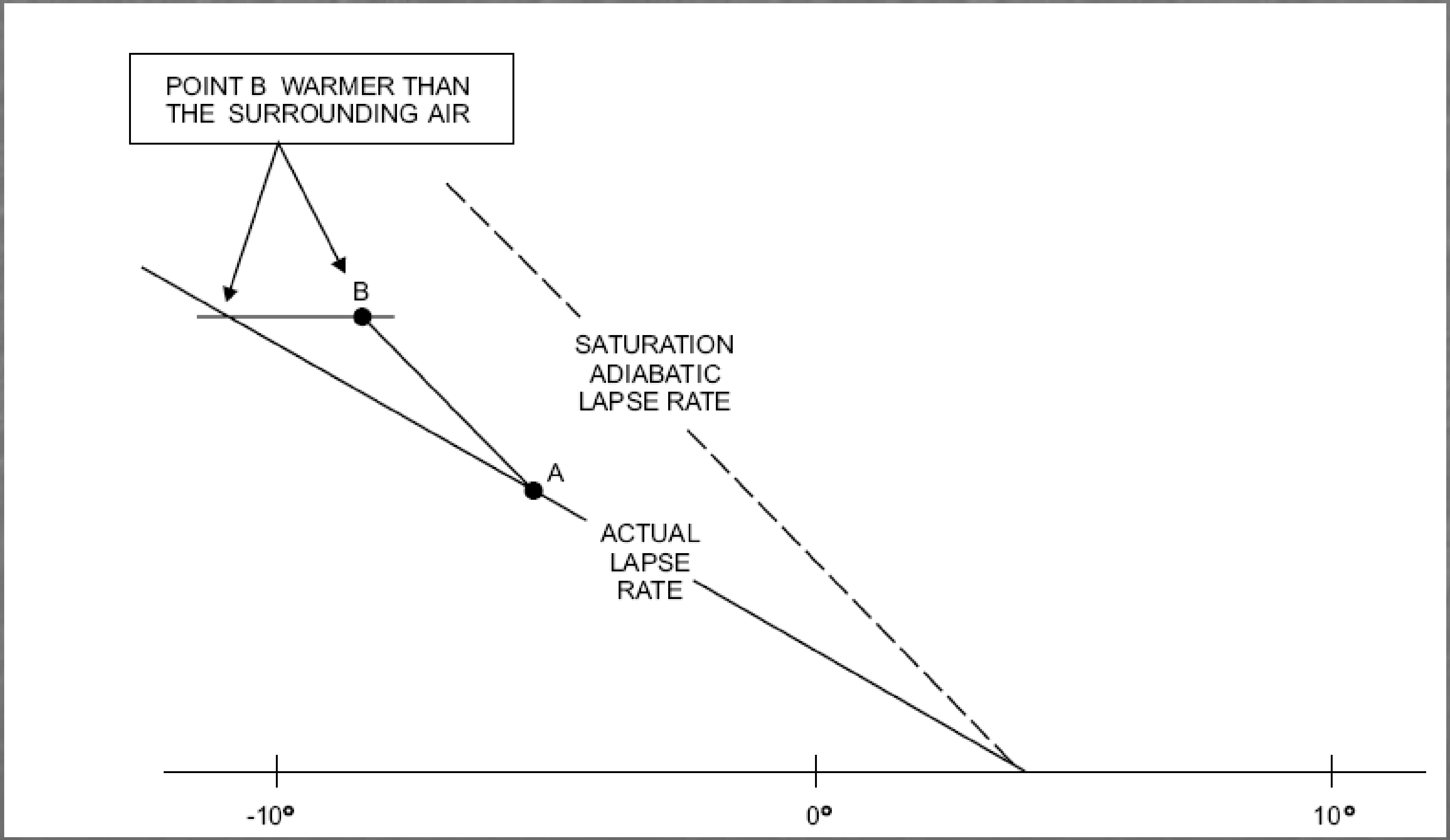


Doymuş havanın kararlı olması



Stability

- Combine to simplify
  - Absolutely Unstable
  - Dry Neutral
  - Conditionally Unstable
  - Saturated Neutral
  - Absolutely Stable


POINT B WARMER THAN
THE SURROUNDING AIR
B
SATURATION
ADIABATIC
LAPSE RATE
A
ACTUAL
LAPSE
RATE
-10°
0°
10°

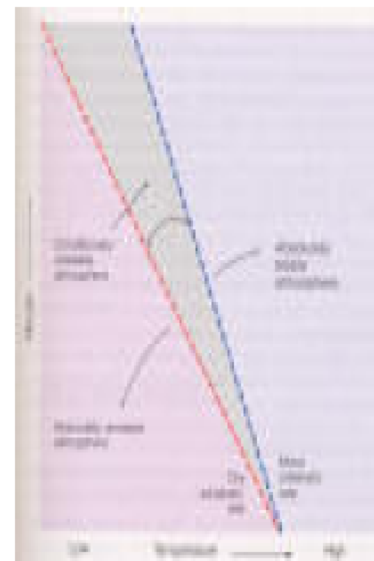
Koşullu kararsızlık

Conditionally Unstable Air

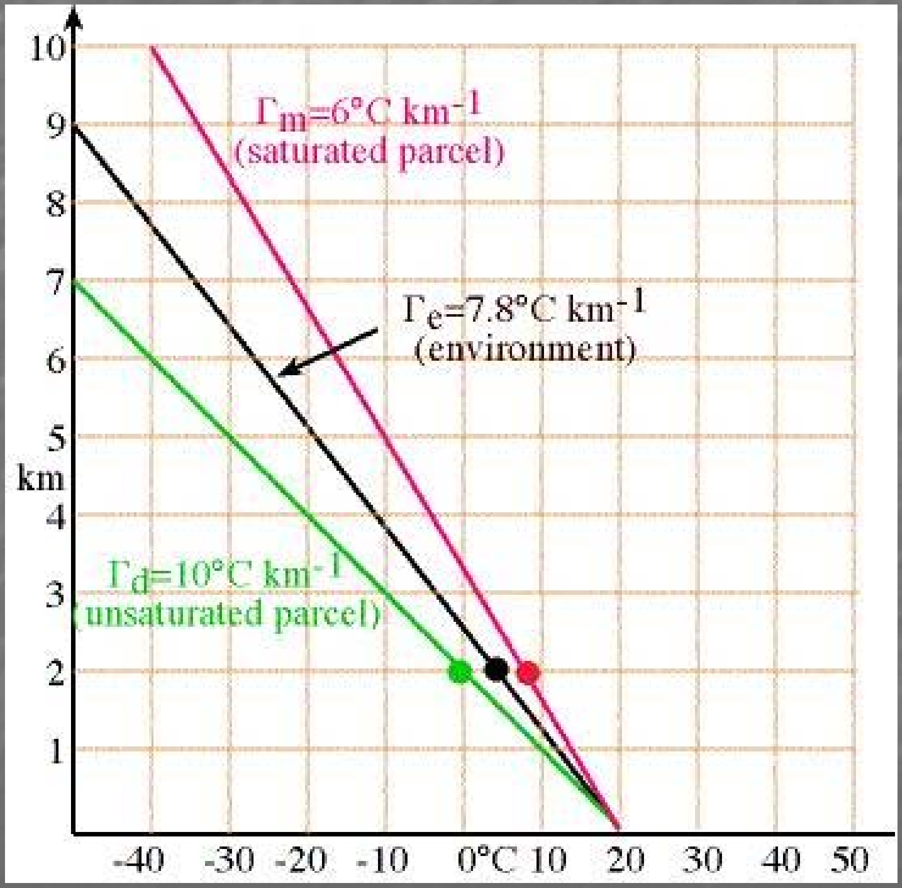
- Conditionally Unstable Air
  - SALR < ELR < DALR
  - depends on whether or not the rising air parcel is saturated

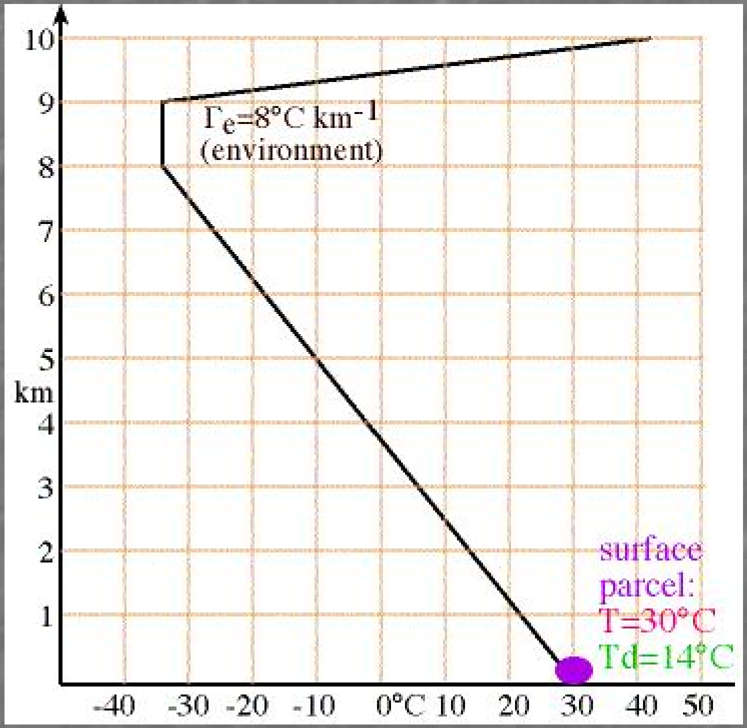
Conditionally unstable air

- What if the environmental lapse rate falls between the moist and dry adiabatic lapse rates?
  - The atmosphere is unstable for saturated air parcels but stable for unsaturated air parcels
  - This situation is termed *conditionally unstable*
- This is the typical situation in the atmosphere

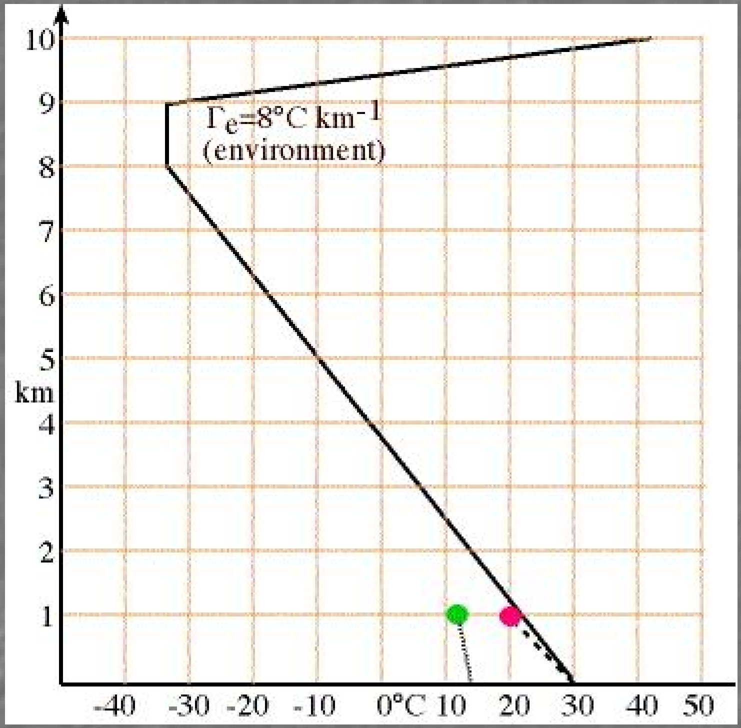


Koşullu kararsızlık (conditional unstability)

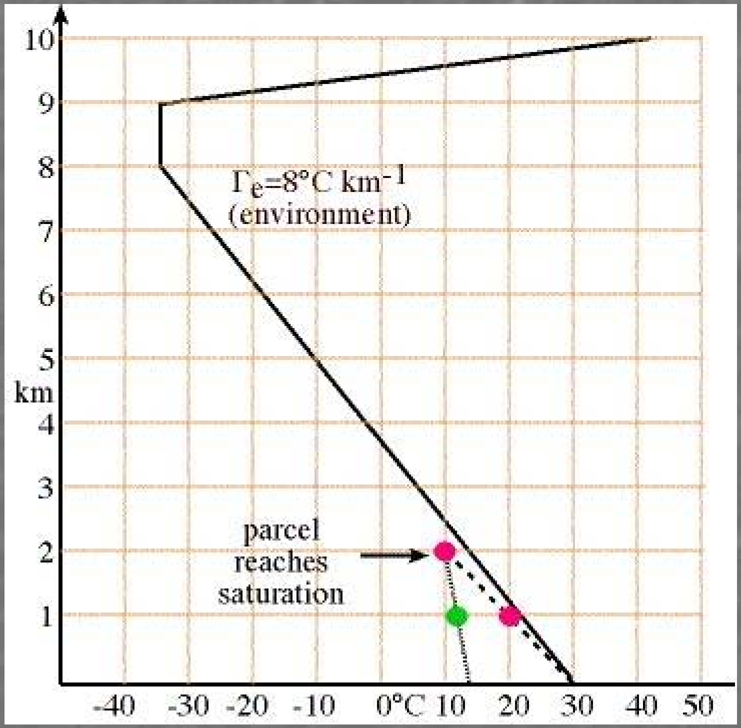




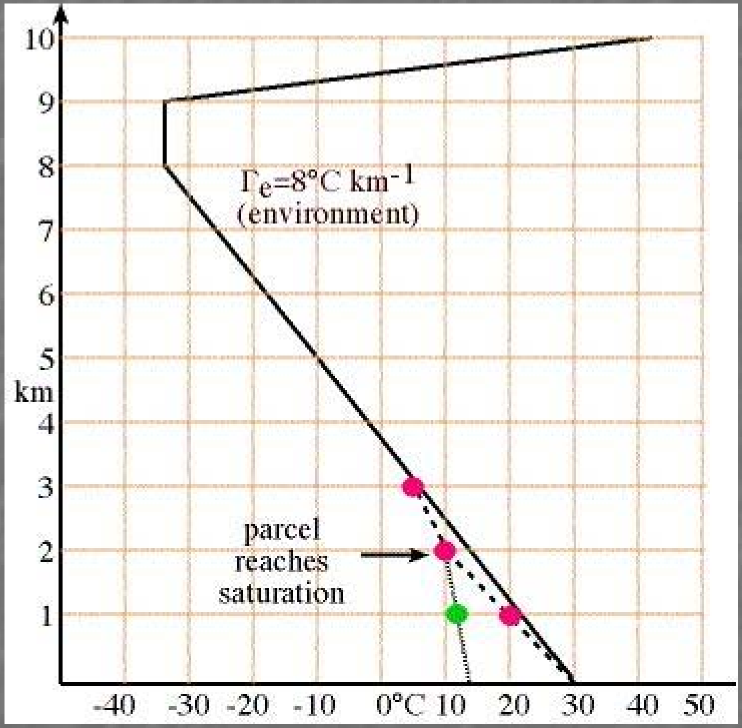
10
9
8
7
6
5
km
4
3
2
1
Γe=8°C km-1
(environment)
surface
parcel:
T=30°C
Td=14°C
-40 -30 -20 -10 0°C 10 20 30 40 50



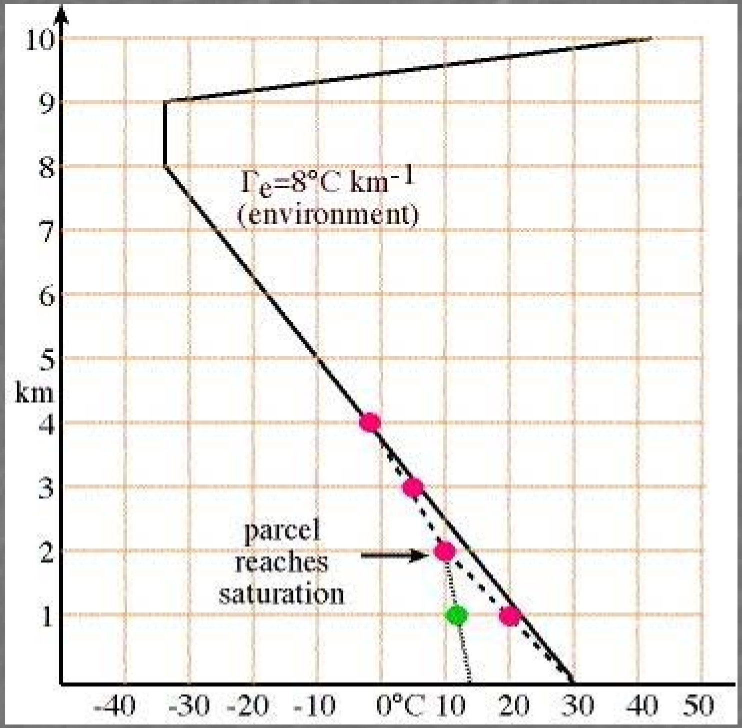
10
9
8
7
6
5
km
4
3
2
1
Γe=8°C km-1
(environment)
-40 -30 -20 -10 0°C 10 20 30 40 50

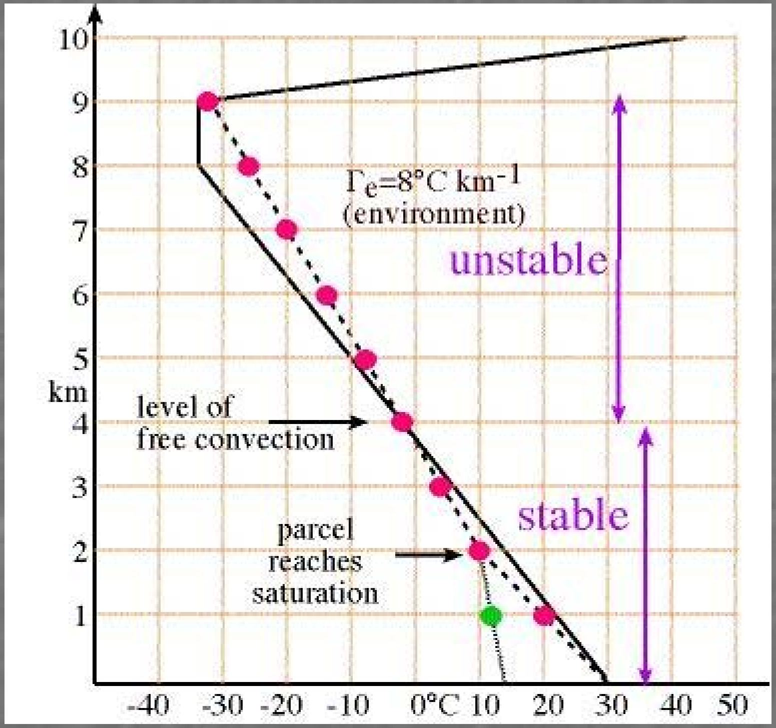


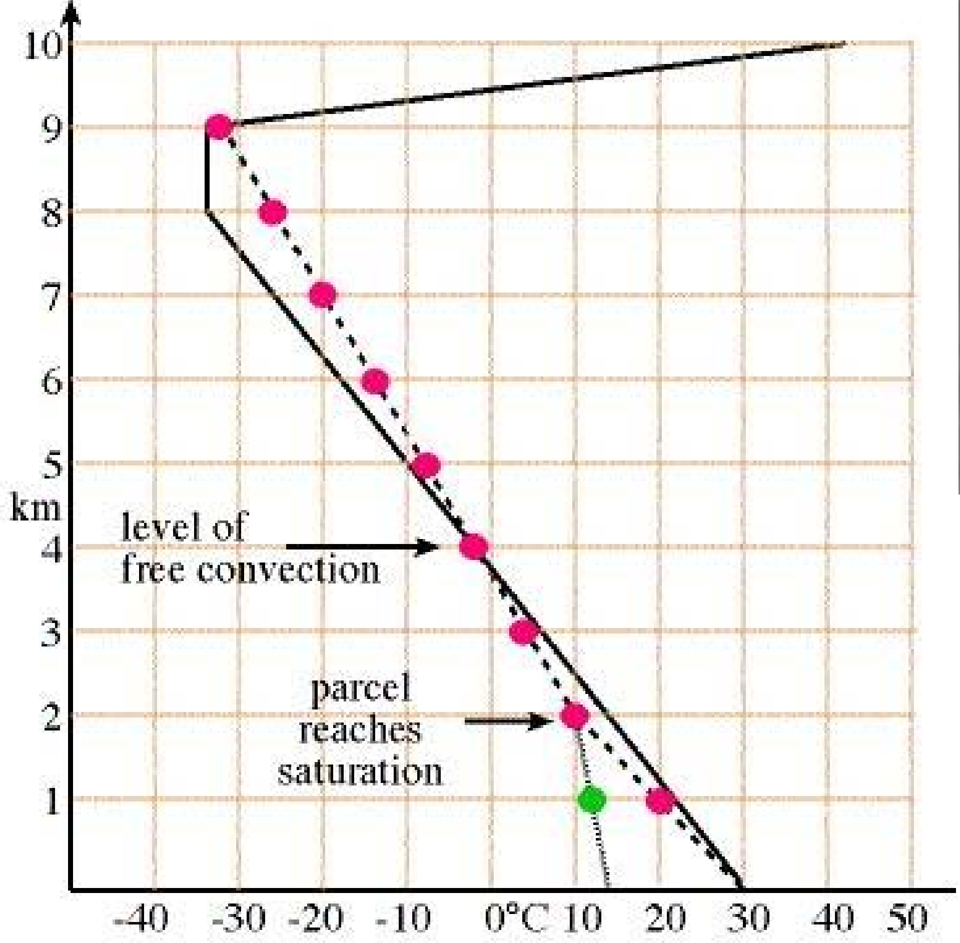
10
9
8
7
6
5
km
4
3
2
1
Γ_e=8°C km^{-1}
(environment)
parcel
reaches
saturation
-40 -30 -20 -10 0°C 10 20 30 40 50

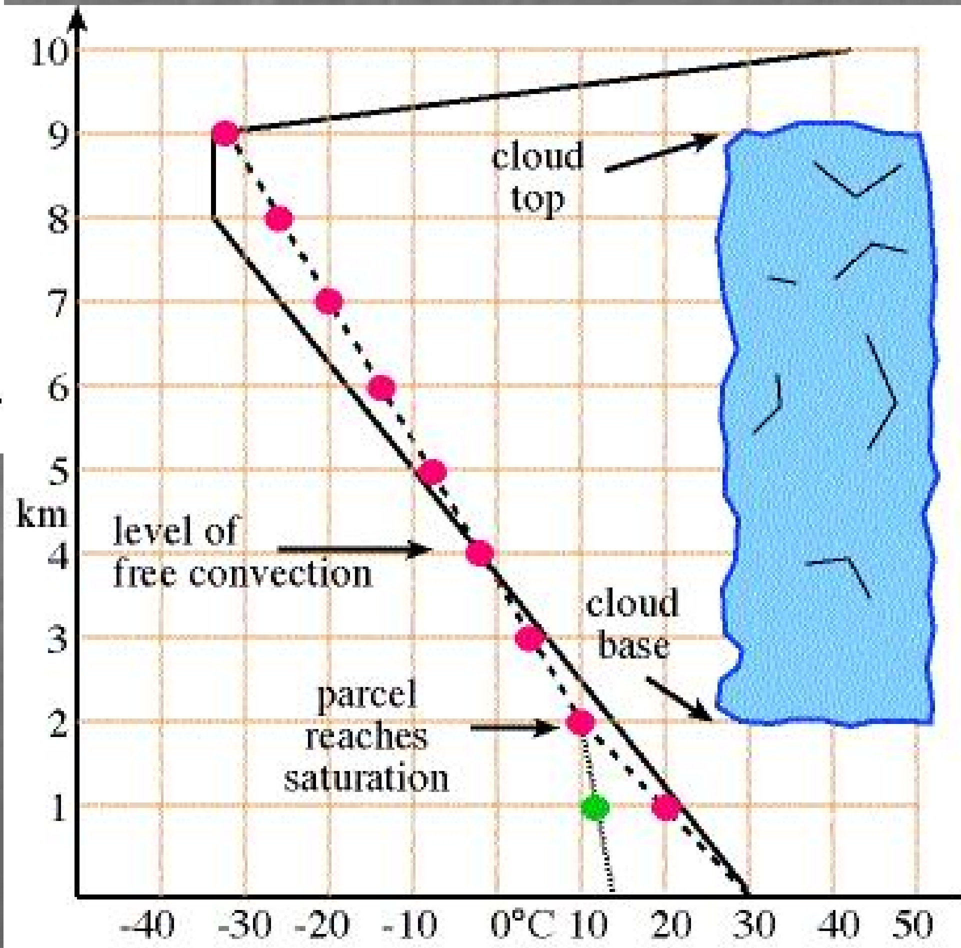


10
9
8
7
6
5
km
4
3
2
1
Γ_e=8°C km^{-1}
(environment)
parcel
reaches
saturation
-40 -30 -20 -10 0°C 10 20 30 40 50


10
9
8
7
6
5
km
4
3
2
1
Γ_e=8°C km^{-1}
(environment)
parcel
reaches
saturation
-40 -30 -20 -10 0°C 10 20 30 40 50


10
9
8
7
6
5
km
4
3
2
1
Γ_e=8°C km^{-1}
(environment)
unstable
level of
free convection
stable
parcel
reaches
saturation
-40 -30 -20 -10 0°C 10 20 30 40 50


10
9
8
7
6
5
km
4
3
2
1
level of free convection
parcel reaches saturation
-40 -30 -20 -10 0°C 10 20 30 40 50


10
9
8
7
6
5
km
4
3
2
1
cloud top
level of free convection
cloud base
parcel reaches saturation
-40 -30 -20 -10 0°C 10 20 30 40 50