METEOROLOGY PART II

REMEMBER - YOU FLY AN AIRPLANE WITH YOUR HEAD, NOT YOUR HANDS.

CLOUDS

1. **Cumulus** – forms in rising air currents and indicate **unstable air.**

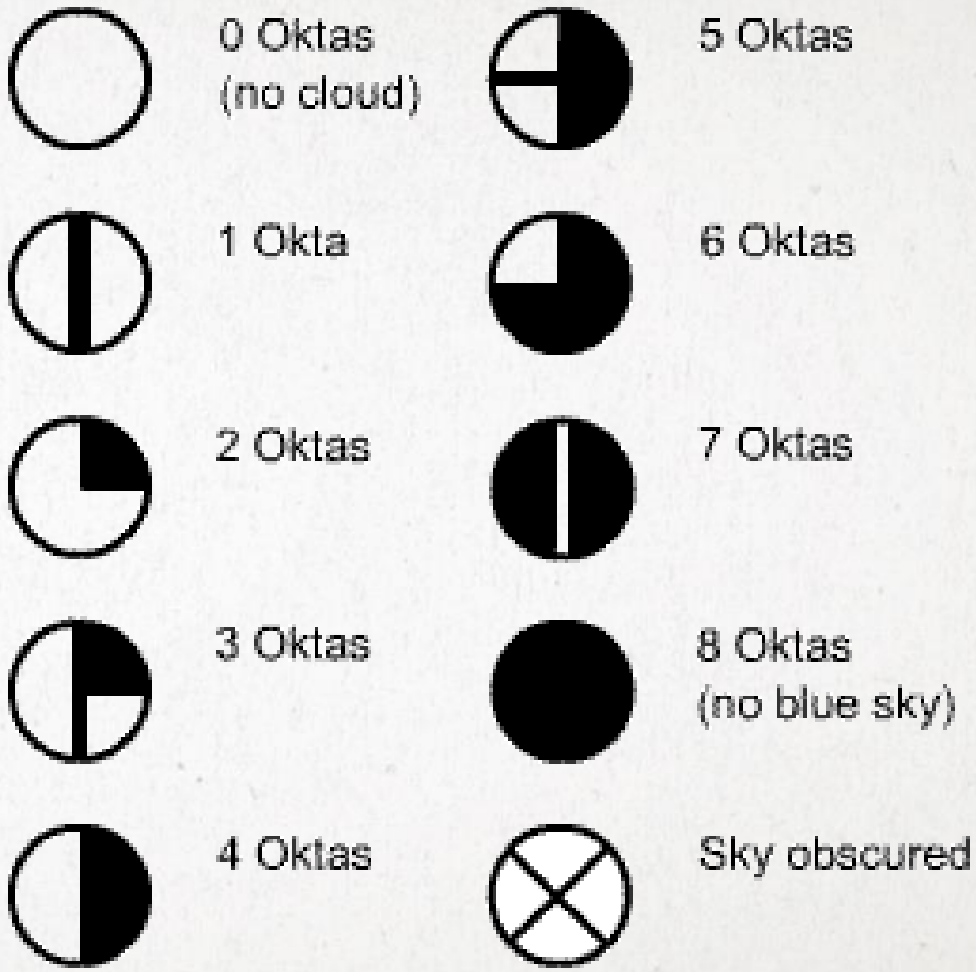
2. **Stratus** **–** forms in horizontal layers and indicate **stable air.**

3. **Nimbus** –rain falls from these clouds

SKY CONDITIONS

The sky is divided into 8 sections called ***oktas***

- Clear – no clouds
- Few – 2 oktas
- Scattered – 3 to 4 oktas
- Broken – 5 to 7 oktas
- Overcast – 8 oktas



ACTIVITY TIME!

- Please refer to your study sheet!

CLOUD HEIGHT

Families	Height of Bases
Low (Strato)	Surface – 6500 ft
Middle (Alto)	6500 ft – 23000 ft
High (Cirro)	16500 ft – 45000ft
Vertical Development	1500 ft and above

CLOUD FORMATION

1. Relative Humidity
2. Condensation nuclei
3. Cooling air is present

Definition: The ratio of water vapor present in the air compared to the amount the same volume could hold if it was saturated.

Definition: Water absorbent particles of solid matter – dust, salt, smoke

QUESTION TIME!

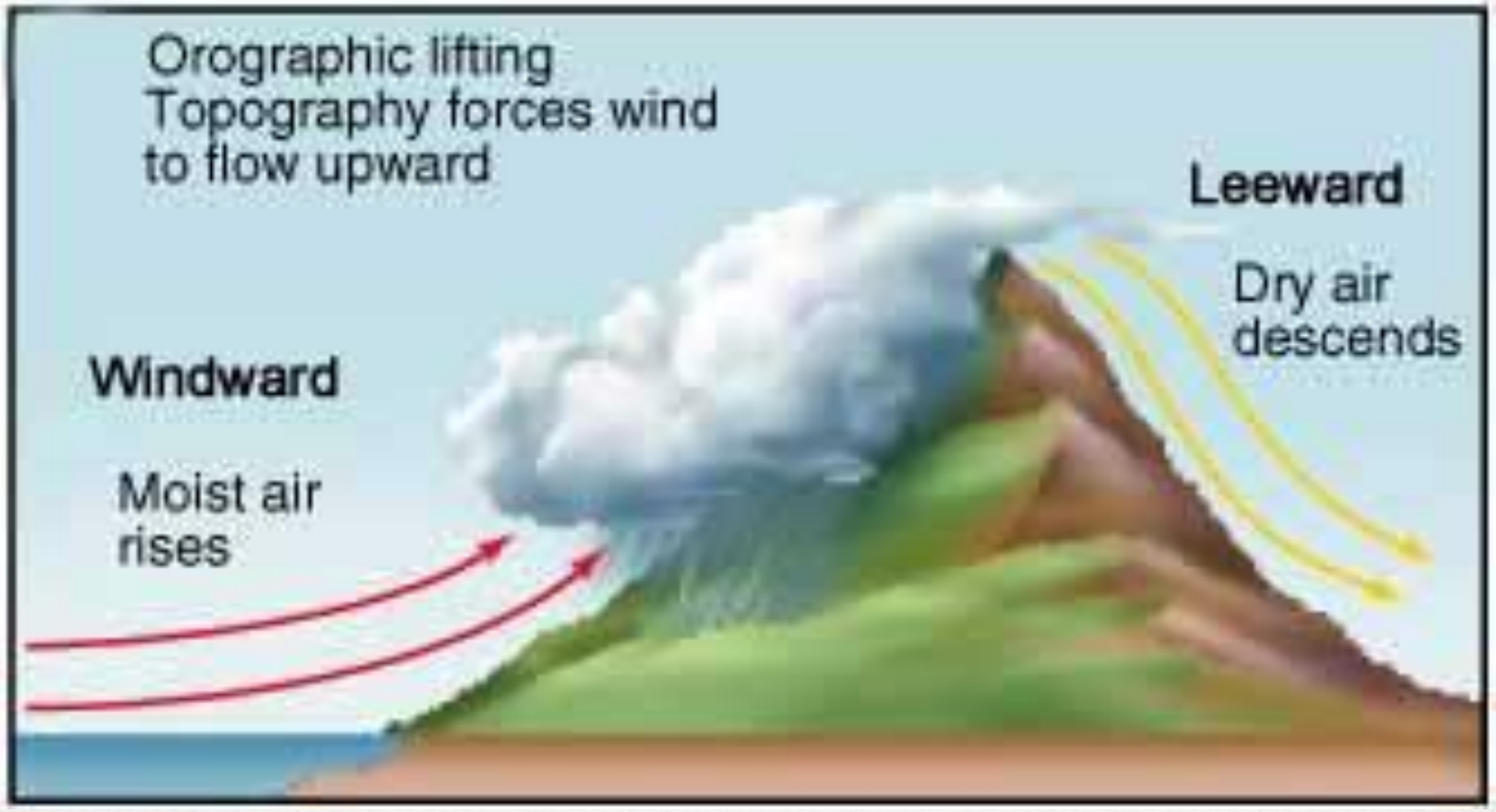
1. If a mass of air is heated and no new water vapour is added, what happens to the relative humidity?

   The relative humidity **decreases**

2. What makes the relative humidity increase?

   When cool air is added

LIFTING AGENT – *OROGRAPHIC* LIFT

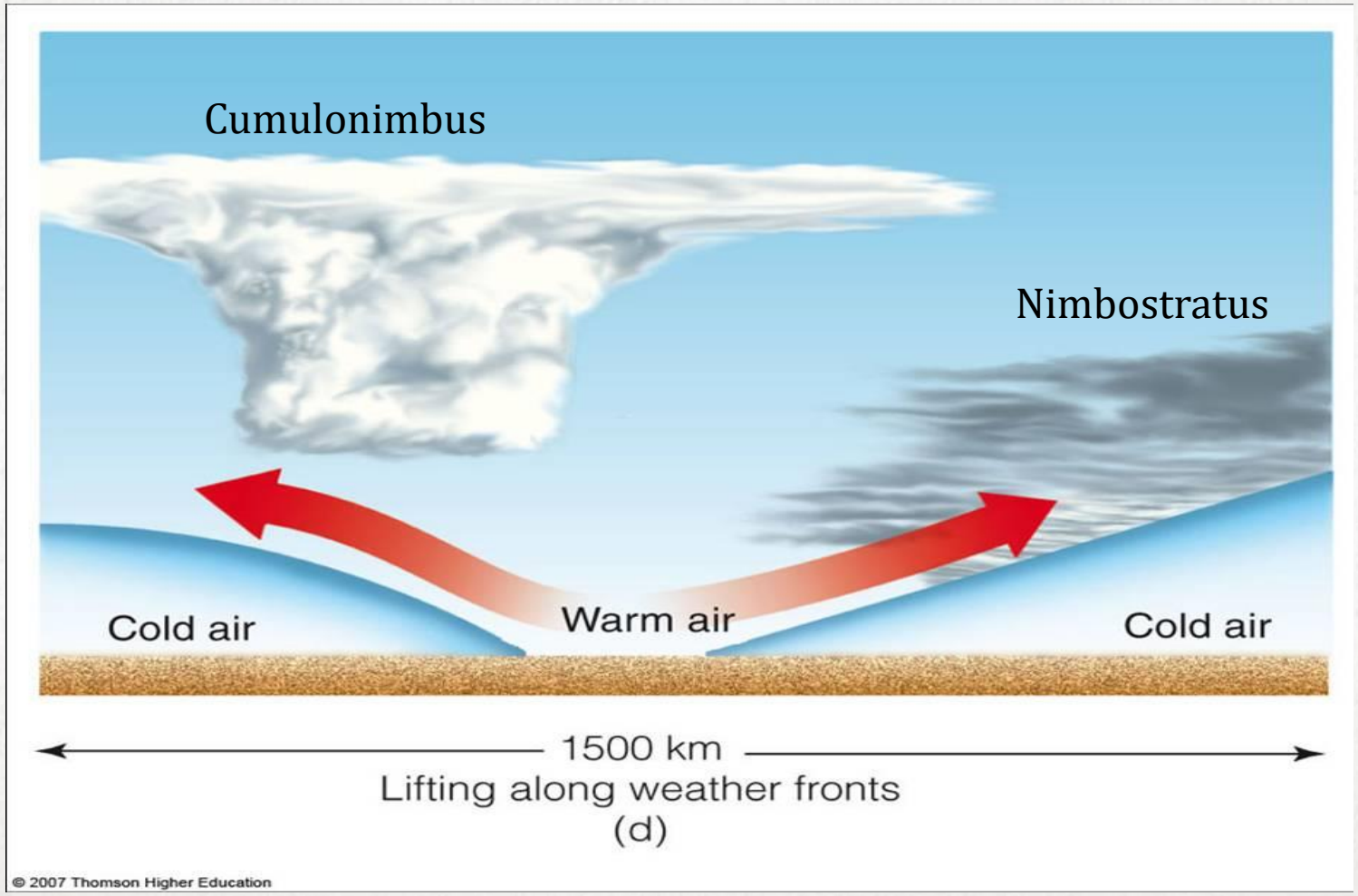


LIFTING AGENT – *OROGRAPHIC* LIFT

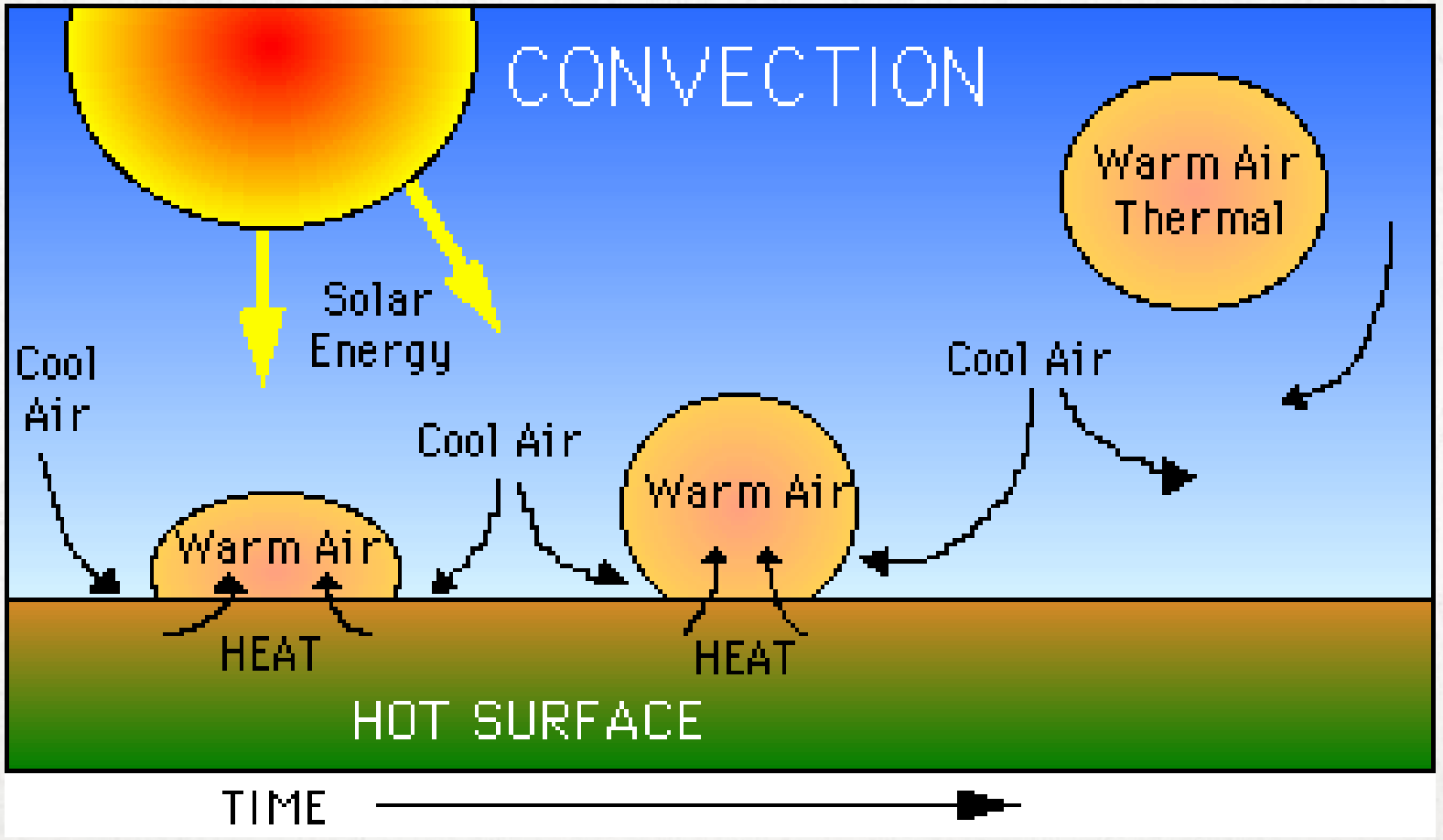
Dew Point

- The temperature to which unsaturated air must be cooled at constant pressure to become saturated

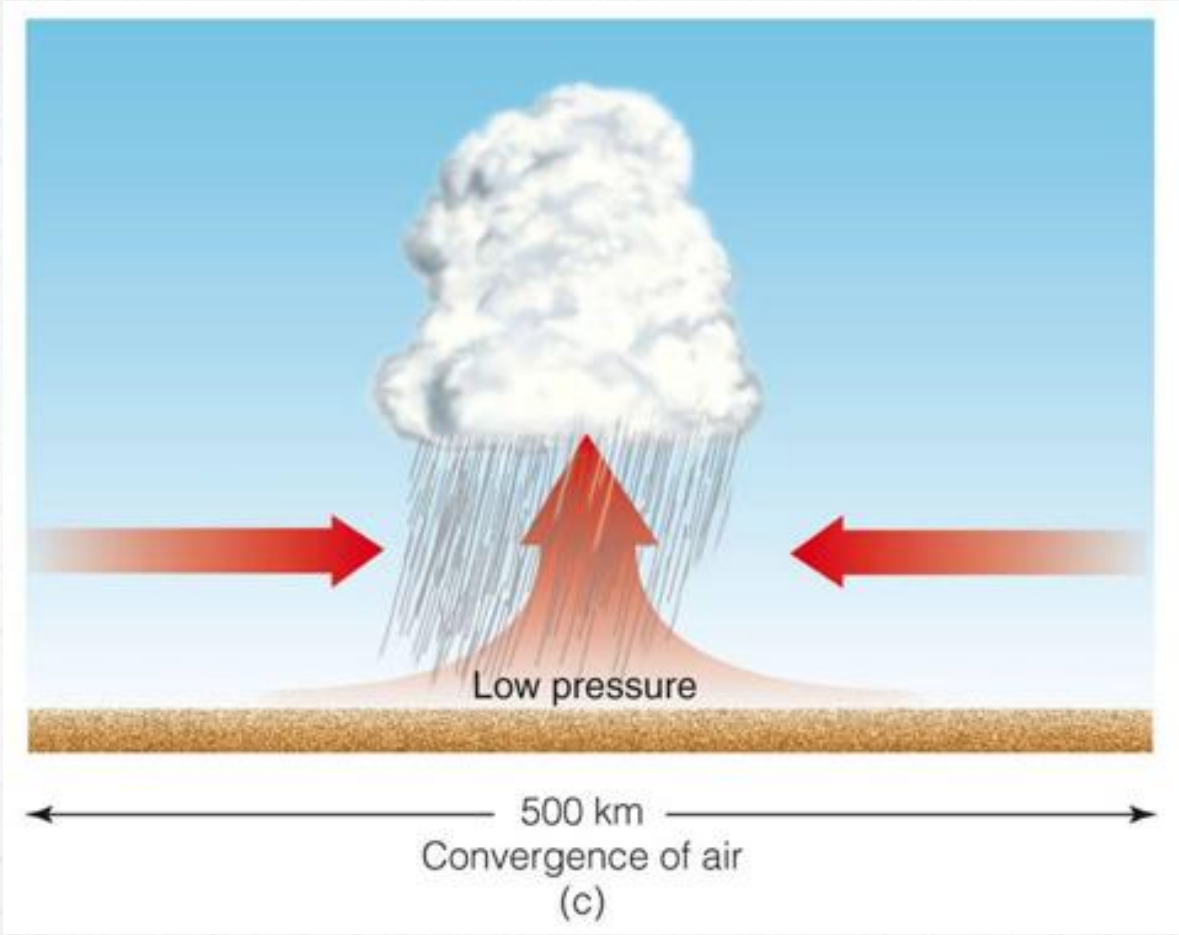
LIFTING AGENT – *FRONTAL* LIFT



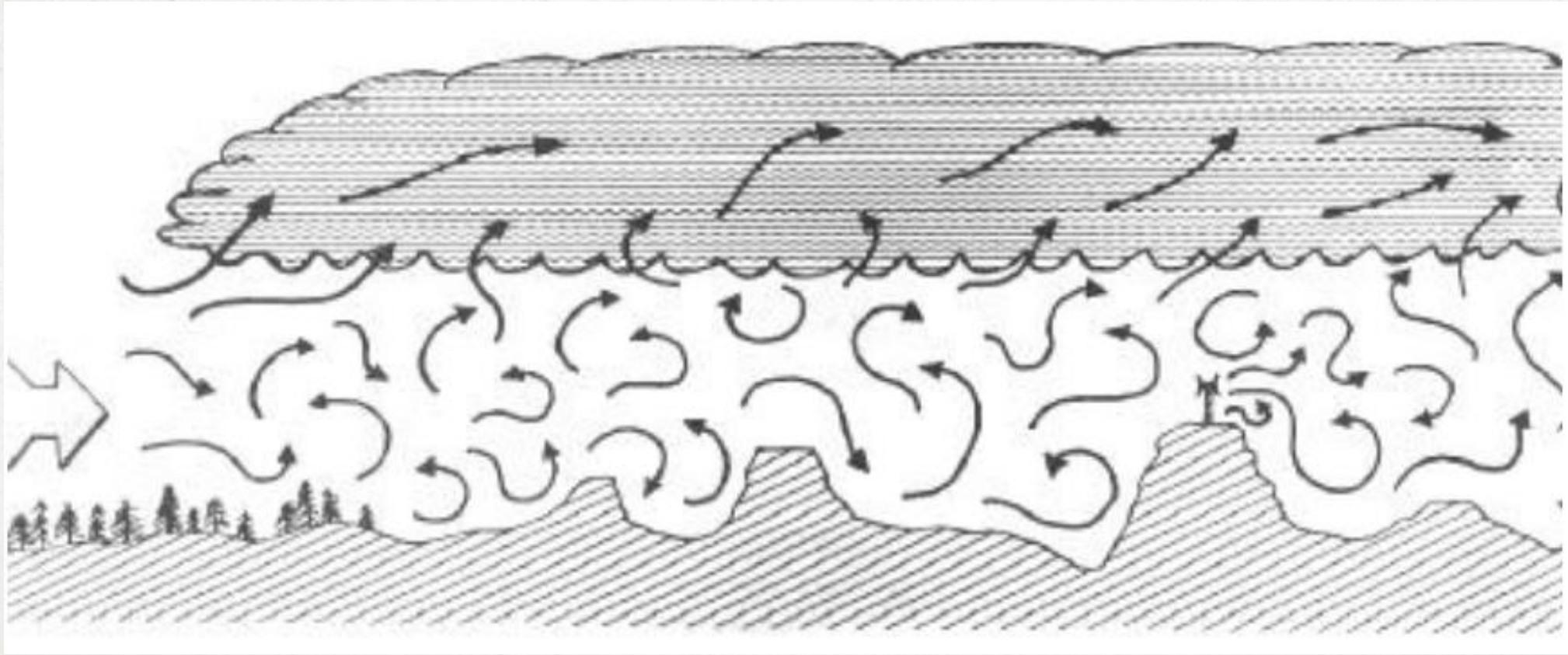
LIFTING AGENT – *CONVECTION*



LIFTING AGENT – *CONVERGENCE*



LIFTING AGENT – *TURBULENCE*



LIFTING AGENTS - SUMMARY

Orographic lift – air blowing against a range of hills or mountains is forced upwards into a region of lower pressure, expands and cools.
Frontal Lift – a mass of warm air is forced aloft and rises over cold air. The rising warm air cools by expansion and clouds are formed.
Convection – Sun heats the earth unevenly, rising currents occur. This is convection. The air rises, expands and cools.
Convergence – Air piles up over a region as at the center of low pressure area. The excess air is forced to rise, expand and cool
Turbulence – Air blowing on uneven surfaces causing uneven heating allowing vertical currents to occur. Air moves upward, expands and cools.

PRESSURE

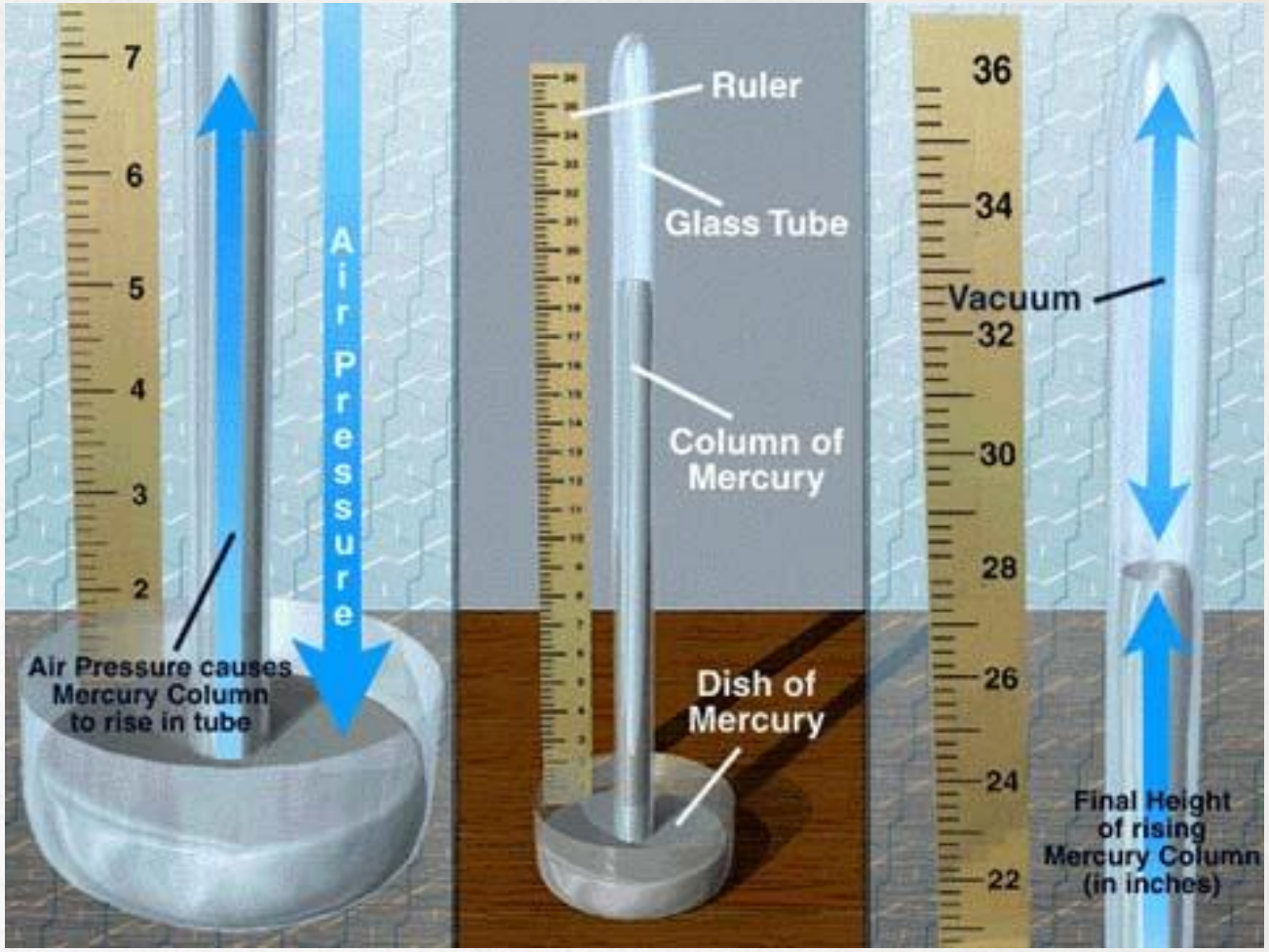
PRESSURE

Definition: The pressure of the atmosphere at any point is due to the ***weight*** of overlying air.

"The force exerted by an air mass is created by the **molecules** that make it up and their size, motion, and number present in the air. **The number of air molecules above a surface determines air pressure.**"

PRESSURE

- Measured by mercury barometer
  - **“Hg**
- Unit of measure: **force by unit area – hectopascal (hPa)**



QUESTION TIME!

- What is the mean sea level pressure in hectopascals?
- **1013.25 hPa**
- What is the mean sea level pressure in inches of mercury?
- **29.92 “Hg**

PRESSURE

HIGH PRESSURE	LOW PRESSURE
“Anti-cyclone”	“Cyclone”
Clockwise and outward	Counter clockwise and inward
Pressure highest in the center	Pressure lowest in the center
Expect fair weather	Expect poor weather

PRESSURE

Pressure always flows from

GRAPHICAL FORECAST AREA

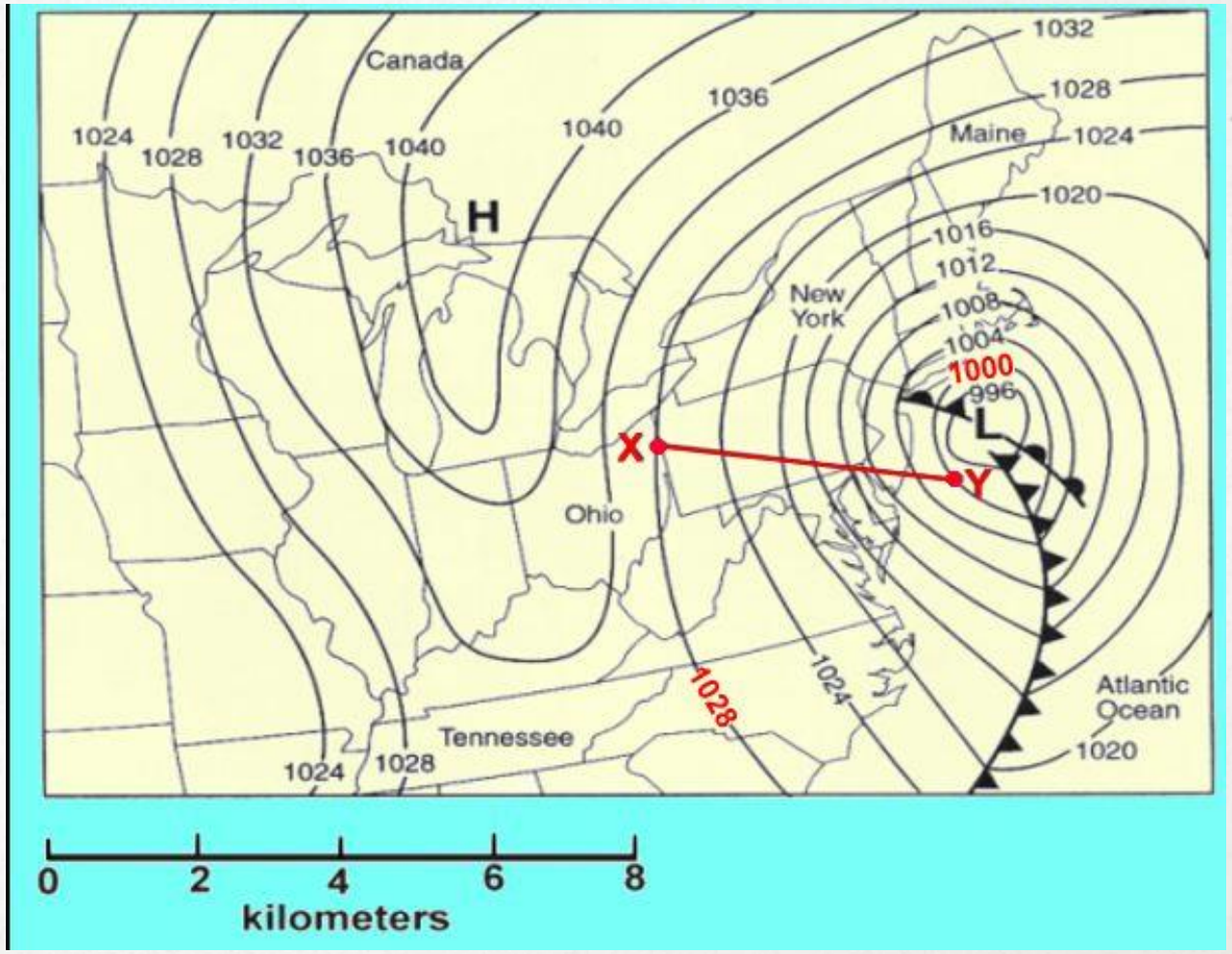
- Website
- https://flightplanning.navcanada.ca/Latest/gfa/anglais/Latest-gfacn33_cldwx_000-e.html?Produit=GFA&Region=33&Langue=anglais&NoSession=&Mode=graph

DEFINITIONS

- **Isobars** – lines that join, on a weather map, areas of equal barometric pressure.
- **Isotherms** – lines that join, on a weather map, areas of equal temperature.
- **Trough** – U shaped area of low pressure with higher pressure on either side
- **Ridge** – area of high pressure with low pressure on either side
- **Col** – a neutral area between two highs and two lows.

PRESSURE GRADIENT

- Definition: The rate of change of pressure over distance is measured at **right angles** to the isobars
- It is steepest when isobars are close
- It determines wind velocity (the closer the isobars the stronger the winds)



PHYSICS LESSON

- We can agree upon the following principle:
  - Anything moving above the surface of the earth will continue to move in a **straight line if no force acts on it.**

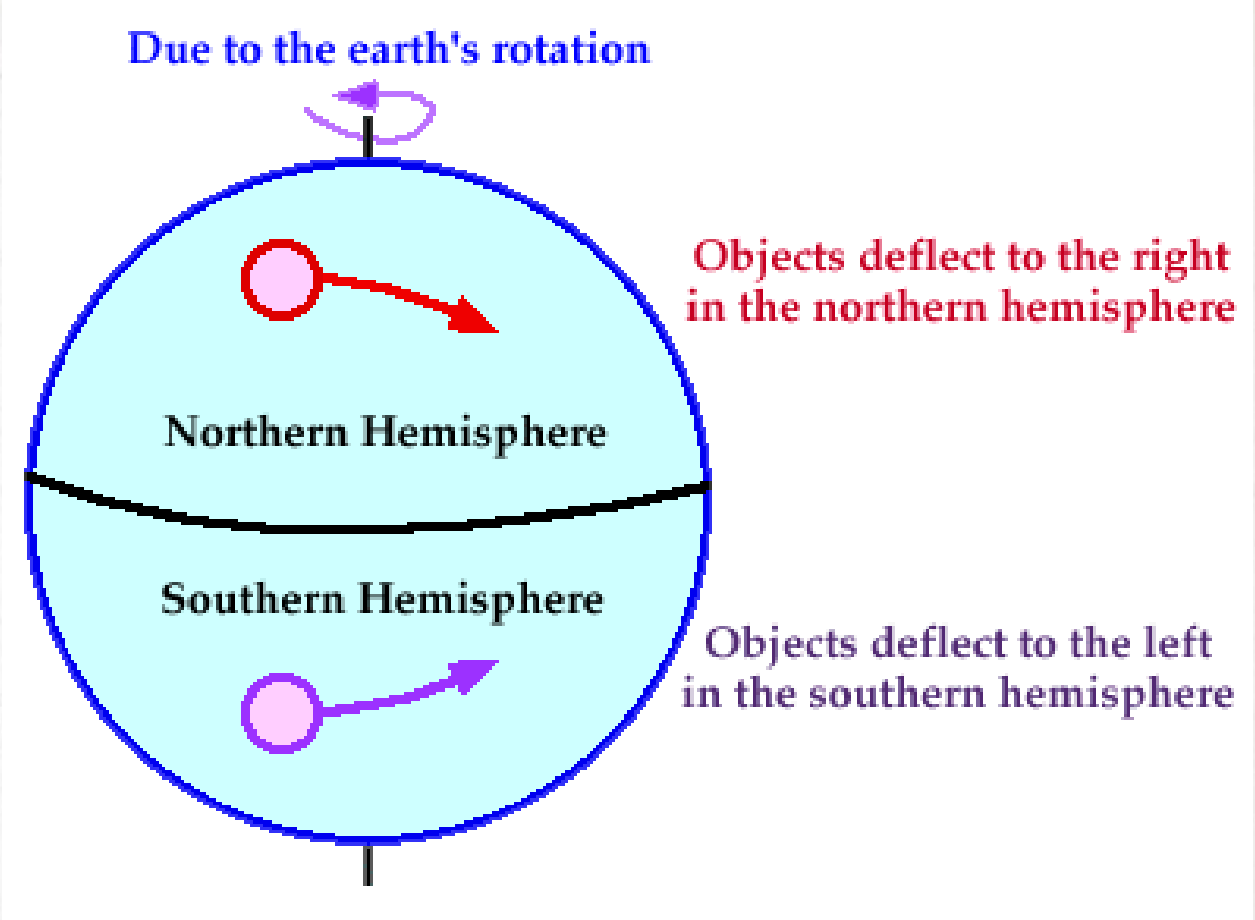
- Therefore – wind must move in a straight line. High pressure must then flow towards low pressure in a straight line!
- Is this statement correct?

PHYSICS LESSON

- Remember: the earth rotates on an angle.

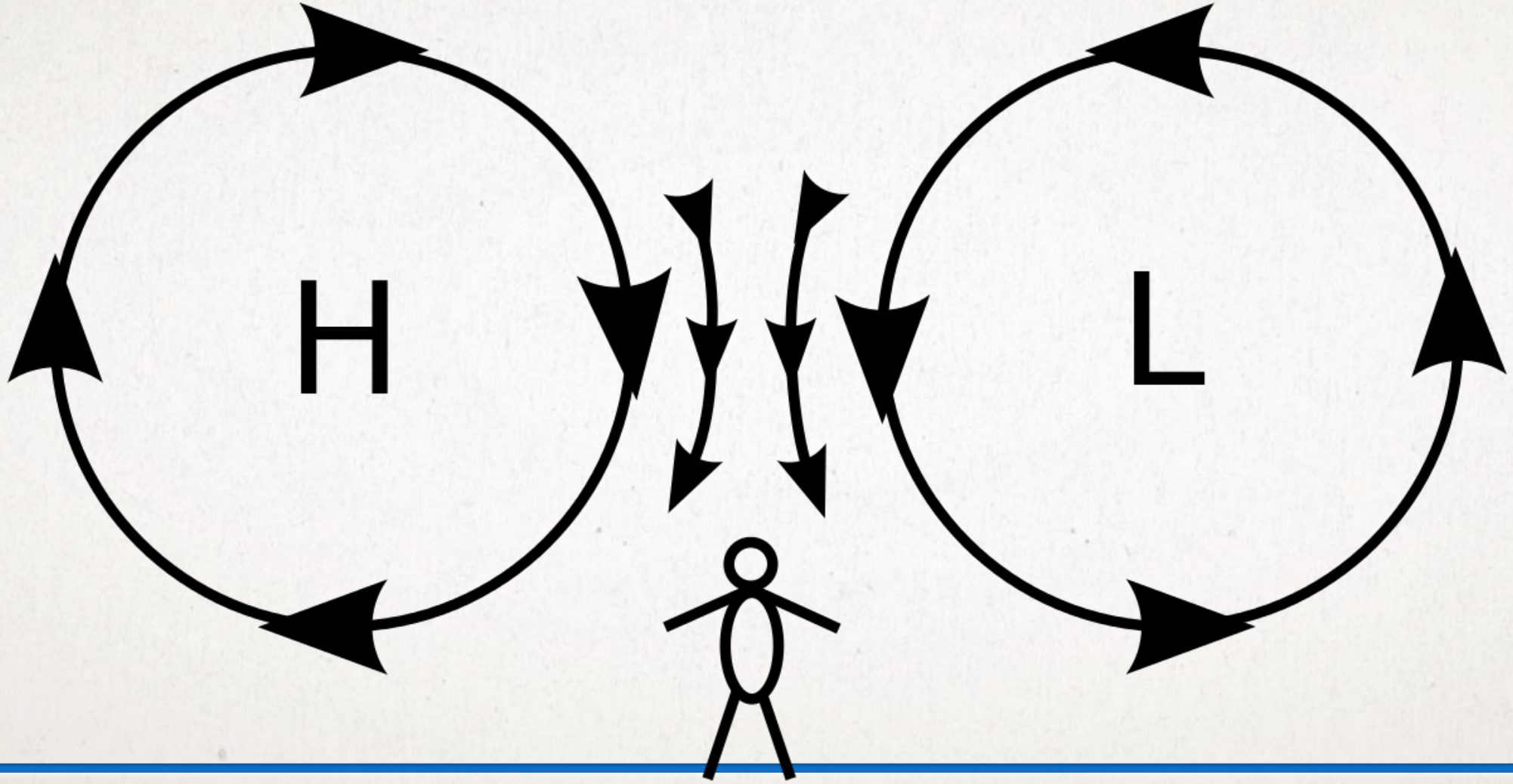
CORIOLIS FORCE

- What can we assume from this information?
- In the Northern hemisphere:
  - Low pressure is deflected to the **right** causing it to flow **counter clockwise**
  - High pressure is deflected to the **right** causing it to flow **clockwise**



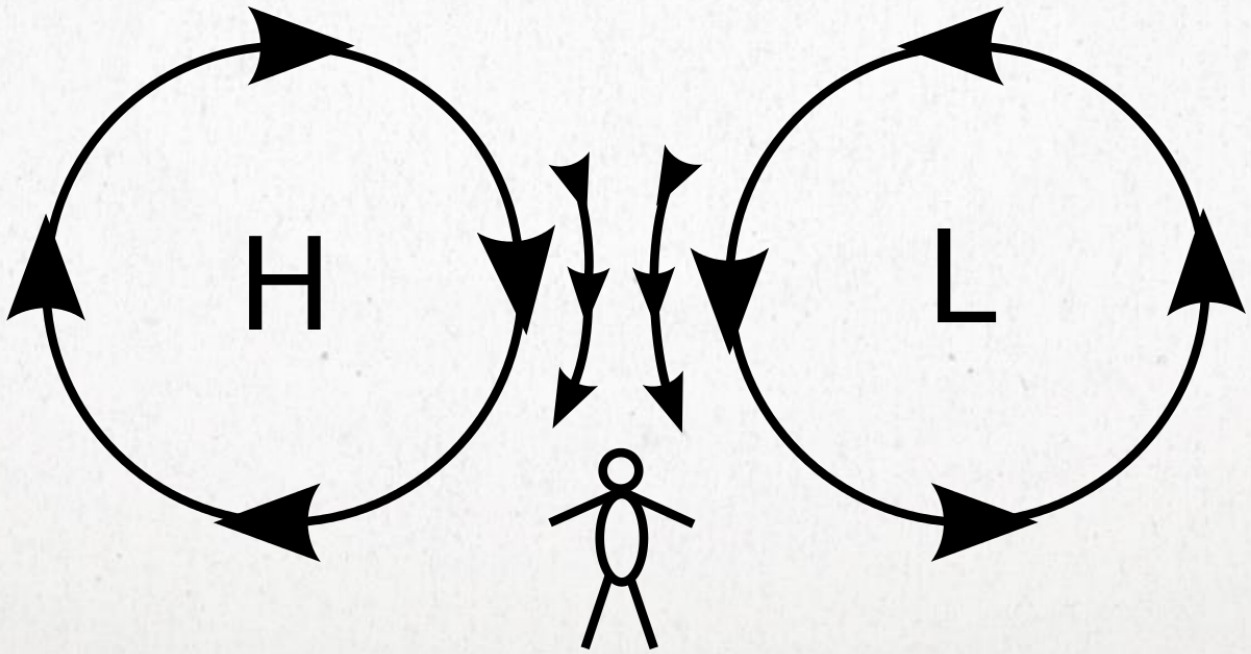
BUY BALLOT'S LAW

*Northern Hemisphere only



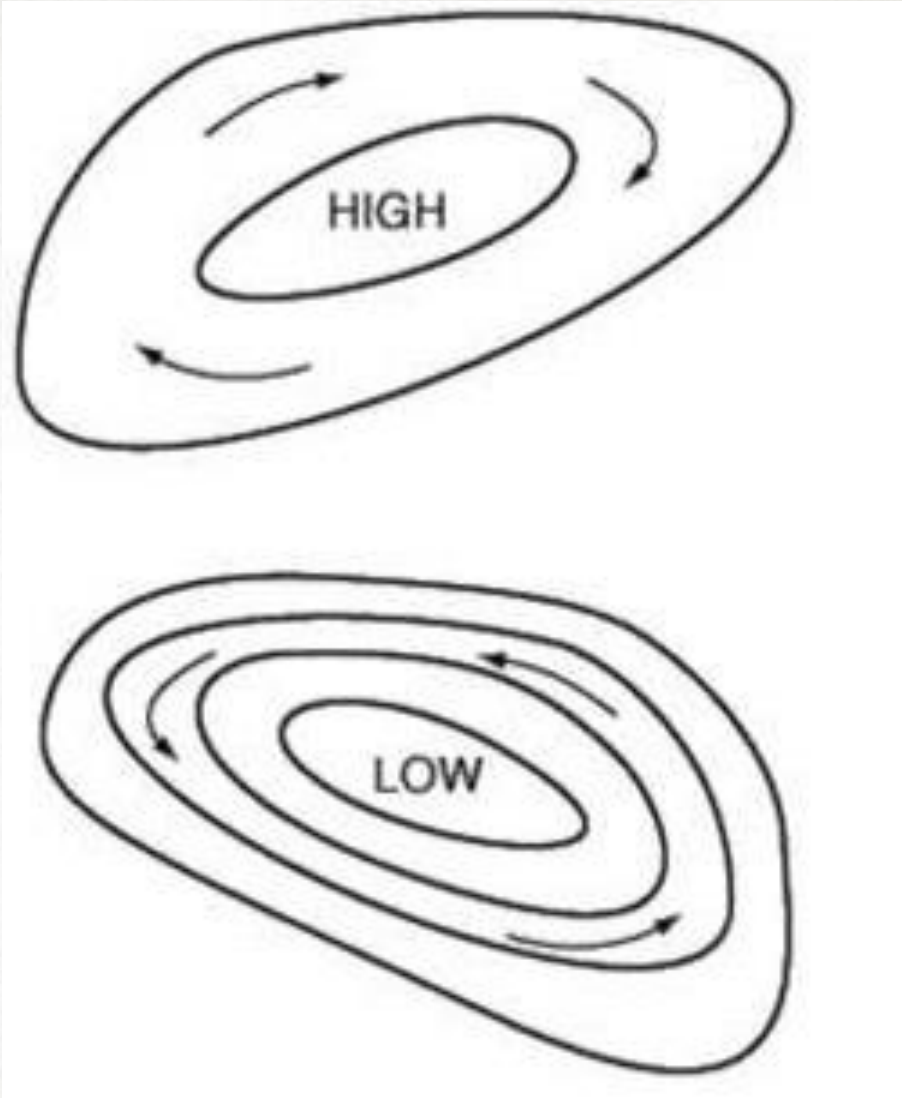
QUESTION TIME!

- How would we change the following diagram if we were in the Southern hemisphere?



SURFACE FRICTION

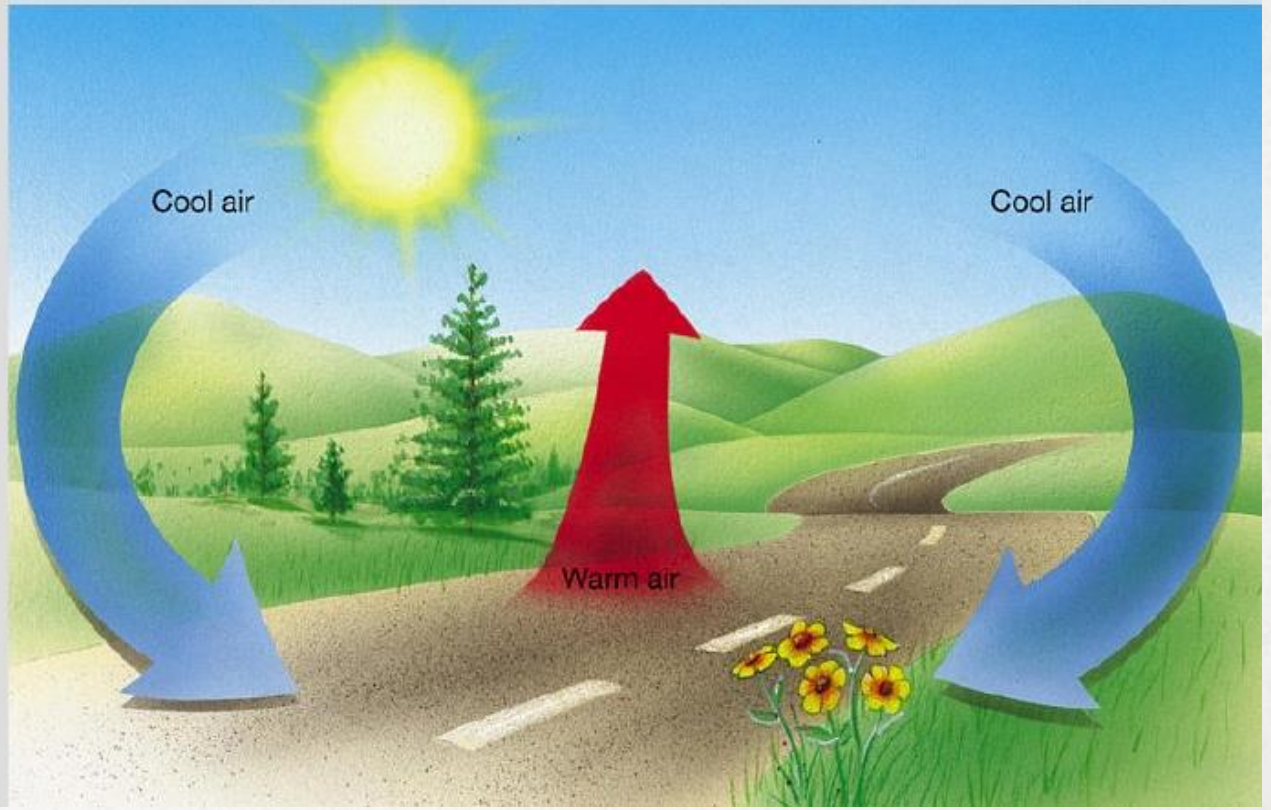
- <u>Definition:</u> Friction between the surface on the earth and the atmosphere will **slow** the movement of the air.
- This affects the direction and speed of air moving from an area of high pressure to low pressure.
- Does not apply above 2000 feet



CONVECTION

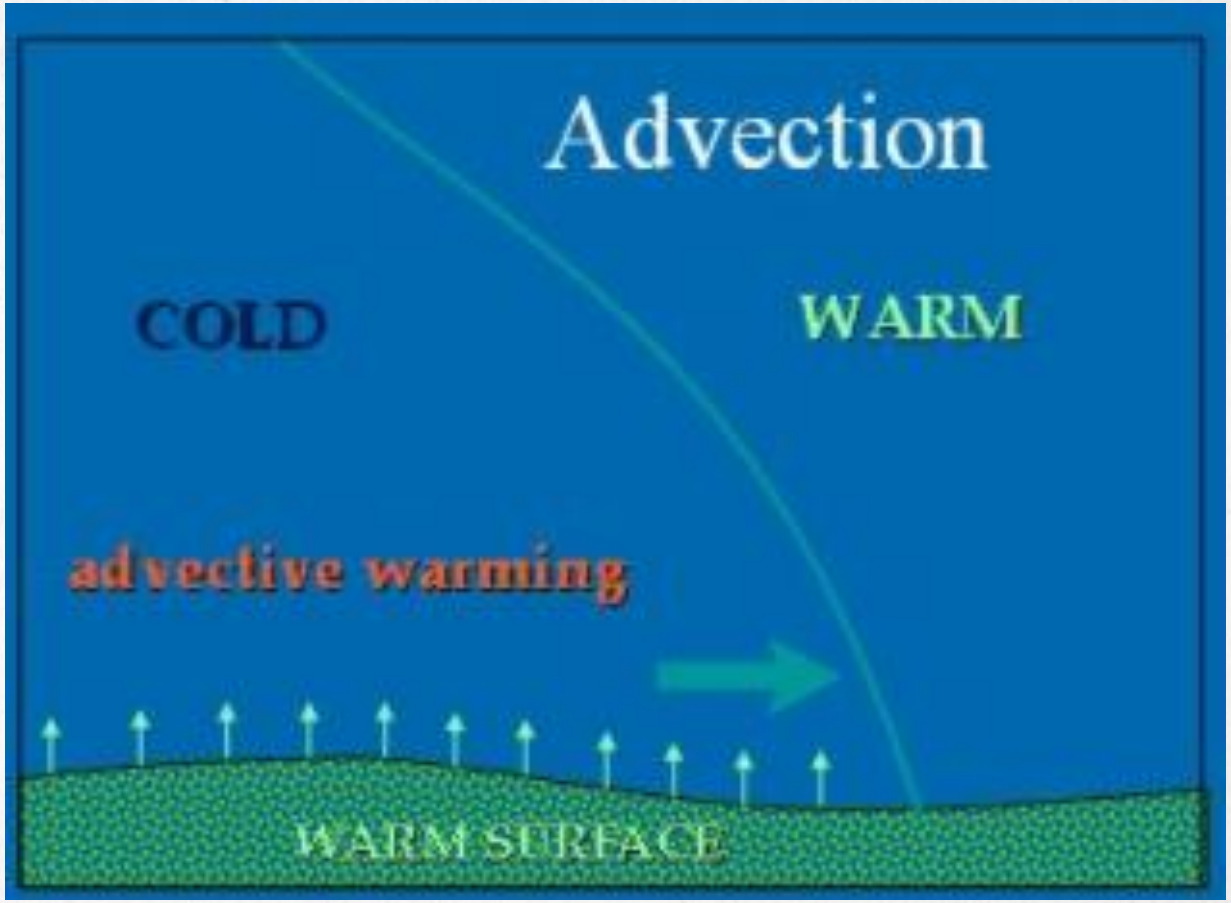
- Ground is warm and the air rises, cold air replaces it causing a vertical circulation

As air above the road warms up, it rises and is replaced by cooler air, forming a *convection current*.



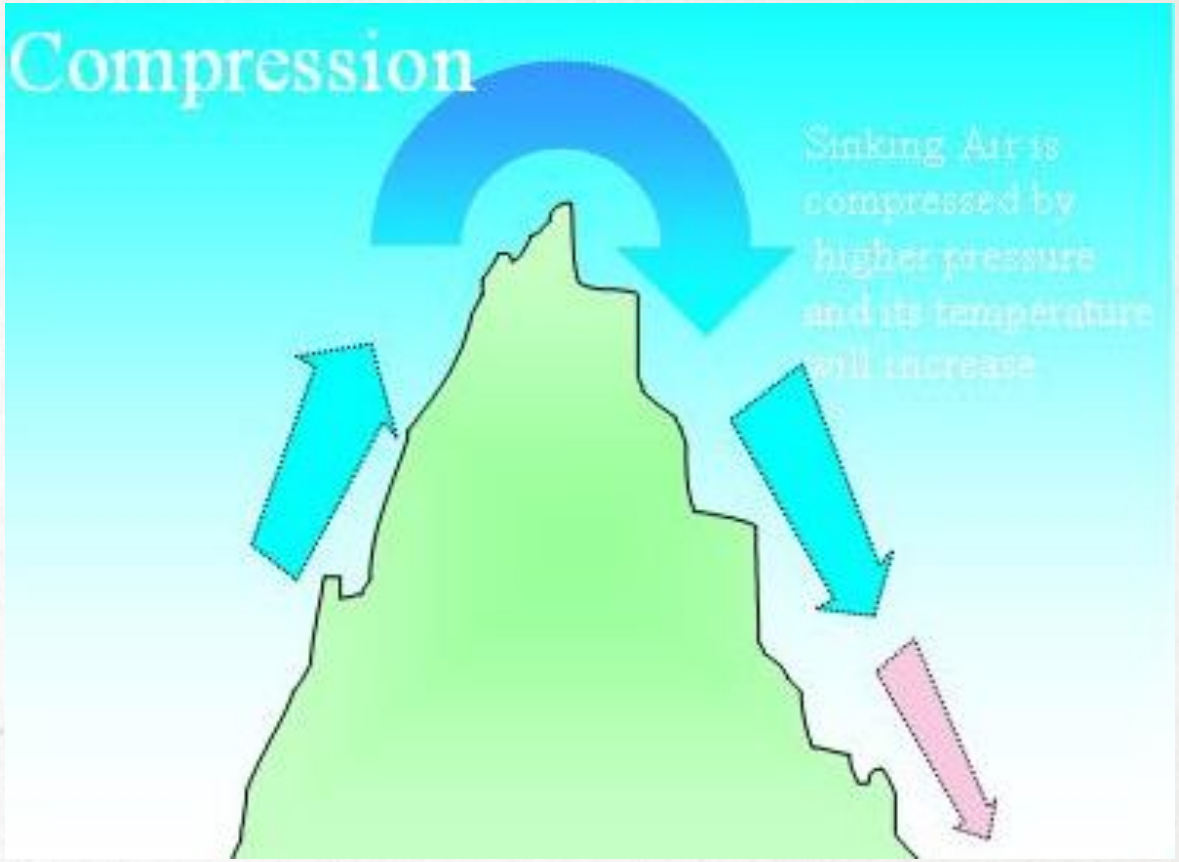
ADVECTION

- Cold air goes over an area of warmer air. The bottom of the cold air mass heats up.
- Also called advection heating



COMPRESSION

- As air sinks, it moves into an area of high pressure – this causes it to be compressed which results in heating the mass of air.



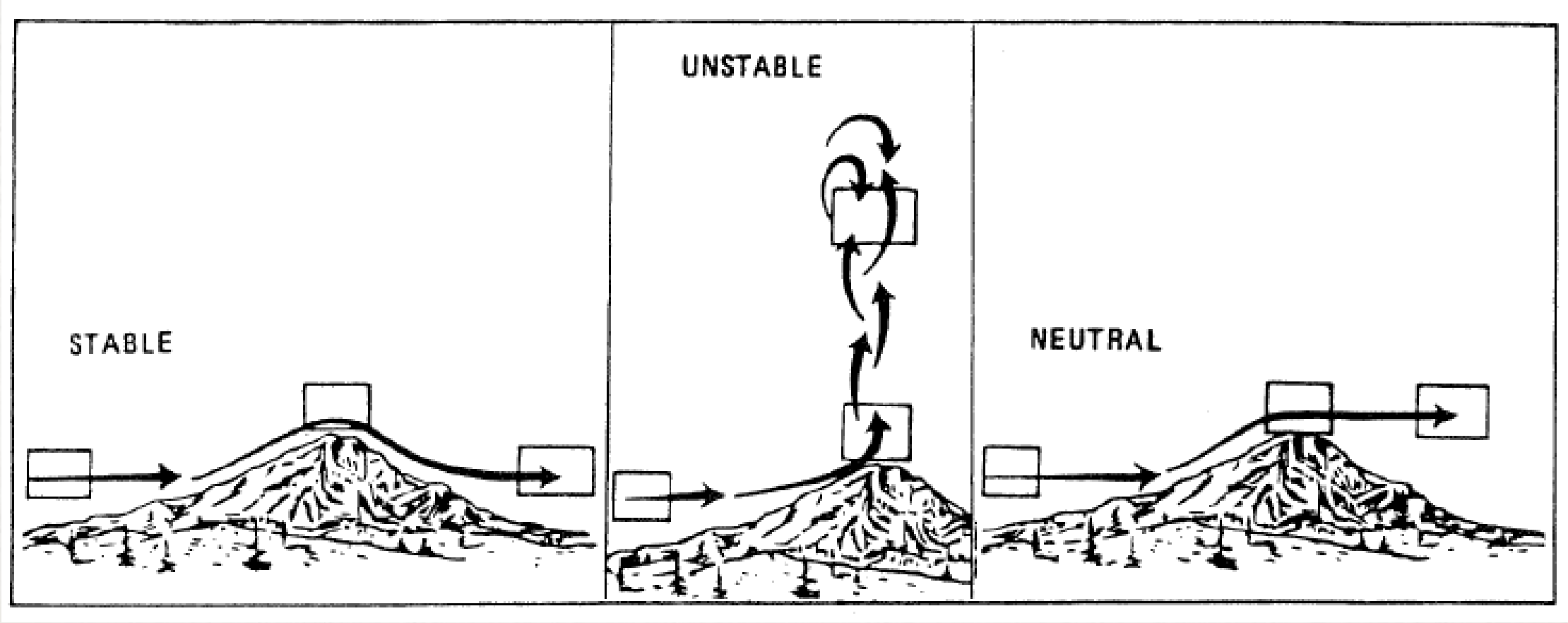
TURBULENCE

- Mechanical turbulence which is the result of friction between the air and the ground causes a mixing process that spreads the surface heat into the air

STABILITY

- **Stability:** The tendency of air to remain at the horizontal level when disturbed. It resist upward and downward displacement.
- **Instability:** The tendency of air to move away from its original horizontal level when disturbed.

STABILITY



LAPSE RATE

- The **lapse rate** is defined as the **rate** at which atmospheric temperature decreases with an increase in altitude.

- Dry Adiabatic – 3 degrees per 1000 ft
- Wet Adiabatic – 1.5 degrees per 1000 ft
- ICAO standard – 1.98 degrees per 1000 ft

STABILITY & LAPSE RATE

- **Unstable air** indicated by steep lapse rate
- Steeper lapse rate = more unstable air
- Greater than the ICAO standard

- **Stable air** indicated by shallow lapse rate
- Shallower lapse rate = more stable air.
- Less than the ICAO standard

STABLE VS UNSTABLE AIR

Characteristic	Stable Air	Unstable Air
Lapse Rate	Shallow	Steep
Cloud Type	Stratus Type	Cumulus Type
Precipitation	Uniform Intensity including drizzle	Showers
Visibility	Poor low level (Fog may occur)	Good, except in precipitation
Wind	Steady winds which can change with height	Gusty
Turbulence	Generally smooth flying conditions	Turbulence may be moderate to severe

AIR MASS

- Definition: A large section of the troposphere with uniform properties of **temperature** **and moisture** **in the horizontal.**
- An air mass can extend for several thousands of miles.
- 5 types – Continental (c) - dry, Maritime (m) - moist, Arctic (A) - cold, Polar (P) - moderate, Tropical (T) - hot.

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PROPERTIES OF AN AIR MASS

Cold Air Mass

- Turbulent
- Good visibility
- Cumuliform clouds
- Shower type precipitation
- Thunderstorms may occur
- Generally stable but heating from below creates instability

Warm Air Mass

- Stable
- Smooth air
- Poor visibility
- Startiform clouds
- Steady type precipitation

FRONTS

- Definition: A transition zone between different air masses.

Cold Front

- The leading edge of an advancing cold air mass
- The slope of the front is very steep
- Narrow weather band – changes occur rapidly
- Can be very severe

Weather in a cold front

- Clouds of vertical development
- Showers
- Wind veer
- Temperature decreases behind the front

Fast moving cold fronts may produce severe thunderstorms and/or squall lines

FRONTS

Warm Front

- The trailing edge of a retreating cold air mass
- Shallow slope
- Wide weather band – up to 500 miles
- Stratiform clouds

Weather in a cold front

- Stratus clods
- Wind veer
- Steady precipitation
- Temperature rises behind front
- Thunderstorms may be embedded in the stratus clouds

APPROACHING WARM FRONT

Sequence of clouds indicating the approach of warm front are:

C – cirrus

C – cirrostratus

A – alto stratus

N – Nimbostratus

S – stratus

Abbreviation – C-CANS

PRECIPITATION

Definition: When water droplets (visible as a cloud) grow sufficiently in size and weight they fall due to gravity.

Forms of precipitation:

- Snow
- Ice prisms
- Ice pellets
- Hail, snow pellets
- Drizzle, rain, freezing drizzle and freezing rain

Precipitation	Cloud types
Drizzle, freezing drizzle, snow	Stratus and stratocumulus
Snow pellets	Heavy cumulus
Ice prism	No cloud necessary
Hail, ice pellets showers	Cumulonimbus
Snow showers, rain showers	Altocumulus, heavy cumulus, cumulonimbus
Snow or rain (continuous)	Thick altostratus, and nimbostratus
Snow or rain (intermittent)	Thick altostratus and stratocumulus

FOG

Definition: Fog is a cloud, usually status, in contact with the ground. It forms when the air is cooled below its dew point.

RADIATION FOG

1. **Radiation Fog**

- Forms on clear night
- Other favorable conditions include: clear skies, moist air, and light winds.
- Ground cools at night by loosing heat – lack of solar radiation. The air in direct contact with the earth's surface is cooled. IF this air is moist and the temperature is lowered to the dew point, fog will form.

FOG

2. Advection Fog

- Forms when moist warm air moves over a cold surface.

3. Upslope Fog

- Caused by the cooling of air due to expansion as it moves up a slope.

4. Steam Fog

- Forms when cold air passes over a warm water surface. Evaporation occur and excess water vapour condenses as fog.

FOG

5. Frontal Fog

- Warm front fogs are the most extensive. They are caused by cold air becoming saturated by evaporation from rain falling from the warm air. Also known as precipitation – induced fog.

6. Ice Fog

- At very low temperature, the air may become full of ice crystals. Ice fog only forms under specific conditions; the humidity has to be near 100% as the air temperature drops to well below 0 °C (32 °F), allowing ice crystals to form in the air. The ice crystals will then settle onto surfaces.

FOG

Ice Fog

Upslope Fog

Steam Fog

THUNDERSTORMS

Definition: A weather phenomena whose presence creates extremely serious hazard to flying. They may be accompanied by:

- Thunder
- Lightning
- Hail
- Heavy rain
- Severe gust and turbulence
- Strong vertical drafts
- Tornadoes
- Micro/macrobursts
- Severe wind shear
- Ice

THUNDERSTORMS

- Thunderstorms must have the following requirements:

  1. Unstable air to high levels

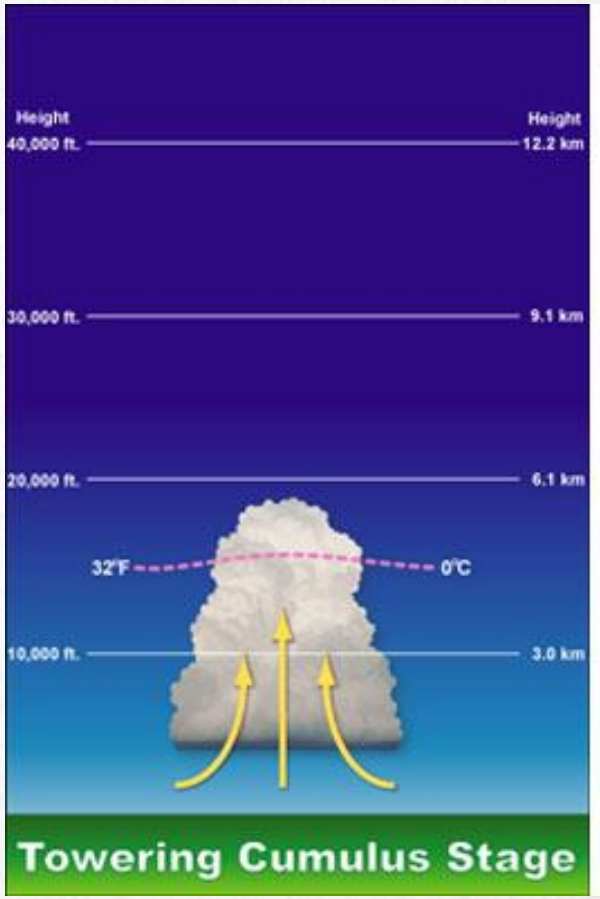
  2. Lifting agents

  3. High moisture content

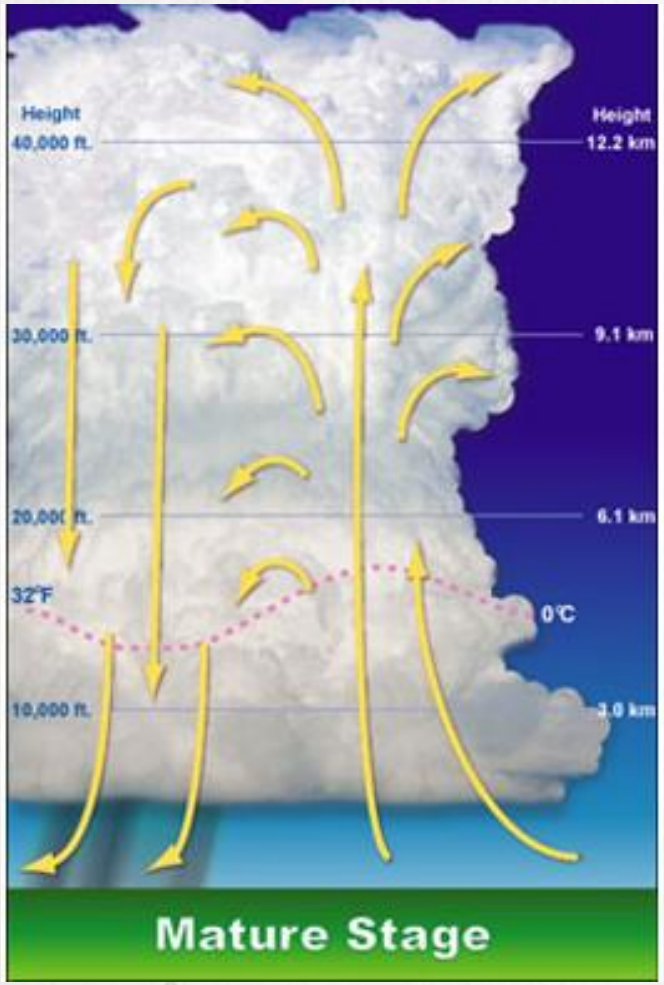
LIFE OF A THUNDERSTORM – STAGE 1

The initial or cumulus stage

- Strong updrafts prevail
- Temperature is higher inside the cloud than the surrounding air
- Diameter ranges from 1 to 2 miles
- Steep lapse rate



LIFE OF A THUNDERSTORM – STAGE 2



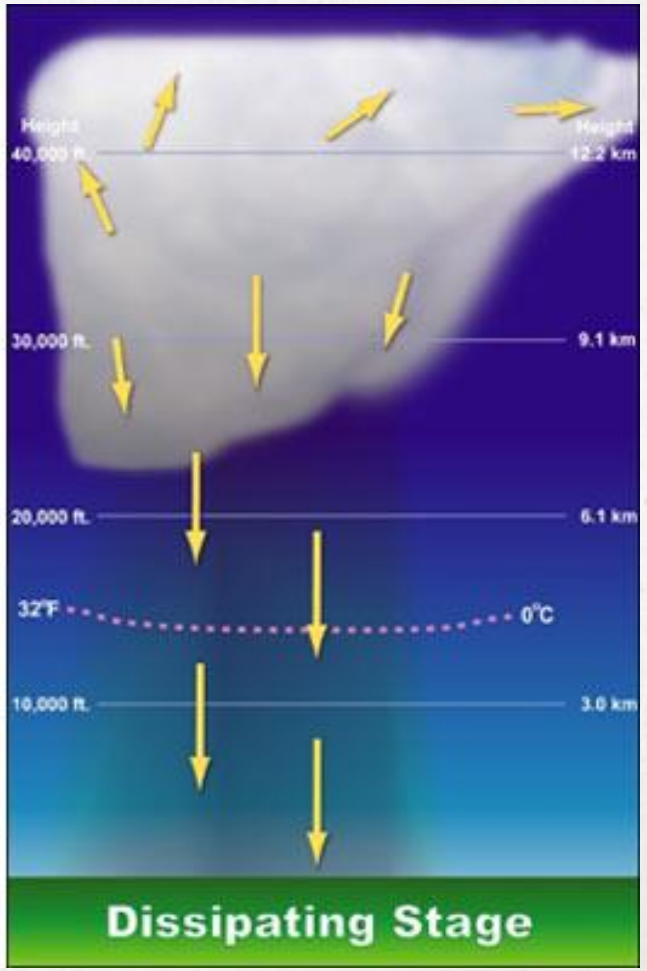
The Mature Stage

- Updrafts penetrate to great heights
- Downdrafts start in the middle and lower levels of cell
- Precipitation starts
- This stage usually lasts between 15 to 30 minutes.

LIFE OF A THUNDERSTORM – STAGE 3

The Dissipating Stage

- Downdrafts occupies all but top of the cloud where updraft persists
- Rain starts to slow and stop
- Top of cloud frays into anvil shape



THUNDERSTORM HAZARDS

- Turbulence – could overstress the aircraft or cause loss of controls
- Winds – dangers of gusts up to 80 knots and rapids changes in direction
- Hail – could cause serious structural damage
- Icing – abundance of super cooled water droplets will cause severe icing
- Lightning – can hamper a pilot's vision for about 30-50 seconds at a time
- Pressure – rapid changes leading to unreliable altimeter readings

QUESTION TIME

- If a pilot encounters a thunderstorm, how far must the stay away?
- Which direction should they fly around the storm?

If you must fly past a thunderstorm, stay at least 15 miles away and pass to the right to encounter more favorable winds.

TURBULENCE

Definition: This is an irregular motion of air resulting from EDDIES and vertical currents.

There are four types/causes of turbulence:

1. Mechanical Turbulence: Friction between the air and the ground especially from man made obstacles causes “Eddies”.
2. Thermal Turbulence: Hot sunny days when the sun heats the earth’s surface unevenly. Convection currents form causing turbulence.
3. Frontal Turbulence: The lifting of the warm air by the sloping frontal surface and friction between 2 air masses produces turbulence.
4. Wind Shear: Sharp changes in wind direction and speed either vertical or horizontal.

CLASSIFICATION OF TURBULENCE

Light: Momentary slight changes in altitude and/or attitude or slight bumpiness

Moderate: Occupants may feel a strain against their seat belts and unsecured objects will be dislodged.

Severe: large and abrupt changes in altitude and/or attitude and usually large variations in indicated air speed.

Extreme: Airplane is tossed about violently and is impossible to control. May lead to structural damage.

AIRCRAFT ICING

Definition: In temperatures at or below freezing, super cooled water droplets may strike an aircraft and freeze. This is known as icing.

Frozen Dew: Dew may form on an aircraft over night. If the aircraft skin temperature falls below freezing this dew will freeze. (White semi-crystalline frost)

Hoar Frost: A white, feathery, crystalline formation that covers the entire surface of the aircraft. Forms in clear air when a cold aircraft enter warmer, damper air during a steep decent.

AIRCRAFT ICING

Rime Ice: An opaque or milky white ice that forms on an aircraft. Forms by the almost instantaneous freezing of small super cooled water droplets. Has no great weight.

Clear Ice: A coating of glassy like ice. Forms as super cooled water droplets freeze slowly and spread. Can increase drag by as much as 300% - 500%.

AIRCRAFT ICING

Fluids – released on the leading edge to flow over the blades of the propeller and wing surfaces

Rubber boots – membranes of rubber attached to the leading edges.

Heating devices – heating vulnerable areas with hot air from the engine or special heaters is a method of preventing the buildup of ice.

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