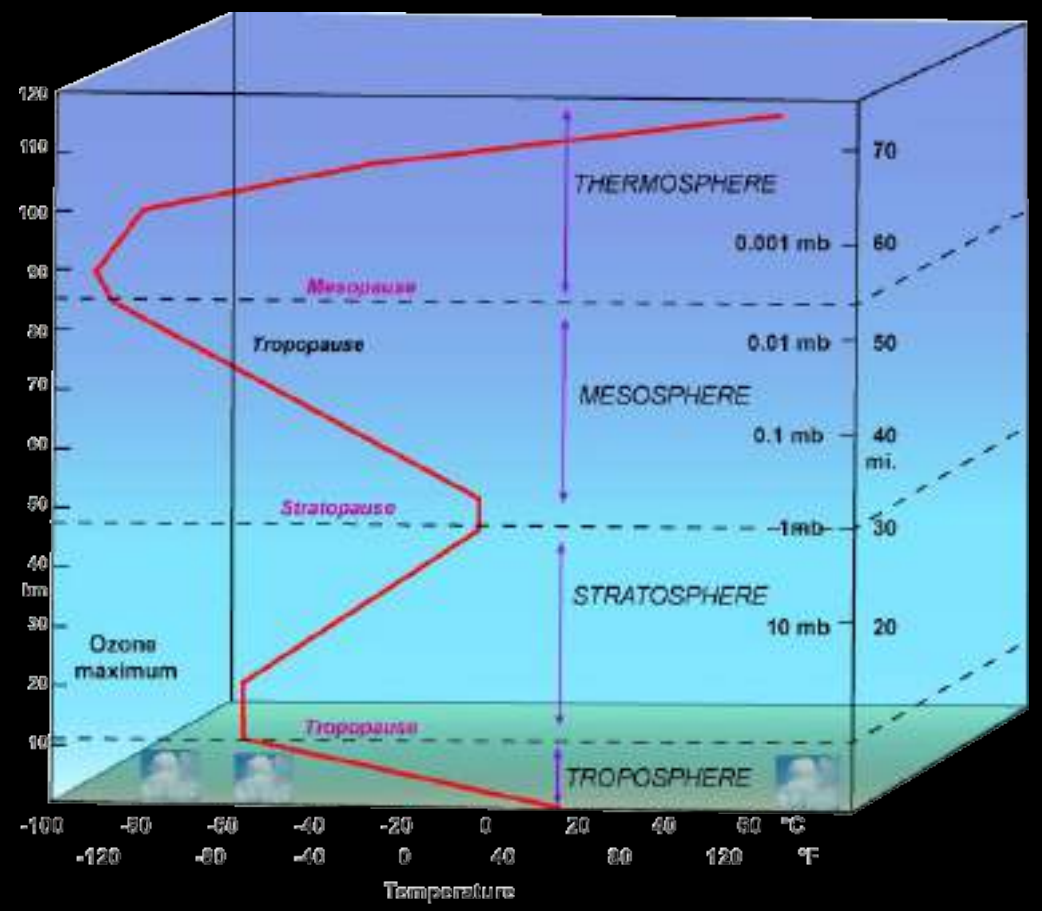
Climatology

Tapan Debnath

Topic

1. Structure of Atmosphere
2. Laps rate
3. Inversion of Temperature
4. Stability and Instability
5. Humidity
6. Precipitation
7. Pressure System
8. Jet stream and Indian Monsoon
9. Airmass

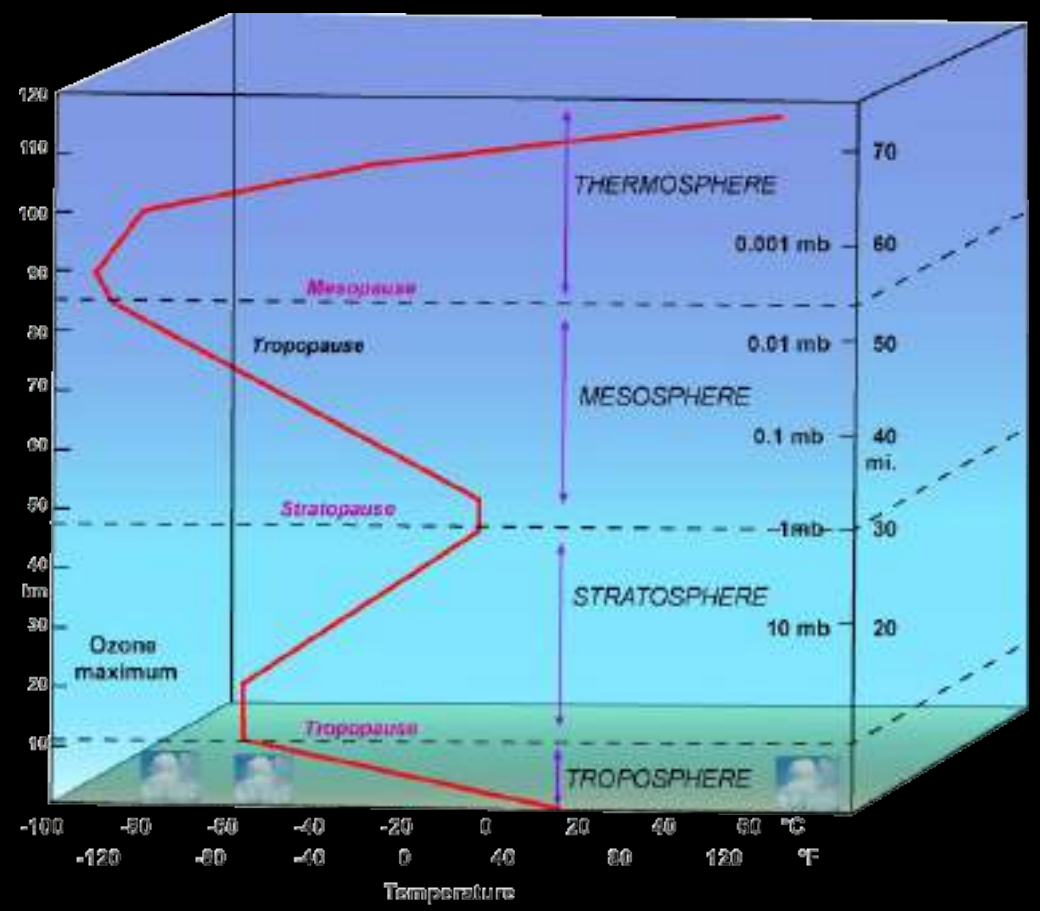
Structure of Atmosphere



- Troposphere

- Temperature decreases with increasing height
- GHG gas absorb long wave terrestrial radiation – transparent to insolation (short wave radiation)
- Heated from terrestrial radiation from earth surface

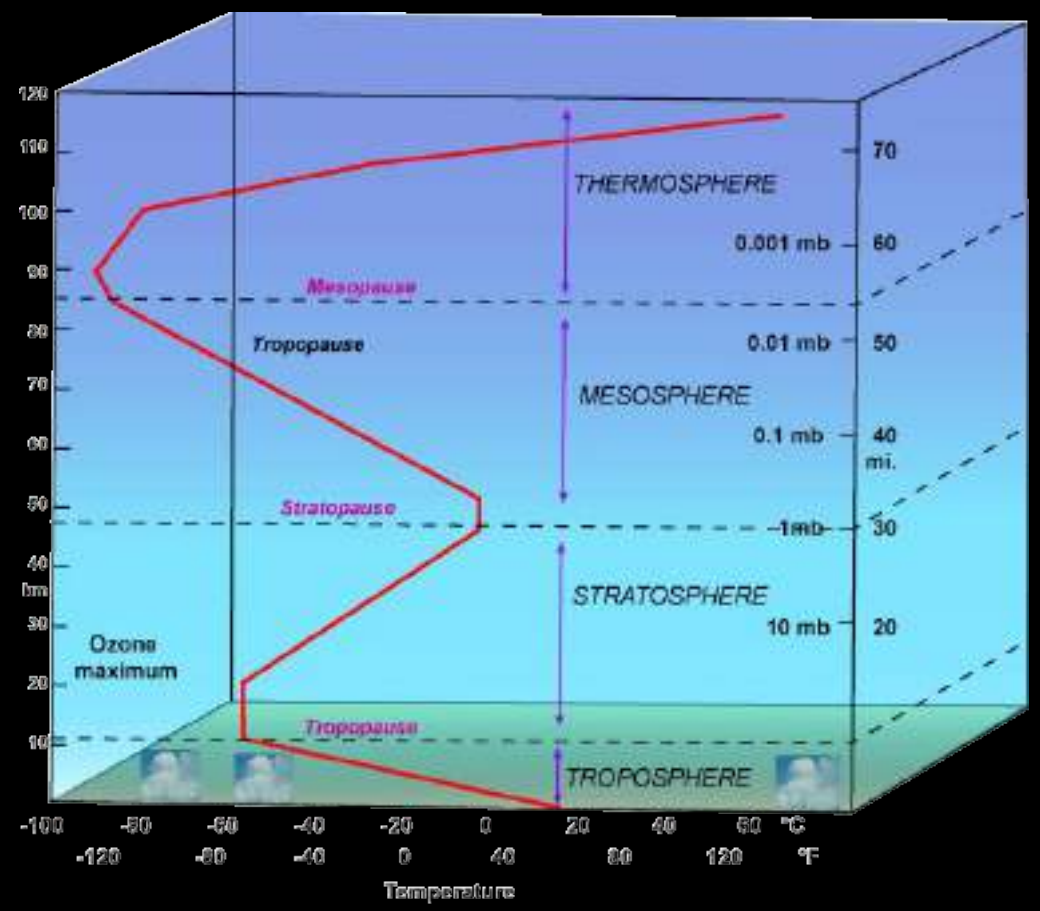
Structure of Atmosphere



- Stratosphere

- Temperature increases with increasing height
- Ozone layer absorbs UV rays from Insolation

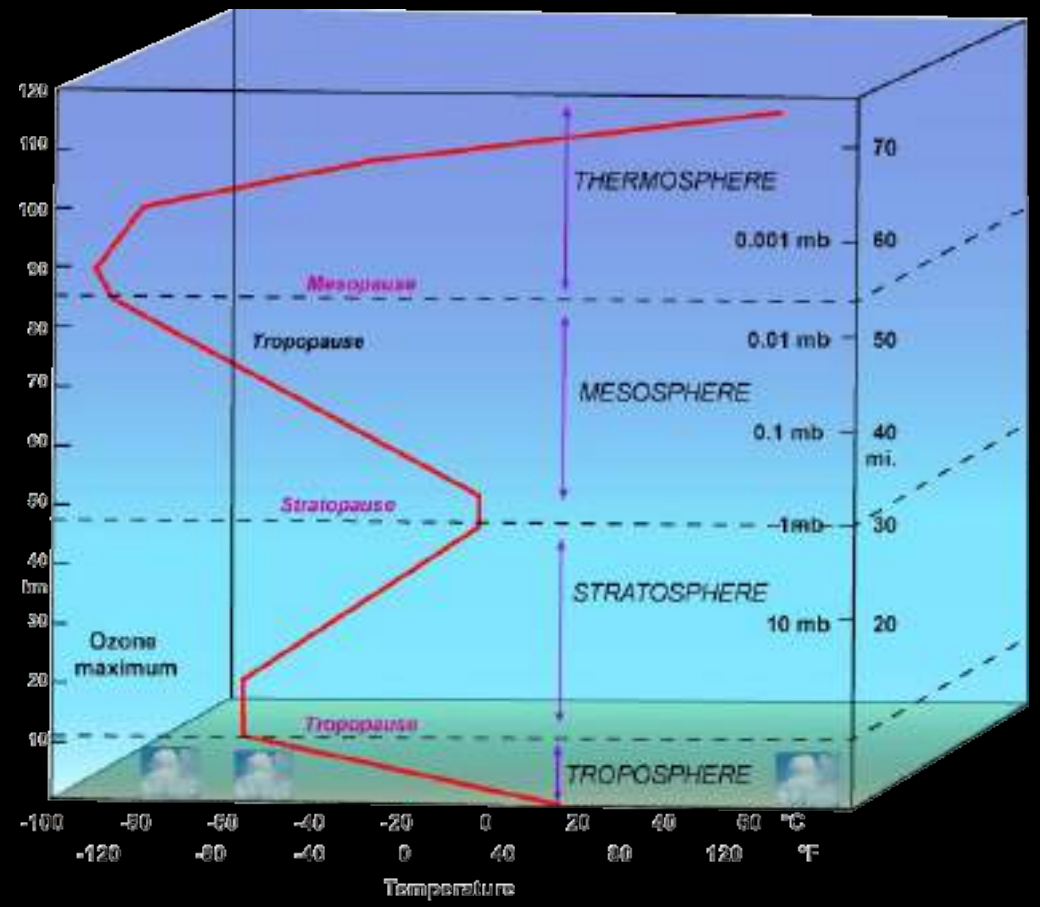
Structure of Atmosphere



- Mesosphere

- Temperature decreases with increasing height
- Absence of GHG gas
- Going away from Ozone layer

Structure of Atmosphere

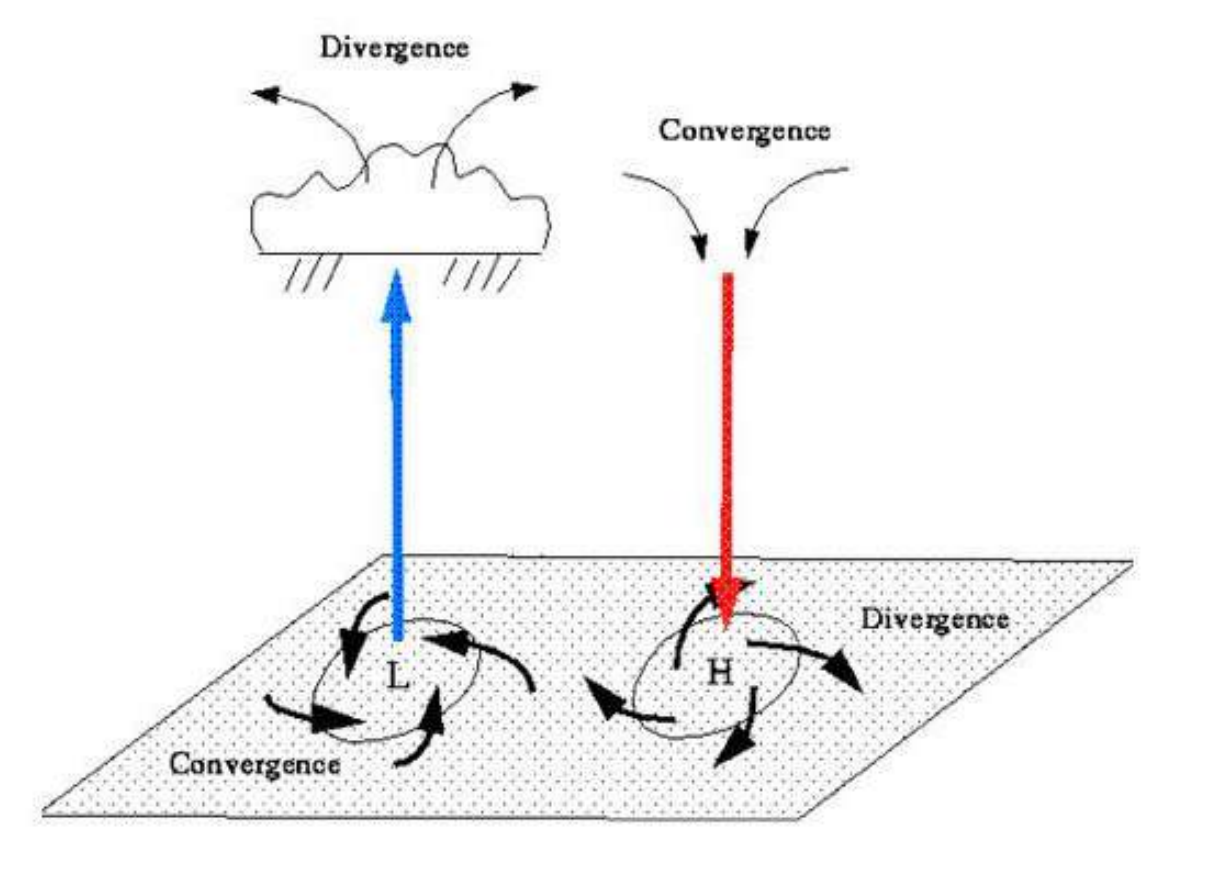


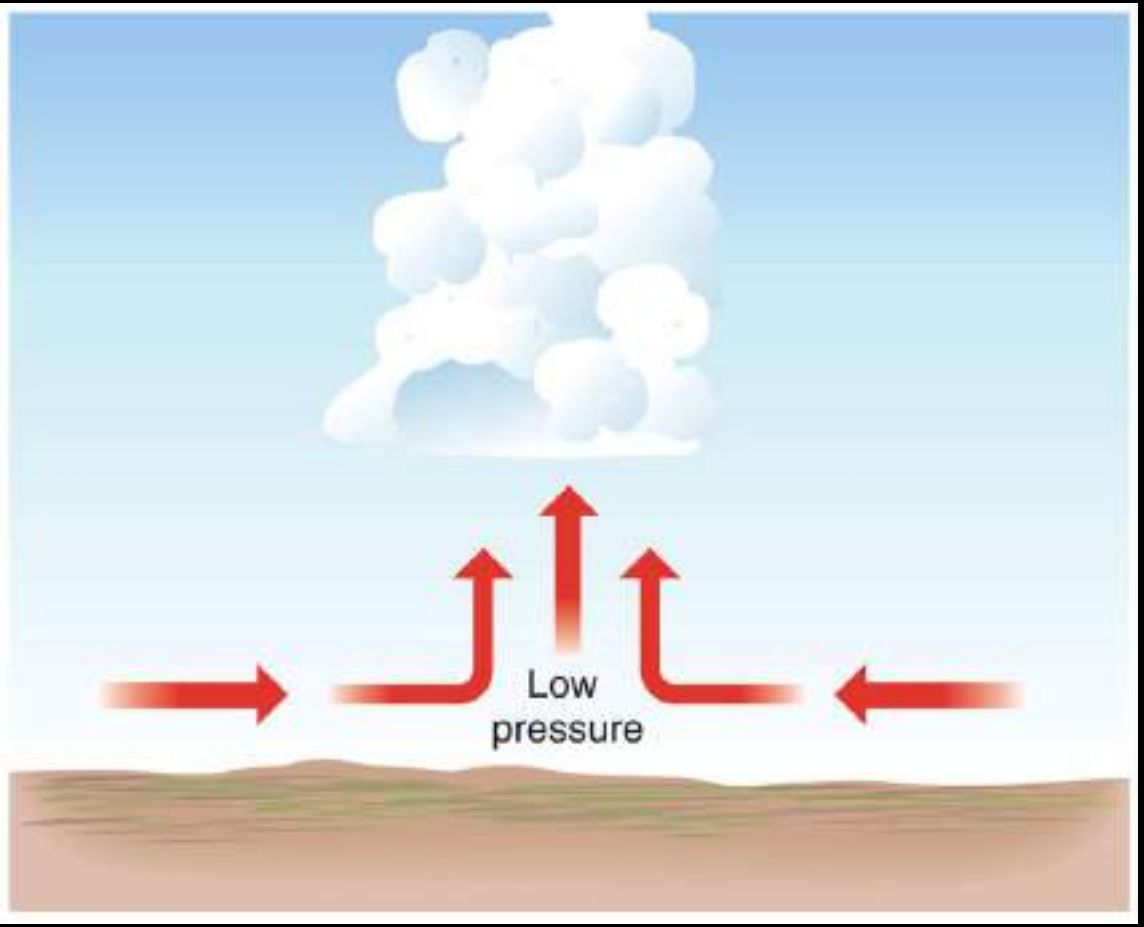
- Thermosphere
- Temperature increases with increasing height
- Gases are in ionic state –extremely hot
- Ionosphere -Imp for radio communication

Discuss

Basic air movement

- Adiabatic lapse rate



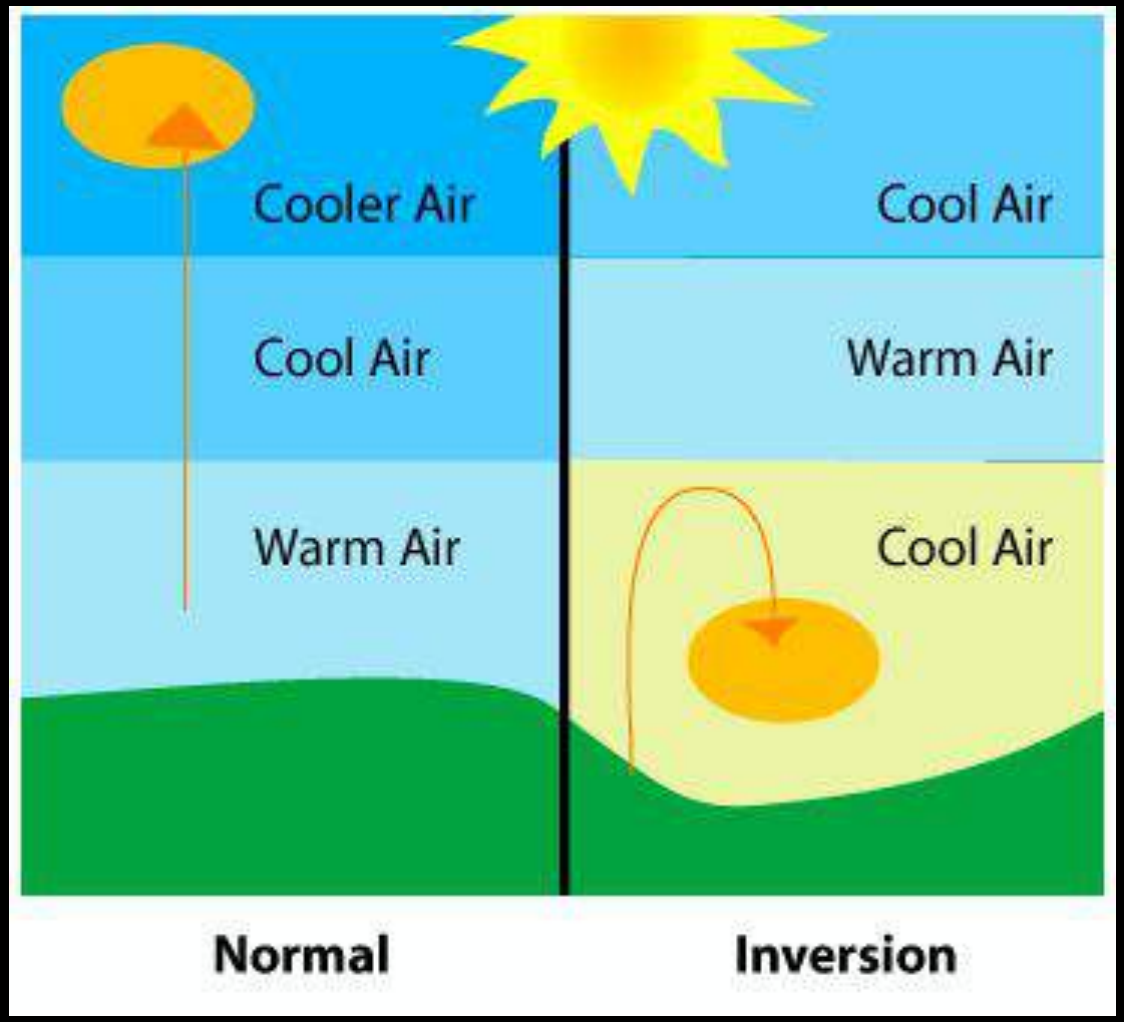


Change of Temperature

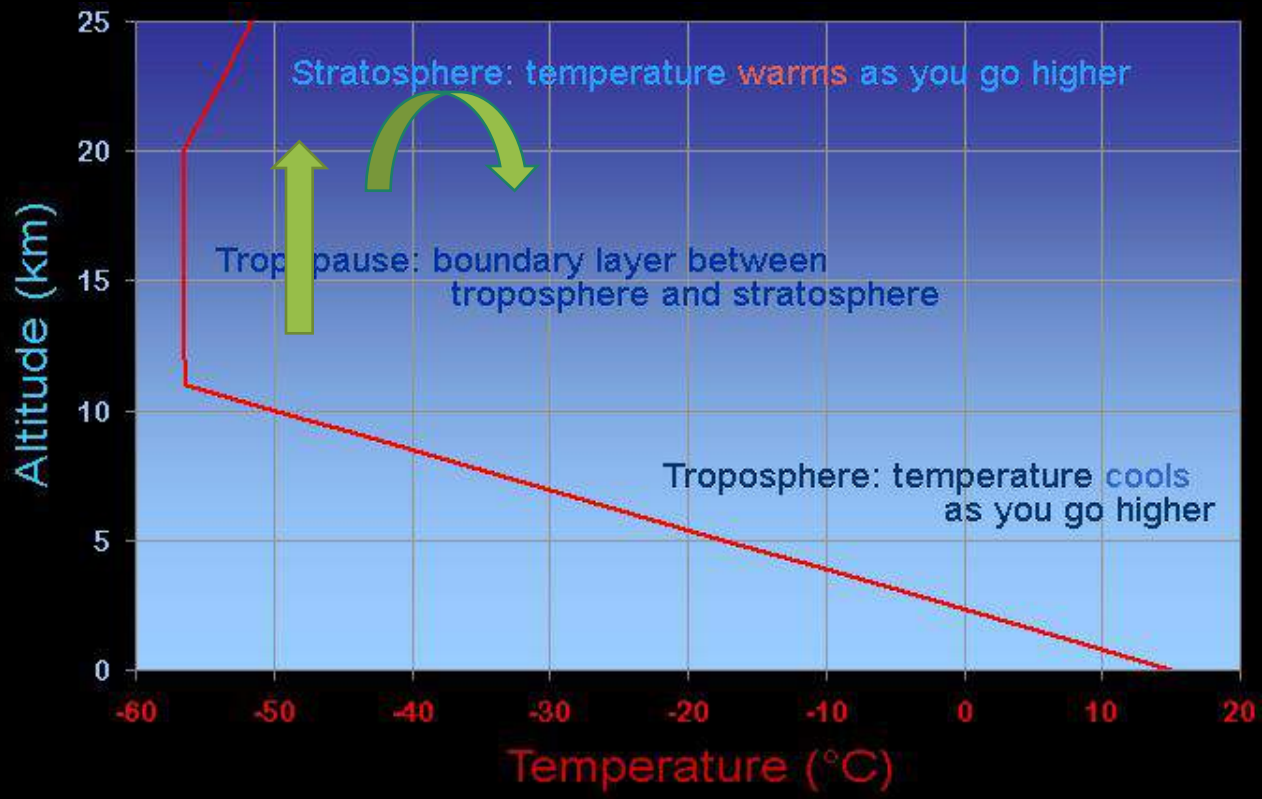
1. **Diabetic Processes**

2. **Adiabatic Processes**

Temperature Inversion

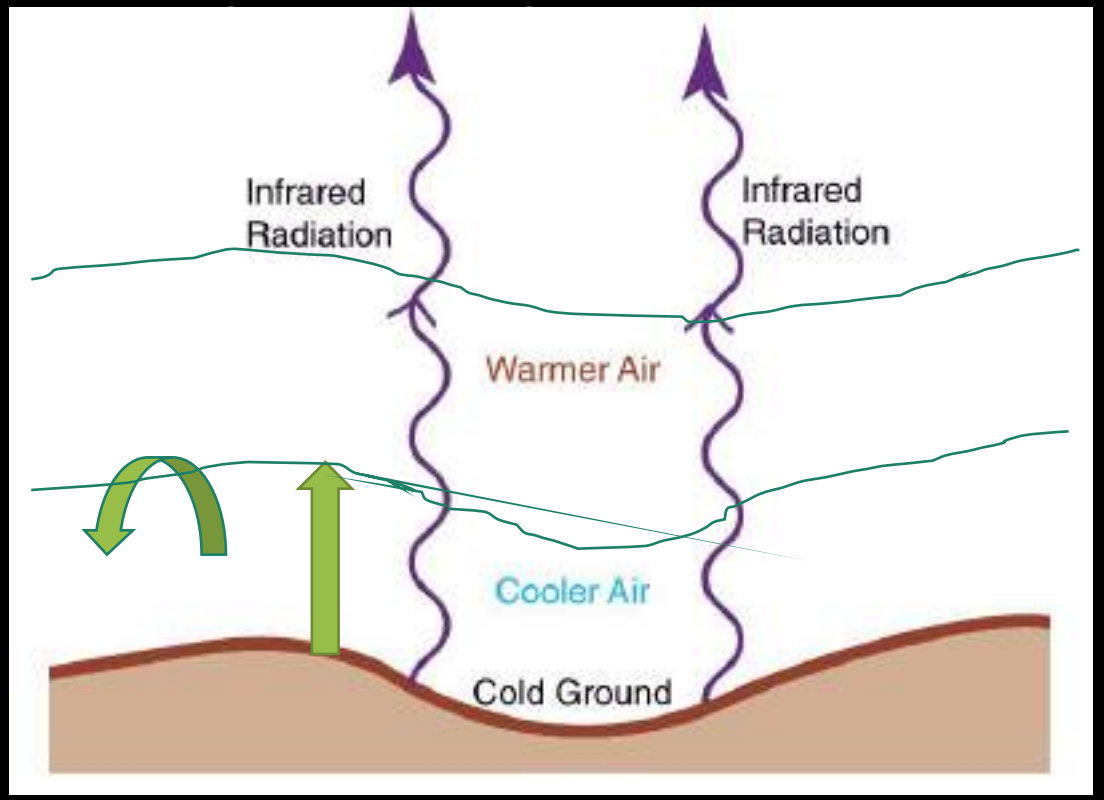


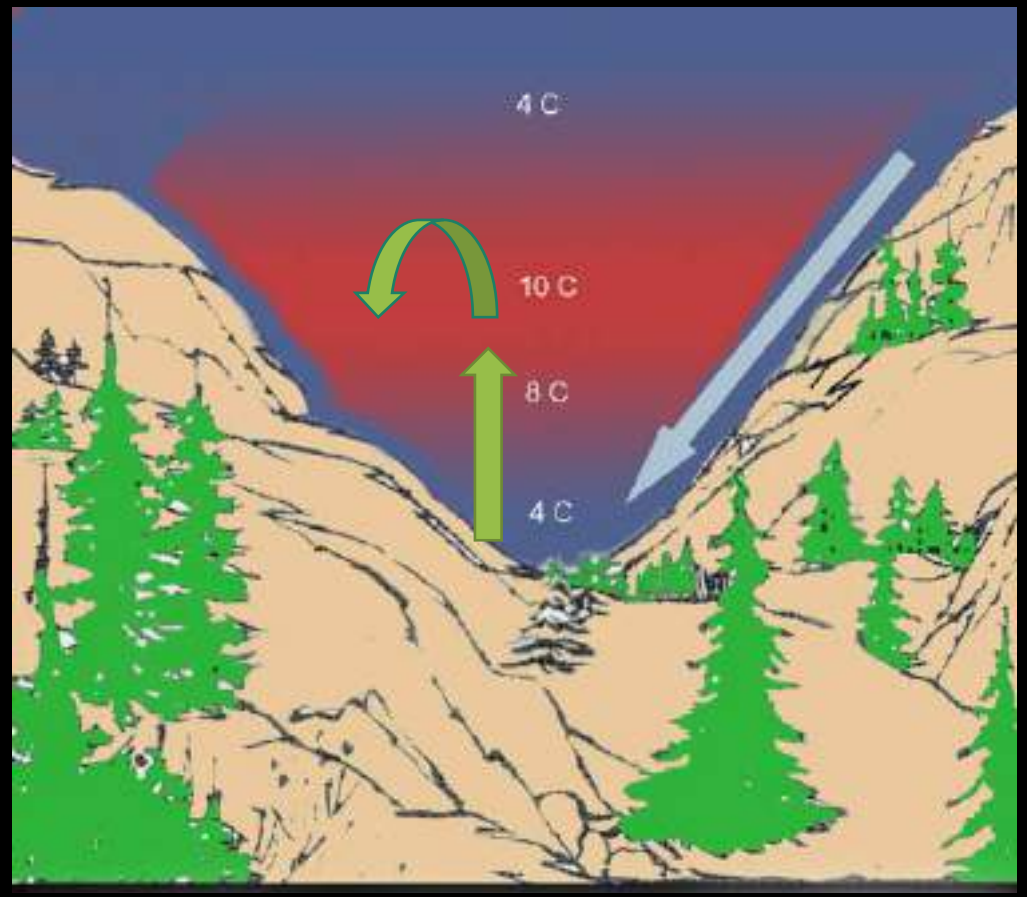
- Ex. Of Temp Inversion - tropopause



Temperature Inversion

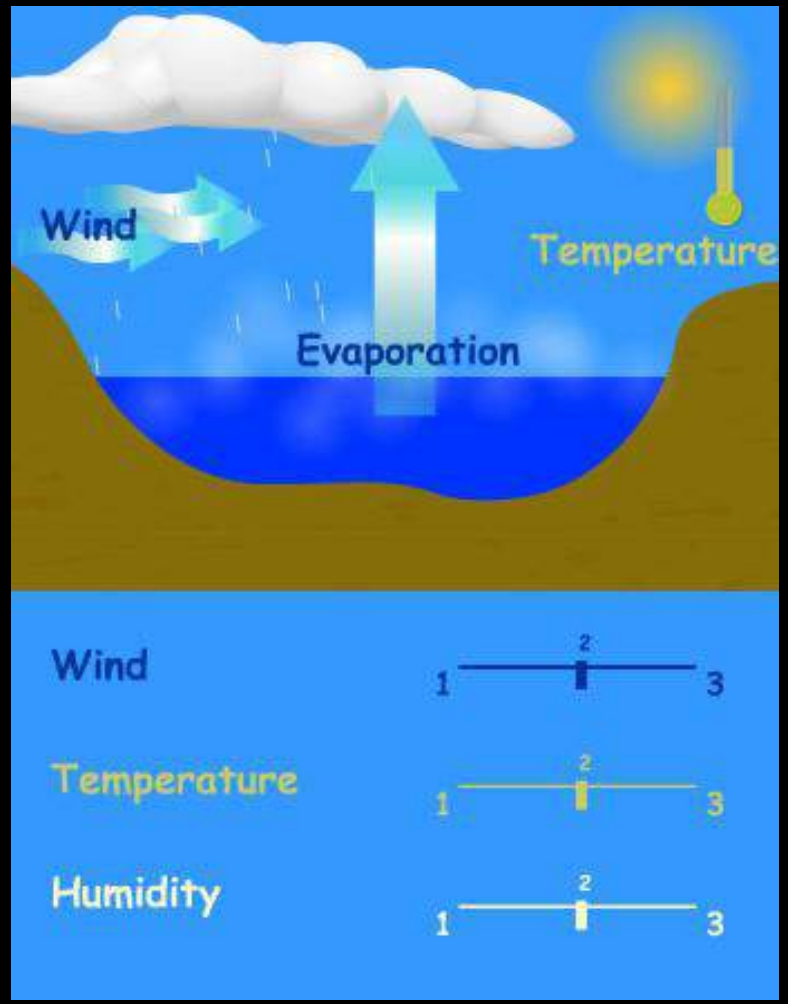
- Ex. Valley inversion





Precipitation process

Evaporation



- **Humidity**
- Relative Humidity
- Absolute Humidity
- Specific Humidity

Precipitation process

Condensation- clouds

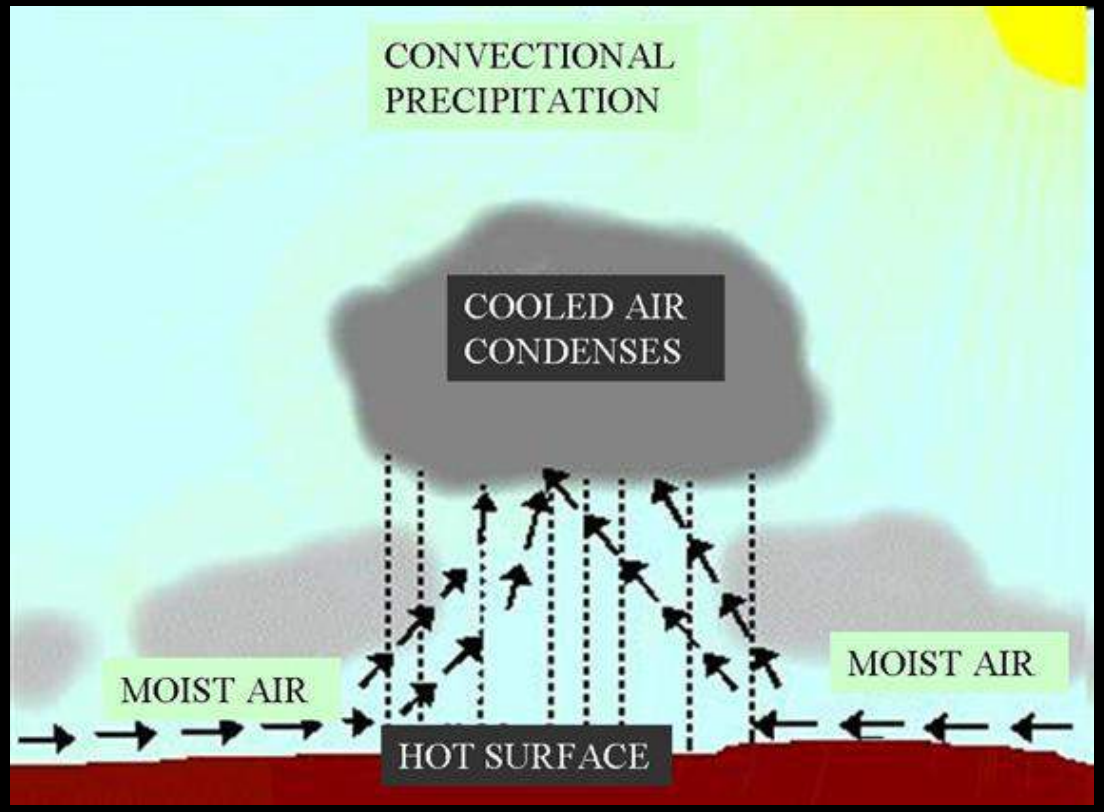
Type of Cloud

1. High cloud
   - Cirrus
   - Cirrocumulus
   - Cirrostratus
2. Medium cloud
   - Altostratus
   - Altocumulus
   - Nimbostratus
3. Low cloud
   - Stratus
   - Cumulus
   - Cumulonimbus

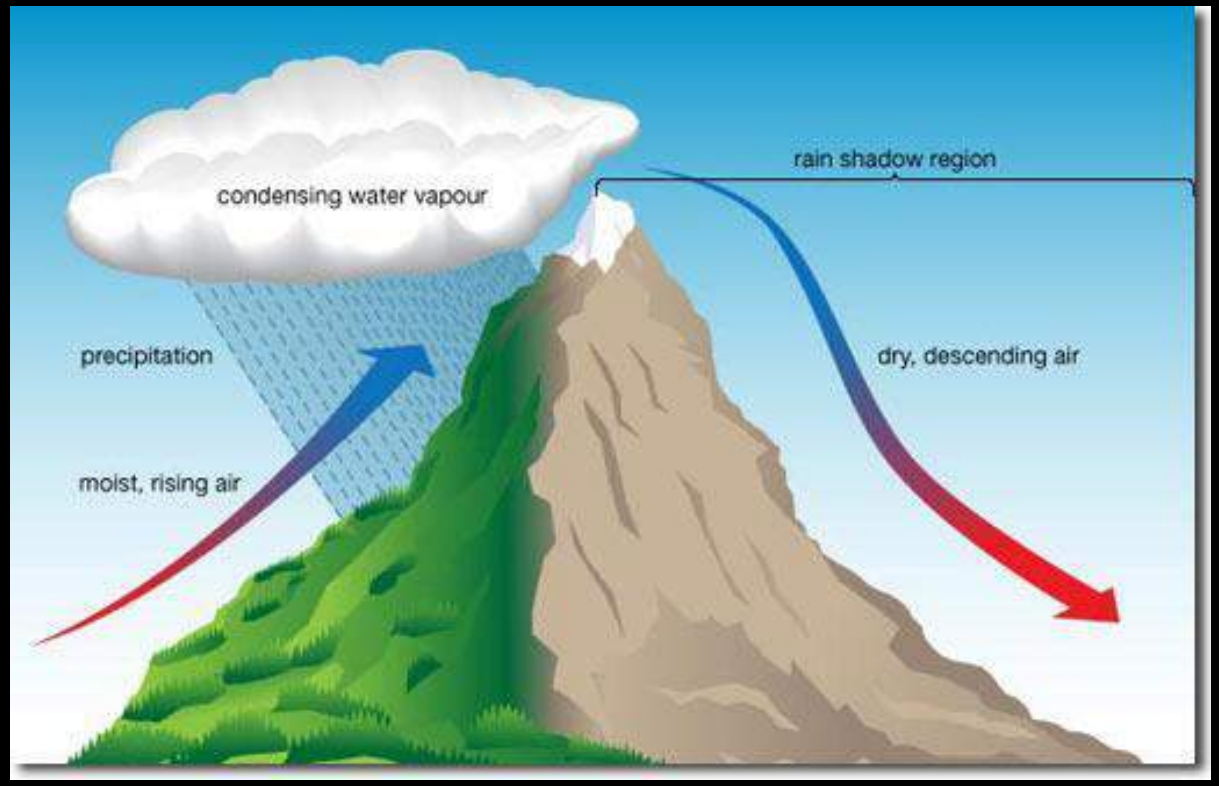
Discuss

Types of rainfall

Convectional rainfall

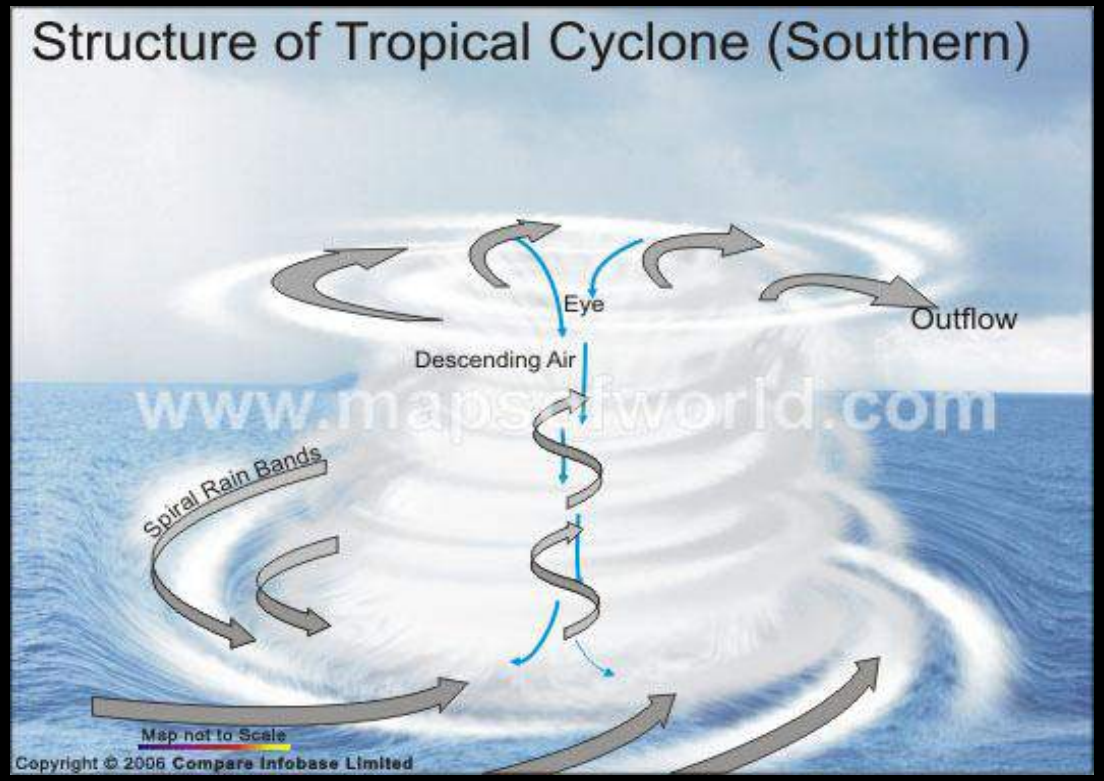


- Orographic rainfall

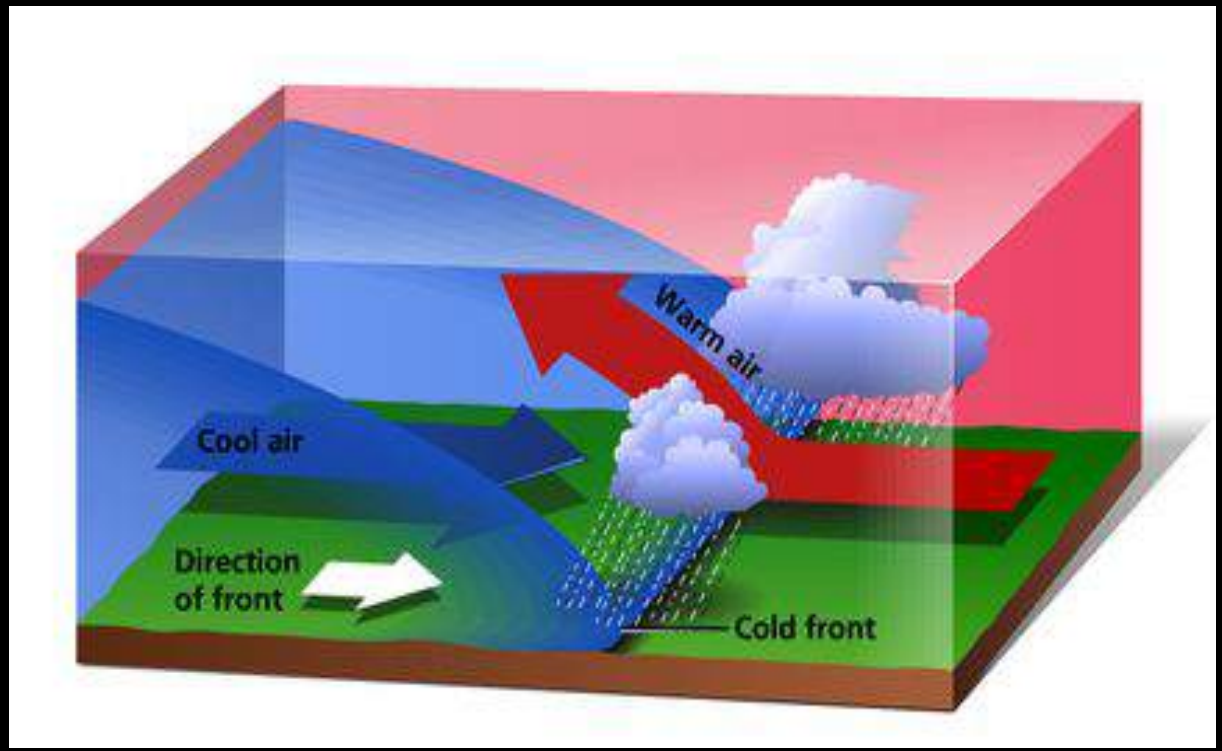


Types of rainfall

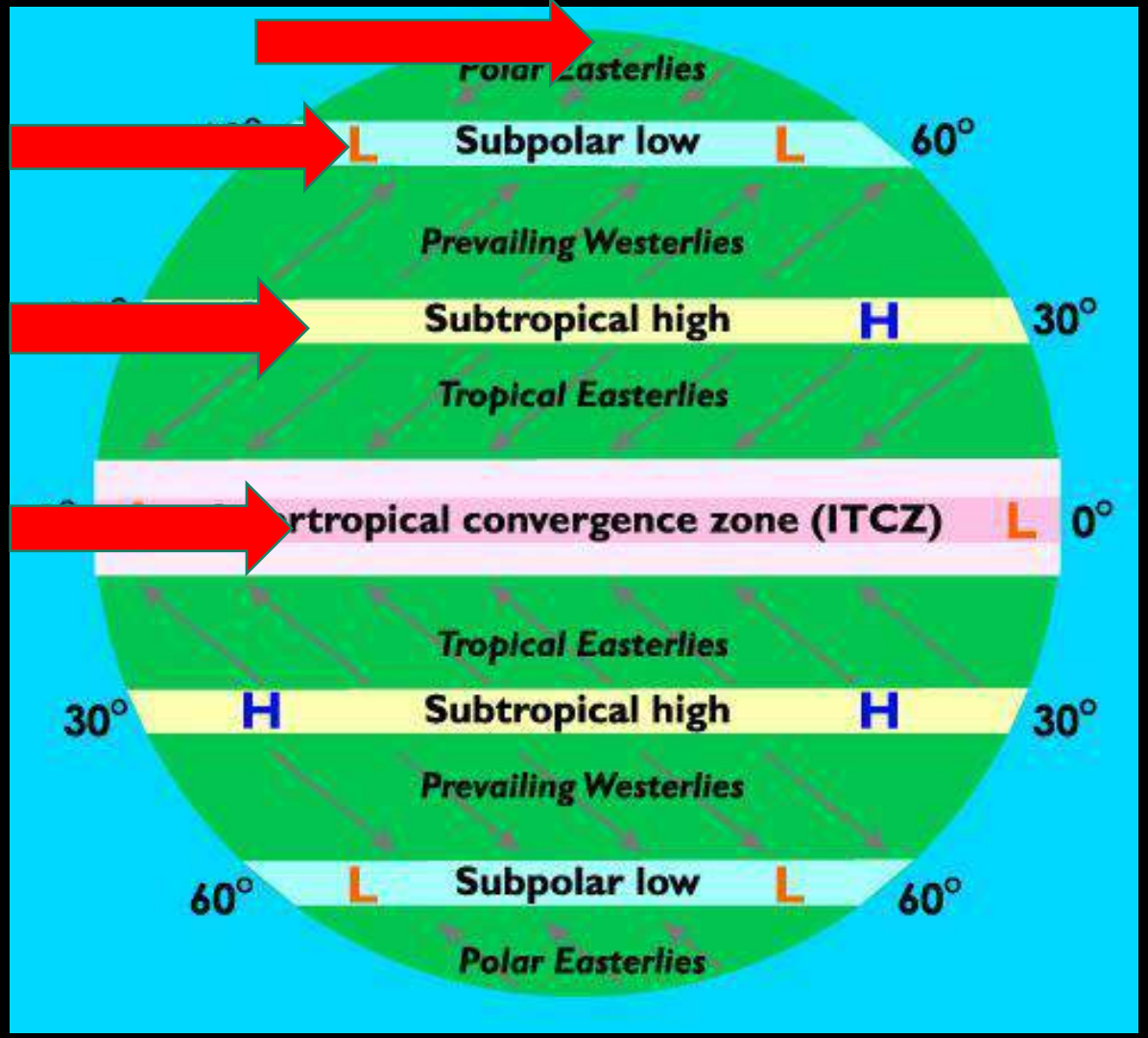
Cyclonic rainfall

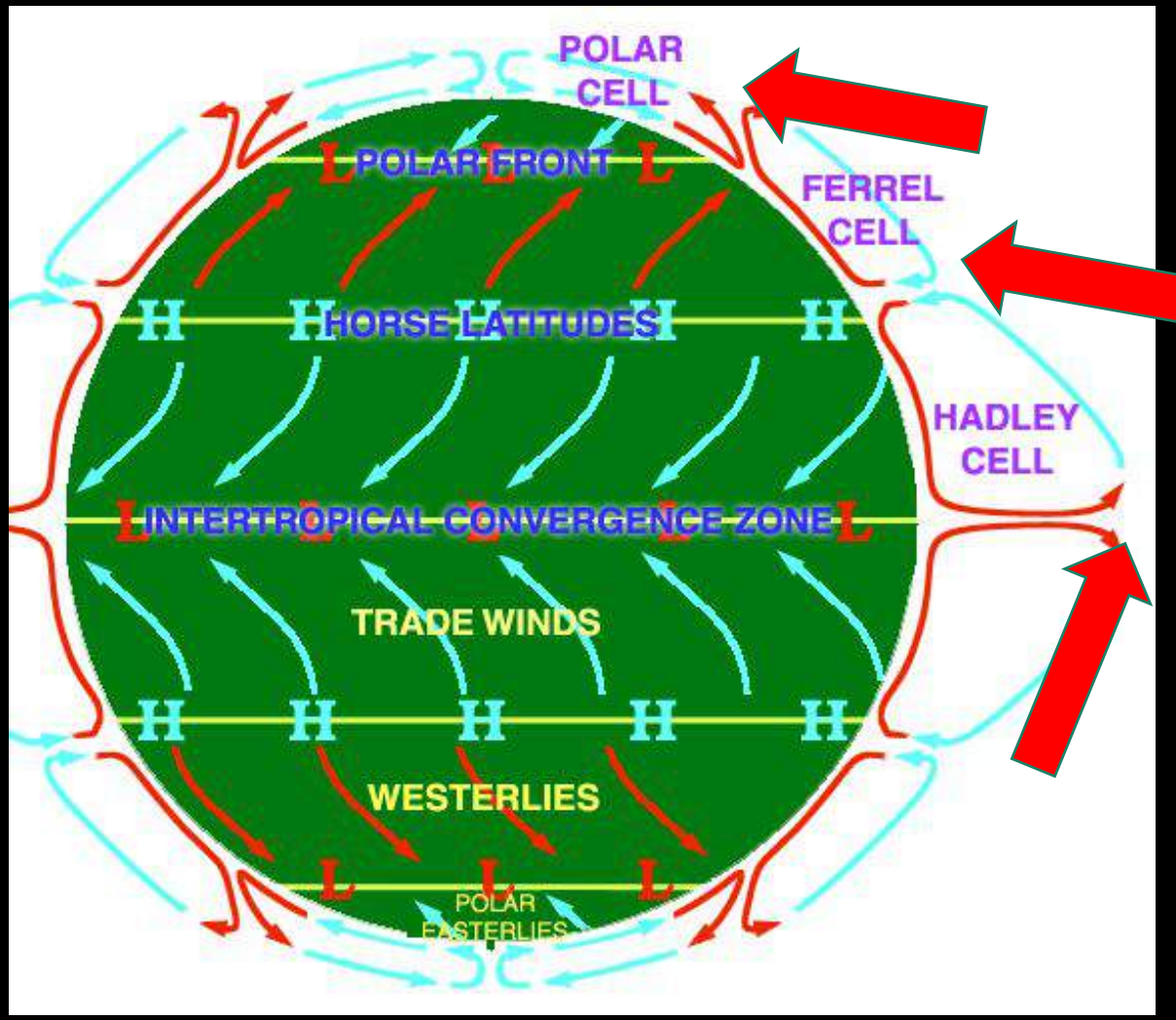


- Frontal rainfall

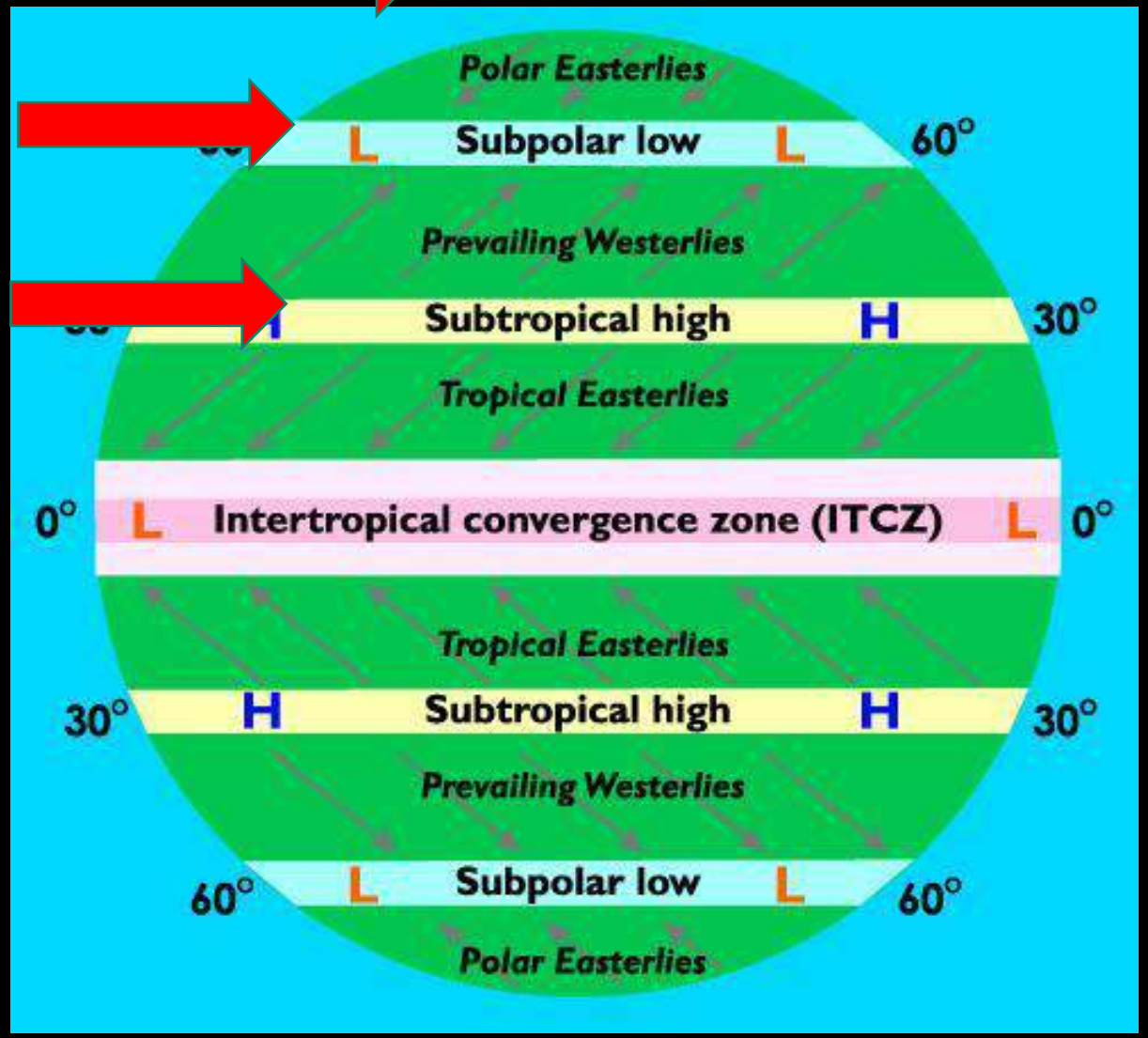


Pressure system of the world



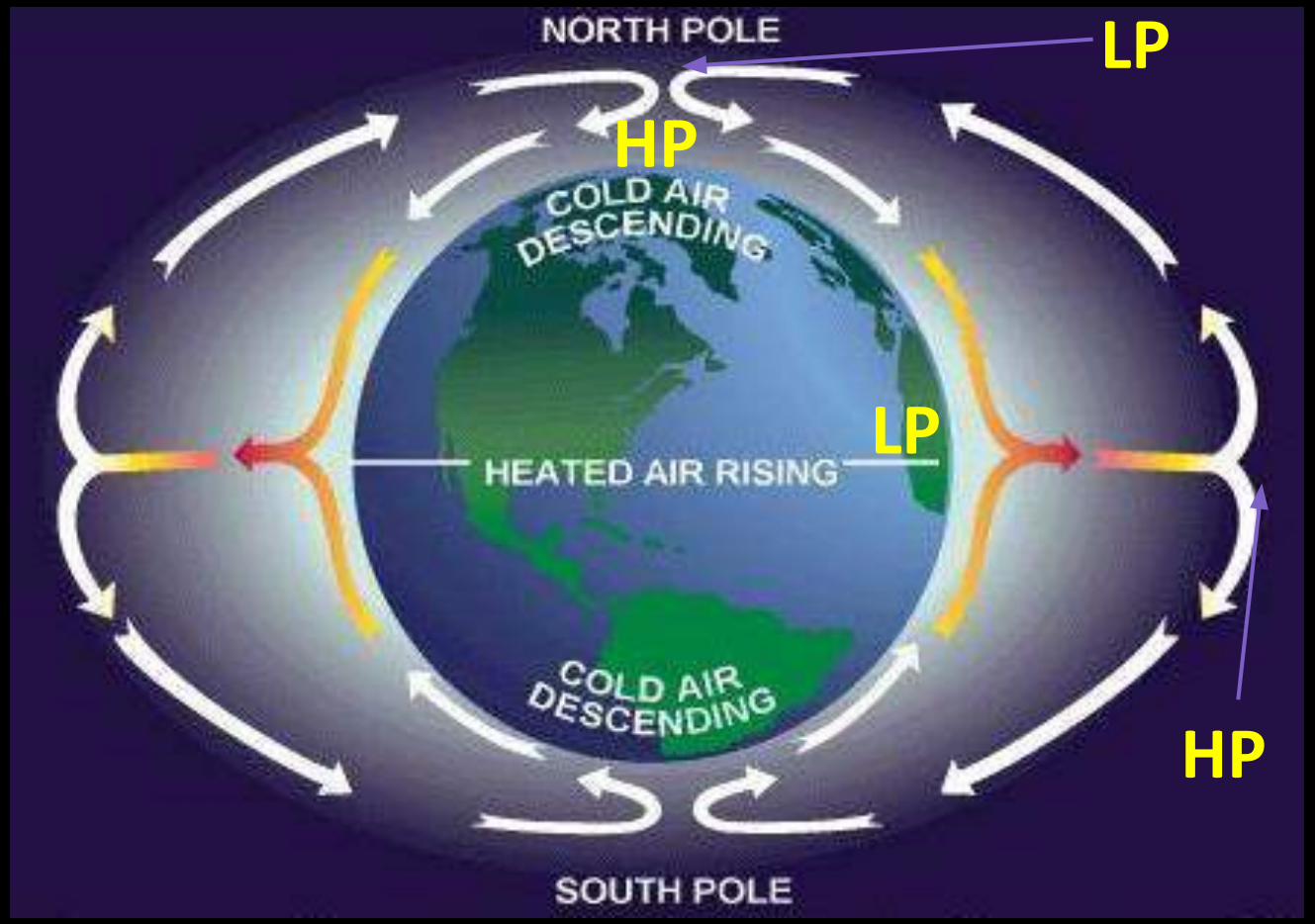


Planetary wind system



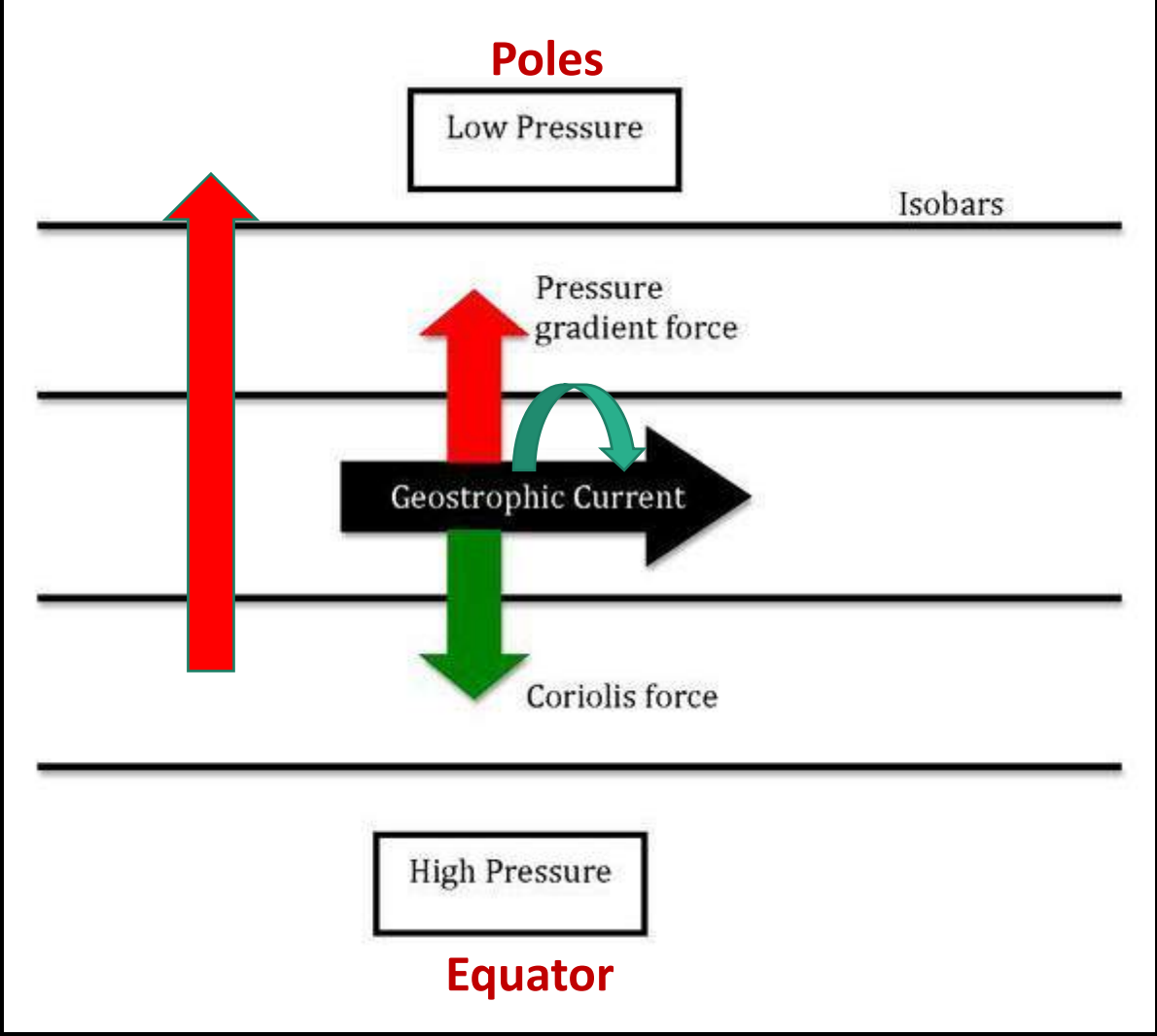
- High pressure to low pressure
- Coriolis force – clockwise in northern hemi and anti-clockwise in southern hemi
- Trade winds
- Westerlies
- Polar easterlies

Upper tropospheric winds



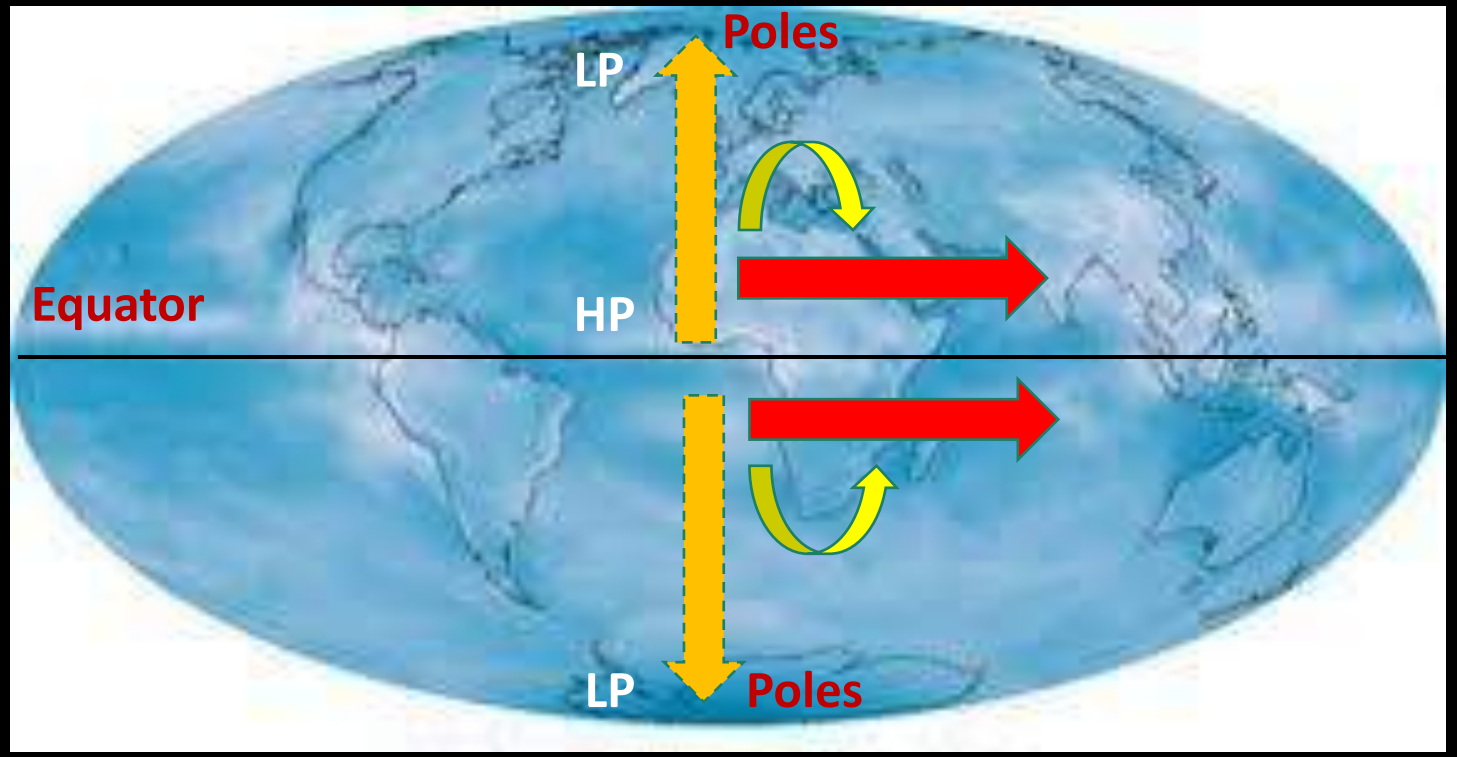
- Around tropopause, there is only one gradient
- Wind accumulated above equator and rarified atmosphere above poles
- HP at the equator and LP at the poles

Geo-strophic winds



- strong coriolis force at tropopause
- Because friction is less - high speed - stronger the coriolis force
- So the deflection is 90 degree
- Such winds called geo-strophic winds

Geo-strophic winds



- Northern hemisphere

Geostrophic deflect clockwise

west to east

In southern Hemisphere: Anti-clockwise movement

Deflect west to east

Westerlies winds

- The upper tropospheric winds / geo-strophic winds blow from west to east at the very high speed

Rossby waves

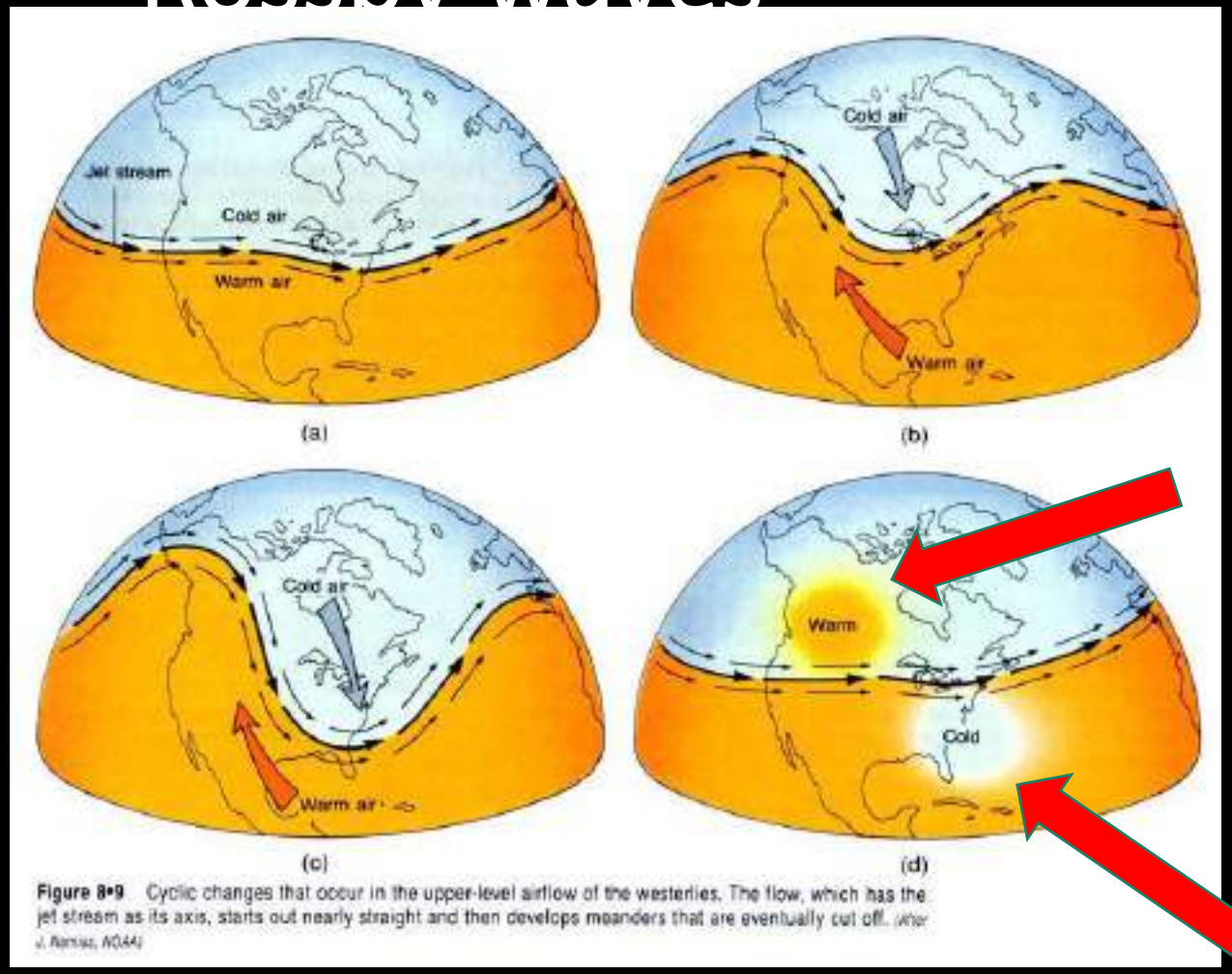
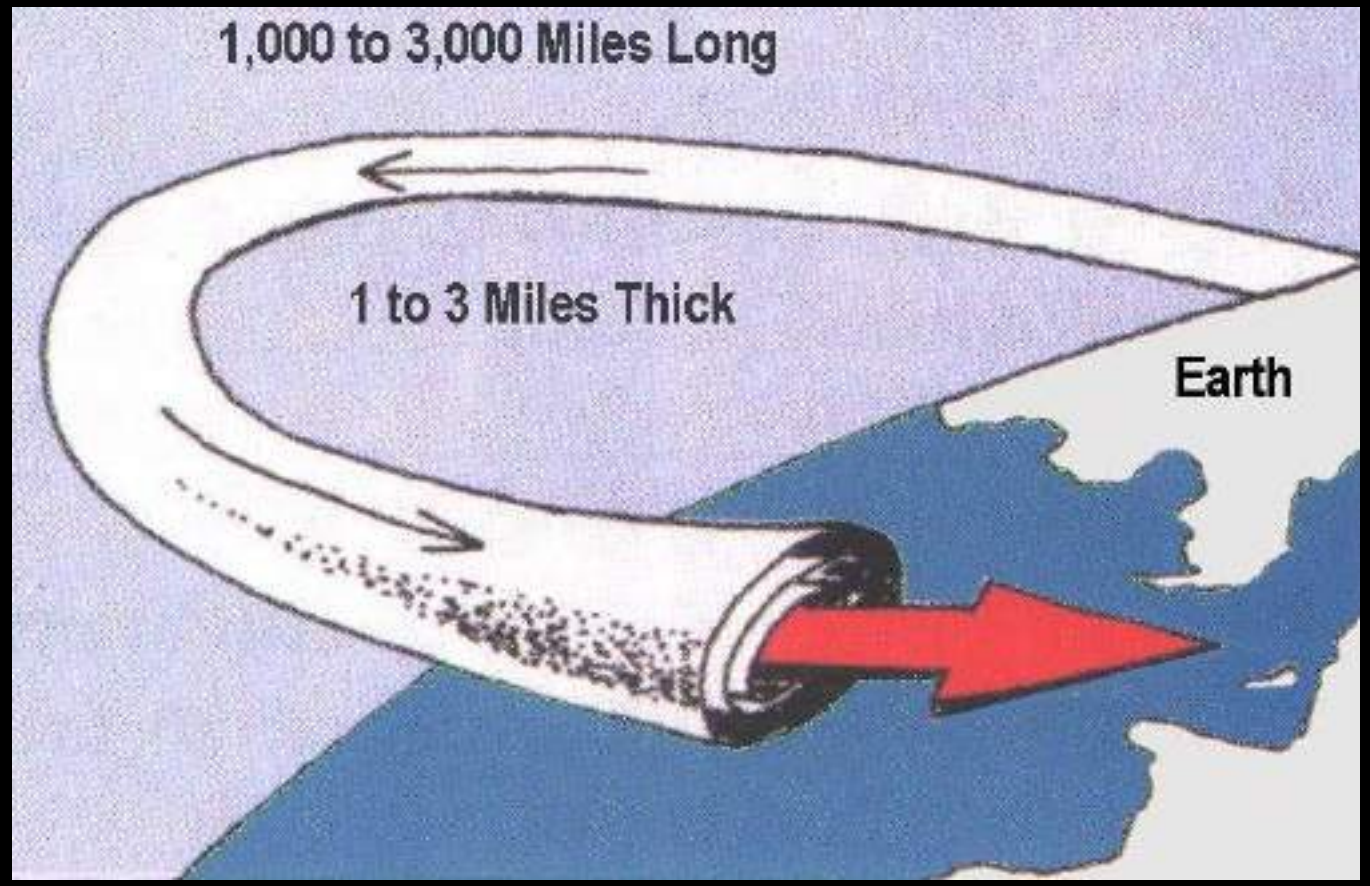


Figure 8•9 Cyclic changes that occur in the upper-level airflow of the westerlies. The flow, which has the jet stream as its axis, starts out nearly straight and then develops meanders that are eventually cut off. (After J. Namias, NOAA)

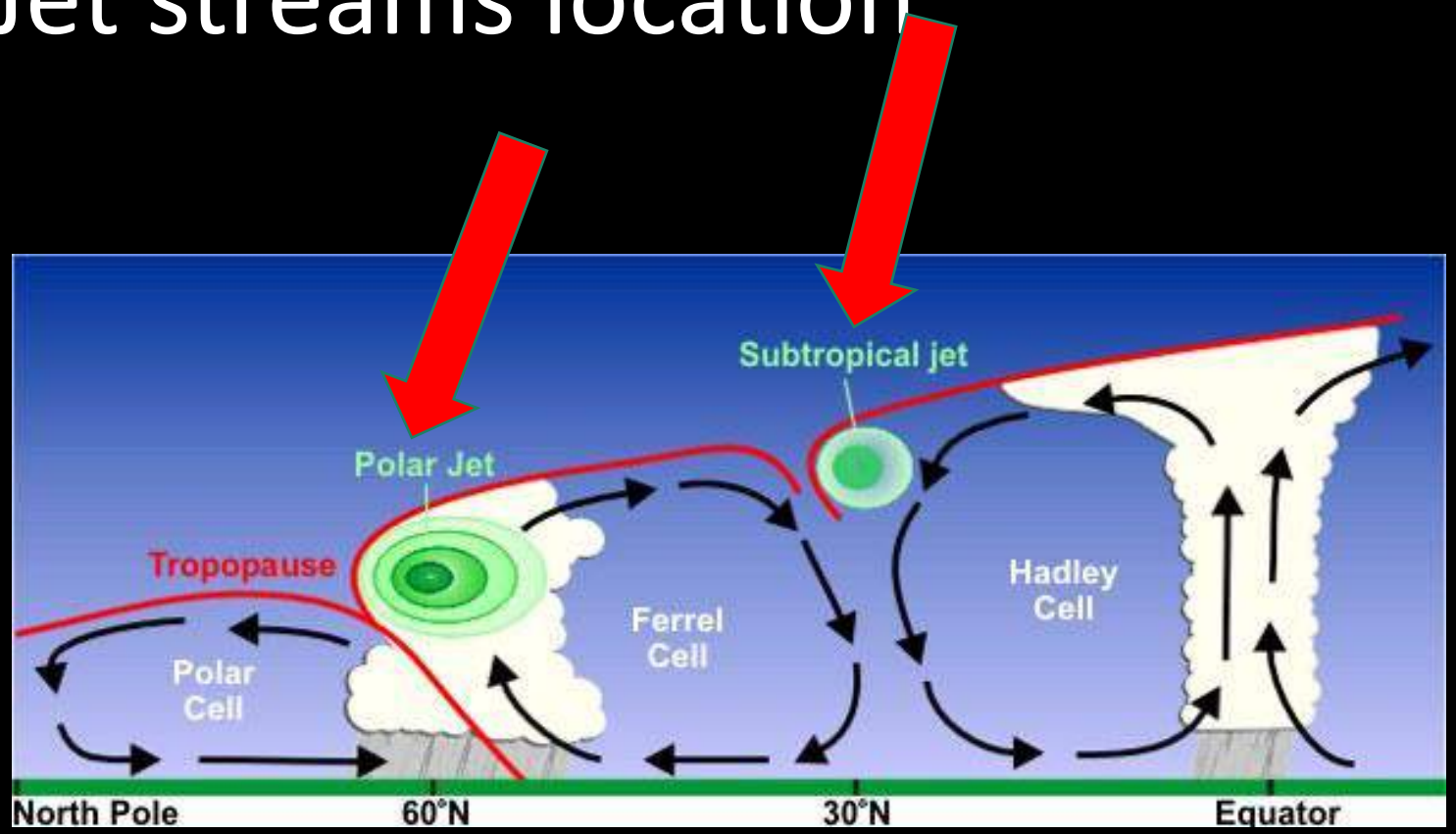
- Westerlies at poles – to maintain the angular momentum- they meander => Rossby waves
- Rossby waves do not meander consistently, but follow a cycle = Index cycle

Jet streams



- In westerlies, there are strong, narrow bands of high speed wind => Jet stream
- Speed of Jet stream 300kmph

Jet streams location



Polar High **SPLP** **STHP** **Eq. LP**

- There are situated at the margins of meridional cells
- 4 permanent Jet streams: 2 Polar Jet and 2 Sub-Tropical Westerly Jet STWJ

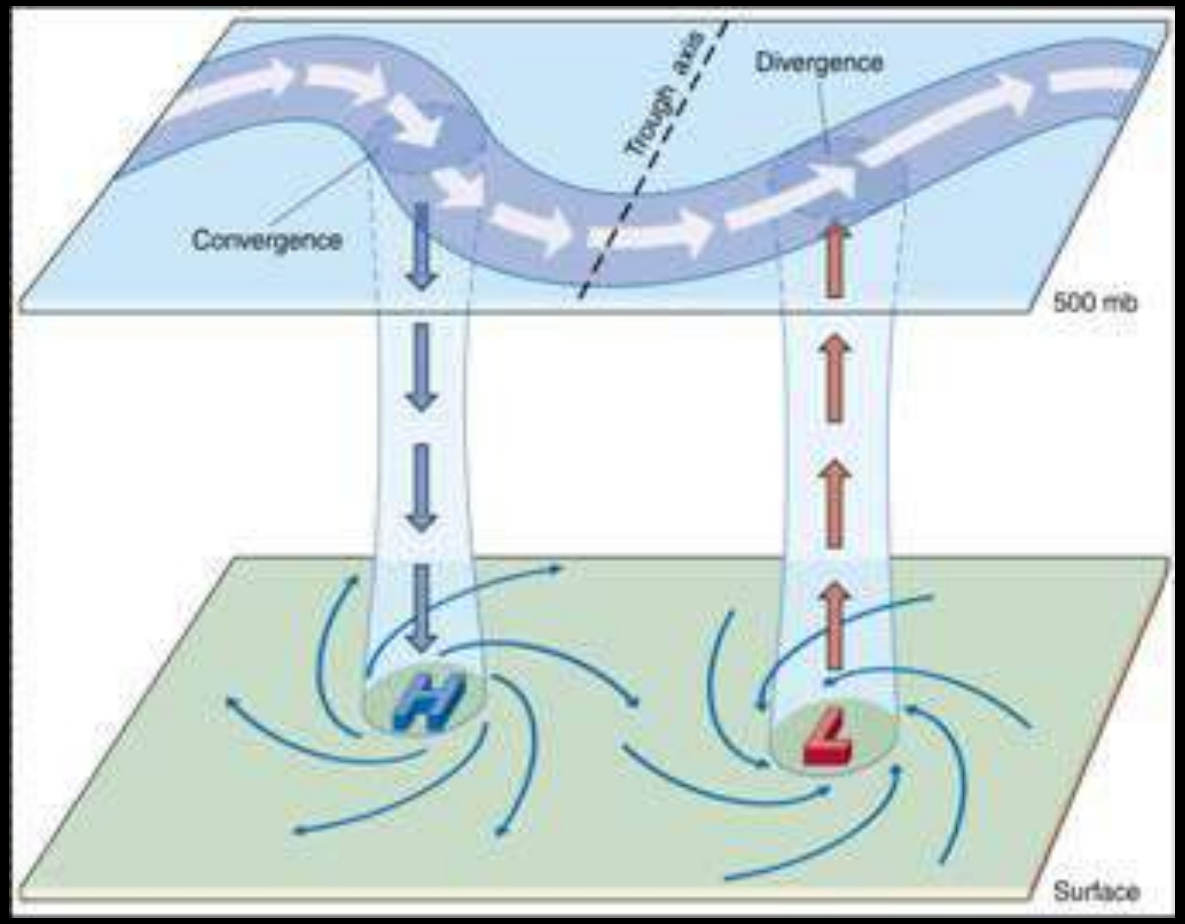
Jet streams


POLAR JET STREAM
SUB-TROPICAL JET STREAM
SUB-TROPICAL JET STREAM
POLAR JET STREAM

Jet streams

- Jet stream embedded in westerlies (Rossby waves) at high latitude, cause pressure variability
- That's why they are called travelling depression

Jet Stream – travelling depressions

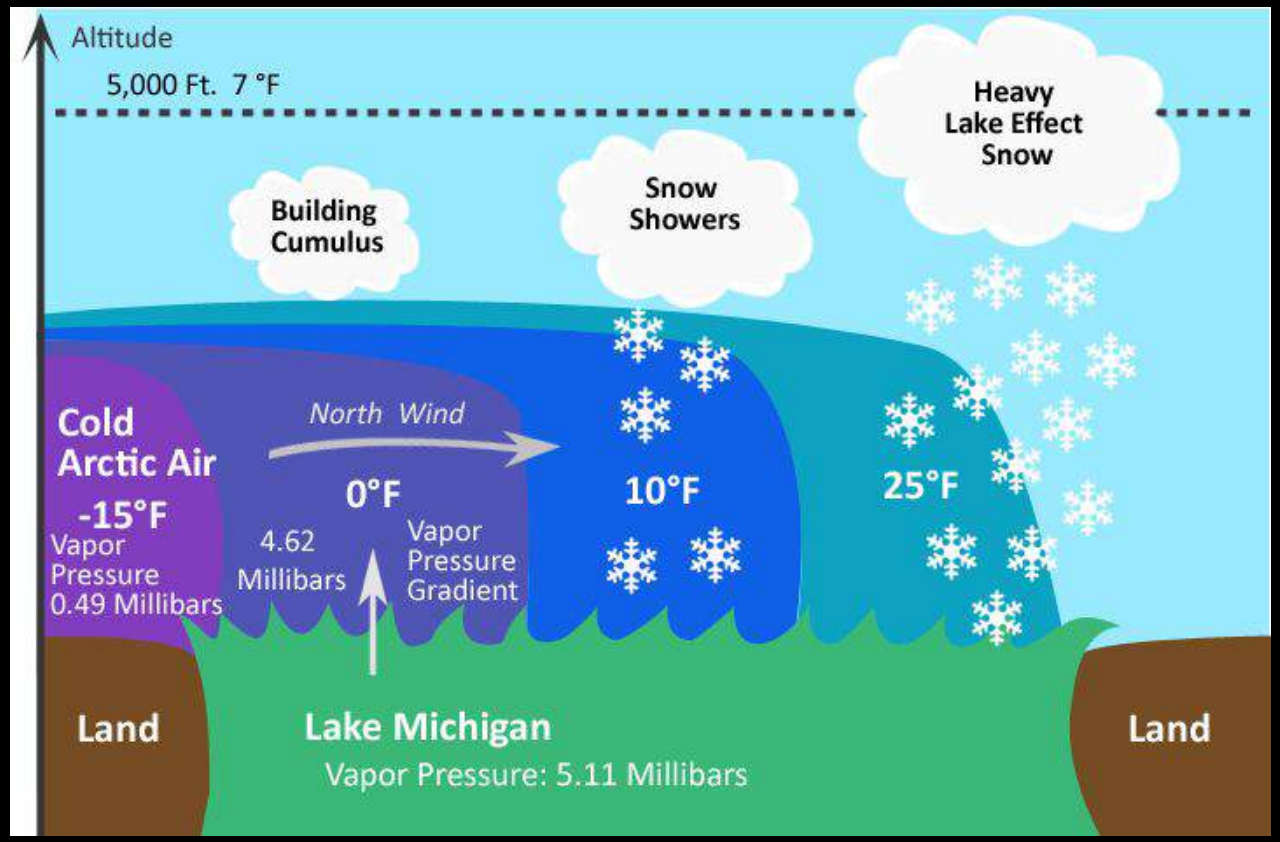


- Any Enquire

Jet stream and Indian Monsoon

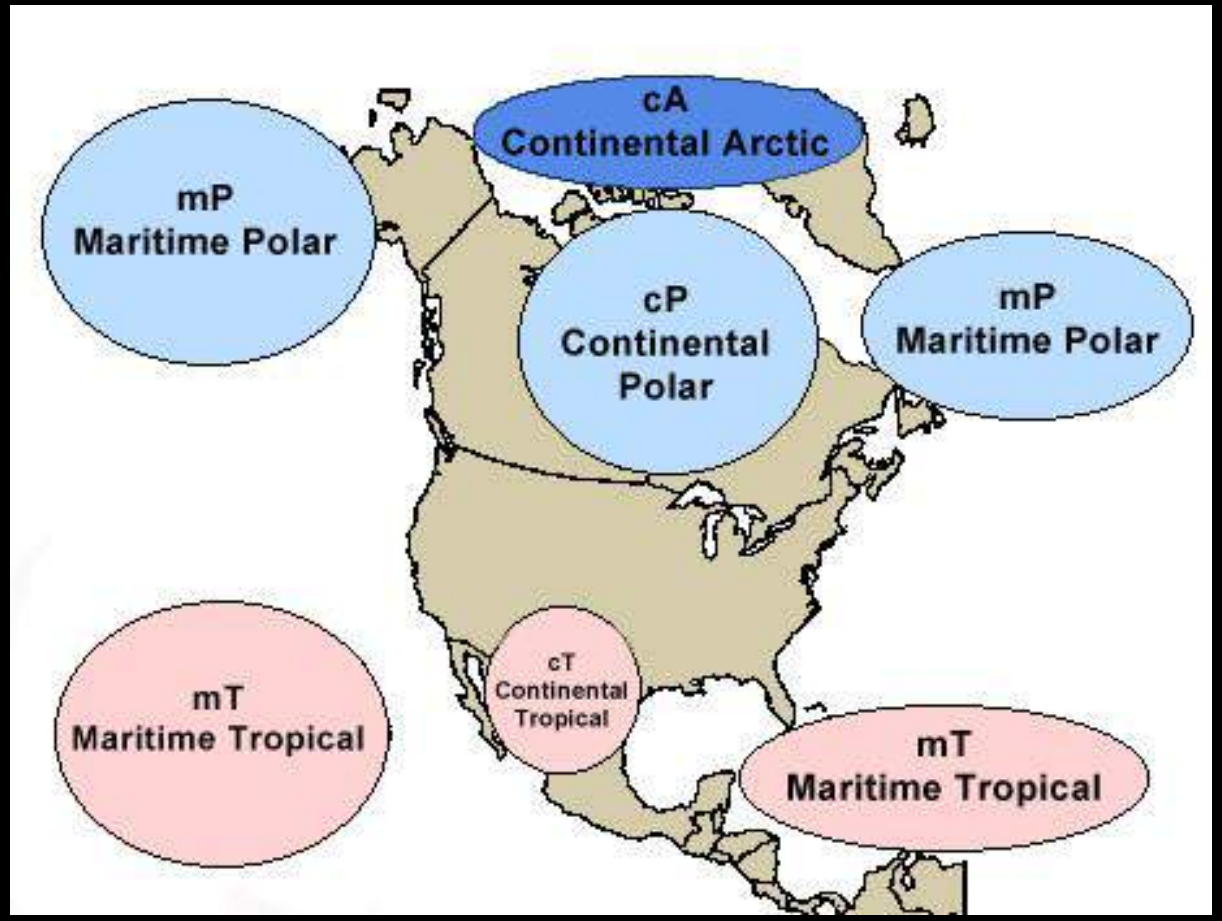
Break Time

Air mass



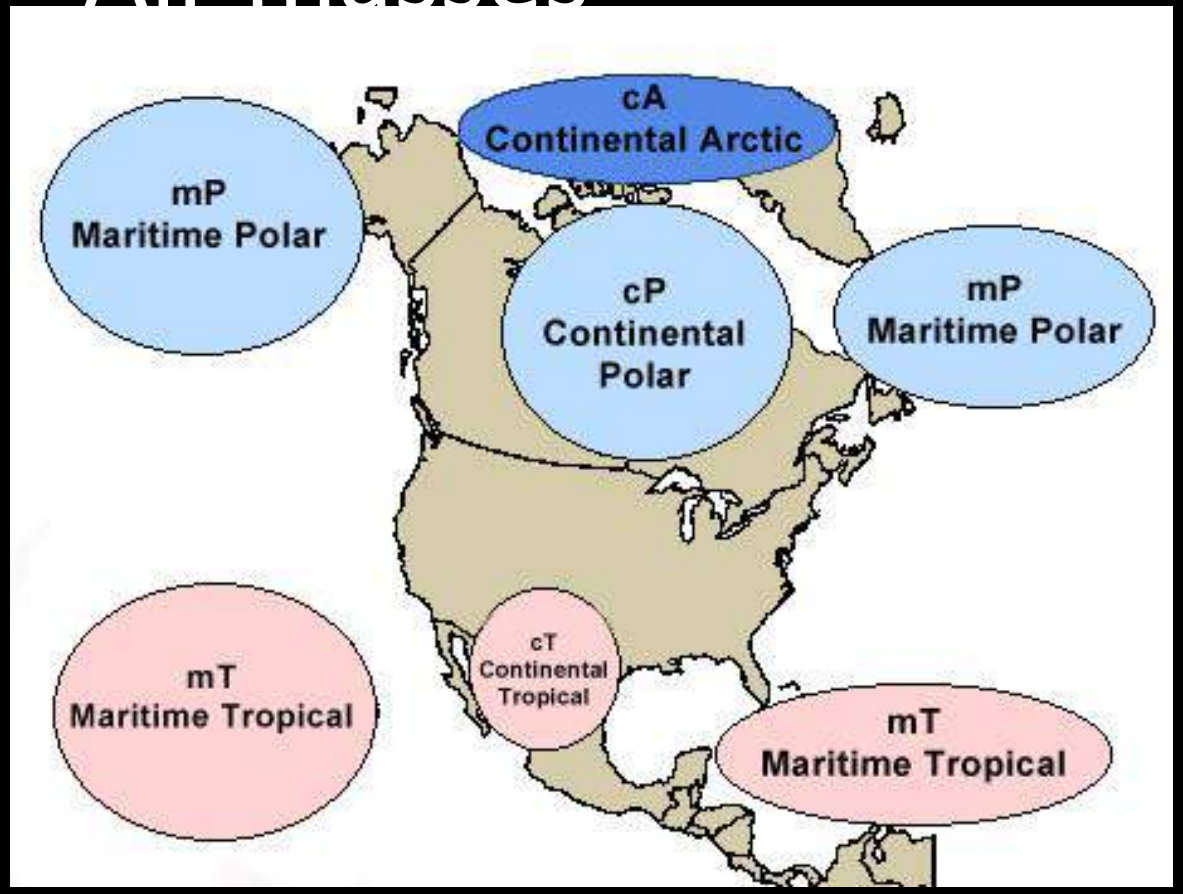
- Large extensive body of air-mass (1000sqkm)
- Height upto Tropopause
- At particular height, one air mass will have uniform temperature and moisture across its width
- Airmasses can be differentiate according to their temperature and moisture content

Air mass



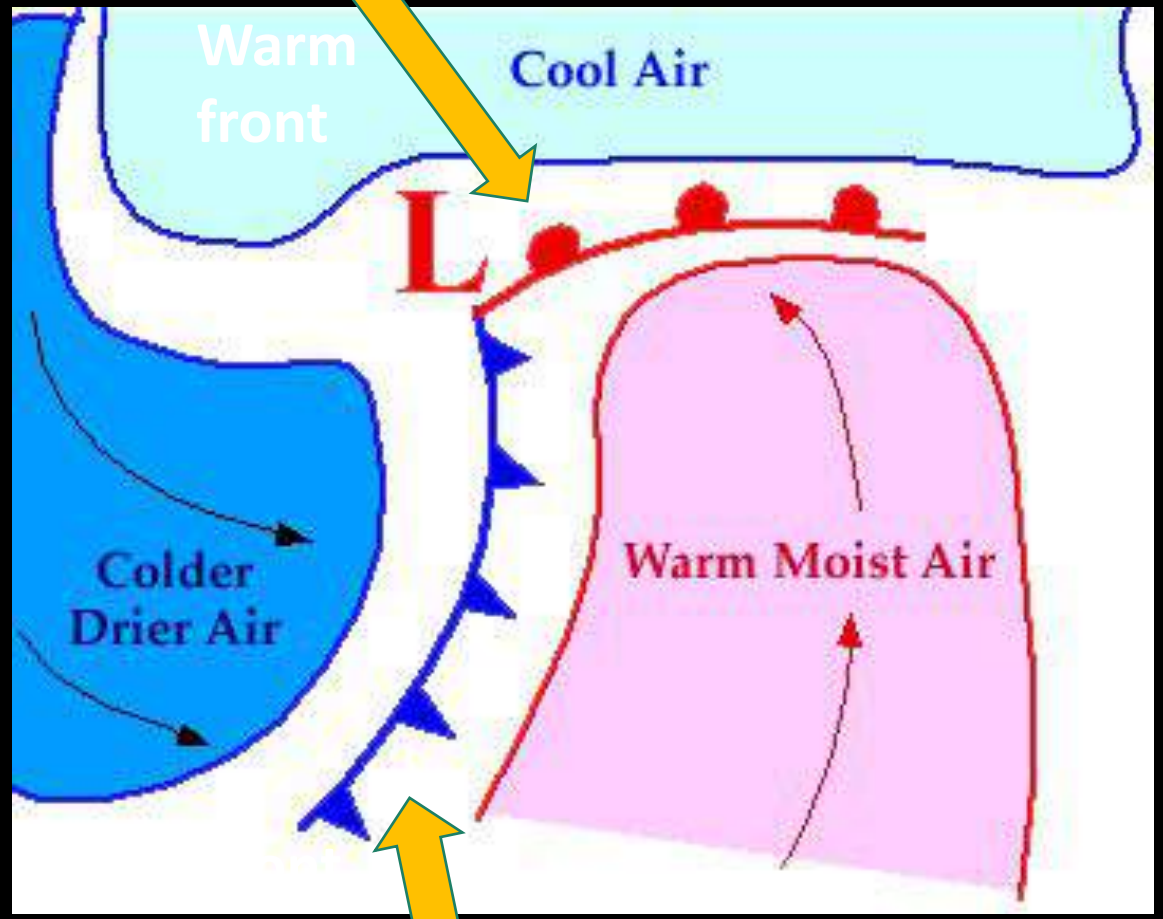
- Air mass acquired properties from the source regions – land, marine, polar, arctic, Antarctic = give them identity. Ex. mP, cT
- Extensive homogeneous surface + longer stay (HP)

Air masses



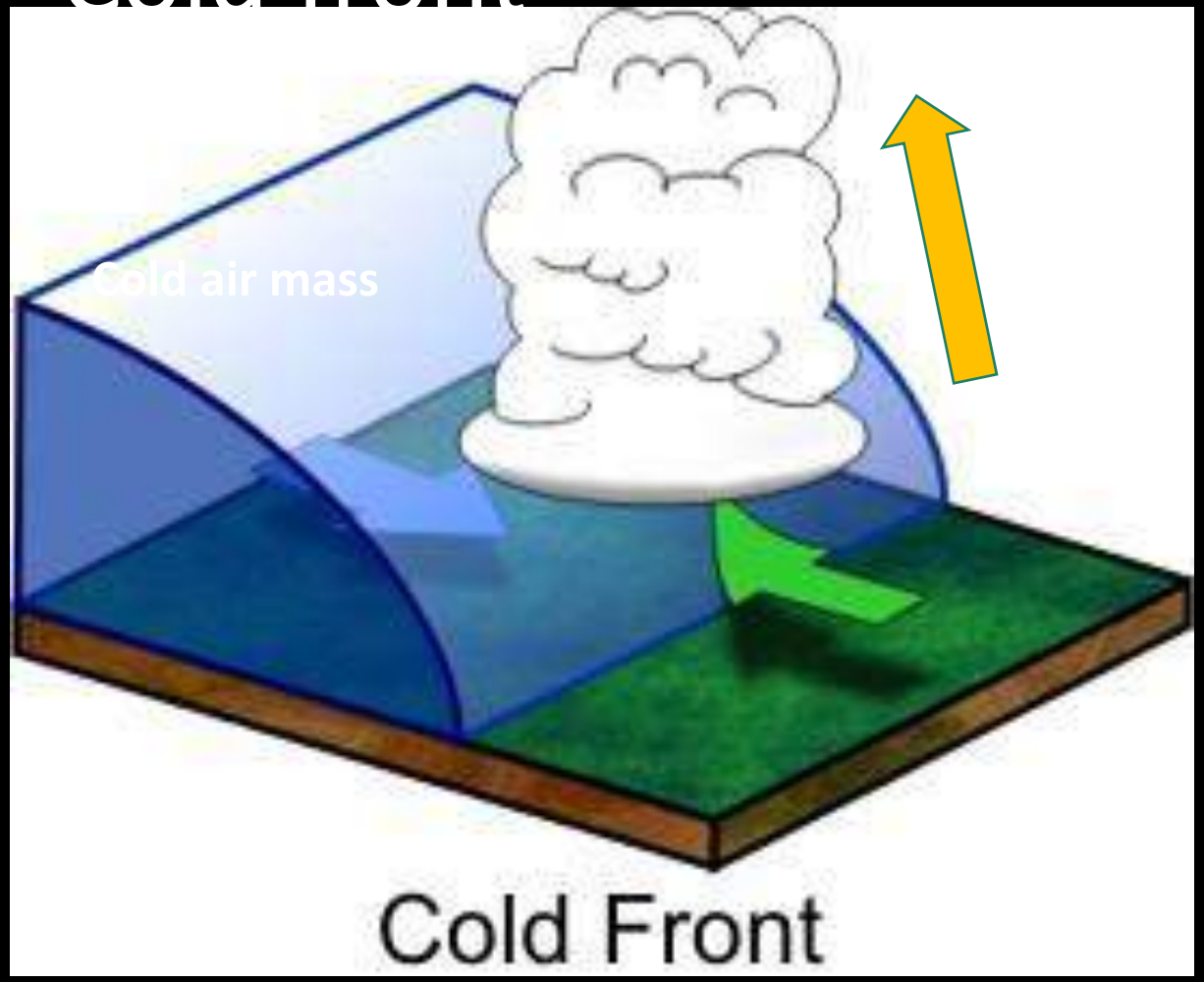
- Air masses do not stay at their source regions forever, they move out. While moving they came across other air masses.

Front



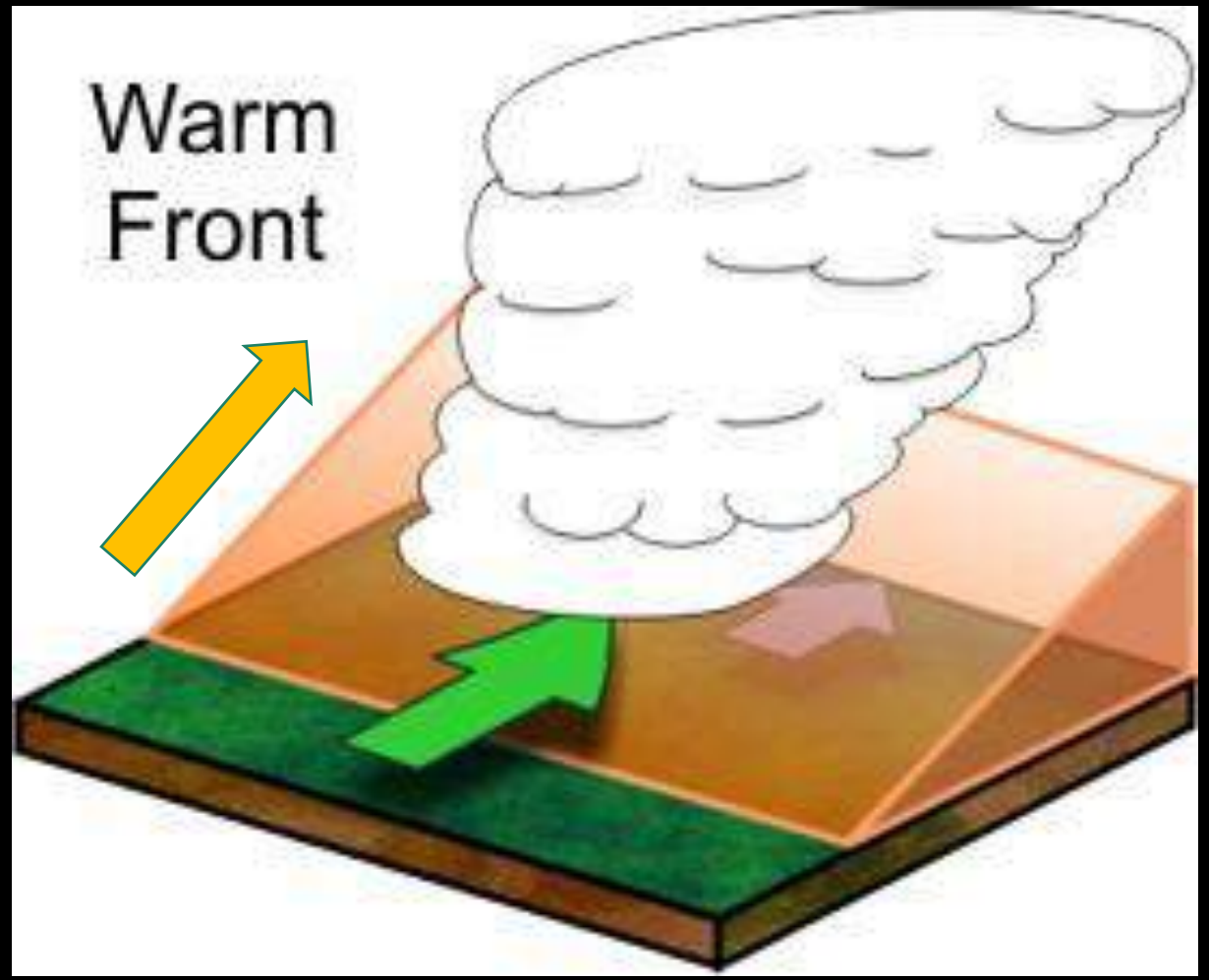
- The relative difference between temperature and moisture decide their interaction with one another
- The border/ meeting region of the two air-mass => Front

Cold front



- If cold air mass move faster than the other than it will lift the warmer one upward => cold front
- the slope will be steep = there will be sudden up-liftment of the warm air = cumulonimbus clouds = cyclonic rain

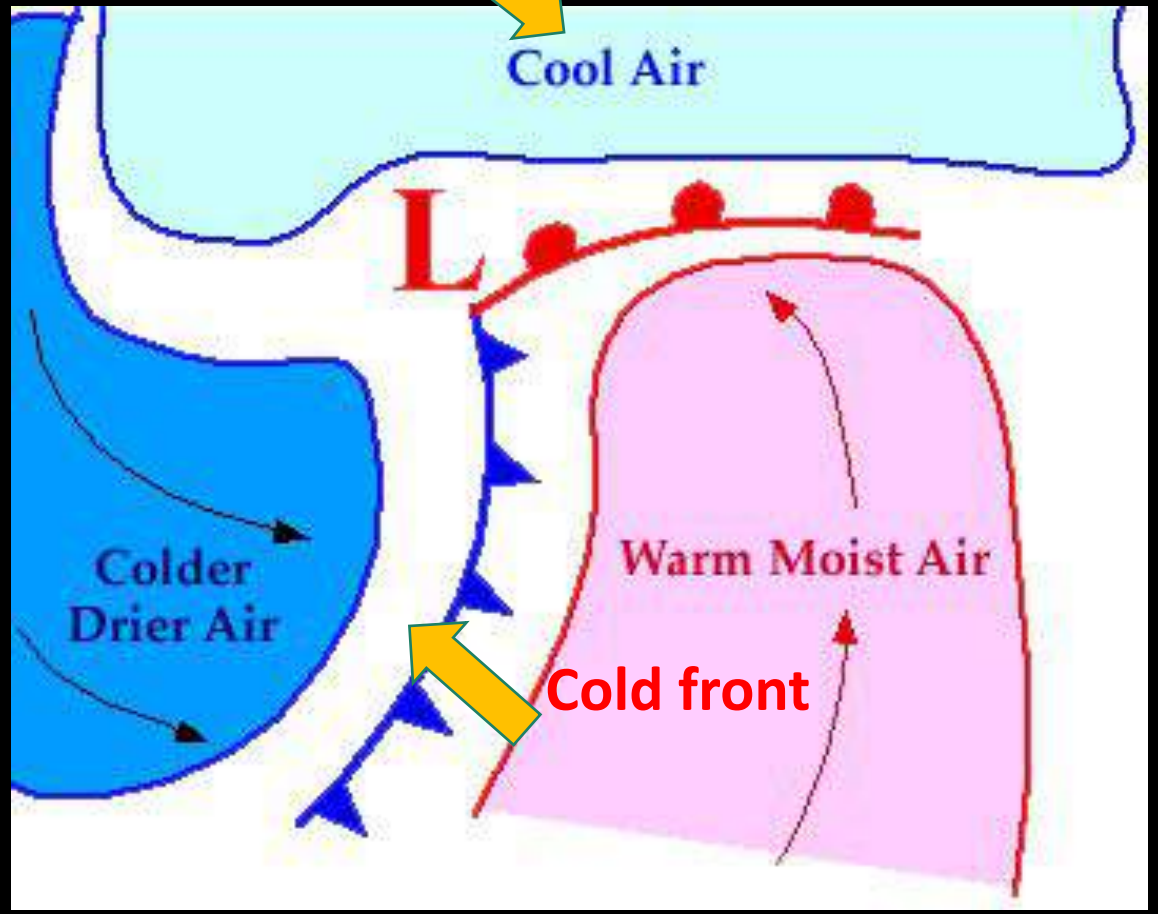
Warm front

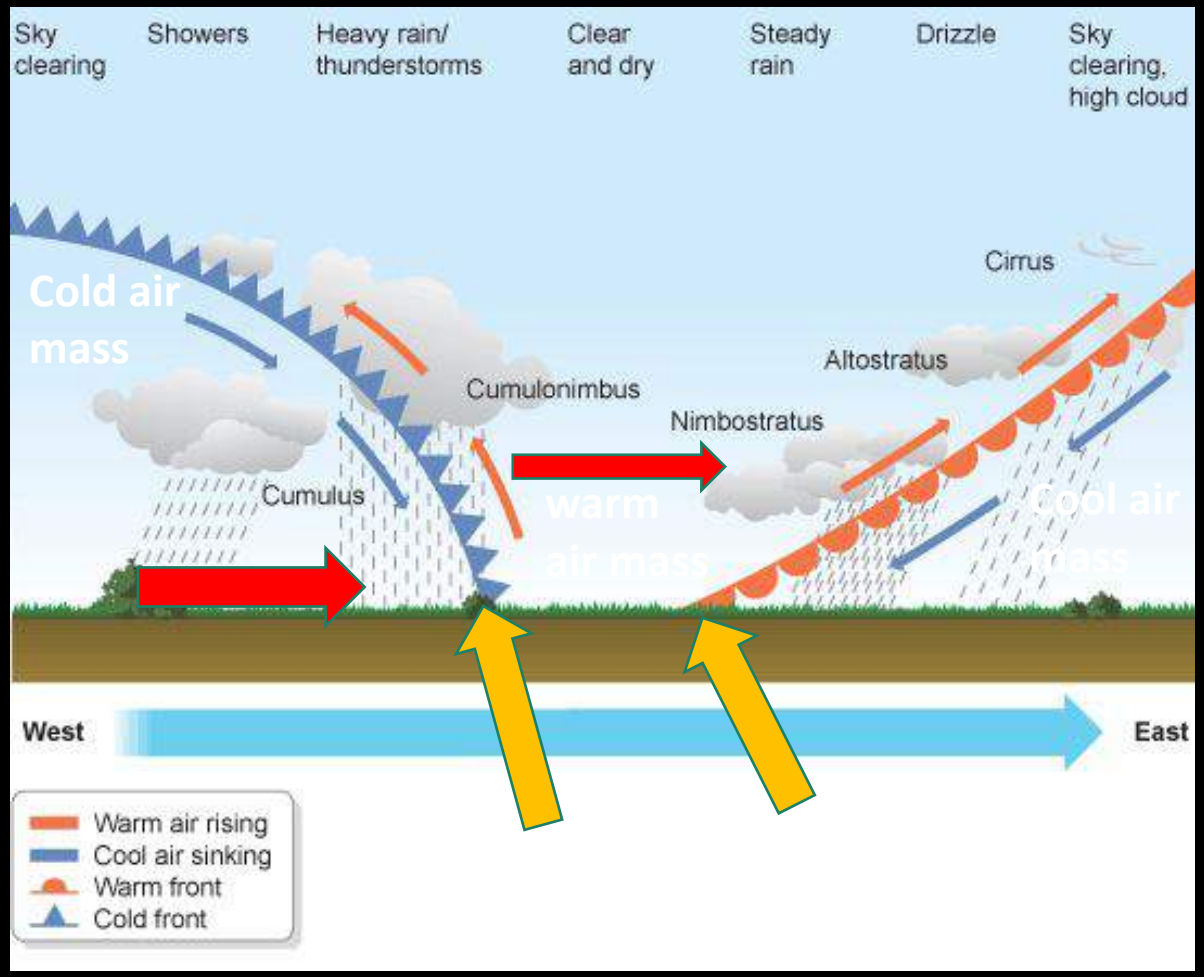


- If warmer air mass is more active than cold front => warm front
- slope will be gentler = there won’t be sudden up-liftment of warm air = uniform prolonged rain – drizzle

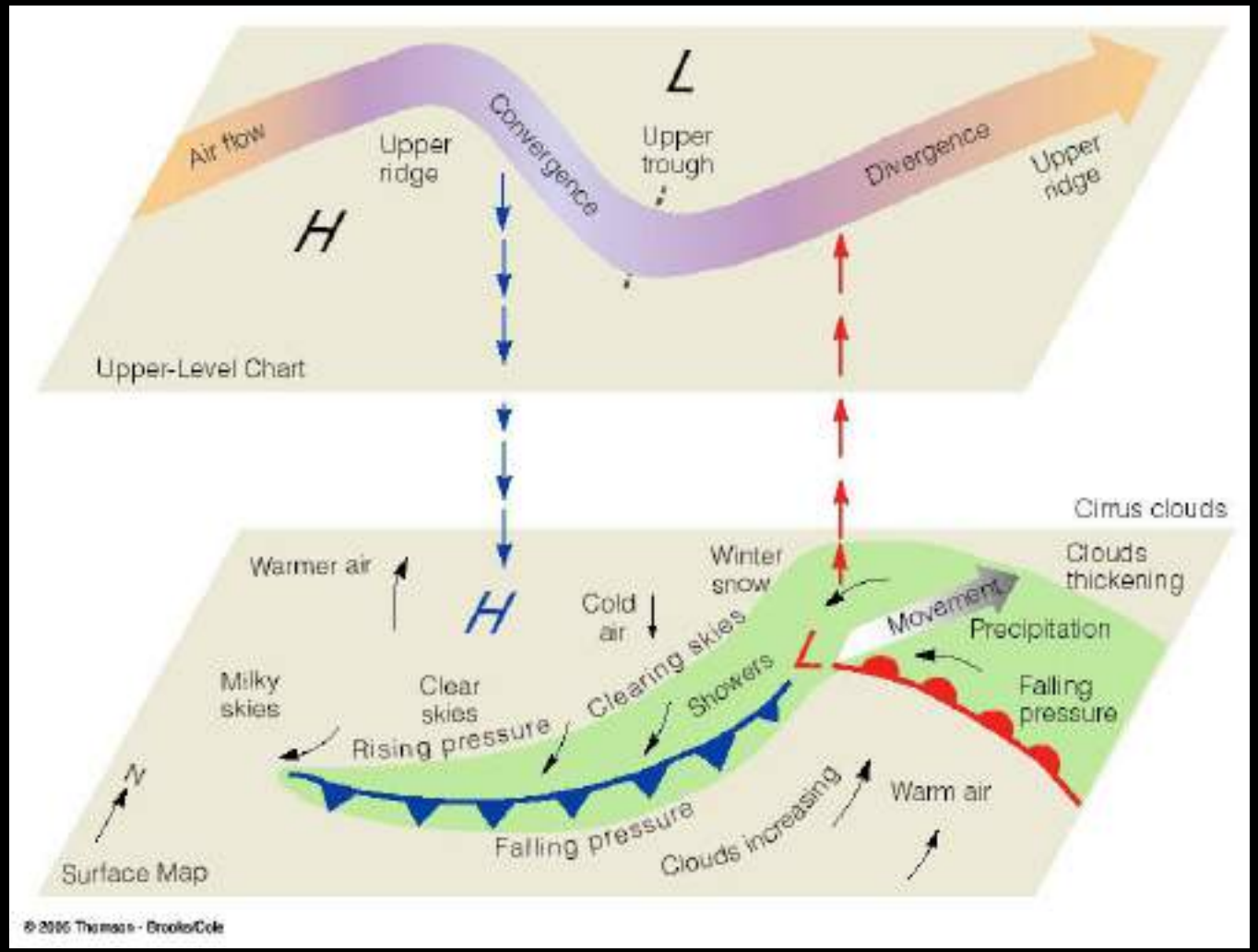
Fronts

Warm front



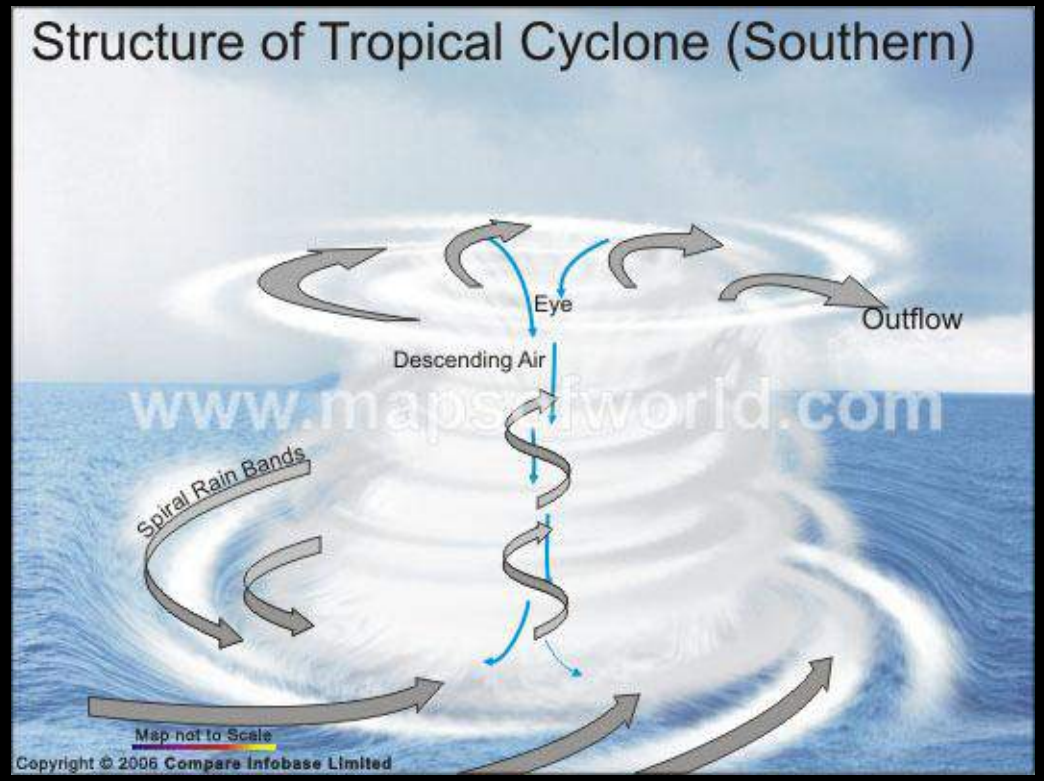


Frontal cyclone



- Also called as extra-tropical cyclone, travelling depressions, cold-core cyclone, wave cyclones

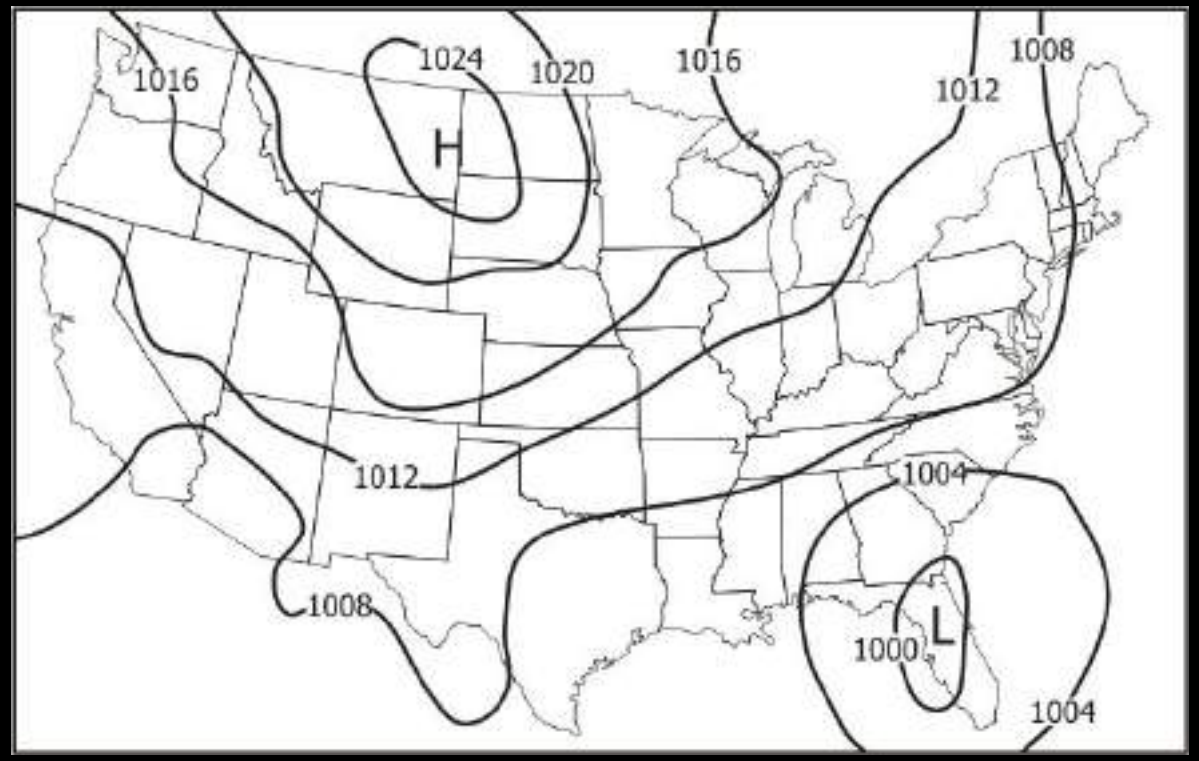
Meaning of cyclone

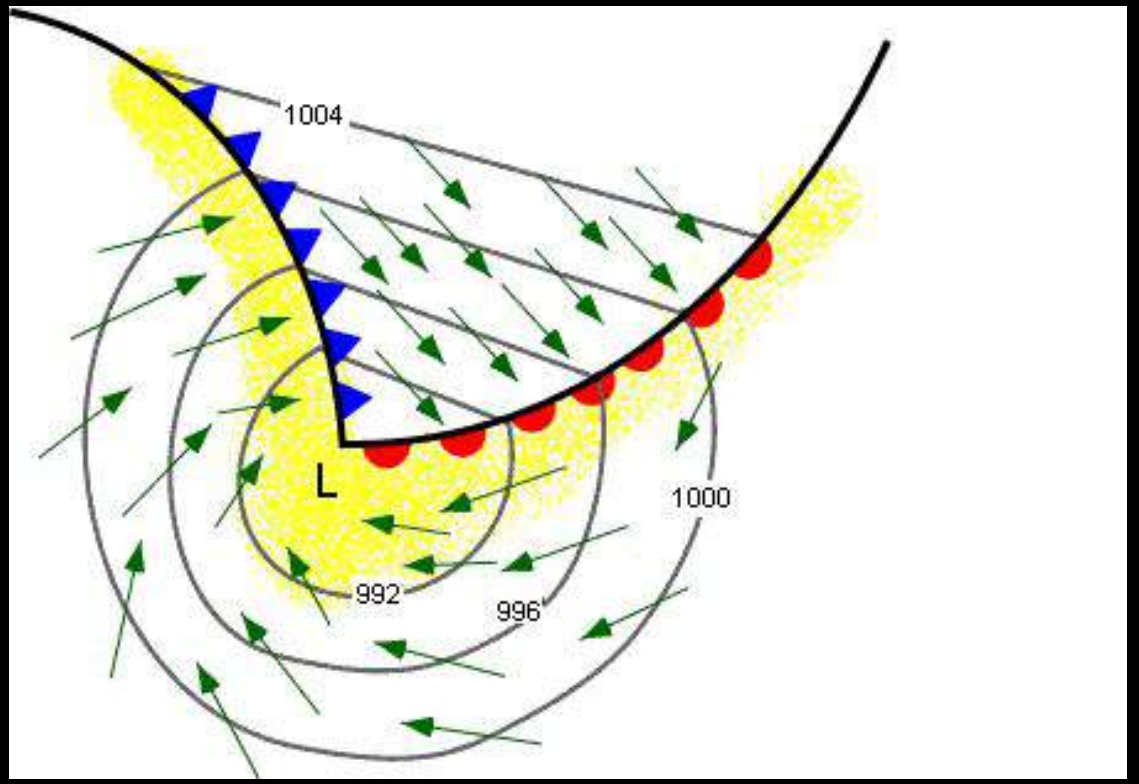


1) Intense LP system
2) Air converges towards the centre
3) In Northern hemisphere convergence – anti-clockwise
4) Closed isobars

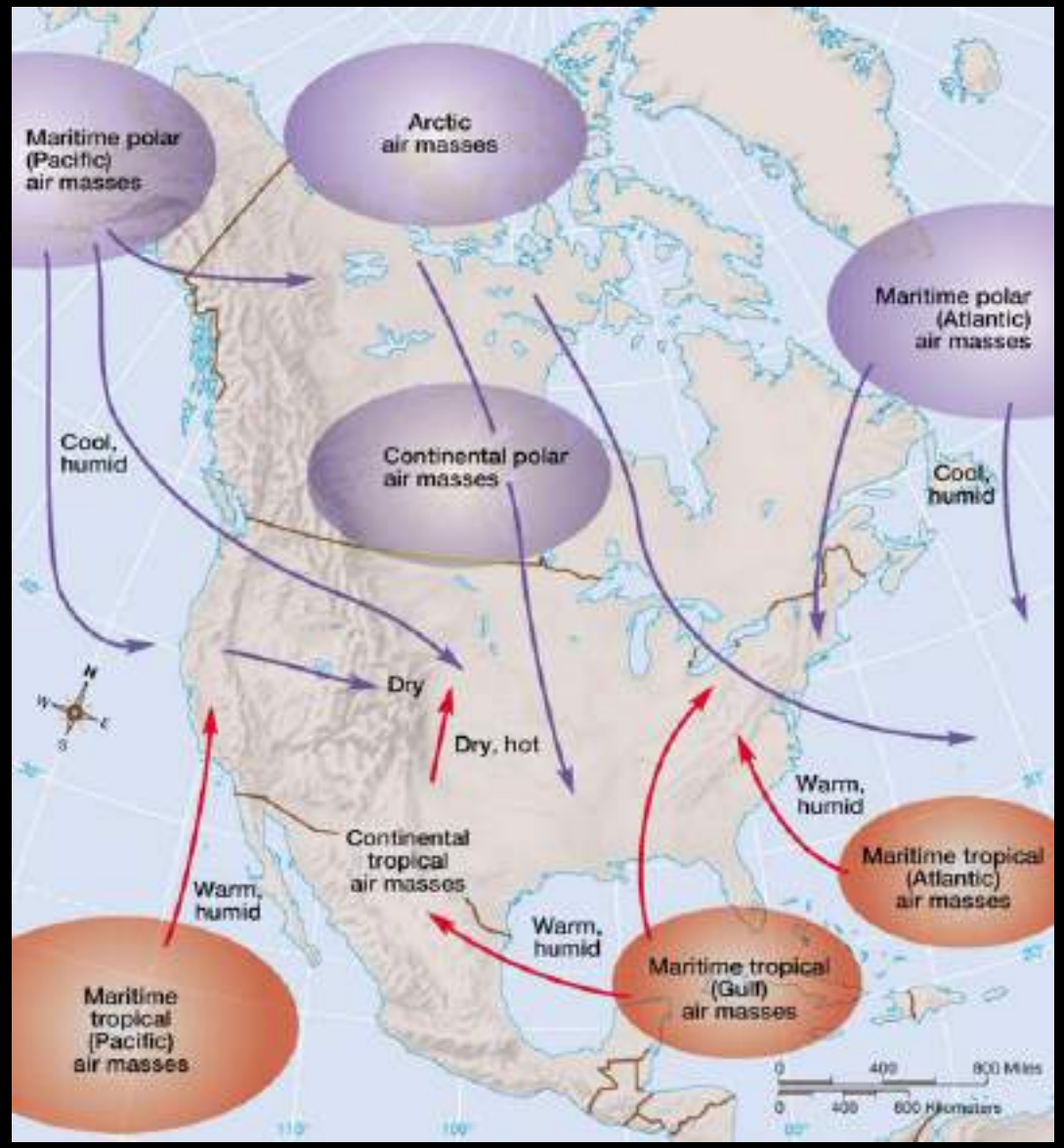
Isobar

- Closed isobar



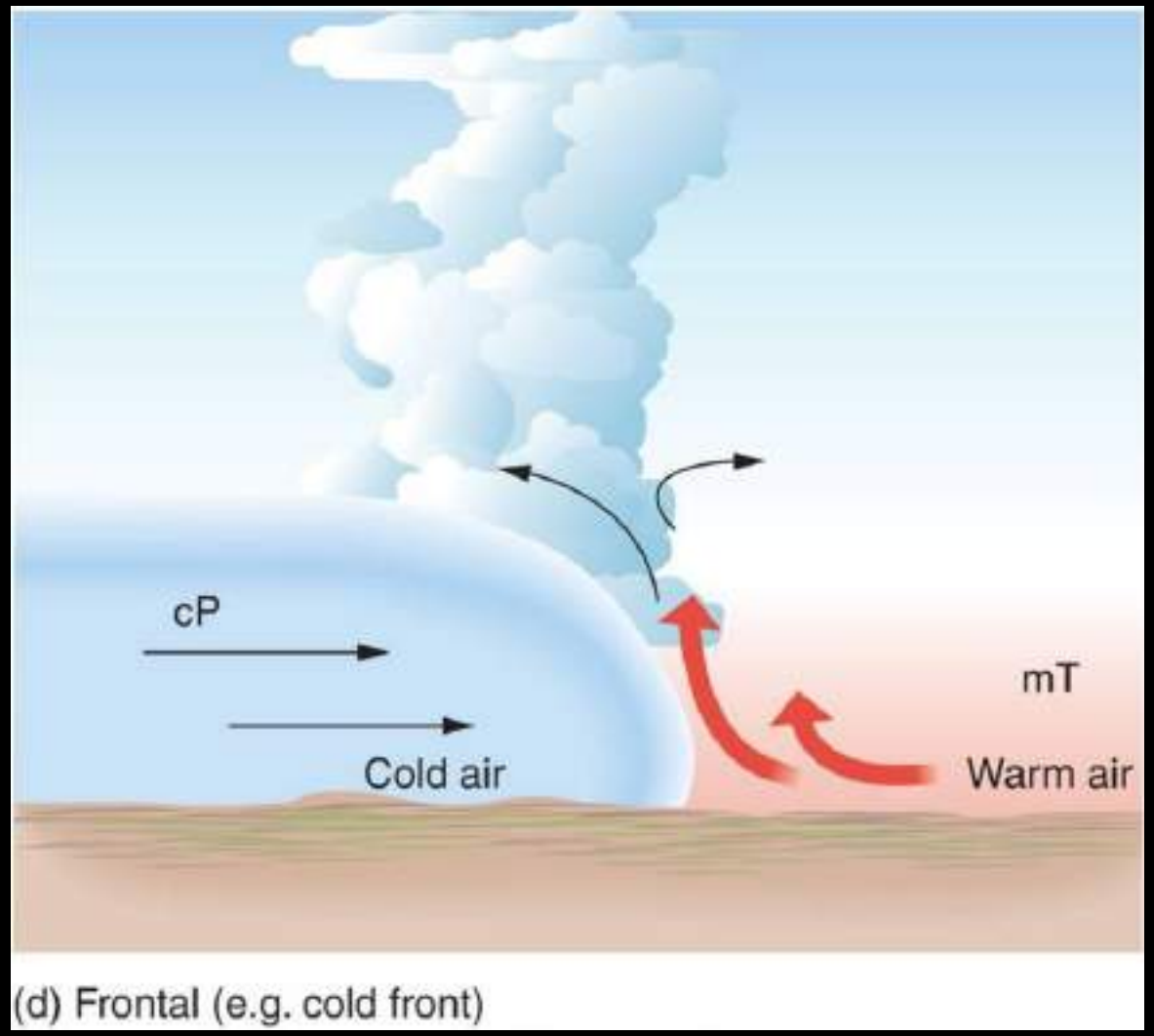


Development of Frontal cyclone



- Movement of airmasses from their source region
- The warm and cold air mass face each other
- A front is created between them
- Called Stationary front

Development of Frontal cyclone

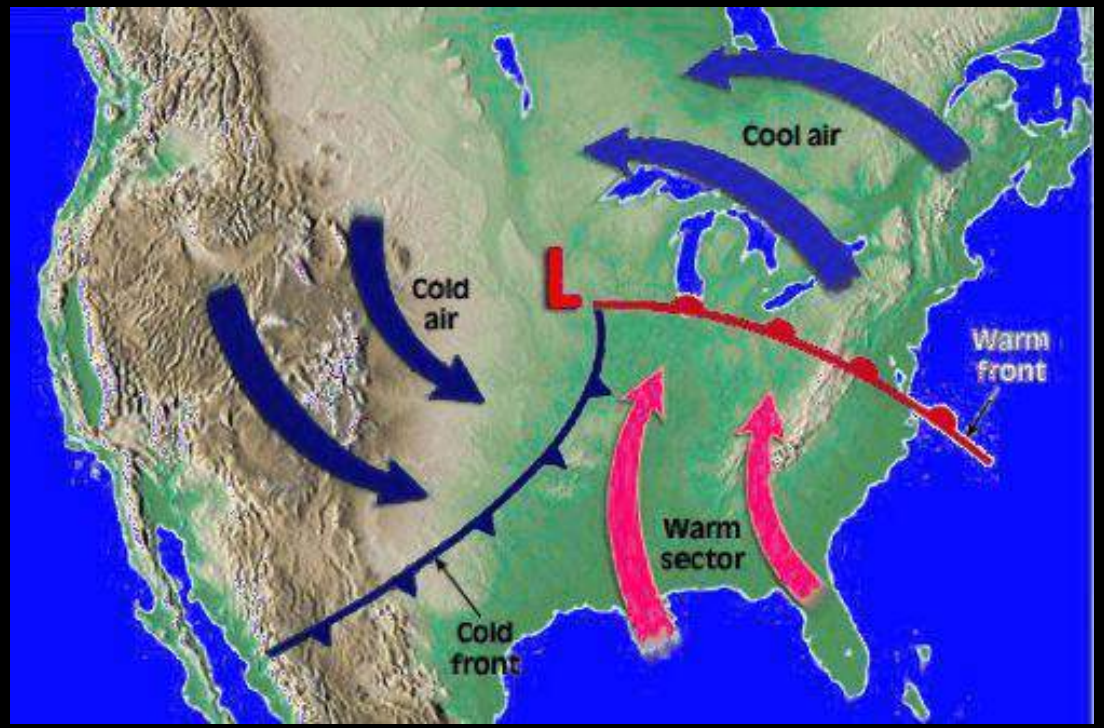


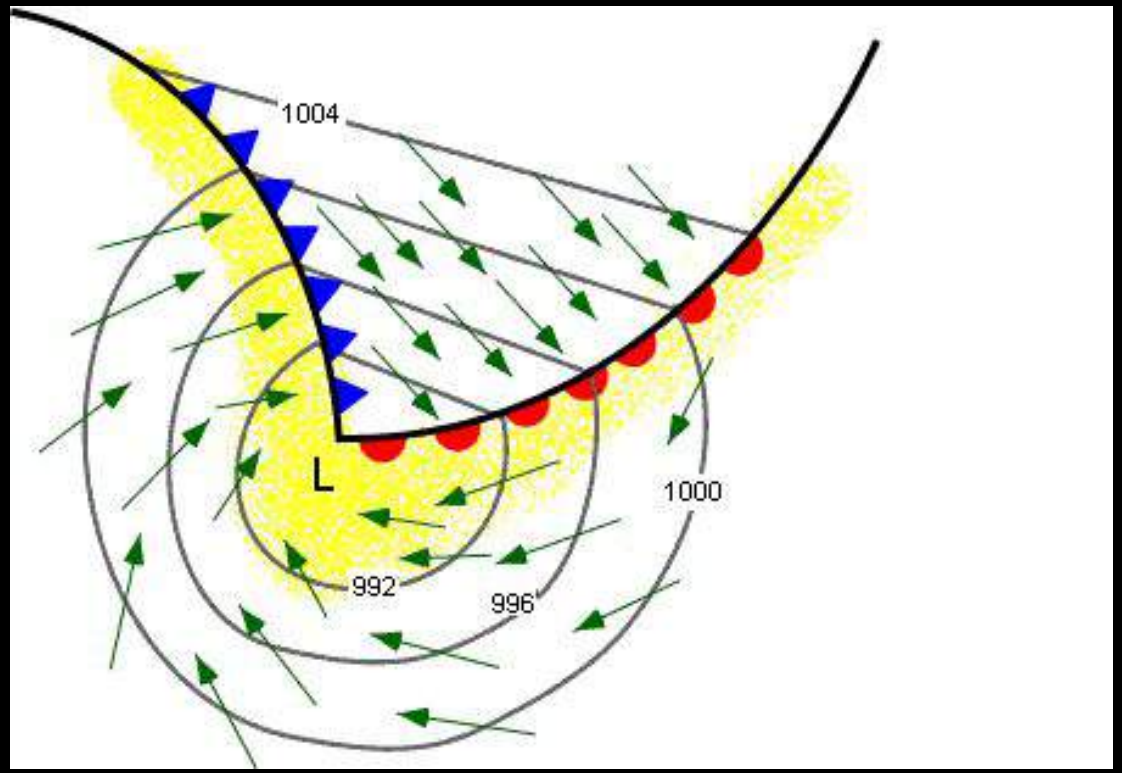
(d) Frontal (e.g. cold front)

- Cold air mass pushed the warm air mass
- Forced upliftment of warm air mass at the cold front =LP
- Two cold air mass convergence – circular due to coriolis force

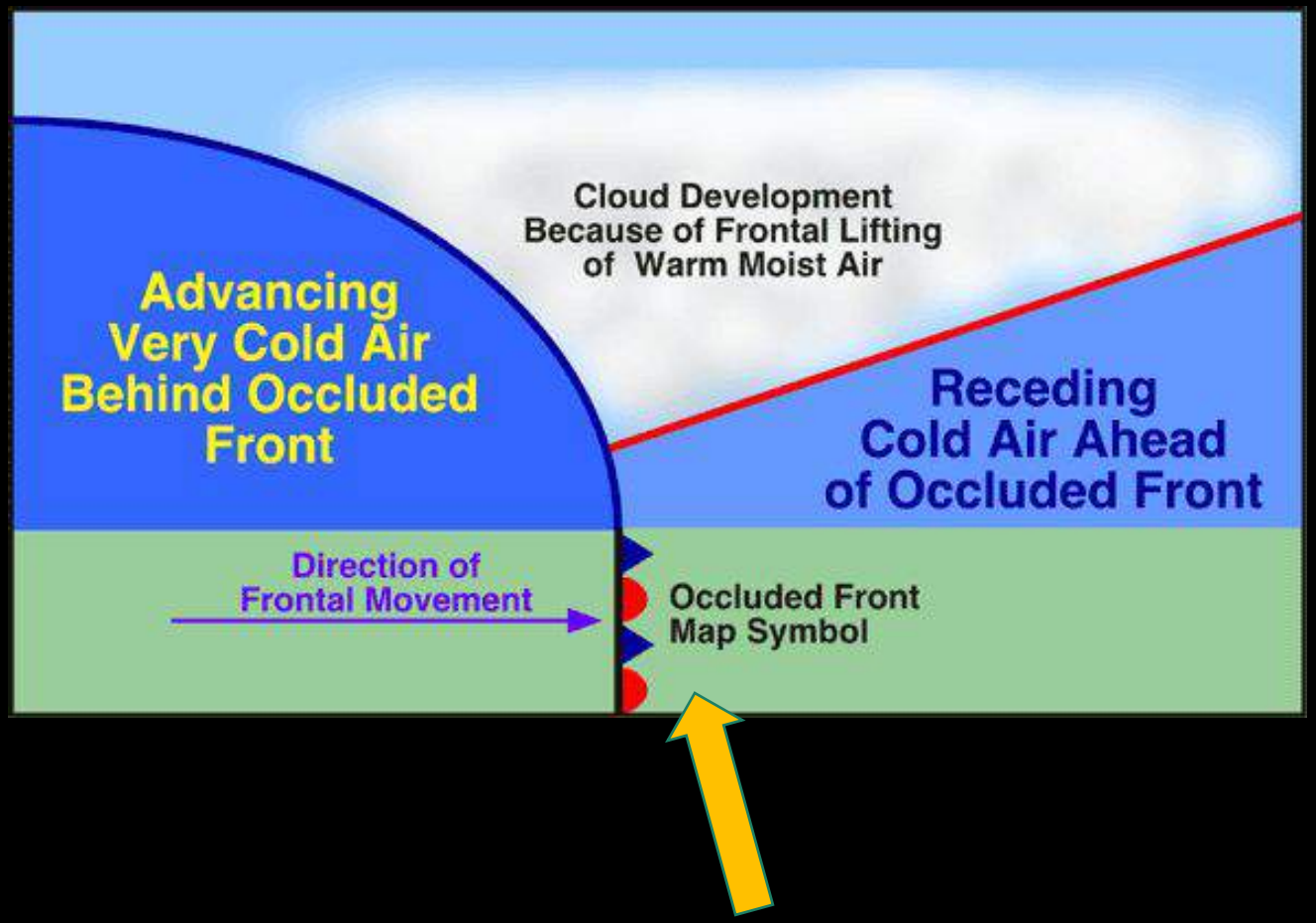
Mature stage

Interaction of air masses



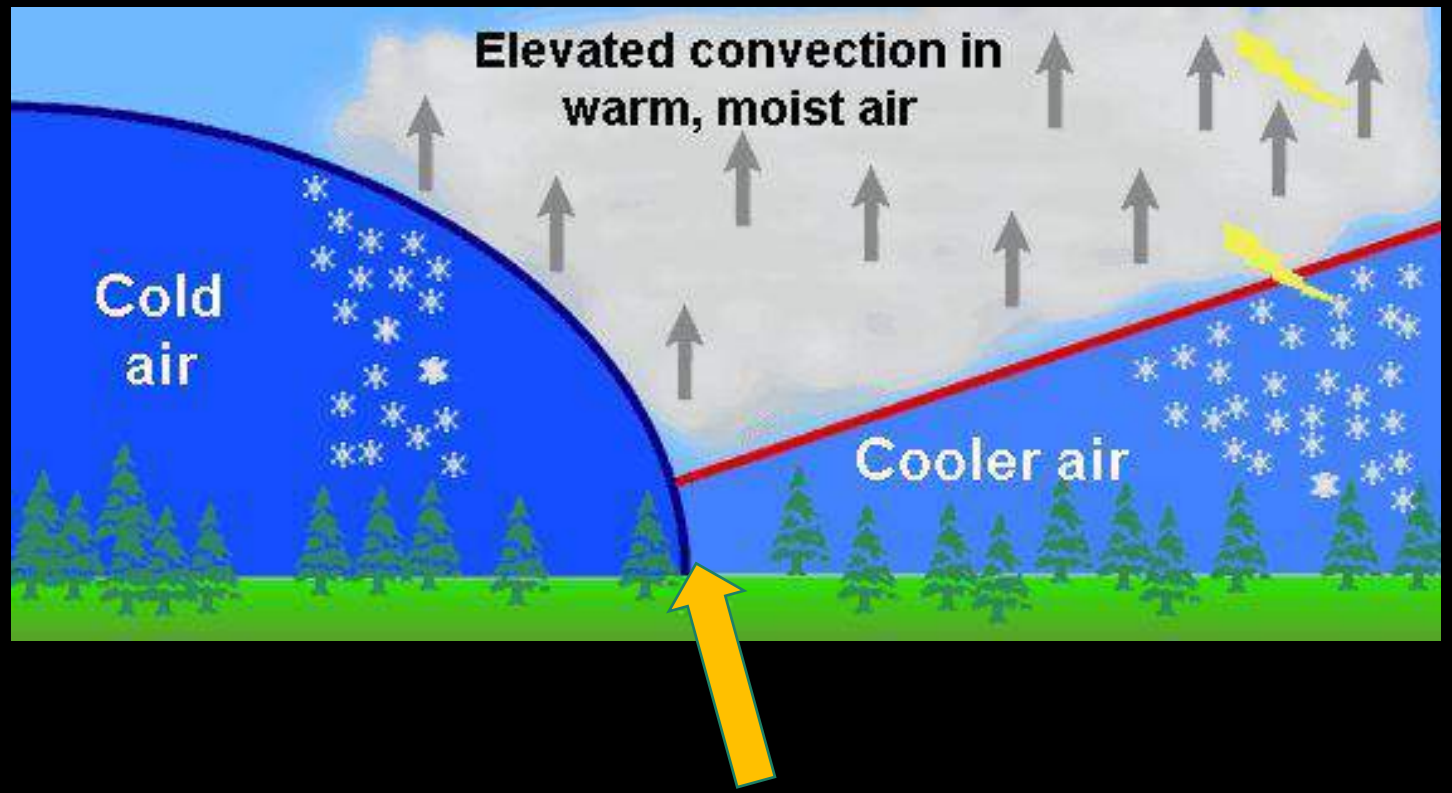


Occluded front



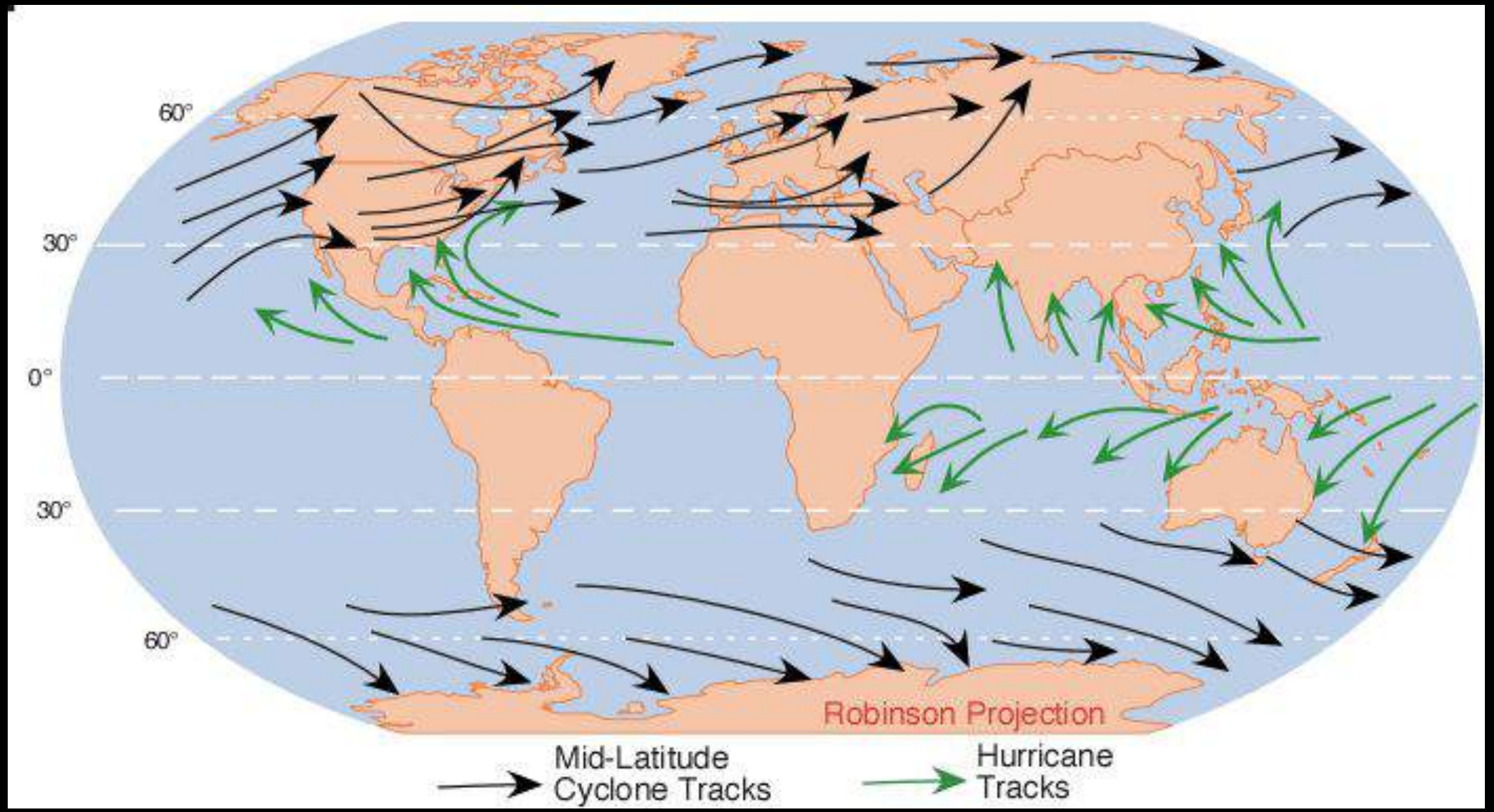
- One cold air mass climb over other cold air mass–warm front is destroyed
- Called occluded front
- Rapid change in temperature and pressure
- Unstable weather conditions

Dissipation of frontal cyclone

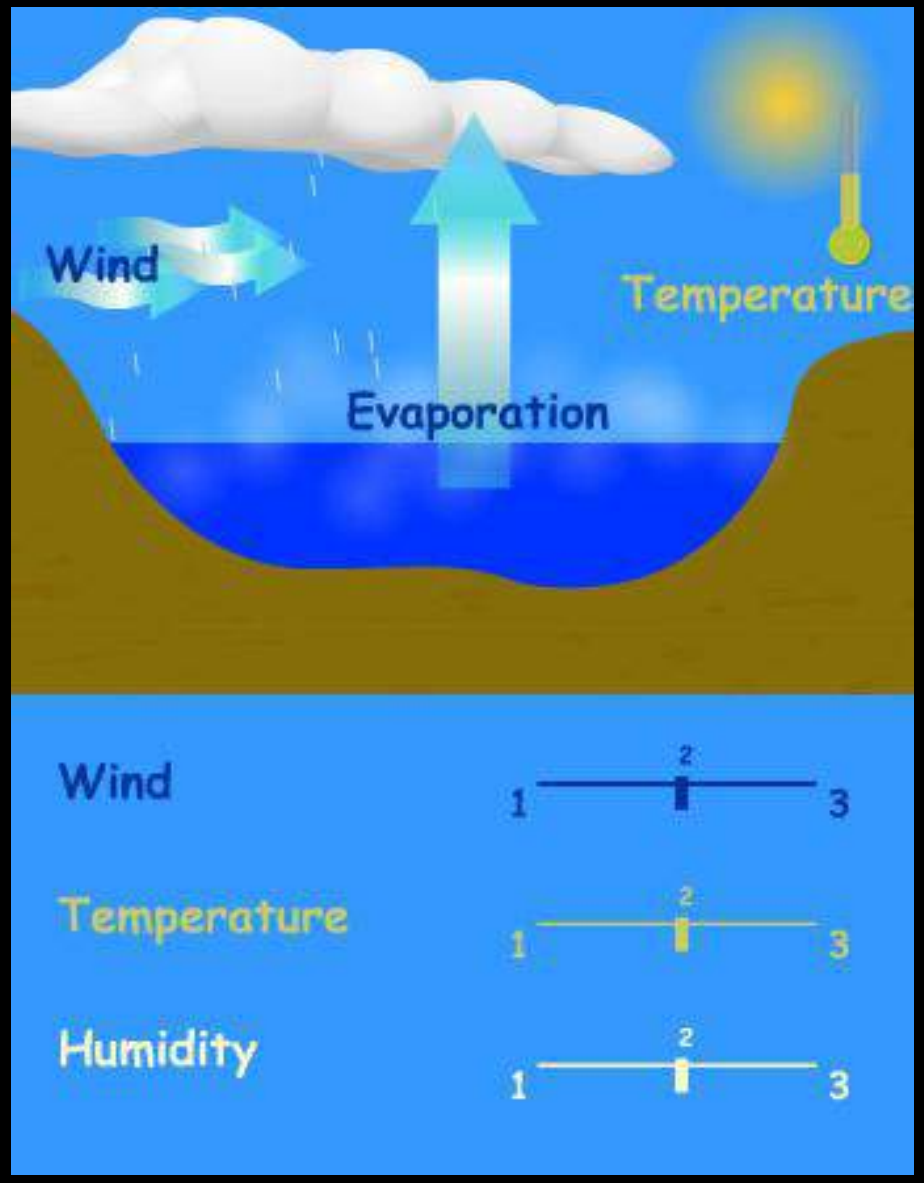


- Frontolysis – no great temperature difference between two cold air masses – front dissipated – LP reduced – cyclone dissipated

Distribution of temperate cyclones



Tropical cyclone

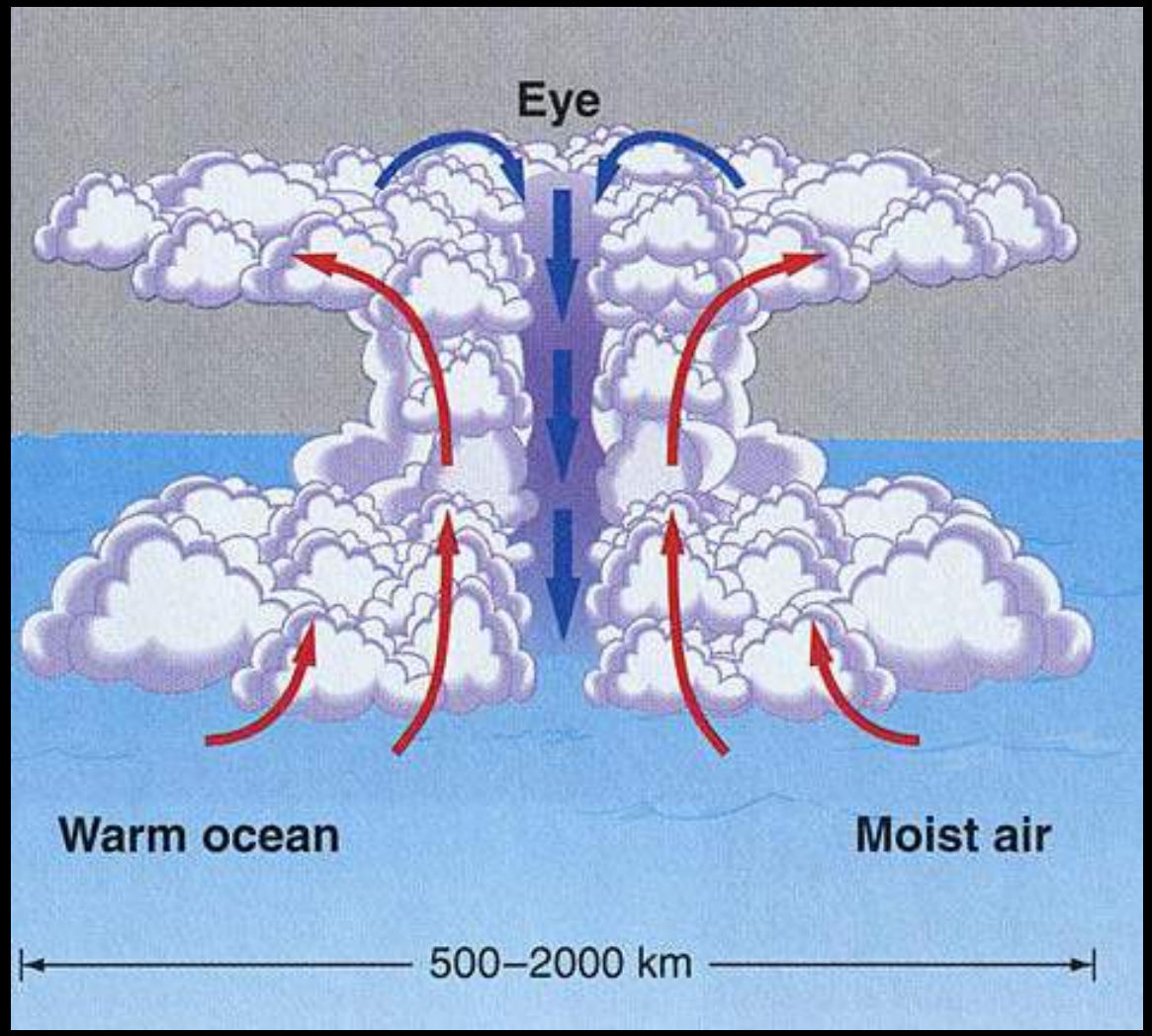


Hurricane –N. America

Typhoon - China

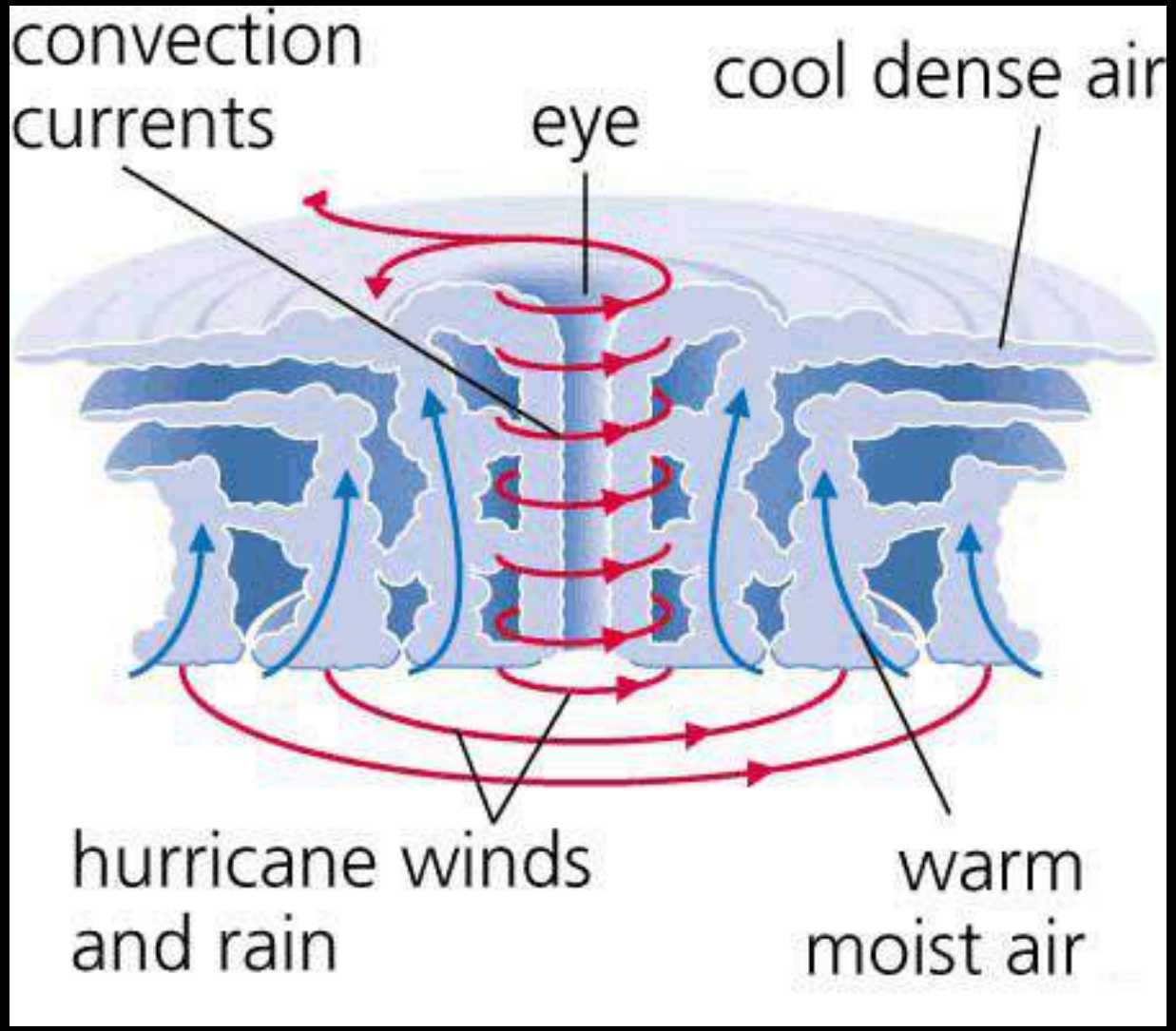
- Late summer
- Increased sea surface temperature = LP

Tropical cyclone



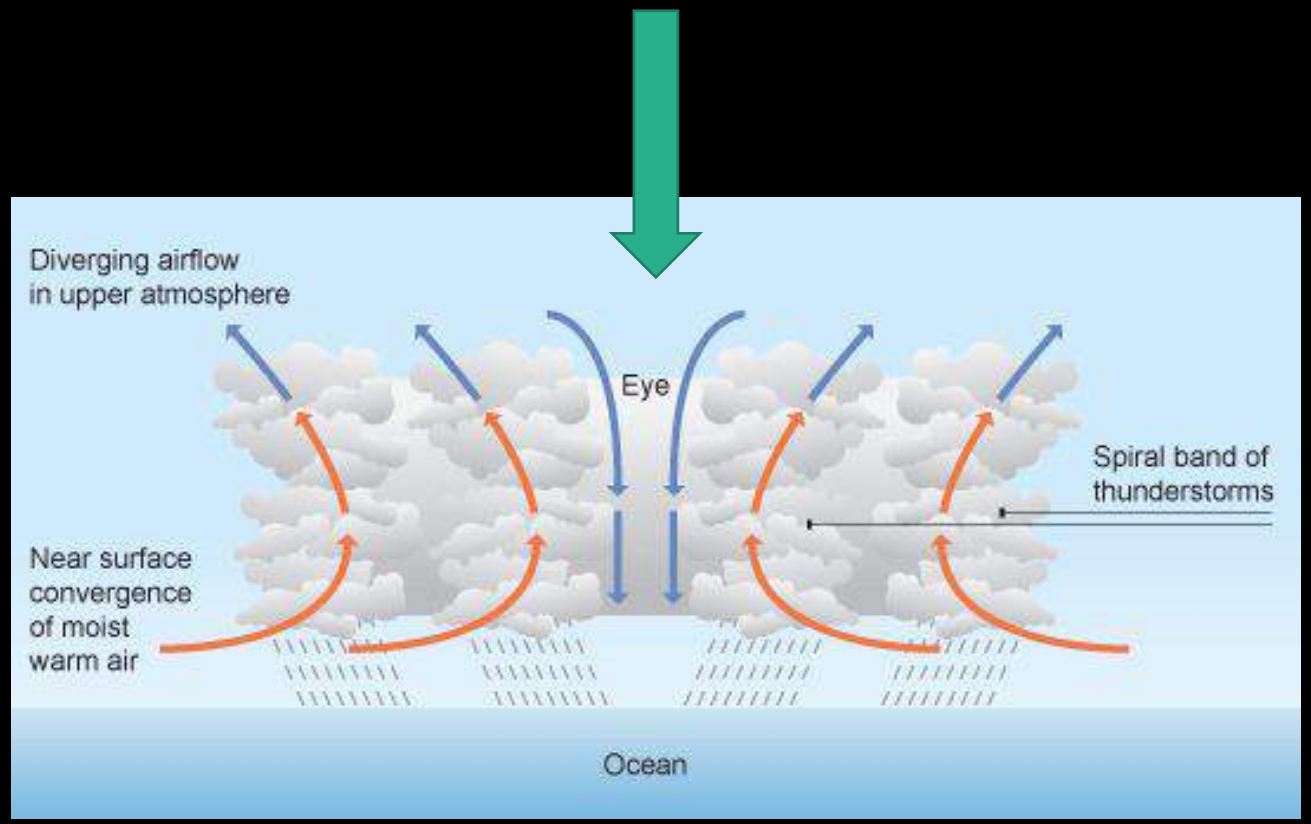
- Convergence of air around LP zone
- Rising moist (wet) air => absolute instability
- Cloud formation =more and more moisture – latent heat of evaporation => cumulo nimbus cloud => cyclone

Mature Tropical cyclone



- Intensification of LP
- Converging air near water surface
- Circulating air rises above (coriolis force)
- Diverging air at the top of cyclone

Eye of the tropical cyclone

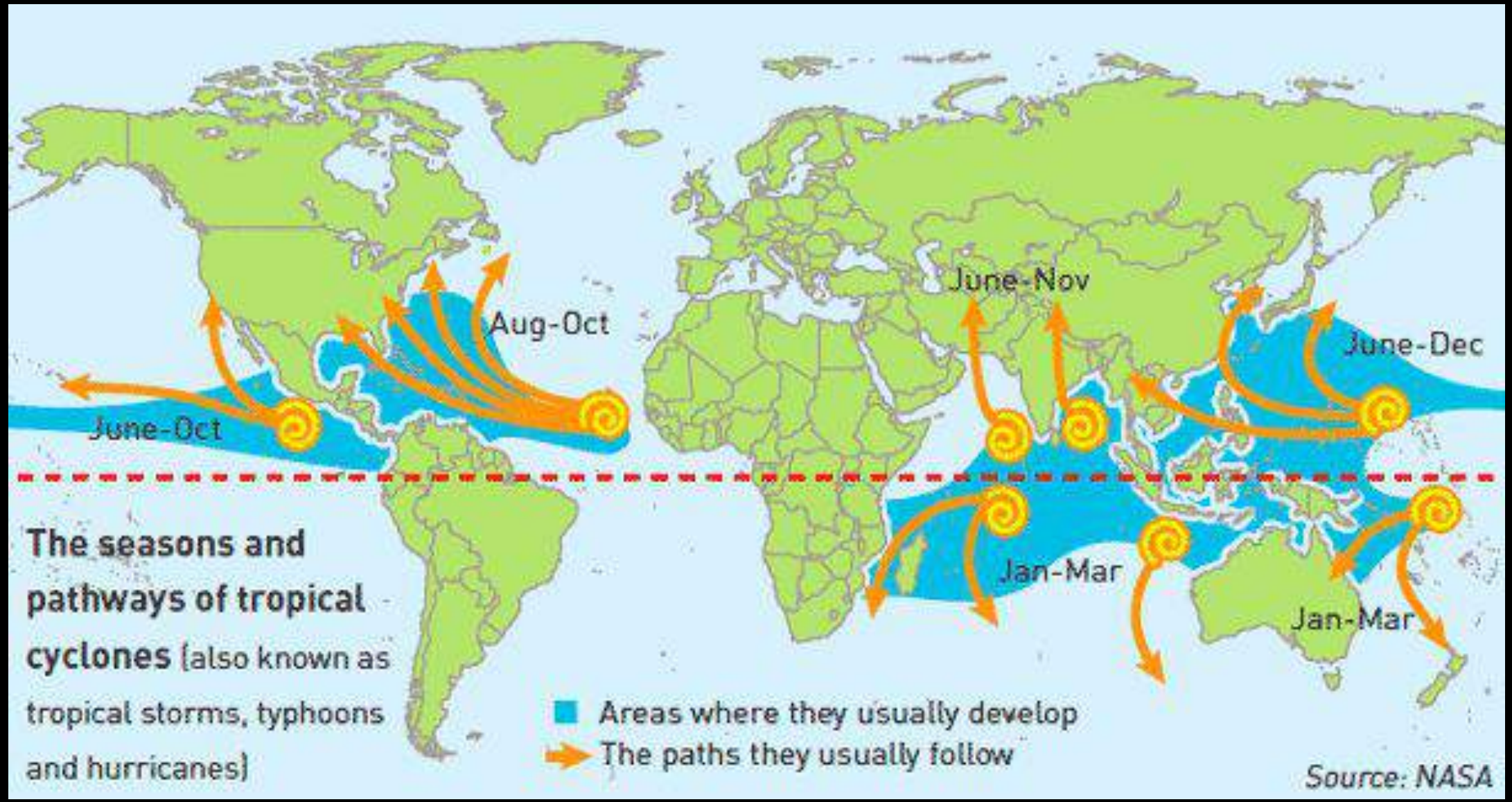


- At the centre of the cyclone – ‘eye’ of the tropical cyclone.
- It is a pressure defect. Because, at ‘eye’ a narrow stream of wind descend = is HP at ‘eye’
- At the eye, there is clear sky.
- Beyond eye wall – extreme low pressure

Properties of tropical cyclones

- Move swiftly
- Always east to west
- It is fuelled by moisture – so when cyclone is cut-off from sea and move towards land – it starts weakening

Distribution of tropical cyclone



comparison

Temperate cyclone

- 30-40 degree latitude
- Dynamically induced
- Due to frontal interaction
- Formed over large area
- Move west to east
- Gradual movement – predictable

- Tropical cyclone

- 8-20 degree latitude
- Thermally induced
- Due to increasing SST
- Small area
- Move east to west
- Swift movement- difficult to predict path

comparison

Temperate cyclone

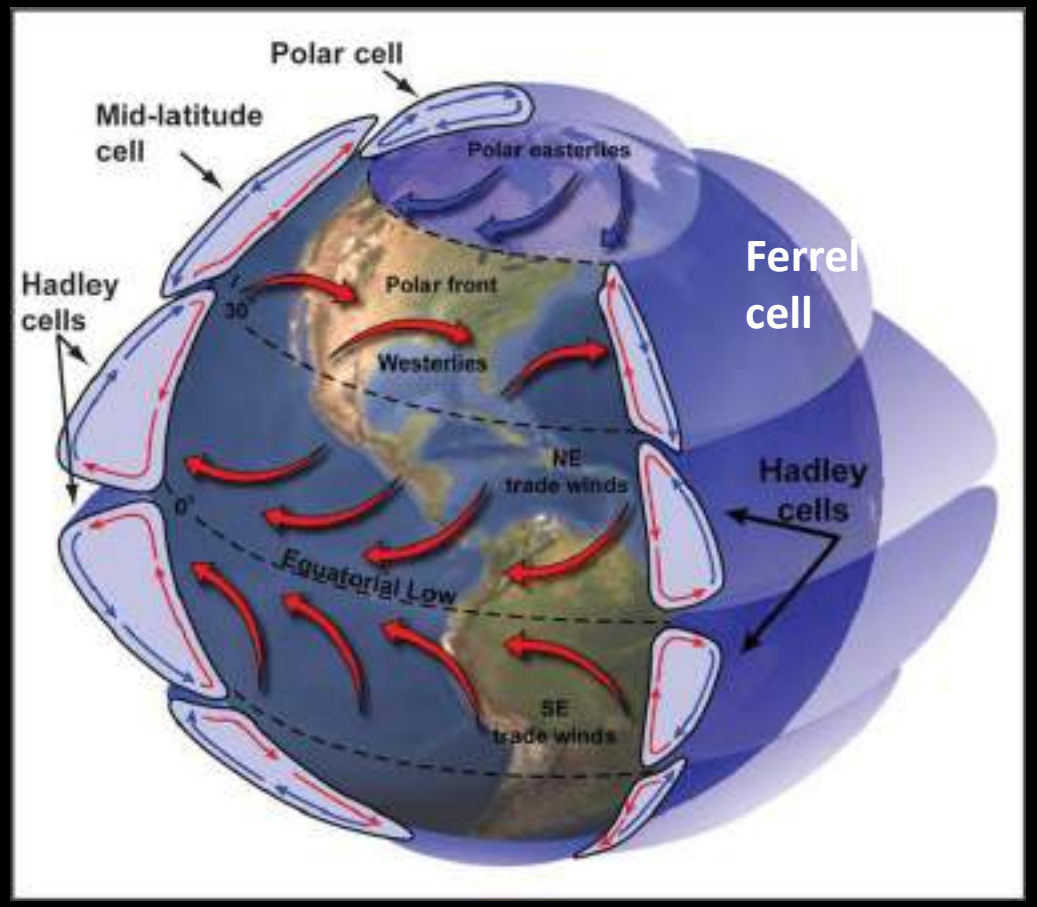
- Wind speed 40-50 kmph
- Pressure gradient 980 mb
- Powerful on land
- Affect mainland
- More time to dissipate

- Tropical cyclone

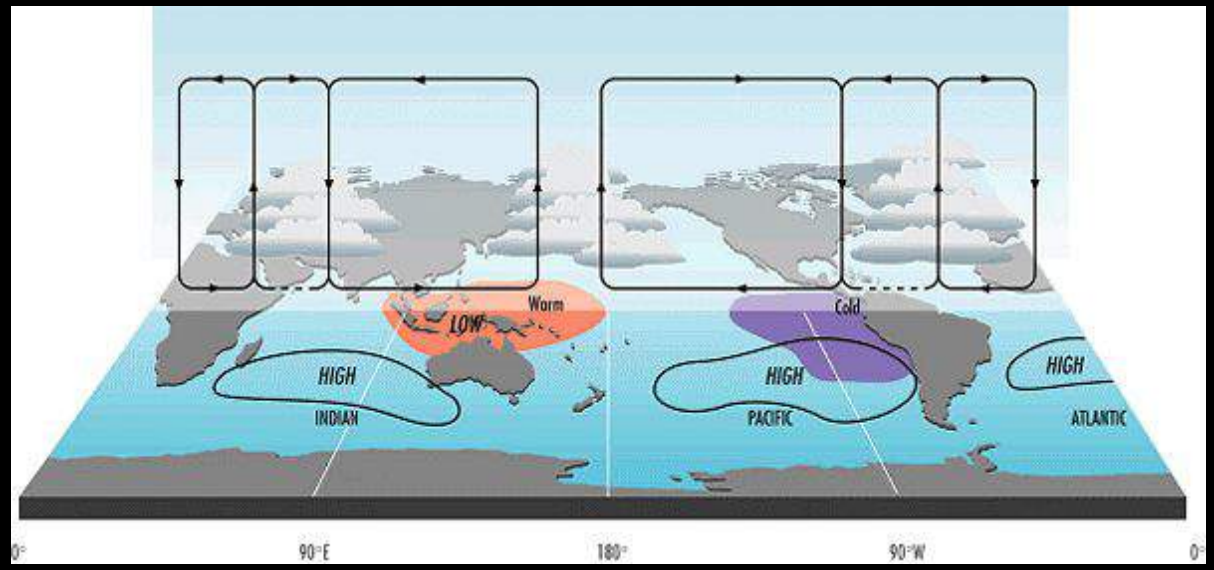
- Wind speed >120 kmph
- Pressure gradient <880 mb
- Weakens on land
- Affect only coastal areas
- Quickly dissipate after coming on land

Pressure gradient cells

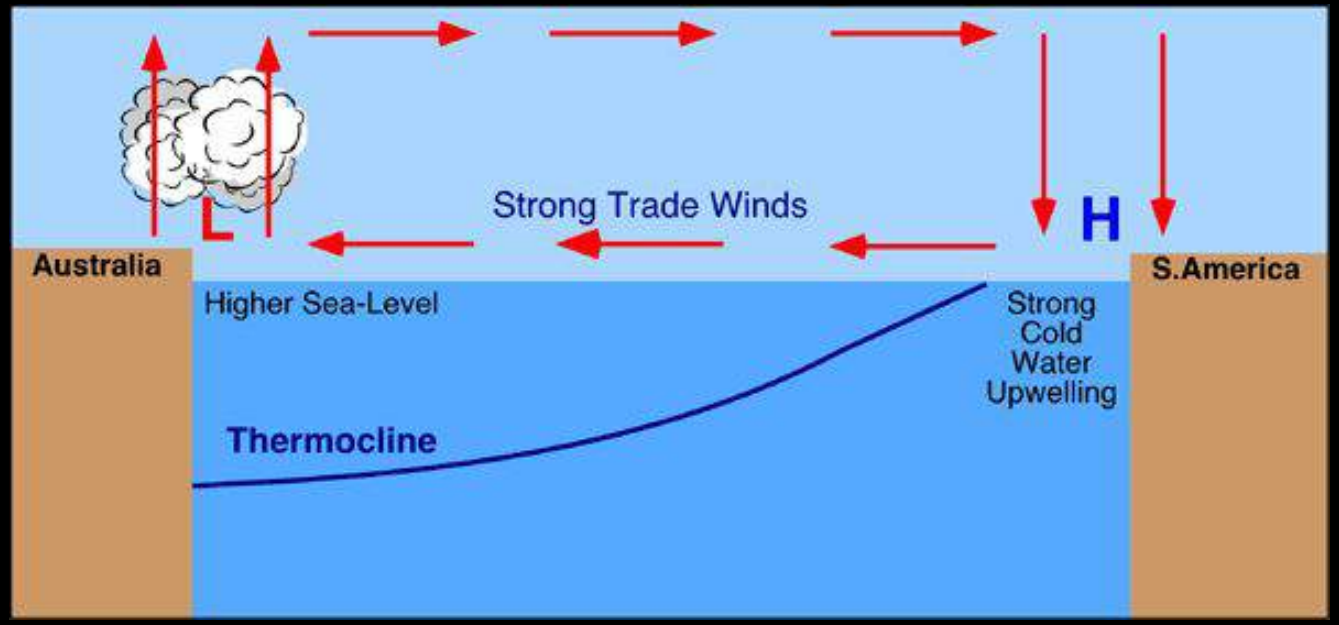
Vertical: Hadley, Ferrell



- Horizontal: walker

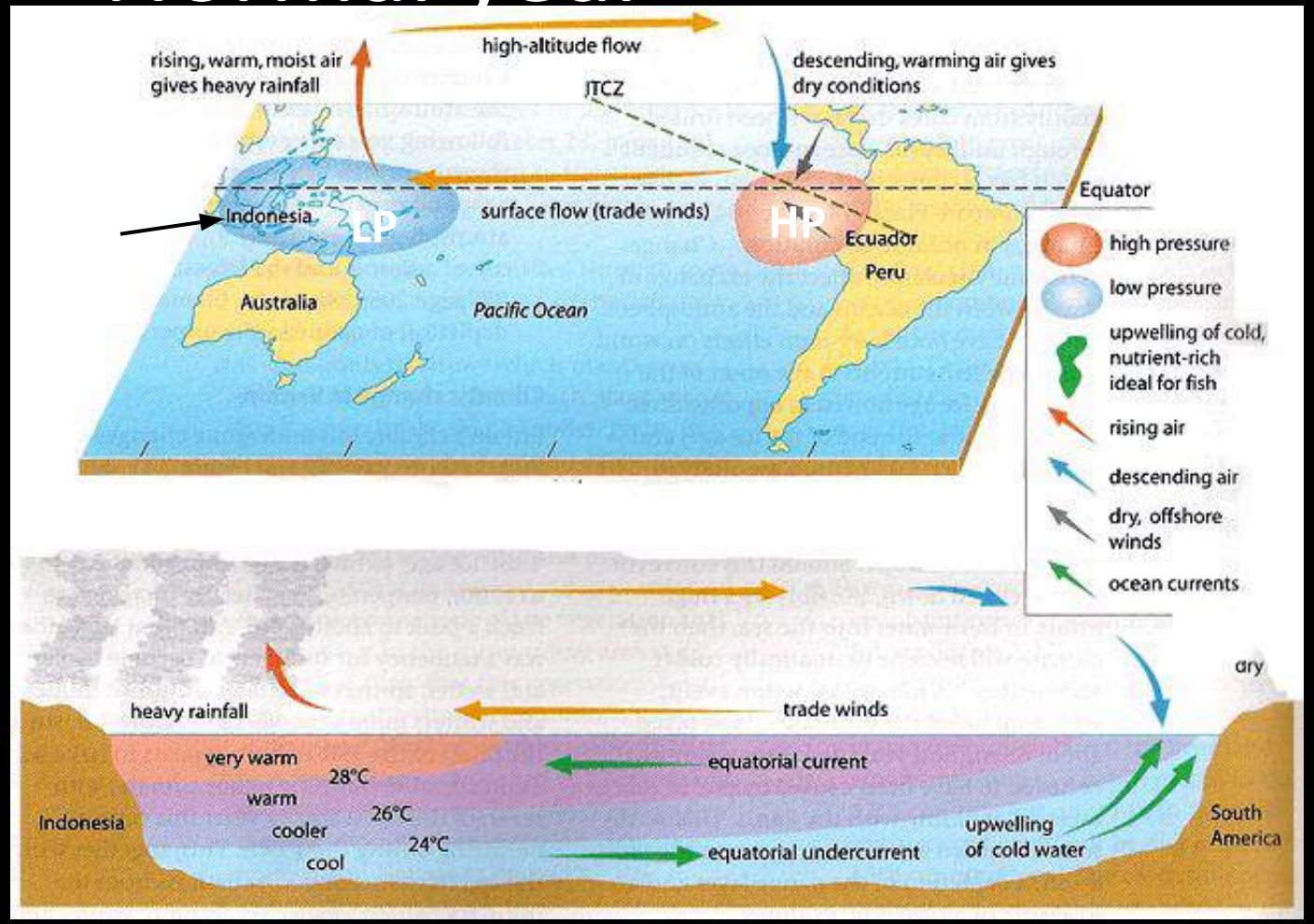


Walkar cell at south Pacific



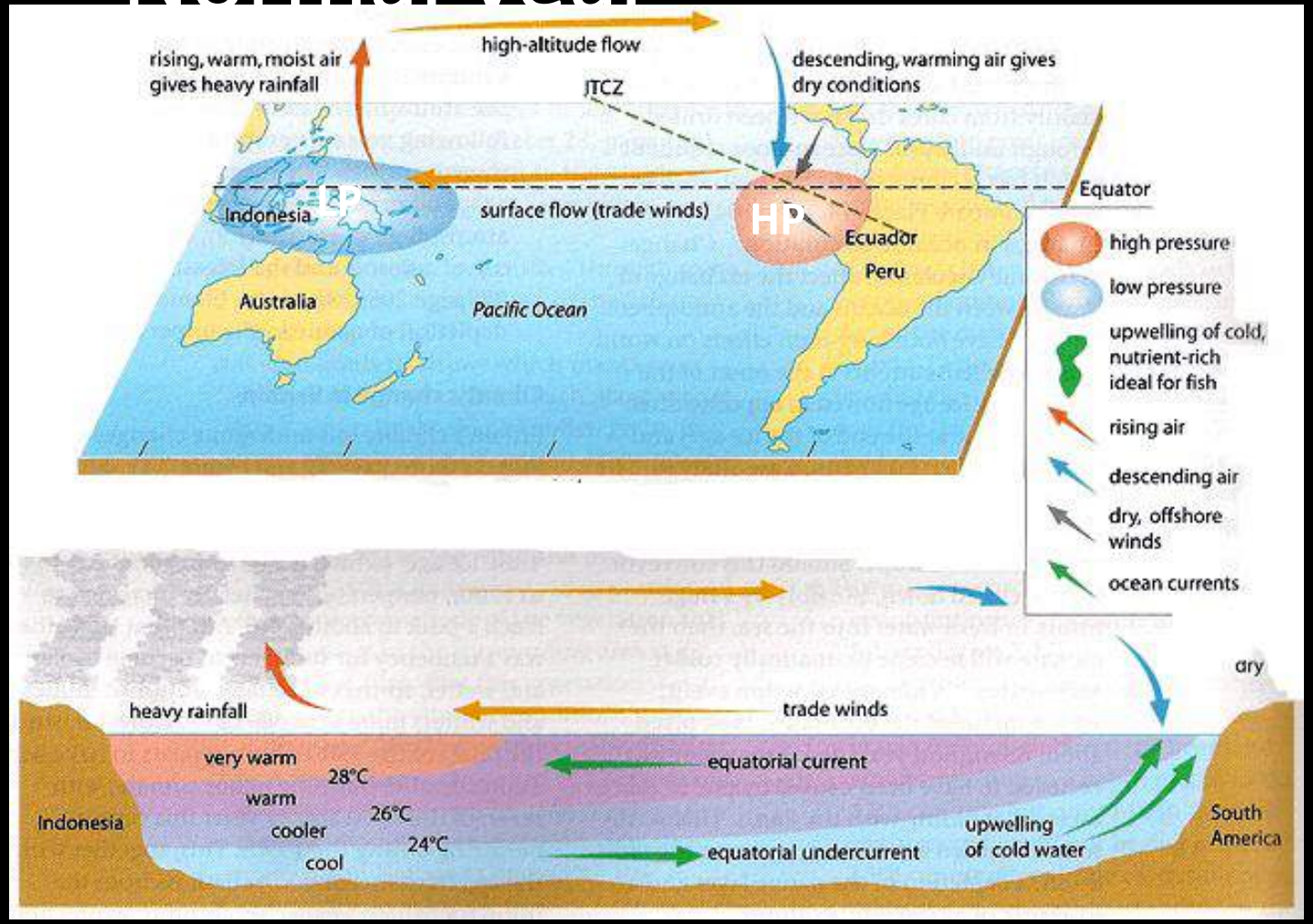
- There are oscillation in pressure gradient and air circulation after intervals of 2-3 years in south Pacific Ocean
- Called Southern Oscillation
- ENSO = EL Nino Southern Oscillation

Normal year



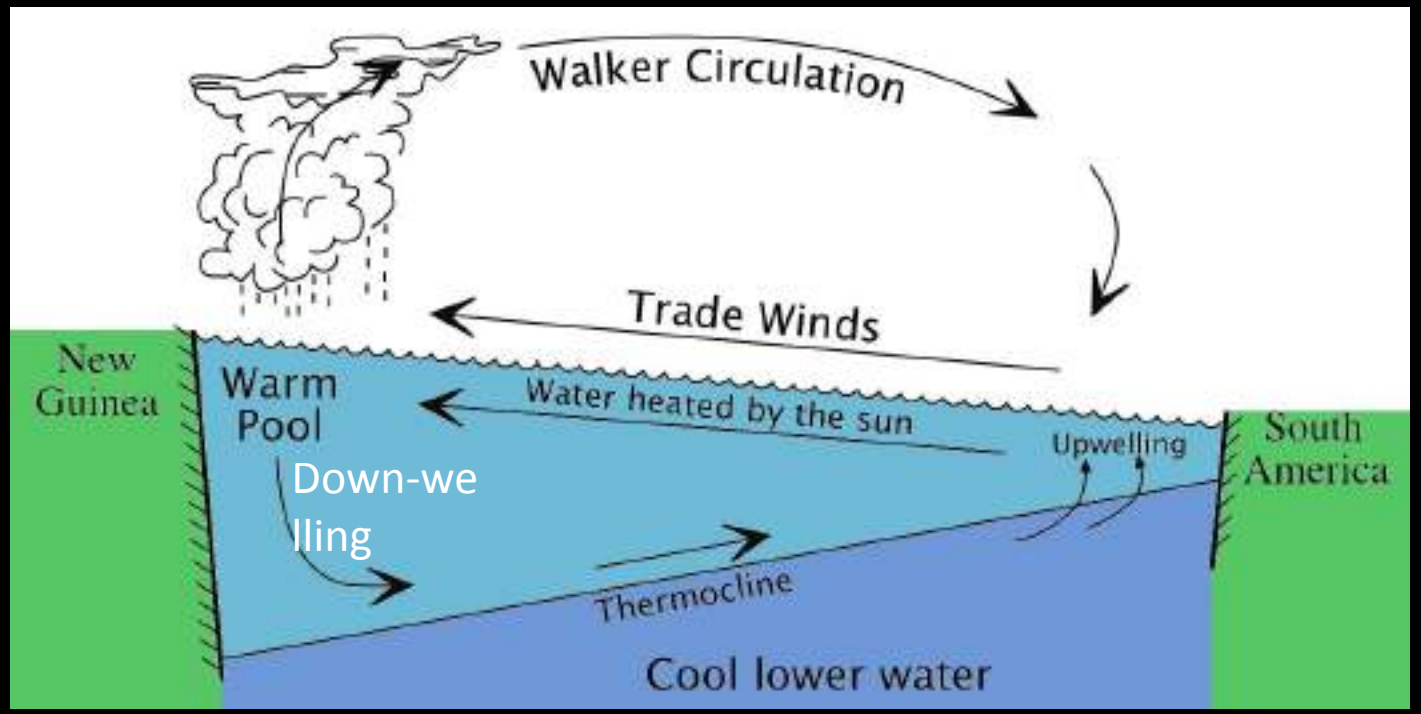
- South equatorial current pile up water at northern Australia – increase SST – called <u>West Pacific Pool</u>
- It brings rainfall in Northern Australia

Normal year



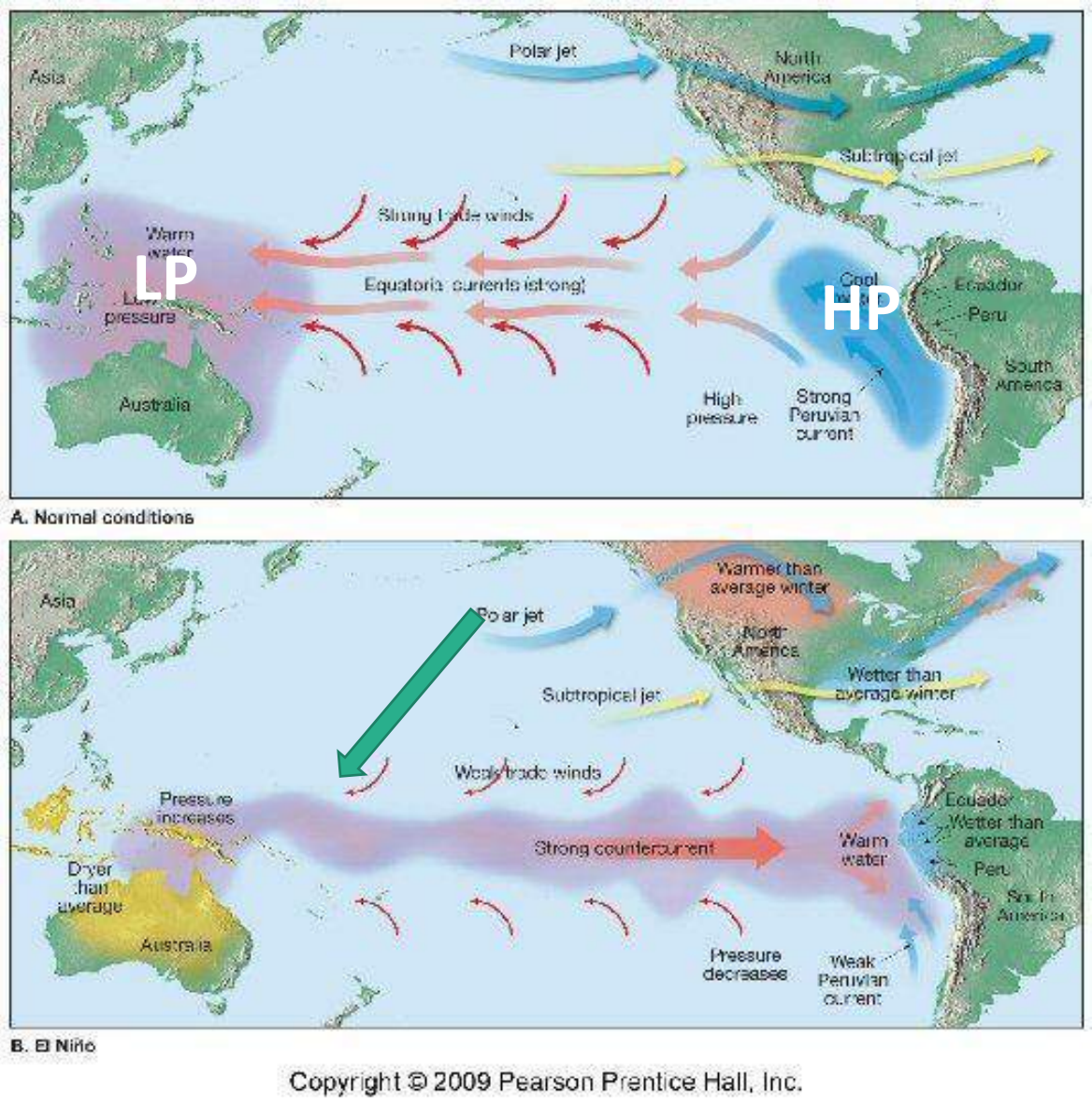
- The diverging air above Australia move towards Peruvian coast
- They descend at Peruvian coast = HP – desiccating effect to Atacama desert
- Completes the Walker cell

Normal year



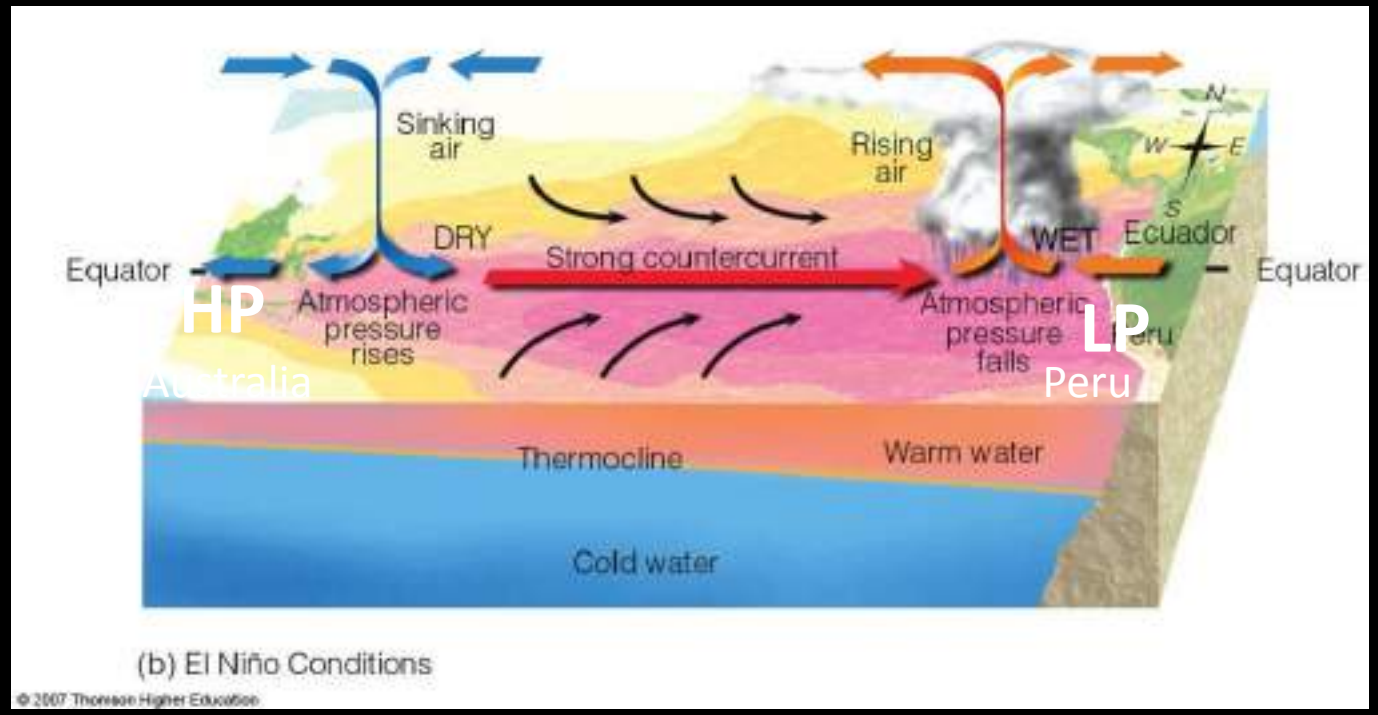
- As south equatorial current take water from east to west, it led water from bottom to come up and take the space
- Up-welling at the Peruvian coast = rich fishing ground

El-Nino year



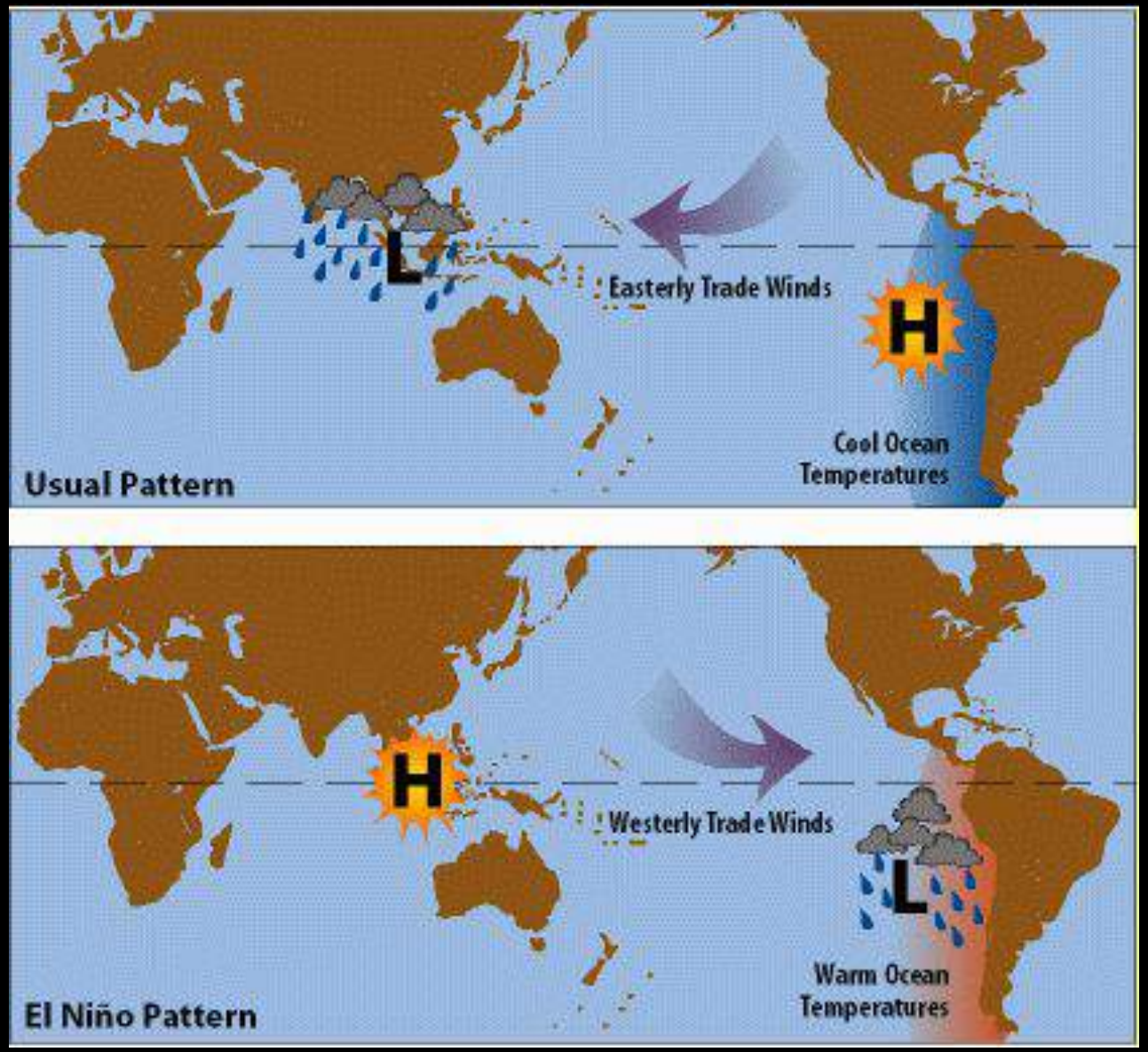
- Direction of walker cell reverses
- South equatorial current weakens (reason unknown)
- Weak piling up of water at Northern Australia
- Weakening of west Pacific Pool

El-Nino year



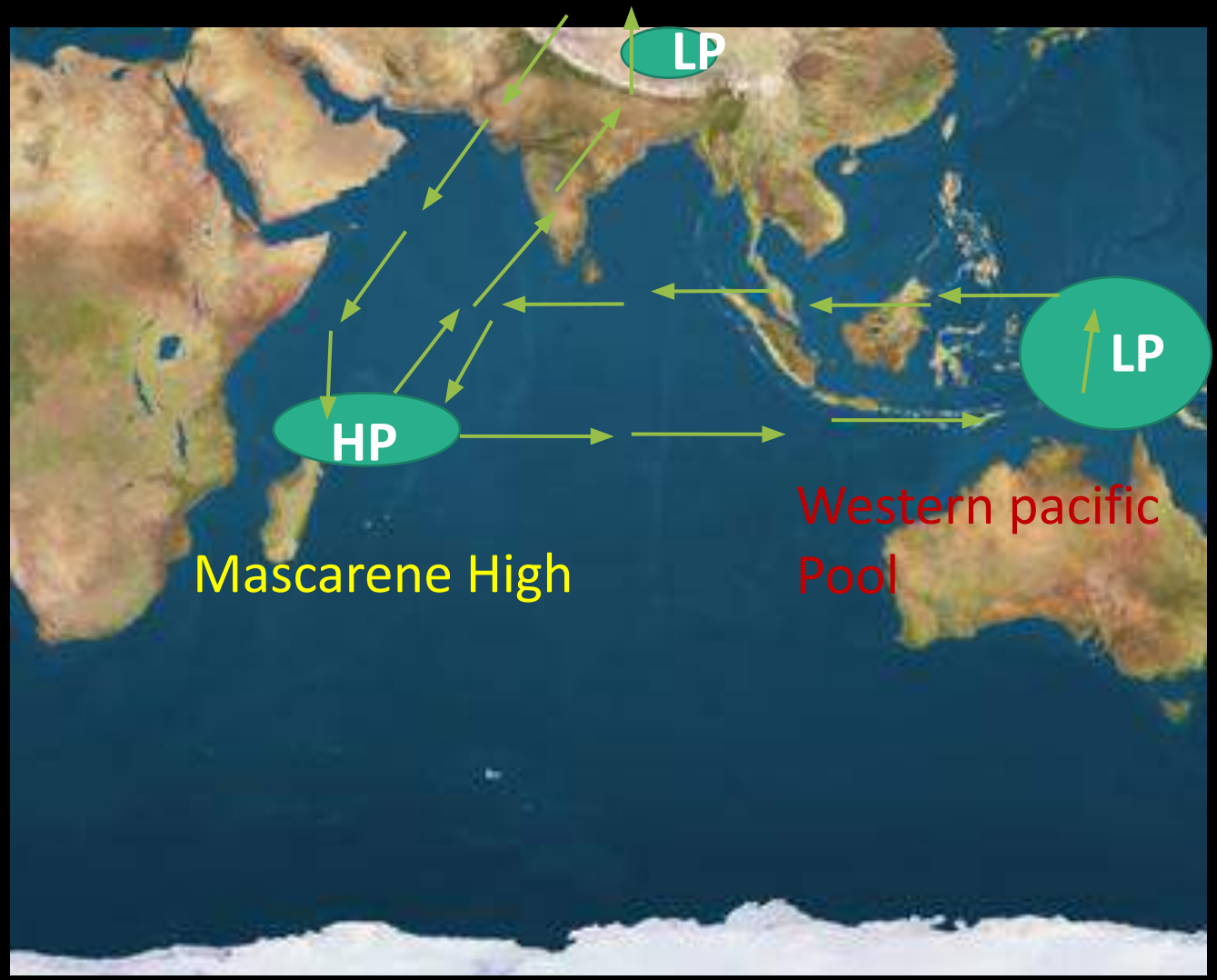
- Ocean water move towards Peruvian coast. Create LP system over there and rainfall at Atacama desert
- The rising and diverging wind above Peru descends over Australia = HP condition – drought in Northern Australia

Implications of El-Nino



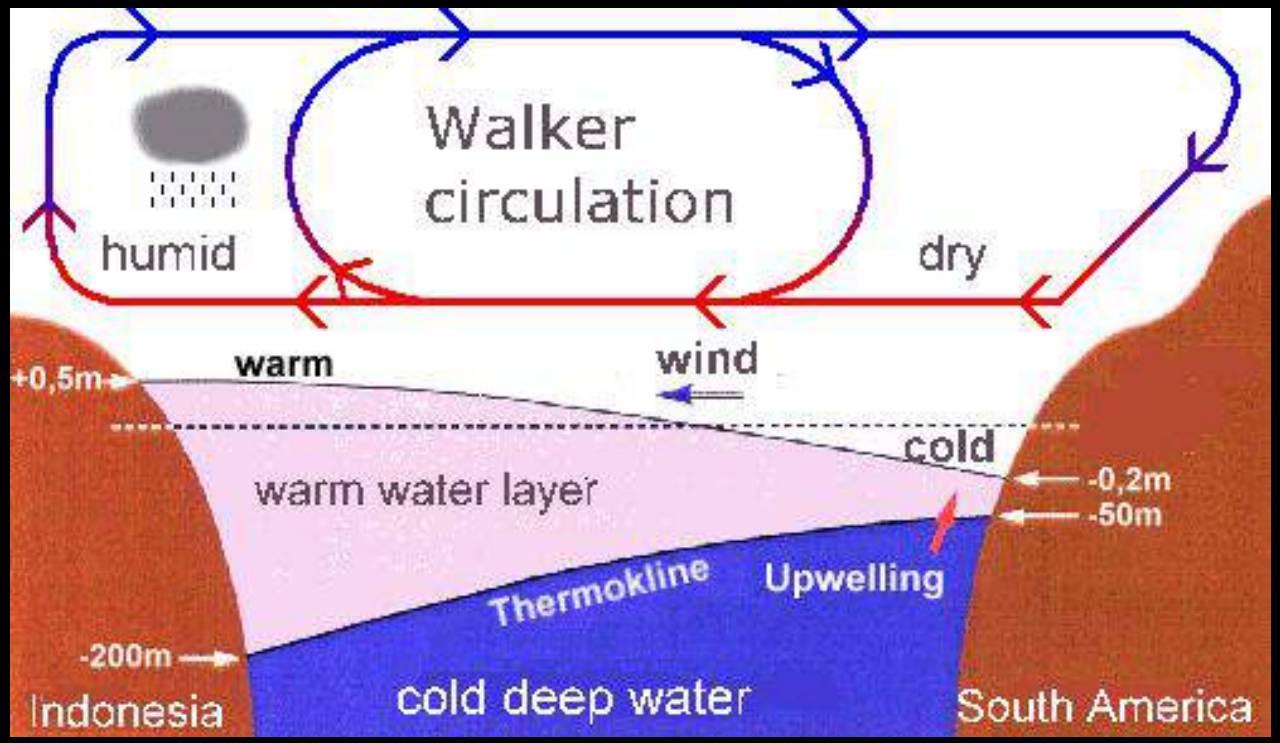
- El-Nino bring drought condition in Indonesia as well – forest fire
- It is responsible for weak monsoon in India

Implications of El-Nino on Indian Monsoon



- Association of El- Nino or Western Pacific Pool with Indian Monsoon
- There can be other atmospheric cells associated with Western Pacific pool
- Still undiscovered

La-Nina



- Intensification of walker cell
- Strong west pacific pool
- Heavy rainfall – flood condition in Northern Australia – good monsoon in India
- Drought in Atacama
- Very good fishing business at Peruvian coast – price crash

Thank you