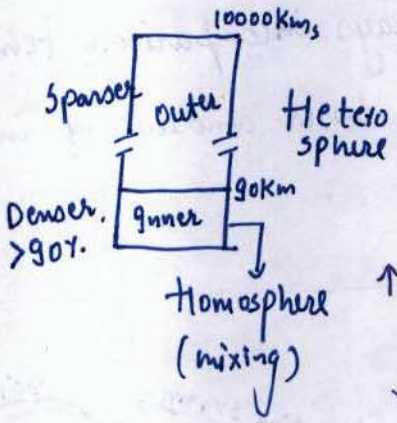
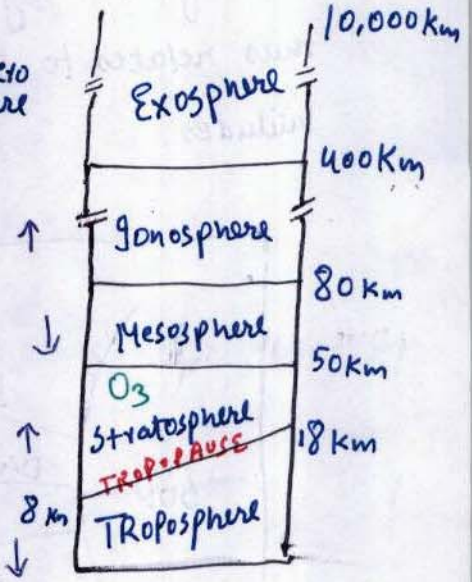
* Atmosphere:

Atmosphere
(Realm of air)

- COMPOSITION
  - Major
    - N_2
    - O_2
    - Inactive (99%)
  - Trace
    - CO_2
    - O_3
    - water vapour
    - Aerosols
    - active
  - Active
    - Stable
      - $(O_2$
      - O_3 (above 20km)
    - Variable
      - W.V.
      - Aerosols
- Structure





* Insolation:

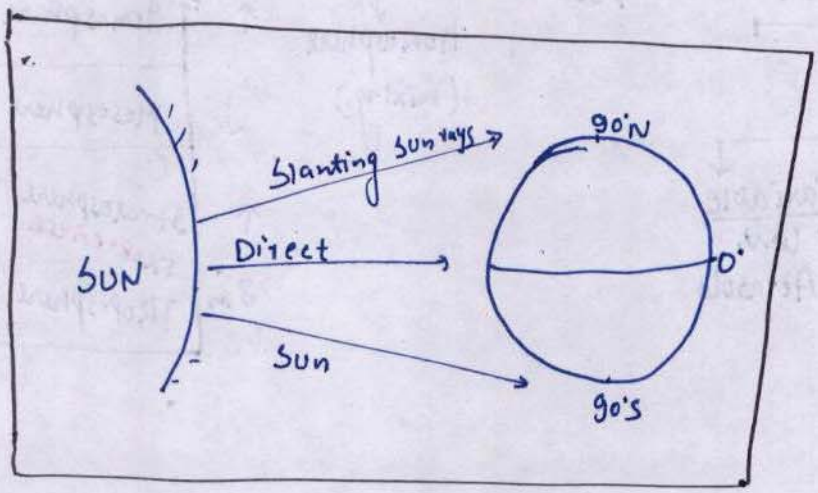
1) The trace amount of Solar radiation received by earth's System (due to involved distance b/w the sun & the earth) is called Insolation.
   i.e. Incoming Solar radiation.
2) With the thick realm of air influence of perihelion & Aphelion positions is not difined in the received amount of Insolation.
3) The near constant amount received by earth's System as varies in its distribution insolation forms the basis of weather mechanism.
4) The distribution pattern is regulated by
   a) Angle of sun rays
   b) Season cycle
   c) Atmospheric influence.

a) Angle of Sun rays:

(i) Two distinctive types of angle of sun rays are distinguished as received by the earth's surface.

ii) The direct sun ray which travels less & spreads less thus relates to higher amount of insolation as received in lower latitudes.

iii) Slanting sun rays in comparison tends to spread more & travel more thus relates to lesser amount of insolation as received in higher latitudes.



(b) Season cycle:

i) The axial inclination of planet earth & its revolution around Sun tends to generate season cycle.

ii) As there is always REVERSAL OF SEASONS b/w the hemispheres insolation distribution projects Variation. e.g. from Spring Equinox (21st March) to Autumn / Fall Equinox (23rd Sept.) ...

.. Northern hemisphere remains insolation surplus (experiencing high Sun season). whereas Southern hemisphere remains insolation deficit experiencing low Sun season.

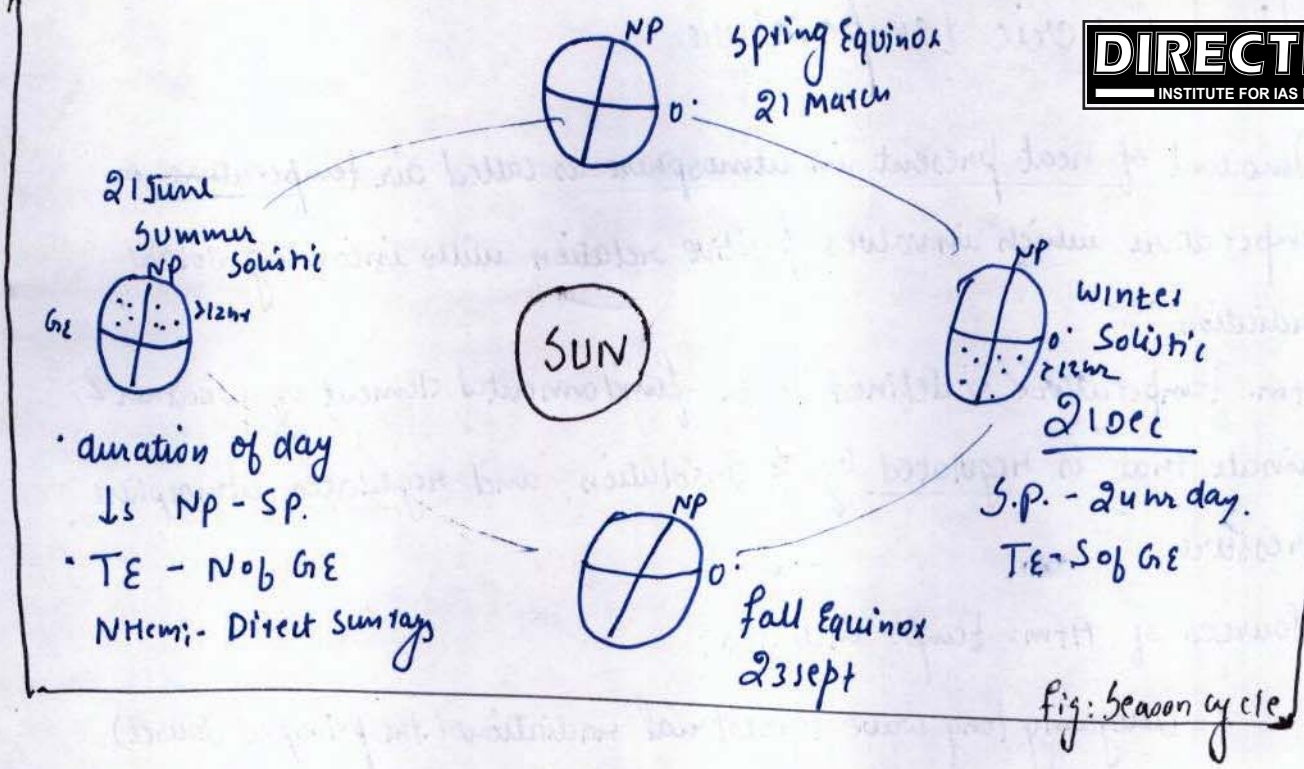


fig: Season cycle

(C) Atmospheric influence:

i) Is implied to be [Secondary determiner] of insolation pattern (applicable at larger scale).

ii) It involves role played by active, variable constituents of atmosphere.

iii) This includes:

→ Scattering - by Aerosols.

→ Absorption - by water Vapour.

→ Reflection - by Cloud cover.

** distribution of Insolation regulated by these factors tends to regulate the pattern of atmospheric temperature.

* Atmospheric temperature :

1) Amount of heat present in atmosphere is called air temperature or temperature which involves positive relation with incoming Solar radiation.

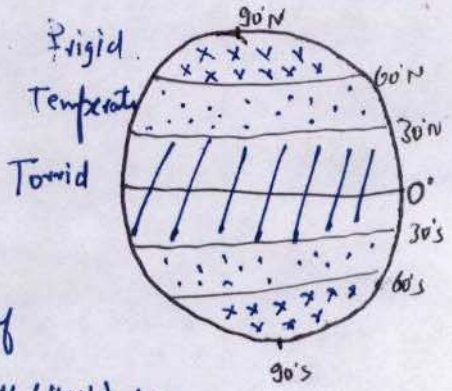
2) Atm. temperature is defined to be fundamental element of weather & climate that is regulated by & Insolation, and regulates atmosphere pressure.

3) Sources of Atm. temp. includes:
   - → Outgoing long wave terrestrial radiation (the principal source).
   - → Incoming short wave Solar radiation (Secondary source).

4) The distribution of atmospheric temperature thus is regulated by:
   - (a) Sign of latitude.] Primary (planetary)
   - (b) land water distribution.]
   - (c) Oceanic currents & prevailing winds] Secondary (regional/local)
   - (d) Cloud cover.
   - (e) height / altitude.

a) Sign of latitude - With increase in sign of latitude atm. temp. decreases that forms the basis of five demarcated thermal zones:

- → Torrid zone - warmest
- → Temperate zones - Moderate temp.
- → frigid zones - lowest temp.



* Sign of latit. → temp. determiner & Angle of Sun rays Insolation determiner but they can't be

(b) Land water distribution :

(i) With more than $2/3^{rd}$ of the earth's surface involving unequal distribution of land and water [longitudnal] pattern of air temperature projects variations than the thermal zones.

ii) These variations are the outcome of 3 defined characterstics of water that tends to maintain temperature (while land shows extremes) :

(a) water being translucent.
(b) mobility of water.
(c) higher specific heat of water.

(iii) This variation in temperature b/w neighbouring land & water in a given Sign of latitude is called temperature anomaly. It is defined to be [variation in the temperature from the latitudnal average.]

The positive temp. anomaly thus depicts higher temperature than the latitudnal average whereas negative temp. anomaly projects lesser temp. than latitudnal average.

The [ideal] pattern of temp. anomaly is :

	+ve anomaly (> than lat. avg)	-ve anomaly (< than lat. avg.)
low latit. 0-45° N/S	land (Indian landmass)	water (Arabian sea)
High latit. 45°-90° N/S	water (Okhostk sea)	land (Siberia)

(iv) The [real] characterstics of temp. anomaly however is depicted in reference to season cycle. Barring the exception of equatorial region (0-10° N/S) & polar regions (80°-90° N/S) rest entire world experiences season cycle.

... It is therefore that land during high sun season will develop positive temp. anomaly whereas during low sun season it will develop negative temp. anomaly.

v) The prevailing temp. anomaly is depicted on map of world by the typical pattern of Isotherms (imaginary line joining the places having same temperature). This represents bents of the Isotherms at shoreline. These bents are regulated by:

(a) Prevailing season.
(b) Relief transition.

for example: Summer Isotherm traced from land to water always bents towards equator whereas the winter Isotherm traced from land to water tends to bent towards pole.

(c) Oceanic currents & prevailing winds:

(i) As secondary determiner these factors influences atmospheric temperature as is best depicted in western European plain where warm North Atlantic drift & onshore westerlies prevails throughout the year making its temperature higher than manchurian plain located at the same sign of latitude.

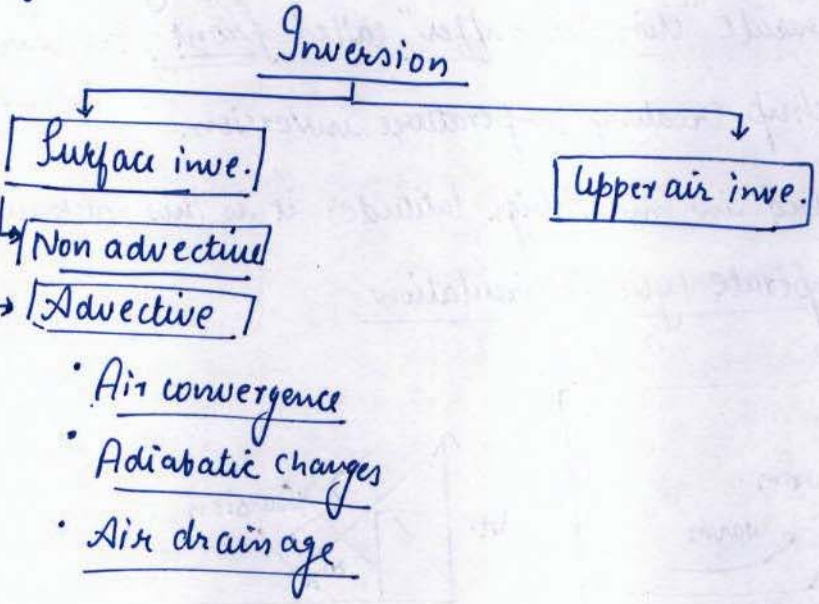
d) Cloud cover:

As secondary determiner of atmospheric temp. clouds in its capacity to reflect both outgoing and incoming radiation develops (i) cloudy nights to be warmer than cloudless nights and
(ii) cloudy days to be colder than cloudless days.

e) Height / altitude / Vertical pattern of air temperature):

(i) Throughout troposphere atmospheric temp. tends to decrease with increasing height (primarily due to increasing distance from the principal source). The Normal rate of decrease of atmospheric temp. called NORMAL LAPSE RATE is 6.5°C/Km.

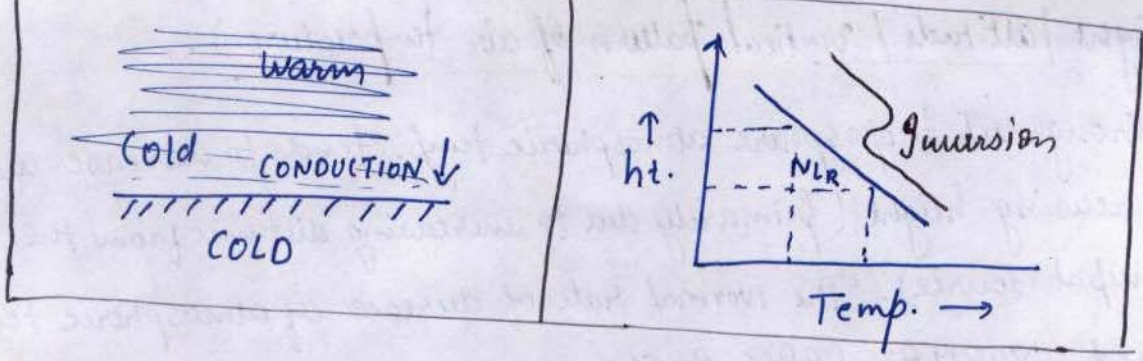
(ii) It is however that in the influence range of conditional determiner temperature tends to increase with increase in height called TEMPERATURE INVERSION. It is based on the location* that inversion is categorised as:



* Surface:

* Non advective This type of inversion is quiet typical to long cold winter nights that are cloudless & windless. This type of inversion involves process of conduction b/w the cold surface and the air column in contact with it. This tends to generate Subsiding convection thus maintenance of warm air column over the cold developing temperature inversion.

* It is this mechanism that leads to formation of fog (smog) during winters.

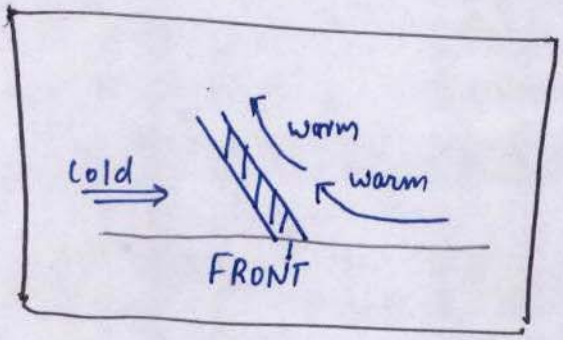


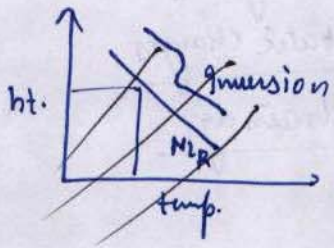
* Advective Surface inversion:

It typically corelates to movement of air at variable geographical locations (irrespective of season cycle). The developed inversion includes:

(a) The air convergence i.e. convergence of two contrasting air columns which tends to generate "climatic buffer" called front, the warmer air tends to marchup creating temperature inversion.

** typically developed in mid & high latitudes it is this mechanism that corelates to temperate cyclonic circulation.

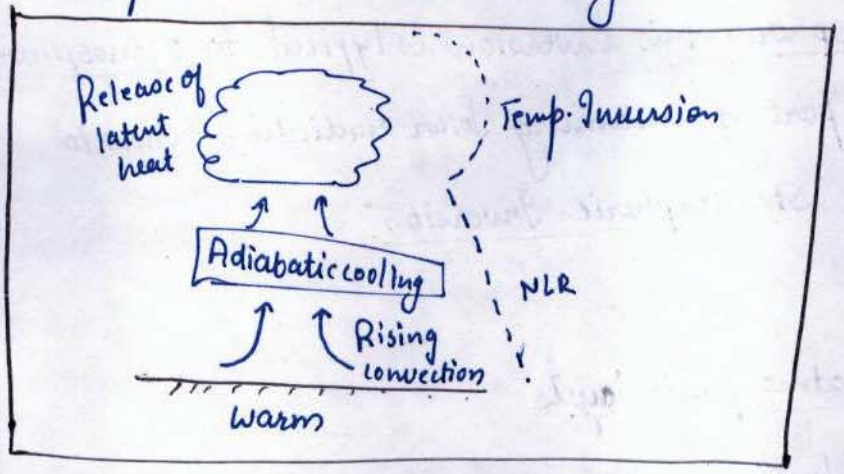




b) Adiabatic changes:

→ Adiabatic changes in the temp. of air column is without any actual addition or subtraction of heat. As the subsiding air column tends to decrease its volume it experiences Adiabatic Warming. In comparison the rising air column tends to expand i.e. increase in its volume experiences ~~adi~~ adiabatic cooling. It is with adiabatic cooling that the following process of condensation that leads to release of latent heat tends to generate temperature

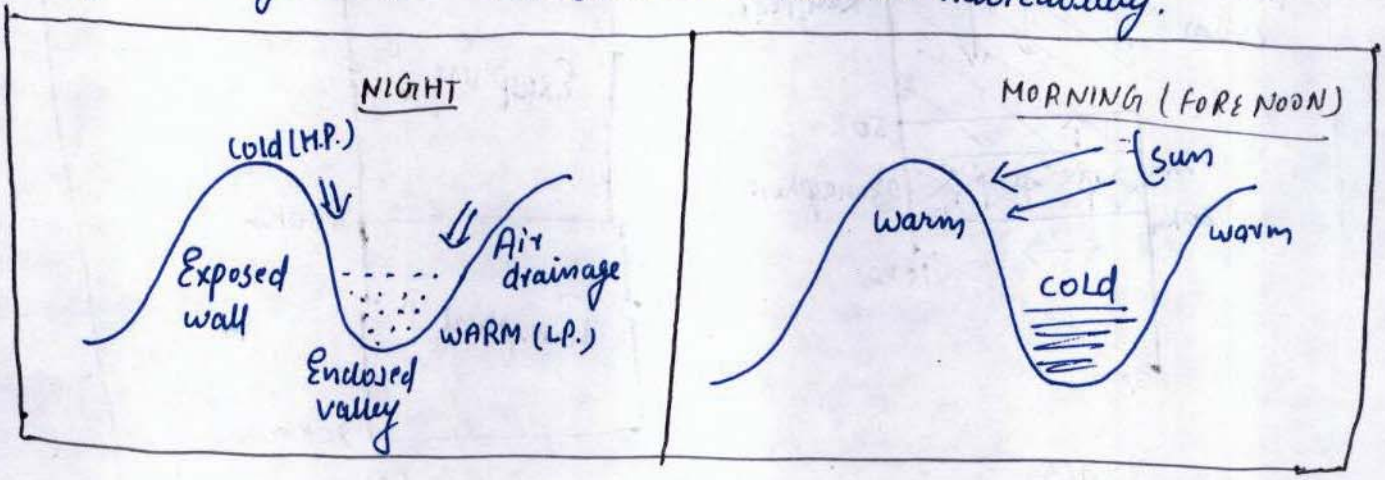
Cloud formation thus makes excellent example of temp. inversion developed due to adiabatic changes.



c) **Air drainage:** The term is applied to denote movement of air following the gradient of prevailing relief. Typical to mountain with deep valley, air drainage is experienced due to differential rate of cooling of exposed mountain wall & enclosed valley floor.

The air drainage tends to accumulate the air column in the valley floor generating temperature inversion on the following day during 4 noon hours due to warming up of the mountain wall.

It is this temperature inversion that sufficiently ensures availability of sun rays on the mountain wall thus its habitability.



(If asked about fundamental then don't cross troposphere).

weather element

* Upper air inversion:

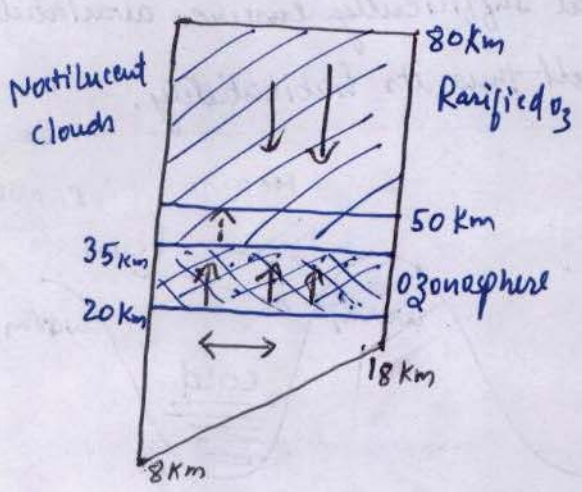
i) Applicable to inner atmosphere this inversion is typical to ozonosphere. Consistent absorption of part of incoming Solar radiation tends to increase temp. generating "Stratospheric Inversion."

* Temperature in other atmospheric layers:

1) Mesosphere - Due to presence of rarified ozone thus decreasing absorption, temp. decreases with increasing height (reflected in the presence of Noctilucent clouds.

2) Ionosphere. Also called Thermosphere. Temp. increases with increasing height due to the electrically charged particles Ions.

3) Exosphere: The rarified most atmosphere, temp. effectivity decreases with increasing height.



Advection - horizontal movt. of air
convection - vertical movt. of air < rising conv.
subsiding conv.

* Atmospheric Pressure & Circulation:

(i) The atmospheric pressure is defined to be the weight that the air column exerts on the earth's surface.

(ii) The avg. air pressure at MSL is 1013.25 mb.

(iii) Air pressure is defined to be fundamental element of weather & climate which is regulated by air convection & is regulator of air advection.

(iv) The air pressure involves two defined mechanism of development:
- → Thermally induced &
- → Mechanically induced

(v) Air pressure system thus developed are called

(a) low pressure system that is the system where air column exerts less weight on the earth's surface. Based on size the low pressure systems are subcategorised as:
- → Trough - an elongated low. &
- → Cyclone - small sized low.

(b) The high pressure system i.e. the system where air column exerts more weight on the earth's surface. Based on size it is subcategorised as:
- → Wedge - elongated high pressure &
- → Anticyclone - small sized high.

* Pressure profile of Planet Earth:

(i) latitudnally seven pressure profiles are identified for planet earth. It includes 3 thermally induced & 4 mechanically induced pressure profiles.

(ii) Longitudnally in the variable influence of land water distribution the pressure pattern projects following characteristics:

(a) Polar highs (PH) - of both northern & southern hemisphres and Sub polar low (SPL) of southern hemisphere projects continuous pressure belts as they correspond to Homogenous relief.

(b) Equatorial low (EL) also projects continuous belt inspite of unequal distribution of land & water as Climatological difference b/w the existing relief is not valid as the climate is regulated by consistent rising convection.

(c) Subtropical high of southern hemisphere projects near cellular characterstics primarily due to dominance of water in unequal land water distribution.

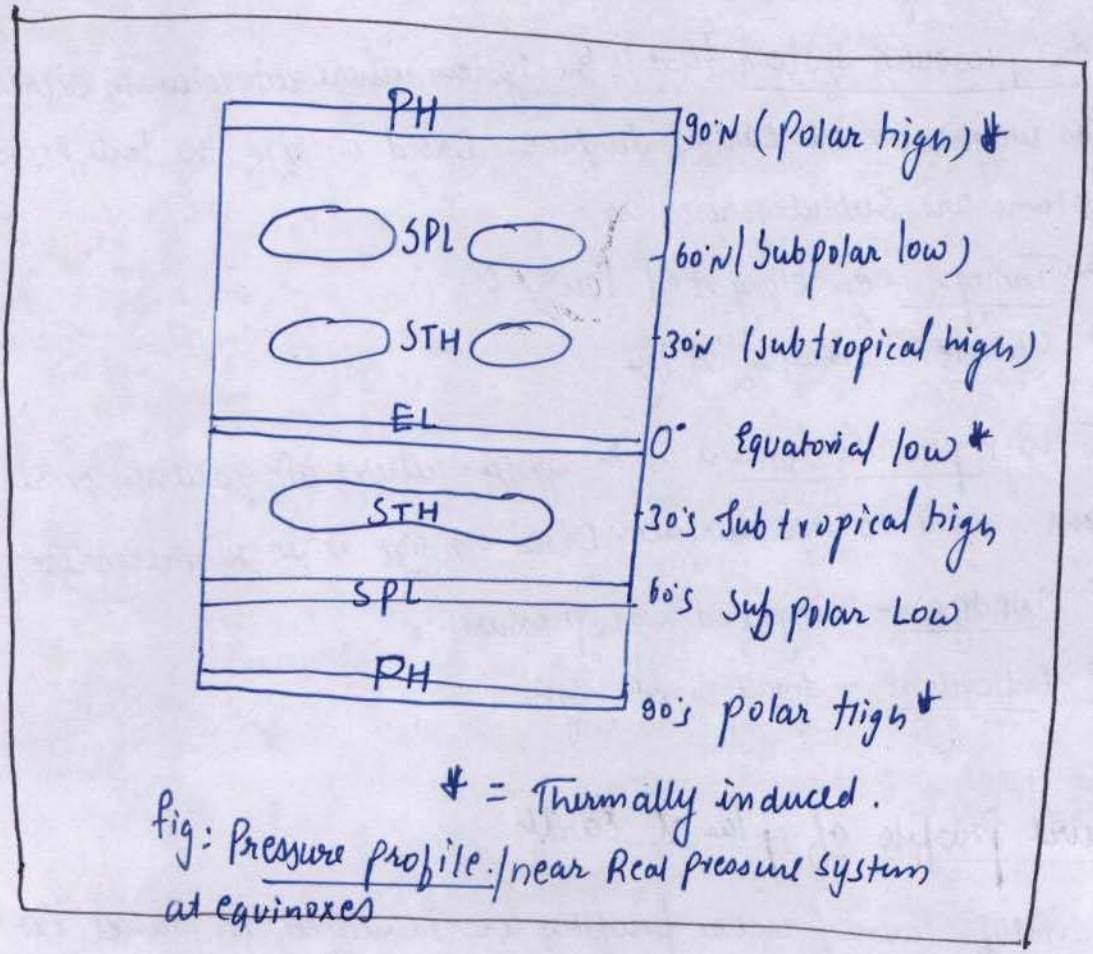
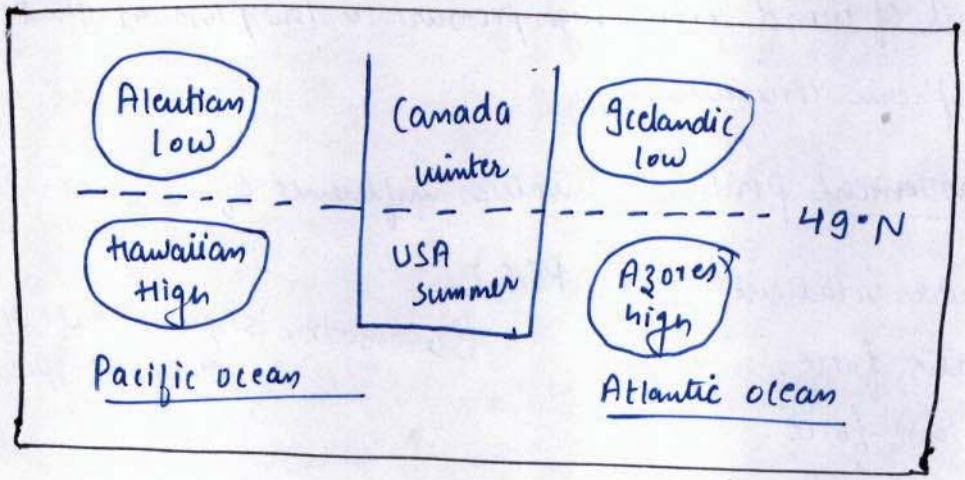


fig: Pressure profile / near Real pressure system at equinoxes

(d) The mechanically induced pressure profiles in Northern hemisphere called Subtropical high & Subpolar low tends to project Cellular characterstics due to unequal distribution of land & water. The Subtropical high relates to Hawaiian High (Pacific ocean) & Azores high (Atlantic ocean) prevailing throughout the year however during

when Subtropical high vanishes from over land these become stronger cellular in their characterstics.

The Subpolar low represents cellular characterstics as developed in open Oceans called Aleutian low (pacific ocean) & Icelandic low (Atlantic ocean) these develops stronger pressure profile during winters when the neighbouring land (canada) develops high pressure.



* Atmospheric Circulation:

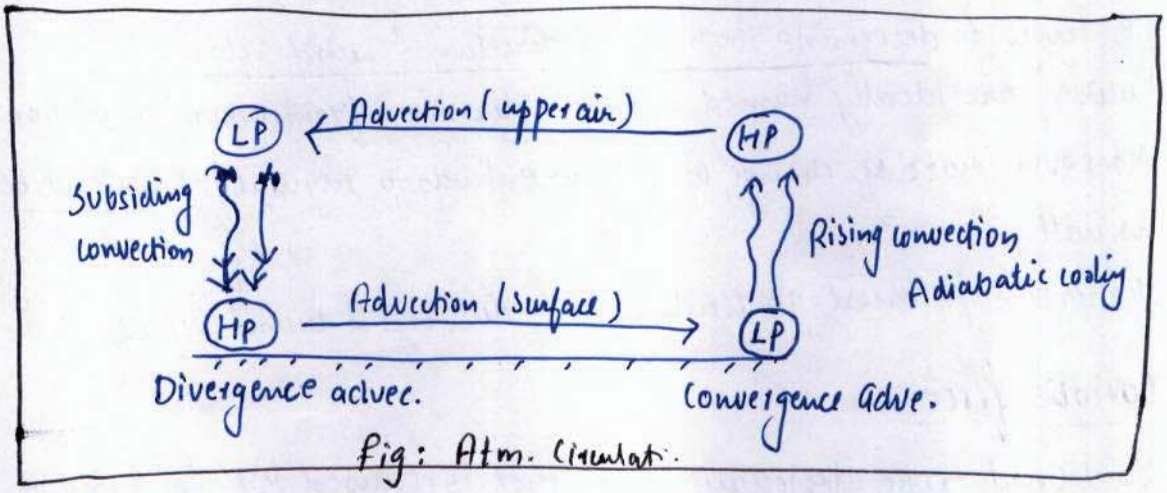


Fig: Atm. Circulat.

→ Atm. circulation is the consistent movement of air that involves Convection & Advection.

The convective air movement forms Vertical air movement which tends to create Pressure difference i.e.

→ Rising air convection develops low pressure on ground & high pressure vertically over.

→ The subsiding air convection in comparison will develop high pressure on ground & low pressure vertically over.

The generated pressure difference causes **advection** i.e. horizontal movement of air popularly called as wind.

** It is movement of wind from high pressure to low pressure that sustains atmospheric circulation.

The advective movement practically involves influence of 3 forces:

(a) Pressure Gradient force. (PGF)
(b) Coriolis force.
(c) friction force.

Barometric slope = rate of change of pressure.

*(a) PGF:

(i) It is the genesis force of wind as wind always move from high pressure to low pressure.

(ii) It tends to determine both wind direction & wind velocity.

(iii) Winds are ideally named after the direction from where they blow Moreover rate of change of pressure tends to regulate wind velocity as well.

** Higher the pressure gradient higher will be the wind velocity.

(b) Coriolis force:

(i) Is defined to be deflective force that is caused by spinning of earth on its axis (with variations in the velocity latitudinally).

(ii) The coriolis effect tends to modify **flow direction of wind**.

Identified as ferrels law this modification involves deflection of wind to its right in Northern hemisphere & to its left in Southern hemisphere.

DIRECTION

(iii) Coriolis force is strongly influenced by both wind velocity and ~~wind dir~~ sign of latitude (with increase in wind velocity & sign of latitude coriolis effect increases).

(c) friction force:

(i) This regulating force largely influences Surface wind.

(ii) like pressure gradient force it tends to influence both wind velocity and wind direction.

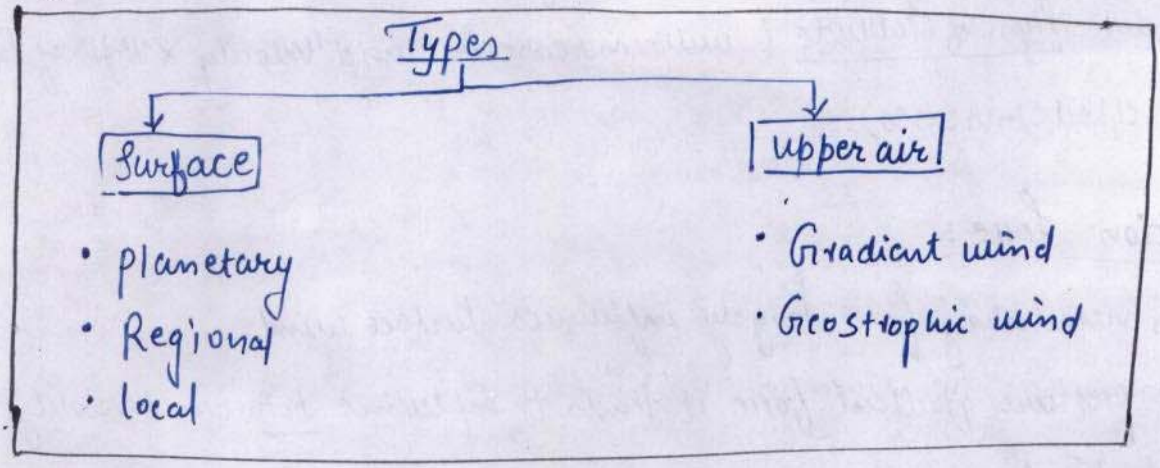
(iii) Influence of frictional drag was analysed by EKMAN i.e. popularly refered as Ekman's Spiral effect.

(iv) Based on the lab experiment Ekman concluded a "correction" of both wind velocity & wind direction" with increase in height.

He distinguished b/w : veering effect & backing effect.

* Veering effect: relates to clockwise correction in the flow direction of wind.
* Backing effect in comparison involves counter clockwise correction.

* Type of advective movements:



i) planetary winds:

(→) Regulated by latitudinal pressure profile, planetary winds are also called prevailing winds or permanent winds.

2) These are categorised latitudinally into 3 defined categories:

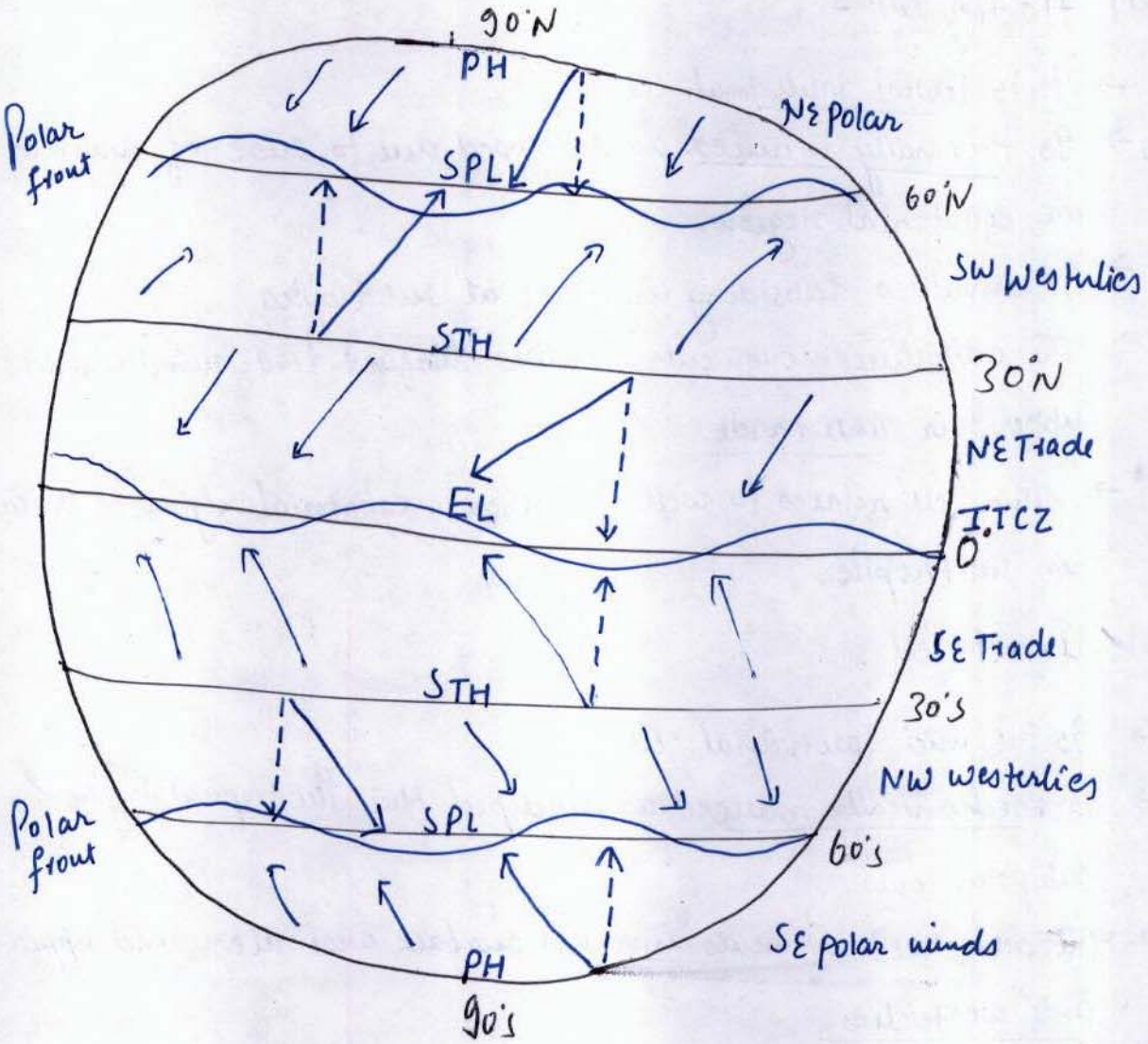
(a) Trade winds: These are lowest latitudinal planetary winds that moves from subtropical highs to equatorial low.
These relates to development of intertropical convergence zone (ITCZ) combined with doldrums along geographic equator.
The trade winds include NE trades of northern hemisphere & SE trades of southern hemisphere.

(b) Westerlies - These are mid latitudinal planetary winds that moves from subtropical highs to subpolar lows. These relates to development of polar fronts. These are southwestern westerlies in Northern hemisphere & Northwest westerlies in South hemisphere.

~~c) Polar~~

(c) Polar winds - These are highest latitudinal planetary winds that moves from polar highs to sub polar lows. They tend to develop polar fronts. These are NE polar winds in northern hemi & SE polar winds in southern hemisphere.

(Equinoxes - Geog. & thermal equator lie over each other).
relates to complex river regimes)



Tricellular Meridional Circulation :

1) The nature of atmospheric circulation in reference to planetary winds involves three defined latitudnal cells in both hemispheres popularly referred as Tri celluler meridional circulation.

2) This circulation represents [classical approach] in the study of atmospheric circulations as gives recognition only to gradient wind (in upper air).

3) The developed cells includes:

(a) Hadley cell -

→ It is lowest latitudnal cell.

→ Is thermally induced as developed due to rise of warmer air in equatorial region.

→ It involves subsiding convection at sub tropics

→ The advective movements involves surface trade winds and upper air anti trade.

** → This cell relates to wetter weather in equatorial region & drier weather in subtropics.

(b) ferrel cell :

→ Is the mid latitudnal cell.

→ Is mechanically induced as developed b/w Subtropical highs & sub polar lows.

→ The advective movements involves surface westerlies and upper air anti westerlies.

** → It relates to wetter weather conditions in sub polar & drier conditions in sub tropics.

(c) Polar cell :

→ Highest latitudnal cell
→ It is thermally induced i.e. developed due to cold air subsidence in polar region.
→ It involves the frontal rise in sub polar latitudes.
→ The advective movement includes surface polar winds & upper air anti polar winds.
→ It relates to dry polar conditions and wetter conditions in sub polar latitudes.

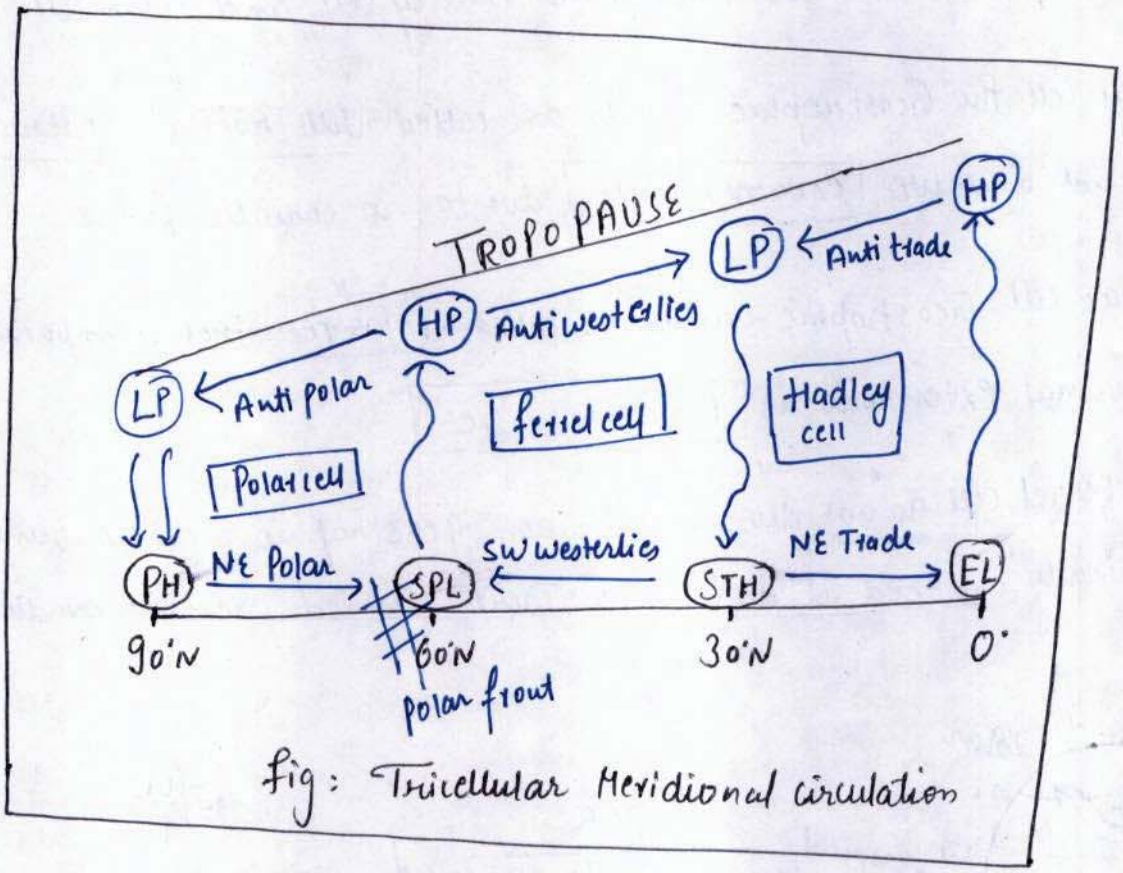


fig: Tricellular Meridional circulation

* Geostrophic Wind :

The upper air wind approached from classical dimension recognises only gradient winds (like surface advection).

* Gradient winds are defined to be advective movement that moves perpendicular or near perpendicular to the Isobars following prevailing pressure gradient force (essentially all the surface winds makes example of Gradient

Post WW II identification of **Upper air westerlies** marked the beginning of recognition to geostrophic winds.

** The **Geostrophic winds** are identified to be the advective movement that is **parallel to Isobars**. These winds are developed when higher velocity wind due to the absence of frictional drag tends to experience strong coriolis effect (coriolis force counterbalancing PGrF). leading to the development of Geostrophic winds.

The Geostrophic winds are related to hadley cell and polar cell.

In Hadley cell the Geostrophic winds are called Subtropical jet streams that do not involve **equatorial belt** due to no coriolis force.

In the polar cell Geostrophic winds are called Polar Jet that incorporate mid latitudnal extensions as **Polar front Jet**.

** The ferrel cell do not develop its own geostrophic flow as being mechanically induced it do not represent desired pressure gradient.

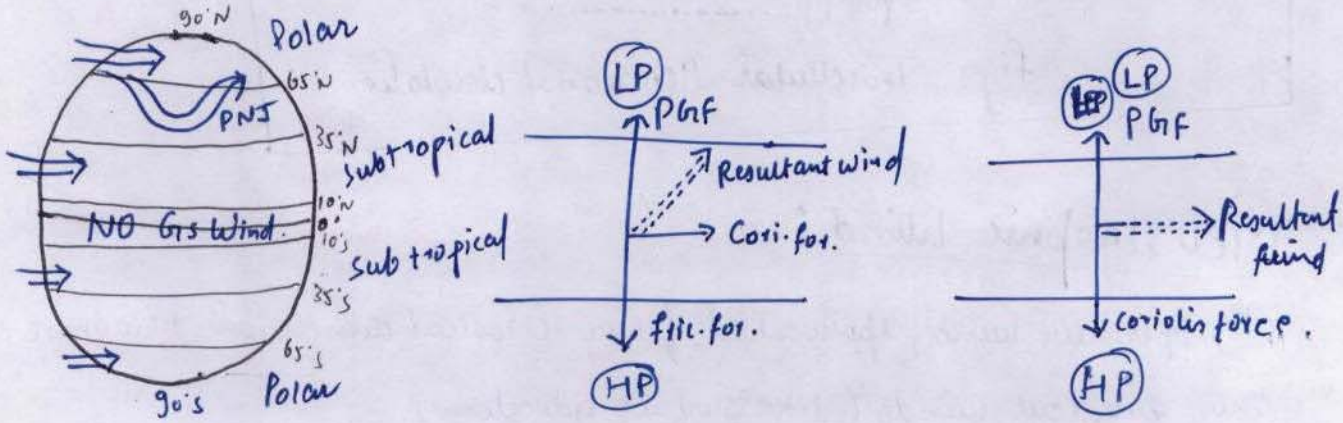


fig: Geostrophic winds

Gradient wind

Geostrophic wind

* Polar Jet:

1. It is characterized with:

a) Is highest latitudnal Jet.
b) Is thus lowest altitudnal Jet (height of tropopause).
c) It moves at highest Isobaric levels. (pressure decrease with altitude)
d) Is the smallest garland of the upper level westerlies. (shape of earth)
e) Do not involve Rossby waves. (absence of land water climatological difference).

2. These Jet streams are popularly called Polar NIGHT JET. As during six continuous months of North polar night these perennial Jet:

a) Attains highest velocity.
b) Develops largest extension.

3. The weather effectivity of polar Jet involves:

(a) Dry conditions in poles.
(b) frontal precipitation in subpolar areas with periodic extensions in mid latitude as polar front Jet generating wetter weather conditions (in relation to temperate cyclonic circulation).

* Sw

Subtropical Jet:

1. This jet stream is characterized with:
   a) lowest latitudnal jet
   b) highest altitudnal jet
   c) flowing at lowest Isobaric level.
   d) largest garland
   e) Absalutely relating to Rossby waves.

2. The weather conditions relating to these jet involves:
   a) drier conditions in subtropics.
   ** b) It also relates to region specific weather condition called **Western disturbances** that are low pressure systems developed in Subtropical marginal water as Mediterrnean sea.
   The subtropical jet tends to block & transport these disturbances causing precipitation in west & South Asia.
   (temp. anomaly b/w land & water) → (carry the rising convective moisture laden currents)
   not atlantic ocean as being open water body it will not have effectivity of temp. anomaly.

* It is only in Northern Indian ocean basin that during Summers Subtropical jet paves way to **tropical easterly jet** that regulates **monsoonal mechanism**.

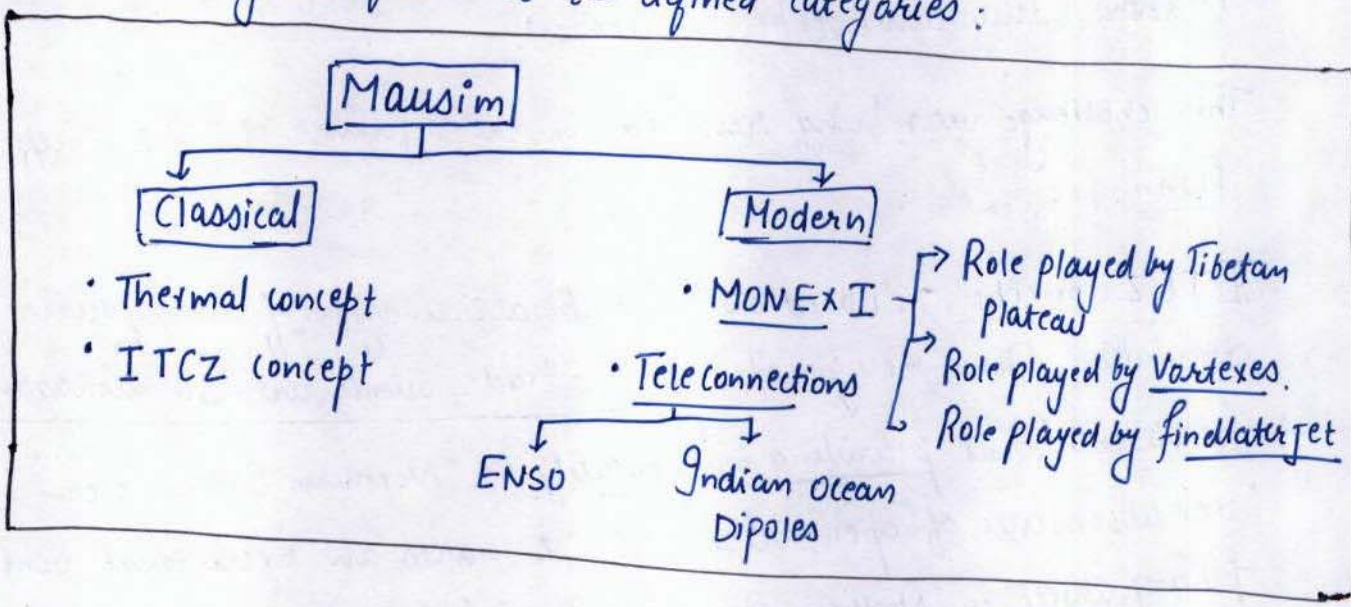
* Polar front jet & tropical easterly jet are not jet streams. → Season specific → region " → east dyn.
   ↳ Not perrenial.
   ↳ Not westerlies.

* Regional winds : Monsoonal Mechanism

1) The regional seasonal winds called monsoonal winds relates to typical weather mechanism that generates Summer concentrated precipitation

2) These winds thus Weather mechanism are experienced in tropical (10°-30° N/S) east margins of the land wherein Indian landmass forms the most dominating example not just due to the size but also due to the complication of involved mechanism.

3] The study of monsoonal mechanism corelates to range of concepts that are boldly classified into two defined categories :



* 1] The term mausim is derived from work of Arab contributors who recognise it to denote seasonal reversal in the wind pattern.

2] The cause of seasonal reversal however is derived from thermal concept originally proposed by Halley, however enriched & enlarged by Hadley

The thermal concept relates seasonal reversal of surface wind pattern to the differential rate of heating & cooling of land and water. During winters offshore NE trade is due to colder land (considered to be enlarged land breeze).

During summers however warmer land results in onshore SW monsoonal winds (enlarged sea breezes).

** Thermal concept though excellently identifies seasonal pressure gradient b/w land & water however could not specify genesis of SW monsoons as these winds are capable of causing precipitation in almost entire India & Indo china peninsula remaining effective for upto 4 months (thus can not be sea breezes).

This challenge was being resolved in the reference of ITCZ concept of Flohn.

ITCZ concept - Based on the elaborate analysis of atmospheric circulation Flohn recognised that SE trade winds are SW monsoon.

→ He observed that prevailing * continentality of Northern Indian ocean basin (i.e. absensence of open ocean). ITCZ makes an exceptional bent placing itself in Northern plains of India (beyond tropic of cancer).

→ This exceptional bent makes SE trade exponentially enter northern hemisphere acting as SE monsoon in Somalia and yemen like countries.

→ In the influence of coriolis force SE trade becomes SW monsoons causing precipitation in India & Indo china peninsula.

** The concept also identifies:

-

→ That SE trade experiences coriolis deflection b/w 40°-60° Edst longitudes.

→ It is therefore that there is absolute absence of west margin climate (desert) in both India & Indo china peninsula (whereas Somalia inspite of being east margin climate is dominantly having OGADEN desert).

** All the major observations made by classical propounders excellently facilitated understanding of monsoonal mechanism but could not justify its unpredictibility.

It was therefore that fresh studies of monsoonal mechanism was initiated establishing modern approaches of monsoonal mechanism.

* MODERN Approaches:

1) Monsoonal Expedition I (MONEX I):

(i) In the late 1960s India marked the begining of analysis of monsoonal mechanism involving both surface and upper air circulation.

(ii) These observations led to the understanding of few defined characterstics of SW monsoons involving:

(a) Role played by tibetan plateau.

(b) Role played by vortexes.

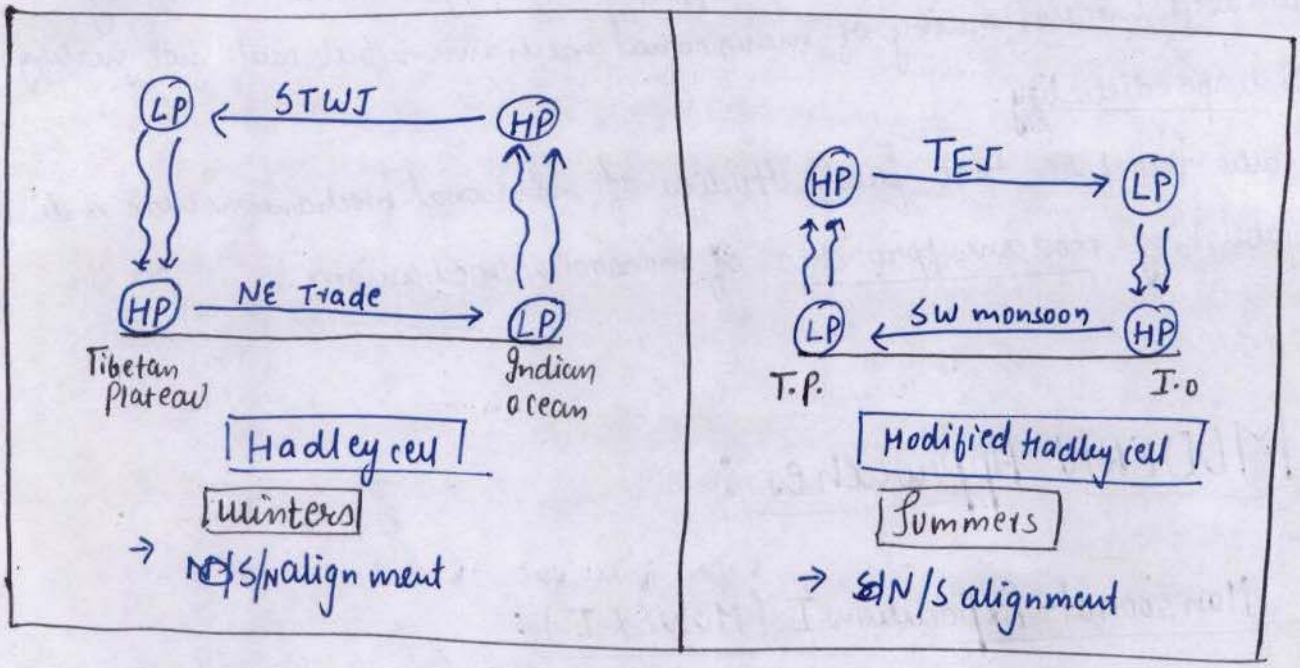
(c) Role of findlater jet.

(a) Role played by Tibetan Plateau:

1) The highest plateau of the world having Lee location thus lacking in favourable availability of sunlight. Tibetan plateau is ideally known for low temperature thus high

2) During high Sun season exponential bend of ITCZ marking its position in Northern plains of India makes tibetan plateau significantly modify its ideal temperature conditions.

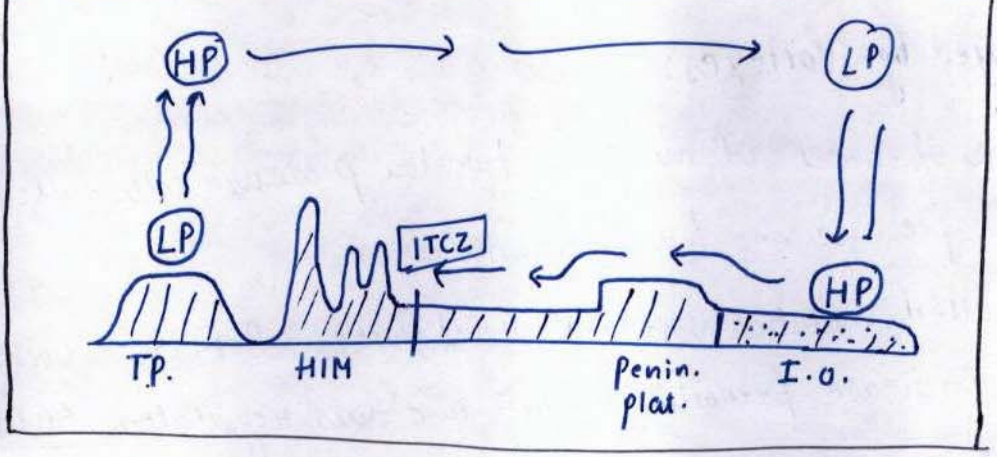
3) The plateau develops high temperature thus low pressure acting as Southern limit of displaced Hadley cell & northern limit of modified Hadley cell (typical to this season).



4) The additional role played by Tibetan plateau corelates to development and maintenance of pressure gradient b/w tibetan low and mascarene high (due to its position on lee side of himalayas).
It is therefore that consistent branches of SE trade tends to encroach Indian landmass as SW monsoons resulting in:

→ Effectivity for upto 4 months.
→ periodicity in precipitation
→ Variations in the length of dry spells.
→ Variation in the amount of precipitation &
→ Variations in the time of precipitation.

Jet | planetary
permanent
Strong High velo



Q→ Explain the role of low altitudnal & low latitudnal jet in Indian monsoon?

(b) Role played by find later jet:

(i) These are low altitudnal jet (1-2 km only) that are also recognised as somali jet.

(ii) Its deuelopment is absolutely related to the pressure gradient b/w mascarane high and low pressure in the marginal water bodies along East Africa. Based on the pressure gradient these high velocity surface winds enhances South east trade thus SW monsoon facilitating favourable monsoonal rain.

It is Somali jet that forms one of the prime facilitator of monsoonal rain in Malabar coast (Kerala + Karnatka - climatic region).

Q easterly jet stream over India

[www.chirapunji.com
Somali jet stream & current & Tropical jet stream

India dry in winter
↳ STWJ
↳ offshore winds
↳ High pressure

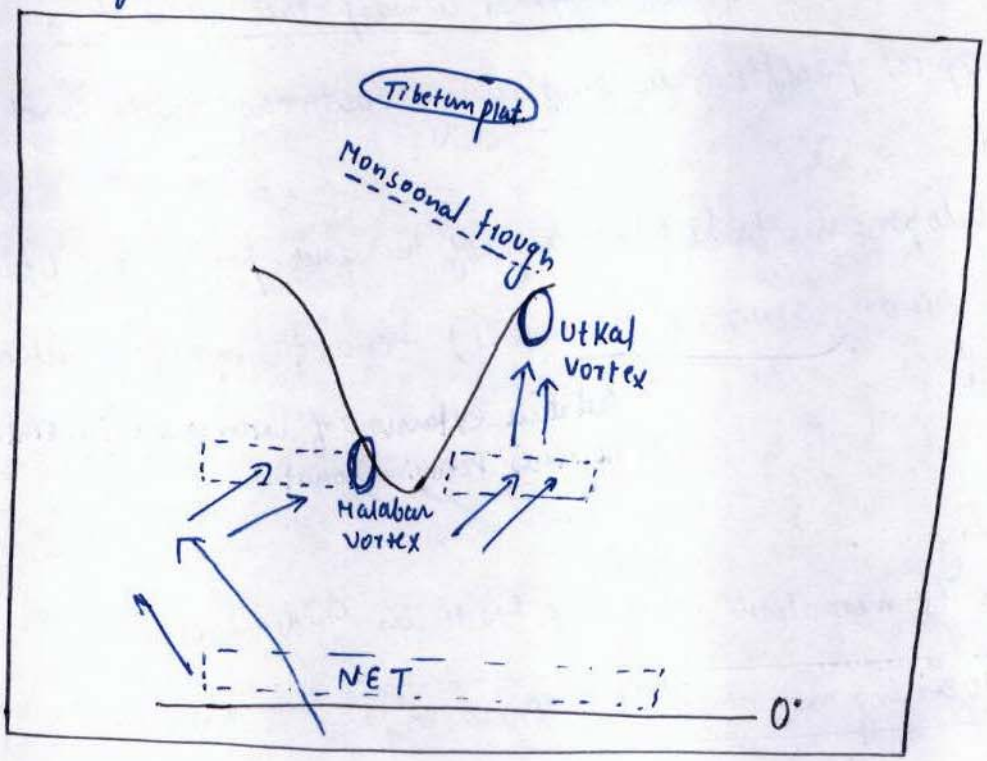
* Role played by Vortexes:

1) At the time of onset of monsoon two low pressure cells called vortexes marks their presence in Indian coastal area.
2) These are called malabar vortex & Utkal vortex. Both these vortexes tends to increase prevailing PGF and thus regulates Sudden begenning of monsoon.
3) It is position of malabar vortex that tends to ensure the first monsoonal showers experienced in malabar coastal plains.
4) It is position of Utkal vortex that in comparison ensures advancing monsoonal rain in Utkal coast (though coromandal coast remains dry during this season).

* Development of Vortex:

1) The term vortex is applied to denote low pressure cell.
2) The Indian vortexes involves their development primarily in the context of longer time taken by Indian ocean to change its pressure profile (from low pressure to high pressure) with change in the season.
3) The North equatorial trough of Indian ocean tends to gradually shift towards north (to sustain alignment with the high sun position).
4) This northward shift is not just simaltaneous to the weakening of the trough but also its divide as arabian sea & bay of bengal trough.
5) These marginal water projecting higher extreme readily converts these troughs into low pressure cells as Malabar vortex & Coromandel vortex.

6) Bay of bengal being more continental registers swifter weakening and northward shift thus generating Utkal vortex at the time of onset of monsoon.



* Tele connections:

1) The regional seasonal winds monsoons tends to project global teleconnections justifying its unpredictibility. These teleconnections is specified with influence of oceanic current system on atmospheric circulation this involves:
   (a) El Nino & Southern oscillation. (ENSO)
   (b) Indian ocean dipole.

(a) ENSO:

1) Stands for periodic change in atmospheric pressure in Southern pacific manipulating the atmospheric circulation.

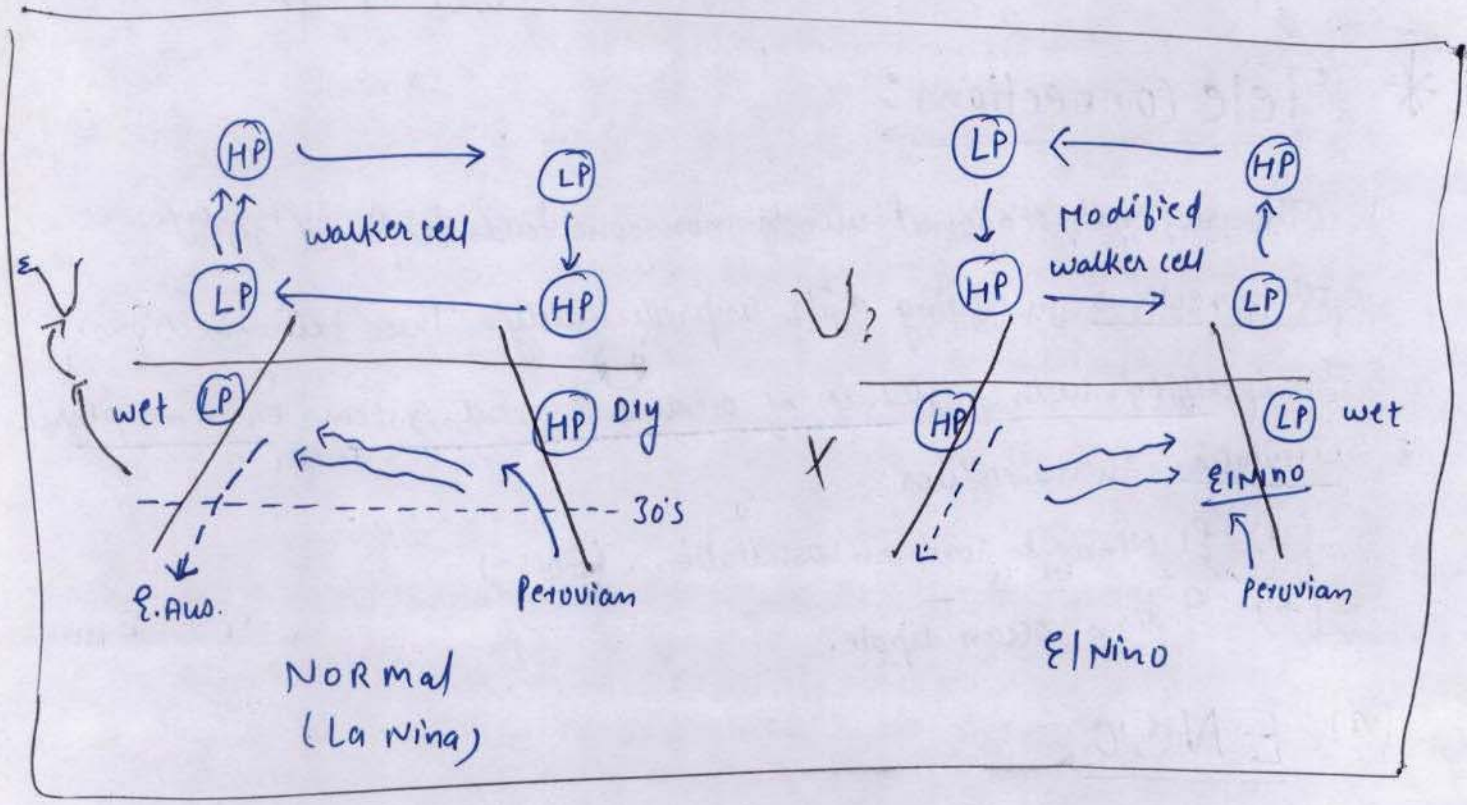
2) This teleconnection was analysed by walker & thus is referred as walker cell & modified walker cell.

The walker cell tends to depict normal atmospheric circulation in South tropical pacific thus sustaining South east trade and SW monsoons.

With the development of El Nino any of the four positions called ElNino 1, ElNino 2, ElNino 3 & ElNino4) tends to modify walker circulation and thus
- → delay
- → weakening
- → complete termination of SE trade in Indian ocean

↳ Relative extension of warm water i.e. elnino towards Peruvian coast

adversely influencing monsoonal mechanism.



(b) DIPOLE:

1) The term is applied to denote west & east boundary currents of Southern Indian ocean basin (mozambique & west Australian current respect.)

2) with 90% of heat added to the climate system by human activity being absorbed by the ocean (IPCC) ocean water is globally experiencing warming effect. Indian ocean being half ocean involves stronger influence.

3) In the erratic sequence Indian ocean dipole tends to generate
→ Neutral mode
→ Positive mode
→ Negative mode effects.

(a) Neutral Mode tends to denote normal sea surface temperature (SST) with precisely no major influence on SE trade thus SW monsoon.

(b) Positive mode it relates to higher SST along mozambique current that tends to generate effective pressure gradient intensifying movement of SE trade thus SW monsoon in Indian ocean.
The positive mode have additional capacity of terminating (or weakening) of effect of El Nino & thus successful monsoon.

** The special report on Oceans & cryospheres (SROCC) of IPCC have identified that warming up of mozambique current can also induce Possible retention of SE trade in Southern hemisphere to failure of monsoon.

(after experience, it can only be determined of its negative positive impact.

(ii) Negative Dipole mode:

It relates to higher SST in the eastern shoreline of the ocean which tends to restrict movement of SE trade in Indian ocean thus restricting SW monsoons. In the combination of these factors (determiners) monsoonal mechanism multiplies its complexities thus unpredictibility

LOCAL WINDS:

1) The large scale surface winds that are developed due to local pressure gradient involving area specific weather effectivity.
2) The local winds are climatologically categorised into two defined categories: called General local winds & special local winds.

(i) General local winds:

→ Marks their presence in larger areas involving repetitive daily temperature range & orography.

(a) It includes Land & sea breezes of the coastal areas i.e. Land breeze during night & sea breeze during day due to the prevailing pressure difference.

- These breezes however are not experienced in equatorial & frigid zone.

(b) The Katabatic & Anabatic winds are typical to tall mountains with deep valleys experiencing differential rate of heating & cooling.

During night time Katabatic winds that are mountain breeze (air drainage) is experienced whereas during daytime it is Anabatic (Valley breeze) is experienced.

(ii) Special category of local winds, includes:

(a) Depression winds

(b) Descending winds.

a) i Polar outbreak:

1) Winter specific local winds absolutely related to extension of polar high pressure (due to apparent shift of sun towards South).

2) The developed pressure gradient generates local winds that increases magnitude of grim winters in mid and low latitudes

3) Blizzards of USA, Purgas of china & Pamparos of Argentina forms prominent examples.

Among these blizzards prove to be strongest due to:

(a) Complete absence of orographic barrier.

(b) Consistent availability of land.

(+)

4) Defined to be cold polar wind accompanied with powdery snow blizzards apart from developing freezing winters in USA is known for Squall line development (most turbulent weather conditions).

(b) (i) Dust devils:

→ Summer effective depression winds that are typical to large sandy deserts.

→ This represents the weather mechanism involving sudden heating of sand resulting in immense low pressure & resultant circulation that tosses moisture less sand particles generating dusty environment thus called dust devils.

→ It is both with sudden cooling of land and enhanced scattering due to excessive concentration of aerosols that tends to generate high pressure in tropical deserts during summers.

→ The developed pressure gradient b/w the desert & the surrounding location tends to generate hot dry winds.

→ It is in the areas where these winds are experienced that Variable weather conditions are generated.

- Creation of heat wave condition with health hazard as experienced in coastal Egypt & Libya involves KHAMSIN or GILIBI (Similar to loo)
- Decreasing humidity level & temperature (evaporational loss of heat) and thus favourable weather conditions as experienced in upper Guinea called HARMATTAN or doctor wind.
- Attainment of moisture by the hot dry wind & causing precipitation in the mediterranean climatic zone (which experiences long hot summer drought) as SIROCCO & MISTRAL
  * Among the two mistral is more known for Blood rain that can prove to be unfavourable for the standing crops & vegetation.

(b)(2) local winds:

(i) Relating to orographic barrier descending winds always tends to experience adiabatic warming.

ii) These winds thus generate warm & dry conditions (relating to the rain shadow interiors).

iii) It is dependent on the temperature of the area where these winds are experienced they are categorised as

(a) favourable winds as Chinook in canada & Foehn in switzerland. this is bcz these winds favourably increases temperature conditions facilitating melt of ice and thus habitability.

(b) The unfavourable winds as Santa Ana of california, USA & Shamoon of Iran. both these ascending winds tends to create higher temperature and aridity causing heat wave conditions as well as the hazard of forest fire.

* ATMOSPHERIC MOISTURE :

1) Amount of water vapour present in atmosphere is called atmospheric moisture.

2] It is active variable constituent of atmosphere i.e. its amount varies from one location to the other.
Amount of moisture in specified air column is called humidity.

3] Source of water vapour in the atmosphere is surface of earth it is therefore that atmospheric moisture study directly correlates to hydrological cycle involving evaporation, condensation & precipitation as defined weather mechanisms.

4] The source of moisture in air column involves process of evaporation that is defined to be the process converting liquid into vapour state.

** Mention of evaporation in climatology always correlates to the processes of transpiration and sublimation.

5] The process of evaporation though is considered to be continuous its rate significantly varies from one location to the other.

6] The determiners of rate of evaporation principally includes
- prevailing air temperature &
- levels of humidity.

7] The levels of humidity is climatologically measured as :
a) Absolute humidity.
b) Specific humidity.
c) Relative humidity.

(a) Absolute humidity:

i] It is defined to be mass of water vapour per unit volume of air.

ii] It is thus referred as [gm/m³]

iii] Utility of absolute humidity in climatological studies is restricted by its swift variation (too variable).

(b) Specific humidity:

i] It is identified to be mass of water vapour per unit mass of air.

ii] It is expressed as [gm/kg]

iii] Providing stable measure of humidity it is utilised in climatological analysis of comparing water vapour amount in different air columns.

iv] General pattern of specific humidity involves decrease with increase in sign of latitude

(c) Relative humidity:

i] It is defined to be the ratio of amount of water vapour present in the air column and its carrying capacity at that given temperature.

ii] It is always expressed as percentage.

iii] It is this measure of humidity that is applied distinguish b/w

a) Unsaturated air

b) Saturated air

c) Super saturated air → It is sup-sat. air that gets condensed.

It also thus helps in determining [Dew point] temperature of the air column with potentials of following weather conditions

e.g.

A	Car. capacity	Carrying	R.H.	← by cooling / adding vapour
30°C	30 units	15 un.	50%	unsaturated
[15°C] cooling	15 units	15 un.	100%	saturated

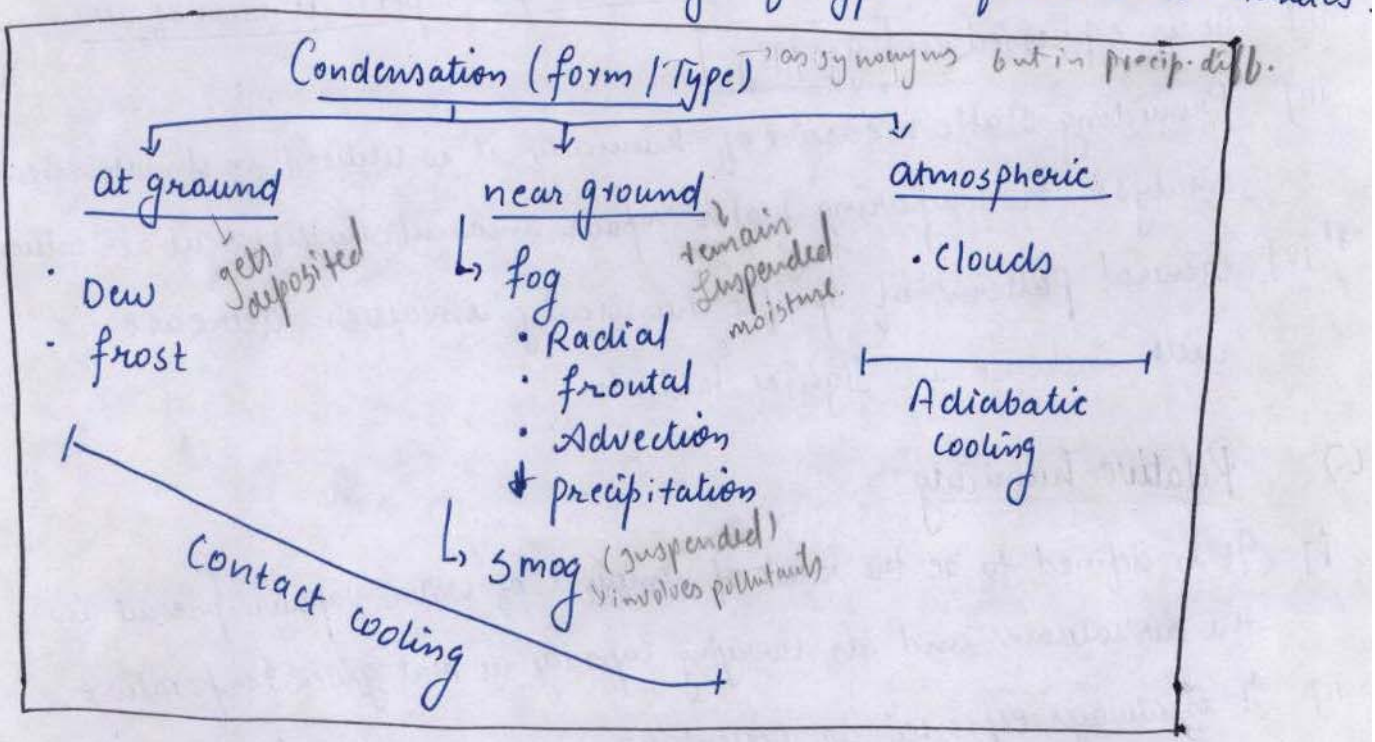
* CONDENSATION :

i) The process of condensation considered to be second step of hydrological cycle requires super saturated air column.

ii) Condensation is defined to be the process of converting vapour back to liquid or solid state.

iii) This process is thus always related to release of Latent heat (of condensation)

iv) Condensation incorporate wide range of types or forms which includes



A] At ground condensation -

i) Involving the process of contact cooling i.e. conduction, this form/type is typical to low sun season (long winter night).

ii) Process of conduction when makes the air column cool below its dew point temperature it tends to condense utilising ground lying objects.

iii) In this type therefore condensed moisture are deposited.

iv) The at ground condensation involves sub category called Dew & frost.

a) Dew: represent deposited water droplets when condensation takes place at temperature over & above freezing point of water making it typical to lower latitude and lower altitude.

b) Frost: in comparison is deposited ice crystals it thus tends to develop with surface temperature below freezing point of water being typical to higher latitude & higher altitude.

B] Near ground condensation:

i] This type or form of condensation is also typical to low sun season involving contact cooling i.e. process of conduction.

ii] It relates to the development of ~~fog~~ FOG that represents suspended condensed particle.

iii] Fog is therefore defined to be structurally & compositionally near surface clouds.

iv] With suspended moisture fog always relates to:
decrease in visibility acting as natural hazard (wherein the density of developed fog is absolutely dependent on amount of water vapour present in air column).

v] With human induced modifications in atmospheric constituents fog prominently represents variable combination of pollutants i.e. Smoke + Fog = SMOG making it the health hazard aswell.

vi] The common types of fog includes:

a) Radiation fog - It is the commonest type that corelates to process of contact cooling. It involves terrestrial radiation first cooling the surface & then the air column to facilitate condensation technically it is this formation process that tends to generate

→ cloudless windless long nights.

① first surface cools down then upper air radially cools

... MIST along comparatively warm coastal areas (as the developed fog do not involve condensed ice crystals).

b) Advection fog:

→ Typical to low sun season in western European plain this fog type involves advection of warm moist air over cold surface to generate contact cooling & condensation (warm westerlies advecting over north atlantic drift to the landmass of Europe).

c) frontal fog:

→ This fog type typically develops in high latitude throughout the year and in mid latitude during winters. It develops when warm moist air converges with cold air experiencing frontal contact and thus the formation of fog.

typical to arctic not antarctic

Involving frontal mechanism in arctic ocean there is rare development of arctic smoke i.e. precipitation fog. The mechanism of its development involves frontal precipitation leading to evaporation of falling moisture and thus adding up of water vapour to the cold moist air near its dew point temperature generating fog.

* CLOUDS:

1) It is defined to be visible aggregates of tiny ice crystals & minute water droplets.
2) As outcome of adiabatic cooling it is commonest form of condensation with its development throughout the year and throught the world / barring the exception of polar latitudes).
3) Clouds are categorised as Genera clouds on three prominent basis

Shape

- Globular
  - Cumulus (Cu)
- Sheet
  - Stratus (St)
- fibraus
  - cirrus (Ci)

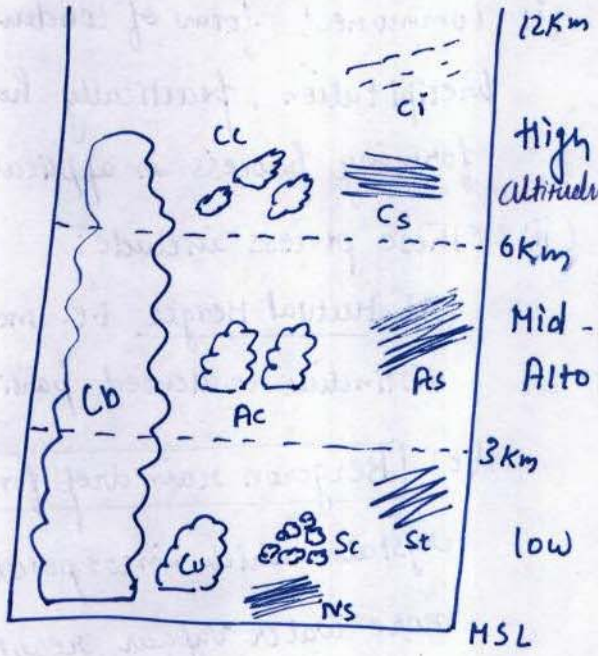
Weather effects

(i) Bad weather
- Nimbus
  - Cumulo Nimbus (Cb)
  - Nimbostratus (Ns)

(ii) fair weather
- Ci (cirrus)
- Cc Cirro cumulus
- Cs cirro stratus

(iii) Rain bearing
- Cu - cumulus
- St - stratus
- Sc - Strato cumulus
- Ac - Alto cumulus
- As - Alto stratus

Height



4) WMO (world Meterological organisation) have identified 12 new features to 10 genera clouds these include:
   (i) Species cloud called volutus cloud i.e. Tail cloud.
   (ii) Accessory cloud i.e. Beaver tail clouds, called flumen.
   (iii) Supplementary features
      - Cauda - Tube
      - Murus - Wall - with tornadoes & thunder
      - Asperitas - Waves
      - fluctus - Breaking Waves
      - Cavum

(Refer Video)

(iv) Special clouds -

- Cataracta genitus (Cataracts) waterfall)
- Selva genitus (Vegetation)
- Flamma genitus (Vulcanism)
- Homo mutatus (Globular with strong upper air wind)
- Homo genitus - Human induced (fly past of aircraft)

restricted vertical growth
wind ?

---

* Rain drop forming process:

(i) Commonest form of condensation clouds do makes the pre-requisite for precipitation, practically however within the clouds rain drop forming process is applicable.

(ii) These process include:

(a) Mutual Merger i.e. merger of droplets and ice crystals as the two distinctive condensed particle to gradually grow in size & thus begin to fall.

(b) **Bergeron rain drop forming process** ~ it is applicable only to ice crystals which incorporate lower vapour pressure and thus attract more water vapour resulting in deposition and thus growth in its size.

(iii) Among the two constituents of clouds it is ice crystals that thus facilitate swifter downdraft and precipitation.

** Water droplets will re-evaporate while descending thus less related to rain compared to ice crystals.

* Continuous strong updraft results in growth of size of ice crystal as ice ball (hail).

* For precip. rain drop form. in clouds is must.

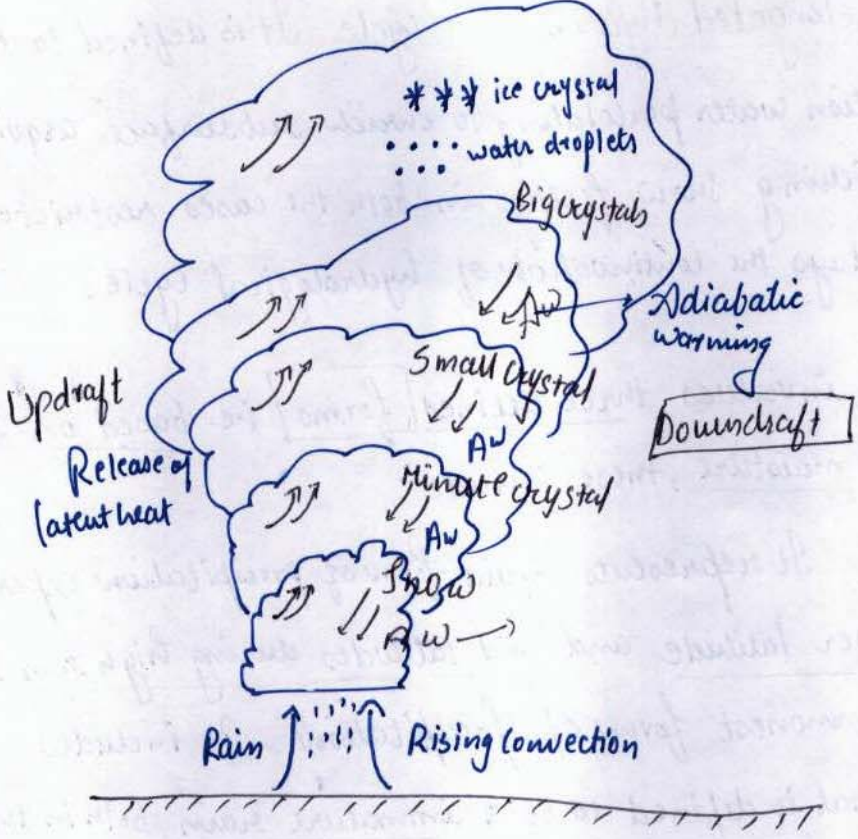


fig: Rain drop forming process

* PRECIPITATION:

1) fall of moisture from the base of cloud is called precipitation.
2) It marks completion of hydrological cycle in the ideal conditions.
3) Practically hydrological cycle involves three defined types restricting the validity of practical completion these include:

(a) Atmospheric hydrological cycle i.e. the hydrological cycle where the falling moisture from the base of cloud tends to get re evaporated before reaching the ground.

** This hydrological cycle is typical to warmer latitudes.

(b) Diurnal or daily hydrological cycle. this hydrological cycle is defined with fore noon evaporation and afternoon precipitation that is completion of cycle on daily basis.

* It is typical to equatorial climate.

(c) Delayed or elongated hydrological cycle. It is defined to be associated with precipitation water percolating to enrich subsurface aquifers or snow fall enriching snow fields in both the cases restricted subsequent evaporation delays the continuation of hydrological cycle.

4) Precipitation involves three defined forms i.e. based on state of precipitated maisture, these include:

(a) Rainfall - It represents liquid form of precipitation experienced in warmer lower latitude and mid latitudes during high sun season. It forms commonest form of precipitation. It includes Drizzle that is defined to be & immature rain both in the size of rain drop and amount precipitated.

(b) Snowfall It represents frozen form of precipitation that is experienced in higher latitudes alongwith mid latitude during low sun season.

It incorporate - Sleet i.e. partially molten snow that is experienced in the areas where surface temperature remains over & above freezing point of water.

→ Glaze (Pinnacle of ice.) defined as refrozen snow in comparison is typical to the areas where surface temperature remains below freezing point of water.

(c) Hail: It is the frozen form of precipitation that is represented as ice balls falling from the base of the cloud.

As its formation process requires Strong & consistent Updraft, it is typical to to warm moist latitudes.

5) The types of precipitation involves categorisation based on mechanism that leads to adiabatic cooling, condensation & precipitation.

Two prominent mechanism based categories of precipitation can be distinguished:

(a) Thermally induced mechanism, this include convectional precipitation (typical to equatorial climate) and Cyclonic precipitation (typical to tropical marginal water bodies).
This type of precipitation do not relate to the precipitation form of snow & its variant.

(b) Mechanically induced precipitation types, it includes
→ Orographic precipitation in all the mountaneous regions involving wetter windward side and drier rain shadow interiors.
→ It also includes frontal precipitation (in mid & high latitudes), ~~this~~
This type of precipitation do not relate to hail only.

ATMOSPHERIC - STABILITY & Instability:

I - NLR ≠ ELR
(6.5°c/km) (variable)

- Adiabatic lapse Rate (Rising air)
  - Dry ALR (10°c/km) unsaturated air
  - wet ALR (5°c/km) (Retarded) Saturated air

ELR depends on surface temp.

II. Stability
a) Subsiding air
b) Pausing of rise
ALR > ELR

III. Instability:
a) Rising air
b) Sustained Rise
ELR > ALR

(a) Absolute Instability
ELR > DALR
e.g. cyclonic / convectional precp^n

(b) Conditional instability
WALR < ELR < DALR
(5°c/km) (7°c/km) (10°c/km)
Instable | Stable.
e.g. orographic & frontal precp^n

Air Masses : Types & Weather effectivity

1) Three dimensional homogeneous masses of air that projects homogenity primarily in context of two major physical properties of air : Temperature & Moisture are called Air masses.

2) Air masses are essentially divide of troposphere involving their physical characterstics in accordance to the ground condition.

3) That part of earth's surface which provides development ground for air mass is called its Source area/region.

* Barring the exception of extensive mountain cordilleras all the location of earth's surface involves potential to be the source region for air masses.

4) The air masses though tends to develop throughout the year they attain stronger homogenity during low Sun season when prevailing stability makes the air column remain in contact with source area for longer time. Developed over the source area air masses are called **Barotropic air mass**.

5) In the influence of prevailing winds when the barotropic air mass advects to new location it not just influence the weather conditions of advected area but also gets influenced by characterstics of new location getting transformed into **Barochinic Air mass** → Thermodynamic, Mechanical

Types of Air masses :

Air masses are principally classified on the basis of :

1) **Latitude** including Tropical airmass (T) and Polar air mass (P).

the principal categorisation also include categories based on : ~~Reli~~

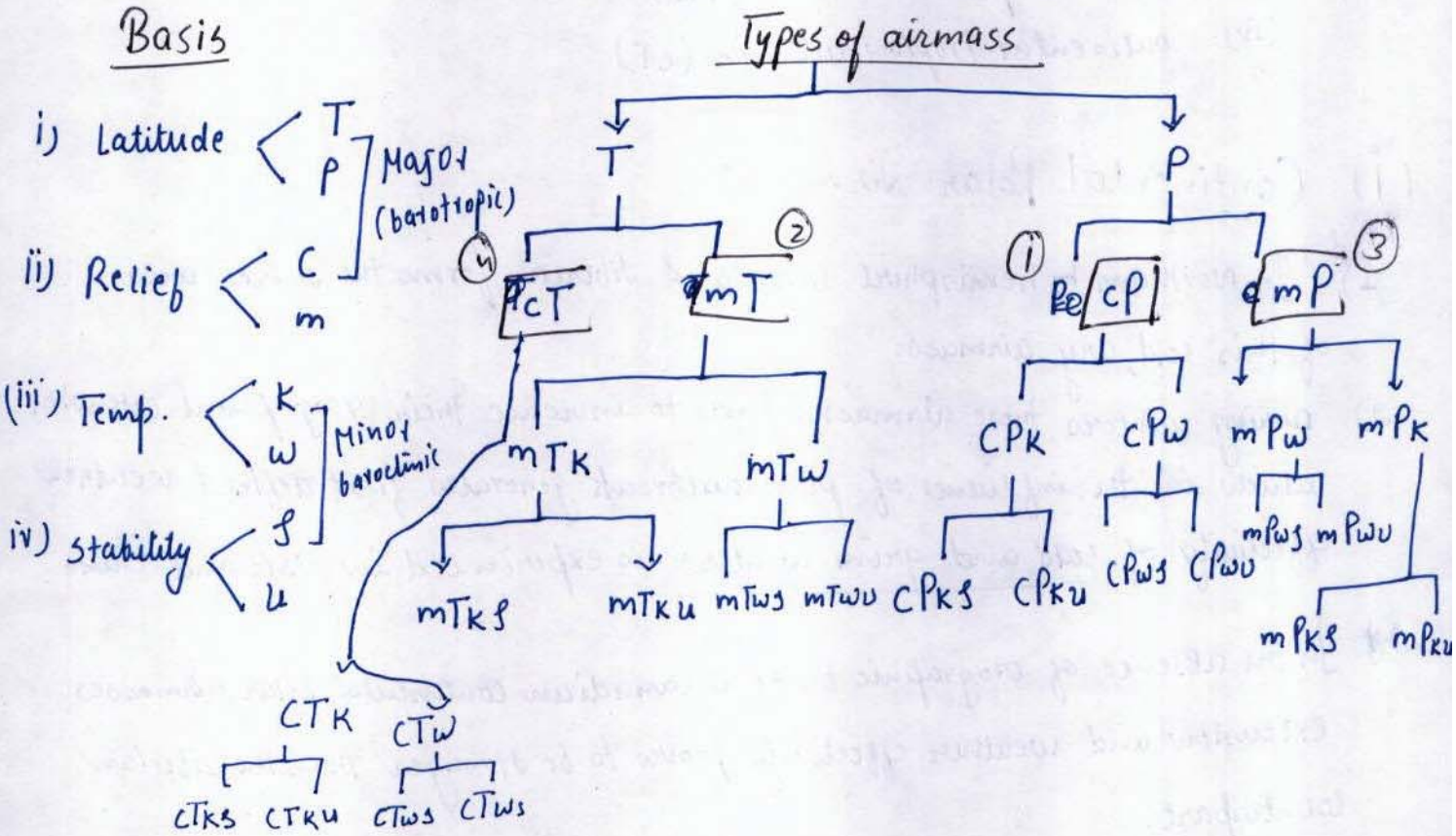
2) **Relief** including (ontinental airmass (c), & maritime airmass (m).

* for the analysis of weather mechanism induced by airmasses only these two criterion of classification is taken into consideration.

The Minor basis of classifying airmasses that prominently relates to modifications that the airmasses experiences in their advection over new areas includes:

3) Temperature that distinguishes b/w Kalt (cold for German) (k) & warm air mass (w).

4) Stability as the criterion to classify airmasses includes distinction Stable airmass (s) and unstable airmass (u).



Weather effectivity of air masses:

1) four major types of airmasses categorised on basis of latitude and relief are considered in the analysis of weather influences induced by them.

2) Though all the four airmasses involve significant range of weather effectivities it is in terms of influenced area and induced diversity of weather conditions that these airmasses are arranged in decreasing order of climatological prominence as

   i) Continental polar airmass (cP)
   (ii) Maritime tropical airmass (mT)
   (iii) maritime polar airmass (mP)
   (iv) Continental tropical airmass (cT)

(i) Continental Polar Airmass:

1) In Northern hemisphere canada & Siberia forms the source area of this cold, dry airmass.

2) During winters these airmasses tends to increase their geographical extension which in the influence of polar outbreak generates first defined weather effectivity of cold and grim winters as experienced in USA and china.

3) In the absence of orographic barrier canadian continental polar airmasses extension and weather effectivity proves to be stronger than the Siberian counterpart.

3] Sufficiently expanded in mid latitude these airmasses comes in the influence of westerlies. The airmasses thus advects towards north east creating **Arctic front** in mid latitude east margins of land, the airmass thus creates frontal precipitation as its added weather effectivity

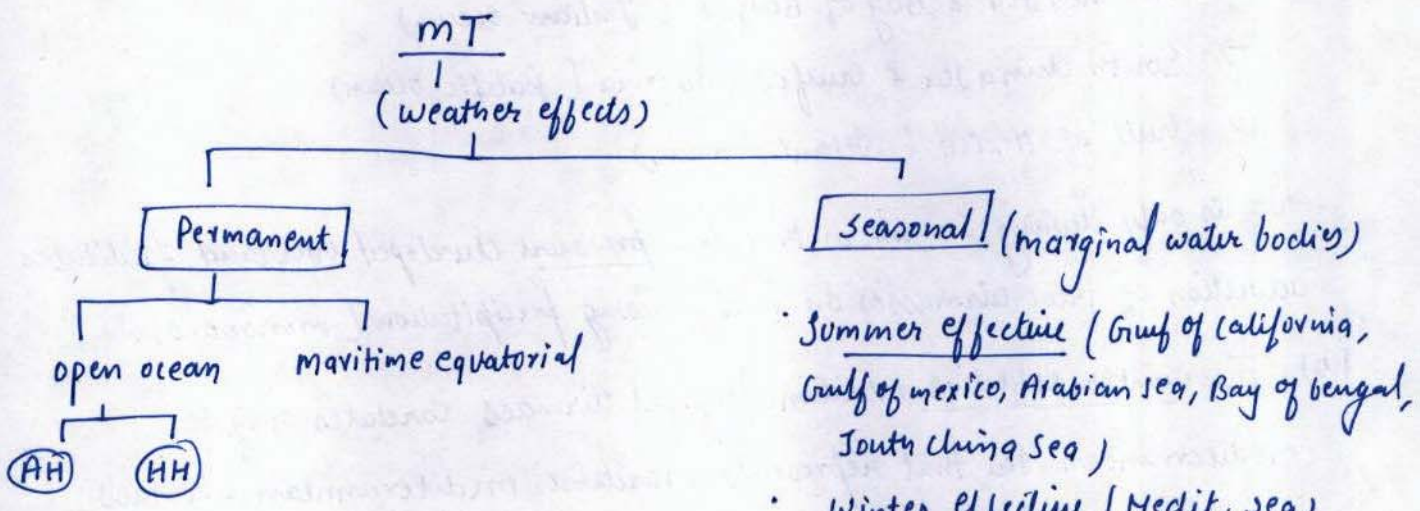
** Canadian airmass develops stronger arctic front due to higher temperature contrast b/w super cold land and west boundary warm oceanic current (Gulf stream).

→ In case of siberian front the arctic front is restricted in its effectivity due to absence of warm oceanic conditions nearby as Kuroshio current is farther.

4] It is with Canadian cP airmass that occasional development of squall line tends to generate turbulent weather conditions as experienced in Southern coastal USA (development of squall line is dependent on thermal contrast b/w USA & Gulf of mexico that is enhanced due to effective polar outbreak).

↳ in S. china sea sq. line not develops due to weak pungast ~~less intensity~~ less intensity of thermal contrast.

(ii) Maritime Tropical Airmass:



1) The warm moist airmass only relates to creation of wetter weather conditions.

2) Relating to water bodies as its source area these air masses though involves consistent perennial existence they project both permanent and seasonal weather effectivities.

3) The permanent weather effectivity relates to:

a) Maritime equatorial airmass, that depicts absolute instability throughout the year generating wetter weather conditions in entire equatorial region (with similar influence on land and water) alongwith rainfall maximas during equinoxes.

b) Opean oceanic maritime tropical airmasses that corresponds to hawaiian high of pacific ocean and Azores high of Atlantic ocean. These air masses experiences perennial advection in the influence of prevailing winds creating ITCZ and polar front. thus wetter weather conditions.

4) The seasonal weather effectivity is induced by maritime tropical airmasses primarily of marginal water bodies. These includes:

(a) Summer effective maritime tropical airmasses that largely corelates to maximum of marginal water bodies including:

→ Arabian sea & Bay of Bengal (Indian ocean)

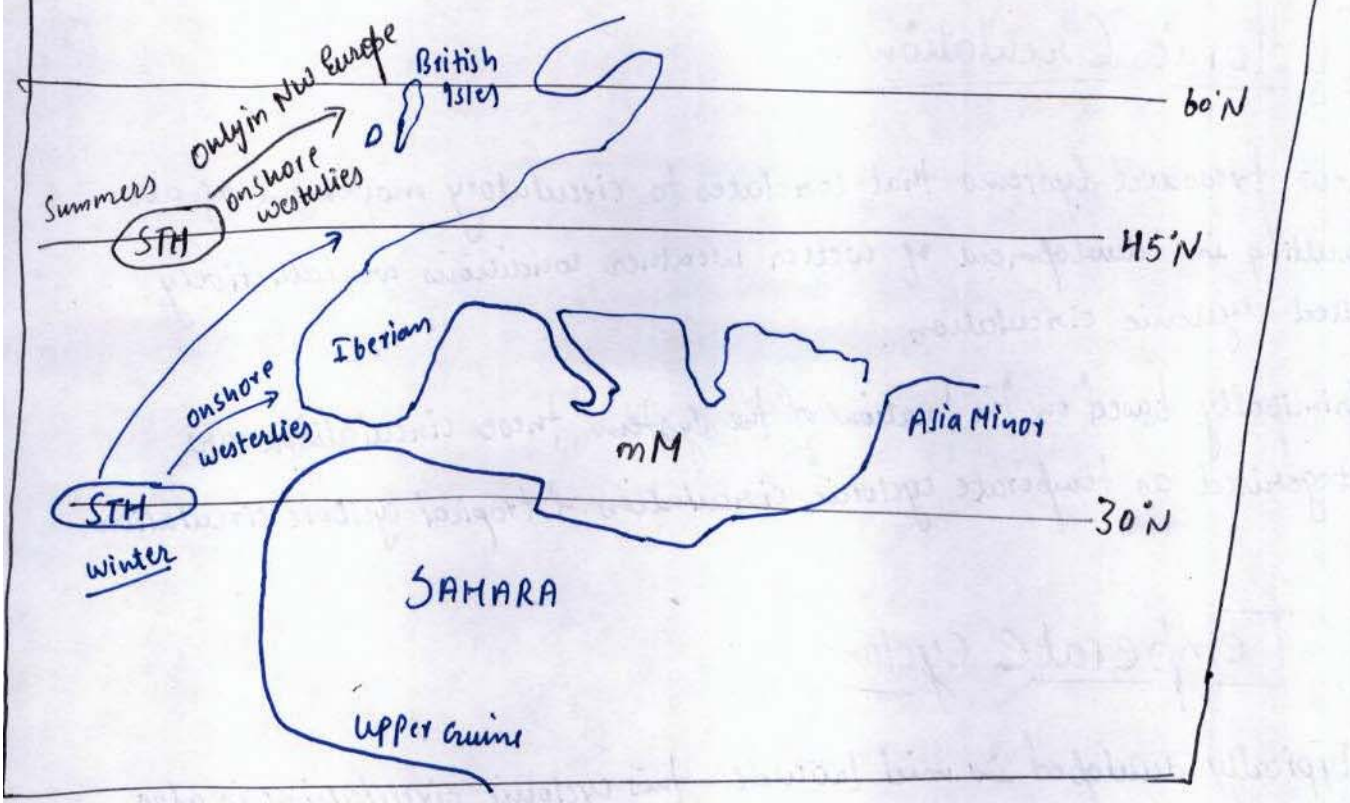
→ South china sea & Gulf of california (Pacific ocean)

→ Gulf of Mexico (Atlantic ocean)

It is only during summers that low pressure developed over land facilitates advection of these airmasses on land causing precipitation (monsoons).

(b) The winter effective maritime tropical airmass corelates only to mediterranean sea that represents maritime mediterannean airmass with effective onshore advection only during winters in the influence of South west westerlies,

* during summers STH will shift northwards & thus medit. sea offshore trades are established creating dry conditions



(iii) Maritime Polar airmass:

1] Cold & moist airmass applied to the water in frigid zone.

2] Due to its lower temperature & thus low specific humidity it is capable of inducing wetter weather conditions as conditional instability (front mechanism)

3] It thus relates to polar front related precipitation throughout the year and Arctic front related precipitation only during winters in east margins of mid latitudnal land.

(iv) Continental Tropical airmass:

1) Warm & dry airmass.

2) It relates to tropical landmasses as its source area.

3) It tends to induce dry weather conditions as is:

→ (a) Experienced over maximum of tropical landmass during winters. (India + sahara)

(b) In tropical west margins of land throughout the year. (Sahara)

* Cyclonic Circulation :

1) Low pressure systems that correlates to circulatory movement of air resulting in development of wetter weather conditions are collectively called cyclonic circulation.

2) Principally based on the location of the system these circulations are categorised as temperate cyclonic circulation & tropical cyclonic circulation.

* Temperate cyclone :

1) Typically developed in mid latitude this cyclonic circulation is also recognised as extratropical cyclone and wave cyclone that is characterized with :

→ Bigger sized system that can influence both mid & high latitudes.
→ Represents conditional instability i.e. frontal mechanism of disturbances.
→ Capable of influencing both land & water however with decreasing precipitation in increase of continentality.
→ long living system with life cycle ranging from 15-20 days.

2] The temperate cyclonic circulation is characterized with defined life cycle that is derived from Polar front theory proposed by Jacob Bjerkens.

In accordance to this theory the defined stages include :

(i) Stage of frontogenesis.
(ii) Division of the stable front & beginning of cyclonic circulation.
(iii) Quick shift of cold front.

(iv) Closing down of warm sector.

(v) Stage of occlusion.

(vi) Stage of frontolysis/ frontal decay.

(i) Stage of frontogenesis:

1] In Northern hemispheric polar front converged contrasting airmasses in the influence of warm Westerlies and cold polar winds tends to develop polar front which projects stable characteristics primarily due to involved contrast between the converged air.

Stability of this front facilitates intrusion of air masses in each others domain.

2] It is this intrusion that tends to divide the stable front into two parts

Cold front	warm front
(i) It is that part of stable front which is developed due to advection of cold airmass.	(i) It is that part of stable front which is developed due to advection of warm air mass.
(ii) This front is thus typical in mid latitude.	(ii) This front is thus typical in higher latitudes.
(iii) Being denser the advecting cold air mass continues to sustain ground contact leading to pushing up of warm air mass.	(iii) Being lighter the advecting warm airmass makes gradual ramp (march) over the cold air mass.
(iv) Along this front therefore abrupt rise forms defined characterstics depicted with steeper gradient.	(iv) Along this front gentler gradient with complete absence of rush to rise is thus identified
v) Nature of gradient represents 1:40 as the common ratio i.e. 1 Km of vertical extension over	(v) Nature of gradient represents 1:80 or 1:200 i.e. 1 km of vertical extension over 80 kms or 200 kms of horizontal expanse

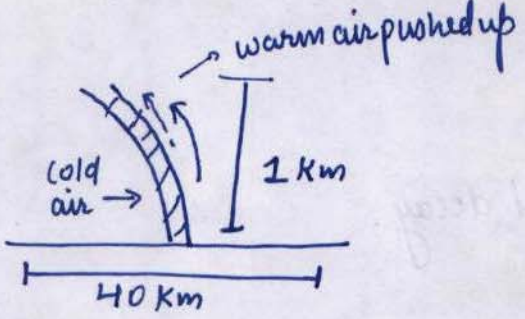


fig: cold front

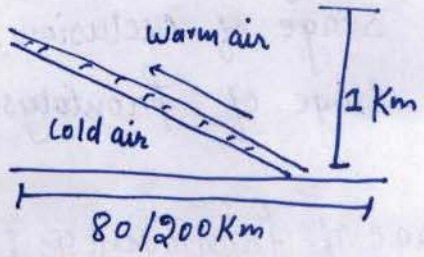
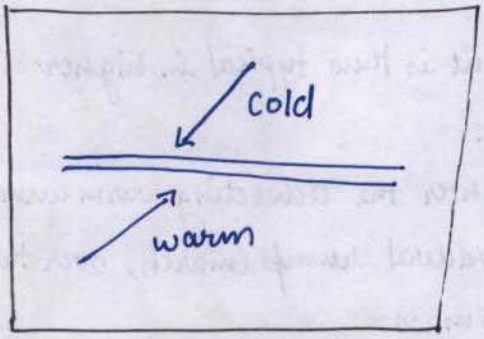


fig: a warm front

(ii) Division of stable front & beginning of cyclonic circulation:

1) Division of stable front eventually results in genesis of pressure gradient in the mid latitude marking the beginning of cyclonic circulation. Approached as **Buy's Ballot Law** sufficiently intruded in lower latitudes involving influence of land water contrast the cold airmass generates sufficient pressure gradient to its left generating cyclonic circulation.



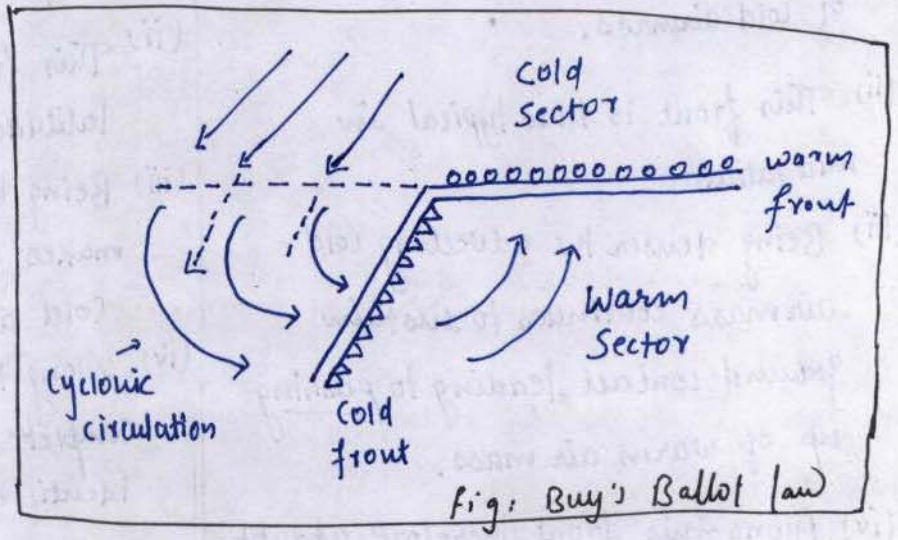


Fig: Buy's Ballot law

(iii) 4(iv) The other two stages that are quick shift of cold front and closing down of warm sector are essentially the transitional phase that represents enlargement of cold sector i.e. increase of area of surface contact of cold airmass leading to the decrease of

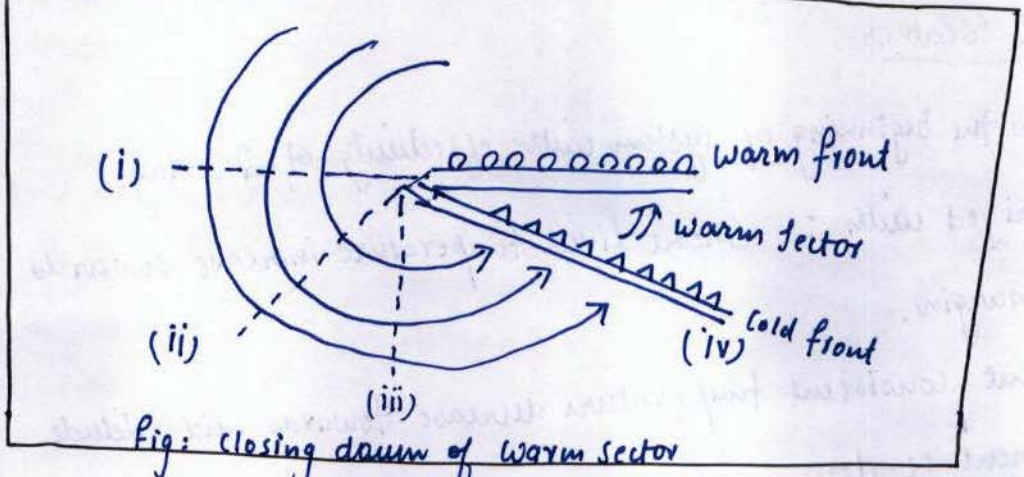


Fig: closing down of warm sector

(v) Stage of occlusion:

1) It is distinguished as defined life stages as warm airmass inspite of loosing ground contact will continue to induce weather instability in both mid and high latitudes.
This stage therefore depicts conclusion of weather effectivities and beginning of frontal decay.

(vi) The stage of **frontal decay or frontolysis** thus is identified with termination of system involving 2-3 days of stable weather conditions (that is followed on by re-establishment of westerlies and beginning of fresh front development).

* Weather effectivity of temperate cyclone:

1) In the life cycle of 15-20 days temperate cyclonic circulation tends to develop four different types of fronts, it is in reference to these fronts that generated weather effectivity are distinguished, these include
   i) Stable front
   ii) Warm front
   iii) Cold front
   iv) occluded front

(i) Stable front weather:

→ Experienced in the beginning of system with effectivity of 2-3 days.

→ It is characterized with: Short lived temperature increase towards high latitude margin.

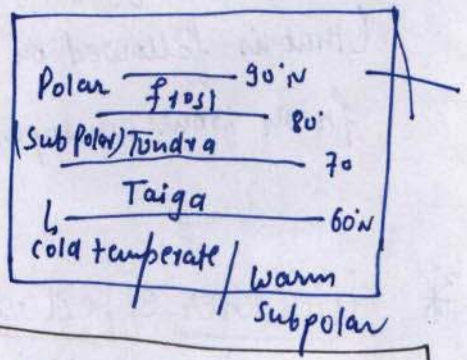
→ It also represent consistent temperature decrease towards mid latitude with development of dew

(ii) Warm front Weather:

→ Technically the warm front weather is characterized with gradual ramp/march of warm air thus multi altitudinal clouds, periodicity of precipitation pertaining to larger area & longer time.

→ Geographically warm front weather projects its importance in restricting polar deserts to frosted area only. It is this frontal precipitation that is experienced in taiga climate throughout the year with upto 30 cm of annual precipitation.

The tundra climate tends to experience Summer concentrated precipitation of upto 20 cm.



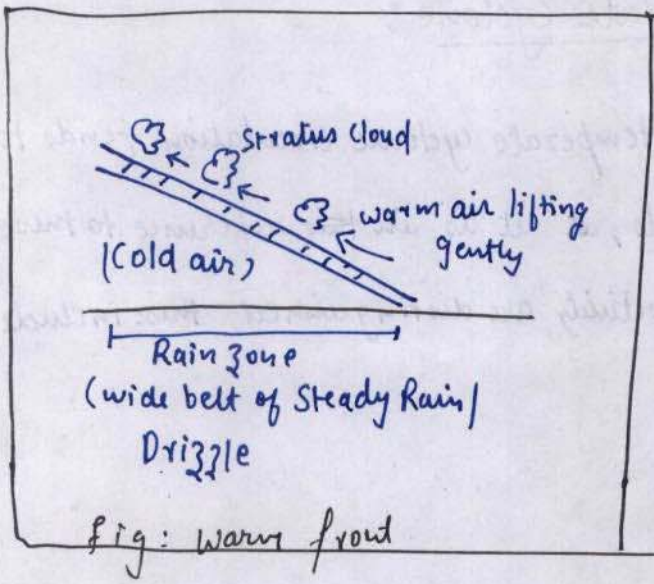


fig: warm front

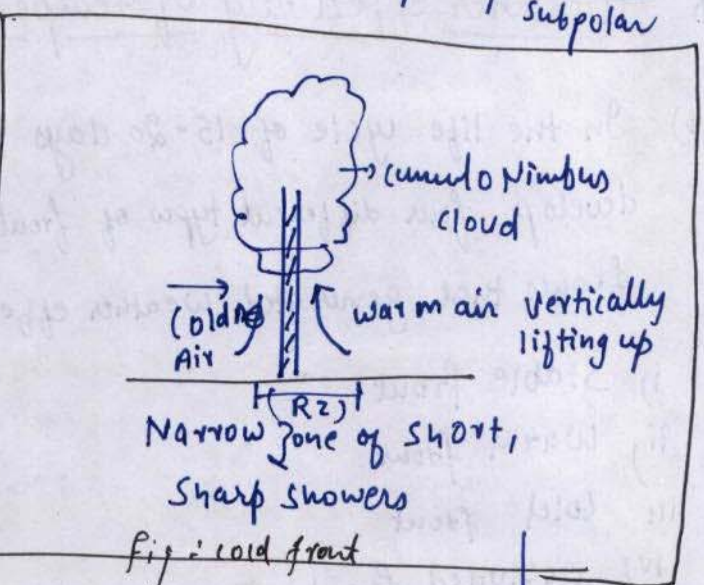


fig: cold front

(iii) Cold front weather:

→ Technically cold front weather relates to abrupt rise and thus intense weather conditions which is characterized with single dominant episode of condensation followed ow by precipitation pertaining to smaller area and shorter time.

→ Geographically weather conditions of cold front do not project exclusive nature i.e. multiple precipitation causing mechanisms is valid in mid latitude

** However continental steppe climate experiencing dependable well distributed precipitation throughout the year is related to cold front weather effectivity.

(iv) Occluded front weather:

→ It is characterized with consistent light showers for 2-3 day both in mid & high latitude depicting conclusion of cyclonic circulation.

Similarity of occluded front weather in both mid and high latitude is related to similarity of warm airmass loosing the ground contact.

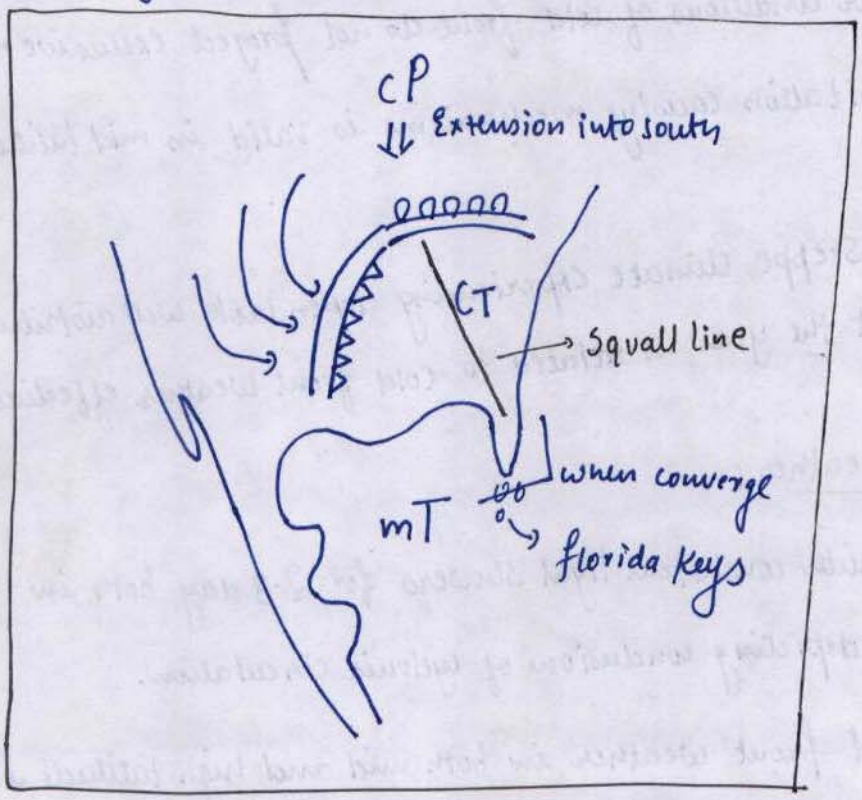
** Squall line:

During winter season North American temperate cyclonic circulation corelates to rare genesis of additional front called squall line.

This front marks its development few kms ahead of cold front in the warmer sector primarily due to the convergence of exponentially warm maritime tropical airmass of Gulf of Mexico and significantly cold continental tropical airmass of united states of America.

→ This rare convergence tends to generate combination of conditional and absolute instability thus turbulent weather.

Commonly developed along squall line is thunderstorms that are cumulo Nimbus clouds involving the capacity of creating heavy precipitation including & hail storm.



→ The developed thunderstorm in the release of latent heat is capable of generating turbulent mesocyclonic circulation that extends upto tropopause level. In this mesocyclone rising warm moist air from the surface when combines with Nurus cloud, tornadoes gets developed.

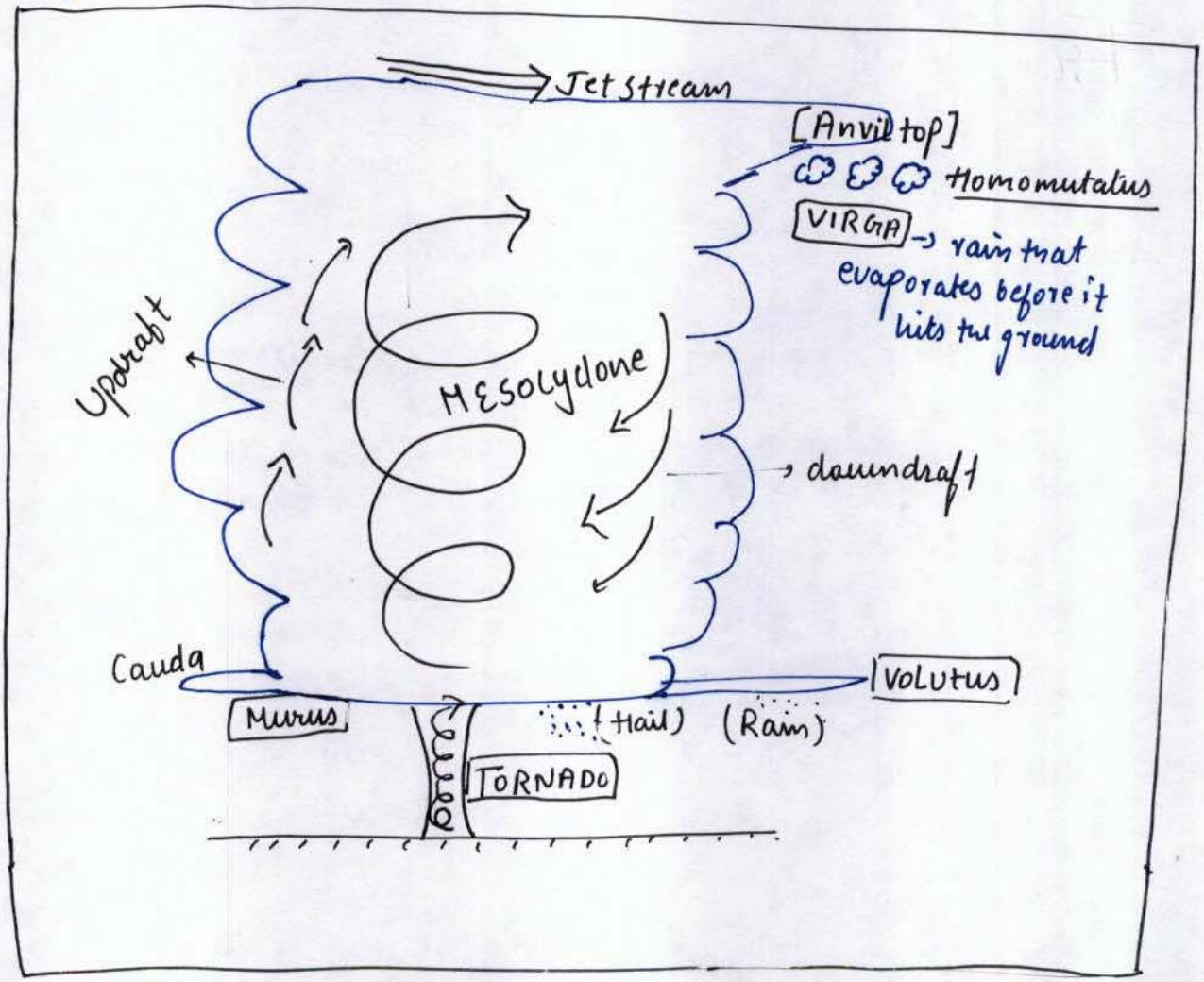
Tornadoes are defined to be funnel of low pressure condensed particle that is characterized with immense sucking capacity of all the ground lying objects generating immense destruction.

Considered to be twisters in USA these are most turbulent low pressure system that involves the life span of 10-15 minutes.

** Turbulances of tornadoes is essentially relcated to its sucking capacity however being related to the part of meso cyclonic circulation it do involves heavy precipitation including hail as its destructive constituent.

→ The same system developed over water bodies as in florida keys is called [Watersprout] that apart from disturbing acquatic habitat causes flood & flooding in coastal areas.

** Water sprouts are best identified as water pillar developed due to sucking capacity of tornado.



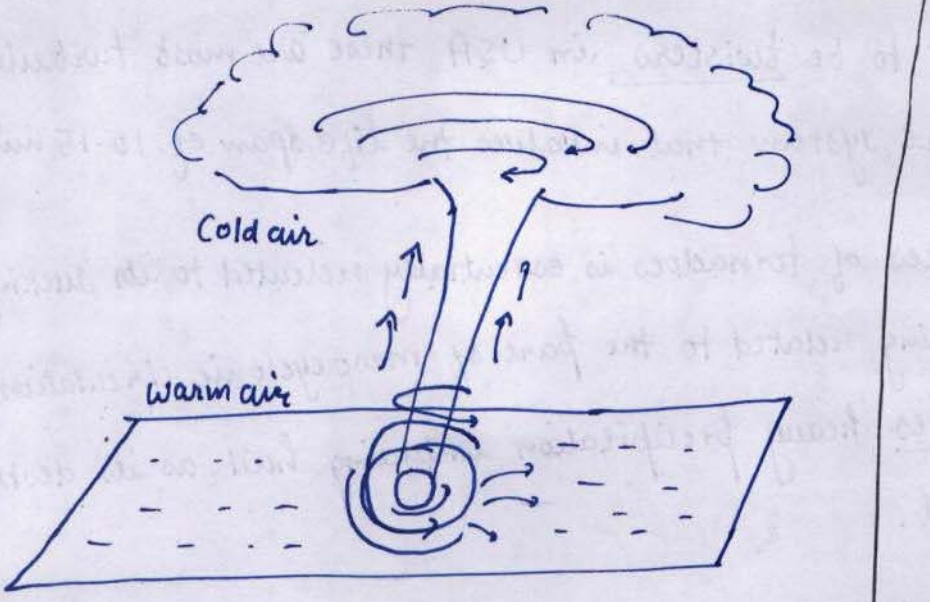


fig: water sprouts

[Tornadoes & dust devils have a fundamental diff. of Moisture].

Er

✱ Tropical Cyclone :

1] Thermally induced low pressure system that inwalves capacity of causing precipitation in the tropical coastal areas is called tropical cyclone.

2] This system as corelates to higher prwailing temperature (25-27°C) with consistent release of latent heat that provides complete energy for its circulation, the system evolves only in tropical - 8°-35°N/S. marginal water bodies that too during autumn season (when the desired temperature & pressure evolves in marginal water).

This precipitation causing mechanism is technically categorised into 3 defined categories called tropical storms, tropical cyclones & hurricanes in increasing order of intensity of circulation (huriccane as the strongest system is likely to generate air pressure of 920 mb).

Regionally the system marks its confinement in restricted number of marginal water bodies that includes :

- → Gulf of California] Hurricane
- → Gulf of Mexico
- → Arabian Sea] Cyclone
- → Bay of Bengal
- → Mozambique channel
- → South china sea] Typhoon
- → East china sea
- → coral sea] Willy-willies
- → Gulf of carpentaria

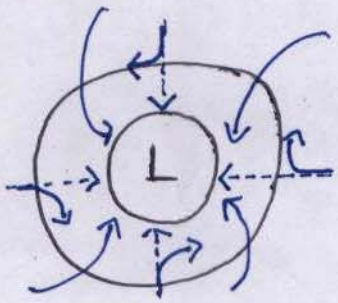
3] The cyclonic circulation marks its genesis as the warm moist air subjected to adiabatic cooling releases latent heat providing additional energy for the movement of air column resulting in condensation and precipitation with strong converging winds.

Commonly every tropical cyclonic circulation is identified with two defined set of circulation called:

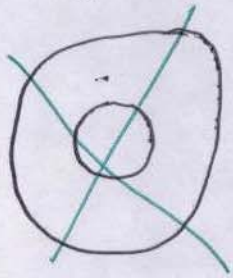
→ Primary circulation
→ Secondary circulation

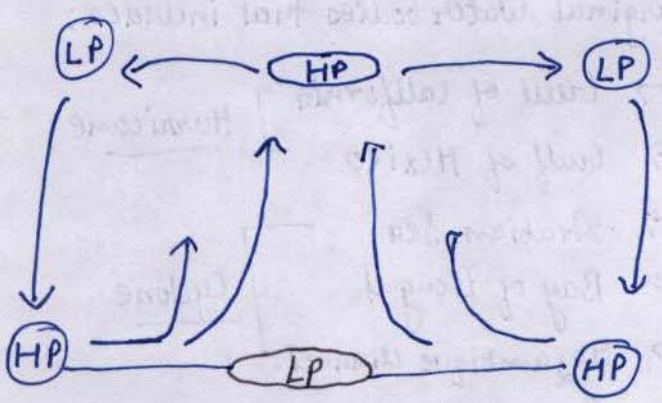
* Primary circulation: represents convergence towards the low pressure centre which in combination of coriolis force develops (anti clockwise convergence in Northern hemisphere & clockwise convergence in Southern hemisphere

* Secondary circulation depicts nature of developed circulation by this system involves upper air divergence alongwith in and up and out & down as the typical nature of air movement.



Primary cir'n





Secondary cir'n

Based on the nature of circulation, Structure and weather effectivity of tropical cyclone is distinguished. This includes:

(a) Rain Zone

(b) Rainless centre

(a) Rain zone: accounts for more than 80% of the total size of the system. It sorrounds the centre of the system & is characterized with strong winds, strong convective rise, thundering & lightning with heavy precipitation.

** Intensity of turbulent weather increasing towards the centre of the system characterized with well developed thunderstorms (Cb clouds).

(b) Rain less zone - forms the centre of the system, also called Eye of the cyclone accounts for less than 20% of the total area of the system.

It relates to highest temperature, lowest pressure however is windless, cloudless & thus rainless centre.

** The eye of the cyclone incorporate Blocking anticyclone at tropopause level. Though it is identified to be the typical high pressure cell developed over surface low pressure it invalves recognisable effective role in intensification of system & termination of system.

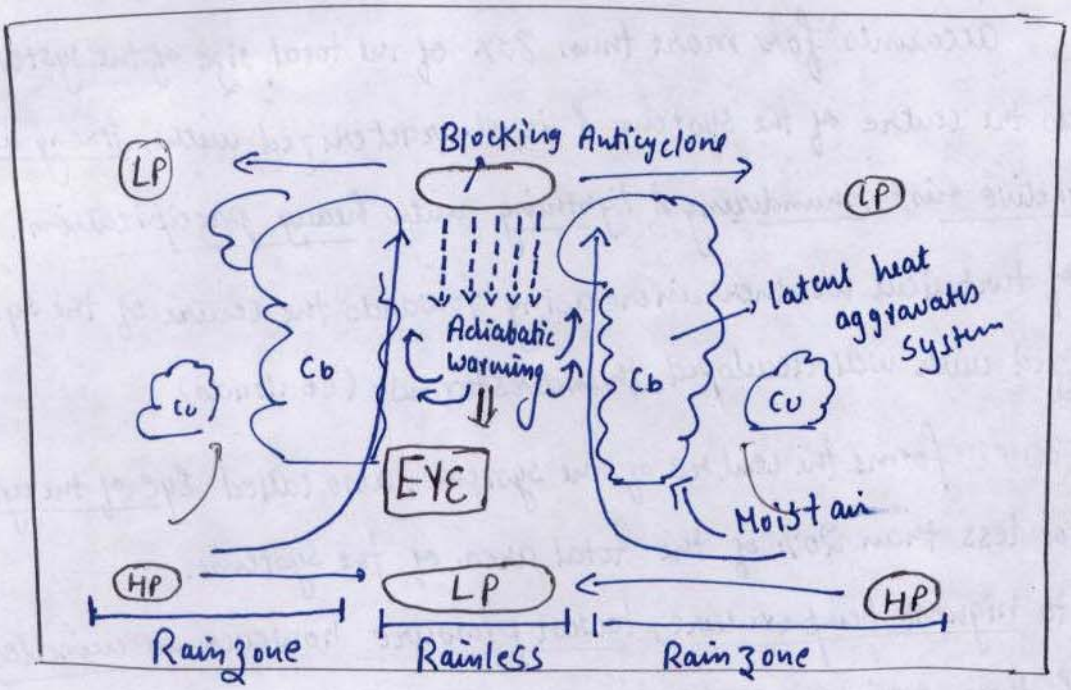
The strong developed system tends to create "funnel of low pressure" which avails the source of subsiding air convection from the blocking anticyclone that gets adiabatically warmed up to intensify the system.

Similarly in the influence of trade winds when the system registers landfall it swiftly becomes weak invalving the influence of:

(a) Lack of supply of moisture.

(b) Increase in frictional drag

The blocking anticyclone facilitates filling up of low & thus termination of the system. The lifespan of tropical cyclone is 4-5 days (maximum recorded expanse is not more than 7 days).



* CLIMATIC CLASSIFICATION:

Climate - Aggregate of weather conditions

(i) Genetic classification - One element - e.g. Thermal zones

(ii) Empirical class'n - 2 most measured elements in ABSOLUTE VALUE → Koppen, Trewartha

(iii) Applied - 2 most measured elements in RELATIVITY → Thornthwaite

* Koppen's Alphabetical Symbols:

Level I - Major climate types

Alphabetical symbols	Climate types	Vegetation
A	Tropical	Megathermal
B	Dry	Xerophytes
C	Subtropical	Mesothermal
D	Temperate	Microthermal
E	Polar	Helkisotherm
H	Montane	Montane

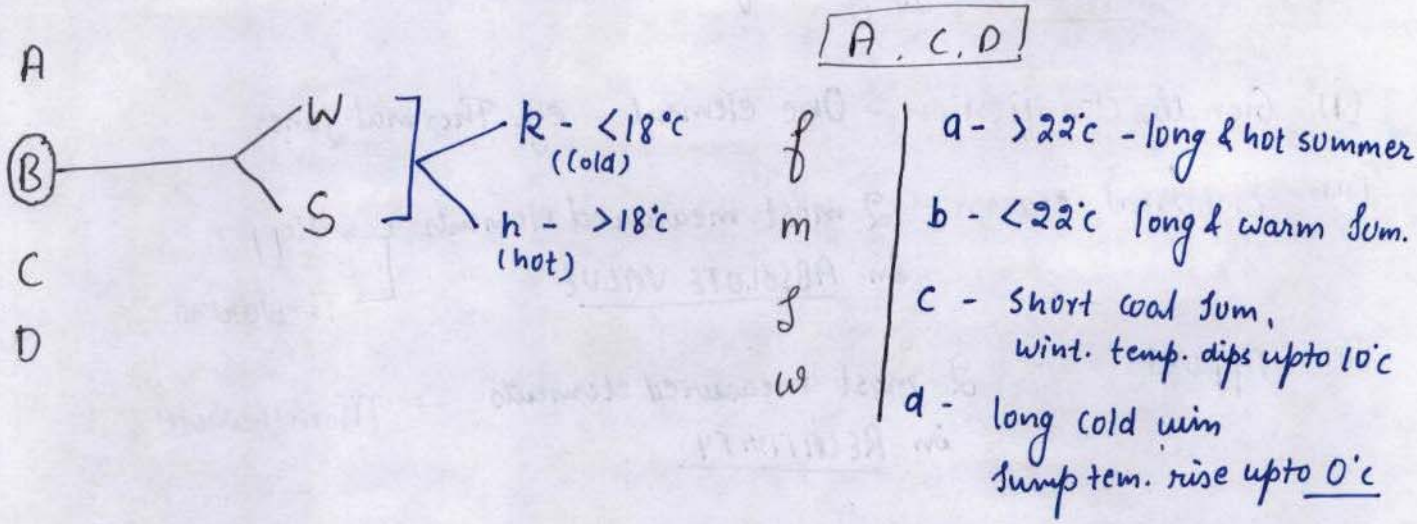
Level I → **Level II**

A
B → W - Desert, S - Steppe
C
D
E → T - tundra

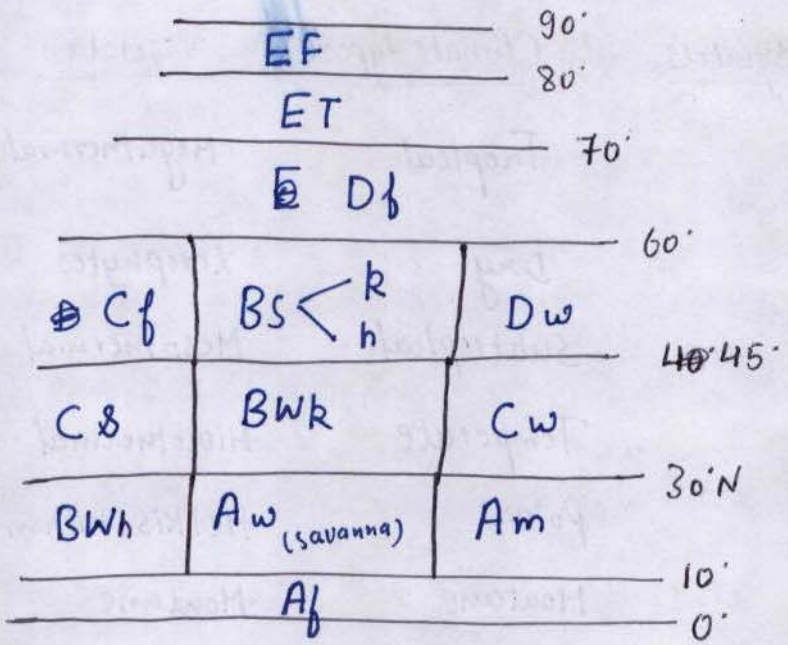
A, C, D

f - well distributed rain
m - monsoon
s - dry summer. (wet winter)
w - dry winter. (wet summer)

Level I Level II Level III



* Koppen's Climatic Classification Scheme :



1) Vladimir Koppen (German climatologist) attempted empirical Category of climatic classi. Scheme in 1931.
2) He based the classification not just on temperature & precipitation but integrated vegetation by taking De Candolle's vegetation classif. of world.

In 1936 attempting amendment to his classification scheme he integrated altitude or height as additional base of classification. Combining all he demarcated six major types of climate:

1] 'A' type of Climate

It is high temperature climate either valid throughout the year or major part of the year. It includes:

(a) Af - equatorial climate

(b) Am - ~~Savan~~ monsoonal climate.

(c) Aw - Savanna climate

(a) Equatorial climate (Af)

(i) latitudnal climate i.e. 10°N/S

(ii) Amazon Basin & Congo Basin as prominent examples.

(iii) Prevailing summers throughout the year with annual range of temp. of only 5°c.

(iv) well distributed precipitation throughout the year with absolute instability of maritime equatorial airmass.

(v) Annual amount of precipitation of more than 300 cm with rainfall maximas during equinoxes.

(b) The Monsoonal & Savana climate (Am & Aw)

(i) Regional climates extensive b/w 10-30° N/S.

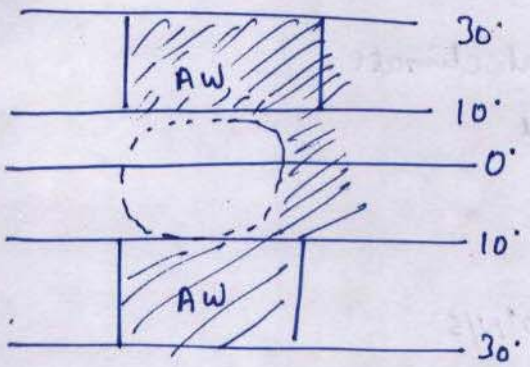
(ii) Both the climate remains in influence of continental tropical airmass during winters & thus remain dry.

(iii) Both involves summer effective maritime tropical airmasses thus wet summers.

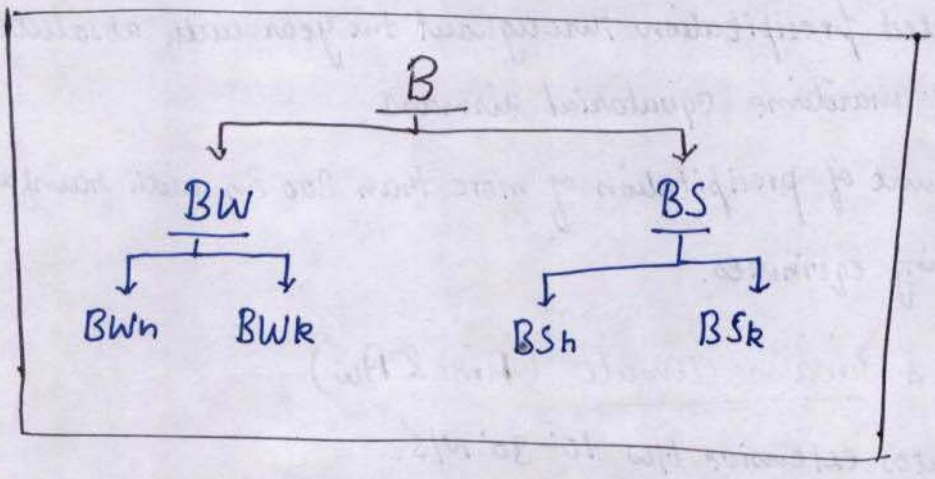
(iv) The monsoonal climate as experienced in India & Indo china peninsula is comparatively wetter climate with annual amount of precep.

---- alongwith involving tropical cyclone caused precipitation.

The Savana climate as is applicable to African Savanna, Brazilian Campos & Australian Nullarbor plains. Being continental is drier i.e. upto 100 cms of rain and complete absence of cyclonic circulation



2] 'B' type of climate:



1] Its drier climate that represents evaporational loss to be more than precipitational gain.

2] The climate is subcategorised into:

a) Desert climate (BW)

b) Steppe climate (BS)

(a) Desert climate (BW):

(i) Identified with highest magnitude of aridity this category of climate is subdivided based on weather mechanism, these include:

→ Tropical desert (BWh)
→ Subtropical desert (BWk)

I Tropical desert (BWh):

→ Its regional climate confined in tropical west margins of land.
→ The location is permanent subtropical high pressure thus tropical

→ It involves perennial offshore trade winds.
→ During summers sudden heating of land generates sudden encroachment of moisture laden winds and thus sudden torrential rain of upto 50 cm. e.g. Sahara Desert.
→ In the influence of east boundary cold current aridity multiplies e.g. Atacama desert the driest tropical desert (12 cm of annual rain), involving influence of peruvian current, coldest of all east boundary current.

II Subtropical desert (BWk):

→ Projects its drier condition due to its continentality.
→ Ideally it involves influence of both easterlies & westerlies.
→ Due to continental location dried up moisture laden wind tends to facilitate upto 30 cm of rain as Kalahari desert in Botswana.
→ The piedmont location increases aridity (rainshadow interior) yielding precipitation of upto 20 cm.
e.g. Patagonia desert, Argentina.

→ Intermountane location of Dzungarian basin however relates to Gurbantu Nuggat the rainless quarter of the world.

(b) Steppe climate (BS)

(i) Semi arid climate type that is typical to mid latitude.

(ii) It involves dependable frontal precipitation throughout the year with annual amount ranging b/w 25-75 cms.

(iii) It is based on the latitudnal location thus prevailing temperature that this climate type is subcategorised as:

I Low latitudnal steppe (BSh):

→ e.g - Pampas of Argentina, Veld of South Africa, Downs of Australia, USA prairies, & Kirgiz Steppe, Kirgizastan.

II The higher latitudnal steppe (BSk):

e.g. Canturbary plains of Newzealand, canadian prairie & Russian steppe.

3] 'C' type of climate:

(i) It is subtropical climate that is depicted with moderate temperature conditions.

(ii) In terms of involved weather mechanism this climatic category commonly involves the influence of warm anticyclone (STH).

(iii) This climatic category incorporate three defined subtypes:

a) China type of climate (Cw)

b) Mediterannean climate (Cs)

c) European climate (Cf)

(a) China type of climate (Cw):

→ Is subtropical east margin climate.
→ It is regulated by easterlies.
→ with the position of subtropical high onshore easterlies experienced only during summer causes summer concentrated rain (onshore trades due to shift of P. belt).
→ Annual amount of precepitation is upto 150 cm.
→ This climatic region includes great plains of china & Piedmont plains of Aplacchian as prominent location.
→ This climate type involves additional precipitation causing mechanism of weak arctic frontogenesis during winter. (In USA justified as Cw lies east of piedmont which does not experience polar outbreak.

* A
* USA don't have savana type due to polar outbreak during winter thus too cold.

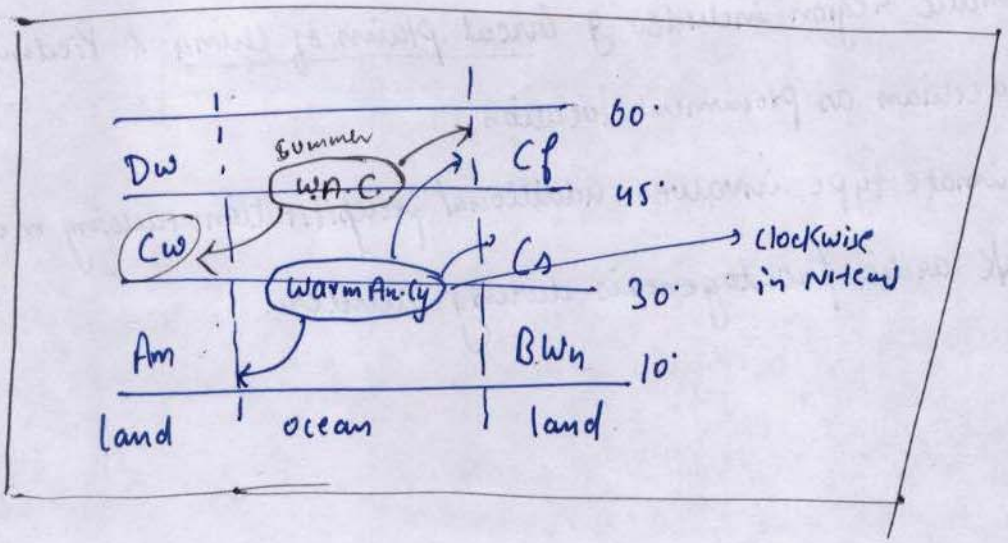
(b) Mediterannean type (Cs):

→ In the subtropical west margins
→ As mediterannea sea shoreline barring the exception of Egypt & libya.
→ It is typical of long-hot summer drought with winter concentrated precipitation.
→ Onshore westerlies experienced only during low sun season tends to cause precipitation in the range of 50-75 cm.

(c) The European climate (Cf):

→ It is wet west marine climate that experiences onshore westerlies throughout the year.
→ Annual amount of precipitation of upto 130 cm is thus well distributed.
→ Largest area of this climate involves European plain which in the influence of warm oceanic current called NAD

.... called NAD forms warmer counterpart of rest of similar climatic region thus is identified as Cfb type of climate. British columbia (canada) in influence of cold California current & Southern Chile in influence of cold peruvian current thus denote much colder conditions i.e. Cfc type of Climate.



4] 'D' type of climate:

(i) Temperate climate that is known for its grim winter conditions.

(ii) It incorporate:

→ Manchurian climate (Dw)

→ Taiga climate (Df)

(a) The Manchurian climate: (Dw)

→ Is confined in temperate east margins of land.

→ It includes Laurantian plateau of canada as other prominent location.

→ It experiences offshore westerlies throughout the year.

→ The only mechanism causing precipitation thus involves Arctic front developed during winters.

→ Annual amount of precip. can be upto 100 cm.

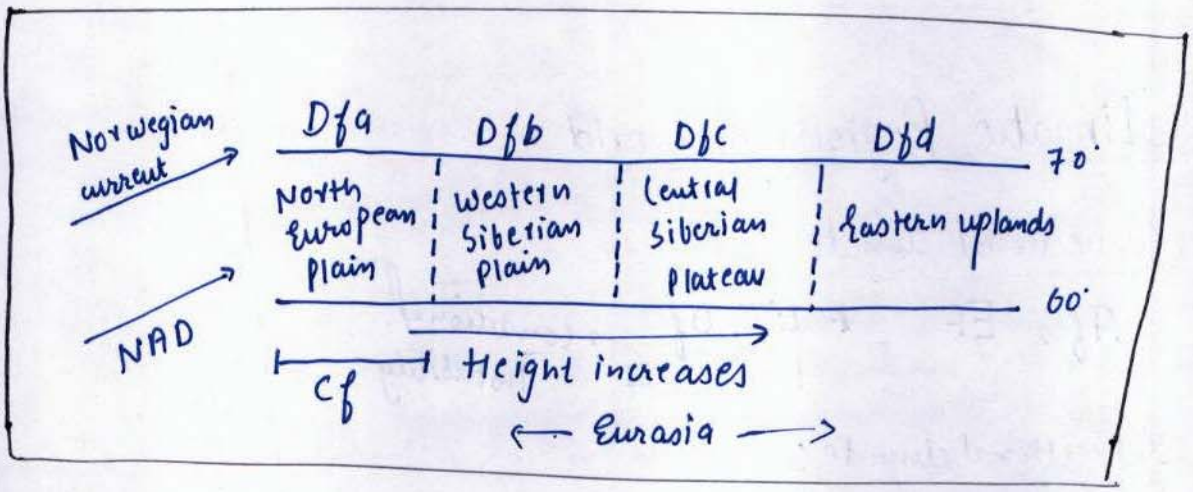
(b) The taiga climate (Df)

→ Is the latitudnal climate confined only in Northern hemisphere.

→ It involves perennial influence of warm front and thus well distributed rain ~~land~~ of upto 30 cm.

→ In Eurasia prevailing warm oceanic current (Norwegian current) and relief forms the reason of temperature based sub categorisation of climatic region. These include:

- → Dfa - Northern European plain.
- → Dfb - west Siberian plain.
- → Dfc - Central Siberian platea
- → Dfd - Eastern upland with Verkhoyansk the cold pole of world.



(5) 'E' type of climate:

→ (i) Polar climate thus latitudnal climate confined both in Northern & Southern hemi.

(ii) It includes:

(a) Tundra climate (ET)

(b) frosted climate (EF)

(a) Tundra climate (ET):

→ It is subpolar climate

→ Have short cool summers that facilitates Ablation of surface ice with subsurface remaining permanently frozen.

→ Only in Northern hemispheric tundra warm frontal precipitation of upto 20 cm during summers forms additional characterstics. (penguin, musk)

(b) Frosted climate (EF):

→ It is the true polar climate.

→ Involves Greenland & Antarctica.

→ with absolute stability throughout year thus polar desert.

→ It is this climate that relates to six continuous months of day & Night sequence.

Climatic Regions of world

① Convectional climate:

Af, EF * ET, Df → conditional instability

② Advectional climate:

Trade winds	westerlies
Am	Cf
Aw	Cs
BWh	BS
Cw	Dw
BWk	

(6) 'H' type of climate:

(i) Montane climate which depicts 3rd dimension repitition of recognised climate type regulated by:

→ latitudnal location of mountain.
→ Height of the mountain.
→ Sun bearing slope.
→ Maritime influence.

* Trewartha's Classification:

1) American climatologist Glen Trewartha attempted climatic classification scheme in empirical category.
2) He completely based the scheme on temperature & precipitation.
3) Use of Alphabetical Symbols is near same to that of Koppen's Scheme.
4) Only two alphabetical symbols are considered to be improvement over Koppen's alphabetical Symbols. i.e.
   → (i) Cfw for china type of climate.
   (ii) Dc i.e. temperate continental for Manchurian type of climate.

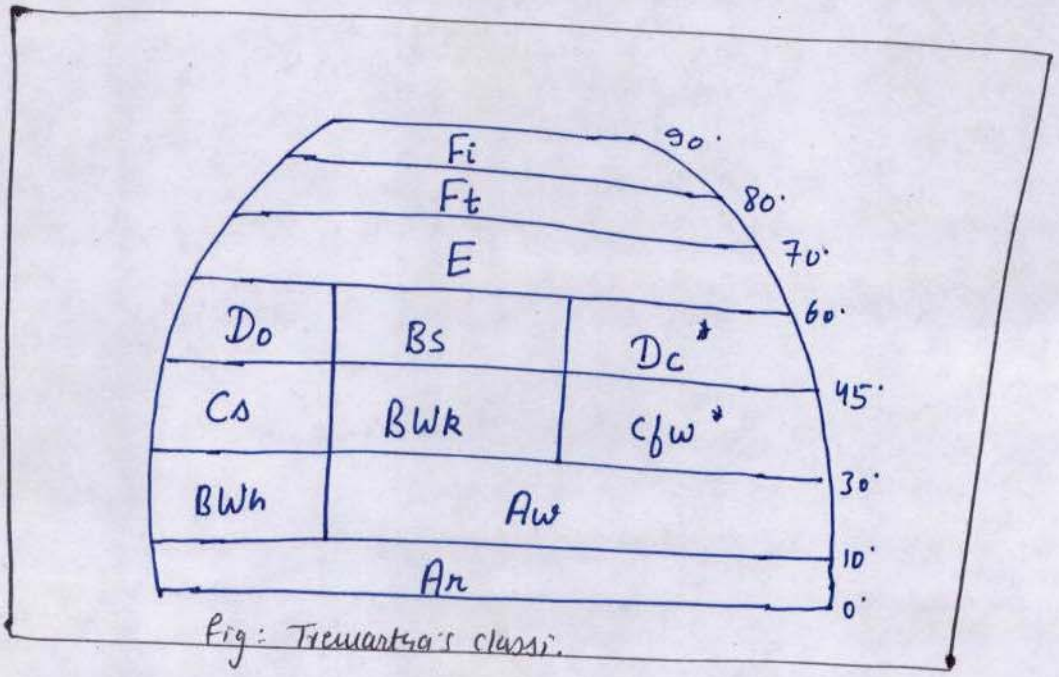


Fig: Trewartha's classi.

Ar - Tropical rainy
Cfw - Subtropical well distributed precipitation with generally dry winters
Dc - temperate continental (due to offshore westerlies throughout the year)
Do - temperate oceanic
E - Taiga
Ft - Tundra
Fi - Ice capped

* Patterns of precipitation: World

(1) WMO identifies 1000mm as the average amount of precipitation of world.

- It significantly varies in reference to four major determiners:

(a) Sign of latitude i.e. with increase in sign of latitude amount of precipitation decreases (due to decrease in temp. & specific humidity).

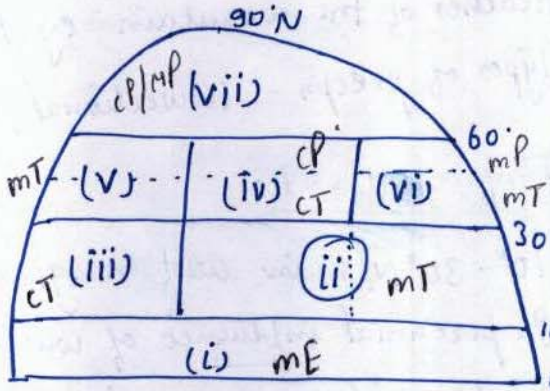
(b) Nature of circulation i.e. if the common characterstics of the atmospheric circulation is denoted with rising convection annual amount of precipitation will be higher irrespective of latitudinal location.

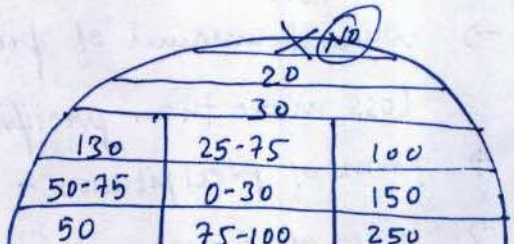
(c) Maritime & continental location i.e. maritime locations are always wetter than the continental counterpart in any given latitudinal location.

(d) Orographic barrier - it influences precipitation pattern in generation of wetter windward & drier rainshadow interior.

2] The pattern of precipitation thus is defined to include Seven precipitation regions called:

(i) Wet equatorial region.
(ii) Trade wind region.
(iii) Tropical deserts.
(iv) Mid latitude deserts & steppe
(v) Westerlies region
(vi) Moist mid latitude
(vii) Polar / Arctic region.





(i) Wet Equatorial region:

→ 10°N - 10°S as Amazon basin.
→ Perennial influence of maritime equatorial airmass (mE) with absolute instability
→ Well distributed precipitation of upto 300 cm or with rainfall maximas during equinoxes.
→ forms of precipitation - rain, drizzle, hail (snowfall in high mountaneous area e.g. Mt. Kilimanjaro)
→ Types of precpn - convectional & orographic.

[* Red sea & persian gulf don't develop cyclones due to absence of required PGF & thus coriolis force

(ii) Trade wind region:

→ 10°- 30° N/S in east margin and continental interior as India and African Savana.
→ Summer concentrated precipitation by maritime tropical airmass.
→ Amount of precpn ranging b/w 75-250 cm (increasing towards the coastal areas)
→ forms of precipitation includes Rain, drizzle & hail (snowfall in high reaches of the mountain e.g. Himalayas)
→ Types of precpn - convectional, cyclonic & orographic.

(iii) Tropical desert:

→ 10°- 30° N/S in west margins of continent as Sahara desert.
→ In perennial influence of continental tropical airmass thus arid conditions involving summer effective, erratic influence of maritime tropical airmass.
→ Annual amount of precipitation ranges b/w 25-50 cm (with evaporational loss more than precipitational gain).
→ forms of precipitation - Rain & drizzle.
→ Types of

(iv) Mid latitude desert & steppe:

→ 30°-60° in continental interiors like as Gobi desert & Eurasian steppe.
→ In the perennial influence of continental airmasses (both continental tropical (cT) & continental polar (cP)).
→ Annual amount of precepn in range of 0-75 cm, increases with increase in sign of latitude (due to dependable conditional instability)
→ forms of precepn - Rain, drizzle, Snow & sleet.
→ Types of precepn - Convectional, orographic & frontal.

(v) Westerlies region:

→ Confined in mid latitude west margins of land as Mediterannean sea and European plain.
→ Involves influence of maritime tropical airmass (mT) (in both seasonal & perennial perspective)
→ Annual amount of precepn in range of 50-130 cm increases with increase in sign of latitude alongwith becoming perennial.
→ forms of precipitation - Rain, drizzle, Snow & sleet.
→ Type of precipitation - Convectional, orographic & frontal.

(vi) Moist mid latitude:

→ Blw 30°-60° in east margins of land as Chinese & Manchurian plain.
→ Involves influence of maritime tropical (mT) & maritime polar (mP) airmasses.
→ Annual amount of precipitation in range of 100-250 cm, decreases with increase in sign of latitude (alongwith becoming seasonal that is winter specific).
→ forms of precipitation - includes Rain, drizzle, snow, sleet & glaze.
→ Type of precipitation - Convectional, frontal & orographic.

(vii) Arctic / Polar desert:

→ In the frigid zone of Northern hemisphere as Norther canada & northern Siberia.
→ The region involves conditional instability generated due to frontal mechanism (in both taiga & tundra climate)
→ Amount of precipitation decreases with increase in sign of latitude (alongwith becoming seasonal)
→ forms of precipitation is snow & glaze (no sleet as it is too cold)
→ Type of precipitation - frontal.

* Appraisal of Koppen's classification:

1] The empirical category of climatic classification scheme proposed by Koppen is utilised in every aspect of geographical studies of climatic regionalisation & utilization of these regions in variable Climate centric study.

2] Validity of this classification is also specified in both the global and larger scale analysis.

3] The classification scheme however is criticized on 3 defined basis:

(a) Use

(i) use of alphabetical symbols: This point of criticism involved 3 defined aspects as:

(a) Unclear use - this is applied in Utility of 'f' type of Climate that is denoted to represent well distributed precipitation however it do not clearly mention involved precipitation amount which include 300 cm (Af) to 30 cm (Df).

(b) Confusing use of alphabetical symbols - This is specifically applied in utilization of 3rd level alphabetical symbols (a, b, c, d) used with tropical, subtropical & temperate climate (A, C, D).
Inspite of providing defined meaning to the alphabetical symbols Koppen used them in RELATIVE REFERENCE within a given climatic category.
e.g. Dfa is warmer than Dfb.

(c) faulty use of alphabetical symbol - This is specified in the alphabetical symbol of manchurian climate (Dw) as this climatic region involves single dominant precipitation causing mechanism of arctic front that makes it remain wet during winters & dry during summer (appropriate symbol should be Ds).

(ii) Over generalization:
Empirical classification in global perspective will by default relate to certain levels of generalization. This point of criticism however relates to complete ignorance of recognisable defined climatic region involving different characterstics compared to its latitudnal location.
e.g. florida peninsula makes the excellent example that locationally may be tropical monsoonal (Am) as recognised by Koppen. However, climatologically it makes excellent example of warm & wet climate involving perennial mechanism of precipitation making it Cfa type of climate (as approached later).

Squall line, T. Cyc. Cir. Monsoon (summer) Tornadoes. ↑ winter

(iii) Koppen's classification is strongly criticized by thornthwaite in highlighting limitations of empirical classification. Thornthwaite emphasized that the ~~practical~~ practical development of different climate with same amount of precipitation cannot be explained by empirical scheme. It rather require applied category of climatic classification that takes into consideration thermal efficiency & precipitation effectiveness.

* Thornthwaite's Classification :

1) American climatologist thornthwaite attempted applied category of climatic classification originally in 1931, based on precipitation efficiency he attempted to categorise 5 humidity provinces denoted with capital alphabetical symbols and also associated it with defined type of vegetation, the outlined categories include :

Symbols	Humidity provinces	Precipitation efficiency (PE) Index	Vegetation
A	Par Moist	Maximum	Rain forest
B	Moist	↓	forest
C	Sub humid		Savanna
D	Semi Arid		Steppe
E	Arid	Minimum	Desert

2] His approach of classification scheme however could not generate the kind of support Koppen's classification scheme attained.

3] Thornthwaite continued to improve his climatic classification scheme eventually developing 1948 classification scheme (which was published in the text entitled (A Rational Approach to Climatic classification).

4) In this scheme he introduced the term Potential* EVAPOTRANSPIRATION & identified it to be the fundamental most element of weather & climate. he defined potential Evapotranspiration to represent that potential amount of moisture which gets evaporated or transpired after the attainment of moisture.

1 Synonym to precipitation

1 out moisture.

3] He advocated that potential evapotran. forms the actual determiner of available moisture in soil & air thus the determiner of prevailing climate.

4] In order to calculate potential evapotranspiration he developed four fold criterion which includes Defined level of alphabetical symbols as well.

5] The involved criterion includes:

→ Humidity provinces demarcated based on Index of moisture.
→ Thermal efficiency provinces demarcated on the basis of thermal efficiency index.
→ Seasonal variations in index of moisture
→ Seasonal variations in thermal efficiency

6] Based on these four indexes thornthwaite outlined 125 climate type out of which he could plot only 32 climates on map of world. This justifies restricted utility of thornthwaite's classification in regional climatology. This utility has more defined significance at larger scale. e.g. Climatic regionalisation of a country like India.

7] This climatic classification scheme is principally known for applied climatology that is application of climatological knowledge in the fields as:

→ Water resource managment
→ Assesement of soil moisture (with its regional seasonal variations).
→ Regional planning.
→ Town planning.
→ Rural development.

like applicable areas.

** Being an applied category of classification thornthwaite's scheme technically proves to be METHODOLOGICAL Improvement over empirical classification schemes (including that of Koppen).

* Alphabetical Symbols of Thornthwaite's classification:

I. Humidity Provinces:

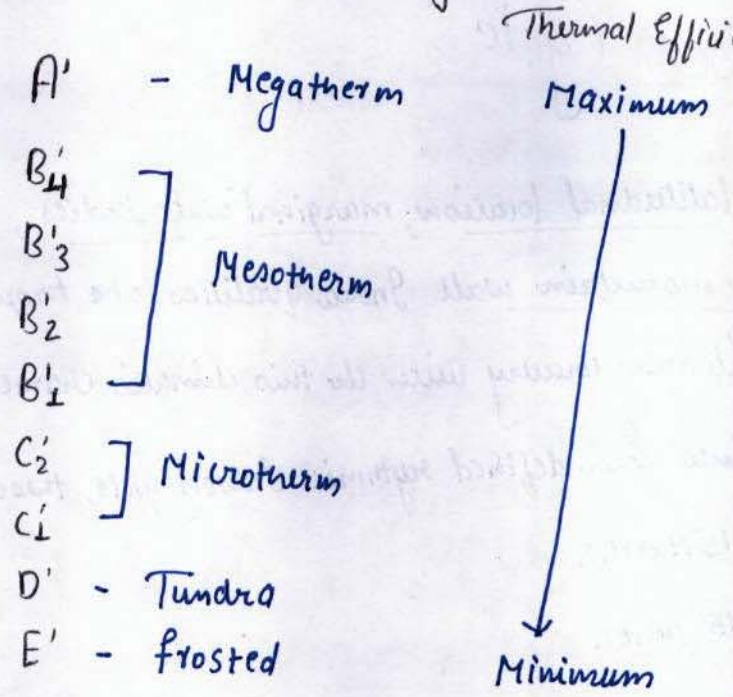
Index of Moisture

A	- Par Moist	Maximum
B_4	→ Moist	↓
B_3		
B_2		
B_1		
C_2	Moist Subhumid	
C_1	dry Subhumid	
D	Semi Arid	
E	Arid	Minimum

III Seasonal variations (Humidity provinces)

	Aridity Index (Humid climate)	Humidity Index (Arid climate)
A		
B_4		
B_3	r - No deficit	d - No surplus
B_2	s Minor Summer deficit	s Minor winter ~~defic~~ Surplus
B_1	w Minor winter deficit	w Minor Summer Surplus
C_2	s_2 Major Summer deficit	s_2 Major winter Surplus
C_1	w_2 Major winter deficit	w_2 Major & Summer Surplus
D		
E	A, B_4, B_3, B_2, B_1, C_2	C_1, D, E

II Thermal Efficiency Provinces:



IV Seasonal variation Thermal Efficiency Provinces:

Percentage Concentration of annual thermal efficiency during Summers (Shorter the duration of Summers more will be the concentration of TE).