Geography

By Neetu Singh

Vol-2

2014

1. Geomorphology
2. climatology
3. oceanography

CLIMATOLOGY

1) Insolation
2) Temperature
3) Pressure & Global Circulation
   * Monsoonal mechanisms*
   * Jet Streams*
Atmospheric moisture
   * Hydrological Cycle
   * Precipitation : Types & Distribution
Cyclones*
   * Tropical & Temperate
Air masses*
Climatic classification
   * Koppen
   * Trewartha
   * Thornthwaite

Atmosphere (Realm of Air)

Composition

Gases

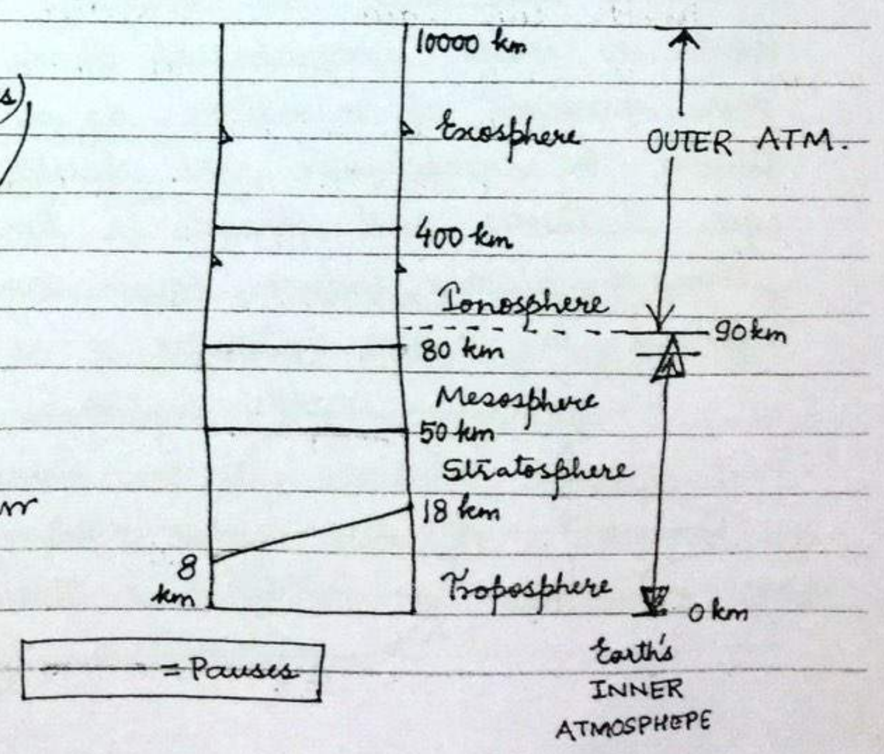
- ajor ($,O_2$)
  X
- Trace
  - CO_2
  - O_3
  - W.V.

Aerosols (Dust Particles)

INACTIVE
No role in
veather
nechanisms

ACTIVE
- Stable
  - CO_2
  - O_3
- Variable
  - Water Vapourr
  - Aerosol

Structure



Earth's shape: Oblate Ellipsoid

[149.6 M km]

ENSOLATION: INCOMING SOLAR RADIATION

. Earth's System is completely dependent on the sun for requirement of heat and light. The total amount heat energy emitted from the surface of sun is lled solar radiation. Small amount of solar radiation t is received by the Earth's system because of the tance b/w the 2 celestial bodies is called insolation. amount of insolation received by Earth's system is gely constant (with minor exceptions generated during ihelion and Aphelion positions). However, the distribution insolation significantly varies. Among the factors that gulates the distribution of insolation:

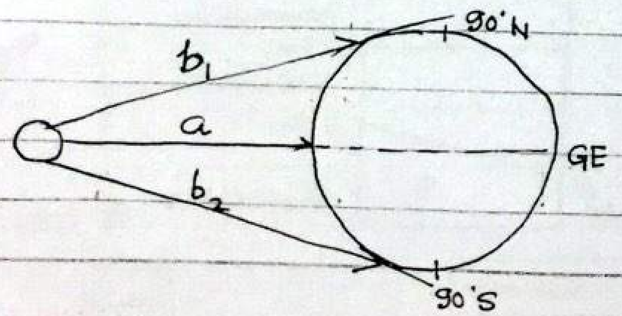
Angle of sun rays

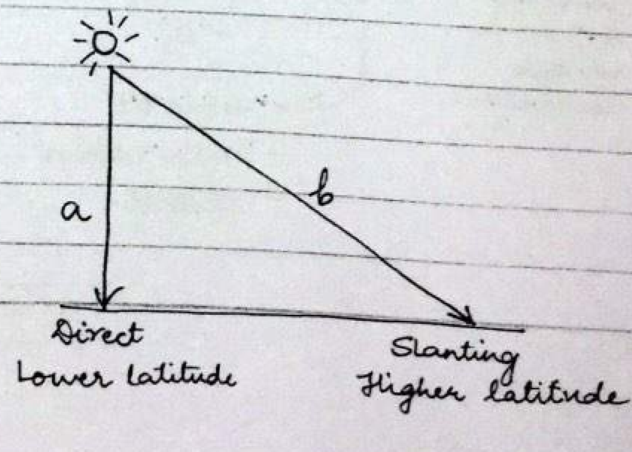
Season Cycles

Atmospheric influence, are included

gle of sun's rays: In reference to the shape of planet th, it receives 2 distinctive types of angle of sun rays ect and slanting.

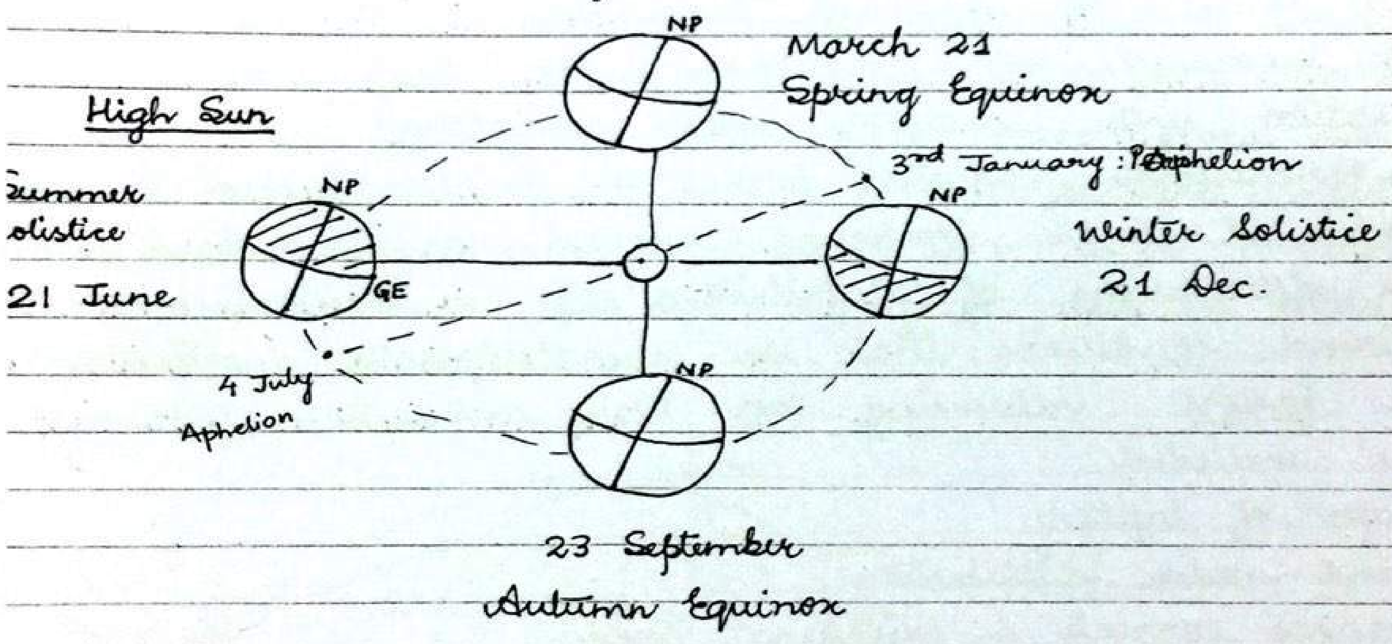
direct sun rays, as travelled less distance and eads in lesser geographical space, it always induces gher amount of insolation as is experienced in lower titudes. In comparision, the slanting sun rays travels rger distances and spreads in larger geographical space , therefore, always induces lower amount of insolation as erienced in higher latitudes.





Plane of the ecliptic

Season Cycle : Axial inclination of the earth and its revolution around the sun causes the shift of thermal equator or high sun. It is this shift that creates reversal of seasons between the hemispheres representing unequal distribution of insolation. In accordance to the season cycles, from Spring Equinox (21 March) to Autumn Equinox (23 Sep), the Northern Hemisphere experiences high sun seasons with 21 June being Summer Solstice. In accordance southern hemisphere experiences high sun seasons from Autumn Equinox i.e 23 Sep to Spring Equinox i.e 21 March with 21st December being the winter solistice



) **Role of atmosphere:** The active variable constituents of atmosphere induces local to regional levels of effectivity in the distribution of insolation. The atmospheric influence includes: scattering carried on by aerosols, absorption carried on by water vapour and reflection carried on by clouds which results in wastage of incoming solar radiation influencing its distribution.

Jarch 2014

Lecture # 19

2. ATMOSPHERIC TEMPERATURE

Perehelion : Nearest (147 Mkm) ⇒ On or near January 3.
Aphelion : Farthest (152 Mkm) ⇒ On or near July 4.

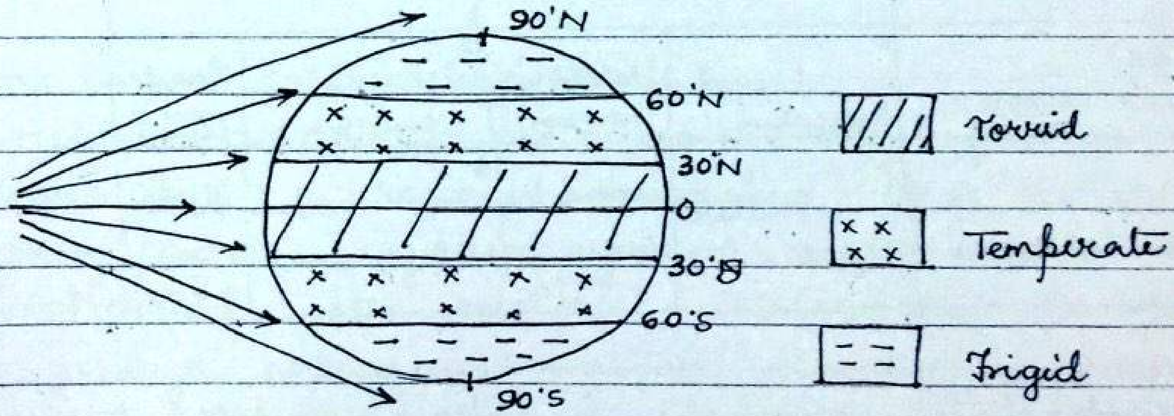
amount of heat present in the atmosphere is fined to be air temperature, atmospheric temp. or mply temp. It is an identified fundamental element of weather and climate which is regulated by incoming olar radiation and in turn regulates atmospheric ressure. The principle source of atmospheric temp. is utgoing long wave terrestrial radiation whereas coming short wave solar radiation forms the condary source. However, in the light of the fact that e source of terrestrial radiation is also the ~~source~~ f inconning solar radiation, atm temp has direct lation with incoming solar radiation.

the terrestrial radiation forms the prinple source of atm. mp., it is the prevailing ground conditions that forms determiners of distribution of air temp. Among the ound conditions, that are climatologically recognised as factors incluencing air temp. distribution, following e included :

ign of latitude
and-water distribution
ceanic currents & prevailing winds
oud cover, and
titude or height

: Sign of Latitude

With geographical equator dividing planet earth into two equal parts called northern & southern hemisphere with each one incorporating 90 degrees of latitude, Climatologically, lower latitude that is proximate to equator & higher latitude that is proximate to poles are distinguished. With ↑ in the sign of latitude, atmospheric temperature continuously decrease because of the decrease in the amount of received insolation. This reln b/w latitude & temperature was analysed by pre-historic contributors: Greek scholars. They recognised 5 thermal zones. The torrid zone, extensive b/w 30°N to 30°S, forms the lowest latitudinal thermal zones with highest temperature. The frigid zones b/w 60° to 90°N & 60° to 90°S forms the highest latitudinal zones, thus have lowest atmospheric temperatures. In b/w these 2 extremes, are temperate zones, that is 30° to 60°N & 30° to 60°S with moderate temp. conditions thro'out the year with its middle latitudinal location



"5" Thermal Zones given by Greek Scholars

Land-Water Distribution

he approach of thermal zones represents absolute validity , describing latitudinal distribution of temperature. It is, owever, based on the perception that surface of the arth have homogenous relief. In practicality, maximum of Earth's surface involves unequal distribution of land and water, with these reliefs revealing different temp conditions. In a given sign of latitude, water, primarily ue to its mobility and translucent characteristics, naintains the temperature whereas land always depicts xtreme. It is in the effect of this factor that horizontal listribution of temperature in regional perspective stand synonym to "temperature anamoly". It is defined to e deviations from normal projected temperature in any given sign of latitude. It involves positive anamoly that is more than normal and negative anamoly i.e. less than normal.

Temperature Anamoly

	+ve		−ve	
0–45° Lower Latitude	* Land (High Sun)	Water (Low Sun)	* Water (High Sun)	Land (Low Sun)
45–90° Higher Latitude	* Water (High Sun)	Land (Low Sun)	* Land (High Sun)	Water (Low Sun)

e temperature anamoly is also correlated to the revailing season cycles where during high sun asons land develops +ve temp. anamoly compared to e neighbouring water & therefore, during low sun season and develops −ve temp. anamoly compared to neighbouring water.

NCERT — Isothermal Maps of World Physical

The characteristics of temperature anamoly is depicted on the map of world in the analysis of "isothermal patterns". Isotherms are imaginary lines drawn to join the places having the same temperature. These are drawn parallel to the latitude and are recognised with some of the typical characteristics of the patterns that depicts anamoly. With the change in the relief, that is, along the shoreline, isotherms always develops bends which by itself justifies that land and water in a given sign of latitude do not develop same temperature. The nature of bends varies in accordance to the prevailing seasons as well as the transition of the relief. ~~As~~ for example, summer isotherm traced from land to water will always show bend towards equator whereas winter isotherm traced from land to water will always bend towards poles.

Season
Relief transition } Nature of bends

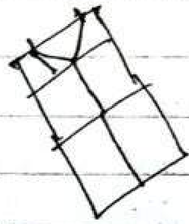
3) Oceanic Currents & Prevailing Winds :

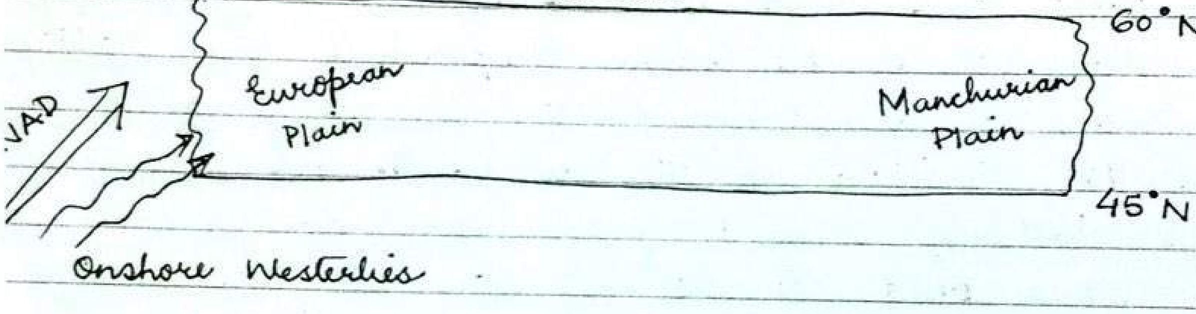
The oceanic currents & prevailing winds influences atmospheric temp. in regional perspective. It is in the effect of warm oceanic current called north Atlantic Drift (NAD) combined with onshore westerlies that European plains always experiences warmer climatic conditions than the similar latitudinal eastern counterpart Manchurian Plains. Beyond this perennial example, significant seasonal example correlates to BLIZZARDS, the cold polar winds accompanied with powdery snow which makes lower latitudinal USA experience polar climate during winters.

Cloud Cover

t still more local levels, atmospheric temperature is also influenced by cloud cover. It is in the effect of this factor that daytime temperature is decreased nd night temperatures increases.

eather & Climate → Only troposphere
tmospheric temp. → Troposphere + Stratosphere

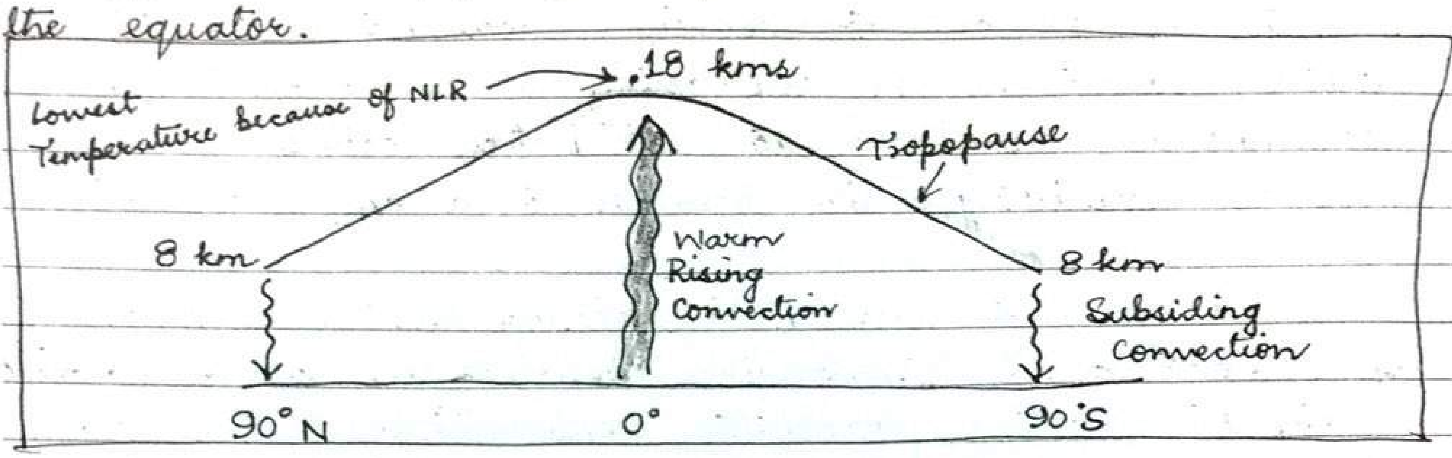




VERTICAL DISTRIBUTION OF TEMP. (HEIGHT / ALTITUDE)

ffect of height or altitude on atmospheric temp. s the fundamental element of weather and climate that it decreases with ↑ in height thro'out troposphere t the rate of 6.5 °C / km of rise called normal apse rate (NAR) or environmental lapse rate. This ↓ of mperature is simply attributed to increasing distance rom the source of atmospheric temperature i.e. terrestrial adiation. The vertical distribution of temperature in roposphere also provides the base to identify variable eight of tropopause at near equator and poles.
t is warm rising convection that makes the height of ropopause higher at equator (18 kms) and it is ubsiding convection that makes the height of tropopause

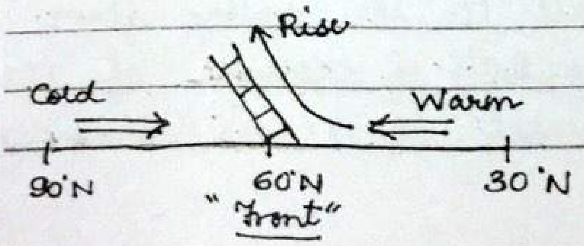
lower i.e. 8 kms over the poles. In the application of NLR, the lowest tropopause temperature is thus recorded over the equator.

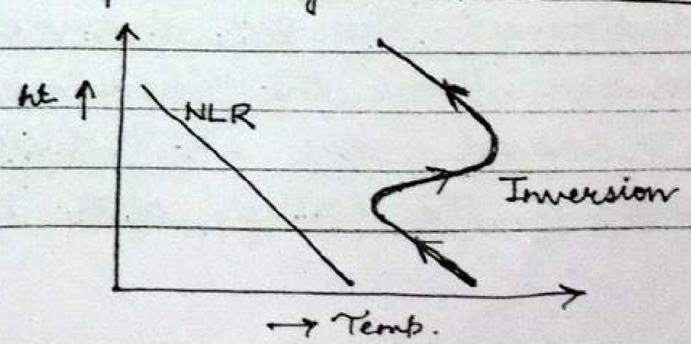


> In troposphere under certain conditions, atmospheric temperature ↑ with ↑ height. Such condition are recognised to be temperature inversion. The specific & reoccuring conditions that generates temperature inversion includes:

i) Air convergence
ii) Adiabatic changes
iii) Air drainage

i) Air Convergence: The factor of air convergence is reoccuring in the mid-latitude at near 60th parallel where reoccuring convergence of cold and warm air columns generates most prominent climatological front. It is along this front, rise of warm air column generates temperature inversion, which forms the preliminary condition for temperate cyclonic circulation.





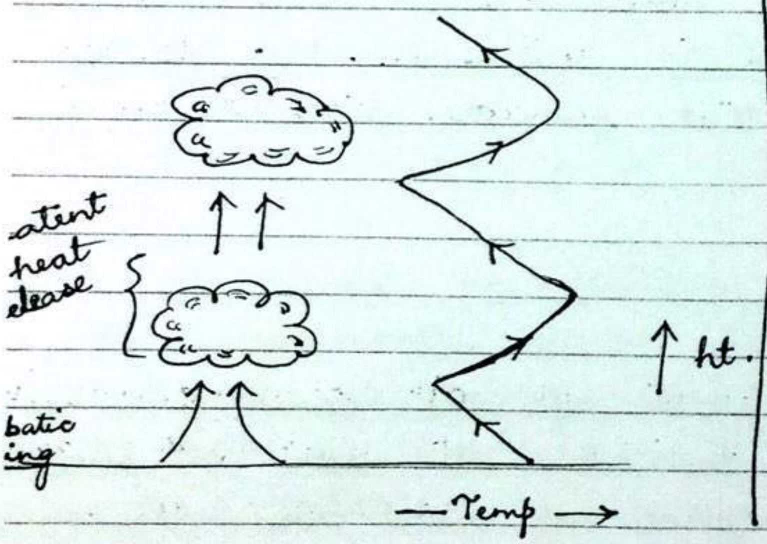
Air : Poor Conductor of heat

Fog : Near ground cloud

diabatic changes

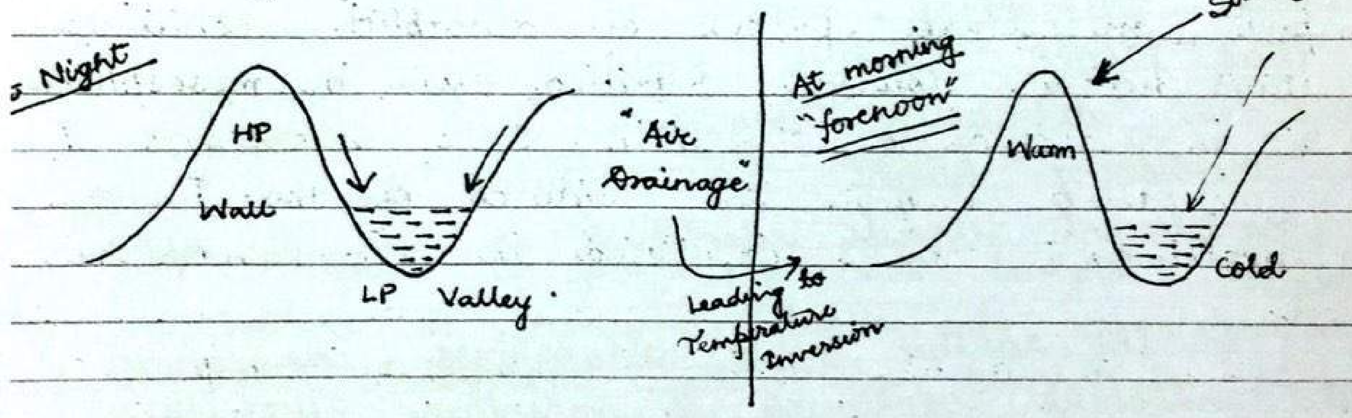
he adiabatic change in air temperature is defined to the change due to vertical movements rather than ctual addition or subtraction of heat. Rising air olumns are subjected to adiabatic cooling effect hereas subsiding air column to adiabatic warming ffect.

It is with adiabatic cooling that reoccuring ulti-altitudinal temperature inversion is generated as diabatic cooling facilitates condensation that marks e release of latent heat of condensation generating nversion.



Air Drainage:

the mountainous regions, with tall peaks & deep valleys, ir drainage related inversion is the common daily development. The air drainage i.e. movement of air olumn from the mountain wall to the valley floor caused due to differential rate of cooling of the vall & the valley after the sunset. It is air drainage that facilitates accumulation of air column in the valley floor to be eventually cooled down with the advancement of night. Such cold accumulated air column in the valley floor combined with heated mountain wall in the forenoon hours of subsequent day generates temp inversion. It is this reoccuring temperature inversion that facilitates mountain walls experiencing favourable penetration of sun rays. Thus, the commercial utilisation in terms of settlement or agricultural development, air drainage related inversion though is experienced throughout the year, it evolves <u>strong characteristics</u> during winters with long nights when is combined with absence of cloud cover and wind.



<u>Vertical distribution of T : Write about T-Inversion</u>

te
: March 2014

Lecture # 20

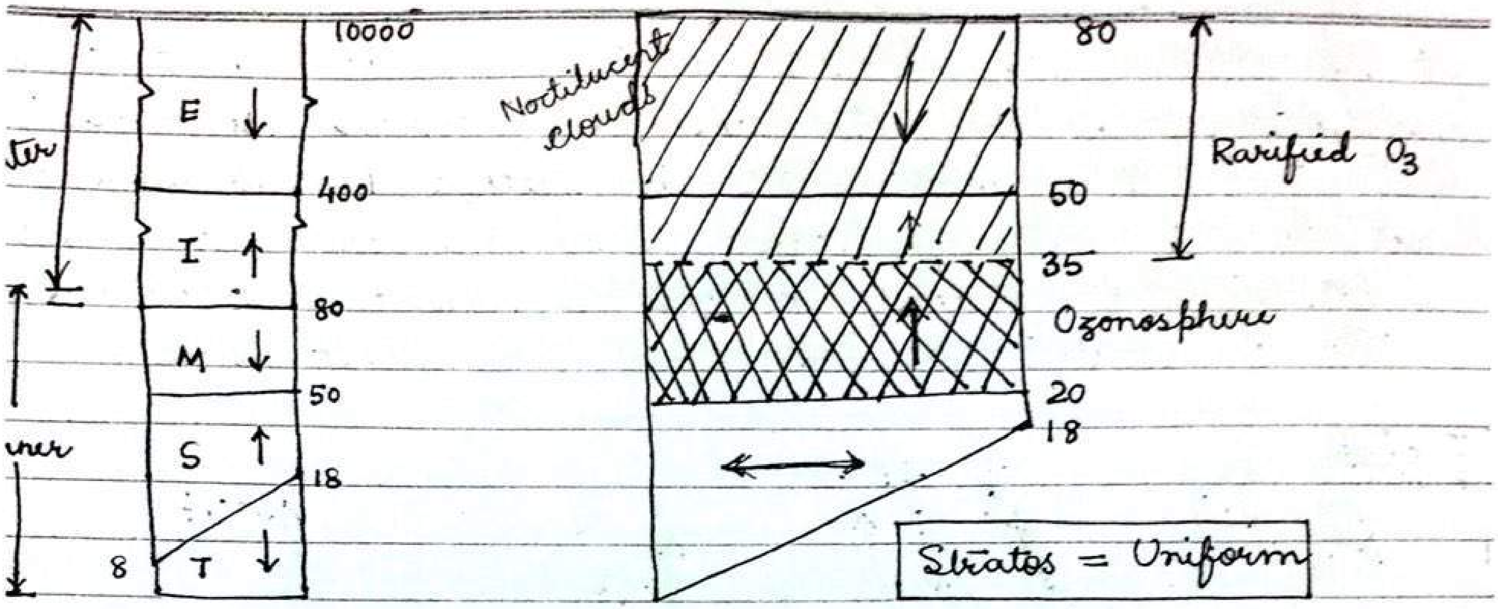
Cloudy Day : T ↓
Cloudy Night : T ↑

HP ⟶ LP (wind)

'EMPERATURE REQD. IN OTHER ATM. LAYERS :
eyond tropopause, atmospheric temperature depicts egular alternating sequence of temperature increase nd decrease due to different set of factors.

In stratosphere, temperature prominently reases with increasing height due to the effective sorption carried on by ozone. It is within this layer at natural densest concentration of ozone called zonosphere is confined (20-35 kms). As the naturally ccuring ozone prevails till the height of 80 km i.e. omplete mesosphere process of absorbtion continues l that height. However, rarified ozone in mesosphere sults in decreasing absorbtion. Thus, decreasing T ith increasing height. The evidence of low T are e noctilucent clouds identified in this atmospheric ayer.

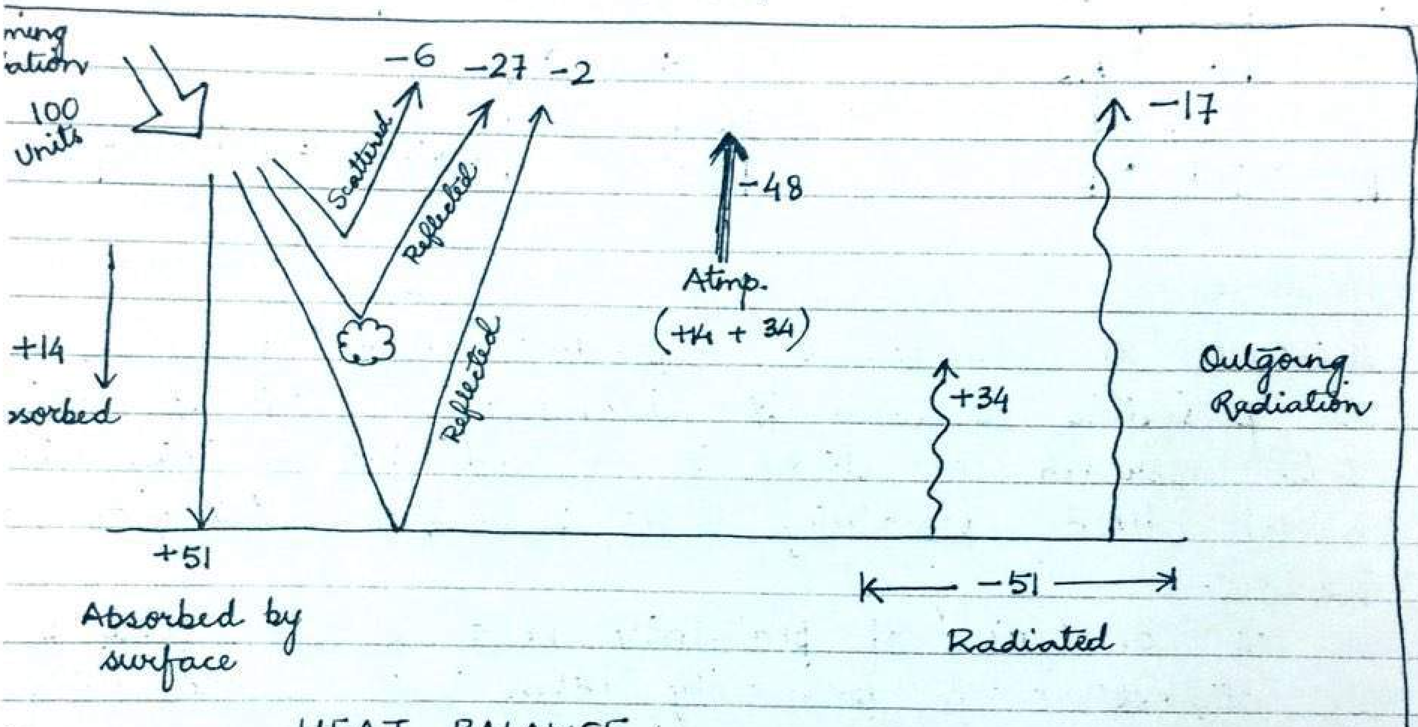
In the earth's outer atmosphere, ionosphere nd exosphere continues to maintain alternating sequence of temperature change where, in ionosphere lectrically charged particles called ions forms the cause of increasing T with increasing height. Whereas eyond 400 kms i.e. in exosphere rarified air marks ↓ in T effectivity with ↑ height.



HEAT BUDGET / HEAT BALANCE

Analysis of atmospheric temperature also correlates to the persisting balance b/w incoming & outgoing radiation. This approach of study is divided into 2 interrelated levels called planetary heat budget & latitudinal heat budget.

In the analysis of planetary heat budget, role played by atmosphere is primarily taken into consideration wherein the atmosphere acting as blanket for planet earth restricts both incoming solar radiation as well as outgoing terrestrial radiation in maintaining the balance between insolation & terrestrial radiation. For the incoming solar radiation though atmosphere plays to a near transparent medium, significant amount is wasted as reflection by cloud cover & scattering by aerosols. Moreover, minor amount is absorbed as well by ozone leading to slightly more than half of incoming solar radiation reaching the earth's surface. It is this role played by atmosphere that restricts the of daytime T. During night, as surface of the Earth radiates back all the absorbed incoming solar radiation it is major part that is blocked by atmospheric constituents like CO_2 called greenhouse gases. It is this blocking that makes atmosphere regulate decrease of night T sustaining habitability of planet earth.



HEAT BALANCE

The planetary heat budget significantly includes the effectivity of global circulation which helps in maintaining <u>latitudinal heat budget</u>. The lower latitudes receiving higher amount of insolation compared to higher latitudes are not developed as <u>heat surplus zones</u> because of the transfer of heat & latitudinal mixing by <u>Global Circulation</u>. There are 2 dimensions of global circulation: (i) Atmospheric circulation & (ii) Gyre Circulation (Oceanic current Systems).

ATMOSPHERIC PRESSURE & GLOBAL CIRCULATION :

The atmospheric pressure or air pressure forms the element of weather & climate that regulates and is regulated by global circulation. It is defined to be the weight ~~of~~ exerted by air column on the earth surface. It is classified into 2 distinctive types of systems which are:

1) LP systems and
2) HP "

The low pressure system represents lesser weight exerted by air column on the earth's surface. It correlates to rising convection which includes both thermal direct and thermal indirect. In terms of geographical sizes, LP systems are classified as troughs and cyclones. The troughs represent bigger LP systems whereas cyclones represent smaller systems.

The HP systems represent higher weight exerted by air column on the earth's surface. It correlates to subsiding convection which includes thermal direct and thermat indirect types. In terms of geographical sizes, the HP systems are classified as Wedges & Anticyclones wherein the wedges represent bigger sized HP systems and anticyclones smaller sized HP systems

The atmospheric pressure in the global perspective of climatological studies is analysed only in horizontal account. In the vertical perspective, each air column represents the distinction in the nature of changing pressure profile. At the mean sea level, the atmospheric ressure is 1013.25 millibars. The horizontal profile of air pressure analysed latitudinally reveals the revalence of 7 pressure belts. Out of these, 3 ressure belts are thermal direct and 4 are thermal ndirect. All these pressure belts represents dynamic atitudinal locations due to apparent shift of sun. oreover, in the effect of unequal land-water distribution ey involve combination of belts as well as ellular profile.

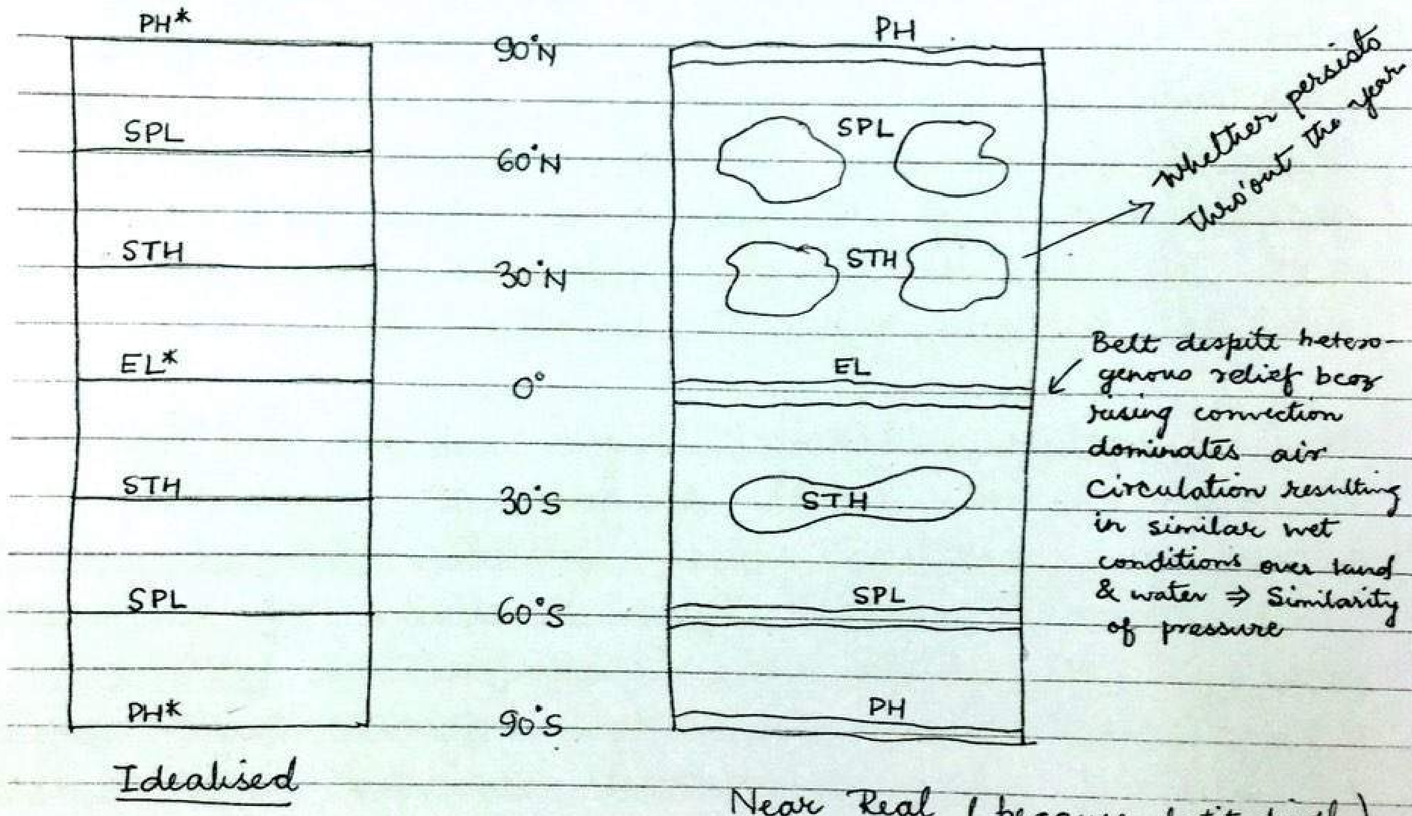


FIGURE : Horizontal Distribution of air pressure

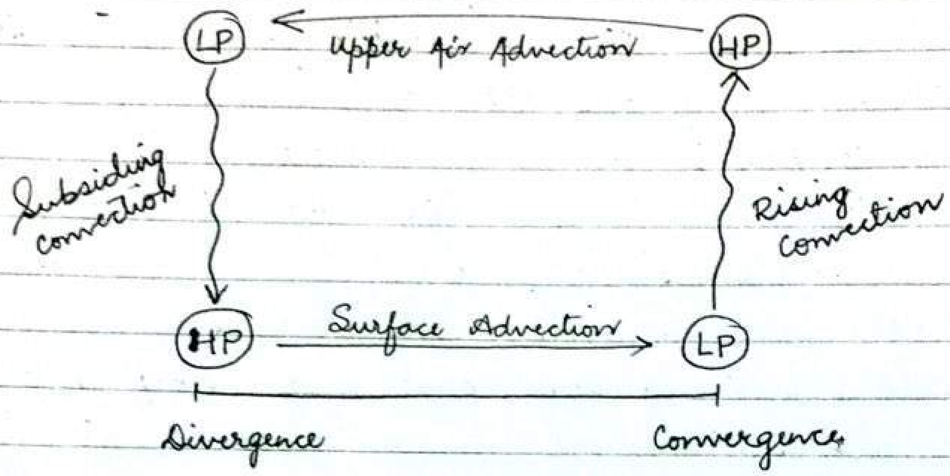
gh Sun, STH	Low Sun, SPL	Distinct Cells in STH & SPL
Hawaiian High in Pacific	⇒ Aleutian Low in Pacific	
& Azores High in Atlantic	& Icelandic Low in Atlantic	
Bcoz Land +ve T-Anamoly	⇒ Bcoz land −ve T-Anamoly	

Polar high of both northern & southern hemisphere & sub-polar low of southern hemisphere forms continuous pressure belts because of homogeneity of relief. The equatorial low also forms the continuous pressure belt inspite of heterogeneity in relief because in this location rising convection dominates the air circulation resulting in similar wet conditions over land and water, thus, similarity of pressure. The subtropical high of southern hemisphere represents unique profile of being near cellular as unequal distribution of land and water is combined with dominance of water bodies. The true cellular characteristics, therefore, is identified with sub-tropical high and sub-polar low of northern hemisphere. The elementary cause of cellular characteristics for both these thermal indirect pressure is unequal land-water distribution.

The subtropical high generates absolute cellular characteristics during high sun seasons when the tropical landmasses generates positive temperature anamoly & thus, low pressure. The well defined cells developed in open oceans are called Hawaiian High in Pacific Ocean & Azores High in Atlantic Ocean. In comparision, the sub-polar low generates absolute cellular characteristics during low sun seasons when the temperate landmasses generates negative temperature anamoly. The well developed LP cells in the open water bodies includes Aleutian Low of Pacific Ocean & Icelandic Low of Atlantic Ocean.

'WIND'

ADVECTION :



e cause and effect interrelation between atmospheric ressure and global circulation relates to the fact that rtical movement of air, called convection, generates essure difference with every rising convection nerating LP on ground and HP vertically over and ery subsiding convection generating HP on ground and vertically over. This generated pressure difference rms the cause of advection. Advection is defined be horizontal movement of air, also called wind. the advective movement is compensatory movement f the generated pressure difference, it always moves rom HP to LP which makes every HP divergence zone nd every LP convergence zone. The advective novements are boldly classified :

WIND

- Surface
  - Prevailing
  - Seasonal winds (Monsoonal)
  - Local
- Upper Air
  - Polar Night Jet
  - Polar Front Jet
  - Subtropical Jet

Date
9th March 2014

Lecture 21

Global circulation : Atmospheric & Gyre both

FACTORS AFFECTING WIND/ ADVECTION:

Horizontal movement of air, wind, is influenced by 3 distinctive forces called pressure gradient force, coriolis force & friction force. The pressure gradient force forms the genesis / ~~force~~ source force of wind as it is the ΔP developed due to convective movement that facilitates the origin of advective movement with wind always moving from HP to LP. The pressure gradient force determines wind direction and it is in accordance to the direction from where the wind moves, the name of the wind is given. Additionally, pressure gradient force i.e. rate of change of pressure also forms the determiners of wind velocity. This rate of change is also called barometric slope or gradient with steeper slope facilitating higher wind velocity.

The coriolis force is the deflective force. For every moving entity on the surface of spinning Earth this force is applicable. The effect of deflective force is best interpreted as Ferrel's Law according to which moving wind gets deflected to its right in Northern hemisphere & left in southern hemisphere. In accordance this force influences only one property of wind i.e. wind direction. It however is influenced by sign of latitude & wind velocity. With ↑ in the sign of latitude coriolis deflection ↑.

Sign of latitude	
0°	– 0%
30°	– 50%
60°	– 86.6%
90°	– 100%

Similarly, with ↑ in the wind velocity coriolis deflection ↑.

The frictional force: It is the ag effect that the surface features induces on orizontal movement of air. This force influences nly the surface winds modifying both its direction nd velocity. The effect of frictional drag on advection as analysed by Ekman and the analysis, therefore, s prominently referred as Ekman's Spiral Effect, which ncludes Veering (Clockwise) and Backing (Counter-clockwise) ffects. Importance of frictional force is in distinguishing surface gradient winds and upper air Geostrophic winds.

PREVAILING WINDS:

he planetary wind movement recognised with permanent haracteristics forms the most prominent surface wind ategory regulated by pressure gradient force, coriolis force and frictional drag. These winds always represent to be the examples of gradient winds. Demarcated in latitudinal profile which is regulated y prevailing pressure belts, the prevailing winds are distinguished as:

(I) Trade Winds
(II) Westerlies
(III) Polar Winds

Surface Gradient Winds ⇒ PGF + FF + CF
Geostrophic Winds ⇒ PGF + CF

) THE TRADE WINDS

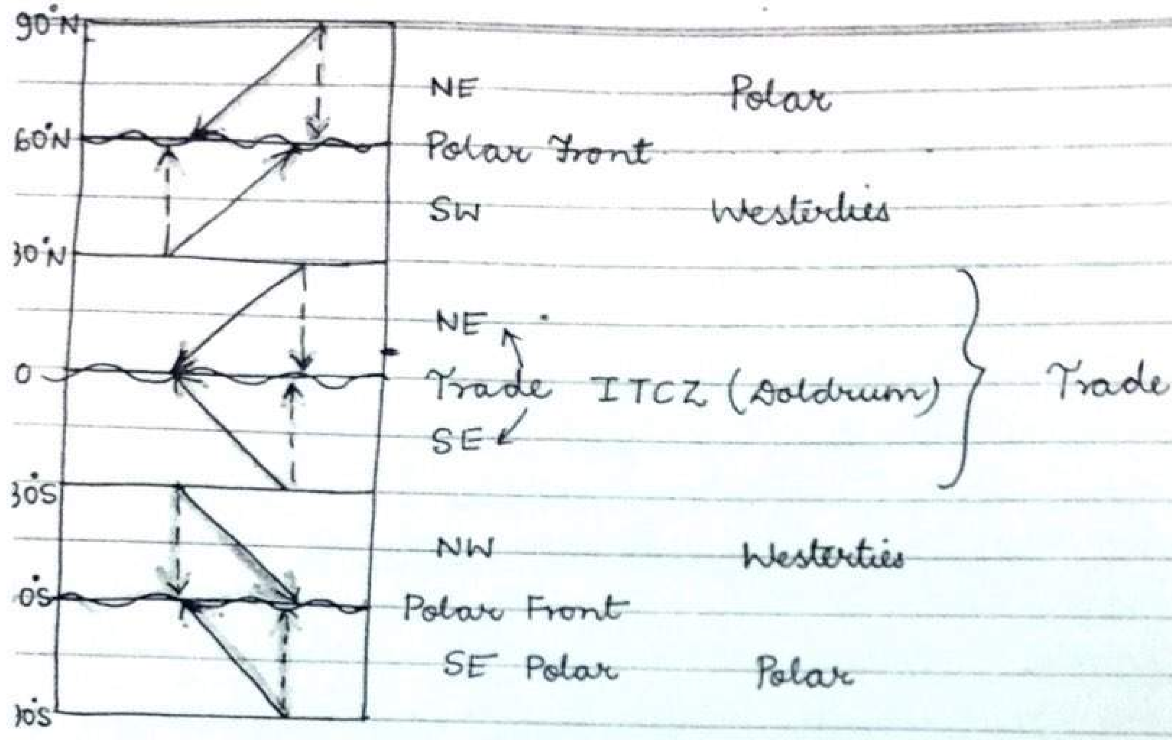
These are the lowest latitudinal prevailing winds that moves from sub-tropical highs to equatorial low. It is NE trade in Northern hemisphere & SE Trade in southern hemisphere. They correlate to the development of inter tropical convergence zone (ITCZ) which regulates monsoonal mechanisms. At equatorial belt, these winds also correlate to the development of Doldrums i.e. quiet zone with complete absence of advective movement regulating equatorial climate.

) WESTERLIES

These are the middle latitudinal planetary winds that are effective in between thermal indirect pressure belts. These are SW westerlies in northern hemisphere and NW westerlies in southern hemisphere. It is these winds that are known to be developing polar fronts which regulates the precipitation pattern of entire middle to high latitudes including temperate cyclonic circulations of northern hemisphere. It is NW westerlies that are also identified to be highest velocity prevailing winds. It is because of less frictional drag.

) POLAR WINDS

These are the highest latitudinal prevailing winds moving from polar highs to sub-polar low. These are NE polar winds in northern hemisphere and SE polar winds in southern hemisphere. Climatologically, these winds generates polar fronts in convergence with westerlies.



---> Direction of pressure gradient

——> Actual direction of winds (PGF + Coriolis Effect)

..ICELLULAR MERIDIONAL CIRCULATION :

..e classical approach of atmospheric circulation ..udies have been oriented towards demarcating ..urface advection and upper air counterpart as ..radient winds. This orientation of study attempts ..o highlight development of 3 cells in the ..eridional dimensions in each hemisphere. In each ..f the cell, every surface wind is recognised with ..pposite flowing upper air counterpart called anti-winds. ..he demarcated cells includes :

Theo (i) Hadley Cell

(ii) Flohn Cell

(iii) Polar Cell

..e **Hadley Cell** is the lowest latitudinal cell developed ..etween equatorial low and sub-tropical high. As its genesis is correlated to rising convection of warm air in the equatorial belt, ~~st~~ it is called thermal direct cell. This cell is comprised of NE Trades, antitrade as advective movement with rising convection at equatorial belt and subsiding convection at STH as parts of circulation. Weather effectivity that is correlated to Hadley cell includes wetter weather conditions in equatorial regions and dry conditions in sub-tropics.

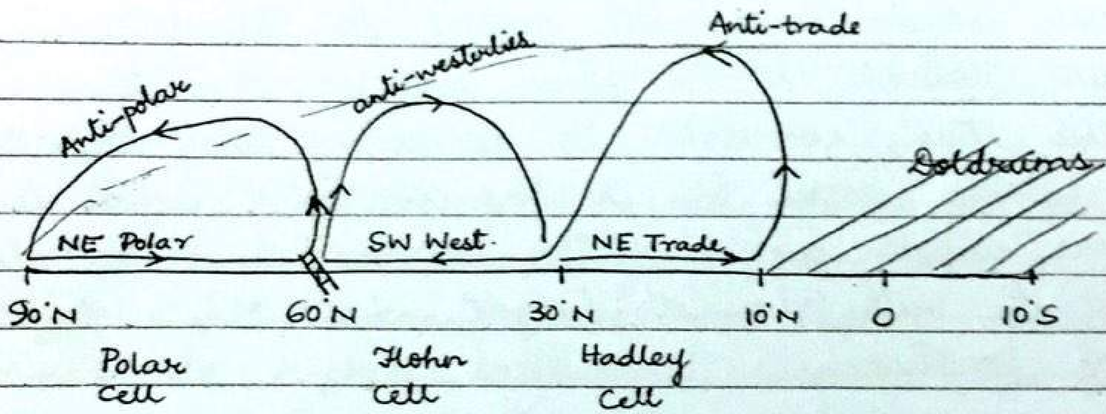
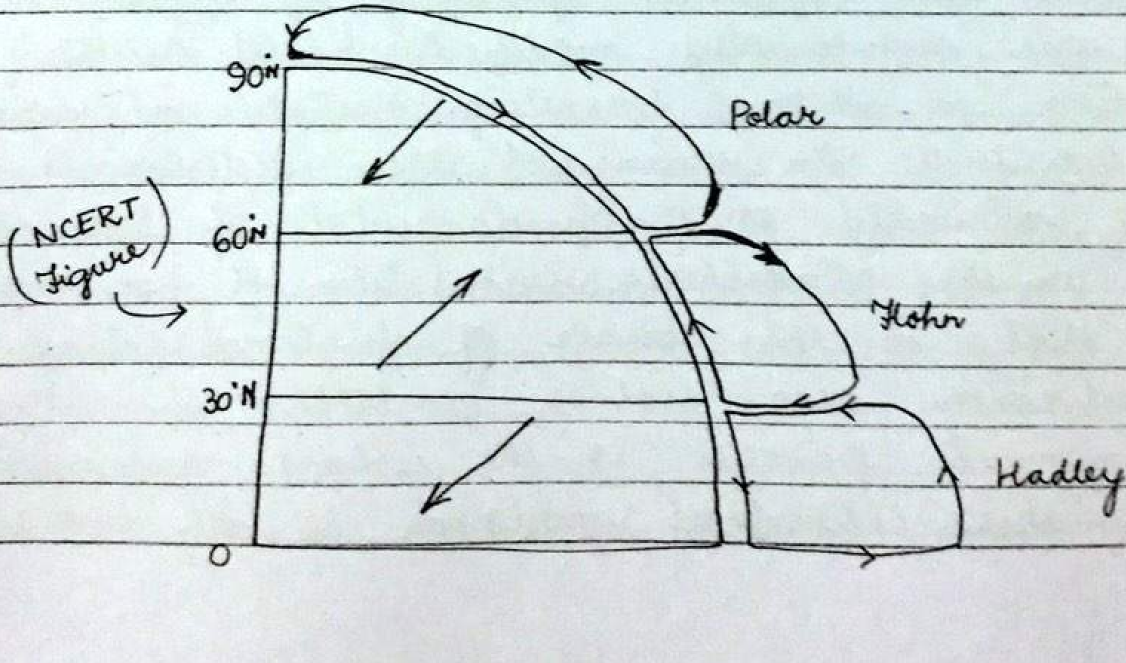


Figure: Tri-cellular Meridional Circulation



e Ferrel Cell is the mid-latitudinal thermal indirect
ll which correlates to sub-tropical high & sub-polar
w pressure belts. This cell is comprised of south
estern (SW) westerlies and anti-westerlies as advective
movements and having subsiding convection at sub-tropical
igh and rising convection at sub-polar low. It
orrelates, therefore, to the prevailing wet conditions in
e temperate latitude along with dry conditions in
ub-tropics.

he polar cells: It is the highest latitudinal thermal
lirect cell which owes its genesis to the subsiding
old air column in the polar region. This thermal
irect cell, thus, correlates to prevailing dry conditions
n the polar areas. It involves NE polar winds and
nti-polar winds as advective movements. It is also
haracterised with lowest height due to its highest
atitudinal location.

JET STREAMS (GEOSTROPHIC FLOW)

ost 1945, the approach of study of upper air
wind was significantly modified based on the
ealisation of strong prevailing westerlies at near
ropopause level. The genesis of these westerlies is
argely attributed to the fundamentals of pressure
rofile in the atmospheric circulation. It, however,
adds that in the absence of frictional drag upper
air advection also evolves geostrophic characteristics
e. movements parallel to the isobars. These geostrophic
flow makes latitudinal garlands in both northern &

southern hemispheres barring the exception of equatorial belt (no coriolis force). It is, therefore, that six different garland systems are identified in the global profile. The fast moving centres of these geostrophic flow are called jet-streams. Jet Streams are completely missing in southern hemisphere because of the dominance of water, making these fast moving tropopause winds confined in northern hemisphere. In accordance to their locations these are distinguished as:

(I) Polar Night Jet — Latitude, thermal direct, tropopause
(II) Sub-tropical Jet — Highest isobaric level
(III) Polar Front Jet — Smallest garland
* Complete absence of Rossby waves

) POLAR NIGHT JET

It is highest latitudinal thermal direct jet stream which flows at lowest tropopause level (8 kms) and it is therefore that this jet stream moves at highest isobaric level. Applicable to highest latitudinal location, this jet stream forms smallest garland with complete absence of Rossby wave characteristics as there is complete absence of climatological difference b/w land and water beyond 60th parallel. This jet stream induces DRY weather conditions in the polar area. It is the perennial jet stream which is named as night jet as during six continuous months of north-polar nights, this jet stream attains maximum latitudinal expanse (60 - 90°) and attains highest velocity (more than 300 kmph).

) SUB-TROPICAL

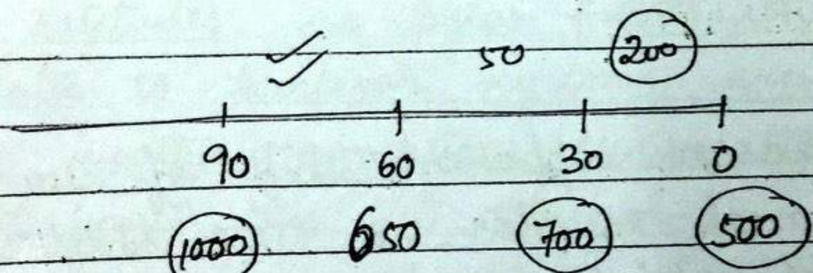
It is the lowest latitudinal thermal direct jet stream.

LP — Disturbances
HP — Stability

{Mid East : West Asia wrt. USA
Mid West : wrt. India
South West Asia : Global}

which flows at highest tropopause level - from among the permanent jet streams (12 – 15 km) and it is therefore this jet stream moves at lowest isobaric level. This jet stream forms largest garland system with most developed Rossby waves representing unequal distribution of land and water. In the specific altitude i.e 10 to 30 - 35° degrees this jet stream correlates its genesis to the thermal rise in equatorial belt. Its weather effectivity, however, is inducing dry weather conditions in the global dimensions. [During winters, in small part of SW Asia and South Asia, this jet stream causes precipitation by blocking and transporting western disturbances which originates in Mediterranean Sea.]

1) Exceptional bend of ITCZ ⇒ Tropical Easterly Jet
2) Polar Front Jet
3) Modified Hadley Cell
4) Temperate Cyclonic Circulations.
5) Monsoonal Winds / Mechanisms
6) Hadley's Thermal Concept
7) Rossby Waves
8) ITCZ Bend Concept by Flohn
9) MONEX
10) Role played by Tibetan Plateau
11) Generation of N-S Alignment

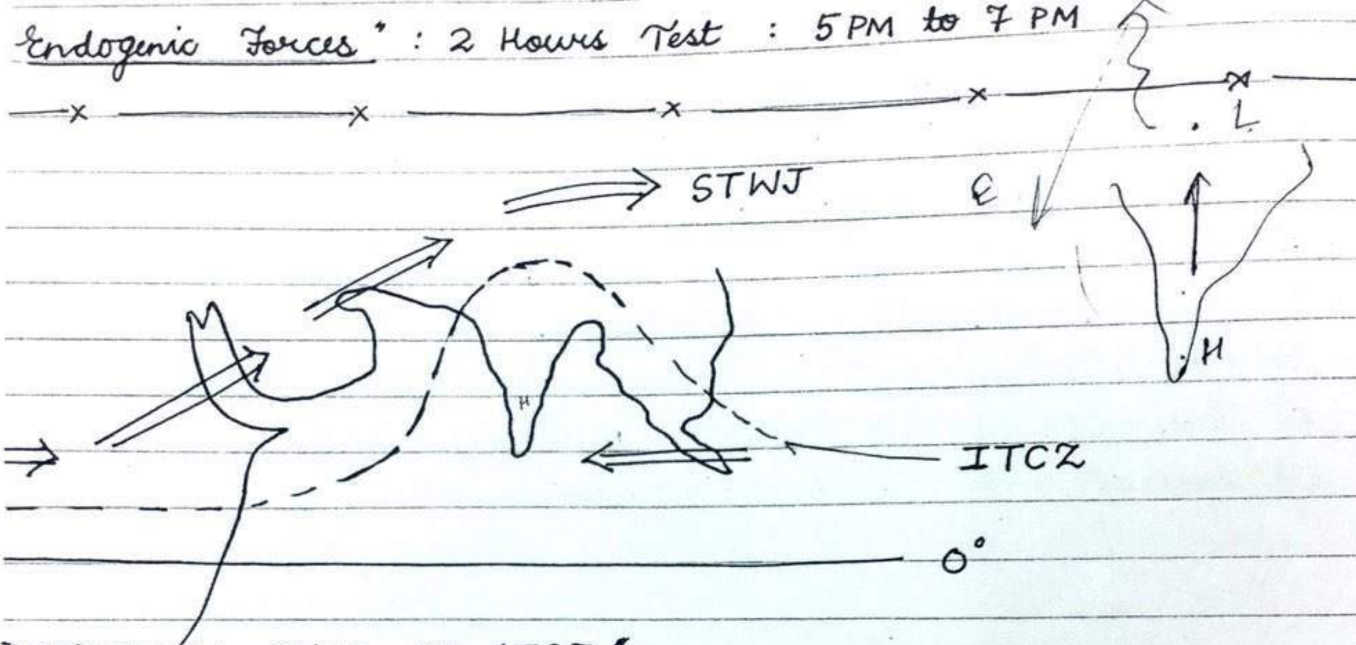


$\Delta_1 > \Delta_2$

March 2014

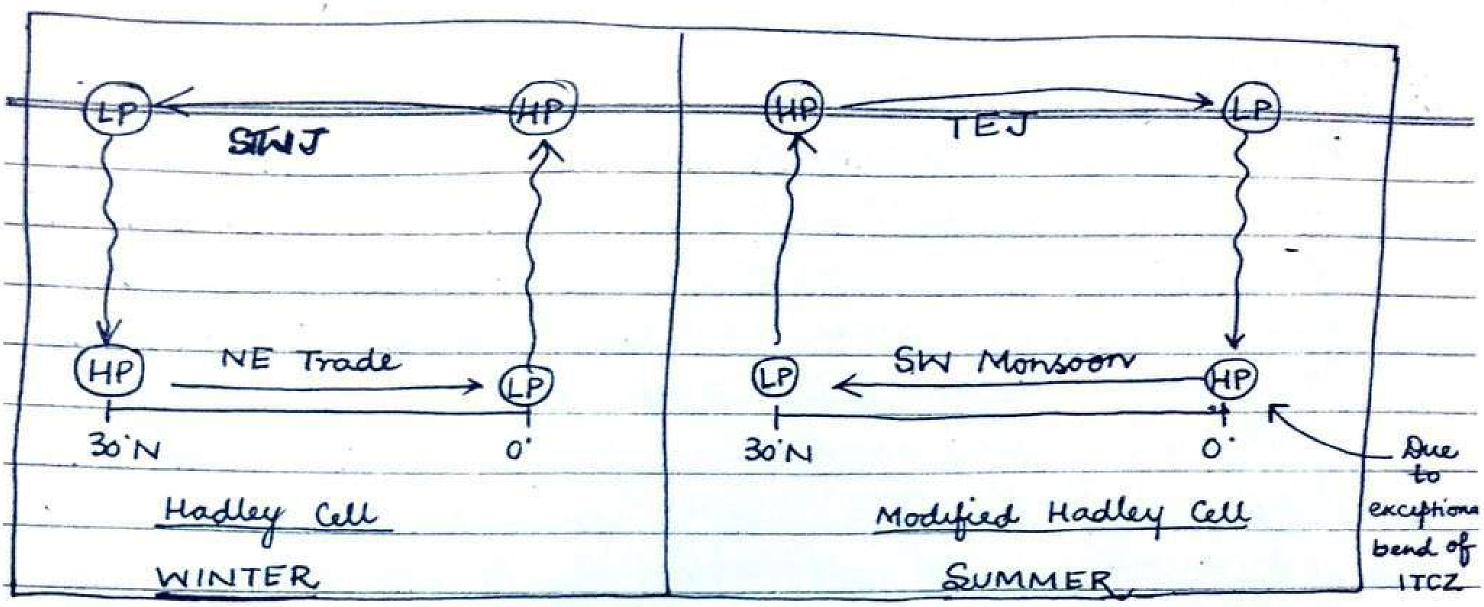
Thermal equator changes.
Geostrophic winds are absent in the Equatorial belt.

"Endogenic Forces" : 2 Hours Test : 5 PM to 7 PM



"EXCEPTIONAL BEND OF ITCZ"

uring high sun season apparent shift of sun towards orth makes 'thermal equator or ITCZ' shift upto 0°N in the global dimension. It is only in the case f northern Indian Ocean basin that prevailing ontinentality generates exceptional bend making ITCZ laced in northern plains of India. This exceptional bend ignificantly displaces sub-tropical jet in south and SE sian regions. Over these regions, during summers, There is the development of regional seasonal easterly pper air wind called tropical easterly jet. It is his jet stream that is the regulator of monsoonal nechanism in the region.



POLAR FRONT JET :

This mid-latitudinal jet stream forms the example of thermal indirect jet. Its development is correlated to genesis of front on ground. It is this polar front which facilitates the extension of polar jet to upto mid-latitudes as polar front jet. This jet stream, thus, correlates to temperate cyclonic circulations and thus, wetter weather conditions. Unlike the thermal direct counterparts, this jet stream is specified with life cycle which is of 15-20 days that involves genesis (no Rossby Waves), maturity (well developed Rossby Waves) and decay as the well-defined phases. It is recognised to be permanent jet as within a week's time, after the decay of the jet stream, there is the fresh development of polar front on ground. Climatologically, this thermal indirect jet stream regulates not just the precipitation pattern of the mid-latitude but also restricts polar deserts to absolute polar areas (±80 - 90 degrees).

MONSOONAL WINDS / MECHANISMS

The regional seasonal surface winds are best represented as monsoons which regulates the climatic characteristics of tropical east margin locations. The beginning of study of monsoonal mechanisms is traced back to pre-historic times with Arab scholars analysing its mechanism as seasonal reversal of the wind pattern. They identified these winds as <u>mausim</u>. This significantly old approach of the weather mechanism involves big range of contribution via classical times to modern time period. Among the major contributors to the monsoonal mechanism, following are included:

Mausim (Monsoon)

- Classical
  - dley (rmal Concept)
  - Flohn (ITCZ Concept)
- Modern
  - MONEX
  - ENSO & Teleconnections.

IONSOONAL MECHANISM

ladley's Thermal Concept based on the recognition of easonal reversal of wind pattern by the Arab scholars dentified the causes of the reversal. He recognised that differential heating and cooling of land & water causes such reversal in the surface wind pattern. During winters, prevailing STH over Indian landmass facilitates offshore NE Trade winds generating drier conditions. During summers, the development of low pressure over Indian landmass results in the movement of SW Monsoons as on-shore winds causing precipitation. In his thermal concept, Hadley compared offshore

* What is the cause of deflection ??

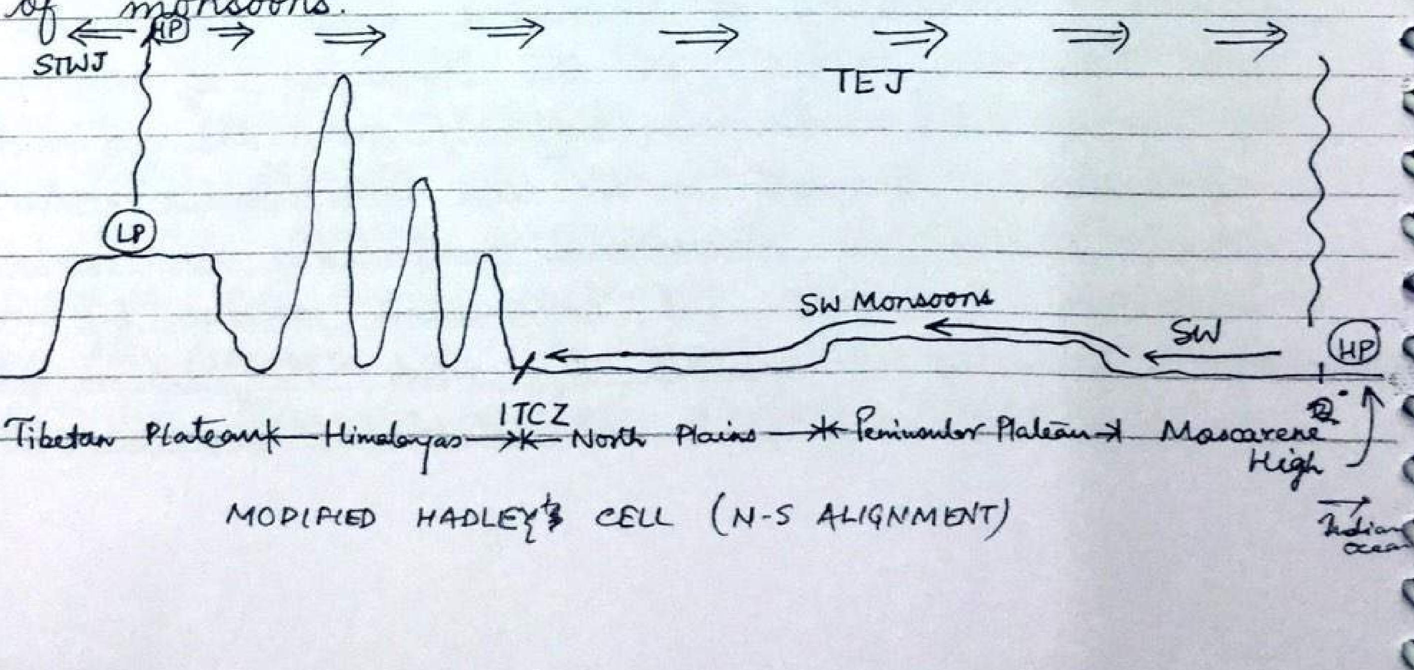
NE Trades to land breeze & onshore SW Monsoons ~~to~~ sea breeze. However, with the capacity of SW monsoonal winds to induce precipitation in the remote continental interior, their comparision with sea breeze was incorrect expression. It was in the concept of ITCZ propounded by Flohn that the first time recognition of SE Trade being SW Monsoons is correlated. Flohn emphasized that prevailing continentality of Northern Indian Ocean basin causes exceptional bends of ITCZ making it placed in northern plains of India. It is in the effect of this bend that SE Trade encroaches in northern hemisphere causing precipitation in coastal Somalia & Yemen as SE Monsoons. And it is approx. b/w 40° to 60° East longitudes that it gets deflected* to become SW Monsoons encroaching India and Indo-China peninsula. Flohn's concept not just identified the genesis of SW Monsoons but also explained absence of west margin climate in Indo-China & Indian peninsula.

MODERN APPROACH

The classical approaches of the monsoonal mechanism excellently facilitated the understanding of surface wind pattern correlating to monsoons. These approaches, however, lacked in the analysis of unpredictability of monsoonal mechanism. Suffering from the consecutive agricultural drought in the late 1960s, India initiated fresh studies of monsoonal mechanism as monsoon expedition (MONEX). The conclusions drawn by MONEX was formally published by mid 70s which added 2 important aspects to the established monsoonal

...tudies :
Role played by Tibetan Plateau
Development of vortexes

The role played by Tibetan ...lateau practically represent upper air circulation in ...e monsoonal mechanism. In this analysis, it was ...oncluded that exceptional bend of ITCZ resulting in to placing in northern plains of India makes the ...betan Plateau generate low pressure marking the ...orthern effective limit of low pressure on ground. ...n accordance, developed HP vertically over causes displacement of sub-tropical jet in Central Asia which makes the existing Hadley Cell getting modified with development of Tropical Easterly Jet generating "N-S Alignment". It is this jet stream that not just mark the development of pressure gradient between Mascarene High and Tibetan Low but also maintains it for upto 4 months facilitating attraction of different branches of SE Trade as SW Monsoons. These different branches availed the expression for analysing periodicity of rain, unpredictability in amount of rain, variability in the onset or retreat of monsoons.



MODIFIED HADLEY'S CELL (N-S ALIGNMENT)

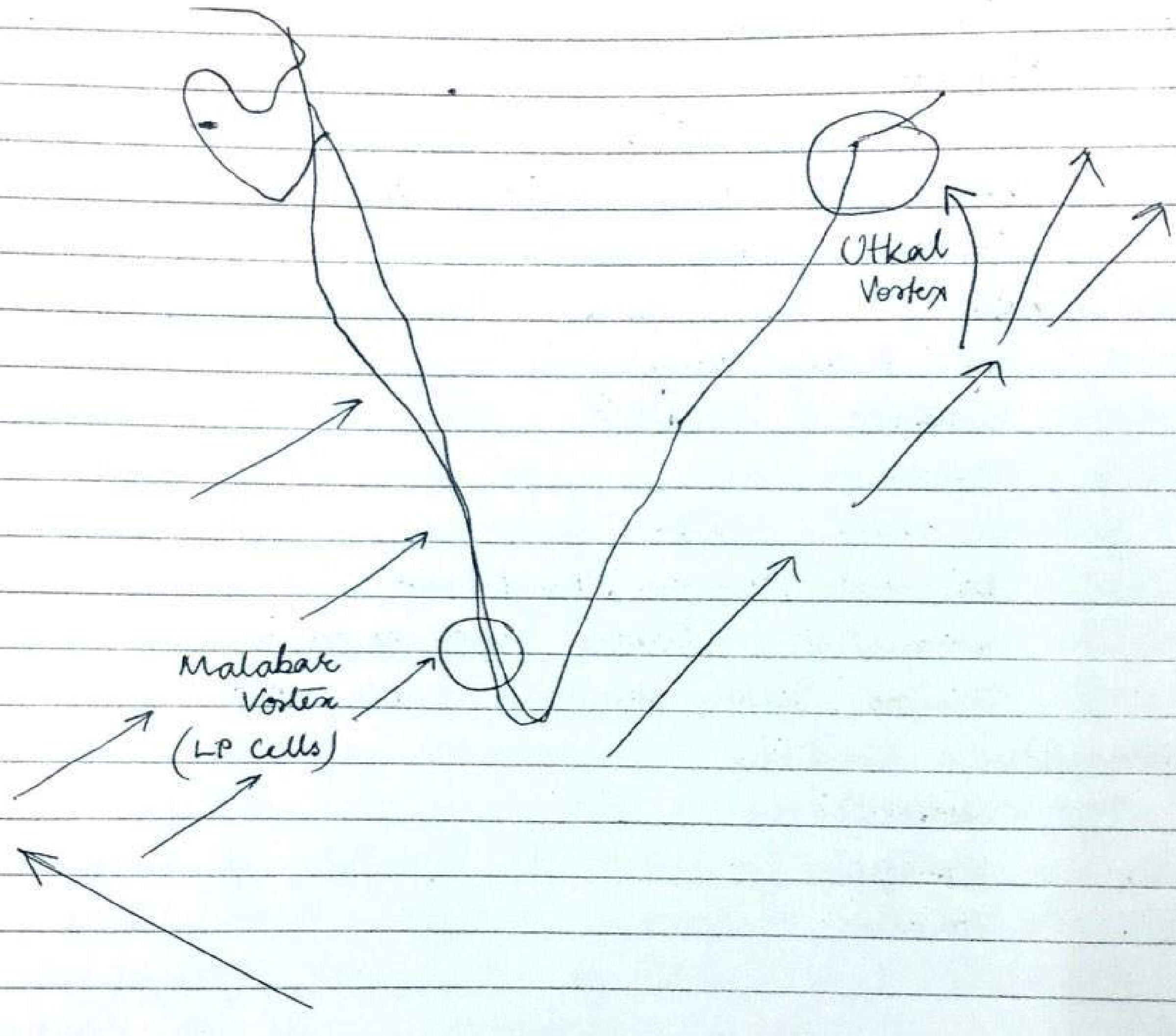
Date
11/03/2014

Lecture # 23

1) Vortex Development
   - Malabar Vortex & its weather effectivity
   - Utkal Vortex
2) ENSO & Teleconnections
   - El Nino
   - Southern Oscillations
   - Walker Cell and modified W.C.
   - East-West Alignment
3) Local winds
   - Land & Sea Breezes
   - Katabatic & Anabatic
   - Depression winds
   - Descending winds
   - Blizzards, Purgas, Pamperoes
   - Harmattan, Sirrocco and Khamsin
   - Chinook, Foehn, Shamoon, Santa Ana
4) Atmospheric Moisture
   - Absolute
   - Specific
   - Relative

- ~~giving of summer~~ : LP over land , dying over water
↳ Swifter because water maintains

tkal Votex



...wide

10 – 35 STJ Expanse winter
20 – 45 STJ " Summer (Except S. & S.E Asia)

Westerly
Permanent } J. Streams
Global

Tropical East Margin
→ Monsoonal

...er ...dia { N–S : TEJ → Summer → LP → Wet
S–N : STJ → Winter → HP → Dry

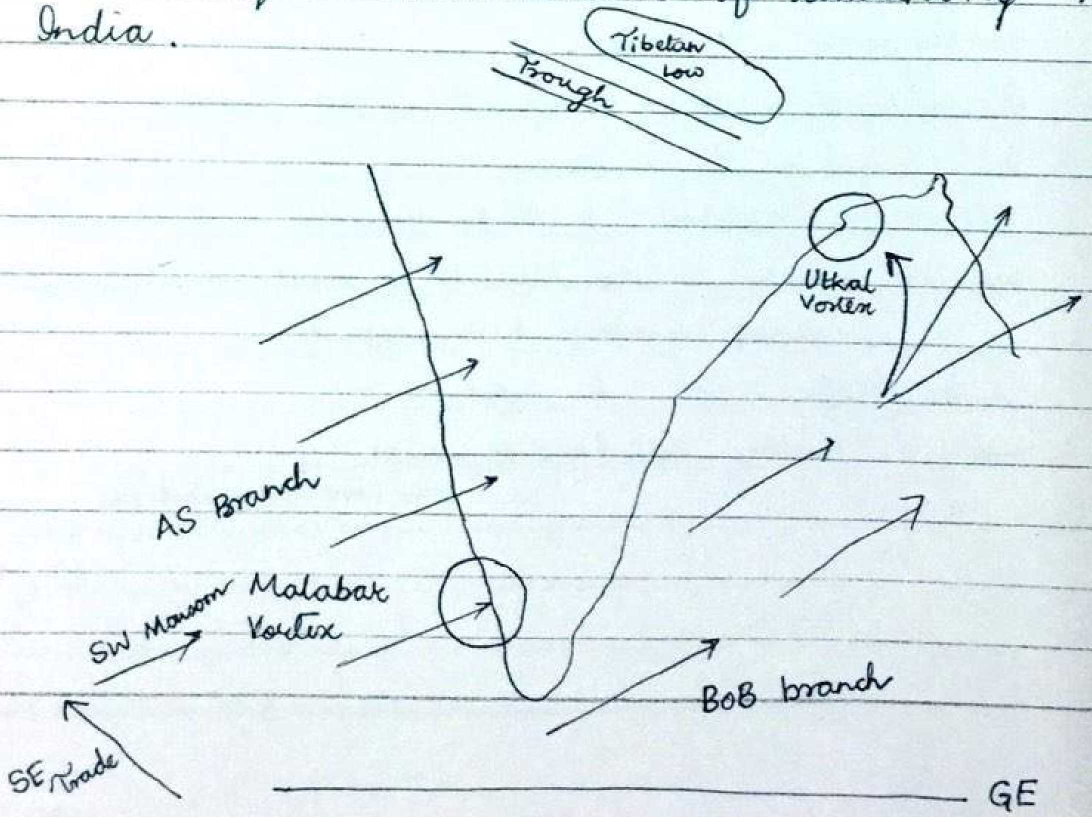
Thermal Concept of Hadley : Differential heating
Land Breeze : ~~NE Trade~~
Sea Breeze : ~~SE~~

Flohn : ITCZ Concept
West Margin not in India & Indo-china
SW Monsoons ≡ SE Trades deflected (B/w 40°E & 60°E)
SE " in Somalia & Yemen

MONEX : Accepts ITCZ bend
SW Monsoons ≡ SE Trade
Unpredictability of Onset & Retreat : Still persists
ΔP = ...than low to ...scarene high
Role played by Tibetan Plateau.
TEJ ⇒ N-S Alignment ⇒ ΔP for 4 months ⇒ attracting SE Trade branches
Different branches ⇒ Unpredictability of onset / retreat / amount
↳ variable moisture holding capacity
Links Surface air to upper air
Modified Hadley Cell (N-S Alignment)
↳ IMD Nomenclature

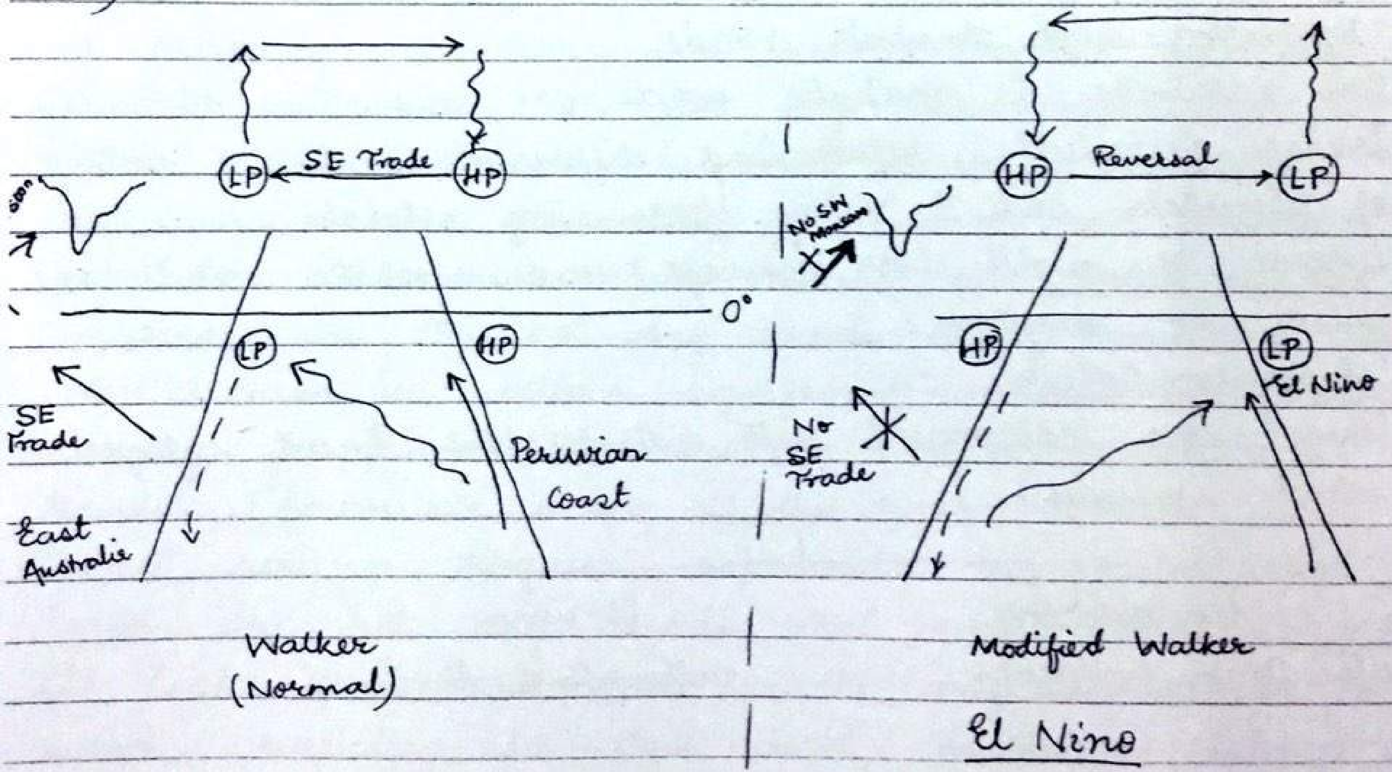
VORTEX DEVELOPMENT :

Apparent shift of sun towards north readily generates -P over Indian landmass in terms of monsoonal trough as well as the Tibetan Low. Along with these developments, slow transition of the pressure profile in the water bodies is also experienced. In the effect of this transition, northern equatorial trough of Indian Ocean shifts towards north and continuously gets weakened. Encountering the Indian landmass, this LP trough also gets divided, which generates LP cells along the shoreline of India, recognised as Malabar Vortex and Utkal Vortex. The Malabar Vortex regulates the characteristics of advancing monsoons, that is first monsoonal showers experienced in Malabar Coast and it is placing of Utkal Vortex that regulates encroachment of moisture-laden winds in Odisha Plains. Additionally, development of vortexes combined with monsoonal trough forms the cause of sudden beginning of monsoons, that is another unique characteristics of advancing monsoons in India.



ENSO & TELECONNECTIONS

Analysis put forth by Monex, though avails the explanation of minor characteristics of Indian monsoons, it do not explain the causes of weakening or complete failure of advancing monsoons. This is explained as the teleconnections that SW monsoons have with <u>El Nino</u> and related <u>Southern oscillations</u> in pacific ocean. Elaborated by <u>Walker</u>, this teleconnection is recognised to <u>Walker Cell</u>. During normal year, prevailing pressure profile in Southern Pacific sustains effective SE Trades, thus, SW monsoons. However, with development of El Nino, modification of Walker Cell causes weakening or complete reversal of SE Trade with similar effect on SW Monsoons. For the successful monsoons, therefore, along with <u>N-S alignment</u> (Modified Hadley Cell) there is the requirement of <u>east-west</u> alignment (Walker Cell).



La Nina: Re-established Peruvian Current.

OCAL WINDS :

(1) These are surface advection and thus represents gradient winds.

2) They are analysed in large scale perspective to interpret weather conditions of specific locations.

3) Commonly, local winds are categorised into 4 categories:

(A) LAND & SEA BREEZES

(B) KATABATIC & ANABATIC

(C) DEPRESSION WINDS

(D) DESCENDING WINDS

Land and Sea Breezes

These are typical to coastal areas with differential heating and cooling of land & water, with sea breeze effective during daytime & land breeze effective during night.

Katabatic and Anabatic Winds

The katabatic & anabatic winds are mountains & valley breezes respectively, representing differential heating & cooling of mountain wall & valley floors. The katabatic winds are typical to nights (air drainage) and anabatic winds are typical to daytime.

Depression Winds

These are categorised into temperature based categories which includes:

Depression

(a) Cold & Dry with Polar Outbreaks

(b) Warm with Dust Devils

(a) Cold Dry with polar outbreaks are typical to winter season, capable of extending cold polar conditions &

significantly lower latitudes. These includes Blizzards, sourced from Canada, experienced in USA; as strongest example (no orographic barrier). Purgas, sourced from Siberia, experienced in China (with broken orographic barrier) with weaker polar outbreak and Pamperoes sourced from Antarctica experienced in Argentina; as weakest example (due to the intervening southern ocean).

(b) The warm winds with dust devils are typical to high sun seasons generated after dust devils. These are the strong winds generated due to sudden heating of sand which creates dusty environment with excessive supply of aerosols in the lower reaches of atmosphere. Dust devils, therefore, generates strong HP sourcing hot dry winds in the neighbouring areas. It is depending on the nature of prevailing conditions that induce weather effectivity are variable. Harmattan, the hot dry wind, experienced in Upper Guinea, decreases humidity levels converting oppressive weather favourable for human and livestock population. These are nick-named as doctor winds. Sirrocco are the hot dry winds that travelling via Mediterranean Sea attains significant amount of moisture causing precipitation in Southern European Islands and Peninsula; favourable winds as the region remains dry thro'out summers. Khamsin experienced in coastal Libya and Egypt are hot dry winds that create health hazard, the heat stroke and thus, is the only unfavourable local wind correlating to dust devil (Indian 'Loo' belongs to same category).

"Chinook" meaning "Snow Eater"

These are always subjected to adiabatic warming and thus are warm winds categorised into favourable and unfavourable categories. It includes Chinook (Canada), Foehn (Switzerland) sustaining commercial utilisation of cold frozen slopes of tall mountains; along with Shamoon (Iran), Santa Ana (California, USA) causing extreme dry and hot conditions which normally leads to forest fires, thus, unfavourable types.

"All katabatic winds are descending winds but not vice-versa". ×———×———×———×

Variable, active : Water Vapour ⇒ { Moisture → for troposphere; humidity → in specified air column }

Evaporation → Condensation → Precipitation

TMOSPHERIC MOISTURE

It is the fundamental element of weather and climate which is defined to be amount of water vapour present in troposphere. For the specific air column, it is humidity that is the applied terminology to denote atmospheric moisture. This active variable constituent of atmosphere is sourced from the surface of the Earth by the process of evaporation. This process is defined by WMO as the process of converting water to gaseous state including the relative processes of transpiration and sublimation. Evaporation is a continuous process which varies in its rate. Determiners of rate of evaporation includes temperature of the air column and its humidity levels.

Climatologically, atmospheric humidity is correlated with two-out-of-three measures of humidity. These includes
(i) Absolute humidity (g/m^3)
(ii) Specific humidity (g/kg)
(iii) Relative humidity. (%)

The absolute humidity, not utilised for climatological purpose, is defined to be mass of water vapour per unit volume of air. This measure as correlates the humidity levels to highly dynamic air volume which changes with the minor change in the level of the air column do not support comparative global analysis.

The specific humidity in comparision is most applied method for the humidity levels of air masses. It is the measure of mass of water vapour per unit mass of air column. With ↑ in the sign of the latitude, ↓ temperature decreases moisture holding capacity, thus, specific humidity, with the warm wet equatorial air-mass depicting specific humidity of upto 8 g/kg whereas cold dry arctic air-mass has as low as 0.2 g/kg of specific humidity.

It is the most ultised method of humidity in climatological studies. It is the ratio of present amount of water vapour and carrying capacity of air at given temperature expressed in percentage. It is this measure that avails the distinction between unsaturated saturated and super-saturated air columns along with recognition of dew-point temperature.

te
03/2014

Lecture 24

Evaporation → Transpiration + Sublimation

Equatorial air column → highest S. humidity

Polar " " → lowest "

It is supersaturated air column that condenses.

Condensation → Liquid or solid state from gaseous phase

The supersaturated air column combined with hygroscopic nuclei paves way to the process of condensation. This process is defined by WMO as the process of converting the vapour to either liquid or solid state. The process of condensation as correlates to cooling of air column below its dew point temperature, it involves contact cooling and adiabatic cooling as the applicable processes. Climatologically study of condensation thus is correlated to forms or types of condensation that are classified in absolute accordance to location of condensation. The demarcated categories includes :

Forms/ Types

1. At ground
   - Dew
   - Frost
2. Near ground
   - Fog
3. Atmospheric
   - Clouds

Contact Cooling (1, 2)

Winter due to Low Sun Season

Day Shorter & Nights Longers

Adiabatic Cooling (3)

Thro'out the year

$$\text{Solid} \xrightarrow[\text{(Added)}]{\text{Latent Heat}} \text{Liquid} \xrightarrow[\text{(Added)}]{\text{Latent Heat}} \text{Gas}$$

Air is poor conductor of heat.

The at ground and near ground condensation forms are typical to low sun seasons when the colder surface induces effective contact cooling by the process of conduction. If the contact cooling results in the utilisation of ground objects as hygroscopic nuclei, the moisture gets deposited either as small droplets or as tiny ice crystals. The former form droplets represents condensation in lower latitude & altitude where the temperature always remain over and above freezing point of water called dew. whereas, the ice crystals are common in higher latitudes & altitudes where the temperature decreases below the freezing point of water developing frost. Both dew and frost makes absolute examples of completion of hydrological cycle without involving the step of precipitation.

In comparision, the near ground condensation called fog is structurally & compositionally forms the example of near surface clouds. These are developed due to the settling of cold dense air during low sun season cooling below the dew-point temperature. The developed condensation utilises aerosols near the ground to develop fog. Though commonly fog are classified in accordance to its density or thickness that influences the visibility for the climatological purposes. Fog types are distinguished on the basis of formation processes including:

Radiation fog
Advection fog
Frontal fog
Precipitation fog

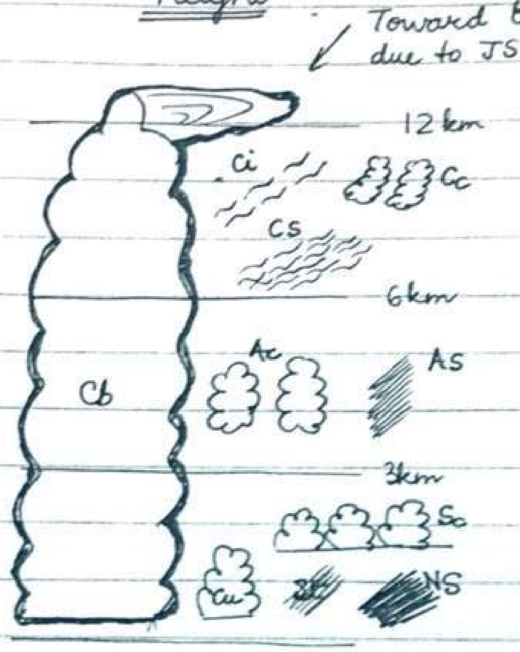
Equatorial region → High Sun Season thro'out / no winter
Polar Region → No Clouds because air column is very dense to rise
Bad Weather → LP

- The radiation fog is the commonest fog type developed due to contact cooling that is process of conduction during low sun seasons.
- Advection fog is most regularly developed in the European plains where warm moist westerly advecting over cold surface gets condensed near ground.
- Frontal fog is the common fog of middle latitude developing when warm moist air column converges with cold air column cooling below the dew point temperature.
- All these 3 types represents the examples of cooling process leading to condensation. Compared to them, the precipitation fog forms the example where the addition of water vapour to the moist cold air column by frontal precipitation facilitates condensation. These are commonly referred as 'arctic smoke' as is the fog form of higher latitude.

Atmospheric Form : Clouds

The commonest form of condensation are clouds which are defined to be visible aggregates of tiny ice-crystals and minute water droplets. They mark their development due to adiabatic cooling relating to near entire world developing throughout the year.

Clouds

Shape	Height	Weather
Globular Cumulus (Cu)		Bad (Nimbus): Cb, Ns
Sheet Stratus		Fair: Cirrus family Ci, Cc, Cs
Fibrous Cirrus		Rain: Cu, St, Sc, Ac, As

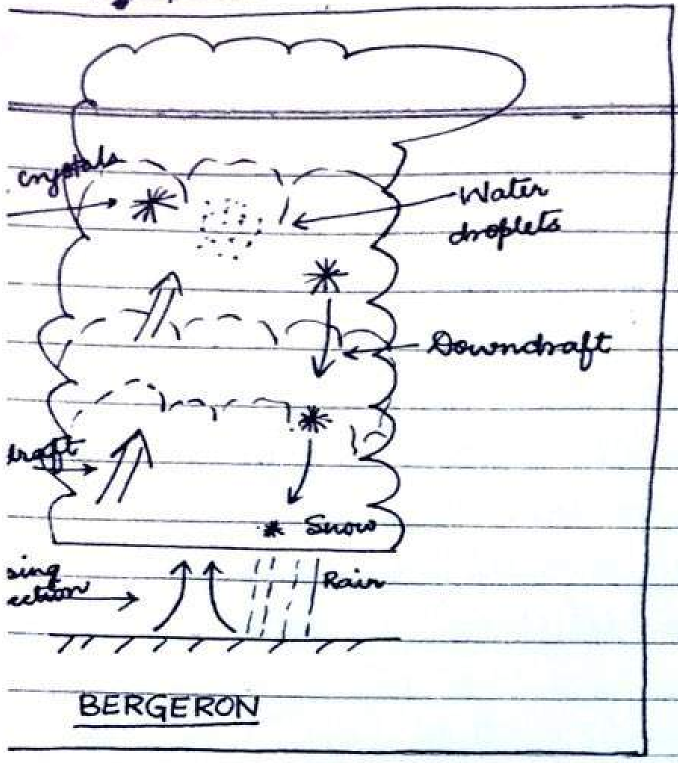
lto → Mid altitude
otal 10.

All bad weather clouds are rain bearing.

CLOUD FORMATION / PRECIPITATION :

It avails one of the 2 requirements for precipitation to take place. Precipitation is defined to be falling of moisture from the base of the cloud. For precipitation to take place rain-drop forming process marks its application within the cloud. It includes mutual merger of small droplets and/or ice-crystals along with more effective enlargement of ice crystals due to the process of deposition as **ice-crystals** have low vapour pressure compared to the water droplets (BERGERON).

Sub-polar → 70° to 80° = Tundra



Type → Mechanism

Precipitation → Type, Form, Distribution

Precipitation as the process is climatologically referred to as the completion of hydrological cycle. It is analysed in three interrelated aspects of form of precipitation, types of precipitation and distribution of precipitation

FORM

It includes the analysis of the state the water that is precipitated from the base of cloud. It includes :

(a) Rain with drizzle

(b) Snow with glaze & sleet

(c) Hail

Rainfall is the commonest form of precipitation experienced in low to mid latitudes. It is defined to be falling of water drops from the base of the clouds. For all the technical purposes, drizzle is defined to be immature rain, representing smaller size of raindrop & smaller amount of precipitation.

Snowfall forms the common ppt. in mid to high latitude. Also referred as frozen form of ppt., it commonly includes 2 variants called sleet and glaze. Sleet are defined to be partially molten snow commonly experienced in middle latitude during winter season. Glaze in comparision is defined to be crystalized snow. It is typical to higher

Desert → Eolian Topography → No strong updraft

altitudes during winters when the ground conditions have temperatures exceptionally below freezing point of water. Hail is the ice ball precipitated from the cloud as the uncommon form of precipitation. It requires strong convective rise and updraft making it confined to lower latitudes (except deserts). This precipitation form is recognised to be natural hazard as the falling force of ice-ball significantly destructs the standing crops. All these forms of precipitation correlates to types of precipitation.

The precipitation types are classified in accordance to the involved mechanism of condensation. These includes:

1) Convectional precipitation
2) Orographic "
3) Frontal "
4) Cyclonic "

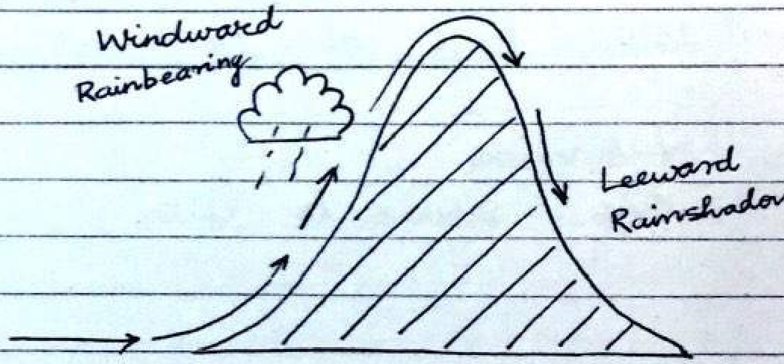
The Convectional ppt. forms the example of absolute instability where warm moist air is subjected to rise, thus, adiabatic cooling, resulting in condensation thus precipitation. This ppt. type commonly includes rainfall and hail as forms of precipitation and is most typical of equatorial climate.

The orographic ppt. forms the example of conditional instability. It correlates to the relief or orographic barrier forcing the wind to rise generating rain-bearing windward slope and rain-shadow leeward slope. This ppt. type includes rain & snow as common forms. It is most typical to monsoonal climate.

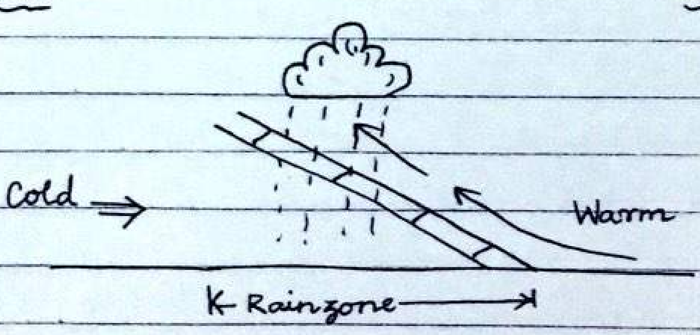
The frontal precipitation forms the example of conditional instability where rising warm air column subjected to adiabatic cooling results in condensation and precipitation. Typical to the mid and high latitudes this precipitation type commonly involves snowfall & rainfall.

The cyclonic precipitation forms the example of absolute instability which relates to rain and hail and is typical to tropical marginal water bodies (tropical cyclones).

Convectional



Orographic



Frontal

TMOSPHERIC INSTABILITY & STABILITY

Normal Lapse Rate i.e. 6.5 °C per km of rise is different than environmental Lapse Rate i.e. dynamic rate of cooling of specific air column.

Adiabatic Lapse Rate (ALR) is the rate of cooling that rising air column is subjected to.

ALR is of 2 types : Dry - ALR (10 °C/km) & Wet - ALR (5 °C/km)

Steeper DALR (10 °C/km) is the rate of cooling of unsaturated air column.

Gentler WALR (5 °C/km) is the rate of cooling of saturated air column (also called retarded ALR).

The retarded ALR is manipulated by release of latent heat of condensation.

N-America

Asia : Siberia to China

Date
13.03.2014

Lecture 25

Avoid moist air if RH< 90%.
Clouds – Commonest form of condensation
Form – Medium –
Types – Mechanism } Ppt.

Specific air column – ELR
Rising " " – ALR → DALR
→ WALR (Due to Latent heat release)

Stability & Instability Contd.

The atmospheric stability represents the conditions of subsiding air column (high pressure). It is also related to the relative lapse rates i.e. ELR being less than adiabatic lapse rate.

Atmospheric instability correlates to rising air column (low pressure) and for the maintenance of instability continuity of rising requires ELR to be more than ALR.

Instability is categorised into absolute instabity and conditional instability.

Absolute instability depicts the condition where ELR is more than DALR. This type of instability correlates to turbulent weather conditions as tornadoes, thunderstorms, tropical cyclones and is also related to convectional precipitation.

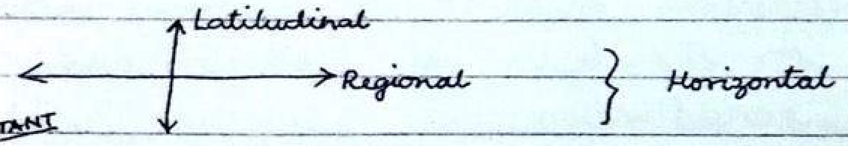
Conditional instability is defined to be developed when ELR is in between WALR and DALR. Practically, it is applied to denote ~~oroger~~ orographic and frontal conditions generating rise, thus, instability.

High Pressure, Clear Sky ⇒ Stability → Don't rise
→ Stop rising

HYDROLOGICAL CYCLES

Movement of water in different realms of environment.
- Includes the processes of evaporation, condensation & precipitation.

Climalologically is categorised into 3 prominent types :=
- atmospheric hydrological cycle, daily hydrological cycle, delayed or elongated hydrological cycle.
- Atmospheric hydrological cycle develops when precipitated moisture gets re-evaporated due to adiabatic warming prior to reaching the ground.
- Daily hydrological cycle common with equatorial climate involves forenoon evaporation and afternoon precipitation completing the cycle within 24 hours.
- Delayed or elongated hydrological cycle develops when precipitated moisture includes biosphere and crynosphere (ice-covered areas).



PORTANT

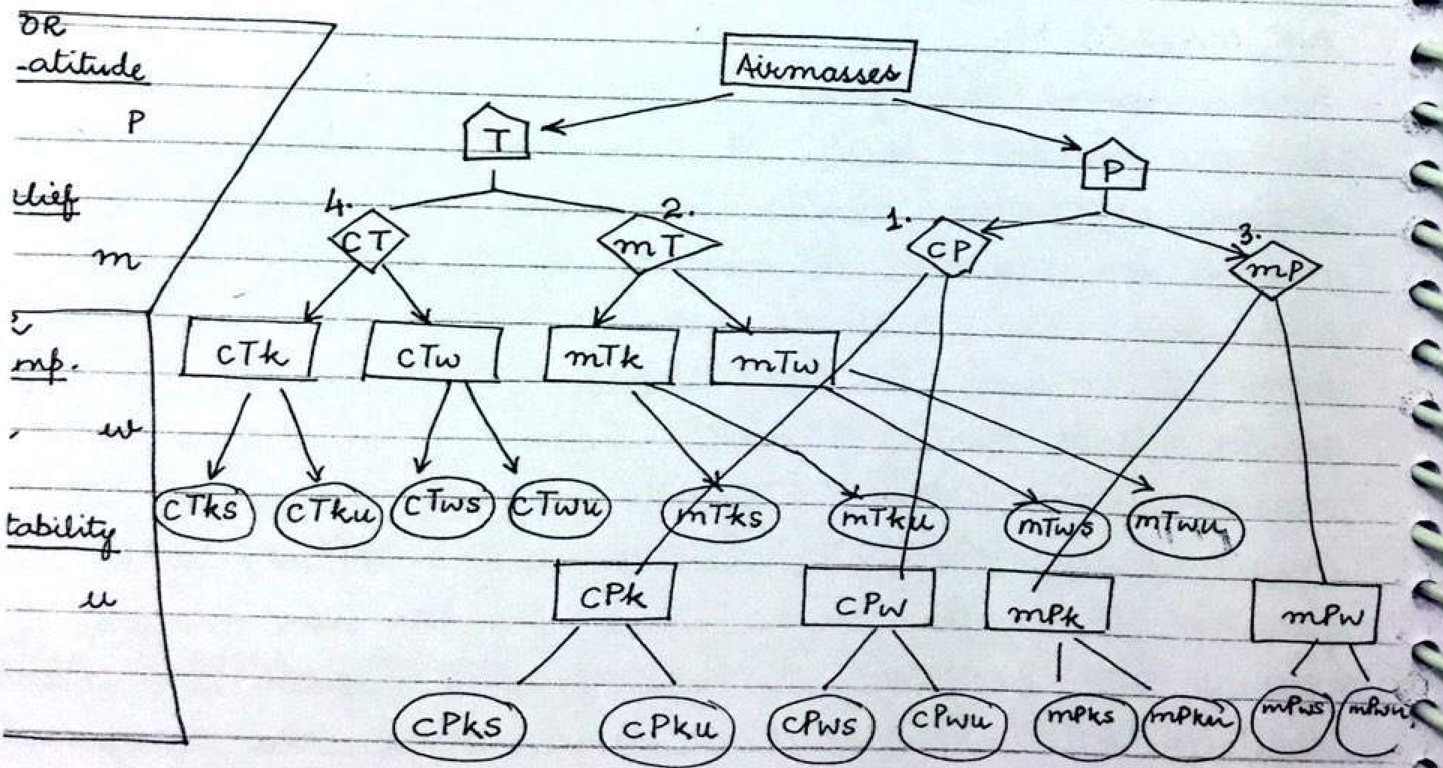
AIR MASSES :

3-dimensional homogeneous masses of air are defined to be air-masses which climatologically functions as thermal engines regulating weather mechanism. Homogeneity of air masses is measured in context of temperature and humidity with both these properties sourced from the surface of the earth. Air masses develop stronger characteristics during season. That part of earth's surface from where an air masses attains ~~their~~ its physical properties is called its source area. Practically, entire surface of the earth qualifies to be the source area for the air masses barring the exception of mountainous regions. Air masses developed in their respective source areas are recognised

* Europe is always under warm NAD ⇒ No sufficiently cold air mass.

---

be barotropic air masses. Movement of barotropic masses in the effect of prevailing winds makes them luence weather conditions of advected areas along with tting influenced by prevailing conditions of advected areas. iese modifications in the air masses is identified to be presenting both conduction & convection. When the air asses adapts to the prevailing conditions of the dvected area, it is called baroclinic air mass. natologically, air masses are classified on the basis f latitudes and relief as major categories. Among e minor demarcations, temperature and stability are lso taken into account. On all the four basis, two es of air masses are distinguished which combines to demarcate 16 different types of air masses. For the obal climatological analysis, however, it is four major r masses, classified on the basis of latitude and lief, that are taken into consideration.



WEATHER EFFECTIVITY of AIR MASSES :

All the four major air masses induces significant range of weather effectivity in their respective areas of influence. It is in terms of diversities of weather conditions and size of the influenced area that the air masses are arranged in order of importance as

1. Continental polar — (1) CP
2. Maritime tropical — (2) mT
3. Maritime polar — (3) mP
4. Continental tropical — (4) cT

1. The Continental polar airmass is the cold dry air mass which relates to 2 different source areas Canada & Siberia. Both these perennial air masses become extensive during winters. Their southward extension makes them induce cold winter conditions in lower latitudinal countries like USA and China. In the support of stronger polar outbreaks, Canadian air mass induces stronger effectivity than Siberian counterpart. Apart from this weather effectivity, southward extension of these air masses makes them come in effectivity of westerlies. Their movement towards NE makes them develop Arctic Front along the shoreline. It is in the effect of these fronts, that the coastal areas experiences winter precipitation. In this weather effectivity also, Canadian air mass proves to be stronger as it encounters warm Oceanic currents at the shoreline, Compared to the Siberian counterpart which encounters positive temperature anamoly of marginal water body. For the Canadian air mass, occasional development of SQUALL LINE at the convergence of exponentially cooled continental tropical airmass (USA) and exponentially

varm maritime airmass (Gulf of Mexico) generates xceptional turbulent weather conditions TORNADOES.

Maritime Tropical Airmass:

mE = maritime Equatorial
mM = maritime Mediterranean

mT
- Permanent
  - Open Oceans
- Temporary (Marginal Water Bodies)
  - Summer Effective
  - Winter Effectivity (mM)

ts warm moist air mass that correlates to lower titudinal (0°-45°) water bodies. These air masses commonly orrelates to development of wetter weather conditions. hese are classified on the basis of consistency of eather influence as permanent and temporary air masses.

The permanent category includes aritime equatorial (mE) as unique example which marks ō effectivity over entire equatorial belt throughout the ear irrespective of land and water. It is with this air ass that perennial absolute instability and convectional ecipitation is mainly associated. Permanent mT air masses lso belongs to open Oceans representing open Atlantic ean (Azores High) and Pacific Ocean (Hawaiian High). These ir masses registering their mobility in the effect of trade inds facilitates development of ITCZ and in the effect of esterlies facilitates development of polar front, with both TCZ & polar front being the significant regulators of recipitation in lower and higher latitudes respectively.

The temporary category includes the air masses of marginal water bodies, which though are permanent in their existence induces weather effectivities only in particular seasons. For most of the tropical marginal water bodies (Gulf of Mexico, Bay of Bengal and South China Sea), weather effectivities are generated during summers when the neighbouring land develops LP attracting these air masses, resulting in monsoonal rains. It is only in the case of Mediterranean Sea that the maritime tropical air mass called maritime Mediterranean (mM) air mass registers effectivities during winters in the support of on-shore westerlies.

Maritime Polar : Wet, Cold (No Absolute Instability)

Specific humidity ↓ with ↑ Latitude

3. Maritime Polar Airmass :

It forms the cold moist air mass typical to the open-northern Pacific and open-northern Atlantic oceans. This air mass induces wetter weather effectivities in terms of facilitating Polar Front and Arctic Front. Unlike mT air mass, it relates to conditional instability only.

. Continental Tropical Air Mass :

The warm dry air mass typical to the tropical air masses induces dry weather conditions. It is in the effectivity of this air mass that during winters entire tropical landmass remains generally dry & the west margins of the land (tropical deserts) remains dry thro'out the year.

/03/2014

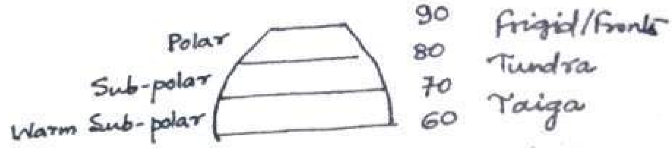
Lecture 26

TEMPERATE CYCLONIC CIRCULATION

This low pressure system is also referred as extra-tropical cyclone or wave cyclone. It correlates to polar front of northern hemisphere that represents maximum contrast in converged air masses. In the effect of warm westerlies and cold polar winds, these cyclonic circulations regulates the precipitation mechanism of extensive latitudinal location i.e. from sub-tropics to sub-polar locations. This cyclonic circulation has 15 to 20 days of lifespan and is largely devoid of any type of turbulent weather mechanism. Analysis of temperate cyclonic circulations is attempted in context of polar front theory propounded by Jacob & Bjerkens. They outlined the life-cycle of temperate cyclonic circulation to be comprised of 6 stages:

(i) Stage of frontogenesis / Stable front
(ii) Division of 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 / Front decay

The stage of frontogenesis represents the convergence of contrasting air masses at near 60th parallel, In the influence of cold polar winds and warm westerlies, It is due to the contrast between the converged air masses that the front is maintained for a comparatively longer time which avails the possibility for the contrasting air masses to intrude in each other's domain. ~~It is~~ This intrusion ~~process~~ ~~that~~ leads to the division of stable front.



COLD FRONT

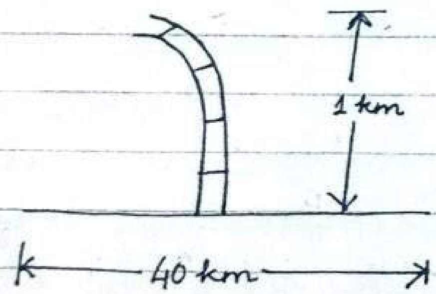
t is that part of stable
ront which is developed
ue to movement of cold
ir mass.

his front thus develops
. the lower latitudes.

enser cold air mass as
lways maintains ground
ntact, it tends to push
lready unstable warmer
ir mass.

t is therefore that the cold
ront represents slight turbulent
eather conditions with abrupt
se.

: is also that the cold
ront thus have steeper profile
hich is normally 1:40 i.e.
km of vertical rise over
, kms of horizontal expanse.



WARM FRONT

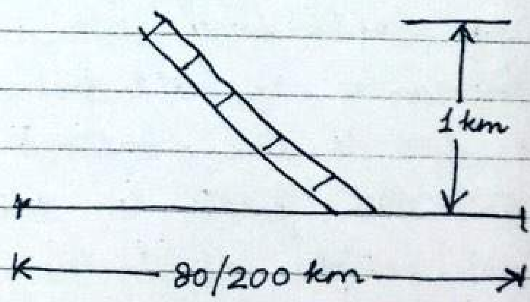
(1) It is that part of stable front which is developed due to movement of warm air mass.

(2) This front thus develop in the higher latitudes.

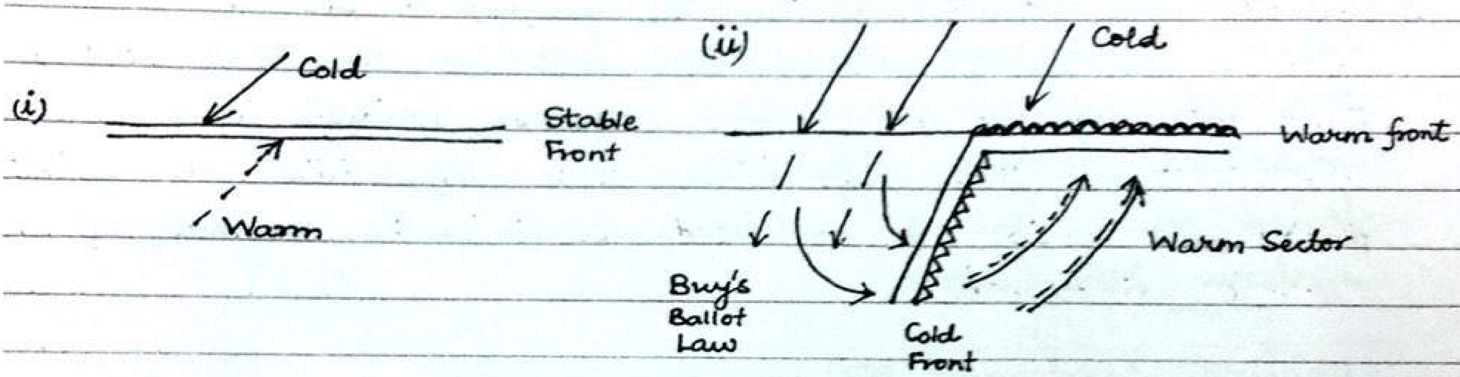
(3) Warm air mass registers gradual march over the ground lying cold air mass with complete absence of rush

(4) It is therefore that warm front weather represents absolute quiet precipitation mechanism

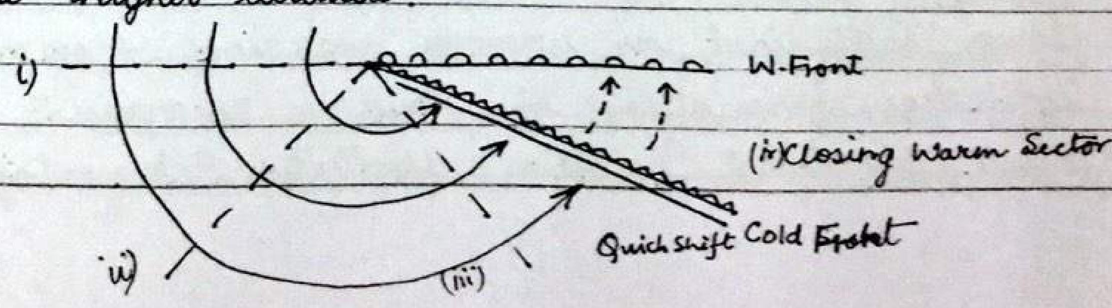
(5) It is also that the warm front thus have gentler profile which is in the normal range of 1:80 or 1:200



The division of the fronts when is applied in specific reference to the warmer latitude, it represents increasing ground contact of the cold air mass resulting in simultaneous change in the pressure profile. Under the effect of polar winds, when cold air mass sufficiently intrudes in lower latitude, it encounters prevailing LP towards its left (Buy's Ballot Law), which results in the beginning of cyclonic circulation.



The beginning of cyclonic circulation paves way to transitional stages. As per the polar front theory, these includes quick shift of cold front and closing down of warm sector. Both these stages corresponds to each other as when the cold dense air swiftly continues to enlarge its ground occupancy, the warm air mass continuously loses out on the ground contact. These developments confined to the lower latitude is simultaneous to the continuous march of warm air mass over the cold in the higher latitude.



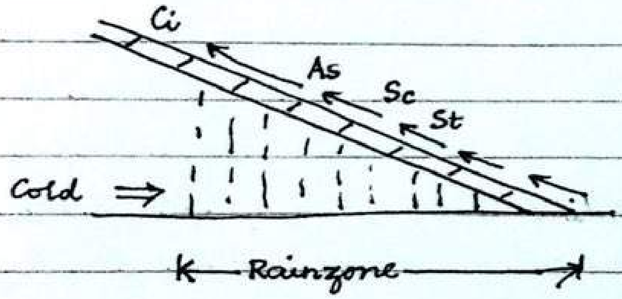
the stage of occlusion represents cold air mass occupying complete geographical expanse of cyclonic circulation with warm air mass either pushed out or marched up. This stage, therefore, marks the beginning of frontal decay along with conclusion of wetter weather mechanism. This stage is followed on by the stage of frontolysis where the developed front gets terminated and cyclonic circulation come to an end. It is because similar characteristics air mass i.e. cold remains in contact with the ground in the entire expanse of cyclonic circulation. Evolving via these stages, temperate cyclonic circulation induces variable and important weather effectivities. These effectivities are interpreted in context of developed front in the sequence of cyclonic circulation:

FRONTS DEVELOPED IN SEQUENCE

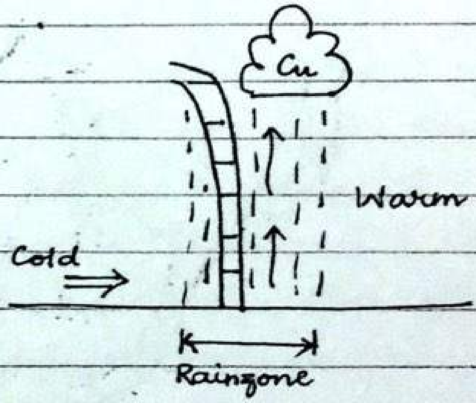
Stable front
Warm front
Cold front
Occluded front

The stable front weather is commonly recognised with quiet transitional weather conditions which depicts the beginning of the cyclonic circulation. The weather effectivities correlated to stable front includes short-lived temperature increase in the higher latitudinal margin with long-lived temperature decrease in the lower latitudinal or warmer margins. Moreover in lower latitudes, formation of dew is recognised to be most prominent weather effectivity representing stable front.

The warm front weather experienced in higher latitude correlates to wetter weather conditions involving gradual march of warm air over cold air mass generating multi-altitudinal clouds, periodic precipitation relating to larger space and longer time. It is warm front weather that generates TAIGA (warm sub-polar) and TUNDRA (sub-polar) climatic regions restricting the polar deserts only in the frosted area. For taiga, ≤ 30 cms of annual precipitation, well distributed throughout the year and for tundra, 20 cms of annual precipitation confined only during summer relates to this front.

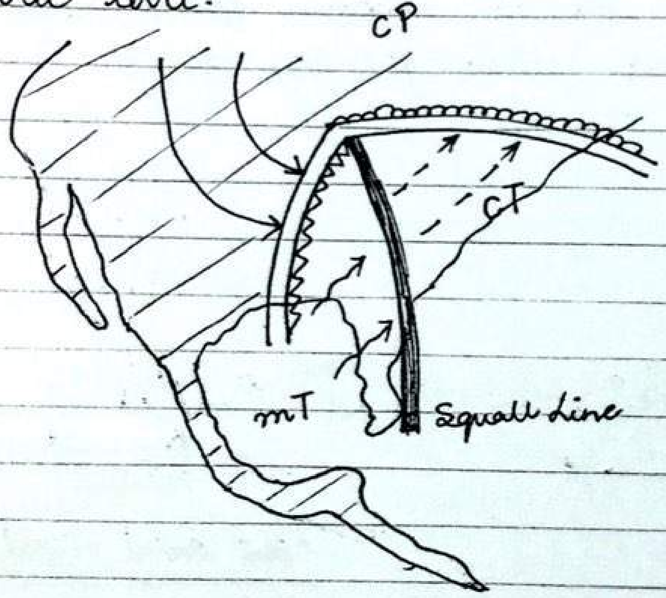


Warm Front Weather



Cold Front Weather

The cold front weather relating to lower latitudes also generates wetter weather conditions. However, unlike the warm front weather, it involves sudden rise one major episode of condensation with one major episode of precipitation resulting in formation of low altitudinal cloud, smaller rainzone and heavier precipitation for shorter duration. This weather effectivity adds to the many mechanism of precipitation in the lower latitude. Confined in the warm sector, specifically in USA, there is occasional development of additional front called SQUALL LINE, few kms ahead of cold front. This occasional development confined to the specific area represents turbulent-most mechanism of tornadoes depicting the immense thermal contrast developed between continental tropical air mass of USA and maritime tropical air mass of Gulf of Mexico due to polar outbreaks. Tornadoes represent combination of absolute and conditional instability, forming a LP funnel with its base on the ground and apex upto tropospheric level.



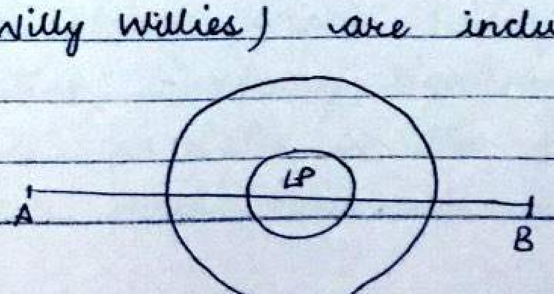
ower latitude — rise of warm air mass abrupt
igher ,, — rise is gradual

Occluded front weather : Develops similar wetter conditions n both the latitudinal location. This represents complete termination of ground contact of the warm air mass. Continuous moderate precipitation is recognised to be depicting the termination of the system with the effectivity remaining valid for 2 or 3-days.
Warm has lost ground contact.

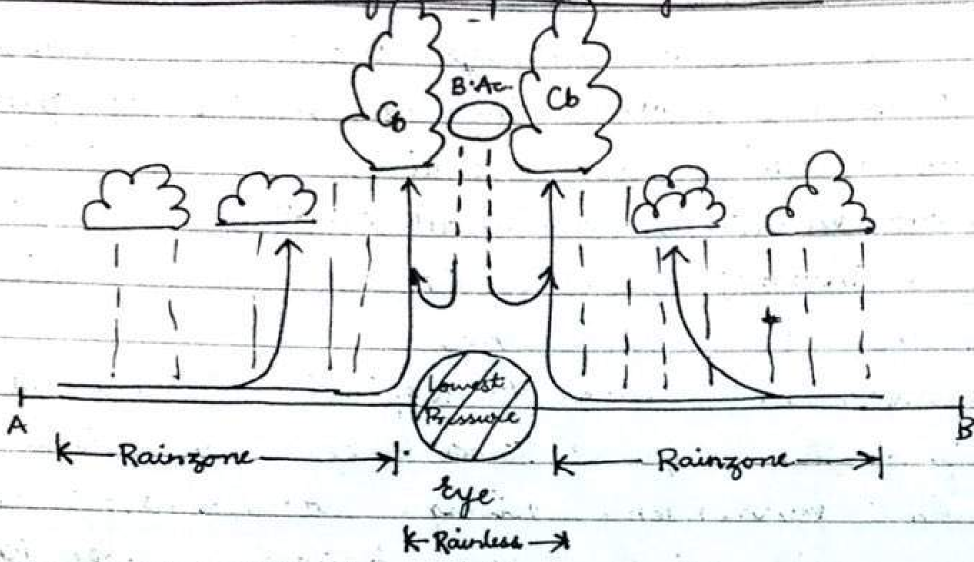
* TROPICAL CYCLONES

The thermal direct low pressure system of lower latitude that forms one of the determiners of precipitation pattern in the tropical east marginal climate is tropical cyclone. This LP system is also called tropical disturbances which involves intensity based categories called tropical storms, tropical cyclones and hurricanes.

Tropical storms are the weakest tropical disturbances with wind velocity in the range of 50-80 kmph representing weaker pressure gradient force. Comparatively stronger system is called tropical cyclone with wind velocity between 80-120 kmph. It is super-cyclones with wind velocity of more than 120 kmph to upto 200 kmph is called hurricanes. Locationally the requirement of tropical cyclones makes it restricted to limited geographical area. Requirement of temperature of 25-27°C, air pressure 920-940 milibars combined with moist air column makes this system confined to tropical marginal water bodies. In specific latitude, this represents 8° to 35° N and S. Absence of tropical cyclones in equatorial belt correlates to the absence of coriolis force along with absence of land-water difference. It is with coriolis effectively that this system registers counter-clockwise circulation in northern hemisphere and clockwise in southern hemisphere. Among the marginal water bodies where this system frequently evolves: Gulf of California and Gulf of Mexico (hurricanes); Bay of Bengal, Arabian Sea and Mozambique Channel (cyclones); South China Sea (Typhoon); Gulf of Carpentaria (Willy Willies) are included.



Structure & Weather of Tropical Cyclones



LECTURE # 27

Date
15/03/2014

⇒ Temperate Cyclone – Due to front
⇒ Tropical " – Due to heating of marginal water bodies.
↳ Trade winds
↳ Eastern boundary more affected
⇒ Naming of cyclones

Structure & Weather : TROPICAL CYCLONE
This LP system which is thermal direct in nature is identified with maximum lifespan of 4 to 7 days. Complete circulation in the effect of trade winds registers their movement towards the eastern margins of the land. In terms of structure, the system is comprised of
(i) Central Eye and
(ii) Rainzone

The Central Eye forms the lowest pressure & highest temp. zone that forms the node of the system. It is its high temp. that makes it completely deprived of advective movements. Accordingly, it represents to be windless, cloudless and rainless part of the tropical cyclone. This structural constituent is also known for blocking anticyclone at the atmospheric levels. Though this anticyclone represents to be the example of HP developed over LP it relates to the important mechanism of sourcing weak subsiding air column that adds to the heat (adiabatic warming) to the eye of the cyclone intensifying the system. Surrounding the eye is rainzone. This structural part of cyclone corresponds to strong winds, heavy precipitation with turbulent weather involving lightening & thundering. Though entire rainzone correlates to the precipitation largely in form of rain and hail, it is intensity of ~~ppt~~.

that goes on decreasing towards the outer margin of the system. As such, it is along the eye wall (transitional zone b/w central eye and surrounding rainzone) that cumulunimbus cloud with heaviest downpour is experienced. Tropical cyclones qualifies to be natural hazards not just because of strong wind velocity & heavy ppt. but also because its on-shore movement generates strong sea-surges that induces saline water to the fertile deltaic plains and causing flooding in the coastal areas. With increasing continentality tropical cyclonic circulation terminates primarily because of decrease in supply of moisture, increase in frictional drag, and ~~&~~ in the effects of blocking anticyclones filling up ~~of~~ of the LP.

Temperate cyclone — Not hazard
↳ Not equal to squall-line

LIMATIC CLASSIFICATION:

ggregates of weather conditions for larger space & onger time is called climate. Climatic classification refore always includes generalisations of the prevailing weather conditions. The entire range of climatic classification schemes developed by climatologists are categorised into 3 bold categories:

1> Genetic Classification Scheme which takes one element of weather & climate into consideration as thermal zones or precipitation zones.

2> Empirical classification which includes temperature & ppt. that are the most studied elements of weather and climate in the absolute value. Koppen's Classification Scheme & Trewartha's classification scheme belongs to this category.

iii) <u>Applied Classification</u> : This approach takes into account relativity of T & ppt. called temperature efficiency & ppt effectiveness as approached by Thornthwaite.

KOPPEN'S CLIMATIC CLASSIFICATION

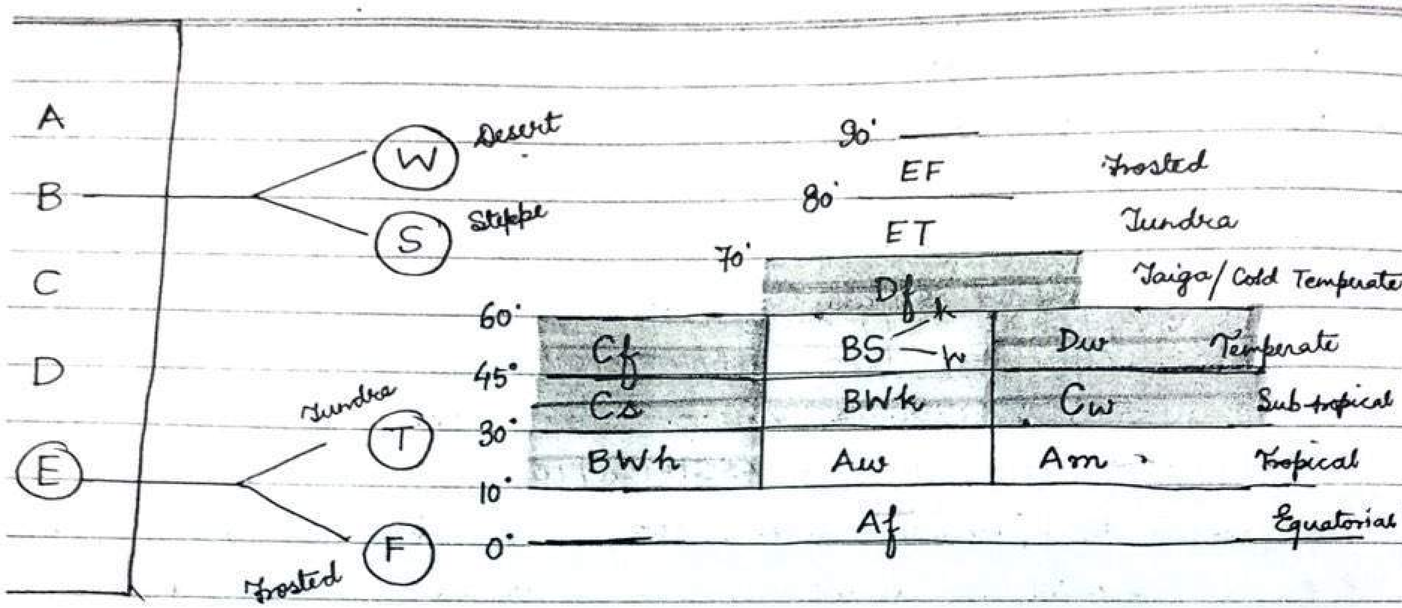
Inspired by the work of De Candolle (1900) who developed first vegetation classification of the world, German scholar Koppen propounded his classification scheme in 1931 with <u>temperature</u>, <u>precipitation</u> & <u>vegetation</u> as the basis of the classification. In 1936, he added altitude or height as the additional base of climatic classification. His scheme includes well defined alphabatical symbols to denote the major global climate types. These symbols are categorised into 3 different levels combining which individual categories of climate are demarcated.

LEVEL 1

Alphabatical symbols includes 6 Capital letters denoting major types of climate with <u>each denoting type of vegetation</u>.

Alphabatical Symbol	Climate	{Type of Vegetation}
A	Tropical	Megatherm
B	Dry	Xerophytes
C	Sub-tropical	Mesotherm
D	Temperate	Microtherm
E	Polar	HELKISOTHERM
H	Montane	Montane

Steppe — Semi arid



vel 2 alphabetical symbols are applied to specify the ature of climate & thus are utilised always with first vel alphabetical symbol. This level includes:

(i) W – Desert
(ii) S – Steppe
} Used with (B) type of climate only

(iii) T – Tundra
(iv) F – Frosted
} Used with (E) type of climate only

(v) f – Precipitation well distributed thro'out the year
(vi) m – 70% of annual rain in 3 months of the year
(vii) s – Dry Summers thus winter rains
(viii) w – Dry winters thus summer rains

evel 3 alphabetical symbols include all lower case symbols urther detailing the prevailing climatic types. The symbol

h – Hot summers with summer T > 18°C
k – Less warm summer with T < 18°C

⇒ Used only with (B) type of climate

a = Long hot summer with summer T > 20°C
b = " Warm " " " " < 20°C
c = Short & Cool " " winter T decreasing to 10°C
d = Long & cold winters with summer T increasing to 0°C

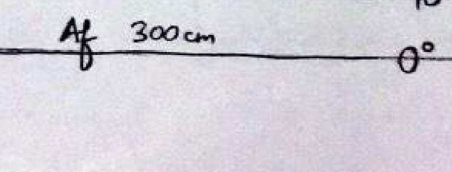
⇒ (A), (C), (D) type of climate.

A TYPE OF CLIMATE

The tropical climate category which represents warm temperature conditions as consistent characteristics. It includes : (i) Equatorial Climate (Af)
(ii) Monsoonal Climate (Am)
(iii) Savanna Climate (AW)

→ The Equatorial Climate extensive b/w 10°N to 10°S represents annual range of temperature to be less than 5°C and annual precipitation upto 300 cms. It includes no season cycles, perrennial effectivity of maritime equatorial air mass. Important examples : Amazon basin

→ The monsoonal & savanna climate represents well defined season cycles with low sun season involving influence of of continental tropical air mass and thus, dry conditions & with high sun season involving influence of maritime tropical airmass, thus, wet conditions. It is due to the difference of coastal & continental locations that monsoonal climate is distinguished from Savanna wherein monsoonal climate relates to more annual amount of precipitation upto 200 cms & is influenced by tropical cyclones. Whereas Savanna climate have lesser precipitation upto 100 cms, with greater range of annual temperature. Locationally, monsoonal climate i.e. tropical east margin is best depicted in India & Indo-China peninsula whereas Savanna climate i.e. tropical continental includes African Savanna as the important location.



High Pressure, Offshore winds } BWh   BWk ⇒ Continentality

TYPE OF CLIMATE

B → BW, BS

BW → BWh, BWk

BS → BSh, BSk

It is drier type of climate that represents evaporational loss to be always more than precipitational gain. It includes two very well defined climates:

1) Desert Climate (BW) and ② Steppe Climate (BS)

The Desert Climate with perrennial aridity involves location & mechanism based 2 sub-categories
(a) tropical desert (BWh) and (b) sub-tropical desert (BWk)
the tropical desert are confined in west margins of land representing permanent location of sub-tropical high pressure, thus, perrennial effectivity of continental tropical air mass. Prevailing offshore winds makes the climate dry in its characteristics. It is during summers that sudden heating of sand causes encroachment of maritime tropical air mass resulting in precipitation of upto 50 cms. Sahara Desert represent the best location. The dryest tropical desert with 12 cms of precipitation annually, Atacama Desert marks the added effect of cold oceanic current.

The sub-tropical deserts are confined in sub-tropical continental interiors and it is continentality that justifies prevailing dry conditions. Annual range of precipitation is in between 0-20 cms with Kalahari Desert (Botswana), Patagonia Desert (Piedmont) in Argentina and Gurbantu (Intermontane, rainless quarter of the world) in China being prominent examples.

High Pressure
Offshore winds } BWh   BWk ⇒ Continentality

TYPE OF CLIMATE

B

BW → BWh

BS → BSh, BSk

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Date
3.03.2014

Geography Lecture 28 After HOLI

B – precipitation based (Arid Climate) & Semi-arid
H – altitude based
A, C, D, E – Temperature
Coastal Somalia → SE Monsoons
Africa do have monsoonal climate
Cameroon to Angola – Savanna Belt
Oceanic currents (cold) ⇒ Driest Desert, Atacama
5 Open oceanic region
Laccolith – Khap Plateau "Cf = Wet west Marine Type"

BS : STEPPE TYPE OF CLIMATE

The temperate continental climate involving precipitation amount of 25 to 75 cms, well distributed throughout the year. Mechanism of precipitation is frontal making precipitation dependable even in the continental interiors. This climate is sub-divided in accordance to their latitude with lower latitudinal steppes i.e. BSh being significantly warmer including Prairies of USA, Pampas of Argentina, Veld of South Africa and Downs of Australia. The higher latitudinal steppes i.e. BSk with comparatively lower temperatures includes Canadian Prairies, European Steppes and Canterbury plains of New zealand.

	BSh (Lower Latitudinal)	BSk (Higher Latitudinal Steppe)
Temperate Continental Climate 25–75 cms rain, well distributed Frontal precipitation mechanism Latitudinal division into BSh & BSk	– Significantly warmer – Examples : ⟨i⟩ Prairies of USA ⟨ii⟩ Pampas of Argentina ⟨iii⟩ Veld of S. Africa ⟨iv⟩ Downs of Australia	– Comparatively lower temperature – Canadian Prairies – European Steppes – Canterbury Plains of N. Zeala

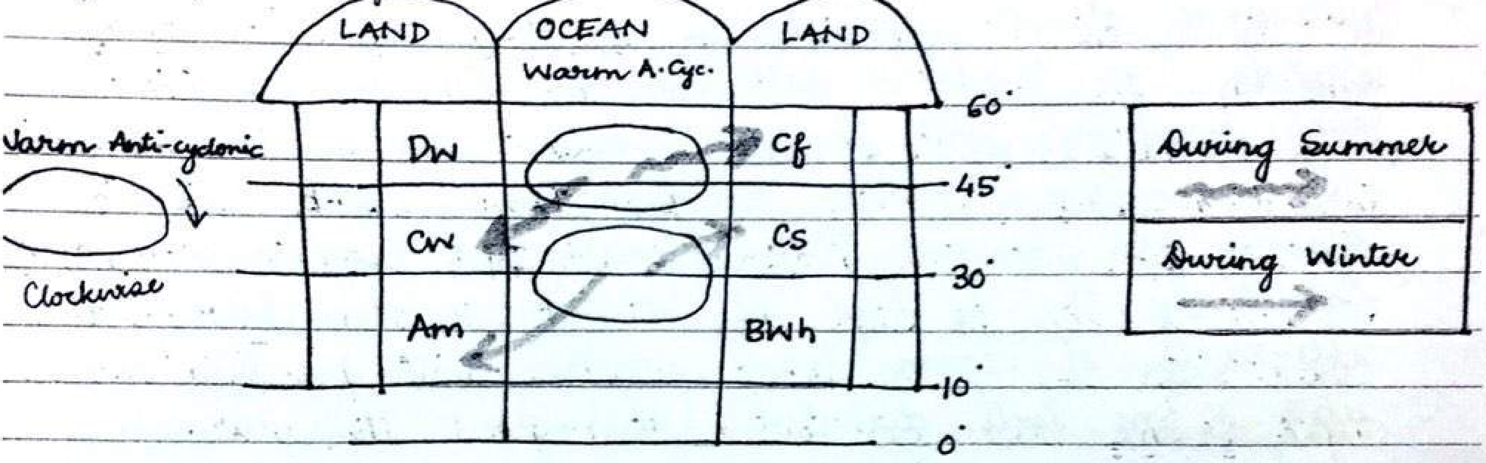
C-TYPE OF CLIMATE (Subtropical Climate)

The subtropical climate which is regulated by warm anti-cyclone i.e. subtropical high pressure cells. It includes
Mediterranean Climate (Cs)
European climate (Cf)
China type climate (Cw)

Mediterranean Climate (Cs) : The mediterranean climate is confined in sub-tropical west margin with most defined characteristics of long hot summer drought. It experiences on-shore westerlies, thus, the effect of mT air mass only during WINTERS. Annual amount of precipitation is between 50-75 cms. The climate attains its name from Mediterranean Sea shoreline that has largest area experiencing this climate (except Egypt and Libya). Central California makes another important location of this climate.

The European Climate (Cf): The European climate also referred to as Wet West Marine climate remains in the influence of westerlies throughout the year. Well distributed precipitation in the range of 125-130 cms makes this climate wettest among the west margin climate. It is in reference to this climate that utilisation of third level of alphabetical symbols have been attempted by Koppen, representing northern European climate to be warmer (Cfb) in the effect of NAD compared to the British Columbia (Canada) and Southern Chile [Cfc], denoting the effect of cold oceanic currents.

China Type Climate (Cw): The China type of climate confined in subtropical east margin experiences upto 150 cms of summer concentrated precipitation caused by on-shore NE Trades. This climate type includes northern Chinese plains and Piedmont plains of Appalachians as important locations. Weak polar outbreak during winter forms the cause of minor amount of winter precipitation. This climate type in its lower latitudinal extension do involve the effectivity of tropical cyclone.



Beyond 60^{th} parallel : Land-water do not matter.
Absolute Stability thro'out the year : Poles
, 60°-70° :: Taiga - Absolute Instability ; Not present in Southern hemisp
ET : Conditional Instability
> Warm front

1) D-TYPE OF CLIMATE // Temperate Climate

Representing the examples of climatic regions with long & cold winters, this climate type incorporates :-
<I> Manchurian type of Climate / Laurentian type (DW)
<II> ~~Laurentian~~ Taiga / Boreal type of Climate (Df)

, Manchurian Climate: The Manchurian climate confined in temperate East margin represents the climate type with upto 100 cms of precipitation in the effectivity of on-shore winds during summers and polar outbreaks related frontal precipitation. During winters, this climate type is practically restricted as the entire region involves upland or plateaus intermixing the climate with that of taiga.

Taiga or Boreal Type of Climate: The Taiga type of climate confined to warm sub-polar latitude (60°-70°N) is a latitudinal climate confined in northern Eurasia and Canada. In Eurasian belt, combination of prevailing relief combined with oceanic currents causes the sub-divide including Dfa (northern European Plain), Dfb (Siberian plain), Dfc (Siberian Plateau) and Dfd (Eastern Mountains). Collectively, the Df type of climate involve perennial effectivity of warm front weather with precipitation upto 30 cms well distributed throughout the year.

Warm front ⇒ Temperate Cyclone
Norwegian Current → Branch of NAD / Extension of NAD
BWk – Rainless quarter of the world (Gurbantü)
Aridity ↑ if cold currents present.
BS → Semi-arid because continental
C-type → Effect of warm anticyclones
Cfb → NAD Effect
Cfc → British Columbia due to cold currents

East Margin

DW
CW
Am

↑ Winter precipitation
↓ Summer Precipitation
⇓ Overall Precipitation

Manchuria → North-East China

"Franc Josef Land"

70° - 80° Tundra
80° - 90° Frosted

5.) E - Type or Polar Climate :=

This climatic category is sub-divided into frosted (EF) and Tundra (ET) categories.

1) The tundra climate confined in sub-polar areas includes brief summers which facilitates melt of surface ice with sub-surface remaining permanently frozen. This generates water logged conditions that sustains life including the phototrophs (green plants) called tundra. Latitudinally this climate marks its confinement upto 80°. However, it is "Frank - Joseph land" that makes the northern limit of this climate in the northern hemisphere. This climate is also correlated with summer frontal precipitation (warm fronts, only northern hemisphere) with upto 20 cms.

2) The frosted climate (EF) represented in Greenland in northern hemisphere & Antarctica in southern hemisphere is absolute stable COLD POLAR DESERT, with 6 continuous months of nights followed by 6 continuous months of day.

10° to 80° → Season Cycle applicable
No season cycle :- Equatorial & Polar
Southern hemisphere :- No temperate cyclones ⇒ No warm front

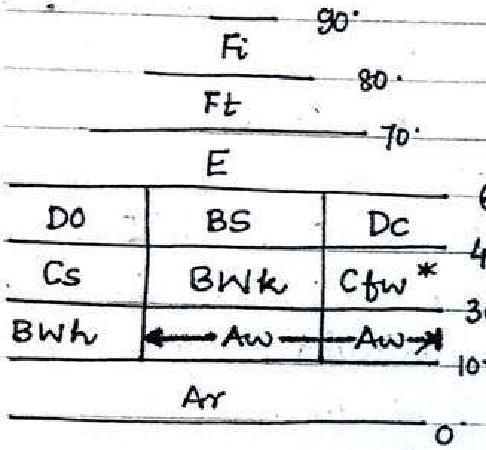
6.) H-TYPE / Montane Climate :

Added in 1936, this climate category is interpreted of its diversity based on four factors :-

<1> Sign of latitude
<2> Altitude
<3> Sun-bearing slopes i.e. southern slopes of Northern hemisphere &
<4> northern slopes of Southern hemisphere
<4> Maritime influence i.e. wetter windward slopes & drier leeward interiors.

'REWARTHA'S CLIMATIC CLASSIFICATION

Empirical category presented by American scholar Trewartha
Modified alphabetical symbols
Improved alphabetical symbol of China type of climate
Is less utilised compared to Koppen.



OBAL PRECIPITATION DISTRIBUTION (Genetic classification)

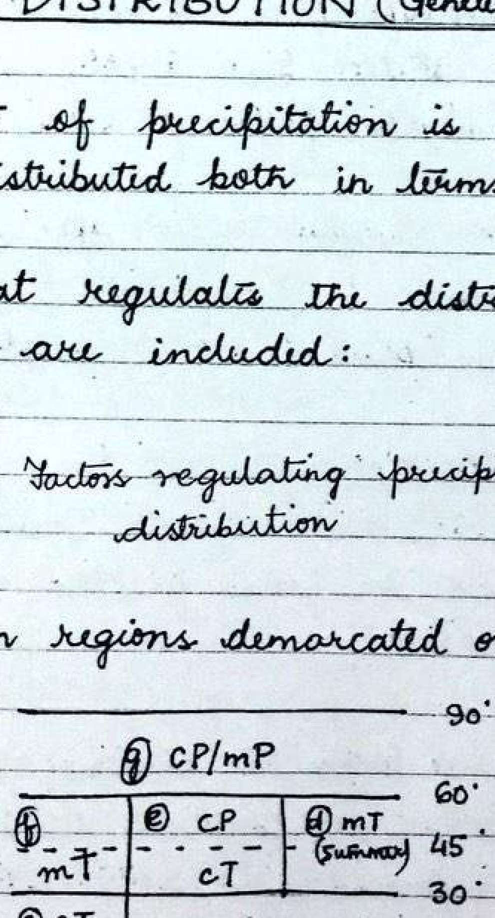
Average global amount of precipitation is 1000 mm (WMO), which is unequally distributed both in terms of space and time.

Among the factors that regulates the distribution of precipitation, following are included:

Sign of latitude
Nature of circulation
Continentality
Orographic barrier

} Factors regulating precipitation distribution

There are 7 precipitation regions demarcated on the map of world including:



a = Wet Equatorial (mE throughout)
b = Trade Wind Belt (mT in summer & cT in winter).
c = Tropical Desert (cT throughout)
d = Moist Sub-tropical climate (mT in summer)
e = Mid-latitude desert & steppe
f = Westerly belt (mT throughout)
g = Polar and arctic deserts (frontal conditional instability)

Koppen's Basis:
- Temperature: A, C, D, E (E further divided on T basis)
- Precipitation: B (major)
  A, C, D also
- Vegetation (finally)
  ↳ Name De condolle

Continental climate always drier than coastal ones.

ē
03.2014

Lecture 29

1. Wet Equatorial Region (10°N — 10°S)
- Warm wet thro'out the year
- perennial effectivity of mE air mass
- Absolute instability with annual ppt. of 300 cms

1. Trade Wind - Belt (10°-30° N/S)
- Along eastern margins of land
- Summer specific ppt. caused by mT air mass
- Involves conditional and absolute instability (orographic)
- Annual ppt. in range of 100-250 cms
- Additionally involves the tropical cyclonic surges as cause of precipitation

Tropical Desert (10°-30° N/S)
- West margin of land
- Permanent location of CT air mass
- Summer effective erratic encroachment of mT air mass causes ppt. of upto 50 cms

Moist Mid-Latitude Sub-tropical (30°-60°
- Along east margin of land
- Involves the effectivity of mT and mP air masses
- Precipitation in the range of 100-150 cms with amount decreasing towards higher latitude though frontal ppt. and winter ppt. marks increase with increase in the latitude.

China type - mT
Manchurian - mP

(e) <u>Mid latitude desert & Steppe</u> (30° – 60°)
- In continental interior
- Involves influence of continental air mass (cT & cP both)

* · Precipitation range b/w 0–75 cms with amount increasing with increase in sign of latitude.
- The temperate grasslands Prairies denoting sub-humid climate (50–75 cms) and steppes denoting semi-arid climate (25–50 cms)

(f) <u>Westerlies Belt</u> (30° – 60° West Margin)
- Regulated by on-shore westerlies
- Ppt. range 50 – 130 cms

* · Amount increasing with increase in sign of latitude with Mediterranean region experiencing seasonal (winter) ppt. whereas European plains experiences precipitation throughout the year.

(g) <u>Polar and Arctic Deserts</u>
- Latitudinal ppt. region
- Extensive beyond 60^{th} parallel
- Involves cold and dry polar air masses

* · Conditional instability induced by warm front weather throughout the year in taiga (30 cms) and during particular summer season in tundra (20 cms) restricts the true desert to absolute polar area.

Df

Gf ↑ precipitation decreases bcoz moisture holding capacity decreases

Af

APPRAISAL OF KOPPEN'S CLASSIFICATION

The empirical classification scheme of Koppen forms one of the most utilised climatic classification scheme for climatological purposes. This approach however is highlighted with some of the important limitations. These include:

Unclear or flexible use of alphabetical symbols

Taking absolute amount of temperature & precipitation for climatic ~~regionalisation~~ regionalisation.

Koppen picked up the alphabetical symbols from the vegetation classification of De Condolle. Its utilisation, however, fails to avail complete description of the recognised climate like 'f' representing well distributed precipitation fails to avail the clarity of big difference of amount that is 300 cms for 'Af' type of climate & just 50 cms for 'Df' type of climate. Flexible utility of alphabetical symbols is also highlighted as limitation where temperature base 3rd level alphabetical symbols are prominently taken into account. Inspite of defining absolute meaning of small 'a, b, c, d' types of climate while utilising, Koppen have treated these alphabets in "relative meanings" generating confusion among the readers. His classification scheme have been strongly criticised on the grounds of utilising absolute value of temperature and precipitation. This criticism is largely attributed to American Scholar Thornthwaite. highlighting the limitation of in using the absolute value, he referred the examples of equatorial climate which inspite of high sun thro'out the year do not relate to highest records of temperature as it is heavy precipitation region. Similarly, near similar amount of precipitation generating Deserts in tropics and forests in subpolar

Absolute ⇒ Empirical
Applied ⇒ More logical

areas remains unexplained with the Koppen's Scheme. Based on these limitations, Thornthwaite attempted his Applied Category of Classification.

THORNTHWAITE'S CLASSIFICATION

The applied category of climatic classification is primarily attributed to American scholar Thornthwaite who presented his first classification scheme in 1931, almost parallel to Koppen's classification scheme. Utilising relativity of temperature and precipitation in his original scheme, he demarcated 5 humidity provinces. Each province was denoted with capital alphabetical symbol with well-defined type of vegetation and lab-calculated index of moisture. The recognised climate includes:

Symbol	Climate	Vegetation	Index of Moisture
A	Par Moist	Rain Forest	Max
B	Moist	Forest	↓
C	Sub-Moist	Savannah	↓
D	Semi-arid	Steppe	↓
E	Arid	Desert	Min

In 1936, and 1938, Thornthwaite attempted improvements to his 1931 scheme. However, his approach never generated the kind of support and utilisation that Koppen's classification attracted. Thornthwaite thereby attempted one of the most sophisticated applied category of classification scheme in 1948 published in the text entitled "A Rational Approach to Climatic Classification."

{Applied can't be absolute rather relative}

In the 1948 scheme, he introduced climatological term called <u>potential evapo-transpiration</u>. He defined it to be the amount of moisture that gets evaporated or transpirated after the attainment of moisture. He emphasized that it is potential evapotranspiration that avails the analysis of actual amount of moisture left out in air or soil to regulate the climate and related activities. It is due to the lack of data availability for potential evapo-transpiration, he demarcated <u>4 different indexes</u> with different set of alphabetical symbols combining which he attempted to calculate potential-evapotranspiration. These indexes include:

1) Humidity provinces based on index of moisture
2) Seasonal variations in humidity provinces
3) Thermal efficiency regions
4) Seasonl variations in thermal efficiency regions

<u>Humidity Provinces</u>

Calculated, based on IOM (Index of Moisture), humidity provinces were simply enlarged list of the original classification scheme. 9 different humidity provinces denoted with capital alphabetical symbols with lab-calculated IOM includes

IOM: Max

A — Par Moist

B_4, B_3, B_2, B_1 — Moist

C_2 — Moist Sub-humid

C_1 — Dry Sub-humid

D — Semi Arid

E — Arid

IOM: Min

②

The seasonal variations in the humidity provinces are denoted with small alphabetical symbols categorised into <u>aridity index</u> & <u>humidity index</u>.
The aridity index being utilised for humid climate and humidity index for arid climate. The distinguished symbols include :

A	r – No Deficit	Aridity Index (Humid)
B_4	s – Minor Summer Deficit	
B_3	w – " Winter "	
B_2	s_2 – Major Summer "	
B_1	w_2 – " Winter "	
C_2		
C_1	d – No Surplus	Humidity Index (Arid)
D	s – Minor Winter Surplus	
E	w – Minor Summer "	
	s_2 – Major Winter "	
	w_2 – Major Summer "	

③

To calculate potential evapo-transpiration, thermal efficiency index based thermal efficiency regions were demarcated by the scholar. In accordance, he distinguished 9 different thermal efficiency regions, each denoted by capital alphabetical symbol. The demarcated symbols includes

Thermal Efficiency (TE)

A'	—	Megatherm	Maximum
B'_4, B'_3, B'_2, B'_1	—	Mesotherm	↓
C'_2, C'_1	—	Microtherm	↓
D'	—	Tundra	↓
E'	—	Frosted	Minimum

Seasonal variations in TE Index :

Denoted with small alphabetical symbols this index is not applied to frosted (E') climate. In this index, there is the calculation of concentration of TE during "summer as the % share of total annual TE. This index clearly depicts " that with ↑ in the sign of latitude, TE concentration during summers will go on increasing".

a', b'_4, b'_3, b'_2, b'_1, c'_2, c'_1, d'	% Concentration of annual TE during summer	Minimum ↓ Maximum

Temperature Efficiency is TEMP. LEFT OUT.

Concluding of Thornthwaite Classification :-

This scheme in the combination of demarcated alphabetical symbols involves near 125 recognised climate types. practically on the map of world, it is not more than 32 climate that can be demarcated. This justifies that Thornthwaite's classification scheme, being specific in nature have restricted value in the global climatic regionalisation. This scheme, however, can be utilised to demarcate the climatic regions of smaller areas as individual countries (India). Thornthwaite's classification certainly makes the methodological improvements over Koppen's scheme in availing relativity of temperature & precipitation in distinguishing the climate type. It is this scheme that is best utilised for all the fields of applied climatology. Among the major fields, agriculture planning specifically crop stand, water resource planning, regional planning, rural & urban development, it is this classification that avails the support to decipher regional and seasonal variations of soil moisture or quality and quantity of sub-surface reservoirs with their regional seasonal variation.

Rice → Tropical Climate, Warmer Climate

→ Japan due to warm Kuro Shio Current

Wheat → India, China, USA

→ Winters