

Atmos

- (1) Envelope of gases around earth's surface.
- (2) Merges with outer space.
- (3) No fixed height ≈ 1000 km
- (4) part of earth, makes earth-atmos system.

ORIGIN

- (1) Diff theories exist.
- (2) Earliest is Premordial. Gaseous Nebula $\rightarrow$ heavy gases became cold, lighter ones differentiated $\rightarrow$ layers.
Accreting Nebula $\rightarrow$ Atmos.
 -ve: outer space has $\uparrow\uparrow$ H_2 , He. But earth Atmos does not.
- (3) Degassing
 1st Phase: Atmos had N_2, CO_2 , vapours.
 2: vapours condensed $\rightarrow$ rain $\rightarrow$ oceans.
 3: CO_2 dissolved. [water has [0-4%], atmos [0.03%]]
 4: N_2 (78%)
 5: O_2 by photosynthesis by cyanobacteria.
 $\therefore$ Atmos formation is Phy n Bio process.

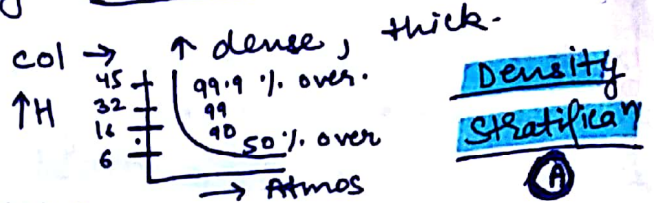
COMPOSITION

- (1) Atmos is mech mix or admixture of gases, no chem mix.
- (2) No segregaⁿ on basis of atomic/molecular mass.
- (3) Acts as single gas.
- (4) Non variable gases [N_2 [78%], O_2 [21%], CO_2 [0.03%], Ar [0.9%], O_3 [0.0004%]]
- (5) Variable component: Water vapour [0-4%] $\downarrow$ with dry-saturated.
- (6) Atmos may become thick/thin but composⁿ remains same.
- (7) Also inc dust, microbes.
- (8) It is dynamic system, circulates, manipulates other earth's process. " bcz of its components. Dust + gases trap & regulate heat [GH effect].
- (9) 99.9% gases [N_2, O_2, Ar] have no GHE $\rightarrow$ no direct role in atmos regulaⁿ. O_3, CO_2, H_2O [↑↑] are GHGs.

(10) Man made components [pollutants, CO, NO, SO, C].

Atmos Structure :-

- (1) Deals with internal argument | orgⁿ of components
- (2) Admixture gases retain indi properties.
- (3) Gases Mix due to weight, compⁿ → layers.
- (4) No stratifican on basis of indi Mol. Density.
- (5) lower layers → carry wt of col → ↑ dense, thick.
- (6) ↑ H → ↓ density.



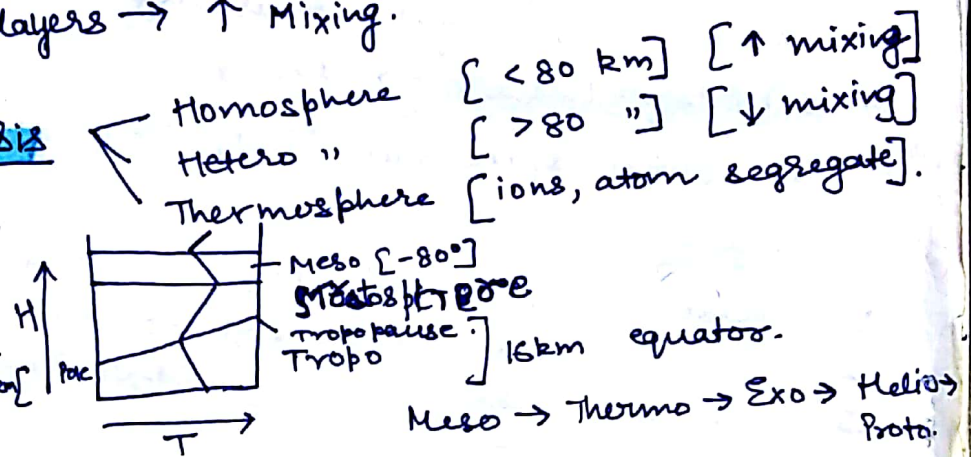
(7) ↑ H₂O in lower layers → ↑ Mixing.

Ⓐ on Mixing Basis

80-200-1000-3000 km
N₂ O₂ He → H₂.

Ⓑ Temp basis

on GHGs properties.



Ⓒ Incoming radian → ↑ energy → not intercepted → do not ↑ T.
Earth/terrestrial radiation → ↓ energy → intercepted → ↑ T.
[atmos heated from below].

Ⓓ ↑ energy → ↓ λ → ↑ D
Ⓔ ↓ " → ↑ λ → ↓ D

Troposphere :-

[variable H, ↑ mixing, ↑ atmos processes, weather layer, ELR [6.4°C/km], more at equator [convecⁿ], Tropopause [no turbulence beyond it]].

ozone :- $\frac{G_a \times U}{\uparrow \text{energy}}$ $\frac{V I M R}{\downarrow \text{energy}}$

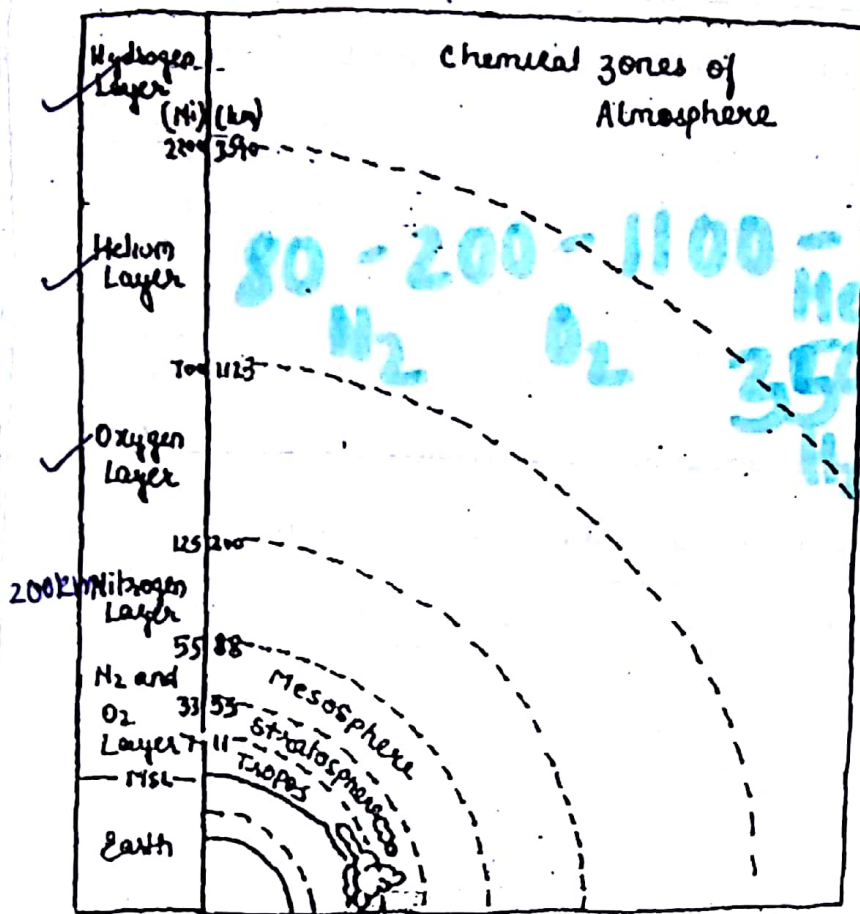
G_a, X blocked by magneto...
UV " " O₃

Stratosphere :-

↓ turbulence.
T ↑ with H here [heated 4m abv] as UV trapped.
Due to inverse LR, vertical rise of air is low → stability.
[In tropos, atmos cools with H → turbulence]. [no mixing]

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temperature continues outward to the mesopause near 80 kilometers (49 mi). Up to the



mesopause, the mixture of gases is about the same as at the surface. For this reason, the lower 80 kilometers of the atmosphere is termed the homosphere. Beyond the 80-kilometer altitude, the composition of the air begins to change. Above the homosphere atmosphere, gases tend to stratify on the basis of molecular weight. This layer is termed the heterosphere. To a height of 220 kilometers (130-mi), molecules of nitrogen largely make up the

atmosphere. Layers of helium and oxygen exit outward from there, the mesosphere merges with a zone called the ionosphere. As the name implies, the ionosphere contains ionized gases and free electrons resulting from absorption of solar radiation. Short-wave radiation from the sun is absorbed, and the energy causes the electrons to split from the atoms of nitrogen and oxygen. The proportion of ionized particles is large because the density of particles is low and solar energy high. The higher in the ionosphere, the fewer particles; the more solar energy available, and the more ionization that takes place. Incoming solar radiation begins to interact with the atmosphere at altitudes beyond 500 kilometers (310 mi). This outer region is also where gaseous particles escape the earth's gravity.

Mesosphere 50-80 km, no O_3 , no trapping, LR normal -90°C at mesopause [80 km].

Homosphere till mesopause.

Thermosphere [gases in atomic/ionic form, absorb insolation to some extent, UV too [some]].

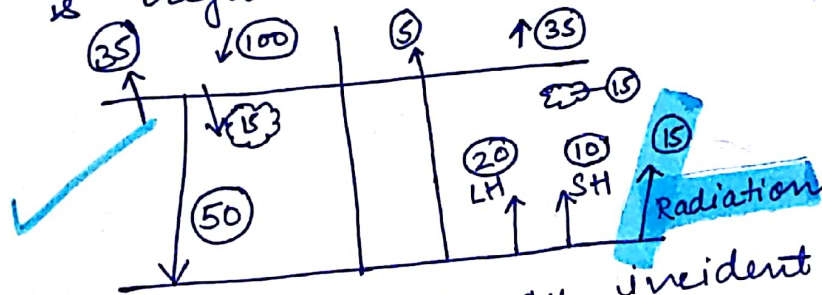
- can have $\uparrow T$ but $\downarrow$ heat as it is rarified.
- 80-800 km. $\rightarrow$ beyond this Exosphere.

Ionosphere is part of thermo with $\uparrow$ ion concⁿ.

- Imp for radio commⁿ.

Heat Budget : ① Study of influx and outflux of heat.

- ② Two ^{study} ways $\left\{ \begin{array}{l} \text{Quantitative [budget]} \\ \text{Qualitative [flow cycles [Hydro, rock cycle]]} \end{array} \right.$
- ③ Earth maintains ambient Temp despite consistently receiving of solar insolation. cc is max by 1°-2°C.
- ④ Insolation is regulated & distributed $\rightarrow$ Net T gain is 0°.



- ① Assume 100 units of energy incident of earth-atmos system
- ② Avg energy received = $1.99 \text{ cal/cm}^2/\text{min}$ = solar constⁿ (avg^y)

- ③ Albedo = 35 units.
- ④ Absorbed by O_3 = 15 units [short wave, $\uparrow$ energy, $\downarrow \lambda$].
- ⑤ " " earth = 50 units. [25 (land), 25 (water)].
- ⑥ 70% (water) area absorbs less as it has $>$ albedo. Also, earth's surface is irregular $\rightarrow \uparrow$ absorption.

- ⑦ outflux ways:-
- $\downarrow$ radiational (5) directly to atmos
- $\uparrow$ Convictional, conductional, LH, SH. (sensible heat)
- 20 10
- 15: radiated terrestrially.

- ⑧ write balance equations.

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- Energy gained by atmos = 60 $\rightarrow$ outer space.
(15 + 15 + 20 + 10)
- Energy lost from earth-atmos =
35 + 5 + 60 = 100.
- $\therefore$ balance w/b Earth surface - Atmos & whole Earth-atmos.
- Heat budget is stnt in energy balance for whole earth-atmos system, not indi lats/locⁿ.
- Tropics are net gainers, Temperatures: net losers.
- Balance at Lat 65°-70°. $\Delta = \pm 0$ here.
- Balance not achieved instantly. $\rightarrow$ lag due to SH capacities, circular system, surface props.
- cc is ex of disrupⁿ in this normal process.
- other disrupⁿ: O₃ hole ($\downarrow$ UV absorbⁿ), cloud cover change, deforestaⁿ, SST, ice cover etc.

Marine heat Budget

- T lag here is $>$ as SH of water is $>$ land.
- $Q = f(Q_i \rightleftharpoons Q_s \rightleftharpoons Q_{LH} - Q_R)$.
- Other energy sources for ocean $\rightarrow$ [volcanoes, biological processes].
- $Q_i = 99\%$ of total received energy.
- compared with above atmos, water surface is 8°C warmer at all lats $\rightarrow$ @ Land-water exchange, water is warmer.
- OCs also regulate T distribⁿ, $\rightarrow$ transfer energy to land, atmos. A warm waters to poles.
- Q_R is due to water-atmos T gradient.
- Q_{LH} " " " - evaporation due to $> 8^\circ\text{C}$ T.

Temp pattern of Atmos

- Insolaⁿ [1.99 Jangleys] min
- Temp pattern is due to heating from below (surface).
- $\therefore$ Atmos' TP is $\approx$ || to Earth surface TP.
- All Energy received via insolaⁿ $\rightarrow$ LCT.

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④ $\downarrow$ LATs receive $\uparrow$ energy $\rightarrow \uparrow T$] LCT.
 $\uparrow$ " " " " $\rightarrow \downarrow T$
 This is due to spherical nature of earth surface.
 [low Lat get $\uparrow$ direct rays [Lat: oblique].
 [" " distance from sun is less].

- ⑤ LCT manifests as E-W isotherms.
 ⑥ Disruptⁿ in LCT = land-H₂O diff, altitude, OCs, winds.
 ⑦ Anomaly +ve, -ve.
 ⑧ ex: (a) equator < T than tropics.
 (b) Tropical / sub-trop margins are warmest due to $\uparrow P \times$
 subsiding air $\rightarrow \downarrow$ rain.
 LCT N > S due to > land $\rightarrow$ isotherms irregular in N,
 smooth " S.
 (d) Altitude (Quito, Kilimanjaro).
 (e) OCs.
 (f) local winds (loo in N, mistral in rhine-rhone).
 (g) seasonal variⁿ, anthropogenic effects, urban plume.



Thermal zones

- ① By greeks $\rightarrow$ tropical (30°N-30°S), frigid (60-90),
 temperate (30-60).
 ② Assumpⁿ: homogenous earth surface [no L-W diff]
 + Land [land has > T at
 - water lower Lat].
 Anomaly 0-45° Land
 45-90 water

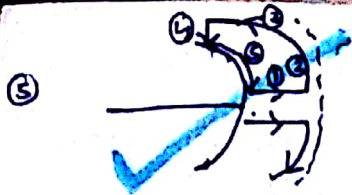
Circulaⁿ Pattern of Atmos

- (1) In motion, in attempt to equalize T & heat diff across
 surfaces & Lats. $\rightarrow$ continuous circulation. $\leftarrow$ horizon- (advectional
 (winds)
 vertical (currents).

Hadley Model

- (1) 1st circulaⁿ model, 19th cent.
 (2) Assumpⁿ: Non rotating earth (XCF), homogenous (XL-W)
 (3) It is thermal model as primary control is thermal.
 (4) Every hemi has 1 vertical, meridional cell [air rises & moves
 along meridian].
 = unicellular model.

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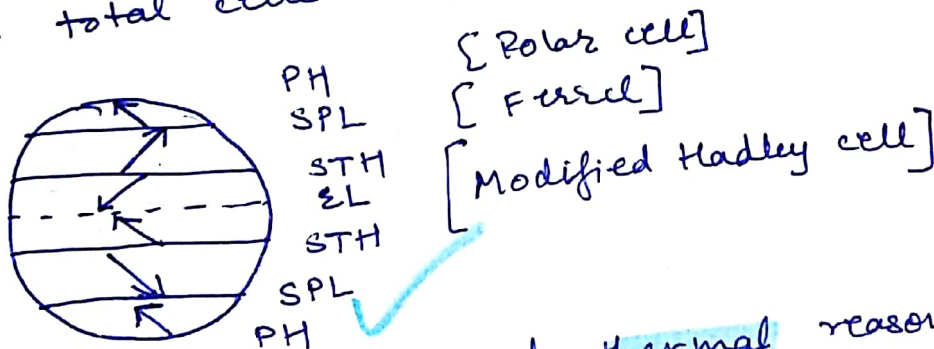
- 1: rises in $\downarrow$ Lat $\rightarrow \downarrow P$ at eq.
- 2: reaches till tropo [warm air can't cross tropo pause]
- 3: moves towards pole
- 4: Sinks at Pole. $\rightarrow \uparrow P$ at Poles.
- 5: Moves back to eq along surface.

⑥ $\uparrow A \downarrow P$ are thermal in origin, here.

⑦ P distribution on surface is in form of continuous LAT belts & they are 3 in all. [2 Polar High, 1 eq low].

Ferrel Modification

- (1) A/c for earth rotatⁿ $\rightarrow \checkmark$ CF [apparent force due to relative motion].
- (2) Still no L-W diff a/c'd.
- (3) Eq thermal heating $\rightarrow$ air rises $\rightarrow$ deflects to Right in N. A left in S $\rightarrow$ cools $\rightarrow$ sinks at tropics (35°) due to pile up. it is indirect thermal.
- (4) $\therefore$ Rise is thermal, Sinking is not. $\rightarrow$ sub-trop $\uparrow P$ cell.
- (5) From ST $\uparrow P$ cell air diverges & moves towards eq from N/E & S/E $\rightarrow$ trade winds.
- (6) circular not perfectly meridional due to CF.
- (7) ST air merges at 55°-65° N/S with air from Polar High $\rightarrow$ forces air to rise $\rightarrow$ SP $\downarrow P$ cell.
- (8) Winds from ST $\uparrow P$ deflect to Right $\rightarrow$ westerlies.
" " " " " $\rightarrow$ Easterlies.
" " " " " as CF $\uparrow$ with Lat.
- (9) $\therefore$ total cells = 3, belts = 7. [1 eq $\downarrow P$, 2 ST $\uparrow P$, 2 SP $\downarrow$, 2 P $\uparrow$].



⑩ Ferrel has suggested thermal reasons + DYNAMIC dynamic model of airⁿ i.e. convergence/divergence $\rightarrow$

⑪ Eq $\downarrow P$, Polar $\uparrow P$ are thermal direct belts. [3]
STH, SPL are thermal indirect [4]

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Merits of Ferrel

- ① CF, rotation.
- ② gave 3 planetary winds [Trades, Westerlies, Easterlies]
- ③ Explains STH, SPL → related climates.
STH deserts, rain on E coast, High Mid lat's ($>65^\circ$) climatic instability due to $\downarrow P$, Mediterranean rain of winter via westerlies.
Mid lats have onshore Westerlies in winter & offshore trades in summer → winter rains. [cali, capetown, Italy, france etc].

Demerits

- ① $\times$ L-W, ② homogenous surface.
- ③ continuous lat belts of pressure (due to no L-W).
- In real, belts are cellular & discontinuous.
- ④ No explainⁿ for local winds, monsoon, air mass etc.
- ⑤ Poor descripⁿ of UT circulaⁿ. [considers UT winds & condition as opposite to surface condition, $\uparrow P$ with $\downarrow P$].
- This is due to assumⁿ that vertical near-meridional cells exist upto tropos but in reality they are not as high.
- ⑥ Talked only abt meridional cell & not lat cell like walker cell.
- ⑦ $\uparrow\uparrow\uparrow$ imp of meridional cells in Poleward distriⁿ of surplus energy. [not in real]. AM, Fronts, RWs explain it better.

P distribun on globe

- (1) Hadley's 3 belts, Pl's 7.
- (2) on considering L-W diff → continuous belts not possl due to diff STH, also distribun can't be zonal / latitudinal
- (3) still conti belts exist due to uniformity of surfaces
ex: in Poles, Equator, SPL of south hemi.
- (4) so 4 conti belts are [EL, 2PH, SPL(S)]. Rest discont.
- (5) Trades are uniform winds & do not change across year → continuous eq. Low P. belt.

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⑥ ITCZ: convergence zone of trade winds. It includes narrow band of gentle, variable winds called doldrums. [area b/w 2 rising warm air $\rightarrow$ still calm $\rightarrow$ no rain]. Fast wind at boundary.



explain effect of L-W diff, SH, cooling/heat $\rightarrow$ discout cells

Seasonal variation of P cells

Winters

- P cells on oceanic waters r near permanent.
- P cells " land vary with season.
- SP Lats can become very cold $\rightarrow$ $\uparrow\uparrow\uparrow$ P ex siberian High
- $\rightarrow$ brings cold weather to Eurasia.] $\rightarrow$ disappear in summer.
- Canadian high in N. America.

Summers

- ST land $\rightarrow$ intense heat $\rightarrow$ $\downarrow\downarrow\downarrow$ P cells [colorado, tibetan, sahara].
- In South, STL is not dev, due to $<$ Land Mass.

Winds

- Horizontal movement of atmos
- Due to T-diff, P-diff, CF, L-W, Seasonal changes on land.

- ① Primary Planetary Global (Ferrel model)
- ① Trades: • N/E, S/E (strong, persistent), onshore on E coast, offshore on west [offshore trade deserts].
- Monsoon are modified trades.

- ② Westerlies of Mid-Lats: onshore on west coast. Stronger in S. (RFSS)
- Resp for WWD.

- ③ Polar Easterlies. cold, create SPL. called Sec-circu

- ③ Regional winds Monsoon, AM, Fronts.
- ③ Local winds / tertiary circulation
- local cold/warm winds, cyclones, tornadoes, Periodic winds [land/sea breeze, Mountain/valley (Kata) (Sinking)]

Warm winds

- ① origin: local heating (loo), ↑ P centre (sirocco) (Sahara desert)
- ② ex: Khamsin (Egypt), ghibli (Libya), Sirocco (Chihli) (tunisia), Levanche (Spain), Harmattan (Guinea) (Doc).
- Brickfielder (Aus outback to S/E), Norwester.

- ③ Also due to adiabatic condⁿ on downward slopes
 due to adiabatic contractⁿ → heating.
 due to adiabatic contractⁿ → rarified atoms → expands → cools → rain.
- adiabatic expⁿ → heating (compress)
- Air Rises → cools → condens → dry → contract → warm wind (leeward)
- (windward)
- ✓ Zonda (Andes)
 ✓ Sirocco (Sahara)
 ✓ Chinook (Föhn alps)

Cold winds / Drainage winds

- Air at Mt cools very fast → ↑ radiational losses → air sinks along Mt slope. → descends along valley → drainage winds
- ex: Mistral (Rhine/Phone), Bora (Alps), Tramontane (Greece), Sea breeze [during day], Pampero, South Easterly, blizzard (Canada), Buran (Siberia).
- (Katabatic) (Mt → valley) (Night)
 (Anabatic) (V → M) (Day).

Local Winds

Land / sea breeze.

Land → sea breeze (day).

UT winds, P pattern

× Circular



- ① Ferrel sugⁿ was wrong.
- ② For UT there is only 1 set of P gradient.
- ③ ↑ P abv eq area × ↓ over Poles. wind = E → Poles
- ④ CF acts → wind flows as UT westerlies.
- ⑤ P → wind → CF
- CF always ⊥ wind.

- ⑥ When wind is ⊥ to both → geostrophic condition.
- ⑦ ↑ H → ↓ Fricⁿ → wind speed ↑ → ↑ CF → geostrophic.
- [wind ⊥ P.L. × ∥ to isobars].

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∴ UT winds are almost entirely westerly, swift moving under GS condⁿ at all Lats.

JS  JS.

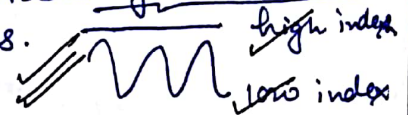
Relatively narrow, shallow, swift band of wind with V abt 300 km/hr. Embedded in UT westerlies. Found at interface of H-F cell, F-P cell & abv Polar vortex. 1st discovered during ↑ alti air travel. Follow meandering path r/t straight [meander ↑ at Poles] to conserve Angular momentum.



UT winds that have sharp meandering paths are called RW.

JS & RW have decisive role in distribun of energy across LATs.
→ interlatitudinal energy balance. [Not ferrel V-M cells].

Meandering has period cycles in amplitude fluctuations from nearly straight to sharp meanders.



Index cycle more perceptible along poles. RSW carry surplus energy from ↓ Lats to ↑ LATs during low index [sharp turn].

3 types of JS

- (1) STWJS at H-F interface 30°-35° N/S.
 - (2) PJS " F-P " 55°-65° N/S. PJS is at SP Lat.
 - (3) PNJS feat of 6 months when Polar areas have continuous darkness
 - (4) TEJ over Ind sub-conti during summers & related to Tibetan ↑ P cell. TEJ has role in strengthening S/W monsoon.
 - (5) SJ Along Eastern Somali S → N during S/W monsoon.
- SJS is called friend later JS.

Elements of climate & weather [T, P, wind, humidity, Precipⁿ, clouds]
dry air $\xrightarrow[\text{vap}]{\text{H}_2\text{O}}$ moist air → condensaⁿ → drops → rain.

① Humidity

humid air measurement :-

- Abs Humidity : wt of vapour / vol of moist air.
- Specific " : wt of vapour / wt of moist air.
- Relative " : amt of vap in air / capacity of air at that Temp.

Index Cycle of the Jet-Stream :- In the first stage the jet-stream lies quite close to the polar regions and flows from due west to east. In the northern hemisphere, the cold air mass is found to the north of the upper-level westerlies. To the south of the jet lies the mild air of mid-latitudes. The westerlies in this stage have shifted towards higher latitudes where there is a lot of cyclonic activity. Pressure systems in this stage have got east-west orientation. North-south pressure gradient is relatively steeper. The air mass exchange between the temperate and tropical region is at its minimum. The first stage thus represents the high zonal index. In the second stage the amplitude of jet-stream waves increases. The whole of the jet moves towards the equator as a result of which there is an inroad of cold polar air southward. The warm air masses from lower latitudes move towards higher latitudes. In the third stage, the bends in the jet streams become sharper and the amplitude of waves registers a further increase. At this stage the tropical air masses move farther north and cold polar air moves farther south. Now the jet stream is positioned nearer the equator an exchange

- 1st: High zonal Index • 1m N.
 2nd: Amplitude ↑, moves towards equator
 3rd: sharper bends, AM ↑ 35, southwards, inter tropical AM
 4th: Low zonal index. Lower meanders of jet cut 4m original JS



① & ② are actual amt & not good unit to measure.
where ③ is 100% or $\rightarrow$ Saturan / super saturan $\rightarrow$ rain

ways to saturate air:- ① add water vapour
② Reduce air's capacity to hold. [cool it]

$\therefore$ In atmos, it is cooling of air by diff mech
that cause saturan & precipitaⁿ.

condensation ① vapour $\rightarrow$ droplets.

② size needed for falling $> .5mm$.

③ occurs on cooling.

④ **Forms** clouds [upper atmos]
Fog [near surface]

Haze (dense) Mist (light)
Dew [condensan on cold surface]
Frost [vap $\rightarrow$ ice]

dew if cooling is
beyond condensan
limit.
occurs at dew pt
(70)
if dew pt $< 0 \rightarrow$ frost.

⑤ clouds shape [cumulus, cirrus, anvil / thunder cloud, stratus (layered)]

⑥ clouds acc to H:-

Low [$< 2000m$, Anvil, fog, cumulus]
Med [$2000-6000$, Alto, cumulus, alto-cumulus]
High [> 6000 , cirrus, crystals, cirro-cumulus]

$\therefore$ [gen mid level clouds [Alto] are layered].

$\therefore$ cirrus $\rightarrow$ feathery, mare's tail.

$\therefore$ cumulus $\rightarrow$ fair weather, bright sky

$\therefore$ cumulo nimbus $\rightarrow$ $\uparrow$ rain, thunder.

$\therefore$ Alto-stratus $\rightarrow$ halo clouds as they scatter droplets.

$\therefore$ cirro-cumulus $\rightarrow$ mackerel sky.

⑦ **TYPES**

A surface ~~or~~ radiaⁿ $\rightarrow$ radiational fogs when land cools fast.
 $\rightarrow$ cools the air abv $\rightarrow$ surface fogs. [absence of clouds is req]

B up-slope fogs

C Advectional horizontal air movement. cold over hot or vice-
ex: cold arctic over warm norwegian $\rightarrow$ Arctic smoke.

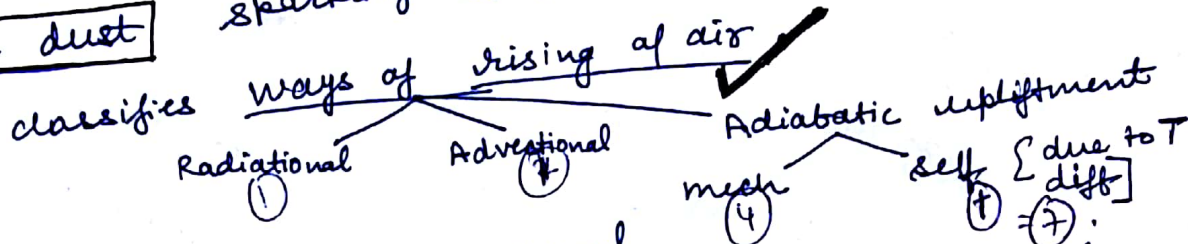
surface radiaⁿ, up slope fog, advectional fog.

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Precipitation

- ① Forms Rain, snow [ice crystal], hailstorm [ice pellets], glaze [rain → ice], sleet []
- ② Hailstorm due to ↑ convection, in summers, during thunderstorm → raises droplets to ↑ H → freeze → fall → upthrust raises again → layered str → fall when weight increases
- ③ Glaze are freezing rains due to cold surface → thin sheets, in ↑ LATs
- ④ Sleet snow → hot surface of land → melts. sparkling suspended ice crystal. In Polars.
- ⑤ Diamond dust

TYPES



Mechanical

- (1) orographic [along mt] (2) convectional
 - (3) convergence / cyclonic (4) Frontal.
- oro on windward side → rises → adiabatic expⁿ → cool.
- convectional pre-monsoon showers.
- convergence Air moves in & converges from all dirⁿ → forced to rise, Reason May be thermal or dynamic.
- ↑ P at meandering wave, ↓ P at surface.] dynamic convergence.
- Frontal due to AMs. cooler AM drives a wedge underneath warmer AM & tosses it up. Boundary of interⁿ is front.



Self upliftment

- ① Due to instable atmos, T gradient → air packet rises in absence of convecⁿ if it is warmer than atmos.
 - ② ELR / NLR : Rate at which tropos cools. It varies season - season & place - place ≈ 6.4°C / Km.
 - ③ Adiabatic LR : cooling due to adiabatic expⁿ related to rarification of atmos with H.
 - ④ Dry ALR > Saturated ALR as moist air has ↑ S.H.
- ∴ DALR (10) > moist (9-4) > SALR (4)

ALR don't vary with season / locⁿ but with moisture.
 A's LR > B's LR.
 [close to y axis has ↑ LR]

ELR varies as in diag.

- (1) ELR < SALR < DALR [no rising]
- (2) SALR < ELR < DALR [SLR rises]
- (3) ELR > DALR > SALR [dalr, salr rise]

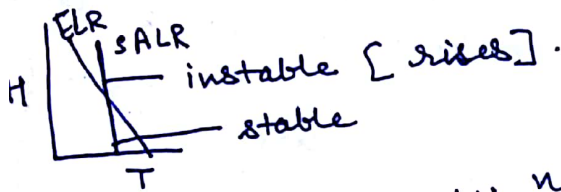
One that is high is stable

∴ Parcel rise if ELR is > than it.

case (1) → state of abs stability.

case (2) → conditional.

case 3 → abs instabⁿ
 ↳ rare, violent twisters created.



Theories of Precipitaⁿ

exceptⁿ: supersaturatⁿ but no condensatⁿ.
 supercooled " " "
 Drops do not fall.

These are explained by theories

conventional
 moist air → cool → droplets fall.
 Bergeron ice crystal theory
 coalescence wake / Langmuir Simpson
 / collin / growth.

Bergeron

For high clouds, ↑ mid dots, that have freezing nuclei / ice crystals. → crystals grow → vapours condense on them as they attract > moisture as saturated VP over ice is less than over droplets. → crystal grows → heavy → fall as snow.
 Artificial cloud seeding uses this technique.

Simpson

clouds in ↓ late or over warm bodies. These are warm clouds having H₂O vapour. Nuclei now is a hygroscopic substance that attracts water [salt crystals, dust etc].

Stages: (1) condensatⁿ [vapour attracted to nuclei]
 (2) growth of droplet → coalescence due to turbulence in cloud

(3) Droplets fall → attract nearby drops [moving body has ↓ P on it's either sides] → collin / coalescence [this is process of wake] → rain. [↓ dominant than Bergeron].

Mid Lats, AM, Fronts

At low lats climate/weather explained by :-

Thermal reasons, Hadley circun, onshore/offshore locn, insolaⁿ, convecⁿ, trades, vertical meridional cells, UT etc.

In Mid Lats & High Lats where condin are dynamic & not of thermal origin :- CF, convergence, divergence, UT westerlies etc are explained by AM, F, temp cyclones, PJs, RW.

Air Mass

- By Bjerkens. These are large bodies of air from surface uptill tropopause, having homogeneity of phy props at a given H. [Horizontal " Not vertical].
- A vertical gradient exists.
- AM₁ can be diff from AM₂ on basis of horizontal gradient [esp at boundaries].
- AM acquire Temp & moisture property from surface over which they lie & form.
- condin^{for} AM shud be stationary, stable, surface flat
- Classifican : (1) Continental (C) & marine (m)
(2) Arctic (A), Antarctic (AA), Polar (P), Tropical (T)
Equatorial (E) [not formed due to ↓ stability]
- Combin not psbl : mA, mAA, E [not formed due to ↓ stability]
CT is rare [convective instability].
- Most imp : CP, mT, mP

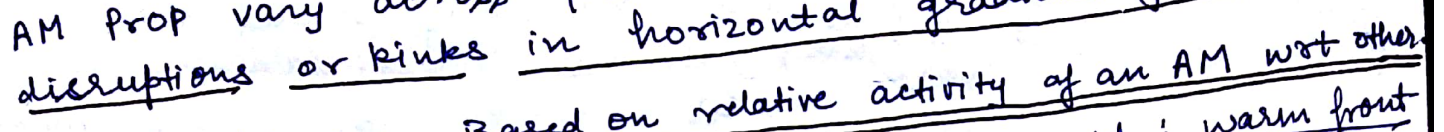
AM modifican & it's influence on weather / Climate :-

- Formed → Move → not modified, Affect place's climate.
- Acc to their modifican they are either cold or warm.
ex: CP Siberian. AM is warm wst Arctic reg. cold wst Eurasia.
- cold AM = CP_R = instable
CP_W = stable
- Cold AM moving over warm → warm rises → unstable.
Lake effect of N. America. [cold CP Canadian AM]
Ex: move over great lakes → rain along shores
CP (Siberian) → to S/E warmer areas → instability → snow → effect on India.
mP over pacific → Rockies.

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Fronts
AM collide with other AM. A interface zone creates unique sets of weather conditions. This " " is called front.
It is 2-D planar surface extending for entire width of AM. It can be for entire H of tropos.
AM prop vary across fronts. $\therefore$ fronts are zones of disruptions or kinks in horizontal gradient of T & moisture.

Based on relative activity of an AM w/ other. warm front



Classifican / Types Based on relative activity of an

- disruptions
- Classification / Types
- Based on relative activity of air masses:
- (1) If warm sector > active : A moves into cold : warm front
 - (2) " " " " " " " " : warm : cold front
 - (3) " neither active, lie side by side : stationary front
 - (4) If cold AM overtakes warm AM : occluded.
- cold front → heavy rain for short time.
warm " → slight " " longer "
- needs to be

Weather Changes
To see " due to warm front, observer needs to be in cold sector. opp for cold front.

warm front weather :-
observer in cold sector → cirrus (x rain) → dark stratocumulus
→ light rain (long time) → fair weather → altostratus →
cirrus → cumulus, T ↑ gradually, P ↓.

heavy rain → cumulonimbus → [sequence]

The diagram illustrates the sequence of cloud types as a warm front approaches from the east. It shows a progression from cirrus clouds in the cold sector, through altostratus and nimbostratus layers, to heavy rain and cumulonimbus clouds at the leading edge of the front.



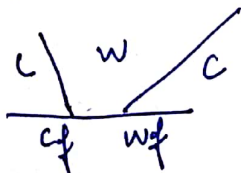
cirrus $\rightarrow$ cumulus $\rightarrow$ cumulonimbus $\rightarrow$ heavy rain $\rightarrow$ cumulonimbus $\rightarrow$ heavy rain
cold front
 obsrv in warm $\rightarrow$ bright $\rightarrow$ heavy rain $\rightarrow$ cumulonimbus $\rightarrow$ heavy rain
 very heavy rain at front / snow too. [opp cloud sequence].
 T $\downarrow$, P $\uparrow$.
 warm. more steep.

warm. more steep.

cold.

Air speed more in cold $\rightarrow$ reduces gap.

when cold overtakes warm $\left\{ \begin{array}{l} \text{drives wedge,} \\ \text{forces it abt} \end{array} \right\} = \text{OF.}$



occlusion destroys front $\rightarrow$ stability as warm is over cold.

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front is nvr vertical

cold creates a wedge below. warm rises

warm front is more slant

Air rises faster for cold front. ★

cold

- 1) unstable
- 2) vertical ↑
- 3) associated with rain & snow
- 4) air rises faster
- 5) sudden, heavy rain

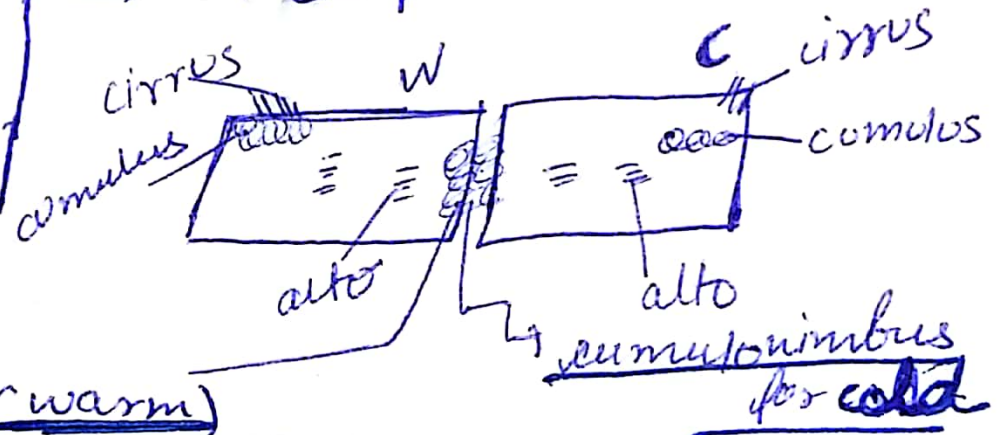
Stratocumulus

(warm)

warm

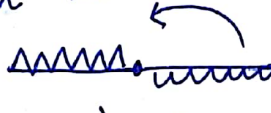
- 1) stable
- 2) ↑ steep

→ continuous rain. not heavy.



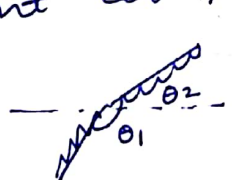
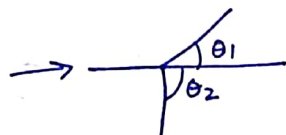
OF associated with variable wind, unpredictable precipitation, variable weather. [Abbe-comby Model]

Travelling depress / Temperate cyclones / mid-Lat cyclones

- ① cyclone is $\downarrow P$ system with air spiralling inwards
- ② $\rightarrow$ convergence at centre $\rightarrow$ air rises $\rightarrow$ unstable condⁿ $\rightarrow$ rain. [isobars should be circular then only air rushes to centre]. 
- ③ Diff in outside - Inside $P = P_{defect}$. $\uparrow PD \rightarrow$ strong cyclone
- ④ CF $\rightarrow$ anti-clock in north. Deflecⁿ $\rightarrow$ spiral
- ⑤ $\downarrow P$ core reasons are :- thermal (surface heating) = warm cyclone or dynamic [UT, convergence] $\rightarrow$ cold core cyclone.
- ⑥ Temperate cyclone is warm & cold front rotating abt common $\downarrow P$ core.
- ⑦ It initiates at interface of 2 AMs having strong property grad. ex. CP AM (siberian) face to face with warm ~~front~~ moist. mT AM.
- ⑧ $\downarrow P$ core develops due to reasons (dynamic) not best known $\rightarrow$ quasi-stationary front becomes active front. $\rightarrow$ AMs rotate $\curvearrowright$ in North. $\rightarrow$ AMs try to intrude into each other. 

Stages in dev of temperate cyclone : BJERKENS

- ① Frontogenesis. $\rightarrow$ quasi stationary front, straight line isobars
- ② Incipient $\rightarrow$ $\downarrow P$ develops, isobars close [not perfectly circular] $\rightarrow$ active fronts develop. $\rightarrow$ spiral inwards. cold front covers more distance.

- ③ Mature : Fronts & the weather seq r well developed. Warm sector reduces progressively due to faster cold front.  
- ④ occlusion $\rightarrow$ Frontolysis $\rightarrow$ stable condⁿ. $\frac{www}{ccc}$

Cold core / temperate are more imp in $\uparrow$ Lat
effect climate / weather of mid LATs a lot.
not as destructive as tropical cyclones.

Tropical	Temperate
→ destructive	→ less destructive
→ diameter: 10-50 km	→ upto <u>1500 km</u>
→ $\uparrow$ energy in short area	→ energy over large diameter
→ short lived (2-3 days)	→ long lived (15 days)
definition of warm core	definition of temperate cyclones. cold core

Sequence of weather changes

Stand at D for all view.
 at D: warm front pass $\rightarrow$ cold $\rightarrow$ OF
 It is gen rare for a stationary observer to see all 3
 weather condⁿ for same temperate cyclone. But as
 2 or more pass, he can c all stages.
 Bright sky (warm F) $\rightarrow$ overcast $\rightarrow$ drizzle $\rightarrow$ clear sky
 $\rightarrow$ heavy rain / thunder.

Locⁿ

- ex: icelandic $\downarrow$ P, norwegian,
canada, siberia, russia)
- In summer (colorado are tropical but certain $\downarrow$ P
 cells of these areas can be carried by JS & RW, during
 their low index cycles, towards temperates.

Track

W $\rightarrow$ E with westerlies

Tropical Cyclone

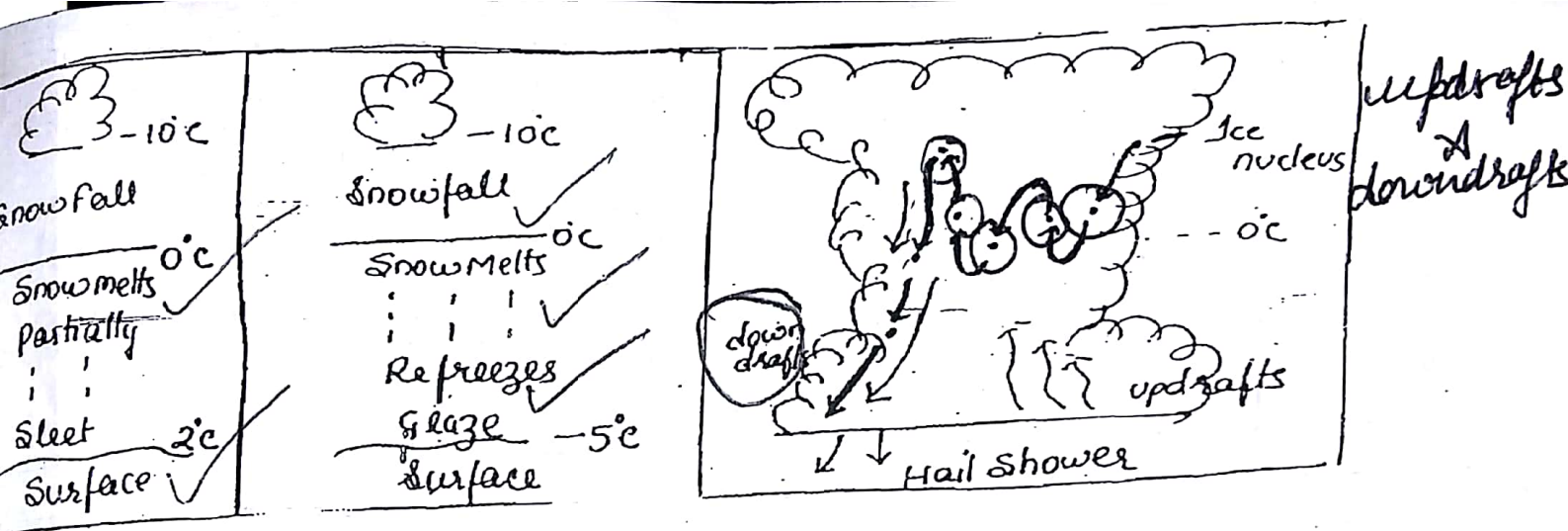
tropical, warm core, formed on land, smaller more danger, $\downarrow$ duran, not
 CF presence is must. $\rightarrow$ circular motion
 Depend on thermal energy provided by latent heat of condensation
 SST atleast 27°C . ex BOB, SC sea, Go Mexico etc. LHC
 Die when hit coast unlike temperate cyclone. $\therefore$ Siberia
 despite being continental receives cyclonic rainfall (temperate
 More frequent during late summers due to $\uparrow$ SST.

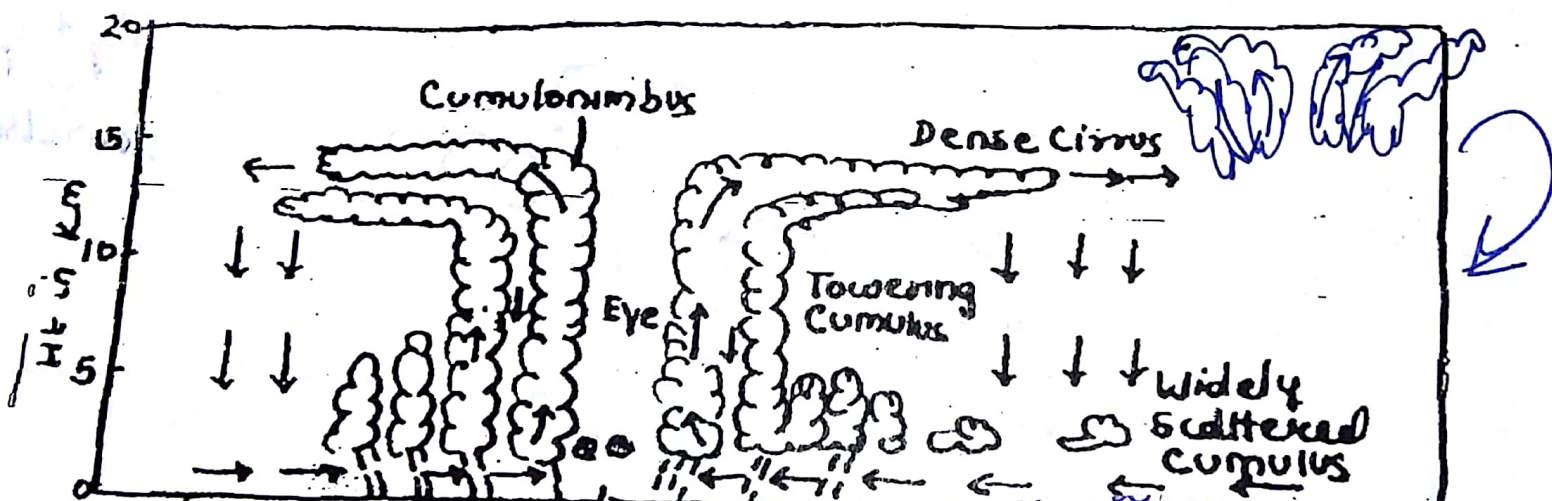
Structure

- ① cumulonimbus cloud / anvil cloud.
- ② Air moves rapidly towards centre $\downarrow$ P core $\rightarrow$ rise
 up around cylindrical eye $\rightarrow$ air spirals up $\rightarrow$ rain
- ③ Within Eye: - light var winds, clear bright sky.
- ④ Eye can be 1-2 km diameter or even 10 km.
- ⑤ Light Rain $\rightarrow$ heavy rain $\rightarrow$ no rain (eye) $\rightarrow$ heavy $\rightarrow$ light.
- ⑥ Weather seq: - dark overcast clouds $\rightarrow$ P falls rapidly
 $\uparrow$ wind speed $\rightarrow$ LR $\rightarrow$ HR $\rightarrow$ NR...

- ⑦ Locⁿ Trop, sub-trop, during late summers, SST $\approx 27^{\circ}\text{C}$.
 BOB, SC sea, Go Mexico.

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- Move E → W under trade winds & effect East coast of continents.
- called Hurricane (GoM), Willy-2 (Aus), Typhoon (China-Japan) etc.
- India's coast orientanⁿ → both coasts affected.

Climatic Classification

equatorial

hot; not hottest, high convection,

W rain 350 cm. Ind: 118 cm, wet primarily

Afternoon tym has high rain, No distinct season

Thunderstorm cloud. very dense forest.

hard wood. Ebony, mahogany, rosewood

Richest biodiversity, tiered trees.

undergrowth. no big mammals, (arboreal) present

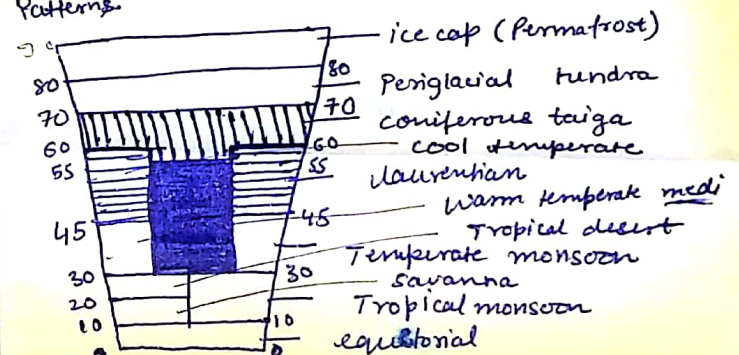
epiphytes present (orchid).

buttered stools. human left tough

Pigmees (Congo), amazonian, Nicobari's, semang, dayaks of borneo. orang asli (Malaysia)

Old growth forest: traditional eco forest → not tampered.

natural regions is method in classifying world env on basis of climate and studying impact of climate on vegⁿ, soil etc. These are units on space on basis of natural Patterns.



is ex Sal, Teak.

undergrowth.

② Tropical Monsoon

- Onshore trades → humid, warm, on E. coast of continents.
- Alternate wet-dry condin due to winds reversal.
- Dry → leaves shed → deciduous ex Sal, Teak.
- Not as dense / tall → ↑ undergrowth.
- Dense popn [India, S. pole, Myanmar] etc.
- Trees exploited → firewood, degraded forests.

③ Savanna

- Semi arid, severe drought → sparse rein
- Grassland, few scattered trees → Parkland Landscape → easy wind flow
- Large mammals → big game country.
- Elephant crosses found → can catch fire → recycles soil.
- S. America [Llanos, catanga, Venezuela, Mottogrosso], N. Aus.
- Africa → best form. [below Sahel belt].
- Tribes Masai, Hausa, Kikuyu.

④ Tropical deserts / Hot deserts

- offshore trade wind, ↑ P deserts. → ↑↑ dry along W. coast
- due to desiccating effect of upwelling, cold currents.
- S. America [Atacama desert, Lima oasis].
- Africa [Sahara, Arabian, Iranian, Libyan, Nubian].
- Israel [negev → green due to micro-irrigation].
- Aus [great Aus outback → sandy, Victorian, stony, Nullarbor plains].

⑤ Temperate Monsoon

- Rain for 8-9 months, wind reversal not perfect.
- East low-mid Lats.
- cooler than tropical. Rain is lesser but well distributed → No empty dry season
- called CHINA TYPE climate [China, Japan], Gulf type [Go Mex, Missi sippi, Texas, Florida]

Natal type → more humid & well distributed ^{than} china type.

⑥ Medi

west margin warm temperate [30-45]

Moderate temp [15°-30°C]

olive, citrus fruits, viticulture
S. cali, San fran, LA, sandiego, Chile, capetown, adelaide,
Perth, auckland, Medi-coast

⑦ Laurentian [45°-60°] East coast.

• Far more cooler, ↑ humidity → rain throughout = cold-humid

• Manchurian grassland, Maple tree, N.Y., connecticut, ottawa,
Quebec city etc.

• only in North Hemisphere.

⑧ cool temp w. margin [45°-60°]

Brit type, moderated temp by OC → not as cold at this Lat.
westerlies bring rain in summer.

Temp cyclones → var weather.

Brit, Ireland, N. France, Norway, Vancouver islands, S. Chile
All NZ except Auckland, Netherland, Belgium, Luxum, Rotterdam etc.

⑨ Middle part [30-55] desert

continental deserts.

↳ land far from coast → continentality.

Gobi desert, Takla makan

cool temp grasslands :- Steppes, Prairies [wheat, grain, bread basket]
corn, maize.

• Iowa, Illinois, Chicago, Arkansas etc.

• Rampas (S. America, Arg, Uruguay)

• Velds (S. Africa) Bushveld (Kalahari), Highvelds (drakensberg).

• Downs (Aus, sheep rearing, goat, cattle, Melbourne, Queensland)
Murray-Darling Basin.

• NZ (Auck (Medi), rest has this).

⑩ Coniferous Taiga [60-70] [North only]

Pines in highlands.

N. Canada, Eurasia [Norway, Sweden, Finland, Russian Siberia].

Cold + humid → temp cyclones / Polar Fronts

Evergreen + Deciduous [fir, spruce, larch, juniper, poplar]

Softwoods → lumbering → Paper industry.

⑪ Tundra < Canadian Eurasian 70-80.

Primitive tribes / hunters

Canada (Eskimo, Inuits), Finland (Lapps), Russia (Sami)

Chukchee.

Very short summers → fast flowering plants (~~ephemerals~~).

Need for climatic classification / challenges

- (1) for: comparisons, predictions, affects, study elements etc.
- (2) challenges: Diff elements, ∞ ways to combine elements, measuring elements, diff climatic regions & variation with them, no 2 climates have same element set, ↑ microlevel diversities, not easy to understand causes & cause-effect relations, dynamic processes ↑ complexity, each element can be expressed in multiple forms, elements can't be studied in isolation.

ways of classification

based on observation

(empirical)

(rain → wet climate)

genetic classification
(analyze & explain obs)

(why rain).

(focus on causes) ↑ T.O.U.T.

Ex of criteria in genetic scheme (P, wind, insolation, rain)
" " " " empirical " (T, rain)
genetic is more analytical, detailed, helps understand reasons
but proponents of empirical study counter it by saying
that so much details dilute purpose of geog to appreciate env.

vegn as basis

vegn is prod of climate → used to represent climatic variables [reverse engg]. vegn is visible index of climate as it is consequence of diff climatic variables.
ex xerophyte (arid), evergreen (↑ rain) etc.

Koppen

- Empirical. 1st to use vegn for climate. 1st in 1908 [basis of next versions].
- Koppen-geiger-Pohl's scheme is modern version.
- Based on de Candolle's vegn map of world.

Koppen

A equator
C warm humid
D cold humid
E cold (sub-tropical)
B deserts: Polar

de Candolle's vegn types
Megatherms
Meso
Micro
Hekiso
xerophytes

(Hot-wet equator-trop)
(warm humid)
(cool humid)
(sub-polar)
(deserts).

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Delineation of Boundaries

From vegⁿ map Köppen marked poleward margins for a representative specie of a climate → Subjective, Arbitrary.

Then he observed Temp & rain to delimit boundaries.

Basis [scientific] logical / empirical / vegⁿ.



10°C isotherm of summer (E) (always) < 10°C (tree line).
 T can be < -3° in winter (D), can be > 10°C in summer
 T mostly > -3° in winter (C)
 T > 18° (A).

- 10°C isotherm = tree line [no trees beyond].
- E further divided on basis of 0°C isotherm of summer where T > 0°C (E_f) & where T can be > 0°C (E_t).
- E_f (Permafrost), E_t (Tundra) (Periglacial).
- He deals with two variables (Temp & rain) (Aridity).
- A C D E (T based) only B is rainfall based. [T bias].

B type aridity = $f_n(\text{Rain}, T)$
 dryness / wetness don't depend on rain alone but temp too as it causes evaporation.
 He gave concept of Effective Precipitation. [Preci - evap = Preci for vegⁿ].
 ∴ He introduces aridity fn.

$$\text{Rain } r = (0.44t - 8.5) / 2 \quad T \text{ in } ^\circ F, \text{ Rain (Mean annual avg) in } ^\circ F$$

If actual Rain $R > r \rightarrow$ Semi arid. $R < r$ (arid).

Limitations

- (1) Ignores percolation loss, evapo-transpiration loss.
 - (2) a/c actual evapo loss & not potential evapo as he ignored moisture availability in atmos.
 - (3) T bias (4) rainfall in 2nd order (5) not genetic
 - (6) Ignores alti, insolan, L-W etc (7) Macro scheme [genⁿ].
 monsoon symb in original (considered savanna variant - have AN later).
- A B C D E: 1st order. At 2nd order he identified seasonal rain
 (rain throughout yr), S (summer dry), W (winter dry), d (dry).
 Monsoon (Aw), Trop (Af), Medi (Cs), Brit (Cf), B_s (Semi-arid)
 Bw (arid), Trop desert (BWh),

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THORNTHWAITE

- applies to microclimate → No map probl.
- Empirical, statistical analysis → complex eqⁿ.
- Don't use T & rain directly (unlike Koppen). Uses complex relaⁿ.
- He was trying to dev a climatic scheme, which could have applied importance in agri. → Applied Approach, ↑ detailed.
- More realistic expⁿ to a/c aridity losses.

1931-33 Scheme

* P/E index (Precipⁿ efficiency index) for rainfall.

$$= \text{Precip} / \text{evaporat}^n \text{ ratio}$$

$$= P/E = 11.5 \left[\frac{x}{t} - 10 \right]^{10/9} \quad \begin{matrix} x (\text{inch}) \\ t (^\circ\text{F}) \end{matrix} \quad \begin{matrix} \text{monthly values summed} \\ \text{up} \rightarrow \text{annual.} \end{matrix}$$

• Based on P/E → 5 HUMIDITY PROVINCES

A (Per-humid) > 127, B (Humid) 64-126, C (Sub humid) 32-63, D (semi arid) 16-31, E (Arid) < 16.

* T/E index (Thermal η index)

$$= \text{Avg } T \text{ of month} / \text{Av Evapo}^n = T's \text{ effectiveness to cause } \boxed{\text{evapo}^n \text{ trans losses}}$$

• T/E = $(t-32)/4$ → 6 THERMAL PROVINCES

• A' (tropical), B' (Mesothermal), C' (Micro), D' (Taiga), E' (Tundra), F' (Perma/frost) [unlike Koppen]

• At Macrolevel, TH uses both T & rain/humidity indices - [unlike Koppen]

• Also represents seasonal varⁿ in rain or, s, w, d.

• eq = AA' or, tropical deserts = EA'd

• ~ 120 combinⁿ of climate probl. He identified 32.

1948 Scheme

→ (PET losses)

Potential Evapo-Trans loss.

- 1) developed a refined Precipⁿ effectiveness of Koppen.
- 2) improved 4m 1933's E-T losses → Potential E-T losses in 1948.
- 3) Aridity in fn of PET not alone ET.
- 4) Area must have ↓ moisture loss due to ↓ moisture available to be lost. ∴ Dryness of area can be more than w/ actual loss suggest.

5) PET index = $1.26 \left[\frac{10t}{I} \right]^a$ $a = \text{complex fn, } I = \left\{ \frac{1+t}{5} \right\}^{1.514}$
 $t \text{ in } ^\circ\text{C}$

6) Moisture index (I_m) = rainfall aspect

$$= \sum \frac{100S - 60D}{PET}$$
S: surplus of yr
D: Deficit " "] incorporates RA indirectly.

climate classificⁿ eventually on (I_m) basis only.

$I_m > 0$

$I_m = 0$

$I_m < 0$

→ A, Per-humid,

[B₄ B₃ B₂ B₁]

Humid

[C₂, C₁], Moist sub-humid

D, E semi arid arid

Macro

A, B, C₂ = moisture surplus
C D E = " deficit.

Micro levels: used aridity & humidity indices.

Evaluation: applied / sci / empirical / vegⁿ
↑ practical utility → agri / drought plan, land mgmt,
soil moisture conservation.

used by ICAR & NBSS LUP.

- veg: ↑ complex, ↑ mathematical, not best for elementary examⁿ
No map, not genetic.

TREWARTHA

Refined & supported Koppen. → supported empirical study in geog.
+ve: gave sci explainⁿ to explain Koppen. said genetic
causal factors can be accommodated in Koppen classificⁿ.

modification

① Lat extent of C, D, E [shifted C, southwards]. Said it
was wide LAT stretch to accommodate (cali, canada, washington
etc) in 1 thermal province → shifted C-D boundary
from -3°C isotherm → 0°C isotherm

K	T
E	F
D	D

cooler C type of Koppen = D type of Trewartha. -3°C D C 0°C

- ② Added new symbol F, maintained boundary of D (10°C)
E = sub polar, F = Polar
F → F_T (Tundra), F_P (Perma)
- ③ Monsoon symbol in orig scheme = AN = 3 mnth moisture deficit unlike Koppen's 1 month deficit.
- ④ Ackd role of coastal locⁿ / maritime effect in studying arid areas
- ⑤ H for highland type (Afterthought in K's)
- ⑥ Used 2 letters unlike 3 by Koppen.
- ⑦ ex C_s (medi), C₂ (Brit), ca (warm sub-tropics)
- ⑧ simpler, ↑ relevant → gud 1-1 match with world vegⁿ.

CC by man

- ① By changing atmos compon [pollutants, GHG]
② " albedo (land use pattern)

→ results

long term
short term

[changed LR, urban plume, smog
modify air circulⁿ due to high rises]

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cc causes — Anthropogenic

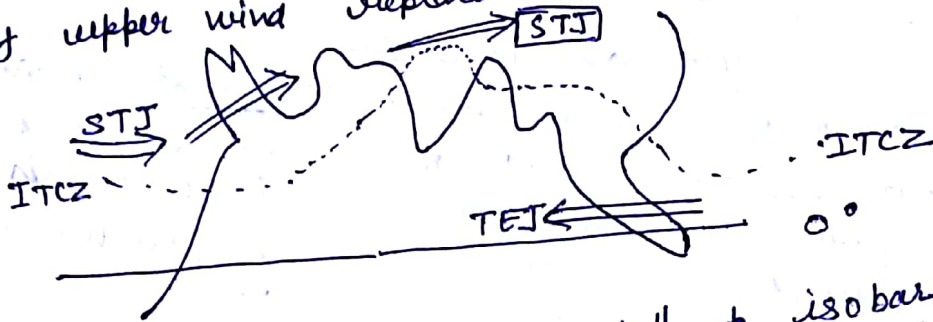
Natural

volcano.
sunspots. (↑ solar warming phase)
E-S geometry [eccentricity, axis tilt] etc.

Climatology Extra

Exceptional Ident of ITCZ

- ② Sub-tropical IS : a thermal direct IS that relates to the prevailing warm condition in equatorial region. The largest garland system in ref to diff L-W distribn is identified with rosby wave characteristic. Flows at highest altitude and has lowest isobaric level of flow unlike counterparts. It induces dry weather in global perspective but in S.W & S Asia it cause winter precipitan by blocking & transporting W disturbances. Shifts towards north during summers. Due to exceptional ident of ITCZ in N.I/O Basin, the IS is displaced elaborately in C. Asia. Under the condn in S. Asia, regional/seasonal easterly upper wind replaces STJS. This is TEJS.



IS

geostrophic flow relates to strong coriolis deflection. These flows found in both hemis as part of atmos circulation but not on equator due to absence of CF. WMO defines IS to be fastest moving centres of geostrophic flow. Velocity 150-200 km/hr. Homogeneity of water dominant relief in S. hemi eliminates possibility of effective IS. 3 major IS in N hemi are :-

① Polar Night JS (PNJS)

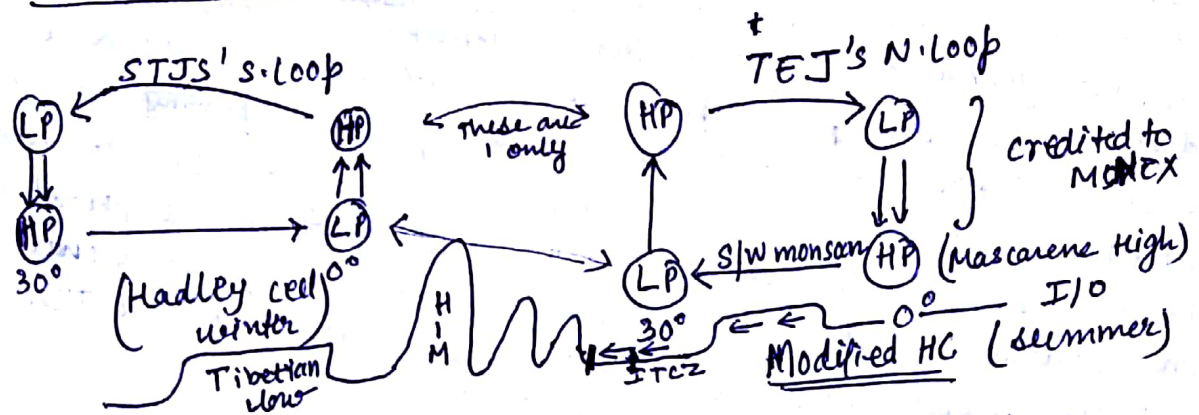
It is highest Latitudinal JS. makes smallest garland system Lozan (65°-90°N), has absence of land-water differences. It is devoid of RW characteristics. Lat do^n justifies its lowest altitude. A highest isobaric level. It induces dry condn in polar areas bcz of sustaining high pressure in polar regions. It is perennial but called PN bcz during 6 months of Polar Night. PNJS develops its max Latitudinal expanse & attains max velocity of 500 km/hr.

③ Polar front JS (PFJS)

Mid latitudinal JS developed due to front off ground. It is thermal indirect JS & is exten^n of PNJS to mid LAT.

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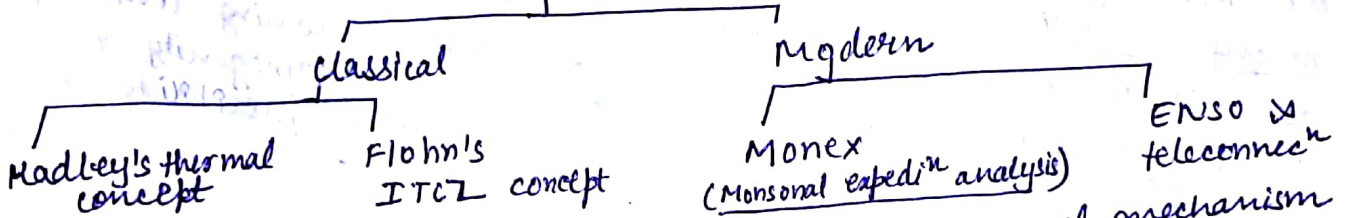
developed near both parallel. However with dev of temperate cyclonic circulation, genesis of wavy isobars induce RW characteristic. Dev of RW denotes maturity index of PFJS. It is at maturity index that PFJS induces wet weather condn in entire mid latitudes. Termination of fronts on ground terminates existence of JS $\therefore$ it is a sequential existence.



Monsoonal Mechanism

Monsoon seasonal winds relate to tropical East Margin lands. These represent seasonal variation in circulation pattern. Arab scholars called it "monsium". In Indian context N-E trades of winter pave way for S/W monsoon depicting reversal of winds.

Approaches



classical approach avails explainⁿ of monsoonal mechanism in context of its surface characteristics adding to seasonal reversals. Hadley outlined that seasonal reversal was due to diff^l heating of L-W referred as thermal concept. This approach explains N/E monsoon in winters due to ↑P over land & ↓P over land in summers as cause of onshore S.W. monsoon.

Flohn in his ITCZ model applied convincing detail abt origin of S/W monsoon. He recd that due to ↑ continentality in N/I/O basin, there is exceptional bent of ITCZ which makes S/E winds of S.Hem^l encroach in N.Hem^l. It causes S/E monsoon in coastal Somalia & coastal Yemen & become S.W monsoon under CF. → W. margin deserts not app to Ind - Indo-china peninsula.

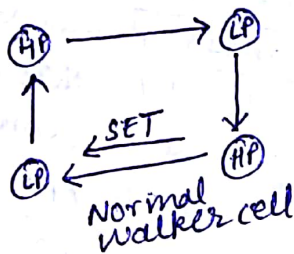
classical approaches of monsoon mechanism attempted explaining fundamental characters of monsoon mechanism by treating it as only a surface wind. But failed to explain cause of unpredictability of monsoon rains. MONEK answers questions related to elementary char of monsoonal mechanism

MONEK was work of India & former USSR in 1970s. It explained

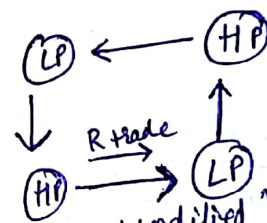
① Role played by Tibetan plateau & analyses of vortex.

In case of Tib Plat MONEK highlights transform of normal anti-cyclonic conditions to cyclonic conditions on ground due to which upper air pressure profile gets reversed. $\therefore$ STIS is displaced & TEJ is established. This plays role in maintaining tibetan low & maritime high on surface creating a P gradient which results in movement of S/E ~~mon~~ trades as S/W monsoon. It is variable branches of S/E trade that encroach as $\rightarrow$ periodicity of rain / unpredictability.

This work of tibetial monsoon is regarded as Modified HC, 2nd conclun is dev of low pressure cell called Vortex in Indian coastal areas at time of onset of monsoon ex Malabar Vortex, Uttal vortex that avail explain of other important characteristics of monsoonal mechanisms.



Normal Walker cell

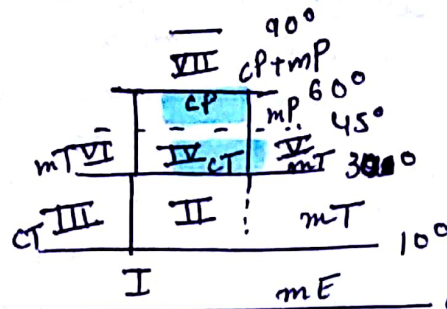


Modified Walker cell

Teleconnection that monsoonal mechanism have with El-nino helps in interpreting characteristics of monsoons like weakening, delay, failure etc. In S. tropical pacific, prevailing distance b/w shorelines forms the cause of individual specific characteristics of boundary currents i.e. Peruvian current & E. Aus current. As the oceanic current influences temp & P profile in coastal areas there is contrasting climatic conditions at 2 shorelines. Normally Peruvian coast is dry & Aus wet. During El-nino warm water replaces Peruvian current & ~~temp~~ P profile changes. This oscillating profile is ref as ENSO ~~but~~ during normal time Walker cell justifies presence of S/E trade & S/W monsoon but during El-nino Walker cell is either weakened or completely replaced $\rightarrow$ affect S/E trade $\rightarrow$ S/W.

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Precipitation distribution of world



Fundamental regulators of distribution of precipitation include Latitude, nature of circulation, L-W differential, orographic barrier

(with $\uparrow$ Lat $\rightarrow$ T $\downarrow$ & humidity $\downarrow$ $\therefore$ PPT $\downarrow$). But nature of convection influences this pattern. where convection is high, PPT will be $\uparrow$ & where nature is of subsiding air col, PPT will be $\downarrow$.

wrt to L-W differences, maritime areas are wetter than continental areas. 3rd is orographic barriers which $\uparrow$ PPT

Based on these 3 regulators, 7 world PPT reg are:-
 I: wet equatorial, II: Monsoonal, III: tropical deserts,
 IV: mid lat deserts/steppes, V: East margin mid lat PPT belt
 VII: Arctic/Polar, VI: west " " " "

(1) Wet eqr regions: highest rain b/w $10^{\circ}\text{N}-10^{\circ}\text{S}$ due to perennial effectivity of maritime Equatorial (ME) air mass & hence perennial instability. Rainfall 250-300 cm well distributed throughout year with some $\uparrow$ post equinoxes. ex: Amazon, Congo, Indonesia

(2) Monsoonal seasonal. In winters it is dry due to $\uparrow$ P & CT airmass. Seasonal effectivity of MT causes convectional & orographic rain. 100-200 cm with $\downarrow$ with $\uparrow$ continentality.

(3) Tropical desert confined in tropical west. Perennial stability due to $\uparrow$ P & CT airmass, during summers excessive heating of sand facilitates dev of short-lived absolute instability $\rightarrow$ torrential downpours. 50 cm annual.

(4) Mid lat desert & steppes continentality $\rightarrow$ $\downarrow$ PPT. It is in terms of latitude & orography that this region marks extreme range of PPT (0-75 cm). In warm temperate regions (upper) orographic barriers $\rightarrow$ rain shadow regions & thus mid-lat deserts. However in these temperate zones frontal - PPT justifies semi-aridity. $\rightarrow$ temp grasslands.

(5) Mid lat East margin

N/E trades as N/E monsoon during high sun. pptn ↓ wid
↑ lat. frontal pptn during winter. 100-150 cm → moist
mid lat zone.

(6) Mid lat west margin westerlies are dominating → wet
marine climate. Frontal rains largely 50-125 cm
This is best ex of rain due to nature of circulation.

(7) Polar arctic deserts strong subsiding convections, complete
absence of L-W differential, Polar & arctic airmass (cP+mP)
→ absolute stability. ^{these} air masses are too cold to hold
moisture & too dense to rise. Two div'n: Taiga / Tundra.
Taiga: warm sub polar belt denoting warm frontogenesis
experiences conditional instability. 30cm.
Tundra conditional instability during summers: 15-20 cm.
∴ polar deserts are confined to absolute polar areas.

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INSOLAN

Sun radiates heat & light whose sum total is called solar radiation & only some % of this is received by earth's system called as insolan (incoming solar radiation). Net insolan received is constant but distribution varies across space and time.

Regulatory factors: $\angle$ of sun's rays, season cycle, Direct sun ray with $\downarrow$ distance to travel and less spatial spread has higher insolan compared to slant rays. $\rightarrow \downarrow$ LATs receive $\rightarrow$ insolan then $\uparrow$ LATs.

Season cycle (temporal perspective) in hemispheric perspective adds to differences in distribution. Inclination of earth's axis w.r.t earth's revolution justifies shift in thermal equator $\rightarrow$ seasons manifest. [thermal equator towards N $\rightarrow$ N faces high sun $\rightarrow$ summer solstice]

At regional level atmospheric constituents regulate net received amount of insolation of insolation [aerosols scatter, water vapours absorb & cloud cover reflect]. ice, a climate feedback.

Terrestrial Radiation makes up primary source of atmos T. variation present on earth surface regulate distribution of T.

- ① Latitude ② Land-water differential etc.

Temp inversion

when in Tropics, $T \uparrow$ with $\uparrow H$, conditions vice:

- ① Air convergence
② Adiabatic changes at mid latitudes
③ Air drainage on Mt Region.

Air convergence advective movement (horizontal) of air columns facilitates convergence of air col at variable geo locn near 60th parallel. warm & cold air masses form front on convergence. where warm air rises over cold air $\rightarrow$ T inversion. It relates to temperate cyclones in mid & high latitudes.

Adiabatic cooling effect. Rising air col is subjected to cooling (adiabatically). It condenses & releases latent heat of condensation $\rightarrow$ TI. $\therefore$ this TI is associated with clouds.

Air drainage in Mt absolute local factor. It is movement of air 4m mt. wall to valley floor due to P difference. (Night). MUDIT JAIN

Dev of P-diff is regulated by differential rate of cooling of exposed Mt wall & enclosed valley floor during night. With cond'n like lack of clouds, long winter night; air drainage to valley develops prerequisite to TI. Cold air col at valley floor & heated Mt develops TI which remains till forenoon

