

24/8

M

1230

Monsoon refers to the seasonal reversal of wind, rhythm of season & rain bearing system, over Indian subcontinent. Monsoon is the single term to define Indian climate, characterised by oscillating pressure system, between land & sea, & reversal & modification of trade winds, by thermodynamic factors. Professor ~~Deane~~ Ramage has identify certain features, attributes of monsoon -

- a) between July & January the reversal of wind, must be by 120° , very often 180° .
- b) during July & January frequency of wind must increase by 40%.
- c) In one of the monsoon month acceleration of the wind must be $3m/sec$.
- d) At least once in two year there shall be cyclonic & anticyclonic reversal between subcontinent & North-Indian ocean.
- e) Reversal of Hadley cell
- f) The maritime tropical air mass, expanding over the subcontinent

According to classical theory of Halley (not Hadley) (thermal concept of monsoon), monsoon winds are land breeze & sea breeze on gigantic scale produced by the apparent shift of sun over the tropics. † P-123- Khullar

In 1951 the dynamic theory of Fohn suggested, that with the shift of the Sun, over Cancer; the ITCZ migrates over Subcontinent & the Equatorial westerlies in the ITCZ; ~~peaks~~ collects moisture from the oceanic sea & Bay of Bengal & transform into South-west monsoon. ~~Acc to~~

Acc to Pingon, with the shift of ITCZ, the South easterly trades, crosses equator & under the influence of Coriolis, they become South westerlies. This monsoon is the thermo-dynamic modification of the trades.

Recent Theory! Theories after 1950.

- a) Dynamic theory.
- b) Jet stream n

Jet Stream Theory! After 1960s monsoon mechanism have been related with the Jet Stream.

by P. Koteswaram. He suggested -

- a) the role of Tibetan Plateau
- b) The role of Tropical easterly Jet
- c) The role of Subtropical Jet in the retreat of monsoon.

Acc to the Munroe theory (Monsoon Expedition) in 1978, the origin of monsoon is related to the formation of Mascarene high & the high pressure at Darwin, Somalia, Arabia & a low pressure of North-Western India.

Thus a synthetical approach is required to understand the monsoon mechanism.

Synthetical theory.

During the Summer ^{Solstice} ~~solstice~~ in the northern hemisphere 3 events ensue (follows)

- a) Development of heat low over north-western India. (Rajasthan, Haryana, Punjab)
- b) The heating of Tibetan platen & development of low pressure. Tibetan platen becomes a heat sink zone, because of the lower Albedo of the rocks & the wide & extensive roof structure with four kilometers altitude. The rising air, at 300 mile or ^{10 to} 12 km altitude develops into anticyclonic flow with a band of air falling over Arabia & another band of air flowing over North-eastern India which becomes tropical easterly Jet due to Coriolis deflection, running parallel to the crest of vindhyas & Northern Sahyadri ($15^{\circ}N$). Finally falling over Somalia, producing the high pressure.
- c) The ~~of~~ shift of ITCZ between $15^{\circ}N$ to $25^{\circ}N$, the ITCZ is a quasi stationary & oscillating zone of tropical air convection. The lifting air, merges with the Tibetan Anti-cyclone, above 200 ~~to~~ 300 mile ~~high~~ altitude. Rest of the air along with the 'outflow from Tibet crosses the equator & falls east of Madagascar, known as the Mascarene ^{one} high pressure.
- d) Over Daman, the high pressure increases to 1081 mb causing acceleration in the South Easterly trades, which converges with the

Outflows of Mascarene high along 10°S & by 1st May to 15th May they cross equator, between 44° to 66° E, longitudes. & due to Coriolis, they become South westerlies. This phenomenon is called origin of monsoon.

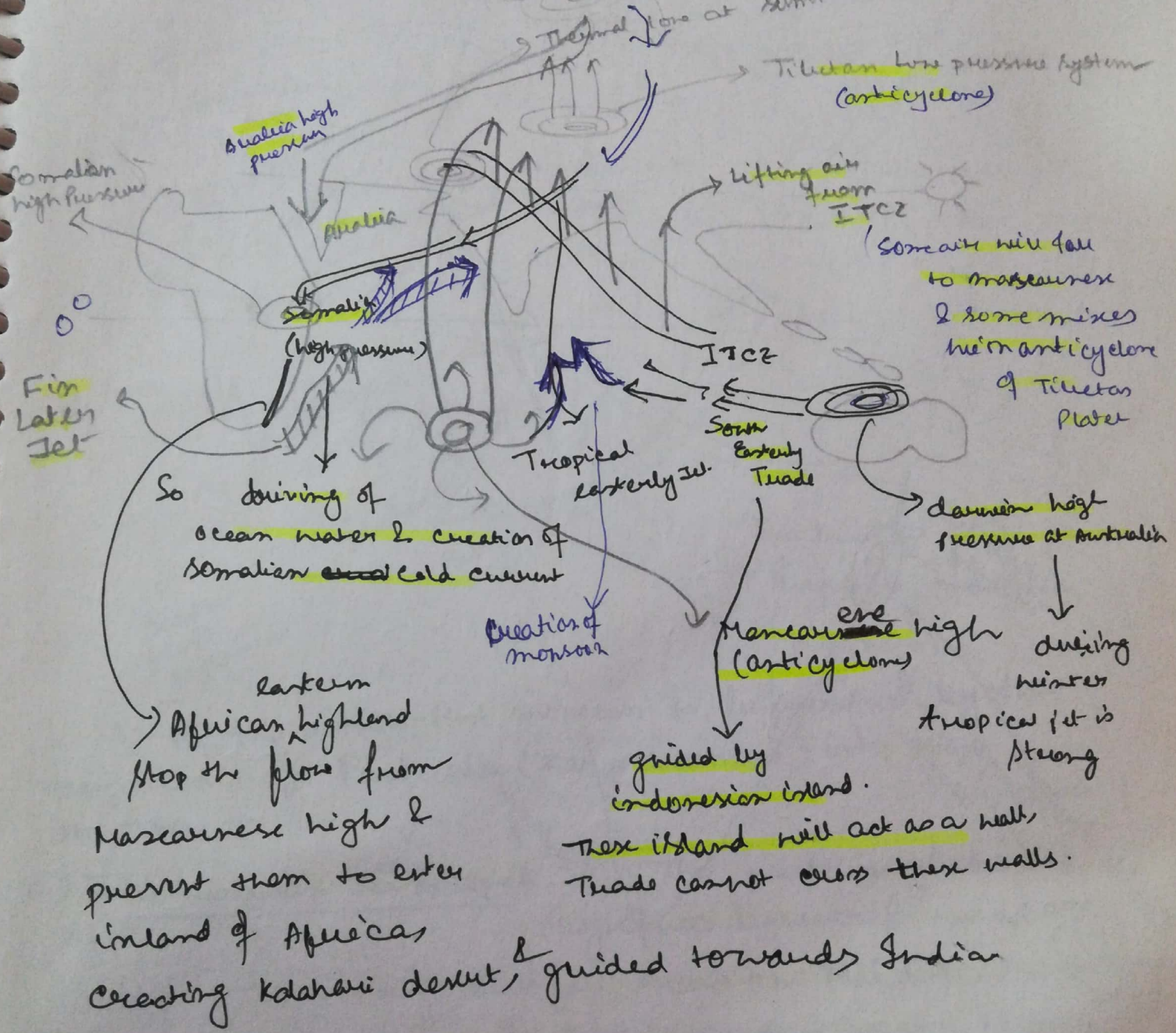
The Burst of Monsoon!

Burst is sudden unpredictable & often, characterised by thunder storm, while advance of monsoon & its retreat are slow. The monsoon burst takes place on 1st June over Malabar. Cumulonimbus cloud, thunder & lightning, thunderstorm, rain denotes the arrival of the monsoon. The burst is predicted by —

- a) The double equatorial low, which is found at 5°N & 5°S ; have unique development. The northern trough either disappears at convergence or the southern trough.
- b) The appearance of tropical easterly jet
- c) High pressure over Darwin & acceleration in South Easterly trade.
- d) High pressure over Somalian coast.
- e) Appearance of final later jet, at 1 to 1.5 km which crosses the equator, & one of the bifurcated branch, become south-westerly, while the other branch moves south & finally dissipated. The dissipation of the Jet

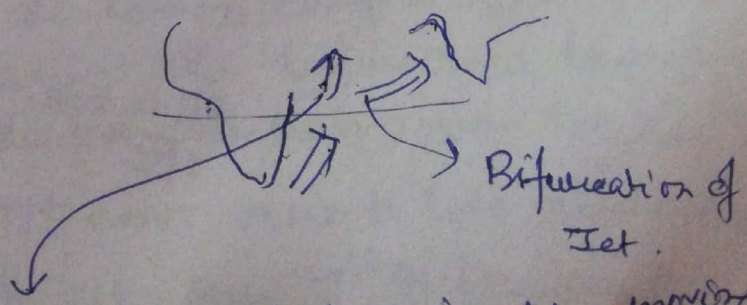
is associated with the Somalian cold current, which reduces its kinetic energy.

Advance of the Monsoon & the main leaving System

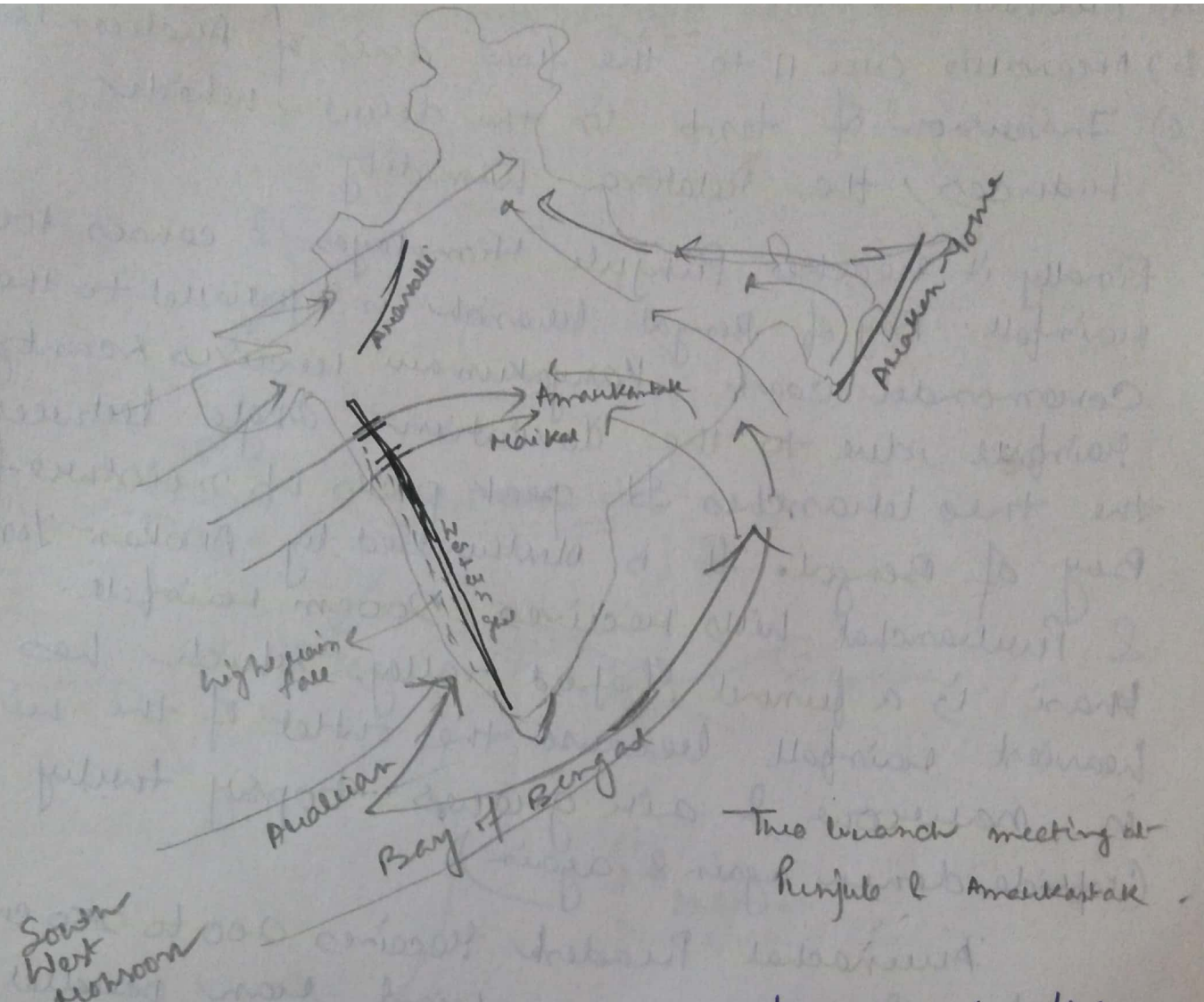


N V I F I G

PLS DRAW A FRESH



Somalian cold current below this northern moving jet, so energy will transfer from jet to water, so this part-jet will disappear.



As the South-West monsoon is bifurcated by the projection of Peninsula (Kanyakumari) into two branches, -

- a) The Arabian Sea Branch :- The western ghats are orographic barrier & winds are oblique, thus heavy rainfall occur on Malabar, 250-300cm. On the Coast - 250 cm & Konkan coast - 200cm. From the Naumada Tapi basin, its bifurcated branch enters Malabar Amarakantak & rains over 100 cm, Kathiawar receives 75 cm due to low orography, while Gujarat plains & Mt. Abu 75 to 80 cm, as the hills obstruct the monsoon winds. But Kachch & Rajasthan receives 40 to 25 cm rainfall

because —

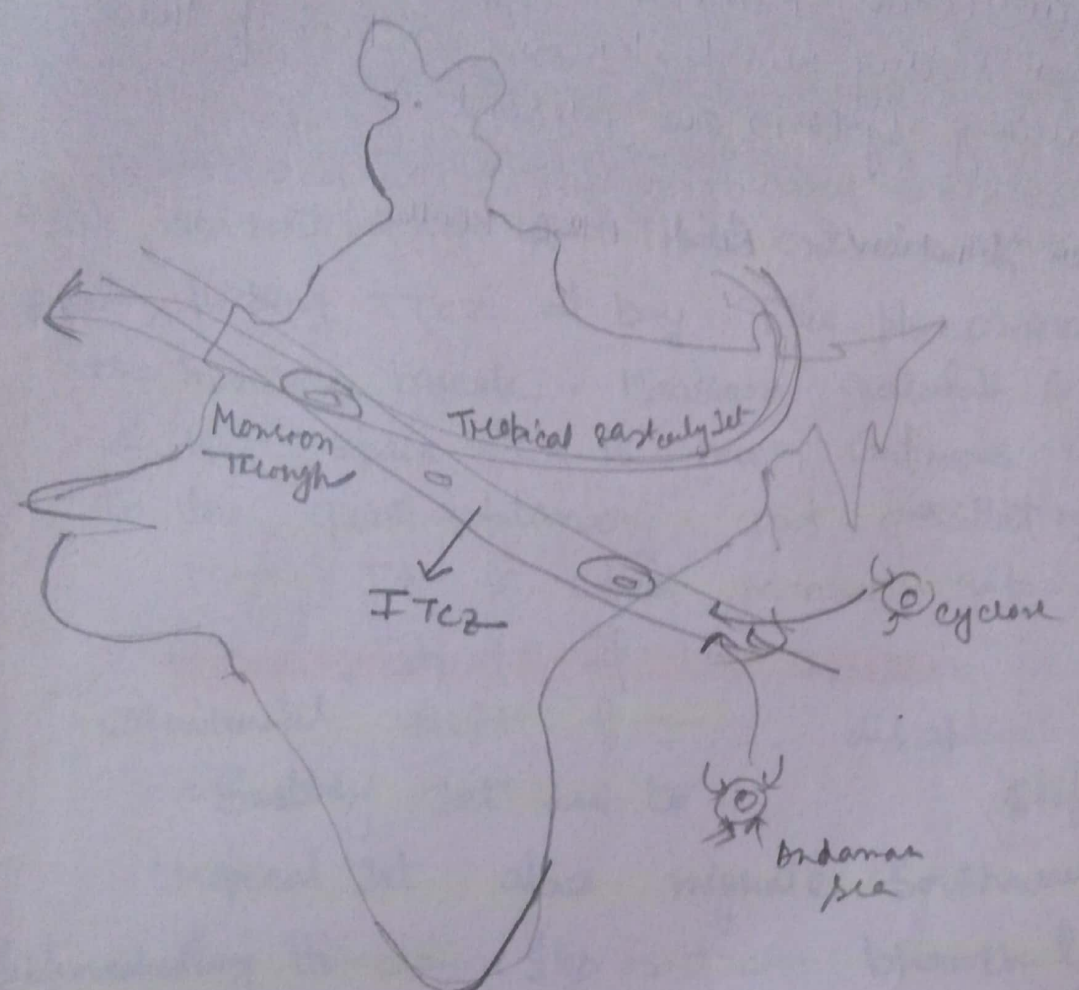
- a) Aravalli's ~~are~~ have lower high-
- b) Aravallis are || to the flow axis of Arabian branch.
- c) Inversion of temp in the desert, which reduces, the relative humidity.

Finally it reaches Purjule Himalayas & causes 100 cm rainfall. Bay of Bengal branch is parallel to the Coromondal coast. Kanyakumari receives scanty rainfall, due to the deviation angle between the two branches. It ~~pick~~ picks up moisture from Bay of Bengal. It is obstructed by Anakan-Yoma. & Purnanchal hills receives 200 cm rainfall. Khasi is a funnel shaped valley, which has heaviest rainfall because the outlet of the wind is narrow & air goes topsy turley (upside down again & again)

Arunachal Pradesh receives 200 to 250 cm rainfall & the monsoon wind runs parallel to the Simalik, causing 100 cm rainfall, over the foothills. Finally meets the bifurcated branch

The northern plains on gangetic basin & central India receives rainfall from the mild tropical cyclone, formed in Andaman sea & travelling into ITCZ. They are the rain bearing systems. They transport moisture from east to West. These cyclones are either formed in the ITCZ or are the travelling routes of the remnant of the ^{Typhoons} ~~Typhoons~~ from the South-Chinese sea.

2054
 + cyclones in Bay of Bengal are not devastating because the distance between land & sea is less, they are rain bearing system.



The location of ITCZ is determined by the tropical easterly jet. The travelling cyclones, or tropical disturbances or rain bearing system are directed by trop easter jet. It appears that ITCZ is dancing at the tunes of TE jet. Rainfall decreases from east to West & Rajasthan receives meagre rainfall. (Malwa & Bundelkhand also)

Role of tropical E. Jet on rain fall over gangetic pln

Odisha & WB — 150 cm

middle gangetic plane — 100 cm

upper " " — 90 cm

Vindhyas, Bundelkhand, Malwa - 80 cm
Haryana - 60 cm Punjab plain - 90 to 100 cm
Jammu hills 100 cm. Monsoon though in the ITCZ,
develops hot & dry wind, known as Loo, if the
rain bearing systems are absent.

For winter situation: Read P-12-6 Khullar

Western Disturbances

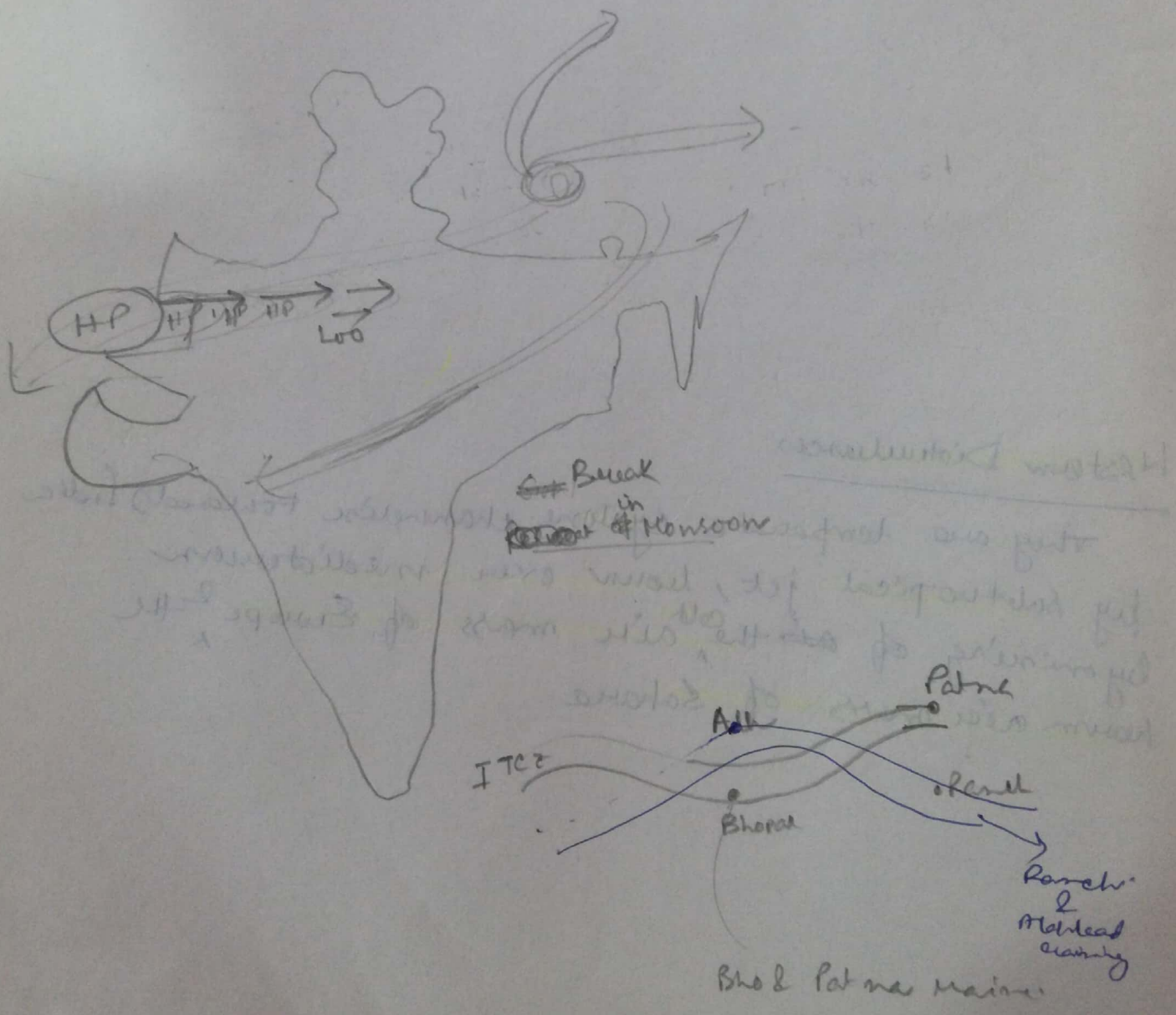
They are temperate cyclone channels towards India by subtropical jet, born over Mediterranean by mixing of ~~at~~ the ^{cold} air mass of Europe & the warm air mass of Sahara.

It picks up moisture ^{from} Black Sea as well but remains south of Caspian, 20-30 cm rainfall over Iran & Afghanistan which helps in poppy cultivation. It enters India from North-West & causes snow fall over Kashmir Himalaya.

Punjab receives 15 cm, Alakhnad - 10, Patna - 5 cm rainfall, which is helpful in Rabi cropping. Western disturbances can continue to April & May months, which delays the summer heat.

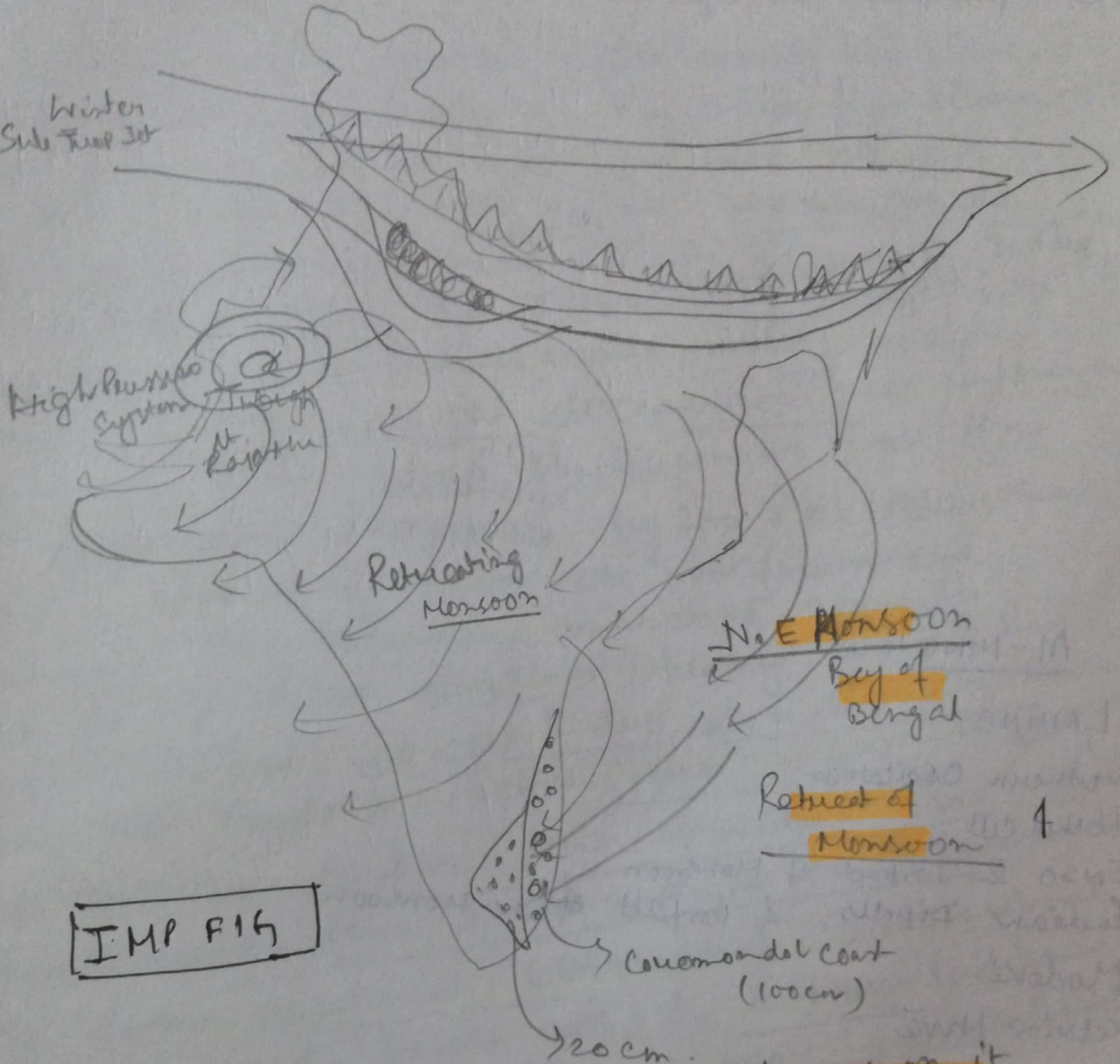
They are called Mauas in Rajasthan & Vatanda district of East Punjab.

© Pake Vortex



Summer time S.T Jet

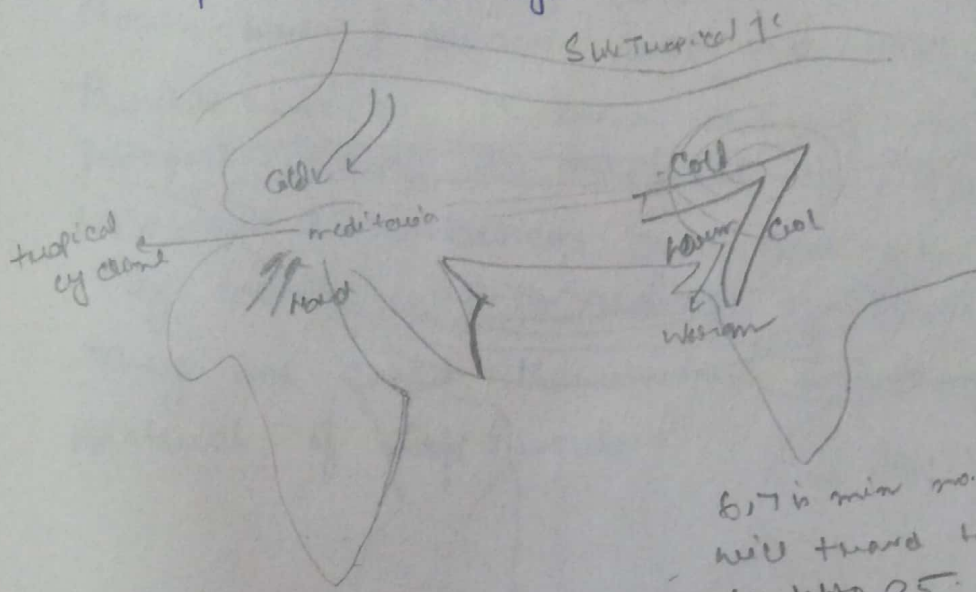
Winter Sub Tropic Jet



IMP FIG

Retreating of Monsoon is a continental phenomenon, it is the N.E monsoon is retreating monsoon over Bay of Bengal.

Thunderstorms are short lived phenomenon stage of a cyclone. Convergence of 3 or 4 thunderstorms together can produce a cyclone.



6, 7 is min no. of west-cold disturbances will travel to India. It may be upto 25.

AL-NINO :-

LANINA

Southern Oscillation

Walker cell

ENSO & Impact of Monsoon

Indian Dipole & Impact on Monsoon.

Modoki.

Kelvin Wave.

Global warming & ALNINO.

La Nina & global impact (Cold Waves, Floods etc)

AL-Nino refers to the warm current which develops along the Peru Coast in Eastern Pacific. It is called 'child of the Christ' because small current has global implication on weather condⁿ. It is also called 'child of the Christ' bec. it originates around 25th Dec.

La Nina on the other hand is known as sister of ALNino. It is cold current.

along the Peru coast with 2°C lesser temperature than the normal. Pacific is the store house of energy & the engine for the major ~~at~~ meteorological events. Thus such phenomenon occur in the Pacific.

During normal year the South-easterly trades are furious, hot & dry winds as they move from Africa. They drive the coastal water and create the cold upwelling zone. Thus high pressure prevails over the Peru coast (Eastern Pacific) & air is sinking. In a process to transfer the atmospheric energy into the sea, the S-Easterly trade drives the equatorial water, which accumulates near Indonesia, where sea level rises by 90 cm to 2m. Also the ^{avg} temperature is greater by 2 to 3° at Peru, sea level is lowered by 90 cm or 1 m from the normal. At Indonesia convective currents are strong, thick cloudiness, heavy rainfall. At 12-14 km, the cold & dry air is diverging, which fall over Eastern Pacific (Peru) & Somalia. Over the sea surface the circulation is high pressure in Peru & Somalia & to Indonesia. This cross equatorial latitudinal 3 dimensional cell is called Walker cell. & Eastern Indian Ocean has (-)ve pressure, while western Indian Ocean has (+)ve pressure.

This is called positive Indian Dipole & the Walker cell circulations helps in the acceleration of South West monsoon, & India have good rainfall.

During the El Niño year, South-easterly trade become weak & the cold upwelling stops.

↑ The Indian Dipole
↓ Normal year

Thus the sea level returns back normal sea. The ~~less~~ region, eastern pacific lacks cloudiness, hence the warming of the water is earlier, & the sea level gradually rises along Indonesia. The sea level falls because the equatorial water is not being driven by the trades. Due to thick cloudiness insolation is intercepted & there is a general cooling.

↳ This high pressure develops over Indonesia. The sea-saw in the sea level between Indo & Peru or between Eastern & Western Pacific is called Southern Oscillation. In Southern Oscillation pressure system reverses, therefore Walker cell circulation is also reversed. Thus from Western Pacific the air circulation is directed toward Peru & a subsurface current of warm Equatorial water is generated & directed towards Peru. This currents are called Kelvin wave. As the Kelvin wave reaches the Peru coast - warm currents are produced, known as Al Niño. Stronger Kelvin waves means warm water of ~~Eastern~~ ^{Western} Pacific gradually extending over central Pacific. Warming of central Pacific is called Modoki. This event has been related with the global warming, which accentuate & accelerated the Al Niño phenomenon. In Modoki event the freq. & intensity of tropical cyclone are greater. ~~INiño~~ ^{ENSO} means Al Niño plus Southern Oscillation. During ~~INiño~~ ENSO South-West monsoon is either weak or disrupted. However this relationship has

not been fully established. In some of the El Niño yr India has received good rainfall.

During ~~ENSO~~ ENSO the Walker cell is shortening & have eastward shift, because the rising air from Indonesia is so weak, that it falls over bay of Bengal, which has high pressure; while Somalia develops low pressure due to direct heating

of the Sun. Thus Western Indian ocean has (+)ve pressure & eastern Indian ocean has (-)ve, known as (-)ve Indian dipole, which disrupts the monsoon. El Niño can also cause complete reversal of the Walker cell over Indian ocean. It also causes disruption in the monsoon.

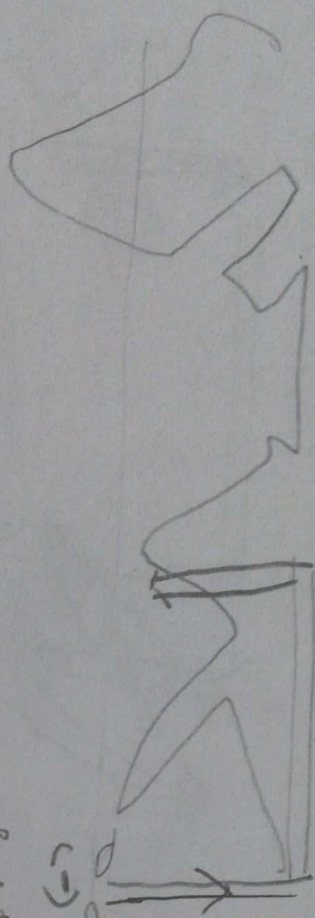
(-)ve Indian Dipole El Niño

During la Niña South - easterly trades are stronger & deeper water upwells, thus avg. temp. along Peru is less by 2°C, & the cold current is stronger. The Walker cell strengthens & the low pressure of Indonesia, extends

still northern Australia. Queensland can have flood, & India monsoon is strengthened. Convergence at ITCZ, increased & the lifting air directed towards Siberia, by mixing into the Tibetan Anticyclone at 10 to 12 km, strengthens the polar vortex & the sea high pressure at pole is immensely great, which generates the cold wave; which crosses Himalaya & can extend till Vindhya. Europe also remain under cold wave & heat

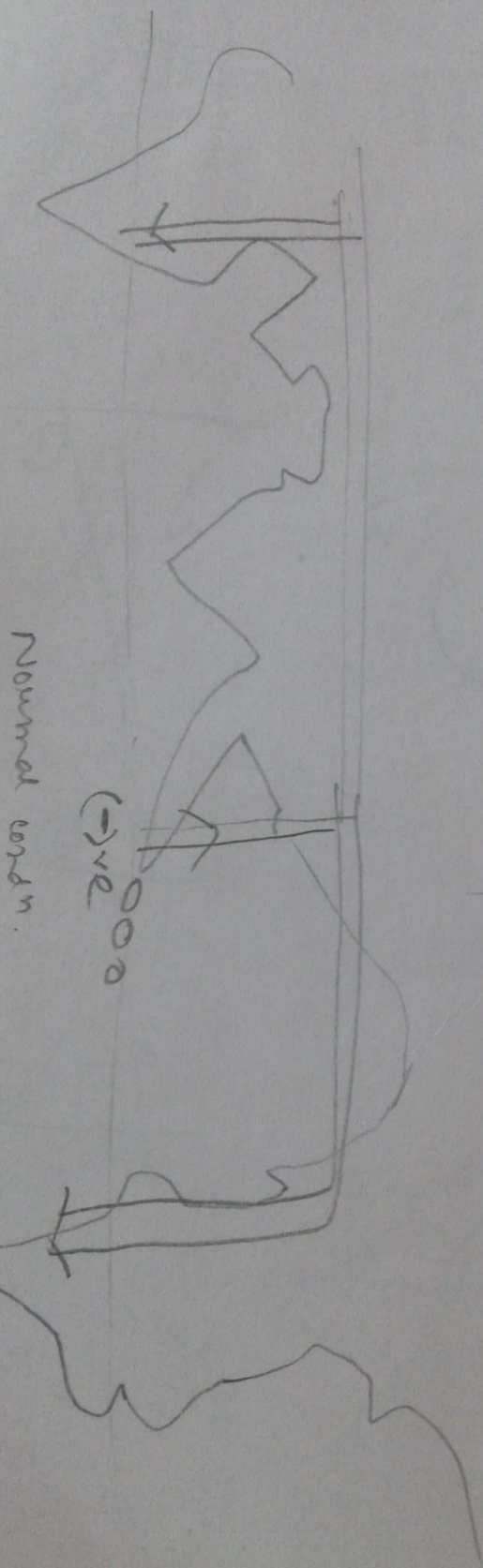
waves are the dry cyclone which ^{has} released the latent heat of condensation.

Lamina
 can cause earth quake, & drought
 in India



air rising & falling in Bay of Bengal

Part of India is (-)
 (+)



Normal earth.

Air rising from India

falling in Peru & Somalia.

El Niño → weaker temperature system, dry system, lesser rainfall.

air rising →
 falling →
 High summer
 report of SE winds →
 less rain →