Climatology of Maritime Continent

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○ Element and Control of Climate

- Elements of weather and climate : air temperature and humidity, rainfall, wind, sunshine duration, etc.
- Control of Climate : geographical latitude (annual migration of the sun), land and water distribution, semi permanent cell of high and low air pressure, air mass, mountain barrier, sea current, and storm such as tropical storm.

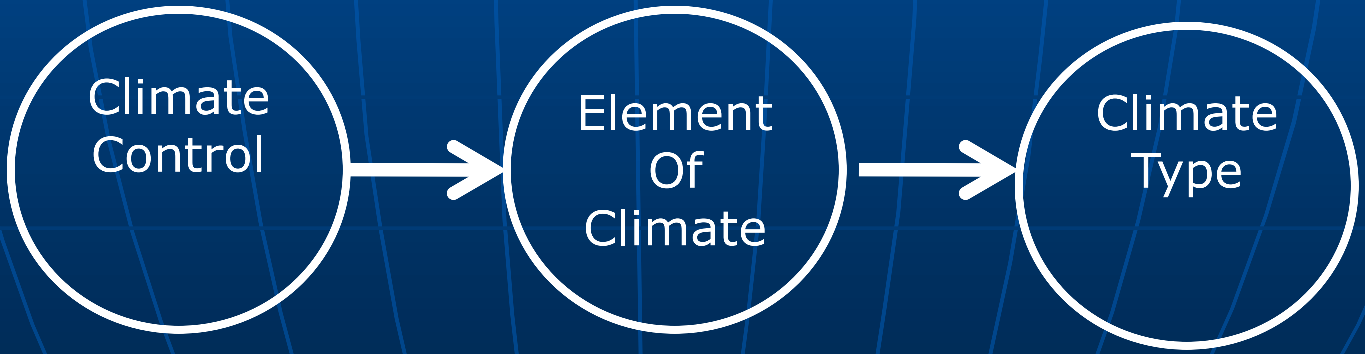


Figure 1. Relationship between climate element and climate control

- **Climatology**
  - Come from the combination of two words Greek i.e., klima means slope of the earth indicating to the conception of place, and logos means science. Thus, climatology can be difined as science to find description and information of the nature of climate, why the climate in some place of the Earth is difference ? and how is the relation between climate and human activities. Climatology can also defined as science to study climate types and factors of its cause in the earth.

○ Season

- Is a period of the extreem climate element, for instance : in summer the extreem climate element is high air temperature; in rainy season, the extreem climate element is the aboundant rainfall (great number of rainfall).
- In the world there are 4 season i.e., winter, spring, summer, and autumn. These terminologies are not usual applied in Indonesia due to the air temperature almost constant through the year, on the contrary the rainfall amount has great monthly variation.

- Climate bounds growing vegetation, so that it bounds the harvest (hasil panen), for example to harvest rice (memanen padi) on paddy field (sawah).
- Climate factors affecting the harvest are; water condition (rainfall amount), duration of growth period, air temperature, sunshine duration and wind. In the case of microclimate, the vegetation location is very important.
- For producting the better harvest, vegetation has generally an optimum climate conditions, and also to pay attention to other factors such as soil condition, market–place and marketing, transportation facilities and disease condition, etc.

- Most of Asian region is located in northern hemisphere (NH), while Indonesia geographycally is located in the environs of equator in latitude between 10^0 N and 10^0 S.
- Indonesia lies between two continents (Asia and Australia and two oceans (Pacific and Indian Ocean).
- Indonesia consist of about 17,508 big and small islands, it has coast line about 80,790 km.
- Indonesia is a part of the earth system as a natural unity between atmosphere, hydrosphere, litosphere, biosphere and cryosphere in Jaya Wijaya, Papua (west part of Indonesia), their interactions form the weather / climate over Indonesia.
- Indonesia is passed by the ITF (Indonesian Throughflow) and the IMC (Indonesian Monsoon Current).

- Indonesia is passed by the fixed equator 0^0, and it is also passed by the ICZ deplacing toward northern and southern hemisphere following solar annual migration.
- As an equatorial region (between 10^0 N and 10^0 S), Indonesia has surplus energy in all seasons. On 21 March and 23 September occur equinoxes i.e., the position of the sun over the equator.
- As a monsoon region, Indonesia is affected by monsoon circulation in consequence of it lies in between two oceans (Pacific and Indian ocean) and two continents (Asia and Australia continent).
- As a maritime and mountainous region, Indonesia has local winds such as sea–land breezes, valley–montain winds, and wind like Föhn. Orographic lifting is efficient when monsoonal winds are forced to rise and converges with sea breeze and valley wind.

- The difference of physical characteristics between ocean and continent, between sea and land, between valley and montain yield monsoon circulation and local winds (sea–land breezes, and valley–montain winds) affecting seasonal and diurnal weather/climate variation.
- Other natural phenomena such as El Niño / La Niña, Dipole Mode, Madden – Julian Oscillation and so on affect the non seasonal climate variation.
- Indonesia has an insolation and latent heat (70% waters) in the considerable number. It has energy surplus in all season.

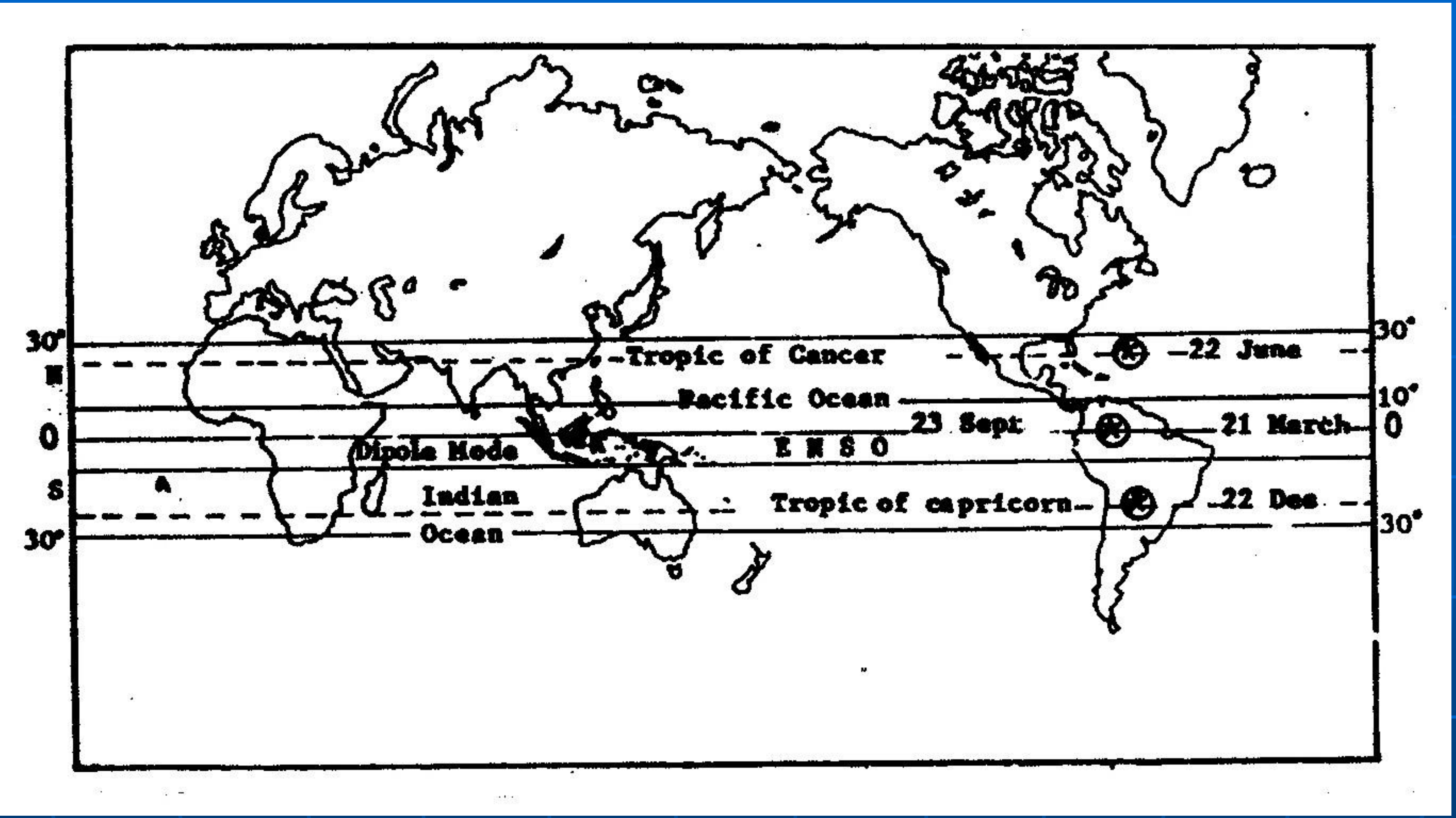


Figure 2. Geographical and meteorological position of Indonesia.
(✷) solar annual migration

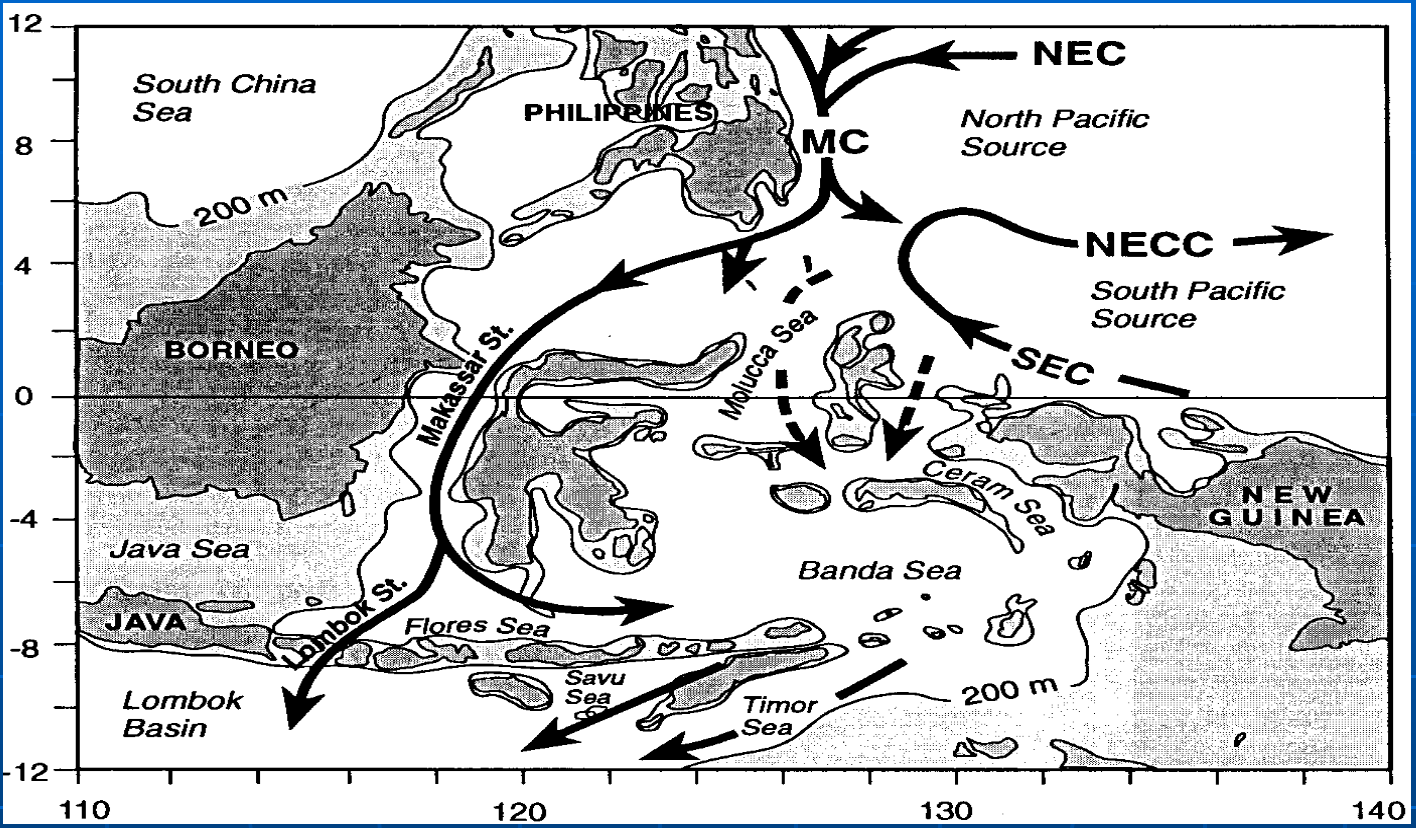


Figure 3. The flow pattern in the Indonesian passages (adapted from Ffield and Gordon[1992]). The North Equatorial Current (NEC) and the resulting Mindanao Current (MC) approach the passages from the north, whereas the South Equatorial Current (SEC) approaches the passages from the south. The North Equatorial Countercurrent (NECC) carries water to the east.

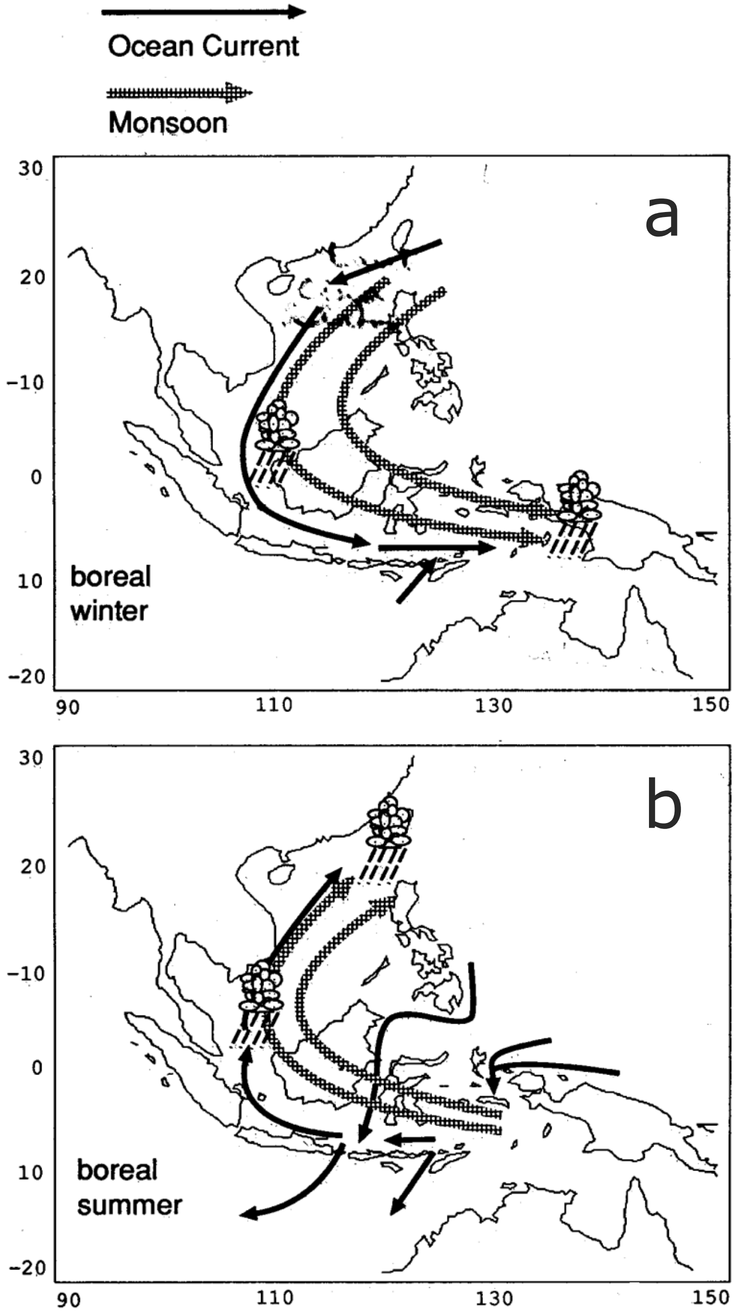


Figure 4. Schematic view of the seasonal salinity variation processes in the Indonesian Seas during (a) boreal winter and (b) boreal summer.

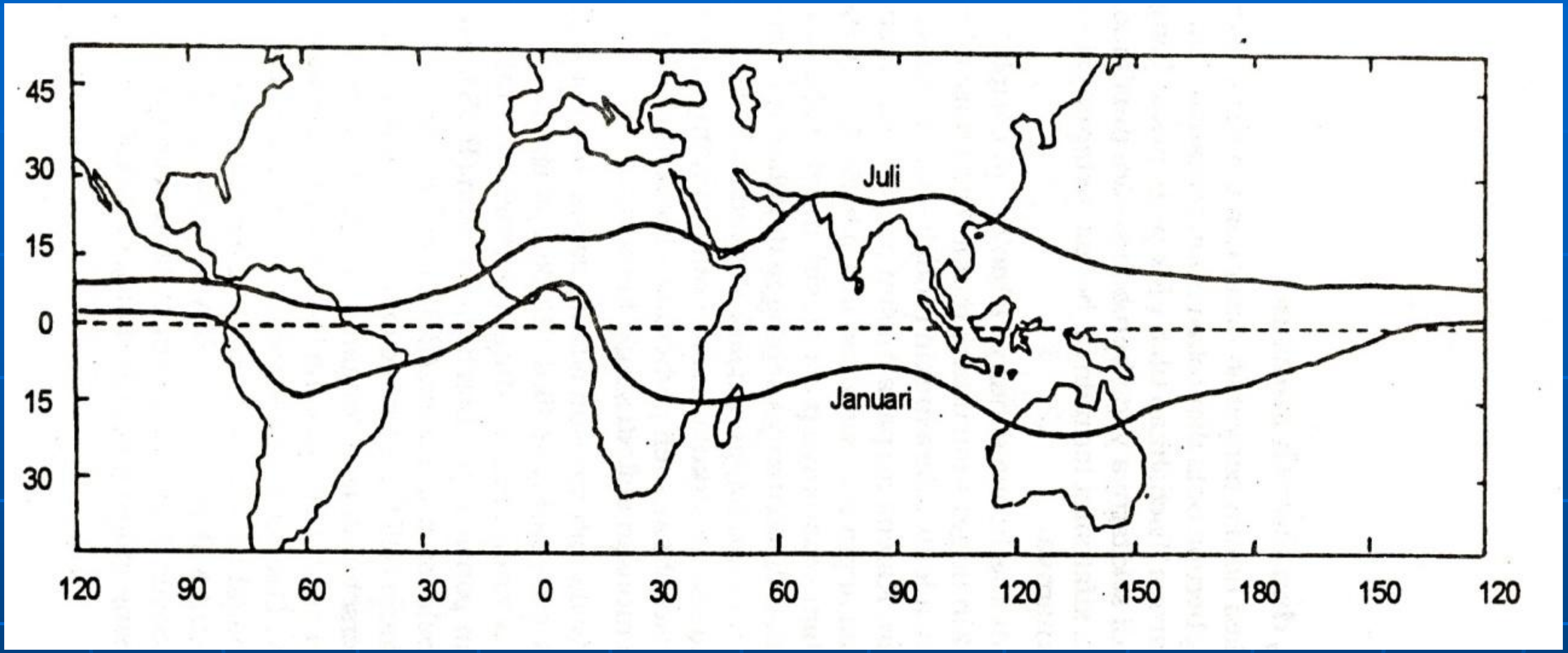


Figure 5. Mean position of ICZ in January and July.

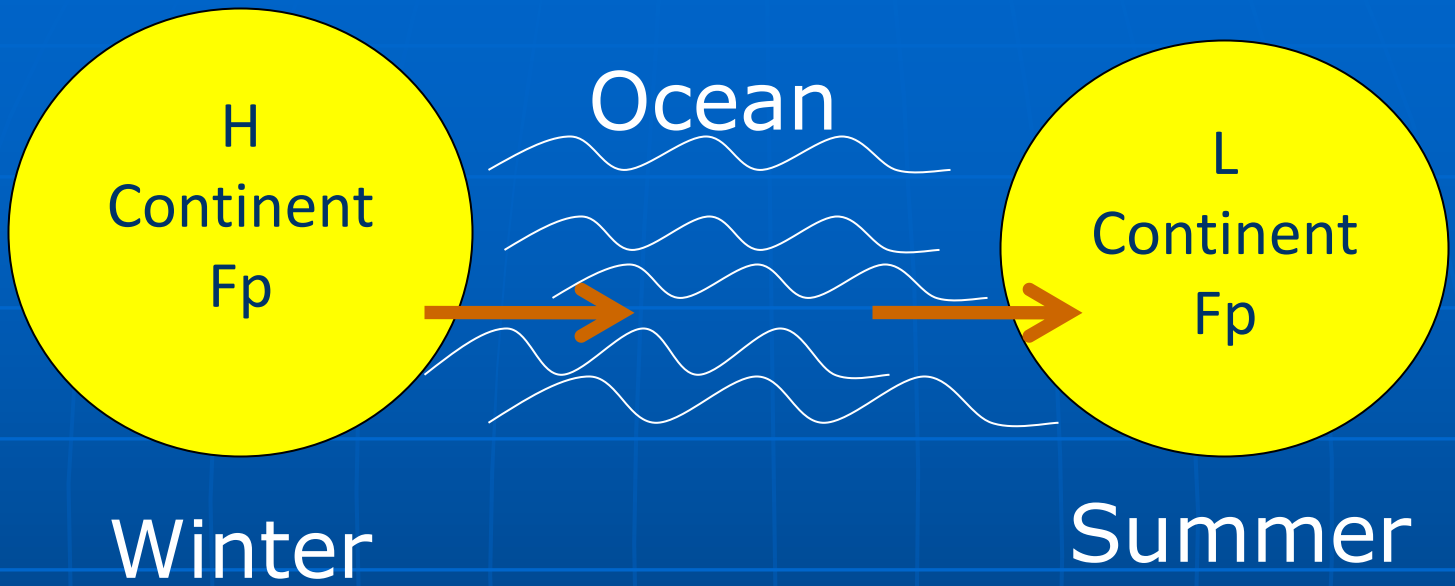


Figure 6. Scheme of monsoon circulation in the hemisphere summer and winter. F_p : pressure gradient force, L : low air pressure, and H : high air pressure.

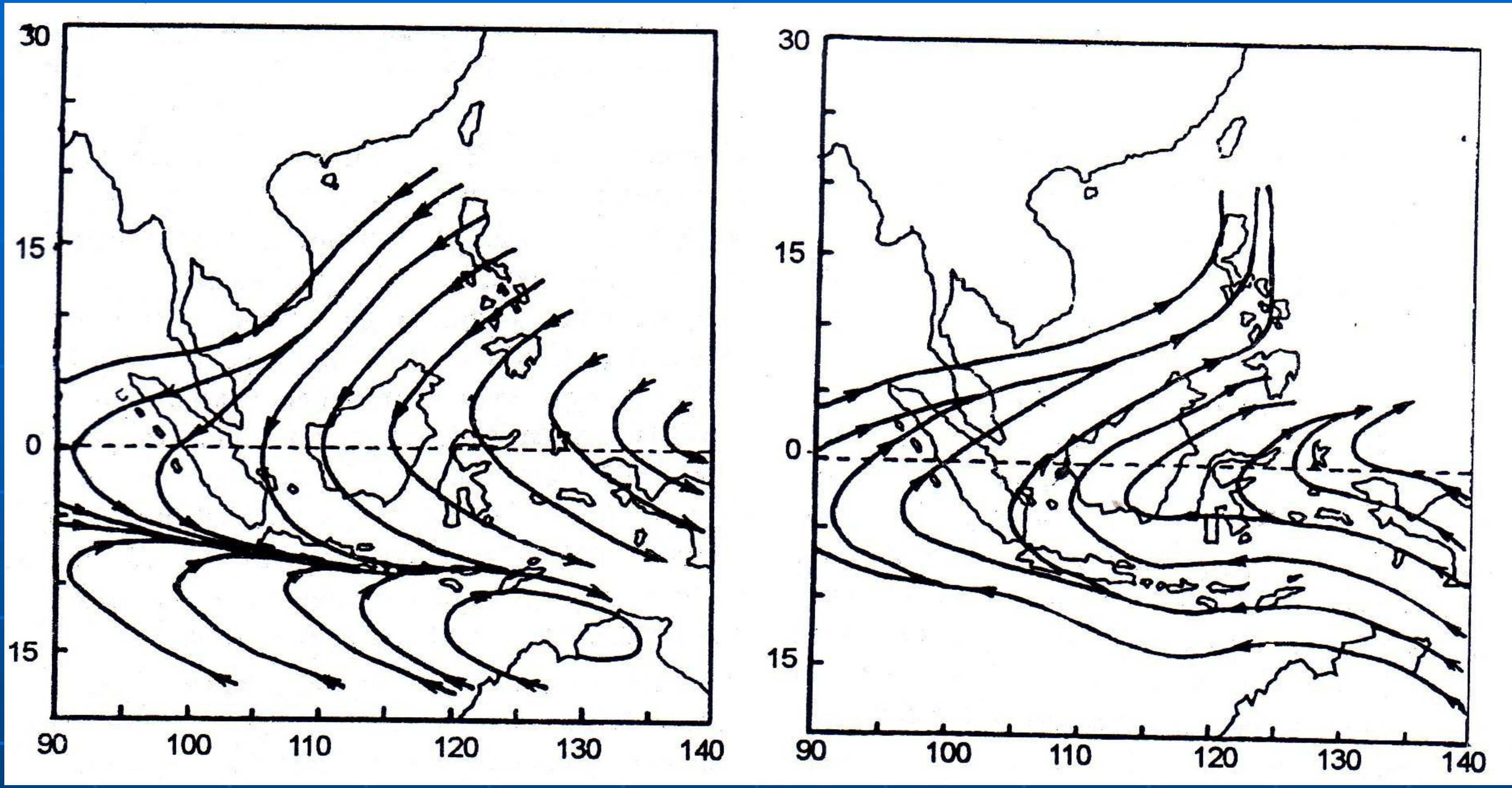


Figure 7. Mean wind patterns in January (left) and July (right).

Table 1. Division of season based on the monsoon in Indonesia.

Southern Hemisphere Indonesia		Northern Hemisphere Indonesia	
Season	**Period**	**Season**	**Period**
Northwest monsoon	Dec – Jan – Feb	Northeast monsoon	Dec – Jan – Feb
First transition	Mar – Apr – May	First transition	Mar – Apr – May
Southeast monsoon	June – July – Aug	Southwest monsoon	June – July – Aug
Second transition	Sept – Oct – Nov	Second transition	Sept – Oct – Nov

Convective Rain :

- Indonesia is the most active convective region
- Convective cloud Cu and Cb are dominant in Indonesia.
- Cause shower, thunder and lightning, simetime tornado
- Convective cloude is formed by bouyancy force :

  $F = gB \;,\; B = T/T' - 1$

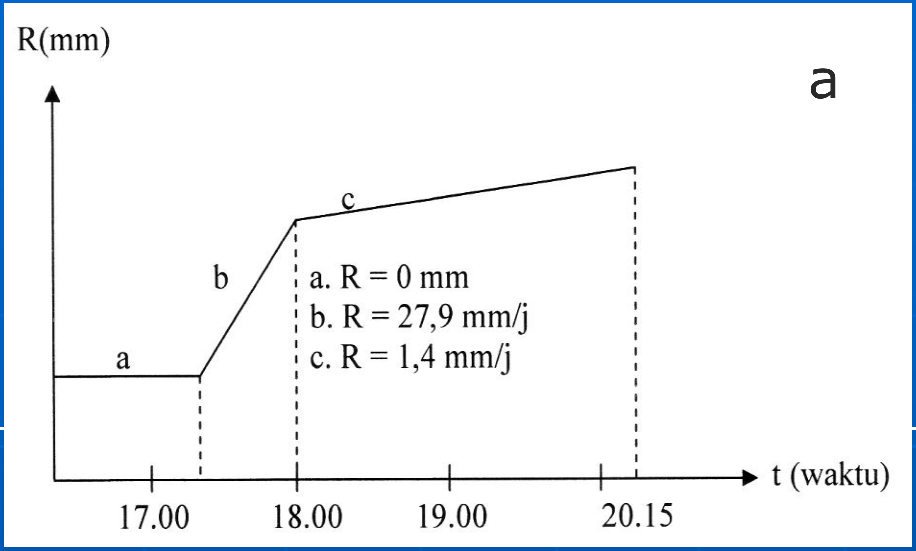
  Where :

  g : gravity

  B : bouyancy term.

  T : temperature of air parcel

  T' : temperature of environment air



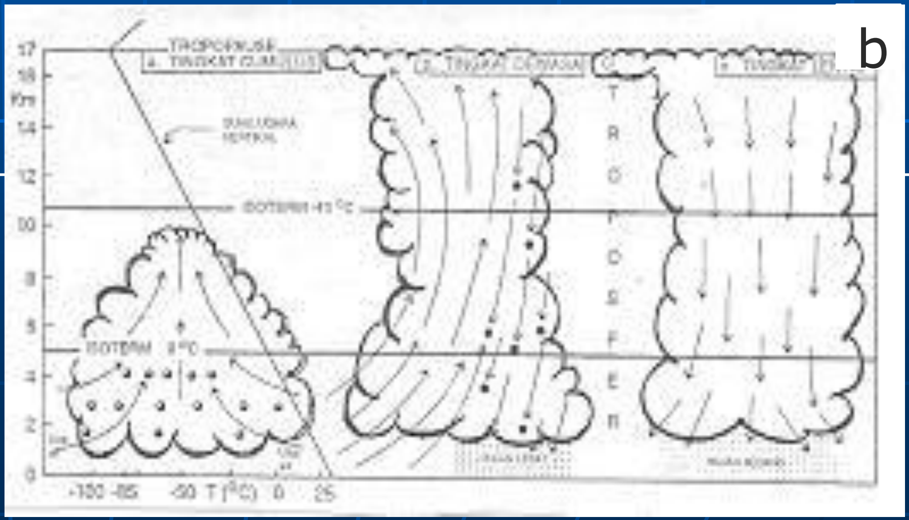


Figure 8.

- Hail Stones.

  Convectional precipitation, because it is formed by rapid updraft, often to great heights in the atmosphere, is usually intense, occasionally it may be in the solid form of hail.

Figure 9. Hailstone in Wamena, Papua (Eastern Indonesia), 3 December 2007, Photo MetroTV.

- In maritime region, the convection is also active at night.

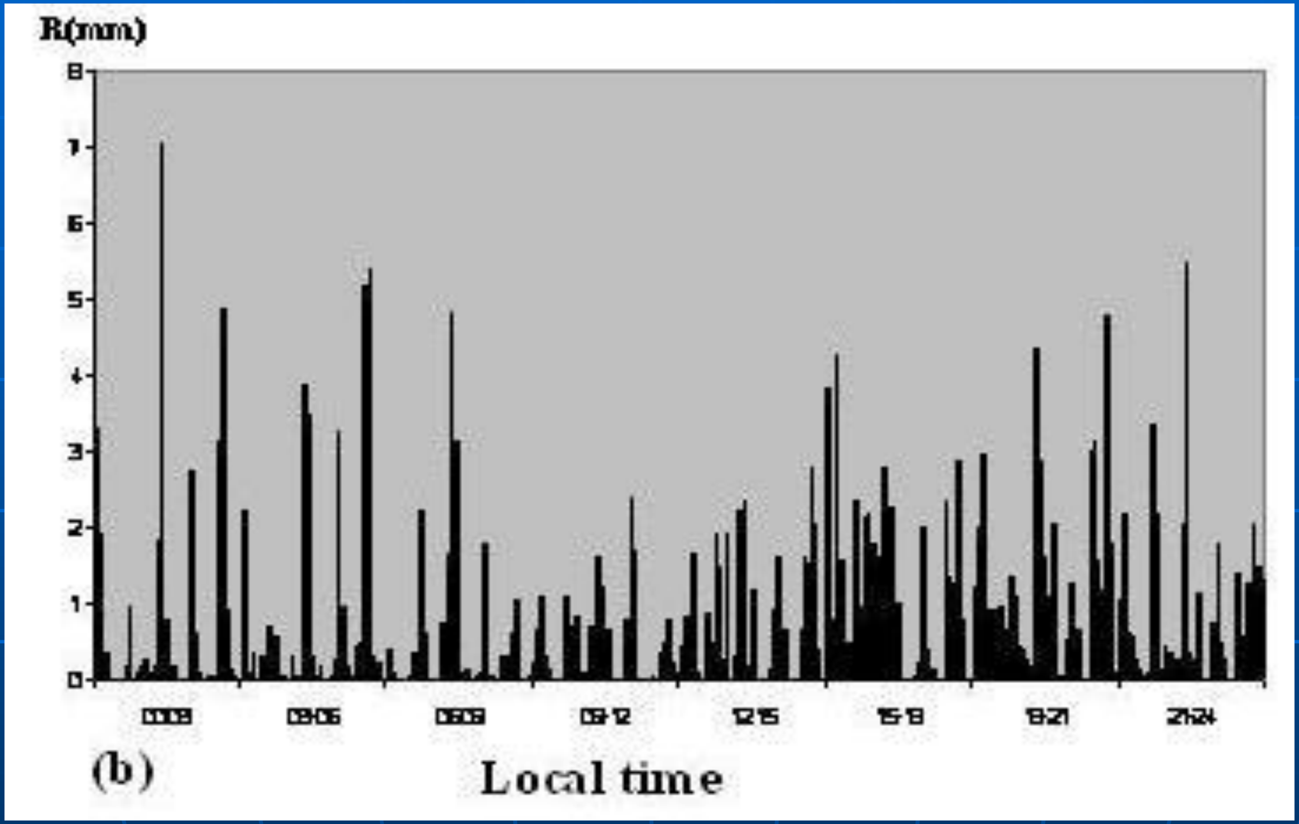


Figure 10. Distribution of 3 – hourly rainfall from 00.00 to 24.00 Local Time in Jakarta.

- **Running hot and cold**

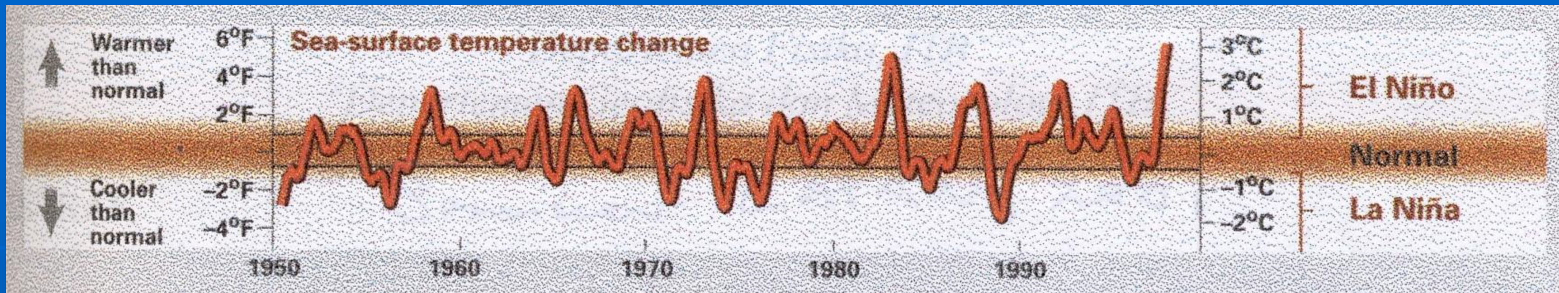


Figure 11a. SST change. During the past 50 years their slow cycle has created of El Niño conditions 31 percent, La Niña conditions 23 percent and normal conditions 46 percent of the time. Sources : Kevin Trenberth, NCAR. Data from NOAA

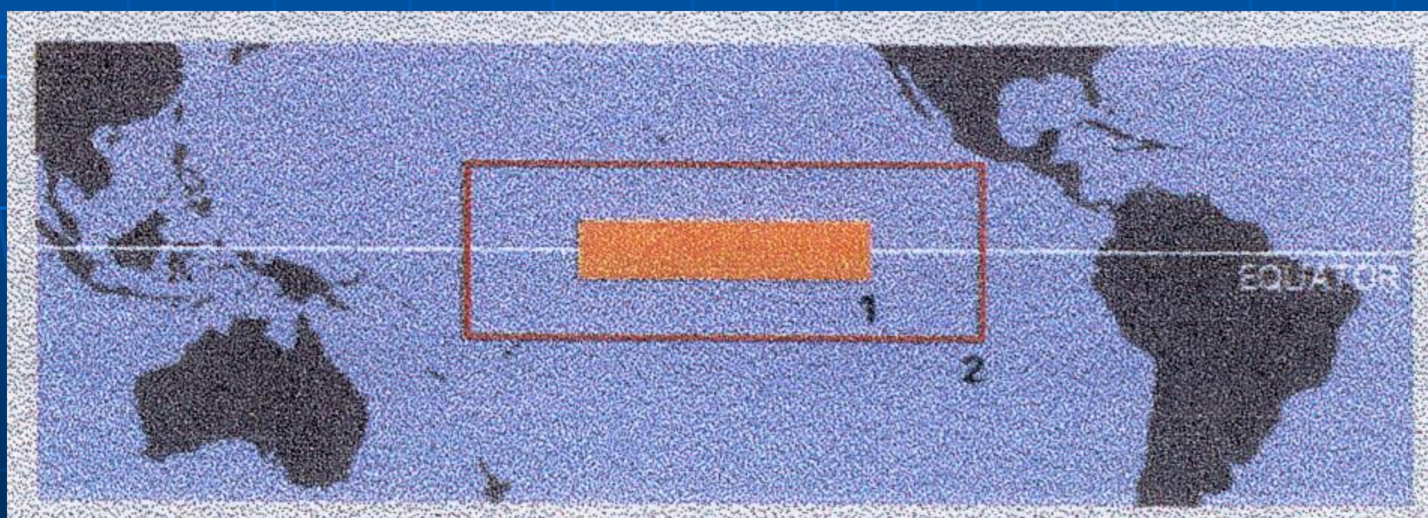


Figure 11b. Information in the graph above is based on data from area west of Peru. 2. Rectangle defines area depicted in cross section in figure 11a.

- **El Niño**
  As easterly trade winds decrease, warm water in the western Pacific flows eastward. This layer, typically 500 ft. deep, flows over cooler, nutrient rich water and blocks its normal upwelling along N – S America. Sea life there can suffer from lack of food.
- **Normal**
  Trade winds maintain a balance between warm western Pacific water and cool water in the eastern Pacific Nutrient rich water, lies 130 ft. below the surface.
- **La Niña**
  Pushed westward by strong trade winds, warm surface water flows toward Asia. Colder deep – sea water upwells to the surface along the Americas. Nutrients become more plentiful, evaporation decreases, reducing storm cloud formation and rain in the region.

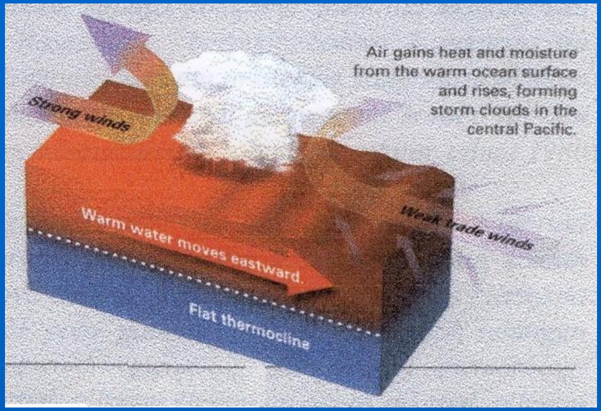


Figure 12a. El Niño events

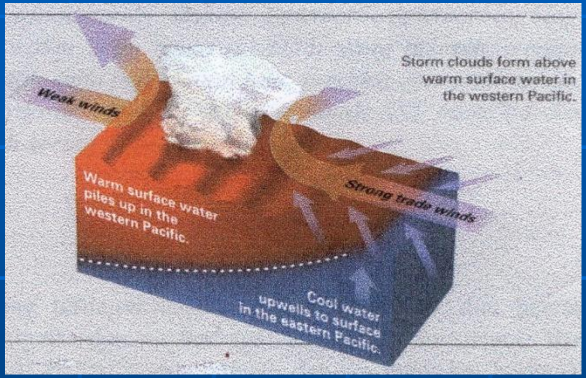


Figure 12b. Normal condition

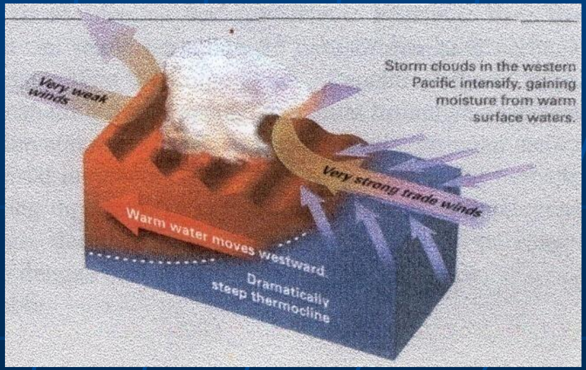


Figure 12c. La Niña events

- **Dipole Mode (DM)**
  - Rainfall in the western Sumatera is influenced by DM (Saji et.al., 2001) in the equatorial Indian Ocean.
  - DM negative / positive, the rainfall in West and South Sumatera increase / decrease.
  - DM is determined by the fluctuation of SST above and below the normal between east coast of Africa and west coast of Sumatera.
  - Dipole Mode Index (DMI) is determined by the difference of SST anomalies in the western (50 ^{0}E–70 ^{0}E, 10 ^{0}S – 10 ^{0}N) and eastern Indian Ocean (90 ^{0}E – 110 ^{0}E, 10 ^{0}S - 0^0 (eq)), see figure 13.
  - DM (+), rainfall in West and South Sumatera is below normal, especially in JJA and SON.
  - DM (–), rainfall in West and South Sumatera is above normal especially in JJA and South Sumatera in SON.

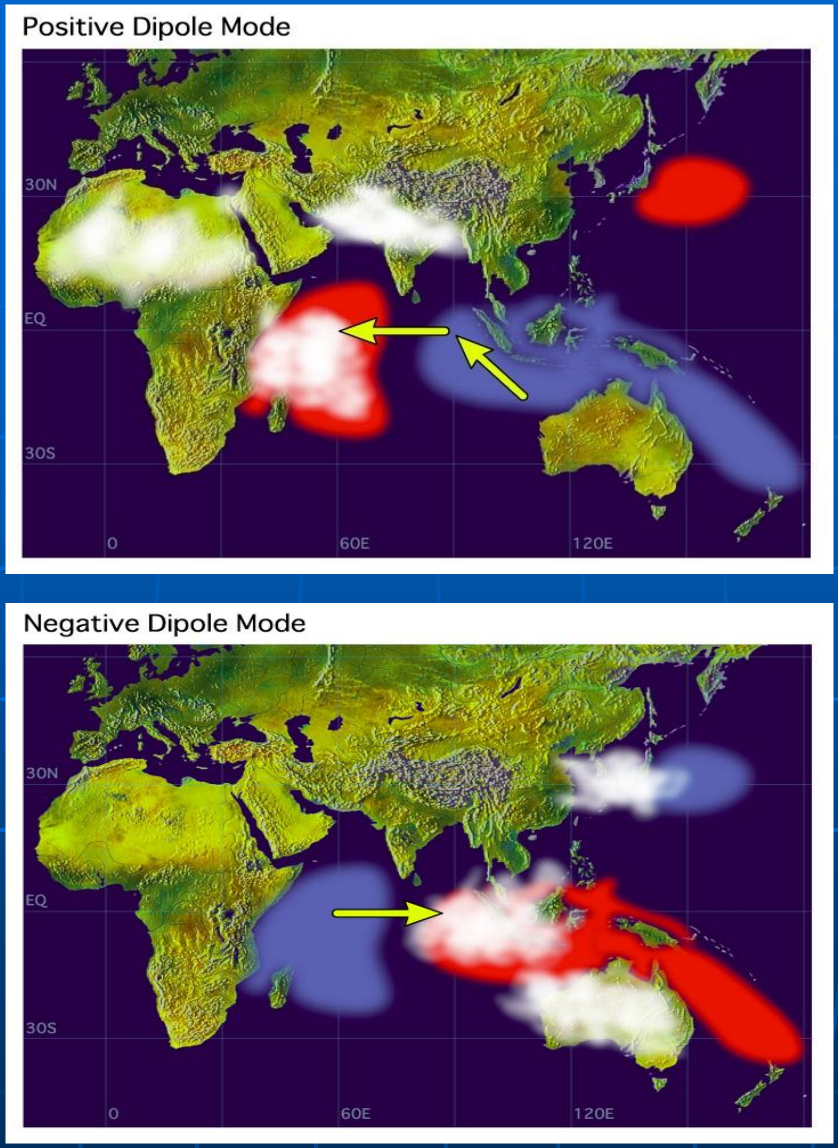


Figure 13. Positive and negative Dipole Mode.

- **Cumulative rainfall amount at a level of 350 mm from the 50th pentad (September 3rd) is related to the rice planting**

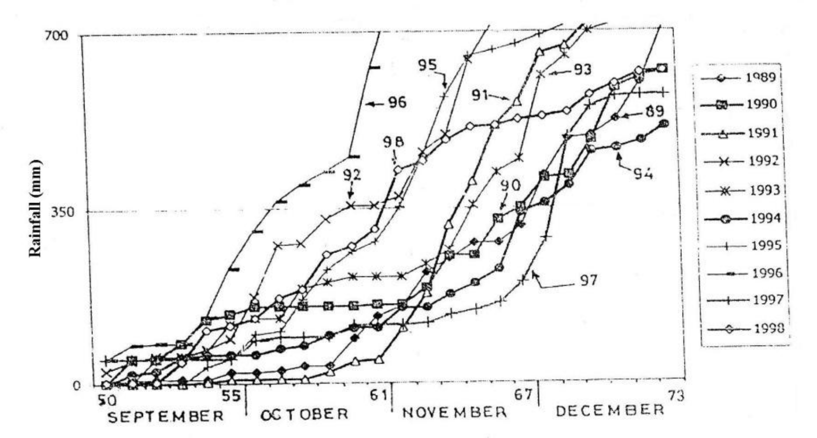


Figure 14a. Cumulative rainfall from the 50th pentad (September 3rd) to 73rd pentad (December 31st) in Bandung area.

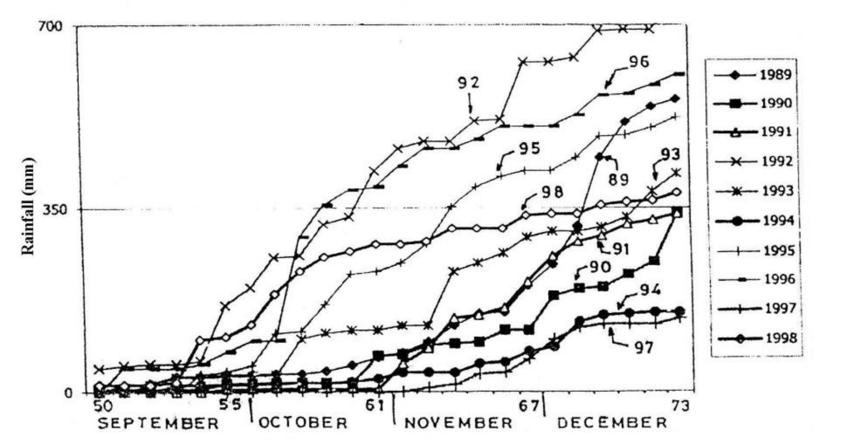


Figure 14b. Cumulative rainfall from the 50th pentad (September 3rd) to 73rd pentad (December 31st) in Jakarta area.

- Orographic Effect on the Rainfall in the Southeast monsoon.
- Figure 15, shows three cross–sections from Java sea to Indian ocean in West Java, Central Java, and East Java.
- During Southeast monsoon period occur föhnlike winds affecting rainfall amount in the north coast of Java.

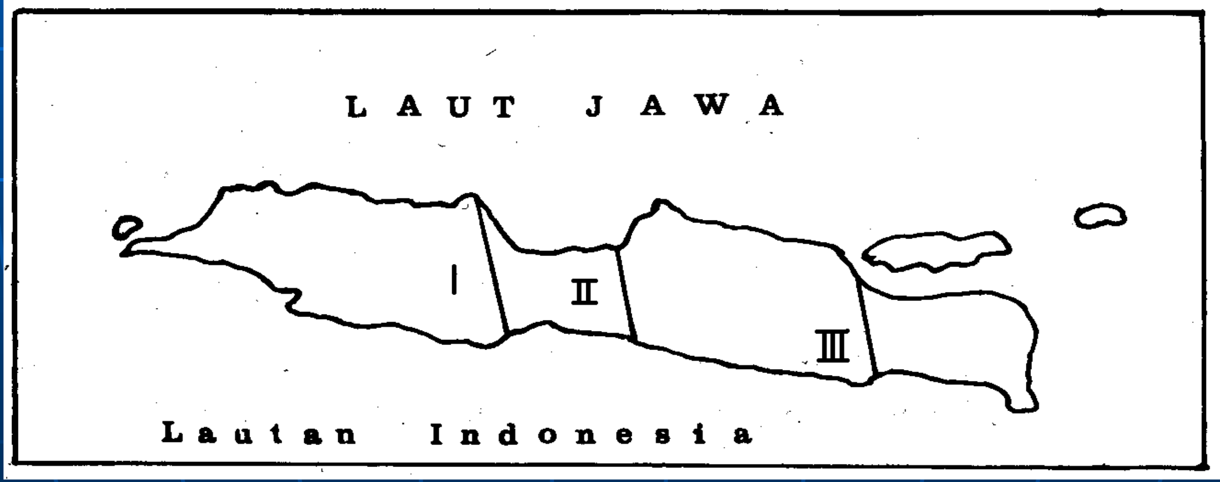


Figure 15. North–South cross–section over Java.

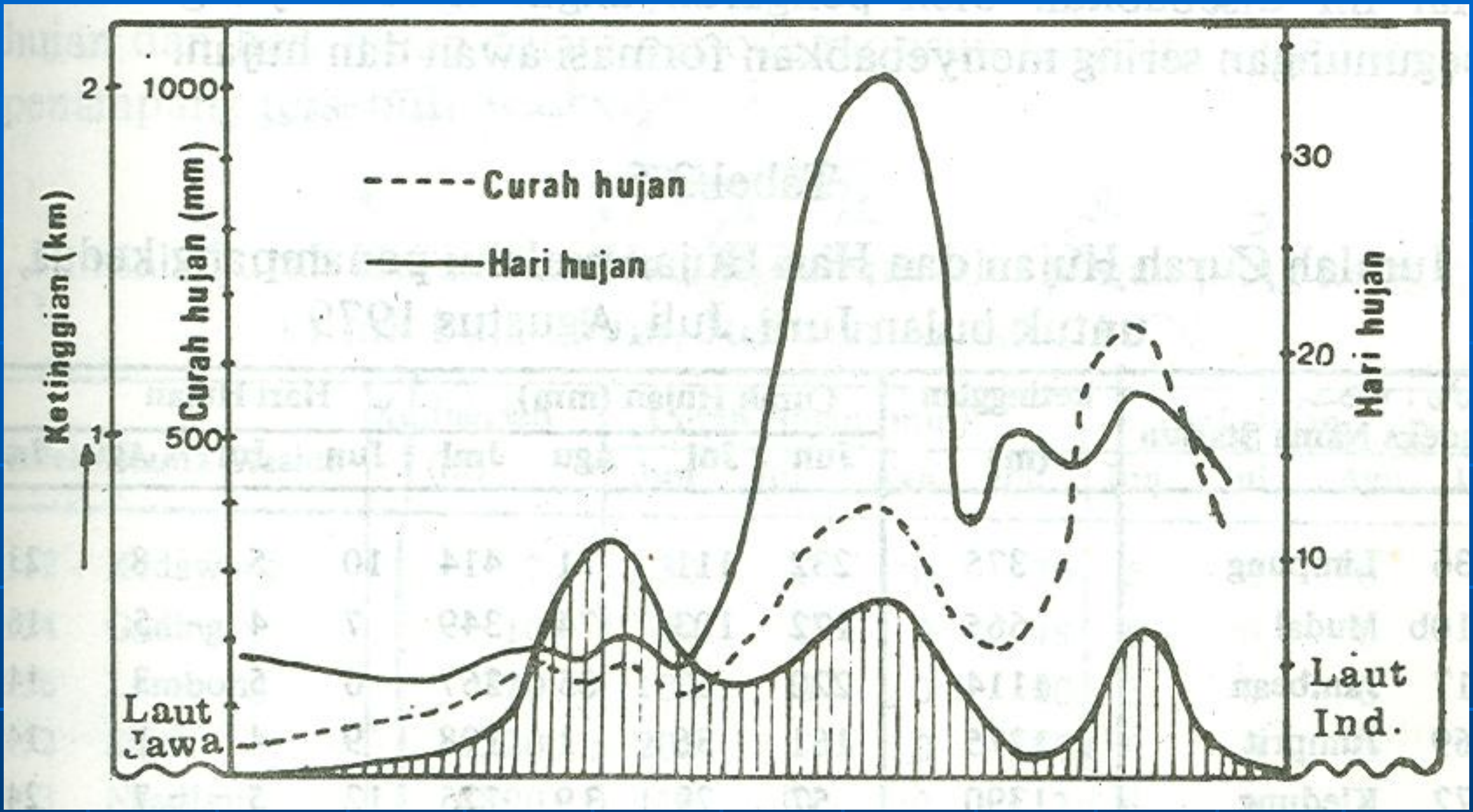


Figure 16. Cross – section from Juntinyuat in the north coast of Java to Pangandaran in the sout coast of Indonesian waters.

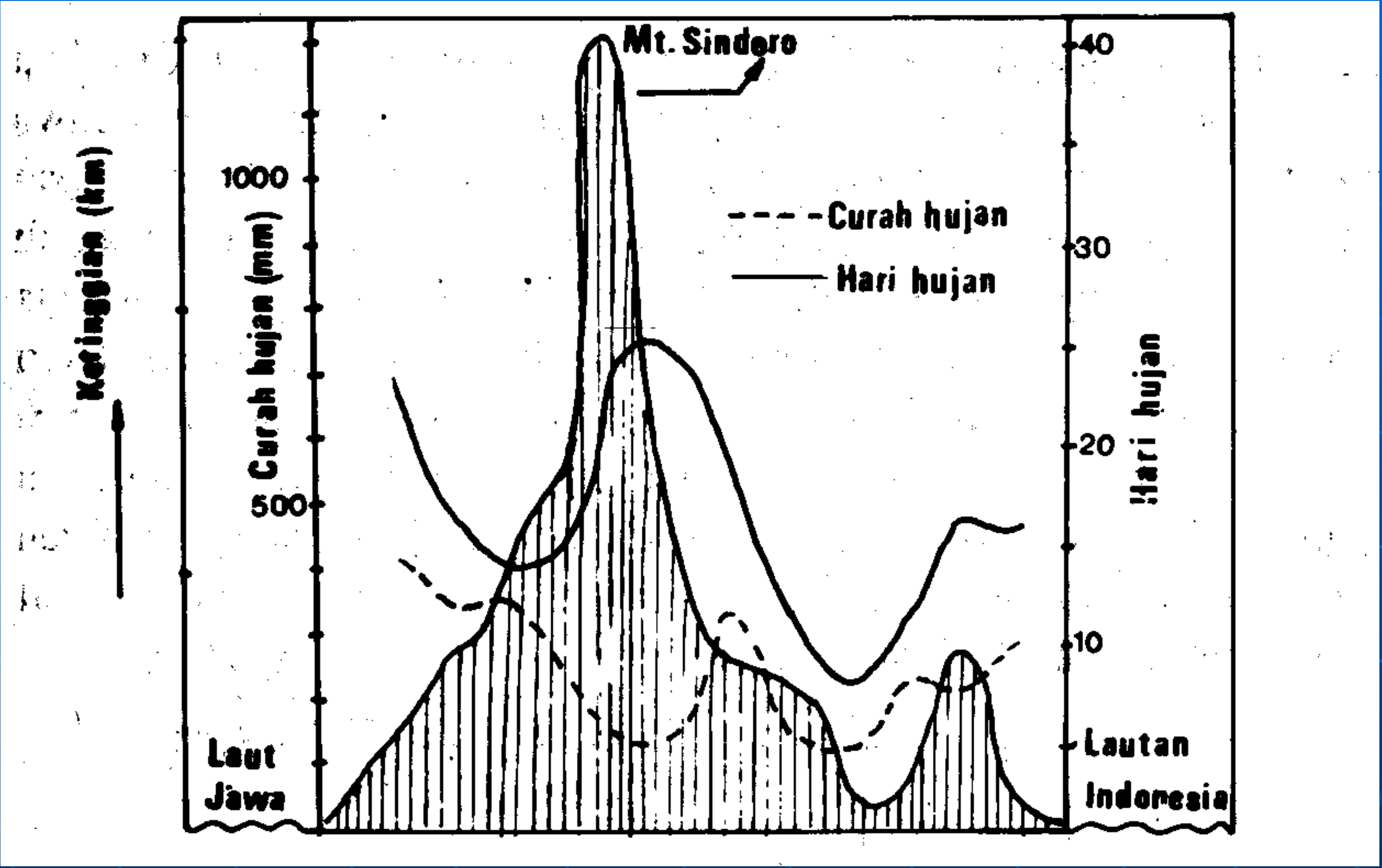


Figure 17. Cross – section from Limpung to Kokap.

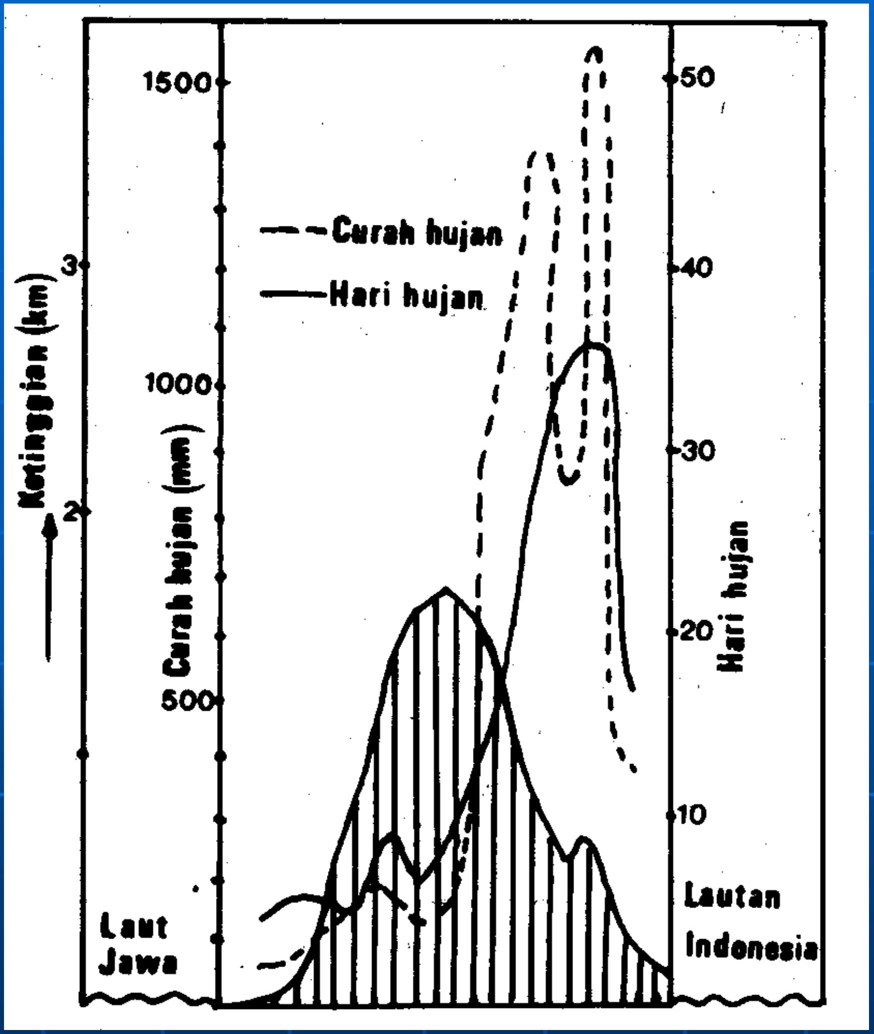


Figure 18. Cross–section from Kedawung to candipura.

○ Climate classification in Indonesia

- In general, the classification is based on the climate elements of air temperature and rainfall, such as Koppen and Thornthwaite method.
- Due to the variation of air temperature is very small through year, while rainfall in great variation; the classification of climate in Indonesia is based only on rainfall, such as the classification according to Schmidt – Ferguson and Oldeman.

○ Schmidt and Ferguson method, 1951.

- Base on quotient the average number of dry months and wet months.
- When rainfall amount per a month is less than 60 mm, called dry month, when it is greatter than 100 mm, called wet month.

- The quotient : $Q = \bar{d}/\bar{w}$, d and w are average dry and wet month respectively.
- Climate types (from climate A to H) are classified by the Q values as follows :

A	:	0	$\leq$	Q	$<$	0.143
B	:	0.143	$\leq$	Q	$<$	0.333
C	:	0.333	$\leq$	Q	$<$	0.600
D	:	0.600	$\leq$	Q	$<$	1.000
E	:	1.000	$\leq$	Q	$<$	1.670
F	:	1.670	$\leq$	Q	$<$	3.000
G	:	3.000	$\leq$	Q	$<$	7.600
H	:	7.000	$\leq$	Q		

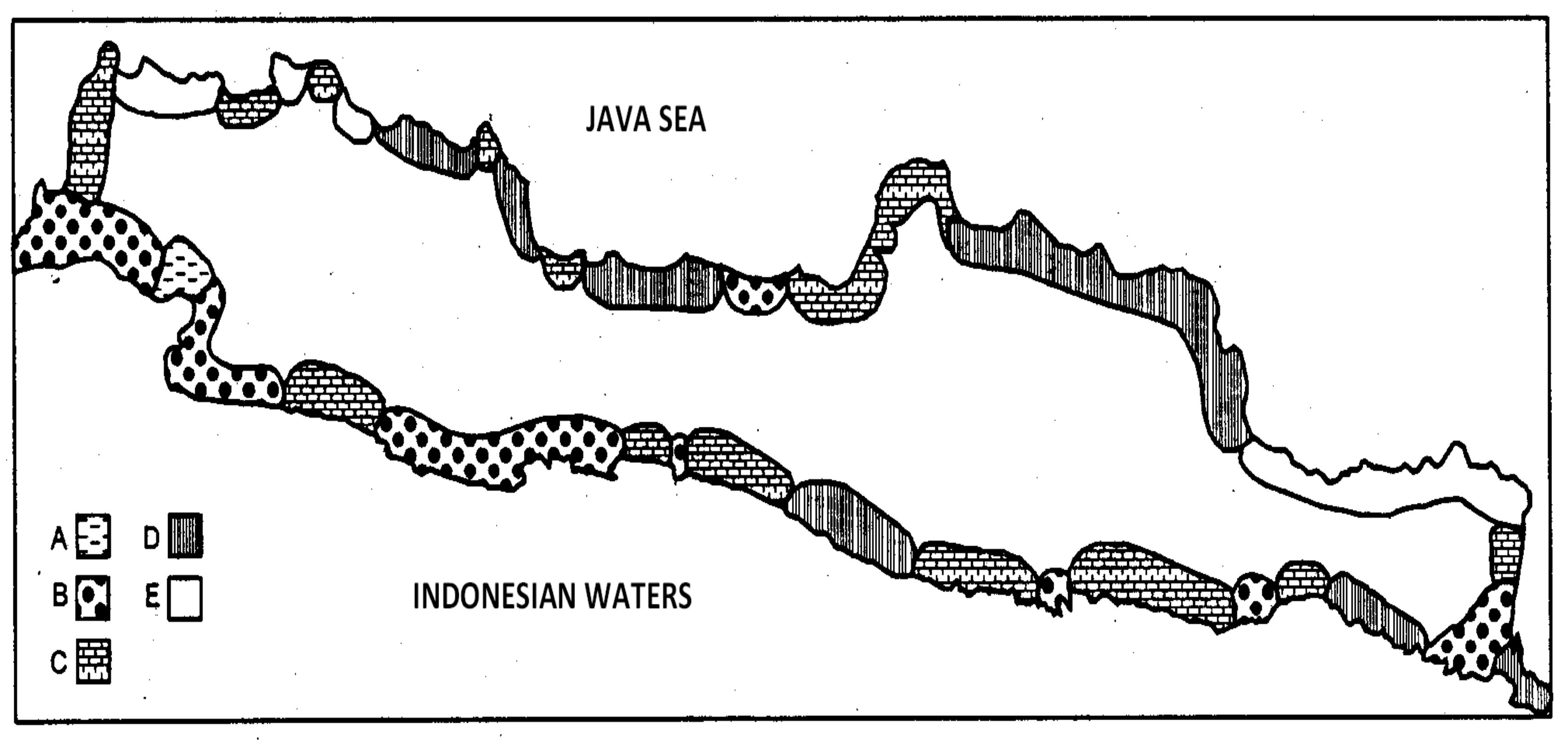


Figure 19. Climate types in marine areas of Jawa based on the Schmidt – Ferguson classification

○ Oldeman method, 1975

- Like Schmidt–Ferguson method, the classification of climate based on the rainfall amount. Oldeman method emphasizes on the agriculture, then this classification is called agro–climatic classification.
- In this method, wet month is defined as a month with rainfall amount $\geq$ 200 mm and dry month when rainfall amount less than 100 mm.
- Based on above criteria, Oldemann divided into 5 principle agroclimate :

  A : when there are more than 9 wet months consecutively

  B : when there are 7 – 9 wet months consecutively

  C : when there are 5 – 6 wet months consecutively

  D : when there are 3 – 4 wet months consecutively

  E : when there are less than 3 wet months consecutively

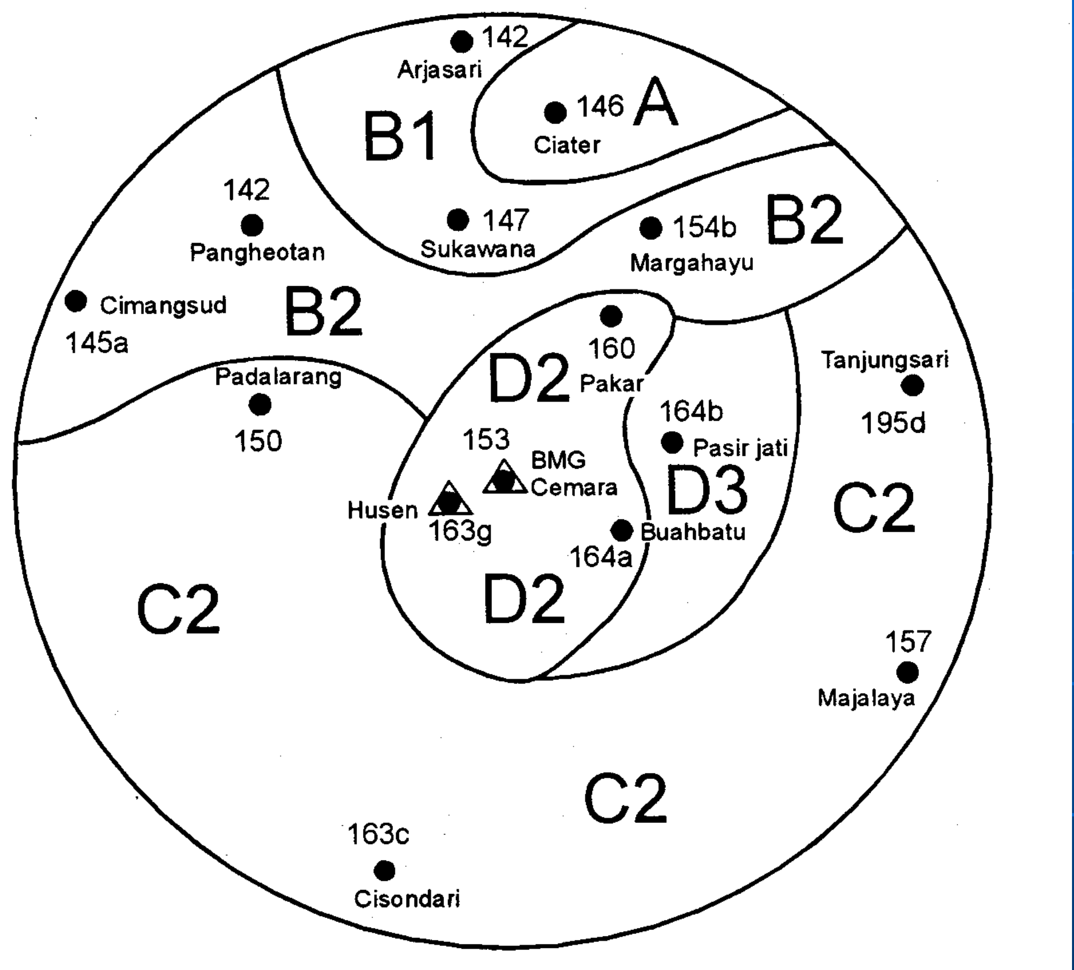


Figure 20. Zones of agroclimate in Bandung areas, according to Oldeman method.

○ The Climate System

- Climate is variable on time scales of months, seasons to centuries and over longer time intervals.
- Climate variability and Change can have significant societal impact.
- Climate influences agricultural yields, water availability and quality, transportation systems, ecosystems, and human health.
- Climate variability and change are a product of external factors such as the sun, complex interaction within the Earths system, and anthropogenic effects.

- The physical components of the climate system include the atmosphere, the oceans, sea ice, the land and its features (including the vegetation, albedo, biomass and ecosystems), snow cover, land ice (including the semi – permanent ice sheets of Antartica and Green land and glaciers), and components of the hydrological scale (including clouds, rivers, lakes, surface and subsurface water).
- These components interact in a wide range of space and time scales. They also interact with the sun, the earth’s rotation and the geometry of its orbit, and basic composition of the atmosphere and ocean.

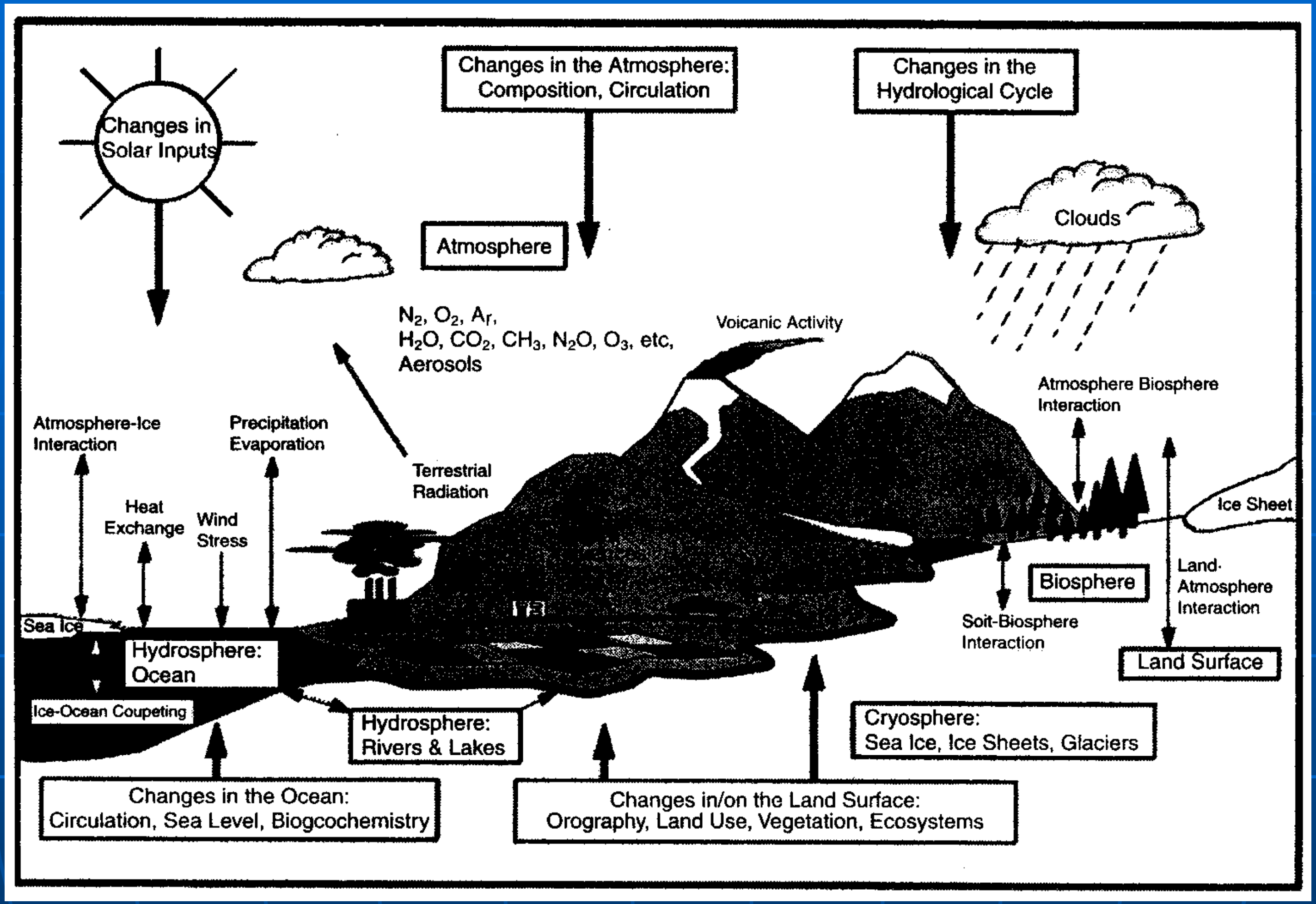


Figure 21. Schematic view of the components of the global climate system (bold), their processes and interactions (thin arrows), and some aspects that may change (bold arrows). (From Baede et al., 2001)

- Climate tends to change by human activities such as urbanisation, deforestation, industrialisation and by nature activities such as continental drift, volcano eruption, change of earth’s orbit, sunspot, and SST oscillation (El Nino / La Nina in Pacific ocean and negative/ positive Dipole mode in Indian Ocean).
- Weather in the morning is generally cold air, clear sky and in the day is hot air, cloudy sky. This weather change is more accurately called fluctuation namely the change which tends repeatedly. Climate change can be known after long time period, some climatologist use a term **climatic trend**.

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