Meteorology in Indonesian Equatorial Region *)

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Abstract

As an equatorial region, Indonesia receives a large number of insolation, and it has an energy surplus in all season. The mixture of sea, land, and the montainous character of most islands, creates a large variety of local climate. The Indonesian region is governed by monsoon Australasia. Do to climate variation in monsoon region flood and drought are meteorological disaster which alternatively wash some places in the Indonesian region. As a monsoon region, drought and flood damage periodically some places in Indonesian. The intensities of drought increase when dry seasons are related to El Niño events and the intensities of flood increase when wet seasons are accompanied by phenomena of La Niña. El Niño events lengthen dry seasons or shorthen rainy seasons, it means that rice planting will be very late.

1. Introduction

Indonesia lies in the equatorial region defined as a region bounded by latitude 10^0 N and 10^0 S or by Earth's vorticity $f = 2\ \Omega \sin \phi = 2 \times 7{,}29 \times 10^{-5} \times \sin 10^0 = 2{,}5 \times 10^{-5}\ s^{-1}$, where Ω is the angle of Earth's rotation and ϕ is the geographical latitude. The equatorial region has energy surplus in all season. The geographical and meteorological position of Indonesia relative to the surrounding oceans and continents is shown in figure 1. Symbol (*) represents the annual solar migration. On 21 March and 23 September the sun is above the equator, while on 22 June and 22 December the sun is above the tropics of Cancer and tropics of Capricorn, respectively.

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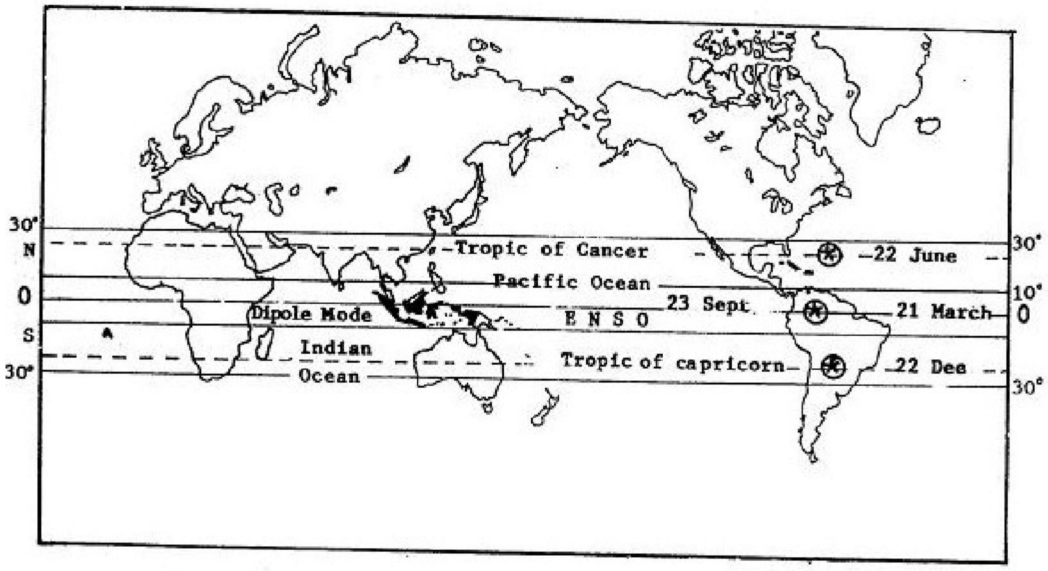

Figure 1. The geographical and meteorological position of Indonesia.

The effect of the Earth's rotation and revolution is the season i.e. winter, spring, summer, and autumn. However, Indonesia does not have all of these seasons, because the air temperature is nearly constant through the year. In contrary, Indonesia has rainy and dry seasons, because its rainfall variation is very high. If wind presistency is used as the base of its season, the southern/northern hemisphere parts of Indonesia have four seasons i.e. northwest/northeast monsoon, the first transitional season, southeast/ southwest monsoon, and the second transitional season. The transitional seasons are indicated by variable winds.

2. <u>The Indonesian Equatorial Monsoon Region</u>

The position of the sun above the equator is twice per year i.e., on 21 March and 23 September called equinoxes. The impact of the equinoxes is marked in the monthly rainfall distribution showing double maxima, for instance station of Pontianak. The equatorial region is passed by meteorological equator called the Intertropical convergence zone (ICZ), where the moist humid trade winds from either hemisphere meet.

There general factors for the existence of the monsoon are :

i. The differential seasonal heating of the ocean and continent. Seasonal contrasts in land – sea surface temperature produce atmospheric pressure changes which yield seasonal wind reversals which are often referred to "the monsoon".

ii. Moist process in the atmosphere releases energy in the form of latent heat of condensation, therefore add to the vigour of the monsoon[1].

iii. Due to the Earth's rotation, air in monsoon currents moves in curved paths. Inter – hemisphere differences in the direction of Coriolis force also cause winds to change direction as they cross the equator. Northeast trade winds become northwest monsoon. On the contrary southeast trade winds become southwest monsoon.

There are three main types of rainfall pattern over Indonesia, namely : i). Monsoonal type, the distribution of monthly rainfall is influenced by monsoon Asia and monsoon Australia. ii). Equatorial type, the distribution of monthly rainfall is affected by equinoxes, so the distribution shows double maxima. iii). Local type, rainfall pattern is influenced by local condition and monthly rainfall distribution is the opposite of monsoonal type[2]. Figure 2 shows the distribution of monthly rainfall in Semarang as monsoonal type, Pontianak as equatorial type, and Ambon as local

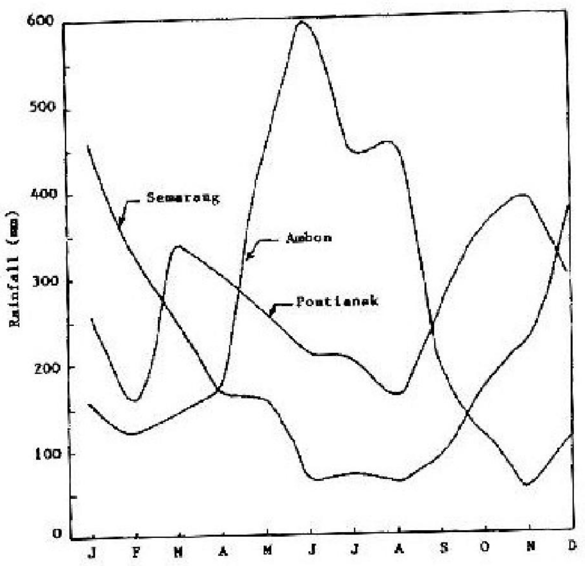

Figure 2. Monthly rainfall distribution for Semarang, Pontianak and Ambon.

Bandung and Jakarta are monsoonal area which have rainy and dry seasons. Rainy season is dominated by west monsoon or westerly wind and dry season is governed by east monsoon or easterly wind. Table 1 shows the average wind direction in midsummer (January) and midwinter (July) of Southern hemisphere[3].

Table 1. The average wind direction in percent.

Wind direction	Bandung		Jakarta	
	January	July	January	July
Calm	20	19	0	0
North	0	1	14	27
Northeast	0	0	2	19
East	3	55	1	40
Southeast	0	0	1	6
South	1	2	0	2
Southwest	0	0	5	3
West	76	23	64	2
Northwest	0	0	13	1

3. Characteristics of Clouds and Rainfall

The troposphere over the Indonesian equatorial region is convectively unstable for all seasons. This case is shown by vertical profiles of equivalent potential temperature (θ_e) from the surface up to the layer of 700 mb. Vertical profiles of θ_e are warmer in the convective clouds compared to in the clear atmosphere condition or in the non convective clouds. Figure 3 shows the vertical profiles of equivalent potential temperature (θ_e) in midsummer and midwinter of southern hemisphere.

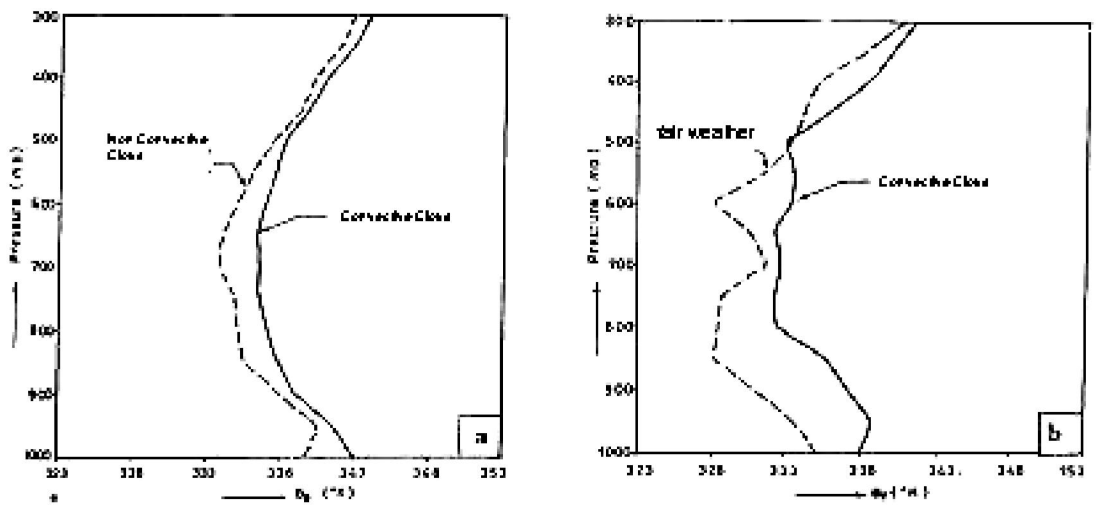

Figure 3. The vertical profiles of equivalent potential temperature (θ_e) over Jakarta in January and July.

Most of convectional rainfall occurs after the maximum insolation or after 12.00 o'clock local time. Convectional rainfall come from convective cloud of cumulus due to unstability of the troposphere through the convectional bouyancy force. Figure 4 shows average amount of 3 hourly rainfall from 00.00 to 24.00 o'clock local time. Convectional rains generally run about one hour or less.

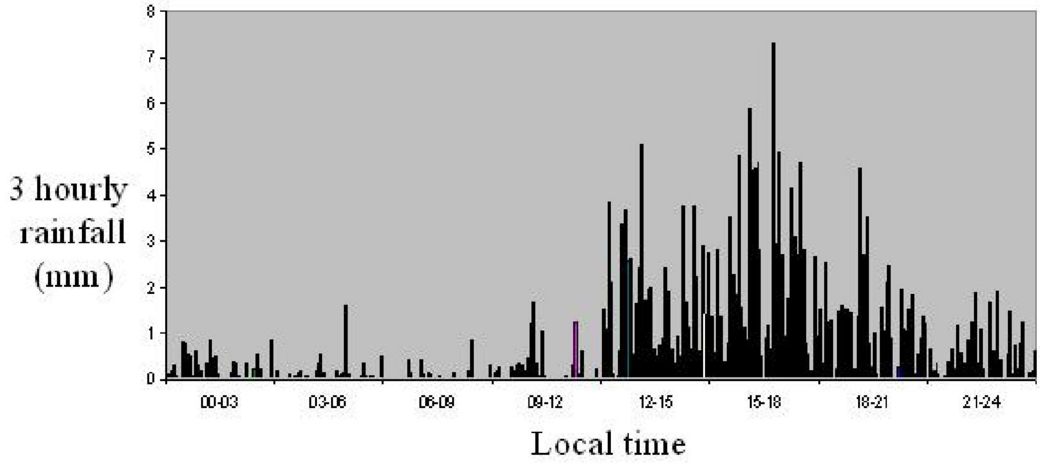

Figure 4. Amount of 3 hourly rainfall from 00.00 to 24.00 L.T in Bandung.

Without consider the characteristics of rainfall (from very light rains to heavy rains), the distribution of rainfall shows that rain is frequently occured in summer and autumn compared to in winter and spring of the hemisphere.

Table 2. Frequency distribution of rainfall in Bandung (Southern Hemisphere)

Rainfall Intensity (mm/h)	**D J F summer**	**M A M autumn**	**J J A winter**	**S O N spring**
Year : 2003	Frequencies			
Very light rain (0,1 – 1,0)	9	3	0	2
Light rain (1,1 – 5,0)	37	21	2	34
Normal rain (5,1 – 10,0)	25	11	1	17
Heavy rain (10,1 – 20,0)	8	12	7	10
Very heavy rain (> 20,0)	2	16	1	6
Year : 2004	Frequencies			
Very light rain (0,1 – 1,0)	4	2	1	2
Light rain (1,1 – 5,0)	45	20	5	12
Normal rain (5,1 – 10,0)	18	22	7	11
Heavy rain (10,1 – 20,0)	19	6	4	5
Very heavy rain (> 20,0)	5	13	0	5

Equatorial Region

4. El Niño and La Niña

In spanish El Niño means “the boy Christ – Child” that is the name given by fishermen of Peru to represent warm current moving seasonally toward South along the coast of Peru *la corriente del Niño* in about Christmas–time. Scientists often call the phenomenon where the atmosphere and ocean collaborate together ENSO, short for El Niño – Southern Oscillation[4]. The opposite of El Niño is La Niña, in Spanish La Niña means “the girls”.

In the EL Niño years, the Walker (zonal) circulation subsides in the western Pacific and ascends in the central and eastern Pacific. On the contrary, in the non El Niño years, the zonal circulation ascends in the western Pacific and descends in the eastern Pacific[5]. In the La Niña years occurs strengthen of the convection in the western Pacific. El Niño and La Niña may be studied from atmospheric circulation system at levels 850 and 200 mb, see figure 5.

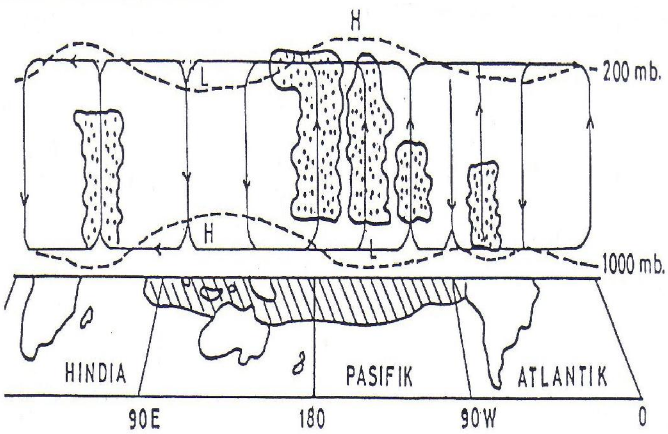

Figure 5a. Zonal equatorial circulation in the El Niño years.

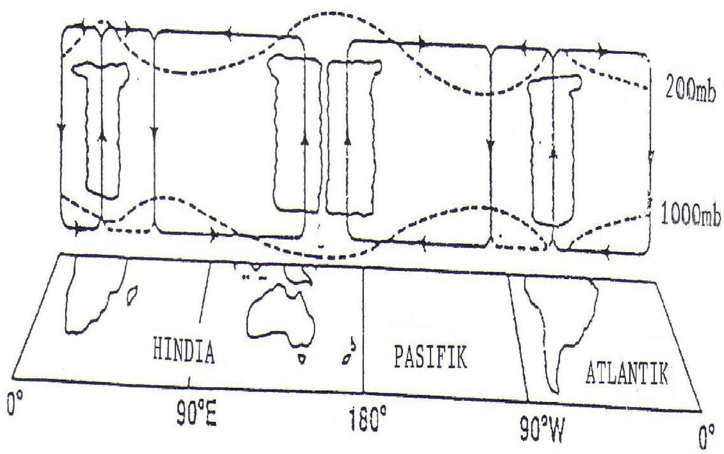

Figure 5b. Zonal equatorial circulation in the El Niño years.

In the El Niño events more than 50% of the Indonesian region has the amount of rainfall belows the normal period[6]. A level of cumulative rainfall equal 350 mm would be a suitable criterion to indicale the end of the transition period. The 350 mm criterion, mainly on account of its association with rice culture, where the soil is generally sufficiently moistened to allow the farmers to prepare the seed beds for the rainy season rice crop[7]. Figure 6, shows the cumulative rainfall from the 50th (September 3) to the 73rd (December 31) pentad in Jakarta area. It is evident that El Niño events cause lengthen dry season or shorthen rainy season, it means that rice planting will be very late.

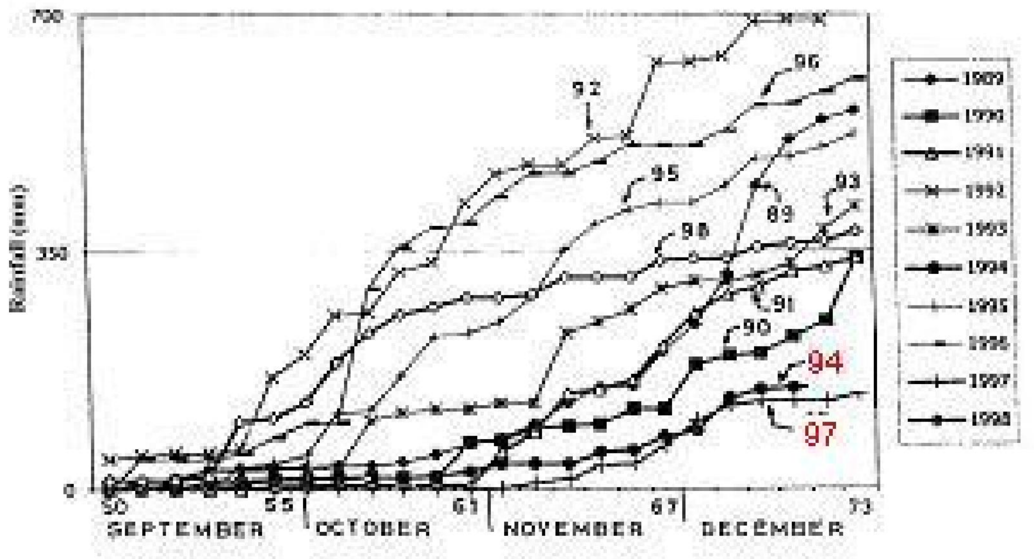

Figure 6. Cumulative rainfall from the 50th to the 73rd pentad in Jakarta area.

Conclusions

Monsoonal areas, such as Bandung and Jakarta are influenced by monsoon winds, that are westerly and easterly winds. Rainfall pattern is affected by monsoon circulation i.e., the monthly rainfall distribution indicates maximum and minimum. El Niño events lengthen dry season, so that cumulative rainfall amount of 350 mm will be reached very late and consequently rice planting will also be very late.

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