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Study of season onset based on water requirement assessment

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Study of season onset based on water requirement assessment

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Abstract. The criteria of season onset and withdrawal in Indonesia determined by Agency for Meteorology Climatology and Geophysics (BMKG) which need a month to confirm the period of the wet season and dry season. The determination of season onset based on the amount of 10-day rainfall equal to or more than 50 millimeters (mm) followed by the next two 10-day rainfall (the amount of monthly rainfall equal or more than 150 mm) for the wet season and vice versa. The determination of 150 mm/month based on water requirement using the reference of evapotranspiration (ETo) in the territory of Indonesia at 5 mm per day. This paper evaluates the determination of season onset by comparing it based on the ETo value of 5 mm/day and ETo from observation data of pan evaporation in the islands of Java and Bali in the period 2003 - 2017. The result of the study shows that the difference of the dry season onset up to 3 months which 25.9 % of stations have no difference, 40.7% have 1-month difference, 22.2% have 2 months difference and 11.1% have 3 months difference. The difference of wet season onset show 40.7% of stations have 1-month difference and 55.6% have no difference. The ETo value of 5 mm/day for criteria of season onset is appropriate and the difference of up to 3 months is still sufficient for early warning purpose.

1. Introduction

Indonesia lies between two oceans (the Pacific and India Ocean) and two continents (Asia and Australia), the climate is strongly influenced by the interannual variation of the tropical sea surface temperature (SST) in which those two oceans associated with El Niño - Southern Oscillation (ENSO) and the Walker circulation [1-3]. Precipitation in Indonesia have monsoonal characteristic because of the position located in the center of Asian-Australian monsoon region especially near and south of the equator with the wet season centered on December–February (DJF), and the dry season in July–August [1, 4].

Studies about season onset of Indonesia have been conducted since 1926 [5, 6] associated with the occurrence of westerly wind [7, 8], easterly wind, convective clouds and intertropical convergence zone (ITCZ) [9]. Other studies also conducted by modification of onset and withdrawal criteria using a combination between rain observation and hydrological onset and withdrawal index (HOWI) to accelerate certainty onset/withdrawal in Makassar and Kupang, which showed 18-20 days earlier [10]. An alternative criterion was also suggested by adding 3 rainy days to support the onset criteria in East Java. The rainfall amount of ≥ 50 mm plus total rainy days of ≥3 days/10-day for rainy season onset, while the onset of the dry season is determined by a rainfall amount of < 50 mm and a total of rainy days of <3 days/10-day [11].

Indonesia Agency for Meteorology Climatology and Geophysics (BMKG) determines the season onset based on the amount of 10-day rainfall equal to or more than 50 mm followed by the next two 10-day rainfall (the amount of monthly rainfall equal or more than 150 mm) for wet season and vice versa for the dry season [12]. The determination of 150 mm per month based on water requirement using the reference of evapotranspiration (ETo) in the territory of Indonesia which tropical humid at 5 mm per day [13]. The ETo concept is to study atmospheric evaporation requirement independently of crop type, crop development and for practical water management. The grass with specific characteristics hypothetically as the reference surface. Table 1 shows the range of values of ETo in the different agro-climatic region.

Table 1. the ETo values average range for several agro-climatic regions in the mm/day [13]

Regions	Mean daily temperature (°C)		
	Cool ~10 °C	Moderate 20°C	Warm 30 °C
Tropics and subtropics - humid and sub-humid - arid and semi-arid	2-3 2-4	3-5 4-6	5-7 6-8
Temperate regions - humid and sub-humid - arid and semi-arid	1-2 1-3	2-4 4-7	4-7 6-9

Evapotranspiration refers to both evaporation and transpiration process, which the amount of water vapor, evaporates from the soil and plants when the soil surface at natural moisture. According to the World Meteorological Organization [14], potential evapotranspiration is the maximum amount of water capacity evaporates under certain climatic conditions from vegetation land cover that has adequate moisture. However, because of the moisture deficiency in the soil profile affect the evapotranspiration that occurs on the surface under the potential value, which refers to as actual evapotranspiration. Potential evapotranspiration for a crop associated with the concept of crop water requirement since both refer to the same amount of water that corresponds to the efficient irrigation water supply needed for maximum yield [15]. Pan evaporation is one of the methods for measuring open water evaporation, the use of US Class A pan has found widely around the world and Indonesia.

The aim of this paper is to evaluate the season onset determined by BMKG by assessing water requirement using ETo value of 5 mm/day and ETo from observation data of pan evaporation in the islands of Java and Bali in the period 2003-2017.

2. Data and Methods

Data employed in this study are monthly rainfall and Class A pan evaporation of 30 stations in Java and Bali during 2003 – 2017. Location of the stations is presented in Figure 1. Estimation of ETo from Class A pan evaporation uses formula [13]:

$$ETo = Eo \times Kp \quad (1)$$

where Eo is panned evaporation and Kp is pan coefficient. The Kp is a correction factor which values range from 0.35 to 0.85 depends on the prevailing upwind fetch distance, average daily wind speed, and relative humidity conditions related to the sitting of the evaporation pan [13,16], and also depend on site location [17]. We use the value of Kp of 0.8 according to the average of wind speed and relative humidity condition of study sites [13,16].

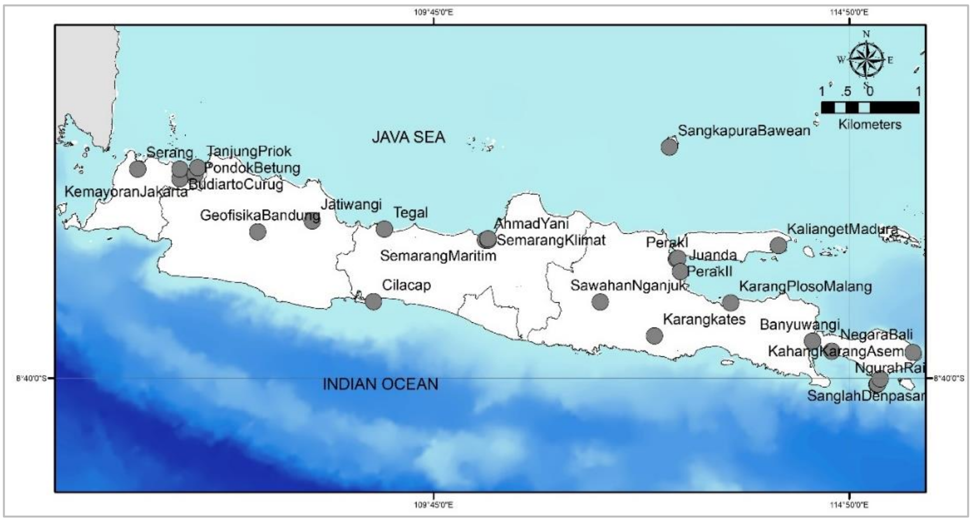

Figure 1. The Location of station sites in Java and Bali

The key aspect of the water cycle is precipitation minus evaporation over ocean or precipitation minus evapotranspiration over land for determining the net water flux into the surface [18]. We use the method of Thornwaite Mather [19] to determine the wet month period and the dry month period using the relationship between rainfall and evapotranspiration. The dry period occurs when rainfall<ETo, while wet period occurs when rainfall>ETo. The concept of climatic water balance is a climatic balance since the quantities precipitation and evapotranspiration are active factors of climate. The relationship of rainfall and ETo were analyzed by plotting the graph as seen in Figure 2 for all study sites by comparing the onset of the dry season and wet season using assumption ETo (150 mm/month) and observation ETo. The onset of the dry season is determined when the dry month period begins and the onset of the wet season is determined when the wet month period begins.

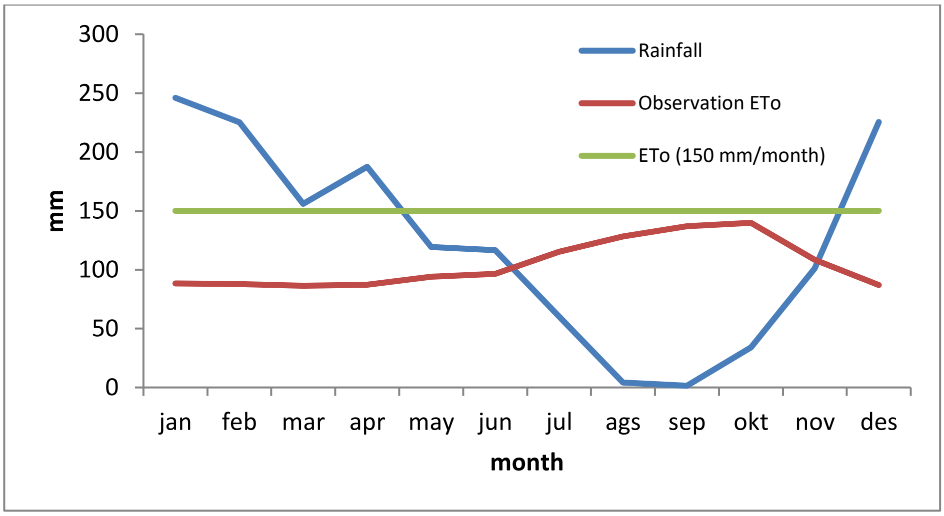

Figure 2. Plotting of rainfall and ETo in Kalianget Station

3. Results and Discussion

ETo based on observation data (Class A pan evaporation) during 2003-2017 range from 52 to 171 mm/month with an average of 103 mm/month. According to Figure 3, ETo observations in Java and Bali have a similar pattern with the highest (lowest) is in October (February). The highest average of monthly ETo in Java Island is at Juanda Station, East Java, meanwhile, in Bali Island the highest average is at Ngurah Rai Station. ETo based on observation data in Java and Bali generally below 150 mm/month as seen in Figure 3. The result of comparison the dry season and wet season onset in 30 stations of Java and Bali Island between the ETo of 5 mm/day and observation ETo are presented in Figure 4 and 5.beginning of the turned-over line. A multiplication sign should be added to the start of turned-over lines where the break is between two multiplied terms.

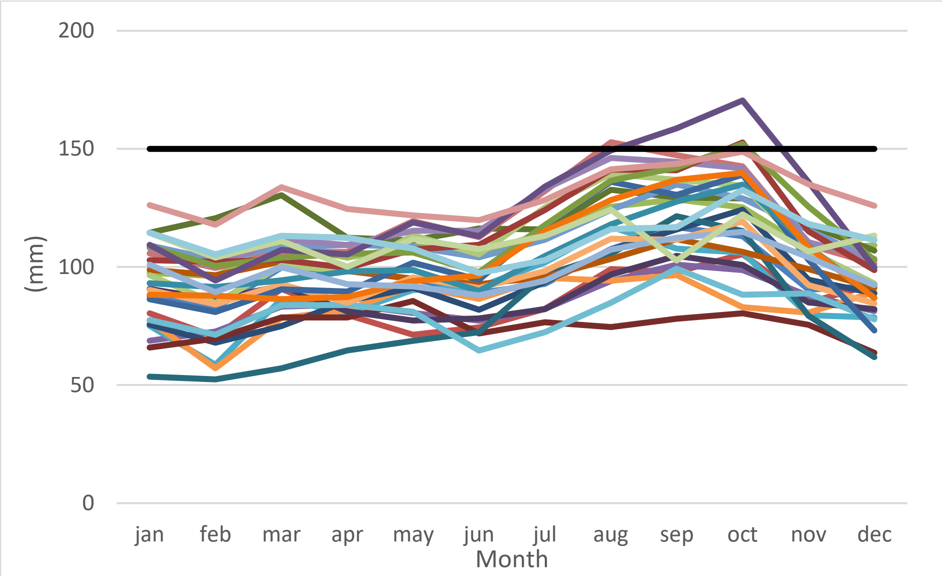

Figure 3. ETo observation of 30 station sites in Java and Bali

According to Figure 4, there are 7 stations have the same time of dry season onset namely Tanjung Priok, Cilacap, Tegal, Sawahan Ngajuk and Karang Ploso Malang which located in Java Island. Meanwhile, in Bali Island are Ngurah Rai and Balai Besar 3. The difference from 1 up to 3 months means that the dry season onset according to observation ETo is delayed from one up to 3 months compared to that based on the ETo of 5 mm/day. The stations that have 1-month difference of dry season onset are 11 stations at Serang, Bandung, Semarang Climate Station and Marine, Karangkates, Sangkapura Bawean, Perak I, Perak II and Juanda in Java Island. Moreover, there are two stations in Bali Island namely Sanglah and Kahang.

There are 6 stations have 2-month difference at Curug, Cengkareng, Jatiwangi, Ahmad Yani, Kalianget and Banyuwangi station and three stations have 3-month difference at Kemayoran, Pondok Betung, and Negara (Bali). Three stations cannot be determined for the dry and wet season onset, namely Darmaga, Baranangsiang and Citeko which are located in Bogor that do not have the type of rainfall as monsoon zone because of topographic/local condition. The distribution of stations according to the difference of dry season onset are outspread and do not show any clustering.

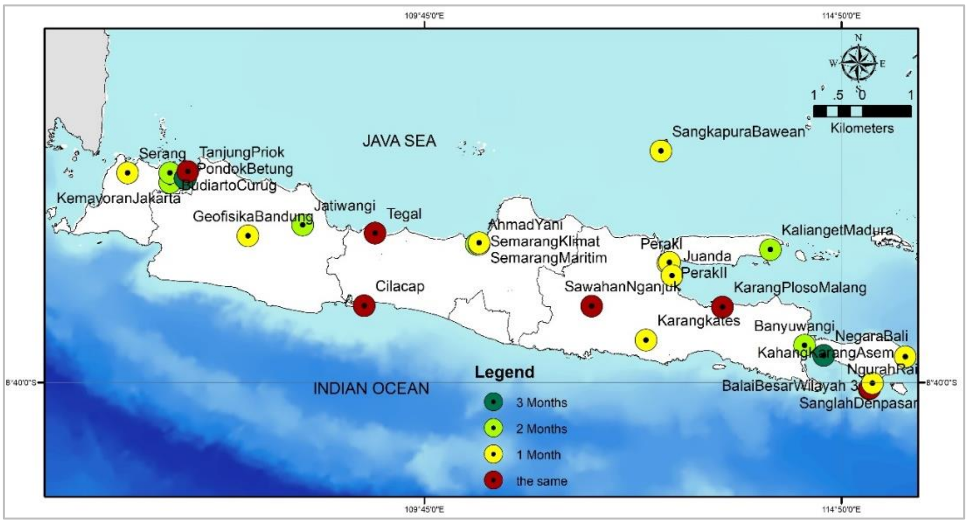

Figure 4. The difference in dry season onset

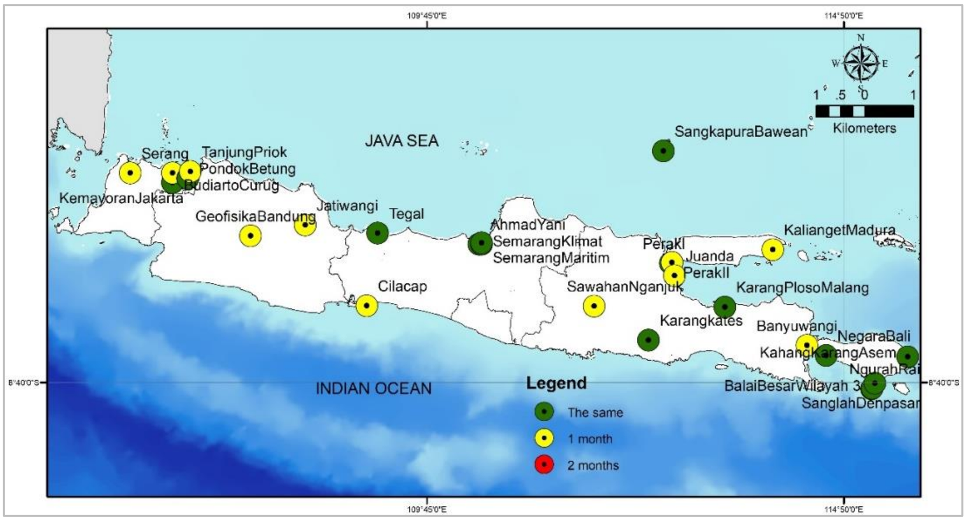

Figure 5. The difference in wet season onset

The difference of wet season onset on Figure 4 shows that there are 15 stations have similar time, 11 stations have 1-month difference and only one station has 2-month difference located at Kemayoran. According to Figure 5, the stations that have a similar time of wet season onset are Budiarto Curug, Pondok Betung, Tegal, 3 stations in Semarang (Ahmad Yani, Semarang Climatology station and Semarang Marine Station), Sangkapura Bawean, Karangkates, Karangploso Malang and all stations in Bali Island. Meanwhile, the stations that have 1-month difference are mostly in the western part of Java, Cilacap and some part of East Java.

Previous study calculated monthly ETo estimation using Thornthwaite method in 7 regions in Indonesia (Aceh, Pontianak, Semarang, Surabaya, Cengkareng, Kupang and Jayapura) are between 140 mm/month to 160 mm/month with an average of 148.49 mm/month which still relevant to the threshold value of 150 mm/month [10].

4. Conclusion

Evaluation of the season onset determined by BMKG was conducted by assessing water requirement using the ETo value of 5 mm/day and ETo from observation data of pan evaporation in Java and Bali. The result shows a difference up to 3 months for dry season onset and up to 2 months for wet season onset. The threshold of 150 mm/month for determination of season onset are appropriate and sufficient for early warning purpose even though the ETo from observation data in Java and Bali generally lower than 150 mm/month

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