Determining the season pattern based on soil moisture under tropical monsoon climate

D P Ariyanto¹,4, R P W Priswita², Komariah¹, Sumani¹ and M Senge³

¹Soil Science Department, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36A Surakarta, 57126, Indonesia
²Master Program of Environmental Science Department, Universitas Sebelas Maret, Surakarta, Indonesia
³Faculty of Applied Biological Sciences, Gifu University, 1-1 Yanagido, Gifu City 501-1193, Japan
⁴Corresponding author: dp_ariyanto@staff.uns.ac.id

Abstract. Climate change increased the variability of maximum and minimum air temperature and rainfall. Air temperature and rainfall, which are parts of weather components, have been become uncertain and may affecting soil moisture. The dry and wet season onset based on rainfall may resulted in different definition if using soil moisture. This research aims to analyze the difference between air temperature and soil moisture inline graphic as parameter of season onset. The climate and soil moisture data were collected from November 2016 to December 2018. The climate and soil moisture data were collected from Jumantono weather station and soil moisture logger, respectively, in Karanganyar District, Indonesia. The results showed air temperature and soil moisture (maximum and minimum) patterns were different. The minimum soil moisture occurred in the dry season, but not the lowest minimum air temperature.

1. Introduction

The current climate change is caused by global warming where there is an increase in greenhouse gases in the atmosphere. Global warming and climate change are issues affecting the tropical environment which are currently heavily discussed by researchers. One of these effects is on ecosystem services such as provisioning and regulating services which are altered especially by weather-related disturbances [1]. Furthermore, changing climate conditions worldwide have affected the global water cycle with severe repercussions on major watersheds [2]. These changing climate conditions involve precipitation and evaporation processes, thus affecting rainfall patterns [3], which in the worst cases result in drought or flood events [4].

Indonesia is a country with two seasons, namely the rainy season and the dry season. The sector that is most dependent on seasonal conditions is the agricultural sector. Agriculture is one sector that supports the national economy in Indonesia. Indonesia is also known as an agrarian country which means most of the population works in the agricultural sector. With the occurrence of climate change, an analysis of the determination of seasons to determine seasonal patterns is necessary. In Indonesia, the prediction of seasonal onset which is released by BMKG is important information. The weather parameter issued by BMKG to determine the seasonal onset is only the amount of ten-day rainfall, regardless of its frequency (total of rainy days) [5]. The climate in Indonesia is also influenced by the tropical monsoon climate which causes frequent extreme weather in Indonesia.
The climate in Indonesia is classified as the tropical monsoon that has a dry season from April/May to September/October and a rainy season from October/November to March/April in a typical year. The dry and rainy seasons are defined as follows [6]. The monsoon seasons are one of the factors that influence climate regulation [7]. The word "monsoon" comes from the word "Mausam" meaning ‘season’ [8, 9] and it is an annual phenomenon. Aldrian et al. (2007) [10] states that monsoon and El Nino Southern Oscillation (ENSO) are more likely to drive seasonal variations and interannual variations from rain and extreme events in Indonesia. In general, rainfall patterns on the island of Java have a monsoonal pattern, wherein one year there is one peak of rainfall, which generally occurs in December - February.

In this research, a study of seasonal patterns was carried out through air temperature patterns and soil moisture. From this research, it can also be used to determine the season pattern so that the determination of the start of the season can be more accurate. Ariyanto 2018 [11] explains that determination of the dry and wet season onset based on rainfall data has been difference towards soil moisture. Determining seasons in Indonesia always requires a more complete and up-to-date method. Therefore, by analyzing the air temperature is expected to more accurately determine the start of the season. The determination of the planting date is an important phase for the development of the next phase of the plant. The initial determination of the right planting time is the cheapest and most efficient way to increase crop productivity [12]. Referring to the various importance related to the determination of season patterns, this study was conducted aiming to find alternative criteria for seasons in Indonesia.

2. Methods

2.1 Materials
The materials used for this study include.
   a) Rainfall data from November 2016 to December 2018
   b) Soil moisture data from November 2016 until December 2018.
   c) Soil surface temperature data from November 2016 until December 2018.

2.2 Methods
This research was carried out in the UNS Climatology laboratory in Jumantono, Central Java Karanganyar. This study uses a mixed approach method between quantitative with exploratory methods. The study was conducted from November 2016 to February 2018. Rainfall data were obtained directly from AWS in the UNS Climatology Laboratory. For soil moisture data collected from loggers at a depth of 0 cm. Rainfall data and soil moisture data obtained will be simplified to decadal.

3. Results and discussion
The monsoon phenomenon has increased in severity due to changes in the global climate. In Southeast Asia, global warming has caused changes in the seasonal atmospheric flow during the monsoon season, resulting in erratic temperature patterns. According to Loo et al. 2015[13], from the late 1970s onwards, an increase in global temperature anomalies corresponded with an increase in global precipitation. Soil moisture is one of the main factors in determining the level of the drought of a land. The higher the level of soil moisture in a land, the less chance of drought in the land. Monitoring the spatial and temporal distribution characteristics of soil moisture is very important. This is because soil moisture can control plant growth, soil hydrological cycle, and the ability of the soil to resist erosion [14]. This research was conducted by observing soil surface temperature and soil moisture data from November 2016 to December 2018. Soil surface temperature and soil moisture can be seen in Figure 1 below.
Based on Figure 1, Graphic of temperature and soil moisture can be seen that based on there is a difference between soil moisture dan temperature soil. Their different air temperature pattern was different towards maximum and minimum soil moisture. The minimum soil moisture occurred in the dry season but not the lowest minimum air temperature. Based on observations from November 2nd, 2016, to December 2018, the highest temperature in was 39.1 °C (November 2018) while the lowest was 22.9 °C (September 2017). Figure 1 shows the difference between air temperature and soil moistures patterns.

The relationship between soil surface temperature and soil moisture is if at high soil temperatures the soil moisture is low and vice versa. This is relevant to the reference which states that soil temperature will affect soil texture and soil moisture, when the texture of the soil has a high temperature indicating low soil moisture [15]. According to Joseph 2006 in Lutfiyana et al. [15] that soil temperature can play a role in determining chemical reactions and soil microbial activity that can break down certain organic compounds into nutrients and soil temperature affect seed germination and sprout growth.

Soil moisture has a close relationship with soil surface temperature. High surface temperatures will increase the rate of evapotranspiration. According to Handoko in Ariyanto et al. [16], the reference evapotranspiration describes the maximum rate of the water loss in a crop determined by the climatic conditions in a tightly closed-canopy crop cover with the adequate water supply. Evapotranspiration by many factors so that the measurement results cannot be calculated directly. The loss of water due to evapotranspiration causes a reduction in water content in the soil so that soil moisture will be reduced.

Soil temperatures fluctuate daily and yearly, mainly influenced by variations in air temperature and solar radiation received by the ground surface [17]. Annual variations in average daily soil temperature at several depths can be estimated using sinusoidal functions [18, 19, 20]. In tropical regions with high rainfall, changes in soil temperature are influenced by rainfall conditions [17].

Soil moisture data show that if soil moisture in March 2017 it can be seen if the highest is 0.65%. This is in accordance with the monthly rainfall data from February to March, which has a monthly rainfall of 533 mm and 240.5 mm. The monthly rainfall data graph can be seen in Figure 2. Monthly Rainfall Data below.
Based on Figure 1 and 2, soil moisture closely related to rainfall. Soil moisture is influenced by the weather conditions such as precipitation, air temperature, and wind speed in providing input and eliminating the existing water content [21] (Moran et al. 2004). Precipitation as input is a source of water in increasing soil moisture. In addition to precipitation, water input is also derived from the loss of groundwater in the underlying layers resulting from evaporation. In bare soils, evaporation is influenced by soil type, groundwater diffusivity, soil surface temperature, soil heating flux, and net radiation albedo. Whereas soil evaporation under the canopy is influenced by net radiation reaching the surface of the soil (after passing through the canopy), soil moisture content, and soil properties.

Research conducted by Saragi et al. [17] shows that changes in rainfall affect the average temperature of the land surface which will also affect the average temperature of the surrounding environment. Lemmela dan Sucksdorff (1981) in Saragi et al. [17] take measurements of soil temperature in the period January 1969 to December 1973 at a depth of 20, 40, 80, 150, 250, 400, and 700 cm. The average monthly soil temperature pattern at various depths over 5 years shows that high variations in soil temperature occur at depths of less than 400 cm, whereas soil temperatures over 400 cm tend to be constant.

Based on Fig 1 and Fig 2, we can know the pattern of the wet and dry seasons every year under Tropical Monsoon Climate. High soil moisture followed by decreasing rainfall can be concluded to be the beginning of the dry season. Based on Figure 1, the dry season starts in the middle of March 2017 to September 2017. Whereas the wet season starts in October 2017 until March 2018.

4. Conclusion
Soil moisture closely related with soil surface temperature. The dry season occurred from middle of March to September 2017, whereas the wet season ranged from October 2017 to March 2018. To determine the accuracy of the seasonal patterns under a tropical monsoon climate, more data such as rainfall data are needed with longer observation time. Therefore, further research with more variables and different regions in Indonesian region which is important. So in the end, an alternative criterion is obtained using other climatic elements that are suitable for all regions in Indonesia, especially for monsoonal rainfall areas.

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