The dynamics of rainfall and temperature on peatland in South Sumatra during the 2019 extreme dry season

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Abstract. During the extreme dry season of 2019 massive fires broke out on peatlands in South Sumatera. This study examines the dynamics of rainfall and temperature in the peatlands of South Sumatera in the 2019 dry season as one of the fire disaster mitigation efforts. The data used are in situ measurement data by the Peatland Restoration Agency's measurement stations on two peatlands in South Sumatera. The results of this study indicate that rainfall in July until October 2019 was very minimal even in one of the study sites in August there was no rain. This shows that rainfall anomaly has occurred along with massive fires so that rainfall is possible to be used as one of the fire control parameters in peatlands. The lack of rainfall in South Sumatera during this period was due to the positive Indian Ocean Dipole phenomenon that occurred in the Indian Ocean. The results of this study also showed that temperature did not have a clear pattern of relationship with fire events on peatlands.

1. Introduction

Indonesia is a country that has very large tropical peatlands, which are around 20 million hectares. These peatlands are spread across almost all parts of Indonesia, especially on the islands of Sumatera, Papua and Kalimantan. The area of peatland on the island of Sumatera is around 6 million hectares, mainly in South Sumatera, Riau and Jambi provinces [1-6].

In every dry season, peatlands burn so that prevention is necessary. In the extreme dry season of 2019, there were massive fires on peatlands in South Sumatera which burned 328,457 hectares of peatlands [7]. One of the prevention methods is controlling the parameters related to peatland fire events. Parameters estimated to be closely related to peatland fires include rainfall and temperature. Therefore, it is necessary to study the dynamics of rainfall and temperature through an accurate measurement system for prevention of future fires.

So far, rainfall and temperature data on peatlands only consist of remote sensing data from satellite measurements [8-13]. In-situ measurements are believed to be closer to the true value when compared to the results of remote sensing measurements. The Indonesian government, through the Peatland Restoration Agency, has set up several stations to measure in-situ parameters related to peatland fires. The parameters are rainfall, temperature, groundwater level, and soil moisture [14,15]. In South Sumatera, several of these stations have been established since July 2017. This study uses rainfall and

temperature data from the measurement results of these stations to assess whether these two parameters have changed significantly during the dry season in 2019.

2. Methodology

2.1. Data

The data used in this study came from the results of in-situ measurements at two stations belonging to the Indonesian Peatland Restoration Agency (BRG) which are located on peatlands in South Sumatera. These data are hourly rainfall and temperature measured for the period 1 January 2019 to 31 December 2019. Station names and coordinates are shown in Table 1.

Table 1. Name of the BRG measuring station and its coordinates

Station Name	Coordinate
Sungai Saleh-1 (SS1)	-2.911, 105.082
Sungai Lumpur-1 (SL1)	-2.677, 105.143

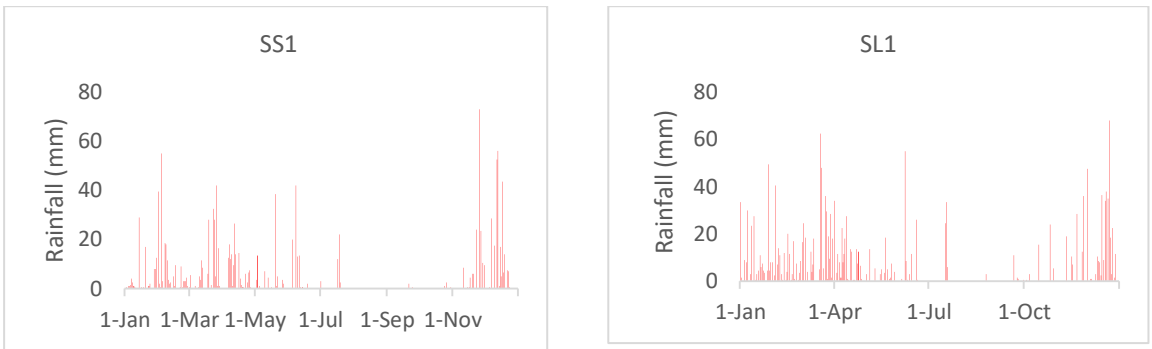
2.2. Data analysis

Rainfall and temperature data that have been obtained are processed to obtain daily average data and monthly average data. Daily average data is displayed in the form of time series graph, and monthly average data is shown in tabular form. Analysis was carried out on the time series graphs and tables obtained to assess whether there was a significant change in the value of rainfall and temperature during the extreme dry season in 2019. If there is a significant change in value, it can be concluded that these parameters have a close relationship with fire events on peatlands in South Sumatera. This parameter can be used as one of the controlling parameters for fire prevention in peatlands.

3. Result and Discussion

3.1. The dynamics of rainfall

The study of the dynamics of daily rainfall is carried out through analysis of daily rainfall time series graph and monthly rainfall data table. The time series graph of the dynamics of daily rainfall at two measurement stations SS1 and SL1 during 2019 is shown in Figure 1. In Figure 1, it can be seen that daily rainfall decreased drastically in July until October 2019.



(a) (b)

Figure 1. Time series of daily rainfall at (a) SS1 and (b) SL1

Table 2 shows the monthly rainfall at these 2 locations. In Table 2, it can be seen that the monthly rainfall in July until October 2019 is much lower than the other months, even in August there was almost no rain at all. This is what causes the peatlands to become very dry, which causes massive fires on the peatlands. The period from July to October 2019 is called the extreme dry season.

Figure 1 and Table 2 show a close relationship between rainfall and fire events on peatlands in South Sumatera. If the parameters of rainfall can be controlled, it can be used as an alternative effort to prevent fires in peatlands.

This extreme drought has had a negative impact on the agriculture, water resources, forestry and environment sectors. This extreme drought is triggered by the anomalous phenomenon of sea surface temperature (SST) in the Indian Ocean. In this phenomenon, the sea surface temperature in East Africa is warmer than the sea surface temperature in Southwest Sumatera. This phenomenon is called the Indian Ocean Dipole (IOD) which strengthened from April 2019 to December 2019 and caused very low rainfall in the dry season period from July to October 2019 [14, 16-20].

Table 2. Monthly rainfall

Month	Rainfall (mm)	
	SS1	SL1
January	90.5	243
February	196	176
March	197.5	369
April	151.5	215.5
May	80	71
June	91.5	106
July	39.5	64
August	0	3
September	2.5	14
October	4	48.5
November	166.5	113.5
December	257	359.5

In general, the dry season in 2019 shows drier conditions than the 2018 dry season and the climatological normal reference for 1981-2010, although not drier than the dry season conditions in 2015 when there was a strong El Nino phenomenon at that time.

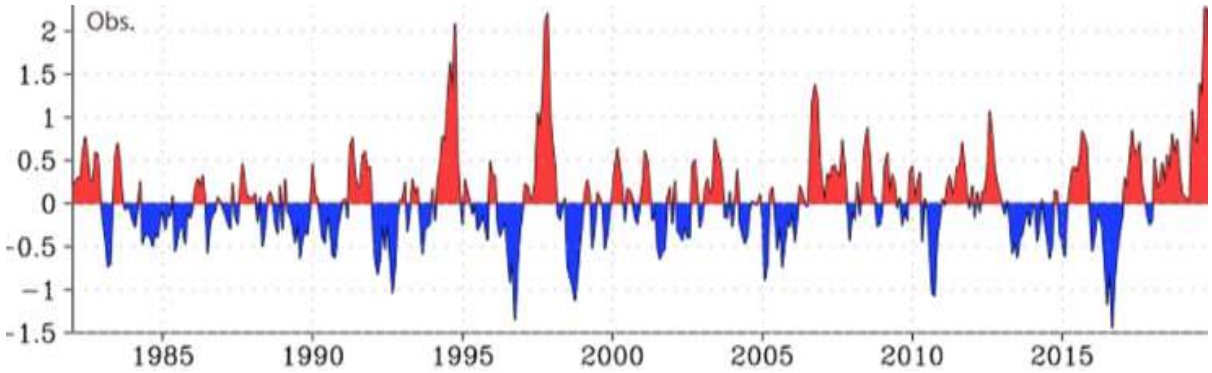


Figure 2. Graphic of Dipole Mode Index [18]

Indian Ocean Diploe (IOD) is an ocean-atmosphere phenomenon in the equatorial region of the Indian Ocean that affects the climate in Indonesia and other countries around the Indian Ocean basin. As the name implies, IOD is characterized by an anomaly of Sea Surface Temperature (SST) between the 'two poles' of the Indian Ocean, namely the West Indian Ocean (50E-70E, 10S-10N) and Southeast (90E-110E, 10S-0S). Horizontal temperature variations at sea level are generally influenced by the position (radiation) of the sun and water mass.

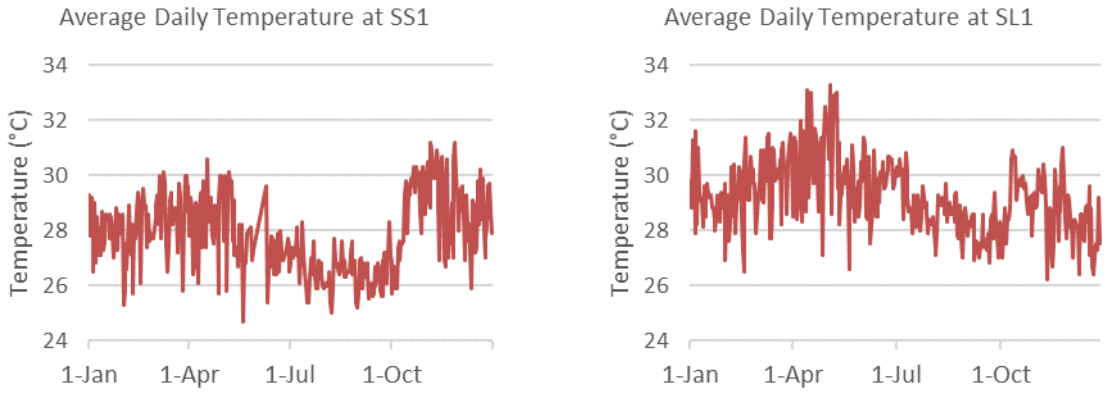
The difference in SST anomaly between the two regions in the West and Southeast Indian Ocean is called the Dipole Mode Index (DMI), and is used to measure the strength of the IOD itself. The period in which the DMI is positive is generally referred to as the positive IOD period (IOD +), and vice versa, when the DMI is negative it is called the negative IOD period (IOD-) [21, 22]. DMI in 2019 has a high value as shown in Figure 2 [18].

In the IOD + period, the waters in the Southeast Indian Ocean were generally colder (temperatures are lower than average), whereas the waters in the western Indian Ocean would be warmer (temperatures higher than average). As a result, convection (which is the initial process of cloud and rain formation) will shift from the East Indian Ocean towards the West, and bring a lot of rain to the eastern part of the African continent. On the other hand, areas of the Eastern Indian Ocean that are "left behind" by convection (such as Indonesia) will suffer from drought.

The IOD- period characteristic is the opposite of IOD +. SST in the Southeast Indian Ocean will be warmer, while in the West it will be colder. This will result in drought in Eastern Africa and increased rainfall in Indonesia, especially West Indonesia which is adjacent to the Indian Ocean.

3.2. The dynamics of temperature

The temperature data used is the hourly average T data which is processed into average temperature per day and per month originating from 2 BRG stations, namely: SL1 and SS1 for the period January 1, 2019 until December 31, 2019. The daily average temperature in the form of a time series graph is shown in Figure 3, and the monthly average temperature is shown in Table 3.



(a) (b)

Figure 3. Time series of average daily temperature at (a) SS1 and (b) SL1

In Figures 3 (a) and (b), it can be seen that in the dry season from July to October 2019 there was a slight decrease in the daily average temperature. In Table 3, it can be seen that at the SS1 location in July to September 2019 the temperature was slightly lower than the other months, while at the SL1 location there was no significant change in temperature during the extreme dry season.

If we look for the relationship between temperature and the IOD + event, which is from July to October 2019, the temperature of the water surface in the Indian Ocean (SST) in the Southeast is lower than the temperature in the West, so it is estimated that the lower SST temperature is related to the low daily average temperature of peatlands in South Sumatera.

If temperature is to be used as a fire control parameter in peatlands, it is quite difficult to apply because the pattern of the relationship between temperature and the incidence of fire in peatlands is not clear. The relationship between temperature dynamics and fire events on peatlands in South Sumatera is not significant.

Table 3. Average monthly temperature

Month	Temperature (°C)	
	SS1	SL1
January	28.04	29.21
February	27.72	29.13
March	28.68	30.10
April	28.38	30.47
May	27.91	30.17
June	27.21	29.71
July	26.70	29.10
August	26.43	28.50
September	26.45	27.89
October	28.48	29.18
November	29.28	28.98
December	28.45	27.96

4. Conclusion

The analysis that has been carried out on the dynamics of rainfall and temperature in the extreme dry season of 2019 shows that rainfall has a very significant change in value, while temperature has also changed but the pattern of change is unclear. This very significant change in rainfall indicates a close relationship between rainfall and the occurrence of fires on peatlands during the extreme dry season of 2019. The change in the value of these two parameters is due to the IOD + phenomenon. If it is used to control fires on peatlands, the rainfall parameter is more likely than temperature because rainfall dynamics have a significant relationship with fire events on peatlands.

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