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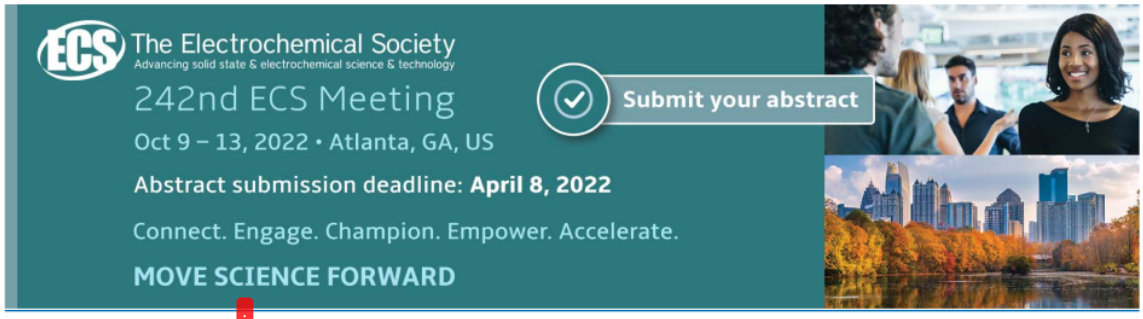

What are the dynamics of hydrometeorological parameters on peatlands during the 2019 extreme dry season?

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Abstract. Peatlands in Indonesia are generally flammable, including peatlands in Kalimantan. The Indonesian government has made efforts to prevent fires on peatlands in Indonesia. One of them is by establishing several stations for measuring hydrometeorological parameters which are managed by the Peat Restoration Agency (BRG). This study utilizes BRG data, especially rainfall and groundwater levels, combined with hotspots data from MODIS satellite measurements during the 2019 extreme dry season at two research locations, namely at BRG stations in Central Kalimantan and West Kalimantan. The objectives of this research is to study the dynamics of these three parameters and find their relationship during the 2019 extreme dry season. To achieve the objectives of this study, an analysis of the time series graphs of these three parameters was carried out during the 2019 extreme dry season. It is hoped that the results of this research will help to prevent severe fires on peatlands, especially in Kalimantan. The results of this study indicate that during this period there was a decrease in rainfall, a decrease in groundwater level, and the emergence of a large number of hotspots. It can be concluded that the hotspots that appear are closely related to the low groundwater level due to low rainfall.

1. Introduction

Indonesia has very large peatlands. The area of peatland in Indonesia is about 20 million hectares or about half of the total peatland area in the world. These peatlands are located in Papua, Kalimantan, Sumatera and Sulawesi. Peatlands in Indonesia are flammable, so efforts should be made to prevent this recurrence[1–6].

The Indonesian government has done many things to prevent severe fires on peatlands. One of them is by establishing an integrated measurement station for hydrometeorological parameters, where these parameters are thought to be closely related to the occurrence of fires in peatlands. The station is managed by the Peat Restoration Agency (BRG). This research makes use of the data from the measurement results of the BRG station, especially the rainfall and groundwater level data combined with the hotspots data from NASA's MODIS satellite measurements.

In 2019 a natural phenomenon called positive Indian Ocean Dipole (IOD +) occurred which caused minimal rainfall in several regions in Indonesia, including Kalimantan. This minimal rainfall has resulted in severe drought and fires on the peatlands. This period is called the extreme dry season which occurred from July 2019 to December 2019 [7–11]. It is interesting to examine how the

dynamics of the hydrometeorological parameters are estimated to be associated with fires on peatlands, including rainfall, groundwater levels and the number of hotspots during this period as an effort to mitigate fire disasters on peatlands.

The purpose of this study is to study changes in rainfall, groundwater levels, hotspots, and the relationship between these three parameters on peatlands in Kalimantan during the extreme dry season in 2019. This research is expected to be able to answer the following questions, namely: (a) What is the pattern of changes in the hydrometeorological parameter values?; (b) How is the relationship between rainfall and groundwater level?; (c) How is the relationship between the groundwater level and the number of hotspots?.

2. Methods

2.1. Data

The data used in this research are hourly rainfall and hourly groundwater levels which are downloaded from the SESAME website at the following address: https://web.sesame-system.com. SESAME (Sensory Data Transmission Service Assisted by Midori Engineering Laboratory) is an in-situ integrated measurement system of several hydrometeorological parameters on peatlands in Indonesia, including in Kalimantan. SESAME was built on the cooperation between the Indonesian government and the Japanese government. SESAME is managed by an institution called the Peat Restoration Agency (BRG) [12]. The data of this research are data from measurement results at 2 BRG stations in West Kalimantan (WK) and in Central Kalimantan (CK). This study also uses hotspots data from NASA's MODIS satellite measurements [5]. Hotspots data is available on the NASA website at the following address: https://firms.modaps.eosdis.nasa.gov. Details about data and stations coordinates are shown in Table 1 and Table 2.

Table 1. Data used in this study

Parameters	Source of Data	Type of data
Rainfall	BRG	In-situ, hourly
Average groundwater level	BRG	In-situ, hourly
Number of hotspots	MODIS	Remote sensing, daily, 0.5°x 0.5°

Table 2. Data of study locations

Station Name	Coordinate
Central Kalimantan (CK)	-3.492, 104.978
West Kalimantan (WK)	-2.911, 105.082

2.2. Data Analysis

To study the dynamics of the parameters of rainfall, groundwater level, and hotspots, time series graphs for these three parameters were made during the 2019 extreme dry season, from July to October. After that, it is analyzed to find out when the extreme values of the three parameters occur. Analysis of the relationship between the three parameters is also carried out by making an overlay graph between these parameters.

3. Result and Discussion

3.1. The Time Series of Changes in Hydrometeorological Parameters

Based on the time series graph of rainfall shown in Figures 1 (a) and (b), it can be seen that very low rainfall occurs from July to September 2019. In these months the peak of extreme dryness occurs in Kalimantan. If we compare the rainfall that occurs at stations in Central Kalimantan with those in West Kalimantan, the rainfall in Central Kalimantan is lower. This is also evident in Table 1, where the total monthly rainfall in Central Kalimantan is lower than the monthly total rainfall in West Kalimantan.

Rainfall in Central Kalimantan is lower than West Kalimantan, resulting in a lower groundwater level in Central Kalimantan compared to the groundwater level in West Kalimantan. This can be seen in the graphs in Figures 1 (c) and (d). The lowest groundwater level in Central Kalimantan reached -

1.46 m occurred in October, while in West Kalimantan it only reached -0.98 m occurred in July. For the average monthly groundwater level, in Central Kalimantan the lowest value was -1.35 m occurred in October and in West Kalimantan was -0.90 m occurred in August as shown in Table 3.

Lower groundwater levels in Central Kalimantan mean that the number of hotspots that appear in Central Kalimantan is more than the number of hotspots in West Kalimantan, as shown in Figures 1 (e) and (f). The highest total number of monthly hotspots was in Central Kalimantan, reaching 1062 which occurred in September, and in West Kalimantan it was 269 which also occurred in September. It can be concluded that the highest number of hotspots in Kalimantan occurred in September.

Table 3. Monthly values of hydrometeorological parameters

	Total of Rainfall (mm)		Average of GWL (m)		Total of Hotspots	
Month	CK	WK	CK	WK	CK	WK
July	6.5	45.0	-0.82	-0.71	143	16
August	52.0	113.5	-1.13	-0.90	535	242
September	7.0	101	-1.32	-0.73	1062	269
October	93.5	258	-1.35	-0.55	126	2

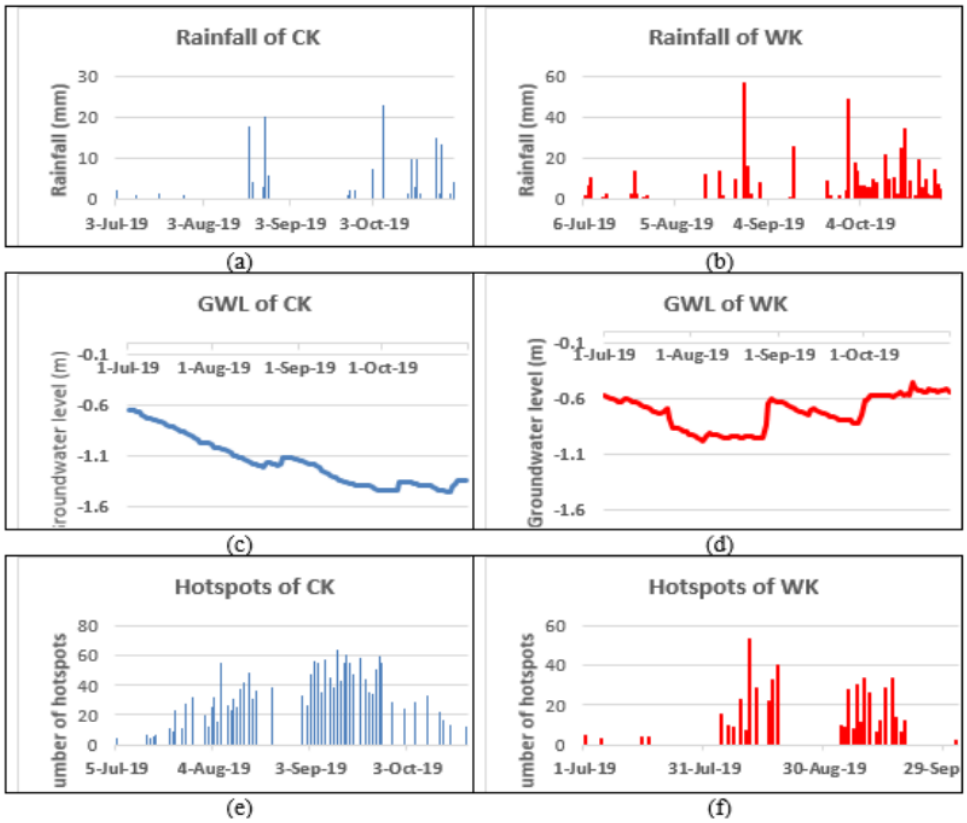
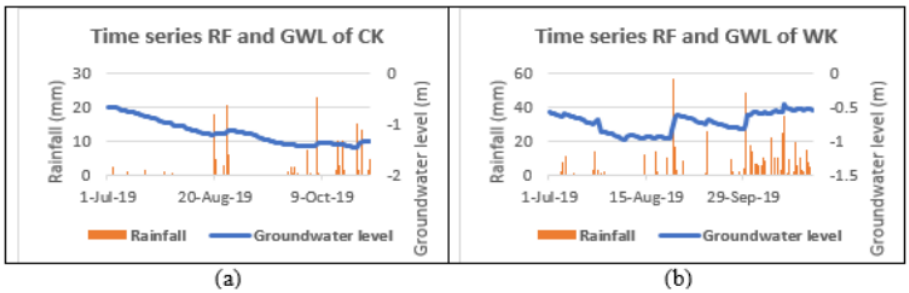


Figure 1. Time series graph of change in hydrometeorological parameters

The extreme dry season in 2019 that occurred in several areas in Indonesia, including in Kalimantan, was the result of a natural phenomenon called positive Indian Ocean Dipole (IOD +). IOD occurs due to anomalous sea surface temperature in the Indian Ocean which can have an impact on excess rain in one place and lack of rain in another. In 2019, parts of Indonesia were affected by a lack of rain, which resulted in an extreme dry season [13,10].

3.2. Relationship between Rainfall and Groundwater Level

The graphs in Figures 2 (a) and (b) show the relationship between rainfall and groundwater levels. It appears that if there is no rain, the groundwater level tends to fall and vice versa. In fact, the rise and fall of the groundwater level in a peatland, apart from being influenced by rainfall, is also influenced by the condition of peatland cover, the types of plants that grow on the peat surface, the maturity of the peatlands, the porosity of the peat soil layer, the susceptibility of the peat soil layer, and the presence of canals near the peatland[14-17].

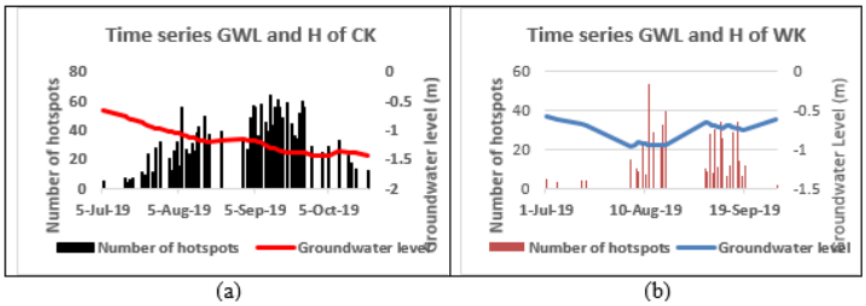


(a) (b)

Figure 2. Overlay graph of rainfall and groundwater level

3.3. Relationship between Groundwater Level and Hotspots

Figures 3 (a) and (b) show a graph of the relationship between the groundwater level and the number of hotspots that appear on the peatlands around the Central Kalimantan and West Kalimantan stations. In these graphs, it appears that when the groundwater level tends to rise, no hotspots will appear and vice versa. Then it appears that the number of hotspots at the Central Kalimantan station is more than the number of hotspots at the West Kalimantan station, while the groundwater level in Central Kalimantan is lower than that in West Kalimantan. Based on this, it can be said that there is a relationship between the groundwater level and the number of hotspots that appear on a peatland. The relationship is that the lower the groundwater level, the more hotspots that appear and vice versa. This is understandable because the lower the groundwater level, the drier the surface of a peatland is, making it easier for hotspots to appear on the peatland [18,19,20].



(a) (b)

Figure 3. Overlay graph of groundwater level and hotspots

4. Conclusion

In the extreme dry season of 2019 on the Kalimantan peatlands, there was low rainfall, low groundwater levels, and the emergence of a large number of hotspots. It was also found that there is a relationship between the rainfall and the groundwater level where the lower the rainfall, the lower the groundwater level and vice versa. There is also a relationship between the groundwater level and hotspots, where the lower the groundwater level, the more hotspots that appear and vice versa.

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