DISCOVERING DEPENDENCE OF COVID-19 ON WEATHER VARIABLES IN MALAYSIA

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ABSTRACT

Weather plays a vital role in the transmission of infectious diseases. This study evaluates the correlation between seven weather variables and COVID-19 in Malaysia. Based on the previous literature, there is a lack of information about the influence of COVID-19 pandemic on environmental factors in Malaysia. Spearman rank correlation test was selected to correlate seven weather variables (relative humidity, global radiation, maximum temperature, mean temperature, minimum temperature, rainfall and wind speed) with COVID-19 cases for the period of March 17, 2020 to April 30, 2020. On the national scale assessment, all the seven weather variables showed a non-significant correlation relationship with COVID-19. By dividing Malaysia into sixteen sub-regions, the correlation analysis shows weather had a larger impact on COVID-19 in five regions of Malaysia, mainly in the western, northern and southern parts of Peninsular Malaysia. The findings also indicate that COVID-19 was negatively correlated with relative humidity and rainfall, where a significant relationship was found in major cities such as Penang, Johor and Selangor. Maximum temperature and wind speed were non-significant correlated with COVID-19 in all the evaluated sub-regions, showing these two weather variables may be less important in the COVID-19 outbreak in Malaysia. In conclusion, relative humidity and global radiation had a larger impact on the COVID-19 outbreak in Malaysia as compared to other weather variables.

Keywords: Coronavirus, COVID-19, Malaysia, Weather, Rainfall, Temperature

I. INTRODUCTION

The first recorded case of the novel coronavirus disease (COVID-19) in Southeast Asia was confirmed in Thailand on January 13, 2020 [1]. Within two weeks, few more cases were detected in the adjacent regions of Thailand, including Malaysia and Singapore [1]. In the following two months, the virus gradually spread across Southeast Asia with up to 309,597 confirmed cases on Jun 4, 2020 [2]. Different lockdown policies were implemented in Southeast Asia to minimize the risk of COVID-19 infection. This includes imposing social distancing and travel restrictions to regions with high risk of COVID-19 infection.

First COVID-19 case in Malaysia was reported on January 25, 2020, which is an imported case from Wuhan, China [3]. Since then, another eight imported COVID-19 cases were found in Malaysia within six days. First local case was recorded on February 3, 2020, a 41-year-old male who travelled to Singapore for a business trip. Consequently, Malaysian government announced a two-week Movement Control Order (MCO) starting from 18 March 2020, restricting mass movement, closure of kindergartens, schools, universities, government premises and businesses [4]. The MCO was extended until June 9, 2020 as proven to be useful in minimizing the COVID-19 outbreak the Ramadan and Raya celebration in Malaysia.

Current studies have shown that weather act as an important role in the transmission of infectious diseases [5,6]. Due to the outbreak of COVID-19, several studies have been conducted to understand the relationship between

weather conditions and COVID-19. Bashir [7] found that the COVID-19 cases in New York City, USA were highly associated with average temperature, minimum temperature and air quality. A similar finding was reported by Tosepu [8], where mean temperature was significantly correlated with COVID-19 cases in Jakarta, Indonesia. A negative linear relationship between COVID-19 cases and temperatures was found in Brazil [9] and Mexico [10], showing that high temperature might influenced the COVID-19 transmission rate in tropical region [11].

The findings and conclusions on the impact of weather conditions on COVID-19 transmission during the last few months are still controversial [11]. For instance, Xie and Zhu [12] mentioned that there is no evidence to support the reduction of COVID-19 cases in warmer condition. By contrast, Méndez-Arriaga [10] concluded that weather factors played an important role on the local infection in Mexico, where tempered regions are more vulnerable than dry or tropical regions. Hence, more similar studies in different geographical and weather conditions regions are essential to address this important research argument.

In this study, we propose a general hypothesis that there is a significant impact of COVID-19 pandemic on the weather variables in tropical region especially in Malaysia. To the best of our knowledge, there is a lack of information about the influence of COVID-19 pandemic on environmental factors in Malaysia. Hence, there is a room for further investigation of the spread COVID-19 that are linked to the weather variables.

This study aims to understand the relationship between seven weather variables (relative humidity, global radiation, maximum temperature, mean temperature, minimum temperature, rainfall and wind speed) and confirmed COVID-19 from March 17, 2020 to April 30, 2020 in Malaysia. The outputs of this research will contribute to the efforts to against the COVID-19 not only in Malaysia, but also Southeast Asia and other tropical countries.

Section 2 describes the study area and data collection that used in this study. Consequently, the methodology of Spearman Correlation Analysis is shown in the same section. Section 3 and section 4 subsequently delivers the results and discussion for the correlation between climate variables and COVID-19 confirmed cases. In the last section, the conclusion is presented.

II. MATERIALS AND METHODS

2.1 Study Area

Malaysia is a typical rainforest tropical country within Southeast Asia that located near to the equator. Malaysia is divided by the South China Sea into two main parts, Peninsular Malaysia and East Malaysia [13]. The population of Malaysia in the first quarter 2020 is about 32.73 million people, and this number is projected to increase up to 41.5 million people by 2040 as stated in a report that produced by the Department of Statistics Malaysia.

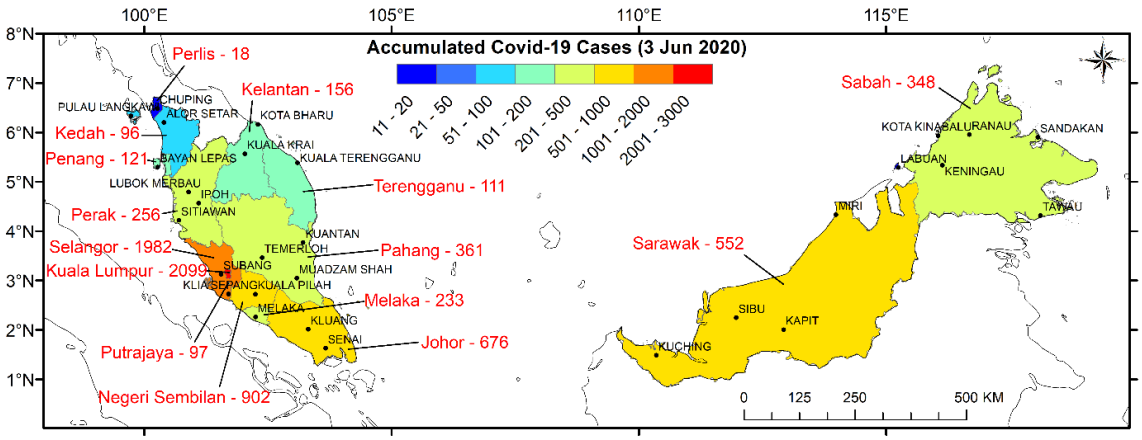


Figure 1: Location of weather stations and accumulated COVID-19 cases in Malaysia on June 3, 2020.

The principal administrative divisions of Malaysia are divided into thirteen states (Kelantan, Terengganu, Pahang, Johor, Melaka, Negeri Sembilan, Selangor, Perak, Penang, Kedah, Perlis, Sabah and Sarawak) and three federal territories (Kuala Lumpur, Putrajaya and Labuan), as shown in Figure 1. Therefore, we also examined the associated weather variables on COVID-19 transmissions in these sixteen sub-regions in Malaysia.

2.2 Data Collection

The numbers of daily confirmed COVID-19 cases in Malaysia were collected from a special COVID-19 web portal (http://covid-19.moh.gov.my/) that created by the Ministry of Health (MOH) Malaysia. The purpose of the web portal setup is to disseminate the COVID-19 related information to public. In general, country scale data is available since the first recorded case, while the number of COVID-19 cases by states and federal territories is only available after the middle of March 2020.

Seven weather variables consist of relative humidity (%), global radiation (WJm^{-2}), maximum temperature (^oC), mean temperature (^oC), minimum temperature(^oC), rainfall (mm) and wind speed (ms^{-1}) at daily scale from January 1, 2020 to April 30, 2020, were collected from the Malaysian Meteorological Department (MMD). A total of 29 weather stations that well distributed across the country were used in this assessment (Figure 1).

2.3 Spearman Correlation Analysis

Spearman rank correlation test was selected due to the non-normally distributed data. Besides that, the method was widely applied to correlate weather variables with COVID-19 [7,8]. The formula used to calculate Spearman Rank Correlation is as follows:

$$r_R = 1 = \frac{6\sum_i d_i^2}{n(n^2 - 1)}$$

where n is the number of data points of the two variables and d_i is the difference in the ranks of the i^{th} element of each random variable considered. The Spearman correlation coefficient can take values from +1 to -1. The value of +1 indicates a perfect association of ranks, meanwhile the value of -1 indicates a perfect negative association of ranks and zero value indicates no association between ranks. The correlation was conducted for the period of March 17, 2020 to April 30, 2020, based on the data available on the MOH website and weather data collected from MMD. Flow chart of exploring the association of weather variables and COVID-19 confirmed cases as shown in Figure 2.

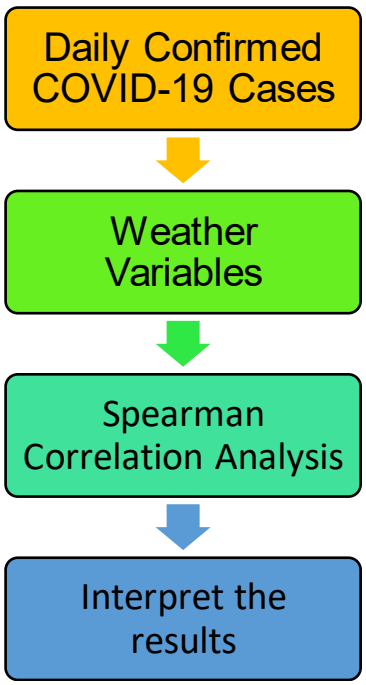


Figure 2: Flow chart of exploring the dependencies of weather variables and COVID-19 cases in Malaysia

III. RESULTS

3.1 COVID-19 Cases in Malaysia

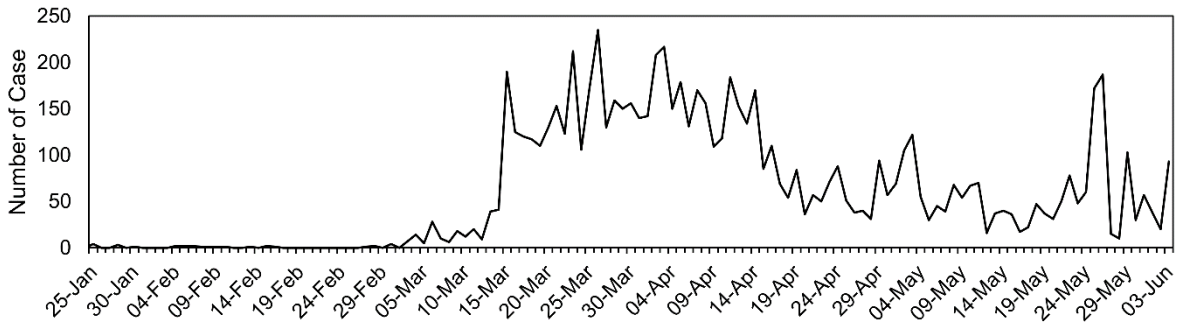


Figure 3: Daily confirmed COVID-19 cases in Malaysia from Jan 25, 2020 to Jun 3, 2020.

Figure 3 shows a sharp increase of COVID-19 cases in the middle of March, with the peaks of confirmed cases were recorded in the end of March and early of April. The highest number of COVID-19 cases was observed on March 26, 2020 with a total number of 235 cases. Due to the MCO implementation, the number of COVID-19 cases started to decline between the mid-April and mid-May. Another peaks were found on May 25 (172 cases) and 26 (187 cases), 2020. Confirmed cases in the latter peaks were mainly detected from foreigner workers at the Bukit Jalil immigration detention centre and other regions of Malaysia.

In general, COVID-19 transmission in Malaysia started from January 21, 2020 to February 27, 2020 due to the imported cases from China [3]. The second wave was found in early March where a sudden dramatically rise in the confirmed cases on March 4, 2020 (14 cases), which was then become worse on March 11, 2020 (20 cases) due to a religious gathering in Seri Petaling Mosque, Selangor, with more than 10000 participants from that different countries [3].

As of 3 June 2020, Malaysia has a total of 7970 confirmed cases (Figure 3). These cases were concentrated in the western part of Peninsular Malaysia, mainly in Kuala Lumpur (2099 cases), Selangor (1982 cases) and Negeri Sembilan (902 cases). In contrast, a relatively low amount of COVID-19 cases can be found in the northern region of Peninsular Malaysia, in the states of Perlis, Kedah and Penang with 18, 96 and 121 reported cases, respectively. Implementation of interstate travel restrictions had reduced the COVID-19 transmission to the northern and east coast regions of Peninsular Malaysia.

3.2 Weather Variability during COVID-19 Pandemic

Changes of all the seven weather variables in Malaysia from March 17, 2020 to April 30, 2020 are shown in Figure 4. Mean relative humidity and global radiation over Malaysia varied from 74.02 to 86.46% and 15.54 to 23.45 MJm^{-2}, respectively, during the evaluated period. Meanwhile, mean maximum temperature, mean temperature and minimum temperature from the 29 weather stations changed from 31.51 to 34.36 ^{o}C, 26.99 to 29.02 ^{o}C and 23.49 to 25.01 ^{o}C, respectively. The highest maximum temperature (38.2 ^{o}C) and lowest minimum temperature (17.3 ^{o}C) were recorded at the Chuping and Ranau stations, respectively as shown in Figure 1.

Figure 4(d) presents the changes of mean daily rainfall from March 17, 2020 to April 30, 2020 over Malaysia. The lowest and highest mean daily rainfall were recorded at 1.03 (April 9, 2020) and 22.07 (April 26, 2020) mm/day, respectively. On the other hand, mean wind speed over Malaysia during the evaluated period was changed from 1.33 to 2.10 ms^{-1}. The highest wind speed was observed at the Sandakan station by 3.5 ms^{-1}, meanwhile, the lowest wind speed of 0.3 ms^{-1} was found at the Kapit station.

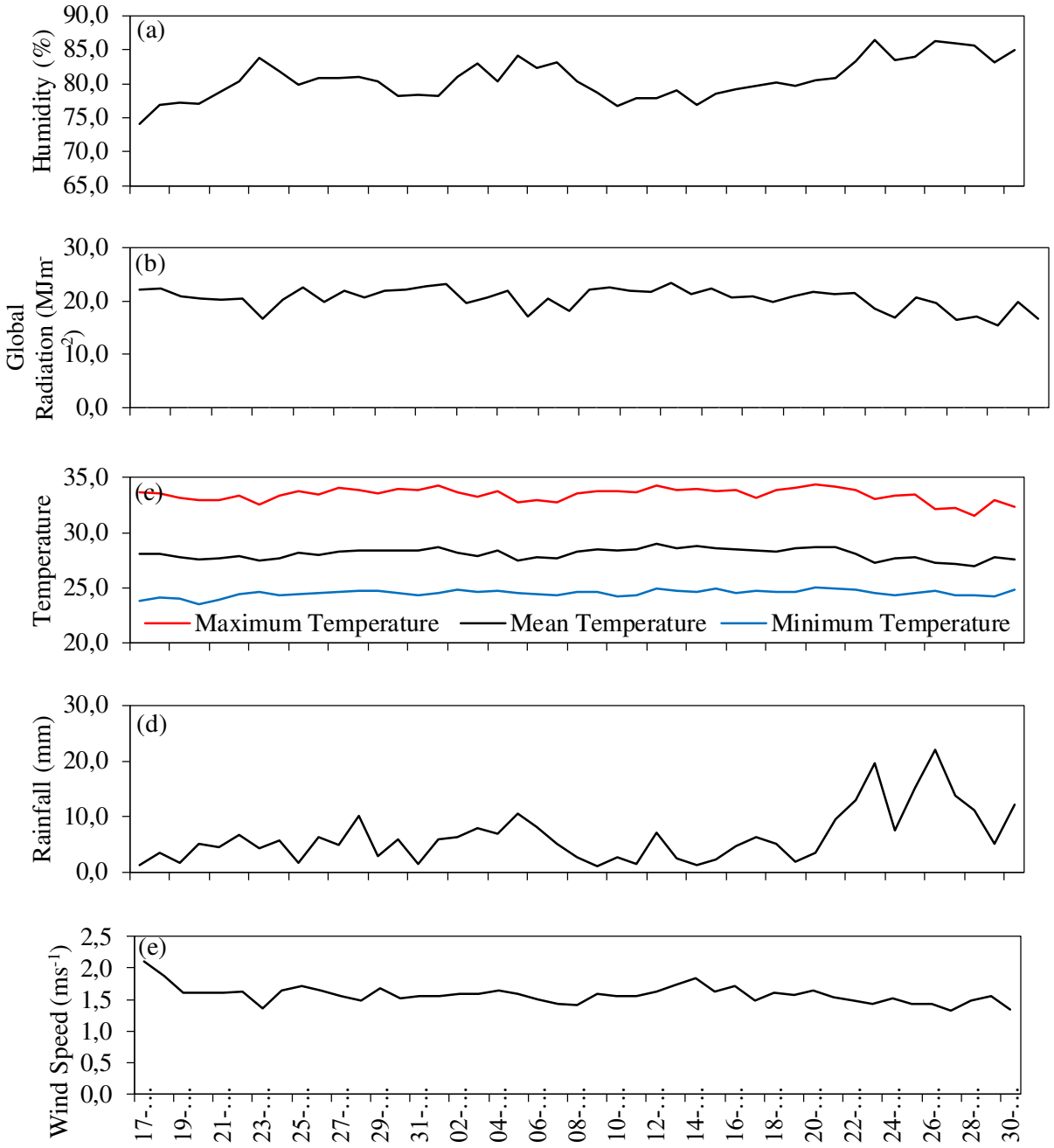


Figure 4: Changes of seven weather variables in Malaysia from March 17, 2020 to April 30, 2020.

3.3 Correlation between Weather and COVID-19

Table 1: Spearman Correlation Analysis between weather variables and COVID-19 cases in Malaysia from March 17, 2020 to April 30, 2020. Bold red colour indicates significant at 95% confident level.

	Relative Humidity	Global Radiation	Maximum Temperature	Mean Temperature	Minimum Temperature	Rainfall	Wind Speed
Malaysia	-0.26	0.26	0.06	0.13	-0.07	-0.29	0.25
Kuala Lumpur	0.17	-0.22	-0.14	-0.20	-0.26	0.11	-0.02
Putrajaya	-0.09	-0.02	0.08	0.10	0.02	0.04	0.00
Selangor	**-0.32**	0.13	0.00	0.29	0.20	-0.26	-0.01
Negeri Sembilan	**-0.32**	**0.35**	0.13	0.19	-0.22	-0.14	0.18
Melaka	-0.16	0.24	0.16	0.17	0.02	-0.18	0.06
Johor	**-0.33**	**0.30**	0.22	0.27	0.05	-0.25	0.21
Pahang	**-0.31**	0.21	0.24	**0.33**	0.04	-0.22	0.09

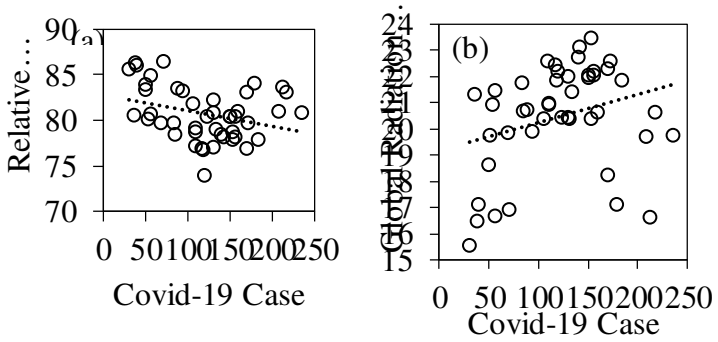
Terengganu	-0.13	0.08	-0.24	-0.12	-0.02	0.01	-0.09
Kelantan	-0.29	0.17	0.10	-0.29	**-0.47**	**-0.46**	0.18
Perak	-0.24	0.09	0.08	0.04	-0.08	-0.13	0.02
Kedah	-0.18	**0.32**	0.09	-0.07	-0.23	-0.08	0.10
Penang	**-0.63**	0.08	0.22	**0.36**	0.28	**-0.32**	0.00
Perlis	-0.10	0.12	0.16	0.21	0.04	-0.13	-0.04
Sabah	-0.18	0.16	-0.11	-0.20	-0.25	0.06	0.27
Sarawak	-0.16	0.22	0.01	0.15	-0.05	-0.05	0.16
Labuan	-0.06	0.15	0.08	0.10	-0.14	-0.02	0.09

Correlation of seven weather variables and COVID-19 cases in Malaysia are presented in Figures 5 and Figure 6 as well as Table 1. For national scale assessment, all the seven weather variables were not significantly correlated with COVID-19 cases in Malaysia. This study supports evidence of Tosepu [8] who reported maximum temperature, minimum temperature, relative humidity and rainfall were insignificant correlated with COVID-19 in Jakarta, Indonesia. Similarly, Briz-Redón and Serrano-Aroca [14] also reported there is no relationship was found between temperature and COVID-19 cases in Spain.

The results of the correlation analysis between weather variables and COVID-19 cases in 16 sub-regions in Malaysia are shown in Table 1. The correlation results show that weather had a large impact on COVID-19 outbreak in Negeri Sembilan, Johor, Pahang, Kelantan and Penang as compared to other regions in Malaysia. At least two weather variables were significantly correlated to the COVID-19 cases in these five regions. For example, relative humidity, mean temperature and rainfall were correlated significantly with the COVID-19 cases in Penang.

Table 1 shows that relative humidity and global radiation had a larger impact on the COVID-19 outbreak in Malaysia as compared to other weather variables in Malaysia. Relative humidity was negatively and significantly correlated with the COVID-19 cases mainly in Peninsular Malaysia, with the highest correlation value of -0.63 in Penang. Meanwhile, global radiation was found to be significantly positively correlated with COVID-19 in Negeri Sembilan, Johor and Kedah (Table 1 and Figure 5b).

Minimum temperature and mean temperature were correlated significantly with COVID-19 cases in Kelantan, Pahang and Penang. By contrast, maximum temperature showed a non-significant correlated to the number of COVID-19 cases in all the sub-regions. In contrast, rainfall was negatively and significantly correlated with COVID-19 cases in Penang and Kelantan, showing that it plays a significant role in the transmission of COVID-19 in northern Peninsular Malaysia. Interestingly, wind speed didn't show a significant correlation with COVID-19 for all evaluated sub-regions. It is possible, therefore, that this variable may be less important in the COVID-19 transmission in Malaysia.



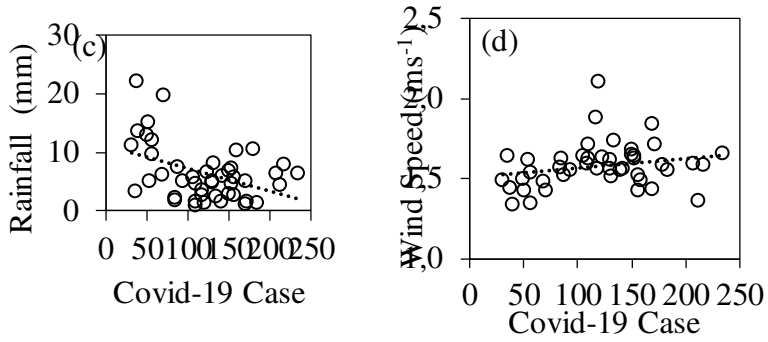


Figure 5: Correlation between COVID-19 cases with (a) relative humidity, (b) global radiation, (c) rainfall and (d) wind speed in Malaysia from March 17, 2020 to April 30, 2020.

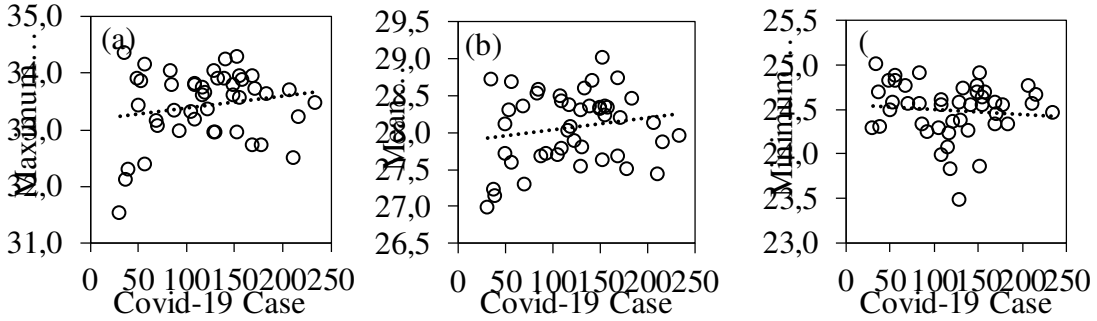


Figure 6: Correlation between COVID-19 cases with (a) maximum, (b) mean and (d) minimum temperatures in Malaysia from March 17, 2020 to April 30, 2020.

IV. DISCUSSION

Similarly, the finding of relative humidity has a larger impact on the COVID-19 outbreak in Malaysia accords with Wu [15] that found a similar finding in a global scale assessment and Bashir [7] in New York City [7]. The finding supports the fact of relative humidity may contribute to the spread of coronaviruses. The reported negative correlation between precipitation and COVID-19 is accordance with the results of Menebo [16] who found negative relationship between rainfall and COVID-19 cases in Osla, Norway. This may be explained by the fact that people prefer to "stay-home" during rainy day, and this would reduce the interaction among human. By constrast, people tend to go out during sunny day. Therefore, lower COVID-19 cases were normally recorded during rainy day, and higher cases during sunny day (high global radiation).

Similarly, Passerini, Mancinelli [17] also reported wind speed was not significant with COVID-19 in five provinces of Italy due to the small ranges in wind speed values (0.5 – 2 ms^{-1}). However, the findings of the current study do not support the research of Şahin [18] who reported wind speed was highly positively correlated with the number of COVID-19 cases in Turkey. A possible explanation for the contrary result is the difference in wind speed level between Malaysia and Turkey, where the latter country had a much stronger wind speed. For instance, the highest recorded wind speed in Turkey during the COVID-19 outbreak period was around 13.7 ms^{-1}, while the highest wind speed was only around 3.5 ms^{-1} in Malaysia.

The most striking result to emerge from the data is maximum temperature was non-significant correlated to the number of COVID-19 cases in all the sub-regions (Table 1). This is accordance to the findings in Jakarta [8], New York [7] and Spain [14], supporting the findings of COVID-19 may not vanish by itself in a warmer weather condition [9]. Therefore, we would suggest Malaysian government don't take high temperatures as one of the considerations in fighting COVID-19.

Our findings may be somewhat limited by some environmental and social-economic factors because this study focused solely on weather variables analysis. Other potential factors such as 'stay-home" policy, population mobility, testing and treatment capacities for COVID-19 may influence the research outcomes due to the changes in the virus behavior [9]. Besides that, good air quality may reduce the transmission of COVID-19 [7], but this study didn't consider this element due to the lack of recent air quality data. Another limitation may affect the findings is testing dates (confirmed cases) might not align to virus transmission dates or infection dates [16] and also weather measurement dates.

V. CONCLUSION

This is the first study to investigate the impact of seven weather variables (relative humidity, global radiation, maximum temperature, mean temperature, minimum temperature, rainfall and wind speed) on the COVID-19 cases in sixteen sub-regions of Malaysia. On the national scale assessment, all the seven weather variables showed a non-significant correlation relationship with COVID-19 cases in Malaysia. In contrast, for a more detailed analysis, the findings show that relative humidity and global radiation had a large impact on COVID-19 in Malaysia due to more significant relationship was found in different parts of Peninsular Malaysia.

Besides that, the results show that COVID-19 was negatively correlated with relative humidity and rainfall in most of the evaluated sub-regions, with a significant relationship was found in major cities in Peninsular Malaysia such as Penang, Johor and Selangor. In contrast, maximum temperature and wind speed had a non-significant correlation relationship with COVID-19 in all the sixteen regions, showing that these two variables may be less important in the COVID-19 outbreak in Malaysia. The findings can be used as reference to World Health Organization and Malaysian government to reduce the risk of COVID-19 in Malaysia and other Southeast Asia and tropical countries.

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