Impact Of Movement Control Order (MCO) Of Covid-19 Pandemic on Aerosol Optical Depth Over Peninsular Malaysia

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Abstract. Recently in 2020, the spread of the Virus COVID-19 leads the government of Malaysia to enforce for a Movement Control Order (MCO) in order to curb the pandemic. Thus, this study aims to analyse aerosol optical depth from MODIS aerosol product over Peninsular Malaysia before and during the MCO. Data before MCO shows a higher AOD concentration in major part of the eastern coast of the peninsular. This might be due mostly to the long range transport of agricultural or biomass burning season that occur in the Mekong sub-region area as reported by ASEAN Specialised Metrological Centre brought to eastern part of the Peninsular with the Northeast Monsoon wind. Both data before and during MCO managed to capture high AOD concentrations in the Greater Kuala Lumpur as well as area southern of the state of Perak confirming that the resuspension of urban, dust, and open biomass burning aerosols from local sources are dominant in this area. As of quantification of the AOD concentration, The highest reduction was at Temerloh, with -40.3% (0.67-0.4), while the lowest reduction was at Bandaraya Melaka with -4.6% (0.43-0.41). Highest increment of AOD during was detected in Sri Manjung, with value of 56.1% and Kulim Hightech as well as Alor Setar not far behind with , 55.1% and 54.8% respectively. It can be clearly seen that Northern and Central Region contribute to the increase of AOD while the Eastern Region contributes to the reduction of AOD for the study area during this MCO. The overall total AOD average is 0.413 before the MCO and 0.432 during the MCO giving a total increment of 4.6%.

1. Introduction

COVID-19 first case was identified in China and since then has spread very quickly throughout the world. As of August 2020 Malaysia logged around 9,000 cases in total (https://kpkesihatan.com/2020/08/28/kenyataan-akhbar-kpk-28-ogos-2020-situasi-semasa-jangkitan-penyakit-coronavirus-2019-covid-19-di-malaysia/) last access 4/10/2021. The spreading of COVID-19 virus causes the Malaysia government to call for Movement Control Order (MCO). During the MCO, all mass gatherings are prohibited; all business and educational institutions must be closed except for
those that are necessary (e.g., water, electricity, energy, telecommunications, postal, transportation, banking, health services, airport, safety, defense, cleaning, retail, and food supply).

https://www.thestar.com.my/news/nation/2020/03/16/malaysia-announces-restricted-movement-measure-after-spike-in-covid-19-cases This resulted in limitation of movement for its 30 million people which has a direct bearing of its anthropogenically emitted trace gases and aerosol.

Aerosol is a solid or liquid particles suspended in the gasses in the atmosphere. Aerosol optical depth (AOD) is a measure of the light lost from a beam due to scattering and/or absorption effect of atmospheric aerosols and is widely used as a key element for assessing the degree of air pollution [1]. High AOD values indicate large number of pollutants in the atmosphere or the pollutant level. Main aerosol types that are prevalent in Malaysia are biomass burning aerosols, aged forest fire aerosol, continental or urban aerosols, maritime aerosols and dust aerosols. [2], [3]. Currently, remote sensing (RS) technology is an important means to detect and monitor aerosol based on the AOD [4]. MODIS has been commonly used in atmospheric aerosol research due to its comparatively long-term aerosol data and because the methods of calibration and cloud screening are very stable and give high precision over land as well as giving almost everyday coverage of data[5]. Thus, this study aim is to analyse the changes of aerosol optical depth concentration over Peninsular Malaysia before and after movement control order was implemented in the country.

2. Methodology

2.1 Study Site

Almost 95% of the population in Malaysia resided on its western area known as the Peninsular Malaysia or West Malaysia. It shares border with Thailand to the north and connected to Singapore at the south through Johor-Singapore Causeway and the Tuas Second Link. It experiences tropical climate with temperature around 23℃ to 31℃ with high humidity level and experiences four seasonal monsoons; Southwest Monsoon (SWM) (late May to September), Northeast Monsoon NEM (November to March), two inter-monsoons in April and October. Its most populated area is known as Klang valley or also refers to as the Greater Kuala Lumpur (GKL) which houses the capital of the country as well as Putrajaya the government administrative area. Apart then GKL the peninsular houses another two other big Metropolitan cities Johor Bahru in the south and Georgetown to the North.
2.2 Data Acquisition

The satellite datasets used in this study is MODIS-Terra sensors at level 2, 10km swath (MOD04). The AOD distribution availability roughly was checked on https://worldview.earthdata.nasa.gov/ to avoid any cloud covers, orbital gap and sun glint in the data. The data were downloaded for the selected dates in conjunction with the availability of the data as it is very well known that optical remote sensing data are every much hampered by cloud cover especially in the tropics. 7 days from the last week of February was chosen for before MCO and 7 days during the MCO period was used as comparison. The satellites data are available at the NASA free and open website https://ladsweb.modaps.eosdis.nasa.gov. To access the data in LAADS DAAC, one must have Earth data account. The data downloaded is in HDF format and was converted to CSV format before being mapped in GIS environment. The value of the AOD can be directly retrieved from the MODIS with the newest AOD algorithm from MODIS, Deep Blue, without any additional computations. The spatio-temporal variations and changes of aerosols during and before the MCO episode over Peninsular Malaysia are mapped. In order to quantify the changes of AOD for peninsular Malaysia during and after the MCO, 20 locations are selected and compared.

3. Results and Analysis

3.1 Spatio Temporal Map of AOD.

![Figure 2](image_url). Spatial distribution of MODIS-Terra AOD before MCO for (a) 17 February, (b) 20 February, (c) 24 February, (d) 25 February, (e) 26 February, (f) 29 February 2020.
On 17th February, it is noted that there was a spike of AOD concentration detected in the middle of the peninsular which corresponds to the forested area in the state of Pahang, with a value of approximately 3.5 to 3.8. Further investigation is needed to determine the spike of the AOD. On the same date, other places such as Johor Bahru, and the GKL areas also recorded a high AOD values as these two are the metropolitan area with high population concentrations and industries as well as high traffic volume. This result reflect the finding of [6]

Apart than 17th of February, the other dates representing data before MCO shows a higher AOD concentration in major part of the eastern coast of the peninsular. This might be due to the long range transport of agricultural or biomass burning season that occur in the area Mekong sub-region as reported by ASEAN Specialised Metrological Centre which has giving out alert on the increase of hotspots in the region starting beginning of Jan 2020 and continue to rise up till middle of March 2020. (http://asmc.asean.org/asmc-alerts/ last accessed 6/10/2020 ) as well as local open burning activities. [7] from their research on air trajectories, found that before MCO air masses affecting the country were particularly from South China Sea northeast monsoon winds. During the MCO the air masses are from two different sources, South China Sea and as well as from Northern Peninsular. Due to this, the data during MCO shows a variation of AOD spatio temporal distribution without specific trend as compared to the map before MCO except for sources that come from local activities that shows high concentration of aerosols in the GKL as well as Southern and Central Perak state.

![Figure 3](image-url)

**Figure 3.** Spatial distribution of MODIS-Terra AOD during MCO as of (a) 25 March, (b) 30 March, (c) 10 April, (d) 12 April, (e) 19 April, (f) 20 April 2020.

Both map before and during MCO managed to capture high AOD concentrations in the GKL as well as area southern of the state of Perak near Sri Manjung. It is suspected that the urban resuspension of dust prevails for GKL [7] and resuspension of dust quarries might be the reasons for area Southern and central of state of Perak. Fossil and open biomass burning aerosols from local sources are also dominant over the Peninsular during this period of inter monsoon. March 2020 has been the highest month with...
hotspot data for peninsular Malaysia as reported by http://asmc.asean.org/asmc-haze-hotspot-monthly-new/ last accessed 6/10/2020

3.2 Quantifying changes of AOD before and during MCO
In order to quantify the changes of AOD for peninsular Malaysia during and after the MCO, 20 locations on the map corresponding with the Continuous Air Quality Monitoring Stations (CAQMS) stations of Department of Environment monitoring stations are selected. The average value for each location during the study period are calculated and shown in Table 1.

Table 1. The variation of AOD before and during the MCO for all the locations selected in study.

| Location              | Average before MCO | Average during MCO | Changes % |
|-----------------------|--------------------|--------------------|-----------|
| Klang                 | 0.46               | 0.62               | 34.78     |
| Nilai                 | 0.38               | 0.42               | 10.53     |
| Inderamahkota         | 0.43               | 0.36               | -16.28    |
| Kulim Hightech        | 0.29               | 0.45               | 55.17     |
| Tangkak               | 0.41               | 0.38               | -7.32     |
| Seri Manjung          | 0.41               | 0.64               | 56.10     |
| Kangar                | 0.33               | 0.38               | 15.15     |
| Seberang perai        | 0.40               | 0.53               | 32.50     |
| Port Dickson          | 0.32               | 0.39               | 21.88     |
| Kuala Terengganu      | 0.50               | 0.40               | -20.00    |
| Paka                  | 0.43               | 0.36               | -16.28    |
| Kota Bharu            | 0.52               | 0.39               | -25.00    |
| Tanah Merah           | 0.44               | 0.29               | -34.09    |
| Bandaraya Melaka      | 0.43               | 0.41               | -4.65     |
| Rompin                | 0.38               | 0.42               | 10.53     |
| Alor Setar            | 0.31               | 0.48               | 54.84     |
| Seremban              | 0.31               | 0.35               | 12.90     |
| Banting               | 0.40               | 0.56               | 40.00     |
| Temerloh              | 0.67               | 0.40               | -40.30    |
| Batu Pahat            | 0.42               | 0.42               | 0.00      |

Before MCO, one of the location that shows high AOD concentration was Temerloh 0.67, while during MCO, the AOD concentrations at Sri Manjung shows highest AOD concentrations. The trend of the AOD concentrations shows a mix of reduction and increment of the pollutants. While reductions of AOD concentrations only occurred at 8 locations, which attributed for 40% from the overall locations, the rest of the locations (55%) shows increase of AOD concentrations with exception of one location in Batu Pahat that shows neutral. The highest reduction was at Temerloh, with -40.3% (0.67-0.4), while the lowest reduction was at Bandaraya Melaka with -4.6% (0.43-0.41). Highest increment of AOD during the study period was detected in Sri Manjung, with value of 56.1% and Kulim Hightech as well as Alor Setar not far behind with, 55.1% and 54.8% respectively. Study by [8] on concentration of PM 2.5 also find similar trend of increment for the city of Alor Setar. Previous study by [5] has shown a satisfactory and statistically significant correlation (R² = 0.55, p< 0.05) of MODIS AOD and ground Aeronet data.
Figure 4 shows the average daily AOD value for the study areas based on region classified as Northern, Central, Eastern and Southern regions. It can be clearly seen that Northern and Central Region contribute to the increase of AOD while the Eastern Region contributes to the reduction of AOD for the study area during this MCO. The overall total average is 0.413 before the MCO and 0.432 during the MCO giving an increment of 4.6%.

![AOD Concentration Based on Region](image)

**Figure 4:** AOD values of MODIS satellite based on region

4. Conclusion

This paper analysed and visualized temporal and spatial AOD concentration distribution from MODIS data over the Peninsular Malaysia during the first episode of Malaysian MCO. From the result, AOD concentration distribution can be observed lower before the MCO for the northern and central region but not for the eastern region. Trans boundary aerosol pollutants brought by the North Eastern wind monsoon (NEM) through South China Sea plays an important role in AOD concentration for the Eastern region particularly during the month of January till March. Nonetheless the Northern and central regions AOD are mostly affected by the local urban and dust pollutants which shows insignificant increase during the study period due most probably to resuspension of urban pollutants and dust.

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