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Monitoring Effects of Lockdown During Covid-19 Pandemic Towards the Air Pollution in Southeast Asia

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Abstract

This research explores one of the most serious environmental threats to human health which is air pollution. The objective of this study is to examine the concentration of several air pollutants that has been affecting the atmosphere specifically in Southeast Asia after the emergence of the pandemic. Throughout this research, the air pollution concentration is monitored using several observation satellites such as NASA GIOVANNI, Ozone Monitoring Instrument (OMI), and MODIS-Aqua to see the difference in air quality before and after the lockdown was implemented in the selected specific area. The average mean for the studied year of each selected pollutant was also observed to see the pattern of the air quality after the pandemic. Thailand and other northern Southeast Asian nations bordering China were found to be the most affected by transboundary pollution, which was brought on by the climatological changes that all Southeast Asian countries experienced. In addition, most Southeast Asian nations are regarded as developing countries that rely significantly on power produced by fossil fuels and individual transportation. Consequently, it significantly worsens the air pollution in the area. This study is significant as it allows the government to regulate the air quality in a specific region and it is important to monitor the air pollution in the atmosphere as it has a substantial impact on human health as well as the environment. By conducting this study, it can be seen that there are major positive changes in air quality in Southeast Asia as it is the result of the lockdown and lack of human activities in each country.

Keywords: Air pollution, nitrogen dioxide, sulphur dioxide, Southeast Asia, Covid-19

1. Introduction

Coronavirus disease, also known as COVID-19, is a well-known, uncontrolled, and infectious disease that is spreading over the world and causing alarm in human society (Parida et al., 2021). The disease is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or coronavirus, a virus that was recently discovered. It was originally discovered as an outbreak in Wuhan City, Hubei Province, China, on December 31, 2019, and then reported to the World Health Organization (WHO) (Lal et al., 2020). Because this is an infectious disease, it can easily transmit from one person to another, making it vital to exercise social distancing. It can also spread between animals and people in particular situations. As a result, it is critical for the human population to exercise social separation of up to 6 feet from one another.

In response to the COVID-19 crisis, Malaysia's government issued a Movement Control Order (MCO) or partial lockdown on March 18, 2020, (Latif et al., 2021). Because of the stringent movement limitations, human activities come to a complete halt since no one is outside, allowing the uncontrollable virus to spread to slow down. However, since human activities are ceasing, these activities have a significant positive effect on the health of the environment notably in terms of air quality in the atmosphere (Latif et al., 2021). For the first time following World War II, global lockdowns in the wake of the COVID-19 epidemic have resulted in a significant reduction in air pollution and favourable environmental consequences. (Parida et al., 2021).
This research will examine the implications of the COVID-19 epidemic on air quality in Southeast Asia, as well as how pollution levels in the region were influenced. This study is significant as it allows the government to

regulate the air quality in a specific region and it is important to monitor the air pollution in the atmosphere as it has a substantial impact on human health as well as the environment. Especially after COVID-19, it will be clearer the reason the air quality needs to be monitored as major changes in the environment happened in the span of a few months with the lack of human activities. Air pollution in Southeast Asia is especially important to be monitored as the countries in that particular region are particularly active in their economic sectors as most of the countries are developing countries.

Southeast Asia's rapidly expanding economy, industrial expansion, urbanisation, and the associated rise in emission sources have had a substantial negative impact on the region's air quality in recent years (Khan et al., 2021). It is well known that air pollutants, in particular Nitrogen Dioxide, Sulphur Dioxide, and Aerosol, can harm both people and the environment. Since this system's purposes are to maintain track of changes and promote sensible use of the land's natural resources to conserve our surroundings, the data acquired through satellite monitoring of each contaminant will have a significant impact. However, Southeast Asia (SEA) was not immune to the newly discovered coronavirus, and as of early March 2020, the outbreak was wreaking havoc in many SEA countries (Kanniah et al., 2020). In order to track and examine the pattern of the pollutant's dispersion in Southeast Asia, the study focused on and discussed the concentration of Nitrogen Dioxide, Sulphur Dioxide, and Aerosol for the years 2020 and 2021.

In Southeast Asia, the air pollution problem is especially critical as the countries in the region are growing rapidly at a fast rate. Southeast Asia has been facing a lot of air pollution problems as the citizens in these countries, especially in the urban areas, would prefer to use individual transportation instead of public transportation. This can cause a heavy impact on the environment as the release from these vehicles contributed to the emissions of some dangerous air pollutants such as Nitrogen Dioxide and Sulphur Dioxide. Following the lockdown, many manufacturing and heavy industries were shut down, and there was a decrease in the use of transportation, as well as several changes in the environment (Facciolà et al., 2021). As a result of the disturbance of anthropogenic-based releases, such drastic attempts to combat the virus may have resulted in a drop in aerosols and airborne pollutants (Lal et al., 2020). Thorough research on the differences in air quality amongst Southeast Asian countries can help the local community to provide a better perspective on the severity of the pollution. Therefore, comparisons of the air quality condition before and after the COVID-19 pandemic is critical as they might give better insights into the air pollution problem that has been happening in the region.

There have been several research gaps from previous studies that were taken into consideration while conducting these studies. In one of the previous research projects by Katsuri Devi Kanniah and others, it focuses on the overall quantity of columnar aerosol in the atmosphere to see how it affects human health, as well as solar radiation, cloud condensation processes, and climate change in South and Southeast Asia. In contrast to prior research, the present project will use satellite observation to explore the impact of MCO/lockdown measures on air quality in the Southeast Asian area, with a particular focus on Malaysia. Next, the research by Manmeet Singh and others focused on the topic of global air quality and quantifies the improvement due to less human activity during the lockdowns using a comprehensive set of high spatiotemporal resolution satellites and combined products of air contaminants. In contrast to the previous study, the quantitative assessment in this focuses on megacities, capitals, and cities with good living standards. It provides useful information on the spatial distribution of changes in air pollution as a result of COVID-19-mandated lockdowns.

Each parameter is graphically presented according to each year and month to provide a better interpretation. These results will further discuss the state of the pollution levels in Southeast Asia during and before the COVID19 outbreak as well as assess the changes in pollutants released in Southeast Asia during the COVID-19 pandemic. For a thorough examination of COVID-19's effects on the chosen contaminants examined in this study over Southeast Asia, it should be highlighted that there should be attention to meteorological and climatological parameters.

The objectives for this study are:

1. To determine the air quality status before and during lockdown due to the COVID19 pandemic in the Southeast Asia region and to evaluate the reduction in anthropogenic emissions during pandemic COVID-19 in Southeast Asia.
2. To examine the monthly concentration of SO_2, NO_2, and aerosol in the Southeast Asia region in 2020 – 2021.

2. Method

The NASA GIOVANNI data which originated from NASA GES DISC were used to look at monthly Nitrogen Dioxide, Sulphur Dioxide, and aerosol concentrations in Southeast Asia in 2020–2021. The mapping was taken each month for both years in order to examine the different patterns of each pollutant's emissions throughout Southeast Asia. In addition, Nitrogen Dioxide and Sulphur Dioxide data from OMI were also included in the analysis. Both data were averaged through the years to compare the differences between the years 2020 and 2021. In this study, one software that is MATLAB was used to analyse the Level 3 datasets collected from NASA GIOVANNI, OMI, and MODIS-Aqua to compare the Aerosol Optical Depth as well as Nitrogen Dioxide and Sulphur Dioxide. It also functions to evaluate the reduction in anthropogenic emissions during the pandemic COVID-19 in Southeast Asia.

NASA GIOVANNI is an internet programme that was designed by NASA GES DISC that allows an enormous volume of Earth science remote sensing data to be viewed, analysed, and made available to the public in a straightforward and intuitive manner. On the Giovanni website provided, The Giovanni User Interface makes it simple to retrieve and present selected data on a variety of plots. The plot source files are also available as a free download in netCDF as well as other file types (Acker & Leptoukh, 2007a). Giovanni even takes into account the results of assimilation models that encompass a wide range of atmospheric, earth's surface, and oceanic characteristics. To add, Giovanni offers a variety of visualisations, with the Time Averaged Map serving as the default. Moreover, The OMI device can distinguish between distinct types of aerosols, as well as contaminants including smoke, dust, and sulphates, and provide data for detecting tropospheric Ozone concentrations (Khan et al., 2021). The total Ozone quantities will be more accurate and precise due to hyperspectral capabilities and long-term radiometric and wavelength self-calibration will be possible as well. Throughout the previous decade, OMI data have been useful in documenting rapid changes in air quality in several regions around the world (Krotkov et al., 2016).

Finally, MODIS-Aqua is a monitoring instrument that has been travelling on board the Terra and Aqua satellites. As Of May 2000, and July 2002, correspondingly, it has been a significant component of NASA's EOS. It offers a variety of aerosol chemicals across the sea and land. Over one to two days, it observes the whole earth's surface within a 2,330-kilometre monitoring range. The position, time, instantaneous radiating energy, and glowing rate of live flames are provided by MODIS fire products (Metya et al., 2020). Since it monitors reflected sunlight, MODIS sensors can only access information on the dayside area. Additionally, NASA's GES-DISC provides access to NASA GIOVANNI, OMI and MODIS-Aqua where the retrieved Aerosol, Nitrogen Dioxide, and Sulphur Dioxide data sets are available at https://disc.gsfc.nasa.gov/.

3. Results and Discussion

The data retrieved for this study were presented and analysed using data mapping. The monthly and yearly results of the data were acquired using the software MATLAB which first necessitates mapping the data using multiple coding methods. Each parameter will be labelled according to each year and month to provide a better understanding of the generated maps. These results will further discuss the state of the pollution levels in Southeast Asia during and before the COVID19 outbreak as well as assess the decline in pollutants released in Southeast Asia during the COVID-19 epidemic to satisfy the objectives of the study. For a thorough examination of COVID-19's effects on the chosen contaminants examined in this study over Southeast Asia, it

should be highlighted that there should be attention to meteorological and climatological parameters.

3.1 Nitrogen Dioxide

Figures 1 and 2 show that Southeast Asia's emission levels vary significantly, and throughout the emergency shutdown period, a decrease in air pollution-related mortality was connected with better air quality. The pattern of air quality is shown to be consistent between the two years' emissions of air pollution. This is because each Southeast Asian country goes through a distinct COVID-19 quarantine period every two years. It is evident that the Nitrogen Dioxide levels in Malaysia underwent some of their most significant and continuous transformations. As an example, the Nitrogen Dioxide levels in Kuala Lumpur, the country's capital, were reduced by over 60% from 2019 levels, compared to a 40% decrease in the nearby state of Selangor. Southeast Asia's Nitrogen Dioxide concentration has drastically decreased, as seen by a colour change that has reached background level, in which the Philippines and Indonesia also had comparable outcomes. For values ranging from 0 to 10×10^{15} mol/cm^2, cyan and red patches represent the Nitrogen Dioxide column saturation concentrations (Naqvi et al., 2021).

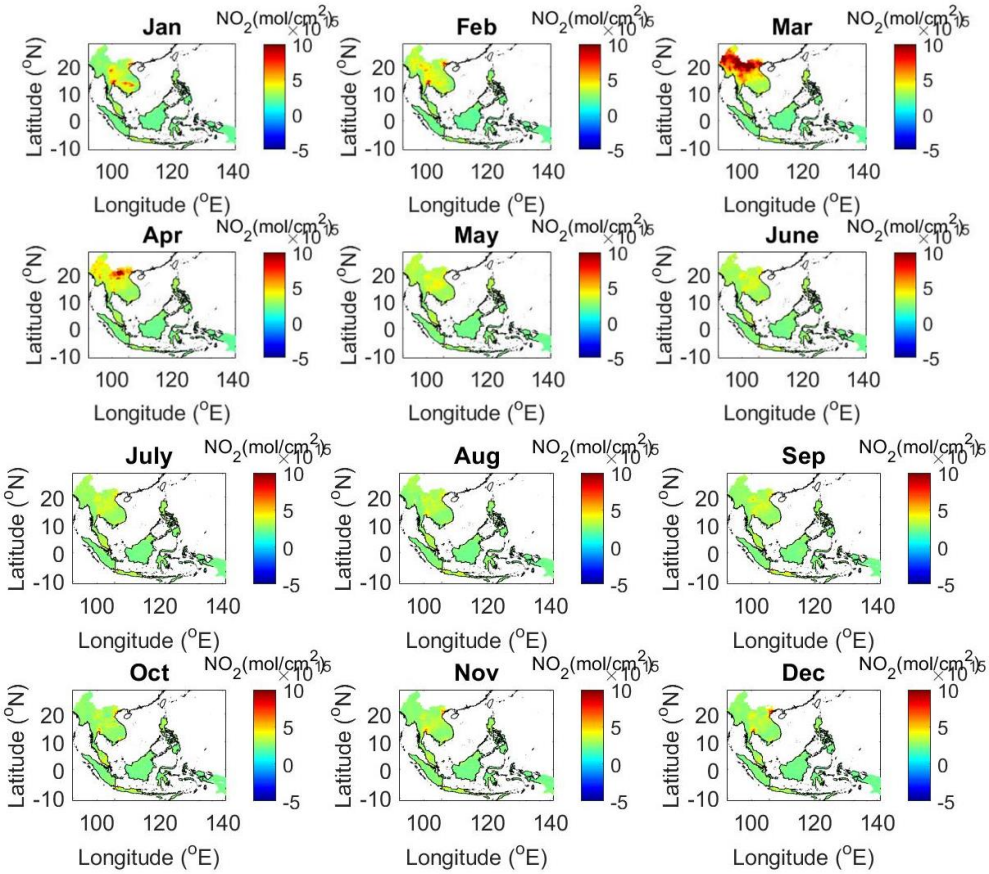

Figure 1. Nitrogen Dioxide pollution mapping for 2020.

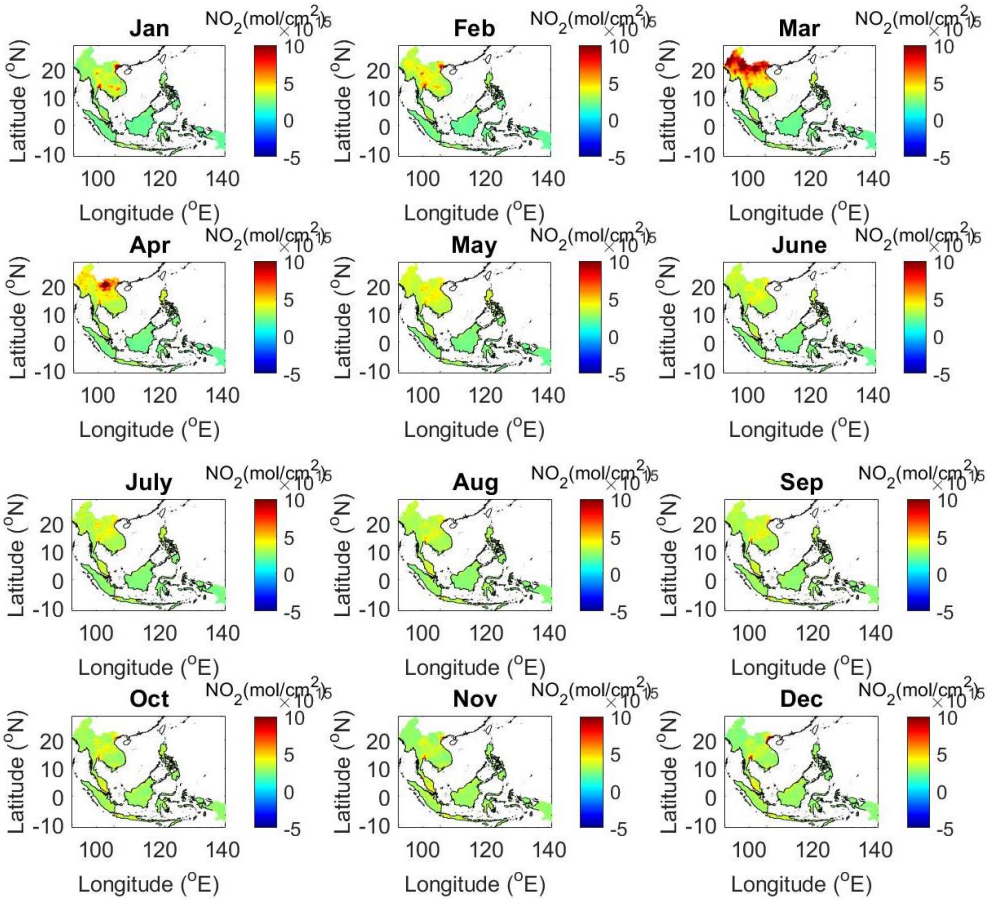

Figure 2. Nitrogen Dioxide pollution mapping for 2021.

Figures 1 and 2 show that the amount of red and yellow patches throughout Southeast Asia was clustered in a concentrated area in March 2020. The places with extraordinarily high colour intensity, however, have completely faded in the latter time period as a result of the enforced closure imposed on each country (Elsaid et al., 2021). Next, although Hanoi's industrial and power facility areas are the country's largest producers of pollution, there was a reduction in Nitrogen Dioxide after the lockout in Vietnam. As noted, since mid-February, Hanoi emissions have decreased by roughly 10% compared to the same period the previous year, demonstrating a slight decrease in regional emissions, in which Ho Chi Minh observed a reduction of regional Nitrogen Dioxide levels of about 15%, especially from transportation. Furthermore, Samut Sakhon, Thailand, saw the greatest decline in Nitrogen Dioxide levels during the COVID-19 epidemic, at 56.4 %, from which the factories are spread out and there is a lot of traffic (Oo et al., 2021). It serves as another piece of evidence that the expansion of Nitrogen Dioxide in Southeast Asian countries is primarily caused by transportation activity. However, because of a number of climatological reasons, the mean monthly air pollution in Southeast Asia spiked in March. In March, both in 2020 and 2021, there was a continuous rise in the level of Nitrogen Dioxide.

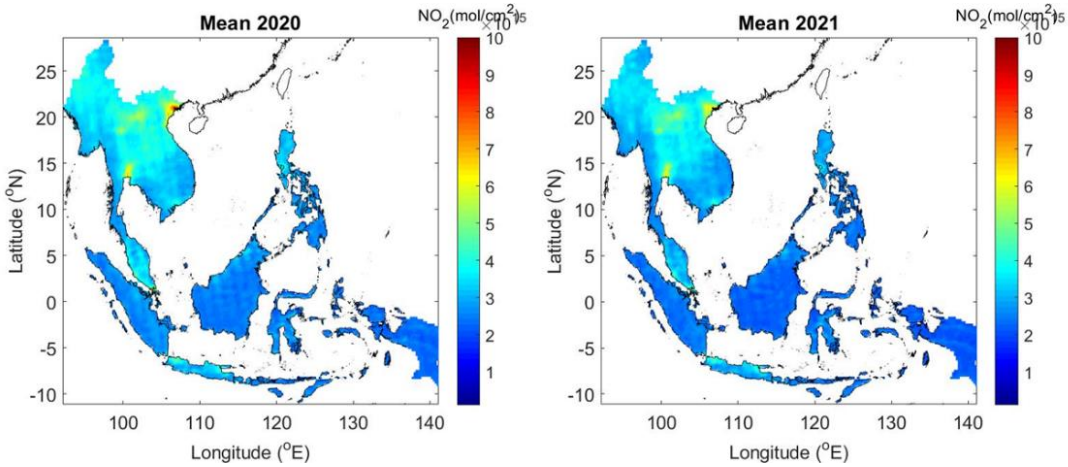

Figure 3. The average mean of Nitrogen Dioxide pollution in both 2020 and 2021.

Figure 3 shows that the largest zone of Southeast Asia had a significant fall in Nitrogen Dioxide emissions. The lockout policy implemented across both years resulted in a relatively small difference in the average mean Nitrogen Dioxide concentration during the years 2020 and 2021. Since the COVID-19 epidemic first broke out, there has been a decrease in Nitrogen Dioxide in Asian and European countries as part of COVID-19 lockdowns, according to reports from NASA and the European Space Agency (ESA) (Oo et al., 2021). The map demonstrates a distinct reduction in colour intensity and a lack of fading in the hotspots where certain pollutants are concentrated in high concentrations over Southeast Asia (Elsaid et al., 2021). Based on the previous study by (Metya et al., 2020), for the first time in the previous five years, a significant decrease in Nitrogen Dioxide levels was observed in three consecutive months, January, February, and March. This large decrease is visible in both 2020 and 2021. This large decrease is visible in both 2020 and 2021. Additionally, Nitrogen Dioxide generates nitric acid and acid rain, both of which are damaging to the ecology as a whole (Zhang et al., 2020). The accumulation of Nitrogen Dioxide exhibits a strong predictable pattern, peaking in March and declining in August. The annual occurrence of large-scale post-monsoon crop residue episodes has been linked to a substantial increase in Nitrogen Dioxide levels across several regions of Southeast Asia (Ul-Haq et al., 2015).

3.2 Sulphur Dioxide

The Southeast Asia region experiences high concentrations of Sulphur Dioxide from January through March, according to the long-term seasonal meteorology of the pollutant (Metya et al., 2020). To worsen the situation, the bordering region, China, plays a major role in coal usage and relies heavily on coal for energy production (Filonchyk et al., 2020). It is clear that the majority of the power stations are concentrated all across north-central China and east-India which exacerbates the problem of sulphur dispersion to the neighbouring Southeast Asian countries. In the same manner as Carbon Dioxide, it is anticipated that emission levels of Sulphur Dioxide will decrease as well providing a noticeable difference in the quality of the air due to the suspension of many industrial operations as well as the restriction of transport systems as a result of the quarantine and lockout of COVID-19.

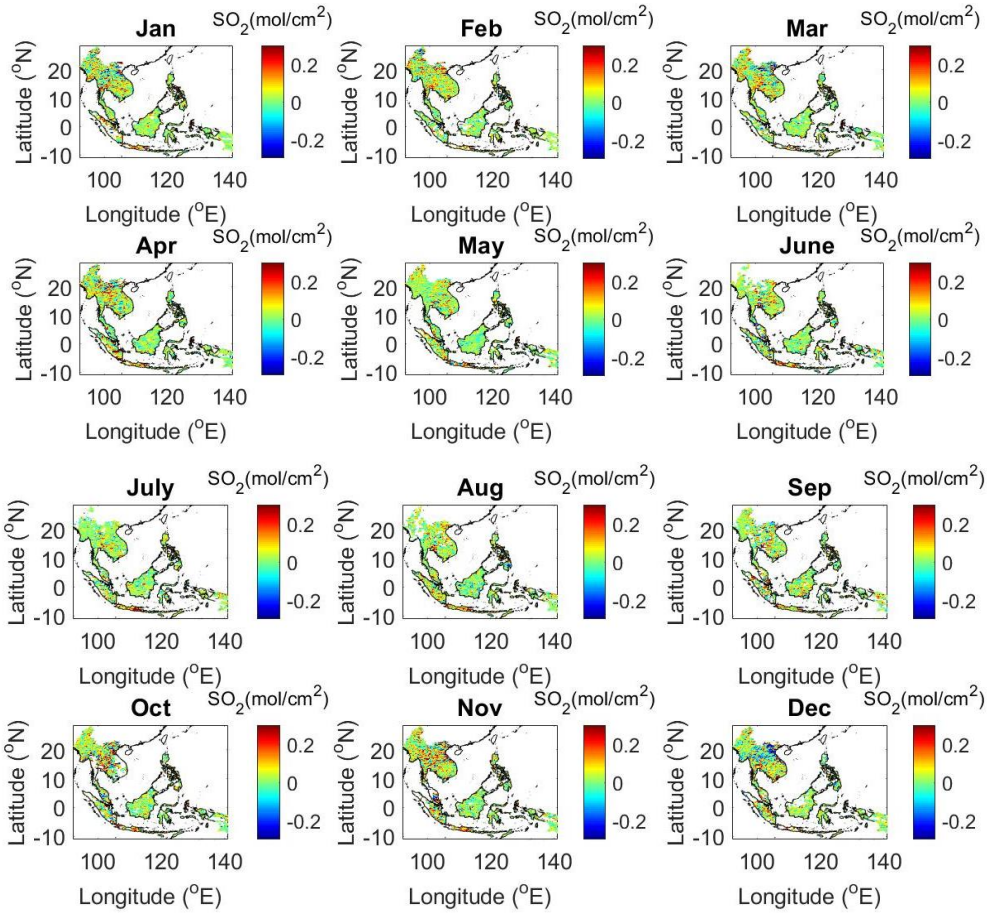

Figure 4. Sulphur Dioxide pollution mapping in 2020.

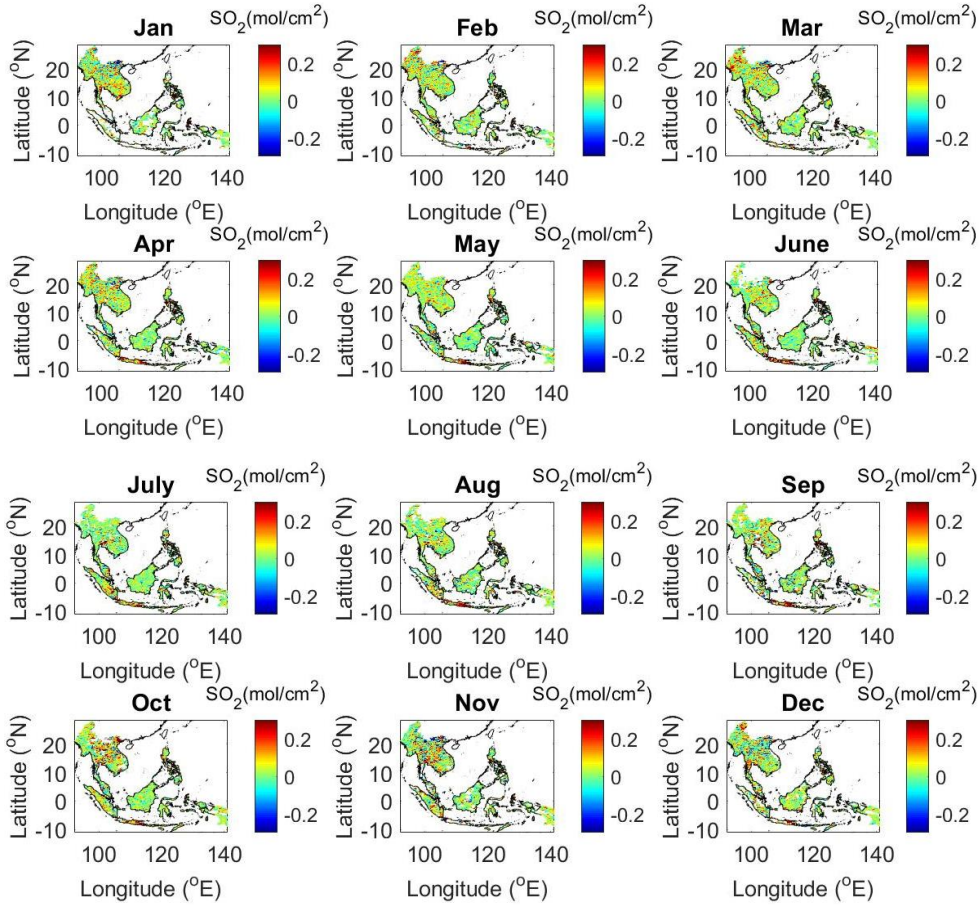

Figure 5. Sulphur Dioxide pollution mapping in 2021.

Sulphur Dioxide levels are shown to have decreased in comparison in Figure 4 and 5 for the years 2020 and 2021. This decline is attributed to the closure of both large- and small-scale operations throughout the COVID-19 lockdown circumstances within every Southeast Asian region. Through 2020, the amount of Sulphur Dioxide in the atmosphere has likely dropped because of an improving energy efficiency brought on by the COVID-19 pandemic, notwithstanding the disturbingly high amounts of Sulphur Dioxide that are still present. The implementation of restrictive regulations to stop COVID-19 from spreading which involves restricting flight operations, securing the border and local industry, and compulsory self-isolation, potentially result in a decline in economic expansion as well as having a favourable influence on the environment. As a result, this permits an improvement in the continent's environmental quality in Southeast Asia.

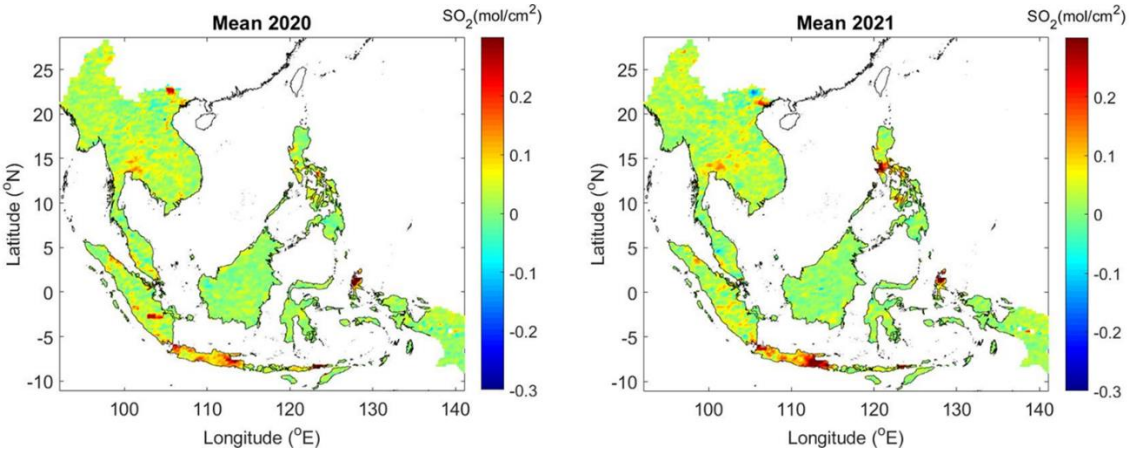

Figure 6. The average mean of Sulphur Dioxide pollution in both 2020 and 2021.

Given the existing circumstances, it is reasonable to conclude that the recent shutdown reduced the concentration of sulphur dioxide on a broad scale, where there is a fall in energy consumption from the group of thermal power plants. Additionally, the COVID-19 pandemic's lockdowns and movement prohibitions have had a mixed effect on the ecosystem in the surrounding area. The overall mean of Sulphur Dioxide for the year 2020, as shown in Figure 6, indicates less contaminated air quality than those for the year 2021. Given that the epidemic initially broke out and covered the entire planet in 2020, it is thought that the year 2020 experienced a greater fall in sulphur dioxide than the year 2021. There is significantly greater pollution in 2021 than there was in 2020 as a result of several governments relaxing some of their tight regulations.

It is undeniable that the Southeast Asia continent's transboundary haze pollution and environmental quality have both significantly improved following the localization of the COVID-19 epidemic. Additionally, referring to Figure 6, it is evident that locations with a predominance of coal-fired power stations emit minimal sulphur dioxide concentration as a result of the lockout due to the reduced demand for energy (Metya et al., 2020). Although there has been a decline in Sulphur Dioxide emissions, not all places with power stations have experienced this dramatic decrease. In certain places, locations near power stations still have significant amounts of sulphur dioxide. For instance, electricity plants continued to run continuously in the Indonesian district of Banten amidst the quarantine (Praveena & Aris, 2021).

3.3 Aerosol

To compare the pre-lockdown period to the present, both the Air Quality Index and the AOD have improved dramatically. The AOD concentration is location- and month-dependent, as seen in Figures 7 and 8, all over the year and during the quarantine, the values in Southeast Asian countries close to China are higher than those in other regions. Along with local contaminants, the land is polluted as a result of anthropogenic activities in the bordering countries. There are international issues with air and atmospheric degradation. In Bangkok, Thailand, for example, the average AOD levels for 2020 and 2021 are consistently rising amidst the shutdown that was in effect.

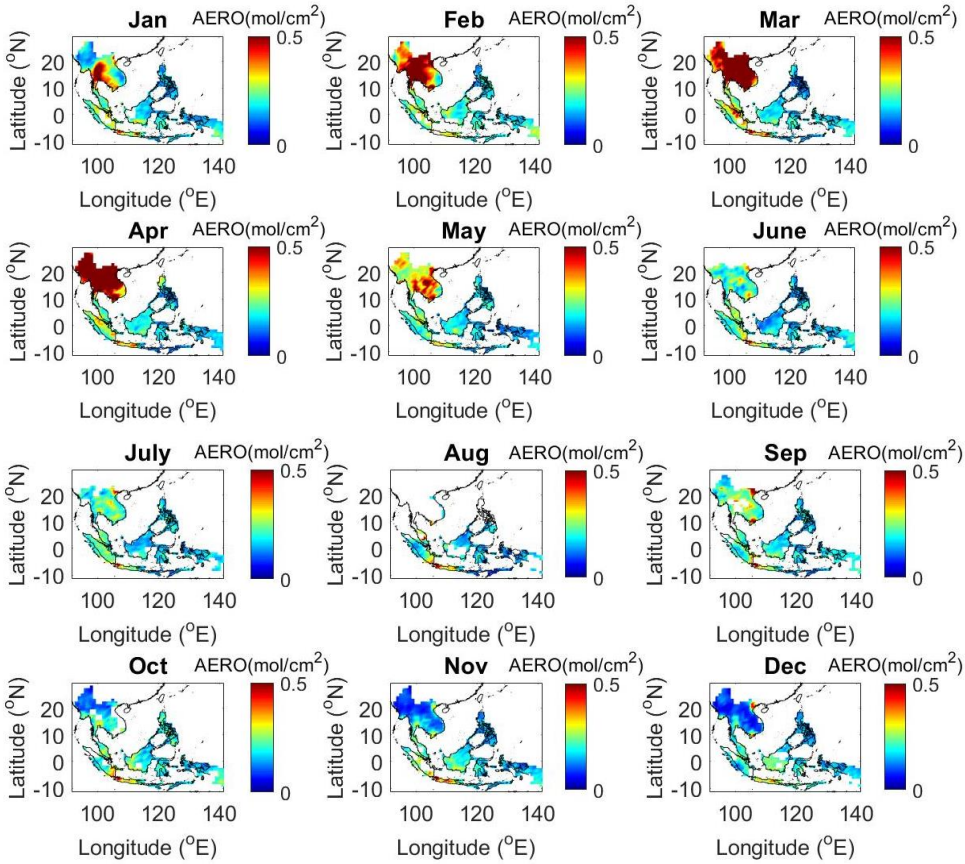

Figure 7. Aerosol pollution mapping in 2020.

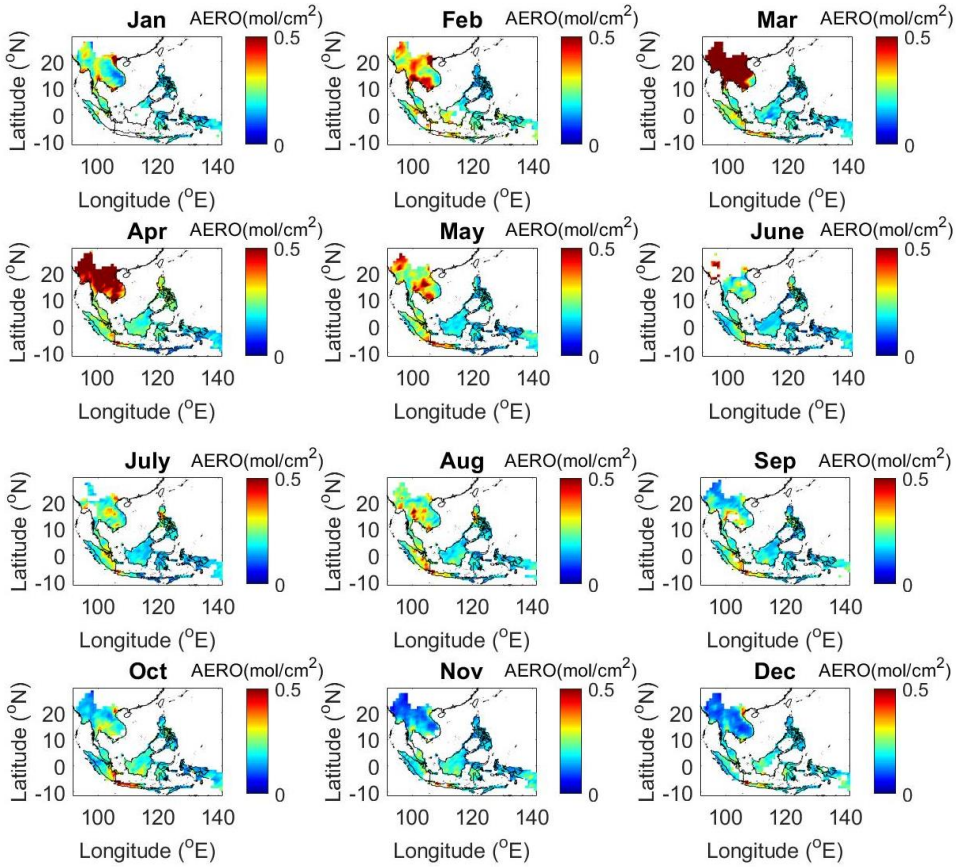

Figure 8. Aerosol pollution mapping from 2021.

Given that both natural and man-made occurrences give some effects on the concentration of atmospheric aerosols in Southeast Asia, it has become overwhelming. In Vientiane, Laos, the rate of expansion in AOD was extremely high in 2020, which can be seen in Figure 7 above. It suggests that there is substantial seasonal and annual variability that is closely correlated with biomass burning practises, local or regional meteorological, and other factors (Kanniah et al., 2020). In contrast, there has been a decrease in regional aerosol emission accumulation in other Southeast Asian countries. Since the AOD is mostly brought on by local and human releases, the northern region of the Southeast Asian peninsula's biomass-burning plumes has little of an impact on these places (Kanniah et al., 2020). For the first time, the catastrophic COVID-19 breakout and ensuing global recession served as the basis for a study that was done in real-time to ascertain how lower emissions would help the global issue of environmental pollution. AOD values have decreased in the areas surrounding Kuala Lumpur, Brunei, Singapore, and Manila, according to a thorough observation of the country's urban centres. Figure 7 and 8 show how the worldwide economic collapse brought on by the coronavirus pandemic created these situations in which different level of AOD indicates the concentration of air pollution in the area.

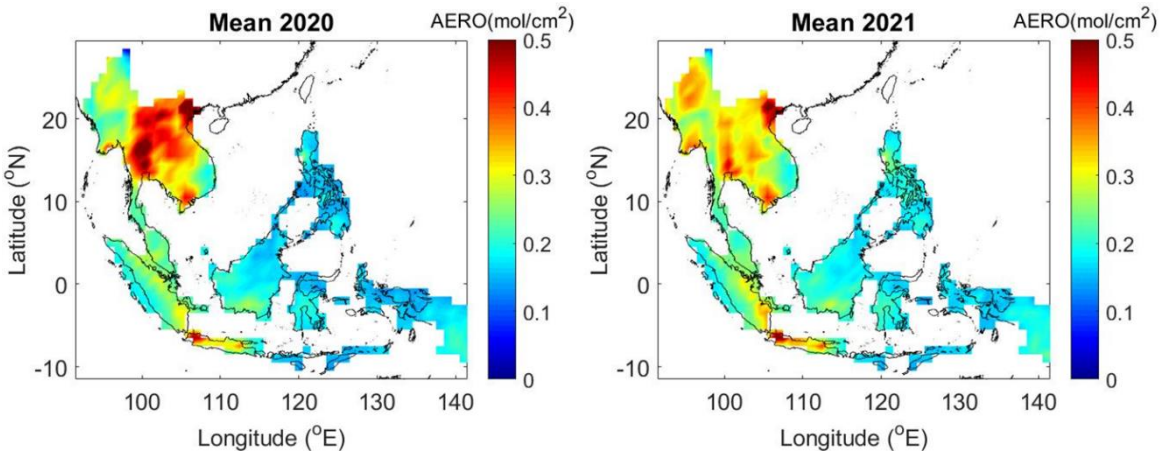

Figure 9. The average mean of Aerosol pollution in both 2020 and 2021.

Figure 9 shows the analysis of satellite measurements of the mean average for aerosol in 2020 and 2021. Starting in February 2020, the COVID-19 epidemic has significantly disrupted daily life for everyone throughout the world. With the exception of the service of critical sectors, the early shutdown stage in the vast majority of countries has resulted in strict limitations on movement, travel, economic, and industrial operations. Upon interfering with anthropogenic activities, Aerosol discharges from human activity may have been significantly reduced, which could have had a variety of effects on the local ecosystem. The shutdown, according to the satellite observation, has significantly reduced the AOD discharge in Southeast Asian regions.

In Figure 9, notably for the year 2021, the decrease in the average mean aerosol concentration for both 2020 and 2021 is clear. In the upper section of Southeast Asia, as depicted in the figure, there is a noticeable difference in the intensity of the red colour for the year 2021 compared to the year 2021. These severe regulations are thought to have significantly decreased human-caused environmental pollution, aerosols, and associated constituent gases (Yang et al., 2022). Contrarily, it was found that the air quality during the pandemic was being negatively impacted by pollution discharge from natural sources, namely burning biomass which effectively concealed anticipated air quality progress associated with the lockdown.

4. Conclusion

In conclusion, analysis of air pollution concentration is important as it shows the difference in air quality which can help the improvement of air quality standards. It is critical to measure air pollution levels on a regular basis and maintain an accurate inventory in order to predict unanticipated circumstances. Air pollution monitoring using satellite observation such as the NASA GIOVANNI, and OMI is used to determine the amount of air pollution concentration on earth. In Southeast Asia, there is a significant decrement in air pollution after the lockdown has taken place in the research made by other researchers. In this study, COVID-19 plays a vital role in the reduction of air pollutants as humans went through self-isolation and no commercial activities were done to prevent the spread of the virus which shows the differences in air quality during the pandemic. Regardless of the negative situation, COVID-19 has imposed, multiple studies have shown that the natural ecosystem has profited immensely from the reduction or elimination of various pollution sources. Nitrogen Dioxide exhibits a significant national level drop while Sulphur Dioxide, on the contrary, exhibits a significantly lower scale of decline at the state level. Furthermore, Satellite data show that the closure significantly reduced the amount of AOD in Southeast Asian nations. According to a number of studies, the performance of the atmosphere has

improved, and main pollutants including carbon dioxide, nitrogen dioxide, sulphur dioxide, and particulate matter discharges have decreased. As a result, their airborne intensity has dropped.

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