The relation between total column ozone with UV radiation and CO$_2$ concentration on the island of Kalimantan during the Covid-19 Pandemic

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Abstract. The concentration of ozone in the ozone layer is minimal, but it means a lot to live. The total amount of column ozone varies, mainly influenced by solar radiation and anthropogenic activity. In this study, the total column ozone during the Covid-19 pandemic, and the effect of UV radiation and CO$_2$ concentration on Kalimantan's island was reviewed. Based on the research results, it can be seen that on Borneo's island in September and October 2019, the total column ozone reached 0.0056 J/m$^2$. From November 2019 to March 2020, the total amount of column ozone decreased to 0.005 J/m$^2$. The total amount of column ozone increased in April 2020 but declined in May 2020, and from June to September 2020, it increased to reach 0.006 J/m$^2$. The numbers are related but not significant with UV radiation (correlation 0.25) and CO$_2$ concentration (correlation -0.40). It can be concluded that UV radiation and anthropogenic activity affect the total column ozone.

1. Introduction
In December 2019, a new coronavirus disease, Covid-19, was reported in Wuhan, China [1]. Covid-19 was confirmed to be transmissible from human to human, so it received significant attention from the WHO (World Health Organization). The previous outbreak, SARS (Severe Acute Respiratory Syndrome), is gradually disappearing due to the summer that appears in July. Several previous studies also reported that Covid-19 is also related to meteorological factors [2]. This research is of concern, the results show a relationship between Covid-19 and air temperature, humidity, and latitude. However, more empirical evidence is needed concerning this in terms of preparations and strategies that can be taken in the future [3].

Several studies have also explained the possible link between latitude and vitamin D deficiency and death from Covid-19 [4]. Vitamin D is greatly influenced by ozone variability because ozone filters UV-B radiation from the sun, an essential vitamin D synthesis [5]. Therefore, it is necessary to know and map the ozone concentration during the range of Covid-19 incidence in Indonesia. The relationship between the total column ozone (TCO), carbon dioxide, and UV radiation is a major challenge associated with global warming. Many human activities result in the release of carbon dioxide into the atmosphere, causing the total ozone column to decrease. This then causes the increase in UV radiation that can enter the Earth's surface. Kalimantan Island is one of the islands located on...
the equator, so that it will receive a very high intensity of solar radiation. Of course, high solar radiation will also cause high incoming UV radiation. Kalimantan Island itself is an island that is quite active in producing carbon dioxide. Carbon dioxide is produced from coal mining activities and land and forest fires. Based on the research that has been done, this study identifies the relationship between the total ozone column to solar radiation and carbon dioxide concentrations in the Kalimantan region during the Covid-19 pandemic.

2. Method
The data used in this study is the total data of the ozone column, ozone concentration, UV radiation, and in the Kalimantan region from September 2019 to September 2020, downloaded on ECMWF (European Center for Medium-Range Weather). The method used is the descriptive analysis method to determine the relationship between parameters using the correlation coefficient value (eq. 1). Mapping is done using the Kriging interpolation method.

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r = \frac{n \sum xy - \sum x \sum y}{\sqrt{\left(n \sum x^2 - (\sum x)^2\right) \left(n \sum y^2 - (\sum y)^2\right)}}
\]  

(1)

3. Result and Discussion

3.1 Total Column Ozon and UV Radiation
After averaging the total ozone column and UV radiation in the Kalimantan area, it can be seen in Figure 1 that there is no clear pattern of the relationship between the total ozone column and UV radiation. The TCO variability is influenced by 1-2% of solar radiation activity, where the energy emitted by solar radiation also affects the TCO variability. UV radiation itself has a maximum value of 2 times a year, namely in March and September. The sun's position causes the UV radiation pattern, of course, at the equinox, causing the incoming radiation to be greater than other months. Likewise, for the effect of UV radiation on TCO, UV radiation only has a small effect on the TCO value. UV rays more influence the TCO value when entering the summer (dry) [6]. The greater the radiation energy emitted, the higher the effect on the TCO value [6]. The total ozone column increased when the Indonesian territory began to apply PSBB (Pembatasan Sosial Berskala Besar) from March 2020 to July 2020. The increase in the total ozone column had increased previously from March 2018 to August 2018. This is possible because of aerosols' greater influence in the atmosphere, direct solar radiation or UV rays.

3.2 Total Column Ozon and CO₂ Concentration
The carbon dioxide concentration itself appears to have a clear annual pattern. It can be seen that the concentration always decreases starting in May before increasing again in August. However, every year's average value must always increase, meaning that carbon dioxide has increased every year. The concentration of CO₂ released into the air is strongly influenced by anthropogenic activities, namely the combustion of biomass, coal, and petroleum. Also, the decay rate of CO₂ gas is prolonged, causing CO₂ to increase its concentration level [7]. Figure 2. shows that when there is a decrease in carbon dioxide concentration, it will be followed by an increase in the total ozone column. This occurred from May to August 2018 and May to August 2019, followed by the rise in the total ozone column. Likewise, for the current pandemic conditions, carbon dioxide concentrations have decreased from April to June 2019, followed by an increase in the total ozone column. The association between total ozone column and carbon dioxide concentration was more transparent, although it did not significantly affect. The decrease in carbon dioxide concentration is, of course, caused by reduced anthropogenic activity [8]. Previous studies that have been conducted have shown that concentration has an inversely proportional relationship with TCO. The more CO₂ gas, the more O₃ gas is released to retain less UV radiation in the ozone layer [7].
Based on the correlation value from September 2017 to August 2020, the total ozone column has a correlation value of 0.36 to UV radiation and -0.27 to carbon dioxide concentration. If it was correlated during the pandemic conditions, from December 2019 to July 2020, the total ozone column against UV radiation and carbon dioxide concentration was 0.25 and -0.4, respectively. This means that the ozone concentration has a relationship with the total ozone column even though the effect is not significant enough.
Figure 3. Total ozone column in Kalimantan region in February 2020 (a) and July 2020 (b)

Based on Figure 3 obtained with the software and using kriging method, the difference in the ozone column’s total value in the Kalimantan region can be seen. Before implementing the PSBB, namely in February 2020, the ozone column's average total value in the Kalimantan region was 0.0054 J/m². Meanwhile, after implementing the PSBB, namely in July 2020, there was an increase in the total ozone column to reach 0.0056 J/m². It also shows that the distribution of TCO values is influenced by the orbit of the sun. In April - August (Summer Solstice), the sun tends to be in the northern part of the earth, while in October - February (Winter Solstice) the sun tends to be in the southern part. This shows the influence of PSBB, in this case, anthropogenic activity on the total ozone column.

4. Conclusion
The total ozone column was related to carbon dioxide concentration, although it was not significant enough based on the correlation value obtained. The total ozone column has a correlation value with carbon dioxide concentrations of -0.27 (September 2017-July 2020) and -0.4 during the pandemic (December 2019-July 2020). Meanwhile, the total ozone column has no apparent correlation with UV radiation with a correlation value of 0.36.

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