TROPHOSPHERIC CARBON MONOXIDE TRENDS OVER MALAYSIA USING SATELLITE-SENSED DATA FOR A PERIOD OF 2000-2018

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Abstract

Tropospheric carbon monoxide (CO) is one of the most significant air pollutant gas that can affect human health, as stated by United States Environmental Protection Agency (USEPA). This study aims to evaluate the trend of CO gas using 18 years of data (April 2000 – December 2018) measured by Measurements of Pollution in the Troposphere (MOPITT) over Malaysia. The results show significant decrease in concentration of CO with mean of monthly carbon monoxide of 113.25 ppbv for the entire period. The seasonal cycle of CO showed maximum levels in December-January, but minimum levels in June-August. The highest values of CO were in west region of Peninsular Malaysia throughout the year. The CO gas was highly concentrated over the west region of Peninsular Malaysia resulted from human activity and abundance sources of CO at this area due to its larger number of human populations, various industrial activities, crowded city with extremely higher traffic.

Keyword: Carbon monoxide trend, Satellite-Sensed Data, MOPITT, Giovanni 4

Introduction

Since few decades ago, environmental problems concerning air pollution has become a big issue around the world. Carbon monoxide (CO) is a chemically reactive trace gas that possess physical characteristic of colourless, odourless, tasteless and a poisonous gas at high concentration. CO is identified as an indirect greenhouse gas that will affect the change in climate by its interactions with methane, carbon dioxide and tropospheric ozone (Zheng et al, 2018). The indirect greenhouse gases are defined as non-methane volatile organic compounds such as nitrogen monoxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO). These gases will react with other chemical compounds producing direct greenhouse gases and these indirectly contribute to global warming (USEPA, 2014). It is emitted during combustion of fossil fuels, burning of the biomass, and from the oxidation reaction of methane by hydroxyl, OH radicals or other hydrocarbon (Salih et al., 2018). CO gas threatened human health because it has 200 times greater affinity for hemoglobin than carbon dioxide (CO_2) (Perutz, 1990). Breathing the high concentrations of CO leads to the lesser amount of oxygen transported in the blood stream to important human organs like the heart and brain. Excessive human exposure to CO gases can cause headaches, confusion, unconsciousness and for long term exposure can cause brain damage or death (Fisher et al., 2011).

Malaysia is one of the Southeast Asia country that contribute significantly to the growth of economy due to high level of urbanization and rapid growth of industrialization (Yuen & Kong, 2009). The rapid growth in industrialization and urbanization has been the source of the release of harmful of gases especially CO as. For the last few decades, concern on sustainable development, environmental pollution, depletion of natural resources and economic hardship in renewable energy investment has increased (Hou et al., 2019; Shahsavari, & Akbari, 2018; Pojani, & Stead, 2015). Therefore, it is extremely vital to identify and keep track on the pollutants changes in atmosphere and other parameters needed to determine its impacts on the health of human and surroundings.

Developing countries like Malaysia lack in mechanism to monitor and track such changes and emissions of pollutants in ground based monitoring networks due to lots of money investment needed. Wth current developments in atmospheric remote sensing area, sensors that is reliable has been developed such as AIRS, MOPITT, SCIAMACHY, IASI and TES14. All of these sensors have been successfully monitored the emission and changes of gases such as CO, CO_2 and CH_4 (Buchholz et al., 2016; Zheng et al., 2018). Satellite observations provide good global coverage and quantitatively data with good spatial and temporal resolution. In addition, satellite observations will increase our capability in analyzing human activities impact on the change of world climate and pollutant composition in the atmosphere. Furthermore, these free downloaded satellite data is one of the useful space tool in observing the condition of earth's atmosphere. Various satellite instruments such as SCIAMACHY, MOPITT, IASI, AIRS and TES14 recorded the value of tropospheric CO concentrations at infrared wavelengths. Among of these instruments, MOPITT is widely used due to its ability to provides the longest consistent time series of satellite CO retrievals to date. Continuous improvements on the algorithm has been done and several times of reprocessing of the archive has been conducted. Hence, MOPITT is particularly the best tools in investigation of pollution transport and CO emission. Therefore, this study was intended to analyze the trend of monthly distribution of CO over Malaysia including Sabah and Sarawak using satellite (MOPITT) data over a period of 2000-2018. Results of this study will help in identifying the trend of carbon monoxide emission over Malaysia, therefore the Department of Environment (DOE) can provide ways in controlling the gas emission.

Materials and Methods

Materials

GIOVANNI 4 interface for visualized and analysed purposes was used in this study. The data of CO concentrations were acquired from MOPITT (Measurements of Pollution in the Troposphere). MOPITT is an instrument that on-board Terra satellite used to measure CO in the troposphere. MOPITT Level3 (MOP03TM_V008) which is considered the most stable instrument with fewer random errors due to geophysical noise was used in this study. The resolution for this product is 1^o x 1^o spatial resolution.

Methodology

Study area covered the latitude range of 10ºS to 31ºN and the longitude range of 90ºE – 130ºE was selected. South of Myanmar, Thailand, Cambodia, Laos, Vietnam, Malaysia and part of Indonesia are included in this study area. These area were selected to check whether these area affect the distribution of CO gas in Malaysia. Area averaged time series graph was plotted for the period of 2000 to 2018. Graph of standard Giovanni time-series was constructed by determining the spatial averages over the selected area of a given variable for each time step within the user's range. Each average value was then plotted against time to create the time-series output. Seasonal time series was also plotted in this study. The Seasonal Time Series calculates an area-averaged time series for each year in the user's selection for a meteorological season monthly, Dec -Feb, March – May, June – August and Sept – Nov. Finally, time-averaged map for the period of April 2000 to December 2018 was plotted. The time-averaged map shows the data values for each grid cell within the user-specified area, averaged (linearly) over the user-specified time range as a map layer. The plotted graph was then analysed.

Results and Discussion

Monthly Long-Term CO Data Trend Analysis

Figure 1 shows the mean CO values monthly time series over Malaysia from April 2000 – December 2018. The average concentration of carbon monoxide recorded was 113.25 ppbv for the entire period. The CO trend was shown to be negative trend per year. These decreasing trends of CO agree with global trend of CO gas data from the National Oceanic and Atmospheric Administration (NOAA) (Girach, & Prabha, 2016) and come to an agreement with previous studies (Yin et al., 2015; Rajab et al., 2011). The decreasing trend of CO could be due to the moistening level of troposphere and tropospheric ozone that has been increased, causing increase in hydroxyl, OH radical (factors that strengthened the depletion of lower-tropospheric CO (Girach, & Prabha, 2016). The primary sink of CO is oxidation by the hydroxyl radical (OH). Furthermore, the decreasing of CO can be related to the government enforcement, pollution reduction strategies implemented, awareness and the development of new technologies in resolving issue of CO pollution. In addition, reduction and good control of open forest fires activities from neighbor country, especially in Sumatera, Indonesia during 2000 – 2018 also affect the low-level concentration of CO in troposphere.

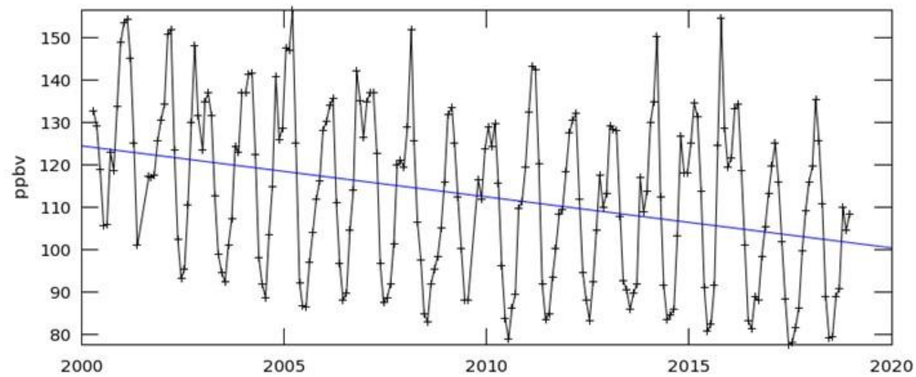

Figure 1 The MOPITT time series, area averaged of thermal only CO mixing ratio profile (daytime) monthly over Malaysia from April 2000 – December 2018 (Source: NASA GES DISC, 2019)

Seasonal Monthly Long-Term CO Data Trend Analysis April 2000 – December 2018

Figure 2 shows the distribution of monthly coverage of CO for January to December during year 2000 to 2018. Overall, CO maximum values occurred during month of December to month of February and the minimum CO values were occurred during June to August. The CO data values varied depend on the meteorological season because the air pollution in Southeast Asia is mainly control by the monsoon regimes. During the winter monsoon that caused the heavy rain throughout the country, cold wind flows from the region of Siberia and northeast Asia carries a substantial volume of pollution to Southeast Asia while crossing through the seriously polluted area of East Asia (Pochanart et al., 2003). During the summer monsoon, there is less impact of air pollution transported due to the fewer regional biomass burning activity has been done, and small amounts of air pollution brought by the marine air masses to southwest Asia from the Indian and Pacific Oceans (Rajab et al., 2011).

Furthermore, the different in CO trend seasonally was mainly resulted from the seasonal photochemical cycle of the concentration of OH in the troposphere. In the Northern Hemisphere, during winter and early spring, the concentration of OH is at minimum and thus the concentration of CO gas is at maximum level (Salih et al., 2018; Novelli et al., 1998).

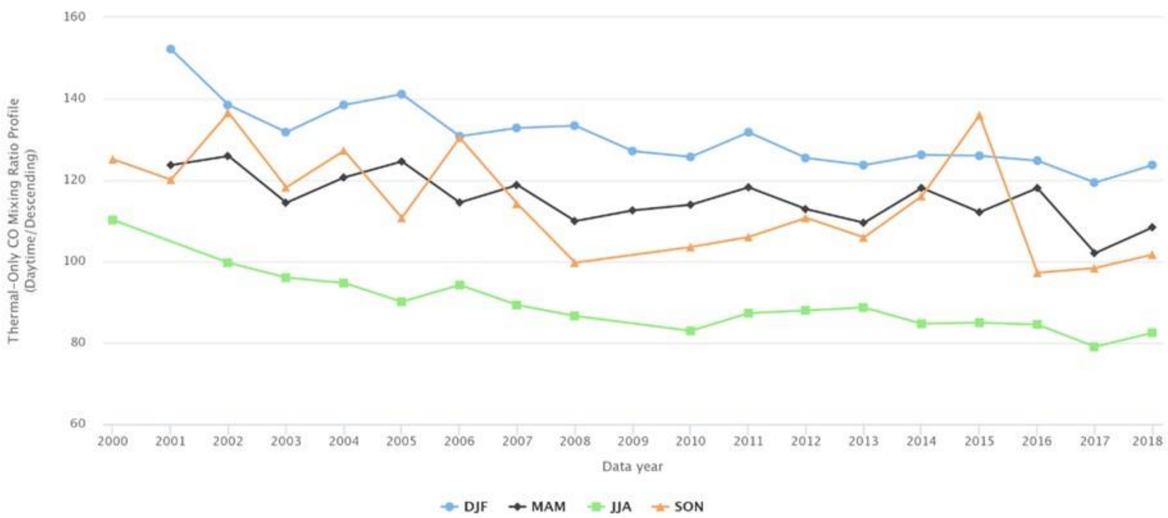

Figure 2 The MOPITT monthly coverage retrieved CO for Dec-Jan-Feb (DJF), March-Apr-May (MAM), June-July-August (JJA) and Sept-Oct-Nov (SON) over Malaysia from April 2000 – December 2018 (Source: NASA GES DISC, 2019)

Overall, the highest values of CO were observed in west region of Peninsular Malaysia throughout the year as depicted by **Figure 3**. The CO gas was observed in high concentration over west region of Peninsular Malaysia compared to any other areas due to the congested cities, various human and industrial activities at this area and affected by the Sumatra peatland fires. This results support findings from Rajab et al. (2011), throughout the year, CO gas were higher in the central and southern regions compared to the other regions maybe because of the various factors such as unidentified CO emitters, crowded cities, and more affected by the peatland fires in Sumatra. The impact of El-Nino that is the natural climate phenomenon that brings hotter and drier weather to South-east Asia also affected the values of CO especially in June -August (Rowlinson et al., 2019).

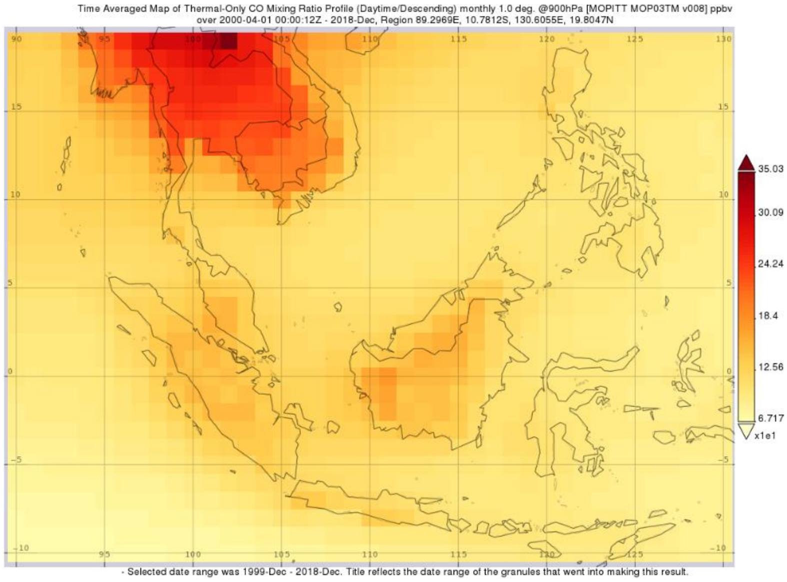

Figure 3 The MOPITT time averaged map of thermal only CO mixing ratio profile over Malaysia from April 2000 – December 2018 (Source: NASA GES DISC, 2019)

Conclusion

The period of 18 years (2002-2018) MOPITT data showed the monthly carbon monoxide mean of 113.25 ppbv for the entire period. Overall, CO data from MOPITT shows decreasing trend over peninsular Malaysia, Sabah and Sarawak. The CO values are strongly correlated with topography and weather conditions. The CO maximum values occurred during December to February (131.04 ppbv) and the minimum CO values occurred during June to August (85.39 ppbv). The highest values of CO were in west part of Peninsular Malaysia throughout the year. The high values of CO over west region of Peninsular were as result of numerous human and industrial activities CO at this area may be because of its large population, congested city and large industrial area and anthropogenic emissions.

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Conflict of interests

Author declares no conflict of interest.

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