DIURNAL VARIABILITY OF TOTAL OZONE, NITROGEN DIOXIDE AND SULFURDIOXIDE COLUMNS OVER BANDUNG, INDONESIA (6.9 S, 107.583 E)

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Abstract

Atmospheric ozone plays important role in preserving living things on Earth from harmful solar ultraviolet radiation. Atmospheric nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) act as very important substances as precursor and destructor of atmospheric ozone. Knowing the importance of these substances therefore LAPAN has conducted observations of total ozone, NO_2 and SO_2 columns in Bandung since 2007 using brewer spectrophotometer. Bandung is an urban area and a capital city of West Java province where rapid development of trading, tourism and industrial activities has declined its air quality. Diurnal variability of total ozone column showed its minimum around 11:00 AM while total SO_2 columns showed relatively stable pattern from early morning to roughly 14:24 PM and then slightly increase to reach its maximum at around 13:00 PM followed by slightly decrease again after. On the contrary, diurnal mean of total NO_2 column values showed relatively stable values over the whole days. Daily trend of total ozone column showed a decrease values while total SO_2 column showed an increase values. On the other hand daily trend of total NO2 column showed relatively stable values over the whole year.

Keywords: Ozone, SO_2, NO_2, brewer spectrophotometer, Bandung

Fig. 1. Brewer spectrophotometer (left) used for the measurement of total ozone, NO_2 and SO_2 columns over Bandung, Indonesia (right) (Source: Nations online project, 2012). It was placed on the top roof of the fourth floor of LAPAN office

INTRODUCTION

Atmospheric ozone is one of gaseous substances that have a very important role in maintaining lives on Earth. Although its natural atmospheric concentration on earth is just 0.01-0.1 ppm (Seinfeld and Pandis, 2008) but its role is very important in absorbing harmful solar ultraviolet radiation before reaches Earth's surfaces. On the contrary, atmospheric ozone also acts as an important green house gas and a secondary pollutant produced by its precursors such as carbon monoxide (CO) and methane (CH_4) with aid of direct sunlight.

Atmospheric nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) have very important role in the production or destruction of atmospheric ozone. They both also act as major air pollutant in the urban area that can lead to acid rain and photochemical smog.

Knowing the important of all those substances therefore since 2007 National Institute of Aeronautics and Space (LAPAN) has undergone monitoring of total ozone, NO_2 and SO_2 columns in Bandung using brewer spectrophotometer. As shown in fig. 1.

Bandung is a basin-shaped urban area surrounded by mountain and located about 768 above sea level. Bandung's climate is humid and cool, with average temperature 23.5 ^{0}C, average rainfall 200.4 mm and average number of rainy days 21.3 per months. Bandung city is one of tourist and education purposes destination (Kota Bandung, 2011). The rapid development of trading, industrial and tourism activities in Bandung has lead to decrease in air quality of Bandung where ozone, NO_2 and SO_2 can be used as indicators. This paper discussed about the diurnal variability of these three substances along with their daily trend over Bandung in 2009.

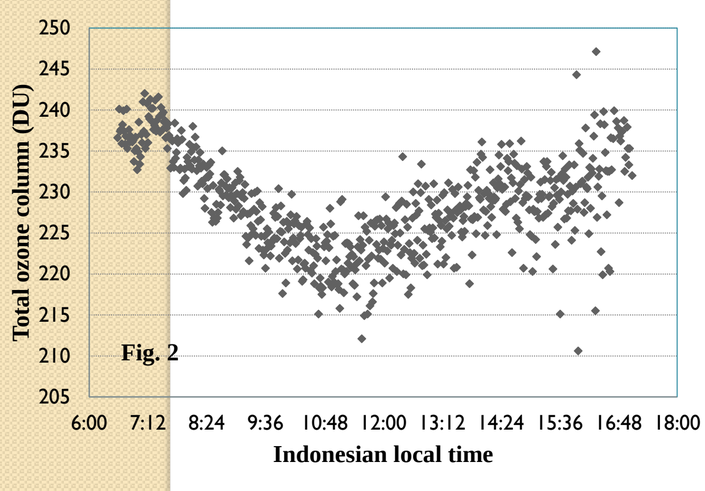
DATA AND METHODE

Data used for ozone, NO_2 and SO_2 analysis were total columns data measured by brewer spectrophotometer in Bandung in 2009. Year 2009 was selected because of its data completeness. Unit used for total ozone and SO_2 columns were Dobson unit (DU) while total NO_2 column was molecules/cm^2.

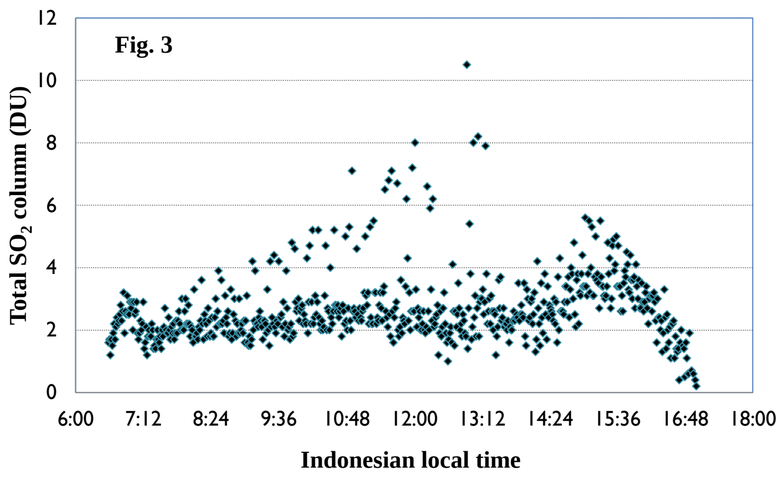
The 24 hours data were then selected where only data with error less than 2.5 were used. Direct solar measurements were selected over solar zenith measurement because of its completeness. Diurnal and daily mean were then calculated to analyze their variability values over the whole year.

RESULT AND DISCUSSION

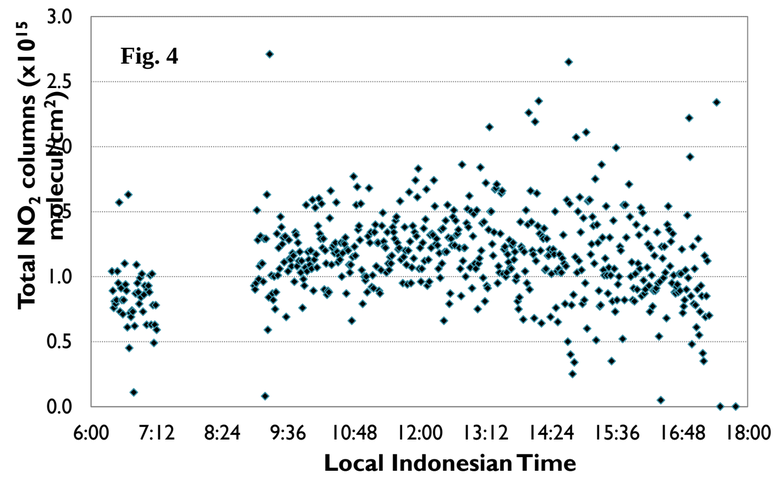
Diurnal variabilities of Total Ozone, NO_2 and SO_2 columns in Bandung in 2009



Diurnal mean of total ozone column ranged from 211 DU to 247 DU as shown in fig. 2. Its values were relatively high during early morning and were then decreasing to its minimum at noon. They were then increasing again to relatively high values during late afternoon. This profile was different from surface ozone measured by Hidayati, et. al (2009) in Bandung where its values were found maximums at noon since production of ozone with aid of direct sunlight was also maximum. On the contrary, measurement of total ozone column over Madrid, Spain showed its maximum values of daily profile at noon. Its profile showed similarity with daily surface ozone profile measured in the same locations (Anton, et. el., 2010).

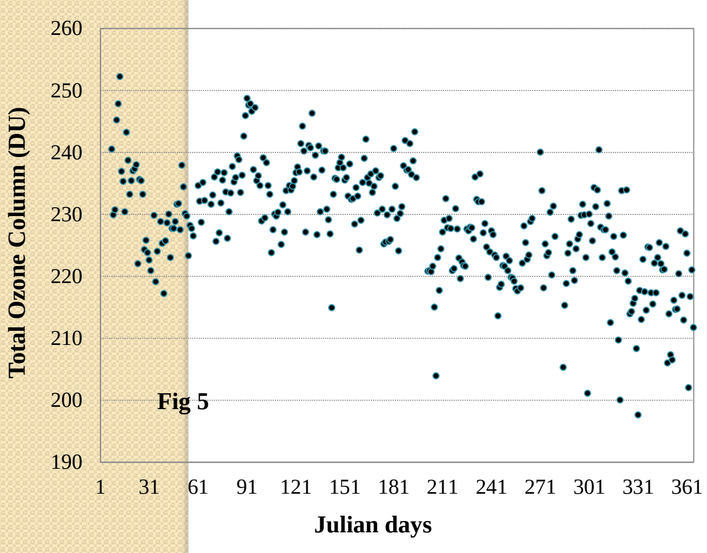


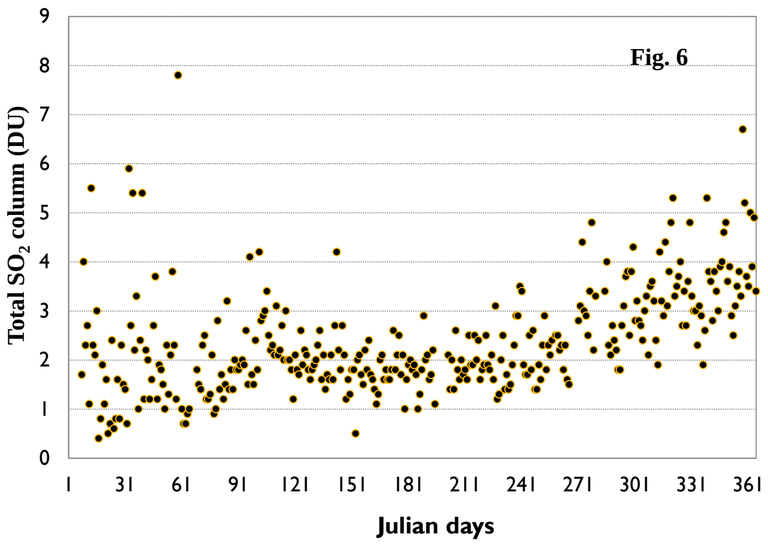
Diurnal mean of total sulfur dioxide (SO_2) columns ranged from 0.2 DU to 10.2 DU as shown in figure 3. Its value was relatively stable from early morning to afternoon. But there was a slightly increase in late afternoon roughly at 03:00 pm and slightly decrease after. Sources of atmospheric sulfur in Bandung were dominated by industrial activities, transportation and Mount Tangkuban Perahu in North of Bandung. Diesel consumed in Indonesia has still relatively high sulfur content (Ministry of Environment, 2007).

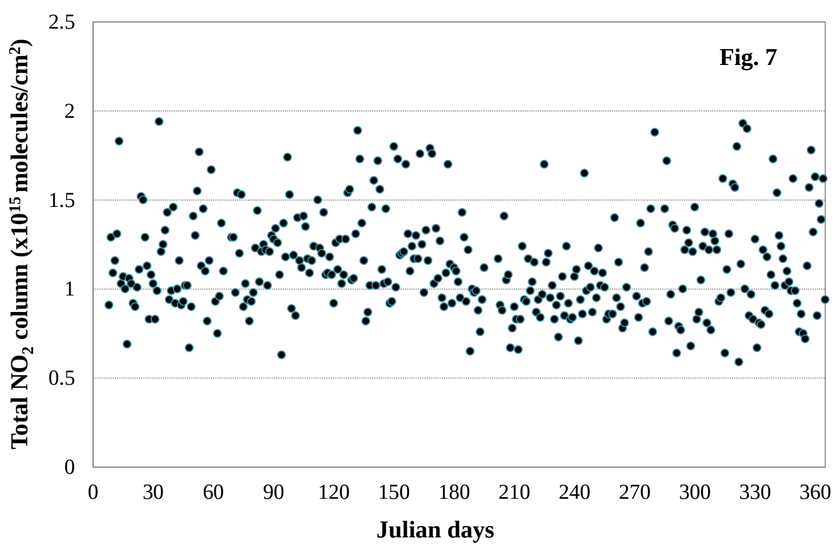


Diurnal mean of total NO_2 columns ranged from 0.05 × 10^{15} molecules/cm^2 to 2.71 × 10^{15} molecules/cm^2 as indicated in figure 4. Generally, diurnal mean pattern of total NO_2 column values showed stable values over the whole day. Surface NO_2 measured by Hidayati, et. al (2009) showed different diurnal pattern where during early morning its value was increasing to reach its maximum around 06:30 AM and then sharply decreased to reach its stable values from 09:00 AM onwards.

Trend of Total Ozone, SO_2 and NO_2 columns in Bandung in 2009







Daily mean of total ozone, SO_2 and NO_2 columns ranged from 198 DU to 252 DU; 0.4 DU to 7.8 DU; and 0.59 × 10^{15} molecules/cm^2 to 1.59 × 10^{15} molecules/cm^2 as shown in figure 5, 6 and 7, respectively. Its values tend to decrease over the whole year. Daily mean values of total ozone column showed sharp decrease while total SO_2 column showed sharp increase. On the contrary, total NO_2 column values showed relatively stable values over the whole year.

This decrease of total ozone column values which could be related to condition of stratospheric ozone should be taken into precaution because of its very important role. On the contrary, increase of total SO_2 column values which could be related to condition of surface SO_2 should also be taken into precaution because of its role as a major gaseous pollutant and also an ozone destructor in the atmosphere.

Conclusion

Diurnal variability of total ozone column showed its minimum around 11:00 AM while total SO_2 columns showed relatively stable pattern from early morning to roughly 14:24 PM and then slightly increase to reach its maximum at around 13:00 PM followed by slightly decrease again after. On the contrary, diurnal mean of total NO_2 column values showed relatively stable values over the whole days. Daily trend of total ozone column showed a decrease values while total SO_2 column showed an increase values. On the other hand daily trend of total NO_2 column showed relatively stable values over the whole year.

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