Spatial distribution of ozone over Indonesia (Study case: Forest fire event 2015)

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Abstract. Tropospheric ozone is known as surface ozone and caused several health impact. The objective of this study was to analysis spatial distribution of tropospheric ozone over Indonesia case study forest fire event in 2015. Monthly observation measured by Ozone Monitoring Instrument (OMI) have been analysed from January – December 2015 to study spatial distribution of tropospheric ozone related to forest fire event 2015. The study discovered high level of tropospheric column ozone (TCO) from October to November 2015. The result shows increasing average of TCO from September to October almost 6 DU. Meanwhile, monthly number of hotspot is higher in September 2015 with total number 257 hotspot which is acquired by Moderate Resolution Imaging Spectrometer (MODIS) Terra version 6.1 with confidence level same or more than 90%. The hotspot distribution compared with spatial TCO distribution and shows interesting time lag with respect to hotspot distribution, one month. Further study for daily comparison of TCO and forest fire event needed. This result suggested that the tropospheric ozone over the Indonesian region increases in 2015 were remarkable and corresponded to forest fire event.

1. Introduction

The abundance of ozone over world is 10% in troposphere, meanwhile good ozone in stratosphere is 90% of total abundance. Tropospheric ozone is considered to be important because of their impacts for human health and loss growth [1,2]. In Indonesia, national air quality standard of tropospheric ozone is 120 part per billion (ppb) [3]. Previous study mention about biomass burning does contribute 4-5% increases of global tropospheric ozone in tropic, which is Indonesia fires contribute during El Nino, as indicated of regional effect within and near burning area in troposphere. Actually, the biomass burning not directly produce tropospheric ozone, however produce volatile organic compounds (VOCs), CH_4, and CO in the presence of NOx and Sunlight which is ozone reaction in troposphere [4].

Tropospheric ozone concentrations measured in Indonesia have two location, first is in Kototabang, West Sumatera and secondly in Kemayoran, Jakarta [3]. Spatially tropospheric ozone does not represent from two location observation, need satellite observation for generate tropospheric ozone abundance. Many techniques deriving tropospheric column ozone (TCO) globally and have some improvement. The

ozone monitoring instrument (OMI) and Microwave Limb Sounder (MLS) combination of Aura derived TCO globally using tropospheric residual method [5].

This paper presents the analysis of tropospheric column ozone from OMI measurements for the period January-December 2015 to identify their spatial variations related to hotspot, as indicator of forest fire, over Indonesia.

2. Data and Analysis

In the present study, monthly mean tropospheric column ozone (TCO) data for the period January-December 2015 were used. The TCO over Indonesia with spatial resolution 1 degree latitude by 1.25 degree longitude was derived from Ozone Monitoring Instrument (OMI) observations. The explanation method to generate tropospheric column ozone by subtracting Microwave Limb Sounders (MLS) stratospheric column ozone from OMI total column ozone data can be seen in previous study [5]. The daily hotspot data for the same period as TCO data were used and was obtained from Moderate Resolution Imaging Spectrometer (MODIS) on board the National Aeronautics and Space Administration's (NAS) terra satellite platforms version 6.1 with 1 km x 1 km spatial resolution (url: http://firms.modaps.eosdis.nasa.gov) [6].

Indonesia lying between the Indian Ocean and Pacific Ocean. The present study focuses on the tropospheric O_3 over Indonesia (12ºN - 15ºS and 90º - 150ºE). Mapping the tropospheric column ozone data using Matlab 2017a and hotspot distribution is mapped by ArcGIS 10.5.

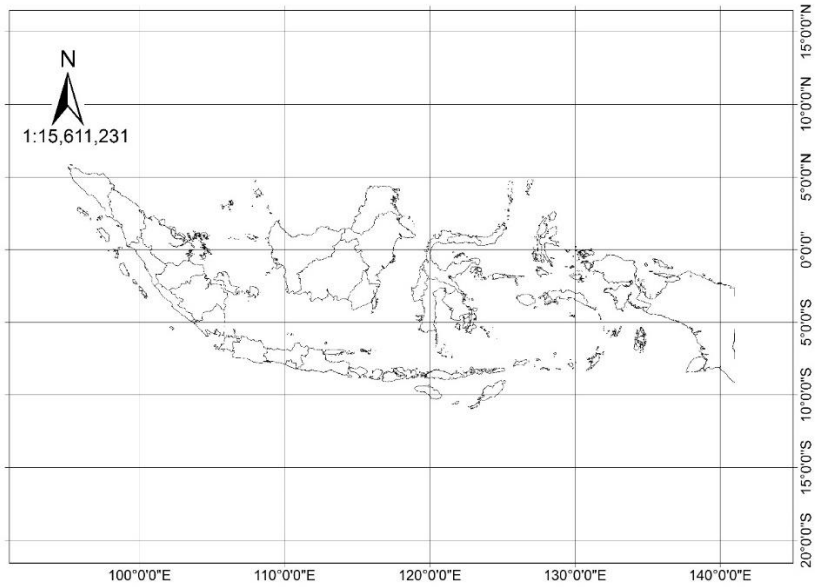

Figure 1. The locations used for the study.

3. Result and Discussion

The variation of TCO from January to December in 2015 (12ºN-15ºS and 90º-150ºE) is illustrated in figure 2-4. There is gradual increase in spatial distribution of TCO from east toward the south west of Indonesia from January to December 2015. October illustrated a very high TCO distribution with November follows close behind. This progression coincides with the number of hotspot in September until November 2015. The TCO unit is Dobson Unit (DU). The interval of TCO value is 5 DU with minimum value 10 DU and maximum 50 DU (which have gradation color dark blue to dark red).

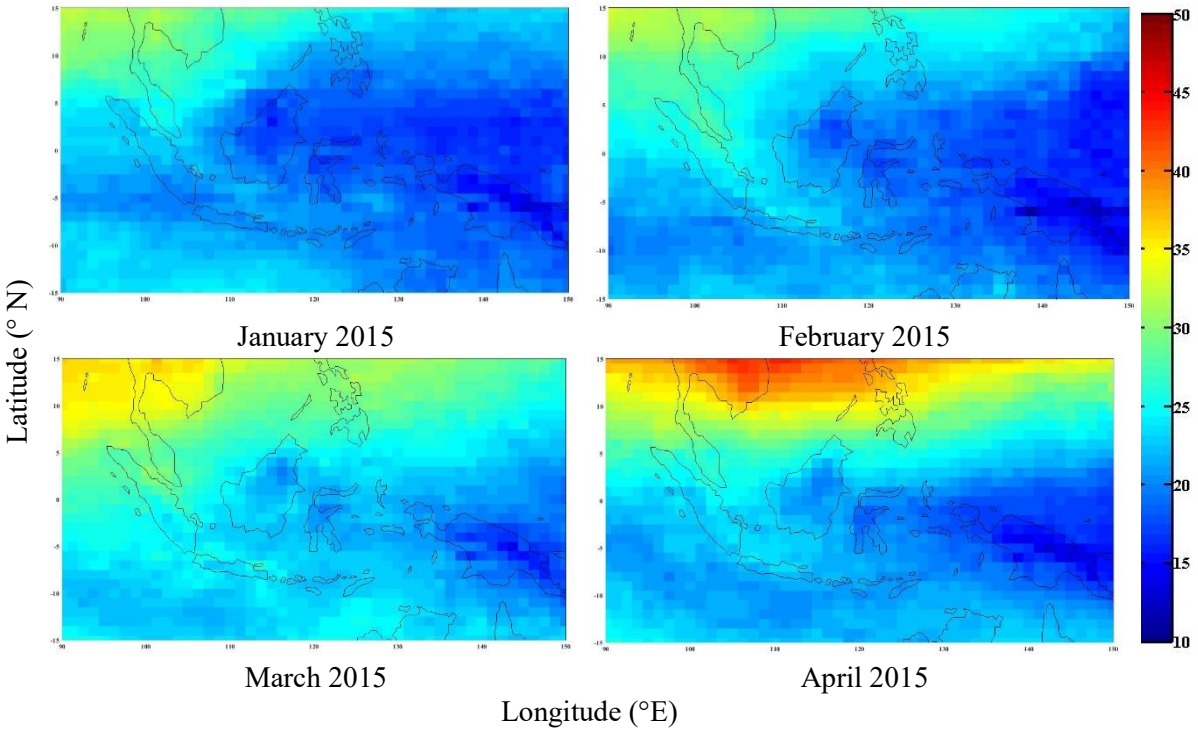

Figure 2. Spatial distribution of tropospheric ozone from January to April 2015 (DU) over Indonesia.

The spatial variations of tropospheric ozone from January to April 2015 is shown in figure 2. The highest value, which have red color, show in April 2015 but that is not Indonesia region. Highest value in north of Indonesia affected by global pattern of tropospheric ozone. Based on figure 3, the gradual variation of tropospheric ozone is higher in west of Indonesia and lowest in east part of Indonesia.

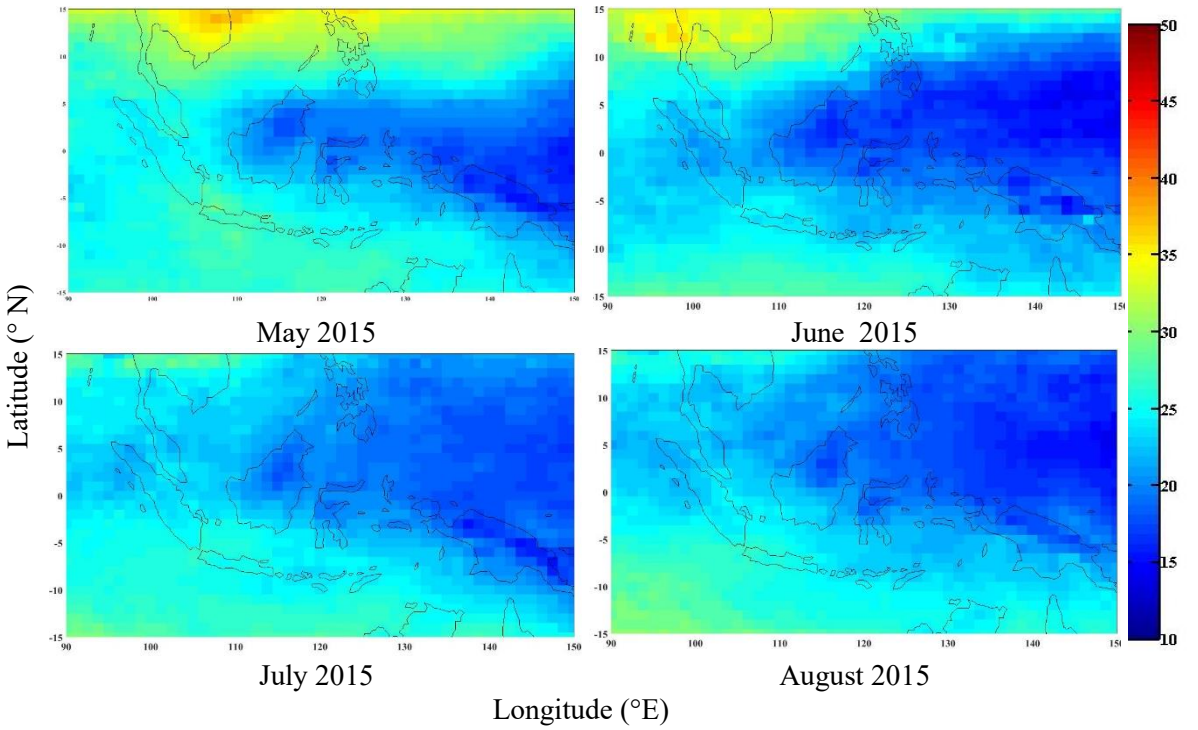

Figure 3. Spatial distribution of tropospheric ozone from May to August year 2015 over Indonesia.

In figure 3, spatial distribution of tropospheric ozone over Indonesia from May to August 2015 is shown. The average of tropospheric ozone in May, June, July, and August are 23.1 DU, 20.8 DU, 22.1 DU and 21.8 DU. The deviation standards from May to August 2015 are 2.9, 3, 2.7, and 3.1. It means average value can be representative of data distribution. Figure 4 show the spatial distribution of tropospheric ozone over Indonesia from September to December 2015. Based on figure 4, the highest concentration shown in October around Southern Sumatera Island, Indonesia and South of Indonesia (e.g. Java, Bali, Nusa Tenggara).

The maximum concentration of tropospheric ozone in September, October, November, and December are 32 DU, 39.7 DU, 36.7 DU and 30.6 DU and the average concentration each month are 24.5 DU, 30 DU, 26.8 DU and 24.5 DU, respectively.

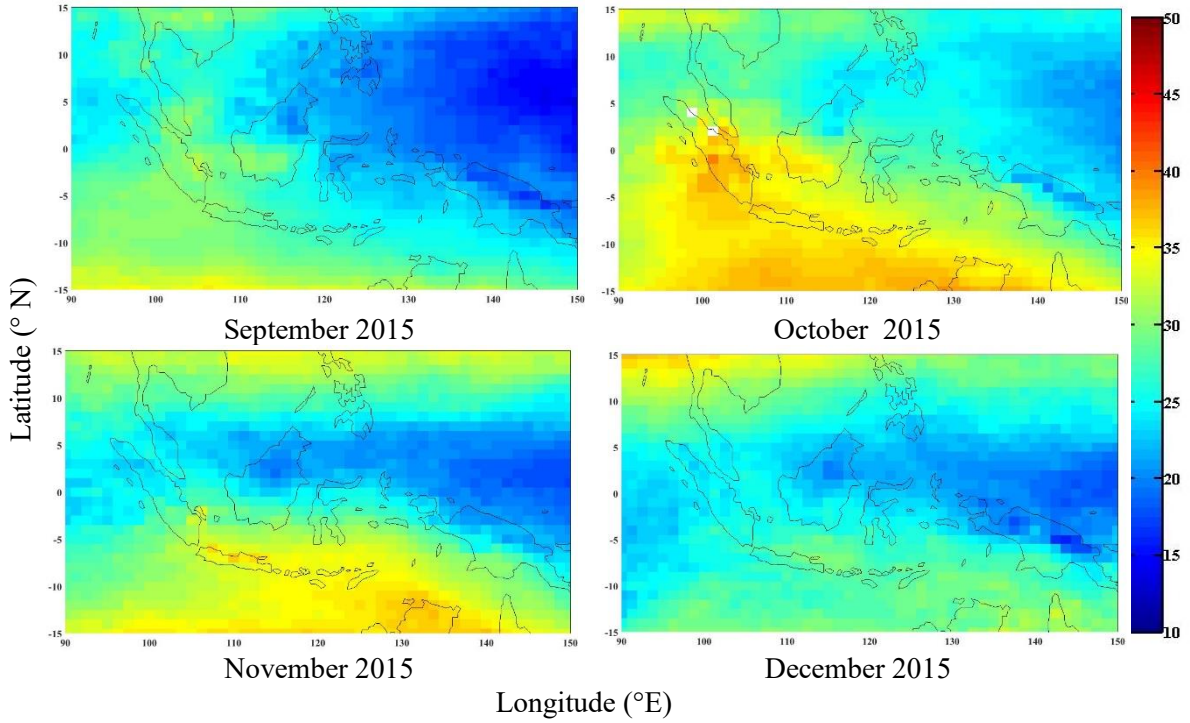

Figure 4. Spatial distribution of tropospheric ozone from May to August 2015 (DU) over Indonesia.

Compared with the TCO values of 20.5-39.7 DU in October for years 2015 and 16.3-33.7 DU in October for years 2014, the increases of TCO were about 4.2-6 DU. We suggested that the TCO increase could be attributed to the extensive forest fires in Sumatera with total forest fire area is 30,984.98 Ha in 2015 and largest forest fire area is in Center Kalimantan of 122,882.90 Ha [7].

Actually, the forest fire reported to data and information of Indonesian disaster reveals that highest number of forest fire in October with total event is 26 event [8]. The higher hotspot number in Indonesia also illustrated in figure 5. Here is hotspot distribution over Indonesia with confidence level 90% capture by Terra MODIS C6 (figure 5). We suggested there is correlation with highest values of TCO in October 2015. The highest number of hotspot in September and October is in Central Kalimantan, 87 and 73 hotspot. As mention in previous study, there are carbon and nitrogen which is found in biomass burning laboratory result of experiment and it leads to produce ozone in troposphere [9]. The duration after biomass burning and producing of tropospheric ozone is one month. We recognized that because when highest number of hotspot in September 2015, the tropospheric ozone increased one month after.

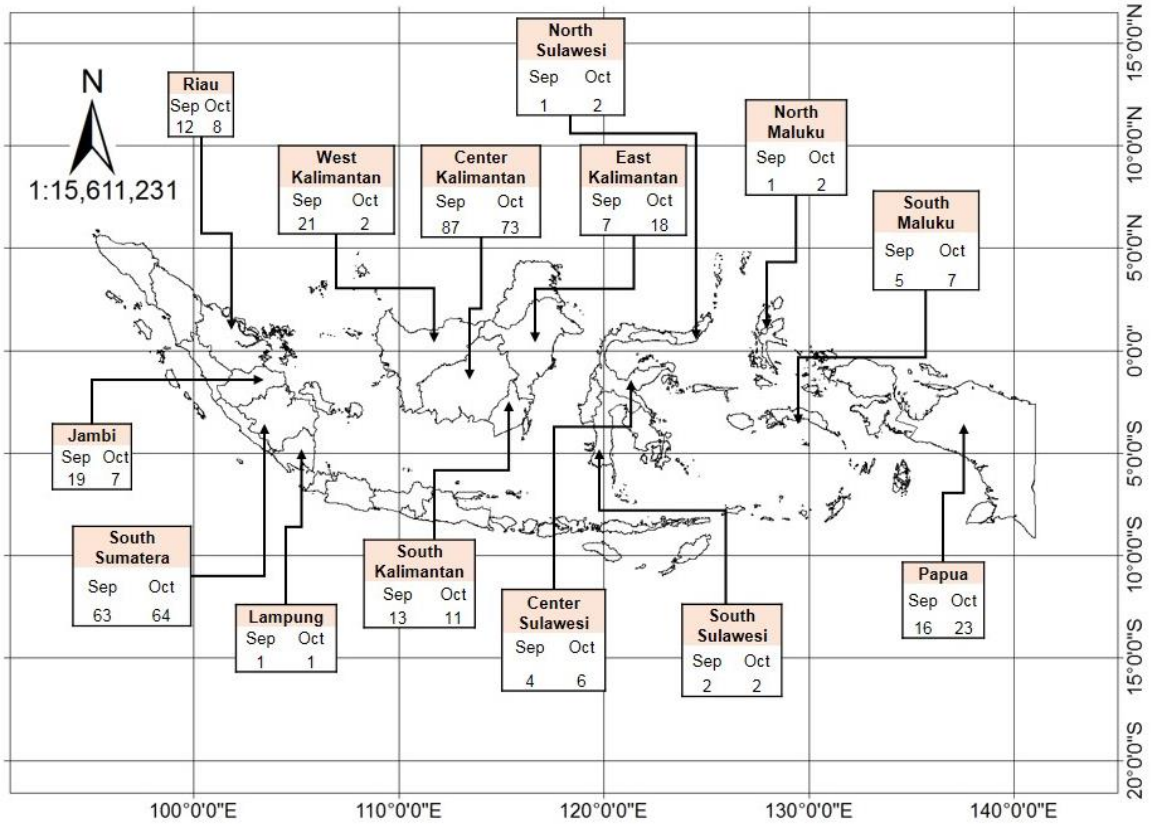

Figure 5. Hotspot distribution over Indonesia from September – October 2015 captured by Terra MODIS C6 with confidence level 90%.

4. Conclusion

We have studied the effects of biomass burning on tropospheric ozone in Indonesia derived from Aura OMI/MLS measurements for the time period January-December 2015. Biomass burning is interpreted by hotspot as indication of a fire event. Forest fire was increased substantially in Indonesia in year 2015 compared to previous years. The OMI measurements show sizeable increases from September to October and decreases from November to December 2015. Comparing the TCO distribution with hotspot reveals that there is time lag when hotspot is higher the TCO increases one month after that event. Having average of TCO over 12ºN-15ºS and 90º-150ºE monthly for year 2015, it shown increases almost 5.9 DU from September to October 2015. Highest decreasing of average TCO about 3.7 DU occur in period October into November 2015.

References

[1] Chieppa J, Art C and Lori E 2015 Effects of tropospheric ozone on loblolly pine seedlings inoculated with root infecting ophiostomatoid fungi *Envir. Poll.* **207** 130-137

[2] Sun J, Feng Z and Ort D R 2014 Impacts of rising tropospheric ozone on photosynthesis and metoblite level on field grown soybean *Plant Scien.* **226** 147-161

[3] Meteorology, Climatology, and Geophysic Agency of Indonesia 2013 *Buku informasi perubahan iklim dan kualitas udara di Indonesia. Pusat Perubahan Iklim dan Kualitas Udara* (Jakarta: Climatology Division, Meteorology, Climatology, and Geophysic Agency of Indonesia)

[4] Ziemke J R, S Chandra, B N Duncan, M R Schoeberl, O Torres, M R Damon and P K Bhartia 2008 Recent biomass burning in the tropics and related changes in tropospheric ozone *geophy. Res. Let.* **36** 1-10

[5] Ziemke J R, Chandra S, Duncan B N, Froidevaux L, Bhartia P K, Levelt P F and Waters J W 2006 Tropospheric ozone determined from Aura OMI and MLS: evaluation of measurements and comparison with the global modeling initiative's chemical transport model *Journal of Geophysc. R.* **111** 1-18
[6] Louis G 2015 *Modis collection 6 active fire product user's guide revision A* (Department of Geographical Sciences University of Maryland)
[7] SIPONGI 2017 Rekapitulasi luas kebakaran hutan dan lahan (Ha) per provinsi di Indonesia tahun 2011-2016 accessed in http://sipongi.menlhk.go.id/hotspot/luas_kebakaran
[8] National Board for Disaster Management 2015 Data and information of Indonesian disaster accessed in http://dibi.bnpb.go.id/data-bencana
[9] Levine J S 2003 Biomass burning: the cycle of gases and particulates from the biosphere to the atmosphere *Treatise on Geochem.* **4** 143-158