ESTIMATION OF BIOMASS BURNING ACTIVITIES OVER EAST ASIA FROM SATELLITE OBSERVATION RECORDS

Kwon-Ho Lee

Gangneung-Wonju National Univ., 7 Jukheon-gil, Gangneung 25457, Korea Korea
Email: kwonho.lee@gmail.com

KEY WORDS: biomass burning, air pollution, satellite, remote sensing

ABSTRACT: Biomass burning is an activity that burns flora and fauna. It is caused by natural causes such as lightning and friction, and human activities such as land improvement and farmland incineration. Approximately 90% of biomass burning is attributed to human activity, with the remainder occurring as a result of spontaneous combustion, with an increasing global trend. Biomass burning activity has a complex impact on global radiative energy balance, carbon cycle, nitrogen cycle, and hydrological cycle, as well as sources of air pollutants as well as land cover changes due to combustion. Observations from the Earth Observation Satellites are very important as a means to observe a wide area and a non-approach area. It has been collected information on the occurrence of fires from numerous satellite observations since the past and has been collecting information on the occurrence of fires. Using the long-term satellite fire products, seasonal variations with strong correlation in the occurrence of fires and fire counts was found. In addition, Biomass burning activities with air pollutants of aerosols and gases shows positive correlation. These results indicate that a significant contribution to regional environmental and climate changes in East Asia.

1. INTRODUCTION

Biomass burning is one of a significant emission source of air pollutants, carbonaceous materials, and radiation energy. In detail, active fires can increase the concentrations of gaseous materials such as carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOX), and particulate matter (PM) (Cheng et al., 1998). Therefore, it has been considered to be a parameter for climate change (Ramanathan et al., 2005; Crutzen and Andreae, 1990; etc.), alters their radiative properties (Hauglustaine et al., 1994), and also have significant effects on human health and regional visibility (Lightly et al., 2000).

Satellite observation of global observation coverage with high spatial resolution has been useful tool for monitoring wildland fire. Satellites are able to provide quantified and qualified information about biomass burning occurrences, spatial extents, and intensities, as well as long-term trends. For example, the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra and Aqua satellites are providing global active fire products and burned area (Roy et al., 2008; Justice et al., 2002). In this study, MODIS fire products (MODIS operational product code names: MOD14 for Terra and MYD14 for Aqua) were used to estimate the spatio-temporal variations in the occurrence of biomass burning and the influence of fires on the emitted atmospheric substances. The main objectives of this study are to investigate the trend of occurrence of biomass burning and the impact of biomass burning on the atmospheric environment by using the satellite observation data.

2. METHODOLOGY

Daily MOD14 fire and thermal anomaly data for March 2000 to August 2019 were collected from the NASA's Land Processes Distributed Active Archive Center (LP DAAC) (available at https://earthdata.nasa.gov/). The fire detection algorithm for MODIS is based on the brightness temperatures techniques from two thermal infrared channels of the 11 μm and 4 μm wavelengths. More detailed description of the algorithm of the MODIS fire detection algorithm is given in Justice et al.(2002). The annual and seasonal trends in the occurrence of fires and the impacts as an emission analyzed with an integrated analysis of MODIS fire products, MODIS aerosol products, and MOPITT CO data. In addition, correlation analysis between the fire occurrences and the amount of atmospheric emission was also conducted to investigate the impacts of biomass burning activities on the regional atmospheric environment.

3. RESULT

After March 2000, the long-term MODIS observation provided fire occurrences and aerosol optical thickness (AOT) over the study area. Figure 1 shows an example of the biomass burning occurrences at the maximum counts for a year of 2003. Numerous fires have been occurred according to geographic locations which may be different from burning origins. In this example, the most frequent occurrences were found over Siberian region covered with boreal forest.

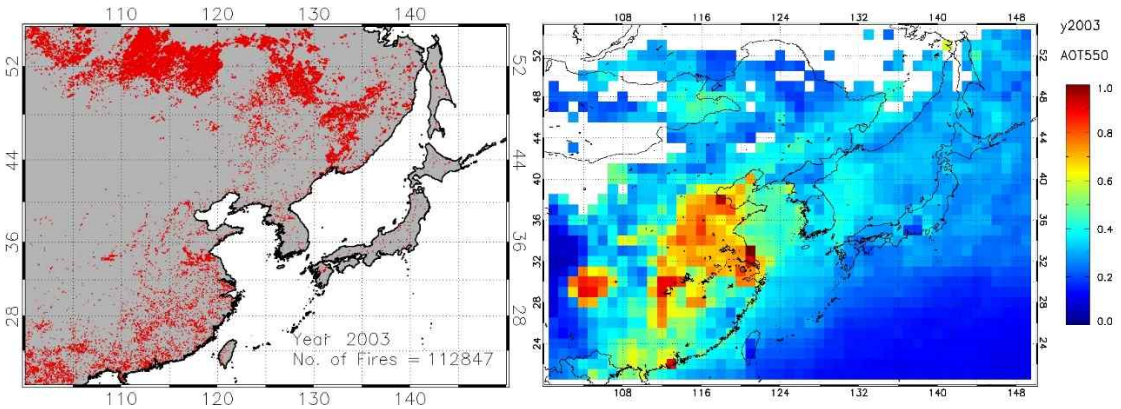

Figure 1. Yearly accumulated MODIS fire products (MOD14) (left) and yearly mean AOT (right) for a year 2003.

Time series of monthly MODIS fire counts and aerosol are presented in Figure 2. Biomass burning occurrence shows seasonal variations and some distinct peaks of the first occurring in 2003 and 2008. In general, the number of fire counts are increasing in the spring season in this time series. Figure 2 also shows the long-term variation of the AOT during the same period. The correlations between fire occurrences and the AOT in this figure were used to find the relation between the increment of biomass burning fire occurrence and the air pollutants emitted from the burning activities. Obviously, series of fire counts are well matched to the variations of the AOT. The same time frame of highest AOT recorded in 2003 is found for the highest number of fires. This means large amounts of atmospheric pollutants were emitted from biomass burning activities and resulting the increments of the regional air quality. The positive correlation of the fire counts corresponding with the AOT indicates that the regional atmospheric pollution is highly depending on the biomass burning origins.

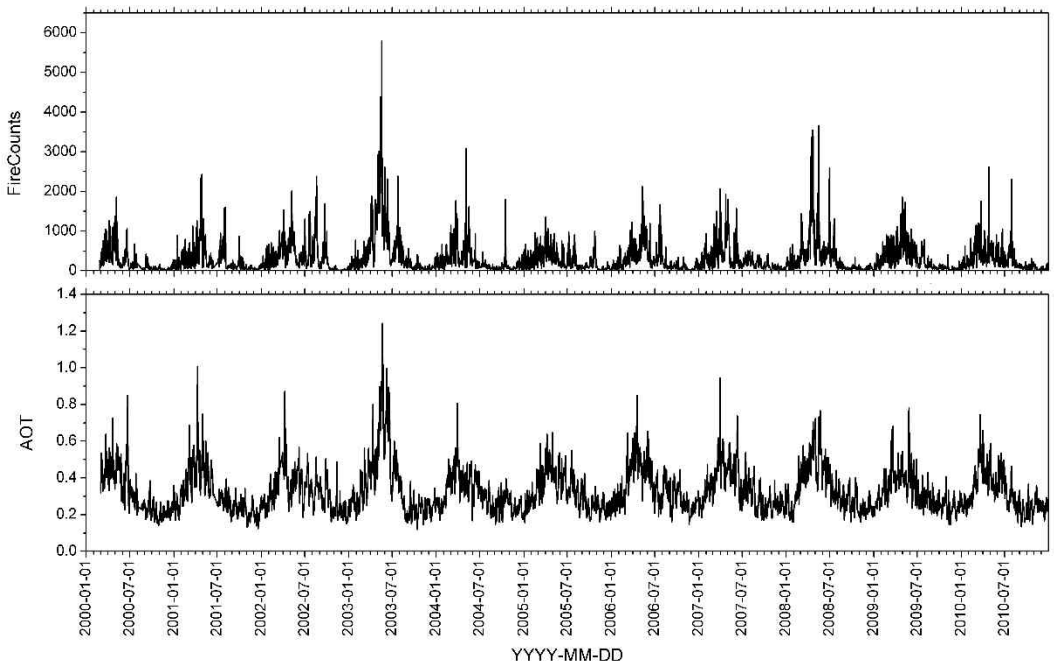

Figure 2. Time series of the MODIS fire counts (top) and AOT (bottom) over study area.

4. SUMMARY

In this study, the trend of biomass burning fires was analyzed by using the long-term satellite observation records and the frequency of fire occurrences with the possibly emitted air pollutants were compared. The results from the geospatially trend analysis showed that the biomass burning fires were found on quasi-seasonal timescales. When the total counts in the yearly values were compared to the seasonal fire counts, a larger than 40% of fire occurrence for the spring season was found. The highest frequencies were found for a year of 2003 with 112847 fire counts because of the historical boreal forest fires. Comparing the variations of biomass burning fires with those of the air pollutants sampled at a same geographical location, the annual trends of AOT showed a similar pattern to the trend of fire occurrence. The correlation between wildland fire occurrence and annual AOT was also confirmed. Current results can be used as an information for the effects of unknown emissions from biomass burning on the regional atmospheric environment.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(NRF-2019R1I1A3A01062804)"

References

Cheng, L., McDonald, K.M., Angle, R.P., Sandhu, H.S., 1998. Forest fire enhanced photochemical air pollution. A case study. Atmospheric Environment 32(4), **pp.** 673-681.

Crutzen, P.J., Andreae, M.O.**,** 1990**.** Biomass burning in the tropics: impact on atmospheric chemistry and biogeochemical cycles. Science 250(4988), **pp.**1669-1678.

Justice, C.O., Giglio, L., Korontzi, S., Owens, J., Morisette, J.T., Roy, D., Descloitres, J., Alleaume, S., Petitcolin, F., Kaufman, Y.**,** 2002**.** The MODIS fire prod- ucts. Remote Sensing of Environment 83(1-2), 244262, http://dx.doi.org/10.1016/S0034-4257(02)000767

Ramanathan, V., Chung, C., Kim, D., Bettge, T., Buja, L., Kiehl, J.T., Washington, W.M., Fu, Q., Sikka, D.R., Wild, M.**,** 2005**.** Atmospheric brown clouds: impacts on South Asian climate and hydrological cycle. Proceedings of National Academy of Sciences of the United States of America 102, **pp.**5326-5333.

Lighty, J.S., Veranth, J.M., Sarofim, A.F. (2000) Combustion Aerosols: Factors Governing Their Size and Composition and Implications to Human Health. Journal of the Air & Waste Management Association 50(9), **pp.**1565-1618.