EFFECTS OF AEROSOLS ON THE KOREAN PENINSILA CAISED BY FIREWORKS IN CHINA DURING CHINESE LUNAR NEW YEAR

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ABSTRACT:

This study investigated the effects of fireworks using aerosol optical depth (AOD) and aerosol optical properties (AOP) from Terra/Moderate Resolution Imaging Spectroradiometer (MODIS) and Sunphotometer, and PM (Particulate Matter) data were observed in Gwangju, South Korea and Shanghai, China. During the Lunar New Year period in 2014, the $PM_{2.5}$ concentration by fireworks in Shanghai showed the highest concentration on the day of Lunar New Year, and air pollutants of long-range transport by fireworks were affected the increase of PM_{10} concentration and aerosol optical depth over the Korean peninsula). These results show that the effect of fireworks, which was recognized as a local air pollution problem, can be transported to the Korean peninsula from China. The results of this study can be very useful for monitoring the atmosphere by firework effect over the Korean Peninsula.

1. INTRODUCTION

Fireworks, which contain a large amount of heavy metals, increase air pollution. Berger et al., 1995 showed that Pb used an igniter to cause a flame explosion, Mn and Mn dioxide as fuel and oxidants for bright light, and Cr as a combustion rate catalyst for the propellant. Ni is an electric ignition device for fireworks.

Licudine et al., 2012, Perrino et al., 2011; Vecchi et al., 2008; Wang et al., 2007 showed a study on the relationship of the fireworks festival to the atmospheric environment at the New Year's Chinese Lantern Festival, the American Independence Day, the French Revolutionary Day, Bastille Day, and Diwali, India. The effects of airborne fireworks on the aerosol mass and chemical characteristics were observed mostly.

Devara et al., 2015; Vyas and Saraswat, 2012 showed aerosol optical properties of fireworks and focused on regional atmospheric changes of pollutants from fireworks. However, it was not the spatial distribution of long-rage transported air pollutants

In China, the New Year, which is January 1st of the lunar calendar, is called Lunar New Year. In China's Lunar New Year, also known as the spring festival, fireworks are held to celebrate the Lunar New Year to pursue the longevity. The Chinese government is taking measures to prevent the increase of air pollution and fire every year. However, fireworks are still being performed mainly in large cities and populated areas, and air pollutants are serious.

In this study, airborne pollutants caused by fireworks during the Chinese New Year period in China were transported over long distances and analyzed the PM data measured in Shanghai and Guangzhou, China.

The backward trajectory analysis was performed for a path of the long-ranged transport aerosol, and the satellite data was used to monitor the AOD (Aerosol Optical Depth) value.

2. METODOLOGY

In this study, PM and satellite data in Shanghai, China where the pollutants are generated by fireworks every year and Gwangju, Korea area which is expected to be affected by the pollutants were used from January 28 to February 2, 2014 during the Lunar New Year.

The Moderate Resolution Imaging Spectro-radiometer (MODIS) Level 1B and Level 2 collection 6 use measured data from NASA's Level-1 and Atmosphere Archive and Distribution System (LAADS; http://ladsweb.nascom.nasa.gov). And MODIS L1B data from Terra satellite was used to calculate AOD. At this time, the analysis algorithm was calculated with 1 km resolution using MODIS SaTellite Aerosol Retrieval (MSTAR) method proposed by Lee and Kim 2010 and MODIS / Terra Level 2 collection 6 data using AOD data of 10 km resolution.

PM_{10} concentration data of Gwangju area was obtained by using D/B of national air quality measurement network measured by β-ray method and the data of AirKorea (http://airkorea.or.kr) 1 hour averaged PM_{10} Respectively.

The US Consulate in Shanghai (32.211 °N, 121.448 °E) has an air quality monitoring site that measures $PM_{2.5}$. The instrument was used to analyze the 1 hour average data measured by MetOne BAM-1020 on Twitter (https://twitter.com/cgshanghaiair).

To confirm the movement of pollutants caused by fireworks, data of Hybrid Single-Particle Lagrangian Integrated Trajectory model (www.arl.noaa.gov/HYSPLIT.php) provided by NOAA Respectively. The weather field used in the HYSPLIT model is the GDAS1 model provided by National Centers for Environmental Prediction (NCEP) Global Data Assimilation System (GDAS).

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3. RESULTS

Figure 1 shows the MODIS L2 10km resolution AOD (right) analyzed from Terra's MODIS L1B from January 29, 2014 to February 2, 2014, and the 1 km resolution AOD (left) analyzed by MSTAR algorithm from Terra. AOD is a measure of the amount of light scattered and absorbed by aerosol, which is higher when a large amount of aerosol is distributed in the air. During the observation period, it was confirmed that the high concentrations of aerosol generated in China due to the westerlies were transported to Japan via the Korean peninsula over a long distance. Before the fireworks began, on January 29, the concentration of aerosol optical thickness was less than 0.3 on the Korean peninsula. The aerosol optical thickness around Shanghai increased remarkably from January 30, the day before the Lunar New Year. After the Lunar New Year (January 31), high concentrations of AOD in excess of 1.0 were measured in Shanghai, China, and satellite data confirmed that aerosol affects the southern part of the Korean Peninsula and Jeju Island due to long-ranged transportation.

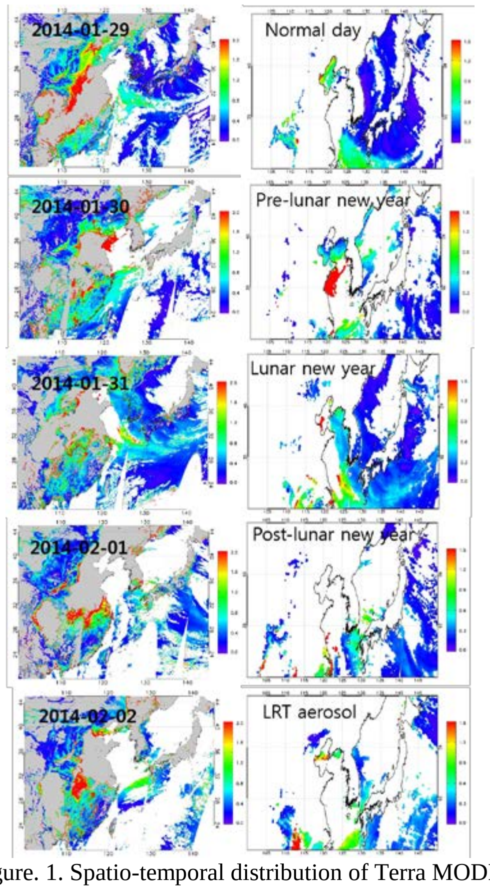


Figure. 1. Spatio-temporal distribution of Terra MODIS MSATR AOD (left) L2 AOD (right) over Northeast Asia during Lunar New Year period in 2014

MODIS L2 collection 6 of Terra satellites was averaged 10 km × 10 km lattice averaged 10 km pixels from 2001 to 2014 to see the change of AOD caused by repeated fireworks every year. 2 (d), 1 day before (Fig. 2 (b)) and 1 day after Lunar New Year (Fig. 2 (c)) were averaged. Two days before the lunar New Year's Day, the average AOD in the area around Shanghai was relatively low compared to the Lunar New Year.

The average AOD increased significantly around the Huangpu River, which can best illuminate Shanghai's main populated area and night view, and the increase of AOD from Shanghai to the surrounding area from the Lunar New Year.

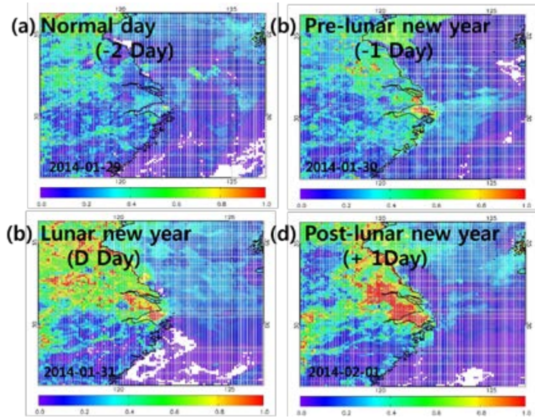


Figure. 2. 14-year Average MODIS-AOD for (a) normal day, (b) pre-lunar new year, (c) lunar new year, and (d) post-lunar new year

Figure 3 shows the $PM_{2.5}$ concentration per hour and the concentration of PM_{10} measured at the Gwangju metropolitan area from January 29, 2014 to February 2, 2014, measured at the US consulate in Shanghai, China, measured during the Lunar New Year period. In Shanghai, the concentration suddenly increased from 22 on January 29, two days before the Lunar New Year, exceeding 100 $\mu g/m^3$ at 23:00. The concentration of $PM_{2.5}$ gradually increased, so that the average $PM_{2.5}$ concentration was increased to 356 $\mu g/m^3$ for 1 hour from 23:00 on January 30 to 31:00 on January 31 (Lunar New Year). This was about 10 times higher than the US EPA average of 24 $\mu g/m^3$ for 24 hours (https://www.epa.gov). And was about 4.7 times higher than the standard 24 hour $PM_{2.5}$ concentration of 75 $\mu g/m^3$ in China. In case of Gwangju, on January 30, at 15:00 11 $\mu g/m^3$, it showed a clear day with PM due to precipitation. However, PM_{10} concentration rapidly increased at 22:00 and was 129 $\mu g/m^3$ on January 31 (Lunar New Year). Which is about 2.6 times higher than Korea's annual mean standard PM_{10} concentration (50 $\mu g/m^3$). In Gwangju area, there is almost no industrial activity due to Lunar New Year holidays, and a sudden increase of PM_{10} concentration in the state of very low PM concentration due to the cleaning action by precipitation is externally influenced by PM due to air pollutants.

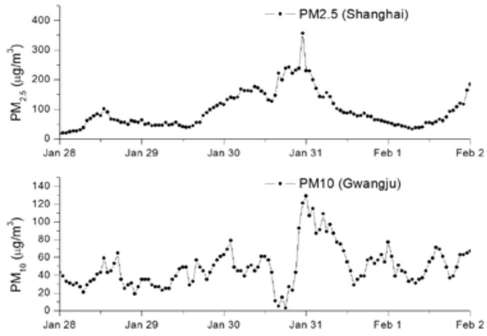
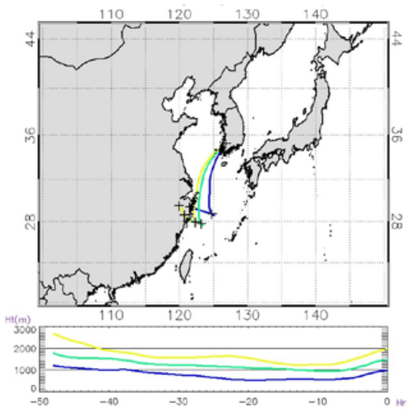


Figure. 3. Hourly variation of $PM_{2.5}$ concentration in Shanghai, China and PM_{10} concentration in Gwangju, Korea during Lunar New Year period in 2014

To analyze the source of imported PM_{10}, backward trajectory analysis was performed for 48 hours at 1,000m, 1,500m, 2,000m height using the HYSPLIT model of NOAA at 00:00 on February 1, 2014, where PM_{10} concentration was highest (Figure 4). Backward trajectory analysis provides primary information on air mass transport routes and possible sources of air pollutants. Air pollutants from Shanghai, China, passed through the western part of Jeju Island and received direct nutrition from Gwangju area. Therefore, as a result of the satellite data and backward trajectory analysis, the cause of the high concentration of PM_{10} that occurred suddenly in Gwangju during the Lunar New Year in 2014 is attributed to the PM effect of the fireworks in Shanghai, China. Air pollutant particles transported from China were estimated to drastically increase PM_{10} concentration in Gwangju area.



4. CONCLUSION

In this study, we analyzed the effects of high concentration PM on the Korean peninsula from the fireworks display in Shanghai, China. Using the MODIS data from Terra satellite, we analyzed the changes of AOD during the 2014 Lunar New Year period. The increase of AOD in the Shanghai area of China was observed, and the aerosol generated was transported over a long distance, which also affected the increase of PM_{10} concentration in the Gwangju area of the Korean Peninsula.

From 2001 to 2014, the AOD changes during the Lunar New Year period rapidly increased from one day before the Lunar New Year, and showed a high AOD value (1.0> AOD) during the Lunar New Year.

The concentration of $PM_{2.5}$ in the Shanghai area in China increased also rapidly before the Lunar New Year, and was the highest at 24:00 on the Lunar New Year (356 $\mu g/m^3$). During the Lunar New Year period, PM_{10} concentration was up to 129 $\mu g/m^3$ in Gwangju area. The HYSPLIT analysis of NOAA analyzed the high concentration of air pollutants affecting the Gwangju area on the Korean peninsula. In conclusion, high concentrations of aerosols from fireworks in China are transported over long distances and directly affect the atmosphere of the Korean peninsula.

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