

4.4 ESTIMATION OF DRY DEPOSITION OF DUST IN ASSOCIATION WITH A WINTER-TIME YELLOW SAND EVENT OBSERVED OVER SOUTH KOREA DURING 25 TO 28 JANUARY 1999

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1. INTRODUCTION

Every year in spring the Korean peninsula including Japan frequently experiences Yellow Sand events that originate from inland Asia in the regions of loess, Gobi and sand deserts. Synoptically, the Yellow Sand phenomenon in Korea is reported as a weather phenomenon when the Asian dust is suspended in the atmosphere to reduce the visibility. Usually the color of the sky is often seen to be yellowish so that this weather phenomenon is called Yellow Sand.

The consequence of the dust events is not only soiling the exposed materials but also causing respiratory and eye disease and also causing the change of chemical compositions of soil due to dust deposition on the ground. In addition, the production and long-range transport of mineral aerosols from the Asian continent impact atmospheric chemistry and the radiative balance over the region and biological productivity in the North Pacific Ocean (Gao et al., 1992).

Yellow Sand events are frequently observed in Korea in March, April, and May with the maximum frequency in April (Chung and Park, 1995). The occurrence frequency varies widely from year to year. However, the Yellow Sand event is not restricted to the spring time only in Northeast Asia. A distinctive Yellow Sand phenomenon was observed in Korea during 25- 28 January 1999. The maximum concentration of the total suspended particulate (TSP) during this period was 10 times higher than that of the monthly mean concentration at the most of the monitoring sites over South Korea.

The purpose of this study is to estimate dry deposition of TSP over South Korea for this extraordinary intense episode using the inferential method

2. DATA AND METHOD

Hourly observed TSP concentrations obtained from the routine air pollution monitoring network composed of 25 sites and meteorological data at 64 stations over South Korea (Fig. 1) for the period of 25 to 28 January 1999 were used for the estimation of dry deposition of TSP in South Korea.

The dry-deposition flux of dust (Yellow Sand) is calculated as the product of dry-deposition velocity and measured TSP concentration at the height of 3-4 m above the surface using the inferential technique. The dry-deposition velocity of the dust is estimated following Draaijers et al. (1997) and Park and Lee (2000).

3. TIME VARIATIONS OF TSP CONCENTRATIONS IN SOUTH KOREA

The observed Yellow Sand event in South Korea can be identified by the increase in TSP concentrations observed at the air monitoring sites in Korea.

The average concentration of TSP for all sites in January, 1999 was $70 \mu\text{g m}^{-3}$ in Korea (MOE, 1999). Fig.

2 shows time series of hourly mean TSP concentrations for the period from 0100 LST 25 to 2400 LST 28 January 1999 observed at four sites that are located from northwest to southeast roughly parallel to the passage of the Yellow Sand event over Korea (Fig. 1).

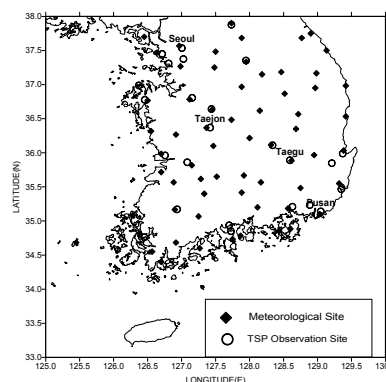


Fig. 1. Locations of TSP monitoring sites(O) and surface meteorological observation stations(◆) in South Korea

The first dust storm was detected at 0900 LST 25 January at the northwest part of Korea and progressively moved southeastward to Pusan where it was detected at 1600 LST 25 January 1999 (Fig. 2). The maximum concentration of TSP in association with the first dust storm occurred at 1500 LST in Seoul, 1700 LST in Taejeon, 2100 LST in Taegu on 25 January and 0100 LST on 26 January in Pusan with their maximum concentrations of $860 \mu\text{g m}^{-3}$, $660 \mu\text{g m}^{-3}$, $790 \mu\text{g m}^{-3}$ and $800 \mu\text{g m}^{-3}$, respectively. The duration period of the first dust storm was about 15 hours at Seoul, Taejeon and Taegu sites. However, it lasted for about 20 hours in Pusan. The second dust storm started at 1300 LST 26 in Seoul, 1500 LST 26 in Taejeon, 1800 LST 26 in Taegu and 0000 LST 27 January in Pusan and lasted for 32~34 hours at all sites. The second dust storm was much weaker than the first dust storm (Fig. 2).

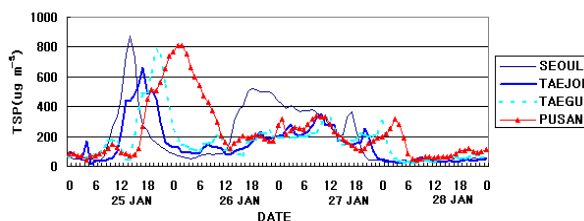


Fig. 2. Time series of TSP concentration($\mu\text{g m}^{-3}$) observed in Seoul, Taejeon, Taegu and Pusan.

4. DRY DEPOSITION FLUX OF TSP

Using the observed TSP concentration and the estimated dry deposition velocity, dry deposition flux of TSP is estimated over South Korea and the results are given in Fig. 3. Before the dust storm moves into the Korean peninsula, the dry deposition flux of TSP is less

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than $7 \text{ mg m}^{-2} \text{ hr}^{-1}$ all over Korea (Fig. 3a). However, during the Yellow Sand period the maximum dry deposition of TSP occurs at 1500 LST 25 January 1999 in the central part of Korea with the maximum value of $70 \text{ mg m}^{-2} \text{ hr}^{-1}$ (Fig. 3b). The first dust storm has passed over the Korean peninsula after 0600 LST 26 January 1999 when the dry deposition flux of TSP reduces to less than $10 \text{ mg m}^{-2} \text{ hr}^{-1}$ all over the Korean peninsula. The second dust storm moves into the Korean peninsula before 1500 LST 26 January (Fig. 3c) from west and yields a maximum dry deposition flux of $43 \text{ mg m}^{-2} \text{ hr}^{-1}$ in the eastern central parts of Korea at 1200 LST 27 January (Fig. 3d). This storm moves out of the Korean peninsula after 0600 LST 28 January, yielding the maximum dry deposition flux of TSP less than $10 \text{ mg m}^{-2} \text{ hr}^{-1}$ in the whole analysis domain.

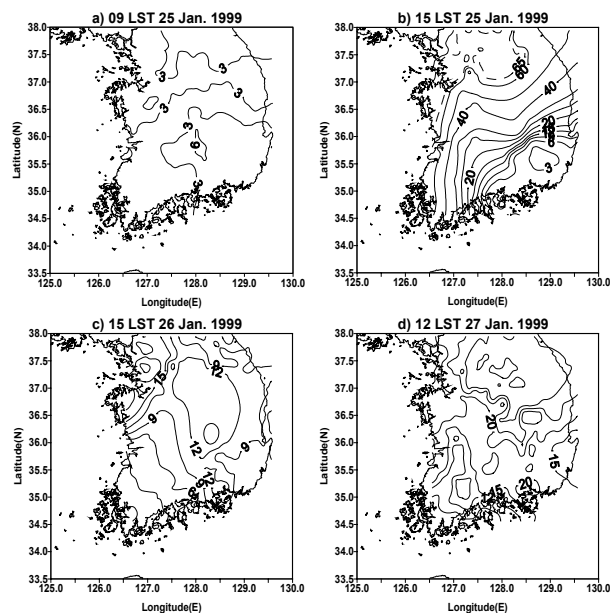


Fig. 3. Spatial distributions of TSP dry deposition flux ($\text{mg m}^{-2} \text{ hr}^{-1}$) for the Yellow Sand event period

The time series of total dry deposition of TSP over the whole analysis domain (the domain area is $117,810 \text{ km}^2$) is given in Fig. 4. The maximum total dry deposition of TSP occurs at 1600 LST 25 January with the maximum value of $5,200 \text{ t hr}^{-1}$ which is equivalent to the area mean dry deposition flux of $44.1 \text{ kg km}^{-2} \text{ hr}^{-1}$. The second maximum total dry deposition occurs at 1200 LST 27 January with the maximum value of $2,300 \text{ t hr}^{-1}$ that is equivalent to the area mean dry deposition flux of $19.5 \text{ kg km}^{-2} \text{ hr}^{-1}$. These values are much larger than the area-mean dry deposition flux of $2.5 \text{ kg km}^{-2} \text{ hr}^{-1}$ after the Yellow Sand event.

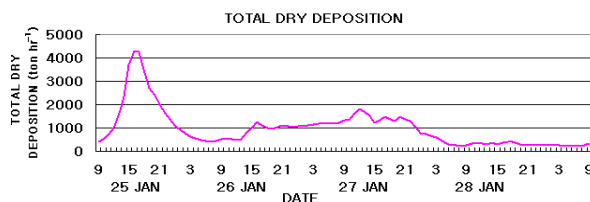


Fig. 4. Time variations of the total dry deposition (t hr^{-1}) in South Korea. The area of the analysis domain is $117,800 \text{ km}^2$.

The first dust storm dumps TSP of $49,960 \text{ t day}^{-1}$ from 0900 LST 25 to 0800 LST 26 January in South Korea. This is equivalent to the area-mean dry deposition flux of $424 \text{ kg km}^{-2} \text{ day}^{-1}$. The second dust storm produces total dry deposition amount of $30,990 \text{ t}$ for the first day (from 0900 LST 26 to 0800 LST 27 January) and $32,200 \text{ t}$ for the second day (from 0900 LST 27 to 0800 LST 28 January). The equivalent area-mean deposition flux is $263 \text{ kg km}^{-2} \text{ day}^{-1}$ for the first day and $273 \text{ kg km}^{-2} \text{ day}^{-1}$ for the second day. After the dust storm period from 0900 LST 28 to 0800 LST 29 January the total dry deposition amount of TSP over South Korea reduces to $9,040 \text{ t day}^{-1}$ that is equivalent to the area-mean deposition flux of $77 \text{ kg km}^{-2} \text{ day}^{-1}$. Consequently the first dust storm caused 5.5 times higher TSP dry deposition whereas the second dust storm attributed to 3.5 times higher than the mean value of the after Yellow Sand event over South Korea.

5. SUMMARY AND CONCLUSIONS

Dry deposition of TSP in association with a Yellow Sand event observed over South Korea during 25 to 28 January 1999 has been estimated using the inferential method with the use of measured TSP concentrations at 25 sites and the surface meteorological data observed at 64 stations scattered over South Korea.

Before the dust storm moves into the Korean peninsula, the TSP concentration in Korea is less than $100 \mu\text{g m}^{-3}$. However, the dust storm boosts the TSP concentration level by a factor of 5 ~ 10 within several hours, with peaks up to $960 \mu\text{g m}^{-3}$. During the chosen episodic period, the first dust storm causes the total TSP dry deposition of $49,960 \text{ t}$ for a day and the second dust storm produces the TSP dry deposition of $63,190 \text{ t}$ for two days in the whole region ($117,810 \text{ km}^2$) of South Korea. These values are respectively 5.5 and 3.5 times higher than the mean TSP deposition amount ($9,040 \text{ t day}^{-1}$) during the non Yellow Sand period, suggesting potential impact of Yellow Sand on the eco-environmental system in Korea.

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