Lidar Measurement of Long-Range Transport Dust from Middle East Asia/North Africa

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Abstract

Dust layers in the free troposphere have been observed with the lidars in the stations of lidar monitoring network of NIES. The observed dust distributions were compared with the results of the regional and global dust transport models (CFORS, NRL NAAPS, and SPRINTARS). The results of the analysis suggest the source of the dust layers were from the North Africa or Middle East Asia. The trajectory analysis using NOAA HYSPLIT showed that the dust originated in those regions.

1. Introduction

Mineral dust in the atmosphere generated by strong surface wind play an important role in the radiation properties of the atmosphere and atmospheric chemistry. Every spring season, a large amount of mineral dust, so called yellow sand or Asian dust, is emitted in the North Asian region and is transported to the east of China, Korea, and Japan. It is known that the major sources of Asian dust that reached to northeast China and Korea are Gobi Desert in Mongolia and Inner Mongolia The dust from Taklimakan is generally transported in higher altitudes and often observed in the free troposphere over Japan. There are also cases of Middle Eastern and Saharan mineral dust observed in the East Asia

To study the emission and transport of mineral dust and air pollution aerosols in East Asia, a network of continuously operated lidars was developed by the National Institute for Environmental Studies (NIES). With the network, dust plumes are occasionally observed in the free troposphere.

As a typical case of long range transported dust from North Africa, In March, 2005, at the station of Tsukuba, Suwon, and Gosan, the elevated dust layer were observed yet there were no major dust emissions from the Taklimakan and Gobi Deserts in the period. We deduced a Saharan origin of the dust plumes using by the comparison of regional model of CFORS with the global model of NAAPS and SPRINTARS. We also performed a backward trajectory analysis using NOAA HYSPLIT model

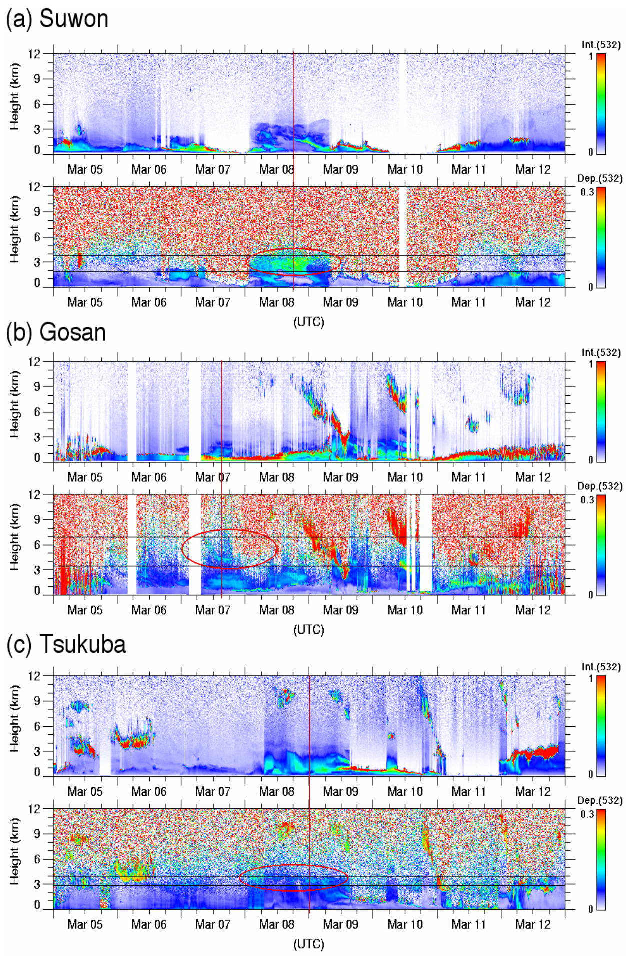

Fig. 1. THIs of the lidar range-corrected backscatter signal and total depolarization ratio at 532 nm observed in (a) Suwon, (b) Gosan, and (c) Tsukuba in March 5-12, 2005.

2. Lidar system and network observation

In the NIES lidar network, we use the lidars that measure the backscattering at 532 nm and 1064 nm, and the depolarization ratio at 532 nm. Figure 1 shows the time-height indications (THIs) of the range-corrected backscatter signal and the total depolarization ratio. A dust layer with a total depolarization ratio of 10-25 % was observed in Suwon (00:00, March 8 - 08:00, March 9, 2005 ,UTC) at altitudes of 2-4 km. At the Gosan site, a thin layer of the dust was observed (8:00 to 15:00, March 7) at the altitude of 4-7 km with a total depolarization ratio higher than 12 %. In Tsukuba, a thin dust layer was observed (00:00, March 8-15:00, March 9) at altitudes of 3-4 km. The depolarization ratio at the layer was 15-20%. The extinction coefficient is approximately 0.05 km^{-1} at the laminar plumes at Gosan and Tsukuba.

3. Comparisons with models

Figure 2 shows the THI plots of dust concentration calculated with CFORS for Suwon, Gosan, and Tsukuba, and with NAAPS for Gosan and SPRINTARS for Gosan. In the CFORS results, there are no high concentration dust plumes in March 7-8 where the dust layers were observed by the lidars, except for some low concentration dust in the lower part of the plume in Suwon. On the other hand, NAAPS and SPRINTARS results show a high concentration dust plume at altitudes of 3-8 km in March 7-9. The NAAPS and SPRINTARS results for Suwon and Tsukuba are similar to those for Gosan. The observed dust layers in Gosan and Tsukuba in Fig. 1 show the laminar structure. The results with NAAPS and SPRINTARS, however, show the thicker structures. All of the three models showed no major dust emission in Taklimakan and Gobi Deserts during the period. A comparison of this simulation with the operational run shows that the dust above 3 km shown in Fig. 2(d) is of Saharan origin. NAAPS simulated dust events on Feb 25-27 and Feb 28-Mar 2 in the Sahara Desert. The results of the trajectory analysis are consistent with the NAAPS simulation described above and shows the origin is the Sahara Desert. The transport path was similar to that in the Middle East dust case in 2003

4. Conclusion

We have observed cases of long-range transported dust that came from Middle Asia or North Africa In March 2005, using a NIES lidar network, the Saharan dust that transported to East Asia was observed. The transport models and the backward trajectory analysis have shown the origin to be the Sahara Desert. However, differences from the observations were seen in vertical profiles of the dust distribution. Also, difference between models was seen in the dust concentration. Validating the models in the case studies will be essential for understanding the effects of long-range transported dust on climate.

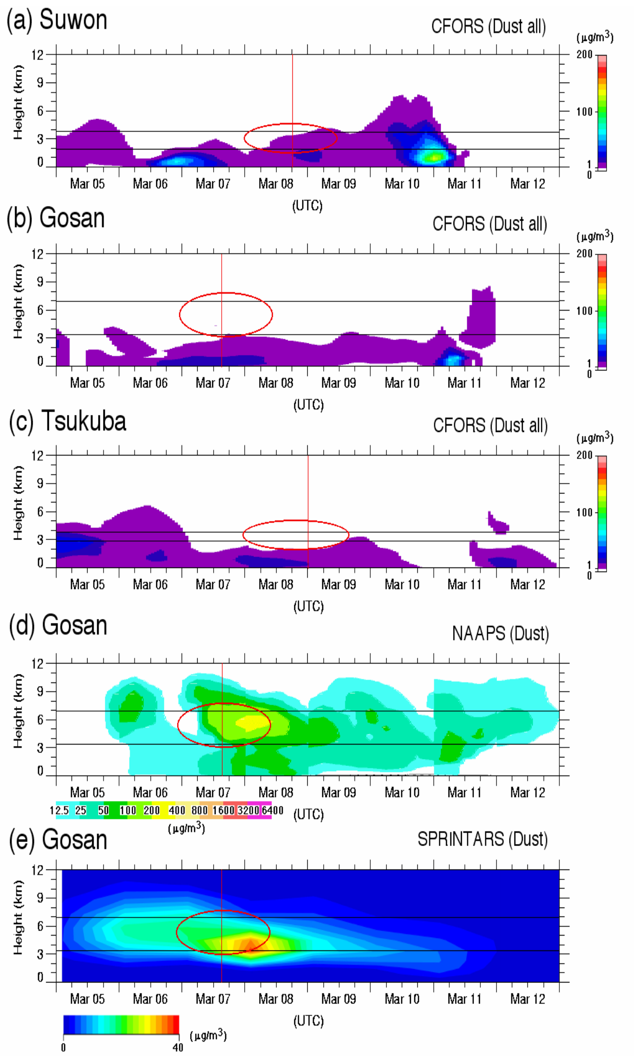

Fig. 2. THIs of dust concentration in March 5-12, 2005 calculated with CFORS for (a) Suwon, (b) Gosan, and (c) Tsukuba, and calculated with (d) NAAPS for Gosan and with (e) SPRINTARS for Gosan.