Lidar depolarization ratio values of long transported and local dust

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Abstract: Depolarization ratio of dust was measured using a slant-path lidar in the Center for Environmental Remote Sensing (CEReS), Chiba University. During the dust event (25-26 May 2018), values of depolarization ratio ranging from 0.15 – 0.30 were measured. The high depolarization ratio occurred during the middle part of the dust event presumably due to scatterers near the ground. Dusts above the ground exhibited depolarization ratios ranging from 0.15 – 0.2.

Key Words: Depolarization ratio, Slant-path LIDAR, Extinction coefficient, Dust

1. Introduction

Depolarization ratio is a parameter that measures the sphericity of scatterers in the atmosphere. This can be measured using a lidar system by taking the ratio of the perpendicular polarization signal to the parallel polarization signal [1-3]. Spherical scatterers have depolarization ratio close to zero. Dusts, on the other hand, can have depolarization ratio as high as 0.4[4]. In this work, we present measured depolarization values of dust observed in Chiba during the dust event from 25-26 May 2018. The location of the source of the dust is examined using the backward trajectory model.

2. Instruments

2.1 Slant-path lidar

A slant-path lidar was operated before, during and after the dust event in last May 2018. The lidar uses a 532 nm wavelength laser and is operated at a frequency of 1kHz. The system is placed on the 5th floor of the CEReS building and is pointed to the north direction with an elevation angle of 30^{o}. A polarizing beam splitter is used to separate the backscatter signal into parallel and perpendicular polarization components. Data are obtained every 1 min. The lidar signals are digitized and stored in the computer for analysis.

2.2 Optical particle counter

A Rion KC-01E optical particle counter is operated as part of Atmospheric Data Collection Lidar (ADCL) instruments routinely operated in CEReS[5]. This optical particle counter can measure counts from aerosols with sizes 0.3, 0.5, 1, 2 and 5 μm. When dust particles are present in the atmosphere, counts in the larger diameter bins (2 and 5 μm) tend to increase. Local dusts are usually observed when wind speeds are high. When dust events due to long transport happen, the rise of the counts in the larger diameter bins occur even though the observed wind speed values are not high.

2.3 HYSPLIT backward trajectory model

The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model is used to infer the location of the source of the dust. The backward trajectory model can be implemented on the National Oceanic and Atmospheric (NOAA) website (*https://ready.arl.noaa.gov/hypub-bin/trajtype.pl*). In this work, the back trajectory is chosen to be 150 hours before reaching Chiba area. The Global Data Assimilation System (GDAS) system is the meteorology type used in the backward trajectory analysis.

3. Results and discussion

The slant-path lidar was operated continuously from 25 May 2018 15:00 to 26 May 2018 09:00. The lidar was set to take data every 1 min. Before the operation, data from both parallel and perpendicular channels were obtained to investigate the response of each photomultiplier tube (PMT). Assuming that the scattering properties of aerosols in the atmosphere do not change during the time of the exchange of the PMTs, the ratio of the PMT signals for each channel should be nearly equal to unity if the two PMTs have the same response. This ratio, when not equal to unity, is used to correct the response signal of the PMT. In this work, the measured average signal ratio of the PMTs is around 2.4.

Figure 1 shows the time height indication of the depolarization ratio derived from the SP lidar data. Depolarization ratio values are observed to slightly increase with time below 3 km starting at 18:00 of 25 May 2018. A decrease of depolarization ratio is observed at 06:00.

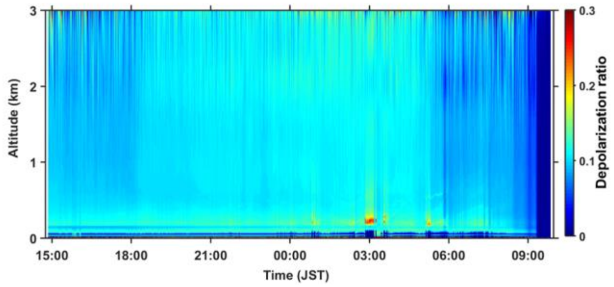

Fig. 1. Measured depolarization values from slant-path lidar from 25-26 May 2018 (15:00-09:00).

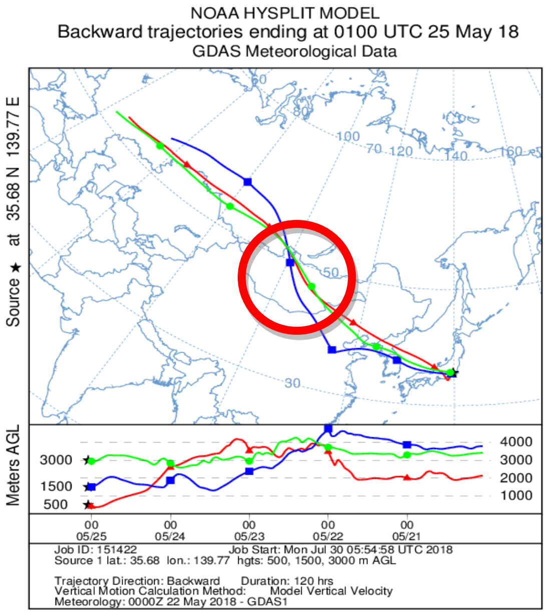

Fig. 2. Backward trajectory (NOAA HYSPLIT model) of air mass from 21 – 25 May 2018. Gobbi desert is encircled.

Figure 2 shows the backward HYSPLIT trajectory of the air mass from 19 to 25 May 2018 UTC (09:00 26 May 2018 JST). The air mass near and above the ground observed in Chiba on 26 May 2018 shows that it has passed Gobbi desert on between 21 and 22 May 2018 (circled portion of Fig. 2). This indicates that the air mass may have carried dust from Gobbi desert via long transport. The air masses continue to pass over eastern China and Korea. The air masses exhibit a downward trajectory when they reach Chiba on 26 May. The dust particles carried by these air masses can be detected by remote sensing instruments in Chiba. Between 25 and 26 May 2018, the observed depolarization ratio during the dust event in Chiba shows values ranging from 0.15 – 0.20 above 1 km (Fig. 1). Near the ground, the depolarization ratio values peaked to around 0.3 and this may be due to local dust. The local wind speed values during the dust event ranged from 0 to 7 ms^{-1}. In Chiba University, a National Institute for Environmental Studies (NIES) lidar has been continuously operated. This lidar system uses 532 and 1064 nm wavelengths with depolarization ratio obtained at 532 nm. The observed depolarization ratio values lie in the range 0.2 - 0.25, which is consistent with the SP lidar data discussed here.

Ground optical particle measurements also show increase of particle counts in the large diameter bins. Figure 3 shows the temporal change of dN/dlnD in the 2 – 5 μm bin size during 21-29 May 2018. The increase of the counts in the 2 – 5 μm bin size starting on 25 May coincides with the high depolarization ratio measured from the SP lidar. This increase in particle counts is an indication of the increase of the number of coarse particles. These counts increased and reached up to 2200 of the next day.

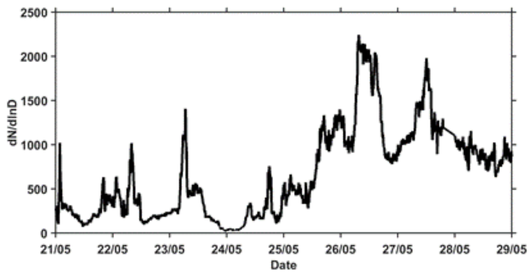

Fig 3. Temporal change of d*N*/dln*D* from 21-27 May 218 from Rion KC-01optical particle counter.

4. Conclusion

Data from lidar observations have yielded depolarization ratio values of dust during the dust event in Chiba on 25-26 May 2018. Backward trajectory analysis of the air mass indicates that these dust have possibly come from Gobbi desert. The depolarization ratio of these dust is between 0.15 and 0.20. Local dusts show depolarization ratio of ~ 0.3.

References

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