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インドとインド海の上空で観測されたダスト粒子の偏光解消度垂直分布

Vertical distributions of depolarization ratio by dust particles observed over India and the Indian Ocean

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Abstract
Continuous dust layers were observed over India and the Indian Ocean from March 22nd to April 6th, 2007, by the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) lidar. The backward trajectories showed that the air parcels were most possibly originated from India, and moved slowly at the altitude of 2 - 4 km following anticyclonic motion over the Indian continent for more than one week. The particle depolarization ratio of those dust layers showed a special vertical structure; it is decreasing with increasing altitude, which is different from the nearly vertically constant structure of dust originating from African and Asian deserts as suggested by other researchers. To study the possible reasons for the above vertical structure of depolarization ratio over India and Indian Ocean, the dust origin, weather condition, and the particle orientation in the atmosphere are discussed.

1. Introduction

Dust particles affects Earth's climate directly by scattering and absorbing of radiation, and indirectly by modifying the optical properties and lifetime of clouds. The irregular shapes of dust particles limit accuracy in our understanding their radiation properties. Depolarization ratio is a useful parameter for identifying the non-spherical particles. In this study, the depolarization ratio distribution of dust particles will be provided, its special distribution observed over India and the Indian Ocean, and reasons that cause the distribution will be discussed.

2. Data and analysis

CALIPSO Level 1 data are used for analysis. Particle depolarization ratio δ_P is calculated by:

$$\delta_P = \frac{R\delta_T - \delta_m}{R-1} \qquad (1)$$

Where, backscattering ratio R is defined as the ratio of the total backscattering to the molecular backscattering. δ_T is calculated directly from the ratio of the two polarization components of the attenuated backscatter at 532nm. δ_m is the molecular depolarization ratio, which is approximately equal to 0.0036 at 532nm. Dusts are identified when high values of particle-depolarization ratio appear and backscattering ratio R is less than 5.

3. Results and discussions

3.1 dust events over India and Indian Ocean

Nighttime portion of CALIPSO Version 1 data during March and April 2007 were analyzed. Continuous dust layers observed over India and Indian Ocean drew our attention. The dust layers exited at the altitude of 2 to 4 km a.s.l. appeared from March 22nd to April 6th, 2007. The attenuated backscatter coefficient β of the dust layers were at around 0.01 to 0.001, backscattering ratio R was in the range of 0.0 - 3.3, the particle depolarization ratio δ_P was in the range of 0.1 - 0.4. The backscattering ratio R was calculated by using attenuation corrected backscattering coefficient retrieved from the attenuated backscatter coefficient β. (The details of the method will be presented at the symposium.) Backward trajectories (NOAA HYSPLT model)[1)] of each dust layers were calculated for ten days. The backward trajectories showed that there was a lasting anticyclonic wind over India, and that most of the air parcels ascended from ground level at India one week ago, and moved anticyclonically over the Indian continent slowly.

3.2 Vertical distribution of particle depolarization ratio

Fig.1 shows an example of particle depolarization ratio distribution of the observed dust event over India and the Indian Ocean. The particle depolarization ratio shows a clear structure, with higher values at the bottom of the dust layer and a decrease with increasing altitude. Dusts over Asian deserts (Takalamakan and Gobi desert) were also analyzed. We found a nearly constant vertical distribution of δ_P. Similar studies have been made by Liu et al.[2]. They also reported a nearly constant vertical distribution of the particle depolarization ratio through the dust layer during the long-range transportation of Saharan dust to the Gulf of the Mexico. The difference in those results could be caused by the difference in particles characteristics from different origins or their orientation in the air. As the preferential orientation of dust particles due to the gravity effects has been discussed by Li and Osada [3], the alignment of dust particles due to electric field has been suggested by Ulanowski et al. [4]. Details will be discussed in the symposium.

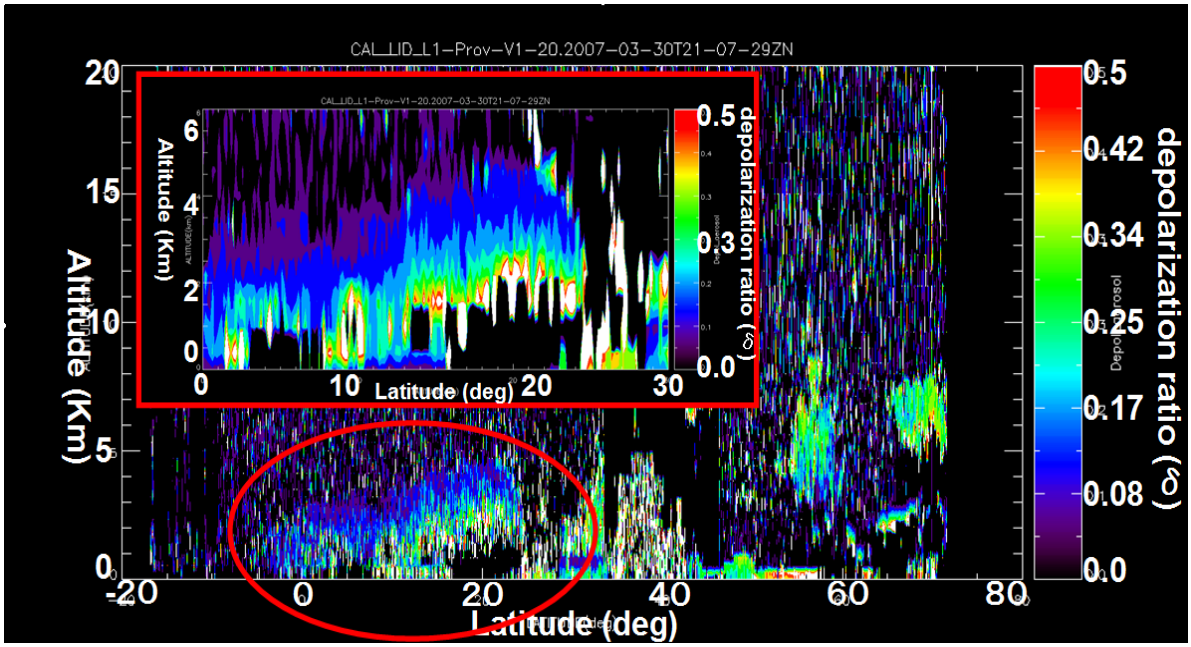

Fig 1. Vertical distribution of particles depolarization ratio over Indian Ocean on Mar. 30, 2007.

Acknowledgments

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References

1) Draxler, R. R. and Rolph, G. D., 2003: HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD.
2) Li and Osada. Preferential setting of elongated mineral dust particles in the atmosphere. Geophys. Res. Lett. 34, L17807, doi:10.1029/2007GL030262, 2007.
3) Liu, et al. CALIPSO lidar observations of the optical properties of Saharan dust: A case study of long-range transport. J. Geophys. Res.113, D07207, doi:10.1029/2007JD008878, 2008.
4) Ulanowski et al. Alignment of atmospheric mineral dust due to electric field. Atmos. Chem. Phys. Discuss., 7, 13203-13241, 2007.