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CALIPSO Observations of the Transport of Mineral Dust over the Arabian Sea and Indian Ocean during the Asian Summer Monsoon Season

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CALIPSO provides a unique opportunity to investigate the altitude variation of aerosol backscatter coefficient (β_a) and depolarization ratio (VDR, which is a measure of the non-sphericity of aerosols) on a global scale. Satellite observations during the past few decades have shown persistent occurrence of an intense aerosol plume engulfing the Arabian Sea during the Asian summer monsoon season (June-September), in which the column integrated aerosol optical depth (AOD at 550 nm) often exceeds 0.7. This plume is presumed to be produced by the sea salt aerosols generated in-situ by the high ocean surface winds and the long-range transport of mineral dust from the Arabian Desert. While the spatio-temporal variations of AOD in this plume are reasonably well understood, the information on the aerosol types and their altitude variations are mostly lacking. In the present study, the altitude profiles of β_a and VDR obtained from the CALIPSO observations along the sub-satellite tracks are used to discriminate the highly non-spherical aerosols (mainly mineral dust) from the largely spherical aerosols of marine origin over the Arabian Sea and Indian Ocean during the Asian summer monsoon period of 2006-2008. The altitude profiles of β_a and VDR obtained from CALIPSO are compared with the collocated measurements of the above parameters obtained within $\pm$20 minutes of satellite pass using ground-based Micropulse Lidar (MPL) observations at Trivandrum (8.5ºN, 77ºE), a station located in the southwest coast of Peninsular India. These observations are in agreement in the lower atmosphere below 3 km, up to which good data were available from CALIPSO during the period of observation. Along with the air back-trajectory analysis and the AOD retrieved from MODIS data, the CALIPSO observations are used to obtain the 3-dimensional distribution of aerosols and investigate the pathways of atmospheric transport of different aerosol types over the Arabian Sea and the Indian Ocean regions [40-75ºE; 20ºS-30ºN]. Intensity of this plume maximizes during the June-August period, when the altitude profiles of β_a over the Arabian Sea at north of 10°N show a well-mixed aerosol layer below 1 km and an elevated aerosol layer between 1 to 5 km with a rather moderate decrease in $\beta_a$with altitude. In this region, the mineral dust is prominently observed throughout the altitude band between the surface and 5 km with VDR in the range of 0.1-0.3. Between 10ºN and 5ºS, the dust layer is present only above 1 km with VDR in the range of 0.1-0.2, the upper boundary of which monotonically decreases from $\sim$5 km at 10ºN to $\sim$2 km at 5ºS. In contrast, the aerosols present below $\sim$1 km in this region are highly spherical with VDR$<$0.04. This appears like a front with pristine oceanic airmass containing mostly spherical aerosols penetrating from south Indian Ocean to the north Arabian Sea and the dust-laden airmass from Arabia riding over this airmass towards the south Arabian Sea and Indian Ocean.