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AEROSOLS IN THE UTLS REGION AT TROPICS

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1. Introduction

Studies on background aerosol system in the troposphere and stratosphere are very important for understanding the properties of particulate matter in the upper atmosphere and their role in the radiative forcing of the atmosphere. While transport processes mainly govern the aerosol property in the upper troposphere, gas to particle conversion through heterogeneous condensation and nucleation is important in the stratosphere. During major volcanic eruptions in addition to particulate matter, abundant precursor gases are injected into the upper troposphere and lower stratosphere. As the vertical mixing across the troposphere is less efficient the species which are injected into the stratosphere will have a longer life time in this region which through prevailing transport can get transported globally and remain in these altitudes for several years before entering into the troposphere and finally get lost through cloud cycling. Even though no major volcanic eruptions happened after the eruption of Mt. Pinatabo (in 1991) mid-latitude measurements (*Deshler et al., 2003*) suggests that stratospheric aerosol level remains larger than the background level observed before 1970. However, except for satellite borne measurement [*Bingen et al, 2004*] studies over tropics are rather sparse. Information on particle habit could be obtained only through depolarization, which is not available from satellites. In this context, lidar based studies from tropics becomes important and with this in mind, studies on the characteristics of aerosols in the UTLS (Upper Troposphere Lower Stratosphere) are carried out using the dual polarization observations from the tropical station Gadanki, [13.5^{o}N, 79.2^{o}E] for the period 1998-2003.

2. Methodology

The monostatic lidar system located at National Atmospheric Research Laboratory (NARL), Gadanki operating at 532 nm (Sunilkumar et al., 2003) having dual polarization capability, is used for this study. Lidar backscattered signal on different nights are used to retrieve the altitude profiles of backscatter coefficients, extinction coefficient, backscatter ratio and linear depolarization ratio (δ) employing standard algorithms (Fernald, 1984). The lidar is operated for 5-10 nights in a month (having visually clear sky condition) and the data collected between 23 00 and 24 00 hr are used for this study.

3. Results and Discussion

In the absence of intense volcanic eruption (like Mt. Pinatobo) the data during the study period could be treated as that of the prevailing background aerosol system in the UTLS region. Fig. 1a shows the typical altitude profiles of mean aerosol backscatter coefficient derived from lidar on different nights during the year 1999. These mean profiles generally show a decreasing trend with increase in altitude in troposphere and stratosphere. But on few nights backscatter profiles shows an enhancement in the upper troposphere. These are due to the presence of thin cirrus clouds. Note that these clouds are so thin that the lidar beam could penetrate the cloud and provided measurable signal even from higher altitudes. The altitude profiles of aerosol extinction coefficient (α) are obtained by multiplying the backscatter coefficient with the lidar ratio (ratio of extinction to backscatter) the value of which is taken as 40 which is quite reasonable for the aerosols in the upper troposphere and stratosphere. Fig. 1b shows a contour plot of mean aerosol extinction coefficient in the UTLS region (as a function of the day of the year and altitude). Aerosol extinction in the UTLS region shows significant annual variation. This annual pattern also varies with altitudes. Notably high values are observed in the UTLS region during winter and summer months. As the occurrence of cirrus clouds is quite frequent in the upper troposphere these clouds are clipped off and the profiles are linearly interpolated between the base and top of the cloud for examining the annual pattern of background aerosol system. A threshold value of 2 for backscatter ratio and 0.04 for linear depolarization ratio (LDR) is used for screening the clouds. Though the cloud screening has decreases the absolute value of extinction coefficient in the UT region, its temporal pattern remained more-or-less same.

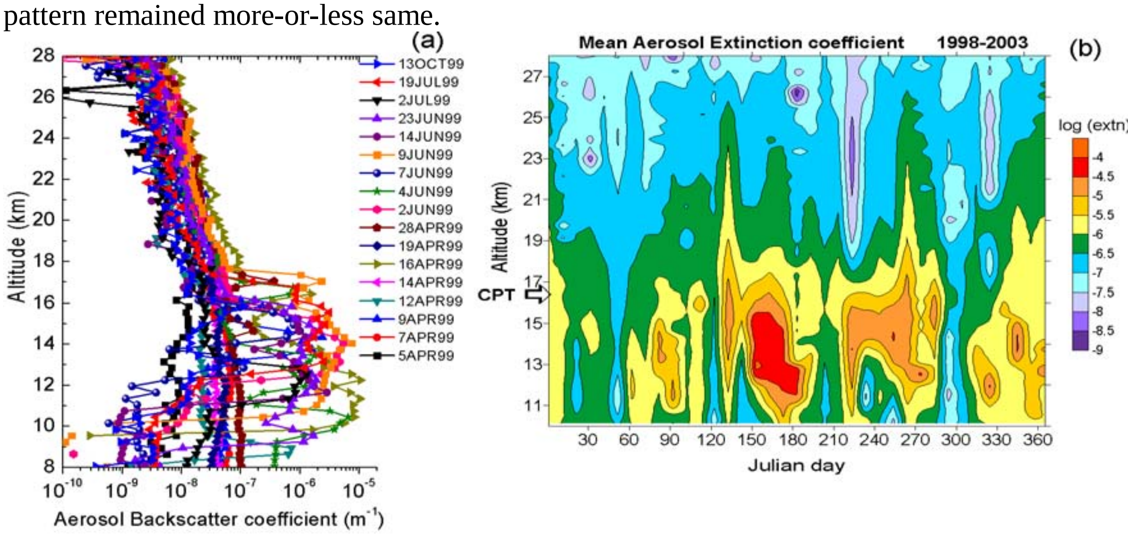

Fig 1. Typical altitude profiles of aerosol backscatter coefficient derived from lidar on different nights during the year 1999 (a). Contour plot of mean aerosol extinction coefficient showing the annual variation of aerosols in the UTLS region (b). The mean cold point tropopause (CPT) is marked by an arrow mark.

From the altitude profiles of α(h) and δ(h), the aerosol optical depth (AOD) and weighted mean linear depolarization ratio (δ) are estimated at different altitude region within a slab thickness of ~2km. The AOD is estimated by integrating the extinction coefficient between the base (h_1) and top (h_2) of the slab under consideration and δ is estimated as $\int_{h_1}^{h_2} \delta(h)dh \,/ \int_{h_1}^{h_2} dh$. Monthly mean AOD in the lower stratosphere (LS) region shows a broad peak during April to June period followed by a secondary peak during winter months of November to January (Fig. 2) with a clear minimum during the S-W monsoon period. Significant aerosol loading is observed just above the tropopause (coldest temperature point), displays the characteristics of tropical stratospheric reservoir. However aerosol loading just below the cold point is also found to be larger than that in the lower regions (12- 14 km). The mean AOD in the UT region is minimum during July-October. While a peak in AOD is observed in LS during May, correspondingly a dip is seen in the UT region.

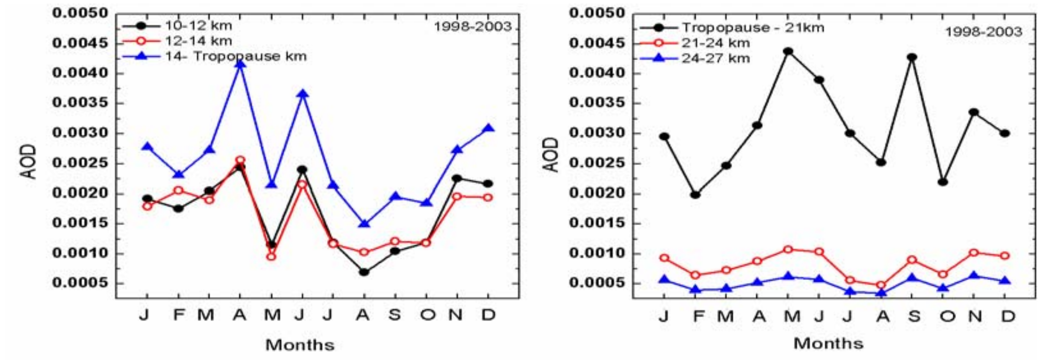

Fig 2. Month-to- month variation of AOD at UTLS region

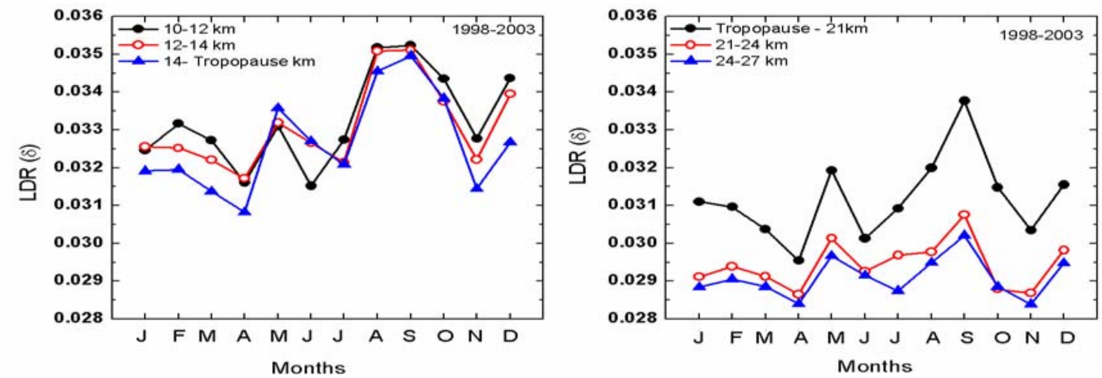

Fig 3. Month-to- month variation of weighted mean LDR (δ) at UTLS region

The mean value of δ in the LS also shows a pronounced seasonal variation with high values during the summer monsoon period with a secondary peak during the dry (winter) months (Fig. 3). A minimum in δ is distinctly observable during the months of April and November. A similar trend is observable in the UT region also. High values of δ during the summer months could be attributed to the exchange of non-spherical aerosols from the lower troposphere into LS. They could be ice particles from high altitude cirrus. The observed variation in aerosol AOD and δ could be an indication for stratosphere-troposphere exchange (STE) processes

Conclusion

1. The study suggests that stratospheric aerosol system is not much disturbed due to volcanic activity during the period 1998-2003.
2. Aerosol loading is quite significant in the UT and LS region irrespective of season. This could probably be associated with vertical transport into the upper troposphere as well as STE.
3. Relatively high values of δ' in the LS indicate that the aerosols in this region are relatively more non-spherical in nature, which could probably due to particle transport from the upper troposphere.

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