Features of upper troposphere and lower stratosphere aerosols observed by lidar over Gadanki, a tropical Indian station

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Received 22 September 2007; revised 9 April 2008; accepted 23 May 2008; published 10 September 2008.

[1] Upper troposphere (UT) and lower stratosphere (LS) aerosol characteristics are studied over a tropical station Gadanki (13.5°N, 79.2°E), using 532-nm Nd:YAG lidar during 2001–2005. Scattering ratios (SR) and aerosol extinction are found to exhibit seasonal and interannual variations in UT (10–15 km) and LS (18–30 km). SR is about 1.00–1.2 in the 10- to 30-km altitude region. Aerosol extinction is about 0.5–6 × 10^{-3} km^{-1}. SR in UT in 2001 and 2004 during winter is lower than that of summer, whereas LS winter profiles are found to have higher SR values. SR values apparently experience a shift in altitude corresponding to the seasonal change in tropopause indicating a relation between the two. UT integrated extinction is about 2.5 times higher than LS extinction. The correlation between UT and LS monthly mean aerosol extinction was weak and negative with a coefficient of 0.4. UT and LS aerosol extinctions over Gadanki are found to exhibit an increasing trend during 2001–2005. The percentage contribution of integrated aerosol extinction in the 10- to 30-km region to aerosol optical depth (AOD) is about 12%. Correlation coefficient between monthly mean AOD and the 10- to 30-km integrated extinction is about 0.6. The increasing trends in UT and LS aerosols seem to support the finding that emissions from subtropical and tropical Asia may have already started to influence the amount of sulfur containing gases reaching UT and LS. This becomes relevant in the climate change context as it has been shown that increasing aerosol abundances may be impacting the monsoon.


1. Introduction

[2] Optical and physical characteristics of aerosols vary as a function of altitude and residence time. The stratospheric aerosols are quite different from the tropospheric aerosols. The aerosols in the stratosphere have a longer residence time of a few months to years when compared to about a week in the lower troposphere. Tropospheric aerosols are short-lived due to gravitational settling and rainwash, produce regional and seasonal effects, whereas stratospheric aerosols are long-lived and produce long-term global effects. Vertically resolved aerosol physical and optical properties are important to understand the role aerosols play in altering the radiation budget of the Earth’s atmosphere. The tropical upper troposphere (UT) and the lower stratosphere (LS) is a crucial region for understanding aerosol characteristics and stratosphere–troposphere exchange.

[3] Banded structures in stratospheric aerosol distributions were seen during both quiescent and volcanic periods [Trepte et al., 1994]. Maximum optical depths were found over the tropics and high latitudes while minima were encountered in the 15° to 45° latitude region [Trepte et al., 1994]. The observed aerosol reservoir over the tropics was attributed to troposphere–stratosphere exchange, which gets aided by the enhancement in lofting associated with the easterly shear of quasi biennial oscillation (QBO). The vertical transport of mass between the stratosphere and troposphere is a crucial process in atmospheric physics and chemistry. The timescales of vertical mixing distinguish the troposphere from the stratosphere; throughout the troposphere transport of air and chemical species can occur in few hours via strong updrafts associated with cumulus formation typically in the vicinity of Intertropical Convergence Zone (ITCZ), while it may take months to years for vertical transport over a similar altitude range in the stratosphere [Seinfeld and Pandis, 1998]. The largest net upward transport into the stratosphere occurs in the tropics which consequently can affect the global middle atmosphere [Rosenlof, 1995].

[4] In addition the tropical UT is the region of high nucleation rate and newly formed particles, and can survive