Abstract

Optical investigations using ground based and balloon-borne photometers and lidar are the means by which the present work on tropospheric and stratospheric aerosols is carried out and reported herein. The thesis focuses on the optical properties of tropospheric aerosols, their day to day and seasonal variations and of stratospheric aerosols, their formation, evolution and decay.

A quantitative treatment of the role of aerosols in the Earth-atmosphere system continues to be a challenging task because of the wide variety of aerosol particles exhibiting different optical properties and large variations in aerosol abundances over different geographical areas and with respect to seasons. The composition of the atmospheric aerosol is exceedingly complex and our knowledge of the physical and chemical properties, which govern the aerosol size distribution and concentration, is still poor, because the measurements exhibit a wide range of uncertainty. In recent years, there has been a significant activity in developing comprehensive global models based on the observed features of tropospheric and stratospheric aerosols. However, at low and equatorial latitudes, there has been a scarcity of data for a long time. Even if the data exist, the data will be available only on one parameter and other aerosol parameters have to be assumed or calculated on that basis and as many of the aerosol parameters are not directly related to each other, makes aerosol modeling a tough assignment. Ground based and balloon-borne measurements form the heart of this work, the results of which have given a comprehensive data set and enabled us to understand various aerosol properties in troposphere and in stratosphere and the relative importance of the various processes which control the size parameter and number density responsible for the formation of stratospheric aerosol layer and its decay. The results are useful in climate models and for modelers developing radiation parametrisation schemes to study quantitatively the impact of aerosols on the atmospheric radiation balance.

The thesis comprises of five chapters.

• Chapter 1 gives a background for the thesis. Description of aerosols, aerosol characteristics such as their sources, residence times, sinks and the effects are outlined. The

present day understanding about aerosols is summarised. Some key issues relating to aerosols are discussed. The need for aerosol studies and the importance of tropical aerosols is stressed. A very brief history of Indian measurements is also outlined. The scope and the importance of the present work is presented.

• Chapter 2 gives a general description of the various physical and optical properties of aerosols and their consequences which are covered in this work. Aerosol size distributions, results on Mie scattering theory both for a single aerosol particle and for an ensemble of particles representing an aerosol size distribution, extinction, scattering and absorption coefficients, important radius range for optical investigations, aerosol phase functions, asymmetry factor and single scattering albedo are explained and their importance is discussed in detail.

As the thesis is divided thematically, the following two chapters have in them the work done on tropospheric and stratospheric aerosols, alongside the instrumentation, data analysis and the results obtained.

• Chapter 3 deals with the features of aerosols over Ahmedabad observed with a Sun-tracking photometer. An automatic Sun-tracking photometer was developed and employed to measure the aerosol optical depths at selected wavelength bands. A brief description of the instrumentation, calibration procedure, measurements, data analysis and the results obtained on the diurnal, day to day and seasonal variations of aerosols observed over a period of 5 years, from 1991 to 1995 which covers the Gulf oil fires in early 1991 and Pinatubo eruption in mid-1991 are explained and discussed. From the measurements of transmitted solar radiation intensities the aerosol optical depths are obtained. The relation between the aerosol optical depths and other meteorological parameters is explored.

• Chapter 4 can broadly be classified on the basis of experimental and modeling work carried out by the author.

The experimental part describes the two high altitude balloon flights, conducted from Hyderabad during October 1991 and April 1992 to study the stratospheric aerosol layer formed due to Pinatubo volcanic eruption in June 1991. Sun-tracking and Sun-scanning photometers were employed onboard the balloons to measure the vertical profiles of direct and scattered solar radiation intensities. From the direct solar radiation intensities, the aerosol extinction coefficients, mode radius, mass of the layer and from the scattered radiation intensities the aerosol size parameter, number density and asymmetry factor are determined. A newly set up Nd:YAG lidar system is described and measurements conducted to study the Pinatubo layer over Ahmedabad for over a period of 3 years from April 1992 to May 1994, data analysis, results obtained on scattering ratios, aerosol backscatter and extinction coefficients, the time evolution of the mass of the Pinatubo layer, peak scattering ratio and comparison of the results with El Chichon eruption are presented and discussed.

A simple model is developed to study the decay of volcanic aerosol layer formed at stratospheric altitudes and changes in the aerosol size distribution, taking into account the aerosol microphysical processes of growth, coagulation and sedimentation. Model results on the time evolution of aerosol optical depths at stratospheric altitudes, for different initial aerosol amounts, corresponding to eruptions of widely varying magnitudes are presented and discussed. The experimental lidar results obtained on Pinatubo (present work) and El Chichon (data available in literature) are compared with the model results and discussed.

• The summary of the results obtained and suggestions for future research are envisioned in Chapter 5.