EXPERIMENTAL INVESTIGATION OF AEROSOL PROPERTIES AND MODELLING OF ITS IMPACT ON RADIATION BUDGET

HARISH GADHAVI

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PHYSICAL RESEARCH LABORATORY

AHMEDABAD – 380 009, INDIA

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Harish Gadhavi

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Physical Research Laboratory
Ahmedabad 380 009 India

CERTIFICATE

I hereby declare that the work presented in this thesis is original and has not formed the basis for the award of any degree or diploma by any university or institution

Harish Gadhavi
(Author)

Prof. S. Krishnaswami
(Thesis Supervisor)
Physical Research Laboratory
Ahmedabad 380 009 India

Dedicated to

Mummy and Papa

ABSTRACT

Motivated from the rising concern for global climate change as a consequences of changes in atmospheric composition, this work was undertaken to investigate properties of one of the very important atmospheric components, aerosol. A detailed study of aerosol vertical profile and other aerosol properties is carried out over Ahmedabad from February 2002 to November 2004. In addition, specific field measurements at variety of places such as Antarctica, Western Gujarat, and Central India are carried out to study the spatial inhomogeneities. The observed aerosol physical and optical properties are further used to study their influence on radiation budget by employing radiative transfer models and by calculating radiative forcing.

Aerosol extinction values are characterised by a large day-to-day variation typical of urban location, while inter-annual and seasonal variations are higher that they are above the standard deviation of the daily mean value. Extinction values for year 2003 are highest during the study period, significantly higher than 2002 while marginally higher than 2004 values. Well known seasonal variation expected over India i.e. summer time increase in AOD is also observed over Ahmedabad. AOD is found to be around 0.2 during winter and around 0.8 during summer. Interestingly the observed variation is found to be different at different altitude levels. It is found that variation in aerosol extinction above 1 km is mainly responsible for the observed seasonal variation. Measurements of aerosol properties such as scattering and absorption coefficients show different seasonal variation than that of AOD with summer time low and winter time high values. Absorption coefficient over Ahmedabad is found to be in the range of 0.2 to 4 x 10^{-5} m^{-1} with a mean value of 2.1 x 10^{-5} m^{-1} and scattering coefficient is in the range 0.7 to 2.6 x 10^{-4} m^{-1}. Single scattering albedo calculated from absorption and scattering coefficients is 0.87 ± 0.09.

Contrary to observations made over Ahmedabad, which is an urban site, very different aerosol properties are observed during field studies at different locations. For example over Maitri-Antarctica, AOD is found to be very low (0.036±0.018 at 400 nm) during Jan-Feb 2001 with a flat spectral dependence, which is typical of a pristine region. The average mass concentration of PM_{10} particles at Maitri for the campaign period is 9.1±6.0 μg/m^3, of which 63 % of mass is contributed by coarse mode particles. Also, interesting day and night differences are observed in the measurements of vertical profile carried out over Western Gujarat during Dec – Jan 2003 and in central India during Feb 2004. At locations nighttime AOD is found to be 12 to 80 % lower than the nearest neighbour daytime AOD. Difference in boundary layer height is also observed during the field campaigns that can be attributed to differential heating between ocean and land over the peninsular India.

Measurements of aerosol extinction profile are carried out by airborne lidar for the first time in India. Measurements have been carried out on experimental basis and the usefulness of airborne observation is demonstrated in studying the boundary layer and free tropospheric aerosols.

Radiative forcing computation is made using observed aerosol properties in radiative transfer model. Large absorption in the atmosphere over Ahmedabad is found which ranges from 20 to 80 W/m^2 depending on season. Study on vertical profile of aerosol radiative forcing and their seasonal variation reveals that in the boundary layer aerosol radiative forcing is a factor of 2.5 higher during May than February and produces additional heating rate of ~1 K/day. Top of the atmosphere (TOA) aerosol radiative forcing (ARF) over Maitri-Antarctica is found to be positive 0.45 W/m^2 mainly because of highly reflective snow surface underneath. However, ARF over Antarctica is sensitive to the sun-earth geometry. For the same amount of aerosol, ARF over Maitri varies from +0.7 W/m^2 in December to -0.15 W/m^2 in April and August, and it becomes zero during no sunshine days in June and July. Importance of surface reflectance for ARF is shown by carrying out calculations over ocean (Bay of Bengal) and continental locations (Ahmedabad, Hyderabad, etc.). Large difference in TOA ARF is observed between ocean and land though the difference in AOD is not of the same magnitude as the TOA forcing is very sensitive to surface reflection.

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