G-O-4

AEROSOL, GASES, AND RADIATIVE FEATURES AROUND ARABIAN SEA DURING ICARB-06 SHIP CRUISE

M C R Kalapureddy, P C S Devara, and S K Saha

PM&A Div., Indian Institute of Tropical Meteorology, Pashan, Pune 411 008, India.
[+]email: kalapureddy1@gmail.com

1. Introduction

The natural aerosol, due to their dominant share (80%), evidently plays vital role on global scale climate whereas the anthropogenic aerosol plays crucial role on regional scale climatic features. So, it is required to delineate the natural and anthropogenic aerosol roles as far as regional features are concern. Continents surrounding the Arabian Sea and the tropical Indian Ocean are responsible for the production of a variety of natural and anthropogenic aerosols. The well established linkage of dynamical and thermodynamical features, such as setting up of low level jet, warm pool, land-ocean thermal gradients, associated with Arabian Sea (AS) during pre-monsoon play vital role on forthcoming monsoonal features of Indian subcontinent. Besides dynamical and thermodynamic linkage, the role of pre-monsoon aerosols over AS region also expected to be play critical role, mainly, on monsoon features over Indian subcontinent (e.g., Devara *et al* 2003) and partly on global climate through radiation budget. Hence, better knowledge on pre-monsoon aerosol characteristics over AS is important. Recently, Indian Space Research Organization-Geo-Bio-sphere Program (ISRO-GBP) organized a nation-wide campaign, Integrated Campaign on Aerosol, Gases and Radiation Budget-2006 (ICARB-06), during March-May 2006. The uniqueness of this campaign, in comparison to earlier ones, is its vast coverage of oceans around India. This campaign covered extensively, east and west coast regions, Bay of Bangal (BoB), Tropical Indian Ocean (TIO) and AS. The aim of the present paper is to report some results on pre-monsoon aerosol characteristics derived from the measurements made, for ICARB-06, onboard ORV Sagar Kanya, in the western part of India, over AS region and Pune.

2. Observations and Database

Aerosol and radiation observations were made with fairly good time resolution (10 minutes) over the BoB, TIO and AS onboard Oceanographic Research Vessel (ORV) Sagar Kanya (SK) during its cruise, SK223 in the pre-monsoon season of 2006. The first leg (SK223A) started in the east coast, Chennai. The BoB and the TIO regions were covered in the first leg during 18 March to 06 April and 07-12 April respectively. The second leg (SK223B) started in west coast on 18 April from Trivandrum to cover western part of IO and AS regions and ended at Goa on 11 May. For this study, the region around west coast of India and adjoining Arabian Sea is only being considered. Further the AS is divided into Coastal AS (CAS), less than 220 km from coast, Mid AS (MAS), between 220 km and 550 km, and Far AS (FAS), above 550 km away from Indian west coast. The cruise track of SK223 for ICARB-06 for the period 09 March - 11 May 2006 can be seen from figure 1. The points on the track show the position of the ship at 0530 UTC on each day and the arrow head shows its direction along the track. For the same period, an urban, in-land station Pune (18º32'N, 73º51'E), observations were also considered for this study. Observations on aerosol and trace gases were made using hand held Microtops II (MT) Sun photometer and Ozonometer. The MT provide columnar water vapor (WV), ozone

and Aerosol Optical Thickness (AOT) at (340, 440, 500, 675, 870 and 1020 nm with a FWHM of 5 to 10 nm) derived from instantaneous solar flux measurements using its internal calibration. A Global Positioning System (GPS) receiver attached with the photometer provides the information on time, location, altitude (pressure). The Down-welling Short Wave (SW) radiation measurements have also been made using Pyranometer. Data recorded around cloud passage on or near by field-of-view (FOV) have been discarded from this analysis. Thus, the observations were possible for about 10 clear-sky and 11 partial clear-sky (clear FOV) days with around 3900 data sets recorded in entire curies in the western part of India. On few occasions, over pristine oceans, the AOT values were noted to be very low (< 0.15 for 500 nm). Observations recorded in western India over the AS during 12 April and 18 April – 10 May, 2006 and at Pune from March-May2006 are considered for this study. The First order Angstrom wavelength exponent (α) is computed from spectral variation of AOT (τ_a) in the wavelength range 340-870 nm using the Angstrom (1964) empirical relationship The second order Angstrom exponent (α') has been derived following Eck *et al* (1999) to quantify the rate of change of slope in $\ln \tau_a$ and $\ln \lambda$ curves using observed AOT at 340, 500 and 870 nm wavelengths.

3. Results and Discussions

In the western India, over Arabian Sea, spectral AOT distribution (figure 2a) shows increasing with increasing longitude from FAS (58.0˚E) to CAS (77.5˚E). Latitudinal distribution of such shows a pockets of higher AOT (see figure 2b) whenever the ship closer to west coast of India. It is interesting to note from figure 2 that the AOT at shortest wavelength ,330 nm, always shows ~30% more compare to other, it indicates the dominance of accumulation mode particles in the spectral aerosol distribution over AS. WV shows gradual decrease with increasing latitude with maximum at 9˚N and minimum at 22˚N whereas pockets of high columnar ozone values are noticed around 17˚N and14˚N and sudden dip in ozone value is observed on 30 April 2006 at 14.5˚N, there was a rain on that day.

Spectral AOT shows non-linear relation of AOT with increasing wavelength (see figure 3). There is sudden fall from AOT at 330 nm to about ~30% to immediate 440 nm and a small increase from there to next 500 nm point out there may exits a bi-model aerosol size distribution (ASD). Higher β (aerosol loading) with lower α value noticed on FOV clear days. In contrast to this, higher α values with lower β noticed on clear sky days indicates accumulation mode particle domination in general over the AS region. It is also noticed that α and β values are relatively smaller than that of Bay of Bengal.

The Pyranometer measured SW fluxes (0.3-3.0 μm) are compared with instantaneous AOT (for 500 nm) corrected to the air mass factor ($1/\mu$) so as to calculate the direct radiative forcing. Normalization of the AOT with μ (= Cosθ) is found necessary as the slant air column length increases with increasing solar zenith angle θ. The direct solar flux represents the solar flux at surface, normal to the angle of incidence, with in cone of about 2.5^o with the Sun at the center. Along with, excluding the data for solar zenith angle larger than 60^o (to avoid effects due to Earth's curvature) also restricted AOT/μ with 0.8. Figure 4 shows scatter plot of measured normalized SW flux with AOT for CAS, MAS and FAS regions. A straight line could be fitted with a negative slope of about 342, 221, and 220 W m^{-2} per unit AOT for CAS, MAS and FAS respectively as shown in figure 4(a-c). Thus, for a 0.1 increase within the prescribed columnar AOT the solar flux decreases by about 34.2, 22.1 and 22.0 W m^{-2} for CAS, MAS and FAS respectively.

Remarkable details on this work will be discussed in the conference, IASTA-07; Due to space limitation much information has not included now.

3. Summary

This report reveals the Sagar Kanya ship cruise observations of columnar aerosol, ozone and water vapor over Arabian Sea (AS) during pre-monsoon under the Nation-wide campaign ICARB-06. It is observed that the far away from Indian west coast the aerosol loading was less and it goes on increasing from mid Arabian Sea (AS) towards Indian west coast and western Indian in-land urban station, Pune, shows more loading compared to the AS. Relative dominance of accumulation mode particle with Bi-model distribution observed over pristine oceans. Large and small diurnal variation of AOT noticed respectively over Far and Coastal AS. Surface radioactive cooling due to aerosols is more over Coastal AS region. The columnar water vapor shows gradual increasing trend from FAS to CAS with maximum and minimum noticed at CAS and Pune respectively. The columnar ozone shows decreasing trend from FAS to Pune.

Acknowledgments: Thanks are also due to the Director, IITM for encouragement. This work was supported by the ISRO-GBP-ICARB project. ICARB project director, K Krishna Moorthy, encouragements are highly acknowledged. Authors are thankful to NCAOR/DOD, Dr M Sudhakar, for the ship and onboard facilities and also to the Sagar Kanya cruise members for their excellent support and co-operation. The useful discussions and support of our group members are gratefully acknowledged.

References

1. Angstrom A 1964 The parameters of atmospheric turbidity; *Tellus* **16** 64-75.
2. Devara P C S *et al* 2003 Relationship between lidar-based observations of aerosol content and monsoon precipitation over a tropical station, Pune, India; *Meteorol. Appl.* **10** 253-262.
3. Eck T F *et al* 1999 Wavelength dependence of the optical depth of biomass burning, urban, and desert dust aerosols; *J. Geophys. Res*. 104(D24) 31333-31349.
4. Satheesh S K and Ramanathan V 2000 Large differences in the tropical aerosol forcing at the top of the atmosphere and Earth's surface; *Nature.* **405** 60-63.

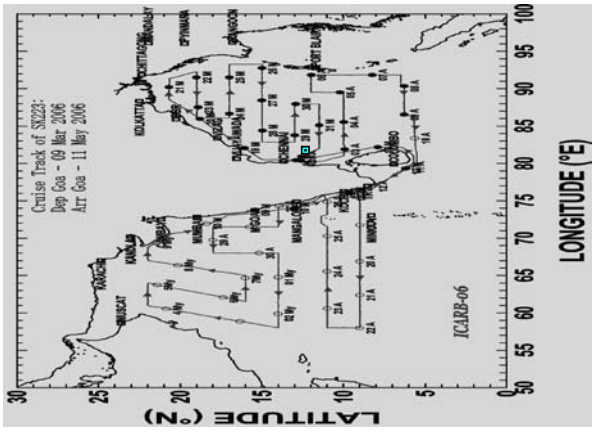

Figure 1: Cruise track of Sagar Kanya for ICARB-06.

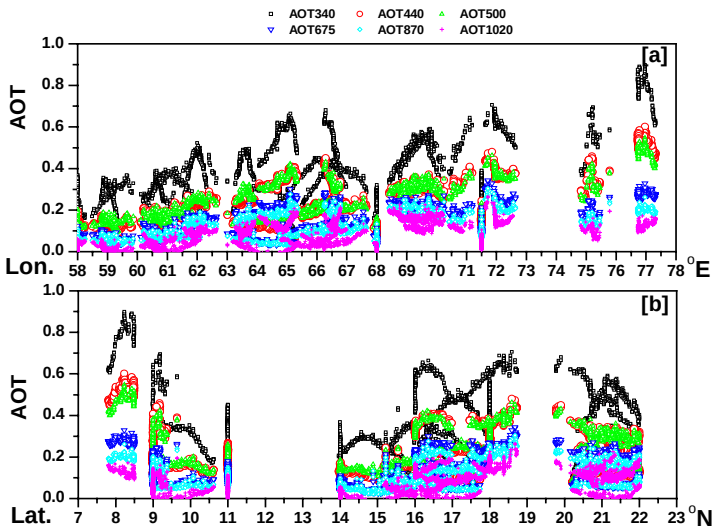

Figure 2: Spectral distribution of AOT observed, during ICARB-06, on board Sagar Kanya in western India with respect to (a) Longitude and (b) Latitude.

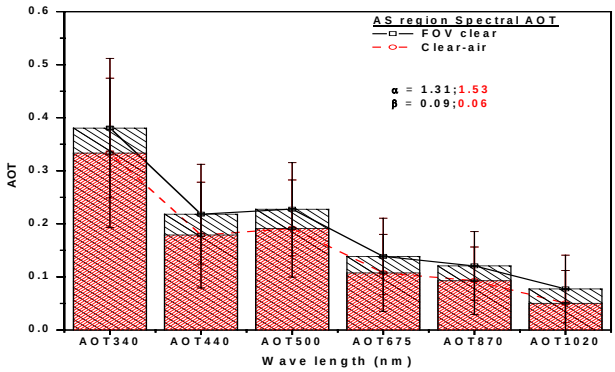

Figure 3: Spectral characteristics of AOT over

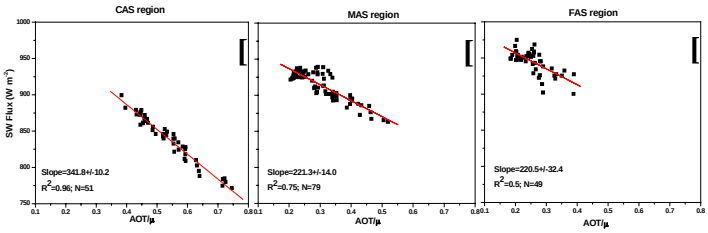

Figure 4: Association between direct solar flux and columnar AOT (at 500 nm) normalized for the air mass