

# **BIOMASS BURNING AEROSOLS CHARACTERISTICS AND RADIATIVE FORCING – A CASE STUDY FROM EASTERN GHATS, INDIA**

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## **INTRODUCTION**

Atmospheric aerosol particles both natural and anthropogenic are important in earth's radiative balance. Aerosols scatter incoming solar radiation and modify short-wave radiative properties of clouds by acting as cloud condensation nuclei(CCN). First effect is termed as “direct radiative forcing” and second, “indirect radiative forcing”. Aerosols exert influence on atmosphere (Charlson et al., 1992) and received much less attention than radiative forcing due to greenhouse gases and clouds. Radiative forcing due to aerosols is comparable in magnitude to current anthropogenic greenhouse gas forcing but opposite in sign(Houghton et al. 1990). One contributing factor for inability of current climate models to accurately estimate surface temperatures may be lack of information on spatial, temporal and radiative properties of aerosols. Biomass burning, which is widely prevalent in tropics is due to savanna fires, shifting cultivation practices, deforestation, fuel wood use and burning agricultural residues (Hao &Liou, 1994). Biomass-burning activities are intense in dry season between December to March in Northern hemisphere and between June to September in Southern Hemisphere (Penner et al., 1994). The present study addresses the variation of aerosol optical depth and related radiative forcing in biomass burning associated with shifting cultivation practices in tropical dry deciduous forests.

## METHODOLOGY

Aerosol optical depth (AOD) has been measured using MICROTOPS-II sunphotometer operating at 380,440,500,675,870 and 1020nm during 16<sup>th</sup> to 20<sup>th</sup>, January,2000 corresponding to non-burning days and 4<sup>th</sup> to 9<sup>th</sup> May,2000 corresponding to biomass burning days in the study area of East Godavari District, Andhra Pradesh.

### **Shortwave Aerosol Radiative Forcing(SWARF):**

SWARF is defined as difference in shortwave fluxes between clear and aerosol regions (SWARF =  $S_0(\alpha_{\text{clr}} - \alpha_{\text{aer}})$  where  $S_0$  denotes incoming solar flux in  $\text{Wm}^{-2}$  and  $\alpha_{\text{clr}}$  and  $\alpha_{\text{aer}}$  denote clear and aerosol sky albedos). A delta-four-stream plane-parallel broadband radiative transfer model (Fu and Liou., 1993) was used to compute shortwave fluxes at top of atmosphere in biomass burning regions over sunphotometer sites. Clear-sky shortwave fluxes were calculated by assuming only background conditions. Surface broadband albedos are assumed to be a function of solar zenith angle(Charlock and Surface., 1997). In previous research, four stream model has been used to calculate TOA, surface, and atmospheric fluxes in clear and cloudy (water and ice clouds) conditions (Charlock and Alberta., 1996). In the current study, this model is modified to account for biomass-burning aerosols by utilizing measured aerosol optical thickness from sunphotometer measurements (Christopher et al., 1998). Delta-four-stream approach agrees with adding-doubling calculations to within 5% for fluxes and is an improvement over two-stream approach (Liou et al., 1988). In this model, correlated-k distribution is used for gaseous absorption and emission. Gases in model include  $\text{H}_2\text{O}$ ,  $\text{CO}_2$ ,  $\text{O}_3$ ,  $\text{O}_2$ ,  $\text{CH}_4$ , and  $\text{N}_2\text{O}$ . Radiative effects of Rayleigh scattering, liquid water droplets, ice crystal, continuum absorption of  $\text{H}_2\text{O}$ , and surface albedo are considered. In this model, shortwave (SW)

spectrum (0.2-4.0  $\mu\text{m}$ ) is divided into 6 bands: 0.2 - 0.7  $\mu\text{m}$ , 0.7 - 1.3  $\mu\text{m}$ , 1.3 - 1.9  $\mu\text{m}$ , 1.9 - 2.5  $\mu\text{m}$ , 2.5 - 3.5  $\mu\text{m}$ , and 3.5 - 4.0  $\mu\text{m}$ . For principal atmospheric gases, four-stream approach matches line-by-line simulations of fluxes to within 0.05% for SW calculations. Size distribution of aerosols has been estimated from measured wavelength dependence of aerosol optical thickness, based on the method suggested by King et al 1978. Turbidity coefficients have been estimated using Angstrom relation (Nagel., 1975).

## **RESULTS AND DISCUSSION**

Aerosol particles showed bimodal type of size distribution both in biomass burning and non-burning periods (Figs. 1-2). During biomass burning period columnar content of aerosols ( $N_t$ ) have been observed to be high. Turbidity coefficient ( $\beta$ ) estimated using Angstrom relation varied from 3.14 to 7.86 suggesting high atmospheric turbidity during burning period. Weighted mean radius of aerosols have been observed to be high during burning period. Radiative transfer calculations show that daily averaged SWARF varies from  $-24 \text{ Wm}^{-2}$  to  $-42 \text{ Wm}^{-2}$  during burning period. Figs. 3 & 4 shows time series of SWARF and AOD for different days during biomass burning period. Maximum SWARFs are found to of the order of  $-70 \text{ Wm}^{-2}$  and corresponding AOD values are found to be greater than 1.3. Time periods when AOD are nearly constant, Solar Zenith Angle (SZA) becomes dominant factor with larger SZA corresponds to larger SWARF. This is because when SZA becomes large, slant path also becomes longer, and incoming solar irradiance experiences a stronger attenuation. This explains why minimum SWARFs are found around local noon where SZAs are nearly zero and AOT values are lower. Fig. 5 shows sensitivity of calculated SWARF values to assumed single scattering albedo ( $\omega_0$ ). Open circles show calculated SWARF with  $\omega_0$  value of 0.86 and closed circles show SWARF

values calculated with an  $\omega_0$  values of 0.90. Most satellite studies use an  $\omega_0$  value of 0.90 because that provides best fit between measured AOT values from sunphotometer and satellite measured radiance values. Using a second order polynomial fit, for  $\omega_0$  value of 0.90 at 0.67  $\mu\text{m}$ , relationship between SWARF and AOT can be expressed as:

$$\text{SWARF} = -0.98 - 78.79 \cdot \text{AOT} + 17.32 \cdot \text{AOT}^2.$$

## Conclusions

The observed negative shortwave radiative forcing denotes a cooling effect because aerosols from biomass burning reflect more of the incoming solar radiation than clear-sky regions. The daily averaged SWARF for the study period ranges from  $-24 \text{ Wm}^{-2}$  to  $-42 \text{ Wm}^{-2}$ . The maximum SWARFs are found when the observed AOT values are also high. Drastic loading of accumulation mode particles has been observed during burning periods in contrast to the large sized particles loading during non-burning periods.

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Fig.1

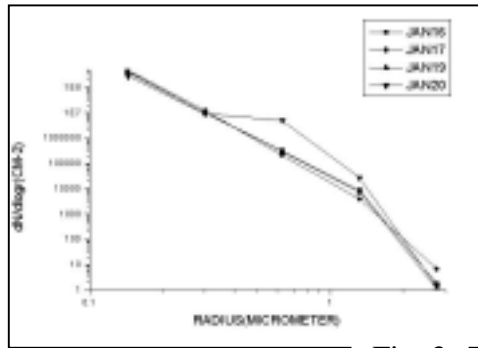


Fig. 2

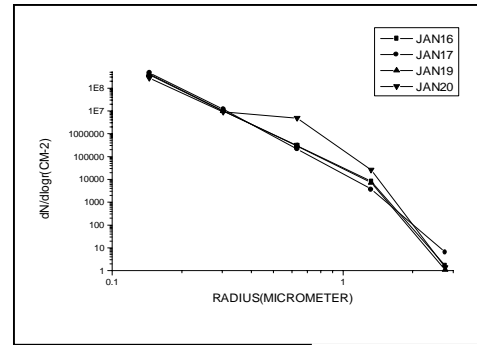


Fig. 3

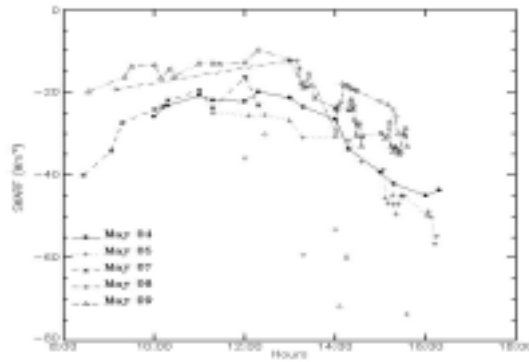


Fig. 4

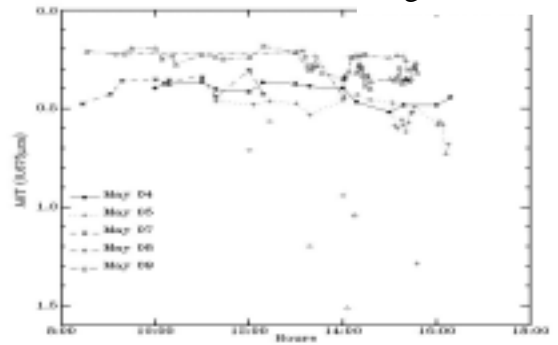


Fig. 5

