

Effective Single Scattering Albedo Estimation using Regional Climate Model

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1. INTRODUCTION

Atmospheric aerosols significantly affect the climate over regional and even global scales by perturbing the radiation balance of the Earth (IPCC, 2007). However, the aerosol effects on atmospheric radiation remain as a major uncertainty in understanding the past and present climates and for predicting the future climate (IPCC, 2007). One of the key reasons associated with this uncertainty is in estimating and optimizing optical characteristics of aerosols such as single scattering albedo (SSA). Ramanathan et al., 2002 describes the importance of optimizing the absorbing aerosol optical characteristics in order to evaluate various impacts of aerosols in model studies. Carbonaceous aerosols [i.e., Black carbon (BC) and organic carbon (OC)], which are induced from various anthropogenic and biomass burning activities (Andreae and Gelencser 2006), and dust, resulting from natural emissions (Zakey et al. 2006), are increasingly recognized as the most important solar radiation absorbing aerosols in the visible spectral range (Fialhoa et al., 2005). Thus, in this study, by modifying the aerosol optical property parameterization of Regional Climate model (RegCM) (i.e., the mass absorption cross-section of these aerosols), we estimate the regional scale Effective Single-Scattering Albedo (ESSA, ϖ). The estimated ϖ values are representative of the visible spectral region: VIS (380-760 nm). This is quite useful for broad band radiative transfer theories to evaluate the aerosol radiative forcing effect on regional scale. In this paper, we present the evaluation of simulated ϖ by comparing with MISR retrieved data at 558 nm, and summarize the regional scale variation of ESSA.

2. MODEL AND METHOD

The RegCM version 4.0 (RegCM4.0), developed by the Abdus Salam International Centre for Theoretical Physics (ICTP) was used to simulate

the distribution of BC, OC and dust aerosols, during the predominant bio-mass burning seasons of South Africa, for the year 2000: August and September 2000. This study used the anthropogenic BC and OC emissions from the Emission Database for Global Atmospheric Research (EDGAR, Olivier et al., 2005) and the biomass burning inventory of BC and OC from Liousse et al. (1996). For dust calculations, we used the dust module developed and implemented by Zakey et al. (2006). The Effective Mass Absorption Cross-section (EMAC, $K_{i\text{eff}}$) of the i^{th} particle in $\text{m}^2 \text{g}^{-1}$, where computed using Eq. (1) below.

$$K_{i\text{eff}}(\lambda) = \frac{\int_{\text{VIS}}^{\infty} [\int_0^{\infty} \alpha_i(r, m_\lambda, \lambda) n(r) dr] I_0(\lambda) d\lambda}{\int_{\text{VIS}}^{\infty} [\int_0^{\infty} \rho_i(r) V(r) n(r) dr] I_0(\lambda) d\lambda} \quad (1)$$

Here, $I_0(\lambda)$ is the solar extraterrestrial spectral energy distribution, which is taken from <http://eosweb.larc.nasa.gov/cgi-bin/sse/daily.cgi>.

r , m_λ , $\rho_i(r)$, $V(r)$ and $n(r)$, which are taken from Hess et al., 1998 database, refer to the radius, spectral complex refractive index, density, volume and the number distribution of the i^{th} particle, respectively. $\alpha_i(r, \lambda)$ is the spectral absorption cross-section of the i^{th} particle, which is calculated from Mie theory. Therefore, rooted in Eq. (1) outcomes, the RegCM4.0 aerosol optical properties were modified. To determine the background dry aerosol scattering optical depths [$\tau_{\text{Scat.}}(R_0)$] (i.e., RH < 25%) we used the climatology studies of Tesfaye et al., (2011). Based on the above basic procedures, the mean values of ϖ were computed and the obtained results were compared with MISR-retrieved data.

3. RESULT

The comparison of the mean values of ω , (i.e. averages of August and September 2000) for both simulated and MISR-retrieved data at 558 nm, is presented in Fig. 1.

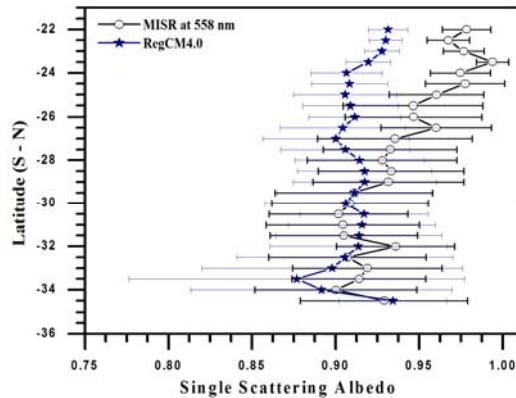


Fig.1: Latitudinal variation of simulated ω and MISR retrieved data at 558 nm.

For the latitudinal range of 34.5° S to 25.5° S (i.e., from the Southern tip of Western Cape to central areas of Gauteng), simulated values of ω were found to be within/at the margin of standard deviations of MISR retrieved data (i.e., the comparison showed a mean deviation $< 4\%$). However, for the latitudinal range of 25.5° S to 22° S, the comparison showed a mean deviation from 4% to 8%. This might be due to the under estimation of the dust emission by RegCM, especially dust particles induced from local agricultural activities. This is due to the RegCM dust emission parameterizations which are effective for cells dominated by desert and semi-desert land cover only.

4. SUMMARY

In this study, by modifying the optical parameterization of Regional Climate model (RegCM), we have computed and compared the Effective Single-Scattering Albedo (ESSA) which is a representative of VIS spectral region. The arid, semi-arid and agriculturally active areas of South Africa showed a higher ESSA (> 0.93). Due to intensive biomass burning and atmospheric processes of BC particles in the south-east coastal areas, lower values of ESSA were observed (~ 0.73 to 0.88). The evaluation of the simulated ESSA, in comparison with

MISR retrieved data, exhibited a very good agreement (deviation $< 8\%$).

ACKNOWLEDGEMENTS

The authors are thankful to Addis Ababa University, Department of Physics, for providing computational facilities and to Fiona Tummon, for her valuable assistance. This work is supported by African Laser Centre and National Research Foundation under the grant (68688/65086/73449), in addition to CSIR-National Laser Centre.

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