PITFALLS IN THE RETRIEVAL OF FINE AND COARSE MODE AEROSOL OPTICAL DEPTH: HOW WELL DO WE UNDERSTAND COARSE MODE EFFECTS INDUCED BY THIN CLOUDS?

Santo V. Salinas, Boon N. Chew and Soo C. Liew

National University of Singapore
Centre for Remote Imaging, Sensing and Processing (CRISP)
Blk SOC 1, Level 2, Lower Kent Ridge Rd. Singapore 119260
e-mail: crsscsv@nus.edu.sg[1], crscbn@nus.edu.sg[2]

1. ABSTRACT

Aerosol optical depth and its first and second spectral derivatives respect to wavelength, are often used to describe the interaction of aerosol particles present on a given size distribution. The first derivative which is also known as the Angstrom exponent (α), can provide a useful measure of the average aerosol dimensions in the sub–micrometer and super–micrometer particle size range. On the other hand, the second derivative (α') provides a useful means to test the departure from linearity, which is inherent from the formulation of the Angstrom law, for a given aerosol size distribution. Since the Angstrom exponent carries information from both the fine and coarse mode of the size distribution, it is of some relevance to ascertain whether a purely fine–mode analog of the Angstrom exponent can be extracted from measured optical depth spectra. By starting from the basic assumption that particle size distribution can be represented as a bi–modal distribution, O'Neill and collaborators [1, 2] were able to extract the fine (τ_f) and coarse mode (τ_c) optical depth from the spectral shape of the total aerosol optical depth ($\tau_a = \tau_f + \tau_c$). Their algorithm, was essentially dependent on the fact that the coarse mode spectral variation is approximately neutral[3]. Once the fine mode ratio ($\eta = \tau_f/\tau_a$) is know, then the equivalent fine mode Angstrom number can be extracted. In previous related work[4, 5], we used this knowledge to extract fine and coarse mode aerosol optical depth as well as the

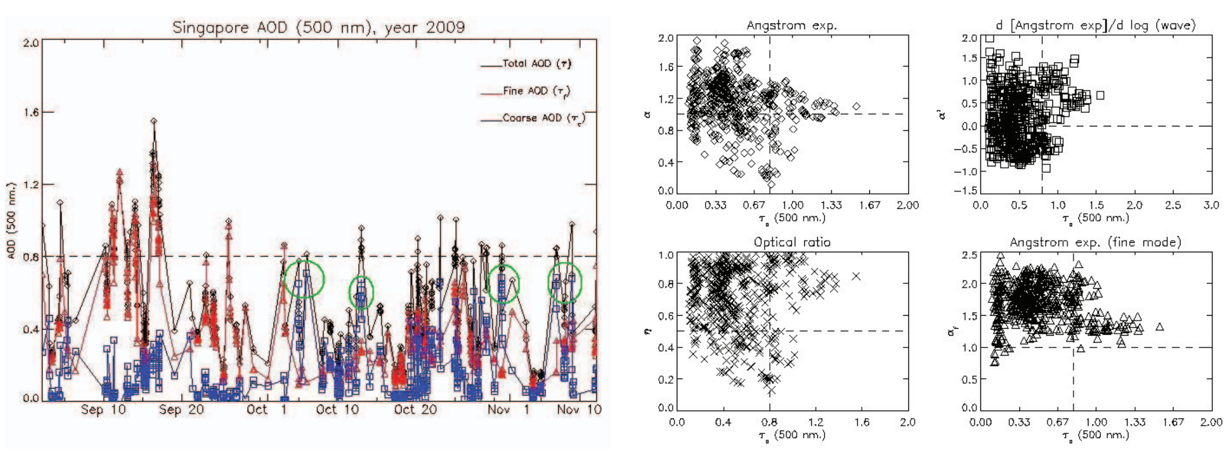

Fig. 1. *Left: Retrievals of fine and coarse mode aerosol optical depth from direct Sun measurements, green circles locates potential anomalous behaviour of the algorithm. Right: Derived fine mode Angstrom number and fine mode optical ratio.*

fine mode Angstrom exponent from direct Sun data at our site (Fig.1). We used this information to analyze the behaviour of fine–mode particles (and its Angstrom number) at small to intermediate optical depth. Our aim was to understand the nature of

Financial support by the Agency for Science, Technology & Research (A*STAR) of Singapore is gratefully acknowledged.

aerosols generated by bio–mass burning events such as those occurring in South–East Asia. From a theoretical perspective, one can look into pure coarse mode events (τ_f = constant) or pure fine mode events (τ_c = constant) and its associated parameters (α_c, α'_c and α_f, α'_f) as a mean to understand the optical behaviour of such events. However, pure fine and/or coarse mode events are rarely found isolated therefore a unified approach such as the spectral discrimination algorithm (SDA,[3]) has to be used. The SDA has few inherent assumptions that need to be understood in order to obtain meaningful retrievals for our region. In this region, the presence of transient thin homogeneous and inhomogeneous cloud are a normal occurrence during the year. Cloud contamination can certainly affect the performance of the SDA algorithm when retrieving fine and coarse mode information. In our retrievals, we have noticed several anomalous events which can be associated with non–homogeneous thin cloud events (green circles in Fig.(1), basic assumptions regarding the spectral behaviour of the coarse model optical depth as well as systematic errors from our cloud filtering algorithm. Herein, we investigated the effect of transient thin clouds as well as the inherent assumptions of the SDA algorithm in order to constrain the anomalies we observed in our retrievals. Firstly, from basic Mie calculations, constructed for purely coarse mode events, we found that that there can be a substantial variability on the fine mode retrieval results depending on the assumed values of α_c and α'_c. Secondly, a cloud filtering algorithm based on both, optical depth and Angstrom number discrimination is essential to obtain unbiased retrievals. Algorithm enhancements and validation, from both simulated and field data will presented.

2. REFERENCES

[1] N. T. O'Neill, O. Dubovik, and T. F. Eck, "Modified Ångström exponent for the characterization of submicrometer aerosols," *Appl. Opt.*, vol. 40, pp. 2368–2375, May 2001.

[2] N. T. O'Neill, T. F. Eck, B. N. Holben, A. Smirnov, O. Dubovik, and A. Royer, "Bimodal size distribution influences on the variation of Angstrom derivatives in spectral and optical depth space," *J. Geophys. Res.*, vol. 106, pp. 9787–9806, 2001.

[3] N. T. O'Neill, T. F. Eck, A. Smirnov, B. N. Holben, and S. Thulasiraman, "Spectral discrimination of coarse and fine mode optical depth," *Journal of Geophysical Research (Atmospheres)*, vol. 108, pp. 4559–+, Sept. 2003.

[4] S. V. Salinas, B. N. Chew, and S. C. Liew, "Retrievals of aerosol optical depth and Ångström exponent from ground-based Sun-photometer data of Singapore," *Appl. Opt.*, vol. 48, pp. 1473–+, Mar. 2009.

[5] S. V. Salinas, B. N. Chew, and S. C. Liew, " Spectral Discrimination of Fine and Coarse Mode Aerosol Optical Depth from AERONET Direct Sun Data of Singapore," *AGU 2009*, Dec. 2009.