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Vertical profile algorithm for aerosol components in ground-based remote sensing data

Futing Wang[a,b], Ting Yang[a,c], Zifa Wang[a,b,c], Haibo Wang[a,b], Yele Sun[a,b], Jianjun Li[d], Guigang Tang[d], and Wenxuan Chai[d]

[a] *State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry,*
Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, 100029, China
2College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, 100049, China
3Center for Excellence in Regional Atmospheric Environment, Institute of Urban Environment,
Chinese Academy of Sciences, Xiamen, 361021, China
4China National Environmental Monitoring Center, Beijing, Chin

***Corresponding author e-mail**: tingyang@mail.iap.ac.cn

The vertical distribution of atmospheric aerosol components is vital to the estimation of radiative forcing and the catalysis of atmospheric photochemical processes. Based on the synergy of ground-based lidar and sun-photometer in Generalized Aerosol Retrieval from Radiometer and Lidar Combined data (GARRLiC), this paper developed a new algorithm to get the vertical mass concentration profiles of fine-mode aerosol components for the first time. Retrieval of aerosol properties was achieved based on the sky radiance at multiple scatter angles, total optical depth (TOD) at 440, 675, 870, and 1020 nm, and lidar signals at 532 and 1064 nm. In addition, the internal mixing model and normalized volume size distribution (VSD) model were established according to the absorption and water solubility of the aerosol components, to separate the profiles of black carbon (BC), water-insoluble organic matter (WIOM), water-soluble organic matter (WSOM), ammonium nitrate-like (AN), and fine aerosol water (AW) content. Results showed a reasonable vertical distribution of aerosol components compared with in situ observations and reanalysis data. The estimated and observed BC concentrations matched well with a correlation coefficient up to 0.91, while there was an evident overestimation of organic matter (OM D WIOM C WSOM, NMB D 0.98). Moreover, the retrieved AN concentrations were closer to the simulated results (R D 0.85), especially in polluted conditions. The BC and OM correlations were relatively weaker, with a correlation coefficient of ~ 0.5. Besides, the uncertainties caused by the input parameters (i.e., relative humidity (RH), volume concentration, and extinction coefficients) were assessed using the Monte Carlo method. The AN and AW had smaller uncertainties at higher RH. Herein, the proposed algorithm was also applied to remote sensing measurements in Beijing with two typical cases. In the clean condition with low RH, there were comparable AN and WIOM, but peaking at different altitudes. On the other hand, in the polluted case, AN was dominant and the maximum mass concentration occurred near the surface. We expected that the algorithm could provide a new idea for lidar inversion and promote the development of aerosol component profiles.

Keywords: retrieval algorithm, aerosol components, vertical profiles, GARRLiC