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Method for estimating the atmospheric content of sub-micrometer aerosol using direct-sun photometric data

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It is well known that the aerosol generated by human activity falls in the sub-micrometer rage [1]. The rapid increase of such emissions led to massive accumulations in the planetary boundary layer. Aerosol pollutants influence the quality of life on the Earth in at least two ways: by direct physiological effects following their penetration into living organisms and by the indirect implications on the overall energy balance of the Earth-atmosphere system. For these reasons monitoring the sub-micrometer aerosol on a global scale, become a stringent necessity in protecting the environment. The sun-photometry proved a very efficient way for such monitoring activities, mainly when vast networks of instruments (like AERONET [2]) are used. The size distribution of aerosols is currently a product of AERONET obtained through an inversion algorithm of sky-photometry data [3, 4]. Alternatively, various methods of investigating the aerosol size distribution have been developed through the use of direct-sun photometric data, with the advantages of simpler computation algorithms and a more convenient use [5, 6].

Our research aims to formulate a new simpler way to retrieve aerosol fine and coarse mode volume concentrations, as well as dimensional information, from direct-sun data. As in other works from the literature [3-6], the main hypothesis is that of a bi-modal shape of the size distribution of aerosols that can be reproduced rather satisfactorily by a linear combination of two lognormal functions. Essentially, the method followed in this paper relies on aerosol size information retrieval through fitting theoretical computations to measured aerosol optical depth (AOD) and related data. To this purpose, the experimental spectral dependence of AOD is interpolated and differentiated numerically to obtain the Ångström parameter. The reduced (i.e. normalized to the corresponding columnar volumetric content) contributions of the fine and coarse modes to the AOD have also been calculated through the Mie theory [7]. As some dimensional (e.g. standard deviations) and physical (e.g. refractive indexes) parameters of the two considered aerosol modes have relatively small variations with little influence on the AOD and Ångström parameter in a given area of interest [3], their values have been set to local annual averages. The theoretical AOD and Ångström parameter have thus been constructed from the corresponding modal contributions using the modal columnar volumetric aerosol contents and the modal radii as fitting parameters. Their values follow from a best simultaneous fit of both AOD and Ångström parameter. Given the fact that the Mie computations are rather time consuming for a satisfactory level of precision, the fitting procedure may be significantly accelerated by computing first the reduced AOD and the Ångström parameter for each mode in a limited grid of values for the modal radii and then constructing interpolation functions that allow a much faster access to intermediate points. Comparison of columnar volumetric aerosol contents and modal radii obtained through our procedure to similar AERONET sky-photometry product data show good correlation and demonstrates the reliability of the proposed method.

References

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