Characterization of Atmospheric Aerosols Using MFRSR Measurements

Contributors

Mikhail D. Alexandrov, *Columbia University*

Research Highlight

Measurements by multifilter rotating shadowband radiometers (MFRSRs) constitute a valuable global dataset with contributions from hundreds of instruments deployed worldwide. The geographical coverage of MFRSR networks is complementary to that of the AErosol RObotic NETwork (AERONET), a network of sunphotometers, and often provides better spatial density of measurement sites, especially in the United States.

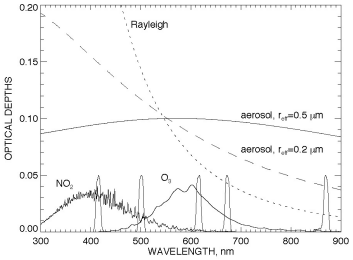
Unlike AERONET, which provides advanced data analysis products such as aerosol size distribution parameters and absorption properties, MFRSR data, for the most part, remain under-utilized, with spectral aerosol optical depth (AOD) and Angstrom exponent being the only significant retrieval products available from the major networks on a regular basis.

To fill this gap, design, improvement and testing of retrieval techniques for MFRSR data has resulted in the recently updated analysis algorithm. The described method allows partitioning of the spectral AOD into fine and coarse mode AOD, and retrieval of the fine mode effective radius. Our sensitivity study demonstrated that for a typical measurement accuracy 0.01 of AOD, the tradeoffs between the spectral aerosol extinction and NO2 absorption in the visible range effectively prevent unambiguous retrieval of NO2 column from MFRSR data, and may also bias aerosol size distribution retrievals. This has prompted us to adopt a new retrieval approach which utilizes climatological NO2 (based on SCanning Imaging Absorption spectroMeter for Atmospheric ChartograpHY, or SCIAMACHY, satellite retrievals) and uses column ozone from Total Ozone Mapping Spectrometer, or TOMS, measurements. The performance of this new approach was evaluated using the long-term dataset from the ARM Climate Research Facility (ACRF) Southern Great Plains (SGP) Central Facility.

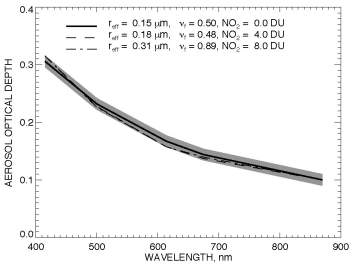
Besides the description of the new retrieval algorithm, we present a detailed intercomparison of total, fine, and coarse mode AOD, and fine mode effective radius between two MFRSRs located at the SGP's Central Facility, and with the correlative AERONET Sun-sky inversion results (Version 2) derived from a co-located CIMEL sunphotometer. The comparison between two MFRSRs demonstrated good consistency of both the measurements and the analysis. Agreement with AERONET inversions was remarkably good; differences in AOD components did not exceed the expected measurement accuracy of 0.01, while the retrieved values of fine mode effective radius showed no relative bias and only 0.03 micron random error (standard deviation of the differences). If only data with large enough AOD (more than 0.06 at 870 nm) are selected, this error is reduced by a factor of two, becoming about 10% of a typical fine mode effective radius value.

Reference(s)

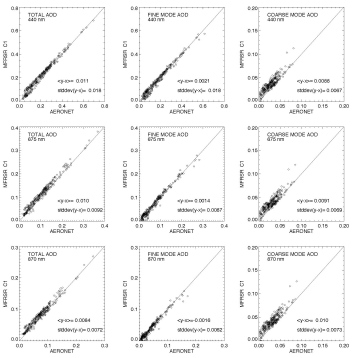
Alexandrov, M.D., A.A. Lacis, B.E. Carlson, and B. Cairns, Characterization of atmospheric aerosols using MFRSR measurements, (J. Geophys. Res., accepted Nov. 2007.



Sample spectral optical depths of atmospheric constituents in 300 - 900 nm spectral range: Rayleigh; aerosols with effective radii of 0.2 and 0.5 micron; NO2 (2 DU column amount); and ozone (300 DU column amount). The MFRSR spectral response functions (in arbitrary units) are shown for the first five channels (415 - 870 nm).



The solid curve is model spectral AOD (in MFRSR channels) derived using Mie theory for bimodal gamma aerosol size distribution with fine mode effective radius of 0.15 micron, coarse mode effective radius of 1.5 micron, 50% fine mode fraction in 870 nm AOD, and zero NO2 amount. The dashed and dash-dotted curves represent two competitive "aerosol+NO2" models fitting the solid curve within 0.01 error margin (grey area).



Point-by-point intercomparison between total, fine, and coarse mode AODs retrieved from MFRSR (C1) data and corresponding AERONET Sun-sky inversions for the year 2000. The AERONET's CIMEL sun-photometer is co-located with MFRSR at SGP's Central Facility.

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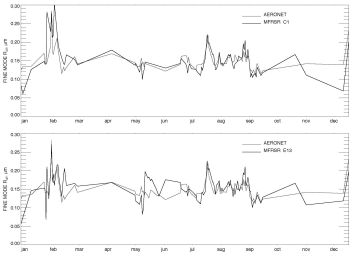
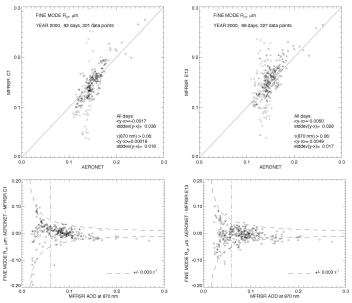
Working Group(s)
Aerosol



Comparison between time series of daily mean fine mode effective radius values from MFRSRs (C1 - top, E13 - bottom) and AERONET retrievals for the year 2000.



Point-by-point intercomparison between the fine mode effective radius values retrieved from MFRSR data (C1 - left, E13 - right) and corresponding AERONET Sun-sky inversions for the year 2000. Top: scatter plots with black and grey diamonds representing the retrievals corresponding to AOD at 870 nm respectively larger and smaller than 0.06. Bottom: dependence of the difference between MFRSR and AERONET values of fine mode effective radius on 870 nm (MFRSR) AOD. The recommended threshold AOD value of 0.06 is shown by vertical dash-dotted lines.