Use of sky brightness measurements from ground for remote sensing of particulate polydispersions

1Teruyuki Nakajima, 2Glauco Tonna, 3Ruizhong Rao, 4Paolo Boi, 5Yoram Kaufman, and 5Brent Holben

1Center for Climate System Research, University of Tokyo, Tokyo, Japan

2Institute for Atmospheric Physics, Consiglio Nazionale delle Richerche, Rome, Italy

3Consiglio Nazionale delle Richerche, Cagliari Research Area, Cagliari, Italy

4Department f Physics, University of Cagliari, Cagliari, Itary

5NASA Goddard Space Flight Center, Greenlelt, USA

Abstract

The software code SKYRAD.pack for retrieval of aerosol size distribution and optical thickness from data of direct and diffuse solar radiation is described; measurements are carried out with sky radiometers in the wavelength range 0.369–1.048 µm. The treatment of the radiative transfer problem concerning the optical quantities is mainly based on the IMS (improved multiple and single scattering) method, which uses the delta-M approximation for the truncation of the aerosol phase function and corrects the solution for the first- and second-order scattering. Both linear and nonlinear inversion methods can be used for retrieving the size distribution. Improved calibration methods for both direct and diffuse radiation, the data-analysis procedure, the results from the proposed code, and several connected problems are discussed. The results can be summarized as follows: (a) the SKYRAD.pack code can retrieve the columnar aerosol features with accuracy and efficiency in several environmental situations, provided the input parameters are correctly given; (b) when data of both direct and diffuse solar radiation are used, the detectable radius interval for aerosol particles is approximately from 0.03 to 10 µm; (c) besides the retrieval of the aerosol features, the data-analysis procedure also permits the determination of average values for three input parameters (real and imaginary aerosol refractive index, ground albedo) from the optical data; (d) absolute calibrations for the sky radiometer are not needed, and calibrations for direct and diffuse radiation can be carried out with field data; (e) the nonlinear inversion gives satisfactory results in a larger radius interval, without the unrealistic humps that occur with the linear inversion, but the results strongly depend on the first-guess spectrum; (f) aerosol features retrieved from simulated data showed a better agreement with the given data for the linear inversion than for the nonlinear inversion