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UNCORRECTED PROOF

Radiative transfer model MCC++ with evaluation of weighting functions in spherical atmosphere for usage in retrieval algorithms

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Abstract

A linearized radiative transfer model MCC++ designed for usage in retrieval algorithms was developed. It calculates the weighting functions with respect to the absorption in all atmospheric layers and the layer air mass factors simultaneously with the intensities. Multiple scattering radiance is calculated by the Monte Carlo methods for spherical atmosphere taking into account the polarization of light, aerosol loading of atmosphere and the Lambertian surface albedo. A validation of the MCC++ model against other radiative transfer models is presented. It includes a comparison of weighting function calculations, a comparison for the scattering limb geometry, a comparison for twilight ground-based observations. As an example, additional errors of Brewer Umkehr retrieval algorithms, when they use the weighting functions calculated for approximation of single-scattering, are evaluated.
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Keywords: MCC++; Radiative transfer model; Weighting functions in spherical atmosphere; Multiple scattering resonance

1. Introduction

Satellite-, air-borne and ground-based optical sounding is used to determine the gaseous and aerosol composition of the atmosphere. To interpret the optical measurements, radiative transfer (RT) models are applied. The advancement of the theory and the accumulated experience of optical sounding allow to formulate special requirements to the RT models applicable to sounding interpretation and to solution of the arising inverse problems (see, for example, Rozanov et al., 1997).

The most-used approach to solution of the inverse problems of the atmospheric optics includes the linearization of the forward model and subsequent application of the well-developed theory of linear inverse problems (Rodgers, 1976). Such an approach is based on the RT model and consists in computations of both the radiance and the derivatives of the radiance with respect to the atmospheric optical characteristics to be retrieved. For example, profile of ozone or another gas, profile of aerosol scattering or microphysical characteristics, or albedo of the underlying surface can be such characteristics. In another notation these derivatives are termed the weighting functions (WFs) for the problem. The commonly used techniques alternate to linearization are based on different iteration algorithms. Usually, the application of such algorithms is also associated with computations of both the radiance and its derivatives.

The development of optical sounding methodology from the multi-wave measurements to the spectral ones required efficient procedures capable to obtain scattered radiance for large massifs of slightly differing wavelengths for development of the forward model. As a rule, these procedures lead to radiative computations under condition of small variations in the optical parameters of the atmosphere. Such computations can be efficiently implemented by determination of the RT characteristics for one wavelength (the

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