The Brewer Umkehr algorithm for ozone profile retrieval: a complete account of multiple scattering of light

O.V. Postylyakov
A.M. Obuhov Institute of Atmospheric Physics, RAS, Pyzhevsky per.3, Moscow, 119017,

C.S. Zerefos
University of Athens, 15784 Athens, Greece

E. Kosmidis
Aristotle University of Thessaloniki, LAP, 54006-Thessaloniki, Greece

I.V. Mitin
M.V. Lomonosov Moscow State University, Russia

Abstract. Umkehr measurements are the source for determination of the ozone vertical distribution. The standard Umkehr retrieval algorithm uses approximate scheme for account of multiple scattering of light: a multiple scattering correction is subtracted from measured intensities (or N-values), but following retrieval uses the weighting functions calculated for single scattering. A version of retrieval algorithm, which treats multiple scattering completely both in the radiance correction and in the weighting functions, is under investigation.

Introduction


This work proposes an approach to reduce retrieval error of Umkehr ozone profile by improving treatment of multiple scattering radiance in the Umkehr algorithm.

Treatment of multiple scattering radiance in standard Umkehr algorithm

A standard Umkehr retrieval algorithm uses approximate scheme to compute multiple scattering of light. A radiative transfer model taking into account only single scattering of light is the basis for real-time processing of data. To correct measured radiance, a look-up table of multiple scattering corrections for preset atmospheric scenarios is used. But besides radiance the retrieval algorithm uses the weighting functions (WFs), which are derivatives of radiance with respect to ozone profile. The WFs are calculated using single scattering approximation. But necessary multiple scattering correction isn’t applied in this case.

The simplified scheme for consideration of the WFs results in increased errors of the ozone retrieval, which was first noticed in paper [Elansky and Postylyakov, 2000]. Since that time, a radiative transfer model MCC++ was developed for application in retrieval algorithms. The MCC++ model take into account all orders of scattering and may calculate both intensities and weighting functions for application in Umkehr algorithm [Postylyakov 2004a, 2004b].

The MCC++ code employs Monte Carlo method of conjugate walk for spherical atmosphere. It is fast enough to be used in a real-time Umkehr retrieval. The MCC++ code allows calculating the weighting functions necessary for inversion of Umkehr radiance measurements within 18 min (Run time was estimated for calculation with accuracy 0.1-1% at the PC based on the AMD Athlon 1460 MHz.). The Umkehr weighting functions are calculated simultaneously at 6 wavelengths from 306.3 to 329.5 nm and 8 solar zenith angles from 77° to 90° for 20 atmospheric layers of 5-km thickness.

Error analysis in case of approximate calculation of weighting functions

We compared retrieval errors of a Brewer algorithm, which take into account approximate weighting functions calculated for single scattering radiance, with errors of an algorithm based on a radiative model treating all orders of scattering. Both
algorithms use the radiance intensity computed for all order of scattering.

![Figure 1. Ozone retrieval rms errors of the extended and standard Brewer Umkehr algorithms for the exact and approximate WFs.](image)

The algorithms, error analysis and retrieved ozone profiles obtained with improved algorithm, completely taking into account multiple scattering, will be presented. The first results of comparison of ozone vertical profiles retrieved by the improved algorithm, profiles [Kosmidis et al. 2004a, 2004b] retrieved by algorithm developed by McElroy et al [1989, 1995] and ozone sounds at Thessaloniki (40.5 N, 23.0 E) will be analyzed.

### References


Kosmidis E., A.F. Bais, C. Meleti, A review on the Brewer-Umkehr measurements made in Thessaloniki, Greece for the last 15 years. This issue. 2004a.

Kosmidis E., C. S. Zerefos, P. Zanis. Comparison and trends derived from Brewer-Umkehr measurements made in Thessaloniki, Greece for the last 15 years. This issue. 2004b


Postylyakov O.V. Linearized vector spherical radiative transfer model MCC++ for application to remote sensing and modeling of spectral observations. This issue. 2004b.