Retrieval of the Microphysical Properties of Stratospheric Aerosols from SAGE II measurements

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Abstract

A new method has been applied to the retrieval problem of aerosol microphysical properties from SAGE II extinction measurements. Internal validation indicates that the new algorithm is performing well and is capable of retrieving particle size distribution parameters even in the case of considerable experimental noise. Retrieval uncertainties of retrieved median particle radius, surface area density, and volume density, are of the order of 35%, 25%, and 15%, respectively, for global SAGE II measurements in December 1999.

Introduction

Stratospheric aerosol have been recognised to play an important role in the climate system by influencing the chemical and radiative balance of the atmosphere. The key parameters associated with aerosols are the size distribution median radius (R), surface area (A) and volume (V) of the particles as well as their composition. Consequently, a precise knowledge of the global distribution of these aerosol microphysical properties is important for chemical, radiative, and dynamical climate modelling.

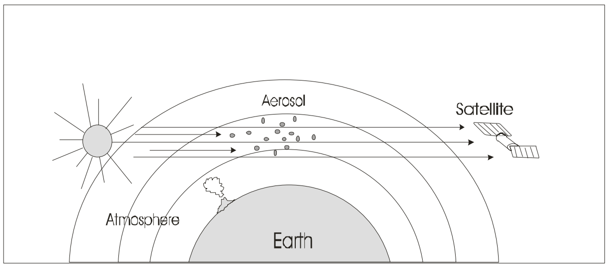

Figure 1: Limb sounding geometry of the solar occultation satellite instrument SAGE II.

Satellite measurements of extinction can be used to retrieve aerosol microphysical properties (Figure 1). However, the high degree of non-linearity of the radiative processes involved, makes this a difficult task. In addition until recently there was a lack of refractive index data for aerosol at stratospheric temperatures. In this study, a novel retrieval method is applied to the aerosol retrieval problem in an attempt to improve the current knowledge. The extinction data used in this retrieval scheme were measured by the Stratospheric Aerosol and Gas Experiment satellite instrument version II (SAGE II).

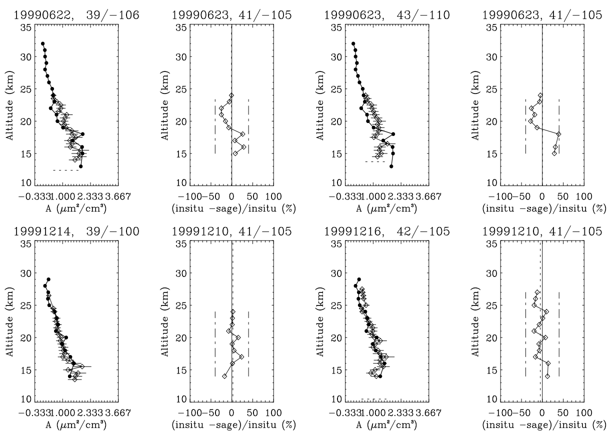

Figure 2: In-situ profiles (dots) and OE retrieval results (a,c,e,g) and the relative difference (b,d,f,h). The vertical lines in figures b, d, f, h mark the uncertainty of the in-situ profiles (dash-dot) and the relative mean difference (dotted).

Validation

The new algorithm was tested on synthetic data and the results compared to the true solution. It can be concluded that the correlation coefficients are particularly good for A and V and the resulting effective radius, the retrieved uncertainties represent the data well, and the algorithm can now with confidence be applied to real measurements.

Retrieval algorithm

In this study, Optimal Estimation (OE) has been applied to the problem of improving the current knowledge and accuracy of aerosol microphysical properties. This inversion technique is based on Bayesian statistics and uses probability density functions to describe the relationship between the atmospheric state, any prior knowledge about the solution space, and a measurement. In this way, *a priori* knowledge forms a constraint and compliments the usually insufficient information content in the measurements with respect to the variables to be retrieved. The retrieval solution is the most likely state and the associated covariance matrix provides an uncertainty estimate on the solution. The new retrieval algorithm also incorporates improved refractive indices data.

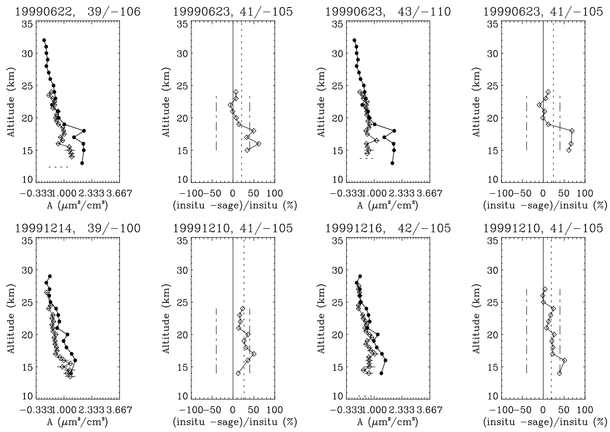

Figure 3: In-situ profiles (dots) and NASA retrieval results (a,c,e,g) and the relative difference (b,d,f,h). The vertical lines in figures b, d, f, h mark the uncertainty of the in situ profiles (dash-dot) and the relative mean difference (dotted).

A comparison of the OE retrieval results with in-situ measurements and retrieval results using a modified Levenberg-Marquardt technique is presented in Figures 2 and 3. Comparison of the retrieval results with ballon-borne in-situ measurement shows that the profiles largely agree within the respective uncertainties. Comparison with NASA´s retrieval results from application of a modified Levenberg-Marquardt algorithm indicate that the new OE results for A and V are systematically smaller. This results in a better match with in-situ profiles.

Retrievals from SAGEII data

Zonal averages of retrieved surface area densities for the year 1999 are presented in Figure 4. In this form the new aerosol information could be useful as input for climate models. Seasonal changes can be observed which are believed to be due to dynamic transport processes.

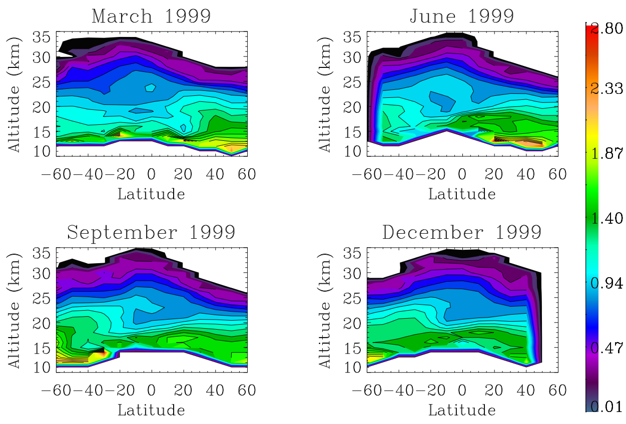

Figure 4: Zonal mean aerosol surface area density (in µm2/cm3) as retrieved from SAGEII data using the new OE algorithm.