25B3 AEROSOL MICROPHYSICAL PROPERTIES INFLUENCE ON LIDAR PARTICLE SIZE RETRIEVAL

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To describe light scattering by atmospheric aerosols, numerous microphysical parameters have to be taken into account. Scattering by one particle is defined by the complex refractive index, the shape and the characteristic size. Scattering by a collection of particles, neglecting multiple scattering effects, is determined by the statistical distributions of those three parameters. The optical coefficients (extinction, parallel and perpendicular backscattering coefficients) are calculated to characterize light scattering by an ensemble of particles. Under some hypothesis, experiments provide us with the optical coefficients, usually at several wavelength. Therefore, we have to solve the inverse problem, it is to say to determine the microphysical parameters of a collection of particles from a given set of optical coefficients.

Using standard fit method, we will present a comparison between inversion results obtained using spherical and non-spherical models of particles. Mean radius and standard deviation of the Pinatubo aerosol stratospheric layer are obtained from multi-wavelength backscattering depolarization Lidar measurements taken in Sodankyla (Finland) on March 1 at 15 km height during the EASOE Campaign. Results are compared with in-situ measurements to test the different models.

Injection of sulfur vapors in the stratosphere results in sulfate aerosols. The refractive index of the solution of H_2SO_4/H_2O liquid droplets depends on the sulfuric acid concentration, which is a function of the ambient temperature and humidity. During EASOE, temperature were known by sounding (between 190 - 210 K) and water vapor contents within the stratosphere is about 4-5 ppmv. Corresponding values of the refractive index for the wavelengths considered in this study ($\lambda = 0.532$, 0.750, and 0.850 μm) are in the range $n = 1.42$ to 1.48

According to *in situ* measurements [Deshler *et al.*, 1992,1993], the typical size distribution for the Pinatubo aerosol appears to be a log-normal distribution centered around 0.1 μm and with a standard deviation $\sigma = 0.08$ μm. A second mode centered around 0.5 μm appears at some altitude levels. Theses results appears to be in good agreement with microphysic theory and previous observation of volcanic aerosols [Turco *et al.*, 1982]. Size retrieval calculations have been performed by fitting lidar signals at three different wavelengths (λ= 0.532, 0.750, and 0.850 μm) with a log-normal distribution of spherical particles and assuming a Rayleigh depolarization of 1.4%. The results show a mean particle radius of 0.78 μm and a standard deviation $\sigma = 0.1\mu m$, with a goodness-of-fit of 70 %. It is not in agreement with Deschler measurements. Therefore we propose to use non-spherical scattering in order to retrieve truthful size distributions. Moreover, during the EASOE campaign in the Arctic, all lidar measurements showed depolarization values for the Pinatubo stratospheric aerosol layer varying between 2% and 4%. Neglecting multiple scattering, the radiation backscattered by a polydispersion of spheres has the same polarization as the incident light and such depolarization is therefore a sign of non-spherical scattering. The low values measured led us to consider slightly deformed spheres.

The scattering calculations for non-spherical particles have been carried out using a numerical code based on the Extended Boundary Condition Method (EBCM), described by Mugnai and Wiscombe [1986]. The effects due to particle shape have been analyzed in detail by considering mixtures of elongated particles and mixtures of particles which can be obtained by continuously deforming a sphere. In the first case, we have used prolate spheroids with axial ratios (elongations) $e = 1.05$ to 3.30, in steps of 0.05. In the second case, the so-called Chebyshev particles [see Mugnai and Wiscombe, 1986], which are obtained by rotating the curve $r(\theta) = r_0[1 + \epsilon T_m(\cos\theta)]$ about the axis $\theta = 0$; here, r_0 is the radius of the unperturbed sphere, $\epsilon(|\epsilon| < 1)$ is the deformation parameter, $T_m(\cos\theta) = \cos(m\theta)$ is the Chebyshev polynomial of degree m. In this study, we have considered Chebyshev particles with waviness parameter $m = 2, 4, 6, 8$ and deformation parameter $\epsilon = -0.3$ to 0.3 in steps of 0.01.

We performed fits using the parallel and the perpendicular signal. Mean radius and standard deviation obtained for diverse mixtures of spherical/nonspherical particles are giver in table 1.

Particle Shape	Mean Radius μm	Standard Deviation μm	Goodness-Of-Fit %
100% Elongated Particles $n = 1.40$	0.16	0.050	85
100% Deformed Spheres $n = 1.40$	0.40	0.075	95
50% Elongated Particles 50% Spheres $n = 1.40$	0.15	0.050	88
50% Deformed Spheres 50% Spheres $n = 1.40$	0.40	0.065	93
100% Elongated Particles $n = 1.48$	0.1	0.01	80
100% Deformed Spheres $n = 1.48$	0.27	0.03	98

Table I. Retrieval of the size of non-spherical particles from the multi-wavelength lidar in Sodankyla (Finland) on March 1 at 15 km height.

The values of Table I for elongated particles show a good agreement with the in-situ measurements. Therefore, deformed sphere could be reasonably used in oder to interpret a whole set of data, while fit using spherical shapes show errors of about 80% on the particle size retrieval. Moreover, consider non-spherical scattering allow to use and interpret perpendicular backscattered lidar signal.

Starting from theses results, test using different mixtures of spherical/non-spherical shapes have been performed. The influence of the value of the refractive index as well as of the size distribution function as been investigated in relation with different microphysical atmospheric conditions. For mixture of different shapes, the depolarization will converge to an average value, representative of the optical properties of the atmospheric aerosols. Therfore, the choice of the shapes composing the mixture apear not to be a critical point. Size distribution will therefore be retrieve with a good accurancy.

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