

DETERMINATION OF ATMOSPHERIC AEROSOL CHARACTERISTICS
FROM THE POLARIZATION OF SCATTERED RADIATION

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ABSTRACT

Aerosols affect the polarization of radiation in scattering, hence measured polarization can be used to infer the nature of the particles. Size distribution, particle shape, real and absorption parts of the complex refractive index affect the scattering. From Lorenz-Mie calculations of the 4-Stokes parameters as a function of scattering angle for various wavelengths the following polarization parameters were plotted: total intensity, intensity of polarization in plane of observation, intensity perpendicular to the plane of observation, polarization ratio, polarization (using all 4-Stokes parameters), plane of the polarization ellipse and its ellipticity. A six-component log-Gaussian size distribution model was used to study the effects of the nature of the polarization due to variations in the size distribution and complex refractive index. Though a rigorous inversion from measurements of scattering to detailed specification of aerosol characteristics is not possible, considerable information about the nature of the aerosols can be obtained. Only single scattering from aerosols was used in this paper. Also, the background due to Rayleigh gas scattering, the reduction of effects as a result of multiple scattering and polarization effects of possible ground background (airborne platforms) were not included.

It is convenient to use radiation initially plane-polarized at 45° to the plane of observation. The total, parallel and perpendicular component intensities are meaningful, but fluctuations in the source, number of particles in the scattering volume, and other variables may reduce their experimental usefulness. The polarization parameters of polarization ratio, polarization, inclination angle and ellipticity are ratios and hence not influenced by these changes in the intensities.

The effect of size distribution can be seen by noting the relative contributions to the scattering parameters of the various log-Gaussian components. Large particles, for example, give a strong forward peak, a

rainbow and enhanced 180° backscattering in the intensities. Small particles, though also different in the parallel and perpendicular components, produce a symmetric angular distribution as the sizes get smaller. The variation of parallel and perpendicular components with angle and the variation in phase difference between them give marked polarization effects especially in the backward scattering region up to but not including 180° backscattering. At scattering angles of greater than about 70° there are marked differences produced by the modified gamma and Junge-type power-law size distribution in position and maxima of the polarization ratio, polarization, inclination and ellipticity. Appreciable difference in the exponents of the power law distributions are distinguishable. Obviously, there are differences in the backscattered intensities between Junge and modified gamma size distribution.

An increase in the real part of the refractive index: moves the rainbow to larger scattering angles; enhances the 180° backscattering; decreases the polarization ratio maximum (around 90°); and increases the slope near 0° inclination angle. An increase in absorption on the other hand, flattens and reduces the intensity curves outside the near forward scattering region, including the rainbow, glory, and 180° backscattering effects. Also the polarization ratio maximum increases, and the inclination angle makes a more gradual transition across the 0° inclination axis as it moves to smaller scattering angles. These effects are much more evident for larger particles. The ellipticity, especially at angles of more than 100° scattering, is also sensitive to changes in the particle characteristics.

It is obvious that these analytical calculations are useful for determining aerosol characteristics. However, in dealing with "real-world" aerosols, a multidiscipline approach must be used. This includes: measurement of the physical and optical characteristics of the particles by various sampling techniques; measurement of the 4-Stokes parameters as a function of wavelength and angle; and analytical calculations based on "real" aerosol characteristics .