ON PHASE FUNCTIONS AND SIZE DISTRIBUTIONS

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ABSTRACT

We wish to lay groundwork for atmospheric radiative transfer analyses which allows for (a) multiple scattering by particulates, (b) inhomogeneous atmosphere, (c) round earth, (d) broad spectral filters, and (e) absorptive and irregular particulates. We attempt to establish approximate analytic relationships between size distributions and phase functions.

In a previous work (A.E.S. Green, G.D. Ward, T. Sawada, R.S. Sholtes, J.M. Schwartz, A. Deepak, D. Eisenhart, R.D. McPeters, and B.D. Reller, J. of Colloid and Interface Science, 39, 3, June 1972), we found it convenient to build up a complex particle size distribution out of an oversized radius distribution function of the form

$$N(r) = \frac{N_o}{1+(r/a)^{\nu}} \qquad (1)$$

We have generated many examples of phase functions associated with this size distribution for $\lambda = 0.5\mu$, for the index of refraction $m = 1.47$, and for various values of ν and large a. For small $\underline{\nu}$ and $\underline{a}$, the phase functions are highly peaked in the forward direction whereas for small a's and large ν's, they are very flat.

As a matter of practical search procedure in inverting a scattering problem, it would be much more efficient to characterize a phase function analytically as a function of angle rather than implicitly through the parameters a and ν, through the use of a Lorenz-Mie scattering code and a numerical procedure for averaging over the size distribution.

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Henyey and Greenstein (HG) proposed in 1941 a one parameter analytic scattering function which is quite versatile for such purposes. We have examined a two parameter (g, τ) generalization of the HG function (GHG)

$$P(\psi) = \frac{g\tau}{2\pi x^{(\tau/2)+1}} \left[\frac{1}{|1-g|^{\tau}} - \frac{1}{(1+g)^{\tau}}\right]^{-1} \qquad (2)$$

where $x = 1+g^2 - 2g\mu$ and $\mu = \cos 4$ which is even more versatile for many problems. The function contains the HG function as a special case when τ set to 1. We have fitted $P(\psi,\lambda,a,\nu)$ for various values of a and ν by a non-linear least square (NLLS) technique to obtain an approximate mapping of the a, ν to τ and g. The utility of this mapping in initial phases of the inversion of scattering data and the use of other analytic functions will be discussed.

In addition the scaling with wavelength of phase functions and extinction coefficients for various size distributions will be examined.