FAST JACOBIAN MIE LIBRARY FOR TERRESTRIAL HYDROMETEORS

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Numerical radiative transfer calculations are essential for understanding and assimilating brightness temperature measurements made at various microwave frequencies and locations [1]. Efficient numerical weather forecasting applications require particularly fast scattering-based radiative transfer simulations [2]. One of the processes that imparts a high computational burden for hydrometeor laden atmospheres is the calculation of hydrometeor absorption and scattering coefficients and the phase asymmetry parameter [1]. The excessive computational overhead is a result of the nested summations required in the calculation of the Mie efficiencies and the subsequent numerical integration of the Mie efficiencies over the hydrometeor drop size distribution [1,3,4]. This paper presents an approach for the fast, accurate computation of the extinction coefficients and the asymmetry parameter for spherical liquid water and ice hydrometeors over a wide range of frequencies, mean hydrometeor diameters, and physical temperature as occur in terrestrial atmospheres. The temperature, frequency and mean diameter ranges for this compact library are : $[-50, +50]^{o}\mathrm{C}$, $[1,1000]$ GHz and $[0.002,20]$ mm respectively. These parameters are cast into functions of three independent variables: frequency, temperature and mean diameter. The function values are then sampled on a logarithmic grid. Trivariate cubic spline interpolation using non uniform B – splines is then used to efficiently represent these three dimensional functions in a compact library [5,6]. A pseudocolor plot of phase asymmetry parameter of polydispersed liquid hydrometeors at $0^{o}\mathrm{C}$ as a function of mean diameter and frequency is depicted in figure 1. By using this method, we achieve four important criteria: 1) fast random computability of the any parameter given the values of frequency, temperature and mean diameter, 2) minimal memory usage by storage of only B – spline coefficients, 3) representation of parameters using well behaved functional forms amenable to analytical differentiation for evaluation of Jacobians [2], and 4) negligibly small and bounded error over the entire domain of the library. These procedures results in considerable acceleration of microwave radiative transfer simulations across a broad frequency spectrum, as demonstrated in calculations for both scattering and non-scattering atmospheres. The methods discussed can also be applied to other geophysical problems requiring rapid calculation of series-based functions of several independent variables using a compact library, where the function evaluation is a time consuming process, and maximum error bounds are critical.

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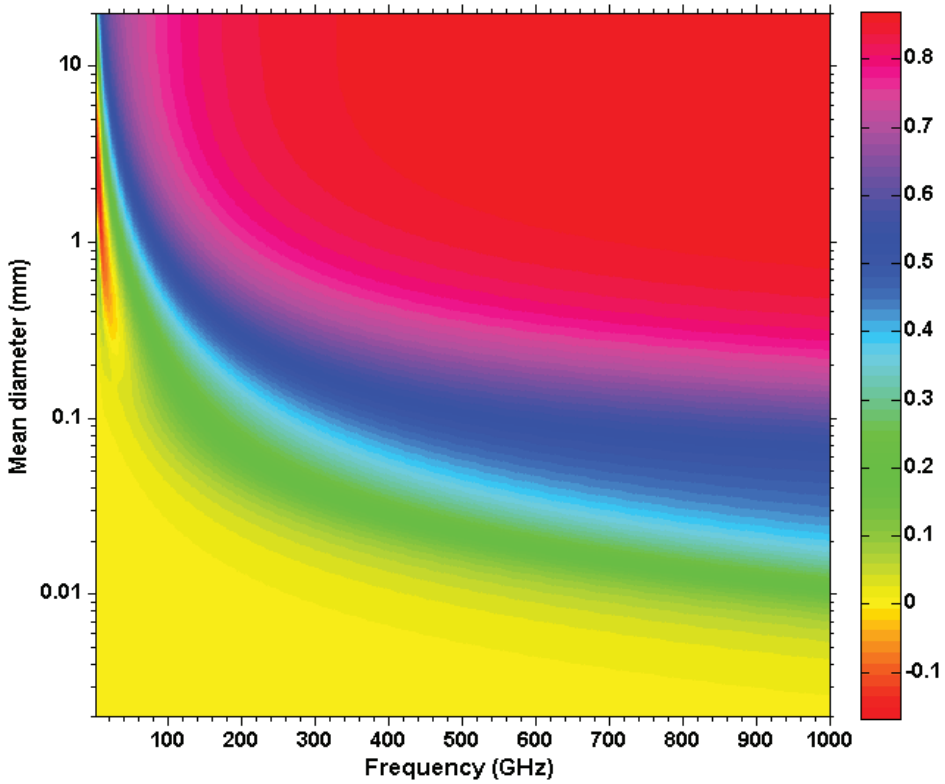

Figure 1 : Phase asymmetry parameter of polydispersed liquid hydrometeors at $0^{o}C$ versus frequency and mean diameter. Exponential drop - size distribution with a liquid fractional volume of 10^{-6} is assumed.