An Algorithm for Deriving Particle Size Distributions for Thin Clouds From Sun and Aureole Measurements Using a Diffraction Approximation

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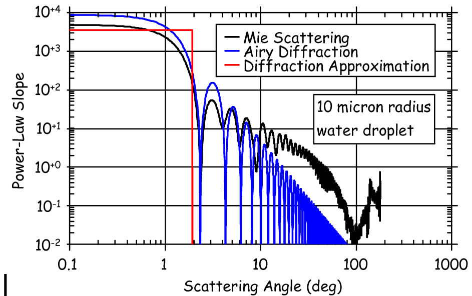
1. Diffraction Approximation



2. Key Theoretical Result

The differential density of spherical scatterers, n(r) (#/area/µm), of radius r (µm) in the column between the observer and the Sun, can be found from

$$n(r) \propto -\ \theta^6\ \partial A(\theta)/\partial\theta$$

where from simple diffraction theory

$r = \lambda\ /\ 2\theta$, and
λ = wavelength (µm)
θ = the angle from center of Sun (rad)
$A(\theta)$ = the aureole radiance (W/cm²/sr)

3. Power-Law (PL) Distributions

When n(r) is represented by a power-law in radius

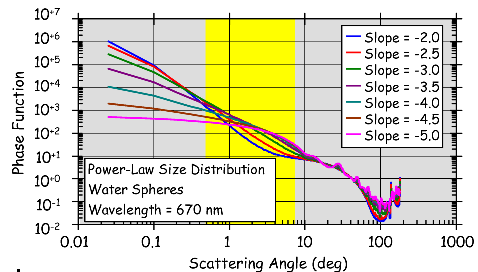
$$n(r) \propto r^{-\alpha}$$

then the forward lobe of the phase function, P(θ), and a resulting aureole, A(θ), also follow a power-law

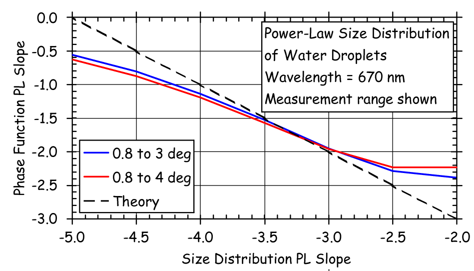
$$A(\theta) \propto P(\theta) \propto \theta^{\alpha-5}$$

Furthermore, the sum of the PL slopes of the size distribution and the aureole is –5 even if an Airy function is used.

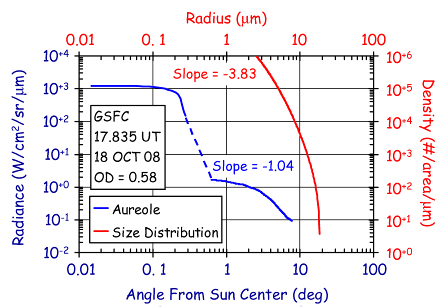
4. PL Distributions of Droplets



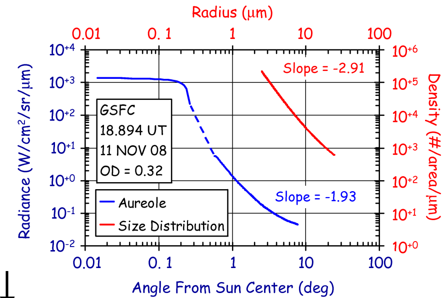
5. Mie Scattering Confirmation



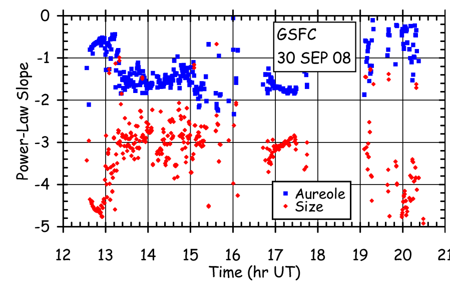
6. Example 1: Cumulus



7. Example 2: Cirrostratus



8. Time Series of PL Slopes



9. Conclusion

The diffraction approximation is a simple, but useful way of retrieving particle size information for thin clouds using SAM measurements of Sun and aureole radiance.

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