Framework for Hydrometeor Electric Scattering Tables

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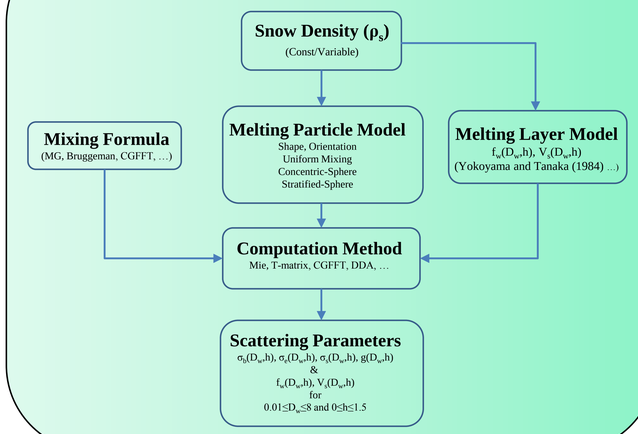
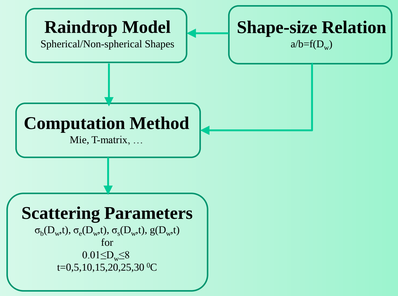
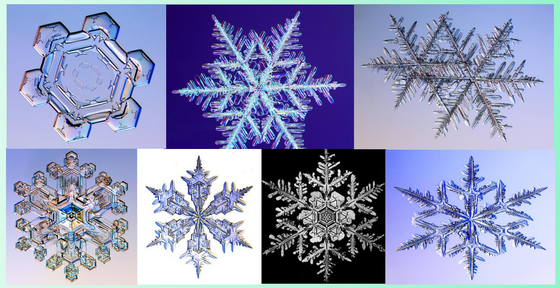
Single Scattering: Mixed-Phase



Single Scattering: Rain



Single Scattering: Snow



Wanted!

Single Scattering Table Outputs

	Scattering Parameter	Dependence
Snow	σ_b, σ_s, σ_e, g	D, ρ_s
Mixed-phase	σ_b, σ_s, σ_e, g, (f_w, v_m)	D, h, ρ_s
Rain	σ_b, σ_b, σ_b, g	D, T

DSD-Integrated Scattering Table Outputs

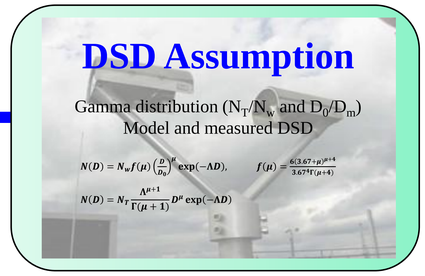
	Scattering Parameter		Dependence
	Radar	Radiometer	
Snow	I_b, I_e	I_{sca}, I_e, I_g	D_0, μ
Mixed-phase	I_b, I_e	I_{sca}, I_e, I_g	D_0, μ, h
Rain	I_b, I_e	I_{sca}, I_e, I_g	D_0, μ, T

Examples of scattering tables and their documents are available at ftp://meso-a.gsfc.nasa.gov/betsy/lliao/scatteringTable/

DSD Integrated

N_w-normalized scattering parameters (N_w=1 $mm^{-1}m^{-3}$)	N_T-normalized scattering parameters (N_T=1 m^{-3})
Radar: $I_b(D_0,\mu,\lambda) = 10\log_{10}\left(\frac{\lambda^4}{\pi^5\lvert K_w\rvert^2 z}\int_{D_{min}}^{D_{max}} f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot\sigma_b(D,\lambda)dD\right)$, dBZ $I_e(D_0,\mu,\lambda) = 4.343\times10^{-3}\int_{D_{min}}^{D_{max}} f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot\sigma_e(D,\lambda)dD$, dB/km Radiometer: $I_{sca}(D_0,\mu,\lambda) = 10^{-6}\int_{D_{min}}^{D_{max}} f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot\sigma_s(D,\lambda)dD$, m^{-1} $I_e(D_0,\mu,\lambda) = 10^{-6}\int_{D_{min}}^{D_{max}} f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot\sigma_e(D,\lambda)dD$, m^{-1} $I_g(D_0,\mu,\lambda) = \frac{\int_{D_{min}}^{D_{max}} f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot g(D,\lambda)\sigma_s(D,\lambda)dD}{\int_{D_{min}}^{D_{max}} f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot\sigma_s(D,\lambda)dD}$	Radar: $I_b(D_0,\mu,\lambda) = 10\log_{10}\left(\frac{\lambda^4}{\pi^5\lvert K_w\rvert^2}\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot\sigma_b(D,\lambda)dD\right)$, dBZ $I_e(D_0,\mu,\lambda) = 4.343\times10^{-3}\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot\sigma_e(D,\lambda)dD$, dB/km Radiometer: $I_{sca}(D_0,\mu,\lambda) = 10^{-6}\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot\sigma_s(D,\lambda)dD$, m^{-1} $I_e(D_0,\mu,\lambda) = 10^{-6}\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot\sigma_e(D,\lambda)dD$, m^{-1} $I_g(D_0,\mu,\lambda) = \frac{\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot g(D,\lambda)\sigma_s(D,\lambda)dD}{\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot\sigma_s(D,\lambda)dD}$

DSD Assumption

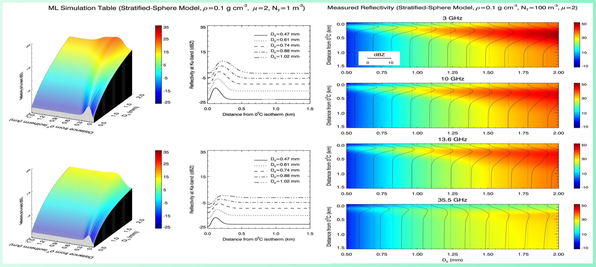


Gamma distribution (N_T/N_w and D_0/D_m)
Model and measured DSD

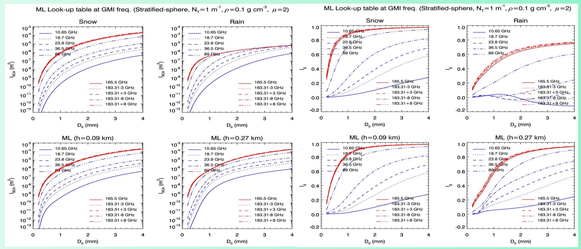
$N(D) = N_w f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)$, $\quad f(\mu) = \frac{6(3.67+\mu)^{\mu+4}}{3.67^4\Gamma(\mu+4)}$

$N(D) = N_T\frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)$

DPR Parameters



GMI Parameters



Hydro. Parameters

- **N_w ($mm^{-1}m^{-3}$)-normalized mass content (I_M) and precipitation rate (I_R):**

  $I_M = \frac{\pi}{6}\times10^{-6}\int_{D_{min}}^{D_{max}} f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot D^3 dD$, g/m^3

  $I_R = 6\pi\times10^{-4}\int_{D_{min}}^{D_{max}} N_w f(\mu)\left(\frac{D}{D_0}\right)^{\mu}\exp(-\Lambda D)\cdot D^3 V(D) dD$, mm/h

  $f(\mu) = \frac{6(3.67+\mu)^{\mu+4}}{3.67^4\Gamma(\mu+4)}$

  Water content: $M = N_w I_M$, g/m^3 ;

  Precipitation rate: $R = N_w I_R$, mm/h

- **N_T (m^{-3})-normalized mass content (I_M) and precipitation rate (I_R):**

  $I_M = \frac{\pi}{6}\times10^{-6}\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot D^3 dD$, g/m^3

  $I_R = 6\pi\times10^{-4}\int_{D_{min}}^{D_{max}} \frac{\Lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu}\exp(-\Lambda D)\cdot D^3 V(D) dD$, mm/h

  Water content: $M = N_T I_M$, g/m^3

  Precipitation rate: $R = N_T I_R$, mm/h