Backscatter Cross Section Dependence on Ice Crystal Habit in Radar Retrieval Algorithms During StormVEx

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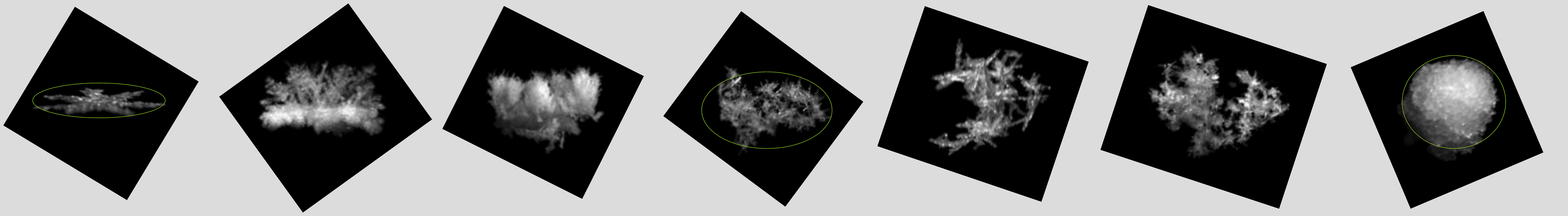
Representing Ice Particle Habit as an Oblate Spheroid

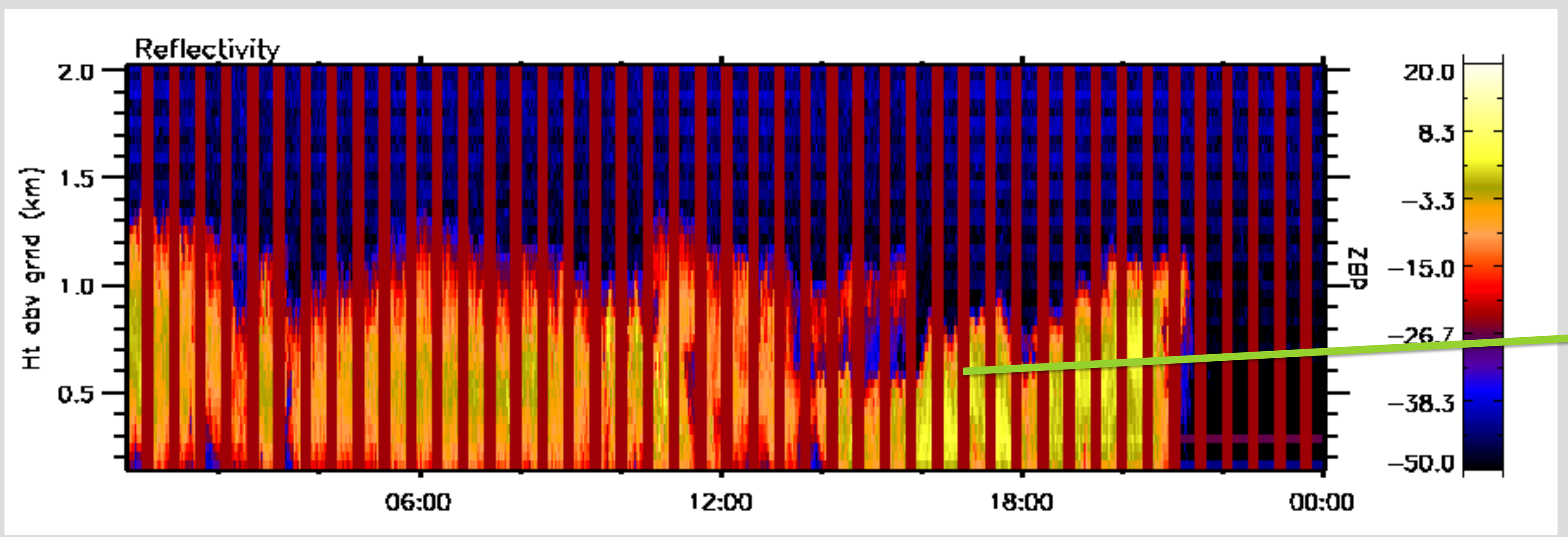
Although an ice particle can vary over a wide range of shapes, sizes, and bulk densities, it can be most easily thought of and represented mathematically as an oblate spheroid made up of a mixture of air and ice. Illustrated below are photos from Tim Garrett's Multi-Angle Snowflake Camera.



Choosing an Ice Crystal Habit Based on the Slant Linear Depolarization Ratio

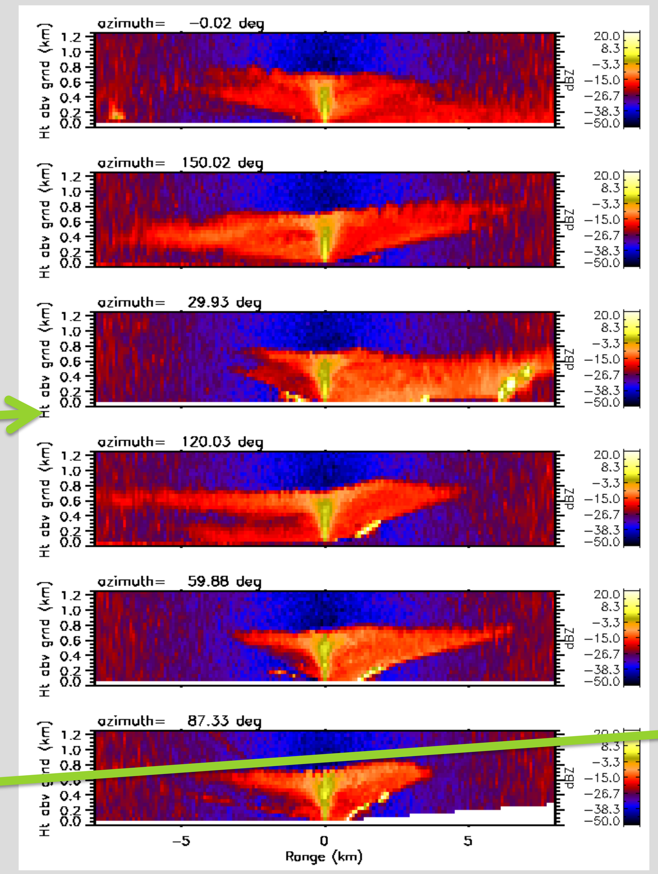
Following Matrosov et al. 2012, SWACR (94GHz) SLDR signature is enhanced in the zenith view by the presence of preferentially oriented ice crystals with low aspect ratios, such as plates and dendrites. As the aspect ratio of the particle increases or the preferential orientation decreases, this SLDR enhancement becomes more relaxed. Using a Chi-Square Goodness of Fit test applied to all scans and all heights, a dominant crystal habit can be estimated and its scattering properties parameterized.

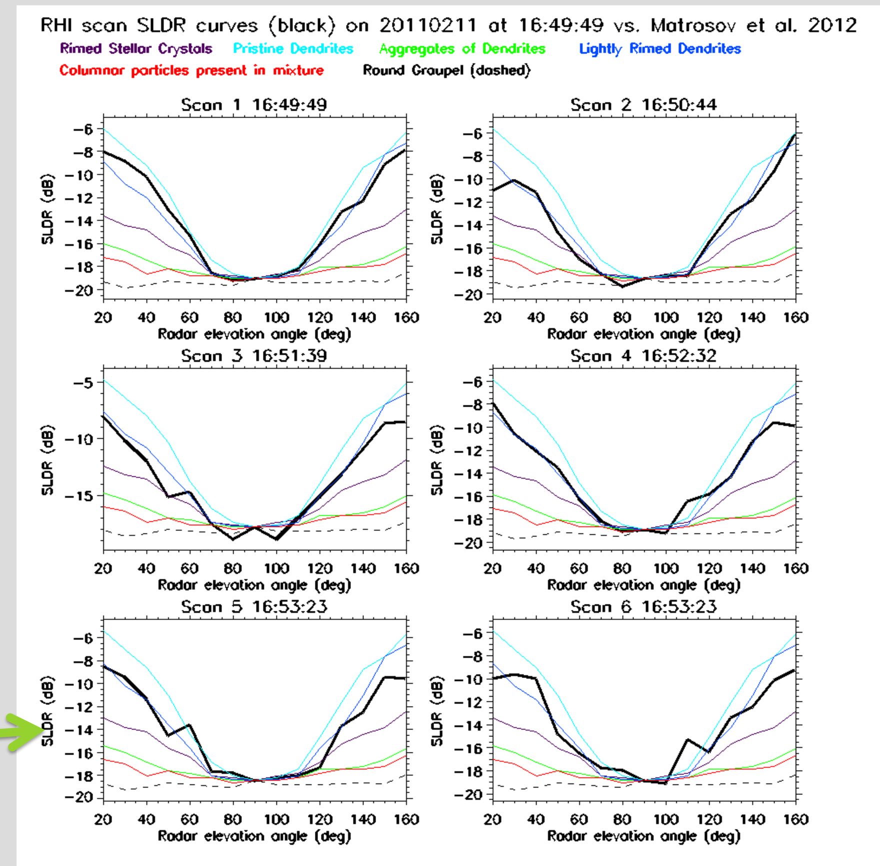
SWACR Scanning Period: 6 min. *SWACR Zenith Period: 30 min.*

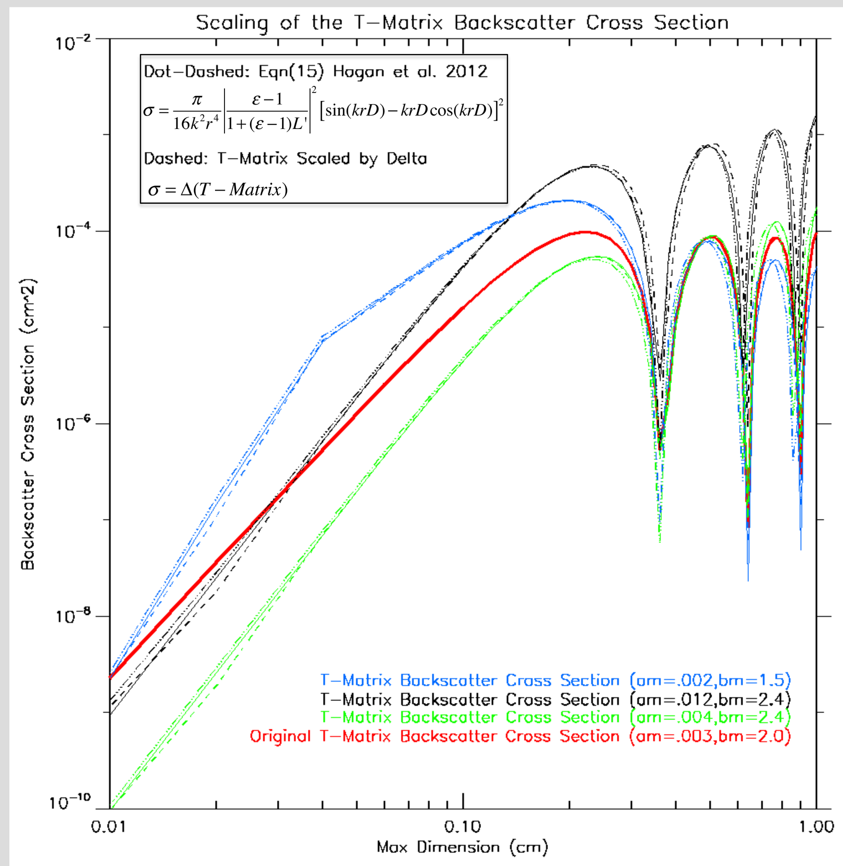


Calculate Depolarization Ratio (DR) for Each Scan at Each Height of Scanning Period

$$DR(dB) = 10\log_{10}(Z_{cross-pol}) - 10\log_{10}(Z_{co-pol})$$

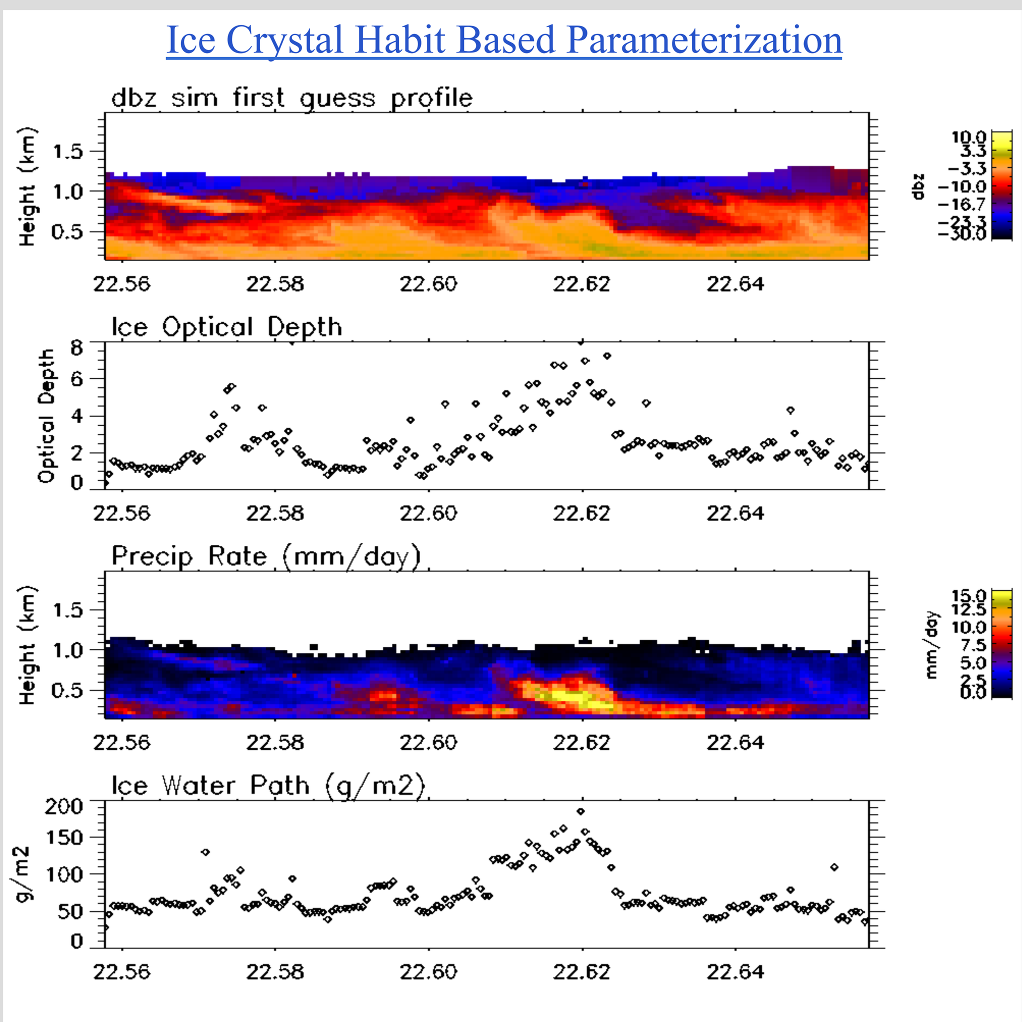


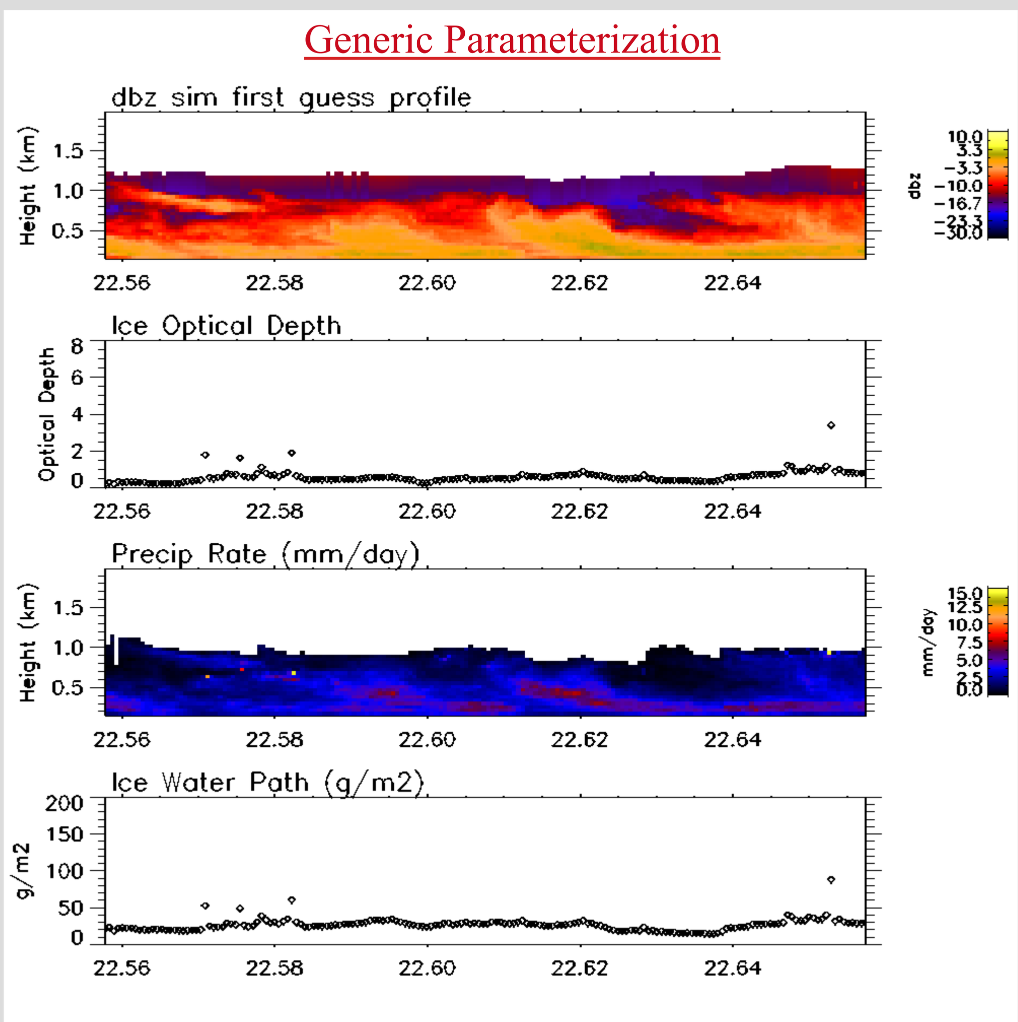


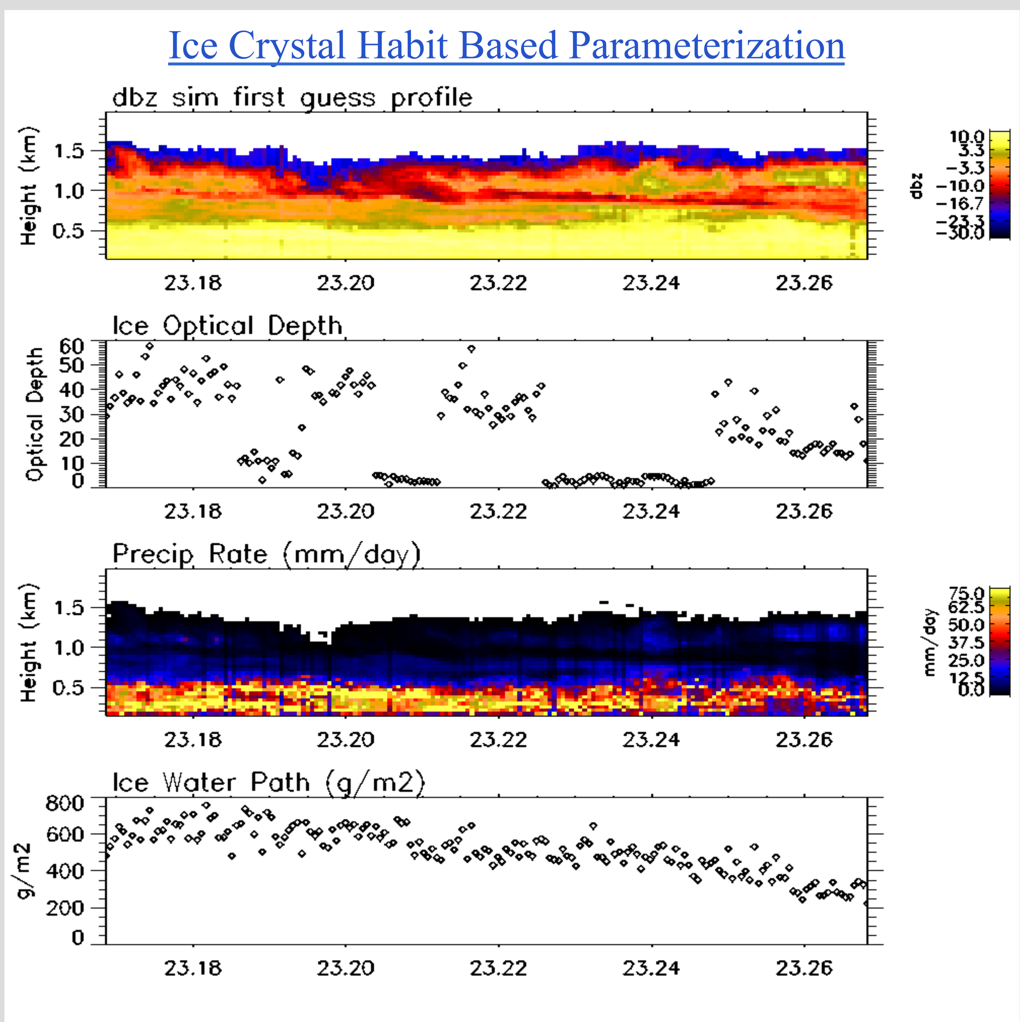


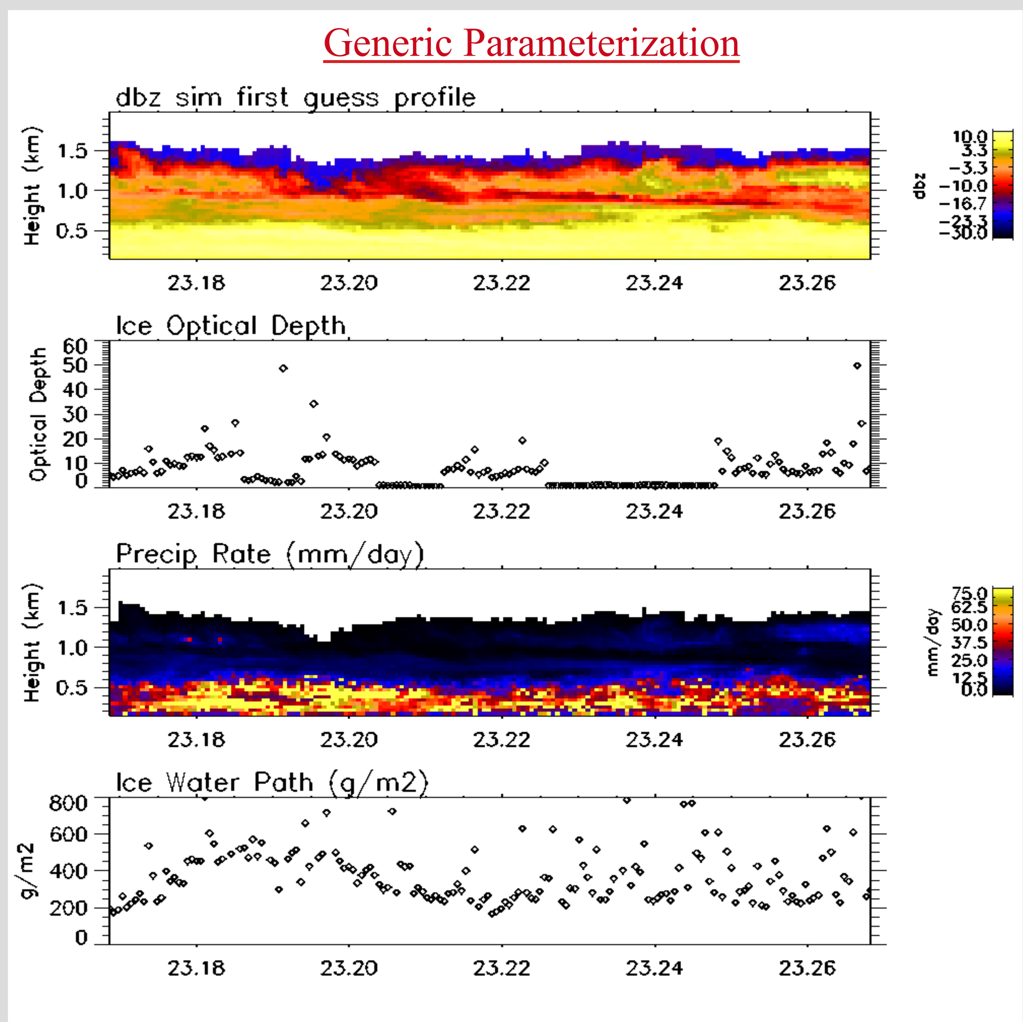
Parameterizing Radar Retrievals Based on Ice Crystal Habit *vs.* Parameterizing Radar Retrievals Based Only on Generic Assumptions

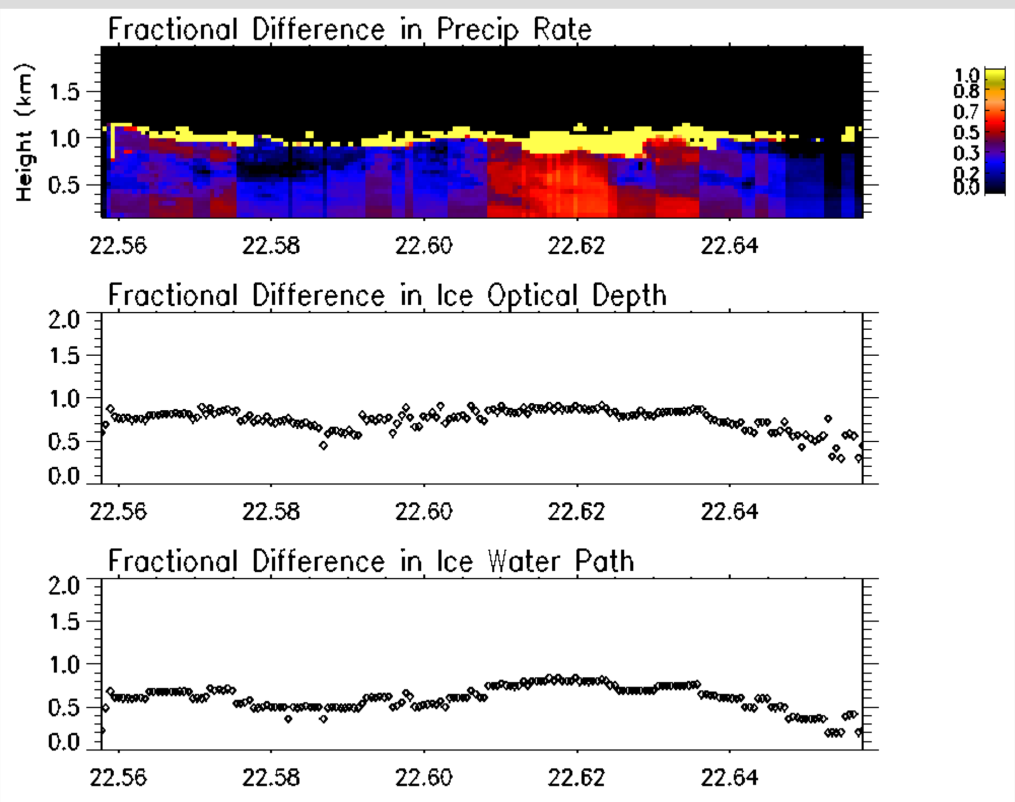
Once a dominant habit has been chosen using the Depolarization Ratio from the SWACR scanning period and the corresponding parameterizations have been made using the Maxwell-Garnett Mixing Rule for the complex permittivity of an oblate spheroid, these parameterizations can be applied to the radar retrieval algorithm for the SWACR zenith period. Shown below are two case studies demonstrating the potential difference in the retrieved microphysics depending on whether a habit based parameterization or a generic parameterization was used.











Parameterize Mass-Dimension & Backscatter Cross Section Based on Habit Choice, Polarizability (α), The Maxwell-Garnett Mixing Rule (ε_{eff}) for Oblate Spheroids, and a T-Matrix Scaling Factor (Δ).

$$\varepsilon_{eff} = \varepsilon_{inclusion} + 3f\varepsilon_{matrix}\left[\frac{\varepsilon_{inclusion}-\varepsilon_{matrix}}{\varepsilon_{inclusion}+2\varepsilon_{matrix}-f(\varepsilon_{inclusion}-\varepsilon_{matrix})}\right] \qquad f = \frac{V_{ice}\rho_{ice}}{a_m D^{b_m}} - 1$$

$$\alpha = \frac{V(\varepsilon-1)}{1+(\varepsilon-1)L} \qquad \Delta = \frac{\alpha_{param}}{\alpha_{tmat}} \qquad \sigma_b = \Delta(T-Matrix)$$