Global ice crystal habits

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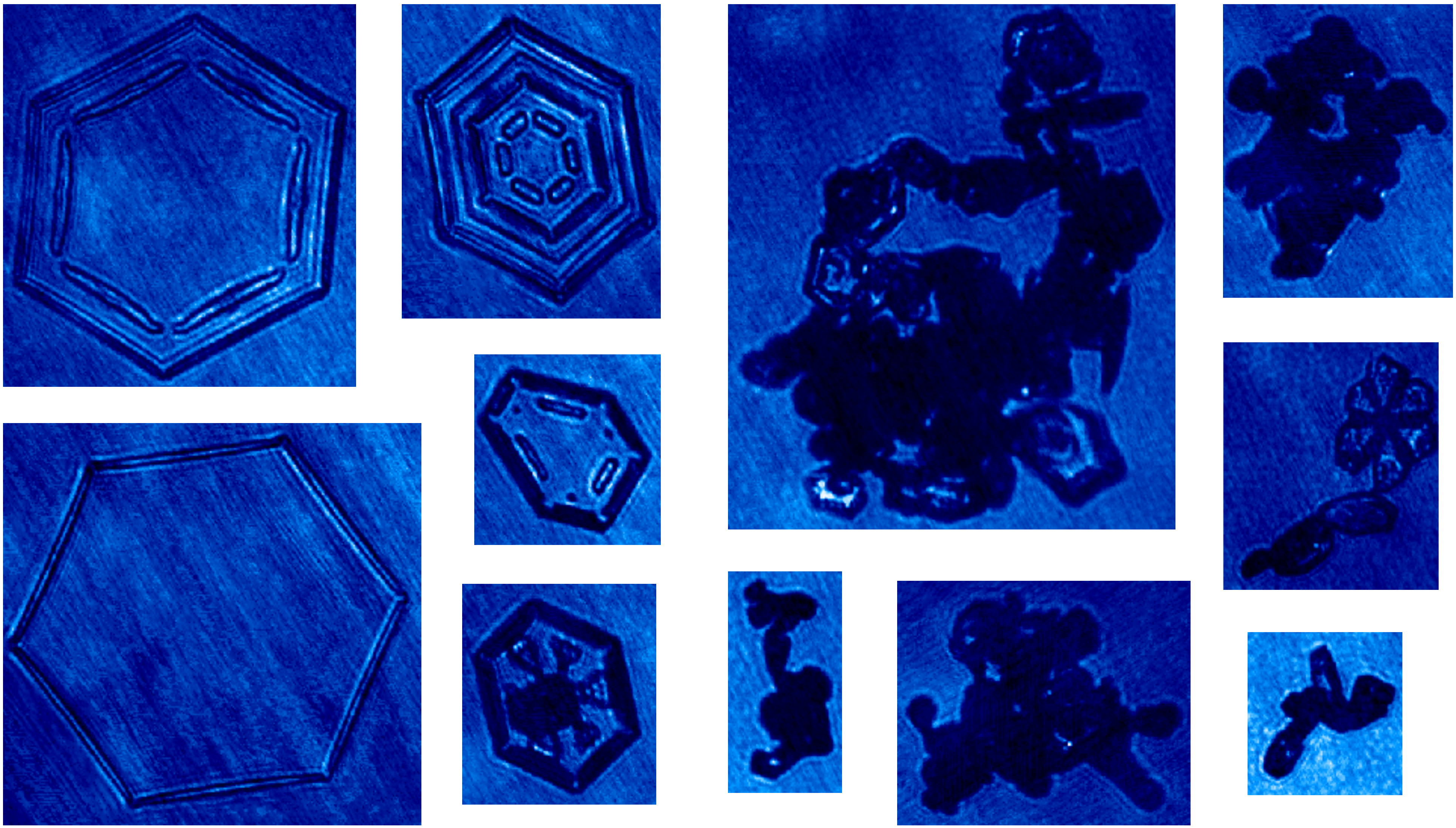
Why are habits important?
(Where and when do we need them?)

- Particle radiative properties
- Particle terminal velocities

- Remote sensor retrievals

- Basically: Particle projected area and particle mass.

Atmospheric particles can be highly variable.



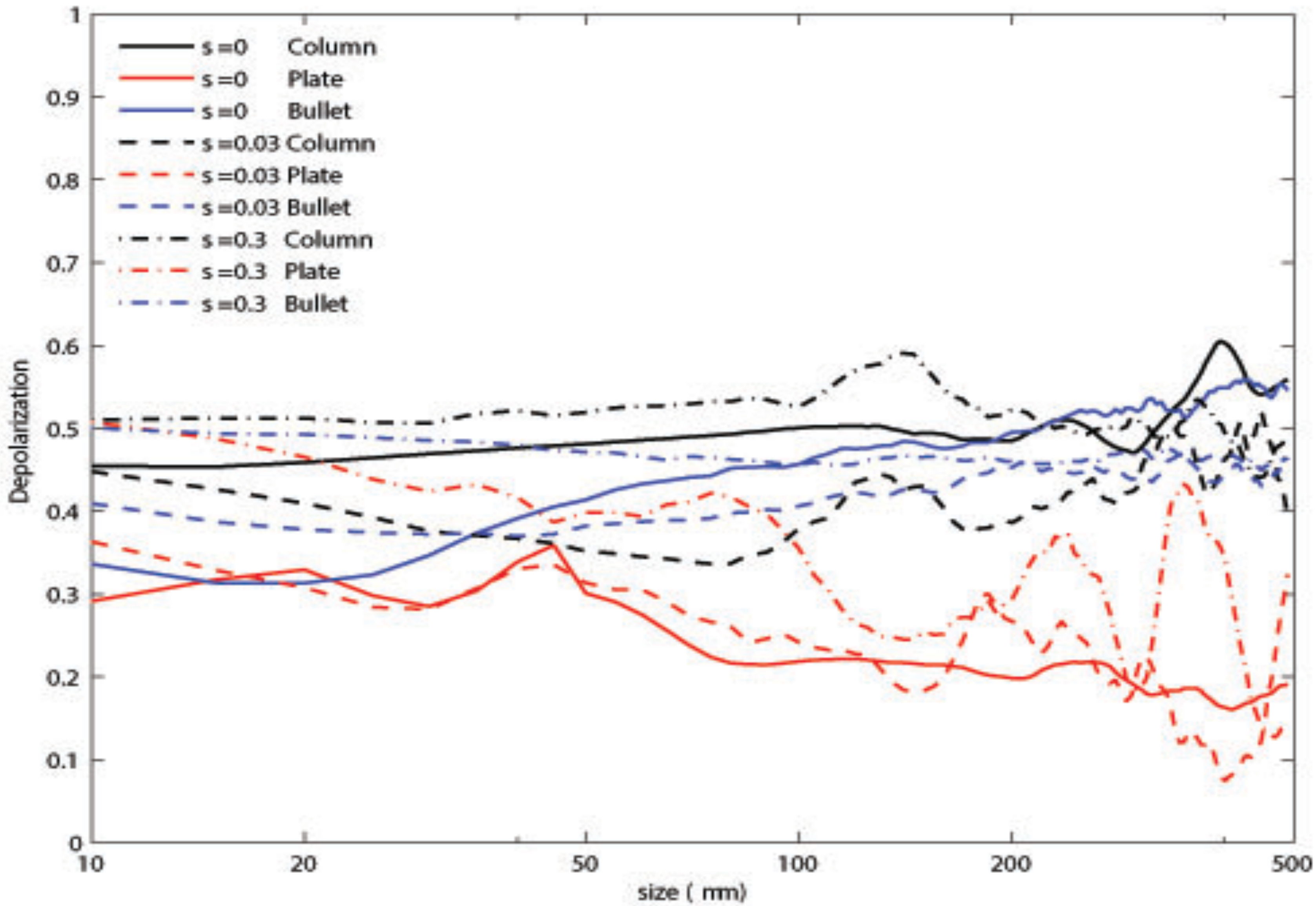
Two pronged approach

- Pristine particle habits in upper could regions (where radiative properties are affected by shapes)
- Fractal particle properties in more dense clouds where aggregation is the dominant particle growth mechanism.

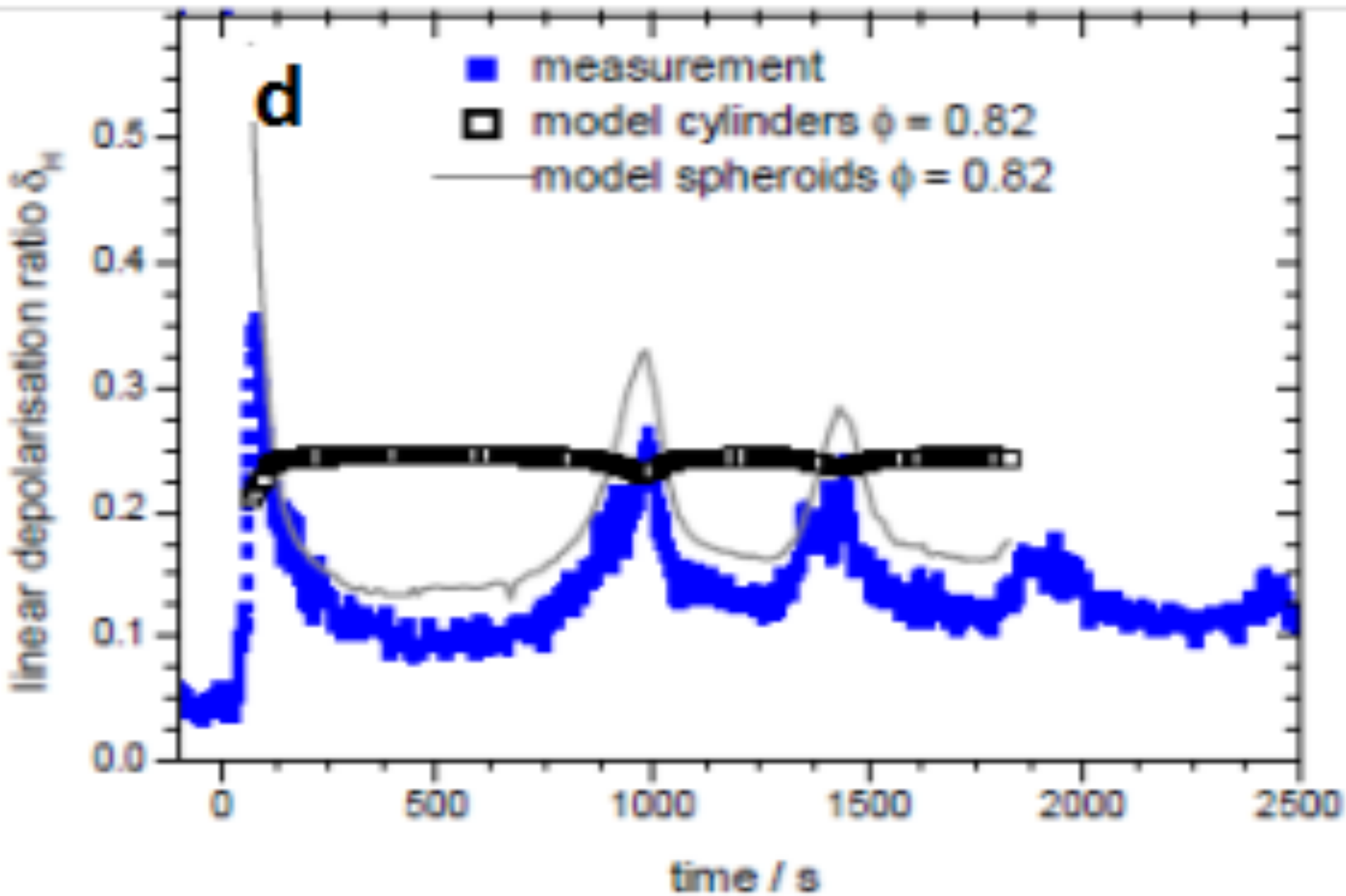
CloudSat CALIPSO habit information

- CALIOP (Cloud–Aerosol Lidar with Orthogonal Polarization): cloud extinction and particle depolarization.
- CloudSat: Radar reflectivity
- Theoretical ray tracing calculations: Calculate depolarization ratio for simple and complex particles.
- Laboratory studies: Measure depolarization ratio to look at variability (uncertainty) as well as particle surface roughness.

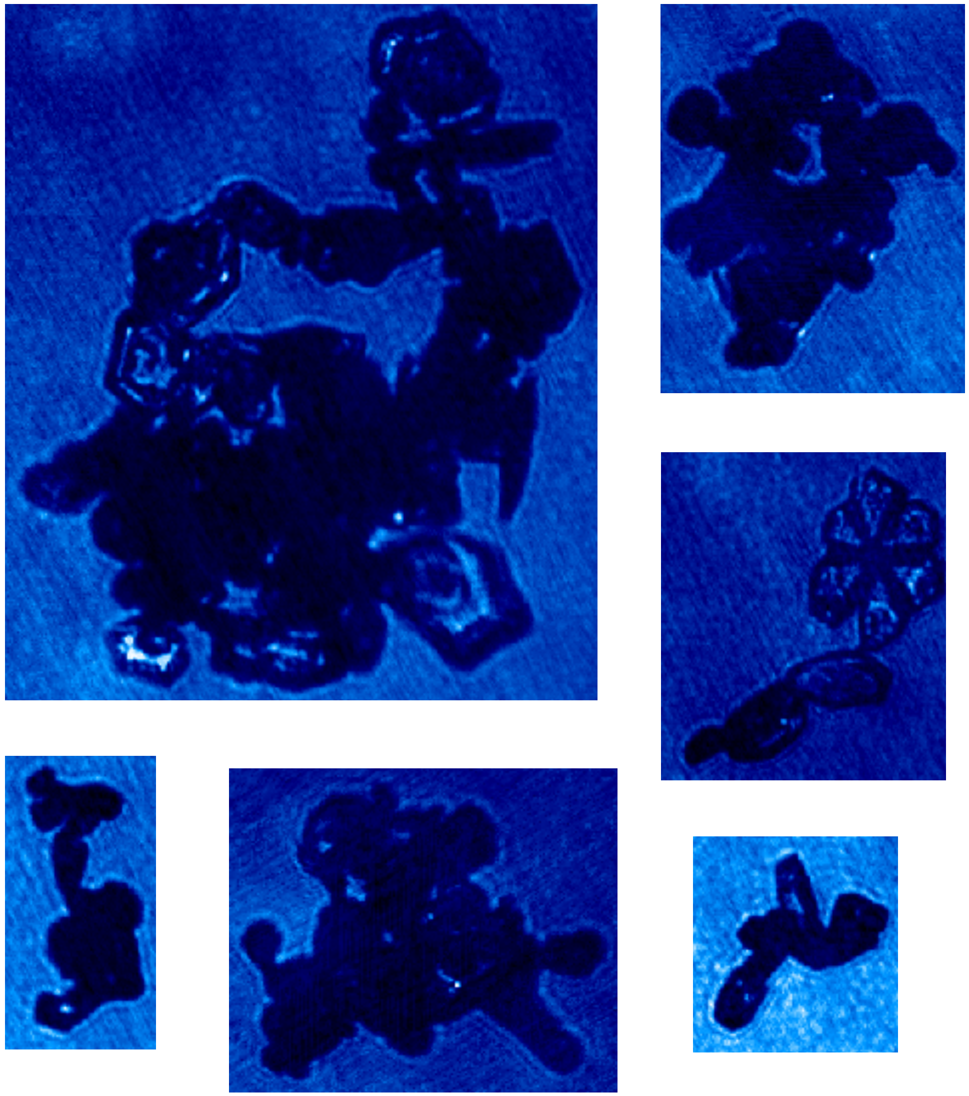
Ray Tracing calculations for simple particles with and without surface roughness



Depolarization ratio measurements in AIDA cloud chamber



What about these? What about situations where we have radar only?



We will characterize particle properties using the fractal method.

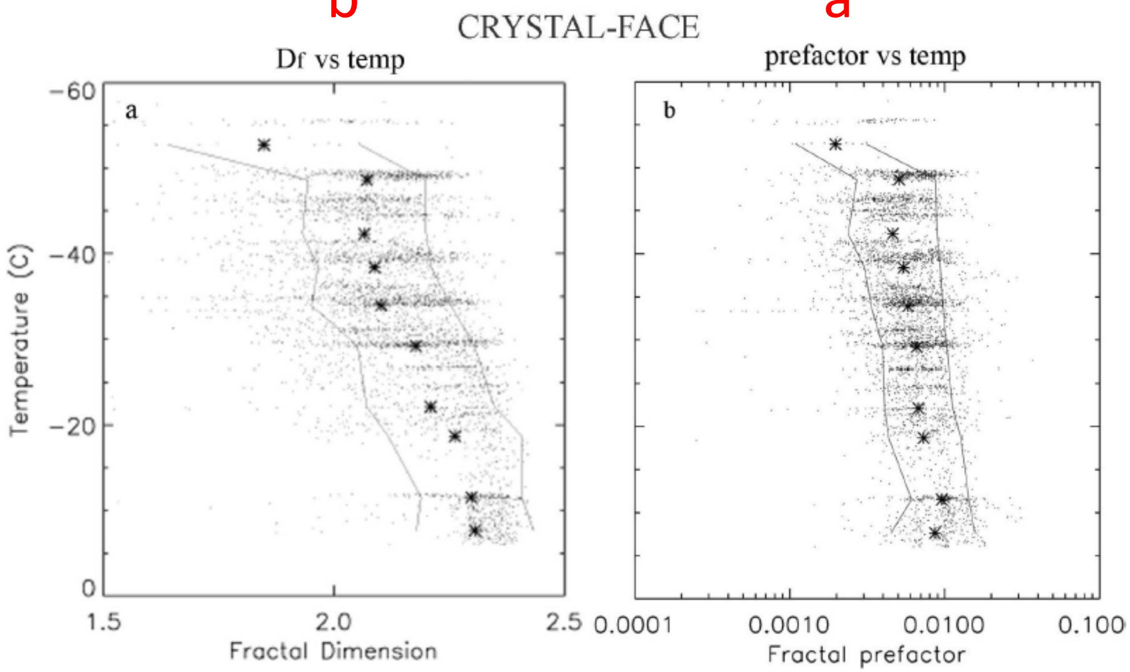
- Area = $\alpha * D^{\beta}$
- Mass = $a * D^{b}$
- Through fractal geometry we can relate b to β and a can be derived from α and β and b.

- Schmitt, C. G., and A. J. Heymsfield, 2010: Dimensional characteristics of ice crystal aggregates from fractal geometry. *J. Atmos. Sci.*, **67**, 1605-1616.

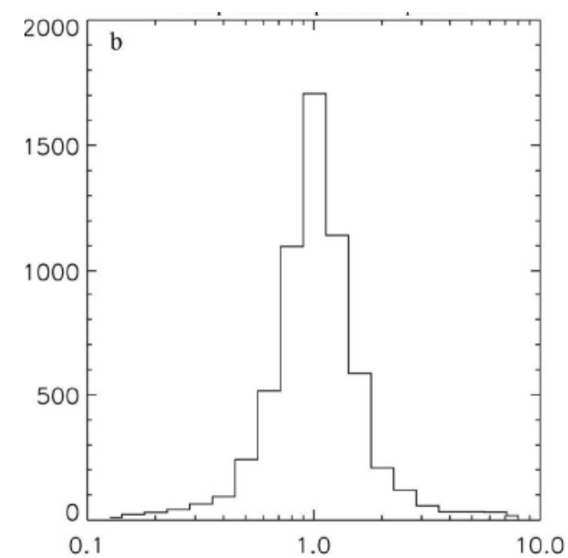
Mass dimensional parameters by temperature for CRYSTAL-FACE

$$\text{Mass} = a * D^{b}$$

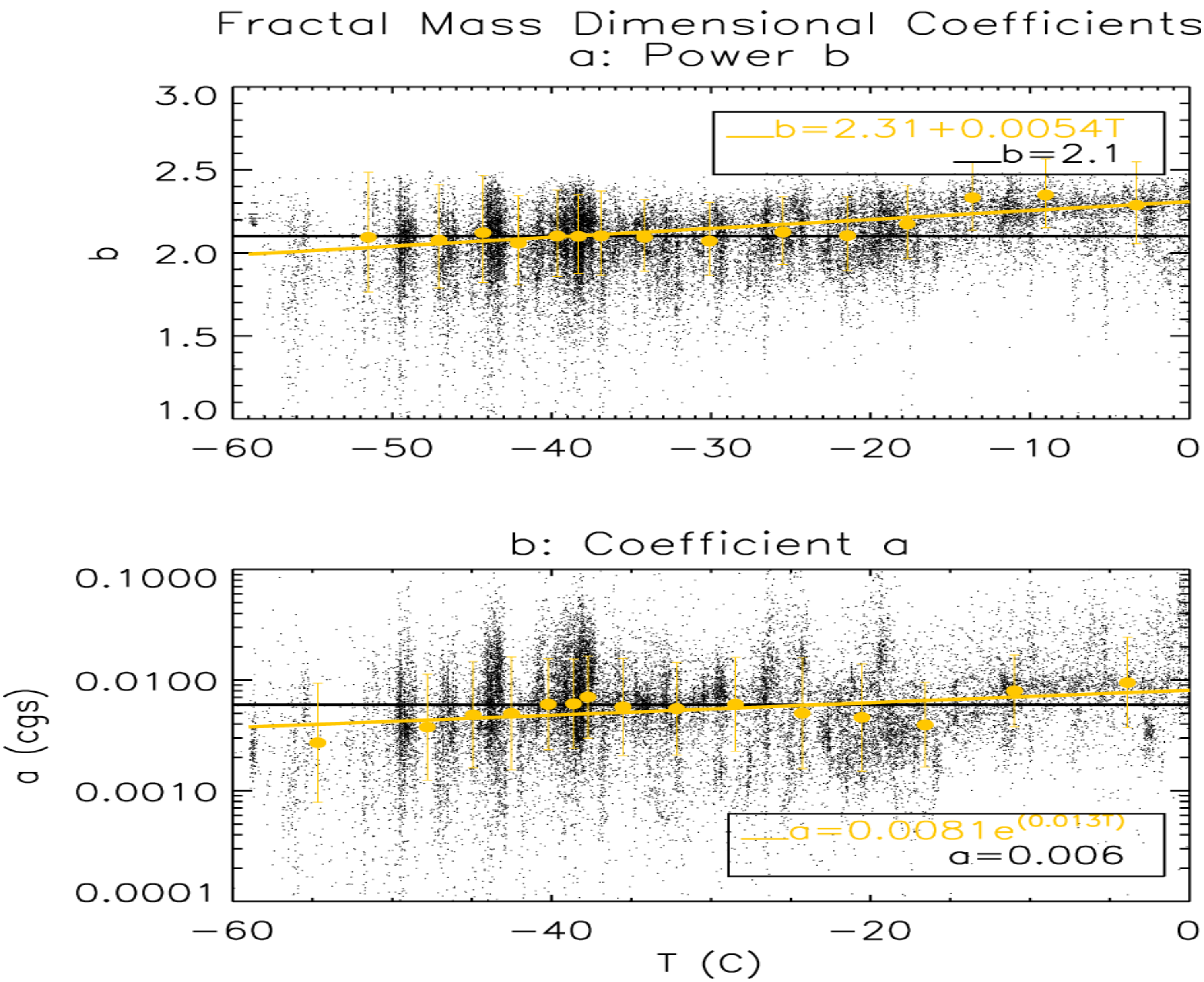
b a



Integrated IWC
IWC CVI



Five field projects: a and b by temp

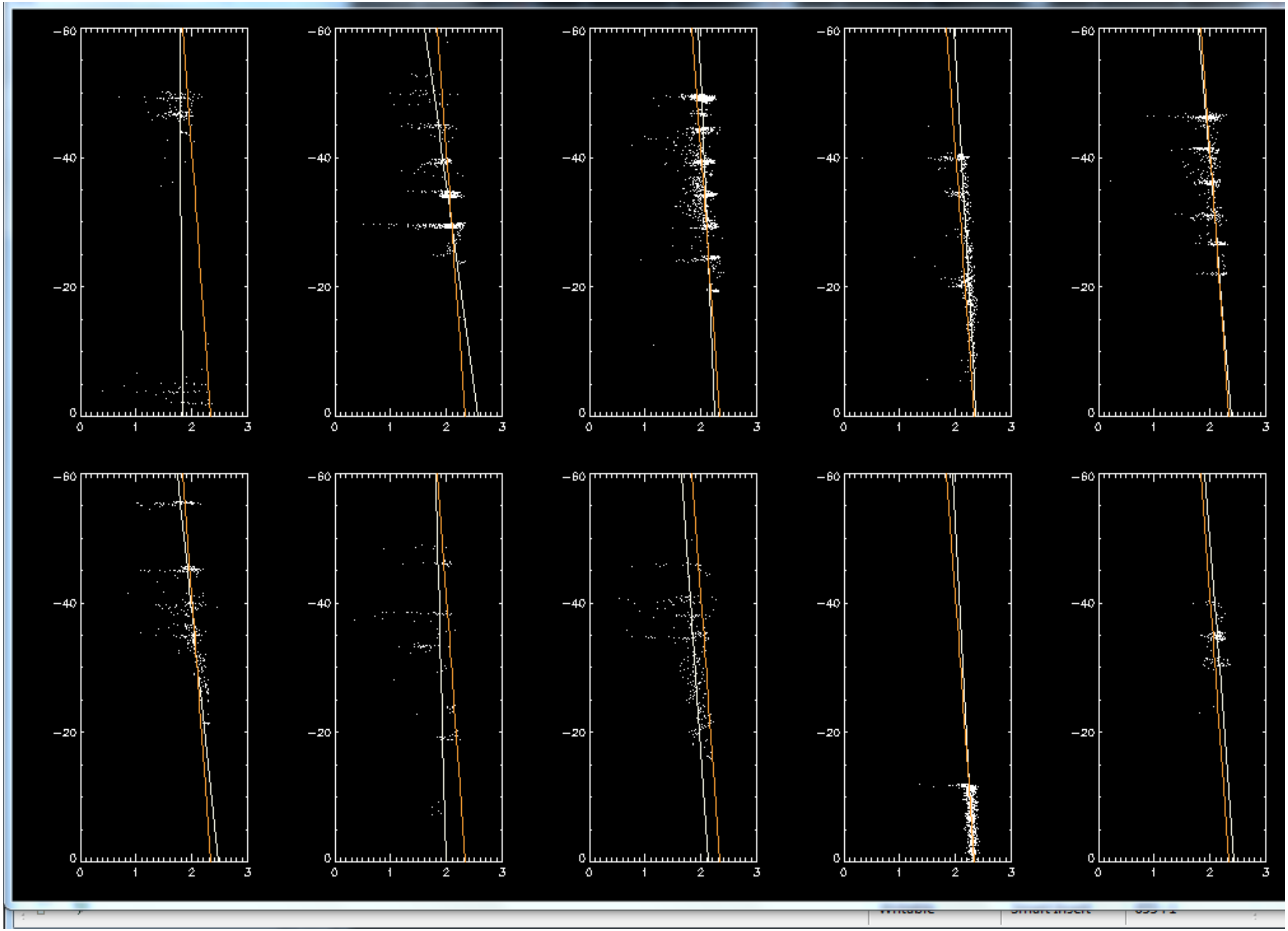


Fractal work

- Area and Mass are related. Using a-D and m-D relationships that are related will improve terminal velocity calculations, radar reflectivity calculations and remote sensing estimates.
- We are developing improved area measurements and will be applying the fractal method to 12 aircraft field projects from the poles to the tropics.

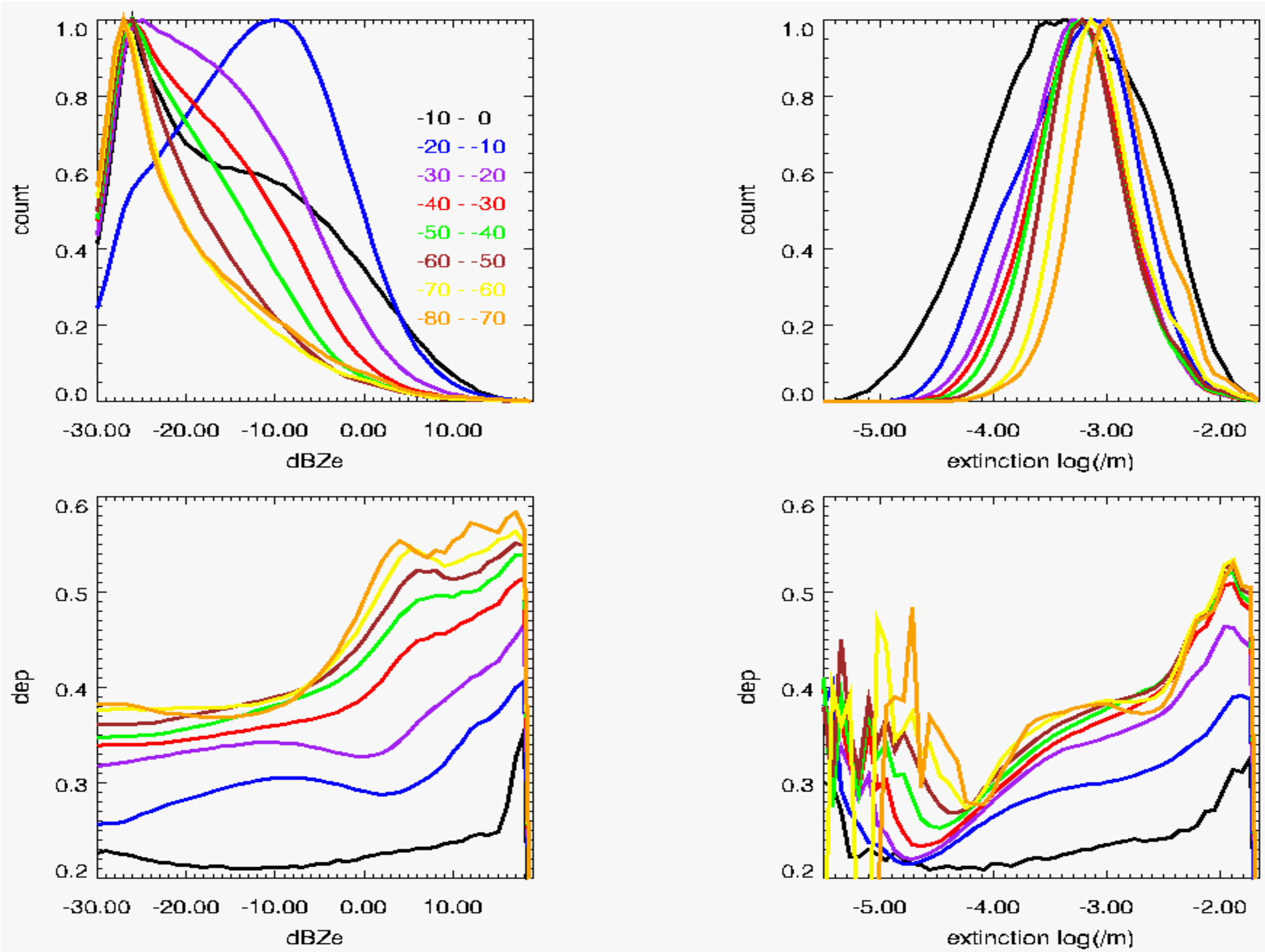
Summary

- CloudSat and CALIPSO data will be used to determine the distribution of particle habits on a global and regional scale by temperature (altitude).
- Laboratory measurements will be used to validate ray tracing calculations as well as to quantify uncertainty in depolarization ratio measurements.
- Typical particle habits and/or particle population fractal properties will be identified for clouds by season, altitude, latitude, and cloud type (continental, maritime, convective, stratiform).



−60
−40
−20
0
0
1
2
3

Depolarization ratio vs dBZe and extinction



SID-3 measurements of forward scattering: Speckled patterns = surface roughness