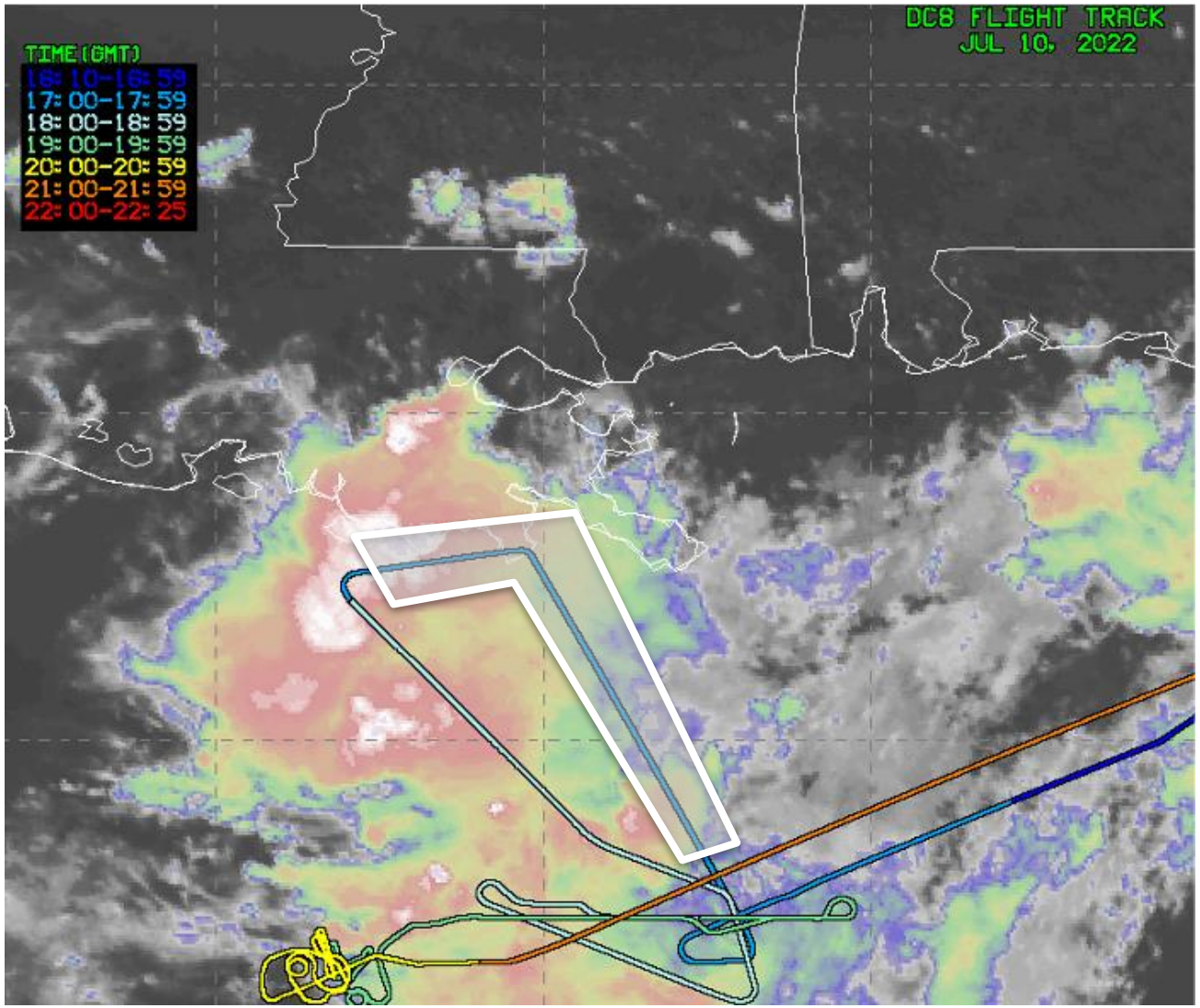
HIWC-2022 Particle Density

This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

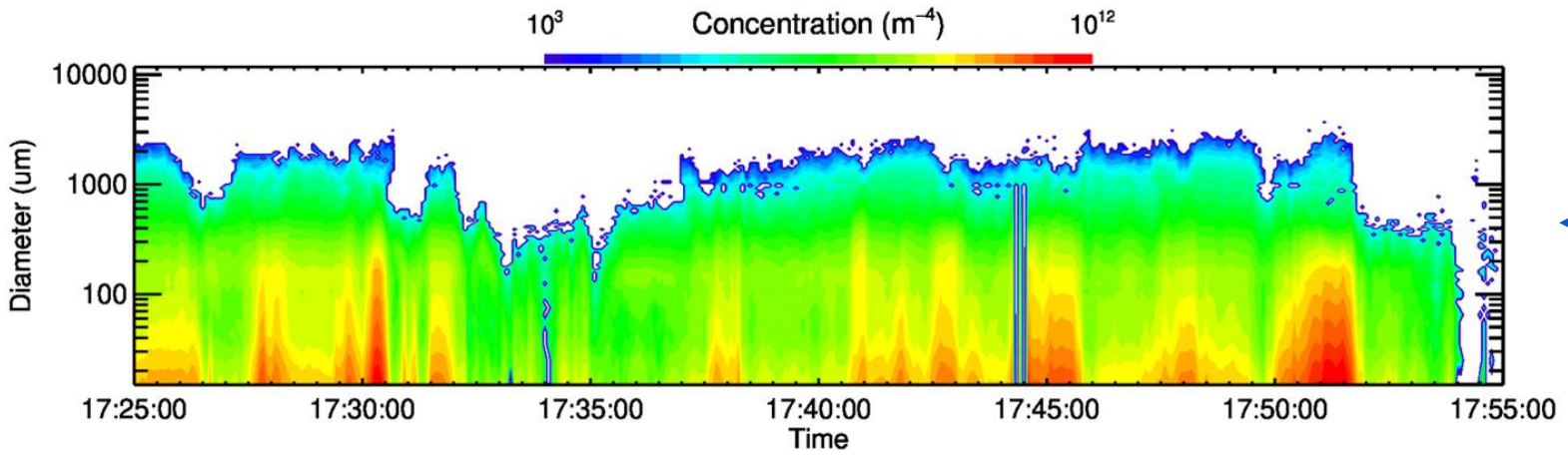
July 10, 2022


DC8 FLIGHT TRACK
JUL 10, 2022
TIME (GMT)
16: 10-16: 59
17: 00-17: 59
18: 00-18: 59
19: 00-19: 59
20: 00-20: 59
21: 00-21: 59
22: 00-22: 25

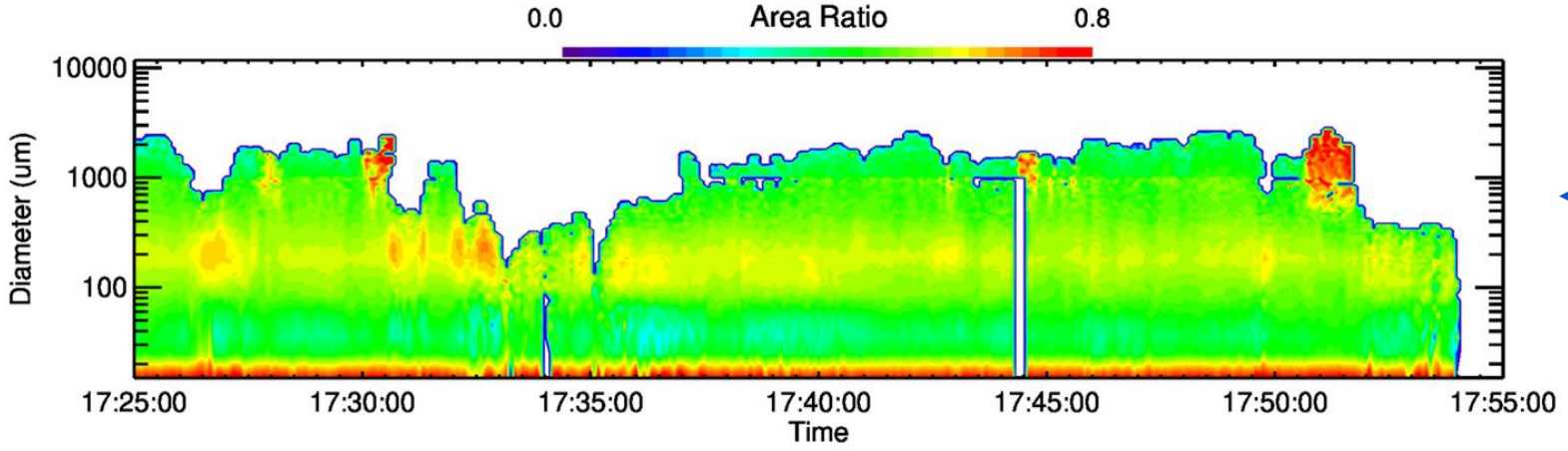

2022-07-10 17:33:16


2022-07-10 17:50:59

July 10, 2022

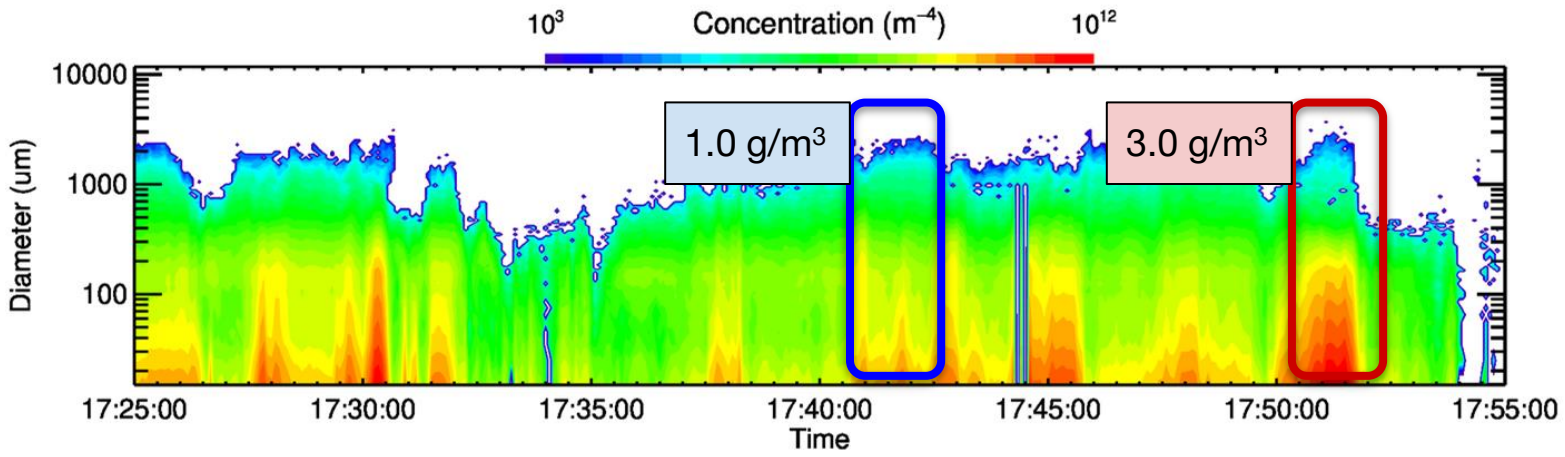


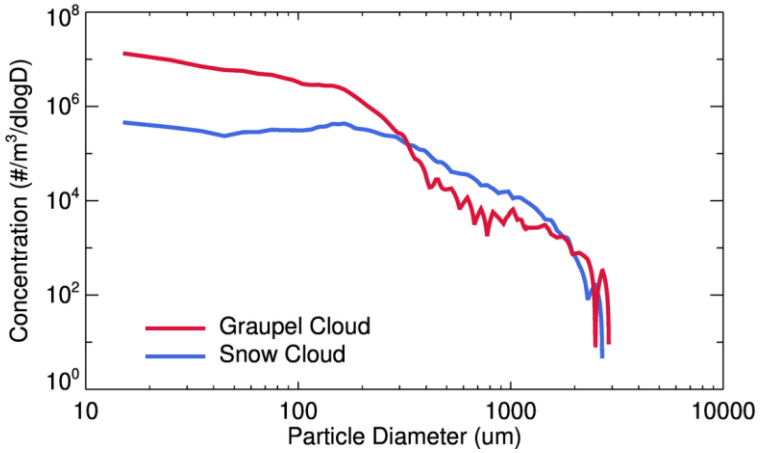
Concentration Time Series

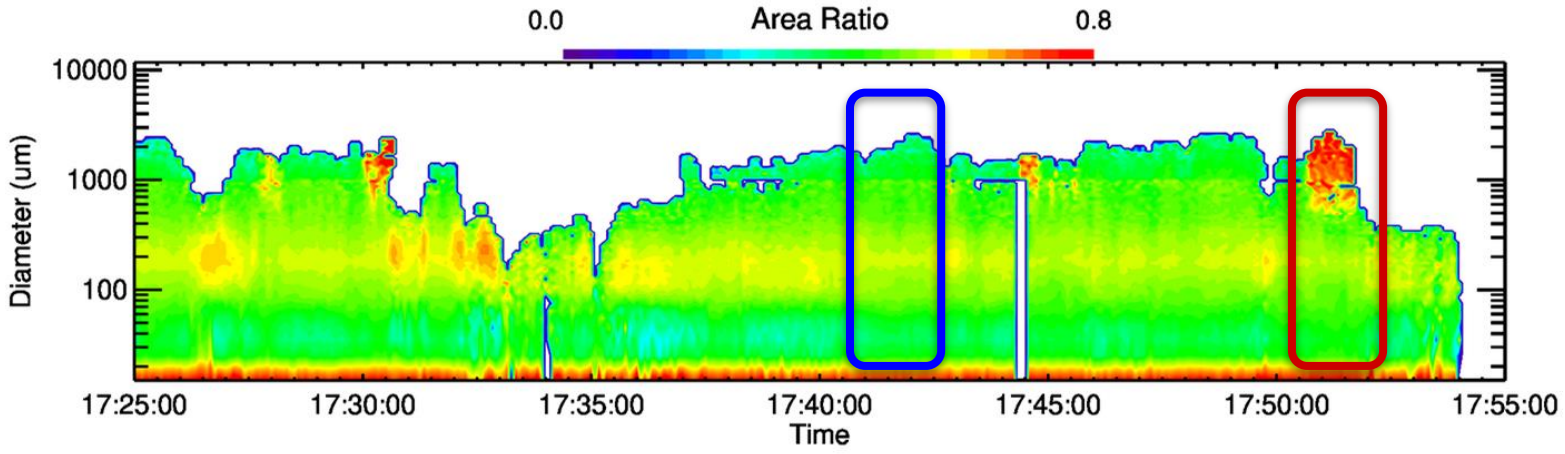


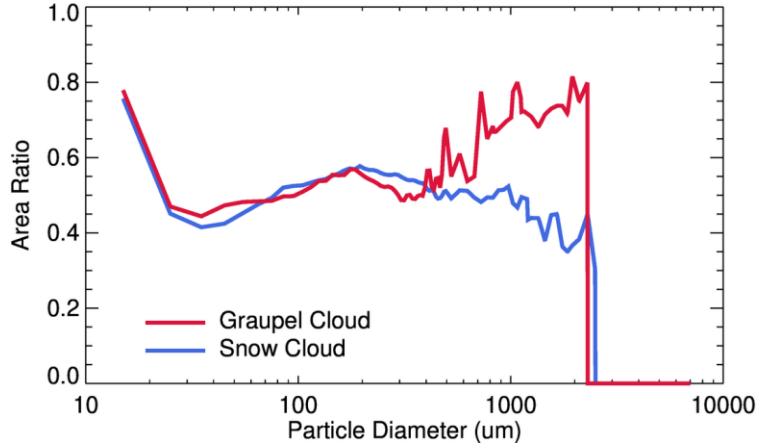
Roundness (shape) Time Series

July 10, 2022


10^3
Concentration (m^{-4})
10^{12}
1.0 g/m^3
3.0 g/m^3
Diameter (um)
10000
1000
100
17:25:00
17:30:00
17:35:00
17:40:00
17:45:00
17:50:00
17:55:00
Time

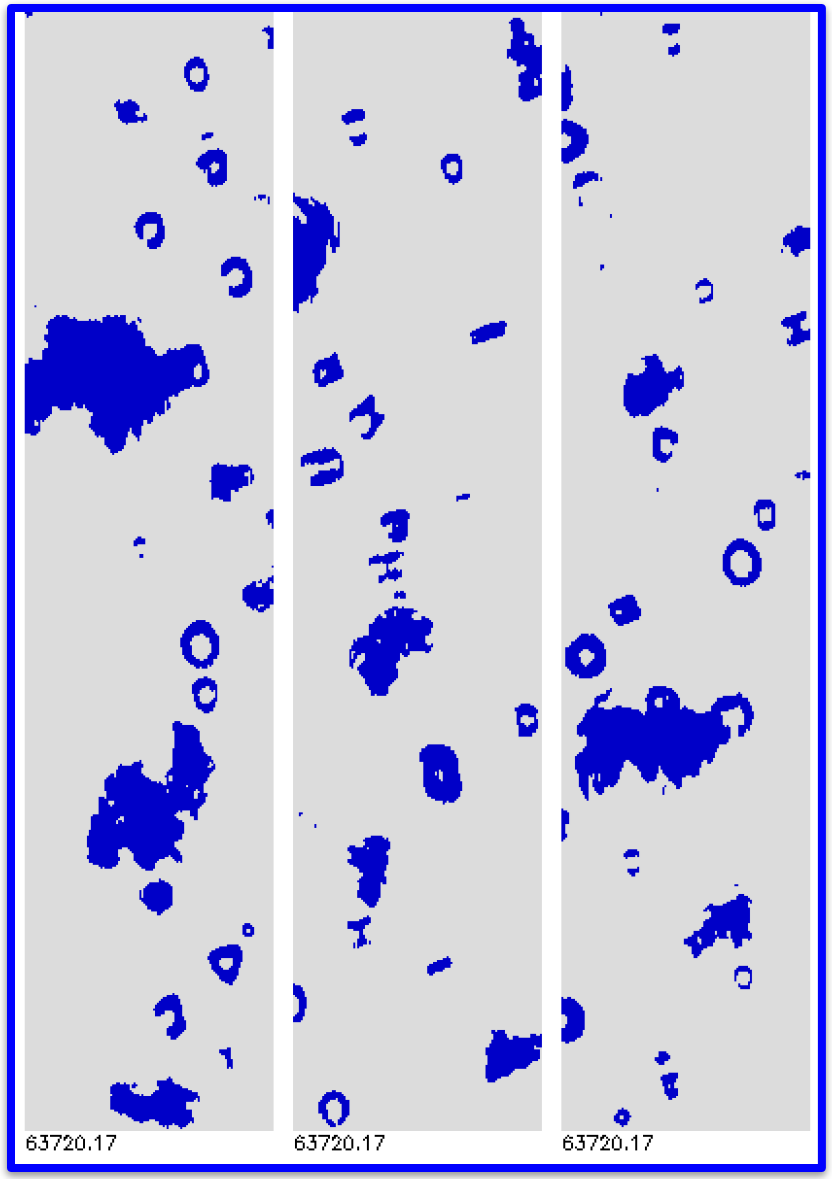

Concentration (#/m^3/dlogD)
10^8
10^6
10^4
10^2
10^0
Graupel Cloud
Snow Cloud
10
100
1000
10000
Particle Diameter (um)


0.0
Area Ratio
0.8
Diameter (um)
10000
1000
100
17:25:00
17:30:00
17:35:00
17:40:00
17:45:00
17:50:00
17:55:00
Time


Area Ratio
1.0
0.8
0.6
0.4
0.2
0.0
Graupel Cloud
Snow Cloud
10
100
1000
10000
Particle Diameter (um)

2D-S

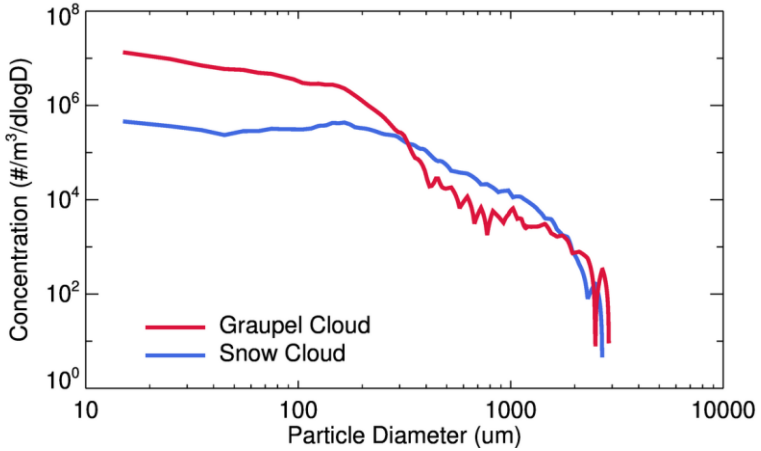
1 mm

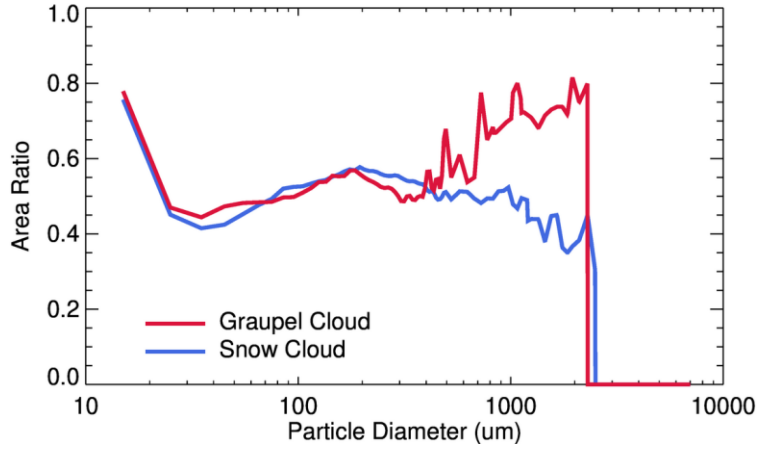


July 10 17:42:00 (-38 C)

Moderate-IWC = 1.0 g/m³

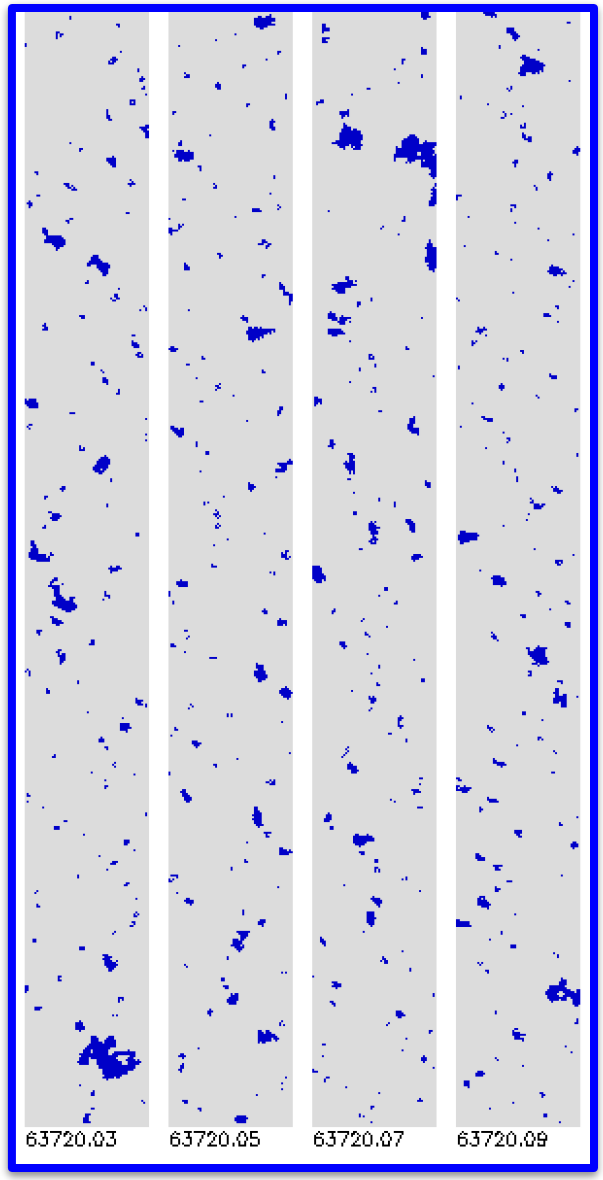
Anvil aggregates





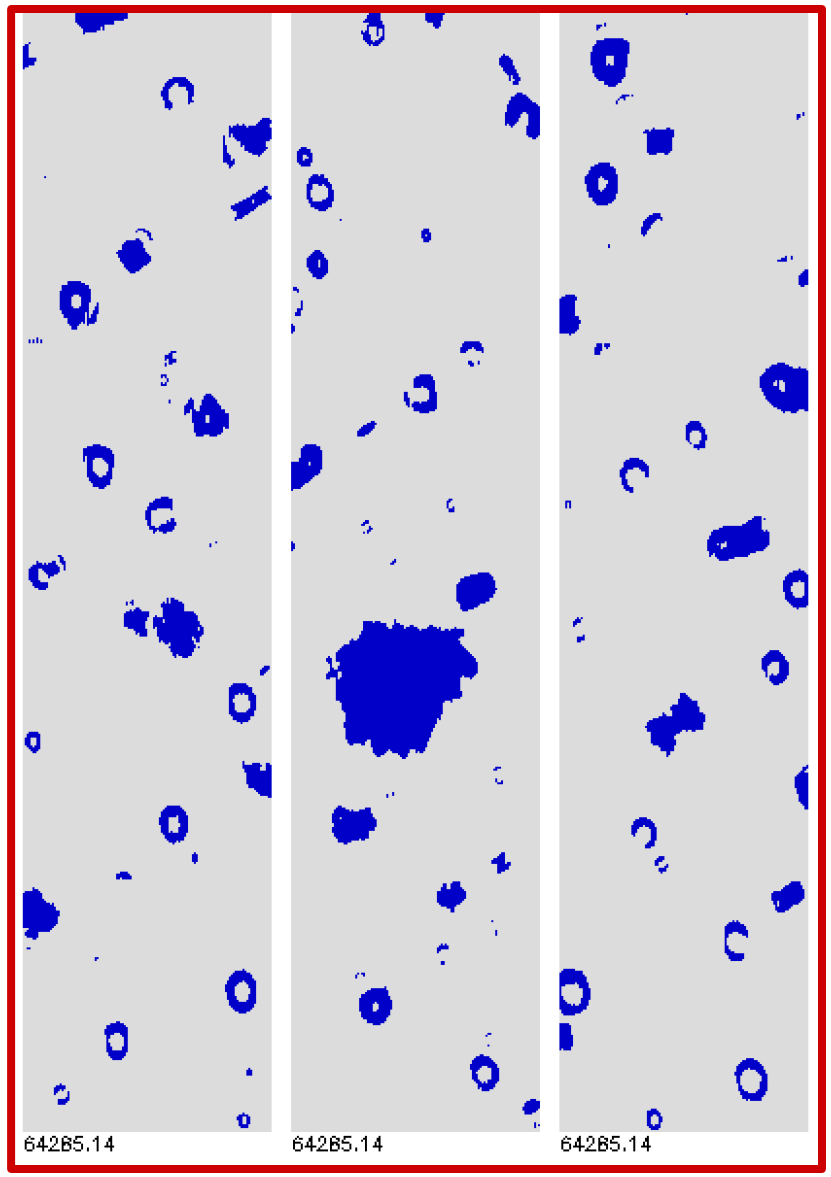
PIP

10 mm



2D-S

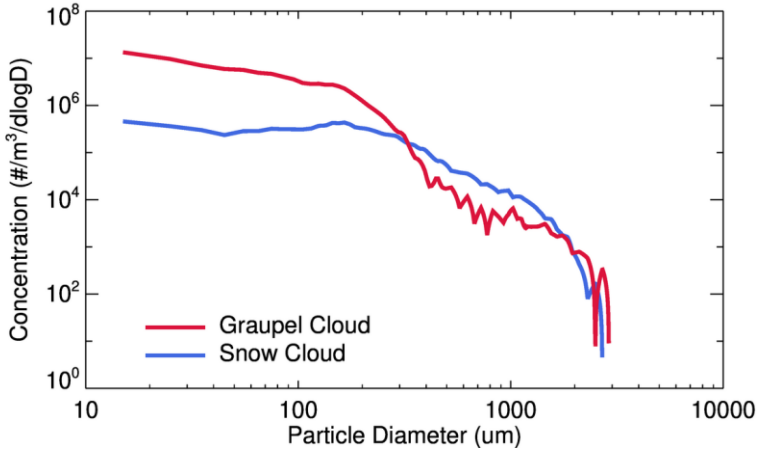
1 mm

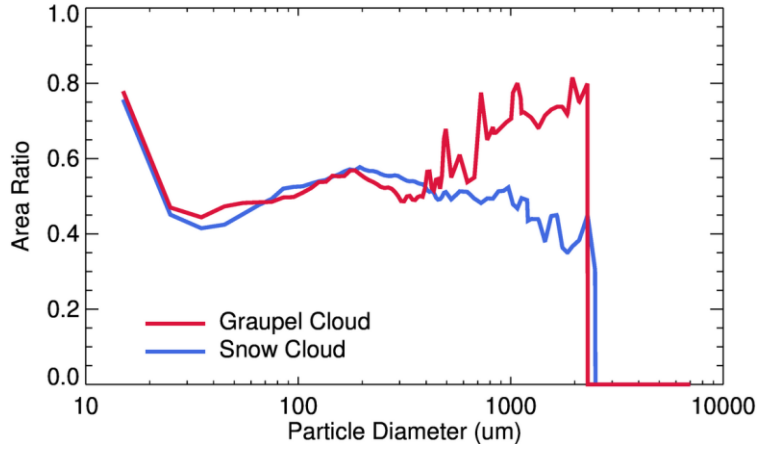


July 10 17:51:25 (-39 C)

High-IWC = 3.0 g/m^3

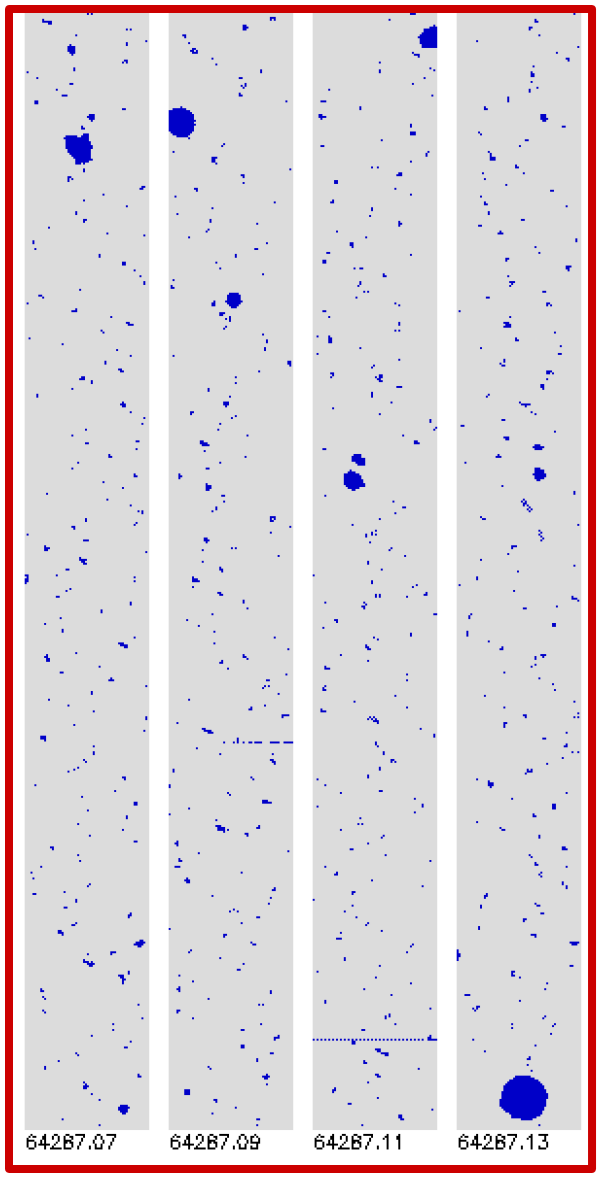
Small ice and graupel





PIP

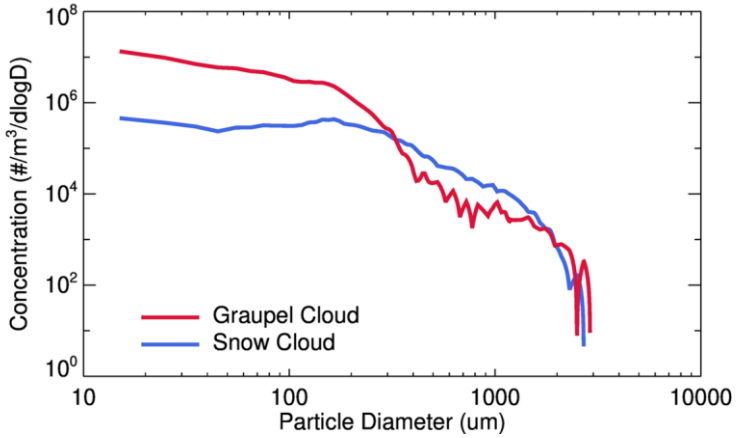
10 mm



Mass-size distribution (MSD)

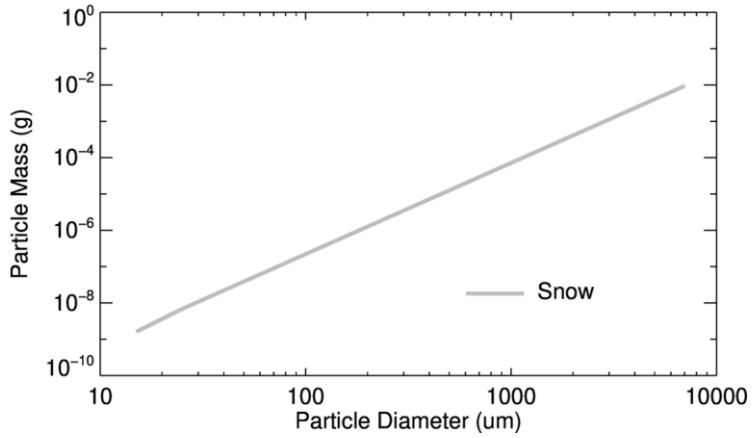
- Product of the particle size distribution and a mass-size parameterization gives MSD
- Most commonly used parameterizations (including HIWC projects) are appropriate for small ice and snow
- Graupel mass is significantly underestimated

PSD



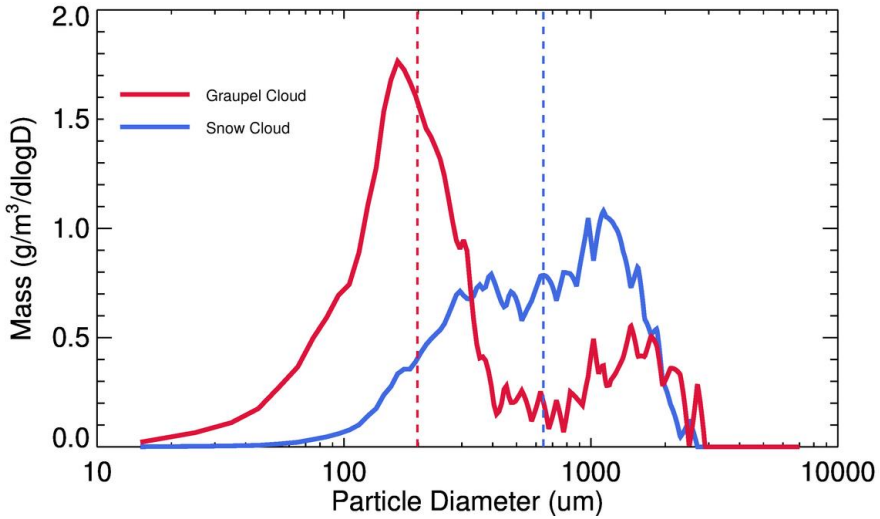
X

Parameterization



=

MSD



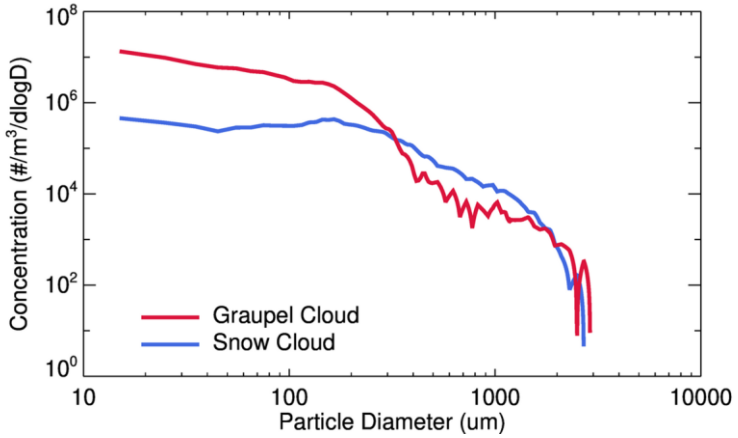
✓ **Snow_IWC = 0.8 g/m³**
IKP2 = 1.0 g/m³

✗ **Graupel_IWC = 1.2 g/m³**
IKP2 = 3.0 g/m³

Mass-size distribution (MSD)

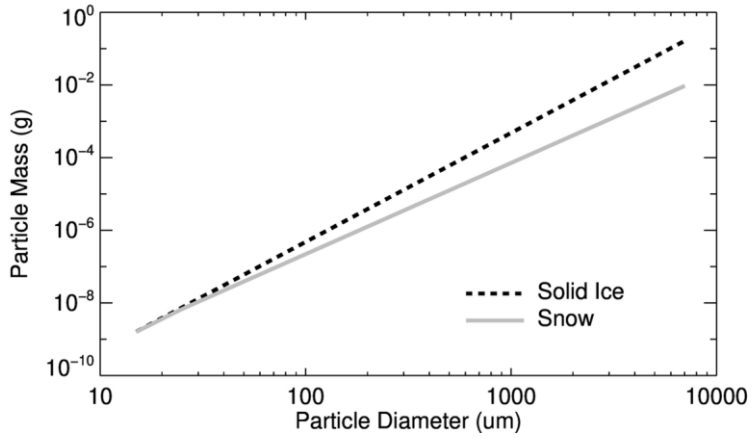
- Apply hybrid approach in graupel cloud pass
  - Snow < 750 μm
  - Solid Ice > 750 μm
- Leads to improved IWC match
- MMD increases significantly from 200μm to 1000μm
- Solid ice is probably too dense, truth may be somewhere in-between

PSD



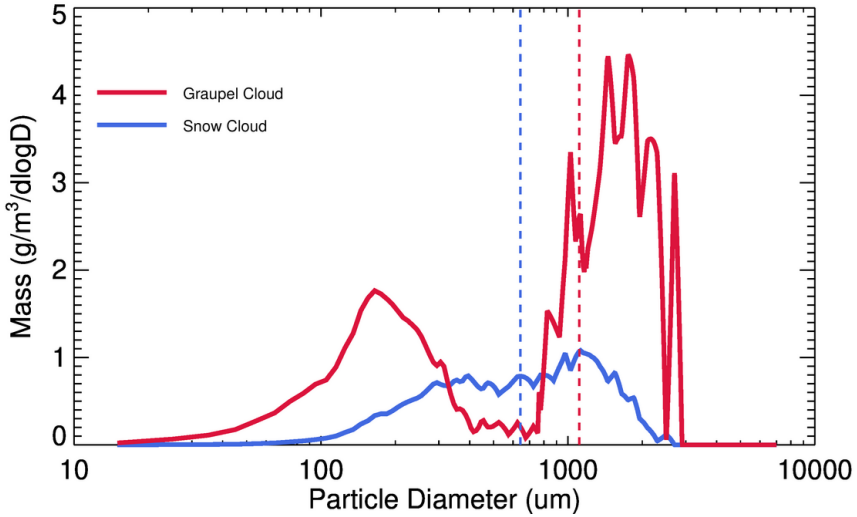
X

Parameterization



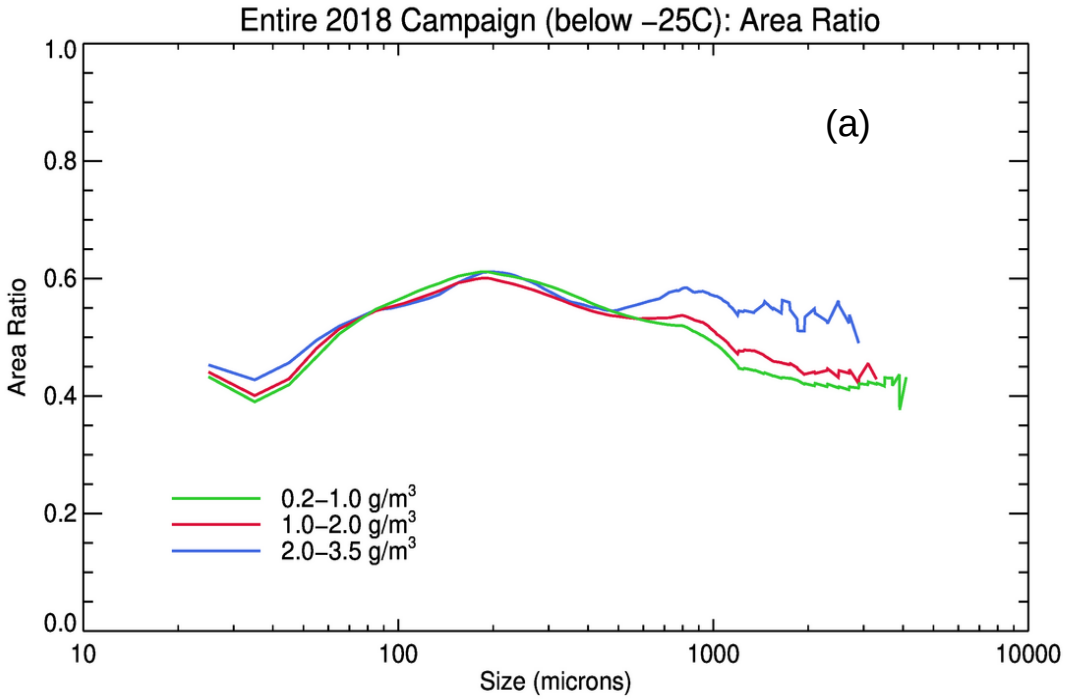
=

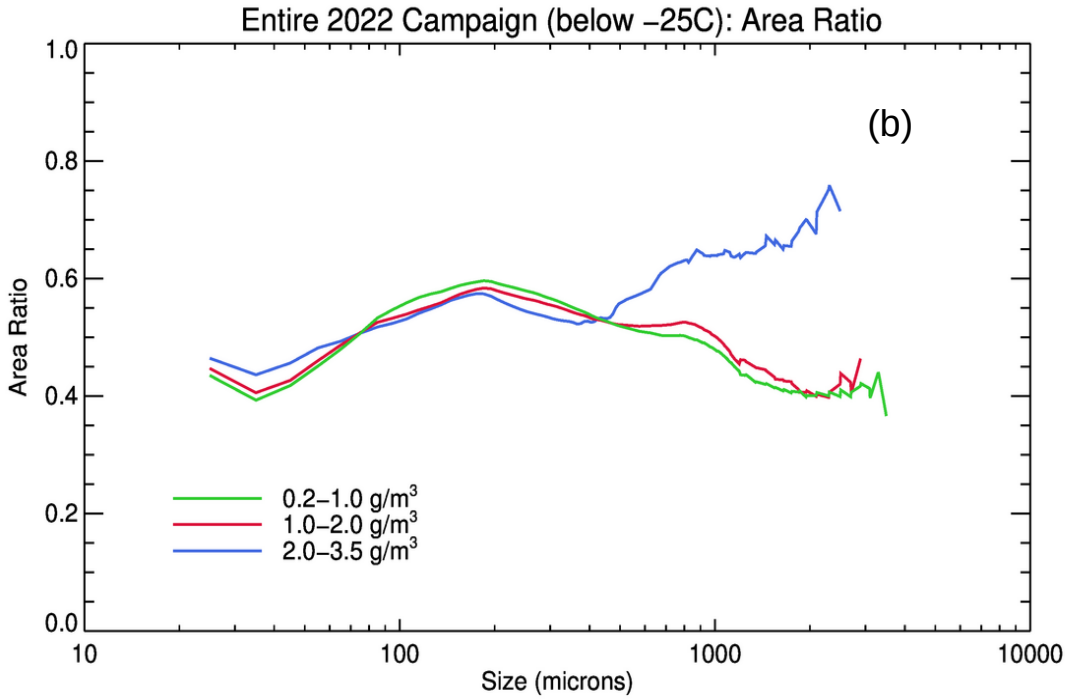
MSD



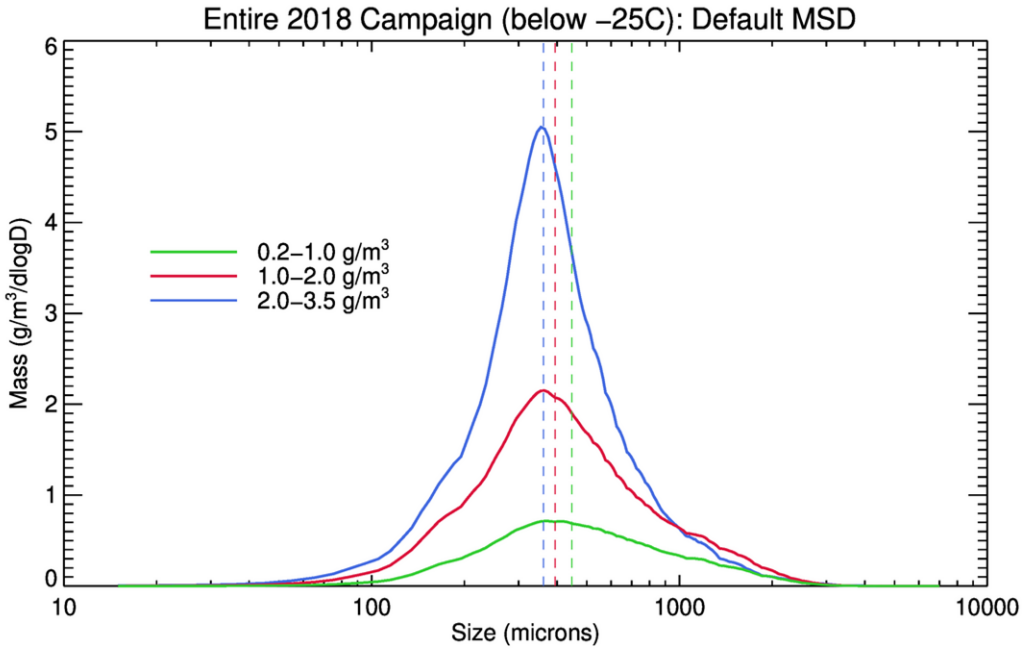
✓ **Snow_IWC = 0.8 g/m³**
IKP2 = 1.0 g/m³

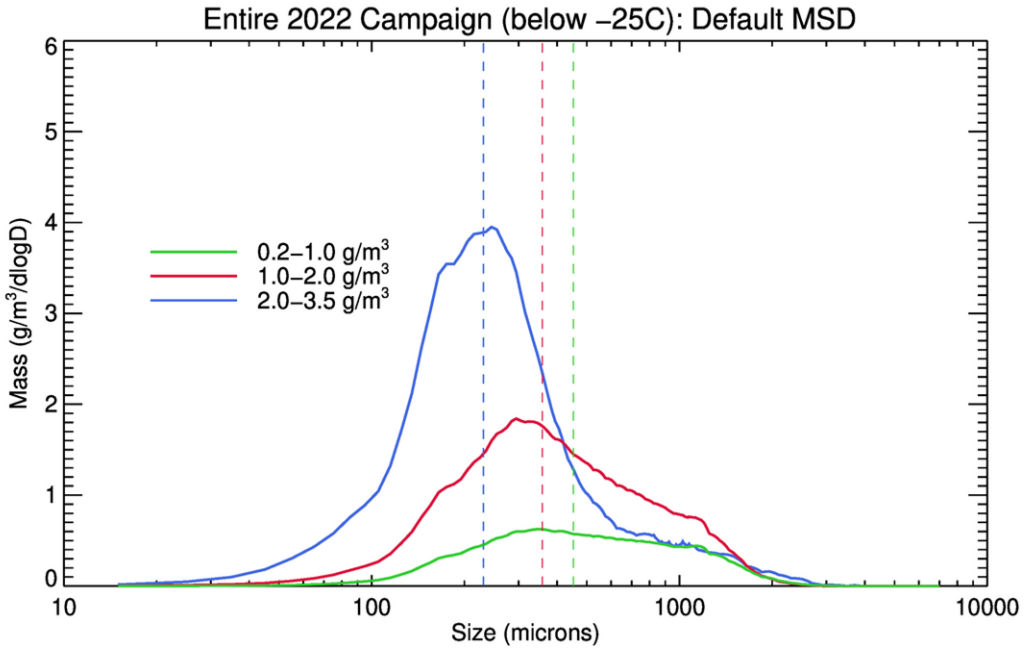
✓ **Graupel_IWC = 2.5 g/m³**
IKP2 = 3.0 g/m³



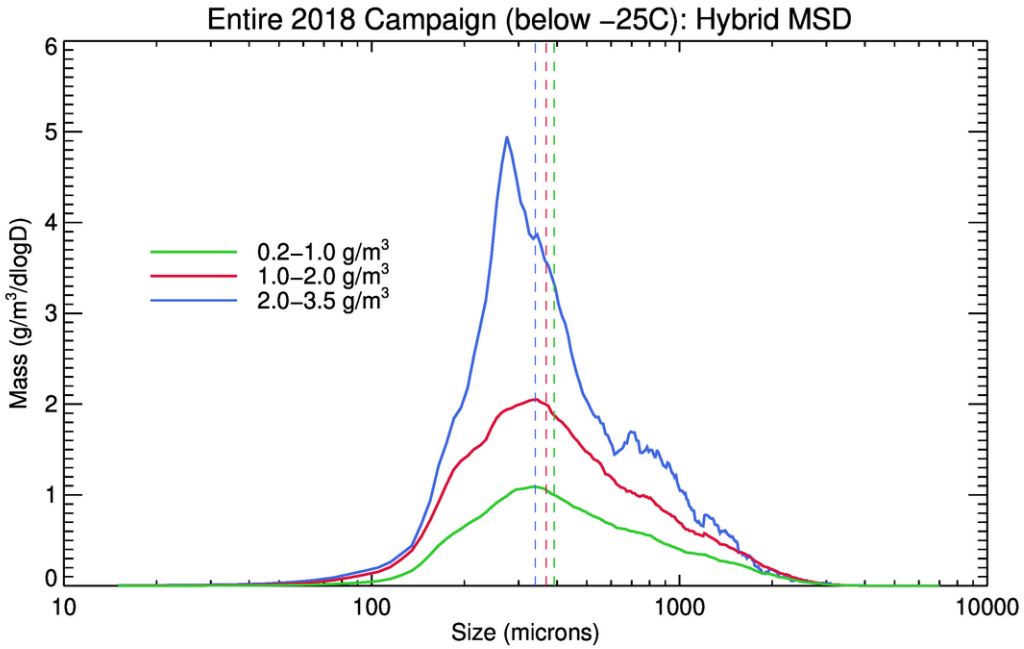


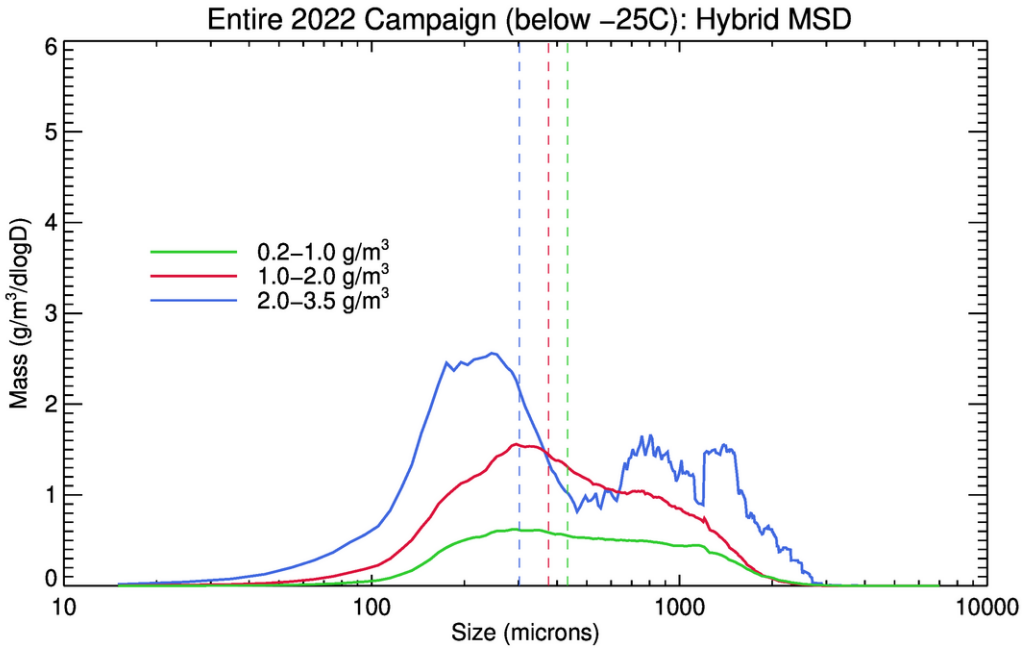
Average area ratio as function of size for the 2018 (left) and 2022 (right) campaigns. The data are stratified in low, medium, and high IWC as measured by the IKP-2. The 2015 results are similar to 2018 and are omitted here.



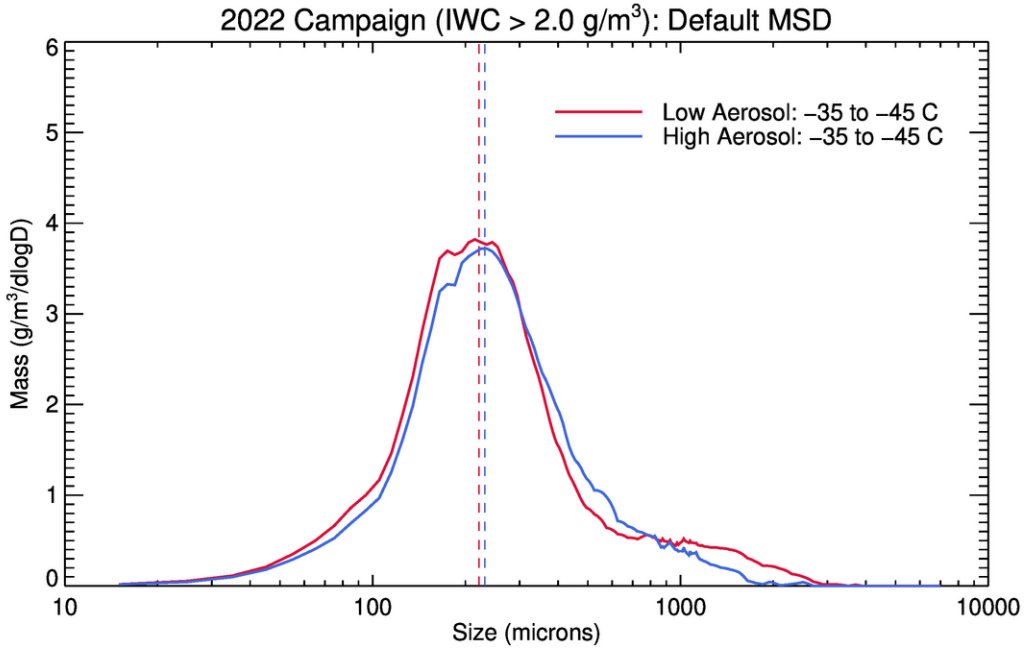


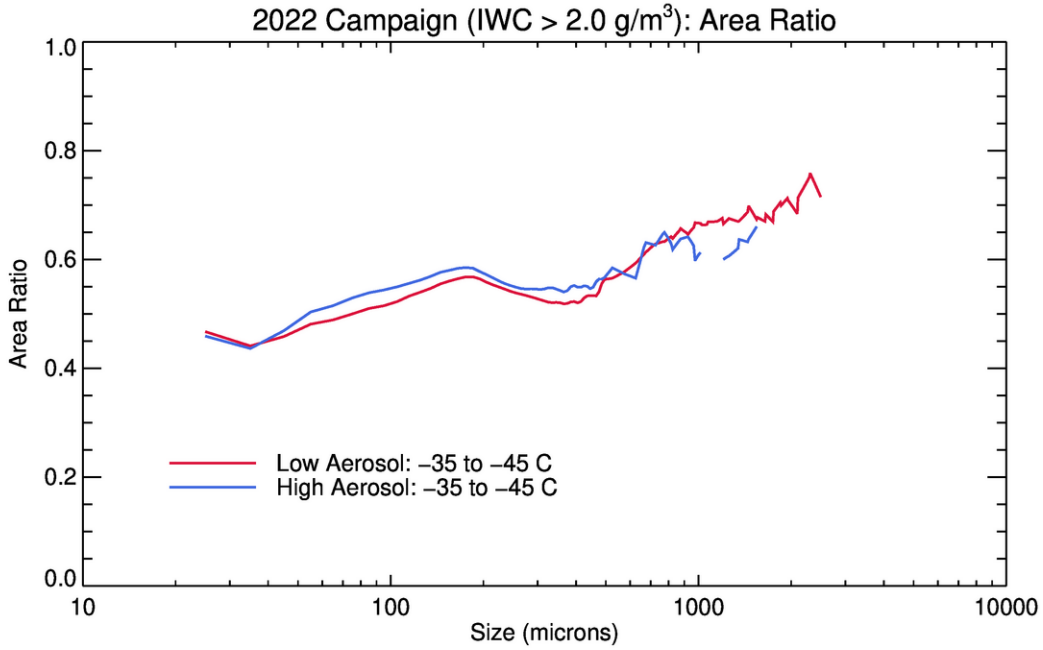
MSDs from 2018 and 2022 as a function of temperature using the standard ice-graupel mass size parameterization.





MSDs from 2018 and 2022 as a function of temperature using a hybrid ice-graupel mass size parameterization.

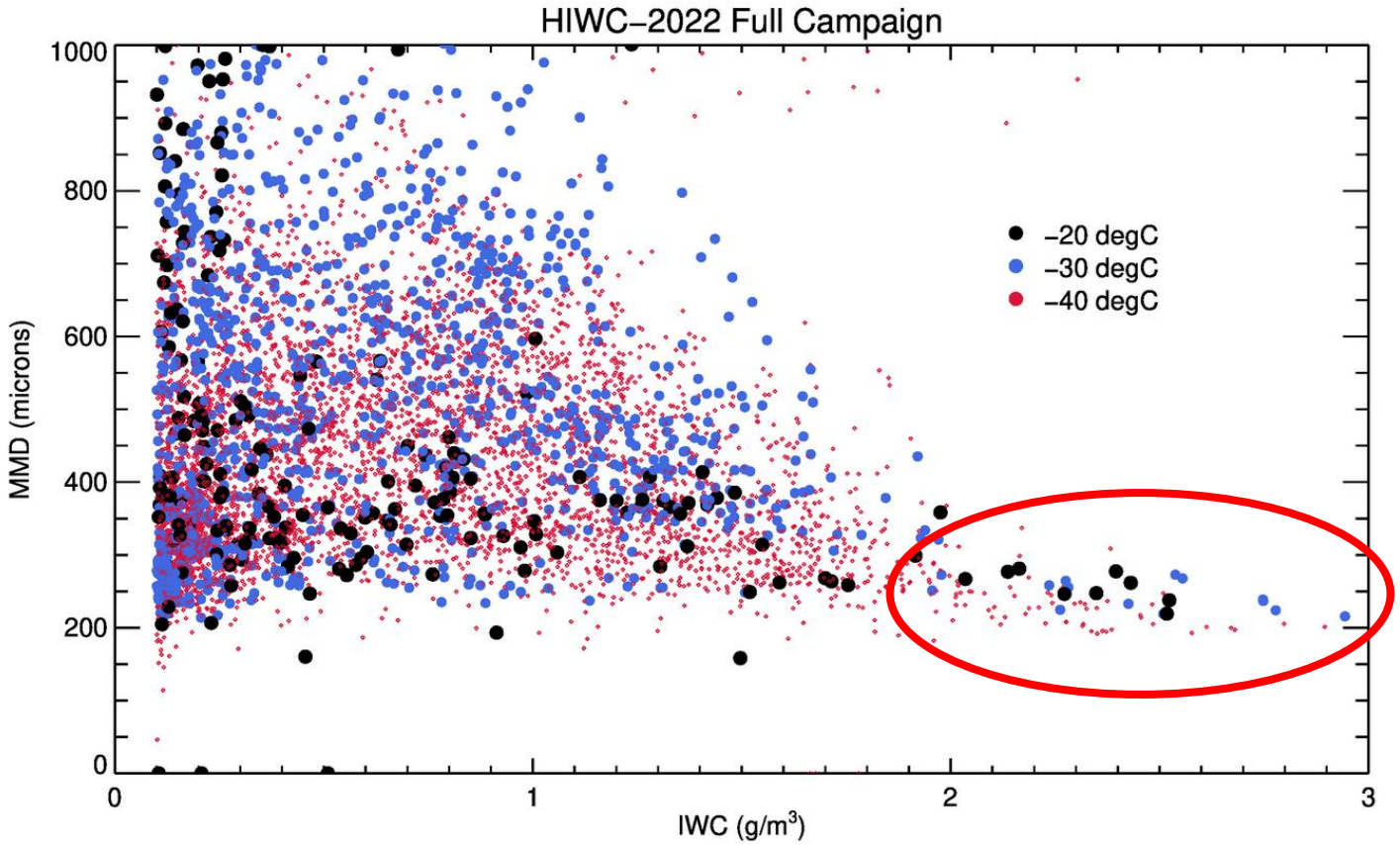




MSDs and area ratio distributions from the 2022 campaign under low aerosol boundary-layer conditions (red) and higher aerosol boundary-layer conditions (blue). Data here are limited to cloud passes where the IKP-2 measured a condensed water content of at least 2.0 g/m3.

Median Mass Diameter (MMD)

- Typical application of snow-based mass-size distribution leads to low MMD in HIWC conditions
- MMD will increase if graupel density is considered, especially in the highest IWC regions



Summary

- Graupel was present in most HIWC could penetrations with IWC above 2 g/m^3
- Current HIWC mass-size parameterization does not take the density of graupel into account, misattributing its mass to small particles
- Using a hybrid parameterization reveals bimodal MSDs in most HIWC clouds