Airborne Observations of Particle Density in High Ice Water Content (HIWC) Cloud Systems

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BACKGROUND

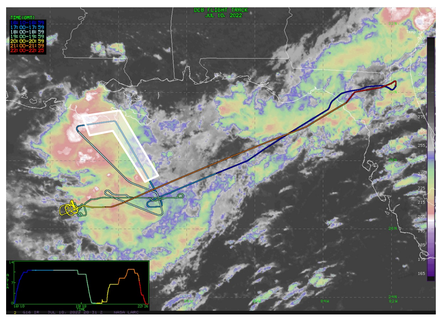
A series of airborne field campaigns has been conducted since 2014 to measure the microphysical properties of high ice-water content (HIWC) clouds in marine mesoscale convective systems (MCS) and tropical storms. In-situ cloud observations from these campaigns confirmed previous observations that high concentrations of **small ice particles** exist in areas of HIWC. However, in the most recent campaign, the majority of HIWC clouds also contained significant amounts of **graupel** and/or **frozen drops** in marine convection.

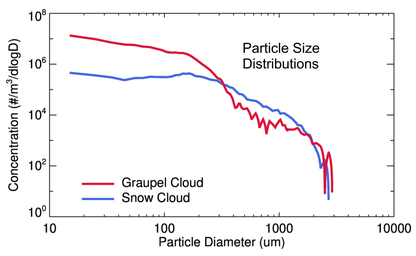
Using a hybrid mass-size parameterization that accounts for both small ice and larger high-density particles, we find:

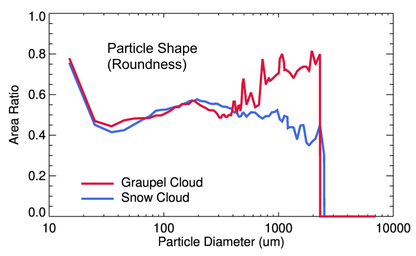
- The mass distributions in cloud regions above 2.0 g/m^3 are often strongly bimodal
- The small particle mode contains roughly half of the collective cloud mass, and the graupel mode contains the other half
- High IWC cloud passes in a tropical cyclone contain less relative graupel mass than the observed MCS cloud systems

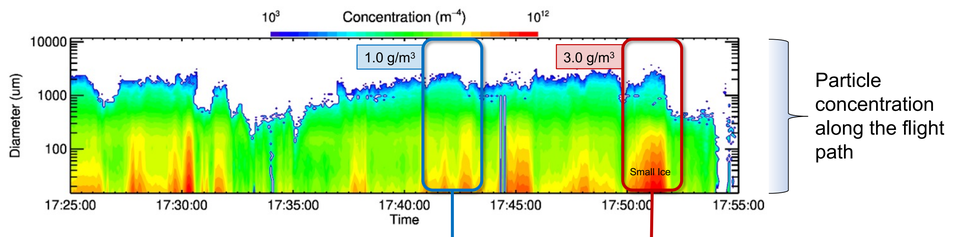
EXAMPLE CASE

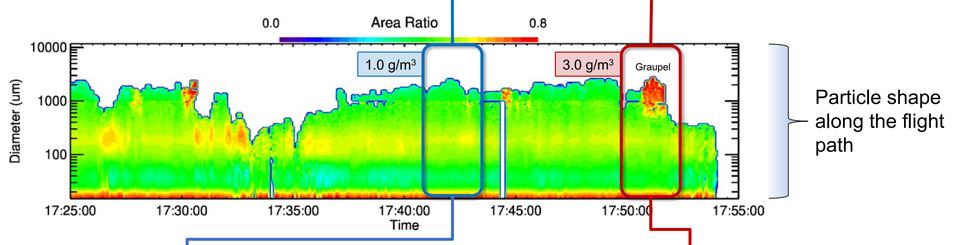
Gulf of Mexico MCS 10-July-2022

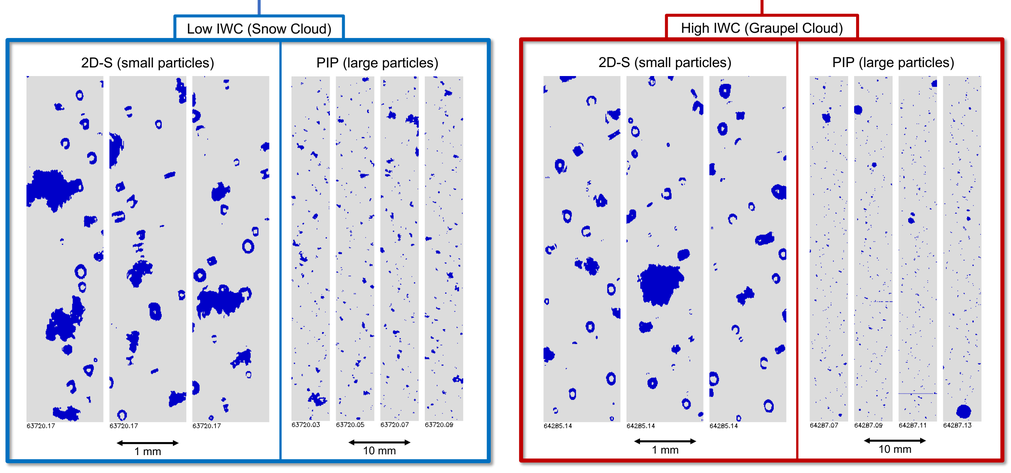






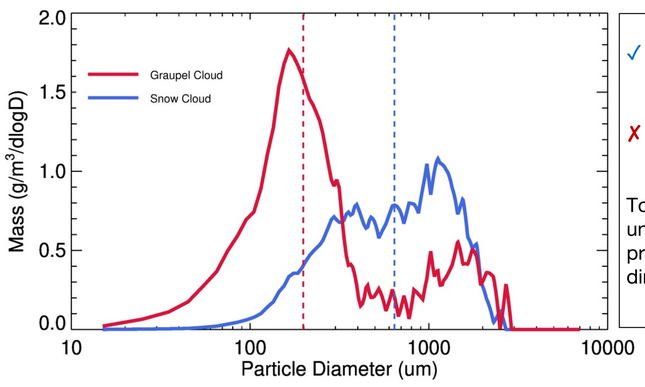






RESULTS

Mass Distribution derived with single (snow) parameterization:

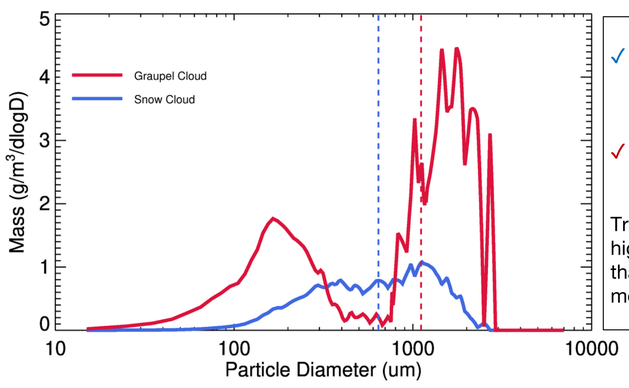


✓ Computed IWC = 0.8 g/m^3
Direct measure = 1.0 g/m3

✗ Computed IWC= 1.2 g/m^3
Direct Measure = 3.0 g/m3

Total mass is significantly underestimated when graupel is present in the cloud, compared to direct measurement by IKP-2

Mass Distribution with hybrid (snow + graupel) parameterization:



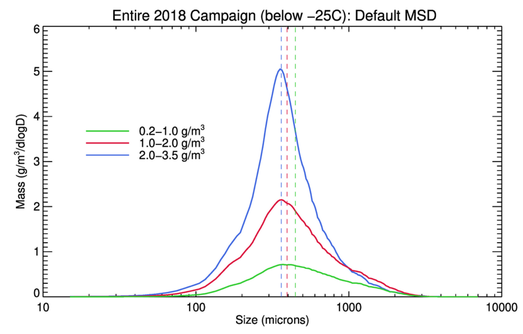
✓ Computed IWC = 0.8 g/m^3
Direct measure = 1.0 g/m3

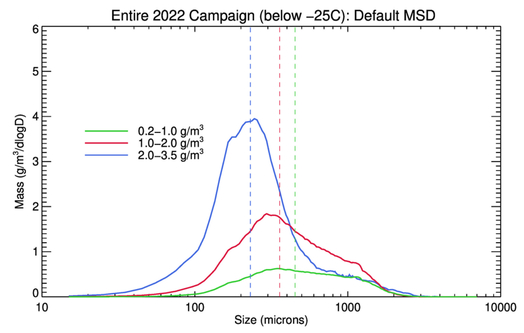
✓ Computed IWC= 2.5 g/m^3
Direct Measure = 3.0 g/m3

Treating the graupel particles with a higher density results in a total mass that is close to the independently measured value

Mass Distributions from entire 2018/2022 projects (simple parameterization):

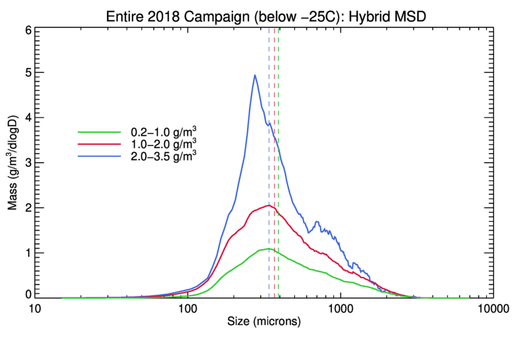
- 2018 HIWC campaign on left panel, mix of marine MCS and tropical storm convection
- 2022 HIWC campaign on right panel, vigorous marine MCS convection

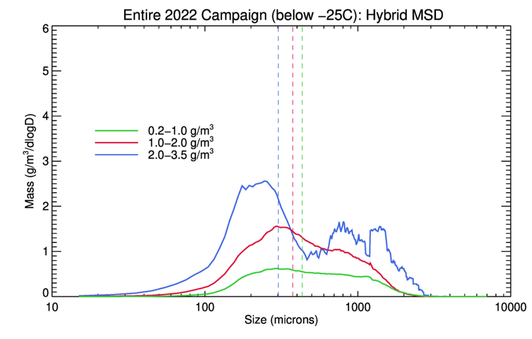




Mass Distribution from entire 2018/2022 projects (hybrid parameterization):

- Bimodal mass distributions in the 2022 campaign, especially in HIWC clouds above 2.0 g/m^3
- Median mass diameter fails to capture bimodal shape of distributions





ACKNOWLEDGMENTS

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