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Defining Characteristic Cloud Drop Spectra From In-situ Measurements

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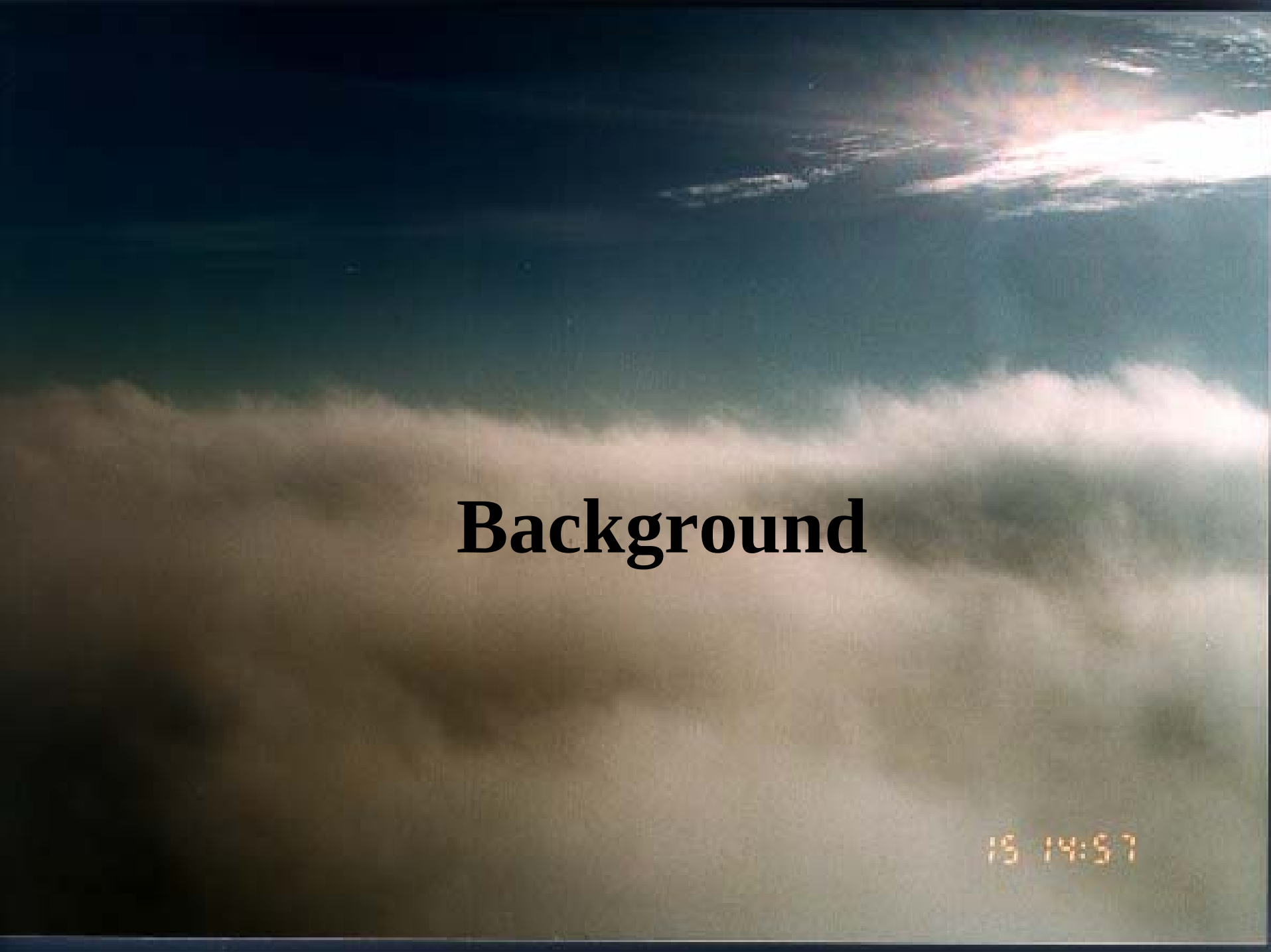
Outline

- Background
- Microphysics Conditions
- Average Drop Spectra
- Characteristic Drop Spectra



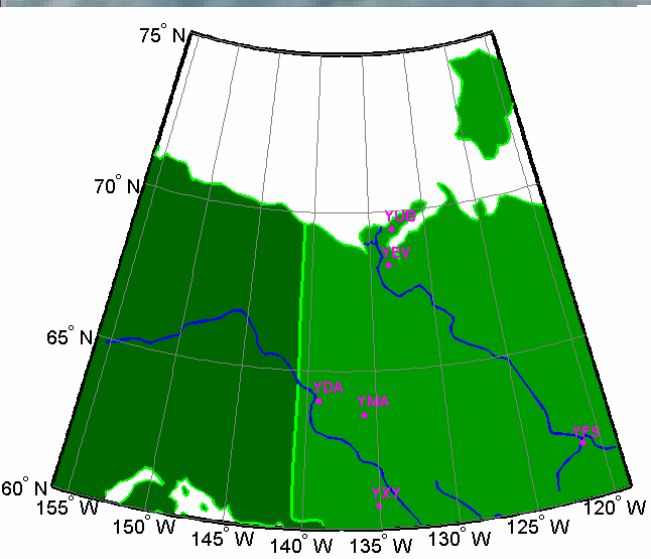
Background

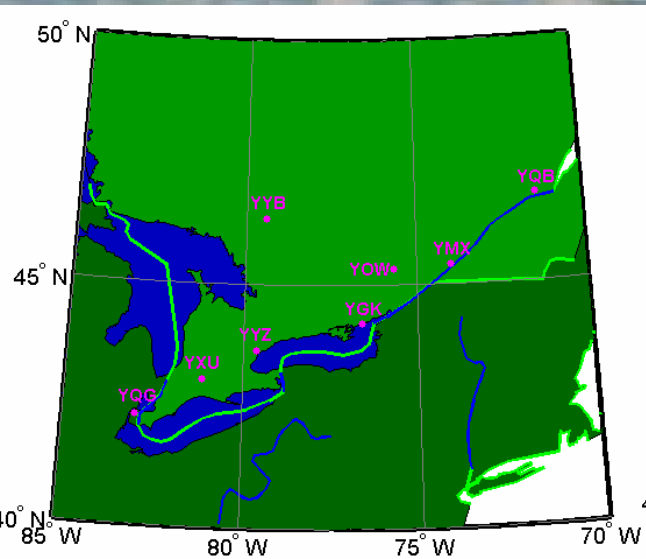
Motivation

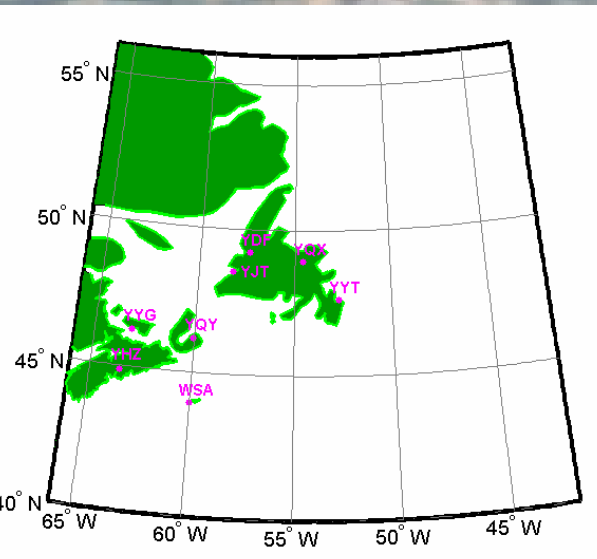
To use natural drop spectra to determine characteristic spectra that encompass a wide range of natural conditions. These spectra could be used for wind tunnel, icing tanker, numerical icing simulation and other applications.

Field Projects Used For This Analysis

• CFDE I	27 Feb 1995 - 24 Mar 1995	48 Hours
• CFDE III	10 Dec1997 -18 Feb 1998	106 Hours
• FIRE.ACE	01 Apr 1998 - 29 Apr 1998	74 Hours
• AIRS	02 Dec 1999 -19 Feb 2000	95 Hours
• AIRS TO	02 Dec 1999 -17 Dec 1999	24 Hours
• Total	97 Flights	347 Hours







Research Aircraft

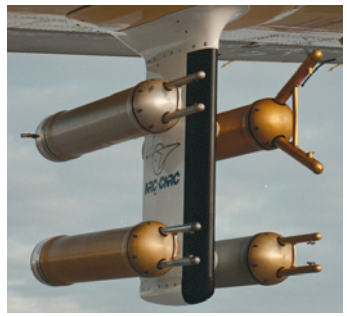
NRC

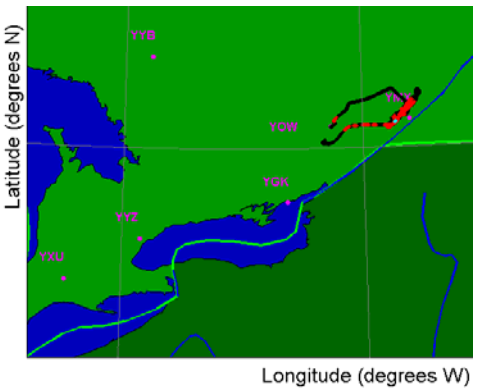
Convair-580

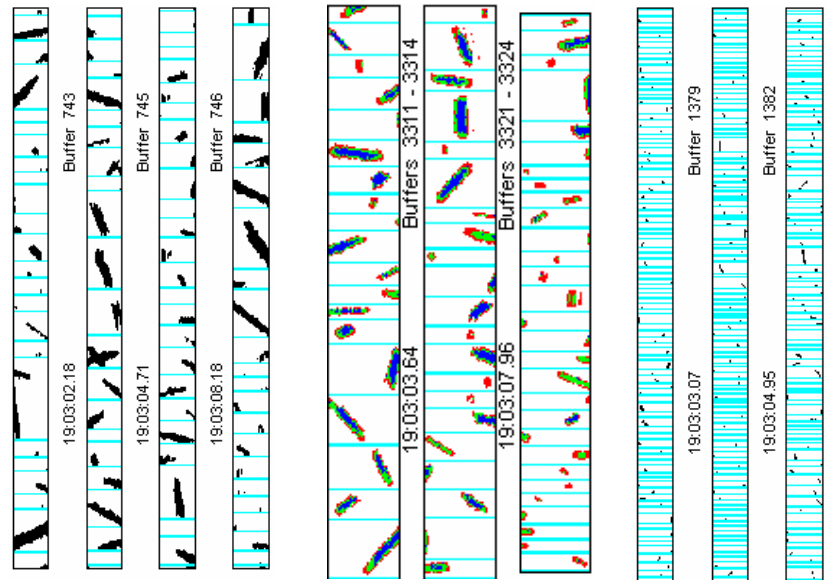
NASA-Glenn

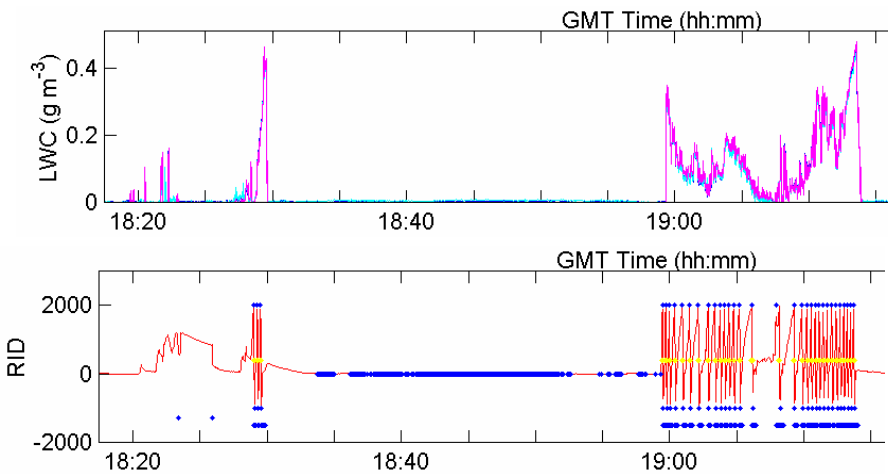
Twin Otter

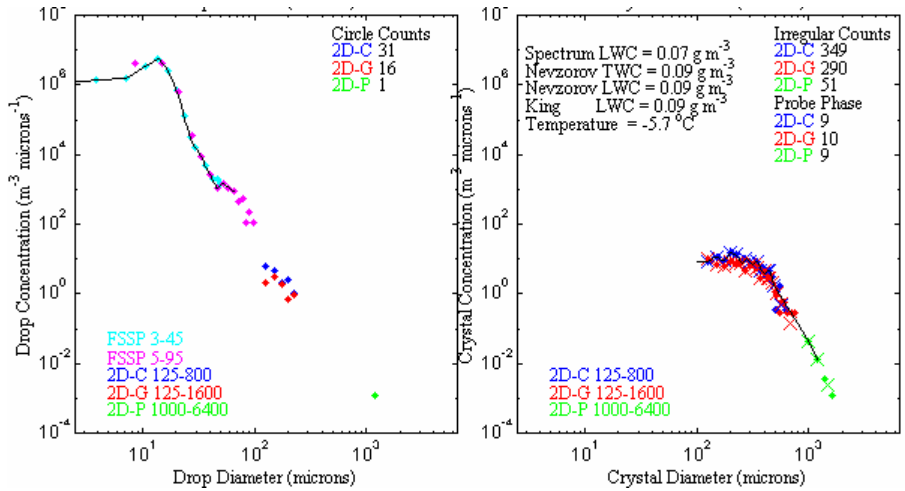
In-situ Measurements









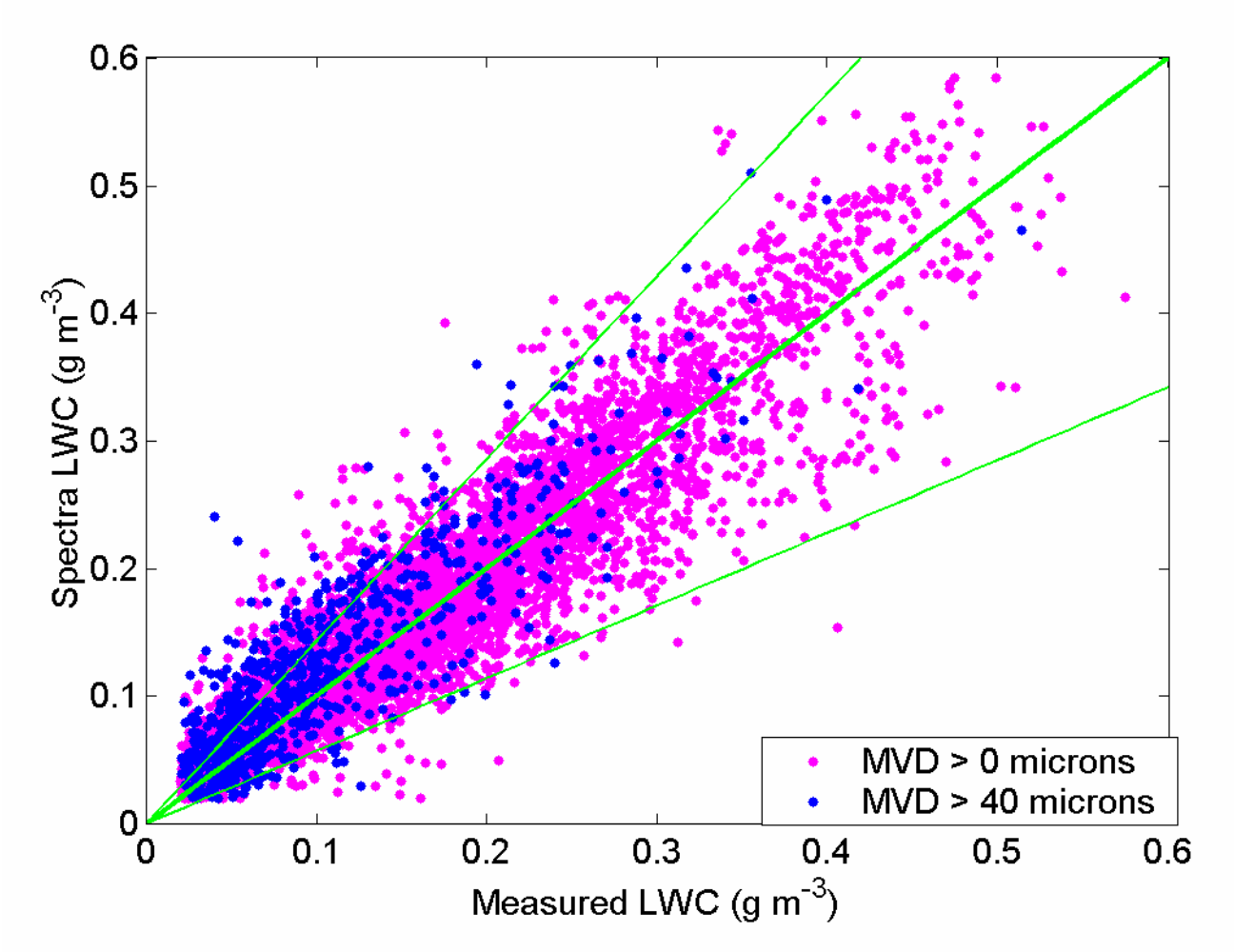


Microphysics Conditions

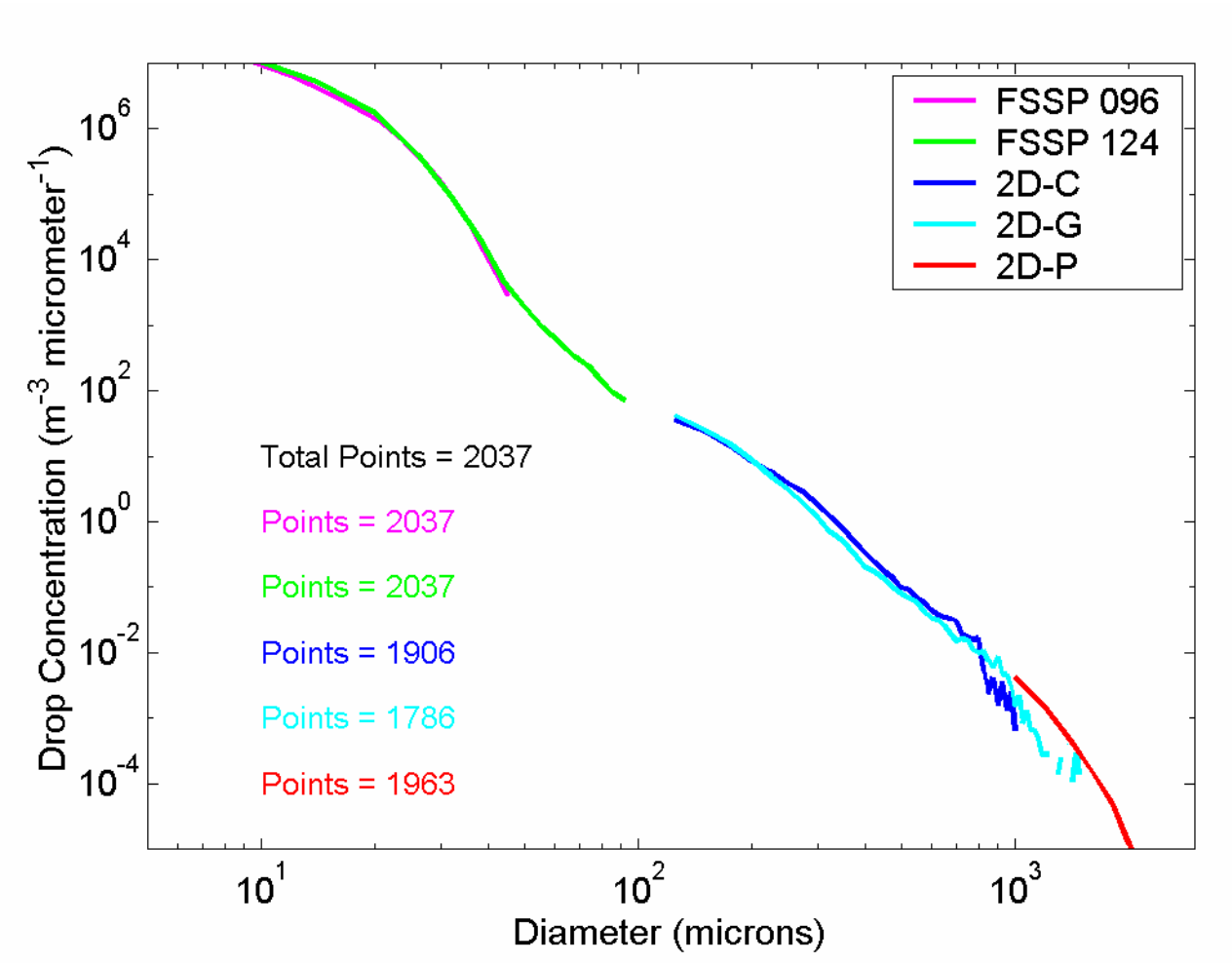
Data Point Summary

Definition	30-s Points	Characteristics
In-Flight	40278	
In-Cloud	13270 (33%)	TWC > 0.005 g m^{-3}
In-Cloud Cold	11986 (30%)	+ Ta ≤ 0°C
In-Icing	9550 (24%)	+ L/M Phase
In-Spectra	6628 (16%)	+ Ice ≤1 L^{-1}
In-SLD	2585 (6%)	+ Dmax ≥ 50 μm

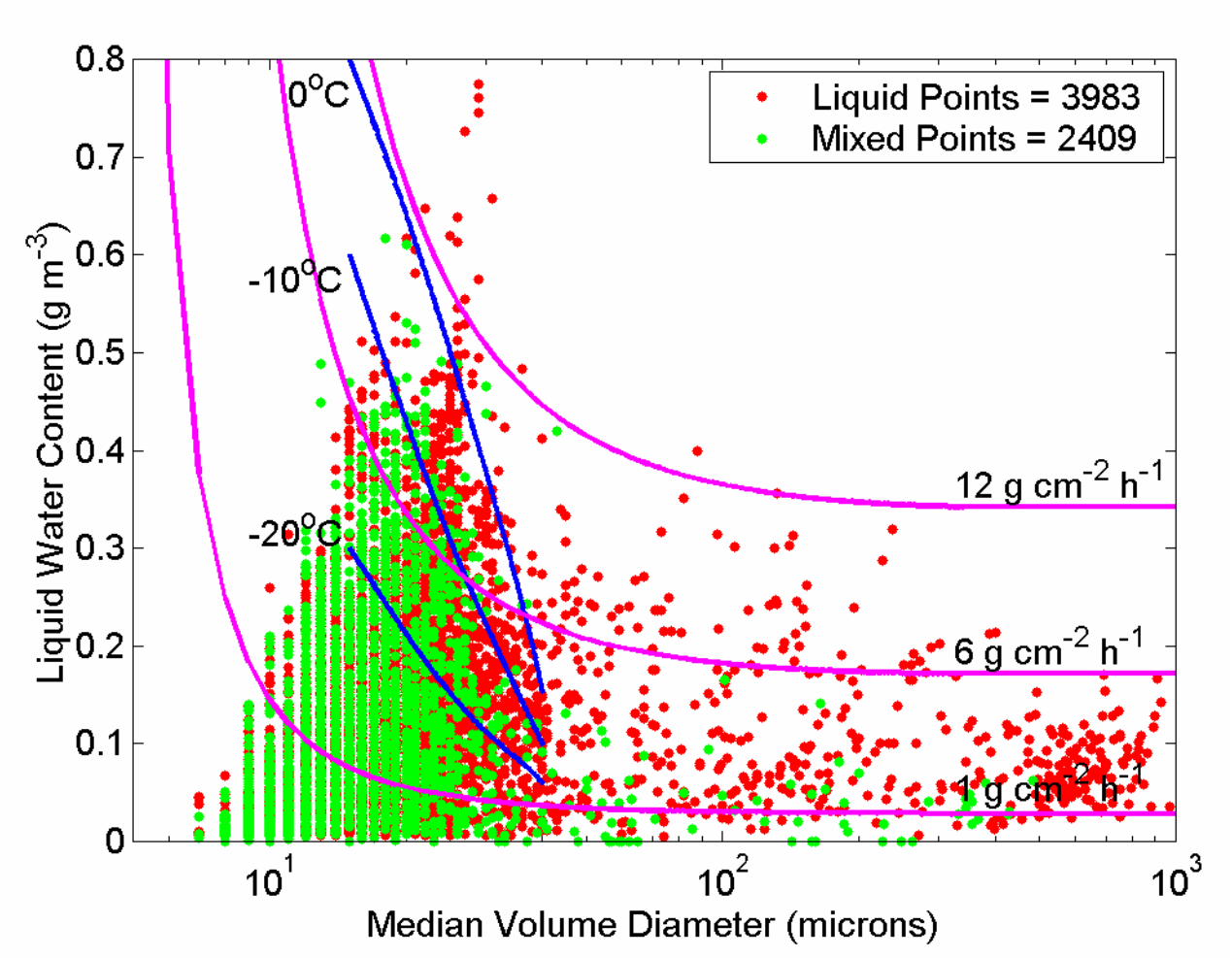
Assessment of Spectra Measurements



Comparison of Individual Probes

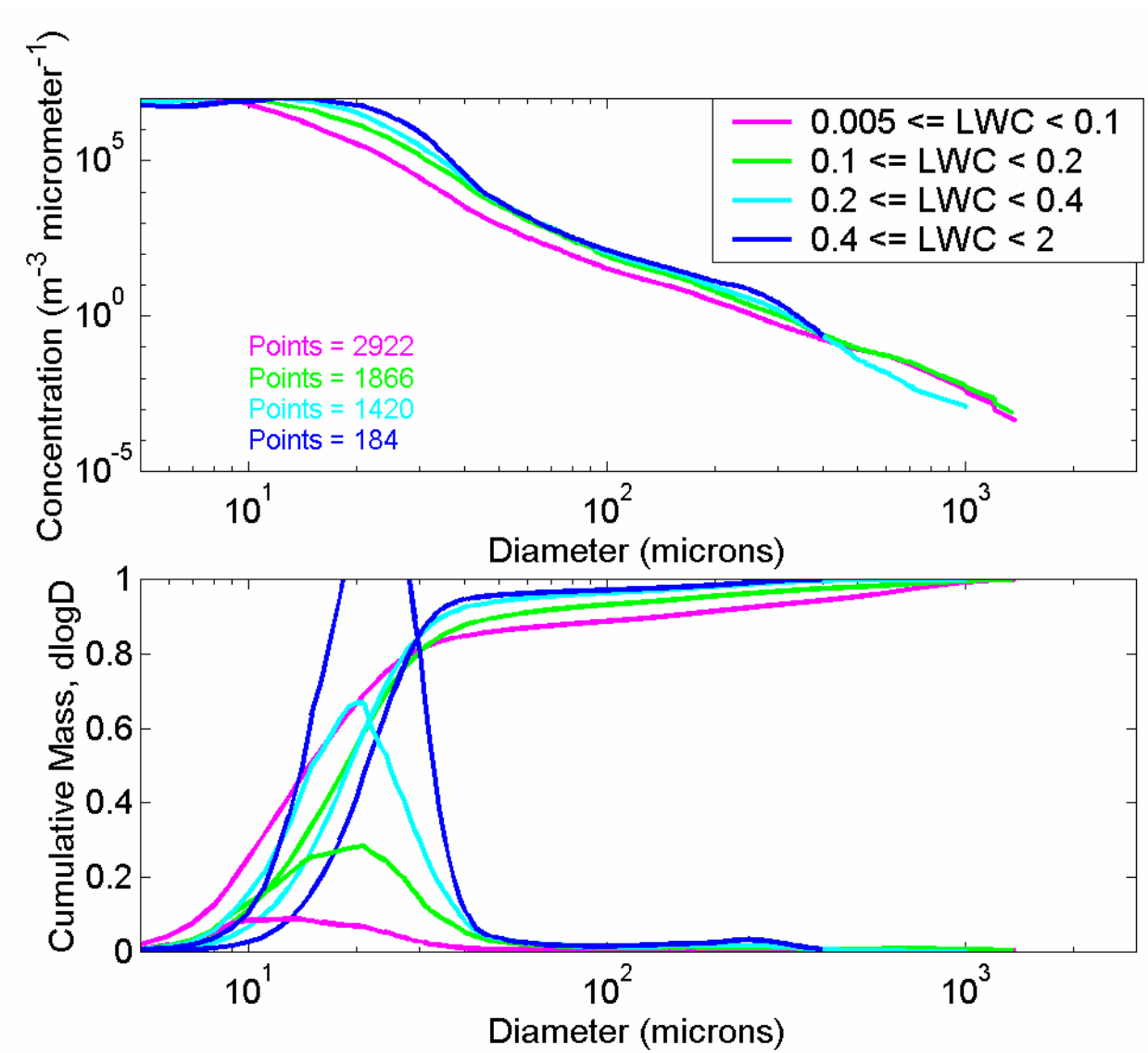


Comparison to Icing Envelopes

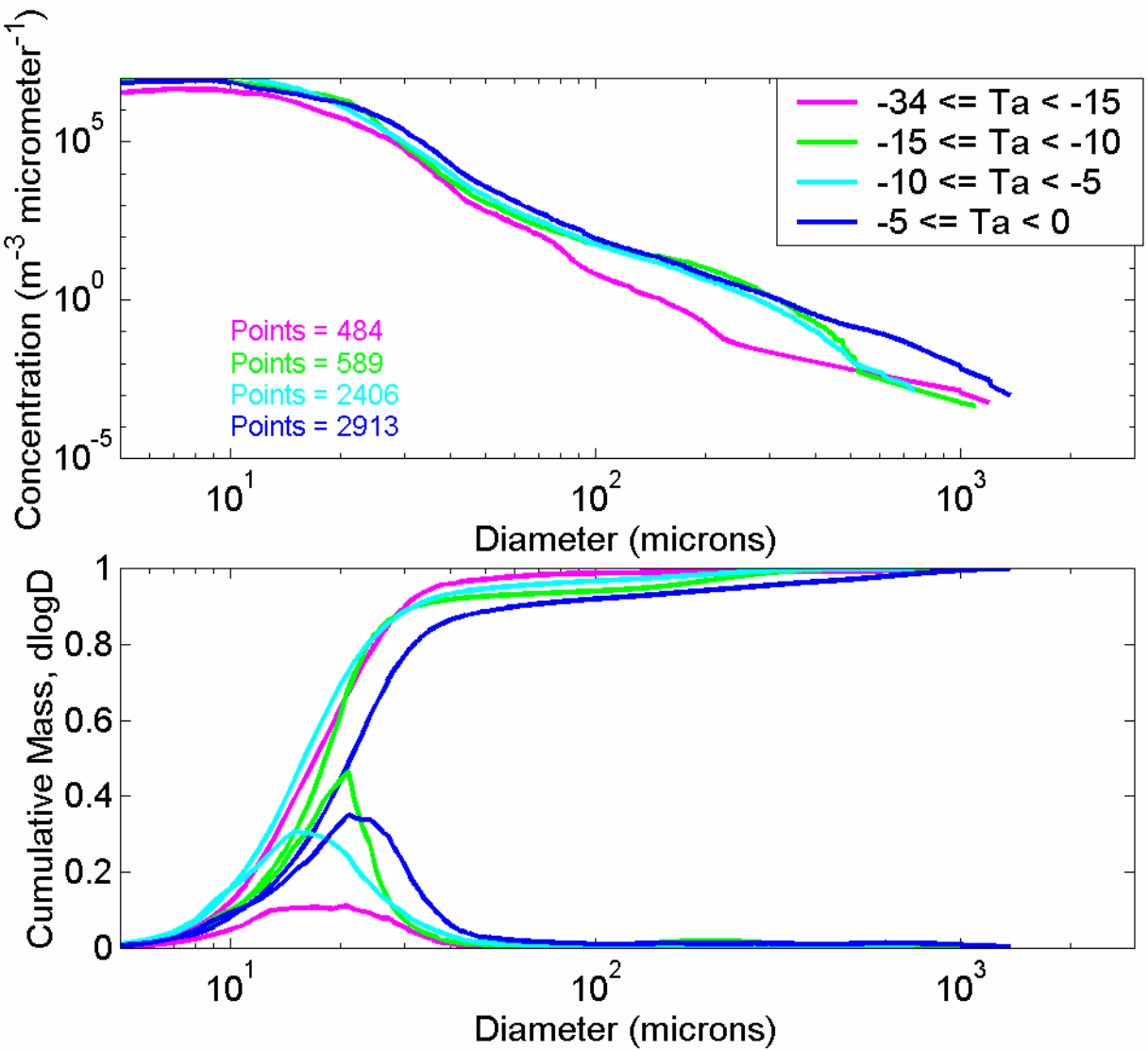


Average Drop Spectra

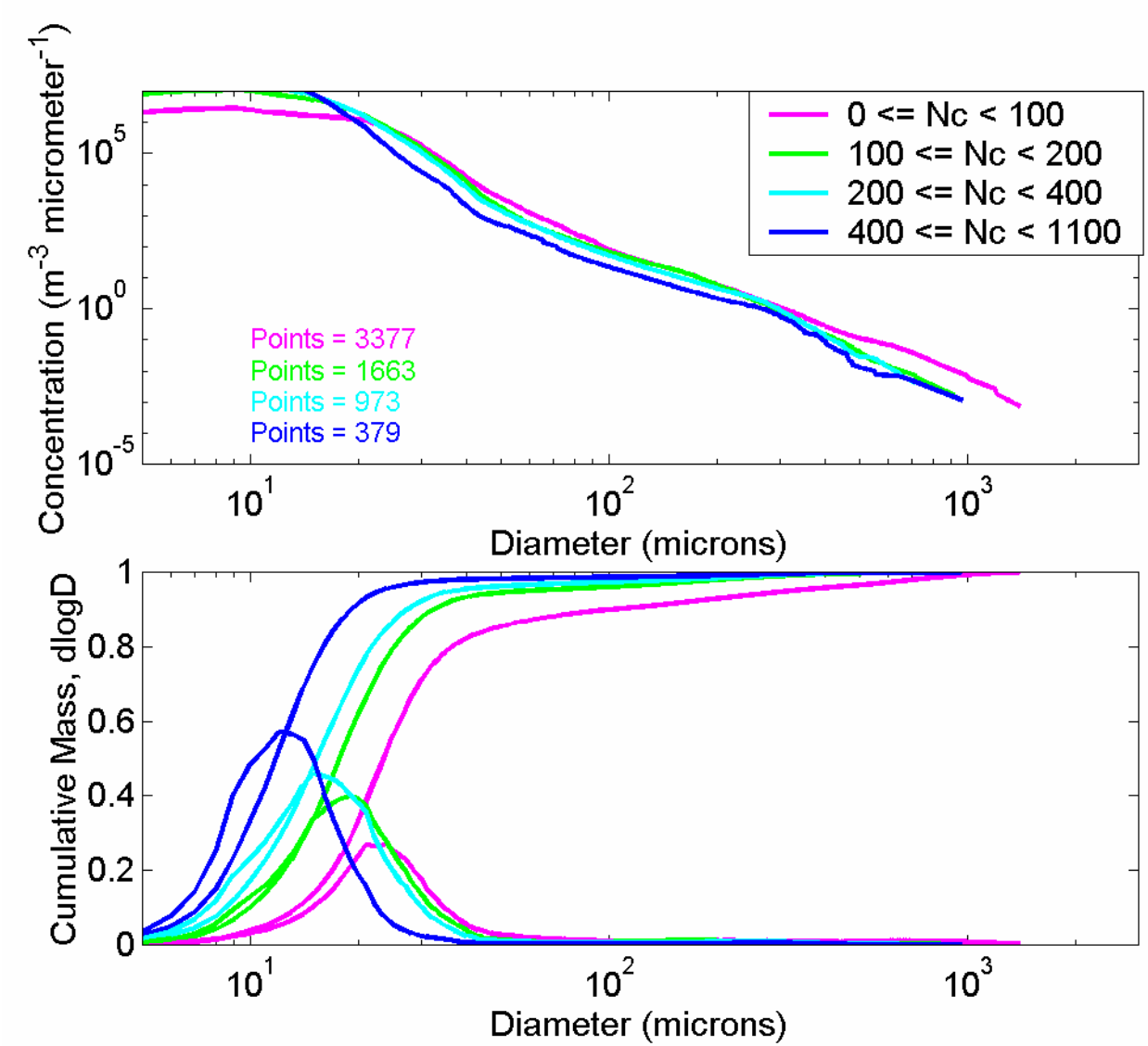
Spectra Variation With LWC



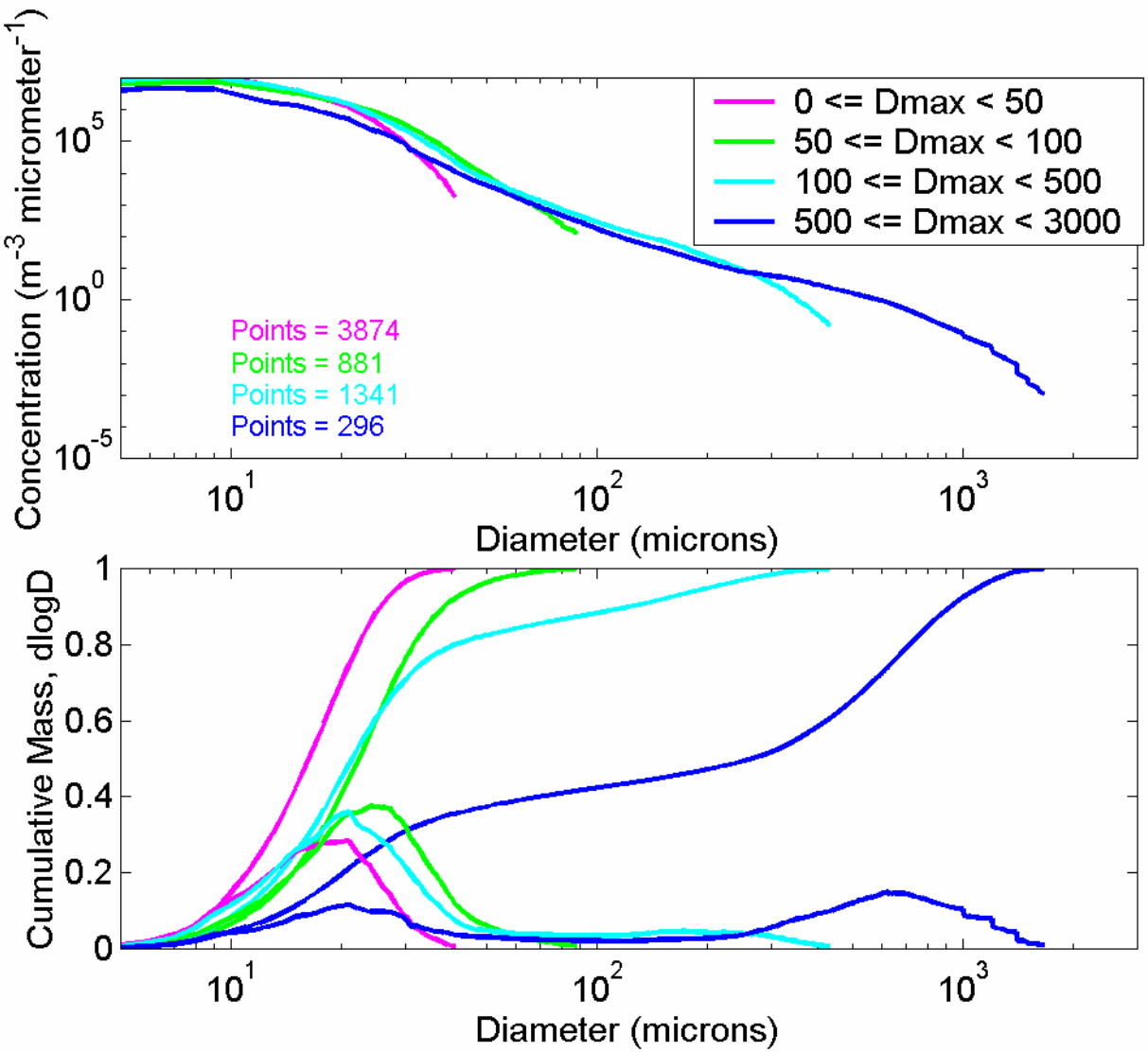
Spectra Variation With Temperature



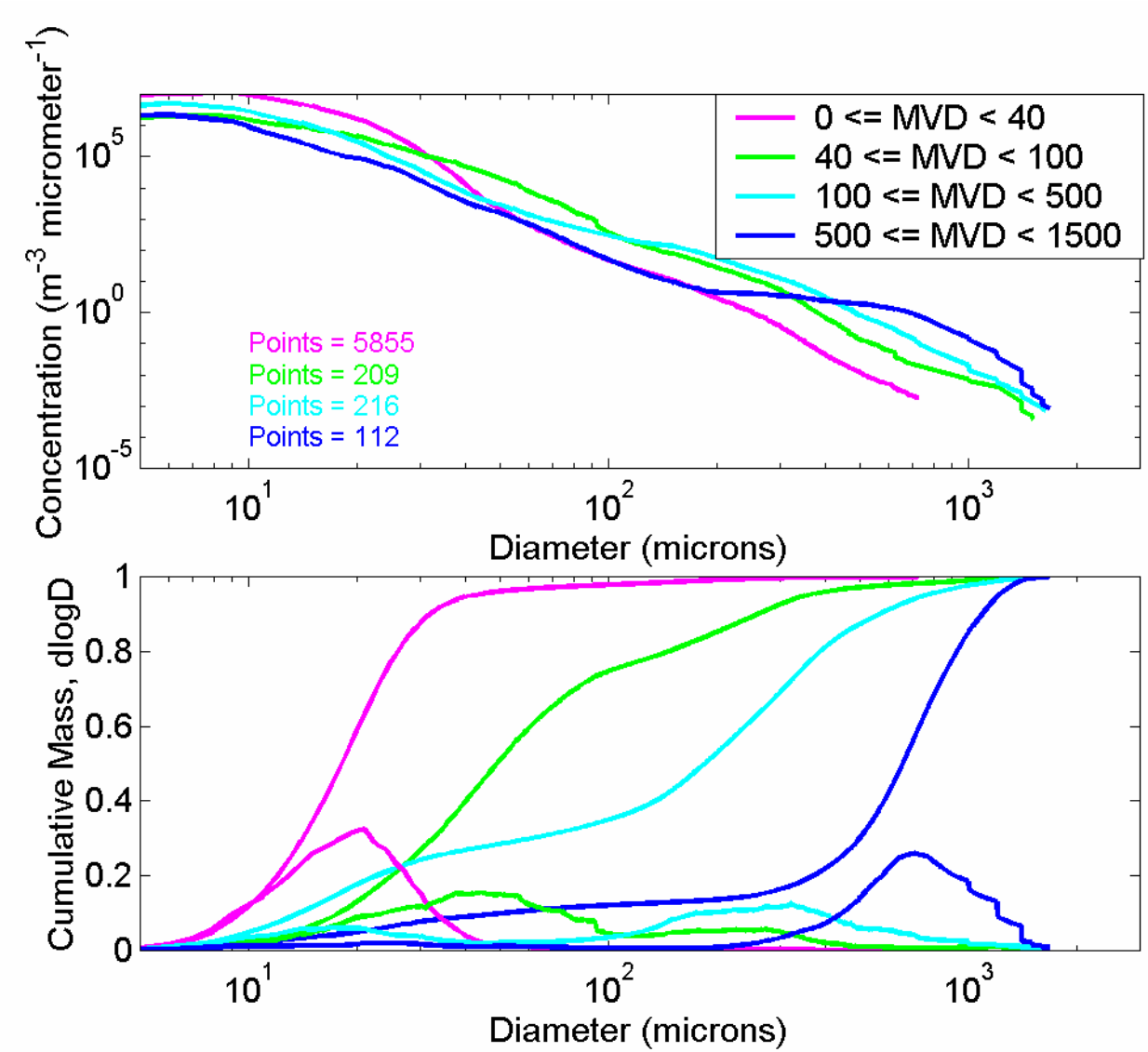
Spectra Variation With Concentration



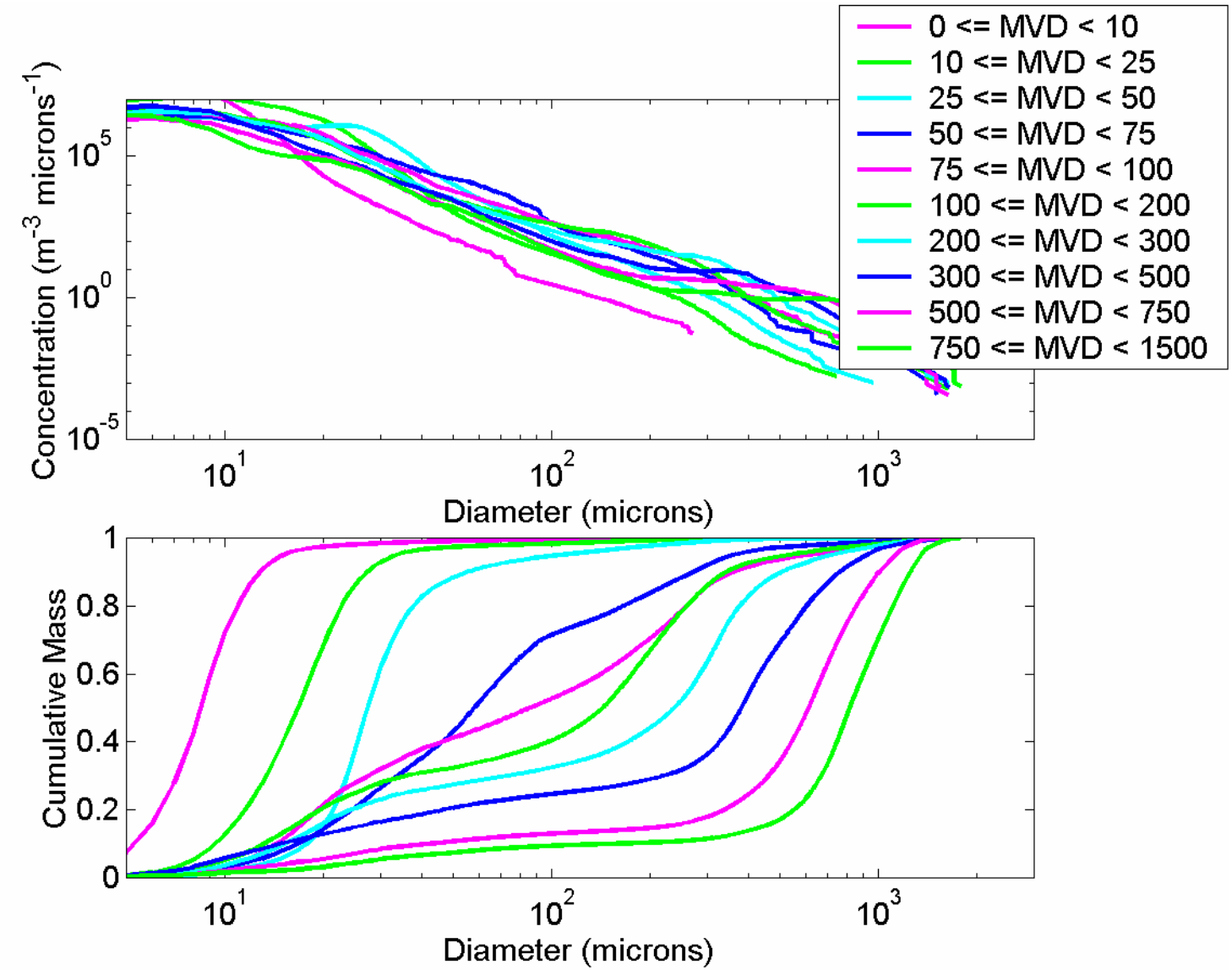
Spectra Variation With Dmax



Spectra Variation With MVD



Fine Scale Variation With MVD

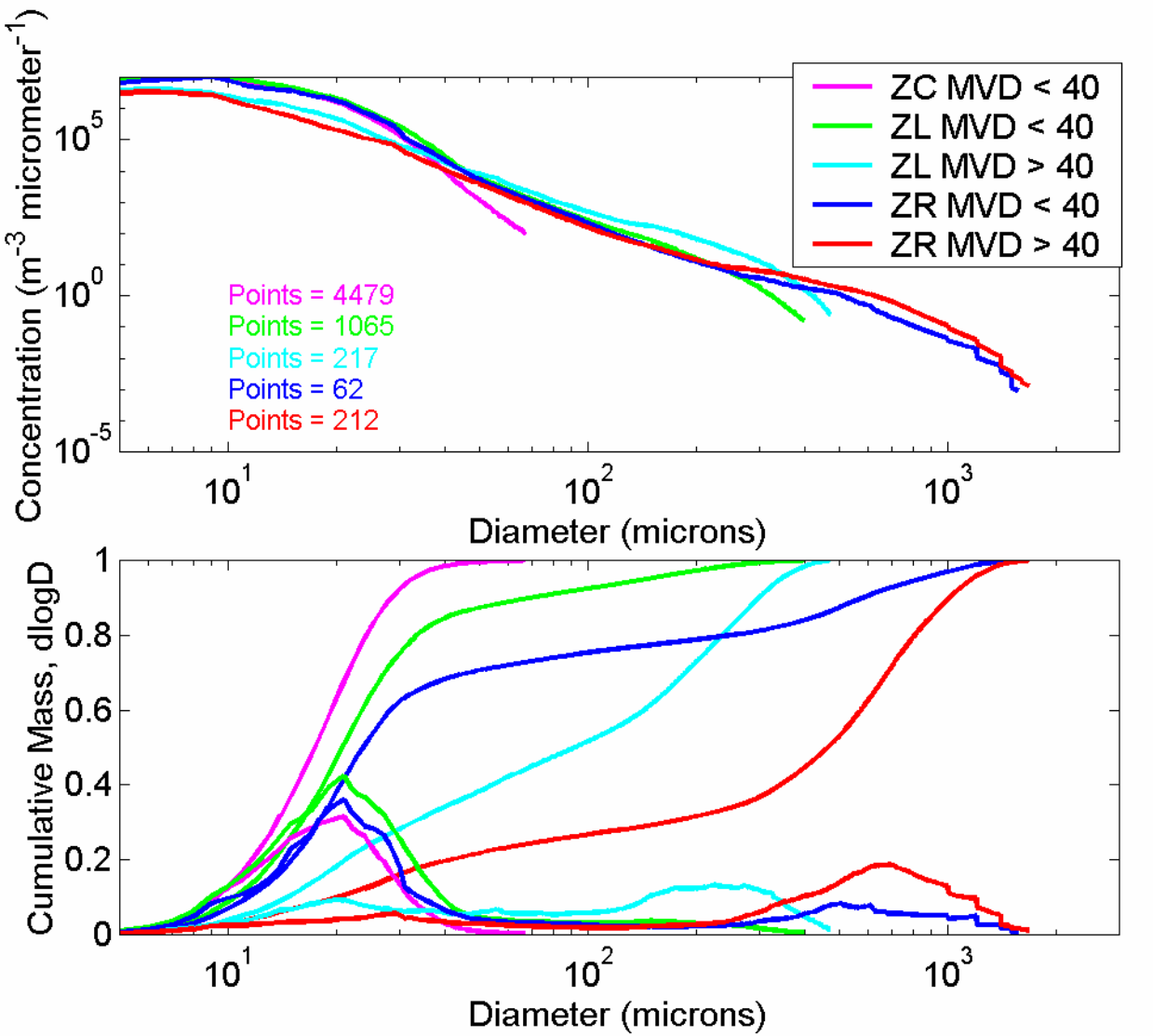


Characteristic Drop Spectra

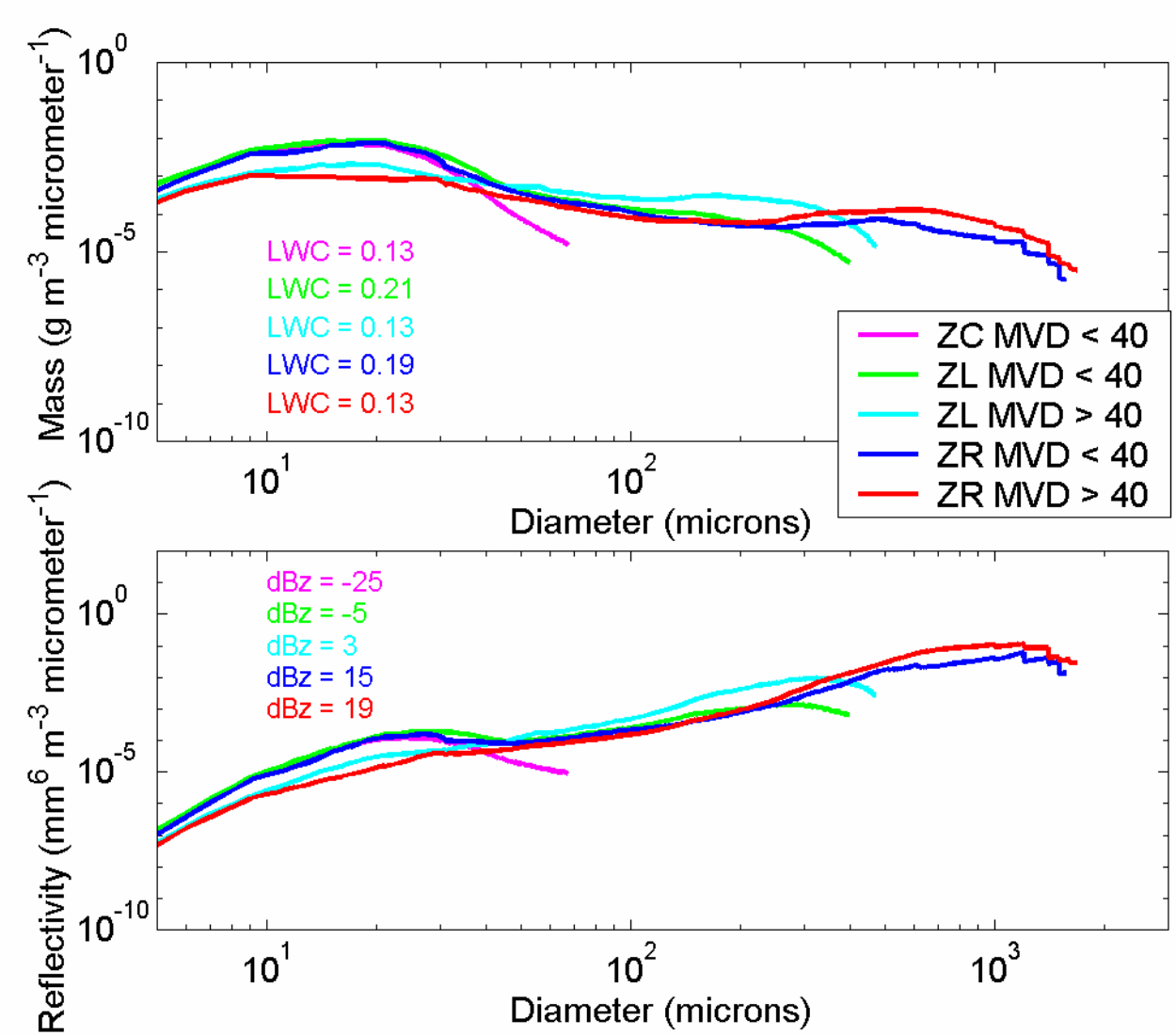
Subsets of the Data

Definition	30-s Points	MVD	Dmax
ZC	4479 (74%)	< 40 μm	< 100 μm
ZL-In	1065 (18%)	< 40 μm	100-500 μm
ZL-Out	217 (4%)	> 40 μm	100-500 μm
ZR-In	62 (1%)	< 40 μm	> 500 μm
ZR-Out	212 (4%)	> 40 μm	> 500 μm

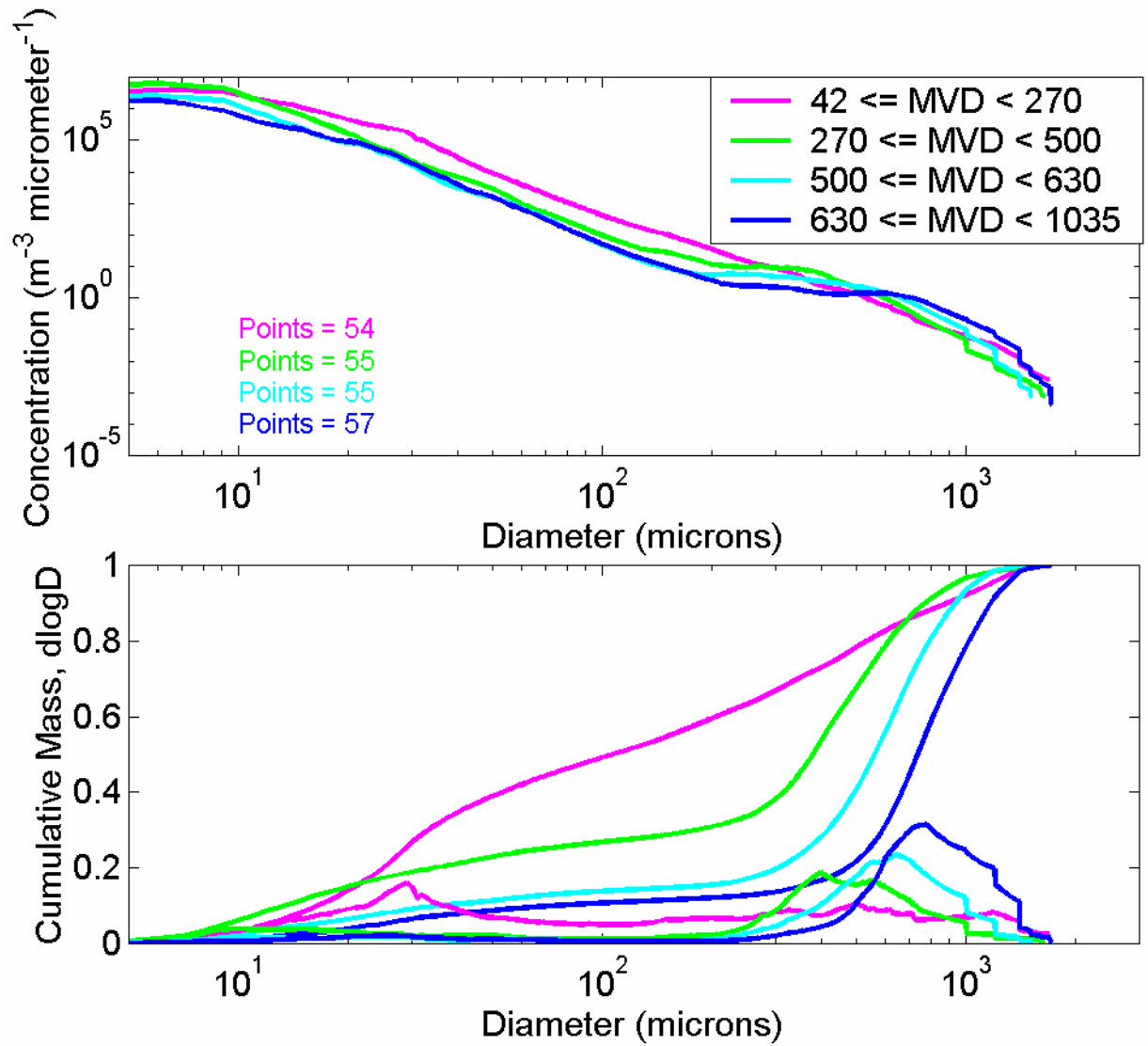
Characteristic Drop Concentration Spectra



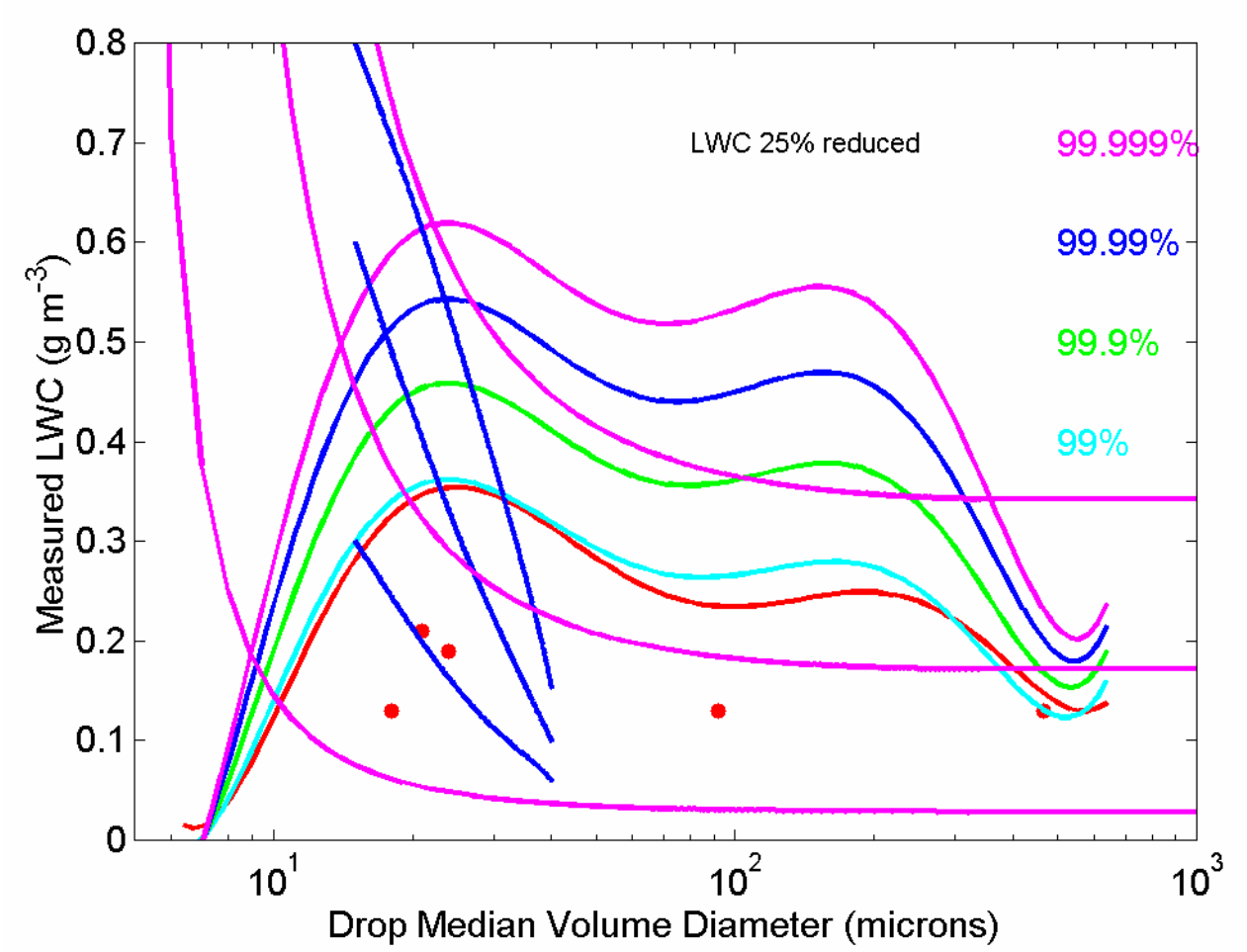
Characteristic Drop Mass Spectra



ZR-Out Variation With MVD



Scaling to Extreme LWC-MVD Conditions

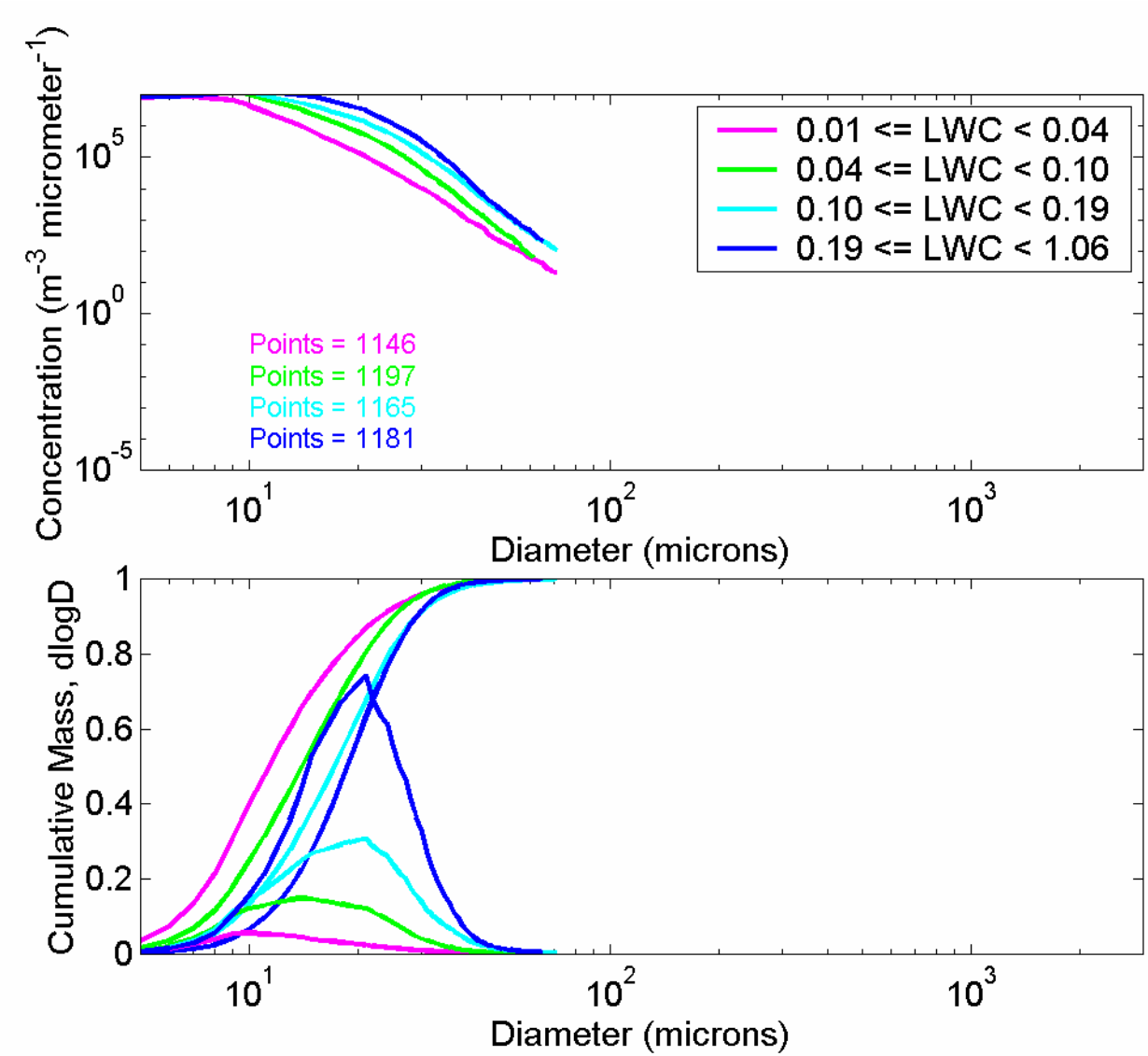


Conclusions

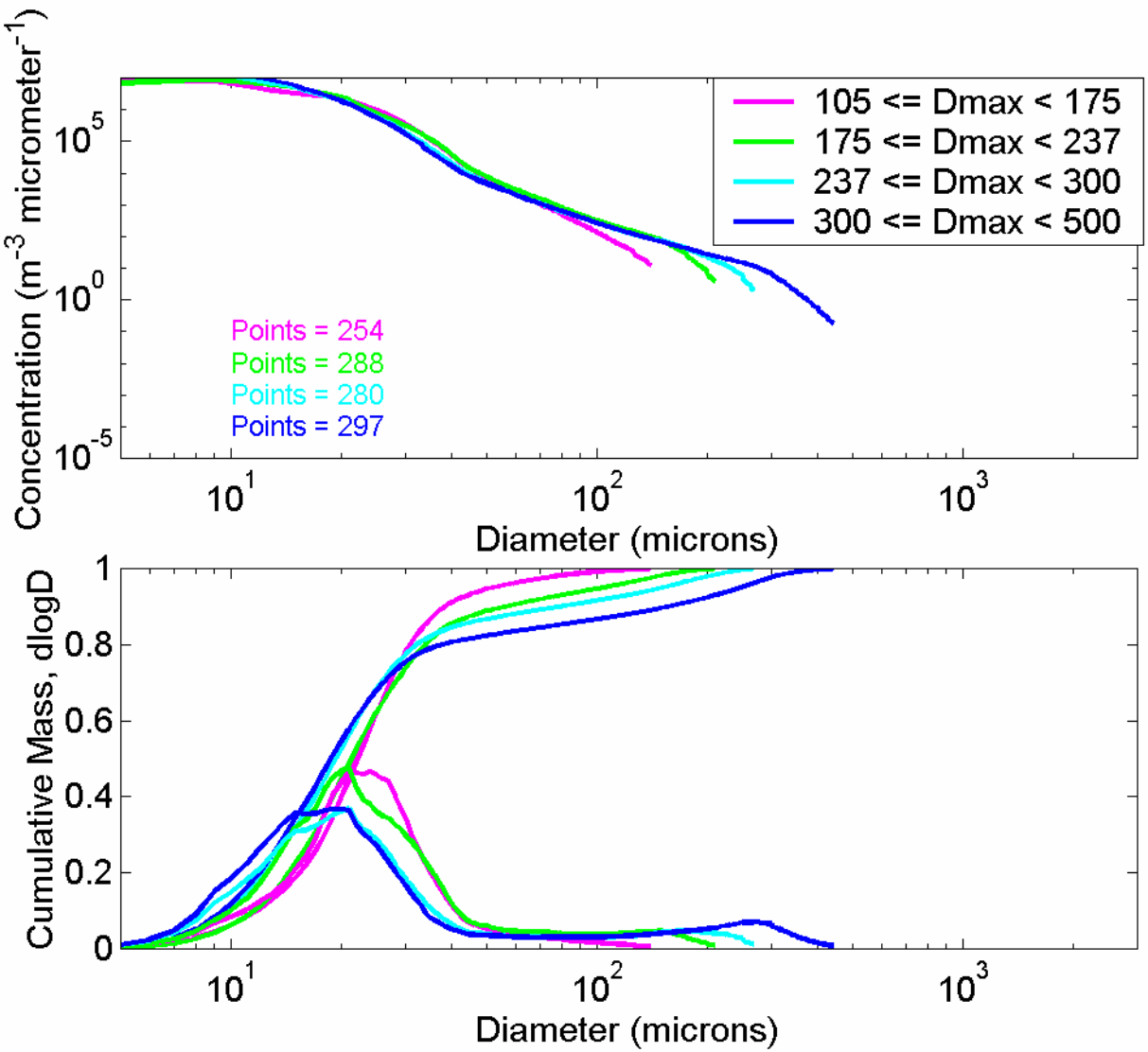
1. Drop spectra were determined for 6628 icing conditions in winter stratiform clouds in northern latitudes. Each drop spectrum was assessed from 1 μm to the maximum drop diameter observed.
2. Average drop spectra were determined. Spectra with SLD were bi-modal in nature. The shapes of the average spectra were highly dependent on MVD and Dmax and slightly dependent on LWC, temperature and droplet concentration.
3. Five characteristic spectra were determined, following Shah et al. (2000), by segregating the data with MVD and Dmax thresholds. These spectra incorporate the majority of observed natural conditions and can be scaled to represent extreme LWC conditions. They could be used in numerical icing simulation studies, or serve as a standard for wind tunnel and tanker experiments.

Questions?

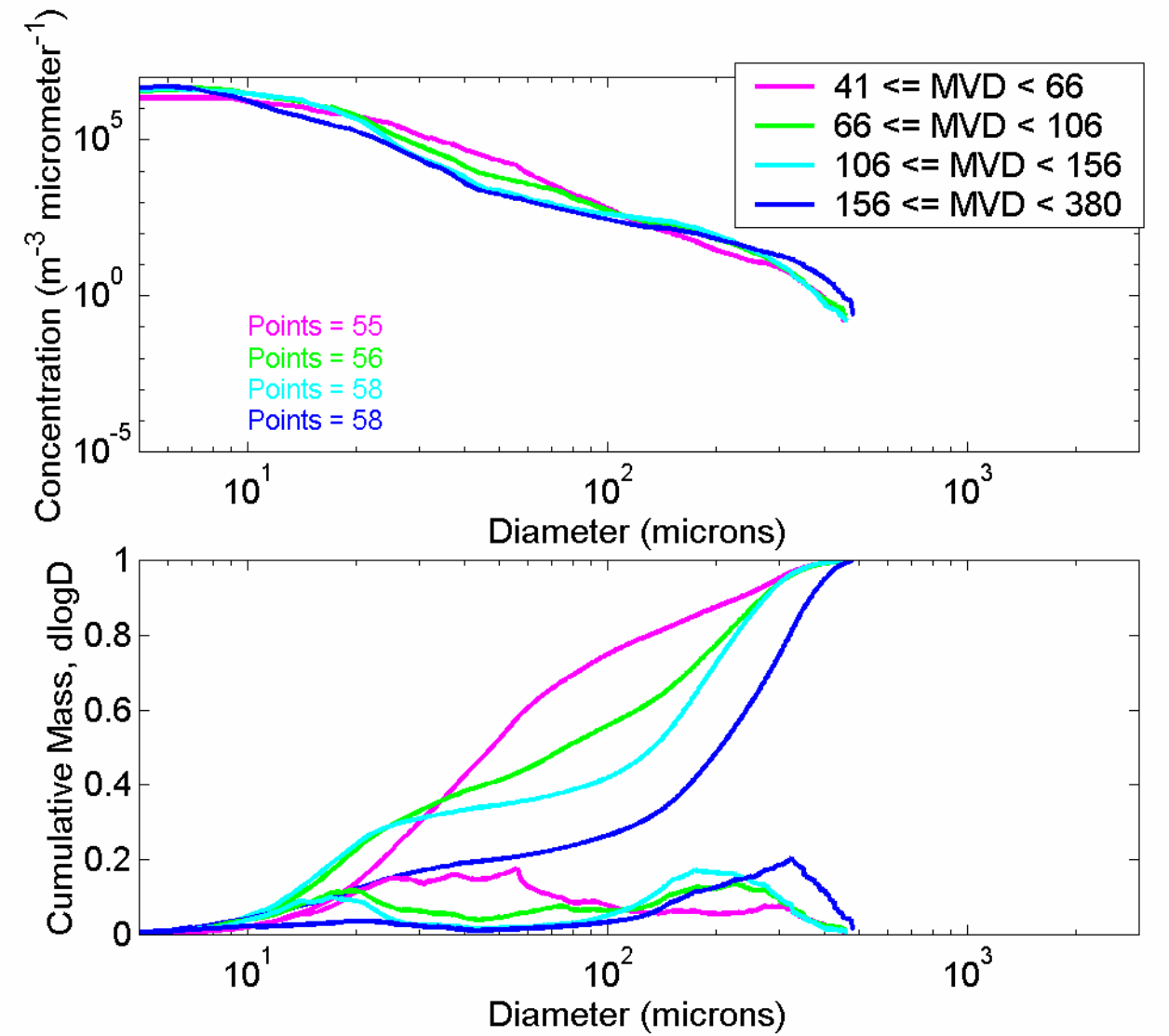
ZC Variation With LWC



ZL-In Variation With Dmax



ZL-Out Variation With MVD



ZR-In Variation With MVD