

# **Canadian Aircraft Icing Research and its Relationship to Cloudsat/CALIPSO**

presented by

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Meteorological Service of Canada

# Characterization of Icing Environment

Being done with funding from  
FAA and TC under the guidance  
of IPHWG



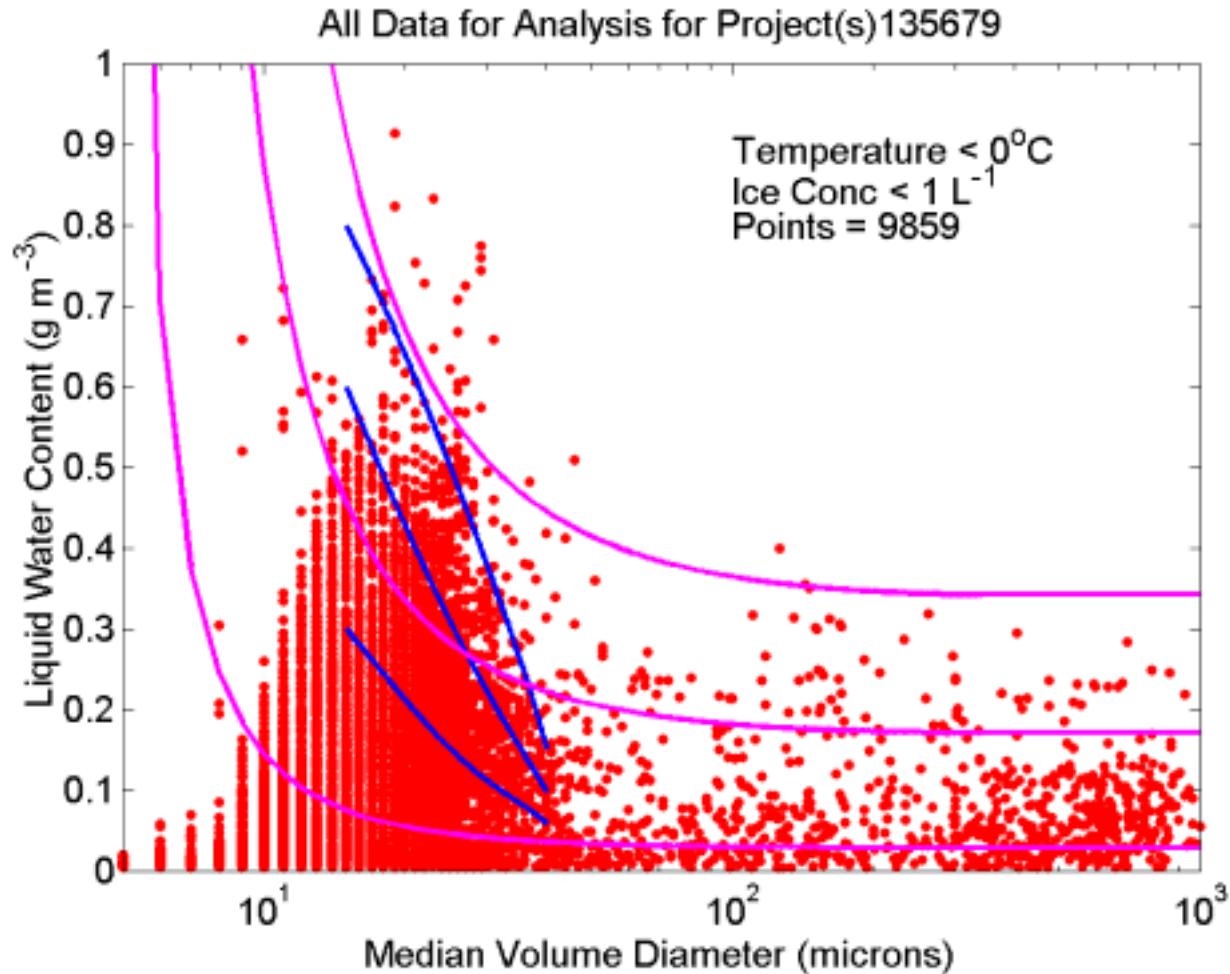
# Summary of the Data

Definition	MSC	NASA	Total
Projects	4	3	7
Flights	81	53	134
Hours	311	91	402
Distance (km)	112068	22984	135052
30-s Points	37356	10945	48301

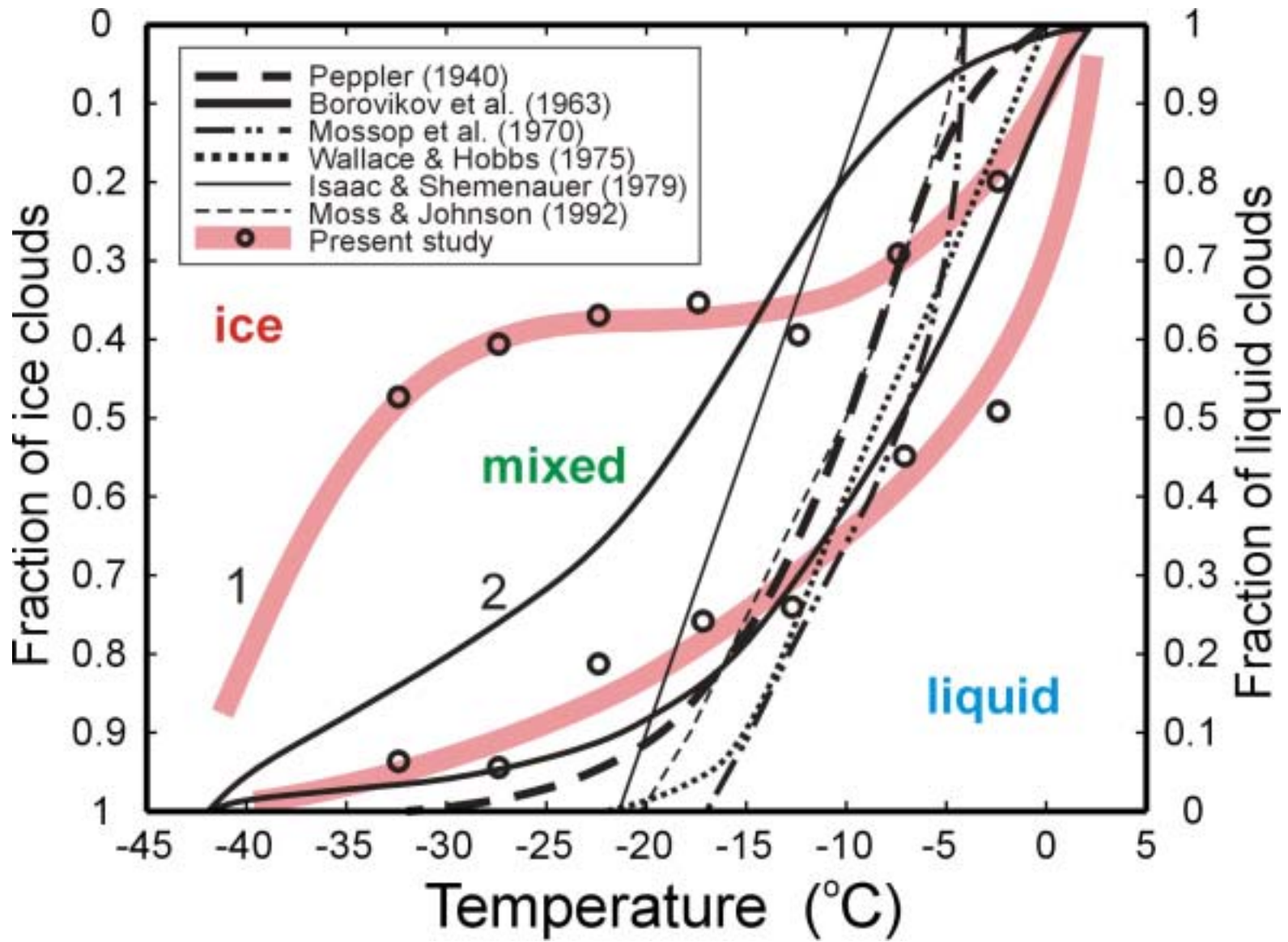
# Summary of In-Cloud Conditions

Definition	30-s Points	Characteristics
In-Flight	48301	
In-Cloud	27497 (57%)	TWC > 0.005 g m <sup>-3</sup>
In-Cloud Cold	22267 (46%)	+ Ta ≤ 0°C
In-Icing	14206 (29%)	+ L/M Phase
In-Spectra	10135 (21%)	+ Ice ≤ 1 L <sup>-1</sup>
In-SLD	2497 (5%)	+ Dmax ≥ 100 μm

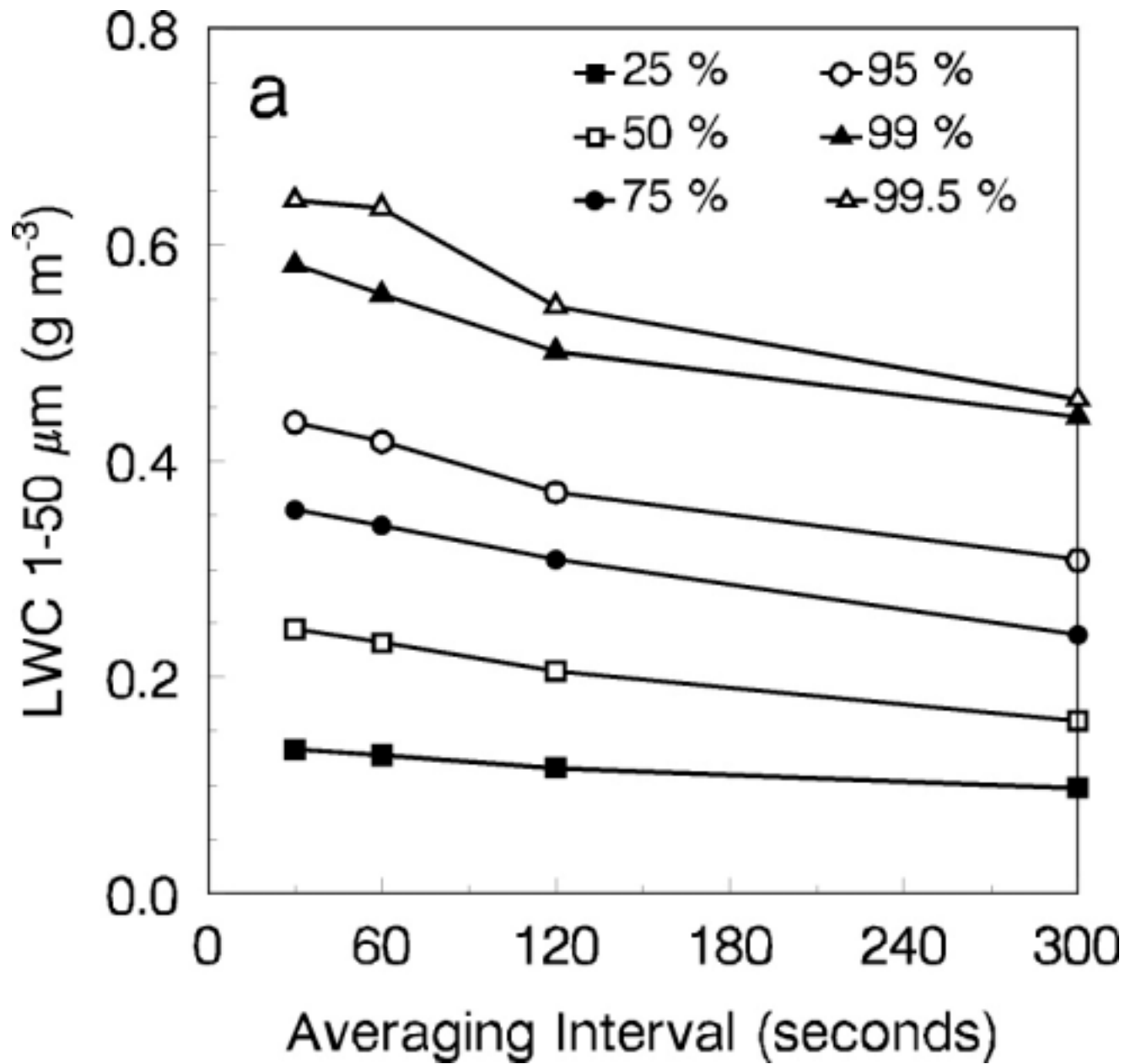
# Raw Data for Estimating Extremes



Each data point represents a 30-s (3-km) MedVD LWC observation.

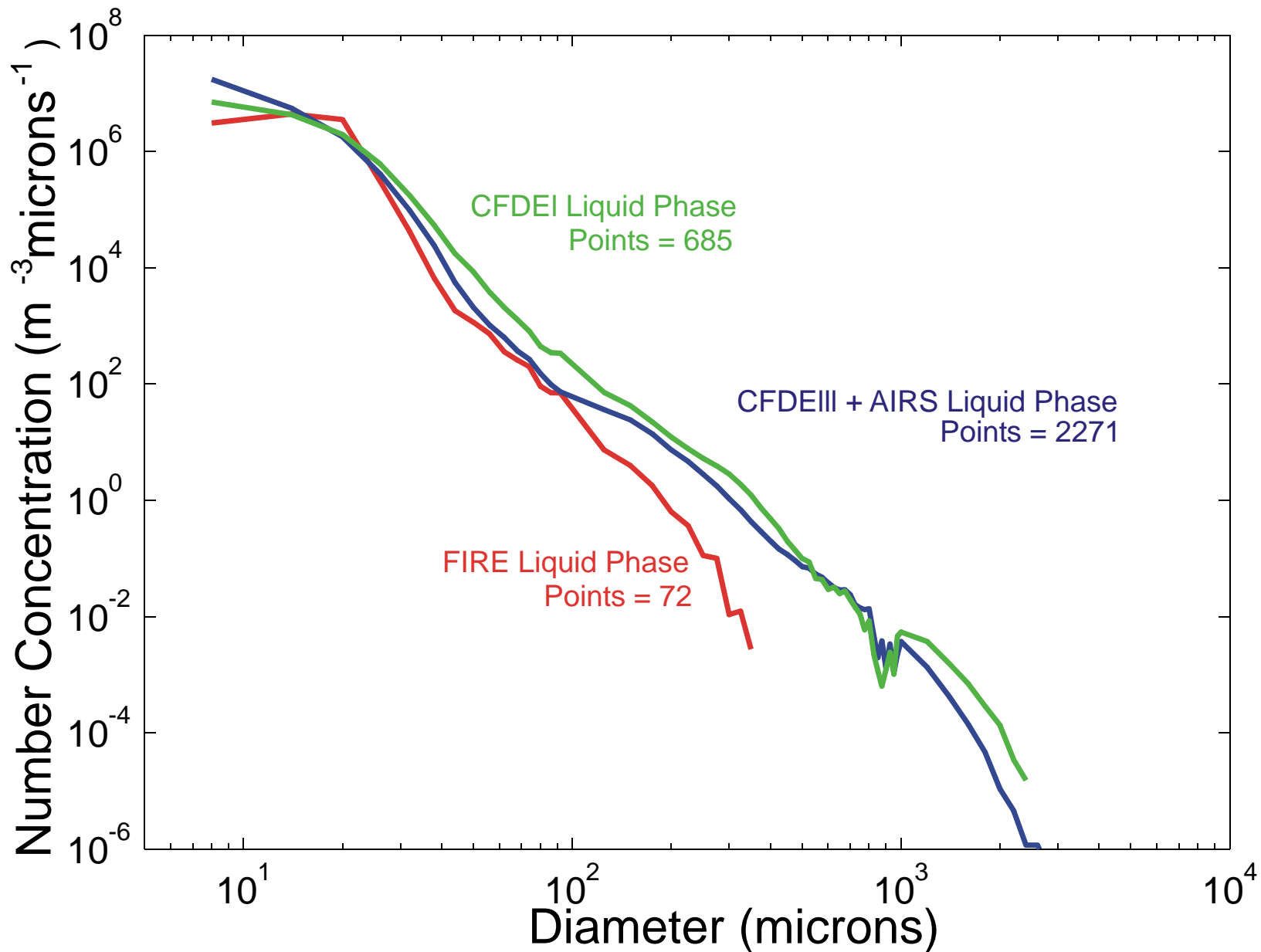


Korolev, A.V., G.A. Isaac, S.G. Cober, J.W. Strapp, and J. Hallett, 2003: Observations of the microstructure of mixed phase clouds. *Quart. J. Roy. Meteorol. Soc.*, **129**, 39-65

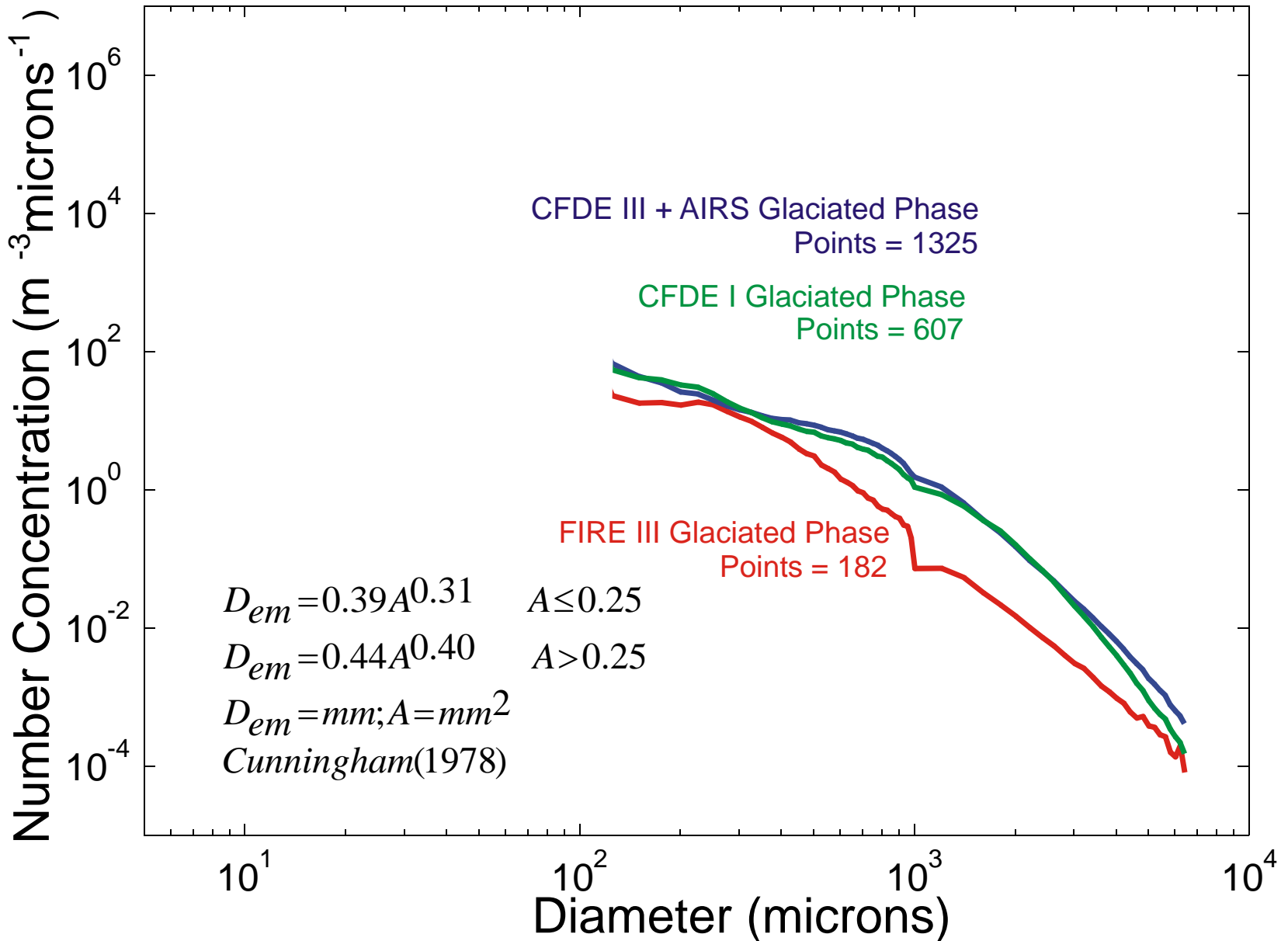


Cober, S.G., G.A. Isaac, and J.W. Strapp, 2001: Characterizations of aircraft icing environments that include supercooled large drops. *J. Appl. Meteor.*, 40, 1984-2002.

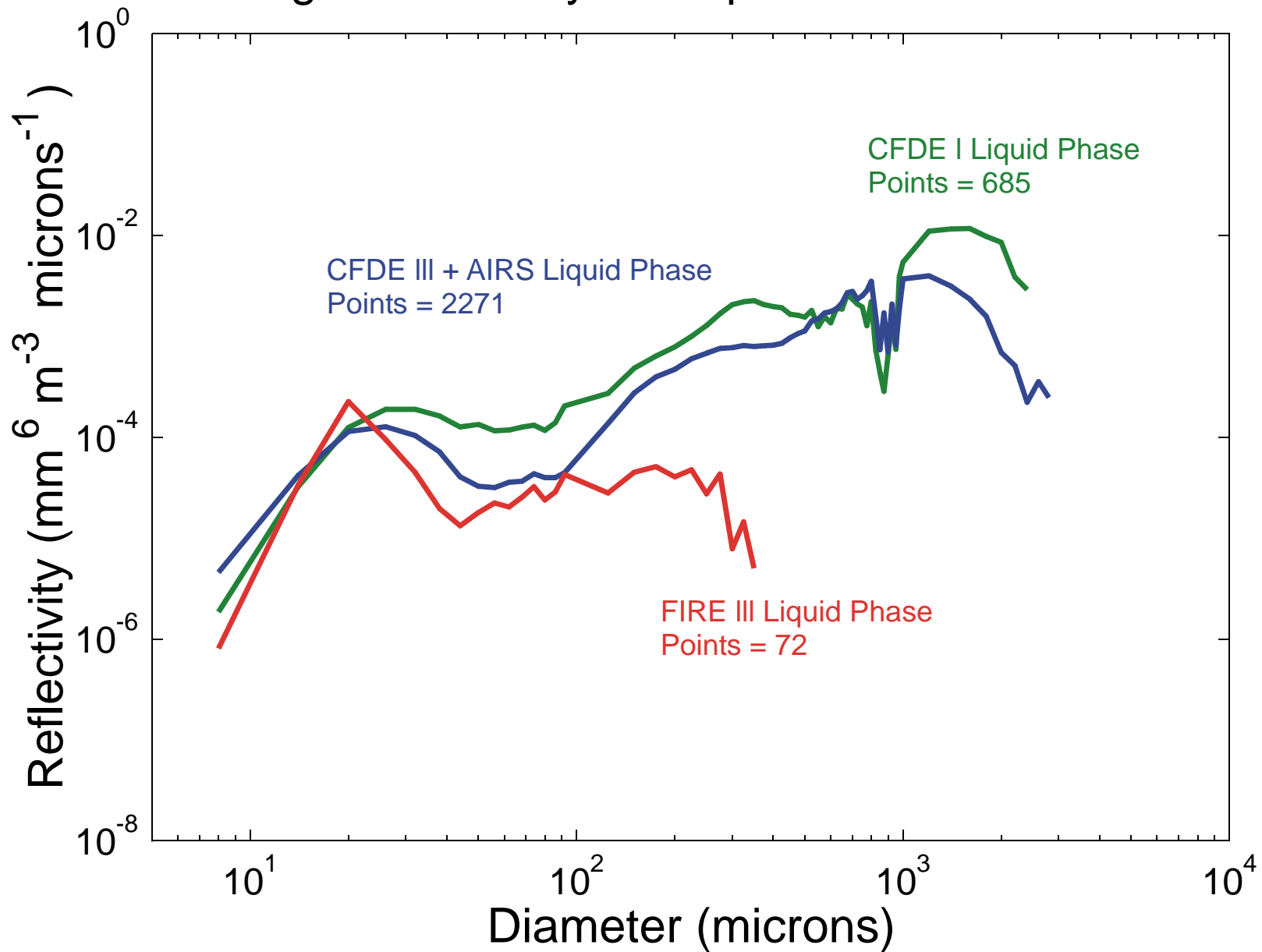
# Average Number Concentration for Liquid Phase



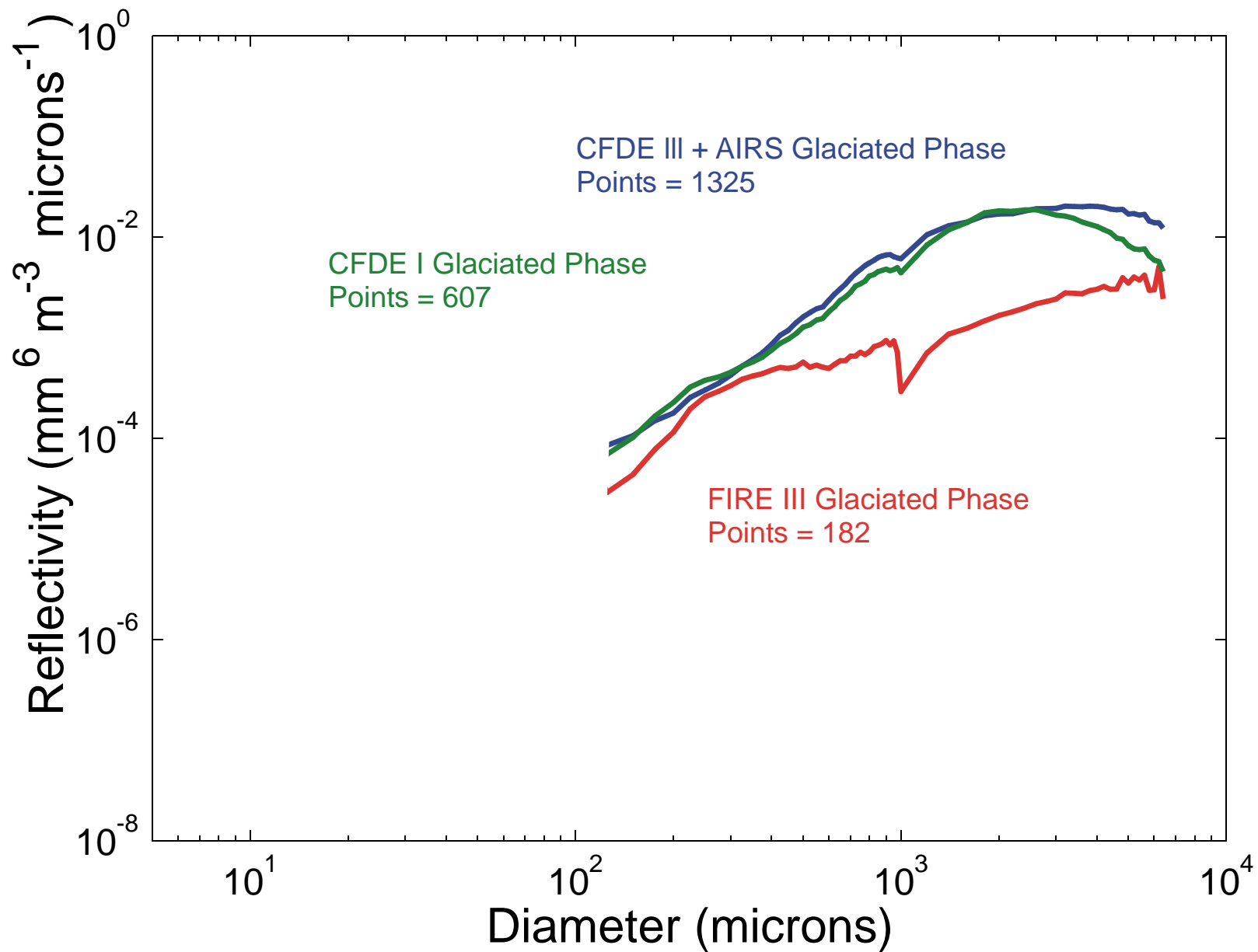
# Average Number Concentration for Glaciated Phase



# Average Reflectivity for Liquid Phase



# Average Reflectivity for Glaciated Phase



# A Description of AIRS II and Preliminary Results

- A large international research program
- Conducted in the Ottawa-Mirabel region
- Operations from 3 Nov 2003 to 13 Feb 2004  
IOP1: 4 Nov-12 Dec, IOP2: 19 Jan-13 Feb
- Focus on aviation meteorology research
- Extensive science plan available on request
- Web site <http://airs-icing.org/>
- Endorsed by Aircraft Icing Research Alliance
- Endorsed by WWRP Aircraft In-flight Icing Project

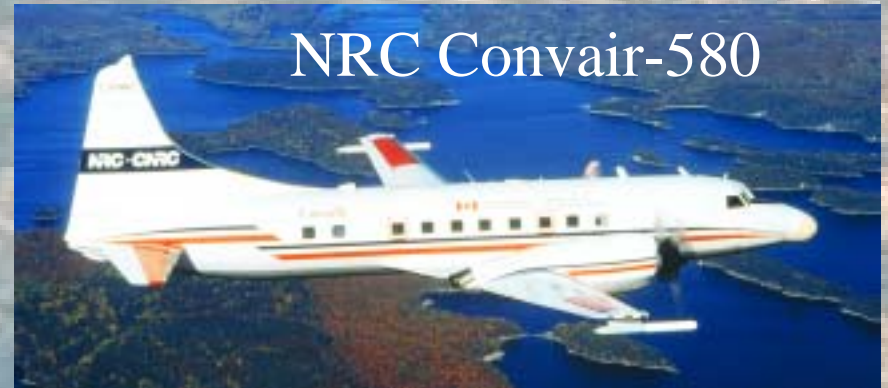
# Surface Instrumentation at Mirabel



# Participating Research Aircraft



NASA ER-2



NRC Convair-580



NCAR C-130



UND Citation



NASA Twin Otter

# Flight Summaries

	No.	Max. Icing Intensity		
	Flights	Severe	Moderate	Light
Convair	22	5	6	9
Twin Otter <sup>1</sup>	18	1	1	3
C-130 <sup>2</sup>	15	0	4	8
Citation <sup>3</sup>	18	0	2	2
ER-2 <sup>3</sup>	9	Flights were above icing		

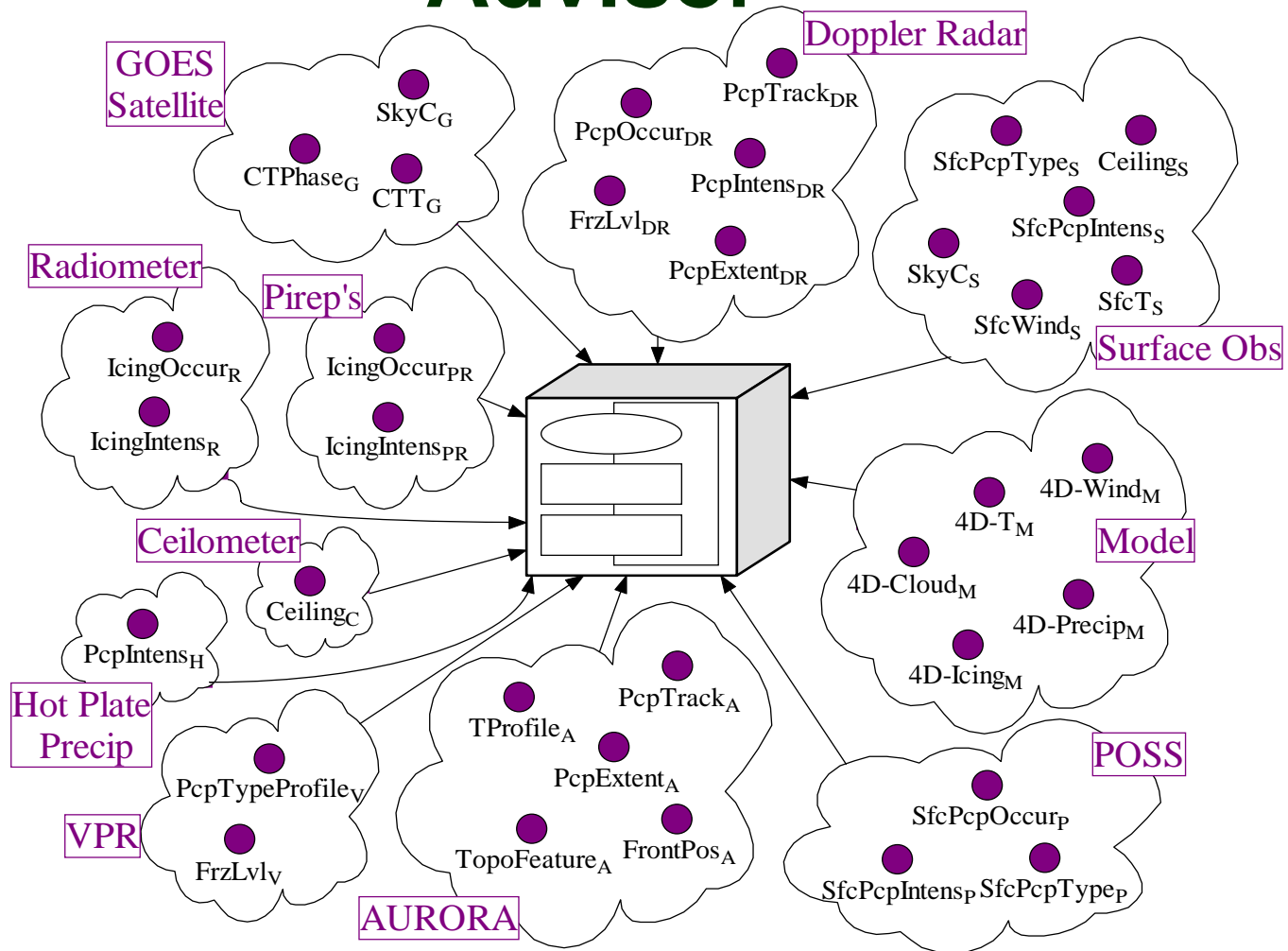
<sup>1</sup> Some Twin Otter flights were ferry flights

<sup>2</sup> Many C-130 flights were made out of Mirabel area

<sup>3</sup> Many Citation and ER-2 flights were for THORPEX

# MSC-AVISA

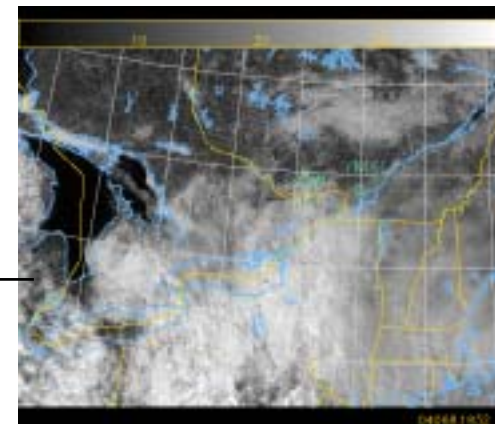
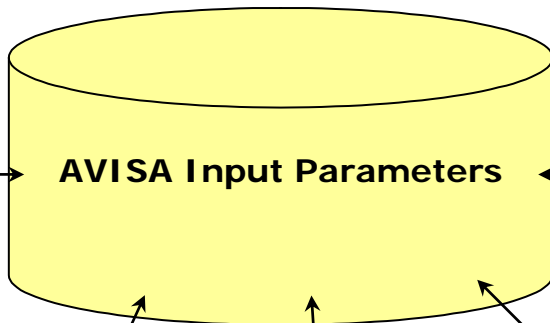
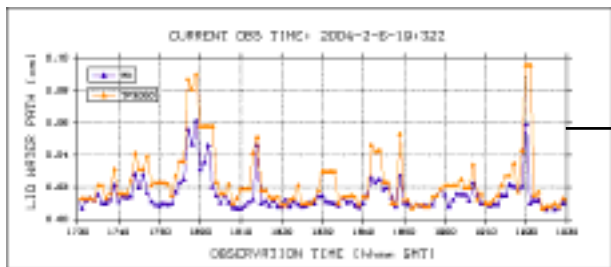
## Airport Vicinity Icing and Snow Advisor



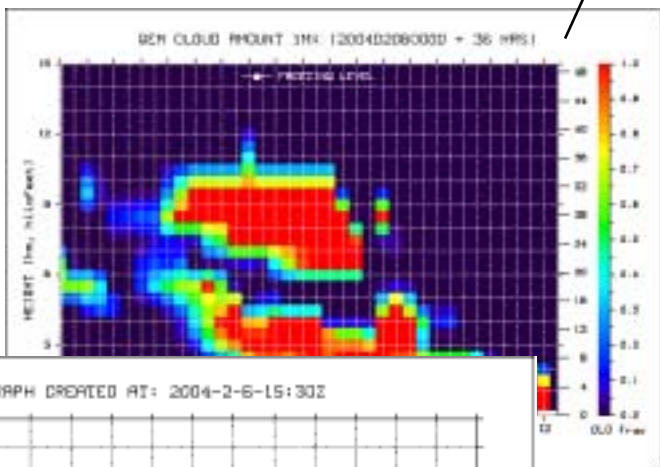
# AVISA Algorithm - Input

GOES Satellite

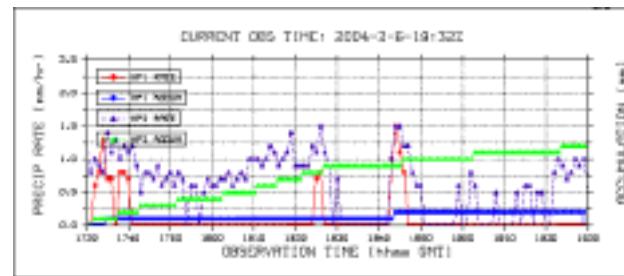
Radiometers



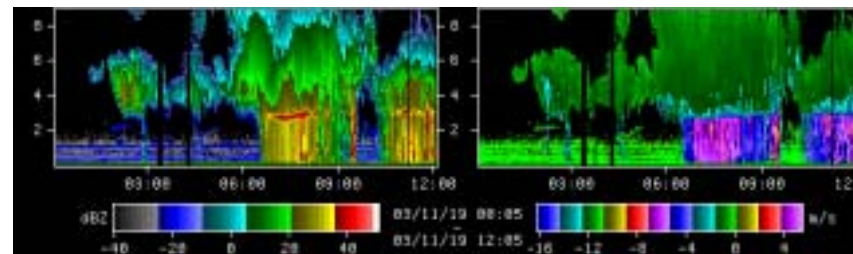
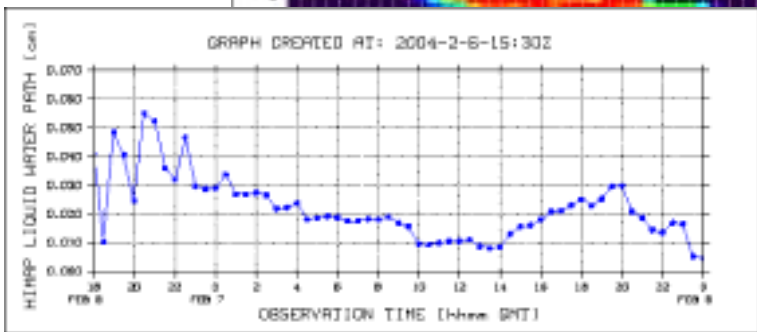
HIMAP & GEM Models



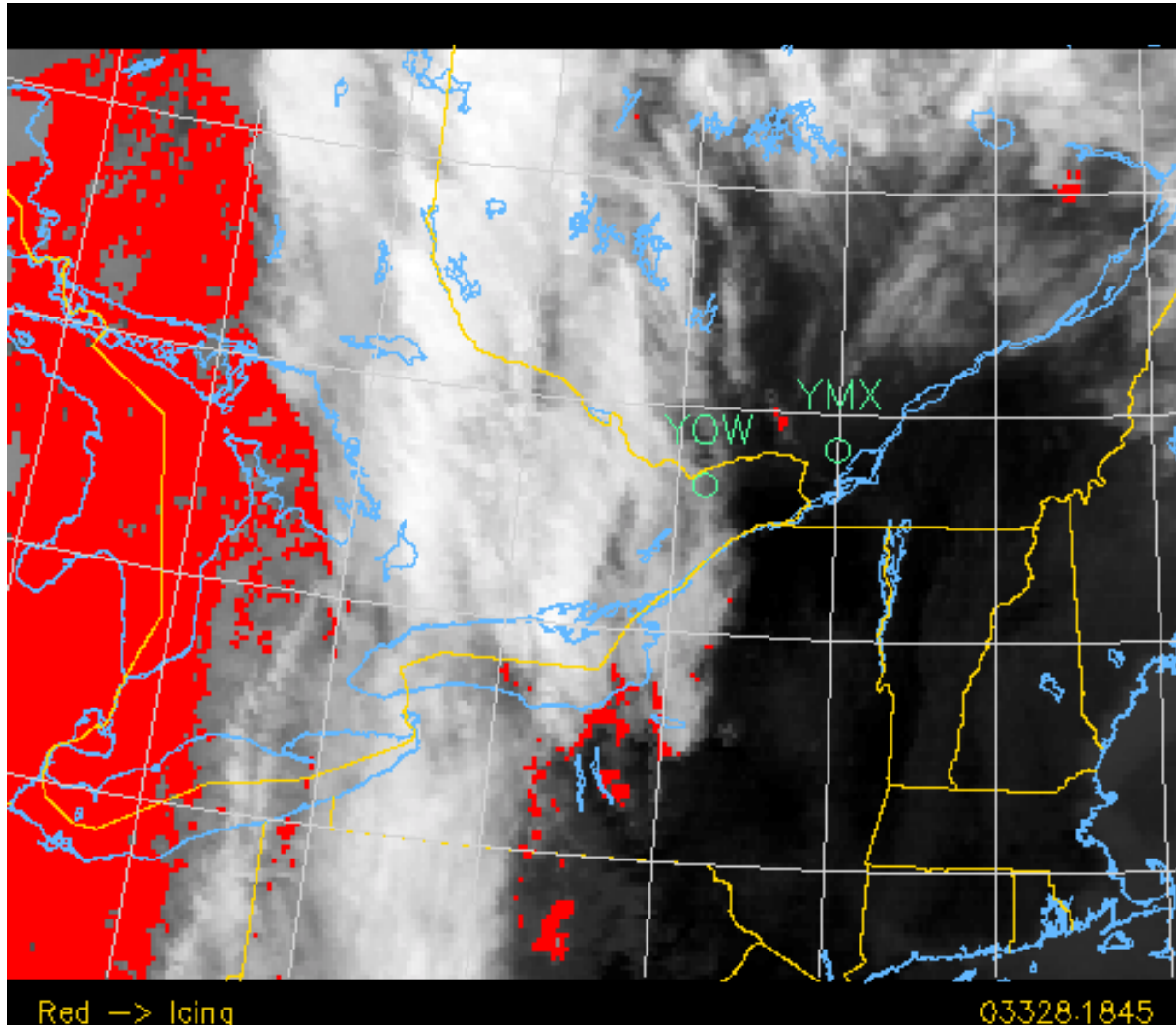
POSS, HP and Met Station



Doppler Radar & VPR



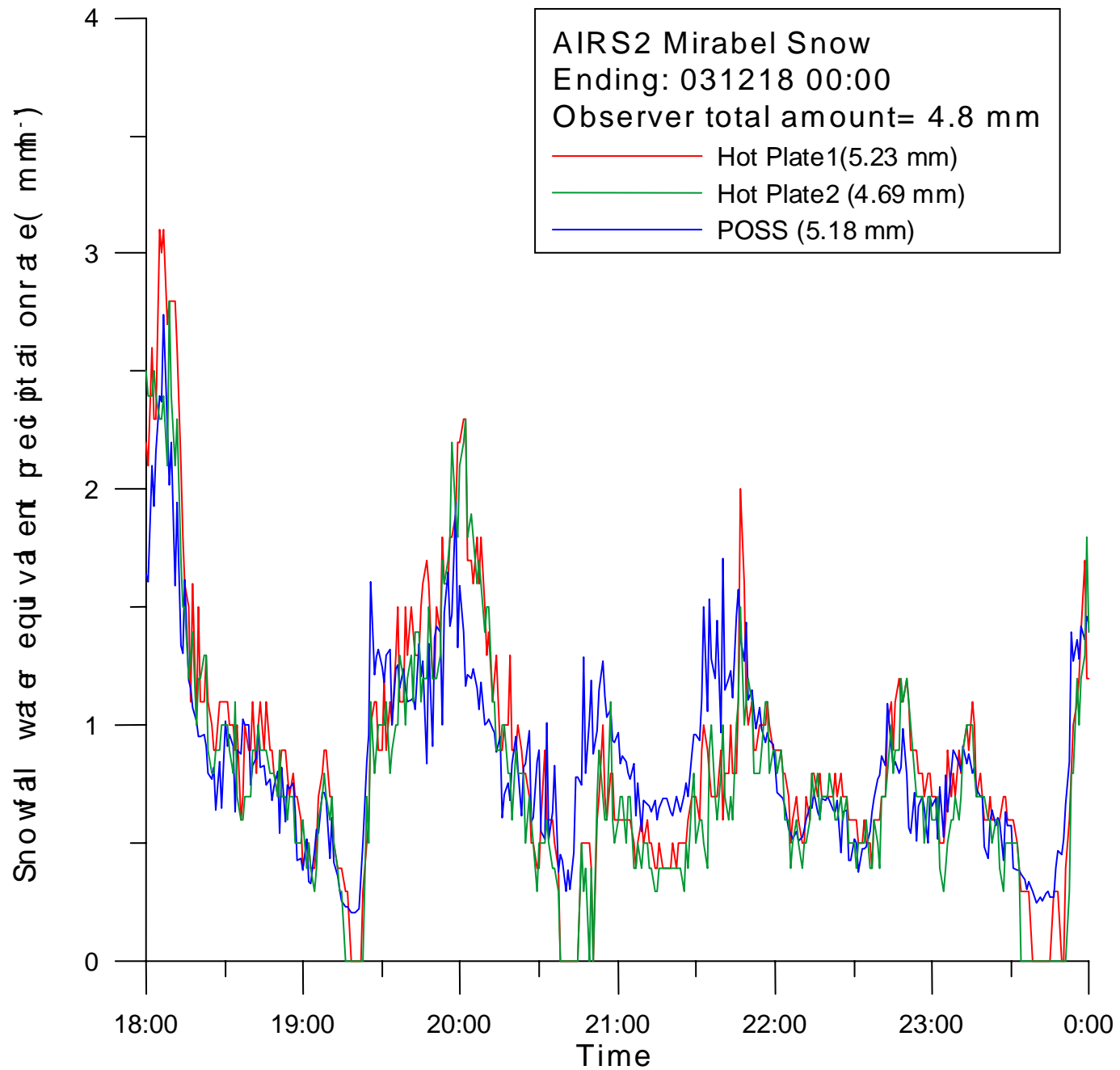
# Satellite Based Icing Predictions



MSC Product using GOES Data. Icing is marked in red. In this case (November 24) the cloud on the right was high level and glaciated, but behind the system was a low level stratiform deck with icing predicted. The Convair found severe icing in the low level cloud, confirming the prediction in this case, and there were many other pilot reports. The Citation, flying over Lake Ontario, did not find significant icing.

## Example of SLW Icing Analysis for 19 November 2003

<b>Flight time over YMX</b>	<b>2045-2345; total flight duration 2000-0000</b>
<b>Flight summary &amp; aircraft data</b>	<b>Flew to Kingston and then to Mirabel. Over YMX, CB ~0.15 km (500 ft), CT ~7.3 km (24 kft) – ice crystals. Icing seen at ~3.6 km (11.8 kft) – LWC=0.4-0.5g/m<sup>3</sup>.</b>
<b>Icing summary</b>	<b>Moderate + severe icing</b>
<b><u>Method</u></b>	<b><u>Method results during times over Mirabel</u></b>
<b>Mount Washington Radiometer</b>	<b>SLW: Inconclusive due to rain, YES after 2330</b>
<b>HIMAP LWC</b>	<b>IB: ~3.0 km, IT: ~6.0 km SLW: YES</b>
<b>Profiling Radiometer</b>	<b>SLW: YES</b>
<b>GOES Icing</b>	<b>SLW: NO Top was too cold and glaciated</b>
<b>VPR</b>	<b>SLW: YES</b>



# Recommendations

- Cloudsat retrieval algorithms can be improved by examining past aircraft data. Problems are expected with mixed phase clouds, which occur frequently.
- Cloudsat validation using aircraft data is not a simple task. (scale effects, instrument problems, etc)
- Ground sites as used during AIRS 2 are recommended. (My preference is for them to be fixed, not mobile) (Include model data)
- High resolution precipitation rates are possible but need to be performed with as many different sensors as possible.