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NRC Convair-580 Atmospheric Remote Sensing Capabilities and Recent Research Activities

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Contributions:

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Acknowledgments: EC/NRC flight crew, S. Cober, students (Short, Fievet, Frebrowski & Shen) and various funding agencies.

National Research Council Canada | Conseil national de recherches Canada

Canada

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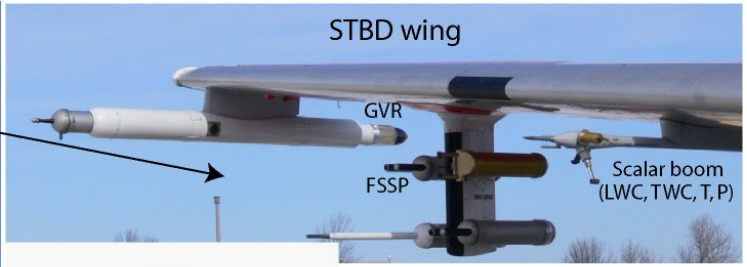
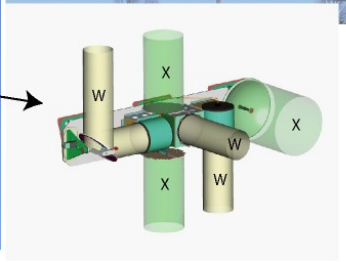
NRC Convair Research Aircraft





- *Principal Canadian airborne atmospheric and geophysical research platform*
  - *Instrumented by NRC, EC and DND*

- *Used for various atmospheric research applications*
  - *Icing*
  - *Hurricane*
  - *Air quality*
  - *Remote sensing system*

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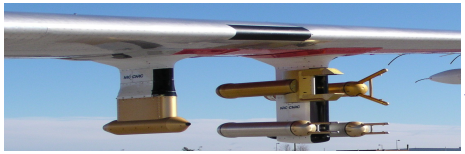
Cloud Radar/Radiometer on NRC Convair 580

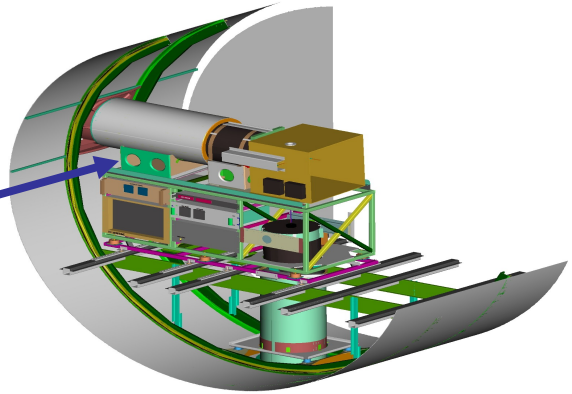
- *1999 – EC Ka-band (35 GHz) radar (EC: W. Stapp et al., FRL: J. Jordan & D. Marcotte)*
  - *First Alliance Icing Research Study - (AIRS I)*
  - *Hurricane Extra tropical Transition (ET) Study – Oct 2000*
- *2003 – Porlarimetric W-band (95 GHz) NIF – AIRS II*
  - *Nadir and Side-view (dual-pol)*
  - *One time installation of University of Wyoming Cloud Radar*
- *2006 –NRC MIC Funding + CSA*
  - *NRC Airborne W and X-band (NAWX) Polarimetric radar system*
  - *ProSensing Inc. 183 GHz G-band Water Vapor Radiometer (GVR)*

AIRSII Project

- Conducted b/N Nov 2003 -Feb 2004 over Quebec and Ontario, Canada
- Collaborative international icing study with both ground and airborne component. The research focus include:
  - Better characterization of icing environment
  - Remote detection of icing and validation
  - Better understanding of icing process and its effect on aircraft

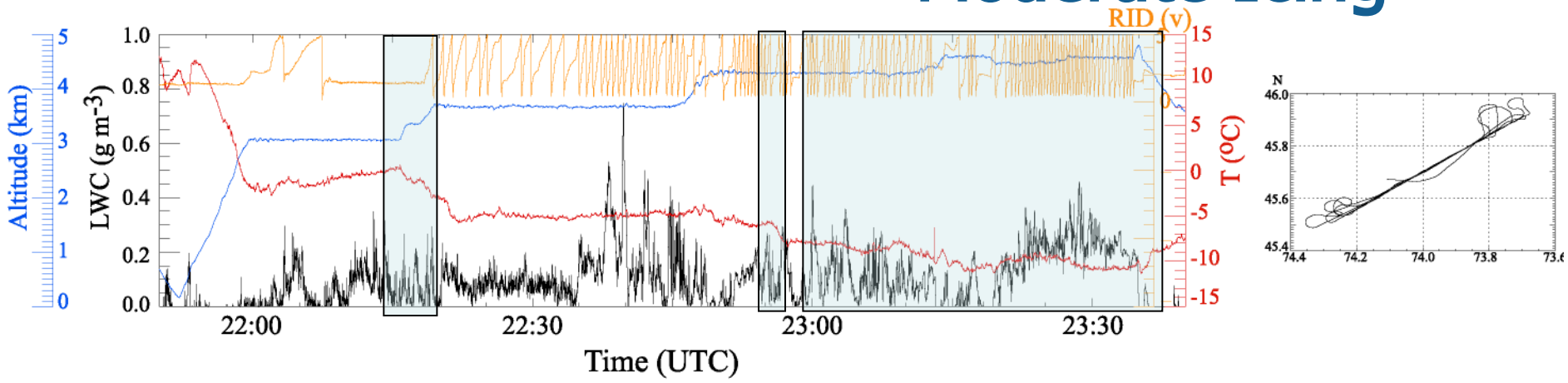
NRC Convair 580 – AIRS II instrumentation





- Arrays of cloud physics probes
  - PMS King LWC
  - Rosemount icing detector
  - PMS FSSP (5 – 95 μm)
  - PMS 2DC
  - Temperature
- Remote sensing instruments
  - University of Wyoming Cloud Radar (WCR)

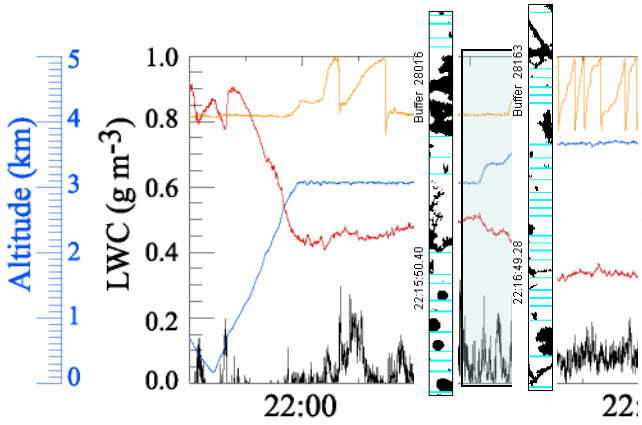
Nov 19, 2003 – Flt #5: Moderate Icing

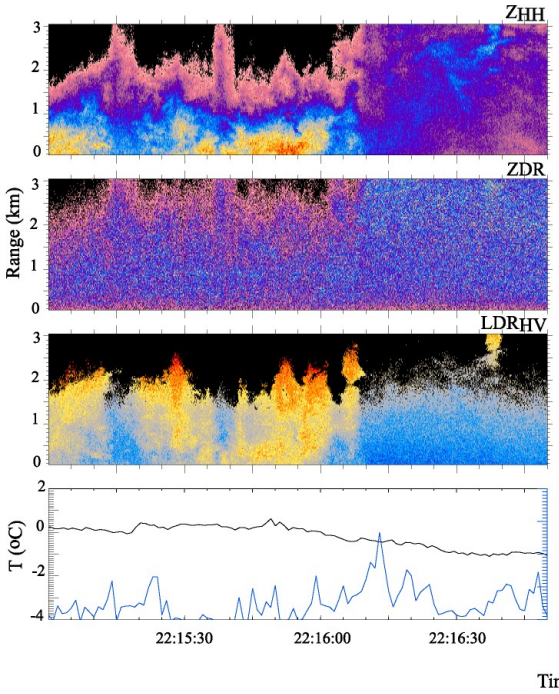


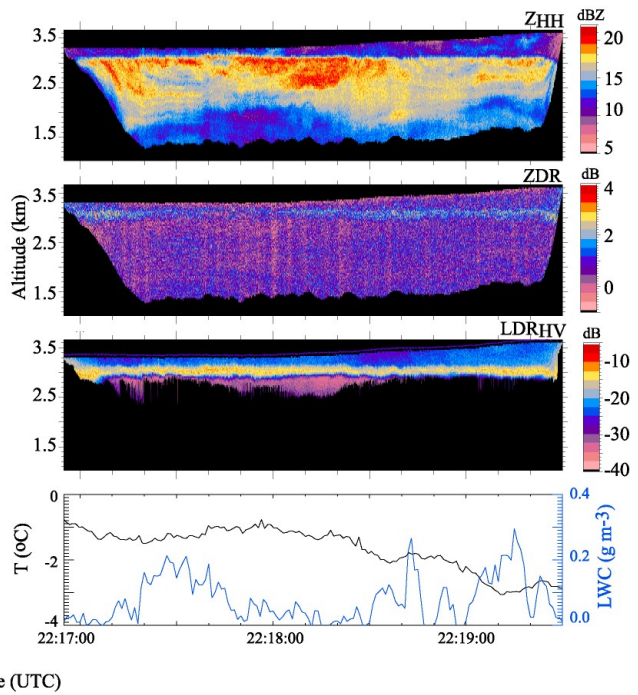
- Moderate icing case over Mirabel
- Repeated horizontal transects at various altitude
- Icing encounter from just above the melting layer to 4.5 km (T~ -10°C)
- Up to 0.8 g m^{-3} LWC

- Radar signatures of Melting xls, mixed phase and icing clouds
- Cloud Z structure
- In-situ and radar data

Nov 19, 2003 – Melting Layer to Mixed Phase







T ~ -3 to 0°C
WCR: dual-pol.

- Melting layer: Z ~15-20 dBZ, LDR ~ -15 to -10 dB, ZDR~ 0-3 dB
- Mixed phase: Z ~ 5-10 dBZ, LDR ~ -30 to -20 dB, ZDR ~ 0-1 dB
- Rain: LDR ~ < -30 dB, ZDR ~ 0 dB

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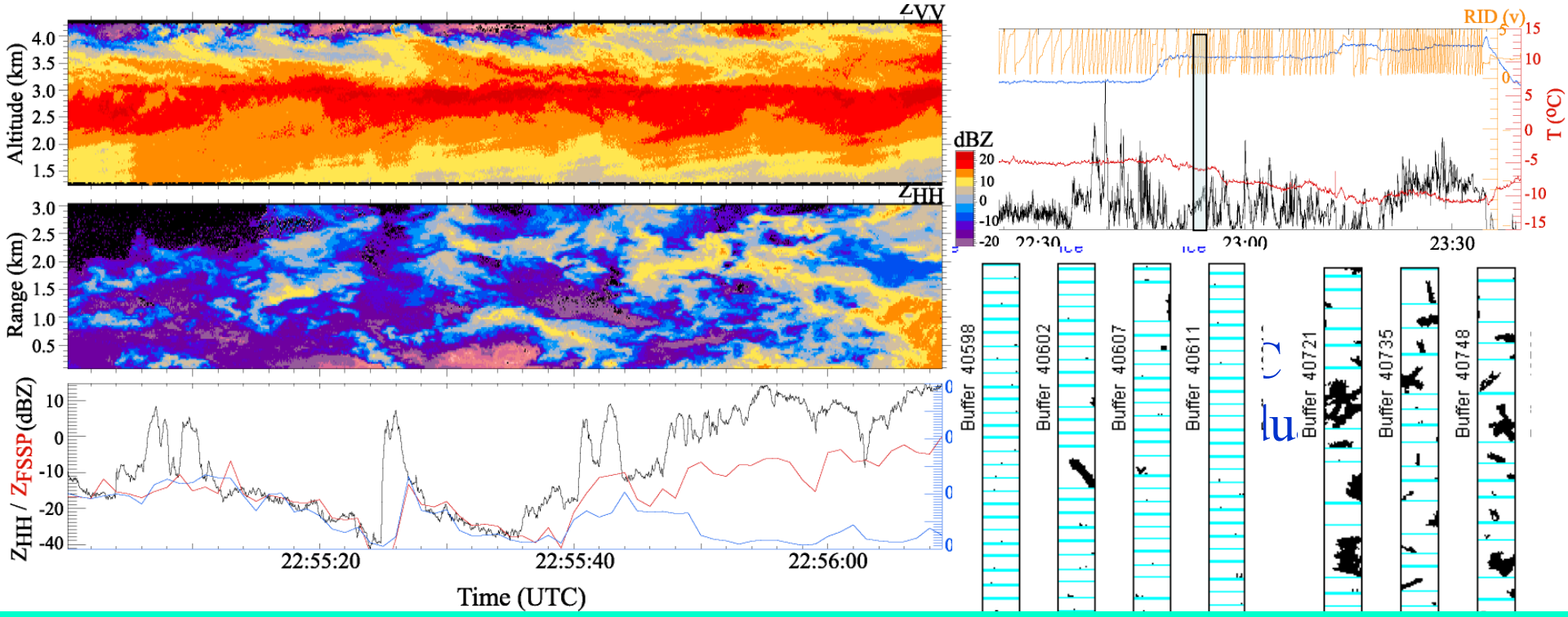
Nov 19, 2003 – Cloud Top – Mixed Phase



- High Z change near cloud top (-30 to 10 dBZ), ML at 3 km
- Weak Z: calculated Z match the WCR Z at 75 m range
- High Z cores: mixed phase / ice

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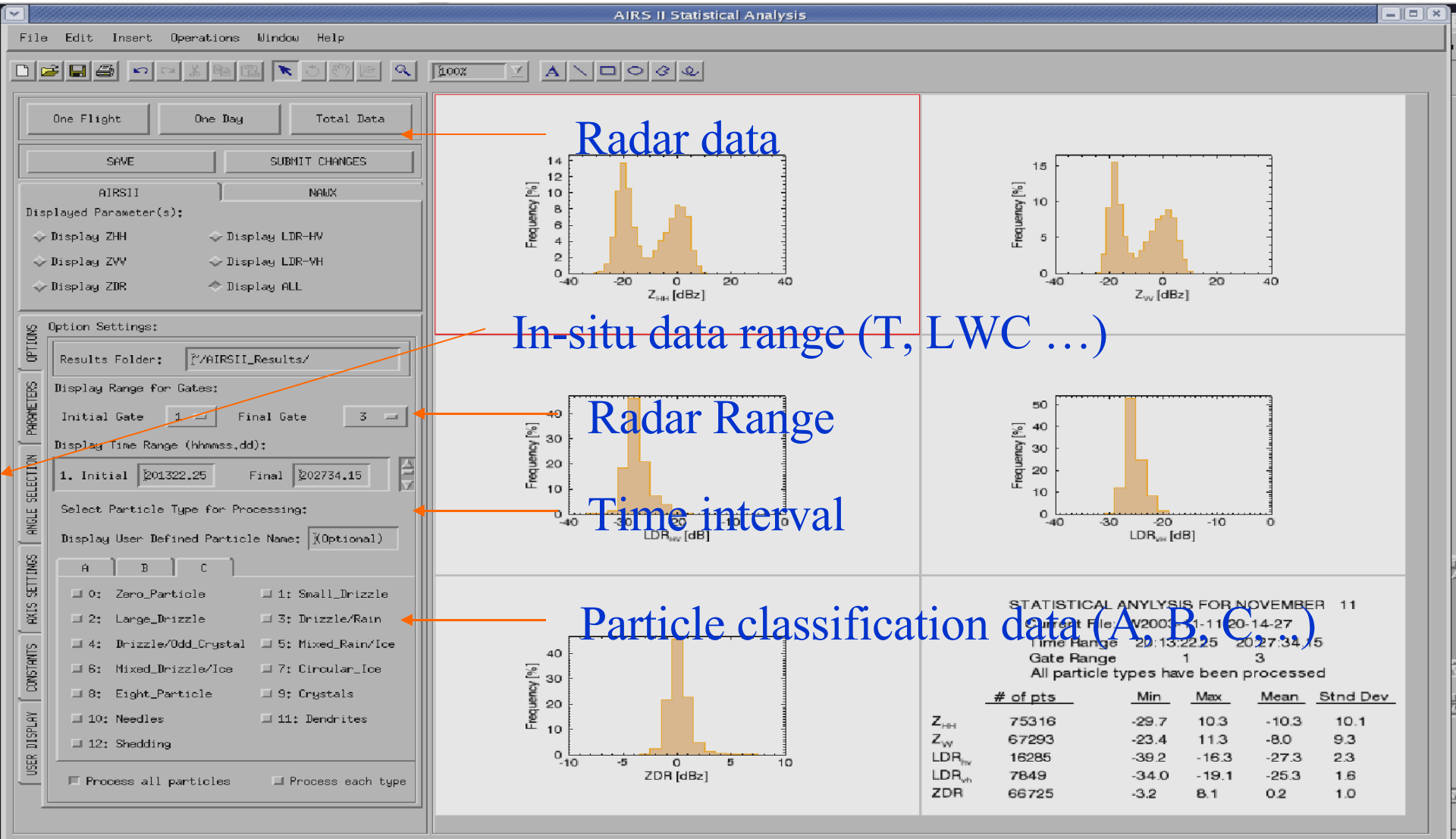
Combining in-situ and radar data



Radar data

In-situ data range (T, LWC …)

Radar Range

Time interval

Particle classification data (A, B, C, .)

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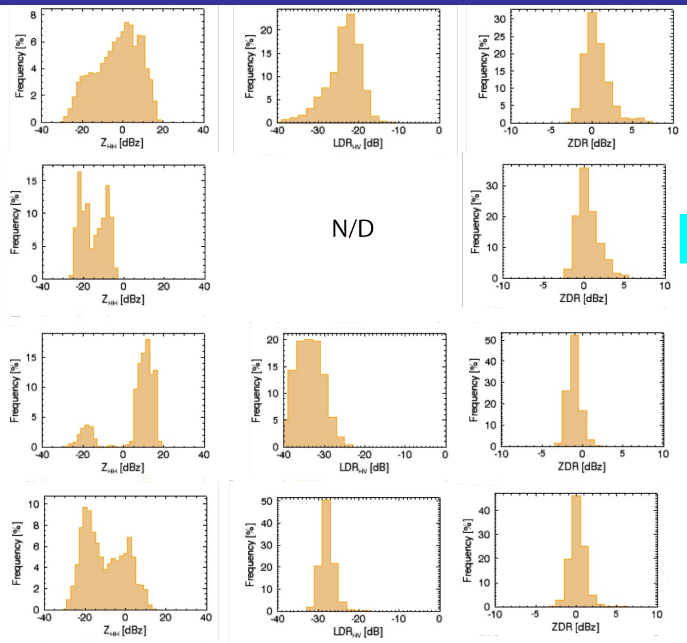
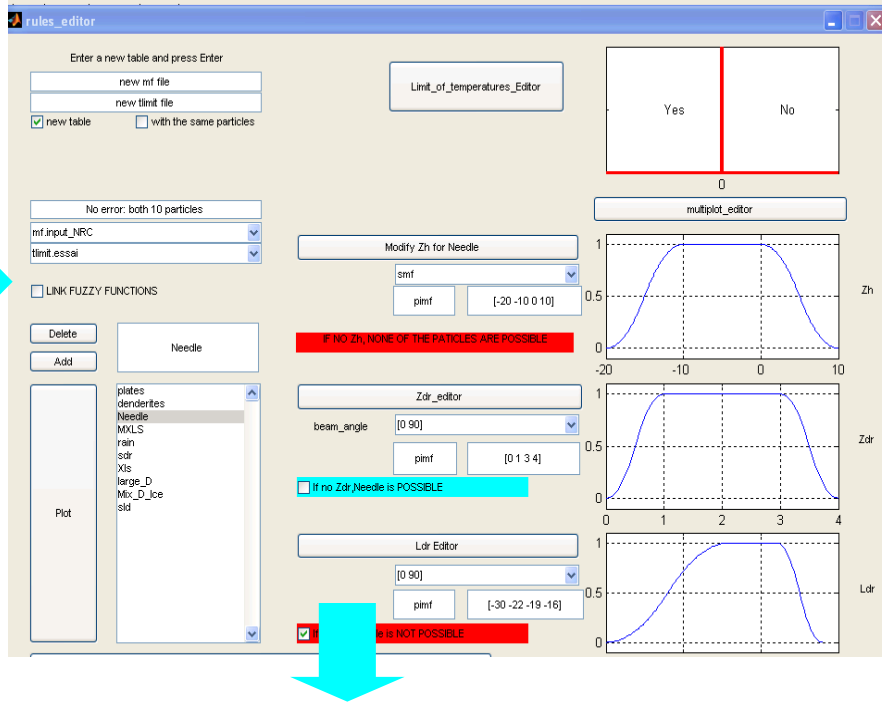
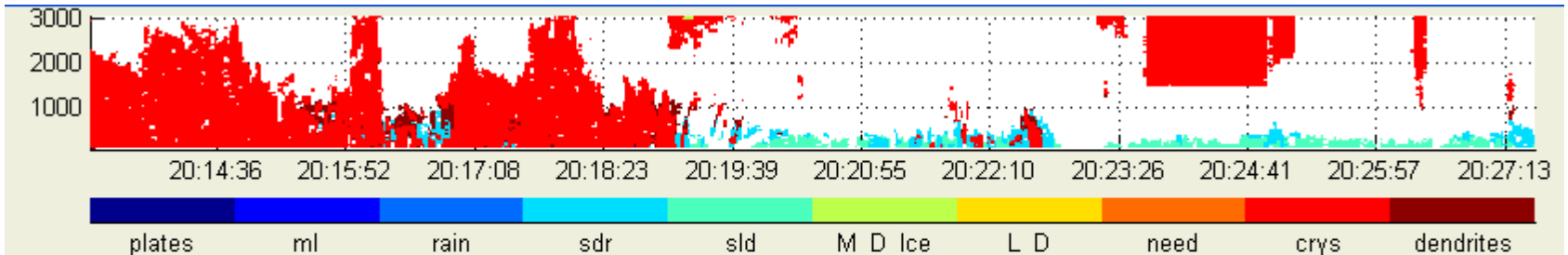
Fuzzy-logic based particle classification

Radar signatures of particles – coincident radar and in-situ measurements



Determine particle membership functions





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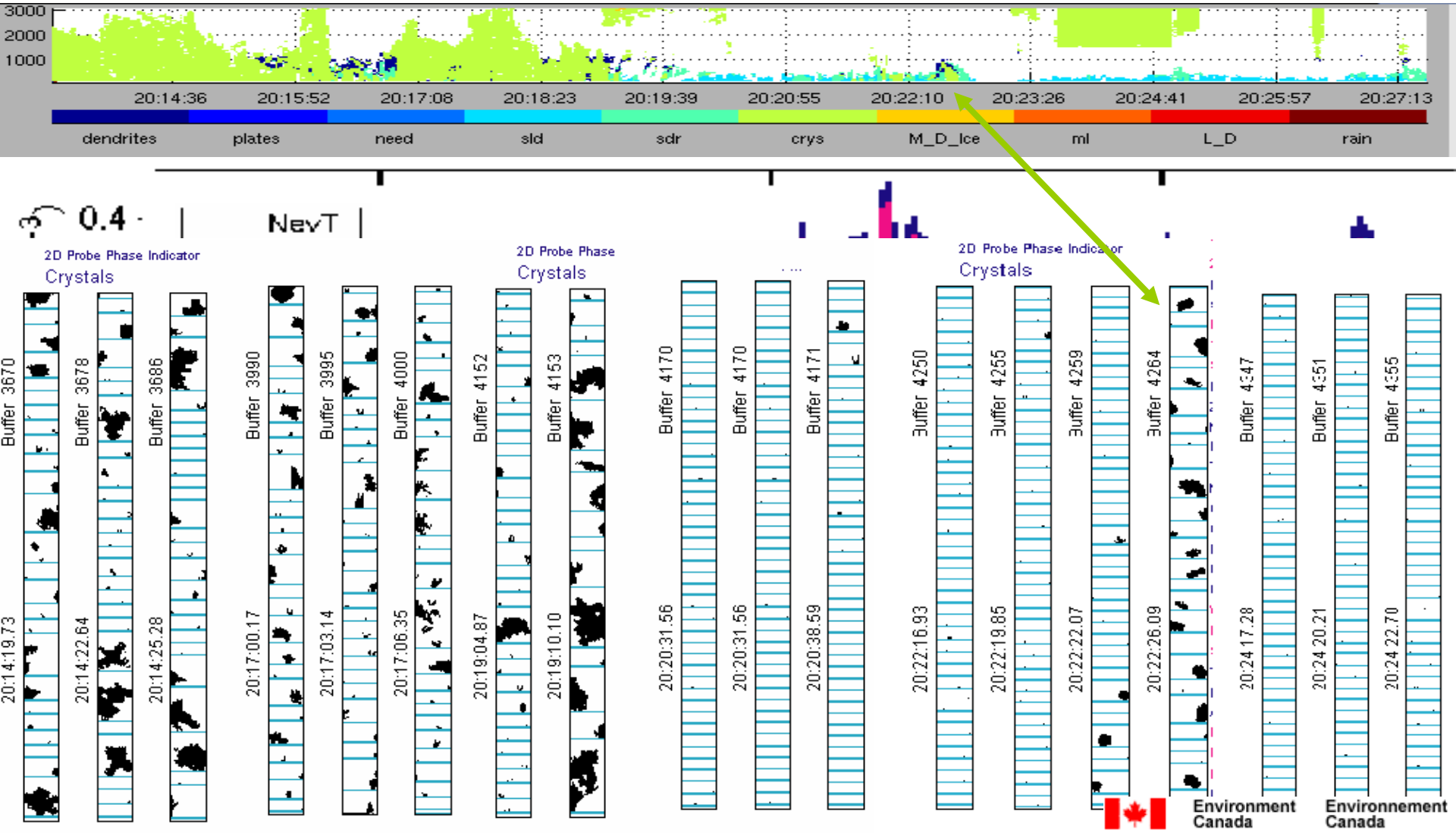
Nov 11: Particle type: Radar / In-situ



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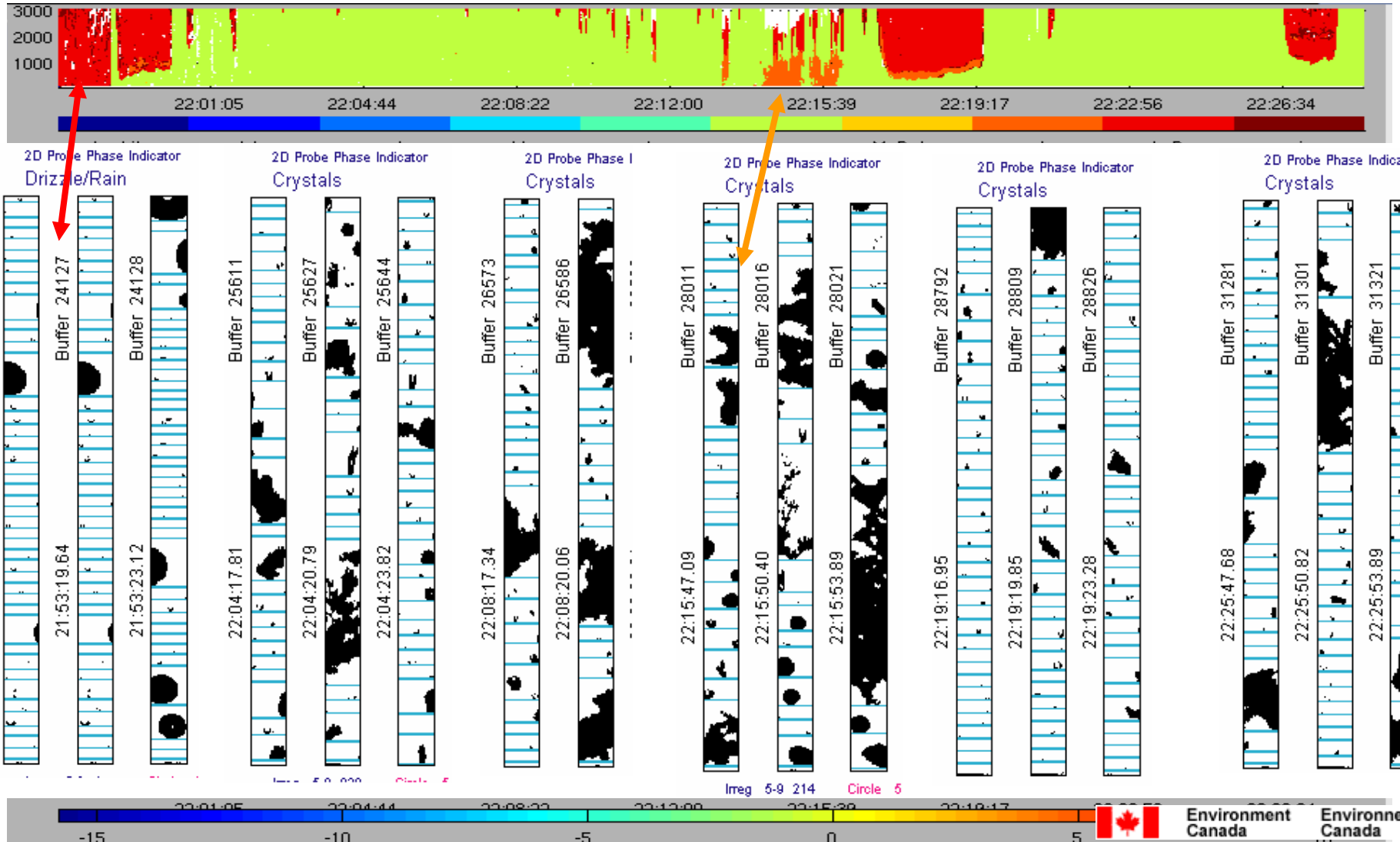
Nov 19: Particle type: Radar / In-situ



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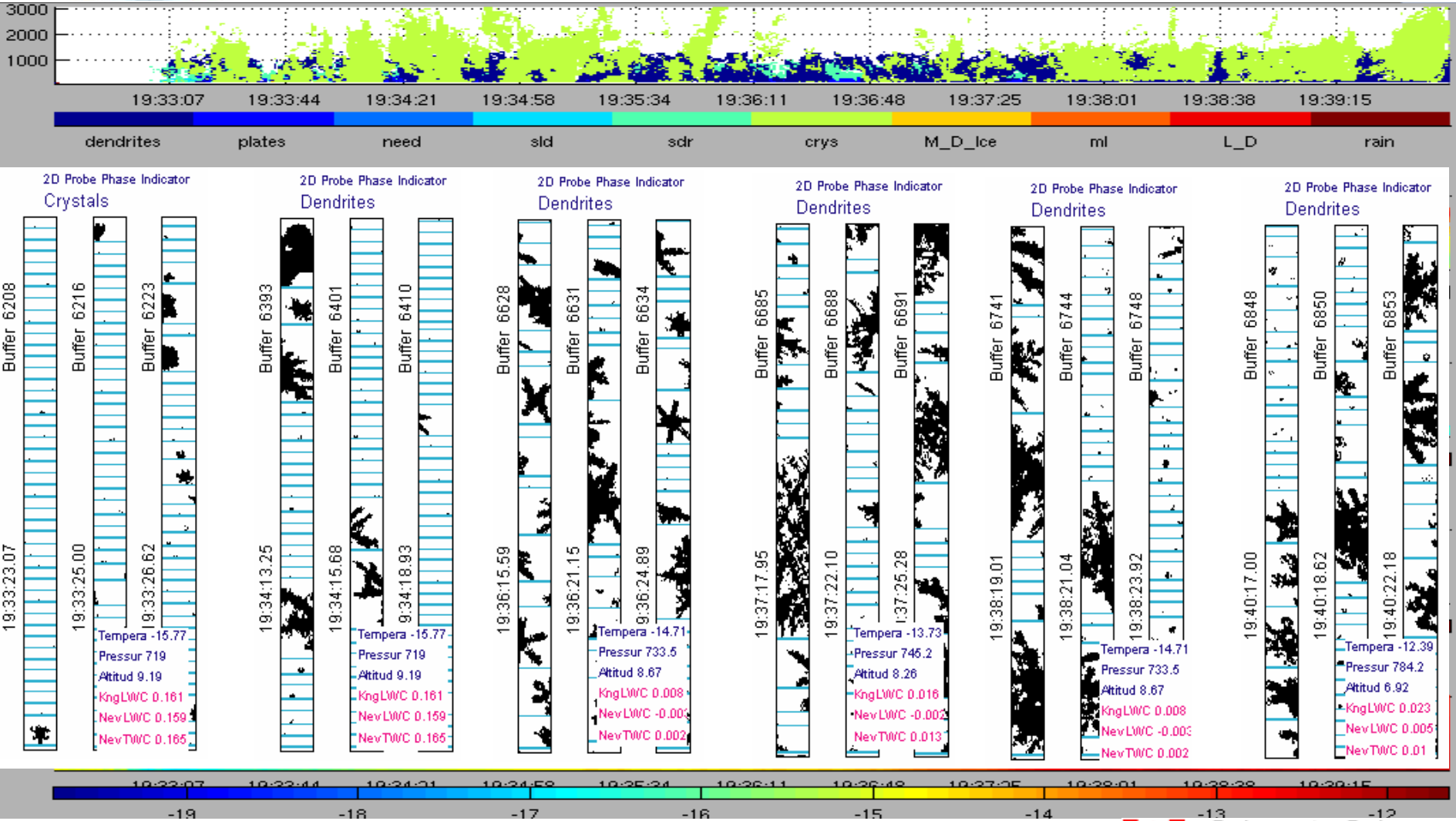
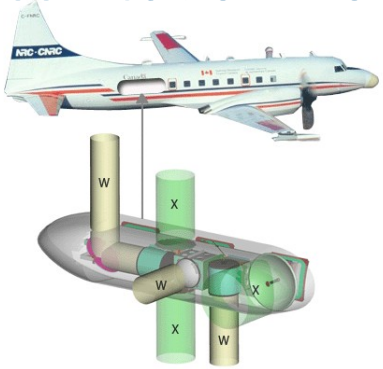
Nov 24: Particle type: Radar / In-situ



Particle Types Identification

- Good agreement between fuzzy-logic particle type classification result including icing from radar with in-situ cloud microphysics data
- Issues/Future work:
  - Identification of mixed phase clouds – plan to add other radar variables: Doppler velocity field, Dual-frequency option, more polarimetric variables
  - Image classification from in-situ measurements



http://www.nawx.nrc.gc.ca

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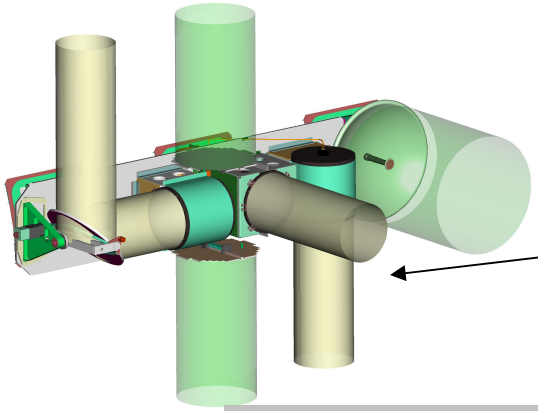
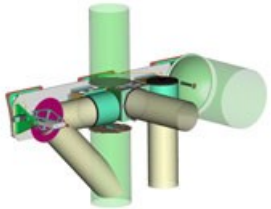
*N*RC *A*irborne *W* and *X*-bands radar (NAWX)





NAWX	W-band	X-band
Transmitted Frequency (GHz)	94.05	9.41
Peak Tx Power (KW)	1.7 - typical	25 (split b/n two ports)
Polarization	Co and Cross	Simultaneous H and V
Doppler	Pulse Pair and FFT	Pulse Pair and FFT
Pulse Duration (μs)	0.1 - 10	0.11-1
Max PRF (KHz)	20	5
Ant. 3 dB BW (°)	0.75	3.5
Antenna ports	5	4
View direction	Up, down and side	Up, down and side

More details/updates: **http://www.nawx.nrc.gc.ca**

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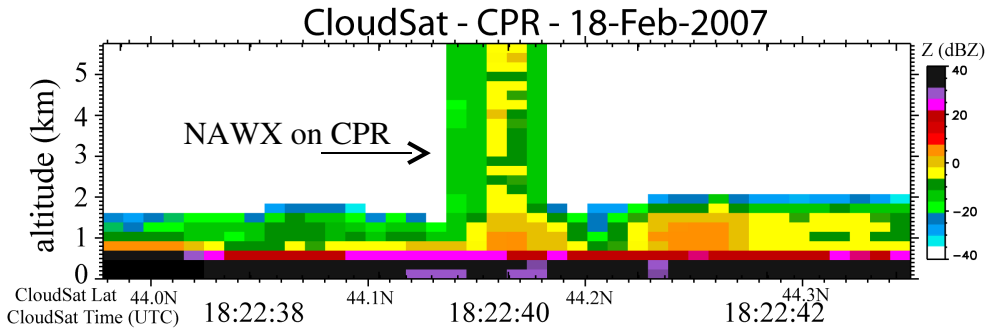
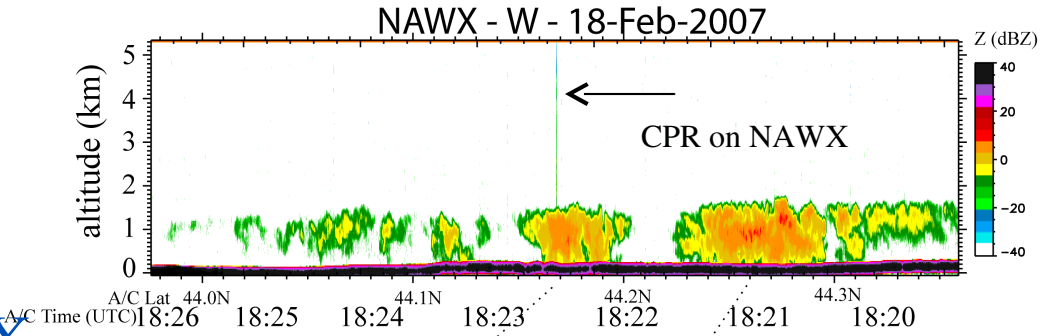
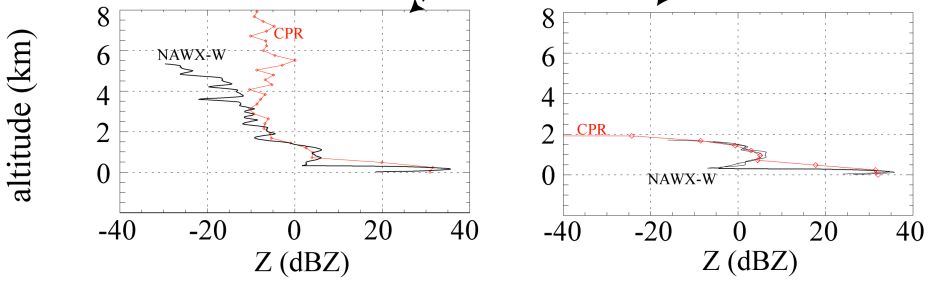
NAWX / CloudSat 18-Feb-2007

Feb 18-2007: Boundary layer Cu Clouds

- A/C at ~ 6 km at the time of the CloudSat pass
- Good agreement of cloud top boundaries by WCR and NAWX
- Difference b/n CPR and NAWX near the surface







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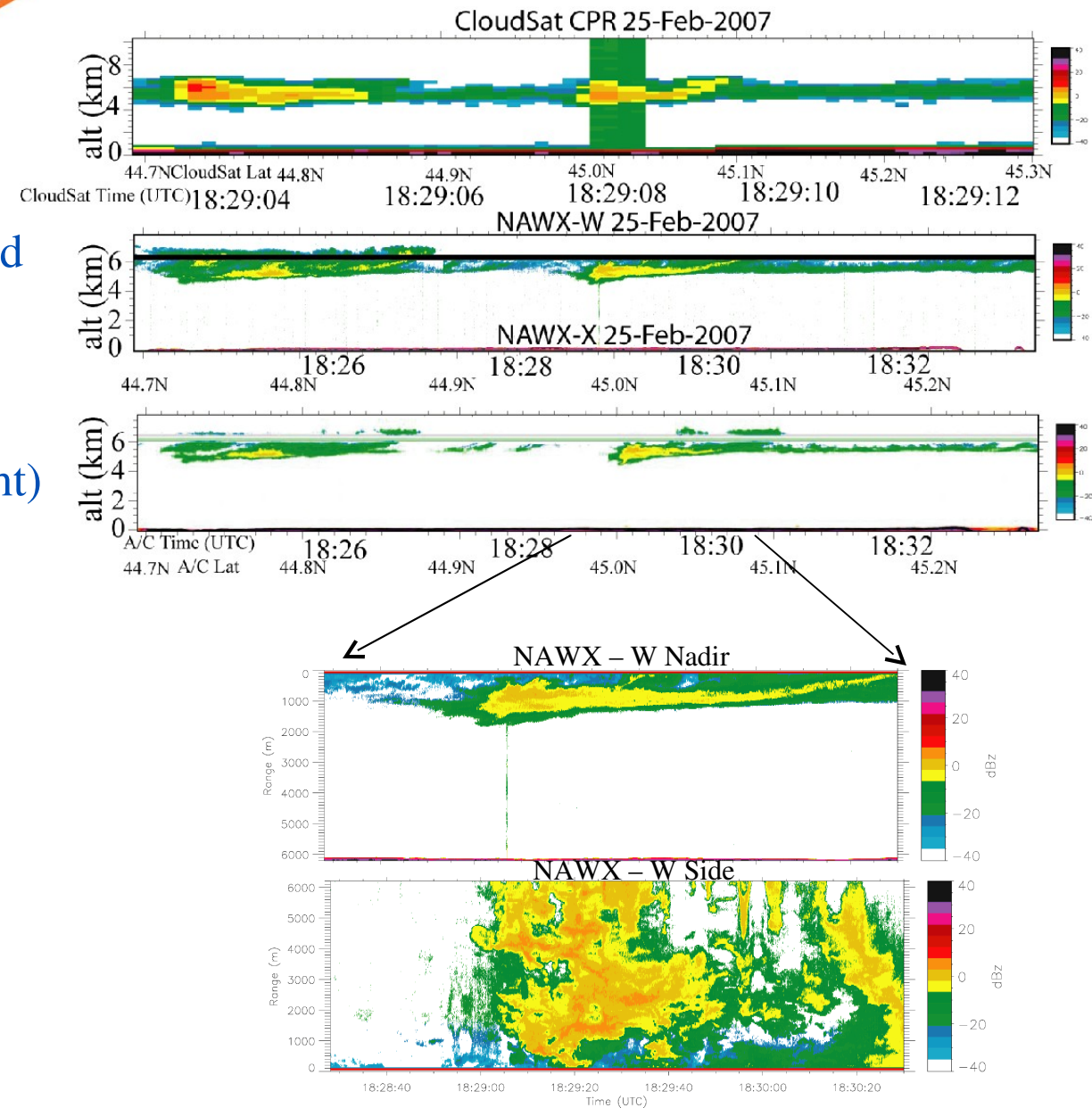
NAWX / CloudSat 25 – Feb-2007

- Mixed phase mid-level cloud – A/C flying just below cloud top
- The images (top three - right) show cloud vertical profiles obtained by CPR and the two NAWX radars.
- Horizontal Z from NAWX



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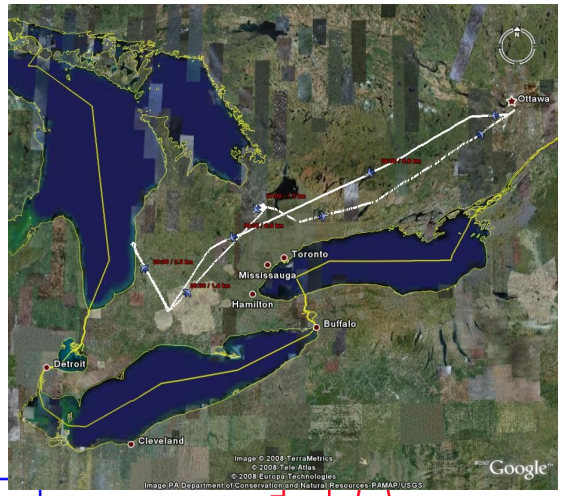
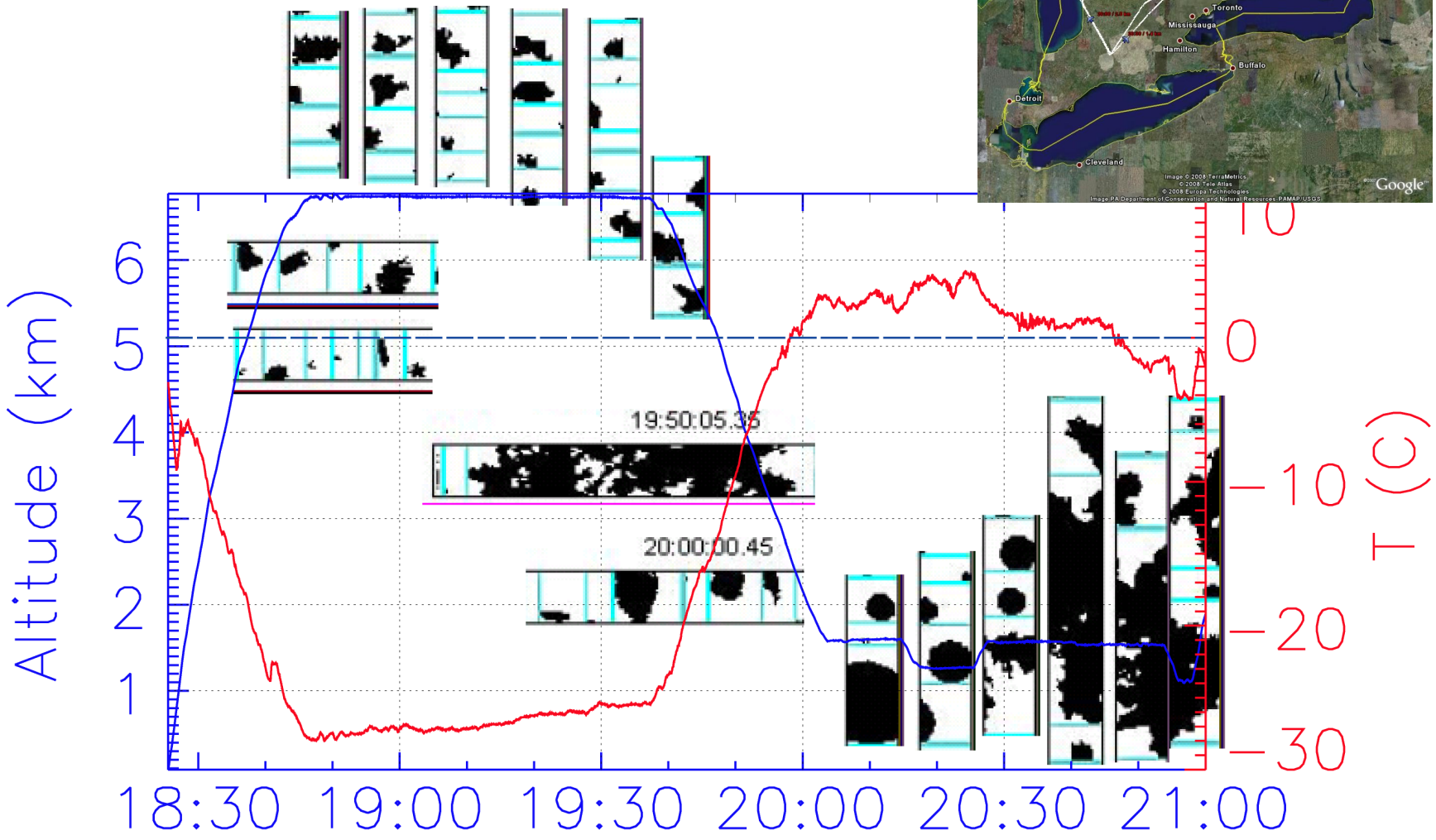
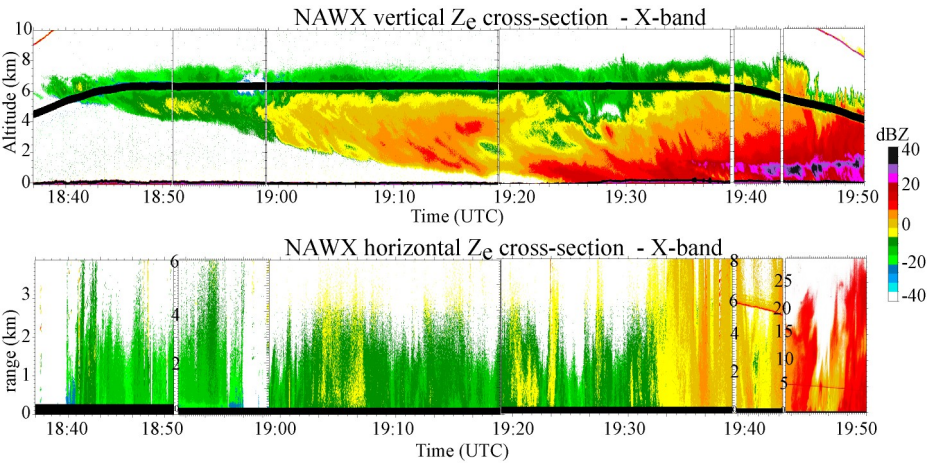
NAWX – 01-Mar- 2007

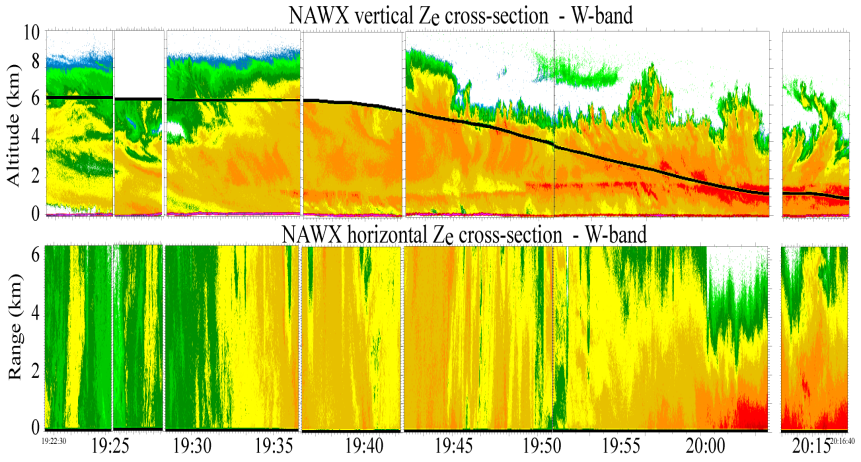
- Flight in winter storm

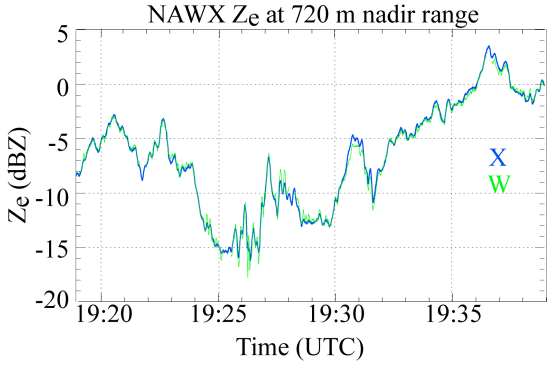


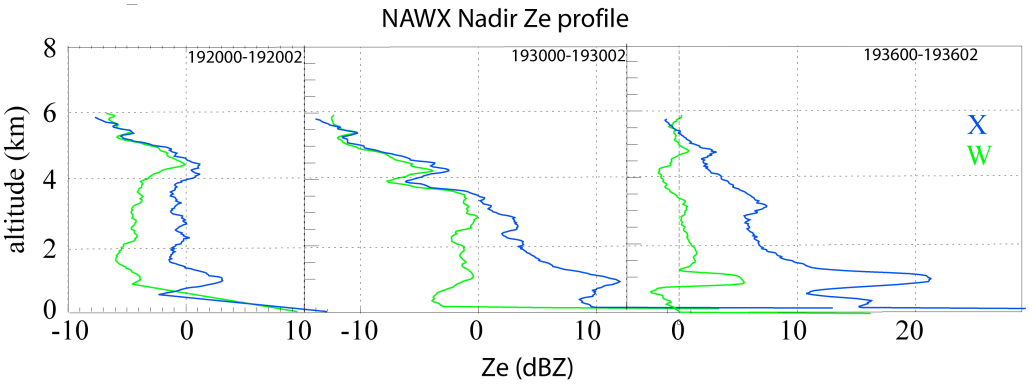


NAWX – 01-Mar- 2007









- X and W Z_e from small (<800 µm) irregular ice crystals
- Vertical profile of X and W Z_e _ note the reduction in W Ze – attenuation + mie effect

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G-band (183 GHz) water Vapor Radiometer (GVR) during C3VP

- Developed by ProSensing Inc. and installed on the NRC Convair in a wingtip pod - looking in Zenith direction
- Measures brightness temperature at 183.31 ±1, ±3, ±7 and ± 14 GHz
- Operated in C3VP, STAR and ISDAC Projects

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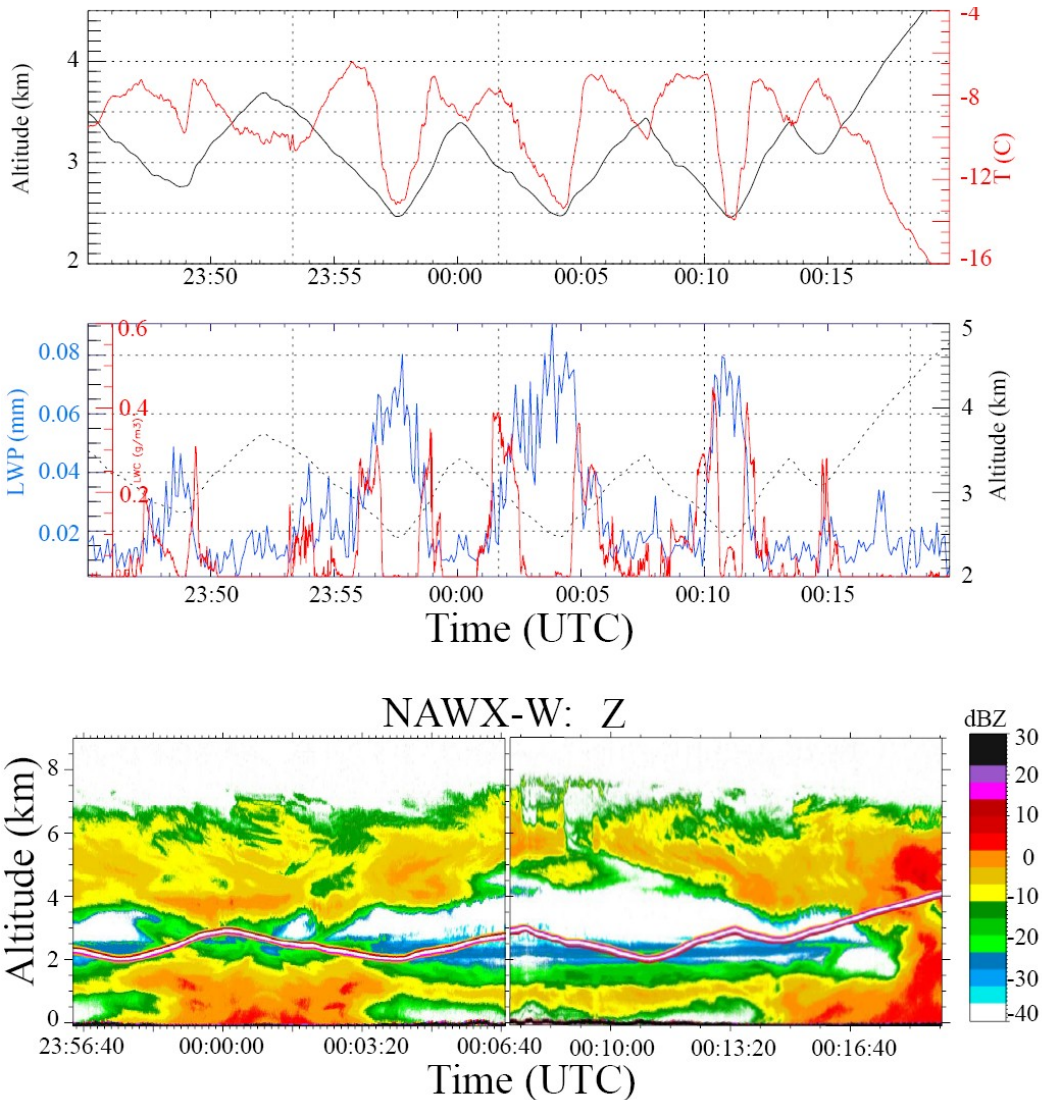
GVR/NAWX – 26-Jan-2007

- Multiple layers- Upper layer: All ice and shallow layer of supercooled drops at the top of the lower layer at T of ~ -10C°
- Convair made repeated porpoise maneuver in the liquid layer
- Good correlation between GVR and in-situ LWC measurement



- Preliminary work on retrievals of r_{eff} and N form combined GVR and NAWX data show good agreement with in-situ data (Pazmany, Wolde and Hudak – 33rd AMS radar conference, Cairns, Australia, 2007)

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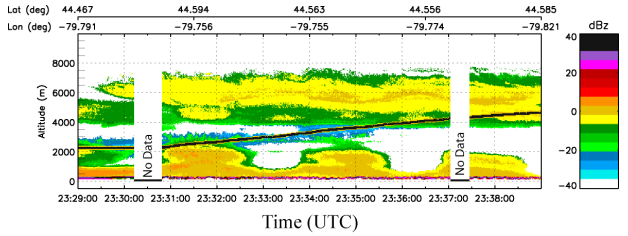

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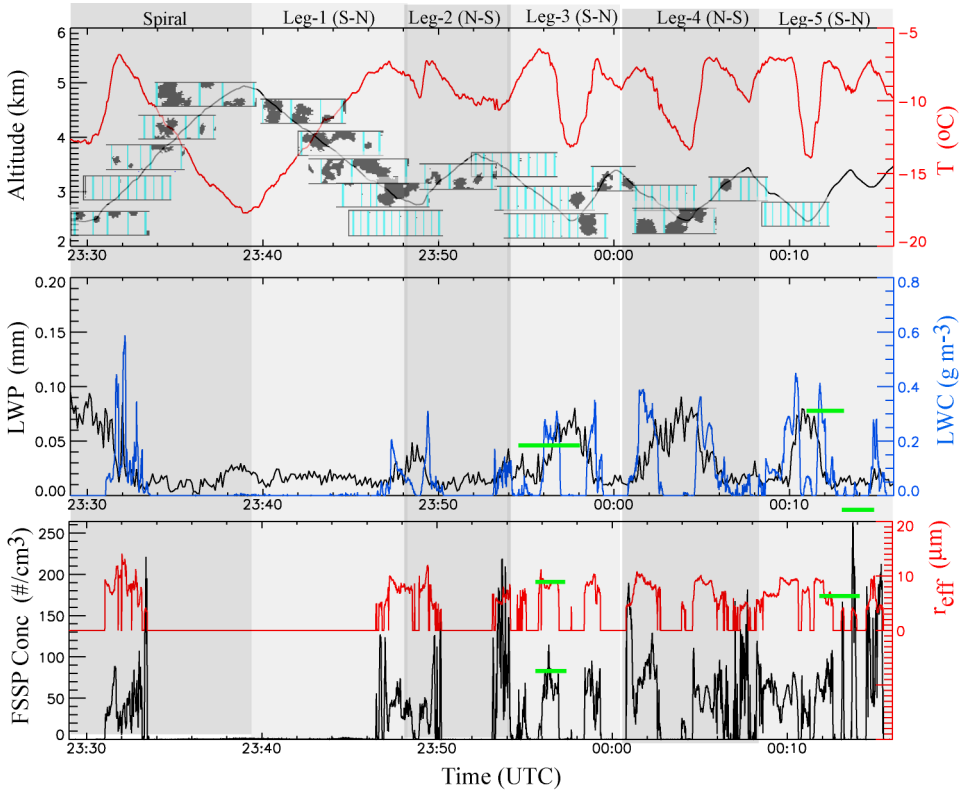

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