ERDC Icing Remote Sensing

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Gov RS Update, 25 Sept 04, NCAR, Boulder, CO

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Outline

1. Program direction
2. WaveBand
3. Radiometer simulations
4. MWISP report
5. AIRS II
6. Automated habit identification

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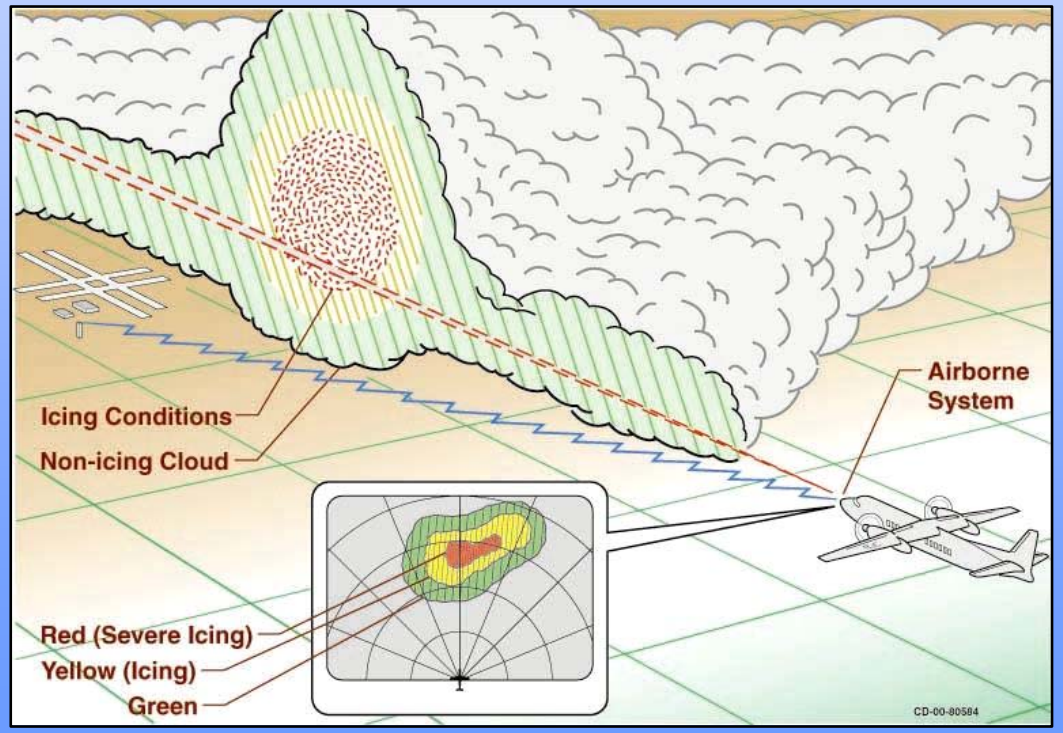
RS Program Direction

- Emphasize Inflight remote sensing for rotorcraft, UAVs, AMT, all DoD
- Characterize meteorological conditions (clustering, ice habits)



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WaveBand MMW Polarimeter

- Phase II funded
- Kickoff 16 October at CRREL
- Determine deliverables and radiometer features
- Contract let 4 November 2003
- Potential multi-functional instrument
- Reviewed by Office of Technology Protection
- AMCOM considers this work of high interest

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Remote Detection of Inflight Icing Conditions

Develop a turn-key radiometer system that meets the following requirements:

a. Design each radiometer to fit within a Particle Measuring Systems canister.

b. Each antenna shall have the same angle of view, 3 degrees or narrower.

c. Dual radiometers and dual frequencies at or near 35 GHz and 94 GHz.

d. Submit design to CRREL for review and approval before proceeding, not later than the end of 1st year contract.

e. WaveBand will perform controlled bench tests extracting the four Stokes parameters over a range of signal outputs to estimate sensitivity. This includes system calibration and validation.

f. WaveBand shall deliver the instruments as early as possible to CRREL to allow field testing by the Government before completion of contract.

g. WaveBand shall deliver a turnkey system to CRREL with a computer and software for instrument control and data acquisition no later than 30 days before end of contract schedule.

h. The Government will take possession of the prototype test radiometer system at completion of contract.

Remote Detection of Inflight Icing Conditions

Funded Phase II SBIR

- Small size, weight, power and cost
- Revolutionary design
- Fit on UAV or helicopter
- Radar or radiometer configuration
- Four Stokes parameters
- Detect icing conditions
- Improved target detection
- Synthetic vision for landing through dust, smoke, or fog
- Detection of wires
- Determine state of the ground

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Polarimeter Simulations

- NASA funding
- Simulate WaveBand polarimeter response in icing
- Use “Fly Thru” RADTRAN
- Model V and H brightness for 35 and 95 GHz
- Look horizontal, and up 2° and down 2° from horizontal
- Average LWC over 45-sec (~ 3-km) segments
- Drop spectra and temperature? Ice crystals?
- Assessed SLDRP flights
- Methodology in: Koenig, Ryerson, Nagle, *Using RADTRAN to Simulate an Aircraft Microwave Radiometer to Detect Icing Potential*, AIAA 2004-0234, Reno
- ILIR to assess other capabilities withdrawn because evaluation methodology insufficiently innovative

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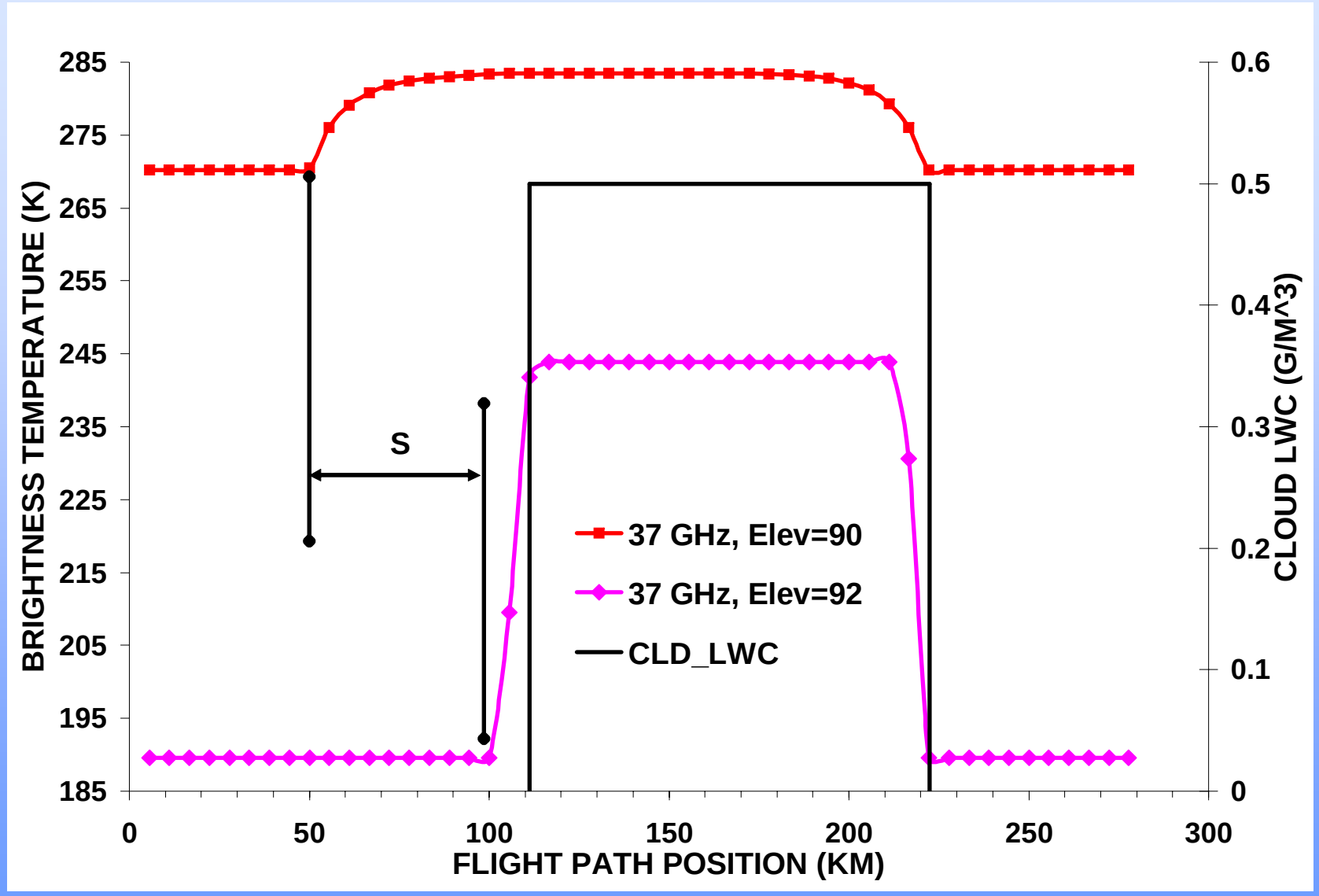

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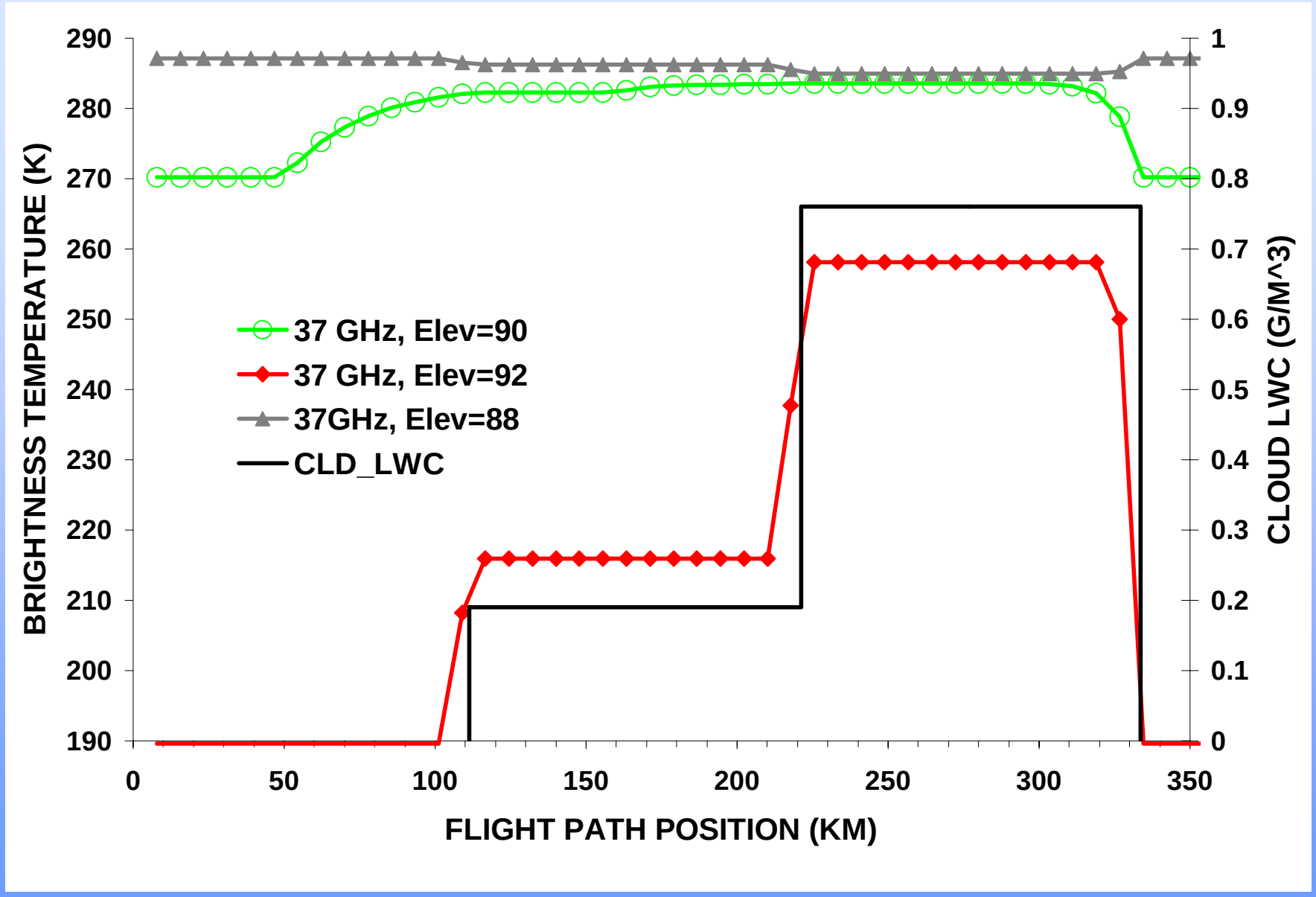

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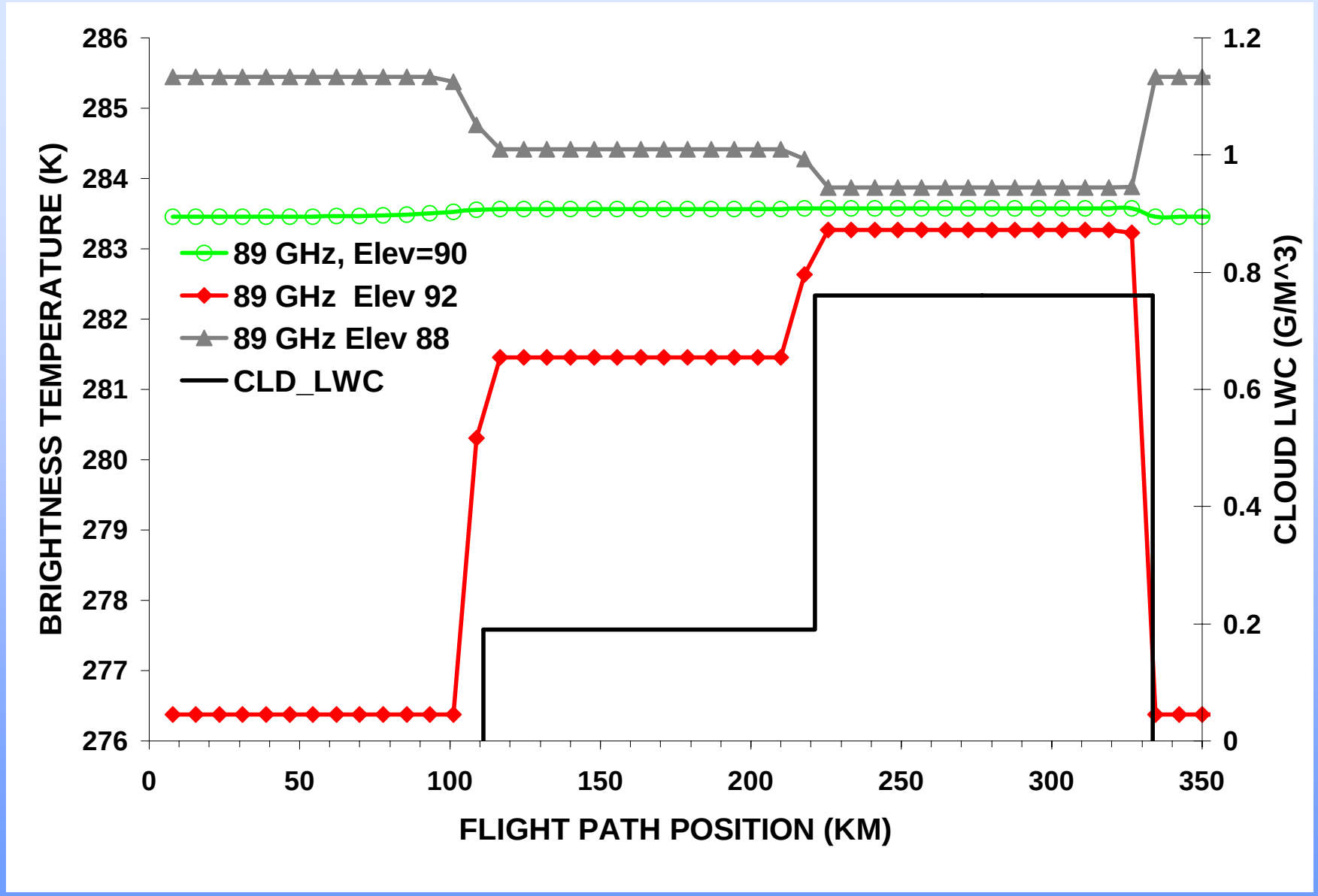
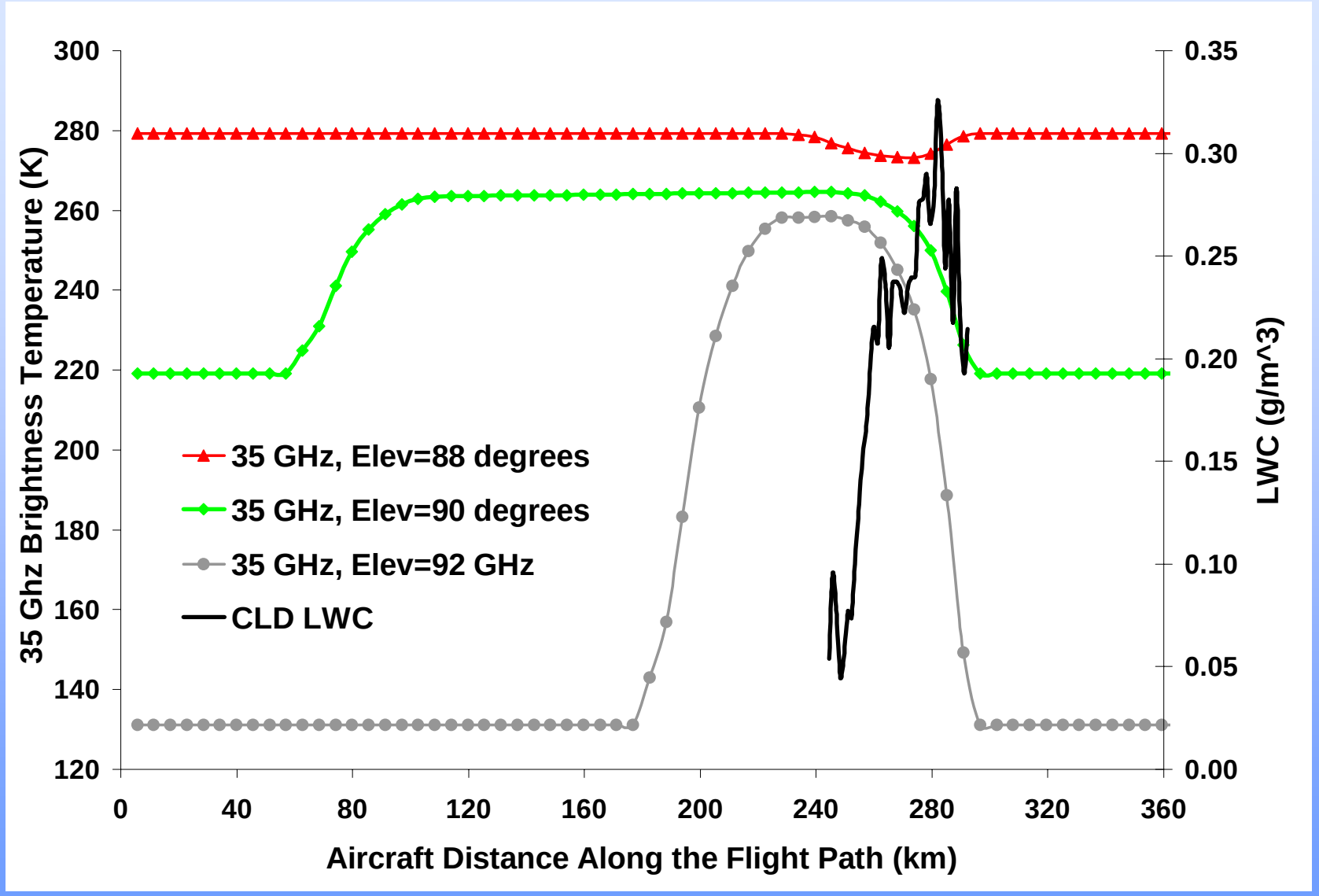

BRIGHTNESS TEMPERATURE (K)
286
285
284
283
282
281
280
279
278
277
276
CLOUD LWC (G/M^3)
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
FLIGHT PATH POSITION (KM)
89 GHz, Elev=90
89 GHz Elev 92
89 GHz Elev 88
CLD_LWC



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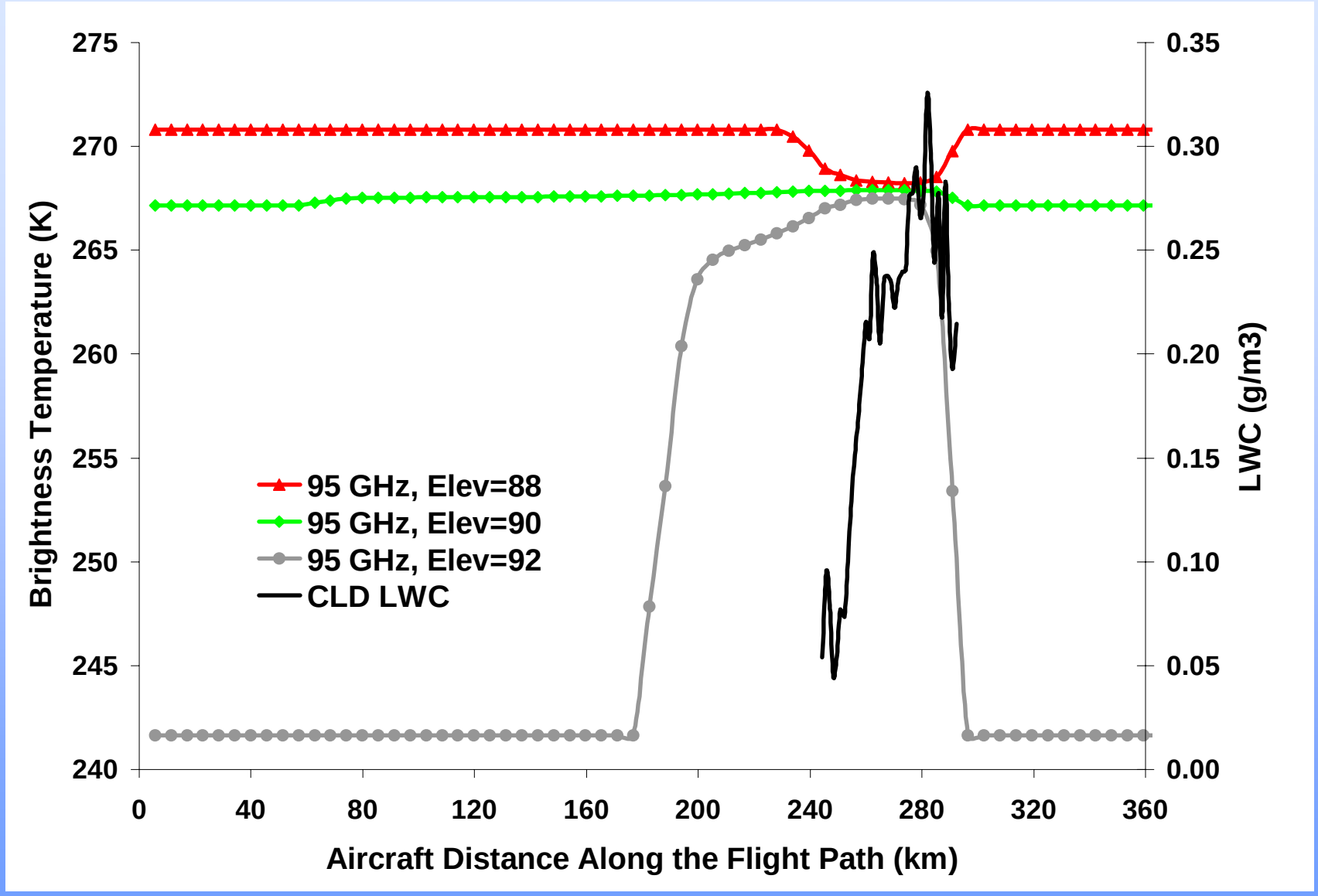

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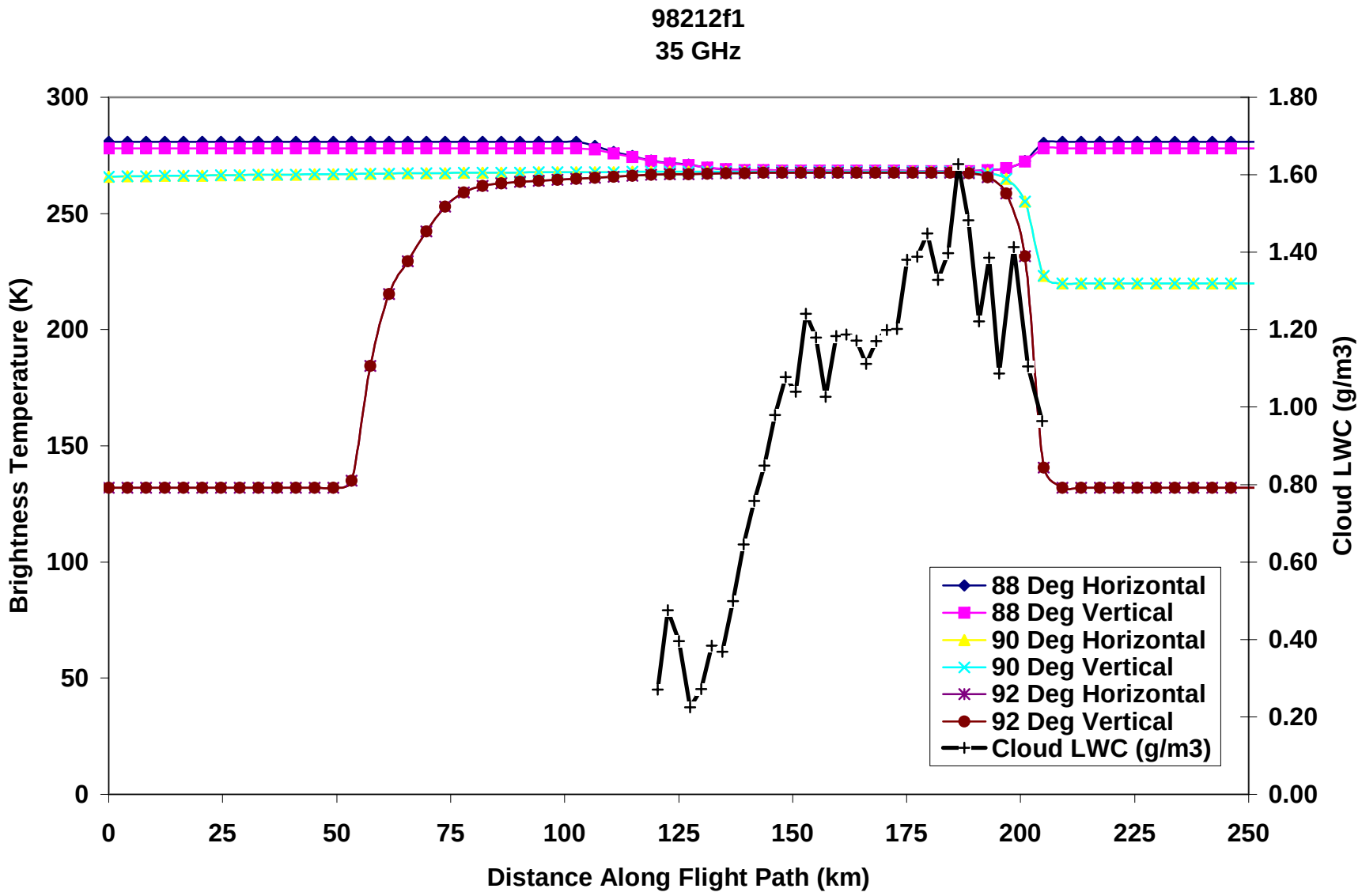

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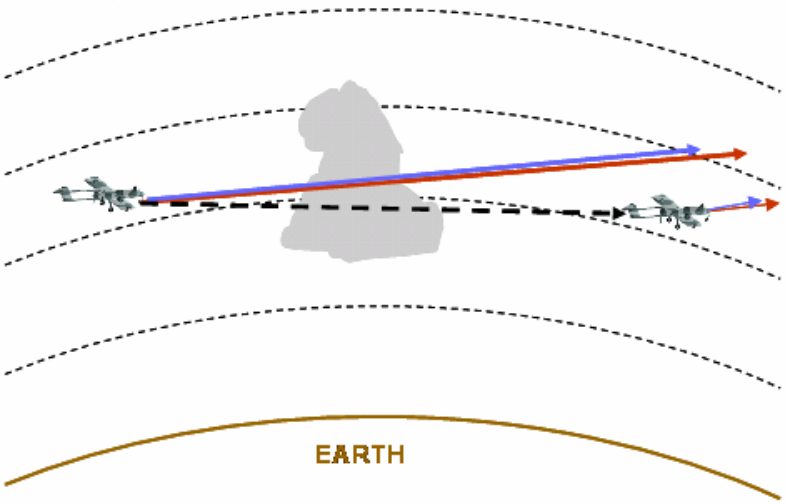
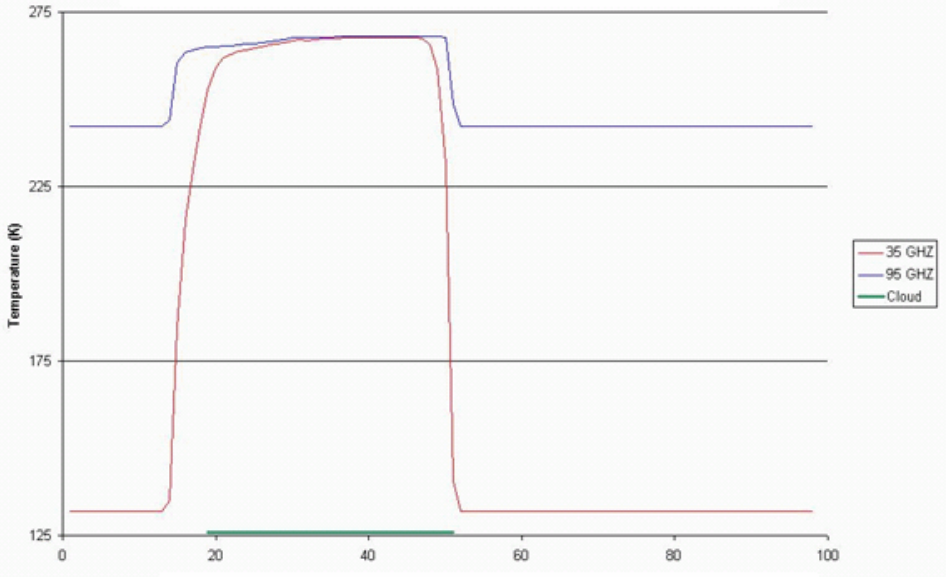
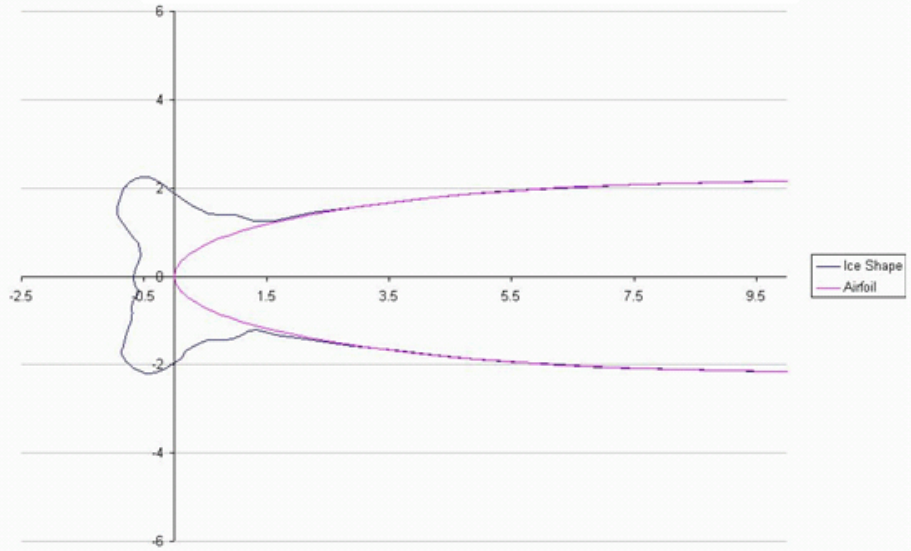
RADTRAN "Fly Thru"



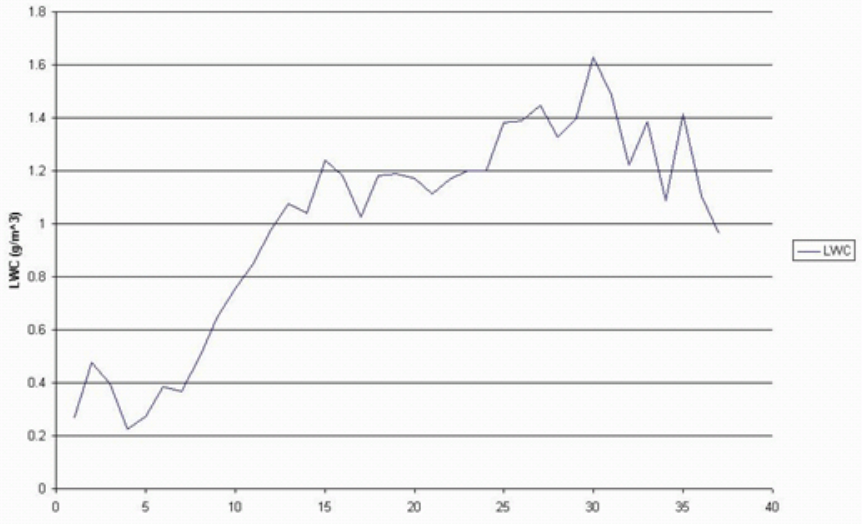
Brightness Temperature



Brightness Temperature



Liquid Water Content



CRREL MWISP Report

- Completed draft
- Reviewed by ERDC Editing and co-authors (Koenig and Scott)
- Integrating editing and co-author comments
- Includes:
  - Instrumentation
  - Weather summary
  - Probe calibration
  - Data processing
  - Products
  - LWC comparison between instruments
  - 5 CDs with 5-min summaries
  - Plymouth State Korolev particle type identification

AIRS-II

- Work with NASA-GRC and NIRSS in IOP #1 at Mirabel 14 November - 5 December (Koenig and Ryerson).
- Provided ASOS ice detector and PC for ground ice monitoring 28 Oct - 7 Nov 03 (instrument failed), and 22 January through 13 February 04
- Max ice accretion IOP #1 ~ 0.08”
- Max ice accretion IOP #2 ~ 0.20”
- Goodrich repaired instrument rapidly - excellent support
- Mirabel surface obs on order
- Using new ASOS algorithm developed by Ramsay and Ryerson

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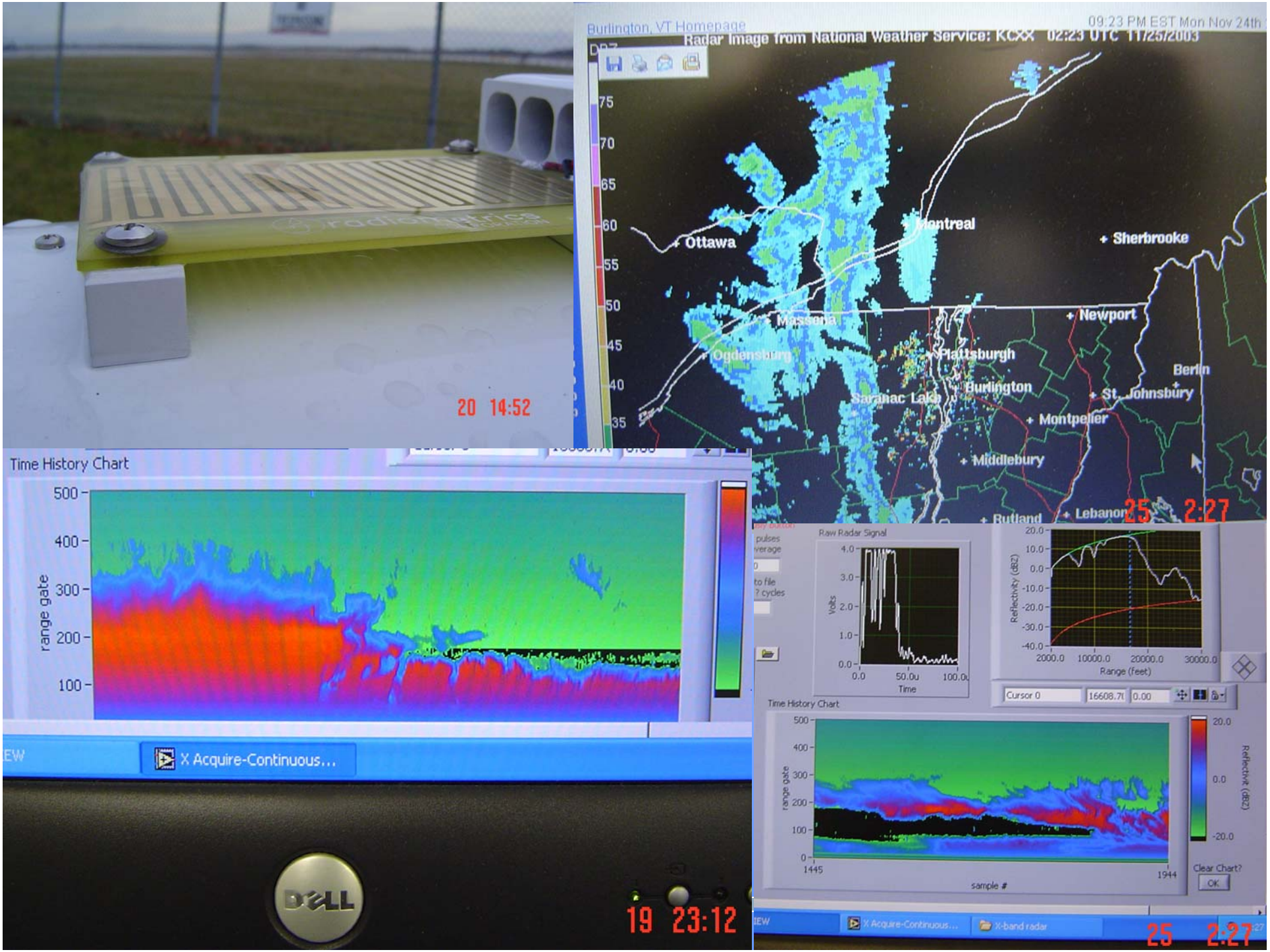
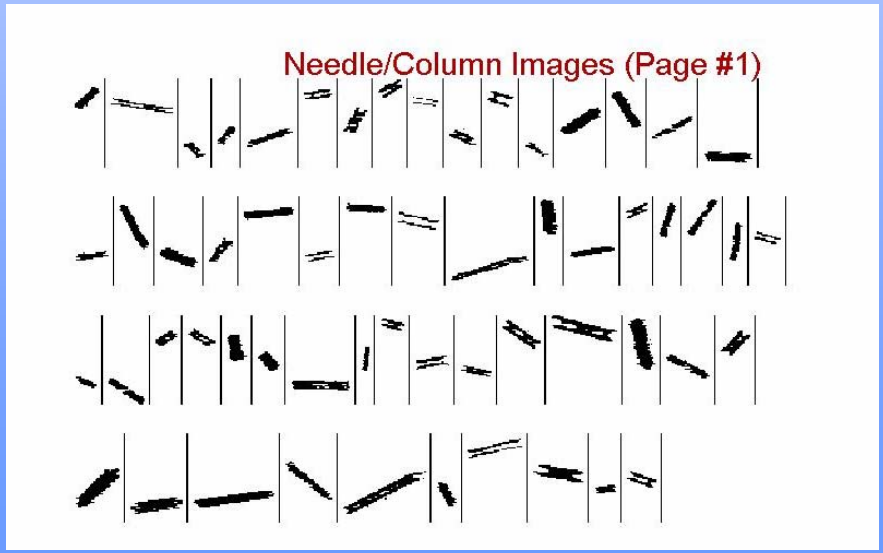

20 14:52
Burlington, VT Homepage
09:23 PM EST Mon Nov 24th
Radar Image from National Weather Service: KCXX 02:23 UTC 11/25/2003
75
70
65
60
55
50
45
40
35
Ottawa
Montreal
Sherbrooke
Massena
Newport
Ogdensburg
Plattsburgh
Berlin
Saranac Lake
Burlington
St. Johnsbury
Montpelier
Middlebury
Rutland
Lebanon
25 2:27
Time History Chart
500
400
300
200
100
range gate
X Acquire-Continuous...
DELL
19 23:12
Raw Radar Signal
Volts
Time
Reflectivity (dBZ)
Range (feet)
Cursor 0
Time History Chart
range gate
sample #
Clear Chart?
OK
X Acquire-Continuous...
X-band radar
25 2:27

Automated Habit Identification

- Using S. Cober software
- Rewrote MatLab software to allow creation of habit databases
- Comparing human and machine selections for drops to determine how well computer represents human judgment after training
- Now selecting columns - single vs crossed. Selecting columns not cut off by image edge.



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Automated Habit Identification

TGXBox: XBoxLen: Box X dimension along flight
TGYBox: YBoxLen: Box Y dimension along diode array
TGArea: PartArea: Particle area - all shadowed pixels
TGPerm: Perimeter: calculate the total perimeter
TGPerC: PermCalc: perimeter computed using the average diameter PermCalc = pi*DiaPAvg
TGXSli: XSliceLen: maximum slice in X dimension of particle
TGYSli: YSliceLen: maximum slice in Y dimension of particle
TGBoAx: BoxAxisRat: axis ratio for the box
BoxAxisRat = max([XBoxLen YBoxLen])./min([XBoxLen YBoxLen])
TGPaAx: PartAxisRat: axis ratio for the particle slices
PartAxisRat = max([XSliceLen YSliceLen])./min([XSliceLen YSliceLen])
TGPaSl: PartSliceRat: Slice to box ratio - largest of (XBoxLen/XSliceLen) or (YBoxLen/YSliceLen)
TGPaAr: PartAreaRat: area ratio for the particle (calculation for ellipse)
PartAreaRat = (0.25*pi*XBoxLen.*YBoxLen)./PartArea; equals 1.0 if a circle.
TGPaPe: PartPermRat: perimeter ratio for the particle (calculation for ellipse)
PartPermRat = ((pi/sqrt(2))*(sqrt(XBoxLen.^2 + YBoxLen.^2))./PermCalc;
TGPaPA: PermAreaRat: perimeter to area ratio for the particle
PermAreaRat = (4.0*PartArea)./(PermCalc.*mean([XBoxLen YBoxLen]));
TGPaHo: PartHoleRat: worst case hole ratio for the particle PartHoleRat = TotHoles./PartArea;
unfilled holes. If there are 4 or fewer holes, then 4 or fewer holes are filled - max of 2
internal and 2 external holes. If more than 4 holes, then no holes are filled.
TGPARa: DiaPARat: compare area and perimeter diameters DiaPARat = DiaPAvg./DiaAAvg;
TGPeBo: PermAreaBox: perimeter to area ratio for a box PermAreaBox = 2.0*(DiaPMax +
DiaPMin)./(sqrt(DiaPMax.*DiaPMin)); equals π for a circle. Should be a different constant
for different particle types.

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Summary

- **WaveBand work is of considerable interest, and is promising.**
- **Must make more progress on radiometer modeling**
- **Locate funding for polarimeter multifuntionality testing**
- **Continuing Cober and clustering work**
- **Complete MWISP report**
- **Wish to continue to participate in remote sensing of icing and cloud physics work**