

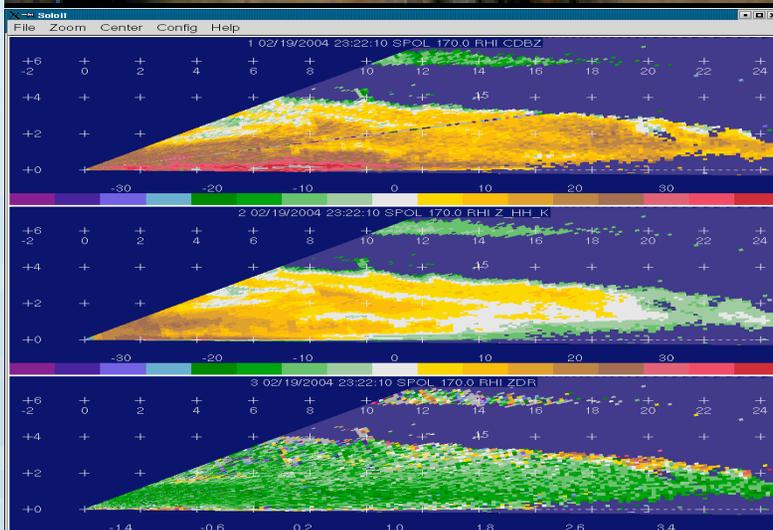
Icing Remote Sensing

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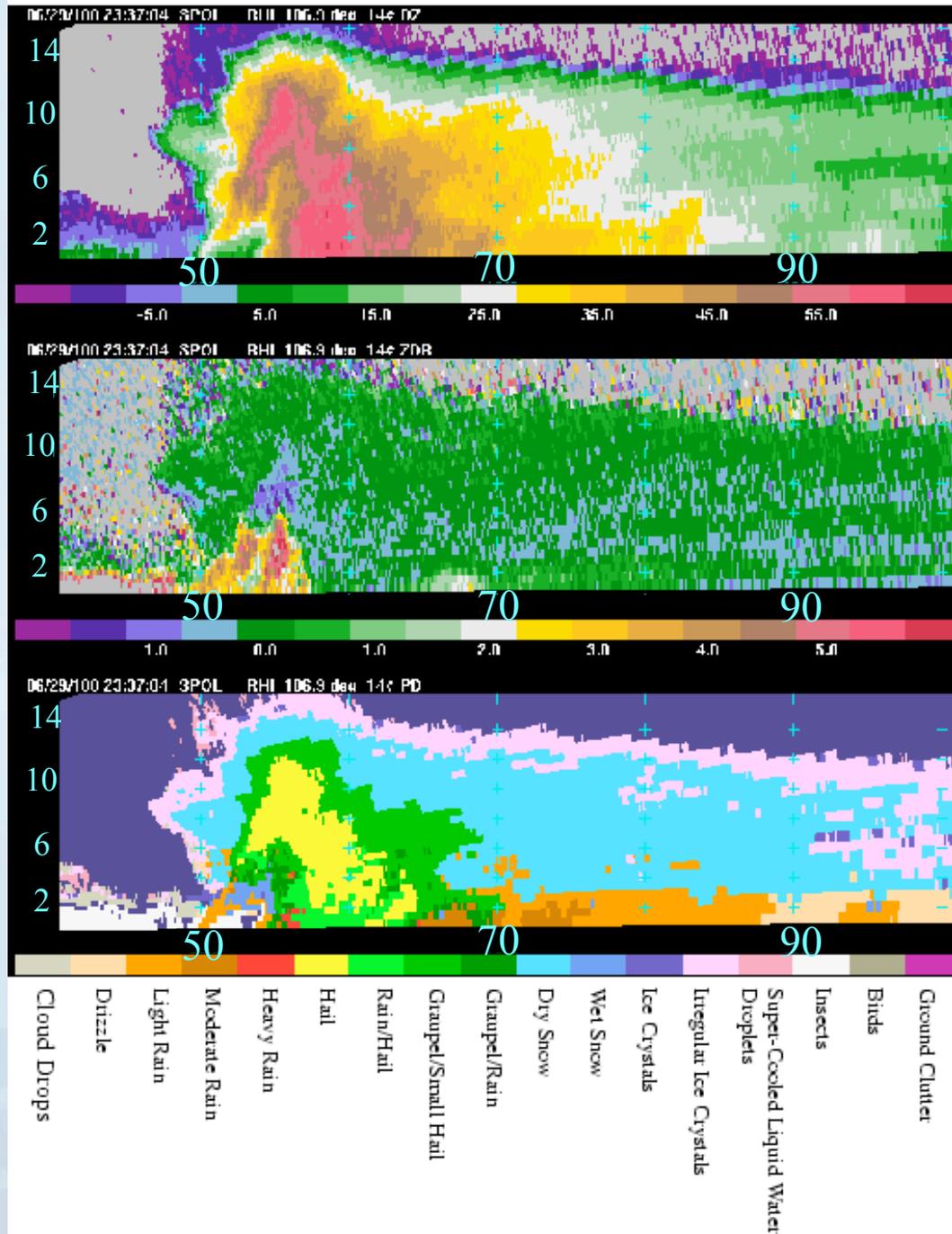


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- I. Introduction
- II. S-Polka system description
- III. Microwave satellite
- IV. GOES and S-Pol
- V. Research issues

STEPS RHI: June 29, 23:37:04

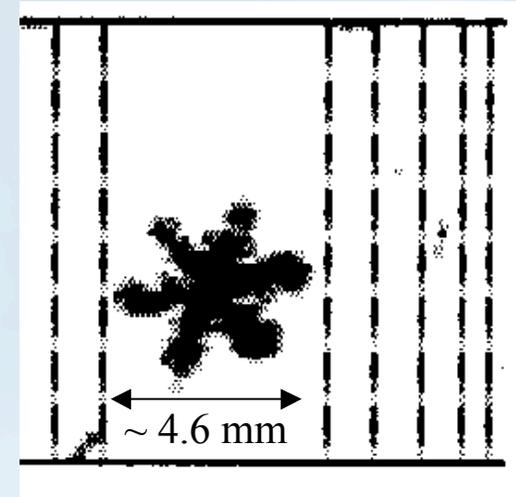
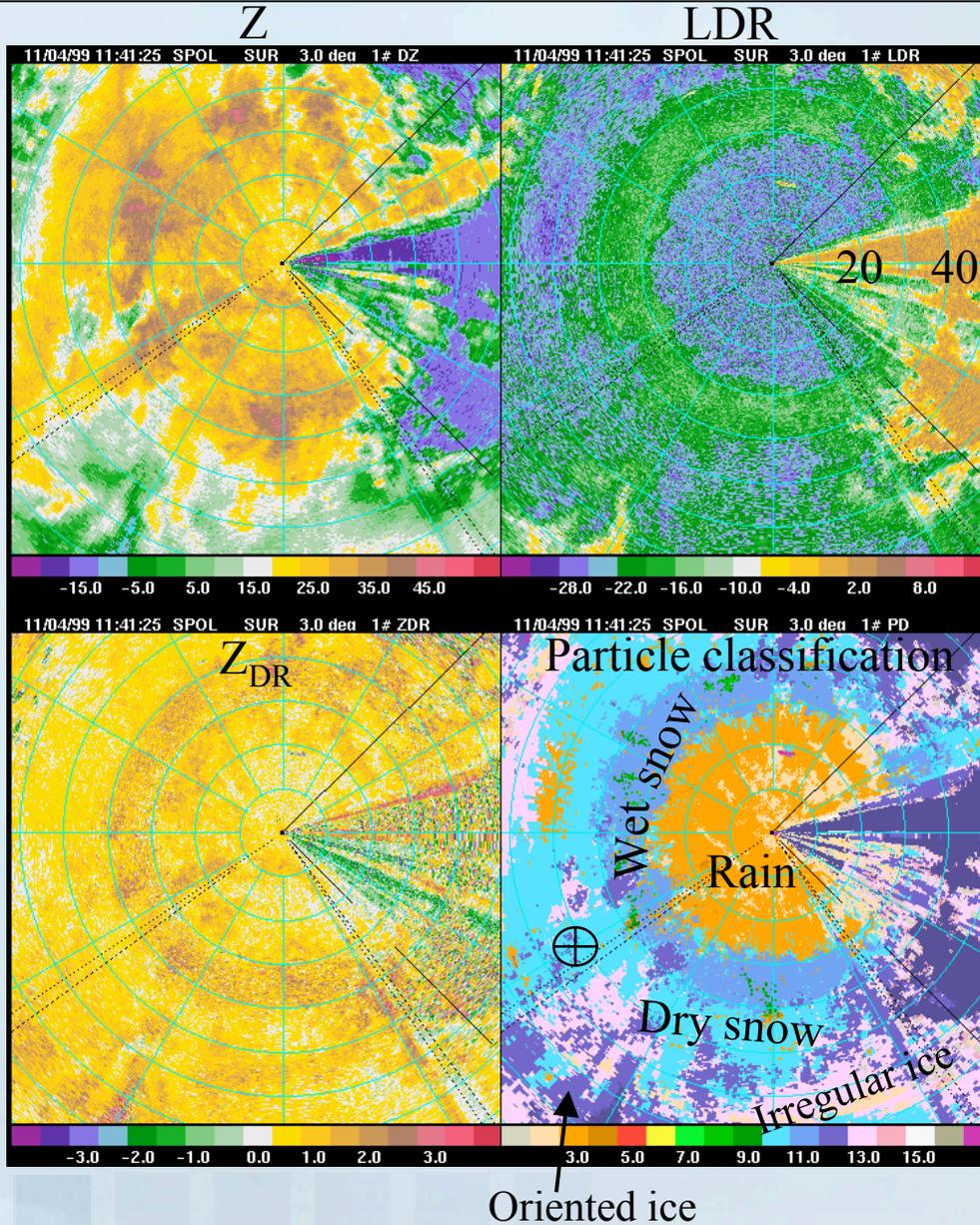


Z_{DR}

Particle ID

Case 3: MAP, Italy 1999

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RICE – no icing occurred

PMS – crystals and aggregates

Radar – dry snow

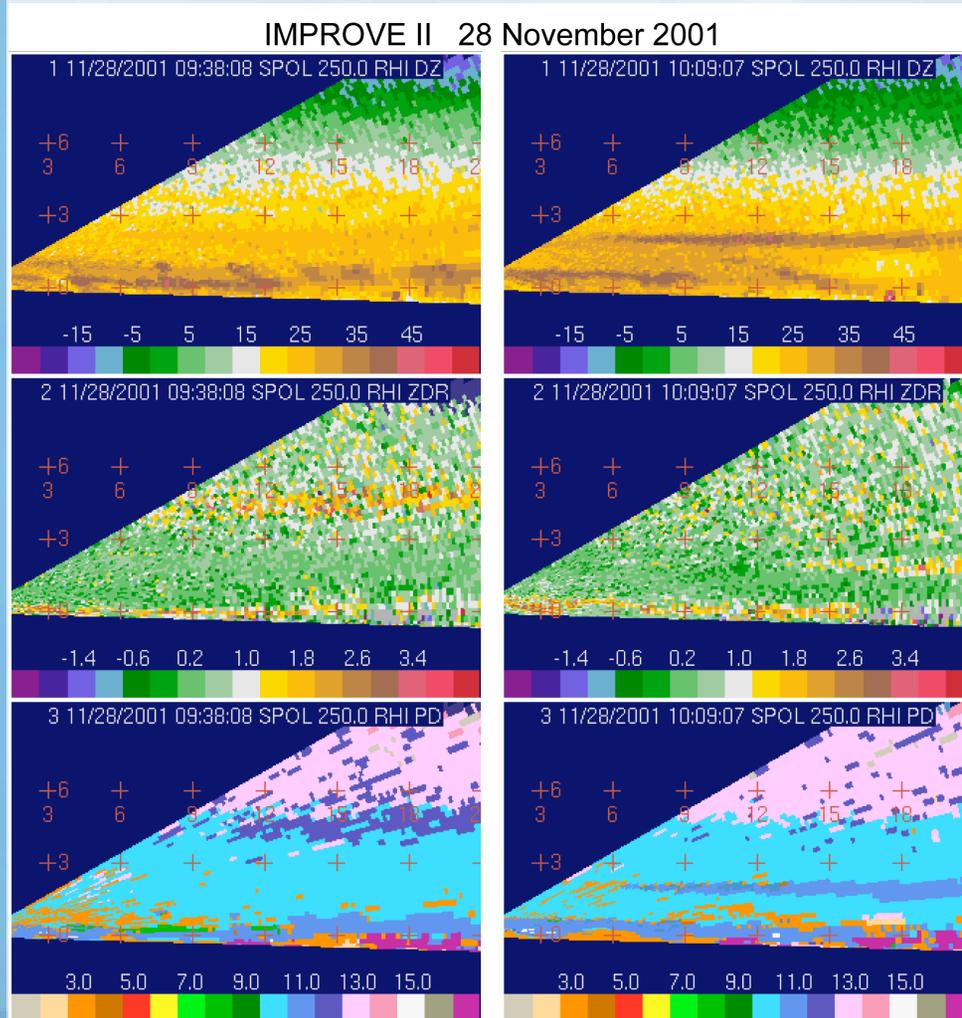
⊕ ~ Aircraft location

Particle Typing Using Polarization radar data



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Hydrometeor Designations



1	Cloud Drops	10	Dry Snow
2	Drizzle	11	Wet Snow
3	Light Rain	12	Ice Crystals
4	Moderate Rain	13	Irregular Ice Crystals
5	Heavy Rain	14	Super-cooled Liq. Drops
6	Hail	15	Insects
7	Rain/Hail	16	Birds
8	Graupel/ Small Hail	17	Ground Clutter
9	Graupel/ Rain		



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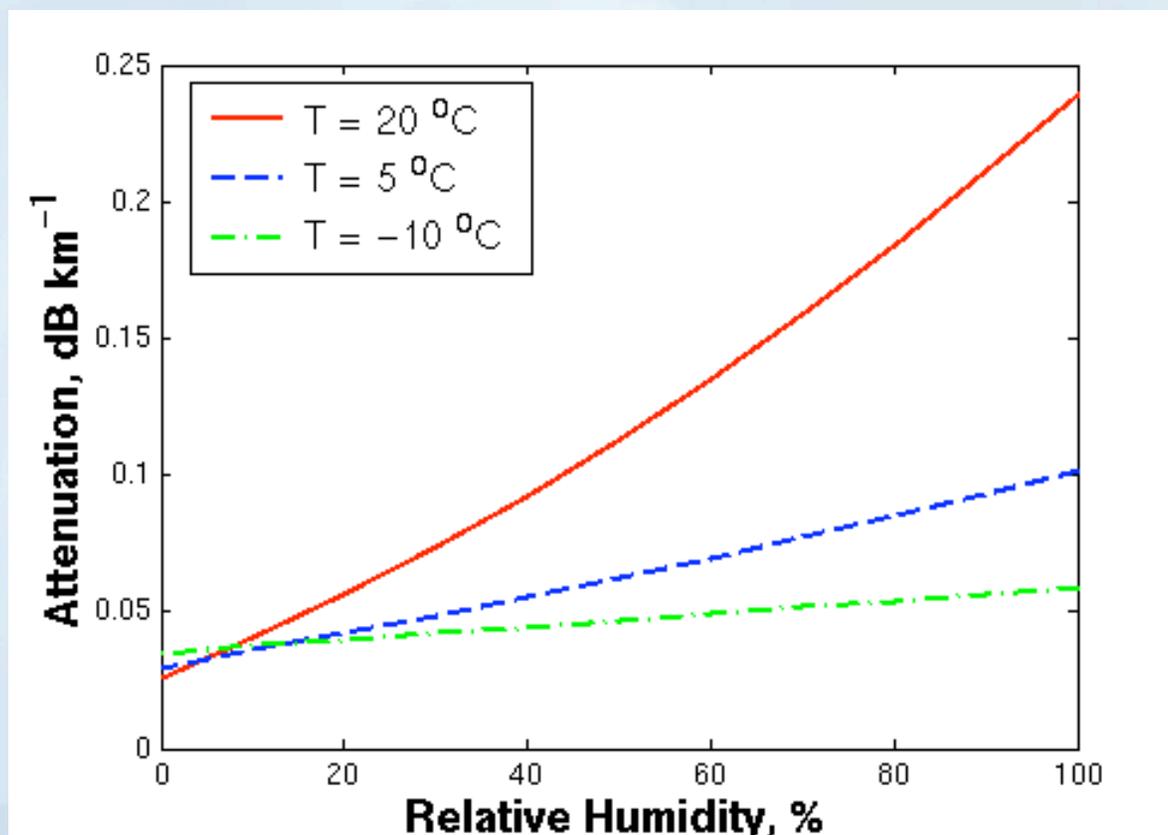
S-Polka radar system at the Marshall field site near Boulder during WISP04 project.

Radar characteristics

Radar band	S	K _a
Frequency (GHz)	2.8	35
Antenna diameter (m)	8.57	0.685
Beam width (degree)	0.91	0.91
Pulse width (10 ⁻⁶ s)	1	1
Peak power (Kw)	600	40
Receiver noise temp. (K°)	240	350
Receiver bandwidth (MHz)	1.2	1.2
Processor gain (dB)	6	6
Transmit path loss (dB)	2.5	5.5
Dry air atten. (dB/km)	0.01	0.025
Cloud atten. (dB/km/(g/m ³))	0.01	1.36

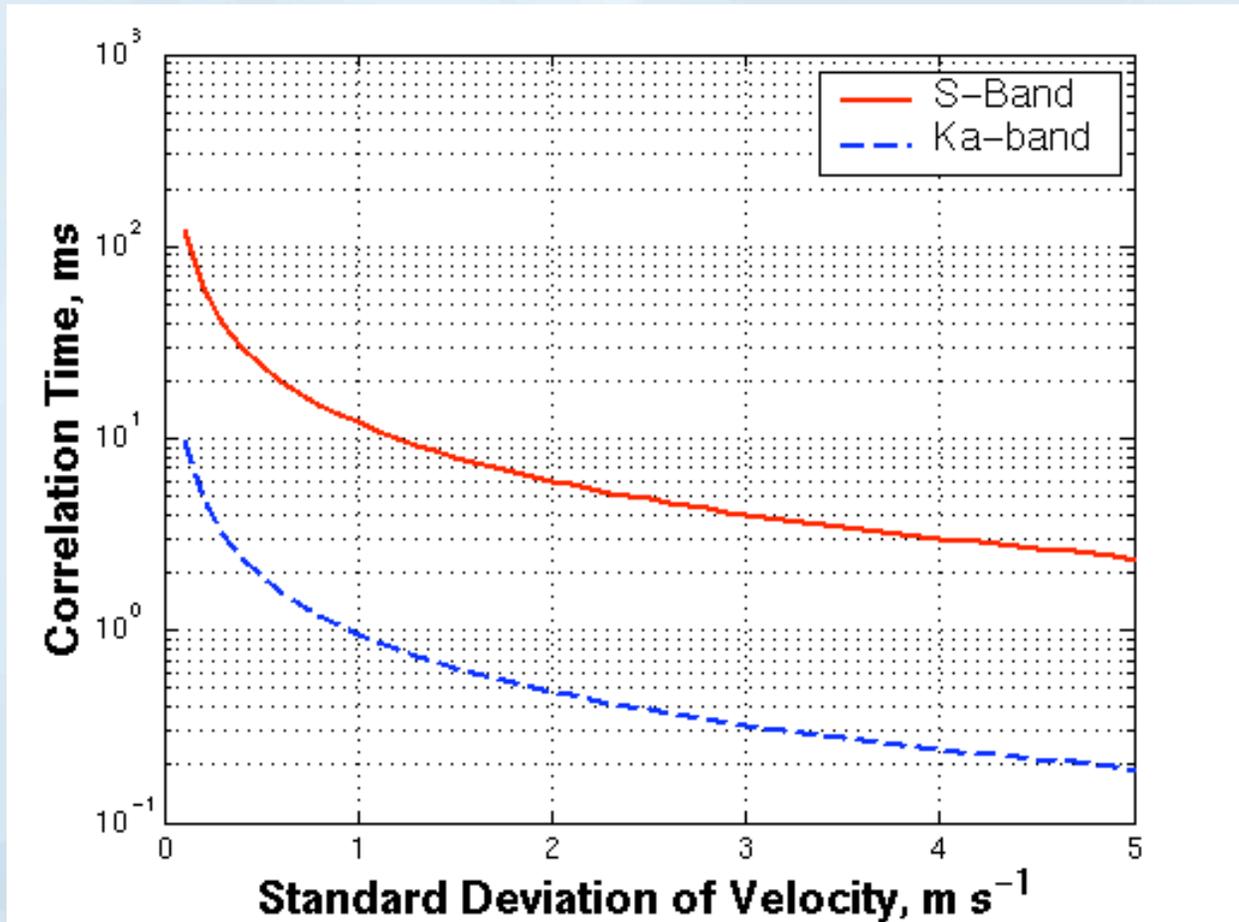


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Ka-band attenuation as a function of relative humidity for various ambient temperatures.



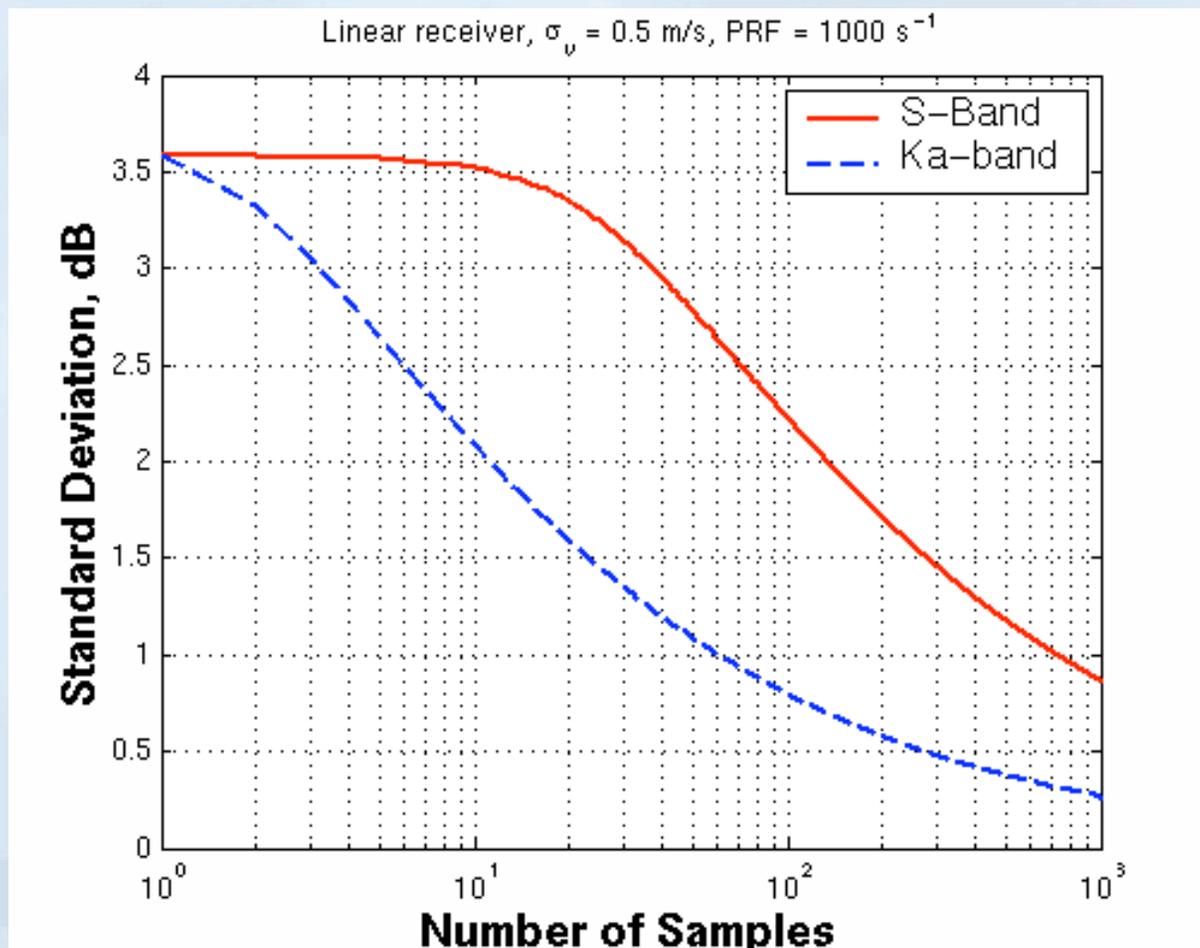


Time-to-decorrelation verses standard deviation of velocity.





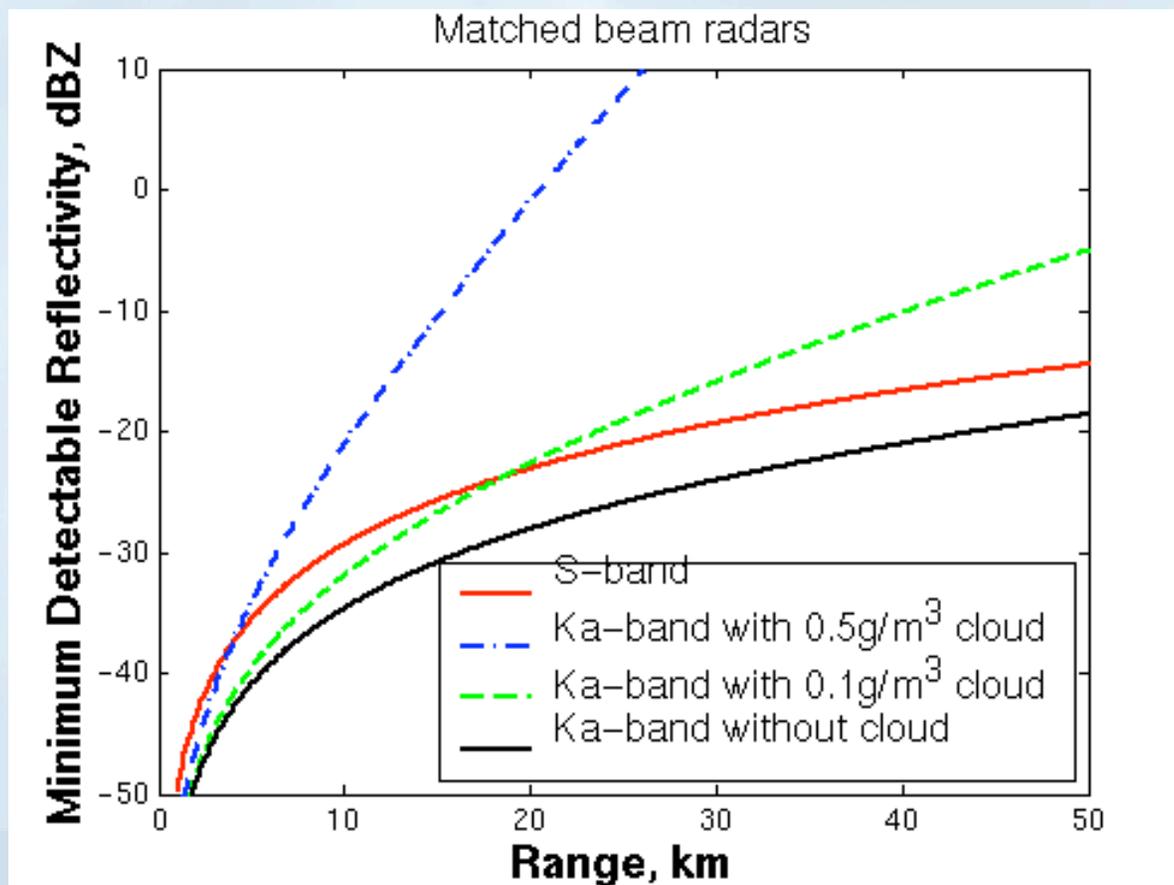
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Error in reflectivity measurement verses number of samples for a specified PRF and standard deviation of radial velocity.



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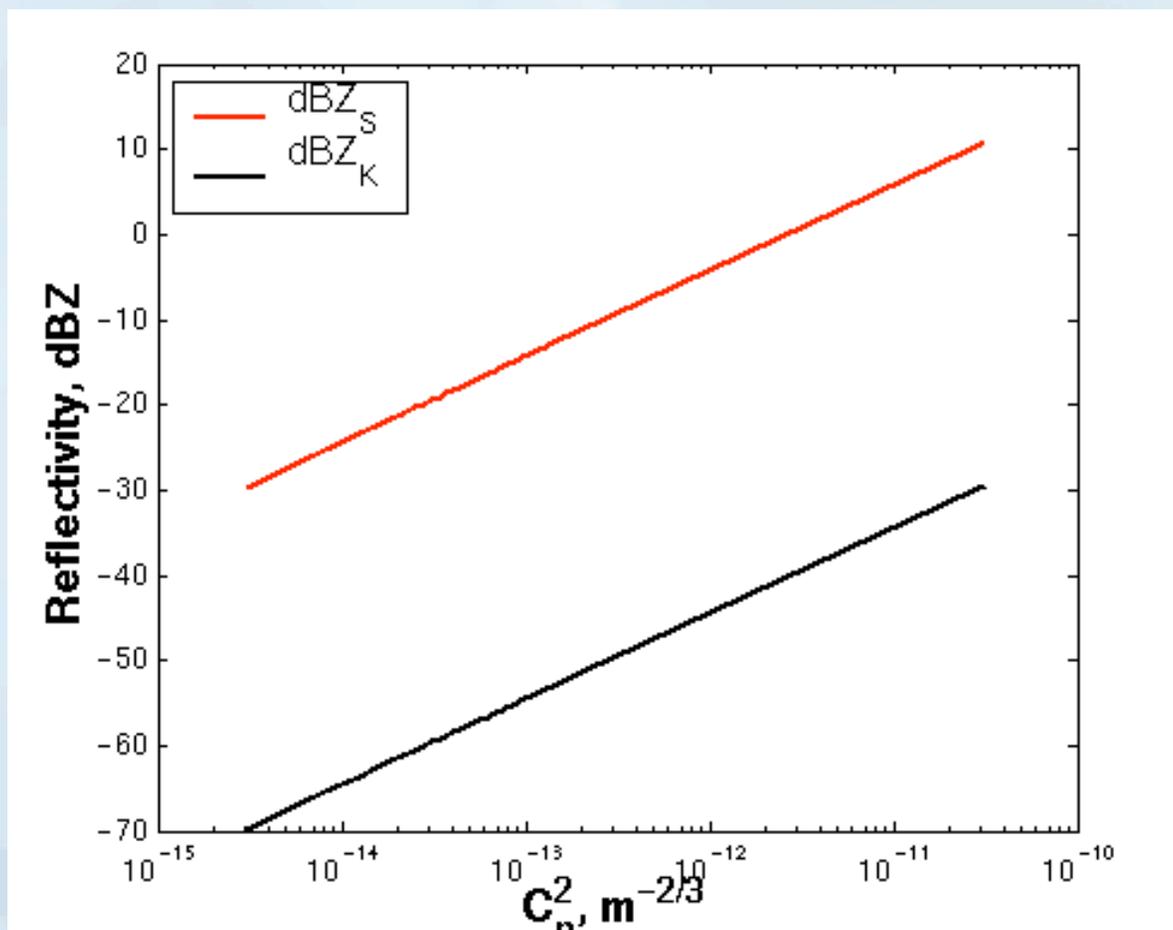


Minimum detectable reflectivity for a matched S- and K_a-band system.



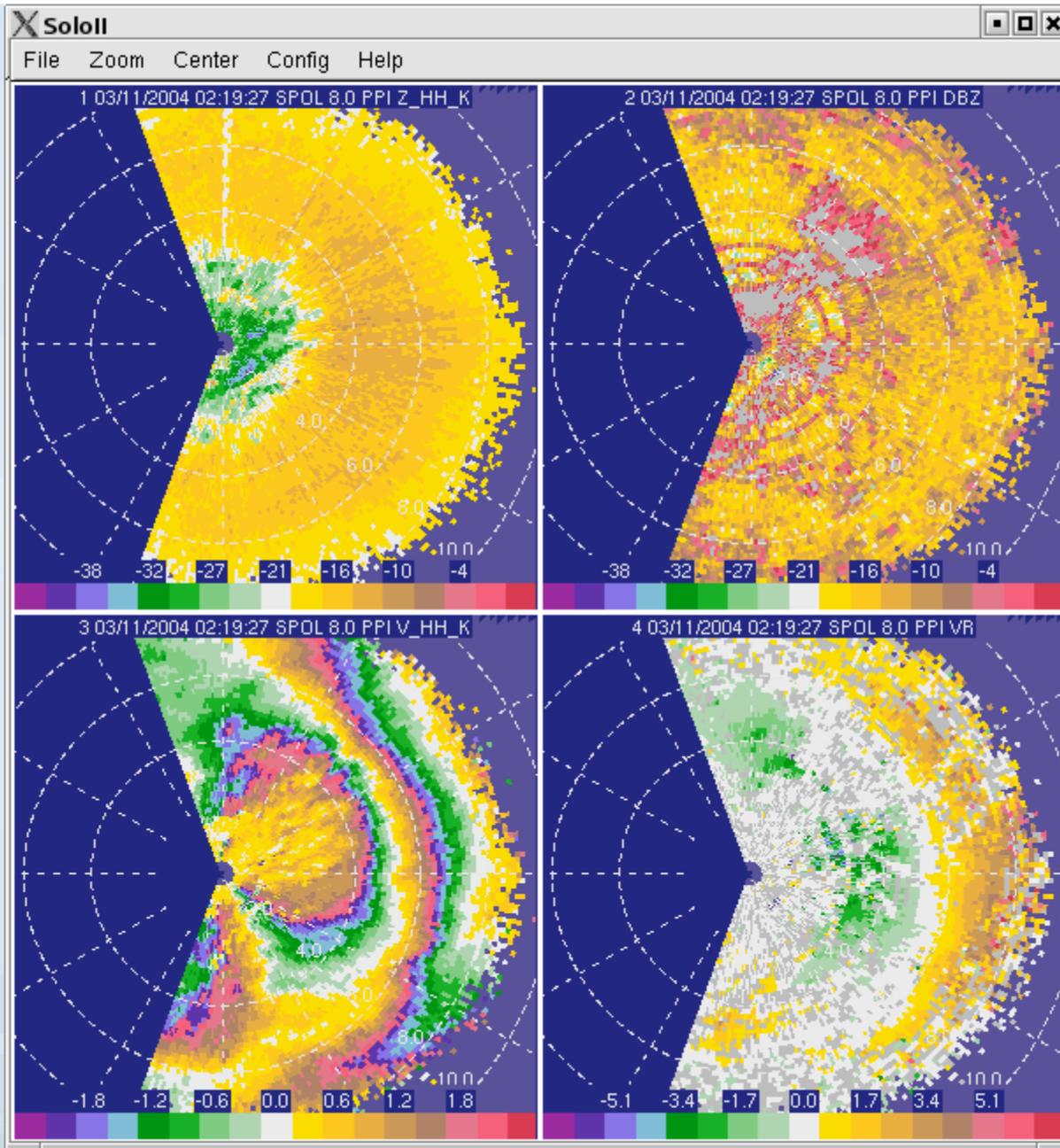


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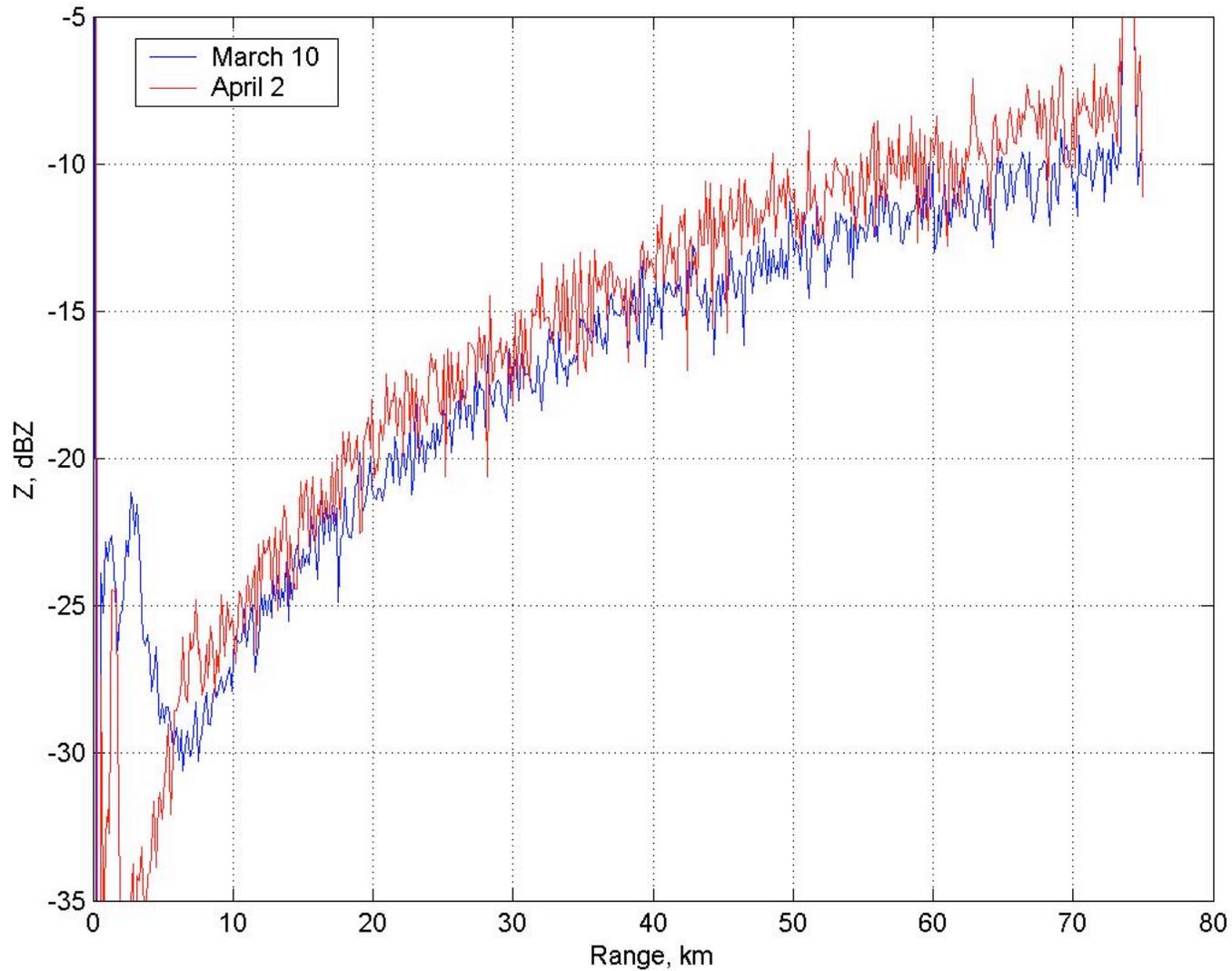


Reflectivity as a function of refractive index structure constant (spatial fluctuation in moisture field)





Sample Plane Parallel Indicator (PPI) Scan From WISP04, 2004.



Plots of minimum detectable reflectivity (dBZ) for SNR = 0 dB. The red line is a plot of the values presented above, the other lines are plots of actual blue sky reflectivity measurements for the days indicated. These plots will likely change when the final data set is produced with all the known corrections applied.

Marshall Test Site

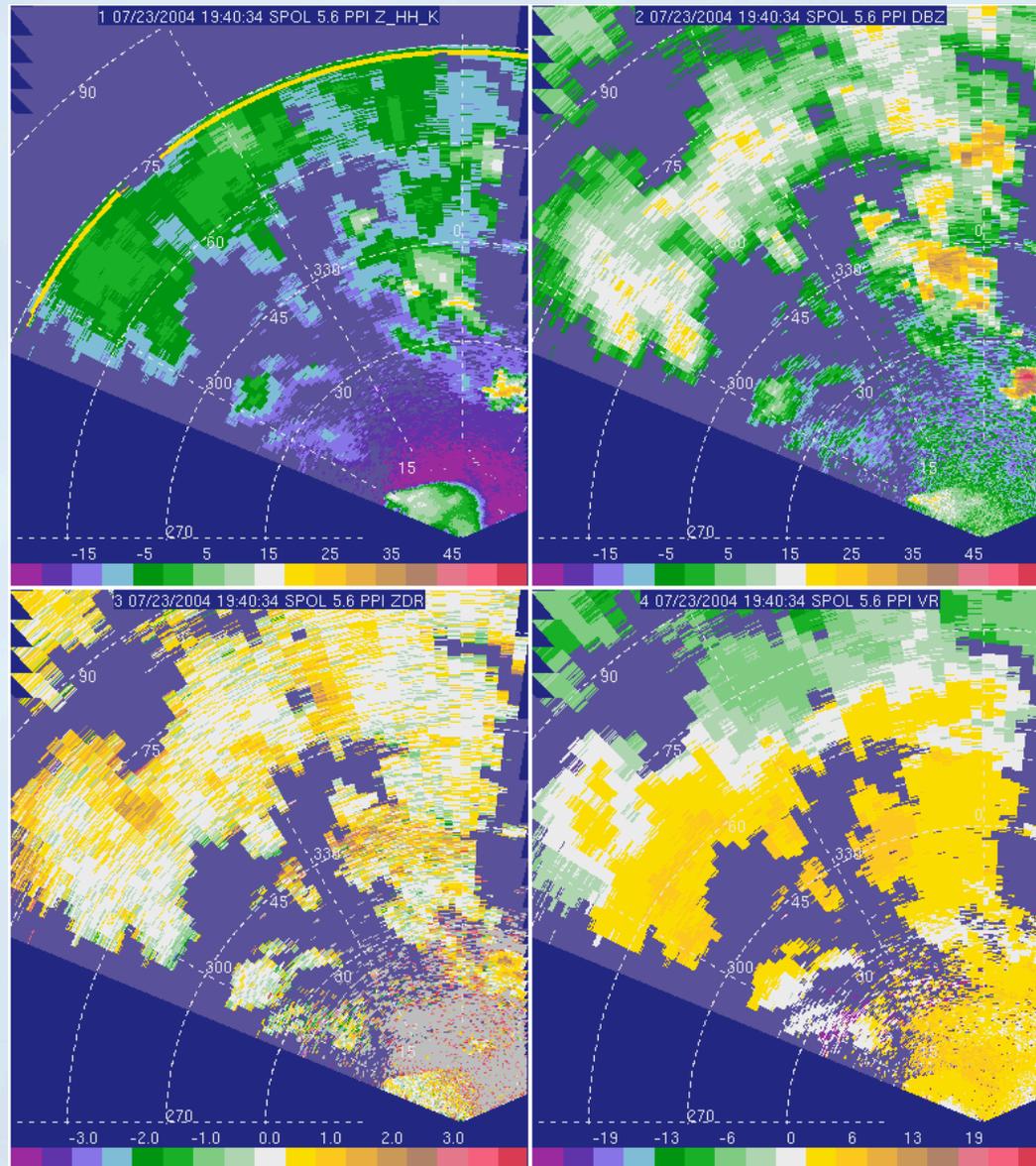


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The following is a brief summary of the data:

- 19 February: light snow, drizzle
- 28 February: upslope cloud, some snow
- 29 February: snowstorm northeast of a line approximately FNL – FTG
- 4 March: heavy wet snow in northerly flow
- 10-11 March: stratiform upslope cloud with high liquid water content
- 27 March: rather patchy cloud
- 2 April: convection and notable Ka-band attenuation
- 3 April: stratiform, uniform cloud



K-band reflectivity (Z_HH_K, upper left), S-band reflectivity (DBZ, upper right), reflectivity difference (ZDR, lower left) and radial velocity (VR, lower right) during NAME project light drizzle event on 23JUL2004 at 19:40 GMT at 5.6 degrees elevation.

Advantages of dual-wavelength system

- Detection and estimation of cloud droplets within 50 km range
- Onset of raindrop formation from drizzle i.e. droplet size
- Better identification of Bragg and particle scatter
- Improved cloud microphysical retrieval using both dual-wavelength and dual-polarization observations

Possible upgrades

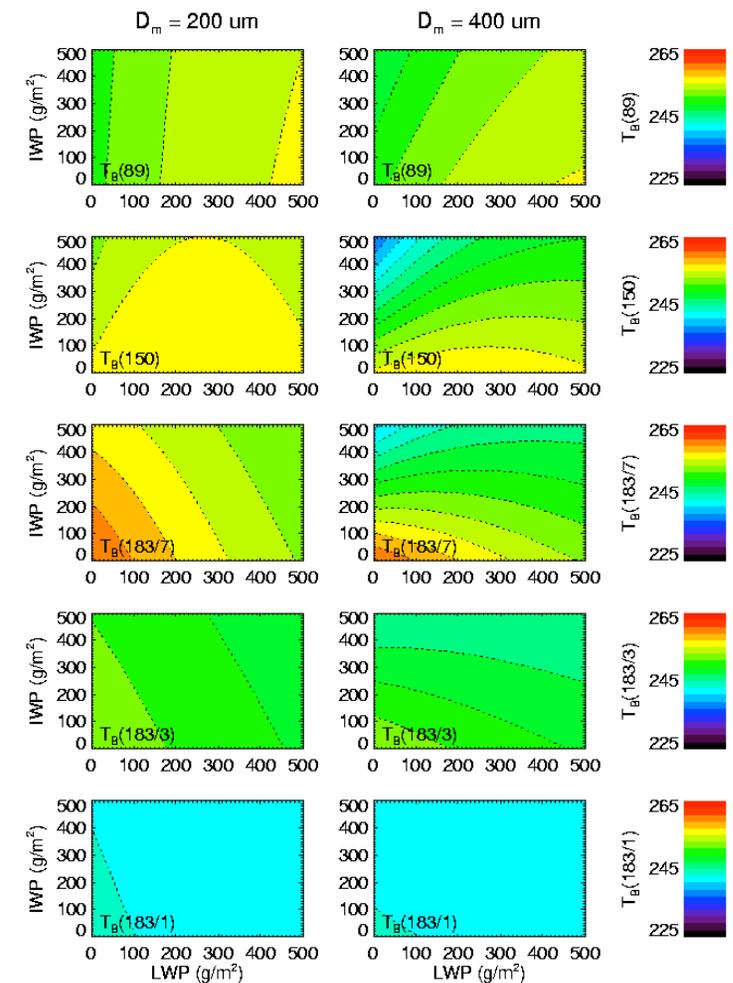
- Improve reliability and sensitivity of the system
- Collocate mm wave radar with NEXRAD and TDWR systems

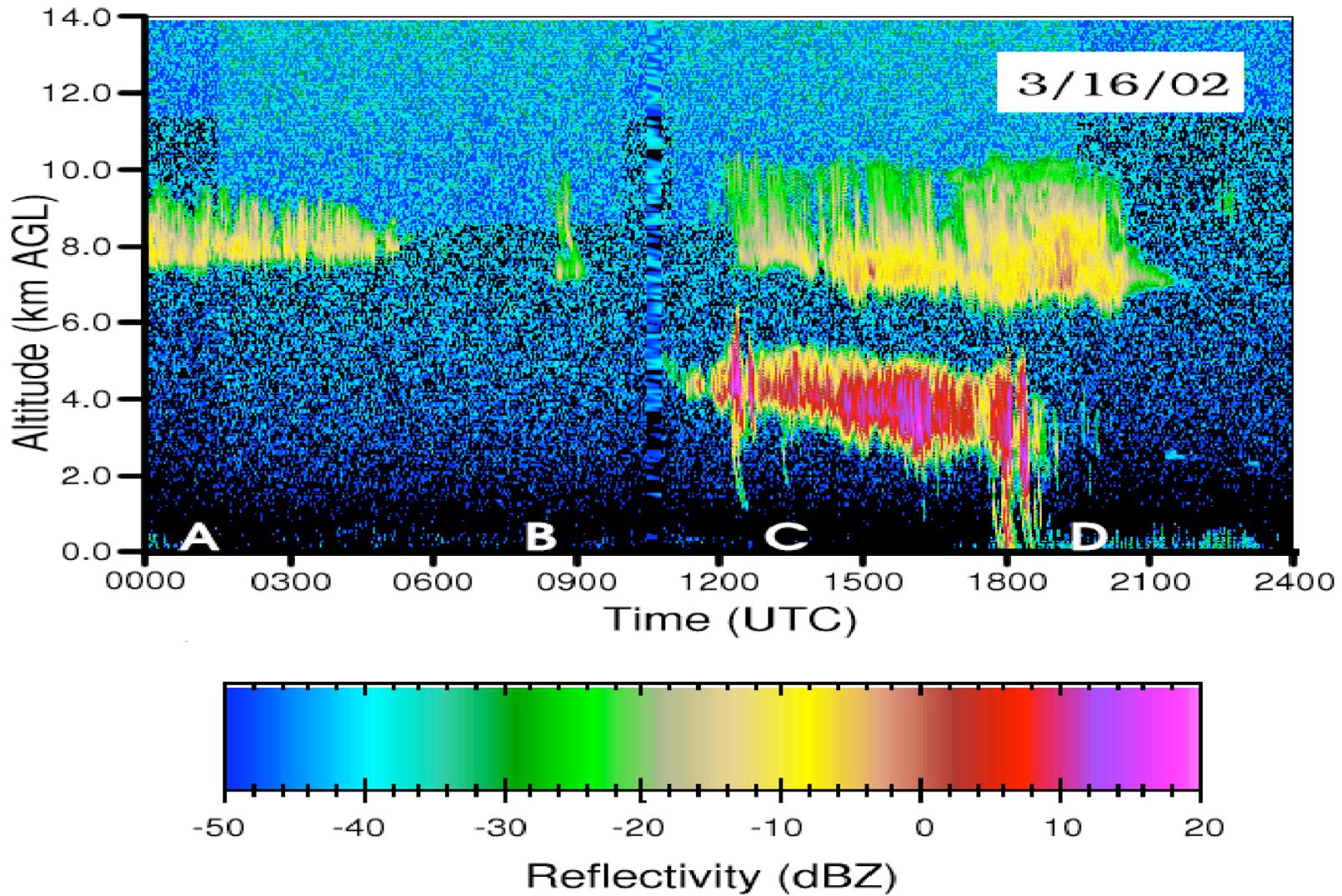
Microwave Radiation Transfer Modeling

Model results for 3-km thick mixed-phase cloud shown at right.

Results for each AMSU-B channel shown as brightness-temperature contours vs. liquid water path (horiz. axis) and ice water path (vert. axis).

Left and right columns show results for medium (200 μm) and large (400 μm) ice particles.

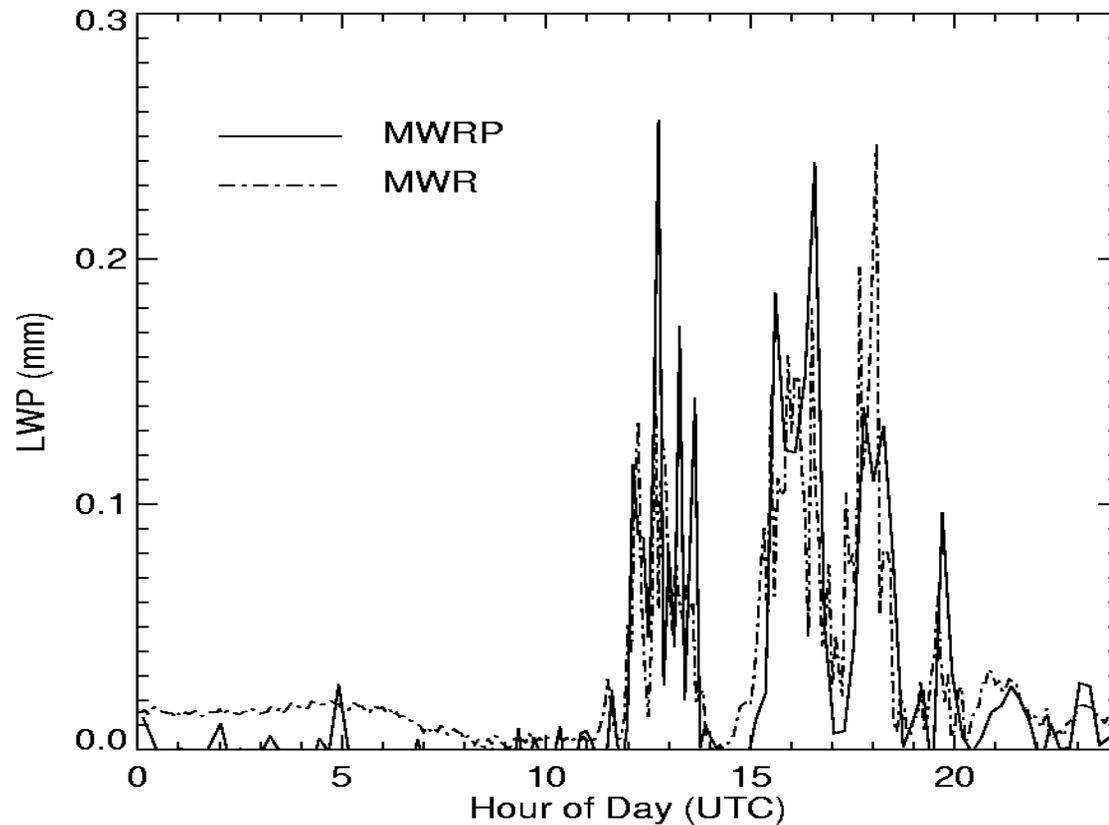




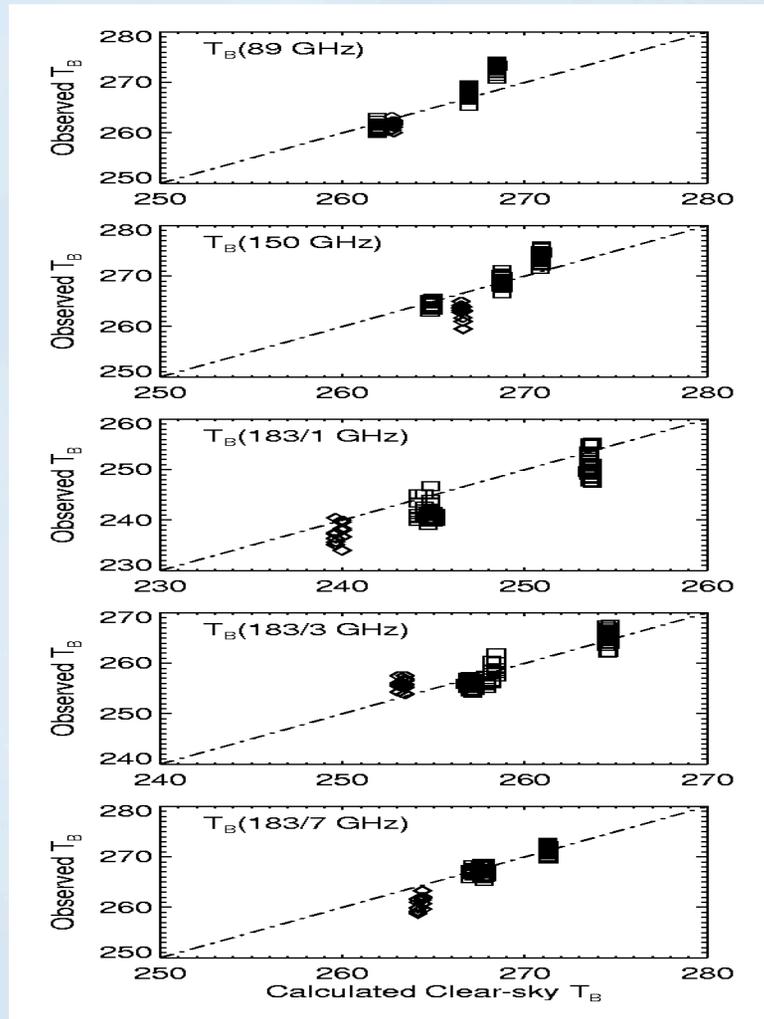
Millimeter-wave radar reflectivity



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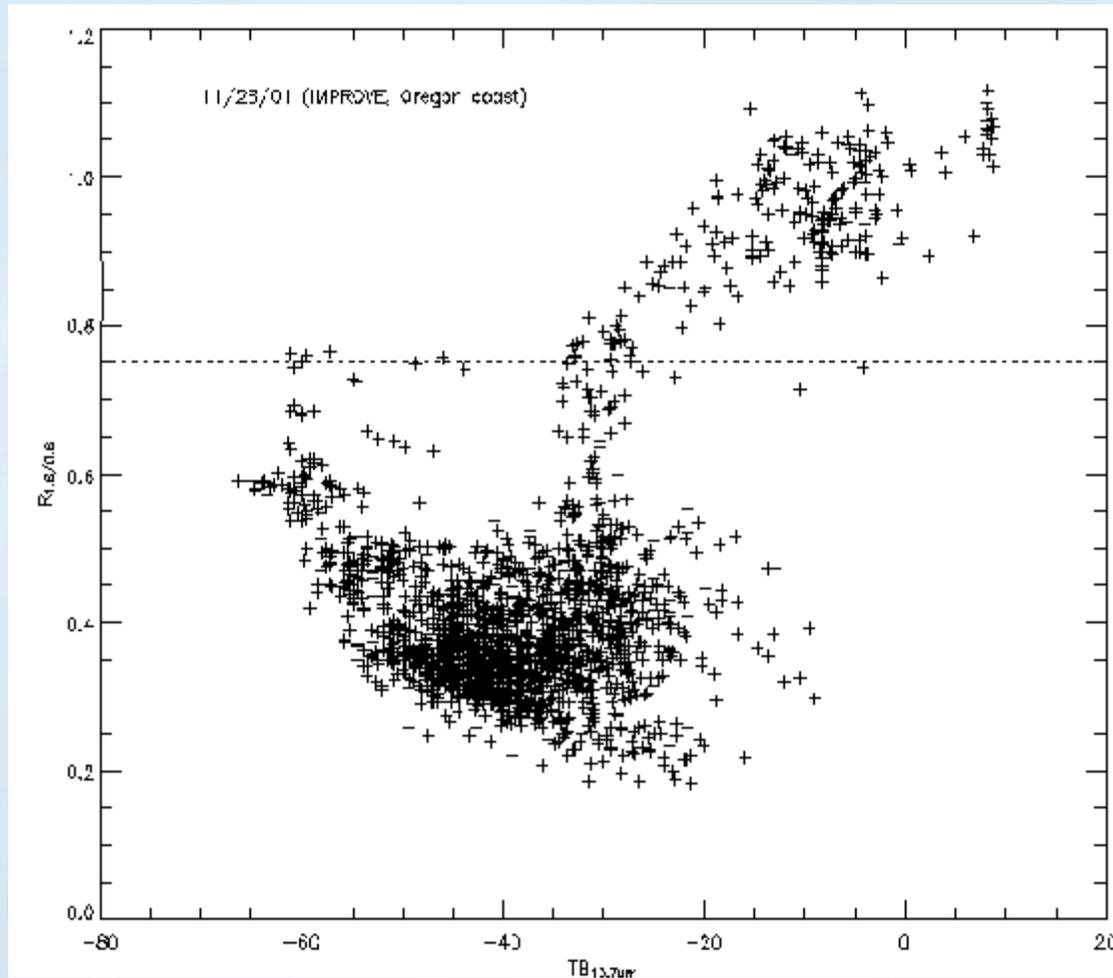
Liquid water path retrievals from 2-channel MWR and 1 2-channel MWRP instruments



Comparison of observed and model-calculated AMSU-B Brightness temperatures.



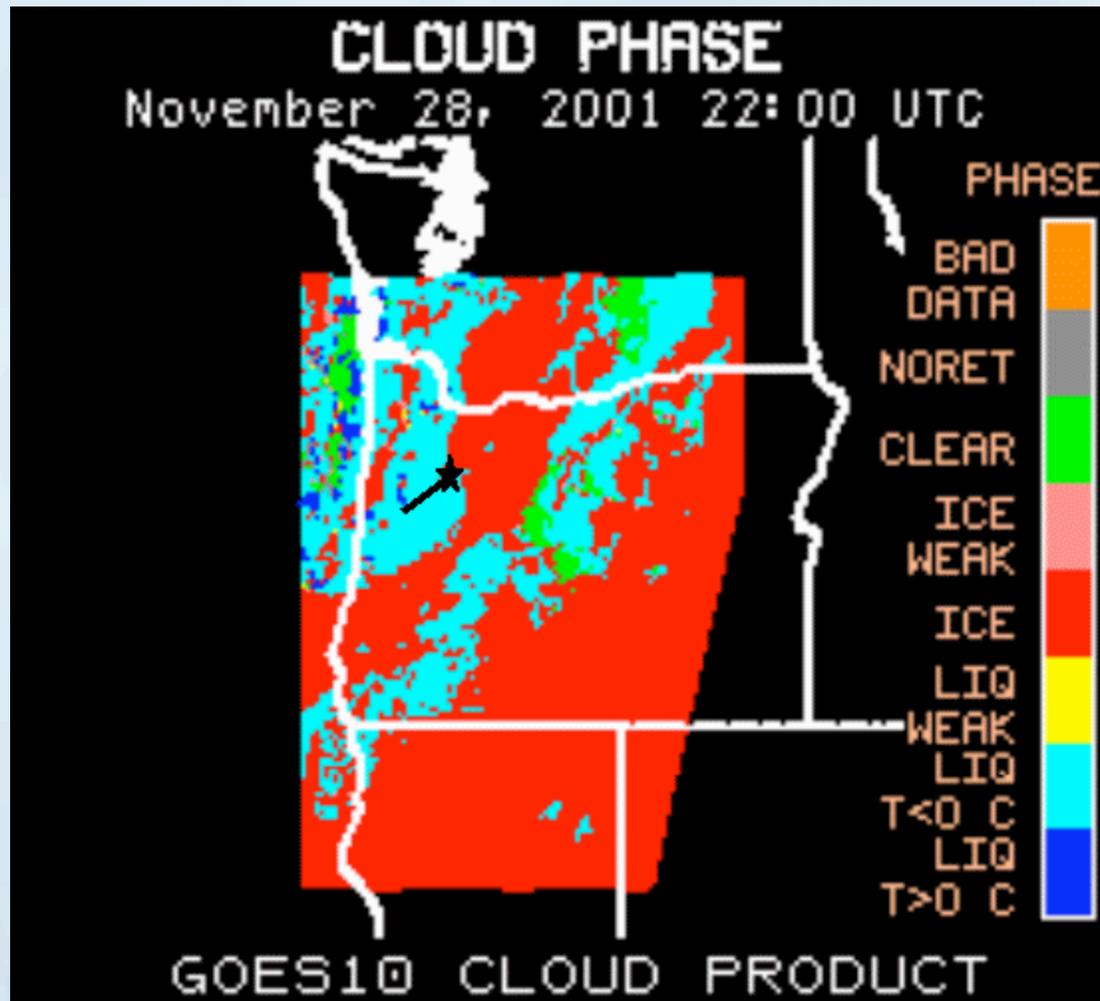
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AVHRR reflectance ratio vs. infrared brightness temperature over the IMPROVE-2 study area on November 28, 2001.



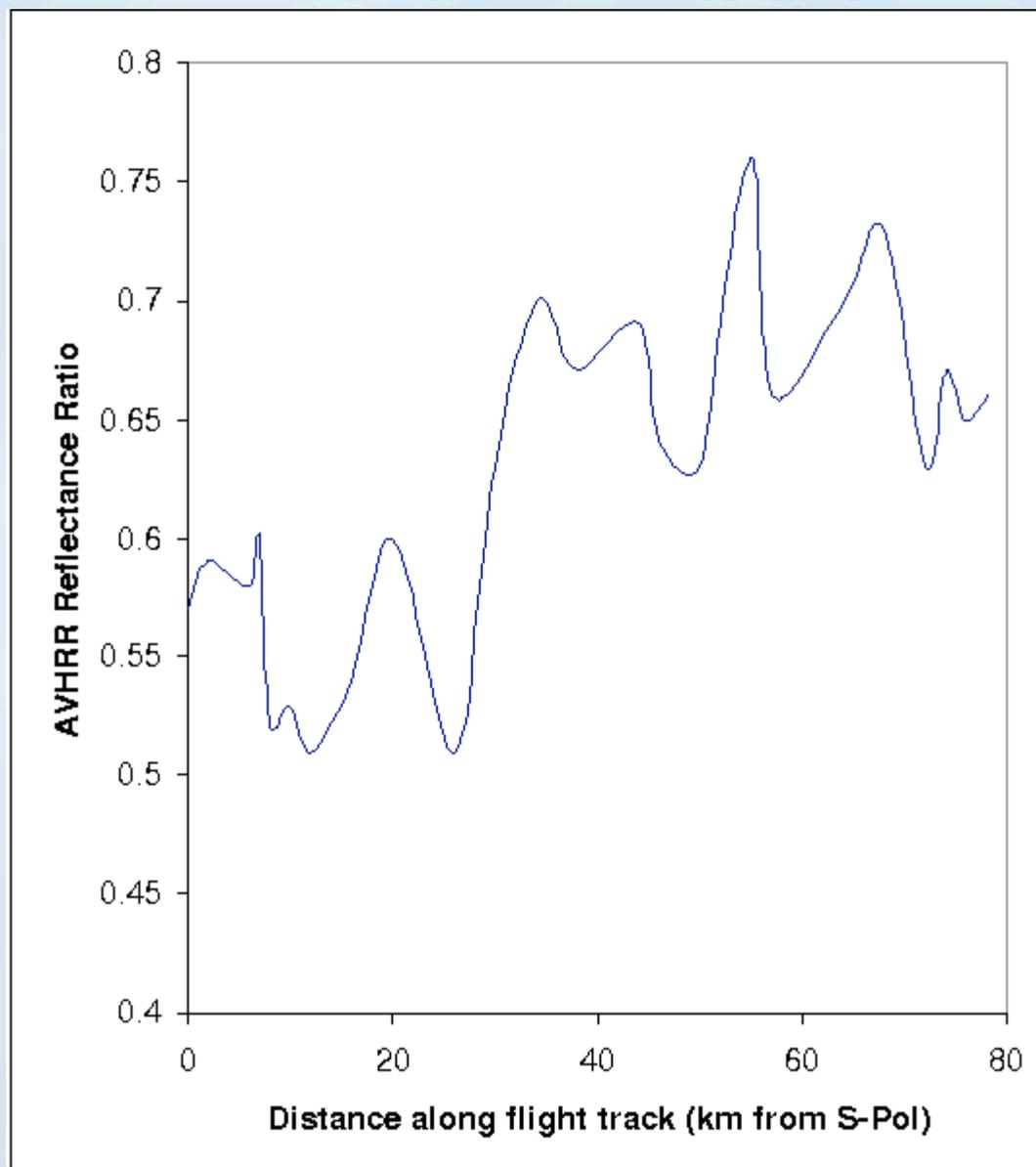
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GOES cloud phase product at 2200 UTC on November 28, 2001. Black star shows the location of the S-Pol radar; black line indicates Convair flight track from 2149-2212 UTC.

	Nov 28	Nov 29	Dec 4
Time of icing observation (UTC)	2145-2200	1815- 1915	n/a
Altitude (m)	4400-5100	600- 3000	n/a
Cloud top temperature (°C)	- 10 to - 15	- 14	- 30 to - 35
Phase	mixed	mixed	ice

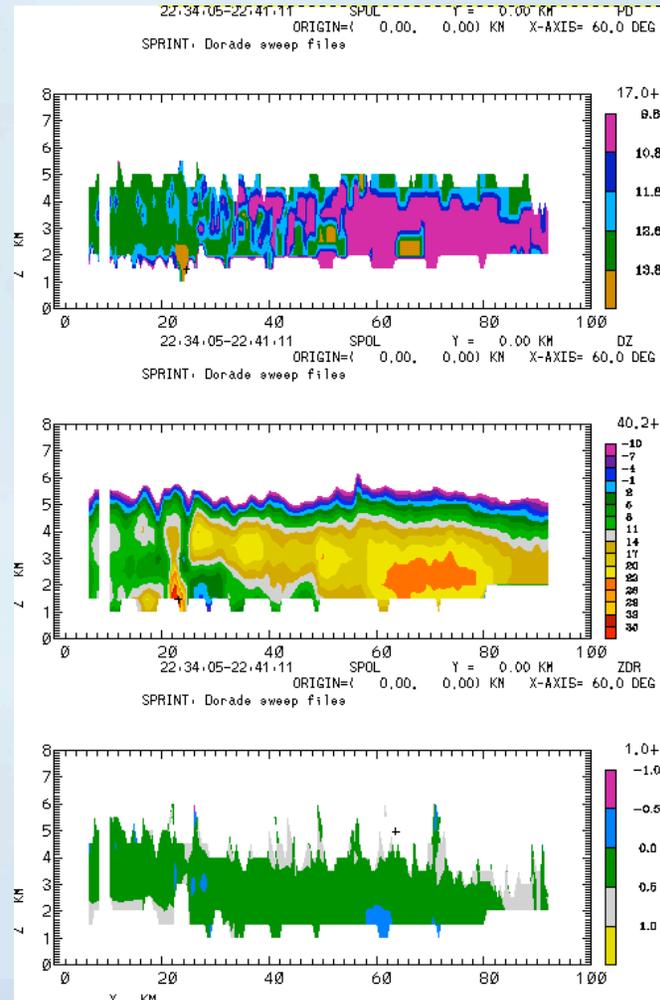
Summary of aircraft cloud observations for IMPROVE-2 case studies



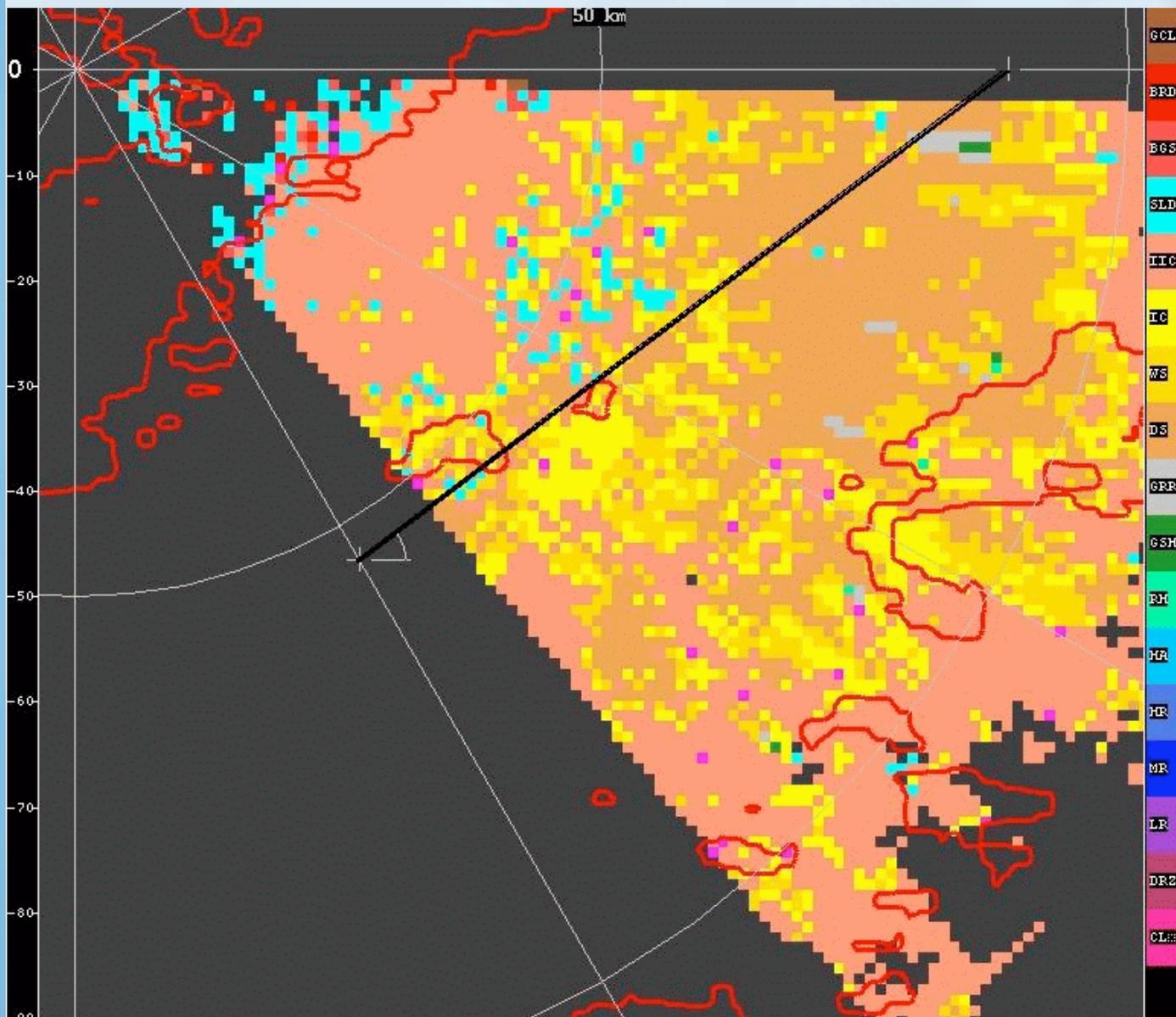
AVHRR reflectance ratio (R1.6/0.6) at 2214 UTC on November 28, 2001 along the Convair flight track shown in Figure 2.



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Vertical cross-sections of (a) PID, (b) DZ, and (c) ZDR along the Convair flight track at 2234-2241 UTC on November 28, 2001



Radar-derived PID (as per colorbar; light blue pixels indicate SLD particles), with AVHRR reflectance ratios superimposed (red contours enclosing values of 0.7 or greater indicate areas of liquid phase) for November 28, 2001 at 22:14 GMT. The solid black line is the aircraft track. White lines are radar range and azimuth indicators.



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Possible research issues

- Dual-wavelength method.
- S-band and ground-based radiometer.
- Microwave satellite and GOES combination.
- Use S-Polka data for validation.