



Improving GPM-Era Higher Latitude Precipitation Retrievals Using Enhanced Microphysical Modeling Tools and Multi-Frequency Radar Observations

Mark Kulie and Ralf Bennartz
University of Wisconsin-Madison

Themes

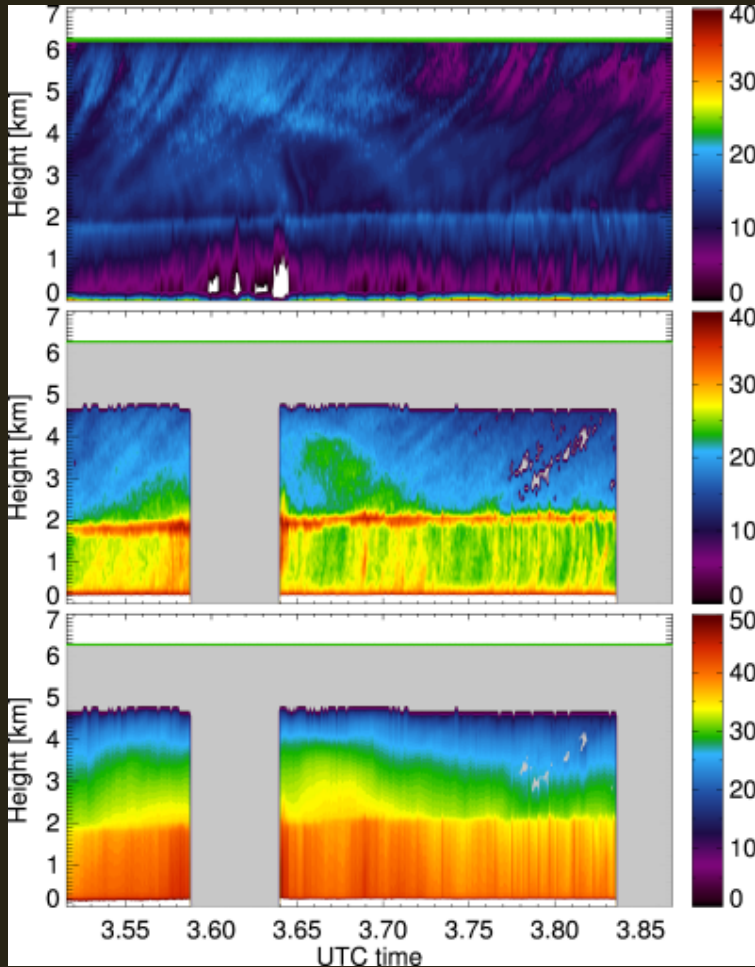
- Microphysical modeling tools
- Modeling  Observations
- Leveraging pre-GPM spaceborne datasets
- Ground-based radar observations

Themes

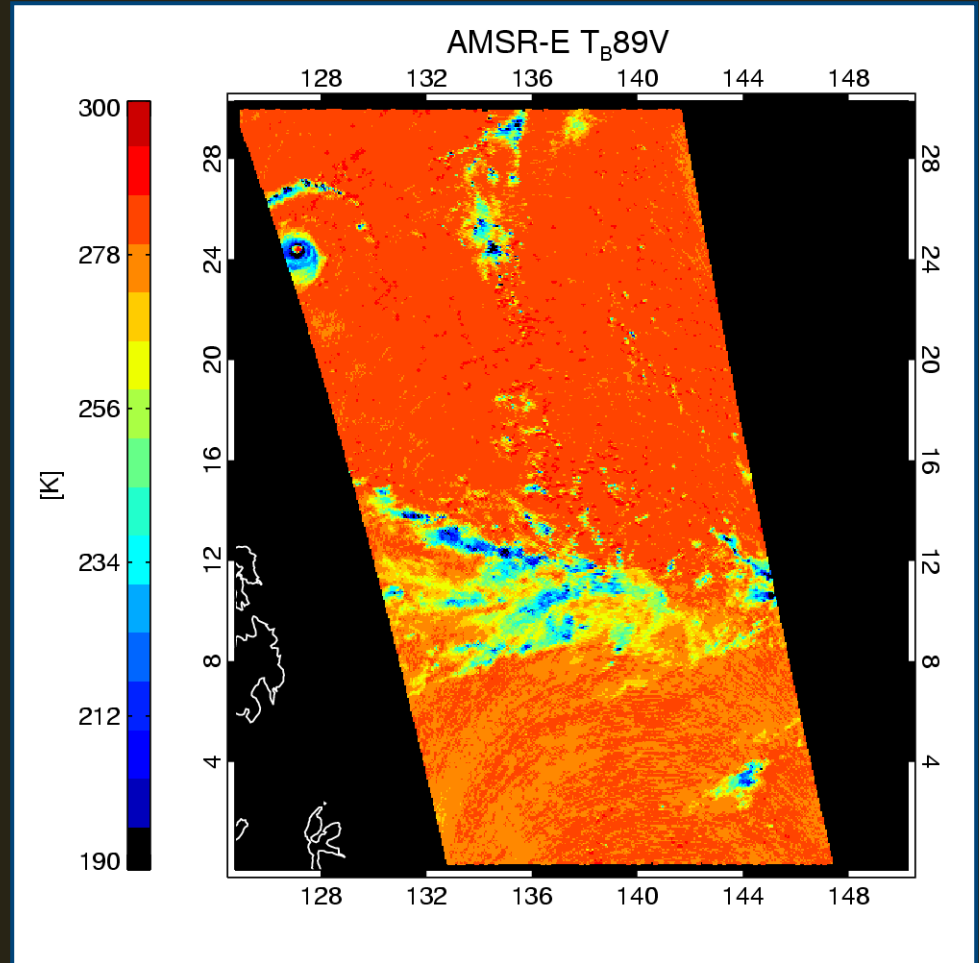
- **Microphysical modeling tools**
- Modeling  Observations
- Leveraging pre-GPM spaceborne datasets
- Ground-based radar observations

Microphysical Modeling: Multi-frequency radar/radiometer consistency

ACR + APR-2



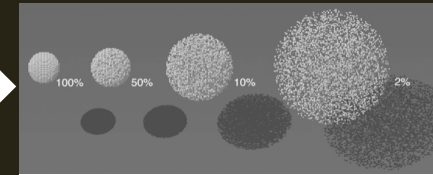
AMSR-E



Microwave Scattering Database

Spheres (Mie theory)

- ✓ Fixed-density
- ✓ Dielectric mixing rules



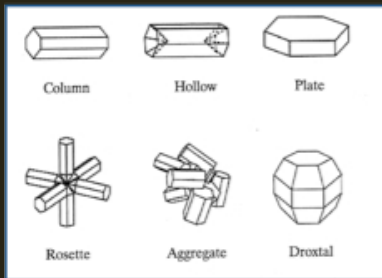
Non-spherical (Discrete Dipole Approximation – DDA)

Liu (2004,2008)

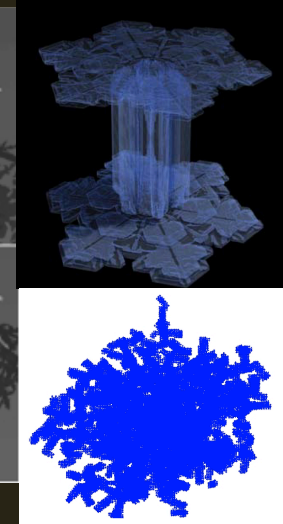
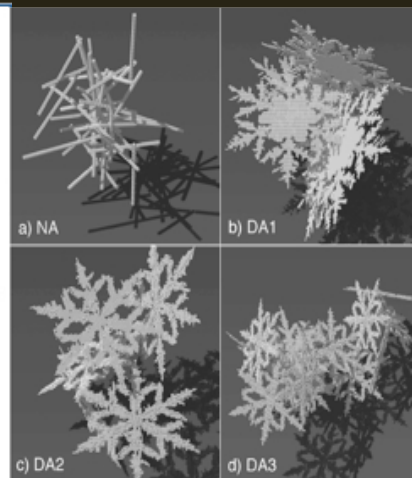
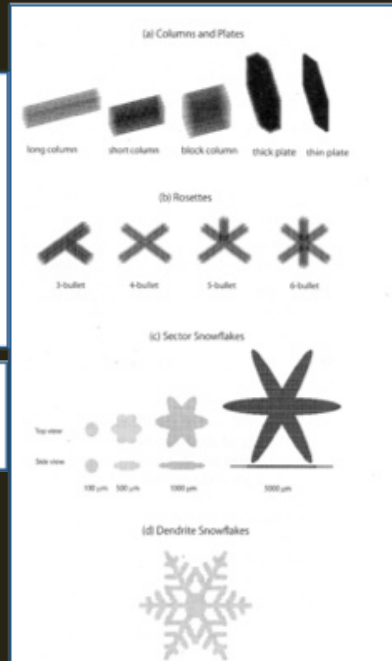
Petty and Huang (2010)

Kuo(Snowflake)

Hong (2007)

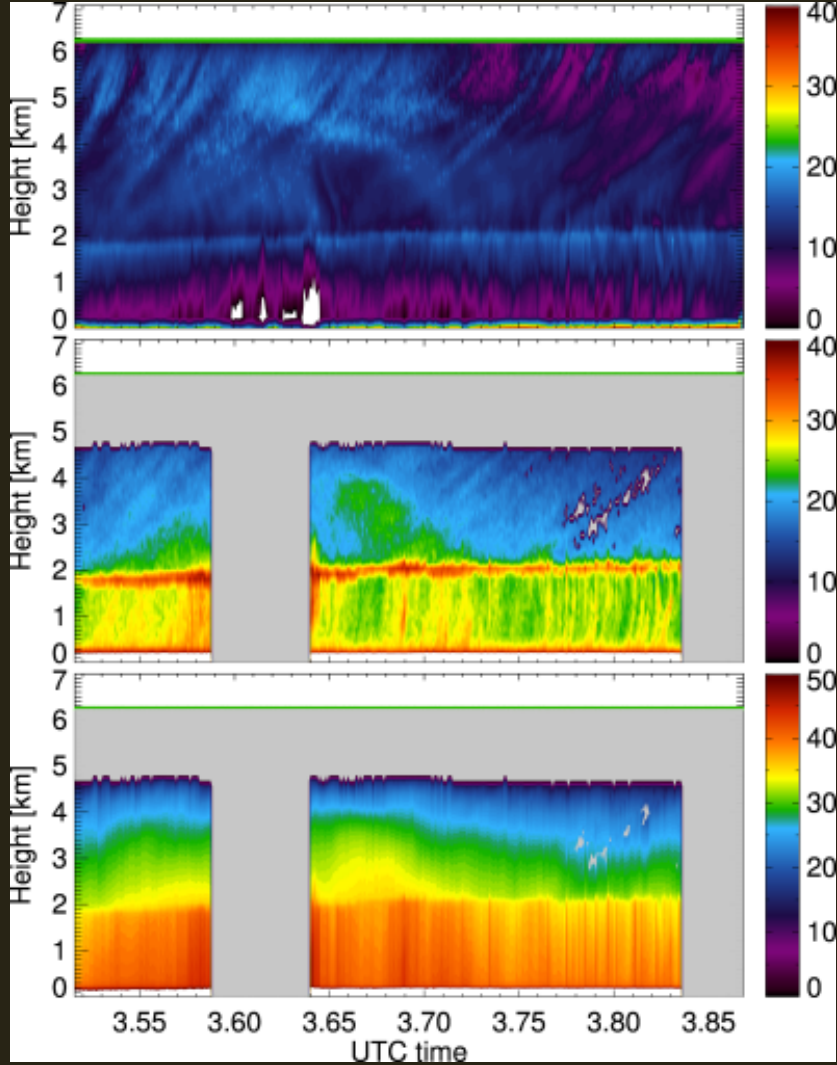


Kim et al. (2007)

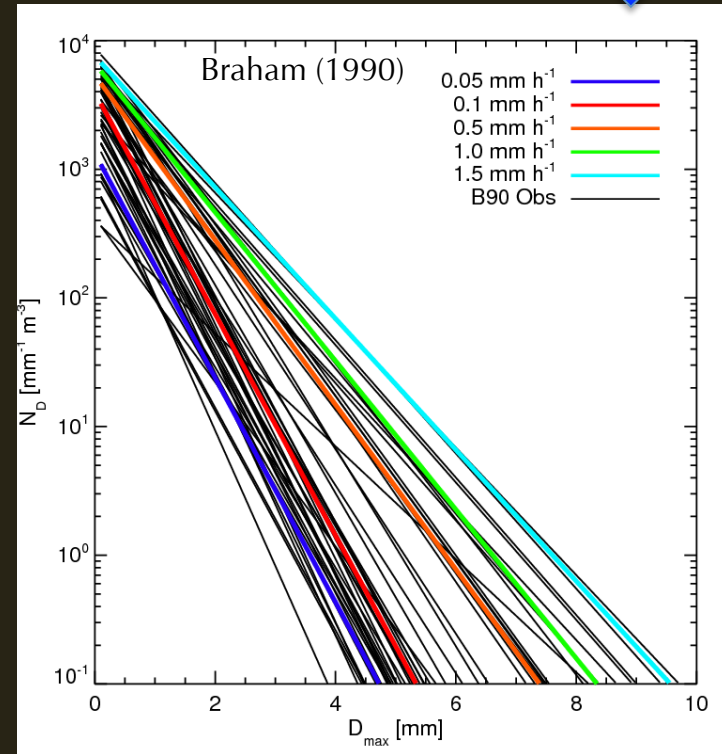


Ori et al. (2012)

ACR + APR-2

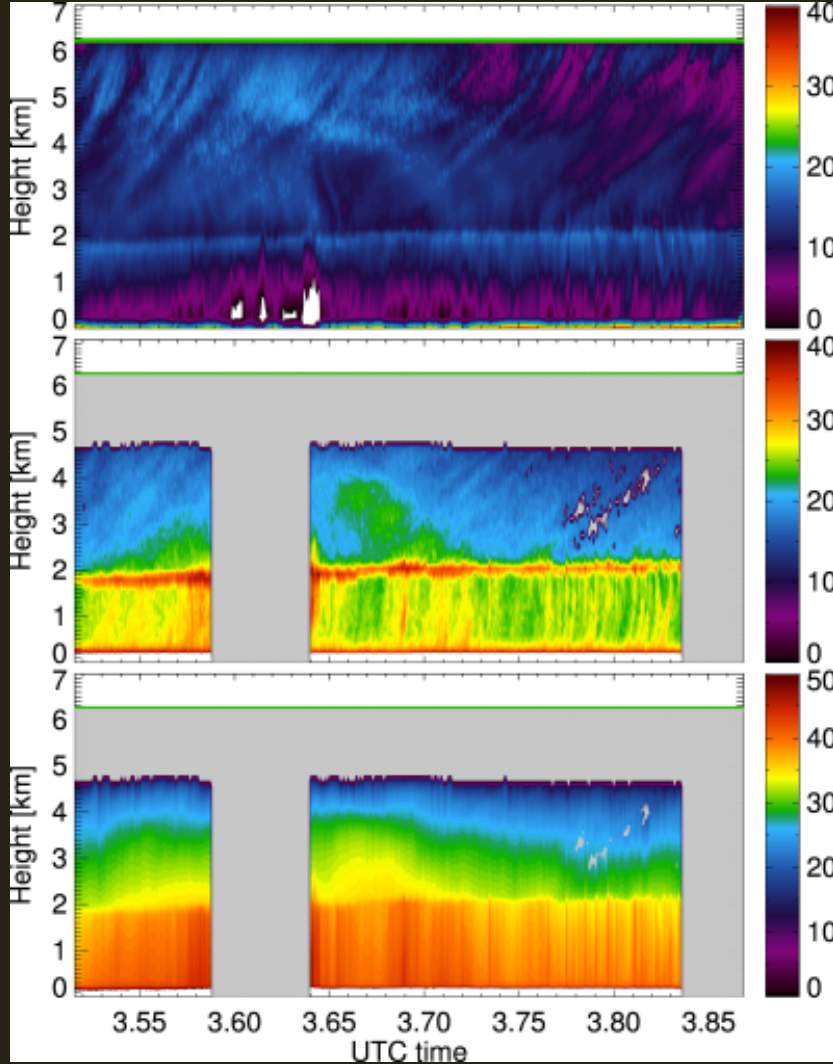


$$Z_{e,\lambda} = \frac{\lambda^4}{\pi^5 |K|_\lambda^2} \int_{D_{\min}}^{D_{\max}} \sigma(D)_{b,\lambda} N(D) dD$$

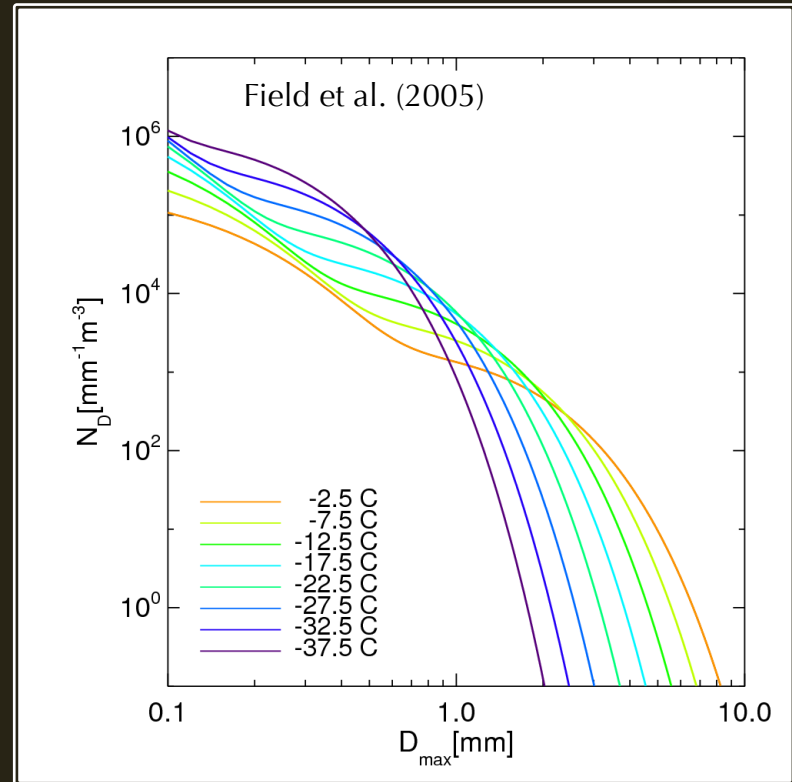


$$N(D) = N_o \exp(-\Lambda D)$$

ACR + APR-2

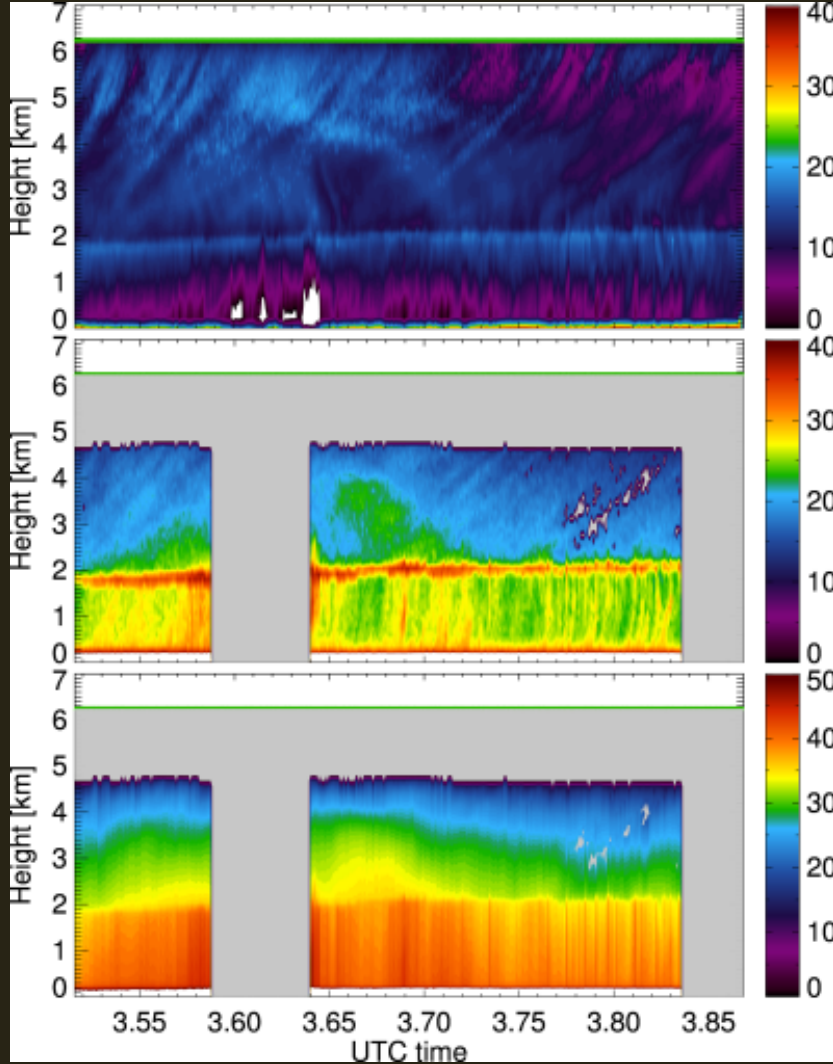


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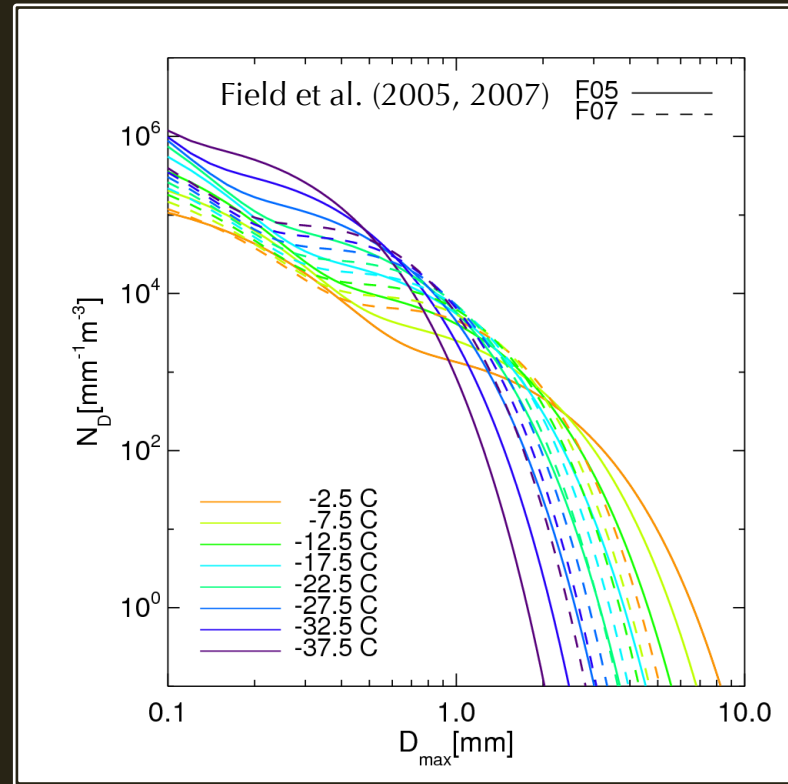


$$N(D) = N_{oD_1} \exp(-\Lambda_{D_1} D) + N_{oD_2} D^{\mu_{D_2}} \exp(-\Lambda_{D_2} D)$$

ACR + APR-2

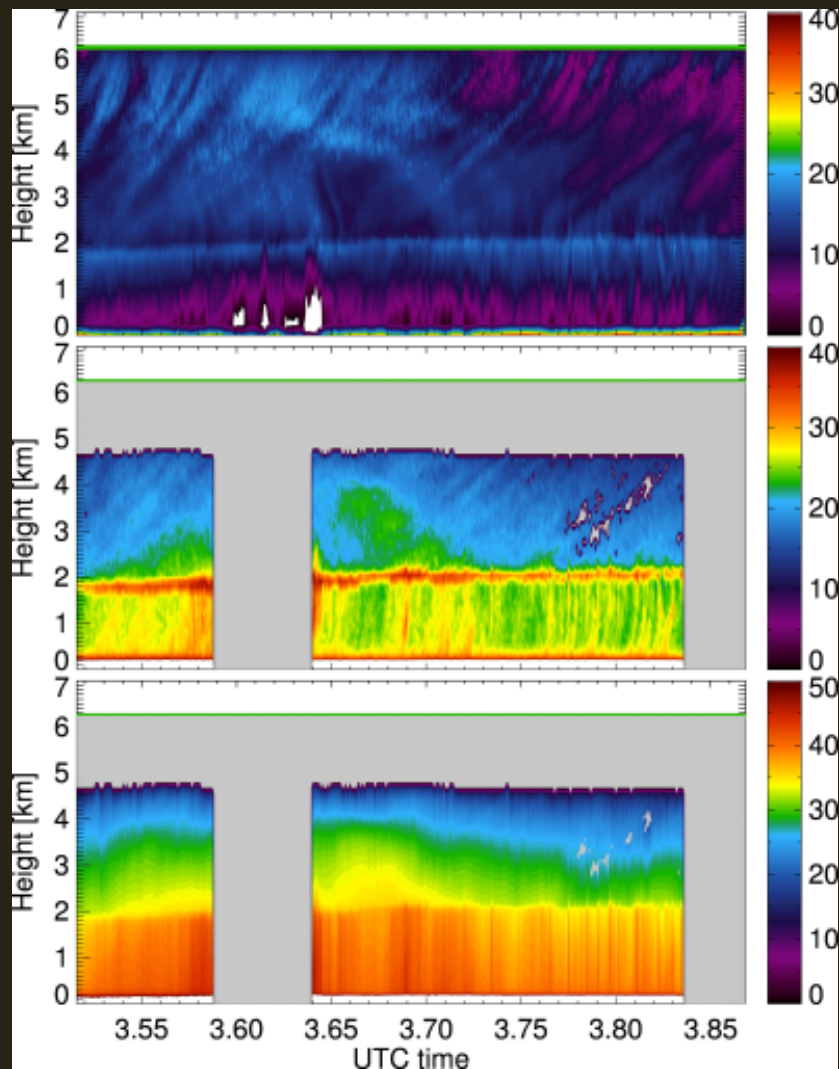


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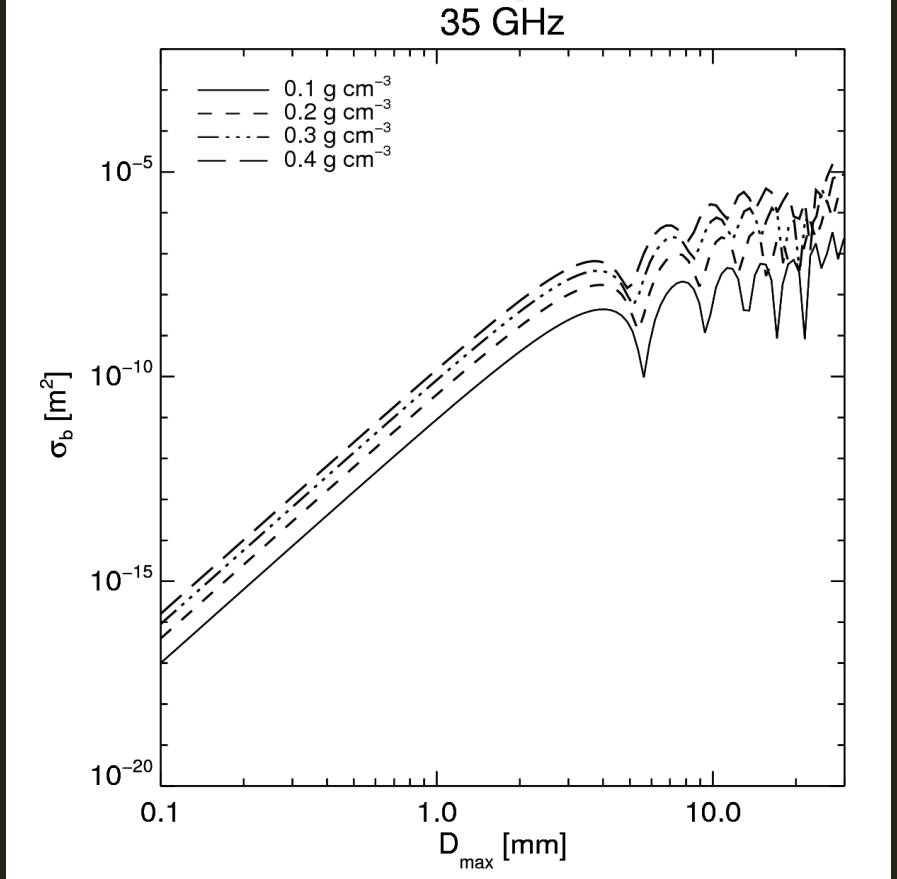
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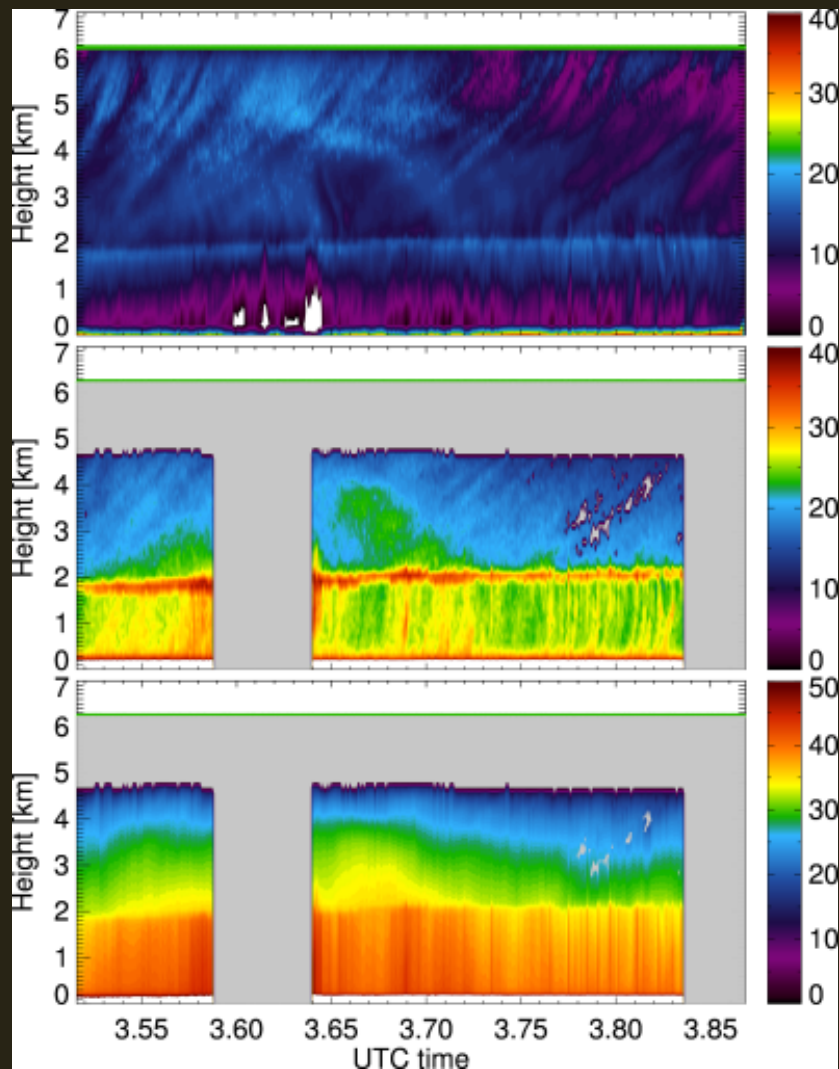


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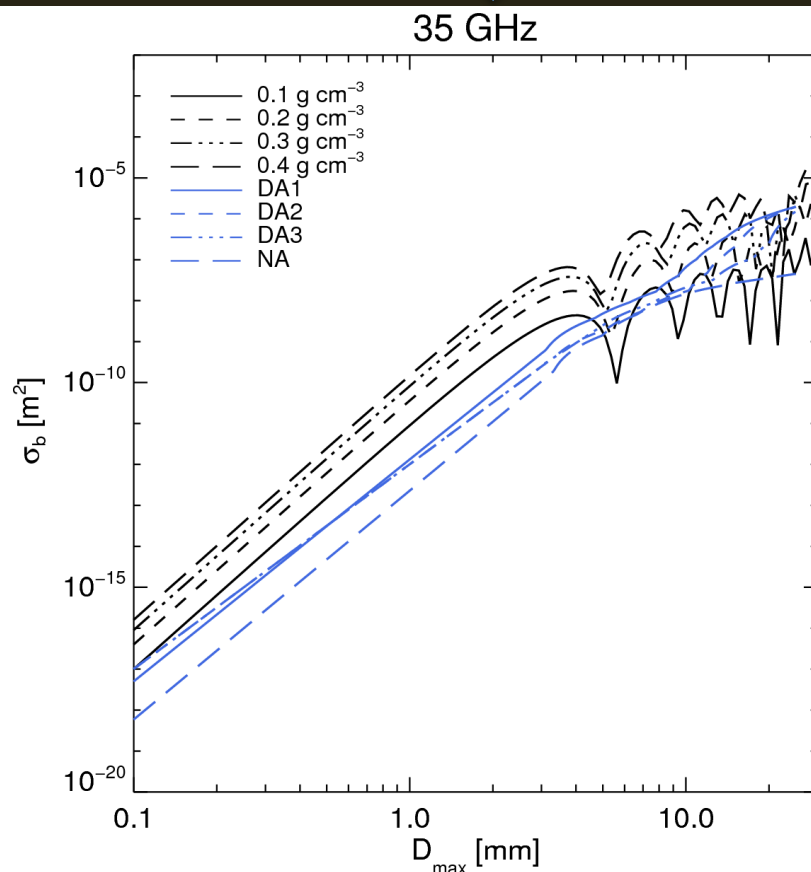


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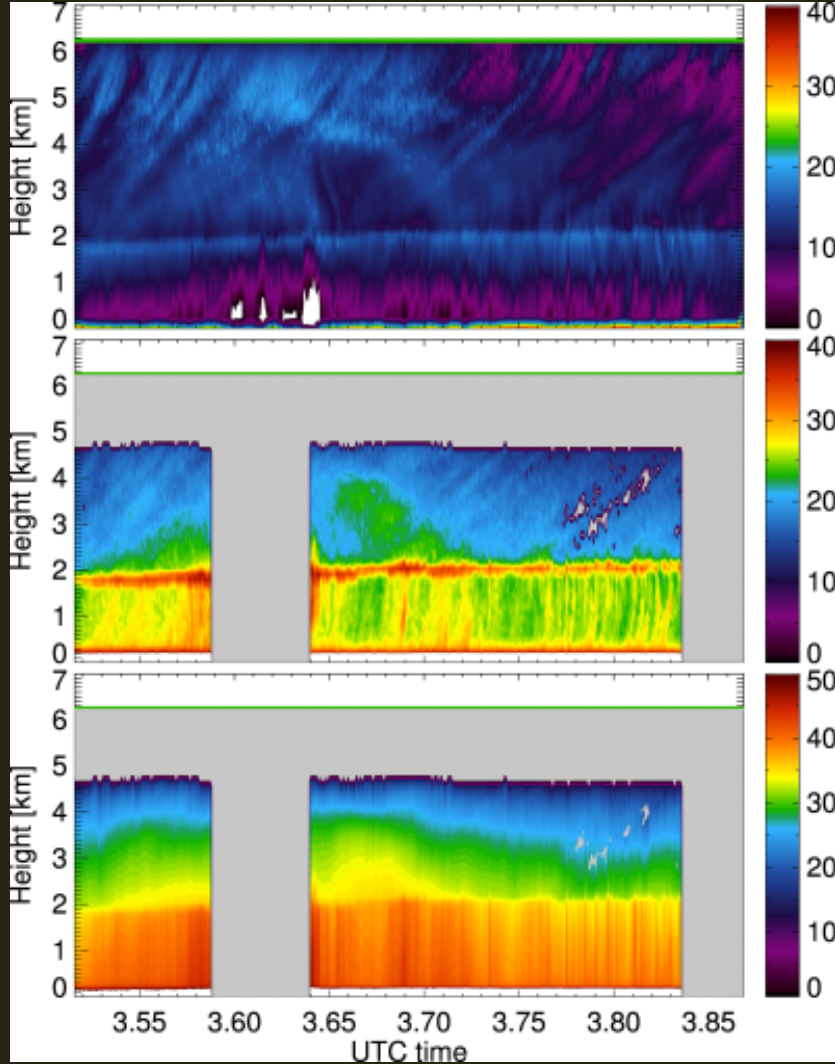


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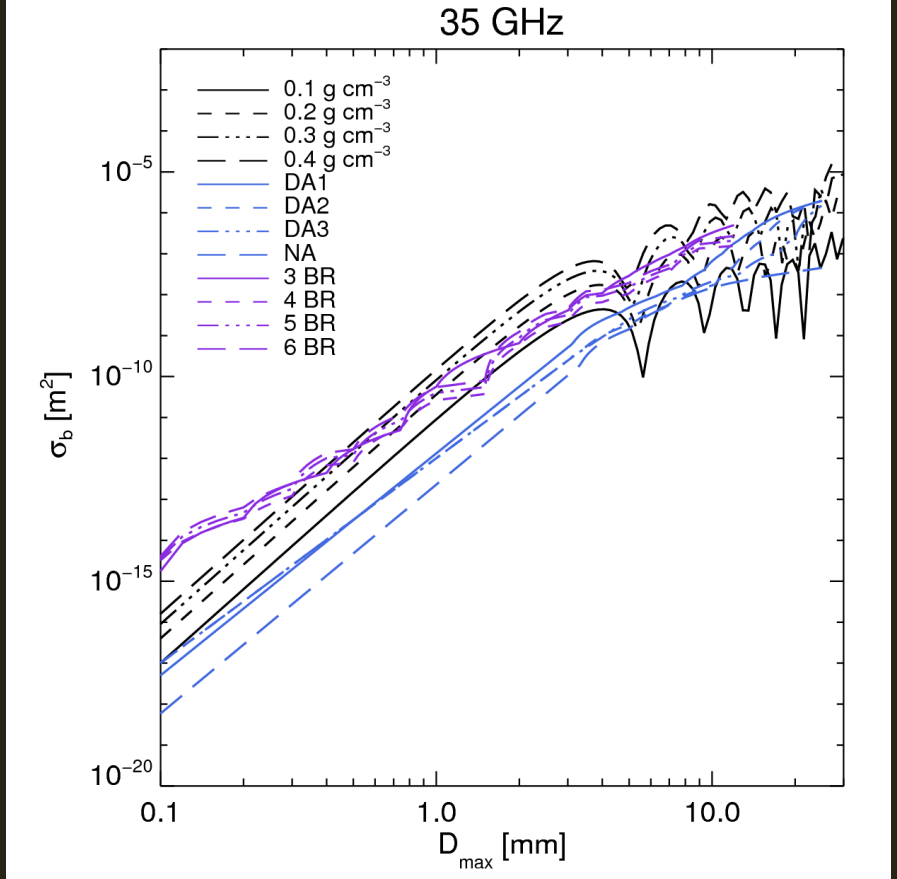


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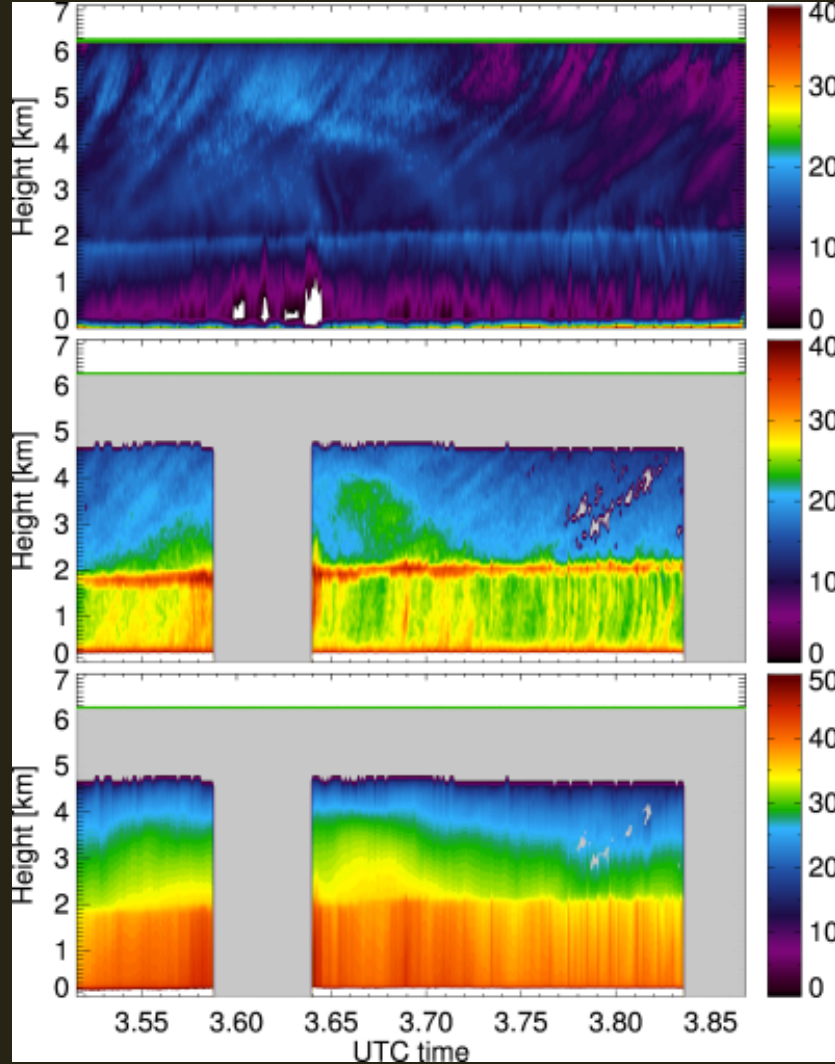


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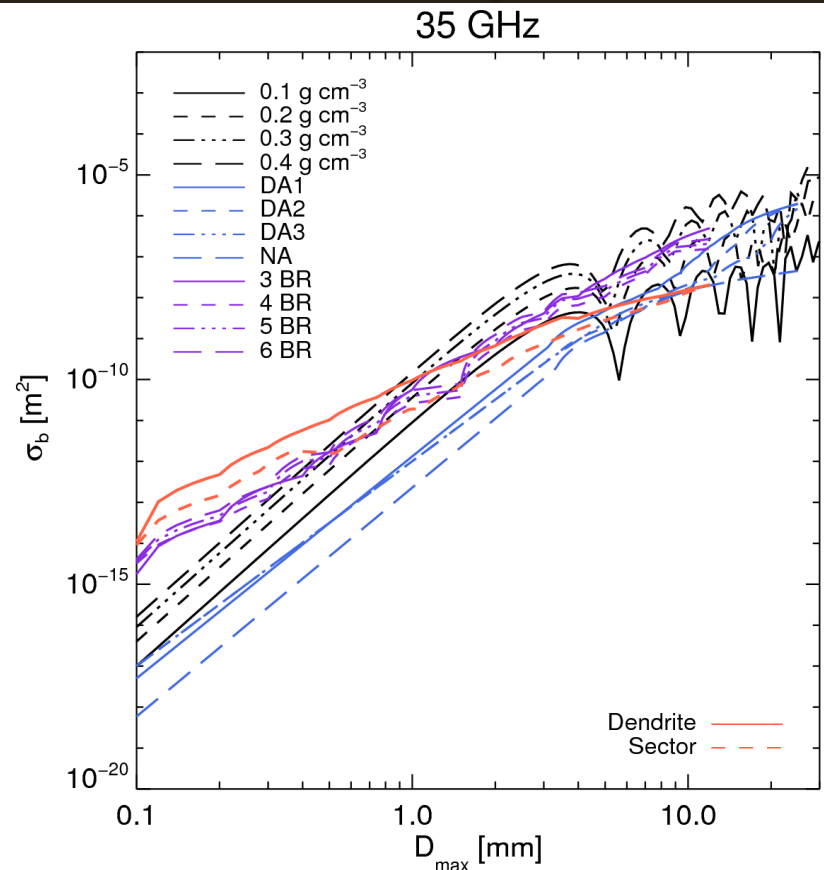


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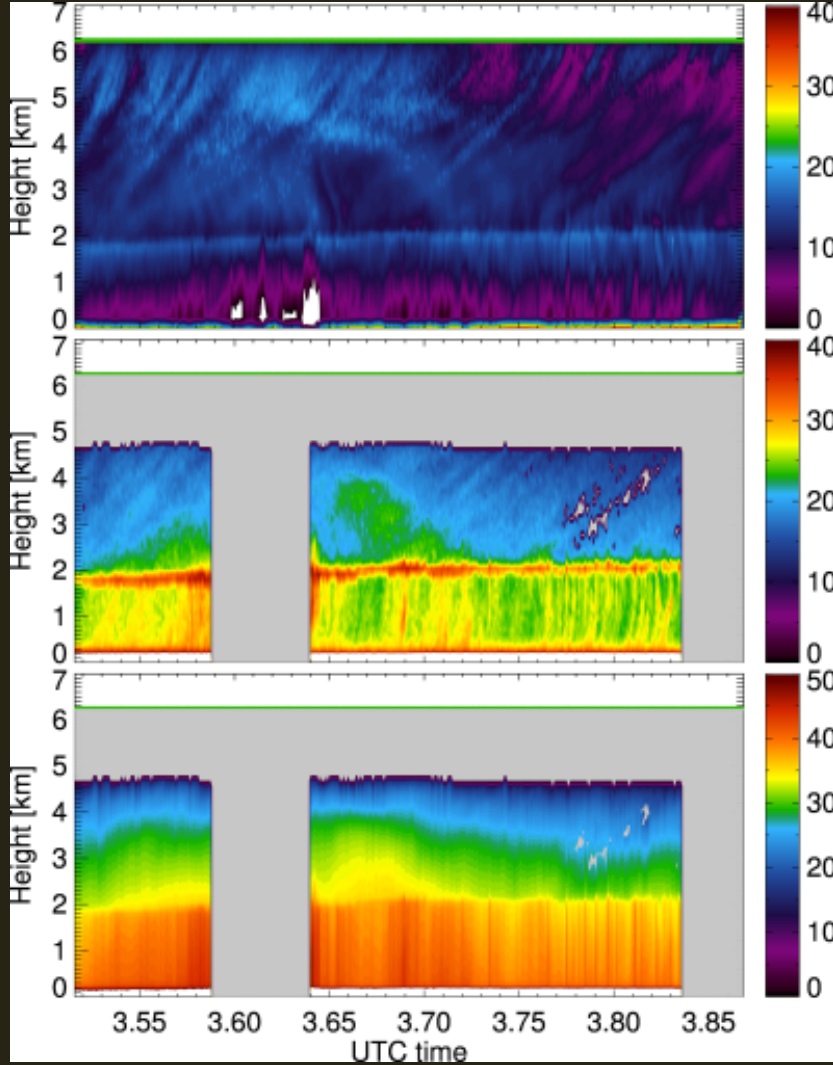


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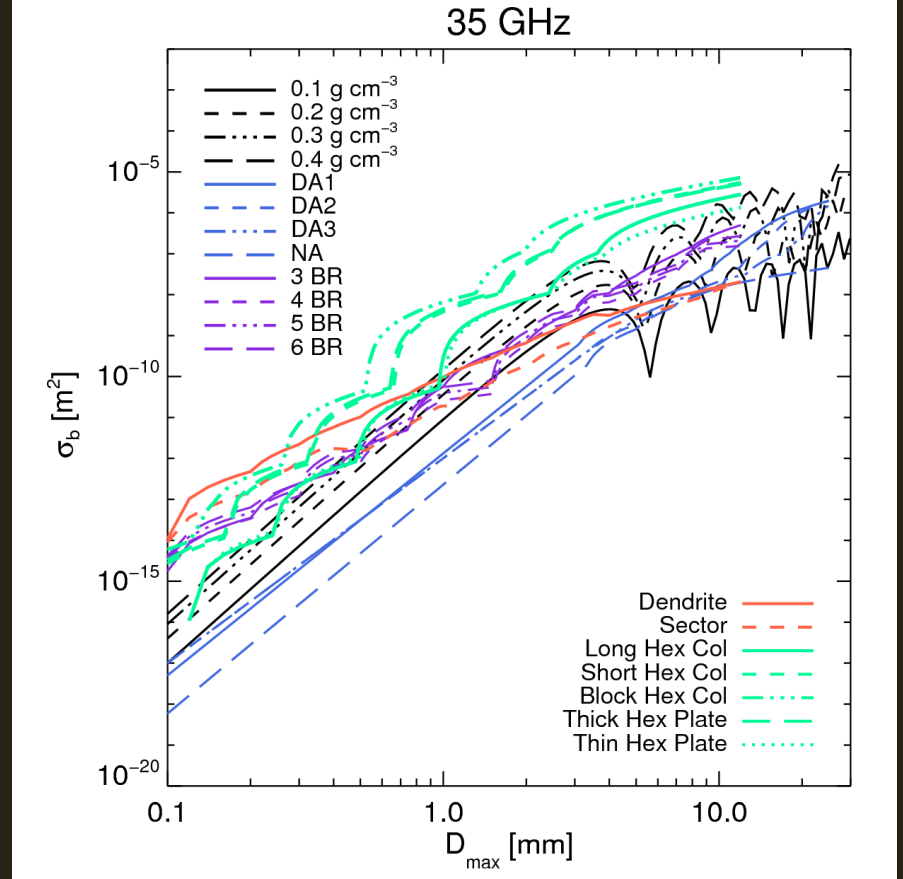


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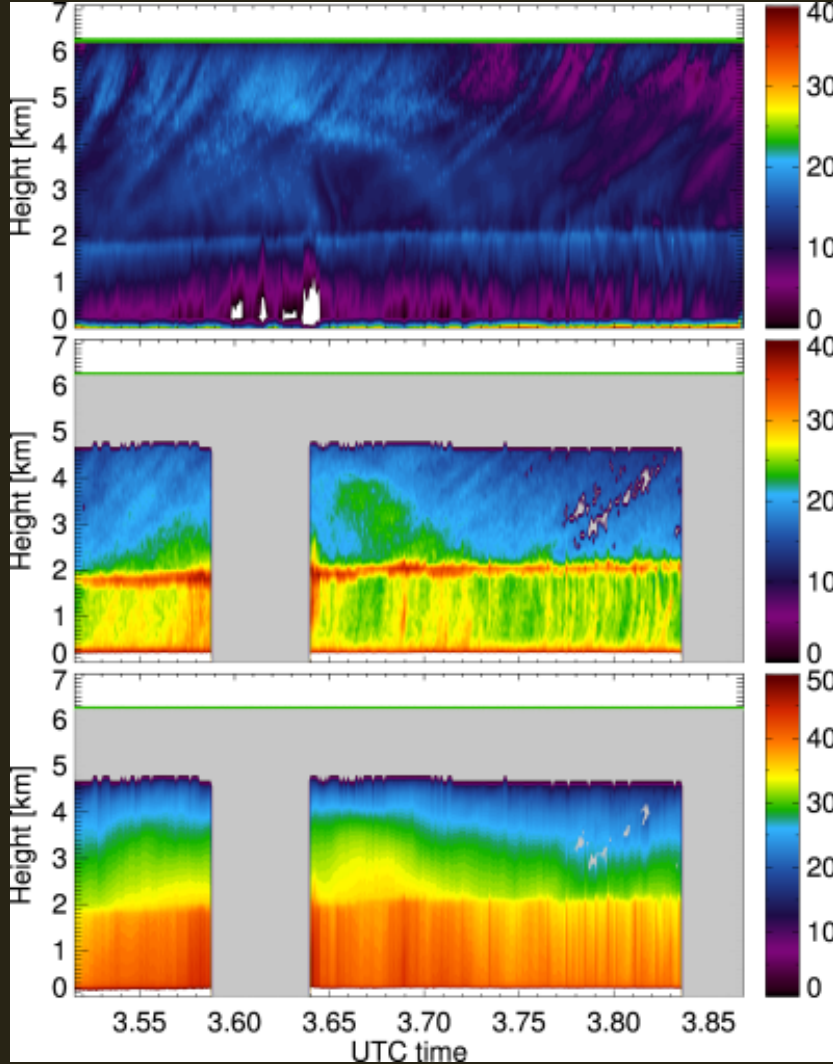


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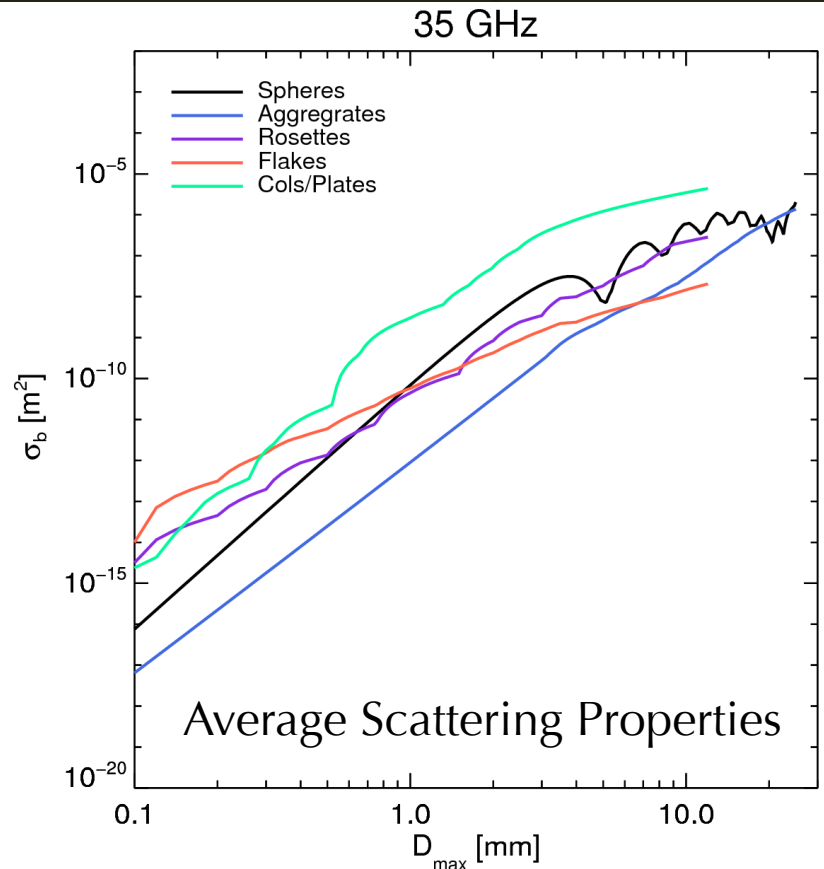


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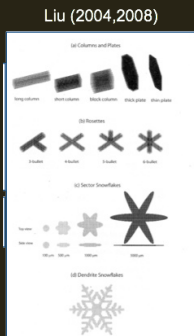


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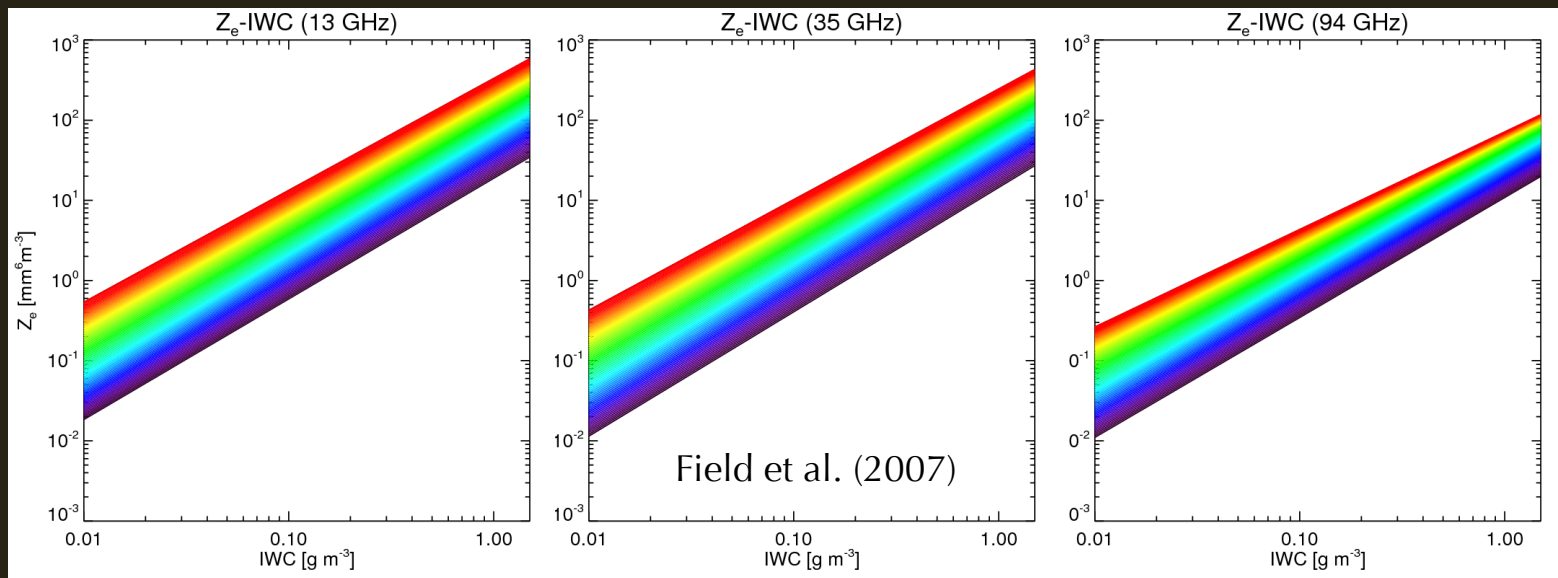
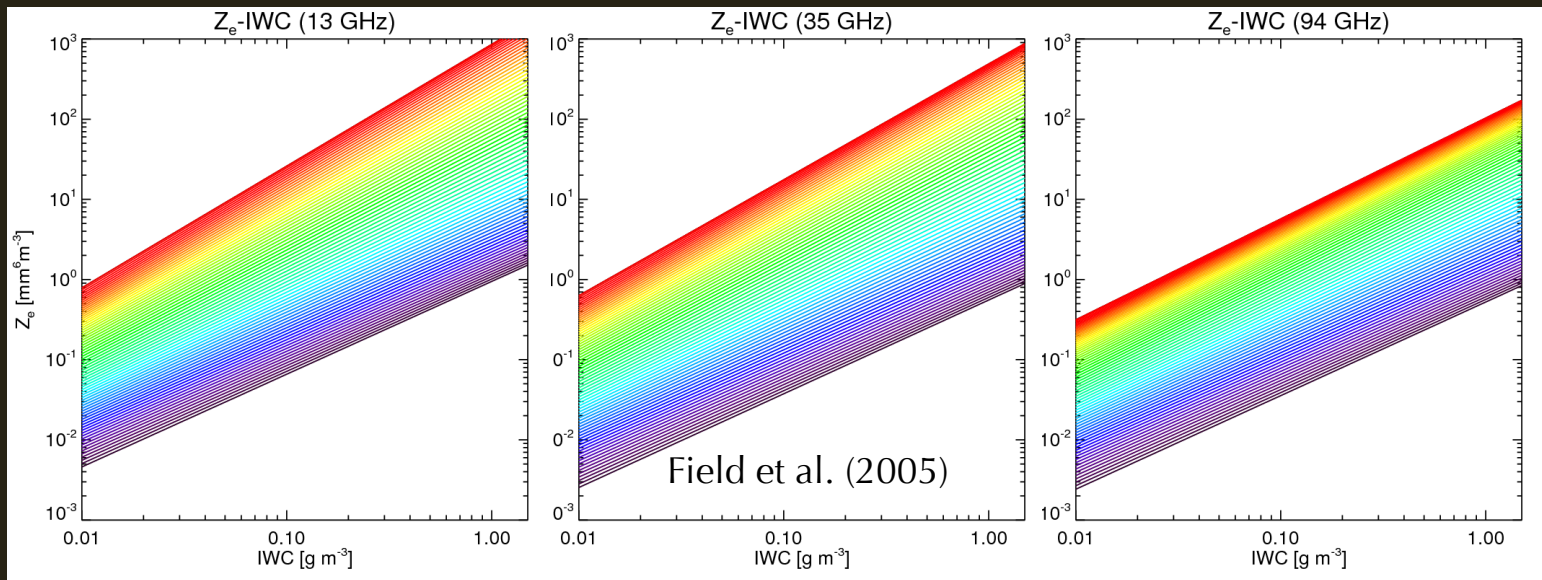
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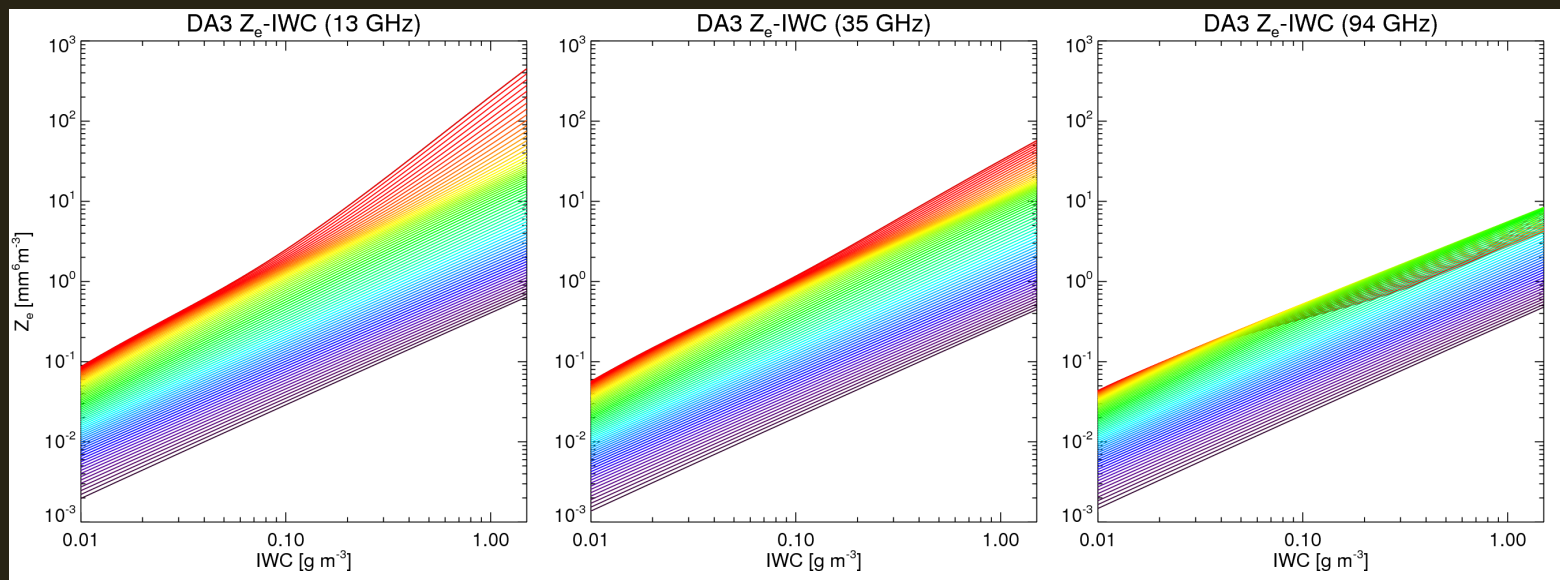
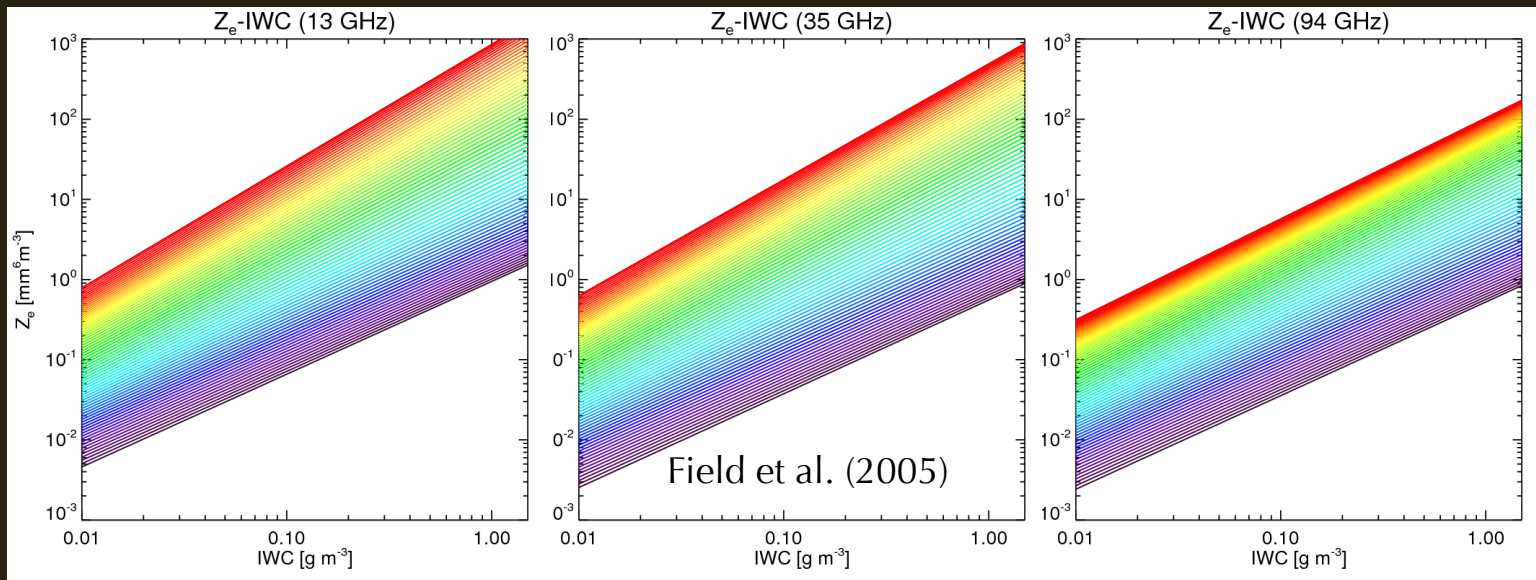
PSD-Averaged Quantities



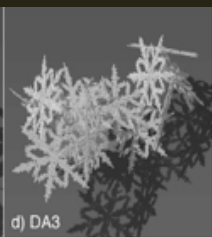
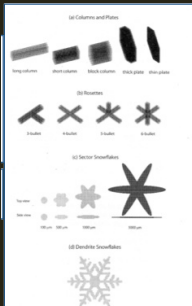
Liu (2004,2008)

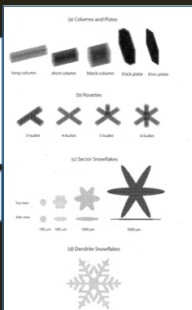


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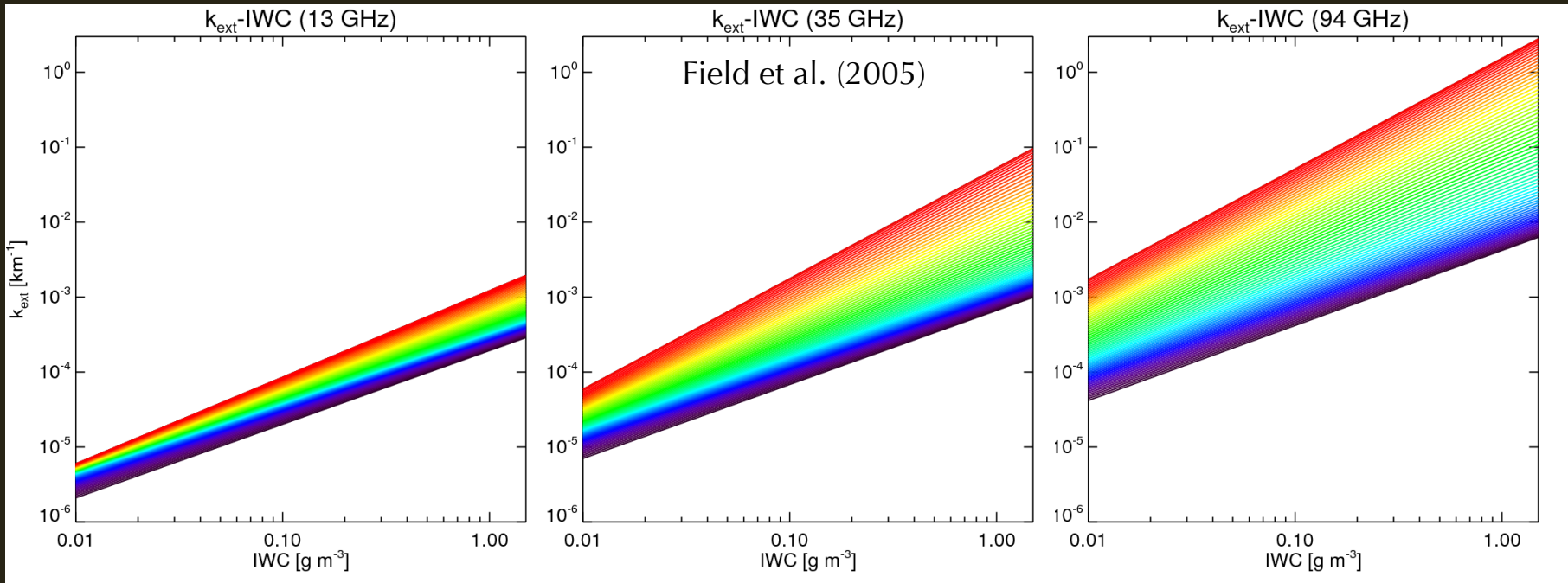


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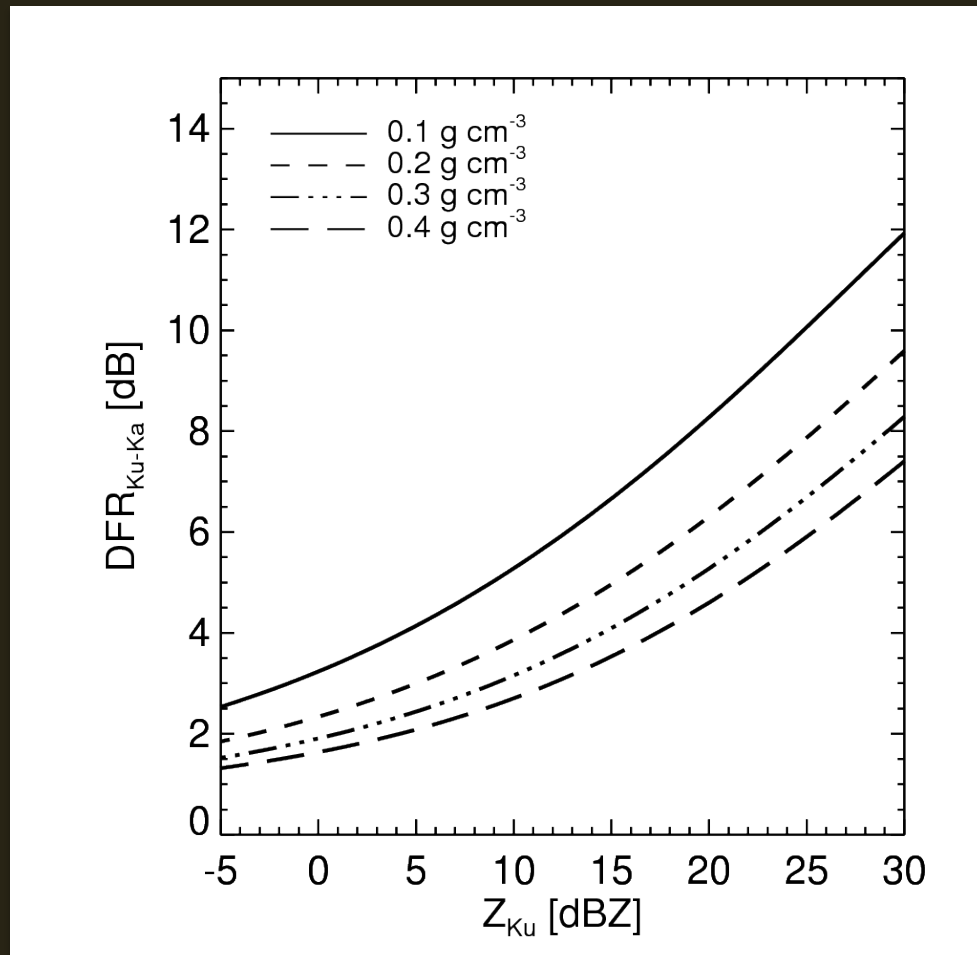




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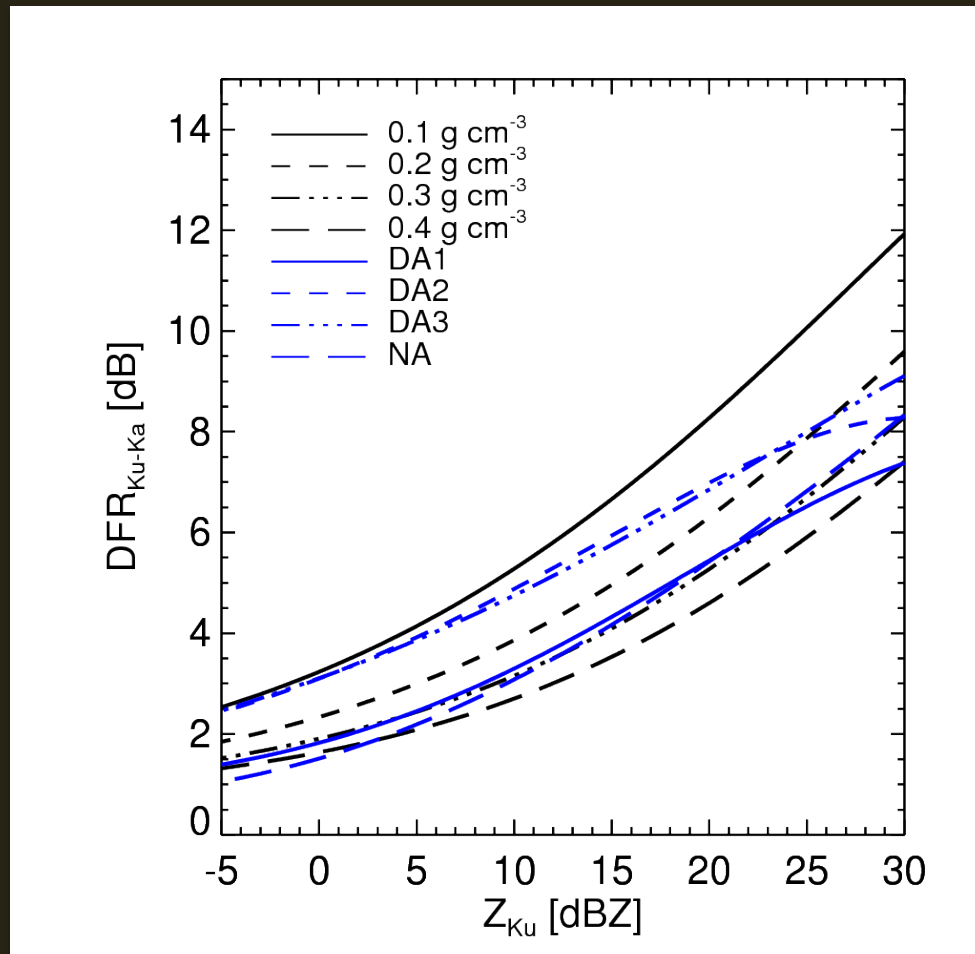


Modeled Ku-Ka Dual Freq Ratio (DFR)



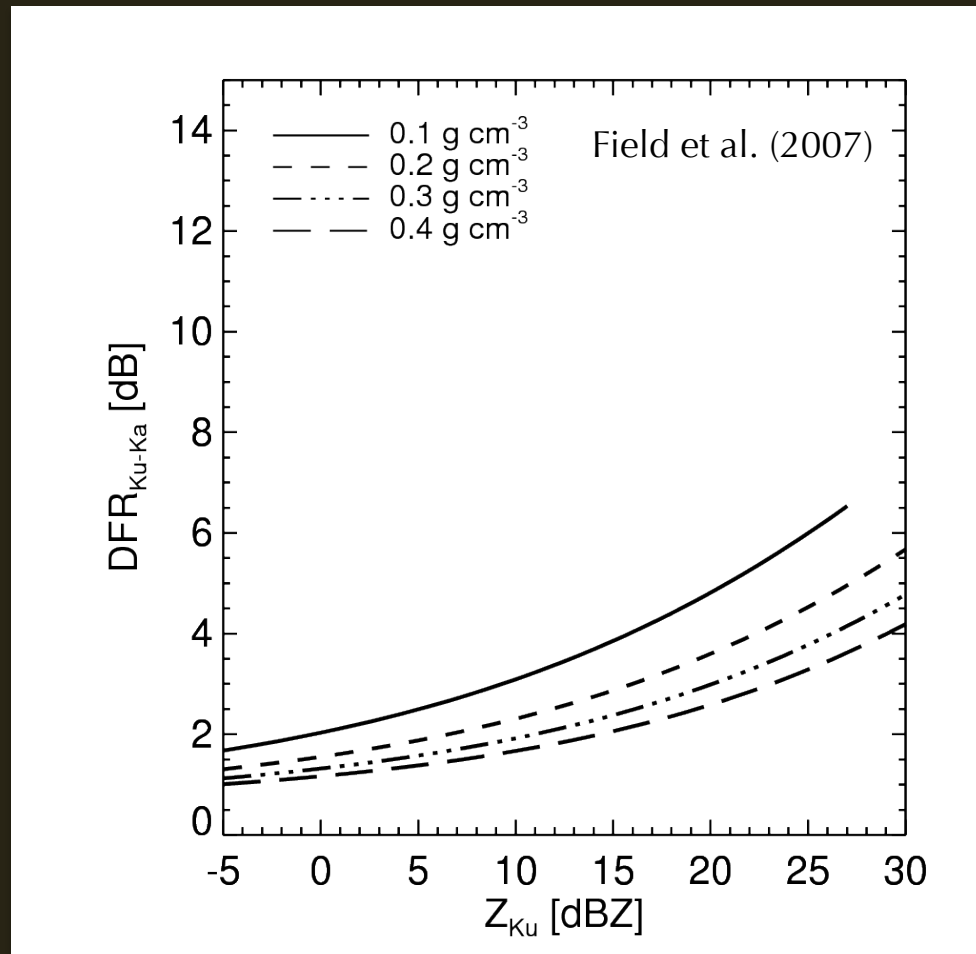
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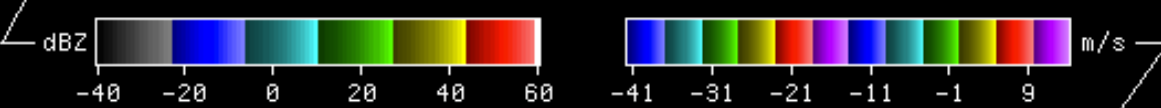
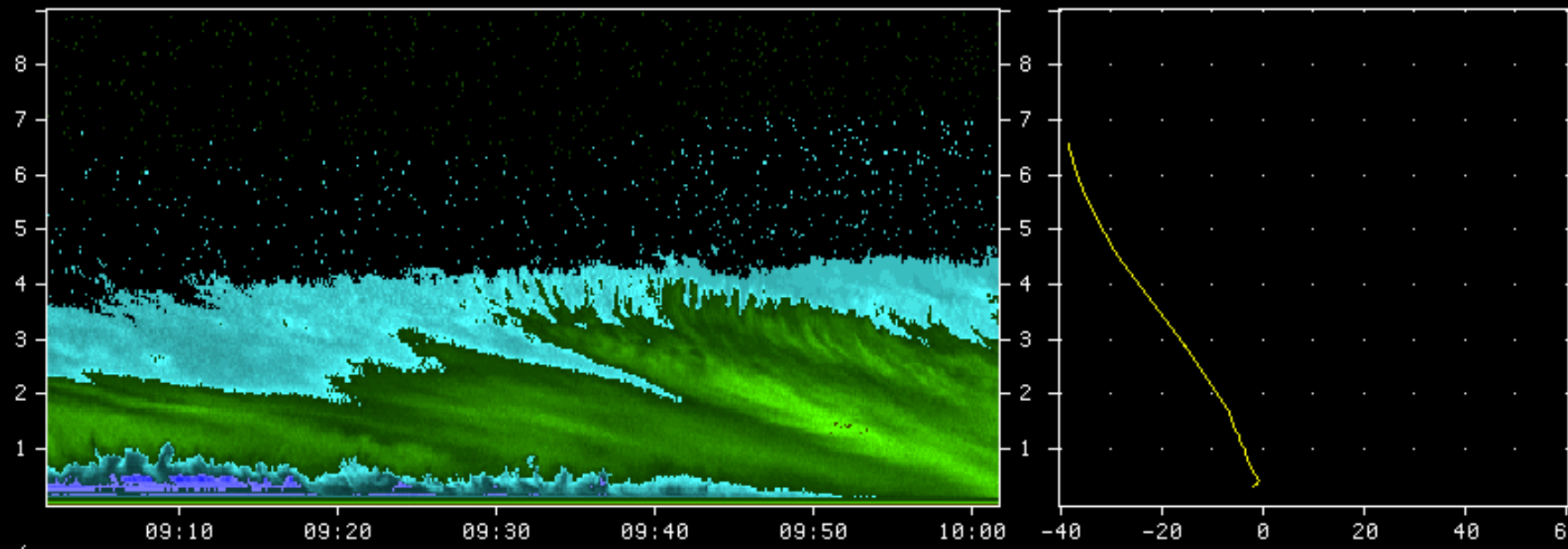


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Themes

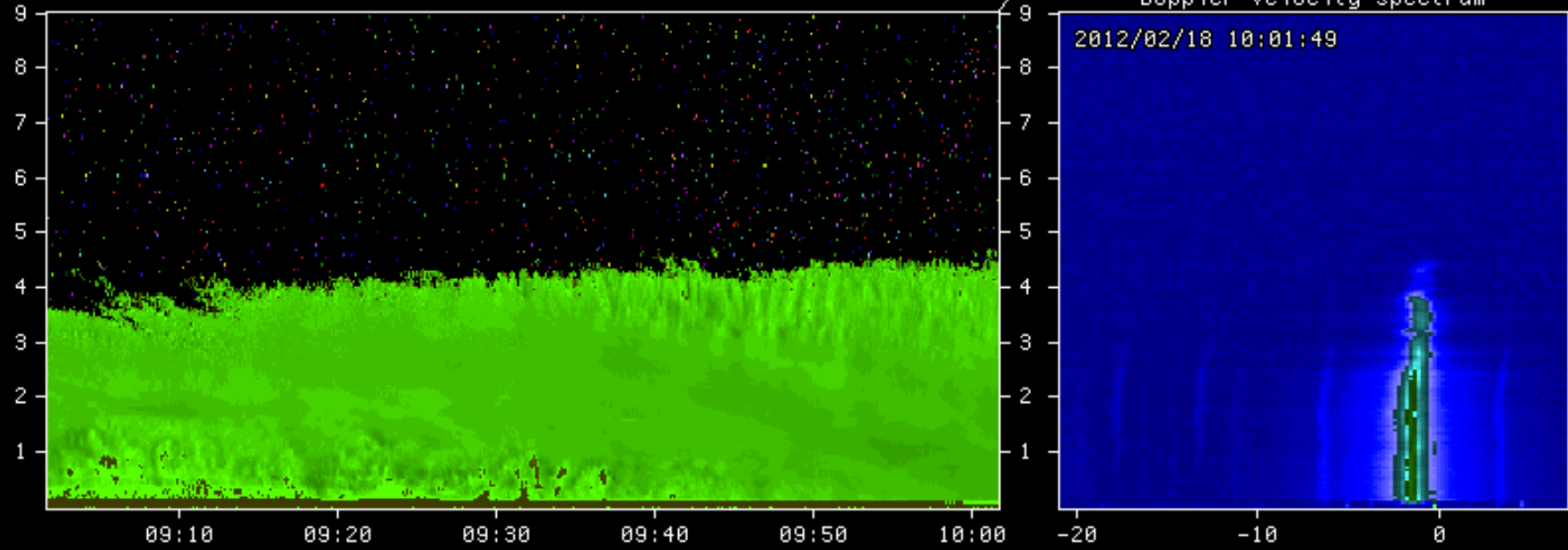
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VertiX Imagery (GCPEX)/ *Imagerie du VertiX*

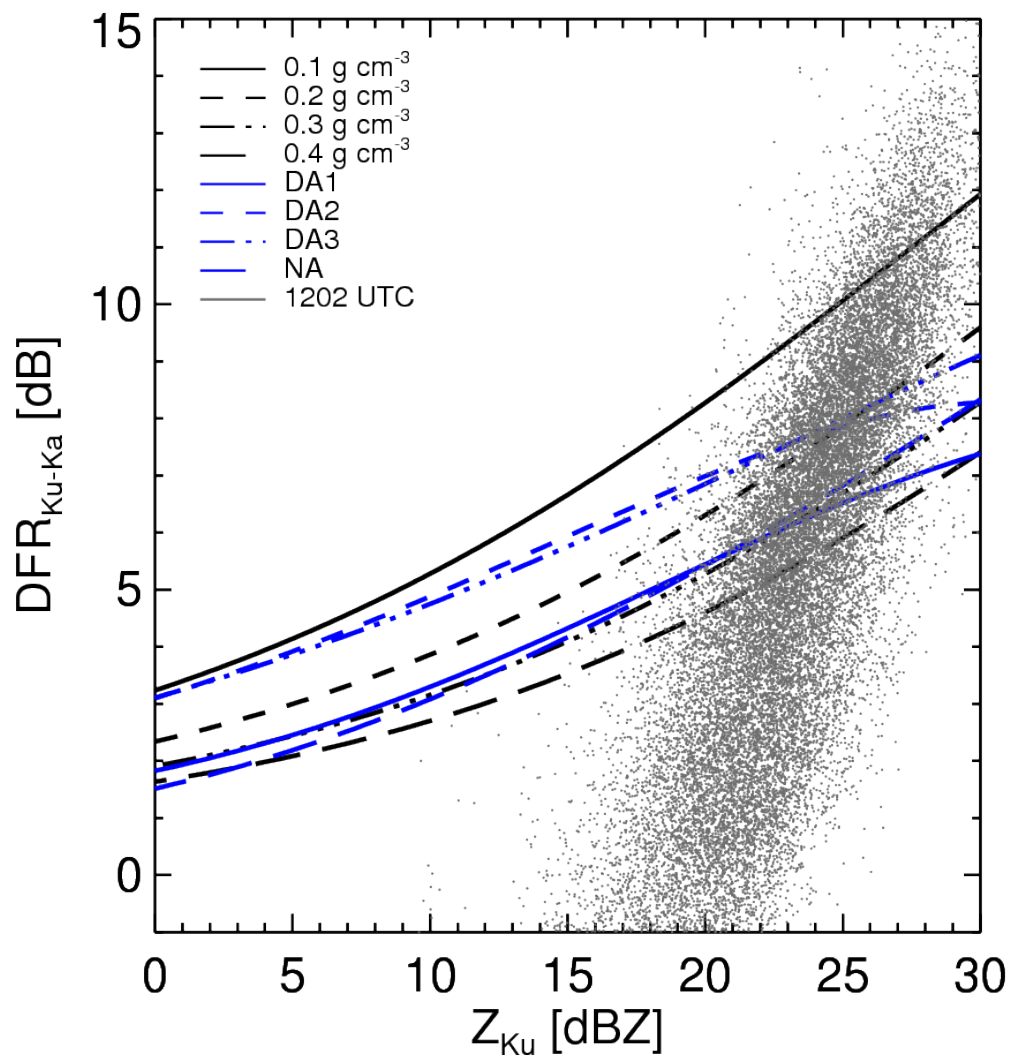


— 13Z RUC2 sounding

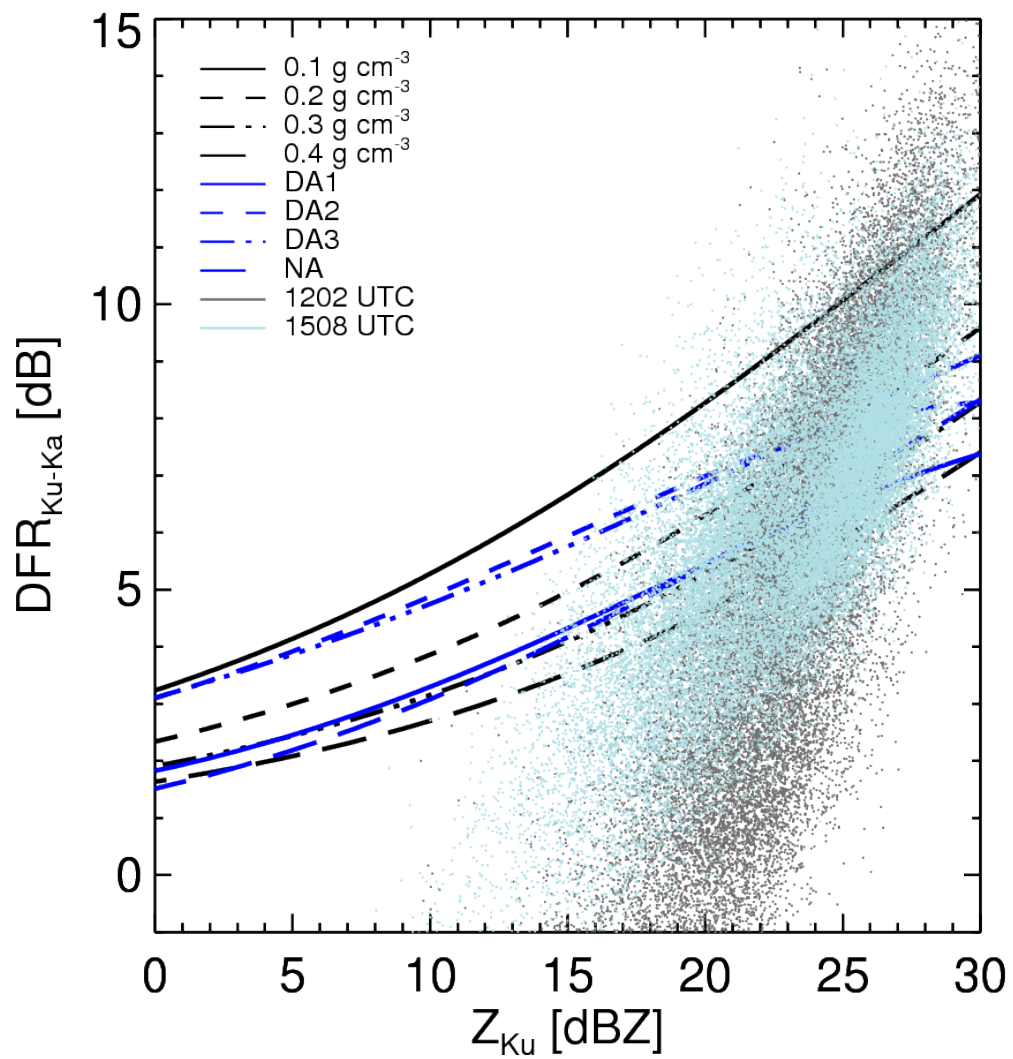
Doppler velocity spectrum



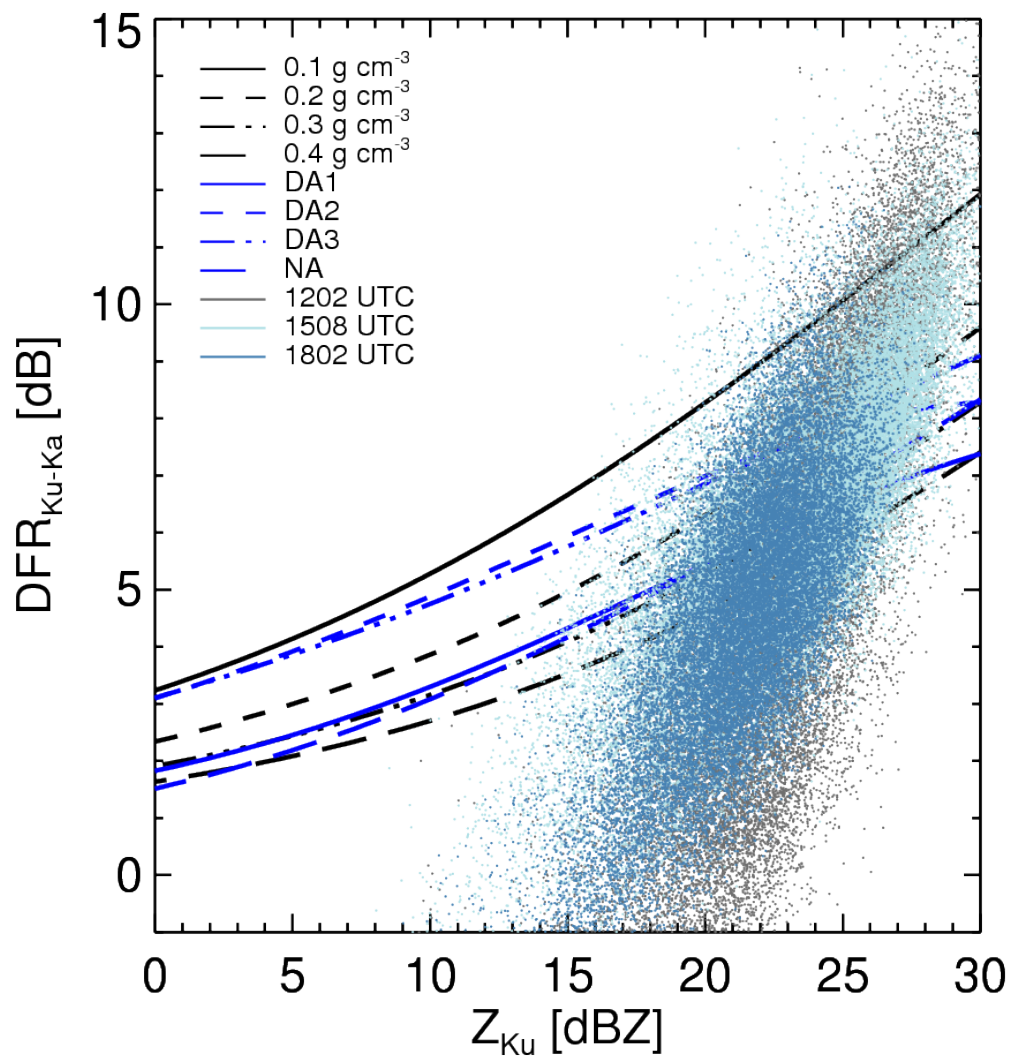
GCPEX D3R 2012-02-18



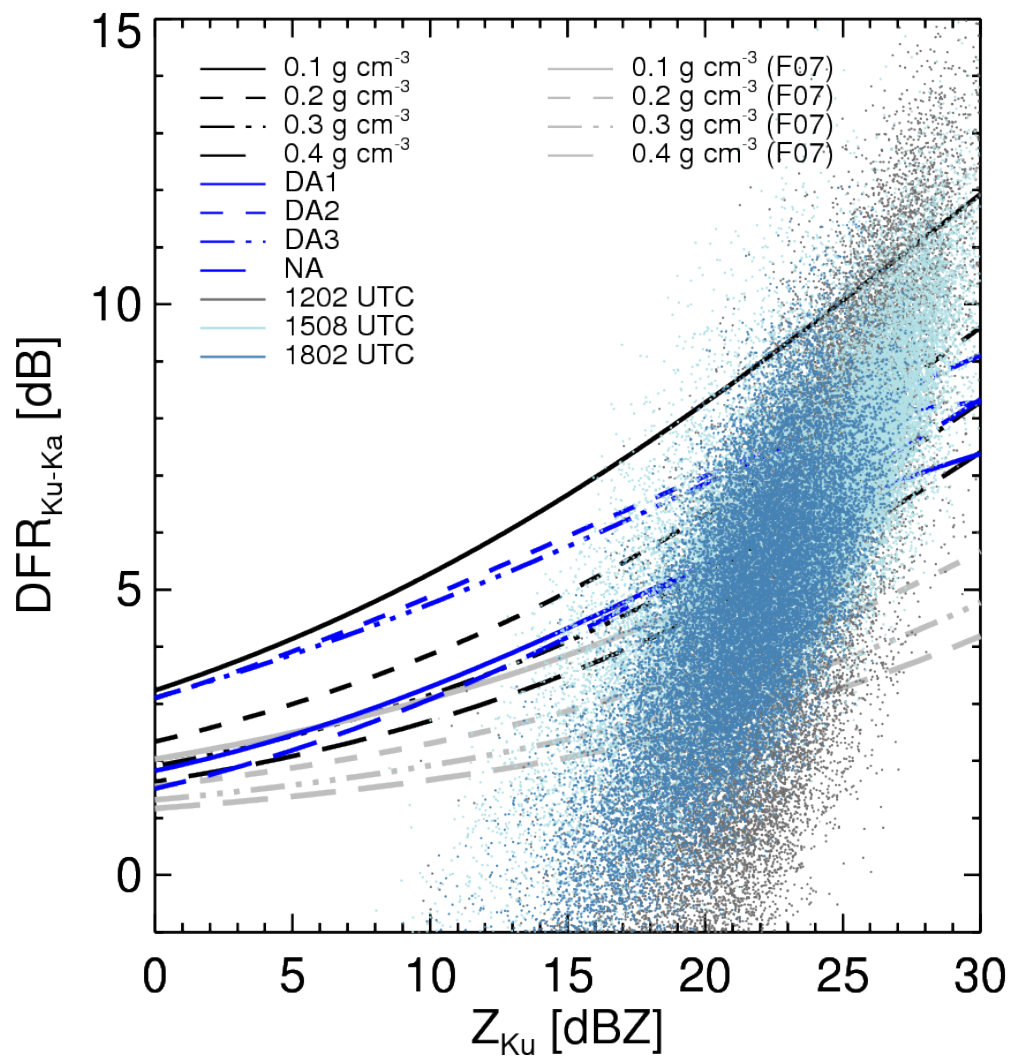
GCPEX D3R 2012-02-18



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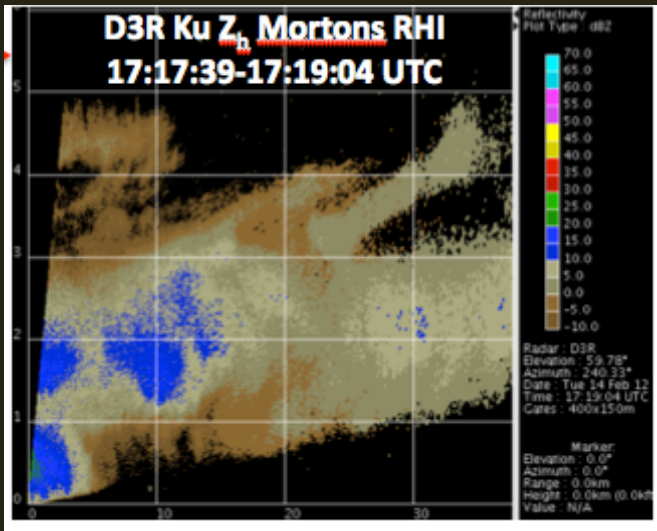


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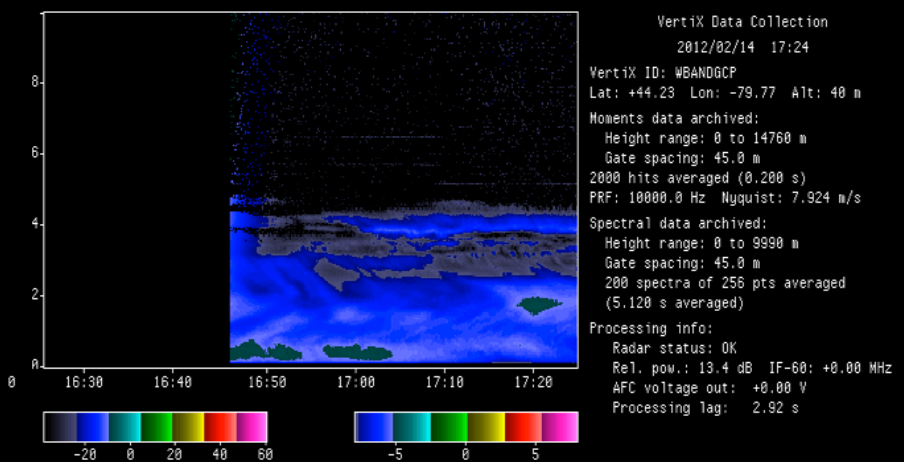
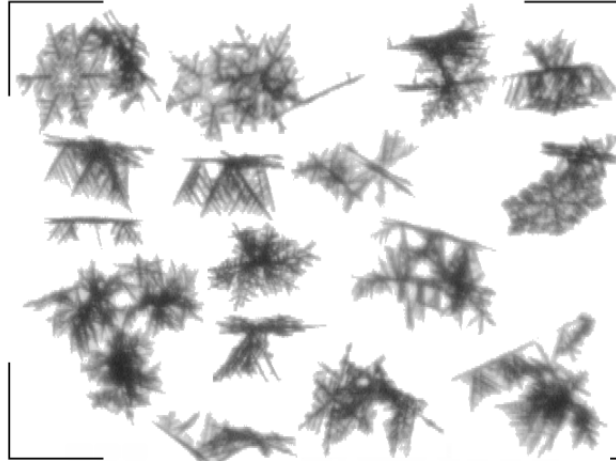


GCPEX: End-to-End Radiative Closure

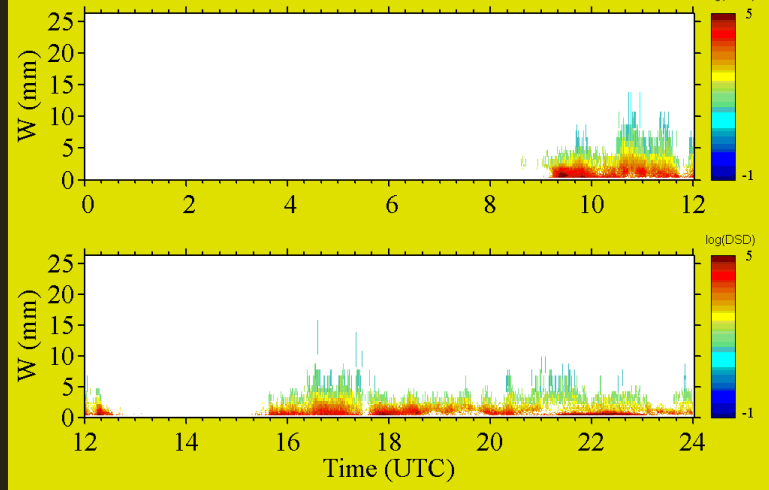
D3R+W-band



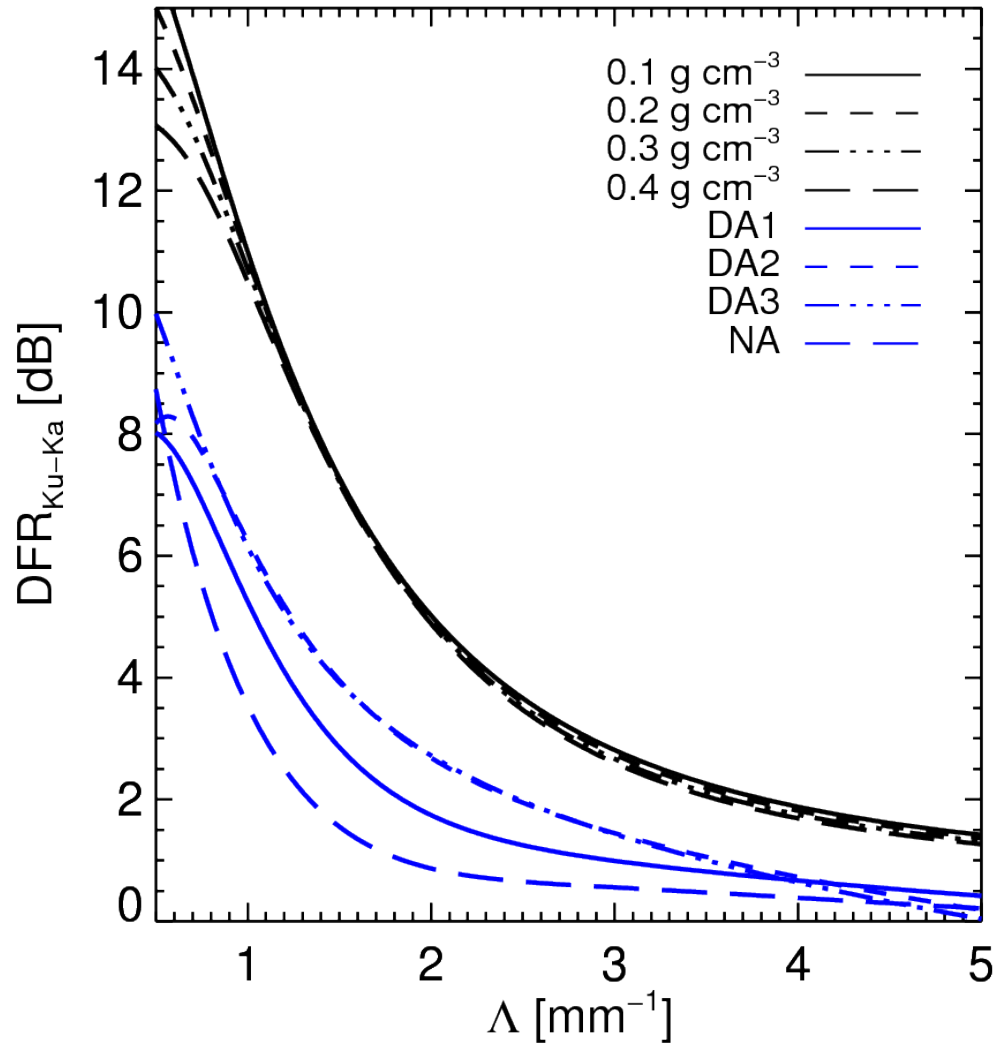
Steamshow. 2012 01 21 07 SVI 5 mm



PVI DSD(m-3 mm-1). CarH: 2012/02/14. fmt(log).

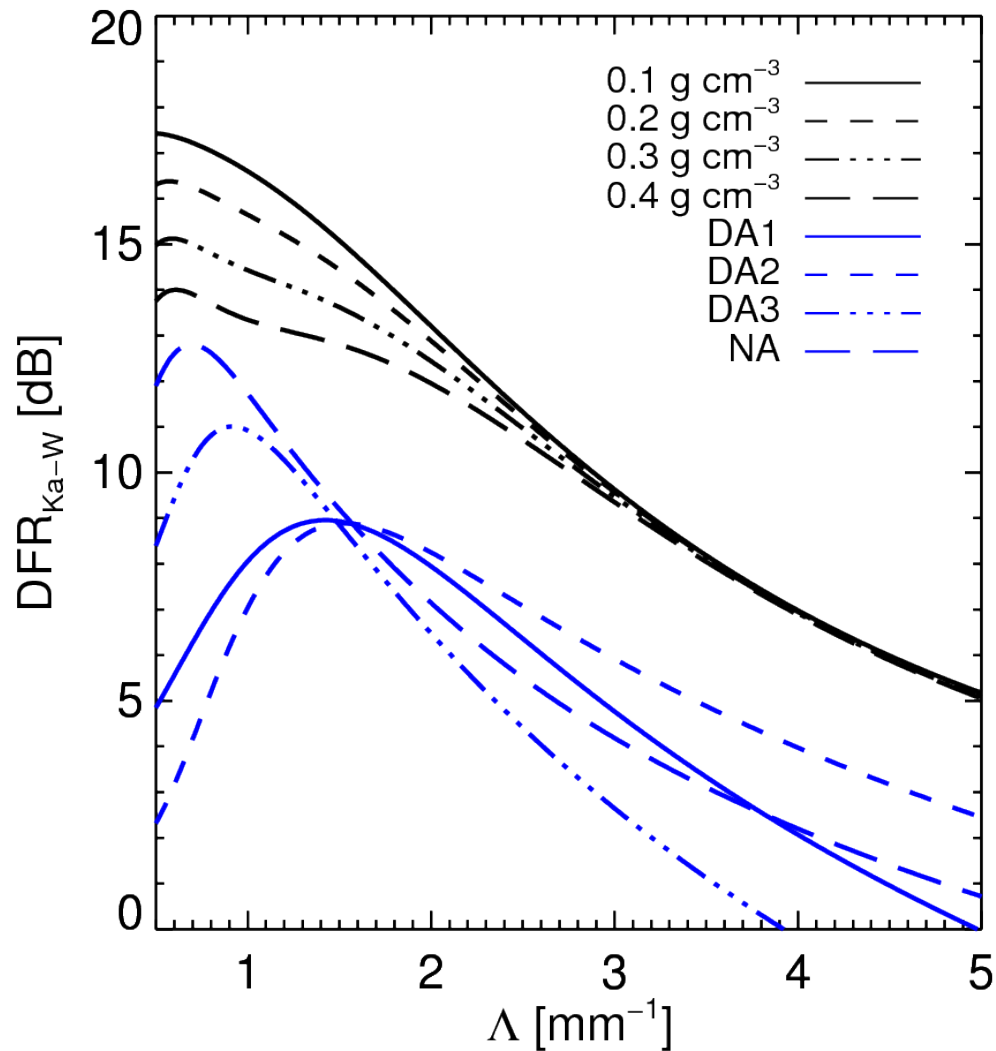


Modeled Dual Freq Ratio (DFR)



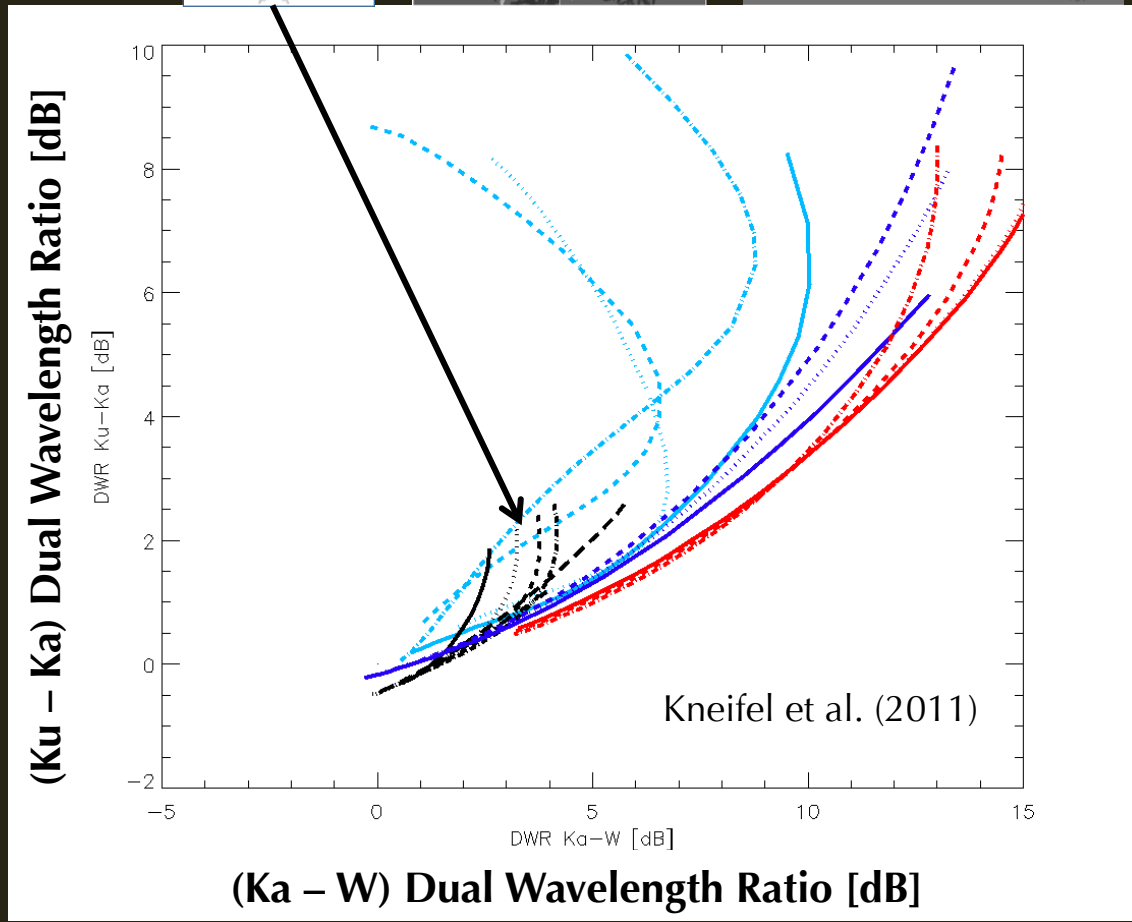
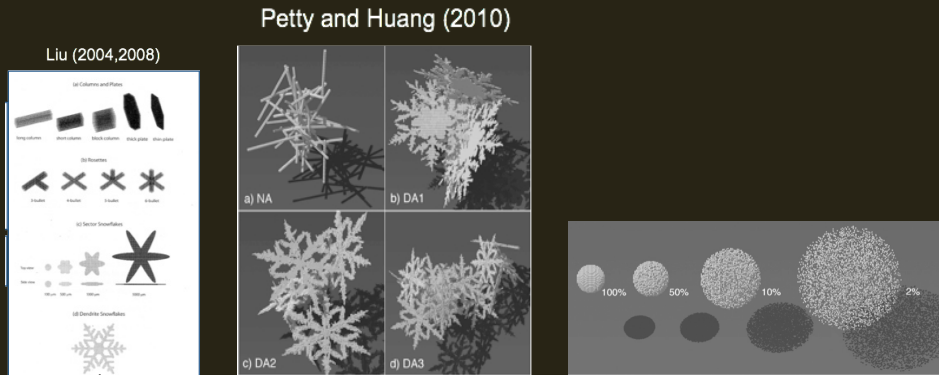
- Scattering database
- Unique signatures?
- Microphysical constraint?
- Observations?

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- Scattering database
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Multi-Freq Radar: Modeling Perspective

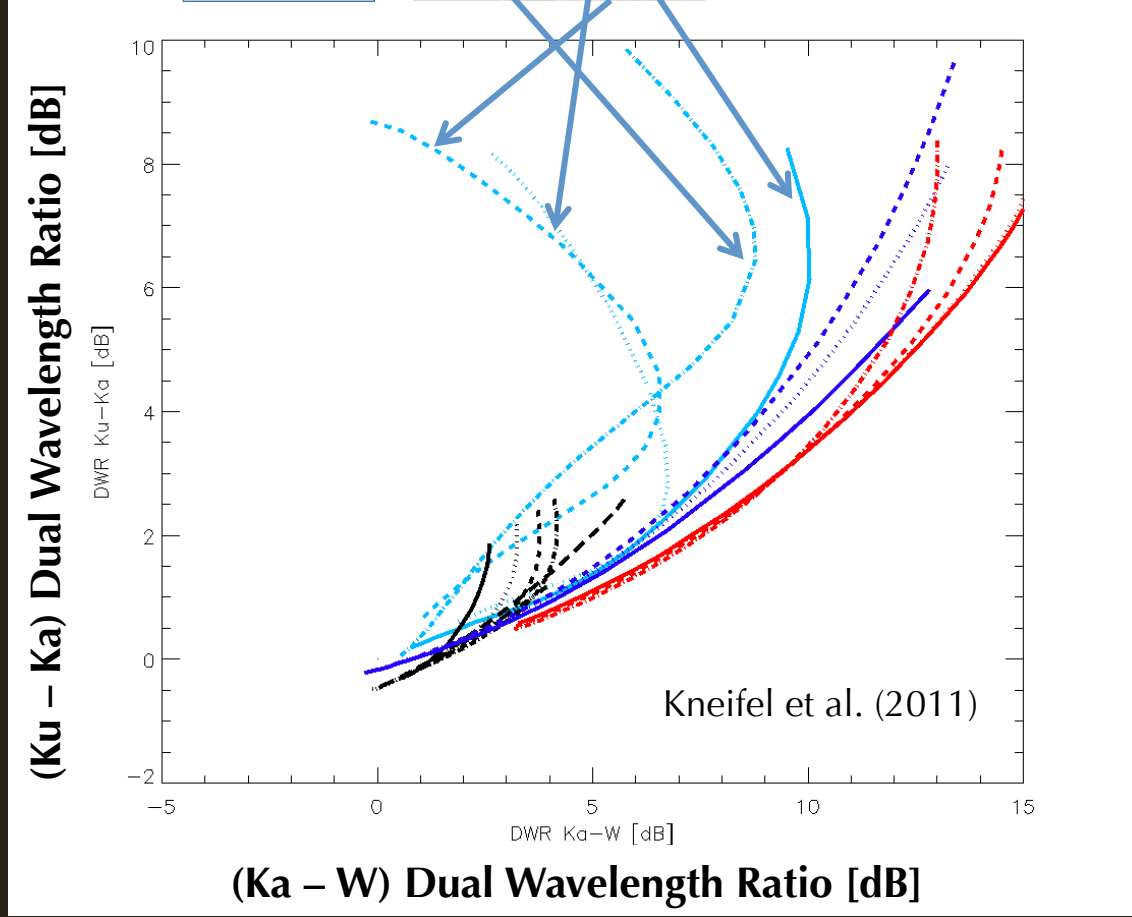
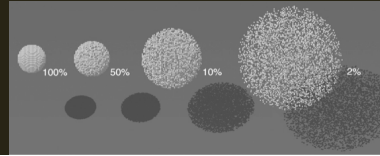
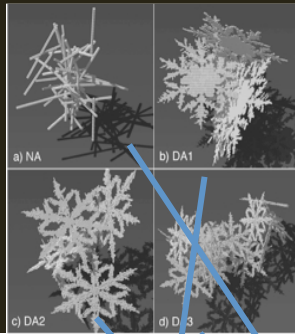
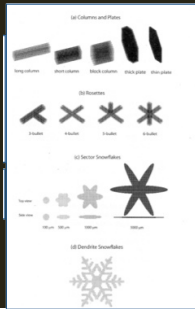


- Exponential size distribution
- Unique three frequency trends
 - Aggregates
 - Pristine crystals

Multi-Freq Radar: Modeling Perspective

Petty and Huang (2010)

Liu (2004,2008)

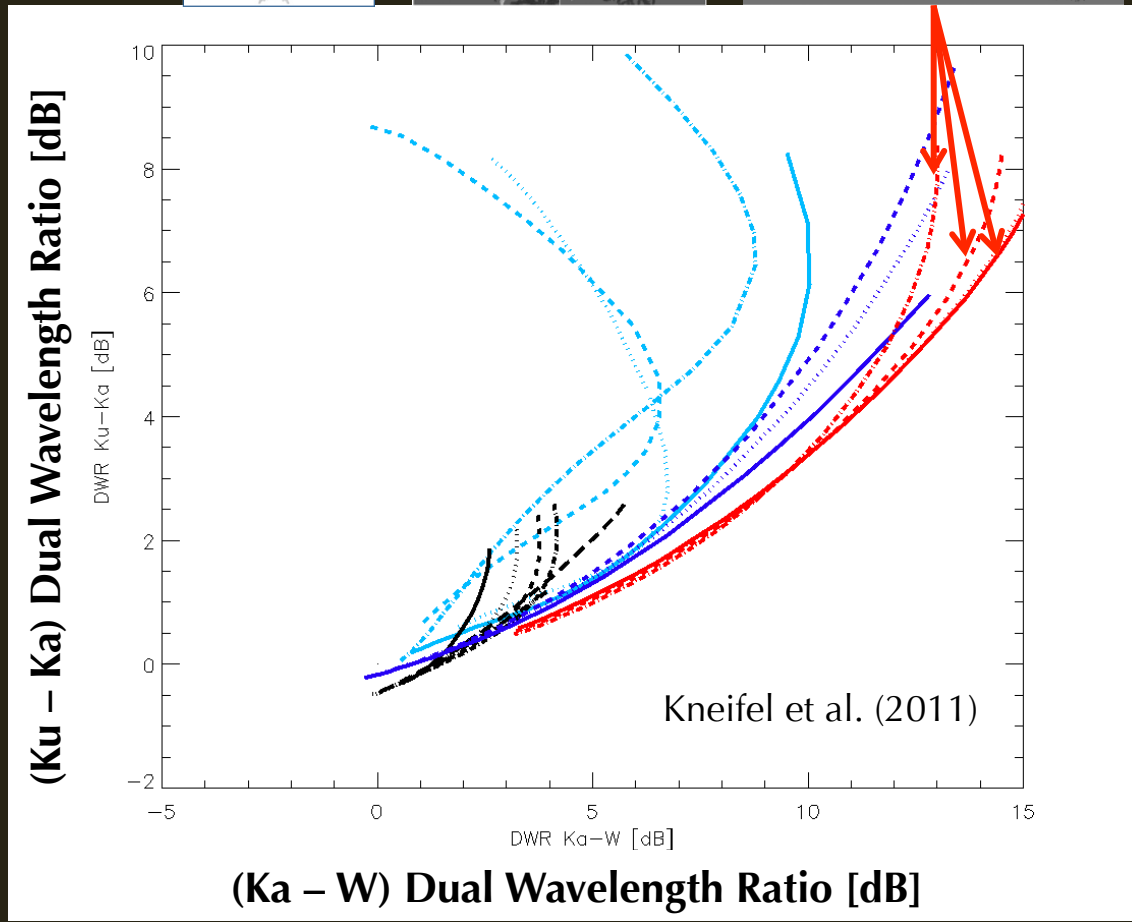
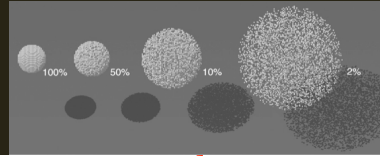
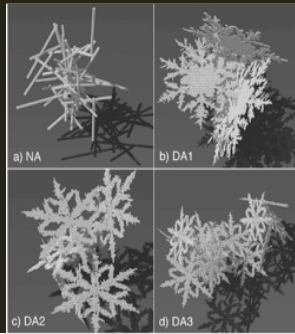
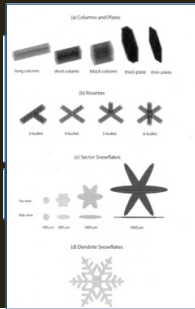


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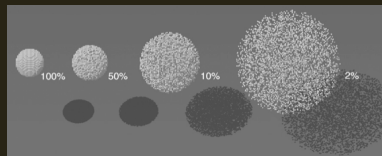
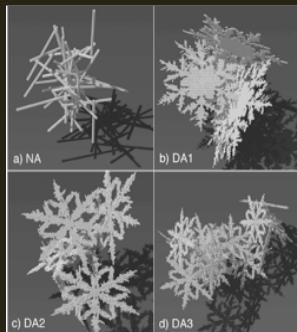
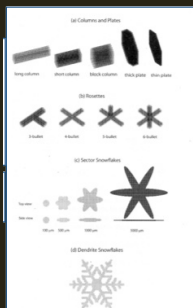


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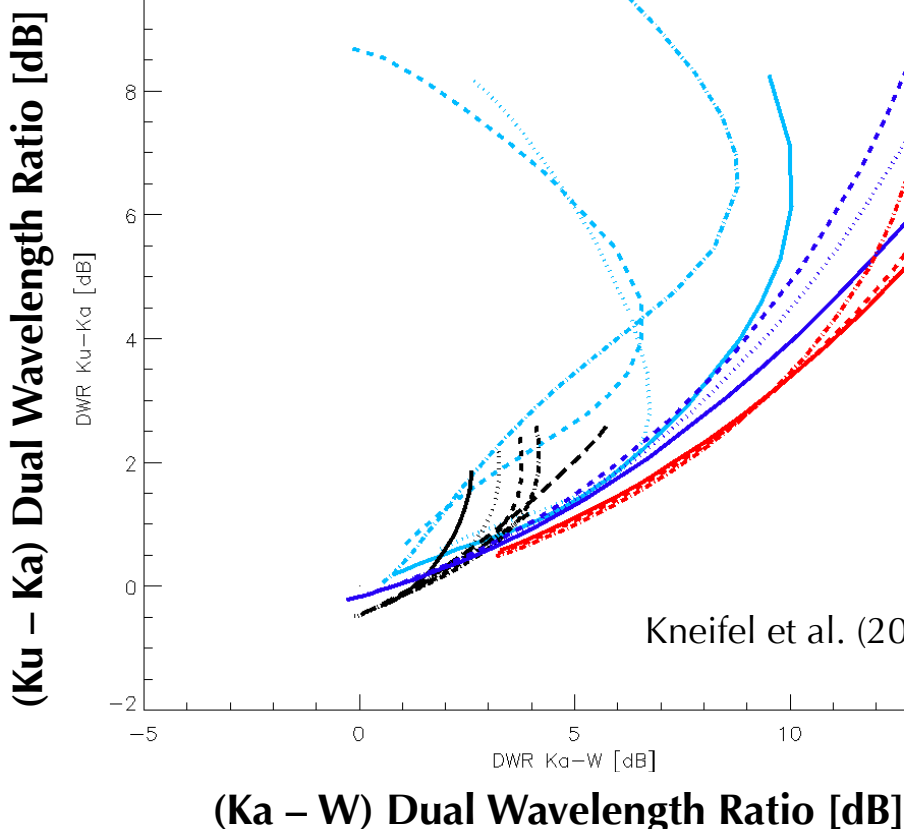
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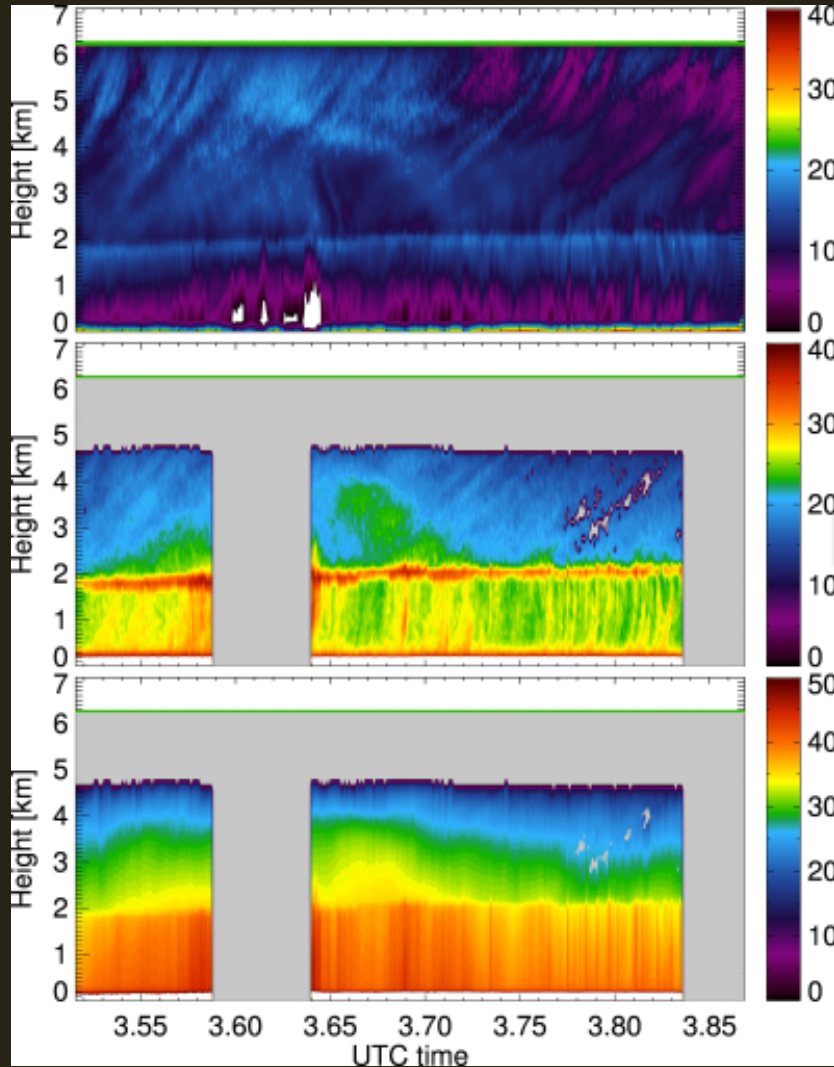


Spheroids

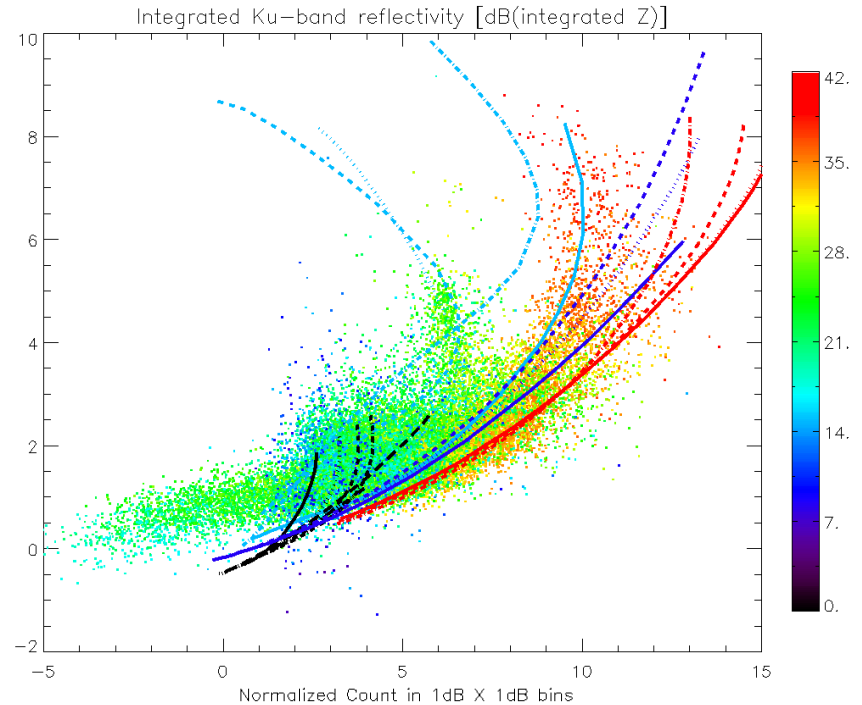


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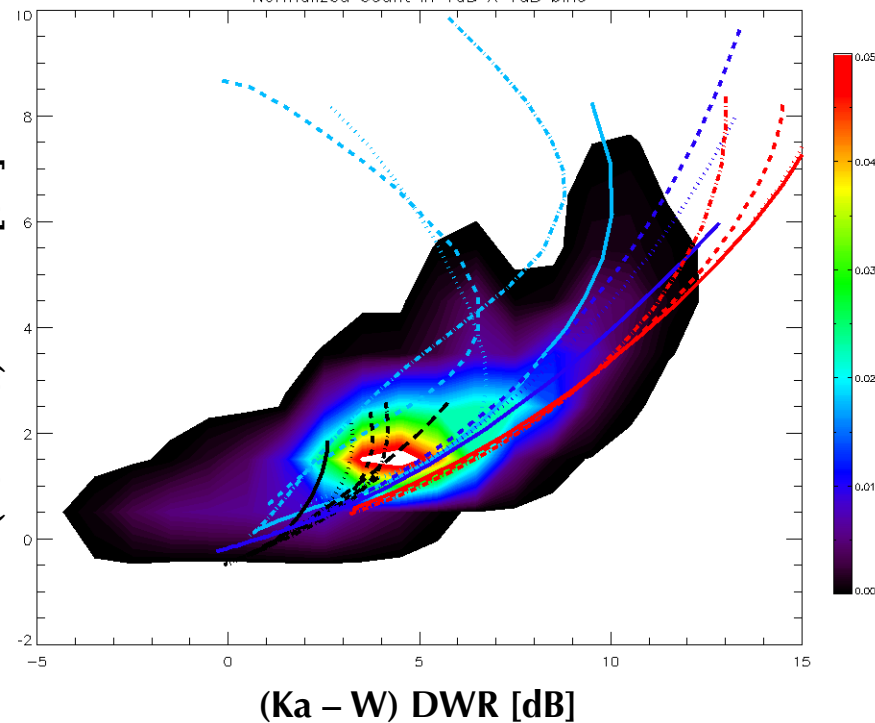
Wakasa Bay ACR/APR-2



(Ku - Ka) DWR [dB]



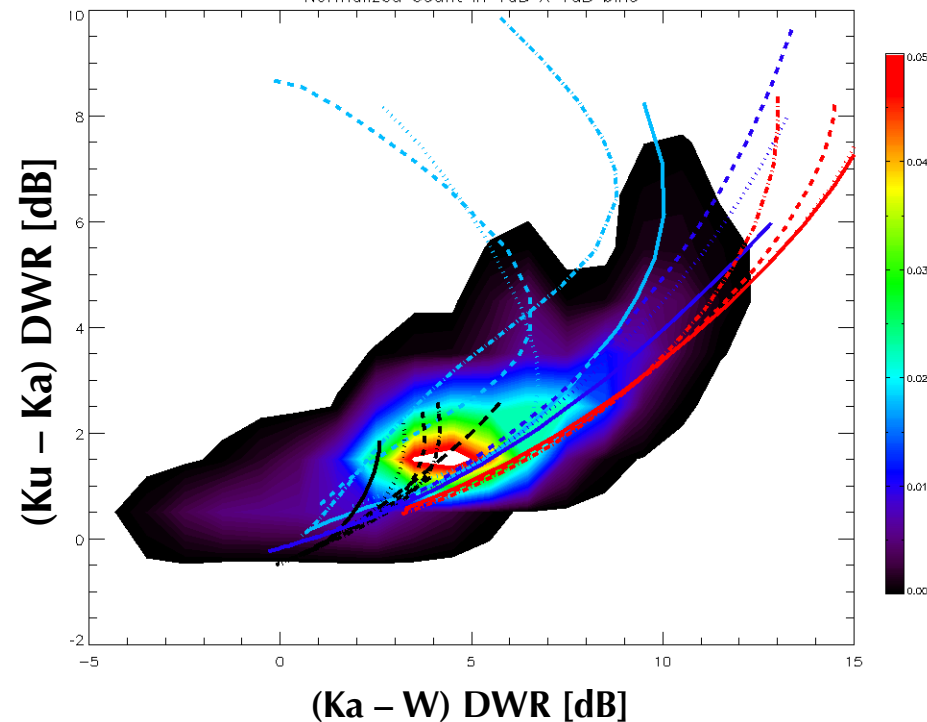
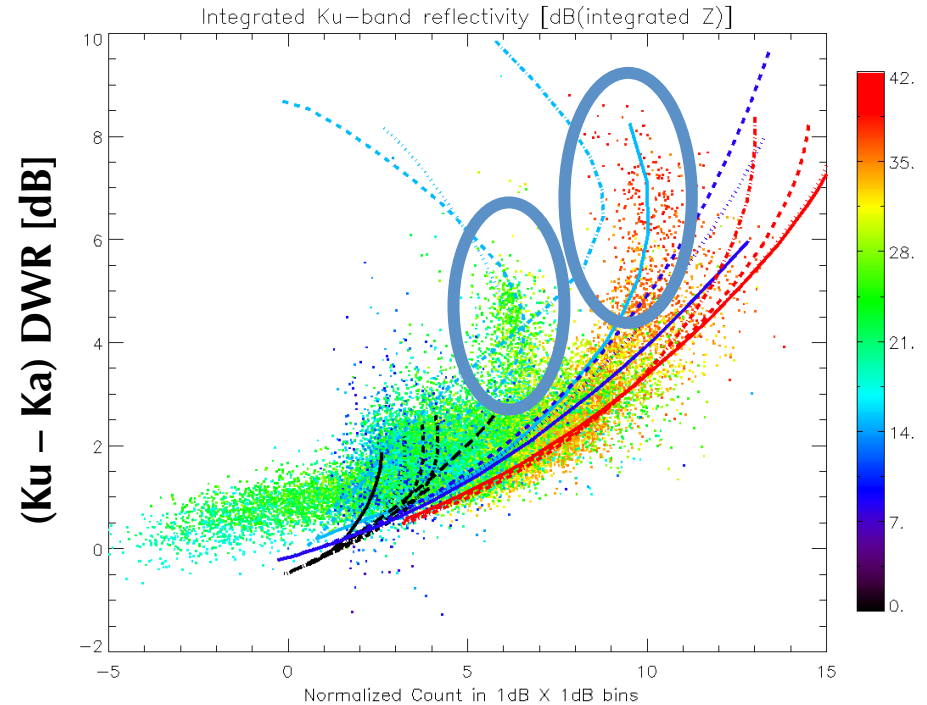
(Ku - Ka) DWR [dB]




27 January (Stratiform rain)

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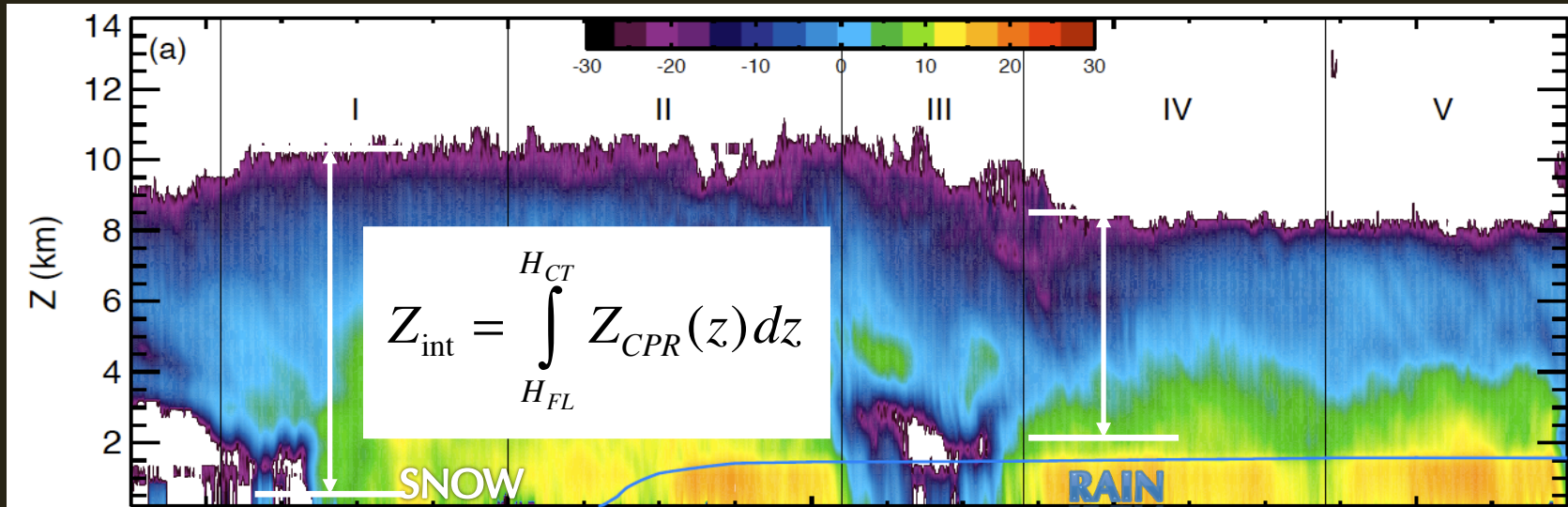
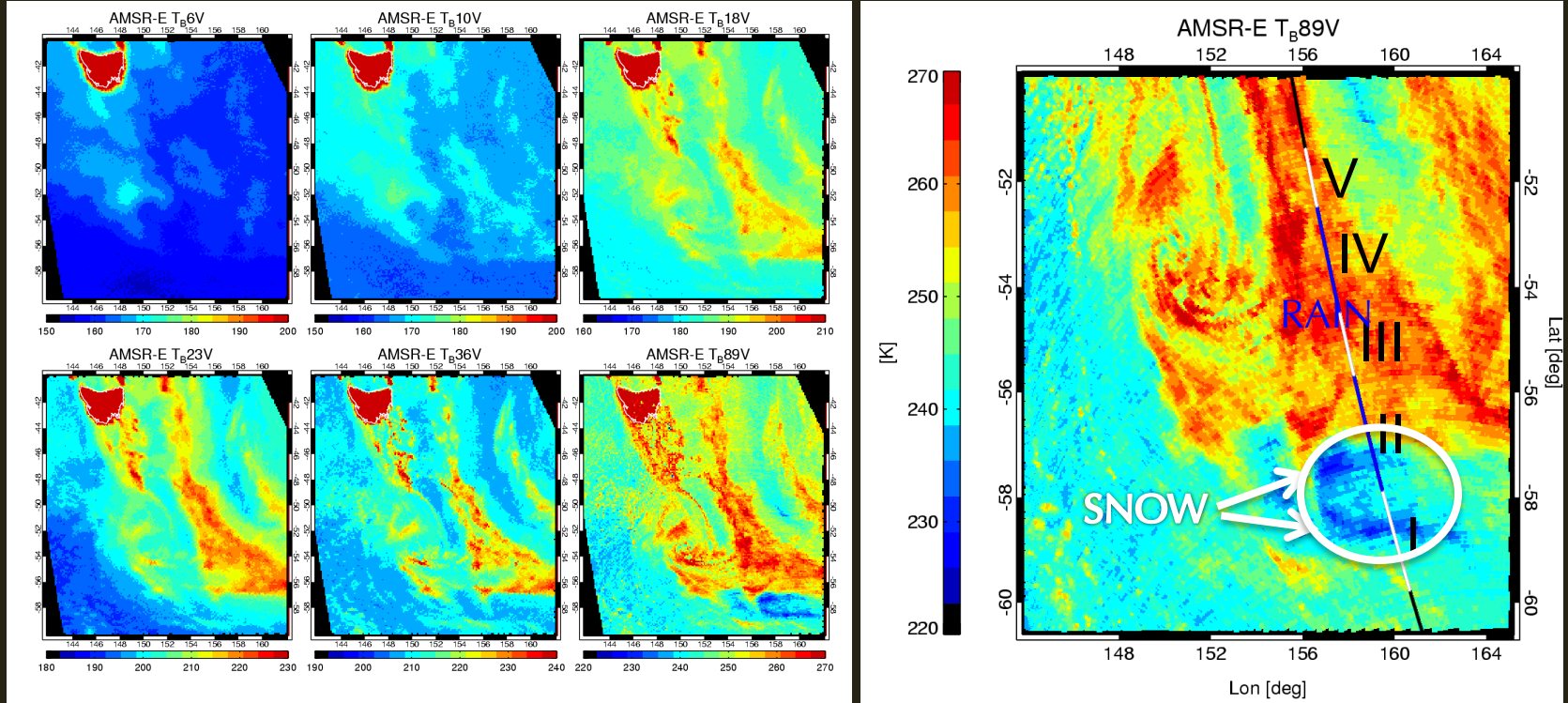
- Data density highest at smaller DWR values
- Higher DWR values: aggregate models
- Attenuation correction shifts points with high integrated reflectivity to the **left**
- Higher DWR's associated with areas closer to bright band (higher integrated Z)



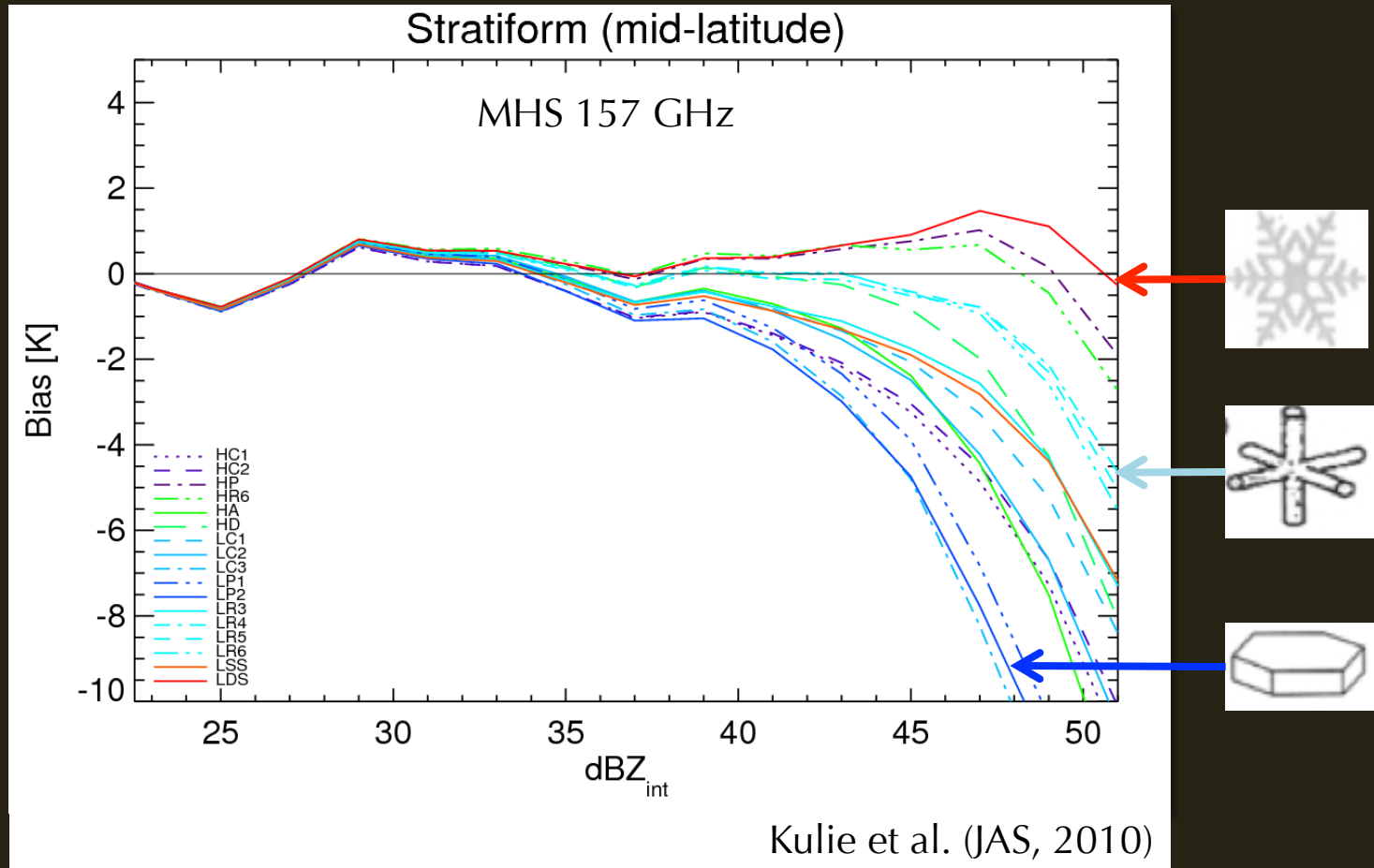
Themes

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CloudSat/AMSR-E 0400 UTC 9 Aug 2006

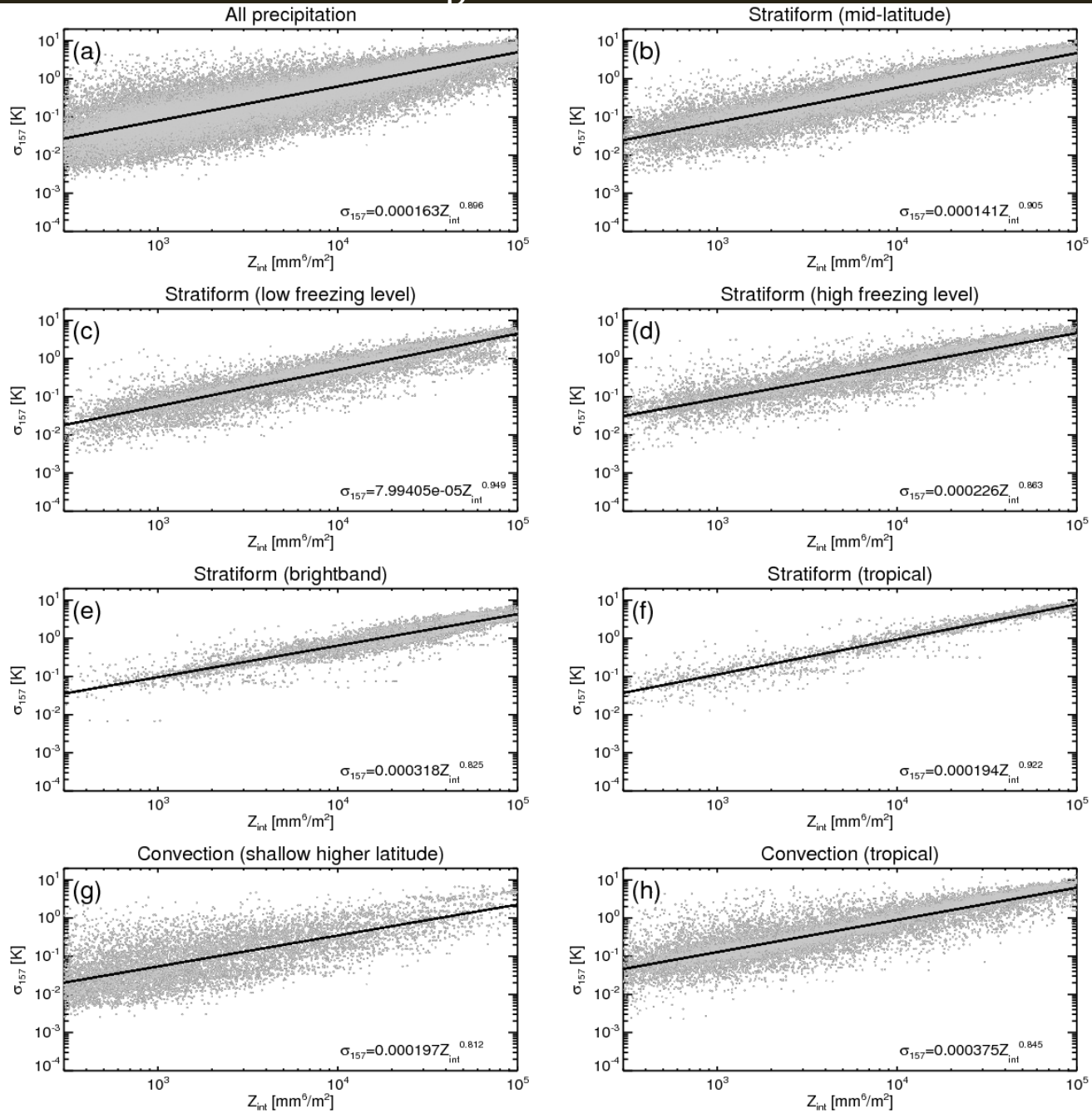


Applications: Eliminate unrealistic models



- CloudSat Z_{int} as proxy for IWP
- Excessive scattering at high Z_{int}
- Extrapolate scattering properties – large D_{max}

Simulated T_B 157 Uncertainties



Goddard Profiling (GPROF) Algorithm

Proxy GPM Microwave
Imager Observations


Profile
Database

Goddard Multiscale
Modeling Framework
(MMF) + Satellite Data
Simulator Unit (SDSU)

Radar: CloudSat

Radiometer: AMSR-E + MHS/AMSU-B

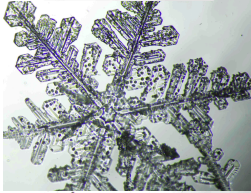
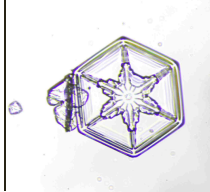
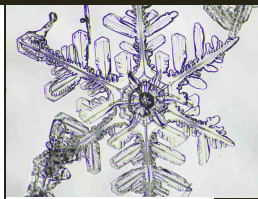
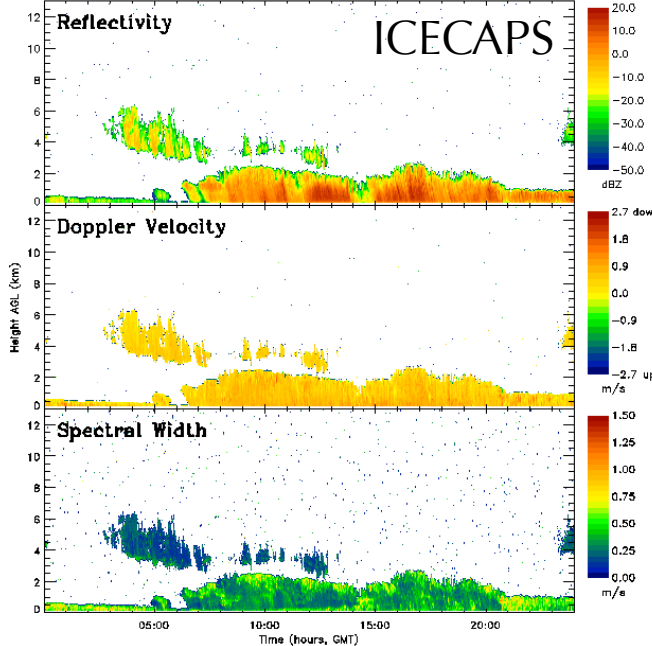
Themes

- Microphysical modeling tools
- Modeling  Observations
- Leveraging pre-GPM spaceborne datasets
- Ground-based radar observations

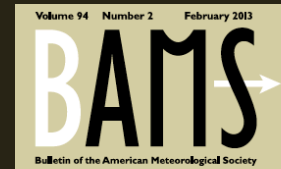
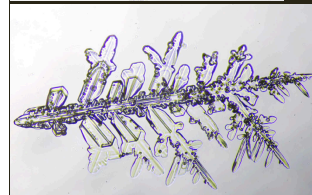
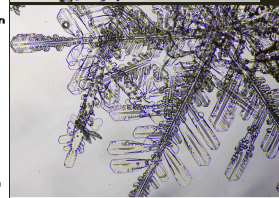
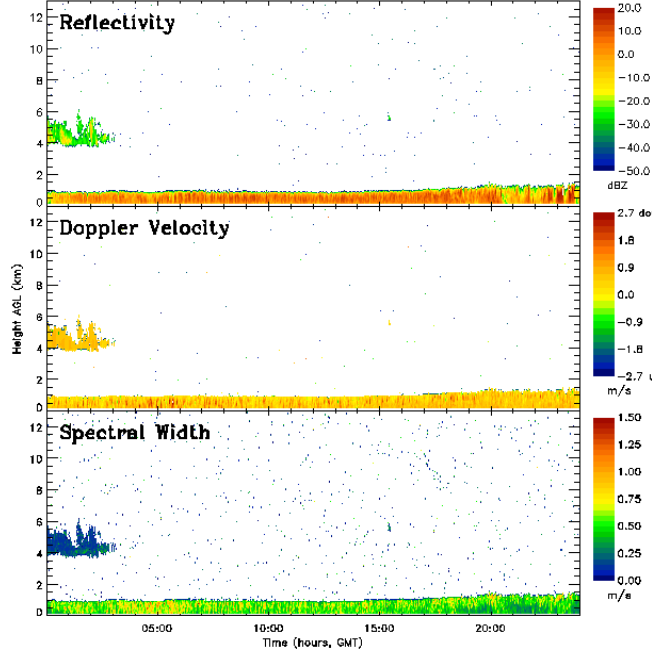
GPM Ground-based Radar Snowfall Observations

- Direct observational validation
- Near-surface details
- Increased sensitivity
- Regime statistics

SUMMIT, Millimeter cloud radar data for June 17, 2012



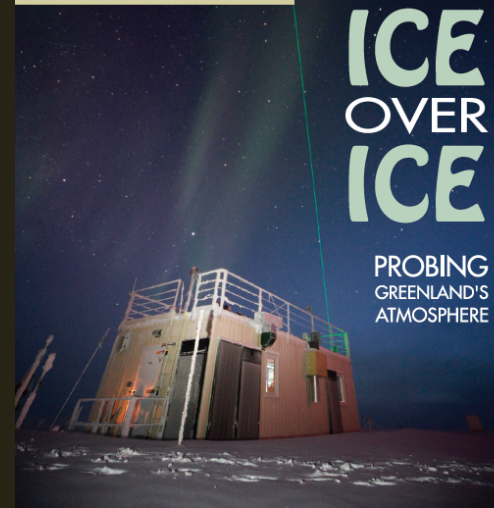
SUMMIT, Millimeter cloud radar data for June 22, 2012



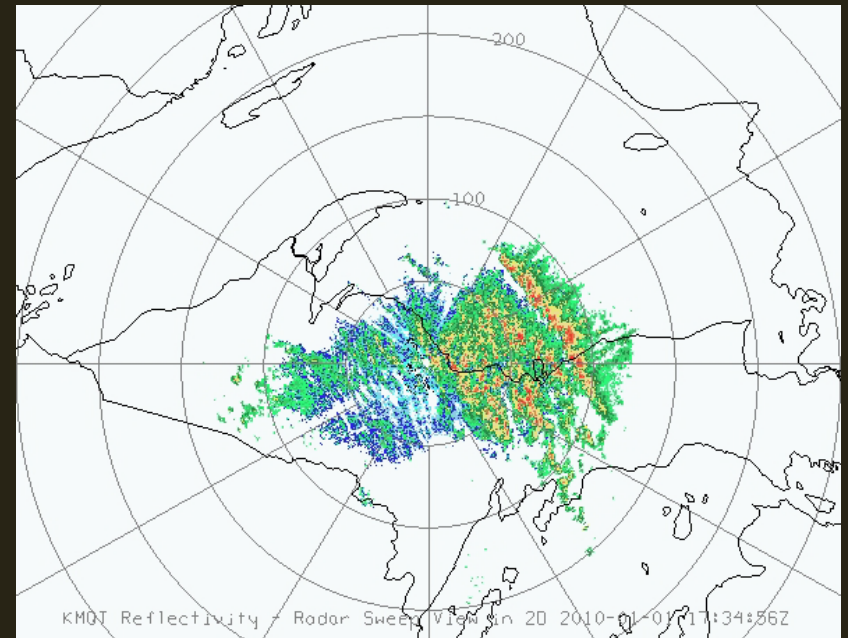
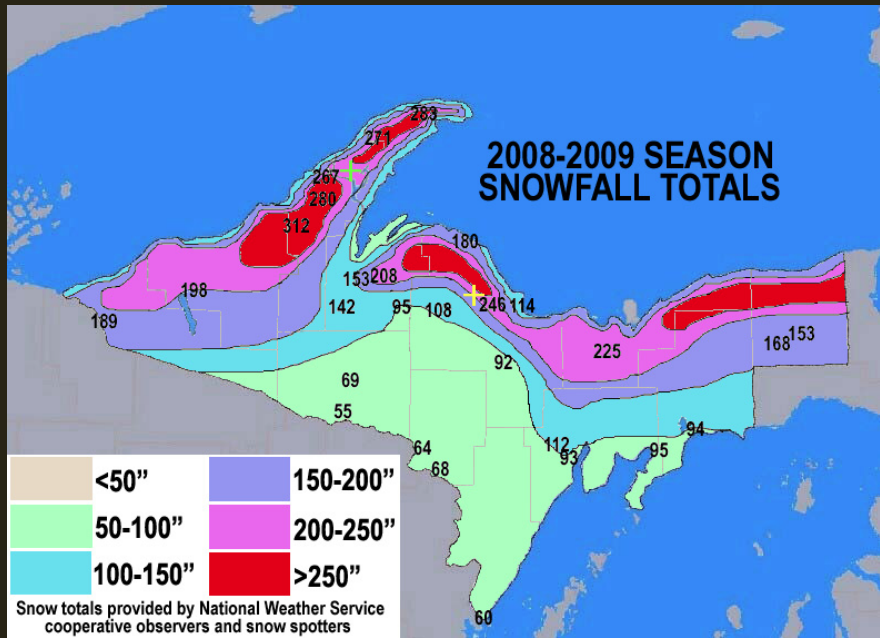
RADIOSONDE LIFE CYCLE
LAND ALBEDO FROM SPACE
WORLD RECORD REVOYOKED

ICE OVER ICE

PROBING
GREENLAND'S
ATMOSPHERE



Micro Rain Radar + Precip. Video Imager

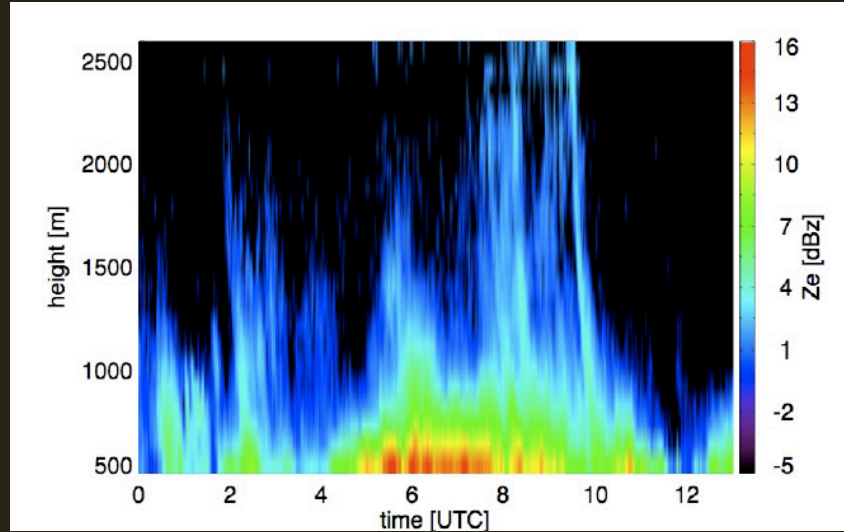
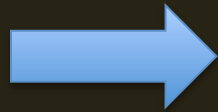


- 2012-'13 & 2013-'14 deployments
- Long-term microphysical + radar obs
- Near surface dBZ features
- Modeling/retrieval improvements
- Validation site

Micro Rain Radar + Precip. Video Imager



Courtesy of Metek



Courtesy of S. Kneifel



Courtesy of P. Kucera



Courtesy of P. Kucera

Summary

- Microphysical models: Multi-freq/multi-sensor consistency
- “Default” ice model candidates
- Mining field campaign data
- Pre-GPM spaceborne radar/radiometer obs
- Ground-based radar observations

Acknowledgments

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