The Hydrometeor Structure of Mesoscale Convective Systems During AMIE / DYNAMO

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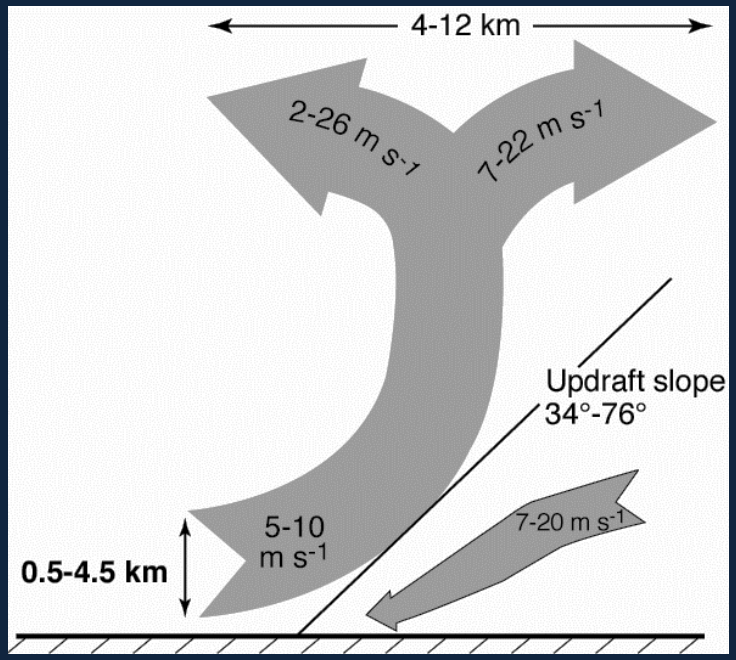
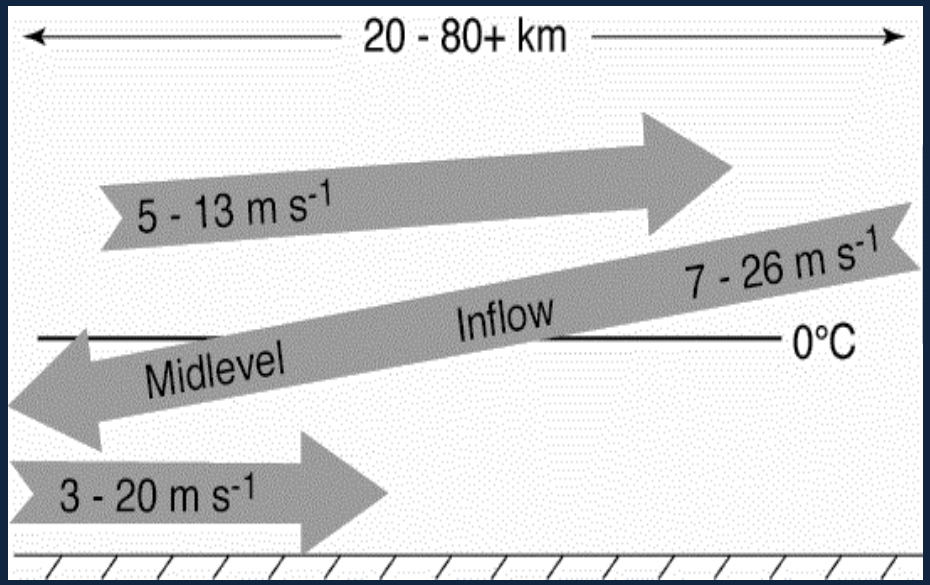
Conceptual Model of Mesoscale Convective Systems (MCSs)

TOGA COARE: 3D, layer airflow

Convective



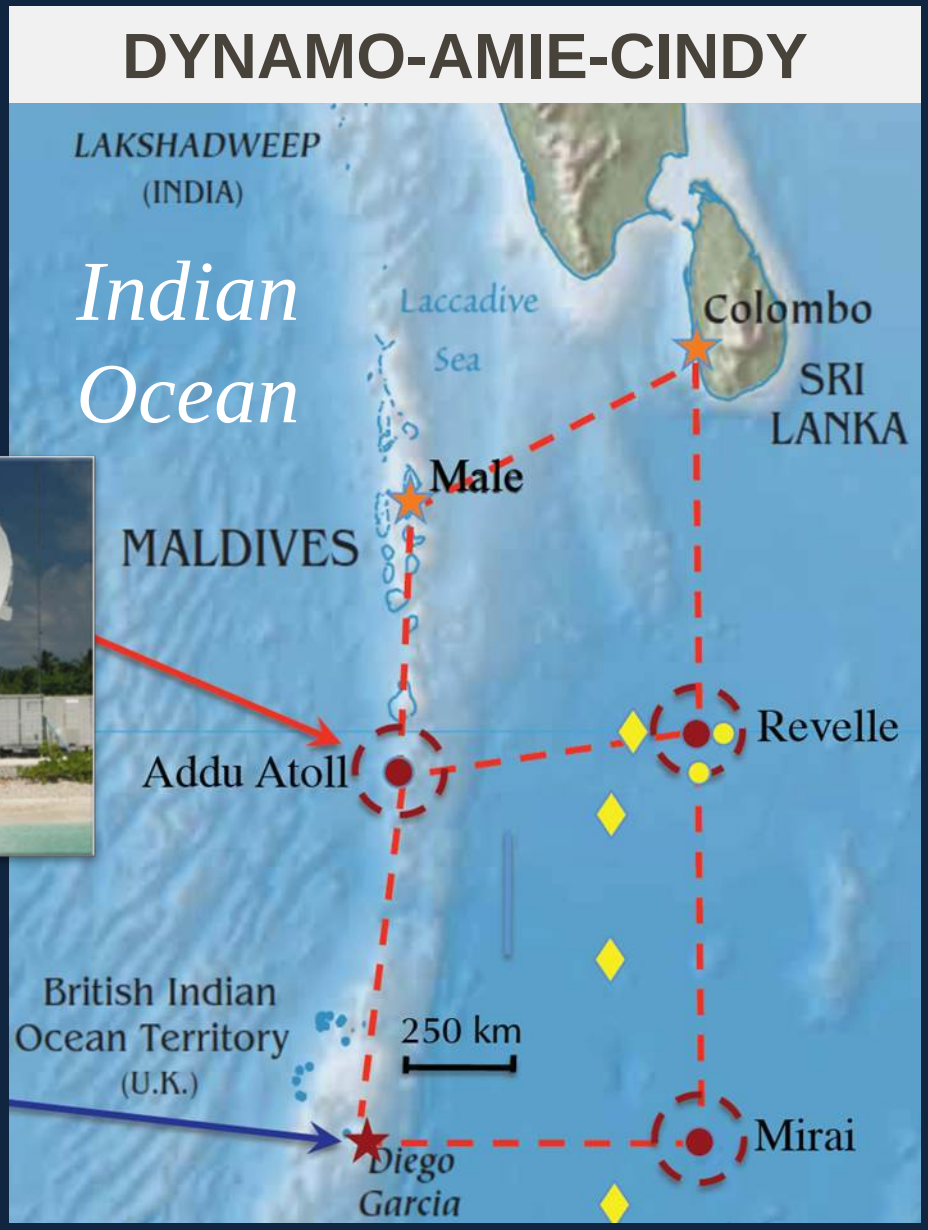
Stratiform



Kingsmill and Houze (1999a)

SPolKa

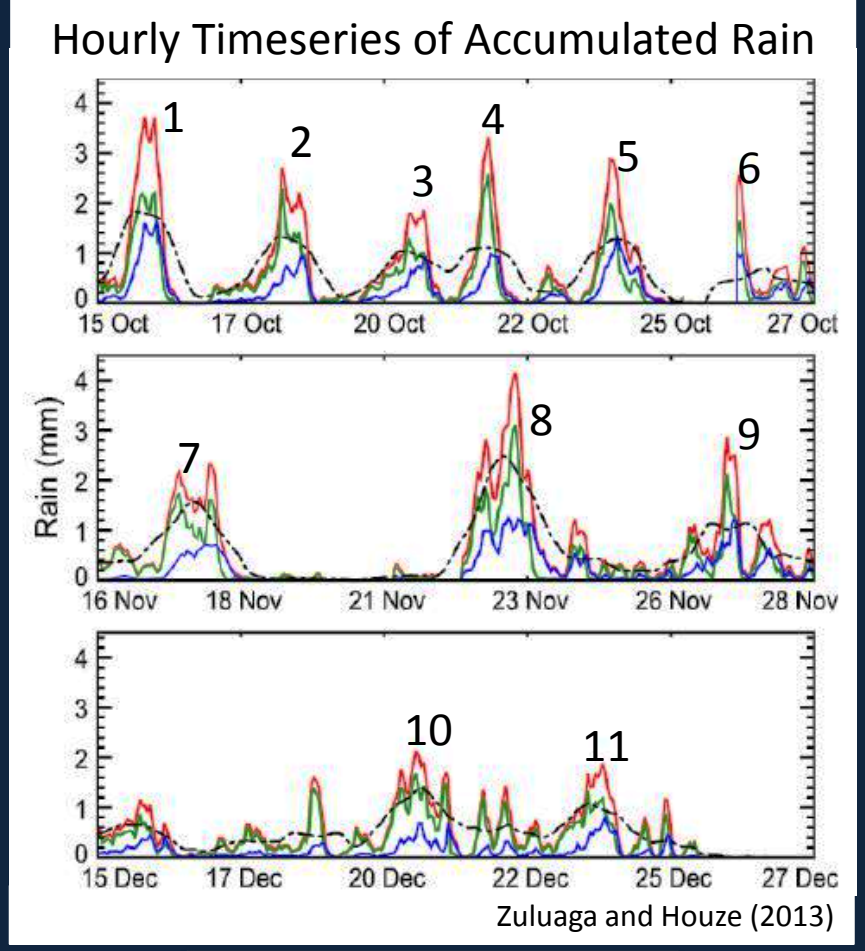
- Addu Atoll, Maldives
- Dual wavelength
  - Only using S-Band
- Doppler
- Dual-polarimetric
  - Particle Identification Algorithm (Vivekanandan et al., 1999)
- RHI sectors

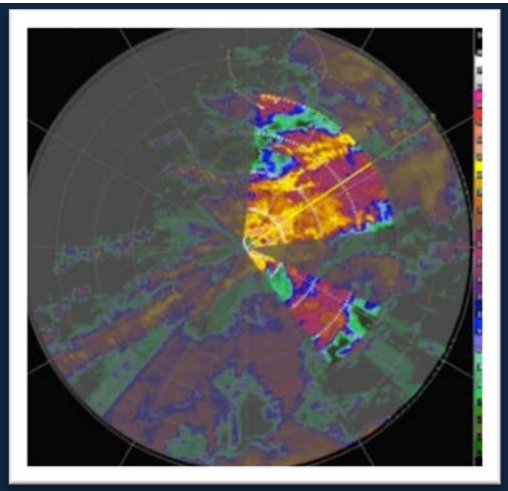


Objective

Characterize hydrometeor structure of MCSs

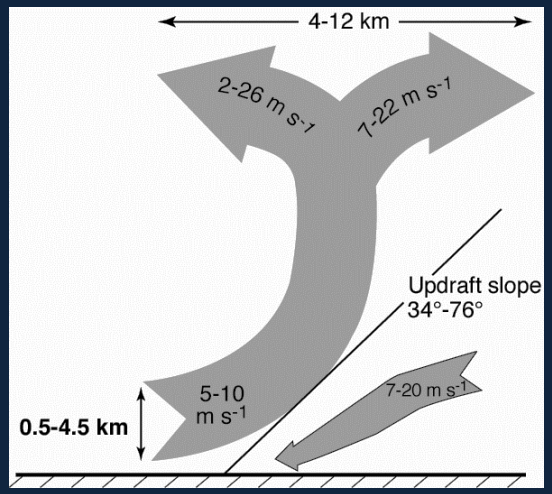
- Composite with respect to kinematic structure



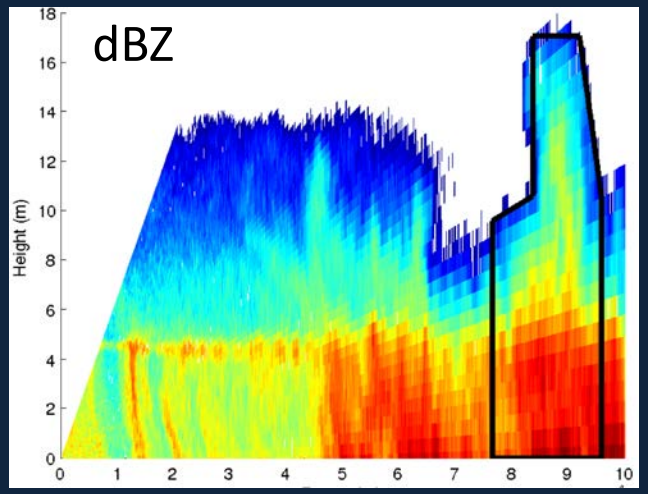


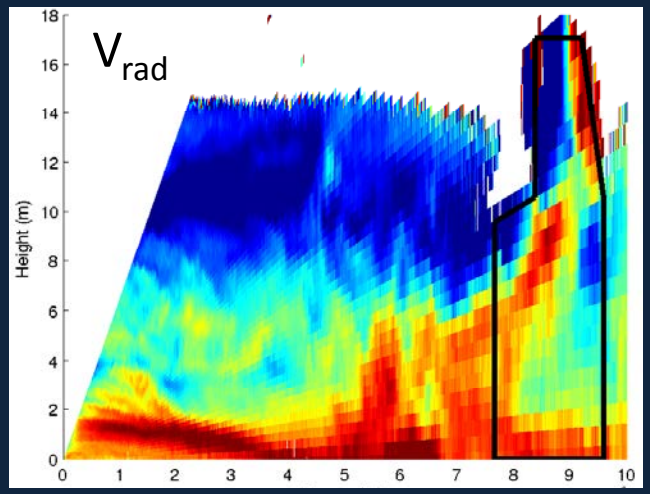
Methodology

- 11 rain maximums during DYNAMO (Zuluaga and Houze, 2013)
- Subjectively identify cases
  - SPolKa radial velocity
  - Layer lifting
  - RHI sector and within 100 km
  - One per storm
- Manually map hydrometeor location using PID
- Composite around layer lifting



Convective Updraft

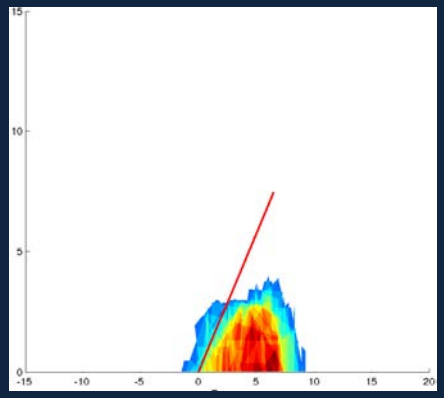




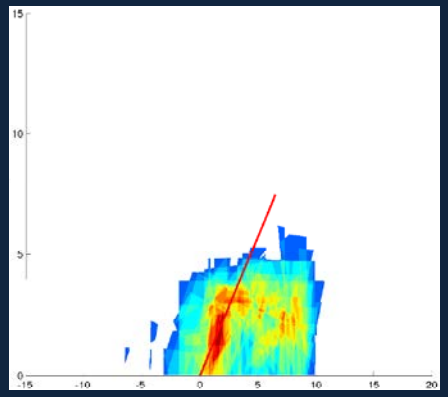
24 Oct 0250 UTC

Convective Updraft

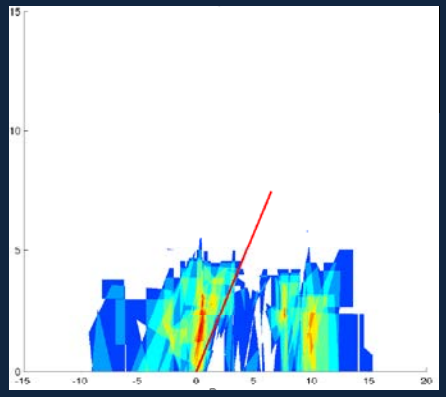
Heavy Rain



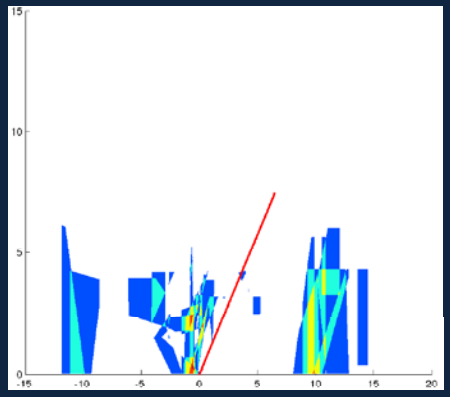
Moderate Rain



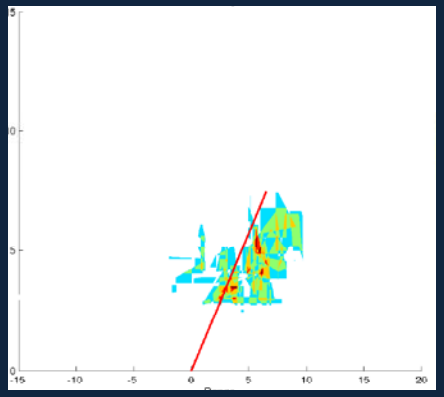
Light Rain



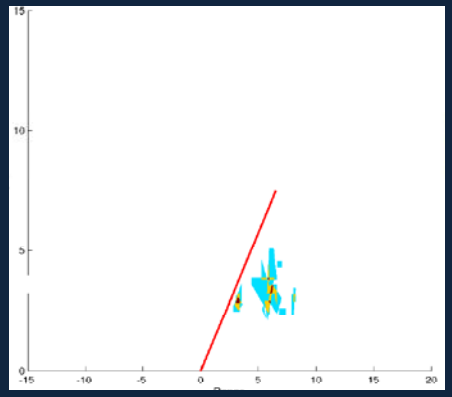
Very Light Rain



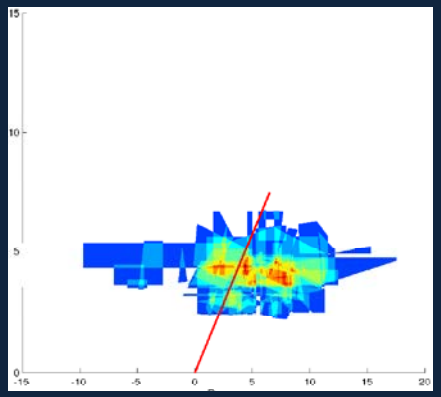
Graupel / Rimed Aggregates



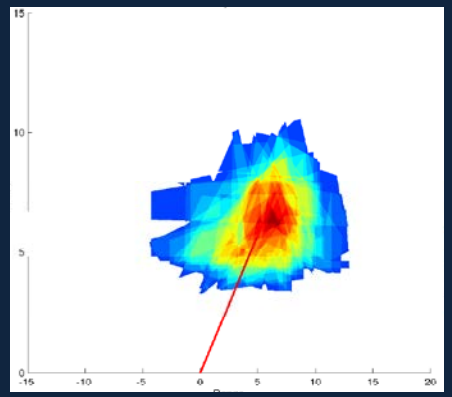
Graupel - Rain



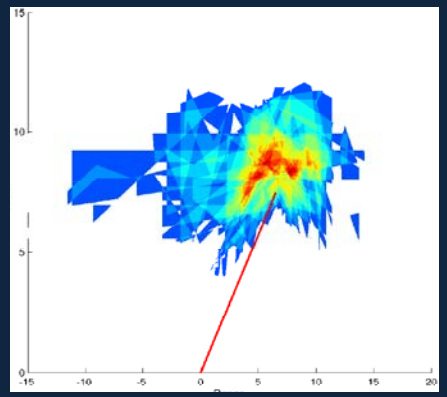
Wet Aggregates



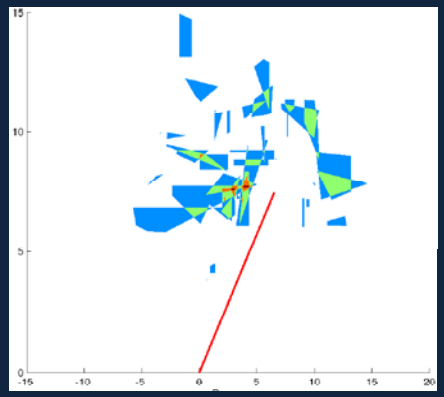
Dry Aggregates



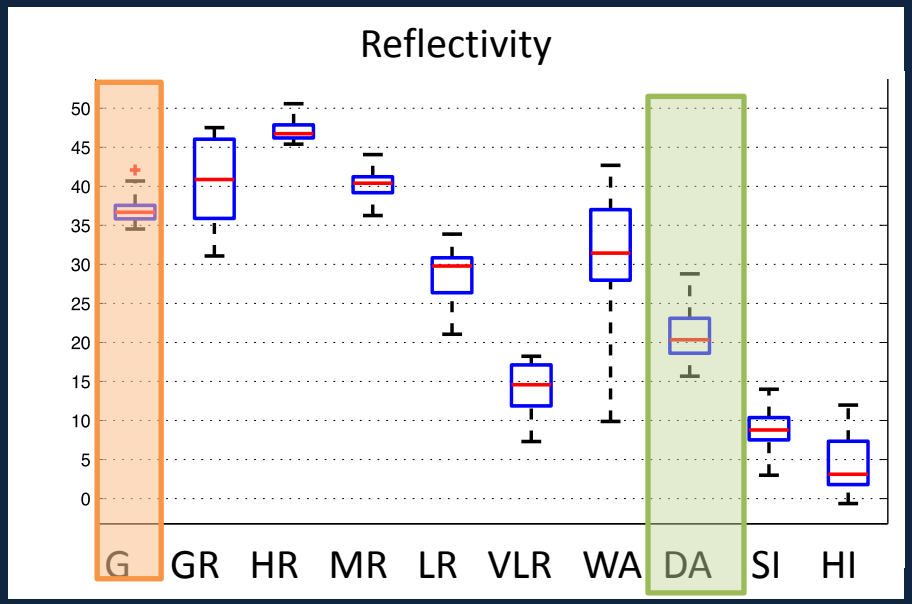
Small Ice Crystals

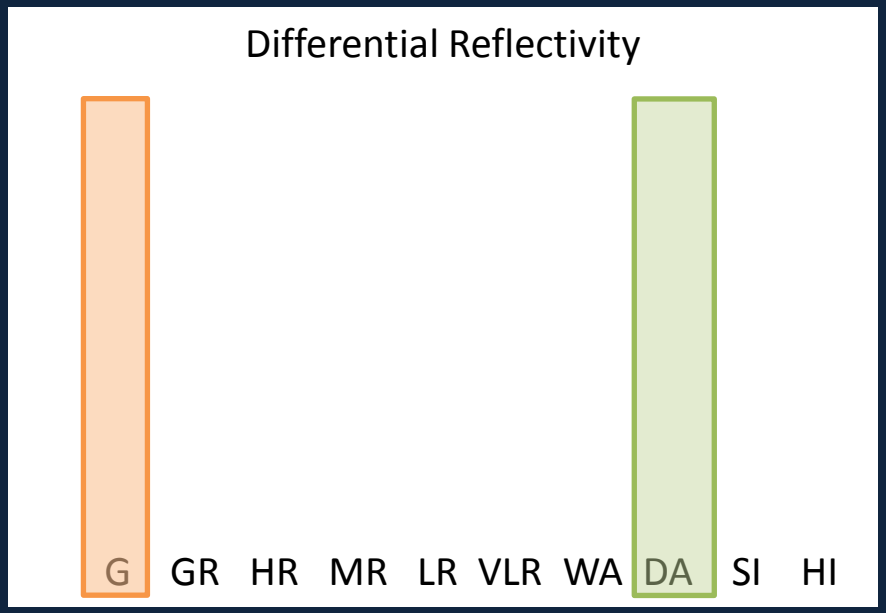


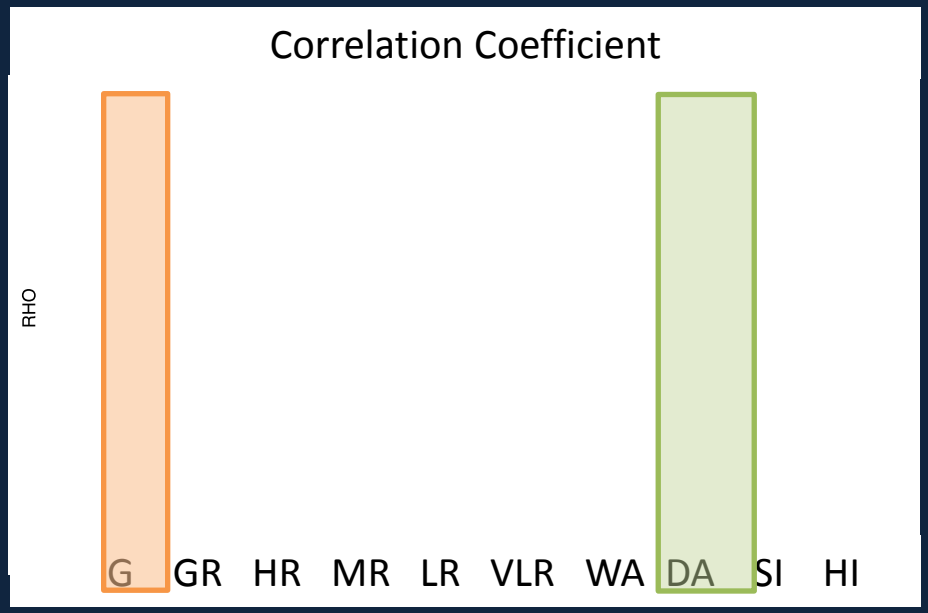
Horz. Oriented Ice

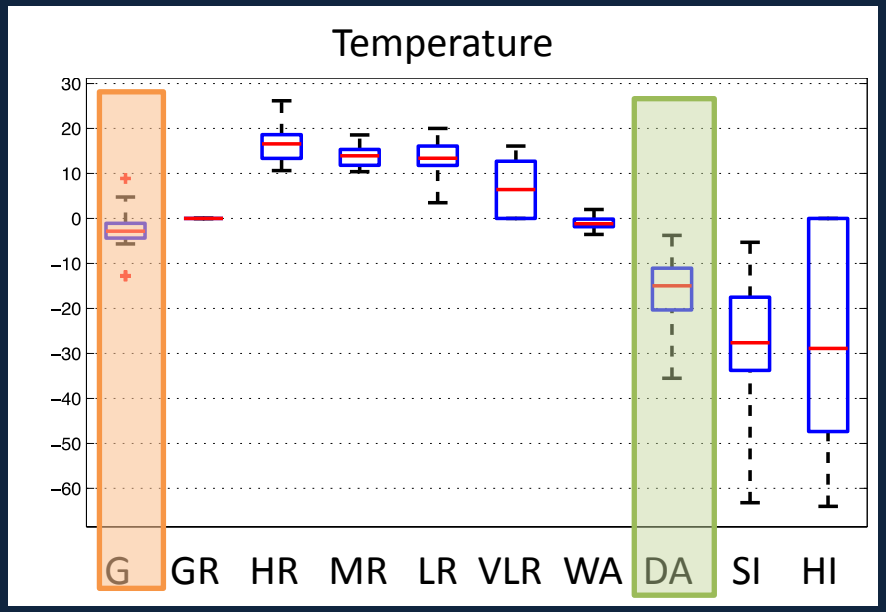


Distribution of Convective Polarimetric Variables

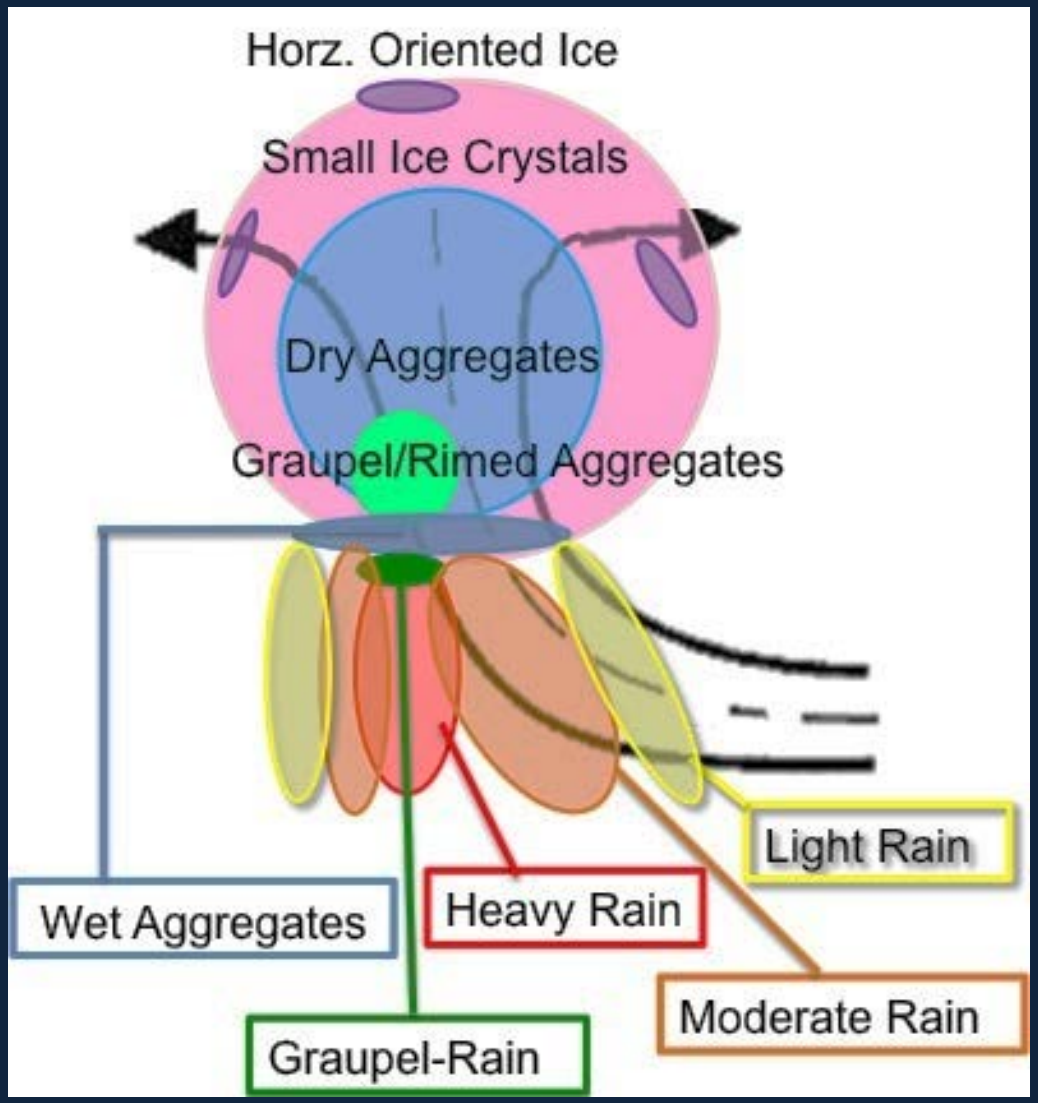


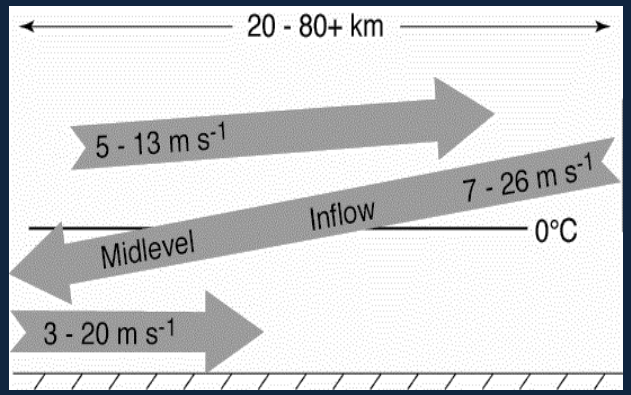




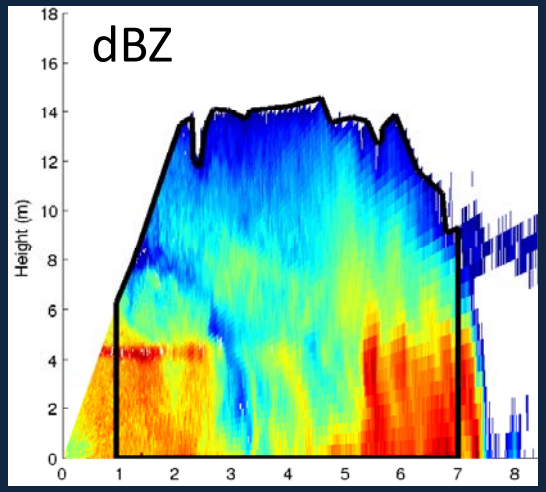


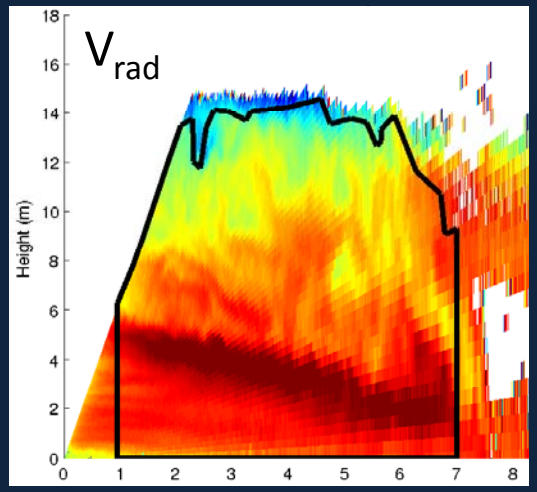
Conceptual Diagram of Convective Updrafts





Mid-Level Inflow

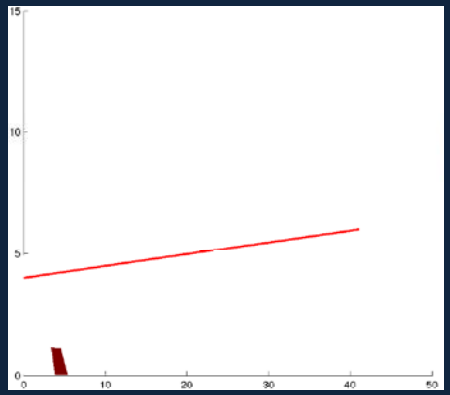




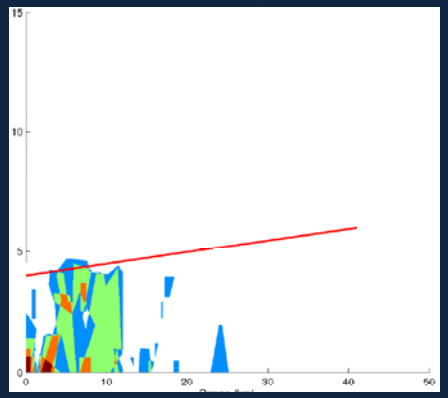
23 Dec 1850 UTC

Leading Line – Trailing Stratiform

Heavy Rain



Moderate Rain



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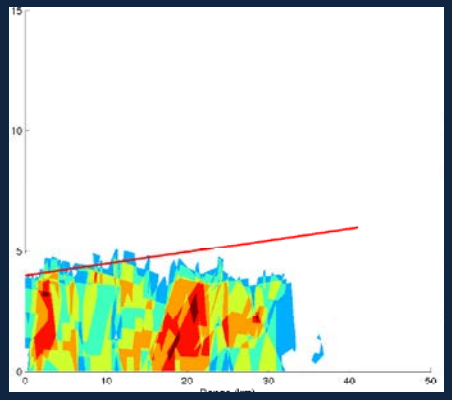

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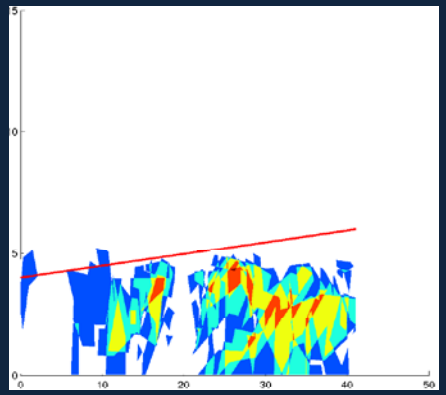
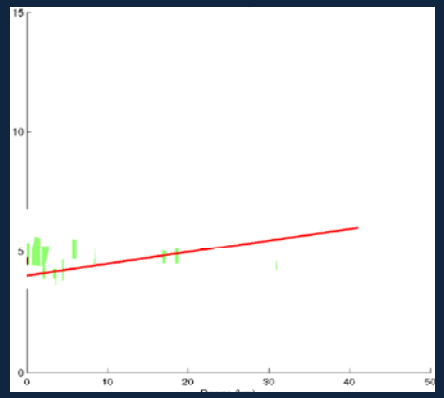
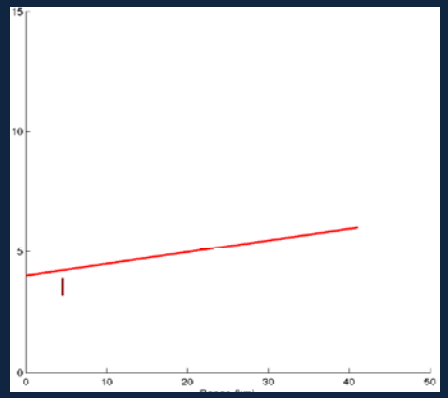


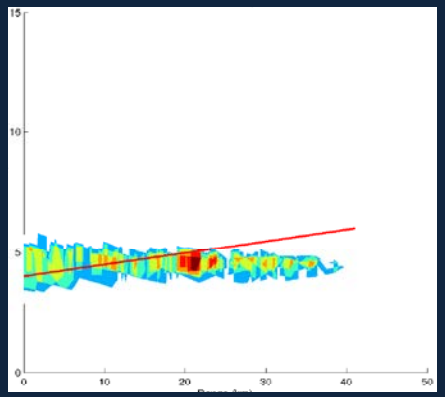
Graupel / Rimed Aggregates



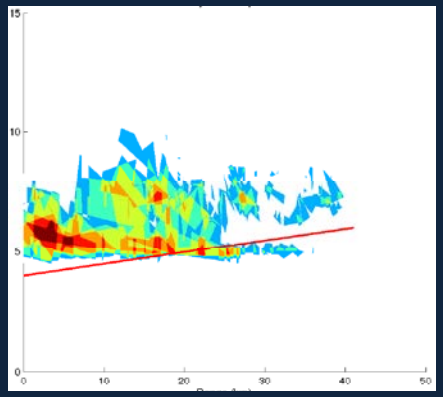
Graupel - Rain



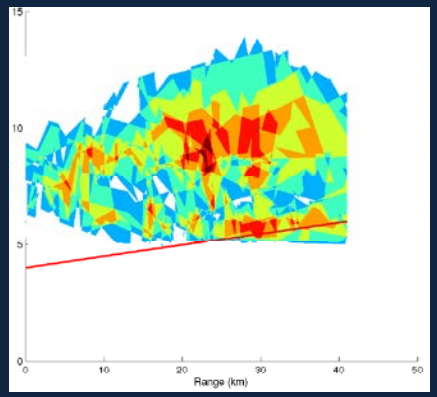
Wet Aggregates



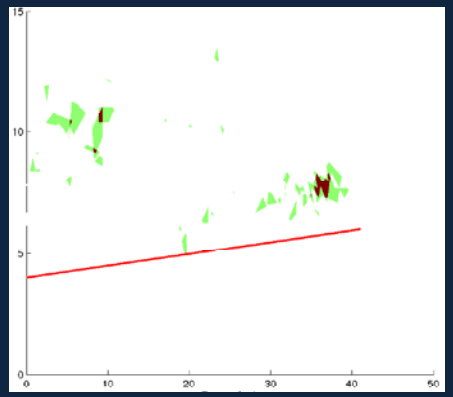
Dry Aggregates



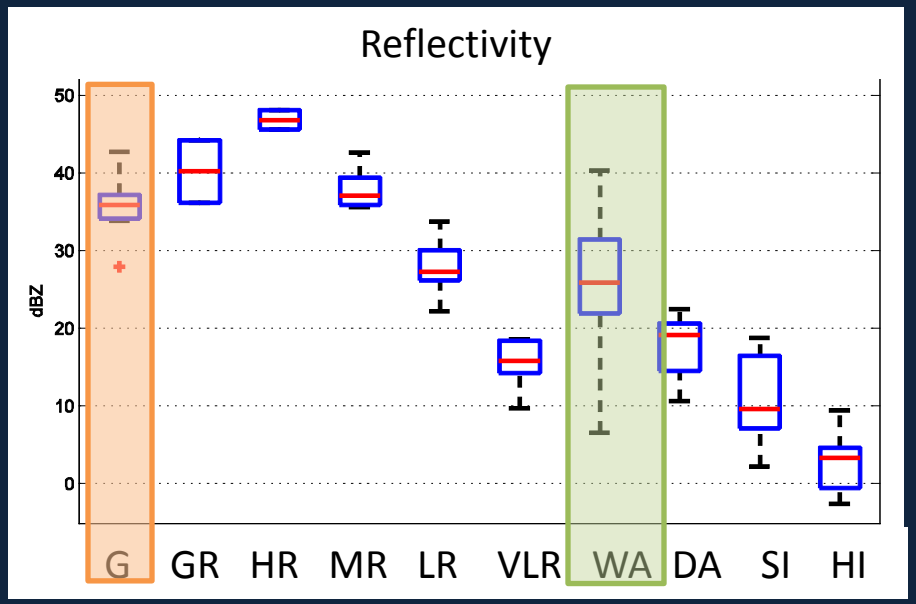
Small Ice Crystals

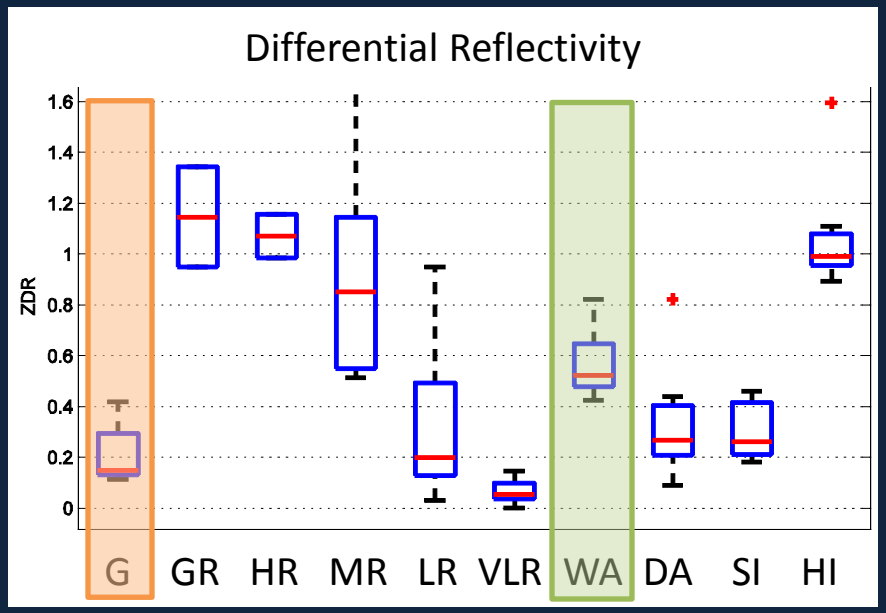


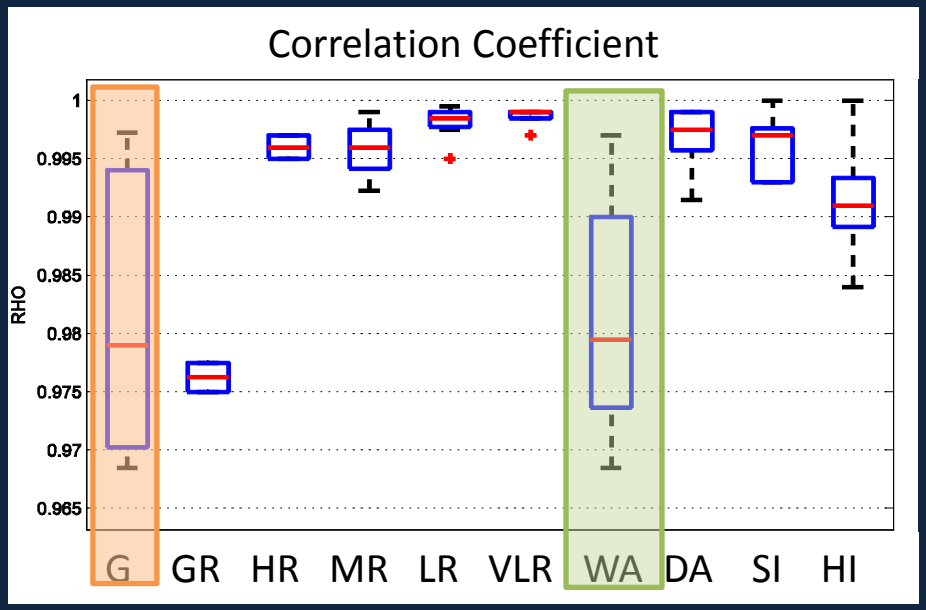
Horz. Oriented Ice

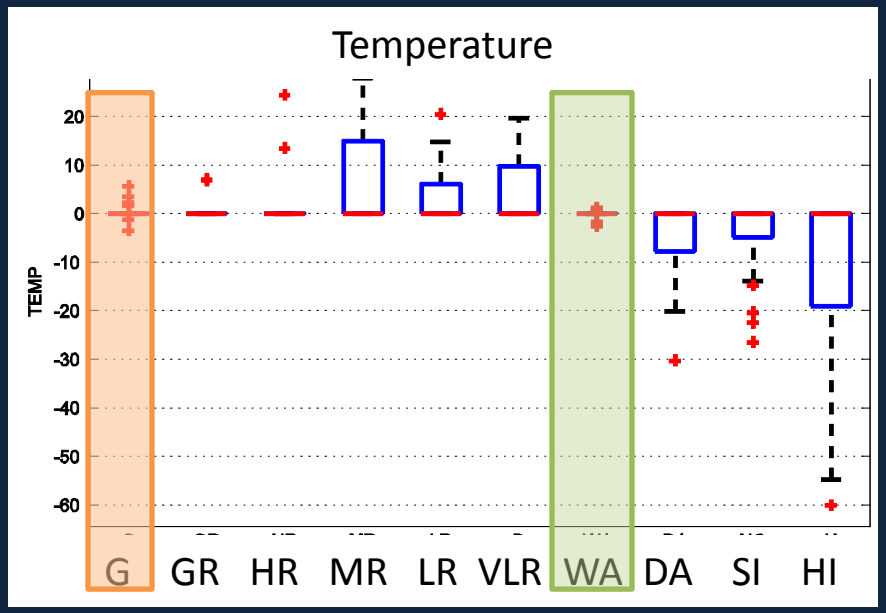


Distribution of Squall Polarimetric Variables

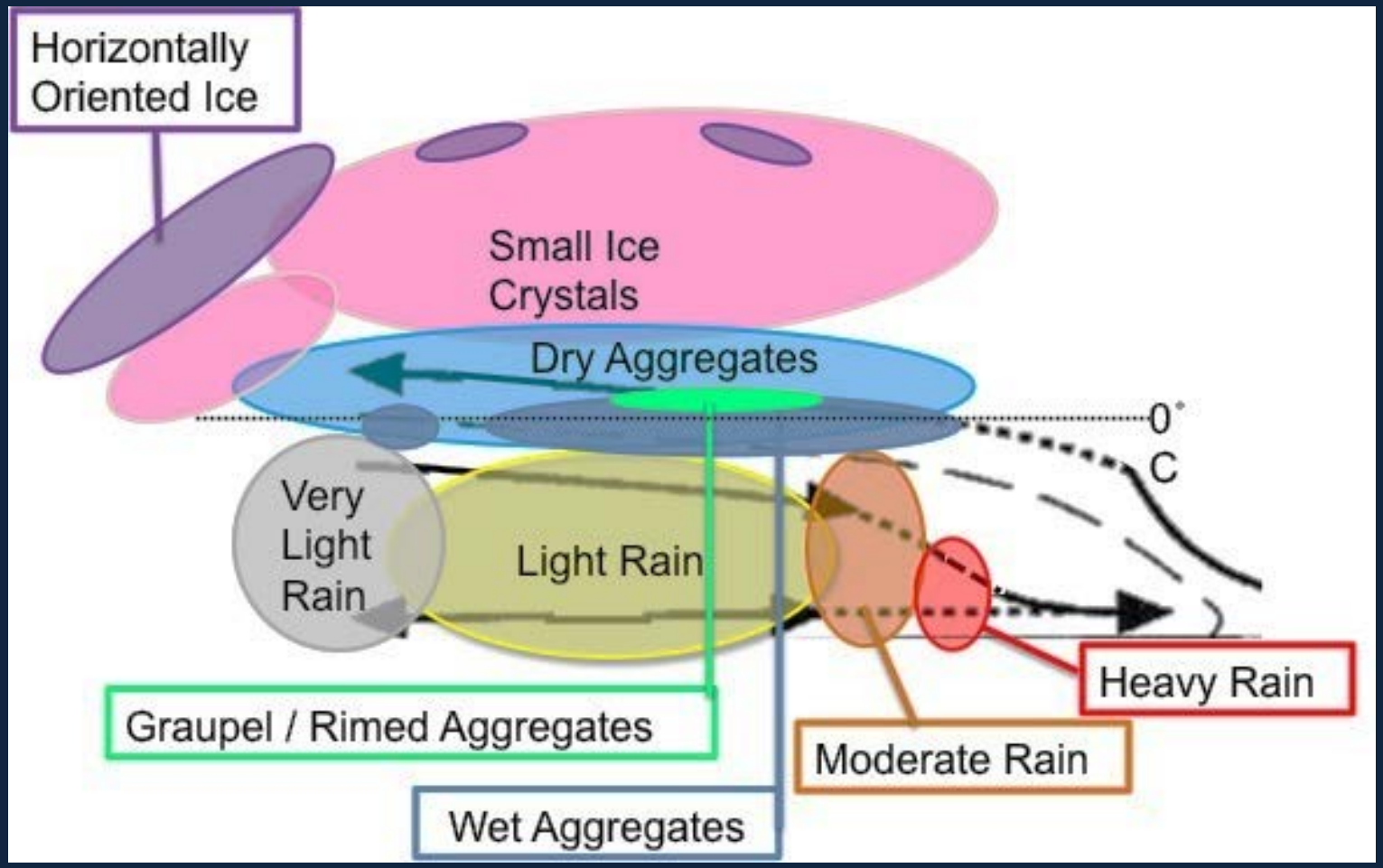




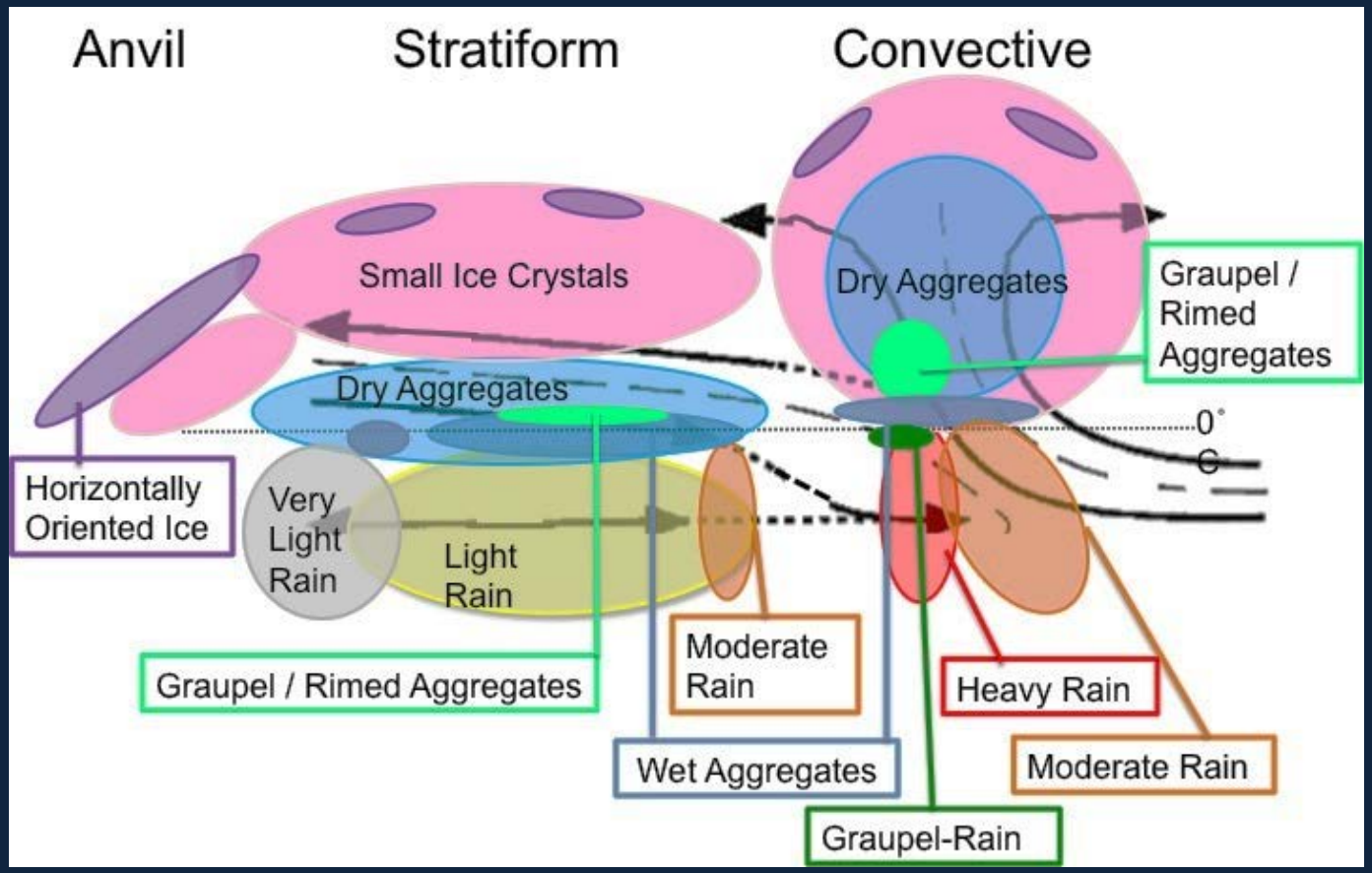




Conceptual Diagram of Mid-Level Inflow



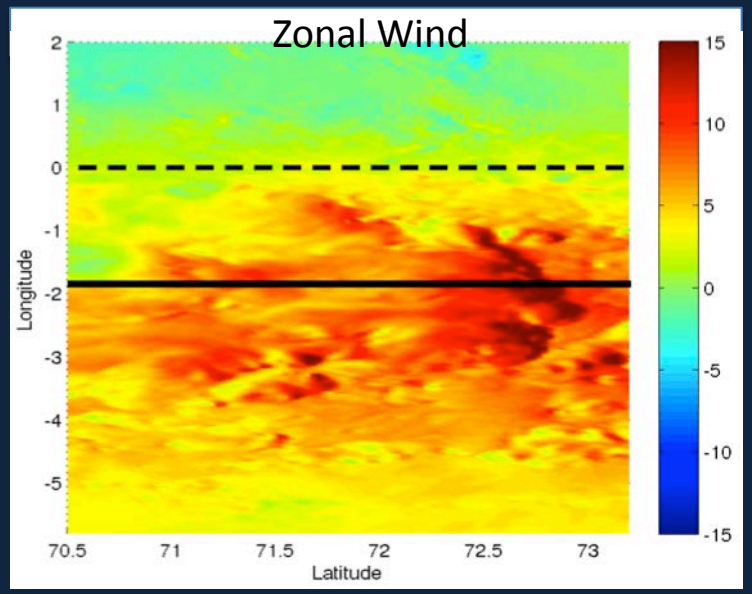
Conclusions

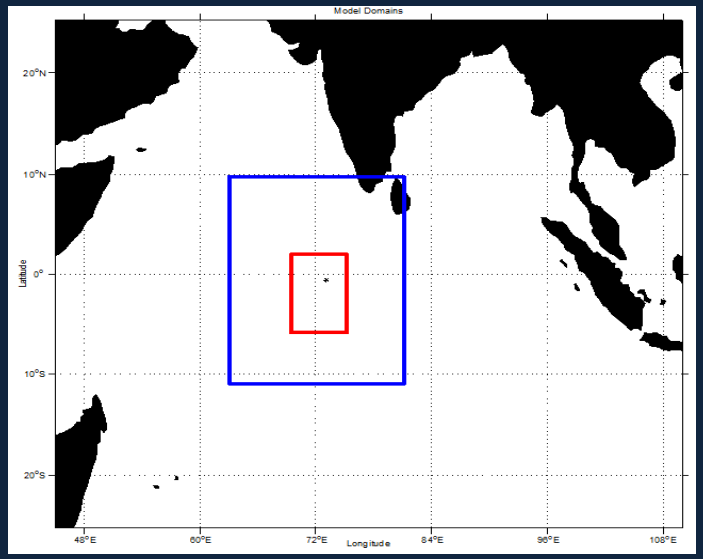


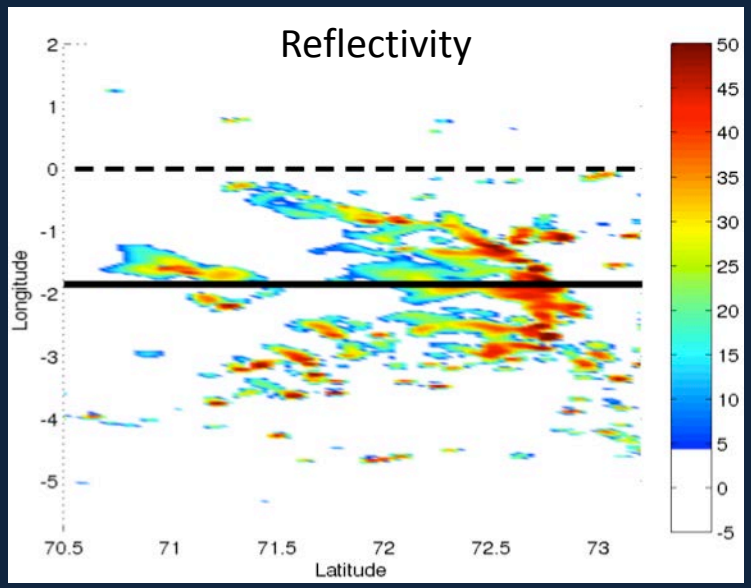
- Comparison of model output and radar observations

Mesoscale Modeling of Squall Line

- WRF 3.4.1
- Resolution: Outer – 9km, Inner – 3km
- Cu Param: Outer – KF, Inner – None
- MP Param: Both - Goddard
- PBL Param: Both – UW
- Forcing: ERAi
- 00 UTC 23 Dec – 00 UTC 25 Dec

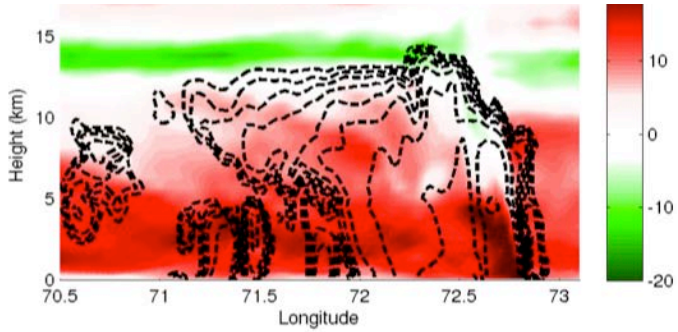




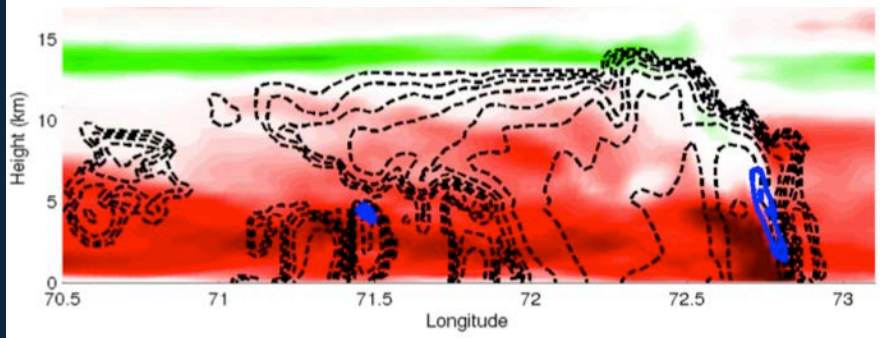


Distribution of Hydrometeor Mixing Ratio

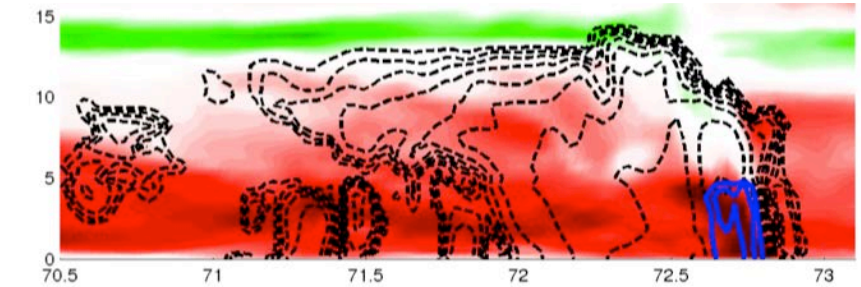
Zonal Wind and Reflectivity



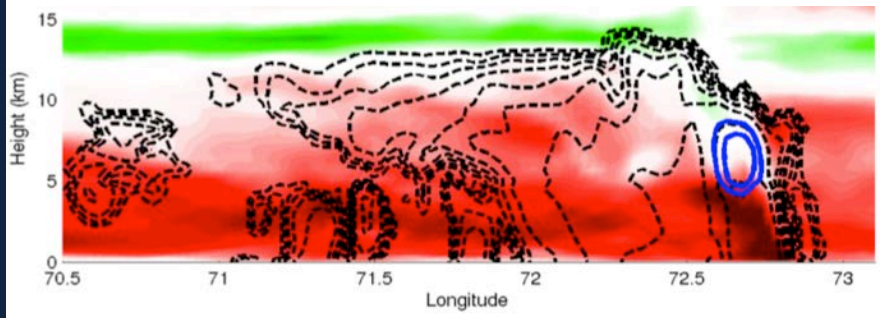
Cloud Mixing Ratio



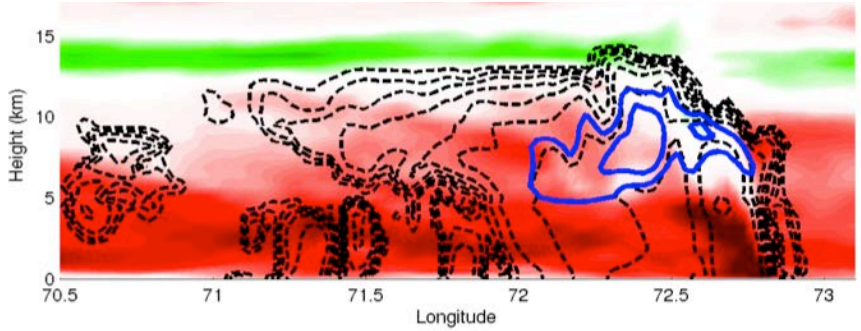
Rain Mixing Ratio



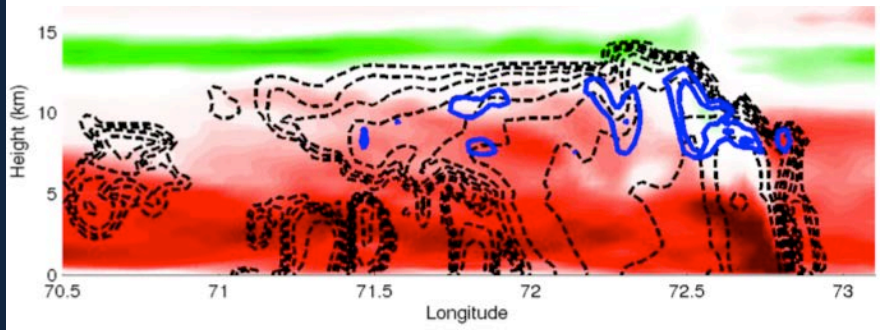
Graupel Mixing Ratio



Snow Mixing Ratio



Ice Mixing Ratio



Model Representation of Anvils over Afirca

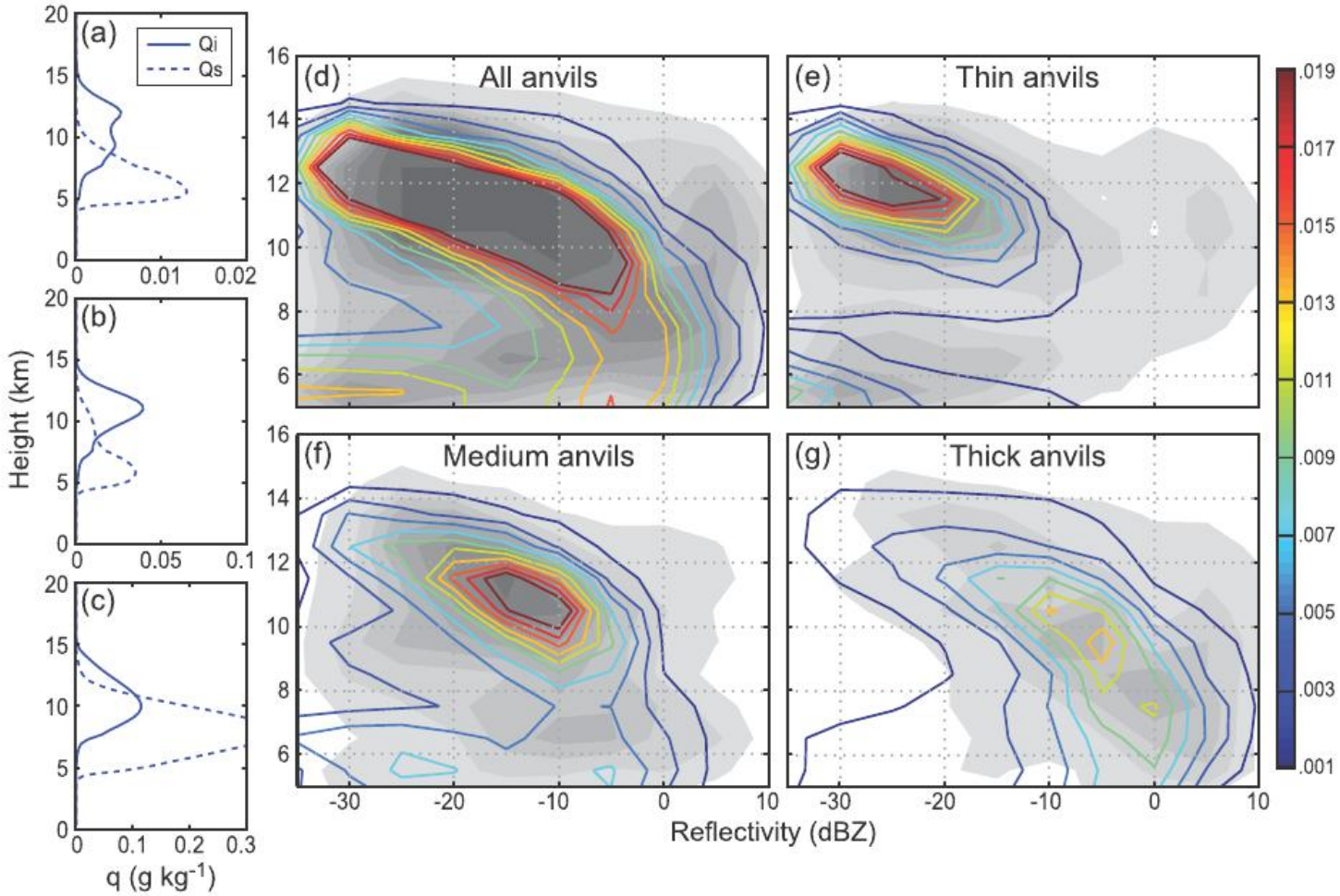


FIG. 6. Mean vertical profiles of mixing ratios (g kg^{-1}) of ice (solid) and snow (dashed) for (a) thin, (b) medium, and (c) thick anvils generated by the WRF using Goddard microphysics. Note the difference in scale on the abscissa of each plot. (d)–(g) CFADs for anvil clouds generated by the WRF using Goddard microphysics overlaid on CFADs for ARM anvil clouds (grayscale). Colored contour interval is as in Fig. 2.

Powell et al., 2012

Questions ?

Extra Slides

Percent Occurrence

	Conv.	Bright.	NonSquall	Squall
Graupel / Rimed Aggregates	1	.92	.79	.77
Graupel / Rain	.556	.8	.51	.33
Heavy Rain	.925	.8	.13	.22
Moderate Rain	1	.08	.72	1
Light Rain	.889	.8	1	1
Very Light Rain	.667	.96	.89	1
Dry Aggregates	.963	.46	1	1
Wet Aggregates	1	1	1	1
Small Ice Crystals	1	1	1	1
Horz. Ice Crystals	.778	1	.96	1

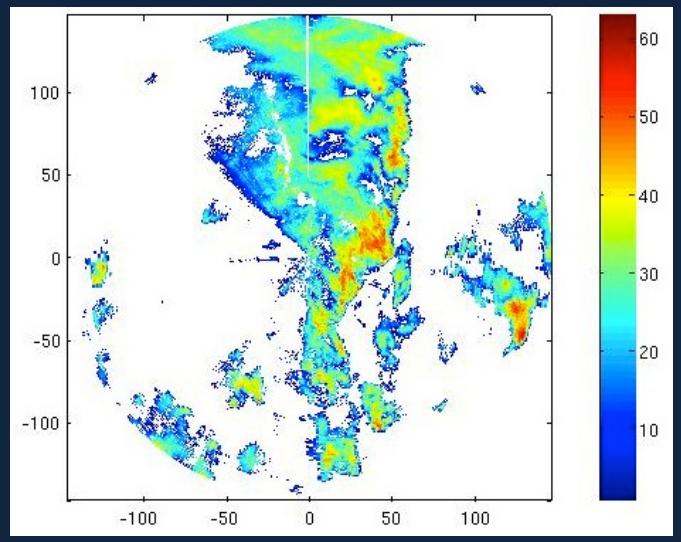
Fraction of Freezing Particles

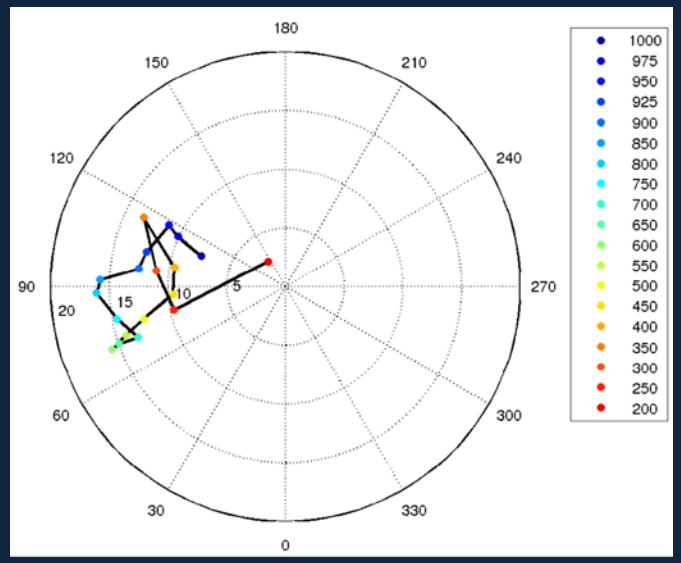
	Conv.	Bright.	NonSquall	Squall
Dry Aggregates	.47	.36	.27	.24
Wet Aggregates	.14	.21	.19	.12
Horz. Ice Crystals	.06	.09	.09	.05
Small Ice Crystals	.32	.32	.43	.57

Types of Mesoscale Convective Systems

Leading Line – Trailing Stratiform

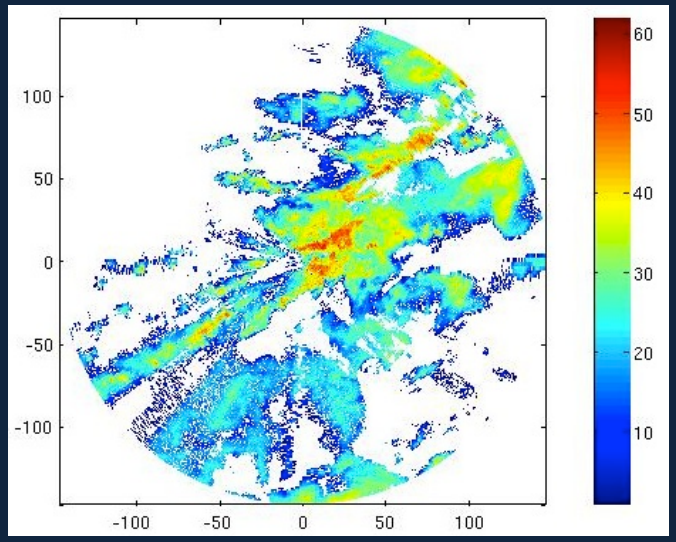
23 Dec 1850 UTC

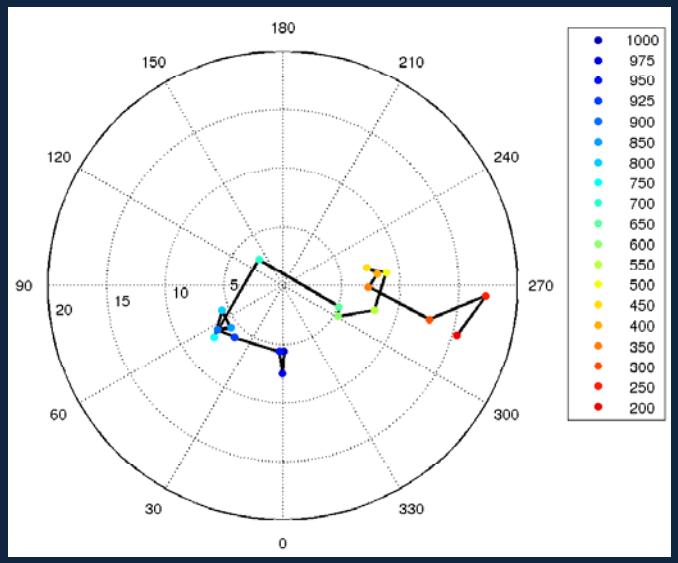




Non-leading Convection

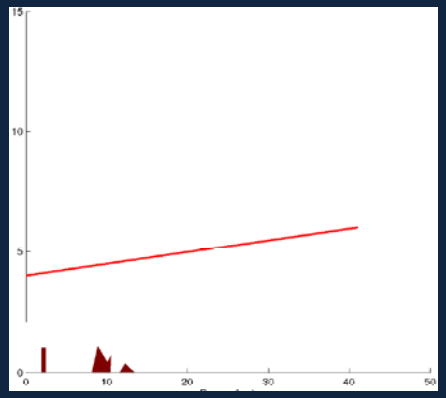
18 Oct 1835 UTC



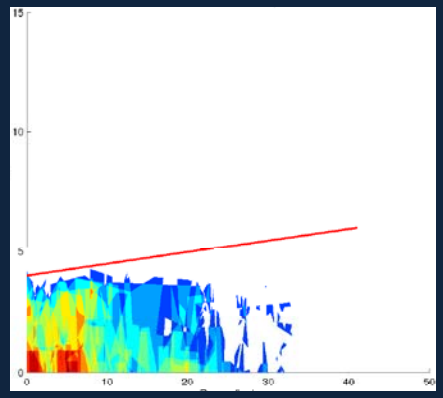


Non-Leading Convection

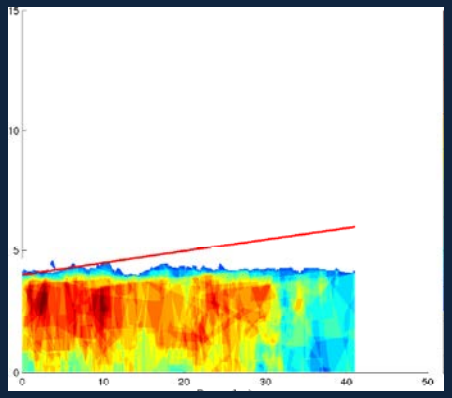
Heavy Rain



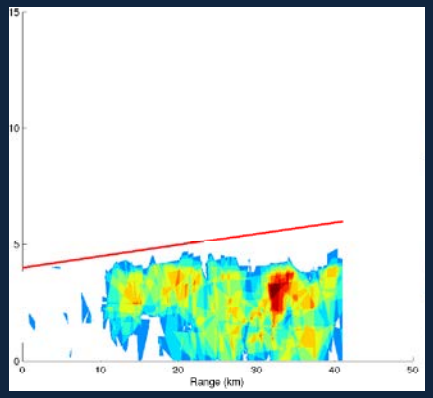
Moderate Rain



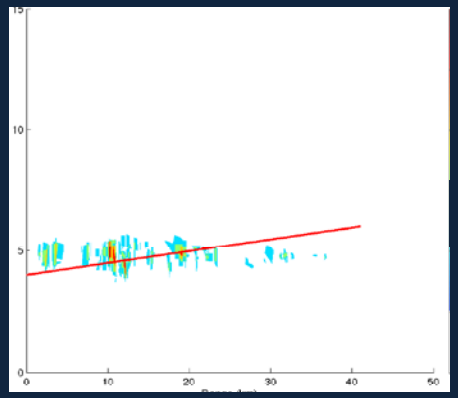
Light Rain



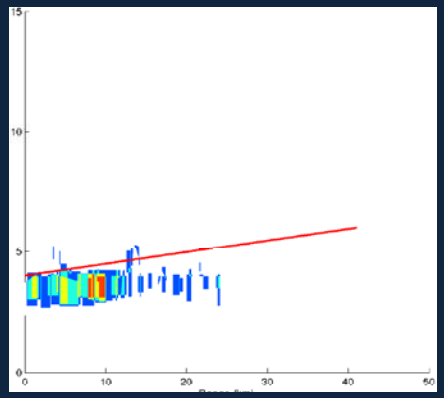
Very Light Rain



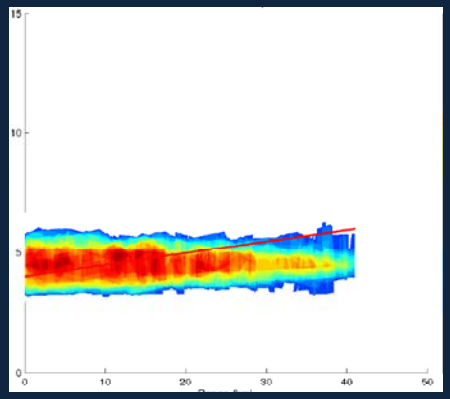
Graupel / Rimed Aggregates



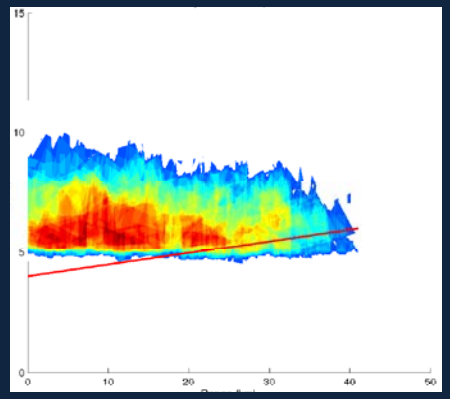
Graupel - Rain



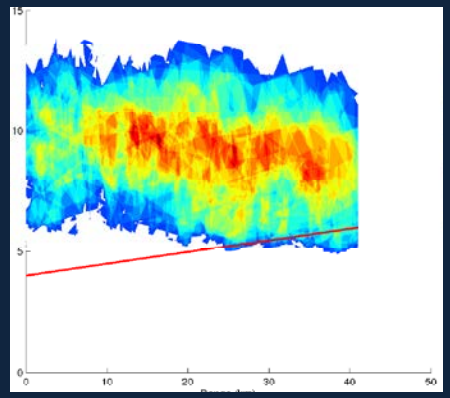
Wet Aggregates



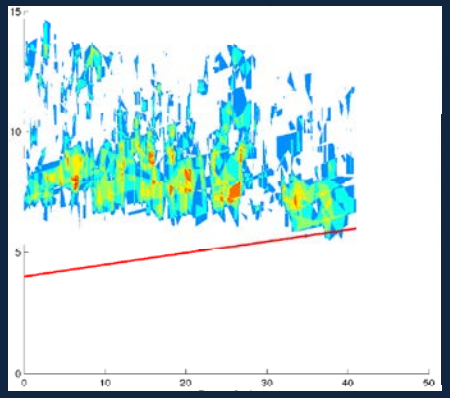
Dry Aggregates



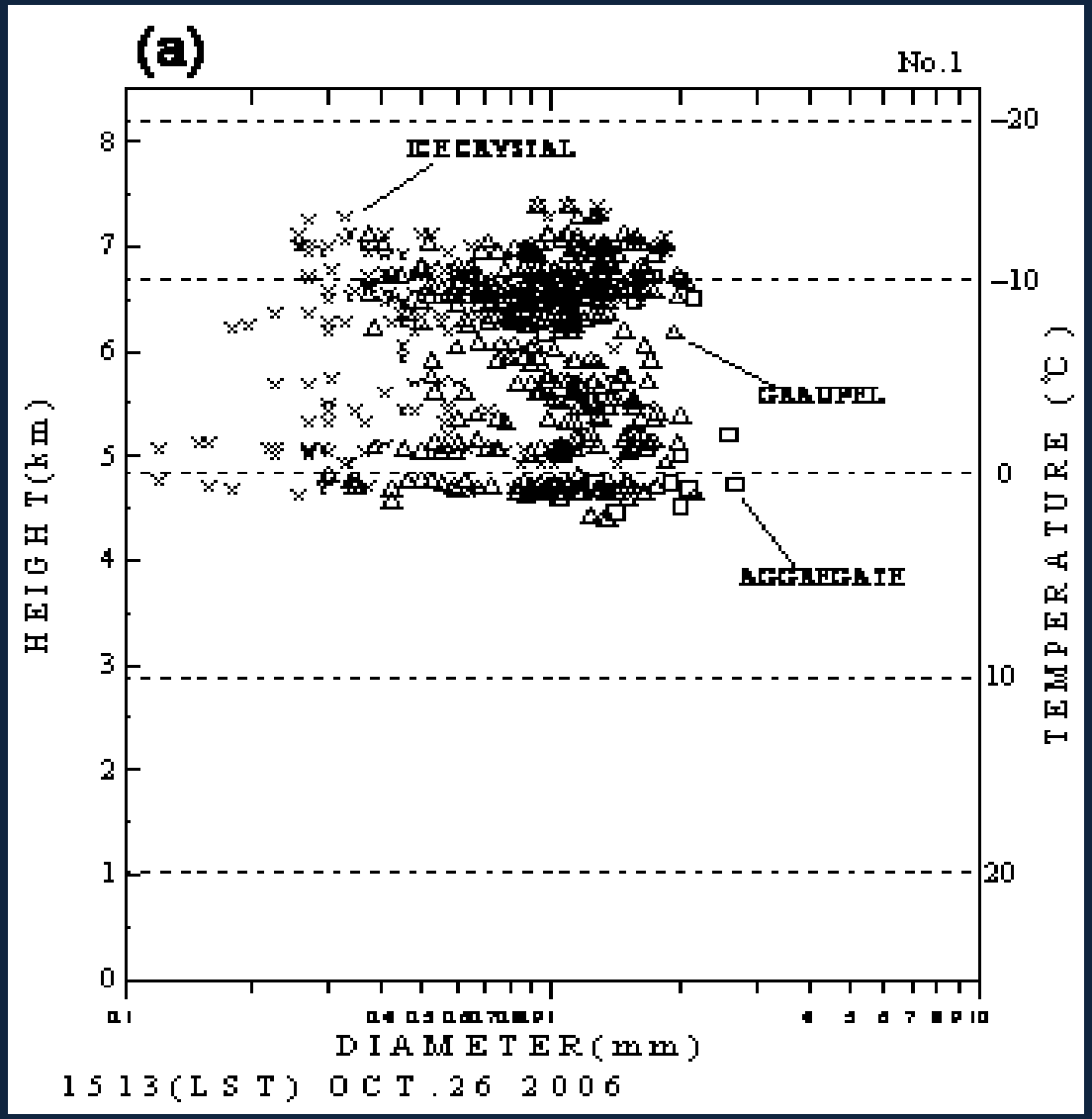
Small Ice Crystals



Horz. Oriented Ice

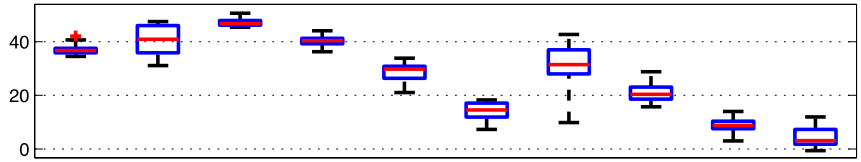


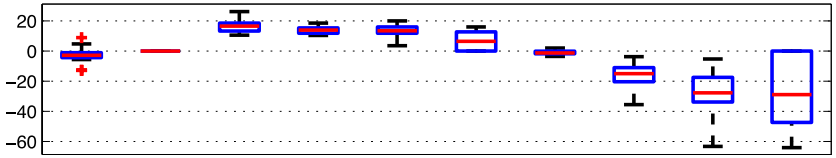
Videosonde Observations in Thick Stratiform during MISMO



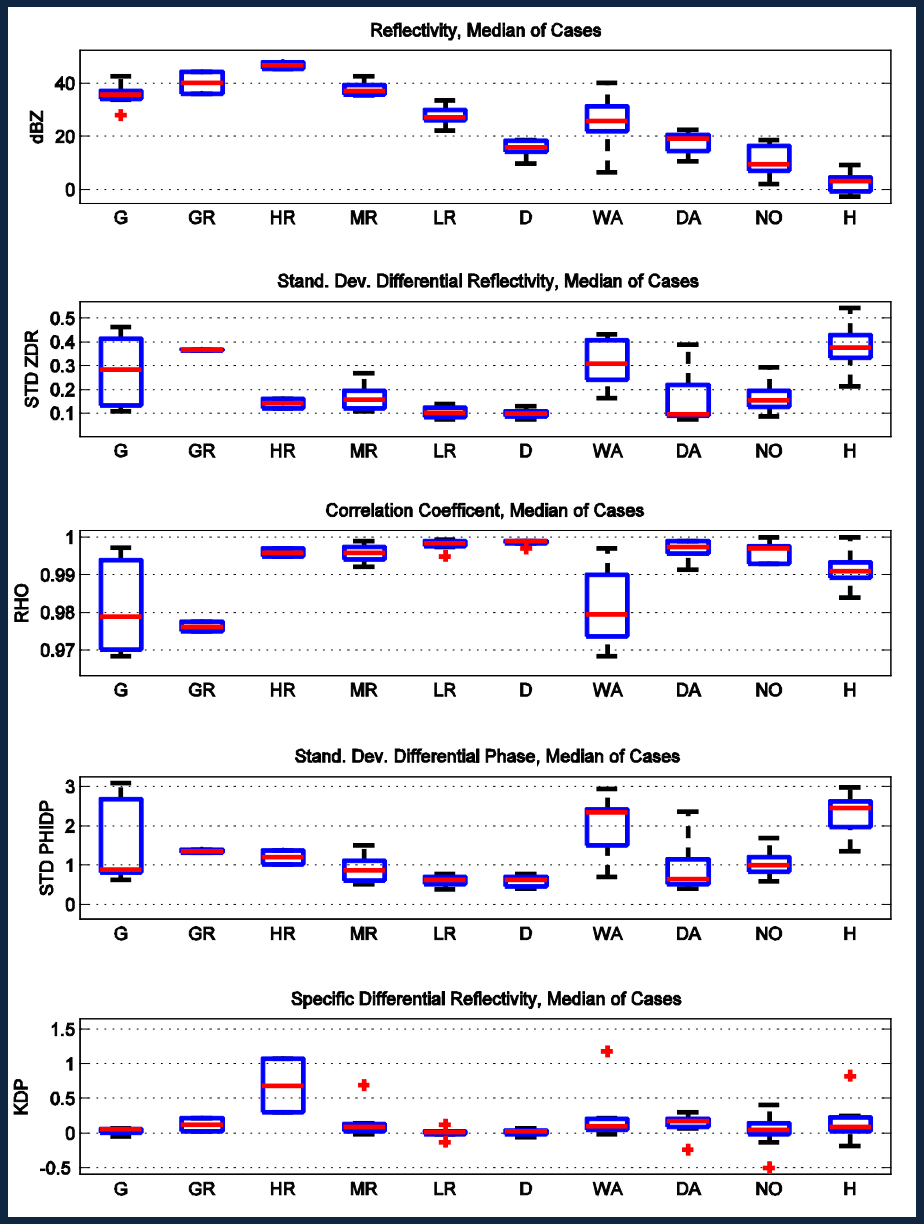
Suzuki,

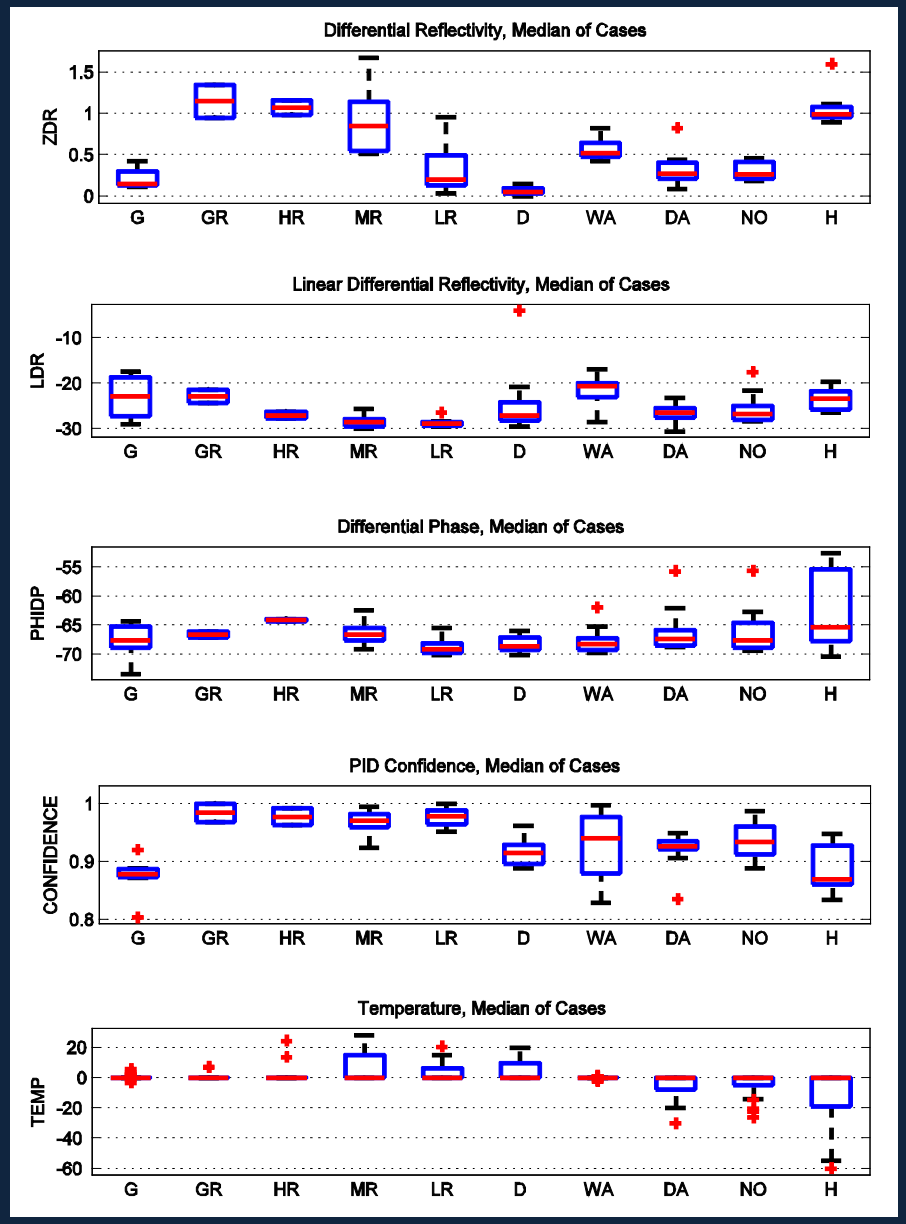
Distribution of Convective Polarimetric Variables



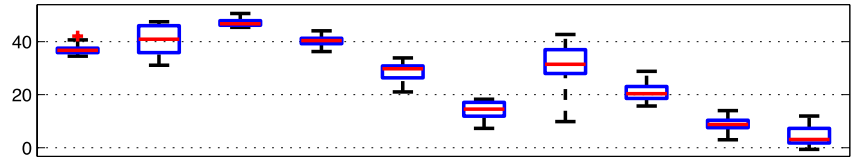


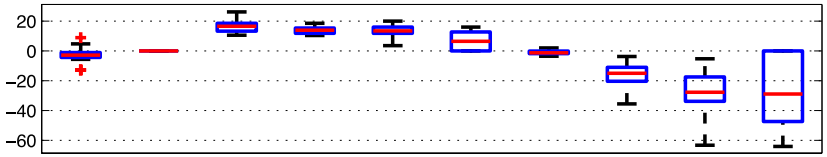
Distribution of Squall Polarimetric Variables



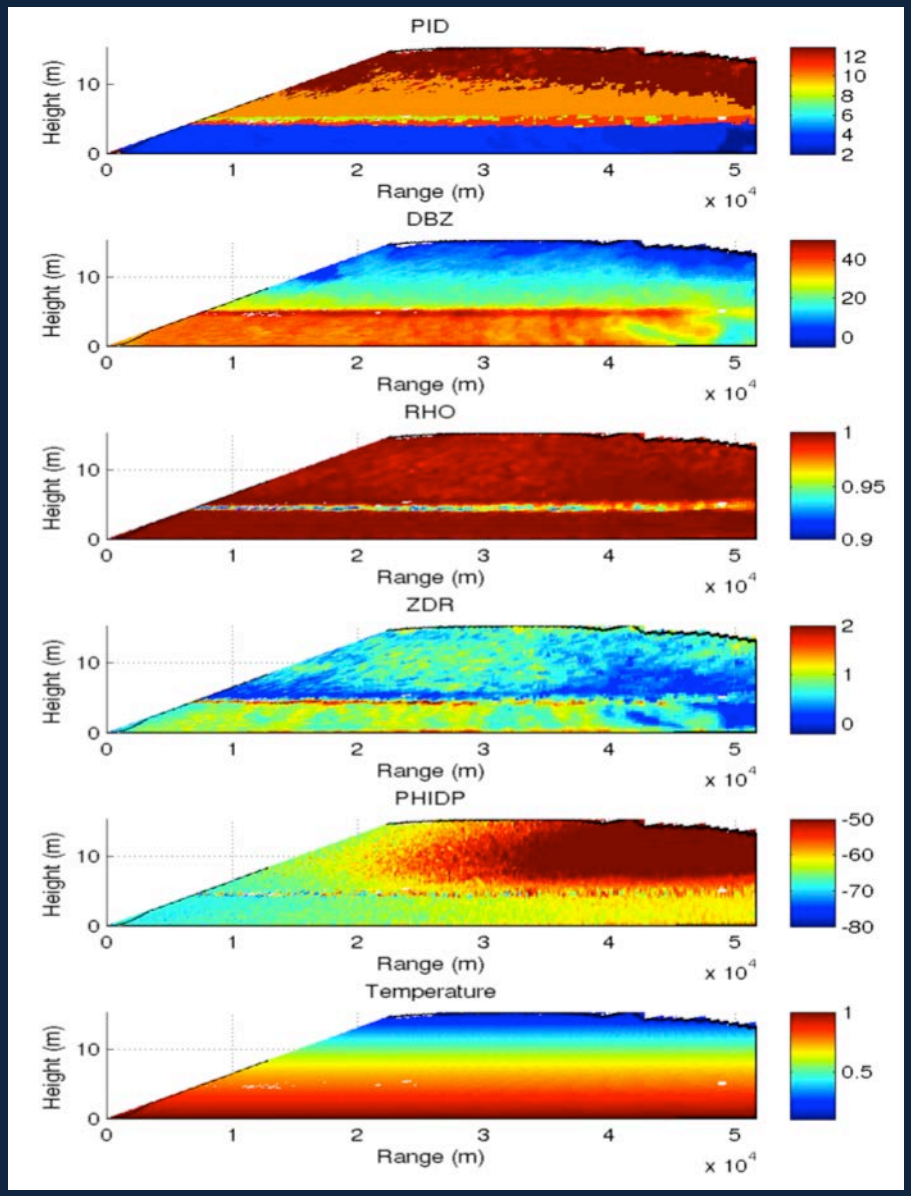


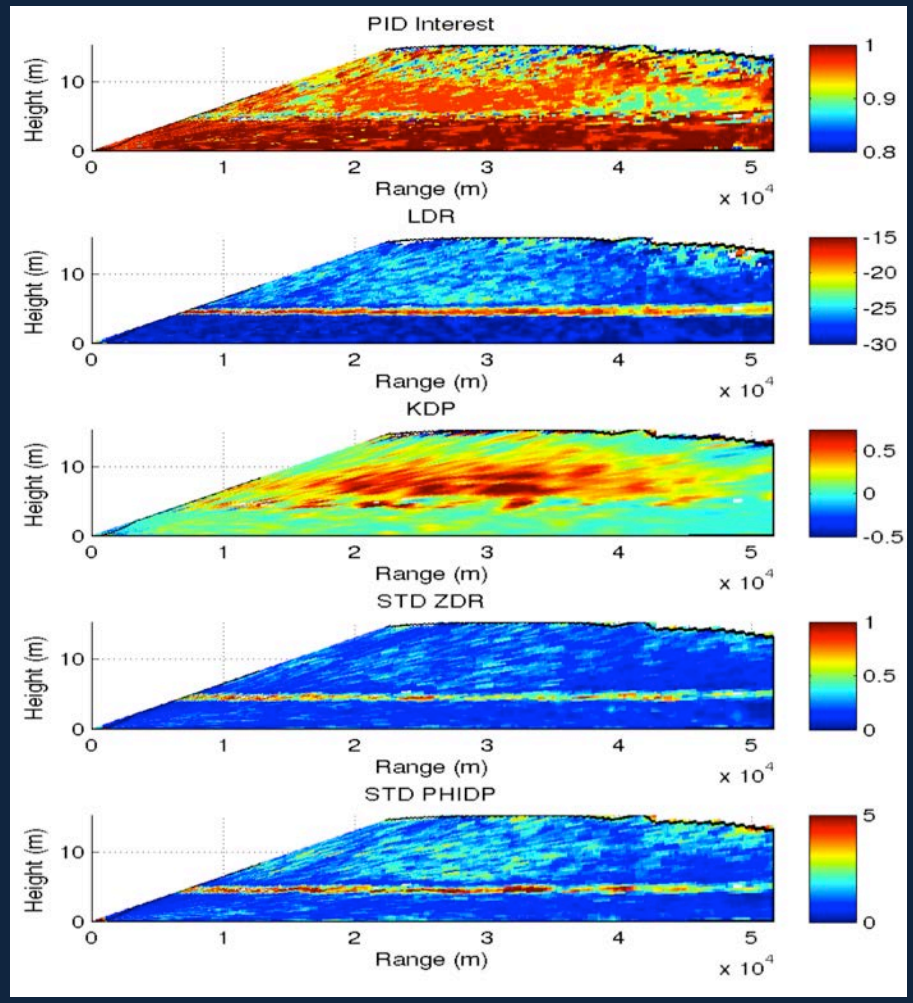
Distribution of Non-Squall Polarimetric Variables



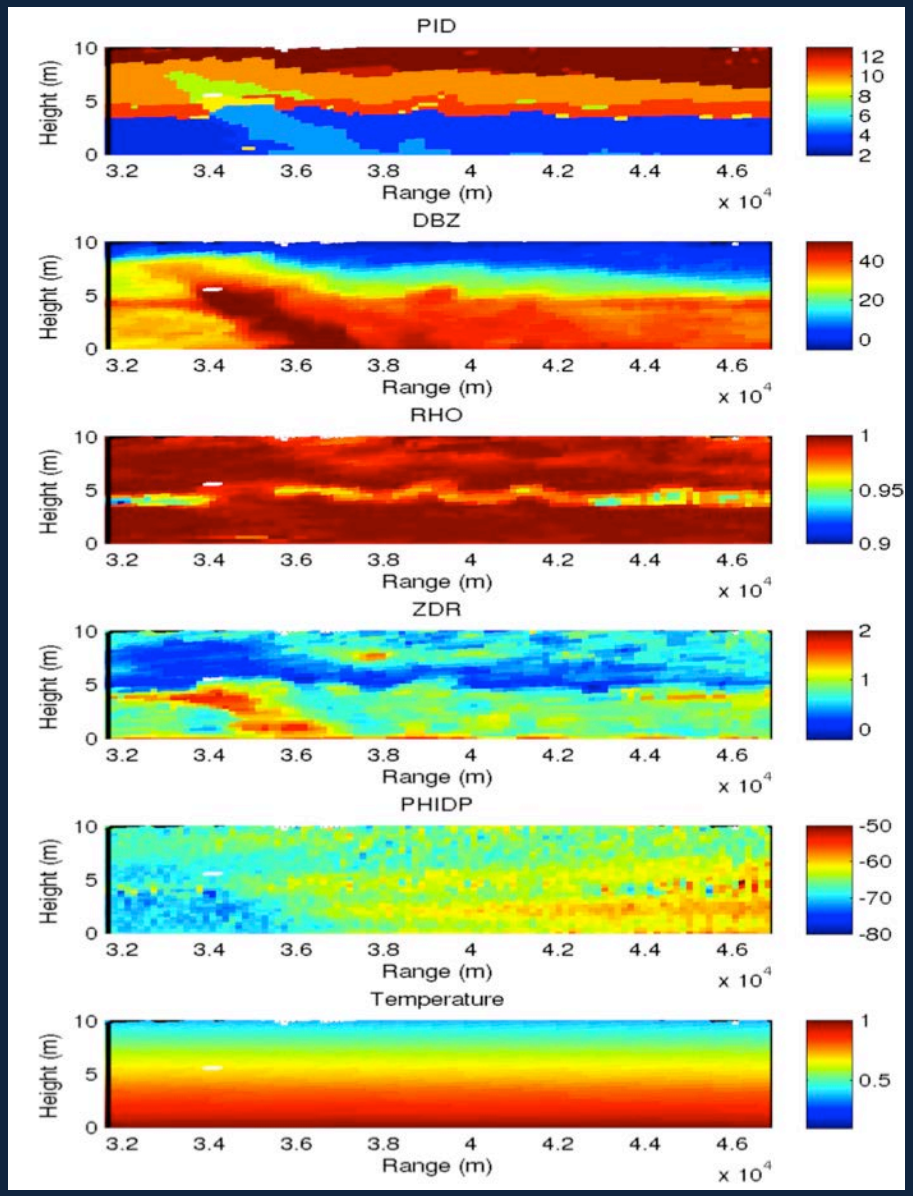


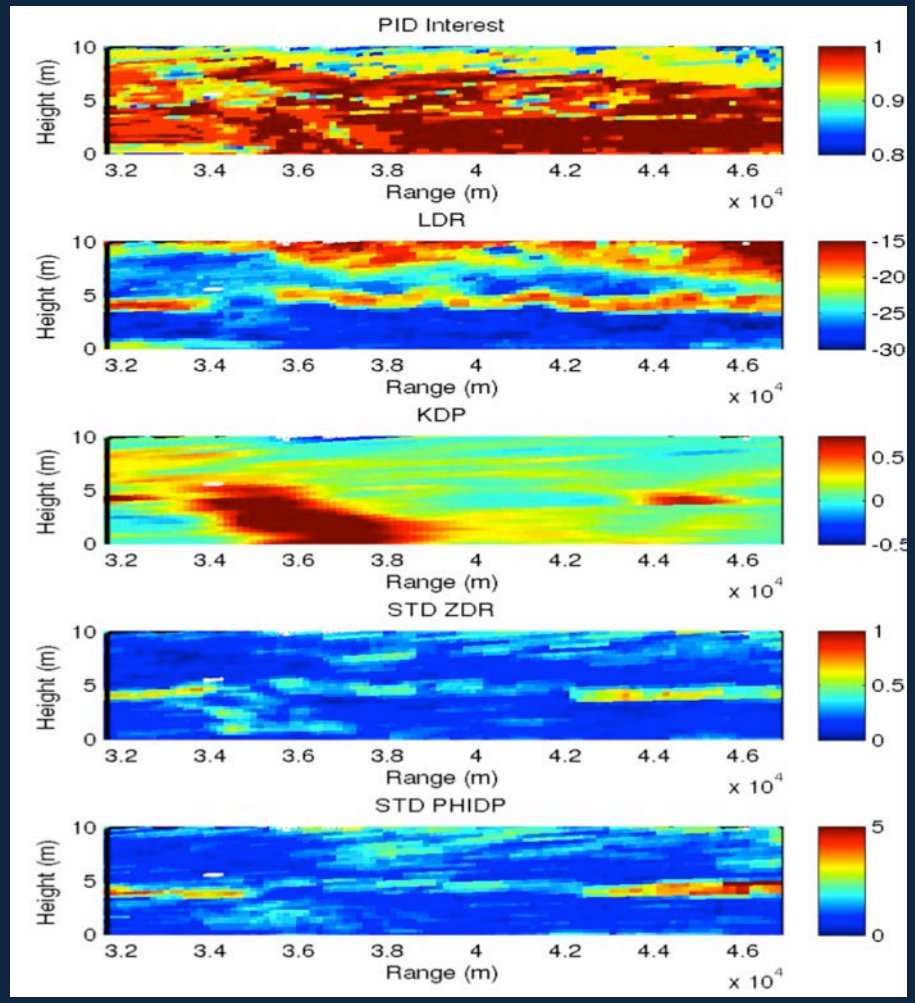
Brightband Example, Nov 23



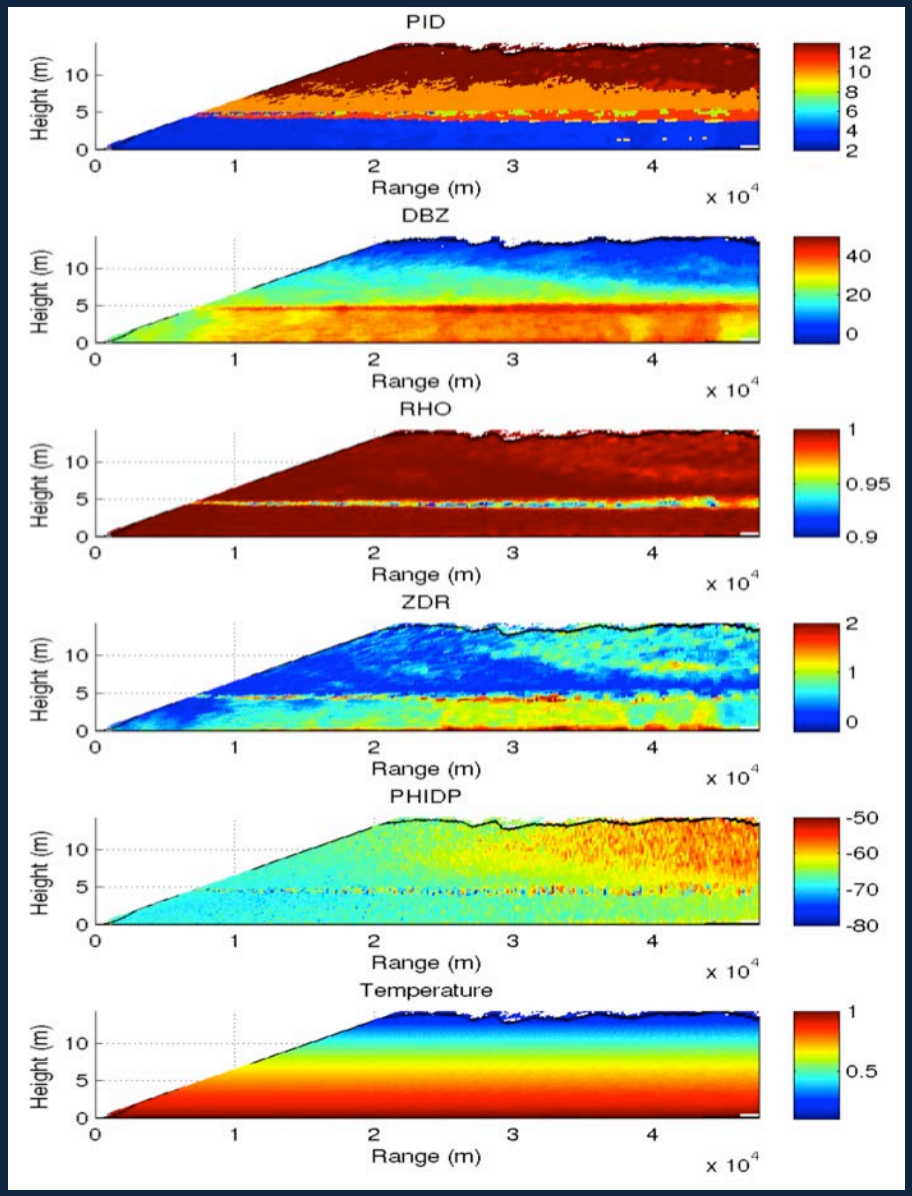


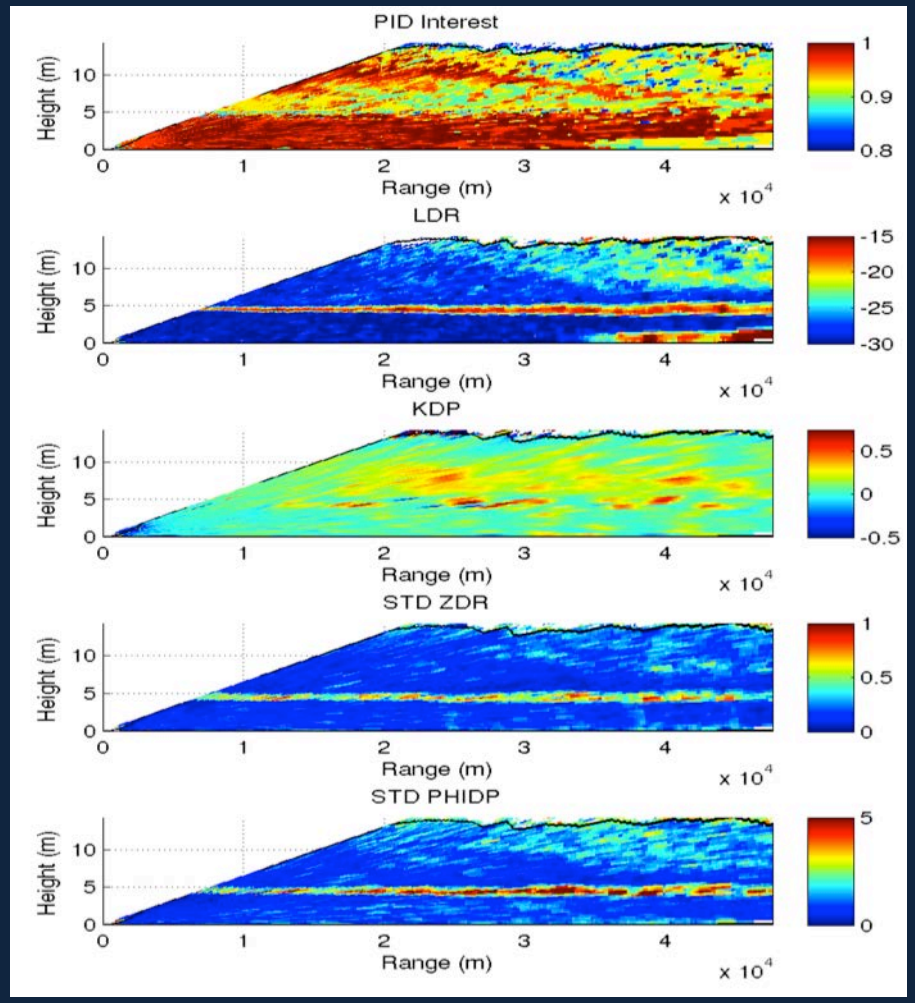
Convective Example Oct 22



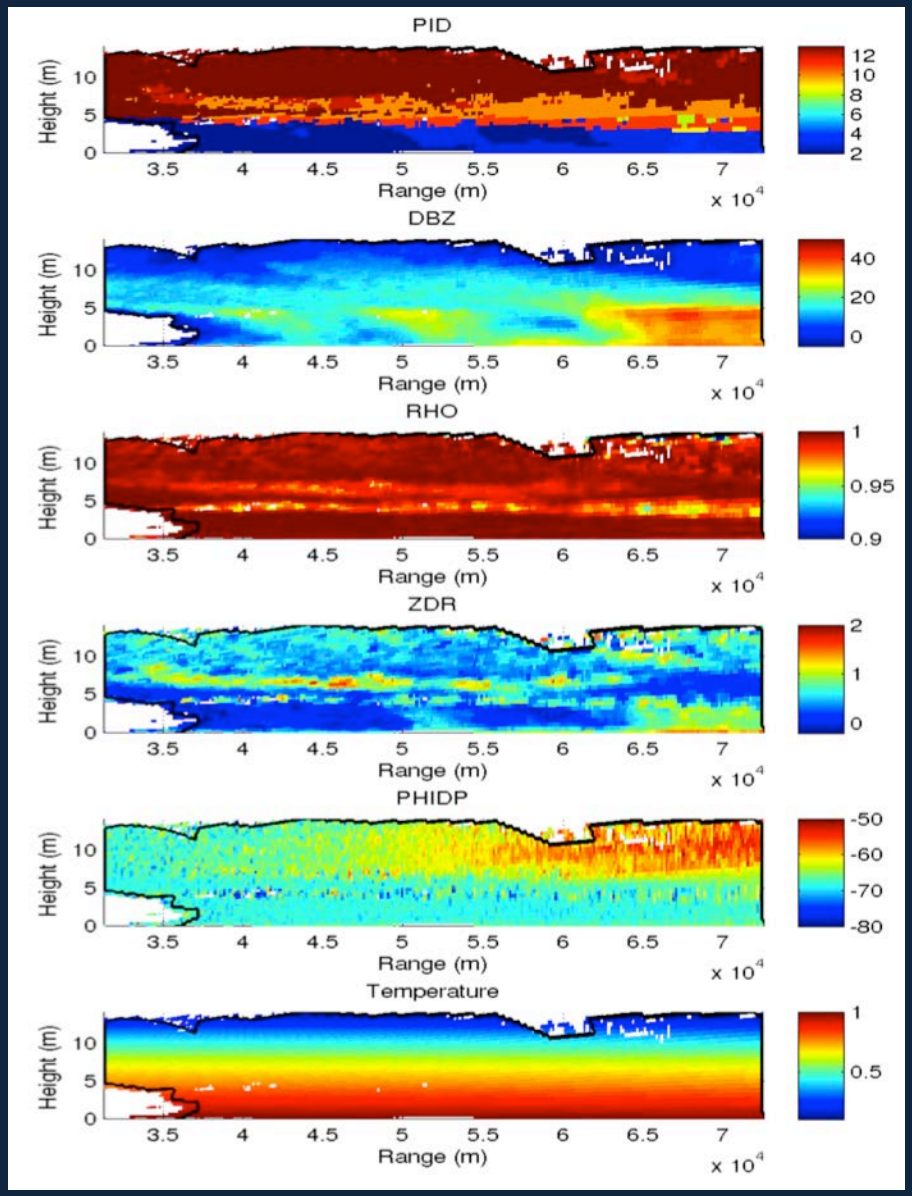


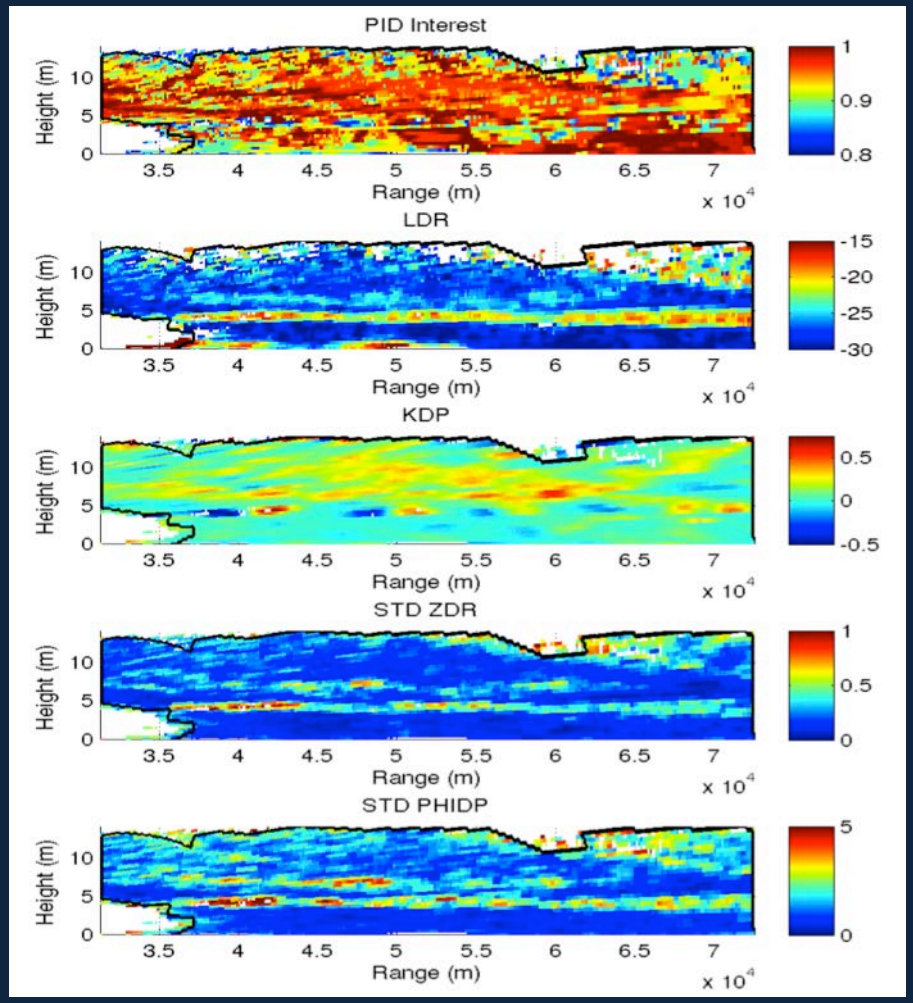
Non-squall Example Nov 18





Squall Example Nov 18





New PID Description – SEATTLE MEETING

	DBZ	ZDR	KDP	RHOhv	LDR	TEMP	
Graupel / Rimed Aggregates	Mod.	Low	Low	High	Mod – Low		
Graupel / Rain	Mod. – High	Mod. – High	Mod. – High	Low	High	➢ 0	Key differences from Graupel is high ZDR, high LDR, low rho
Heavy Rain	High	High	High		High – Mod.	➢ 0	
Moderate Rain	Mod.	Mod. (.2-3)				➢ 0	
Light Rain	Low	Low				➢ 0	
Very Light Rain	Very Low	Low				➢ 0	
Dry Aggregates	Mod.	Low				< 0	
Wet Aggregates	Mod. – High	High	Mod. – Light	Low	High	-8 - 12	Expanded Temp range to removed graupel – rain from bright
Small Ice Crystals	Low	Low					
Horz. Ice Crystals	Low	High	Mod.				