Performance, Validation and Enhancement of GPM-DPR Profile Classification Module

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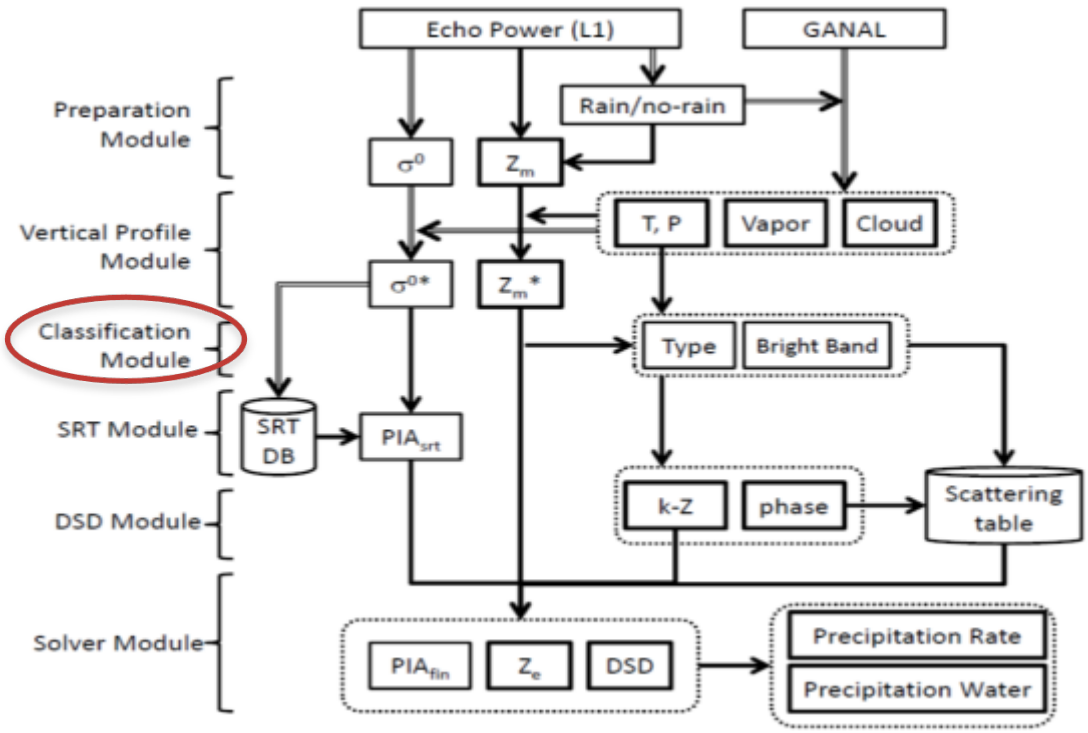
With contributions from the DPR algorithm team

PMM meeting 2015, Baltimore

Outline

- Performance of GPM-DPR profile classification module.
- Validation of profile classification module with ground radar.
- Enhancement of profile classification module.

DPR Profile Classification Module

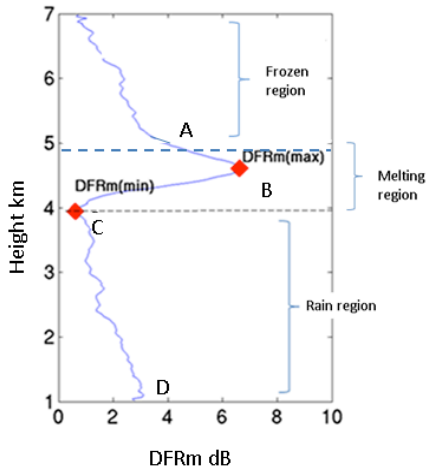


GPM-DPR level 2 algorithm flow chart

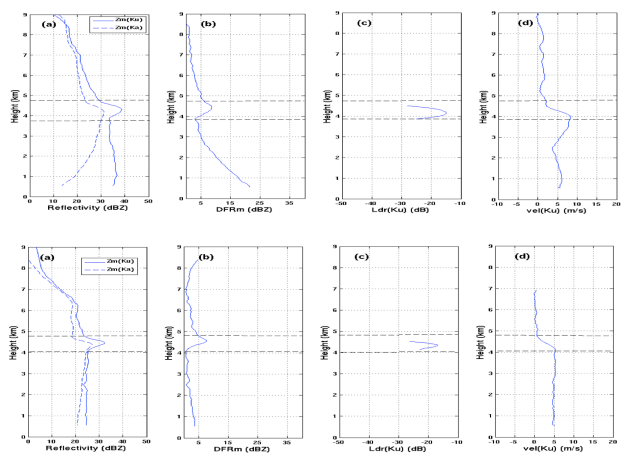
Classification Module

- Classify stratiform, convective , other rain type
- Detect melting layer

DPR Profile Classification Module



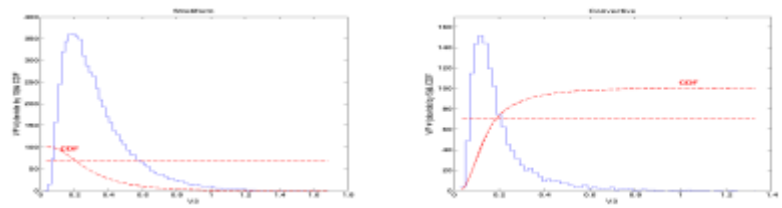
Schematic plot of DFRm profile with key points A, B, C, and D. Point A: slope of DFRm has peak value. Point B: local maximum of DFRm. Point C: local minimum of DFRm. Point D: DFRm value near surface.

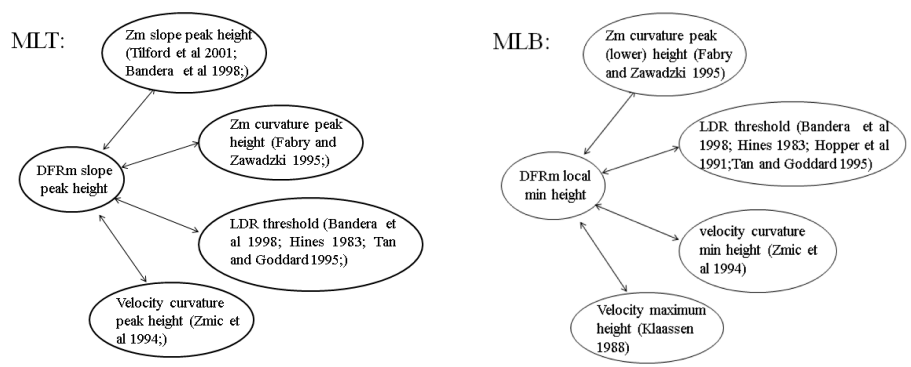


$$DFR_m = 10\log_{10}(Z_m(K_u)) - 10\log_{10}(Z_m(K_a))$$

$$V1 = \frac{DFR_{ml}(\max) - DFR_{ml}(\min)}{DFR_{ml}(\max) + DFR_{ml}(\min)} \qquad V2 = abs(mean(DFR_m\ slope))$$

$$V3 = \frac{V1}{V2}$$





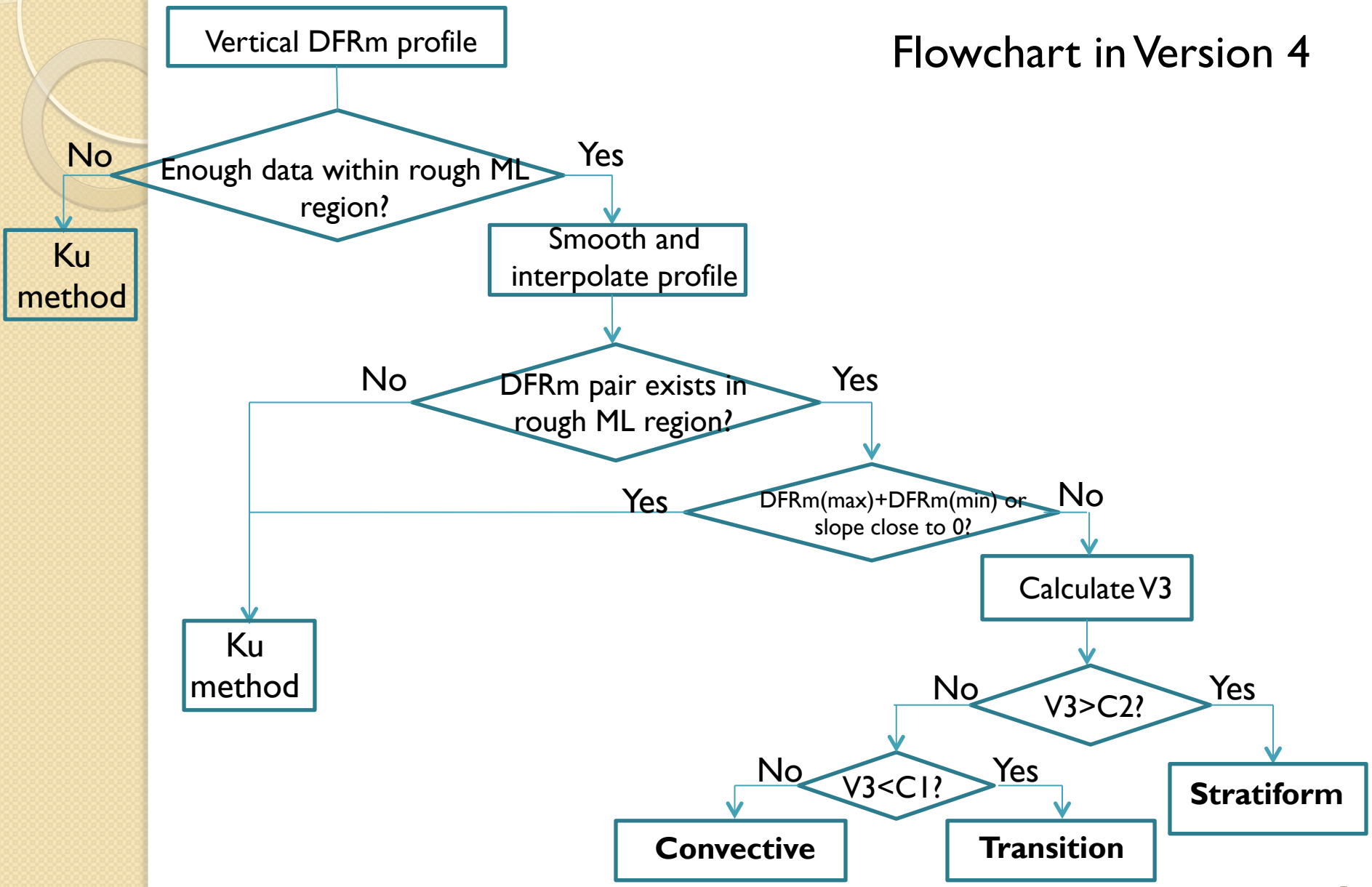
Details refer to papers:

1, M. Le and V. Chandrasekar, Precipitation Type Classification Method for Dual-Frequency Precipitation Radar (DPR) Onboard the GPM, Geoscience and Remote Sensing, IEEE Transactions, Volume:51 , Issue 3, March, 2013.

2, M. Le and V. Chandrasekar, Hydrometeor Profile Characterization Method for Dual-Frequency Precipitation Radar Onboard the GPM, Geoscience and Remote Sensing, IEEE Transactions Volume: 51 , Issue 6, Jun, 2013.

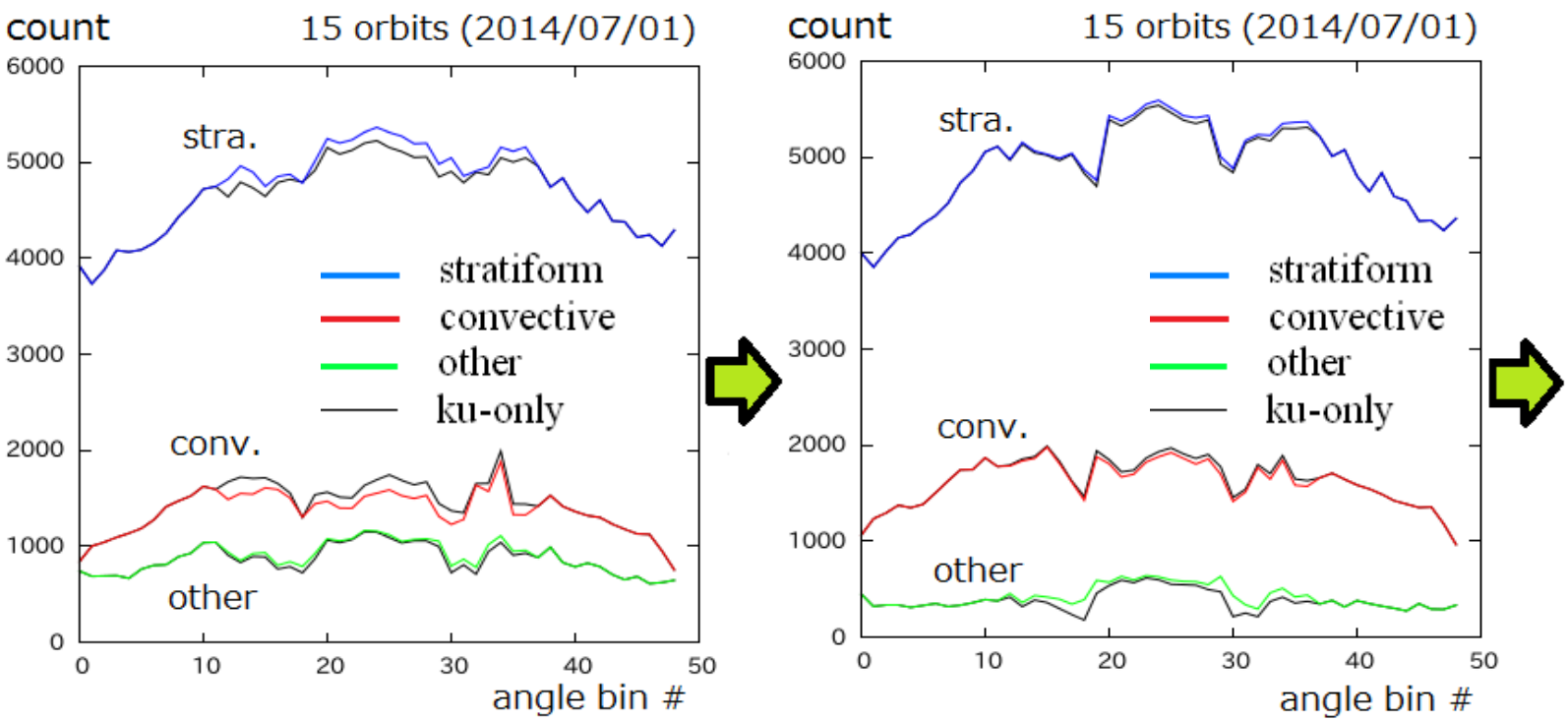
DPR Profile Classification Module

Flowchart in Version 4



Performance of Module

Rain type count comparison between dual-frequency and Ku only methods



Results based on most updated version 4 algorithm

Performance of Module

Cyclones

Name	Cases
HUDHUD	3
KATE	3
NILOFAR	1
Total	7

Hurricanes

Name	Cases
ANA	5
EDOUARD	1
FAY	1
GONZALO	3
NOBERT	1
ODILE	4
POLO	1
RACHEL	3
SIMON	4
VANCE	4
Total	27

Typhoons

Name	Cases
HAGUPIT	8
KALMAEGI	4
NARA	1
NURI	3
PHANFONE	4
VONGFONG	7
Total	27

ule tro

Storm Types:

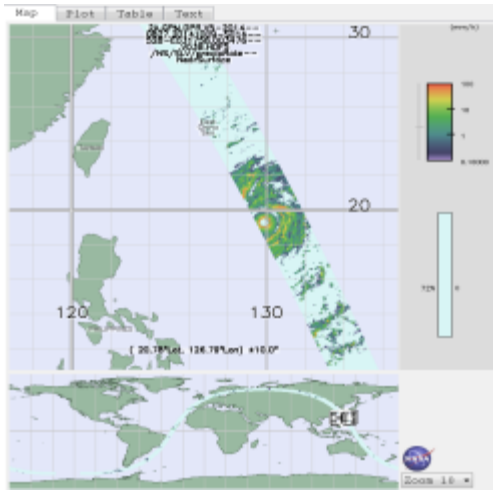
Cy , Typ : storms

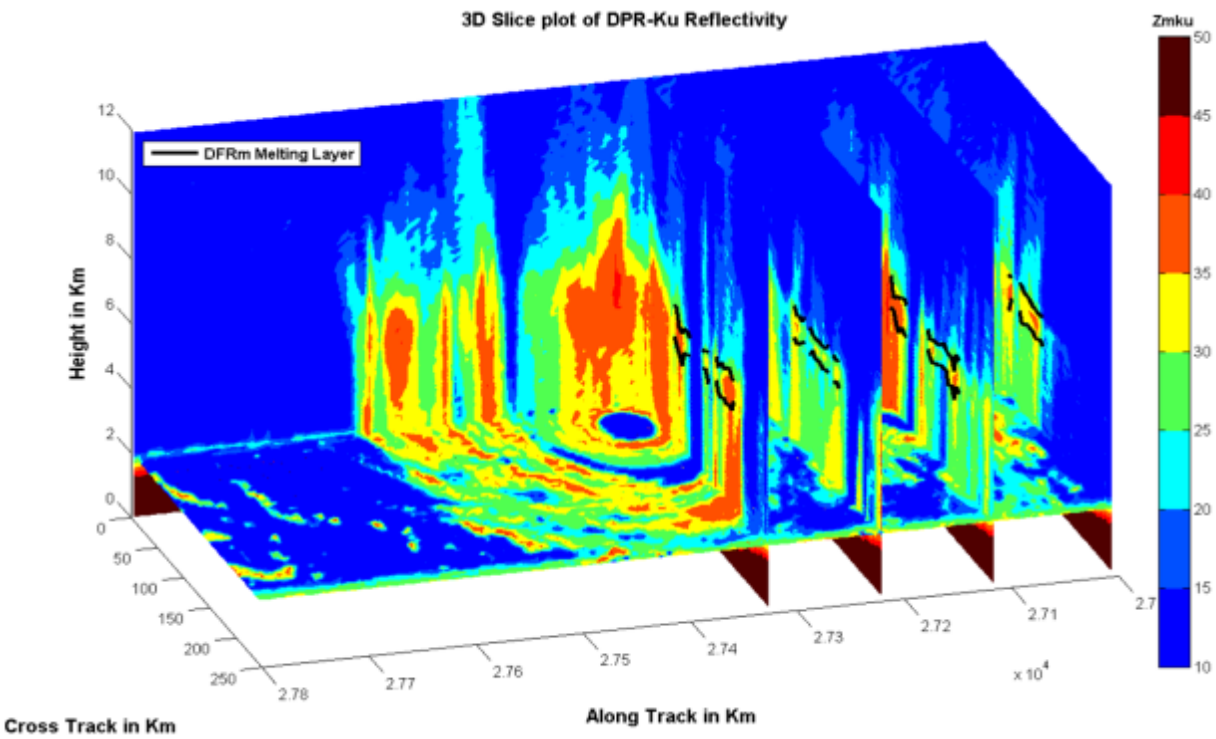
Date Range:

Sep 2014

Performance of Module

Name:	**"VONGFONG"**
Date/ Time:	**Oct 09,2014 02:50 (UTC)**
Satellite:	**GPM-DPR**
Orbit #	**003476**
Lat/Lon:	**9.3N-23.7N 124.8E-139.2E**

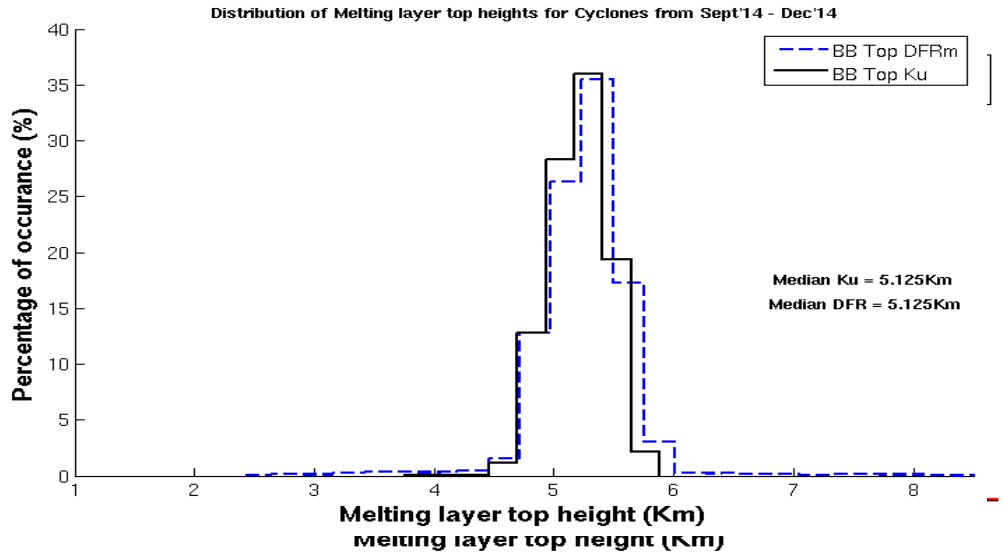


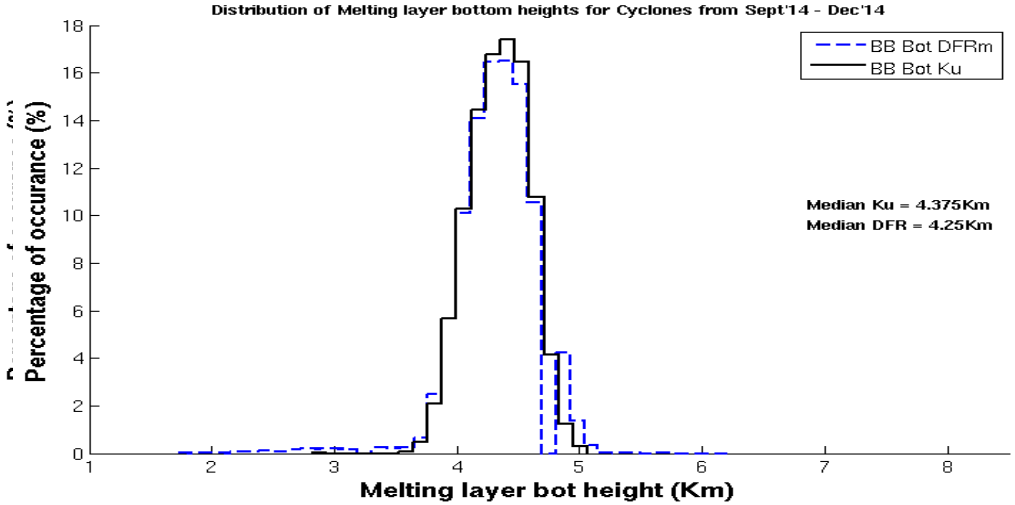


A 3D illustration of a tropical storm Vongfong

Performance of Module

Melting Layer Heights Study of Typhoons (Total cases 27)





Outline

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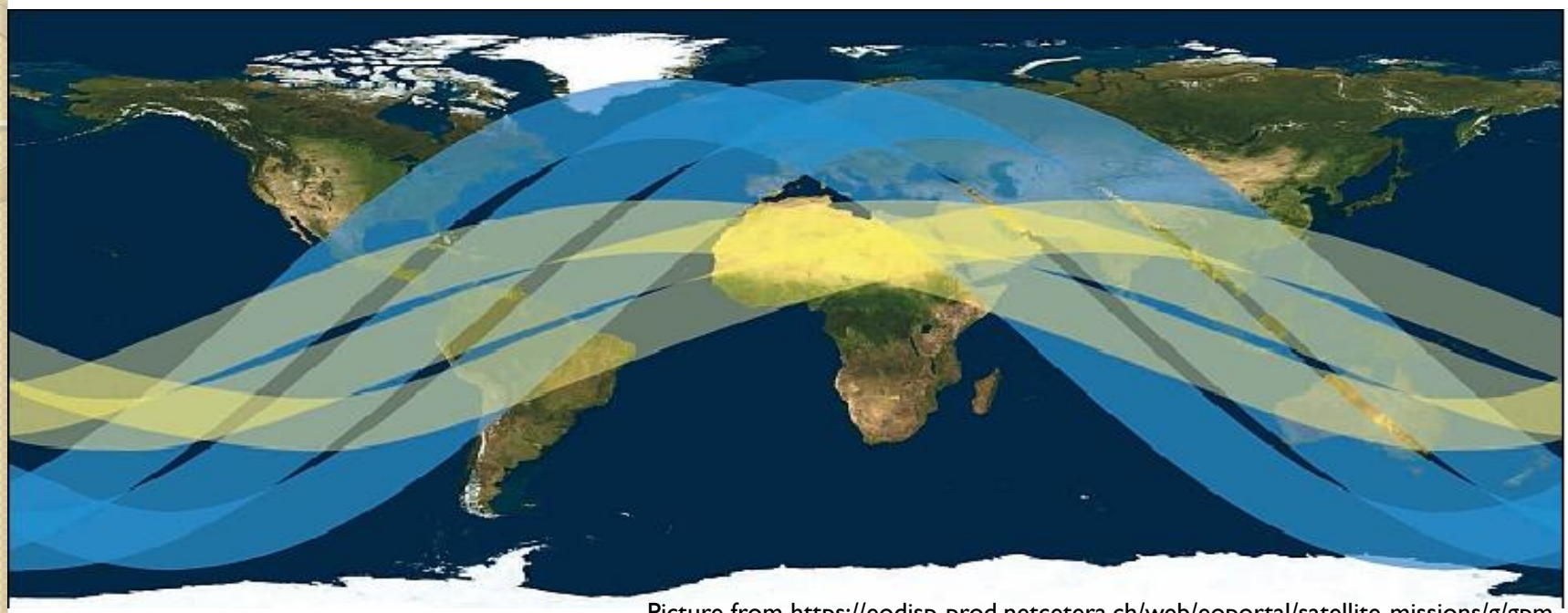
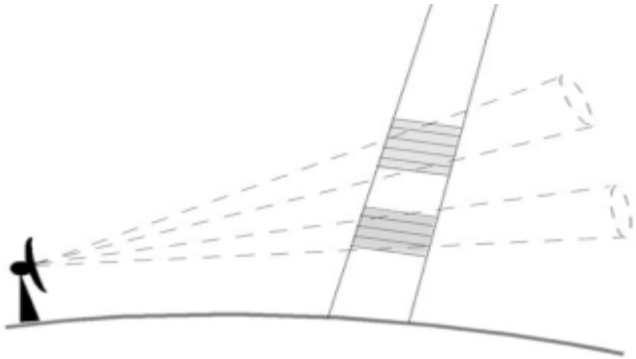
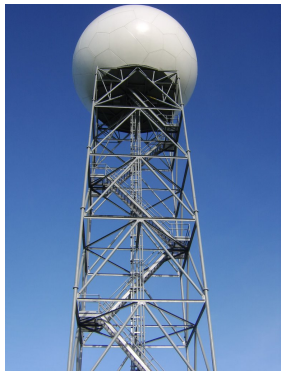
- Validation of profile classification module with ground radar.
- Enhancement of profile classification module.

Validation with Ground Radar (Nexrad)



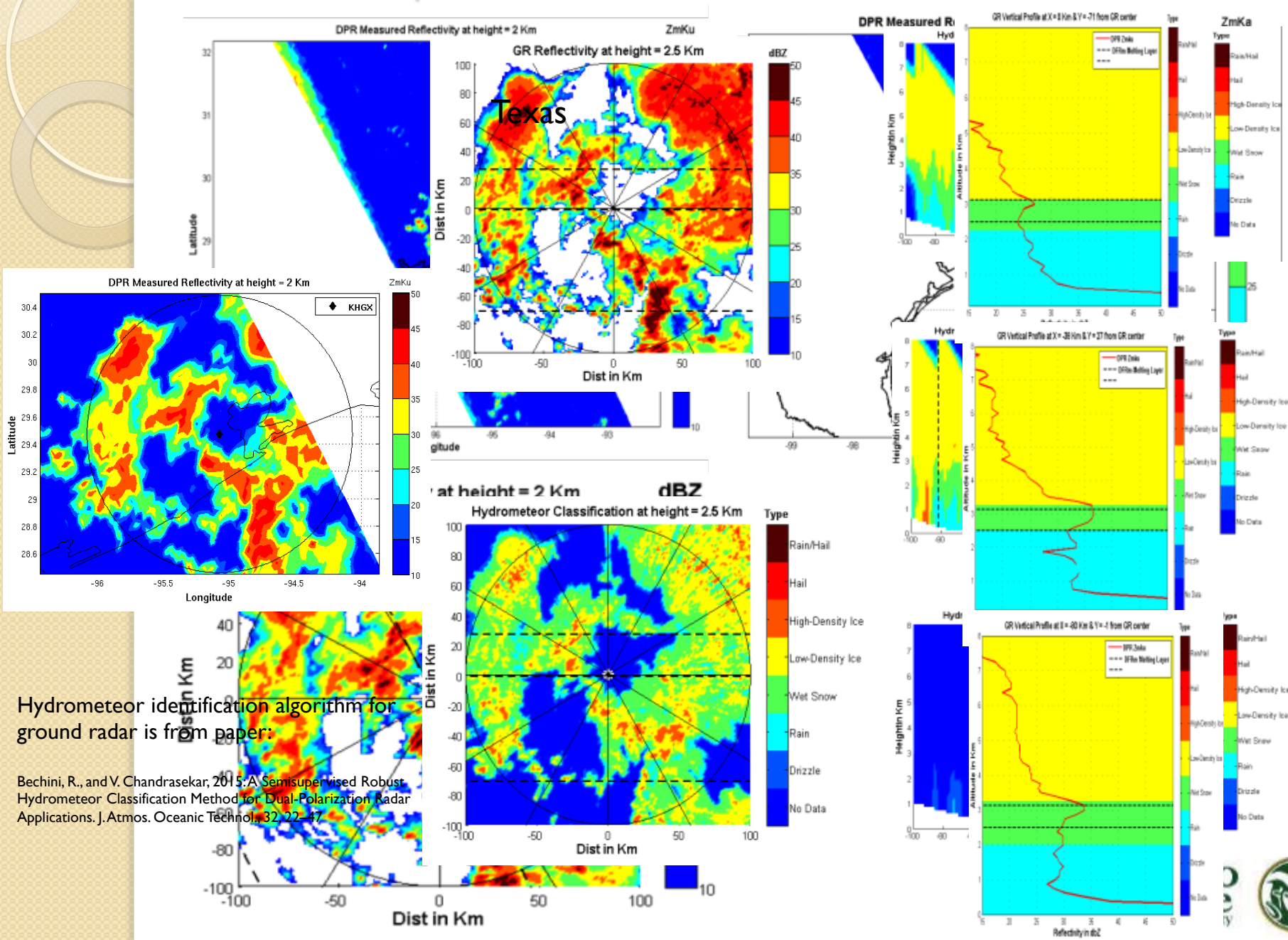
Picture from https://eodisp-prod.netcetera.ch/web/eoportal/satellite-missions/g/gpm





Picture from http://www.nws.noaa.gov

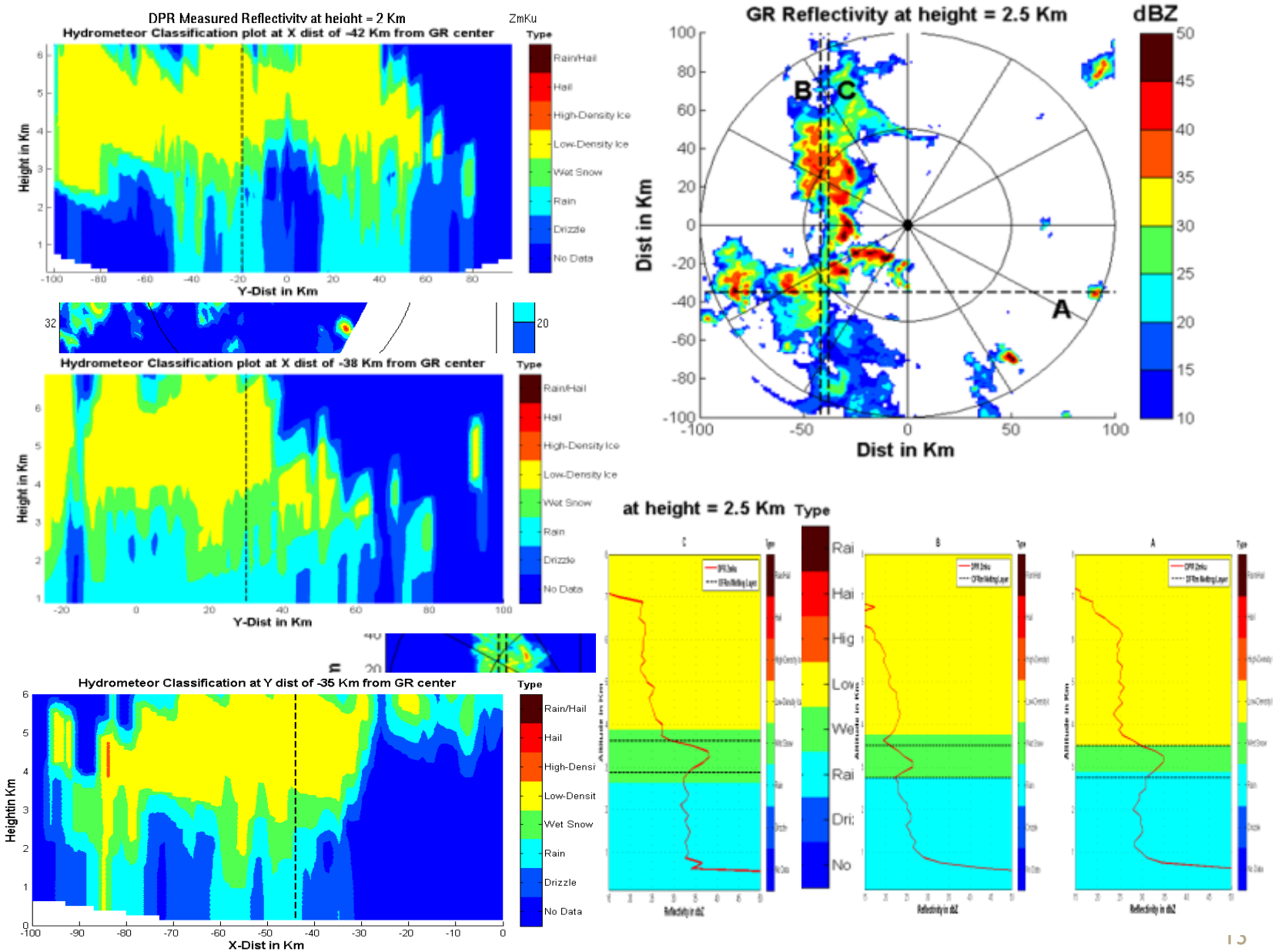
Case 1: DPR overpass with KHGX radar on 01/11/15 at 13:51:52 UTC



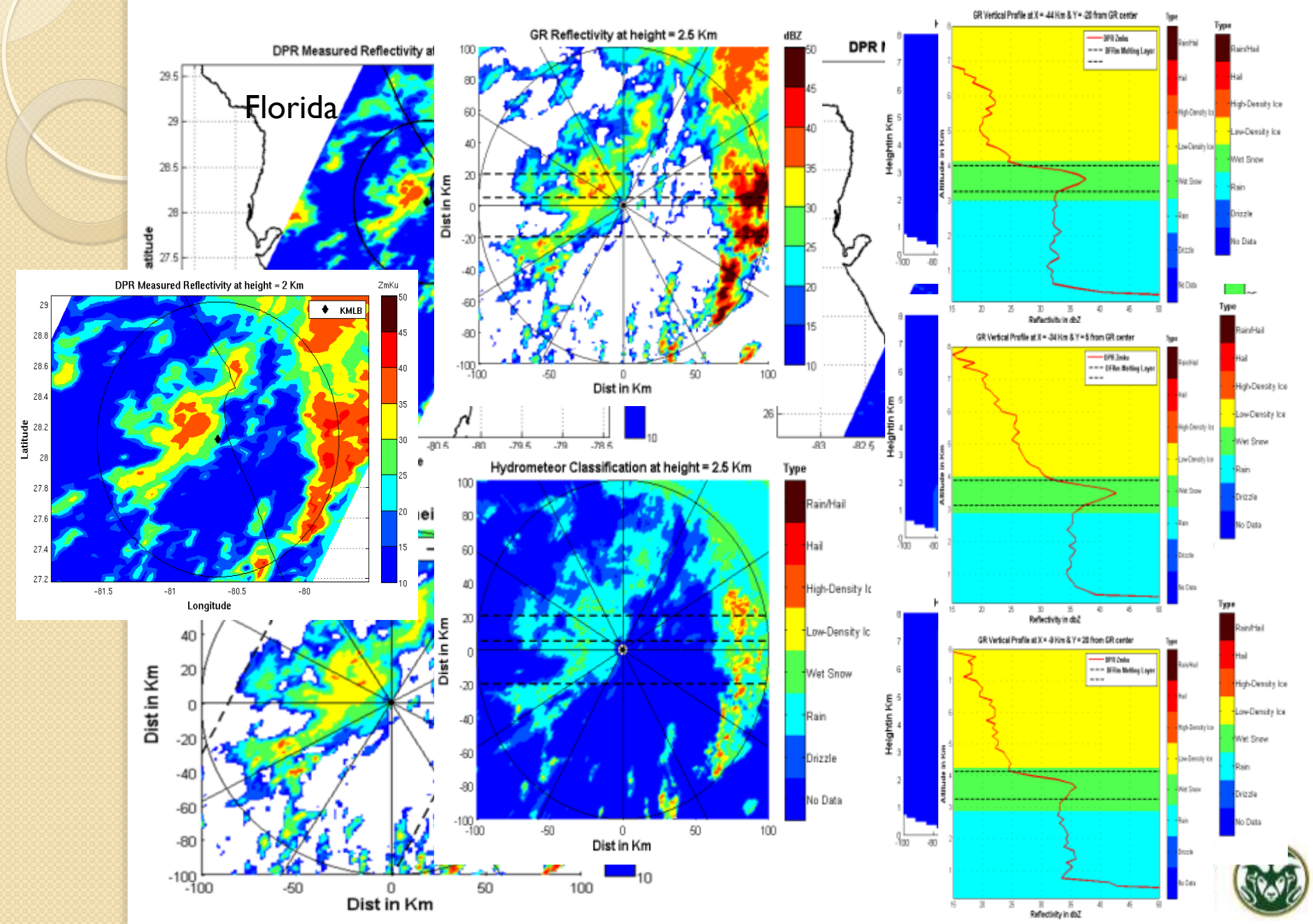
Hydrometeor identification algorithm for ground radar is from paper:

Bechini, R., and V. Chandrasekar, 2015: A Semisupervised Robust Hydrometeor Classification Method for Dual-Polarization Radar Applications. J. Atmos. Oceanic Technol., 32, 22–47.

Case 2: DPR overpass with KFWS radar on 03/18/15 at 08:56:09 UTC



Case 3: DPR overpass with KMLB radar on 01/13/15 at 02:25:17 UTC



Outline

- Performance of GPM-DPR profile classification module.
- Validation of profile classification module with ground radar.
- Enhancement of profile classification module.

Enhancement of Profile Classification Module

- Add the ability to perform snow/rain separation using information from DFRm, reflectivity at Ku and other (storm depth etc).
- Stretch Goal: Add the ability to perform snow type classification (aggregates, graupel etc) using information from DFRm and reflectivity at Ku.
- Add the ability to tag multiple scattering effect.

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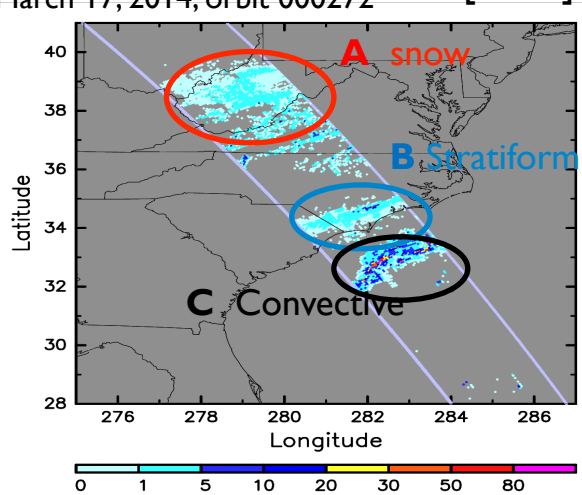
Enhancement of Profile Classification Module

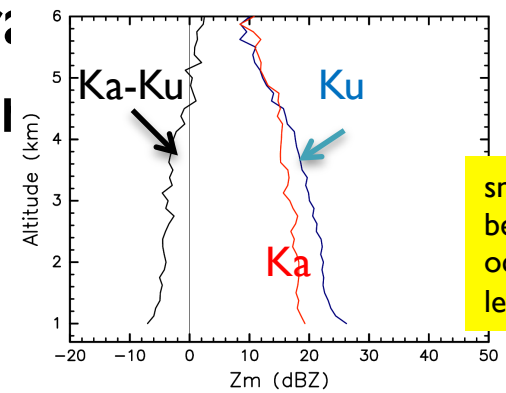
- Snow/ rain separation

Slide curtsey Toshio Iguchi

Rain rate from Ku on GPM/DPR
March 17, 2014, orbit 000272

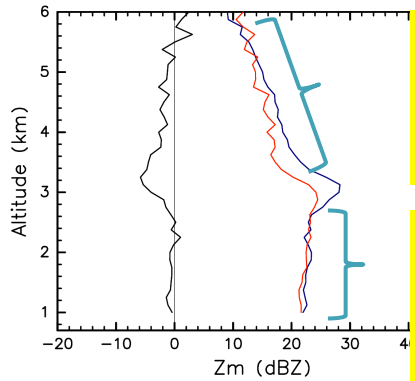


A. Snowfall



snow: Difference between Ku and Ka occurs even when Z is less than 20dBZ

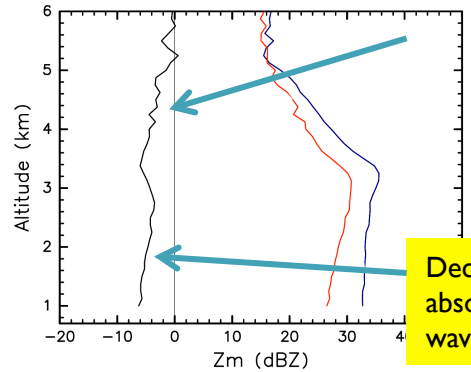
B. Stratiform Rainfall



snow: Difference between Ku and Ka occurs even when Z is less than 20dBZ

rain: very small attenuation at Ka if Z is about 20dBZ or less

C. Convection Rainfall



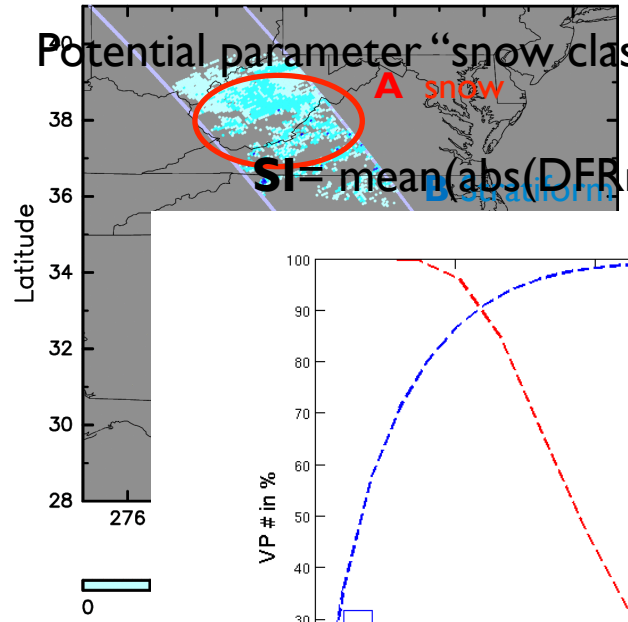
Increase of DFR implies that the decrease above this level is not due to attenuation, but due to the size effect of snow.

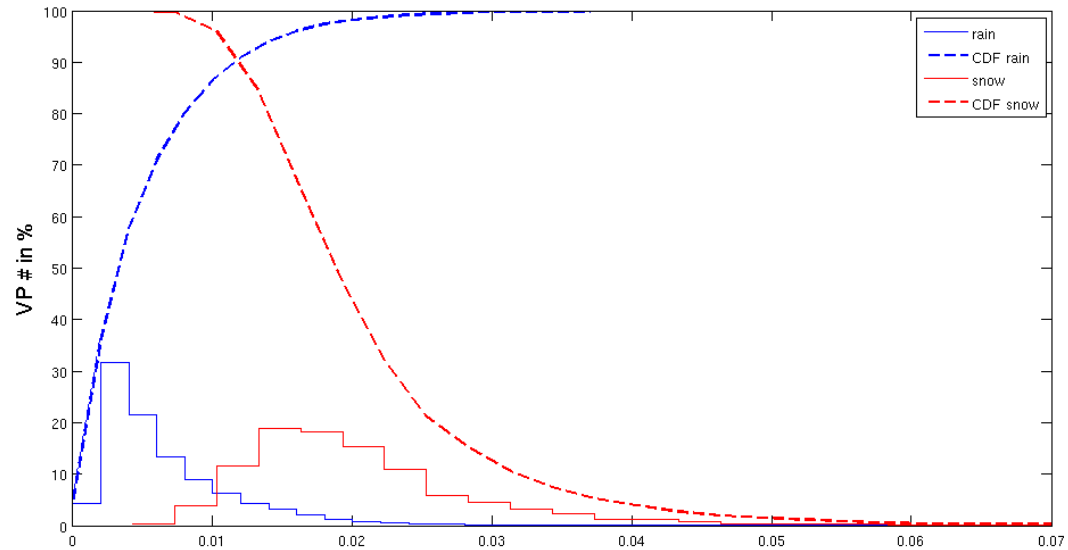
Decrease due to absorption of em waves at Ka-band

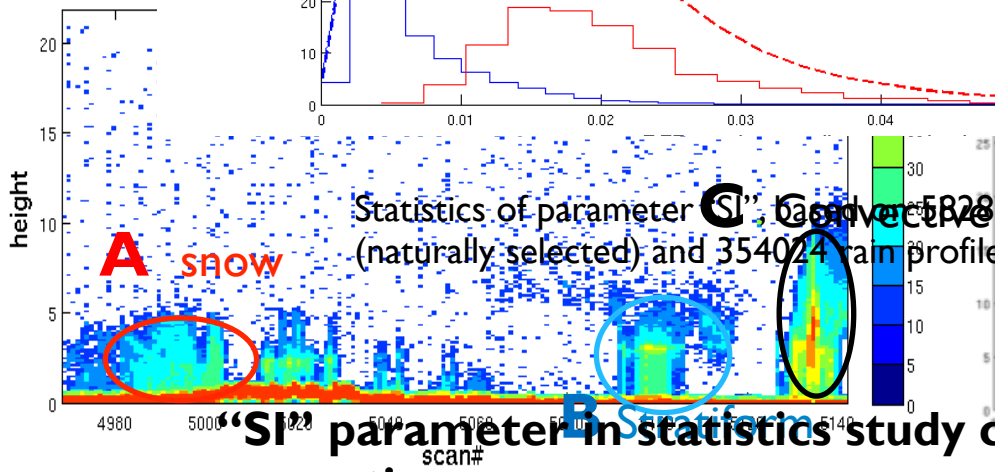
Snow/ rain separation

Potential parameter "snow classification index (SI)" to perform snow/rain separation

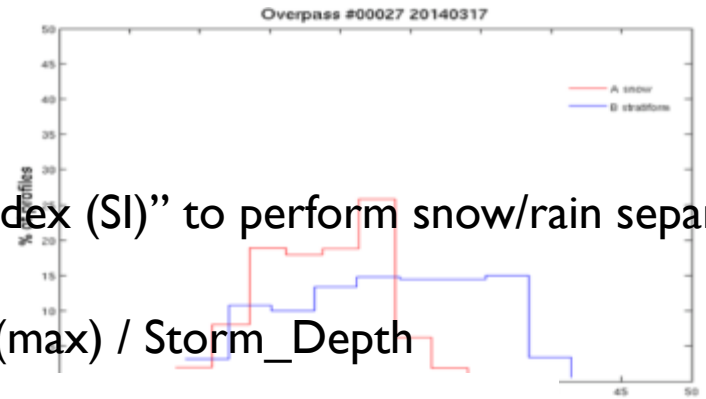
SI= mean(abs(DFRm)) / Zmku(max) / Storm_Depth

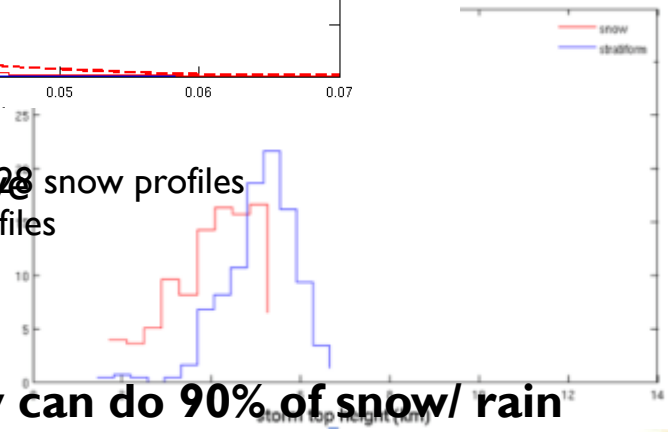






Statistics of parameter "SI", based on 5828 snow profiles (naturally selected) and 354024 rain profiles



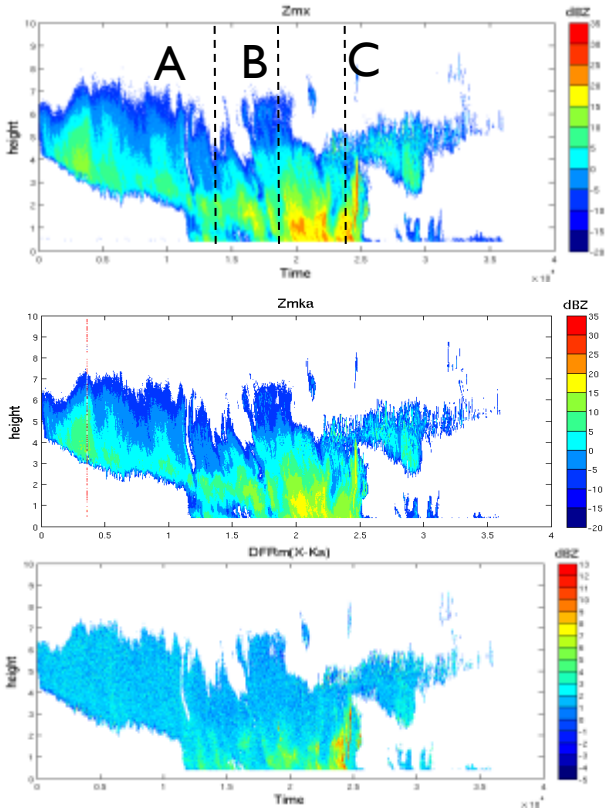


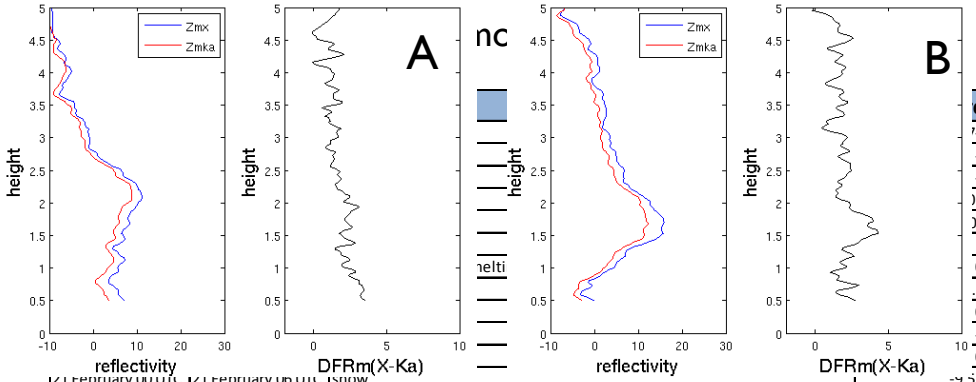
"SI" parameter in statistics study can do 90% of snow/ rain separation

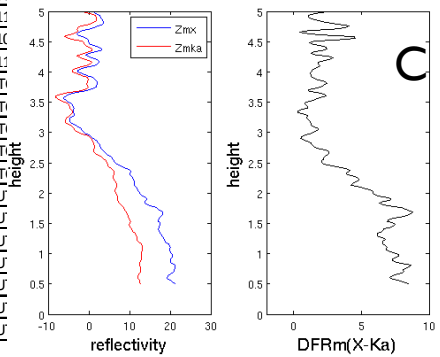
Storm depth differs between snow, stratiform and convective case

ARM radar (X and Ka band)Finland snowfall experiment (BAECC SNEX Feb 1-Apr 30, 2014)

- **Radars & remote sensing**
  - SACR (X, K_a - bands)
  - KAZR (K_a - band)
  - MWACR (W –band)
  - Windprofiler (L-ban)
  - Microwave Radiometers
- Lidars (HSRL, MPL, Doppler)

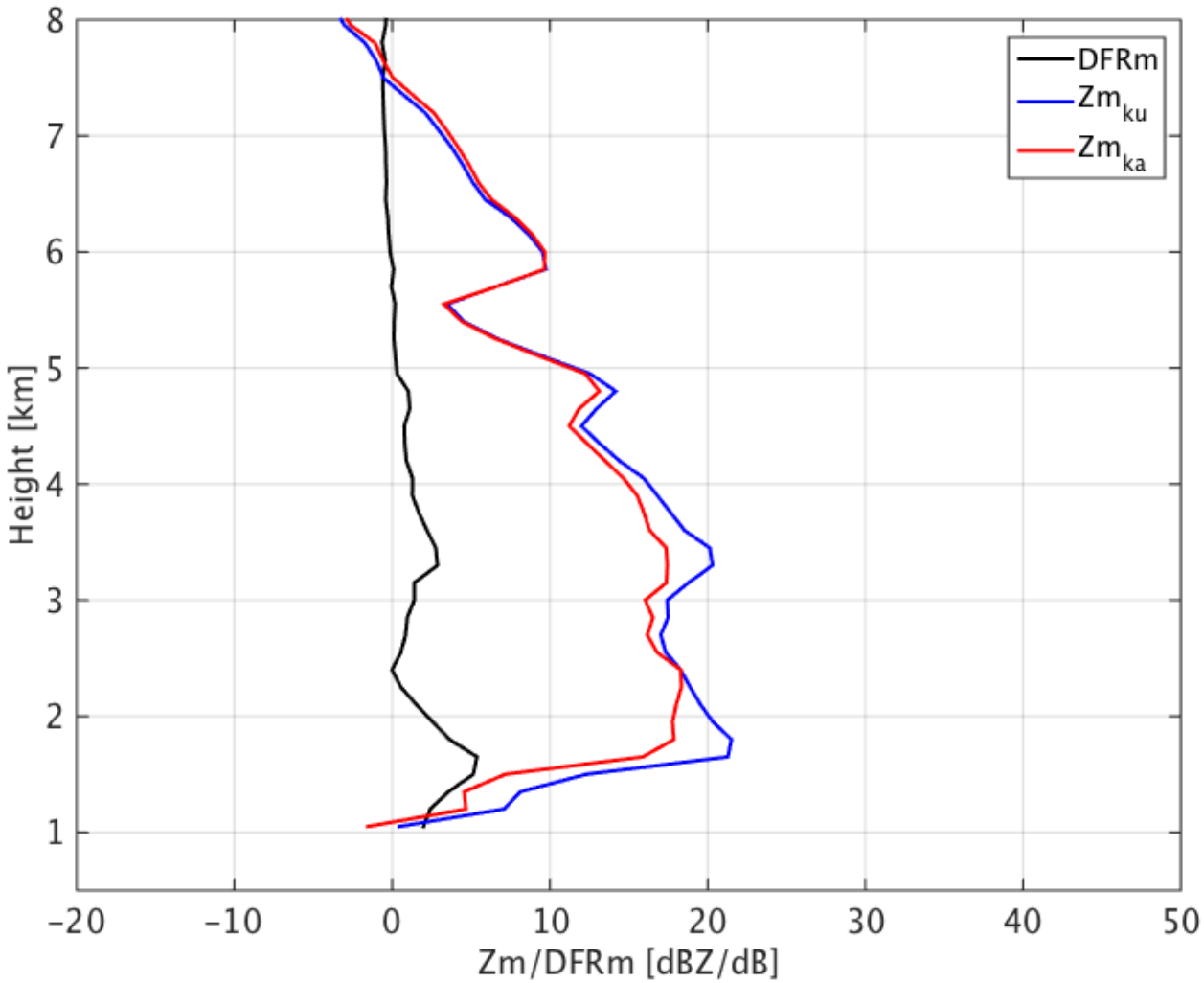






21 February 00 UTC	21 February 06 UTC	snow	-9.5 -(-5.7)
21 February 16 UTC	22 February 08		-2.4-0.9
22 February 10 UTC	22 February 11		1.4-1.8
22 February 22 UTC	23 February 10		0.9 - 2.9
26 February 12 UTC	27 February 11	les	-1.1 - 0.3
28 February 22 UTC	1 March 06 UT	icles	-1.1 -(-0.6)
2 March 06 UTC	2 March 15 UT		-1.8 - 0.4
3 March 02 UTC	3 March 16 UT		-0.2 -0.8
7 March 12 UTC	7 March 18 UT		3.1 - 5.1
7 March 22 UTC	8 March 08 UT		0.6 - 2.8
13 March 21 UTC	13 March 22 U		4.4 - 4.7
15 March 02 UTC	15 March 08 U		-1.2 - (0.1)
15 March 14 UTC	16 March 11 U	g maybe riming	-3.4 -2.2
18 March 05 UTC	19 March 19 U		-8.5 - (-1.5)
20 March 13 UTC	21 March 00 U		-3.9 - (-3.0)
21 March 06 UTC	21 March 15 U		4.2-7.6
23 March 11 UTC	23 March 16 U		2.0-3.7

Observations from D3R Radar Feb 26, 2015 Wallops Island



Enhancement of Profile Classification Module

- Snow type identification

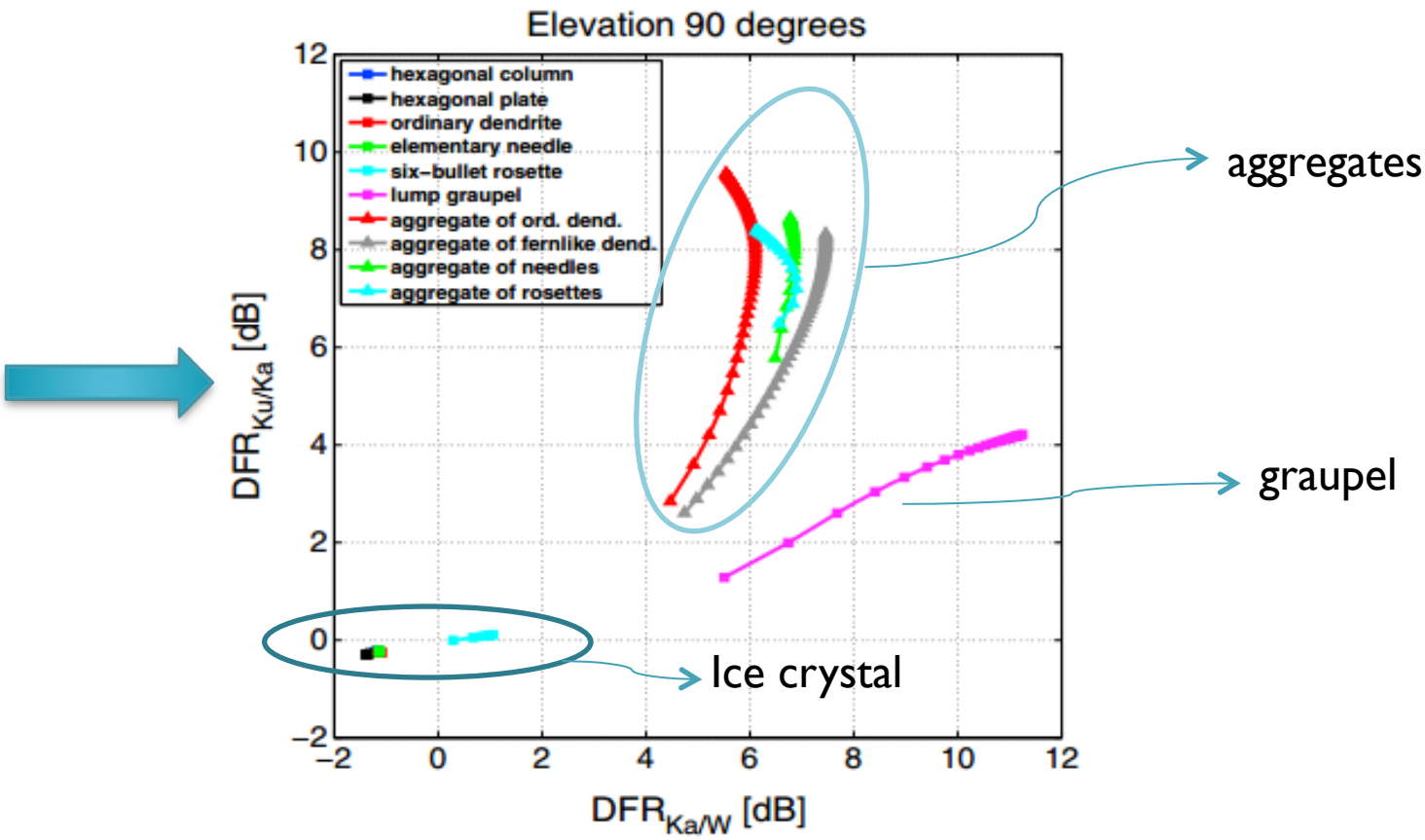
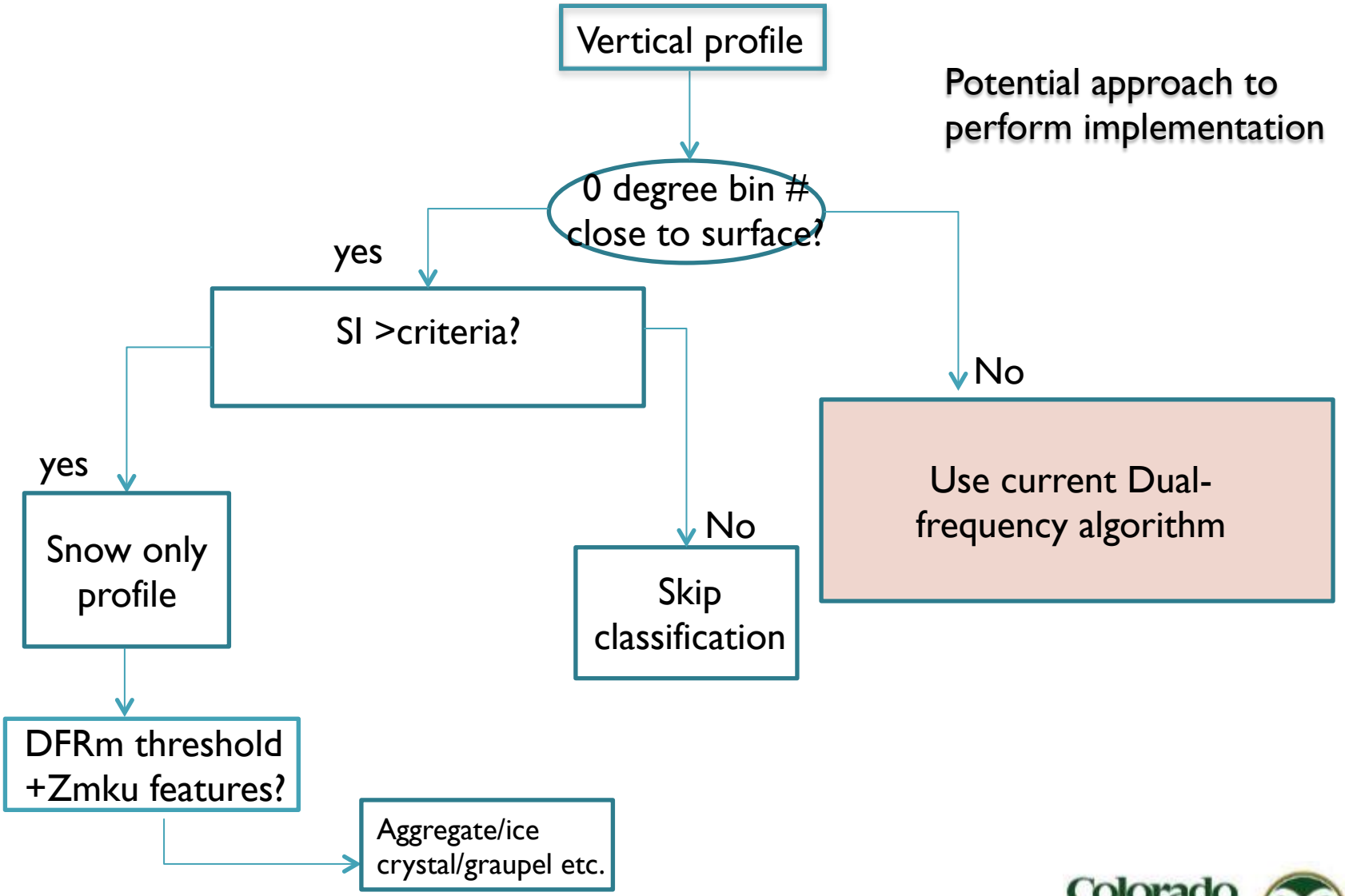


Figure from Tyynela and Chandrasekar, Characterizing falling snow using multi-frequency dual-polarization measurements, Journal of geophysical research: Atmospheres. Vol 119, issue 13, 2014.

Enhancement of Profile Classification Module



Potential approach to perform implementation

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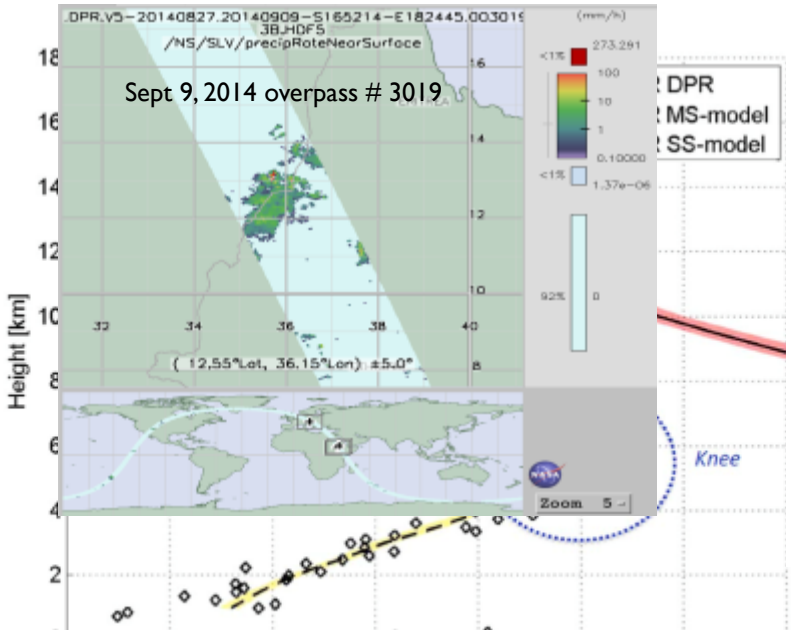
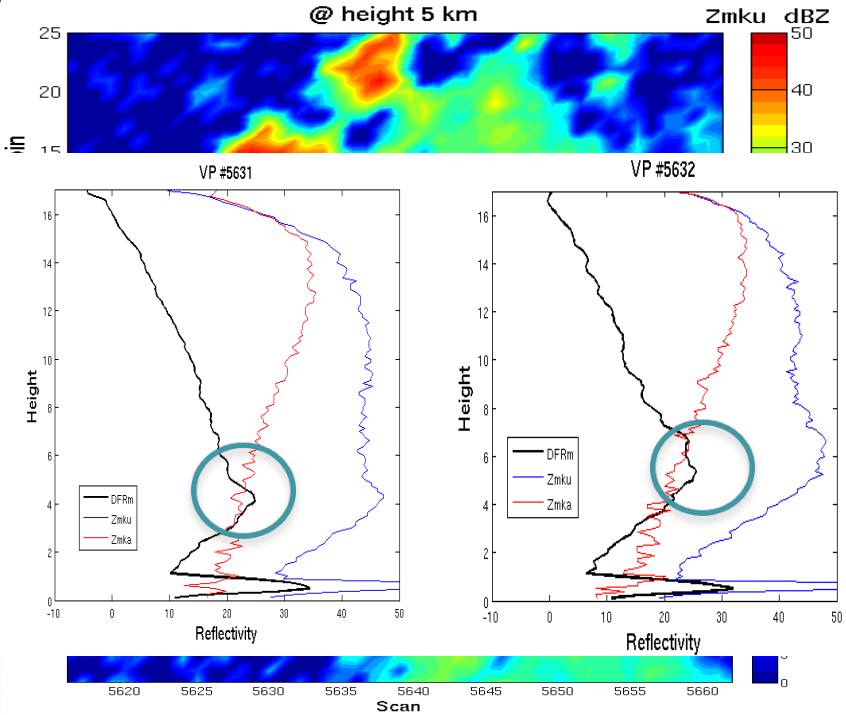
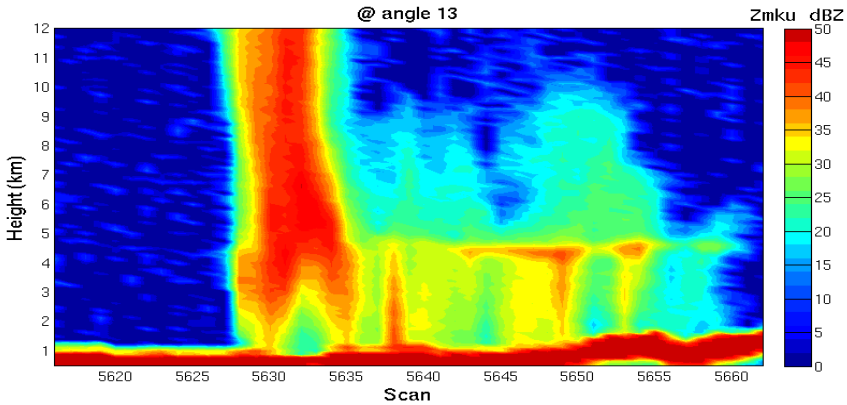
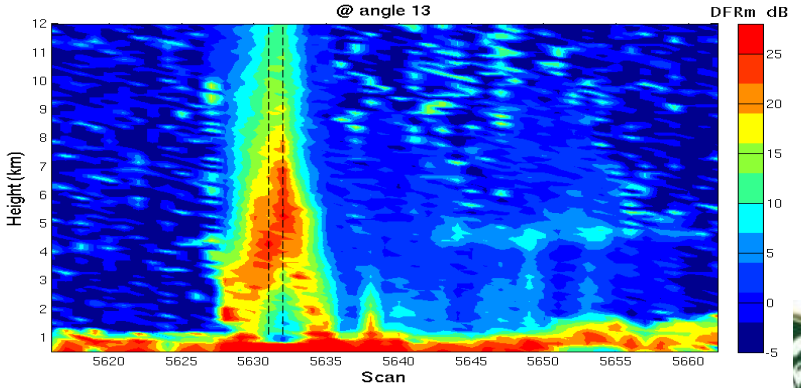
Enhancement of Profile Classification Module

- Multiple Scattering effect



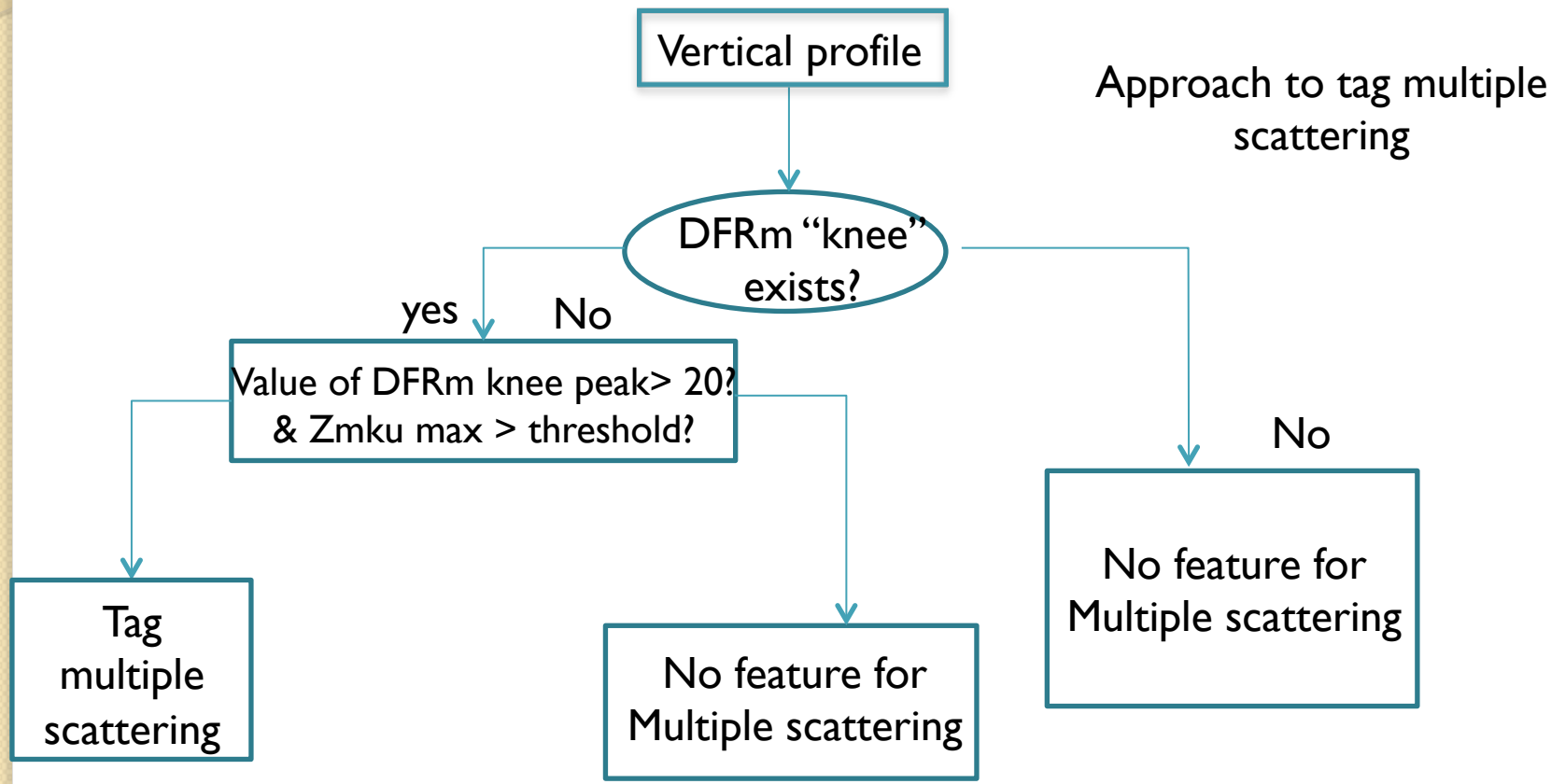






Enhancement of Profile Classification Module

- Multiple Scattering effect



Summary and Conclusion

- GPM-DPR dual-frequency profile classification module is working well. Comparison of dual-frequency algorithm with TRMM legacy Ku algorithm illustrates reasonable results.

- Validations are made with ground radar system and show excellent match in melting layer detection with Nexrad radar.

- Enhancement of the algorithm is needed in several areas including snow/rain separation, snow type identification, and multiple scattering effect etc.

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THANK YOU