Proposal for Dissertation

Space-borne GPM Dual-wavelength Radar Simulation based On TRMM-PR and Ground-based Radar Observation

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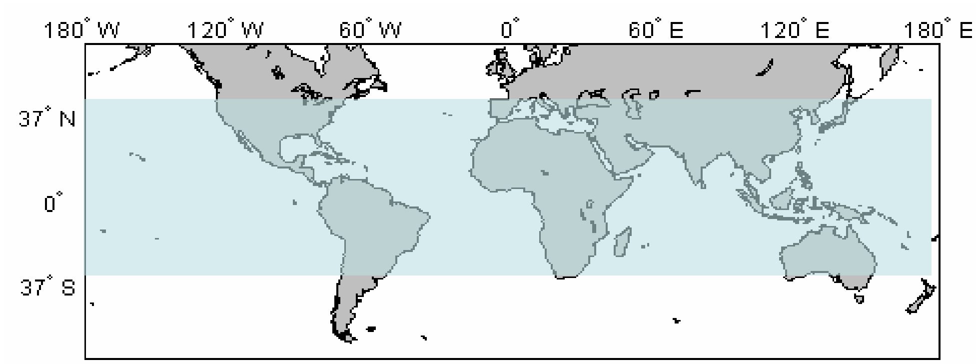
Outline

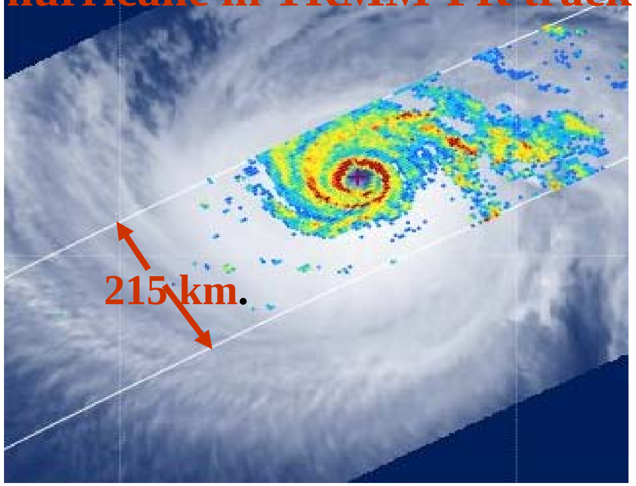
- **Background and Motivation**
- **Objectives of the proposal**
- **Research Tasks to achieve the objectives**
- **Research works that have been done.**
- **Plan to complete this research**

Background : Global Precipitation Observation

- **TRMM : Tropical Rainfall Measurement Mission**
  - Joint mission between NASA and JAXA
  - Observing precipitation over tropical regions between 37°S and 37°N
  - Satellite was lunched in November 1997

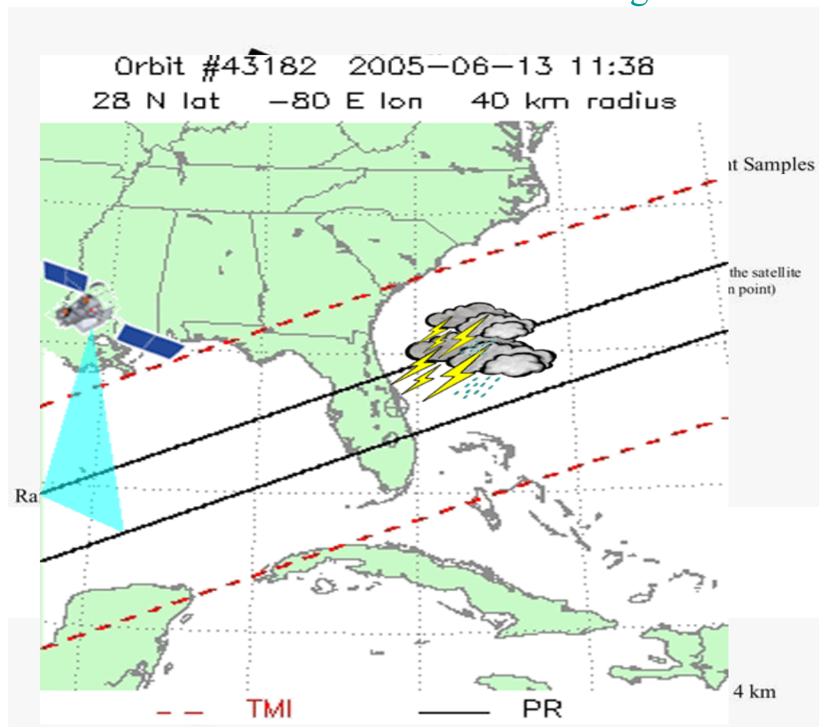


A hurricane in TRMM-PR track



- **PR : Precipitation Radar (onboard TRMM)**
  - 13.8 GHz Ku-band radar (2.17 cm. wavelength)
  - Horizontal resolution at nadir : 4.3 km. (5 km. postboost)
  - Range resolution : 250 m.
  - Swath width : 215 km. (245 km postboost)
  - Altitude : 350 km. (402.5 km postboost)

Note : TRMM was boosted in altitude in August 2001



(Adopted from TRMM data user handbook, 2001)

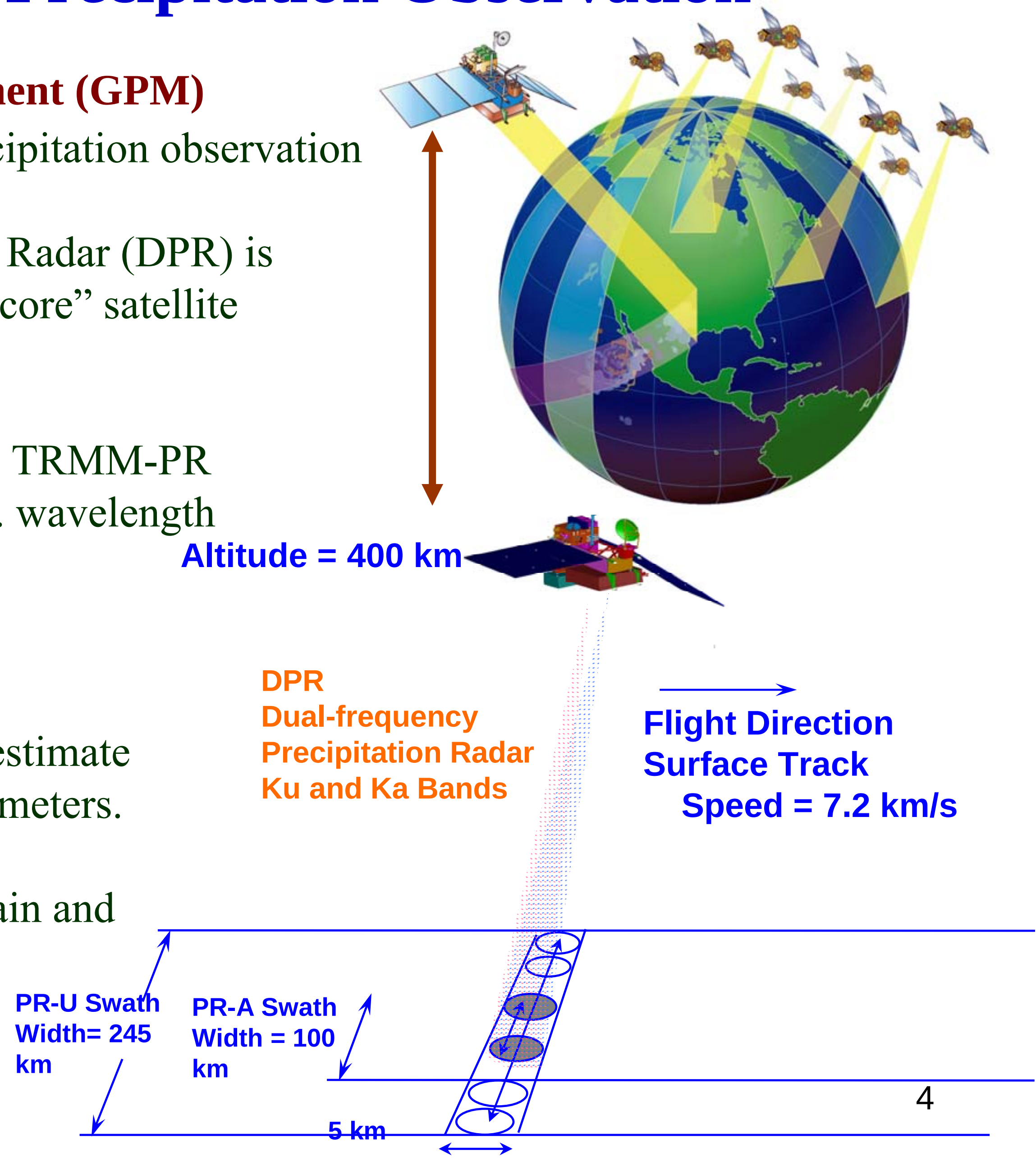
Background : Global Precipitation Observation

Global Precipitation Measurement (GPM)

-Next Generation of Global Precipitation observation
-Follow-on mission of TRMM
- Dual-wavelength Precipitation Radar (DPR) is designed to be onboard GPM "core" satellite

DPR

- Ku-band (13.6 GHz) similar to TRMM-PR
- Ka-band (35.6 GHz) –0.87 cm. wavelength

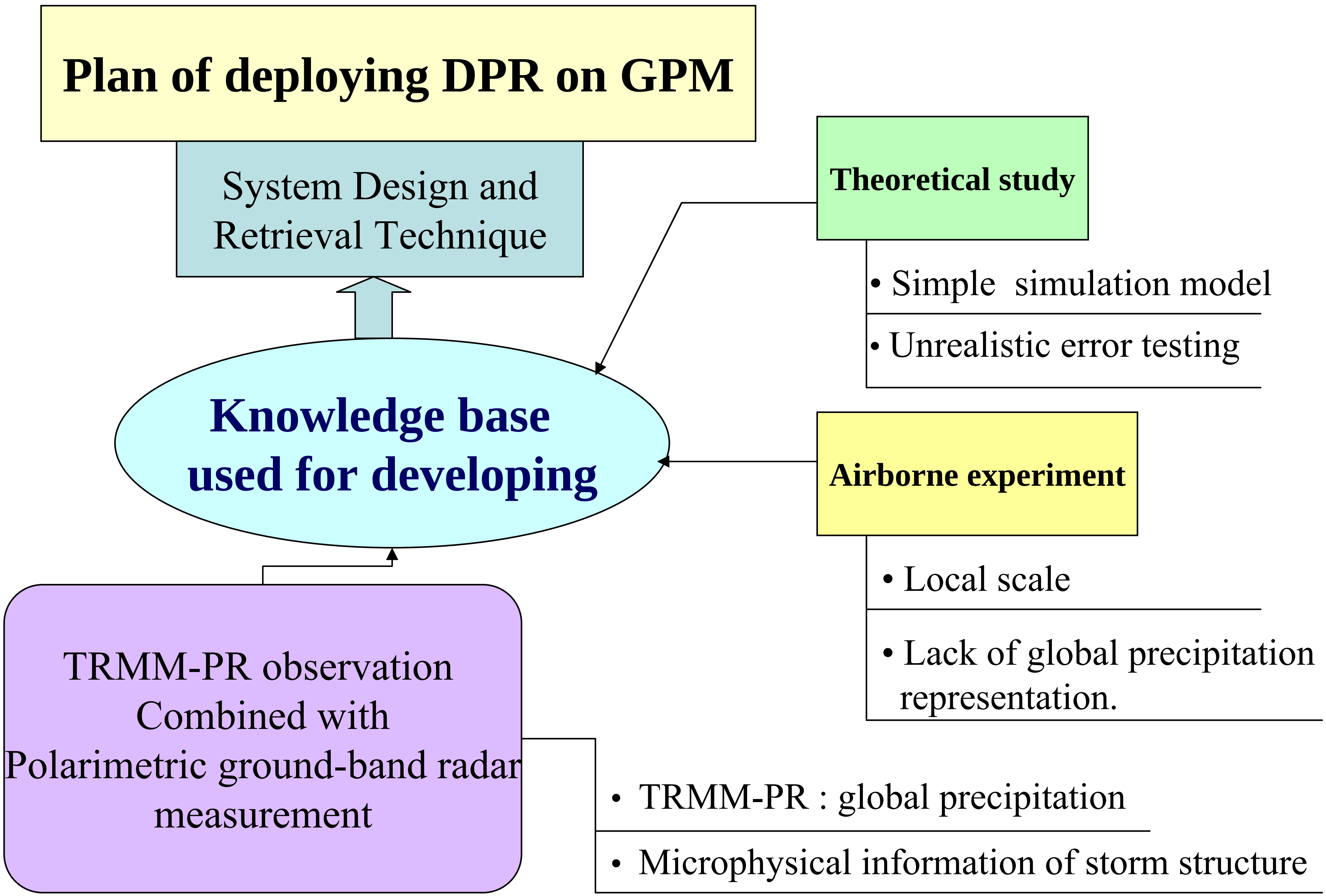


GPM-DPR is expected to..

- Improve accuracy of rainfall rate estimate via accurate estimate of DSD parameters.

- Be able to discriminate between rain and frozen precipitation

Motivation


Plan of deploying DPR on GPM
System Design and Retrieval Technique
Knowledge base used for developing
Theoretical study
• Simple simulation model
• Unrealistic error testing
Airborne experiment
• Local scale
• Lack of global precipitation representation.
TRMM-PR observation Combined with Polarimetric ground-band radar measurement
• TRMM-PR : global precipitation
• Microphysical information of storm structure

Objectives of the Proposal

1) To extensively analyze global TRMM-PR observation and effectively use knowledge gained as a sound basis for modeling the precipitation observation for GPM-DPR.

2) To study inter-connection between characteristics of reflectivity profiles and their associated microphysics based on polarimetric ground-based radar measurements.

3) To infuse the knowledge of precipitation microphysics into TRMM-PR observation analysis, to eventually construct appropriate simulation models of GPM-DPR observations, for the purpose of evaluating the system design and retrieval performance.

Research Tasks to achieve the objectives

1) **TRMM-PR observation analysis**

   - Vertical profile of reflectivity (VPR) classification

   - Drop Size Distribution (DSD) parameters estimate

2) **Microphysical model of precipitation**

   - Theoretical computation of radar reflectivity (Z) and attenuation (k)

   - Model relations between k and Z for different frequency

3) **Polarimetric ground-based radar measurement analysis**

   - Hydrometeor classification

4) Simulation of DPR observations and
   Dual-wavelength retrieval performance evaluation

Outline

- Background and Motivation
- Objectives of the proposal
- Research Tasks to achieve the objectives
- **Research works that have been done.**
- Plan to complete this research and to reach the final goals

Research works that have been done…

1.) Analysis of TRMM-PR observation

1.1) Vertical Profile of Reflectivity (VPR) classification

1.2) Drop size Distribution (DSD) parameters estimate

TRMM-PR attenuation-correction algorithm

$$Z_m(r) = Z_e(r)A(r)$$

Attenuation factor defined as

$$A(r) = \exp\left[-0.2\ \ln(10)\int_0^r k(s)ds\right]$$

Using k and Ze relaton ($k = \alpha Ze^{\beta}$)
Hitchfeld Bordan solution in integral form of Z_m

$$A_{HB}(r) = \left[1 - q\,\beta\int_0^r \alpha(s)Z_m^{\beta}(s)ds\right]^{1/\beta}$$

In dB unit

$$PIA_{HB} = -\frac{10}{\beta}\log(1-\zeta)$$

where

$$\zeta = q\,\beta\int_0^{r_s}\alpha(s)Z_m^{\beta}(s)ds$$

HB solution is unstable when PIA is large

Surface reference (SR) technique is used as a constraint, defined as

$$PIA_{SR} = \Delta\sigma^0 = \langle\sigma^0_{no-rain}\rangle - \langle\sigma^0_{rain}\rangle$$

Estimate most probable PIA (***PIA_e***) for given ζ and $\Delta\sigma^o$

$$PIA_e = -\frac{10}{\beta}\log(1-\varepsilon\zeta)$$

ε is correction factor, defined in a form as

$$\varepsilon = \frac{1-10^{-0.1\beta\Delta\sigma^0}}{\zeta}$$

ε is used to adjust α coefficient of $k = \alpha Ze\beta$. Then It is also called "α adjustment" method.

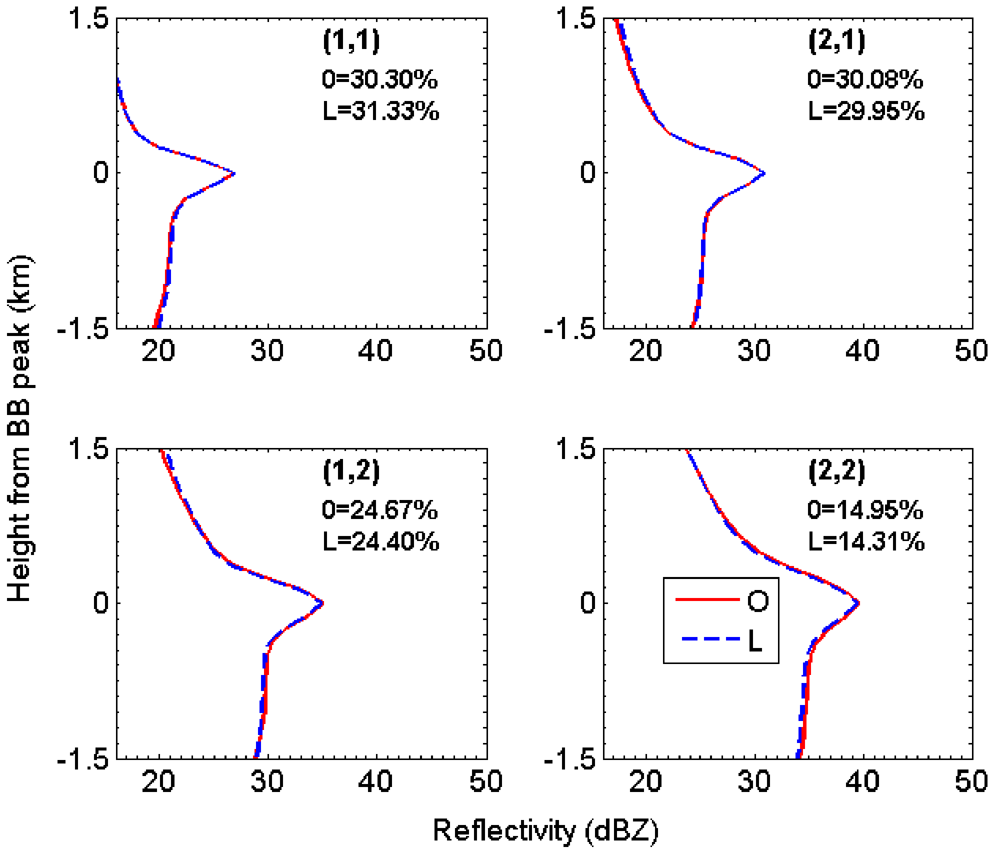
$$Z_e(r) = \frac{Z_m(r)}{\left[1-\varepsilon\,q\,\beta\int_0^r\alpha(s)Z_m^{\beta}(s)ds\right]^{1/\beta}}$$

Research works that have been done…

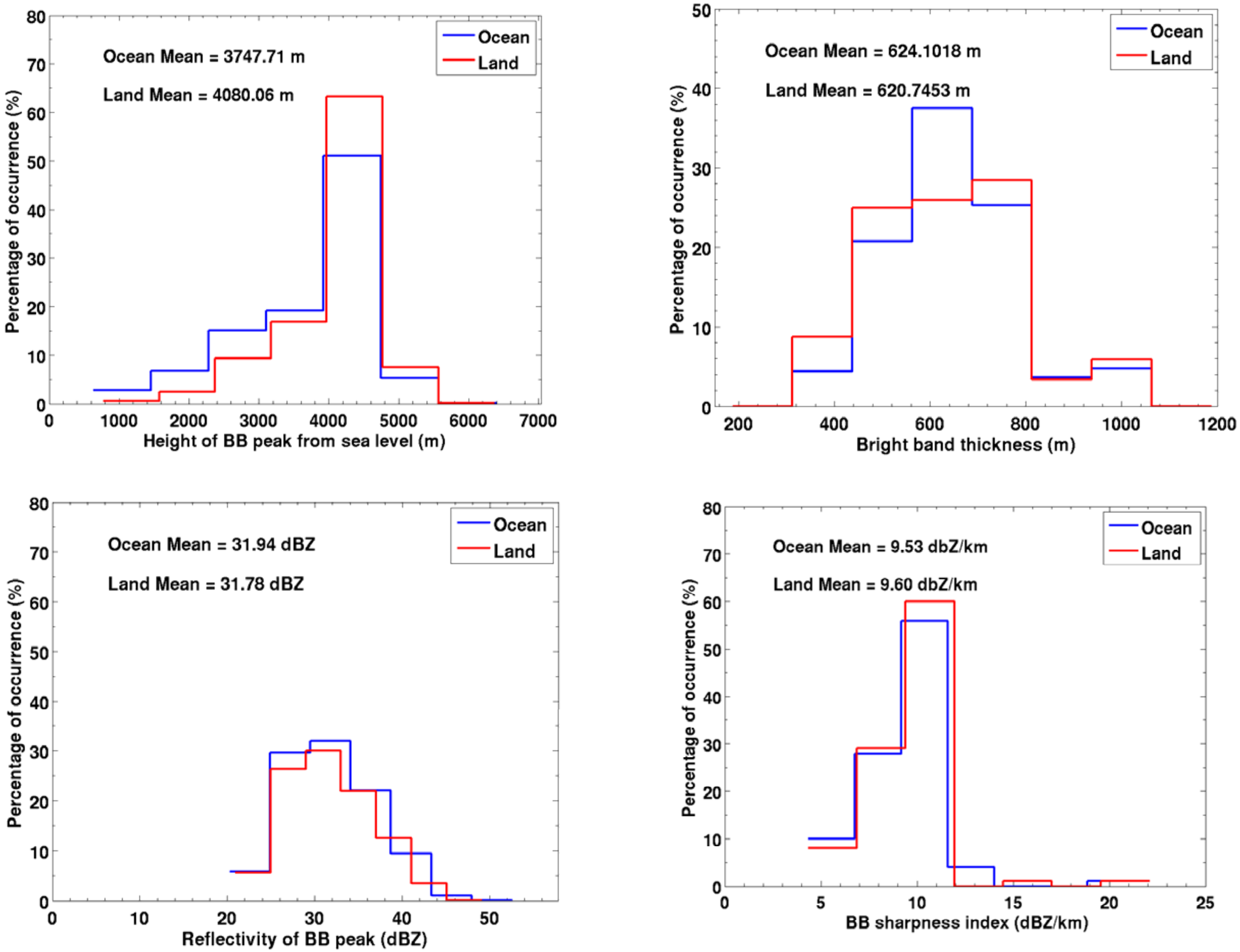
1) Analysis of TRMM-PR observation (Continue ….)

1.1) VPR classification using Self Organizing Map (SOM)

- Stratiform : Bright Band (BB) vertical structure
  - **Comparison between over land and over ocean**

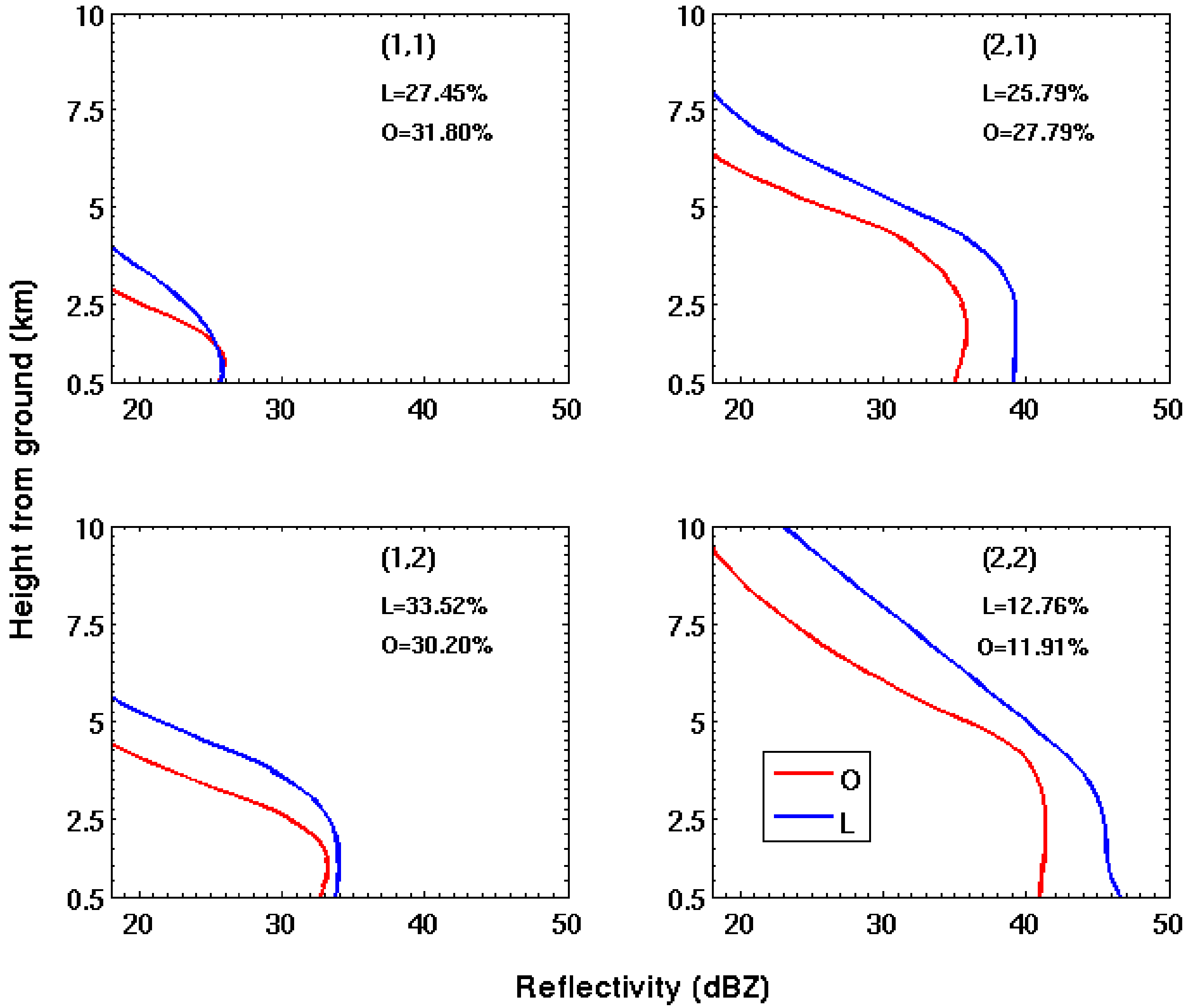


BB characteristics study : Comparison over land and over ocean



- Convective rain

Comparison between Over Land and Over Ocean



1) Analysis of TRMM-PR observation (Continue ….)

1.2) Drop Size Distribution (DSD parameters)

The drop-size-distribution (DSD) is based on the normalized gamma model:

$$N(D) = N_W f(\mu)\left(\frac{D}{D_o}\right)^{\mu} e^{-\left(\frac{3.67+\mu}{D_o}\right)D} dD$$

$$f(\mu) = \frac{6}{3.67^4}\frac{(3.67+\mu)^{\mu+4}}{\Gamma(\mu+4)}$$

μ is shape parameter.
D_o is the median volume diameter in mm.
N_w = intercept parameter ($mm^{-1}mm^{-3}$)

If μ is fixed. *N(D)* is controlled by D_o and N_w

D_o and N_w estimate using TRMM-PR observation

$$k = \alpha Z^{\beta}$$

Normalized by Nw and get new coefficient $\tilde{\alpha}$

$$\left(\frac{k}{N_w}\right) = \tilde{\alpha}\left(\frac{Z}{N_w}\right)^{\beta}$$

$$k = \tilde{\alpha}(N_w)^{1-\beta} Z^{\beta} = \alpha Z^{\beta}$$

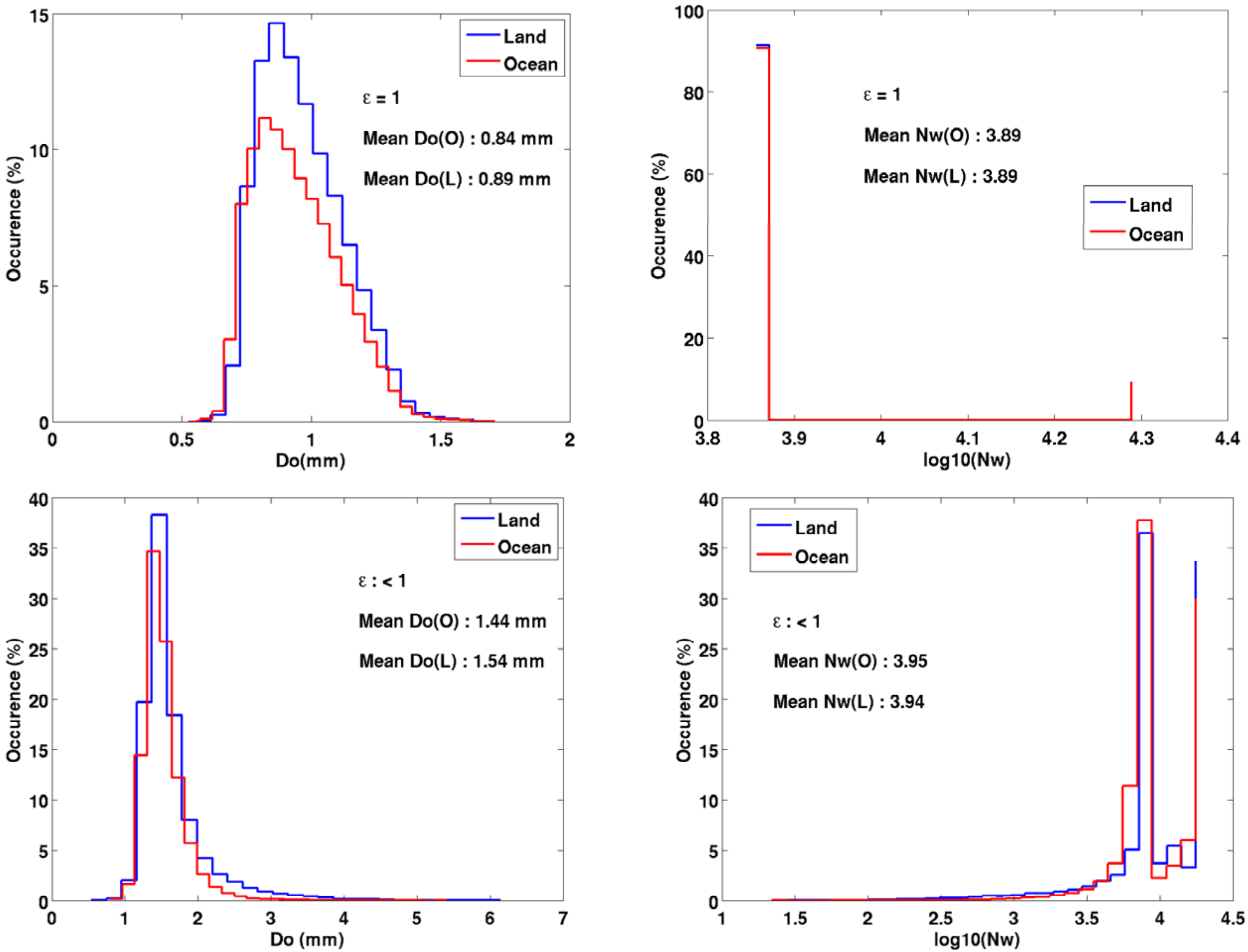
$$\alpha = \tilde{\alpha}(N_w)^{1-\beta} \Rightarrow N_w = \left(\frac{\alpha}{\tilde{\alpha}}\right)^{\frac{1}{1-\beta}}$$

where $\alpha = \alpha_{ini}\varepsilon$

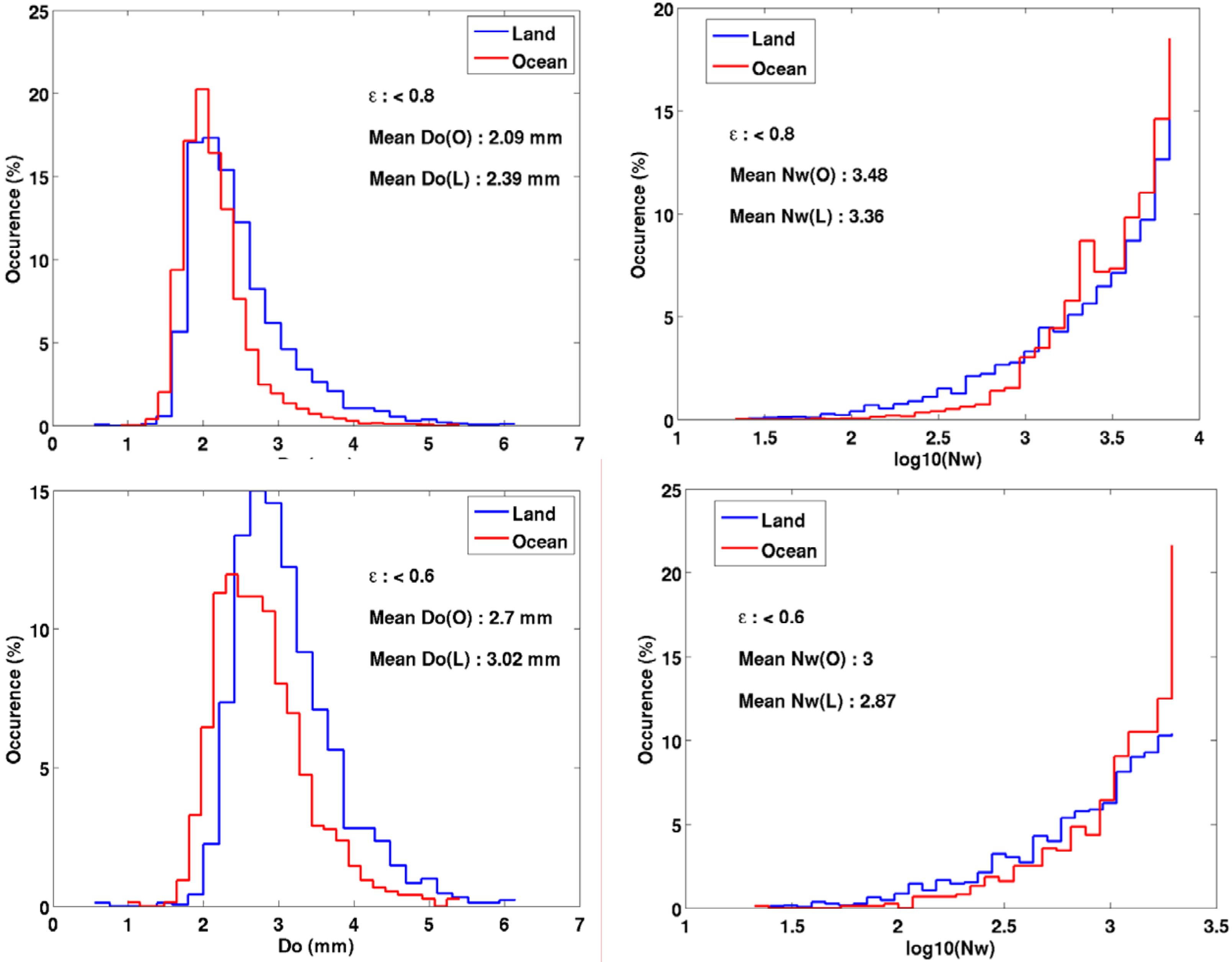
- -

$$D_0 \approx \left[\frac{Z}{N_w C}\right]^{\frac{1}{7}} \qquad C = \frac{f(\mu)\Gamma(7+\mu)}{(3.67+\mu)^{7+\mu}}$$

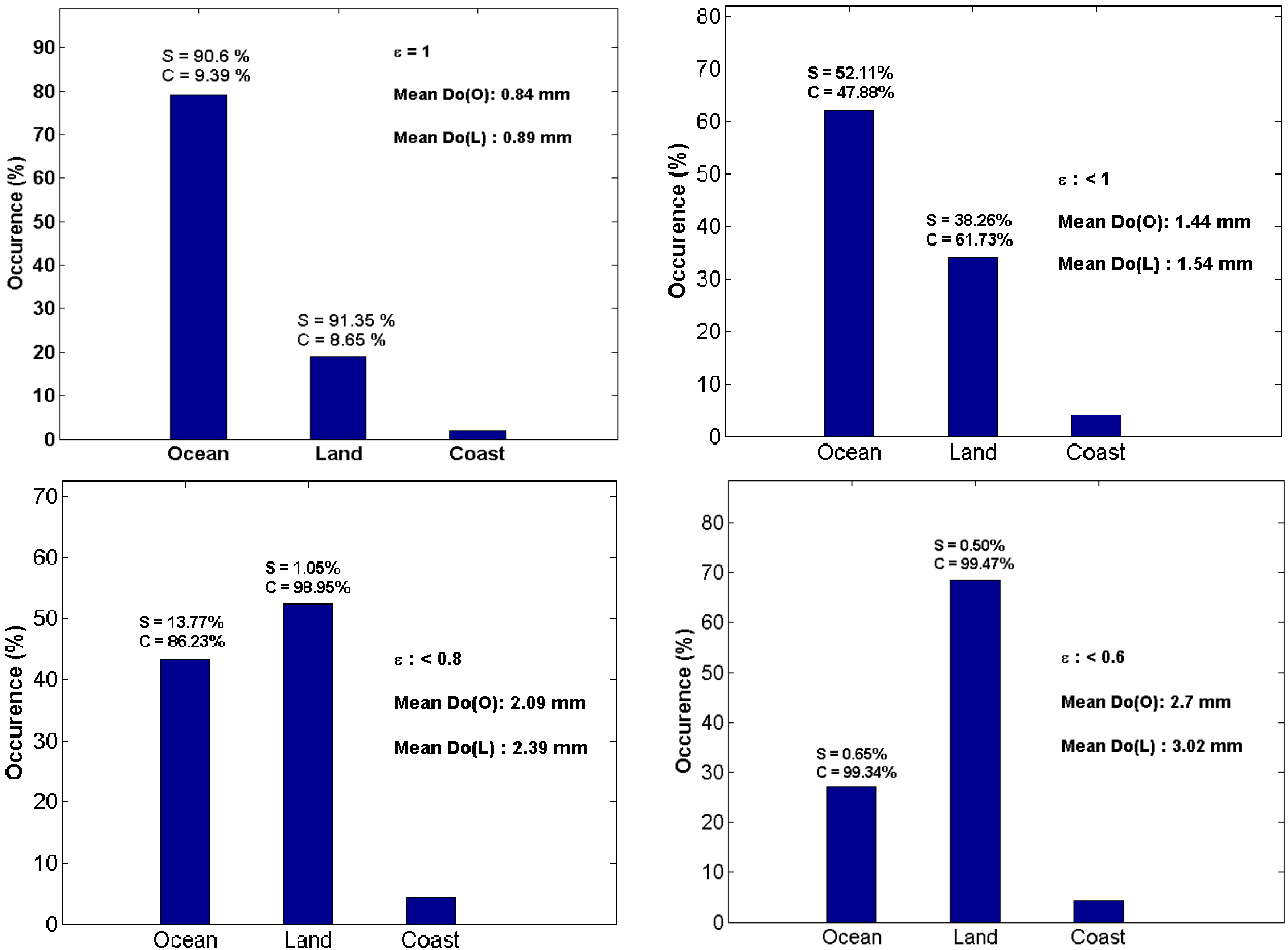
D_o and N_w distribution and ε



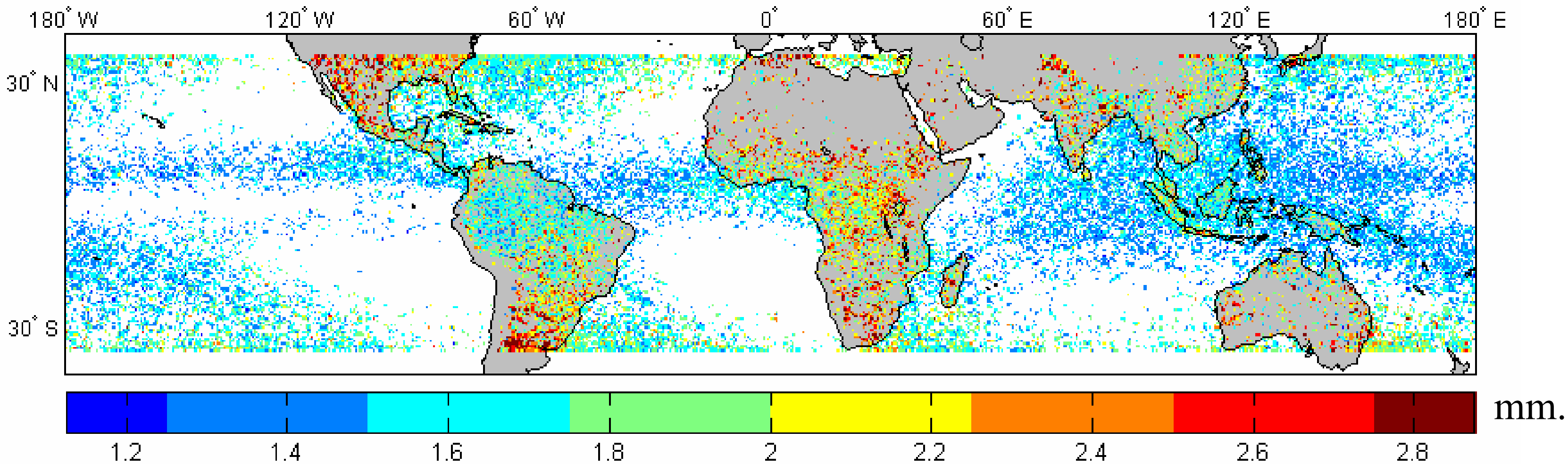
D_o and N_w distribution and ε



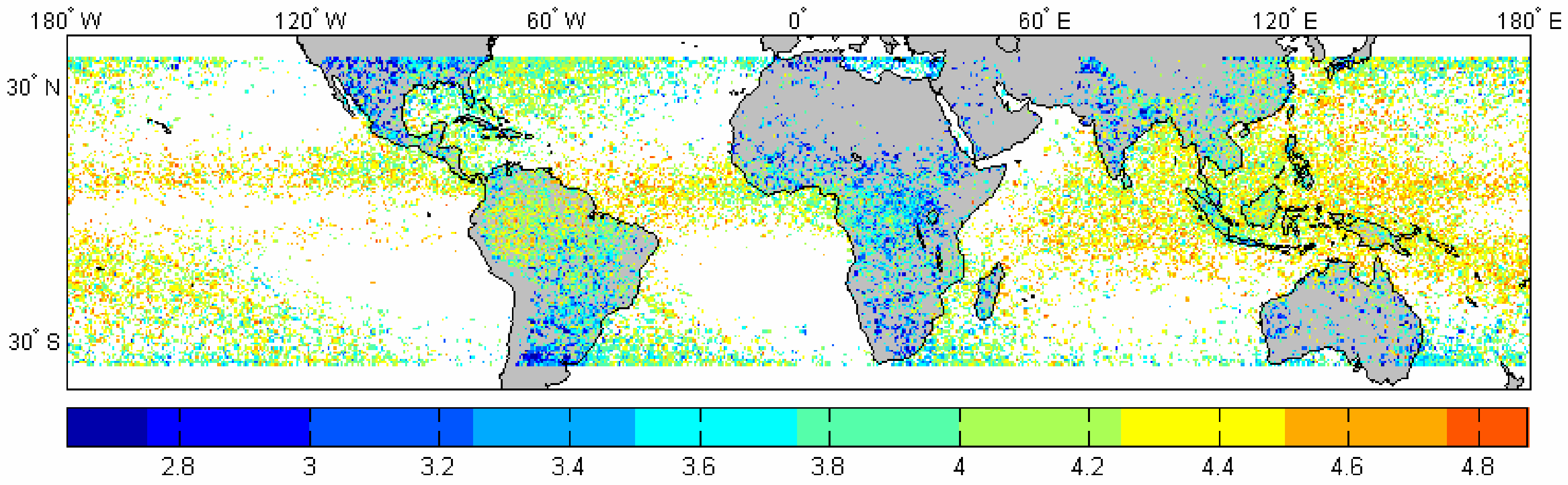
% occurrence of ε over land and ocean : Straitiform and Convective rain proportion



D_o Map : $\varepsilon < 0.8$



N_w Map : $\varepsilon < 0.8$



Research works that have been done (Cont…)

1.) Extensive analysis of TRMM-PR observation

1.1) Vertical Profile Of Reflectivity (VPR) study

1.2) Drop size Distribution (DSD) parameters estimate

2.) Theoretical radar parameters computation

- Radar Reflectivity (Z) and specific attenuation (k) computation in 3 radar frequencies, S-band (2.7 GHz), Ku-band (13.6 GHz) and Ka-band (35.6 GHz) for various hydrometeor types, liquid and frozen particles.

- Calculated coefficients of Z-Z and k-Z relation

2) Theoretical computation of radar reflectivity and specific attenuation

Specific attenuation (k) of wave propagating through hydrometeor defined as

$$k = 4.343 \times 10^3 \int \sigma_{ext}(D) N(D) dD \qquad \text{dB/km}^{-1}$$

σ_{ext} is extinction cross section of particle
N(D) is normalized gamma drop size distribution

Z and k are computed for 3 radar frequencies, i.e.,
S-band (2 .7 GHz) Ku-band (13.6 GHz), Ka-band (35.6).

Effective reflectivity is defined as;

$$Z = \frac{\lambda^4}{\pi^5 |K_p|^2} \int \sigma_b(D) N(D) dD$$

$$where \quad |K_p| = \left| \frac{\varepsilon_r - 1}{\varepsilon_r - 2} \right|^2$$

; ε_r is dielectric constant of precipitation particle

σ_b is back scatter cross section of particle

S-band : Ground-based radar,
Ku and Ka-band : Space-born radar (TRMM-PR or GPM-DPR).

Each frequency, Z and k of four types of hydrometeor are calculated based on 1000 pairs of DSD parameters (Do an Nw) .

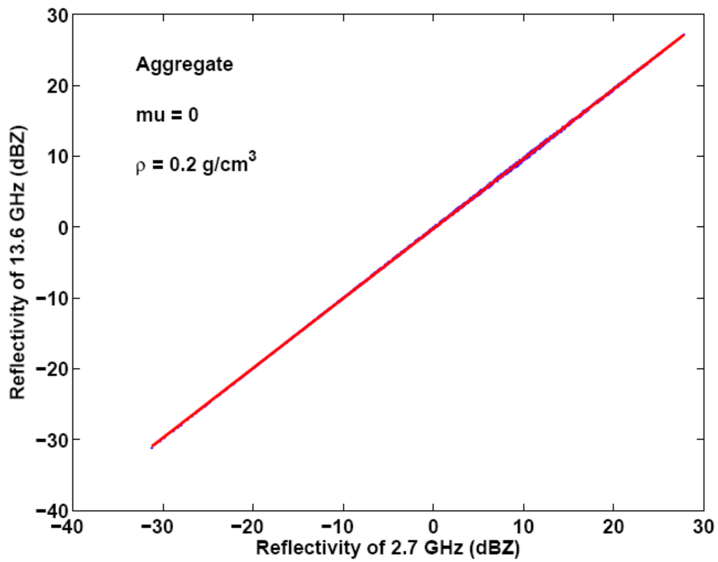
Note : log = log10

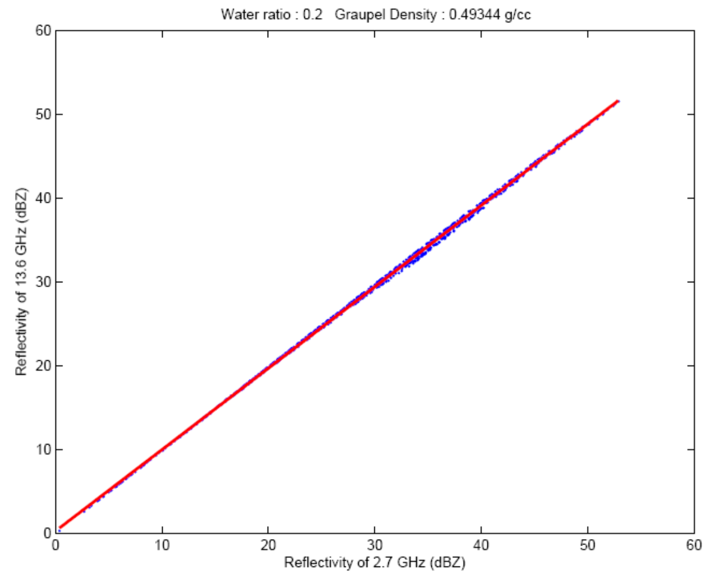
Hydrometeor Type	D_o (mm)	N_w ($mm^{-1}m^{-3}$)	μ
Rain	$0.5 \le D_o \le 2.5$	$3.0 \le \log N_w \le 5.0$	$-1 \le \mu \le 4.0$
Wet graupel	$1.0 \le D_o \le 3.0$	$2.0 \le \log N_w \le 4.0$	0
Aggregate	$0.5 \le D_o \le 2.0$	$2.0 \le \log N_w \le 4.0$	0
Snow	$0.5 \le D_o \le 2.0$	$2.0 \le \log N_w \le 4.0$	0

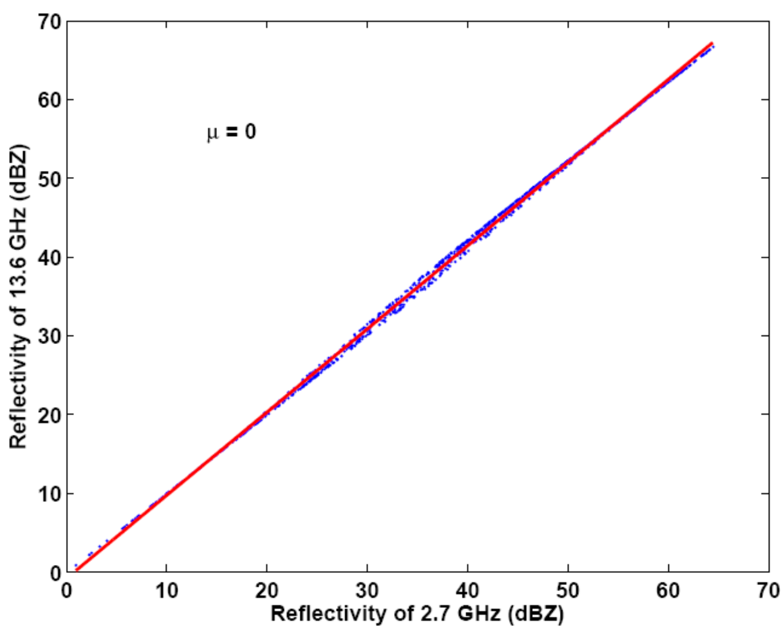
Hydrometeor Type	Density (g/cm^{-3})	Water ratio (WR)
Rain	1.0	
Wet graupel	Vary with WR	0.1 – 0.9
Snow/Aggregate	0.1 – 0.4	

Snow/Aggregate : Density = 0.2 g/cm^{-3}

Graupel : Water Ratio = 0.2



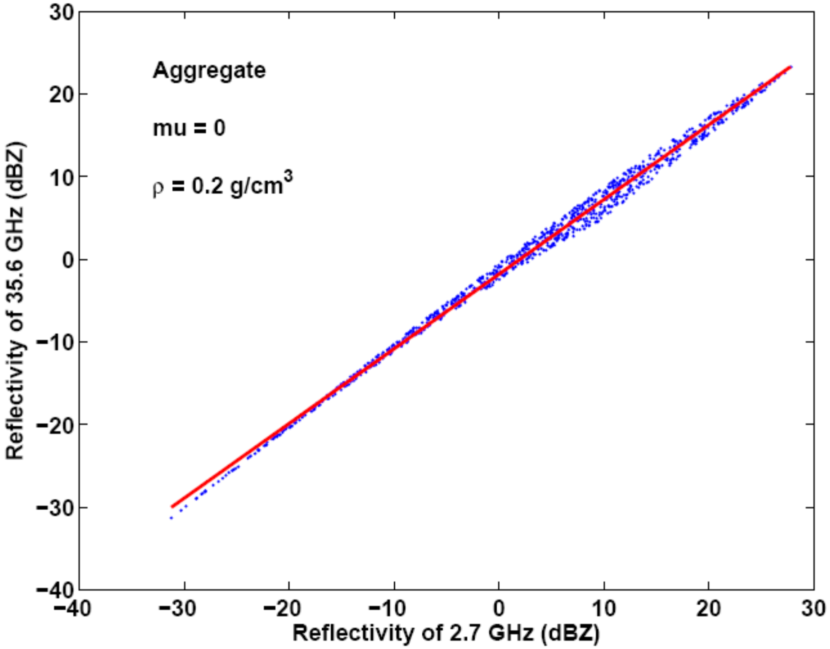




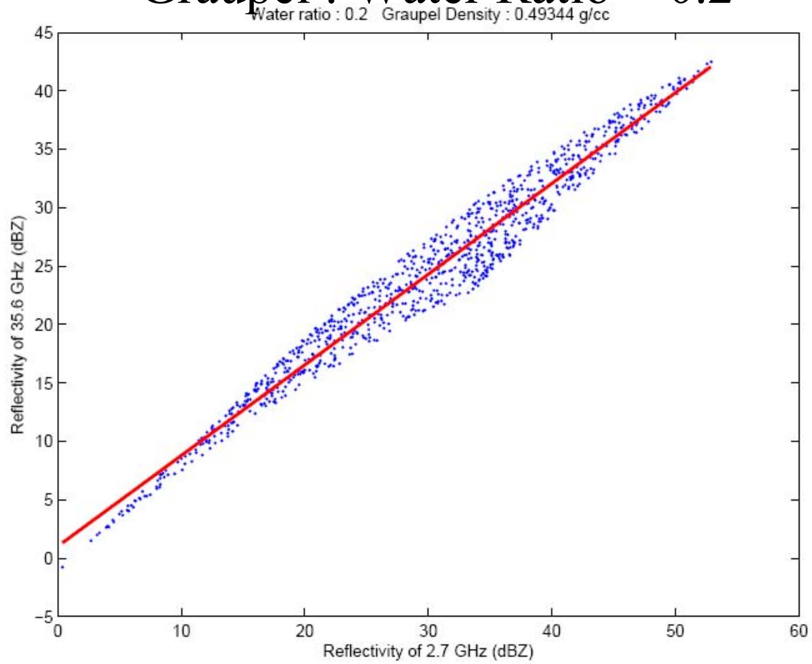
Rain : μ = 0

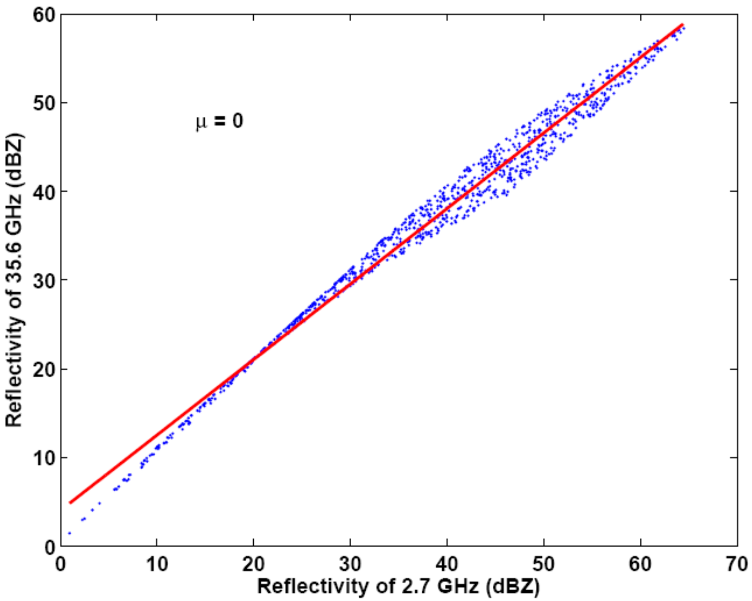
$$Z_{13.6} = a + bZ_{2.7}$$

Snow/Aggregate : Density = 0.2 g/cm^{-3}



Graupel : Water Ratio = 0.2

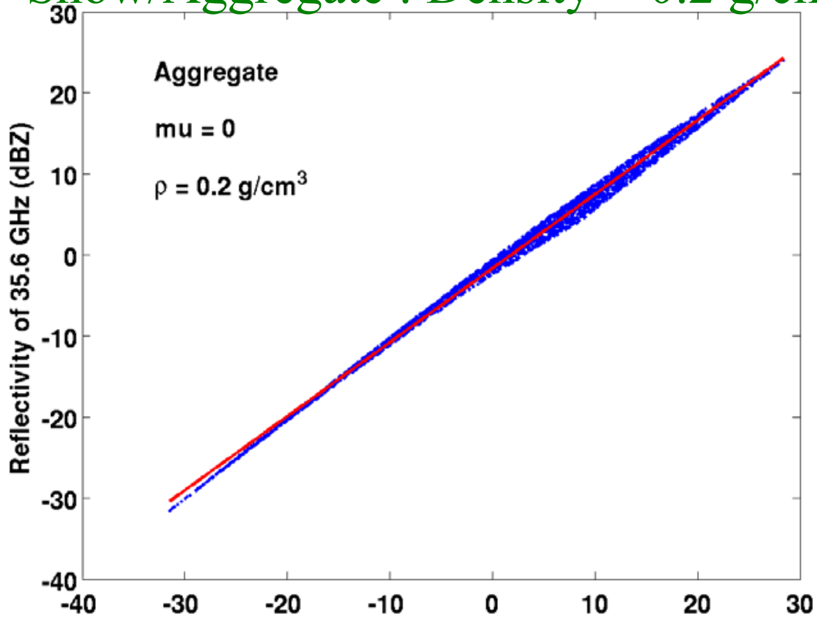




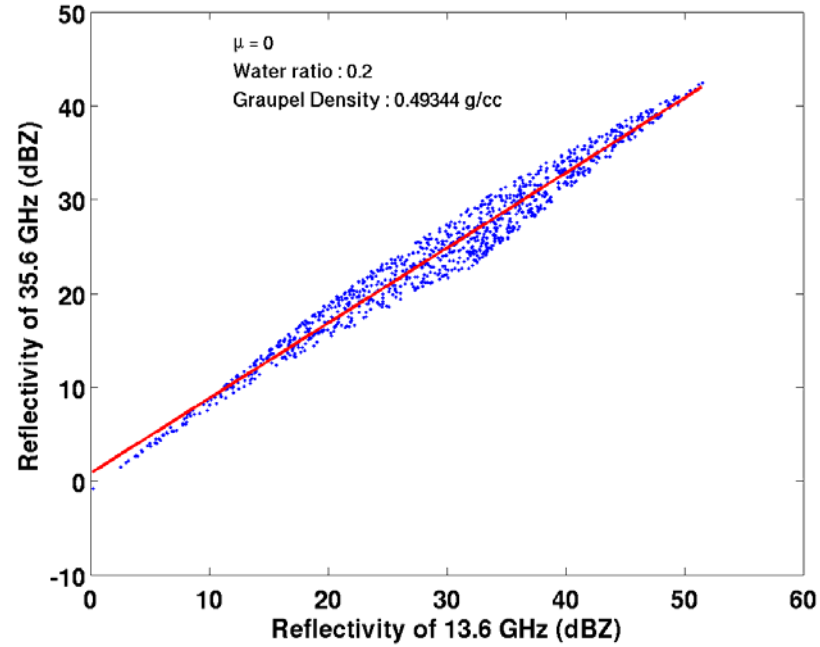
Rain : μ = 0

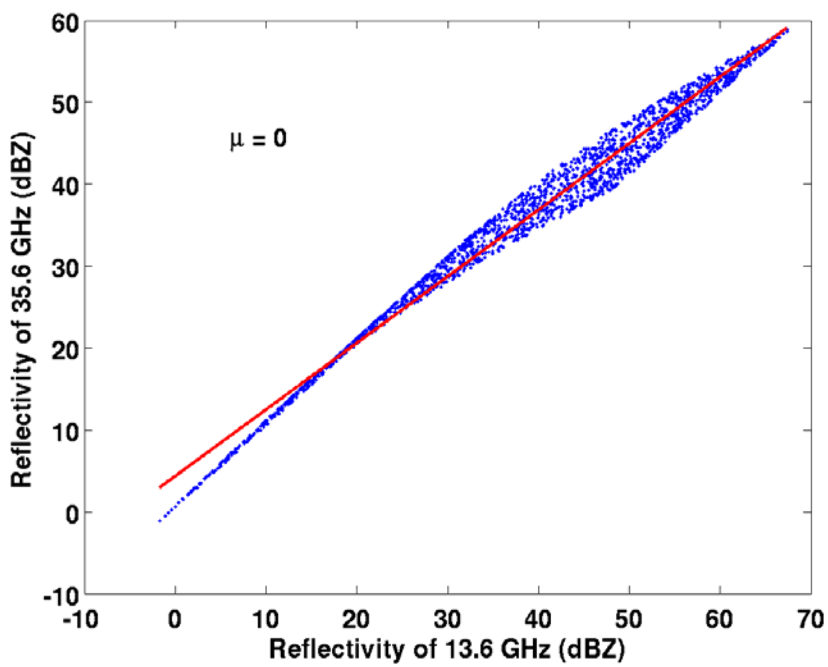
$$Z_{35.6} = a + bZ_{2.7}$$

Snow/Aggregate : Density = 0.2 g/cm^{-3}



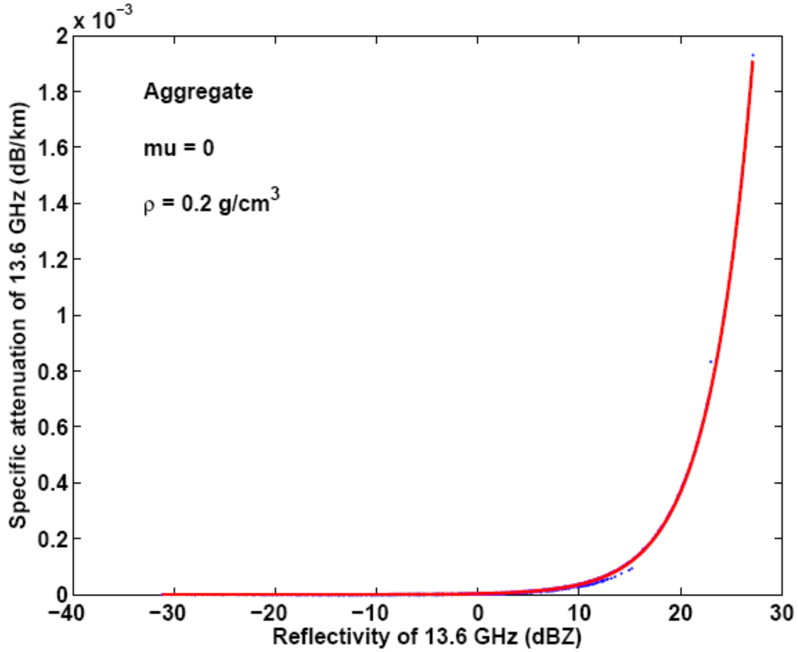
Graupel : Water Ratio = 0.2

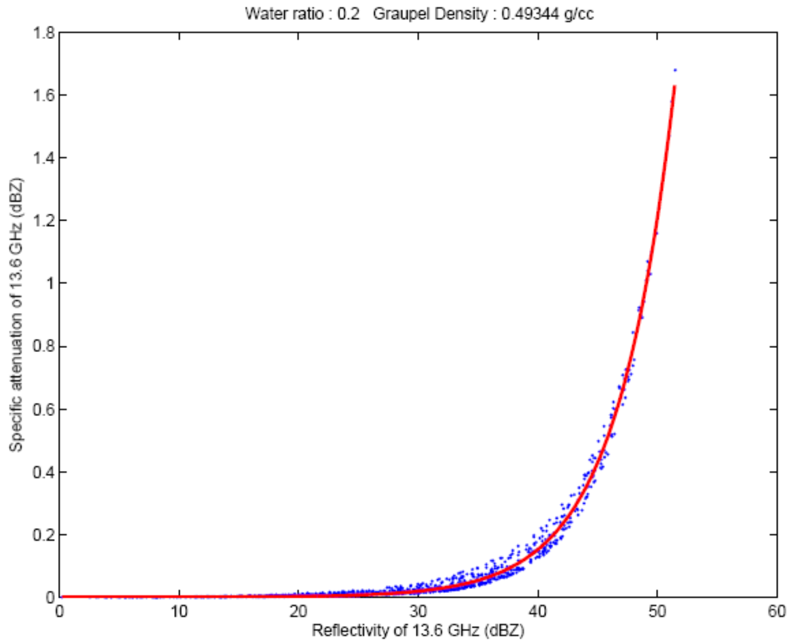


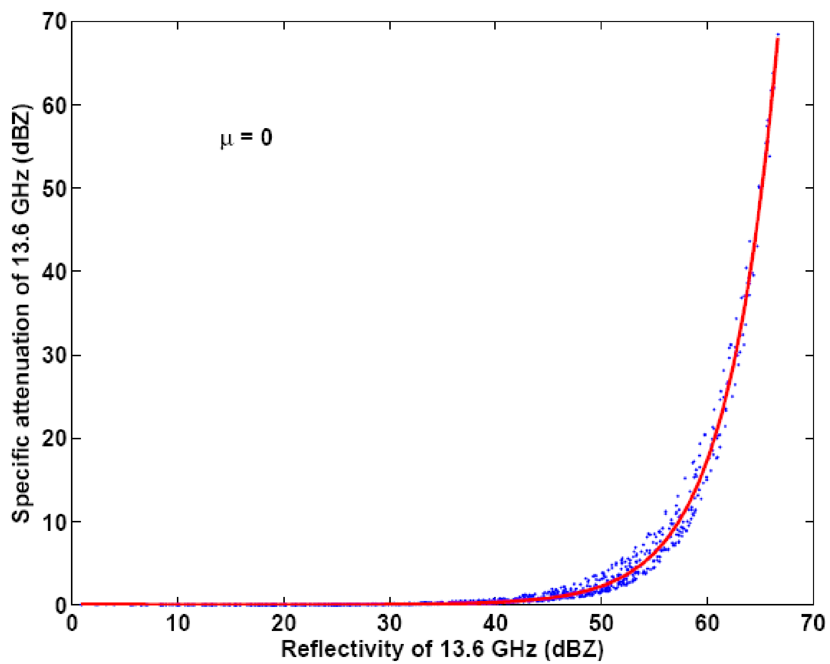


Rain : μ = 0

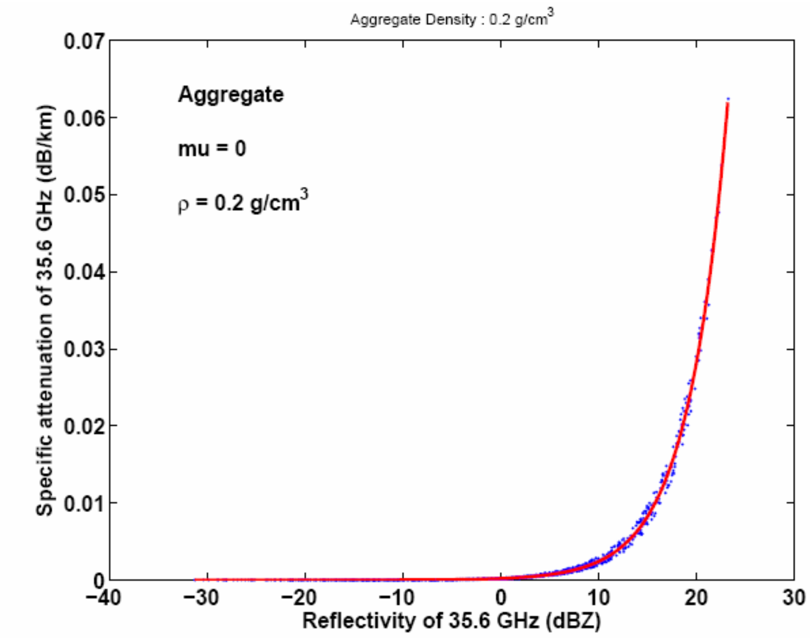
$$Z_{35.6} = a + bZ_{13.6}$$

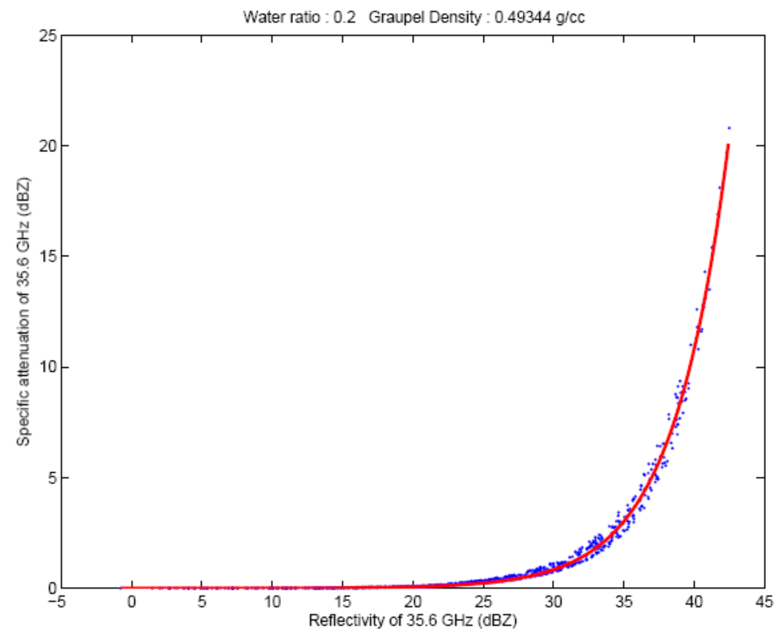


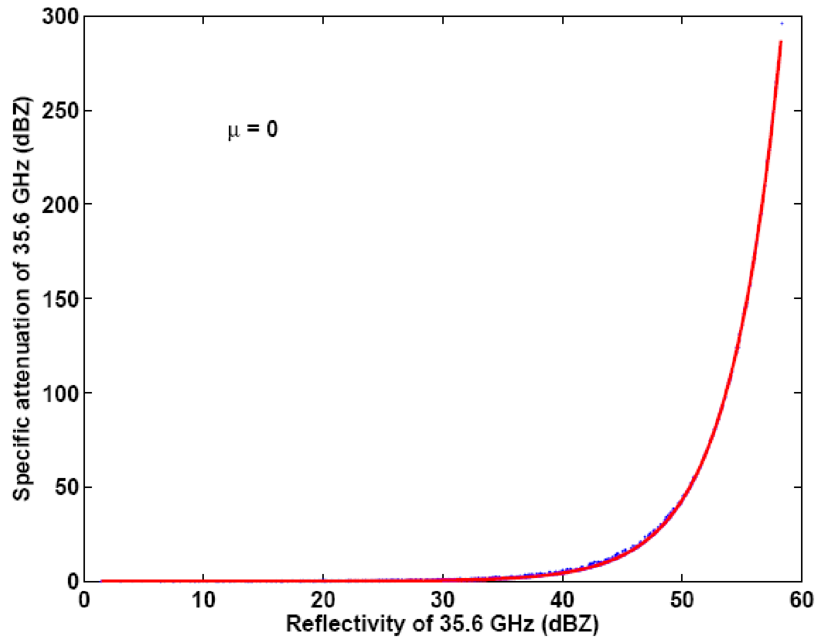




$$k_{13.6} = \alpha Z_{13.6}^{\beta}$$







$$k_{35.6} = \alpha Z_{35.6}^{\beta}$$

$$Z_{35.6} = a + bZ_{2.7}$$

and

$$Z_{35.6} = a + bZ_{2.7}$$

Hydrometeor Type	2.7 and 13.6 GHz	2.7 and 35.6 GHz
SNOW/AGGREGATE		
$\rho = 0.05\ g/cm^3$	1.1234×Z1 - 0.9711	1.2821×Z1 - 0.9535
$\rho = 0.10\ g/cm^3$	1.3451×Z1 - 0.9123	1.2234×Z1 - 0.9467
$\rho = 0.15\ g/cm^3$	1.3214×Z1 - 0.9146	1.2117×Z1 - 0.9234
$\rho = 0.25\ g/cm^3$	1.0557×Z1 - 0.9125	1.1557×Z1 - 0.91234
$\rho = 0.35\ g/cm^3$	1.0211×Z1 - 0.9023	1.1357×Z1 - 0.9111
$\rho = 0.40\ g/cm^3$	1.1256×Z1 - 0.9812	1.1117×Z1 - 0.9034
Wet GRAUPEL		
$WF = 0.1\ \rho = 0.43\ g/cm^3$	1.0407×Z1 - 0.9325	1.2843×Z1 - 0.9124
$WF = 0.2\ \rho = 0.49\ g/cm^3$	1.1087×Z1 - 0.9224	1.1961×Z1 - 0.9412
$WF = 0.3\ \rho = 0.55\ g/cm^3$	1.1571×Z1 - 0.9123	1.2372×Z1 - 0.9221
$WF = 0.4\ \rho = 0.62\ g/cm^3$	1.2152×Z1 - 0.9241	1.0457×Z1 - 0.9324
$WF = 0.5\ \rho = 0.68\ g/cm^3$	1.1357×Z1 - 0.9411	1.2357×Z1 - 0.9455
$WF = 0.6\ \rho = 0.74\ g/cm^3$	1.2123×Z1 - 0.9134	1.4557×Z1 - 0.9221
$WF = 0.7\ \rho = 0.81\ g/cm^3$	1.2257×Z1 - 0.9257	1.1327×Z1 - 0.9454
$WF = 0.8\ \rho = 0.87\ g/cm^3$	1.3571×Z1 - 0.9122	1.3457×Z1 - 0.9024
$WF = 0.9\ \rho = 0.93\ g/cm^3$	1.2571×Z1 - 0.9067	1.4457×Z1 - 0.9024
RAIN		
$\mu = 0$	1.0557×Z1 - 0.8024	0.8508× Z1 - 4.0264
$\mu = 1$	1.0559×Z1 - 0.9579	0.8789× Z1 - 3.2944
$\mu = 2$	1.0550×Z1 - 1.0283	0.8926× Z1 - 3.0596
$\mu = 3$	1.0526×Z1 - 1.0527	0.9131× Z1 - 2.5568

$$Z_{35.6} = a + bZ_{13.6}$$

Hydrometeor Type	13.6 and 35.6 GHz
SNOW/AGGREGATE	
$\rho = 0.05\ g/cm^3$	0.9127×Z1 - 2.8102
$\rho = 0.10\ g/cm^3$	0.9134×Z1 - 2.2474
$\rho = 0.15\ g/cm^3$	0.9135×Z1 - 1.9064
$\rho = 0.25\ g/cm^3$	0.9140×Z1 - 1.4578
$\rho = 0.30\ g/cm^3$	0.9190×Z1 - 1.2383
$\rho = 0.40\ g/cm^3$	0.9189×Z1 - 0.9661
Wet GRAUPEL	
$WF = 0.1\ \rho = 0.43\ g/cm^3$	0.8173×Z1 + 0.1394
$WF = 0.2\ \rho = 0.49\ g/cm^3$	0.8173×Z1 + 0.7840
$WF = 0.3\ \rho = 0.55\ g/cm^3$	0.7808×Z1 + 1.3977
$WF = 0.4\ \rho = 0.62\ g/cm^3$	0.7721×Z1 + 1.6958
$WF = 0.5\ \rho = 0.68\ g/cm^3$	0.7862×Z1 + 1.4886
$WF = 0.6\ \rho = 0.74\ g/cm^3$	0.8090×Z1 + 1.2526
$WF = 0.7\ \rho = 0.81\ g/cm^3$	0.8009×Z1 + 2.0562
$WF = 0.8\ \rho = 0.87\ g/cm^3$	0.7642×Z1 + 3.7875
$WF = 0.9\ \rho = 0.93\ g/cm^3$	0.7335×Z1 + 5.0505
RAIN	
$\mu = 0$	1.0557×Z1 - 0.8024
$\mu = 1$	1.0559×Z1 - 0.9579
$\mu = 2$	1.0550×Z1 - 1.0283
$\mu = 3$	1.0526×Z1 - 1.0527

$$k_{13.6} = \alpha Z_{13.6}^{\beta}$$

and

$$k_{35.6} = \alpha Z_{35.6}^{\beta}$$

Hydrometeor Type	13.6 GHz		35.6 GHz	
	α	β	α	β
SNOW/AGGREGATE				
$\rho = 0.05\ g/cm^3$	2.53e-4	0.9127	2.53e-4	1.0786
$\rho = 0.10\ g/cm^3$	2.52e-4	0.9134	2.26e-4	1.0802
$\rho = 0.15\ g/cm^3$	2.33e-4	0.9135	2.12e-4	1.0821
$\rho = 0.25\ g/cm^3$	2.53e-4	0.9140	1.96e-4	1.0848
$\rho = 0.30\ g/cm^3$	2.29e-4	0.9190	1.98e-4	1.0679
$\rho = 0.40\ g/cm^3$	2.13e-4	0.9189	1.90e-4	1.0714
Wet GRAUPEL				
$\mathrm{WR} = 0.1\ \rho = 0.43\ g/cm^3$	4.23e-4	1.0786	4.17e-4	1.0941
$\mathrm{WR} = 0.2\ \rho = 0.49\ g/cm^3$	4.17e-4	1.0714	4.02e-4	1.1077
$\mathrm{WR} = 0.3\ \rho = 0.55\ g/cm^3$	4.14e-4	1.0848	3.49e-4	1.1354
$\mathrm{WR} = 0.4\ \rho = 0.62\ g/cm^3$	4.21e-4	1.0802	4.25e-4	1.1181
$\mathrm{WR} = 0.5\ \rho = 0.68\ g/cm^3$	4.34e-4	1.0734	9.10e-4	1.0268
$\mathrm{WR} = 0.6\ \rho = 0.74\ g/cm^3$	4.33e-4	1.0786	7.86e-4	1.0241
$\mathrm{WR} = 0.7\ \rho = 0.81\ g/cm^3$	4.21e-4	1.0679	4.28e-4	1.0729
$\mathrm{WR} = 0.8\ \rho = 0.87\ g/cm^3$	4.16e-4	1.0679	6.92e-4	1.0045
$\mathrm{WR} = 0.9\ \rho = 0.93\ g/cm^3$	4.17e-4	1.0679	3.30e-4	1.0220
RAIN				
$\mu = 0$	4.23e-4	0.9949	4.31e-4	0.9995
$\mu = 1$	4.12e-4	0.9324	4.42e-4	0.9949
$\mu = 2$	4.45e-4	0.9926	4.55e-4	0.9906
$\mu = 3$	4.67e-4	0.9221	4.34e-4	0.9926

Research works that have been done…

1) Extensive analysis of TRMM-PR observation

1.1) Vertical Profile Of Reflectivity (VPR) study

1.2) Drop size Distribution (DSD) parameters estimate

2) Theoretical radar parameters computation

- Radar Reflectivity (Z) and specific attenuation (k) computation in 3 radar frequencies, S-band (2.7 GHz), Ku-band (13.6 GHz) and Ka-band (35.6 GHz) for various hydrometeor types, liquid and frozen particles.
- Calculated coefficients of Z-Z and k-Z relation

3) GPM-DPR : system and retrieval algorithm

Dual-wavelength retrieval techniques

1. Attenuation based : Standard Dual-wavelength Technique (SDWT)
   - Attenuation convert to rain rate directly using k-R relation

2. Attenuation-corrected reflectivity base :

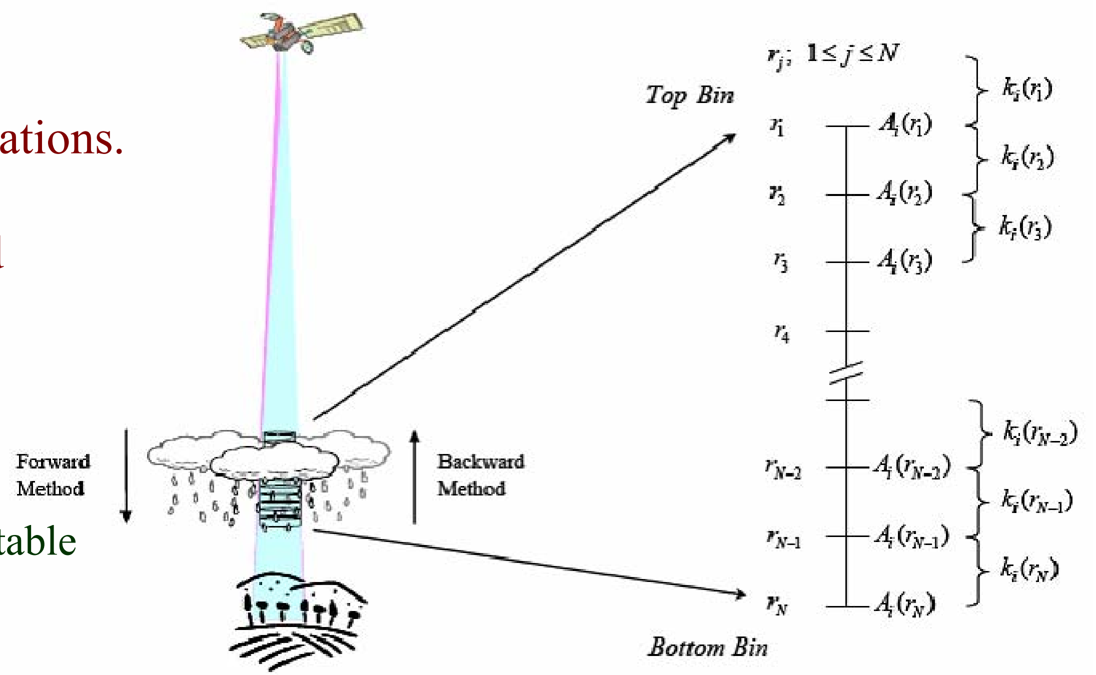
   - Two DSDs parameters (Nw, Do) is inferred by non-Rayleigh scattering

   - Integral or differential equations.

   - Solve forward or backward

Backward : Stable but require SRT.

Forward : SRT is not required but not stable when attenuation is large



Integral equations for Dual-wavelength technique.

$$Z_{mi}(r_j) = Z_{ei}(r_j)\, A_i(r_j)$$

$$Z_{ei}(r) = C_{Zi} \int_D \sigma_{bi}\, N(D)\, dD$$

$$= N_W\, f(\mu)\, D_o^{-\mu}\, C_{Zi} \int_D \sigma_{bi}\, D^{\mu}\, e^{-\Lambda D}\, dD$$

$$= N_W\, f(\mu)\, D_o^{-\mu}\, I_{bi}(D_o(r_j))$$

$$\frac{Z_{e1}(r)}{Z_{e2}(r)} = \frac{\int_D \sigma_{b1}\, D^{-\mu}\, e^{-\Lambda D}\, dD}{\int_D \sigma_{b2}\, D^{-\mu}\, e^{-\Lambda D}\, dD}$$

$$\frac{Z_{e1}(r)}{Z_{e2}(r)} = \frac{\int_D \sigma_{b1}\, D^{-\mu}\, e^{-\Lambda D}\, dD}{\int_D \sigma_{b2}\, D^{-\mu}\, e^{-\Lambda D}\, dD} = \frac{I_{b1}(D_o(r_j))}{I_{b2}(D_o(r_j))} = f_2(D_o(r))$$

$$10\log(Z_{e1}(r)) - 10\log(Z_{e2}(r)) = 10\log(f_2(D_o(r)))$$

$$\delta dBZ_e(r) = f_3(D_o(r))$$

The specific attenuation, $ki(r)$, at a particular range bin can also be derived as,

$$k_i(r) = C_{ki} \int_D \sigma_{ti}(D)\, N(D)\, dD$$

$$= C_{ki}\, N_W\, f(\mu)\, D_o^{-\mu} \int_D \sigma_{ti}(D)\, D^{\mu}\, e^{-\Lambda D}\, dD$$

$$= N_W\, f(\mu)\, D^{-\mu}\, I_{ti}(D_o(r))$$

$$Z_{mi}(r_j) = N_W f(\mu) D_o^{-\mu}\, I_{bi}(D_o(r_j))\, A_i(r_j)$$

$$N_W(r_j) = \frac{Z_{mi}(r)}{f(\mu)\, D_o^{-\mu}\, I_{bi}(D_o(r_j))\, A_i(r_j)}$$

Research works that have been done…

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- Calculated coefficients of Z-Z and k-Z relation

3) GPM-DPR : system and retrieval algorithm

4) GPM-DPR observation simulation

- **Simulated Ku-band (13.6 GHz) and Ka-band (35.6 GHz) radar reflectivity from S-band (2.7 GHz) radar reflectivity**

- Polarimetric ground-based radar data Analysis

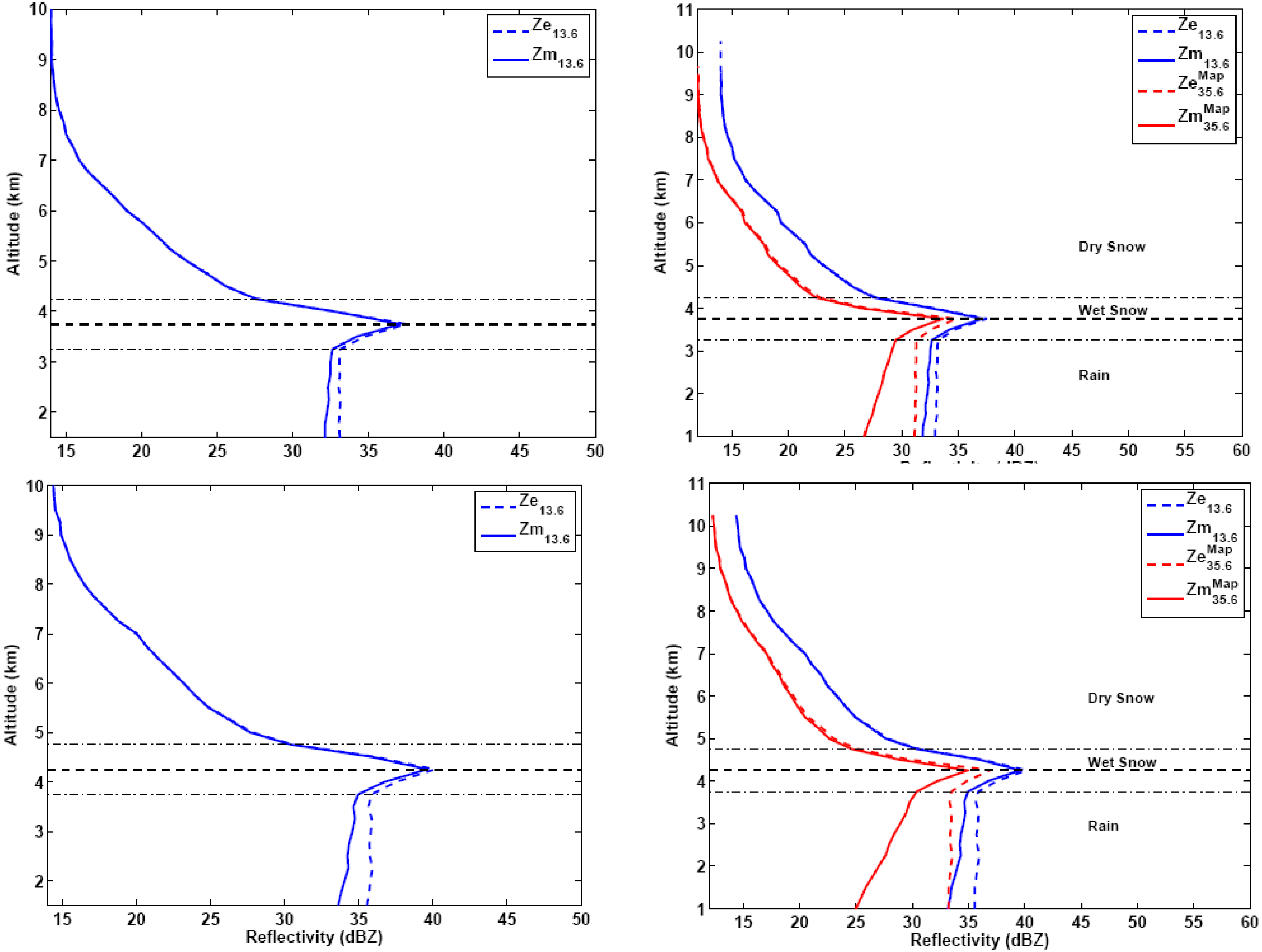
- Hydrometeor Classification using Fuzzy Logic technique

Ku-band to Ka-band Simulation

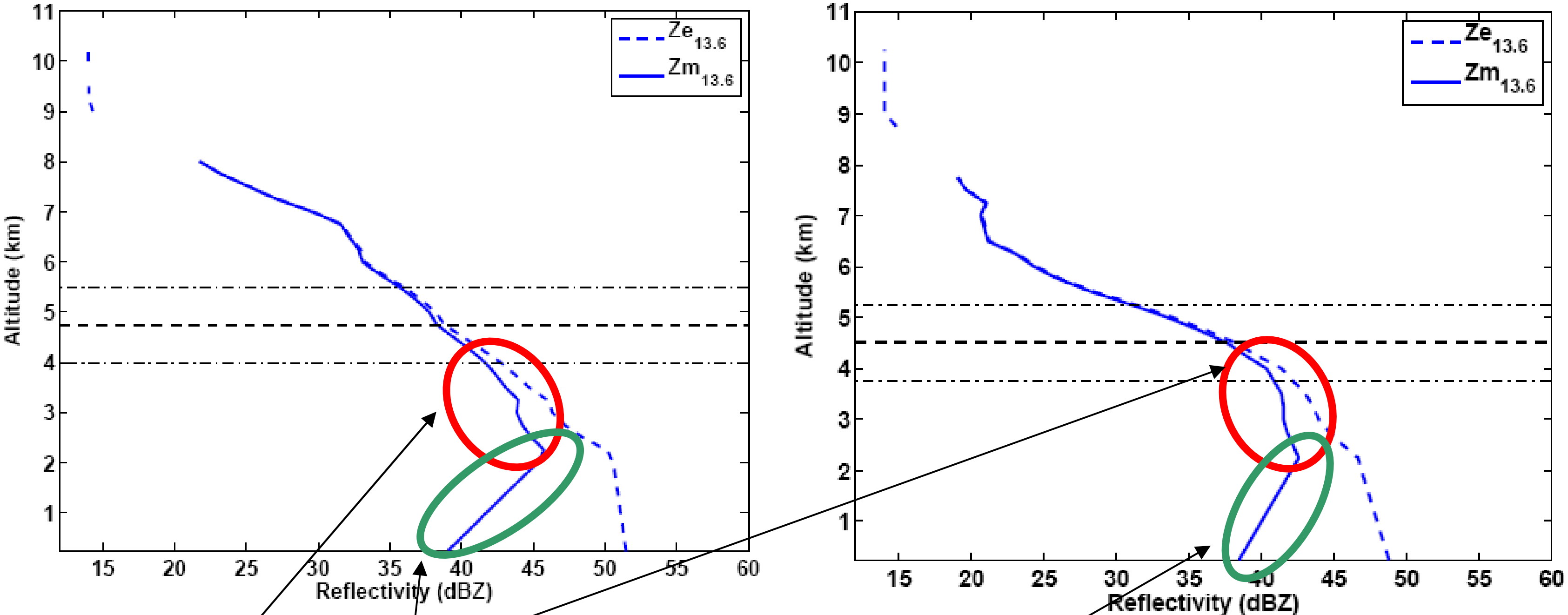
- Stratiform rain with BB

- Convective rain

• Stratiform rain with BB

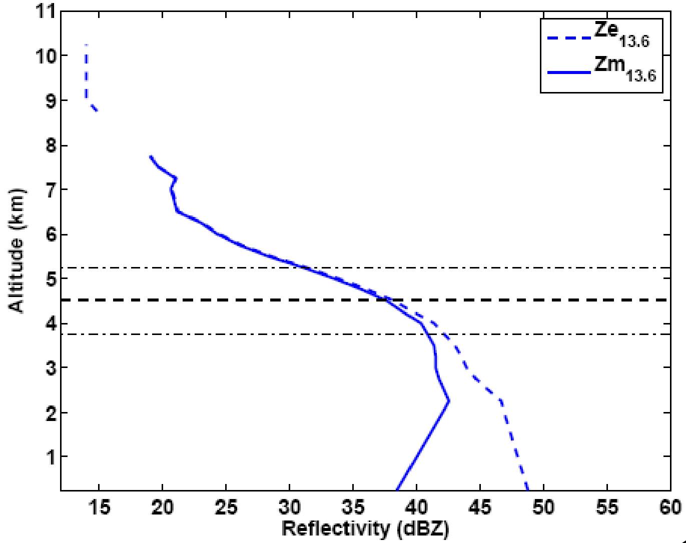


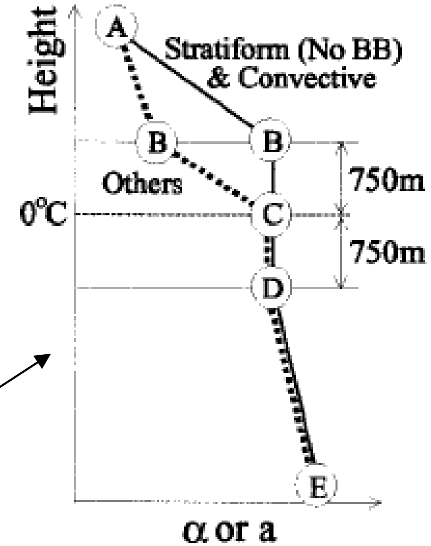
Convective profiles



- Strong observed reflectivity (Z_m) continue over long range
  : Sign of frozen precipitation

- Abrupt change and constantly decrease of Z_m
  : Sign of phase height transition form frozen to liquid precipitation

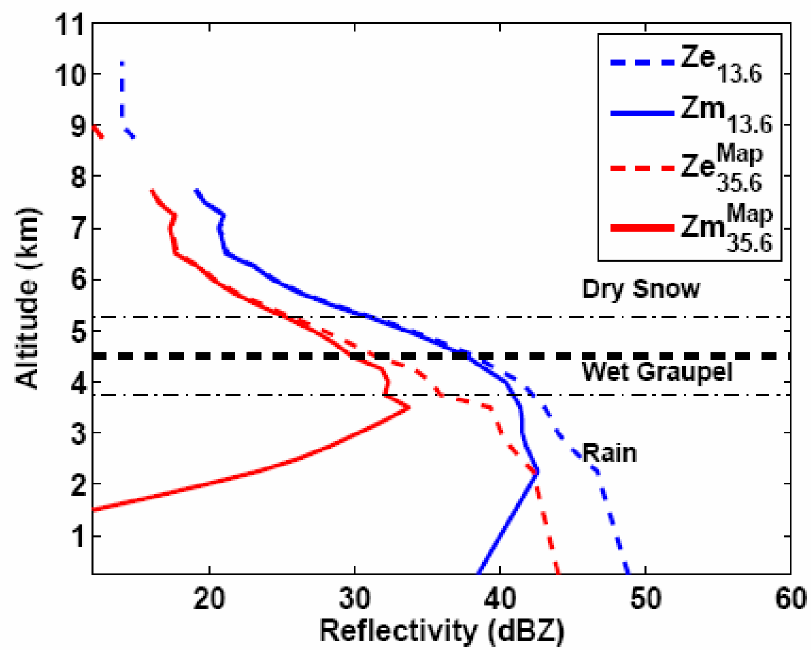


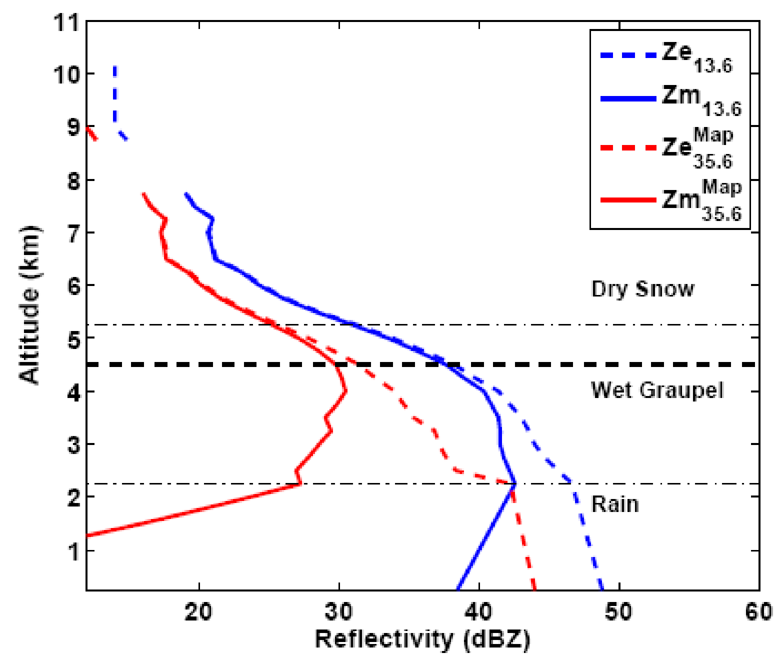


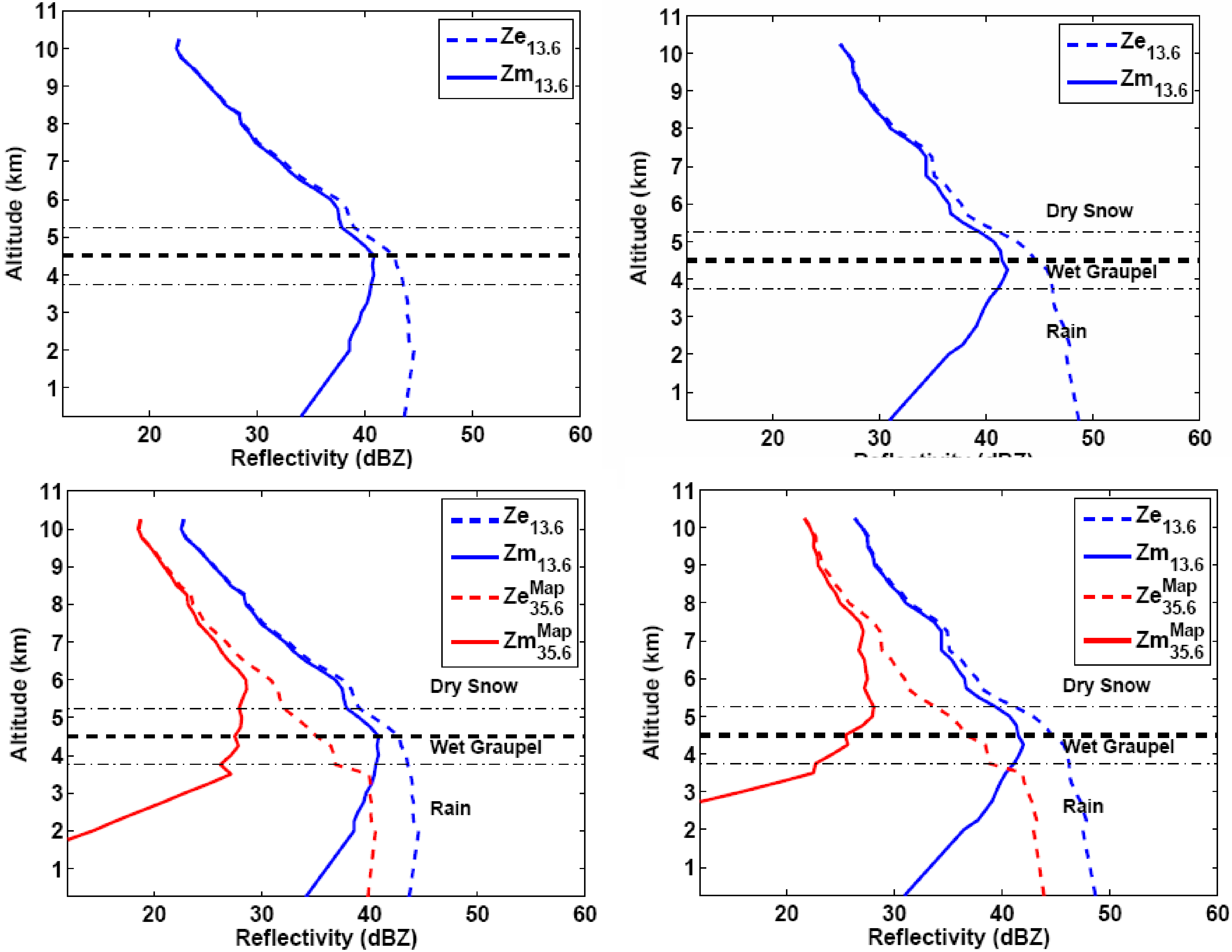
Operational Convective Rain Model Currently used TRMM-PR

Ka-band simulation using TRMM-PR model

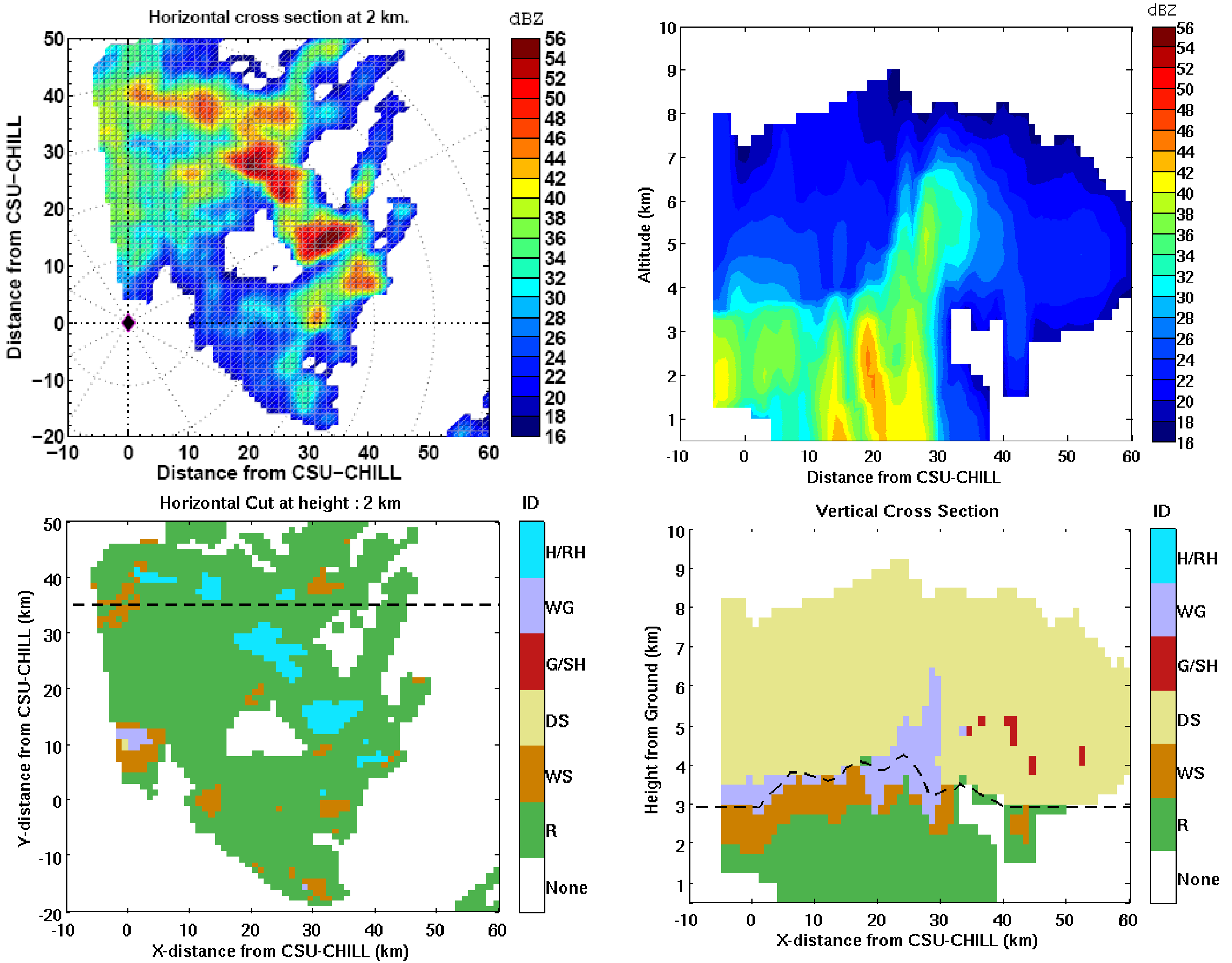
Ka-band simulation using Slope Change point



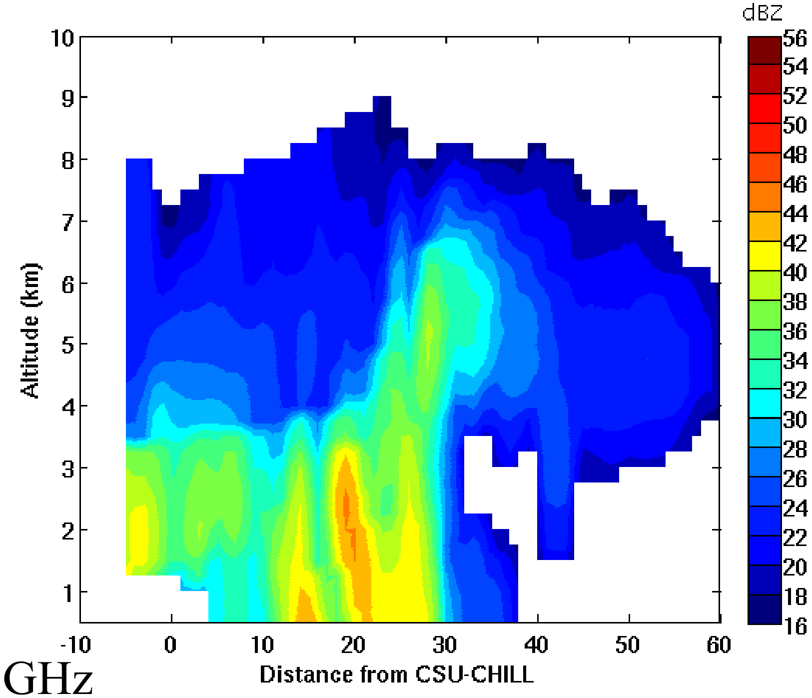



Altitude (km)
Reflectivity (dBZ)
$Ze_{13.6}$
$Zm_{13.6}$
$Ze_{35.6}^{Map}$
$Zm_{35.6}^{Map}$
Dry Snow
Wet Graupel
Rain

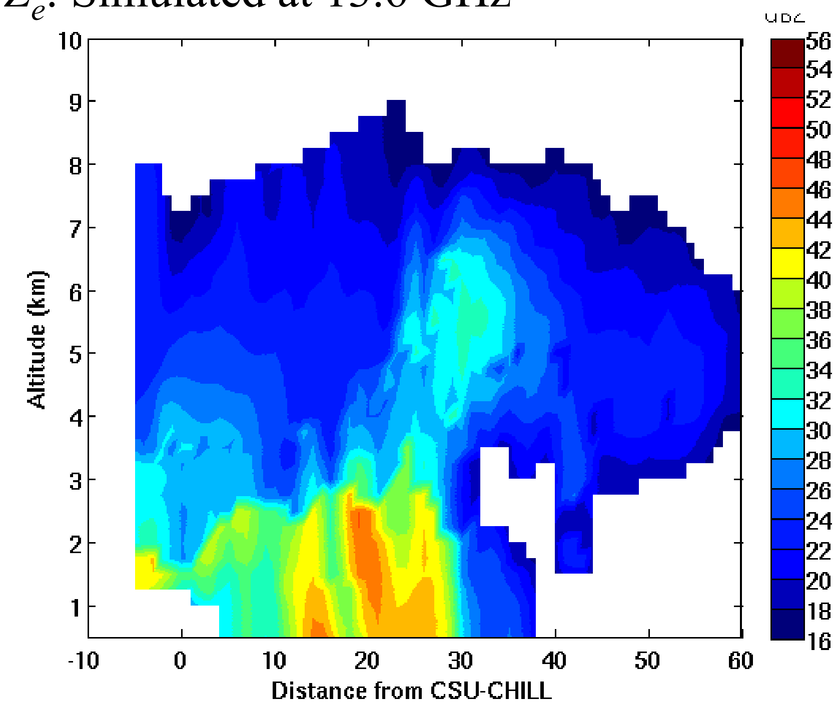
S-band polarimetric radar data: Case Study – STEPS June 20, 2000 :CSU- CHILL



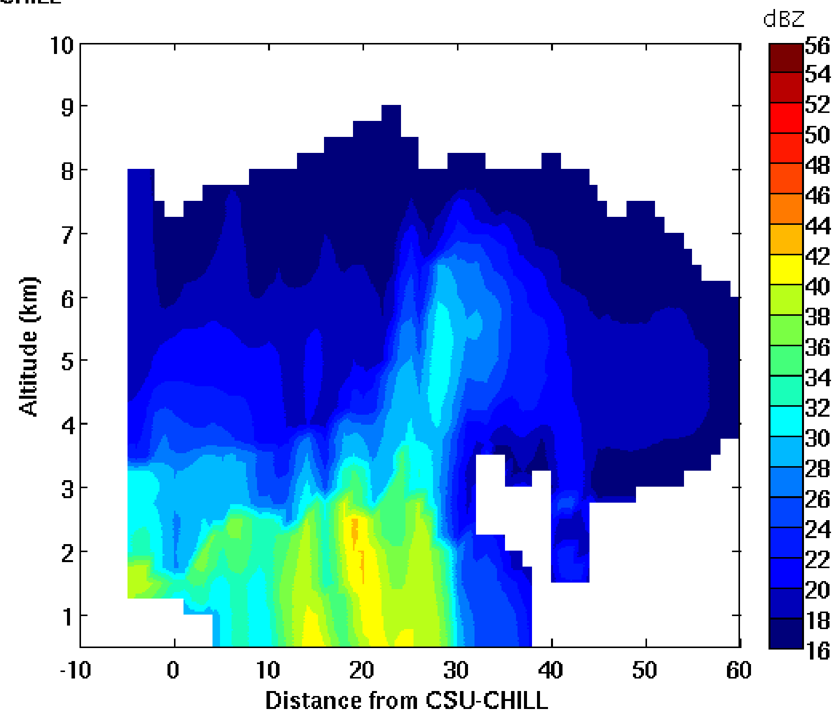
Z_m: 2.7 GHz



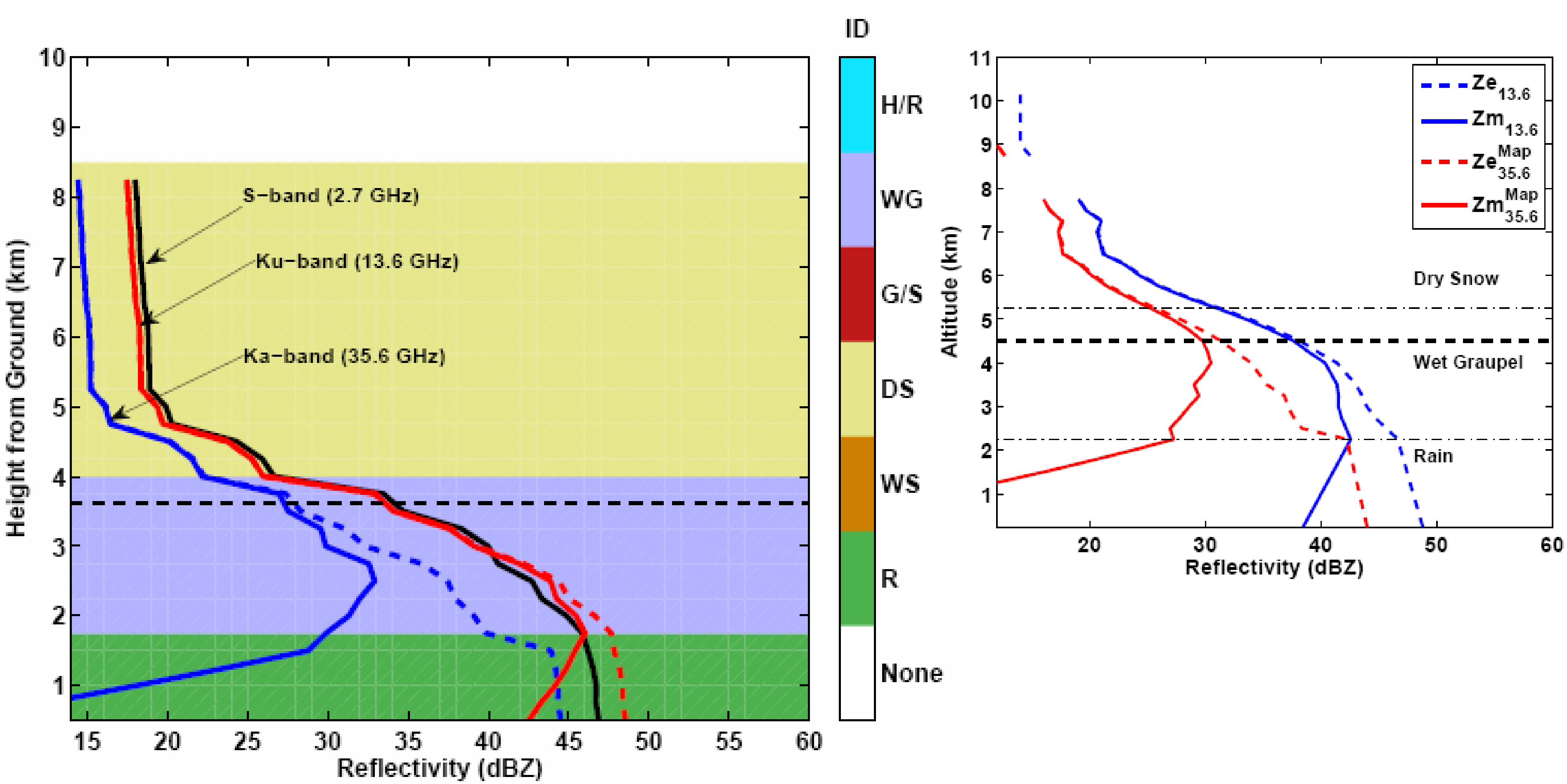
Z_e: Simulated at 13.6 GHz



Z_e: Simulated at 35.6 GHz

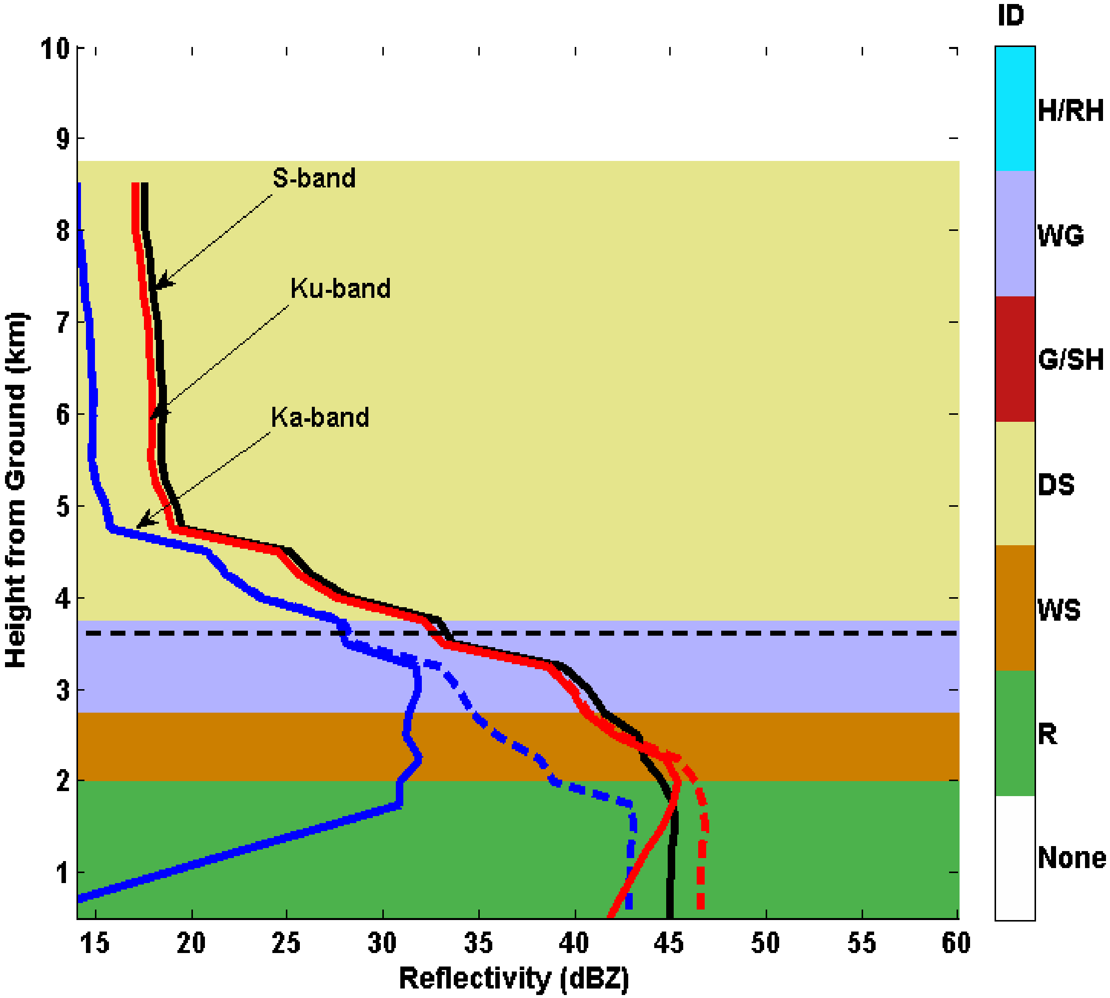


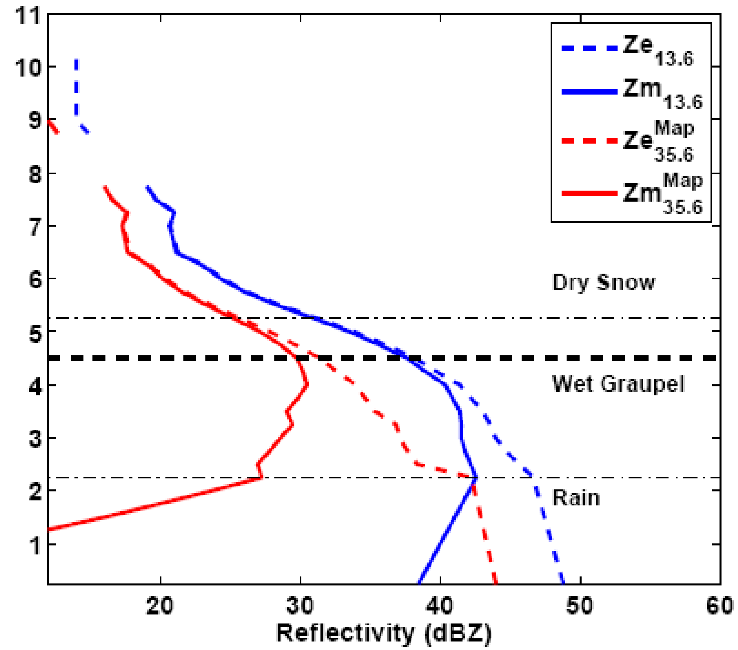
Shows similar reflectivity profile of observed TRMM-PR and simulated TRMM-PR from S-band



S-band ground radar => Simulate Ku and Ka-band as if observed by GPM-DPR

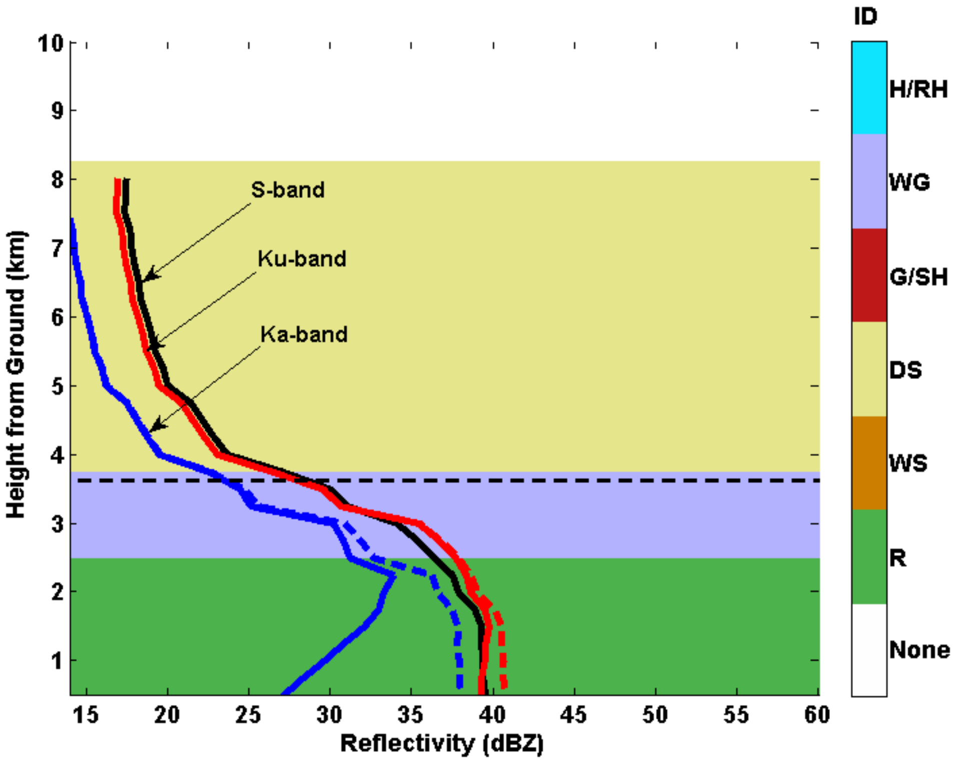
Shows similar reflectivity profile of observed TRMM-PR and simulated TRMM-PR from S-band

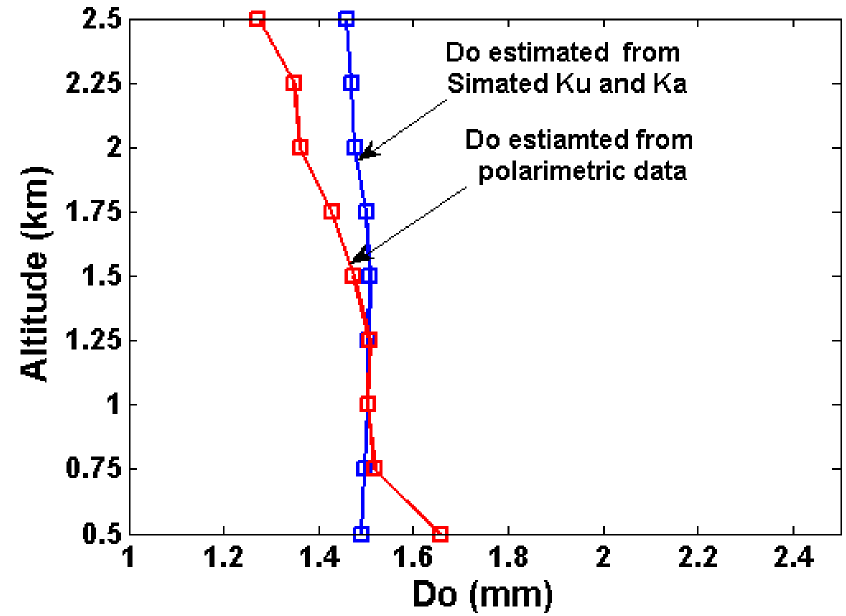


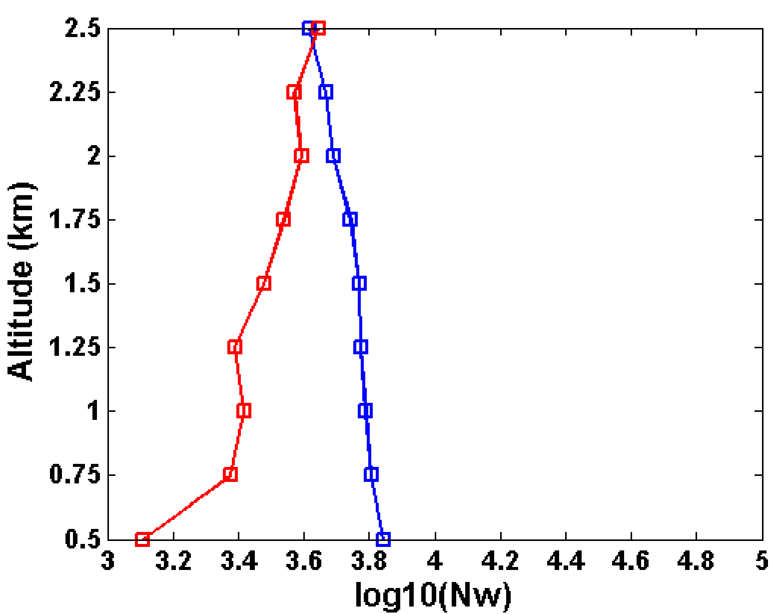


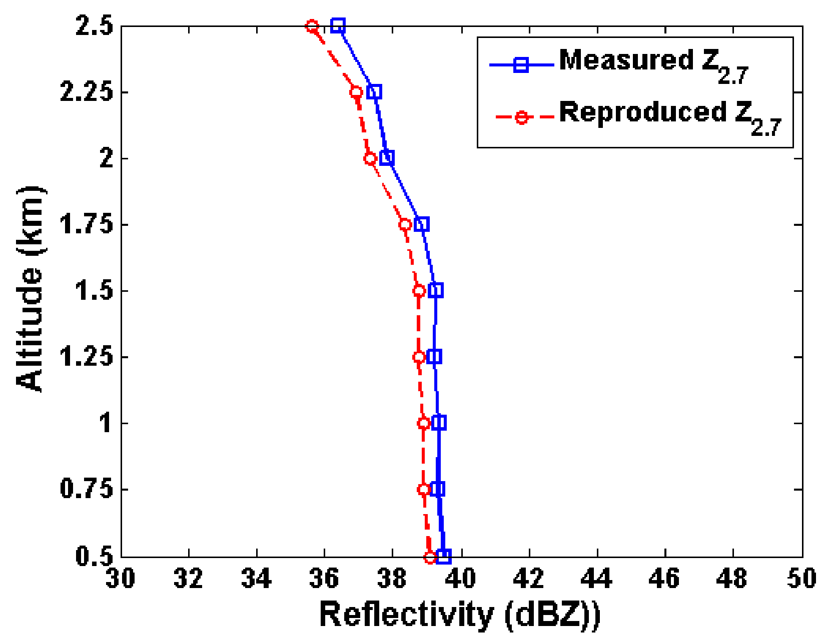
S-band ground radar => Simulate Ku and Ka-band as if observed by GPM-DPR

Apply Dual-wavelength retrieval









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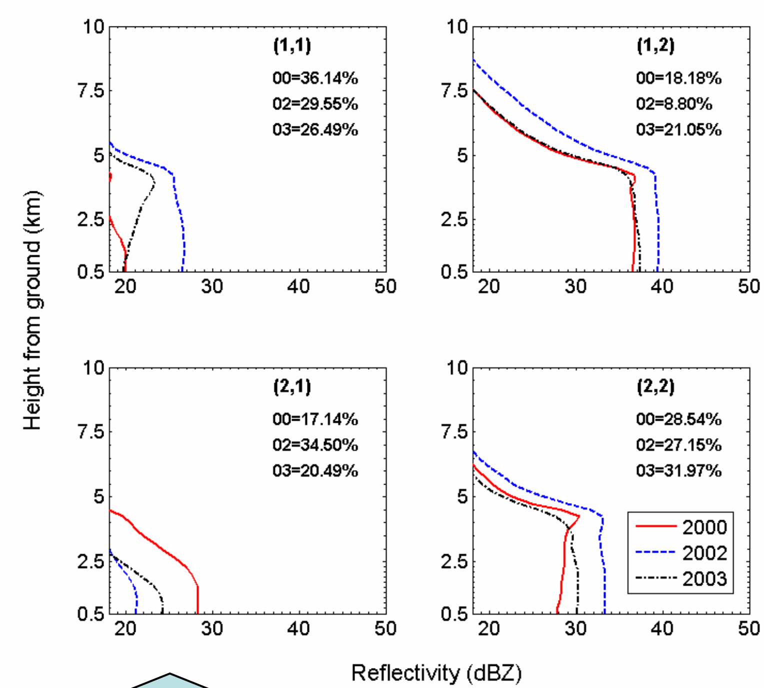
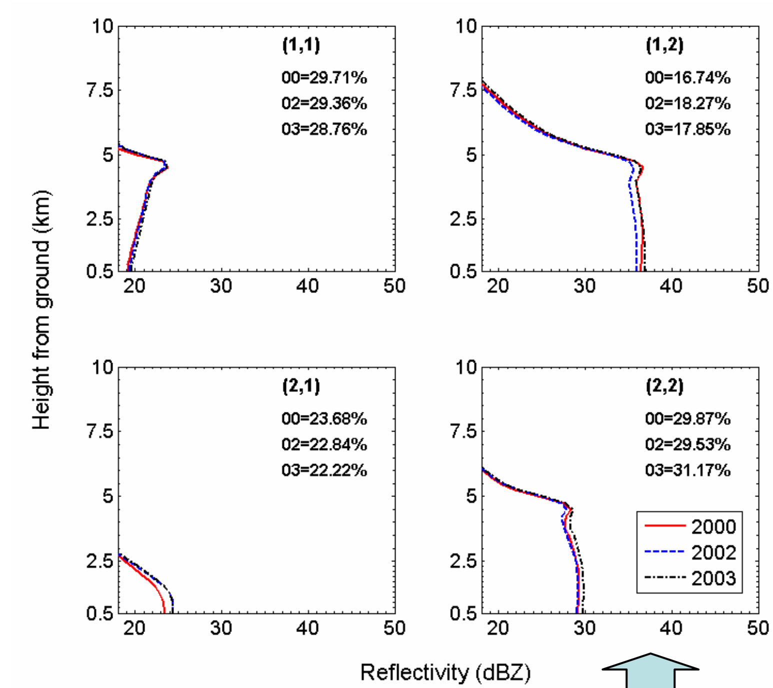
- Hydrometeor Classification using Fuzzy Logic technique
- Simulated Ku-band (13.6 GHz) and Ka-band (35.6 GHz) radar reflectivity from S-band (2.7 GHz) radar reflectivity

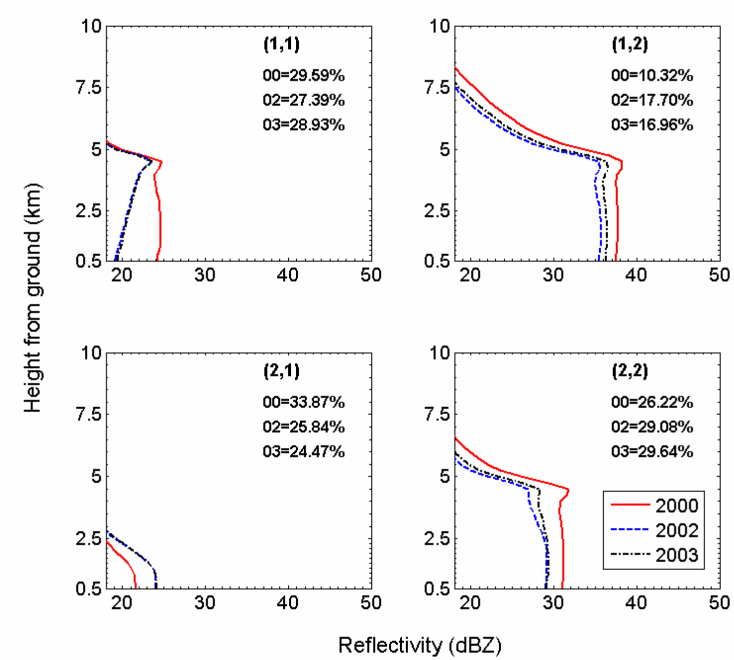
4) Study of tropical storms using TRMM-PR observation



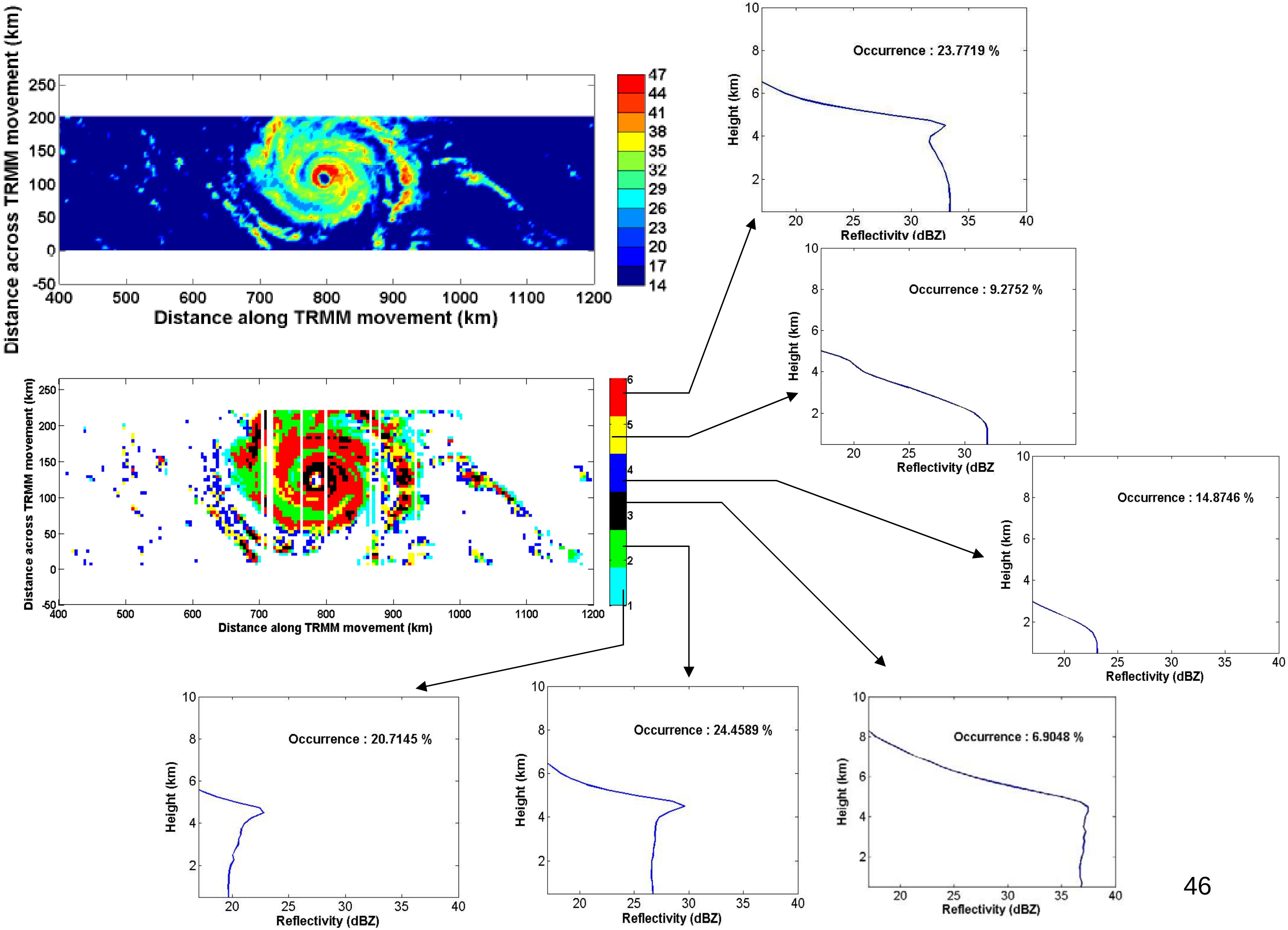
Hurricanes

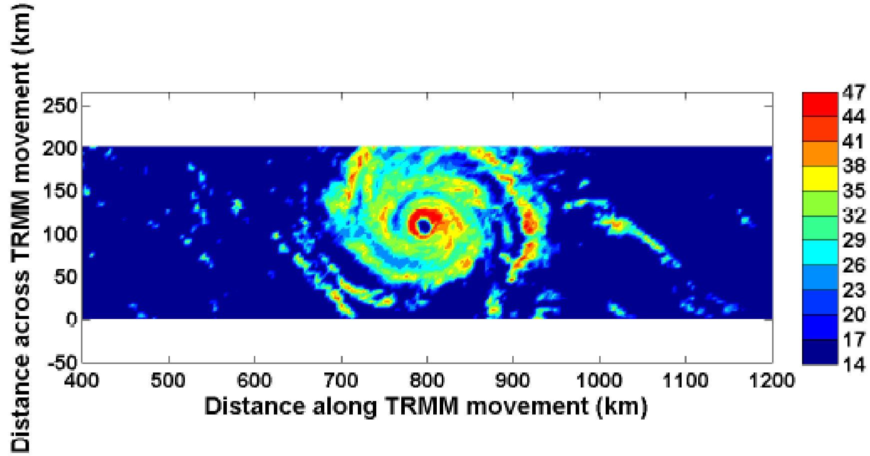


Typhoons

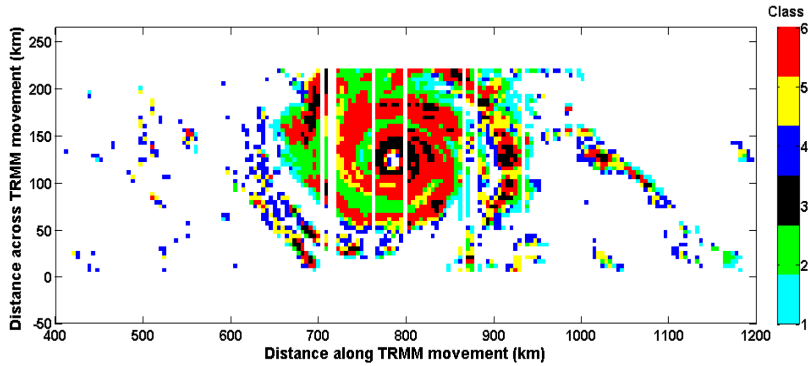


Cyclones


Distance across TRMM movement (km)
Distance along TRMM movement (km)
47
44
41
38
35
32
29
26
23
20
17
14
6
5
4
3
2
1
Occurrence : 23.7719 %
Occurrence : 9.2752 %
Occurrence : 14.8746 %
Occurrence : 20.7145 %
Occurrence : 24.4589 %
Occurrence : 6.9048 %
Height (km)
Reflectivity (dBZ)

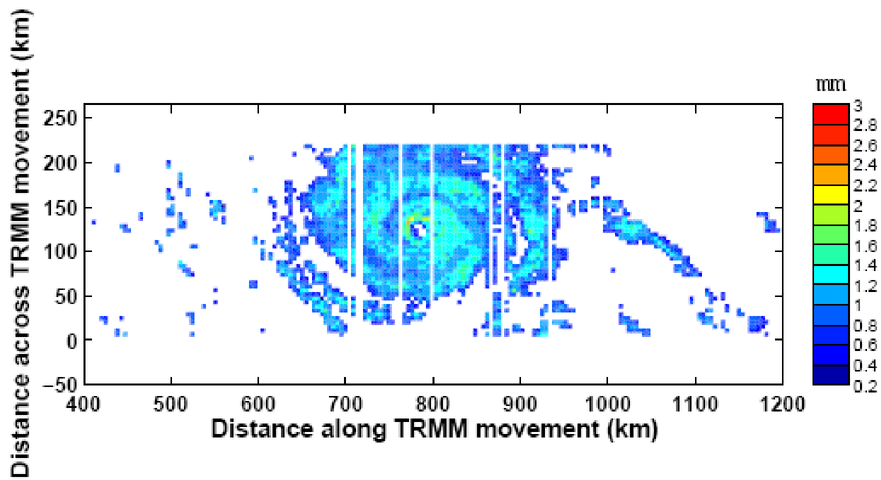


Reflectivity Map (dBZ)



6-Classes VPR Map

(Using SOM)



Do Map (mm)

Do = Median Volume diameter
(a DSD parameter)

Summary and Future Plan of proposal

This proposal has three objectives :

1) To extensively analyze global TRMM-PR observations in term of vertical profile of reflectivity (VPR) and drop size distribution parameters estimation, to effectively use knowledge gained as a sound basis for modeling the precipitation observations for Global Precipitation Measurement (GPM)

2) To study inter-connection between characteristics of VPRs and their associated microphysics via hydrometeor classification based on polarimetric ground-based radar measurements

3) To infuse the knowledge of precipitation microphysics gained from part (b) into TRMM-PR observation analysis in part (a) in order to eventually construct appropriate models simulation of Dual-wavelength precipitation radar (DPR) observations for GPM era space-borne system, for the purpose of evaluating the system design and retrieval performance

Research works that have been done are summarized as follows:

1) Extensive analyze Precipitation observation of TRMM-PR in twelve-month period.

- Classification of vertical profile of reflectivity (VPR) using Self-Organizing Map (SOM).

- Two drop size distribution (DSD) parameters (Do and Nw) estimate.

- DSD parameters : vary between convective and stratiform
  maritime and continental regions

- Appropriate storm structure model for convective rain is needed.

- Analysis of TRMM-PR observation alone is not sufficient to understanding of inter-connection between reflectivity profiles and their underlying mircropysics

2) Theoretical computation of effective reflectivity (Ze) and specific attenuation (k).

- Model relationships of (Ze) and (k) for different operating radar frequencies.

- Coefficients of the models for various hydrometeor types are calculated.

3) Preliminary analysis of polarimetric ground radar measurement

- Hydrometeor classification : The polarimetric radar data

- Inter-connection between reflectivity profiles and underlying microphysics.

- Simulation of Ka and Ku-band radar reflectivity.

- Inference of microphysics structure of the TRMM-PR reflectivity profiles

Plan to complete this research

Five tasks are planned to complete this research:

1) Continue and finish extensive analysis of available polarimetric radar measurements : SOM

- The bottom line here is that similar reflectivity profile structures should posses the same underlying microphysics structure.

- Individual profiles will be used to test validity of presumed correlation between reflectivity profiles and their underlying microphysics

2) Continue and finish extensive analysis of TRMM-PR observation both vertical profile and DSD characteristics over land and ocean using new available data set .

- To enhance our confidence in term of statistical information of global precipitation.

3) Exporting microphysics knowledge gained in step (1) to enhance the microphysical interpretation of TRMM-PR data in step (2).

- Characteristics storm structure between two radar data will be synchronized so that microphysics of TRMM-PR observation can be best inferred

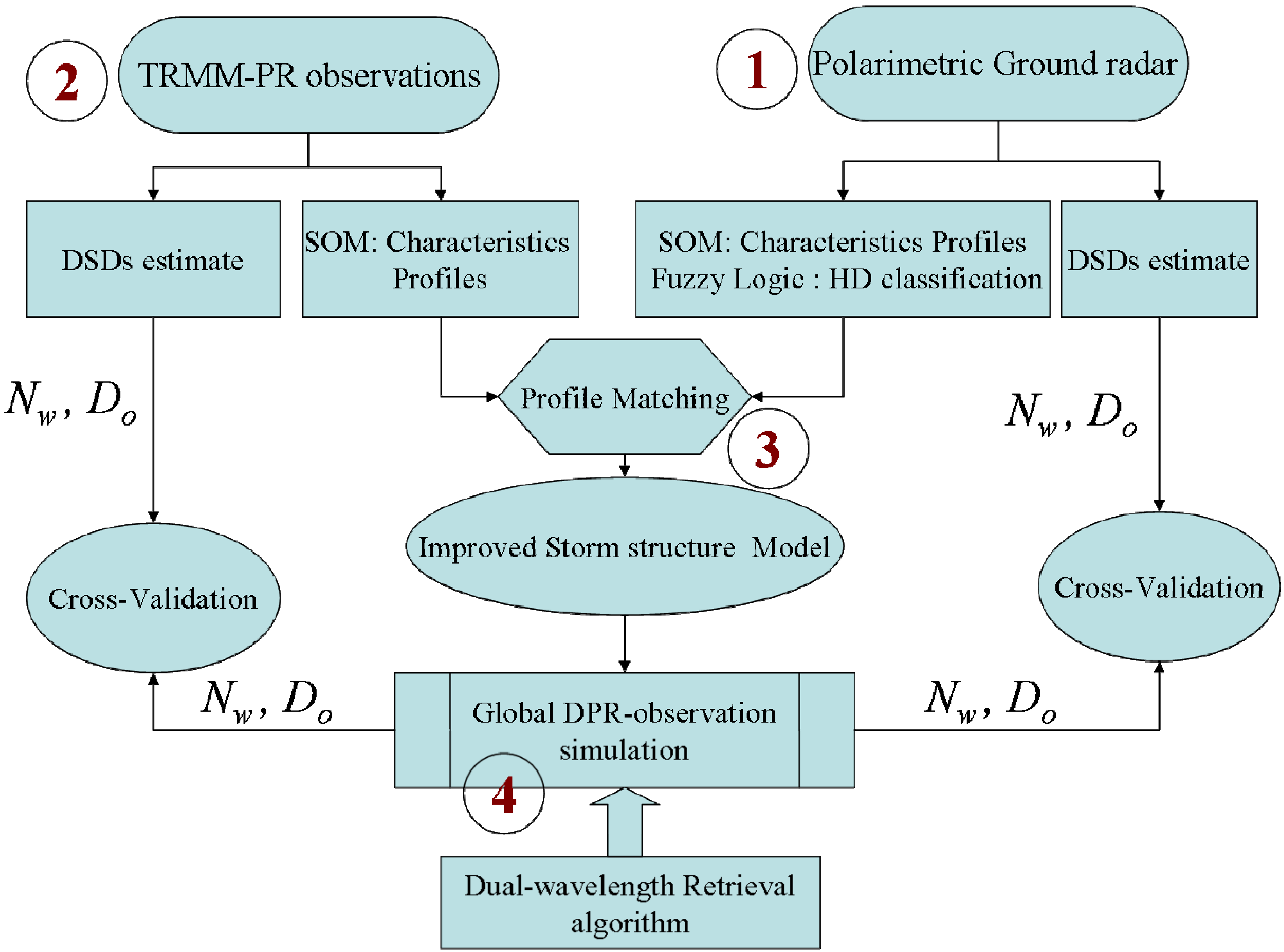
- Microphysical interpretation will be extrapolated to TRMM-PR observation over ocean

4) Global simulation of GPM observation will be carried out and be more realistic via better microphysical description of TRMM-PR data.

- GPM- DPR retrieval algorithms can be tested under various storm conditions with different microphysical storm structure and DSDs.

5) Severe tropical storms, namely, hurricanes, typhoons and cyclones, will be further studied via simulation of GPM-DPR observation

Big picture of the proposal



Thank you

Questions ?

Motivation

• Ka-band radar (35.6 GHz) observation would suffered severely from attenuation in case of intense rain.

• DPR is in the phase of developing and testing system design and retrieval technique. Up to present time, researches on DPR are based on:

1) Theoretical model. (simple storm structure).

- Simple reflectivity profile (assumed simple storm structure and known DSD)
- Can not represent realistic storm characteristics, limiting of usability and unrealistic error evaluation.

2) Airborne experiments.

- Conducted in local scale, lacking in generalizability and global precipitation representation.

USE TRMM-PR global observation as the base-data in developing

DPR system design and retrieval algorithm.

Motivation (cont..)

- TRMM-PR global observation

  - serve well in context of Global precipitation statistics

  - Microphysical interpretation of TRMM-PR observations is relatively poor.

- **Microphysical knowledge of precipitation structure that can be directly related to TRMM-PR observation must be obtained.**

- **Advance of polarimetric ground-based radar measurement can provide such knowledge.**