Variations in microwave scattering properties of precipitation in terms of frozen precipitation depth

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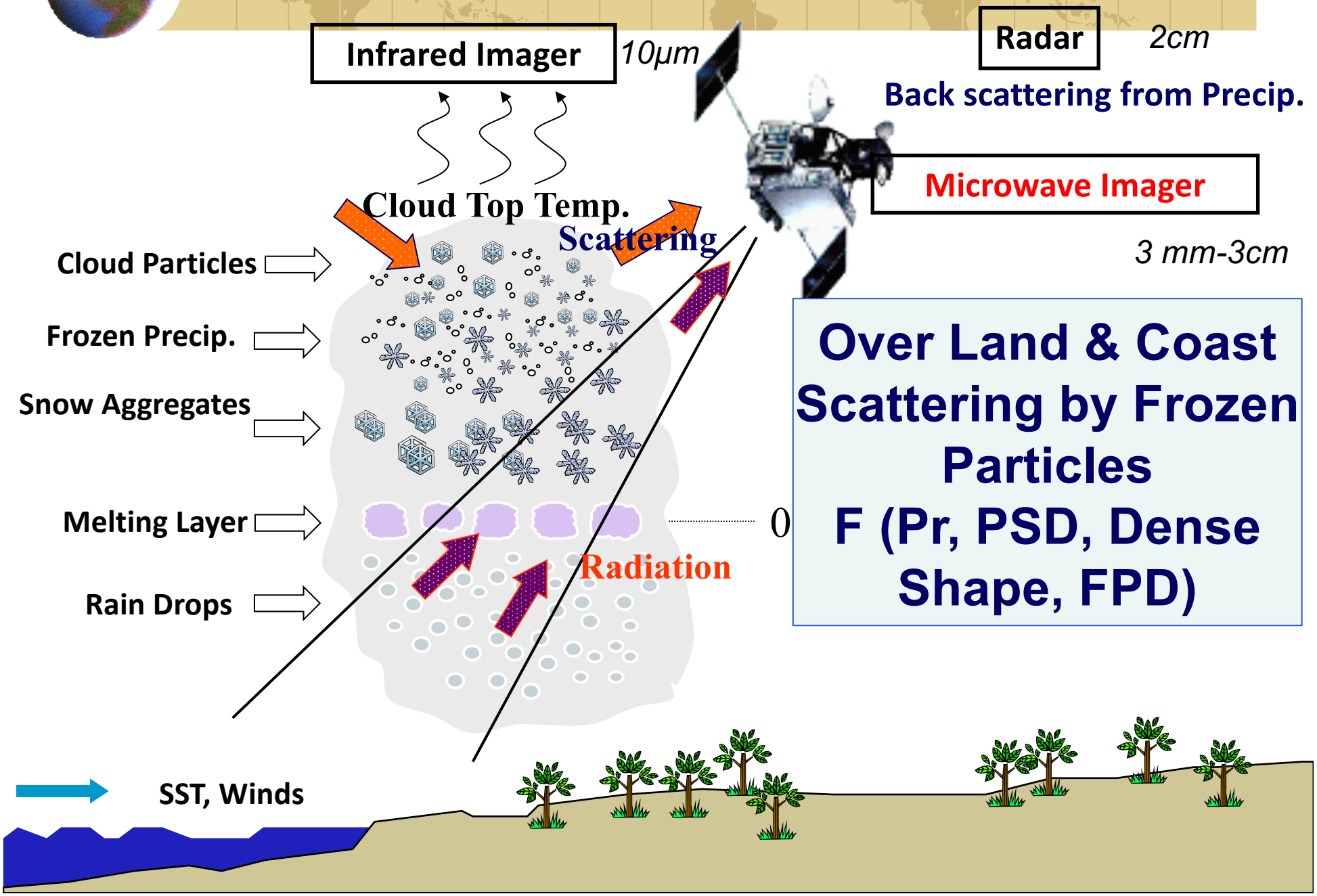
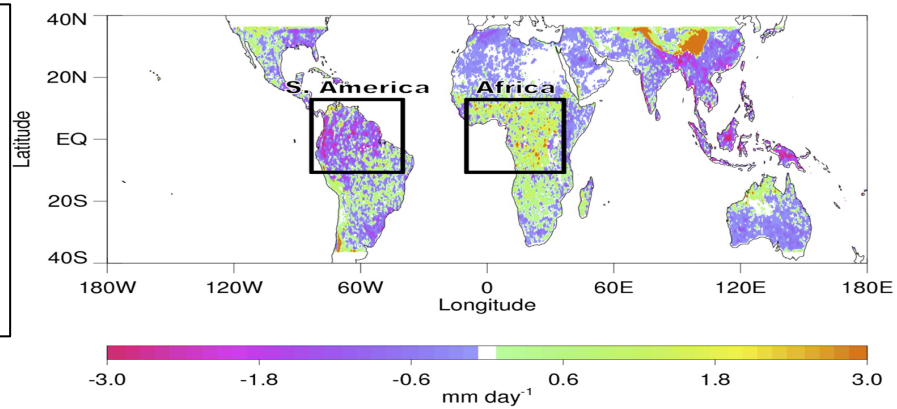
New scattering algorithm for GSMaP V05



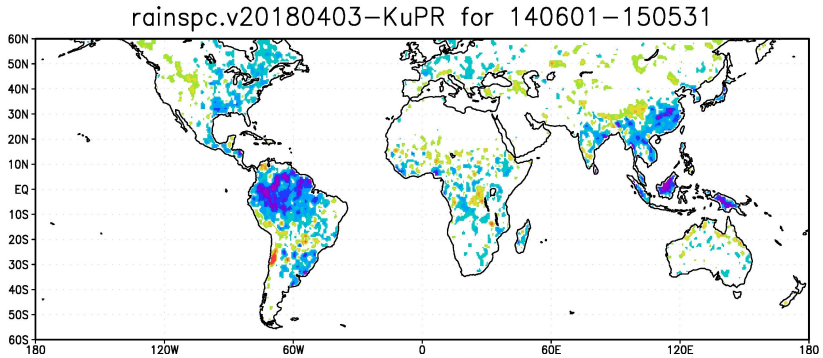
Over Land & Coast
Scattering by Frozen Particles
F (Pr, PSD, Dense Shape, FPD)

Bias of conventional scattering algorithm (Daily precip of PMW-Sat. Radars)

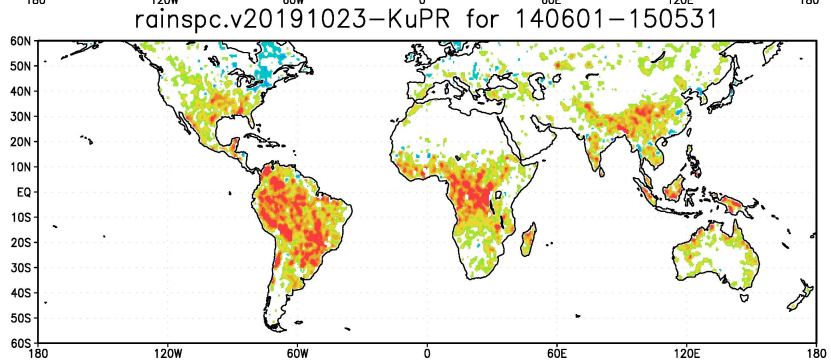
TMI-PR for '08
GPROF2010 v2
(from Petkovic & Kummerow,2017)



GMI-KuPR for Jun.'14
May '15
GSMaP V03



GMI-KuPR for Jun.'14
May '15
GSMaP V04
Correction using PR



Outline

- Introduction
  - Bias of conventional scattering algorithm
- Search for precip characteristics which related with the scattering bias
  - Comparing MWI scattering bias with KuPR precipitation features.
  - Why FPD?: Relation between FPD and profiles and densities of frozen precip
- New scattering algorithm considering FPD
  - Changing precip profile in terms of FPD
  - Changing frozen precip particle density in terms of FPD
- Validation
- Summary

Correlation between scattering bias and KuPR precipitation features, Surface temp, and elevation

Period: Jun.1,2014-May 31, 2015

GPM V06A
GMI retrievals using GSMaP V03 scattering algorithm
JRA55 GANAL and MGDSST

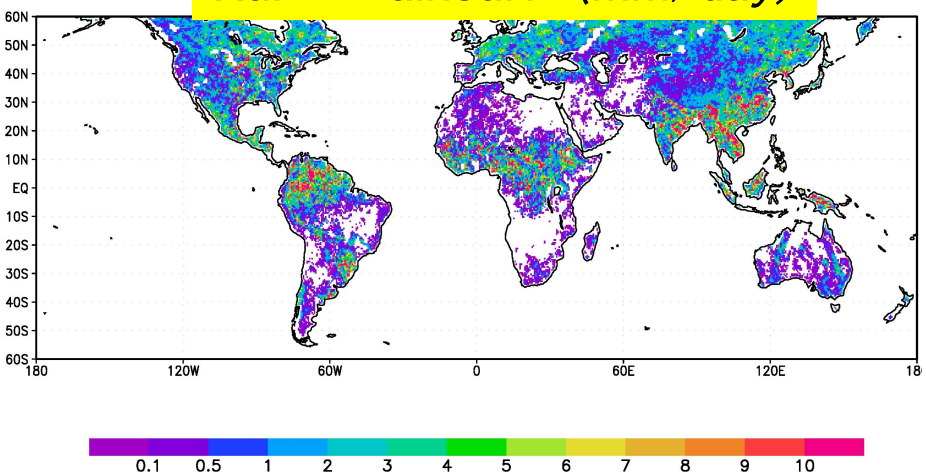
Nbias :
(Pscat-Rainsurf)*2/(Pscat+Rainsurf)
Pscat :GMI retrieval
Rainsurf:KuPR surface precip

FPD=KuPR top level – JRA55 Freezing level height
SRR:Stratiform rain ratio
Pcov:Precipitation coverage
Inhomo:Precipitation inhomogeneity

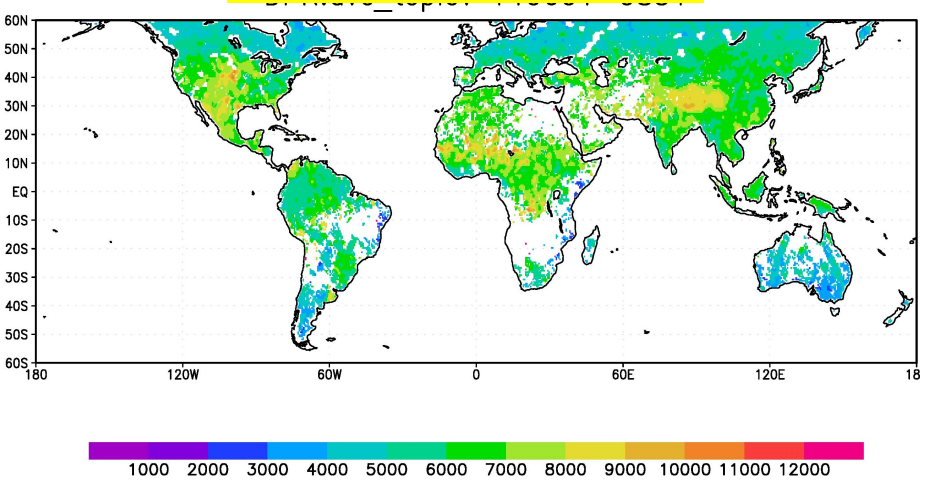
Precip Features	Nbias over Land	Nbias over Coast
Rainsurf	-0.03381	0.017938
FPD	0.54994	0.572301
KuPR top	0.47115	0.408582
FLH	0.0038	-0.1539
SRR	-0.001	0.342114
Pcov	0.20543	0.437991
Inhomo	-0.13003	-0.40636
Surface Temp	0.12127	-0.12396
Elevation	0.00219	-0.02942

Scattering Bias vs. frozen precip depth(Jun.-Aug. ’14)

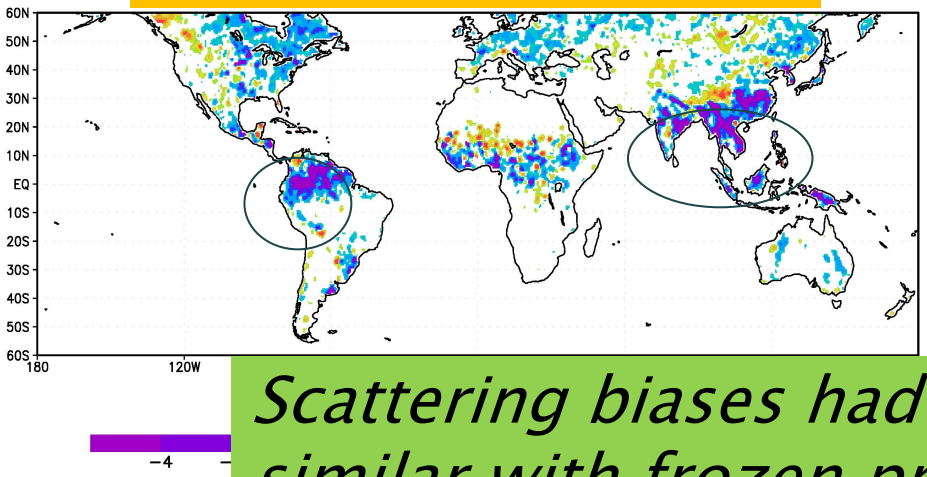
KuPR Rainsurf (mm/day)



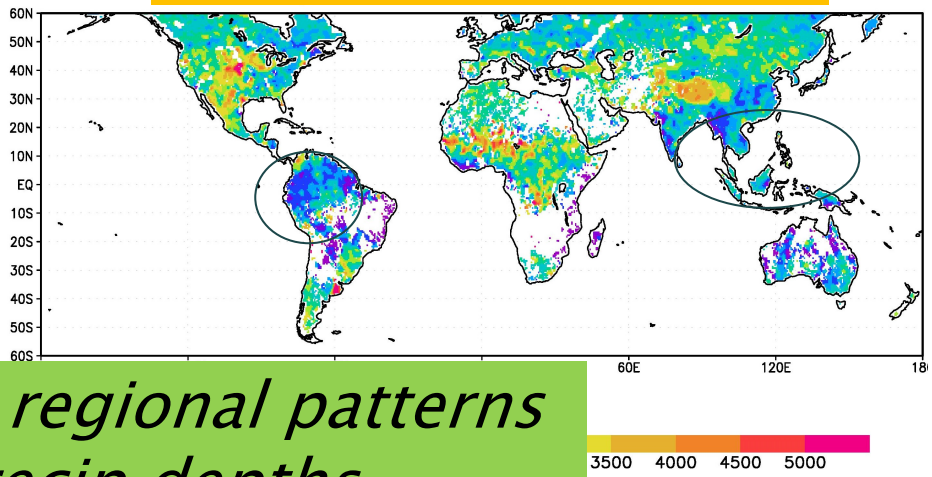
KuPR rain top level



GSMaP.V03.GMI -KuPR



FPD(Raintop- 0C level)



Scattering biases had regional patterns similar with frozen precip depths.

Seasonal differences in scattering biases (mm/day) and FPD(m) (Sep.14- May 15)

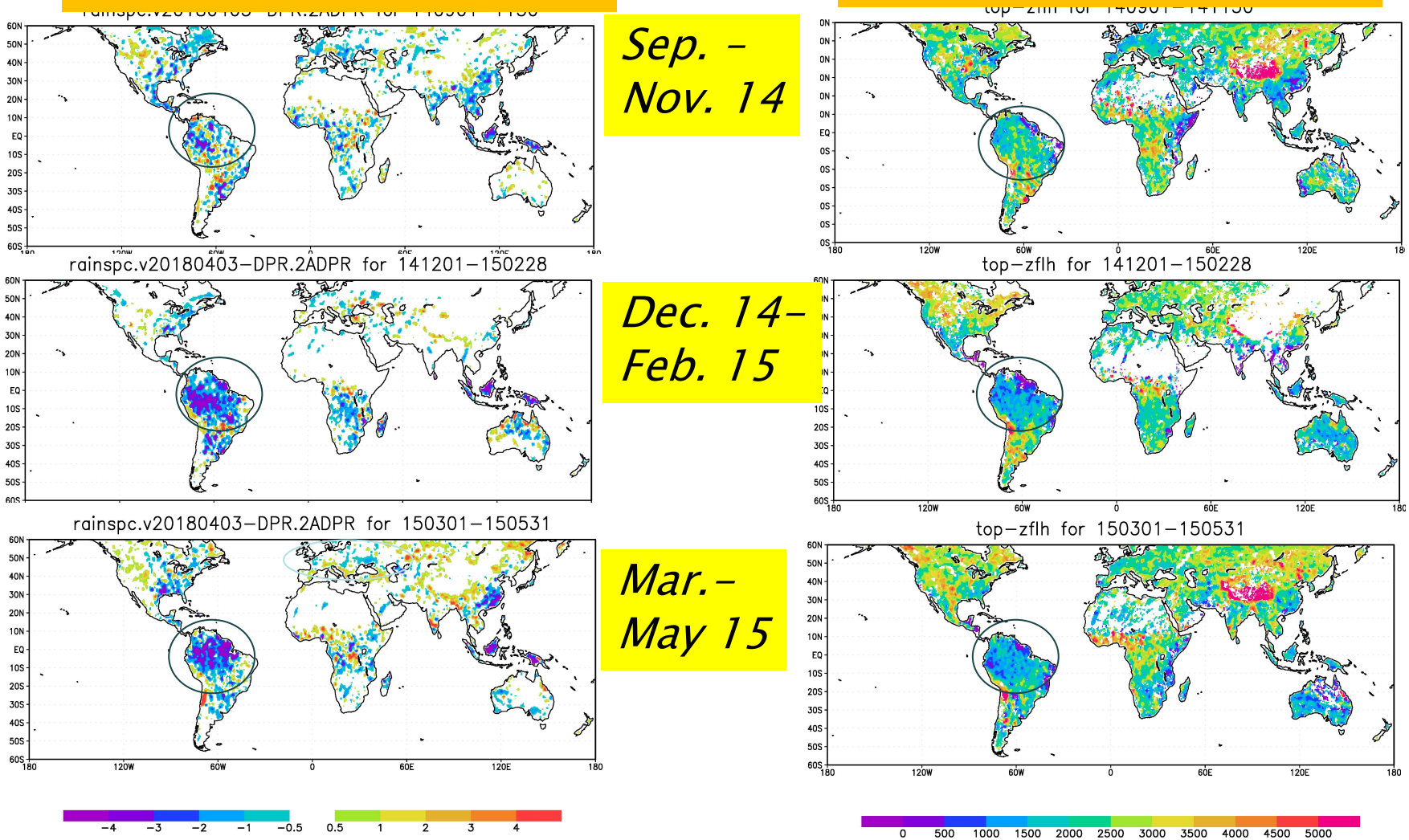
GSMaP.V03.GMI -KuPR

FPD(Raintop- 0C level)

Sep. - Nov. 14

Dec. 14- Feb. 15

Mar.- May 15



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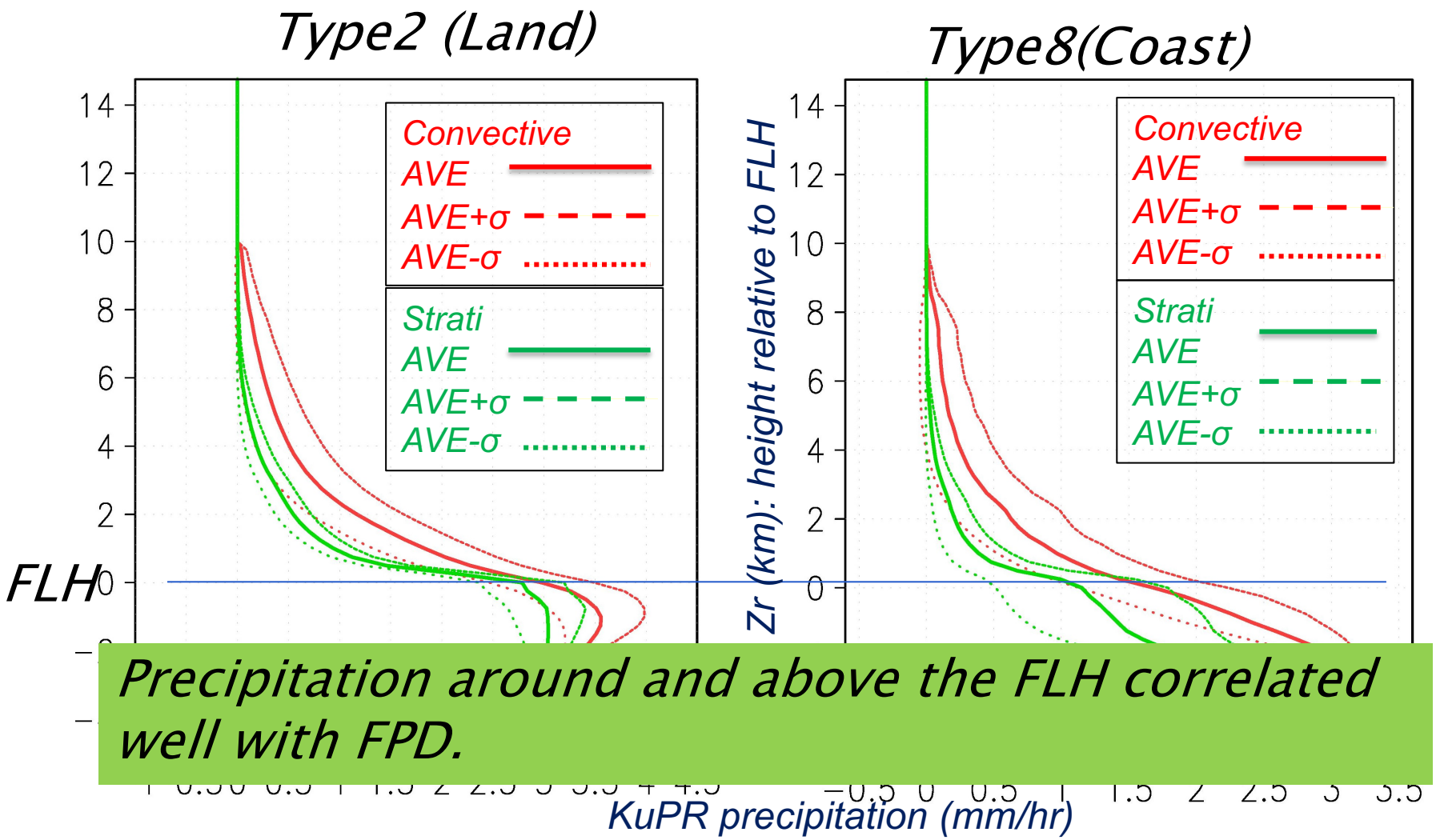
Precip profile variations associated with FPD changes

We derived the Precip variations due to FPD for each precip type with the least square method from KuPR data for the target period:

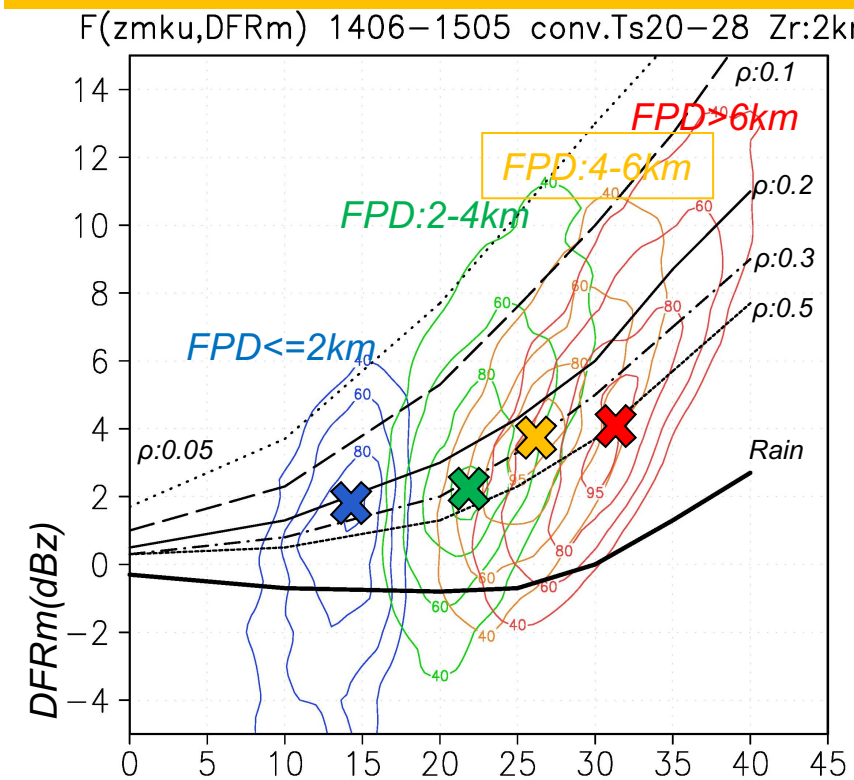


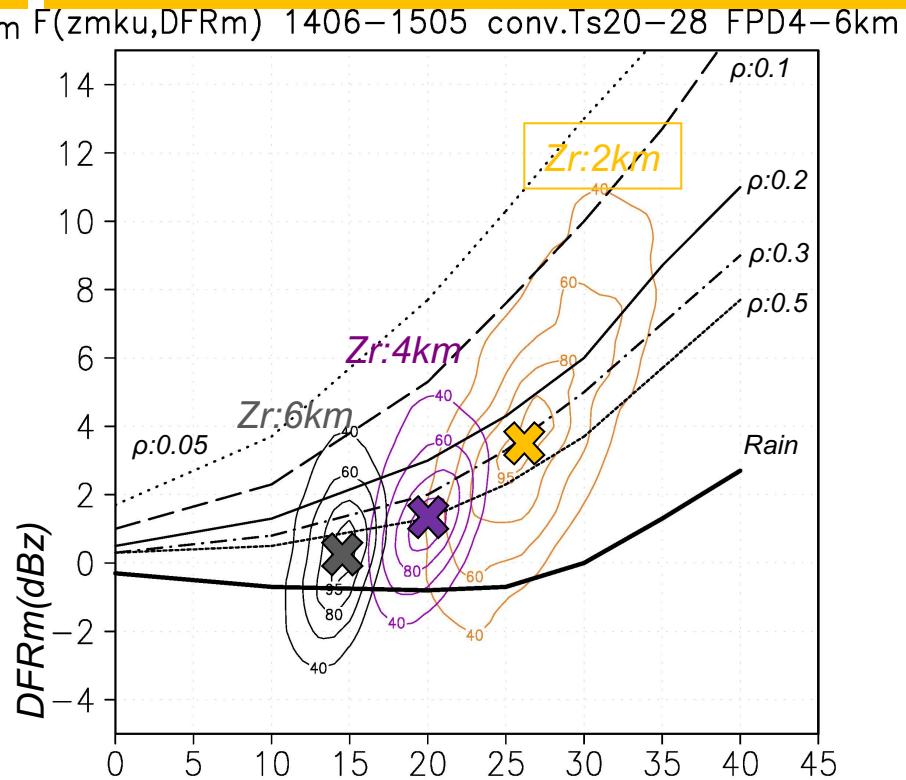
Precipitation around and above the FLH correlated well with FPD.

Variations in frozen precip particle density estimated from (Zm,DFRm)

Convective Ts:20-28C, Zr=2km
Classified with FPD(km) Target period

Convective Ts:20-28C, FPD 4-6km
Classified with Zr (km): height relative to FLH





1) Particle densities tend to increase with FPD.
2) Particle densities increased with height relative to FLH.

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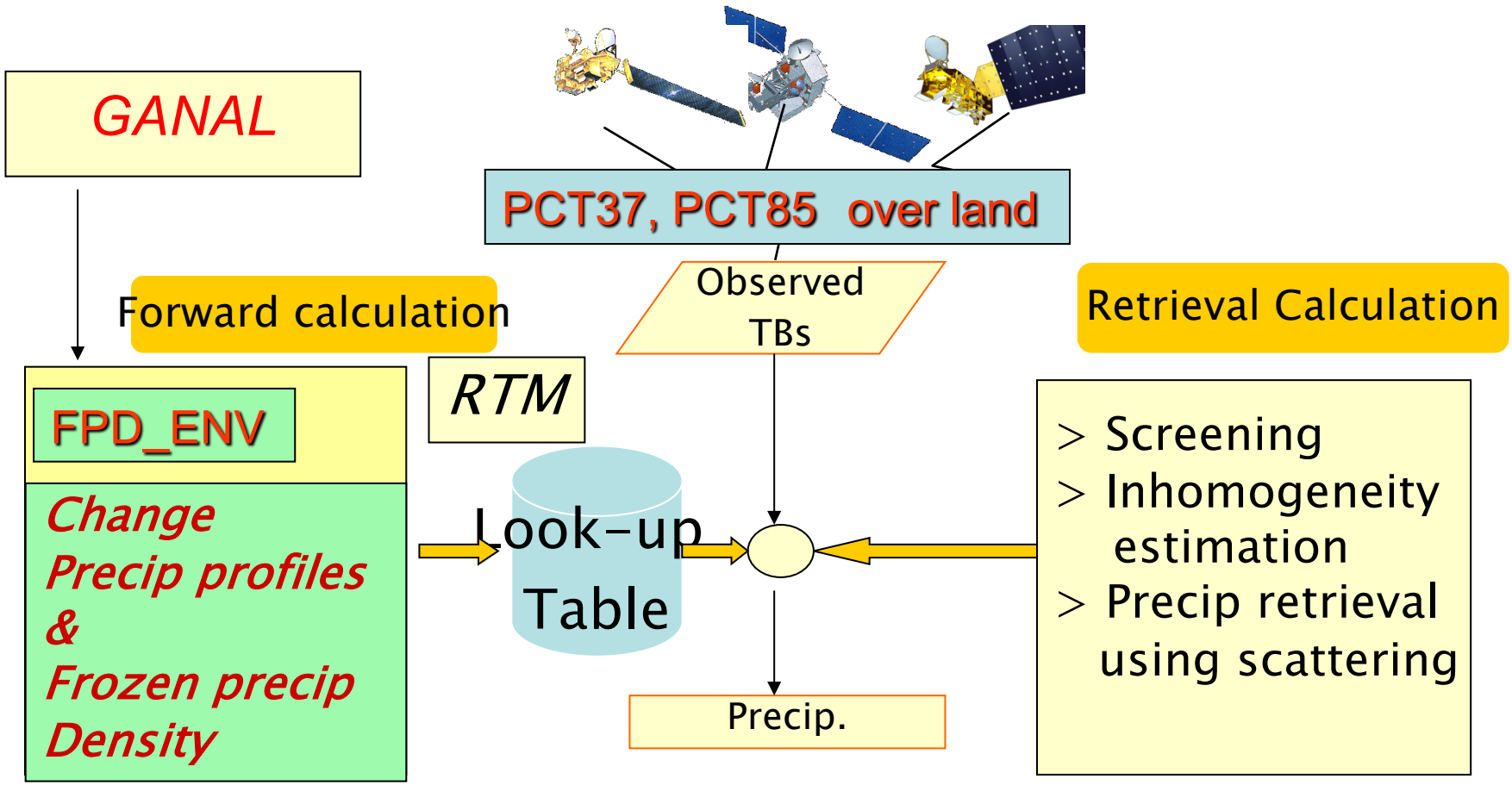
Improvement of scattering algorithm



- *Estimate FPD_ENV from GANAL variables*
- *Change precip profiles in terms of FPD_ENV*
- *Change frozen precip particle density in terms of FPD_ENV*

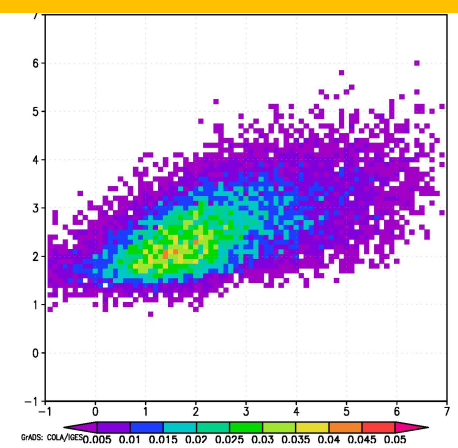
Deriving FPD_ENV from JRA55 variables

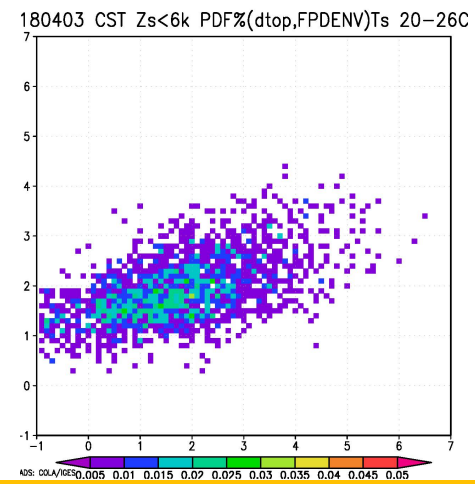
FPD has correlation with JRA55 lapse rate and Relative humidity (RH) at Bottom(<1.5 km),low level (1.5-4.5 km), and mid level (4.5-7.5 km).

SVD fitting between FPD and GANAL env. data and ln(surface precip+1): (FPD_ENV)

Correlation between FPD and FPD_ENV is ~0.52, except Ts < 10C. while the FPD_ENV dynamic ranges are narrower than FPD.

FPD vs. FPD_ENV（1406−1505）
（Land　Ts > 20 C）

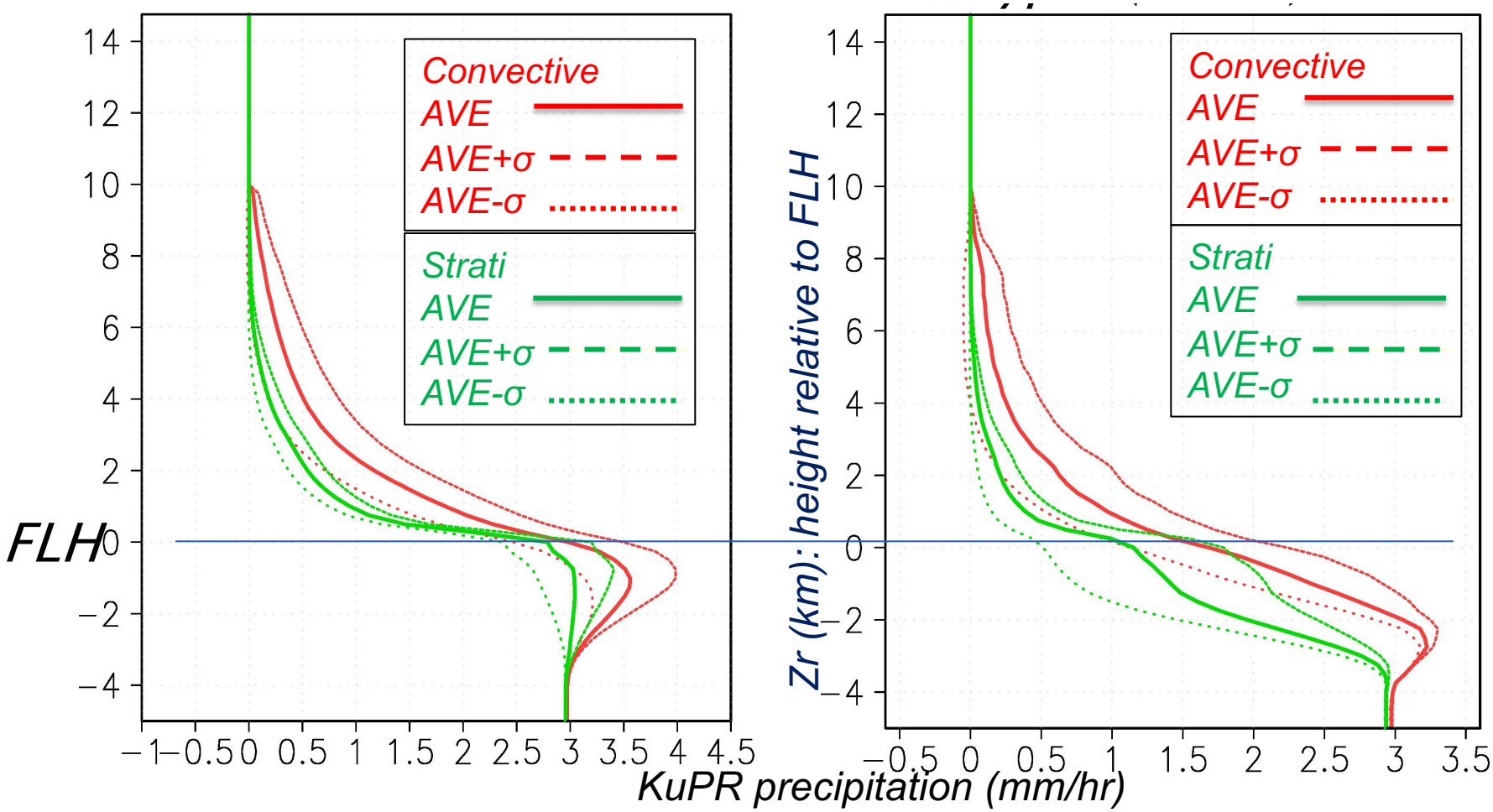




FPD vs. FPD_ENV（1406−1505）
（Coast　Ts > 20 C）

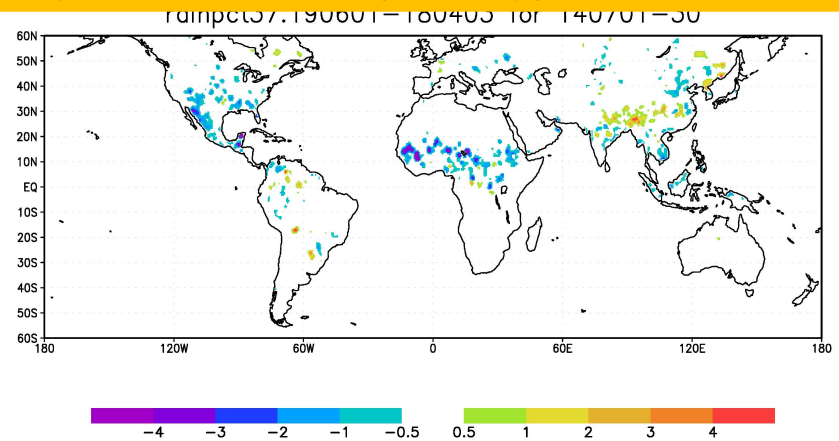
Change precip profile in terms of FPD_ENV

Experimental algorithm 1 (EXP1):
Change the precip profiles using FPD_ENV based on the statistical relation between FPD and precipitation for each type.



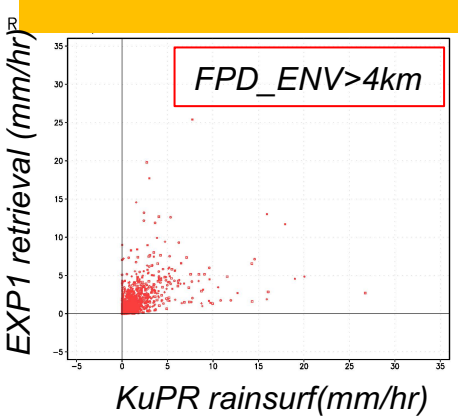
Impact of precip profile changes (EXP1)

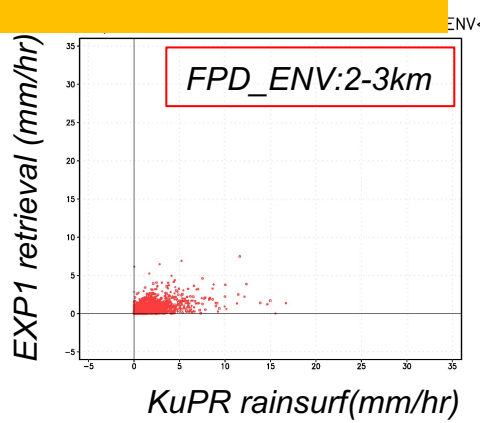
Difference (EXP1-GSMaP.V03.GMI)
Daily mean precip (mm/dy) For Jul. '15



- EXP1 reduced precip over areas with large FPD, such as North America & Africa.
- No significant effect over Amazon, Maritime continent etc.

KuPR suface precip vs. EXP1 retrieval for Jul. '15





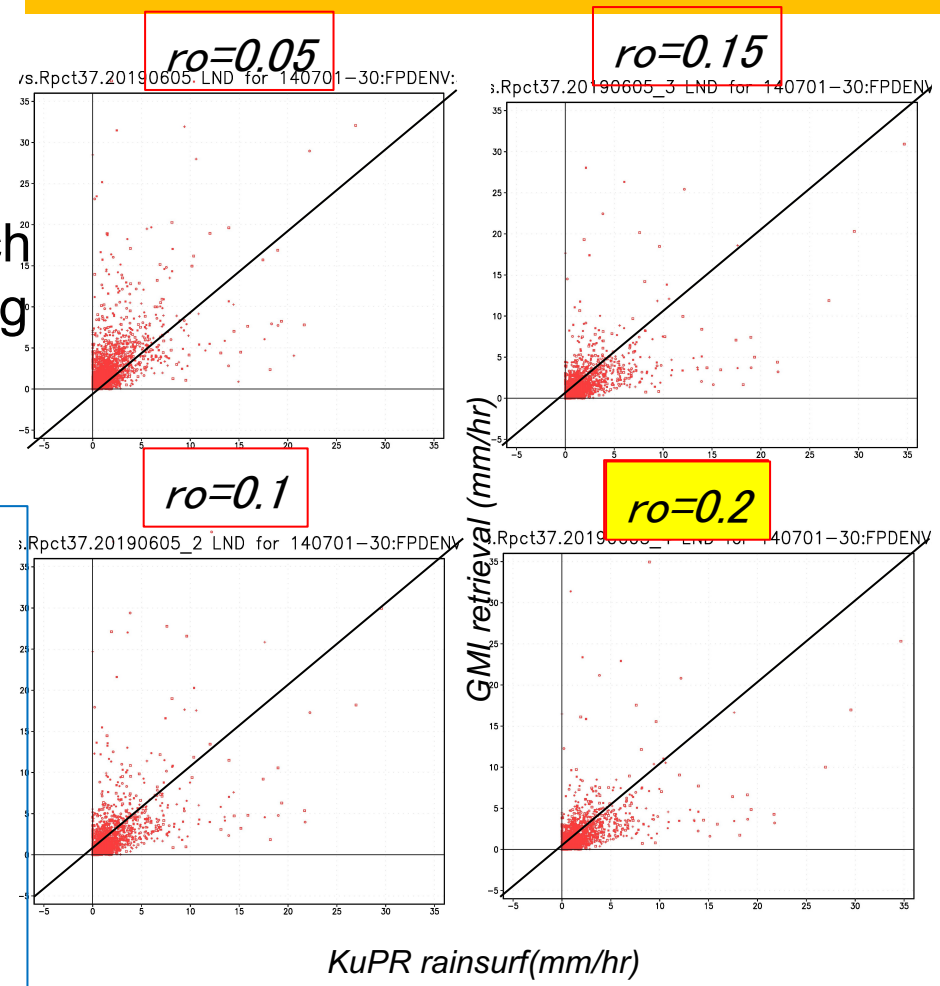
EXP1 also showed dependence of scattering bias on FPD.

Precip profile variation does not seem the main cause of the scattering bias.

Change frozen precip particle density in terms of FPD_ENV

- Densities estimated from (ZmKu, DFRm) are too large.
- We performed experimental forward cal with various densities.
- We chose the optimal density for each FPD_ENV which minimized scattering bias for the target period.

KuPR suface precip vs. GMI retrievals for FPD_ENV:3-4 Km



- FPD_ENV < 1.5 km:
ro=0.05 for 36GHz, 0.25 for 89GHz

- FPD_ENV:1.5-3.5 km:
ro=(FPD_ENV-1.5)*0.075+0.05 for 36GHz
ro=(FPD_ENV-1.5)*0.05 +0.25 for 89GHz

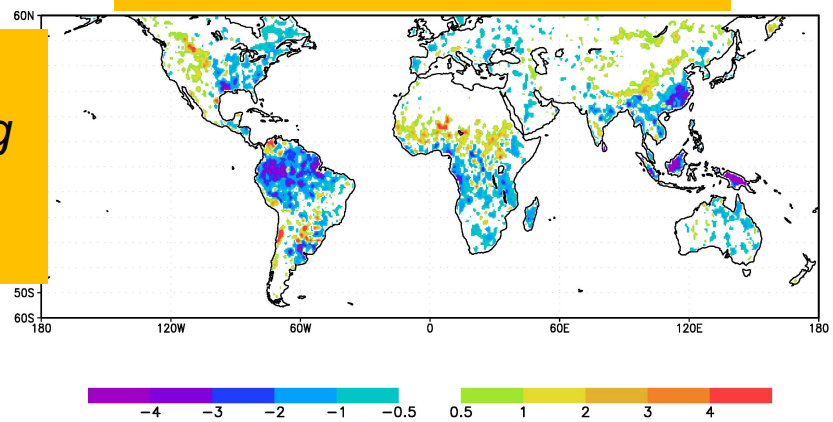
- FPD_ENV > 3.5 km:
ro=0.2 for 36GHz, 0.35 for 89GHz

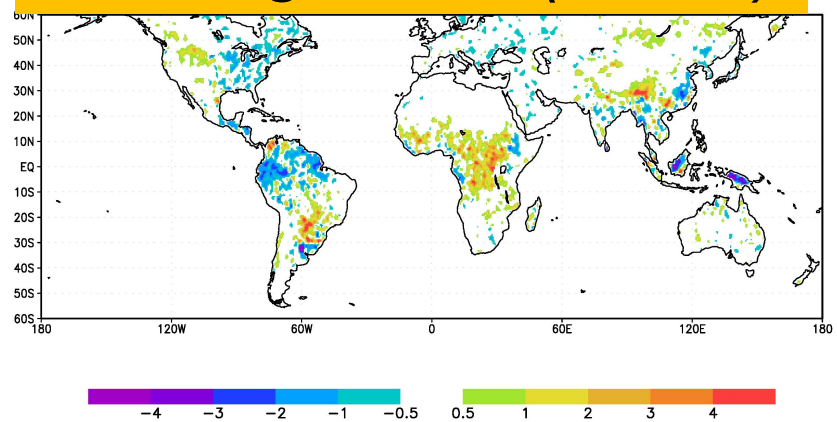
Impact of precip profile+ particle density changes (EXP2) for Jun. '15 - May '16

GSMaP.V03.GMI

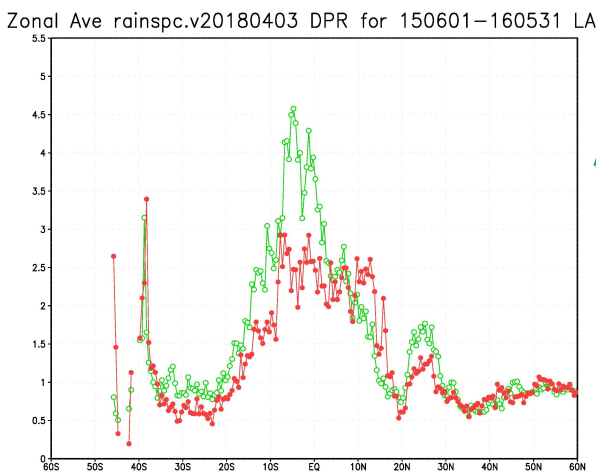
New algorithm (EXP2)

GMI scattering -KuPR (mm/dy)

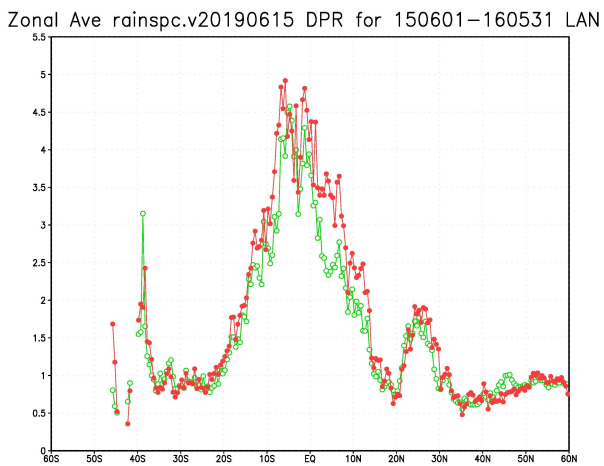




Zonal mean (mm/dy)



KuPR rainsurf,
GMI retrieval

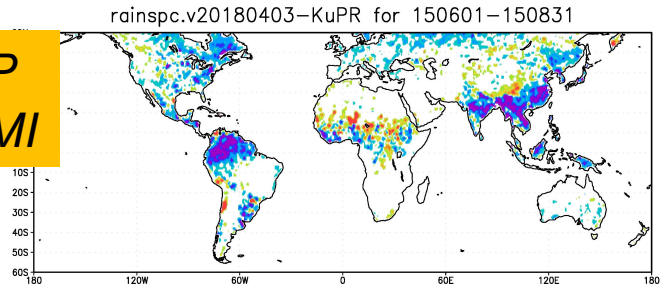


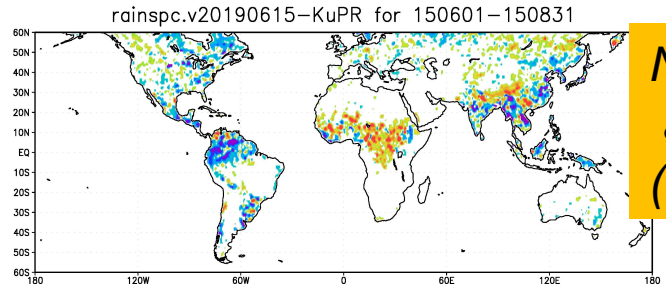
Seasonal differences in scattering biases (mm/day) (Jun.'15– May '16)

GSMaP V03.GMI

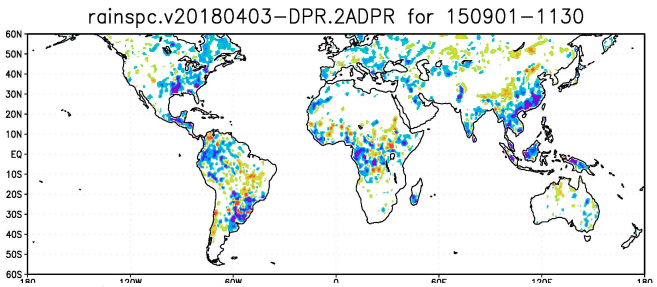
New alg. (EXP2)

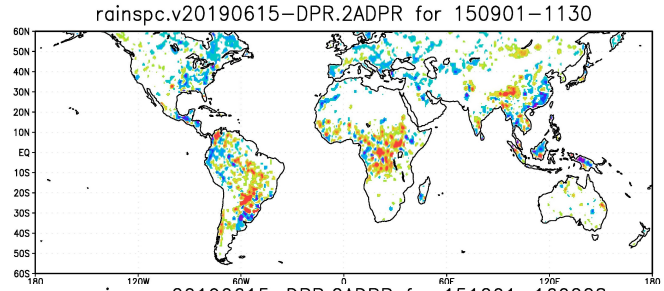
Jun. – Aug. 15



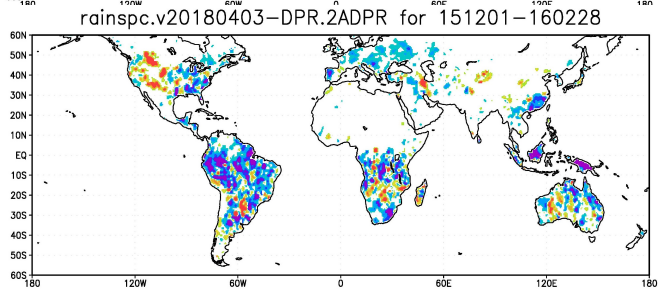


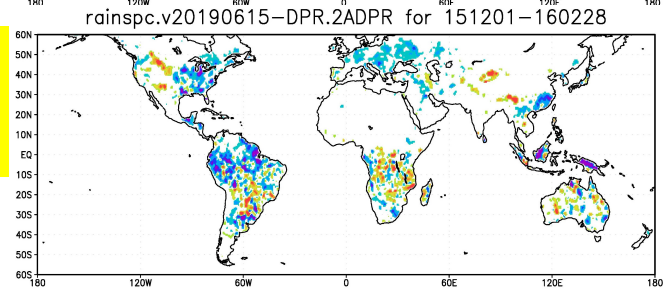
Sep. – Nov. 15



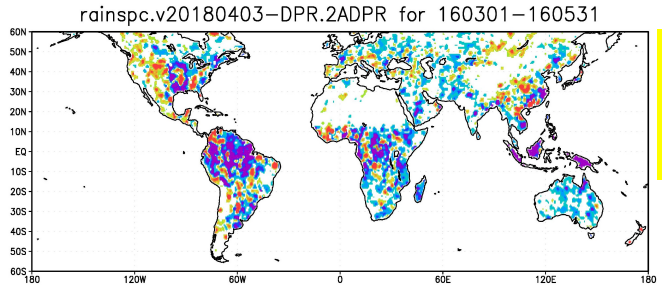


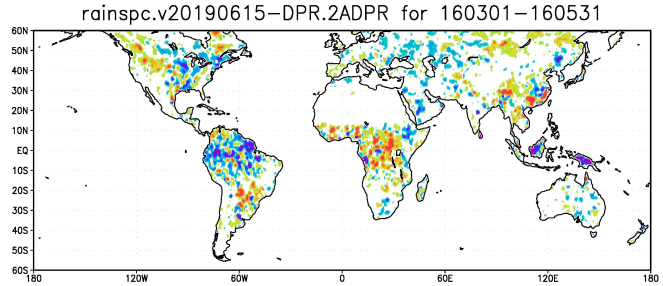
Dec. 15– Feb. 16

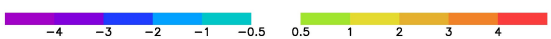


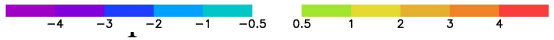


Mar.– May 16









Summary

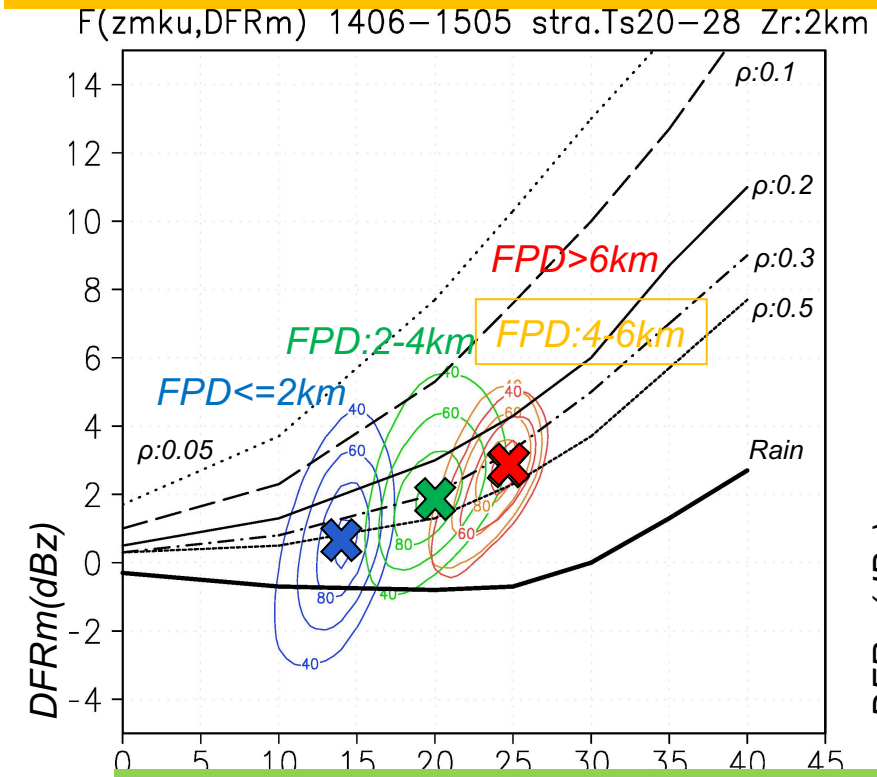
- We found the scattering bias had high correlation with a frozen precipitation depth (FPD).
- FPD variations, in turn, associated with variations in profiles and particle densities of frozen precip.
- We developed a new scattering algorithm, which derived the FPD index (FPD_ENV) from GANAL, and changed precip profiles and frozen precip particle densities in terms of FPD_ENV.
- *The new scattering algorithm alleviated underestimation over Amazon, Monsoon Asia, and Maritime Continent.*

Thank you for your attention!

(ZmKu,DFRm)の頻度分布
V06A ’14年6月—’15年5月の統計値

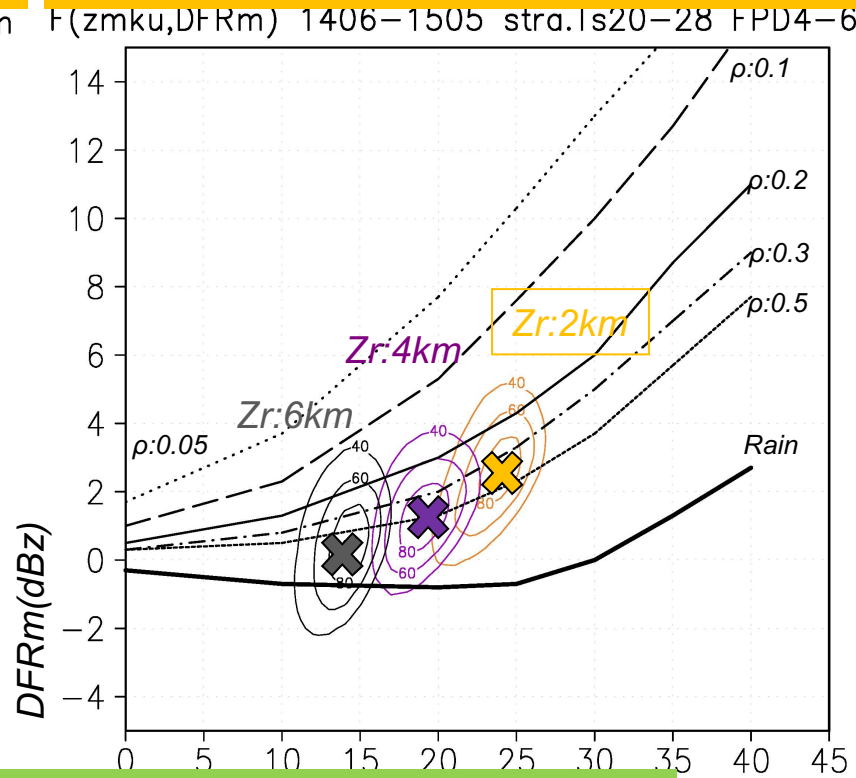
Stratiform Ts:20-28C, Zr=2km

Classified with FPD(km)



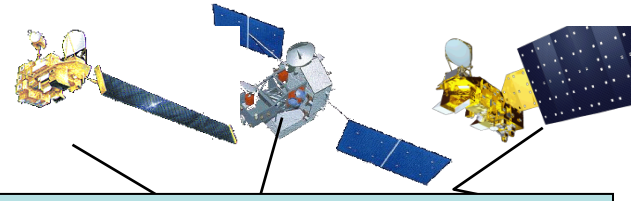
Stratiform Ts:20-28C, FPD 4-6km

Classified with Zr (km): height relative to FLH



FPD毎の固体降水の密度の変動は小い。
同じFPDに対して、FLHからの高度差が大きいほど固体降水の密度が高くなる。

Basic Idea of the Retrieval Algorithm



PCT37, PCT85 over land

Observed TBs

Forward calculation

Retrieval Calculation

RTM

GANAL

Statistical Precip-related Variable Models (PR)

Look-up Table

Screening
Inhomogeneity estimation
Scattering part
Emission part

Precip.

Find the optimal precipitation that gives RTM-calculated TBs fitting best with the observed TBs: