Development of a new scattering algorithm considering frozen precipitation depth and ratio of convective precipitation

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Outline

1. Introduction
2. Bias of the conventional algorithm vs. precip features
    1. Correlation between the bias and the precip features
    2. PDF Variations of DPR and V03 retrievals due to FPD and ratioCP
3. Variations of precip profiles and densities
4. New scattering algorithm
    1. Derive indices of FPD and ratioCP
    2. Change precip-profiles and densities using FPD_ENV
    3. Correct precip using indexes of FPD and ratioCP
5. Validation using GMI and DPR MS data
6. Summary

1. Introduction

Main improvements for the new precipitation retrieval algorithm:
1) Scattering algorithm considering frozen precipitation depth and ratio of convective precipitation
2) Improving over-coast retrieval
3) Bias correction of TBc (0 mm h-1) using TBo

2. Bias of the conventional algorithm vs. precip features

Conventional algorithm(V03) using statistical precip models
Observation data：GMI V05 L1B data
Validation data：DPR V06 MS rainsurf
GANAL: JRA55

Retrieval Algorithm

A priori Information

GANAL

Statistical Precip-related Variable Models (PR)

Forward calculation

- RTM
- Beam fill correction

Retrieval Calculation

- Screening
- Inhomogeneity estimation
- Scattering part
- Emission part

Precipitation

2.1 Correlation between precipitation bias and DPR precipitation features, Surface temp, and elevation

Period: Jun.1,2014-May 31, 2016

Nbias：
(Rainspc-Rainsurf)*2/(Rainspc+Rainsurf)
Rainspc：GMI V03 retrieval
Rainsurf:DPR V06 MS surface precip

FPD=KuPR top level – JRA55 Freezing level height
RatioCP:Ratio of convective precip
Pcov:Precipitation coverage
Inhomo:Precipitation inhomogeneity

Precip Features	Nbias over Land	Nbias over Coast
Rainsurf	0.0293	0.1081
FPD	0.5847	0.5696
RatioCP	−0.0207	−0.3081
Pcov	0.2235	0.4157
Inhomo	0.0026	0.0175
Surface Temp	0.1253	−0.1195
Elevation	0.0780	0.0713

2 .2 FD Variations of DPR and V03 retrievals due to FPD and ratioCP (Land)

ratioCP:0-0.1

ratioCP:0.1-0.5

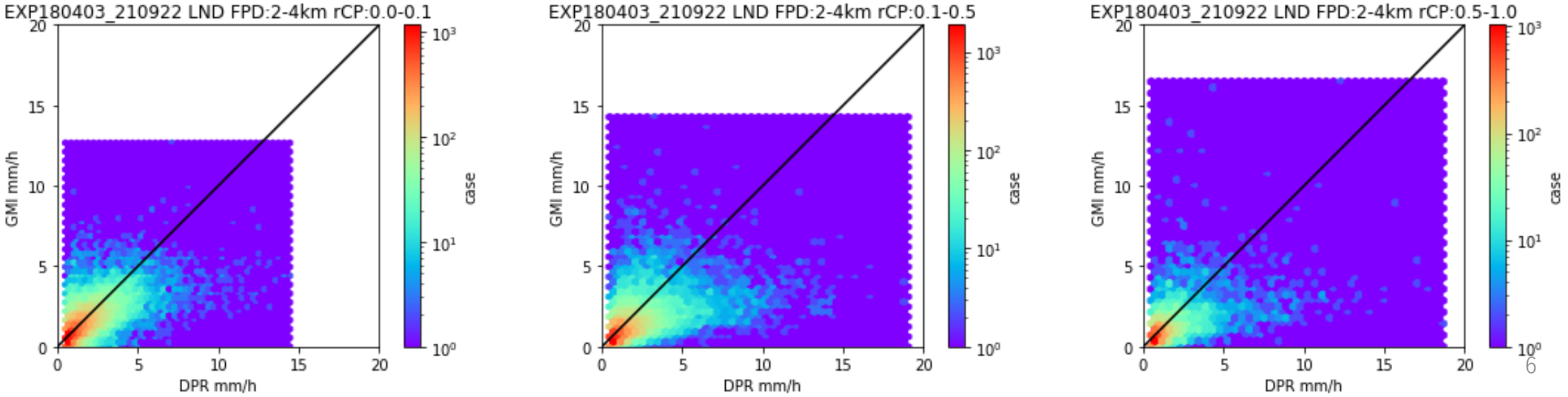
ratioCP:0.5-1.0

FPD:0-2 km

FPD:2-4 km

Variations Rainspc/rainsurf due to FPD are small for stratiform.

Rainspc/rainsurf increases rapidly with FPD for convective



2 .2 FD Variations of DPR and V03 retrievals due to FPD and ratioCP (Land)

ratioCP:0-0.1

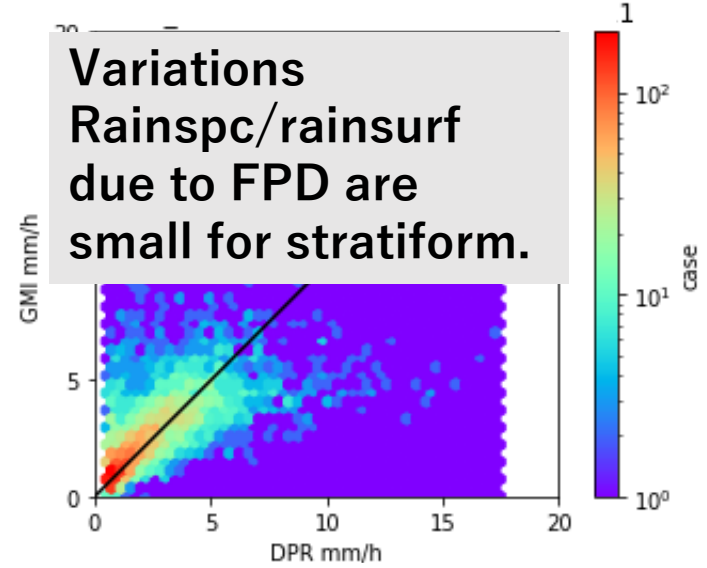
ratioCP:0.1-0.5

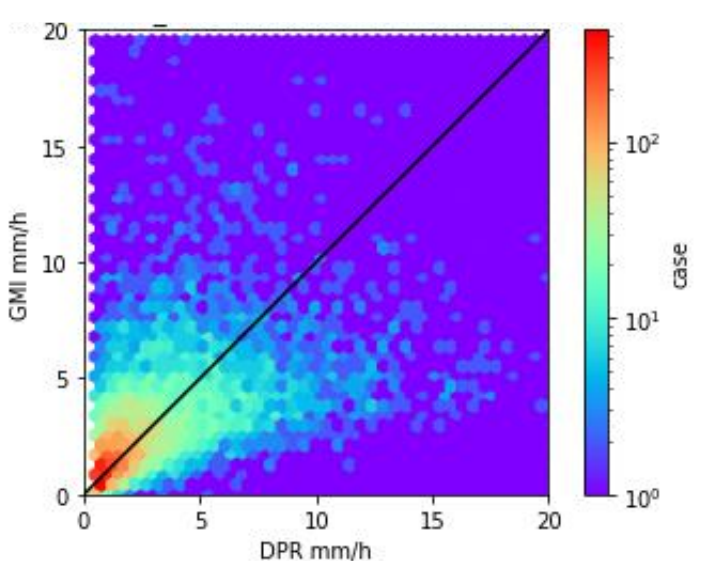
ratioCP:0.5-1.0

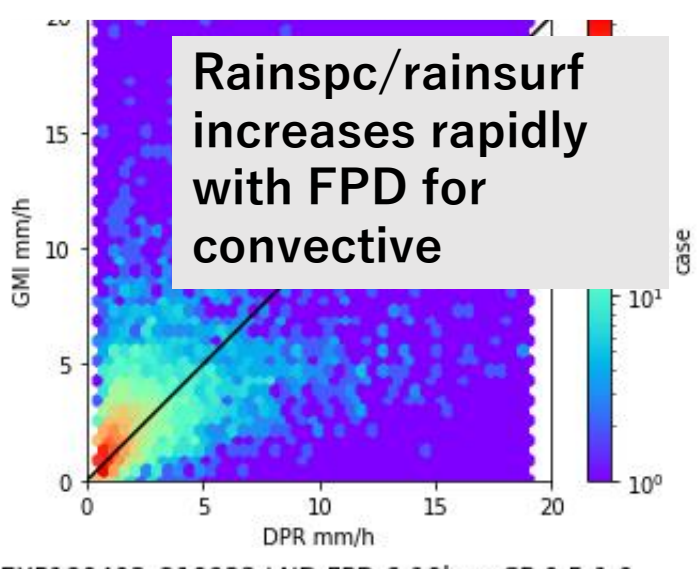
FPD:4-6 km

Variations Rainspc/rainsurf due to FPD are small for stratiform.

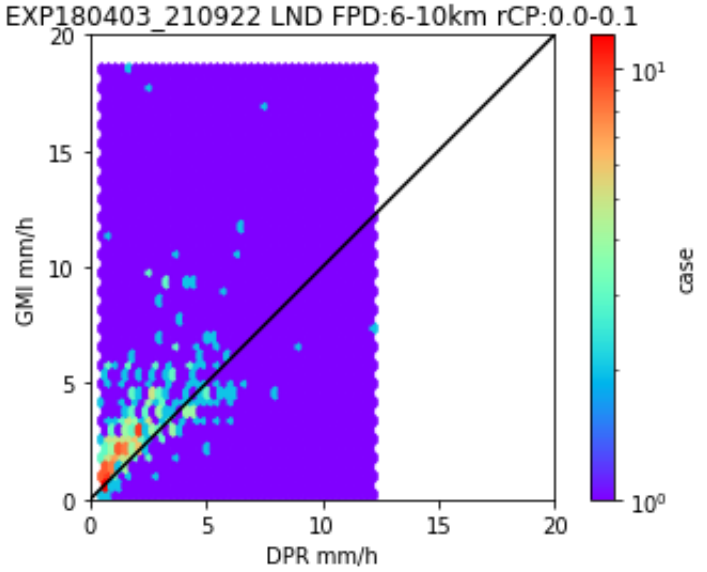
Rainspc/rainsurf increases rapidly with FPD for convective

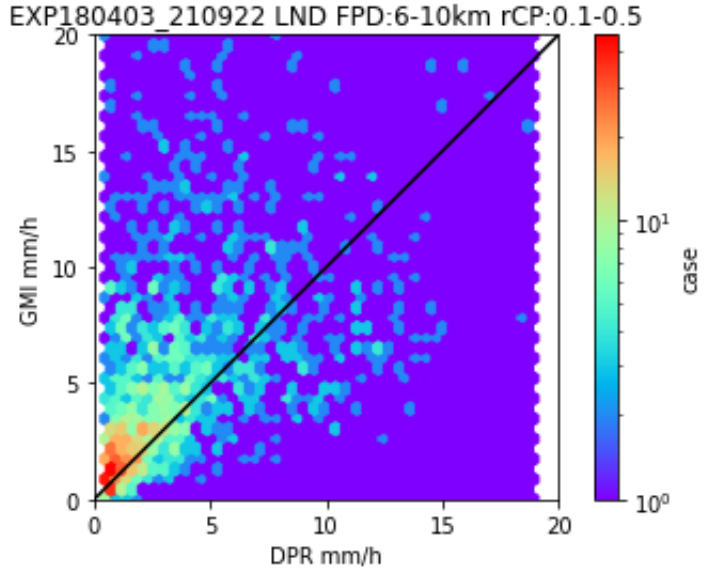


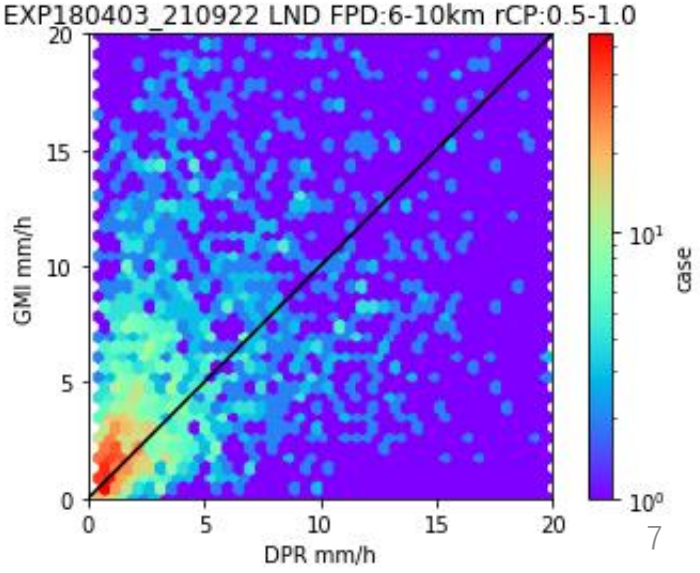




FPD:6-10 km

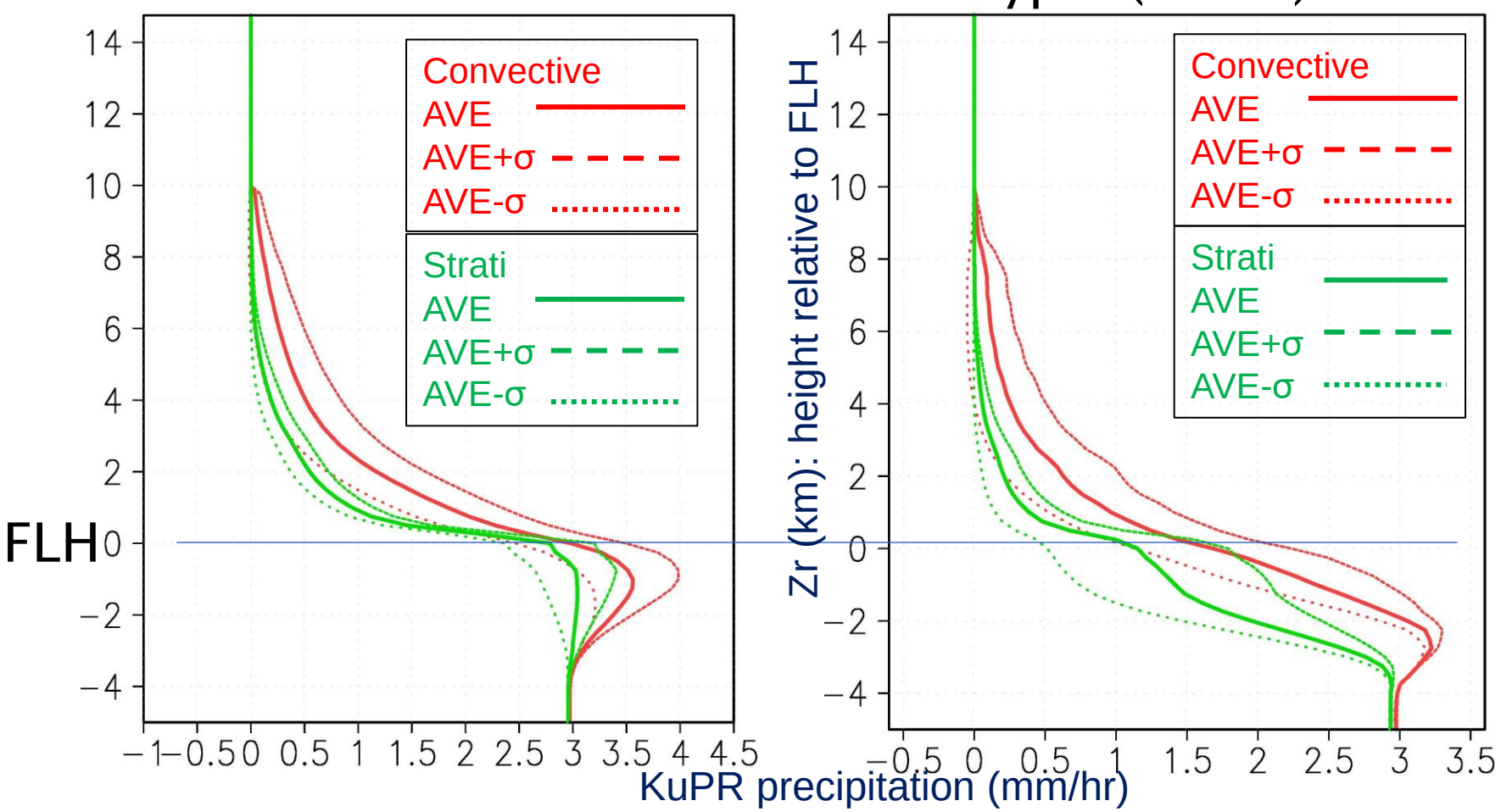






3.1 Precip profile variations associated with FPD changes for Jun. 2014- May 2016

Precipitation around and above the FLH correlated well with FPD.
Convective had larger variations than stratiform.

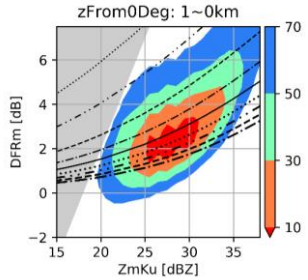


3.2 Frozen precip particle density estimated from ZmKu-DFRm (2015-2018)

PDF of ZmKu-DFRm are plotted for FPD=5 km and z=1 km

From Akiyama et al (2020)

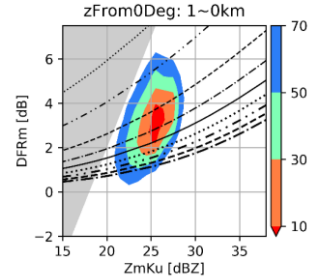
Convective in Tropics Land



Density (g cm^{-3})

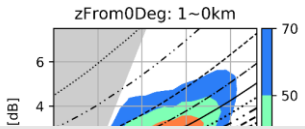
	FPD5km	FPD4km	FPD3km	FPD2km	FPD1km
z5km	0.427682				
z4km	**0.377158**	0.396312			
z3km	**0.354976**	**0.347742**	0.366611		
z2km	**0.335265**	**0.321971**	**0.317511**	0.342421	
z1km	**0.300327**	**0.287433**	**0.279515**	**0.279795**	**0.312776**

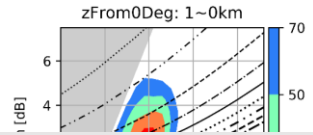
Stratiform (BB) In Tropics Land



Density (g cm^{-3})

	FPD5km	FPD4km	FPD3km	FPD2km	FPD1km
z5km	0.510301				
z4km	**0.41358**	0.473777			
z3km	**0.35177**	**0.385364**	0.429468		
z2km	**0.316275**	**0.326866**	**0.34954**	0.405791	
z1km	**0.276341**	**0.28146**	**0.295108**	**0.322408**	**0.352933**





- Density increases with height from FLH for convective and stratiform.
- Tall convective have larger precip-weighted density than stratiform.

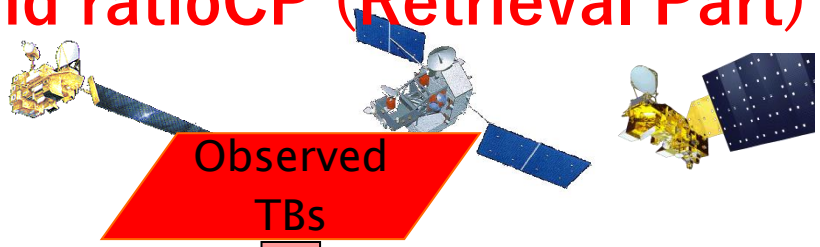
	FPD5km	FPD4km	FPD3km	FPD2km	FPD1km
z5km	0.48915				
z4km	0.443802	0.472305			
z3km	**0.420119**	0.42115	0.440551		
z2km	**0.405827**	**0.394653**	**0.383963**	0.389809	
z1km	**0.35653**	**0.343989**	**0.325628**	**0.305196**	**0.338414**

	FPD5km	FPD4km	FPD3km	FPD2km	FPD1km
z5km	0.528257				
z4km	0.448427	0.494727			
z3km	**0.38857**	0.412698	0.436034		
z2km	**0.353381**	**0.357643**	**0.366813**	0.420327	0.65
z1km	**0.318113**	**0.316835**	**0.317433**	**0.337987**	0.360746

4. New scattering algorithm

New scattering algorithm(V06): algorithm considering FPD,ratioCP

- Change precip-profiles and densities using index of FPD (Forward Cal Part)
- **Correct precip using indices of FPD and ratioCP (Retrieval Part)**



Observed TBs

Retrieval Algorithm

A priori Information

GANAL

Precip Profiles
DSD
Mixed phase
inhomogeneity

Forward calculation

Change precip-related Variables in terms of FPD_ENV

- RTM
- Beam fill correction

Retrieval Calculation

- Screening
- Inhomogeneity estimation
- Scattering part

Correction using ratioCPpix & FPDpix

Precipitation

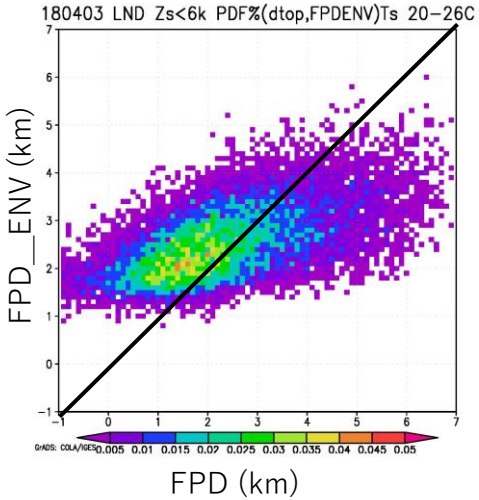
4.1 Derive index of FPD (FPD_ENV) from GANAL

- Normalized lapse rate(dTvdz) $\Gamma_N = (\Gamma - \Gamma_{ms})/(\Gamma_d - \Gamma_{ms})$
- Relative humidity (RH)
- Lnp=ln(Psurf+1)

  Bottom(<1.5 km),low level (1.5-4.5 km), mid level (4.5-7.5 km)

Region Ts	Land <10C	Land 10 - 20 C	Land 20 - 26 C	Land >26 C	Coast <10 C	Coast 10 - 20 C	Coast 20 - 26 C	Coast >26 C
dTvdz_btm	0.057	0.075	-0.056	0.075	0.275	-0.021	-0.084	-0.067
dTvdz_low	-0.088	0.288	0.297	0.319	0.138	0.177	0.336	0.304
dTvdz_mid	-0.106	0.189	0.285	0.207	-0.239	0.093	0.181	0.121
RH_btm	-0.06	-0.135	-0.23	-0.269	-0.024	-0.016	-0.105	-0.155
RH_low	-0.038	-0.122	-0.282	-0.281	0.02	0.094	-0.048	-0.017
RH_mid	-0.064	-0.075	-0.214	-0.21	-0.072	0.139	0.058	0.091
Ln(Psurf+1)	0.143	0.4	0.33	0.387	0.202	0.446	0.343	0.406

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



Based on the above correlation, we derived index of FPD (FPD_ENV) from GANAL.

4.1 Derive index of ratioCP (ratioCPpix) from GMI TBs etc.

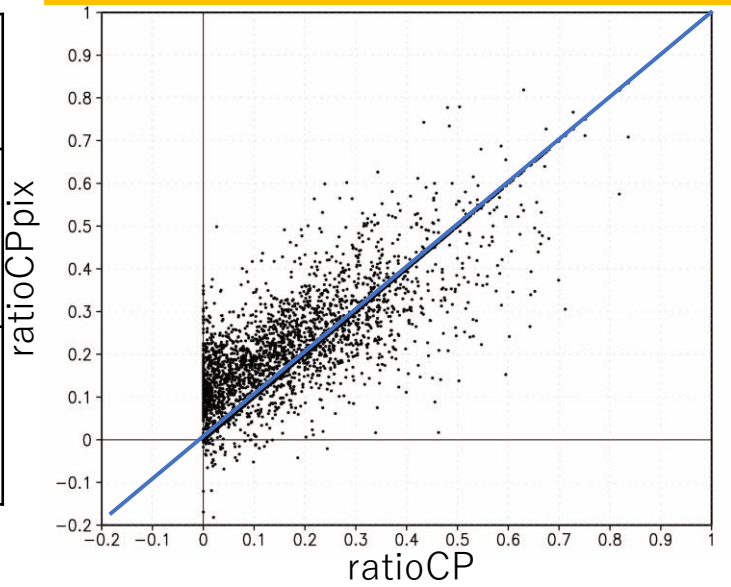
ratioCP had correlation with following variables：

- Index of FPD (FPDpix) derived from GANAL and GMI precip
- Precip inhomogeneity estimated from GMI(Sigma85)
- Polarization difference of GMI TB89(dtb89vh)
- Surface temperature（Ts）

Correlation between ratioCP and the variables (July 2014-April 2015)

	FPDpix	Sigma85	dtb89vh	Ts
Land	0.474	0.591	-0.337	0.330
Coast	0.288	0.604	-0.322	0.206

Scatter between ratioCP and ratioCPpix (July 2014-April 2015)

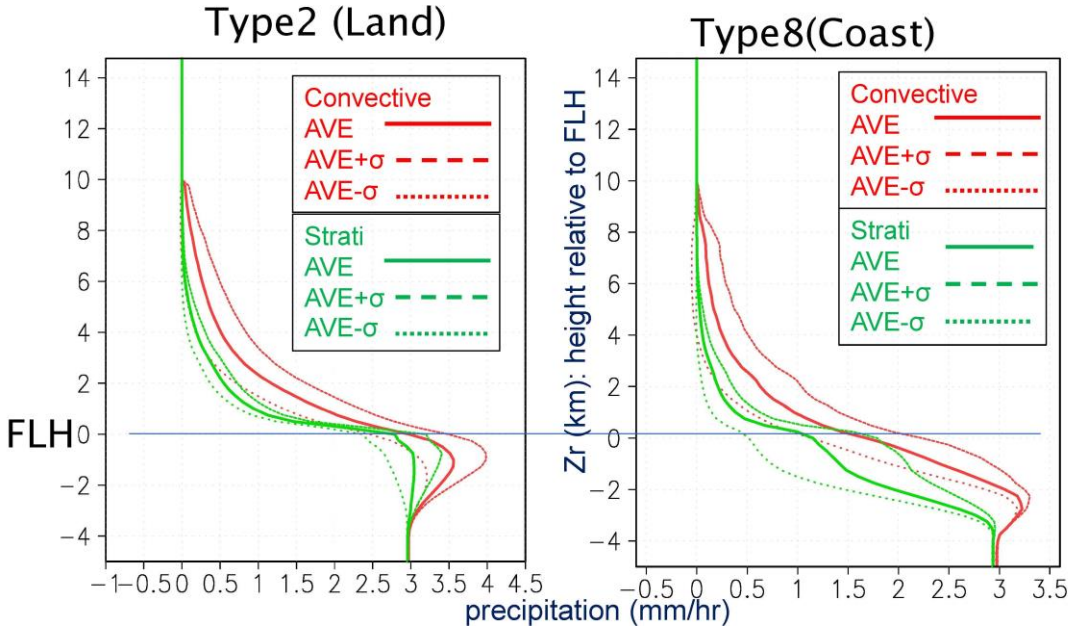


4.2 Change precip-profiles and densities using FPD_ENV

Change precip profiles using FPD_ENV

- Change the precip profiles using FPD_ENV based on the statistical relation between FPD and precipitation for each type.

Precip profile variations associated with FPD changes for Jun. 2014- May 2016



Change precip densities using FPD_ENV

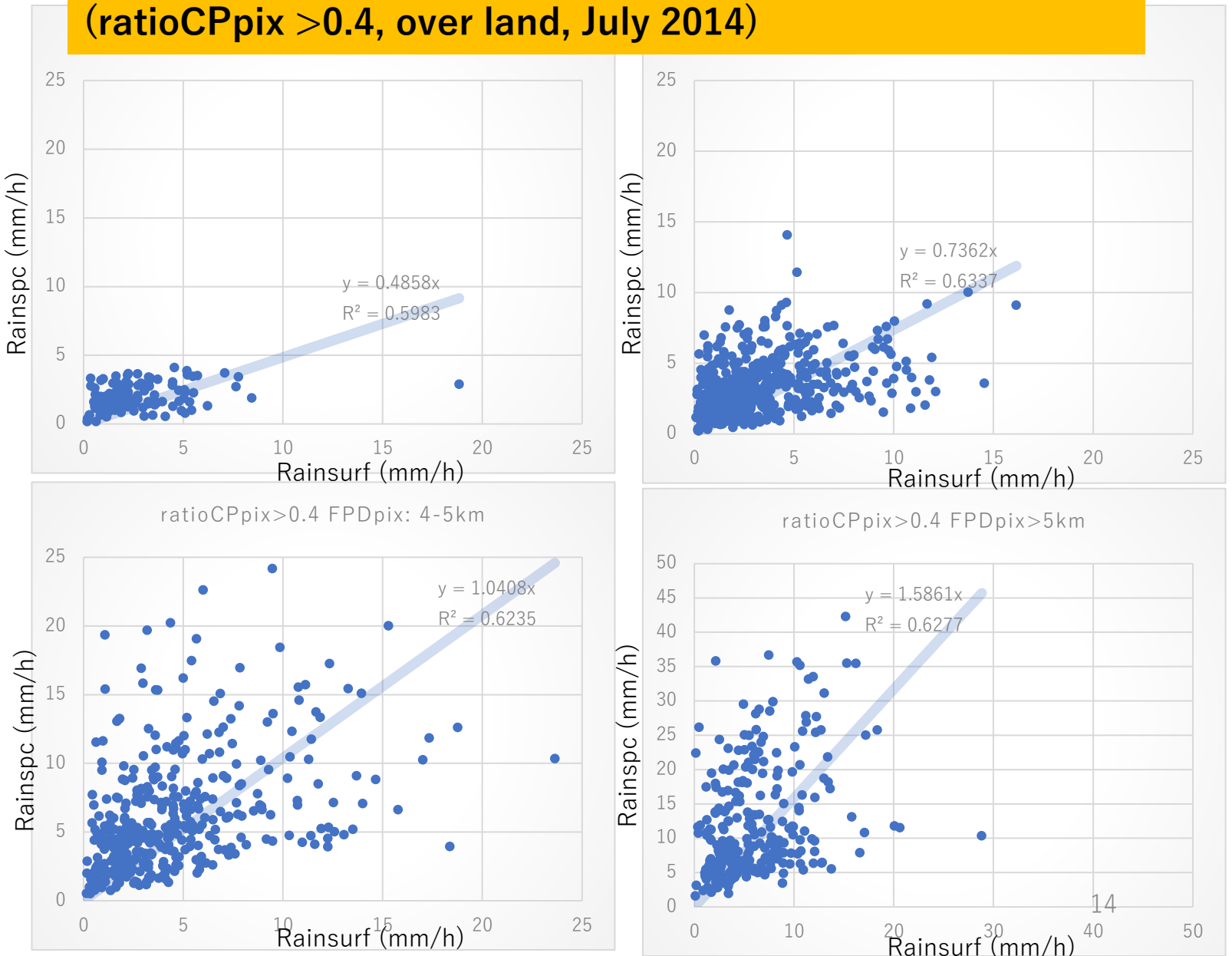
- We performed experimental forward cal with various densities.
- We chose the optimal density for each FPD_ENV which minimized scattering bias for the target period.

89GHz：
Convective(0.65-0.80)
Stratiform(0.50-0.65)
36GHz：
Convective(0.15-0.75)
Stratiform(0.05-0.65)

4.3 Correct precip using indices of FPD and ratioCP

- Variations of (rainspc/rainsurf) due to FPDpix are large for convective precip, even after introducing FPD_ENV in the forward calculation.
- Correct rainspc using ratioCPpix and FPDpix in the retrieval part.

Scatter diagrams of rainsurf vs. rainspc for FPDpix groups (ratioCPpix >0.4, over land, July 2014)

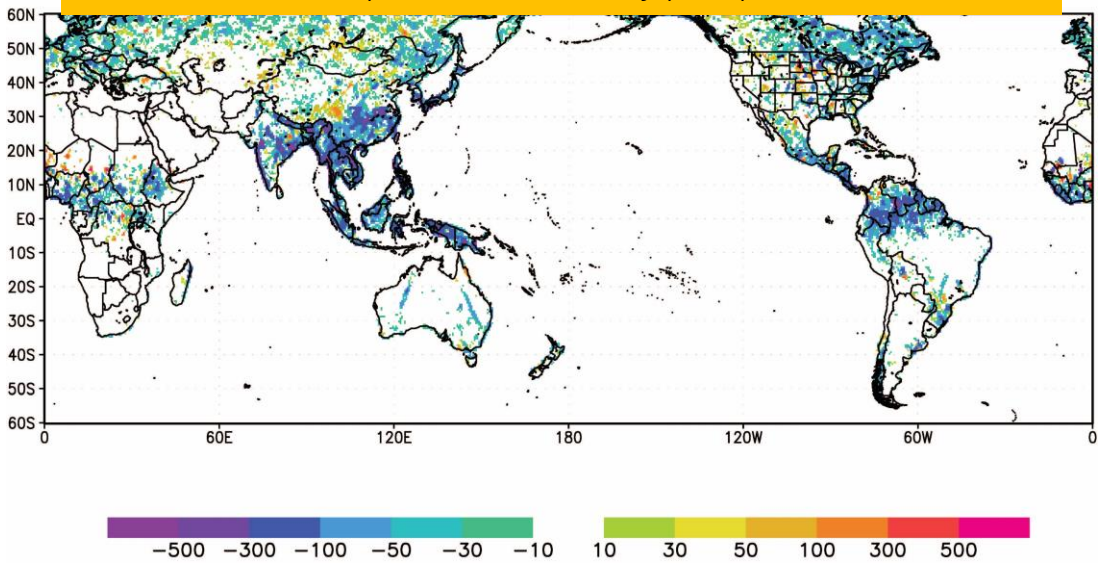


5. Validation using DPR MS data：V03(EXP180403_210922) (Over land and coast, June-August 2014)

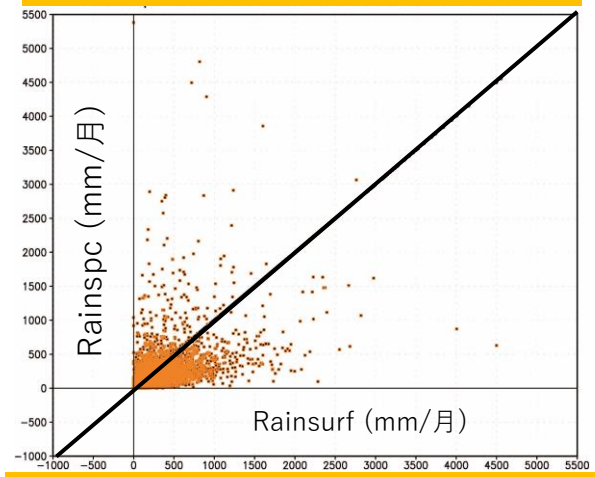
V03(EXP180403_210922)

Using statistical precip-related models

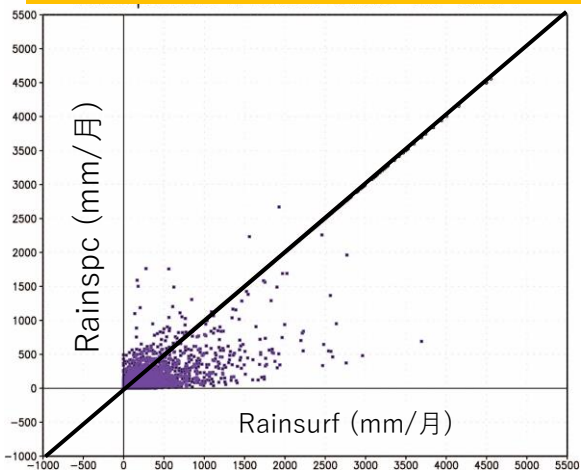
Difference of Rainspc-rainsurf monthly precip over land & coast



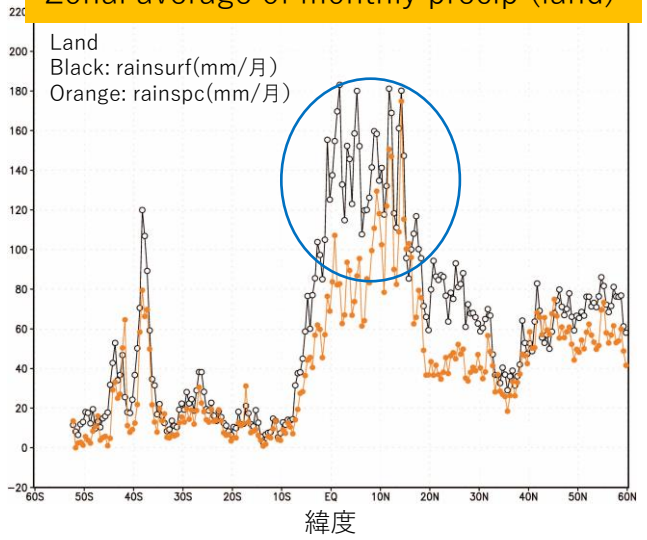
Scattering of monthly precip (land)



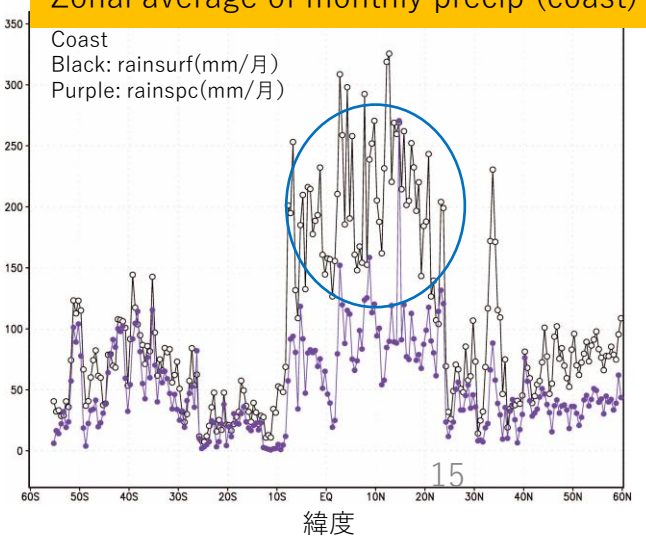
Scattering of monthly precip (coast)



Zonal average of monthly precip (land)



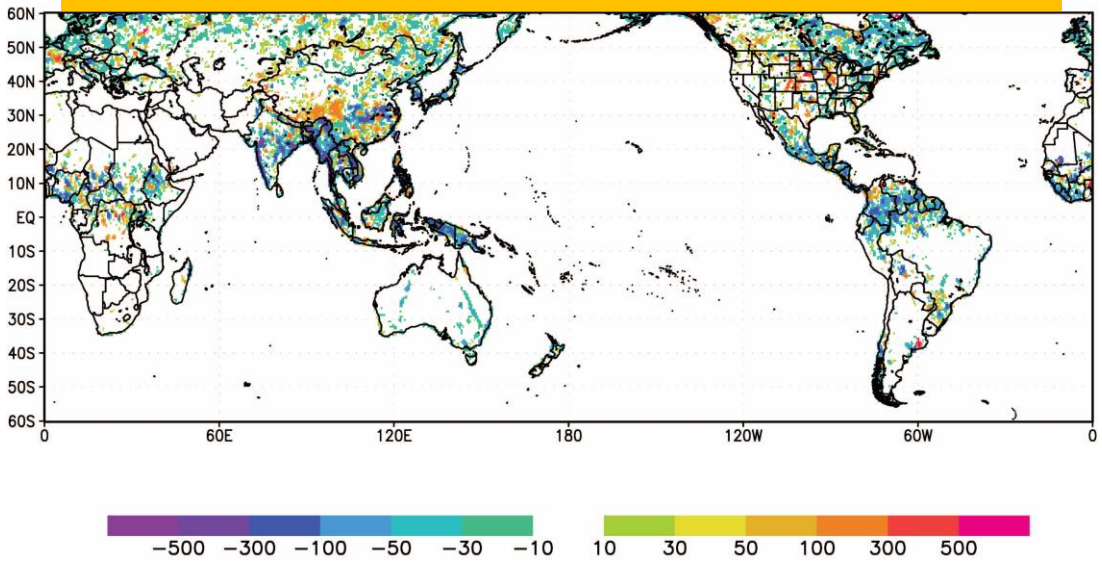
Zonal average of monthly precip (coast)



5. Validation using DPR MS data：V05(EXP210617) (Over land and coast, June-August 2014)

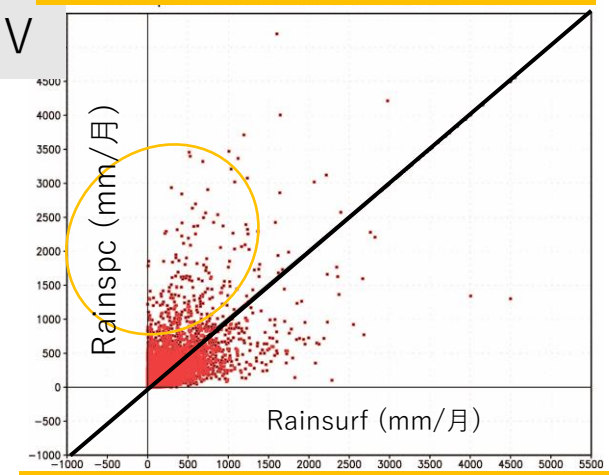
V05(EXP210617): Current version
Change precip-profiles and densities using FPD_ENV

Difference of Rainspc-rainsurf monthly precip over land & coast

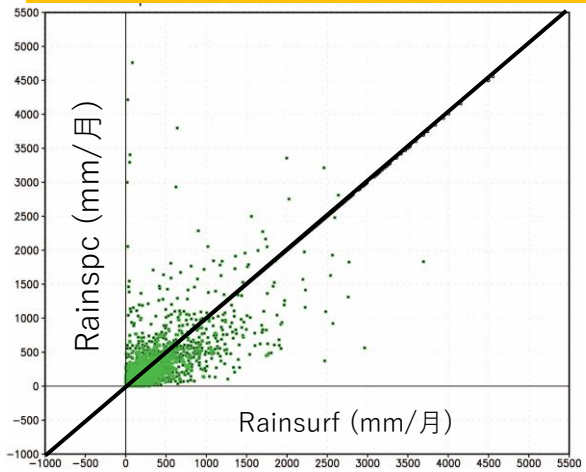


Introducing FPD_ENV in the forward cal. reduced errors in zonal averages.

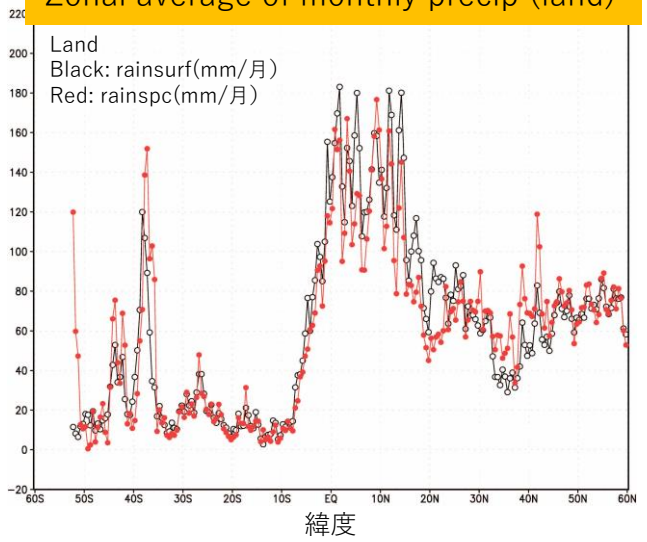
Scattering of monthly precip (land)



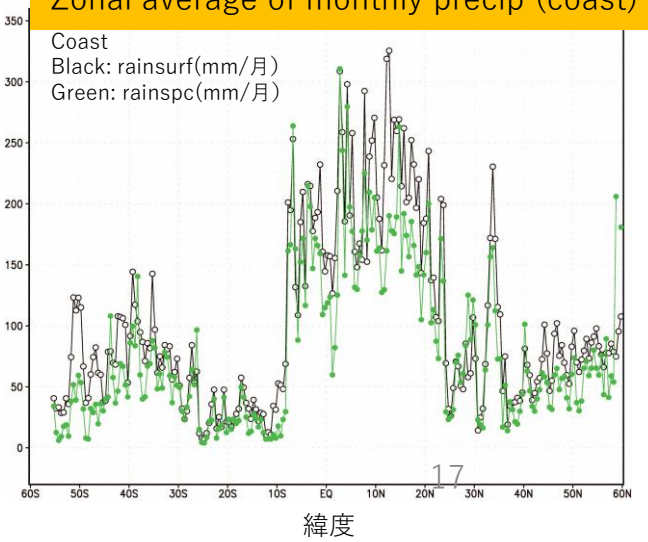
Scattering of monthly precip (coast)



Zonal average of monthly precip (land)



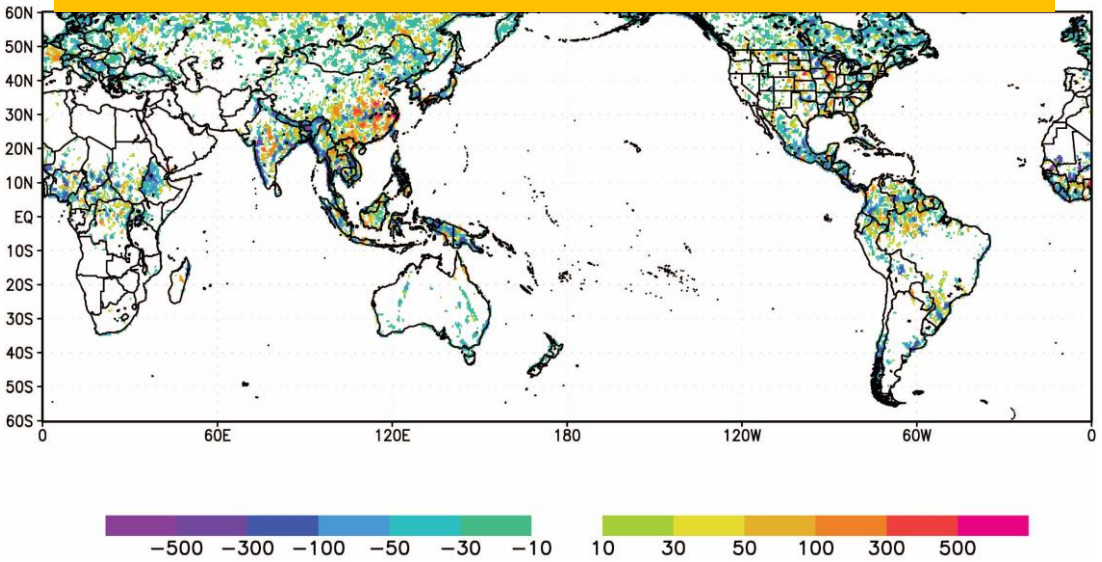
Zonal average of monthly precip (coast)



5. Validation using DPR MS data：V06(EXP210929) (Over land and coast, June-August 2014)

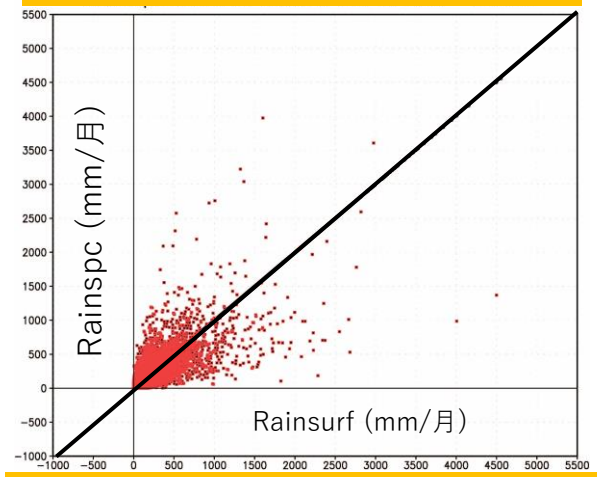
V06(EXP210929)：
V05＋Correction using ratioCPpix & FPDpix

Difference of Rainspc-rainsurf monthly precip over land & coast

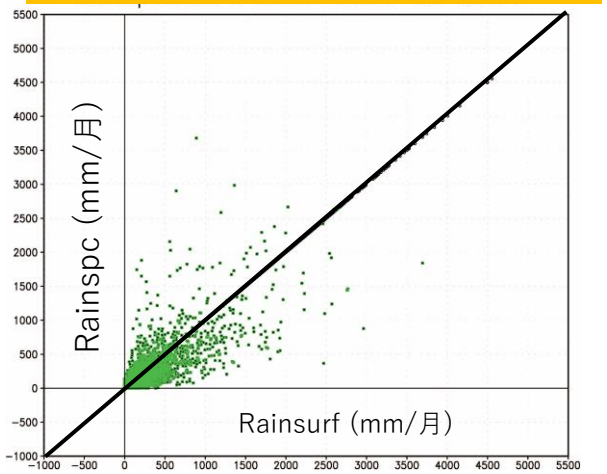


Correction using ratioCPpix and FPDpix reduced random error of rainspc.

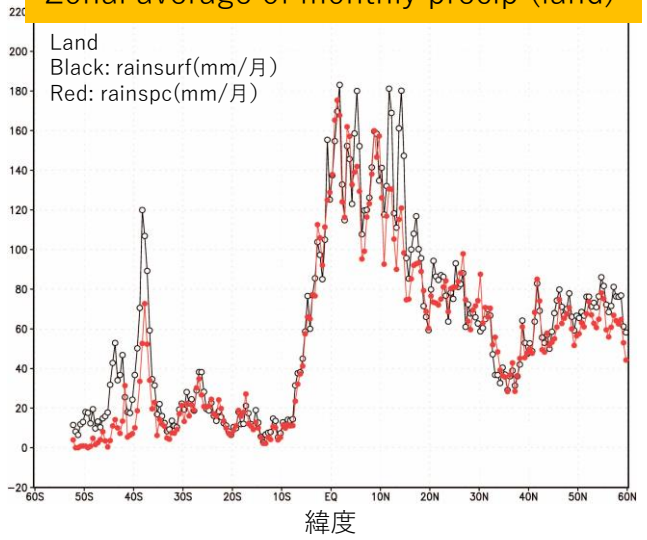
Scattering of monthly precip (land)



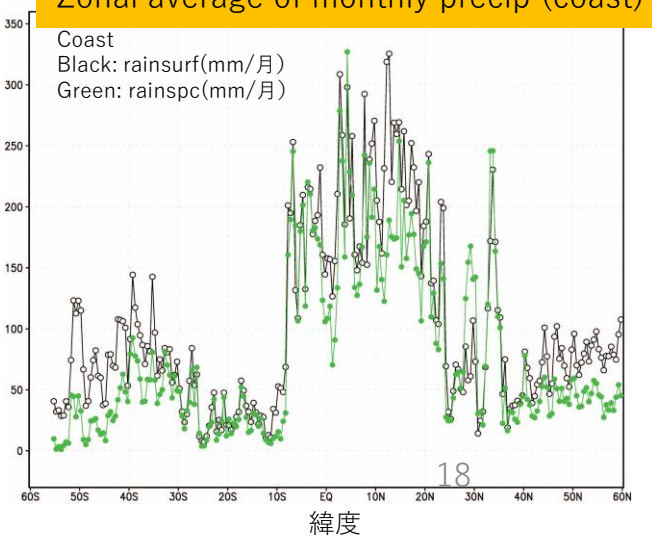
Scattering of monthly precip (coast)



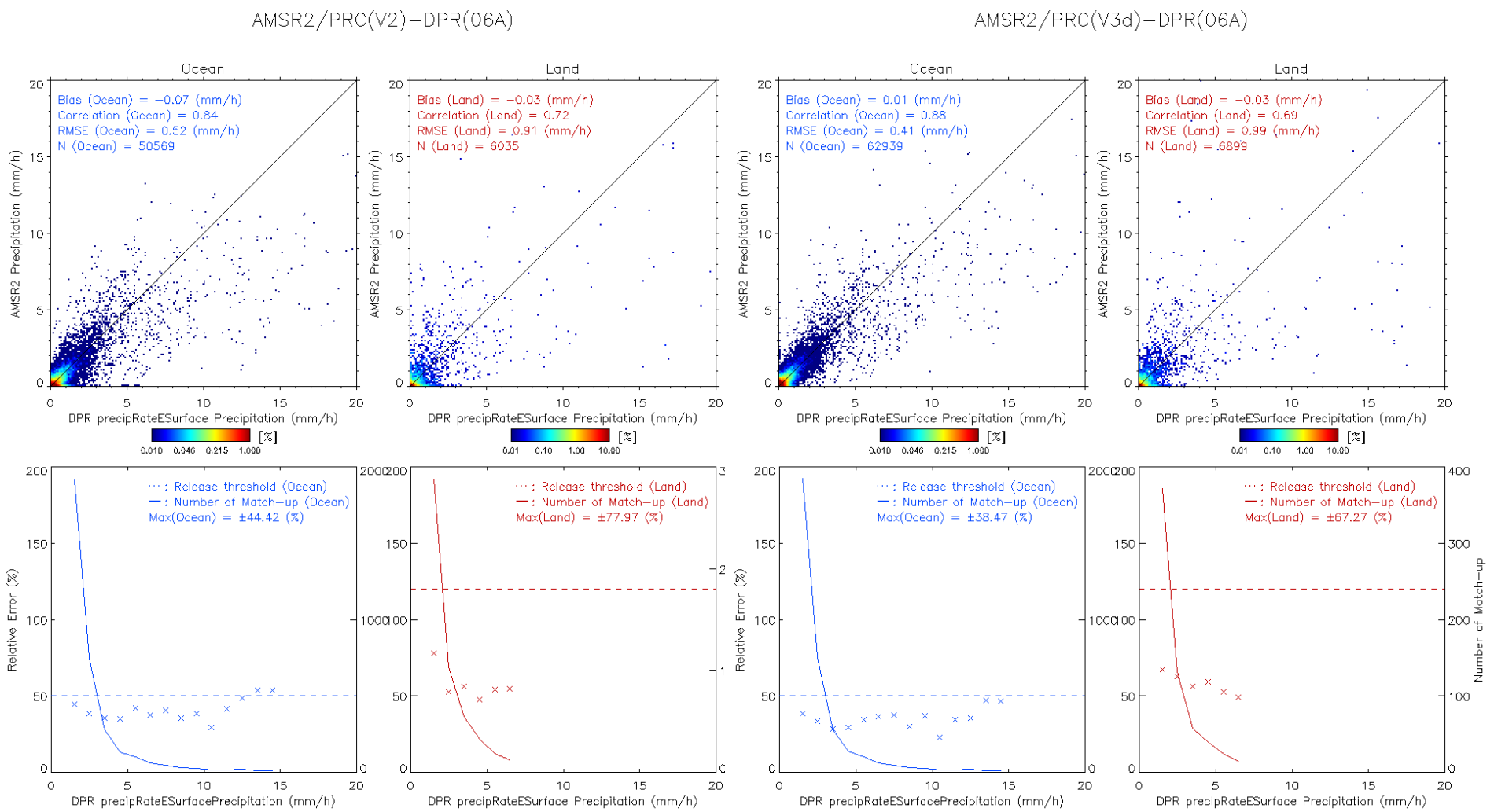
Zonal average of monthly precip (land)



Zonal average of monthly precip (coast)



Area:All 2014/07,10 2015/01,04



AM2 PRC: V2
DPR Ver: 06A

Relative Error (ave)
Sea : 41.75 (%)
Land : 65.61 (%)

AM2 PRC:
EXP211026
DPR Ver: 06A

Relative Error (ave)
Sea : 35.91 (%)
Land : 63.26 (%)

Summary

- We investigated the relationship between the scattering bias of the conventional GSMaP algorithm and the precipitation characteristics observed with the DPR. The results show that the scattering bias is highly correlated with the frozen precipitation depth (FPD). The larger the convective precipitation fraction (ratioCP), the larger the variation of the precipitation bias with FPD.

- We developed a new scattering algorithm that considered FPD, ratioCP.

1)We estimated indices of FPD from the surface precipitation rate, the temperature lapse rate and RH in the middle and lower troposphere and ratioCP from the non-uniformity of precipitation estimated from MWI TB and the polarization difference at 89 GHz.

2)Using the index of FPD for every 5 degrees of latitude and longitude in the forward calculation part, we introduced the variation of precipitation profile and density of frozen precipitation particles.

3)The scattering retrieval values were statistically corrected in the retrieval part using the ratioCP and FPD indices for each pixel.

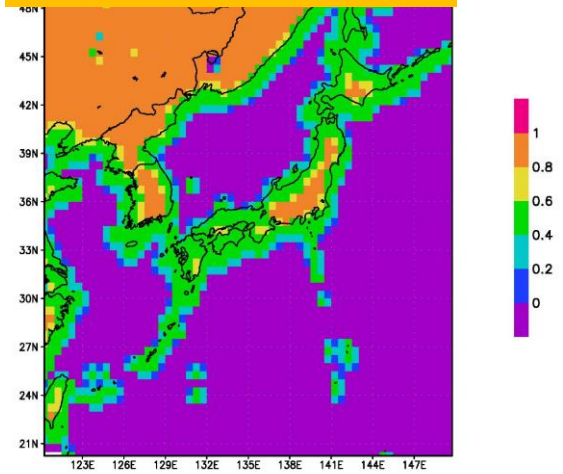
END

- Thank you for your attention

backup

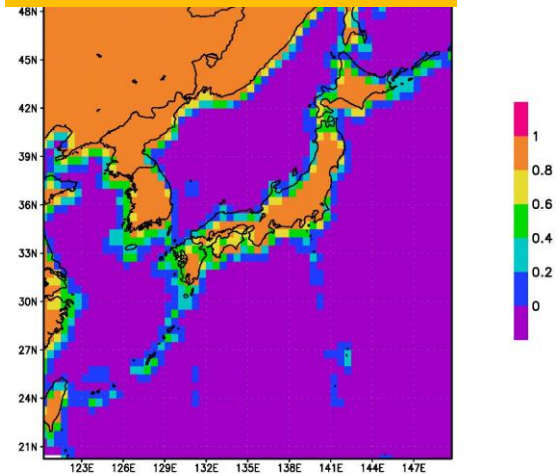
Improving over-coast retrieval

Ratio of Land 10GHz FOV
V04 (Jul. 2014)

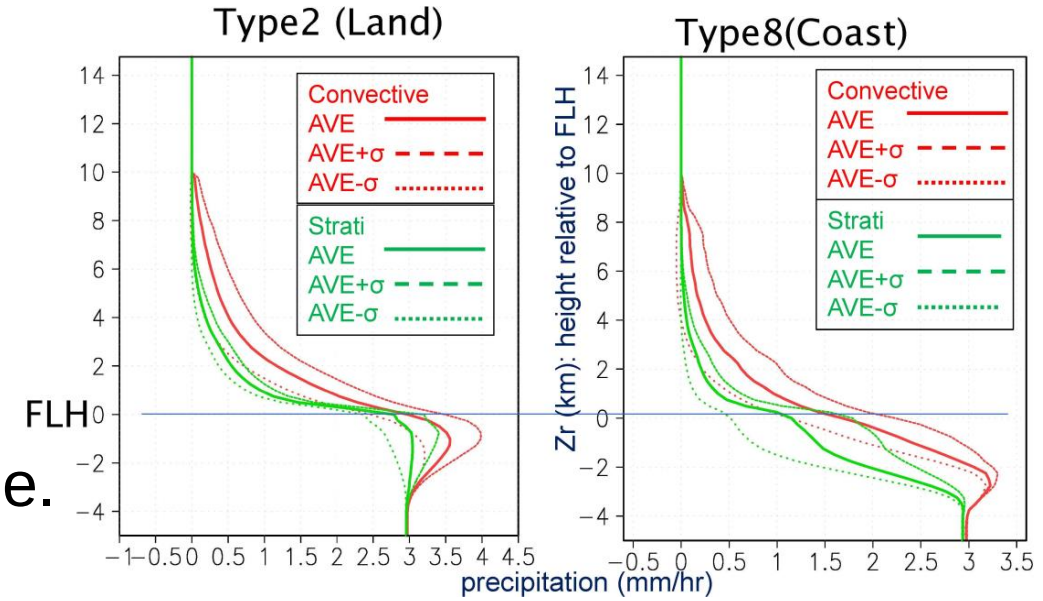


1)Reduce “coastal” pixels in V05 using dynamic LO flag.
（Mega and Shige, 2016)

Ratio of Land 10GHz FOV
V05 (Jul. 2014)



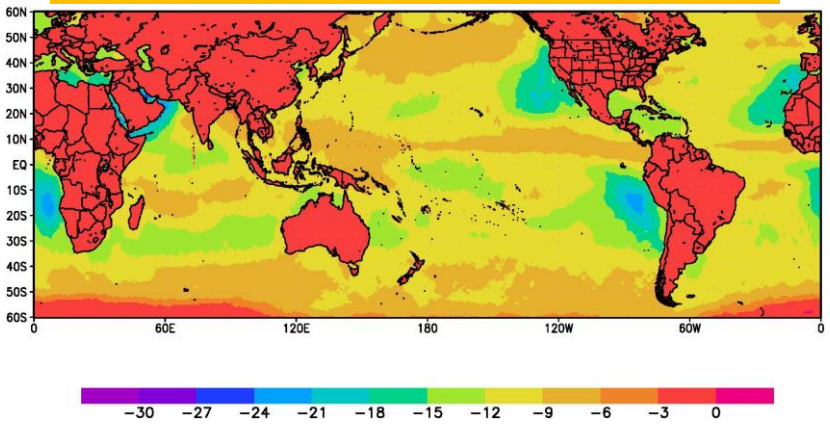
2) Introduce coastal precipitation types and profiles to V05 Data Base.
Use new DBs within 200km from coastal line.



Bias correction of TBc (0 mm h-1) using TBo

1) Rain-free MWI TBo (TB_nr) is detected with the screening algorithm.
2) Averaged biases (5 x 5 deg) are calculated between (TBc (0 mm h-1) and TB_nr.
3) TBcs are corrected with the averaged biases.

Monthly ave. of GMI TB18v bias (Jul. 2014)



Monthly ave. of GMI TB23v bias (Jul. 2014)