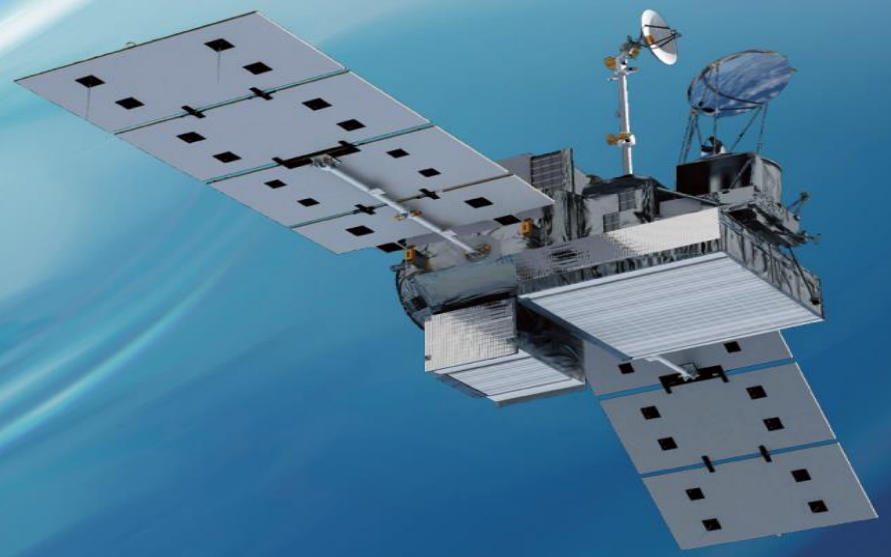
# JAXA GPM Science Status



**Yukari N. Takayabu**

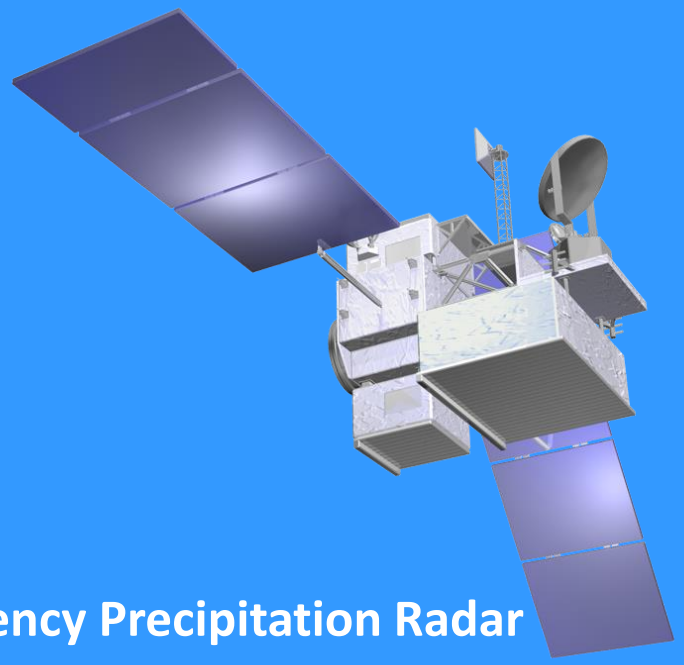
***University of Tokyo***

**NASA PMM 2020**

Online | October 20, 2020

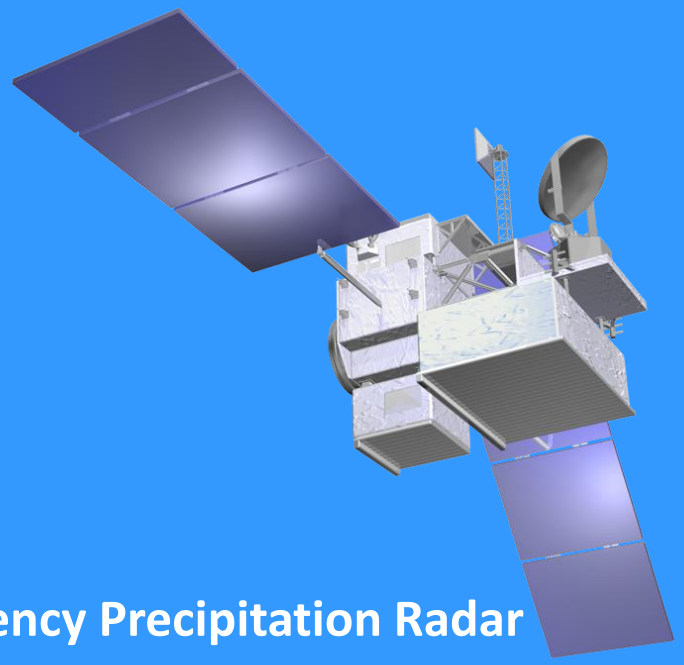
# JAXA PMM 33 proposals

1. Precipitation Studies with GPM DPR
2. Validation Studies
3. Assimilation Studies



GPM Dual Frequency Precipitation Radar

# Precipitation Studies with GPM DPR

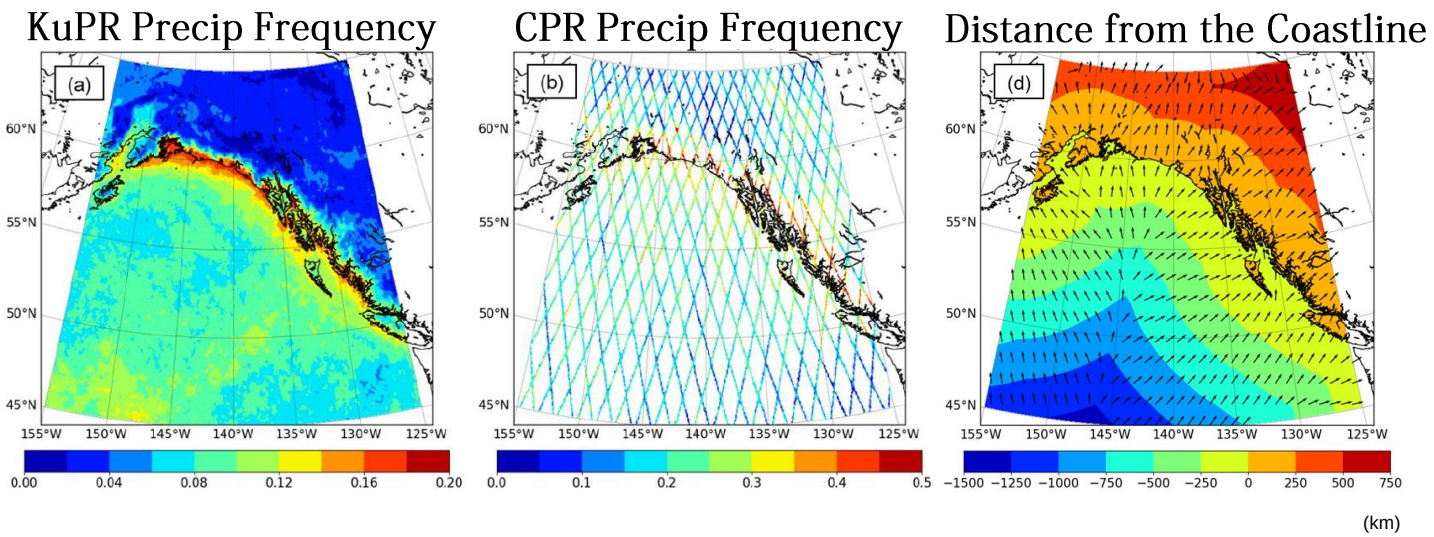


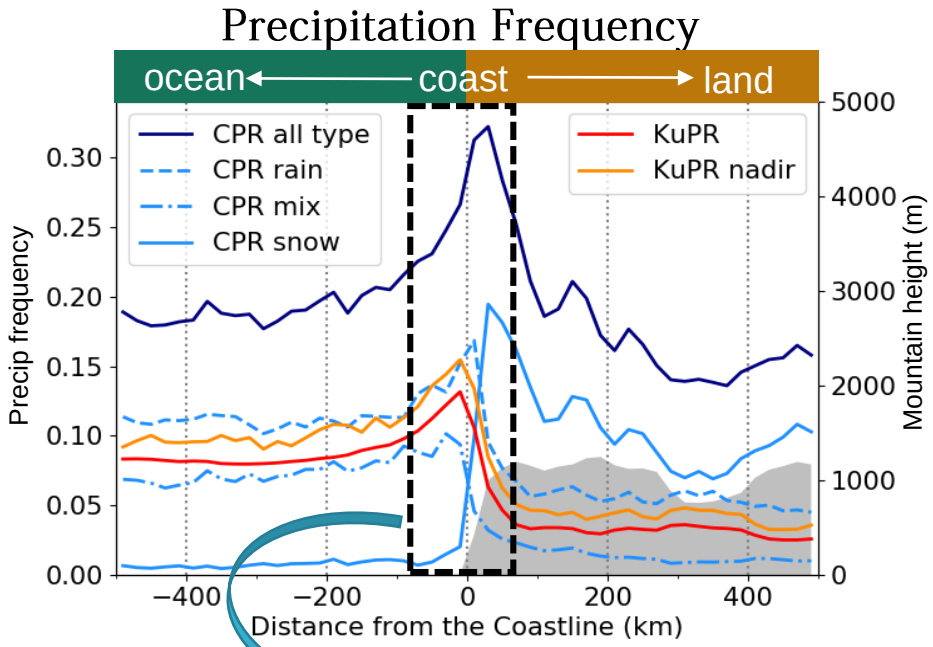
GPM Dual Frequency Precipitation Radar

# Large Precipitation Gradients along the South Coast of Alaska

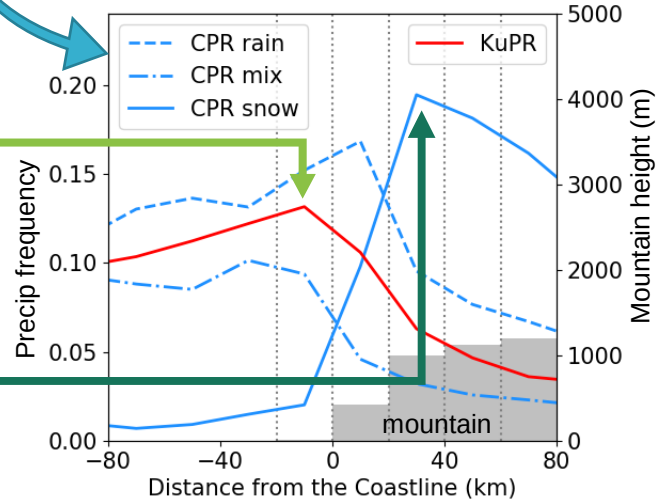
Shoichi Shige (Kyoto Univ)

Aoki, S., and S. Shige, 2021: Large Precipitation Gradients along the South Coast of Alaska Revealed by Spaceborne Radars, *J. Meteor. Soc. Japan*, **99**, https://doi.org/10.2151/jmsj.2021-001.




- Precipitation climatology obtained from GPM DPR KuPR and CloudSat CPR are shown as a function of the distance from the coastline.




Over ocean, **rainfall** and **mixed phase precipitation**, which are captured by both KuPR and CPR, bring relatively large amount of precipitation (having a peak on the **coastal waters** [-20 – 0 km]) as moisture flows are blocked by terrain.

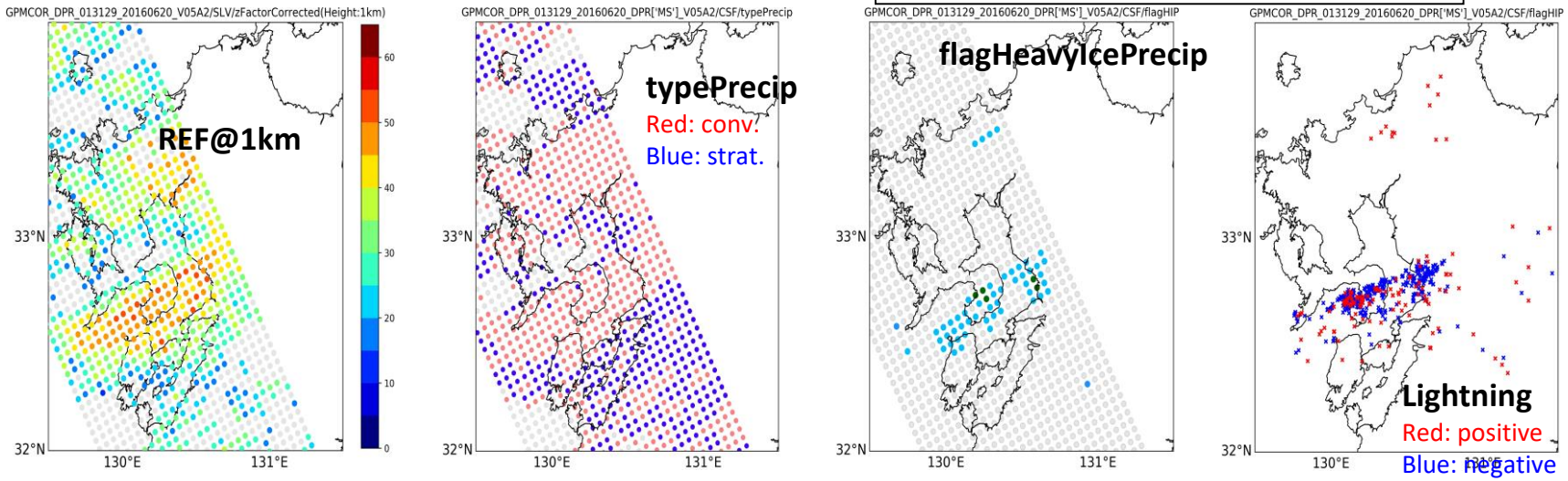
Over land, **light-to-moderate snowfall**, which is well detected by the CPR but rarely detected by KuPR, frequently occur (having a peak on the **coastal mountains** [20 – 40 km]). They are mainly brought by nimbostratus clouds advected from the coast by strong cross-barrier component of winds.

# “flagHeavyIcePrecip” and lightning activity

Kenji Suzuki (Yamaguchi Univ)

“flagHeavyIcePrecip” corresponds to lightning concentration.

**Case 1**: Baiu frontal heavy rain on 20 June 2016

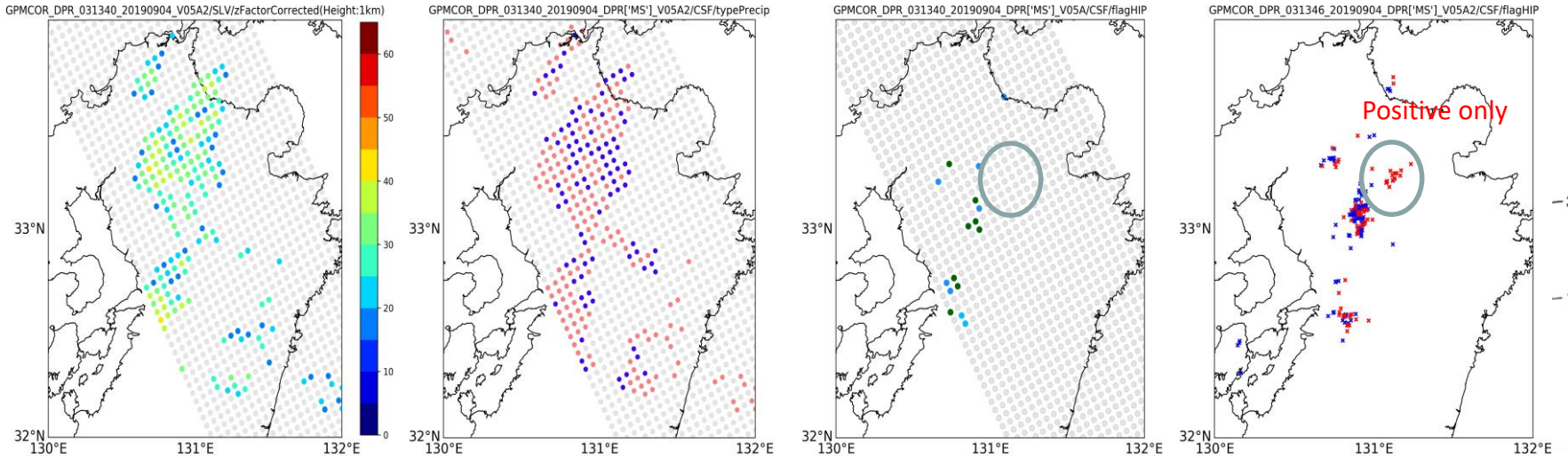



Two case studies: We confirmed that **“flagHeavyIcePrecip” may give us information on lightning activity**.

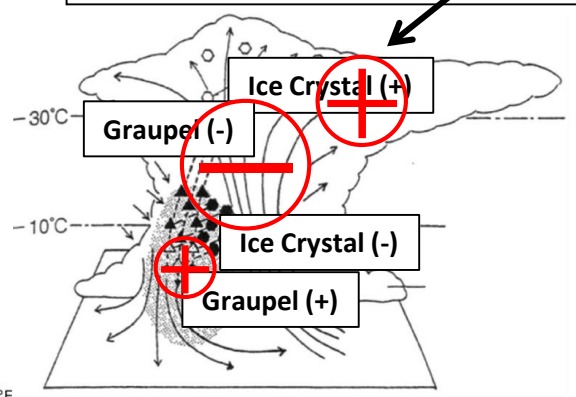
Future works: Comparison with **“BinMixedPhaseTop”** and **“flagGraupelHail”**

Now, other 26 cases that GPM/DPR observed thunderstorms during warm season from 2014 to 2020 in Japan are being investigated.

**Case 2**: Local afternoon thunderstorm on 4 September 2019




Absence of “flagHeavyIcePrecip” may indicate positive charge in upper layer.




Takahashi et al. (1999)

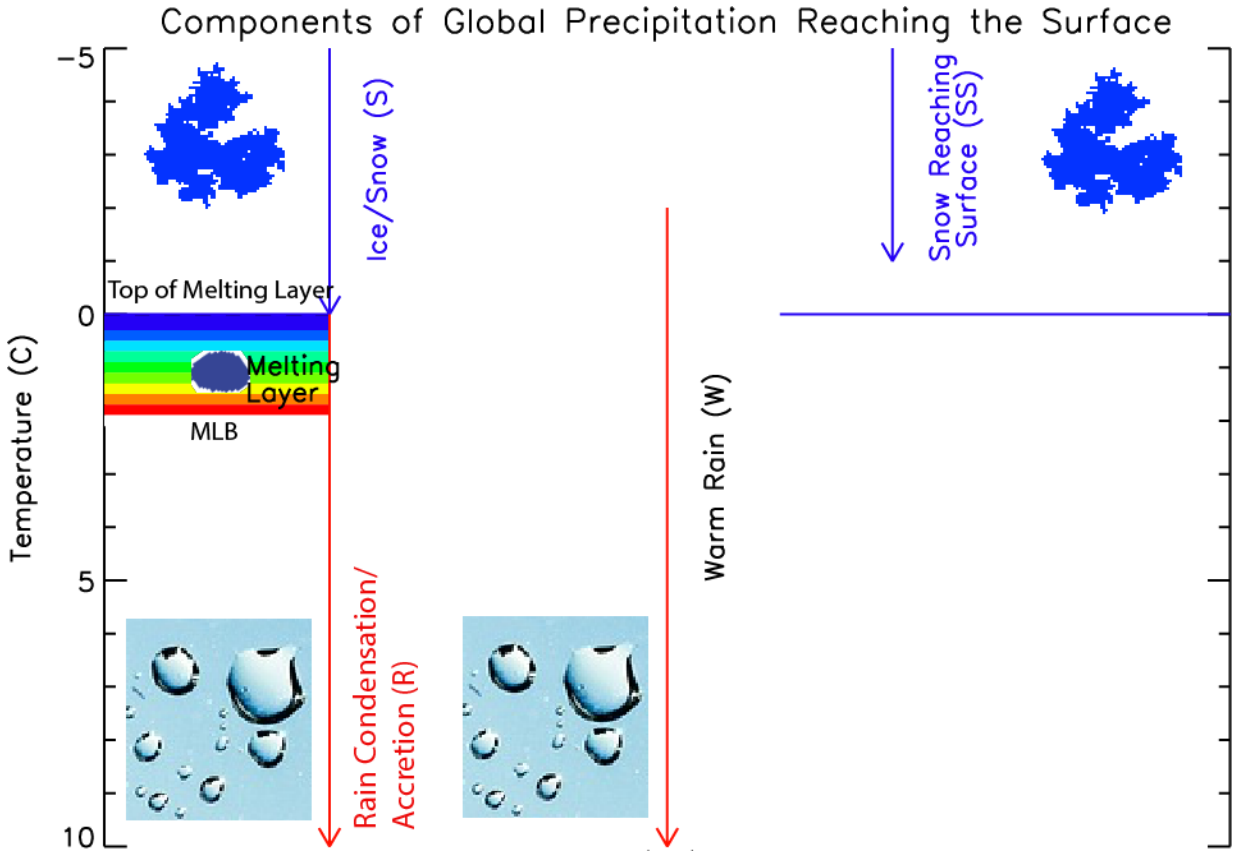
# Contributions of the Liquid and Ice Phases to Global Surface Precipitation: Observations and Global Climate Modeling

A. Heymsfield et al. 2020 JAS

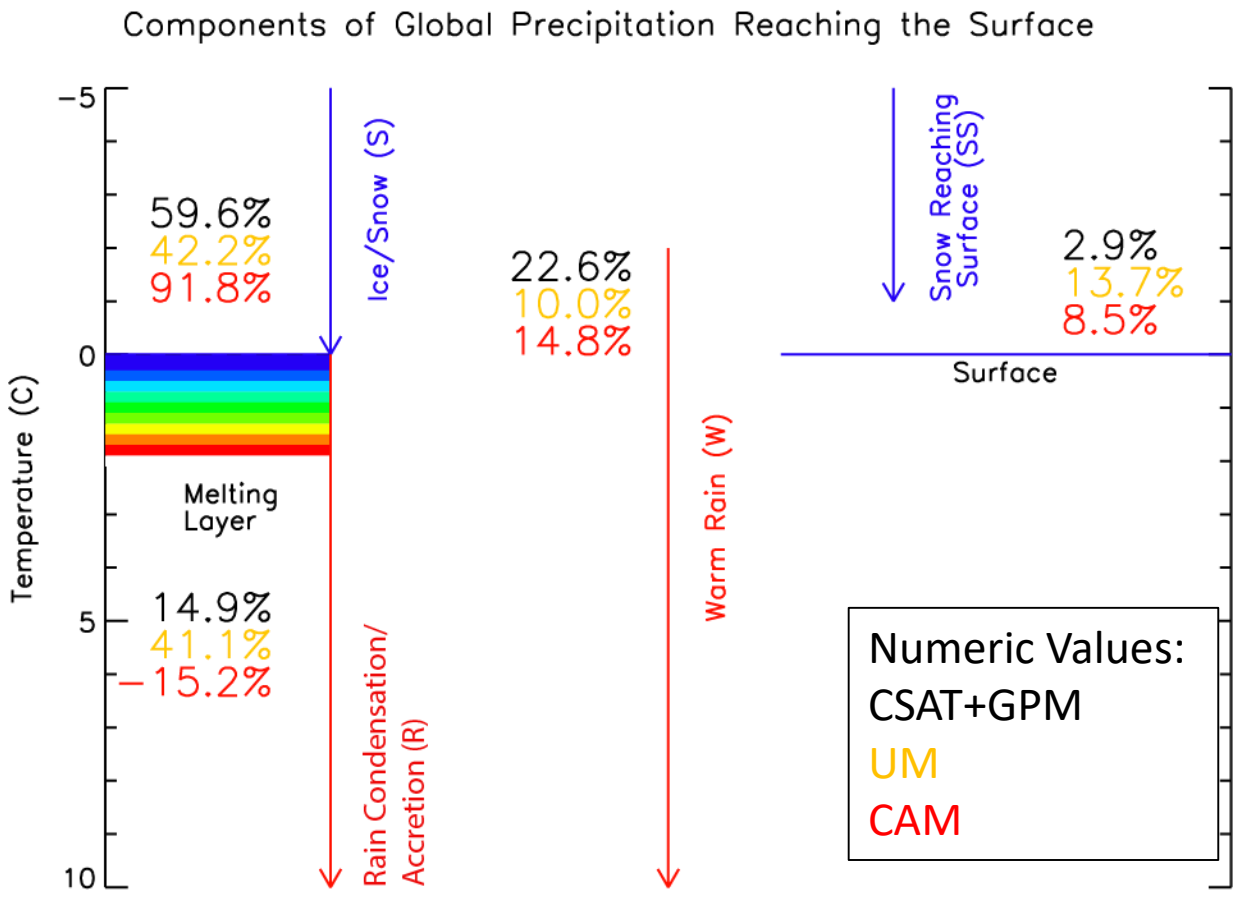
(1) precipitating ice (ice/snow/graupel) that forms above the freezing level and melts to produce rain (S) ~57%
followed by additional condensation and collection as the melted precipitating ice falls to the surface (R) ~15%

(2) growth completely through condensation and collection (coalescence), warm rain (W) ~23%

(3) precipitating ice (primarily snow) that falls to the surface (SS) ~5% with an uncertainty of +/– 5%



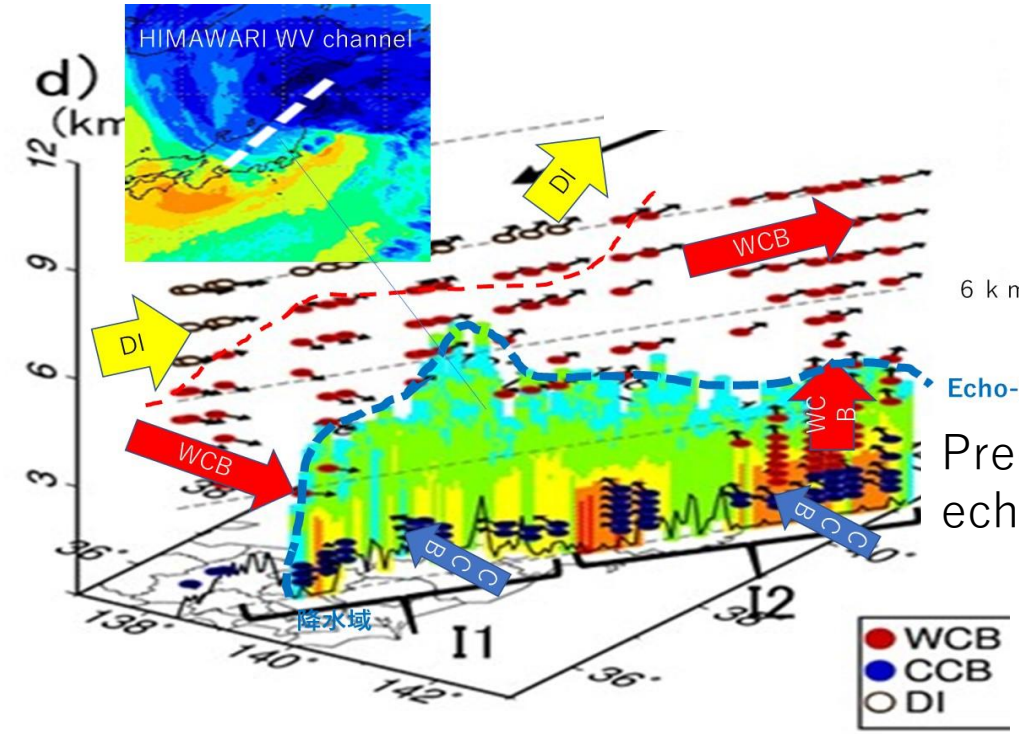

(S)~57% (R)~15% (W)~23% (SS)~5%

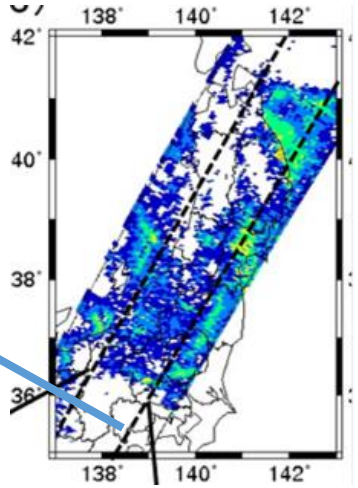


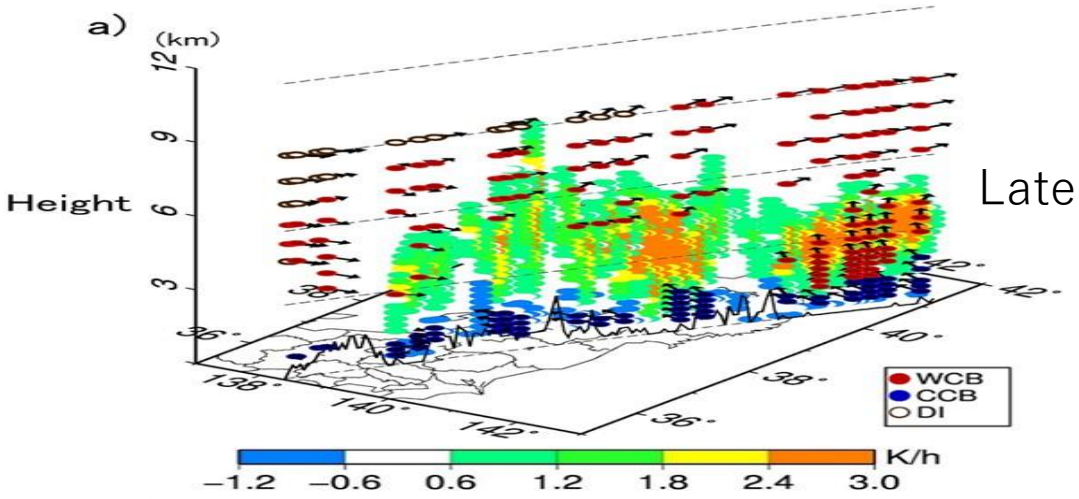

Surface Precipitation (PR)= S +R +W +SS

# Stagnation of the stratiform precipitation with higher echo-top

Sawada and Ueno (2020, submitted to JMSJ special issue)



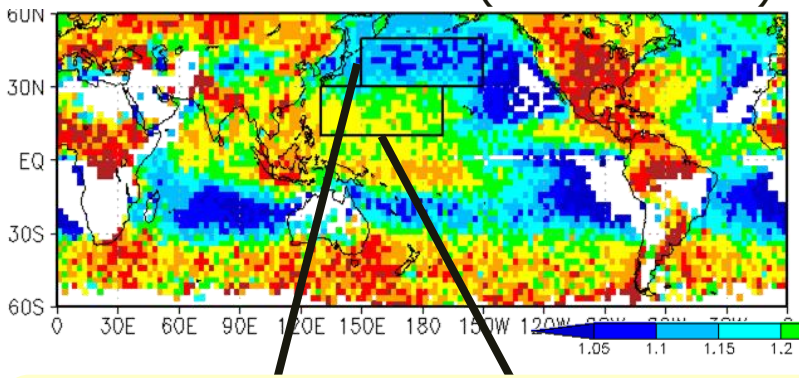

Captured a very detailed structure of an extratropical storm, a stagnation of the stratiform precipitation with higher echo-top, by a trajectory analysis originated from a DPR cross section, over the Japanese mountain range. This structure appears as a result of conveyor belt deformation in the occluding stage.

This structure may be a reason for the over-estimation of the GSMaP rain in the preceding stratiform precipitation of the extratropical cyclones.

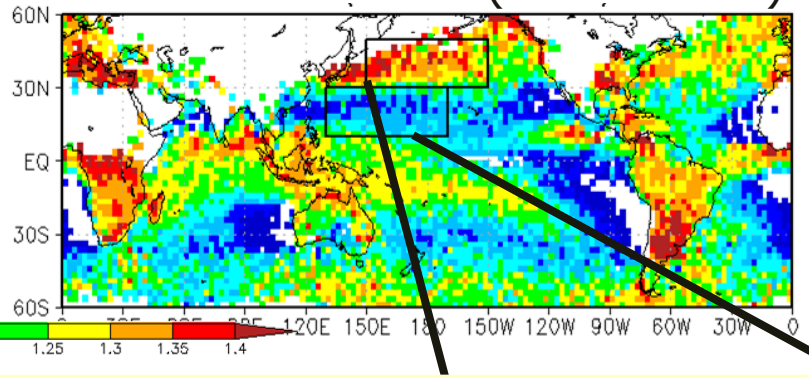
# Global Drop Size Distribution and its seasonal variations derived by DPR

Yamaji et al. (2020, JMSJ)

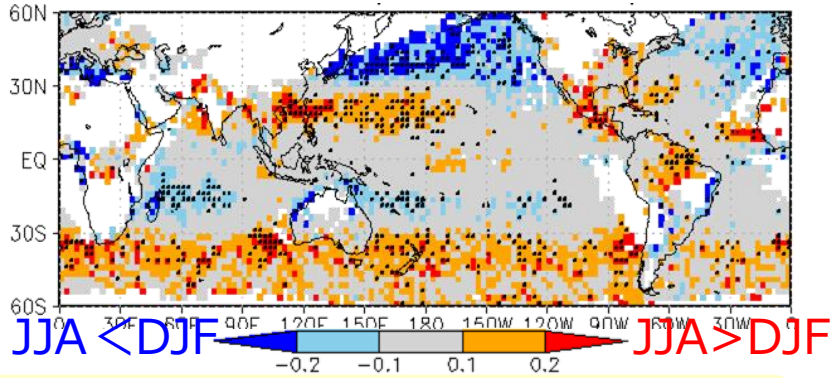
Diameter in **JJA** (2014-2018)




Diameter in **DJF** (2014-2018)



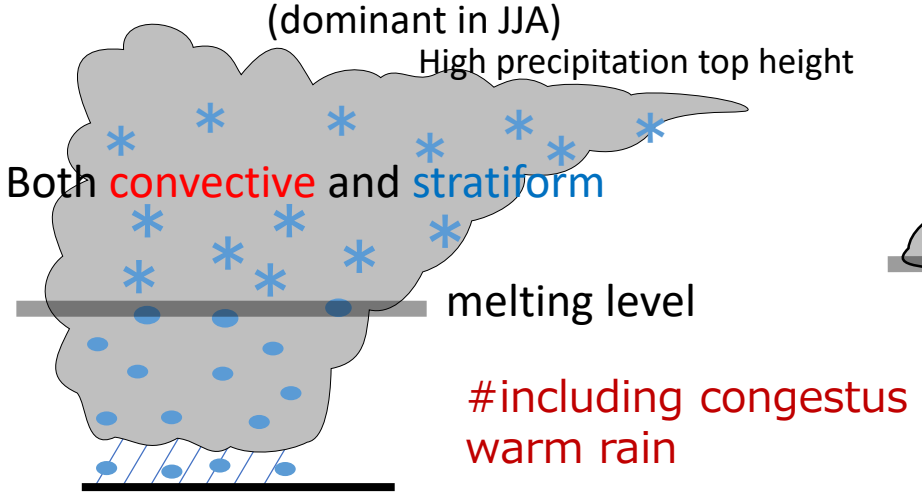

Diff. of Diameter in **JJA** - **DJF**




**Dm data in L2 product show statistically significant seasonal variations, which can be related to the changes in dominant precipitation systems.**

**Different Types of Organized Precipitation System**

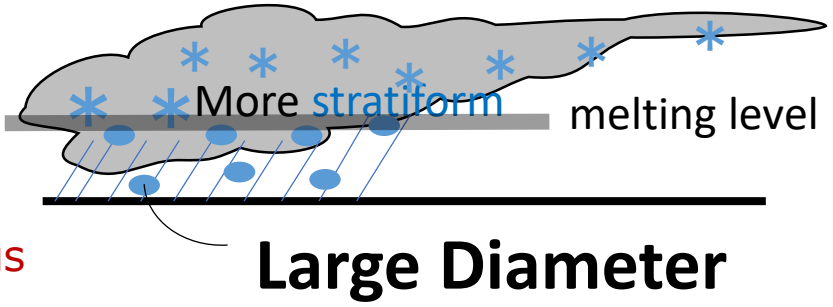
(dominant in JJA)




#Baiu #Squall lines #tropical storms

**Extratropical Frontal System**

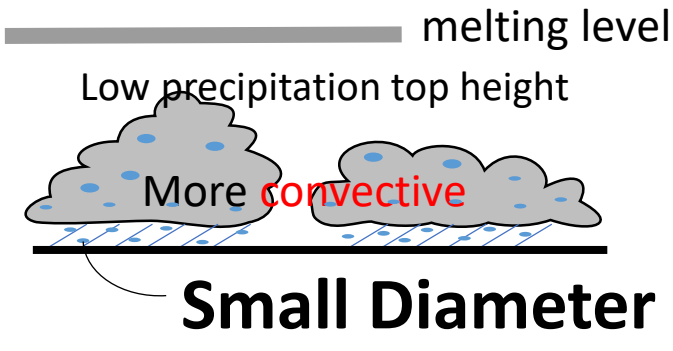
(dominant over mid-latitudes in DJF )




#with ice particles in upper level

**Shallow Convective System**

(dominant over subtropics in DJF )

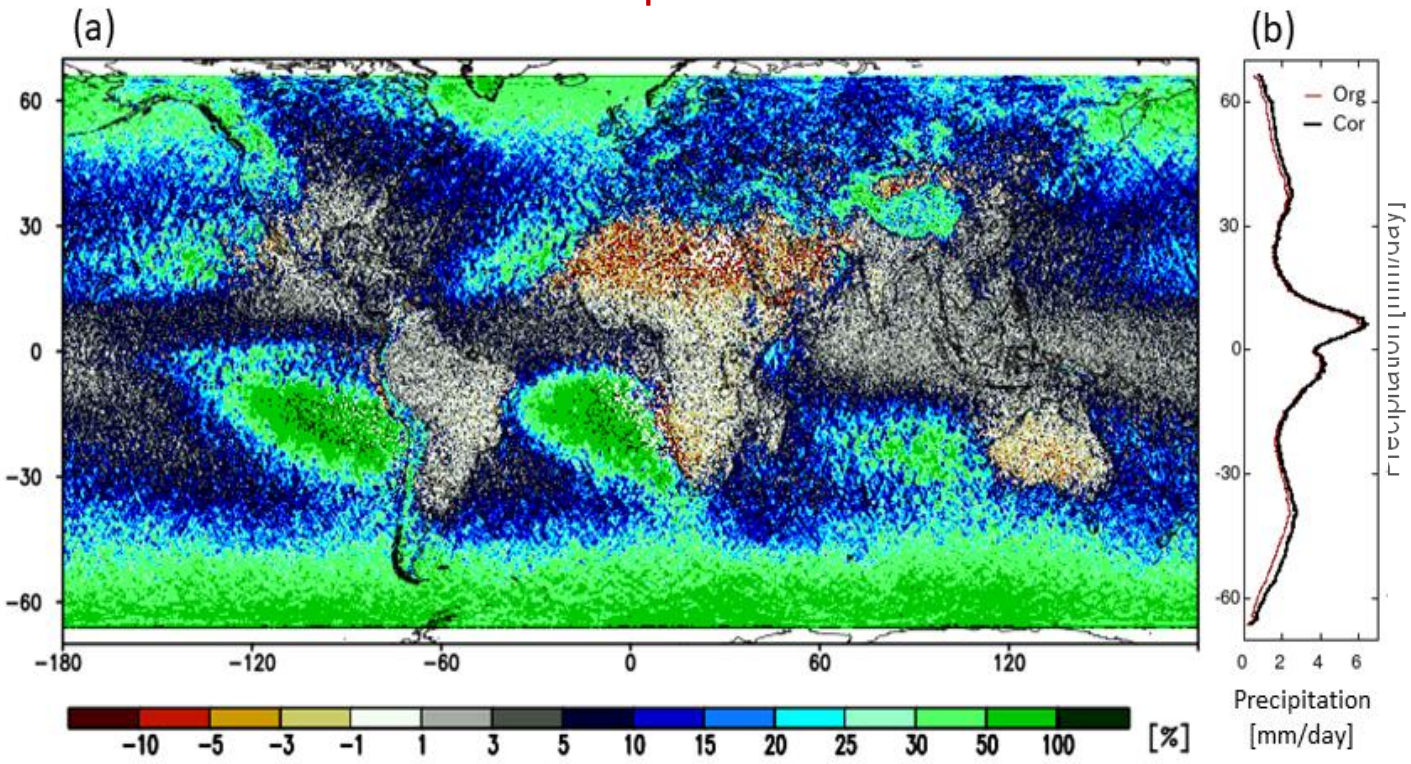



#Trade wind convections

# Correction of Low-level Precipitation Profiles and Missing Shallow Storms

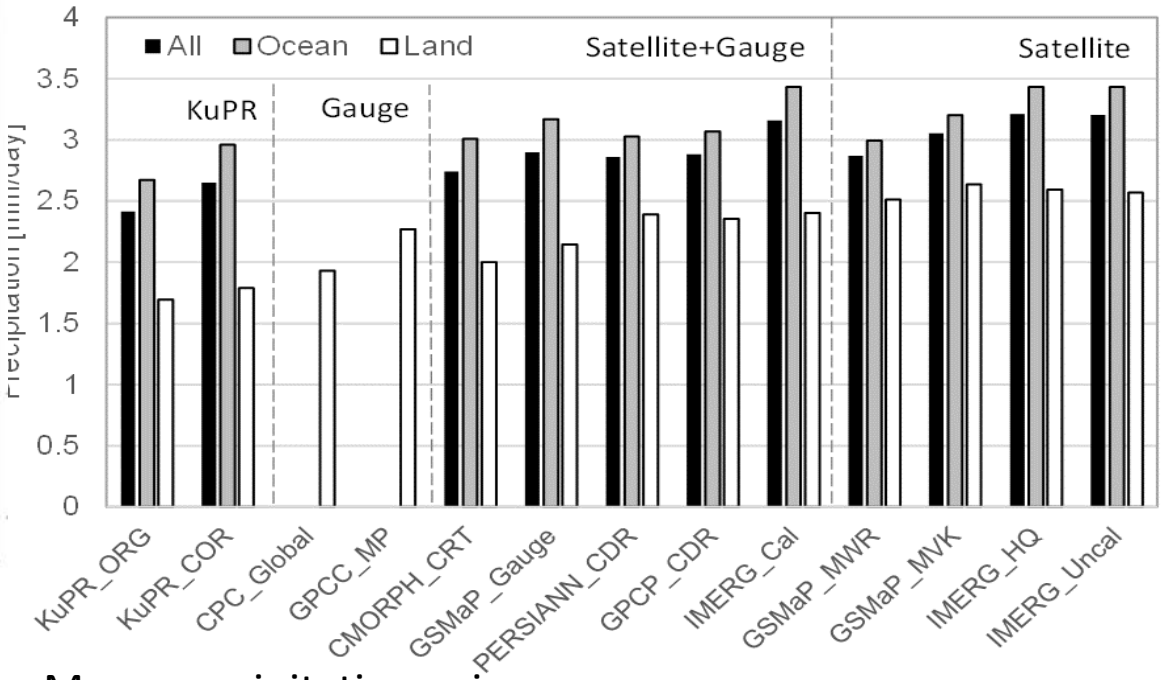
Masafumi Hirose (Meijo Univ)

- LPP correction increases precipitation over the regions where downward increasing precipitation profiles are dominant below 2 km, such as the high-altitudes and at the middle and high latitudes. **The LPP correction increases precipitation by ~5% over the globe.**
- **The correction for shallow precipitation deficiency (SPD) enhances precipitation by ~6% over the globe** and more than 50% over specific low-rainfall oceans in the sub-tropics and at high latitudes.




Map of the combined corrections (a) and the zonally-averaged precip. before and after the correction (b).

June 2014–May 2019, 60°N-S




Mean precipitation using KuPR w/o (KuPR_ORG) and w/ corrections (KuPR_COR), gauge-based observational data (CPC, GPCC), satellite-gauge-blended precipitation datasets, and satellite-only precipitation products

(Hirose et al., submitted to JMSJ)

# Spectral Latent Heating (SLH) V06B released in Aug.2020

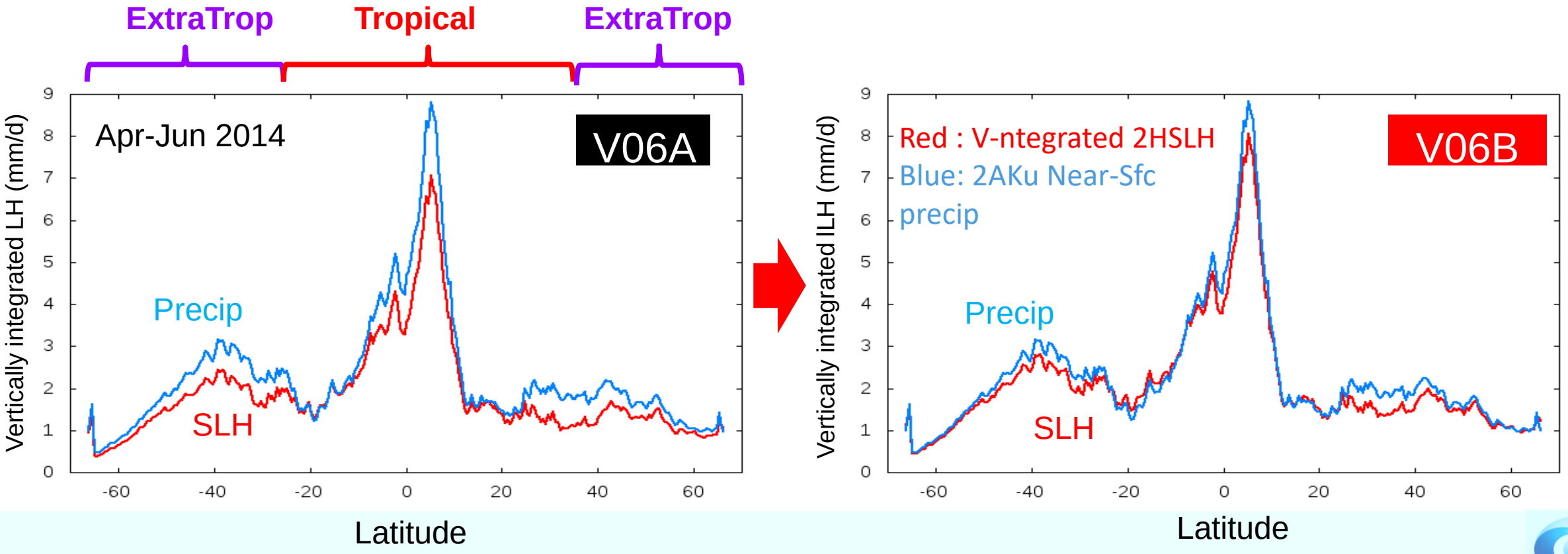
Yukari N. Takayabu

## 1. Tropical module

- Spurious cooling below the melting level of downward-increasing deep strat rainfall is removed.
- All shallow rains in the tropical region are reclassified as convective.

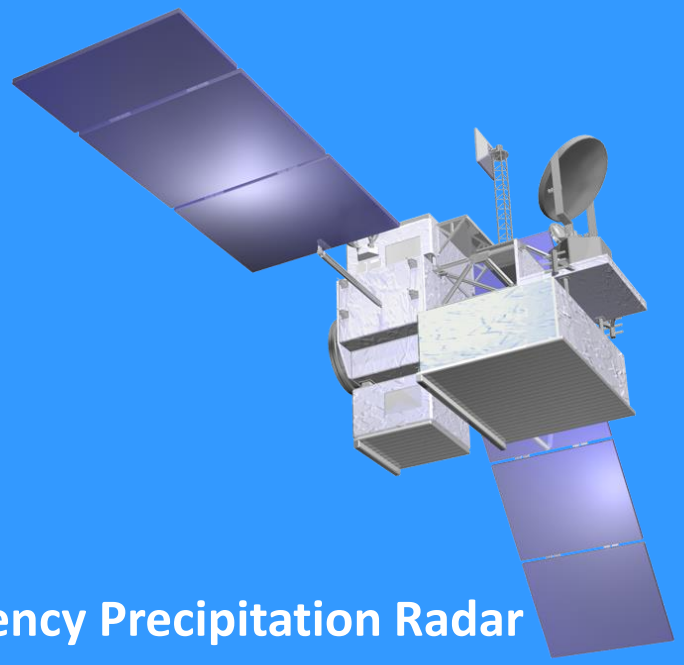
## 2. Extratropical module

- Obtained a correction factor ~0.88 for the effect of hydrometeors condensed outside of the rainfall regions and transported some distance into the rainfall regions and precipitate.




Underestimates of the SLH vs surface precipitation are mitigated

# Validation Studies



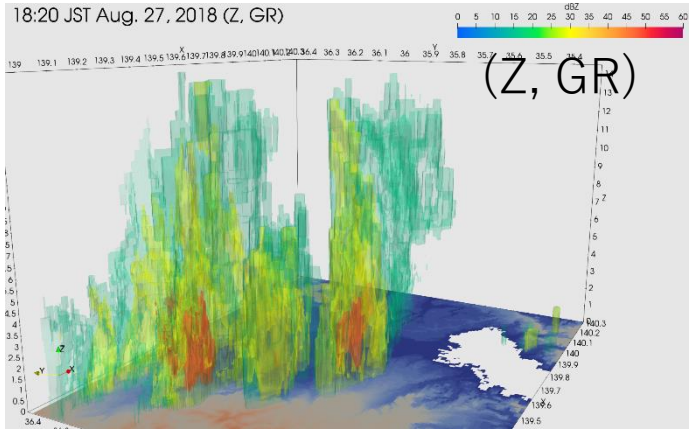
GPM Dual Frequency Precipitation Radar

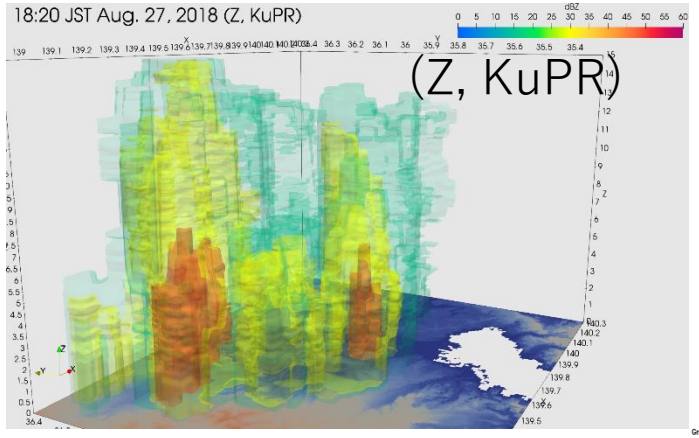
# Evaluation of cloud physical products by ground based radar

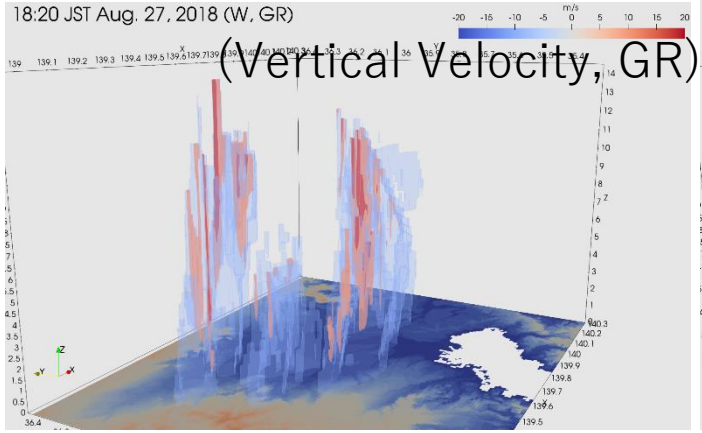
Nobuhiro Takahashi

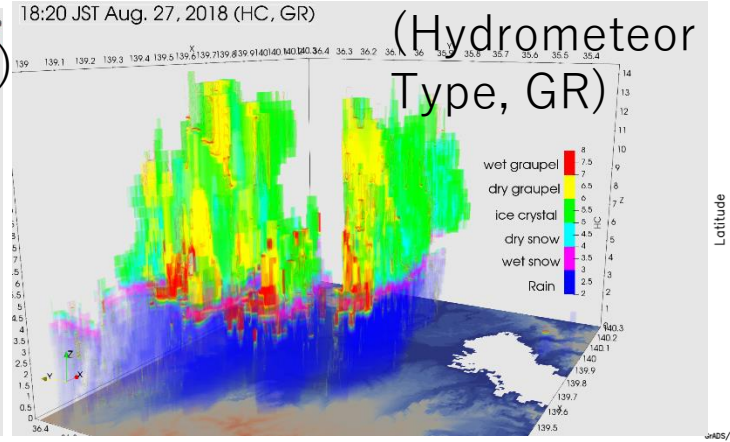
Comparison of cloud physical characteristics from DPR (HIP, liquid top, etc.) and ground based multi-parameter radar (XRAIN network).

- Liquid top (or mixed phase top) is estimated from the difference between DFR and DFRm.
- 3D structure of DPR is relatively wider than ground based observation because of larger foot print.
- HeavyIcePrecip (HIP) region well corresponds to the lightning area and also the region where the strong updraft and graupel are detected.

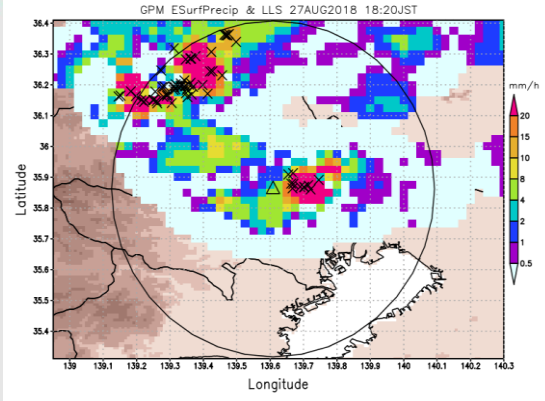


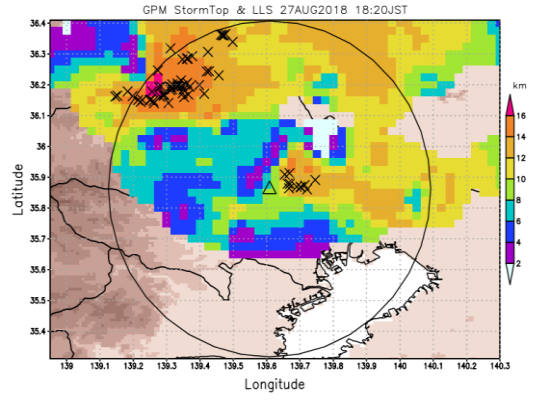



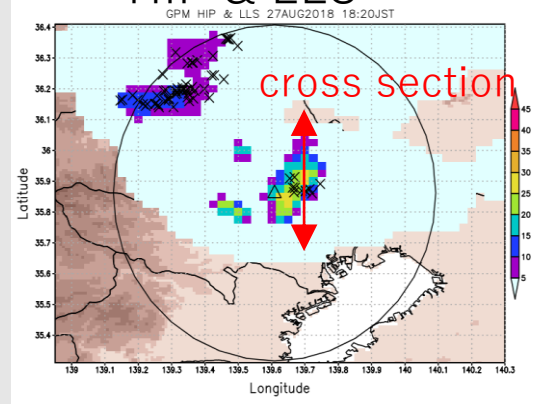

eSurfPrecip & LLS



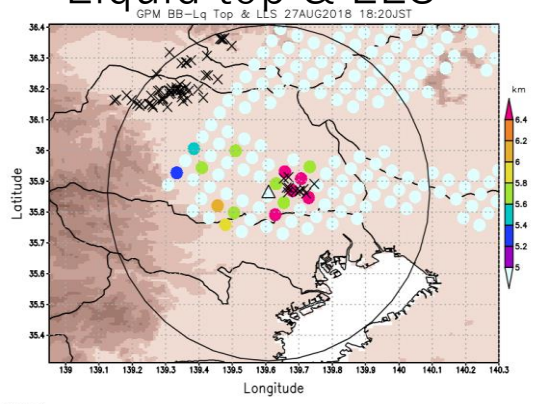

Storm top & LLS




HIP & LLS



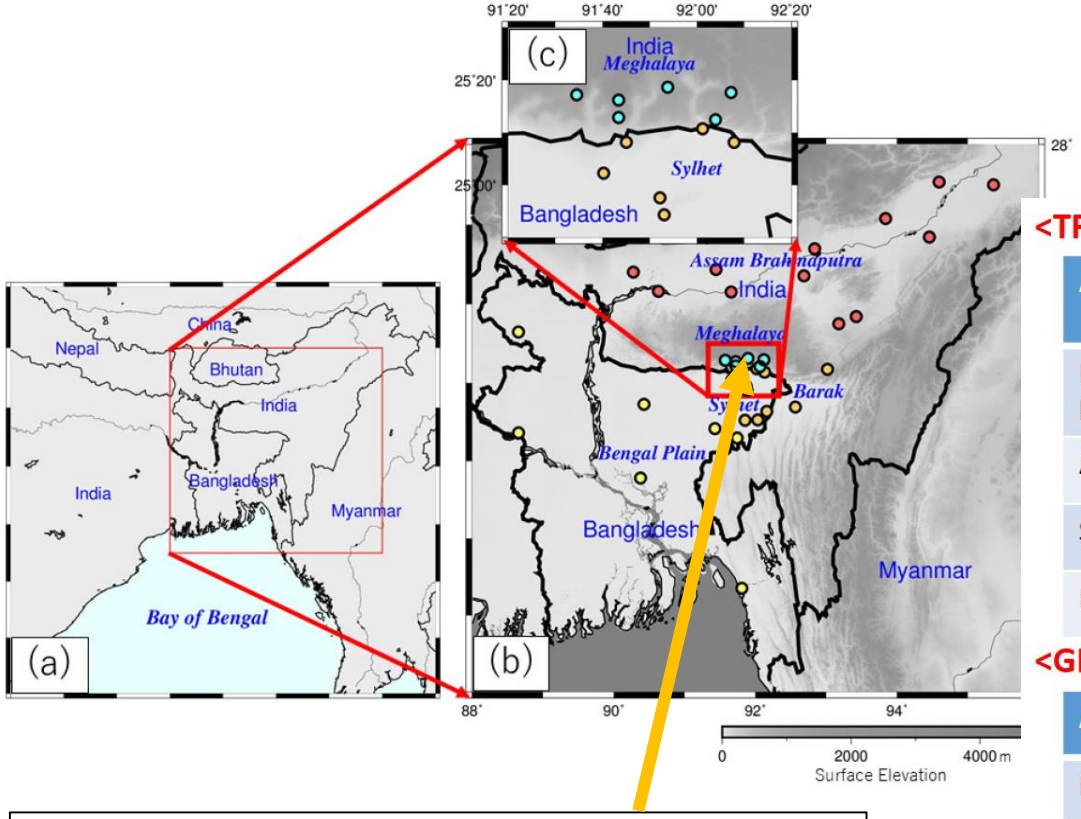

Liquid top & LLS




LLS: lightning location system. Data are provided by Chuden CTI.

# Validation of GPM DPR over the Orographic Heavy Rainfall in North-Eastern Indian Subcontinent

Fumie Murata, T. Terao, M. Kiguchi, Y. Yamane, A. Fukushima, T. Hayashi, H. Kamimera




World Record of CHERRAPUNJI
26,461 mm in 12 month
during August 1860 – July 1861

Comparison between TRMM/GPM radars and rain gauges during monsoon season (Jun.-Sept.) over NE Indian subcontinent based on the method described in Terao et al. (2017)

**<TRMM: Year2004 - 2014> significant underestimation over all area in 99% confidence level**

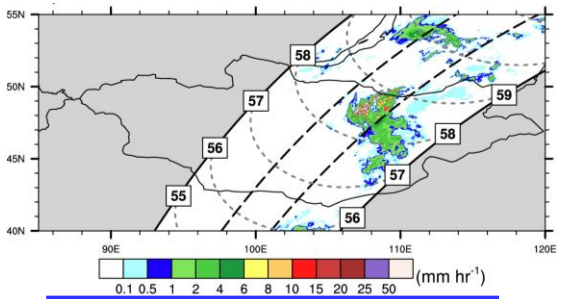
| Area | RG (mm/h) | SAT (mm/h) | SAT-RG(mm/h) | Bias (%) | Nobs | Nrain |
|---|---|---|---|---|---|---|
| Meghalaya/old | 2.23634 | 1.18311 | -1.05323 | **-47.0961** | 3842 | 722 |
| Assam | 0.42674 | 0.36002 | -0.0672 | **-15.6353** | 8422 | 878 |
| Sylhet+Barak | 1.03237 | 0.70460 | -0.32777 | **-31.7491** | 7445 | 1210 |
| BengalPlain | 0.44423 | 0.33498 | -0.10925 | **-24.5929** | 6186 | 571 |

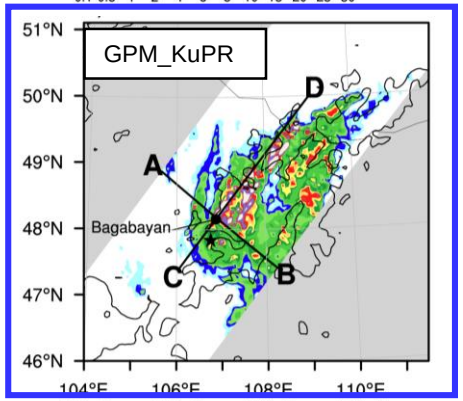
**<GPM: Year2014 - 2019> significant underestimation over only Meghalaya in 99% confidence level**

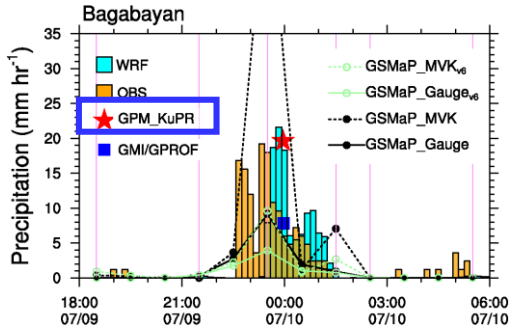
| Area | RG | SAT | Bias (%) | Nobs | Nrain |
|---|---|---|---|---|---|
| Meghalaya/old | 2.10077 | 1.23319 | **-41.2982** | 1171 | 271 |
| Meghalaya/new | 0.93491 | 1.13049 | +20.9200 | 507 | 84 |
| Assam | 0.45627 | 0.34613 | -24.1384 | 2893 | 333 |
| Sylhet+Barak | 0.92362 | 0.74999 | -18.7985 | 1715 | 296 |
| BengalPlain | 0.42857 | 0.58075 | +35.5092 | 1134 | 126 |

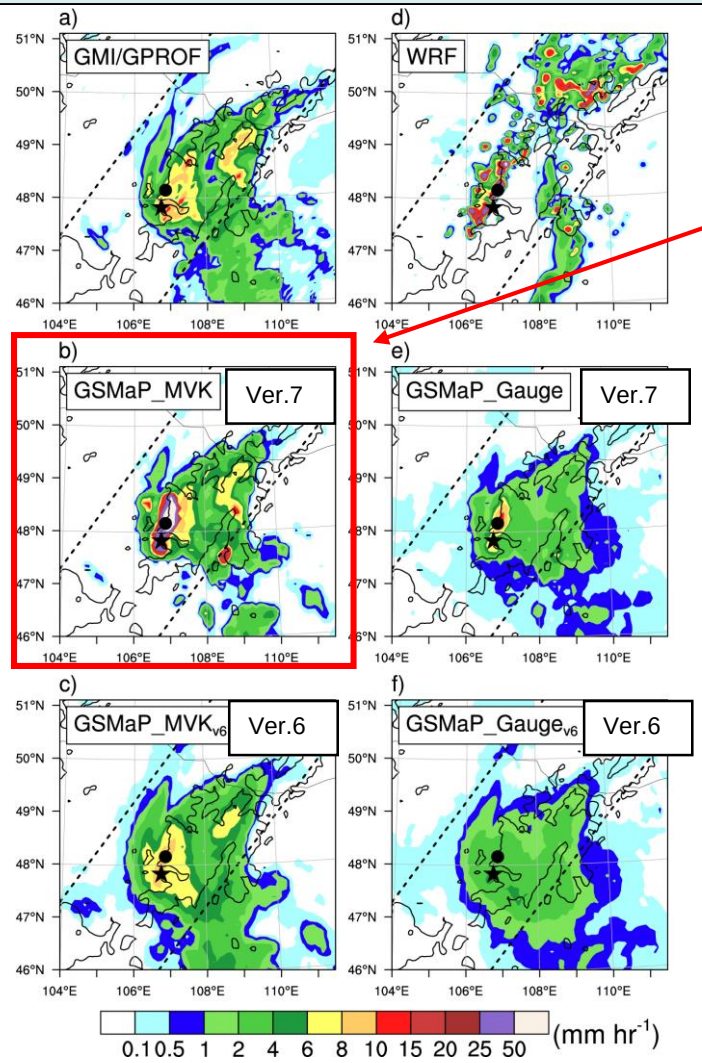
# A case-based comparison of summer precipitation over complex terrain in Mongolia as represented by GSMaP and the GPM core observatory in NEPTUNE-II

K. K. Komatsu, Y. Iijima, Y. Kaneko, and D. Oyunbaatar (submitted to JMSJ, *under revised review)*



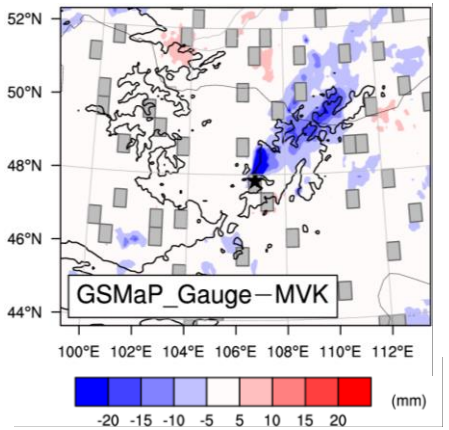




*Horizontal patterns and time series of the precipitation rate (mm hr$^{-1}$) estimated by GPM core observatory, GSMaP products, and numerical modeling.*
*Time series are based on the nearest grid point to the rain gauge station named Bagabayan.*

This study addressed the intercomparison of precipitation estimates of gauged and ungauged GSMaP with their algorithm versions 6 and 7.

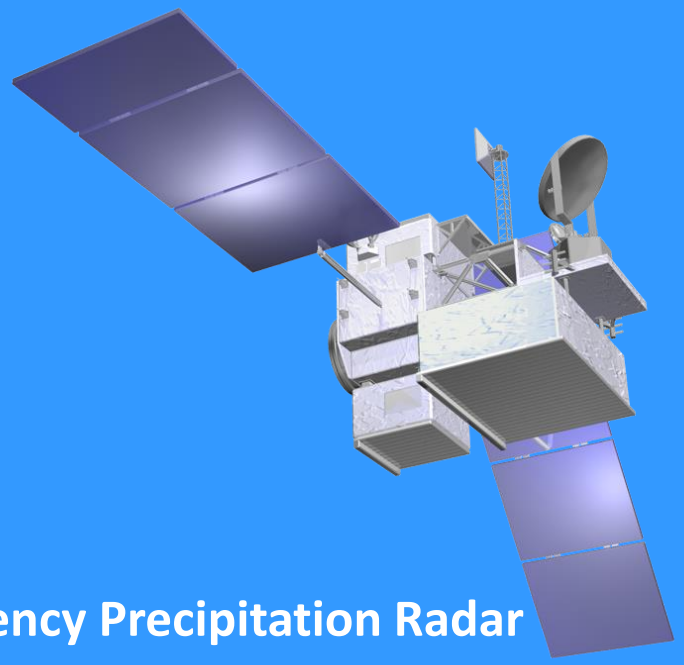
- The latest GSMaP_MVK (v7) succeeded in detecting orographic rainfall similar to GPM_KuPR comparing to the previous algorithm (v6).
- But its intensity was considerably overestimated comparing to the in-situ observation and other products.
- GSMaP_Gauge effectively correct such unreliable extreme rainfall. But the correction trades off the loss of horizontal distribution of precipitation due to the large gap of rain gauge network.
- This may lead the overcorrection of GSMaP_Gauge especially around the mountain where the observatory distribution is quite sparse.




*The anomaly of GSMaP_Gauge vs GSMaP_MVK for 24-hour accumulated precipitation.*
*The gray-shaded grid cells which has more than one rain gauge station in the NOAA/CPC gauge analysis.*

**NEPTUNE-II**: North-eastern Eurasia Precipitation validation and Terrestrial water cycle UNited Experiment (PI: Y. Iijima, Mie University)

# Assimilations



GPM Dual Frequency Precipitation Radar

# Ensemble Data Assimilation with NICAM-LETKF

Takemasa Miyoshi

## 1. Seamless Precip. Forecast System (NEXRA x GSMaP_RNC )

NEXRA

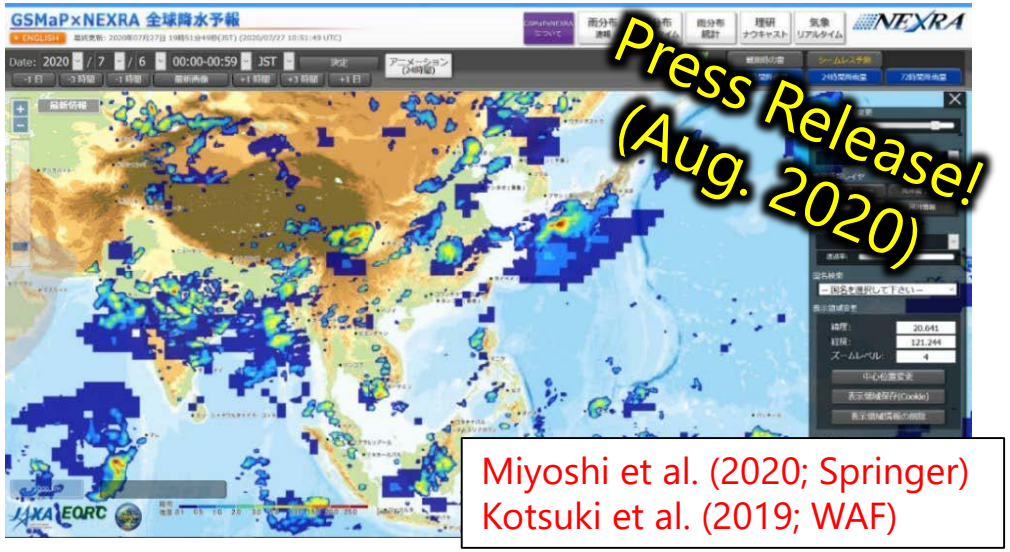
**NICAM-LETKF JAXA Research Analysis**

×

***GSMaP_RNC***

**GSMaP Riken NowCast**

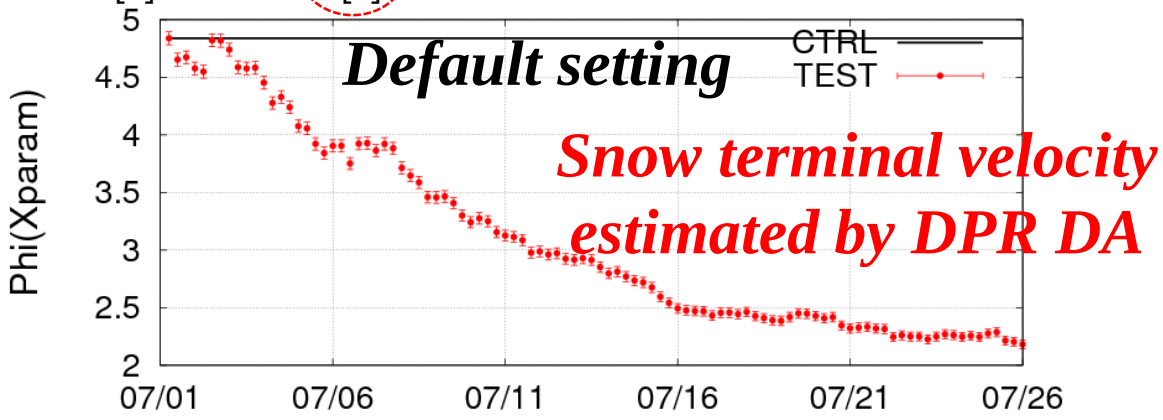
=

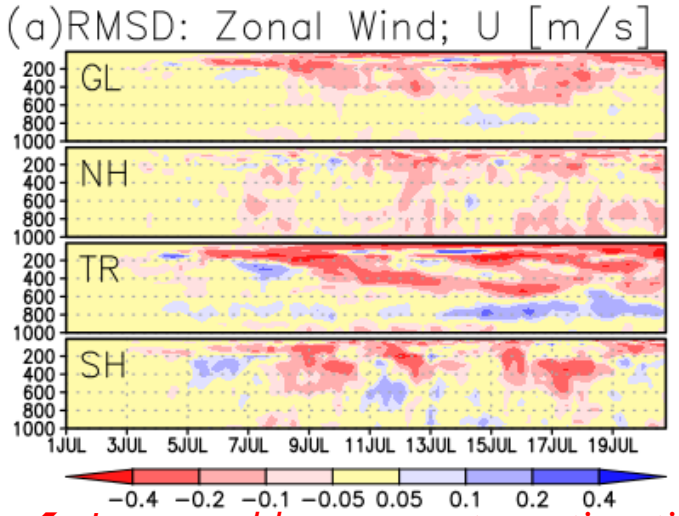



Miyoshi et al. (2020; Springer)
Kotsuki et al. (2019; WAF)

## 2. DPR data assimilation to estimate a microphys. parameter

$$v_{t[s]}(D) = c_{[s]} D^{d[s]} \left(\rho_0 / \rho\right)^{1/2}$$ Snow terminal velocity



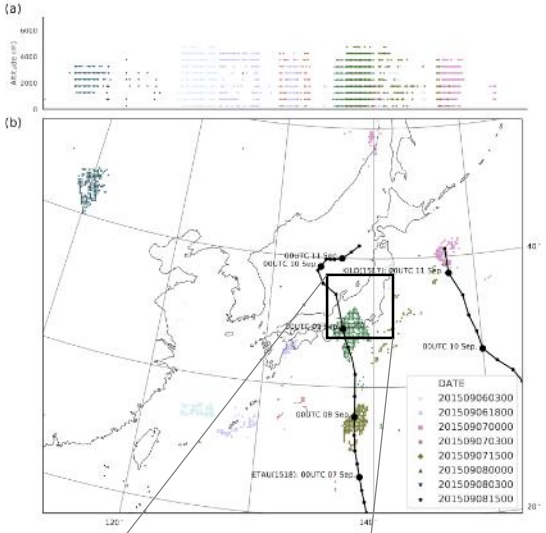




← *Improved by parameter estimation*

# Data Assimilation of GPM/DPR at JMA

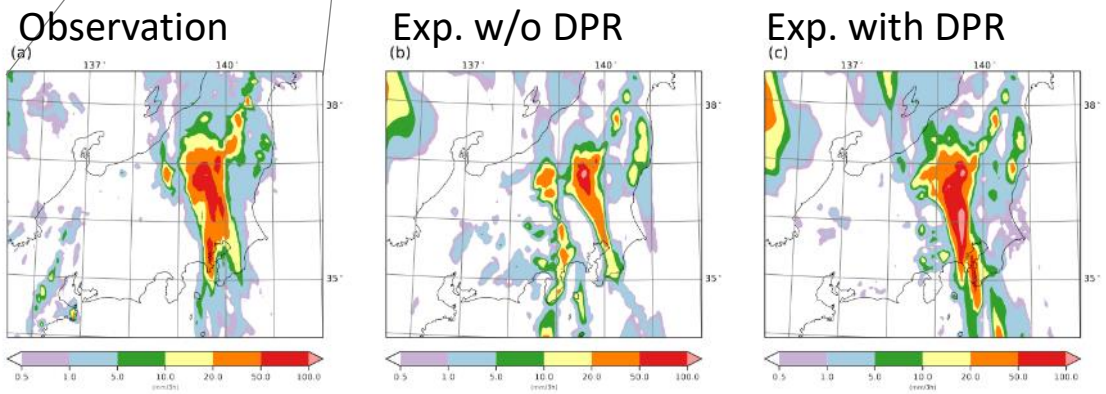
Yasutaka Ikuta

## For short-range forecasting



**1D-MLE + 4D-Var**

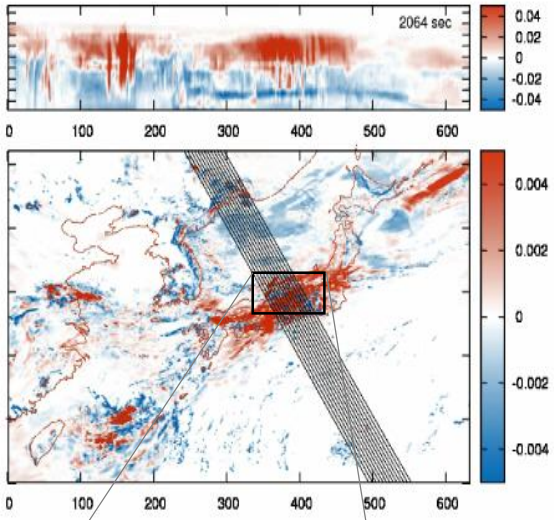
The estimated RH profiles from DPR using 1D-MLE has been assimilated by 4D-Var in operational meso NWP system.




The 3-hr accumulated precipitation of observation and T+33hr forecast of NWP model (5km reso.) at 0900 UTC on 9 September 2015.

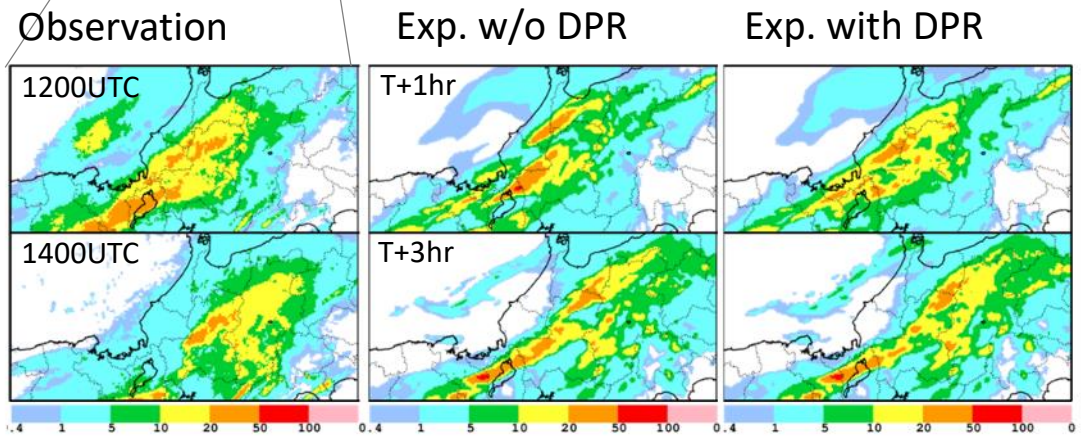
(Ikuta et al. 2020, in revision)

## For nowcasting



**LH-Nudging (in development)**

The tendencies of cloud microphysics scheme in NWP model are modified by the LH-Nudging method with Kalman-gain using DPR-SLH product.




The 1-hr accumulated precipitation of observation and forecast of NWP model (2km reso.) on 5 July 2018.

# Summary

## Advancements in our knowledge of global precipitation

- First global view of the precipitation process partitioning
- Change of microphysics along high-latitude coasts
- Details in precipitation systems (HIP vs Lightning, Extra-trop. systems)
- Seasonal variations of global Dm map
- Corrections in low-level precip profiles and missing shallow systems.
- Release of new SLH V06B with better energy balance

## Validations with Gauges and Ground-based Radars

- XRAIN
- Precipitation in high mountain regions

## Assimilation Usages are also advanced

- Estimate of microphysics parameters with DPR measurements
- Assimilations of DPR and latent heating to a JMA operational model perform well.