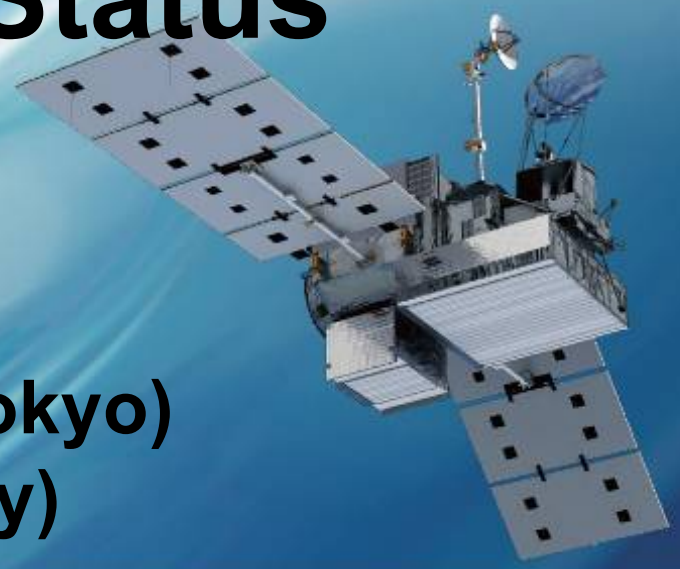
JAXA GPM Science Status



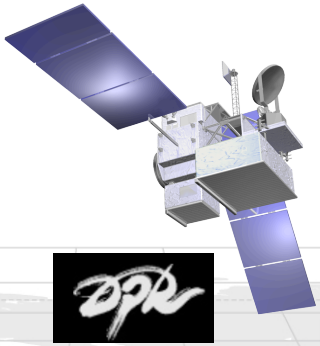
Y. N. Takayabu (University of Tokyo)
N. Takahashi (Nagoya University)

2019 PMM Science Team Meeting, November 5, 2019

Outline

Utilizations of DPR and GSMaP have been advanced

- Dual Frequency used to study Microphysics
- Latent Heating (SLH) Studies
- Ground Validations
- Assimilations for NWP
- Machine Learning Studies



DPR algorithm status will be presented in the following presentation.

DUAL FREQUENCY MEASUREMENTS USED TO STUDY MICROPHYSICS

By S. Shige from KU (Akiyama et al., 2019, GRL, 46)

The relation between ZmKu and DFRm of Heavy Ice Precip (HIP) associated with a cyclone differed from that in a hail storm case.

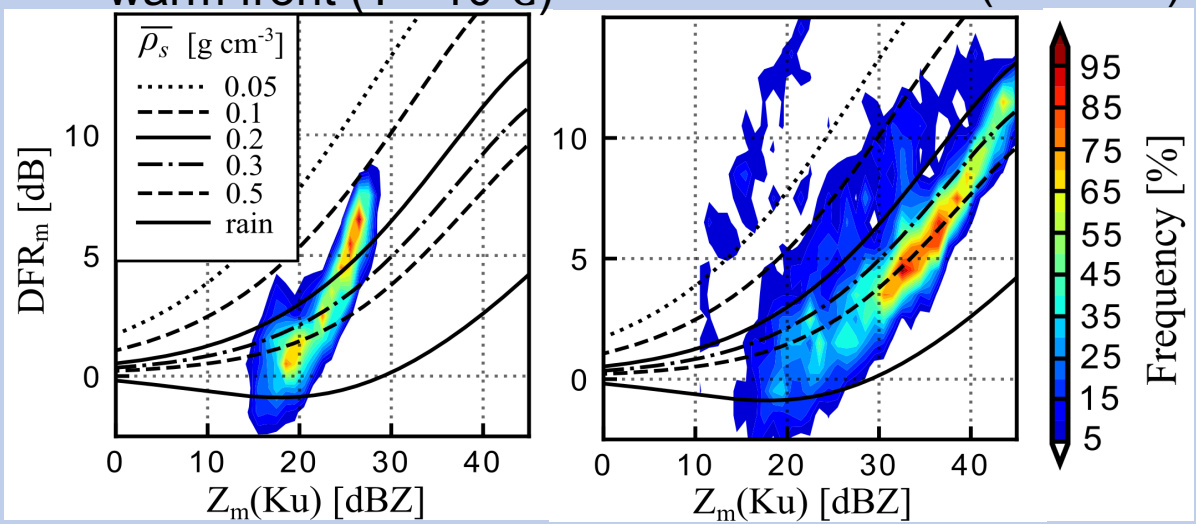
ZmKu-DFRm diagram

It is shown that these diagrams can help to distinguish solid precipitation particles with different ice densities such as hail and large snowflakes.

lines: theoretical relations for each ice densities
color: frequency of observed signals for solid precip

HIP band along warm front (T<-10℃)

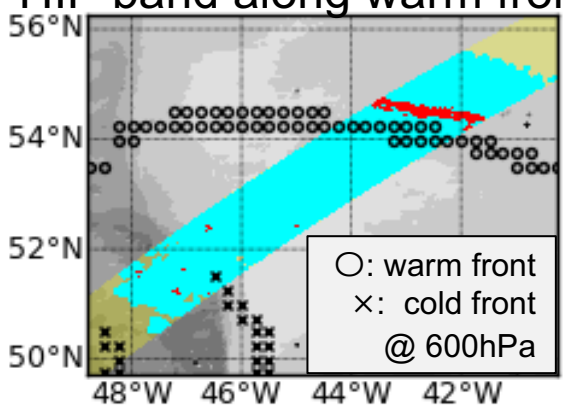
HIP of hail storm (T<-10℃)



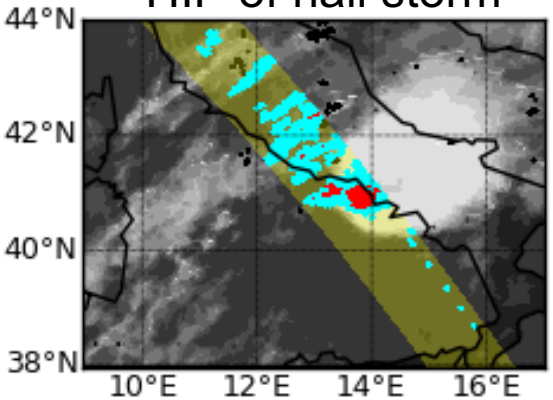
Horizontal view of precip in the cyclone case and the hail storm

Heavy Ice Precip HIP
Other precip
observed by GPM/DPR
IR image (shade in gray scale)

HIP band along warm front



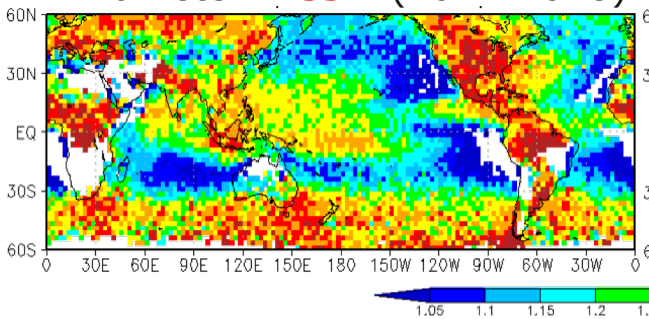
HIP of hail storm



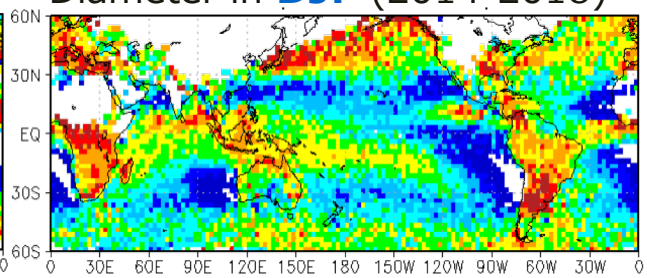
By M. Yamaji (JAXA): **Poster #217**

Seasonal change of Drop Size by GPM/DPR

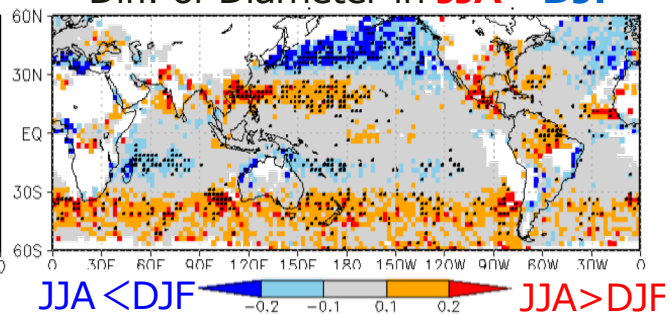
Diameter in **JJA** (2014-2018)



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



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



Mid-latitude: diameter was **larger** in DJF than JJA → frontal systems is dominant in DJF
Subtropics: diameter **was smaller** in DJF than JJA → shallow convection is dominant in DJF

#Baiu #Squall lines #tropical storms	#Trade wind convections	#with ice particles in upper level
Organized Precip. Systems **in JJA**	**Shallow convective** precip. System **in DJF over subtropics**	**Extratropical frontal** precip. System **in DJF over mid latitudes**

- Both stratiform and convective rain.
- higher storm top height

- convective is dominant
- lower storm top height

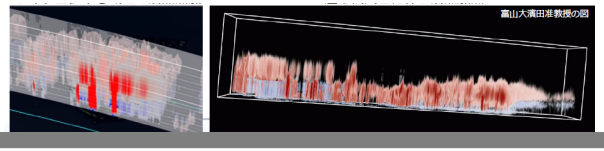
- more stratiform
- moderate storm top height
- with ice particle

Seasonal variations of Dm are statistically significant, which is related not only to the change of precipitation intensity but also to the precipitation characteristics.

LATENT HEATING STUDIES

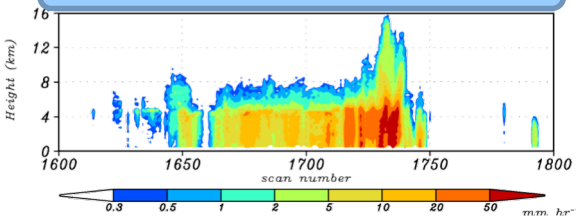
Spectral Latent Heating (SLH) using GPM DPR

PI: Yukari Takayabu (U.Tokyo)



Algorithms

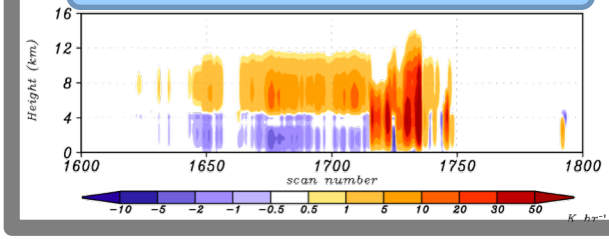
GPM KuPR



Precipitation-SLH Tables

In addition to the LUT for TRMM, Newly developed LUT for mid-latitude.

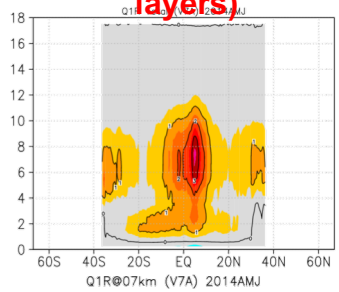
Estimation of SLH

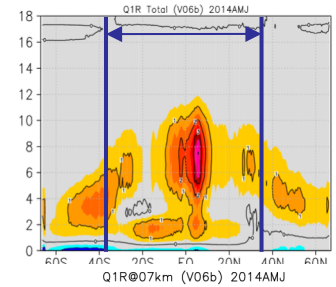


Products/Validation

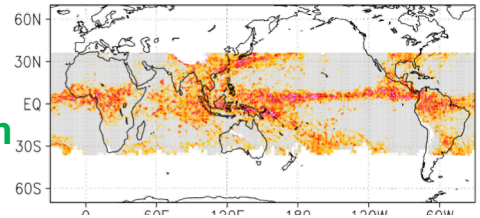
TRMM/SLH V7A (19 layers) **GPM/SLH V06 (80 layers)**

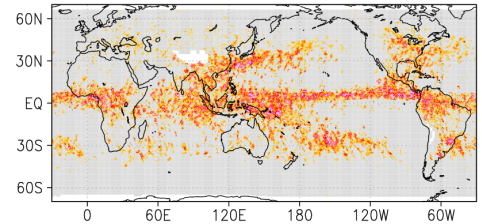
Zonal Mean



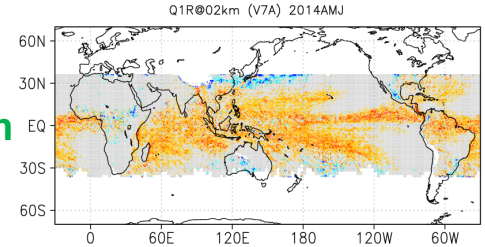


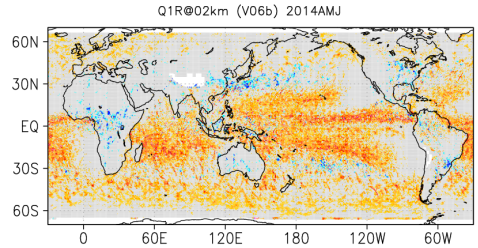
Map @7km





Map @2km





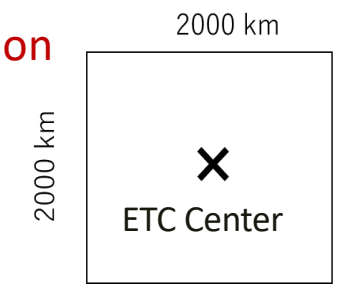
Good consistency and smooth connection to the tropics!

SLH: Latent Heating associated with the intensification of extratropical cyclones (ETC)

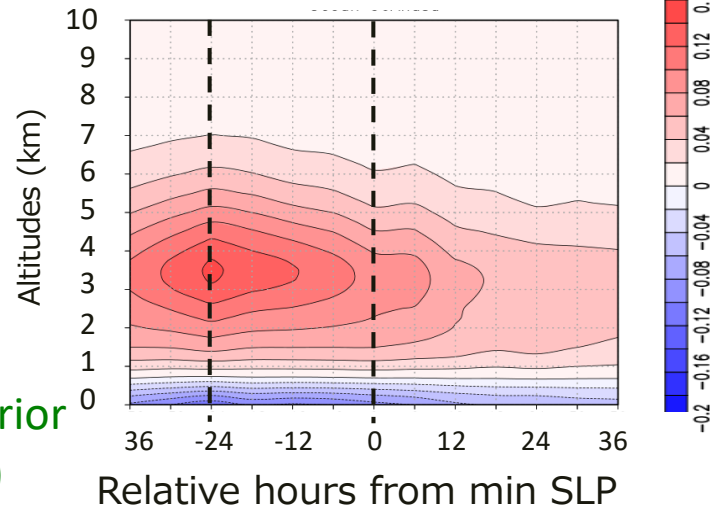
Tsuji and Takayabu (U.Tokyo)

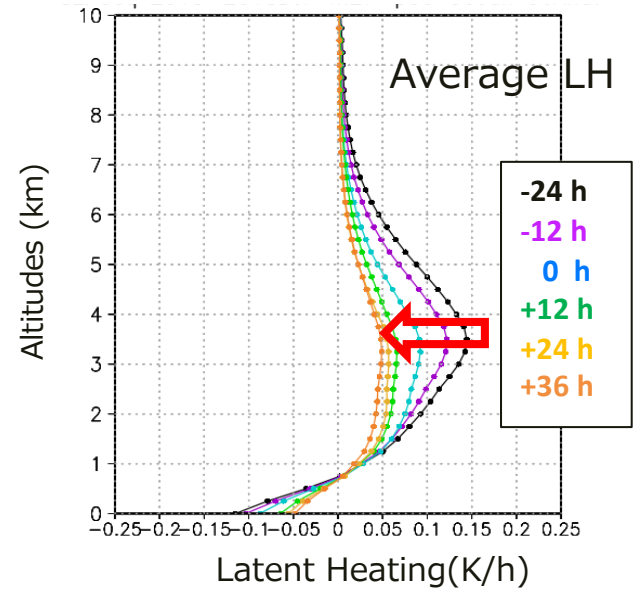
Time series of LH associated with ETC

ETC region

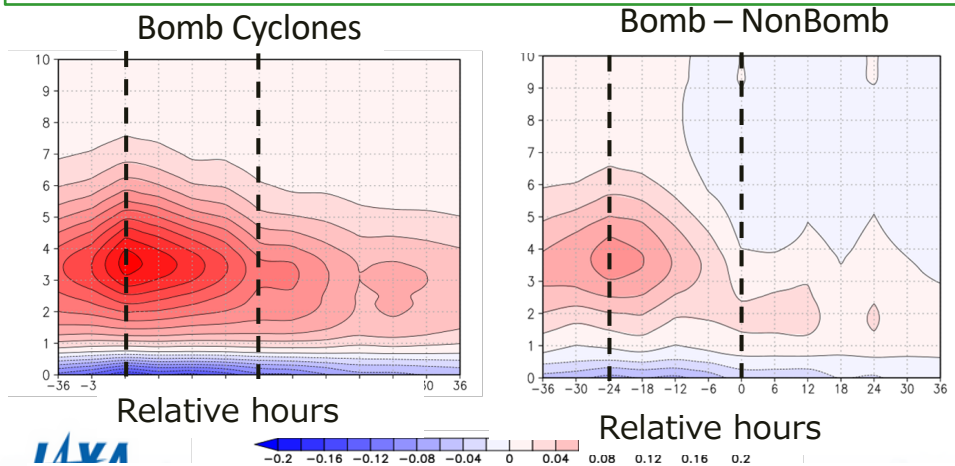


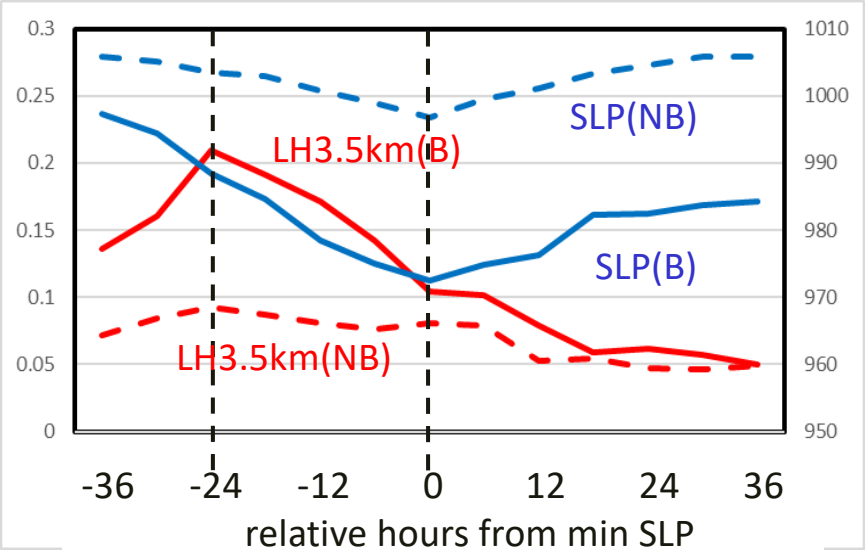
Max heating is found at around 3.5km, 24hours prior to the ETC peak (min SLP)





LH in Bomb vs Non-Bomb Cyclones





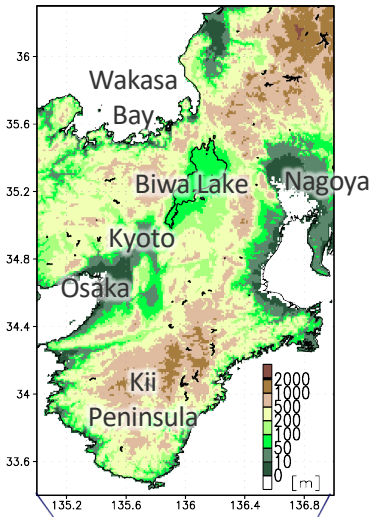
Bomb Cyclones have significantly larger LH at 24 hrs prior to the cyclone maximum

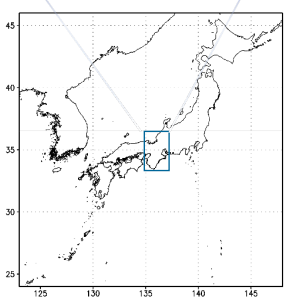
GROUND VALIDATIONS

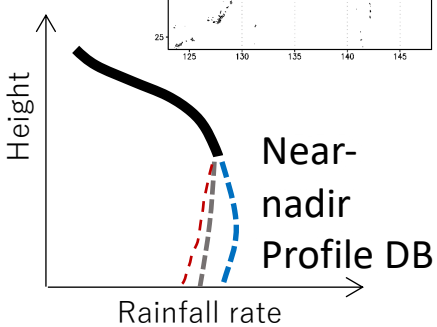
By M. Hirose (Meijo Univ.) **Poster #229**

Low-level profile correction for PR rainfall in Kansai region, Japan

Topography

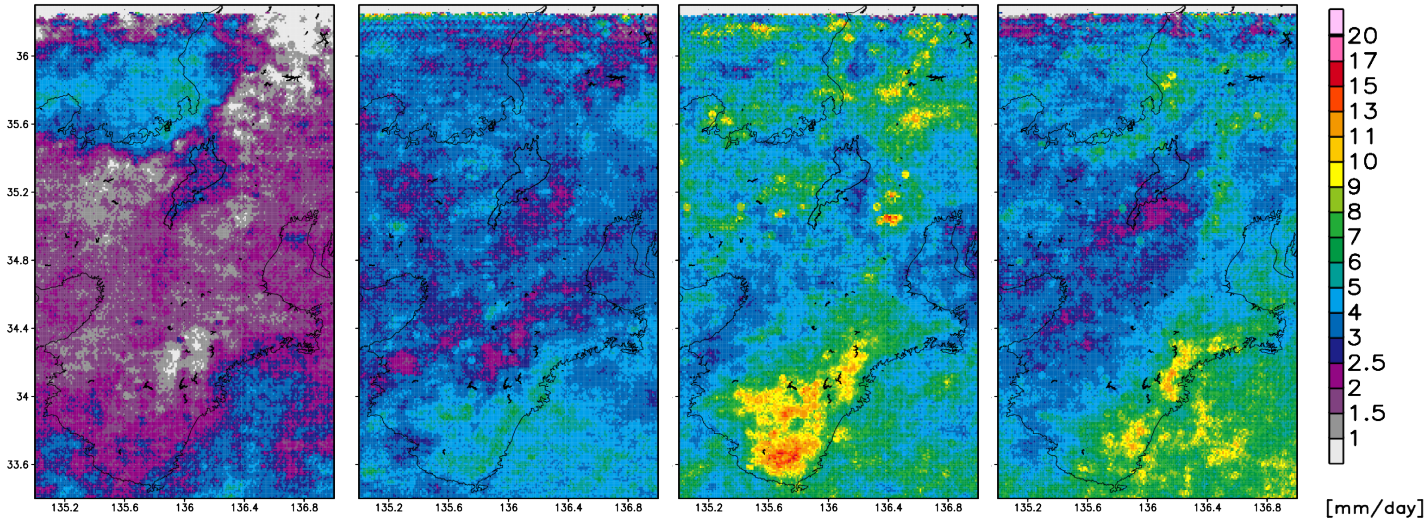




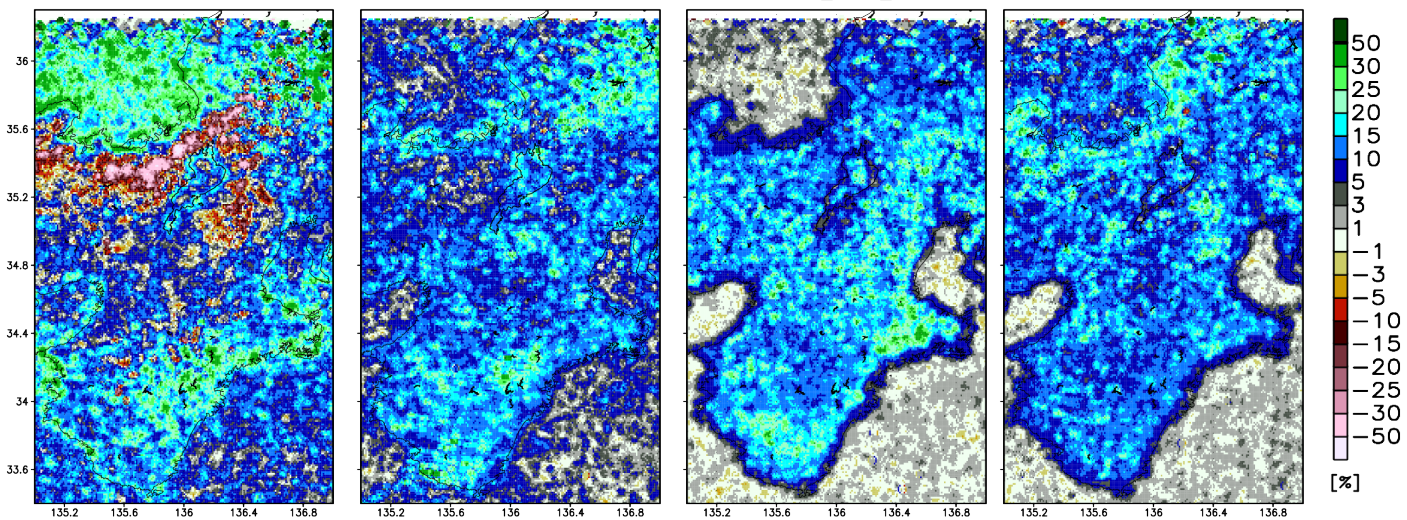


Corrected Rainfall [mm/day]

0.01°



Effect of correction [%]

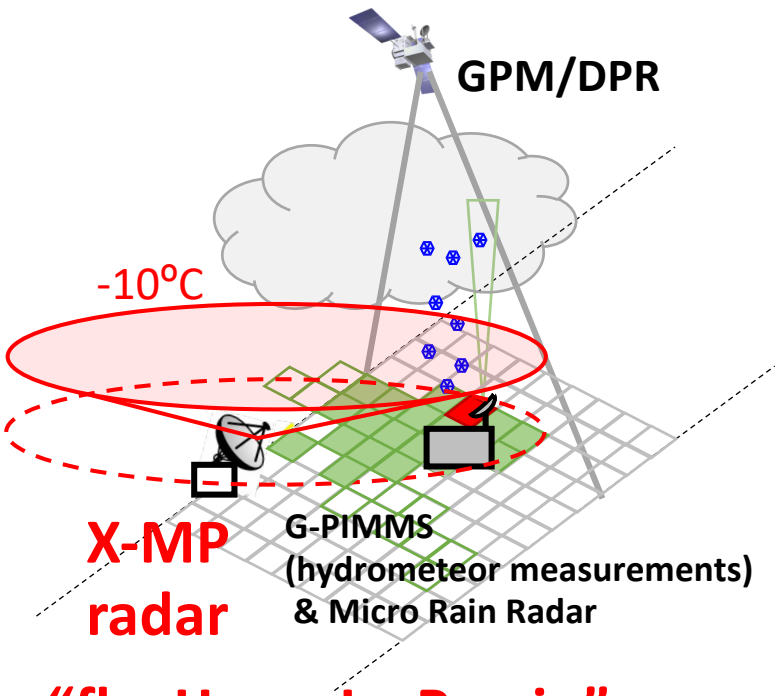


DJF MAM JJA SON

By K. Suzuki from Yamaguchi Univ.

Ground validation of GPM/DPR "flagHeavyIcePrecip" by hydrometeor measurements

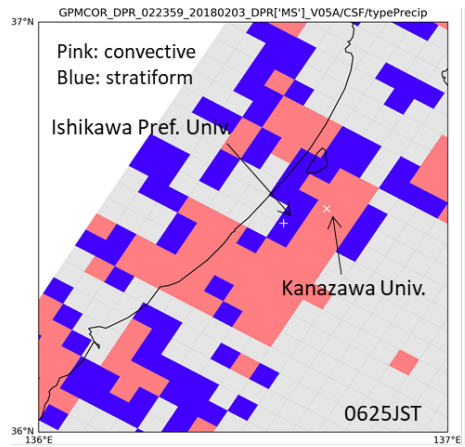
Conceptual image of ground validation using X-MP radar



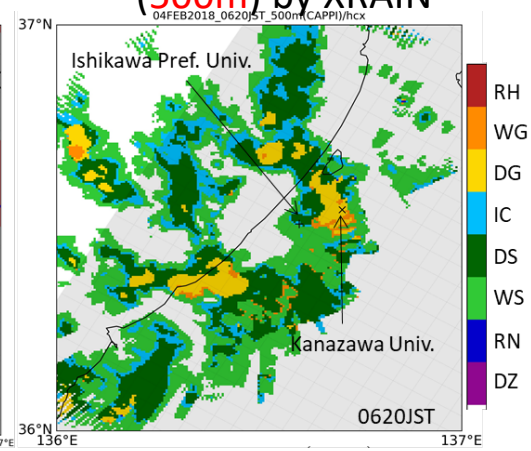
"flagHeavyIcePrecip" correspond well to **Graupel** distribution, which were detect by X-MP radar altitude of **-10°C**.

"flagtypePrecip"

classification by GPM/DPR

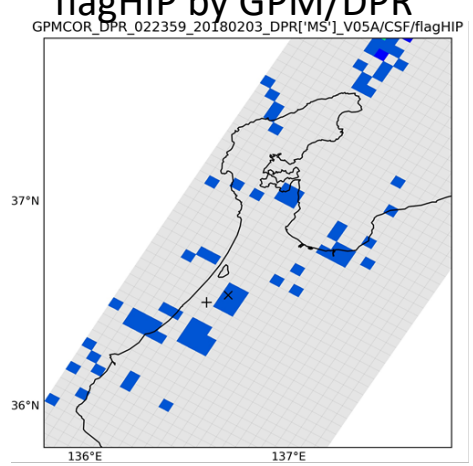


Hydrometeor Classification (500m) by XRAIN

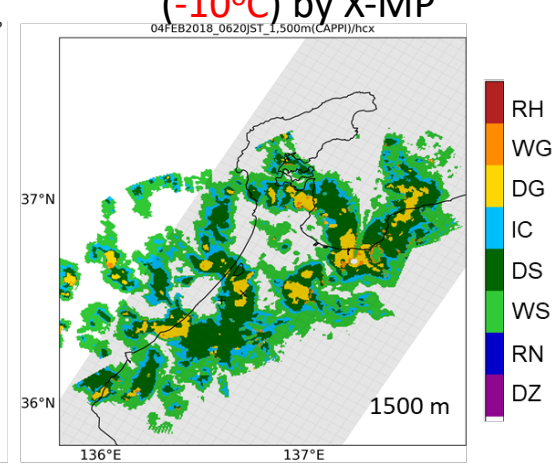


"flagHeavyIcePrecip"

flagHIP by GPM/DPR

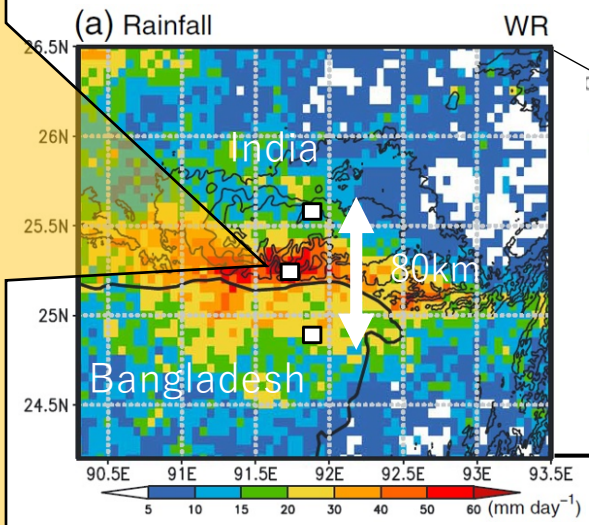


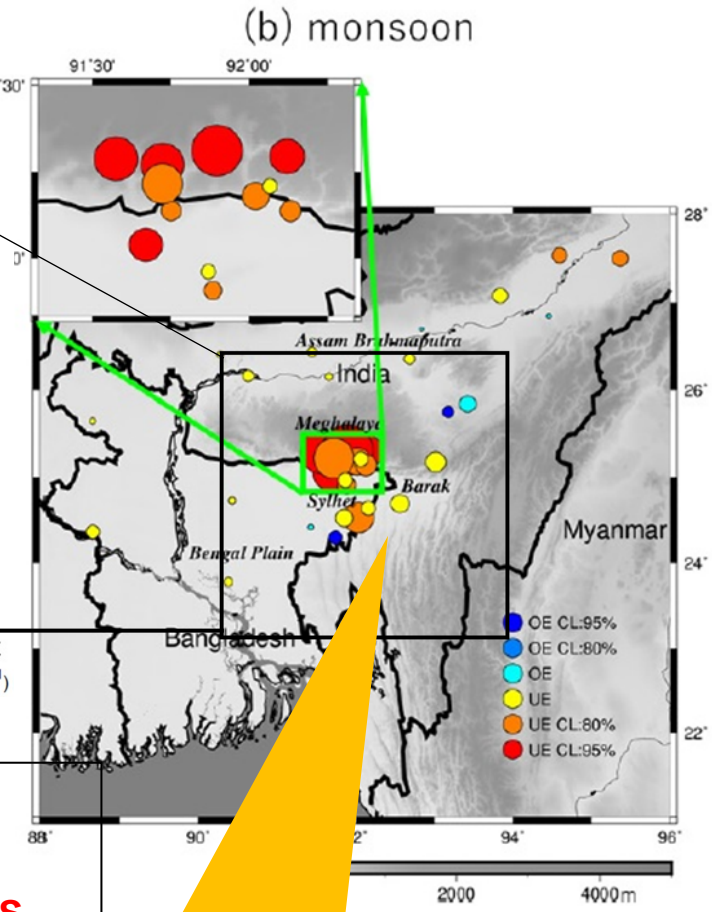
Hydrometeor Classification (-10°C) by X-MP



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

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

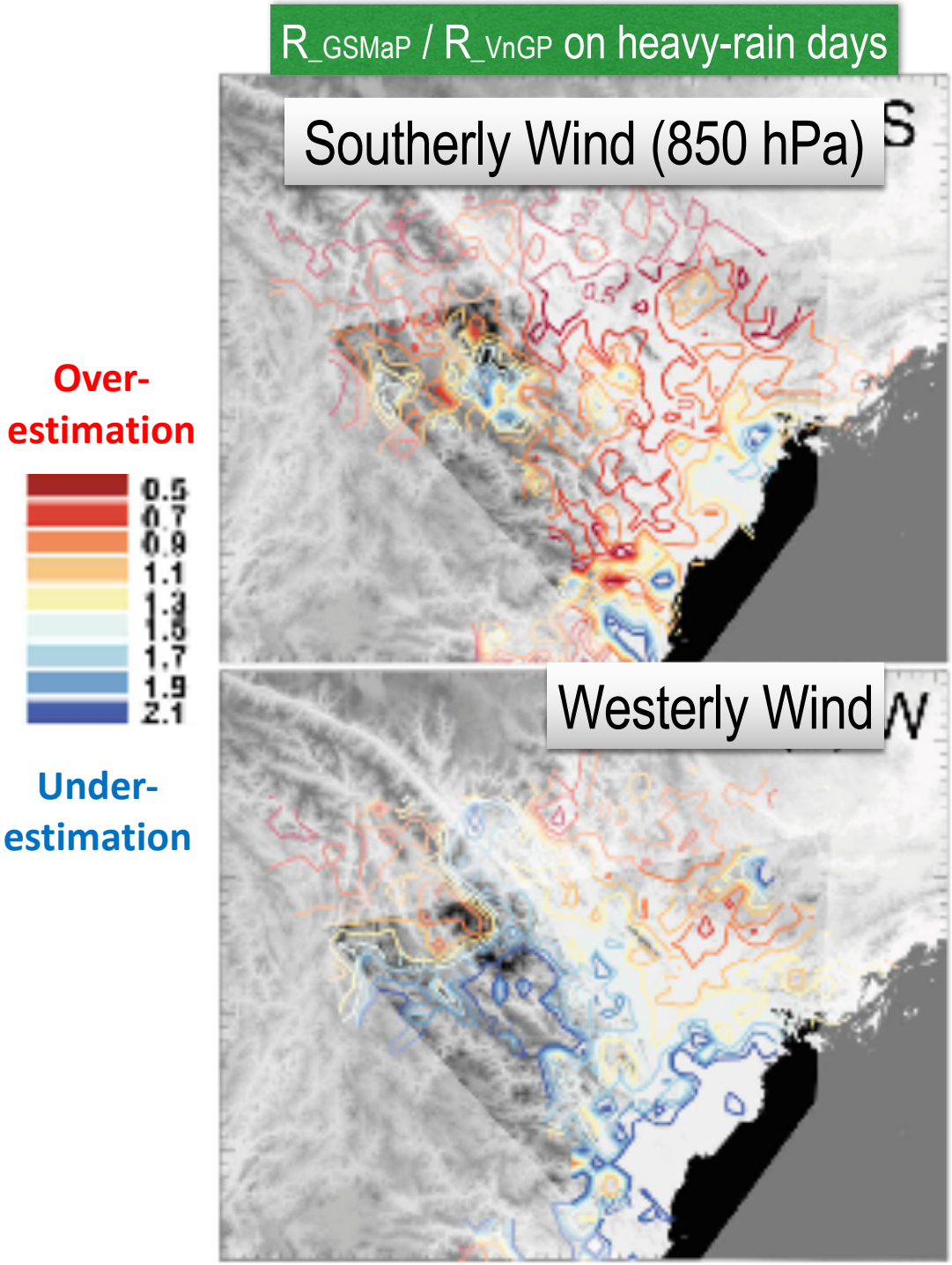


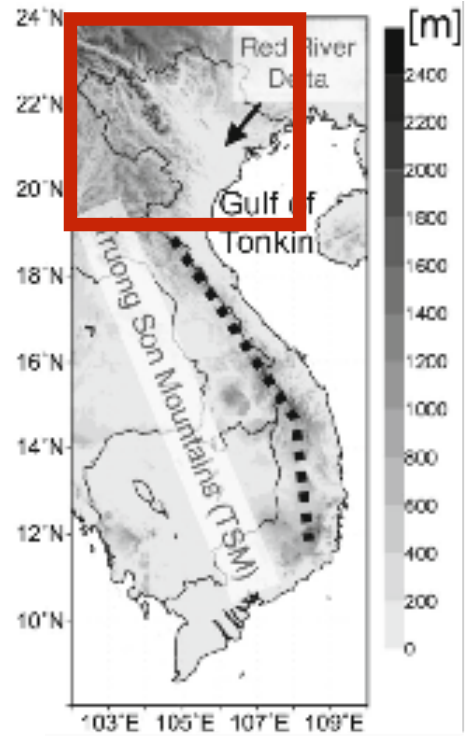


World Record of
CHERRAPUNJI
26,461 mm in 12months
Aug 1860 – July 1861

Large underestimations of monsoon rainfall in TRMM PR

By J. Matsumoto from TMU





Inter-comparison between the gauge-network-based (VnGP) and the satellite-based (GSMaP) rainfall over the complex topography over Vietnam

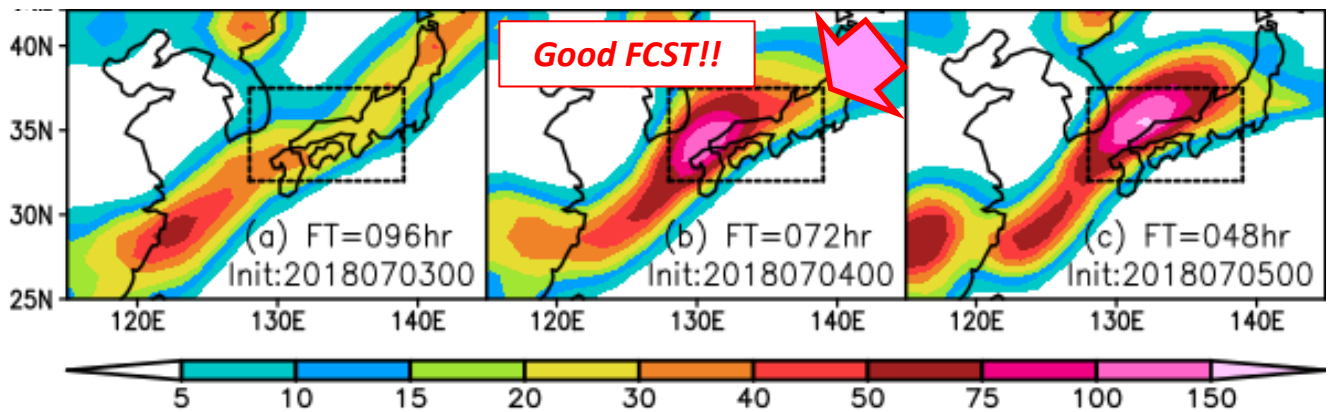
ASSIMILATIONS FOR NWP

Ensemble Data Assimilation with NICAM-LETKF

By T. Miyoshi from RIKEN

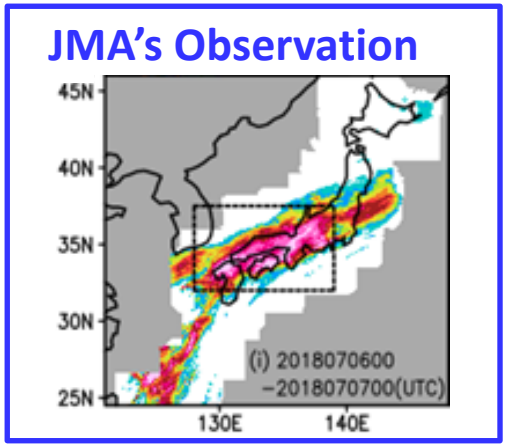
1. NICAM-LETKF JAXA Research Analysis (near-real-time)

Forecasts for Record-breaking Rain Event in July 2018



Kotsuki et al. (2019, SOLA)

24-h precipitation (mm; 0000-2400 UTC July 6, 2018)

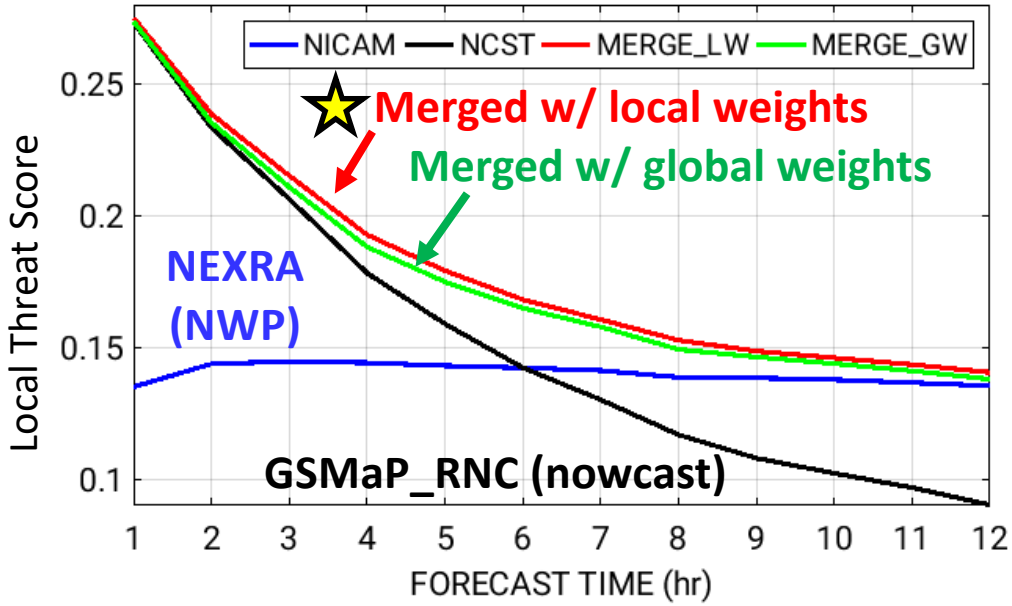


2. Seamless Precip. FCST

(1) Merging NWP & nowcast is beneficial for global QPF.

(2) We developed a new method for locally optimal weighting.

Kotsuki et al. (2019, WAF)

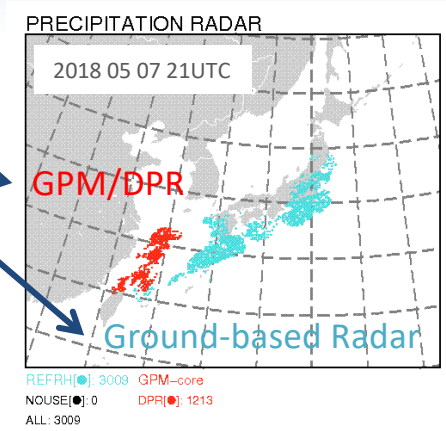


Current State of GPM/DPR Assimilation at JMA

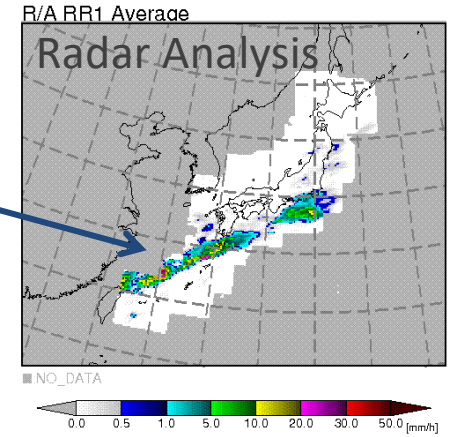
PI: Yasutaka IKUTA

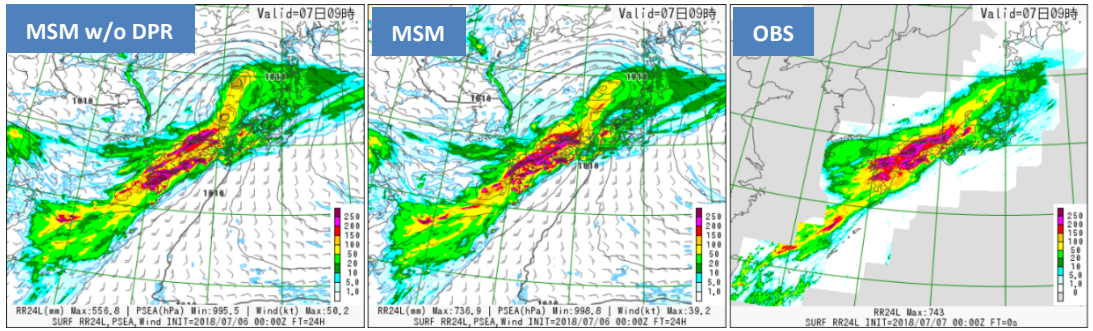
- In the operational Meso-Scale NWP system, **assimilation of GPM/DPR started in March 2016.**
  - **GPM/DPR assimilation method**
    - Indirect assimilation (1D+4DVAR)
    - Assimilation of relative humidity profile retrieved from reflectivity
  - Traditional 4DVAR
    - Climatological background error covariance
    - Hydrometeors are "**not**" analysis variables.

Assimilated as RH profiles



Assimilated as precipitation





2018 07 07 00 UTC [Init: 2018 07 06 00 UTC Lead-time: 24-hour]

Next step of GPM/DPR Assimilation at JMA

PI: Yasutaka IKUTA

Future Plan: Implementation of **Hybrid-4DVar with control variable of hydrometeors** into the operational Meso-Analysis

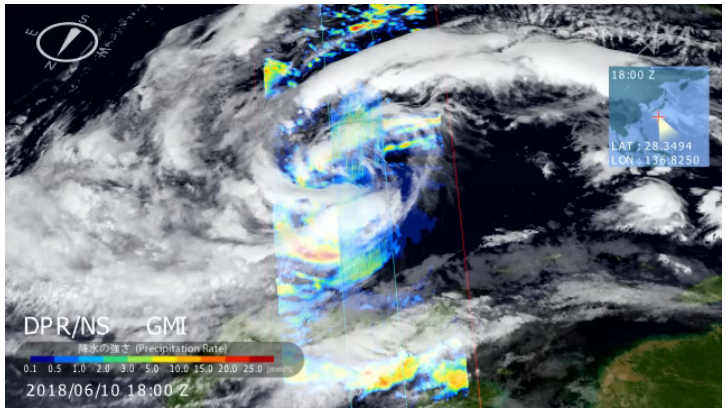
Indirect assimilation

using retrieved RH profiles
in **traditional 4DVAR**

Direct assimilation of GPM/DPR

using reflectivity (KuPR, KaPR) profiles
in **new Hybrid-4DVAR**

JAXA/EORC Tropical Cyclone Database
(http://sharaku.eorc.jaxa.jp/TYP_DB/index_j.shtml)

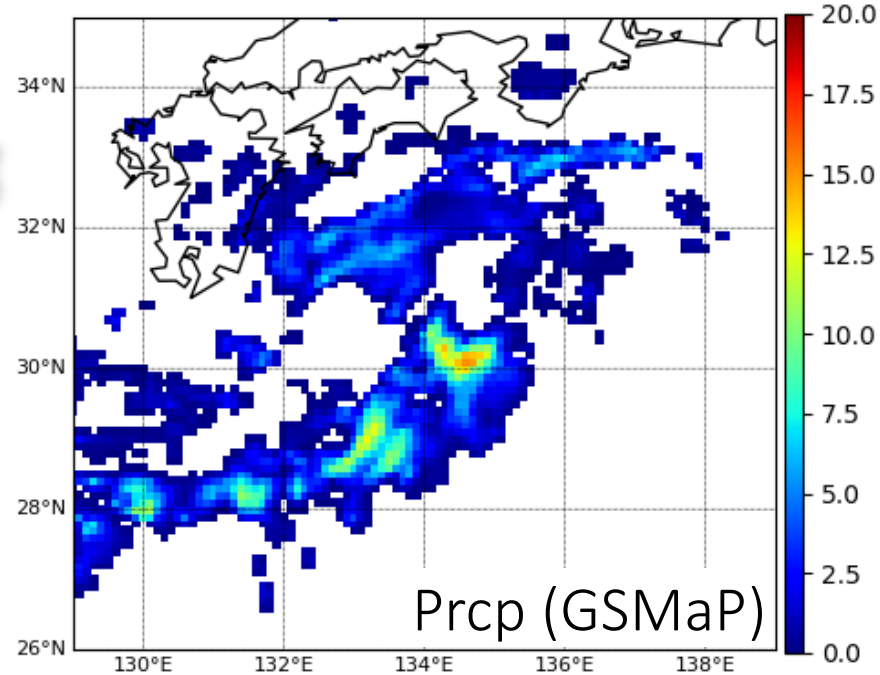


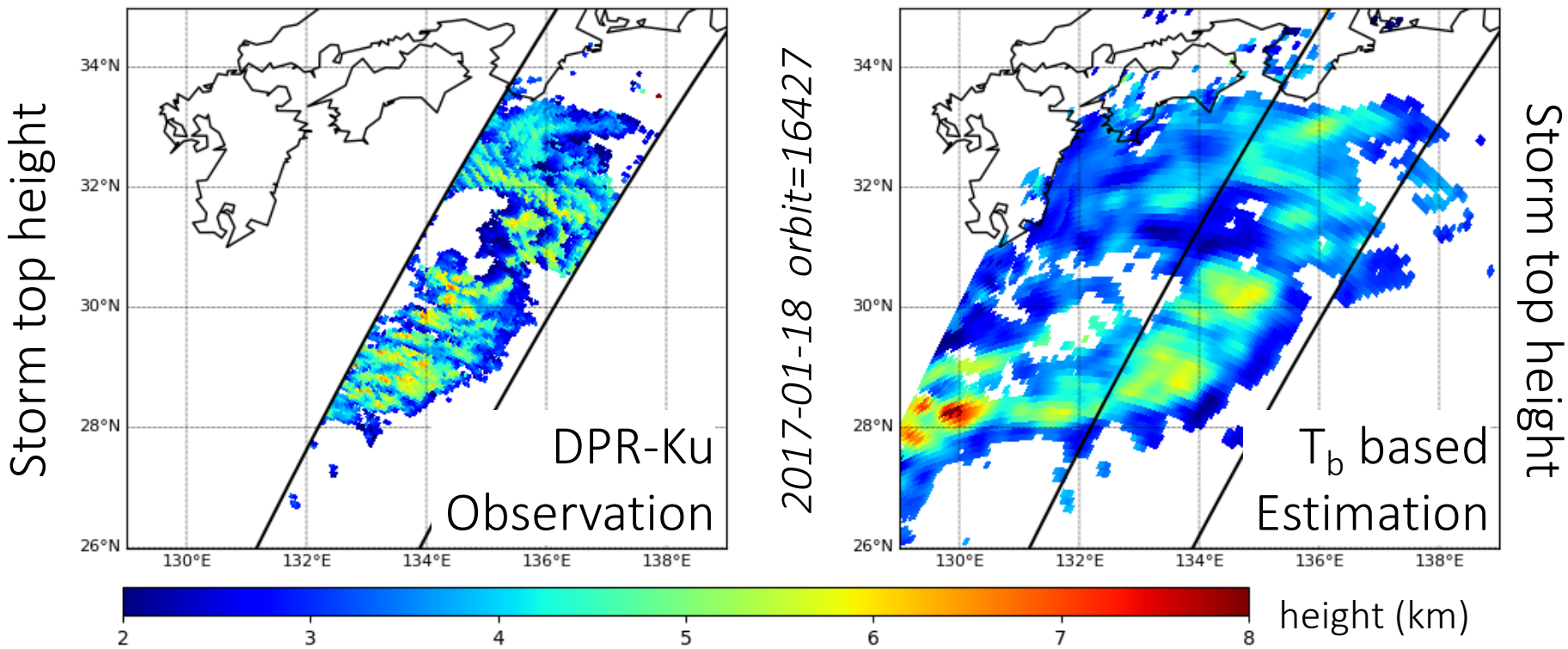
MACHINE LEARNING

Determining Cloud and Storm Structure using Machine Learning

Hyungjun Kim @ U-Tokyo; Poster #238

Neural Network based pseudo radar product (GMI T_b based estimation) successfully reproduces observed **heightStormTop** (DPR-Ku)



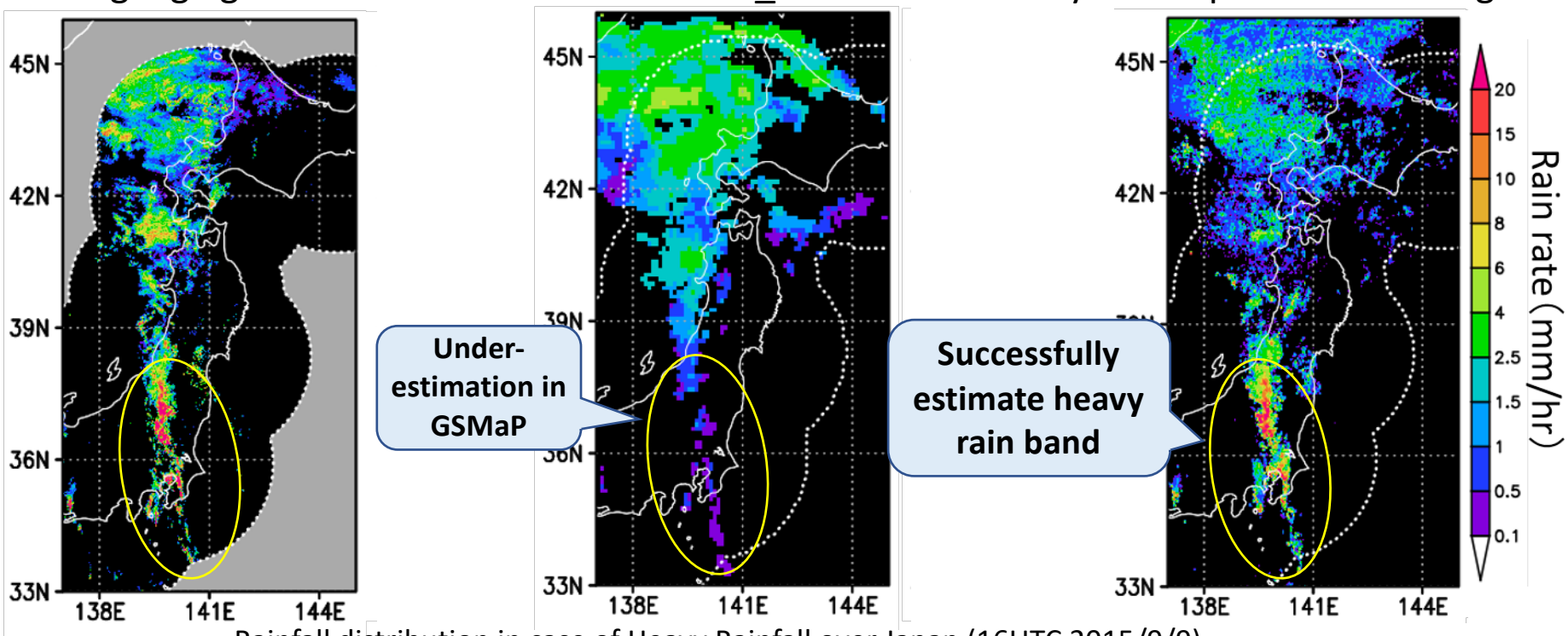


By Hirose, H., S. Shige, M. K. Yamamoto, and A. Higuchi

High Temporal Rainfall Estimations from Himawari-8 Multiband Observations Using the Random-Forest Machine-Learning Method

Hirose, H., S. Shige, M. K. Yamamoto, and A. Higuchi, 2019: High Temporal Rainfall Estimations from Himawari-8 Multiband Observations Using the Random-Forest Machine-Learning Method. *Journal of the Meteorological Society of Japan. Ser. II*.

Radar-gauge ground obs. GSMaP_NRT Newly developed rainfall using AI



Rainfall distribution in case of Heavy Rainfall over Japan (16UTC 2015/9/9)

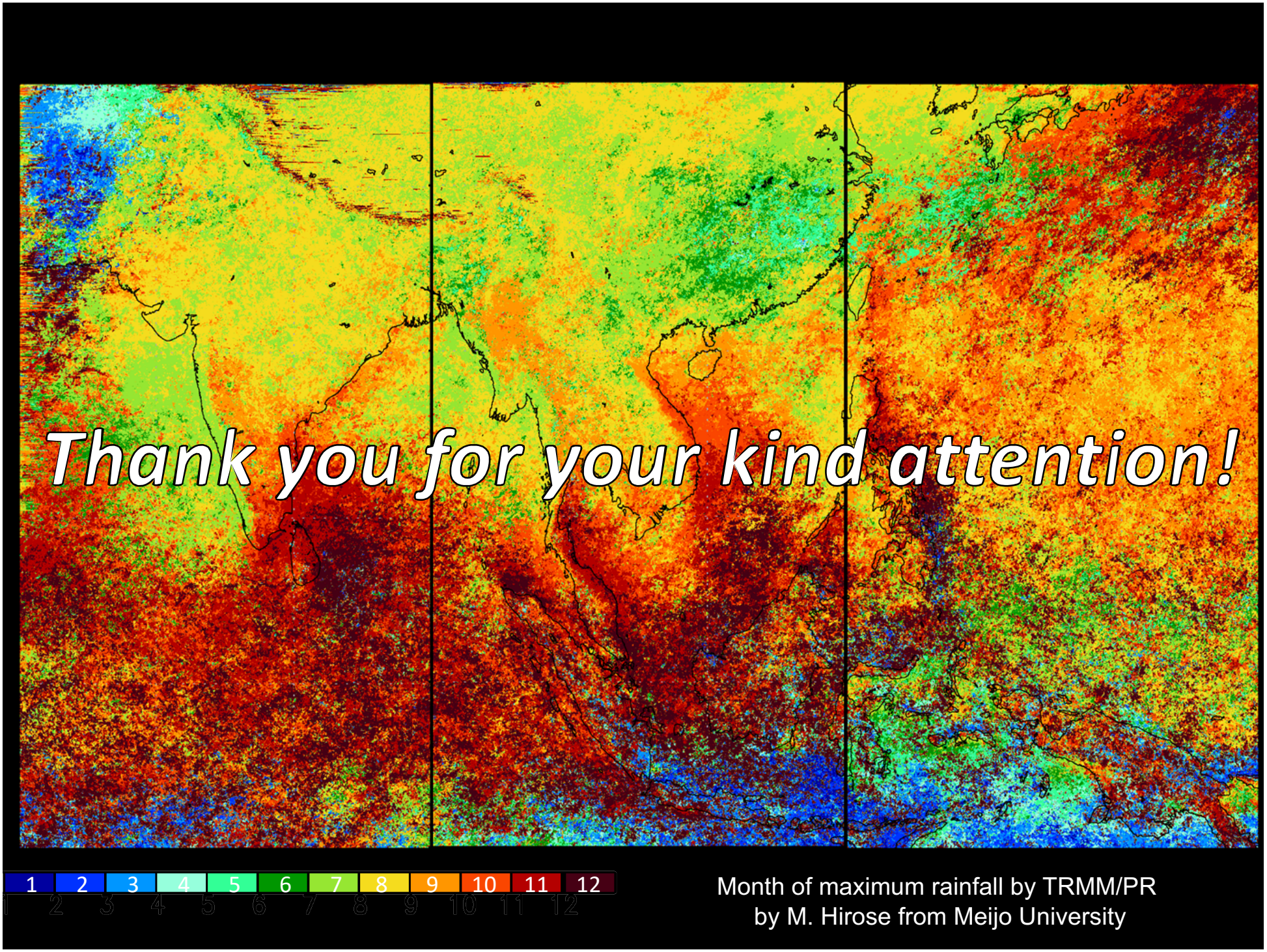
Detection of heavy rainfall from cloud with lower top height is difficult, causing under estimation.

-> Multi band observation by GEO Himawari-8 and machine learning can improve the heavy rainfall from cloud having lower cloud top!

Summary

Utilizations of DPR and GSMaP have been advanced

- Dual Frequency measurements are utilized to study Microphysics
- Latent Heating (SLH) Studies have been extended to mid-latitudes
- Ground Validations are performed over heavy rainfall regions with complex terrain over the Asia
- Assimilations of DPR and GSMaP for NWP are advanced
- Machine Learning Studies show new possibilities for precipitation science


Thank you for your kind attention!
1 2 3 4 5 6 7 8 9 10 11 12
Month of maximum rainfall by TRMM/PR
by M. Hirose from Meijo University

以下スライドは
DPRAlgorithmStatusに含まれそうなもの

(Seto, 2019 IGARSS)

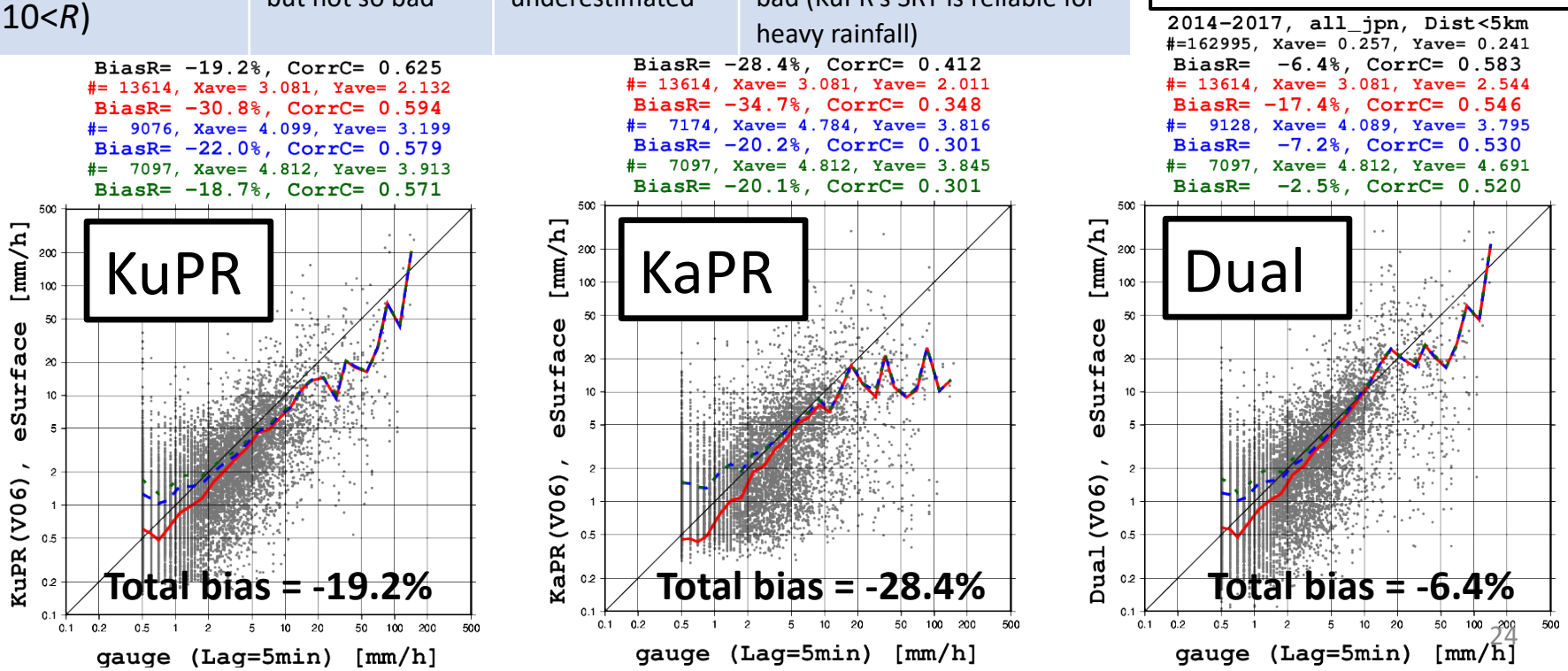
Evaluation of DPR V6 algorithms by rain gauges

- Generally, **Dual-frequency algorithm** selects KuPR for detection and KaPR for attenuation correction → **has smaller bias than single-frequency algorithms**

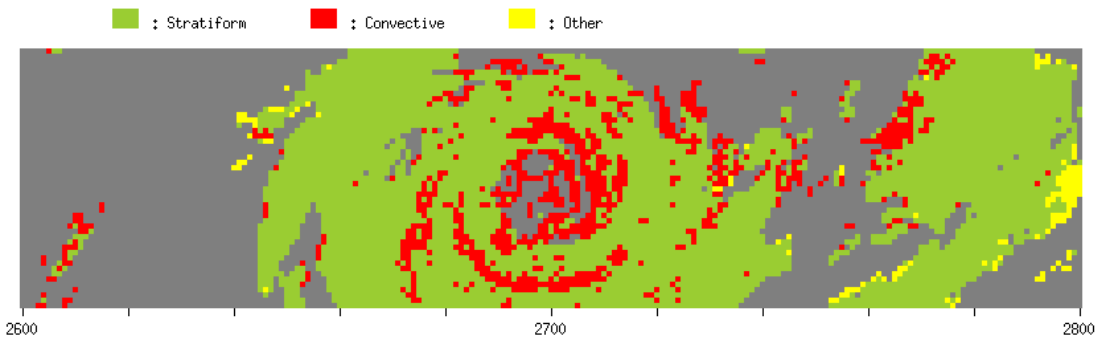
	KuPR	KaPR	Dual-frequency
Weak rainfall (R<1)	Good	Poor (KaPR's sensitivity is worse than KuPR)	Good (as KuPR is mainly used for rain detection)
Normal rainfall (1<R<10)	Underestimation (KuPR's SRT is not reliable)	Good (KaPR's SRT is reliable)	Good (as Dual-frequency SRT is more reliable and accurate)
Heavy rainfall (10<R)	Underestimated, but not so bad	Severely underestimated	Underestimated, but not so bad (KuPR's SRT is reliable for heavy rainfall)

Evaluation of rain rate estimates with rain gauge dataset over Japan

Black：all match-up cases
Red：gauge > 0
Blue：gauge > 0 AND each product > 0
Green：gauge > 0 AND all products > 0



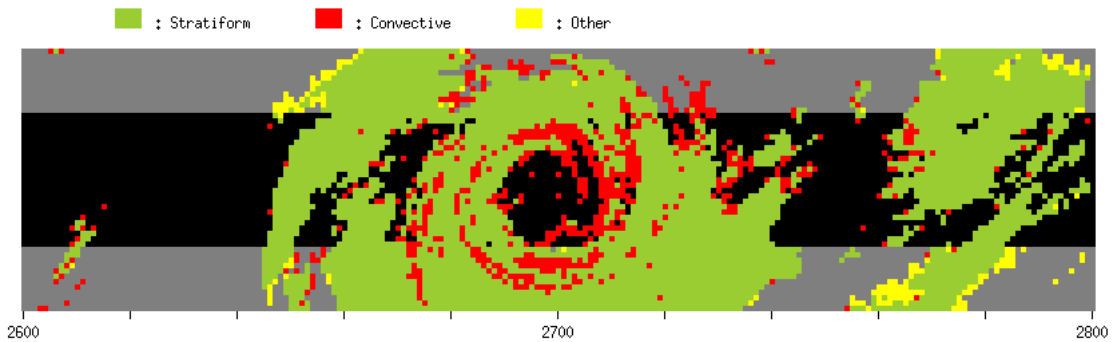
By J. Awaka from TMU



Orbit: 031343 (2019/09/14)
Scans: 2600-2800

Here V6X means the data obtained by JAXA 2019-1018 GPM DPR codes.

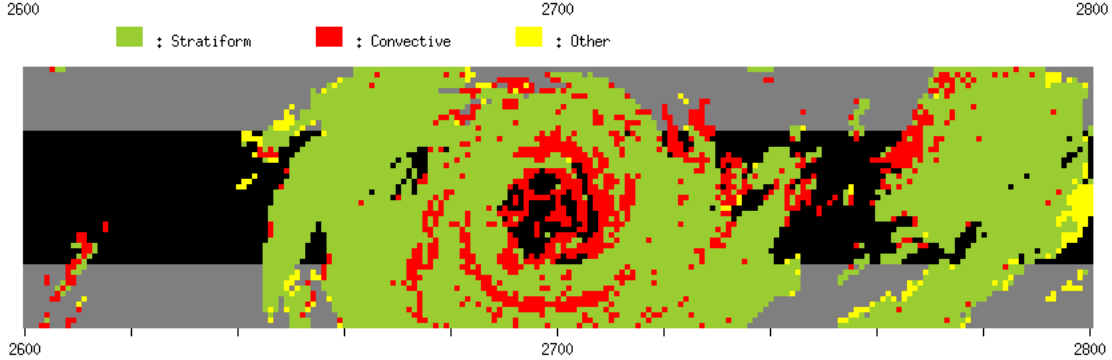
V6X Ku



V6X Ka

In V6X, HS Ka data fill the outer swath.

Rain Type Map



V6X DPR

Small differences are observed between Ku-band map and DPR map.

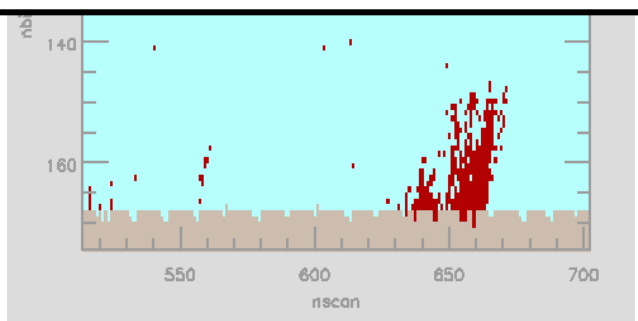
By K. Kanemaru from NICT

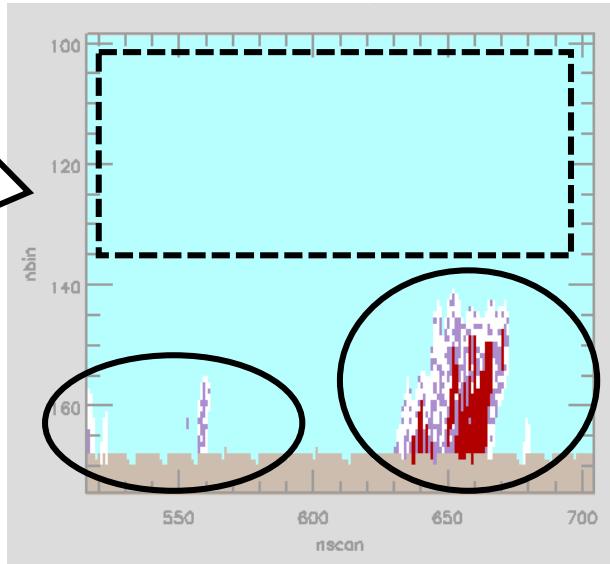
improves precipitation judgement

KuPR V06A (Z_{min} ~ 15 dBZ)

New (Z_{min} ~ 12 dBZ)

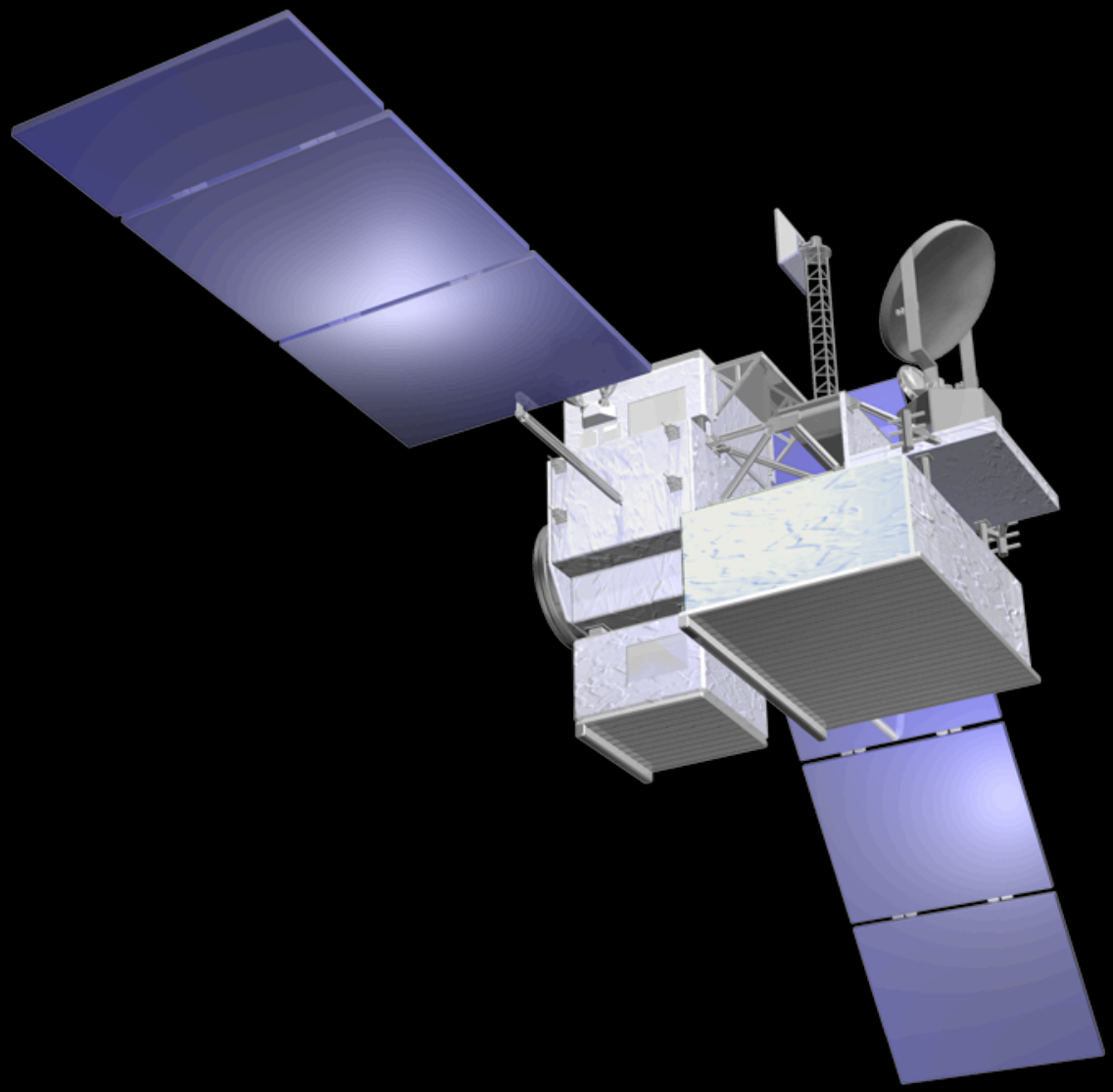
New precipitation judgment improves detectability and reliability.
The new method will be adopted in the next version (V07).





Angle-bin #25 of GPMCOR_KUR_1806300604_0737_024636_L2S_DU2_06A.h5

GPM Dual Frequency Precipitation Radar



JAXA - GLOBAL SATELLITE MAPPING OF PRECIPITATION
GSMaP
衛星全球降水マップ
GSMaP