

# JAXA GPM/DPR Calibration and Validation Plan

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National Space Development Agency of Japan (NASDA)  
→ **Japan Aerospace Exploration Agency (JAXA)**



# Outline



- ◆ Japanese calibration and validation will focus on DPR in GPM.
  - TRMM PR experiences
  - DPR calibrations
  - Focal points for liquid precipitation
  - Focal points for solid precipitation
  - Validation plan before/after launch
  - Summary and requirements



# GPM/ DPR validation



Processing flow

Parameters

Engineering values

Transmit power,  
Received power,  
Antenna beam  
direction

Calibration  
by ARC

algorithm

DSD (drop size distribution),  
Classification (Convective/Stratiform),  
Particle type,  
temperature & humidity profile,  
Melting layer model,  
Gaseous attenuation, ...

Validation

Physical values  
(Products)

Rainfall rate, Rain accumulation  
Liquid/Ice water content,  
Precipitation type classification,  
Latent heat release, ....



# TRMM PR cal/val

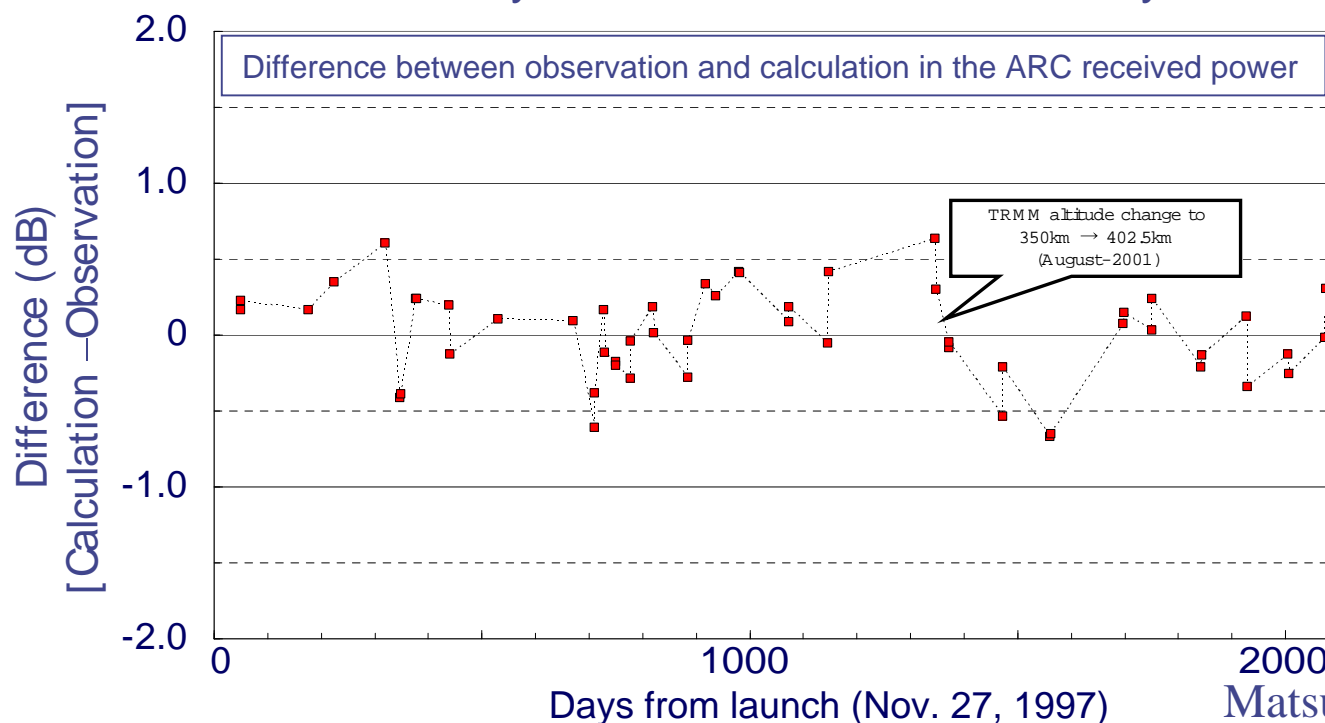
## Calibration

### ◆ Internal calibration

- Internal calibration indicates that receiver characteristics after FCIF including log amplifier. The results were quite stable.

### ◆ External calibration by ARC (Active Radar Calibrator)

- Absolute calibration of (transmitted/received) power and Z measurement
- From launch to now, ARC calibration have continued.
- PR is well calibrated by ARC within  $\pm 0.5\text{dB}$  accuracy from launch to now.



Matsushima et. al (2003)



# TRMM PR cal/val



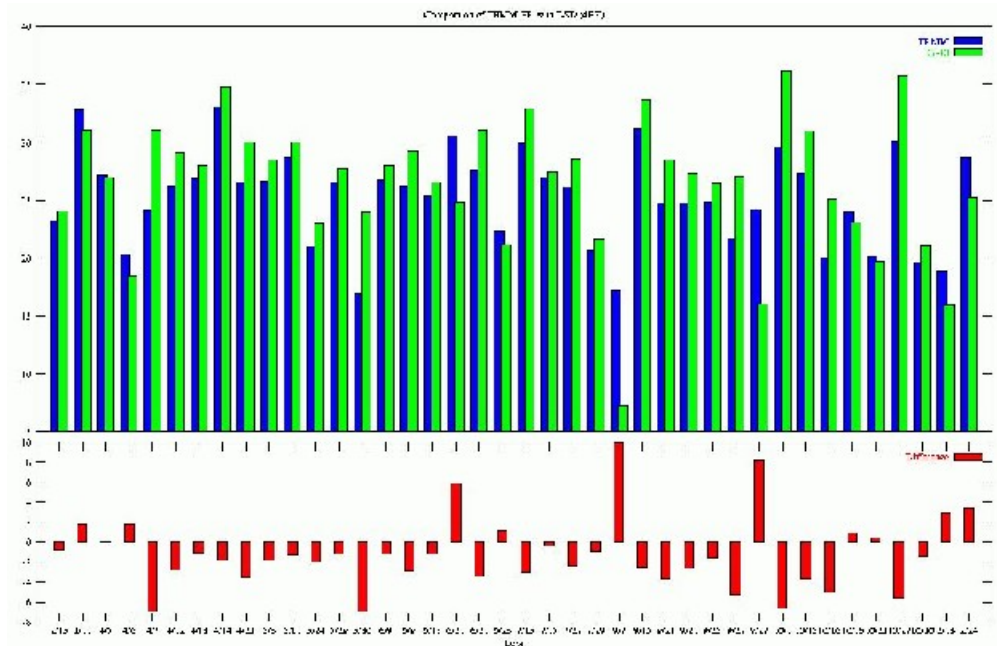
## Validation

- ◆ Regression type validations were conducted for Z-factor and Rain rate
  - Instantaneous comparison → Z-factor
  - Accumulation value → Rainfall amount

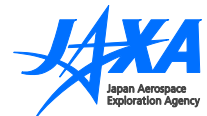
## Z-factor validation

### 1. PR vs. Disdrometer

- ◆ PR reclectivity variation is consistent with disdrometer except small bias (Disdrometer > PR)



Disdrometer vs. PR (Nakamura, 2000)

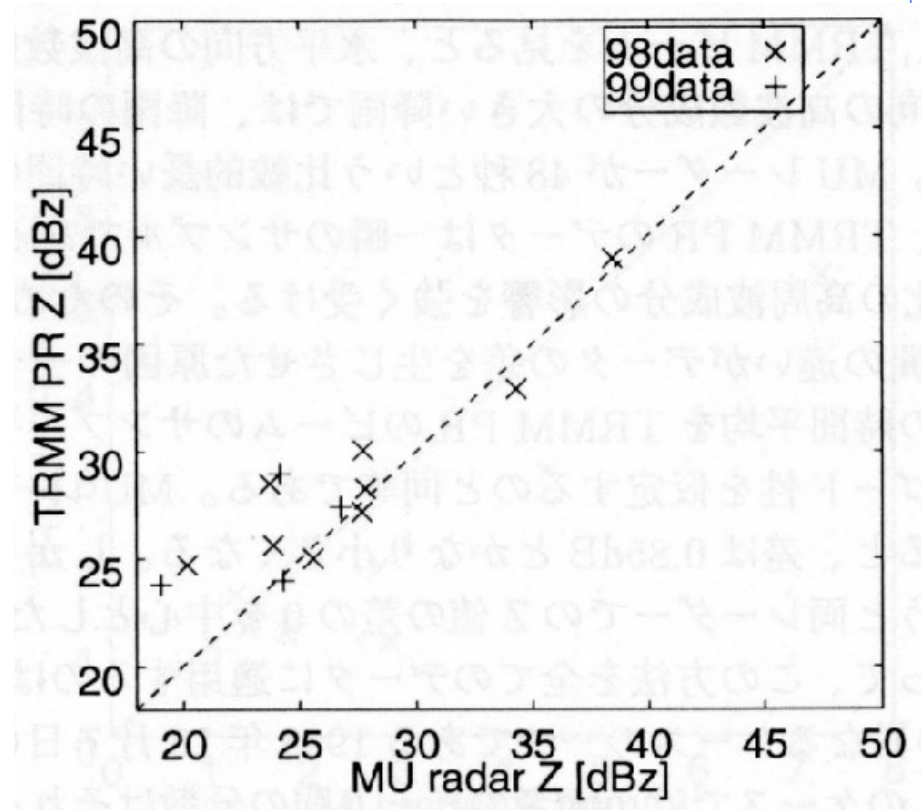


# TRMM PR cal/val



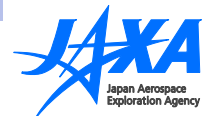
## 2. PR vs. MU radar

- ◆ Sampling volume of MU radar was adjusted to PR IFOV.
- ◆ Good agreement between PR and MU radar (offset bias was within 1 to 2 dB)



MU radar vs. PR (Sato, 2000)

Conventional operational radar data do not work for ground validation because of variance of the radars.

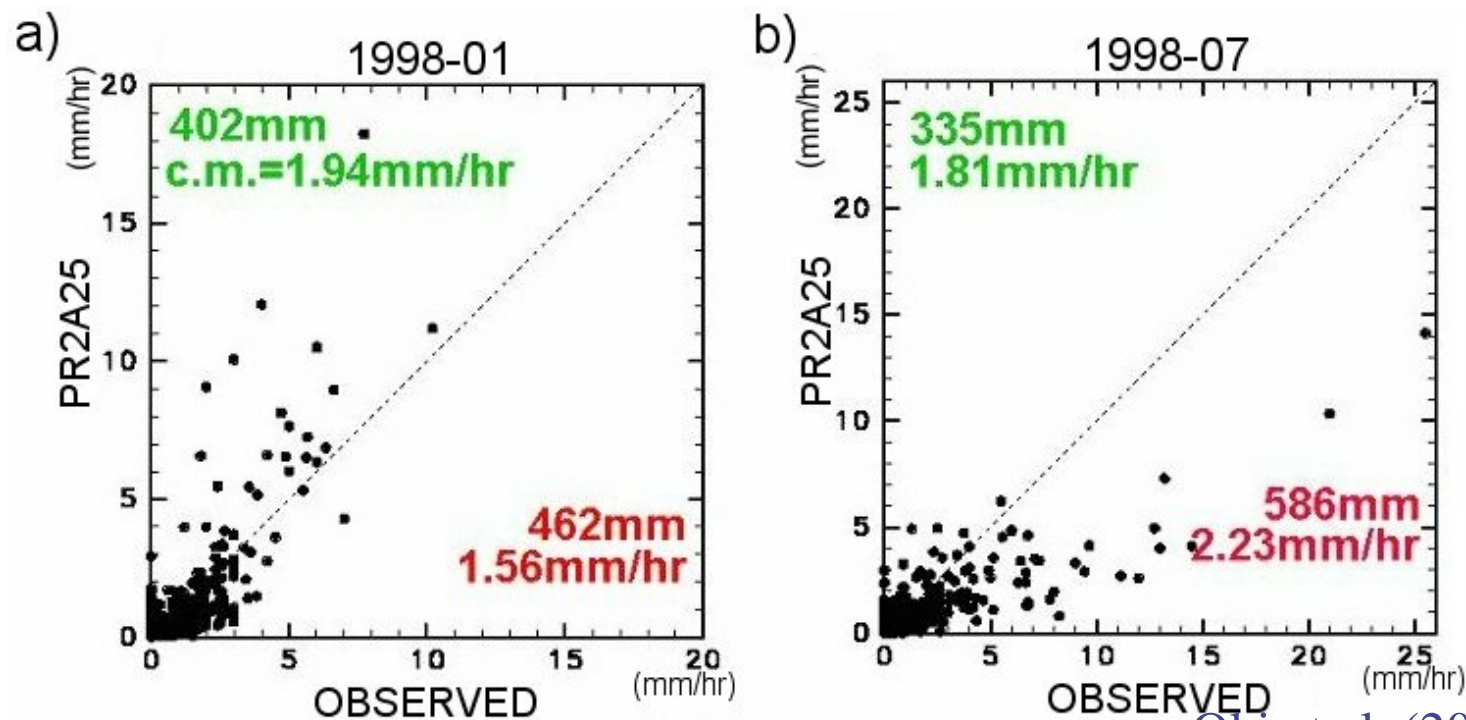


# TRMM PR cal/val

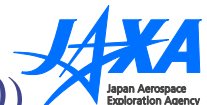


## Validation of Rain rate

- PR vs. AMeDAS and Radar-AMeDAS
  - Rainfall rate averaged in  $0.5^\circ \times 0.5^\circ$  estimated by PR are compared with ground-based raingauge data and radar-based rain data.
  - There is a seasonal dependence of rain intensity.
  - (Retrieval error was greater than sampling error.)



Oki et al. (2000)



# From TRMM experiences

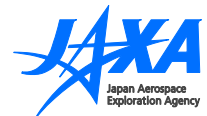


- ◆ Simple comparison is never enough.
  - TRMM is too good to be validated by regression-based traditional validation. In other words, space-borne measurement is now precise independent measurement.
- ◆ Precise and comprehensive precipitation system measurement is required
  - "Physical validation" may be more important for microwave rain retrieval. However, DPR algorithm aims to "2nd order" accuracy, and precipitation system validation is again important.



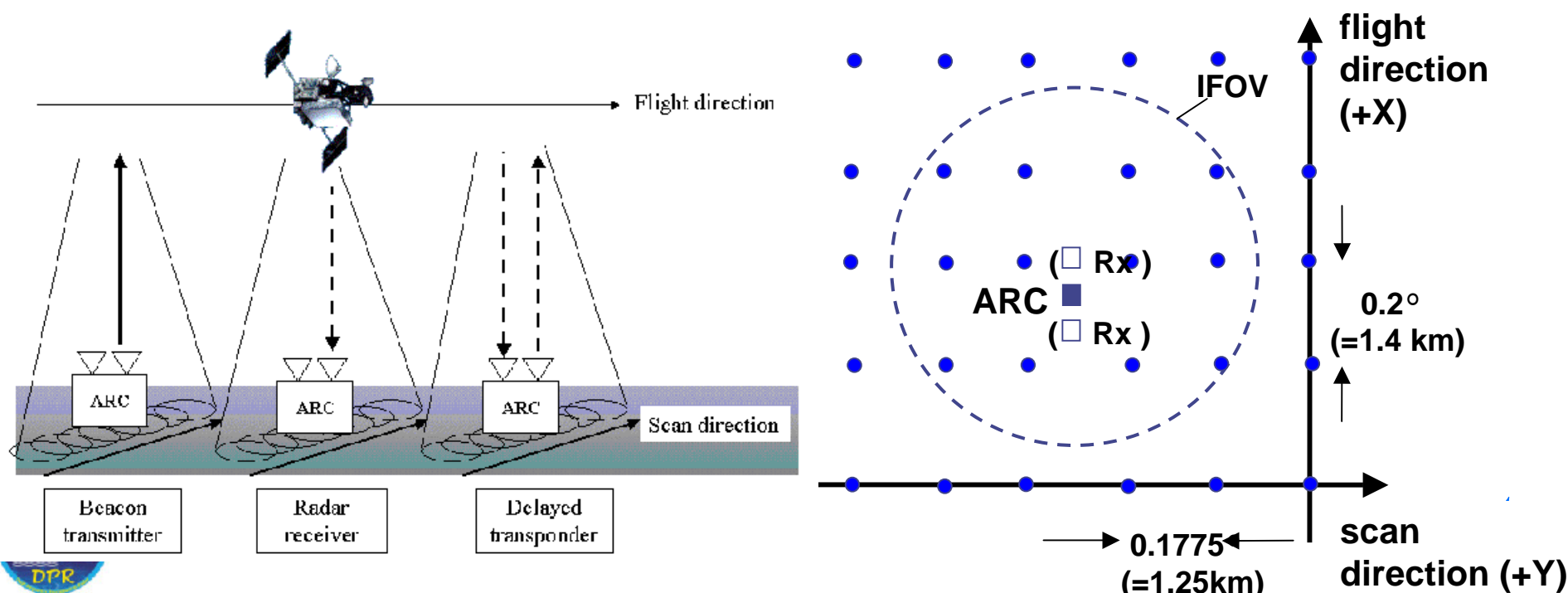
- ◆ Algorithm specific validations for each algorithm are required.
- ◆ Special validation site is required for the physical validation

→ Super sites (Okinawa, Wakkanai)



# DPR calibration

- ◆ Firstly, Same calibration as TRMM PR
- ◆ New items for DPR calibration
  - It is necessary where the ARC set within PR footprint (beam).
    - ◆ Multiple ARCs (or receivers) are required for fine resolution.
    - ◆ Better angular resolution would be helpful. But it is trade off with along track resolution
  - Post-launch beam matching measurement between two radars (new task of external cal. for GPM/DPR) using Multiple ARCs

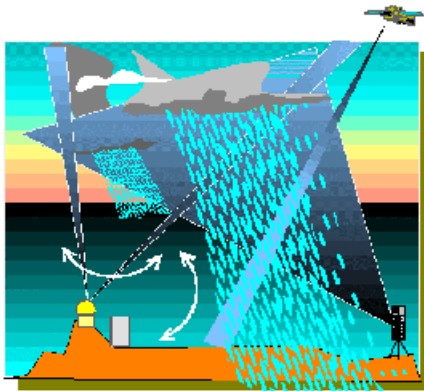


# Japanese Super Site for GPM



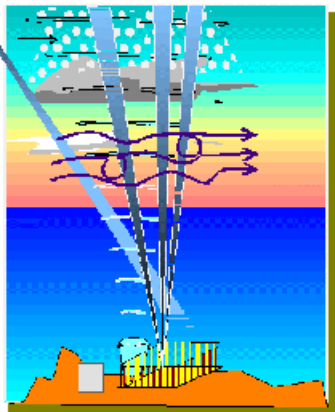
- ◆ For DPR validation, Japanese super sites will be set up in Okinawa and Wakkanai.

## Okinawa site



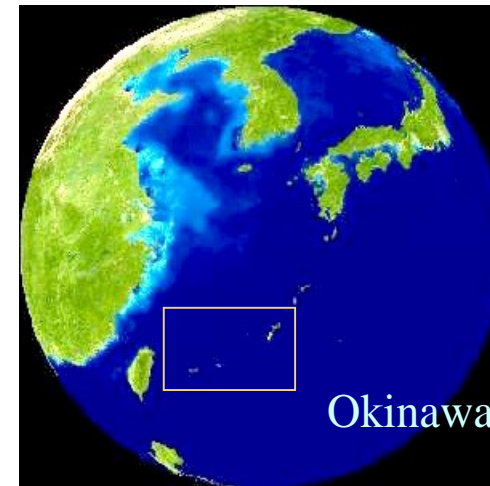
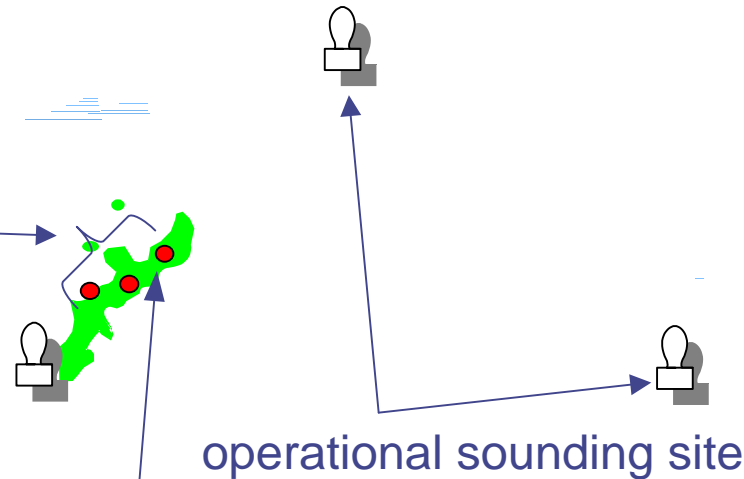
Precipitation Radar Facility

- C-band pol. Radar
- Raingauges
- Disdrometers
- Micro rain radar...

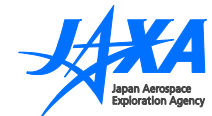


Wind Profiler Facility

- 400MHz WP
- 1300MHz WP



Okinawa



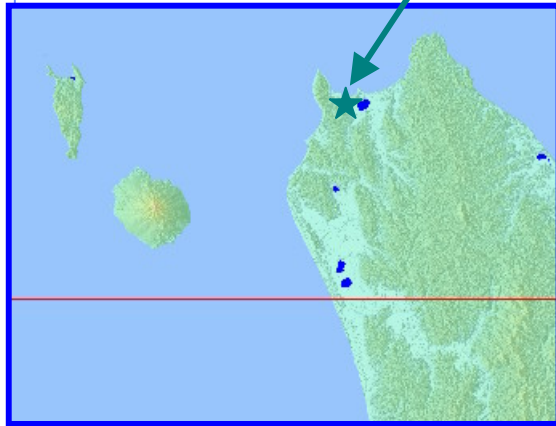
# Japanese Super Site for GPM



## Wakkanai site for solid precipitation

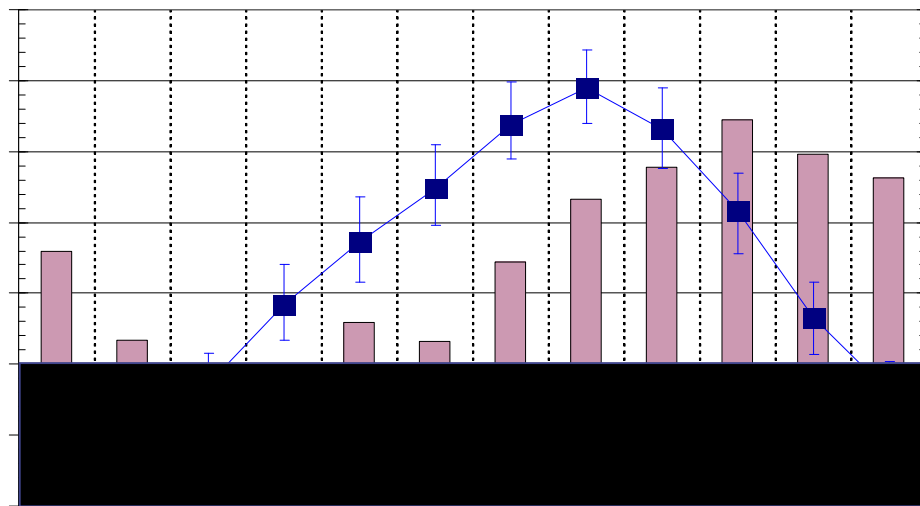
Wakkanai: 45°23'30" N, 141°41'12" E

Wakkanai (Japan)



Temperature

25.0 °C  
20.0 °C  
15.0 °C  
10.0 °C  
5.0 °C  
0.0 °C  
-5.0 °C  
-10.0 °C



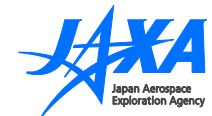
Rainfall

175.0 mm  
150.0 mm  
125.0 mm  
100.0 mm  
75.0 mm  
50.0 mm  
25.0 mm  
0.0 mm

Rainfall	89.6 mm	58.4 mm	49.3 mm	49.1 mm	64.6 mm	58.0 mm	85.9 mm	108.1 mm	119.3 mm	136.2 mm	124.0 mm	115.9 mm
Temperature (Average)	-5.0 °C	-5.1 °C	-1.4 °C	4.2 °C	8.6 °C	12.4 °C	16.9 °C	19.5 °C	16.6 °C	10.8 °C	3.3 °C	-2.0 °C

Month

- It snows for 6 months in Wakkanai.
- Wind profiler
- Video disdrometer, MRR, Ku and W-band radars, etc



# For Validations of DPR



## ◆ Focal points (liquid precipitation)

### 1. From TRMM Experience

- ◆ Minimizing spatial/temporal mismatching for comparison between DPR and GV radars

### 2. Same problem as TRMM PR

- ◆ Effect of non-uniform Beam filling to precipitation rate and attenuation estimation

### 3. New validation issues for DPR

- ◆ DSD validation
- ◆ Attenuation correction including gaseous and cloud attenuation



# For Validations of DPR



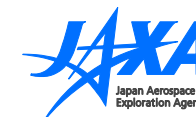
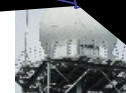
## 1. Minimizing spatial/temporal mismatching for comparison

From TRMM experience, spatial and temporal matching is a key point for the precise validation analyses using comparison.

### ◆ one line/one plane observation

- In order to minimize the mismatching for comparison between DPR and GV radar, PPI scans by fixed elevation in short interval.
- In order to get vertical information in detail, RHI scans along (cross) track direction

### ◆ Sampling volume differences is still a problem.

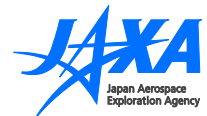
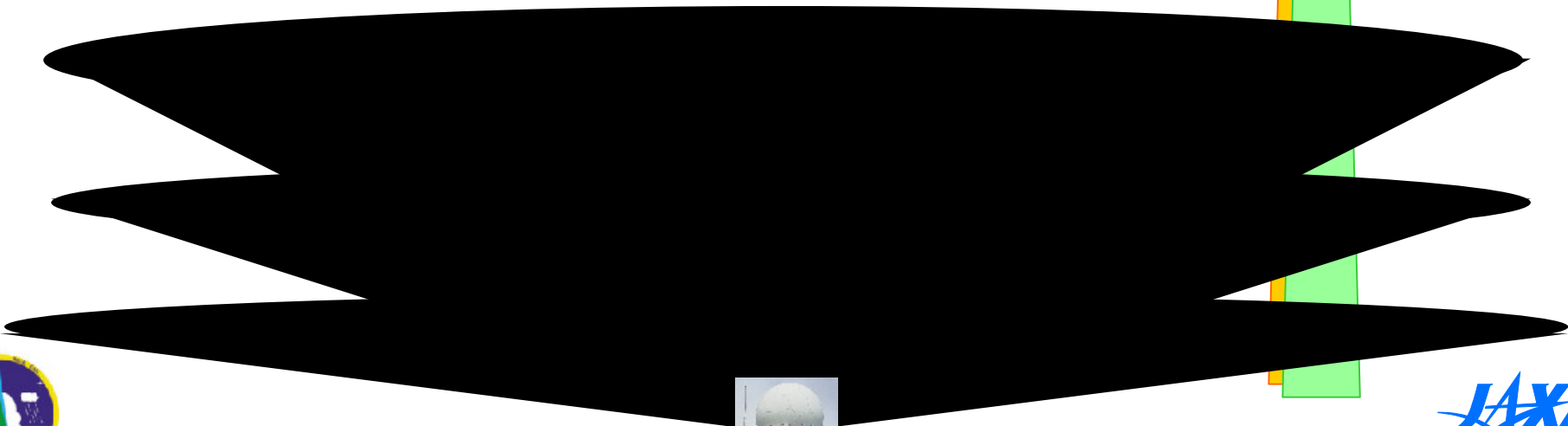
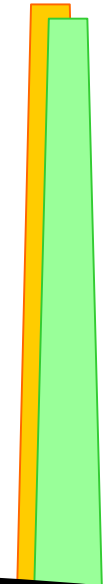
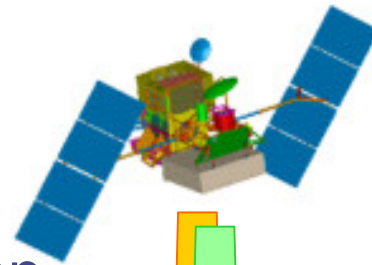


# For Validations of DPR



## 2. Effect of non-uniform Beam filling

- ◆ Before launch, Okinawa radar will be continuously operated using volume scan and the characteristics of the beam filling in DPR IFOV will be confirmed.
- ◆ After launch, case studies by Okinawa radar will be conducted using simultaneous data of DPR.



# For Validations of DPR



## 3. New validation issues for DPR

### ◆ TRMM PR (Ku)

- DSD → uncertain parameter, algorithm matter
- Attenuation → including DSD uncertainty

### ◆ GPM DPR (Ku and Ka)

- DSD, attenuation → Estimated values by dual-frequency algorithm



Precise validations for DSD and attenuation are very important.



# For Validations of DPR



## DSD validation

- ◆ DSD aloft statistics by WP(s)
- ◆ disdrometers

## Attenuation correction including gaseous and cloud attenuation

- ◆ Z-factor comparison between DPR and WP(s)
- ◆ DSD aloft statistics by WP(s)
- ◆ Discrimination of attenuation and Mie scattering effect
  - Airborne and ground-based dual-wavelength radar an upward/downward simultaneous observation
  - Cloud attenuation estimation ← 95GHz radar



CAMPR, SPIDER  
(ground-based)

Wind Profiler

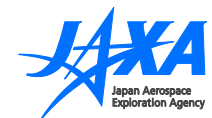


# For Validations of DPR



## ◆ Focal points (solid precipitation)

- Algorithms?
- Density,  $N_0$ ,  $D_0 \rightarrow$  Snow rate
  - ◆  $N_0$  and  $D_0$  can be derived by dual frequency radar for rain rate. But we have three parameters for snow. Statistics of snow density is required.
- We will try to get upper layer data above melting level at Okinawa.
  - ◆ Conventional method using polarization radar for the classification of solid particles.
  - ◆ Spectrum differences in C, Ku, Ka and W for detection of terminal velocity of snow.
- Campaign observation in CRL Wakkanai during winter season using wind profilers, Ku/W-band radars, multi-parameter radar, etc.



# Cal/ Val plan for DPR

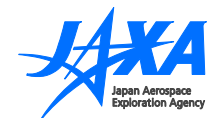


## ◆ Before launch

- DSD database using disdrometer, WP, etc.
- Facility development for DPR validation during TRMM lifetime
- Confirmation of Beam filling using volume scan data
- DSD estimate aloft by WP(s)
- X/ Ka simultaneous data by ground-based radars for algorithm validation of DPR
- Estimated DSD vs. ground-measured DSD (like WPs vs disdrometers)
- W/(X, Ka) → cloud attenuation: statistics



Establishment of DPR algorithm for rain and snow



# Cal/ Val plan for DPR



## ◆ After launch

- Sensor calibrations using ARCs
- Regression type validations for default validation and physical validations
- Continuous observation at CRL Okinawa site and case studies
- Campaign observation for snow rate in CRL Wakkanai using wind profilers, multi-parameter radar, snow particle observation system, etc...



# Summary



- ◆ Japanese calibration and validation will focus on DPR in GPM.
- ◆ Physical validation as well as convectional validation is important using well-calibrated WP, multi-parameter radar and disdrometers, etc.
- ◆ There are three focal points for rain validation. For snow, further complicated parameters and problems exist.
  
- ◆ We request to other validation activities for DPR validation;
  - Similar operation as CRL Okinawa and Wakkanai supersites
  - Collecting basic data for simulation of DPR products for verification of the DPR algorithm
  - Specialized observation for snow particles for the establishment of solid precipitation algorithm.



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