FIELD EXPERIMENT FOR GPM GROUND VALIDATION USING THE DUAL KA-RADAR SYSTEM

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1. INTRODUCTION

Global Precipitation Measurement (GPM) started as an international mission and follow-on mission of the Tropical Rainfall Measuring Mission (TRMM) project to obtain more accurate and frequent observations of precipitation. Japan Aerospace Exploration Agency (JAXA) is in charge of developing GPM/Dual-frequency Precipitation Radar (DPR) algorithms as the sensor provider and producing and delivering hourly global precipitation map to make useful for various research and application areas. In order to secure the quality of precipitation estimates, ground validation (GV) of satellite data and retrieval algorithms is essential.

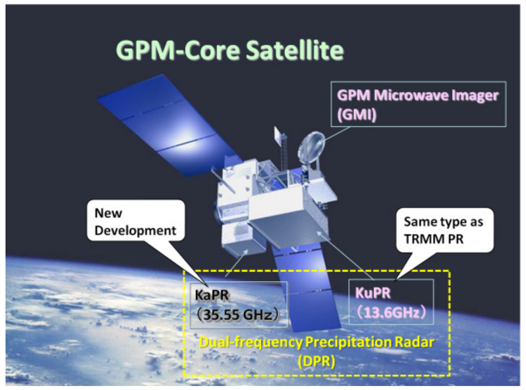

Fig. 1. The concept of the GPM-core satellite and Dual-frequency Precipitation Radar (DPR)

2. TWO-WAY MEASUREMENT USING IDENTICAL KA-BAND RADARS

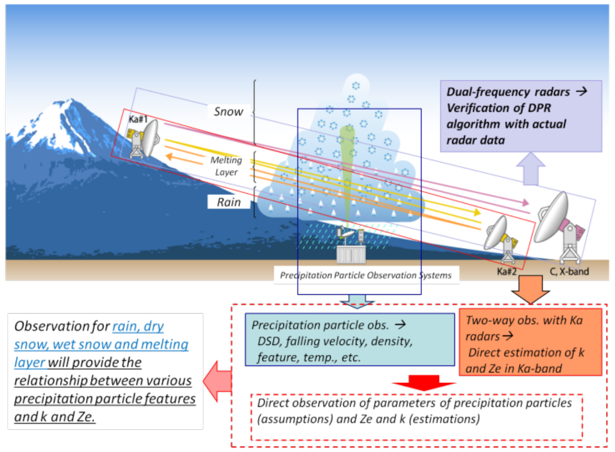

Fig. 2. The concept of the simultaneous observations using the two folding Ka-radars, X/C-band radar and precipitation particle observation system

For validation of DPR algorithm, it is important to validate the specific attenuation (k) and the equivalent radar reflectivity factor (Ze) independently.

$$Z_A(r) = Z_e(r) - \int_A^r k(s)ds \qquad (1)$$

$$Z_B(r) = Z_e(r) - \int_r^B k(s)ds \qquad (2)$$

From (1) + (2)

$$Z_A(r) + Z_B(r) = 2Z_e(r) - \int_A^B k(s)ds \qquad (3)$$

$Z_A(r)$, $Z_B(r)$: measured reflectivities of radar A and B at r
$Z_e(r)$: true reflectiviy at r, $k(r)$: attenuation coefficient at r

k and Ze can be directly estimated using the same total attenuation amount between the two radars with same specifications regardless of the precipitation phase.

- Two ground-based Ka-band radars is constructed for two-way measurement.
- Several observation sites are configured for the observation targets (rain, dry snow, wet snow, melting layer).

3. JAXA KA-BAND RADAR SYSTEM

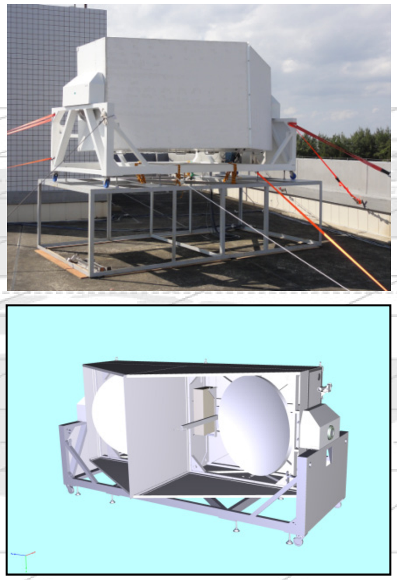

Fig. 3. Outlook of the JAXA Ka-radar

Table 1. Major specifications of the Ka-band radar

Radar type	FMCW type
Frequency	35.25 GHz
Antenna	Two 1.2 mφ offset parabolic antennas
Beam width	0.6 degrees
Transmitter	TWTA
Transmitting power	100W
Sensitivity	-20 dBZ at 10 km
Minimum range resolution	12.5 m
Minimum observable range	< 500 m
Maximum observable range	15 km/30 km
Doppler velocity range	< 10 m/s
Data	Averaged Z, Doppler velocity and width, raw I, Q, etc

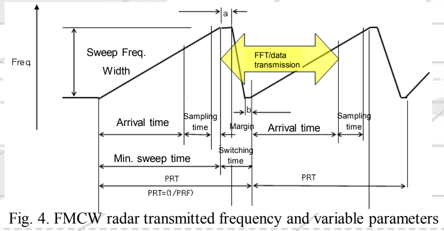

Fig. 4. FMCW radar transmitted frequency and variable parameters

Table 2. Observation modes for Ka radar

Mode	Pulse repetition interval [μsec]	Number of sweep	Observation range [km]	Range resolution [m]
Normal	200/400	256/512	15	50
Fine	200/400	256/512	15	12.5
Long range	300/400	256/512	30	50
High sensitivity	300	256	15	250

Required conditions of Ka radar construction for the two-way measurement

i. to observe the precipitation echo between the long distance,
ii. to detect the weak echo with the attenuation by precipitation particles, and
iii. to avoid the radio wave interference each other and the ground clutter.

Frequency modulated, continuous wave (FMCW) system uses a long pulse with a low transmitted power, and is suitable.

Transmission signal is generated by digital synthesizer. → Operation parameters can easily be changed.

4. SYSTEM EVALUATION

Comparison between Ka radar and well-calibrated radar (C-band Okinawa Bistatic Polarimetric Radar (COBRA) of NICT) and disdrometer for system evaluation.

- Similar cross sections of reflectivity between Ka radar and COBRA
- Good correlation of reflectivities on scatter diagrams with COBRA and disdrometer

Ka radar has good performance quantitatively for GV experiments.

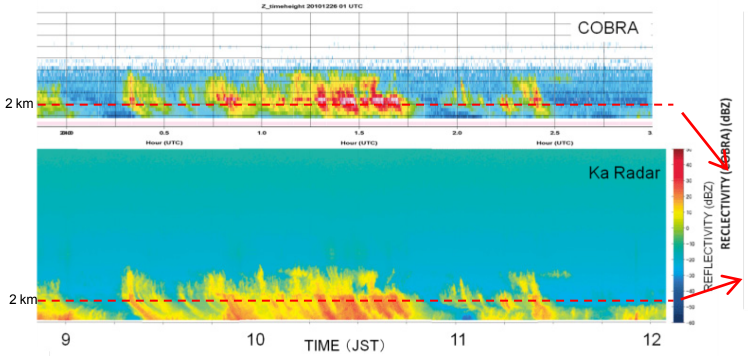

Fig. 5. Time-height cross sections of radar reflectivity measured by COBRA (upper) and Ka radar (lower)

Fig. 6. Simultaneous observation of COBRA and Ka radar

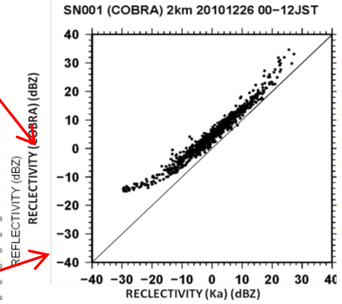

Fig. 7. Scatter diagram of radar reflectivity by a Ka-radar and C-band radar.

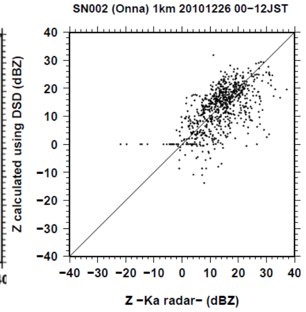

Fig. 8. Scatter diagram of radar reflectivity by a Ka-radar and a disdrometer

5. PRELIMINARY RESULT OF TWO-WAY MEASUREMENT

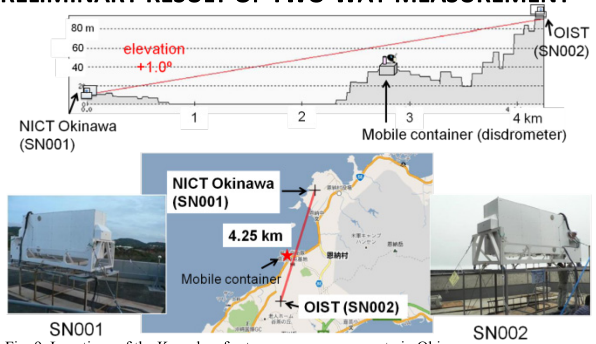

Fig. 9. Locations of the Ka radars for two-way measurements in Okinawa

Time-range section of Z (21-22 JST, 24 May 2011)

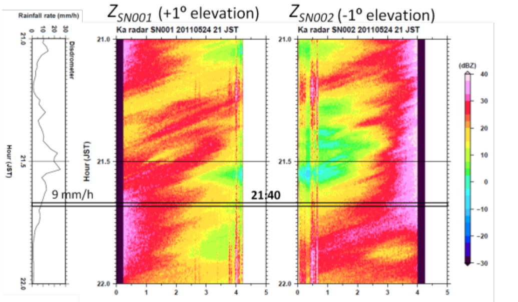

Fig. 10. Time series of reflectivity profiles of Ka radars [range resolution: 12.5 m, temporal resolution: 20 s]

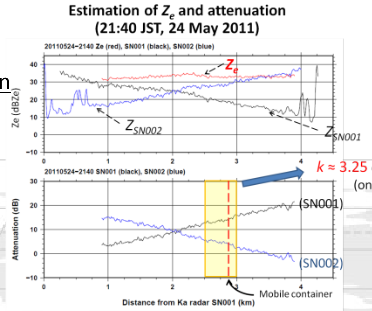

Fig. 11. Reflectivity (Zm and Ze) profiles from two Ka radars

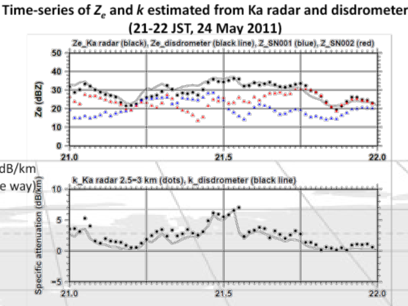

Fig. 12. Time series of Ze and k estunated from Ka radar and disdrometer

A field experiment using the dual Ka-radar system is conducted in Okinawa Island.

- Equivalent reflectivity factors (Ze) and equivalent reflectivity factors (k) values can be calculated from the profiles of Ka radar on two-way measurements.
- These values are well correlated with those from DSD estimated by disdrometer.

The result of two-way observation is quite reasonable.

6. FUTURE PLAN

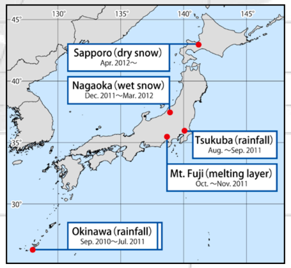

Fig. 13. Japanese observation sites for GPM/DPR pre-launch ground validation

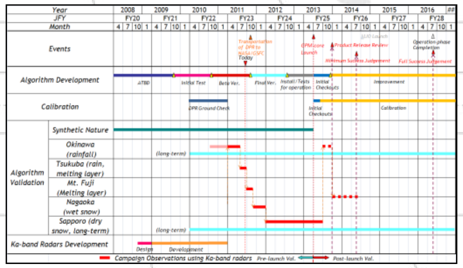

Fig. 14. Schedule for GPM/DPR pre-launch ground validation

Five observation sites are prepared for the DPR algorithm validation targeted to several types of the precipitation (rain, dry snow, wet snow and melting layer.

Campaign Observation on Mt. Fuji will be conducted from next month!