Global Precipitation Mission (GPM) and Dual-Wavelength Radar (DPR)

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1. INTRODUCTION

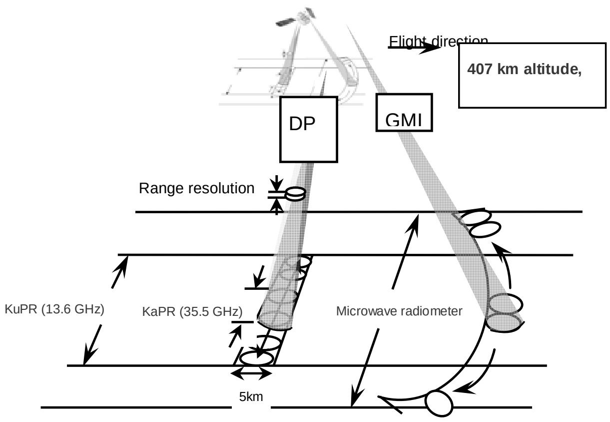
Global precipitation measurement is essential not only for the research of the global change but also for the water resources management. Currently, satellite precipitation measurement is not sufficient for the detailed study of the precipitation and is far from enough for the water resources management which requires very high spatial and temporal resolution. To fill the gap at least partly, the Global Precipitation Measuring (GPM) was proposed jointly by US and Japan. The basic concept of GPM is to provide three hourly global precipitation map using eight constellation satellites equipped with microwave radiometers and a core satellite equipped with a dual-wavelength radar (DPR) and a microwave radiometer. GPM is partly a follow-on mission of the Tropical Precipitation Mission (TRMM), but GPM will extend the observation to cold regions where solid precipitation frequently exists.

The role of Japan for the space segment of GPM is development of DPR which is an essential sensor for GPM. As TRMM results show that the precipitation radar provides not only independent rain estimates but also three dimensional structure of rain systems. The three dimensional structure of precipitation system helps much for understanding the accuracy of rain retrieval algorithms for microwave radiometers. The core satellite which will be equipped with DPR and a microwave radiometer will give us a great opportunity for simultaneously observation of precipitation systems with better accuracy. The non-sun synchronous orbit is required for crossing the orbits of constellation satellites as well as for resolving diurnal cycle of the precipitation.

2. DUAL-WAVELENGTH RADAR

The core and essential sensor is the DPR which applies the active phased array type as the same as the TRMM precipitation radar but with Ku and Ka -band dual channels. The antenna scans perpendicular to the flight track while the microwave radiometer (GPM microwave imager: GMI) has a conical scanning. The swaths of DPR are 245 km and 120 km for Ku and Ka bands, respectively (Fig. 1). As Table 1 shows, the Ku band radar of the DPR is nearly the same as the TRMM precipitation radar [1]. This makes smooth extension of the TRMM precipitation radar observation.

The Ka-band radar in the DPR scans in two fashions (Fig. 2): one has matched beams with the Ku-band radar and the range resolution is 250 m. The data from this scanning are the primary data for dual-wavelength radar rain retrieval. The other is a high sensitivity mode which is interlaced and the range resolution is 500 m. The longer range resolution results in a higher sensitivity which is required for light rain and solid precipitation detection.



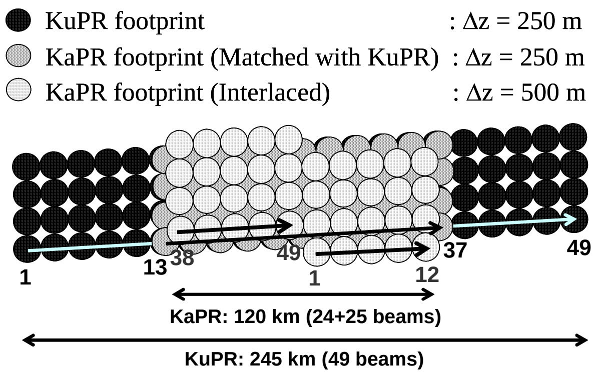


Fig. 1 Precipitation observation by core satellite.

Fig. 2 Scanning geometry of DPR

Table 1 Main Characteristics of DPR

	KuPR	KaPR
Frequency	13.597 and 13.603 GHz	35.547 and 35.553 GHz
Horinzontal Resolution	5 km (at nadir)	5 km (at nadir)
Swath Width	245 km	120 km
Scan period	0.7 sec	0.35 sec
Range Resolution	250 m	250 m / 500 m
Observation Range	18 km to -5 km ASL	18 km to -3 km ASL
Minimum Detectable Rainfall Rate	0.5 mm/hr (defined by $Z = 200R^{1.6}$)	0.2 mm/hr (defined by $Z = 200R^{1.6}$)
Measurement Accuracy	within ± 1 dB	within ± 1dB
Beam-matching Accuracy	< 1000 m	
Data Rate	< 112 kbps	< 78 kbps
Mass	< 370 kg	< 300 kg
Power Consumption	< 380 W	< 300 W
Size	2.4 × 2.4 × 0.6 m	1.4 × 1.0 × 0.7 m

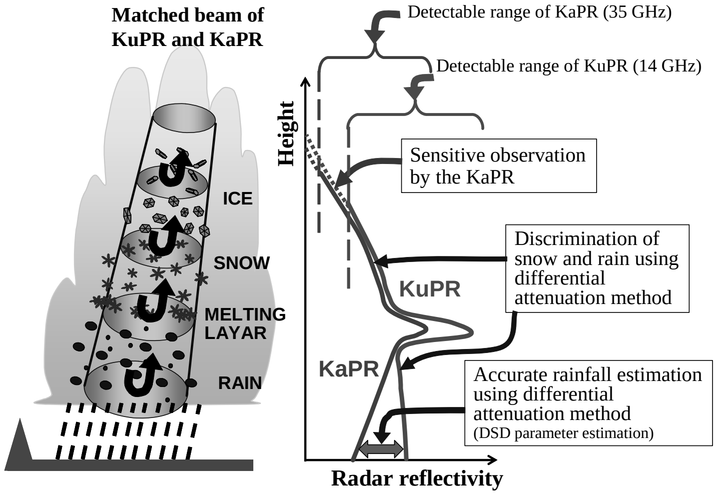


Fig. 3 Concept of rain profiling algorithm for DPR

Rain retrieval using DPR is also being developed. Using two wavelength data, two parameter raindrop size distribution could be retrieved, which would result in precise rain retrieval (Fig. 3) (*e.g.*[2] [3]). The shorter wavelength radiowave suffers from rain attenuation and also deviation from Rayleigh scattering occurs. Thus, the difference of the received signatures at the two wavelengths includes the Mie scattering effect and the rain attenuation effect. The solid precipitation rate is a new challenge. The solid precipitation have parameter of density which varies significantly. The shape also deviates significantly from a sphere.

Several algorithms would be applied to DPR: dual-wavelength radar algorithm, Ku-band single wavelength approach, and the Ka-band single wavelength approach according to the availability of received powers at the two wavelength. Combination with microwave radiometer could be another technique. The high sensitivity data from shorter wavelength radar will enable the light solid precipitation measurement. However, the sensitivity is about 12 dBZ according to the current design. This sensitivity may limit the light solid precipitation measurement.

3. GROUND VALIDATION

An important findings of TRMM validation is that simple conventional rain data comparison is not enough. The space measurement has so much improved that the regression type parameter tuning is not satisfactory. We need validation for radiometrically consistent rain retrievals. The required data might be very similar to those required from microwave radiometer algorithms. The detailed comprehensive three-dimensional precipitation structure is required. The structure data includes: phases of the precipitating particles (i.e., pristine crystals, snow crystals, graupels, aggregates, raindrops, and melting snow), size distributions, water vapor distribution, and cloud distributions. The polarization rain radars and cloud radars are very desirable for obtain these parameters. Windprofiler radars have potential to derive the dropsize distributions aloft. The surface condition is another important one. For DPR, the so-called surface reference technique [4] could be more complicated and improved from TRMM PR. The surface backscattering cross sections should also be measured. For the surface observation, dense gauge network is essential.

From the comprehensive observations, a simulation of satellite measurements can be performed using forward calculations. Rain profiling algorithms for DPR and GMI can be applied to the simulated measured quantities, such as, measured radar reflectivity at two wavelengths, microwave brightness temperatures. Comparing the results, error characterization could be performed. Another advantage of this method is that the simultaneous observation of precipitation from both ground and space is not required. TRMM experience tells us that simultaneous rain observation is only about once a month at one ground site. The above concept is different from a simple conventional end-to-end direct comparison.

Snow estimate validation is another big issue. Even on the ground, the water equivalent snowfall observation is difficult, and we may need “snow supersites”. The rain/snow over ocean is difficult even for TRMM. Methodology should be developed.

The validation methodology for three-hourly rain mapping from constellation is different from the instantaneous estimates. For the TRMM case, comparisons with other ground/space data, such as GPCP data were performed. Similar methodology is expected for GPM. For the surface observation, dense gauge network is essential. The spatial and temporal matching in space and ground observations is critical. For the upscaling of the GV site observation not only in space but also in time, the super site and/or dense gauge networks should be embedded in the operational radar/raingauge networks.

ACKNOWLEDGEMENTS

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