

A simulation study of the Doppler measurements for a Ku-band spaceborne precipitation radar

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A future satellite mission of precipitation observations is discussed in Japan. From a low-orbit satellite, it is difficult to directly observe temporal evolution of precipitating clouds. The dynamical structure of precipitation helps better understandings of the lifecycle of precipitating clouds. Thus, the Doppler capability of a spaceborne precipitation radar is expected to provide data for global dynamical characteristics of various precipitation systems. However, the Doppler measurements of precipitation from space is challenging because of a fast-moving platform and a radar's finite field of view (FOV). Since the radar onboard the spacecraft quickly passes above precipitating clouds, the decorrelation of precipitation signals due to the beam broadening effect degrades the Doppler measurement accuracy. Moreover, a spatial variability of precipitation within the FOV causes mixing of the motion between precipitating particles and spacecraft, which is called as an effect of the non-uniform beam filling (NUBF).

This study investigates the Doppler capability of the spaceborne precipitation radar based on simulation experiments by using high-spatial resolution ground radars and numerical model data. Here, we assume two Ku-band Doppler radar systems: A) a single large antenna system and B) a dual small antenna system. Since the contamination of the platform motion is proportional to the platform velocity and the radar's beamwidth, the single large antenna system mitigates the contamination due to the platform motion. On the other hand, the dual antenna system adopts the displaced phase center antenna (DPCA) technique. A signal processing with dual antennas deployed along the platform motion can cancel out the platform motion so that mitigation of the beam broadening and NUBF effects is expected even if the FOV is coarser than the large antenna system. A quantitative evaluation between the two systems is conducted. For the single large antenna system (FOV of 2.5 km), the mean Doppler velocity error of precipitation (> 15 dBZ) is evaluated in the range from 2.3 to 5.0 m/s. Although the large error is originated from a residual error of the imperfect NUBF correction, the error is mitigated from 0.7 to 1.5 m/s when a 5-km average in the along-track direction is applied. For the dual antenna system with the DPCA technique (FOV of 5 km), the error is evaluated in the range from 0.6 to 1.1 m/s. We plan an additional analysis to evaluate error estimates in the air vertical velocity subtracting the precipitation falling velocity from the Doppler velocity.

Keywords: Spaceborne Precipitation Radar, Doppler measurement, Error evaluation