Development and observation of Ku-band broad band radar for meteorological application

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Rainfall observation using a weather radar has the major advantage that it is possible to observe precipitation widely in a short time. In addition, Doppler observation of a weather radar provides us with information of atmospheric flow in a precipitation area. Nowadays, many weather radars are deployed all over the world and contribute to weather forecast, warning and so on as an important infrastructure.

Most conventional radars, for both operation and research, are S-, C- and X-band radars covering 100 to 300 km in radius with the range resolution of 100 m and the time resolution of 10 min roughly, which are appropriate for the precipitation system of macro or mesoscale. The products of conventional radars are valid especially for research of mesocyclones, squall lines, etc. which are relatively large scale phenomena in mesoscale. On the other hand, smaller scale weather phenomena such as thunderstorms, tornadoes and microbursts, which often damage our lives seriously, cannot be detected by conventional radars owing to the resolution. In order to sufficiently analyze a weather phenomenon, a weather observation instrument is needed to resolve this phenomenon with the resolution over 10 - 100 times in space and 10 times in time. In the work with respect to the other weather phenomenon of lightning, the observation using lightning detection and ranging (LDAR) system indicates that vertical developments of lightning activity with micro scale in thunderstorms are followed by tornadoes, downbursts, etc. and it is insufficient of conventional radars to confirm this.

Furthermore, the rain rate obtained by conventional radars does not necessary correspond to that of ground based equipments, such as rain gauges and disdrometers. The non-uniformity distribution of precipitation in a rain scattering volume is considered as a cause of this disagreement. The weather radar equation is constructed under the assumption that the distributed particles completely fill the resolution volume in a same phase at a range bin. Another cause is that conventional radars cannot obtain precipitation profiles at low altitude, because the radar beam overshoots by the altitude of several kilometers in the range roughly over 150 km due to the earth's curvature and cannot be transmitted at low grazing angle due to the surrounding landform. In addition, monostatic radars, most conventional radars have monostatic antenna systems, cannot observe in a close range, because the receiver must be turned off during transmitting. The vertical pointing observation for precipitation using the wind profilers indicates that reflectivity profile of precipitation changes by several dBs even under the altitude of 400 m, affected by evaporation, drop, break up and coalescence of raindrops.

In this study, we developed the Ku-band broad band radar (BBR), a remarkably high resolution Doppler radar for meteorological application designed to detect, analyze and predict the small scale weather phenomena already mentioned. In the BBR, pulse compression is used for the high resolution. In the result, the range resolution is about 5 m and the time resolution is 1 min per 1 volume scan (VoS). The low coupling level (-70 dB) with the low power transmission (10 W) enables the BBR to observe the precipitation profiles from 50 m to 15 km for accurate estimation.

In our previous work, we developed the prototype BBR, the vertical pointing version, and showed the estimate accuracy and the availability of high resolution observation for precipitation. In this presentation, the first radar of the BBR network with volume scanning capability is presented. The descriptions of the BBR about the configuration and the signal processing procedure, the accuracy of the reflectivity factor estimated by the comparison of the BBR and a disdrometer and the initial observation result of the volume scan are shown.