

# Multi-sensor observation of evolution from cumulus to cumulonimbus in Tokyo metropolitan area

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Recently, weather radar network which consists of X- and C-band polarimetric radars has matured in Japan. This nationwide network enables Quantitative Precipitation Estimation (QPE) with high resolutions (1 minute and 250 m), and is used for a monitoring of localized heavy rain. So now a social request is shifting from the monitoring to the forecast of the heavy rain. This kind of forecast needs a seed of cumulonimbus development as an initial condition. The weather radar is a suitable instrument to find the seed. But when the ordinary weather radar finds it, the rainfall has already started. To make the lead time of the forecast longer, we should monitor the pre-stages of cumulonimbus, such as horizontal convergence and cumulus clouds. For this purpose, we installed microwave radiometers, Doppler lidars, Ka-band cloud radars around Tokyo metropolitan area. Furthermore, X-band Multi-Parameter Phased Array Weather Radar (MP-PAWR) also covers the area, and is a powerful instrument to capture the three-dimensional structure of precipitation system. In this presentation, an evolution from cumulus to cumulonimbus is analyzed by using multi-sensor data.

Figure 1 shows a time evolution of radar reflectivity observed by the Ka-band cloud radars and Vertically Integrated Liquid (VIL) observed by the MP-PAWR in the afternoon on 3 August 2018 (Japan Standard Time). At this time, three cloud radars made sector-PPI observation (4 tilts in 1 minute by each radar), and the MP-PAWR acquired volume data every 30 seconds. At 1405 JST, the cloud radars captured scattered cumulus cloud echoes with the reflectivity less than -10 dBZ and horizontal scale less than 2 km. The life time of these clouds was about 10 minutes, and the clouds seemed to appear randomly. While these clouds appeared and dissipated, the MP-PAWR did not capture the precipitation. The maximum reflectivity and horizontal scale of these clouds gradually became larger. From 1440 JST to 1445 JST, one cloud developed rapidly, and weak precipitation was captured by the MP-PAWR at 1445 JST. However, this precipitation (cumulonimbus) did not develop well, and dissipated in 10 minutes. After 1505 JST, obvious cumulonimbus was captured by the MP-PAWR, and this matured at 1520 JST. The cumulus cloud which evolved to this cumulonimbus appeared at 1450 JST. These clouds development was also captured by geostationary meteorological satellite Himawari-8, but the development and dissipation of these clouds were not obvious in visible image (0.64  $\mu\text{m}$ ).

The Ka-band cloud radar analysis indicated that many cumulus clouds with short life time were generated before the cumulonimbus were detected. The cumulus generation in this manner was often observed in other cumulonimbus events. This cumulus activity may help the cumulonimbus generation by the moistening in mid-troposphere. Precipitable water observation by the microwave radiometer, which was about 50 mm at 1300 JST and about 55 mm at 1430 JST on 3 August 2018, supported this process in the event described above. The cloud radar analysis also showed that the cumulus clouds which evolved to cumulonimbus had larger reflectivity ( $> -5$  dBZ) and horizontal scale ( $> 5$  km) than non-evolving clouds.

Figure 1: Time evolution of radar reflectivity observed by the Ka-band cloud radars (left) and Vertically Integrated Liquid (VIL) observed by the MP-PAWR (right) from 1405 JST to 1540 JST on 3 August 2018. Left image shows the ka-band maximum radar reflectivity aloft between the heights of 2000 m and 5000

m ASL. Open circles indicate the locations of Ka-band cloud radars used in this analysis. Open square in VIL image indicates the location of the MP-PAWR.

Keywords: cumulus, cumulonimbus, cloud radar, MP-PAWR

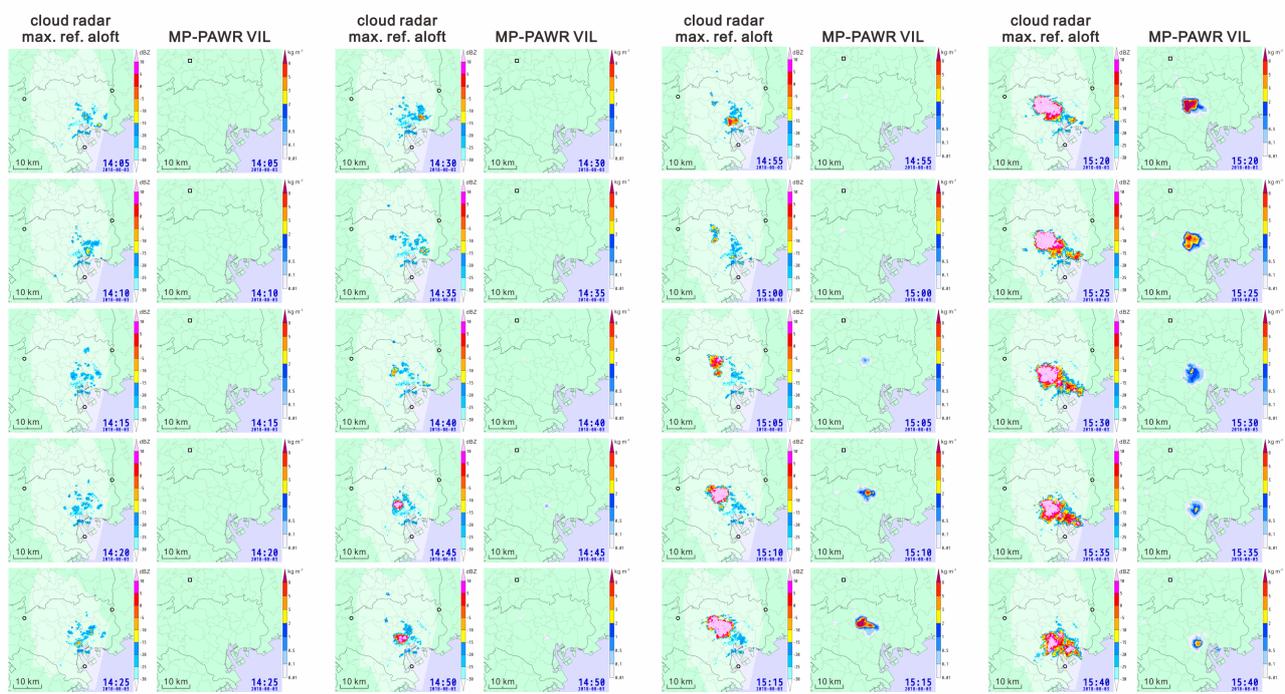


Figure 1