Case study of environmental conditions and cloud microphysical properties of winter convective clouds developed in the Kanto plain

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In winter, convective clouds sometimes develop and cause local snowfalls and lightning strikes in the Kanto plain in Japan. To understand and forecast these winter convective clouds, detailed observations of environmental conditions and cloud microphysical properties are required. In this study, we performed a case study on the winter convective clouds on 26 January 2019, and examined the temporal variation of environmental conditions and properties of cloud and precipitation by using Japan Meteorological Agency (JMA) analysis data, dense surface meteorological observation data, Himawari-8 data, JMA operational radar data, photograph data of precipitation particles derived from citizen science, disdrometer and microwave radiometer data obtained at the Meteorological Research Institute in the Tsukuba, Ibaraki.

On 26 January, the surface pressure pattern was the winter monsoon type and the upper cold vortex moved to the northern Japan. Since the Kanto plain was located on the southeastern side of the cold vortex, synoptic condition was favorable for convection development in the Kanto plain. In respect of the mesoscale environments, the low-level convergence line was formed in the Kanto plain by west-northwesterly and northerly airflows that crossed the mountain areas. The Himawari-8 infrared images captured the cloud street associated with the convergence line from 13:30 JST (=UTC+9h), and radar echoes of convective clouds were observed by JMA Tokyo radar from 14:40 JST. Two convective clouds developed in the convergence line and passed over Tsukuba from about 15:30 to 16:30 JST. From the results of one-dimensional variational (1DVAR) analysis combined with numerical weather model and microwave radiometer data, it was found that thermodynamic environments significantly got unstable at 15 JST because of increases of low-level atmospheric temperature and influence of upper cold air flow.

Disdrometer in Tsukuba observed precipitation of two convective clouds from 15:34 to 15:44 JST and from 16:03 to 16:32 JST. Results of zenith-looking observation by micro rain radar showed the existence of echo at the altitude of 3-5 km 5-10 minutes before the surface precipitation at 15:34. Liquid water path (LWP) derived by the microwave radiometer significantly increased about 20 minutes before the surface precipitation by the first convective cloud, and the value of LWP in the case of second convective cloud was smaller than that of the first one. Results of disdrometer observation showed characteristics of the precipitation particles were similar to that of typical lump graupel, and fall velocity of the particles from the first convective cloud was significantly greater than that of second one. Photograph data by citizen science revealed that the graupel particles from the first convective cloud had densely rimed structures compared with those of second one. These differences of cloud microphysical properties would be due to the difference of the life stages of the convective clouds.

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