

# Observations of convective storm and tornado-like vortex using X- and Ka-band radars and Doppler lidars in Tokyo, Japan

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The National Research Institute for Earth Science and Disaster Resilience (NIED) in Japan set up remote sensors including microwave radiometers, scanning coherent Doppler lidars, and Ka-band radars in the Tokyo Metropolitan area in 2013 and 2014, in addition to the existing X-band polarimetric radars. These instruments have been used during the summer months for observation of cumulus initiation, cumulonimbus development, and the environments in which these formations occur (Iwanami et al. 2015, 37th Conf. Radar Meteor.). The results obtained are valuable for predicting cumulonimbus-cloud development using numerical weather prediction models and data assimilation. On 4 July, 2017, a stationary front (Baiu front) was present over northern Japan, and a small typhoon approached the Kanto region from western Japan. Ahead of the rainfall region of the typhoon, a southerly wind brought hot wet air to eastern Japan, and several convective storms developed in Tokyo. Our instruments succeeded in collecting observational data during the initiation and development stages of cumulonimbus cloud, and an associated tornado-like vortex. Our two Doppler lidars, which are spaced about 13 km apart, performed Plan Position Indicator scans and detected signatures of this vortex in the form of positive and negative Doppler velocities. Before this, the lidars observed an overall southerly wind and the southward migration of a northerly wind region near the ground. The vortex appeared at the edge of the northerly wind region. Ka-band radar observations detected the first echo of the storm almost 30 minutes before the vortex formed. This echo was 10 minutes earlier than the first echo obtained using X-band radar. The convective echo moved to the northeast, new echoes appeared recurrently at the initial point, and then the convective region became elongated in the downstream direction. The vortex formed at the southwest head of the convective region and a  $Z_{DR}$  column was observed by the X-band polarimetric radar at that location.

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