

U022-05

Room:304

Time:May 22 15:35-15:50

Statistical features of cumulonimbus first echoes generated in the Tokyo Metropolitan Region on mid-summer days

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Heavy rainfall often occurs in the Tokyo Metropolitan Region, Japan during the afternoons on fine mid-summer days. For example, a heavy rainfall event occurred in Nerima-ku, on 21 July 1999 when rain fell at an hourly rate of 131 mm, and heavy rainfalls occasionally occur around the Tokyo Metropolitan Region, with notable peak hourly rainfalls exceeded 50 mm. Such heavy rainfall in the metropolitan region should be seriously considered with respect to disaster mitigation and water circulations in urban areas. X-band Doppler radar observations were carried out to investigate the generation of cumulonimbus in southern Kanto including the Tokyo Metropolitan area on mid-summer days for 9 years.

An initial convective echoes, named as first radar echoes, observed by the radar are discussed in this study. Cumulonimbus echoes are here defined as convective radar echoes of greater than 28 dBZ intensity in the mature stage of the echo. These convective echoes were traced back to the formation echoes or initial convective echoes, defined here as the first echoes of cumulonimbus. Total of 85 days over the 5 years from 1999 to 2008 satisfy the above criteria for mid-summer days, and first echoes were observed for 24 of these 85 days, yielding a total of about 520 first echoes. The mean daily frequency of first echo generation for a 10x10 km mesh area during mid-summer days, which was defined as the standardized number of first echoes per mid-summer days (85 days). Many first echoes were observed over Boso Peninsula and at the foot of Tanzawa mountain regions. It is remarkable that first echoes were also generated over the plain that encompasses Tokyo metropolitan region. In this analysis, many of the first echoes were generated over the mountain areas, with 36% of first echoes occurring around Tanzawa and 16% over Boso Peninsula; 15% occurred over the plain upon which Tokyo metropolitan region is located. The regions with the highest frequencies of first echoes (above 0.2 times/day) were the north to northwest parts of the Tokyo metropolitan region.

The temporal distribution of first echoes denotes the occurrences at different times of the day. The most active period of first echo generation was between 1100 and 1700 JST. In the evening, the frequency of first echoes dropped by half relative to that during the daytime, with few recorded after 2100 JST. Many of the first echoes generated in the metropolitan region were observed between 1400 and 1700 JST. First echoes were generated between 0 and 6 km above ground level (AGL), with 75% generated in the altitude range of 0-3 km. The number of first echoes shows an abrupt decrease above 3 km in elevation, accompanied by a marked change in the dominant regions of origin. The fact that the average height of first echoes at Tanzawa (1.5 km AGL) was much less than that at Tokyo metropolitan region (above 3 km AGL) indicates that the mechanism of convection was different between the mountain region and the metropolitan region.

Keywords: cumulonimbus, first radar echo, Doppler radar, heavy rainfall