Radar Echo Population of Thunderstorms and Feasibility Study on Nowcasting of Thunderstorm-induced Local Heavy Rainfalls

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This study shows a statistical analysis of air-mass type thunderstorms generated in the Tokyo Metropolitan Area on 5 August 2008 using three-dimensional radar reflectivity data. Possibility of nowcasting local heavy rainfalls induced by the thunderstorms is also examined by using the radar data and the lightning data.

Keywords: local heavy rainfall, urban flash flooding, three-dimensional radar observation

1. Introduction

Local heavy rainfalls and resulting flash flooding in urban areas caused from rapidly developing thunderstorms, in particular, from air-mass type thunderstorms has been discussed by meteorologists and hydrologists in this decade because issuing heavy-rainfall warnings with adequate lead-time have great difficulty due to abrupt changes of the rainfall manner of thunderstorms. A heavy rainfall coming from two thunderstorms generated at the center of Tokyo on 5 August 2008 killed five persons working in a sewer tunnel. This abstract summarizes the statistical aspect of radar echoes about the total number of 179 of thunderstorms generated in the Tokyo Metropolitan Area during the daytime on the day under the condition in which prominent synoptic disturbances did not exist (Fig. 1). We also give a possibility of nowcasting of local heavy rainfalls resulted from the thunderstorms using 1 km-mesh three-dimensional radar reflectivity data and lightning data which are provided from the Japan Meteorological Agency.

2. Results

2.1. Three-Dimensional Radar Echo Population

One third of the total thunderstorms had diameter less than 3.5 km and the average diameter of 5.5 km. The mode of the lifetime of the storms were 20 to 40 minutes (Fig. 2) and 88 % of the storms diminished up to 60 minutes after their initiation. The echo top height of the half of the storms reached 15 km, near the tropopause. Although the rainfall amount estimated from radar reflectivity was less than 40 mm for the half of the storms, one third of the total storms counted greater than 60mm. Vertically integrated liquid water (VIL) ranged from 1.4 to 42.4 kgm^2 . The maximum VIL was equivalent to 70 % of the precipitable water estimated from the upper sounding. The traveling speed of the storms was less than 2 kms^1 accordance with weak wind speeds in the lower to middle troposphere. The time from echo initiation to rainfall peak was as short as 10 to 30 minutes for almost all the storms (Fig. 3). The horizontal size in this case was nearly equal to the cases reported from other areas in the world, whereas the echo top height was larger than those of the other cases [1].

2.2. Feasibility of Nowcasting Local Heavy Rainfalls Induced by Thunderstorms

Very-short-term forecasting (nowcasting) concerning occurrence time and rainfall intensity of rainfall peak in the thunderstorms is examined. Five methods: formation aloft and descending of precipitation core, time-changes of VIL, time-change of echo-top height, lightning activity and quantitative forecasting of rainfall intensity using the persistent method, the extrapolation method and the RadVil [2] are adopted to eight active thunderstorms which were related to the heavy-rainfall warnings issued from JMA on the day. Some of the five nowcasting methods were effective for every thunderstorms (Fig. 4), whereas common methods available for all the thunderstorms were not identified in this study.

3. summary

- Local heavy rainfalls induced by air-mass thunderstorms occasionally make flash flooding in urban areas.
- Statistical properties of thunderstorms generated around Tokyo on 5 August 2008 are understood using JMA 3-D radar data.
- A feasibility study on nowcasting thunderstorm-induced local heavy rainfalls is made using the 3-D

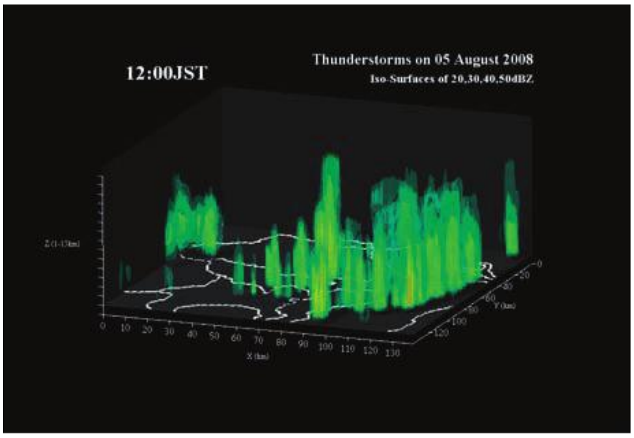

Fig. 1. 3-dimensional view of radar echoes in the Tokyo Metropolitan Area at 1200JST 5 August 2008.

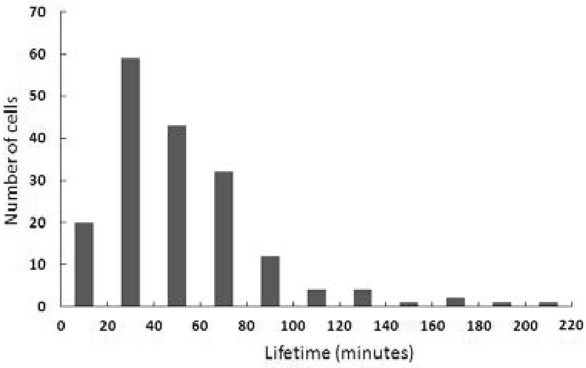

Fig. 2. Histogram of thunderstorm lifetime.

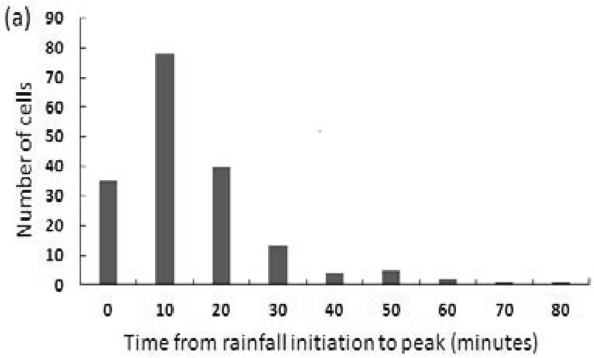

Fig. 3. Histogram of time from rainfall initiation to peak.

radar data and lightning data, however, definitively effective methods are not found.

- Synthetic understanding of thunderstorms are required as well as improving numerical modeling and data assimilation techniques.

Acknowledgements

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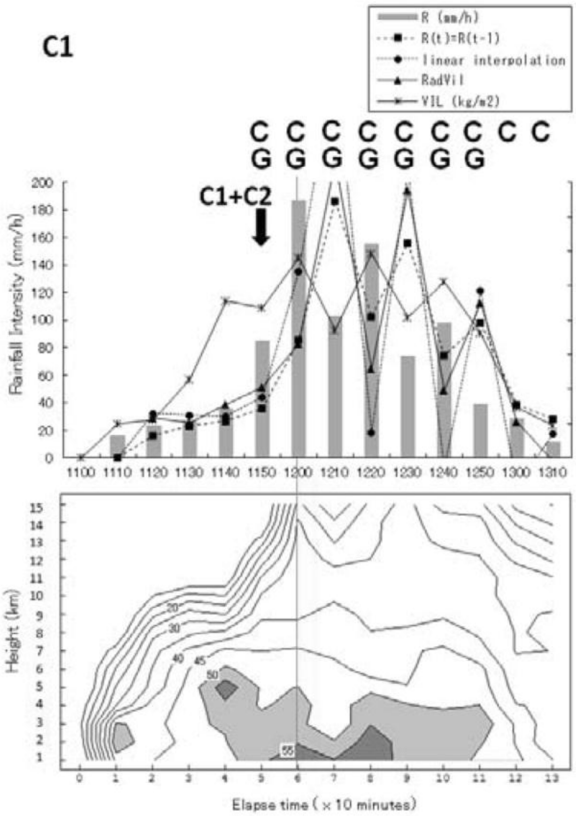

Fig. 4. Time change of rainfall intensity, VIL, lightning activity (C and G) and three quantitative forecast of rainfall intensity in an active thunderstorm. Time-height cross-section of reflectivity (dBZ) at the center of the thunderstorm is also shown below.

References:

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