Observations of solid precipitation particles using the Falling-Snow Observatory of Snow and Ice Research Center NIED in Nagaoka

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1. Introduction

The Falling-Snow Observatory of NIED (FSO) was established to observe solid precipitation particles precisely for understanding how they influence winter precipitation, deposited snow, and snow-related disasters. The FSO is consisted with two main facilities. One is operated for falling snow observation and the other for deposited snow observation. The former is a recording system of falling snows captured by a CCD camera. Images of them and positions in the captured area are translated into numerical data by image processing and stored in memories of a computer. The latter is a low-temperature room (–5°C) into which natural snows are falling through roof windows. We can catch falling particles in the room and examine them carefully under a microscope after taking photographs.

Comparing both observations in two facilities we could find that relations between particle size and fall speed, that were acquired from recording data of falling snows, well reflect types of solid precipitation. Therefore from the data of the automated recording system we could obtain continuous information about types of solid precipitation particles, i.e. graupel or aggregates in different riming stage, as well as other quantitative data, i.e. number of particles per unit volume and their size distribution, throughout winter season.

In this study we introduce how we recognize predominant types of precipitation particles in each snowfall event using the FSO and some observational results.

Fig. 1. Snapshot of the observation site.

2. Recording system of falling snow

For detecting the natural speed of falling hydrometeors, the measuring part of the system was placed in a space enclosed by double-net fences (Fig. 1). The configuration of recording system is shown in Fig. 2. Precipitation particles falling into the narrow space (0.2 m in width) under weak wind condition are illuminated by halogen lamps and photographed through the zoom lens of a CCD video camera set at a distance of 2 m. The shutter speed of the camera was set at 1/4000 second. At this high shutter speed, the displacement of particles due to falling motion was negligibly small. The size of captured image was 0.12 m (H) x 0.16 m (W) which corresponds to 240 pixels x 640 pixels.

Particles were recorded continuously for 1 second at every 5 seconds, and images were stored in an image processor (resolution: 240 x 640 dots, 256 levels). In the image processing, binarization of all captured images with an appropriate threshold level was carried out to detect precipitation particles. Then, for each detected particle, data concerning the position of the highest pixel, maximum horizontal width, lowest position, peripheral pixels and so on were calculated and stored in the computer's hard disk.

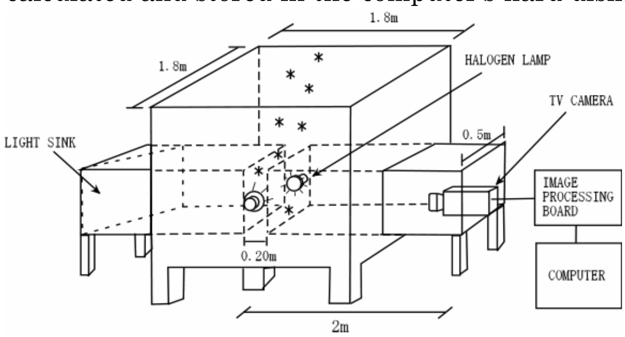

Fig. 2. Configuration of the automated recording system of falling snows..

3. Identification of types of solid particles

Operating the above automated recording system of particles, we carried out manned observations of fallen snows with a microscope during remarkable snowfall events in the low-temperature room (–5℃). We caught particles in the room and took microscopic photographs of particles. From these photographs, we could observe constituent crystals and extent of riming

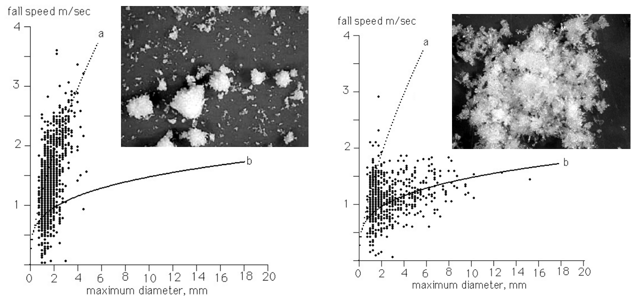

Fig. 3. Relationships between particle size and fall speed acquired from the recorded data and microscopic photos taken at same snowfall events.

of snowflakes, and types of graupel.

Figure 3 shows typical two cases of inter comparison between the manned observation and the recording data. Each spot in the graphs corresponds to size and fall speed of one particle measured by the automated recording system for about 10 minutes. Curves a and b in the graph are the best-fit curves of the cone-shaped graupel and the heavy rimed snowflake obtained by Locattelli and Hobbs, 1974. The microscopic photographs of predominant precipitation particles taken at the same period shown in the Figure. Left hand case and right hand one in the figure show that typical precipitation particles are cone-shaped graupel and heavily rimed snowflakes, respectively, and that the spots are distributed around corresponding best-fit curve. The same comparisons were carried out for cases of other types of solid precipitation particles and good agreements between size-speed relations and types of particles were found. These results suggested that the relationship between particle size and falling speed of snows acquired from numerical data well represented the types of precipitation particle and that we could obtain continuous information about types of solid hydrometeors from data of the recording system as well as quantitative data, i.e. numbers of particles of observed space and size distribution.

4. Observational resuls

We have worked the FSO every winter season from 2002-03 winter and could observe a few or several heavy snowfall events in a season. The observational results suggested that types of precipitation particles changed drastically according to precipitation system and they seemed to relate to 'snowfall modes' (Nakai,2005). The typical cases are shown in Fig.4. Snapshots of radar reflectivity of snowfall events (b) and (d) in Fig 4 show snowfall mode L-mode and S-mode respectively. In both cases the same mode lasted at least for a few hours. The size-speed graph a) and c) correspond to particles measured for about a hour during L-mode and S-mode period respectively. The observational results indicates that a predominant type of L-mode type precipitation was a graupel type and that of S-mode was a aggregates type. The same tendency was frequently found in our observations. Types of solid precipitation affect Z-R relation and estimation of precipitation amounts. so that to clarify the relation between types of particles and snowfall mode is important.

Moreover types of particles were also observed to affect density of deposited snow and accumulation rate of snow cover. Some kinds of snow crystals and large graupel were observed to form a weak layer in deposited snow which causes avalanche.

4. Future studies

Above mentioned size-speed relations are based on numbers of particles, but mass flux is more important. Now we are trying to translate the relation into that based on flux to clarify predominant types of solid precipitation during a target period. That might lead to more precise interpretation of relations between types of solid precipitations and snowfall mode, radar power return, precipitation process in a cloud, and other particle-type-related matters.

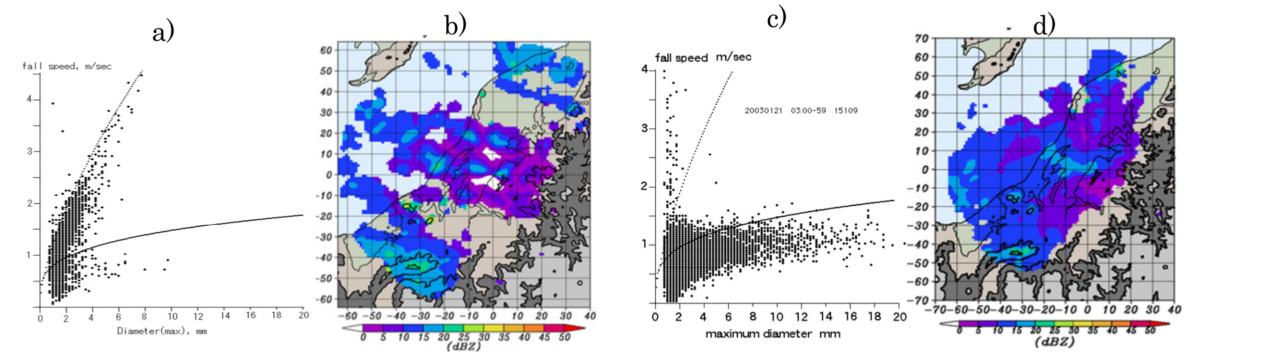

Fig. 4 Size and fall speed relations for particles fallen for 1 hour and snapshots of the radar echo patterns of the NIED radar at Nagaoka Institute, that express typical mode in the same periods.