Jour. Fac. Sci., Hokkaido Univ., Ser. VII (Geophysics), Vol. 7, No. 2, 159–168, 1982.

# A New Method for Measuring Snow Crystals (Snow Crystal Measuring System)

**Katsuhiro Kikuchi, Shigeyuki Tsuboya*, Yoshio Asuma**

*Department of Geophysics, Faculty of Science, Hokkaido University, Sapporo 060, Japan*

**and**

**Kazuo Inatsu**

*Nippon Denshi Kagaku Co., Ltd., Joyo, Kyoto 610–01, Japan*

(Received September 1, 1981)

**Abstract**

An instrument for measuring snow crystals (Snow Crystal Measuring System) was tentatively designed and developed by the authors to estimate the spatial density of snow crystals including their shapes and size by remote control from an observation room. The instrument consisted of a collector, controller, television monitor, and videotape recorder. Therefore, a watching the television monitor in actual field works gives us an information about the snowfalls, for instance, the shapes and size of snow crystals, and the beginning and time change of intensity of snowfalls. Further, the analysis of videotapes gives us an information about the spatial density (precipitation intensity) and size distributions of snow crystals. The instrument has various advantages as follows: infinite continuous recording by using a turn table, objectiveness for data, analyzing ability for data, physical protection of workers and so on.

## 1. Introduction

It has become necessary to obtain increasingly precise and accurate information on precipitation particles, namely, individual shape, size and spatial density (precipitation intensity) and so on in the fields of cloud physics, radar meteorology and atmospheric electricity.

For the measurements of individual precipitation particles, especially for the measurements of rain drops mainly, a filter paper method has been used universally till the present. A modified filter paper method was adequate for continuous measurements. On the other hand, for the measurements of individual snow crystals, the following methods have been

* Present affiliation: Sekine Gakuen Senior High School, Joetsu, Niigata Pref.

used; i.e. photomicrograph, replica solution, filter paper and shadow photograph (Higuchi, 1956). These methods, however, are unsuitable for continuous measurements of spatial density (precipitation intensity). The replica solution method is relatively good compared with other methods. If however we wish to obtain data for spatial density of snow crystals at several minute intervals using the replica solution method, an observer is forced to work constantly. Recently, different new methods for measuring precipitation particles have been developed in succession (Cannon, 1975; Carrera, 1976; Knowllenberg, 1976), however, some of these are not suitable for the continuous measurements of spatial density of snow crystals.

An instrument was tentatively designed by the authors to estimate the spatial density of snow crystals including their shapes and size by remote control from an observation room.

## 2. Instrument

The snow crystal measuring system (SCMS) developed by authors consists of a collector ($600^H \times 500^W \times 400^D$ mm) which is set up outside and a controller

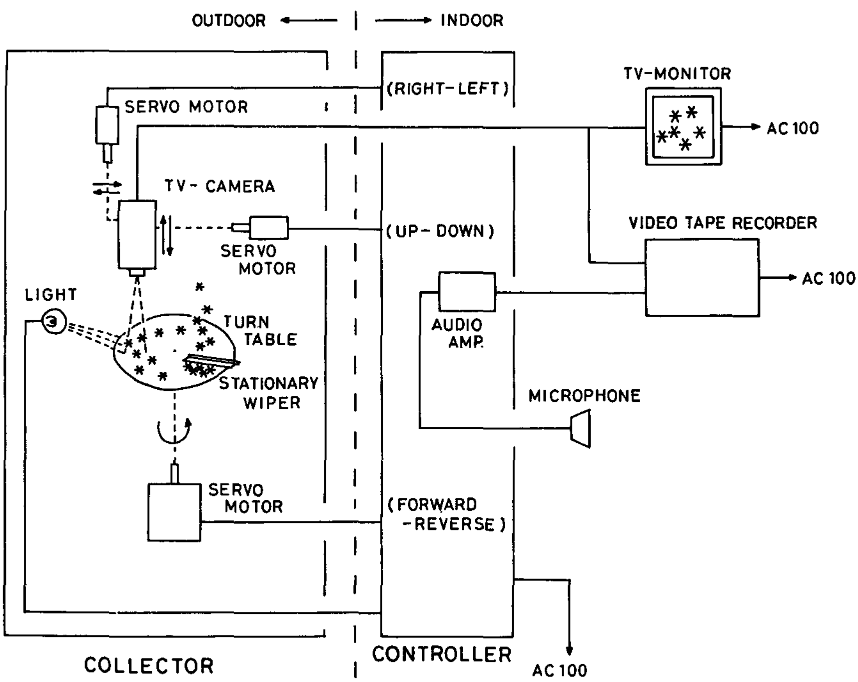



Fig. 1 Schematic figure of snow crystal measuring system (SCMS).

which is set up in an observation room as shown in Fig. 1. The collector consists mainly of a turn table of 37 cm in diameter receiving falling snow crystals entering from an intake ($160^{W} \times 120^{D}$ mm) and a television camera for recording the crystals (Fig. 2). The angular speed and forward or reverse motions of the turn table are controlled by a relatively large servo motor. The magnification of the television camera used in this instrument is changeable from one to eight times by zooming. The position of the television camera to the turn table, namely the field of view, up and down, and right and left to the turn table, is controlled by two relatively small servo motors, respectively as shown in Fig. 1. The control of the collector is operated entirely by the controller. The controller consists of three parts, namely, it controls the operation of turn table, television camera and audio amplification. Falling snow crystals on the turn table observed by the television camera are scrutinized by a television monitor and recorded by a videotape recorder as shown in Fig. 3. After the snow crystals on the turn table are recorded, they are removed from the turn table by a stationary wiper as shown in Figs. 1 and 2. Therefore, the analysis of videotapes gives us the necessary information regarding the shapes, size and spatial density (precipitation intensity) of snow crystals.

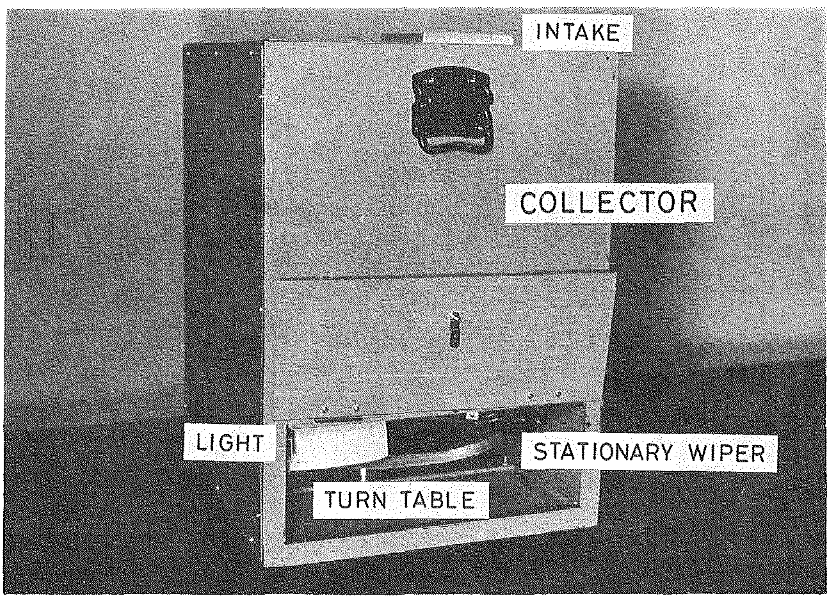



Fig. 2 Photograph of the collector of the SCMS.

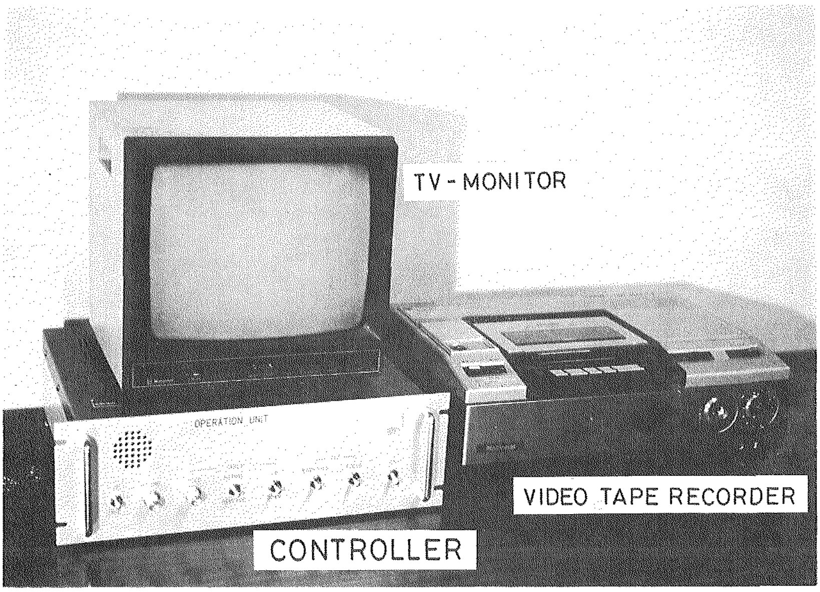



Fig. 3 Photograph of the controller of the SCMS.

## 3. Measurements

Fig. 4 shows one of the examples of relatively large densely rimed dendrites. The photograph was taken when the turn table was stopped. Although the crystal sizes are relatively large in this example, size and structure of the crystals are recognized in detail. In this case, the position of the light source was not suitable, as a result two halation spots were found in line on both sides, after that, however, the position of light source had been improved. Fig. 5 shows an example of snow crystals of two radiating assemblage of dendrites and an ordinary dendritic crystal at the upper right corner. The photograph was taken when the turn table was moving. In this case, since the angular speed of the turn table was relatively fast, the fine structure of the crystals was not clear. Figs. 6–8 show a comparison between a number flux of snow crystals collected and replicated on the glass slides and a number flux of snow crystals recorded by this instrument for calculation of precipitation intensity. The measurements were carried out mainly on December 1979 at Inuvik (68°22′N, 133°42′W), Northwest Territories, Canada as a part of the Polar Experiment-North (POLEX-North). In all figures, the left pictures were made of as follows; the snow crystals replicated

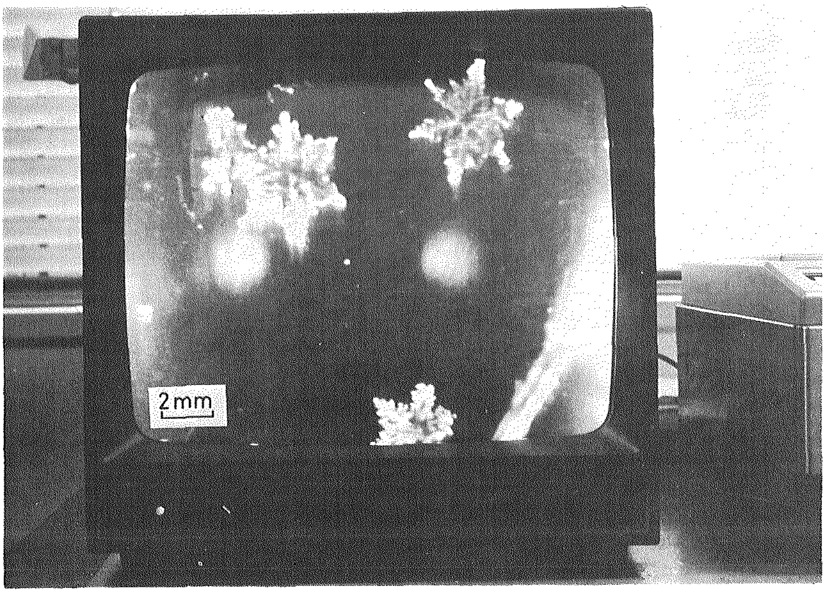



Fig. 4 An example of snow crystals on the TV-monitor when the turn table was stopped.

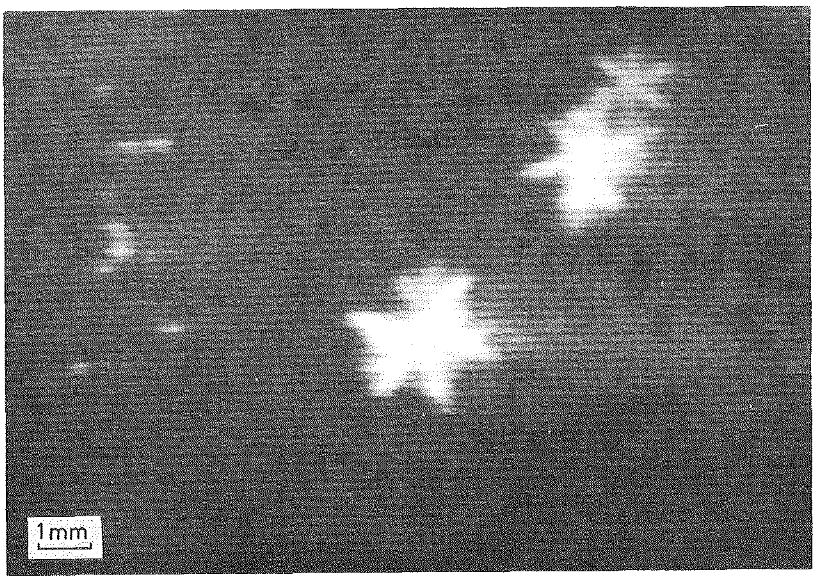
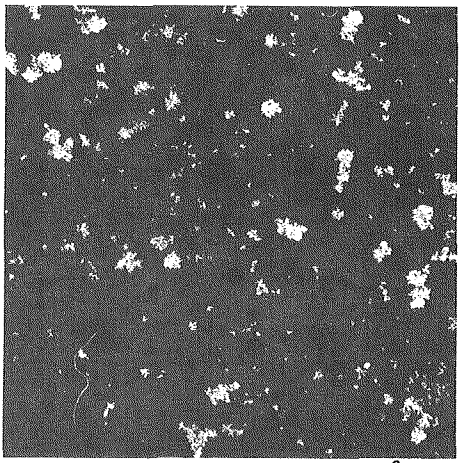
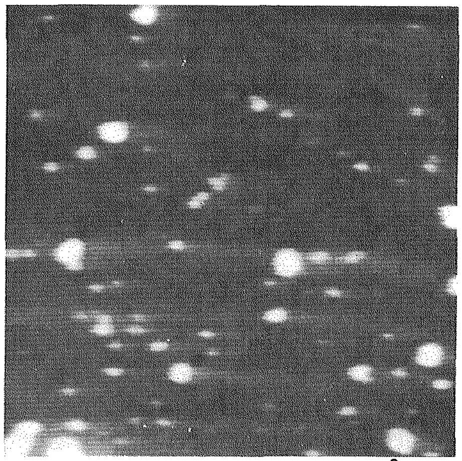



Fig. 5 An example of snow crystals on the TV-monitor when the turn table was moving.

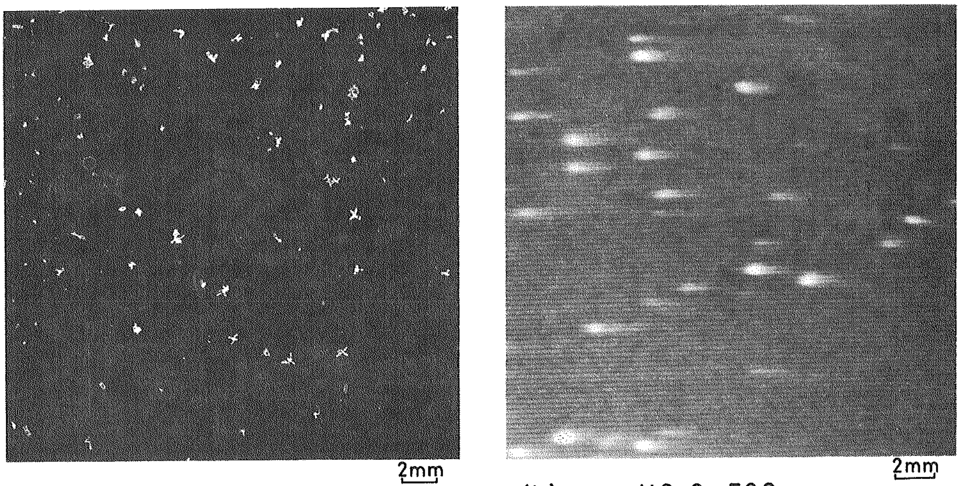
on glass slides by the replica solution method were inserted directly to a photographic enlarger and were enlarged on printing papers. On the other hand, the right pictures were made of as follows; the snow crystals recorded by a video tape recorder were taken photographs by a 35 mm regular size camera and were enlarged on printing papers. The magnification of pictures taken by both techniques was nearly the same on the figures. As a matter of course, the number of snow crystals is not equal in a pair of pictures because the collection time on glass slides and on video tapes is not equal. Fig. 6 shows an example of densely rimed crystals of crossed plates (formerly side planes). The white stripes seen on the right side of individual snow crystals in the picture of video tape are afterimages. The afterimage was remarkable when the angular speed of the turn table is relatively fast. In the measurement using this instrument, as the main objective was the estimation of precipitation intensity, the magnification was selected at low power to record a relatively wide area of the turn table. Hence, the fine structure of snow crystals was not clear. Fig. 7 is an example of a combination of bullets and columns which are the most typical types of snow crystals in cold temperature regions. As the size of snow crystals is relatively small in this example, the data obtained




0950LST 15 DEC. 1979

Fig. 6 A comparison of snow crystals of densely rimed crystals of crossed plates replicated on a glass slide (a) and recorded by the SCMS (b).




(a) NO. 4-42 (b) NO. 6-736

1900LST 10 DEC. 1979

Fig. 7 A comparison of snow crystals of a combination of bullets and columns replicated on a glass slide (a) and recorded by the SCMS (b).

by the video tape failed to clarify the exact type of snow crystals. In that case, it is suitable to watch the TV-monitor as high magnification and after to record video tape as low magnification. Fig. 8 shows the same crystal shapes as in the previous case, however, the precipitation intensity is relatively heavier than in the previous case. At times, they could not be distinguished from each other, hence errors in the estimation of the precipitation intensity were unavoidable. In that case, the angular speed of the turn table is desirable to be fast.

Fig. 9(a) shows the correlation between the number flux of all snow crystals obtained by the replica solution method and the number flux of all snow crystals obtained by this instrument (SCMS). Although it is possible to count small sizes and high number concentrations of snow crystals on glass slides obtained by the replica method, for instance, in the cases of small particles of ice fog or of drifting and blowing snow, it is very difficult to count individual particles when the number flux of snow crystals obtained by SCMS exceeds the $1.0\ cm^{-2}\cdot sec^{-1}$. Therefore, the observation limit when the SCMS was operated under the condition in which the magnification of the video camera is four as in this experiment is $1.0\ cm^{-2}\cdot sec^{-1}$. And further the correction to

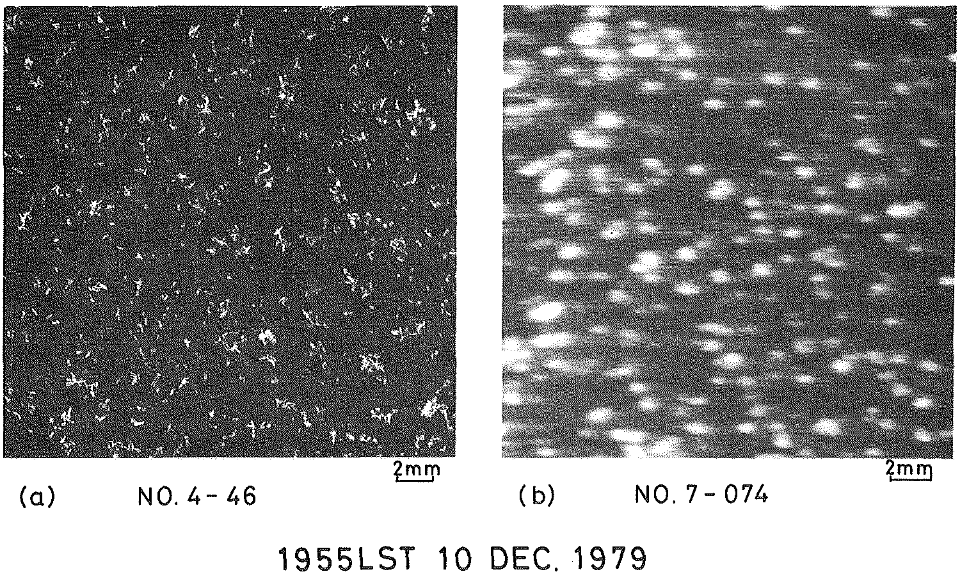



Fig. 8 A comparison of snow crystals of a combination of bullets and columns replicated on a glass sldie (a) and recorded by the SCMS (b) when the precipitation intensity is relatively heavier.

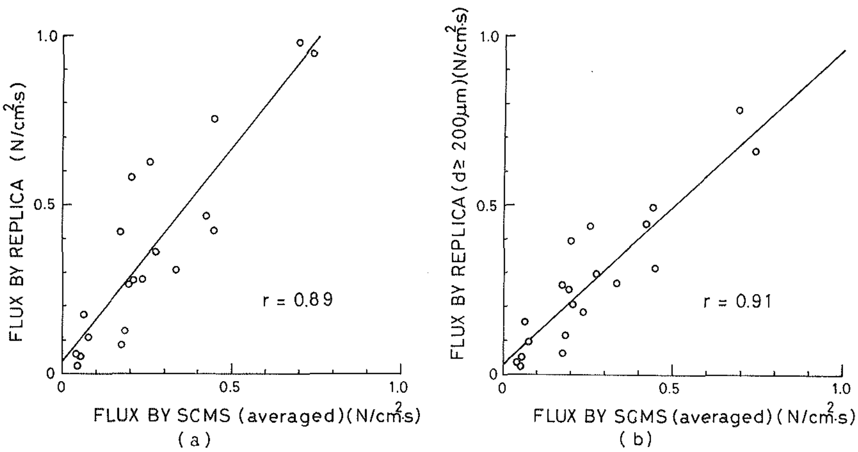



Fig. 9 (a) A correlation between the number flux of snow crystals obtained by the replica method and the number flux of snow crystals averaged for 5 frames of TV-monitor obtained by the SCMS.

(b) A correlation between the number flux of snow crystals larger than $d \geq 200\,\mu m$ obtained by the replica method and the number flux of snow crystals averaged for 5 frames TV-monitor obtained by the SCMS.

collection time was considered. Because, the exposure time of glass slide by replica method was selected depending on the precipitation intensity, for instance, 10, 20, 30, 45 and 60 seconds. On the other hand, the SCMS was operated constantly independing on the precipitation intensity. For that reason, averaged 5 frames of SCMS obtained during collection time of the replica method were used to compare with the values obtained by the replica method. The equation for both relation is $Y=1.27X+0.03$ and the correlation coefficient is 0.89. Furthermore, considering that the countable minimum size of snow crystals is limited to larger than 200 $\mu$m in diameter in the case of the replica method, the result is shown in Fig. 9(b), the equation for both relation is $Y=0.94X+0.03$ and the correlation coefficient is 0.91. Here, X and Y mean the number flux obtained by the SCMS and the replica method, respectively.

## 4. Conclusions

An instrument for a snow crystal measuring system (SCMS) designed tentatively by the authors in the present paper has various advantages as follows; infinite continuous recording by using a turn table, objectiveness for data, analyzing ability for data and physical protection of workers and so on comparing the measurements by photomicrograph, replica solution, filter paper and shadow photograph methods. However, we are considering improvements of this instrument as follows; an indicator for recording the change of angular speed of the turn table, variable diaphragmatic aperture of intake depending on the precipitation intensity, time indicator for recording the collection time and so on.

## Acknowledgements

The authors heartly thank to Mr. C.P. Lewis, Scientist-in-Charge and Mr. J.D. Ostrick, Operations Manager, Inuvik Scientific Resource Centre, Inuvik, Northwest Territories, Canada and Prof. T. Takeda, the leader of the POLEX-North at Inuvik, Water Research Institute, Nagoya University, for their help in carrying out the observation. This work was made as a part of the project "POLEX-North (Polar Experiment-North)" under the Grant-in-Aid for Special Researches, the Ministry of Education, Science and Culture of Japan.

## References

Gannon, T.W., 1975. A photographic technique for measurement of atmospheric particles in situ from aircraft, J. Appl. Meteor., **14**, 1383–1388.

Carrera, N.J., 1976. Snow crystals photographed in situ in winter storms, Preprints. International Conference on Cloud Physics, 1976. Boulder, 85–90.

Higuchi, K., 1956. A new method for the simultaneous observation of shape and size of a large number of falling snow particles, J. Meteor., **13**, 274–278.

Knollenberg, R.G., 1976. Three new instruments of cloud physics measurements: The 2-D spectrometer, the forward scattering spectrometer probe, and the active scattering aerosol spectrometer, Preprints. International Conference on Cloud Physics, 1976. Boulder, 554–561.