NOTES AND CORRESPONDENCE

On Lightning Discharges in Winter Thunderstorms

By Tosio Takeuti, Minoru Nakano, Masahiro Nagatani and Hiroshi Nakada

Research Institute of Atmospherics, Nagoya University, Toyokawa
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There are in general relatively few lightning discharges during winter thunderstorms, and so observation of these discharges is rare. For this reason the study of winter thunderstorm has in general been limited to statistics of the storm days etc. and we are not familiar with any reports discussing the characteristics of lightning discharges during such storms. The characteristics of lightning discharges in winter are very interesting for the following reason: the temperature of the cloud base of a winter thundercloud is the same as that of the middle part of a summer thundercloud. It therefore can be assumed that a winter thundercloud may be similar to the upper half of a summer thundercloud. Moreover the height of the cloud base of the winter thundercloud is very lower than that of summer one. Hence, the characteristics of the discharges in winter may be different from those in summer. For instance there are frequent reports of aircraft being struck by lightning in spite of relatively few discharges during the winter months in Japan. Our first observation of winter discharges was made during 1972/73 at Unoke near Kanazawa which is in the region of frequent thunderstorm activity in Japan. As this was our first experience, the observations were limited to only a few fundamental items such as number of discharges, field changes due to the discharges, etc. The main characteristics observed are now listed:

a) Discharge Frequency: Fig. 1 shows a sequence of surface weather maps for the days when the discharges occurred within about 20km of the observing station. From the figure the thunderstorms can be divided into two types. One is the frontal type of storm where more than fifteen discharges a day have been recorded and the other is the non-frontal type where less than five discharges a day have been recorded. Here the storm is called non-frontal one when

we cannot find a passage of a cold front through the observatory Unoke on the synoptic surface weather map on the storm day. So it is not sure whether the non-frontal storm is accompanied by a local front not be shown on the map or not. Diurnal variations of occurrence times of the discharges for these two types have been analyzed and the results are shown in Fig. 2 indicating the diurnal distribution. So far as shown in Fig. 2 it has no peak activity in winter afternoon in contrast to the summer storms.

b) Intensity of the discharges: To exactly compare the intensity of summer and winter discharges we must investigate the quantity of charge dissipated by both types of discharge; however, this experiment was not performed during this period. Instead of comparing the charge we compared the field change due to the discharges. The results are shown in Fig. 3 and illustrate that the intensity of discharges in winter are the same as those measured during summer months by Hatakeyama (1958) but a little higher than those measured by Mühleisen et al. (1968) in southern Germany.

c) Polarity and Multiplicity of ground discharges: This might be the most important result of our observations. In general, negative charge in a thundercloud is brought down to the earth by a cloud to ground discharge. The percentage of occurrence of the other case where a positive charge is brought down to the earth has been reported to be only 3.4% in summer in Japan (Ishikawa 1961). During a two hour period of a thunderstorm on Jan. 10 1973 we recorded twelve field changes due to lightning discharges. Four out of these twelve were ground discharges, all of which have brought down a positive charge from the cloud to the earth. Although only four events were recorded in this winter storm, the

Fig. 1. Surface weather maps on the thunderstorm days at 21 JST. Dotted lines on Dec. 29 and Jan. 10 show the positions of the fronts at 9 JST and the arrows show the movements of the centers of the lows. The closed circles indicate the position of the observatory Unoke. The numbers in parenthesis show the number of discharges recorded on that day

Fig. 2. Diurnal variation of occurrence of discharges. The ordinate shows the number of days when discharges occurred at the time shown in abscissa.

probability that, during summer storms, four successive ground discharges would all bring down positive charge to the earth is thought to be very small. Ishikawa (1961) reported that only the first return stroke brings down positive charge and successive return strokes bring down negative charge. The number of return strokes in the four ground discharges occurring in this January 1973 storm was always one, hence there is thought to be good agreement between Ishikawa's report and our results. It could be an interesting task to investigate whether the successive return strokes in winter discharges also bring a positive charge down to the earth or

Fig. 3. Relation between field change and distance from the station to the discharge. The distance being measured by time difference between field changes and arrival of thunder. The arrow shows the field change is larger than the value of that point.

not. This problem will be investigated in our next observation period.

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竹内利雄・仲野 資・長谷正博・中田 滉
名古屋大学空電研究所