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# POTENTIAL GRADIENT AND RADAR ECHOS FROM AN ISOLATED THUNDERSTORM

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**Abstract**

It was found by the simultaneous observations of the surface potential gradients and the radar echos from an isolated thundercloud that the positiveward excursion of the gradient in the middle of the electrical disturbance was almost exactly associated with the sudden raising of the radar echo top. It is suggested from this observed fact that the lower positive pocket charge in a thundercloud is produced in a strong updraught during the growth of the cloud tower.

## 1. Introduction

During a passage of thundercloud near an observation site W type variation is most frequently observed on recording of potential gradient. This fact leads to a generally recognized electric charge distribution in a thundercloud of positive polarity with a small pocket of positive charge in the lower center of main negative charge. Kuettner [1950] imagined from his measurement at the Zugspitze that the lower positive charge is generated in a strong downdraught which is in the center of electrical activity. The charge generates at the temperature level of $-8°C \sim 0°C$, where graupel is growing. On the other hand Wichmann [1952] has suggested that the pocket positive charge is produced at the temperature level of 0°C or higher, so that liquid water plays a role in the charge production. In the pioneering work by Workman and Reynolds [1949] they showed that the measurement of radar echo is the most effective way to investigate "electrical activity as related to thundertorm cell growth". In the present study we correlate the potential gradient at the ground level with the radar echos from a thundercloud, and investigate in what stage of growth of the cloud the positive center value of the potential gradient appears as a result of production of the positive pocket charge.

## 2. Observations

In the summer season of 1965, the simultaneous observations were made of

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the surface potential gradients and the radar echos from a thundercloud by using a 8.6 millimeter wave radar (REI) in Kyoto city. During 12h-13h JST on August 24, an effect of an isolated thundercloud was observed. In Fig. 1 are plotted the PPI radar echos observed at Osaka, about 40 km south-west of Kyoto. As is seen in Fig. 1 the storm cloud moved over the net of observation sites to the east-north-east. Precipitation was observed at 20 stations in the area within 20 km from C station. In Fig. 1 is also shown the total precipitation (millimeter) at the stations where rain was observed. It is shown from the precipitation distribution in Fig. 1 that the center of cloud base moved to the north-east through between B and C stations. Four mill type field meters had been set in the observation net but the operation of one of those field meters was in failure during the cloud passage. The optential gradients were then recorded at A, B and C stations in Fig. 1. The REI radar was operated at C station. The potential gradients observed are reproduced in Fig. 2 for the whole duration of the cloud passage. At B station the recording was missed in the period

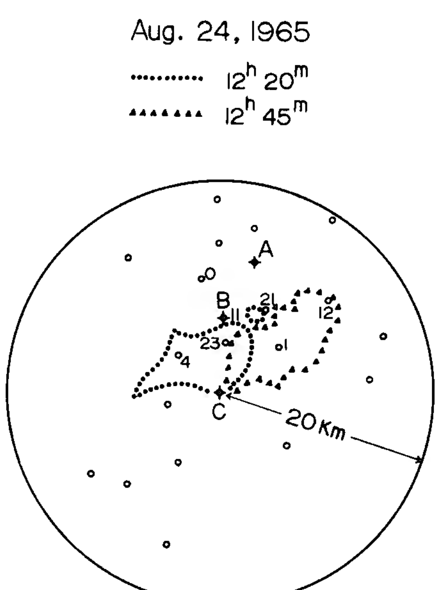


Fig. 1. PPI radar echos observed at Osaka about 40 km south-west of Kyoto. A, B and C are the stations where the potential gradients were observed. The REI radar was operated at C station. Circles are rain observation stations. The total precipitation (mm) is shown at the stations where rain was observed.

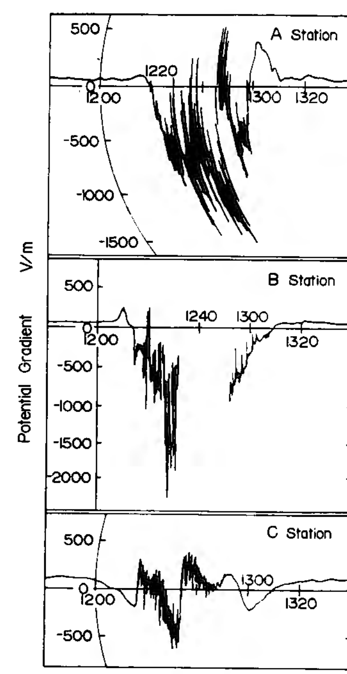


Fig. 2. Potential gradients observed at A, B and C stations. At B station recording was interrapted by instrumental failure from 12h 32m to 12h 52m.

from 12h 32m to 12h 52m due to the instrumental failure. At C station the potential gradient was originally recorded with very low sensitivity, so that the reproduced one is rather rough both in amplitude and time scales.

Let us follow the potential gradient change with the time at A station referring to those at the other stations. The storm became active at about 12h 20m and the value of the general potential gradient got negative. Before the potential gradient recovered to positive value at about 12h 58m, there seem two excursions of the general potential gradient toward positive value starting at about 12h 32m and 12h 44m. In the second case the excursion is specially clearly seen in the figure in which the potential gradient almost suddenly turned toward positive and reached the positive maximum value.

The radar echos were observed in the period from 12h 22m to 12h 59m. The echo distributions composed of REI radar photographs were reproduced every 2 km height levels in Fig. 3 at the four time stages representatively: 12h 30m–12h 33m, 12h 33m–12h 36m, 12h 43m, and 12h 44m–12h 45m. Before 12h 43m the echo top was observed at or below 10.5 km level and the echos repeated the subsiding after the raising. Soon after that time the echo top raised higher

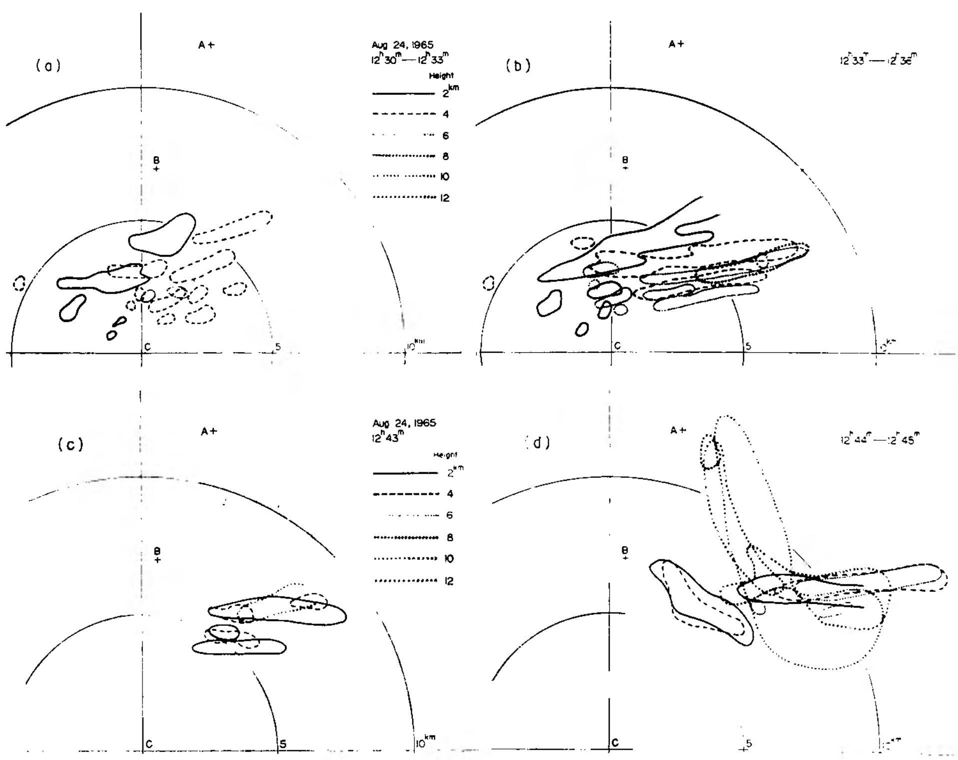


Fig. 3. Radar echos shown every 2 km height levels observed at C station. Time sequences of the raising and subsiding of the echos are shown in (a), (b), (c) and (d) successively.

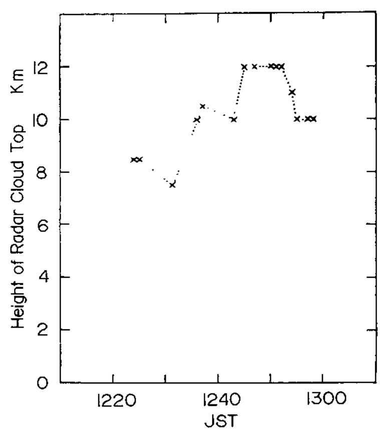


Fig. 4. Time variation of the height of radar cloud top.

and reached 12 km height level. As is seen in Fig. 3 (d) the echos developed toward A station. The high level echos were then observed continuously from 12 km height level till 12h 52m.

Heights of radar echo top are plotted against the time in Fig. 4. It is interesting to correlate these with the potential gradient change. It is very clear that the raising of the radar cloud top caused the positiveward excursion of the potential gradient.

## 3. Conclusion

It was found by the simultaneous observations of an isolated thundercloud that the excursion of the potential gradient toward positive value in the middle of the electrical disturbance was almost exactly associated with the sudden raising of the cloud top. Each excursion of the potential gradient would correspond to the life cycle of a cloud tower, and the positive pocket charge would be produced in the strong updraught during the growth of the cloud tower. The conclusion will be made concrete based on further experimental data.

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