Comments on "Electrification of Condensing and Evaporating Liquid Drops"

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23 July 1974

The experiments performed by Takahashi (1973) have revealed some interesting phenomena associated with the condensation and evaporation of water to and from the surface of a metal sphere. If it can be shown that electrical charging effects similar to those described can be expected to take place in a population of evaporating and/or condensing cloud droplets, then this effect will be of considerable importance not only in the electrification of the liquid phase of clouds, but wherever water is exchanged between surfaces and the atmosphere. Takahashi discusses these applications to cloud electrification on the understanding that the laboratory and in-cloud situations are entirely equivalent. We feel, however, that this equivalence has not been established satisfactorily, for the following reasons.

The experiment involves the evaporation and condensation of water from and to the surface of a metal sphere, the temperature of which can be controlled by circulation of a coolant. This sphere is supported by two lucite cylinders, and the potential difference between the sphere and ground can be measured by means of an electrometer. Changes in this potential difference are measured in association with the condensation and evaporation of water on the sphere, and are taken to arise solely due to the transfer of electric charge to and from the sphere.

Referring to work by Phillips and Gunn (1954) on the electrification of spheres by moving ionized air, the author describes his own experimental setup as similar to that used by Phillips and Gunn, the only important difference being the incorporation of temperature control. On inspection of the original paper, a further difference is evident, inasmuch as Phillips and Gunn measured the charge on an isolated sphere by induction, lowering the sphere into a Faraday cage connected to an electrometer. A potential difference across the surface of a sphere does not necessarily require a net charge to be present, since such a voltage can arise due to various causes such as thermoelectric, electrochemical, contact and double-layer effects. The induction method insures that only the net charge is measured. As the authors point out ". . . changes in contact electromotive forces present serious problems in all measurements of electrostatic potential of less than half a volt . . .".

In Takahashi's experiment it seems quite possible that potential differences arising from one or several of the above causes could have been present. The potentials measured were within the range −0.6 to +1.2 V, so that the caution issued by Phillips and Gunn is certainly applicable. Takahashi apparently was aware of this danger, since he describes various tests designed to investigate this possible effect, and found that "there was no electrification without condensation." However, he does not appear to have carried out any test which eliminates the possible intrusion of these spurious effects while condensation and evaporation were occurring. The measurements of potential difference changes were made over periods of several hours, and from the description of the apparatus, it appears likely that temperature differences could have existed between the metal sphere and the lucite supports, upon which water could also have condensed.

In view of the above considerations, we believe that it is legitimate to question the extent to which the observed potential difference changes were indicative of the transfer of electric charge to and from the sphere. Until this question is satisfactorily resolved, it is doubtful that any useful conclusions can be drawn concerning the possible role of these effects in a real cloud.

REFERENCES

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