NOTES AND CORRESPONDENCE

Comments on "Calculations of Electric Field Growth Within a Cloud of Finite Dimensions"

A. K. KAMRA

Indian Institute of Tropical Meteorology, Poona-5

4 October 1976 and 22 December 1976

Illingworth and Latham (1975) do not consider the effect of electrical forces acting on the particles while calculating the growth of electric field by the precipitation charging mechanism in their cloud model of finite dimensions. Still they dismiss the effect as negligible by stating that ". . . the regions of highest field do not coincide with those of the largest hydrometeorcharges or charge-to-mass ratios." In calculating the separation velocity of ice crystals and pellets through the interaction zone, they do not include the change in their terminal velocities caused by electrical forces acting upon them. Therefore their calculations cannot be used to assess the effect of electrical forces on the field growth. Further, in all precipitation charging mechanisms the magnitude of electric charges which separate under gravity to produce electric fields are only fractions of the total positive and negative charges which remain intermixed between the upper and lower separated charges. Also, in an inductive charging mechanism, the charge exchanged between the colliding particles is proportional to the electric field itself. Illingworth and Latham's statement is not in conformity with these features of precipitation charging mechanisms. Neither is their statement based on any experimental observation. The present understanding of the distributions of electric fields in clouds and the electric charges on the particles is, in this author's views, inadequate to support such a statement.

Illingworth and Latham conclude that the maximum electric field that can be generated by the precipitation charging mechanism in their model is less than that predicted by the infinite cloud models. However, electric fields in excess of 4 kV cm^{-1} have been observed in thunderclouds (Winn and Moore, 1971, 1972; Winn *et al.*, 1974). This suggests that some other mechanism not dependent upon the growth of precipitation may be responsible for the generation of such high electric fields.

REFERENCES

Illingworth, A. J., and J. Latham, 1975: Calculations of electric field growth within a cloud of finite dimensions. *J. Atmos. Sci.*, **32**, 2206–2209.

Winn, W., and C. B. Moore, 1971: Electric field measurements in thunderclouds using instrumented rockets. *J. Geophys. Res.*, **76**, 5003–5017.

——, and ——, 1972: Reply (to Freier). *J. Geophys. Res.*, **77**, 506–508.

——, Schwede, G. W., and C. B. Moore, 1974: Measurements of electric fields in thunderclouds. *J. Geophys. Res.*, **79**, 1761–1767.

Reply

A. J. ILLINGWORTH AND J. LATHAM

Physics Department, University of Manchester Institute of Science and Technology, Manchester M60 1QD, England

9 November 1976

It is well established (Winn and Moore, 1971; Winn *et al.*, 1974) that the regions of intense electric fields within thunderclouds extend over only a few hundred meters. However, most of the charge contributing to those high fields will reside outside of these regions, and levitation effects will be of great importance only if these weaker, surrounding fields are sufficiently high to affect significantly the particle velocities. The studies of Kamra (1970) and Gay *et al.* (1974) show that fields in the region of 2 or 3 kV cm^{-1} are required in order to produce appreciable changes in the velocities of precipitation particles; the terminal velocities of the small cloud particles are so much less than the updraft velocities that any changes will be negligible. Thus levitation effects will be unimportant.

We do not conclude from our model that high electric fields cannot be generated by a precipitation charging mechanism. Rather, we maintain that the conditions under which breakdown can be achieved in the available time are much more restrictive than predicted by the infinite-disc model of field growth.

REFERENCES

Gay, M. J., R. F. Griffiths, C. P. R. Saunders and J. Latham, 1974: The velocities of charged hydrometeors and the production of high fields in thunderclouds. *Quart. J. Roy. Meteor. Soc.*, **100**, 296–308.

Kamra, A. K., 1970: Effect of electric field on charge separation by the falling precipitation mechanism in thunderclouds. *J. Atmos. Sci.*, **27**, 1182–1185.

Winn, W. P., and C. B. Moore, 1971: Electric field measurements in thunderclouds using instrumented rockets. *J. Geophys. Res.*, **76**, 5003–5017.

——, G. W. Schwede and C. B. Moore, 1974: Measurements of electric fields in thunderclouds. *J. Geophys. Res.*, **79**, 1761–1767.

CORRIGENDA

The following correction should be made in the paper "A Radiation Model of the Polluted Atmospheric Boundary Layer" by Ronald Welch and Wilford Zdunkowski (*J. Atmos. Sci.*, **33**, 2170–2184). The CO_2–H_2O overlap term (third term on the right-hand side) of Eq. (15) should be replaced by

$$200\pi\Big\{-B_{667}(0)T_{H_2O}(z,0)\epsilon_{CO_2}(z,0) + \int_z^0 B_{667}(z')\frac{d}{dz'}[\epsilon_{CO_2}(z,z')T_{H_2O}(z,z')]dz'\Big\}.$$

This change in no way alters the results, as the correct formulation is used in the numerical work.

* * *

Errors were also noted in the article by Robert Gall, "The Effects of Released Latent Heat in Growing Baroclinic Waves" (*J. Atmos. Sci.*, **33**, 1686–1701).

1) The label on the abscissa of Fig. 1, p. 1689, is reversed; 25°N should appear on the left-hand side and 60°N on the right-hand side.
2) The footnote on page 1694 should read "It was suggested by a reviewer that this result may be due in part to reflection at the 'upper lid,' located at $\sigma=0$, where $\dot{\sigma}\equiv 0$, ..."

Note that in the second error, a dot was left off over the second σ.