Comments on "Numerical Simulation of the Life History of a Hailstorm"

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Orville and Kopp (1977) are right in my view to stress the importance of the cloud dynamics and its interaction with the water substance. I agree, too, that highly simplified dynamical models can be valuable in shedding light on the sensitivity of various processes to changes in the model constraints. However, the authors' comparison of their model results with the observational description of a particular hailstorm

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[Browning and Foote (1976)] suggests to me that they are seeking more realism from their model than is justified by the nature of the model.

I am concerned most about the limitations imposed by the spatially two-dimensional nature of their model, especially when applied, as in this case, to a highly three-dimensional supercell storm. It has been argued (Moncrieff, 1978) that two-dimensional models are not capable of representing the essence of the dynamical organization of such convective storms. Regardless of whether or not this is true in all respects, it is possible to identify some specific limitations of the authors' model which do severely restrict its realism.

One limitation related to the two-dimensional nature of the model arises from the need to modify the initial wind profile by decreasing the wind shear in the plane of the model. The authors have decreased the shear to a mere 20% of the observed value while retaining a thermodynamic sounding with high instability. This has the effect of greatly increasing the convective Richardson number, a nondimensional number which according to Moncrieff and Green (1972) really ought to be preserved. As a result it is difficult for the weak inflow in the model to sustain the intense updrafts which result from the strong buoyancy forces. There may have been an element of unsteadiness in the actual storm because a perfect balance between buoyancy and shear is unlikely; however, the procedure adopted in the model will have exaggerated this unsteadiness and might account for the occasional constriction of the updraft reported by Orville and Kopp. Admittedly the initial surface inflow of 2 m s^{-1} in the model was allowed to increase with time, but it did not attain anything like the relative inflow of almost 20 m s^{-1} which was observed 50 km ahead of the storm, let alone the 35 m s^{-1} horizontal component of inflow measured just ahead of the updraft.

Another limitation of the model is its failure to represent the effects of the strong components of the wind perpendicular to the plane of the model, both in the environment and in the outflow from the updraft aloft. One important effect of these wind components is that they carry the precipitation particles, descending from the forward overhang, to one side of the updraft inflow and thereby tend to restrict the reentry of these particles back into the updraft core (Browning, 1977, p. 37). The lack of these components in the model (along with a possible underestimate of the updraft intensity, overestimate of its tilt, or misrepresentation of the microphysics) may account for the failure to reproduce the observed weak-echo vault. The absence of the vault in the model probably implies unrealistic reentry of hailstone embryos into the main updraft and also unrealistic precipitation trajectories in a part of the storm near which major hailgrowth is likely to have occurred.

Considerations such as these lead me to the view that progress in understanding the airflow and precipitation growth in supercell storms, and perhaps in most hailstorms, really requires the use of three-dimensional models. Because the growth of hail and the effects of water loading may depend rather sensitively on the precise form of the particle trajectories, it may well be necessary to calculate such trajectories within the framework of kinematic models in which detailed three-dimensional patterns of airflow and the precipitation distribution have been deduced observationally from multiple-Doppler radar and other techniques.

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