Comments on "A Z–R Relationship for the GATE B-Scale Array"

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ABSTRACT

It is shown that the Z–R relationship determined by Cunning and Sax (1977) includes additional useful information of cloud physics. The physical processes by which the tropical rainshafts were formed was simple, probably with a single method of drop formation. Comparable Z–R relationships from the Marshall Islands are given. It is shown that the selection of R as the independent variable usually results in a larger coefficient and a smaller exponent than when Z is taken as the independent variable.

Additional very useful cloud physics information is implied in the paper by Cunning and Sax (1977). This information interestingly results from the analytical process they used to obtain a drop-size sample sufficient for meaningful distributions from tropical cumuli rainshafts.

First, Cunning and Sax found that they could combine the drop-size distributions from consecutive samples taken in flights through a rainshaft to obtain one distribution. In other words, very little difference was found in varying parts of the rainshaft. This single combined distribution was then used to determine a rainfall rate for that pass through the rainshaft. A common concept of a rate distribution in a rainshaft is of a low rate near the edges increasing to a maximum near the center of the shaft. Cunning and Sax acknowledge that this is the norm for the GATE data (Cunning and Sax, 1977, p. 1336). However, since they attempted to sample through the rain core for each rainshaft, most of the impacted drops would have been recorded in the rain core. Thus, the predominate rainfall rate sampled in each pass was the rainfall rate for the core. The fact that the several penetrations of the same rainshaft resulted in a series of rainfall rates with relatable drop-size distributions means that the physical process by which the showers were formed was simple, probably with a single method of drop formation.

Second, after studying their data Cunning and Sax, found that the drop-size distributions of most rainshafts, when separated into rainfall rates, could be grouped and averaged by rainfall rate. The high correlation of derived rainfall rates with drop-size distributions noted within the individual rainshafts was also found in the grouped data. This likely means that there was a single method of drop production for all rainshafts on all days. Midlatitude rains do not maintain that simplicity of rainfall rate—drop-size distribution relationships (Nicholass and Larke, 1976). Therefore, tropical rainshafts should prove to be a valuable "laboratory" for future cloud physics experiments.

These facts appear important in the understanding and modeling of the warm-rain processes. The distributions are much simpler than those measured in midlatitude showers involving the ice phase and also in continuous rains with imbedded showers falling from altostratus and altocumulus in the deep tropics. Raindrop-size distributions measured in 1959–60 in the Marshall Islands resulted in a relationship of $Z=184R^{1.40}$ (Mueller and Sims, 1967). This is to be compared with $Z=170R^{1.52}$ determined by Cunning and Sax. When only trade wind showers in the Marshall Islands were analyzed, the study resulted in a relationship of $Z=126R^{1.47}$. Similarly, continuous rains resulted in $Z=226R^{1.46}$. The Marshall Island relationships were determined with R as the dependent variable and Z as the independent variable. Mathematically, the Marshall Island Z–R relationships should be expressed as $R=cZ^b$. This was desired, as with the GATE experiment, to determine the rainfall rate from the radar echo information. Inquiry into the procedures of least-square regression by most authors including Cunning and Sax, unless otherwise stated, has shown that R is taken to be the independent variable. The selection of R as the independent variable usually results in a larger coefficient and a smaller exponent than when Z is taken as the independent variable.

The Marshall Island data were collected using a raindrop camera which sampled one-seventh of a cubic meter volume 2 m above sea level every 1.5 s, usually limited to only 1 m^3 min^{-1}. Raindrop sizes were strati-

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fied into 0.1 mm diameter class intervals with the lower limit of size resolution near 0.5 mm diameter.

REFERENCES

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