

# Supplement eA.2: From $Z_e$ to other quantities



# First, a word of caution

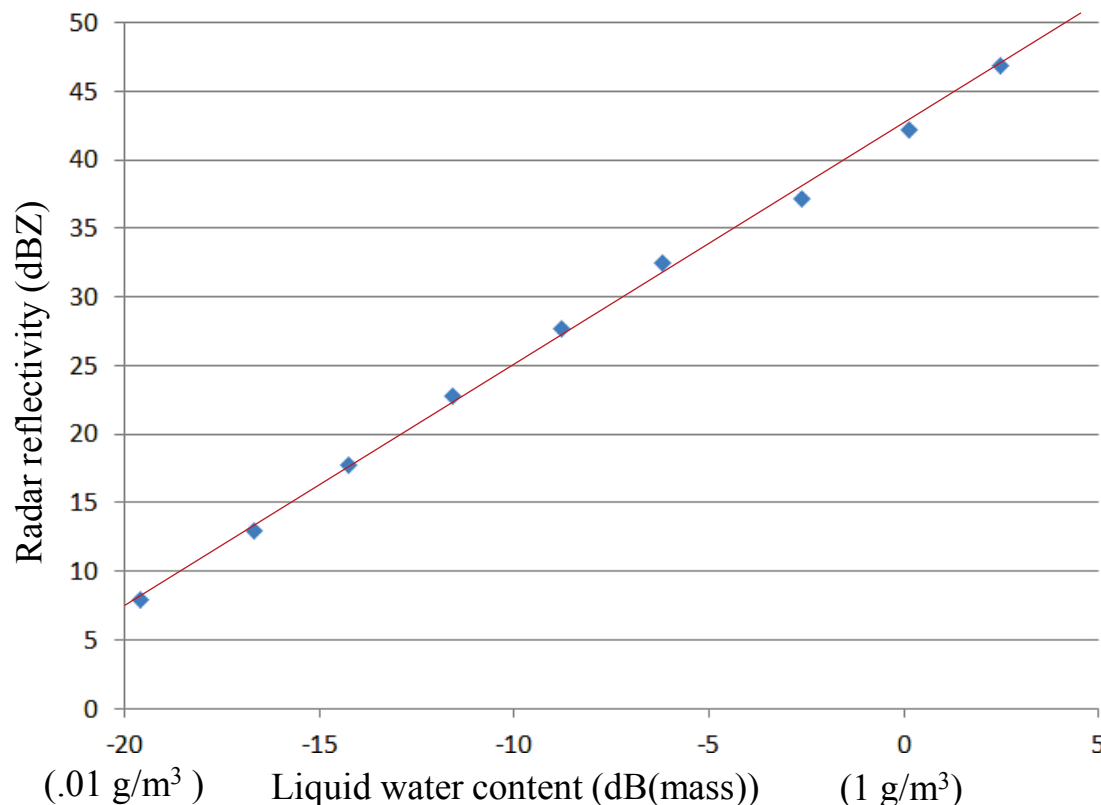
For a variety of applications, simple ways of transforming reflectivity to other quantities (mass, rain rate, etc) and back are often needed. The following formulas were designed for such purposes.

However, remember that in the absence of a universal hydrometeor size distribution, these relationships remain approximations that may have considerable errors (often of the order 40%). These errors are also correlated in space, because the physics that shape hydrometeor size distributions is also correlated in space. Expect significant differences from one storm to another\*.

As a result, these relationships vary considerably, and the formulas to follow can be expected to provide good information only on average.

\*See: Lee, G.W., and I. Zawadzki, 2005: Variability of drop size distributions: Time-scale dependence of the variability and Its effects on rain estimation. *Journal of Applied Meteorology* **44**, 241–255.

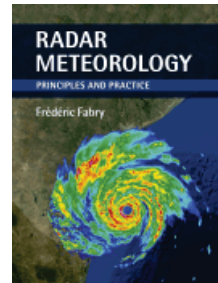
# Not quite power-law relationships



Consider this scatter plot of reflectivity (dBZ) against dB(water mass) derived from 5 years of drop size distributions ( $\rightarrow$  small errors) from the supplement e03.3.

If we try to pass a line through these points, it almost, but not quite fit.

While errors appear to be small, we are being misled by the logarithmic plot: the reflectivity is systematically underestimated by  $\sim 20\%$  in the middle of the range, and generally overestimated elsewhere.



# Power-law approximations

All that being said, true relationships have functional forms that are ugly to characterize\*. Hence, here are a few power-law relationships for rain, based on our climatological drop-size distributions:

$$M \approx 0.00372 Z_e^{0.572}$$

$$R \approx 0.0265 Z_e^{0.681} \left( \frac{101325T}{288.15P} \right)^{0.5}$$

$$Z_e \approx 17700 M^{1.75}$$

$$Z_e \approx 210 R^{1.47} \left( \frac{101325T}{288.15P} \right)^{-0.5}$$

\*The relationships above were simply derived from the data in supplement e03.3. You are welcome to find better fits, or try with other long-term data. 4