7A.2 SOME EFFECTS OF THE STOCHASTIC STRUCTURE OF RAIN ON REMOTE SENSING OBSERVATIONS PART 2: *Z-R* RELATIONS AND RAINDROP SIZE DISTRIBUTIONS

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1. REMARKS

It is shown that physically-based, linear relations between the radar reflectivity factor, *Z*, and the rainfall rate, *R*, (as well as between other parameters) apply in *statistically homogeneous* rain (Jameson and Kostinski 2001a). This conclusion is proven theoretically using a 'generalized' *Z-R* relation based upon the physical consideration of *R* and *Z* as random variables. This relation explicitly incorporates details of the drop microphysics as well as the variability in measurements of *Z* and *R*. In *statistically homogeneous* rain, this generalized expression shows that the coefficient relating *Z* and *R* is a constant, resulting in a linear *Z-R* relation. A physical explanation is that the statistical homogeneity of the rain requires that the pdf of *D*, *p(D)*, be 'steady' so that the ratio R/Z is constant (Jameson and Kostinski 2001a; 2001b). In such rain the drop size distributions have intrinsic, physical interpretations independent of the measurement process. Furthermore, convergence toward these distributions is fastest in 'steady' rain (Jameson and Kostinski 2001c) as discussed in Part 1.

In *statistically inhomogeneous* rain, however, the coefficient relating *Z* and *R* varies in an unknown fashion so that one must resort to statistical fits, often power laws, in order to relate the two quantities empirically over widely varying conditions. The 'justification' for non-linear power law *Z-R* relations is not physical, but rather statistical in that they provide convenient parametric fits for estimating mean *R* from measured mean *Z* in statistically inhomogeneous rain. Accordingly, the interpretations of drop size distributions in statistically inhomogeneous rain now depend upon the measurement process. Furthermore, in statistically inhomogeneous rain, different remote sensing instruments, even if pointed at the same target, will see different total drop size distributions simply because the beam-widths are not the same (Jameson and Kostinski 2001b). This will affect all algorithms which assume that different instruments are viewing the same set of drops.

Finally, examples suggest that such generalized relations between two variables defined by such sums are potentially useful over a wide range of remote sensing problems and over a wide range of scales. Application of such relations, however, requires the extraction from the non-Rayleigh signal statistics, common to almost all radar and radiometer observations, of the component of the variances due to the distribution of mean values (see Jameson and Kostinski 1996; 1999).

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