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Reply to comments by Zhen-Jia Wu and Ali Tokay on 'Spurious power-law relations among rainfall and radar parameters' (July B 2002, **128,** 2045–2058)

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We are pleased that Wu and Tokay (2005; hereafter WT) found our recent work (Jameson and Kostinski 2002; hereafter JK2) worthy of careful examination, and that WT agree with our results concerning the effects of small sample size on Z–R relations. Thus, their comment is not about the scientific validity of the results reported in JK2 but rather about the range of implications. In fact, the comment is about a single sentence from the Concluding remarks, namely: '. . . that past power-law regressions among rainfall and radar parameters. . . are very likely to be artefacts of under-sampling'. We concede that the quoted sentence, when taken literally and out of context, should have been supplemented by a reminder of the second and, perhaps more obvious, route to spurious exponents, namely that of heterogeneity of the rain field as discussed in Jameson and Kostinski (2001; hereafter JK1) reviewed in JK2. Specifically, we refer WT and the reader to p. 530 of JK1, subsection 3(b), entitled 'The impact of statistical inhomogeneity on Z–R relations' as well as to their Fig. 8, p. 532. Apparently, we failed to review this point with sufficient clarity in JK2, and we now welcome this opportunity to further elucidate our results.

Together, JK1 and JK2 point out that spurious non-unity exponents in Z–R relations can arise from two distinct causes: (i) the heterogeneity of rain, along with the associated mixture of drop size distributions and their linear Z–R relations (see the bottom of p. 2055 and top of 2056 in JK2); (ii) insufficient sampling of linear Z–R relations in statistically homogeneous conditions (JK2). While WT claim to comment on JK2 (confined to statistically homogeneous rain), they actually construct a heterogeneous dataset (three islands, five cases per site, separated by months) in explicit violation of the conditions of item (ii) above and the assumptions of JK2. Indeed, why not concatenate data from the entire globe and, say, 10 years of observations?

Using this heterogeneous set of observations, WT show that data smoothing via re-binning or concatenation does not affect the resulting Z–R relations. This is hardly surprising, given the extreme heterogeneity of their data (e.g. see Fig. 8 of JK1). However, stability alone need not imply unique, meaningful results (or, as WT put it, 'a natural linkage') because statistical regressions are dominated by most frequent data, e.g. fits to 1000 cases of drizzle and three cases of heavy rain are not likely to reveal much about the physics of heavy rain.

Moreover, an infinite variety of different sets of different drop-size distributions and the associated linear Z–R relations can be combined to yield one particular final, nonlinear Z–R relation (see pp. 2055–2056 of the Concluding remarks in JK2 and pp. 530–533 in JK1). Indeed, the WT heterogeneous dataset is dominated by small rainfall rates, with 75% of the values less than 3 mm h^{-1}. Under these circumstances, the low rain rates control the regressions (as discussed in JK1 and in JK2 appendix), regardless of concatenation. Worse yet, in heterogeneous conditions, coarser re-binning used by WT is not equivalent to collecting additional useful information about the same rain events. In fact, proper sampling is even more problematic in heterogeneous conditions than it is in homogeneous conditions as discussed in Kostinski and Jameson (1999, pp. 114–115). This problem is the foundation of the sentence to which WT object.

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