Sensitivity of power functions to aggregation: bias and uncertainty in radar rainfall retrieval

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Rainfall retrieval using weather radar relies on power functions between radar reflectivity Z and rain rate R. The nonlinear nature of these relations complicates the comparison of rainfall estimates employing reflectivities measured at different scales. Transforming Z into R using relations that have been derived for other scales results in a bias and added uncertainty. We investigate the sensitivity of Z-R relations to spatial and temporal aggregation using high-resolution reflectivity fields for five rainfall events. Existing Z-R relations were employed to investigate the behavior of aggregated Z-R relations with scale, the aggregation bias and the variability of the estimated rain rate. The prefactor and the exponent of aggregated Z-R relations systematically diverge with scale, showing a break that is event-dependent in the temporal domain and nearly constant in space. The systematic error associated with the aggregation bias at a given scale can become of the same order as the corresponding random error associated with intermittent sampling. The bias can be constrained by including information about the variability of Z within a certain scale of aggregation, and is largely captured by simple functions of the coefficient of variation of Z. Several descriptors of spatial and temporal variability of the reflectivity field are presented, to establish the links between variability descriptors and resulting aggregation bias. Prefactors in Z-R relations can be related to multi-fractal properties of the rainfall field. We find evidence of scaling breaks in the structural analysis of spatial rainfall with aggregation.