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Equilibrium raindrop size distributions in heavy rain

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Numerical simulations show that, in falling rain, because of the microphysical interactions between falling drops, the drop size distribution (DSD) evolves. Two processes are mainly involved: coalescence and collisional breakup. From the results of their computations, several authors have suggested that, owing to the competing effects of these processes, falling DSD are leading towards an equilibrium state, that is a state in which their shape does not vary any more. When the equilibrium conditions are reached, the number density of drops, as a function of their equivalent spherical diameter, can be written $N(D) = R\psi(D)$, where $\psi(D)$ is a generic shape function and R is the rainfall rate. It is easy to show that a consequence of this equation is that the relation between the radar reflectivity factor of the rain Z and R is simply a linear relation of the form $Z = aR$, where a is a coefficient (it is well known that the usual form of this relation is $Z = aR^b$ with b between about 1.2 and 1.6). Thus, computing Z-R relations in rain and looking for $b \approx 1$ is a way to examine if the theoretical concept of equilibrium DSD applies in nature. From the computation, it seems that the equilibrium DSD shape could be reached only after a large number of drop interactions, that is in heavy rain, and when the fall height of the rain is important. The object of the proposed paper is to present the main results of an investigation on the equilibrium distribution performed from a large dataset of DSD collected in heavy rain, with disdrometers, in several places in Europe and equatorial area. We found that the Z-R relations sometimes approach the linear form in the leading edge of the convective systems. The slopes of the DSD in heavy rain does not vary but it seems that the proportion of the small drops is dependent on the rain rate.