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Comparison between natural Rain drop size distributions and corresponding models near equilibrium state during warm rain

laurent barthes and cécile mallet

Université de Versailles-Saint-Quentin en Yvelines (UVSQ) CNRS/INSU, LATMOS-IPSL, France
(laurent.barthes@latmos.ipsl.fr)

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The study of the vertical evolution of raindrop size distributions (DSDs) during rainfall, from the freezing level isotherm to ground level, is a key to improving our understanding of the microphysics of rain. In numerous domains such as remote sensing, telecommunications, soil erosion, and the study of the rain's efficiency in "washing" the atmosphere, the DSD plays an important role. Among the different processes affecting the evolution of DSD, breakup and coalescence are two of the most significant. Models of coalescence and breakup lead to equilibrium of the raindrop size distribution (DSD) after a fall through sufficient vertical height. At equilibrium, the DSD no longer evolves, and its shape is unique whatever the rain rate or LWC. This implies that the DSD is known, to within a multiplication constant. These models based on experimental measurements have been developed over the past 40 years. The Low and List (1982a,b) parameterization (hereinafter LL82) and the Greg M. McFarquhar (2004) model are both based on the same laboratory experiments, which lead to an equilibrium drop size distribution (EDSD) with two or three peaks, and an exponential tail with a slope of approximately Λ=65 cm^{-1}. Numerous measurements using disdrometer collected in different climatic areas: Paris, France (Mars to October 2000), Iowa-City (April to October 2002), and Djougou (Benin June to September 2006) corresponding to 537 hours of rain period have shown that for high rain rates, close to a state of equilibrium, this slope lies between Λ=20 - 22 cm-1. This latter value is corroborated by others measurements found in the literature (Hu & Srivastava, 1995). Hu & Srivastava suggested that the Low and List parameterization may overestimate the effects of the breakup process. This hypothesis is in adequation with recent laboratory experiments (A.P. Barros 2008) in which the authors conclude that the number of fragments droplets produced when small drops and large drops collide is overestimate.

As new parameterization of LL82 is not possible due to the lack of new sufficient large experimental dataset, we have simply tried in the present study to "compensate" the problem previously mentioned by replacing the coalescence/breakup model proposed in LL82 by another one in which the breakup process is less dominant. In order to evaluate the relevance of this modification, some of the DSD parameters such as slope, mean volume diameter, and relation between moments are calculated, and comparisons with experimental DSD are made. Simulations at equilibrium lead to a DSD tail with a slope of 23 cm^{-1} and a mean volume diameter equal to 2.5 mm. These values are in good agreements with experimental data. Similarly, the linear relationship between No* and the rainfall rate is also in good agreement.

In the last part, the modified parameterization is then used to study the evolution of an initially gamma-like DSD in a 1D vertical rain shaft.

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