1.18 WHY THE GENERALIZED GAMMA? - AN ANSWER BASED ON MEASUREMENTS WITH METEOROLOGICAL PARTICLE SPECTROMETER AND 2D VIDEO DISDROMETER

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The generalized gamma (GG) formulation for representing rain and ice particle size distributions has been considered by several researchers in the past 15 years. From theory the GG form is mathematically sound and has the following desired properties: (a) it reduces to standard gamma, exponential, and Weibull forms (which are special cases) and as a limiting case to the log-normal form, (b) any power law of drop diameter (D) such as mass or mass flux also falls in the GG form and (c) it maximizes relative entropy under moment constraints (Wu and McFarquhar, private communication). The DSD formulation used herein is based on double-moment normalization using the 3^{rd} and 4^{rd} moments as the reference moments (M_3,M_4) and the intrinsic shape of the normalized distribution h(x) where $x=D/D_{43}$ is the scaled diameter and D_{43} (i.e., mass-weighted mean volume diameter, Dm′) is the ratio of M_4 to M_3. The h(x;μ,c) is chosen of the gamma form with two shape parameters (μ,c). Thus, N(D) is expressed in compact form as $N(D)=M_3/D_{43}^4$ h(x; μ,c)=N_0'h(x; μ,c). This form has the advantage that any moment of the DSD can be expressed as power laws of the two reference moments and (μ,c); in particular the lower order moments (M_0-M_2) which are involved in modeling microphysical processes such as coalescence and break-up which control the DSD shape at the small drop and large drop ends as well as the plateau region in between. Most currently available disdrometers cannot accurately measure the small drop end ($D<$ 0.5-0.7 mm) due to poor resolution and sensitivity issues.

In this study, we consider measurements of rain drop size distributions (DSD) using collocated high resolution (50 microns) Meteorological Particle Spectrometer and moderate resolution (170 microns) 2D-video disdrometer from two different rain climatologies (Greeley, Colorado, and Huntsville, Alabama, USA). The combination of the two instruments yields what we term as the “full” DSD spectra, e.g. over 1-minute, covering the size range from 100 microns to large rain drops whose shape cannot generally be represented by the standard gamma (SG) model, but requires the additional flexibility of the GG model, with the two abovementioned shape parameters (μ,c). With (M_3,M_4) as reference moments, the SG value of c=1 was not reached for majority of the cases, even when considering $0.6<c<1.4$. This finding also highlights a problem with DSD assumptions in the rainfall retrieval algorithm employed for the Global Precipitation Measurement mission Core satellite.

Examples of events will include light precipitation, stratiform rain and convective rain events as well as outer bands of hurricane Irma and tropical storm Nate. The latter two are special cases, which fortuitously had crossed our instrumentation site. Evidence for equilibrium-shaped DSDs will also be discussed by comparing measurements with numerically modeled DSDs under the condition of balance between coalescence and break-up processes. We demonstrate that most of the DSD variability, for example with rain rate can be attributed to variability in N_0' and D_{43}' allowing for identification of number-controlled or size-controlled DSDs.