ESTIMATION OF RAINDROP SIZE DISTRIBUTION IN MEXICO CITY BY A NETWORK OF DISDROMETERS: IMPLICATIONS FOR Z-R RELATIONSHIPS

ROBERTA K. MOCVA-KUREK(1), MIGUEL A. RICO-RAMIREZ(2) & ADRIÁN PEDROZO-ACUÑA(1,3)

(1) National Autonomous University of Mexico (UNAM), Program of Master and Doctorate in Engineering, Mexico City, Mexico, rkurekm@ingen.unam.mx
(2) University of Bristol, Department of Civil Engineering, Bristol, United Kingdom, m.a.rico-ramirez@bristol.ac.uk
(3) Mexican Institute of Water Technology (IMTA), General Director, Jiutepec, Mexico, apredozaa@ingen.unam.mx

ABSTRACT

Knowledge on drop size distribution (DSD) and their spatial-temporal variability is very important in hydrology, e.g. for radar quantitative precipitation estimation (QPE) and erosive process studies. DSD, being a central topic in radar meteorology, because it conducts a good conversion of radar reflectivity factor (Z) in rainfall (R). The disdrometers are used to measure the DSD at a given location and are useful in determining the shape of the DSD, it enables a better estimation of the coefficients of reflectivity-rainfall (Z-R) relationship that is used in precipitation measurement with weather radars. The lack of a specific Z-R relationship for the weather radars located in Mexico City and the presence of a dense network of 39 optical disdrometers (OTT Parsivel2) with 1 min resolution (namely OH-IIUNAM) motivates the present study. This paper presents the first evaluation of the spatial-temporal shape variability of the normalised gamma DSD within the city and the calibration of a Z-R relationship considering the DSD using data from 9 OH-IIUNAM disdrometers. The preliminary results show that the normalised gamma distribution can represent the DSD shape in Mexico City, as well as that DSD and Z-R relationship presents a spatial and temporal variability. In addition, highlighting the importance of determining a local Z-R equation.

Keywords: Drop size distribution (DSD); disdrometer data; Z-R relationship; Mexico City.

1 INTRODUCTION

Knowledge about the raindrop size distribution (DSD), that is, physics characteristics of rainfall (Testud et al., 2001), is very important for several applications, such as soil erosion, efficiency of the rain’s washing of the atmosphere, interaction between rainfall and electromagnetic waves. The last application refers to the operation of weather radars, consequently quantitative rainfall estimates (Mallet and Barthes, 2009; Raupach and Berne, 2015).

Weather radars allow rainfall monitoring at high spatial-temporal resolutions than traditional rain gauge networks, which is essential for an adequate management of urban hydrological processes. Rainfall estimations using ground-based weather radars rely on radar reflectivity (Z)-rain rate (R) relationships, which play a crucial role for the quantitative use of this instrument for an adequate estimation of rainfall. However, much uncertainty remains in this process, which prevents the use of this radar-derived rainfall amounts quantitatively for hydrological purposes.

Indeed, Z and R are related to each other via the DSD, which is defined as the mean number of raindrops in a particular diameter interval present per unit volume of air (mm$^{-1}$m$^{-3}$). Commonly, Z-R relationship are often used as a power-law of the form $Z=aR^b$ (see Marshall and Palmer, 1948), where the parameters $a$ and $b$ can be calibrated using DSD measurements (Bringi and Chandrasekar, 2001a). Disdrometers are instruments that measure the DSD at a point location and are useful in determining the shape of the DSD (Bringi et al., 2003; Raupach and Berne, 2015), thus enables a better estimation of Z-R relationship. Before commercialization of disdrometers, the study of DSD and adjusting Z-R relationship was impossible in operational use of weather radars (Licznar and Krajewski, 2016).

Usually, the general exponential and gamma distributions are used to characterize DSDs. The first is the most popular equation to DSD evaluation, from a pioneer study of Marshall and Palmer (1948). However, recently the normalized gamma distribution has been used in many studies, showing good performance (e.g. Bringi et al., 2003, 2011; Mallet and Barthes, 2009).

The general expression of the normalization of the DSD is presented in Testud et al. (2001). The normalization makes it possible to compare DSDs rainfall with widely divergent characteristics (Bringi et al., 2003). The DSD spatial-temporal variation is present not only inside the storm but also in different storm types and climates (Bringi et al., 2003), which justifies the present study.
Mexico City has a network of 39 optical disdrometers, OTT Parsivel2® (OTT, 2016), for real-time rainfall monitoring, making it one of the densest networks in the world, namely, the Hydrological Observatory, of the Institute of Engineering of the National Autonomous University of Mexico (OH-IIUNAM). This scenario for Mexico City, allows the possibility to explore the spatial shape of the normalized DSD and the calibration of a Z-R relationship, considering the DSD; consequently, making this study the first to perform a preliminary evaluation for Mexico City. In summary, this paper looks at improving radar rainfall measurements by adjusting the Z-R relationship for the local conditions in Mexico City.

2 METODOLOGY

2.1 Study area

The study area covers an urban region of Mexico City, where OH-IIUNAM network and weather radar have recently been installed (Figure 1). The weather radar (X-band and dual polarization) having been installed last year by SACMEX (Water Systems of Mexico City) for spatial real-time storm monitoring. Climate in this region is characterized by a dry period and a humid period, the last comprising the months between May and October (summer) and rain typically being convective, which consequently causes flash floods.

![Figure 1. Location of the disdrometers network (OH-IIUNAM) and SACMEX radar in Mexico City.](image)

2.2 Disdrometer data

For this study, N(D) and rainfall time series ("measured DSD" and "R measured by disdrometer") with temporal resolution of 1-min measured between 05/2017 and 09/2018 by only 9 OH-IIUNAM disdrometers (yellow dots in Figure 1) were used. For a concise evaluation, it is necessary to focus on the same time period for all data series. Given that the installation of OH-IIUNAM network was throughout 2018, it is not possible to use all data from all disdrometers. For seasonal evaluation, summer defined for a period between May and October, and winter November through April.

The Parsivel2® laser disdrometer measures the size and fall velocity of hydrometeors, in other words, measuring the DSD at every minute. The principle of measurement consisting on the attenuation of signal when a particle crosses the laser beam of 54 cm². The hydrometeors are classified into a 32 x 32 matrix according to their class of diameter and velocity (Tokay, Wolff and Petersen, 2014). From this matrix, the disdrometer processor calculates N(D) (see equation in Tokay et al., 2014) and estimates many hydrometeorological variables. This instrument is sensitive to particle size of liquid precipitation and solid precipitation from 0.2 to 8 mm and from 0.2 to 25 mm, respectively. The particle speed range is between 0.2 and 20 m/s (OTT, 2016).

The selected number of 1-min DSD, for each disdrometer, was defined by three conditions based on the raw data N(D): 1) values equal to or more than 4 consecutive diameter classes, 2) drops with a maximum diameter ($D_{\text{max}}$) equal to 8 mm (N(D) data with large drops were discarded possibly due to hail storms), 3) classifying as drizzle or rain by METAR/SPECI weather code of the disdrometer processor. The first condition relating to the measured error, the second and third ensuring the evaluation of only liquid particles. Bringi and Chandrasekar (2001b, 2001a) mention the values of $D_{\text{max}}$ (6-8 mm) for adjustment of analytical forms of the DSD, as well as $R_{\text{max}}$ restriction ($\leq 300$ mm h⁻¹). Many papers also present DSD evaluation for $D_{\text{max}}$~6 mm (e.g. Testud et al., 2001).

2.3 Adjustment of normalized gamma DSD and Z-R relationship
Based on Bringi and Chandrasekar, (2001b), Testud et al., (2001) and Bringi et al. (2003), for each 1-min N(D) data of each OH-IIUNAM disdrometer, the mass-weighted mean diameter ($D_m$), liquid water content ($W$) and generalized intercept parameter ($N_w$) are calculated by moments of the drop size distribution N(D):

$$D_m = \frac{\int_0^\infty N(D)D^4 dD}{\int_0^\infty N(D)D^3 dD}$$

[1]

$$W = \frac{\pi \rho \omega}{6} \int_0^\infty N(D) D^3 dD$$

[2]

$$N_w = \frac{4^4}{\pi \rho \omega} \left( \frac{W}{D_m^4} \right)$$

[3]

where $N$ is number of particles per unit volume and per interval of diameter ($m^{-4}$), $D$ is drop diameter (mm) and $\rho_w$ is water density. $D_m$, $W$ and $N_w$ are expressed in mm, g m$^{-3}$ and mm$^1$m$^{-3}$, respectively, and are calculated without adjustment of the distribution.

Additionally, each N(D) data was normalised by $F(D/D_m) = N(D)/N_w$ (where, $D_i$ is drop diameter in $i$ diameter class and $N(D_i)$ is the drop concentration) and the best-fitting normalised gamma distribution is determined by only $\mu$ parameter. The general expression of normalised gamma is (Testud et al., 2000; Bringi and Chandrasekar, 2001b):

$$N(D) = N_0 f(\mu) \left( \frac{D}{D_o} \right)^\mu \exp \left[ -\left( 3.67 + \mu \right) \frac{D}{D_o} \right]$$

[4]

where,

$$f(\mu) = \frac{6}{(3.67)^4} \frac{(3.67+\mu)^{\mu+4}}{\Gamma(\mu+4)}$$

[5]

The $\mu$ describe the shape of the DSD and is adjusted through equation no. 16 in Testud et al. (2001) based on D/D$_m$, searching the best $\mu$ in range of -3 and 15 as Bringi et al. (2003). The $N_w$ first obtained (eq. 3) is readjusted using $\mu$ for a better adjustment and applied in Eq.[4]. The $D_o$ is the median volume diameter, which represents the drop diameter divided in two equal parts of the liquid water content, making this very difficult to obtain. For gamma DSD, $D_o$ is related with $D_m$ by (Ulbrich, 1983):

$$\frac{D_o}{D_m} = \frac{3.67 + \mu}{4 + \mu}$$

[6]

In radar meteorology, moments of the DSD can represent most of the integral parameters of the DSD (Testud et al., 2001). In sequence, using the moments of the normalised gamma DSD obtained from the adjusted parameters ($N_w$, $\mu$, $D_o$), the rainfall ($R$) and radar reflectivity factor ($Z$) are calculated (Atlas et al., 1977; Bringi and Chandrasekar, 2001b):

$$R = 0.6\pi \times 10^{-3} \int v(D) D^3 N(D) dD$$

[7]

$$Z = \int D^6 N(D) dD$$

[8]

where $v(D)$ is the terminal fall velocity of raindrops (m s$^{-1}$). $R$ and $Z$ are expressed in mm h$^{-1}$ and mm$^6$ m$^{-3}$, respectively. The terminal fall velocity model proposed by Atlas, Srivastava and Sekhon (1973) was used in this study:

$$v(D) = 9.65 - 10.3 \exp (-0.6D)$$

[9]

For comparison, $R$ calculated with measured DSD’s and $R$ measured by disdrometer was used for this study. In resume, the final data series for each OH-IIUNAM disdrometer contains parameters of normalized gamma DSD ($N_w$, $\mu$, $D_o$), $R$ and $Z$ from normalised gamma DSD’s, $R$ from measured DSD’s and $R$ measured by disdrometer. Furthermore, the final data series is calculated according to seasons (see section 2.2), and the variables were segregated in 11 rainfall classes (Tokay and Short, 1996; Nzeukou et al., 2004).

For every disdrometer subset, the Z-R relationship is adjusted according to the most widely implemented power law proposed by Marshall and Palmer (1948): $Z=aR^b$, with $a=200$ and $b=1.6$ (Marshall, Hitchens and Gunn, 1955). These coefficients are usually estimated through an empirical approach, such as logarithmic linear regression (least squares fitting) between Z-R pairs. A threshold in rainfall of the R<5 mm h$^{-1}$ was applied to each time series (Atlas et al., 1999; Bringi et al., 2003). According to Atlas et al. (1999) small drops are difficult
RESULTS AND DISCUSSION

A small difference in the shape of the average measured DSD is observed between rainfall classes (Figure 2), which was expected. In all classes, the drop concentration displays same bumps in central values of 0 and 1 mm, this reinforces that there is always higher presence of smaller drops, regardless of rain type. The lower drop concentration in all diameter classes is verified for light rain (<2 mm) and a slight increase in drop concentration in the last diameter classes, similar in Nzeukou et al., (2004) for tropical latitudes. In general, the average DSD shape is remarkably alike in all OH-IIUNAM stations, which shows that the precipitation growth is similar in the urban area of Mexico City.

Figure 2. Average measured DSD from each OH-IIUNAM disdrometers data classified in 11 rainfall class.

Table 1 summarizes parameters Nw, Do and µ of the normalised gamma DSD adjusted and number of minutes evaluated (rainy minutes) for the complete and seasonal data series, as well as for 11 rainfall classes.

Considering the spatial distribution (see Figure 1) of these results it is possible to make some observations. The highest number of rainy minutes was recorded in the center-west urban zone (Cuajimalpa, V. Hermosa and IIUNAM) and have low rainfall (<10mm hr⁻¹), it suggests a non-uniform spatial distribution of rainfall occurred during the analysis period. Few minutes have values > 80 mm hr⁻¹ and rarer >120 mm hr⁻¹.

The complete data series, Nw values show that there is a considerable spatial variation (min 6.0E⁻³ / max 9.7E⁻³ mm⁻¹m⁻³), but all values are proximate Marshall and Palmer (1948) value for exponential DSD (8.0E⁻³ mm⁻¹m⁻³). The highest values were observed in the northwestern zone. The µ also shows variations between stations (min. 5.94 / max. 8.72), but without a pattern. In contrast, the Do presents very low spatial variation.

Regarding the seasonal series, most rainy minutes occurred during the summer, which was expected by the type of climate. In winter, the rain is characterized by a low intensity, rarely having values >40mm hr⁻¹. In general (complete data), the Nw parameter is lowest in winter period, D0 of all disdrometers is higher in winter
period and μ has little variation between seasons and is slightly lowest in winter. All parameters in the summer data period have values and spatial distribution similar to the complete period.

The behavior of parameters between rain classes is variable, for Nw and μ, a general trend cannot be identified. This relation (R-parameters) has been studied by many authors (Ulbrich, 1983; Nzeukou et al., 2004) without leading to universal conclusions. In this study, in some stations high and low values are in upper classes respectively, but this does not represent a trend. On the other hand, high values of Dρ are proportional to high intensities. The Dρ behavior is consistent because heavy rain usually has large drops.

Figure 3. Normalizing of the DSD by D/Dm and scaling the N(D)/Nw for all OH-IIUNAM disdrometers (points) and representation of normalised gamma DSD for several μ (3 to 15 in steps of 0.5) (lines).

Table 1. Normalized gamma DSD parameters adjusted for each OH-IIUNAM disdrometers. Note that '<X>' represents the expected value of X. (continue)
<table>
<thead>
<tr>
<th>R (mm)</th>
<th>Complete data</th>
<th>20 &lt;= R* &lt; 40</th>
<th>4 &lt;= R* &lt; 6</th>
<th>2 &lt;= R*&lt; 4</th>
<th>20 &lt;= R* &lt; 40</th>
<th>6 &lt;= R*&lt; 10</th>
<th>4 &lt;= R*&lt; 6</th>
<th>2 &lt;= R*&lt; 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 &lt;= R*&lt; 4</td>
<td>43275 40258 3017</td>
<td>3.835 3.852 3.507</td>
<td>1.01 1.00 1.15</td>
<td>8.58 8.65 7.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 &lt;= R*&lt; 6</td>
<td>33143 30565 2578</td>
<td>3.770 3.787 3.475</td>
<td>0.87 0.86 0.99</td>
<td>9.59 9.69 8.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 &lt;= R*&lt; 10</td>
<td>4648 4440 3503</td>
<td>4.067 4.077 3.781</td>
<td>1.18 1.16 1.27</td>
<td>6.81 6.91 5.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 &lt;= R*&lt; 12</td>
<td>1868 1774 94</td>
<td>4.072 4.083 3.781</td>
<td>1.36 1.34 1.86</td>
<td>5.67 6.01 3.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 &lt;= R*&lt; 20</td>
<td>1551 1511 40</td>
<td>3.956 3.960 3.430</td>
<td>1.59 1.56 2.20</td>
<td>4.54 4.63 1.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 &lt;= R*&lt; 40</td>
<td>1220 1170 50</td>
<td>3.798 3.812 3.181</td>
<td>1.97 1.93 2.80</td>
<td>2.66 2.72 1.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 &lt;= R*&lt; 60</td>
<td>636 599 37</td>
<td>3.562 3.579 3.109</td>
<td>2.39 2.33 2.52</td>
<td>0.98 0.98 0.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 &lt;= R*&lt; 80</td>
<td>140 134 6</td>
<td>3.539 3.539 3.111</td>
<td>2.60 2.56 3.55</td>
<td>0.25 0.21 1.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 &lt;= R*&lt; 100</td>
<td>46 42 4</td>
<td>3.729 3.726 2.814</td>
<td>2.73 2.52 4.96</td>
<td>0.43 0.38 1.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 &lt;= R*&lt; 120</td>
<td>15 13 2</td>
<td>3.944 3.973 2.135</td>
<td>3.20 2.79 2.79</td>
<td>0.54 0.62 0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 &lt;= R*&lt; 160</td>
<td>4 3 1</td>
<td>3.301 3.409 2.467</td>
<td>4.59 4.86 5.24</td>
<td>1.12 1.24 0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Normalized gamma DSD parameters adjusted for each OH-IIUNAM disdrometers. Note that <X> represents the expected value of X. (finished)
The $R$ estimated from normalised gamma DSD adjusted (mean parameters show in Table 1) and measured DSD has $r$ very close to the value 1, but when these values are compared with $R$ measured by disdrometer, they do not have a perfect fit (Table 2). Given these results, normalised gamma DSD can be considered for a good estimate of rainfall. Scatter plots show that most of the errors in $R$ estimates are with low rainfall. In these cases, the presence of large drops in measured DSD was observed.

The $R$ from measured disdrometer is calculated by the processor embedded but the OTT does not reveal all details (OTT, 2016) and conditions of the algorithms that are used for estimation. Licznar and Krajewski (2016) comment about this problem and stresses that the processor is based on a different algorithm for each rain type identified, that is, they apply internal corrections. Also, it is unclear if OTT uses the measured fall velocities rather than the theoretical fall velocities given by Eq [9], or a different equation. Additionally, the authors mention the diameter error because the Parsivel only measure in horizontal beam and DSD equations use volume diameter. In resume, it’s very difficult to obtain the perfect fit.

Table 2. Pearson correlation matrix of rainfall obtained from three different methods: $R$ measured by the disdrometer (method 1), $R$ estimated from normalised gamma DSD (method 2) and $R$ estimated from measured DSD (method 3), for all OH-IIUNAM disdrometers.

<table>
<thead>
<tr>
<th>Method 1 X Method 2</th>
<th>Method 1 X Method 3</th>
<th>Method 3 X Method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>max. values (mm h$^{-1}$)</td>
<td>$r$</td>
</tr>
<tr>
<td>Aragon</td>
<td>0.9329</td>
<td>99.84 x 152.13</td>
</tr>
<tr>
<td>Coapa</td>
<td>0.9410</td>
<td>178.63 X 178.16</td>
</tr>
<tr>
<td>Cuajimalpa</td>
<td>0.9227</td>
<td>109.64 X 277.34</td>
</tr>
<tr>
<td>Dos Rios</td>
<td>0.7302</td>
<td>93.81 x 247.30</td>
</tr>
<tr>
<td>IIUNAM</td>
<td>0.9324</td>
<td>104.18 X 327.99</td>
</tr>
<tr>
<td>Madin</td>
<td>0.9640</td>
<td>110.46 X 199.36</td>
</tr>
<tr>
<td>Prepa 4</td>
<td>0.9618</td>
<td>149.72 X 172.13</td>
</tr>
<tr>
<td>SACMEX</td>
<td>0.9226</td>
<td>145.83 X 178.30</td>
</tr>
<tr>
<td>V. Hermosa</td>
<td>0.9875</td>
<td>119.80 X 131.26</td>
</tr>
</tbody>
</table>

The Z-R relationship fitted also show some spatial variation for complete and seasonal data series (Figure 4 and Table 3), corroborating with the variability of DSD between stations, and follow the trend of the low values of $a$ and $b$ coefficients on the northwestern and western zone, respectively.
In general, verifying a good fit of the normalised gamma DSD and the variables derived from it using The presence of spatial variation of the DSD parameter and Z–R from normalised gamma DSD and Z–R equation to avoid the equation being affected by the low rain rates.

The coefficients values obtained for complete and summer data series are very close. In the winter data series, the a coefficient increases in relation with the complete data series and for some stations the difference is high (a max = 305.49 - IIUNAM).

Table 3. Z-R relationship for all OH-IIUNAM disdrometers for complete, summer and winter data series.

<table>
<thead>
<tr>
<th></th>
<th>complete</th>
<th></th>
<th>summer</th>
<th></th>
<th></th>
<th>winter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n° of Z-R pairs</td>
<td>a</td>
<td>n° of Z-R pairs</td>
<td>a</td>
<td>n° of Z-R pairs</td>
<td>a</td>
<td>n° of Z-R pairs</td>
</tr>
<tr>
<td>Aragon</td>
<td>14670</td>
<td>215.774</td>
<td>1.674</td>
<td>13806</td>
<td>211.836</td>
<td>1.677</td>
<td>862</td>
</tr>
<tr>
<td>Coapa</td>
<td>16604</td>
<td>201.837</td>
<td>1.647</td>
<td>15617</td>
<td>197.697</td>
<td>1.644</td>
<td>987</td>
</tr>
<tr>
<td>Cuajimalpa</td>
<td>22201</td>
<td>180.3018</td>
<td>1.609</td>
<td>20949</td>
<td>174.1807</td>
<td>1.606</td>
<td>1252</td>
</tr>
<tr>
<td>Dos Rios</td>
<td>16885</td>
<td>194.985</td>
<td>1.525</td>
<td>15848</td>
<td>189.671</td>
<td>1.520</td>
<td>1037</td>
</tr>
<tr>
<td>IIUNAM</td>
<td>19865</td>
<td>204.174</td>
<td>1.671</td>
<td>19109</td>
<td>199.986</td>
<td>1.673</td>
<td>756</td>
</tr>
<tr>
<td>Madin</td>
<td>8417</td>
<td>176.604</td>
<td>1.652</td>
<td>7075</td>
<td>169.434</td>
<td>1.656</td>
<td>1342</td>
</tr>
<tr>
<td>Prepa 4</td>
<td>18918</td>
<td>199.064</td>
<td>1.595</td>
<td>17904</td>
<td>194.536</td>
<td>1.591</td>
<td>1014</td>
</tr>
<tr>
<td>SACMEX</td>
<td>17173</td>
<td>220.293</td>
<td>1.683</td>
<td>16251</td>
<td>217.771</td>
<td>1.669</td>
<td>922</td>
</tr>
<tr>
<td>V. Hermosa</td>
<td>23482</td>
<td>177.011</td>
<td>1.654</td>
<td>22357</td>
<td>171.396</td>
<td>1.659</td>
<td>1125</td>
</tr>
<tr>
<td>data from all stations</td>
<td>158215</td>
<td>195.885</td>
<td>1.631</td>
<td>148918</td>
<td>190.985</td>
<td>1.629</td>
<td>9297</td>
</tr>
</tbody>
</table>

4 CLOSING REMARKS

In Mexico City, the dense OH-IIUNAM real-time (1-min) rainfall monitoring network by Parsivel2® laser disdrometers allowed the preliminary study of spatial shape of DSD and adjustment to normalised gamma distribution, as well as calibration of Z-R relationship considering the variables derivates of this fitted DSD.

The main preliminary results are:

- Most of the rain occur in the summer and present low intensities (up to 20 mm hr⁻¹). However, some extreme events result in intensities exceeding 120 mm hr⁻¹.
- In general, verifying a good fit of the normalised gamma DSD and the variables derived from it using the proposed methodology and the conditions for the selection of the disdrometer data (only rain and drizzle and N(D) with D<8 mm). This indicates that gamma distribution can represent the DSD shape, and, R and Z calculated from moments of this DSD adjust well for this data range.
- The presence of spatial variation of the DSD parameter and Z-R relationship was verified. Preliminary, it can be said that the higher Nw values are related to lower a values (complete data series).
- The temporal variation of DSD and Z-R relationship also were found. Between summer and winter there are changes in behavior of parameters and variables. In winter, Nw is lower and a is higher).
- The mean Do increases with increasing rain intensity.
- The R from normalised gamma DSD versus measured by disdrometer show a good adjustment, indicating a good fit of the DSD shape.

In resume, these results highlight the importance of determining a local Z-R equation and study of spatial DSD shape, as well as the normalised gamma distribution can represent a DSD shape. This study can be considered pioneer because of the number of disdrometers evaluated and a first step into DSD evaluation.

Future work is aimed at applying this methodology for all OH-IIUNAM disdrometers to obtain best spatial characterization of DSD shape. In respect a Z-R relationship, the next step is to apply the coefficients with SACMEX weather radar data for rainfall estimates.

REFERENCES


