

# Analysis on the microphysical features of raindrop size distribution in mountainous area Fujian

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**Abstract.** Microphysical parameters of raindrop size distribution got at Youxi from March to October 2014 were used to analyze microphysical characteristics of natural precipitations under different synoptic systems in mountainous area Fujian. When in small and moderate rain, there are large numbers of small raindrop contribute to the rainfall intensity mainly under warm convergent zone or low-vortex shear, which contains cumulus and stratus-cumulus mixing precipitation (half and half). However, the size spectrums under low-vortex shear have broadest width and obvious double-peak or multi-peak structures. The precipitations under typhoon or intertropical convergence zone are more stable with single-peak size spectrums and centralized raindrops distribution. The parameters  $\mu$  and  $\lambda$  meet the linear function, and they both decrease with rainfall intensity increasing.

## 1. Introduction

The raindrop size distributions data in this research are collected from March 2014 to October by PARSIVEL<sup>2</sup> locate in Youxi, mountainous area of Fujian. Microphysical parameters of raindrop size distribution and radar echo data are used to analyze macroscopical and microscopical characteristics of natural precipitations under different synoptic systems in mountainous area Fujian. Based on the surface and upper weather chart, the synoptic systems liable to cause precipitation are chosen: low-vortex shear, upper trough, warm convergent zone, high pressure zone and typhoon or intertropical convergence zone.

Compared with PARSIVEL, the accuracy of data by PARSIVEL<sup>2</sup> is improved. The correlation analysis result of rainfall calculated from raindrop size distribution by PARSIVEL<sup>2</sup> and observed by rain gauge is 94.8%. So the data by PARSIVEL<sup>2</sup> can reflect the actual variation of precipitation. In this research, the calculation formulas of microphysical parameters are:

$$\text{rainfall intensity: } I = \frac{\pi}{6} \int N(D) D^3 V \rho dD \quad (1),$$

$$\text{volume medium diameter } D_0: 2 \int_{D_{\max}}^{D_0} D^3 N(D) dD = \int_{D_{\min}}^{D_{\max}} D N(D) dD \quad (2),$$

When the rainfall intensities are equal, there are more large raindrops for  $D_0$  larger; the small represents more small raindrops. Based on meteorological standards<sup>[1]</sup>, the precipitation are classified as slight rain ( $I > 0.1 \text{ mm/h}$ ), light rain ( $0.1 \leq I < 1.5$ ), moderate rain ( $1.5 \leq I < 7 \text{ mm/h}$ ), heavy rain ( $7 \leq I < 15 \text{ mm/h}$ ), and storm rain ( $I \geq 15 \text{ mm/h}$ ).

## 2. Radar echo characteristics



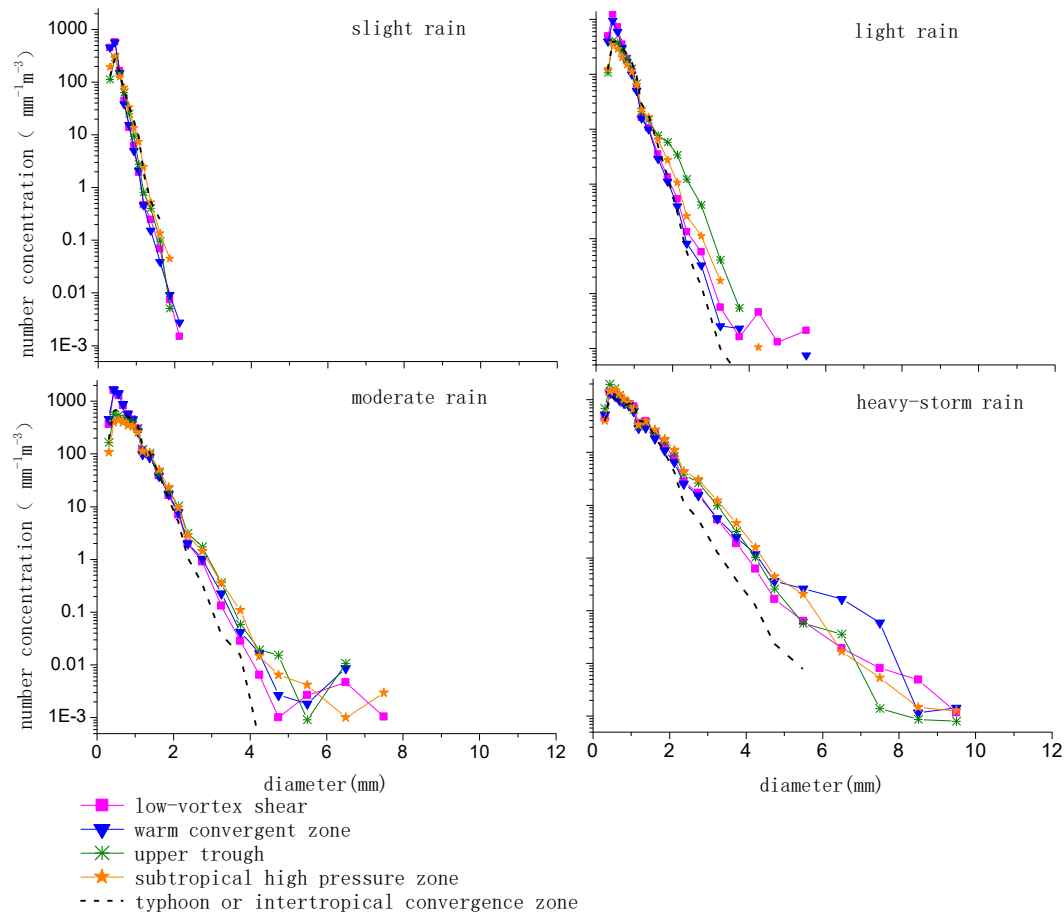
**Table1. Radar echo characteristics under different synoptic systems**

Synoptic system	cloud type	number of days	echo intensity (dBZ)	echo top height(km)	negative temperature zone thickness(km)	rainfall intensity (mm/h)
low-vortex shear	mix	19	20-35	6-16	1.2-11.8	0.23-11.16
	cumulus	19	25-40	6-19	2.0-13.0	0.15-21.1
	stratus	2	15	4-5	1.0-1.9	0.21-0.52
upper trough	mix	6	25-35	7-12	3.4-7.5	0.27-5.38
	cumulus	1	40-50	9-17	5.0-13.3	6.69
warm convergent zone	mix	6	20-35	7-14	3.2-9.9	0.28-2.7
	cumulus	5	25-35	9-14	2.9-9.0	0.56-8.95
high pressure zone	cumulus	14	25-40	6-19	0.8-14.0	0.3-14.6
typhoon or intertropical convergence zone	mix	2	30-35	11-12	6.5-6.7	2.29-2.68
	cumulus	2	40-50	8-11	5.2-5.3	0.21-6.26

The characteristics of cloud and radar echo under different synoptic systems are analyzed in table1. The cloud types under low-vortex shear mainly consists of stratus-cumulus and cumulus, and a small amount of stratus. Under low-vortex shear, rainfall intensity of cumulus is higher than stratus-cumulus, echo intensity; echo top height and negative temperature zone thickness are also higher. The upper trough precipitations are mostly made by stratus-cumulus of which radar echo characteristics still lower than cumulus. The radar echo characteristics of stratus-cumulus and cumulus under warm convergent zone are about the same. Precipitation clouds under high pressure zone are cumulus only, the radar echo characteristics are similar to low-vortex shear. Under typhoon or intertropical convergence zone, the cloud types contain stratus-cumulus and cumulus, but echo top height and negative temperature zone thickness of stratus-cumulus higher than cumulus is different from the other synoptic systems.

### 3. Raindrop size distribution characteristics

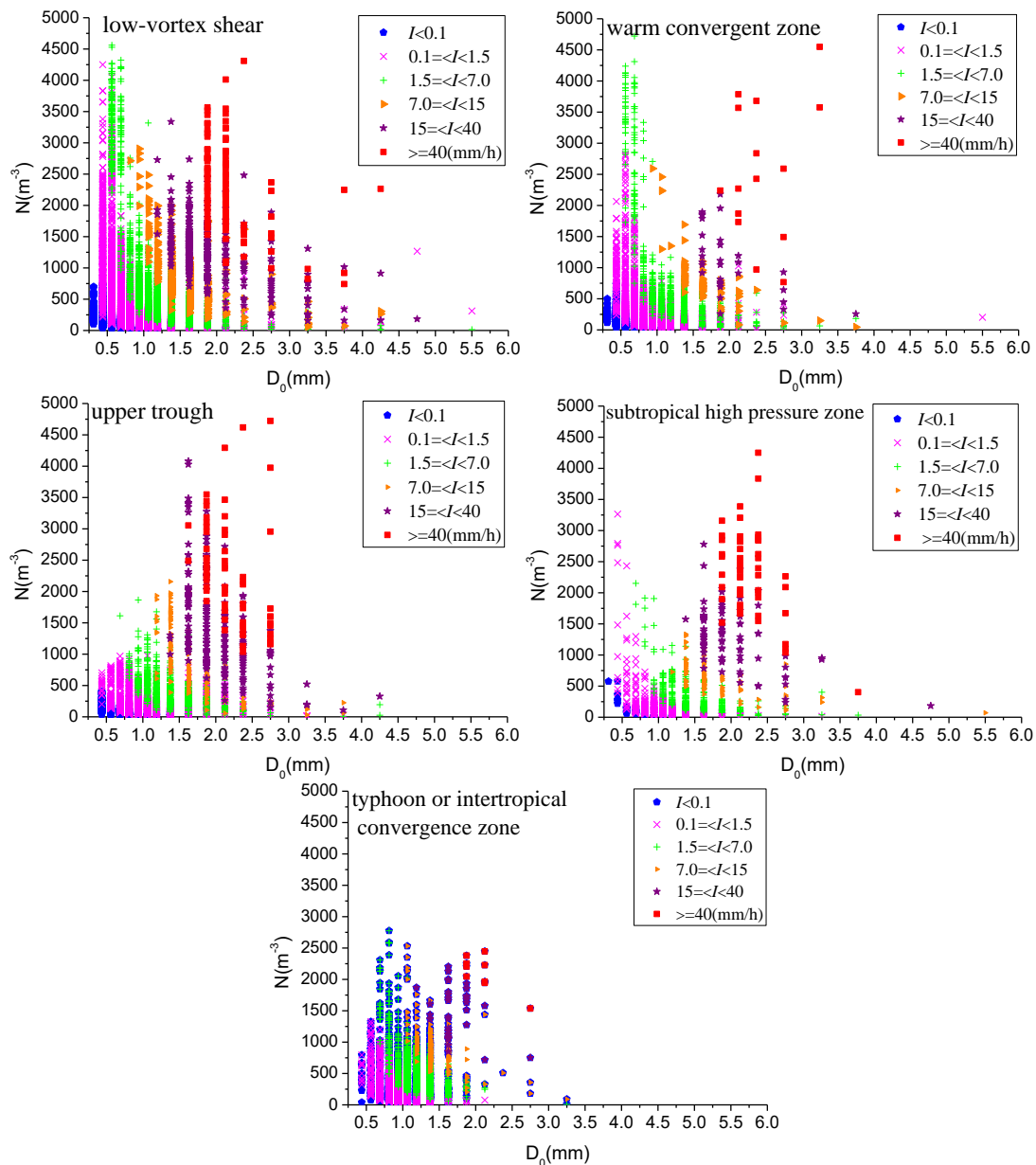
#### 3.1. Raindrop size spectrum



**Figure 1 Variation of raindrop size spectrums with rainfall intensity under different synoptic systems**

According to synoptic systems classification in figure 1, the width of size spectrum under low-vortex shear was broadest, of which double-peak appears from light rain. In the next places, those were under warm convergent zone, subtropical high pressure zone and upper trough, of which spectrum widths broaden and double-peak or multi-peak appear from moderate rain. The narrowest one was under typhoon or intertropical convergence zone. The type of spectrums under typhoon or intertropical convergence zone and subtropical high pressure zone were single-peak.

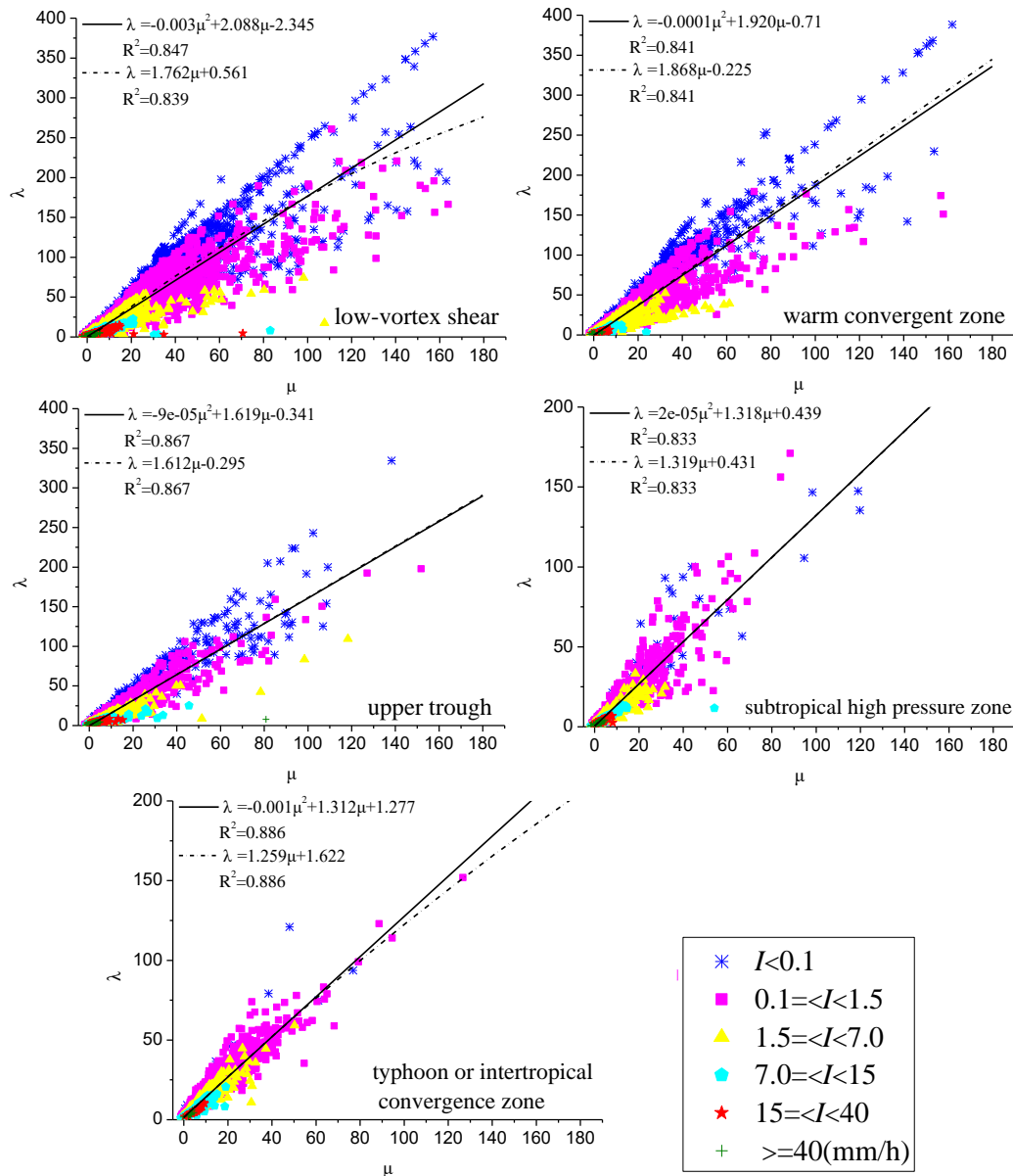
The size spectrums had broader width and double-peak or multi-peak when rainfall intensity increases. The maximum diameters of raindrops in slight and light rain are both not more than 6mm. In moderate rain, the spectrum width of raindrop size distribution broaden to 8mm, double-peak or multi-peak appear at the same time. When rainfall increase to heavy-storm rain, the spectrum width can broaden to 9.5mm, or multi-peak or multi-peak appear more obviously.



**Figure 2 raindrop concentration  $N$  and volume medium diameter distributions  $D_0$  with rainfall intensity under different synoptic systems**

The relation of raindrop concentration  $N$  and volume medium diameter  $D_0$  distributions with rainfall intensity under different synoptic systems are analyzed in figure 2. The volume medium diameter and raindrop concentration both increased with increasing of rainfall intensity when rainfall intensity  $I$  less than 40mm/h. In contrast, when  $I$  is heavier than 40mm/h, the volume medium diameter decreased and raindrop concentration increased, which may relates to small droplets increasing by the broken process in rainstorm. Specially, there are large numbers of small raindrops diameter less than 1mm under low-vortex shear and warm convergent zone, when  $I$  less than 7mm/h. Differently, under upper trough and typhoon or intertropical convergence zone, the high value of volume medium diameter distribute in 0.5-1mm.

### 3.2. Gamma parameters



**Figure 3 Gamma parameters distribution with rainfall intensity under different synoptic systems**

The Gamma distribution  $N = N_0 D \mu e^{-\lambda D}$  has been widely used in cloud physics research, especially the microphysical parameterize in model and rainfall estimation dual polarization radar. The parameters  $N_0$ ,  $\mu$  and  $\lambda$  have certain relationships with each other. Most studies [2] considered that the fitting results show parameters  $\mu$  and  $\lambda$  meet the binomial function. However the fitting results in figure 3 are different. Under upper trough, warm convergent zone and high pressure zone the parameters  $\mu$  and  $\lambda$  meet the linear function. As well as under low-vortex shear and typhoon or intertropical convergence zone, the fitting results by binomial function and linear function are similar, relativity of linear fitting is a little lower.

Moreover, many researches [3-5] of parameters  $N_0$ ,  $\mu$  and  $\lambda$  varying with rainfall intensity had different outcomes. From figure 3, it could be found that the parameters  $\mu$  and  $\lambda$  decrease with rainfall intensity increasing. This conclusion is similar to that found by Wu [6] for the typhoon precipitations in Taiwan. Thus, the variation characteristics of Gamma parameters with rainfall intensity related to the region.

#### 4. Conclusion

1. The size spectrums have broader width and double-peak or multi-peak when rainfall intensity increase; the width of size spectrum under low-vortex shear was broadest, in the next places, those were under warm convergent zone, subtropical high pressure zone and upper trough; the narrowest one was under typhoon or intertropical convergence zone.

2. The double-peak or multi-peak also appears with rainfall intensity increasing. They happen under low-vortex shear, warm convergent zone and upper trough; the type of spectrums under typhoon or intertropical convergence zone and subtropical high pressure zone were single-peak.

3. The volume medium diameter and raindrop concentration both increased with increasing of rainfall intensity that less than storm rain; in contrast, when rainfall intensity was more heavy than rainstorm, the volume medium diameter decreased and raindrop concentration increased; there were large numbers of small raindrop contribute to the rainfall intensity mainly under low-vortex shear and warm convergent zone when in small and moderate rain.

4. The Gamma parameters  $\mu$  and  $\lambda$  can meet the linear function, and they both decrease with rainfall intensity increasing, which related to the region.

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