RAIN DROP SIZE DISTRIBUTION OVER GADANKI, INDIA DURING SOUTHWEST AND NORTHEAST MONSOON

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1. Introduction

Monsoons are the most complicated yet interesting phenomena as it is associated with rain in large areas and can affect 60% of population leaving under its influence. Further, it plays a significant role in modulating global climate. Among these, Indian summer monsoon (or south-west (SW) monsoon) is the most significant one. Numerous reports are available in literature on the dynamics of the monsoon system (monsoons, 1987 and references therein). Though, the principal rainy season for Indian subcontinent as a whole is the summer monsoon, some parts of India, particularly east coast of south peninsula, gets about 50% or more of the annual rainfall in post monoon season (so called north-east (NE) monsoon). The general features of these monsoon systems, mainly large-scale features, are well known and are well documented (please visit IMD website, www.imd.ernet.in). For instance, the onset of monsoon (1 May for SW monsoon and 20 October for NE monsoon with a deviation of a weak on either side), the seasonal rainfall and the diurnal variation of rainfall. However, much is not known about the differences in the microphysics of cloud systems [for ex, the drop size distribution (DSD)] in these seasons. It is due mainly to lack of suitable measurements at these locations. Recently a UHF wind profiler and disdrometer has been installed at Gadanki (13.5 N, 79.2 E), India under Indo-Japanese colloboration program. It enabled us to study the differences in the microphysics of the cloud systems in SW and NE monsoon seasons. It forms the crux of the present paper.

2. Data and Instrumentation

The Lower Atmospheric Wind Profiler (LAWP) operates at a frequency of 1.3 GHz is located at Gadanki, about 120 km from Chennai and about 80 km from the coast, in southern India. It has been installed in August 1997 and since then operating continuously by providing wind and reflectivity information with a good height and time resolution. The data collected between October 1997 and September 2000 has been used for the present study. Complete description of LAWP and initial results can be found in Reddy et al. (2001). The disdrometer used in the present study is of impact type, originally developed by Joss and Waldvogel (1969). It is located close to LAWP and provides the DSD at 1 min. intervals. Important rain parameters are derived from the available DSD using standard moments method. The present disdrometer data has been successfully evaluated by comparing with the nearby Optical Rain Gauge products (Reddy et al., 2003). Disdrometer has been operating continuously since September 1997, except for few months in 1998 due to malfunctioning of the instrument. For the present study, the data collected between September 1997 and December 2001 are used. Further, seasons are divided as follows with the months May to September comes under southwest monsoon season, while the northeast monsoon comprising October, November and December months.

3. Results and discussion

UHF profiler is an excellent instrumentation system for providing continuous measurements of wind as shown in Figure 1. It shows time series of wind velocity and direction for over one year of observations starting from March 1999 to September 2000. It clearly shows a shift in wind direction from northeasterly to southwesterly in May and again back to northeasterly in late September coinciding with the onset of southwest and northeast monsoon systems. Another noted difference in the wind pattern between these seasons is the magnitude of wind. A strong Low Level Jet (LLJ) apparent at about 2 km with peak magnitude reaching 20 m/s in southwest monsoon season is not seen in northeast monsoon season.

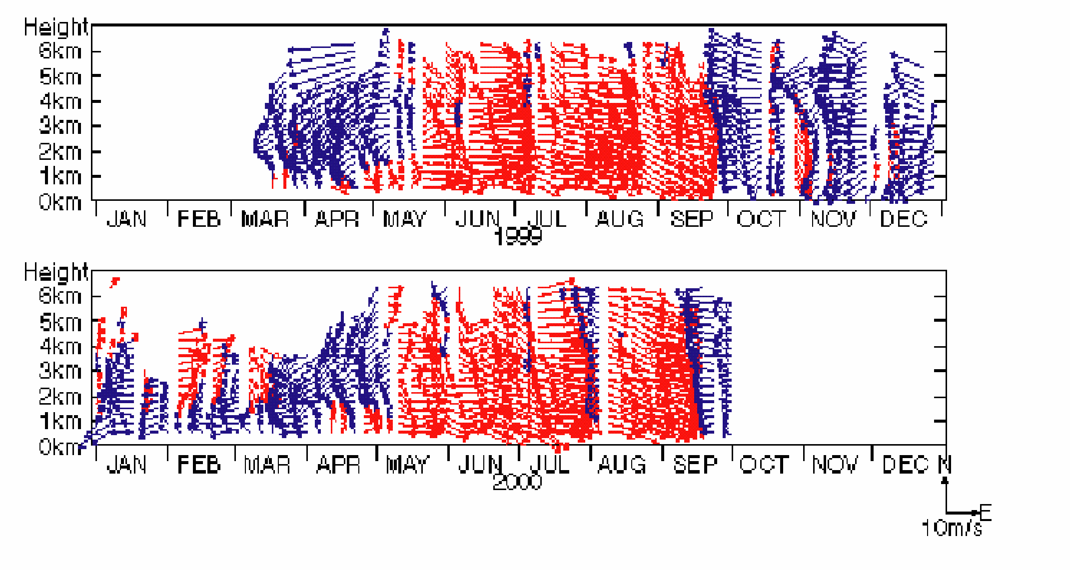

Figure 1. 5 day mean horizontal winds observed from March 1999 to September 2000.

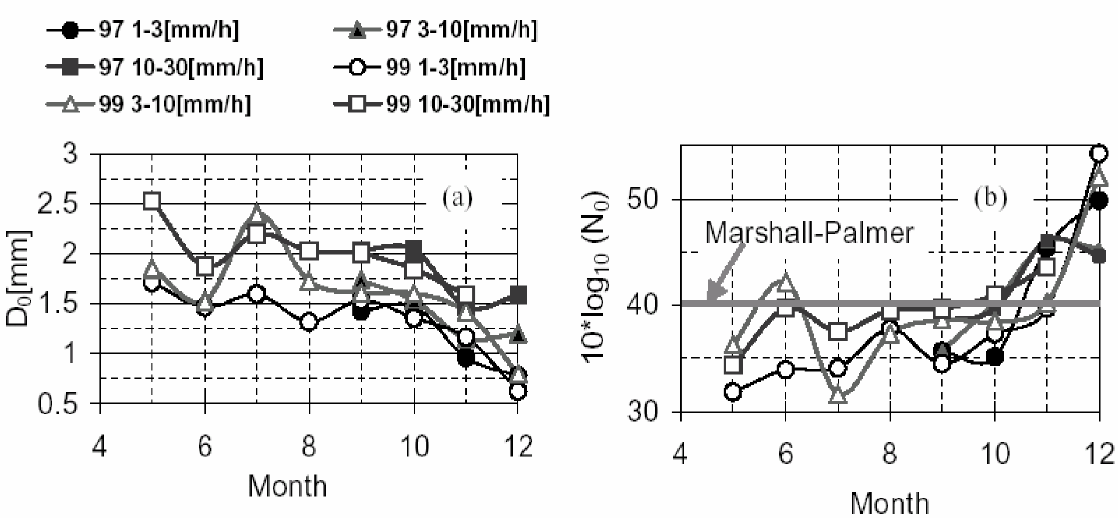

Figure 2. Monthly variation of (a) median volume diameter and (b) N_0.

Disdrometer has collected 5639, 1584, and 9421 minutes of 1 min. samples of DSD during the years 1997, 1998 and 1999 respectively. The rain parameters, median volume diameter (D_0), rainrate (R) and Reflectivity factor (Z) have been estimated from the DSD using the standard method (Rao et al. 2002, Reddy et al., 2003). Further, the gamma parameters (shape, slope and the intercept) are derived using the method proposed by Kozu and Nakamura (1991). The data has been grouped into 3 categories based on the magnitude of R. Monthly variation of D_0 and N_0 has been plotted in Figure 2 (a) and (b), respectively, for all the groups. It is clearly evident from the Figure that D_0 values are higher in SW monsoon season than in NE monsoon season. On the other hand, obviously, the N_0 shows an opposite trend with low values in SW monsoon and high values in NE monsoon. The observed trend is similar for all the groups.

The estimated R and Z are used to derive the Z-R relationships, which is in the form of $Z= 10^a R^b$, where *a* is the intercept and *b* is the slope of the best-fit line on log Z and logR plot. September and December months are chosen to represent SW and NE monsoon seasons. Figure 3(a)-(d) shows the scatter plots of dBR Vs dBZ for all the samples collected in September and December months for 1997, 1999, 2000 and 2001.

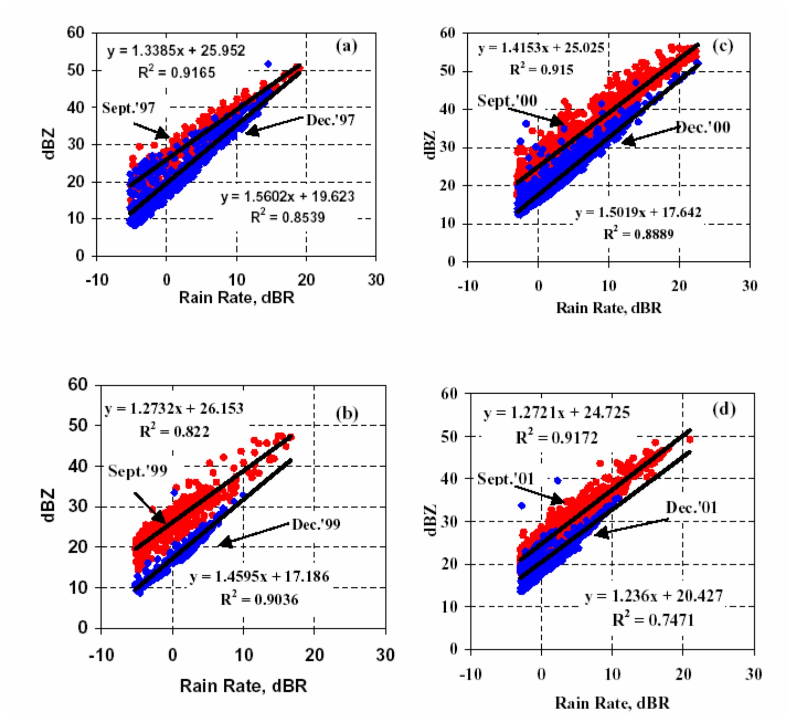

Figure 3. Scatter plots of dBR vs dBZ for samples collected in September and December during (a) 1997, (b) 1999, (c) 2000 and (d) 2001.

It also includes, straight line fitted to the data, the correlation coefficient, the slope and the intercept. Further, it can be noted from the Figure that the intercept and the slopes are different for September and December. The variation of a and b against the month are shown in Figure 4. It can be seen from the figure that, the variation of the intercept is similar to that of D_0 with high values in SW monsoon season and low values in NE monsoon season. On the other hand, the variation of b is not so significant.

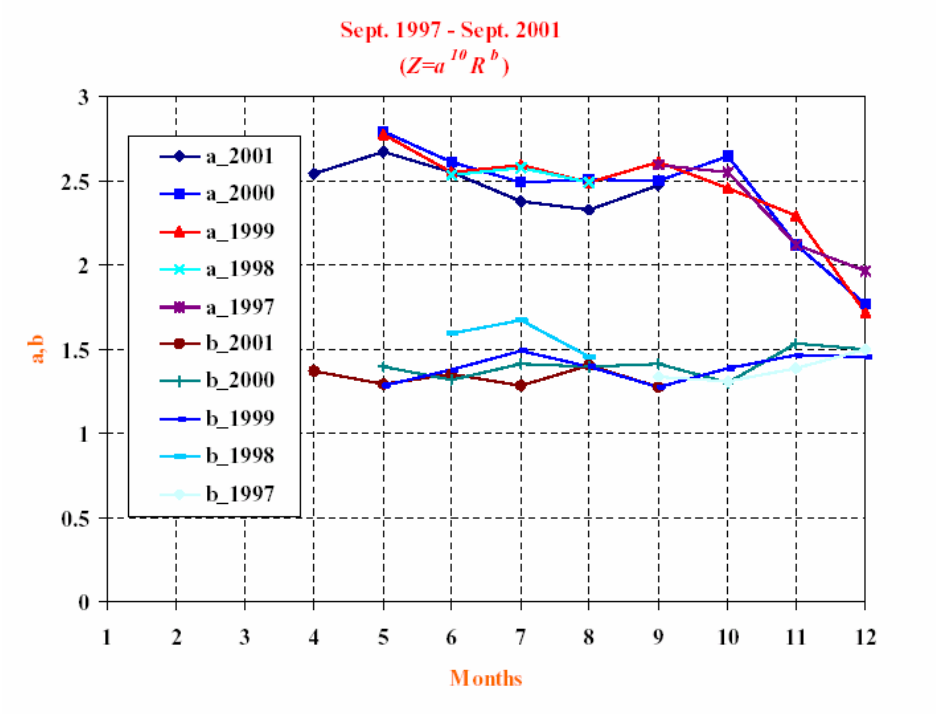

Figure 4. Monthly variation of slope and intercept parameters.

The DSD seems to be distinct in two monsoon seasons. The large median volume diameter (D_0) and the intercept parameter (a) in SW monsoon season clearly suggest that the large drops are more frequent in this season. It can also be seen from the Figure 3, where Z seems be to more in September than in December for any R. It is plausible as the dependence of Z on DSD is high (6^{th} power). The large drops seen in SW monsoon is not unusual as it the season in which updrafts (convection) are strong because of high ground temperatures. These strong updrafts hold the small drops aloft till they grow bigger enough to overcome the upward force by updrafts. The large D_0 is mainly because of these strong updrafts and also evaporation of small drops, which is significant in SW monsoon season.

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