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South-West and North-East Monsoon Precipitations Bright Band Characteristics over Kadapa, Semi-arid Regions of India

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Abstract: Long-term (3-yrs) observation of precipitation during Southwest (SW) and Northeast (NE) With and without Bright Band/melting layer using a Micro Rain Radar (MRR) is investigated. Profiles of DSD in Bright Band (BB) and Non-Bright Band (NBB) cases demonstrate that the BB rain events are associated with higher number concentration of larger drops and NBB events are associated with higher concentration of smaller drops.
Keywords: Micro Rain Radar, bright band, melting level, and Monsoon

I. INTRODUCTION

Many applications of weather radar quantitative precipitation estimates, such as heavy rainfall surveillance, hydrological modelling, or numerical weather prediction data assimilation, require the detection and characterisation of the radar Bright Band (BB) [1-4]. The Micro Rain Radar (MRR) at 24 GHz is a one-of-a-kind meteorological radar profiler for Doppler spectra of hydrometeors in height ranges ranging from the ground to 6000 metres. The MRR's excellent temporal and height resolution allows it to track the genesis of frozen hydrometeors, the melting zone (bright band), and rain drop formation [5].

The BB can occasionally be missing during stratiform precipitation, according to White et al.[1] and Martner et al. [6]. These are known as non-bright band (NBB) periods. Martner et al. [6] show a statistically significant (P value of 0.01) difference in R and drop size distribution (DSD) between BB and NBB periods in Cazadero and Bodega Bay, California. Martner et al. [6] also hypothesise that during NBB times, precipitation can still go through a freezing and subsequent melting phase before reaching the surface. Martner et al. [6] on the other hand, do not explain the underlying mechanism for the occurrence of NBB precipitation.

Due to the importance of Z-R relationships, much research has been done on Z-R interactions [7,8]. Although there have been many studies on Z-R relationships up to this point, scientists continue to hunt for Z-R relationships specific to areas and types of precipitation. The present study's Z-R connections will be helpful for Doppler Weather Radar monsoon rain retrieval across southern India (DWR).

Yogi Vemana University's Semi-arid-zonal Atmosheric Research Centre (SARC) in Kadapa studied variations in bright band (BB) and non-BB (NBB) raindrop size distribution and rain integral characteristics during the southwest (June to September) and northeast (October to December) monsoons. The present research examined rain features such as rain rate, radar reflectivity, and DSD during BB and NBB over Kadapa. The investigation includes variations in DSD and RD (integrand of rain rate integral; rain intensity, Z-R relations for different rain categories, and variations in DSD according to BB and NBB scenarios. The paper is organized as follows: Section 2 describes the observation site, instruments data, and methods in further detail. Section 3 contains the results and discussion.

II. INSTRUMENTATION AND DATABASE

Micro rain radar (MRR) has been deployed to observe the vertical profiles of rain parameters. The MRR is a vertically pointing FM-CW (Frequency Modulated Continuous Wave) Doppler radar that runs at a frequency of 24.1 GHz with a modulation of 1.5 - 15 MHz depending on the height resolution. The MRR outdoor equipment, which includes the dish antenna and radar receiving unit, is erected on a pole next to the ancient Science building at Yogi Vemana University in Kadapa, India. In addition, the indoor unit, which consists of an RS 232 data transmission interface and PC-based software, is installed for online control, visualisation of data, transfer, and storage. Fig. 1 shows the outdoor and the indoor unit of the MRR. Observations with the WPR were carried out fairly continuously from 01 April, 2010 to 31 March, 2013. A total of 1140 days of MRR data are available until March 2007 for analysis.

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Non-availability of the MRR data is mainly due to the power failure at the observational site and due to the malfunctioning of the instrument.

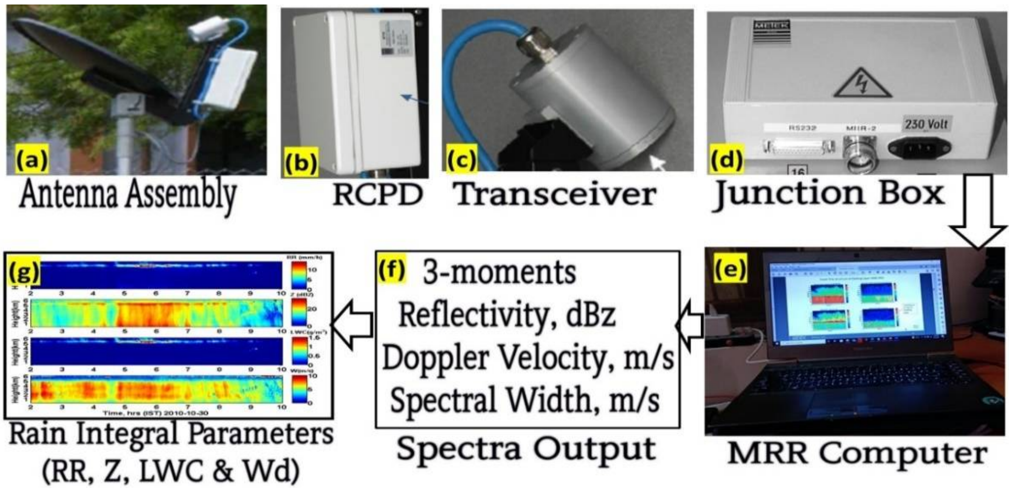

Fig. 1: Experimental set-up of the Micro Rain Radar (MRR) & its components and Data processing Procedure. (a) Parabolic Dish Antenna Assembly, (b) RADAR Control and Processing Device (RCPD), (c) Transceiver, (d) Junction Box, (e) MRR Computer, (f) Doppler Spectra output- 3 Moments, and (g) a sample of Rain Integral (DSD) parameters

III. RESULTS AND DISCUSSION

We also categorize different forms of precipitation based on whether bright bands are present in the radar reflectivity profile. The bright band is identified by Fabry and Zawadaki (1995) [3] as the amplified backscattered component of the vertical radar reflectivity profile due to the presence of the melting layer. The melting layer has a higher reflectivity than a water droplet.

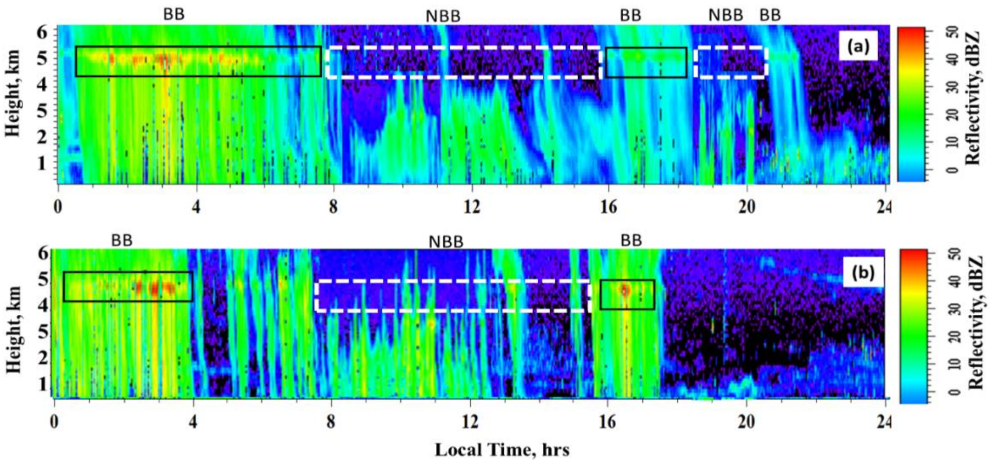

Fig. 2: Time–height cross-sections of radar reflectivity observed during (a) southwest on 26-07-2013 and (b) northeast monsoon on 25-10-2013 precipitation events observed from the MRR.

The relationship between reflectivity and rain rate in BB and NBB circumstances and the vertical DSD profiles have been studied. A technique to locate BB occurrences in the MRR data was developed by Cha et al. (2009) [2]. To find the BB, the radar reflectivity gradient between 4.8 km and 5.8 km height is estimated, as seen in Fig. 2 during southwest and northeast monsoon. Among these, the analysis has focused on significant and persistent BBs and NBBs. The results show that BB conditions happen when the rain rate is less than 7 mm per hour. Because DSDs differ in higher rain classes, we only investigated NBB categories with rain rates below mm h^{-1} to compare DSD spectra with BB cases. Then, DSD, RR(D), and Z-R relations were discovered for these two types of precipitation.

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A bright band between 4.1 and 4.4 km above the ground level is visible during a rain event during the northeast monsoon, according to the vertical radar reflectivity profile depicted in Fig. 2 (b). Further observation revealed a Bright band between 00:20 and 03:40 LT. However, no indication of a bright band could be seen between 08:00 and 15:36 LT. These exhibit a total transformation from stratiform to mixed and, subsequently, convective rain types. A bright band could also appear partially later in the day. It may only be inferred that the non-bright band noticed at part of the time of the day mentioned above is a case of weakness in magnitude and is not always related to the convective rain type.

The vertical DSD and RD profiles for BB and NBB instances are shown in Fig. 3. The melting layer signal between 4 and 5 km elevations may be seen in the DSD profile for the BB.. The NBB example contains no distinct signature. While the DSD in the NBB case varies with altitude, it does so in the BB instance, where the DSD is essentially constant from below the melting layer to the lowest level. The DSD profiles of BB and NBB can be compared to show that NBB has a significantly larger concentration of smaller dips. On the other hand, BB has a higher number concentration of bigger drops. The RD profiles for BB show the percentage of different-sized raindrops in the total volume of precipitation at various heights [Fig. 3(c)] and NBB [Fig. 3(d)]. The highest values of RD are obtained in the BB scenario at D1.3 mm at 200 m, which is nearly constant along the vertical column. A monotonically declining distribution is seen at greater altitudes in NBB situations, where the peak location is observed at D 1.1 mm up to an altitude of 1700m. The contribution of rainwater from droplets smaller than 1 mm is highest at higher altitudes. Figure 4.11 shows the DSD and RD for the disdrometer as well as the BB and NBB cases using MRR (right panel) at the lowest level (200 m) (left panel). From both disdrometer and MRR measurements, a higher concentration of smaller raindrops accompanies the NBB category (D1mm) than the category. Additionally, MRR observations reveal bigger raindrops concentrated in the BB group. This section systematically demonstrates the variations between DSDs under BB and NBB settings during the monsoon season.

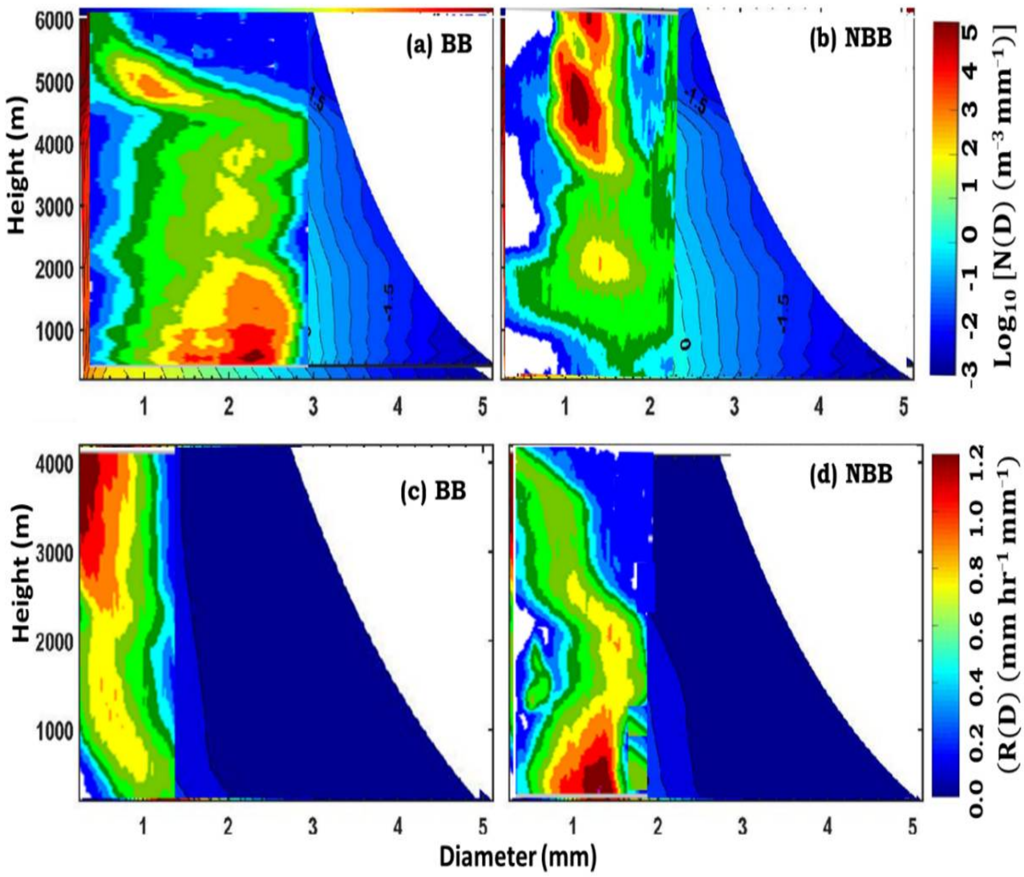

Fig. 3 Vertical profile of DSD parameters viz., Raindrop Size Concentration, N(D) and R(D) obtained from MRR for[(a) & (c)] appearance of Bright Band (BB) and [(b) & (d)] Non-appearance of Bright Band (NBB), respectively.

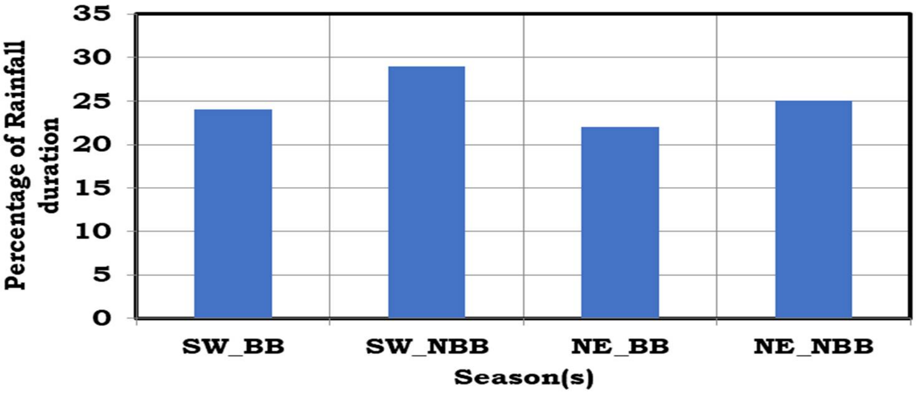

Fig. 4: Percentage occurrence (duration in minutes) of the Bright band (BB) and no bright band (NBB) of southwest and northeast monsoon.

Figure 4 shows that the SW monsoon lasts longer than the NE monsoon regarding stratiform [Bright Band (BB)] precipitation persistence. This graph shows that the SW monsoon tends to produce a larger proportion of stratiform precipitation and a little more convective [No Bright Band(NBB)] precipitation than the NE monsoon.

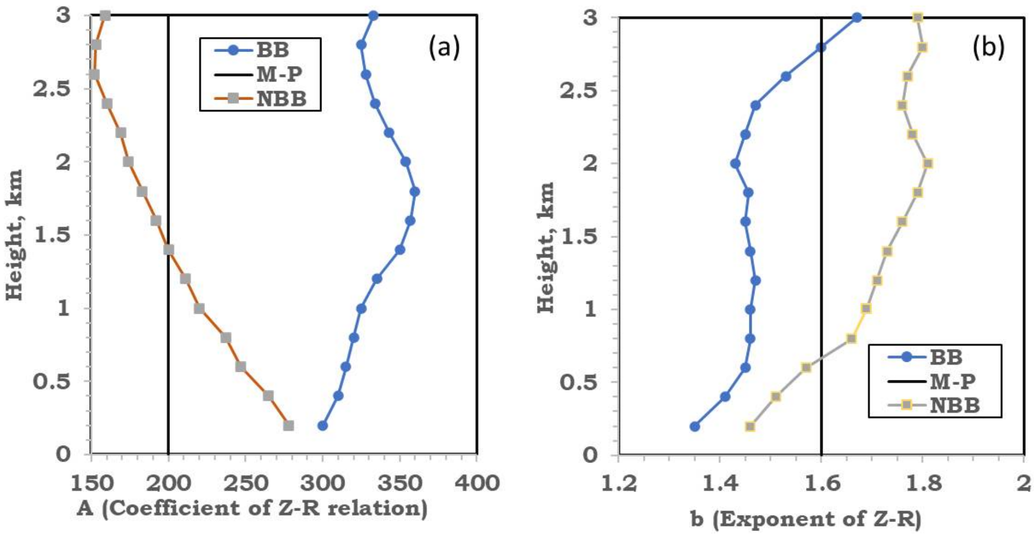

Fig.5: Vertical distribution of coefficient (a) *A* and (b) *b* of *Z-R* relationship during BB and NBB cases. The vertical line denotes the coefficient of the Marshall and Palmer model ($Z=200R^{1.6}$).

Because Z-R offers a quantifiable way to remotely determine the rain rate of a cloud system using weather radar, relationships between radar reflectivity (Z) and rain rate (R) are studied. The vertical profiles of the Z-R relations' (a) coefficient and (b) b-exponent in the BB and NBB situations is shown in Fig. 5. The Z-R relation profile implies that DSD varies and that different precipitating systems are related to different microphysical characteristics[8]. According to the exponent (b) values for the BB example, which are well within the range of 1 b to 1.63, changes in number concentration influence the variability in the raindrop size distribution. It demonstrates that a combination of size- and number-controlled processes resulted in the evolution of the DSD spectra [8]. The interaction between changes in number concentration and drop size determines the variation in the raindrop size distribution. But for the NBB, the value of "b" switches from mixture-controlled to size-controlled (i.e., b 1.63 DSD spectra). Smith and Krajewski [9] reported the exponent value (1.79 for a size-controlled process based on lognormal raindrop size distributions) in a prior paper. These Z-R exponent values are substantial between 1500 and 2500 metres during NBB, consistent with their findings. The large coefficient values during BB situations point to the development of comparatively more significant decreases. However, multiple smaller drops in NBB situations show a lessening of the aggregation process between raindrops in the atmosphere, leading to lower coefficient values.

IV. ACKNOWLEDGEMENT

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REFERENCES

[1] A.B.White, D.J.Gottas, E.T. Strem, F.M.Ralph, and P.J.Neiman, "An Automated Bright band Height Detection Algorithm for Use with Doppler Radar Spectral Moments",J.Atmos.Ocean.Technol.,vol.19,pp.687–697,2001.

[2] J.-W.Cha, K.-H. Chang, S. S. Yum, and Y.-J. Choi, "Comparison of the bright band characteristics measured by Micro Rain Radar (MRR) at a mountain and a coastal site in South Korea", Adv. Atmos. Sci., Vol.26(2), pp.211–221,2009. .

[3] F. Fabry and I. Zawadzki, "Long-term radar observations of the melting layer of precipitation and their interpretation," J. Atmos. Sci., vol.52(7), pp.838–851,1995

[4] A.Garcia-Benadí, Bech, J.;Gonzalez, S, Udina, M., Codina, B. A, "New Methodology to Characterise the Radar Bright Band Using Doppler Spectral Moments from Vertically Pointing Radar Observations" Remote Sens, vol. 13, pp.4323(1-20), 2021.

[5] G. Peters, B. Fischer, H. Münster, M. Clemens, and A. Wagner, "Profiles of raindrop size distributions as retrieved by micro rain radars," J. Appl. Meteorol. Vol.44(12), pp.1930–1949, 2005.

[6] B.E. Martner, S.E.Yuter, A.B.White, S.Y.Matrosov, D.E.Kingsmill, and F.M. Ralph, "Raindrop Size Distributions and Rain Characteristics in California Coastal Rainfall for Periods with and without a Radar Bright Band", Journal of Hydrometeorology, Vol.9(3), pp.408–425, 2008.

[7] E.Adirosi, L. Baldini, A. Tokay, "Rainfall and DSD parameters comparison between micro rain radar, two-dimensional video and PARSIVEL2 disdrometers, and S-band dual-polarization radar", Journal of Atmospheric and Oceanic Technology, 2020 doi:10.1175/jtech-d-19-0085.1

[8] M.Steiner, R. A., Jr. Houze, and S.E. Yuter, "Climatological characterization of three-dimensional storm structure from operational radar and rain gauge data", J. Appl. Meteorol. Vol.34, pp.1978–2007,1995.

[9] J.A.Smith, and W.F. Krajewski, " A modeling study of rainfall rate-reflectivity relationships". *Water Resources Research*, Vol.*29*(8), 2505-2514, 1993.