Estimation of rain parameters from spectral moments of L-band wind profiler using Multi-Layer Perceptron Network model

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Two Multi-Layer Perceptron (MLP) models are developed to estimate the radar reflectivity factor (dBZ) and rain intensity (R) from the spectral moments of an L-band wind profiler. Out of the four spectral moment inputs of the MLP models, the backscattered power (P) and Doppler velocity (V\textsubscript{D}) were found to have better correlation with the rain parameters. The model results were validated with the Joss Waldvogel Disdrometer (JWD) observations. For the training and validation data sets of dBZ, the root mean square error (rmse) of estimated and observed data sets were found to be 5.05 and 5.32 dBZ with correlation coefficients of 0.90 and 0.86, respectively. Similarly, for the training and validation data sets of R, the rmse for estimated and observed values were found to be 4.27 and 7.74 mmh\textsuperscript{-1} respectively with correlation coefficients of 0.95 and 0.78. The developed models were validated with a rain event on 22 June 2000, that consisted of rain from both convective and stratiform regimes. The error between the estimated and observed rain accumulation was found to be \textasciitilde 5%. The height profiles of estimated dBZ were able to identify the bright band during stratiform rain by virtue of high values of reflectivity gradient at around 4.0 km height. Though ambiguity in the estimation of R was observed at bright band level, overall estimated parameters were in good agreement with general characteristics of convective and stratiform rain.

Keywords: L-band wind profiler, Spectral moments, Joss Waldvogel Disdrometer, Radar reflectivity factor, Rain intensity, Multi-Layer Perceptron network

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1 Introduction

Measurement of rain parameters by remote sensing technique is a fundamental objective in radar meteorology. There are two types of sensors, i.e. passive and active, for rain measurement by the remote sensing technique. The passive sensors, such as microwave radiometer, measure radiance that is the end product of the integrated effects of the electromagnetic absorption-emission and scattering through the precipitating cloud along the sensor view path. However, height assignment of cloud systems by passive remote sensing is not very specific. On the other hand, active sensors provide specific height information of precipitating systems based on the time delay of back scattered return power. Presently many active sensor systems e.g. scanning reflectivity radar, Doppler weather radar, polarimetric radar and profiling micro rain radar are being utilized for rain measurements by using back scattered power in terms of radar reflectivity factor (Z). The common approach for measuring rainfall intensity from backscattered power is by utilizing the empirical Z-R relations, where Z is calculated by using the following radar equation

\[ P_r = \frac{C|K|^2|Z|}{r^2} \]  \hspace{1cm} \text{... (1)}

where \( P_r \) is backscattered power from the target, \( K \) the dielectric constant of the target, \( C \) the radar constant and \( r \) the range of the target. Here, \( Z \) is a function of rain drop size distribution and is independent of radar frequency.

The wind profilers were originally developed to measure the height profiles of the three components of wind velocity. Subsequently however, many researchers demonstrated its utility for the identification/classification of precipitating systems and in measuring the rain parameters, i.e. radar reflectivity factor and rainfall intensity. The precipitating signatures obtained from the wind profiler are due to Rayleigh scattering from
hydrometeors. The Rayleigh scattering component observed by a vertically incident profiler results from convolution of normalized atmospheric turbulent probability density function with the hydrometeor reflectivity spectral density and it is expressed as follows

\[ S_{\text{Rayleigh}}(\nu) = S_{\text{air}}(\nu - \overline{\nu}) \times S_{\text{hyd}}(\nu) \]

\[ = \frac{1}{\sqrt{2\pi\sigma_{\text{air}}^2}} \exp\left[\frac{-(\nu - \overline{\nu})^2}{2\sigma_{\text{air}}^2}\right] \times S_{\text{hyd}}(\nu) \quad \cdots (2) \]

where \( \nu \) is the fall velocity of hydrometeor; \( \overline{\nu} \), the air velocity either in the upward or downward direction; and \( \sigma_{\text{air}} \), the spectral broadening of clear air Doppler spectrum. The hydrometeor spectrum in stationary air is represented by

\[ S_{\text{hyd}}(\nu) = N(D)D^6dD/d\nu \quad \cdots (3) \]

where \( N(D), D \) and \( dD/d\nu \) are number concentration of the hydrometeor distribution, the rain drop diameter and the coordinate transformation from terminal fall speed to diameter space, respectively.

Extensive research has been carried out to estimate rain drop size distribution (RDSD) from the Doppler spectra of either individual or combined use of Very High Frequency (VHF) and Ultra High Frequency (UHF) wind profilers. For RDSD retrievals and subsequently to estimate the rain parameters, the wind profilers suffer from certain limitations, viz.

(i) **Non-linear response of the receiver during rain -**

During clear air measurements, clear air wind profiler receiver has a linear response. However, during rain, when backscattered signal is very strong, profiler receiver has a non-linear response and an increase in the incident power produces only a small increase in the measured signal power \( S \). At some point the receiver even becomes completely saturated and further increase in incident power leads to no measurable increase in \( S \). In addition, the wind profilers are not calibrated, which implies that radar reflectivity factor \( (Z) \) can not be determined directly.

(ii) **Another limitation is the assumptions made in certain models**, both physical and empirical. Also, due to the natural variation of RDSD with respect to either \( Z \) or \( R \), there is an inherent limitation of the parametric approach to follow a particular model for the estimation of rain parameters.

In the past, non-parametric technique based Multi-Layer Perceptron (MLP) networks have been utilized to solve many diverse problems in microwave remote sensing. A similar approach is utilized for the first time to estimate the rain parameters from Doppler spectra of L-band wind profiler. The motivating factor of the present study is to enhance the capability of the wind profiler as a rain profiling system during rainy situations, when clear air echoes are completely masked by precipitation echoes. The main objective of the present study is to develop MLP network models to estimate the radar reflectivity factor \( (\text{dBZ}) \) and rainfall intensity \( (R) \) from the spectral moments of L-band wind profiler; and to study the characteristics of the precipitating systems in terms of height profiles of the estimated parameters. The multivariable MLP based non-parametric techniques are important because of their ability in dealing with the above mentioned errors common to wind profiler data. First of all, the inclusion of the multivariable parameters reduce the total dependency of dBZ and \( R \) measurements on normalized back scattered power. In the present study, these parameters are estimated with the help of combined use of all the spectral moments of the Doppler spectra of L-band wind profiler and DSD spectra from Joss Waldvogel Disdrometer (JWD). Moreover, the training of the spectral moments with dBZ as measured from the independent system will overcome the limitation of the non-linear response of the receiver during rainy situations to a certain extent. Further in the proposed methodology, it is not necessary to assume a specific model for the retrieval of rain parameters, and to take into account the natural variation of the rain parameters.

### 2 System description and data preparation

National Atmospheric Research Laboratory (NARL), at Gadanki (13.5°N, 79.2°E), India, has the facility of collocated instruments. For the present work, observations of L-band wind profiler and Joss Waldvogel Disdrometer (JWD) for the years 1998-2000 were utilized. The L-band wind profilers operated at 1357 MHz is very sensitive to precipitation particles due to Rayleigh scattering, where scattering cross-section is inversely proportional to the fourth power of wavelength. The system description of the L-band wind profiler is shown in Table 1.

For the extraction of atmospheric parameters from the back scattered signals of wind profiler it requires
extensive signal processing. The signal processing of these signals mainly consist of estimation of 0th, 1st and 2nd moments of Doppler spectrum\textsuperscript{27}. These moments correspond to total power ($P$), mean Doppler shift ($f_D$) and variance ($\sigma^2$) of the Doppler spectra and they are estimated by the following expressions\textsuperscript{27}:

\begin{align*}
P &= \sum_i P_i \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad 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layers. Every node, except the input layer nodes, computes the weighted sum of its inputs and applies an activation function, a sigmoid function to compute its output. This output is then transmitted to the nodes of the next layer. The objective of the MLP learning is to set the connection weight in such a manner as to minimize the error between the network output and the target. The back propagation gradient decent method of learning is utilized for this purpose.

The architectural diagram of the present MLP is shown in Fig. 1. The present MLP networks consist of three layers, viz. input layer with four nodes, hidden layer with 15 nodes and output layer with one node. It is to be mentioned here that the optimum number of hidden nodes were found to be 15 in the present MLP network. The two MLP networks were trained separately by using the four input vectors from the L-band wind profiler, i.e. $P$, $V_D$, $\sigma$, and SNR and output vectors as dBZ and $R$ from the JWD. For the present study the whole data set consists of $\sim 1000$ points. The data set is divided into two parts, i.e. 90% is utilized for training and remaining 10% for validation of the trained MLPs. The above network architecture is realized through the MATLAB toolbox based on Levenberg-Marquardt (L-M) back propagation algorithm. The advantage of using this algorithm is that it converges quickly as compared to most of the other algorithms. It can train any network as long as its weight, net input and transfer function have derivative function. The L-M algorithm uses the approximation to the Hessian matrix in the Newton method, where the weight vectors $X_i$ is updated as

$$X_{i+1} = X_i - [J^T J + \mu I] - J^T E_i \quad \ldots \quad (12)$$

where $J$ is the Jacobian matrix that contains first derivative of the network error with respect to weight and bias; $I$ the unit matrix; $E_i$ the error at output node and $\mu$, the learning parameter. Depending upon the magnitude of $\mu$ the method transit smoothly between the two extremes: Newton method ($\mu = 0$) and well known steepest decent method ($\mu = \infty$). For L-M algorithm the performance index to be optimized is defined as

$$F(w) = \sum \left[ \sum (d_{kp} - o_{kp})^2 \right] \quad \ldots \quad (13)$$

where $d_{kp}$ and $o_{kp}$ are the target and output values of the $k$th output and $p$th features.

After the supervised training to the prepared input data set with respect to target dBZ and $R$, the weight matrices for input- hidden layers and hidden-output layers in both the cases were estimated. These two developed MLP network models were designated as MLP_dBZ and MLP_R. Thereafter, with the help of developed MLP network models the dBZ and $R$ were estimated for the given set of input spectral moments data.

4 Results

Simultaneous observations of the L-band wind profiler and JWD during convection-precipitation campaign at NARL, Gadanki were utilized for this work. A rain event on 22-23 June 2000 was selected to study the typical characteristics of different moments of Doppler spectra during rainy situations. This event consists of rain from both the convective and stratiform regimes. The height-time intensity (HTI) plots of $P$, $V_D$, $\sigma$ and SNR of Doppler spectrum are shown in Figs. 2(a), (b), (c) and (d), respectively. On this day, the convective rain started at around 2142 hrs LT and as evident from the profiler observations, it was characterized by high values of backscattered power up to the upper height of $\sim 6$ km [Fig. 2(a)]. In general, the convective rain is characterized by high intensity rain at ground. The stratiform type of rain is identified through the presence of bright band, which is indicated by a band of high value of back scattered powers at around 4.2 km. The bright band started to form at around 0131 hrs LT onwards on 23 June 2000. The stratiform rain at the ground is characterized by low intensity rain for longer duration of time. Figure 2(b) shows the mean Doppler velocity of falling rain drops. It was observed that Doppler velocity of rain drops vary from 1 to 10 m/s. The downward velocity is indicated by $-ve$ sign.
During convective regime the maximum Doppler velocity is found to be around 10 m/s at higher altitudes. Figure 2(c) shows the HTI plot of spectral width of Doppler spectra. Large values of SW present during convective rain indicate strong turbulence in the atmosphere. This parameter has positive correlation with rain as heavy rainfall in the ground was preoccupied by strong turbulence in the atmosphere. Figure 2(d) shows the HTI plot of signal-to-noise ratio during non-rainy and rainy situations. This parameter is a good indicator of rainy and non-rainy situations. Though its variation with rain intensity is not very significant, its value jumped from -10 dB to ≥ 10 dB from non-rainy to rainy situation. During this period, the temporal variation of dBZ and R at ground are shown in Figs. 2(e) and (f), respectively. During the convective spell the values of reflectivity factor were varying in the range ~ 40-50 dBZ, whereas during the stratiform period its values were < 40 dBZ and minimum values observed up to 20 dBZ. Similarly, the temporal variation of \( R \) shows three spells of convective rain with intensity ranging from 25 to 78 mm h\(^{-1}\). These spells started at 2137 hrs LT (JWD data is available from 2143 hrs LT onwards) and ended at 0110 hrs LT followed by stratiform type of rain with low rain intensity < 5 mm h\(^{-1}\).

The near simultaneous and collocated data points of the wind profiler and JWD are considered to study the characteristics of moments of the profiler with respect to dBZ and \( R \). For this purpose, the scatter plots for \( P\)-dBZ, \( V_D\)-dBZ, \( \sigma\)-dBZ and SNR-dBZ are shown in Figs. 3(a), (b), (c) and (d), respectively. For the scatter plots, the dBZ values were considered from 10 dBZ onward. The power law is fitted to these data sets and their corresponding equations are provided in the respective panels. Maximum value of exponent (0.53) in the power law was observed for the \( P\)-dBZ relation and its values were found to be in descending order for \( V_D\)-dBZ, \( \sigma\)-dBZ and SNR-dBZ. The correlation coefficient (CC) for each scatter plot is also provided in the respective panels. Maximum correlation (0.70) was found for \( V_D\)-dBZ and the CC were in decreasing order for \( P\)-dBZ, \( \sigma\)-dBZ and SNR-dBZ. Similarly, Figs 4 (a), (b), (c) and (d) show the scatter plots for \( P\)-\( R \), \( V_D\)-\( R \), \( \sigma\)-\( R \) and SNR-\( R \), respectively. For these scatter plots the rain intensity values were considered from 0.1 mm h\(^{-1}\) onward. The power law is fitted to these data sets and their corresponding equations are provided in the respective panels. Maximum value of exponent (0.107) in the power law relation was observed for \( P\)-\( R \) plot and its values were found to be in decreasing order for \( V_D\)-\( R \), \( \sigma\)-\( R \) and SNR-\( R \). The correlation coefficient for each scatter plot is also provided in the respective panels. Maximum correlation (0.47) was found for \( V_D\)-\( R \) and the CC were in decreasing order for \( P\)-\( R \), SW-\( R \) and SNR-\( R \). Interestingly, though the SNR-\( R \) relation has least values of exponent and correlation coefficient (CC) but it is a good indicator of rain. It
Fig. 3—Scatter plots for (a) returned power versus radar reflectivity factor, (b) Doppler velocity versus radar reflectivity factor, (c) spectral width versus radar reflectivity factor and (d) SNR versus radar reflectivity factor during the rainy situations.

Fig. 4—Scatter plots for (a) returned power versus rain intensity, (b) Doppler velocity versus rain intensity, (c) spectral width versus rain intensity and (d) SNR versus rain intensity during the rainy situations.
was observed that as soon as rain started its SNR jumped from negative to positive values.

After developing the weight matrices of the MLP network model with the help of supervised training, as discussed above, the dBZ and R were estimated by using the spectral moment as inputs from the training and validation data sets. The estimated dBZ from the training and validation data sets were further validated with the observed dBZ. Pixel-to-pixel comparison of the estimated and observed dBZ for training and validation data sets are shown in Figs 5(a) and (b), respectively. The root mean square error (rmse) value for training data set with respect to observed values was found to be 5.05 dBZ, with a bias of -0.02 dBZ and correlation coefficient of 0.90 [Fig. 5(a)]. The rmse value for validation data set was found to be 5.32 dBZ with a bias of 0.93 dBZ and CC of 0.86 [Fig. 5(b)]. Figures 6(a) and (b) show pixel-to-pixel

![Fig. 5—Pixel-to-pixel comparison of estimated and observed radar reflectivity factor for (a) training data set and (b) validation data set](image1)

![Fig. 6—Pixel-to-pixel comparison of estimated and observed rain intensity for (a) training data set and (b) validation data set](image2)
comparison of model estimated and observed $R$ for the training and validation data set. It was observed that most of the time the peaks of the estimated rain intensity were following the observed intensity, though in some cases there were some differences in magnitudes. The rmse values for training and validation data set were found to be 5.32 mm$h^{-1}$ and 7.74 mm$h^{-1}$, respectively. The correlation coefficients for training and validation data set were found to be 0.95 and 0.78, respectively.

An independent validation of the model estimated dBZ and $R$ with the ground JWD observations was carried out for a rain event on 22 June 2000. Further, the model estimated parameters were also compared with the results from the multivariable regression method$^{33}$. This event consists of both convective and stratiform rain. The details of this rain event are provided in Figs 2(a)-(d). The temporal variation of dBZ as estimated from MLP_ dBZ and multivariable regression method, along with the observed values are shown in Fig. 7(b). The rmse for the MLP_ dBZ estimated values with respect to the observed values was found to be 5.10 dBZ with a bias of -1.08 dBZ and CC of 0.84. The rmse for the regression method was found to be 5.44 dBZ and bias of 1.34 dBZ with a CC of 0.69. It showed that the results obtained from the MLP_dBZ model were reasonably improved compared to that of regression model. Similarly, Fig. 7(a) shows the temporal variation of $R$ as estimated from MLP_ $R$ model and multivariable regression model along with the observed values on this day. With respect to observed values, the rmse for the MLP_ $R$ estimated values was found to be 4.40 mm$h^{-1}$, with a bias and CC of 0.17 mm$h^{-1}$ and 0.91, respectively. In case of regression model, the rmse value of 8.77 mm$h^{-1}$ was found with a bias and CC of 3.21 and 0.33 mm$h^{-1}$, respectively. The observed and MLP_ $R$ estimated total rain accumulation were found to be ~ 21 mm and ~19 mm, respectively with an error of ~ 5.0 %. Here the rain accumulation from the profiler measurement, i.e. MLP_ $R$ was underestimated compared to rain accumulation from JWD. Rajopadhya et al.$^{34}$, have reported an error, between estimated and observed rain rate, of around 4% with a correlation coefficient of 0.76. In this referred work the rain intensity was calculated from the RDSD, which was estimated by fitting the Gamma function to the Doppler spectra of UHF profiler at the height of 1.9 km, by taking into account the vertical clear air velocity.

Further, on 22 June 2000, the height profiles of dBZ and $R$, as estimated by the proposed
methodology are shown in Figs. 8(a)-(d) and 8(e)-(h), respectively. The presented height profiles are at different stages of convective and stratiform rain. Figures 8(a) and (b) show the height profiles of dBZ during the initial and mature stage of the convective systems, respectively. During initial convective stage, the reflectivity factor of around 32 dBZ were observed up to ∼2.0 km, whereas during mature stage the significant values of reflectivity factor of 40-50 dBZ were observed up to ∼4.5 km. Figures 8(c) and (d) show the height profiles of dBZ during different stages of stratiform rain. At the initial stage of the stratiform rain, at 0154 hrs LT, the presence of bright band is quite obvious at a height of around ∼4.0 to 4.5 km by virtue of high value of reflectivity gradient of ∼37 dBZ/km. At around 0216 hrs LT, at the later stage of the stratiform rain, the bright band was not very prominent as concluded by virtue of low value of reflectivity gradient of ∼12 dBZ/km at around same height [Fig. 8(d)]. Interestingly, the values of the estimated dBZ at the lower heights are quite comparable with the JWD observations at ground, which are provided at each panel. Similarly, for the same day Figs 8(e) and (f) show the model estimated height profiles of R during the initial and mature stage of the convective systems, respectively. During initial convective stage, the low values of R of the order of 2-10 mm/h were observed, whereas during the mature stage, high values of R, of the order of 50-90 mm/h were observed up to ∼5 km. Figures 8(g) and (h) show height profiles of R during different stages of stratiform rain. During stratiform situation, the overall values of estimated R were low, i.e. of the order of 2-10 mmh⁻¹. At the bright band level, there is an ambiguity of high values of R, which require a correction for the realistic measurements of these parameters at bright band level. During the absence of strong bright band, this ambiguity is reduced to certain extent [Fig. 8(h)]. Overall, the values of the model estimated R at the lower heights is reasonably comparable with the JWD observations at ground, which are provided in each panel.

On 18 May 1999, a case study was carried out to compare the height profiles of model estimated dBZ and R with the Precipitation Radar (PR) observation [on board of Tropical Rainfall Measuring Mission (TRMM) satellite]. On this day, the TRMM satellite passed nearly over the radar site during precipitating time (TRMM orbit number 8463). For this comparison, the 2A25 data product of PR was utilized. The nearly coincident footprints of TRMM-PR and L-band profiler were selected for analysis.
The pixel resolution of PR is 16.0 km\(^2\) with a height resolution of 250 km and a beam width of 1\(^\circ\). The profiler and PR estimated height profiles of dBZ and \(R\) are shown in Figs 9(a) and (b), respectively. As these two systems have different height resolution, therefore, the MLP and PR estimated rain parameters are plotted at 150 and 250 m resolutions, respectively. The important feature of this comparative study of dBZ is the detection of a bright band at around ~ 3.7 km, by virtue of reflectivity gradient of 11 dBZ/km signifying the presence of weak bright band during stratiform precipitation [Fig. 9(a)]. Though the height profile of \(R\) from MLP\(_R\) is comparable with PR measurements, it had slightly underestimated rain rate compared to PR. For the height profile of \(R\), at the bright band level, the ambiguity of rain rate estimation from MLP\(_R\) is relatively less due to the presence of weak bright band [Fig. 9(b)]. Though this comparison may not be statistically very significant, overall good agreement was found between the height profiles of model and PR estimated dBZ and \(R\).

5 Summary and discussions

Artificial Neural Network (ANN) based two MLP models have been developed to estimate the dBZ and \(R\) from the spectral moments of the L-band wind profiler at NARL, Gadanki. The characteristics of the spectral moments of the L-band wind profiler were studied with respect to rain parameters. It was observed that back scattered power \(P\) was most closely related with these parameters by virtue of higher value of exponent in the power law relations between these two parameters. The fall velocity of rain drops is most closely related with these parameters in terms of high value of correlation coefficient. The SNR parameter of the profiler, though poorly correlated with rain parameters, was a good indicator to represent rain or no-rain situations. Overall good agreement between the estimated rain parameters from the proposed methodology and the JWD measured parameters were observed. It was also found that the MLP model performed better compared to parametric regression models. The estimated rain parameters from the proposed methodology were also able to show the general characteristics of the convective and stratiform rain by virtue of its high values of dBZ and \(R\) up to upper heights during convective rain and the presence of bright band during stratiform rain. It was noticed that during the presence of strong bright band there is significant error in the rain rate estimation at that height.

The ambiguity of the rainfall estimation at the bright band is expected because different microphysical processes dominate the precipitating mechanisms. The MLPs estimated dBZ and \(R\) were compared with the PR estimated height profiles over Gadanki. Significantly the height profiles of dBZ from both the systems have shown bright band signature at around 3.7 km height. There are many reasons to expect the discrepancy in the model estimated and the observed rain parameters\(^3\). There is a limitation of sample volumes in the estimation of height profiles of the rain parameters. In the present study, the spectral moments at the lower most reliable range bin (0.75 km) were trained with the JWD
observations, which is essentially a point observation. Now to further estimate the rain parameters at higher range bins, which have increasingly different sample volume, the errors in the estimation of height profiles of these parameters are expected to increase. The difference between the measurements from these two systems could also be attributed to the ambient atmospheric conditions such as humidity and temperature, which determine the rate of evaporation of the drops that fall from the retrieved heights to the ground (JWD).

During thunderstorm or squall line seasons there may be advection and convergence at the surface that may have effect on the fall velocity of the hydrometeor particle. It is important to mention here that the TRMM ground validation field campaigns were carried out by utilizing a standard 915 MHz profiler during Texas and Florida Underflights Experiment (TEFLUN)-A and TEFLUN-B in 1998. In that experiment the profiler was calibrated with collocated RD-69 JWD at the lowest range gates. In the present study, an L-band wind profiler operated at 1.3 GHz has been utilized to estimate the reflectivity and rain profiles with the help of collocated RD-69 disdrometer. The study shows that the MLP based techniques can be utilized to estimate the rain parameters from the L-band wind profilers with a reasonably good accuracy, though it was originally developed to measure the clear air velocity. A practical implication of the proposed methodology is that it will contribute to the ongoing effort to enhance the capability of the wind profiler as a rain profiling system, when the clear air echoes are masked by the precipitation echoes.

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