Establishing Radar Reflectivity - Rainfall Rate Relationship in terms of Spectral Width thresholds

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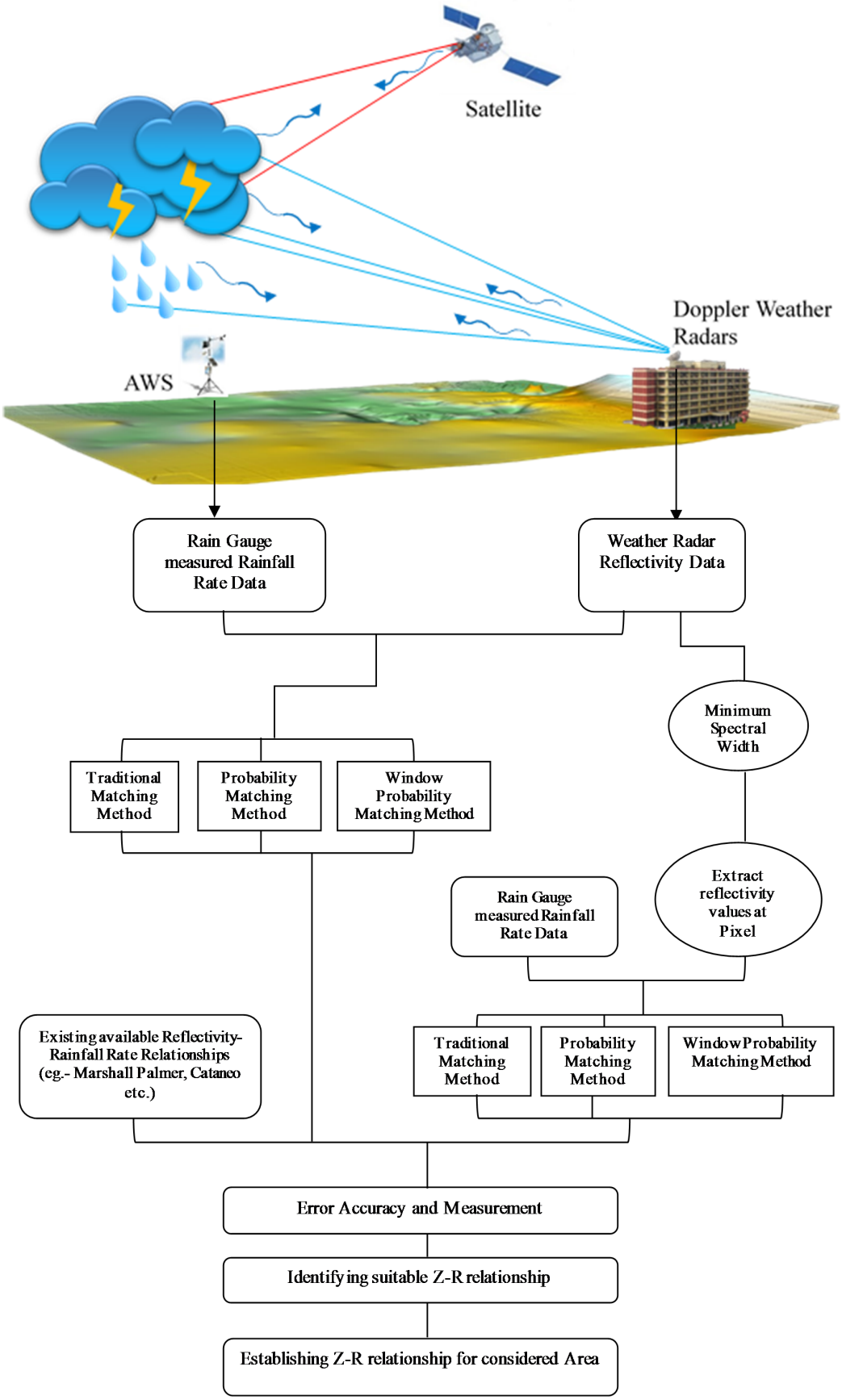
In this study, the reflectivity values at minimum spectral width are chosen for establishing the relation between measured rainfall and weather radar reflectivity. Spectrum Width (W) is a measure of dispersion of velocities within the radar sample volume. In a situation, where shear and turbulence is small within a control volume, the spectrum width will be small vice versa. A technical way of defining spectrum width is the standard deviation of the velocity distribution within a considered control volume. In atmosphere during the condensation, the tiny droplets grow and impact with their neighbours as they are carried by shear and turbulent air motion until they become large enough so that the force of gravity overcomes that of shear friction and they begin to fall. Form the aforementioned it can be inferred that there is a more probability of occurrence of rainfall at lower spectral width values. So, here it is assumed that the cloud cell is matured and ready to give rainfall where the spectral width (turbulence) is optimum. So, it can be established the reflectivity –rainfall relationship by considering reflectivity values at a threshold of spectral width values.

For this, the C-band operational weather radar installed at India Meteorological Department, New Delhi data was taken for establishing Z-R relation. The location of the radar is at $28^0$35'23.28" N, $77^0$13'18.84" E and 253m height above the sea level. It covers the world’s third most urbanized area Delhi NCR and other many cities with coverage of 250km radius. It can be observed that the highly complex surface process influences the weather system in the considered area due to this urban complex terrain. The average annual rainfall of the study area is approximately 714 mm. The radar records parameters at every ten minutes and scans through ten vertical sweeps with antenna raising from 0.5 deg to 21 deg angles. At present three-year datasets (2012, 2013 and 2014) were taken for establishing Z-R relationship. The radar covers with a spatial resolution of 300m ×1deg azimuthal and with a temporal resolution of 10min interval. Total 24 Automatic weather stations (AWS) which have been deployed within the 100km radius of radar measuring field data were collected. The temporal resolution of the rainfall events from the AWS is at 1-hour interval.

The reflectivity data was extracted at every 10min where the spectral width is minimum in any control volume above the considered rain gauge. The extracted data were aggregated into 1-hour to match with the rain gauge data. Then, the Z-R relation was established with threshold spectral width approach. Along with this, the relation was fitted using Traditional Matching Method (TMM) and Probability Matching Method (PMM) proposed by Calheiros and Zawadzki by considering reflectivity value at a 1km height from ground level and exactly above the chosen rain gauge station. The Window Probability Matching Method (WPMM) proposed by Rosenfeld et al. also used by considering reflectivity values of 1km ×1km window at 1km height to establish Z-R relation. Similarly, the Z-R relation was fitted using reflectivity at thresholds of spectral width by PMM and WPMM techniques. The detailed methodological flow chart is shown in the attached figure. The minimum spectral width in this area was observed as 0.031 m/s, but the considered thresholds depended on the cloud types and its condition at the considered region. The spectral width criteria were applied for the control volumes below the melting layer which is 7000m above ground level in the study area and above the boundary layer height. The proposed approach was compared with Z-R

relation developed by TMM, PMM, WPMM, basic Marshall-Palmer power law equation and other developed Z-R relations for a similar type of climate zones all over the world. The proposed approach was shown a good correlation coefficient of 0.8244 compared to the normal method which was 0.6079. It can be concluded that the proposed scheme for establishing Z-R relation over a particular region is useful for operational Quantitative Precipitation Estimation (QPE) to give early flood and flash flood warning.

Keywords: Reflectivity, Rainfall rate, Z-R relationship, Spectral Width, Turbulence in Cloud, Doppler Weather Radar


Satellite
Doppler Weather Radars
AWS
Rain Gauge measured Rainfall Rate Data
Weather Radar Reflectivity Data
Minimum Spectral Width
Traditional Matching Method
Probability Matching Method
Window Probability Matching Method
Extract reflectivity values at Pixel
Rain Gauge measured Rainfall Rate Data
Existing available Reflectivity-Rainfall Rate Relationships (eg.- Marshall Palmer, Cataneo etc.)
Traditional Matching Method
Probability Matching Method
Window Probability Matching Method
Error Accuracy and Measurement
Identifying suitable Z-R relationship
Establishing Z-R relationship for considered Area