Comparative Study of Rainrate Estimation from DWR Reflectivity

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Abstract

Doppler Weather Radars provide information on wind speed and turbulence, in addition to detecting the location, intensity (reflectivity), and movement of weather systems, including both regular and severe weather events. This study investigates the accuracy of rainfall estimations derived from Doppler Weather Radar (DWR) reflectivity data provided by the Indian Meteorological Department (IMD) during a cyclonic event. The DWR reflectivity data is used to compute rainfall rates, offering high-resolution insight into the distribution and intensity of precipitation associated with cyclones. To validate these radar-based rainfall estimates, we compare them with rainfall data from the ERA5 reanalysis by the European Centre for Medium-Range Weather Forecasts (ECMWF) and the Global Precipitation Measurement (GPM) IMERG satellite product. A comprehensive statistical analysis, including correlation, bias, and root mean square error (RMSE), is conducted to assess the performance of the radar-derived rainfall estimations. By evaluating the consistency between DWR reflectivity-derived rainfall and the ERA5 and GPM IMERG data, this study aims to enhance the understanding of cyclone-associated rainfall patterns and improve forecasting accuracy. The findings will contribute to refining rainfall estimation methods and improving early warning systems for better disaster preparedness and response during extreme weather events.
The results of this comparative analysis can inform future improvements in operational radar systems and enhance cyclone monitoring and forecasting, ultimately aiding disaster management and preparedness efforts.

1. Introduction

The Doppler Weather Radars give information on wind speed and turbulence that are related to regular and disaster weather systems, in addition to their location, intensity (reflectivity), and movement. The government can take prompt corrective action thanks to the predictions and warnings that are issued based on this information, which is crucial in identifying, tracking, and monitoring severe weather phenomena. The progress of WSR-98D/S is a prerequisite for the revision process. (Chandrasekhar, et. al, 2012).
The National Weather Service utilized the Marshall and Palmer Z-R relationship for their network of WSR-57 weather radars, even though various additional empirical constants have been found. The Z-R connection was altered to Z = 300 R^1.4 when the National Weather Service swapped out the WSR-57 radars with the more advanced WSR-88D radars.
The tropical Z-R connection, the WSR-88D default Z-R relationship, and rain gauge data will all be compared in this article to determine how much rainfall happened. Additionally, the potential for a stronger Z-R link will be investigated. (Fournier, 1999)
Using radar observations repeatedly rainfall estimation can be possible, elevation wise radar observation can give a clear image of cloud property and it's extension, accordingly class of cloud it will be helpful to estimate the rainfall potential of this cloud (Kucera et al 2004, Suresh et al 2005). Following clear Standard Operating Procedures is a crucial component of a quality system. Actually, the entire procedure—from turning on the weather radar system to producing and distributing Doppler weather radar data to different stakeholders.
If wind flow direction can be observed then DWR data will be helpful for pre warning, in which regions have a chance to receive heavy rainfall. Neither the well-developed tall eye walls nor the characteristic spiral bands that are often associated with cyclones were visible in the reflectivity photos of the cyclonic storm. The threshold settings of 22 dBZ for reflectivity photos were found to provide a better fixing of the storm center during this storm, as the storm eye became more visible due to the exclusion of neighboring weak cells. Still, it was impossible to distinguish distinct spiral bands. While the storm moved over the Bay, the size and form of the eyes were constantly changing. The 24-hour cumulative rainfall's spatial patterns and structure were improved by the better track prediction. The original TC vortex's asymmetry, strength, and organization all significantly improve when the TC is within radar range. Consequently, there are significant improvements in both the track and intensity simulations. From table 1 it is clear that both datasets were comparable and discrepancies in the DWR data as the cyclone is approaching near the shore and near to the station. Even though there are some differences but it can be helpful in the estimation of heavy rainfall locations as the cyclone is approaching towards any station and precursory measures can be taken inadvance along with the usage of numerical models.
In this study super cyclonic storm AMPHAN is selected for the estimation of rain rate using IMD DWR reflectivity parameter, where rainrate is estimated from DWR reflectivity data and a comparison was made between GPM IMERG precipitation and IMD DWR over Kolkata station.

$$Z = \int [N(D)D^6 dD] R = \left(\frac{PI}{6}\right) * \int [N(D)D^3 W(D) dD]$$

2. Figures and Tables

Date & Time	DWR	GPM
20-05-2020 0100UTC	3.98	3.19
20-05-2020 0200UTC	3.46	3.37
20-05-2020 0300UTC	3.21	2.12
20-05-2020 0400UTC	2.43	3.19

Table 1: Comparison of rainrate derived from DWR with GPM IMEG Rainfall on Landfall day.

Table shows the comparison of rainrate between DWR and GPM IMERG rainfall on Land fall day. From the table it is clear that the estimated rainfall rate from DWR is almost comparable with GPM IMERG on the landfall day.

Figure 1 shows the GPM IMERG precipitation of Zonal mean value is calculated accordingly as Total value of all pixel per total pixel. It shows the hourly accumulated rainrate from GPM for the landfall day. Figure 2 and 3 shows the spatial plot of hourly rainrate derived from GPM on the land fall day. The AMPHAN cyclone has made landfall between 1000 UTC to 1200 UTC of 20^{th} May 2020. Highest rainfall estimated from 10:00 am – 12:00pm. The maximum rainfall observed near 74 mm/h & lowest observed 20 mm/h. Over the 250 km scan buffer of the radar. In the map this is visible that high value of rain rate is observed on continent. According to the zonal mean in line graph plot, the pic of the rain rate is 1.12 mm/h in the time period. Accordingly it has been seen trend of rainfall rate of the cyclone Amphan the highest rainfall receive in the time of landfall (Crossing West Bengal – Bangladesh coastal region as a very severe cyclonic storm across Sundarbans, near lat.21.65°N/long. 88.3°E during1000-1200 UTC), with intensity of 157.42 Km/hr gusting to 185.73 Km/hr and before three hours of landfall and after also , according to radar scans those scans are 08:02:52, 09:02:07, 10:02:08, 11:02:23, 12:02:23, high rainfall rate observed near about 74 mm/h. and accordingly zonal mean of rainfall rate, 1.10 mm/h this highest pic of rainfall in the point 11:02:23. Observed by Kolkata Radar. Figure 4 shows the peak rainfall from IMD DWR observed on the landfall day and histogram. These estimations offer important information for early warning systems and resource allocation, as well as for disaster management and response operations. Longitudinal variation and latitudinal variation of rainfall, of the landfall day.

Fig 1. GPM IMERG precipitation during Cyclone land fall day.

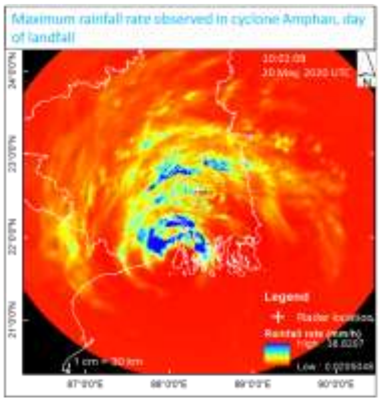

Fig 2 maximum rainfall observed on land fall day

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