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Study of Rainfall via Radar Image during Typhoon Morakot in Taiwan

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Abstract - This paper examines the rainfall patterns associated with 2009 Typhoon Morakot in Taiwan and uses radar imagery to obtain dBZ values. The study focuses on correlating these dBZ values with actual rainfall data collected from Ruiyan and Hualien rainfall stations. The results show a positive correlation between the dBZ values and the observed rainfall during Typhoon Morakot. This research lays the foundation for future efforts to develop advanced precipitation forecasting models and contributes to a better understanding and prediction of precipitation events in similar contexts.

***Keywords*:** Typhoon Morakot, Rainfall, dBZ value, Correlation

1. Introduction

Typhoon Morakot [1]–[3], which hit Taiwan in 2009, is known in meteorological history for having a lasting impact on the island and changing our perception of extreme weather. The aftermath of this powerful typhoon highlighted Taiwan's vulnerability to strong tropical systems and the importance of accurate rainfall data in disaster preparedness and response [4], [5]. According to meteorologists, radar image interpretation has made it possible to understand and predict weather phenomena in significant part. Another key parameter that is significant, particularly in relation to rainfall [6], is the measurement of reflectivity in decibels of Z (dBZ) [7]. To convert radar data into a visual representation of hail intensity, this metric—often shortened as dBZ—is crucial.

Raindrops and other hydrometeors produce varying degrees of reflectivity depending on how they interact with radar signals. A standardized measurement of this reflectivity is provided by the dBZ scale, which provides meteorologists with important information about the amount, type, and distribution of precipitation in a particular area. We can make more precise and timely forecasts by gaining a deeper understanding of precipitation patterns by analysing dBZ values on radar images.

During the destructive aftermath of Typhoon Morakot in 2009, the relationship between reflectivity values on radar images expressed in dBZ and the actual rainfall on the island became evident, posing a significant and complex challenge. Comprehending and quantifying this correlation is essential [8] for enhancing rainfall prediction models, increasing early warning system accuracy, and enhancing disaster preparedness in areas susceptible to typhoon-related rainfall extremes. While radar images provide invaluable real-time information on precipitation patterns, it can be challenging to pinpoint the precise relationship between the recorded dBZ values and the corresponding precipitation amounts. Typhoon-induced rainfall and Taiwan's varied topography make it difficult to simplify the interpretation of radar data. Therefore, it is essential to investigate the correlation between dBZ values and actual rainfall during Typhoon Morakot to develop more precise and region-specific rainfall prediction models.

This paper aims to investigate the relationship between the dBZ from radar images and the actual rainfall that Taiwan experienced during typhoon Morakot in 2009. The foundation this study offers for comprehending the current correlation values makes it essential for use in subsequent research. This study focuses on the rainfall stations located in the Ruiyan and Hualien regions at that time.

2. Methods, Results and Discussion
2.1. Method

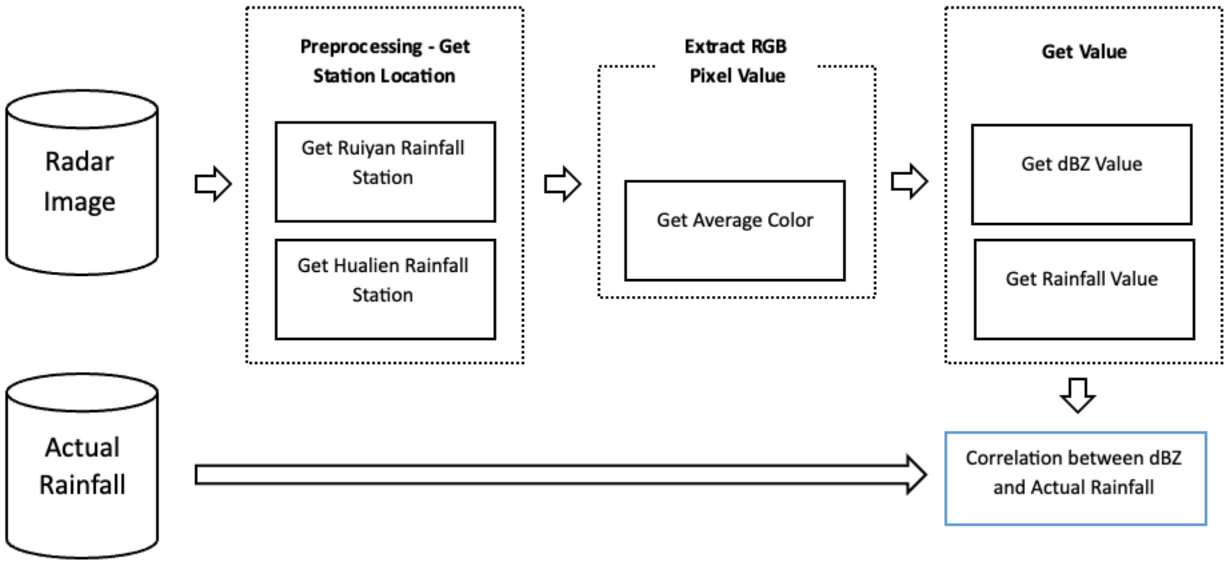

Fig. 1: Flowchart of experiment

The process flow for obtaining the initial data - the radar image - to compare the precipitation data from the radar image with the actual precipitation is shown in the flowchart in Figure 1. First, data is collected from radar images from the Data Bank for Atmospheric & Hydrologic Research [9]. Radar images SSL - □□□□□ □□ are the data used and the period used is for the 2009 Typhoon Morakot from August 2nd to 12th. Figure 2 shows the radar images of it, which have a pixel count of 500 x 900. We then use a more thorough method to extract the locations of the precipitation stations (Ruiyan and Hualien) from this image. Finding the longitude and latitude of each desired precipitation station is the first step in locating precipitation locations. Next, we perform the procedure to determine the location in the image by removing 9x9 or 6x6 pixels from the original image to represent the location of the precipitation station. Figure 2 shows the image cropping process. The next step is to use the image to determine the location of the precipitation station. While actual precipitation records data every hour, this website's radar image records radar conditions every ten minutes for an entire day. Figure 2 shows the procedure for slicing the image according to the location of each precipitation station. The slice image is then analysed based on its average color [10]–[12] and its average color value is compared to the reference image (each color is represented by one of 18 classes corresponding to dBZ values [13]). However, it should be noted that there are differences in color details in some cut images. This will make a difference in the RGB and average color values. As a result, to obtain the dBZ class determination, it will be adjusted to the average value close to a particular class. The final step is to correlate the dBZ value with the actual precipitation for each station after the entire process is complete.

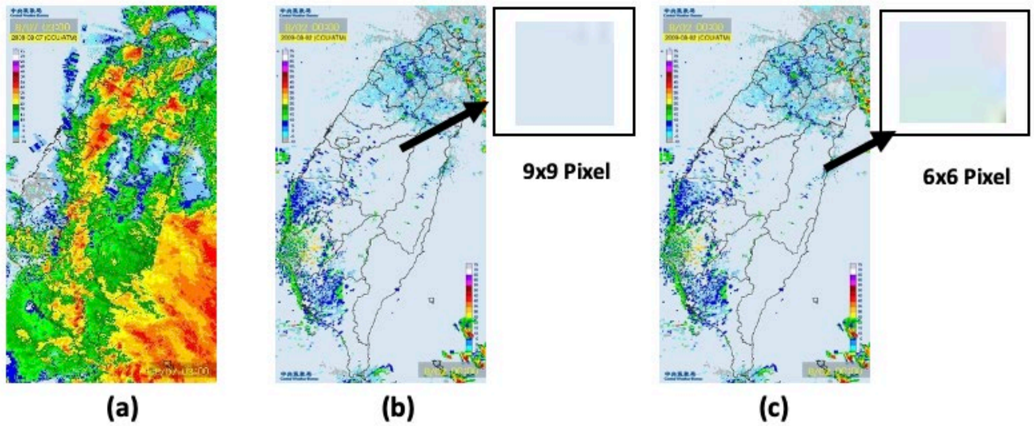

Fig. 2: (a) Radar Image, (b) Ruiyan Station, (c) Hualien Station

2.2. Results and Discussion

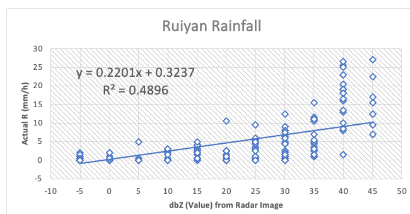

Fig. 3: Correlation between dBZ from Radar Image and Actual Rainfall (Ruiyan Station)

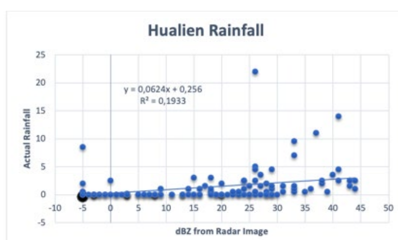

Fig. 4: Correlation between dBZ from Radar Image and Actual Rainfall (Hualien Station)

Figures 3 and 4 show the correlation results between dBZ and actual precipitation at Ruiyan and Hualien stations during Typhoon Morakot in 2009 (August, 2-12). It is important to note that the observed data distribution has minor variations due to influencing factors such as prevailing winds, the presence of mountains, and seasonal variations during the typhoon. These variations reflect the dynamic nature of radar conditions. Despite these influencing factors, there is a positive relationship between the dBZ values derived from radar images and the actual precipitation recorded. This correlation highlights the utility of dBZ as a valuable indicator for assessing precipitation patterns during extreme weather events.

4. Conclusion

In summary, our experiment demonstrated a discernible correlation between dBZ values extracted from radar images and actual rainfall at Ruiyan and Hualien stations during Typhoon Morakot. This correlation suggests the potential utility of dBZ values as a predictive indicator for rainfall during typhoon events. The findings provide a solid groundwork for future investigations that may consider integrating additional meteorological factors, such as wind speed and temperature, to enhance the overall accuracy of rainfall predictions. Furthermore, this study advocates for more sophisticated developments in predictive models, offering a pathway for more precise and comprehensive rainfall forecasting in the future, particularly in the context of typhoon events.

Acknowledgements

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