# Improvements of Rainfall Rate Measured by Radar for Tripoli City - Libya

Kamil S. Ali and Medhat H. Said

Abstract—Continuation of the current research activities undertaken at the academy of graduate studies aimed to improve the rainfall rate measurements by radar, so three empirically derived Z-R relationships, for drizzle, moderate, and heavy rain are needed. **For the purpose C-band weather radar of wave length(5.5 cm) was used in this research, where the radar reflectivity was calibrated with the rainfall rates measured by four weather stations located within the range of radar wave propagations. Three Z-R relations were established and the results compared with the general formula of Tripoli City for resent rain storms detected in the region. Progress has been achieved and the standard deviations for each cases was also given.**

**Keywords: Improvements, Rainfall rate, Weather radar, Z-R relationships.**

## I. INTRODUCTION

The rainfall rate measurement by radar could be enhanced by kralege of the characteristics of radar echoes which produced by different type of precipitation. In studying the echo intensity level for various precipitation types in Tripoli City large differences were found. Maximum intensity level was found to be (50 dBz) in heavy thunderstorm, while for moderate rain it's found to be within level (40 dBz), for light drizzle rain it's found to be between(15-30dBz). So it's necessary to form three Z-R relationships for three categories of rain storms. In so doing the results will very likely be improved with respect to the results in using one single Z-R relation. To improve the radar measure of rainfall rate it's important to compare the radar measure with that of raingauges, because the drop variation with heights due to change in temperature, the radar measure of rainfall is due to volume measure, while the raingauge is correspond to approximate value measure of rainfall rate, in addition the radar readings gives at appreciable height over raingauges locations, further more the radar beam is usually not uniformly fell with precipitations and it varies widely for drizzle, moderate, and heavy thunder rain storms. In addition the rain measurements readings affects by drifting of low level winds which varies with the rain storm categories, and accordingly the relationship of radar reflectivity (Z) and the rainfall rate (R) is varies even in the storm geographical location. So it's necessary to compare the radar measure of rainfall rate with that of raingauge measure for each rain storm type. Three Z-R relationships for drizzle, moderate, and thunder rain storms were achieved by calibrating the radar with the four weather stations located within radar range. Comparison of radar measured value with raingauges for several rain storms events for the rain seasons of the last three years in Tripoli City is shown.

Prof., Kamil S.Al-Sheikh Ali received his Ph.D in Applied Physics Aston University in Birmingham, M. Sc., in meteorology and climatology, and M.Sc., in remote sensing by radar from Birmingham University (U.K). He is currently professor of physics at the academy of graduate studies Tripoli – Libya. His research interest are in radar meteorology, energy system design, and the effects of climatic changes (e-mail: Kamilaliamen@yahoo.com).

Mr. Medhat H. Said Hassan Ahmed graduated from Nasser University, Department Communication Eng. and received his M. Sc., in Eng. Sciences from the Academy of Graduate Studies in Tripoli-Libya, his research interest in storm study by radar, and communication Eng. (e-mail: Medht2004@yahoo.com).

## II. EXPERIMENTAL SETTINGS

Empirically derived Z-R relationships requires calibrations of radar reflectivity factors ($Z$ mm$^6$/m$^3$) caused by precipitations and rainfall rates (R mm / h) measured by weather stations distributed within radar range wave propagations for three categories of rain precipitations drizzle, moderate, and heavy thunderstorms. For the purpose C-band weather radar of wave length (5.5 cm) was used with

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Plan Position Indicator [PPI] scan. The storm image was processed and mapped in six colors horizontal (x-y plan), the radar azimuth angle scan from ($0^o$ to $360^o$), while that of elevation angle [RHI] varies from (-$1^o$ to $93^o$), the radar range is [200km]. The radar data was collected during the rain seasons of 2006, 2007, and 2008 by the radar located in Tripoli International Air Port, while the rainfall data was obtained from four met. Office stations distributed in Tripoli City geographical locations which are Al-hadba, Sedi Al-masri, Tajora Al-bahria, and Tajora Al-zeraia weather stations

## III. DERIVATION OF THREE Z-R RELATIONSHIPS FOR TRIPOLI CITY

Improvement measurements of rainfall rate by radar can be enhanced by search for the most appropriate set of Z-R relations. Such research should allow for more accurate determination of rainfall rate with radar for different type of precipitation. From storms studies in Tripoli City it's noted that the reflectivity (Z) is widely variable from (20 to 45) dBz and hence it's expected that the two constants (a) and (b) in Z-R relationship [2] are widely variable also where :

$$Z = aR^b \ldots\ldots\ldots\ldots(1)$$

Research was achieved to form three empirically derived Z-R relationships, which is for drizzle, moderate, and heavy rain storms for Tripoli City. The radar reflectivity (Z) given in dBz can be measured using the radar equation [3] where:

$$\overline{P}_r = C_1 C_2 \frac{K}{r^2} Z \ldots\ldots\ldots(2)$$

Where :

$\overline{P}_r$ : Is the average power returned from rain.

$r$ : Is the range of storm from radar.

$C_1$ : Is a function of the radar parameter.

$C_2$ : Is a constant related to the dielectric properties of precipitation particles.

$K$ : Is a function of radar including transmitted power, beam width, wave length, antenna gain, and receiver gain.

$Z$ : Is the reflectivity factor which is defined by[3] as :

$$Z = \sum N_D D^6 (mm^6 / m^3) \ldots\ldots(3)$$

The radar reflectivity (Z) can be calibrated with the rainfall rate ($R_g$) measured by ground raingauge of four weather stations which are Al-hadba, Sedi Al-masri, Tajora Al-bahria, and Tajora Al-zeraia wide are located within (50km) of radar position. Fig.(1), fig.(2), and fig.(3) shown the outcome of calibrating the radar reflectivity (Z) with the raingauges measure of rainfall rate ($R_g$).

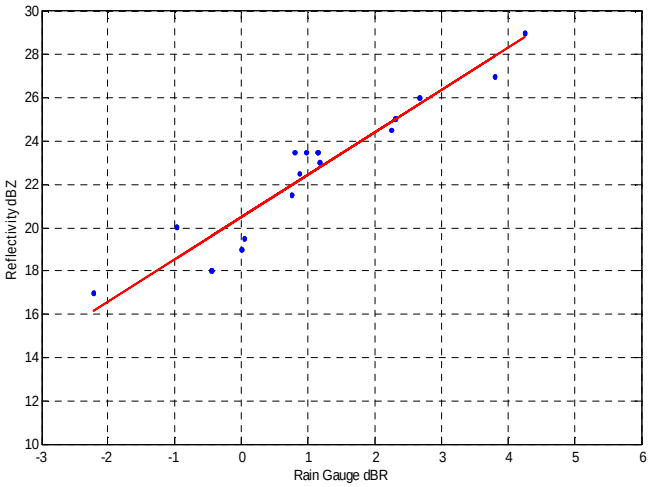


Fig. 1, Relationship Between (dBR $_g$ vs dBZ) for drizzle rain on Tripoli City

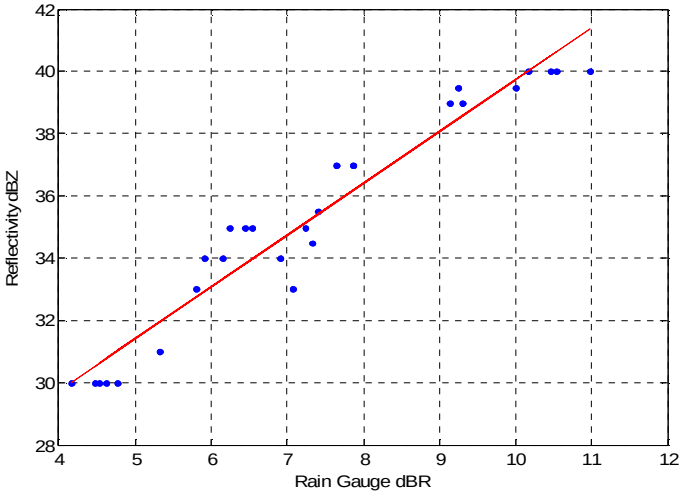


Fig. 2, Relationship Between (dBR $_g$ vs dBZ) for moderate rain on Tripoli City

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

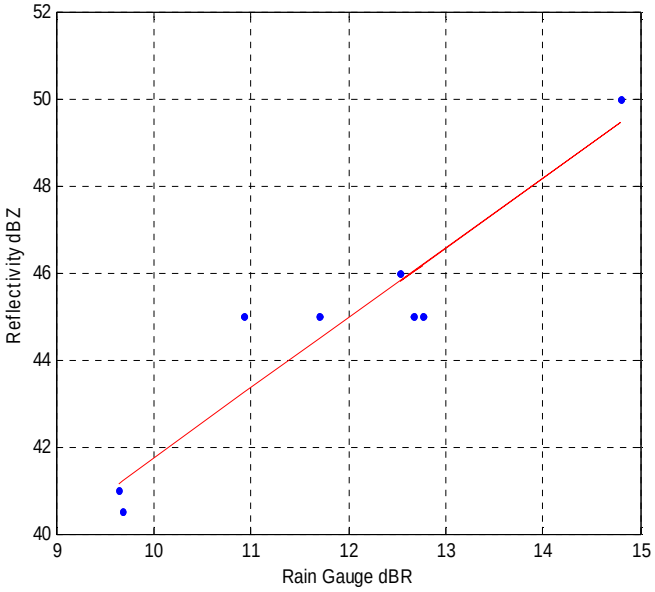


Fig. 3, Relationship Between ($dBR_g$ vs dBZ) for heavy rain storms on Tripoli City

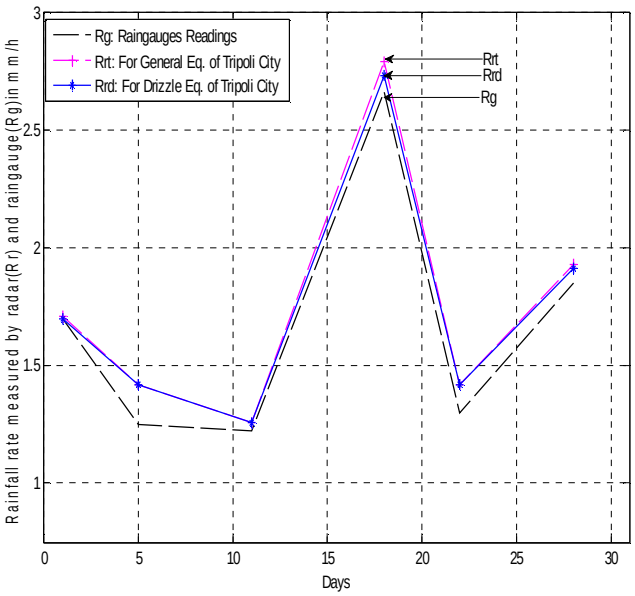


Fig. 4, Comparison of Rainfall Rate Measured by Radar for drizzle rain on Tripoli City

From the plot of three regression lines, the values of constants (a) and (b) in Z-R relationship can be calculated, and it was found to be equal to : 112, 203, 365 for (a) and 1.95, 1.66, 1.61 for (b) respectively, and hence according to the data analysis of experiments conducting with four weather stations the three sets of Z-R relationships for Tripoli City can be written as follows:

$$Z_d = 112R^{1.95} \quad \ldots\ldots(4) \quad \text{for drizzle rain}$$

$$Z_m = 203R^{1.66} \quad \ldots\ldots(5) \quad \text{for moderate rain}$$

$$Z_h = 365R^{1.61} \quad \ldots\ldots(6) \quad \text{for heavy rain}$$

## IV. CONCLOTION AND DISCUSSION

Based on the results obtained it seems to be clear that it's possible with some Z-R parameter to improve rainfall rate measurements by empirically derived Z-R relations for three types of precipitation drizzle, moderate, and heavy rain storms this knowledge has been used to improve rainfall rate measurements in Tripoli City. Figures (4), (5), and (6) shown the outcome of the experimental conducting where the rainfall rate measured by radar.

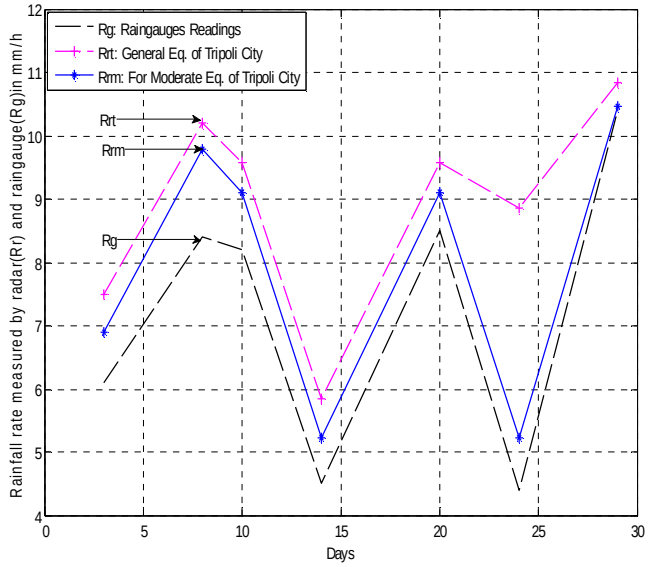


Fig. 5, Comparison of Rainfall Rate Measured by Radar for moderate rain on Tripoli City

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

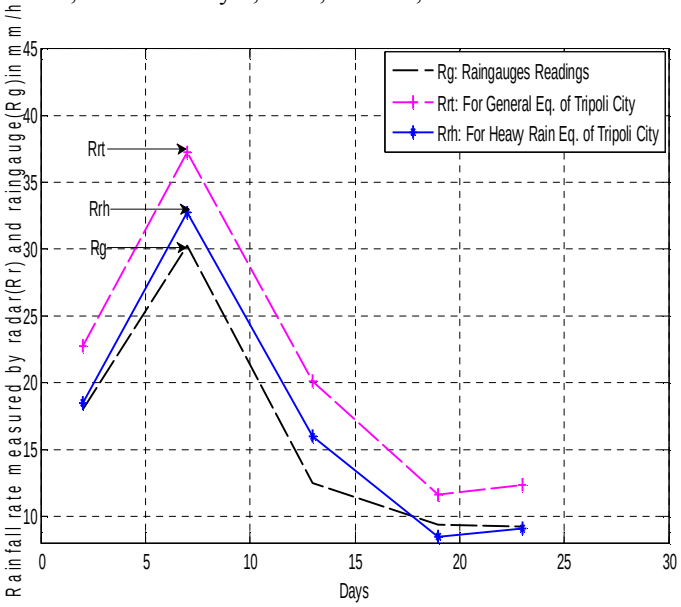


Fig. 6, Comparison of Rainfall Rate Measured by Radar for heavy rain on Tripoli City

The data were compared with general Tripoli Z-R relationship suggested by [8] where ($Z=116R_r^{1.87}$), and data was compared with the raingauges measure as a reference. By comparison the standard deviation for drizzle, moderate, and heavy rain was found to be (0.128, 0.75, 2.125) respectively, while in using Tripoli general Z-R relationship the standard deviation was fond to be (4.30). The results shown the necessity of using three Z-R relations for three categories of rain storms rather using one single general formula to improve the rainfall rate measurements by radar. The rain storm on Libya is greatly influenced by Mediterranean sea, where the low level vertical separation of rain storms varies from (600 m to 1300 m) this causes small changes in laps rate ($dT/dH$), this causes limiting variations in drop size distribution, and hence causes limited variations in radar reflectivity (Z). Tripoli City is influenced by northly and north westerly wind [9], and this situation greatly affects the city climate mainly temperature, wind speed and humidity.

## REFERENCES

[1] Simon Kingsley and Shoun Quegan *" Understanding Radar Systems"* fiest edition, 2001.
[2] Merrill I. Skolnik, *" Radar Hand Book ", second edition*, 1990.
[3] Merrill I. Skolnik, *" Introduction to Radar Systems"*, third Edition, 2001.
[4] Ramon Nitzberg, *" Radar Processing and Adaptive Systems"*, first edition, 1989.
[5] R. Jeffrey Keeler, *" Weather Radar Calibration"*, second edition, 2001.
[6] Jury Joss, *" Radar Meteorology "*, third edition, 2004.
[7] Marshall, J.S. Langille, R.C. and Palmer, W.M.K.,(1947). Measurement of rainfall by radar. J. Meteor., 5, P165.
[8] Kamil S. A and Medht H. S "*Determination of Radar Z-R relationship for Tripoli City*"
[9] Kamil S.A and Omer Saeed "*The statistical Analysis of Surface Wind Speed and Direction for Tripoli City "*, academy press, 2009.

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)