Determination of Radar Z-R Relationship For Libya – Tripoli City

Kamil S. Ali and Medhat H. Said

Abstract—**Work has been undertaken at the academy of graduate studies aimed to improve the rainfall rate measurements by radar, so deriving the empirical Z-R relationship for Tripoli City is needed, and also finding a correction factor between Radar and Raingauges readings was of our concern. For the purpose C- band weather radar was used for rainfall rate measurements and calibrated with the four meteorological weather stations located within 50 Km radius of the radar position. The objective was achieved, and Comparison of Tripoli Z-R relation with Marshall and Palmer general formula, for resent weather event in Tripoli city, was also given.**

Keywords: Calibration, Correction, Rainfall rate, Weather radar.

I. INTRODUCTION

In evaluating the capability of radar as a hydrological tool it is necessary to compare radar measurements of rainfall rates with those given raingauges, since the drop size distribution is varying according to the changes in the laps rate (dT/dH) for difference geographical locations, and it is recognized that the compared measurements of different character with raingauges give an almost approximate values of point rainfall rate, while the radar values correspond to a volume averaged rainfall rate. The averaging volume width or the extent of the post detection integration, in addition the radar measured rainfall rate at an appreciable height over the ground. Even if the rain measurements is below the cloud base the readings affects by drifting of low level winds, and also the time delay between radar and raingauges causes further discrepancy between the two measurements, further more the radar beam is usually not uniformly fell with precipitation. The relationship of radar reflectivity (Z in mm^6/m^3) and rainfall rate (R in mm / h) is varies between storms and within storms events in the same geographical location and season (Joss- 1968). It is recognized that the radar, raingauge comparison is necessary where the total amounts over several hours of rainfall are considered. An attempts to establish a Z-R relationship was achieved by calibrating the radar and raingauges readings, and also a correction factor between the two readings was established based on comparison for several weather events throughout the years 2006, 2007, and 2008 in Tripoli city.

II. EXPERIMENTAL TECHNIQUE

Formation of Z-R relationship requires calibration between radar reflectivity factor (Z) and rainfall rates (R) measured by local meteorological weather stations exists around radar location close to Tripoli International Air Port. Fig. 1, shows the scan rang of radar and four raingauges around Tripoli area used in this project.

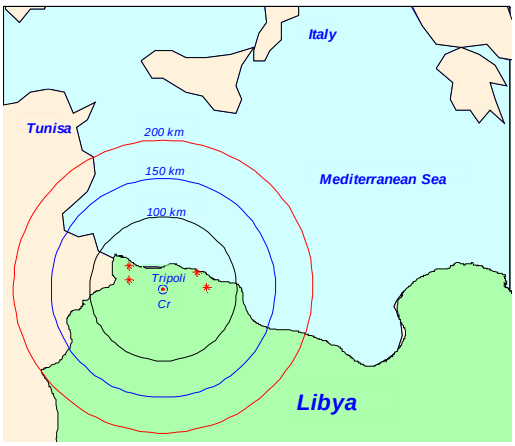

Fig. 1, Scan Range of Radar and Four Raingauges around Tripoli Area.

C- Band weather radar with Plan Position Indicator (PPI) scan were used. So the image was mapped in a horizontal (x-y plan). The azimuth angle varies from (0^o to 360^o), while that of elevation varies from (-1^o to 93^o). The radar range used is (200 km). The radar readings was calibrated with four meteorological weather stations distributed around Tripoli area, which are: Al-hadba, Sedi Al-masri, Tajora Al-bahria, and Tajora Al-zeraia weather stations. The computer program was used to analysis the data of radar echoes and view the image of scan on color monitor, where the values of reflectivities has colored in six levels.

III. DETERMINATION OF TRIPOLI Z-R RELATIONSHIP

The meteorological data used in this study came from four weather stations, and from the radar center close to Tripoli International Air Port. The radar data depending on several rainstorms in Tripoli region.
The rainfall rate (R) can be empirically related to the reflectivity factor (Z)
which is given in the expression as in [2].

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

Where (a) and (b) are constants.
An attempt was achieved to derive Z-R empirical equation for Tripoli city. The radar reflectivity (Z) given in dB can be measured and calibrated with the rainfall rate (Rg) given in dB measured by the raingauges of four meteorological weather stations, which are: Al-hadba, Sedi Al-masri, Tajora Al-bahria, and Tajora Al-zeraia which are located subsequently at position of latitude: 32^o - $48^{'}$, 32^o - $54^{'}$, 32^o - $54^{'}$, and 32^o - $52^{'}$ eastwards, and of longitude: 13^o - $10^{'}$, 13^o - $11^{'}$, 13^o -$21^{'}$, and 13^o -$26^{'}$ northwards. Fig. (2) shows the radar reflectivity (Z) in (dB) and raingauges (Rg) measured in (dB).

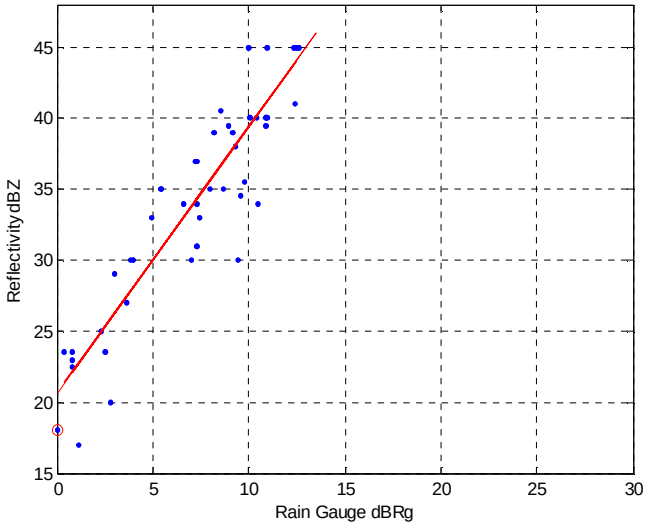

Fig. 2, Relationship Between (dBR_g vs dBZ) of Tripoli City.

From the plot of regression line the values of the two constants (a) and (b) can be extracted, and hence according to the data analysis of four meteorological weather stations the Z-R relationship of Tripoli city can be given as follows:

$$Z = 116\, R_r^{1.87} \quad \ldots\ldots\ldots\ldots (2)$$

IV. DETERMINATION OF CORRECTION FACTOR BETWEEN RADAR AND RAINGAUGE MEASUREMENT OF RAINFALL RATE

Since these are some differences of precipitation measured by radar and that by raingauges due to the weather fluctuating, and the radar beam filling of precipitation from storm to storm and within the same storm, so it is necessary to find a correction factor to the radar measured of rainfall rate. This was achieved by fitting the regression line to the

radar (Rr) and raingauges (Rg) readings of the four meteorological weather stations for the rainstorms detected during the years 2006, 2007, 2008. Fig. 3, shows the outcome of the data analysis

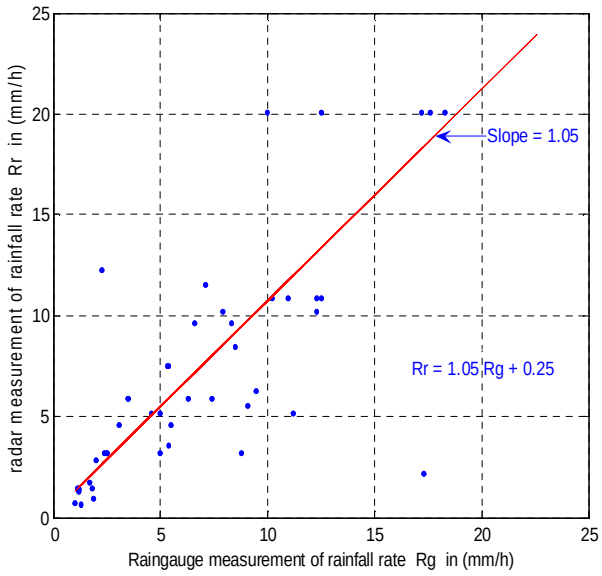

Fig. 3, Correlation of Radar and Raingauge Measurement of Tripoli City.

From the regression line the best fitted line was found to be :

$$Rr = 1.05Rg + 0.25 \quad \ldots\ldots\ldots(3)$$

Equation (3) can be used to correct the rainfall rates measurements for Tripoli city.

V. RESULTS AND DISCUSSION

From the data analysis it is clear that there are differences between precipitation measured by radar and that by raingauges, so (Rr– Rg) can be extracted for every weather rainstorm events. Fig. 4, shows the radar and raingauges measured of rainfall rates during rainstorms season of 2006, differences in measurements was found, and it is believed that this happen because of the vertical separation varies from (600 m to 1300m) between the raingauges and radar measurement of rainfall rates, this causes a drifts in precipitations, and also the variations of samples sizes due to change in temperature with heights causes this differences.

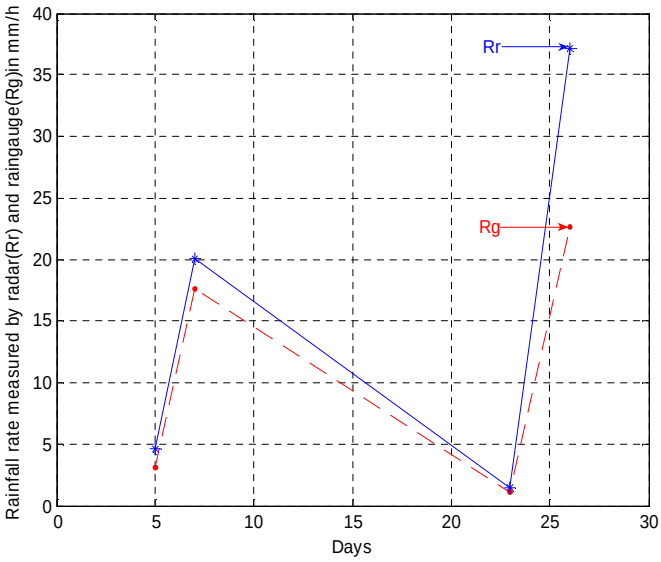

Fig. 4, Comparison of Radar and Raingauge Measurements of Rainfall Rate of Tripoli City on December 2006.

Fig. 5, shows the rainfall rate measured by radar and that by raingauges for Tripoli city, for comparison difference Z-R relation was used, first is the general equation suggested by Marshall & Palmer [7] which is ($Z = 200R^{1.6}$), and that of empirically derived Tripoli formula ($Z=116R_r^{1.87}$) before and after using the correction factor, this was compared with the raingauges measure as a reference.

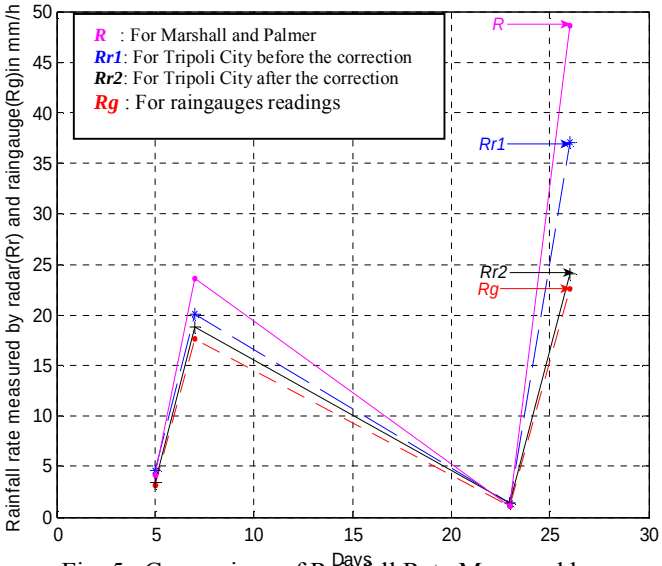

Fig. 5, Comparison of Rainfall Rate Measured by Radar and Raingauges.

By comparing the results with Marshal and Palmer relation the standard deviation was found to be (5.82) while by using Tripoli

formula it's found to be (4.30). The mean absolute difference between radar readings and raingauges was (0.58) before using the correction factor, while after using the correction it was found to be (0.26). This results shows the necessity of using the correction factor of formula (3) to reduce the radar error in measuring rainfall rates. It's notes that the radar reflectivity varies from (20dBZ to 45dBZ) and a accordingly the rainfall measured by radar varies from (0.92mm/h to 20.06 mm/h). The climate of Libya is jointly influenced by the desert in the south, and the Mediterranean Sea in the north, with no influenced of high mountains between the two zones. In summer the entire country is hot, while in winter the coastal north westly is relatively cold, Tripoli city located in the north west of coastal area, this location affected by rainstorms comes from north and north west mainly.

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Kamil S.Al- Sheikh Ali was born in Mosul, Iraq in June the 1st.1942 he has engaged with the Scientific research council, and technological institute of Iraq, since his completion his degrees, M.Sc.,in meteorology and climatology ,M.Sc.,in remote sensing by radar ,and his Ph.D. ,in applied physics (ion sources) in 1983 from Birmingham university and Aston university in Birmingham ,UK. ,He is now Professor of Electrical engineering and computer sciences in the Academy of graduate studies in Tripoli-Libya .He has performed researches in the fields of Radar meteorology ,thin film technology, photovoltaic system design ,Energy measurement of energetic neutrals and ions particles and in performance of ion sources in scientific and industrial activities in lecturing and supervision in ,M.Sc., courses in Electrical Engineering and Physics .
Prof., kamil involved in scientific activities at Osaka university specifically in Amorphous semiconductor Technology in1985, he involved in renewable energy, activities held in California USA in 1986, and in particles physics technology held in Brookhaven national lab., (BNL), New York 1989.
E-mail: Kamilaliamen@yahoo.com

Medhat H. Said Hassan Ahmed Was born in Zletin-Libya 1978. He received his B.sc degree in Electrical Engineering-Communication Dept., from Nasser University, in 2001 and the Master degree in Engineering Sciences from The Academy of Graduate Studies, in Tripoli – Libya in 2008.
E-mail: Medht2004@yahoo.com