Plant Archives Vol. 20, Supplement 2, 2020 pp. 625-629 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

COMPARISON BETWEEN SATELLITE RAINFALL DATA AND DAIN GAUGE STATIONS IN THE AL-ADHAIM WATERSHED, IRAQ

Mohammed S. Sh.*, Tabark J.A. and Atyaf J.M.
Department of Civil Engineering, College of Engineering, University of Waist, Iraq
*Corresponding author E-mail: msewan@uowasit.edu.iq

Abstract

Plans to decrease the effects of drought and flooding in many watersheds is hindered by the absence of poorly extensive networks of rainfall-measuring ground meteorological stations. This results in a paucity of rainfall data, which form the principal inputs in many hydrological models. Satellite rainfall data is, therefore, used as a good substitute in such scenarios. In this research, the validity of two types of satellite data viz., the Tropical Rainfall Measuring Mission (TRMM) product 3B43 and NASA Prediction of Worldwide Energy Resource (POWER)) are verified, using the ground monitoring stations. These data are essential for the simulation models of the Al-Adhaim watershed, the main tributary of the Tigris River, located in northern Iraq. Visual interpretation, simple statistics [coefficient of determination (R^2) and the slope of linear regression, as well as the correlation coefficient (R)] were used to compare the time series. Very good results were seen from this comparison in both cases, which indicated that satellite rainfall data could be used as the input for the hydrological models.

Keywords: Rainfall data, AL-Adhaim watershed, NASA-POWER, TRMM.

Introduction

It is wise to get a clear understanding of precipitation behavior because of the growing demand for water resources for industry, agriculture and power generation. Rainfall needs to be estimated to assess and manage the water resources for environmental and human consumption Aylon *et al.* (2010) and Tobin *et al.* (2010). Every year, floods and droughts cause significant loss to human life and other extensive damage. Hydrological models to study climate change and water resource management require rainfall data throughout the year. Many areas lack sufficient ground monitoring stations Ballari *et al.* (2016), Ragab *et al.* (2002), Kim *et al.*(2008) and Collick *et al.* (2009). Besides, rain gauges are subject to different methodological and random errors, wind, drifting of snow, evaporation of containers and other factors Mekonnen *et al.* (2009). The enormity of these errors ranges from (2-50%, 2-10%, 0-4%, 1-2%, and 10-50%), respectively Melesse *et al.* (2010) and Nešpor *et al.* (1999). Random errors are the other type, which represent instrumental and observational errors. Both types of errors result in a difference of up to 30% between the actual and measured precipitation Rubel and Hantel (1999).

Therefore, at present, satellite products act as important tools in providing the information necessary for the hydrological models in cases where rain measuring instruments are unavailable or recorded data are lacking Cheema *et al.* (2012), World, (1983), and Creutin, *et al.* (2003). Some hydrologists used satellite data as the inputs for the hydrological models Hughes (2006) and Kidd, *et al.* (2010), while others used the data to fill up the paucity in the data with different statistical methods Dile *et al.* (2014), and Tesemma *et al.* (2010).

The Tropical Rainfall Measuring Mission "TRMM" is a combined assignment of the National Space Development Agency (NASDA) of Japan and the National Aeronautics Space Administration (NASA) of the United States, and was designed to measure energy and precipitation Uhlenbrook *et al.* (2010), Betrie *et al.* (2011) and Kummerow *et al.*, (1989). Many studies prefer to use the TRMM 3b43 product because it collects rainfall estimates from multiple satellites, as well as controls the rain measurements Tobin *et al.* (2010). Additionally, it has a spatial precision of 0.25° x 0.25°, while the temporal precision is monthly.

In order to support renewable energy, NASA's Prediction of Worldwide Energy Resource (POWER) is working on improving the data sets from Earth Sciences and Climate Research Ebert *et al.* (2007). The NASA data collection includes daily precipitation, incident solar radiation, Tmax, Tmin, wind speed, relative humidity (RH), and dew point temperature data for each 1◦ × 1◦ network (about 111 km2 at the equator) of the total globe, Collischonn *et al.* (2008).

This study aimed at validating the satellite rainfall data by comparing them with the data observed for use as inputs to the time-step in several rainfall-runoff simulation models.

Many prior studies included a comparison of the rainfall measurement stations with satellite data to validate the satellite data for use in several meteorological research studies in different countries, as well as in many simulation models and a range of water-related applications, such as Chokngamwong *et al.* (2005) Which observed a correlation of 0.85 between the values of measurement stations and satellites, while Villarini and Krajewski (2007). In Oklahoma, found a correlation between satellite data values and rainfall measurement stations. Dinku *et al.* (2007) by comparing the satellite data with the values of the measuring stations, observed root mean square error and Nash Sutcliffe efficiency of 25% and 0.81, respectively. Almazroui (2011) explained, by using a comparison between the TRMM precipitation data and rainfall stations, that a high correlation (R = 0.91) was obvious, for the 1998 to 2009 period, in Saudi Arabia.

Study Area and Data Collection

1.1 Background

Al-Adhaim basin is situated on the northeastern boundary of Iraq nearby the Iranian border. Between 35º 43' 20" to 35º 8' 28" N and 44° 42' 19" to 45º 31' 20" E. The total basin area is 11908 km² (see Figure.1), which lies totally inside Iraqi borders. The river of Adhaim is a major the Tigris river tributary, and Al-Adhaim Dam was built on AL-Adhaim River 19 years before. To distinguish the type of climate is dry, semi-dry or humid, the average annual rainfall was found for the study area depending on the effective rain-gauge station data and the result was 610 mm, which makes the area fall under the semi-dry classification, according to Almazroui M (2011).

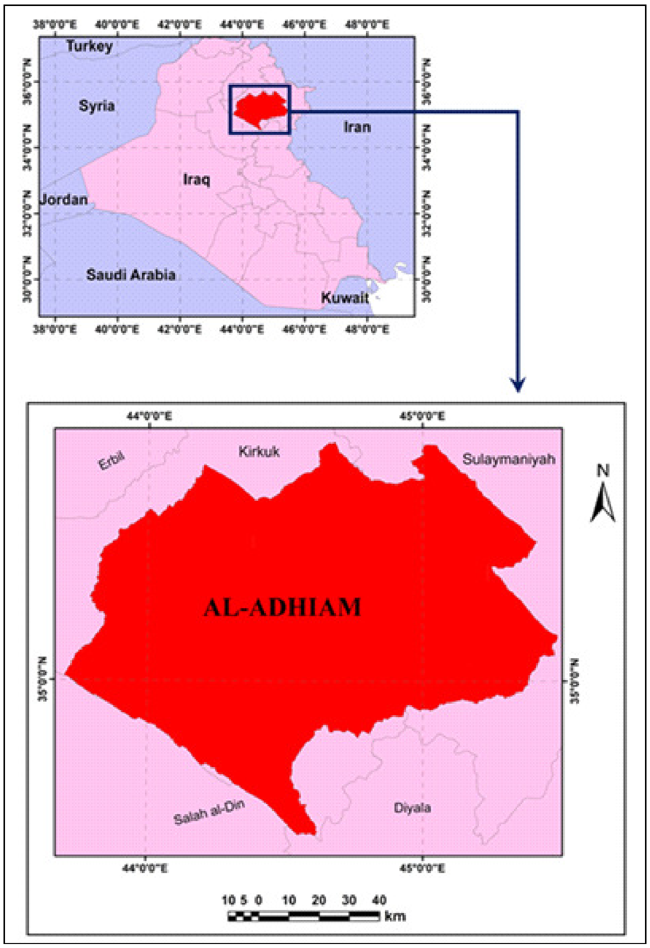

Fig. 1 : Location of AL-Adhaim watershed.

1.2 Rain gauge station data

Data on the monthly rainfall were collected from the Iraqi Meteorological Organization and Seismology (IMOS), from 1991 to 2002, for the stations present in the basin (shown in Table 1).

Table 1 : Lists the rain gauge stations, latitudes and longitude.

No.	Station names	Latitude	Longitude
1	Tuz	34.88	44.65
2	Kirkuk	35.46	44.4
3	Adhaim	34.55	44.50
4	Hawija	35.31	43.78
5	Chamchamal	35.51	44.83

1.3 Satellite data

The Prediction of Worldwide Energy Resource (POWER) from the National Aeronautics and Space Administration was the first source for the satellite data collection in this study from the site (http://power.larc.nasa.gov/), as it is available to the public Van Wart et al. (2015).

The TRMM or Tropical Rainfall Measuring Mission (product 3B43 v7) is the second source used to collect satellite data, which is available online from (https://giovanni.gsfc.nasa.gov/giovanni/), where the spatial precision is 0.25° x 0.25°, and its temporal precision is done every month Raghunath (2006).

Materials and Methods

In this study, two types of satellite data were evaluated for their use as inputs for the hydrological models, the Prediction of Worldwide Energy Resource (NASA-POWER) and TRMM product 3B43 v7. The best approach to evaluate the satellite rainfall data may be to make comparisons between the rain gauge stations and satellite data (based on the availability of the monthly data for the rainfall measurement stations). The first type of satellite data, NASA, was compared with the rainfall measurement stations. The second type of satellite data is the average monthly precipitation (TRMM product 3B43 v7), which is the combination of the (TMI) TRMM Microwave Imager and (PR) TRMM Precipitation. This was also compared with the observed average rainfall data. To estimate the strength of the relationship, these comparisons were based on the visual Interpretations and simple statistics (R, R² and slope).

Results and Discussion

1. Comparison of the rainfall data (NASA with the rainfall stations measured).

The results show a slight difference in the relationship between the monthly precipitation data for NASA and the observed data, as shown in Figure 1, for the Tuz station the coordinates of which are shown in Table 1, with the correlation coefficient value for the period (1991-2002) equal to 0.916.

Figure 2 shows the linear relationship between the NASA rainfall data and that of the station measured, where the results indicate a good concurrence between the two data sources according to Van Wart et al (2015), the strong correlation occurs when the value R is greater than 0.7

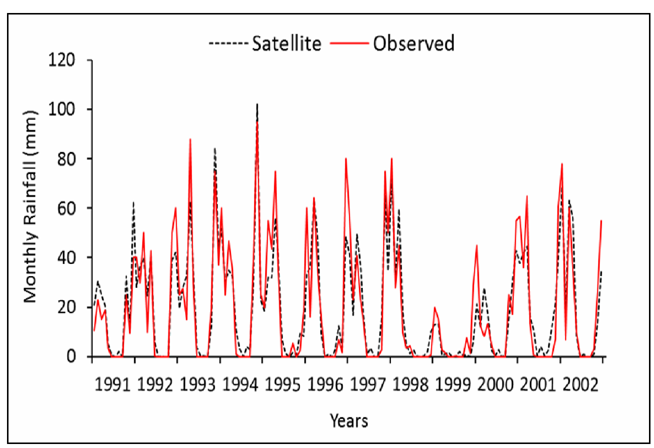

Fig. 1 : Comparison of the rainfall data for the Al-Tuz station for the time period, 1991-2002.

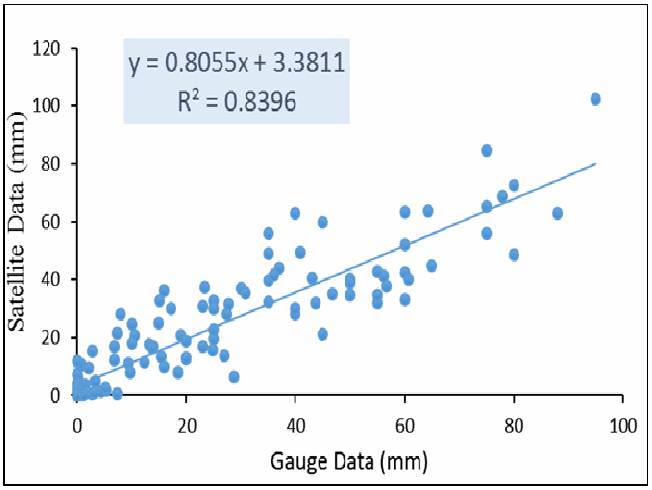

Fig. 2 : Scatter plot of rainfall data from NASA and the rain-gauge station.

For the Al-Adhaim station, good results were achieved on comparison with the satellite data (NASA), as shown in Figures (3, 4) where the coefficient of correlation is R = 0.93.

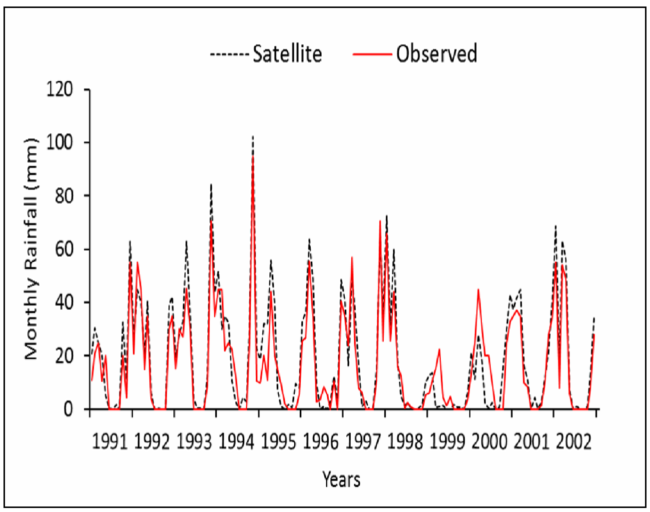

Fig. 3 : Comparison of the satellite rainfall data with that of the rain gauge (mm/month) observed.

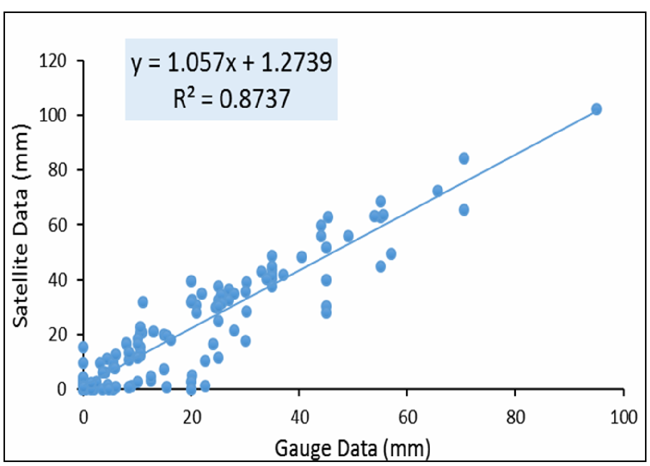

Fig. 4 : Scatter plot of rainfall data from NASA and that of the rain-gauge station.

The linear relationship value is also high when the rainfall data of the Kirkuk station was compared with the NASA data as show in Figure.5 and Figure. 6. where the coefficient of correlation is about (R =0.92). This result indicate a good relationship.

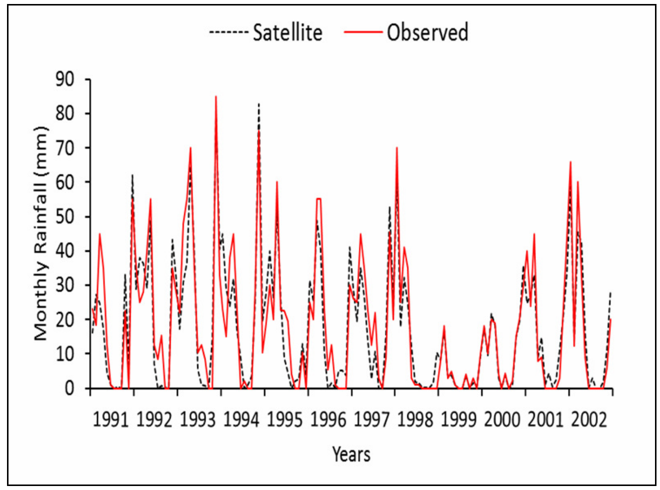

Fig. 5 : Comparison of the monthly rainfall records station and NASA

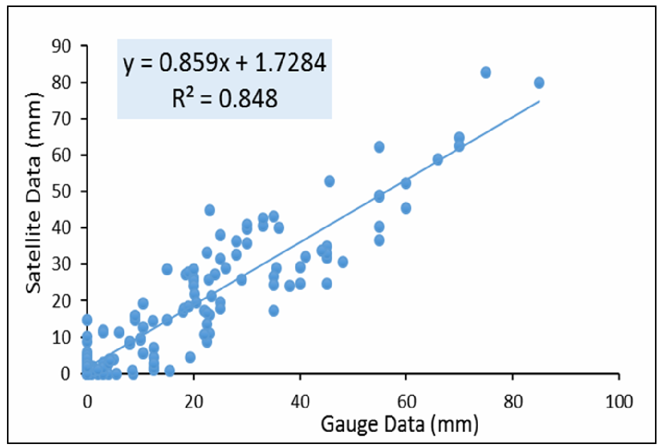

Fig. 6 : Scatter plot of the rainfall data from NASA and the rainfall records station.

2. Comparison of the TRMM with the rain gauge stations measured.

Figure 7 Shows the results of the comparison between the average monthly precipitation of the TRMM data and the average rainfall for the stations observed, where the correlation coefficient value is good (R = 0.91).

Using the Thiessen Polygon method, the average monthly precipitation of the ground stations was extracted.

Figure 8 Shows the scatter plot, in which the linear relationship between the TRMM and rainfall data observed (rain-gauge station) is seen. The statistical regression was given by this equation (y=c+mx) where c represents the constant and m mean the slope.

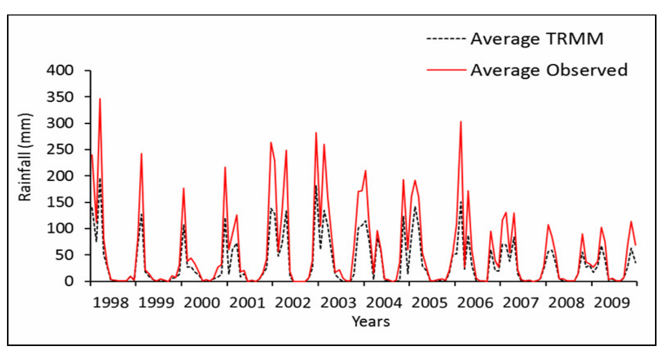

Fig. 7 : Comparison between the average monthly rainfall obtained from the rain-gauge stations and TRMM data.

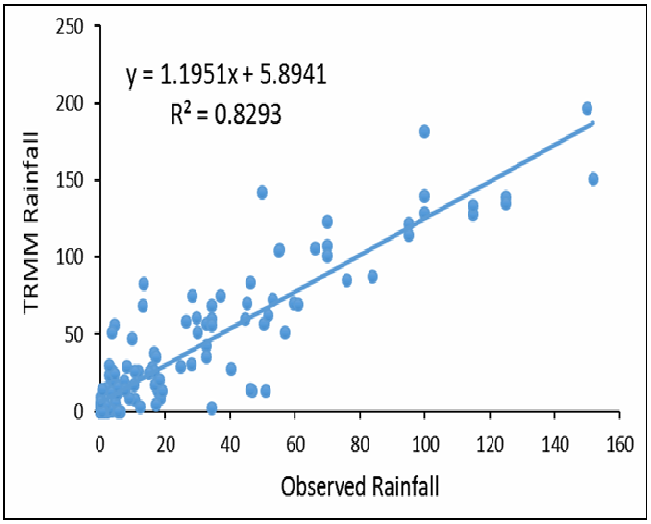

Fig. 8. Comparison of the monthly rainfall records station and NASA.

Conclusion

Several regions, unfortunately, lack ground meteorological stations, besides a shortage of recorded data. Therefore, the satellite rainfall data were verified by comparing them with data of the ground stations in this study, for use as inputs in the simulation hydrological models in the future. Satellite data (NASA) were compared with the observed data for the three stations available in the Al-Adhaim Basin for the period 1991-2005, and then a comparison was made of the TRMM data with the ground stations, for the period 1998-2009. The statistical analysis was performed using functions (R^2 - slope - r) in order to determine the strength of the relationship between these comparisons. The results obtained when using the TRMM data are ($R = 0.91$, $R^2 = 0.82$ and the slope = 1.195) which were very good; the data from NASA also achieved good results. Based on this, satellite data may be used to simulate several different hydrological processes.

References

Almazroui, M. (2011). Calibration of TRMM rainfall climatology over Saudi Arabia during 1998–2009 Atmosp. Resear., 99: 400-14.

Aylon, E.; Fernandez-Colino, A.; Murillo, R.; Navarro, M.V.; Garcia, T. and Mastral, A.M. (2010). Valorisation of waste tyre by pyrolysis in a moving bed reactor, Waste Management J., 30: 1220–1224.

Ballari, D.; Castro, E. and Campozano, L. (2016) Validation of satellite precipitation (TRMM 3B43) in ecuadorian coastal plains, andean highlands amazonian rainforest. Inter. Arch. Photo, Remo. Sens & Spat. Infor. Sci. 41.

Betrie, G.D.; Mohamed, Y.A.; Griensven, A.V. and Srinivasan, R. (2011). Sediment management modelling in the Blue Nile Basin using SWAT model Hydro. Ear. Syst. Sci., 15: 807-18.

Boiyo, R.; Kumar, K.R. and Zhao, T. (2017). Statistical intercomparison and validation of multisensory aerosol optical depth retrievals over three AERONET sites in Kenya, East Africa Atmosp. Resear, 197: 277-88.

Chandler, W.S.; Whitlock, C.H. and Stackhouse, P.W. (2004). NASA climatological data for renewable energy assessment Transa.-Americ. Soci. Mechan. Engi. J. Sol. Ener. Engi., 126: 945-949.

Cheema, M.J. and Bastiaanssen, W.G. (2012). Local calibration of remotely sensed rainfall from the TRMM satellite for different periods and spatial scales in the Indus Basin Inter. J. Remo. Sens., 33: 2603-27.

Chokngamwong, R.; Chiu, L. and Vongsaard, J. (2005). Comparison of TRMM rainfall and daily gauge data in Thailand Americ. Geophys. Uni. Spring Meeting Abstracts.

Collick, A.S.; Easton, Z.M.; Ashagrie, T.; Biruk, B.; Tilahun, S.; Adgo, E.; Awulachew, S.B.; Zeleke, G. and Steenhuis, T.S. (2009). A simple semi-distributed water balance model for the Ethiopian highlands. Hydro. Proc. An Inter. J. 23: 3718-27.

Collischonn, B.; Collischonn, W. and Tucci, C.E. (2008). Daily hydrological modeling in the Amazon basin using TRMM rainfall estimates J.Hydro., 360: 207-16.

Creutin, J.D. and Borga, M. (2003). Radar hydrology modifies the monitoring of flash-flood hazard Hydro. Proc., 17: 1453-6.

Dile, Y.T. and Srinivasan, R. (2014). Evaluation of CFSR climate data for hydrologic prediction in data-scarce watersheds: an application in the Blue Nile River Basin JAWRA J. Americ. Wat. Resou. Associ., 50: 1226-41.

Dinku, T.; Ceccato, P; Grover-Kopec, E.; Lemma, M.; Connor, S.J. and Ropelewski, C.F. (2007). Validation of satellite rainfall products over East Africa's complex topography Inter. J. Remo. Sens., 28: 1503-26.

Ebert, E.E.; Janowiak, J.E. and Kidd, C. (2007). Comparison of near-real-time precipitation estimates from satellite observations and numerical models Bulle. Americ. Meteoro. Soci., 88: 47-64.

Hughes, D.A. (2006) Comparison of satellite rainfall data with observations from gauging station networks J. Hydro., 327: 399-410.

Kidd, C.; Levizzani, V. and Laviola, S. (2010). Quantitative precipitation estimation from Earth observation satellites Rainfa. Sta. Sci., 191: 127-58.

Kim, U.; Kaluarachchi, J.J. and Smakhtin, V.U. (2008). Generation of Monthly Precipitation Under Climate Change for the Upper Blue Nile River Basin, Ethiopia 1. JAWRA J. Americ. Wat. Resou. Associ., 44: 1231-47.

Kummerow, C.; Barnes, W.; Kozu, T.; Shiue, J. and Simpson, J. (1998). The tropical rainfall measuring mission (TRMM) sensor package J. atmosp. Ocean. technol. 15: 809-17.

Li, M. and Shao, Q. (2010). An improved statistical approach to merge satellite rainfall estimates and raingauge data J. Hydro., 385: 51-64.

Mekonnen, M.A.; Wörman, A.; Dargahi, B. and Gebeyehu, A. (2009). Hydrological modelling of Ethiopian catchments using limited data. Hydro. Proc. An Inter. J. 23: 3401-8

Melesse, A.; Abtew, W.; Dessalegne, T. and Wang, X. (2010). Low and high flow analyses and wavelet application for characterization of the Blue Nile River system. Hydro. Proc. An Inter., J. 24: 241-52.

Nešpor, V. and Sevruk, B. (1999). Estimation of wind-induced error of rainfall gauge measurements using a numerical simulation J. Atmosp. Ocean. Technol. 16: 450-64.

Ragab, R. and Prudhomme, C. (2002). Sw—soil and Water: climate change and water resources management in arid and semi-arid regions: prospective and challenges for the 21st century Bio. Engi. 81: 3-4.

Raghunath, H.M. (2006). Hydrology (Principle. Analysis. Design): Revised second edihin, new Age internatial (P) Ltd. Publishers, 4835/24, Ansari Road, Daryaganj, New Delhi-110002.

Rubel, F. and Hantel, M. (1999). Correction of daily rain gauge measurements in the Baltic Sea drainage basin Hydro. Resear. 30: 191-208.

Tesemma, Z.K.; Mohamed, Y.A. and Steenhuis, T.S. (2010). Trends in rainfall and runoff in the Blue Nile Basin: 1964–2003. Hydro. Proc. 24: 3747-58.

Tobin, K.J. and Bennett, M.E. (2010). Adjusting satellite precipitation data to facilitate hydrologic modeling J. Hydro. 11: 966-78.

Uhlenbrook, S.; Mohamed, Y. and Gragne, A.S. (2010). Analyzing catchment behavior through catchment modeling in the Gilgel Abay, upper Blue Nile River basin, Ethiopia Hydro. Ear. Syst. Sci., 14: 2153-65.

Van Wart, J.; Grassini, P.; Yang, H.; Claessens, L.; Jarvis, A. and Cassman, K.G. (2015). Creating long-term weather data from thin air for crop simulation modeling Agricul. Fores. Meteoro., 209: 49-58.

Villarini, G. and Krajewski, W.F. (2007). Evaluation of the research version TMPA three-hourly 0.25×0.25 rainfall estimates over Oklahoma Geophys. Resear. Lett. 34.

World Meteorological Organization (1983). Guide to meteorological instruments and methods of observation. Secretariat of the World Meteorological Organization.