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An overview of global solar radiation measurements in Ghardaïa area, south Algeria

Kacem Gairaa, Yahia Bakelli

Applied Research Unit for Renewables Energies, Ouargla road, Ghardaïa, Algeria.

Abstract
This paper presents an overview of actual solar radiation data measurements in Ghardaïa site (32.360 N, 3.810 W, 450 m above MSL). Global solar radiation and surface temperatures were measured and analyzed for one complete year from 1 January-31December 2005. The data thus recorded are compared with corresponding data of the 22-year average of NASA's surface meteorology and solar energy-model. Hourly, daily and monthly solar radiation was made from five-minute recorded by EKO Pyranometer. The highest measured daily and monthly mean solar radiation was found to be 369 and 326 (W/m^2), and the highest five minute averaged solar radiation values up to 1268 (W/m^2) were observed in the summer season from May to September, and the yearly average daily energy input was 21.83 (MJ/m^2/day). Besides the global solar radiation, the daily and monthly average temperature variations are discussed. The collected data indicate that Ghardaïa has a strong potential for solar energy applications.

Keywords: Global solar radiation; Measurements; NASA's SSE model.

1. Introduction

Energy is a continuous driving force for economic development, social advancement, and improved quality of life, the growing world population combined with the fast depleting reserves of fossil fuels has encouraged researchers in the field of engineering to pursue development and use of renewable energy resources [4, 5].
Studies on solar radiation have become an important issue for renewable energy issues stemming from oil crises, global warming and other environmental problems, thus increasing the need of reliable measurements of surface solar radiation [5].
Solar energy applications require a complete knowledge and detailed analysis about the potentiality of the site, so a database at ground level is an important feature in solar energy conversion systems, and can used in several forms and for a variety of purpose[16,17] .
This information can be gathered from different data sources, such as ground measurements by pyranometers [16] or reference cells or derived from satellite data. One of the most accurate methods to evaluate the surface solar radiation is to use pyranometers at many locations in the given region, and look after their day-to-day maintenance and recording. When measurements are recorded, a strict quality control is mandatory in order to build a confident database.
The solar radiation received from the Sun without having been scattered by the atmosphere is called the direct (beam) solar component, and the solar radiation received from the Sun after its direction has been

changed by scattering by the atmosphere is called the diffuse solar component. Global solar radiation is the algebraic sum of two solar components; direct (beam) and diffuse [3].
Due to its geographical position in the solar belt, Algeria is blessed with an abundance of solar energy and has the opportunity to utilize this bounty of natural energy effectively, promoting a clean environment, and developing renewable energy technologies in the region.
Ghardaïa city is a dry and arid site, characterized by an exceptional sunshine, most often, it has a very important rate of insolation (75% on average) and the mean annual of global solar radiation measured on horizontal plane exceeds 20 (MJ/m^2). The sunshine duration is more than 3,000 hours per year, which promotes the use of solar energy in various fields.
Many models have been developed, and many studies based on these models have been performed to estimate solar energy. An analysis study of hourly diffuse solar radiation on horizontal surface was presented by Karatasou et al [1], they used data for Athens site for establish relationships between the diffuse fraction and clearness index (Kt). Mustafa G [2] and Oturanc et al [13] performed an analysis of daily total horizontal solar radiation measurement for 9 cities and for Konya city in Turkey. They compared actionograph data with pyranometer data of some stations, and developed a nonlinear model between the monthly average daily global solar radiation and the ambient temperature. They observed that the maximum value of the monthly average daily hours of bright sunshine occurred in June reaching 14.58 hours, while the minimum value was recorded during December with 9.41 hours. They also observed that, the error increase in winter months and decreased in summer months.
Measurement of solar energy radiation in Abu Dhabi was presented by M.D Islam et al [6], who found that the highest daily one-minute average daily solar radiation was 1041 (W/m2) While the yearly average daily energy input was 18.48 (MJ/m2/day).
Global solar radiation data in north-eastern Saudi Arabia was investigated by Ahmet Aksakal et al [7, 9] from 1 January-31 December for one complete year. The highest measured daily and monthly mean solar radiation were found to be 351 and 328 (W/m^2), respectively and the highest one-minute averaged solar radiation values up to 1183 (W/m^2) were observed in summer season.
Chanchal Kumar et al [8] studied the diffuse solar radiation on tilted surface in Lucknow, India. They used the isotropic and anisotropic model, and they proposed the last one for estimation the diffuse solar radiation on inclined surface for Lucknow site.
Solar radiation measurements and their analysis for the USA are presented by Stoffel et al and Wilcox et al [14, 15]. They showed how the solar measurements are important for policy decisions, technology selection, designing, monitoring the performance of solar energy conversion systems and models development; they presented also different instruments for the measurement of solar radiation and their calibrations.
In the present paper, we measured solar energy radiation and temperature for a one complete year, and we then supported our measurements by comparing them with corresponding data of the 22-year average of NASA's surface meteorology and solar energy-model (SSE model).

2. Experimental setup

The site of the measurement station was located at the Applied Research Unit for Renewable Energy of Ghardaïa city (32.360 N, 3.810 W and 450 m above MSL). This study was carried out in 2005 for a complete year. The meteorological data and the global solar radiation measurement instruments were set at the roof of solar radiation laboratory. An *EKO MS-64 Pyranometer* was used to measure global solar radiant flux; its short wave sensitivity is 7.0 ($mV/ kW.m^{-2}$). The temperature air surface measurements data, was made by TECNOEL sonde Thermo-Igromertiche, its calibration accuracy is ± 1.5% and temperature sensitivity is 0.1(° C/ mV).
A data logger and a CAMPBELL SCIENTIFIC CR10X data acquisition system were installed in the solar radiation laboratory for reading measurements. From the raw data stored for every five minute, the mean, maximum and minimum hourly values were calculated. From the hourly data set, daily and monthly statistics were made for the solar radiation and temperature data.

3. Results and discussion

Daily mean and maximum temperatures and solar radiation data indicate that the values are higher in the summer months and lower in the winter season. Figure 1 shows the observed daily average and daily maximum global solar radiation for the entire year of 2005. The daily maximum of 1268 (W/m^2) and the

highest daily mean of 369 (W/m^2) were recorded on June 19 and May 21, respectively. Daily mean solar radiation values were high during the period of 26 March to 27 September.
Monthly average daily and peak daily global solar radiations for the year of 2005 are given in Figure 2. The month of June appears to have the highest monthly average daily radiation of 326 (W/m^2). The month of December was recorded to have the lowest monthly average daily solar radiation of 143 (W/m^2). Average daily energy input for the whole year was 21.83 (MJ/m^2/day), which agrees with the global solar map [11, 12].

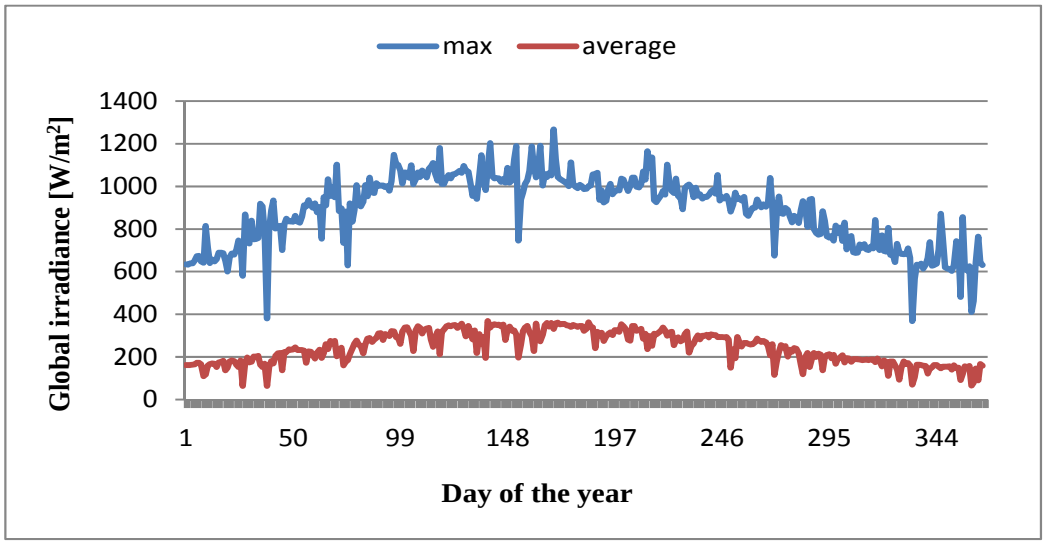

Figure 1. Daily averages and daily peaks of global solar radiations throughout the year

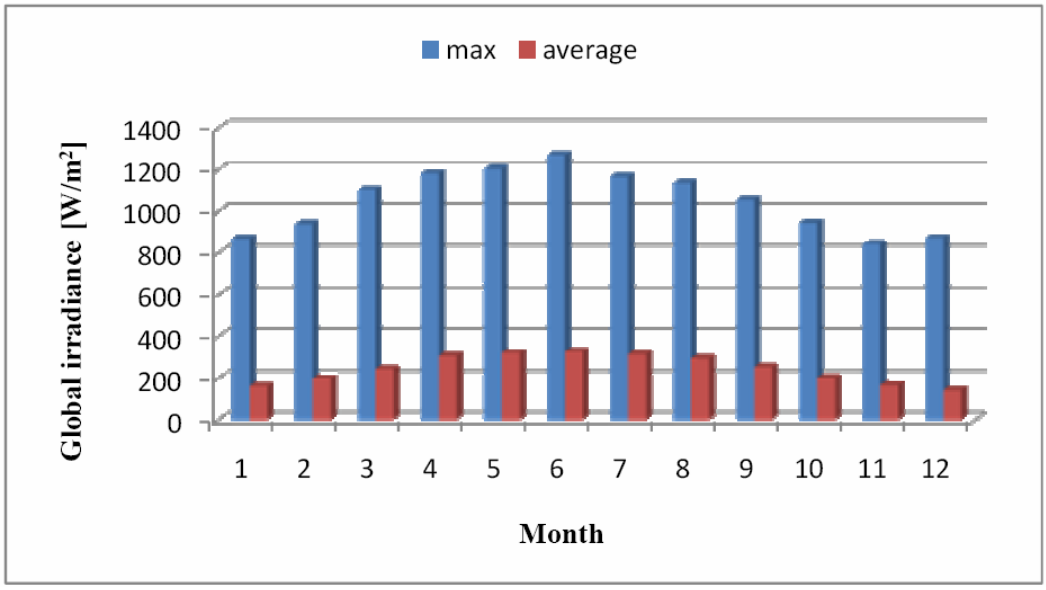

Figure 2. Monthly averages and monthly peaks daily total solar radiation

We compared also our measurements of the monthly mean daily values of global solar radiation for Ghardaïa with the larger time-series data of the NASA SSE model [10], as shown in Table 1. Our measurements agreed with the 22-year average global solar radiation data of the NASA SSE model and can be considered representative.
The highest daily mean and maximum temperatures were 43.87°C and 48.81°C on 27 and 29 July, respectively, as seen in Figure 3. The minimum recorded temperature was 0°C on 29 January.
Monthly average daily temperature variations are shown in Figure 4. The highest monthly average daily temperature is calculated to be 37.4°C in July. However, the highest daily temperature occurred in July.

Using the NASA (SSE) model; we also compared the temperature of Ghardaïa with them and we found that, the measured data agree with NASA SSE model with slight deviation, as shown in Table 2.
When we look at Tables 1 and 2, we see that, especially in summer, the general trend is that, global radiation is high where the temperature is high

Table 1. Monthly mean daily values of global solar radiation (MJ/m^2) for Ghardaïa

Month	Present Measurement	NASA SSE model (22-year average)
January	13.57	10.36
February	16.92	14.86
March	22.38	19.11
April	25.48	24.51
May	27.14	26.71
June	29.10	27.50
July	27.95	28.26
August	25.29	25.45
September	21.23	20.34
October	17.48	14.47
November	15.14	10.80
December	11.96	09.21
Annual	21.14	19.30

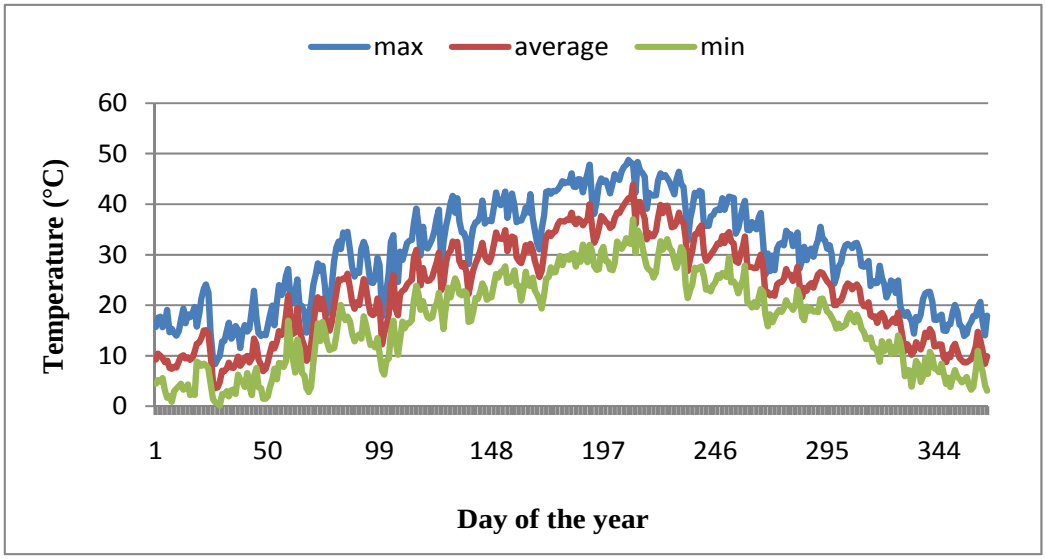

Figure 3. Daily average, minimum and maximum temperature throughout the year

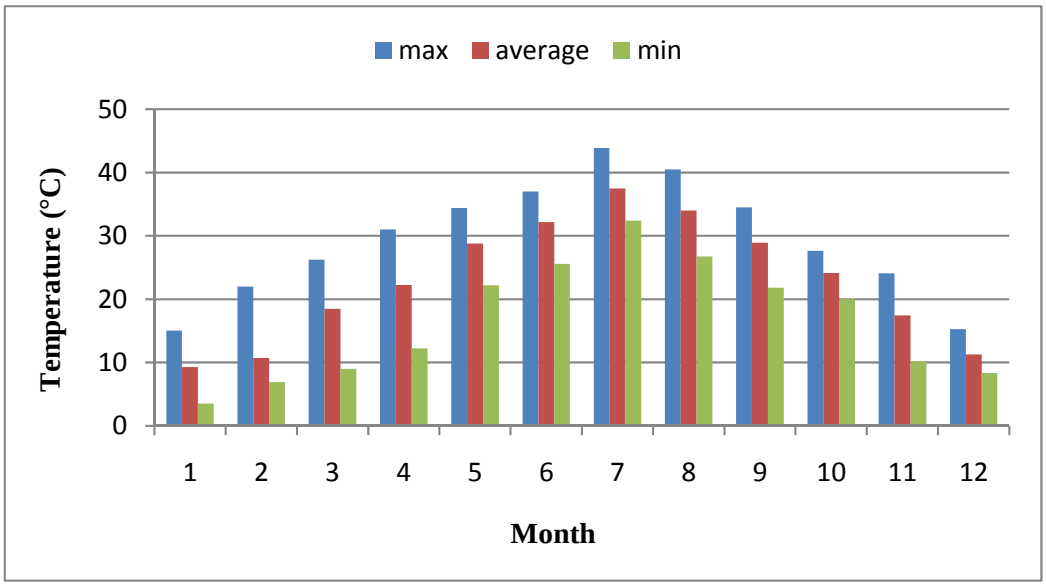

Figure 4. Monthly average daily means, minimum and maximum temperature

Table 2. Monthly averaged temperature (°C) of Ghardaïa

Month	Present Measurement	NASA SSE model (22-year average)
January	09.32	08.62
February	10.74	10.71
March	18.48	14.35
April	22.25	18.63
May	28.80	23.85
June	32.19	29.03
July	37.48	31.84
August	33.98	31.48
September	28.88	26.71
October	24.15	20.86
November	17.43	14.54
December	11.30	09.97
Annual	22.91	20.50

4. Conclusion

In this study, global solar radiation and temperature data were measured to get a better view of the solar energy potential in Ghardaïa area. The total solar radiation of Ghardaïa throughout the year, indicate a strong potential for utilizing solar energy. Daily average global solar radiation data show that average values are higher in the summer season from May to August and are comparatively lower in the winter months. The highest daily average solar radiation value of 369 (W/m^2) was measured on May 19, whereas the daily maximum global radiation of 1268 (W/m^2) was recorded on June 18. Average daily energy input throughout the year 2005 was 21.83 (MJ/m^2/day), which agrees with the global solar map. The NASA SSE model supports our measurement as a representative one.

The maximum temperature in the summer exceeds 48°C. The highest daily maximum and monthly average temperatures were 48.81°C and 43.87°C on 29 and 27 July.

Solar radiation in Ghardaïa area is promising; the higher values of global radiation energy recorded in summer season were 28 (MJ/m^2/day) and lower ones during winter were 14 (MJ/m^2/day).

References

[1] Karatasou. S, Santamouris. M, Geros. V. Analysis of experimental Data on diffuse solar radiation in Athens, GREECE, for building applications. International journal of sustainable energy 2003, 23(1-2), 1-11.
[2] Mustafa G. Analysis of daily total horizontal solar radiation measurements in Turkey. Energy sources 2001, 23, 563-570.
[3] Trabea. A.A. Analysis of solar radiation measurements at Al-Arish area, North Sinai, Egypt. Renewable Energy 2000, 20, 109-125.
[4] El Chaar L., Lamont L. A. Global solar radiation: Multiple on-site assessments in Abu Dhabi, UAE. Renewable Energy 2010, 35, 1596-1601.
[5] De Souzaa J L., Nicaciob R M., Mouraa M A L. Global solar radiation measurements in Maceio´, Brazil. Renewable Energy 2005, 30, 1203-1220.
[6] Islam M D., Kubo I., Ohadi M., Alili A. Measurement of solar energy radiation in Abu Dhabi, UAE. Applied Energy 2008, 35, 515-519.
[7] Ahmet Z S., Ahmet A., Mehmet S. Solar-energy availability in the Northeastern Arabian Peninsula. Applied Energy 1999, 64, 323-329.
[8] Chanchal K P., Katiyar A K. A note on diffuse solar radiation on a tilted surface. Energy 2009, 34, 1764-1769.
[9] Ahmet A., Shafiqur R. Global solar radiation in Northeastern Saudi Arabia. Renewable Energy 1999, 17, 461-472.
[10] http://eosweb.larc.nasa.gov/sse
[11] http://www.solar4power.com/map9-global-solar-power.html/
[12] Alnaser W E., Eliagoubi B., Al-Kalak A., Trabelsi H., Al-Maalej M., El-Sayed H M., Alloush M. First solar radiation atlas for the Arab world. Renewable Energy 2004, 29, 1085-1107.
[13] Oturanc G., Hepbasli A., Genc A. Statistical Analysis of Solar Radiation Data. Energy sources 2003, 25, 1089-1097.
[14] Wilcox S., George R., Myers D. Solar Radiation Data Set. A Solar Resource Assessment Workshop. Denver, Colorado, October 29, 2008.
[15] Stoffel T., Wilcox S. Solar Radiation Measurements. A Workshop for the National Association of State Universities and Land Grant Colleges, Hydrogen, Electric Technologies and Systems Center, August 4, 2004.
[16] Duffie J P., Beckman. Solar Engineering of thermal process. W.A, New York, 1991.
[17] Iqbal M. An introduction to solar radiation. Academic Press, Canada, 1983

K. Gairaa is engineer in mechanics (with specialization in energy) from University of Batna-Algeria in 2003, he work in scientific research as assistant researcher in renewable energy with five years of experience; he has ten works between communications and publications on national and international conferences/journals. Currently, he is responsible for characterization and evaluation of Ghardaïa's solar radiation and potential.
E-mail address: gisol47@gmail.com

Y. Bakelli is M.Sc in Automation from INHC University of Boumerdes-Algeria in 2006 He got his engineer degree in electronics from USTHB University in 1992, he work as researcher in Algerian renewable energy centre from 1993 until now in photovoltaic solar field; he has many research papers in international and national journals/conferences, currently he prepare Ph.D degree in Photovoltaic systems Characterisation.
E-mail address: bakelli_yahia@yahoo.fr

