International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-6, September 2015
ISSN: 2395-3470
www.ijseas.com

Study Monthly variation of solar radiation with temperature result from Satellite and actual measurements over Kuwait

Essam El-Demerdash

Kuwait Meteorology, Kuwait.

Abstract

This paper compares the daily solar irradiation available at surface estimated by Satellite against qualified ground measurements made in stations located in Kuwait. Study solar radiation variation result from Satellite and actual measurements over Kuwait. The annual variation of solar radiation from actual measurements and satellite over Kuwait studied. Also studied monthly variation of solar radiation result from actual and satellite measurements over Kuwait. This variation studied with some factors effect on this variation, as clouds, and Gulf wars.

Using the clearness index, also known as atmospheric transmissivity or transmittance, this study evidences that the re-analyses often predict clear sky conditions while actual conditions are cloudy. The opposite is also true though less pronounced: actual clear sky conditions are predicted as cloudy. In regions where clouds are rare, e.g. Kuwait may be used to provide a gross estimate of monthly or yearly irradiation. Satellite-derived data sets offer less uncertainty and should be preferred ground stations.

Introduction

The solar radiation impinging at ground level is an essential variable in solar energy. It is often called surface solar irradiance or irradiation (SSI) in solar energy, solar flux or solar exposure when dealing with measurements, and down welling shortwave flux, or down welling surface shortwave flux in numerical weather modeling.

The present article deals with the surface daily solar irradiation, i.e. the energy received per surface unit during a day.

Study the variation of actual solar radiation measurements by using Kuwait and Jahra stations. Applications under concern are construction of time-series or maps for locating favorable areas for solar plants, pre-feasibility studies or monitoring of existing plants.

There are several means to assess the daily irradiation [6]. Ground measuring stations and satellite observations are two of them, sometimes in combination [2, 13].

Models for weather forecasts are used in a re-analysis mode to reproduce what was effectively observed. The SSI in re-analyses is diagnostic. It is computed by a radiative transfer model and hence depends on the representation of the whole set of radiatively active variables of the atmospheric column above the point. There are several available re-analyses.

Advantages of re-analyses for companies and practitioners in solar energy are the worldwide coverage, the multi-decadal temporal coverage, and their availability at no cost. Re-analysis estimates should not be mistaken with observed data in SSI because while the re-analysis method assimilates state variables such as temperature, moisture and wind, physics variables such as radiation and cloud properties derive from a model and include the uncertainty of this model. However, because of the advantages listed above in coverage, availability and costs, re-analyses are appealing to companies and several are using re-analyses in their daily work.

This paper aims at establishing the quality of re-analyses when compared to qualified ground measurements. Our study complements their work and other similar studies in meteorology for limited areas and adds more evidence by comparing Satellite re-analyses ground stations located in Kuwait. The limitation in geographical coverage of the present study is explained by the expertise of the authors who are dealing with this area for long. Our study reports on re-analyses, a comparison is also performed with the database HelioClim-1 of daily irradiation created by MINES Paris Tech within the HelioClim project [3] and extensively validated against ground measurements. HelioClim-1 is a well-known database of easy access on the Web at no cost with many

usages and approximately 400 requests per working day [8]. It will be seen whether the re-analyses offer better accuracy than HelioClim-1. Refs. [4, 24] have compared measurements made at several ground stations located in the same area: Mozambique, to HelioClim-1 and have found that though Mozambique is fairly homogeneous regarding SSI, the differences between HelioClim-1and ground measurements are spatially variable. Similar conclusions were reported by Ref. [1] for North Africa (Algeria, Egypt and Tunisia) and Ref. [10] for Southern Africa. This paper examines whether re-analyses exhibit less variable errors in homogeneous climatic areas.

The statistical criteria are first monthly variation of temperature the coefficient of determination for direct radiation is 0.62, with the root mean square error (RMSE) of 11.7 W/m^2 and the mean absolute error (MAE) of 9.4%. Secondly monthly variation of solar radiation the coefficient of determination for direct radiation is 0.92, with the root mean square error (RMSE) of 7.55 W/m^2 and the mean absolute error (MAE) of 6.14%.

====================================

2. Material and methods

==================================

2.3. HelioClim-1 database

The Helio Clim Project is an ambitious initiative of MINES Paris Tech launched in 1997 after preliminary works in 80's [3] to increase knowledge on the SSI and to offer SSI values for any site, any instant over a large geographical area and long period of time, to a wide audience. The project comprises several databases that cover Europe, Africa and the Atlantic Ocean. These databases use satellite images as inputs for their creation and updating. The HelioClim-1 database offers daily means of the SSI for the period 1985-2005. The accuracy of the HelioClim-1 data has been assessed by comparison with ground measurements made by high-quality pyranometers on a daily basis. If well-calibrated and well-maintained, these pyranometers exhibit a relative uncertainty of 10% of the daily mean of SSI at a 95 per cent confidence level [12]. Ref. [9] compared 55 sites in Europe for the period June 1994eJuly 1995 and 35 sites in

Africa for the period 1994-1997. Ref. [1] compared HelioClim-1 data with ground measurements in Algeria, Egypt, and Tunisia. Refs. [4, 11] performed a similar study for Mozambique, while Ref. [10] focused on Southern Africa. These works demonstrated that the HelioClim-1 database offers good quality for Africa, the Mediterranean Basin, and more generally for latitudes comprised between – 45^{o} and + 45^{o}. Outside these limits, the quality may decrease because of the characteristics of the satellite images used for the construction of HelioClim-1 [3] though this is not a systematic effect and local conditions may prevail. The HelioClim-1 has many usages as illustrated by published works in various domains: oceanography, climate, energy production, life cycle analysis, agriculture, ecology, human health, and air quality [8]. The Global Earth Observation System of Systems (GEOSS) is a project aiming at proactively linking together existing and planned observing systems around the world and supporting the development of new systems where gaps currently exist. The GEOSS Data-CORE (GEOSS Data Collection of Open Resources for Everyone) is a distributed pool of documented data sets with full, open and un-restricted access at no more than the cost of reproduction and distribution. The HelioClim-1 database has been identified as a Data-CORE by the GEOSS in November 2011 [7]. Previously, Helio Clim-1 was open to researchers and students at no cost on a case-by-case basis. HelioClim-1 can easily be accessed at no cost on the Web (www.soda-is.com).

=====================================

2.4. Ground measurements

Environment Public Authority stations measure solar radiation in Kuwait, and by using the measurements of these stations and make check on it, then start to use it in our research.

==

2.5. Method for comparison

Comparison was carried on the SSI and the clearness index (KT). If E denotes the daily SSI and E_0 denote the daily irradiation received on a horizontal surface at the top of atmosphere, KT is defined as: KT ¼ E = E_0 (1)

The clearness index is also called global transmissivity of the atmosphere, or atmospheric transmittance, or atmospheric transmission. The greater KT is the clearer the atmosphere. Values of KT around 0.7 denote clear sky conditions. The changes in solar radiation at the top of the atmosphere is due to changes in geometry, namely the daily course of the sun and seasonal effects. KT is a stricter indicator of the performances of a model regarding its ability to estimate the optical state of the atmosphere. E_0 is a function of the day in the year and of the solar constant which is the mean yearly value of the solar radiation received by a plane normal to the sun rays located at the top of atmosphere. E_0 in Eq. (1) is estimated by the model of Ref. [5]. The solar constant in this model is 1367 W m□2, equal to that used in HelioClim-1. The deviations were computed by subtracting measurements from re-analyses estimations and HelioClim-1. These deviations are summarized by the bias, i.e. the mean value of the deviations, the standard-deviation, the root mean square error (RMSE), and the correlation coefficient. Relative bias and RMSE are also computed by dividing the bias and the RMSE by the mean value of the observations for the station under concern. The deviations are computed separately for each re-analysis and HelioClim-1. Consequently, the number of samples and the mean of the observations may vary slightly.

The statistical criteria used are the coefficient of determination (R2), the root mean square error (RMSE), and the mean absolute error (MAE), as defined in the following:

$$R^2 = \frac{\left(\sum_{i=1}^{N}\left(F_{Pred,i} - F_{Pred}\right)\left(F_{Meas,i} - F_{Meas}\right)\right)^2}{\sum_{i=1}^{N}\left(F_{Pred,i} - F_{Pred}\right)^2 \sum_{i=1}^{N}\left(F_{Meas,i} - F_{Meas}\right)^2}$$

International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-6, September 2015
ISSN: 2395-3470
www.ijseas.com

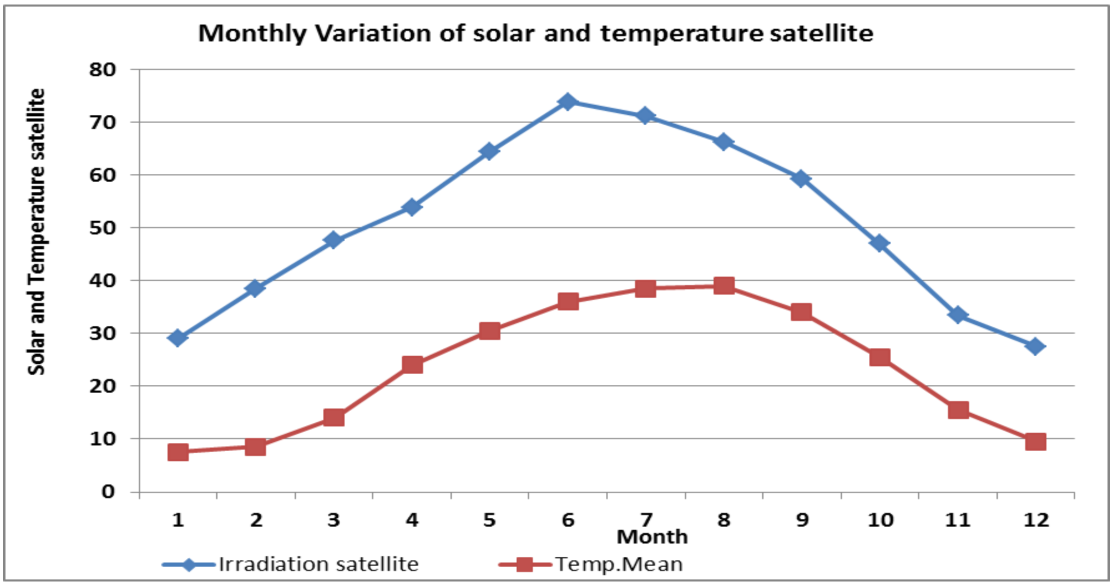
$$\text{RMSE} = \left[\frac{\sum_{i=1}^{N}(F_{Pred} - F_{Meas})^2}{N}\right]^{0.5}$$

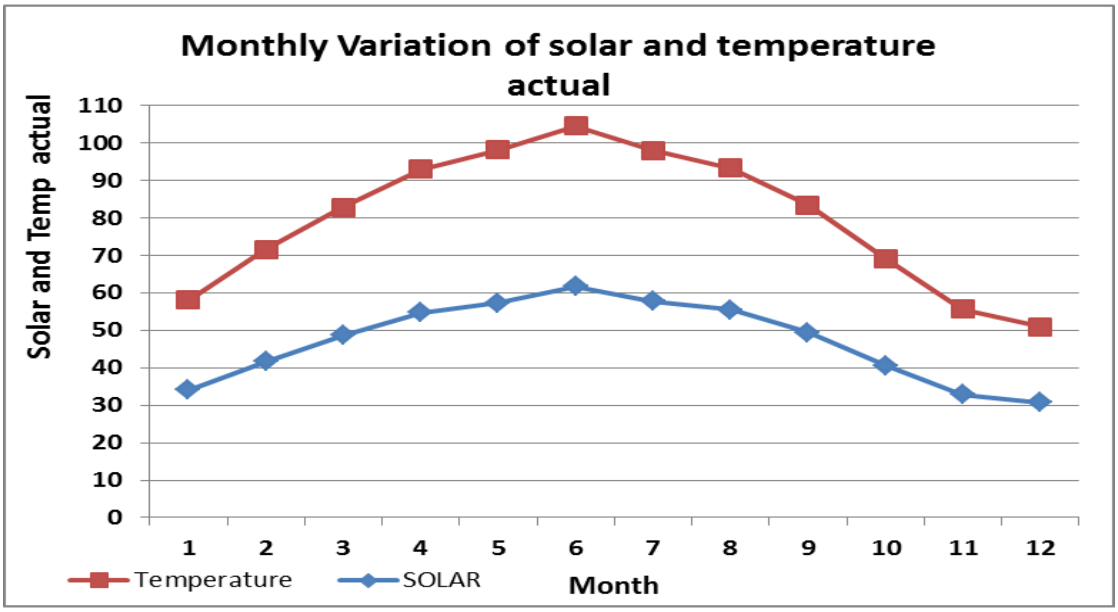
$$\text{MAE} = \frac{1}{N}\left[\sum_{i=1}^{N}\frac{(F_{Pred} - F_{Meas})}{F_{Meas}}\right]$$

Where $F_{Pred,I}$ and $F_{Meas,i}$ are the i_{th} predicted and measured data, F_{Pred} and F_{Meas} are the mean values of the predicted and measured data

===========================

3. Results





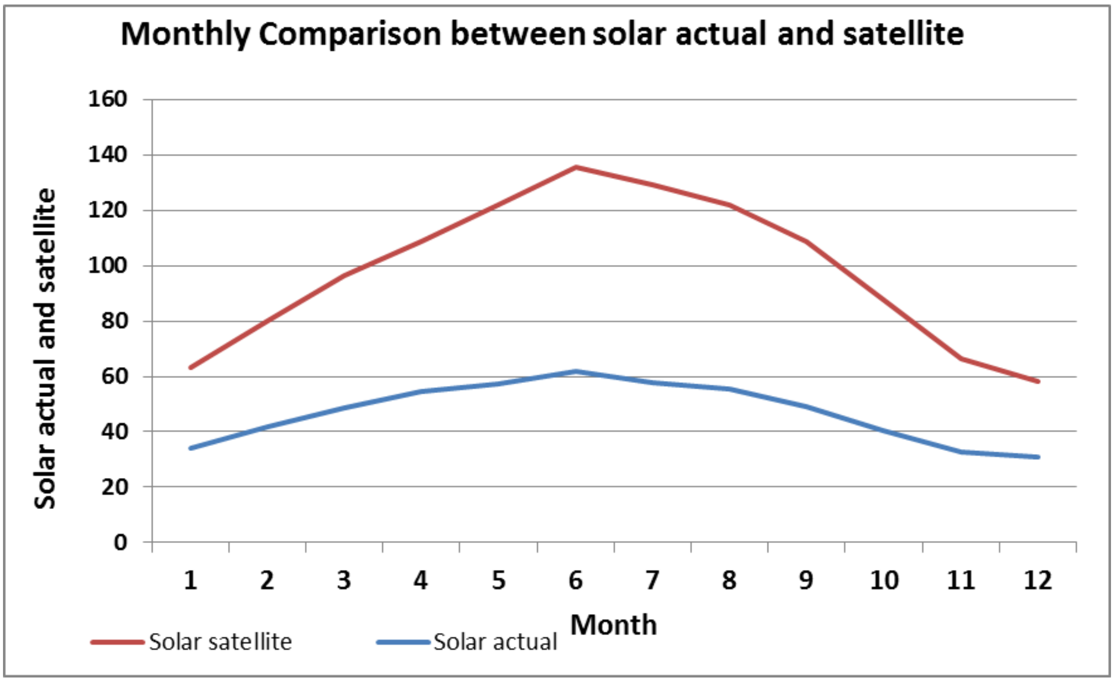
Figures (1, and 2): Monthly variation comparison

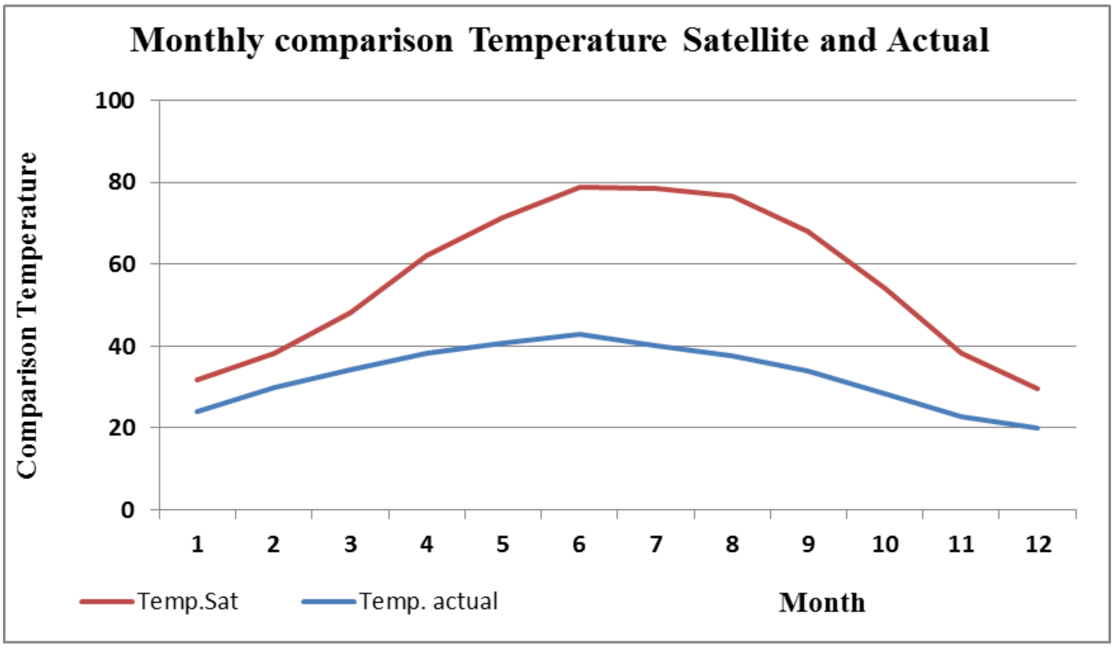
Figures (1, and 2) are Monthly variation comparison solar irradiation plots with temperature for for Kuwait city, and Jahra city in Kuwait. These stations were selected for their different by ratio in climate due to its nature. The soil is generally sandy and the sky is very clear in boreal summer.

Fig. 1 and 2 give the monthly variation SSI measurements from HelioClim-1 estimates plot with temperature for Kuwait city, and Jahra city in Kuwait.

==

International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-6, September 2015
ISSN: 2395-3470
www.ijseas.com





Figures (3, and 4): Monthly variation

Figures (3, and 4) are Monthly variation comparison solar irradiation plots with actual temperature for Jahra, and Kuwait cities. Fig. 3 and 4 give the monthly variation SSI measurements from HelioClim-1 estimates plot with ground measurements temperature for Jahra, and Kuwait cities.

====================================

4. Discussion

Figures (1, and 2) are Monthly variation comparison solar irradiation plots with temperature for for Kuwait city, and Jahra city in Kuwait. These stations were selected for their different by ratio in climate due to its nature. The soil is generally sandy and the sky is very clear in boreal summer.

Fig. 1 and 2 give the monthly variation SSI measurements from HelioClim-1 estimates plot with temperature for Kuwait city, and Jahra city in Kuwait.

Also Figures (3, and 4) are Monthly variation comparison solar irradiation plots with actual temperature for Jahra, and Kuwait cities.

Fig. 3 and 4 give the monthly variation SSI measurements from HelioClim-1 estimates plot with ground measurements temperature for Jahra, and Kuwait cities.

The statistical criteria are first monthly variation of temperature the coefficient of determination for direct radiation is 0.62, with the root mean square error (RMSE) of 11.7 W/m^2 and the mean absolute error (MAE) of 9.4%. Secondly monthly variation of solar radiation the coefficient of determination for direct radiation is 0.92, with the root mean square error (RMSE) of 7.55 W/m^2 and the mean absolute error (MAE) of 6.14%.

=====================================

5. Conclusion

From figures we note that solar radiation and temperature values from HelioClim-1 are agreement in behavior in increasing and decrease in the two cities. Also Note that agreement between solar radiation and temperature values from ground measurements. Finally found that the agreement in the two cities between temperature calculated by Helio Clim-1 and ground measurement although different values use in its.

We remark that the values of temperature calculated from Helio Clim-1 are the average value from maximum and minimum values. And because of that the calculated values did not take into account the effect of seasons of the year in terms of extreme weather clouds and dust on the amount of radiation also effect of Aerosols Optical Depth.

And because of that the calculated values did not take into account the effect of seasons of the year in terms of extreme weather clouds and dust on the amount of radiation also effect of Aerosols Optical Depth.

And shows that radiation in Kuwait higher rate than normal or average radiation anywhere else, and confirms that climate change in Kuwait Result and discussion.

==

Acknowledgements

The authors thank the company Transvalor which is taking care of the SoDa Service for the common good, therefore permitting an efficient access to the HelioClim databases.

==

References

[1] Abdel Wahab M, El-Metwally M, Hassan R, Lefevre M, Oumbe A, Wald L. Assessing surface solar irradiance in Northern Africa desert climate and its long-term variations from Meteosat images. Int J Remote Sens 2009; 31: 261-80. http://dx.doi.org/10.1080/01431160902882645.

[2] Beyer H-G, Czeplak G, Terzenbach U, Wald L. Assessment of the method used to construct clearness index maps for the new European Solar Radiation Atlas (ESRA). Sol Energy 1997;61:389-97. http://dx.doi.org/10.1016/S0038-092X(97)00084-4.

[3] Blanc P, Gschwind B, Lefevre M, Wald L. The HelioClim project: surface solar irradiance data for climate applications. Remote Sens 2011a;3:343-61.

http:// dx.doi.org/10.3390/rs3020343.

[4] Blanc P, Gschwind B, Lefevre M, Wald L. Validating Meteosat-derived surface solar irradiance in Mozambique. In: Halounova L, editor. Proc. 30th EARSeL symposium. Thermal remote sensing; 2011. p. 561e8. held in Prague, Czech Republic, 30 May - 2 June 2011. Available at: http://www.earsel.org/symposia//2011-symposium-Prague/Proceedings/.

[5] Blanc P, Wald L. The SG2 algorithm for a fast and accurate computation of the position of the Sun. Sol Energy 2012;86:3072e83. http://dx.doi.org/10.1016/ j.solener.2012.07.018.

[6] Cros S, Mayer D, Wald L. The availability of irradiation data. Report IEA-PVPS T2-04: 2004. Vienna, Austria: International Energy Agency; 2004. p. 29.

[7] GEOSS. SoDa service releases 21 years of data on surface solar radiation. CORE; 2011. Available at: www.earthobservations.org/art_012_004.shtml.

[8] Lefevre M, Blanc P, Espinar B, Gschwind B, Menard L, Ranchin T, et al. The HelioClim-1 database of daily solar radiation at earth surface: an example of the benefits of GEOSS data-CORE. IEEE J Sel Top Appl Earth Obs Remote Sens 2014;7(5):1745-53. http://dx.doi.org/10.1109/JSTARS.2013.2283791.

[9] Lefevre M, Diabate L, Wald L. Using reduced data sets ISCCP-B2 from the Meteosat satellites to assess surface solar irradiance. Sol Energy 2007;81: 240-53. http://dx.doi.org/10.1016/j.solener.2006.03.008.

[10] Lefevre M, Wald L. Solar radiation in Southern Africa: assessing the quality of the HelioClim-1 database. In: 9th EMS conference, Lodz, Poland, 10-14 September 2012.

[11] Wald L, Blanc P, Lefevre M, Gschwind B. The performances of the Helio Clim databases in Mozambique. In: Proceedings ISES solar world congress 2011, 28 August- 2 September 2011, Kassel, Germany. Resource assessment; 2011.p. 268-75.

[12] WMO. Guide to meteorological instruments and methods of observation. 7th ed. Geneva, Switzerland: World Meteorological Organization; 2008,WMO-No 8.

[13] Zarzalejo L, Polo J, Martin L, Ramirez L, Espinar B. A new statistical approach

for deriving global solar radiation from satellite images. Sol Energy 2009;83:480-4. http://dx.doi.org/10.1016/j.solener.2008.09.006.