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Investigations of the measured solar radiation, relative humidity and atmospheric temperature and their relations at Dhofar University

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ABSTRACT

Salalah is one of the marvelous cities in Oman with a distinguished climate during the year. It locates at 17.0167° N, and 54.0929° E. We measured the Solar Flux, Relative Humidity and Atmospheric Temperature at Dhofar University every minute and daily through winter season (December, 21 to March, 21). The maximum, minimum, average, and accumulative parameters were calculated. The best time, day, and month of Solar Flux are found. The relations between different weather parameters are discussed. The parameters of atmosphere at Dhofar University are calculated and discussed.

Solar energy is one of the best sources of renewable energy. It is clean, safe, and none- pollutant for environment. It is known that one hour of solar energy reached the surface of the earth equivalent to all needs of energy for all humans on the earth for one year. Solar energy data is vital for doing feasibility studies for solar energy systems. Solar data are needed in many applications like designing: PV systems, solar collectors, solar dryers, and in buildings (Can Ertekin 1999 and Sabziparvar 2007). Solar flux reaching the earth surface is the main source among all types of known renewables. Solar data values of direct normal irradiance allow one to derive precise information about the performance of solar energy systems (Gabriel Lopez 2000). There are different techniques and devices used to measure the solar radiation. The received solar energy depends on the time during a day and during the season. Also it depends on the geographical place (Scharmer 2000). For a country like Oman, the economical and efficient application of solar energy is dependant on solar data. Different types of devices can be used to measure the solar flux like: pyrheliometer, pyranometer (Paulescu 2013). The collected solar data is very important for researchers or any person working in the solar field. There are many scientists used different models to predict the solar flux.

In the present work, solar energy measurement have been done for the first time at Dhofar University (AlSaadah-Salalah) to utilize solar energy for useful purposes.

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AlSaadah-Salalah is at 17.0167° N, and 54.0929° E. There are different places where are several researches measure the solar data like Hyderabad-Pakistan (Akhlaque 2009), Saudi Arabia (Mohandas 2010) and Turkey (Ozgoren 2012).

2. EXPERIMENTAL

We installed the Automated Weather Station (AWS) on the roof of the Chemical Engineering Department – College of Engineering- Dhofar University- AlSaadah-Salalah-Oman. The station composed of pyranometer (first class), and relative humidity/atmospheric temperature (RH/AT). The specifications of the pyranometer and the RH/AT are illustrated in Tables 1 and 2, respectively. The AWS is bought from Coastal Environmental Systems, Inc.

The pyranometer used is first class (S80124, coastal Environmental Systems). This is a solar radiation sensor that can be applied in scientific grade solar radiation observations. It complies with the "first class" specifications within the latest ISO and WMO standards. The scientific name of this instrument is pyranometer.

It serves to measure the solar radiation flux that is incident on a plane surface in W/m^2 from a 180 degrees field of view (also called "global" solar radiation). Working completely passive, using a thermopile sensor, the sensor generates a small output voltage proportional to this flux. Employing two glass domes, certain measurement errors are reduced; in particular thermal offsets, so that a high measurement accuracy can be attained. The sensor can directly be connected to most commonly used data logging systems. It can be used for scientific meteorological observations, building physics, climate- and solar collector testing. A common application is for outdoor solar radiation measurements as part of a meteorological station. This application requires horizontal leveling; leveling feet and a level are included. The cable can easily be installed or replaced by the user. Applicable standards are ISO 9060 and 9847, WMO (World Meteorological Organization), and ASTM E824-94. It can also be used for stability estimations according to EPA.

Pyranometer specifications:
ISO classification: first class
Spectral range: 305 to 2800 nm
Sensitivity (nominal): 15 μV/ Wm^{-2}
Temperature range: -40 to +80°C
Range: 0 to 2000 Wm^{-2}
Temperature dependence: < 0.1%/°C
Calibration traceability: WRR

The relative humidity and air temperature sensor is compact and easy to use. The relative humidity element is a hygroscopic capacitive type. It is fully interchangeable. These elements never need calibration. Instead, elements can be easily replaced without the expense and inconvenience sometimes associated with the calibration process. The membrane filter/mechanical housing of the sensor protects it from dust and dirt.

Specifications of RH:
RH Accuracy: +/- 3%
RH Resolution: 0.1%
RH Range: 0 - 100% RH
Operational Temperature Range: -30°C to +60°C
Storage Temperature: -80°C to +80°C
AT Accuracy: +/- 0.6°C
Time Constant, Max: 1 second in well-stirred oil 15 seconds in still air
Shield: Gill multi-plate naturally ventilated shield
Typical Error In Full Sunlight: 0.5°C

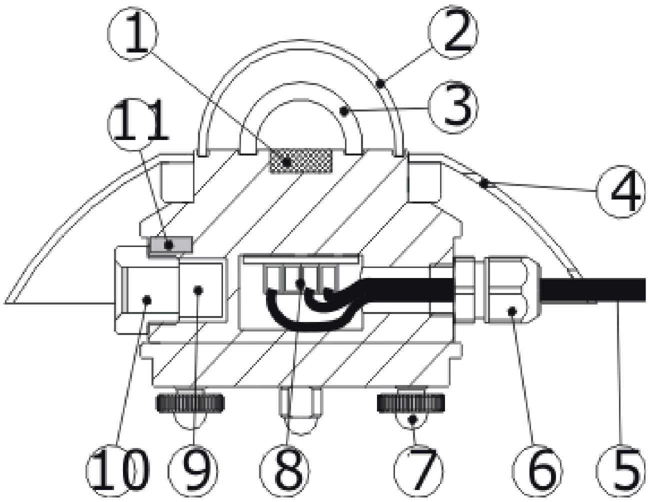

Fig. 1 Solar radiation sensor: (1) sensor, (2, 3) glass domes, (5) cable, standard length 5 m, (9) desiccant

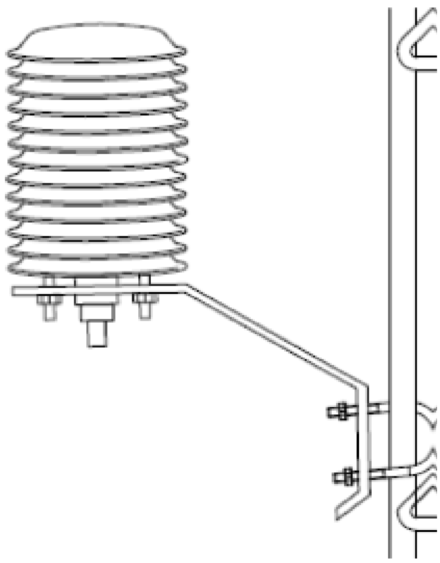
Fig. 2 RH/AT sensors included in the AWS

The AWS is connected to a PC and controlled by software (INTERCEPT V1.17.62). The AWS is working day and night continuously recording the readings every minute. The collected data are processed, analyzed and plotted.

The AWS is shown in Fig. 3.

Fig. 3 Automated weather station at Dhofar University

3. RESULTS AND DISSCUSION

The solar flux (W/m^2), RH (%), and AT (°C) are recorded every minute for 24 hours continuously. The files are converted into excel extension. The data is processed and plotted. Different calculations are done. These calculations include: 1. maximum solar flux (SF), accumulative SF, and average SF. 2. Maximum relative humidity (RH), and average RH. 3. Maximum atmospheric temperature (AT), and average AT. These are done during a day, during a month, and during winter season. Fig. 4 below illustrates the collected SF, RH and AT for December 1, 2012.

We see from Fig. 4 that the 1. Maximum: SF is 807.000 W/m^2 occurred at 11:58 and 11:59; RH is 57% occurred at 6:23-7:09; and AT is 30°C at 15:04-15:55. 2. Average during the day: SF is 476.532 W/m^2; RH is 39.814%; and AT is 25.8°C. 3. Accumulative during the day: SF is 323,089 W/m^2. 4. Minimum: SF is 0 W/m^2 where there is no sun light; RH is 30% at 16:05; and AT is 21.5°C at 6:36.

The relation between (SF, RH, and AT) maximum, minimum and average, (SF) accumulative during December 2012 is shown in Figs. 5, 6, and 7.

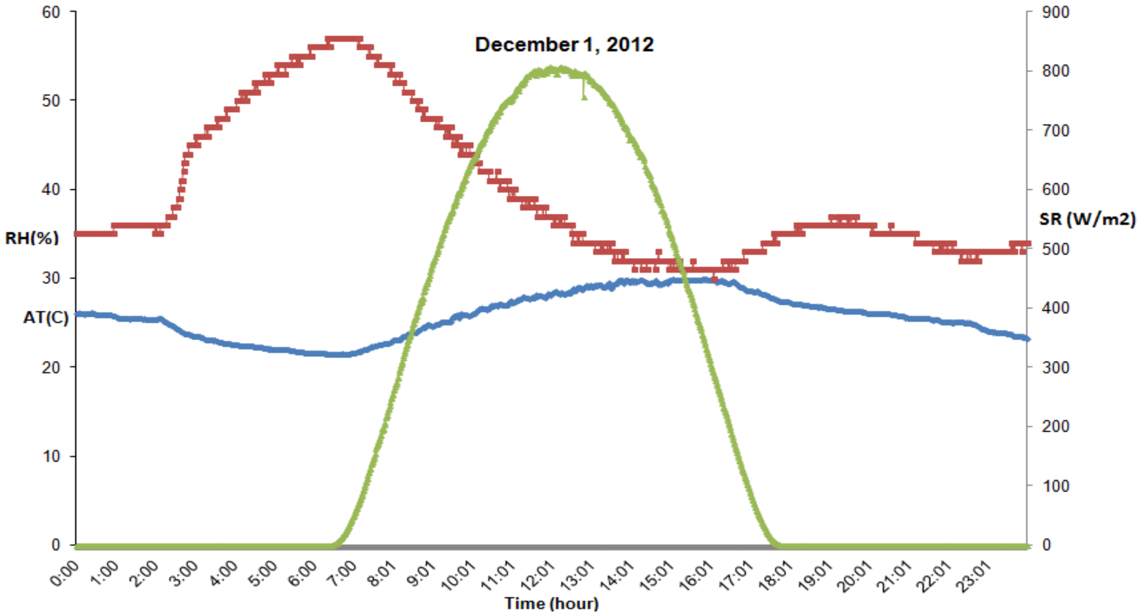

Fig. 4 SF, RH and AT during December 1, 2012

For December 2012 we found from Figs. 5, 6, and 7 that: Maximum SR is 1051 W/m^2 occurred at day 9 and at time 12:22. Maximum RH is 82% occurred at day 9 and at time 1:39. Maximum AT 35.5°C at day 12 and 13 where the time is 10:08 and 8:50, respectively.

The same calculations are done for the rest months of winter (January, February, and March). The results are summarized in Tables 3, 4, and 5 below.

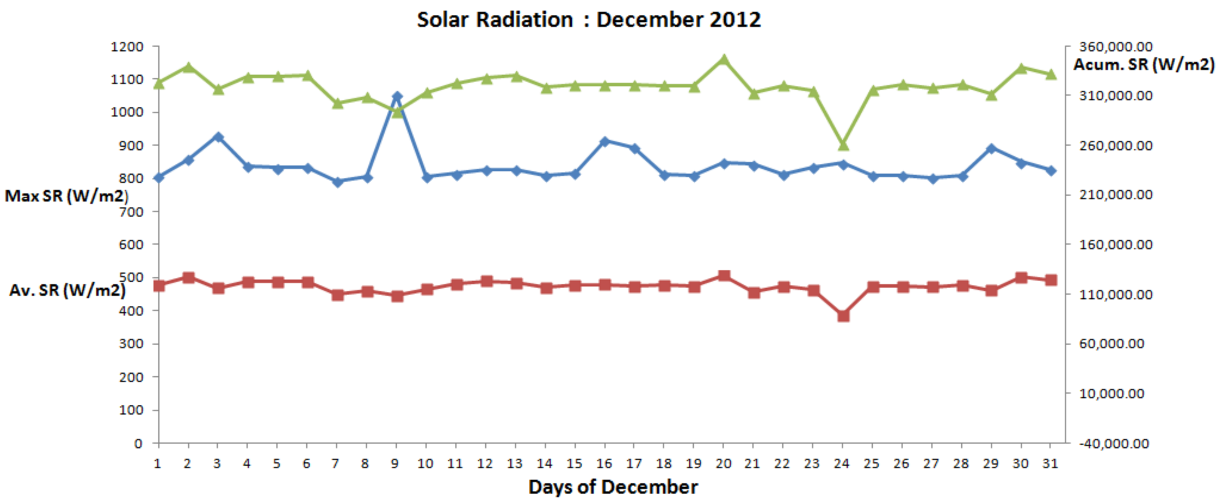

Fig. 5 Maximum, Average and accumulative SF for December

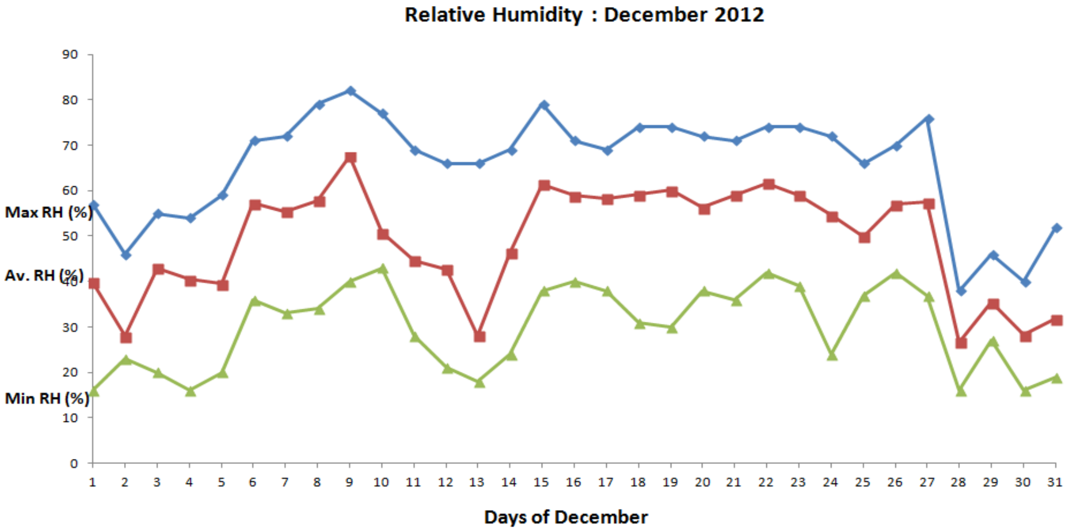

Fig. 6 Maximum, minimum and average RH for December 2012

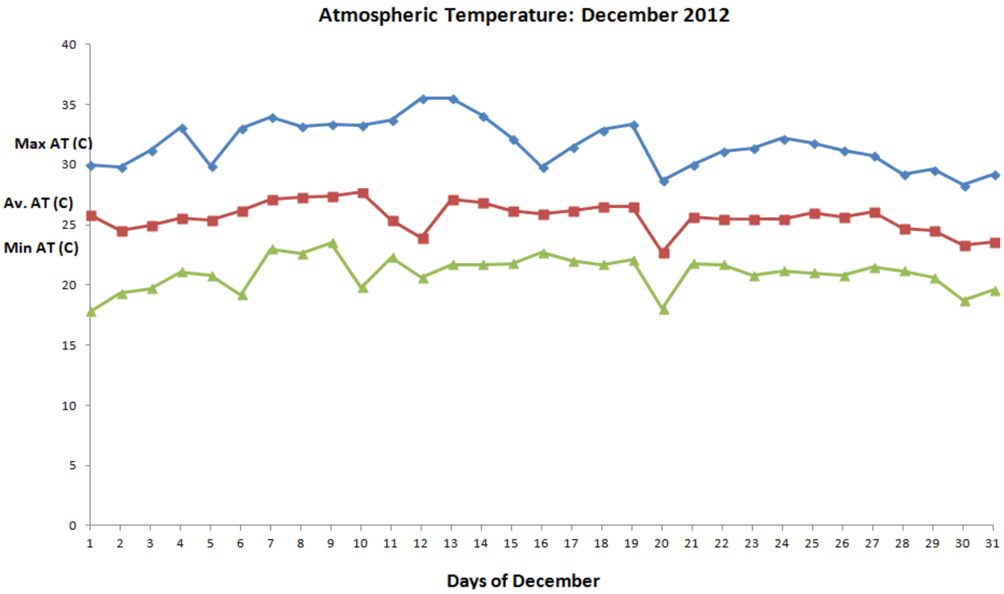

Fig. 7 Maximum, minimum and average AT for December 2012

Table 3 Maximum, average accumulative SF for winter season

Month	Max			Accumulative (W/m^2)
	Value (W/m^2)	Day	Time	
December 2012	1051	9	12:22	9,904,771
January 2013	1282	29	12:25	9,599,519
February 2013	1249	12	12:36	10,670,886
March 2013	1360	26	12:18	12,586,630

Table 4 Maximum, average RH for winter season

Month	Max			Average (%)		
	Value (%)	Day	Time	Max	Average	Min
December 2012	82	9	1:39	65.81	48.91	29.74
January 2013	75	9 30	5:20 6:06	61.2	47.57	30.6
February 2013	88	3	5:38-5:47	65.25	49.79	32.28
March 2013	88	26	3:38-339	72.03	50.57	31.06

Table 5 Maximum, average AT for winter season

Month	Max			Average (°C)		
	Value (^{o}C)	Day	Time	Max	Average	Min
December 2012	35.5	12 13	10:08 8:50	31.71	25.68	20.98
January 2013	32.3	3	11:24	28.84	23.24	19.07
February 2013	32.2	15	16:15	29.38	24.06	19.66
March 2013	36.4	8	9:43	32.24	26.82	22.35

From the previous tables, March is the best month in winter for solar energy conversion.

There are many solar data measurements in different places in the world like Turkey (Can Ertekin 1999, Ozgoren 2012), Saudi Arabia (Mohandas 2010), Pakistan (Akhaque 2009), Iran (Sabziparvar 2007) and Spain (Lopez 2000).

3. CONCLUSIONS

The collected data in Dhofar University revealed that the region (AlSaadah-Salalah) is one of the places that have a plenty of solar radiation that can be used for different purposes for solar energy conversion applications. The maximum SF (1360 w/m^2) and the maximum accumulative SF (12,586,630W/m^2) is in March. The maximum RH (88%) occurred in March and the minimum values is in December (29.74%). The maximum AT (36.4°C) occurred in March while the minimum value (19.07°C) is in January.

So, we conclude that March is the best month in winter for solar energy conversion at Dhofar University.

Acknowledgements

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