

ESTIMATION OF GLOBAL SOLAR RADIATION FROM SAURAN STATIONS IN SOUTH AFRICA USING AIR TEMPERATURE BASED HARGREAVES-SAMANI & CLEMENCE MODELS

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RENEWABLE ENERGY POSTGRADUATE SYMPOSIUM CONFERENCE

2018

LAYOUT OF THE PRESENTATION

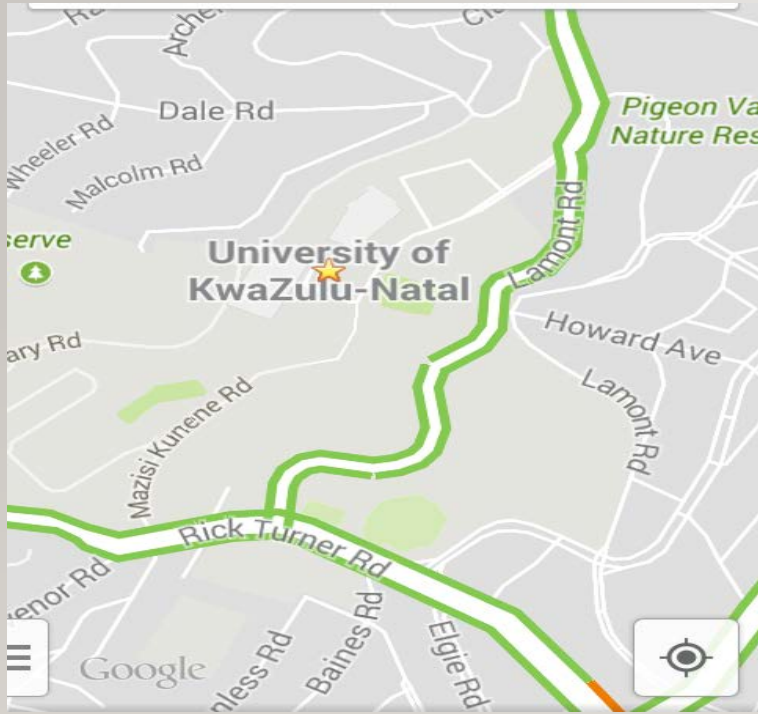
- Introduction
- Study area
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- In 2020 renewable energy is expected to supply 15% of electricity in South Africa [4-6].
- knowledge of solar radiation data is important for designs and installation of solar designs [4-6].
- Global solar radiation is the total amount of solar energy received from the surface.
- Availability of quality measuring equipment (pyrheliometer and pyranometer) in South Africa[6].
- Several empirical methods have been developed for estimating global solar radiation.
- 11 SAURAN station sites in South Afrika .
- Reliability of temperature data from KZH SAURAN station.
- This study focuses on estimating global solar radiation using the air temperature data from one of the South African Universities Radiometric Network (SAURAN) stations around South Africa.
- Hargreaves-Samani & Clemence models use air temperature data only, Hence they were selected.

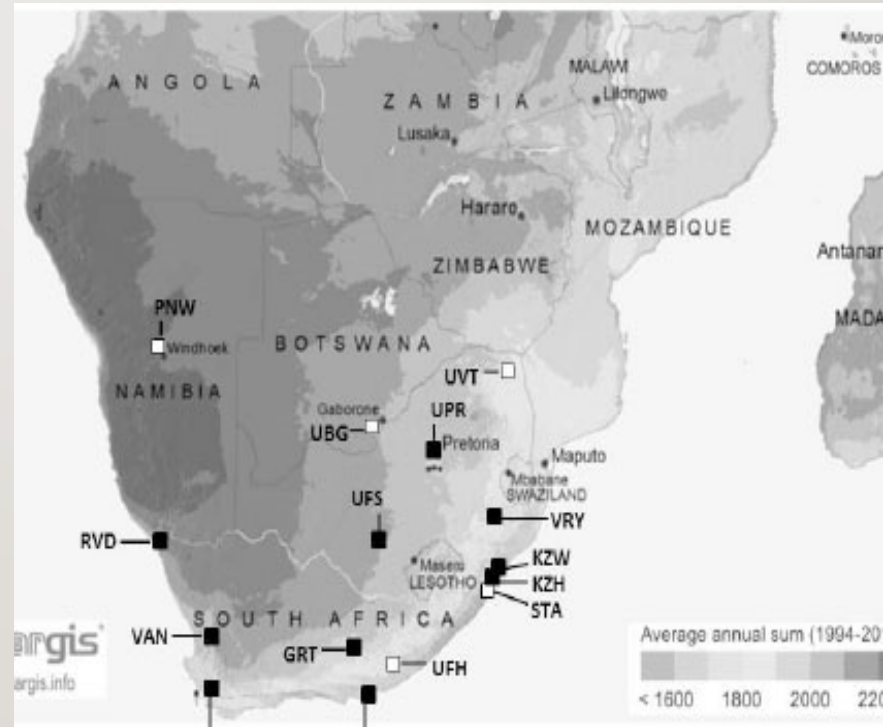
STUDY AREA

- There are 11 SAURAN stations installed in South Africa [9,10].
- The station under study is University of Kwazulu – Natal Howard college (KZH), situated in Durban at Kwazulu- Natal Province, South Africa
- KZH is situated in a coastal area [9,10]
- It consists of the following geographic coordinates: latitude (29.87098 ° E), longitude (30.97695° S) and altitude (150 m) [9,10].
- The following picture1 shows the geographical location of KZH.
- Picture 2 shows the places where the SAURAN station are installed.
- Active SAURAN stations are marked with black.

- Picture 1



- Picture 2



METHODOLOGY

- Three years air temperature data (2014-2016) was downloaded from SAURAN stations.
- Data analysis
- KZH SAURAN station data complete.
- Hence KZH station was selected for this study
- Extraterrestrial solar radiation(H_o) was calculated through MATLAB software.

- $$H_o = \frac{24 * I_{sc}}{\pi} \left[1 + 0.033 \cos \left(360 * \right.$$

solar radiation [8,13,14].

- Equations (2) and (3) were used
- The models use daily minimum (T_{min}) and maximum air temperature(T_{max}) data as inputs [13].
- $$H = K_r H_o \sqrt{T_{max} - T_{min}} \quad (2)$$
- $K_r = 0.19$ [14]
- Clemence model was designed for estimating global solar radiation in south African sites which record air temperature only (16).
- The model gives H as: $H = (1.233 * H_o * \Delta T + 10.593 * T_{max} - 0.713 * T_{max} * \Delta T +$

METHODOLOGY CONTINUES

- The two models are validated statistically using the computational MATLAB software. [17,18]
- i.e. Mean Bias Error (MBE), Root Mean Square Error (RMSE), Mean Percentage Error (MPE), coefficient of determination (R^2) and t-statistic test (t) [17,18]
- R^2 is used to assess the performance of the model [18].

- The following equations were used to express the statistical analysis:

- $$RMSE = \left[\frac{1}{n} \sum_{i=1}^n (H_{im} - H_{ie})^2 \right]^{\frac{1}{2}}, \quad (6)$$

- $$MBE = \frac{1}{n} \sum_{i=1}^n (H_{im} - H_{ie}) \quad (7)$$

- $$MPE = \frac{1}{n} \sum_{i=1}^n \left(\frac{H_{im} - H_{ie}}{H_{im}} \right) \times 100\% , \quad (8)$$

- $$R^2 = \left[1 - \sum_{i=1}^n \frac{(H_{im} - H_{ie})^2}{(H_{im} - \bar{H}_{im})^2} \right] \quad (9)$$

- $$t = \left[\frac{(n-1)(MBE)^2}{(RMSE)^2 - (MBE)^2} \right]^{1/2} \quad (10)$$

METHODOLOGY CONTINUES

- where, H_{im} and H_{ie} represents the i^{th} measured daily global solar radiation values and estimated daily global solar radiation values respectively[17,18]
- n denotes the total number of observations, $\overline{H_{im}}$ denotes the mean measured global solar radiation and $n-1$ represents the degrees of freedom [18].

RESULTS AND DISCUSSION

- The estimated global solar radiation data are then compared with the observed global solar radiation .
- MATLAB software was used to plot scattered plots
- Three scattered plots for the years 2014 - 2016 are presented below as figures 1-3 .
- Figure 1: Comparison between estimated and measured global solar radiation for KZH station in 2014

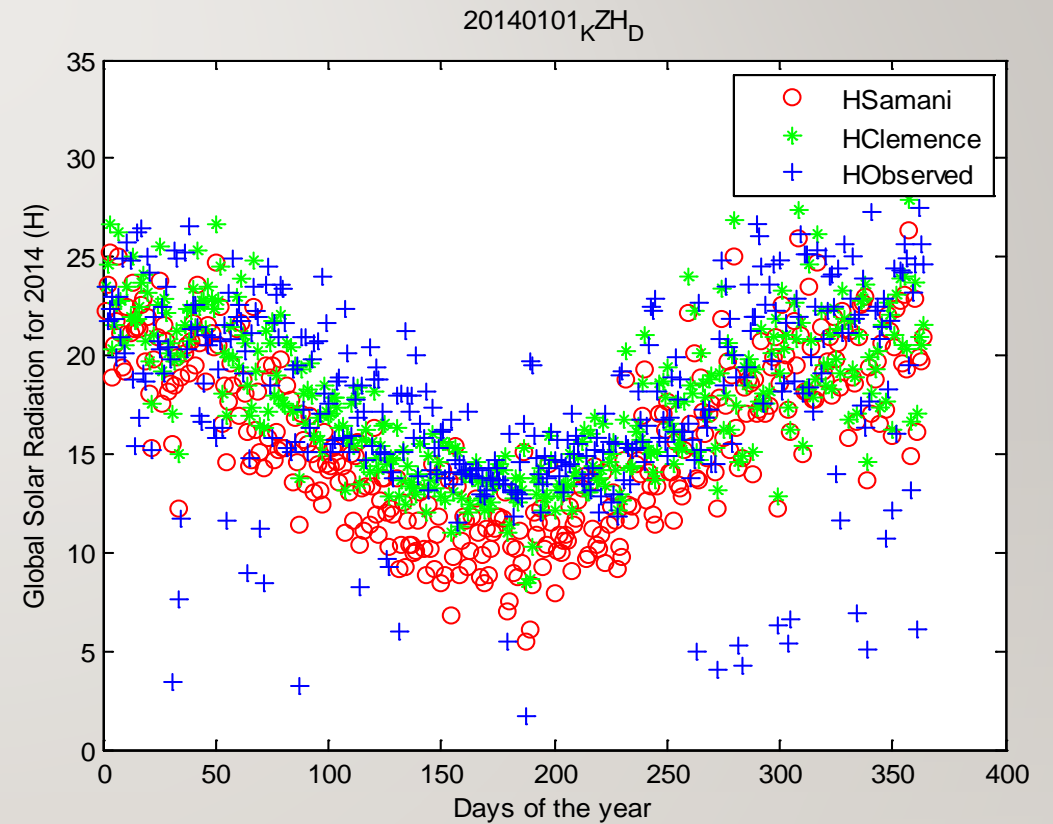


Figure 2: Comparison between estimated and measured global solar radiation for KZH in 2015

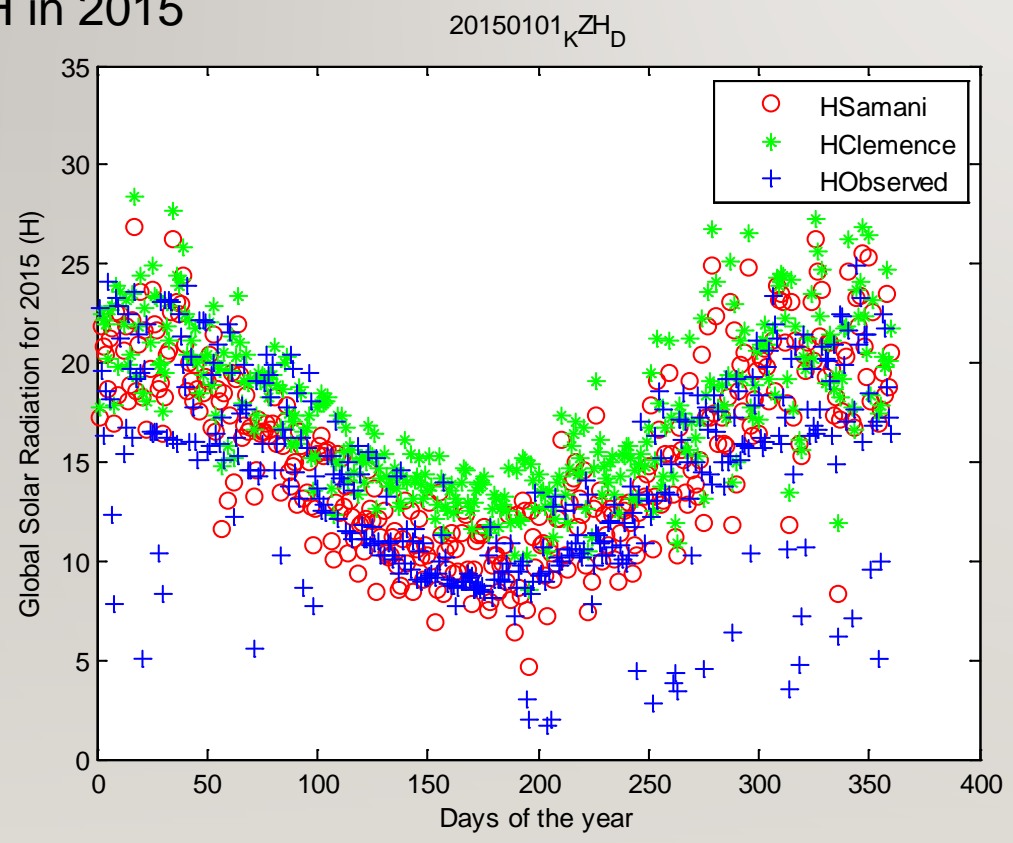
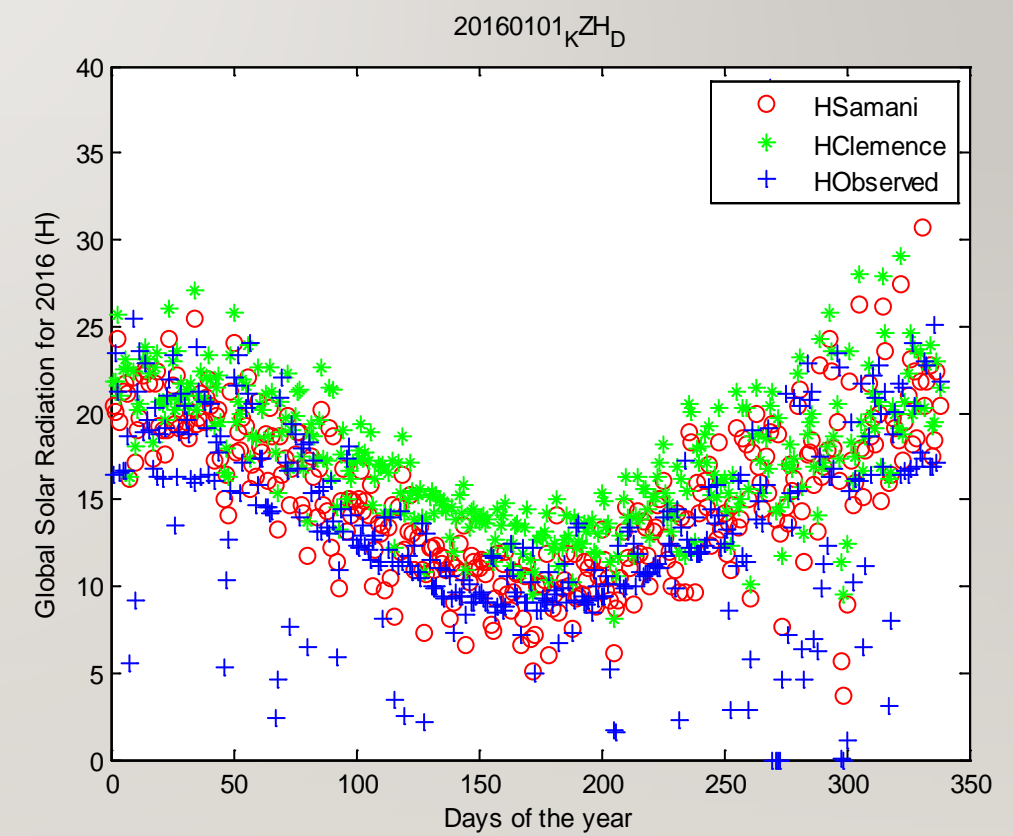


Figure 3 : Comparison between estimated and measured global solar radiation for KZH in 2016



RESULTS AND DISCUSSION CONTINUES

- Figure 1: estimated global solar radiation correlates well with measured global solar radiation for both models
- Figure 2 :there is a slight overestimation by Clemence model in April 2015
- Figure 3:Overestimation by Clemence model from April to may in 2016.
- Table 1:Both models obtained lowest values of MBE ranging between 0.013 to 0.0088.
- Clemence model obtained the MPE value of 1.0801 for 2015 ,showing overestimation.
- Hargreaves _Samani obtained lower values of MBE and MPE in all the years.
- Both the models obtained good values of RMSE, R^2 approaching 1 ,the statistic t value is 1 for both models, which proves the statistical analysis formulas to be valid.

Table 1: Statistical validations of the models for estimating monthly mean daily global solar radiation in KZH stations.

Year	MBE (MJ/m ²)		MPE %		RMSE (MJ/m ²)		R ²		t-Value	
	Samani	Clemence	Samani	Clemence	Samani	Clemence	Samani	Clemence	Samani	Clemence
2014	0.0013	0.0036	0.1285	0.3619	0.0246	0.0691	0.9995	0.9962	1.000	1.000
2015	0.0078	0.0108	0.7788	1.0801	0.1418	0.2063	0.9802	0.9657	1.000	1.000
2016	0.0057	0.0088	0.5667	0.8822	0.1083	0.1685	0.9898	0.9778	1.000	1.000

CONCLUSION

- Hargreaves- Samani model was observed to be having lower values of MBE and MPE for 2014 to 2016.
- Both models have good values of R^2 approaching 1 and t -statistic value of 1.
- Hargreaves -Samani & Clemence models have been proven to have a good performance based on the values of R^2 approaching 1 for KZH.
- It can therefore be concluded that Hargreaves -Samani & Clemence models are suitable for estimating monthly mean global solar radiation in University of kwazulu natal Howard college.

FUTURE WORK

- It is in our interest to estimate global solar radiation from other SAURAN stations temperature data in south Africa.
- It would be great to work with sunshine hour models like Angstrom-Prescott model, which will be compared with air temperature models for estimating global solar radiation in particular area.

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ACKNOWLEDGEMENT

- GEOSUN.....
- University of Venda
- Supervisors :N.E Maluta and Mrs. T.S Mulaudzi
- Sponsors : Center for renewable and Sustainable Energy studies

THANKS FOR LISTENING