Journal of Energy Technologies and Policy www.iiste.org
ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online)
Vol.8, No.8, 2018

Estimating Global Solar Radiation in Bale Robe Town Using Angstrom-Prescott and Hargreaves-Samani Models

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Abstract
The demand for energy, consumption of forest for firewood and charcoal, and the pollution rate of atmosphere are increasing in alarming rate as worldwide particularly in developing countries like Ethiopia. Following hydro energy the forest is the main source of energy for the communities of Robe town. The town is growing rapidly and facing high shortage of energy source from household to organization level. Therefore, for many reasons like solar energy which is free of environmental pollution, renewable and abundantly accessible has to be considered and studied for the development of project on energy harvesting. The first objective of this study was to determine seasonal value of global solar radiation GSR by using Angstrom-Prescott AP and Hargreaves-Samani HS models in Bale Robe town. The second one is to estimate variation between the two models for this town. The data were obtained from Robe meteorological station which was measured over a period of the year 2010 to 2014. The measured data of the daily sunshine duration and daily maximum and minimum temperature were used to estimate seasonal mean values of GSR and their percentage difference between Angstrom-Prescott AP and Hargreaves-Samani HS models in Bale Robe town and analyzed using linear regression. The findings of the study in general, revealed that, GSR in different seasons summer, autumn, winter and spring season were 18.80 $MJm^{-2}day^{-1}$, 22.76 $MJm^{-2}day^{-1}$, 26.64 $MJm^{-2}day^{-1}$ and 23.94 $MJm^{-2}day^{-1}$ respectively using Angstrom-Prescott model. Using Hargreaves-Samani model the value of GSR found to be in summer, autumn, winter and spring seasons were 20.60 $MJm^{-2}day^{-1}$, 24.42 $MJm^{-2}day^{-1}$, 28.60 $MJm^{-1}day^{-1}$ and 26.12 $MJm^{-2}day^{-1}$ respectively. The results of the study showed that, there were peak values of GSR estimated in winter and spring and low value of global solar radiation has been observed in summer and autumn in both models. The percentage difference between the two models showed that AP and HS models were favorable models that predict seasonal value of GSR in Bale Robe town in the absence of instrumental installations which are important to measure GSR directly. Based on the finding, peak value of GSR obtained in a seasons of winter and spring with AP and HS models. Hence, both models used successfully to estimate seasonal value of GSR with relative accuracy.
Keywords: GSR in Robe, sunshine duration, air temperature, AP and HS model

1. Introduction

The sources of energy can be broadly grouped into two: conventional and nonconventional energy sources. Nonconventional (renewable energy) sources are those being generated by the same rate as they are being utilized. Hydro, wind, tidal, biomass, solar thermal, solar photovoltaic (PV) and geothermal sources are examples of renewable energy sources. Conventional (nonrenewable) energy sources are consumed without any replacement. They are depleted from time to time and are not generally environment friendly. Fossil fuel-based energy sources including oil, coal, and natural gas are examples of conventional energy sources (Getnet 2011). The demand of energy, the consumption of fossil fuels and pollution levels are increasing with an alarming rate worldwide. Looking into the seriousness of problem, various stoke-holders have now become aware of the urgent need for management of resource and energy conversation activities. The energy consumed in the house-hold sectors were perhaps the single largest consumer of energy in the nation's economy in developing countries of the world (Genwa and Chouhan, 2012).

The sun is the largest energy source for our planet. It is the ultimate source of all energy except tidal and geothermal power. Even the energy in the fossil fuels indirectly comes from the sun. The sun radiates 174 trillion kWh of energy to the earth per hour, in other words, the earth recieves $1.74x10^{17}$watt of power from the sun (Gelma Boneya, 2011). Global solar radiation is an important parameter necessary for most ecological models and serves as input for different photovoltaic conversion systems. Hence, it is of economic importance to renewable energy alternatives. The solar radiation reaching the earth's surface depend, on climatic condition of the specific site (location) and this is essential for accurate prediction and design of a solar energy system (Burari and Sambo, 2001).

To estimate global solar radiation at a site it needs installation of measuring devices such as Pyranometers at many locations in the given region. Unfortunately, there are very few metrological stations that measure global solar radiation, especially in developing countries (Eggers-Lura, 1978). For such stations where no measured data are available, the common practice to estimate global solar radiation from other measured meteorological parameters like relative sunshine duration, surface pressure, air temperature, relative humidity and precipitation using empirical and physical model (WMO, 1981). When global solar radiation is used to generate electrical energy for any specific site, a provision should be made to forecast solar energy, which will convert to electric energy to recover the load demand. That is, the amount of solar energy for the place ought to be known. Technology for measuring global solar radiation is cost and has instrumental hazards (Alam et al., 2005). Although, solar radiation data are available in most meteorological stations, many stations in developing countries suffer from a shortage of these data.

In many applications of solar energy, the most important parameters that are often needed are the average global solar irradiation and its components. This estimates the amounts of monthly average solar radiation from more readily available meteorological parameters such as the sunshine duration, extraterrestrial radiation. Several empirical models have been developed to calculate global solar radiation using various parameters. Angstrom (1924) developed the earliest model used for estimating global radiation, in which the sunshine duration data and clear sky radiation data were used. The solar radiation reaching the Earth's surface depends upon climatic conditions of a location, which is essential to the prediction, and design of a solar energy system. GSR has been the focus of many studies due to its importance in providing energy for Earth's climate system (Falayi et al., 2011). The other method to estimate solar radiation was obtained by using atmospheric transmittance model (Cambell and Norman, 1998) while other authors have used diffuse fraction (Reindl et al., 1990) and clearness index models (Battles et al., 2000) Parametric or atmospheric transmittance model requires details atmospheric characteristic information (Wong and chow, 2001). This model gives high-accuracy for clear sky/cloudless conditions, which is leading some author to use this model to evaluate the performance of an empirical model under cloudless conditions (Battles et al., 2000). There are numerous authors proposed this kind of model as mentioned in (Gueymard, 2003). However, pure parametric model was not used in this study, since there is no detail atmospheric condition data for the site. Meteorological parameters frequently used as predictors of atmospheric parameters since acquiring detail atmospheric conditions require advance measurement. Meteorological parameters such as sunshine duration, cloud cover, ambient temperature, relative humidity, and precipitation data have been used to estimate atmospheric transmittance coefficient in parametric model. This kind of model is called meteorological model (WMO, 1981).

Because people of Bale Robe town use fire wood as main source of energy and this causes environmental degradation or deforestation which makes problems like heavy flood, famine and others. Especially women and children are the most affected social communities. In ruler areas of developing countries women are responsible to collect firewood to their home and also bring to market as source of income. Women in town such countries are responsibility to buy from market and cut woods in to pieces to be final usage. The researchers are interested to study in Robe town because of the highest population of town in the Bale zone is total dependent on forest wood and hydro energy. Moreover this area is found in the tropical zone where it get sun light properly throughout the year.

In this area there are no research findings which have been done before to estimate GSR. Therefore, the objective of this study is to predict global solar radiation using sunshine duration and air temperature together with a known model that is appropriately described in different literatures and also try to identify seasonal value and the percentage difference between the two models from 2010 to 2014 in Bale Robe town. The data were obtained from Robe meteorological station from the measurements of sunshine duration and air temperature.

2. Materials and methods

Ethiopia is located in tropical region in which the Sun comes overhead twice a year and the most favorable region for solar energy. The average daily duration of sunshine is approximately 8-10 hours (Bekele and Palm, 2009). Robe Town is located in the South-Eastern Ethiopia 442km away from Addis Ababa at an altitude of 2,492 m above sea level with latitude of $7^0$7'N and longitude of 40^0E. The mean annual maximum and minimum temperatures are 22.2^0 and 7.75^0 respectively. It is characterized by cold climate type with annual rainfall of about 1200 mm.

2.1. Source of Data

The sunshine hour, maximum and minimum air temperatures data of five consecutive years (2010-2014) obtained from Bale Robe Meteorological Station for estimating seasonal global solar radiation.

2.2. Methodological and Data Analysis

Several empirical models exist to evaluate global solar radiation, using available meteorological and geographical parameters such as sunshine duration, difference between the maximum, $T_{max,}$ and minimum, $T_{min,}$ daily temperature and latitude. In this study two models were used to estimate daily mean value of global solar radiation. The models were grouped and examined according to the type of equation as outlined below. Daily mean values of global solar radiation on a horizontal surface were estimated from sunshine hour using AP model and temperature difference using HS model for, Summer(Jun. Jul. Aug), Autumn(Mar. Apr May), Winter(Dec. Jan. Feb.) and Spring(Sep. Oct. Nov.) seasons. Microsoft office excel software was used for data analysis.

The first model used sunshine duration to estimate daily mean value of solar radiation on a horizontal surface can be described using Eqn. (2.1) as (Prescott, 1940; Ahmed et al, 2009; Medugu and Yakubu, 2011):

$$H=H_o\ (a+b\ (\frac{S}{S_o}) \quad (2.1)$$

Where, H is incoming daily global solar radiation (in $MJm^{-2}day^{-1}$).
H_o, is daily Extra-terrestrial solar radiation (in $MJm^{-2}day^{-1}$),
S, is bright sunshine hour per day (in hr)
S_o, is Astronomical day length (in hr)
'a' and 'b' values are known as Angstrom constant and they are empirical.

The value of the monthly average daily values of extraterrestrial irradiation (H_o) can be calculated from the following equation (Prescott, 1940, Togrul, 2009); (Medugu and Yakubu, 2011):

$$H_o=\frac{24}{\pi}I_{sc}\ [1+0.033\cos(\frac{360n}{365})][\cos\varphi\cos\omega_s\sin\omega_s+\frac{\pi\omega_s}{180}\sin\varphi\sin\delta] \quad (2.2)$$

Where I_{sc} is the solar constant (=$1367Wm^{-2}$), φ the latitude of the site, δ the solar declination, ω_s the mean sunrise hour angle for the given month, n the number of days of a year starting from the first January.

For a given month, the maximum possible sunshine duration (monthly average day length (S_o) which is related to ω_s, the mean sunrise hour angle can be computed from the following equation below (Duffie and Beckman, 1991).

$$S_o=\frac{2}{15}\omega_s \quad (2.3)$$

The solar declination (δ) and the mean sunrise hour angle (ω_s) can be calculated from the following equation respectively in Akinoglu and Ecevit, (1990):

$$\delta=23.45\sin[\frac{360}{365}(n+284)]\ \&\ \ \omega_s=\cos^{-1}(-tan\varphi\tan\delta) \quad (2.4)$$

The constants a and b in Eqn (2.1) s regression coefficient (Medugu and Yakubu, 2011) given as:

$$a=-0.110+0.235\cos(\varphi)+0.323\frac{S}{S_o}\ \ \&\ b=1.449-0.553\cos(\varphi)-0.694\frac{S}{S_o} \quad (3.5)$$

The daily value of global solar radiation (H) was normalized by dividing with daily values of extraterrestrial radiation (H). We can define clearness index (C_r) as the ratio of the values of the monthly global radiation H, to the calculated/predicted horizontal/ extraterrestrial solar radiation (Ho) (Falayi *et al*., 2011).

$$C_r=\frac{H}{H_o} \quad (2.6)$$

In this study, H_o and S_o were computed for each day in a month by using Equations (2.2) and (2.3), respectively.

The second model evaluated global solar radiation of the site using data of the difference between daily mean value of maximum temperatures (T_{max}) and daily mean value of minimum temperatures (T_{min}) on a horizontal surface. Based on this principle, Hargreaves and Samani (1982) recommended a simple equation to estimate solar radiation using the temperature difference, ΔT: calculated as (Allen et al., 1998).

$$H=H_o\ [K_r\ (T_{max}-T_{min})^{0.5}] \quad (2.7)$$

H represents daily mean value of global solar radiation ($MJm^{-2}day^{-1}$), H_o is daily mean value of extraterrestrial radiation ($MJm^{-2}day^{-1}$), T_{max} and T_{min} are the daily mean value of maximum and minimum in (^0C), respectively. Solar radiation was determined using Eq. 2.6 as stated by Allen et al. (1998), Allen, (1997) presented a method for estimating K_r as a function of elevation and is presented as

$$K_r=K_{ra}\ [\frac{P}{P_o}]^{0.5} \quad (2.8)$$

Where K_r is the adjustment coefficient ($^0C^{0.5}$), K_{ra} is an empirical coefficient initially fixed as 0.17 for arid and semiarid climate regions, where land mass dominates and air masses are not strongly influenced by a large water body, K_r was calculated for location of interest as followed by (Chandelet al., 2005).

The ratio $\frac{P}{P_o}$ was defined as $\frac{P}{P_o}$=exp (-0.0001184*h), (2.9)

Where P and P_o are the mean atmospheric pressure at sea level (101.3KPa), respectively and h is the altitude of the place in meters (Chandel et al., 2005). Proposed a model, (2.6) as;

$$H=H_o\ [K_{ra}\ (\exp(-0.0001184*h)^{0.5})\ (T_{max}-T_{min})^{0.5}] \quad (2.10)$$

$$H=H_o\ [0.197(T_{max}-T_{min})^{0.5}] \quad (2.11)$$

3. Results and discussions

In this section the analysis of the data and their interpretations and contains discussions which are related to the findings of the work. The present study estimates the value of extraterrestrial radiation (H_o) by using equation (2.2), values of each day /month, of each season (summer, spring, winter and autumn) in the year of 2010-2014 G.C. The relevant data that was obtained from Meteorological Station to calculated global solar radiation (H) using equation (2.1) and presented for the whole period where shown in the Table (2 & 3). To compute the calculated value of seasonal mean GSR H, the values of a & b inserted in to the above equation (2.5) and the correlation was used to compute H at Bale Robe town. The result of the leaner regression for Summer(Jun, Jul, Aug.), Autumn(Sep, Oct, Nov.), Winter(Dec, Jan, Feb.) and Spring(Mar, Apr, May) can be seen in table 3 below.

3.1. Calculated monthly mean value of GSR with input parameters in Bale Robe town from 2010 to 2014.
From ***Table 2***, it was observed that the monthly global solar radiation is not uniform throughout the period of study. Peak radiation is observed in the month of December, January, February and March with values 22.2MJm^{-2}day^{-1}, 23.2MJm^{-2}day^{-1}, 22.7MJm^{-2}day^{-1} and 21.4MJm^{-2}day^{-1} respectively with Angstrom-Prescott model and again peak radiation observed in the month of December, January, February and March with values 27.9MJm^{-2}day^{-1}, 29.1MJm^{-2}, 29.0MJm^{-2}day^{-1} and 27.9MJm^{-2}day^{-1} respectively with Hargreaves-Samani model.

The research finding in Maiduguri, Nigeria showed that the monthly global solar radiation is not uniform throughout the period of study. Peak radiation is observed in the months of February, March and April with values of 24.5MJm^{-2}day^{-1}, 24.6MJm^{-2}day^{-1} and 24.1MJm^{-2}day^{-1}, respectively. On the other hand, the months of June, July and August recorded least amount of solar radiation average values of 21.8MJm^{-2}day^{-1}, 19.3MJm^{-2}day^{-1} and 19.3MJm^{-2}day^{-1}, respectively. This is as a result of the peak period of the cloud cover in Maiduguri due to the rainy season. In general, higher value of solar radiation is obtained in dry season than wet season using the Angstrom model (Musa et. al., 2012).

On the other hand, better value of global solar radiation was observed with Hargreaves-Samani model than Angstrom-Prescott model in all months of study because of less sunshine hour and heavy cloud sky in this location.

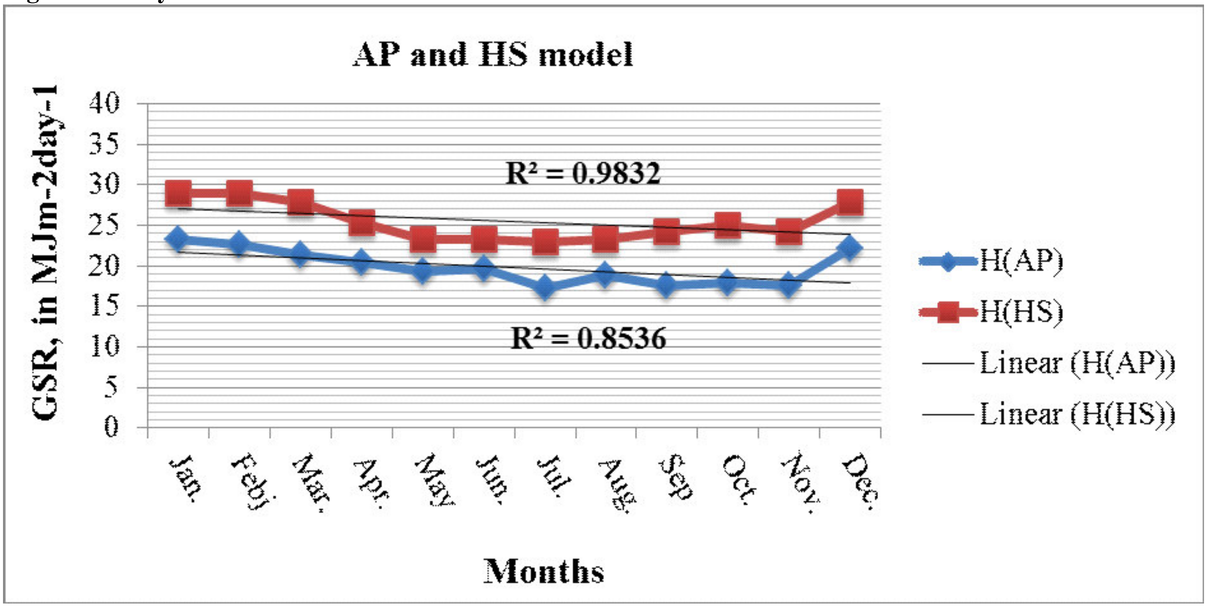
Table.1. Monthly mean values of GSR with some parameters for AP and HS model.

Equations	**Model**	**Months**	**a**	**b**	**S/S_o**	**H**	**H_o**	**H/H_o**	**R**	**R^2**
		Jan.	0.38	0.34	0.83	23.2	36.1	0.64	0.8090	0.6545
		Feb.	0.36	0.39	0.73	22.7	37.3	0.61	0.6921	0.4789
		Mar.	0.32	0.48	0.60	21.4	37.7	0.57	0.9403	0.8842
		Apr.	0.30	0.47	0.55	20.5	36.6	0.56	0.9551	0.9122
		May.	0.30	0.51	0.54	19.3	34.7	0.56	0.9358	0.8758
$H/H_o= a+b(S/S_o)$	AP	Jun.	0.32	0.47	0.60	19.6	33.4	0.59	0.9483	0.8992
		Jul.	0.27	0.58	0.44	17.3	33.9	0.51	0.9660	0.9332
		Aug.	0.28	0.56	0.48	18.8	35.7	0.53	0.9731	0.9469
		Sep.	0.25	0.62	0.40	17.6	37.1	0.47	0.9727	0.9461
		Oct.	0.27	0.59	0.46	17.9	37.2	0.48	0.9698	0.9406
		Nov.	0.31	0.51	0.58	17.6	36.2	0.49	0.9578	0.9174
		Dec.	0.37	0.37	0.78	22.2	35.6	0.62	0.9242	0.8541
	Ave		0.31	0.49	0.58	19.8	36.0	0.60	0.9203	0.8536
Equations	**Model**	**Months**	**k_r**	**K_{ra}**	**$T_d^{0.5}$**	**H**	**H_o**	**H/H_o**	**R**	**R^2**
		Jan.	0.197	0.17	4.21	29.0	36.1	0.80	0.9923	0.9847
		Feb.	0.197	0.17	4.09	29.0	37.3	0.78	0.9885	0.9772
		Mar.	0.197	0.17	3.89	27.9	37.7	0.74	0.9994	0.9989
		Apr.	0.197	0.17	3.63	25.3	36.6	0.69	0.9858	0.9718
		May.	0.197	0.17	3.52	23.3	34.7	0.67	0.9659	0.9330
		Jun.	0.197	0.17	3.66	23.3	33.4	0.70	0.9979	0.9958
$H/Ho=0.197(T_d)^{0.5}$	HS	Jul.	0.197	0.17	3.55	23.0	33.9	0.68	0.9923	0.9846
		Aug.	0.197	0.17	3.44	23.3	35.7	0.65	0.9857	0.9716
		Sep.	0.197	0.17	3.42	24.2	37.1	0.65	0.9965	0.9931
		Oct.	0.197	0.17	3.39	25.0	37.2	0.67	0.9985	0.9970
		Nov.	0.197	0.17	3.66	24.2	36.2	0.67	0.9980	0.9959
		Dec.	0.197	0.17	4.1	27.9	35.6	0.78	0.9975	0.9950
	Ave		0.197	0.17	3.71	25.5	36.0	0.71	0.9915	0.9832

The coefficient of determination (R^2) for AP model was 0.8536 in ***figure.1.*** indicated that 85.36% of the variation of global solar radiation was explained by the months from the linear fit. And the coefficient of determination (R^2) for HS model was 0.9832 indicates the only 98.32% of the variation of global solar radiation can be accounted by months from the linear fit again. Fraction of sunshine, maximum temperature and minimum temperature has the highest values of correlation coefficient R and coefficient of determination R^2. The R^2 value of 0.986 indicates that 98.6% of the clearness index is accounted that it was indicating serious overestimation and underestimation on a long-term basis (Nwokoye et. al., 2014).

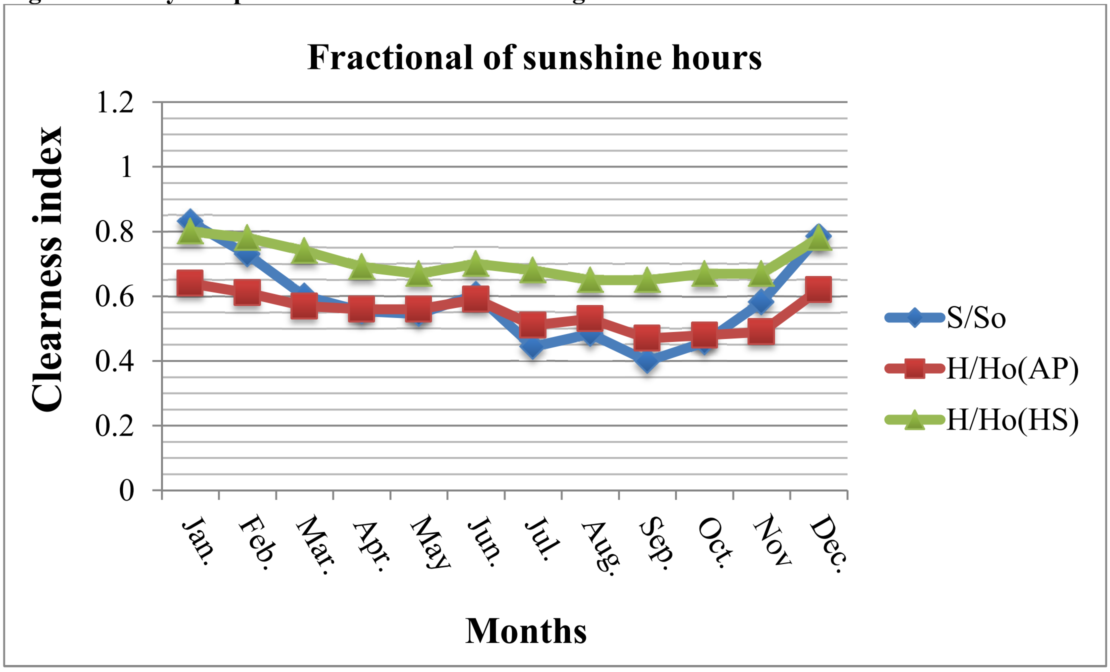
In fig.1 for the particular site the predicted mean global solar radiation $\overline{H}$ from 2010 -2014 at Bale Robe town over the period of study with Angstrom-Prescott model and Hargreaves-Samani model with results were 19.8MJm^{-2}day^{-1} and 25.5MJm^{-2}day^{-1} respectively. The researcher observed that the global solar radiation of the above listed month's fluctuated from month to month throughout the period of study. The variation in available solar radiation was the result of variation in cloud transmittance factor and clearness index during different periods (Khem.et, .2012). This is due to the fact that the weather condition of Bale Robe varies from time to time.

Fig.1. Monthly mean values of GSR for AP and HS model from 2010-2014.



In fig.2, the correlation variation of calculated clearness index with AP model and HS model and fractional sunshine hour of a month at Bale Robe town in a period of five years shown below. There is significant difference in the value of both parameters. The clearness index of both models decreased remarkably with the cloudy skies crossing over the incoming global solar radiation. The weather condition of each month could be identified by calculating the ratio of average monthly global solar radiation on a horizontal surface (H) to the monthly horizontal extraterrestrial radiation (H_o). Clearness index C_r (H/H_o) & S/S_o are the percentage deflection by the sky of the incoming of global solar radiation. Hence both indicate the levels of variability of global solar radiation due to a change in atmospheric condition in a given locality. According to Duffie and Beckman, (2006) it depends on the location and time of the year considered: $0.3<C_r<0.7$ indicates partly cloudy skies condition (Falayi et al., 2011). Therefore, the present work of clearness index with AP model showed, C_r=0.55 for the studied years and with HS model C_r =0.71 which imply partly less cloudy skies.

Fig. 2. Monthly comparison b/n H/Ho & S/So using AP and HS models from 2010 to 2014.



3.2. Calculated mean seasonal values of GSR and input parameters from 2010 to 2014 for AP and HS models.

Table.3 shows that in the overall average years of the seasons of the location from 2010-2014, there was predicted values of global solar radiation during summer, autumn, winter and spring. The estimated result with values is 18.4MJm^{-2}day^{-1}, 17.7MJm^{-2}day^{-1}, 22.7MJm^{-2}day^{-1} and 20.4MJm^{-2}day^{-1} respectively for AP model. From the table above the result shows winter and spring global solar radiation was over estimated and summer and autumn was underestimated in Angstrom-Prescott model in Bale Robe town. Using fraction of sunshine hours the result of GSR was obtained from the linear regression equation of relation shown below.

$$H/H_o=a+b(S/S_o)$$

The researcher found in Trans-Himalayan regions in Nepal global solar radiation significantly fluctuates from season to season and the value observed that for summer, autumn, winter and spring to be 10.3MJm^{-2}day^{-1}, 12.2MJm^{-2}day^{-1}, 14.9MJm^{-2}day^{-1} and 17.4MJm^{-2}day^{-1} respectively. Therefore, maximum amount of global solar radiation were available in spring and winter as well as minimum amount of global solar radiation were available in summer and autumn (Khem et. al., 2012).

In Hargreaves-Samani model there was an overall average years of the seasons from 2010 to 2014. There were a predicted value of global solar radiation during summer, autumn, winter and spring and the estimated result with values was 23.2MJm^{-2}day^{-1}, 24.5MJm^{-2}day^{-1}, 28.6MJm^{-2}day^{-1} and 25.5MJm^{-2}day^{-1} respectively. From the table the result shows that winter and spring global solar radiation was over estimated the same as in Angstrom-Prescott model. Peak radiation was observed with Hargreaves-Samani model than in Angstrom-Prescott model. As shown from the table the regression equation that the researcher used to determine the result of GSR in winter and spring gave better result for both Angstrom-Prescott and Hargreaves-Samani model. Using the temperature difference the result of GSR was obtained from the linear regression equation by using Hargreaves-Samani relation shown below.

$$H/H_o=0.197(T_{max.}-T_{min.})^{0.5}$$

Table.2. Seasonal mean values of GSR with some parameters for AP and HS models.

Model	Seasons	Equations	a	b	S/S_o	H	H_o	H/H_o	R	R^2
AP	Summer	H/H_o=0.29+0.54(S/S_o)	0.29	0.54	0.51	18.4	34.3	0.54	0.9625	0.9264
	Autumn	H/H_o=0.28+0.58(S/S_o)	0.28	0.57	0.49	17.7	36.8	0.48	0.9668	0.9347
	Winter	H/H_o=0.37+0.37(S/So)	0.37	0.37	0.78	22.7	36.3	0.63	0.8084	0.6535
	Spring	H/H_o=0.31+0.49(S/S_o)	0.31	0.49	0.57	20.4	36.3	0.56	0.9677	0.8906
Ave			0.31	0.49	0.59	19.80	35.93	0.55	0.9204	0.8513
Model	Seasons	Equations	K_r	K_{ra}	$T_d^{0.5}$	H	H_o	H/H_o	R	R^2
HS	Summer	$H/H_o=0.197(T_{dsu})^{0.5}$	0.197	0.17	3.55	23.2	34.3	0.68	0.9920	0.9848
	Autumn	$H/H_o=0.197(T_{dat})^{0.5}$	0.197	0.17	3.49	24.5	36.8	0.67	0.9977	0.9954
	Winter	$H/H_o=0.197(T_{dwi})^{0.5}$	0.197	0.17	4.14	28.6	36.3	0.79	0.9928	0.9857
	Spring	$H/H_o=0.197(T_{dsp})^{0.5}$	0.197	0.17	3.69	25.5	36.3	0.70	0.9837	0.9677
Ave			0.197	0.17	3.72	25.45	35.9	0.71	0.9916	0.9832

Fig.3. Shows that during summer (Jun, Jul and Aug) season value of GSR was better in HS model than AP model from 2010 to 2014. Due to the fact that, the reflection of GSR is mainly by clouds and this play an overriding part in reducing energy of solar radiation at a location (Burari and Sambo, 2001). Besides, sunshine duration and air temperatures were direct correlation with global solar radiation, in the particular site, clouds, gases, pollution (including aerosols) and other factors, this available power on the surface thus, earth gets 800 times less solar energy from the sun at each moment (Schiermeir et. al., 2008) .Therefore, the predicted mean global solar radiation for this season over the period of study with Angstrom-Prescott and Hargreaves-Samani model given in table 3 above. It also observed that global solar radiation throughout the study is almost similar in both AP and HS model and the value that estimated during this season was low when compared to autumn; winter and Spring due to rain bearing clouds that pervades the sky. On the other hand, under cloudy condition temperature is low, Since parts of the incoming solar radiation never reaches the earth, while night temperature are relatively higher as the cloud limits loss by outgoing low wave radiation(Hargreaves and Samani, 1982). This is as a result of the peak period of the cloudy covers in Bale Robe town due to the rainy season.

Fig. 3. Result of GSR during summer season using AP and HS models

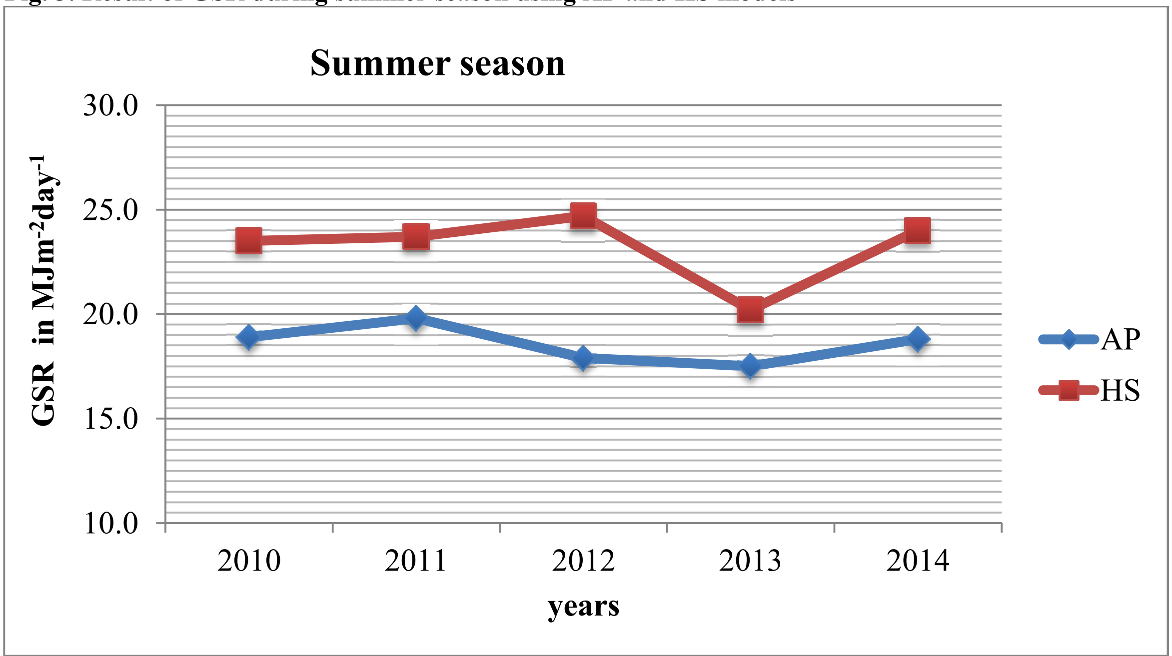


Fig.4 shows that predicted mean value of global solar radiation of autumn (Sep Oct and Nov) season from 2010 to 2014 can be estimated using Hargreaves-Samani model and Angstrom-Prescott model. The result showed that the increments of global solar radiation have been changed by 0.7$MJm^{-2}day^{-1}$ and 1.3$MJm^{-2}day^{-1}$ from summer season with Angstrom-Prescott and Hargreaves-Samani model respectively. Seasonal variation of global solar radiation is about 10.4$MJm^{-2}day^{-1}$ and 17.3$MJm^{-2}day^{-1}$ in summer and spring respectively (Oki and Shiina, 2003). There is a vast climatic variation in every 100m to 200m change of altitude. It also known that the higher the altitude greater the total irradiance under the clear and intermediate condition, but under the over cast days the solar irradiance is very low in comparison with sunny days (Oki and Shiina, 2003). From the graph the values have been varied from 2010 to 2014 because of medium period of the cloud covers varied during these period. Because of the transmittance of solar irradiance and time of the year is sensitive to cloudiness (Angstrom1924; Prescott1940).. In addition the earth is also surrounded by the atmosphere which contains

various gaseous constituents' suspended dust and other minute solid and liquid particles. Because of this, global solar radiation of autumn season is varied from summer season in the given period of the location due to a variation of climatic condition.

Fig. 4. Result of GSR during autumn season using AP and HS model.

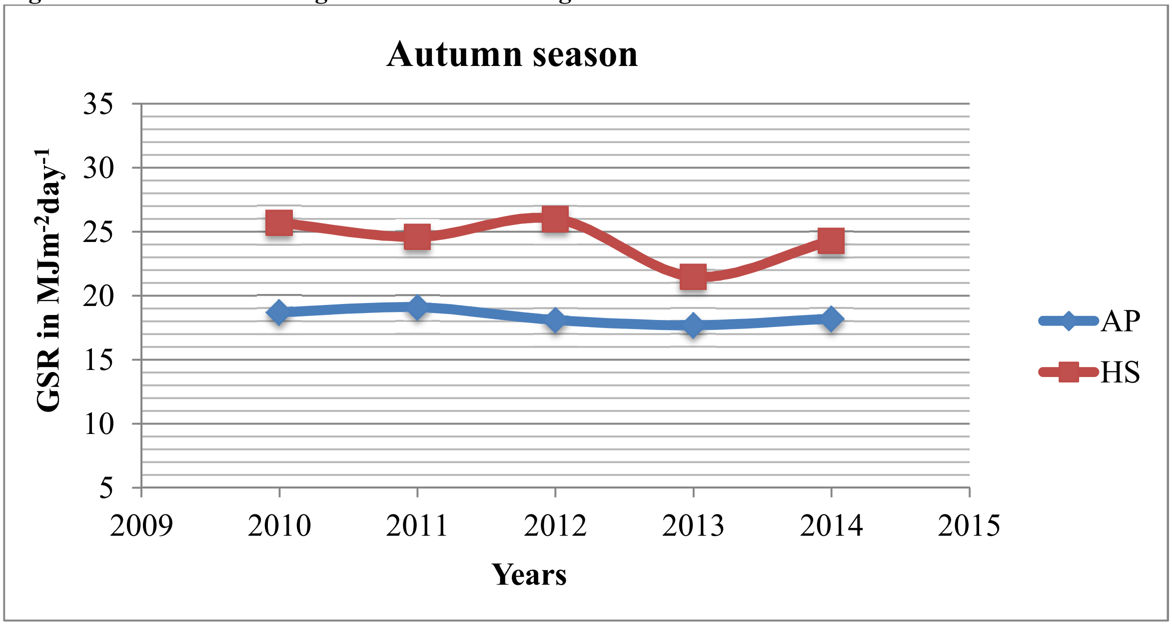


Fig.5 showed that the predicted value of global solar radiation during winter (December, January and February) season with Angstrom-Prescott model and Hargreaves-Samani model in Bale Robe town in a period of 2010 to 2014 should have been evaluated from parameters that are obtained in Bale Robe Meteorological Station. During this season peak radiation has been estimated from the given parameters at this location. This implies that a clear sky will obviously fall within this season and hence a high solar radiation is experienced. Finally winter season is a dry seasonal period in that place. The value of global solar radiation in Winter that studied in Nepal was 14.9MJm^{-2}day^{-1}, it can be concluded that the maximum clear sky of this season has maximum amount of energy is available in a given period (Krishna et. al., 2014).

Fig. 5. Result of GSR during winter season using AP and HS model.

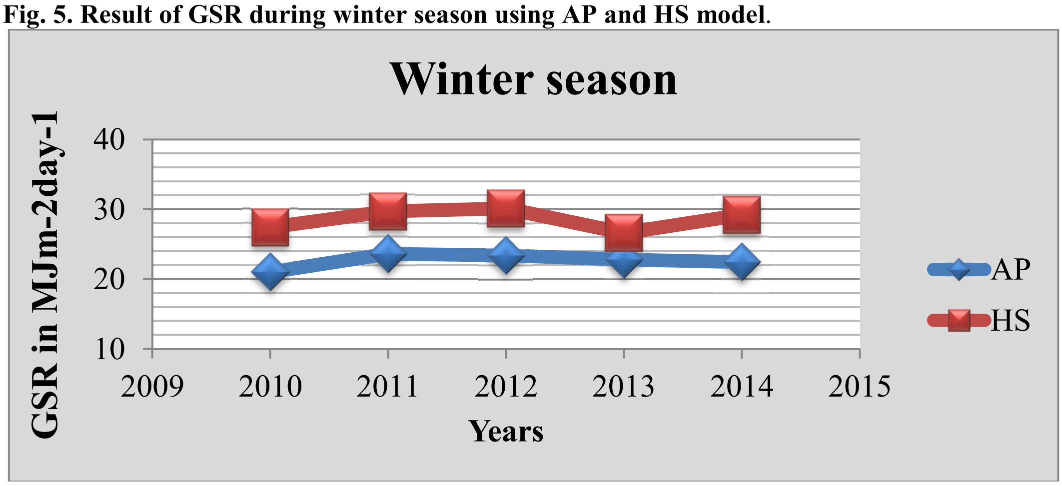
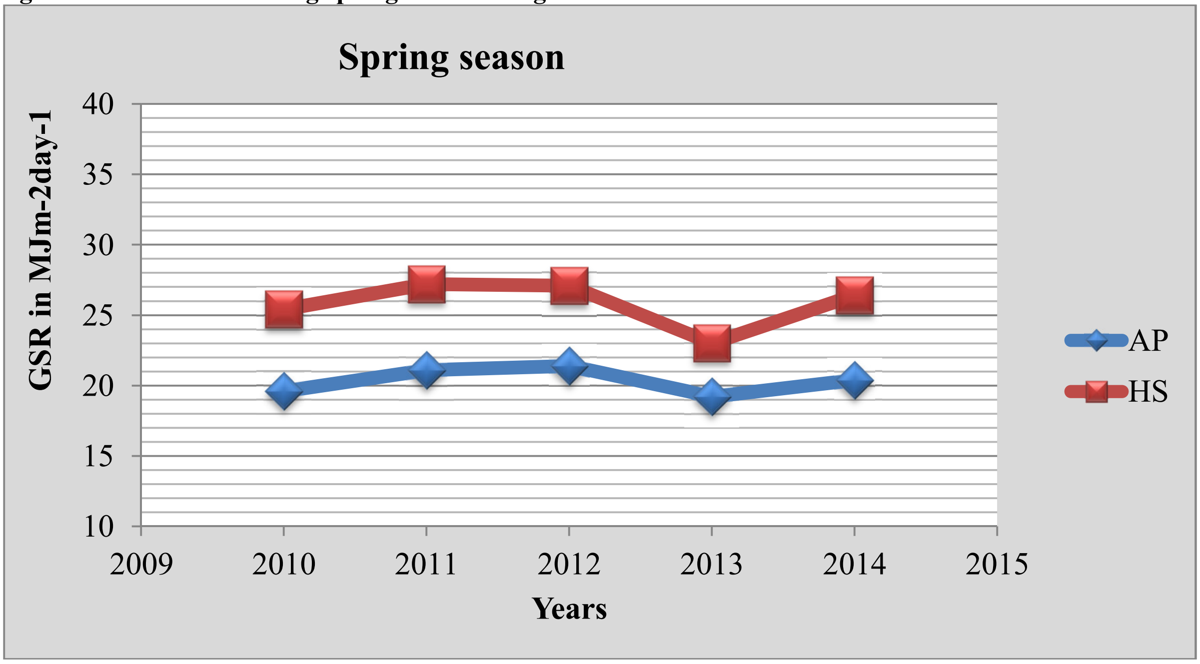


Fig.6 showed that the estimated value of global solar radiation during spring (March, April and May) season with Angstrom-Prescott model and Hargreaves-Samani model at Bale Robe town in a period of 2010 to 2014 have been predicted. Comparing the results, we can see that, the value is calculated from linear regression analysis similar to the one that should be analyzed above. Global Solar Radiation significantly fluctuates in season to season. Lukla represents the High Mountain region in the northern part of Nepal. The solar energy is found at Lukla in spring season to be 17.4MJm^{-2}day^{-1}(Khem et. al., 2012). The result showed, the value that estimated in spring season has been best in comparison with summer and autumn seasons at a location in a period of 2010 to 2014 using AP and HS models. Since the weather condition in Bale Robe town is not continuously uniform, the value is also varied in a period from 2010 to 2014. From the graph we also saw that during spring and winter almost the sky is clear to obtain a peak radiation of global solar radiation in this location. Therefore, spring and winter seasons were a dry seasonal period at Bale Robe town to estimate good

result from the parameters that is obtained from Meteorological Station. This implies that clear skies obviously fall within the seasons of winter and spring.

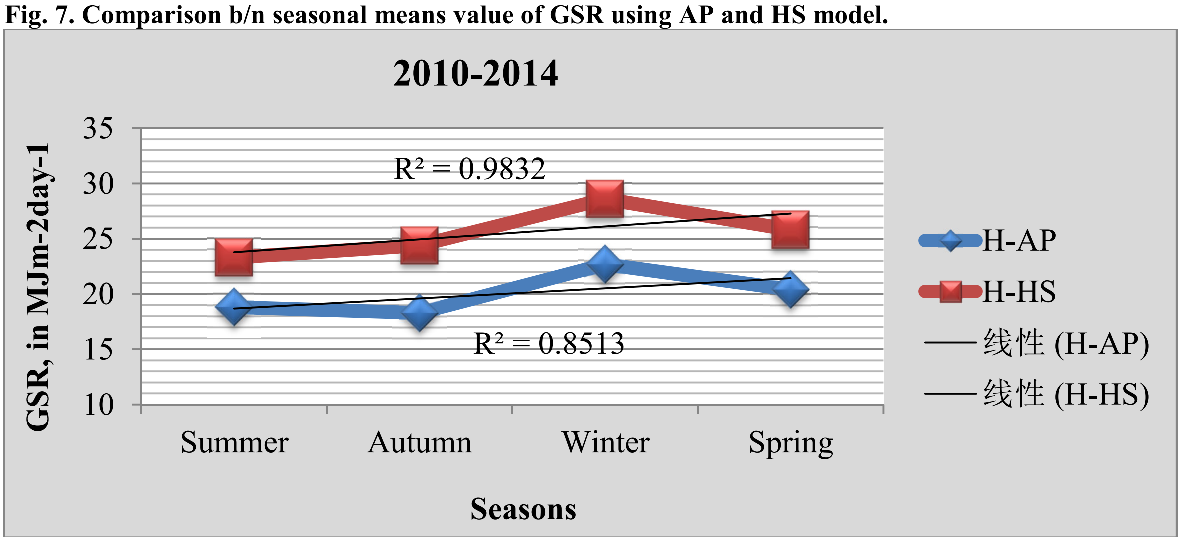
Fig. 6. Result of GSR during spring season using AP and HS models.



In fig.7 the estimated GSR of the location with both models were uniform. With AP model coefficient of determination (R^2) with value 0.8513 implies 85.13% of global solar radiation accounted using the ratio of daily mean sunshine hour to daily mean value of day length and coefficient of determination (R2) of 0.9832 with HS model also implies 98.32% of global solar radiation was explained by these seasons from a linear fit Bristow and Cambell (1984) Allen (1997) and Paulescu et al. (2006). And these certainly showed that the correlation linear fit of winter and spring seasons explained that, GSR estimation was better result in both models. The sun shined-based model perform well in terms of coefficient of determination with R2=99.89% while the Samuel (1991) model provide to be the best estimator with R2=99.93% given by the linear Angstrom-Prescott (1940) model (Akpootu et. al., 2013).

The figure showed that the major maxima occurred during winter season with values of 22.7MJm-2day-1 and 28.6MJm-2day-1 in AP and HS model respectively, the minor maxima occur during spring season with a value of 20.4$MJm^{-2}day^{-1}$ and 25.5$MJm^{-2}day^{-}1$ for AP and HS model respectively. With these seasons the increment of GSR of a winter changes from the mean average of spring by 2.3MJm^{-2} days-^{1} with AP model and 3.1$MJm^{-2}day^{-1}$with HS model. Because of vast climatic variation in every 100m to 200m change of altitude as a result global solar radiation is varied from season to season (M. Oki and H. Shiina, 2003).

Fig. 7. Comparison b/n seasonal means value of GSR using AP and HS model.



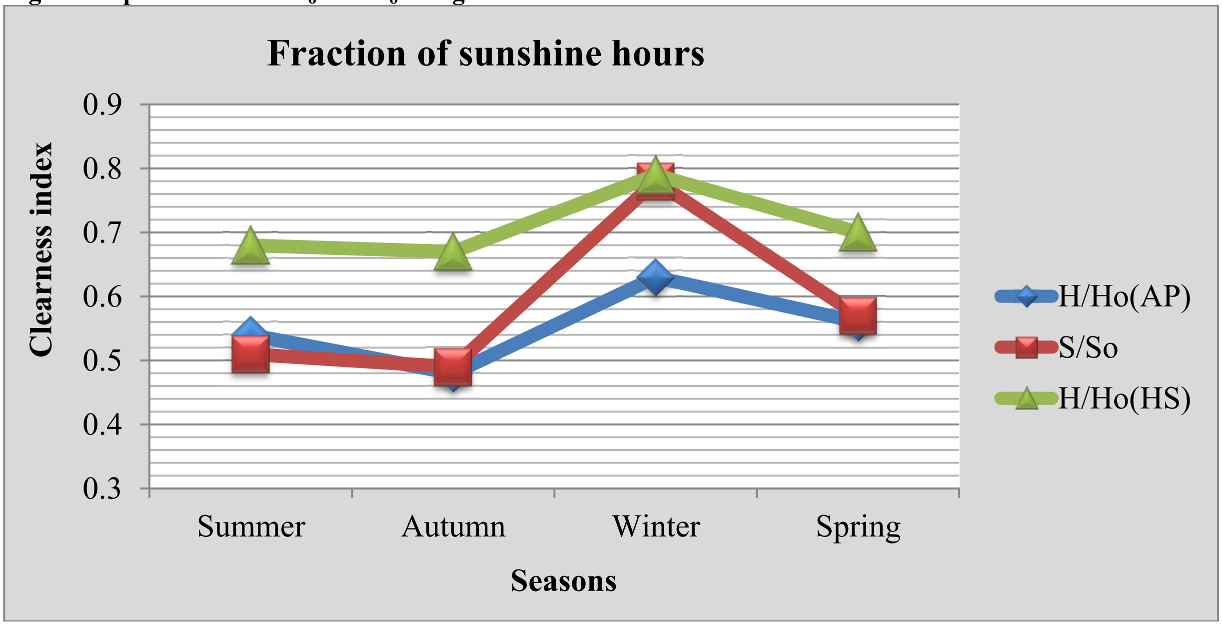
Based on the Angstrom-Prescott and Hargreaves-Samani model given in equation (3.1) and (3.7), ***figure. 8.*** observed that the correlation H/H_o related to the fraction of sunshine hour (S/S_o) of AP model by the constant a=0.31, b=0.49 and H/H_o that is obtained from temperature difference $(T_{max}-T_{min})^{0.5}$ of HS model, by the constant K_r=0.197 and K_{ra} =0.17 respectively. Over the study area from 2010 to 2014, the linear regression equation has been explained from the work with Angstrom-Prescott model given as:

$$\bar{H}=\bar{H}o\ (0.31+0.49\bar{S}/\bar{S}o)$$

And with Hargreaves-Samani model $\bar{H}=\bar{H}o\ (0.197(\bar{T}max-\bar{T}min)^{0.5})$

This correlation can also be applied for predicting global solar radiation in other locations with similar weather conditions. The clearness index C_r is also fluctuated from season to season. For summer, autumn, winter and spring were 0.75, 0.33, 0.65 and 0.25 respectively. Therefore, it can be seen that the maximum clear sky days occur in spring and minimum clear sky days found in summer. From this maximum amount of energy is available during spring and minimum in autumn (Bhattarai et. al., 2012).

Fig 8.Comparison b/n H/H_o & S/S_o using AP and HS models from 2010-2014 of a seasons.



4. CONCLUSION AND RECOMMENDATION.

4.1. CONCLUSION.

Analysis result on GSR is indispensible for the proper and effective design and prediction of the solar system performance. However, direct measuring is not available in many areas. Therefore the need for empirical equation becomes effective alternative to predict GSR through observed data. This project is aimed to evaluate the seasonal GSR and its variability's from 2010-2014 with temperature and sunshine hour by using HS and AP models in Bale Robe town respectively. In this study daily data on sunshine hour and maximum and minimum temperatures were collected from Bale Robe meteorological station. Moreover, daily sunshine hours and temperature were added in to monthly as well as this monthly were categorized in seasons (summer, autumn, winter and spring). The estimated GSR trend was examined by the use of linear regression analysis. The main statistical parameter resulting from the regression analysis indicated the temporal change of GSR of the seasons in that place. Solar energy is one of the most important alternative energy sources. To design any solar energy device, solar energy parameters and its components were very important. Solar energy offers us clean and sustainable energy for the future.

The findings of the study in general, revealed that, GSR in different seasons summer, autumn, winter and spring season were 18.80 $MJm^{-2}day^{-1}$, 22.76 $MJm^{-2}day^{-1}$, 26.64 $MJm^{-2}day^{-1}$ and 23.94 $MJm^{-2}day^{-1}$ respectively using Angstrom-Prescott model. Using Hargreaves-Samani model the value of GSR found to be in summer, autumn, winter and spring seasons were 20.60 $MJm^{-2}day^{-1}$, 24.42 $MJm^{-2}day^{-1}$, 28.60 $MJm^{-1}day^{-1}$ and 26.12 $MJm^{-2}day^{-1}$ respectively. Hence, the result of this project clearly indicate the main significance developing empirical models for estimating seasonal values of GSR and their variability's on a horizontal surface reaching the earth for particular geographical location. Based on the finding, peak value of GSR obtained in a seasons of winter and spring with AP and HS models. Both models used successfully to estimate seasonal value of GSR with relative accuracy.

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Appendices

Appendix A.

Table.1.Daily mean sunshine hour, T_{max}, T_{min}, GSR and calculated parameters in Bale Robe town using AP and HS model(January-December, 2010-2014).

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
1	-23	87.1	9.6	12	0.38	0.35	35.6	23	21.9	6.1	15.8	0.2	26.9
2	-23	87.1	9.1	12	0.37	0.37	35.6	22.2	21.3	5.8	15.5	0.2	26.5
3	-22.9	87.1	9.3	12	0.37	0.36	35.6	22.9	22.3	6.1	16.2	0.2	27.4
4	-22.8	87.1	10.3	12	0.4	0.3	35.7	23.5	23.3	5.1	18.2	0.2	29
5	-22.7	87.1	10.7	12	0.41	0.28	35.7	23.6	23.6	4.6	19	0.2	29.8
6	-22.6	87.1	9.7	12	0.38	0.34	35.7	23.1	23.6	5.2	18.4	0.2	29.4
7	-22.5	87.1	10	12	0.39	0.32	35.7	23.4	23.6	5.2	18.4	0.2	29.3
8	-22.3	87.2	7.4	12	0.32	0.47	35.8	20	22.6	6.7	15.9	0.2	27.3
9	-22.2	87.2	7.8	12	0.33	0.45	35.8	21.1	22.7	6.1	16.6	0.2	28
10	-22.1	87.2	9.6	12	0.38	0.34	35.8	23.3	23.3	6.1	17.2	0.2	28.5
11	-21.9	87.2	9.1	12	0.37	0.37	35.9	22.9	22.9	6.4	16.5	0.2	28
12	-21.8	87.2	9.6	12	0.38	0.34	35.9	23.2	22.9	6.1	16.8	0.2	28.2
13	-21.7	87.3	10.4	12	0.4	0.3	35.9	23.7	23	4.2	18.8	0.2	29.8
14	-21.5	87.3	9.8	12	0.39	0.33	36	23.6	23.6	4.4	19.2	0.2	30.2
15	-21.3	87.3	8.9	12	0.36	0.38	36	23	23.5	4.9	18.6	0.2	29.7
16	-21.2	87.3	8.8	12	0.36	0.39	36	23.1	23.4	5.9	17.5	0.2	28.9
17	-21	87.3	9	12	0.36	0.38	36.1	22.4	23.6	5.9	17.7	0.2	28.9
18	-20.8	87.4	9.8	12	0.39	0.33	36.1	23.6	23.6	5.4	18.2	0.2	29.3
19	-20.6	87.4	9.1	12	0.37	0.37	36.2	23.1	23.3	6.5	16.8	0.2	28.3
20	-20.4	87.4	9.1	12	0.37	0.37	36.2	23.1	23.5	6.2	17.3	0.2	28.7
21	-20.2	87.5	9.9	12	0.39	0.33	36.2	23.7	23.9	6.4	17.5	0.2	28.9
22	-20	87.5	9.4	12	0.38	0.36	36.3	23.2	23.6	5.8	17.8	0.2	29.2
23	-19.8	87.5	9.9	12	0.39	0.33	36.3	23.7	24.2	6.5	17.7	0.2	29.1
24	-19.6	87.5	10.2	12	0.4	0.31	36.4	24	23.5	5.9	17.6	0.2	29.1
25	-19.3	87.6	10.4	12	0.4	0.3	36.4	24	23.3	4.3	19	0.2	30.3
26	-19.1	87.6	10.8	12	0.41	0.27	36.5	24.1	24	4.6	19.4	0.2	30.7
27	-18.9	87.6	10.7	12	0.41	0.28	36.5	24.2	24	5	19	0.2	30.4
28	-18.6	87.7	9.9	12	0.39	0.33	36.5	23.9	24.3	5.7	18.6	0.2	30.1
29	-18.4	87.7	10	12	0.39	0.32	36.6	23.8	24.8	6.5	18.3	0.2	30
30	-18.1	87.7	9.4	12	0.38	0.36	36.6	23.8	23.9	6.5	17.4	0.2	29.3
31	-17.9	87.8	9.5	12	0.38	0.35	36.7	23.6	24.2	5.9	18.3	0.2	30
AVE. STD.	-20.9	87.4	9.6	12	0.38	0.34	36.1 ±0.3	23.2 ±0.9	23.4	5.7	17.7	0.2	29 ±1.1

n_d		w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
32	-17.6	87.8	8.9	12	0.36	0.38	36.7	22.6	24.3	5.3	19	0.2	30.6
33	-17.3	87.8	9	12	0.37	0.38	36.8	23.1	24.8	6.5	18.3	0.2	30.2
34	-17.1	87.9	8.7	12	0.36	0.4	36.8	21.9	23.9	6.7	17.2	0.2	29.3
35	-16.8	87.9	8.9	12	0.36	0.39	36.9	22.8	24	7.3	16.7	0.2	28.9
36	-16.5	88	9.2	12	0.37	0.37	36.9	23.7	23.7	8	15.7	0.2	27.8
37	-16.2	88	7.4	12	0.32	0.47	36.9	20.5	24.3	6.6	17.7	0.2	29.8
38	-15.9	88	8.8	12	0.36	0.39	37	22.3	23.7	6.8	16.9	0.2	29
39	-15.6	88.1	6.8	12	0.31	0.51	37	18.6	23.6	8	15.6	0.2	27.5
40	-15.3	88.1	7.2	12	0.32	0.48	37.1	18.9	23.5	7.7	15.8	0.2	27.7
41	-15	88.2	8.2	12	0.35	0.42	37.1	21.9	23.7	7.1	16.6	0.2	28.7
42	-14.7	88.2	7	12	0.31	0.49	37.2	19	23.1	8.1	15	0.2	27.2
43	-14.4	88.2	8.4	12	0.35	0.41	37.2	21.4	24	7.5	16.5	0.2	28.7
44	-14.1	88.3	7.3	12	0.32	0.48	37.2	21	23.6	8.4	15.2	0.2	27.5
45	-13.7	88.3	7.6	12	0.33	0.46	37.3	21.7	23.4	7.9	15.5	0.2	27.8
46	-13.4	88.4	9.3	12	0.37	0.36	37.3	24	24	7.2	16.8	0.2	29.2
47	-13.1	88.4	7.1	12	0.31	0.49	37.4	21.1	23.5	8.3	15.2	0.2	27.5
48	-12.8	88.5	9.8	12	0.39	0.33	37.4	24.4	24.2	8.1	16.1	0.2	28.5
49	-12.4	88.5	9.2	12	0.37	0.37	37.4	23.4	24.7	7.3	17.4	0.2	29.8
50	-12.1	88.5	9.3	12	0.37	0.36	37.5	24	24.6	7.1	17.5	0.2	30
51	-11.7	88.6	8.9	12	0.36	0.39	37.5	23.8	24.3	8	16.3	0.2	29
52	-11.4	88.6	9	12	0.36	0.38	37.5	23.6	24.2	7.6	16.6	0.2	29.1
53	-11	88.7	9.2	12	0.37	0.37	37.6	24.1	24.3	7.3	17	0.2	29.6
54	-10.7	88.7	9.5	12	0.38	0.35	37.6	23.9	24.2	6.7	17.5	0.2	30.1
55	-10.3	88.8	10.3	12	0.4	0.3	37.6	24.8	24.4	7.2	17.2	0.2	29.9
56	-9.9	88.8	10.2	12	0.4	0.31	37.6	24.7	24.6	7	17.6	0.2	30.1
57	-9.6	88.9	8.6	12	0.36	0.4	37.7	22.2	24.2	7.8	16.4	0.2	29
58	-9.2	88.9	9.7	12	0.38	0.34	37.7	24.1	23.6	8	15.6	0.2	28.1
59	-8.8	89	9.5	12	0.38	0.35	37.7	24.5	23.8	7.9	15.9	0.2	28.4
60	-8.5	89	10.5	12	0.41	0.29	37.7	25	25.6	8	17.6	0.2	31.2
AVE.	-13.3	88.4	8.7	12	0.36	0.39	37.3	22.7	24.1	7.4	16.6	0.2	29
STD.							±0.3	±1.8					±1.0

n_d	δ	$_s$	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
61	-8.1	89	7.8	12	0.33	0.45	37.8	22.4	24.8	7.5	17.3	0.2	29.8
62	-7.7	89.1	7.5	12	0.32	0.47	37.8	22.7	24.3	7.5	16.8	0.2	29.4
63	-7.3	89.1	6.8	12	0.31	0.51	37.8	21.1	24.3	7.8	16.5	0.2	29.2
64	-6.9	89.2	7.1	12	0.32	0.49	37.8	21.9	24.4	8.5	15.9	0.2	28.7
65	-6.5	89.2	8.4	12	0.35	0.41	37.8	23.6	24.1	7.8	16.3	0.2	29
66	-6.2	89.3	7.3	12	0.32	0.48	37.8	22.5	24.2	8.4	15.8	0.2	28.4
67	-5.8	89.3	7.6	12	0.33	0.46	37.8	22.3	23.5	8.8	14.7	0.2	27.5
68	-5.4	89.4	6.9	12	0.31	0.5	37.8	21.6	24.1	8.8	15.3	0.2	28
69	-5	89.4	8.5	12	0.35	0.41	37.8	23.2	23.5	8.3	15.2	0.2	28
70	-4.6	89.5	9.8	12	0.39	0.33	37.8	24.8	24.5	6.6	17.9	0.2	30.6
71	-4.2	89.5	9.6	12	0.38	0.35	37.8	24.3	24.2	6.6	17.6	0.2	30.3
72	-3.8	89.6	9.2	12	0.37	0.37	37.8	24	24.6	7.6	17	0.2	29.9
73	-3.4	89.6	6.5	12	0.3	0.52	37.8	18.8	22.6	7.9	14.7	0.2	27.6
74	-3	89.7	4.9	12	0.26	0.62	37.8	17.3	22.5	8.6	13.9	0.2	26.8
75	-2.6	89.7	7.6	12	0.33	0.46	37.8	21.2	22.9	8.3	14.6	0.2	27.4
76	-2.2	89.8	6.5	12	0.3	0.52	37.8	19.8	22.9	9.2	13.7	0.2	26.7
77	-1.8	89.8	6.3	12	0.29	0.54	37.8	19.5	22.2	9.2	13	0.2	25.8
78	-1.4	89.9	6.9	12	0.31	0.5	37.8	21.6	23.2	8.9	14.3	0.2	27.2
79	-1	89.9	6.1	12	0.29	0.55	37.8	19.9	23.5	9.7	13.8	0.2	26.8
80	-0.6	90	6.9	12	0.31	0.5	37.8	20.3	23	9.3	13.7	0.2	26.7
81	-0.2	90	6.7	12	0.3	0.51	37.7	20	23.2	9.2	14	0.2	26.8
82	0.2	90.1	7.6	12	0.33	0.46	37.7	22.3	23.7	8.1	15.6	0.2	28.4
83	0.6	90.1	6.2	12	0.29	0.54	37.7	19.1	23.4	7.8	15.6	0.2	28.6
84	1	90.2	7.6	12	0.33	0.46	37.7	22	23.3	8.2	15.1	0.2	28
85	1.4	90.2	6	12	0.28	0.55	37.6	19.2	22.8	9.3	13.5	0.2	26.4
86	1.8	90.3	7.9	12	0.34	0.44	37.6	22.6	23.7	7.3	16.4	0.2	28.9
87	2.2	90.3	7.7	12	0.33	0.46	37.6	23	23.8	8.7	15.1	0.2	27.8
88	2.6	90.4	6.6	12	0.3	0.52	37.6	21.4	23.7	9.5	14.2	0.2	27
89	3	90.4	5.6	12	0.27	0.58	37.5	18.1	22.6	8.9	13.7	0.2	26.4
90	3.4	90.5	7	12	0.31	0.49	37.5	21.7	22.9	8.3	14.6	0.2	27.4
91	3.8	90.5	7.1	12	0.31	0.49	37.5	21.6	22.7	9.3	13.4	0.2	26.2
AVE.	-2.2	89.8	7.2	12	0.32	0.48	37.7	21.4	23.5	8.4	15.1	0.2	27.9
STD.							±0.1	±1.8					±1.3

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
92	4.2	90.6	6.5	12	0.3	0.49	37.4	20.9	23.1	8.7	14.4	0.2	27.1
93	4.6	90.6	7	12	0.31	0.5	37.4	21.8	22.8	9.2	13.6	0.2	26.3
94	5	90.7	6.5	12	0.3	0.52	37.3	21	23	9.2	13.8	0.2	26.5
95	5.4	90.7	7.2	12	0.32	0.47	37.3	22.4	22.5	9.9	12.6	0.2	25.4
96	5.8	90.8	8	12	0.34	0.44	37.2	22	23.1	8.9	14.2	0.2	26.8
97	6.2	90.8	6.1	12	0.29	0.57	37.2	18.5	22.3	9.7	12.6	0.2	25.1
98	6.6	90.9	8	12	0.34	0.42	37.1	23	23.4	9.8	13.6	0.2	26.1
99	7	90.9	7.2	12	0.32	0.43	37.1	21.5	23.1	9.7	13.4	0.2	25.9
100	7.4	91	8	12	0.34	0.45	37	22.3	23	9.2	13.8	0.2	26.3
101	7.7	91	7.2	12	0.32	0.48	37	21.9	23.7	9.2	14.5	0.2	26.9
102	8.1	91	7.1	12	0.31	0.48	36.9	21.2	23.8	9.1	14.7	0.2	27.1
103	8.5	91.1	5.7	12	0.28	0.48	36.9	18.7	22.2	9.5	12.7	0.2	25.1
104	8.9	91.1	4.3	12	0.24	0.58	36.8	16.5	22.5	9.6	12.9	0.2	25.3
105	9.2	91.2	5.5	12	0.27	0.58	36.8	18.2	23.1	10.1	13	0.2	25.4
106	9.6	91.2	5.2	12	0.26	0.47	36.7	17.1	22.9	9.4	13.5	0.2	25.6
107	10	91.3	4.4	12	0.24	0.54	36.6	16.9	22.4	10	12.4	0.2	24.5
108	10.3	91.3	7.1	12	0.31	0.44	36.6	20.6	23.5	9.1	14.4	0.2	26.5
109	10.7	91.4	6.3	12	0.29	0.47	36.5	20.8	22.9	9.9	13	0.2	25.2
110	11.1	91.4	5.9	12	0.28	0.51	36.4	19.8	22.1	9.3	12.8	0.2	24.7
111	11.4	87.2	8.5	12	0.35	0.41	35.9	22.6	22.5	10.2	12.3	0.2	24.2
112	11.8	91.5	8.9	12	0.36	0.34	36.3	22.9	22.5	9.2	13.3	0.2	25.3
113	12.1	91.6	6.6	12	0.3	0.42	36.3	20.5	22.9	9.7	13.2	0.2	25.1
114	12.5	91.6	7	12	0.31	0.44	36.2	21.6	22.6	9.6	13	0.2	24.9
115	12.8	91.6	6.1	12	0.29	0.46	36.1	19.5	22.2	9.8	12.4	0.2	24.2
116	13.1	91.7	6.6	12	0.3	0.5	36	20.1	22.4	10.8	11.6	0.2	23.4
117	13.5	91.7	7.7	12	0.33	0.41	36	21.8	23.5	9.5	14	0.2	25.6
118	13.8	91.8	5.5	12	0.27	0.5	35.9	18.5	22	10.4	11.6	0.2	23.3
119	14.1	91.8	7.4	12	0.32	0.38	35.8	21	22.8	10.1	12.7	0.2	24.4
120	14.4	91.9	6.5	12	0.3	0.51	35.8	19.8	22	10.1	11.9	0.2	23.6
121	14.8	91.9	8	12	0.34	0.4	35.7	22.2	22.3	10.3	12	0.2	23.4
Ave.	9.7	91.1	6.7	12	0.3	0.47	36.6	20.5	22.8	9.6	13.1	0.2	25.3
STD.							±0.5	±1.8					±1.1

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
122	15.1	91.9	7.9	12	0.34	0.44	35.6	20.8	22.4	9.2	13.2	0.2	24.8
123	15.4	92	6.2	12	0.29	0.54	35.6	19.5	22.2	8.9	13.3	0.2	24.8
124	15.7	92	5.9	12	0.28	0.56	35.5	16.9	23.5	10.6	12.9	0.2	24
125	16	92.1	6	12	0.29	0.55	35.4	19.5	22.2	10.6	11.6	0.2	23.1
126	16.3	92.1	5.3	12	0.27	0.59	35.4	18.1	21.6	10.9	10.7	0.2	22
127	16.5	92.1	4.4	12	0.24	0.65	35.3	15.4	22.3	10.4	11.9	0.2	23.3
128	16.8	92.2	5.1	12	0.26	0.61	35.2	17.7	22	10.6	11.4	0.2	22.7
129	17.1	92.2	7.7	12	0.33	0.45	35.1	21.4	23.1	10.3	12.8	0.2	24.1
130	17.4	92.2	6	12	0.29	0.55	35.1	19.3	22.4	10.9	11.5	0.2	22.8
131	17.7	92.3	4.9	12	0.25	0.62	35	16.4	21.8	10.9	10.9	0.2	22
132	17.9	92.3	6.6	12	0.3	0.52	34.9	20.2	22.4	10.8	11.6	0.2	22.6
133	18.2	92.4	5.8	12	0.28	0.56	34.9	18.6	22.6	11	11.6	0.2	22.7
134	18.4	92.4	7.3	12	0.32	0.48	34.8	20.8	22.7	10.2	12.5	0.2	23.5
135	18.7	92.4	7.3	12	0.32	0.48	34.7	19.9	22.9	9.6	13.3	0.2	24.2
136	18.9	92.5	7.2	12	0.32	0.49	34.7	20.9	22.9	9.2	13.7	0.2	24.6
137	19.1	92.5	7.8	12	0.33	0.45	34.6	21.4	23.2	8.4	14.8	0.2	25.5
138	19.4	88	7.7	12	0.33	0.45	37	21.8	23.2	10.1	13.1	0.2	25.2
139	19.6	92.6	7.3	12	0.32	0.48	34.5	21.6	22.6	10.4	12.2	0.2	23
140	19.8	92.6	8.5	12	0.35	0.41	34.4	21.4	22.2	10.8	11.4	0.2	22.3
141	20	92.6	5.6	12	0.27	0.58	34.4	18.1	21.7	10.2	11.5	0.2	22.2
142	20.2	92.6	6.6	12	0.3	0.52	34.3	18	21.7	9.1	12.6	0.2	23.2
143	20.4	92.7	6	12	0.28	0.56	34.3	17.9	21.6	9.7	11.9	0.2	22.5
144	20.6	92.7	7.4	12	0.32	0.47	34.2	20.1	22	8.6	13.4	0.2	23.8
145	20.8	92.7	6.2	12	0.29	0.54	34.1	17.6	21.9	9.5	12.4	0.2	22.9
146	21	92.7	8.2	12	0.34	0.42	34.1	20.7	23.2	9.7	13.5	0.2	24
147	21.2	92.8	4.8	12	0.25	0.62	34	16.5	22.3	11.3	11	0.2	21.5
148	21.4	92.8	7.5	12	0.33	0.47	34	20.3	23.1	10.6	12.5	0.2	23
149	21.5	92.8	7.8	12	0.33	0.45	33.9	20.5	22.4	9.7	12.7	0.2	23.1
150	21.7	92.8	7	12	0.31	0.5	33.9	18.2	22.2	9.6	12.6	0.2	22.9
151	21.8	92.9	7.1	12	0.31	0.49	33.8	19.5	22.5	9.3	13.2	0.2	23.4
152	22	92.9	8	12	0.34	0.44	33.8	20	23.1	9.9	13.2	0.2	23.5
AVE.	18.9	92.3	6.7	12	0.3	0.51	34.7	19.3	22.4	10	12.4	0.2	23.3
STD.							±0.7	±1.7					±1.0

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
153	22.1	92.9	9.1	12	0.37	0.37	33.8	21.4	23.2	9.6	13.6	0.2	23.8
154	22.2	92.9	8.1	12	0.34	0.43	33.7	20.7	22.9	9.5	13.4	0.2	23.7
155	22.4	92.9	8.5	12	0.35	0.41	33.7	20.9	23	9.6	13.4	0.2	23.6
156	22.5	93	9.3	12	0.37	0.36	33.6	21.9	22.7	8.8	13.9	0.2	23.1
157	22.6	93	8.4	12	0.35	0.41	33.6	21.2	23.3	8.8	14.5	0.2	24.5
158	22.7	93	9	12	0.36	0.38	33.6	21.1	23.2	9.5	13.7	0.2	23.9
159	22.8	93	8.5	12	0.35	0.41	33.5	21.2	23.3	9.7	13.6	0.2	23.7
160	22.9	93	9	12	0.36	0.38	33.5	21.5	23.7	9.6	14.1	0.2	24.1
161	23	93	8.3	12	0.35	0.42	33.5	21.2	24.1	9.5	14.6	0.2	24.4
162	23	93	8.8	12	0.36	0.39	33.4	21.4	24	10	14	0.2	24
163	23.1	93.1	6	12	0.29	0.55	33.4	18.7	23	10.8	12.2	0.2	22.2
164	23.2	93.1	8	12	0.34	0.44	33.4	19.6	23.2	9.7	13.5	0.2	23.5
165	23.2	93.1	8.8	12	0.36	0.39	33.4	21.1	23.1	9.4	13.7	0.2	23.6
166	23.3	93.1	7.9	12	0.33	0.45	33.4	19.4	22.9	9.8	13.1	0.2	23.1
167	23.3	93.1	6.3	12	0.29	0.54	33.3	16.6	23.3	9.2	14.1	0.2	24
168	23.4	93.1	7.4	12	0.32	0.47	33.3	18.7	23.3	8.8	14.5	0.2	24.3
169	23.4	93.1	7.8	12	0.33	0.45	33.3	19.4	23.1	8.8	14.3	0.2	24.1
170	23.4	93.1	6.7	12	0.3	0.51	33.3	17.9	23.2	9.6	13.6	0.2	23.6
171	23.4	93.1	6	12	0.29	0.55	33.3	18.2	22.8	10	12.8	0.2	22.9
172	23.4	93.1	7.5	12	0.33	0.47	33.3	19.8	23.2	10.4	12.8	0.2	22.8
173	23.4	93.1	5.4	12	0.27	0.59	33.3	16.9	21.9	10	11.9	0.2	21.8
174	23.4	93.1	8.2	12	0.34	0.43	33.3	20.5	22.8	9.4	13.4	0.2	23.4
175	23.4	93.1	6.8	12	0.31	0.5	33.3	19.4	22.3	10	12.3	0.2	22.3
176	23.4	93.1	7.2	12	0.32	0.48	33.3	20.1	22.9	9.4	13.5	0.2	23.3
177	23.4	93.1	6	12	0.28	0.55	33.3	18.4	23	10.3	12.7	0.2	22.6
178	23.4	93.1	5.4	12	0.27	0.59	33.3	16.6	23	9.4	13.6	0.2	23.5
179	23.3	93.1	6	12	0.28	0.55	33.3	17.9	22.6	9.9	12.7	0.2	22.7
180	23.3	93.1	6.2	12	0.29	0.54	33.3	18.4	22.1	9.5	12.6	0.2	22.6
181	23.2	93.1	7.6	12	0.33	0.46	33.3	19.5	22.8	9.5	13.3	0.2	23.2
182	23.2	93.1	5.6	12	0.27	0.58	33.3	17.4	22.5	10.6	11.9	0.2	22
AVE.	23.1	93	7.5	12	0.32	0.47	33.4	19.6	23	9.6	13.4	0.2	23.3
STD.							±0.1	±1.6					±0.7

ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online)
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n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
183	23.1	93	5.3	12	0.27	0.59	33.4	15.7	23.1	9.8	13.3	0.2	23.3
184	23	93	6.4	12	0.3	0.53	33.4	19.1	22.9	9.4	13.5	0.2	23.5
185	22.9	93	7.8	12	0.33	0.45	33.4	20.3	22.9	9.4	13.5	0.2	23.4
186	22.8	93	7.9	12	0.34	0.44	33.4	20.8	23.4	8.6	14.8	0.2	24.6
187	22.8	93	5	12	0.26	0.61	33.4	16	23	10	13	0.2	23.1
188	22.7	93	4.4	12	0.24	0.65	33.5	15.1	22.6	10.3	12.3	0.2	22.4
189	22.5	93	3.3	12	0.21	0.71	33.5	12.8	21.6	9.3	12.3	0.2	22.5
190	22.4	93	6.9	12	0.31	0.5	33.5	19.5	22.8	8.5	14.3	0.2	24.2
191	22.3	92.9	6	12	0.29	0.55	33.6	18.1	22.4	9.4	13	0.2	23.2
192	22.2	92.9	6.9	12	0.31	0.5	33.6	19.6	22.9	9.3	13.6	0.2	23.7
193	22	92.9	4.3	12	0.24	0.65	33.6	14.6	22.8	9.9	12.9	0.2	23.1
194	21.9	92.9	7	12	0.31	0.49	33.7	19.6	23.2	9.5	13.7	0.2	24
195	21.8	92.9	7.2	12	0.32	0.49	33.7	19.6	22.6	9.6	13	0.2	23.3
196	21.6	92.8	4.6	12	0.25	0.63	33.8	15.8	22.3	9.6	12.7	0.2	22.9
197	21.4	92.8	5.7	12	0.28	0.57	33.8	18.4	22	10.4	11.6	0.2	22
198	21.3	92.8	7.3	12	0.32	0.48	33.8	20.3	23.2	8.8	14.4	0.2	24.6
199	21.1	92.8	6.5	12	0.3	0.52	33.9	19.6	22.3	9.2	13.1	0.2	23.5
200	20.9	92.7	3.5	12	0.22	0.7	33.9	14.3	21.4	10.1	11.3	0.2	21.8
201	20.7	92.7	4.1	12	0.23	0.67	34	15.2	21.8	10	11.8	0.2	22.3
202	20.6	92.7	6.7	12	0.3	0.51	34	19.1	22	9.8	12.2	0.2	22.6
203	20.4	92.7	3.7	12	0.22	0.69	34.1	14.5	21.6	9.9	11.7	0.2	22.1
204	20.2	92.6	3.5	12	0.22	0.7	34.1	13.9	21.5	10.4	11.1	0.2	21.7
205	19.9	92.6	5.5	12	0.27	0.58	34.2	17.1	22	9.5	12.5	0.2	23.2
206	19.7	92.6	4.8	12	0.25	0.62	34.2	16.7	21.8	10.1	11.7	0.2	22.4
207	19.5	92.5	4.8	12	0.25	0.62	34.3	16	22.7	9.2	13.5	0.2	23.9
208	19.3	92.5	5	12	0.26	0.61	34.4	17.2	21.7	9.8	11.9	0.2	22.7
209	19.1	92.5	3	12	0.2	0.73	34.4	12.7	20.7	10.2	10.5	0.2	21.3
210	18.8	92.4	5.8	12	0.28	0.57	34.5	18.8	21.5	9.7	11.8	0.2	22.6
211	18.6	92.4	4.5	12	0.24	0.64	34.5	16.6	21.8	9.4	12.4	0.2	23.2
212	18.3	92.4	6.8	12	0.31	0.5	34.6	20.4	21.5	9.8	11.7	0.2	22.6
213	18.1	92.3	6.8	12	0.31	0.51	34.6	20	21.3	10	11.3	0.2	22.3
AVE.	21	92.8	5.5	12	0.27	0.58	33.9	17.3	22.2	9.6	12.6	0.2	23
STD.							±0.4	±2.4					±0.8

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
214	17.8	92.3	5	12	0.26	0.61	34.7	16.1	20.6	10.1	10.5	0.2	21.4
215	17.5	92.3	4.7	12	0.25	0.63	34.8	15.3	21.2	10.3	10.9	0.2	22
216	17.3	92.2	6.9	12	0.31	0.5	34.8	19.8	21.7	10.2	11.5	0.2	22.7
217	17	92.2	6.5	12	0.3	0.52	34.9	20.3	22.1	9.2	12.9	0.2	24
218	16.7	92.2	4.6	12	0.25	0.63	35	16.3	20.1	9.6	10.5	0.2	21.9
219	16.4	92.1	4.7	12	0.25	0.63	35	17.1	21.1	9.7	11.4	0.2	22.5
220	16.1	92.1	5	12	0.26	0.61	35.1	17.2	20.5	10.1	10.4	0.2	21.6
221	15.8	92	5.5	12	0.27	0.58	35.2	17.6	21.5	10	11.5	0.2	22.9
222	15.5	92	4.5	12	0.24	0.64	35.2	16	20.8	9.8	11	0.2	22.3
223	15.2	92	6.7	12	0.3	0.51	35.3	19.2	21.4	9.4	12	0.2	23.4
224	14.9	91.9	6.4	12	0.29	0.53	35.3	19.9	21.9	9.4	12.5	0.2	23.9
225	14.6	91.9	6.3	12	0.29	0.53	35.4	20.2	21.8	10	11.8	0.2	23.2
226	14.3	91.8	6.3	12	0.29	0.54	35.5	19.5	21.8	9.2	12.6	0.2	24.1
227	14	91.8	4.6	12	0.25	0.63	35.5	16.8	21.7	10	11.7	0.2	23.2
228	13.7	91.8	7	12	0.31	0.5	35.6	20.8	21.8	9.5	12.3	0.2	23.9
229	13.3	91.7	6.4	12	0.3	0.53	35.7	20.3	22.1	10.1	12	0.2	23.6
230	13	91.7	6.8	12	0.31	0.51	35.7	20.5	21.6	9.9	11.7	0.2	23.3
231	12.7	91.6	6.4	12	0.3	0.53	35.8	19.1	21.7	9.7	12	0.2	23.7
232	12.3	91.6	6.6	12	0.3	0.52	35.9	20.2	21.3	9.1	12.2	0.2	24
233	12	91.5	6.6	12	0.3	0.52	35.9	20.6	22.5	8.7	13.8	0.2	25.5
234	11.6	91.5	6.4	12	0.29	0.53	36	20.5	21.9	8.5	13.4	0.2	25.3
235	11.3	91.4	5.4	12	0.27	0.59	36	18.2	21.3	9.4	11.9	0.2	23.9
236	10.9	91.4	7.7	12	0.33	0.45	36.1	21.7	21.7	8.6	13.1	0.2	24.9
237	10.6	91.4	8.3	12	0.35	0.42	36.2	22.9	22.5	8.9	13.6	0.2	25.6
238	10.2	91.3	4.4	12	0.24	0.65	36.2	17.2	21.3	9.7	11.6	0.2	23.6
239	9.8	91.3	4.1	12	0.23	0.66	36.3	16.2	20.1	10.7	9.4	0.2	21.3
240	9.5	91.2	5.8	12	0.28	0.56	36.3	19.2	21.2	9.9	11.3	0.2	23.2
241	9.1	91.2	6.5	12	0.3	0.52	36.4	20.9	21	9.2	11.8	0.2	23.9
242	8.7	91.1	5	12	0.26	0.61	36.5	17.7	20.1	10.2	9.9	0.2	21.8
243	8.3	91.1	5.4	12	0.27	0.59	36.5	18.4	20.6	9.2	11.4	0.2	23.4
244	8	91	5.7	12	0.28	0.57	36.6	18.2	21	10	11	0.2	23.1
AVE.	13.2	91.7	5.9	12	0.28	0.56	35.7	18.8	21.4	9.6	11.7	0.2	23.3
STD.							±0.6	±1.9					±1.1

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
245	7.6	91	6.2	12	0.3	0.54	36.6	19.5	20.9	10.6	10.3	0.2	22.5
246	7.2	90.9	6.1	12	0.29	0.55	36.7	20.1	21.3	9.9	11.4	0.2	23.7
247	6.8	90.9	4.2	12	0.24	0.66	36.7	16.2	20.7	8.5	12.2	0.2	24.2
248	6.4	90.8	5.3	12	0.27	0.59	36.8	18.5	21.3	8.4	12.9	0.2	25.1
249	6	90.8	6.6	12	0.3	0.52	36.8	21.4	21.3	9.6	11.7	0.2	24.1
250	5.7	90.7	6.1	12	0.29	0.55	36.9	20.7	20.9	10	10.9	0.2	23.2
251	5.3	90.7	5.1	12	0.26	0.6	36.9	18.6	20.5	9.9	10.6	0.2	23
252	4.9	90.6	5.6	12	0.27	0.58	36.9	19.6	21	7.7	13.3	0.2	25.8
253	4.5	90.6	5.2	12	0.26	0.6	37	18	21.1	8.5	12.6	0.2	25
254	4.1	90.5	6.3	12	0.29	0.53	37	20.2	21.3	8.6	12.7	0.2	25.1
255	3.7	90.5	7.2	12	0.32	0.48	37.1	21.2	20.8	8.4	12.4	0.2	24.8
256	3.3	90.4	3	12	0.21	0.72	37.1	14.4	20.1	9.2	10.9	0.2	23.4
257	2.9	90.4	5.3	12	0.27	0.59	37.1	18.6	20.6	8	12.6	0.2	25.1
258	2.5	90.3	5.1	12	0.26	0.6	37.2	18.5	21.4	7.9	13.5	0.2	26.1
259	2.1	90.3	4.2	12	0.24	0.65	37.2	16.6	21.1	8.4	12.7	0.2	25.3
260	1.7	90.3	4.2	12	0.24	0.66	37.2	15.9	21.4	9.7	11.7	0.2	24.4
261	1.3	90.2	4.3	12	0.24	0.65	37.2	17	20.8	9.2	11.6	0.2	24.2
262	0.9	90.2	6.3	12	0.29	0.53	37.3	20.7	21.1	9	12.1	0.2	24.8
263	0.5	90.1	4.4	12	0.24	0.65	37.3	17.1	20.9	8.7	12.2	0.2	24.7
264	0.1	90.1	5.4	12	0.27	0.59	37.3	18.9	21.3	10.7	10.6	0.2	23.3
265	-0.3	90	5	12	0.26	0.61	37.3	18.5	21.1	9.6	11.5	0.2	24.2
266	-0.7	90	4.3	12	0.24	0.65	37.3	16.5	21	9.4	11.6	0.2	24.3
267	-1.1	89.9	4.4	12	0.24	0.65	37.4	17	20.7	9.2	11.5	0.2	24.2
268	-1.5	89.9	3.1	12	0.21	0.72	37.4	13.5	20.6	9.4	11.2	0.2	24
269	-2	89.8	3.2	12	0.21	0.72	37.4	14.2	20.1	9.5	10.6	0.2	23.3
270	-2.4	89.8	3.6	12	0.22	0.69	37.4	13.9	20.2	9.7	10.5	0.2	23.1
271	-2.8	89.7	4.7	12	0.25	0.63	37.4	16.2	20.2	9.3	10.9	0.2	23.5
272	-3.2	89.7	4	12	0.23	0.67	37.4	15.8	20.1	8.8	11.3	0.2	24
273	-3.6	89.6	2.5	12	0.19	0.76	37.4	12.7	19.2	9.4	9.8	0.2	22.5
274	-4	89.6	4.1	12	0.23	0.66	37.4	16.9	20.5	9.2	11.3	0.2	24.1
AVE.	1.9	90.3	4.8	12	0.25	0.62	37.1	17.6	20.8	9.1	11.6	0.2	24.2
STD.							±0.3	±2.4					±0.9

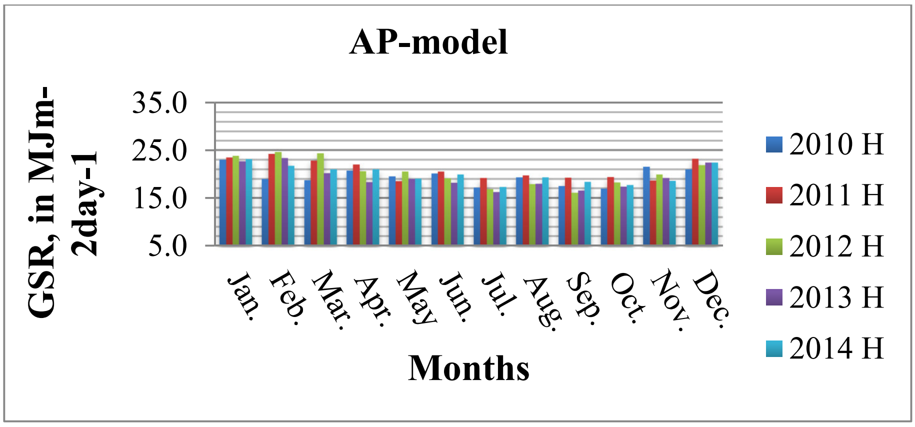
n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
275	-4.3	89.5	3.4	12	0.22	0.7	37.4	14.4	19.7	9.6	10.1	0.2	22.7
276	-4.7	89.5	5	12	0.26	0.61	37.4	17.7	19.9	10.2	9.7	0.2	22.2
277	-5.1	89.4	4.6	12	0.25	0.64	37.4	17.6	20.3	9.2	11.1	0.2	23.8
278	-5.5	89.4	6.2	12	0.29	0.54	37.4	20.5	20.9	8.2	12.7	0.2	25.5
279	-5.9	89.3	5.8	12	0.28	0.57	37.4	19.5	20.4	10.2	10.2	0.2	22.8
280	-6.3	89.3	5.1	12	0.26	0.61	37.4	17.9	20.9	9.4	11.5	0.2	24.3
281	-6.7	89.2	3.3	12	0.21	0.71	37.4	14.1	19.7	10.2	9.5	0.2	22
282	-7.1	89.2	4.3	12	0.24	0.65	37.4	16.4	20	10.3	9.7	0.2	22.2
283	-7.5	89.1	4.2	12	0.24	0.65	37.4	15.7	20.1	8.7	11.4	0.2	24
284	-7.8	89.1	6.3	12	0.29	0.54	37.4	19.8	20.4	8	12.4	0.2	25.2
285	-8.2	89	4.2	12	0.24	0.66	37.4	15.8	19.7	8.9	10.8	0.2	23.3
286	-8.6	89	4.3	12	0.24	0.65	37.3	15.8	19.5	8.8	10.7	0.2	23.2
287	-9	88.9	5.6	12	0.27	0.58	37.3	19.6	20.3	7.9	12.4	0.2	25
288	-9.3	88.9	3.3	12	0.21	0.71	37.3	13.9	19.4	8.5	10.9	0.2	23.3
289	-9.7	88.8	6.4	12	0.3	0.53	37.3	19.8	20.3	9.4	10.9	0.2	23.4
290	-10.1	88.8	5.5	12	0.27	0.58	37.3	17.7	19.1	8.7	10.4	0.2	22.7
291	-10.4	88.7	6.9	12	0.31	0.5	37.2	20.9	20	8.2	11.8	0.2	24.4
292	-10.8	88.7	4.4	12	0.24	0.65	37.2	17.2	20.1	9.5	10.6	0.2	23.2
293	-11.2	88.7	5.4	12	0.27	0.59	37.2	17.8	19.7	9.9	9.8	0.2	22.2
294	-11.5	88.6	6.2	12	0.29	0.54	37.2	19.5	19.9	8.2	11.7	0.2	24.2
295	-11.9	88.6	7.4	12	0.32	0.47	37.1	21.1	20.9	7.9	13	0.2	25.5
296	-12.2	88.5	4.3	12	0.24	0.65	37.1	15.3	19.6	7.6	12	0.2	24.5
297	-12.6	88.5	4.9	12	0.26	0.62	37.1	17.1	19.8	8.5	11.3	0.2	23.7
298	-12.9	88.4	5.7	12	0.28	0.57	37	18.2	19.5	7.4	12.1	0.2	24.4
299	-13.2	88.4	6.6	12	0.3	0.52	37	18.7	20	7	13	0.2	25.5
300	-13.6	88.3	8.9	12	0.36	0.38	37	22.4	21	6.3	14.7	0.2	27.1
301	-13.9	88.3	5.5	12	0.27	0.58	36.9	17.2	20	6.8	13.2	0.2	25.5
302	-14.2	88.3	6.7	12	0.3	0.51	36.9	17.9	19	8.2	10.8	0.2	22.6
303	-14.5	88.2	5.7	12	0.28	0.57	36.9	18.7	20	8.2	11.8	0.2	24.1
304	-14.8	88.2	5.6	12	0.27	0.58	36.8	19.3	20.9	7.1	13.8	0.2	26.2
305	-15.1	88.1	5.4	12	0.27	0.59	36.8	18.5	20.8	8.3	12.5	0.2	25
AVE. STD.	-10	88.8	5.4	12	0.27	0.59	37.2 ±0.2	17.9 ±2.1	20.1	8.6	11.5	0.2	24 ±1.3

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
306	-15.5	88.1	8.3	12	0.35	0.42	36.8	19.5	20.1	7.8	12.3	0.2	22.5
307	-15.8	88.1	5.4	12	0.27	0.59	36.7	20.1	19.9	6.8	13.1	0.2	23.7
308	-16.1	88	5.8	12	0.28	0.56	36.7	16.2	20.1	6.9	13.2	0.2	24.2
309	-16.3	88	6.1	12	0.29	0.55	36.6	18.5	19.5	7.2	12.3	0.2	25.1
310	-16.6	87.9	6.4	12	0.3	0.53	36.6	21.4	20	8	12	0.2	24.1
311	-16.9	87.9	6.9	12	0.31	0.5	36.6	20.7	20.4	7.7	12.7	0.2	23.2
312	-17.2	87.9	6.8	12	0.31	0.51	36.5	18.6	21	7.6	13.4	0.2	23
313	-17.5	87.8	6.8	12	0.31	0.51	36.5	19.6	20.6	8	12.6	0.2	25.8
314	-17.7	87.8	7.1	12	0.31	0.49	36.4	18	20.2	7.5	12.7	0.2	25
315	-18	87.8	8.8	12	0.36	0.39	36.4	20.2	20.1	9.4	10.7	0.2	25.1
316	-18.2	87.7	6.5	12	0.3	0.52	36.4	21.2	19.5	6.7	12.8	0.2	24.8
317	-18.5	87.7	6.6	12	0.3	0.52	36.3	14.4	20.5	6.9	13.6	0.2	23.4
318	-18.7	87.7	5.5	12	0.27	0.58	36.3	18.6	21	9.1	11.9	0.2	25.1
319	-19	87.6	5.6	12	0.27	0.58	36.3	18.5	20.4	8.5	11.9	0.2	26.1
320	-19.2	87.6	6.3	12	0.29	0.54	36.2	16.6	21.3	8.6	12.7	0.2	25.3
321	-19.4	87.6	5.3	12	0.27	0.59	36.2	15.9	20.5	7.3	13.2	0.2	24.4
322	-19.7	87.5	6.4	12	0.3	0.53	36.1	17	20.6	7.8	12.8	0.2	24.2
323	-19.9	87.5	9	12	0.37	0.38	36.1	20.7	21.2	7.1	14.1	0.2	24.8
324	-20.1	87.5	9	12	0.37	0.38	36.1	17.1	21.8	5.5	16.3	0.2	24.7
325	-20.3	87.4	10	12	0.39	0.32	36	18.9	22	5.3	16.7	0.2	23.3
326	-20.5	87.4	6.7	12	0.3	0.51	36	18.5	20.7	6.1	14.6	0.2	24.2
327	-20.7	87.4	7.1	12	0.31	0.49	36	16.5	21.4	6.9	14.5	0.2	24.3
328	-20.9	87.4	7.8	12	0.33	0.45	35.9	17	21.3	7.5	13.8	0.2	24.2
329	-21.1	87.3	5.4	12	0.27	0.59	35.9	13.5	22.8	7.4	15.4	0.2	24
330	-21.2	87.3	6.3	12	0.29	0.54	35.9	14.2	23.4	7.3	16.1	0.2	23.3
331	-21.4	87.3	3.6	12	0.22	0.69	35.8	13.9	19.3	8.2	11.1	0.2	23.1
332	-21.6	87.3	7.3	12	0.32	0.48	35.8	16.2	17.2	6.8	10.4	0.2	23.5
333	-21.7	87.2	7.5	12	0.32	0.47	35.8	15.8	21.2	6	15.2	0.2	24
334	-21.9	87.2	7	12	0.31	0.5	35.7	12.7	20.9	6.7	14.2	0.2	22.5
335	-22	87.2	7.2	12	0.32	0.48	35.7	16.9	20.8	6.6	14.2	0.2	24.1
AVE. STD.	-19.1	87.6	6.8	12	0.31	0.51	36.2 ±0.3	17.6 ±2.4	20.7	7.3	13.4	0.2	24.2 ±0.9

n_d	δ	w_s	S	S_o	a	b	H_o	H	T_{max}	T_{min}	T_d	K_r	H
336	-22.1	87.2	8.1	12	0.34	0.43	35.7	21.5	20.3	5.5	14.8	0.2	26.1
337	-22.3	87.2	8.9	12	0.36	0.39	35.7	21.2	21.2	5.9	15.3	0.2	26.5
338	-22.4	87.1	9.2	12	0.37	0.37	35.6	22.8	21.7	6.3	15.4	0.2	26.5
339	-22.5	87.1	10.2	12	0.4	0.31	35.6	23.3	22.1	4.2	17.9	0.2	28.8
340	-22.6	87.1	9.8	12	0.39	0.33	35.6	23.2	22.2	4.8	17.4	0.2	28.3
341	-22.7	87.1	8.9	12	0.36	0.38	35.6	21.9	21.8	5.3	16.5	0.2	27.8
342	-22.8	91.1	9.2	12	0.37	0.37	36.5	22.8	21.9	5.8	16.1	0.2	27.8
343	-22.9	87.1	9.5	12	0.38	0.35	35.6	23	21.4	5.9	15.5	0.2	26.7
344	-23	87.1	9.6	12	0.38	0.35	35.5	22.8	21.8	5	16.8	0.2	27.8
345	-23.1	87	10.1	12	0.39	0.32	35.5	23.4	22.5	4.4	18.1	0.2	28.9
346	-23.1	87	8.1	12	0.34	0.43	35.5	20.6	21.8	5.2	16.6	0.2	27.6
347	-23.2	87	9.5	12	0.38	0.35	35.5	22.9	22	4.9	17.1	0.2	28.1
348	-23.3	87	10.5	12	0.4	0.3	35.5	23.4	22.1	3.8	18.3	0.2	29.1
349	-23.3	87	9.2	12	0.41	0.37	35.5	22.7	22.4	5.8	16.6	0.2	27.7
350	-23.3	87	8.4	12	0.35	0.41	35.5	21.8	21.4	6	15.4	0.2	26.6
351	-23.4	87	8.8	12	0.36	0.39	35.5	22.4	22	5.8	16.2	0.2	27.3
352	-23.4	87	7.7	12	0.33	0.45	35.5	21.2	21.9	6	15.9	0.2	27.1
353	-23.4	87	9	12	0.36	0.38	35.5	21.4	22	5.8	16.2	0.2	27.3
354	-23.4	87	10.3	12	0.4	0.3	35.5	23.4	21.7	4.4	17.3	0.2	28.2
355	-23.4	87	10.3	12	0.4	0.3	35.5	23.4	22	4	18	0.2	28.9
356	-23.4	87	10.3	12	0.4	0.31	35.5	23.4	22.6	3.5	19.1	0.2	29.7
357	-23.4	87	10.3	12	0.4	0.3	35.5	23.4	23.2	4.2	19	0.2	29.7
358	-23.4	87	9.8	12	0.39	0.33	35.5	23	23.3	4.8	18.5	0.2	29.2
359	-23.4	87	9.4	12	0.38	0.36	35.5	23	23.1	5.7	17.4	0.2	28.3
360	-23.4	87	10.2	12	0.4	0.31	35.5	23.4	22.4	4.6	17.8	0.2	28.7
361	-23.3	87	8.6	12	0.35	0.41	35.5	21.6	22.1	5.4	16.7	0.2	27.8
362	-23.3	87	7.5	12	0.33	0.47	35.5	20.7	22	5	17	0.2	28
363	-23.3	87	7.2	12	0.32	0.48	35.5	19.3	21.4	6.4	15	0.2	26.1
364	-23.2	87	7.8	12	0.33	0.45	35.6	19.8	21.8	5	16.8	0.2	27.9
365	-23.1	87	8	12	0.34	0.44	35.6	19.9	21.9	5.1	16.8	0.2	27.7
366	-23.1	87	8.5	12	0.35	0.41	35.6	21.2	22.8	5.4	17.4	0.2	28.4
AVE.	-23.1	87.2	9.1	12	0.37	0.37	35.6	22.2	22	5.2	16.9	0.2	27.9
STD.							±0.2	±1.2					±1.0

Journal of Energy Technologies and Policy
ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online)
Vol.8, No.8, 2018

Appendix. B



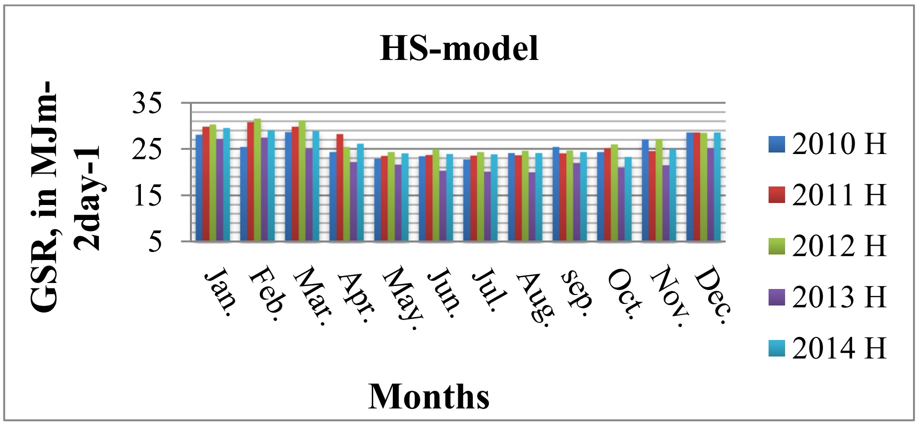


Fig 1.Mean monthly values of GSR in AP and HS model from the year 2010-2014.

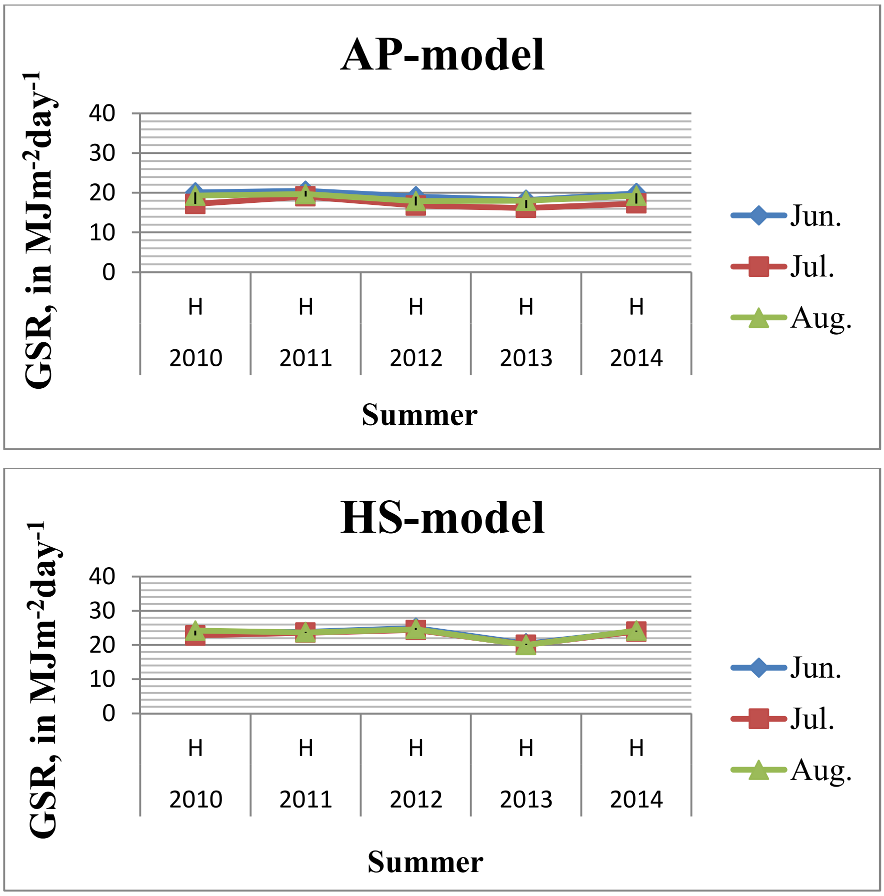


Figure 2. Mean GSR of summer season using AP and HS model from the year 2010 to 2014.

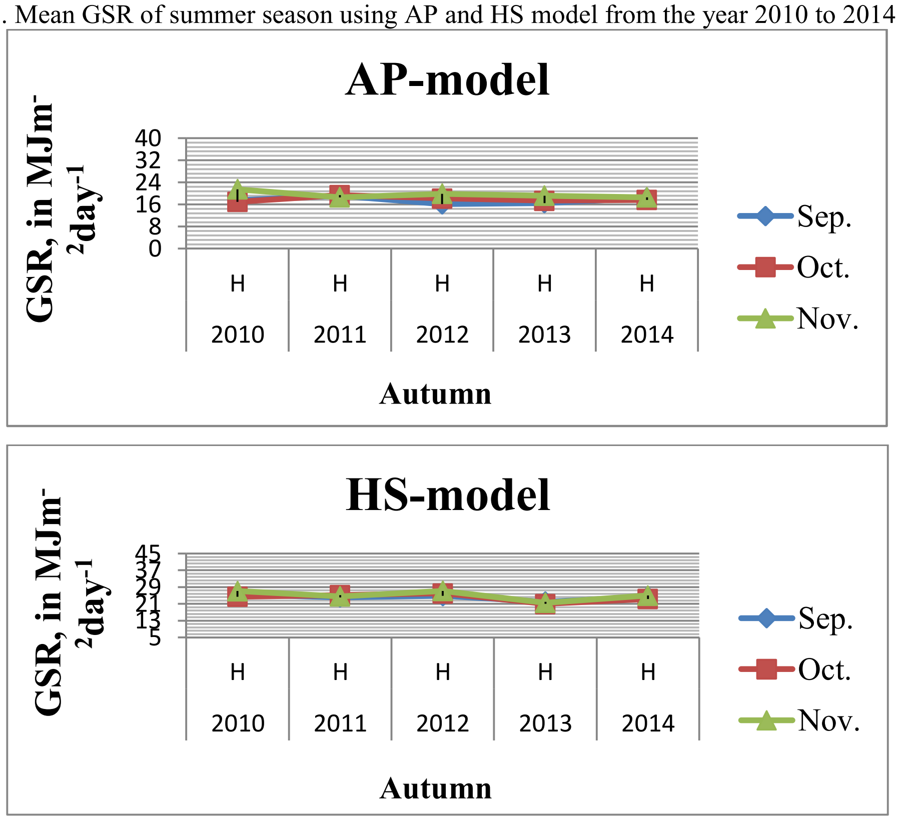


Figure 3. Mean GSR Autumn season using AP and HS model from the year 2010 to 2014.

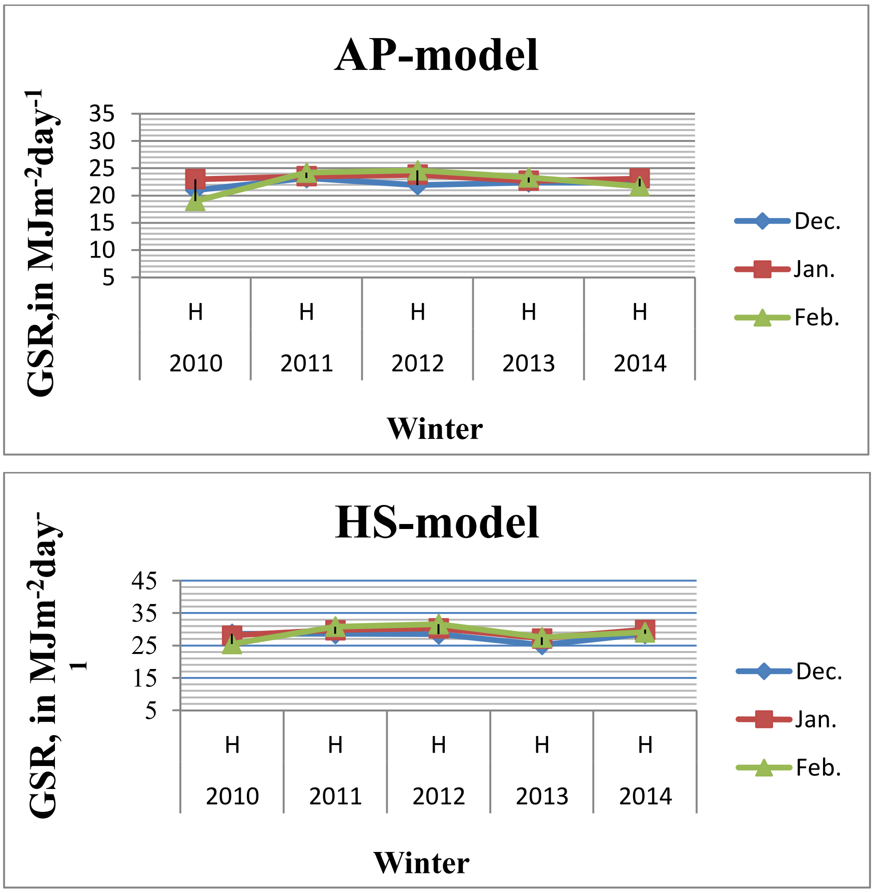


Figure 4. Mean GSR Winter season using AP and HS model from the year 2010 to 2014.

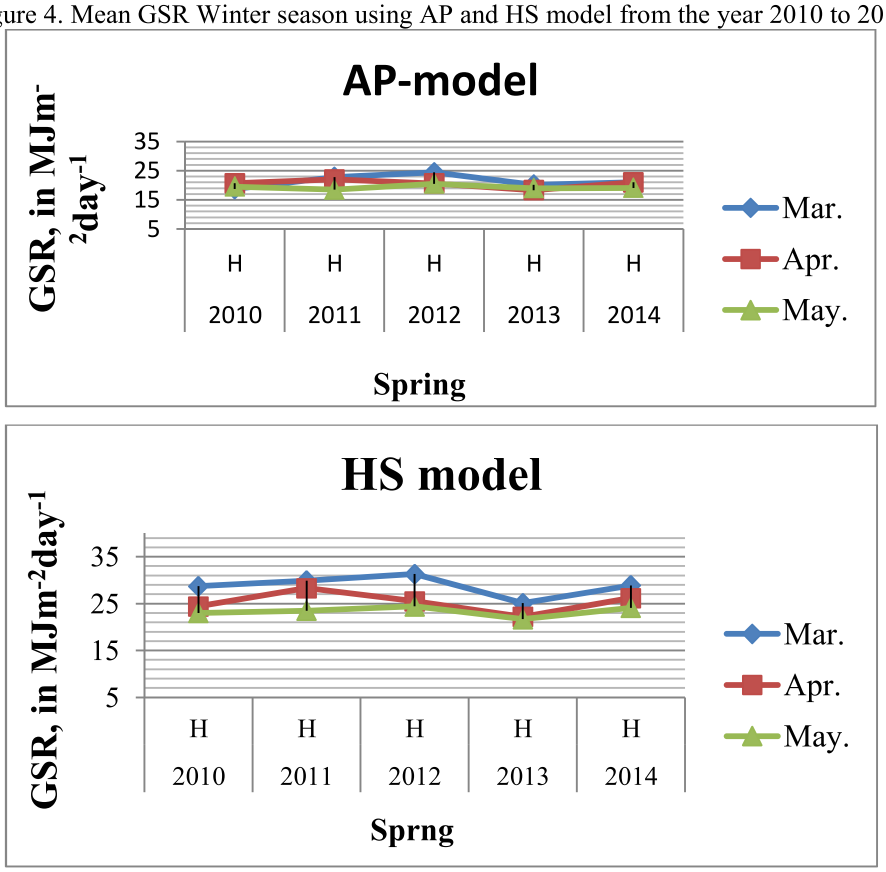
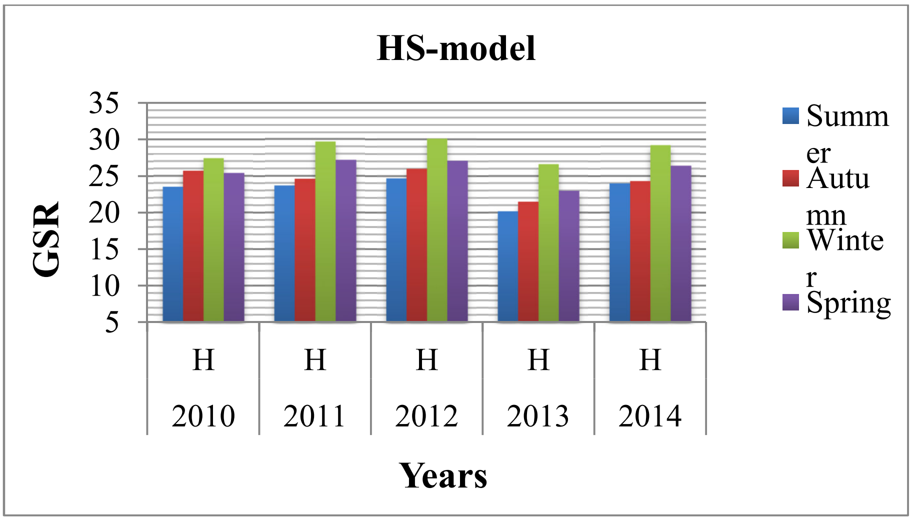


Fig 5.Mean GSR Spring season using AP and HS model from the year 2010 to 2014.



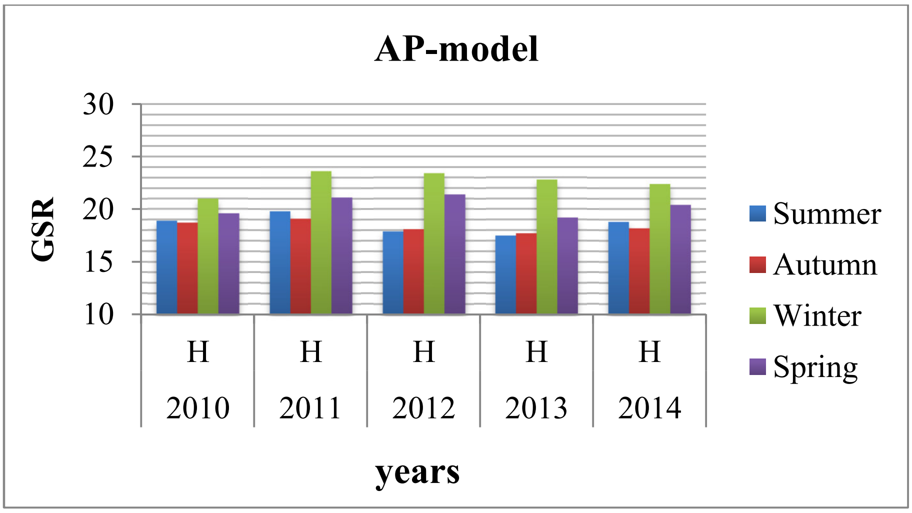


Fig 6.Seasonal mean GSR from AP and HS model from the year 2010-2014.

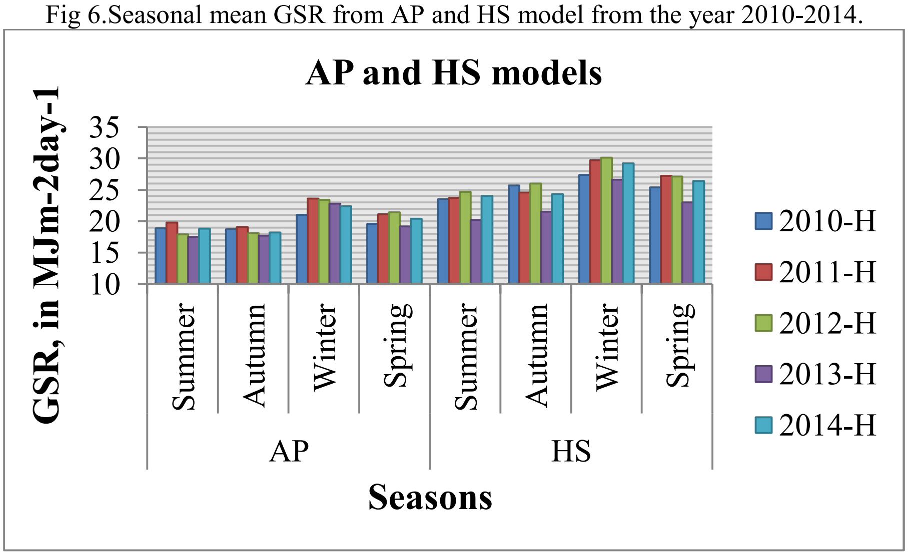


Fig 7. Comparison of mean seasonal GSR using AP and HS model from year 2010-2014.