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Determining Standardized Anomalies of some Atmospheric Parameters of Warri

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ABSTRACT

This report delves into the determination of standardized anomalies in various atmospheric parameters within Warri, Delta State. Focusing specifically on soil heat flux and net radiation, the investigation aims to uncover irregularities and variations in these critical parameters over a ten-year period (2009-2018). The need for such analysis arises from the significance of these atmospheric factors in understanding local climate patterns and their implications for the environment. To address this inquiry, comprehensive data sets were collected from the Nigerian Meteorological Agency (NiMet). The collected data underwent meticulous analysis, wherein the mean, standard deviation, and, most importantly, standardized anomalies were computed. The results of this study were presented graphically, showcasing the standardized anomalies plotted against the twelve months of each year. The graphical representation not only aids in visualizing the temporal variations but also serves as a platform for a detailed discussion of the findings. Through this analysis, the research offers a comprehensive understanding of how soil heat flux and net radiation deviate from their typical values, contributing to an anomaly of the atmospheric conditions in Warri, Delta State.

1. INTRODUCTION

The atmosphere is a complex natural gaseous system that is essential to support life on planet earth. Air is the mixture of gases that fills the atmosphere, giving life to the plants and animals that makes the earth such a vibrant place (Woodford, 2010). The atmosphere of the earth is the layer of gases, commonly referred to as 'air' that surrounds the earth and is retained by gravity. It absorbs ultraviolet (UV) solar radiation, warming the surface through heat retention (greenhouse effect), reducing extreme temperature between day and night (diurnal temperature variation). The Earth's atmosphere is a dynamic system where various parameters interact to govern weather patterns and influence long-term climate trends. Atmospheric parameters: temperature, pressure, humidity, wind speed, net and soil radiation. 'Qun'ou Jiang et al. (2014), according to the energy budget equation, it is found that downward short-wave radiation and downward long wave radiation are the significant factors influencing the energy balance especially for the net surface radiation. Therefore, this study firstly analyzes the seasonal and inter-annual variation of downward long wave radiation and downward short-wave radiation and then explores the spatial distribution changes of net surface radiation from 2030 to 2050. The energy simulation results indicate that downward long wave radiation and downward short-wave radiation will all have small-scale increase with time going by, while the net surface radiation will decrease from 2030 to 2050. However, the spatial disparity is

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extremely significant Smith 2022. There is obvious variation in each season; however, the inter-annual differences are not significant Johnson 2022. Summer has the highest downward long wave radiation and short-wave radiation, followed by spring and autumn, and the lowest are in winter. Bing Tong et al. (2022), the objective of this study is to examine how soil moisture (SM) and atmospheric conditions (net radiation, and vapor pressure deficit,) affect surface evaporation fraction. The peak of net radiation appeared around 12:00 and peaks of other components slightly lagged. Zhu et al. (2017), an improved satellite-based approach to estimate the daily net radiation is presented, in which sunshine duration were derived from the geostationary meteorological satellite (FY-2D) cloud classification product. The estimated daily net radiation values were validated against ground data for 12 months in 2008 at four stations with different underlying surface types David 2022. The close agreement between the estimated daily net radiation and observations indicates that the proposed method is promising, especially given the comparison between the spatial distribution and the interpolation of sunshine duration. Potential applications include climate research, energy balance studies and the estimation of global evapotranspiration. Sunmonu et al. (2020), the soil heat flux, net radiation and soil temperature from the soil heat flux plate; an all-wave net radiometer, and soil thermometer were recorded every 10 seconds and averaged over 2 minutes interval. The results show the represented minimum value for the entire period of the study due to the cloudy condition of the sky which reduces the amount of incoming solar radiation reaching the earth surface.

2. METHODOLOGY

2.1. The Study Area

Warri (Fig.1) is in Delta State, Nigeria located on latitude 5.52°N and longitude 5.75°E with an elevation above sea level of about 6.0 m having a population of over five hundred thousand. The city

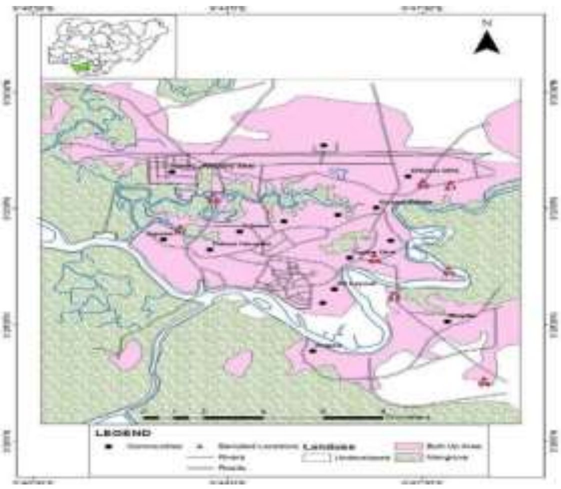

Fig. 1. Map of Warri, Delta State, Nigeria (Avwenagha E. O et al., 2014).

shares boundaries with Ughelli/ Agbarho, Sapele, Okpe, Udu and Uvwie; however, most of these places, notably Udu, Okpe and Uvwie, have been integrated to the larger cosmopolitan Warri. Effurun serves as the gateway to and the economic nerve of the city. Warri is predominantly Christian

with mixture of African traditional religions like most of the Southern Nigeria. The city is known nationwide for its unique Pidgin English language (Avwenagha E. O et al., 2014).

1.1. Collection of Data

Gathering the data relevant to the study or problems to be solved. Monthly net radiation and heat flux data used were collected from the archive of the Nigerian Meteorological Agency (NIMET) Warri. In this study monthly maximum net radiation, soil heat flux for ten years (2009 to 2018) was used.

Calculate the Mean (Average): Add up all the data points and divide by the total number of data points. This gives you the average. i.e.**:**

$$\mu = \frac{\sum K_1}{N} \quad (1)$$

Calculate the Standard Deviation: Find the difference between each data point and the mean. Square these differences, sum them up, and then divide by the number of data points. Finally, take the square root of this result. This gives you the standard deviation, which measures the spread of the data.

i.e.**:**

$$\boldsymbol{\sigma} = \sqrt{\frac{\sum (K_1 - \mu)^2}{N}} \quad (2)$$

Calculate the Z-Score *ω* **(Standardized Anomaly):** For each data point, subtract the mean and then divide by the standard deviation. i.e.**:** $\omega = \frac{K_1 - \mu}{\boldsymbol{\sigma}}$ ***(***Olaniran et al, 2020).

Calculation Data

$$\mu = \frac{\sum K_1}{N} \quad (3)$$

$$\boldsymbol{\sigma}^2 = \frac{\sum (K_1 - \mu)^2}{N} \quad (4)$$

where;

K_1 = Data Points

μ = Mean Data over a Period of Observation

σ = Standard Deviation over the Period of Observation

N = Number of data points

To calculate for the standardized Anomaly (*ω*)

$$\omega = \frac{K_1 - \mu}{\boldsymbol{\sigma}} \quad (5)$$

Fig 2 shows plot for Standardized Anomaly of net radiation for 2009 - 2018. Similar plots are shown in fig 3. for Soil heat flux through the same period. The plots span from January to December of each of the years considered. (2009) shows the Standardized Anomaly variations to be constant except for the dip in August, which is a little, dry season period. The maximum values for (2010) are between May and July respectively, being the highest, which exemplify the rainy season and the minimum net radiation in September. 2011 shows that there is a slight increase in net radiation from the month of January and March and decreasing gradually in the remaining months and a dip in April and July. 2012 shows that there is a slight increase in net radiation from the month of August and decreasing gradually in the remaining months and a dip in April. 2013 shows that there is a slight increase in the pattern of variation from the month of January to March and a dip in April, reaches its peak in September. 2014 shows that there is a slight increase in the pattern of variation from the month of April, this was recorded as the highest peak attained, and a dip in January. The pattern of variation was relatively low in 2014 unlike in 2013. 2015 shows that there is a slight increase and decrease in the pattern of variation. It reaches its peak in April, and a dip in September. 2016, there is a slight increase which was constant in the month of April, September and December having same respectively and a dip in January, May, July, August and October having same respectively. 2017 shows that there is a slight increase in the pattern of variation and reaches its peak in April and a dip in the month of September. 2018, the pattern of variation over the year reaches its peak in May and has a minimum net radiation in April. Though the increase in net radiation extends till July.

3. RESULTS AND DISCUSSION

TABLE 1. Results of Standardized Anomaly for Net Radiation (Rn).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	0.05	0.06	0.16	0.18	-0.01	0.15	-0.05	-0.25	0.10	-0.01	0.04	0.05
2010	0.09	0.04	-0.02	0.01	0.28	-0.01	0.22	0.06	-0.12	-0.10	0.01	0.06
2011	0.29	0.03	0.16	-0.25	-0.21	-0.03	-0.30	0.03	-0.17	-0.06	0.06	-0.01
2012	-0.21	-0.12	-0.10	-0.43	-0.23	-0.04	-0.19	0.23	0.05	0.07	0.03	0.06
2013	-0.17	-0.06	0.09	-0.43	0.05	-0.02	0.12	0.03	0.54	0.23	0.01	0.00
2014	-0.12	-0.07	-0.09	0.44	0.01	-0.01	0.04	0.11	0.01	0.02	0.04	0.05
2015	0.07	0.12	-0.16	0.44	0.07	-0.03	0.12	-0.19	-0.30	-0.14	-0.17	-0.19
2016	-0.01	0.00	0.01	0.01	-0.01	0.00	-0.01	-0.01	0.01	-0.01	0.00	0.01
2017	-0.01	0.00	-0.03	0.10	0.01	0.00	0.04	0.01	-0.08	0.00	0.00	-0.04
2018	0.01	0.00	-0.01	-0.08	0.03	0.00	0.01	-0.02	-0.04	-0.01	-0.01	0.01

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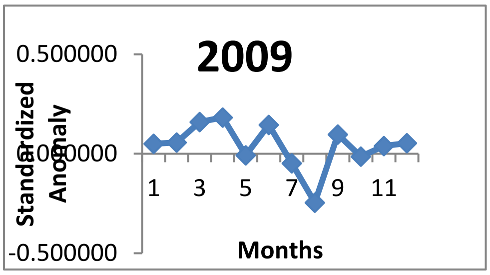
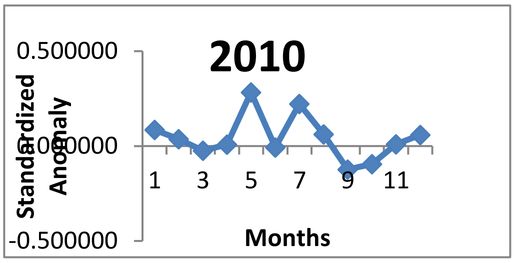
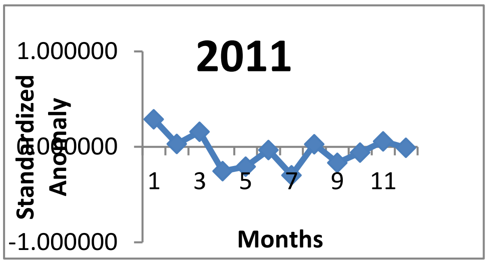
Table 2. Results of Standardized Anomaly for Soil Heat Flux (G).

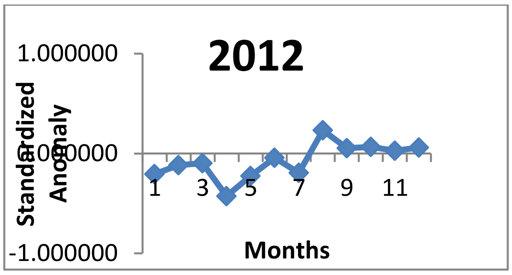
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	0.76	0.13	1.38	0.93	0.61	1.04	0.13	-0.94	3.05	0.20	-0.45	1.59
2010	2.06	2.69	1.38	2.32	1.62	0.64	1.43	1.68	-0.11	-0.20	-0.45	-0.43
2011	-0.91	-0.13	0.07	0.24	-1.42	-1.37	-1.60	-1.47	-0.53	-0.98	0.00	-0.18
2012	0.02	-1.41	-0.92	-0.45	-1.75	-2.57	-2.03	-1.99	-0.32	-1.76	0.00	-0.18
2013	0.02	-1.15	0.72	-0.10	0.27	-0.56	-0.30	0.63	0.11	1.37	0.00	-0.93
2014	0.76	-0.13	-0.92	-1.49	-0.74	0.24	1.43	1.15	-0.32	-1.37	-2.27	-0.43
2015	-1.65	0.13	-1.57	-1.49	-1.08	0.64	-0.30	0.10	-0.53	-0.20	-0.91	-2.20
2016	-0.72	-0.64	0.72	0.59	0.94	0.64	0.13	0.10	-1.37	1.76	1.36	1.59
2017	0.95	0.90	0.72	0.24	0.94	0.64	1.00	0.10	0.11	0.20	1.36	0.83
2018	-1.28	-0.38	-1.57	-0.80	0.61	0.64	0.13	0.63	-0.11	0.98	1.36	0.33

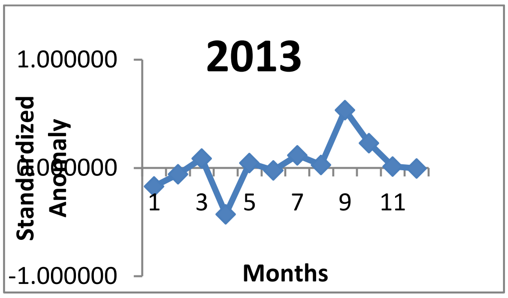
Graphical representation of Net Radiation Standardize Anomalies (1009-2018)

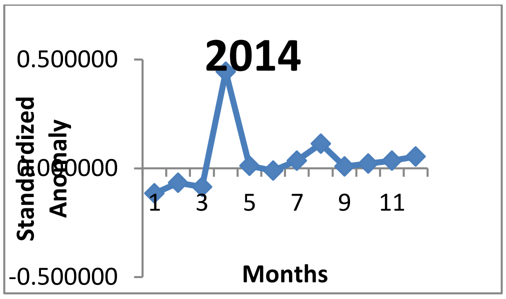

2009
0.500000
-0.500000
Standardized Anomaly
1 3 5 7 9 11
Months

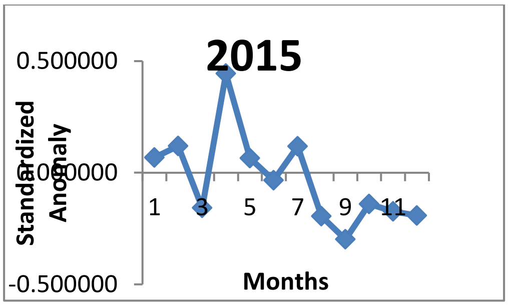

2010
0.500000
-0.500000
Standardized Anomaly
1 3 5 7 9 11
Months

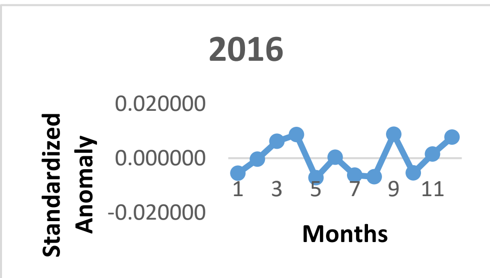

2011
1.000000
-1.000000
Standardized Anomaly
1 3 5 7 9 11
Months


2012
1.000000
-1.000000
Standardized Anomaly
1 3 5 7 9 11
Months


2013
1.000000
-1.000000
Standardized Anomaly
1 3 5 7 9 11
Months


2014
0.500000
-0.500000
Standardized Anomaly
1 3 5 7 9 11
Months


2015
0.500000
-0.500000
Standardized Anomaly
1 3 5 7 9 11
Months


2016
0.020000
0.000000
-0.020000
Standardized Anomaly
1 3 5 7 9 11
Months

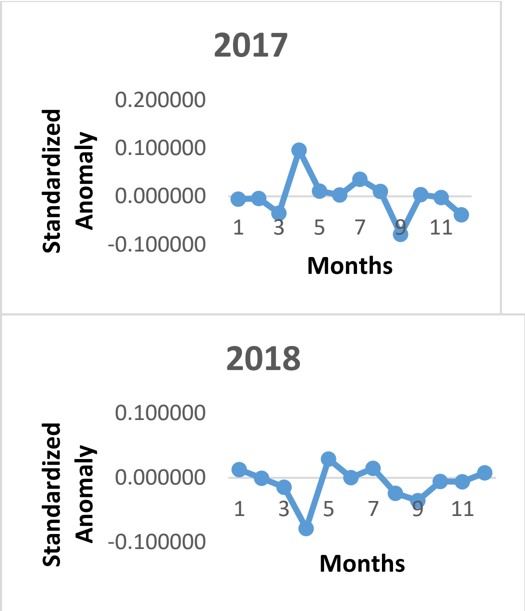
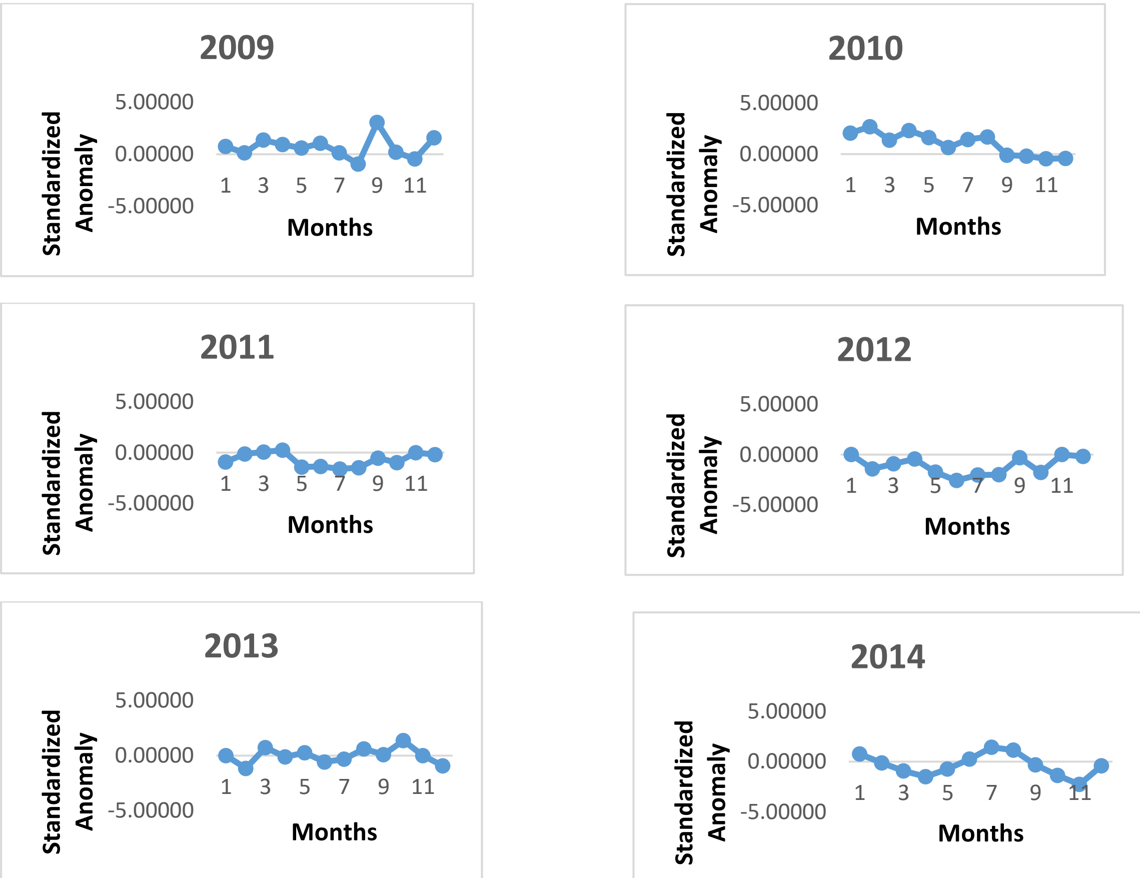


Fig 2. The graphs of Standard Anomalies of Net Radiation for (2009 – 2018)

Graphical representation of Soil Heat Flux Standardize Anomalies (1009-2018)



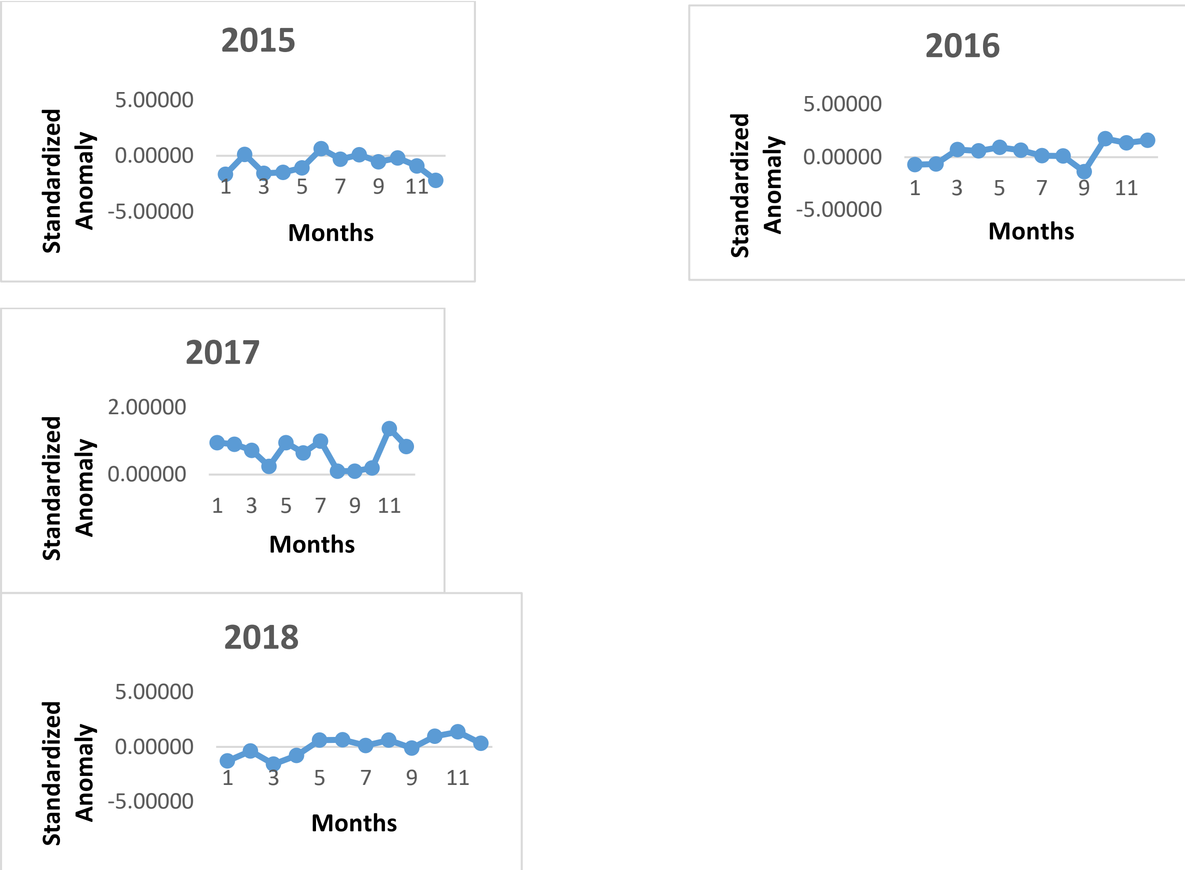


Fig 3. The graphs of Standard Anomalies of Soil heat flux for (2009 – 2018)

3.1. Standardized Anomaly of Soil Heat Flux

Fig 3. shows the graphical representations of Soil heat flux Standardized Anomalies.The plot spans from January 2009 to December 2018. Thus, the higher soil heat flux was mostly recorded during the dry seasons. This is evident from the results of the variation in the soil heat flux (SHF). In 2009, the pattern of variation reaches the peak in September and has a minimum soil heat flux in August. In 2010, there is a dip in the month of November and December, reaches the peak in February which is a dry season. 2011 shows that there is a slight increase in the pattern of variation for the month of January to April. It reaches its peak in the month of April and a dip in the month of May, June, July and August. 2012 shows that there is a slight increase in the pattern of variation for the month of January and a dip in June and July. 2013 shows that there is a slight increase in the pattern of variation for the month of October and a dip in February. 2014 shows that there is a slight increase in the pattern of variation for the month of July and a dip in November. 2015 shows that there is a slight increase in the pattern of variation for the month of June and minimal in December. 2016 shows that there is a slight increase in the pattern of variation for the month of October and a dip in September. 2017 shows that there is a slight increase in the pattern of variation for the month of November and a dip in August and September. 2018 shows that there is a slight increase in the pattern of variation for the month of November and minimal in January and March.

3.2. Standardized Anomalies Variational trend

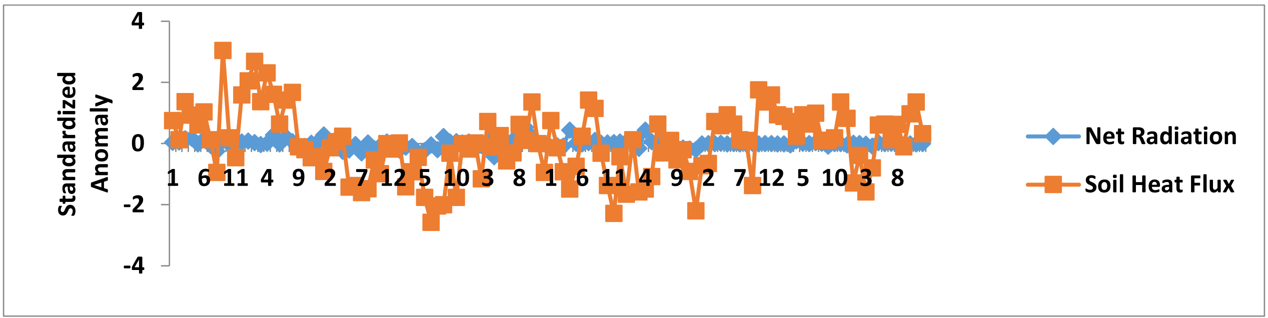


Fig. 4. Variational Trend of Standardized Anomalies for the two parameteFig 4. shows that there is a slight decrease in the variational trend in the month of August 2009, September November and December 2010, April and July 2011, June 2012, April and February 2013, January and November 2014, September and December 2015, January, May, July, August and October having same and September 2016, September 2017, April and January 2018 and slight increase in the variational trend in the month of May and July 2009, February 2010**,** January and March2011, April, August January 2012, September, October 2013, April, July 2014, April , June 2015, April, September and December having same, October 2016, April , November 2017, November, May 2018.

4. CONCLUSION

In this study, we have attempted to quantify the relationship between the Inter-annual variations in the monthly net and soil heat flux. Net radiation was lowest in rainy season, due to the solar angle during this season. Furthermore, rainy season was highest decreasing percentage compared to dry season. In this study, the one-peaked daily behaviors of Rn in sunny days were dominated by the Sun's daily path, quantified as Zenith Angle. Apart from Rn, soil water content was proven to influence soil heat flux, since it determines the thermal properties for heat transfer. Soil heat flux increased when soil moisture was lower and decreased as soil moisture continued to Increase. In summary, this work provides a supplemental understanding on the influence of soil moisture on soil heat flux and variations in net radiation.

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