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An Investigation of the Influence of Solar Activities Variability on Earth's Climate Change

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Abstract

This study investigated the influence of solar activities variability on Earth's climate change using Sunspot (R) number, F10.7 (sfu) and sea surface temperature. The sunspot number was used to determine the correlation between the increase in sunspot number and the sea surface temperature that has been one of the basic indices for the study of Earth's climate change. It is noteworthy that the F10.7 (sfu) was used to classify the intensity of solar activity. The result shows that the sunspot number varies with the sun activities and the increase in the number of sun spot has little effect on the sea surface temperature, however, the long term effect of the increase in the sunspot number may have significant effect on the climate change. It is therefore concluded that the variability in the solar activities leading to the increase and decrease in the sunspot number may contribute to the increase in the sea surface temperature which could have adverse effect on Earth's climatic condition.

Keywords: Solar activities; climate change; Sunspot number; Intensity; solar radio flux.

Introduction

The variability of the sun spans for a broad large scale, these include the sun's lifetime brightness, the variation due to magnetic activity that ranges from day to years that resulted to approximately 11years sunspot cycle popularly known as solar cycle. The variability of the sun modulates the activity of the atmosphere, thereby influences the weather and causes climate change Gray *et al.,* (2010). The variation in the shining intensity of the sun may cause discrepancies in the Earths radiation model thereby prompting changes in near the Earth temperature. The discrepancies in sun activities has been classified as High , medium, Low solar activities according to the variability sun's intensity that could be determined by sun activity indices F10.(7sfu) Fröhlich (2011) The F10.7 index is measured in solar flux units (sfu), where 1 sfu is 10−22 W/m2 Hz. F10.7 ranges between 50 and 300 sfu. The measure of solar activity is preferred to the sunspot number and area indices due its objectivity, and its measurements does not varying with weather conditions Hathaway 2015. F10.7 is highly correlated with the sunspots number(0.940) and the core–wing ratio of the Mg II line (0.956) .This is often taken as an index of solar UV variability Gray *et al.,* (2010) The temperature of the earth is controlled by the equilibrium between the received radiative energy from the sun and the thermal emission of the radiative energy from the Earth to the space Solomon *et al.,* (2007) John *et al.,* (2022 it is worthy to note that increase in thermal emission due to sun variability increases the earth temperature, the earth therefore gain its equilibrium by adjusting its temperature to balance the thermal radiation to the received solar energy. Therefore an increase or decrease in sea surface temperature (SST) due to variability in sun activities as shown by the sunspot number may have significant effect on past, present and future of the Earth's climatic condition. This is because the sea is the largest accumulator of solar energy that reaches the Earth, the water cover over 70% of our planet's surface, it can also store large amounts of heat with a minimum increase in temperature increase in temperature. The ability to store and release heat over long periods of time gives the ocean a central role in stabilizing Earth's climate system. Lindsey and Dahlman (2020)

The study and investigation of the Earth's climatic condition are of interest to various scientific fields (Tzanis *et al.,* 2019; Philippopoulos *et al.,* 2020,) Many studies have dealt with the connection between solar energy output and atmospheric parameters Haigh (2007). Another study has discovered significant variations in both tropospheric and sea surface temperatures due to solar activity variations, and an assessment of the possible physical processes was also provided. Zherebtsov *et al.,* (2019) In particular, various authors have reported on the response of Sunspot (R) number, F10.7 (sfu) and sea surface temperature to the solar variability as proxies to ascertain the effect of solar activities of Earth climatic condition.(Zherebtsov *et al.,* ;2019)

Introduction contd

On the contrary, some studies reported insignificant correlations between solar activity and other variables, This expresses the complication that may be involve in the subject of Solar Activities Variability on Earth's Climate Change. For example, Aparicio *et al.,* (2020) studied the relationship between the Sunspot Number and surface solar irradiance in Madrid and reported, non-significant correlations between seasonal variations of climatic parameters and volcanic eruptions, Based on the above studies, it is clear that the search for the solar activity effects on Earth's climate condition is a relatively recent research field. This present work, adopted the use of climatic data that cover 2 full solar cycles (cycles 23 and 24), and we used multiple solar activity indices to produce a more investigation to the correlation between the variability of the Sun and the earth climate change as a means of contributing to the existing knowledge.

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Materials and Methods

The Solar activity data such as sunspot number and F10.7cm used in this research were obtained from NSSDCs OMNI web service Htpp://nssds.gsfc.nasa.gov/omniweb and The Earth Climate data, Sea Surface temperature (SST) were obtained from Third Hadley Centre Sea Surface temperature data set (HADSST3) provided by the uk met office/Hadley Centre. (met office Hadley Centre Observation Data Set). The correlation between the Climatic data and solar activities were observed from solar cycle 23 and 24 which is approximated 24 years of solar variability. Solar activities index variation F10.7 (sfu) was classified with criterion as low solar activity if F10.7 is ≤100, moderate if F10.7 is100 ≤ 150 and high if the F10.7 ≥ 150 (Adebesin *et al.,* 2015; Bjoland *et al.,* 2021) this classification is necessary to determine the effect of solar activity on climate change. The Sunspot numbers revealed the clear variations that existed in the maxima and lengths of the solar cycles (Friis-Christensen *et al.* 1991, Liao *et al.* 2001). Sunspots provides the first indications of the possibility of solar eruptions that may precede geomagnetic storms on the Earth Sunspot rate could help in calculating space weather, the state of the ionosphere, and hereafter the conditions of short-wave radio propagation or satellite communications (*Stu Turner 2020).* They are regions of reduced surface temperature caused by concentrations of magnetic field flux that inhibit convection. Sunspots usually appear in pairs of opposite magnetic polarity. The index termed 'sunspot number' has been used to quantify the abundance of dark spots that appear in the sun The long and detailed historical record of Sunspot Number (here denoted R) is defined as stated in Equation 1

$$R = K \times (10 \times G + I) \qquad \text{(Equation 1)}$$

Where G is the number of sunspot groups visible on the Sun; I is the total number of individual spots visible; and K is an instrumental factor to take into account differences between observers and observatories[8]. Therefore, sunspot number (R) was used in this a study to measure the annual sunspot number which will be calculated from monthly mean values.

Sea Surface Temperature (SST) is the water temperature close to the ocean's surface. It is a strong indicator of productivity, pollution, and global climate change; the climate change Global SST is an essential climate variable for understanding the climate system and quantifying ongoing climatic change and its increase above the average threshold value 3.5°C denote climate change. Therefore, the global average near-surface air temperature, which is the standard diagnostic used to describe global warming was adopted as a driver.

Results and Discussion

Figure 1 -3 Panels (a) shows the plot of annual average Sea Surface Temperature (SST) represented by black dotted line and Sun spot number (R) represented by red line while the Panels (b) of the figures depicts the plots of (SST) and F.10.7 (sfu) (denoted by blue continuous line). Figure 1 Panel (a) represents the variation of the SST with Sunspot number (R) while Panel (b) shows the variation of solar activities indices F10.7 (sfu) during the high solar activity years within the solar cycle 23 and 24. It could be observed from panel (a) that SST increases with increase in sun spot number(R) together with increase in solar activities as shown in Panel (b) of the Figure. It shows a long term variation of the sun during HSA could affect the earth climatic condition. It could also be observed in the figure that the sunspot number correlates positively with the solar activity. This implies that Sunspot number R and solar activity index F10.7 (sfu) are in same phase during the High solar activity year of solar cycle 23 and 24.

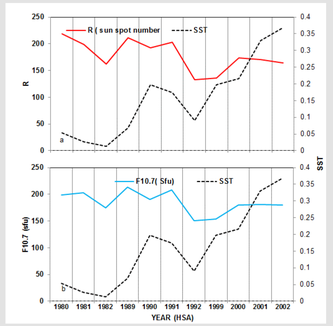


Fig.1. The variations of Sea surface temperature with sunspot number and solar activity index F10.7 (sfu) during HSA within solar cycle 23 and 24

The variations of the sea surface temperature with the sunspot number during MSA and LSA as shown by F10.7 is depicted in Figure 2 and 3 (Panels a and b) respectively. On both figures the SST varies directly as R and F10.7. The R and the F10.7 are in positive phase

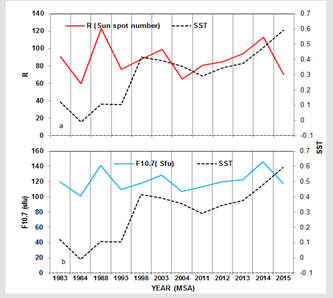


Fig.2 The variations of Sea surface temperature with sunspot number and solar activity index F10.7 (sfu) during MSA within solar cycle 23 and 23

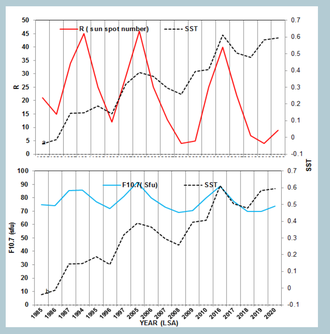


Fig.3. The variations of Sea surface temperature with sunspot number and solar activity index F10.7 (sfu) during LSA within solar cycle 23 and 23

In comparing the variation of the sea surface temperature that ids used as a proxy for climatic condition in this study. It could be observed that the sea surface temperature during LSA is greater (0.612) than that of the MSA(0.59) and MSA greater than HSA (0.36) . That is the Sea Surface Temperature decreases with increase in solar activities, this implies as the lower atmosphere is getting hotter the upper atmosphere is getting cooler. Joanna (2003) Therefore an extended solar minimum may cause increase in the earth temperature. It is therefore concluded that the variability in the solar activities leading to the increase and decrease in the sunspot number may contribute to the increase in the sea surface temperature which could have adverse effect on Earth's climatic conditions.

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