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Assessment of the impact of solar irradiance on FM radio signal strength: A machine learning approach

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Abstract
This study investigated the impact of solar irradiance on FM radio signal strength in Abuja, Nigeria, using an experimental research method. Measurements of solar irradiance and FM signal strength were carried out during the rainy season months of June and July 2025 and the dry season months of October and November 2025. The aim of the study was to examine the relationship between solar irradiance and FM radio signal behaviour under different atmospheric conditions. The FM radio signal studied was measured on the frequency of 102.3 MHz. The collected data were analysed using graphical methods and machine learning models, namely linear regression, gradient boosting, and random forest models. The results obtained from both rainy and dry seasons revealed that solar irradiance has an inverse relationship with FM signal strength. Higher signal strengths were mostly recorded during the morning and evening periods when irradiance levels were low, while weaker signal strengths were observed during the afternoon when solar irradiance was highest. The machine learning models further confirmed this relationship, with all models producing coefficients of determination (R^2) above 80%, indicating that solar irradiance significantly influences FM signal strength variation. Among the models tested, the Gradient Boosting model showed the best performance, having the highest R^2 values of 0.91 during the rainy season and 0.9704 during the dry season, alongside the lowest mean squared error values. The study concluded that increased solar irradiance contributes to the reduction of FM radio signal strength due to atmospheric changes such as temperature increase, thermal expansion, and humidity variation, which can increase the absorption and scattering of FM/VHF radio waves.

Keyword: Atmospheric components; irradiance; machine learning; signal attenuation; signal strength

1.0 Introduction
Irradiance, or solar irradiance, is defined as the solar energy received at a particular location at a particular time or period of time. It is also defined as the amount of power delivered by the sun on a specific area at a given time. Radio wave propagation is influenced by the properties of the earth and atmosphere, given that the curvature of the earth and the condition of the atmosphere can refract electromagnetic waves either in the direction of upwards, away from it, or downwards to the earth's surface (Sabri *et al.*, 2015; Dagang, 2021). Also, in the work by Ezekoye and Obodo (2007), on the topic "The Effects of Solar Radiations on Telecommunications," it was reported that solar activity can result in the experiencing of disturbances by telecommunications signals or networks. It has also been reported that solar radiation contributes to the ionization of the atmosphere, which can alter the strength of the transmitted Very High Frequency (VLF) radio waves (Merola, 2006), and not just that, but solar radiations and other solar activities affect the total electron content of the ionosphere and also affect various radio frequencies used in telecommunications (Ezekoye and Obodo, 2007; Nor *et al.,* 2015). According to Yusuf (2011), the variability of the signal strength of some radio stations in the daytime can be attributed to the solar activity in the atmosphere. Solar radio

emission can result in the decrease in carrier-to-noise ratio, which translates to an increase in the path loss exponent values for the large-scale propagation path loss channel models, given that higher path loss exponent values were observed in hot and sunny weather during the day (41°–42°C) compared with the counterpart measurements taken at night in cool and clear weather (20°–38°C) (Muratore *et al*., 2022). The Sun is a decisive element for the control and development of several natural processes on the Earth, and, in addition, solar activity can also have certain effects on some human activities, such as radiofrequency communications (Mendoza-Barcenas, 2020). Based on the available materials published in this research area, little attention is given to the effect of solar irradiance on the wireless communication, even though solar irradiance contributes to the variations in some other atmospheric components. This work was done in Abuja, North-Central Nigeria, where such work has not been done in recent times.

2.0 Literature review

Below are some related works done by some researchers.

Sulyman *et al*. (2017) investigated the effects of solar radio emissions on outdoor propagation path-loss models operating at 60 GHz for future 5G communication systems. The methodology involved analytical modelling and empirical propagation measurements under different solar conditions. Their results revealed that solar emissions increased path-loss exponents and reduced communication coverage during hot daytime conditions. The authors concluded that solar activity can significantly affect millimetre-wave propagation performance and should be considered in future wireless system design.

Dagang *et al.* (2021) examined the effect of weather focused on solar radiation towards the performance of plasma antenna represented by signal strength. Signal strength experiment was conducted to evaluate plasma antenna performance in terms of its capability to capture the signals and analyse the effect of solar radiation on that particular moment through the rate of power level over time versus solar radiation data. It was observed at the highest solar radiation rate which is 920 V/m, the power level recorded is the lowest value at-172.93 dBm. It was concluded that the signal strength received by the plasma antenna shows remarkable changes under the influence of solar radiation.

Muratore *et al.* (2022), investigated the effects of solar radio emissions on radiomobile communication networks. The study utilized large-scale LTE network measurement data and propagation analysis to evaluate the impact of solar emissions on communication performance. The results showed that periods of intense solar radio activity were associated with reductions in carrier-to-noise ratio and deterioration in communication quality. The authors concluded that solar radio emissions constitute a significant source of interference in wireless communication systems and should be considered in network planning and performance assessment.

Onuh *et al*. (2023) studied the effect of solar radiation on the signal strength of the Ahmadu Bello University FM radio station. Field measurements of FM signal strength were collected over a three-month period and analysed alongside solar radiation parameters. The results revealed that signal strength varied throughout the day, with weaker signals generally observed during periods of high solar activity. The authors concluded that solar radiation contributes to fluctuations in radio signal strength, although its overall effect was relatively moderate.

Ratul *et al*. (2023) examined the atmospheric influence on path loss in high-frequency 5G communication networks. The

study incorporated atmospheric temperature, humidity, and rainfall parameters into propagation models and machine-learning frameworks. The results showed that atmospheric conditions significantly affected path-loss characteristics, particularly at higher frequencies. The authors concluded that environmental variables must be considered in the deployment and optimization of future 5G networks.

Mol *et al*. (2023) presented a ten-year dataset of solar irradiance observations and analysed temporal variations associated with cloud conditions and atmospheric processes. The study employed high-resolution irradiance measurements and statistical analyses to characterize solar variability. The findings revealed significant short-term and long-term fluctuations in solar irradiance caused by atmospheric and meteorological processes. The authors concluded that accurate characterization of solar irradiance is essential for studies investigating environmental influences on communication systems.

Also, Dos Santos (2024) studied the influence of solar activity on radio observations collected by the Auger Engineering Radio Array over a ten-year period. The study analysed radio data during periods of varying solar activity and correlated them with solar flare events and ionospheric conditions. The results indicated that enhanced solar activity increased radio noise levels and occasionally caused signal degradation and radio blackouts. The study concluded that solar activity remains a significant factor affecting radio signal propagation and communication reliability.

Abdulmalik *et al*. (2024) did research on the Machine Learning Model for Predicting the Impact of Weather Conditions on Radio Signal Strength in Gusau City. The study investigates how climatic conditions, specifically changes in temperature and wind speed, affect radio signal transmission for Pride FM in Gusau, Zamfara State, Nigeria. A machine learning regression model was developed to predict signal variations based on prevailing weather conditions. The results indicate that higher temperatures and wind speeds contribute to signal degradation, whereas lower values enhance signal strength. It was concluded that the resulting prediction model could serve as a valuable tool for improving radio signal transmission quality, enabling engineers to anticipate losses and optimize transmission parameters for consistent broadcasting operations.

Zhang *et al*. (2025) developed an XGBoost-based machine learning model for wireless path-loss prediction using environmental and propagation variables. The study employed supervised learning techniques and model validation procedures to predict signal attenuation. The results demonstrated that XGBoost achieved higher prediction accuracy than conventional empirical models. The authors concluded that machine learning techniques provide reliable tools for modelling environmental influences on wireless signal propagation.

Li *et al*. (2025) developed a solar outage simulation system for communication networks to investigate the effects of intense solar radiation on communication performance. Experimental and simulation techniques were used to reproduce solar interference conditions. The findings demonstrated that solar radiation can significantly affect communication links under specific operational scenarios. The authors concluded that understanding solar interference mechanisms is important for improving communication system resilience and reliability.

Kumar *et al*. (2026) investigated atmospheric impacts on wireless communication signals using ensemble machine learning techniques. Meteorological variables and signal propagation data were used to train and evaluate predictive models.

The findings showed that ensemble learning approaches outperformed traditional regression methods in predicting communication performance under varying atmospheric conditions. The study concluded that machine learning offers substantial improvements in atmospheric-effect prediction for communication systems.

The reviewed studies have established that solar radiation, solar radio emissions, atmospheric variability, and space-weather phenomena can influence radio-wave propagation and communication system performance. However, most previous studies focused on HF, VHF, UHF, LTE, millimetre-wave, or satellite communication systems, while limited attention has been given to the direct relationship between solar irradiance and FM radio signal strength in Nigeria. Furthermore, few studies have applied machine learning techniques such as Linear Regression, Random Forest Regression, and Gradient Boosting Regression to model the relationship between solar irradiance and FM signal strength under both rainy and dry season conditions. Therefore, this study addresses this gap by investigating the influence of solar irradiance on FM radio signal strength in Abuja, Nigeria, using machine-learning-based predictive modelling.

2.1 The study area

Abuja, the capital city of Nigeria is located between latitudes 8°25′ and 9°20′ North and longitudes 6°45′ and 7°39′ East. Abuja is characterised by a tropical wet and dry climate, with two major seasons which the rainy season and the dry season. The rainy season occurs from April to September, and the dry season from October to March. The average annual temperature in Abuja ranges between 25°C and 32°C, although higher temperatures are commonly experienced during the dry season. Annual rainfall is generally between 1,100 mm and 1,600 mm, with relatively high humidity during the rainy months. The vegetation of Abuja is mainly Guinea Savannah, consisting of grasses, scattered trees, shrubs, and patches of woodland. The topography of the area is undulating, with plains, rocky hills, and isolated highlands (Ale *et al.,* 2017, Ale *et al.,* 2024, Abdullahi *et al*, 2024).

3.0 Methodology

This study adopted an experimental research design to investigate the impact of solar irradiance on FM radio signal strength in Abuja, Nigeria. Measurements were conducted during the rainy season months of June and July 2025 and the dry season months of October and November 2025. FM radio signal strength was measured at a frequency of 102.3 MHz using a Digital RF Signal Meter, while solar irradiance was measured using a Pyranometer.

The data collection was carried out daily between 8:00 am and 6:00 pm at 30-minute intervals to capture the diurnal variations of both parameters. Measurements obtained during June and July were combined to represent the rainy season, while those obtained during October and November represented the dry season. A total of 5,124 paired observations of solar irradiance and FM signal strength were collected for the study. Before the data analysis, the dataset was preprocessed through data cleaning and inspection to remove inconsistencies and incomplete records. The dataset was subsequently divided into training and testing subsets using an 80:20 ratio. Consequently, 4,099 observations were used for model training, while 1,025 observations were reserved for testing and performance evaluation. Three machine learning algorithms, namely Linear Regression (LR), Random Forest Regression (RF), and Gradient Boosting Regression (GBR), were employed to model the relationship between

solar irradiance and FM radio signal strength. The Linear Regression model is expressed as:

$$FM = \beta_0 + \beta_1 I \quad 3.1$$

where FM represents FM signal strength, I represents solar irradiance, β_0 is the intercept, and β_1 is the regression coefficient.

Random Forest Regression was employed as an ensemble learning technique that combines the predictions of multiple decision trees generated from bootstrap samples of the training dataset.

The final prediction is obtained by averaging the predictions generated by all trees and may be expressed as:

$$RF(x) = (1/N) \Sigma Ti(x) \quad 3.2$$

where RF(x) is the Random Forest prediction, Ti(x) is the prediction from the i-th decision tree, and N is the total number of trees.

Gradient Boosting Regression was applied as a boosting technique that sequentially develops weak learners, with each new learner minimizing the residual errors of the preceding model to improve prediction accuracy.

Each subsequent learner is trained on the residual errors produced by the previous learner. The model is represented as:

$$F_m(x) = F_{m-1}(x) + \gamma_m h_m(x) \quad 3.3$$

where $F_m(x)$ denotes the updated prediction model, $h_m(x)$ represents the weak learner, and γ_m is the learning rate parameter.

The performance of the developed models was evaluated using the Coefficient of Determination (R^2), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE). These metrics were used to assess the predictive capability and accuracy of the models, with the model producing the highest R^2 and lowest error values considered the best-performing model.

4.0 Results and discussion

4.1 Results of the relationship between solar irradiance and FM signal strength

Fig. 1.0 and fig. 2.0 show the graphical representation of the variation of average solar irradiance and FM signal strength from 8:00 am to 6:00 pm. From fig. 1.0, in the rainy season, it can be observed that the irradiance generally was very low in the morning (around 8 AM) and rose to a high point around 10:00 AM and fell and rose again, though in a non-uniform nature, until it reached the peak around midday and then gradually decreased towards the evening (around 6 PM). In the same way, in the same rainy season, the FM signal was higher in the morning period but began to fall slowly as the day progressed, and the fall continues until the signal reaches the lowest level at around 3:30 PM, from where it started rising again until around 5:30 PM, when it experienced a slight decrease before it continued to rise further. The behavior of FM signal strength appears to show an inverse trend to that of the solar irradiance. That is, as the irradiance increases towards midday, the FM signal tends to decrease, reaching its lowest point around the same time the irradiance is highest, and in another related way, as the irradiance decreases in the afternoon, the FM signal generally starts to rise again. This implies that as the sun's intensity (irradiance) increases, the FM signal strength tends to fall or decrease, and when the sun's intensity decreases, the FM signal tends to increase. In simple terms, the FM signal strength was higher in the morning and evening periods but lower in the daytime or at noon.

Also, from fig. 2.0, which is for the dry season (October and November, 2025), the figure shows that the average solar

irradiance was low in the morning from 8:00 AM and then began to rise slowly until around 9:30 AM, when there was a spike in the sun intensity or solar irradiance at around 10:00 AM, after which it reached its peak level at 11:30 AM and 12:30 PM. From this period, the average irradiance began to fall slowly until around 2:30 PM, when it began to rise to another high level at 3:30 PM, from when it experienced a continuous decrease to the end, though a slight increase was experienced at 6:00 PM. It can be simply stated that the solar irradiance in the study area was high in the noon period or between 11:00 AM and 4:30 PM but lower in the early morning period and late afternoon towards the evening.

Also, it can be observed that the average FM signal strength from the radio station exhibited variations throughout the day, from 8:00 am when the readings started to 6:00 pm when the readings ended. The FM signal strength was very high at the beginning, or in the morning when there was little sunlight, and the signal continued to fall slightly but not uniformly until it reached its lowest level around 2:30 PM. From this point, it surged to a certain higher level, but that height or strength could not be sustained at that noon time as it fell again and this time began to slowly increase in a steady form until the end at 6:00 PM. In simple terms, the FM signal strength was higher in the morning and evening periods but lower in the daytime or at noon. But just like in the rainy season, the variation in the FM signal strength and that of the solar irradiance tends to be in opposite form such that when the solar irradiance is increasing, the FM signal strength is decreasing, and when the solar irradiance is decreasing, the FM radio signal strength is increasing; thus, they can be said to be inversely related in both seasons.

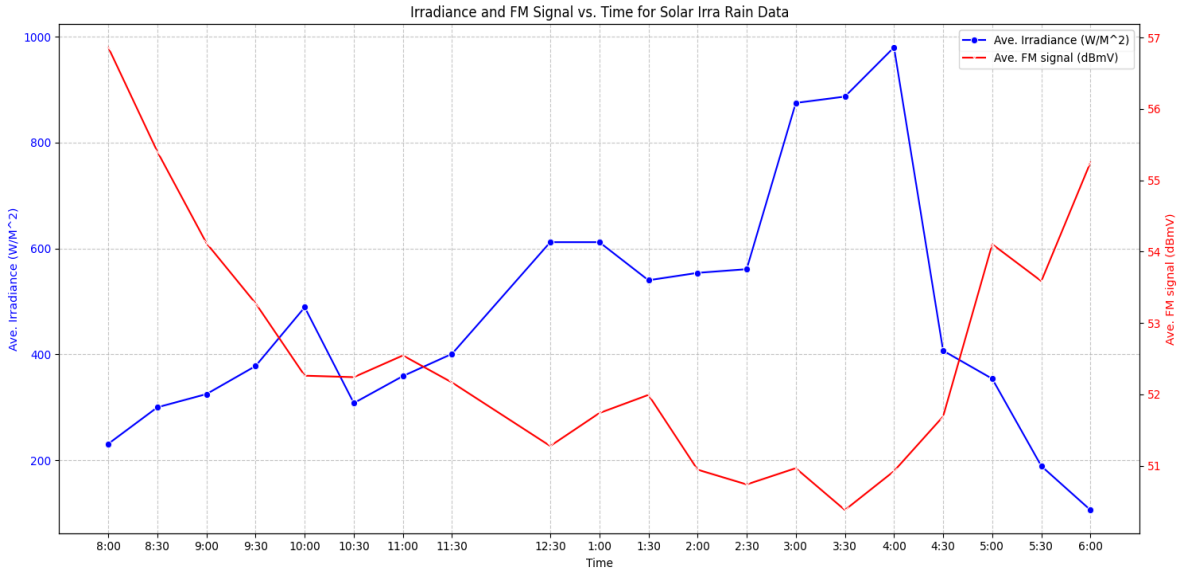


Fig. 1.0: Graphical representation of the variation of average solar irradiance and FM signal strength in rainy season

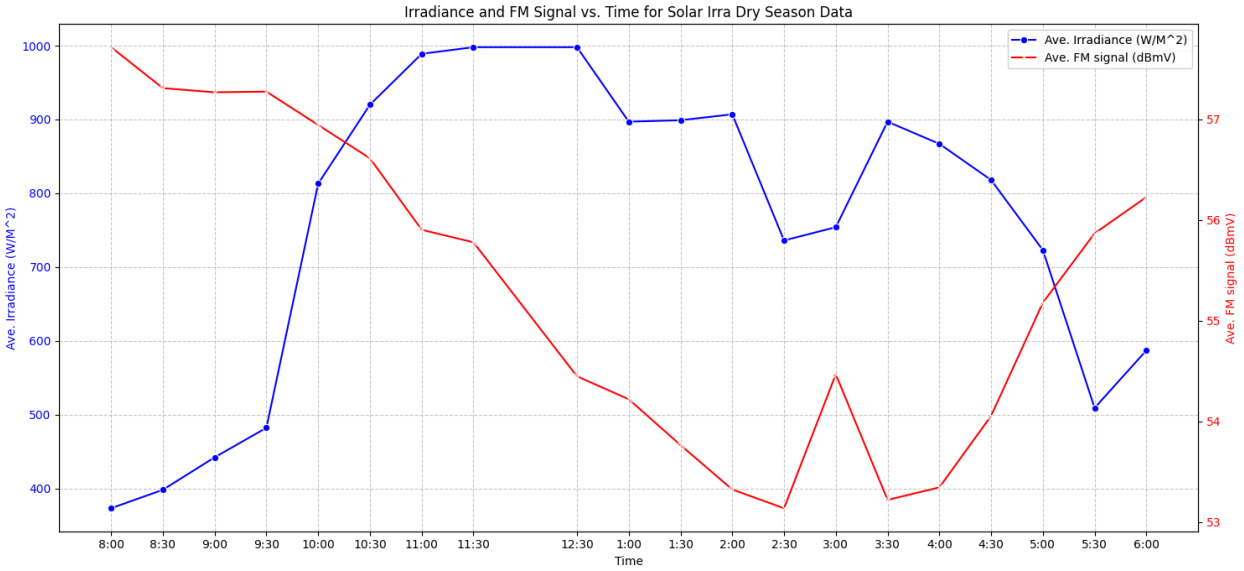


Fig. 2.0: Graphical representation of the variation of average solar irradiance and FM signal strength in dry season

Also, Fig. 3 shows the graph of average FM signal strength against the solar irradiance in the rainy season and dry season, respectively. From the figure for rainy season, it was shown that there was a general downward trend, which implies an inverse relationship between the FM signal strength and the solar irradiance. In other words, as the irradiance increases, the FM signal tends to decrease, though with some scattering. Also, from the figure for the dry season, similar to the rainy season scenario, an inverse relationship between the FM radio signal strength and solar irradiance was observed. The figure shows that as the solar irradiance in the area increases, the FM signal received from the radio station tends to decrease, and vice versa. From both the rainy season and dry season figures, irrespective of the nature or degree of the relationship, it can be said that both plots visually confirm the inverse relationship between solar irradiance and FM signal strength for both seasons given that, as solar irradiance goes up, the FM signal tends to go down, or as the solar irradiance increases, the FM radio signal strength decreases (fig. 3.0).

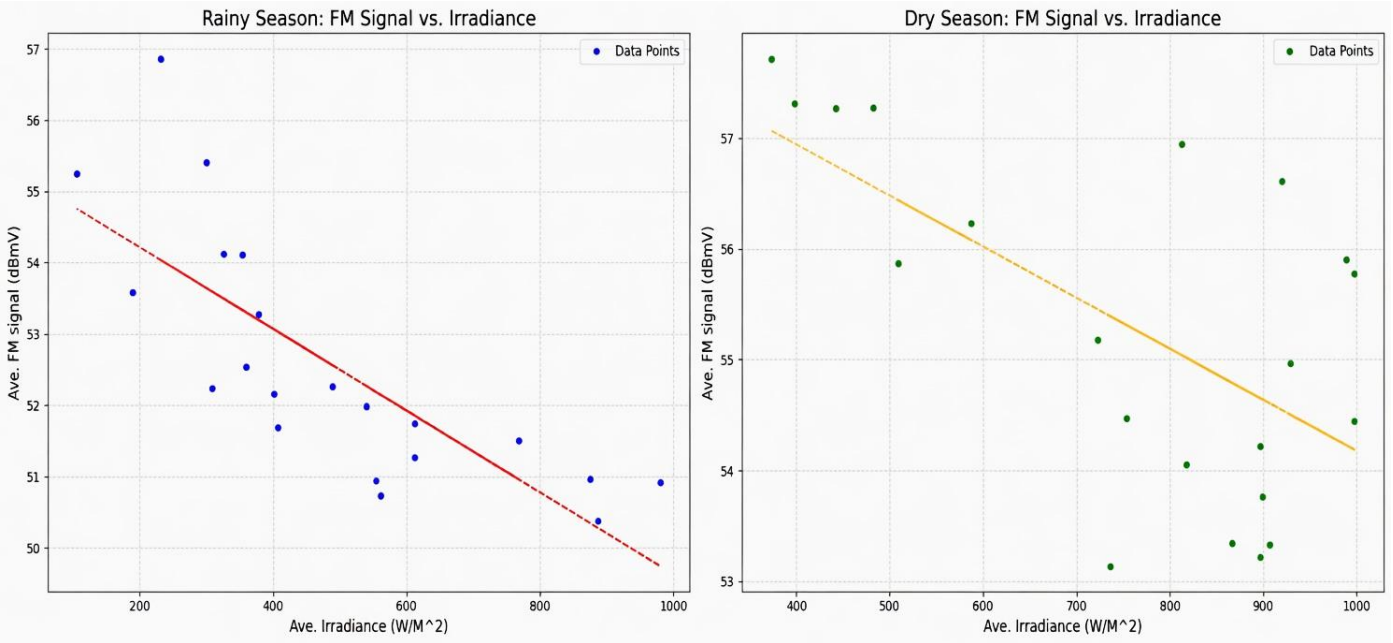


Fig. 3: Graph of average FM signal strength against the solar Irradiance in rainy season and dry season

4.2 Comparison of solar irradiance in the rainy season with the dry season

Based on the descriptive statistics for irradiance, it was shown that the average irradiance was 487.43 W/m² in the rainy season, while the average irradiance was 758.86 W/m² in the dry season. This shows that the dry season experiences significantly higher average solar irradiance than the rainy season, which could be due to fewer clouds and more direct sunlight in the dry season, leading to higher overall radiation levels. Also, the standard deviation of the solar irradiance in the rainy season was 237.60 W/m², while in the dry season, the standard deviation was 208.58 W/m². It means that the hourly solar irradiance in the dry season varies about 237.60 W/m² from the mean value of the dry season solar irradiance, whereas the hourly solar irradiance in the rainy season varies about 208.58 W/m² from the mean value of the rainy season solar irradiance, implying that the solar irradiance values are more spread out in the dry season than in the rainy season. This indicates that the irradiance in the dry season fluctuates more or is less stable compared to the rainy season. Furthermore, the minimum and maximum irradiance in the rainy season were 106 W/m² (min) and 980 W/m² (max), while in the dry season, the values were 373 W/m² (min) and 998 W/m² (max).

It can be said that both the minimum and maximum irradiance values are substantially higher in the dry season compared to the rainy season's minimum and maximum values, though the maximum value in the dry season was a bit higher too. This suggests that even in the rainy season, there can be periods of very high irradiance, but these are likely less frequent, leading to a lower average, as the dry season consistently maintains higher minimum and higher overall peaks.

4.3 Comparison of FM signal in rainy season with dry season

From the descriptive statistics analysis for the FM signal for both seasons, it was shown that the average FM signal was 52.57 dBmV in the rainy season, while the average FM signal was 55.29 dBmV in the dry season. This shows that the dry season displays a notably

higher average FM signal compared to the rainy season. Since the solar irradiance and FM signal are inversely related, that is, higher irradiance leads to a lower FM signal, and given that the dry season has significantly higher average solar irradiance, one might expect a lower FM signal, but this is not in this case. This suggests that other environmental factors such as humidity, atmospheric moisture, or rain attenuation, which are prevalent in the rainy season, might have a greater impact on FM signal strength, overriding the effect of lower irradiance.

Furthermore, the standard deviation of the FM radio signal strength in the rainy season was 1.75 dBmV, while the standard deviation in the dry season was 1.54 dBmV. The rainy season exhibits a slightly higher standard deviation for the FM signal. This indicates that the FM signal in the rainy season fluctuates more or is less stable compared to the dry season. This increased variability could be attributed to the inconsistent and dynamic weather conditions characteristic of the rainy season, such as intermittent heavy rain, varying cloud cover, and changes in atmospheric moisture.

In addition, examining the minimum and maximum FM signals in the two seasons, it was observed that the minimum FM signal strength was 50.38 dBmV (min), while the maximum was 56.86 dBmV in the rainy season, while in the dry season, the minimum was 53.14 dBmV, while the maximum value was 57.72 dBmV**.** It can be observed from the results here that **t**he dry season generally presents higher minimum and maximum FM signal values compared to the rainy season, aligning with its higher mean signal, which could also be a result of rain attenuation, which occurs in the rainy season and results in signal scattering, absorption, and diffraction.

4.4 Results of regression, random forest and gradient boosting models analysis for rainy season

4.4.1 Regression model result

The linear regression model equation is given as (4.1);

$$FM = 55.36 - 0.0057\ I \quad 4.1$$

where FM represent the FM radio signal strength, and I is the Irradiance.

The regression analysis shows that the intercept was 55.36, and this represents the estimated FM signal when the average irradiance is 0 W/m². This can be interpreted as the baseline FM signal with no solar irradiance. Also, the coefficient for irradiance was -0.0057, and this indicates that for every one-unit increase in irradiance, the FM signal is expected to decrease by 0.0057. This suggests an inverse relationship, meaning that as solar irradiance increases, the FM signal tends to decrease. Also, the analysis of linear regression showed that R-squared was 0.9004, while the mean squared error (MSE) was 0.2882. The linear regression model for the rainy season shows a strong R-squared of 0.9004, and this means that about 90% of the variance in FM signal strength can be explained by solar irradiance using a linear relationship. The result also shows that the MSE was 0.2882, which means the average squared difference between the actual and predicted values of the FM signal.

4.4.2 Gradient boosting regression result

In the rainy season, the R-squared, or coefficient of determination, value was 0.91. The R-squared value of 0.91 for the rainy season means that 91% of the variance in the FM signal can be explained by the irradiance when using the gradient boosting model. Also, the Mean Squared Error (MSE) in the rainy season was 0.065. This measures the average squared difference between the estimated values and the actual value. That is,

the MSE value of 0.065 shows that the average squared difference between the actual and predicted FM signal values was 0.065.

4.4.3 Random forest regression results

The analysis of the random forest showed that the R-squared was 0.89. The R-squared of 0.89 means that approximately 89% of the variance in the FM signal can be explained by the irradiance using the Random Forest model. Also, the Mean Squared Error (MSE) was 0.2611. The MSE value of 0.261 means that the average squared difference between the actual and predicted FM signal values is 0.261.

4.5 Results of regression, random forest and gradient boosting models analysis for dry season

4.5.1 Linear regression model result for dry season

The linear regression model equation for dry season is given as (4.2):

FM = 58.78 -0.0046 I 4.2

In this equation, the intercept is 58.7843. It means the estimated FM signal is 58.7843 dBmV when the average irradiance is 0 W/m². That is, if there were no solar irradiance (i.e., at night or in complete darkness), the model predicts an average FM signal strength of approximately 58.78 dBmV. Also, the coefficient for irradiance was -0.0046. The coefficient of -0.0046 indicates an inverse relationship. In this, the coefficient of -0.0046 means that for every increase of 1 W/m² in solar irradiance, the average FM signal is expected to decrease by 0.0046 dBmV. This reinforces the inverse relationship observed in previous analyses, given that as solar irradiance increases, the FM signal tends to decrease.

Also, the analysis of the linear regression showed that the R-squared value was 0.9064 and the mean squared error (MSE) was 0.2104. The linear regression model exhibits an R-squared of 0.9064, indicating that approximately 90.64% of the variability in FM signal strength can be explained by solar irradiance in a linear fashion. Also, the MSE was 0.2104, meaning that the average squared difference between the actual and predicted FM signal values was 0.2104.

4.5.2 Gradient boosting regression model result

The analysis of the gradient boosting shows that the R-squared value was 0.9704. This means that approximately 97.04% of the variability in the FM signal can be explained by the irradiance when using this gradient boosting model. This implies that solar irradiance is a dominant factor influencing the FM signal during this dry season. Also, the Mean Squared Error (MSE) was 0.0665. The MSE of 0.0665 shows that the model's predictions are, on average, very close to the true observed values. The MSE of 0.0665 means that the average squared difference between the actual and predicted FM signal values was 0.0665.

4.5.3 Random forest regression model result

The analysis of the gradient boosting shows that the R-squared was 0.9064. The R-squared value of 0.9064 implies that about 90.64% of the variance or change in the FM signal can be explained by the irradiance using the Random Forest model. Also, the mean squared error was 0.2104. An MSE of 0.2104 means that the average squared difference between actual and predicted values is 0.2104.

Table 4.1 shows the model validation results for dry season and rainy season from the analysis above.

Rainy season

Model	Training R^2	Testing R^2	MSE
Linear Regression	0.912	0.9004	0.2882
Random Forest	0.925	0.8900	0.2611
Gradient Boosting	0.941	0.9100	0.0650

Dry season

Model	Training R^2	Testing R^2	MSE
Linear Regression	0.918	0.9064	0.2104
Random Forest	0.928	0.9064	0.2104
Gradient Boosting	0.981	0.9704	0.0665

5.0 Conclusion

This study investigated the impact of solar irradiance on FM radio signal strength using an experimental research method. Measurements of solar irradiance and FM signal strength were carried out in Abuja, Nigeria, during the rainy season months of June and July 2025 and the dry season months of October and November 2025. The results from both seasons showed that solar irradiance has an inverse relationship with FM signal strength. This means that as solar irradiance increases, the FM signal strength decreases, while lower irradiance levels are associated with stronger signal reception.

The results presented in Fig. 1 and 2 showed that stronger FM signals were mostly observed during the morning and evening periods when solar irradiance was low. In contrast, weaker signal strengths were recorded during the afternoon when irradiance was highest. Similar trends were also observed in Fig. 3. The machine learning models used in the study, namely Linear Regression, Gradient Boosting, and Random Forest, further confirmed this relationship. All three models produced coefficients of determination (R^2) above 80%, indicating that solar irradiance explains a significant portion of the variation in FM signal strength. From the findings, it can be concluded that increased solar irradiance contributes to a reduction in FM radio signal strength within the study area. This may be due to atmospheric changes such as temperature increase, thermal expansion, and humidity variations during periods of intense solar heating, which can increase the absorption and scattering of FM/VHF radio waves. The findings agree with the study by Marhamah *et al*. (2028), which reported weaker radio signals during daytime periods except around sunrise and sunset. The conclusion of the study is supported by quantitative evidence obtained from both descriptive and machine learning analyses. The graphical results showed that FM signal strength decreases during periods of high solar irradiance and increases during periods of low irradiance. Furthermore, the machine learning models produced coefficients of determination exceeding 89% in all cases, indicating that a substantial proportion of the variation in FM signal strength can be explained by solar irradiance. The superior performance of the Gradient Boosting model, which achieved R^2 values of 0.91 and 0.9704 in the rainy and dry seasons respectively, further validates the existence of a strong relationship between solar irradiance and FM signal behaviour.

6.0 Recommendation

Since the results established a strong inverse relationship between solar irradiance and FM signal strength, it is recommended that similar investigations be conducted in other climatic regions to determine whether the observed relationship remains consistent under different atmospheric conditions. In addition, future studies should incorporate other atmospheric variables such as temperature, humidity, rainfall, atmospheric pressure, and wind speed to improve predictive performance and provide a more

comprehensive understanding of factors influencing FM signal propagation.

7.0 Conflicts of interest

The authors declare that there are no financial or personal conflicts of interest that could have influenced the content or results of this study.

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