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Weather Parameters Influence on Radio Wave Transmission Signals in Some Selected South-Western Parts of Nigeria

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Meteorological variables such as water vapor, temperature and atmospheric pressure greatly influence radio signal transmission. In this study, the influence of air temperature variations of some selected locations in the South-Western part of Nigeria on specific attenuation, radio refractivity and water vapour were investigated using the weather parameters obtained from Nigerian Meteorological Agency (NiMeT) for two years (2022 and 2023). The result revealed dependence of specific attenuation on temperature as lower attenuation of 0.047 dB/Km was observed at higher temperature of 28.5°C. The surface radio refractivity in the sampling areas was found to be higher (372 N-units) during the rainy seasons and lower (247 N-units) during the dry seasons. Also, during the periods of high temperature, the water vapour content in the atmosphere

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was low (0.62 g/m^3) signifying water vapour effects on radio propagation during the days of low temperature. In conclusion, the radio wave transmission signals were influenced by the weather parameters in the examined location.

Keywords: Weather parameters; radio wave transmission signals; South-Western Nigeria; air temperature; attenuation.

1. INTRODUCTION

Radio signal transmission is often influenced by some primary meteorological parameters such as water vapor, temperature and atmospheric pressure together with some troposphere secondary weather conditions (Ayantunji, et al., 2011). Refraction, reflection, absorption, polarization, diffraction and scattering occurrences are major determinants of radio waves. These factors are usually caused by the aforementioned meteorological and primary variables. Usually when the rain is about to begin sometimes around April, the atmospheric temperature is normally perceived to be moderately high (Ayegba, et al., 2021). However, as the volume of relative humidity and rainfall increases, the air temperature decreases. Temperature measures the average kinetic energy that an object or a body possesses while the Earth's atmospheric temperature at various layers or the evaluated temperature at varying levels of the Earth's atmosphere is referred to as "atmospheric temperature" (Chima, et al., 2020). It is influenced by some parameters like humidity, solar radiation, altitude and transitions in water state. The pressure exerted by the earth's atmosphere at any particular point is the atmospheric pressure (Sheu, et al., 2021). This is the product of the gravitational acceleration and the atmospheric column mass of the unit area above the specific point. The measurement of the extent of water vapor availability in a air-water mixture when compared with the maximum amount possible is called the relative humidity. It expresses the volume of water vapor available in air and it is expressed as the percentage of the amount required for saturation at the same temperature (Felix, et al., 2024). The radio frequency signal quality reduces while travelling via the atmosphere and across the link due to the scattering and absorption of radio signal by atmospheric particles. The lowering in the signal strength has a substantial consequence on the information received at any point (Michael, et al., 2023).

In communications, radio wave propagation is apprehended majorly with the effects and properties of the medium via which the signal is being transmitted. The quality of terrestrial television signals that the viewers are receiving is also very imperative to stakeholders. Although the transmitter transmits these radio waves being received by the receiver, the strength of the received signal of these radio waves is an essential factor to be considered due to their relation to some atmospheric components (Odu, et al., 2024). The signal transmitted or received at a given location is altered when the moisture quantity in the air at a given location changes. In a real environment, the earth's shape; atmospheric parameters like humidity, temperature and wind; and interaction with the object on the ground such as trees, hills, valleys, water bodies, buildings and mountains are some of the factors that alter radio signals.

Several studies relating to the effects of weather parameters on radio wave transmission signals have been presented. Michael (2023) investigated the effect of ground and air temperature on very high frequency radio signals. It was stated that some factors influencing radio wave propagation such as rain, wind, temperature and water content can combine in various forms to alter the radio wave propagation such that it may cause radio signals to be heard at far distance beyond its planned horizon causing its attenuation which thus, makes it unreachable to its designed horizon. The effect of temperature and ground water on VHF radio wave propagation in tropical climate has also been previously investigated (Suleman, et al., 2017). Mat et al. (2018) conducted the modelling of tropical weather effects on Ultra-High Frequency (UHF) radio signals using SmartPLS. It was found that changes in weather conditions affected the signal where all weather predictors provide a significant relationship to the signal where the coefficient of determination was 0.314 for frequency 1800 MHz; and 0.254 for frequency 2160 MHz. It was also revealed that humidity, temperature and wind were inversely correlated to RPL. However, humidity was found to be the toughest predictor influencing the RPL of communication signals for frequency 1800 MHz (Agbo, et al., 2023).

Recently, Felix et al. (2024) assessed the effects of relative humidity, atmospheric pressure and atmospheric temperature on the signal strength of Maloney FM Radio, 95.9 MHz, Keffi, Nasarawa State. Data gathered (relative humidity, atmospheric pressure, atmospheric temperature and the strength of the Maloney radio signal) from January 2023 to June 2023 between 6.00 a.m. and 6.00 p.m. daily at an interval of 30 min in Karshi, Abuja (a neighbouring town to Nasarawa state where the radio station is located), was applied for the study. It was revealed that atmospheric pressure and temperature negatively correlate with signal strength while relative humidity positively correlates with received signal strength in all the six months under study. In another study, Odu et al. (2024) characterized the influence of radio wave refractivity in South-South Nigeria. A methodology that combines computer models with empirical observations was applied to clarify the influence of radio wave refractivity on wireless communication systems with a focus on South-South Nigeria. Radio frequency CRF/measurements were conducted at certain places with the aid of conventional Drive Test Method. The study was able to reveal the influence of weather patterns on service quality and network performance provided by Glo, MTN, Airtel and 9mobile network providers in the southern Nigerian states of Cross River, Bayelsa, Akwa Ibom, and Rivers State.

However, one of the major challenges faced on daily basis by telecommunication companies is attenuation of radio signals which arises due to variations in meteorological parameters such as air temperature, air pressure and relative humidity. Limited research investigating the extent at which the normal atmospheric parameters affect the propagation of radio waves has been conducted. This study examines the influence of air temperature variations of some selected locations in the South-Western part of Nigeria on specific attenuation, radio refractivity and water vapour. The selected locations were Lagos, Abeokuta, Ondo, Ado, Ibadan, Osogbo and Ogbomoso. The selection of these locations was due to high concentration of radio stations being state capitals and densely populated nature. Weather parameters were obtained from Nigerian Meteorological Agency (NiMeT) for two years (2022 and 2023) from January to December.

2. STUDY AREAS

The variations in the specific attenuation with variations in temperature in the South-Western region of Nigeria which comprises Lagos, Abeokuta, Ondo, Ado, Ibadan, Osogbo and Ogbomoso for the years 2022 and 2023 were examined. The study areas are indicated with dots on the map of Nigeria presented as Fig. 1.

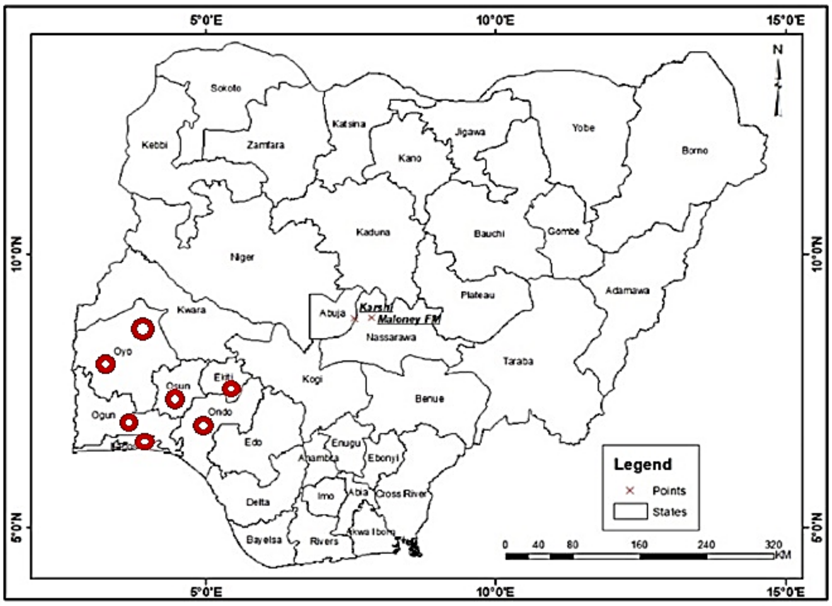


Fig. 1. Map of Nigeria showing the study areas

2.1 Materials and Methods

Weather parameters used in this study for the selected South-Western states of Nigeria were gathered from Nigerian Meteorological Agency (NiMeT). The analyses were done for all the months of the years 2022 and 2023. The hourly variations of meteorological parameters for each day were used for the deduction of daily mean variation. Figs. 2, 3, 4 and 5 represent the automatic rain gauge, anemometer, atmospheric thermometer and hygrometer respectively used for data collection.

2.2 Data Collection and Analysis

Weather parameters were obtained from Nigerian Meteorological Agency (NiMeT) from January to December for the years 2022 and 2023. Measured data were air-temperature, attenuation, surface refractivity and water vapour. A meteorological calculator shown in Fig. 6 was utilized in the data analysis.

Fig. 2. Automatic Rain Gauge

Fig. 3. Anenometer (Wind Speed)

Fig. 4. Atmospheric Thermometer

Fig. 5. Hygrometer

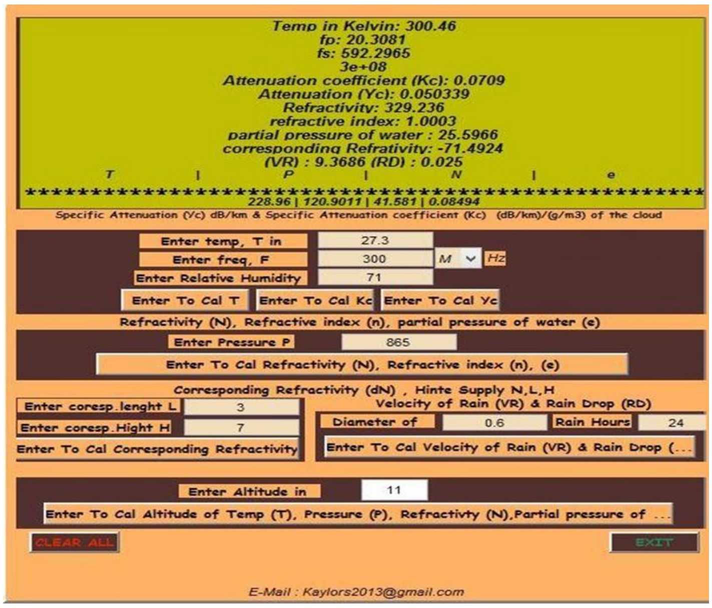
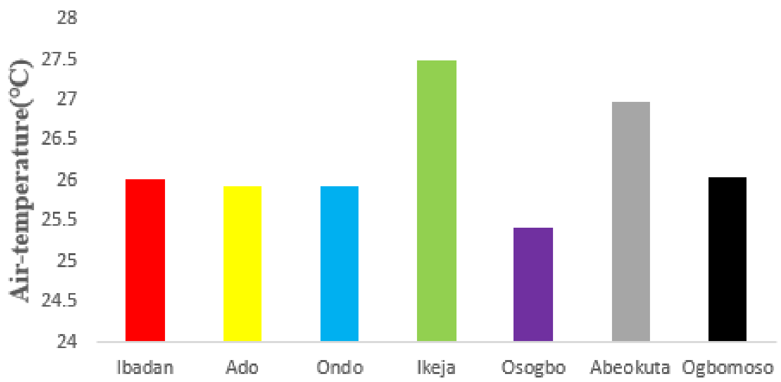


Fig. 6. The meteorological calculator

3. RESULTS AND DISCUSSIONS

3.1 Air-Temperature Influence on Specific Attenuation

Figs. 7a and 7b present the temperature variations in the selected sampling locations (Lagos, Abeokuta, Ondo, Ado, Ibadan, Osogbo and Ogbomoso) of the South-Western region of Nigeria for the years 2022 and 2023 respectively while Figs. 8a and 8b are the corresponding changes in the specific attenuation observed for each of the locations. The results revealed decrease in the level of attenuation as the temperature increases across the locations. The attenuation loss in dB/Km as modelled by International Telecommunication Union (ITU) is 0.05 dB/Km. However, for these regions, the average attenuations for the years 2022 and 2023 were 0.057 dB/Km and 0.055 dB/Km respectively. The average values were slightly higher than the standard value. This is because the air-temperature with which the standard value was modelled is different from that of these regions (Ukhurebor, et al., 2018). Only the value for Ogbomoso corresponded to the standard value. Thus, for propagation of radio signals to be effective in these regions, transmitters should be designed using the observed average experimental value, which is 0.056 dB/Km. A similar study conducted in Keffi, Nasarawa State using Maloney FM Radio, 95.9 MHz as sampling location revealed negative correlation between atmospheric temperature and signal strength (Felix, et al., 2024). The study conducted by Elsayed (Elsayed, et al., 2024) applied advanced diversity multiplexing with hybrid N-SM/OMI M-ary spatial pulse-position modulation schemes for atmospheric turbulence mitigation of MIMO-RF/FSO DWDM communication systems. The result revealed alleviation of signal degradation due to atmospheric turbulence resulting from the inclusion of SM in FSO communications. This yielded a significant reduction in the bit error rate (BER) as compared to other systems.



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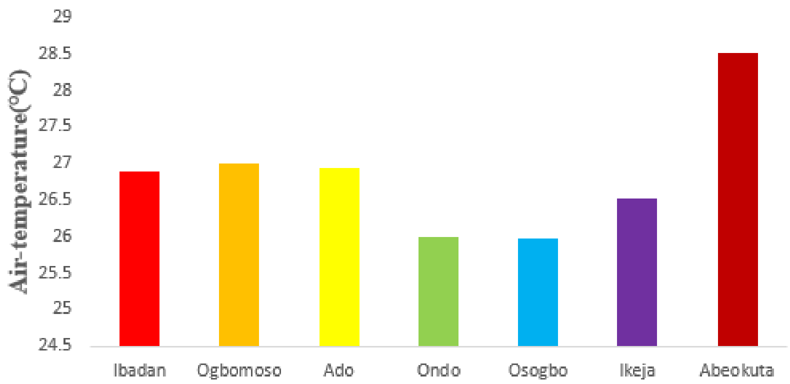
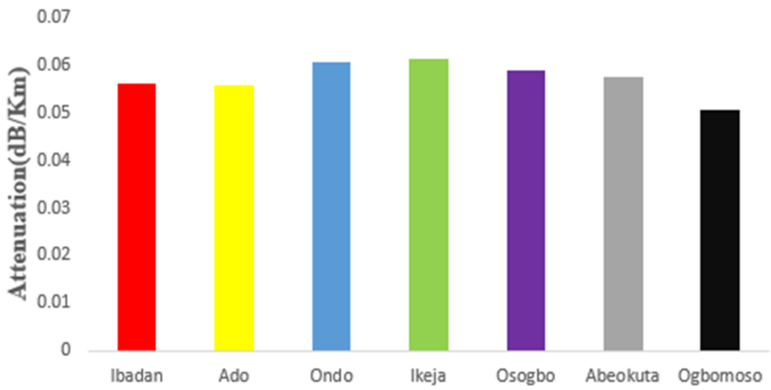


(b)

Fig. 7. Air-temperature variations over some selected locations in South-Western region of Nigeria for (a) 2022 and (b) 2023



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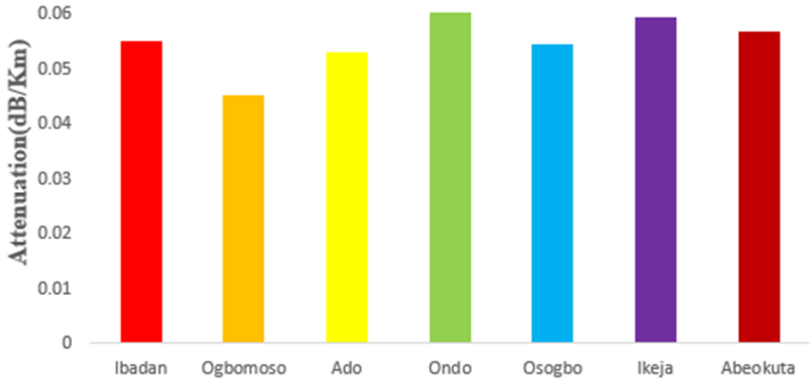
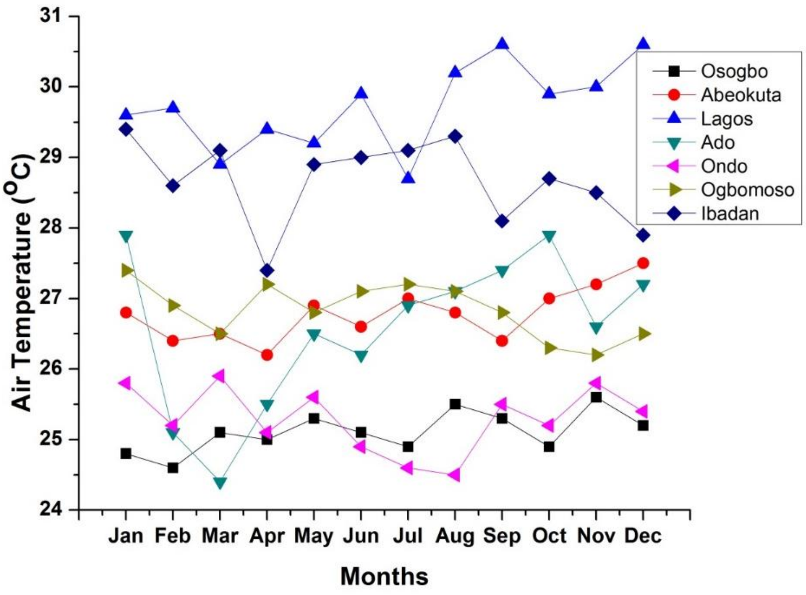


(b)

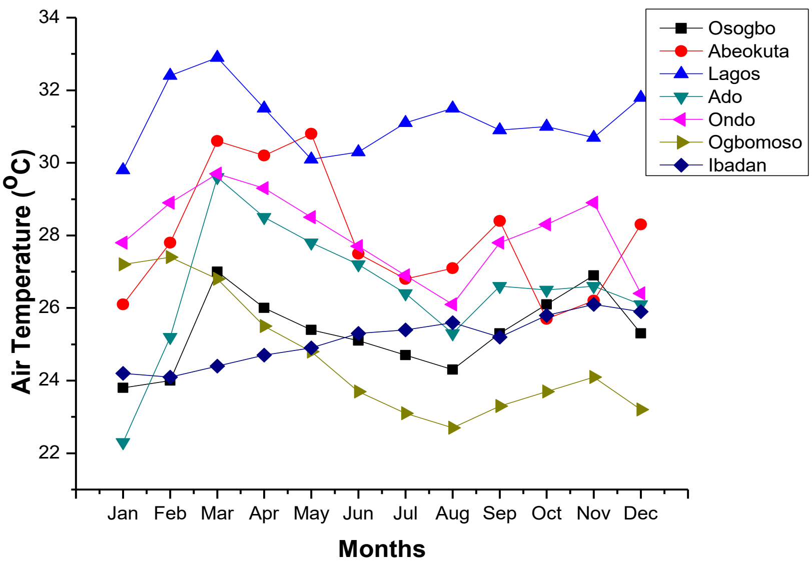
Fig. 8. Attenuation variations over some selected locations in South-Western region of Nigeria for (a) 2022 and (b) 2023

3.2 Air-Temperature Influence on Radio Refractivity

Figs. 9a and 9b present the mean air temperature variations over the months in the selected sampling locations [Lagos (Ik), Abeokuta (Ab), Ondo (On), Ado (Ad), Ibadan (Ib), Osogbo (Os) and Ogbomoso (Ogb)] of the South-Western region of Nigeria for the years 2022 and 2023 respectively while Figs. 10a and 10b are the corresponding changes in the radio refractivity observed for each of the locations. The relationships between radio refractivity and air temperature for all the states in the region showed that for every increase in air temperature, there is a corresponding decrease in radio refractivity. This simply means that for days or months which have low temperatures, the radio refractivity will be high and so the radio propagation will be adversely affected (Obiegbu, et al., 2023). Comparing the rainy season months from April to October with the plot for the dry season months, uniform refractivity values were observed. During the rainy season, refractivity values were observed to be higher than the values obtained in the dry season. These high values are attributed to extensive cloud cover and saturation of the atmosphere with larger amount of water vapour during this period. Also, during the rainy seasons, air temperature values were observed to be lower than the values obtained in the dry seasons. The study conducted by Odu et al. (2024) using network providers in the southern Nigeria as case study presented similar results. The study conducted by Chima et al. (2020) investigated the impact of weather parameters on the signal strength of satellite Dish in Enugu metropolis. The result showed reduction in the air temperature during rainy season. In another study, diversity coding techniques was applied under the effect of turbulent weather phenomenon for diversity enhancement of dense wavelength division multiplexing MIMO-FSO fault protection protocols systems over atmospheric turbulence channels (Elsayed, et al., 2024). The results revealed the effectiveness of the approach in mitigating atmospheric turbulence and improvement in the power penalty at both bit-error-rate values. Currently, the efficiency of free-space optical (FSO) communication was improved via the combination of hybrid on–off keying modulation, M-ary digital pulse position modulation, and M-pulse amplitude and position modulation (Elsayed, et al., 2024). The study analyzed and enhanced the bit-error-rate performance using methods such as the moment generating function, modified Chernoff bound, and Gaussian approximation. The simulation results revealed the viability of the proposed technique for the examined hybrid links in both optical-wireless and fiber-optic communication systems with significantly enhanced overall efficiency.

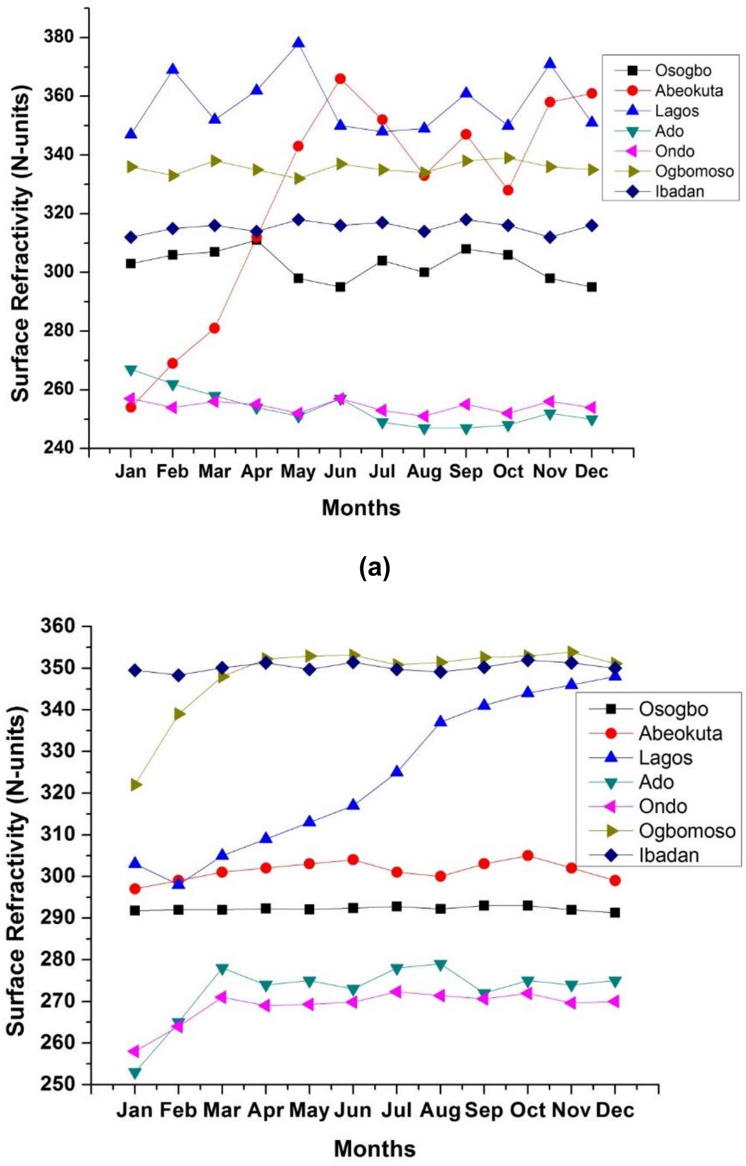


(a)



(b)

Fig. 9. Monthly mean air temperature variations over some selected locations in South-Western region of Nigeria for (a) 2022 and (b) 2023



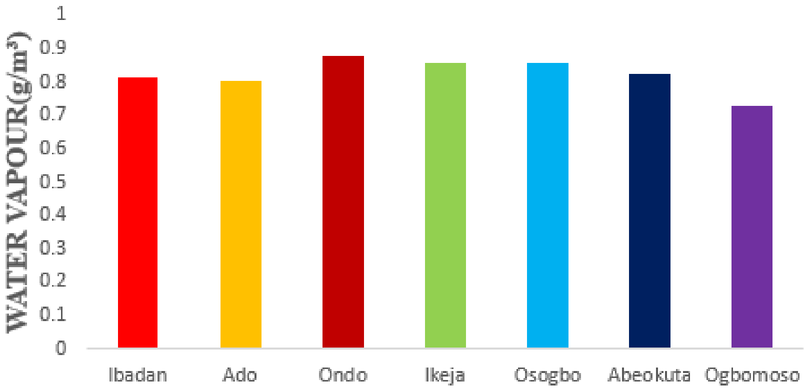
(a)

(b)

Fig. 10. Monthly mean surface refractivity variations over some selected locations in South-Western region of Nigeria for (a) 2022 and (b) 2023

3.3 Air-Temperature Influence on Water Vapour

Figs. 11a and 11b present the water vapour variations in the selected sampling locations (Lagos, Abeokuta, Ondo, Ado, Ibadan, Osogbo and Ogbomoso) of the South-Western region of Nigeria for the years 2022 and 2023 respectively. The results of the variations in water vapour of the atmosphere with variations in temperature (Figs7a and 7b) showed that during the periods of high temperature, the water vapour content in the atmosphere was low. This implies that water vapour greatly affects radio propagation during the days of low temperature (Gunashekar, et al., 2006, Alade, et al., 2023). Generally, signal strength will reduce during the rainy seasons but high during dry seasons. The study conducted by Ukhurebor et al. (2018) using EBS radio station in Benin City located in South-South, Nigeria as case study also investigated the influence of meteorological variables on UHF radio signal and rapid reduction in the water vapour present in the atmosphere was observed when the atmospheric temperature was high during the examined period.



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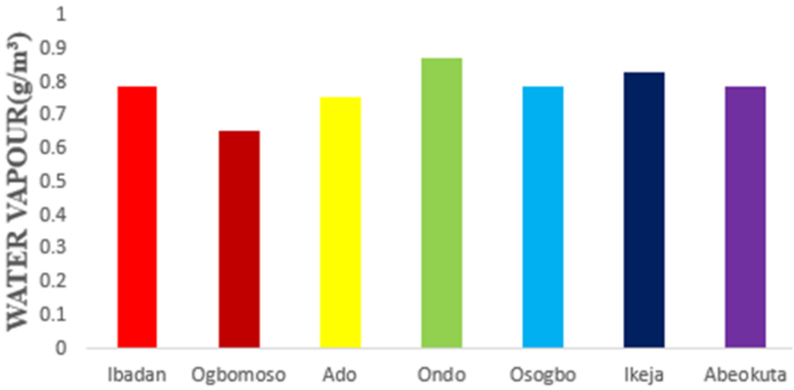

(b)

Fig. 11. Water vapour variations over some selected locations in South-Western region of Nigeria for (a) 2022 and (b) 2023

4. CONCLUSIONS

This study has investigated the influence of air temperature variations of some selected locations in the South-Western part of Nigeria on specific attenuation, radio refractivity and water vapour. It was observed that specific attenuation depends greatly on temperature. The higher the temperature, the lower the level of attenuation. Thus, for propagation of radio signals to be effective in this region, transmitters should be designed using the observed average experimental value of the attenuation loss in dB/Km, which is 0.056 dB/Km. Also, the surface radio refractivity over the Western region in Nigeria was found to be higher during the rainy seasons and lower during the dry seasons. This means that for months which have low temperatures (July, August and September), the radio refractivity will be high and so the radio propagation will be adversely affected. The results of the variations in water vapour of the atmosphere with variations in temperature also showed that during the periods of high temperature, the water vapour content in the atmosphere was low. This means that water vapour greatly affects radio propagation during the days of low temperature. Generally, signal strength will reduce during the rainy seasons but high during dry seasons.

DATA AVAILABILITY STATEMENT

Data will be made available on request.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

Agbo, G. A., Okoro, O. N., & Amechi, A. O. (2023). Atmospheric refractivity over Abuja, Nigeria. *International Research Journal of Pure and Applied Physics, 1*(1), 37-45.

Alade, M. O. (2023). Investigation of the effect of ground and air temperature on very high frequency radio signals. *Journal of Information Engineering and Applications, 3*, 9-16.

Ayantunji, B. G., Okeke, P. N., & Urama, J. O. (2011). Diurnal and seasonal variation of surface refractivity over Nigeria. *Progress in Electromagnetics Research, 30*, 201-222.

Ayegba, A., Ojo, J. S., & Adediji, A. T. (2021). Statistical analysis of atmospheric parameters, noise temperature, and digital terrestrial television signal strength over Jos Metropolis, Plateau State, Nigeria. *Heliyon, 8*, 12345.

Chima, A. I., Onyia, A. I., & Chikeleze, P. C. (2020). Investigating the impact of weather parameters on signal strength of satellite dish in Enugu metropolis. *International Journal of Astrophysics and Space Science, 8*, 11–15.

Elsayed, E. E. (2024). Atmospheric turbulence mitigation of MIMO-RF/FSO DWDM communication systems using advanced diversity multiplexing with hybrid N-SM/OMI M-ary spatial pulse-position modulation schemes. *Optics Communications, 562*, 130558.

Elsayed, E. E. (2024). Performance enhancement of atmospheric turbulence channels in DWDM-FSO PON communication systems using M-ary hybrid DPPM-M-PAPM modulation schemes under pointing errors, ASE noise, and interchannel crosstalk. *Journal of Optics*.

https://doi.org/10.1007/s12596-024-01908-9

Elsayed, E. E., Hayal, M. R., Nurhidayat, I., Shah, M. F., Elfikky, A., Boghdady, A. I., Juraev, D. A., & Morsy, M. A. (2024). Coding techniques for diversity enhancement of dense wavelength division multiplexing MIMO-FSO fault protection protocols systems over atmospheric turbulence channels. *IET Optoelectronics, 18*(1-2), 11-31.

Felix, A., Abdullahi, A., Olufemi, A., & Jaiyeola, O. P. (2024). Effects of some weather variables on the signal strength of Maloney FM radio, Nasarawa State, Nigeria. *Heliyon, 10*, e25978.

Gunashekar, S. D., Siddle, D. R., & Warrington, E. M. (2006). Trans horizon radio wave propagation due to evaporation ducting: The effect of tropospheric weather conditions on VHF and UHF radio paths over the sea. *Resonance*, 51-62.

Mat, R., Hazmin, S. N., Umar, R., Ahmad, S., Zafar, S. N. A. S., & Marhamah, M. S. (2018). The modelling of tropical weather effects on ultra-high frequency (UHF) radio signals using SmartPLS. *IOP Conference Series: Materials Science and Engineering, 440*, 012041.

Michael, O. A. (2023). Investigation of the effect of ground and air temperature on very high frequency radio signals. *Journal of Information Engineering and Applications, 3*, 16–22.

Obiegbu, U. A., & Anene, C. R. (2023). Experimental study on the impact of meteorological variables on ultra-high frequency radio signal generated by Anambra Broadcasting Corporation (ABS) for sustainable development in Awka, Anambra State, Metropolis, Nigeria, 2023.

Odu, O. J., Adebayo, A. D., Donatus, B. E., & Ayibapreye, K. B. (2024). Characterization of the influence of radio wave refractivity in South South Nigeria. *International Journal of Recent Research in Electrical and Electronics Engineering, 11*(3), 12-21.

Sheu, A. L. (2021). The impact of atmospheric conditions on satellite signals between 10 GHz–14 GHz at Ku band in low latitude region of Oyo, southwestern Nigeria. *FJPAS, 6*, 85–93.

Suleman, K. O., Bello, I. T., Tijani, L. O., Ogunbode, A. O., & Olayiwola, W. A. (2017). Effect of temperature and ground water on VHF radio wave propagation in tropical climate. *International Journal of Scientific & Engineering Research, 8*(1), 1391-1396.

Ukhurebor, K. E., & Umukoro, O. J. (2018). Influence of meteorological variables on UHF radio signal: Recent findings for EBS, Benin City, South-South, Nigeria. *IOP Conference Series: Earth and Environmental Science, 173*, 012017.

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