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Assessment of Radio Refractivity and Frequency Modulated Radio Signal Strength Variability with Time in Broadcasting System using Osun State Broadcasting Cooperation (OSBC), FM 104.5 MHz as a Reference Station

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Abstract:- Radio Refractivity and frequency modulated radio signal strength were simultaneously synchronized through a self-developed frequency modulated radio signal Strength (FMRSS) and radio refractivity (RF) Meter to acquire data for this research work. The meter was tuned to Osun State Broadcasting Cooperation (OSBC) at FM 104.5 MHz to acquire data over period of 66 days from 23/11/2021 to 05/12/2021, 17/12/2021to 31/12/2021 and 01/01/2022 to 05/02/2022 respectively. The data were processed and the result viewed to infer the relationship between radio refractivity and frequency modulated radio signal strength.. Critical overview of all curves of the analysis reflects the same result that frequency modulated radio signal strength varied inversely to radio refractivity. That is, at a rising point of radio refractivity, frequency modulated radio signal strength is observed falling. Though mostly the two may have the same variation trend-lines direction, it is clearly featured in nearly all the analysis figures that a fall in radio refractivity increases the strength of OSBC frequency modulated radio signal at any point of reception during broadcasting operation. Therefore, a good reception of frequency modulated radio signal strength (FMRSS) is always achievable when all climatological parameters are at the normal states of favorable weather condition of moderate pressure, relative humidity and a fairly high temperature where radio refractivity will be at a low level for an improved frequency modulated radio signal strength in broadcasting operation. This has recommended a reasonable determination of frequency modulated radio broadcasting station site location with stronger transmitting equipment (transmitter and antenna) and appropriate antenna height positioning, that will favor low radio refractivity and strong frequency modulated radio signal strength.

***Keywords**:- Radio, Refractivity, Signal, Strength, Frequency, Modulation, Tuned, Penetrable, Broadcasting, Operation, Climatological, Transmitting Equipment, ,Pressure, Relative Humidity and Temperature.*

I. INTRODUCTION

In an accurate examination of the contributive effects of atmospheric parameters on frequency modulated (FM) radio signals, there is need to have a field strength meter that can simultaneously access radio frequency modulated signal strength and radio refractivity with its parameters such temperature, relative humidity and pressure (1) (2) (3). Most past researchers based their findings on manual measurements, while it is necessarily important to conduct a continuing logging of data for proper examination of the effects of the necessary atmospheric parameters on the FM signals. Refractivity and frequency modulated (FM) radio signal strength were simultaneously synchronized through a frequency modulated radio signal strength and radio climatological parameters meter to acquire data for this research work.

Wireless communication companies and radio stations depend on the received signals from the signal transmitter, which rests mostly on site location as a function of atmospheric parameters of the area to conclude on the most proficient points in placing their cellular towers. Broadcasters wish to place their transmitters at proficient points to cover wide range during a broadcast communication operation. The signal strength is function of transmitter power output, source antenna position reference the transmitting antenna (3) (4) and importantly, the variations in the atmospheric conditions as it travels through atmosphere (5). Information on the compositions and state of the earth's atmosphere assists in understanding radio waves propagation and the kind of communication system (receiver and transmitter) to be developed or installed at a particular location (6). The atmospheric parameters within the troposphere are very important and these include temperature, pressure, relative humidity and wind (5). These factors determine the level each of reflection, refraction, diffraction and scattering and absorption of FM radio signal. Also, signal frequency may be shifted between the transmitter and receiver due to relative motion, which shows clearly that radio waves propagation is a space-time-frequency phenomenon. Therefore, it is crucial to understand that the propagation influences cannot be

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quantified in any accurate sense, but can only be explained on the basis of their statistics (7).

II. METHODOLOGY

The method used involved a direct acquisition of values for both refractivity and frequency modulated radio signal strength using a self-developed frequency modulated radio signal strength and radio refractivity meter. The meter was installed at Owode-Ede, Ede North Local Government Area, Osun State, a position near Osun Secretariat, Osogbo. The meter was tuned to Osun State Broadcasting Cooperation (OSBC), FM 104.5 MHz for the required data over period 66 days from 23/11/2021 to 05/12/2021, 17/12/2021to 31/12/2021 and 01/01/2022, 02/02/2022 and 04/02/2022 respectively.

The data were processed and the result viewed to infer the relationship between radio refractivity and frequency modulated radio signal strength. Seven days data were reported from the whole processed data for this publication to avoid unnecessary lengthy tables and curves in our report. Days used include 23/11/2021,01/12/2021, 17/12/2021, 31/12/2021, 01/01/2022, 1/2/2022 and 04/02/2022 labelled as table 1 to table 7.

T able 1: Data for day 23/11/2021

Date	**Time**	**Station x 10^4 (Mhz)**	**Signal Strength(dB)**	**N radio refractivity**
11/23/2021	11:27:43	10405	18	421.87
11/23/2021	11:29:13	10450	40	424.42
11/23/2021	11:31:04	10450	43	427.99
11/23/2021	11:41:05	10450	39	430.74
11/23/2021	11:54:31	10250	26	451.23
11/23/2021	11:55:58	10450	39	450.75
11/23/2021	12:06:00	10450	32	451.84
11/23/2021	12:16:02	10450	37	459.77
11/23/2021	12:26:04	10450	35	464.71
11/23/2021	12:36:06	10450	38	468.13
11/23/2021	12:46:08	10450	38	470.41
11/23/2021	12:56:10	10450	38	471.61
11/23/2021	13:06:11	10450	38	469.28
11/23/2021	13:16:13	10450	41	465.58
11/23/2021	13:26:15	10450	41	466.34
11/23/2021	13:36:17	10450	41	470.77
11/23/2021	13:46:19	10450	41	471.28
11/23/2021	13:56:21	10450	42	468.36
11/23/2021	14:06:23	10450	40	461.87
11/23/2021	14:16:25	10450	41	457.84
11/23/2021	14:26:26	10450	41	452.94
11/23/2021	14:36:28	10450	41	453.75
11/23/2021	14:46:30	10450	40	444.41
11/23/2021	14:56:32	10450	42	445.27
11/23/2021	15:06:34	10450	41	445.88
11/23/2021	15:16:36	10450	41	443.75
11/23/2021	15:26:38	10450	40	447.22
11/23/2021	15:36:40	10450	40	449.06
11/23/2021	15:46:41	10450	40	449.48
11/23/2021	15:56:43	10450	40	449.07
11/23/2021	16:06:45	10450	40	448.63
11/23/2021	16:16:47	10450	40	448.99
11/23/2021	16:26:49	10450	41	449.01
11/23/2021	16:36:51	10450	40	450.82
11/23/2021	16:46:53	10450	40	448.19

Table 2: Data for day 01/12/2021

Date	Time	Station x 10^4 (Mhz)	Signal Strength(dB)	N radio refractiivty
12/1/2021	6:39:10	10450	26	437.25
12/1/2021	6:49:12	10450	27	438.13
12/1/2021	6:59:14	10450	27	445.05
12/1/2021	7:03:44	10450	19	449.49
12/1/2021	7:13:45	10450	26	450.32
12/1/2021	7:23:47	10450	26	446.49
12/1/2021	7:33:49	10450	27	444.2
12/1/2021	7:43:51	10450	29	442.95
12/1/2021	7:53:53	10450	28	442.21
12/1/2021	8:03:55	10450	29	441.11
12/1/2021	8:13:57	10450	32	441.02
12/1/2021	8:23:58	10450	31	445.16
12/1/2021	8:34:00	10450	30	444.75
12/1/2021	8:44:02	10450	30	442.96
12/1/2021	8:54:04	10450	32	441.54
12/1/2021	9:04:06	10450	29	440.7
12/1/2021	9:14:08	10450	30	440.81
12/1/2021	9:24:09	10450	29	440.3
12/1/2021	9:34:11	10450	31	440.38
12/1/2021	9:44:13	10450	32	445.26
12/1/2021	9:54:15	10450	32	449.35
12/1/2021	10:04:17	10450	32	451.48
12/1/2021	10:14:19	10450	32	453.17
12/1/2021	10:24:20	10450	32	453.91
12/1/2021	10:34:22	10450	30	454.94
12/1/2021	10:44:24	10450	32	456.04
12/1/2021	10:54:26	10450	31	457.45
12/1/2021	11:04:28	10450	30	456.65
12/1/2021	11:14:30	10450	29	456.73
12/1/2021	11:24:32	10450	29	458.61
12/1/2021	11:34:34	10450	30	452.8
12/1/2021	11:44:35	10450	29	455.93
12/1/2021	11:54:37	10450	29	454.74
12/1/2021	12:04:39	10450	28	455.76
12/1/2021	12:14:41	10450	28	450.84

Table 3: Data for day 17/12/2021

Date	Time	station x 10^4 (Mhz)	Signal Strength(dB)	N radio refractiivty
12/17/2021	21:02:30	10450	22	349.27
12/17/2021	21:12:32	10450	27	351.91
12/17/2021	21:22:34	10450	26	358.68
12/17/2021	21:32:35	10450	26	364.66
12/17/2021	21:42:37	10450	25	362.58
12/17/2021	21:52:39	10450	24	357.46
12/17/2021	22:02:41	10450	25	355.37
12/17/2021	22:12:43	10450	25	352.43
12/17/2021	22:22:45	10450	25	345.18
12/17/2021	22:32:47	10450	3	342.85
12/17/2021	22:42:48	10450	4	341.65
12/17/2021	22:52:50	10450	4	341.28
12/17/2021	23:02:52	10450	4	340.99

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12/17/2021	23:12:54	10450	5	342.91
12/17/2021	23:22:56	10450	5	343.41
12/17/2021	23:32:58	10450	4	343.65

Table 4: Data for day 31/12/2021

Date	Time	station x 10^4 (Mhz)	Signal Strength(dB)	N radio refractiivty
12/31/2021	7:21:10	10450	24	390.92
12/31/2021	7:31:12	10450	28	391.3
12/31/2021	7:41:13	10450	28	389.11
12/31/2021	7:51:15	10450	29	390.49
12/31/2021	8:01:17	10450	27	391.37
12/31/2021	8:11:19	10450	26	392.47
12/31/2021	8:21:21	10450	28	390.19
12/31/2021	8:31:23	10450	30	392.56
12/31/2021	8:41:24	10450	29	393.27
12/31/2021	8:51:26	10450	26	397.76
12/31/2021	9:01:28	10450	23	401.41
12/31/2021	9:11:30	10450	24	402.16
12/31/2021	9:21:32	10450	26	404.07
12/31/2021	9:31:34	10450	30	408.92
12/31/2021	9:41:36	10450	32	413.45
12/31/2021	9:51:38	10450	30	415.04
12/31/2021	10:01:39	10450	27	414.86
12/31/2021	10:11:41	10450	29	414.55
12/31/2021	10:21:43	10450	29	415.89
12/31/2021	10:31:45	10450	30	413.43
12/31/2021	10:41:47	10450	30	416.08
12/31/2021	10:51:49	10450	29	412.21
12/31/2021	11:01:51	10450	29	412.89
12/31/2021	11:11:52	10450	27	411.32
12/31/2021	11:21:54	10450	19	408.16
12/31/2021	11:31:56	10450	32	407.35

Table 5: Data for day 01/01/2022

Date	Time	station x 10^4 (Mhz)	Signal Strength(dB)	
1/1/2022	12:03:27	10450	17	386.35
1/1/2022	12:13:29	10450	27	385.12
1/1/2022	12:23:31	10450	27	398.36
1/1/2022	12:33:33	10450	28	410.55
1/1/2022	12:43:34	10450	32	413.33
1/1/2022	12:53:36	10450	30	403.18
1/1/2022	13:03:38	10450	28	397.31
1/1/2022	13:13:40	10450	28	386.99
1/1/2022	13:23:42	10450	26	389.81
1/1/2022	13:33:44	10450	28	393.01
1/1/2022	13:43:46	10450	28	386.84
1/1/2022	13:53:48	10450	28	390.34
1/1/2022	14:03:50	10450	28	390.67
1/1/2022	14:13:51	10450	32	387.16
1/1/2022	14:23:53	10450	31	382.16
1/1/2022	14:33:55	10450	31	380.02
1/1/2022	14:43:57	10450	29	372.37
1/1/2022	14:53:59	10450	28	380.29
1/1/2022	15:04:01	10450	28	376.27

1/1/2022	15:14:03	10450	27	381.53
1/1/2022	15:24:05	10450	25	377.05
1/1/2022	15:34:07	10450	26	379.57
1/1/2022	15:44:08	10450	23	372.15
1/1/2022	15:54:10	10450	21	371.99
1/1/2022	16:04:12	10450	25	374.9

Table 6: Data for day 02/01/2022

Date	Time	station x 10^4 (Mhz)	Signal Strength(dB)	N radio refractiivty
1/2/2022	6:44:57	10450	30	404.42
1/2/2022	6:54:59	10450	28	405.37
1/2/2022	7:05:00	10450	26	420.15
1/2/2022	7:15:02	10450	32	425.53
1/2/2022	7:25:04	10450	32	425.61
1/2/2022	7:35:06	10450	33	427.85
1/2/2022	7:45:08	10450	31	424.89
1/2/2022	7:55:10	10450	34	427.97
1/2/2022	8:05:12	10450	35	430.67
1/2/2022	8:15:14	10450	35	433.87
1/2/2022	8:25:15	10450	34	438.62
1/2/2022	8:35:17	10450	36	440.27
1/2/2022	8:45:19	10450	35	439.12
1/2/2022	8:55:21	10450	35	435.17
1/2/2022	9:05:23	10450	34	434.7
1/2/2022	9:15:25	10450	34	431.61
1/2/2022	9:25:27	10450	31	429.29
1/2/2022	9:35:29	10450	31	431.77
1/2/2022	9:45:30	10450	33	431.68
1/2/2022	9:55:32	10450	32	430.25
1/2/2022	10:05:34	10450	33	430.36
1/2/2022	10:15:36	10450	33	430.89
1/2/2022	10:25:38	10450	31	438.7
1/2/2022	10:35:40	10450	32	434.52
1/2/2022	10:45:42	10450	30	430.21

Table 7: Data for day 04/01/2022

Date	Time	station x 10^4 (Mhz)	Signal Strength(dB)	N radio refractiivty
1/4/2022	8:58:02	10450	35	318.6
1/4/2022	9:08:04	10450	37	318.83
1/4/2022	9:18:05	10450	36	324.63
1/4/2022	9:28:07	10450	38	326.56
1/4/2022	9:38:09	10450	38	325
1/4/2022	9:48:11	10450	38	325.97
1/4/2022	9:58:13	10450	38	326.95
1/4/2022	10:08:15	10450	38	326.16
1/4/2022	10:18:17	10450	38	325.36
1/4/2022	10:28:18	10450	38	322.91
1/4/2022	10:38:20	10450	39	322.85
1/4/2022	10:48:22	10450	39	322.83
1/4/2022	10:58:24	10450	37	323.17
1/4/2022	11:08:26	10450	37	323.79
1/4/2022	11:18:28	10450	36	324.23
1/4/2022	11:28:29	10450	36	322.73

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1/4/2022	11:38:31	10450	37	327.17
1/4/2022	11:48:33	10450	37	325.83
1/4/2022	11:58:35	10450	36	328.36
1/4/2022	12:08:37	10450	36	330.96
1/4/2022	12:18:39	10450	36	329.27
1/4/2022	12:28:41	10450	37	325.55
1/4/2022	12:38:42	10450	36	325.94
1/4/2022	12:48:44	10450	37	326.19
1/4/2022	12:58:46	10450	37	328.61

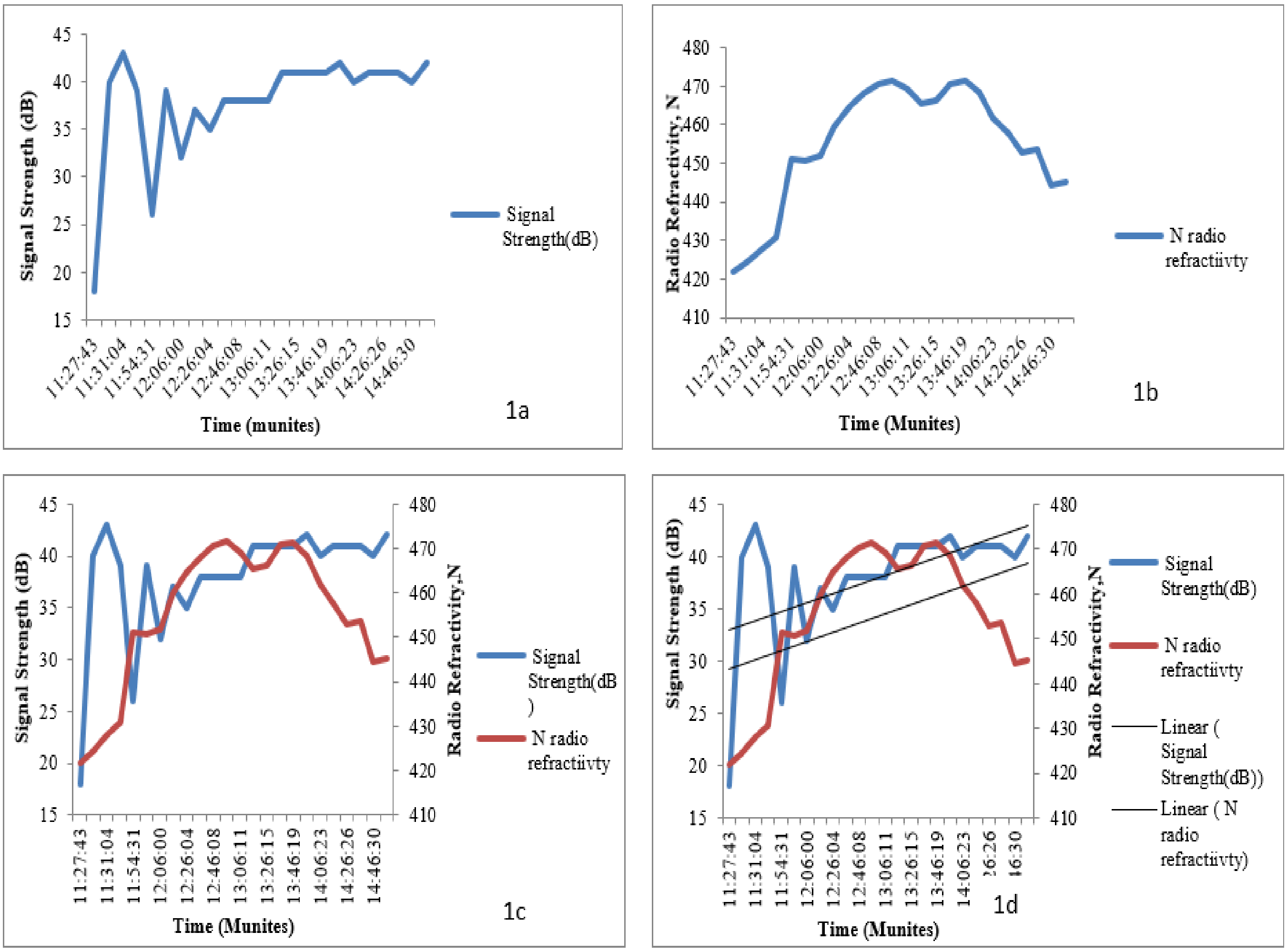


Fig 1: Time correlation of refractivity and frequency modulated signal strength curves for OSBC on 23/11/2021.
(a) Variation of FMRSS with time as it propagates in atmosphere from transmitter to the recipient.
(d) Variation of refractivity with time during FMRSS propagation in atmosphere from transmitter to the recipient.
(c) Comparison curves of both FMRSS and refractivity of the broadcasting station for specified period.
(d) Shows the variation trend lines of FMRSS and refractivity during the propagation.

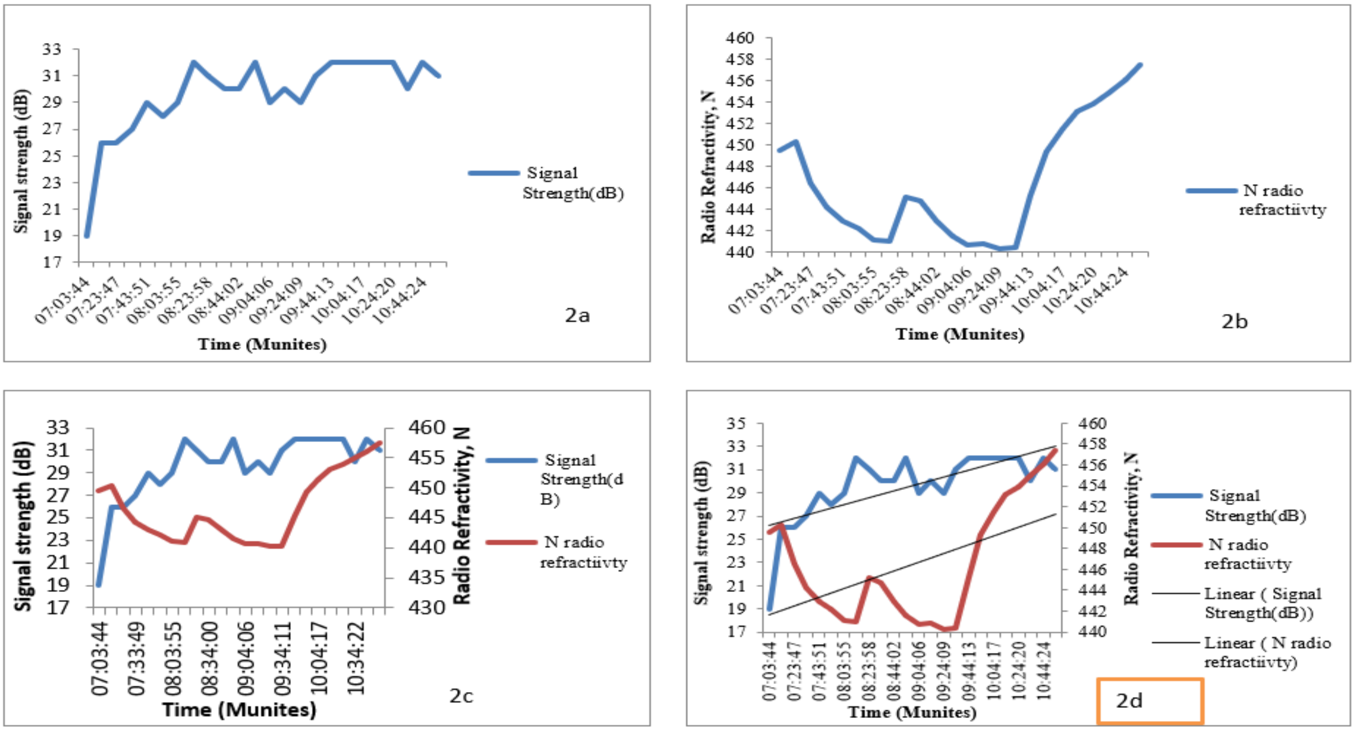


Fig 2: Time correlation of radio refractivity, N and frequency modulated signal strength curves for OSBC on 01/12/2021.
(a) Variation of FMRSS with time as it propagates in atmosphere from transmitter to the recipient.
(b) Variation of refractivity with time during FMRSS propagation in atmosphere from transmitter to the recipient.
(c) Comparison curves of both FMRSS and refractivity of the broadcasting station for specified period.
(d) Shows the variation trend lines of FMRSS and refractivity during the propagation.

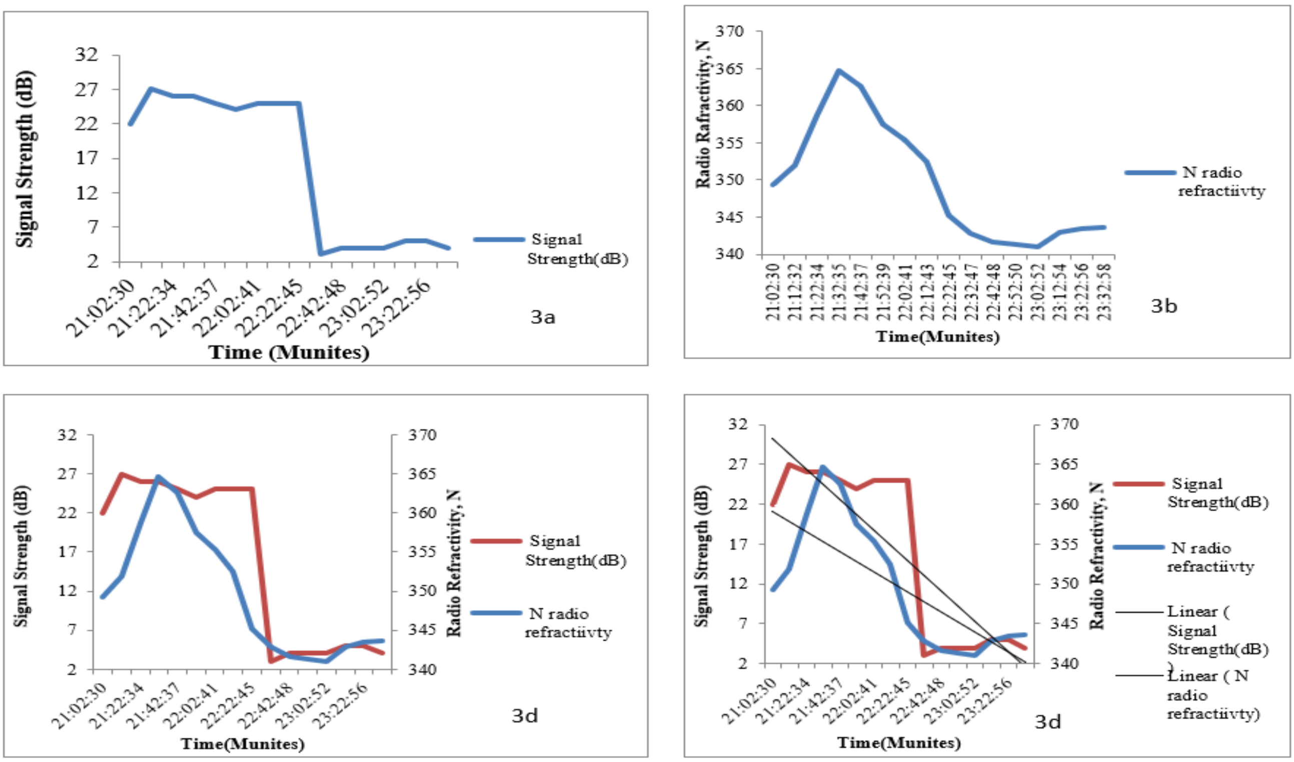


Fig 3(a, b, c & d): Time correlation of radio refractivity, N and frequency modulated signal strength curves for OSBC on 17/12/2021.
(a) Variation of FMRSS with time as it propagates in atmosphere from transmitter to the recipient.
(b)Variation of refractivity with time during FMRSS propagation in atmosphere from transmitter to the recipient.
(c) Comparison curves of both FMRSS and refractivity of the broadcasting station for specified period.
(d) Shows the variation trend lines of FMRSS and refractivity during the propagation.

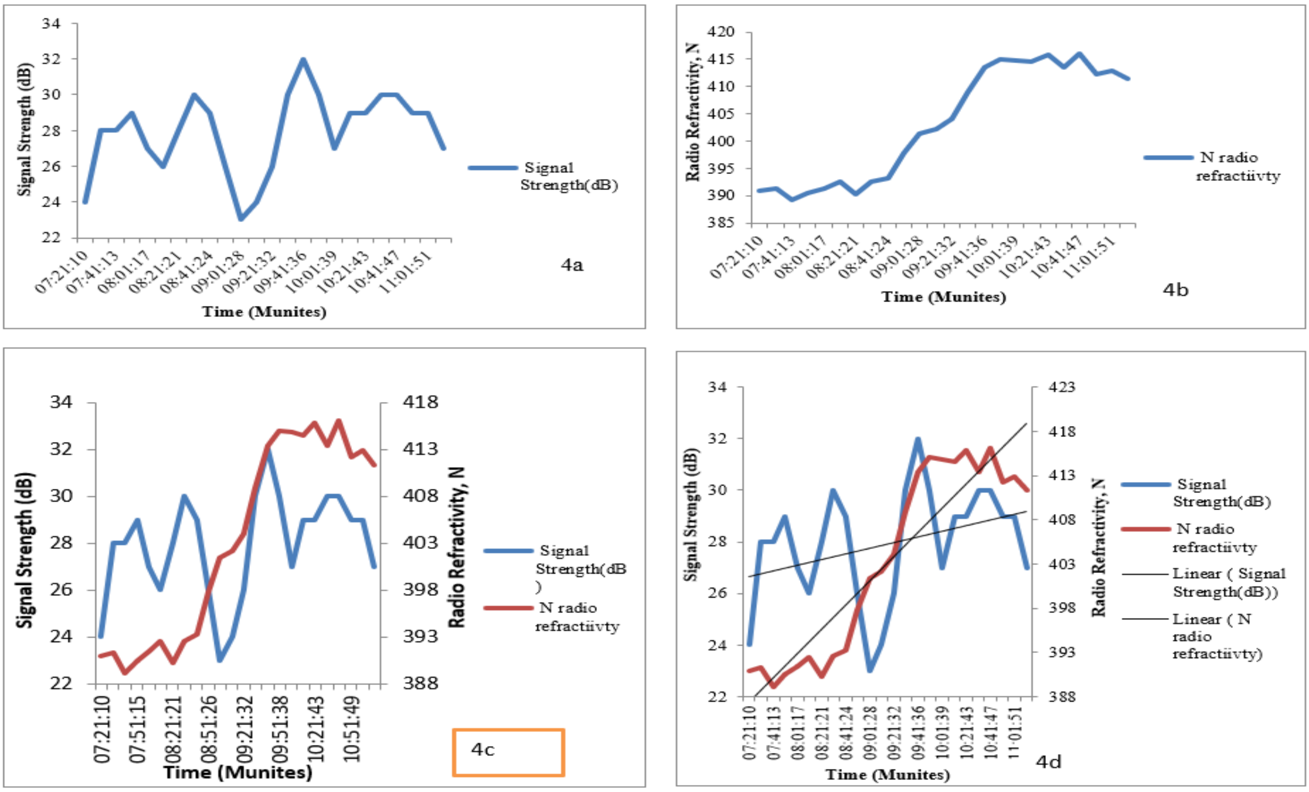


Fig 4: Time correlation of radio refractivity, N and frequency modulated signal strength curves for OSBC on 31/12/2021.
(a) Variation of FMRSS with time as it propagates in atmosphere from transmitter to the recipient.
(b) Variation of refractivity with time during FMRSS propagation in atmosphere from transmitter to the recipient.
(c) Comparison curves of both FMRSS and refractivity of the broadcasting station for specified period.
(d) Shows the variation trend lines of FMRSS and refractivity during the propagation.

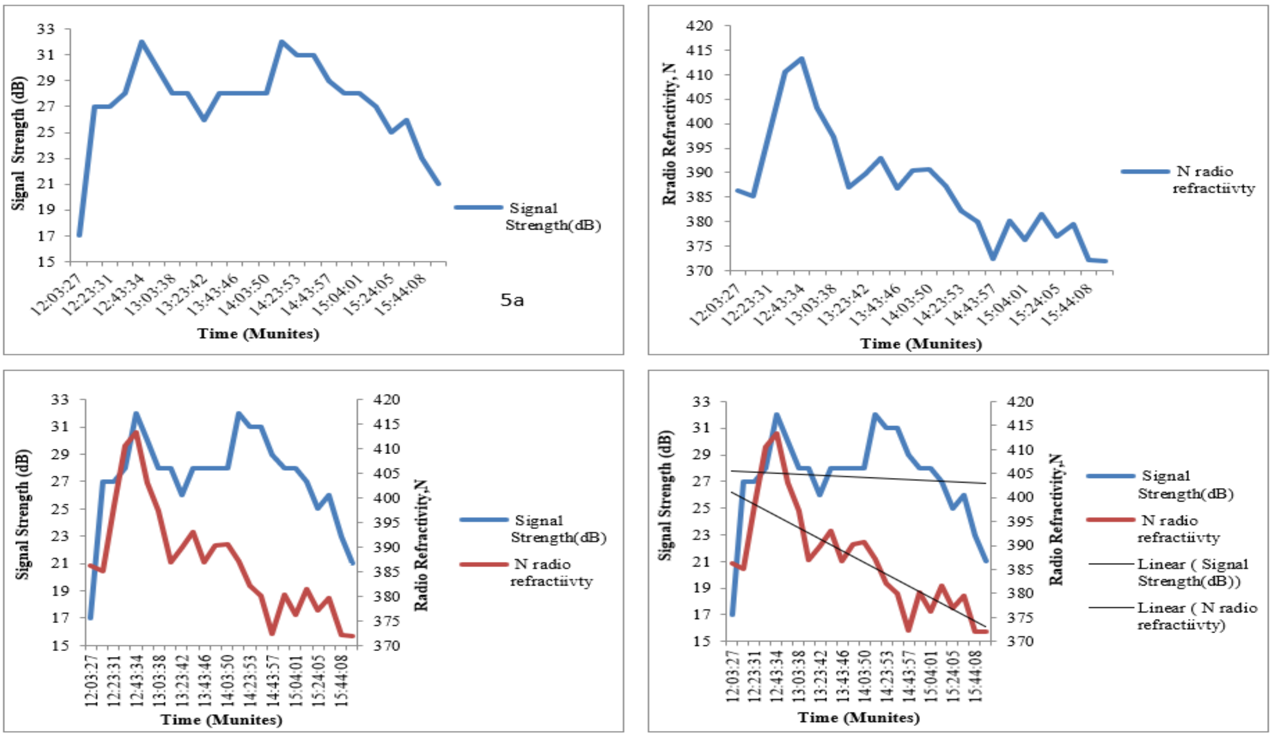


Fig 5: Time correlation of radio refractivity, N and frequency modulated signal strength curves for OSBC on 01/01/2022.
(a) Variation of FMRSS with time as it propagates in atmosphere from transmitter to the recipient.
(b) Variation of refractivity with time during FMRSS propagation in atmosphere from transmitter to the recipient.
(c) Comparison curves of both FMRSS and refractivity of the broadcasting station for specified period.
(d) Shows the variation trend lines of FMRSS and refractivity during the propagation.

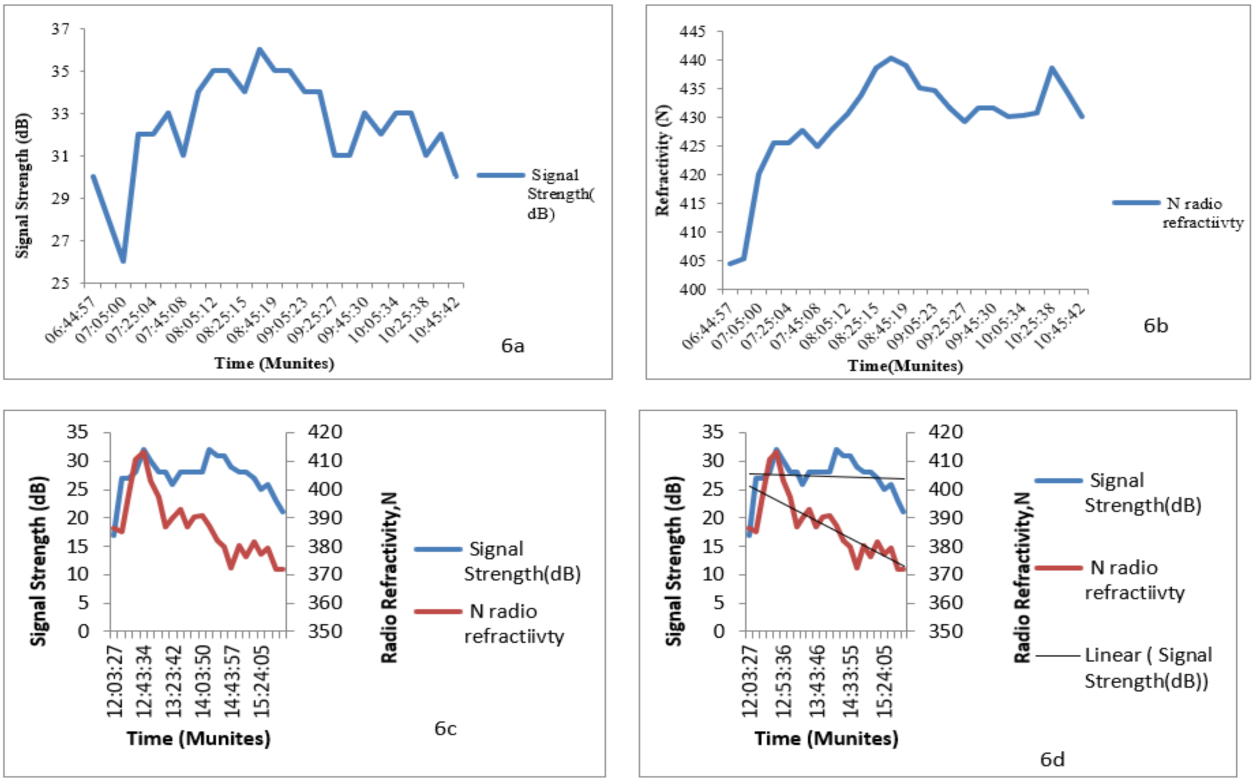
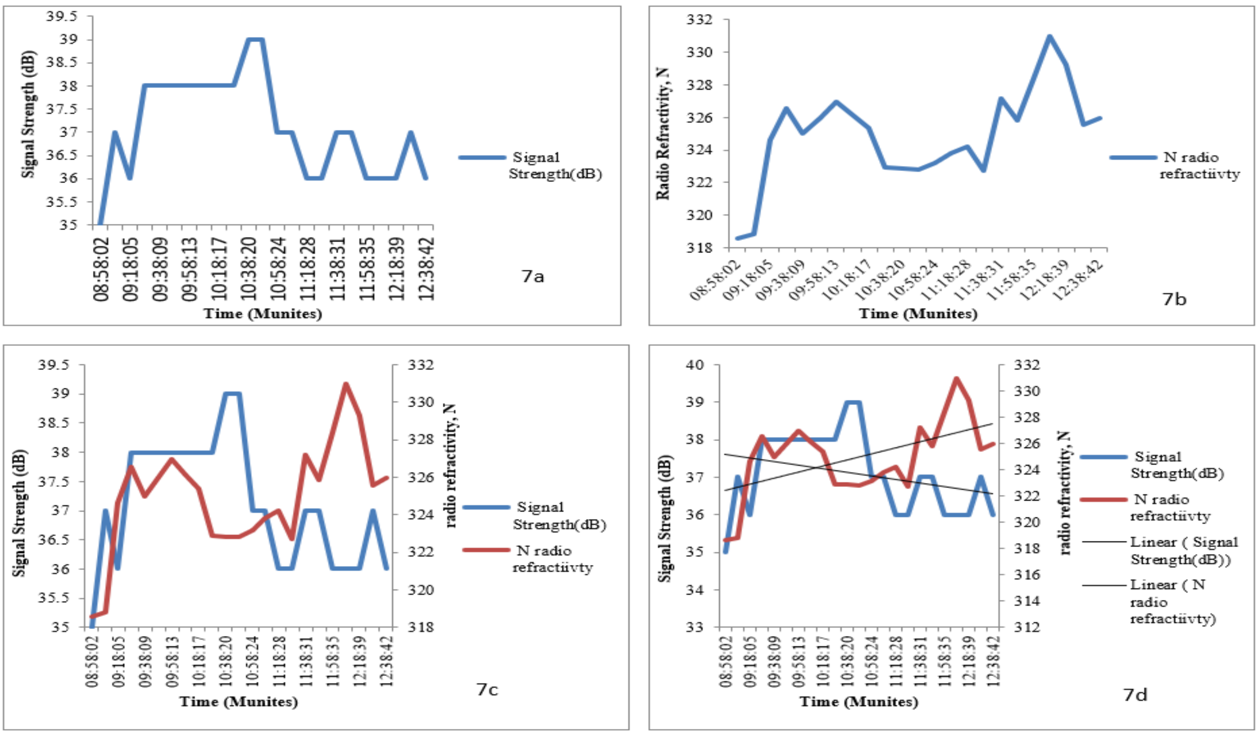


Fig 6: Time correlation of radio refractivity, N and frequency modulated signal strength curves for OSBC on 02/01/2022.
(a) Variation of FMRSS with time as it propagates in atmosphere from transmitter to the recipient.
(b) Variation of refractivity with time during FMRSS propagation in atmosphere from transmitter to the recipient.
(c) Comparison curves of both FMRSS refractivity of the broadcasting station for specified period.
(d) Shows the variation trend lines of FMRSS and refractivity during the propagation.



Figures 7: Time correlation of radio refractivity, N and frequency modulated signal strength curves for OSBC on 04/01 /2022.
(a) Variation of FMRSS with time as it propagates in atmosphere from transmitter to the recipient.
(b) Variation of refractivity with time during FMRSS propagation in atmosphere from transmitter to the recipient.
(c) Comparison curves of both FMRSS and refractivity of the broadcasting station for specified period.
(d) Shows the variation trend lines of FMRSS and refractivity during the propagation.

III. DISCUSSION

Critical overview of the above curves reflects the same result that frequency modulated radio signal strength varied inversely to radio refractivity. That is, at a rising point of radio refractivity, frequency modulated radio signal strength is observed falling. Though mostly the two may have the same variation trend-lines direction, it is clearly featured in nearly all the above figures that a fall in radio refractivity increases the strength of OSBC frequency modulated radio signal at any point of reception during broadcasting operation. The only exception of figure 3 presents a case where the organization observed a stoppage in operation with the signal strength dropped to the lowest level irrespective the corresponding level of the radio refractivity.

IV. CONCLUSION AND RECOMMENDATION

The above analyses maintain the algorithm of radio refractivity, N as a function of other climatological parameters that determine the rate of change in the velocity of frequency modulated radio signal moving from one layer to another in the atmosphere reference time. The system algorithm for N is shown below.

$$N = (n-1) \times 10^{6} \quad (1)$$

$$N = N_{dry} + N_{wet} = \frac{77.6}{T}\left(P + 4810\frac{e}{T}\right) \quad (2)$$

$$H = \frac{100e}{e_{s(t)}} \quad (3)$$

$$e_{s(t)} = ae^{\frac{bt}{(t+c)}} \quad (4)$$

$$N_{dry} = 77.6\frac{P}{T} \quad (5)$$

$$N_{wet} = 3.732 \times 10^{5}\frac{e}{T^2} \quad (6)$$

where n is the refractive index of air, N (N-units) is atmospheric refractivity, e (hPa) stands for water vapour pressure and e_s (hPa) is saturation vapour pressure, T is air temperature (K) , t is dew point temperature in ^oC and H is relative humidity.

Therefore, a good reception of frequency modulated radio signal strength (FMRSS) is always achievable when all climatological parameters are at the normal states of favorable weather condition of moderate pressure, relative humidity and a fairly high temperature where radio refractivity will be at a low level for an improved frequency modulated radio signal strength in broadcasting operation.

This has recommended a reasonable determination of frequency modulated radio broadcasting station site location with stronger transmitting equipment (transmitter and antenna) and appropriate antenna height positioning, that will favor low radio refractivity and strong frequency modulated radio signal strength.

REFERENCES

[1]. Ale Felix, Agboola A. Olufemi, Halidu D. Ibrahim, Abdullahi Ayegba, Jegede John Olu, Wysenyuy Desmond Fonyuy, Ademu Victor (2017): “Investigation Of The Influence Of Atmospheric Temperature And Relative Humidity On FM Radio Signal Strength: A Case Study Of We FM Abuja”, International Journal Of Scientific & Technology Research, Vol. 6 (11), pp 70-74

[2]. Ale Felix, Abdullahi Ayegba, Yakubu John (2018): “Assessing the Effects of Temperature and Relative Humidity on the Signal Strength of We FM Abuja, Nigeria During Harmattan Period”, International Journal of Trend in Scientific Research and Development, Vol. 2(3), pp1318-1322.

[3]. Amajama, J., (2015). “Association between Atmospheric radio wave refractivity and UHF Radio signal”. American International Journal of Research in Formal, Applied and Natural Sciences, Vol. 13, No. 1, pp. 61 – 65.

[4]. Michael, A. O., (2013). “Further Investigation into VHF Radio Wave Propagation Loss over Long Forest Channel”. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. Vol. 2 No. 1, pp. 705 – 710.

[5]. Amajama, J., (2016). “Impact of Atmospheric Temperature on (UHF) Radio Signal”. International Journal of Engineering Research and General Science. Vol. 4, No. 2, pp. 619-622

[6]. Joseph, A., & Oku, D. E. Wind versus UHF Radio signal. International Journal of Science, Engineering and Technology Research, 5(2), 583-855.

[7]. Michael O. A., (2013). “Investigation of the Effect of Ground and Air Temperature on Very High Frequency Radio Signals”. Journal of Information Engineering and Applications. Vol.3, No.9, pp. 16-22

[8]. Prasad, M. V. S. N., Rama R. T., Iqbal A., and Paul, K. M., (2006). ‘‘Investigation of VHF signals in bands I and II in southern India and model comparisons’’, Indian Journal of Radio and Space Physics, Vol. 35, pp.198 – 205.

[9]. Roshidah M, Marhamah M. S., Sabri A., Roslan U., Yew B. S., Nor H. S. (2016). “Temperature Effect on The Tropospheric Radio Signal Strength for UHF Band at Terengganu, Malaysia”. International Journal on advanced science engineering information technology. Vol. 6. No. 5, pp. 774

[10]. Isaakidis, A.S and Xenos, D. (2004). “Ten years analysis of tropospheric refractivity variations”. Annals of Geophysics Vol 47, pp 1-6.

[11]. Lear, M.W. (1980). “Computing atmospheric scale height for refraction corrections” (NASA) mission planning and analysis division Lyndon B Johnson space center.

[12]. Otasowie, P.O. (2008). "A study and analysis of microwave link degradation due to Atmospheric conditions" (A case study of Akure-Owo digital microwave link) Ph.D. Thesis submitted to the University of Benin, Benin City, Nigeria.

[13]. Otasowie, P.O. and Edeko, F.O. (2009). "An investigation of microwave link degradation due to Atmospheric conditions" (A case study of Akure-Owo digital microwave link) Advances in Materials and System Technologies Vol. 62-64 pp 159-165.

[14]. Webster, A. R (1987). "Angle-of-arrival and tropospheric multipath propagation", IEEE Transactions on Antenna and Propagation, Vol. 35, No. 1, pp. 94-99.

[15]. Manning, T. (1999). "Microwave Radio Transmission Guide" British library cataloguing in the publication data. pp 89-115.

[16]. Hall, M.P.M. (1979). "Effects of the Troposphere on Radio Communications" Peter Peregrines Ltd. Stevenge UK. pp 178-190.

[17]. Bashir, S.O. (1989). "Three years statistics of Refractive Index Gradient and Effective Radius factor for the state