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Prognostication of Radio Refractivity in Transmission Link: Diurnal and Seasonal Variation of Surface Refractivity Over Jos-Plateau State

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Abstract: *This work, investigates the diurnal and seasonal variation of surface refractivity over Jos-plateau state using meteorological parameters on the tropospheric radio refractivity during dry and wet seasons for Jos. Ten months in-situ meteorological data obtained from National meteorological agency (NMA) Heipang measurement at a station located at Jos south (8^0 54^1 O^{11} E, 9^0 55^1 O^{11} N) in Nigeria from August 2012-May 2013. The data used for the computation of radio refractivity is a five minutes interval of the variations of metrological parameters for each day in the troposphere for Jos. Thirty (30) minutes averages of radio refractivity during dry and wet seasons were calculated from the data obtained. The result indicated that the 30 minutes averages of radio refractivity during wet season are greater than the result in dry season. This is as a result of variation in meteorological parameters such as relative humidity and temperature which causes the radio refractivity to vary at different time of the day. The variation pattern in Jos is observed because of the altitude (1000m above sea level). At this altitude the pressure variation seems to be insignificant.*

The result shows that the surface refractivity generally have higher values during wet season than dry season. The results also show that the diurnal refractivity variation is basically a function of local meteorological parameters (pressure relative humidity, temperature).

Keywords: *Transmission link, Radio Refractivity, Diurnal and Seasonal Variation.*

1. INTRODUCTION

Radio is the wireless transmission of signals through free space by an electromagnetic radiation of a frequency significantly below that of visible light in the radio frequency range from about 3 kHz to 300GHZ. These waves are called radio waves (Puri, 2004).

The propagation of radio wave signal in the troposphere is affected by many processes which include the variation of meteorological parameters such as temperature, pressure and humidity. These are associated with the changing in weather in different season of the year and the variations in the meteorological parameters have resulted in refractivity changes.

According to Grabuer and kvicera (2008), multi path effects also occur as a result of large scale variation in atmospheric radio refractive index such as different horizontal layer having different refractivity the effects occur most when the same radio wave signals follow different paths thereby having different time of arrival to its target point.

The effect would result to interference of the radio wave signals with each other during the consequence of this large scale variation in the atmospheric refractive index is that the radio wave propagating through the atmosphere become progressively curved towards the earth the range of the radio waves is determine by the height dependence of the refractivity, thus the refractivity will not vary as the height changes but also affect radio signal.

2. RADIO REFRACTIVITY THEORY

Propagation of Radio waves in the VHF, UHF and SHF bands are affected by meteorological conditions in the troposphere. The refractive index n of air depends on the atmospheric pressure P (in Mb), the temperature T (ink), and the water vapour pressure, e (in mb) of the atmosphere

(Hall, 1979). The radio refractivity N and the refractive modulus M for air, for frequencies up to $100GH_8$, are given by the ITU- R formula (ITU- R 1987).

$$N = 77.6P/T + 3.73 \times 10^5 e/T^2 \quad (N - Units) \tag{1}$$

$$M = (n - 1) \times 10^6 + u/R \times 10^6 \ (N - units) \tag{2}$$

Where P is the atmospheric pressure, e is the water vapour pressure which can be calculated from the relative humidity and the saturation vapour pressure e_s, using the relationship described in Rec. ITU – R.P (2004) and T is the absolute temperature. Also, h (km) is the height of atmospheric layer above the earth surface and R (km) is the height of atmospheric layer above the earth's surface and R (km) is the radius of the earth for VHF and UHF bands at standard conditions, the atmospheric property which is basic to radio ray tracing is the radio refractive index n. However, when evaluating refraction effects from the common meteorological variables, the refractivity N is normally used (Barday, 2003). In terms of the refractive index n, equation (1) can be expressed as;

$$n = N \times 10^6 + 1 \tag{3}$$

For an ideal condition of the atmosphere, the atmosphere is uniformly stratified and the vertical gradient of the refractive index is assumed constant and defined by:

$$k = \frac{1}{1+Rdn/dh} = \frac{1}{1+RdN10^6/dh} = \frac{10^{-6}}{Rdm/dh} \tag{4}$$

Where; k is the effective earth-radius factor. The water vapour pressure e can be calculated from the relative humidity H and the saturation vapour pressure e_s given by

$$e = \frac{He_S}{100} \text{ (hpa- unit)} \tag{5}$$

With;

$$e_s = a \exp\left(\frac{bt}{t+c}\right) \text{ (hpa - unit)} \tag{6}$$

Where, H: relative humidity ($^o/_o$)

t: Celsius temperature (^oC)

e_s: Saturation vapour pressure (hpa) at the temperature t (^oC) and the coefficients a, b, c are: for water

a = 6.1121, b = 17.502, c = 240.97

(Valid between – 20^o and + 50^o with an accuracy of ± 20%)

3. MATERIAL AND METHODS

The device used for the measurement is the Davis 6162 wireless vantage Pro 2, manufactured by Davison instruments. The device is equipped with the integrated sensor suite (ISS), a solar panel (with alternative battery power source) and wireless console, which provides the user interface data display and analogue-to-digital conversion. The device uses the combination of an aspiration to minimize the effects of solar radiation induced temperature error. The ISS houses the external sensor array for measurement of pressure, temperature, relative humidity, UV index, solar radiation, rainfall rate among others. The console is connected to a computer through the data-logger from which the stored data are retrieved the frequency of the ISS varies between 868.1 and 868.6mHz while the error margin of the ISS device for temperature, pressure and relative humidity are ±0.1^{o}C, 0.5hpa and 2% respectively.

3.1. Method of Data Collection

Ten month data (August 2012-May 2013) employed for the study were radio meteorological data obtained from Hie-pang meteorological agencies a station in Jos with measurement (18^o 54^oE, 9^o 55^o 0^oN) in Nigeria which is the weather station employed for data collection and the instrument for the measurement is the Davis 6_16_2 wireless vantage Pro 2 equipped with the integrated sensor suit (ISS), a solar panel (with an alternative battery source) and the wireless console. The ISS is positioned at the ground level for continuous measurement of the surface weather parameters

which are atmospheric pressure, temperature and relative humidity. The data is then transmitted by wireless radio to the data logger attached to the console/receiver located on the ground from which the data are then copied to the computer; the instrument has an integration time of 30 minutes.

Mean values were then obtained by averaging the 30minutes recorded data. Consequently, the daily and monthly mean values were respectively obtained. The data obtained were used to calculate the refractivity value for both the dry and wet seasons from this range of propagation path, using radio refractivity equation to give data point representing diurnal variation for each of the twelve months. Each day is further averaged to give a data point for each month and the seasonal variation for each of the twelve months. Following Agunlejika O., Raji T.I., (2010), description, Nigeria being a tropical region has two seasons- the Wet and the dry. The wet season is characterized by heavy rainfall. It falls between the months of April and October and the international telecommunication union Recommendation (ITU- R) representative months for these seasons are the month of May and August. The dry season, on the other hand, is characterized with scanty or no rainfall and dry dust laden atmosphere. The season lies between the month of November and March. The ITU –R representative months for the dry seasons are November and February.

4. RESULTS AND DISCUSSION

The tables below shows the data collected from the month of October 2011to September 2012 from Hie-pang meteorological agencies station in Jos, Plateau state, Nigeria.

Table1. *Measurement at Ground Surface over the Month of August, 2012*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	20.04	91.5	885	20341.71965
00.30AM	19.81	93	885	20665.26585
01:00AM	19.55	93.6	885	20814.065
01.30AM	19.1	94.3	885	20980.64116
02.00AM	19.27	94.6	885	21076.29058
02:30AM	19.23	94.2	884	21037.46863
03:00AM	19	94.7	884	21172.65609
03:30AM	18.43	94.8	884	21239.11346
04:00AM	18.36	94.8	884	21290.12922
04:30AM	18.35	95	884	21378.18555
05:00AM	18.17	94.9	884	21411.02157
05:30AM	18.09	95.7	884	21614.24821
06:00AM	17.85	95.1	884	21541.38695
06:30AM	18.05	95.4	884	21639.55721
07:00AM	18.15	95.5	884	21707.86145
07:30AM	18.2	95.5	884	21732.41837
08:00AM	18.54	93.6	884	21395.45457
08:30AM	19.08	89.8	884	20674.42877
09:00AM	18.96	90.6	884	20856.11395
09:30AM	19.18	90.7	884	20893.96256
10:00AM	19.08	91.2	884	20992.68389
10:30AM	20.25	83.8	884	19537.30291
11:00AM	20.08	84.5	884	19681.2888
11:30AM	20.81	81.2	884	18990.57917
12:00PM	21.07	80.7	884	18859.17842
12:30PM	22.11	75.26	884	17757.33329
01:00PM	21.27	78.87	884	18426.60572
01:30PM	21.62	76.51	884	17902.40912
02:00PM	20.48	85.9	884	19695.2296
02:30PM	20.55	83.7	884	19212.60298
03:00PM	19.36	88.7	884	20153.23519
03:30PM	19.34	90.8	884	20533.76373
04:00PM	20.36	83.5	884	19110.92842
04:30PM	20.62	80.1	884	18435.77554

05:00PM	20.22	83.6	884	19099.33265
05:30PM	19.76	84.5	884	19273.81343
06:00PM	19.3	86.3	883	19622.77499
06:30PM	19.15	86.5	883	19661.5485
07:00PM	18.91	86.6	883	19712.79575
07:30PM	18.78	87.9	883	19997.68594
08:00PM	18.56	87.4	883	19933.08547
08:30PM	18.17	87.7	883	20033.3053
09:00PM	18.02	88.9	883	20301.03605
09:30PM	18.07	89.8	883	20534.01302
10:00PM	18.23	89.6	883	20538.58786
10:30PM	18.13	89.7	883	20616.67632
11:00PM	17.97	88.1	883	20342.76039
11:30PM	18.18	88.7	884	20496.5061

Table2. *Measurement at Ground Surface over the Month of September, 2012*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	19.15	92	887	20649.86141
00.30AM	19.26	92.4	887	20765.40424
01:00AM	19.03	92.9	887	20906.53054
01.30AM	19.21	93.7	886	21109.18391
02.00AM	19.4	93	886	21012.97829
02:30AM	19.39	93.4	886	21125.31771
03:00AM	19.41	92.5	886	20990.24734
03:30AM	19.4	92.8	886	21089.61707
04:00AM	19.42	93.1	886	21165.93784
04:30AM	19.13	94.7	886	21521.10428
05:00AM	19.11	95.1	886	21617.72784
05:30AM	19.13	95.2	886	21655.64045
06:00AM	19.2	94.7	886	21600.25909
06:30AM	19.18	95.2	886	21717.16364
07:00AM	18.85	95	887	21705.96007
07:30AM	16.78	96.3	887	22000.04471
08:00AM	16.23	96.9	888	22166.67977
08:30AM	16.62	97	888	22270.94069
09:00AM	16.96	97	889	22380.46297
09:30AM	17.57	96.6	889	22402.05125
10:00AM	17.93	96.3	889	22410.56163
10:30AM	18.54	92.3	889	21668.06567
11:00AM	19.24	89.8	888	21181.32339
11:30AM	20.62	85.7	888	20355.45789
12:00PM	22.32	84.8	888	20180.52118
12:30PM	21.57	77.87	887	18739.28158
01:00PM	21.82	72.87	886	17685.84724
01:30PM	22.3	66.44	885	16341.0501
02:00PM	23.08	68.59	885	16734.78813
02:30PM	23.59	73	884	17542.06012
03:00PM	24.52	59.6	884	14848.81591
03:30PM	26.39	53.24	884	13552.14018
04:00PM	27.79	48.99	884	12670.75424
04:30PM	27.71	50.08	883	12855.35563
05:00PM	28.83	41.88	883	11206.49648
05:30PM	24.7	68.58	883	16404.29385
06:00PM	22.92	75.5	884	17729.95259
06:30PM	21.51	81.9	884	18956.72678
07:00PM	20.55	88	884	20138.69112
07:30PM	20.12	88.4	885	20220.21305
08:00PM	19.97	92.3	885	21017.77569
08:30PM	20.02	94.3	886	21406.74523

09:00PM	19.88	95	886	21585.97473
09:30PM	19.99	95.7	887	21763.30446
10:00PM	19.76	95.9	887	21845.88341
10:30PM	19.65	96	887	21903.03775
11:00PM	19.6	96.3	887	21974.754
11:30PM	19.63	96.2	887	21986.64503

Table3. *Measurement at Ground Surface over the Month of October, 2012*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	19.42	93.2	886	19903.38177
00.30AM	20.68	81.4	886	17768.38518
01:00AM	19.91	86.8	885	18811.54357
01.30AM	19.49	90.2	885	19498.3994
02.00AM	19.26	93	885	20081.70445
02:30AM	19.07	94.5	885	20407.19745
03:00AM	19.21	94.7	885	20495.15576
03:30AM	19.54	94.9	885	20588.75765
04:00AM	19.64	93.7	885	20405.29206
04:30AM	19.36	94.8	885	20665.40728
05:00AM	18.96	95.2	885	20794.76313
05:30AM	18.63	96.3	885	21043.00378
06:00AM	18.15	96.6	885	21155.75283
06:30AM	17.88	96.6	885	21202.08932
07:00AM	18.38	96.7	886	21281.78221
07:30AM	19.9	92.9	886	20602.51301
08:00AM	22.27	81.1	886	18392.04909
08:30AM	23.81	72.58	887	16779.11332
09:00AM	24.9	66.75	887	15676.78161
09:30AM	24.82	67.76	887	15862.43351
10:00AM	26.18	63.86	887	15062.06482
10:30AM	28.05	52.78	887	12869.45216
11:00AM	28.6	51.61	886	12558.69264
11:30AM	28.4	53.45	886	12814.06146
12:00PM	28.15	51.26	886	12305.31585
12:30PM	28.59	46	885	11236.8778
01:00PM	23.85	62.02	885	14135.32743
01:30PM	20.89	70.99	885	15719.10313
02:00PM	20.87	71.76	885	15808.43335
02:30PM	20.66	71.36	885	15721.93712
03:00PM	21.85	71.63	884	15775.08262
03:30PM	23.89	64.46	884	14481.28133
04:00PM	24.54	61.31	884	13901.4186
04:30PM	26.37	55.43	883	12827.11983
05:00PM	23.6	65.2	884	14642.21381
05:30PM	22.41	73.92	884	16253.04464
06:00PM	21.35	80.6	884	17502.74438
06:30PM	20.1	86.3	884	18581.43566
07:00PM	19.53	89.9	884	19290.61088
07:30PM	19.19	92.7	885	19849.34819
08:00PM	18.8	92.7	885	19908.43
08:30PM	18.8	93.3	886	20083.54428
09:00PM	17.93	94.6	886	20388.24726
09:30PM	18.08	95.6	886	20643.88665
10:00PM	18.42	95.2	886	20629.43654
10:30PM	18.57	95.2	886	20691.0625
11:00PM	18.84	94.3	887	20586.86567
11:30PM	19.11	93.3	887	20451.06526

Table 4. *Measurement at Ground Surface over the Month of November, 2012*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	18.33	47.3	886	11901.64823
00.30AM	18.3	49.76	886	12423.55993
01:00AM	17.24	53.1	886	13123.15581
01.30AM	16.89	54.6	885	13457.81738
02.00AM	17.01	47.07	885	12055.16705
02:30AM	17.37	53.13	885	13286.0762
03:00AM	16.04	58.81	885	14451.86611
03:30AM	15.59	59.43	885	14628.52691
04:00AM	15.34	58.57	885	14519.69281
04:30AM	15.12	58.02	885	14467.677
05:00AM	14.94	60.21	885	14964.21675
05:30AM	15.2	55.8	885	14141.24911
06:00AM	15.33	51.01	885	13237.36315
06:30AM	16.93	41.87	885	11459.38483
07:00AM	16.94	46.46	886	12436.16242
07:30AM	19.27	42.9	886	11758.57166
08:00AM	23.07	29.58	886	9107.280145
08:30AM	23.73	26.4	887	8478.51159
09:00AM	24.96	25.33	887	8267.36498
09:30AM	24.69	24.64	887	8121.478331
10:00AM	26.39	24.33	887	8029.843224
10:30AM	26.98	23.2	887	7762.561795
11:00AM	28.27	20.43	887	7148.545974
11:30AM	27.96	20.94	886	7179.622157
12:00PM	28.2	20.77	886	7071.152506
12:30PM	28.53	20.87	885	7010.761109
01:00PM	29.3	20.08	885	6779.50155
01:30PM	27.51	21.31	885	6939.724405
02:00PM	28.27	21.49	885	6903.238814
02:30PM	29.16	19.88	884	6540.548452
03:00PM	30.09	19.71	884	6466.714334
03:30PM	29.91	19.06	884	6305.850466
04:00PM	29.44	19.06	884	6266.687662
04:30PM	28.82	20.29	884	6468.069075
05:00PM	27.17	22.21	884	6805.847916
05:30PM	26.09	24.26	884	7183.40942
06:00PM	24.5	27.58	884	7798.75656
06:30PM	22.92	31	885	8450.35428
07:00PM	21.25	36.48	885	9491.347037
07:30PM	19.94	42.29	885	10608.08121
08:00PM	19.25	43.7	886	10917.52693
08:30PM	18.41	44.08	886	11035.4982
09:00PM	17.89	46.34	886	11515.7624
09:30PM	17.55	46.62	887	11625.402
10:00PM	17.79	45.88	887	11542.48618
10:30PM	17.47	44.2	887	11273.98245
11:00PM	19.63	34.07	887	9383.236589
11:30PM	19.45	36.36	886	9866.925189

Table 5. *Measurement at Ground Surface over the Month of December, 2012*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	17.43	24.62	886	7832.269228
00.30AM	17.21	24.9	886	7929.179788
01:00AM	16.82	25.04	886	7996.854153
01.30AM	16.46	26.07	886	8243.082268
02.00AM	15.96	26.27	885	8319.156742

02:30AM	15.93	25.86	885	8279.847479
03:00AM	15.59	27.27	885	8608.399077
03:30AM	15.47	27.37	885	8671.319347
04:00AM	15.53	27.47	885	8732.021652
04:30AM	15.46	26.86	885	8648.326855
05:00AM	15.51	27.37	885	8794.296404
05:30AM	14.95	26.79	885	8717.039006
06:00AM	14.49	28.19	885	9049.477917
06:30AM	14.33	27.99	885	9052.363179
07:00AM	14.11	28.16	886	9133.074777
07:30AM	14.74	27.82	886	9104.154751
08:00AM	16.86	23.61	886	8264.020211
08:30AM	18.39	23.67	887	8306.847492
09:00AM	19.08	22.61	887	8105.881977
09:30AM	20.25	18.97	887	7347.519127
10:00AM	21.48	18.8	887	7296.483864
10:30AM	21.81	17.81	887	7060.899741
11:00AM	22.74	17.19	887	6882.329245
11:30AM	24.41	15.41	887	6443.641814
12:00PM	24.32	15.72	886	6427.878216
12:30PM	24.63	16.23	886	6448.216009
01:00PM	25.74	15.51	886	6214.666549
01:30PM	25.69	15.13	885	6047.868431
02:00PM	25.97	15.65	885	6065.327516
02:30PM	26.38	14.55	884	5770.80989
03:00PM	26.79	14.59	884	5711.036021
03:30PM	26.72	15.03	884	5739.712767
04:00PM	26.03	16.91	883	6046.445564
04:30PM	26.05	16.02	883	5838.145191
05:00PM	23.99	17.97	884	6189.769085
05:30PM	22.82	20.19	884	6597.350547
06:00PM	21.94	20.27	884	6610.570373
06:30PM	20.97	21.78	885	6911.69586
07:00PM	20.66	22.84	885	7139.577093
07:30PM	19.6	24.62	885	7506.3072
08:00PM	19.56	24.79	886	7572.914635
08:30PM	18.6	25.95	886	7829.373945
09:00PM	18.4	26.98	886	8067.767275
09:30PM	18.32	26.57	887	8035.650436
10:00PM	17.68	28.11	886	8371.175079
10:30PM	17.26	28.87	886	8563.605705
11:00PM	17.22	28.84	886	8603.422202
11:30PM	16.41	30.48	886	8969.971826

Table 6. *Measurement at Ground Surface over the Month of January, 2013*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	18.3	19.29	883	6695.464193
00.30AM	17.66	19.9	883	6852.923972
01:00AM	17.93	20.14	883	6936.939562
01.30AM	17.54	20.35	883	7013.724799
02.00AM	17.54	20.35	883	7500.317186
02:30AM	15.2	25.69	883	8156.957455
03:00AM	15.08	23.81	882	7813.264275

03:30AM	15.69	22.27	883	7545.26234
04:00AM	15.99	19.67	882	7062.096564
04:30AM	15.71	19.91	883	7150.487511
05:00AM	15.33	19.16	883	7032.038985
05:30AM	15.97	18.99	883	7031.536538
06:00AM	15.94	18.27	883	6918.339943
06:30AM	16.13	18.71	883	7043.669413
07:00AM	16.09	17.14	883	6754.089919
07:30AM	16.46	17.72	884	6913.053572
08:00AM	17.94	15.5	884	6474.742809
08:30AM	19.39	14.43	884	6279.617028
09:00AM	20.18	13.64	884	6124.303338
09:30AM	21.24	13.71	884	6144.037461
10:00AM	22.81	13.43	884	6082.791205
10:30AM	23.09	13.16	883	5997.729906
11:00AM	24.19	12.95	883	5905.492715
11:30AM	25.76	12.61	883	5778.88717
12:00PM	27.16	13.12	883	5812.821877
12:30PM	27.76	11.61	882	5422.953074
01:00PM	28.85	11.68	882	5355.861561
01:30PM	29.12	12.47	882	5428.190354
02:00PM	29.55	12.02	881	5253.920804
02:30PM	30.05	11.54	881	5086.36541
03:00PM	30.51	12.02	881	5110.661375
03:30PM	31.23	11.61	881	4970.575907
04:00PM	31.05	12.53	881	5095.336387
04:30PM	30.06	12.36	881	5024.527714
05:00PM	28.8	13.8	881	5266.203062
05:30PM	27.55	14.41	882	5364.373334
06:00PM	25.95	16.36	882	5721.293407
06:30PM	22.85	21.77	882	6739.694306
07:00PM	20.68	25.77	882	7501.258821
07:30PM	20.46	26.36	883	7640.764772
08:00PM	19.69	27.15	883	7824.130478
08:30PM	19.71	26.95	883	7822.620989
09:00PM	20.24	25.2	883	7532.622948
09:30PM	19.67	24.86	883	7510.90828
10:00PM	19.34	25.41	883	7657.281614
10:30PM	18.96	25.31	883	7683.178488
11:00PM	18.07	29.92	883	8614.477752
11:30PM	17.58	29.65	883	8613.53527

Table7. *Measurement at Ground Surface over the Month of February, 2013*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	15.01	26.27	888	7887.889698
00.30AM	14.73	26.27	887	7922.281007
01:00AM	14.73	25.32	887	7786.557739
01.30AM	14.71	24.67	886	7690.808912
02.00AM	14.7	24.32	886	7668.537199
02:30AM	14.57	24.77	886	7793.370329
03:00AM	14.39	25.35	886	7939.947252
03:30AM	14.13	26.1	886	8123.944196
04:00AM	14	26.31	886	8200.134383
04:30AM	13.67	26.51	886	8275.178222

05:00AM	13.46	27.68	886	8541.393744
05:30AM	13.09	28.43	886	8714.017062
06:00AM	12.8	29.32	886	8927.586518
06:30AM	12.4	30.41	887	9189.684725
07:00AM	12.06	31.17	887	9380.832455
07:30AM	12.32	31.14	887	9400.699893
08:00AM	12.96	30.59	887	9328.494179
08:30AM	14.66	28.33	888	8911.473578
09:00AM	15.15	28.26	888	8919.576078
09:30AM	15.94	27.26	888	8724.99987
10:00AM	16.93	24.07	888	8064.695203
10:30AM	17.28	22.97	888	7808.825131
11:00AM	17.76	22.09	888	7593.957267
11:30AM	19.6	19.31	888	6972.434365
12:00PM	20.03	18.18	887	6676.795997
12:30PM	20.52	16.1	887	6190.89157
01:00PM	21.29	15.28	887	5951.633915
01:30PM	22	14.45	886	5711.378615
02:00PM	21.97	14.59	885	5662.014221
02:30PM	22.46	13.7	885	5422.074021
03:00PM	21.94	13.63	885	5349.50303
03:30PM	21.9	12.92	885	5163.754474
04:00PM	21.98	13.09	885	5155.019232
04:30PM	21.42	14.08	885	5308.884044
05:00PM	20.81	13.91	885	5252.745322
05:30PM	19.4	15.65	885	5564.936862
06:00PM	18.62	16.44	885	5709.890751
06:30PM	17.89	17.33	885	5883.080311
07:00PM	17.57	17.92	885	6015.874208
07:30PM	17.16	18.43	886	6134.281545
08:00PM	17.08	18.78	886	6230.988825
08:30PM	16.84	19.56	886	6409.566186
09:00PM	16.74	19.43	886	6420.127152
09:30PM	16.37	20.04	887	6574.489997
10:00PM	16.06	20.38	887	6678.095321
10:30PM	15.82	20.52	887	6744.951583
11:00PM	15.19	22.13	887	7084.281833
11:30PM	14.72	22.96	887	7285.140364

Table8. *Measurement at Ground Surface over the Month of March, 2013*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	21.87	56.82	884	12286.75464
00.30AM	21.75	60.58	884	12984.09185
01:00AM	21.61	62.09	883	13291.58756
01.30AM	21.11	64.34	883	13725.03548
02.00AM	20.99	64.89	883	13862.01043
02:30AM	20.61	65.33	882	13976.06478
03:00AM	20.04	67.73	882	14442.76357
03:30AM	20.18	68.31	882	14590.25111
04:00AM	20.38	67.42	882	14469.48422
04:30AM	20.11	68.62	882	14720.60342
05:00AM	20.02	68.83	882	14795.76844
05:30AM	20.13	69.27	882	14913.20431
06:00AM	20.11	69.24	882	14947.12037
06:30AM	19.78	70.64	882	15239.91773
07:00AM	20.19	69.38	883	15053.59491

07:30AM	22.56	63.59	883	14048.61023
08:00AM	26	51.32	883	11843.01519
08:30AM	26.93	49.01	884	11440.39773
09:00AM	27.66	45.14	884	10739.54791
09:30AM	27.97	40.04	884	9802.646552
10:00AM	28.68	30.68	884	8089.067755
10:30AM	30.85	23.57	884	6777.899727
11:00AM	31.36	23.77	884	6786.364695
11:30AM	32.43	20.04	884	6075.158963
12:00PM	32.44	21.03	883	6201.907307
12:30PM	32.97	18.54	883	5702.887419
01:00PM	33.77	13.59	882	4767.92425
01:30PM	33.84	12.67	882	4552.929042
02:00PM	35.08	10.58	881	4134.424561
02:30PM	34.47	9.73	881	3943.108737
03:00PM	34.62	9.66	881	3891.173406
03:30PM	34.79	9.51	880	3828.642352
04:00PM	34.25	9.39	880	3779.877214
04:30PM	34.17	9.32	880	3745.267988
05:00PM	33.47	9.4	880	3743.115592
05:30PM	31.98	10.38	880	3903.701661
06:00PM	30.6	10.21	881	3875.31166
06:30PM	29.74	10.76	881	3973.090612
07:00PM	27.95	10.79	881	3988.985458
07:30PM	28.65	10.04	881	3871.191167
08:00PM	28.21	9.63	882	3822.330185
08:30PM	26.13	11.79	882	4215.396571
09:00PM	24.23	14.39	882	4687.323035
09:30PM	24.74	24.78	883	6517.505893
10:00PM	23.84	48.53	883	10683.05824
10:30PM	22.97	53.59	883	11598.9205
11:00PM	22.81	61.12	883	12949.50611
11:30PM	22.13	66.22	883	13880.79909

Table9. *Measurement at Ground Surface over the Month of April, 2013*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	20.31	89.9	885	19039.1282
00.30AM	20.29	88	884	18739.67902
01:00AM	20.97	82.4	885	17747.16225
01.30AM	20.95	80.4	884	17422.69317
02.00AM	20.87	81.4	884	17034.17162
02:30AM	20.87	81.4	884	17687.19611
03:00AM	21	78.21	883	17149.06736
03:30AM	20.96	76.43	883	16859.17693
04:00AM	20.98	73.08	883	16276.32414
04:30AM	20.94	75.68	883	16797.4652
05:00AM	20.54	77.29	884	17142.90949
05:30AM	21.04	78.9	884	17483.24962
06:00AM	20.85	81.6	884	18025.67668
06:30AM	20.53	86.1	884	18904.26265
07:00AM	22.7	57.3	884	13506.64303
07:30AM	22.32	72.5	884	16387.73777
08:00AM	22.11	76.7	885	17201.75313

08:30AM	23.61	68.35	885	15639.50237
09:00AM	26.2	45.73	885	11374.28044
09:30AM	28.6	41.24	886	10517.2678
10:00AM	29.54	38.64	886	9996.675352
10:30AM	30.1	36.13	886	9469.318901
11:00AM	30.53	36.88	885	9526.129913
11:30AM	31.11	37.22	885	9502.852679
12:00PM	30.99	33.01	885	8636.41173
12:30PM	31.05	33.12	885	8567.809148
01:00PM	31.33	32.5	884	8367.237846
01:30PM	31.87	30.22	884	7877.901728
02:00PM	32.41	29.29	883	7638.859361
02:30PM	31.48	28.47	883	7433.174328
03:00PM	31.41	30.28	883	7711.551892
03:30PM	30.15	29.23	883	7501.238091
04:00PM	31.07	28.64	882	7382.43919
04:30PM	29.85	31.41	882	7870.910242
05:00PM	30.03	30.6	882	7732.16925
05:30PM	28.65	47.85	882	10786.9456
06:00PM	26.11	59.29	882	12831.68581
06:30PM	25.52	61.97	883	13338.60201
07:00PM	24.63	65.7	883	14033.52145
07:30PM	24.43	66.9	883	14286.51396
08:00PM	24.11	68	884	14526.35405
08:30PM	24.23	67.11	884	14417.20916
09:00PM	24.04	68.34	885	14686.2005
09:30PM	24.01	69.16	885	14883.7387
10:00PM	23.97	68.08	886	14731.17244
10:30PM	23.74	68.49	886	14852.4579
11:00PM	22.94	72.73	886	15665.10703
11:30PM	22.7	74.06	885	15952.32427

Table10. *Measurement at Ground Surface over the Month of May, 2013*

Local Time	T (^{0}C)	H (%)	P (Mb)	N (N- Unit)
00:00AM	20.73	92.8	887	20158.49276
00.30AM	20.7	92.2	887	20077.87261
01:00AM	20.84	92.4	887	20147.87354
01.30AM	20.9	90.7	886	19856.92213
02.00AM	21.12	88.3	886	19422.56688
02:30AM	21.52	84.4	886	18717.57188
03:00AM	21.37	85.4	886	18933.60471
03:30AM	20.76	88.5	886	19552.91437
04:00AM	20.49	90.4	886	19941.72271
04:30AM	20.34	91.4	886	20170.4914
05:00AM	20.1	91.8	886	20276.16644
05:30AM	19.6	93.5	886	20630.03893
06:00AM	19.7	93	886	20570.284
06:30AM	20.14	91.5	886	20324.49059
07:00AM	20.92	86.5	886	19402.71801
07:30AM	23.18	77.42	887	17698.8046
08:00AM	23.49	73.62	887	16987.55334
08:30AM	24.54	66.84	887	15685.79354
09:00AM	25.21	67.89	887	15866.56846
09:30AM	26.19	63.58	887	15004.54573
10:00AM	27.55	57.67	887	13811.89976
10:30AM	27.02	63.12	887	14768.41072
11:00AM	26.01	68.34	887	15655.13814
11:30AM	27.99	59.67	887	13931.45371

12:00PM	28.62	58.77	887	13662.63225
12:30PM	28.18	56.55	886	13125.48768
01:00PM	28.7	55.05	886	12730.35238
01:30PM	29.61	51.52	886	11992.24811
02:00PM	29.95	48.89	885	11421.46758
02:30PM	30.14	37.56	885	9287.485255
03:00PM	27.82	47.59	884	11028.58373
03:30PM	29.18	41.79	884	9936.481533
04:00PM	27.09	46.71	884	10786.61222
04:30PM	26.97	48.09	884	11019.60193
05:00PM	26.39	53.89	883	12050.84332
05:30PM	25.35	60.94	884	13328.5796
06:00PM	24.72	63.99	884	13906.84501
06:30PM	24.72	63.99	884	15360.92355
07:00PM	24.72	63.99	884	14627.3658
07:30PM	22.1	67.62	884	15204.04062
08:00PM	22.29	70.56	885	16223.39018
08:30PM	21.65	75.93	885	16049.84212
09:00PM	21.61	74.68	886	16539.89139
09:30PM	21.67	77.1	886	16942.09647
10:00PM	21.04	79.02	887	17863.35013
10:30PM	20.66	83.8	886	18028.35772
11:00PM	20.59	84.4	886	18785.94821
11:30PM	20.25	88.2	886	18462.52126

The diurnal and seasonal variation of refractivity over Jos for ten months is shown in figure 3 to figure 4.10.

August

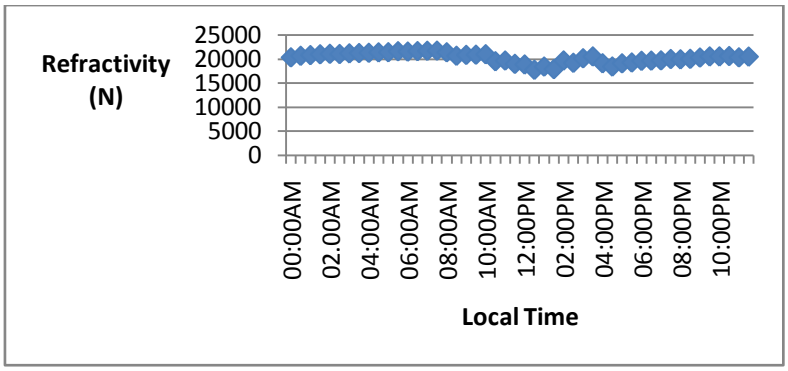

Fig3. *Diurnal Variation of surface Refractivity over the month of August 2012 for wet season*

The variation of refractivity over the month of August is shown in Fig 4.1, the refractivity start rising from 20,000 N-units around 12:00am to 22,000N-units around 7:30am, then sharply drops to 18,000N-Unit around 12:30pm and begins to rise to 21,000N-unit around 3:00pm and drops to 19000N-unit around 4:30pm. It then begins to rise back to 21,000N-unit and ranges between 20,000-21,000N-unit throughout the day. That is figure 4.1 which represent the raining season, radio refractivity is found to have the peak values during early hours of the day and late hours of the night corresponding to the time that the atmosphere is mostly dominated by moisture content of water vapor which eventually increases humidity in the atmosphere. At the late hours of the day, a decrease in radio refractivity was observed corresponding to the period when there is sun-shine.

September

The variation of refractivity over the month of September ranges between 20,000-21,000N-unit from around 12:00am-7:00am local time and then drops sharply to 10,000N-unit around 1:30pm local time and begins to rise steadily to 19,000N-unit to around 11:00pm local time, i.e. Radio refractivity ranges during the early hours of the day then drops sharply at noon time and rises steadily at late hours.

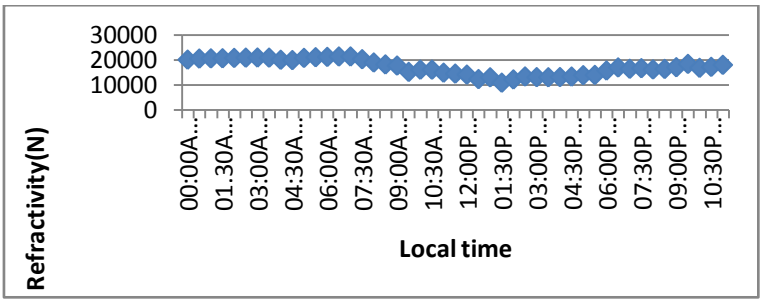

Fig4. *Diurnal Variation of surface refractivity over the month of September 2012 for wet season*

October

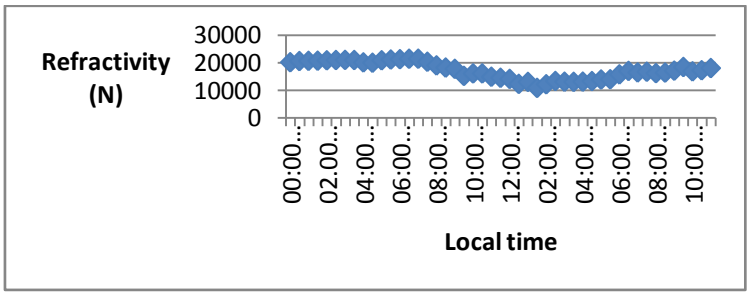

Fig5. *Diurnal Variation of surface refractivity over the month of October 2012 for dry season*

The variation of refractivity over the month of October shows that the value of refractivity rises from 20,000-22,000N-units around 12:00am to 7:30am local time then declines sharply to 11,000N-unit around 1:30pm local time then begins to rise steadily to 18000N-units for the rest of the day.

November

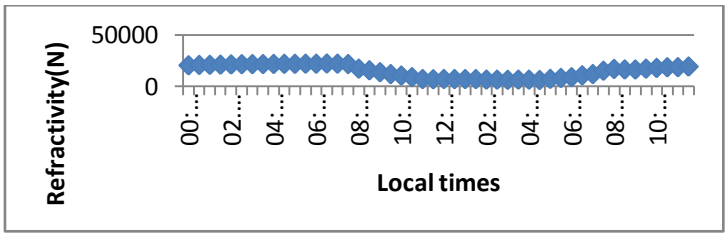

Fig6. *Diurnal Variation of surface refractivity over the month of November 2012 for dry season*

The variation of refractivity over the month of November shows that the refractivity value rises from 20,000-23,000N-units from around 12:00am to 6:30am local time then it declines sharply from 22,000N-unit around 7:30am local time to 6000N-unit around 4:30pm local time and starts rising back to 19,000N-unit for the rest of the day. The result shows that the refractivity over Jos for dry season is as a result of variation in the wet term of the refractivity. This can therefore be deduced that the refractivity values are dependent on the temperature and pressure.

December

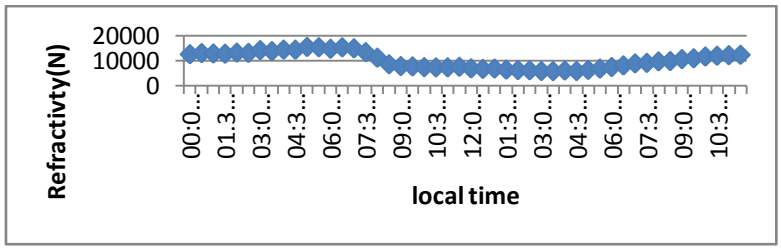

Fig7. *Diurnal Variation of surface refractivity over the month of December 2012 for dry season*

The variation of refractivity over the month of December show that the reactivity values rises from 12,500-15,5000N-units around 12:00am-6:30am local time, then start dropping from 15000N-unit-5,900N-unit around 7:30am-4:30pm local time and then rises back up to 12,100N-unit around 11:00pm local time.

January

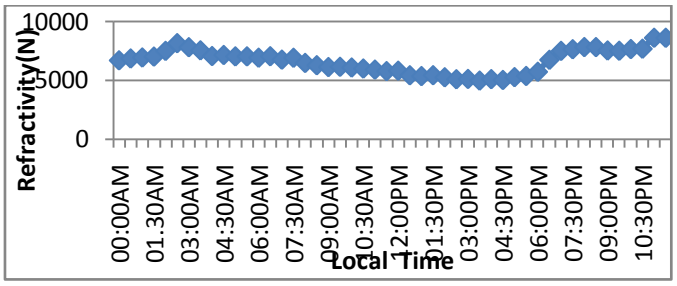

Fig8. *Diurnal Variation of surface refractivity over the month of January 2013 for dry season*

The variation of refractivity over the month of January shows that the value of refractivity start rising from 6800N-unit-8100N-unit around 12:00am-3:00am local time, then drops to 5000Nuint around 4:30pm local time and then rises back to 8800N-unit around 11:30pm local time.

February

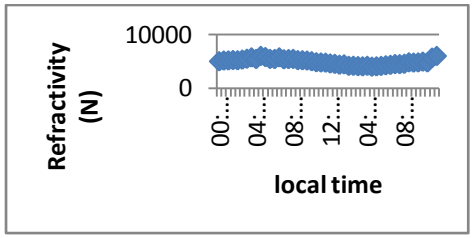

Fig9. *Diurnal Variation of surface refractivity over the month of February 2013 for dry season*

The variation of refractivity over the month of February shows that the value rises from 5000-6000N-units around 12:00am-4:30am local time, then a sharp decline is seen from 5800N-unit – 4000N-unit around 5:00am-4:30pm and rises back to 6000N-unit around 11:00pm local time.

March

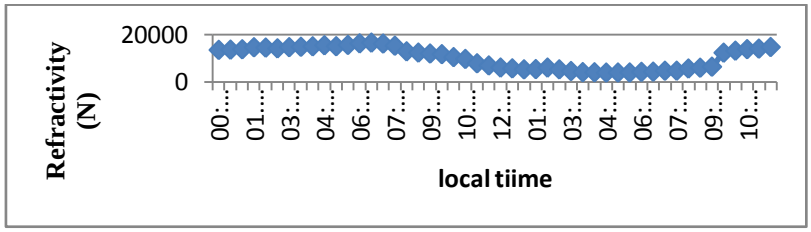

Fig10. *Diurnal Variation of surface refractivity over the month of March 2013 for dry season*

The variation of refractivity over the month of March shows that the value start rises from 13,200-16200N-unit around 12:00am-6:30am local time then a sharp drop is seen around 7:00am from 16000N-unit to 4000N-unit around 5:00pm and then a steady rise begins around 6:00pm – 11:30pm local time from 4200-14200N-unit.

April

The variation of refractivity over the month of April shows that the value start dropping from 19000-6000N-unit around 12:00am-4:00am local time, then rises back up to 19000N-unit around 6:30am and a sharp drop is seen from 19000-13800N-unit around 6:30am-7:00am local time, it then rises back up to 17600N-unit from 7:00am to 8:30am. It then drops from 15800-7600N-unit

around 8:30am to 4:00pm local time and begins to rise from 8000-16000N-unit around 4:30pm-11:00pm local time.

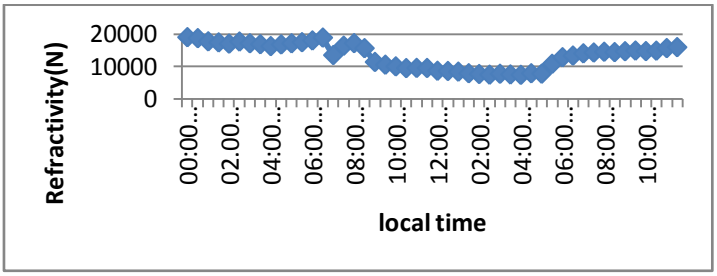

Fig11. *Diurnal Variation of surface refractivity over the month of April 2013 for wet season*

May

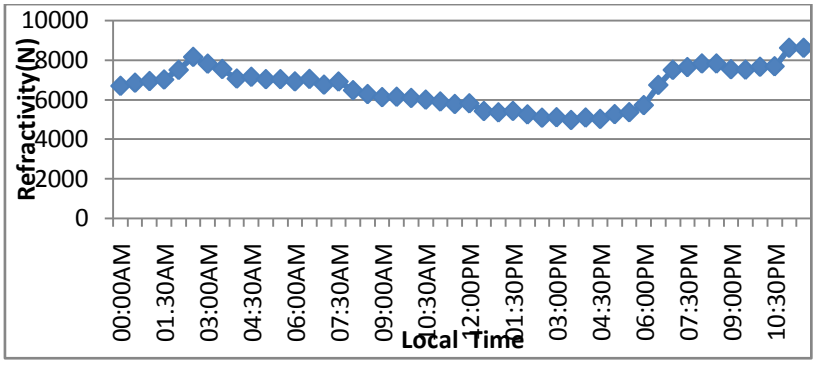

Fig12. *Diurnal Variation of surface refractivity over the month of May 2013 for wet season*

The variation of refractivity over the month of may shows that refractivity starts rising from 6800-8100N-unit around 12:00am-3:00am local time then a sharp drop from 7900-5000N-unit around 3:30am-4:30pm local time and rises back up from 5100-8800N-unit around 5:30pm-11:30pm local time.

5. CONCLUSION

The research work has shown that the effects of metrological parameters(relative humidity, pressure, temperature) on the tropospheric radio refractivity in Jos has being attributed to seasonal variations in weather in the troposphere. This variation was observed to be more significant during the rainy season than the dry season in Jos owing to the rise in tropospheric temperature and humidity and it is therefore resulted to very high radio refractivity.

1. The diurnal variation seems to be mainly driven by the dry component in the rainy season and the wet component in the dry season
2. The refractivity shows a seasonal variation with high value in the rainy season and low value in the dry season.
3. The surface variation of refractivity in Jos has day-night cycle period.
4. Dry season refractivity is highly variable unlike the wet season refractivity which has small variability.
5. The diurnal variation of refractivity is a function of local meteorology as observed from results obtained for Jos study area while the seasonal variation is not influenced by climate in Jos because the influence of local topography is pronounced.

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