A Vb.Net Class Library and a Client Application for Radio Refractivity

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ABSTRACT

A VB.NET class library has been developed for surface radio refractivity (N_s), reduced-to-sea-level refractivity (N_o) and modified refractivity (M). The class library contains thirty functions, seven properties and five powerful methods which are polymorphized with at least seven members each. Using our dynamic class library, an accurate, flexible and windows-based software package was developed and applied to study radio refractivity at four Meteorological stations in Nigeria. Calculated results were compared with other researchers' works and found to be in agreement. Results from our application show that N_o values range between 306-385 N-Units at Abuja site; 304-378 and 294-395 N-Units respectively at Enugu and Sokoto sites. AkureFUTA site has the highest N_s value while Sokoto has the least value. Other accurate results for all the sites were obtained for N_s and M. Software developers will find our class library useful in their works, and the scientific community will benefit tremendously from the use of our package.

General Terms

Class library, Radio refractivity, Client application

Keywords

Reduce to sea-level, Modified Refractivity, Surface Refractivity

1. INTRODUCTION

Nearly all who is concerned with the study and use of atmospheric parameters with regard to communication needs the knowledge of radio refractivity to character the atmosphere for terrestrial and earth-satellite communication purposes. A computer software package without a code component (server) is like a man without intestine. A programmer who comes up with a full-fledged computer software application without any class library (code component) is like an Agriculturist who grows maize without seed which, to say the least, a day dreamer, who should be told loud and clear to developed one for himself and others. Code component (CC) is the intestine and heart of all applications. It is the tool required to accomplish a well-conceived idea(s) toward progress and growth. No software application is better and stronger than its building blocks (servers) just as no edifice is better and greater than its foundation. What a package does is mainly a function of its server(s). There is yet no VB.NET class library and software package on radio refractivity, N that is window-based in Nigeria and most developing nations. We observed that researchers write codes, use them and throw them away having served the purpose for which they were intended. Other new investigators have to write theirs, "re-investing the wheel", using programmers' term of wasting time, energy and resources doing what someone had done previously [5,13]. This unhealthy and unacceptable attitude should be addressed with the provision of a flexible and accurate VB.NET code component which could be utilized by all and sundry to develop computer software application for the calculation of radio refractivity and its related parameters. Also, the provisions of an accurate server will whet the programming appetite of software developers to develop quality software application for surface refractivity N_s, reduced-to-sea-level refractivity N_o and modified refractivity M.

An attempt to produce a software package to compute surface refractivity and reduced to sea-level refractivity has been made [1]. This interactive package is not window-based and lacks editing and most common utilities known to modern software application. Besides, keying-in large data via the keyboard is boring, time-consuming and irritating. Attractive and robust software, RefractSoft 2.0, will be developed to address these shortcomings. This paper thus focuses on the development of a flexible and accurate class library component (DLL server) and a client application for N_s, N_o and M using Microsoft Visual Studio 2008.

2. RADIO REFRACTIVITY MODELS

The surface radio refractivity, N_s is sensitive to changes in temperature, t (^{o}C) and water vapour pressure, e; however, it is relatively insensitive to variations in pressure, p [7-8], and its relationship to these parameters is given by [12].

$$N_s = \frac{77.6P}{T} + \frac{(3.73x10^5).e}{T^2} \tag{1}$$

The dry term (first term in equation 1) is an index for the thermal seasonal changes and is fairly constant, accounting for about 265 N-units of the total refractivity [9-10]. The wet term (second expression in equation 1) depends on water vapour pressure, e and temperature, T (K). Vapour pressure, e is related to relative humidity, Rh(%) by

$$e = \frac{Rh.e_s}{100} \tag{2}$$

The value of the saturation vapour pressure, e_s could be obtained using this expression [2, 4, 6-9].

$$e_s = \frac{5854}{T^5}.10^{(20-2950/T)} \tag{3}$$

Radio refractivity, N varies with height, h (km), and its variation with height is given by

$$N(h) = N_s \exp\left(-h/H\right) \tag{4}$$

Using the average N_s value of 315 N-units for the ITUR model atmosphere and the scale height, H value of 7.353 km, eqn. (4) becomes [6-7]

$$N(h) = 315\exp(-0.136h) \quad (5)$$

To remove the dependence of surface refractivity on site altitude, thereby providing more accurate description of the refractive variations than the non-reduced form [8-11], the concept of reduced to sea-level refractivity, N_o has been introduced, which is given by

$$N_o = N_s \exp\left(h/H\right) \quad (6)$$

Where H is the scale height which has a numerical value of 7.0 km in the tropics [6-8]. N_s is the surface refractivity and could be evaluated using eqn. (1). The modified refractivity, M, which relates the site altitude, h and the radius of the earth, a to surface refractivity is given by

$$M = N_s + \frac{h}{a}.10^6 = N_s + 157h \quad (7)$$

Using VB.NET, a high-level Computer Language, codes were written for all the equations above, except equations (2) and (3), which had been treated elsewhere [2]. What was done to these equations was to modify the algorithm in line with Microsoft DataGridView control which was used as input-output for them.

3. CLASS LIBRARY COMPONENT

The reusable strength and reliability of code components (CCs) are frequently tapped by software developers during client application development. A well-designed CC is capable of reducing code length at the client application side. Consequently, it reduces errors and saves time and energy required to develop application for use. Class library is a dynamic link library which shares the same address location with the application(s) using its functionalities, hence very fast. Our CC, dvRadioRefractCls has five powerful overloaded methods. The dvComputeDryTerm method is for computing dry term part of refractivity and has seven overload types.

The dvComputeWetTerm method is employed to evaluate wet term component of N_s and has eight overloads. dvCalReducedSeaLevelRefract and dvComputeModifiedRefract methods compute N_o and M and both methods are overloaded. dvComputeNoM method is for computing N_s, N_o, M and their related parameters. It has to be separated for ease of maintainability. By overloading the methods we have few method names to recall with varying argument data types. There are thirty functions in dvRadioRefractCls class and seven properties. These functions are inaccessible in the client application being declared as private.

4. DATA

Three basic inputs are needed in order to calculate N_s: temperature, t, pressure, p and relative humidity, Rh. Besides, t, p and water vapour pressure e could be accepted as inputs for computation. In addition to these, site elevation is required to be able to evaluate N_o and M. There are two ways to glean data from the users. Data could be keyed-in through the keyboard or uploaded from user's supplied file. But the interactive keying-in of data is time-consuming and boring when large data are involved. Thus, data upload from external file supplied by the user is the solution. Both ways are provided for in our client package, RefractSoft 2.0.

The Meteorological data used for this work are procured from the sites shown in Table 1 together with their coordinates (Coord.), data periods, altitudes(Altd.) in metres and site location in Nigeria. The AkureFUTA data are hourly t, p and e from Adeyemi's work (1992). Accepting input data in various formats, so as to provide flexibility to the user of our package is a task that was given adequate attention as you will see later.

Table 1: Station Name and their Properties

Site Name	Coord.	Periods	Altd.	Location
Abuja FCT	9.15N, 7.00E	1991-2000	343.1	North-Central
AkureFUTA	7.20N, 5.20E	1991-1992	480.0	South-West
Enugu	6.28N, 7.33E	1990-1999	141.0	South-East
Sokoto	13.01N, 5.15E	1990-1999	350.8	North-West

5. MENUS

Menus are standard fixture of a window which enables a large number of related items to be organized logically for easy access and use. Menus are the most popular windows user interface component which is implemented through the Main Menu control [5, 13]. There are seven main menus in figure 1 which only two of them will be shown upon loading; some will be shown when data is accepted and the rest after computation. When the first input is accepted, Save, Print, ShowData and Compute main menus are shown. The Tasks menu has six submenus as seen in figure 1. The Dry Term and Wet Term menus permit the two components of surface refractivity, N_s to be computed using different input formats. To compute both components together, Dry-Wet Term menu could be employed. The Dry Term submenus have four submenus which are based on the different input data and formats; and the seven for Wet Term submenu is seen in figure 1 to its right. The first two submenus return a single value for data t and e, and t, p and RH respectively. The captions of the submenu are informative. What are to be used for calculation are shown and the method by which the input will be accepted. Both Dry_Wet and N_s submenus have eight submenus each. Also, N_o and M submenus possess three submenus each, which in turn has six submenus as could be seen in figure 2.

By clicking Show Data menu the keyed-in data will be shown in a Microsoft DataGridView (DGV) control as you can see in figure 3 and Hide Data menu will be displayed, which when clicked, hides the input data from sight. When Compute menu is clicked, result will be computed as the appropriate method is called to do that. The steps described here apply to other submenus, but with varying user interfaces (UI) to glean different inputs. The UI in figure 3 is for collecting inputs for t, p, e, site altitude and scale height when the third submenu of reduce to sea-level refractivity, N_o submenu is clicked; and anywhere these inputs are required. Our UI design is simple to understand and flexible to use.

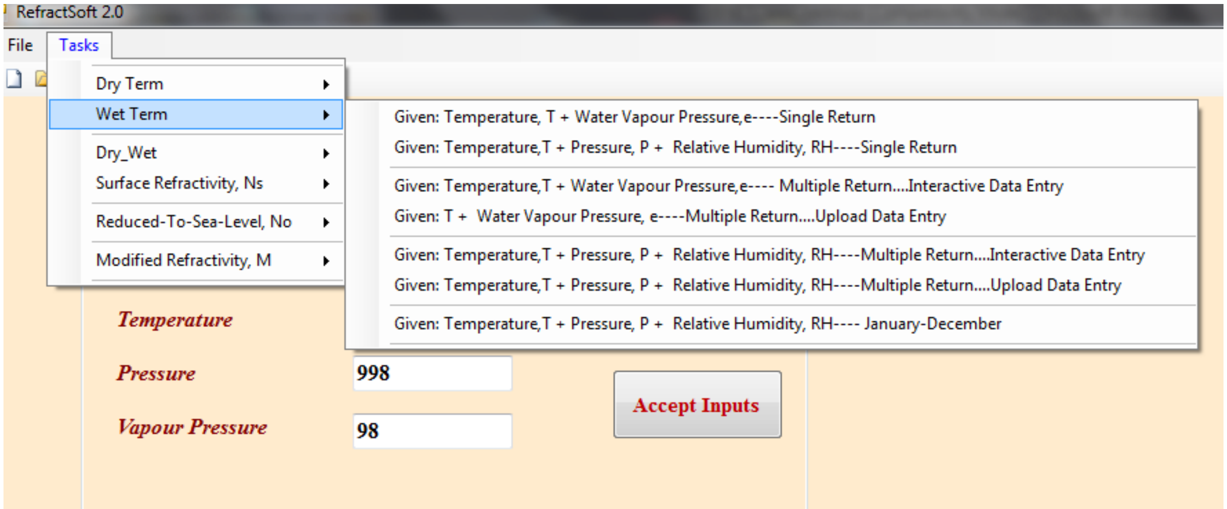

Figure 1: User Interface for dvRefractSoft 2.0, showing Wet Term submenus

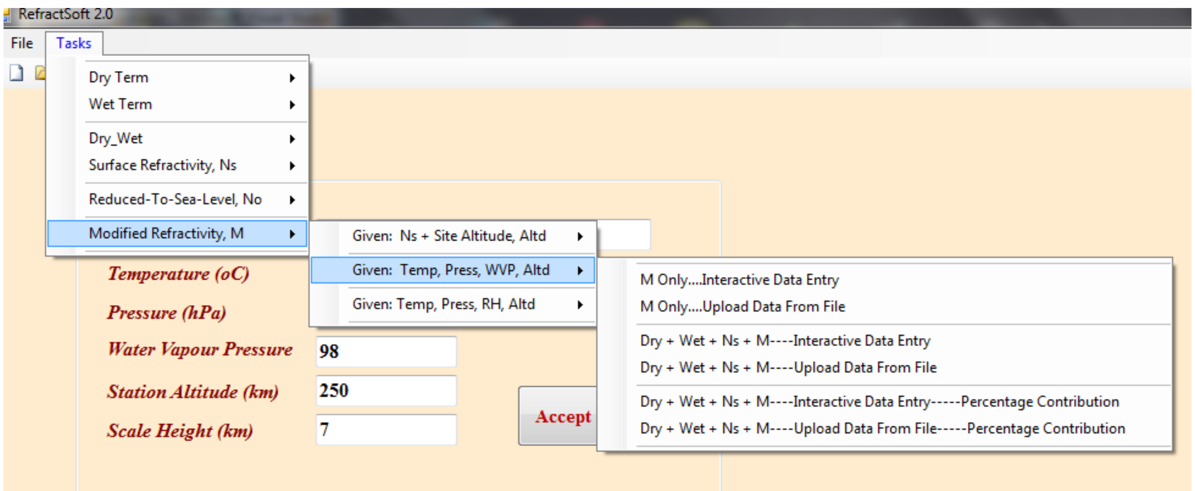

Figure 2: Typical User Interface for Modified Refractivity

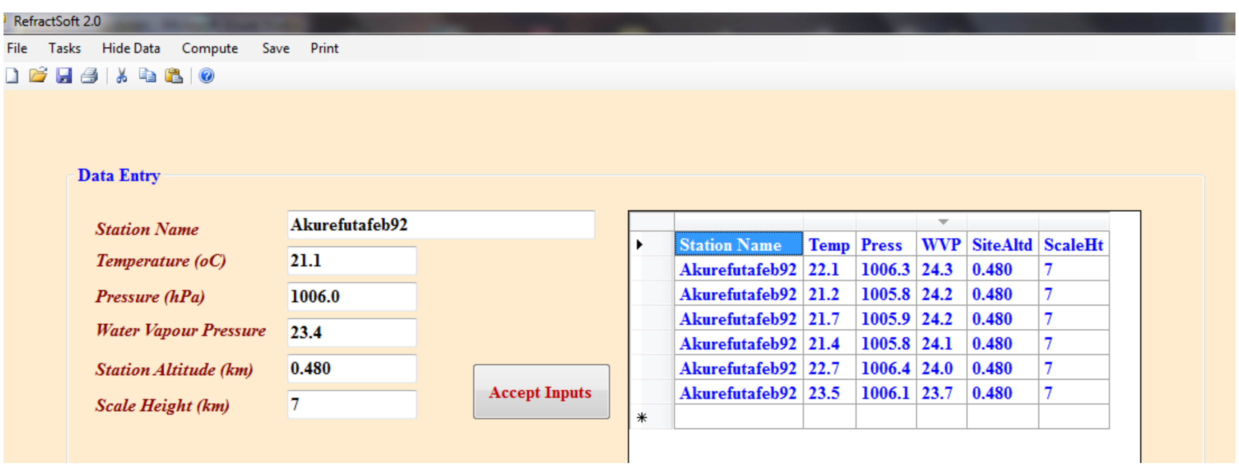

Figure 3: User Interface for Data Entry for t, p, e, altitude and scale height

6. NUMERICAL COMPUTATIONS

Single and multiple result(s) could be generated for all the parameters computed. When Upload Data menu is clicked, the open dialog box is opened for user to supply their input file. The file will be opened and the content uploaded into a DGV control for use. Upon successful uploading of data, user is informed to click Compute menu. Whichever option is selected, the appropriate method will be summoned to compute it right inside the server and the output result will be shown together with the inputs. Several and adequate error checks are provided for in our package and server to prevent unacceptable character and/or number from being accepted; thus application crash is prevented.

In addition, all the results generated are compared with other researchers' and with those obtained from Microsoft Office Excel application to verify the accuracy of our server and client application. Although hundred thousand inputs could be accepted, validated and processed, results to be displayed will be drastically reduced so that many of them could be shown for accuracy of both the server and client application to be ascertained.

6.1 Surface refractivity

Table 2 is the result for Dry Term submenu for Enugu site, January-December, 1990 as column 1 shows. The first three columns are the inputs and the order is expected that way for correct result to be gotten; the last column is the dry term result. Similar result for wet term was computed but lack of space won't permit its display.

Table 2: Dry Term Result for Enugu Site

EnuguJanDec90	Temp	Press	DryTerm
Jan	22.7	1010.0	265.052
Feb	22.2	1010.7	265.685
Mar	24.2	1010.2	263.767
Apr	24.2	1009.0	263.454
May	23.7	1011.2	264.473
Jun	22.5	1013.3	266.098
Jul	22.5	1013.7	266.203
Aug	22.8	1014.2	266.065
Sep	22.6	1013.3	266.008
Oct	22.7	1012.2	265.630
Nov	23.6	1011.0	264.510
Dec	23.1	1010.3	264.773

Table 3 gives comprehensive results for Abuja site (1991-2000). The Meteorological style of data entry (year-----Month: Jan to Dec) was accepted and the result computed for each month for all the given years. NR stands for NO Result and will be inserted in the result DGV control if any of the input data is zero, as could be seen for 1993, 1994 and 2000.

Table 3: Abuja site dry term result

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1991	269.76	266.35	265.04	265.38	266.59	267.43	268.29	267.78	267.72	268.45	270.4	272
1992	271.94	269.44	265.59	265.66	266.87	267.72	267.91	268.46	268.32	268.1	270.29	272.39
1993	271.98	268.93	266.51	264.75	NR	267.14	267.74	267.77	267.98	267.32	267.1	NR
1994	269.3	267.89	NR	264.48	NR	NR	NR	NR	NR	NR	NR	NR
1995	271.63	268.6	264.57	263.55	265.42	266.56	267.14	268.05	267.8	267.21	269.95	271.16
1996	270.48	265.87	264.2	264.1	265.97	267.44	268.23	267.78	267.77	268.22	270.96	271.52
1997	270.03	269.82	264.27	265.42	265.96	266.78	267.05	267.4	267.25	267.04	268.15	270.67
1998	270.88	267.16	264.52	262.59	266.28	266.69	266.83	266.53	266.7	268.96	269.21	270.05
1999	269.09	266.1	263.41	264.84	265.61	266.14	266.99	267.02	267.1	266.88	268	271.08
2000	269.01	268.61	264.86	NR	264.92	267.01	266.81	267.14	267.07	266.85	268.25	NR

Similar compact and comprehensive result was computed for Wet Term. Dry and wet terms could be computed together via dry-wet submenu (see Table 4 for Enugu result). Also, both terms with their percentage contributions could be calculated as Table 5 depicts for t, p and e inputs for AkureFUTA site, January 15, 1992. Data supply flexibility is built into our package for all the parameters computed. The first four columns in Table 4 are the inputs; the dry and wet terms are in columns 5 and 6. The percentage contributions of dry and wet terms occupy the last two columns of Table 5. Besides showing dry and wet terms together, the sum (N_s) could also be shown as could be seen in Table 6. Table 7 gives the percentage contributions, in addition to what is seen in Table 6. DryC is dry term contribution; WetC is wet term contribution and PercentageC is percentage contribution. It should be noted that result similar to dry term in Table 3 could be obtained for N_s but space will not permit its display.

Table 4: Dry-Wet term result for Enugu site, 1990

Enugu	T	P	RH	DryTerm	WetTerm
Jan	22.7	1010.0	66	265.052	76.987
Feb	22.2	1010.7	50	265.685	56.767
Mar	24.2	1010.2	53	263.767	67.007
Apr	24.2	1009.0	73	263.454	92.293
May	23.7	1011.2	78	264.473	96.013
Jun	22.5	1013.3	81	266.098	93.468
Jul	22.5	1013.7	86	266.203	99.238
Aug	22.8	1014.2	83	266.065	97.341
Sep	22.6	1013.3	84	266.008	97.456
Oct	22.7	1012.2	81	265.630	94.484
Nov	23.6	1011.0	76	264.510	93.051

Dec	23.1	1010.3	75	264.773	89.393

Table 5: Typical Akure site result with the PercentageC

T	P	e	DryTerm	WetTerm	DryC	WetC
21.2	1007.2	20.3	265.665	87.482	75.23	24.77
19.8	1007.4	19.9	266.989	86.580	75.51	24.49
19.4	1007.2	19.4	267.301	84.636	75.95	24.05
18.9	1006.9	19.2	267.679	84.051	76.10	23.90
18.6	1006.7	18.7	267.901	82.031	76.56	23.44
18.4	1006.7	18.1	268.085	79.508	77.13	22.87
18.1	1007.0	18.0	268.441	79.231	77.21	22.79
17.8	1007.4	17.5	268.825	77.189	77.69	22.31
17.5	1007.9	17.3	269.236	76.465	77.88	22.12
18.8	1008.1	18.4	268.090	80.604	76.88	23.12
24.6	1006.6	17.1	262.474	72.018	78.47	21.53
28.3	1006.1	16.5	259.122	67.795	79.26	20.74

Table 6: Typical result for N_s at Akure site

T	P	e	DryTerm	WetTerm	Ns
21.2	1007.2	20.3	265.665	87.482	353.147
19.8	1007.4	19.9	266.989	86.58	353.569
19.4	1007.2	19.4	267.301	84.636	351.937
18.9	1006.9	19.2	267.679	84.051	351.730
18.6	1006.7	18.7	267.901	82.031	349.931
18.4	1006.7	18.1	268.085	79.508	347.592
18.1	1007.0	18.0	268.441	79.231	347.672
17.8	1007.4	17.5	268.825	77.189	346.014
17.5	1007.9	17.3	269.236	76.465	345.701
18.8	1008.1	18.4	268.09	80.604	348.694

Table 7: N_s Result Plus Percentage Contribution Of Dry And Wet Terms

Enugu90	Temp	Press	RH	DryTerm	WetTerm	Ns	DryC	WetC
EnuguJan90	22.7	1010.0	66	265.052	76.987	342.040	77.49	22.51
EnuguFeb90	22.2	1010.7	50	265.685	56.767	322.452	82.40	17.60
EnuguMar90	24.2	1010.2	53	263.767	67.007	330.774	79.74	20.26
EnuguApr90	24.2	1009.0	73	263.454	92.293	355.746	74.06	25.94
EnuguMay90	23.7	1011.2	78	264.473	96.013	360.486	73.37	26.63
EnuguJun90	22.5	1013.3	81	266.098	93.468	359.567	74.01	25.99
EnuguJul90	22.5	1013.7	86	266.203	99.238	365.441	72.84	27.16
EnuguAug90	22.8	1014.2	83	266.065	97.341	363.406	73.21	26.79
EnuguSep90	22.6	1013.3	84	266.008	97.456	363.464	73.19	26.81
EnuguOct90	22.7	1012.2	81	265.630	94.484	360.114	73.76	26.24
EnuguNov90	23.6	1011.0	76	264.510	93.051	357.561	73.98	26.02
EnuguDec90	23.1	1010.3	75	264.773	89.393	354.166	74.76	25.24

6.2 Reduced To Sea-Level Refractivity

The Reduced to sea-level menu has similar structure as N_s menu. Figure 4 depicts the seasonal variations of N_o at Abuja site. Tables 8-10 show results for reduced to sea-level, N_o at Akure and Sokoto sites. The site altitude (Saltd) in km, as well as scale height (SCHT) in km is required as input along with t, p, Rh or e. Table 9 presents the result for N_o (last column), N_s (second to the last column) and the percentage contributions of N_s (columns 6 and 7). Table 10 for Sokoto site was produced the same way Table 3 was generated, but a property was set to give better information on the culprit data which prevented result from being computed.

This write only property should be set before calling the method; else the default value of NR (for NO Result) will be used. With this property, which was also used for Table 11, informed comment(s) could be inserted any where t or p or Rh or e is zero.

Table 8: N_o Result for Akure Site, October, 13 1991

T	P	e	Saltd	SCHT	N_s	N_o
22.5	1006.2	23.5	0.48	7	364.617	390.497
22.5	1006.2	23.5	0.48	7	364.617	390.497
22.2	1006.0	23.2	0.48	7	363.753	389.571
22.2	1006.0	23.2	0.48	7	363.753	389.571
22.2	1005.5	23.2	0.48	7	363.622	389.431
22.0	1005.0	23.0	0.48	7	362.947	388.708
22.0	1006.0	23.0	0.48	7	363.210	388.990
22.0	1006.0	23.1	0.48	7	363.639	389.449
22.0	1007.0	23.1	0.48	7	363.902	389.730
22.2	1007.0	23.3	0.48	7	364.444	390.311

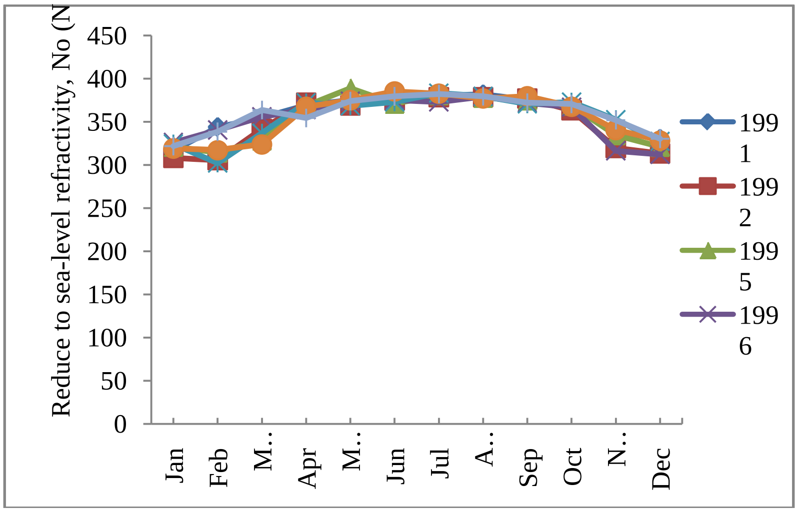

Figure 4: Seasonal Variations of N_o at Abuja for the years shown

Table 9: Akure Site Result for N_o, N_s and Percentage Contributions, Oct.13, 1991

T	P	e	Saltd	SCHT	DryC	WetC	N_s	N_o
22.5	1006.2	23.5	0.48	7	72.47	27.53	364.62	390.50
22.5	1006.2	23.5	0.48	7	72.47	27.53	364.62	390.50
22.2	1006.0	23.2	0.48	7	72.70	27.30	363.75	389.57
22.2	1006.0	23.2	0.48	7	72.70	27.30	363.75	389.57
22.2	1005.5	23.2	0.48	7	72.69	27.31	363.62	389.43
22.0	1005.0	23.0	0.48	7	72.84	27.16	362.95	388.71
22.0	1006.0	23.0	0.48	7	72.86	27.14	363.21	388.99
22.0	1006.0	23.1	0.48	7	72.77	27.23	363.64	389.45
22.0	1007.0	23.1	0.48	7	72.79	27.21	363.90	389.73
22.2	1007.0	23.3	0.48	7	72.63	27.37	364.44	390.31

Table 10: Typical Sokoto site result for N_o

Sokoto	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	301.82	302.25	**294.26**	329.70	351.88	359.53	372.98	372.71	365.28	334.37	307.33	303.24
1991	299.51	297.41	304.99	325.72	369.45	368.35	375.17	376.07	370.55	350.19	300.76	299.62
1992	303.03	297.45	299.98	320.81	357.18	359.46	371.58	378.94	368.36	339.99	302.74	299.60
1993	303.49	297.41	300.09	307.24	347.59	332.04	364.71	375.93	369.91	339.76	t=0	t=0
1994	309.85	298.53	294.75	337.95	345.48	358.00	373.80	**395.24**	372.52	361.93	309.51	303.50
1995	t=0	300.98	297.93	324.03	351.39	359.46	368.97	380.38	371.22	347.51	309.67	303.87
1996	t=0	299.50	294.59	307.21	359.63	364.75	365.57	375.46	t=0	t=0	300.85	304.87
1997	302.46	298.54	t=0	t=0	t=0	t=0	t=0	t=0	t=0	355.32	t=0	305.68
1998	304.23	301.86	299.20	323.28	349.93	366.25	372.31	374.74	375.72	354.58	304.52	311.53
1999	t=0	297.63	300.75	321.80	365.87	356.22	372.81	376.78	t=0	t=0	t=0	t=0

6.3 Modified refractivity

The modified refractivity M menu as seen in figure 2 has identical pattern as N_s and N_o menus. Similar results like that for N_s and N_o were computed for M. Figure 5 shows the variations of N_s and M at Enugu site. A typical result for Sokoto is shown in Table 11; however, space could not allow us to display more results.

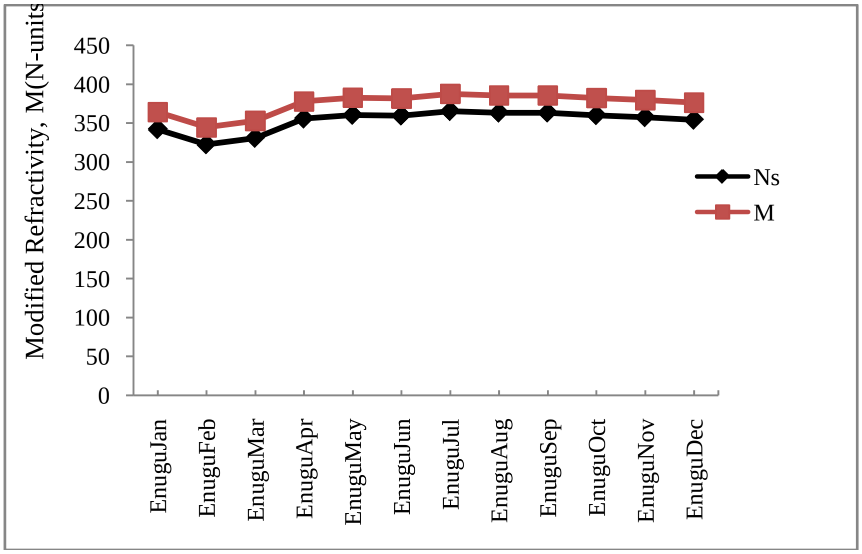

Figure 5: Seasonal variations of N_s and M at Enugu Site, 1990

Table 11: Modified Refractivity Result for Sokoto Site

Sokoto	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1990	342.77	343.19	**334.95**	369.35	390.49	397.03	409.83	410.34	405.06	373.80	347.39	345.91
1991	340.57	338.56	345.16	365.55	407.24	405.42	411.91	413.55	410.11	388.88	341.14	342.44
1992	345.10	336.90	341.34	360.21	395.50	396.96	408.50	414.10	405.43	380.99	345.43	338.93
1993	343.73	337.95	342.89	347.30	388.61	368.26	405.84	411.25	403.98	381.84	t=0	t=0
1994	352.40	342.19	336.03	376.50	383.67	396.33	411.39	**430.99**	410.17	397.99	350.1	344.37
1995	t=0	338.96	337.35	362.08	386.51	400.79	403.09	413.86	408.16	385.60	347.16	342.98
1996	t=0	340.56	335.88	347.27	395.82	402	405.69	412.19	t=0	t=0	344.43	345.05
1997	341.64	341.40	t=0	t=0	t=0	t=0	t=0	t=0	t=0	391.73	t=0	349.07
1998	344.44	345.40	339.65	365.29	391.63	402.09	409.97	415.49	412.43	389.52	344.71	348.92
1999	t=0	338.15	338.74	363.72	403.06	392.58	409.66	416.62	t=0	t=0	t=0	t=0

7. DISCUSSION

AkureFUTA site results for N_s vary between 310-387 N-units. Table 12 gives the summary of range values for the remaining sites for N_s, N_o and M. For emphasis the minimum and maximum values in Tables 10 and 11 in bold font. For all the sites, higher values were obtained during raining season periods (March-September in Nigeria) than dry season (see figures 4 and 5), which betrays the high dependence of the parameters on e.

Table 12: Result Summary Range

Site	N_s	N_o	**M**
Abuja	290-366	306-385	344-419
Enugu	299-369	304-378	321-391
Sokoto	280-376	294-395	335-431

The dry term percentage contributions are generally higher than that for wet term. This observation is in agreement with the results of Owolabi(1970), Kolawole(1981), Adeyemi(1992) and Adenugba (2003). The results calculated using RefractSoft 2.0 application were compared with other researchers' works and found to be in agreement, indicating the accuracy of our codes.

Several input and output formats are available, and each has its merits. The choice is for user to decide on which one to use. In Tables 8 and 9, columns Saltd and SCHT for site altitude and scale height respectively keep occurring for that particular site, thus for a single site the input technique is not efficient. However, for several sites from different regions where scale height is not identical, the technique is very efficient as it permits the varying effects of the scale height to be seen in a single location. There are many and diverse errors checked at both the server and client application; and all of them work to specifications; consequently they prevent applications malfunctioning and crash. It is sufficient to say that all the applications utilities work to specifications.

8. CONCLUSION

A carefully modularized class library has been developed for surface radio refractivity, reduced to sea-level refractivity and modified refractivity parameters that are frequently used by atmospheric scientists and physicists; communication experts and Engineers in system design and planning. There are thirty functions and seven properties in the server, dvRadioRefractCls, besides five polymorphized methods through which the server could be exposed. As a building block, our server could be utilized elsewhere to hasten application development. The application developed using dvRadioRefractCls class library was not only flexible to use, but accurate as comparisons of results with previous works revealed. Results obtained show that AkureFUTA site has the highest N_s value while Sokoto site has the least value. Our application will function in any Microsoft Visual Studio platform and its compatibles. Additional inputs and output formats to give further flexibility to user are required. Besides, statistical tool should be provided in order to assist user further in their work.

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