Time Delay Profiles for Reilable Communication Navigation and Surveillance Services in Indian Subcontinent

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Abstract:- In this paper, work based on international reference ionosphere (IRI). Though, several models such as IRI 2014 are available, IRI-90 was selected as it is basic and directly intractable with little efforts. Also, Estimation of electron density is demonstrated towards localisation of model helps better services of these.

Key words: *International ionosphere, communication, navigation, surveillance systems, Indian subcontinent.*

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1. INTRODUCTION

Revolution in wireless communication since Marconi includes satellite aided communications and missile guiding etc. Atmosphere effects the communication considerably. The prominent layers of atmosphere are, troposphere, stratosphere and ionosphere. Among all these, most of the effect on the communication signal is by the ionosphere. The time delay error contributed by the ionosphere for a single frequency user can be reduced, though not completely eliminated, by way of appropriate models. Propagation effects of the ionosphere are very complex. Ionospheric time delay models that yield good results at one place can prove to be useless at other places. This prompts development of model to individual continents instead of available global model. One of such model is the Klobuchar's single frequency time delay model is based on Bent's electron density model. In Bent model only a few measurements were available for low latitude regions. As the TEC behaviour in many parts of the world has a diurnal maximum near 1400-hrs local time, Klobuchar made the peak amplitude of the cosine curve to coincide with 1400 hrs in his time delay model. But for Indian conditions it is observed that the peak amplitude occurs at different times. For example, at Kurukshetra (India) it is reported by R.S. Dabas that the peak amplitude occurs at 1500 hours. In the present work Klobuchar's model, as it is, cannot be used as it takes into account the whole ionosphere and always considers the DC offset as 5 nano secs during night times. Also, Klobuchar has taken the mean ionospheric height as 350Kms and used several approximations for calculating the time delay. Moreover, the algorithm was best suited for mid-latitude regions of the world. The behavior of TEC in the equatorial and high latitudes is less well known. In view of these drawbacks, it is proposed to develop a time delay algorithm, based on recent International Reference Ionspheric models model to suite the Indian sub-continent, for various altitudes.

2. VARIOUS IONOSPHERIC ELECTRON DENSITY MODELS

Ionosphere is the atmosphere that extends the altitude range from 60Km to 1000Km above the earth[1]. Out of several parameters of the model, ionospheric electron density is essential for a wide range of users such as e.g., radio and telecommunications, satellite tracking and Earth observation from space. Considerable efforts have, therefore, been concentrated on modeling this ionospheric parameter. Ionospheric predictions are generally made using models that are either physically, statistically or empirically based theoretical models provide the means to determine how well our current understanding of the physical mechanisms, that are believed to be responsible for the formation of the ionosphere is consistent with the observed ionospheric behaviour. These models are time dependent and provide ionospheric information as a function of height, location and time. The main disadvantage of using the theoretical models is their complexity, which requires large amount of computer time (super computers). The statistical or parametric models provide results for particular ionospheric parameters. In order to obtain a complete electron density profile, the results obtained from these models are to be combined with an assumed vertical distribution for the ionization. Empirical models attempt to extract systematic ionospheric variation from the past data records. These models describe the average conditions of the non-auroral, non-disturbed ionosphere. Usually, these models employ a physically or chemically based representation of the lower ionosphere with a statistical representation of the upper atmosphere. These models generally specify the electron density on a global scale by virtue of the global nature of the statistical model contained with them. Various electron density models including the Bent model that has been used extensively for satellite tracking, the phenomenological Chiu model, the semi-empirical SLIM model based on theoretically obtained grid values, the recent FAIM model that uses the Chiu formalism together with the SLIM results and the International Reference Ionosphere (IRI).

A.BENT Model

The model describes the ionospheric electron density as a function of latitude, longitude, time, season and the solar radio flux. The topside is represented by a parabola and three exponential profile segments and the bottom side by a bi-parabola. It doesn't include the lower layers (D, E, F1) and uses a simple quadratic relationship between CCIR's M(3000)F2 factor and the height of the F2-peak This is however not suitable for countries like India as the data from Indian locations is not incorporated.

B. International Reference Ionosphere (IRI)

The IRI is a standard empirical ionospheric model established on behalf of International Union of Radio science (URSI) and Committee On Space Research (COSPAR). Improvements have been incorporated in the model IRI-90 that's that has been implemented as basis in proposed model. The latest version of the International reference ionosphere, IRI2000 [2], contains a dependence on geomagnetic activity based on an empirical storm-time Ionospheric correction model (STORM). The new storm correction in IRI is driven by the previous time history (33 hours) of ap and is designed to scale the normal quiet-time F layer critical frequency (foF2) to account for storm-time changes in the ionosphere.. extension of current model using this is under progress.

The IRI-90 model is based on experimental observations of the ionospheric plasma. Some of the most significant modifications made in IRI-90 for the calculation of the electron density profiles include, a new set of coefficients for the F2-region peak electron densities and peak heights, introduced as new option in addition to the coefficients of the CCIR numerical maps. Also, an analytical representation for the middle atmosphere using LAY functions and improvements in the calculation of thickness parameters for the bottomside ionosphere, Improvements in the E-region peak electron density variations and extension of the calculation of profiles to plasmaspheric altitudes are included.[2-10]

C. Proposed Methodology

The procedure of computing the coefficients to estimate ionosphere time delay of space bound objects from 10km to 300km is discussed elsewhere[1]. The comparative analysis made between the IRI model-predicted and the measured electron density profiles as shown, in general, a quite reasonable agreement. Further, IRI-90 model is giving better results in comparison with the Bent model due to the more detailed representation of the bottomside density structure In view of the above IRI-90 is preferable to estimate the electron density within the Indian subcontinent, which varies with Latitude, Longitude, Solar activity, Month, Time and Altitude. The IRI provides the normalized electron density profile or profile shape. It is then combined with values of the F-region, peak electron density and peak height predicted by the International Radio Consultative Committee(CCIR). These profiles are provided for suitably chosen locations, hours, seasons and levels of solar activity.[11-23] . In IRI-90, it was observed in calculation of FoF2, 13 sets of coefficients are used to compute this that will be useful to calculate electron density. If the local values of FoF2 are available for a solar cycle or so, based on numerical techinics the coefficients could be derived from the data.

3. RESULTS AND DISCUSSION

The IRI-90 model is made user compatible which was in Fortran IV. The model gives directly profiles. This model is studied and a methodology how to calculate electron density is understood by making the model intractable. To calculate it is essential to select the height at which the electron density to be calculated. Based on the electron density, That height is assumed one of the regions than spans from lower E to the higher F2 region. At every step a subroutine will be executed and result is noted as out come of the step. An example is chosen both for day and night times to estimate electron density. Location, Month of the day are arbitrary. Location is identified by geodetic latitude and longitude in degrees. The 15th day is assumed as mean of the month. Local time is selected so that maximum value could be identified at that time. Sunspot number represents high solar activity. However, electron density value estimated is reasonably agreed with the value of algorithm.

(i)Day time

Eectron density and peak height predicted by the International Radio Consultative Committee(CCIR). These profiles are provided for suitably chosen locations, hours, seasons and levels of solar activity.

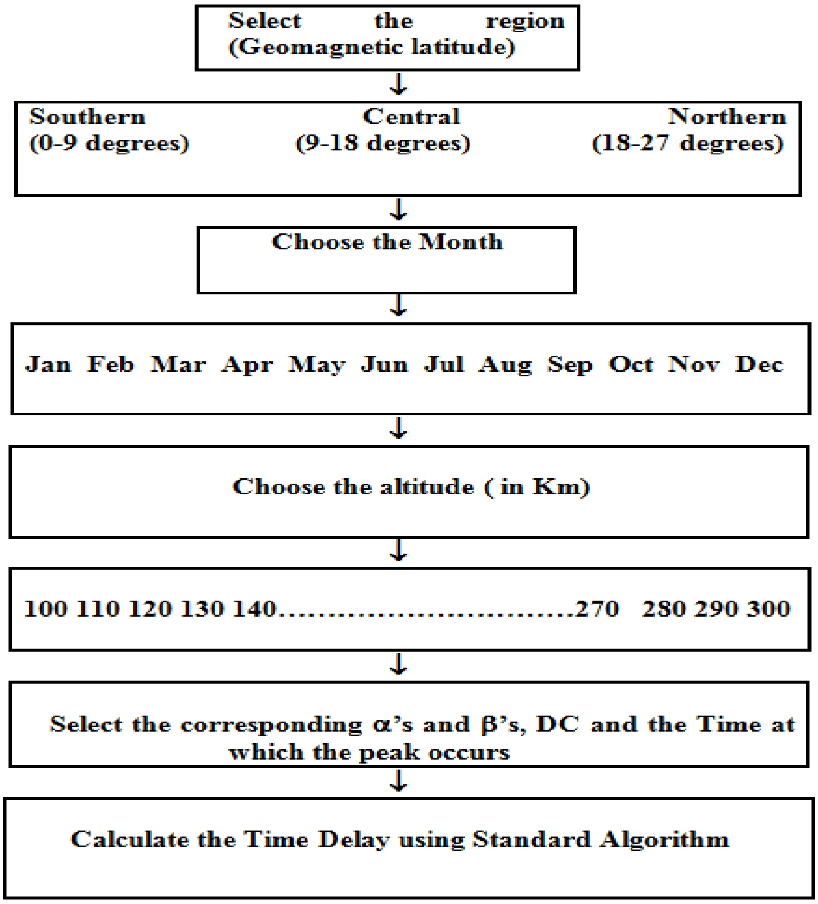

Figure1: Computation of Time delay using coefficients[1]

A. Methodology of Estimation of Electron density at Day time

Following Parameters are considered as in put.
. Geodetic latitude (Φg) = 45.10 N; . Geodetic longitude (λg) = 293.10 E; . MONTH and DAY = October,15.
. Local time (HOUR) = 12.5 hours; . Solar sunspot number (R) = 100.;

The procedure of computing electronic density is derived from IRI-90 algorithm of D.Bilitza and a sample follows estimation follows.
Common calculations:
1. B0 is computed considering density option as Gulyaeva – h0.5
foF2 /NmF2 is calculated using URSI-89 model.
3. hmF2 is estimated using CCIR-M3000 model.
Top side profile : Height selected is 400Km.
The estimation of the electron density at 400 km following these steps.
Step1: Estimation of Geomagnetic latitude (Φm) in degrees.
Step2: Estimation of Total field (Gauss), downward vertical component (Z), X, Y components in the equatorial (X to zero longitude), Dip inclination angle (DIP) in degrees, Rawer's Modified dip (SMODIP)
Step3: Estimation of Day Number
Step4: Estimation of solar declination, zenith angle, sunrise and sunset times.
Step5: Estimation of Mean F10.7 cm solar radio flux and restricted solar activity
Step6: Estimation of Critical frequency of F2 (foF2) layer in MHz
foF2 = 9.6970 MHz
Step7: Estimation of critical frequency of E layer foE in MHz
Step8: Calculation of height of F2 layer of maximum density
hmF2 = 287.144449 Km
Step9: Calculation of relative electron density (ne)
(Should be used only h.hmF2)
ne = 0.7605
Estimation of absolute electron density
ED = ne. 1.24.1010.foF2
= 8.2379.1011 el/m3

TABLE1: Day time ELECTRON DENSITY VALUES FOR OTHER REGIONS

Height (km)	Region	Electron density (el/m^3)
220	F2	6.3440x.10^{11}
205	F1	2.629x10^{11}
130	Transition	1.38144.10^{11}
110	E	1.311x10^{11}
100	Lower E	1.287.10^{11}

For Night time, similar calculations carried out. The electron densities are less compared to day time. For example at 140Km, Height.

4. CONCLUSIONS

Most of the communication, navigation and surveillance services uses communication or navigation satellites. The atmosphere plays a vital role in accuracy of services. Ionosphere is major source that requires electron density computation. IRI-90 is the most suitable model that is relevant for Indian conditions. An example discussed for day and night times to demonstrate the calculation of electron density. Using this,

A time delay model to estimate the ionospheric delay for space bound objects at any altitude upto 1000Km from ground is proposed. The procedure for constructing electron density profiles is outlined. Using IRI-90 model the time delay profiles are obtained. The coefficients earlier developed[1], will be more relavant, if the calculations are with more local data such as FoF_2, hmF_2 etc. Novelty of the proposed model is it is attempted for Indian conditions. The same model can be extended recent versions.

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