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Study The Skip Distance of Radio Wave Propagation For Extraterrestrial Region of Pakistan

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ABSTRACT

In this study the physical behavior of the ionospheric layer in Pakistan's atmospheric region, the Exploratory Data Analysis (EDA) is performed. Using these analyses, probabilistic and mean deviation models are developed to study the skip distance for radio-wave propagation of ionospheric F_2 layer for the Pakistan atmospheric region. These models provided a full description of the essential processes. The Time plot shows the seasonality behavior of the skip distance for radio-wave propagation. The frequency distribution plot of skip distance for radio wave propagation shows the normality of the data. The information attained from these forecasts by analyzing these models, can be further worked with very likely parameters and variables in the physical system to get a favorable performance. Such an approach is well explained within the possibility of computational analysis. The models presented in this paper along with their physical interpretations are helpful for public and private sector organizations.

Keywords : Skip distance, radio wave propagation, Atmospheric trend, Ionospheric F_2 layer, exploratory data analysis, Pakistan regions.

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I. INTRODUCTION

The ionosphere is very important in radio wave communications, which absorbs large quantities of radiant energy from the sun, thus becoming heated and ionized. F2 layer is the superficial layer of the ionosphere. When radio waves penetrate inside of the ionosphere presence in this intermediate of moving particles such as ions and electrons shared with the influence of the magnetic field. Skip distance is a termed as the shortest distance from a transmitter measured along the surface of the earth, at which a sky wave of fixed frequency (> f_c) will be returned to Earth. That there should be a minimum distance may come as a shock. One expects there to be a maximum distance, as limited by the curvature of the Earth, but nevertheless a definite minimum also exists for any fixed transmitting frequency [1-2]. For a given ionosphere, there will be some limiting upper frequency reflected vertically at the height of maximum electron density. At frequencies above this critical frequency, there is a ground distance from the transmitter at points along which illumination is not possible by waves reflected from the ionosphere. This distance is known as the skip distance. The skip distance increases as the wave frequency increases and in the limit for a high frequency can extend to the maximum ground range possible for rays launched at grazing incidence, in that case all rays escape into space. It follows that there is a maximum frequency for which waves can be reflected to a fixed point of reception. This is the frequency making the distance from the transmitter to the point equal to the skip distance [3]. The term skip zone applies to the annular belt around a radio transmitter where it signals cannot be received. It extends beyond the ground-wave range, but lies within the so-called skip distance or the distance from the transmitter to appoint where a specified radiated frequency first returned to earth [3-4]. In case of long distance communication, the optimum frequency is generally controlled by reflection from the F2 layer, but in some cases the situation during noon time is controlled by E and F1 layer. When the distance is intermediate between 2000-1000km and reflection occurs from the lower height of the E-layer at the angle of incidence of the wave to be much more glance than for the F2 layer. The optimum frequency increases with the path distance up to the maximum distance for one hop transmission and this distance is on the average about 4000km for the F2 layer and 2000km for the E layer. At a short distance the optimum frequency is essentially equal to the critical frequency, because the value of sec (i) is then nearly equal to 1. For long distance, the value of F2 layer maximum usable frequency is three times the critical frequency. Large distance may be obtained by the aid of layers F2 [5-7].

We have performed EDA to exhibit the results in such a way as to make them recognizable. It will provide a comprehensive characterization of the underlying system in the form of mathematical models. The information attained from such analysis can be further employed to vary possible parameters and variables in the system to achieve an optimal

performance.
The Formula for the skip distance $d = 2x\sqrt{2a_c h'}$
In this formula a_c is the effective radius of the earth, which is equal to = 5280 mils or 8497 km, and h' is the virtual height of F2 layer.

II. METHODOLOGY

The study was based on the analysis of skip distance of radio wave propagation of ionospheric F2 layer for Pakistan's atmospheric region. Using exploratory data analysis approach, we have used ionospheric recorded data of the year 1990 on 256 D.G sonde for evolution, analysis of skip distance through Time plot, Box plot, Dot plot, Frequency plot, Empirical plot and Interval plot.

III. Exploratory Data Analysis

To proceed further with the quantitative study of our data of skip distance of radio-wave propagation for the Pakistan atmospheric region. We have employed EDA (which is now being incorporated into the formal statistical theory) it will provide a comprehensive characterization of the underlying system in the form of mathematical models.

$Y_t = \acute{a}_1 Y_{t-1} + e_t$

$\acute{a} = 0.99858$, $e_t = 0.00374$

$Y_t = 4192.076$

Such a statistical approach is well within the feasibility and approach of available computational softwares such as STATISTICA, MINITAB and SPSS make extensive use of robust / resistant statistics and relies heavily on graphical techniques [8-9].

For the descriptive parameters regarding the skip distance for radio-wave propagation data of the year 1990 for Pakistan air space and the corresponding Time plot is referred in Figure 1. The illustration signifies temporal variation of each value of the skip distance for radio wave propagation of ionospheric F2 layer in terms of its calculated skip distance. The area under the horizontal line segment at a particular height represents the temporal variation of skip distance. The Time plot shows the seasonality behavior of the skip distance for radio-wave propagation. The constructed Box plot of skip distance of the Karachi station for epoch 1990, Figure 2. It shows that the normal distribution relatively well describe the distribution of these data and provide information on the median value of the path loss, which can be seen to be likely closed the most probable value, and equal to it in the Gaussian case. Dot plot, is illustrated in Figure 3. It is used to categorize a two dimensional and quantitative characteristic object of skip distance for radio wave propagation. The observation of the curve allows determining the type of the path loss attenuation follow the probability density curve appears. A Frequency plot is the data analysis method for summarizing the distributional information of a variable, as in Figure 4. The frequency distribution plot of skip distance for radio wave propagation shows the normality of the data. The Empirical Cumulative Frequency distribution plot as in Figure 5 shows the half Gaussian curve of skip distance for radio wave propagation of ionospheric F2 layer data. The Interval plot shows the mean durability of data of skip distance for radio wave propagation of ionospheric F2 layer as in Figure 6. The interval plot shows a symmetric behavior of the skip distance data. The response variable is divided into equal sized intervals. Tables 1, 2, 3 and 4 give the parametric estimates drawn from the same population for skip distance of the ionospheric F2 layer. The calculated value of the Coefficient of Variation (6.5%), skew ness, mean, median and mode of skip distance for radio wave propagation of the ionospheric F2 layer shows a smaller amount of variation in the natural data, as in Table 2. For same samples, we have the following estimates:

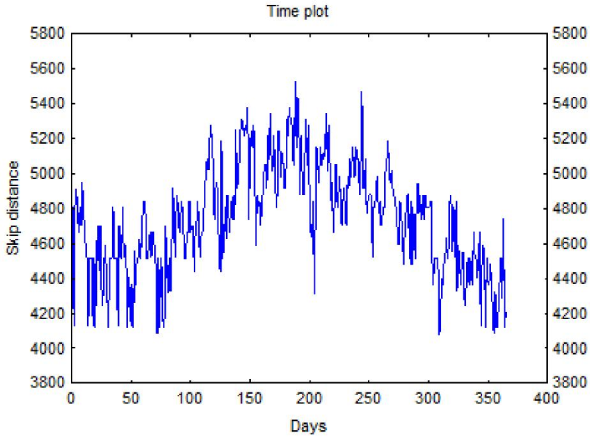

Fig. 1 The temporal variation of skip distance for radio wave propagation of the ionospheric F2 layer during the year 1990.

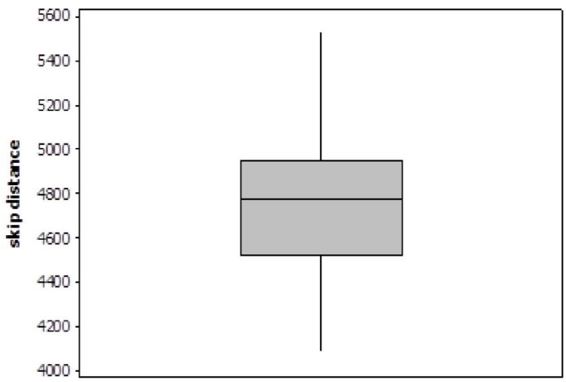

Fig. 2 Box plot of skip distance for radio wave propagation of the ionospheric F2 layer of the year 1990.

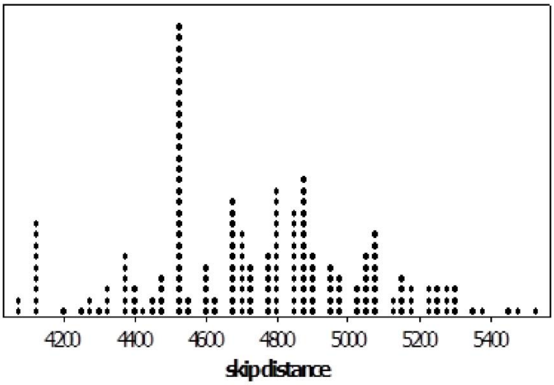

Fig. 3 The Dot plot of the skip distance for radio wave propagation of the ionospheric F2 layer of the year 1990.

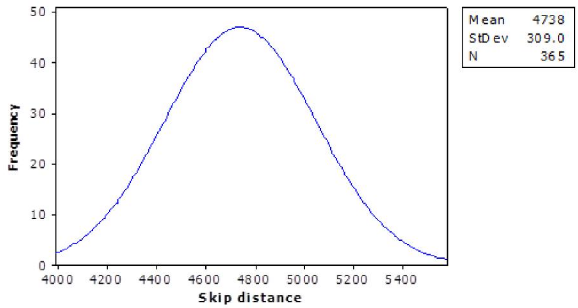

Fig. 4 The frequency distribution plot of skip distance for radio wave propagation of the ionospheric F2 layer during the year 1990.

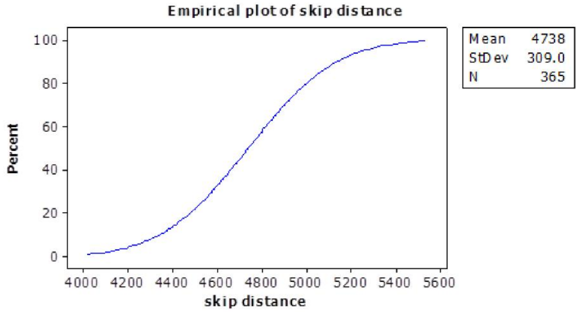

Fig. 5 The half Gaussian plot of skip distance for radio wave propagation of ionospheric F2 layer during the year 1990.

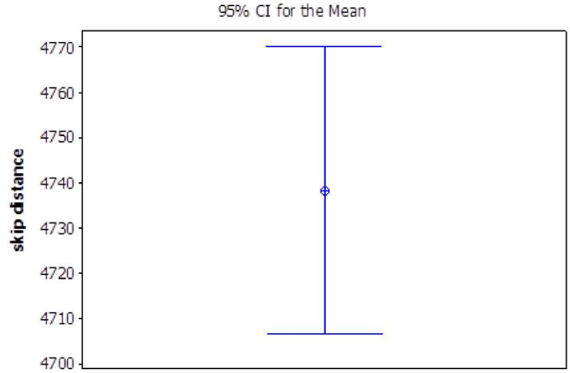

Fig. 6 The interval plot of skip distance for radio wave propagation of the ionospheric F2 layer during the year 1990

Table 1. Frequency distribution of skip distance for radio wave propagation

C.I	F Test	C.F
4000.0<x<=4200.0	21	21
4200.0<x<=4400.0	26	47
4400.0<x<=4600.0	86	133
4600.0<x<=4800.0	60	193
4800.0<x<=5000.0	96	289
5000.0<x<=5200.0	47	336
5200.0<x<=5400.0	26	362
5400.0<x<=5600.0	3	365
Total	365	

Table. 2 Parametric Description of skip distance for radio wave propagation of the ionospheric F2 layer at the Pakistan air space

Parameters	Statistical Values
Mean	4738.2
Median	4771.5
Mode	4515.8
Range	1449.6
St. Deviation	309.0
C.V.	6.52
S. E. Mean	16.2
Trim. Mean	4739.3
Skewness	-0.02

Table. 3 Descriptive statistics of skip distance for radio wave propagation of the ionospheric F2 layer

Minimum	4080.9
Maximum	5530.5
Lower Quartile	4515.800
Upper Quartile	4946.800
Quartile Range	431.0
$Q_1 - (3/2)$ QR	3869.3
$Q_3 + (3/2)$ QR	5593.3

Table. 4 Forecasting Statistics of Skip distance for radio wave propagation of the ionospheric F2 layer

Case	Forecast	Lower 90%	Upper 90%	Std. Error
366	4198.034	3639.596	4756.472	338.642
3 67	4191.878	3402.706	4981.049	478.561
368	4185.730	3219.904	5151.556	585.686
369	4179.591	3065.168	5294.014	675.797
370	4173.462	2928.411	5418.513	755.011
371	4167.341	2804.454	5530.228	826.468
372	4161.229	2690.219	5632.239	892.035
373	4155.127	2583.700	5726.553	952.928
374	4149.033	2483.501	5814.565	1009.995
375	4142.948	2388.605	5897.291	1063.850

IV. CONCLUSIONS

A complete description of the process has been provided using the models mentioned in this communication, to compute the skip distance for radio wave propagation of the ionospheric F2 layer during the year 1990. The Time plot shows the seasonality behavior of the skip distance for radio-wave propagation. The Box plot shows that the normal distribution relatively well describes the distribution of the skip distance data. The frequency distribution plot of skip distance for radio wave propagation shows the normality of the data. The Empirical Cumulative Frequency distribution plot shows the half Gaussian curve of skip distance for radio wave propagation of ionospheric F2 layer data. The calculated value of the Coefficient of Variation, skew ness, mean, median and mode of skip distance for radio wave propagation of the ionospheric F2 layer shows a smaller amount of variation in the data. The interval plot shows a symmetric behavior of the skip distance data. These forecasts may be more operational towards vary likely parameters in the corporal classification to achieve a favorable presentation.

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Sonde.

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