Estimation of the Periods of Occurrence of Spread– F Over Ouagadougou

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Abstract

Spread F data from the ionogram Collected in Ouagadougou (west Africa) were used to investigate the rate of occurrence of medium-scale irregularities in the electron concentration in the F-region of the ionosphere at all the seasons of the year. It was observed that at both equinox and solstices irregularities occur mostly at night, which is the same period at which scintillation also occur, when data were considered on an hourly basis.

Occurrence of spread F was also studied during magnetic storms and during quiet periods. It was shown that spread- F is observed during disturbed period as well as quiet periods. At equinox, the values of the thickness of spread-f is seen to be higher for the quiet periods than the disturbed days throughout, but at solstices it is only in the evening period that the thickness for the quiet period is more than that of the disturbed periods.

Keywords: ionosphere, ionogram, irregularities, equinox, solstices, quiet and disturbed periods.

1.0 Introduction

Spread F data obtained from a typical Ionogram showing records of the ionospheric conditions indicated by the relationships between the frequency of radio pulse emitted upward and the vertical height of echoes reflected from the ionosphere from Ouagadougou (Geo latitude 12.37^{o}N, Geo longitude 358.47^{o}N) are used for my study. Spread F occurs mainly in the dawn hours during magnetic storm (disturbed period) and during quiet periods (Soicher et al 1997). Data for the months of January, April, July and October are used for my analysis each representing different seasons of the year.

Spread f is an indication of the occurrence of irregularities in the f2 region (Dieminger et al 1995). It is also referred to as the ionogram signature of the f-region irregularities in the ionosphere. The f-region of the ionosphere is the ionized region above the E-layer.

The ionosphere is under constant agitation by a variety of external influences which causes the irregularities in this region. Apart from this irregularities in the ionosphere the agitation is either caused by scintillation or ionospheric storm.

Spread f phenomenon is particularly severe near the magnetic equator and in the auroral zones. In middle and high latitudes these irregularities appear to occur in patches with horizontal extent up to several hundreds of kilometers which drift with speeds of around the 100m/s.

The most likely time of occurrence is between 2100 and 0100LT (Dieminger et al 1995).

The F-region of the ionosphere is subdivided into f1 and f2 region. The f1 region denotes that part of the atmosphere between heights of about 140km to about 220km. The temperature in the f1 region increases rapidly with heights from around 500K at 140km to over 1000K at 220km.

The data used for my study is from the ionogram recorded from Ouagadougou (Geo latitude 12.37^{o}N, Geo longitude 358.47^{o}N) for different seasons of the year i.e. equinox and societies. The ionogram is scaled on an hourly basis between the hours of 1900 and 0700LT. The ionogram signature on the ionosonde is considered from the two ends of the spread referred to in this work as the bottom and topside of the spread.

Occurrence statistic of spread F(over Ouagadougou) which is the word-wide probability distribution of spread F per local time. Spread – F occurrence was recorded only between 1900 and 0700 LT. In summer (solstices) higher night time occurrence was observed at low and high solar activity.

In Equinox (winter) higher percentage occurrence takes place during low solar activity especially in the later part of the night (Saksena 1996).

2.0 Methodology

The values of the height of occurrence of spread F (Hmin and Hmax) and the corresponding frequencies of occurrence were obtained from the ionogram data obtained in Ouagadougou using an ionosonde.

Also the number of times spread F occur (rate of occurrence) per day were also determined on an hourly basis mainly by observation. The case of fig Ig is a typical case of which spread does not occur.

3.0 Definition Of Parameters Used.

i. **Fmin** – This is the minimum frequency at which spread F occur. It indicate the frequency at the bottom side of the spread and is measures in Megahertz (MHz)

ii. **Fmax** – This is the maximum frequency at which spread F occur. It indicate the frequency at the topside of the spread and is also measured in Megahertz (MHZ).

iii. **Hmin** – This is the minimum height at which spread F occur. i.e the average height at the bottom side of the spread. It is measured in kilometer (km).

iv. **Hmax** – This indicate the maximum height at which the spread occur. It is the average height at the topside of the spread and is also measured in kilometers (km).

v. **Bo** – This parameter indicate the thickness (in km) of spread F at the bottomside of the spread.

vi. **B_1** – This also indicate the thickness of spread F at the topside of the spread. It is also measured in kilometers (km).

The graphs of the average values of Hmin and Hmax are plotted against the local time (LT) for months of January, and October representing two seasons of the year. From these graphs the average minimum and maximum heights at which spread F occur can be determined. Also the time at which the heights is greatest is also determined.
Also, the graph of the rate at which spread F occur was plotted against the local time per month. The time at which the occurrence is greatest can easily be determined from the graphs.
For the quiet and disturbed periods the five most disturbed days and the five most quiet days of the months were considered. The periods at which the Ap index is less than 26 is considered to be a quiet day and disturbed if otherwise.

Graphs of their average values of heights (Hmin and Hmax) are plotted against the local time. The graph shows the periods when the values of Hmin or Hmax become lower or higher for quiet and disturbed periods. Also the graph of B_1 against local time for both quiet and disturbed periods are plotted.

Table 3.1 lonogram readings with time.

JANUARY

Fmin (MHz)	Bo (km)	Hmin(km)	Fmax (MHz)	B1 (km)	Hmax(km)	LT	Date
1.65469	25	271.875	5.7495	71.875	329.6875	0:00	04-01-91
1.65469	81.25	278.125	5.71845	68.75	296.875	1:00	
1.70011	28.125	248.4375	6.69084	31.25	312.5	2:00	
1.70934	25	243.75	6.61877	150	400	3:00	
1.71862	28.125	229.6875	5.35867	37.5	325	4:00	
1.92561	25	237.5	4.45755	46.875	310.9375	5:00	
1.8241	37.5	253.125	3.70796	65.625	395.3125	6:00	
2.34009	18.75	296.875	7.49667	53.125	384.375	7:00	
1.76579	31.25	421.875	6.72717	43.75	568.75	19:00	
1.8241	56.25	428.125	6.7637	59.375	579.6875	20:00	
1.8241	75	403.125	6.69084	150	512.5	21:00	
1.84397	37.5	318.75	8.35419	87.5	443.75	22:00	
1.75625	34.375	267.1875	8.49102	115.625	360.9375	23:00	

APRIL

Fmin (MHz)	Bo (km)	Hmin(km)	Fmax (MHz)	B1 (km)	Hmax(km)	LT	Date
1.56746	12.5	296.875	11.4369	143.75	484.375	0:00	10/41991
1.45303	9.375	270.3125	6.7637	18.75	346.875	1:00	
1.53388	15.625	260.9375	8.9635	59.375	439.0625	2:00	
1.5256	12.5	256.25	9.01217	46.875	410.9375	3:00	
1.48485	12.5	262.5	8.9635	34.375	398.4375	4:00	
1.8241	25	153.125	8.49102	31.25	390.625	5:00	
2.01086	9.375	298.4375	8.49102	25	362.5	6:00	
3.55075	12.5	262.5	11.5614	28.125	395.3125	7:00	
1.90486	15.75	435.875	5.7495	18.75	534.375	19:00	
1.86405	87.5	565.625	5.71845	34.375	701.5625	20:00	
1.95714	103.125	623.4375	4.31504	146.875	639.0625	21:00	
1.89458	43.75	487.5015	5.7495	115.625	632.8125	22:00	
1.85398	131.25	396.875	6.7637	78.125	542.1875	23:00	

JULY

Fmin (MHz)	Bo (km)	Hmin(km)	Fmax (MHz)	B1 (km)	Hmax(km)	LT	Date
1.87417	43.75	440.625	4.73114	121.875	535.9375	0:00	6/7/1991
1.78502	12.5	371.875	4.70559	103.125	454.6875	1:00	
1.49291	9.375	301.5625	5.71845	62.5	456.25	2:00	
1.75625	9.375	282.8125	5.5657	50	428.125	3:00	
1.66368	9.375	276.5625	5.78072	84.375	457.8125	4:00	
1.72795	9.375	270.3125	5.97163	87.5	406.25	5:00	
2.25304	18.75	296.875	6.80043	18.75	334.375	6:00	
3.55075	12.5	250	9.3098	18.75	350	7:00	
1.8241	12.5	334.375	6.69084	12.5	475	19:00	
1.88434	131.25	478.125	4.70559	106.25	590.625	20:00	
1.86405	43.75	418.75	4.48175	153.125	651.5625	21:00	
1.93606	65.625	514.0625	3.95691	215.625	585.9375	22:00	
1.84397	15.625	410.9375	4.73114	56.25	468.75	23:00	

OCTOBER

Fmin (MHz)	Bo (km)	Hmin(km)	Fmax (MHz)	B1 (km)	Hmax(km)	LT	Date
1.80445	15.625	264.0625	8.35419	131.25	375	0:00	1/10/1991
1.65469	15.625	242.1875	8.44516	93.75	371.875	1:00	
1.65469	18.75	246.875	8.39955	128.125	482.4125	2:00	
1.67271	18.75	246.875	6.80043	25	362.5	3:00	
1.65469	12.5	287.25	6.94934	18.75	390.625	4:00	
1.73733	21.875	242.1875	7.14007	109.375	401.5625	5:00	
2.02178	9.375	276.5625	7.74425	25	337.5	6:00	
3.06776	9.375	267.1875	11.4369	40.625	357.8125	7:00	
1.68179	109.125	564.0625	7.14007	75	740.625	19:00	
1.97846	96.875	592.1875	5.84367	243.75	656.25	20:00	
1.92561	84.375	545.3125	7.10151	212.5	625	21:00	
2.20477	84.375	407.8125	7.10151	178.125	698.4375	22:00	
1.65469	37.5	381.375	6.7637	175	509.375	23:00	

3.2.1 Results of Occurrences Rate.

The following deductions were inferred through general out look or sighting of the graph of number of occurrence (N) against local time for the various mouths of the year. Figures 3a-3d

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(i) **January: figure 3a**

For the month of January, spread F occurs throughout the period of 1900 LT to 0700LT with the maximum occurrence at the 2100 LT when it occurs for 30 days of the month. The minimum number of occurrence of spread f is at 0700LT when it occurs for only 6 days of the month.

(ii) April: figure 3b

Here spread of also occurs from 1900LT to 0700LT with the highest occurrence at the 2000LT where it occurs for 29 day of the month. The least occurrence is at 0700LT when it occurs for just 3 days of the month.

(iii) July: figure 3c

Here spread f occurs between 2000LT and 0600LT. Spread f occurrence reaches its maximum at 0100LT and 0300LT when it occurs for 28 days of the month. Its least occurrence is at 0500LT when it occurs for 14 days of the month. It is important to note that here there is no spread f beyond 0500LT.

(iv) October: figure 3d

Spread f occurs between 1900LT and 0700LT for the month of October. At 2000LT the number of occurrence reaches its peak at 25days of the month. At 0700LT the least number of occurrence of 5 days is observed.

3.2.1 Summary of Results of Occurrence Rate.

It is pertinent to note from the above inferences that spread f occurs most at between hours of 2000LT and 0100LT. This Unique observation conform with what was suggested by Dieminger et al 1995 on his study of spread f.

At equinoxes (April, October). Spread f occurs throughout the period of 1900 to 0700LT with the spread reaching its maximum at 29 days for April. Also here at 1900LT the occurrence rate is as high as 23 days for October.

At solcities (January, July) spread f does not necessarily occur throughout the periods of 1900 to 0700LT. For July especially spread f occur between 2000LT and 0500LT and disappear before and beyond this hours. Here, we have the highest number of occurrence of 30 days at 2000LT for January.

Result of the Height of Occurrence.

The minimum and maximum heights of occurrence of spread f were also observed and the following inference deduced from the graphs.

Table 3.2a: Occurrence Statistics for January

NO OF OCCURRENCE (N)	LOCAL TIME (LT)	Jan
8	19	
29	20	
30	21	
27	22	
23	23	
26	0	
23	1	
23	2	
24	3	
21	4	
22	5	
17	6	
6	7	

Table 3.2b: Occurrence Statistics for April

NO OF OCCURRENCE (N)	LOCAL TIME (LT)	April
4	19	
29	20	
28	21	
28	22	
27	23	
27	0	
25	1	
26	2	
24	3	
16	4	
8	5	
7	6	
3	7	

Table 3.2c: Occurrence Statistics for July

NO OF OCCURRENCE (N)	LOCAL TIME (LT)	July
0	19	
24	20	
24	21	
26	22	
27	23	
28	0	
28	1	
28	2	
28	3	
18	4	
14	5	
0	6	
0	7	

Table 3.2d: Occurrence Statistics for October

NO OF OCCURRENCE (N)	LOCAL TIME (LT)	Oct
23	19	
25	20	
22	21	
22	22	
21	23	
21	0	
21	1	
20	2	

18	3	
16	4	
13	5	
16	6	
5	7	

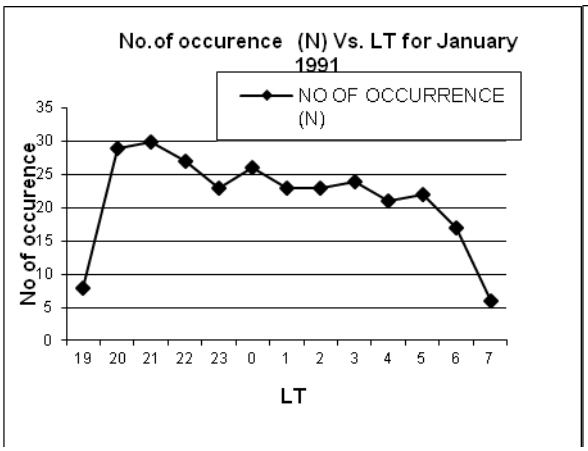

Fig. 3a: Number of occurrence vs LT for January

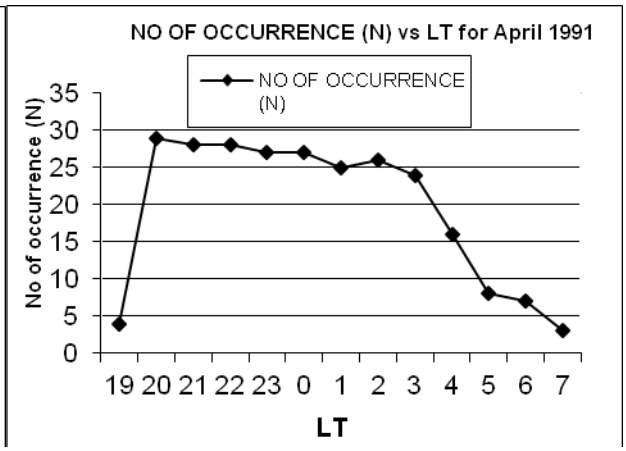

Fig. 3b: Number of occurrence vs LT for April

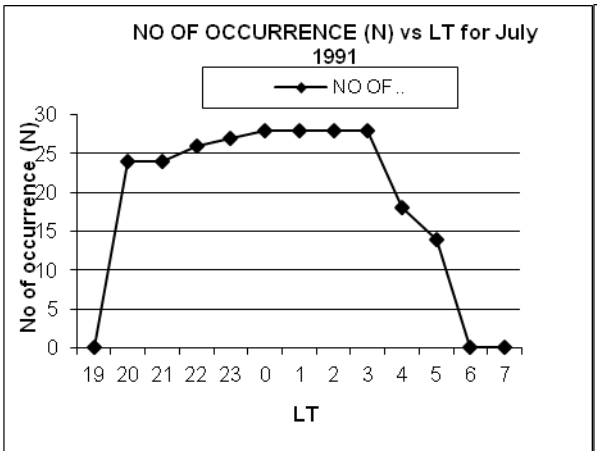

Fig. 3c: Number of occurrence vs LT for July

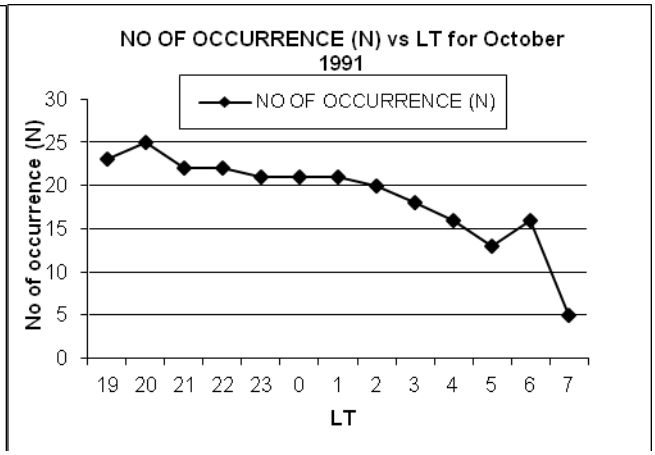

Fig. 3d: Number of occurrence vs LT for October

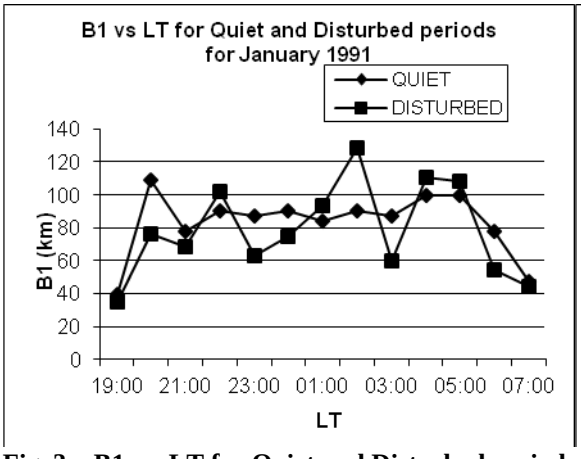

Fig. 3e: B1 vs. LT for Quiet and Disturbed periods

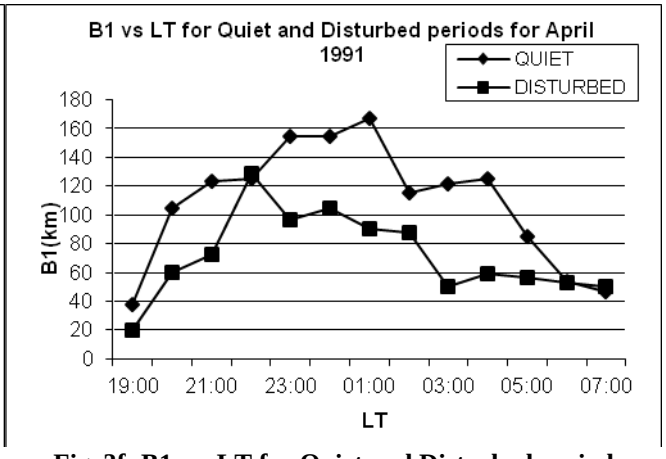

Fig. 3f: B1 vs. LT for Quiet and Disturbed periods

For January **for April**

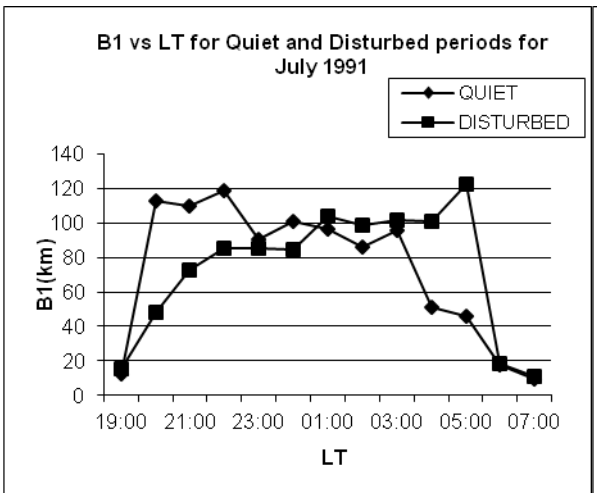

Fig. 3g: B1 vs. LT for Quiet and Disturbed periods For July

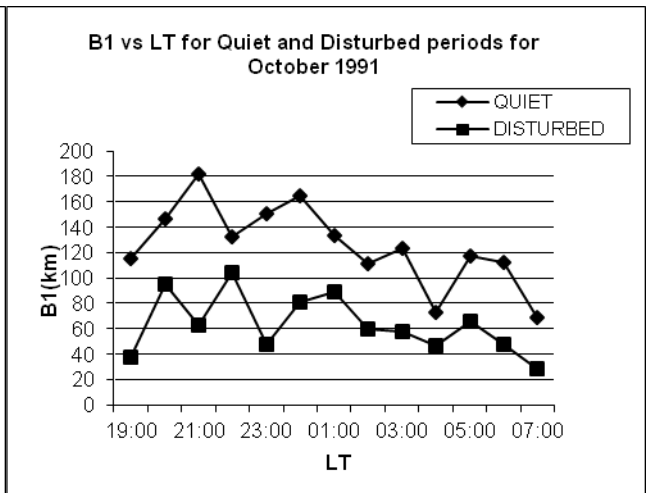

Fig. 3h: B1 vs. LT for Quiet and Disturbed periods for October

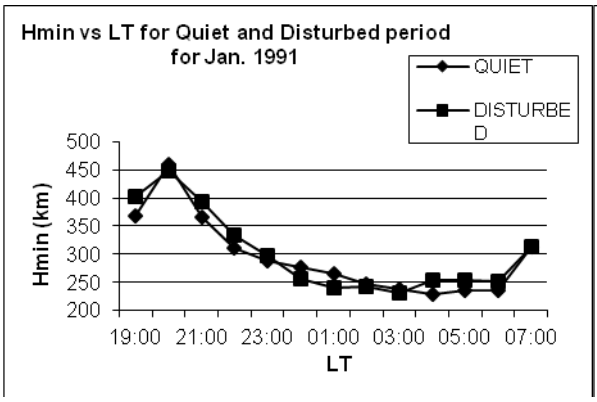

Fig. 3i: Hmin vs. LT for Quiet and Disturbed period For January

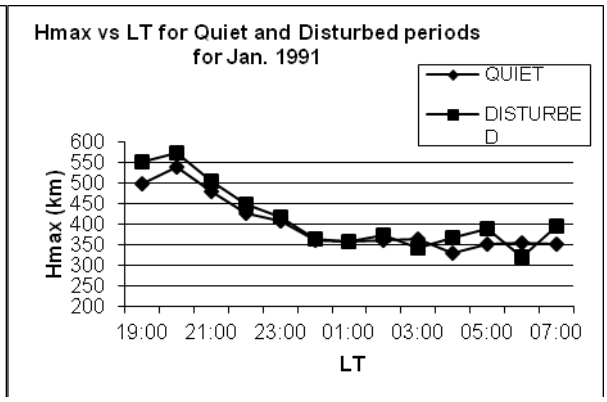

Fig 3j: Hmax vs. LT for Quiet and Disturbed period for January

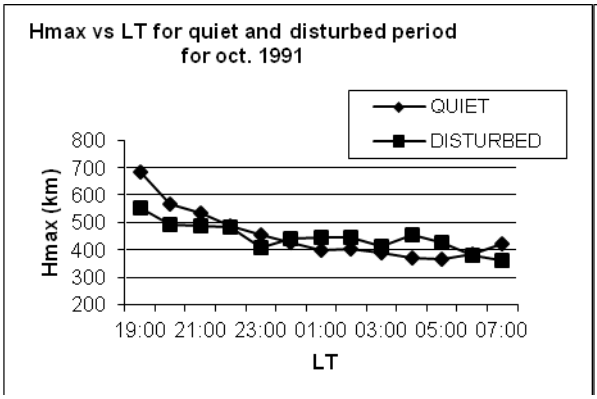

Fig. 3k: Hmin vs LT for Quiet and Disturbed period for January

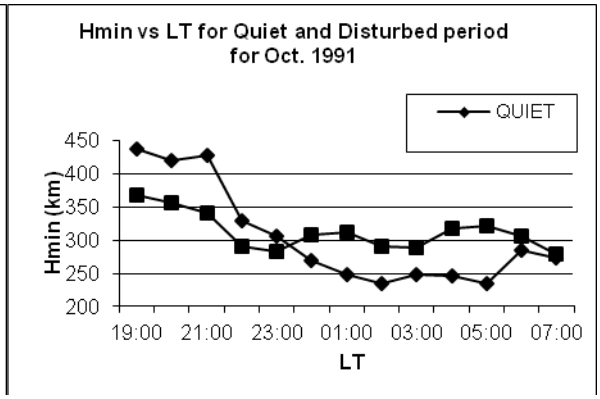

Fig 3l: Hmax vs LT for Quiet and Disturbed period for January

i. **January: figures 3i and 3j**

The maximum height of occurrence (Hmax) is greater at the 2000LT with the height of 580.996km and least at 0400LT at the height of 340.5242km. Hmin (minimum height of occurrence) is also greater at the 2000LT with the height of 449.74798km and least at 0400LT with the height of 237.19758km. The curve of the variation of Hmin with the LT is similar in pattern.

ii **October: figures 3k and 3l**

For the month of October Hmax reaches its peak value at 1900LT at a height of 653.8996km and least at 0500LT at the height of 371.2379km. Hmin also has its highest value at the 1900Lt with the value of 442.7520km and least value at 0200LT with the height of 248.67742km.

The curves of Hmin, Hmax with the local time also follow the same trend.

According to Diemenger 1995, spread F which is the region of maximum electron density and occurs mostly between the height of 220 and 500km.

The height range of both the Hmin and Hmax of the spread fall within this ranges of height except for some exceptional cases where the maximum height is slightly above this 500km. This observed height ranges can thus be said to conform with the theoretical values.

At equinoxes (April, October) the maximum height of occurrence is as high as ~650km, while for solcities (January, July) it is as high as ~580km. The reason for the higher value of Hmax at equinox than solcities is due to the fact that equinox is more magnetically disturbed than solstices. Hence, the every likelihood of vertical movement of electrons in the F2 region in the upper direction. This conform with the observation of Adeniyi J.O et al 1998 in the study of the effect of magnetic storm on the bottomside profile parameters.

4.0 Summary of result of quiet and disturbed periods

The interesting thing is that spread F is observed both at very quiet and disturbed period. This observation conform with what Soicher H. et al observed in their study of spread of during quiet and disturbed period.

At both equinox and solstices the variation in the height of occurrence of disturbed and very quiet period were less in the day time but in the evening and night time they exhibit a very wide variation this also conform with theoretical observation made by Soicher in his study.

4.1 Result of thickness of occurrence (B_1)

The graph of thickness of occurrence against Local time was also plotted for both very quiet period and magnetically disturbed period. Very interesting results were obtained;

(i) **January: figure 3e**

Spread F is very thick in the evening time for very quiet period from i.e from 1960 to 2300LT the night to the early morning the thickness of the spread is more for the magnetically disturbed period than the quiet periods.

(ii) April: figure 3f

Here, the thickness of spread f is more for the quiet period that the disturbed period throughout i.e both in the evening and night periods till the early hour of the day.

(iii) July: figure 3g

Between the hours of 1900 to midnight the thickness of spread is higher for the quiet period and that of the disturbed period becomes higher than that of very quiet period for from 0100LT upward.

(iv) October: figure 3h

The thickness of spread f is always more for the quiet period than the magnetically disturbed period. It is also important to note here that the graph follow the same pattern.

4.2 Summary of result for thickness of Occurrence for quiet and disturbed period B_o and B_1

The most interesting thing to note here is that at equinox (April, October) the values of the thickness of spread f is higher for the quiet period that the disturbed days throughout. Whereas, at solstices (January, July) it is only in the evening period that the thickness of the quiet period is more than that of the disturbed period.

The difference in the thickness of the spread in the f2 layer at quiet and disturbed period is due to movement of ionization in the vertical direction. From the study of Adeniyi and Redicella on the effect of magnetic storm on the thickness of

spread in the F_2 layer we were made to understand that the main effect of magnetic storm on the thickness of spread is observed only in the day time i.e between 0700 and 1700LT. This is the reason why the thickness for the quiet period is always greater than that of the disturbed periods especially at equinox.

Conclusion

The result of this work can be concluded that spread F, which is the irregularities in the F region is a phenomenon that occur mostly in the night time, the quiet and disturbed magnetic conditions for all the seasons of the year ie at both equinoxes and solcities. In most cases there is no spread F occurrence in the day time. The average height of occurrence of spread –f as in this work is between 200 and 600km into the ionosphere.

Between the hours of 2100 and 0100LT is when spread – F is thickest as shown in his study. It is important to note here that the thicker the spread, the longer radio signal stays in the ionosphere before returning back to the earth receiver. Except in some cases the thickness of spread F for the quiet period (B_1) is always more than that for the disturbed period especially in the evening periods.

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