CHAPTER 5

COMPARATIVE STUDY OF VHF SCINTILLATIONS DURING LOW AND HIGH SOLAR ACTIVITY PERIODS
CHAPTER 5

COMPARATIVE STUDY OF VHF SCINTILLATIONS DURING LOW AND HIGH SOLAR ACTIVITY PERIODS

5.1 INTRODUCTION

Studies of Ionospheric and Spread-F scintillations at equatorial latitudes reveal the existence of an intense belt of Ionospheric irregularities in the nighttime F-region. This poses a serious problem to the design and operation of satellite radio communication systems in the frequency range of 100 MHz to several GHz band. So to understand the dynamic characteristics and seeding mechanisms of these equatorial ionospheric irregularities many techniques have been employed such as HF Ionosonde, air glow photometers, VHF-radars, rockets and satellites. The above studies have established that, at least during the development phase of an irregularity event, meter to kilometer scale sizes of irregularities co-exist (Farely et al., 1970; Woodman and Lattoz, 1976; Morse et al. 1977; Tsunoda and Towle, 1979). Anderson and Haerendel (1979), Abdu et al. (1983,1985) in Brazil and Dabas and Reddy (1990) in the Indian zone using multi-station scintillation measurements determined the plasma bubble-rise- velocities strongly depend on the east-west electric field of F-region dynamo.

Somayajulu et al. (1984) and Dabas and Reddy (1986) established that the latitudinal extent of post-sunset scintillation-producing irregularities during
equinoctial periods of high sunspot years are essentially controlled by the
generation and growth of plasma bubbles and associated F-region irregularities
over the magnetic equator, based on multi-station VHF nighttime scintillation
observations in the Indian zone.

The occurrence patterns of amplitude scintillations of trans- ionospheric
radio signals vary significantly at equatorial and near-equatorial regions. Their
morphological features largely depend on local time of the day, season, sunspot
number and the ambient conditions of the Ionosphere (Krishna Murthy \textit{et al.},
1979). Maruyame and Matuura, 1984) showed evidence that the ionospheric
irregularities are magnetic field aligned and these field lines control the
movement of irregularities to a great extent. Abrupt, changes in several
parameters, such as the vertical drift velocity of the Ionospheric F-layer, the
neutral wind velocity and the ion-neutral atom collision frequency, play an
important role in the triggering process (Aarons, 1993) of the Ionospheric
irregularities.

5.2 DATA AND METHOD OF ANALYSIS

In general the VHF scintillation studies are made for investigating the
phenomena of F-layer and Ionospheric irregularities for different geographic
locations of low, mid and high latitudes. This kind of research will provide the
useful information in understanding the dynamics of the ionosphere and its
characteristics. In the present study an attempt has been made to compare
characteristic features of scintillations recorded at this near equatorial station
Anantapur during the low solar activity period (2005-06) and high solar
<table>
<thead>
<tr>
<th>Station</th>
<th>Geographic Location</th>
<th>Sub-inospheric point Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td>Wallair</td>
<td>17° 7' N</td>
<td>83° 3' E</td>
</tr>
<tr>
<td>Anantapur</td>
<td>14° 7' N</td>
<td>77° 6' E</td>
</tr>
</tbody>
</table>

Fig 5.1: Details of the network stations (dashed line denotes the geographic longitudes and the solid lines geomagnetic field lines)
activity period (1997-99) for 250.649 MHz FLEETSAT satellite radio study since beacon signals positioned at 73° E longitude. The geographical location of this station along with the co-ordinates is as shown in fig.5.1. The following parameters are taken into consideration for comparison and understanding the phenomenon of VHF scintillations at this near equatorial station. They are:

(i) Typical scintillation records occurrence on the same day of both the periods.

(ii) Diurnal and seasonal variations in the occurrence of night time Scintillations.

(iii) Occurrence of day time scintillations.

(iv) Effect of Solar activity on VHF scintillations.

(v) Effect of magnetic activity on VHF scintillations

(vi) Drift velocities of ionospheric irregularities

(vi) Patch durations.

5.3 RESULTS AND DISCUSSION

5.3.1 Occurrence of Scintillations on certain Typical Days

Fig. 5.2 is a typical plot showing the duration of occurrence of scintillation at Anantapur for both the periods. It may be seen from this figure that the scintillations occur in patches of small, long, and very long durations in both the periods. The possible reasons for a good correlation between scintillations on certain days and absence of clear correspondence between
Fig 5.2: A plot showing the occurrence of VHF scintillations on some typical days at Anantapur
scintillations on certain other days are described in the following sections of this chapter.

Fig. 5.3 shows the typical record of nighttime scintillation on 6th March 1998 at Anantapur and Waltair and also of 6th March 2006 of Anantapur. The onset of scintillation occurs at Anantapur around 2020 hrs LT (98), 2017 hrs LT (06) and at Waltair around 2032 hrs LT (98) with a delay of 12-15 minutes. The scintillation occurrence is single patch at both stations during 98. The scintillation duration at Anantapur shown in middle panel is between 2020 and 2115 (55 minutes duration) and the top panel shows the occurrence of scintillations at Waltair between 2032 and 2203 hrs LT (91 minutes duration), but in 2006 the bottom panel shows the occurrence consists of two patches of duration 2017-2040 hrs LT (23 minutes) and 2118-2230 hrs LT (72 minutes).

In Fig. 5.4, the top panel shows the record at Waltair, the middle panel shows the record of scintillations at Anantapur. On 6th April 1998 and bottom panel shows the scintillation record of 6th April 2006 at Anantapur. It is observed from the figure that the scintillations started around 2133 hrs LT at Anantapur, 2137 hrs LT at Waltair (98) and at 2025 at Anantapur (06) with onset delay of 4-12 minutes.

It is observed from the above patches that the scintillation occurred at Anantapur consists of three patches with durations spread between (2133 - 2146), (2204-2345), (2258-0120) hrs LT. At Waltair also scintillations occurred as three patches with durations spread between (2137-2204), (2752-0036), (0115-0234) hrs LT. The scintillation occurrence in 2006 at Anantapur
Fig 5.3: Typical Sample records of Night time Scintillations recorded simultaneously at Anantapur and Waltair on 06th March 1998 and 06th March 2006 at Anantapur.
Fig 5.4: Typical Sample records of Nighttime Scintillations recorded simultaneously at Anantapur and Waltair on 06\textsuperscript{th} April 1998 and 06\textsuperscript{th} April 2006 at Anantapur
also consists of three patches during (2025-2031), (2120-2341) and (2349-0000) hrs LT. It is interesting to note from this figure that the patch durations are increasing from first patch to third patch both at Anantapur and Waltair (98). But the durations of patches at Anantapur are comparatively longer than the patch durations at Waltair and the occurrence is almost continuous at Anantapur and it is discrete at Waltair. The scintillations are of Category-I type at both places. But the scintillation record at Anantapur (06) compared to Anantapur (98) it is interesting that the scintillation activity is more and consists of category II, III and IV. The onset and decay of scintillation at Waltair is abrupt, whereas at Anantapur the onset is gradually increasing and decreasing and some times with abrupt ending and ending.

5.3.2 Monthly variation of Scintillations occurrence

The variations in the monthly sunspot numbers and percentage occurrence of scintillations at a near-equatorial station Anantapur for pre and post-midnight hours during the period 1997-98 with Rz = 62.5 is a high solar active period compared to 2005-06 with Rz=25.32 are presented in Fig. 5.5 (a,b,c) respectively.

From the figure, it is observed that the scintillation occurrence is predominant during the pre-midnight hours. It is interesting to note that the percentage of scintillation occurrence at Anantapur is maximum in January 2006 around 58.06% as compared to February 1998 around 52.23% during pre-midnight hours of winter season and the maximum occurrence of post-midnight scintillations occurs during March 2006 and March 1998 of equinox season of
32.26% and 64.34% respectively. It is also observed that the percentage of scintillation occurrences at Waltiar is also maximum during March 1998 with 62.9% during the pre-midnight and 48.1% during the post-midnight.

5.3.3 Effect of Solar Activity on Scintillation Occurrence

It is known from the earlier studies that the solar activity primarily controls the occurrence of scintillations (Rama Rao et al 1980, Das Gupta et al 1981, Rastogi 1982, Rama Rao et al 1985, Thyagi and Das Gupta 1990, Pathan et al 1992). Thus there was a suggestion that the solar control of scintillation activity is more pronounced at temperate latitude than at an equatorial latitude (Thyagi and Das Gupta 1990, Pathan et al 1992). Present station Anantapur falls in the near equatorial region and it is expected that the scintillation activity may show some dependence on solar activity.

Hence an attempt is made by the author to compare the occurrence of scintillations during the moderately high solar active period 1997-98 with minimum Rz =12.7 (December 98) and a maximum Rz =92.9 (September and March 98), and the low solar activity period 2005-06 of minimum Rz=4.7 (February 2006) and maximum Rz=42.7 (May 2005). The occurrence of pre and post-midnight scintillations during these periods are presented fig. 5.5. It is readily seen from the figure that there is strong control of solar activity on the occurrence of scintillations for the months from April 2005 to January 2006 and the scintillation activity for both pre and post-midnight hours is found more during the low solar activity period as compared to moderately high solar activity period during the months from April 05 to January 06 and it is reverse
Figure 5. Monthly average % occurrences of Pre & Post-Midnight Scintillations at Anantapur during High solar (1997-98) and Low Solar (2005-06) active periods.
for the months of February 06 to April 06 it may be due to local conditions and the location of the station near equatorial region.

The monthly average sun-spot number $R_z$ is also plotted in Fig 5.5. On a closer observation, the influence of sun-spot activity on the scintillation activity during 1997-98 at Anantapur reveals the gradual increase and the trends of scintillations are also similar. But in the case of 2005-06 the scintillation activity is not following for the months of March 05 to October 05 and later months following the sunspot activity. Further, the correlation coefficient between pre-midnight scintillations of 97-98 and 05-06 is $R_{pre} = 0.016$ and for post-midnights $R_{post} = -0.060$, for the over all night time scintillations $R_{night} = 0.247$. The correlation co-efficient of pre and Post-nights of 97-98 is 0.863 where as for 05-06 it is 0.547. This clearly indicates that the scintillation occurrences are more in 2005-06 compared to 1997-98. The results are consolidated and presented in Table 5.1.

From the earlier studies, Rama Rao et al. (1985) reported that the occurrence of scintillations during pre-midnight hours is greater than that of the post-midnight hours in all the months and also reported that the occurrence of scintillations is minimum except during equinoctial months of 1984 where the solar activity is considerably high ($R_z = 60$). They have also reported that there is no significant scintillation activity during summer months during this low sunspot activity period.
Table 5.1
Results of the correlation studies between the Night time VHF Scintillations at Anantapur

<table>
<thead>
<tr>
<th>Correlation between</th>
<th>Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-mid night Scintillation activity of 97-98 and 05-06</td>
<td>0.016</td>
</tr>
<tr>
<td>Post-mid night Scintillation activity of 97-98 and 05-06</td>
<td>-0.060</td>
</tr>
<tr>
<td>Pre and Post-midnight Scintillation activity of 97-98</td>
<td>0.863</td>
</tr>
<tr>
<td>Pre and Post-midnight Scintillation activity of 05-06</td>
<td>0.547</td>
</tr>
<tr>
<td>Over all Nighttime scintillation activity of 97-98 and 05-06</td>
<td>0.247</td>
</tr>
</tbody>
</table>

Das Gupta et al. (1981) studied the characteristics of VHF scintillations at Calcutta (22.6°N, 88.4°E), a station near the anomaly crest in the Indian zone revealed that with increasing sunspot activity the occurrence of scintillations increases remarkably during winter, while the occurrence during the local summer showed a little change. Rastogi et al. (1990) have shown that the equatorial scintillation activity decreases much faster with the decrease of sunspot activity in the Indian sector than in the American sector.

5.3.4 Seasonal Variations of Nighttime Scintillations

The average diurnal variations of percentage occurrences of nighttime scintillation activities during the three seasons namely, equinox, winter and summer at Anantapur during high and low solar activity period of March 1997 to April 1998 and March 2005 to August 2006 are presented in Fig. 5.6. From
this figure it is seen that the scintillation occurrences observed at this near equatorial station Anantapur are higher during high solar active period 1997-98 as compared with scintillations during low solar activity period 2005-06 for all the three seasons. Further, the scintillation occurrences are maximum in equinox followed by a moderate activity in winter and a meager activity in summer except during summer season of 2006.

It is also interesting to note that the peak scintillation activities are observed around 2200 hrs LT during equinox, 0000 hrs LT in winter at Anantapur. During summer a minor peak around 0000 hrs LT is observed at Anantapur during the high solar activity period 1997-98. But, during the low solar activity period the peak scintillation activities are observed around 2200 hrs LT in equinox, 2300 hrs LT in winter and 0030 hrs LT in summer.

From the figure it also observed that the seasonal peak occurrence of scintillations is maximum around 20.9% in equinox, around 15.7% in winter followed by 4.3% in summer at Anantapur during 1997-98 where as in 2005-06 the scintillation activity is maximum around 29.18% in equinox 05 and 31.5% in equinox 05-06, 24.31% in winter and 18.44% in summer 05 and 47.83% in summer 06. From above overall observations the percentage of scintillation activity is around 16.65% more during 2005-06 compared to 1997-98. It may be due to typical characteristics of this near equatorial station and to confirm this further investigations should be carried out at this station.

The onset of scintillations is around 1800 hours LT in equinox followed by winter at 2000 hrs LT and in summer around 2130 hrs LT at Anantapur
Figure 5.6: Seasonal Variations in occurrence of Scintillations summer, winter and equinox during High solar (1997-98) and low solar (2005-06) activity period at Anantapur.
during 97-98 and during the period 05-06, the onset is around 1830 hrs LT in equinox, winter and 1845 hrs LT in summer hrs LT. In general, the trends shown by scintillations that the onset time scintillations are earlier in 05-06 except in equinox. The results of all these observations are consolidated and presented in Table 5.2 and 5.3.

Rama Rao et al. (1994) at Nuzivid (16.8°N, 80.8°E) and Vali et al (1994) at Nagapur (21°N, 79°E) studied the amplitude scintillations at a low latitude station, during April 91 to April 93 and reported the seasonal occurrence of scintillations is maximum during equinox followed by winter and summer. Vyas and Chandra (1994) reported that the maximum occurrence of scintillations is around 2100 hrs LT during equinox. While Rama Rao et al. (1990) at Waltair and Gupta et al. (1983) at Delhi (28° N 77° e) during the high solar active period, 1979-80 have reported maximum (50%) occurrence of scintillations during summer, which drops to 10% during winter.

Table 5.2
Seasonal variation of Scintillation activity at Anantapur during 97-98 and 05-06

<table>
<thead>
<tr>
<th>Scintillation Activity period</th>
<th>Season</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equinox</td>
<td>Winter</td>
<td>Summer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peak</td>
<td>Onset</td>
<td>Peak</td>
<td>Onset</td>
<td>Peak</td>
</tr>
<tr>
<td>1997-98</td>
<td>2200 Hrs</td>
<td>1830 LT</td>
<td>0000 Hrs</td>
<td>2000 Hrs</td>
<td>0000 Hrs</td>
</tr>
<tr>
<td></td>
<td>2005-06</td>
<td>2215 LT</td>
<td>1840 Hrs</td>
<td>0031 Hrs</td>
<td>1830 Hrs</td>
</tr>
</tbody>
</table>
Table 5.3
Maximum Percentage occurrences of Scintillations at
Anantapur during 97-98 and 05-06

<table>
<thead>
<tr>
<th>Period</th>
<th>Season</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equinox</td>
<td>Winter</td>
<td>Summer</td>
</tr>
<tr>
<td>1997-98</td>
<td>20.9%</td>
<td>15.7%</td>
<td>4.3%</td>
</tr>
<tr>
<td>2005-06</td>
<td>29.18%</td>
<td>24.31%</td>
<td>18.44%</td>
</tr>
</tbody>
</table>

The significant characteristics of nighttime scintillations presented above for high and low solar activity periods are summarized as follows.

(i) The occurrence of scintillations are observed continuously during the both the periods at this near equatorial station Anantapur, and the scintillations in patches of varying durations are observed more in 2005-06 compared to 1997-98.

(ii) The onset of scintillations during 1997-98 are generally abrupt type and found that the onset of scintillations are earlier in 2005-06 except in equinox compared to 1997-98.

(iii) Equinoctial maxima in occurrence are prominent followed by winter and summer respectively during both the periods except in summer 06

5.3.5 Effect of Magnetic Activity on Scintillations Occurrence

To study the effect of geo-magnetic activity on the percentage occurrence of scintillations, international Magnetically Quiet and Disturbed days are selected during the period 1997-98 and 2005-06 from each monthly data out of the entire period observations mentioned above. The average percentage occurrence of scintillations at Anantapur for the Quiet and disturbed
Fig 5.7: Magnetic activity effect on Scintillation occurrence at Anantapur during Quiet and Disturbed days of 1997-98 and 2005-06
days are presented in Fig. 5.7. In general, it is seen from this figure, that the occurrence of nighttime scintillations is found to be lower on magnetically Disturbed days, when compared with the occurrence on magnetically Quiet days during both the periods of high and low solar activity. However, occurrence of scintillations during the early sunset hours (1830 - 1945 hrs LT) for both periods, but during 05-06 before the early hours of sunrise (0500-0600hrs LT) is slightly higher on disturbed days than on Quiet days. These results are in good agreement with the results reported from the equatorial and low altitude stations (Rastogi et al., 1990; Mathew et al., 1992 and Singh et al., 1993).

5.3.6 Distribution of Scintillation Patch Durations

Amplitude scintillations are found to occur in large numbers as discrete short-duration patches, long and very long duration patches at this near equatorial station, Anantapur for both the periods of 97-98 and 05-06. During the period from March 1997 - April 1998, out of 328 days scintillations are observed for 106 days and out of 426 days the scintillations are observed for 224 days during the period March 2005 -April 2006 at Anantapur. The total number of patches observed is 135 in 97-98 and while those observed during 05-06 are 227. These patch durations observed at Anantapur during both the periods are presented in Fig. 5.8. The number of patches with durations less than 180 min at Anantapur is 115 and 142, and patches with duration more than 180 min are 20 and 52 during 97-98 and 05-06 respectively. These observations show that the occurrence of different patch durations are higher
Figure 5.8: Distribution of scintillation patch durations at Anantapur during High solar (1997-98) and Low Solar (2005-06) active periods.
in 05-06 compared to 97-98 except 30 minute duration patches at this near-equatorial station, Anantapur.

5.3.7 **Daytime Scintillations**

In general from Ionospheric scintillation observations studied at equatorial and low latitude stations using VHF signals from orbiting and geostationary satellites is a nighttime activity of transionospheric signals caused by F-region ionization density irregularities has been one of the most intensively studied phenomenons. In contrast, daytime scintillation activity has not received much attention mainly because of its mild nature and relatively less frequent occurrence. Near the magnetic equator daytime scintillation activity at VHF is more or less a regular phenomenon (Krishna Murthy *et al.*, 1979). At low latitudes, during certain months of the year, daytime scintillation activity at VHF has been observed to be quite frequent.

The present study reports the results of an investigation of daytime scintillation obtained both for 97-98 and 05-06 during high and low solar activity period at this near-equatorial station, Anantapur. From the present observations, it is found that the daytime scintillations have their maximum occurrence for both periods around noontime. Daytime occurrence of scintillations is rather low during the period of observations from March 1997 to April, 1998 pertaining to high solar activity period Rz = 62.5. Where as in case of the period March 2005 to April 2006 pertaining to low solar activity period Rz=25.54 is around 5% higher. These daytime scintillation events observed can be grouped into two categories, viz.
Figure 5.9: Monthly Occurrences of Daytime Scintillation Events at Anantapur during High (97-98) and Low (05-06) Solar Active Periods
(i) An extension of nighttime events into daytime hours and

(ii) Exclusive occurrence of scintillations during daytime hours (mostly pre-noon hours) of short duration.

A typical plot showing the daytime scintillations occurrence is shown in Fig. 5.9 for the above periods. Out of the total number of 222 days of observations during March 1997 to April 1998, daytime scintillation activity is observed for only 21 days and out of 189 days of observations 38 days of daytime scintillations present during March 2005-April 2006 at Anantapur. The daytime scintillation activity is around 10.65% more during low solar activity period compared to high solar activity period. It is noticed from this figure that these events show maximum occurrence during summer month of June in 05 and in March 97 and February 98 in equinox and winter months. The daytime events are attributed to Sporadic-E (Es) layer occurrence, which is also reported to be a localized phenomenon. Even in the earlier literature, the similarity in the occurrence of scintillation events during daytime, at the closely spaced stations, is not reported.

Similar results of summer daytime scintillations with peak occurrence around noon was reported earlier by Das Gupta and Kersely (1976); Rastogi and Muller (1981) and were reported to be associated with sporadic-E. Evidence of daytime scintillations and their association with sporadic-E at tropical latitudes was also shown by Sahu and Manohar Rao (1986) and Mathew et al. (1992). From the VHF scintillation data recorded at Haringhate
(22° N), Das Gupta et al. (1980) reported summer daytime scintillations with principal maximum in the pre-noon hours during the low solar activity period.

5.3.8 Drift of Ionospheric Irregularities

If the irregularities are present immediately after sun-set, they move from east to west, and later show drifts directed away from the equator (northwards for the Indian sub-continent). The sub-ionospheric points of the ray paths from Anantapur and Waltair are relatively situated (by about 250 Km latitudinal and about 750 Km longitudinally). Data of Scintillation Patches with similar characteristics occurring with time delays are chosen to compute the east-west and west-east movement of irregularities. Only 24 events of Scintillations exhibiting similar characteristics at Anantapur and Waltair could be observed over 390 days during March 1997 and April 1998.

Figure 5.10 presents typical scintillation records showing the Eastward drift velocities directed from Anantapur towards Waltair, while Fig. 5.11 presents scintillation records showing the Westward drift velocities directed from Waltair towards Anantapur. The typical record of nighttime scintillation on 6th March 1998, the onset of scintillation at Anantapur is around 2020 hrs LT and at Waltair around 2032 with a delay of 12 minutes. Similar scintillation recorded on 16th April, 1998 the onset of scintillation at Anantapur is around 2015 hrs LT and at Waltair around 2024 hrs LT with a delay of 9 minutes. The occurrence of scintillation at Anantapur is of modulated type of long duration patch (2015 to 2330 hrs LT) whereas the scintillation occurrence
Fig 5.10: Typical Scintillation record showing the Eastward drift velocities

Fig 5.11: Typical Scintillation record showing the Westward drift velocities
at Waltair has an abrupt starting and abrupt ending with two short duration patches.

Out of these 24 events, 15 of them have prior onset of scintillations at Anantapur and appear to be drifting North-Eastwards since Waltair is situated north east of Anantapur. The remaining 09 events show prior onset at Waltair and appear to be drifting south-west wards since Anantapur is situated south-west of Waltair. Thus the eastward drift of irregularities predominates, over the westward drift. Rastogi et al. (1990) showed that the drift of irregularities at equatorial latitudes was generally westward in the initial stages of formation of F-region irregularities and changed to eastwards when the irregularities were fully developed.

The velocity component in the movement of the irregularities in the west-east direction is calculated by taking the time difference in seconds divided by the distance between Anantapur and Waltair in meters. The velocity components thus computed range between 230 ms$^{-1}$ and 1244 ms$^{-1}$. The variation of eastward (west-east) drift velocities are presented in Fig 5.12(A). In similar manner Waltair to Anantapur i.e westward (east-west) drift velocities are also estimated and they are presented in Fig 5.12(B). These velocity components range between 248 ms$^{-1}$ and 1120 ms$^{-1}$. In both the cases higher drift velocities are observed immediately after sunset and the decrease in velocities is observed as dawn approaches. Further, the eastward drift is appears to be a whole night phenomenon observed between 1900 hrs LT
Fig 5.12: Zonal Drift Velocities of Ionospheric Irregularities
(A) Anantapur to Waltair(W-E) and (B) Waltair to Anantapur(E-W).
and 0400 hrs LT whereas the westward drift appears to be a pre-midnight phenomenon between 2000 hrs LT and 2300 hrs LT.

(i) When the irregularities occur soon after the sunset i.e. within 90 minutes after sunset, the onset of scintillations is seen earlier at low latitude station Waltair compared to Anantapur.

(ii) However, if the occurrence is delayed by more than 90 minutes after the sunset, then the onset of scintillation is first seen at Anantapur, the near-equatorial station followed by Waltair.

This is clearly shown in Fig. 5.12 (a,b). Similar results are reported from Bombay (Kopurkar and Rastogi, 1985) and Waltair (Rama Rao et al., 1988 and 1996) using the Geostationary satellite signals and from the multi-station studies in the equatorial region (Koparkar et al., 1991, Pathan et al., 1992). Spaced polarimeters were used by Abdu et al. (1985) to study the Zonal plasma drifts in Brazil. They noticed drifts of 230 m/s at 2100 hrs LT decreasing during the course of the night to about 80 m/s around 0300 hrs LT.

5.3.9 Scintillation Index (SI)

Scintillation Indices were computed and it is found that SI is varying between and 10-60% during 1997-98 and 5-52% during 2005-06 at Anantapur. The high values of scintillation indices confirm the presence of strong and moderately strong scintillations.
5.4 SUMMARY OF RESULTS

1. The association of the low latitude scintillations with those of the equatorial latitudes is well established (Somayajulu et al., 1984; Pathan et al. 1992), indicating that the occurrence of scintillations at near-equatorial latitudes and in low latitude belt is primarily controlled by the generation, growth and dynamics of the scintillation producing irregularities over the equator. The same results observed during 2005-06.

2. During the present study (2005-06), it is observed that out of the total days of observations during both the periods simultaneous data of scintillations available at Anantapur. Nelson et al. (1986) suggested that no spread-F event could be identified over low latitudes without a corresponding event over the equator; as these irregularities associated with field aligned plasma depleted regions which rise over the magnetic equator; where their generation is more favored.

3. Though the onset of scintillations is found earlier during 05-06 compared to 97-98 except in equinox. Basu et al. 1978 and Dabas and Reddy (1986) reported that the scintillations at off-equatorial latitudes observed only when the plume structure extends up to 1200 - 1300 Km over the magnetic equator. At lower latitudes, scintillations can be generated even if the plumes having lower heights and hence result in longer durations.
4. It is also reported that scintillations are observed continuously for longer durations at lower latitudes (near-equatorial) and as discrete patches at higher latitudes. This feature is in good agreement with the results reported here and from other similar studies (Chandra et al., 1993).

5. The sunset line moving westward at a velocity of nearly 500 m/s is a necessary condition to indicate but not sufficient to form a scintillation patch. However, during some evenings, irregularities are developed in a systematic manner and move westward.

6. It is also reported that scintillation patches seen 90 minutes after ionospheric sunset, appeared first in the west and then moved eastward. Similar results are also reported from the Indian sector (Rama Rao et al. 1988; Koparker et al. 1991; Pathan et al., 1992).

7. The irregularities show both eastward and westward drifts during the present period of observations, depending upon the time of the onset of scintillations. Westward drifts are observed if the onset of scintillations occur around 1930 hrs IST (which is less than 90 minutes after ionospheric sunset), whereas scintillations with late onset after (1930 hrs IST) show clear eastward drift of irregularities.

8. Further, the eastward drift of irregularities is observed to be a whole night phenomenon while the westward drift happens to be a pre-midnight phenomenon.
REFERENCES


