Equatorial Effects on Nighttime Pc3 Pulsations

Y S SARMA, T S SAstry & S V S SARMA
National Geophysical Research Institute, Hyderabad 500 007

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Nighttime Pc3 pulsations observed simultaneously during 1976-79 at Choutuppal (geomag. lat., 7°.5), an inland non-electrojet station and at Etaiyapuram (geomag. lat., -0°.6), a station near the dip equator, have revealed an enhancement of the meridional component at the dip equator. The enhancement factor of these nighttime signals shows a local time variation reaching a maximum value of about 2.0 around midnight. It is also noticed that, while the nighttime occurrences of Pc3s increased with increase in solar activity, the percentage of nighttime enhancement showed an inverse relation. The results are examined in the light of a possible mechanism for nighttime enhancement of SCs, SIs, etc. at the dip equator.

1. Introduction

Effects observed in geomagnetic variations at sites close to the dip equator have been receiving attention for more than two decades. It is well known that the geomagnetic fluctuations such as SCs, SIs, etc. are enhanced in amplitude during daytime at the dip equator and this enhancement is attributed to the influence of the equatorial electrojet. While the observational studies for the transient phenomena including SCs, SIs and other irregular fluctuations are fairly adequate, similar studies in the case of ‘pulsations’ have just begun. Interestingly, the magnetic pulsations are also reported to be showing amplification at the dip equator during daytime. Matuura was the first to report enhancement of Pc5 pulsation amplitudes at the equator. Recent works of Sarma, Jain and Srinivasacharya and Sastry et al. throw further light on this aspect revealing daytime enhancement in pulsation amplitudes of Pc3 and Pc4 classes at the dip equator in the Indian region.

The Pc pulsations are generally believed to be mainly daytime phenomena. But an examination of pulsation records from Etaiyapuram (geomag. lat., -0°.6) and Choutuppal (geomag. lat., 7°.5) has shown that the pulsations of the Pc class, particularly Pc3, Pc4, can be observed even during nighttime on many occasions. With a view to study the nighttime effects, if any, on Pc pulsations at the dip equator, a comparison of nighttime Pc3 pulsations (occurring between 1800 and 0600 hrs LT) was carried out from the simultaneous records of Choutuppal (a non-equatorial station) and Etaiyapuram (a station at the dip equator) obtained during 1976-79.

2. Data Analysis and Results

The stations at Choutuppal and Etaiyapuram are equipped with magnetic induction-type pulsation recording systems, having almost identical frequency response characteristics. The Choutuppal station was established in 1969 and that at Etaiyapuram towards the end of 1975. Thus simultaneous records are available from 1976 onwards. Pulsations are recorded at both the stations at two speeds, namely, 30 mm/min and 90 mm/hr, covering the period ranges 0.2-20 sec and 20 to more than 600 sec, respectively. For the investigation of Pc3 pulsations described in this paper, low frequency records (period range: 20-600 sec) are utilized.

It is noticed from a detailed examination of the pulsation records at either of the stations during the entire 4-yr period (1976-79) that Pc3 pulsations occur even during nighttime on many occasions. The duration of these Pc3 pulsation regimes is found to be often 1 to 3 hr, occasionally lasting for several hours. These signals appearing during nighttime are generally well defined, though with lesser amplitudes. A few typical examples of nighttime events observed simultaneously at Choutuppal and Etaiyapuram are presented in Fig. 1(a)-(d).

Data for nighttime Pc3 pulsation events occurring during 1800-0600 hrs LT are grouped seasonwise and yearwise and presented in Table 1. It may be seen from Table 1 that the nighttime Pc3 occurrences show an increase from 1976 to 1979. They also show a seasonal dependence with a preference for equinoxes and winter as compared to summer during each of the four years.

A peculiar feature noticed during the comparison of the nighttime records from Choutuppal and Etaiyapuram is that on some occasions the Pc3 pulsation amplitudes in $H_x$ component are enhanced at Etaiyapuram compared to those at Choutuppal.
Fig. 1[(a)-(d)]—Typical Pc3 events observed simultaneously at Etaiyapuram and Choutuppal showing \( H_x \) and \( H_y \) amplitude enhancement at Etaiyapuram.

Examples of simultaneous Pc3s at the two stations on four such occasions are presented in Fig. 1[(a)-(d)]. This feature is better appreciated through a quantitative examination of the data on Pc3 amplitudes at the two stations. For this purpose pulsation signals in \( H_x \) component, which are well correlated at both the places and having periods in the range 20-40 sec and amplitudes ~100 \( \text{my} \) and more, are used. The periods and amplitudes of well defined pulses are measured, and the amplitudes (in mm) are reduced to the field units (\( \text{my} \)) by means of the respective sensitivity factors. From these data the ratios \( H_x(\text{Et})/H_x(\text{Ch}) \) (designated as \( R_x \)) are computed for each of the events. The \( R_x \) values so obtained for 1976-79 are plotted against local time in Fig. 2. It is seen from Fig. 2 that during the main nighttime interval 2000-0300 hrs LT (excluding the day-night transition hours around 1800 and 0600 hrs LT) most of the points are above an \( R_x \) value of 1.25, reaching as much as 4.0 occasionally. The hourly mean value of \( R_x \) is seen to undergo variation with local time exhibiting a broad maximum (~2.0) around local midnight.

Another interesting feature is the yearly variation of the percentage of nighttime enhancements. Though the number of nighttime occurrences of Pc3 signals increased from the quieter year (1976) towards the active year (1979), the percentage occurrence of nighttime enhancements decreased from 56% in 1976 to 10% in 1979 (Table 1). Fig. 3 shows the yearly total
The document discusses equatorial effects on nighttime Pc3 pulsations. It includes a table showing seasonal and annual variations of nighttime (1800-0600 hrs LT) Pc3 pulsations for the period 1976-79, and a diurnal variation of the signal enhancement of nighttime Pc3 events ($R_x$) with $R_x > 1.5$. The table includes the number of nighttime Pc3 events ($N$), the number of Pc3 events which showed enhancement ($N_{R_x}$), and the annual sunspot numbers for the years 1976-79.

### Table 1—Seasonal and Annual Variations of Nighttime (1800-0600 hrs LT) Pc3 Pulsations for the Period 1976-79

<table>
<thead>
<tr>
<th>Year</th>
<th>Winter</th>
<th>Equinox</th>
<th>Summer</th>
<th>Total</th>
<th>Winter</th>
<th>Equinox</th>
<th>Summer</th>
<th>Total</th>
<th>Events showing enhancement</th>
<th>Sunspot number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>47</td>
<td>39</td>
<td>3</td>
<td>89</td>
<td>25</td>
<td>25</td>
<td>-</td>
<td>50</td>
<td>56.2</td>
<td>13</td>
</tr>
<tr>
<td>1977</td>
<td>63</td>
<td>33</td>
<td>38</td>
<td>134</td>
<td>10</td>
<td>4</td>
<td>7</td>
<td>21</td>
<td>15.7</td>
<td>28</td>
</tr>
<tr>
<td>1978</td>
<td>56</td>
<td>104</td>
<td>24</td>
<td>184</td>
<td>7</td>
<td>18</td>
<td>2</td>
<td>27</td>
<td>14.7</td>
<td>92</td>
</tr>
<tr>
<td>1979</td>
<td>50</td>
<td>37</td>
<td>28</td>
<td>115</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>10.4</td>
<td>155</td>
</tr>
</tbody>
</table>

### Discussion

Several types of geomagnetic phenomena are observed to show special characteristic features in the region around the dip equator. Apart from the well-known enhancement of $S_q$ variation due to equatorial electrojet, disturbance variations such as SCs, SIs, and other irregular fluctuations in the horizontal (NS) component tend to get amplified at the dip equator, particularly during daytime. Occasional nighttime enhancement at the dip equator of SCs, SIs, etc., is also reported for the American zone.

While Yacob and Khanna do not find any appreciable nighttime enhancement at the dip equator in India for irregular fluctuations, Kane finds occasional nighttime enhancement of SCs and SIs in the Indian electrojet region, particularly at Annamalainagar. In the case of irregular fluctuations, Onwumechilli and Ogbuehi reported a definite enhancement for most of the nighttime events in the African zone. Gupta reports some enhancement of nighttime SCs, SIs, and bays at Annamalainagar near the dip equator in the Indian zone but the enhancement is rather small in magnitude amounting to 10 to 20% only. Rastogi et al. did not find any nighttime enhancement of these features in the Indian zone, but reported a distinct amplification of these phenomena at the dip equator in the American zone. Thus, while daytime enhancement at the dip equator for these variations is unambiguous, the nighttime results do not seem to be conclusive, though there is some positive observational evidence for the nighttime enhancement in the American zone. Interestingly enough, the pulsation signal strength, like the SCs and SIs, also shows a very clear daytime enhancement at the dip equator as shown by Sarma and Sastry et al.
for the Indian zone. The results of the present study, besides pointing out the fact that the nighttime occurrence of Pc3 pulsations in the equatorial zone is not uncommon, bring out a clear enhancement of these nighttime signals at the dip equator. Though the enhancement seems to be occasional and does not exist for all the events that appeared during night, this feature, whenever it is seen, is found to be unambiguous and distinct.

In this connection it may be pointed out that daytime enhancement of SCs, Sls and other irregular fluctuations at the dip equator are attributed to the influence of the equatorial electrojet and, in fact, are shown to be very closely related to the strength of the electrojet as mentioned earlier. In the case of pulsations too, the enhancement at the dip equator can be considered to be in some way related to either or both of the possible mechanisms, viz. (i) convergence of magnetoacoustic wave mode as suggested by Matoura\(^1\) and (ii) the influence of the equatorial electrojet.

It is interesting to note here that Rastogi et al.\(^11\) attributed the nighttime enhancement of SCs and Sls in the American zone to the possible existence of remanent electrojet current system in the nighttime ionosphere. It may be conjectured that the nighttime Pc3 enhancement at the dip equator observed in the present study reflects, in part, the possible influence of such a remanent equatorial jet current system.

Further, in case if any such nighttime remanent electrojet current system should exist, it might be expected that it would also show day-to-day variability, like other ionospheric parameters, depending on ionospheric-magnetospheric conditions. In fact, the normal daytime electrojet current strength is shown to be inversely related to the magnetic activity\(^12\). From a study of electron density distribution observed for different magnetic conditions, Rastogi and Rajaram\(^12\) have shown that quiet magnetic conditions are analogous to the strong electrojet days, while weak jet conditions correspond to magnetically disturbed days. This analogy would help in understanding the yearly variation of nighttime enhancement of equatorial Pc3 events from solar quiet years to solar active years. This is because the increase in the nighttime Pc3 occurrences from solar quiet to solar active years could be due to increased magnetic activity level up to a certain limit as the solar activity increases, while the observed decrease in the percentage enhancement of nighttime events from solar quiet to active years may be due to weak electrojet conditions that might prevail during magnetically active periods as envisaged by Rastogi and Rajaram\(^12\).

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