Ionospheric Effects of the Leonid Meteor Showers Over Ahmedabad

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ABSTRACT

Rapid radio soundings were made over Ahmedabad (23.0° N, 72.4° E) during 17-19 November of years 1998 to 2001 to study the effects of the Leonid meteor showers in the ionosphere. Quarter hourly data for the years 1996-97 were also used. The occurrence frequency of the sporadic-E for the three nights of 17-19 November shows progressive increase from 1996 to 1998 followed by decrease. Some of the ionogram traces during the peak Leonid shower activity in 1998 and 1999 show multiple structures between 100 and 150 km, not seen in normal sporadic-E events.

INTRODUCTION

The Leonid meteor shower is known to have strong activity every 33 years, which is the period of the Tempel-Tuttle, the parent comet of the shower. During the last return in 1966, visible meteors with an hourly rate of 140,000-150,000 were reported in the West Coast of America [1]. A meteor outburst of Leonids was observed in November 1994 and strong meteor shower was predicted to occur in 1998 or 1999 [2]. One of the effects of the meteor showers is the enhanced activity in the formation of sporadic-E layers in ionosphere. Rapid radio soundings were made over Ahmedabad to study the effect of the Leonid meteor shower in the ionosphere. Ionograms recorded over Ahmedabad, Thumba and Kodaikanal during November 1998 showed an enhanced sporadic-E activity [3]. The ionospheric effects observed over Ahmedabad during the Leonid shower days for the years 1998-2001 are described here.

RESULTS

Daily mean percentage occurrence of sporadic-E over Ahmedabad for the three days of 17-19 November of years 1996 to 2001 from the hourly ionograms are shown in Fig. 1. An increase is seen from the year 1996 with mean occurrences

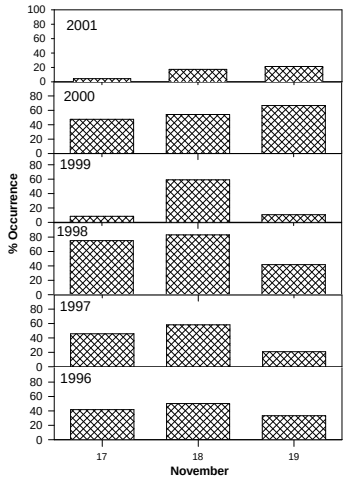


Figure 1. Daily mean percentage occurrence of sporadic-E over Ahmedabad for the days 17-19 November of years 1996-2001 based on hourly data.

less than 40% during 1996, less than 50% during 1997 and reaching 80% during 1998.

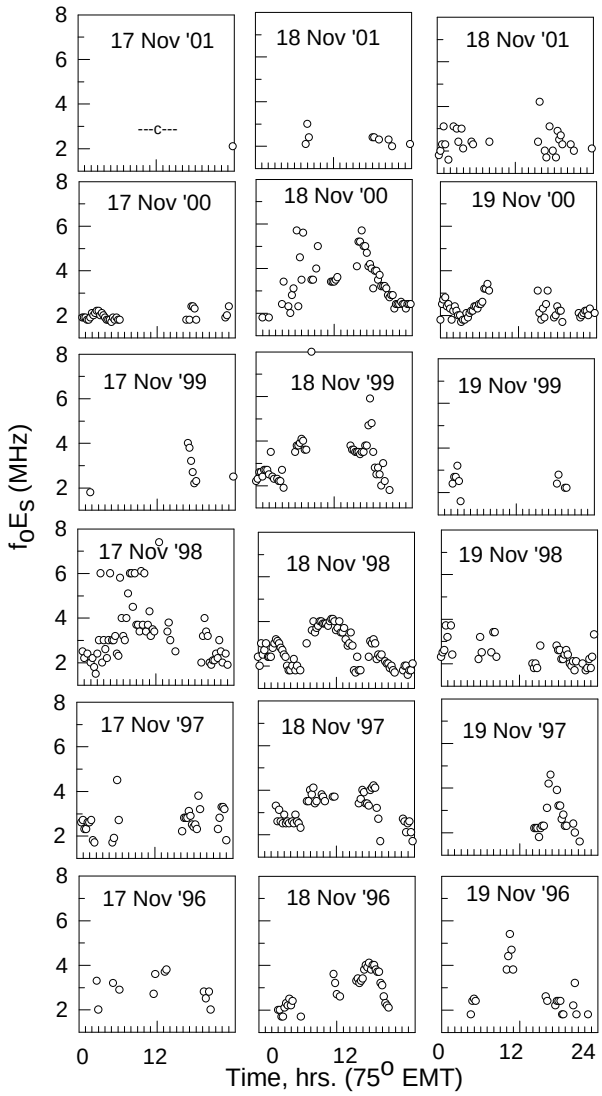
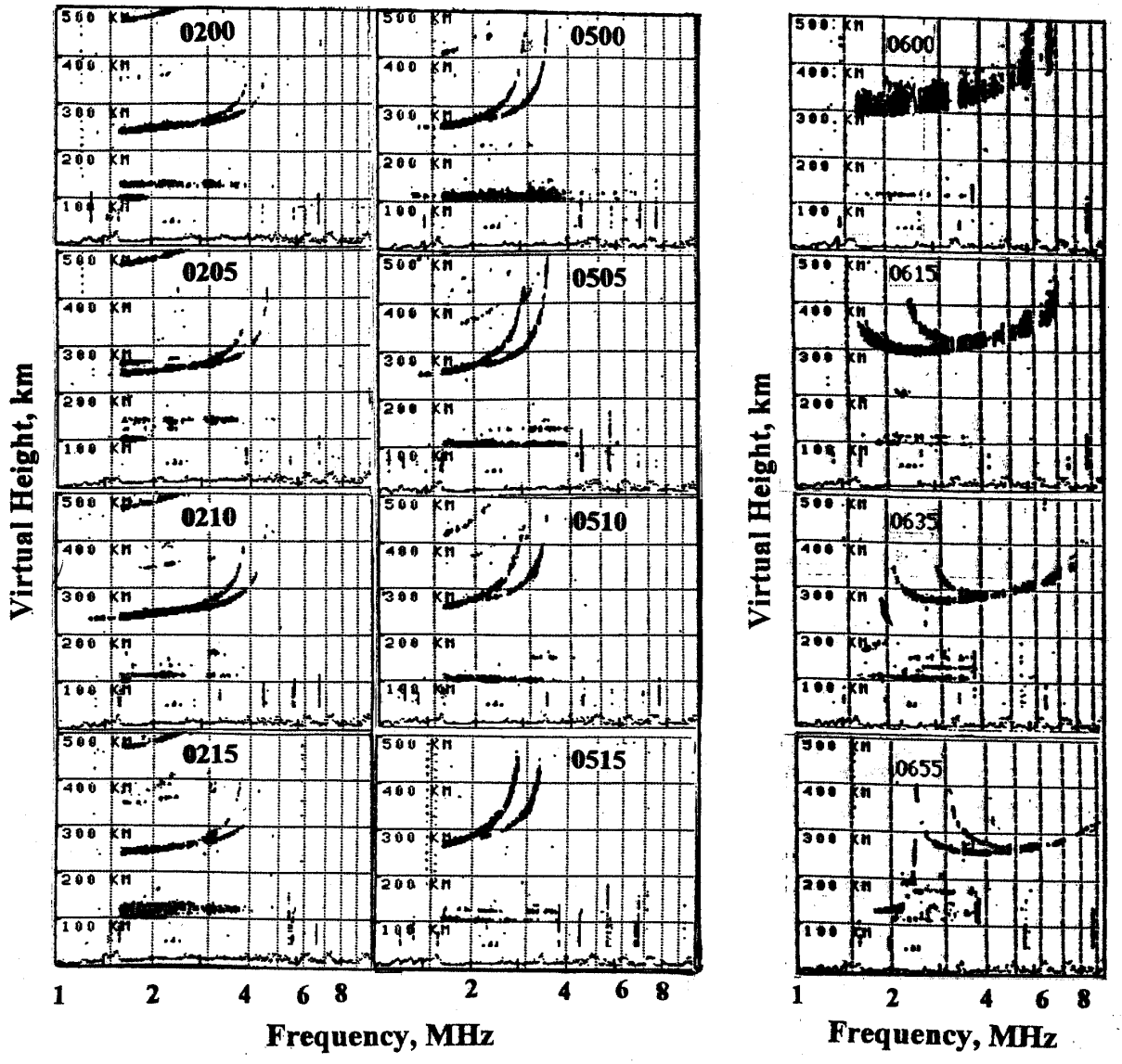


Figure 2. Daily variations of f_oE_s over Ahmedabad for the period 17 to 19 November for the years 1996-2001 from the quarter hourly data.

The occurrences are less than 60% for the years 1999-2001. The daily variations of the quarter hourly values of f_oE_s, the critical frequency, for the three days (16-18 November) of the years 1996 to 2001 are plotted in Fig. 2. The progressive increase in the number of points for the years 1996 to 1998 indicates the increase in the occurrence of sporadic-E from the year 1996 to 1998. There is an increase in the value of f_oE_s in the early hours (around 04h) on 18 November 1998. An increase is also seen between 01 and 02h of 19 November 1998. However looking at the points during the night of 17-18 November only, one can see a progressive increase from 1996 to 1998 and then decrease. Thus there is evidence for the meteor shower activity enhancing the ionization of sporadic-E layers.

Few selected ionograms recorded over Ahmedabad during the early hours of 17 November 1998 and 18 November 1999 are reproduced in Figure 3a, b. It is interesting to note that some of the sporadic-E traces show multiple structures. These characteristics are different from those seen in the normal sporadic-E events and are probably due to the meteoric ionization produced due to bursts of meteors travelling at different velocities.



(a) (b)

Figure 3. Selected ionograms over Ahmedabad for (a) 17 November 1998 and (b) 18 November 1999 showing sporadic-E with multiple structures.

DISCUSSION

Several studies have been made on the correlation of meteoric activity with the sporadic-E layers [4 and references therein]. Schafer and Goodall [5] reported association of the intermittent E_s echoes at altitudes between 100 and 200 km with the Leonid meteor showers. Appleton and Naismith [6] reported longer-duration sporadic-E during periods of shower activity. Ellyet and Goldsborough [7] have identified three classes of meteor produced sporadic-E, termed as E_m. Class 1 of E_m is the instantaneous partially reflecting echo due to a single meteor trail, which has lifetime of minutes at ionosonde frequencies. Class 2 E_m is of rare occurrence where meteor shower is sufficiently strong so that it controls the top frequency of E_s echo on ionogram. Class 3 of E_m is the E_s layers produced by subsequent action of wind shears on residual meteor ion concentration. Correlation of the percentage occurrence of class 1 E_m with meteor rate count has been confirmed [8]. From the VHF (49.68 MHz) oblique propagation experiment conducted in Japan during IGY period, intensity of scattering was found to be correlated with the meteor burst rate [9]. It has been reported from in-situ measurements of electron density from Thumba, near the magnetic equator that sharp layers of ionization are preferably present on days with meteoric activity [10].

Girija Rajaram and Chandra [11] studied the signatures of the Dhajala meteorite event over the western part of India on the night of 28 January 1976 on the radio soundings from Ahmedabad. The meteorite event was sighted over Ahmedabad at 2040h. Sporadic-E layer trace at 130 km was seen at 2100h and three strata separated by about 6 km were seen both at 2115 and 2130h. Since night E_s over Ahmedabad during the month of January is not frequent (there was no sporadic-E activity during ± 15 nights in the local time of 20-22h) the sporadic-E layer observed was associated with the Dhajala meteorite event.

The stratified feature of the sporadic-E layers adds further credence to the meteoric origin of the ionization. Ionization layers during meteor showers have been observed stratified at 5km intervals between 100 and 125 km [12, 13]. Multiple layers of sporadic-E, with semi thickness of 5 km and separated by 10 km, have been observed over Thumba from the Rocket-borne Langmuir probe data on meteor shower days [10]. It is concluded that the strong meteoric shower activity results in the formation of sporadic-E layers.

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