Day-to-day variability of the equatorial electrojet strength

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The *H* ranges at the equatorial electrojet locations Ancon, Peru and Trivandrum, India, show substantial periodicities in the 2-20 day range which are absent in solar flux, and hence, should be attributed mainly to planetary wave activity and more so in quiet-sun intervals. However, the results for the two locations differ in details, indicating that these effects may not be global. The variations are seen mostly in the daytime values, indicating their association with the daytime electrojet strength only.

Keywords: Equatorial electrojet, Electrojet, Magnetic field component

1 Introduction

In the dynamo region of the lower thermosphere (100-150 km), the atmosphere is partially ionized. Whereas collisions of ions with neutrals impart motion to the ions, the electrons are essentially tied to the magnetic field lines and an electrostatic field is produced. Due to the high ionization during the daytime, the region is conducting and the electric field drives currents. Because of the unusual geometry of the magnetic field close to the magnetic equator (dip angle almost zero), the vertical Hall currents are greatly inhibited and a vertical polarization field is formed which, when crossed with the predominantly horizontal north-south magnetic field *H*, produces a particular strong current system named as the "equatorial electrojet"[1-3]. It is located near ~105 km altitude, with halfwidths of ~10 km in altitude and 2.5° in latitude[4]. Variations of the horizontal component *H* of the magnetic field measured at ground are related to the currents flowing in the dynamo region.

The *H* component has a maximum value near noon, and the *H* range (maximum minus minimum value of *H* during the day) varies with season (larger at

equinoxes) and solar cycle (larger for higher solar activity). An interesting aspect is the day-to-day variation of the *H* range, which can change by as much as a factor of 2 from one day to another. For quiet days, Kane[5] showed that, on an average, the electrojet strength was not well-correlated with direct solar radiation, but was well-correlated with noon-time E-region drifts and was associated with $h'F2$ and the bite-out of $foF2$ at the equator. Nevertheless, it is surmised that these changes may be related to the changes in solar flux or in geomagnetic activity, or may be due to planetary (Rossby) waves rising upwards from the stratosphere[6]. Some of these could be due to the middle atmospheric planetary waves of tropospheric origin (forced by features at earth's surface such as mountains or large land masses or by meteorological patterns), as was found in the E- and F2-regions above Huancayo (Peru) by Forbes and Leveroni[7] and Forbes et al.[8], who pointed out that free Rosby (resonant mode) oscillations with periods 2, 5, 10 and 16 days may regularly penetrate from the stratosphere into the ionosphere/thermosphere[9,10]. Parish et al.[11] subjected the data of *H* measurements of the equatorial electrojet at Huancayo, Peru

(12.00°S, 75.30°W geogr.; 0.72°S geomagn.) for 1979 (solar activity peak) to a spectral analysis and reported periodicities of 2-45 days, suggesting an association with free Rossby (resonant mode) oscillations, perhaps excited either in the lower atmosphere or *in situ* in the E- and F-region equatorial ionosphere. The interannual variability was investigated by Parish *et al.*[12], using data for 1979-1986.

In the present paper, results are presented for the day-to-day variation of H ranges at the equatorial electrojet locations Ancon, Peru (12.08°S, 77.02°W geogr.; 0.8°S geomagn.) and Trivandrum, India (8.48°N, 76.97°E geogr.; 1.1°S geomagn.) for two recent intervals, (i) Nov. 1998-Aug. 1999 in the rising part of solar cycle 23 (1996 onwards), and (ii) the year 1996 (minimum between solar cycles 22 and 23).

2 Method of spectral analysis

The daily values were subjected to maximum entropy method[13,14] (MEM) of spectral analysis, which locates peaks much more accurately than the conventional Blackman and Tukey (BT) method[15]. However, the amplitude (power) estimates in MEM are not very reliable[16-18]. Hence, MEM was used only for detecting all the possible peaks T_k ($k = 1$ to n), using length of the prediction error filter (LPEF) as 50% of the data length. These T_k were then used in the following expression:

$$f(t) = A_o + \sum_{k=1}^{n}\left[a_k \sin\left(2\pi t/T_k\right) + b_k \cos\left(2\pi t/T_k\right)\right] + E$$

$$= A_o + \sum_{k=1}^{n} r_k \sin\left(2\pi t/T_k + \phi_k\right) + E \wedge \qquad \dots (1)$$

where, $f(t)$ is the observed series and E the error factor. A multiple regression analysis[19] (MRA) was then carried out to estimate A_o (a_k, b_k), and their standard errors (by a least-square fit). From these, amplitude r_k and their standard error σ_k (common for all r_k in this methodology, which assumes white noise) were calculated. Any r_k exceeding 2σ is significant at a 95% (*a priori*) confidence level.

3 Results for rising solar activity (Nov. 1998-Aug. 1999)

3.1 Plots

Figure 1 (plot 1) shows the solar flux of Lyman-α (121.6 nm), which is relevant for E-region

ionization[20]. As can be seen, there were 9 peaks during 11 Nov.1998-2 Aug.1999 (marked by vertical lines), with peak spacings of 22-29 days, with an average value of 27 days, and the amplitudes (peak-to-trough) were substantial (~15%). Thus, this interval had a substantial solar rotation periodicity. Plot 2 shows the daily range (maximum minus minimum of H values) at Ancon. There are large fluctuations from day to day with values as low as 50 nT and as high as 280 nT. A 2-3 day periodicity is indicated, but it could be erratic. Plot 3 shows the H ranges smoothed by calculating moving averages over 5 consecutive days. There are many peaks (marked by dots), which were more than the 9 peaks of Lyman-α. Thus, periodicities smaller than 27 days are indicated. Plot 4 shows the H ranges smoothed by calculating moving averages over 11 consecutive days. Now, there are 9 peaks, but these do not coincide exactly with the Lyman-α peaks (vertical lines). There are lags and leads of 0-8 days, indicating that the effect of solar flux might be getting distorted in the E-region. Plot 5 shows the monthly average H ranges and illustrates the well-known seasonal increase during equinox months[21].

Plots 6, 7, 8, 9 are for the H range at Trivandrum, India. The characteristics are similar to those for Ancon, and there is no clear-cut matching with the 27-day peaks of solar flux (vertical lines).

3.2 Spectral analysis

The MEM locates peaks very accurately. For a series of say 100 data points, using artificial samples as inputs and examining the outputs, it has been revealed[16-18,22] that the periodicities in various ranges can be detected with roughly the following accuracies: 2-3, (±0.05); 4-7, (±0.10); 8-12, (±0.20); 13-16, (±0.30); 16-25, (±0.40); 26-30, (±0.50); 30-40, (±1.0); 40-60, (±3.0); the numbers in parentheses are the standard errors. Even periodicities comparable with the data length can be detected but with larger errors, for example, 80±5. In the present analysis, the data series are of ~120-150 data points. Hence, 13.0, 13.5, 14.0, or 26.0, 27.0, 28.0 can be resolved as separate periodicities.

Figure 2 shows the results of a spectral analysis (amplitudes versus periodicities). To check stationarity, the data were divided into two parts: (a) 11 Nov. 1998-22 Mar. 1999 and (b) 23 Mar. 1999-2 Aug. 1999, each of 132 consecutive days. The following may be noted from Fig. 2:

(i)   For Lyman-α, Fig. 2(a) (plot 1) shows the spectra of daily values with a prominent peak at 26.2 days and two subsidiary (but statistically significant, above the 2σ limit indicated by the hatched portion) peaks at 15.3 and 21.2 days. Figure 2(b) (plot 1) also shows similar peaks, though the last peak is at 27.1 days, slightly larger than the peak in Fig. 2(a). This is because Fig. 1 (plot 1) has one spacing of only 22 days, which reduces the average slightly.

(ii) For daily values of Ancon *H* range, plot 2 of Fig. 2(a) shows strong peaks at 14.7 and 26.1 days. The latter matches well with 26.2 of Lyman-α, indicating a strong influence of solar flux.

However, the peak near ~15 days is weak in Lyman-α, but very strong in Ancon *H*, indicating the contribution from some other source too. There are other smaller periodicities at 2-3, 5.6 and 8.8 days which are absent in the Lyman-α series and hence, must be of non-solar origin, probably due to planetary waves. Correspondingly in Fig. 2(b), Ancon *H* range has peaks at 14.8 and 28.4 days, matching almost with 15.5 and 27.1 days of Lyman-α, indicating again the solar influence. The other peaks at 2-3, 5.6, 6.7, 10.5 days should be due to planetary waves.

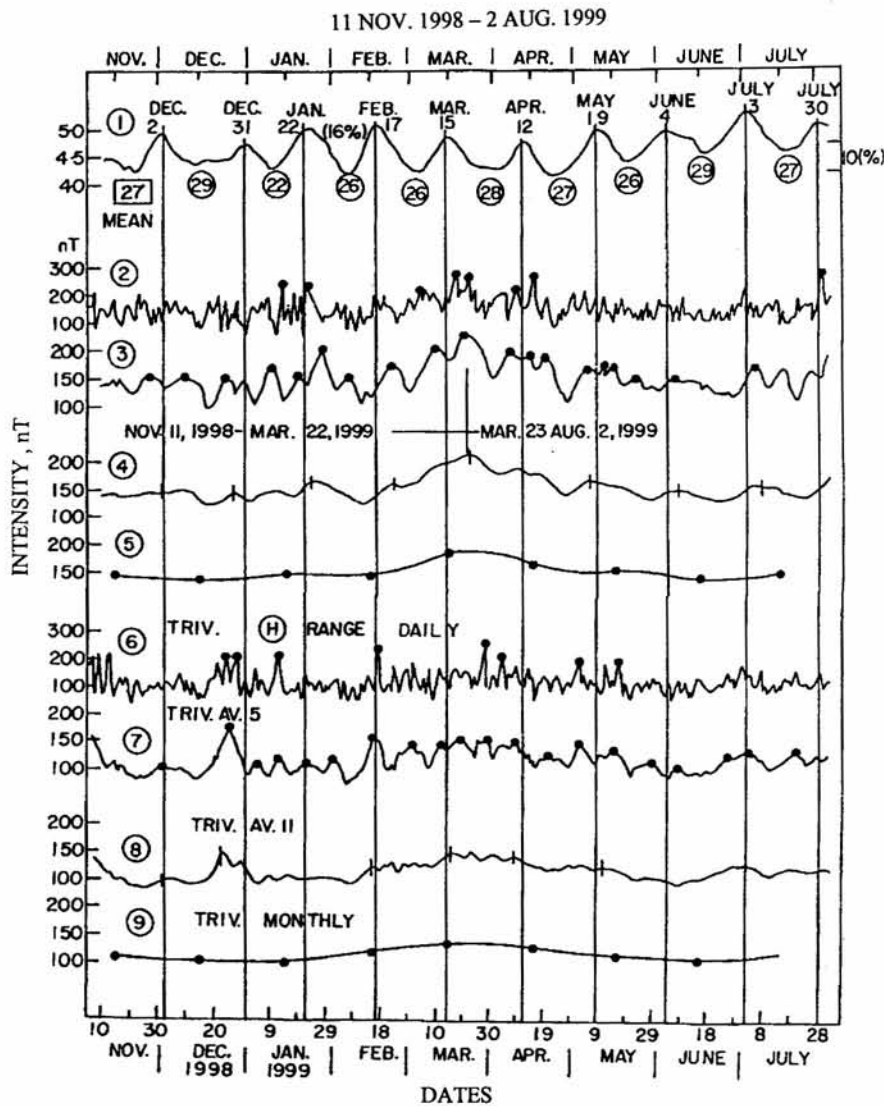(iii) For Ancon *H* ranges smoothed over 5 days, plot

Fig. 1—Plots of daily values for the 264 day intervals during 11 Nov. 1998-2 Aug. 1999 for (1) Lyman-α (121.6 nm. Woods *et al.*[20]: circled numbers indicate spacings in days between successive peaks) and Ancon *H* range for (2) Daily values, (3) 5-day moving averages. (4) 11-day moving averages, (5) monthly values; [Similar plots for Trivandrum *H* range are shown in plots (6), (7), (8) and (9).]
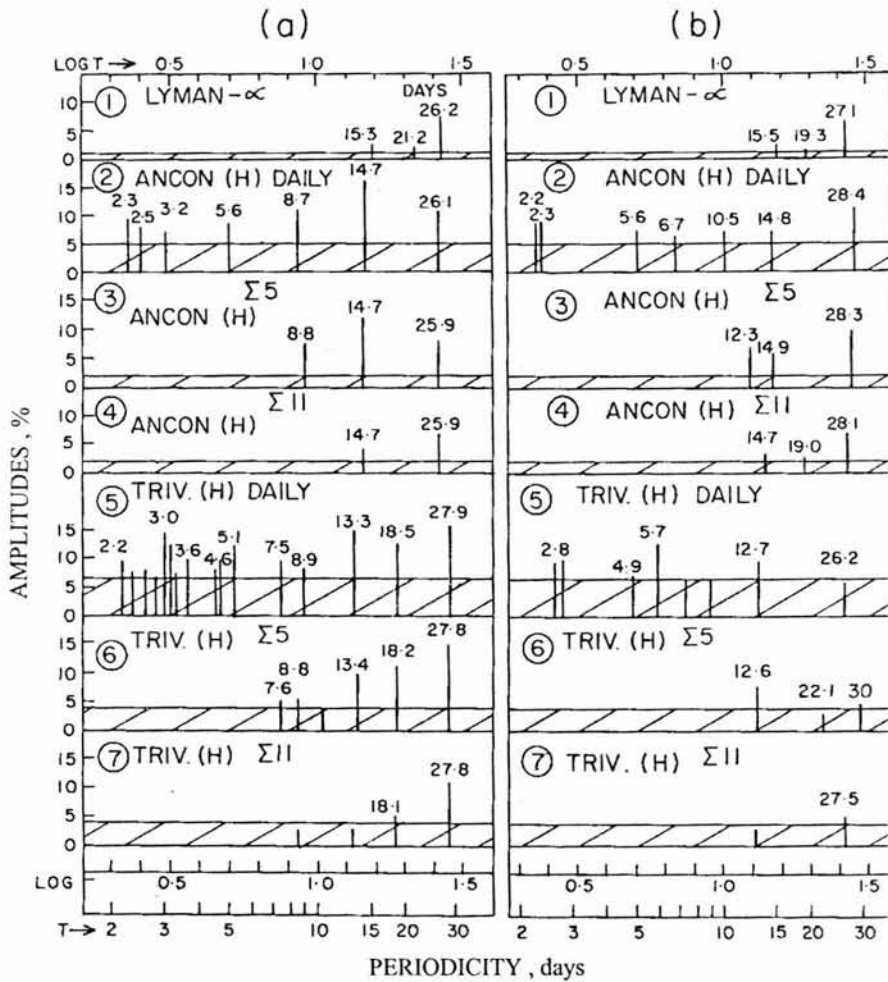
Fig. 2—Spectra (amplitudes versus periodicities) for the two 132-day intervals (a) 11 Nov. 1998-22 Mar.1999 and (b) 23 Mar.-2 Aug. 1999, for (1) Lyman-α and Ancon H range for (2) Daily values, (3) 5-day moving averages, (4) 11-day moving averages and Trivandrum H range for (5) Daily values, (6) 5-day moving averages (7) 11-day moving averages

3 of Fig. 2(a) shows only 8.8, 14.7 and 25.9-day periodicities, as effects of smaller periodicities are wiped out. It is true for plot 3 of Fig. 2(b).

(iv) For Ancon H ranges smoothed over 11 days, plot 4 of Fig. 2(a) shows only the solar influence at 14.7 and 25.9 days and the effect of planetary waves is wiped out. It is true for corresponding plot of Fig. 2(b).

(v) For daily values of Trivandrum H range, plot 5 of Fig. 2(a) shows strong peaks at 13.3 and 27.9 days, the latter almost matching with 26.2-day peak of Lyman-α. However, the peak near ~14 days is weak in Lyman-α, but very strong in Trivandrum H, indicating the contribution from some other source also. There are other smaller periodicities at 2-3, 5.6 and 8.8 days, which are absent in the Lyman-α series and hence, must be of non-solar origin, probably due to planetary

waves. In Fig. 2(b), Trivandrum H range has a strong peak at 12.7 days, which is different from the weak peak at 15.5 days of Lyman-α. Trivandrum H peak at 26.2 days is weak and barely significant, but matches with 27.1 days of Lyman-α. The other peaks at 2-3, 5.6, 6.7 and 10.5 days should be due to planetary waves. There is a peak at 18.5 days in Trivandrum H which is absent in Lyman-α.

(vi) For Trivandrum H ranges smoothed over 5 days, plot 6 of Fig. 2(a) shows only 8.8, 13.4, 18.2 and 27.8-day periodicities, as smaller periodicities are wiped out. For corresponding plot of Fig. 2(b), the 26.2-day peak seen (barely significant) in the daily values (plot 5) has split into two small and barely significant peaks at 22.1 and 30 days.

(vii) For Trivandrum *H* ranges smoothed over 11 days, plot 7 of Fig. 2(a) shows mainly the solar influence at 27.8 days and the effect of planetary waves is wiped out. It is true for plot 7 of Fig. 2(b), where a small but significant peak is seen at 27.5 days.

Thus, there is a clear evidence of solar influence as well as of planetary waves, but the characteristics are somewhat different for the two locations Ancon, Peru and Trivandrum, India.

4 Results for 1996 (low solar activity)

4.1 Plots

In a quiet-sun year, the effects of solar flux and geomagnetic disturbances would be absent and the day-to-day variations could be attributed to other sources. However, though 1996 was a quiet-sun year, the activity was not low throughout the year. Plot 1 of Fig. 3 shows the Zurich sunspot numbers R_z. From the middle of January to the end of October 1996, the sunspot numbers are ~20 or less (at high sunspot activity, these numbers exceed 100) with a few
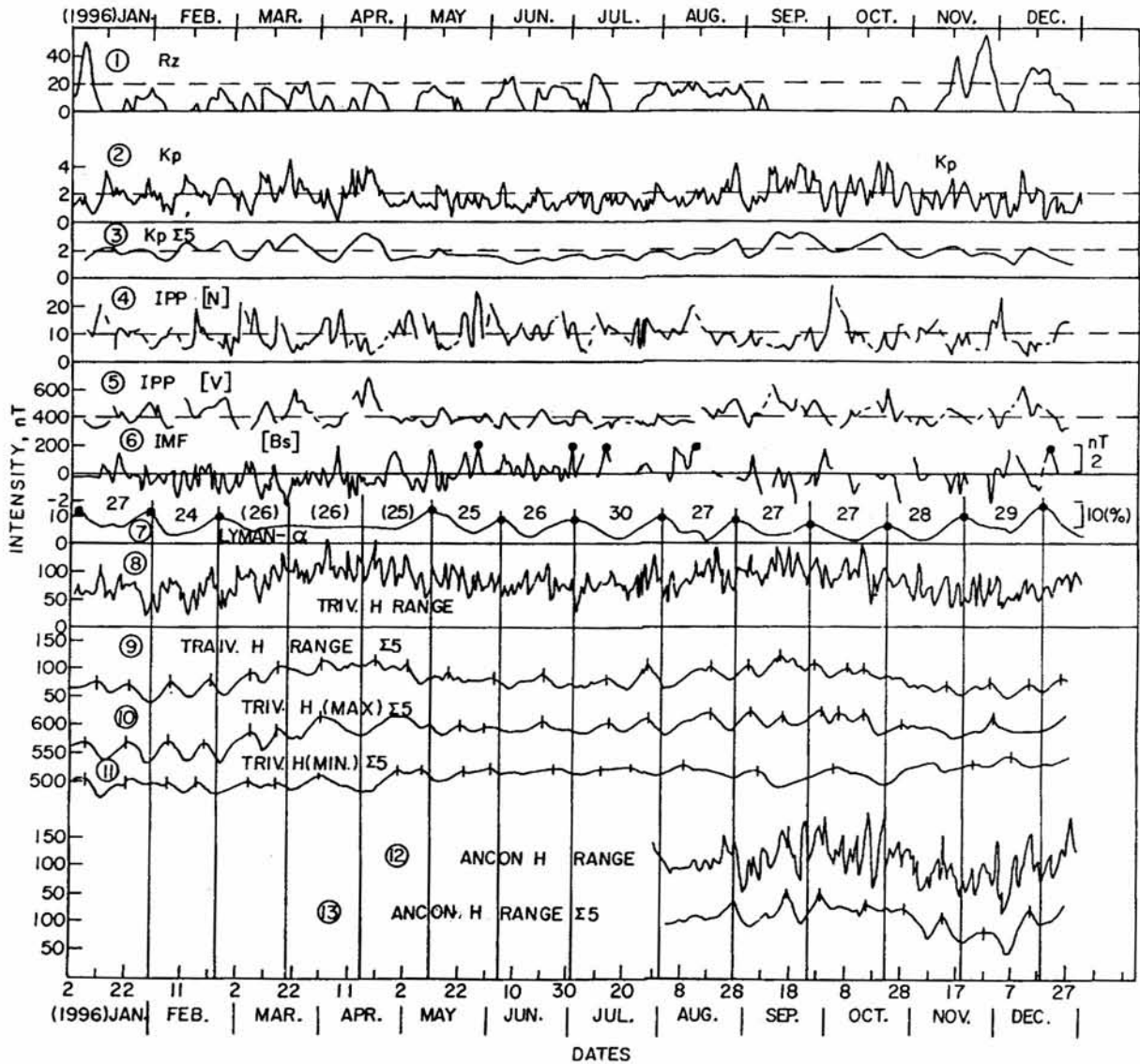

Fig. 3—Plots of daily values for 1996 for (1) Sunspot number R_z, (2) Geomagnetic index K_p, (3) 5-day moving averages of K_p, (4, 5, 6) interplanetary plasma parameters (IPP): Number density *N*, Flow speed *V*, North-south magnetic field component B_s, (7) Lyman-α (121.6 nm, Woods *et al.*[20]; circled numbers indicate spacings in days between successive peaks), (8) Trivandrum *H* range daily values, (9) 5-day moving averages of Trivandrum *H* ranges, (10) Trivandrum *H*(max), (11) Trivandrum *H*(min), (12) Ancon *H* range daily values, (13) 5-day moving averages of Ancon *H* ranges

stretches of ~10 days each of consecutive zero values, the longest being 13 September-24 October (42 days). Plot 2 is for the geomagnetic daily index K_p. For many days, the index is between 2.0 and 4.0, indicating moderate disturbances. But during May-August 1996, it is mostly below 2.0, indicating a comparatively quiet interval, as seen in plot 3, which shows K_p values smoothed over 5 consecutive days. The interval 13 September-24 October (42 days), when sunspot numbers were zero, does not seem to be geomagnetically quiet.

Plots 4, 5, 6 are for interplanetary plasma parameters (IPP). Plot 4 is for the number density N, which seems to be high (exceeding 20 particles per cm^3) on many days, even during May-August 1996 when K_p was low. Plot 5 is for the solar wind flow speed which seems to be ranging from 300 to 600 km/sec, but was below 400 km/sec during May-August 1996. Plot 6 is for interplanetary magnetic field (IMF). For causing geomagnetic storms, only the north-south component (B_s) is important and hence, only B_s is plotted. It ranges between about −2.5 nT and +5.0 nT. Since only negative values of B_s exceeding the quiet solar wind level of 5 nT are relevant for geomagnetic storms[23], all values of B_s were very low during 1996 and, hence, the K_p values also were low. In particular, during May-August 1996, the B_s values were mostly northwards (positive B_s) and this interval was exceptionally quiet (K_p below 2.0).

Plot 7 is for solar Lyman-α. Surprisingly, there were 27-day oscillations during most of the time in 1996 (except during March-April) with peak-to-trough magnitudes of ~10%, slightly lesser than 15% as seen during November 1998-August 1999. Thus, solar influence would not be absent, and peaks would be expected at the vertical lines.

Plot 8 is for the H range (daily values) at Trivandrum. Considerable day-to-day fluctuations are seen. In plot 9 for H ranges smoothed over 5 consecutive days, there are many more peaks than envisaged in the vertical lines (27-day sequences). Thus, periodicities smaller than 27 days are indicated. Plots 10 and 11 are for the H(max) near noon and H(min) near midnight values. Except for some differences, the peaks in plots 9, 10 and 11 are more or less similar.

For 1996, Ancon H data were available only for August onwards. Plot 12 shows the daily ranges and plot 13 shows the H ranges smoothed over 5 consecutive days. The maxima do not tally with the vertical lines, showing poor relationship with the solar flux. Also, there are many other maxima, indicating other influences.

4.2 Spectral analysis

For spectral analysis, data were divided into three equal parts namely, (a) January-April, (b) May-August and (c) September-December 1996, the second (middle) part being the most quiet geomagnetically. The plot 1 of Fig. 4(a) shows the spectra for Lyman-α with a prominent peak at 24.8 days and subsidiary peaks at 13.5 and 30.1 days. A peak at 27 days is not seen, because, as seen in plot 7 of Fig. 3, the Lyman-α series did not have a clear 27-day sequence during January-April. Plots 1(b) and 1(c) in Fig. 4 show clear prominent peaks in Lyman-α at 28.1 days, as these were seen clearly in plot 7 of Fig. 3 also for May-December 1996.

Plot 2(a) of Fig. 4 is for Trivandrum H range (daily values) and shows peaks at 13.9 and 30.1 days, matching with the Lyman-α peaks. However, the H range has other peaks at 2.3, 3.1, 3.9, 5.4, 6.2 and 19.0 which should be due to planetary waves. In plots 2(b) and 2(c), there is no peak corresponding to the 28.1-day peak of Lyman-α. Instead, the H range shows peaks at 31.7 days in plot 2(b) and 37 days in plot 2(c). There are many other peaks which can be attributed to planetary waves.

Plot 3 of Fig. 4 refers to Trivandrum H range smoothed over 5 consecutive days and shows the same periodicities as in plot 2 except that the lower periodicities (5 days or less) are wiped out as expected.

The plots 4 and 5 refer to Trivandrum H(max) and H(min) daily values smoothed over 5 consecutive days. The peaks in plots 4 and 5 do not match exactly among themselves, and the plot 1 of Lyman-α is more akin to plot 4 of H(max) than to plot 5 of H(min). Also, the amplitudes of H(min) are much smaller than those of H(max). Thus, the peak of the electrojet has better relationship with solar fluxes.

Since Ancon H data were only for August 1996 onwards, only the period (c) could be studied. Plot 6 of Fig. 4 shows the spectra for Ancon H range (daily values) and several periodicities are revealed, some of which are similar to those of Trivandrum H range (plot 2). However, the plot 6 shows a peak at 27.0 (though barely significant), similar to Lyman-α (28.1 in plot 1) and which is absent in plot 2. In plot 7 for Ancon H range 5-day moving averages, lower periodicities are wiped out, but peaks at 10.9, 14.9,
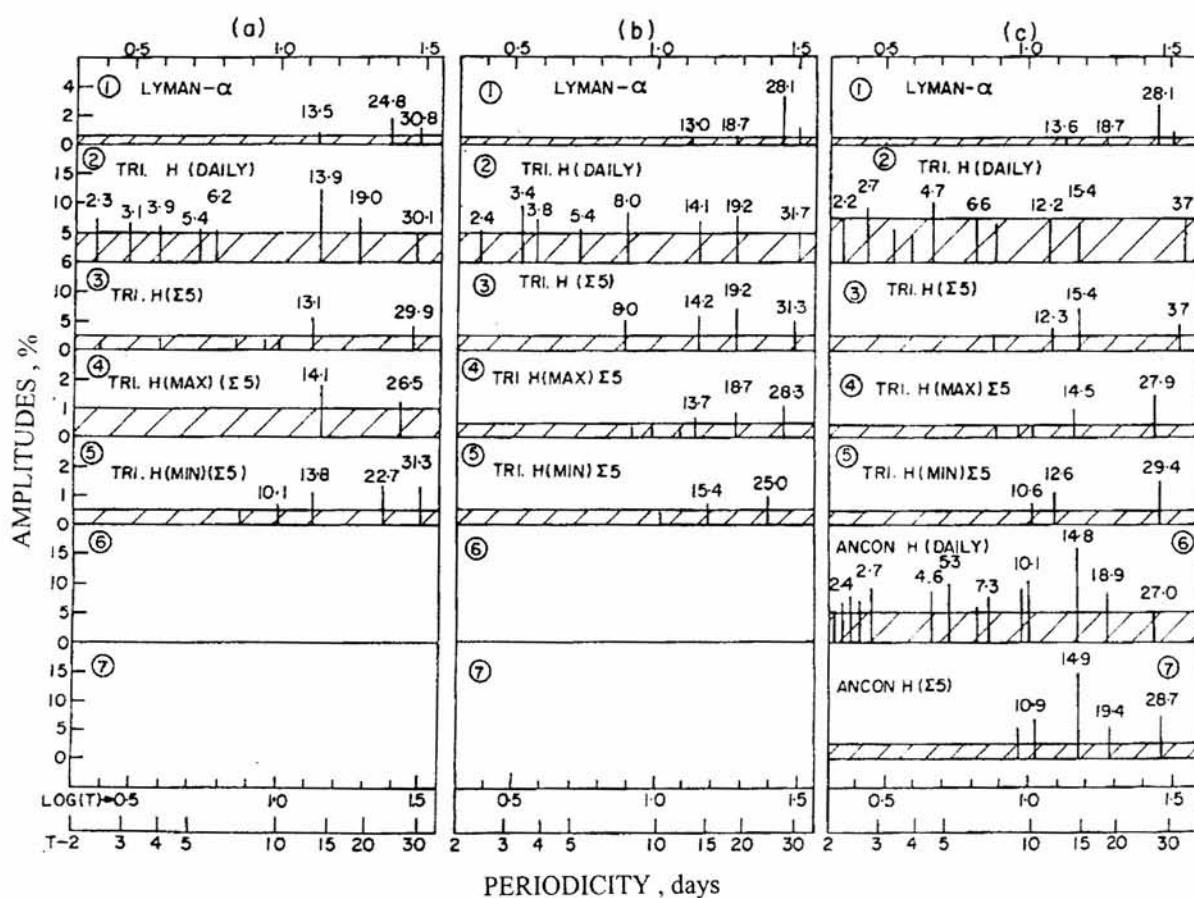
Fig. 4—Spectra (amplitudes versus periodicities) for the intervals (a) Jan.-Apr., 1996, (b) May-Aug. 1996, (c) Sep.-Dec. 1996, for (1) Lyman-α and Trivandrum *H* range for (2) Daily values, (3) 5-day moving averages, (4) *H*(max). (5) *H*(min), (6) Ancon *H* range daily values and (7) Ancon *H* range 5-day moving averages

19.4 and 28.7 days are clearly seen. These are not exactly the same as those for Trivandrum *H* range 5-day moving averages (plot 3). Thus, some local (not global) effects seem to be operating.

5 Quantitative estimates

In various spectra, power is distributed in various periodicities from 2 to 40 days. The percentage power in these periodicities is grouped for 2.0-2.9, 3.0-3.9, 4.0-6.9, 7.0-12.2, 12.3-14.5, 14.6-22.5, 24-31 and 32-40 day periodicities (Often, there was substantial power in periodicities exceeding 40 days, but this will be ignored as it represents mostly long-term trends like seasonal variations). The results for Lyman-α, Ancon *H* range and Trivandrum *H* range for the 5 intervals, namely (i) 11 Nov. 1998-22 Mar. 1999, (ii) 23 Mar.-2 Aug., 1999, (iii) January-April, 1996, (iv) May-August 1996 and (v) September-December 1996 are given in Table 1.

The following may be noted from Table 1:

(i)   For Lyman-α, the variance was mostly in the ~27-day periodicity, except during January-April 1996 when there was no clear peak near 27 days. Instead, there were two peaks at 25 and 31 days. In plot 7 of Fig. 3 for Lyman-α, the 27-day wave is obscure for this interval. In particular, the power in the 2-4, 4-7, 7-12 day ranges was almost zero.

(ii) For *H* ranges at Ancon and Trivandrum, the power in the 2-4 day range is substantial (30-50%), indicating that this range is unrelated to solar flux.

(iii) For *H* ranges, the power in the 4-12 day range is also substantial (~30%), indicating that this range also is unrelated to solar flux.

(iv) For *H* ranges, the power near 13.5 days (half solar rotation) was often substantial (8-25%) and

Table 1—Percentage variances for Lyman-α, Ancon *H* range and Trivandrum *H* range for the 5 intervals for periodicity groups 2.0-2.9, 3.0-3.9, 4.0-6.9, 7.0-12.2, 12.3-14.5, 14.6-22.5, 24-31, 32-40 days (The numbers in parentheses are some individual periodicities in days.)

Interval	Parameter	Values of parameters for periodicity groups (days)							
		2.0-2.9	3.0-3.9	4.0-6.9	7.0-12.2	12.3-14.5	14.6-22.5	24-31	32-40
11 Nov. 1998-22 Mar. 1999	Lyman-α	0	0	0	1	0	12 (15&21)	87 (26.2)	0
	Ancon *H*	24	10	17	17	0	24 (14.7)	8 (26.1)	0
	Triv. *H*	20	25	17	10	9	7 (18.5)	12 (27.9)	0
23 Mar.-2 Aug. 1999	Lyman-α	0	0	0	1	0	6 (15&19)	93 (27.1)	0
	Ancon *H*	30	8	19	16	0	8 (14.8)	19 (28.4)	0
	Triv. *H*	37	10	32	10	8	0	3 (26.2)	0
Jan.-Apr. 1996	Lyman-α	0	0	1	1	9 (13.5)	0	89(25&31)	0
	Ancon *H*	No data	-	-	-	-	-	-	-
	Triv. *H*	31	17	13	5	26 (13.9)	5 (19.0)	3 (30.1)	0
May-Aug. 1996	Lyman-α	0	0	1	2	1 (13.0)	2 (18.7)	94 (28.1)	0
	Ancon *H*	No data	-	-	-	-	-	-	-
	Triv. *H*	33	24	13	10	8 (14.1)	9 (19.2)	0	3(32)
Sep.-Dec. 1996	Lyman-α	0	0	1	1	2 (13.6)	5 (18.7)	91 (28.1)	0
	Ancon *H*	38	11	26	26	0	36 (15&19)	2 (27.0)	
	Triv. *H*	39	13	23	12	0	6 (15.4)	0	7(37)

invariably more than that for Lyman-α (0-9%). Thus, for this periodicity also, there should be considerable contribution from non-solar sources.

(v) For *H* ranges, the power in the 15-22 day range seems to be due to solar flux as well as other sources, almost equally.

(vi) The 27-day periodicity, very prominent in the solar flux, is reflected well in *H* ranges only in high solar activity intervals and not in quiet-sun conditions.

6 Quiet-day sequences in 1996

In 1996, there were sequences of continuous days when the daily sunspot numbers were zero. Those with 10 or more days were: 11-20 Jan. (K_p=2.43), 4-14 Feb. (K_p=2.10), 25 Apr.-5 May (K_p=1.41), 21-31 May (K_p=1.64), 14-25 July (K_p=1.57), 13 Sep.-24 Oct. (K_p=2.57) and 28 Oct.-8 Nov. (K_p=1.65). Thus, four of these were geomagnetically quiet (K_p < 2.00) periods. The plots of the hourly values of Trivandrum *H* are shown in Fig. 5. Besides the dates, the other numbers show the daily K_p values. In all events, the *H* maxima (marked by dots) seem to have spacings of ~5±1 days (occasionally 2-3 days), indicating the effects of planetary waves. The *H* minima (marked by crosses) seem to have much lesser day-to-day fluctuations, indicating that such effects are lesser or non-existent when the electrojet is weak or missing as in the night. Some night values (marked with a square) are abnormally low and are due to magnetic storm effects on *H* (ring currents far above the ionosphere), as indicated by higher K_p values.

7 Discussion and conclusions

Analysis of the data of *H* component daily ranges at the locations Ancon, Peru and Trivandrum, India, reveals the following:

(i) The solar flux (Lyman-α) during 1996 and 1998-1999 had prominent 27-day oscillations, though the percentage amplitudes were smaller in 1996 (~6.5% in 1998-1999, ~3.5% in 1996). These were reflected in the geomagnetic *H* component ranges at the equatorial electrojet locations only during high solar activity (1998-1999). Parish *et al.*[12] have mentioned that during years of low solar activity, solar flux variations might be less important.

(ii) The solar flux had negligible power in other periodicities, but *H* ranges had considerable power in periodicities in the 2-25 day range. These could be attributed to other sources such as planetary waves, and more so during low solar activity.

(iii) The periodicities in *H*(max) and *H*(min) at Trivandrum were not completely alike, indicating that the values near noon had other influences (probably lunar). Also, the *H*(min) amplitudes were much smaller than those of *H*(max), indicating that the variations were mainly in the daytime electrojet strength.

(iv) The periodicities of *H* ranges for Ancon and Trivandrum were not all alike, indicating that all of these were not global. Some local effects are indicated.
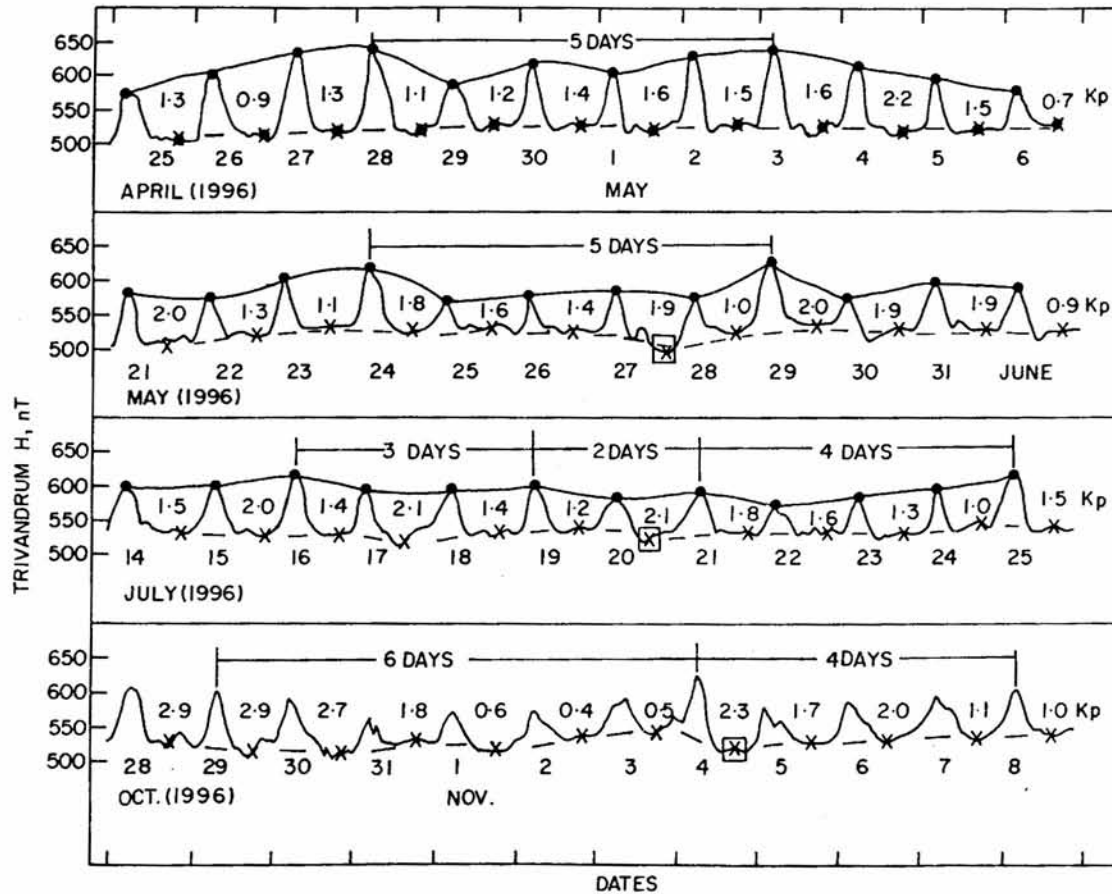
Fig. 5—Plots of hourly values of Trivandrum H for sequences of days when daily sunspot numbers were zero [Besides the dates, the other numbers are daily K_p values; H maxima are marked by dots and are joined by full lines. The spacings between largest H maxima are indicated in days. The H minima are marked by crosses and are joined by dashes (squared crosses indicate abnormally low values).]

(v) In sequences of ~10 consecutive days when sunspot number was zero and K_p values were low (below 2.00), the planetary waves of 4-6 days were seen clearly.

Planetary waves observed in the troposphere and stratosphere are associated with resonant or Rossby normal modes of the atmosphere. Their horizontal and vertical structures are greatly influenced by the background wind and temperature structure through which they propagate[24]. Rossby normal modes have a variety of periodicities[25-33] such as: 1.7 days, (3,0) mode; 1.8 days, (2,0) mode; 4-6 days, (1,1) mode; ~10 days, (1,2) mode; 11.5 days, (2,4) mode; 16 days, (1,3) mode; and 17.5 days, (1,4) mode. Thus, the presence of a large variety of periodicities in H ranges is not surprising. The solar influence of a 27-day periodicity on H is seen only at higher solar activity, indicating that an establishment of a solar connection needs larger solar emissions. Incidentally, variations

of electrojet strength are known to have a lunar component[34] (~29 days). The noon-time values, for example H(max), would have such a lunar periodicity; and 'lunar aliasing' with a 16-day planetary wave would introduce a 14.75-day periodicity[11]. This would creep in the H ranges also. Some of the 14-15 day peaks may be due to this effect. In Fig. 4, the H(max) and H(min) values show somewhat different spectral characteristics, which may be partly due to lunar effects in H(max).

There are two aspects which may complicate the conclusions. First, the H values are affected by ring current effects. Such a correction was tried for a small sample and it was noticed that the H peaks were better aligned. However, the betterment was not very striking, probably because the effects were not very different and were rather small for day and night. Secondly, the variation of the electrojet H range is a combined effect of the daily variations of the E-region ionization and the east-west electric field. These are

affected differently during daytime and nighttime. Thus, the stations 180° apart in longitude could have different effects. Some of the discrepancies noted in the present analysis (non-globality) are probably due to these reasons. Nevertheless, the main effect seems to be due to planetary waves, particularly during solar minimum period.

Acknowledgements

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