

6300 Å night airglow and the geomagnetic control of the equatorial anomaly

P. V. KULKARNI, F.A.Sc.

Physical Research Laboratory, Ahmedabad 380009

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ABSTRACT

The intertropical red arc in the night airglow studied from a low latitude station (Mt. Abu, India) shows that in the years of high solar activity and on the magnetically quiet nights the arc is well developed and can be detected up to midnight or even in the early morning hours. In the beginning of the night and on many nights the arc appears overhead at 12° to 15° geomagnetic latitude. As the night progresses the movement of the arc towards the magnetic equator can be traced by azimuthal 6300 Å scanning. The intensity of the arc and its equatorward velocity vary from night to night. On the magnetically disturbed nights the arc is poorly developed, fades before midnight and its southward velocity is less. In the years of low sunspot activity also the arc is weak.

These observations are consistent with those of the F-region Appleton equatorial anomaly at night time which presumably shows that the bulk of 6300 Å is due to the dissociative recombination of electrons with oxygen (and nitrogen) ions.

EQUATORIAL 6300 Å night airglow emission and its behaviour from the region of equatorial Appleton anomaly was first pointed out by Barbier and his collaborators from the airglow data obtained from the African Stations (Weill 1967). Later J. W. King (1968) showed many similarities between the above-mentioned data and the Appleton anomaly in the nighttime F region. King also suggested the use of 6300 Å emission measurements to derive information about the F region anomaly during its disappearance phase.

6300 Å emission night airglow data was obtained (Barbier *et al.* 1961) simultaneously from ground based observations at Tamanrasset (22.8° N geog. latitude, Geomagnetic lat. 25.3° N) and from an aeroplane flying at a speed of 2.5° latitude per hour from Tamanrasset towards the south. These observations showed the presence and the southward movement of the 6300 Å intertropical arc.

From the ground based observations of 6300 Å on the magnetic equator (Thumba, India) Kulkarni and Rao (1972) have reported the approach of the 6300 Å anomaly on the local northern and southern horizons before midnight. If the height of the 6300 Å emission is assumed to be 300 km above the ground, at 75° zenith angle, the line of sight intercepts the layer at about 1000 km. As the night progressed the northern and southern arcs moved towards the zenith. After a few hours the zenith became bright showing the advancement of the anomaly to the local zenith. However, these data are obtained on a few nights only.

The OGO 4 data presenting (Chandra *et al.* 1973) isophote maps of 6300 Å shows the 6300 Å anomaly on the either side of the equator but is unable to say much on the progress of the anomaly with time because the data are restricted.

At Mt. Abu (India) (Geog. lat. 24.6° N, Long. 72.7° E, Geomag. Lat. 15.4° N) which happens to be almost under the Appleton anomaly we have been operating the all sky scanning photometer for the past six years and along with other night airglow emissions 6300 Å is studied. Some general conclusions from our observations will be stated first and then we shall discuss one special period of observations.

(1) In the years of high solar activity the 6300 Å intertropical arc is a phenomenon which is seen, in general, over Mt. Abu on almost all nights when K_p index (sum) (*i.e.* ΣK_p) is less than 20 for that day. When ΣK_p is less than 10 there are very good chances that a strong anomaly in the beginning of night is seen over Mt. Abu (dip 34°), or sometimes even slightly north of Mt. Abu. The anomaly is then neatly aligned in the east-west direction. A well developed arc over Mt. Abu on a magnetically quiet night very probably moves towards south. The southward movement is apparent from the successive 75° zenith angle, and 0°–360° azimuth scans. Approximate velocity of movement can be estimated. The strong and well developed anomaly shows clear 6300 Å enhancements in the eastern and western directions with minima in the northern and southern directions, in the said scans, at the beginning of the night. As time progresses the two intensity peaks come nearer and ultimately merge into a single peak at south around midnight. Then the single peak as if “sets” on the southern horizon and the 0°–360° azimuth scan at 75° zenith angle becomes more or less featureless.

(2) In the years of low solar activity, statistically, the 6300 Å intertropical arc is either weakly developed or not at all developed at the beginning of the night. Again when the arc is weakly developed its velocity towards the south is smaller than that in case (1) above; sometimes the arc does not move at all but goes on fading on the spot and the structure is

lost before midnight. Similar thing happens in the high solar activity period when the night is magnetically disturbed ($\Sigma K_p > 20$). But in this case though the arc is not well developed usually southern part of the sky remains brighter than any other part of the sky up to midnight or even little after. This suggests that the arc is developed at the southern latitude of Mt. Abu.

Some of the features stated above are pointed out in the data obtained at Mt. Abu in the month of December 1971, under complete black out conditions at Mt. Abu and around, sky remained excellent and around new moon, data were acquired throughout the nights. Data are reduced and calibrated according to the standard procedure and isophote maps of sky at half hour intervals are drawn. Ionosonde data from Ahmedabad (150 km south of Mt. Abu) were also available.

The period 14th December 1971 to 18th December is peculiar. Table 1 shows the ΣK_p indices (sum) on those days, and the night airglow observations taken at Mt. Abu.

It will be seen from this table that there is a quiet day (15th December 1971) sandwiched between two disturbed days (13th and 17th December 1971). We present the hourly intensity of 6300 Å emission at a constant zenith angle 75° and at 0° to 360° azimuth (North-East-South-West-North) on the nights of December 13-14 (figure 1), December 15-16 (figure 2) and December 17-18 (figure 3). In the scanning mode of the photometer, higher intensities on the eastern and western horizon indicate the presence of the anomaly. It will be noted that on the night of 15-16th December the anomaly is distinctly seen over Mt. Abu in the beginning of the night (2000 hrs IST) and later seen moving towards the south. The two peaks also are closing. Little after midnight (0100 IST) the two peaks have merged into one in the south and it is quite bright; then in the next hour the southern intensity has fallen from 600 R at 0100 IST to 225 R at 0200 IST. After 0100 IST the 6300 Å tropical arc is "out of sight" from the southern horizon of Mt. Abu. On this night therefore it may be estimated that the southward velocity of the 6300 Å arc and hence the equatorial anomaly is around 150 km/hr. In the beginning of the night because the arc

Table 1. December 1971

Day	..	13	14	15	16	17	18	19
ΣK_p	..	23	5	7	10	42	27	18
300 Å Data	..	Yes	Yes	Yes	No	Yes	No	
Night of	..	13-14	14-15	15-16	16-17	17-18	18-19	

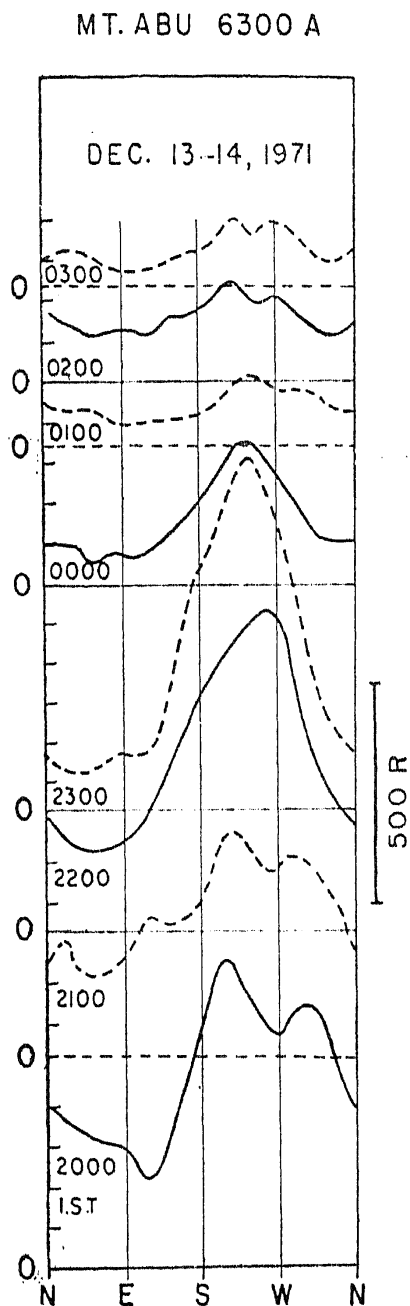


Figure 1. Hourly scans at zenith angle 75° and 0° - 360° azimuth (North-East-South-West) showing the ill-developed anomaly ($\Sigma K_p = 23$).

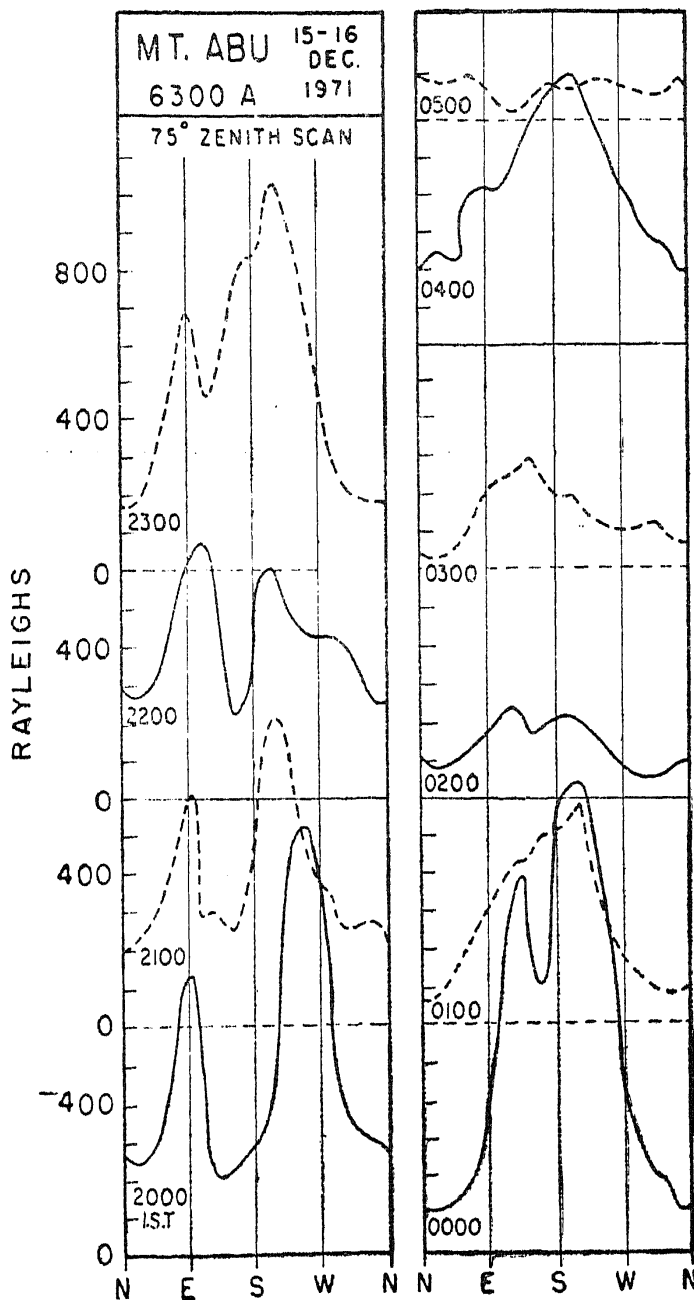


Figure 2. Hourly scans at zenith angle 75° and 0° - 360° azimuth (North-East-South-West) showing the well developed anomaly ($\Sigma K_p = 7$).

is more or less east-west passing through the zenith of Mt. Abu rough estimate of the half width of the arc could be done. If it is assumed that the 6300 Å emission layer is at 250 km height, the half width of the arc on the eastern and western horizons (at 75° zenith angles) would be 250 km and 375 km respectively. This is shown diagrammatically in figure 4.

On the magnetically disturbed days (13th and 17th December 1971) there is no clear development of the arc and also the southern horizon by

midnight is featureless though, before midnight it is somewhat brighter compared to the other directions.

The southward velocity of the arc in the above case may be compared with the velocity of 100 km/hr estimated by King (1968) from Barbier's 6300 Å data at Tamanrasset on the night of 14–15 November 1960. On this day and on the following and preceding days it will be seen that the ΣK_p index was high. This is shown on table 2.

Table 2. November 1960

Day	..	10	11	12	13	14	15	16	17
ΣK_p	..	12	25	33	67	37	42	45	26

MT. ABU 6300 Å 75° ZENITH SCAN
DEC. 17-18, 1971

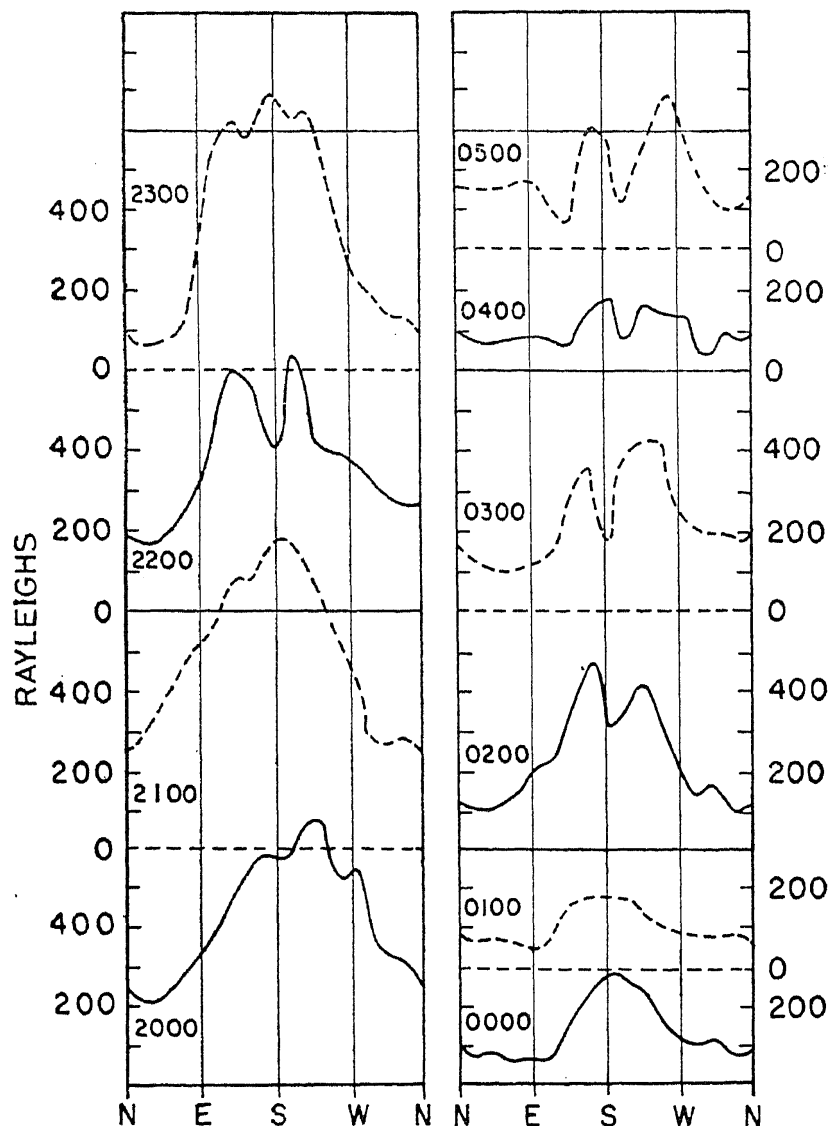


Figure 3. Hourly scans at zenith angle 75° and 0°-360° azimuth (North-East-South-West) showing the ill-developed anomaly ($\Sigma K_p = 42$).

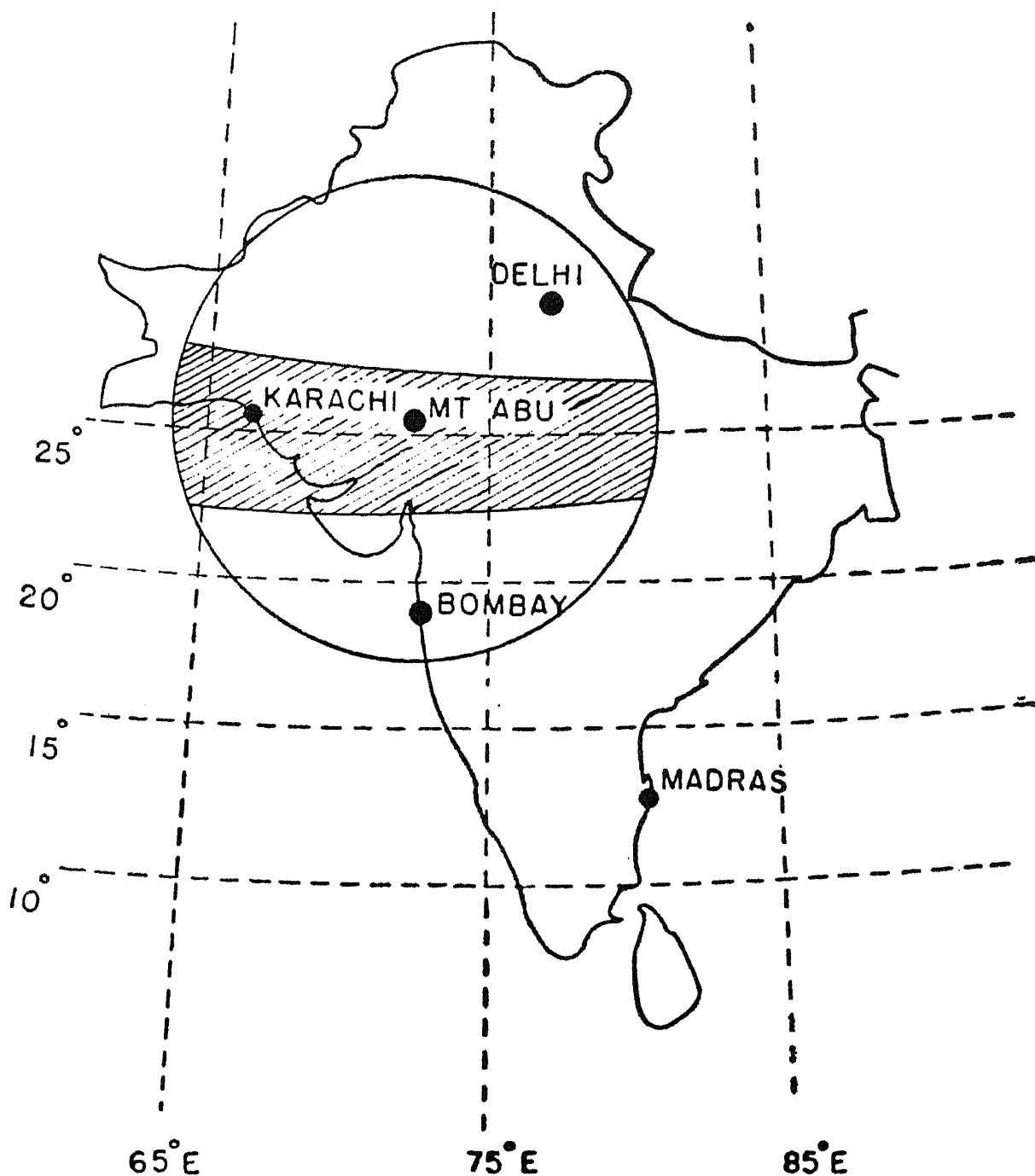


Figure 4. Half intensity band of 6300 Å arc seen at the zenith of Mt. Abu.

Therefore it is felt that during the disturbed period the 6300 Å arc has not moved with the velocity it would have in the undisturbed period. The above feature may be compared with that of the F-region anomaly pointed out by King *et al.* (1967) who mentions that on the magnetically disturbed days the Appleton anomaly is less developed.

Some general features of the fading of 6300 Å anomaly which are described above from the observations at Mt. Abu are shown in figures 5 and 6.

Figure 5 (a). The anomaly is well developed in the beginning of the night over Mt. Abu and proceeds towards south (December 28–29, 1967) $\Sigma K_p = 9$.

MT. ABU 6300 Å ZENITH ANGLE 75°

28-29 DEC. '67

1-2 JAN. '68

12-13 JUN. '72

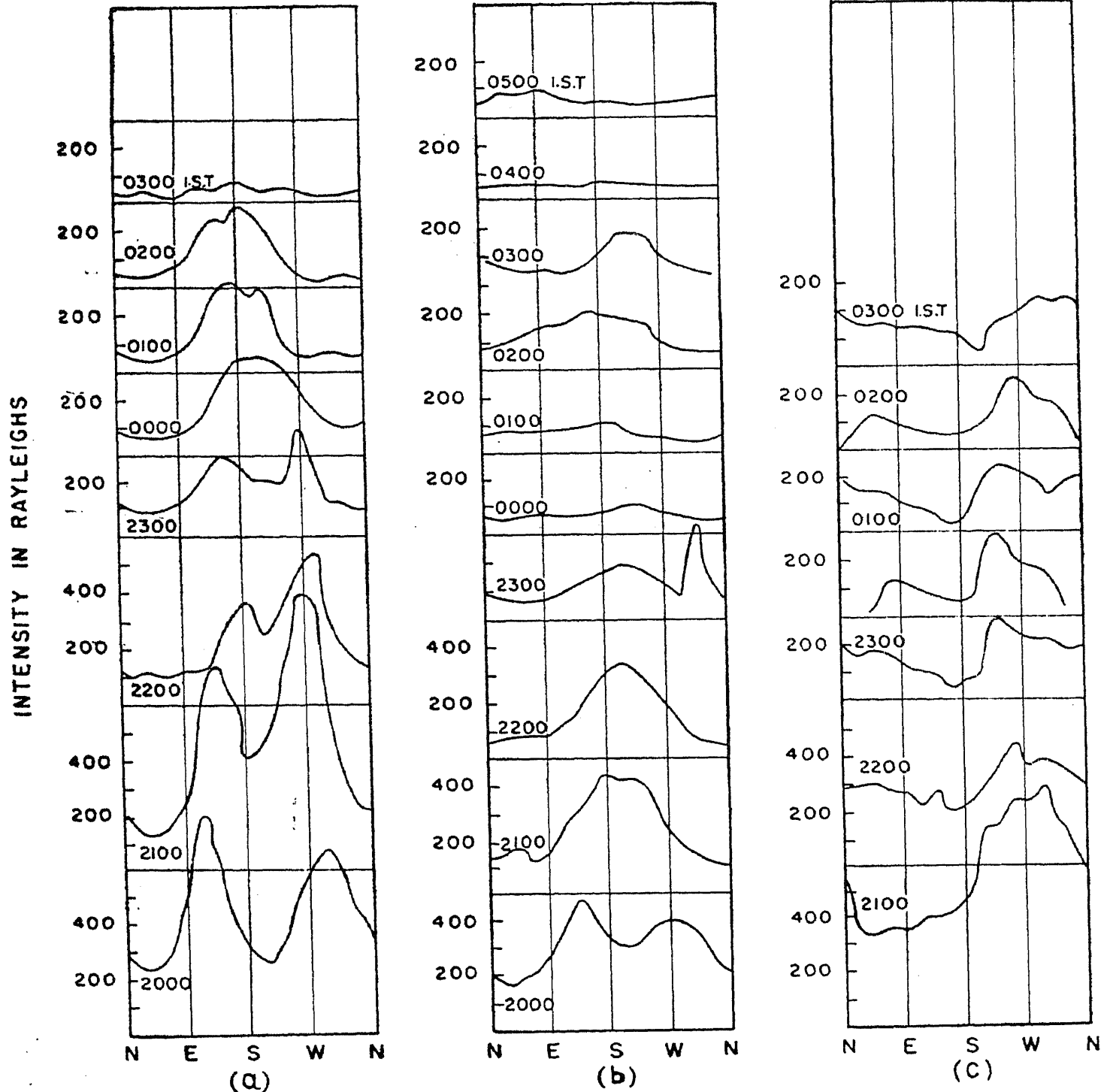


Figure 5. Different forms of the 6300 Å anomaly seen from Mt. Abu (for description see text).

Figure 5 (b). Anomaly not developed over Mt. Abu, weakly developed towards south and disappeared later (January 1-2, 1968) $\Sigma K_p = 33$.

Figure 5 (c). In the low solar activity years even when ΣK_p is low anomaly is not well developed. (June 12-13, 1972) $\Sigma K_p = 6$.

Figure 6. On two successive nights (November 18-19, $\Sigma K_p = 13$; and November 19-20, $\Sigma K_p = 13$) the anomaly is well developed but on one night (November 18-19) it shows structure while the other night there is no structure.

The midnight maximum of 6300 Å reported earlier from Lwiro (Barbier and Glaume 1962) and from Thumba (Kulkarni and Rao 1972) then can be attributed to (i) local lowering of the ionosphere or (ii) due to the approach of the equatorial anomaly which would increase total electron content. In the later case the approach of the anomaly could be detected through its appearance from south and north on the 6300 Å isophote maps (figure 7).

Though we have seen the equatorward movement of the 6300 Å anomaly from Mt. Abu and Thumba separately we have not yet seen the same simultaneously. It is believed that it should be possible to trace the

MT. ABU 6300 Å ZENITH ANGLE 75°

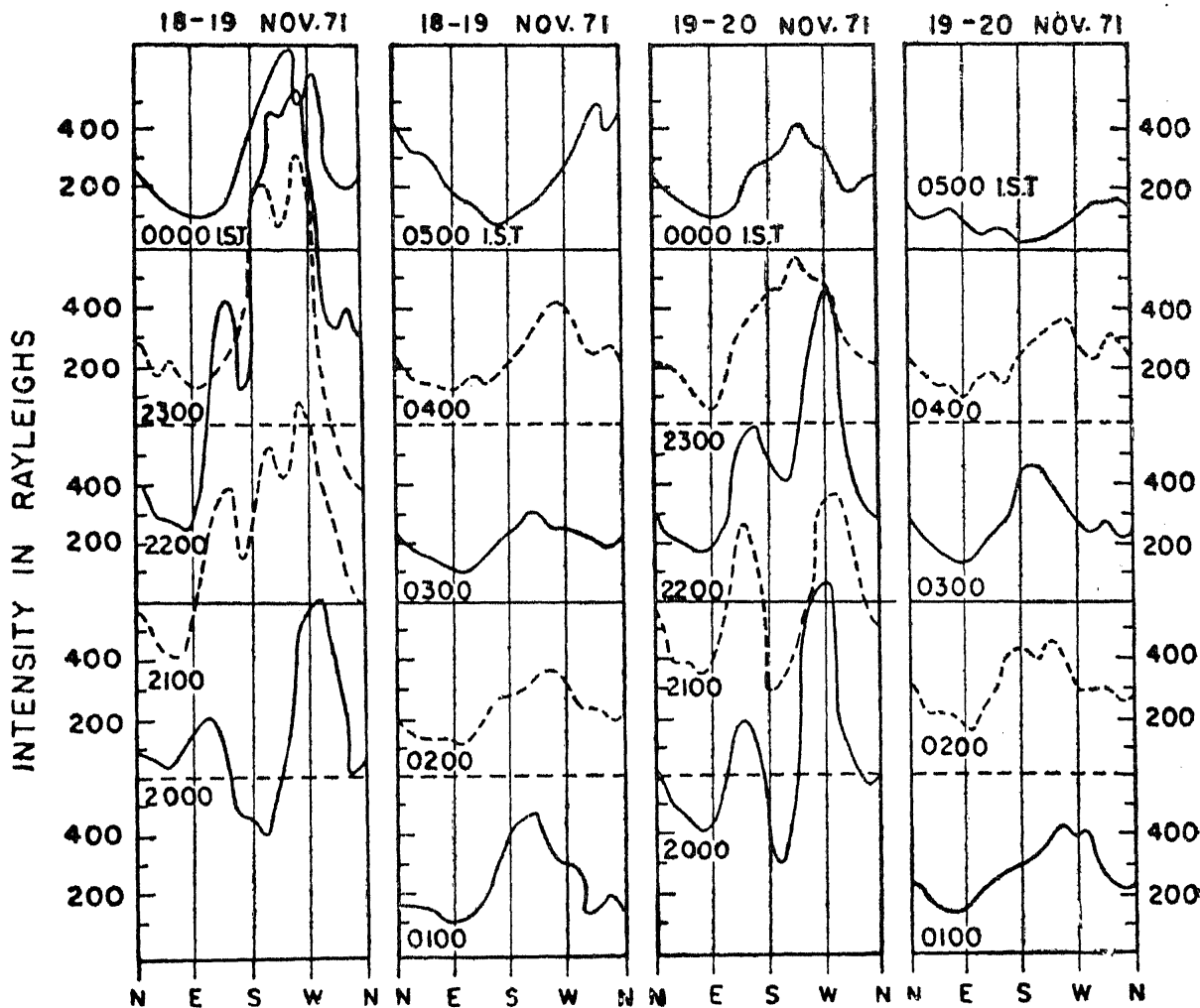


Figure 6. Different forms of the 6300 Å anomaly seen from Mt. Abu (for description see text).

NEYYAR DAM

8 MAR 1970

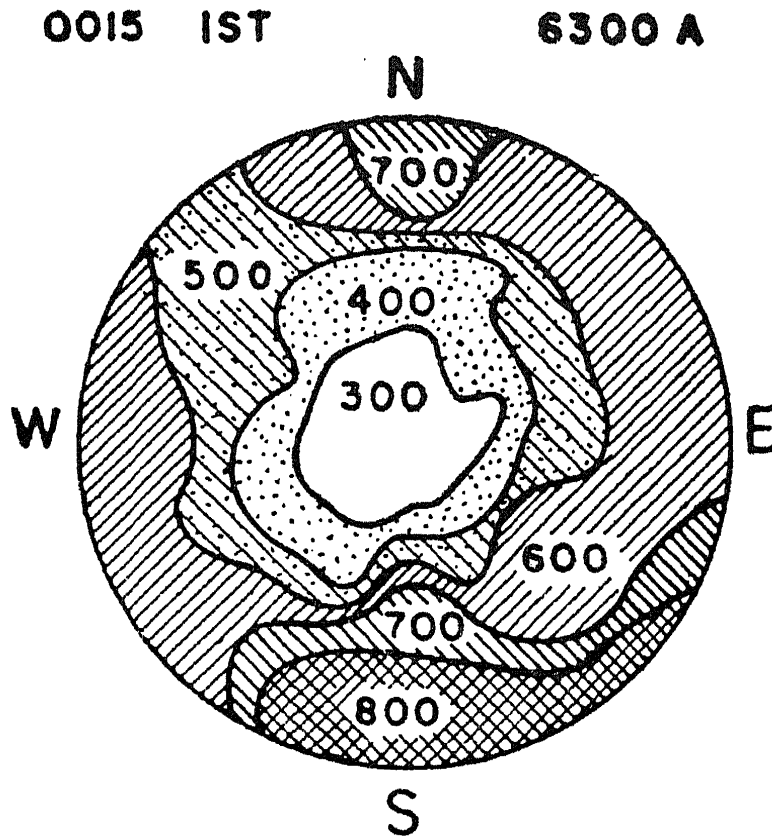


Figure 7. Isophote map of 6300 Å over the magnetic equator which is approximately along East-West. Numbers denote intensity in Rayleighs.

movement of the anomaly and note its magnitude throughout the night with a chain of three airglow stations observing 6300 Å night emission from magnetic equator to the maximum of anomaly region ($\approx 30^\circ$ dip). Study for one to two years will be extremely useful in understanding the decay phase.

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