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**Synoptic auroral distribution: A survey using Polar ultraviolet imagery**

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**Abstract.** The global distribution of the ultraviolet auroral emission was investigated for the period between April and July 1996 using over 17,000 imagery acquired by the ultraviolet imager (UVI) on board the Polar satellite. Average brightness of the N\textsubscript{2} Lyman-Birge-Hopfield (LBH) auroral emissions at 1700 Å, which is approximately proportional to the total energy flux of precipitating electrons, was calculated with dayglow subtracted. The results of this investigation indicate that there exist two distinctive auroral emission regions, one in the premidnight sector of the auroral oval and one in the postnoon sector of the auroral oval. The maximum occurrence of nightside aurorae is found to be centered at 2230 magnetic local time (MLT) and 68\textdegree magnetic latitude (MLAT) while the dayside aurorae maximize at both 1500 MLT and 75\textdegree MLT and 1000 MLT and 75\textdegree MLAT, with the later one much weaker. This statistical auroral distribution is quite similar to previously reported distribution of discrete aurorae, suggesting that at this wavelength and at the sensitivity of the UVI detector, discrete aurorae contribute a major portion of the total emissions. The seasonal distribution of the nightside LBH auroral emissions is found to be consistent with previously reported particle result, namely nightside discrete auroral activities are more common in the dark hemisphere (winter) than in the sunlit hemisphere (summer). However, on the dayside part of auroral oval, auroral emissions are brighter in summer than in spring. The dayside auroral emissions, in particular the 1500 MLT bright spots, are also found to be correlated with the maximum region 1 upward field-aligned currents which are most intense in summer because of a higher ionospheric conductivity produced by photoionization in the dayside region. These results point up the controlling role played by ionospheric conductivity and further illustrate how dayside and nightside aurorae behave in fundamentally different ways.

1. **Introduction**

The auroral oval [Feldstein, 1973a; Feldstein and Starkov, 1967], when viewed from space above the north polar region, appears as a continuous ring of luminosity encircling the geomagnetic pole, along which complex forms of discrete arcs and bands [Akasofu, 1976; Meng and Lundin, 1986; Murphree et al., 1987; Rostoker et al., 1987] are frequently found to be embedded in a broader, less structured diffuse aurora [Lui and Anger,
1973]. Although the existence of auroral ovals (one for each hemisphere) was discovered from the early ground-based observations of a limited field of view [Feldstein, 1973a, b; Akasofu, 1966; Lassen, 1963, 1969], the morphology of auroral oval thereby inferred is surprisingly not significantly deviated from the instantaneous view of the global auroral oval that can only be acquired by satellite imagers [Lui and Anger, 1973; Akasofu, 1976; Frank et al., 1982].

Nightside discrete aurorae appear dynamically and randomly distributed along the diffusive background oval. During magnetically active periods, interesting auroral phenomena such as auroral bulges, westward traveling surges, and omega bands are repeatedly seen in the evening/midnight sector, known as auroral substorms [Akasofu, 1968]. A typical auroral substorm can last for about 1-3 hours and is a major source of auroral luminosity on the nightside of auroral oval. Dayside discrete aurorae near the noon meridian appear to be persistent and do not depend strongly on the nightside activity [Murphree et al., 1981; Evans, 1985; Lui et al., 1989; Liou et al., 1997]. Meng and Lundin [1986], through analyzing the DMSP visible imaging data, showed examples of clear topological disconnection between the dayside and the nightside discrete aurorae and a poor correlation between the formation of midday aurorae and the concurrent nightside substorm, suggesting the existence of two independent physical processes responsible for the dayside and nightside discrete auroral activities. Dayside discrete auroral activities are generally considered as a consequence of a direct magnetosheath plasma injection at the noon cusp/cleft region and an increase of solar wind energy and momentum transfer in the magnetospheric boundary layers.

It is generally agreed that aurorae are the effect of the solar-magnetospheric-ionospheric interaction. The Sun provides the ultimate energy source in the form of solar wind which interacts with the Earth’s magnetic field creating geomagnetic activities and auroral phenomena in the polar region through complex magnetosphere-ionosphere coupling processes which are not yet fully understood. Therefore the most natural way of studying auroral phenomena is probably through relating the occurrence of auroral substorms to the observable parameters of the solar wind. For example, it has been known for a long time that the intensity and the occurrence rate of aurorae are correlated with the solar activities, such as the 11-year sunspot circle and 27-day rotational period of the Sun. Arnoldy [1971] has shown a high correlation between the auroral zone magnetic activity AE index and the time integrated southward component of interplanetary magnetic field (IMF). The occurrence rate of discrete auroral arcs along the oval was also found to be highly correlated with the geomagnetic Q index [Feldstein and Starkov, 1967] and the geomagnetic Kp index [Danielsen, 1980].

Less attention has been given, however, to the effect of solar optical radiation, the major form of energy emitting from the Sun. This may affect auroral phenomena in a more direct way, namely the ionospheric/atmospheric response due to the solar radiation through direct heating of neutral particles in the ionosphere/atmosphere to increase the ionospheric conductivities and currents. In this connection it should be recalled that the actual acceleration of electrons in aurorae occurs at relatively low altitudes, between 1 and 3 RE, where the magnetosphere interfaces with the ionosphere. In a recent study using DMSP precipitating electron data, Newell et al. [1996b] showed that the occurrence rate of intense (> 5 ergs cm−² s−¹) discrete aurorae are suppressed by sunlight, i.e., discrete aurorae are more likely to occur in darkness (winter) than in sunlight (summer), and they attributed this intriguing result to the ionospheric conductivity feedback mechanism as proposed by Ogawa and Sato [1971] and Sato [1978]. The feedback mechanism, in general, states that a localized conductivity increase in the ionosphere caused by a patch of electron precipitation will draw more field-aligned currents from the ionosphere to the magnetosphere and hence more precipitating electrons to enhance conductivities. The physical significance of this finding is that the Earth’s ionospheric conductivity plays an active role in the formation of intense nightside discrete aurorae. This result may have a profound impact on the current theories of auroral substorm in which the Earth’s ionosphere passively responds to the dynamically active magnetosphere. In this report, we will investigate this topic, among others, by using global ultraviolet images acquired from the auroral ultraviolet imager (UVI) on board the Polar satellite. The advantage of the imager is it obtains a simultaneous view of the entire oval using a single instrument (a “synoptic” view).

This study is carried out using the Lyman-Birge-Hopfield filter at 1700 Å, since the intensity of auroral emission at this wavelength is approximately proportional to the total precipitating electron energy flux, with little sensitivity to the characteristic energy of the precipitation [Strickland et al., 1993]. This paper is organized as follows. Section 2 gives a short description of the instrumentation and how we processed the imagery. Results and discussion will be present in section
3 followed by a short conclusion in section 4.

2. UVI Imager and Data Preparation

The Polar satellite was launched on February 24, 1996, into a highly elliptical 2 × 9 $R_E$ polar orbit with an orbit period of approximately 18 hours. The UVI imager on board the Polar spacecraft was designed to simultaneously acquire global auroral images and quantitatively extract fundamental information about the incident auroral electrons [Torr et al., 1995]. The Polar UVI is a large aperture (f/2.9), narrow angle (8° circular field of view) snapshot camera with a special two-dimensional focal plane mechanism design. When combined with a despin system, the UVI is capable of monitoring the northern hemisphere auroral oval for about 9 hours of every 18 orbit and can provide approximately 2300 images per day (or 37 s per image) with a resolution of 0.04° per pixel, equivalent to a best spatial resolution of 40 km at an assumed 120 km source altitude. There are four narrowband filters ($\Delta \lambda \sim 100 \text{ Å}$) alternatively operated in a regular mode on UVI covering the major FUV emissions from 1300 to 1800 Å: two for the O I emission lines at 1304 and 1356 Å, respectively, and two for detecting the N$_2$ Lyman-Birge-Hopfield (LBH) emissions at a shorter wavelength band, LBH-short, near 1500 Å and a longer wavelength band, LBH-long, near 1700 Å, respectively [Torr et al., 1995].

To attain coverage of all or most of the auroral oval, UVI has to operate under different sunlight conditions and image both dark and sunlit parts of the polar region. This means auroral images are usually contaminated by dayglow emissions. A dayglow removal scheme is therefore necessary in order to extract auroral emissions from the raw images. To model the dayglow intensity for many wavelengths is not trivial, and usually it involves a real time modeling of atmosphere and complete knowledge of the dayglow spectrum for all the neutral species in the upper atmosphere. For example, the 1304 Å band is optically thick, and therefore its emission rate is affected not only by the concentration of atomic oxygen but also by the atmospheric opacity and multiple scattering [Meier and Lee, 1982]. Both the 1356 Å and the LBH-short passbands reside in the strong absorption region of the O$_2$ Schumann-Runge continuum. Although the majority of dayglow at these two bands comes from above the O$_2$ absorption region, auroral emissions at these two bands are strongly absorbed by molecular oxygen at low altitudes where molecular oxygen is abundant and energetic precipitating electrons can easily reach. Therefore it is not easy to use these measured line emissions to infer the actually total energy input from the magnetosphere. The longer wavelength dayglow emission, LBH-long, however, do not experience O$_2$ absorption and are relatively independent of the energy distribution (i.e., characteristic energy) of precipitating electrons [Strickland et al., 1993]. Therefore, because of its simpler behavior, we will only use images taken at the LBH-long band for this study.

The database used for this study is selected from LBH-long images acquired by UVI from April 1, 1996, to July 28, 1996. Intensity of the observed total emissions is first converted to a useful physical unit as photon flux collected in the instrument aperture and normalized to nadir position. The second step is to determine the dayglow, which is modeled by binning image data outside of the auroral region by solar zenith angles. In our case the maximum magnetic latitude is chosen to be 60° at an assumed source height of 120 km to assure that auroral features are not included. A typical dayglow profile as a function of the solar zenith angles is then obtained after compiling the whole data set. A cosine function is also used to extent and smooth the dayglow profile over all solar zenith angles. Auroral emissions are finally obtained by subtracting UV dayglow from the calibrated images. The final step is to bin the auroral emissions from each image by magnetic local time (MLT) and magnetic latitude (MLAT) with the size of each bin being 1/3 hour × 1° MLAT. The geomagnetic coordinate system used for this study is adapted from the PACE magnetic field model defined by Baker and Wing [1989]. The whole data set is processed, and the auroral brightness is averaged to produce the auroral distribution in magnetic latitude and local time. Data are also processed on a monthly basis to study the relationship between the LBH-long auroral emission and sunlight.

3. Results and Discussion

We have processed approximately 4 months of UVI data at the LBH-long band. This time interval of study was roughly determined by the start of regular data collection (March 30, 1996) through the onset of instrumental problems (in August 1996). We have checked the camera’s sensitivity by comparing the daily averaged LBH-long dayglow from time to time. It was found that the camera’s sensitivity was stable throughout the whole data collecting period until July 28, 1996, which marks the ending period of the data set. This conclu-
Figure 1. A map of average northern auroral intensity at LBH-long band (λ ~ 1700 Å ± 50 Å) in the geomagnetic latitude-local time format. Contours of magnetic latitudes are drawn from 60° (outermost edge of the plot) to 90° (center of the plot) with an increment of 5°. Local times are hourly drawn and marked counterclockwise along the 60° magnetic latitude for every 3 hours starting at 0000 MLT on the bottom of the plot.

The general characteristic of the global auroral LBH-long emission can be summarized as follows. The LBH-long auroral oval emissions are confined to a belt whose center is shifted several degrees antisunward of the geomagnetic pole. There are three distinctly different emission peak regions along the northern auroral oval. The most intense auroral emission appears to occur near the midnight region approximately centered at 2230 MLT and 68° MLAT and extended more than 3 hours of MLT, representing the statistical nightside auroral storm distribution. A weaker local maximum emission is located in the postnoon sector and centered about 1500 MLT and 75° MLAT. This is coinciding with the maximum region 1 upward field-aligned currents [Iijima and Potemra, 1976] and the so-called 1400 MLT bright spots [Evans, 1985; Meng and Lundin, 1986]. Newell et al. [1996a] reported that electron precipitation-associated discrete aurorae are more common at 1500 MLT than any other local time; however, these dayside aurorae have much lower electron characteristic energies (below 1 keV) and also lower energy fluxes (typically below 1 erg cm⁻² s⁻¹) than do the nightside. A much weaker local intensity peak appears in the prenoon sector centered around 0900 MLT and may coincide with the morning “warm” spot identified by particle measurement [Newell et al., 1996a].

We have also processed data on a monthly basis, and the results are shown in Plate 2. Plates 2a - 2d corresponding to the 4 months of data from April to July, respectively, show the monthly averaged photon fluxes. The format of each panel is similar to that of Plate 1. The numbers of images sampled are 4012 for April, 4207 for May, 4722 for June, and 4825 for July, and are also listed on the bottom of Plate 2.

In April, Plate 2a, the most intense auroral emission appears to occur near the midnight region approximately centered at 2230 MLT and 68° MLAT. A midday gap with average photon flux below 4 photons cm⁻² s⁻¹ can be seen on the dayside between 1000 and 1300 MLT. In May, Plate 2b, the whole pattern of average auroral emissions changed a little from that of April. The location of maximum intensity did not change but the...
Plate 1. Maps of monthly averaged auroral emissions, as a function of magnetic latitude (from 60° to 90° and local time, derived from the Polar UVI imagery at LBH-long band (λ ~ 1700 Å ± 50 Å) for (a) April, (b) May, (c) June, and (d) July 1996. The format for each panel is similar to that used in Plate 1.
auroral intensity on the morningside decreased about 30% and the intensity of the midday gap seen in April increased. It also appeared that the intensity maximum near the midnight sector decreased slightly, while the average intensity in the afternoon region increased by about 20%. For the month of June, Plate 2c, the distribution of auroral emissions appeared to change significantly from the two previous months in several respects. First, the whole pattern of auroral emissions reveals two local time maxima along the oval: one centered at 2200 MLT and 69° MLAT and the other centered at 1500 MLT and 76° MLAT. Second, the center of the weakest auroral region continuously shifted clockwise from 1200 MLT in April and 0600 MLT in May to 0400 MLT in June. Third, the maximum intensity of the nightside auroral emissions decreased dramatically by about 30% from May to June and the latitudinal width of the auroral emission in the late evening region decreased. The most interesting change of all is the enhanced bright spots appeared in the afternoon quadrant approximately centered at 1500 MLT. In July, Plate 2d, the trend of the fade out of nightside emissions and the intensification of the emission in the afternoon region seen in June continued and the maximum intensity of the afternoon bright spots has moved poleward by about 1° - 2° MLATs. Surprisingly the 1500 MLT dayside bright spots dominate in brightness along the auroral oval. A new enhanced emission spot centered at 0900 MLT and 73° MLAT can be seen in July and may coincide with the morning “warm” spot identified by particle measurement [Newell et al., 1996a].

3.2. Suppression of the Nightside Aurorae

One of the major findings from this study is that nightside aurorae show progressive decreases in intensities from April to July. There are two potential candidates which may cause this suppression of nightside aurorae: one is the change in geomagnetic activity and the other is the seasonal effect.

It has been known that geomagnetic activity shows a semiannual variation [Cortie, 1912; Russell and McPherron, 1973] and that the auroral occurrence rate is highly correlated with the geomagnetic activity [Sandford, 1968; Danielsen, 1980]. Since the geomagnetic activity is generally enhanced during the equinoxes, i.e., geomagnetic fields are more disturbed in spring (and fall) than in summer (and winter), one may simply attribute the gradual decrease in auroral emissions on the nightside from April (spring) to July (summer) to this effect. To investigate this, we have listed the cumulative Kp index in Table 1.

Table 1. Cumulative Kp Index and F10.7 Solar Flux From April to July 1996

<table>
<thead>
<tr>
<th>Month</th>
<th>F10.7 x 10^{-22} W m^{-2} Hz^{-1}</th>
<th>Kp</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>69.9 (70.3)</td>
<td>288 (2.0)</td>
</tr>
<tr>
<td>May</td>
<td>71.7 (71.9)</td>
<td>203 (1.9)</td>
</tr>
<tr>
<td>June</td>
<td>71.8 (71.8)</td>
<td>165 (1.5)</td>
</tr>
<tr>
<td>July</td>
<td>73.5 (73.0)</td>
<td>146 (1.8)</td>
</tr>
</tbody>
</table>

Numbers in the parenthesis denote the average values.

The monthly Kp index does indeed reveal a gradual decrease from April to July, indicating the semiannual geomagnetic activity variations, and therefore part of the nightside auroral emissions may reflect seasonal geomagnetic activity variations. This, however, may not be the only cause, as the following two considerations make clear. First, we expect a dramatic decrease in auroral intensities from April to May due to a large decrease in the cumulative Kp index from 288 in April to 203 in May as shown in Table 1. However, this is not seen in Plate 2. Moreover, the nightside emissions drop significantly from May to June when they are under sunlight, although Kp changes only modestly from 203 to 165. Second, we have to realize that the UVI camera does not operate 24 hours per day because there are missing periods when the Polar satellite was not orbiting above the north pole. Therefore the average Kp index, which is given in the parentheses in Table 1, would be more representative to the actual geomagnetic activity over the sampling periods. One can see from the average Kp index that the images used for this analysis are actually taken at relatively quiet periods (1.5 ≤ Kp ≤ 2.0) with a small dip in June (Kp = 1.5). This corrected Kp variation is not consistent with the continuous decreases in the observed auroral emissions along the nightside oval from April to July shown in Plate 1. Therefore it seems unlikely that the geomagnetic activity variations play a major role on the observed auroral emissions on the nightside.

To justify our conclusion, we have also processed the same image data set under different geomagnetic activities defined by Kp for the months of April and June, and the results are shown in Plate 3. In Plate 3 the top (bottom) two panels show the average LBH-long auroral distribution in April (June) for Kp < 1+ (left panel) and for 2 < Kp < 2+ (right panel), respectively.
Plate 2. Maps of monthly averaged auroral emissions for (a) and (b) April and (c) and (d) June, sorted by two geomagnetic conditions: $Kp < 1+$ for the two panels on the right and $2- < Kp < 2+$ for the two panels on the left. The definition of the plots is the same as that for Plate 1.
With a direct comparison between Plates 3a and 3b or Plates 3c and 3d, one can easily see that the average auroral luminosity increases, as one would expect, with the increase of geomagnetic activity. However, when comparing auroral emissions at the same Kp value between April and June (i.e., different solar zenith angles), one can clearly see that auroral emissions on the nightside are consistently suppressed from April to June for both Kp values, indicating that suppressions of the nightside auroral emission are independent of the geomagnetic activities. On the other hand, the nightside aurora weakened from April to July may be attributed to the suppression of sunlight as suggested by Newell et al. [1996b]. They analyzed 8 years of DMSP particle data and found that the probability of intense discrete aurorae (> 5 ergs cm⁻² s⁻¹) is reduced in sunlit conditions (solar zenith angle < 85°) by a factor of 3 compared to that in darkness (solar zenith angle > 110°). They attributed this effect of sunlight suppression to the ionospheric feedback mechanism [Ogawa and Sato, 1971; Sato, 1978]. Since our result of the nightside auroral emission resembles the result of [Newell et al., 1996b], we might simply attribute the decreases in nightside auroral emissions from April to July to the sunlight effect too. One has to be cautious about this assertion in comparing results from two different types of measurements. As mentioned in section 2, the typical spatial resolution of UVI is about 20 - 40 km, and hence it cannot resolve the fine structured discrete aurora from the less structured diffuse aurora. Although we are not certain of the relative contribution from two different arcs to the average nightside auroral emission shown in Plates 1 and 2, it may be adequate to say that to a good approximation, the main feature of the nightside auroral emission represents the discrete aurora. Another question is that if auroral emissions are suppressed by sunlight, one would expect that the average nightside auroral emission will be the weakest in June (the summer solstice is on June 23) but not in July as indicated by this study result. The limited auroral emissions data alone presented here are not statistically sufficient in themselves to prove the controlling role of sunlight. However, they clearly do support the particle observations, which included direct summer/winter comparisons (excluding the equinoxes) over 8 years.

### 3.3. Enhancement of Dayside Auroral Emissions

In contrast to the suppression of nightside aurorae by sunlight, dayside aurorae appear to brighten in sunlight. Incidentally, this result is consistent with the particle observations, but only if the 1500 MLT spot consists mainly of events below the 5 ergs cm⁻² s⁻¹ threshold [cf. Newell et al., 1996a]. It is generally agreed that dayside auroral arcs, first identified by Anger [1987] with auroral scanning photometer on ISIS 2, in the midday section of the auroral oval are persistent and more or less independent of the auroral activity in the nightside oval [Murfree et al., 1981; Evans, 1985; Meng and Lundin, 1986; Liou et al., 1997]. Thus dayside auroral activity should not necessarily be associated with magnetospheric substorms which take place mainly in the nightside part of the oval, and the differing effect of sunlight on dayside versus nightside aurorae is simply one more fact illustrating their separate phenomenology. There are a couple of points that support the consistency between different observations. First, our results indicate that during a relatively quiet time (June and July compared to April and May) the auroral intensities maximize in postnoon and prenoon (with the latter much weaker), which is consistent with the results of Danielsen [1980] derived from ground observations. Second, the dayside maximum auroral emission is found to be centered at 1500 MLT and is consistent with the long-term statistical precipitating particle measurements [Newell et al., 1996a]. The 1500 MLT bright spots, historically called “400 MLT” bright spots, are generally found to be coincidence with the maxima region 1 upward field-aligned currents reported by Hjáma and Potemra [1976]. This coincidence of maximum location among the auroral emissions, particle precipitation, and field-aligned currents supports the concept that upward field-aligned currents are created by downward precipitating electrons which are accelerated down into the ionosphere and create discrete aurorae.

It is well known that an increase in geomagnetic activities will enhance auroral brightness alone the oval. This can be seen from Plate 3. From Plates 3a to 3b, it shows that the LBH-long auroral emission alone the oval, except the midday gap, in April was enhanced as the average geomagnetic activity Kp index increased from 1 to 2. This enhancement is also illustrated in Plates 3c and 3d for June. Nonetheless, Plate 3 also shows that the enhancement of dayside auroral emissions in sunlight is not associated with the changes in geomagnetic activities in the surveyed summer months. For a fixed value of the Kp index, say Kp = 1, one can see from Plates 3a and 3c that dayside auroral intensities increased significantly from April to June. A consistent trend can also be seen in Plates 3b and 3d for Kp = 2.

Like geomagnetic activities, large-scale Birkeland cur-
rents also reveal seasonal variations. The intensities of Birkeland currents on the dayside, from approximately 1000 to 1800 MLT, are found to be larger in summer than in winter by an average factor of 2, and the summer/winter ratio of the current intensities in the nighttime oval from the premidnight region to 0800 MLT is found to be close to 1 [Fuji et al., 1981]. Generally, the major source of the dayside and nightside ionospheric conductivities are different. Particle precipitation is considered as the main source of the nightside ionospheric conductivities while solar photoionization is the main source of the dayside ionospheric conductivities. Therefore the solar flux and solar zenith angle play the major role in producing ionospheric conductivities on the dayside. In this study, the solar radio emission flux F10.7 (see Table 1) indicates a small increase throughout the entire surveyed periods from 69.9 (April) to 73.5 (July). Since the solar zenith angle minimizes at summer solstice (June 23), we may expect that the dayside ionospheric conductivities, and consequently the Birkeland currents and the precipitating electrons, will increase from April to June. Our result that shows a brighter dayside auroral emission in July may be due to a slight increase in solar F10.7 radio flux and Kp index. It is worth to note that according to Fuji et al. [1981] the upward field-aligned currents on the dayside appear at higher latitudes by about 1° - 3° during the summer in comparison to the winter. Our results show a general agreement with their results.

3.4. A Unifying View of Dayside/Nightside Auroral Arc Formation

From the discussions given in sections 3.2 and 3.3, it is suggested that the sunlight, hence the ionospheric conductivity, may have played a major role in the formation of auroral arcs on both dayside and nightside parts of the auroral oval. One way to treat the nightside and dayside phenomena as a whole with respect to conductivity is to consider that the electron acceleration process in an aurora is associated with the driving of a current out of the magnetosphere. Wherever a current is driven, an aurora will appear, and in general the more intense the current the more frequent aurora will be. However, whether or not an aurora becomes an intense event with multikilovolt acceleration and many ergs cm\(^{-2}\) s\(^{-1}\) depends on whether the ionospheric feedback mechanism is at work. In general, this mechanism works only when ionospheric conductivity is insufficient to support the currents that the magnetosphere wishes to drive. Thus aurorae are more frequent where the driven currents are stronger; aurorae are most intense where ionospheric conductivity is the lowest.

Aside from the discrete aurora, the two other main sources of conductivity are the gradient/curvature drift electrons which fall into the Earth’s magnetic field loss cones (i.e., diffuse aurorae) [Newell et al., 1996b] and the solar radiation. Because energetic electrons drift toward dawn, it is in the dusk/midnight region and in darkness that ionospheric conductivity is lowest and where intense discrete aurorae are most common.

The location where the currents out of the ionosphere maximize is precisely coincident with the 1500 MLT hot spot, which indeed is the most probable site for observing discrete aurorae anywhere in the oval [Newell et al., 1996a]. However, the particle data indicate that these aurorae rarely grow into intense events, generally remaining below 1 keV in electron energy and less than 5 ergs cm\(^{-2}\) s\(^{-1}\) in electron energy flux. The occurrence of these relatively weak aurorae is probably proportional to the strength of the Birkeland currents, which maximize in summer. Indeed, in the summer they are so frequent that they in total represent a significant contribution to the overall auroral radiance, apparently averaging a greater emissivity than anywhere in the nightside oval in July. However, even under these conditions the particle data indicate that the 1500 MLT spot simply contains many weak aurorae, and not intense aurorae.

4. Conclusion

We have presented what, so far as we know, are the first global distribution of auroral UV emissions directly derived from a large set of global auroral images. Images of a total of 17,372 used for this study were acquired by the Polar UVI imager over the north polar region from April to July in 1996, and results were organized as a map of northern auroral distribution in magnetic latitude and local time system. It was found that there are three distinctly different auroral distributions along the northern auroral oval. The strongest emission is located in the premidnight sector centered at 2230 MLT and 68° MLAT and extended more than 3 hours of MLT. A weaker emission was found to be located in the postnoon sector centered at 1500 MLT and 75° MLAT. A much weaker emission, which may not be clearly identified in all seasons as shown in Plate 2, may be seen in the prenoon sector centered about 0900 MLT.

Results were also organized on a monthly basis to show a possible solar radiation effect on the occurrence of discrete aurorae. It was found that discrete aurorae are seasonally affected in such a way that the nightside
(dayside) auroral emission decreases (increase) gradually from April to July. Because the difference in auroral emissivity is much larger than the relatively small changes in $K_p$ during this observational period and because it also holds for subsets with fixed $K_p$, we believe that the observed seasonal variation can be attributed to the ionospheric conductivity feedback mechanism and is consistent with the previous results based on intense electron acceleration events.

The UVI data show that the dayside aurora exhibits a totally different response characteristic to sunlight compared to its counterpart in the nightside auroral oval, namely, dayside auroral emissions are enhanced by sunlight. This can be consistent with the particle results as long as the summer increase consists of more frequent relatively weak aurorae ($< 5$ ergs cm$^{-2}$ s$^{-1}$). Indeed, the present results show that the total dayside emissions in June and July can exceed the nightside auroral emissions. The behavior of dayside auroral emissions in different sunlight conditions has never been investigated; however, we suggest that this enhancement of dayside, particularly in the vicinity of 1500 and 0900 MLT regions, bright spots in sunlight is closely linked to the seasonal trend of the region 1 upward field-aligned currents and the ionospheric conductivities which both maximize in summer. The frequency of auroral occurrence appears to be controlled by the strength of Birckland currents out of the ionosphere; however, very intense aurorae occur where ionospheric conductivity is lowest.

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References


SYNOPTIC AURORAL DISTRIBUTION


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