Ionization Enhancements in the Post-midnight Hours at some Antarctic Stations and the Diurnal Excursion of the Auroral Oval

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An analysis of various ionospheric parameters at Sanae, Antarctica, indicates that the diurnal excursion of the auroral oval contributes to the behaviour of the ionosphere at Sanae in the early morning hours, at all altitudes and even during magnetically quiet conditions. This influence was found to be much less pronounced at Winnipeg and Campbell Island, both of which lie on the same geomagnetic latitude as Sanae, but they differ from Sanae in that the former lies in the northern hemisphere and the latter, although southern hemisphere, lies outside the South Atlantic geomagnetic anomaly. The implications are that the auroral oval, oı some associated ionizing phenomenon, moves further towards the equator in the southern hemisphere, and that this may be more pronounced in the vicinity of the magnetic anomaly than it is elsewhere.

'n Ontleding van die onderskeie ionosferiese parameters by Sanae, Antarktika, dui daarop dat die daaglikse ekskursie van die aurora-ovaal die gedrag van die ionosfeer by Sanae in die vroeë oggendure, op alle hoogtes en selfs onder magneties stil toestande, beïnvloed. Hierdie invloed is baie minder merkbaar by die eilande Winnipeg en Campbell, wat albei op dieselfde geomagnetiese breedte as Sanae lê, hoewel hulle van Sanae verskil in dié opsig dat eersgenoemde in die noordelike halfrond lê en laasgenoemde buite die Suid-Atlantiese geomagnetiese anomalie. Die implikasies hiervan is dat die aurora-ovaal of 'n geassosieerde ioniseerverskynsel verder na die ewenaar beweeg in die suidelike halfrond en dat dit in die omgewing van die magnetiese anomalie moontlik opvallender as elders is.

Introduction

In earlier papers (*Torr*, 1971; *Torr & Torr*, 1971) we discussed the effects of the diurnal excursion of the auroral oval on the airglow at Sanae (70°S, 2°W). Large (>50 R) nighttime enhancements occur in 6 300, 5 577 and 4 278 Å. These enhancements are usually accompanied by sporadic-E and increases in the 30 MHz riometer absorption and occur more frequently with higher magnetic activity. The enhancements generally occur shortly after midnight, reaching a maximum between 0200 and 0300 local time and lasting two to three hours. It was concluded that these factors were consistent with the diurnal excursion of the auroral oval. The oval is nearest the equator near or shortly after midnight. *Feldstein* (1966) has reported that the auroral oval lies at 70° geomagnetic latitude on the nightside during magnetically quiet times, but that it can reach 59° when Kp goes above 5. Sanae lies at 60° geomagnetic latitude. Further substantiation was provided by the ratio I6300/I5577 which is $\sim$ 0,7 in the pre-midnight hours but changes to $\sim$ 0,3 during the enhancement. The latter figure is fairly typical for aurorae. Similarly, I6300/I4278 is $\sim$ 2,3 in the pre-midnight hours, changing to 0,8 during the enhancement, a figure in agreement with the 0,5 to 0,9 found by *Eather* (1969) for normal aurorae.

In this paper we have examined some of the ionospheric parameters to see whether their variation is influenced by the movement of the auroral oval or not.

Effects on Ionospheric Parameters

Initially the analysis appeared to be hampered by the fact that there is usually an ionospheric blackout at Sanae as soon as there is any degree of magnetic disturbance. However, on looking, for example, at fmin, at low Σ Kp or geomagnetically quiet conditions, it was found that there is usually an enhancement in this parameter in the post-midnight hours. This may be seen in Fig. 1 which shows the number of times a given ionospheric parameter exceeds a threshold value at any hour of the night. The threshold was selected by increasing it steadily from a low value until the post-midnight enhancement was filtered out of the lower values. For these purposes, only data for the winter months (May to August) were used as the early sunrise in summer tends to obscure the effects. Data for the years 1962 to 1971 were used, but each individual year follows the same pattern.

Also shown in Fig. 1 is the normalized frequency of zenith auroral occurrence observed at Sanae in 1964 (*Robertson*, 1965). These crosses follow the shape of the enhancements remarkably well and strongly support the conclusion that the diurnal excursion of the auroral oval is a major contributor to the behaviour of the early morning ionosphere at Sanae. This is true for all altitudes even at magnetically quiet times. On the basis of auroral oval theories for the northern hemisphere, we would expect auroral influence to be observable at Sanae only during magnetic activity.

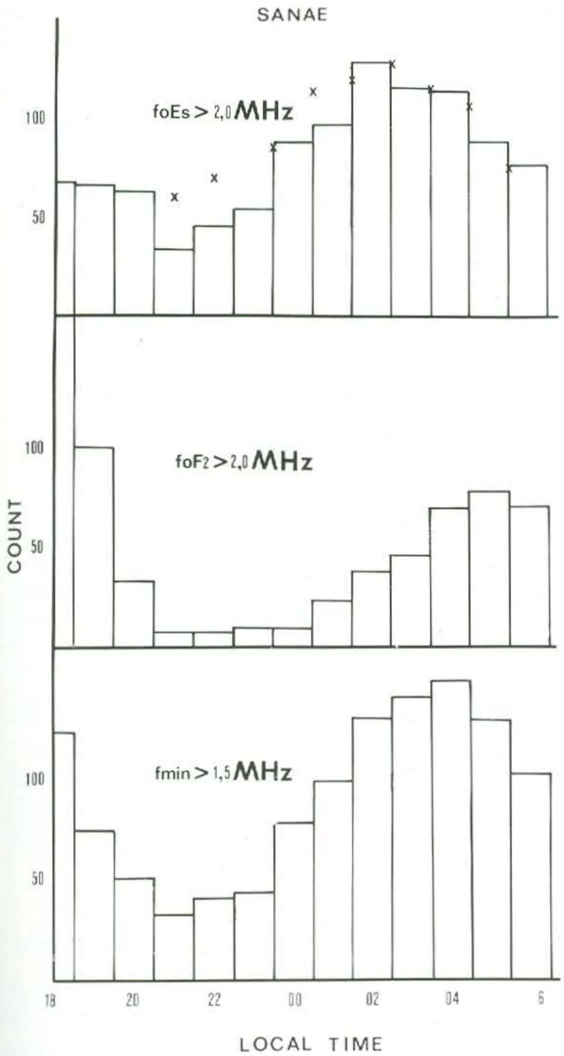

Fig. 1. Number of times fmin, foF2 and foEs at Sanae exceed the given threshold at a given hour of the night.

A similar analysis was therefore performed for a northern hemisphere station on the same geomagnetic latitude, *viz* Winnipeg (50°N, 97°W). In this case data for January, February, November and December, 1962 were used. The results of this are shown in Fig. 2. There is a small indication of a post-midnight enhancement in fmin and foEs data (but not as pronounced as at Sanae) and there is no enhancement in foF2.

Fig. 3 shows the results for Campbell Island (53°S, 169°E) which lies at the same geomagnetic latitude as Sanae but well outside the South Atlantic Magnetic Anomaly. Data for the winter months of 1962, 1965 and 1971 were used. In this case there is evidence of a connection between the excursion of the auroral oval and foEs, but not foF2 or fmin.

Fig. 4 shows the same thing for Halley Bay (75°S, 27°W) which, like Sanae, lies within the influence zone of the magnetic anomaly. In this case data for the winter months of 1967 to 1970 were used. As for Sanae, the enhancement is to be seen in all three parameters.

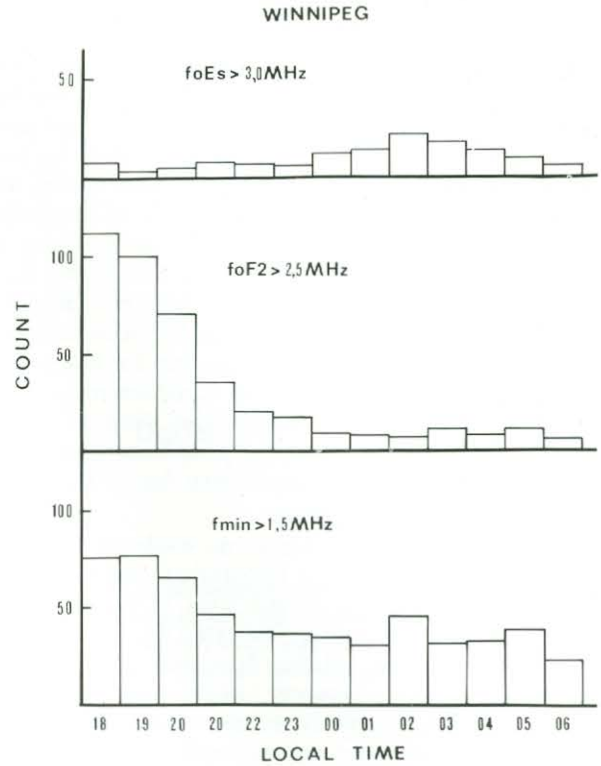

Fig. 2. Same as Fig. 1 for Winnipeg.

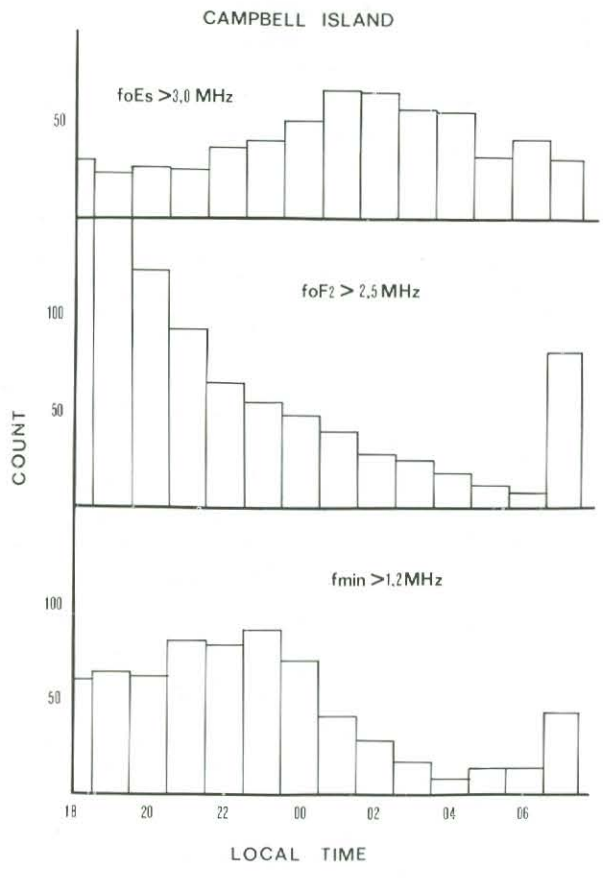

Fig. 3. Same as Fig. 1 for Campbell Island.

Discussion

Some evidence has been provided which indicates that there may be differences in the extent of the diurnal excursion of the auroral oval in the two hemispheres. Fig. 5 is reproduced from *Bond & Thomas* (1971) and shows the movement (in colatitude) with Kp of the equatorward and poleward boundaries of the oval. The poleward boundaries vary in a similar way in both hemispheres, although in the south the high latitude boundary does lie further towards the pole. For low Kp, the equatorward boundary also varies in a similar way in both hemispheres, but for higher Kp it appears that it moves further equatorwards in the southern hemisphere. However, this diagram represents observations from stations at different longitudes and so smooths out any asymmetry due to the South Atlantic Magnetic Anomaly.

To the authors' knowledge, no evidence has been provided previously for a longitudinal asymmetry in the diurnal excursion of the oval in the southern hemisphere, as seems to be indicated by the difference between the Sanae – Halley Bay and the Campbell Island data. It is, however, likely that the mirror heights of quasi trapped particles will be lowered in the magnetic anomaly region, resulting in observable ionospheric effects there (*Gledhill & Torr*, 1966; *Gledhill, Torr & Torr*, 1967; *Torr & Torr*, 1968; *Kühn*, 1971). Electron precipitation patterns over the northern polar cap have been reviewed by *Paulikas* (1971). More Antarctic stations will have to be examined in order to throw further light on this problem. The treatment in this paper serves merely to indicate the phenomenon but does not allow comparison from station to station for similar magnetic disturbance conditions. This is being analysed at present.

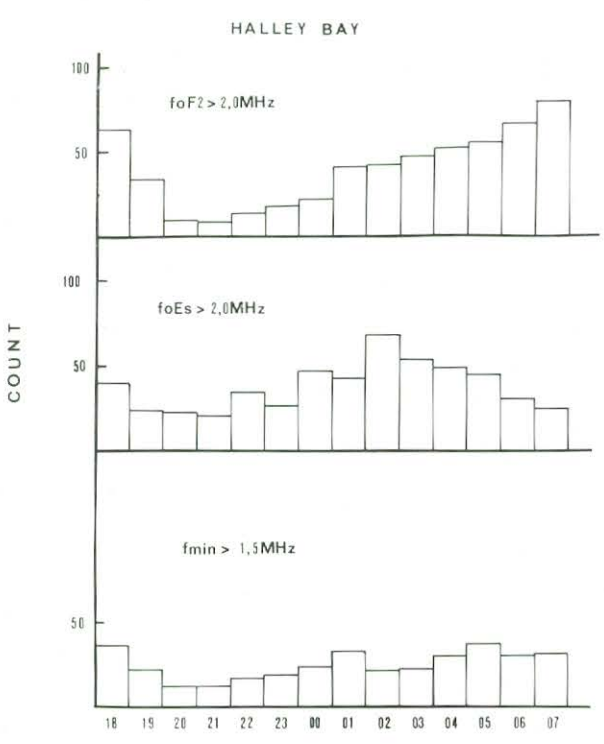

Fig. 4. Same as Fig. 1 for Halley Bay.

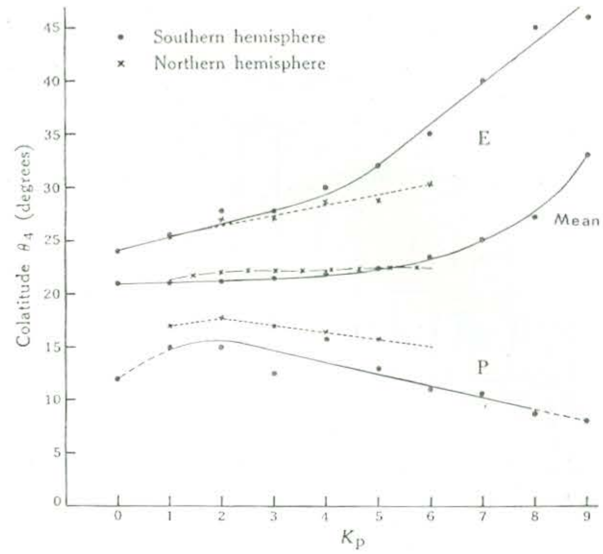

Fig. 5. Locations of the mean positions of the poleward (P) and equatorward (E) envelopes of the auroral ovals at geomagnetic midnight. Reproduced from Bond & Thomas (1971) with permission of the Australian Journal of Physics.

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